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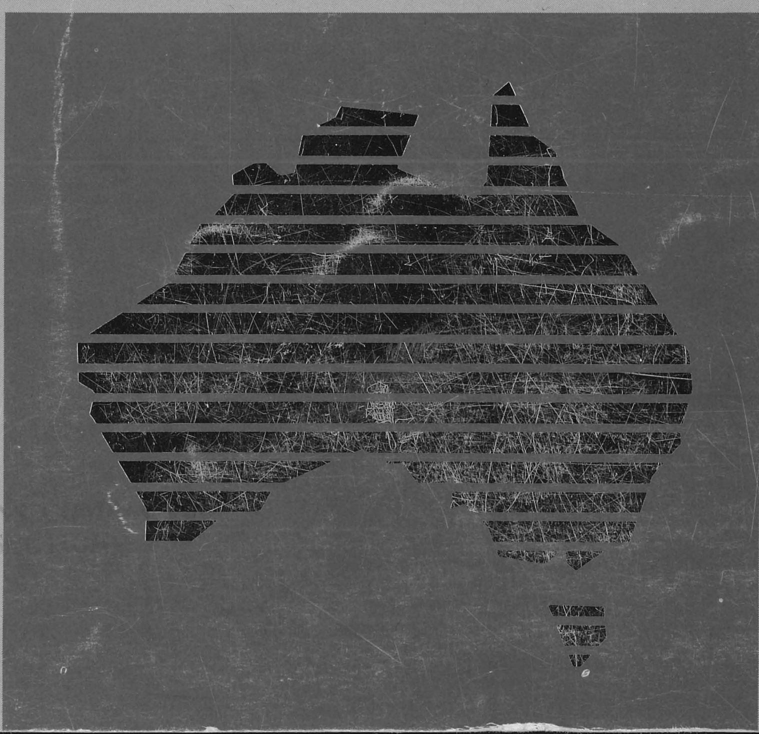

DEPARTMENT OF PRIMARY INDUSTRIES AND ENERGY

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BUREAU OF MINERAL RESOURCES, GEOLOGY & GEOPHYSICS

AUSTRALIAN BUREAU OF AGRICULTURAL AND RESOURCE ECONOMICS

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CONTENTS

Australian and world macroeconomic developments and prospects

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Australian Bureau of Agricultural and Resource Economics

During the 1980s, the dominant feature of the Australian and major industrialised economies, particularly the United States, Japan and the Federal Republic of Germany, has been the emergence and persistence of large current account imbalances and associated substantial changes in net external asset positions. The further correction of these external imbalances is likely to be the focus of macroeconomic policies over the next several years.

The Australian experience has broadly paralleled that of the United States. In both countries, a sharp rise in the federal budget deficit in the early 1980s was a major contributing factor to the deterioration in the external accounts. Both countries also accumulated a large foreign debt during the first half of the 1980s. More recently, the federal budget in Australia has moved into surplus, while in the United States it remains in substantial deficit. Although the current account deficit in each country has declined somewhat, further changes in the level of domestic expenditure, particularly fiscal restraint in the United States, still appear to be needed. Failure to reduce the US federal budget deficit in 1989 and 1990 would increase the risk of adverse market reaction, leading to the possibility of lower world economic growth than might otherwise occur.

The Australian Economy

. Recent developments

During the 1980s, the most striking feature of the Australian macroeconomic experience has been the emergence of a large current account deficit and foreign debt. The current account deficit as a share of gross domestic product peaked at 6 per cent in 1985-86, compared with an average of 2 per cent between 1960-61 and 1979-80 (figure 1). Although a decline of about 1 percentage point was recorded in each of the subsequent two years, stalling of this downward trend is likely in 1988-89.

Largely as a result of successive large current account deficits, Australia's net foreign debt relative to gross domestic product increased sharply from 5.6 per cent in 1979-80 to a peak of 32 per cent in 1986-87 (figure 2). However, this deterioration also reflects a marked switch from equity to debt financing in the 1980s and valuation effects of the depreciation of the Australian dollar during 1985 and 1986. Indeed, it is largely due to the appreciation of the Australian dollar since mid-1986 that net external debt has since fallen slightly from its peak to around 31 per cent of gross domestic product (Reserve Bank of Australia 1988).

This paper is an update of the Bureau's paper presented at the National Agricultural Outlook Conference, January 1989.

Figure 1: Australia's current account balance as a share of gross domestic product

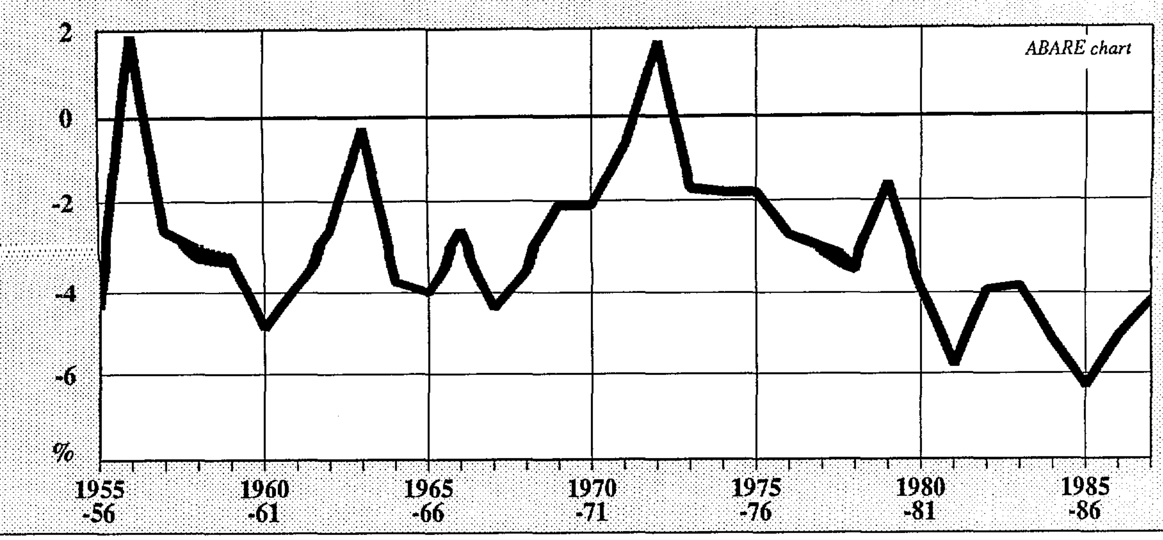


Figure 2: Australia's net foreign debt as a share of gross domestic product

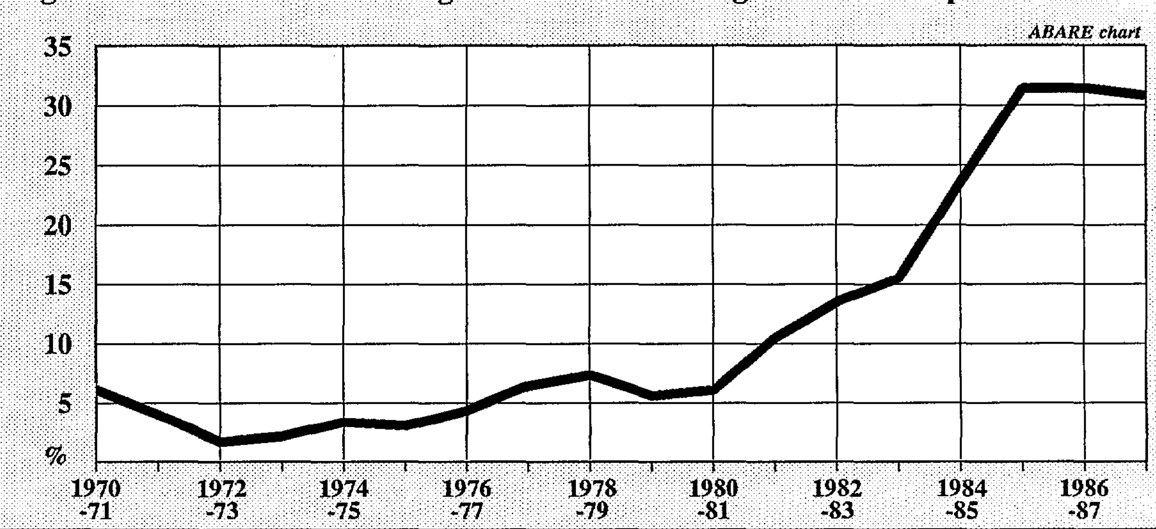
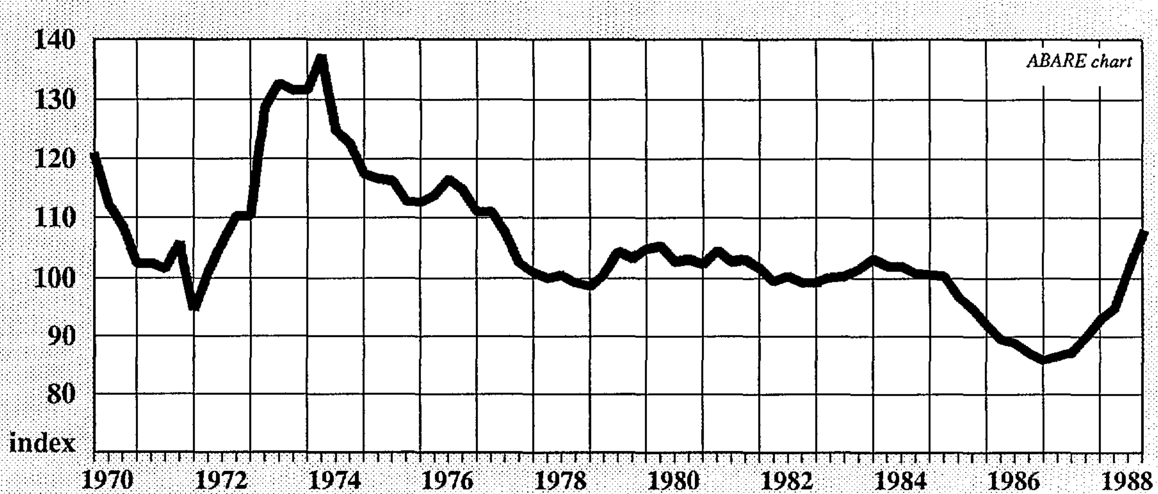


Figure 3: Australia's terms of trade



To analyse these issues further the current account may be decomposed along the lines of the balance of payments into the balance of trade on goods and services, net income and net transfers. These components are expressed as shares of gross domestic product in table 1. The growing burden of servicing Australia's foreign debt has already resulted in a considerable increase in the net income deficit. The net income balance, as a share of gross domestic product, reached a deficit of 3.8 per cent in 1987-88, compared with an average of 1.8 per cent in the 1970s. In addition, the trade deficit increased markedly in the mid-1980s as a result of a sharp fall in Australia's terms of trade during 1985 and 1986 (figure 3). However, with the subsequent recovery in the terms of trade, the trade deficit fell in both 1986-87 and 1987-88, accounting for most of the reduction in the current account deficit in both years (Reserve Bank of Australia 1988). To achieve a lower current account deficit, the trade account will need to strengthen further to offset the increased debt servicing commitments.

There is an alternative way to analyse the current account deficit which also provides some insights into recent and prospective developments. When domestic expenditure exceeds national income, the current account is in deficit. The consequent shortfall in domestic saving relative to domestic investment must be met by foreign capital inflow. Historically, the public sector has been a net borrower (see table 1). Expansionary fiscal policy contributed to the increase in the current account deficit in the early 1980s. In particular, the net public sector borrowing requirement, as a share of gross domestic product, increased significantly from 3.1 per cent in 1980-81 to 6.7 per cent in 1983-84. The subsequent marked tightening in fiscal policy led in 1987-88 to a budget surplus and a substantial decline in the net public sector borrowing requirement, to 0.3 per cent of gross domestic product. The Treasury expects that, for the first time on record, there will be no net borrowing by the public sector in 1988-89 (Commonwealth of Australia 1988). However, these public sector developments have been offset by the sharp decline in private sector saving relative to gross domestic product since 1983-84, which was associated to some degree with the marked deterioration in Australia's terms of trade in the mid- 1980s.

Changes in the real exchange rate provide the necessary price signals for the export and import competing sectors to attract resources from the rest of the economy and are needed to complement adjustment in the level of domestic expenditure. The real effective value of the Australian dollar declined sharply by 37 per cent between the December quarter 1984 and the September quarter 1986 (figure 4). Bureau research indicates that a real exchange rate about 15-20 per cent below its end 1984 level is broadly consistent with the achievement of a sustainable current account deficit (O'Mara, Wallace and Meshios 1988). Consistent with this analysis, the real exchange rate has recovered from its mid-1986 level. Although there was some overshooting in the real appreciation of the Australian dollar during 1988 and early 1989, this was corrected by late February 1989.

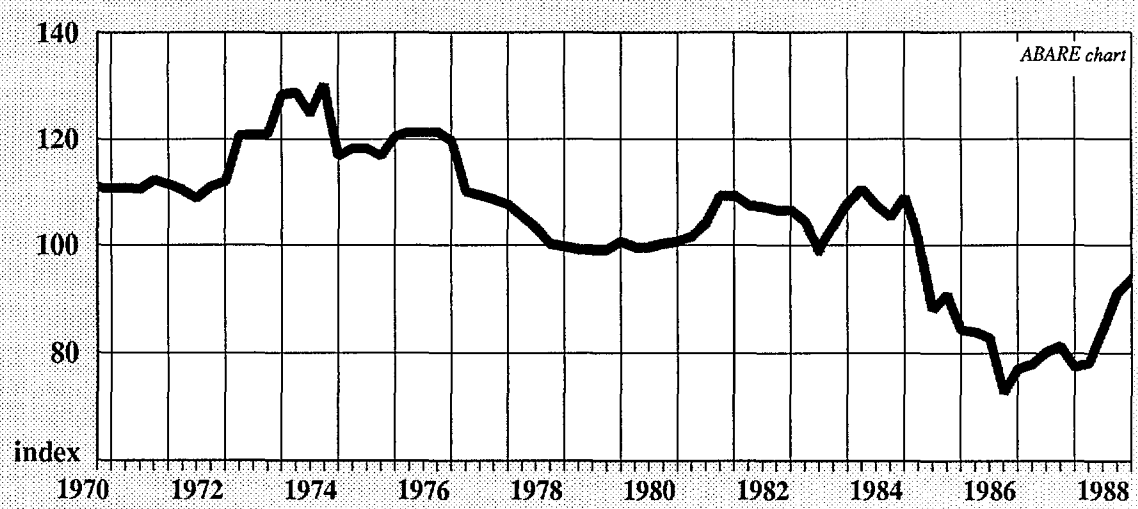
Associated with the increase in the real exchange rate, the nominal value of the Australian dollar has appreciated significantly since late 1987. The trade weighted value of the dollar peaked at 67 in early February 1989, well above the near record low of 50.7 in November 1987. Against the US dollar, the Australian dollar strengthened to US89c in early February 1989 from US68c in November 1987. This strengthening in the Australian dollar was underpinned by a rise in interest rates and occurred despite a deterioration in the current account deficit and an increase in the rate of inflation. However, the announcement of the relatively high December quarter inflation

Table 1: CONTRIBUTIONS TO THE CURRENT ACCOUNT BALANCE (Shares of gross domestic product)

	Balance of payments(a)			National saving-investment balance(b)						
				Private			Public			
Year	Trade in goods and services (1)	Net income (2)	Net transfers (3)	Saving (4)	Investment (5)	Net lending (6)	Saving (7)	Investment (8)	Net lending(c) (9)	Current account balance (10)
	%	%	%	%	%	%	%	%	%	%
1970-71	-0.0	-2.0	-0.1	17.3	18.1	-0.9	6.6	7.8	-1.2	-2.1
1971-72	1.1	-1.8	-0.1	18.2	17.6	0.6	6.7	8.0	-1.3	-0.7
1972-73	3.7	-1.7	-0.2	20.5	17.1	3.4	5.6	7.3	-1.7	1.7
1973-74	0.0	-1.4	-0.3	15.8	16.7	-1.0	6.4	7.1	-0.7	-1.7
1974-75	-0.4	-1.1	-0.3	17.8	14.7	3.1	3.5	8.4	-4.9	-1.8
1975-76	0.4	-1.8	-0.4	18.4	15.7	2.7	3.9	8.4	-4.5	-1.8
1976-77	-0.7	-1.8	-0.3	17.4	16.2	1.2	3.8	7.8	-4.0	-2.8
1977-78	-1.1	-1.8	-0.2	17.9	16.0	1.9	2.7	7.7	-5.0	-3.1
1978-79	-1.1	-2.0	-0.3	18.1	16.8	1.3	2.5	7.2	-4.7	-3.4
1979-80	0.6	-2.2	-0.1	18.4	16.4	2.0	3.4	7.0	-3.6	-1.6
1980-81	-2.0	-1.9	-0.1	17.5	18.4	-0.8	3.7	6.8	-3.1	-3.9
1981-82	-3.7	-2.0	-0.1	16.7	19.1	-2.4	3.9	7.3	-3.4	-5.8
1982-83	-2.3	-1.6	-0.1	18.3	16.3	2.0	1.9	7.8	-5.9	-3.9
1983-84	-1.5	-2.5	0.1	18.5	15.6	2.9	0.7	7.4	-6.7	-3.8
1984-85	-2.3	-3.1	0.1	16.6	16.8	-0.1	2.0	7.1	-5.1	-5.2
1985-86	-3.2	-3.4	0.3	15.7	17.2	-1.5	2.7	7.5	-4.8	-6.3
1986-87	-2.0	-3.6	0.5	15.2	16.7	-1.5	3.8	7.4	-3.6	-5.1
1987-88	-1.0	-3.8	0.6	14.0	18.0	-3.9	5.9	6.2	-0.3	-4.2
1970-71 to 1979-80(d)	0.3	-1.8	-0.2	18.0	16.5	1.4	4.5	7.7	-3.2	-1.7
1980-81 to 1987-88(d)	-2.2	-2.7	0.2	16.6	17.3	-0.7	3.1	7.2	-4.1	-4.8

(a) Note that (10) = (1) + (2) + (3). (b) Several components of the saving-investment balance were derived residually: (6) = (10) - (9); (4) = (5) + (6); (7) = (8) + (9). (c) Negative of the net public sector borrowing requirement. (d) Period average.
Sources: Australian Bureau of Statistics; Treasury.

Figure 4: Australia's real exchange rate



figures and a substantial increase in the January 1989 current account deficit resulted in a sharp reversal in financial market sentiment. As a consequence, the Australian dollar depreciated markedly in mid-February.

Although the monetary aggregates have increased rapidly since mid-1988, short term interest rates have increased sharply. The top prime lending rate was 18.0 per cent in mid-February 1989, compared with 13.5 per cent in January 1988.

The increase in domestic interest rates together with the rapid monetary growth rates, particularly in the second half of 1988, indicate that private sector demand has increased strongly over this period. This strong growth in domestic expenditure has placed upward pressure on domestic prices. The consumer price index rose by 2.1 per cent in the December quarter 1988, following increases of 1.9 per cent in the September quarter and 1.7 per cent in the June quarter. However, the measured inflation rate has been affected recently by measurement difficulties relating to the cost of housing. These have overstated the underlying rate of inflation in the September and December quarters, and are likely to do so again in the March quarter 1989. Nevertheless, the underlying rate of inflation has exceeded earlier expectations and reflects the strength of domestic demand.

The strength of domestic demand growth also accounted for a large part of the deterioration in the trade and current account deficits since mid-1988. In particular, strong growth in imports outweighed the increase in exports. In the first seven months of 1988-89, the current account deficit was $9.6b, compared with $7.1b in the corresponding period of 1987-88. However, it should be noted that there are seasonal influences in the trade account. Rural exports tend to increase in the second half of the financial year, and this pattern is expected to be more pronounced in 1988-89 because of the lack of wool and wheat stocks to smooth the seasonal pattern. In addition, import growth which has been particularly strong in 1988-89 to date is likely to slow as the tightening of fiscal and monetary policies takes effect.

. <u>Domestic prospects</u>

The achievement of a sustainable external position is a key macroeconomic objective of economic policy (EPAC 1988; Commonwealth of Australia 1988;

OECD 1988a). A current account deficit of 1-2 per cent of gross domestic product is probably consistent with the stabilisation or gradual reduction in Australia's foreign debt.

In preparing its outlook for commodity prices, the Bureau has assumed that fiscal policy will continue to make a major contribution to the external adjustment process. It is assumed that by the mid-1990s the current account deficit will have been reduced to a more sustainable level. The main macroeconomic assumptions are outlined in table 2.

The recent increase in the current account deficit appears to be largely the result of strong growth in private investment expenditure, much of which will expand the productive capacity of the economy and enhance longer run growth prospects. In these circumstances, for the current account deficit to resume a downward trend in the short term, the public sector will need to become a net lender to offset the effects of this strong growth in private sector demand.

If the necessary adjustments are not made to fiscal policy, there is a risk that financial markets will force the burden of expenditure restraint onto the private sector by reimposing a very high risk premium onto the Australian interest rate structure, such as occurred in 1985 and 1986. The resulting high level of interest rates would choke off both consumption and investment expenditure, with the latter reducing Australia's medium term economic growth prospects.

The tightening in monetary policy in 1988 is expected to help restrain private expenditure somewhat over the short term. Real gross domestic product is assumed to rise by around 3.0 per cent in both 1988-89 and 1989-90, compared with an increase of 3.7 per cent in 1987-88. While growth in domestic demand is assumed to be strong overall in 1988-89, it is likely to moderate in 1989-90. In particular, growth in private investment expenditure is likely to be strong in both years. It is assumed that the volume of net exports will contribute to growth in 1989-90. It is also assumed that real public consumption and investment will decline in both years, reflecting further fiscal restraint. Over the medium term, it is assumed that the economy will sustain this growth rate, underpinned by continued growth in the export and import competing sectors. Economic growth of 3.0 per cent is assumed for the long term, reflecting the combined effect of growth in the labour force, growth in the capital stock and advances in technology.

In preparing its commodity forecasts, the Bureau has assumed that the inflation rate will rise slightly from 7.3 per cent in 1987-88 to 7.5 per cent in 1988-89 and then decline to about 5.5 per cent in 1989-90 and 5.0 per cent in later years. This decline largely reflects the expected easing in demand pressures. It is assumed that annual growth in the monetary aggregates will average less than 10 per cent over the medium to long term. Should the authorities allow the money supply to grow more rapidly, the actual inflation rate may be higher than assumed. Conversely, lower monetary growth rates may result in a lower inflation rate than presently assumed.

The Bureau has also assumed that short term interest rates will resume a downward trend later in 1989 as growth in domestic demand slows and the inflation rate declines. Interest rates are expected to continue to fall over the medium term. It is assumed that, by the mid-1990s, the Australian real interest rate will decline to and stabilise at around 4 per cent, in line with the assumed average level of real interest rates overseas.

Table 2: MACROECONOMIC ASSUMPTIONS

Item	1987 (actual)	1988 (actual)	1989	1990	Annual average 1991-2000
	%	%	%	%	%
Australia					
Gross domestic product - percentage change from previous year	4.1 (2.7)	3.0(s) (3.7)	2.8 (3.0)	3.0 (3.0)	3.0
Consumer price index - percentage change from previous year	8.5 (9.3)	7.7 (7.3)	6.8 (7.5)	4.7 (5.5)	5.0
Interest rates - prime lending rate	16.2	14.8	16.7	14.5	9.0(a)
Exchange rates					
- Trade weighted index of the value of the $A(b)	54	59	61	59	52(a)
- USc/$A	70	78	82	79	75(a)
- yen/$A	101	100	103	97	75(a)
International					
Gross national product - percentage change from previous year					
- OECD	3.3	4.0(s)	3.0	2.5	3.0
- United States	3.4	3.8	2.6	2.0	3.1
- Japan	4.2	5.5(s)	4.2	3.5	3.5
- Germany, FR	1.8	3.4	2.5	2.5	2.5
- South-East Asia	8.2	7.0(s)	6.0	5.0	5.0
- China	9.4	11.0(s)	8.5	7.5	7.5
Consumer price index - percentage change from previous year					
- OECD	3.3	3.7(s)	3.9	4.2	4.2
- United States	3.7	4.1	4.2	4.0	4.5
- Japan	-0.3	1.0(s)	2.0	2.5	2.5
- Germany, FR	0.2	1.2	2.0	2.5	2.5

(a) Refers to 2000. (b) Base: May 1970 = 100. (s) Estimate.

Note: Figures in parentheses are for financial years - for example, 1986-87 under 1987.

Over the short to medium term, Australia's real effective exchange rate is assumed to decline slightly from its level in the December quarter 1988 (figure 4). This implies a real effective exchange rate which is around 15-20 per cent below the December quarter 1984 level. Such a level is broadly consistent with the achievement of a sustainable current account balance over the medium term (O'Mara, Wallace and Meshios 1988). Associated with this outlook, Australia's terms of trade are assumed to be approximately unchanged from their September quarter 1988 level and the real exchange rate is assumed to be steady over the longer term. Consistent with the real exchange rate and inflation outlook, it is assumed that the nominal trade weighted index of the Australian dollar will fall from 61 in 1989 to 52 in 2000 (table 2).

However, the actual real exchange rate outcome may differ from that assumed. For example, the exploitation of any new mineral resource would place upward pressure on the real exchange rate, while a sustained decline in the terms of trade would tend to place downward pressure on the real exchange rate. More generally, exchange rates will continue to be subject to considerable short term volatility, particularly if financial markets are dissatisfied with the pace of adjustment of the current account deficit.

The World Economy

. Recent developments

Economic growth in the OECD group of countries is estimated to have been about 4.0 per cent in 1988, considerably stronger than previously expected. Earlier forecasts were heavily influenced by the October 1987 share market fall (OECD 1988b). Many of these earlier predictions were based on historical evidence which suggested that, following a sharp fall in share prices, a slowdown in private consumption and investment expenditure could be expected to occur within six months and to last for at least one year (Runkle 1988).

The share market fall now appears to have represented a sudden change in market sentiment, reversing the speculative activity that had contributed to the earlier share price increases. In late 1987, governments generally adopted more expansionary monetary policies to offset an expected slowdown in growth in private consumption and investment expenditure. However, such a slowdown did not eventuate and the policy shift served to further stimulate domestic demand. It also became apparent that the underlying rate of economic growth at the time of the share market decline was quite strong in many countries.

By the middle of 1988, the risk of a marked slowdown in economic growth had diminished. Indeed, the unexpected strength of aggregate expenditure and economic growth in the first half of 1988 heightened concern over the possibility of a re-emergence of inflationary pressures. In other words, there was concern that, as most economies moved closer to full employment and full capacity utilisation than they had been for some years, continuing strong growth in expenditure would place upward pressure on prices. Hence, monetary policies were tightened in most countries in mid-1988. The most immediate effect was some upward movement in interest rates. For example, in the United States, the prime lending rate was 11.5 per cent in late February 1989, compared with 8.5 per cent in May 1988. Over the same period, short term interest rates also increased in Germany and Japan.

There is some uncertainty over the likely impact of the tightening of monetary policy. If the monetary authorities judged the policy change accurately, both a resurgence of inflationary pressures and a serious economic slowdown are likely to be avoided. However, if the policy shift occurred too late and did not go far enough (that is, monetary policy still remained too expansionary), a re-emergence of inflationary pressures may not be prevented. If the tightening in monetary policy was too severe, economic growth is likely to slow, at least in the short term.

To date, inflationary pressures in the major industrialised economies have increased but have remained moderate. In the OECD group of countries, consumer prices are estimated to have increased on average by about 3.7 per cent in 1988, compared with a rise of 3.3 per cent in 1987. In addition, OECD economic growth moderated in the second half of 1988. These developments suggest that the general tightening of monetary policy since mid-1988 was well judged. However, there has been increasing concern in recent weeks over re-emerging inflationary pressures, particularly in the United States. For example, US consumer prices rose by 4.6 per cent during the year ended January 1989, compared with a recent low of 3.9 per cent during the year ended June 1988. This resulted in a further tightening in US monetary policy in February 1989.

. <u>International prospects</u>

A major international macroeconomic problem continues to be the persistent large current account imbalances in the United States, Japan and Germany (figure 5). Although these imbalances converged slightly in 1988, they remained large by historical standards, at around -2.8 per cent of gross national product for the United States, 2.5 per cent for Japan and 4.0 per cent for Germany. To correct these external imbalances, adjustments are required in each country to both the real exchange rate relative to its level earlier in the 1980s and the level of domestic expenditure.

A substantial realignment of real exchange rates has already occurred since early 1985 (figure 6). The real exchange rates of the United States and Germany appear to be close to their equilibrium level. However, the real appreciation of the yen may have been too large and a slight real depreciation may be required over the medium term (O'Mara 1988).

This analysis takes into account actual and prospective changes in the terms of trade and net external asset position of each country, compared with the most recent year of approximate internal and external balance - assumed to be 1980 in the case of the United States and 1981 for Japan and Germany. The terms of trade have increased in all three countries, but most strongly in Japan. By contrast, there have been divergent movements in net external asset positions. The United States has accumulated a large foreign debt, which will need to be serviced in future years through a stronger balance of trade than occurred in 1980. Japan and, to a lesser degree, Germany have accumulated foreign assets in recent years. To achieve a sustainable current account balance, the expected increase in net income accruing to each country will need to be offset by a weaker trade account than occurred in 1981.

Progress in achieving the required adjustments to domestic expenditure in these countries has been considerably more limited. Although the US budget deficit was reduced from a peak of 5.2 per cent of gross national product in fiscal year 1983 (year ended September 1983) to an estimated 3.2 per cent in fiscal year 1988, further progress is required. Japan and, to a lesser

Figure 5: Current account balances as a share of gross national product

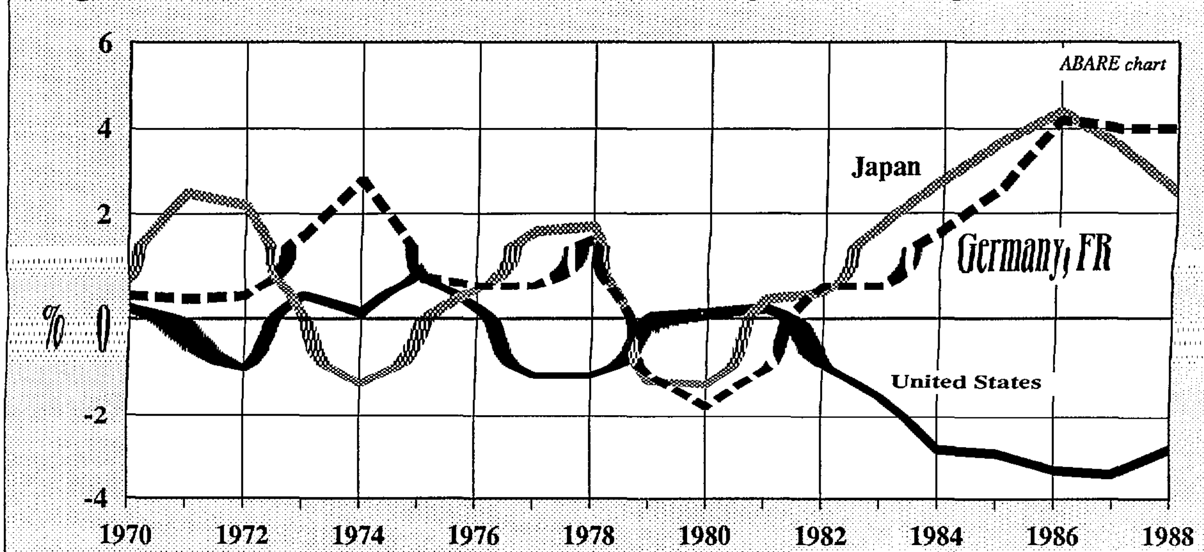
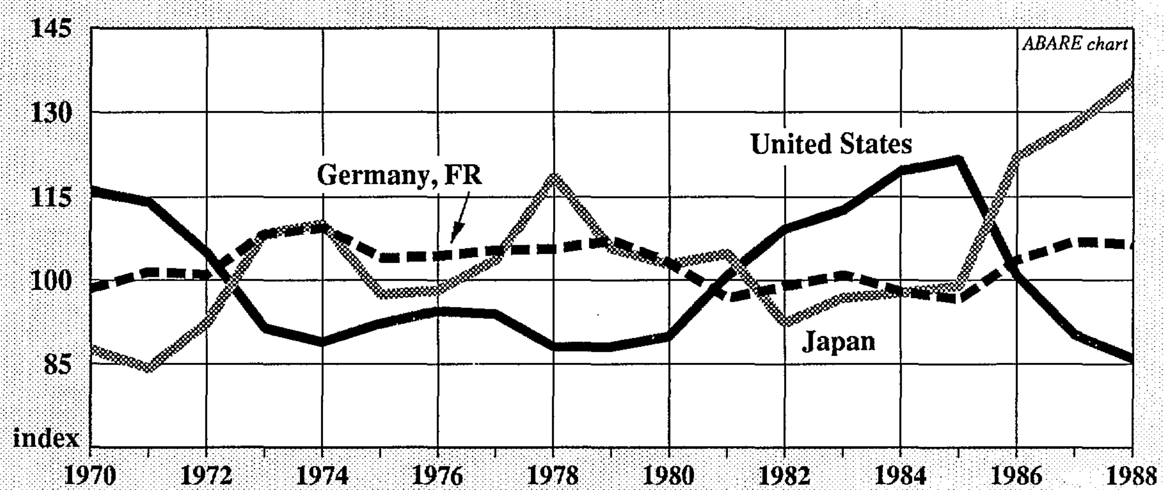


Figure 6: Major real exchange rates



degree, Germany have adopted fiscal policies designed to stimulate domestic demand.

In preparing its short to medium term outlook for primary commodities, ABARE has assumed that the newly elected US President will take decisive fiscal policy action to reduce the federal budget deficit. It is further assumed that the consequent fall in interest rates and improvement in market sentiment would stimulate private sector expenditure, offsetting some of the reduction in public sector expenditure. Relatively strong growth in domestic expenditure in Japan, Germany and the newly industrialising countries of South-East Asia is expected to offset, at least partly, the reduced stimulus of the US economy to world economic growth. ABARE has assumed that the adjustments required to correct the current account imbalances in the United States, Japan and Germany will be completed by the mid-1990s.

An important aspect of the economic outlook over the medium and long terms is the limited scope of the major industrialised countries for achieving higher rates of economic growth through increasing the utilisation of available capacity. Several of the major economies, including those in

Western Europe, are now considered to be operating at or close to full capacity (Gordon 1988). For example, in the United States, the seasonally adjusted unemployment rate reached a fourteen year low of 5.3 per cent in December 1988, and capacity utilisation is at a relatively high level. Under these circumstances, growth in the labour force and capital stock, and productivity increases through technological change, are likely to represent more binding constraints on future economic growth than has been the case for several years.

The main international macroeconomic assumptions are given in table 2. In particular, ABARE has assumed that economic growth in the OECD region was a relatively strong 4.0 per cent in 1988, and will moderate to about 3.0 per cent in 1989 and 2.5 per cent in 1990 before recovering slightly to annual rates of around 3.0 per cent over the medium and long terms. Inflationary pressures are expected to increase moderately over the short term. On average, consumer prices in the OECD countries are assumed to rise by around 4 per cent in 1990 and later years.

Over the medium to long term, China and the newly industrialising South-East Asian countries are likely to experience the strongest growth in the world economy, averaging 7.5 and 5.0 per cent, respectively. As a result, this region is expected to account for a growing proportion of world economic output. Major economic reforms during the 1980s have increased the efficiency with which resources are used in the Chinese economy, and this trend is expected to continue, although at times subject to short term capacity constraints. Strong economic growth is expected to continue in South-East Asia in response to progressive adoption of new technology and strong investment. However, despite these assumed rapid growth rates, ABARE has estimated that gross domestic product per person in these countries will remain well below average OECD levels over the outlook period. Hence, while productivity and economic growth rates have tended to converge over time in the OECD countries (Dowrick and Nguyen 1987), this convergence principle is unlikely to restrain growth in the South-East Asian economies over this period.

If the United States takes a different stance in fiscal policy to that assumed, this would represent a major risk to the international economic outlook. In particular, failure to cut the US budget deficit significantly would be likely to lead to a strong adverse reaction in financial markets, resulting in higher US interest rates, which would force the burden of adjustment onto the private sector. This could result in a period of considerable volatility in the US dollar. Such a course of action could be disruptive to economic growth in both the US economy and the rest of the world. Indeed, during November 1988, the US dollar depreciated sharply as concern heightened over the expected fiscal policy stance of the newly elected President. However, in early 1989, the US dollar recovered somewhat.

A further risk to the international economic outlook lies in the possibility that the US government may impose greatly increased protectionist measures in an attempt to reduce the US current account deficit. Such a move, however, would be detrimental to the efficient use of resources in the US economy. Further, because it would do little to reduce the gap between aggregate expenditure and production in the United States, such a move would not succeed in reducing the US external imbalance. It may also encourage retaliatory action by other countries, damaging international trade.

There is some evidence that, in the absence of coordinated policy action on the part of the three major industrialised countries to maintain world economic activity, economic growth in the OECD region may be around 1-2 percentage points a year lower over the medium term than has been assumed, particularly if world protectionism increases (Wallace, Bramma and O'Mara 1988). This has important implications for international prices of primary commodities. For example, it has been estimated that, should the annual rate of economic growth in the OECD region decline by 1-2 percentage points, prices of primary commodities would be reduced by as much as 12 per cent after five years (OECD 1988a). Under present circumstances, however, the impact on commodity prices could be a little less pervasive because world stocks of many commodities are now relatively low. Hence, demand for additional stocks could at least partly offset the effects of slower growth in final consumer demand. Further, even if this more pessimistic scenario for economic growth and commodity prices were to eventuate, most commodity prices would be likely to remain well above their levels in 1985 and 1986.

Concluding Comments

The correction of large current account imbalances in Australia and the major industrialised economies is likely to be a key focus of macroeconomic policies over the next several years. In Australia, failure to reduce the current account deficit sufficiently quickly will heighten the risk of adverse market reaction and force a greater burden of external adjustment onto the private sector. A similar outcome would occur in the United States in the absence of a significant reduction in the US budget deficit. Under these circumstances, world economic growth and international trade may be adversely affected.

On balance, the large current account imbalances recorded in recent years in Australia and the major industrialised countries are expected to be reduced gradually to more sustainable levels over the medium term. This outlook is based on the assumption that action will be taken to cut the US budget deficit and that fiscal policy in Australia will also be tightened further. Strong growth in domestic demand in Japan, Germany and the newly industrialising countries of South-East Asia is likely to provide some stimulus to world economic growth and international trade, partly offsetting the effects of any reduction in US import demand.

References

Commonwealth of Australia (1986), Budget Statements 1985-86: Budget Paper No. 1, AGPS, Canberra.

___ (1988), Budget Statements 1988-89: Budget Paper No. 1, AGPS, Canberra.

Dowrick, S. and Nguyen, D.T. (1987), OECD Economic Growth in the Post-War Period: A Test of the Convergence Hypothesis, Centre for Economic Policy Research, Discussion Paper 181, Australian National University, Canberra.

EPAC (Economic Planning Advisory Council) (1986), Issues in Medium-Term Budgetary Policy, Council Paper No. 16, AGPS, Canberra.

___ (1988), Australia's Medium Term Growth Potential, Council Paper No. 30, AGPS, Canberra.

Gordon, R.J. (1988), 'Back to the future: European unemployment today viewed from America in 1939', Brookings Papers on Economic Activity 1, 271-304.

OECD (Organisation for Economic Co-operation and Development) (1988a), Economic Surveys: Australia, OECD, Paris.

___ (1988b), Economic Outlook 43, OECD, Paris.

O'Mara, L.P. (1988), Exchange rates and agriculture: a macroeconomic view from down under! An ABARE paper presented at the December 1988 meeting of the International Agricultural Trade Research Consortium, San Antonio, Texas, 14-16 December.

___, Wallace, N.A. and Meshios, H. (1988), 'The current account, monetary policy, market sentiment and the real exchange rate: some implications for the farm sector', Australian Journal of Agricultural Economics (in press).

Reserve Bank of Australia (1988), Report and Financial Statements, Sydney.

Runkle, D.E. (1988), 'Why no crunch from the crash?', Federal Reserve Bank of Minneapolis Quarterly Review, Winter, 2-7.

Wallace, N., Bramma, K. and O'Mara, P. (1988), 'Current account imbalances of major Western economies', Quarterly Review of the Rural Economy 10(4), 393-403.

Recent influences on world mineral industry performance

P C F Crowson

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INTRODUCTION

The past two years have seen dramatic rises in the prices of most mineral commodities no matter the currency in which these prices are expressed. These rises came after several years of recession when much of the mining industry had given up all hope that prices would ever stage any significant revival. Each mineral and metal has inevitably responded in individual ways to slightly varying stimuli. The manner in which most prices have moved in concert does, however, suggest broadly common causes. Much has been written in the past decade about whether the problems ofthe mining industry were cyclical or structural. Until the revival of prices it was reasonable to argue that the industry's ills were due entirely to structural influences, and that things would never be the same again. Today it would be possible to make a case for cyclical factors, of varying lengths and intensities. The distinction between either set of influences is somewhat artificial, but it is now more important than a few years ago. The dying man is mainly concerned with the fact of death rather than the proximate cause. The convalescent does need to know the reason for his past sickness in order to avoid a recurrence.

Coherent explanations of the performance of the world mineral industry inevitably embrace both structural and cyclical influences affecting both supply and demand. This paper discusses both sides of the balance and then looks at several specific issues for the industry and governments as we move into the 1990s.

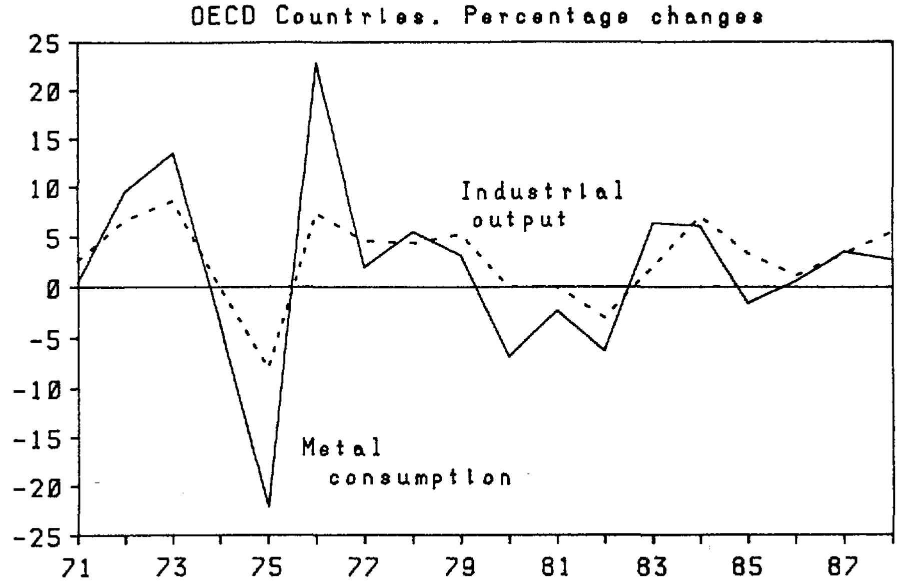
DEMAND

The most obvious reason for the revival of mineral markets has been a resurgence of demand. The world economy is entering its seventh year of expansion since the 1982 recession. There are recessionary clouds on the horizon, as there have apparently been for the past four years, but few forecasters are looking to a downturn comparable to those of 1975 or 1982. Chart 1 shows the relationships between year-on-year changes in the OECD Area's industrial production, and its consumption of non-ferrous metals back to 1971.

The index of metal consumption is based on consumption of aluminium, copper, lead, zinc, nickel and tin, weighted by the average turnover of each in 1980-85 in real SDR terms. The constituent metals have performed rather differently from one year to the next, and this index is a rough and ready attempt to depict the overall pattern. The figures for 1988 are provisional, and probably understate the performance of metals. The chart shows that there has been a reasonable relationship between consumption and economic activity, as measured by industrial production. Several consecutive years of growth of the latter have boosted consumption of metals (and of other minerals). The implications of that boost are discussed later.

CHART 1 NON FERROUS METALS & ECONOMIC ACTIVITY

OECD Countries. Percentage changes

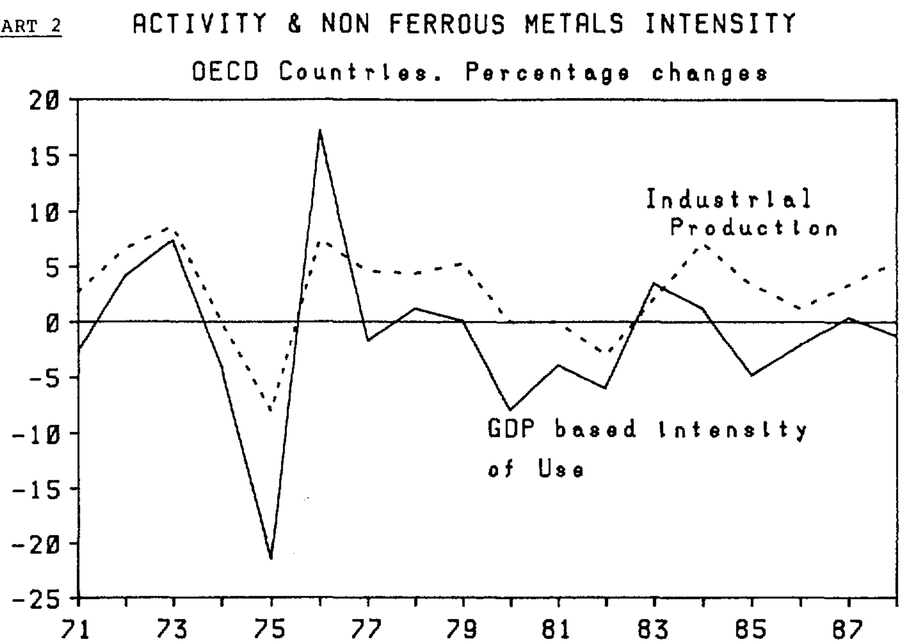


The chart suggests that the link between industrial output and metals demand may have loosened but not that it has become uncoupled, as many have argued. Here it is necessary to raise the awesome spectre of intensity of use, a descriptive Frankenstein that has captured the imaginations of many commentators, often to the exclusion of common-sense. Measures of intensity of use, such as metals consumption per unit of GDP, merely describe trends but they do not explain them. The tendency for demand for metals to rise less rapidly than economic activity in response to technical progress of all types goes back many decades. The relationship between metals consumption and activity moves cyclically around this long run tendency as Chart 2 shows.

Again the chart is based on an index of non-ferrous metals consumption. Part of the fall in intensity of use in the early 1980s was cyclical, as was the check in 1985.

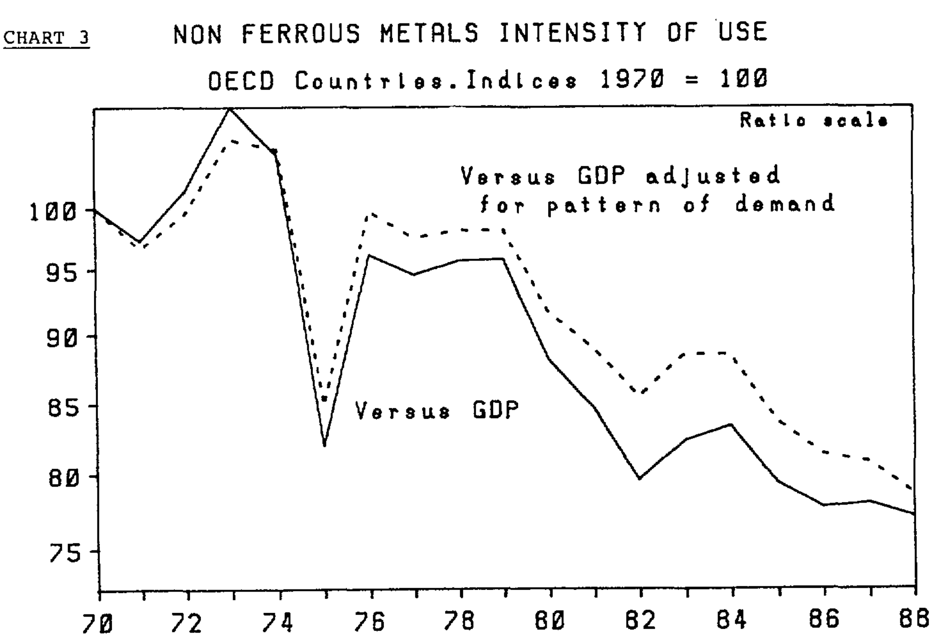
Many factors other than technical change influence the demand for metals. An obvious one is the overall balance of demand between investment and consumption. The proportions of minerals and metals going into investment goods of all types, including construction materials, vary widely, but they are typically higher than the shares going into consumption. For the six non-ferrous metals taken as a group roughly 70% goes into investment broadly defined. During the decade from 1973 investment fell as a proportion of GDP, thereby dragging down demqnd for metals. Since 1983 the share of investment in GDP has risen, and the OECD Secretariat predicts further increases to 1990. Capital spending is rising in response to improved profits, tightened capacity utilisation, and the widespread need to replace and upgrade physical infrastructure. Up to 1979-80 the share of investment continued to grow in the non-OECD countries, but it then fell, reinforcing the OECD's decline. It too has levelled out.

CHART 2



The next chart shows the effects of trends in investment on the OECD's intensity of use of non-ferrous metals.

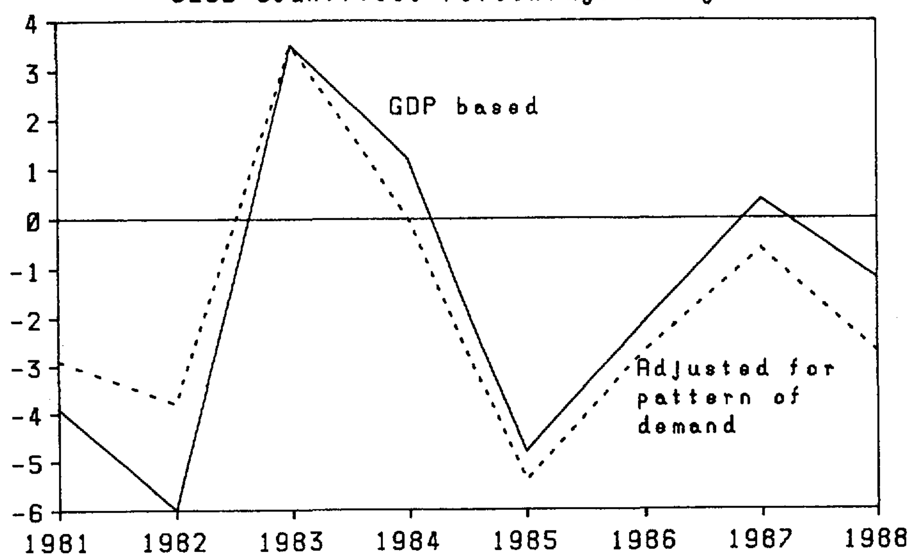
CHART 3



The solid line is the conventional measure. The dotted line relates consumption to an index of activity in which investment accounts for 70 % of the total and all other categories of spending for the balance. The adjusted measure has fallen less over the longer term than the conventional index. More interesting are the recent trends, shown as percentage changes in the next chart.

CHART 4 NON FERROUS METALS INTENSITY OF USE

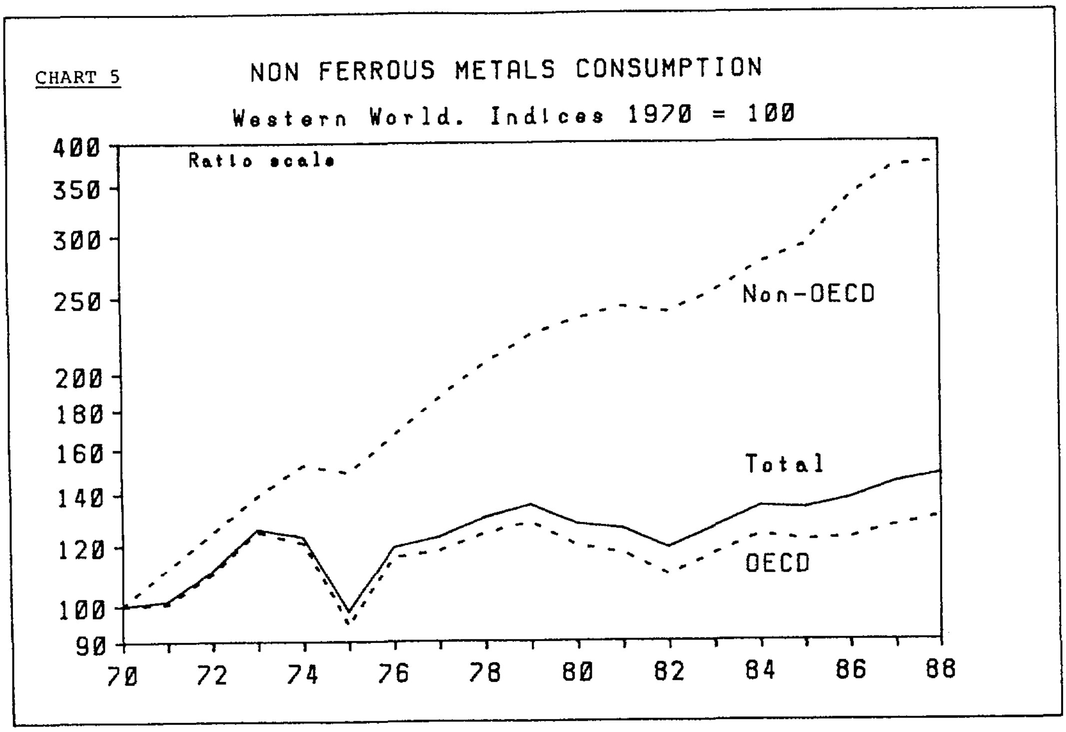
OECD Countries. Percentage changes



Up to 1983 the decline in investment accentuated the fall in measured intensity of use, whereas the growth of investment has subsequently worked in metal's favour.

Another major influence on demand has been the management of inventories and work in progress of all types in the OECD economy as a whole. Over the past decade the ratio of stockbuilding to changes in total output has fallen substantially. This ratio normally fluctuates considerably over the course of the business cycle, but recent falls appear to be more than cyclical. Total stockbuilding amounted to 24% of the change in output between 1964 and 1973, to 34 % between 1973 and 1979, and to only 17% in the 1979-88 period. The ratio has been even lower in the past three years. For a wide variety of reasons the economy has,by implication, managed on falling levels of working capital. This in turn has reduced the intensity of use of inputs such as metals. The scope for further reductions becomes progressively more limited, and the decline may have already gone too far. For metals the historically low levels of visible stocks relative to consumption, and persistent backwardations on terminal markets combine to suggest that a higher level of inventories is desirable.

Demand for metals in the OECD Area has been increasingly supplemented by the growth of other consuming nations. In both the 1975 and 1982 recessions demand merely faltered in those countries whilst it fell back within the OECD. The next chart shows separate indices of non-ferrous metals consumption for the OECD, non-OECD countries, and Western World as a whole since 1970.



In 1980 the non-OECD countries accounted for 13% of total consumption of the six metals covered, on a weighted basis. By 1988 their share was over 18%. In the present decade their demand has risen by an annual average of just over 6%, compared with under 1% for the OECD, and nearly 2% for the Western World as a whole. Between 1985 and 1988 the respective growth rates were 9%, 2.3% and 3.4 % per annum. The non-OECD nations, taken en masse are now significant consumers whose performance is raising the overall growth rates. Australia is well sited near the most rapidly expanding group of nations in the wider grouping. Collectively the South East Asian economies are performing for the metals industry in the late 1980s, the role played by Japan and some Southern European countries twenty years before.

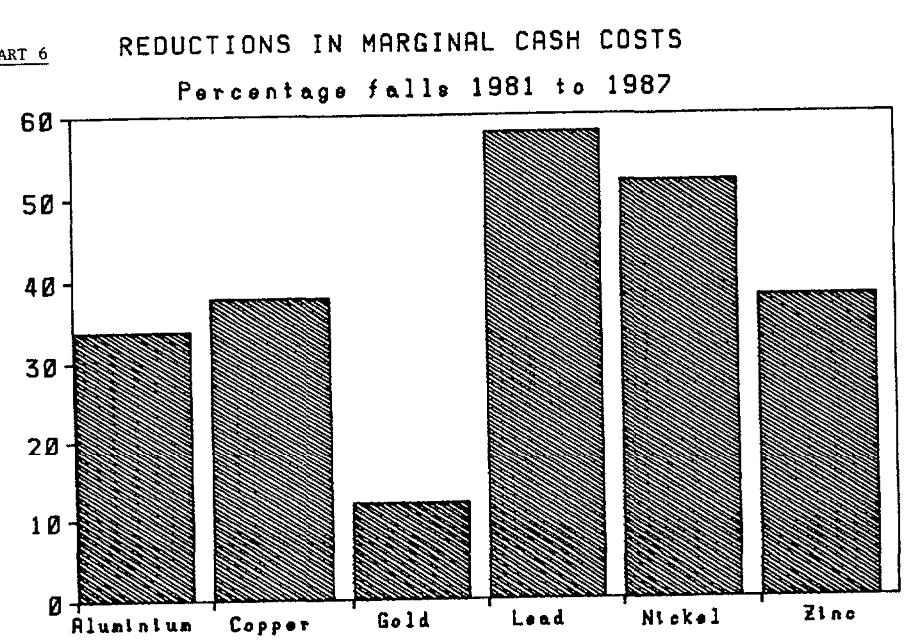
The conclusion on demand is that several factors accentuated the adverse effects of technical change in the decade or so up to the mid 1980s. Whilst these factors are now pulling in the opposite direction, they can only mitigate rather than reverse the impact of technology on the OECD Area's demand for minerals. Even with continued rapid growth in the non-OECD countries, the rapid growth rates of the pre-1973 era are highly unlikely to return. Provided the newly industrialising countries are not hamstrung by increased protection in the mature economies, demand for metals should perform better in the next than in the past decade. Protectionist threats lurk in the United States' continued ambivalence over tackling its various deficits, and possibly in Europe's move towards a Single Market by the end of 1992. Such a move was, however, enshrined over thirty years ago in the Treaty of Rome for achievement by the early 1970s. Europe's failure to progress more rapidly helps explain the stagnation of the decade between 1975 and 1985. The renewal of the impetus towards the Single Market has stimulated European economic activity to the benefit of mineral producers worldwide. It is part of the broader trend towards liberalisation, deregulation, and even privatisation which has set the tone of the past few years throughout the world. There is no inherent reason why the Single European Market should be protectionist no matter what has been written about Fortress Europe.

SUPPLY

The influence of rising demand on prices depends on the responsiveness of supply. For much of the period since the 1973-74 boom the mining industry has laboured under the burden of considerable excess capacity. The main development of recent years has been the evaporation or sterilisation of that excess. Virtually across the board, perceptions of over-supply have given way to realisations that effectively available capacity is restricted. Large invisible stocks, slack demand, the delayed contributions of earlier investment, and persistently weak prices discouraged exploration and development. As one remedy after another was exhausted, all producers were forced to become more efficient in order to survive. Very often a sudden and unpredicted shift in exchange rates has provided the final spur to cut costs. The wild swings in exchange rates during the 1980s in response to short term capital flows have affected most major mineral producing countries at one time or another. Mineral producers were caught in a vicious squeeze between weak or falling revenues, in domestic currency terms, and deteriorating competitiveness whenever their currencies appreciated in value. The process is still continuing, although the major currencies have been relatively more stable against each other since the signature of the Louvre Agreement in early 1987. Until such time as the United States' structural imbalances are corrected, however, mineral producers remain prone to ambush by currency shifts.

Even when expressed in a currency basket, such as the SDR, marginal cash costs of production have fallen considerably since their peak in the early 1980s. The next chart shows the reductions in real SDR terms between 1981 and 1987 for six metals.

CHART 6



This chart shows the falls in the cash costs of producers at the upper quartile on each metal's cumulative cost curve. The reductions 90% along the curves were broadly similar. In money terms the falls were even greater. Interestingly, gold showed the smallest fall over the period, a reflection of its different circumstances from those of the other metals. That apart, producers of most mineral commodities achieved similar reductions to those shown.

The reductions in costs were achieved in many different ways. Higher cost operations have closed down throughout the world, but especially in the United States, Europe and Japan when their exchange rates moved adversely. Manpower costs have been reduced through rationalisation, wage reductions and the abolition of restrictive practices. Governments and suppliers often helped by cutting charges or production related taxes. Productivity has been improved through investment in new technology at all stages of mineral production. Immediately inessential expenditures were cancelled or postponed, and companies often reorganised their operations to emphasise low costs at the expense of the life of the resource. It is impossible to disentangle these separate elements which were usually closely intertwined.

The scope for reducing costs has not been fully realised, although most of the more easily achievable cuts have been. What has become apparent, however, is that it is impossible to defer many costs indefinitely. With the revival of demand and the rundown of inventories, producers were often unable to raise their output. Frequently insufficient ore was accessible because of too little advance development. Also cutbacks in repairs and maintenance had left the industry too prone to breakdowns and disruptions. With the revival of prices, workers, suppliers, and governments have wished to share in the industry's increased prosperity, just as they suffered from its recession. Aside from the possible adverse effects on costs, they provide added sources of potential disruption.

Typically the owners of loss-making mines and plants hang on for as long as possible before shutting them down. There is usually a lag between a revival in markets and the deferment or reversal of decisions already made. The revival may, after all, prove temporary; the mining industry suffered several false dawns before the present upsurge. Thus zinc mines were still closing in 1987-88, for example, even as markets were tightening. The facilities which close are often the oldest and least efficient. Considerable investment would have been needed to make them competitive when they closed down, let alone when markets subsequently improve.

The mineral industry's emphasis on cost reductions has been accompanied by a considerable amount of corporate restructuring. Whilst some commentators claim to discern grand overriding themes behind this restructuring, each decision contains its own unique elements. The belief that mining companies throughout the world, and operating in different sectors, react in a Pavlorian fashion to a specific stimulus, is somewhat facile. Several themes are, however, discernible. The variations on these themes are still reverberating. They include :

- The widespread takeovers of mining companies by major oil companies in the 1970s and early 1980s, followed by their withdrawal a few years later. Whilst the oil companies were the major performers in this particular re-enactment of the nursery rhyme about the Grand Old Duke of York, they were not alone. There were others who diversified into mining, and who have since left, sadder, if not wiser. Whatever the rationale behind their initial involvement, the oil companies became disillusioned, a process undoubtedly accelerated by the economic circumstances of their own industry. With hindsight it is clear that the influx of companies without the traditions or sentiment of the existing firms greatly assisted the mining industry's necessary restructuring. On their withdrawal, they left much leaner and fitter organisations than they found, often with re-constructed balance sheets carrying little or no debt.

- Mergers or joint ventures in order to exploit to the full possible cost reductions or economies of scale. Examples include the rationalisations of the United States' lead and zinc industries, the creation of a unified Highland Valley copper operation in British Columbia, the merger of the European lead and zinc interests of Penarroya and Preussag in Metaleurop, and in Australia the recent formation of Pasminco, and the coalescence of parts of Western Australia's gold industry.

- Defensive rationalisation or overseas investment by companies threatened by adverse currency movements, and deteriorating competitiveness. Several of the rationalisations listed under the previous heading might equally fit here. Many companies, reliant on domestic markets in the United States, Europe, and Japan, have felt threatened by the shift in the world's economic centre of gravity, discussed earlier. The response can take different forms. Thus Japanese copper and zinc smelting companies are not only trying to secure future supplies of concentrates through investments in overseas suppliers, but they are also contemplating the construction of new smelters overseas. Mitsubishi, for example, is to build a greenfield copper smelter in the USA, and Furukawa is taking a stake in the new ER&S smelter. The Europeans are no less active, as witnessed by Outokumpu's varied investments in potential sources of ores and concentrates of several metals. Its domestic mines are becoming exhausted or uncompetitive. As a digression it is rather puzzling that some mining companies have apparently wished to diversify forward into smelting and refining when so many smelters are concerned about their longer term raw material supplies. Can they all be right?

- Diversification by gold companies wishing to invest their healthy cash flows. They take a more buccaneering approach to their investments elsewhere than most of their established rivals.
One danger is that their successes in the gold industry may not have prepared them sufficiently for the more complex and cyclical markets they are entering. The next economic downturn could spring surprises for some of these companiess.

- An unwillingness of many established mining companies to invest in additional capacity. They remain uncertain about the longer term outlook for their traditional products and do not wish to precipitate a downturn by over-investment. They also wish to reduce their dependence on the mining industry. Thus Phelps Dodge has moved into carbon products. Inco has followed a different tack by borrowing money to pay greater dividends to its shareholders.

- The marking-time of many state owned mining companies in less developed countries. Until a few years ago, these were widely projected to take increasing shares of world output. With rare exceptions, such as Codelco and CVRD, they have suffered from the impoverishment of their countries, associated with the international debt crisis. Their revenues have been diverted towards national Exchequers, leaving them with insufficient funds to maintain their output let alone expand. Neither commercial banks, nor the international agencies, are too willing to lend additional funds for modernisation, let alone for new projects. Several state owned companies have become prime candidates for complete, or partial, privatisation, in for example, Mexico, Brazil, the Philippines and possibly Chile. Against that trend, host countries are becoming more assertive after a decade or so of retreat. The tax provisions of mining agreements are back on the Agenda in many places now that the mining industry is earning profits.

Specific corporate actions seldom have single clearly defined motives, and they may fit into several of these categories. Not all the rationalisations and mergers of recent years can be fitted easily into any of them. Enrepreneurial and opportunistic managements will always seize opportunities as and when they present themselves.

What has been apparent in recent years is that relatively few companies have been actively developing major new mineral projects. The position has, of course, varied from one mineral to another. With some well publicised exceptions, most investment has been in the modernisation or expansion of existing facilities rather than in new grass root projects. Often the exceptions have been based on recently discovered projects rather than on those in the inventory of resources discovered in earlier years when economic circumstances were very different. Looking ahead, the present pattern of exploration presents a challenge to the future availability of minerals. Today the vast bulk of expenditure, on mineral exploration, two-thirds in Australia, and over four-fifths in Canada, is for gold or other precious metals. The beginnings of a switch back away from gold are discernible as gold markets falter, and tax provisions change. It will, however, take time to reorientate the priorities of mineral exploration.

SOME CONCLUDING ISSUES

The direction of exploration is an issue for the longer term rather than for near or medium term supply. Provided that the prices of minerals do not sink back to their recession-hit levels, there will be sufficient economic incentive to explore. More immediate issues do, however, arise on the supply side of the industry.

- During the 1980s there has been a major shakeout of labour in most mining countries. Many technically qualified and skilled workers have obtained alternative employment, and they will not be easily attracted back. The flow of new entrants from schools and colleges has meantime dwindled, and many degree courses in mining disciplines have ceased or are under threat. The industry, worldwide, needs to ensure that this trend is halted or even reversed if it is not to experience serious labour shortages.

- Trade in most minerals, uranium being a significant exception, is relatively free from political interference. True, there may be tariffs or quotas in some markets, but these are usually non-discriminatory. The US imposition of sanctions on trade with South Africa, which have been followed by many other countries, has been a recent exception. Whatever their intended effects, they appear to have prolonged and depressed the recession in several mineral markets, most notably for steam coal and possibly iron ore. Governments clearly need to think through the full consequences and implications of any of their actions.

- Mining has not been the only depressed industry in the early 1980s. That its experiences have been shared by many of its suppliers and service industries has helped the industry to hold down its costs. With the revival of international trade, excess capacity is being eliminated in these industries as much as in mining, and their prices are rising. One such field is shipping where bulk freight rates have increased considerably. This increase, in particular, will reawaken debates about the appropriate location of mineral processing that have been stilled during the recession.

- Deregulation, liberalisation, and privatisation in Western economies are being matched by the restructuring of the Chinese, Soviet and East European economies. The Eastern Bloc has collectively had a significant impact on the mineral industries during the 1980s. Chinese demand bolstered several markets in the recession, whilst Russian sales have bridged the supply gap in nickel. Variable, and often unpredictable, Chinese trade has complicated the markets for a variety of minerals. Always providing that restructuring proceeds, the Eastern economies should become even more interdependent with the West, with beneficial effects on the mineral industries.

In conclusion, the world's mineral industries have emerged scathed, but in reasonable shape from a period of considerable structural and cyclical change. They will face further challenges over the next decade, but against a background of a better balance between demand and the capability to supply.

Australian minerals and petroleum industry - highlights of 1988

Resource Assessment Division

Bureau of Mineral Resources, Geology & Geophysics

This paper briefly reviews the main features of Australia's minerals and petroleum industry in 1988 and the implications of some of these features for the industry over the next 2 to 3 years. A more detailed review of events in 1988 for 15 mineral commodities is contained in BMR's Preliminary Summary for each of these commodities, and statistics of mineral production and trade are set out in BMR's Quarterly Summary Statistics. A detailed account of petroleum exploration activity and results is given in BMR's Petroleum Exploration and Development in Australia - Activity and Results, 1988.

The paper also discusses the success of minerals and petroleum exploration in maintaining a mineral resource base adequate for future needs, and some possible longer term effects of recent trends in exploration.

Prices

1988 generally was a good year for most sectors of the Australian mineral industry, reflecting the conditions in world markets. Despite some increased production, continuing strong world demand coupled with supply disruptions particularly in base metals meant that world stocks of many commodities remained low and prices remained well above the levels that had prevailed up to the first part of 1987. The price of gold was a notable exception, trending down through 1988. However, for Australian producers, Australian equivalent prices of most commodities were eroded in the latter part of the year by the substantial appreciation of the Australian dollar against the US dollar and other currencies.

Figure 1 shows the London Metal Exchange and Australian prices in 1987 and 1988 for the major metals whose price is set daily and Table 1 compares the annual average prices of these commodities in these two years.

Prices of aluminium, copper, nickel, zinc and mineral sands (rutile, zircon and ilmenite) established new records in 1988 in current dollar terms but not in terms of constant dollars. Australian producers of thermal coal received a price increase of about 20% in US dollar terms after protracted negotiations with Japanese buyers; coking coal producers had earlier received increases of less than 10%. Contract prices for iron ore fell early in the year, but tighter supply towards the end of the year resulted in spot price increases of nearly 20% and contract price increases for 1989 shipments of up to 17% in US dollar terms.

World oil prices fluctuated in 1988 as changes in OPEC production levels affected supplies, but finished considerably below the levels of the early part of the year.

Production

The value of Australian mine production of most major commodities is estimated to have risen in 1988 (Table 2). Exceptions were black coal, iron ore and petroleum, three of Australia's most important mineral products, which together make up about 60% of the value of mine production and 40% of the value of mineral exports. The estimated value of production of all three fell, black coal by 4%, petroleum by 14% and iron ore by 11%. As a result, the total value of mine production fell slightly, from $21.2 billion in 1987 to an estimated $20.9 billion in 1988.

The estimated quantity of mine production of most commodities in 1988 was about the same as in 1987, the increased values of production generally resulting from higher average prices. Gold production increased by 36% to 150 t, the highest annual production recorded, with the opening of 26 new mines; diamond production was a record also. Nickel production fell by 13% to 62 000 t because of lower head grades at the Western Australian operations and lower ore production at Greenvale. Cessation of treatment of high grade ore at Nabarlek led to uranium production falling by 7% to 4165 t, despite commencement of production at Olympic Dam.

Aluminium metal production increased with completion of the second potline at Portland; greatly increased mine production of gold led to refined gold production increasing by 21% despite the halving of production from gold bullion of overseas origin. Output of refined lead and silver fell because of loss of production following a fire at Port Pirie, Australia's only lead refinery, early in the year.

Announcements in 1988 indicate that the quantity of production of several commodities is likely to increase substantially in the next two to three years, although final decisions on some projects still have to be made. Some proposed developments involve an increase in the degree of further processing of mine production (with resulting added-value) either as part of an integrated mining and processing operation, expansion of capacity at existing smelting or refining plants, or construction of capacity at new operations.

Mineral sands figured prominently in announcements of new projects. Proposals included: Development of the Cooljarloo deposit north of Perth involving a mining operation and synthetic rutile plant with capacity of 130 000 t/yr and a pigment plant with capacity of 55 000 t/yr; a possible new mine at West Eneabba and possibly a synthetic rutile plant to use ilmenite from the mine; these two operations would mean additional annual mine capacity of 75 000 t rutile, 610 000 t ilmenite, 130 000 t zircon, and 4000 t monazite. Proposed mineral sands mining operations near Agnes Water, north of Gladstone, near Horsham in Victoria, and at Jangardup, in the south of Western Australia, would increase the industry's capacity further.

The downstream end of the mineral sands sector also saw several developments: Production of high purity zirconia began at a new plant near Perth; and a new 70 000 t/yr chloride route pigment plant near Bunbury, which eventually will replace a 36 000t/yr sulphate plant nearby, was commissioned in November. Government approval was given for Stage 1 of a proposed rare earths plant at Pinjarra, WA; the output of this stage is a product containing rare earths and thorium hydroxides. Approval has not been given, on environmental grounds, for stage 2, involving further processing of this product. A second rare earths processing plant proposed for Port Pirie is intended to use non-radioactive raw materials imported from China as feedstock.

Base metal mine and refinery production will increase in 1989 with the operation of Olympic Dam for a full year (45 000 t/yr of refined copper) and expansion of the Hellyer mine in Tasmania (including commissioning of a mill at the mine site) to an ore production rate of 1 Mt/yr resulting in production in concentrates of about 108 000 t zinc, 51 000 t lead, 4000 t copper and 120 t silver. Commencement of operations at Golden Grove, WA, (95 000 t/yr zinc in concentrates) and the combined Thalanga and Lady Loretta operation in North Queensland (30 000t zinc and 4000t lead in concentrate annually) will increase Australian mine production further in 1990. The Hilton mine near Mount Isa is to be brought to large scale production, with its own concentrator, increasing total annual mine output from Mount Isa and Hilton from 180 000 to 200 000 t of lead and from 200 000 to 250 000 t of zinc. A new 60 000 t/yr lead smelter, using the recently developed Isasmelt process, will enable the increased output of lead concentrates to be smelted. Zinc concentrates will continue to be exported.

The capacity of the copper refinery at Port Kembla is to be doubled to 80 000 t of refined copper by the end of 1990 by replacement of the blast furnace and construction of a 175 000 t/yr sulphuric acid plant and modernisation of the tank house; between a quarter and a half of the concentrates required for the increased capacity are likely to be imported. Work to modernise the Port Pirie lead refinery and Risdon zinc refinery is in progress also and studies of the feasibility of expanding capacity at Risdon are also in progress.

1988 also saw major rearrangements of ownership in the base metals sector in Australia. North Broken Hill Holdings Ltd and Peko-Wallsend Ltd merged early in the year and the lead and zinc interests of the new group were combined later in the year with those of the CRA group in a separate company, Pasminco Limited. The new company, equally owned by the two groups (and with public shareholding also) will be one of the world's largest base metals producers. The merged company reportedly will undertake a large capital investment to enhance its international market competitiveness. Pasminco did not acquire CRA's Port Kembla copper smelter and refinery; a 40% interest in this was sold, in principle, to Japanese interests early in 1989.

In the iron ore sector, the first expansions in capacity for several years occurred in 1988. These were three scree ore operations which began production in 1988 or early 1989 with a combined annual production of over 3 Mt of lump ore, near Newman, near Tom Price and at McCameys; and expansion of capacity at Orebody 29 at Newman proceeded. Production, initially at the rate of 3 Mt/year, will begin at the jointly owned Australian-Chinese iron ore operation at Channar in 1990.

Commencement of diamond production from the Bow River alluvial deposits in 1988 and, as proposed, from the low grade alluvial deposits at Argyle in 1989 will contribute another 3.5 million carats to Australia's annual production. Australia already provides more than a third of the world's natural diamond production. The gem content of diamonds from these two deposits is higher than that of the Argyle pipe (which is about 5% gem quality and 45% cheap gem quality, the remainder being industrial quality material.

Gold production is expected to increase substantially over the next two to three years to more than 200 t as new mines are opened and capacity expansions at some existing mines come into effect. It is then expected to fall as many smaller mines close because their resources are exhausted.

Following its acquisition of the interests of the former joint venturers in the Agnew nickel operation, WMC announced that it would begin production by open cut from a new orebody (Rocky's Reward) at a rate of about 12 000 t/yr of contained nickel. This will help offset lower production at WMC's Kambalda operations. The Yabulu nickel refinery probably will continue operating by treating imported laterite ore, although the Greenvale mine which presently feeds the refinery is likely to close within five years; an expansion in capacity from about 22 000 t/yr to 35 000 t/yr contained nickel is being considered by the owners.

Several proposals to expand existing coal mines or develop new operations were announced in 1988; however, few of these are likely to be commissioned before 1992.

Commissioning in 1989 of a plant to extract gallium from alumina refinery waste at Pinjarra will mark another step in Australia's entry to markets for high technology materials.

Petroleum exploration remained at a high level in the Cooper/Eromanga Basins; oil was discovered in 4 new fields in the sparsely explored western-most part of the basin and production has commenced from some of these.

The discovery of the James oilfield in middle-to-late Triassic sediments close to the northwest edge of the Cooper Basin is significant, because the field lies in a sparsely explored part of the basin and the discovery was the first made in the youngest geological sequence in the Cooper Basin.

A high level of exploration also continued in offshore Western Australia, and several new fields were discovered in the Bonaparte and Carnarvon Basins; development wells were drilled also on fields in these basins. Notably, a new program of drilling began in the Barrow Island oil field, one of Australia's oldest onshore fields.

A decision was announced to proceed with the development of five small fields in the Gippsland Basin - Perch, Dolphin, Whiting, Tarwhine and Seahorse - capable of producing 25 000 bbls/d. This development results mainly from the Government's decision in 1987 to allow the first 30×10^6 bbls production from new fields to be excise-free.

Trade

The fob value of exports of mineral primary products in 1988 was $18.6 billion - 14% more than in 1987 and a new record.

The quantity exported (in all forms), of copper, gold, iron ore, lead, and silver, increased substantially (gold by 65%) and the quantity of most other major commodities increased also. However, the quantity of black coal exported fell by 1%.

Increased quantities and/or higher prices resulted in the value of exports of most commodities increasing, the largest increases being shown by aluminium (54%), copper (7%), gold (57%), zinc (25%), and zircon concentrates (72%). The value of exports of black coal fell by 8% and of crude oil by 23%. Coal lost, to wool, the position of Australia's leading export commodity, a position it has held since 1980. However, black coal was again by far the main mineral export earner, accounting for a quarter of mineral primary product exports. The ratio of steaming coal to coking coal exported continued to increase and steaming coal accounted for a third of the value of coal exports in 1988. Japan remained the main market, taking about half of each of Australia's coking coal and steaming coal exports. Other important markets were Republic of Korea and Taiwan Province for coking coal, and Republic of Korea, Taiwan Province and Netherlands for steaming coal; some exports to Netherlands would have been transhipped to other countries.

Although the value of imports of many mineral primary products increased in 1988, these increases were more than compensated for by a decrease of $328 million in the value of imports of enriched crude and other refinery feedstock, and the total value of imports fell from $1.910 billion to $1.73 billion.

The increased value of exports and decreased value of imports led to an improvement in the balance of trade in mineral primary products to a record $16.8 billion. This compares with the negative balance of trade for all merchandise of $0.4 billion in 1988.

Profitability

The higher prices for many major commodities in the latter part of 1987 and in 1988 resulted in greatly improved profitability for the minerals industry.

The AMIC mineral industry survey for 1988 (which does not include petroleum) showed that net profit return on average shareholders funds increased from 6.4% in 1986--87 to 14.7% in 1987--88. Notably, the improvement in profitability was in the smelting and refining sector; profitability in the exploration and mining sector was little changed. Available data indicate that results in the latter sector were depressed by lack of profitability in the coal mining part of the sector, which in New South Wales incurred a loss of $151 million in 1987--88.

Exploration

Both offshore and onshore private petroleum exploration expenditure increased in 1987--88; total expenditure increased by 62% to $495 million, of which $272 million was spent onshore and $223 million offshore.

The number of onshore exploration wells remained about the same as in 1987, but the number of offshore exploration wells increased from 15 in 1987 to 32 in 1988. This is a reflection of the current interest in offshore exploration drilling, particularly in the North West Shelf and Timor Sea areas which are presently considered to have the greatest potential for future discoveries. The Cooper/Eromanga and Bowen/Surat Basins remained the most activily explored onshore basins.

The number of development wells decreased both onshore and offshore; 48 development wells were drilled - 32 onshore and 16 offshore - compared with 53 in 1987. Development drilling was mainly in the Cooper/Eromanga Basins, onshore, and in the Gippsland Basin offshore.

Private exploration expenditure for minerals other than petroleum increased from $557 million to $799 million in 1987--88, an increase of 44%. The increase resulted almost entirely from an increase in gold exploration expenditure (Figure 2), by 63%, from $357 million to $581 million, 73% of total exploration for minerals other than petroleum. The greatest proportional increase was in exploration for mineral sands which rose by 71% to $12.5 million. Exploration for base metals (Figure 2) increased in 1987/88 after decreasing every year since 1983--84 but exploration for coal fell from $36.6 million to $24.5 million.

As would be expected from the interest in gold, most of the total mineral exploration expenditure (58%) was in Western Australia and a further 20% was in Queensland.

Indications are that mineral exploration will remain at about the same level in the current fiscal year, with perhaps some increase in the proportion spent on base metals and a decrease in the proportion spent on gold.

Mineral resources

BMR has published estimates of national resources of mineral commodities for each year, on a reasonably consistent basis, starting with 1976. Table 3 shows the percentage increase in economic demonstrated resources (EDR) from the end of 1976 to the end of 1988 for the major commodities. It should be noted that some changes from year to year, especially in the early part of the period, may be partly the result of lack of consistency in the data.

The table shows that EDR of most major commodities increased during the period, despite extraction of resources by mining; EDR of gold increased more than eightfold (Figure 3). EDR of tin appear to have decreased from 1976 to 1988. However, the data for 1976 are not comparable with those for later years. Disregarding this year, estimated EDR of tin rose from 170 kt in 1977 to 262 kt in 1985 then, because of low prices and exhaustion of economic resources at some deposits, fell to 202 kt in 1988, giving an overall increase of 19% in the 11 year period.

Fig.1 METAL PRICES, 1987-88

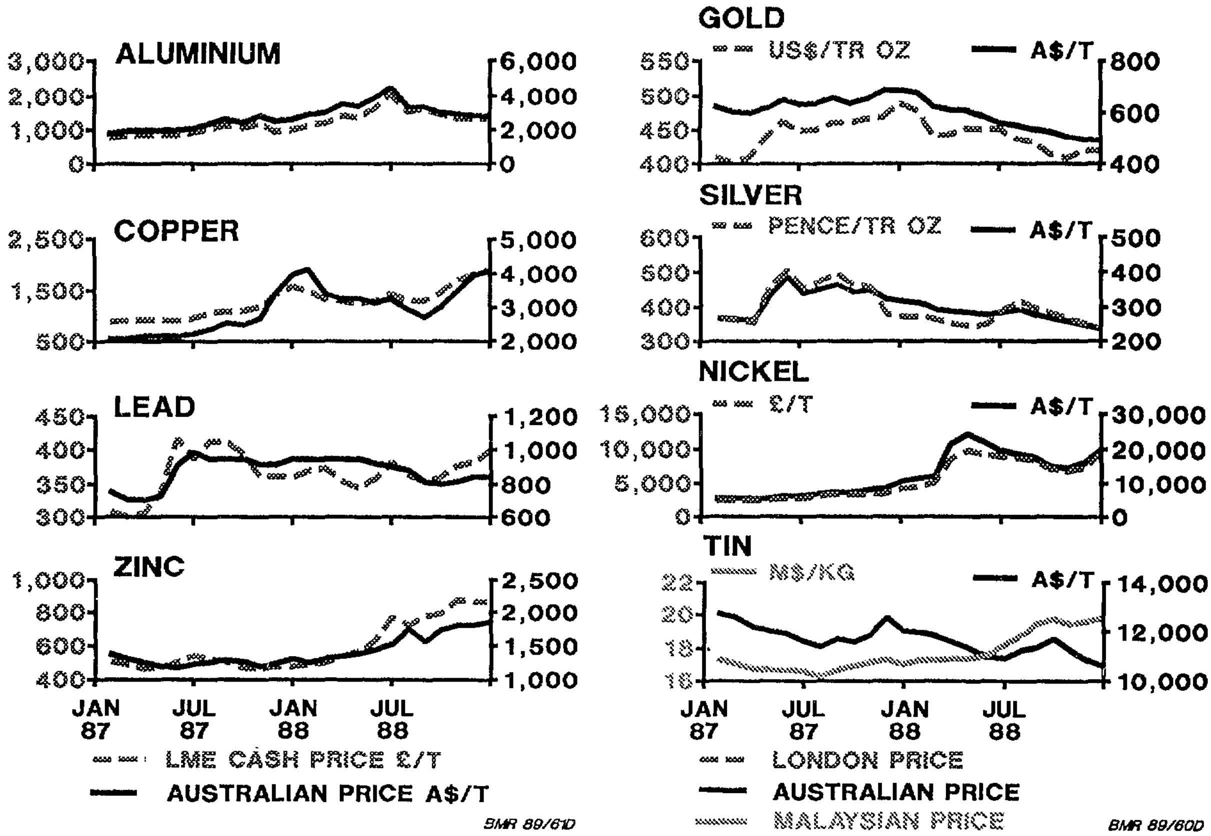


Fig.2 PRIVATE MINERAL EXPLORATION EXPENDITURE 1979-80 TO 1987-88

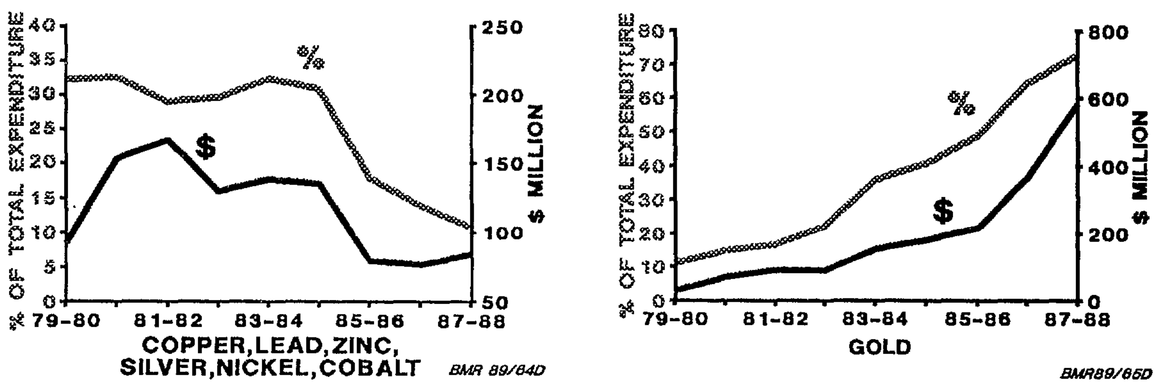
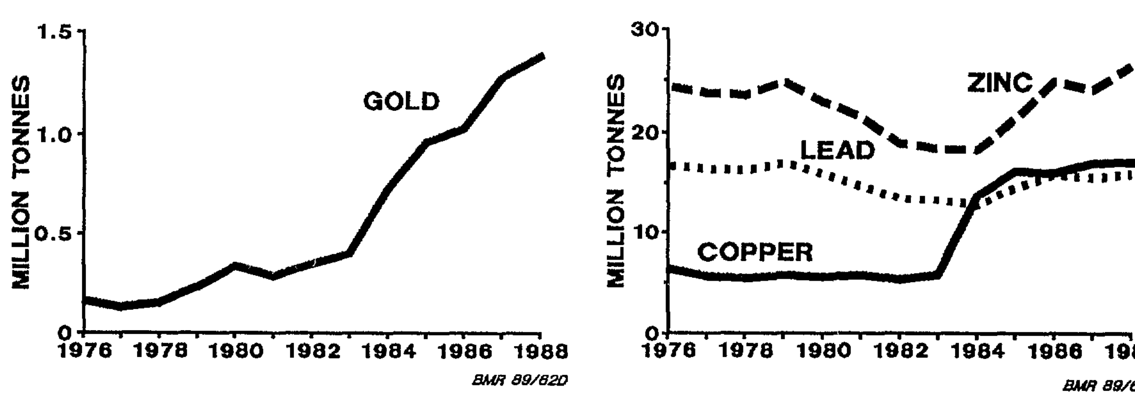


Fig.3 ECONOMIC DEMONSTRATED RESOURCES, 1976-88



The single number for iron ore EDR obscures a complex resource position in regard to ore types available and their quality. The classification does not distinguish between ores that produce predominantly a lump or fines product.

The two major determinants of iron ore quality are the iron and phosphorus contents. EDR are mainly higher grade ores, i.e. those with a high iron content and low phosphorus content; they include also relatively minor quantities of lower grade ores suitable for beneficiation. Ores with a high iron content but also a high phosphorus content are classified as paramarginal. Resources of premium iron ore, i.e. high-grade, hard, low phosphorus ore of the Mount Whaleback/Mount Tom Price type, are less than 20% of total EDR.

The Minister for Resources directed BMR to carry out a study during 1988 of ways of further enhancing market prospects for higher impurity iron ore. This report, which is now being considered, paid particular attention to the problems of the marketability of high phosphorus ores.

Of those commodities listed in Table 3 (excluding tin), resources of only lead and nickel decreased in the 12 year period, i.e. additions to EDR did not keep pace with production of these two commodities even though a substantial quantity of new resources of each was discovered in the period. EDR of nickel decreased partly because of depletion of resources and partly because of low nickel prices in the mid 1980s.

Annual estimates of EDR of the base metals (copper, lead and zinc) are shown in Figure 3. EDR of each of lead and zinc moved in parallel because the two occur together in most Australian deposits. However, explorers have directed attention to zinc-rich deposits because of the poor market outlook for lead and as a result, EDR of zinc have increased although EDR of lead have decreased. Recently discovered deposits on the Lennard Shelf, which are essentially zinc deposits, and copper-zinc deposits at Golden Grove also contribute to EDR of zinc. Although EDR of copper increased over the period, the increase resulted largely from testing of the Olympic Dam deposit; further, most EDR of copper are in two deposits, Olympic Dam and Mount Isa.

Discoveries of new resources are of two kinds: One kind is extensions of orebodies in existing mines, which normally result in incremental changes in EDR from year to year as inferred ore is proved up. However, orebodies are finite and new deposits must be found to replace existing mines as these eventually are worked out. Additions to EDR by discovery of new deposits (the second kind of discovery) are intermittent; they tend to produce a sudden increase in the year to year trend of resource totals, although this does not occur until several years after the initial discovery of the deposit.

In addition to the changes produced by discovery and mining, EDR may increase if prices increase relative to costs (i.e. resources are transferred from the subeconomic to the economic category); and vice versa.

Excluding Olympic Dam, exploration for base metals in Australia over the past decade has done little more than find sufficient resources to replace those that have been mined or have become uneconomic because of lower prices.

Although they have been overshadowed since the late 1960s by aluminium, coal and iron ore and more recently, gold, the base metals together are still an important part of the Australian mineral industry. Aggregate value of their mine production makes up about 7% of the total value of mine production, and eight different base metal smelting and refining operations draw feed from Australian deposits.

Exploration expenditure for gold and for base metals together with silver, nickel and cobalt is shown in Figure 2. There has been little exploration for silver or cobalt alone and BMR estimates that exploration for nickel makes up only a small part of the total expenditure shown because of low nickel prices over most of the period. Consequently, Figure 2 is a good indication of the trend in exploration interest in base metals. This has decreased in recent years because of low prices and the great interest in exploration for gold, and there must be some doubt as to whether EDR levels for copper, lead and zinc will be maintained in the medium term.

The increase in exploration expenditure for the base metals in 1987/88 is encouraging, but in real terms expenditure was little changed from 1986/87 to 1987/88. The large increase in base metal prices since mid 1987, and the fall in the price of gold during 1988 are likely to result in renewed interest in base metal exploration. Nevertheless, a substantial increase in exploration effort is needed to ensure that new EDR are discovered at a rate sufficient to give long term assurance that current production levels can at least be maintained.

Petroleum resources

Australia's economic demonstrated resources of crude oil, condensate and LPG in 1988 were about the same as in 1987; however the resources of sales gas increased significantly by about 2.3 $x10^9 m^3$. This increase was mainly a result of reclassification of previously sub-economic demonstrated sales gas resources to the economic category. Since 1976 the remaining economic resources of crude oil and condensate have increased from 264 x $10^6 m^3$ to 352 x $10^6 m^3$, and natural gas resources have increased from 324 x $10^9 m^3$ in 1976 to 1065 x $10^9 m^3$ in 1988. These increases have been partly due to the revision of resources estimates for known fields. Australia's economic crude oil resources have declined slightly during the 1980s, but this decline has been more than compensated by a rise in condensate resources. Rising condensate production in the 1990s is expected to compensate partly for a decline in crude oil production.

Assessments of Australia's undiscovered resources of crude oil and sales gas, made in 1986, indicated an average of 380 x $10^6 m^3$ undiscovered crude oil and an average of 650 x $10^9 m^3$ undiscovered sales gas. An assessment of condensate, revised in 1988, indicated an average of an additional 80 x $10^6 m^3$ undiscovered condensate. The assessments indicated that the most prospective areas for undiscovered crude oil are in the offshore Bonaparte, Carnarvon, and Gippsland Basins, and the most prospective areas for undiscovered sales gas are in the offshore Carnarvon, Browse and Bonaparte Basins. These areas were generally the most actively explored offshore areas in 1988, as indicated earlier.

Outlook

With increased production of several major commodities in the next two to three years, and the likelihood that prices will remain above the levels of the mid-1980s - but probably not at early 1988 levels - the outlook is that the value of mine production will continue to increase for the next two to three years at least.

Exports of mineral primary products will increase also because of the increased quantity of mine production. The possible increase in the degree of processing of some commodities, particularly in the mineral sands sector, is likely to result in the value of exports increasing more than commensurately with the value of mine production.

Use of imported ores as feed for some refineries, which has occurred only sporadically in the past, will result in some increase in the value of mineral imports, but a much greater increase in the value of exports.

In the short term, the two major determinants in the profitability and competitiveness of the minerals sector will be the extent to which it can contain costs, and the value of the Australian dollar against other currencies, especially the United States dollar.

Substantial increases are expected in the levels of petroleum exploration and development drilling offshore in 1989. Offshore exploration drilling could increase by up to 50% mainly because of drilling commitments in the Bonaparte, Browse and Carnarvon Basins - the areas presently considered to have the highest potential for further offshore exploration; this gives hope for additions to resources.

The Queensland Government has endorsed a proposal to sell natural gas from the Queensland part of the Cooper Basin to South Australia; this is expected to provide a further stimulus for exploration in the basin.

Development drilling offshore is expected to increase also in 1989, particularly in the Gippsland Basin.

The expected increases in petroleum exploration and development activities offshore will probably be offset by forecast falls of about 30% in the levels of exploration and development activities onshore compared with those of 1988. Seismic survey activity in 1989 is also expected to be less than in 1988, particularly in the onshore areas.

Looking to the longer term, economic demonstrated resources of most of the major commodities are adequate to support production at current or even increased levels for the next 20 years at least and much longer for some commodities. Diamonds, gold, mineral sands, nickel, and crude oil are exceptions to this generalisation. However, inferred resources of gold are large, and large resources of mineral sands currently classified as paramarginal demonstrated could well become economic with further development studies.

Over the last 12 years, the exploration industry has succeeded in discovering sufficient new resources to replace those mined in the same period, with a few exceptions. Crude oil resources were the same at the beginning and end of the period. However, Australia has been only sparsely explored for petroleum, and there is considerable potential for further substantial discoveries. The continent is highly prospective for mineral discovery and we can be confident that new deposits will continue to be discovered, especially as continued improvement of the geoscience knowledge base and exploration technology enable exploration to be directed increasingly to the less obvious deposits.

The industry will have the resource base needed for continued long-term production. As long as those resources can be worked profitably, the industry will continue to be a major contributor to the Australian economy.

TABLE 1

ANNUAL AVERAGE PRICES, 1987 and 1988

	UK (£/t)		Australia ($/t)	
	1987	1988	1987	1988
Aluminium	955	1 437		
A$ equivt			2 226	3 252
Copper	1 080	1 460	2 532	3 377
Gold				
US$/troy oz	447	437		
A $/troy oz			639	561
Lead	364	368	870	884
Silver				
Pence/troy oz	428	368		
A$/troy oz			326	276
Nickel				
£/t	2 957			
US$/t		14 318		
A$/kg equivt			6.96	18.18
Tin	-	-	12 004	11 308
Zinc	488	625	1 249	1 563

TABLE 2

1987 AND ESTIMATED 1988 AUSTRALIAN MINERAL PRODUCTION

	Unit of Quantity	1987 Quantity	1987 Value ($'m)	1988(e) Quantity	1988(e) Value ($'m)
Bauxite	'000t	34 102	306.4(a)	35 200	700
Black Coal	'000t	178 399	4 771.2(a)	173 532	4 600
Brown Coal	'000t	44 877	312.8	41 924	325
Copper	t	232 695	411.0(b)	236 047	640
Diamonds	'000 carat	30 332	246.5	34 554	285
Gold	kg	110 696	2 219.3(b)	150 000	2 725
Iron Ore	'000t	101 748	2 039.7(b)	96 084	1 825
Lead	t	489 150	458.7	474 229	410
Manganese	'000t	1 853	105.3	1 985	125
Nickel	t	74 554	324.1	62 358	625
Oil	ML	31 874	5 669.9	30 200	4 530
Gas	$10^6 m^3$	15 173	981.5	15 650	1 095
LPG	ML	3 883	411.6	3 950	435
Ilmenite	'000t	1 498	123.4	1 590	105
Rutile	t	246 263	141.5	233 000	140
Uranium	t	4 457	376.7	4 165	340
Zinc	t	778 386	293.9(b)	765 613	385
Zircon	t	456 590	104.5	490 000	210
TOTAL - PRINCIPAL MINERALS			19 814.4		19 500
TOTAL - OTHER MINERALS			1 392.8		1 375
TOTAL MINERAL PRODUCTION			21 207.2		20 875

(a) Excludes Western Australia; included in 'Total-Principal Minerals'
(b) Excludes Tasmania; included in 'Total - Principal Minerals'.
(e) Estimated by BMR

TABLE 3

CHANGE IN AUSTRALIAN ECONOMIC DEMONSTRATED RESOURCES (EDR) 1976 - 1988

Commodity	EDR 1976 (1)	EDR 1988 (1)	EDR % Change	Prod'n (1977-1988) (2)	Gross Added EDR (1977-1988)(3)
Bauxite (Mt)	2698	3205	19	349.78	856.78
Black Coal,recoverable (Gt)	20	50	150	1.53	31.53
Brown Coal,recoverable (Gt)	31	42	35	0.43	11.43
Copper (Mt)	6.3	17.1	171	3.06	13.86
Gold (t)	161	1378	756	584.45	1801.45
Iron Ore (Gt)	13.7	16	17	1.09	3.39
Lead (Mt)	16.7	16	-4	5.81	5.11
Ilmenite (Mt)	50.5	61.2	21	15.22	25.92
Rutile (Mt)	9.8	10.3	5	2.88	3.38
Zircon (Mt)	15.6	15.7	1	5.29	5.39
Nickel (Mt)	1.8	1	-44	1.02	0.22
Petroleum:(a)					
Crude Oil (GL)	231	232	0.4	304.74	305.74
Condensate (GL)	33	120	264	17.08	104.08
Natural(sales) Gas (TL)	324	1065	229	139.3	880.30
Tin (kt)	329	202	-39	183.83	56.83
Uranium,recoverable (kt)	237	480	103	33.09	276.09
Zinc (Mt)	24.3	26.3	8	8.72	10.72

(1) End of year.
(2) Includes allowance for losses during recovery.
(3) Sum of production and increase in resources from 1976 to 1988.
(a) Mid year. 1976 data is proved/probable reserves declared commercial.

The 1988 minerals industry survey: restored profitability

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Australian Mining Industry Council

1.Background

The 1988 Minerals Industry Survey was the twelfth produced by the Australian Mining Industry Council. Such a long series represents a detailed statistical description of the minerals industry's financial performance, as well as an up to date snap-shot of the industry for the year in review. The Survey was initiated at a time when the emergent mining sector was badly served by statistics.

The aim of the Survey therefore was and is to provide timely and accurate data on the industry and to promote a more informed debate on the industry's role in the economy.

This paper provides an overview of the 1988 Survey, with particular emphasis on profitability, investment, taxation and employment. Issues affecting industry performance with recommendations for an improved outlook for the industry are discussed briefly.

Table 12 from the Survey, showing the ten year survey from the industry is appended to the paper.

2.Overview

The strong mining investment push in the late seventies and early eighties was poorly rewarded. Revenue growth from increased production was drastically curtailed by poor mineral prices. Poor prices and profitability made it difficult to reduce the borrowings that had been used to finance the investment surge. The result was an aggregate debt to equity ratio peaking at 1.27 in 1985/86.

Profits fell precipitously from 1979/80 to 1981/82 then recovered gradually as industry reacted to its new circumstances by reducing costs and limiting spending on exploration and investment. But that recovery was extremely fragile. Net profit as a percentage of shareholders' funds showed an average annual increase of less than 5% for the six years up to 1986/87. Still by that year the survey provided some evidence that the industry, despite continued poor price levels, was achieving some success in improving its performance.

For the year under review, 1987/88, operating revenue increased by 8.3% to 16.9 billion dollars, continuing the steady increase of the previous year. This improvement masked major variations in the revenue of the two major sectors which make up the industry.

This split, between the bulk minerals (coal and iron ore) sector and the smelting and refining metals sector, is one of the features of this survey. Spectacular price increases were recorded for nickel and aluminium, while copper, zinc and lead all showed healthy gains. The extent and duration of the price increases were largely unanticipated after a prolonged period of excess supply and consequently depressed price levels. The permanent closure overseas of high cost production facilities, continued growth in western world industrial production, and supply disruptions through industrial and political activity, combined to generate the price surge.

The bulk minerals, coal and iron ore, recorded falls despite small increases in negotiated contract prices. The appreciation of the Australian dollar against the US dollar accounted for the fall. Most sales contracts for world traded minerals are denominated in US dollars with the result that movements against that currency are immediately reflected in Australian dollar prices.

Coal, iron ore and gold, where prices were also low, are three of the four largest mineral exports from Australia and therefore account for a large weighting in Australia's mineral export basket. Price decreases for these minerals cancelled out the price increases for base metals.

These price movements, when combined with volume falls, resulted in mining sector sales falling by 3.6%. Smelting and refining sales, however, increased by 37.7%. That increase was largely the result of increased prices as noted above and increased production levels particularly in the alumina and aluminium sector.

In 1987/88 profitability in the industry improved, with a particularly strong increase in the smelting and refining sector. Overall net profit increased by 1.1 billion dollars to 1.8 billion dollars. As a percentage of shareholders' funds that represented 14.7%, significantly better than the 5% noted above.

While the improvement was welcome it came at the end of six years of extremely low profitability. The ten year average of net profit return on average shareholders' funds was still a poor 8.7%. A further point to note is the uneveness in profitability. All the improvement was in smelting and refining, a sector which had recorded losses in every year since 1983/84. The positive side of this development was that it was the value-adding export industries which were most successful, at least in the current year.

Another highlight of the survey was the reduced reliance by the industry on debt. Outstanding borrowings of respondents at year end were 11.6 billion dollars, significantly less than the 12.9 billion dollars figure reported in 1986/87. It is particularly encouraging that companies are reconstructing balance sheets. Borrowings appear to have peaked in 1985/86 and are now declining to more manageable levels. As a result of this interest expense fell by 0.195 billion dollars to 1.1 billion dollars.

All of the decrease occurred in foreign currency borrowings, partly through repayments and 0.184 billion dollars through revaluation consequent on the strengthening of the Australian dollar. Foreign currency denominated debt fell from the 8.4 billion dollars reported in last year's survey to 6.8 billion dollars, approximately six months of export sales by respondents.

Employment by respondents fell significantly over the year, with most of the reduction concentrated in the bulk minerals sector as it restructured in the face of poor industry conditions. Increased employment in the gold sector however is not reported here. Employment in exploration increased in 1987/88 reversing a long term decline, while that in smelting and refining recovered from a significant drop the previous year.

The forecasts of respondents for 1988/89 give a varied picture with exploration expenditure expected to fall by 13% to 324 million dollars while expenditure on fixed assets is forecast to grow by 44% to 3.2 billion dollars. This particularly bullish outlook deserves special comment.

3.Investment Outlook

The industry is re-investing the profits back into export industries. The 44% increase in capital spending in 1988/89 is evenly distributed across both mining and smelting and refining sectors. Perhaps most surprisingly the biggest increase is expected in coal, and most of that in Queensland. Such faith in a commodity whose price is at or near an historic low can be explained in two ways. Firstly, while the near term outlook is uncertain the medium term outlook for steaming coal is improving. Secondly the Coal Industry tribunal decisions are expected to bear fruit. A seven day mining operation requires a certain amount of re-equipping. That should start in the current year, bringing improved outut and of course improved productivity and competitivenss.

Iron ore is another sub-sector attracting significant investment. All the existing large mines have active investment programs underway. When combined with the new developments such as Channar, export capacity should be sharply increased.

Base metal developments are taking place at Olympic Dam, Hilton, Golden Grove, Hellyer, and at most smelters. Gold and diamond mine investment continues to grow. Increased investment in gold mining to increase output to offset falling prices and the threat of future tax is occurring.

While the investment forecast is impressive ,Australia's potential is far from being fully realised. For example the world market for alumina and aluminium is looking particularly strong at the moment and additional refinery and smelter capacity will be needed to meet expected world demand. Australia could attract that investment, but we must compete with Canada, Venezuela and the Arabian Gulf to win it. That means we have to be more cost competitive at every stage of the feasibility, construction and operational cycle.

Access to our resources is being stifled by the results of an increasing community ignorance of the nature of the industry development. Access to land for exploration and even development is becoming increasingly difficult as government seeks to protect larger and larger areas through reserves and regulations under the broad umbrella of saving the "environment", without recognition of the ability of industry to operate in a non destructive way given changing and improving technologies in land use management by both the mining and processing sectors.

In addition, our construction costs are too high, a function of high and unreliable, labour cost per unit of output. In this respect it is imperative that we pursue further freeing up of the labour market as a prerequisite for productivity gains. Sections of our heavy engineering and transport industries are inefficient. There is also still too much protection given to some domestic equipment producers.

Perhaps of even greater importance is the relative cost of energy in Australia compared with alternative supplier countries. Our coal fired plants are generally more expensive to run than large hydro plants. But worse, the monopoly position of most power generation authorities in this country has led to cost inefficiencies which are passed on to consumers. The problem is compounded by the impact of state government revenue raising imposts and political distortions in tariff structures.

These impediments to expansion require a concerted effort by government and unions to achieve the micro reforms currently on the political agenda. That is not to imply that managers have nothing to do. In this respect it is pleasing to see the 34% increase in research and development forecast for 1988/89. But as well as improving our performance through technological advances, we are improving our market base across the world and working hard to improve our industrial relations

4.Government and Taxation

For the year 1987/88 the industry was again a major contributor to government revenues. Direct taxes on the mineral industry rose in 1987/88 by 11.3% to 1.4 billion dollars. Within the direct taxation category, royalty payments fell by 6.0% while income tax rose by 24%. This rise was to be expected in a year of sharply improved profitability.

Total payments to government by the industry fell slightly but still amounted to 3.8 billion dollars. The fall was a result of reduced payments for provision for government services. That was caused by the reduced rail freight and port payments consequent on the lower volumes of coal produced and exported. This underlines the vested interest of government in maintaining an environment where the industry can grow.

Fringe benefit tax payments rose marginally to 40 million dollars over a full 12 month period compared to 37 million dollars over nine months in the previous survey. This suggests that companies cashed out fringe benefits wherever possible. Even so the tax cost the industry an additional 542 dollars per employee. This employment tax falls particularly hard on the mining industry. We must provide remote area housing and meet recreation leave costs, yet we are penalised for it. This is a significant change from the period when employees in remote areas attracted a reasonable tax refund.

The after rebate cost of diesel and fuel excise rose by 34.4% to 43 million dollars. Before rebate the cost was 153 million dollars an increase of 26.4% over the 1986/87 figure.

5. Employment and labour costs

The total number of people employed decreased from 78,111 over the year to 72,167. The decline was mostly evident in the coal and iron ore sectors as they restructured over the course of the year. The survey does not cover many of the emergent small gold producers and hence the increased employment in this sector is not shown.

Respondents paid 3.2 billion dollars in labour costs for the year, which represented an increase in total expenditure per employee of 4.7%. Gross salaries and wages per employee increased by 6.2%.

In a major departure from the trend of previous years the prime beneficiaries of the increase in gross wages per employee were the employees rather than government. Group tax payments per employee declined marginally from 11,523 dollars to 11,189 dollars, although payroll tax per employee increased from 1,872 dollars to 1,982 dollars.

Australian Bureau of Statistics' data showed a marked deterioration in industrial relations in the coal mining sector in 1987/88, but an improvement in the "other" mining category. The number of working days lost in the coal industry totalled 445,000 compared with 172,000 in 1986/87. In relative terms, the performance of the coal industry was fifty times worse than the national average. Working days lost in the coal industry per thousand employees for the twelve months to June 1988 was 14,292. The equivalent figure for the "all industries" group was 282. In sharp contrast to the poor result in the coal industry, industrial disputation in the "other mining" category improved. The number of working days lost was just over 60,000, less than half of the 1986/87 figure.

6. Conclusion.

In the context of our persisting current account deficits and foreign debt problem, the Australian mining industry is playing a critically important and constructive role. As seen from the 1987/88 results, increased profitability is being utilised to reduce debt and invest in additional productive capacity. AMIC maintains that there are too many restrictions and secondary taxes on the industry, and believes that the Federal Government could take the following initiatives, to allow further investment and increase national output.

- Improve access to land for exploration, recognising the need to extend and develop our resources base for the next century now.

- Continue to reduce protection levels on inputs to the industry.

- Reinforce the micro reform initiatives especially in the transport sector and within that, coastal shipping and the waterfront.

- Remove the discriminatory coal export levy and uranium export levy.

- Provide full rebate on excise paid on diesel and fuel oil.

- Remove the cost of fringe benefits tax on remote area activities.

Overall, the 1988 Minerals Industry Survey does show a return to profitability, but clearly after a long period of heavy investment and a relatively buoyant time for the metals and processing sector.

The industry must of course be profitable to allow continuing investment. Unless it can improve the profitability levels consistently, which will only occur with the correct macroeconomic and microeconomic climate, not only will the industry suffer, but the nation generally.

References

1988 Minerals Industry Survey, compiled from data collected by Coopers & Lybrand, published by Australian Mining Industry Council, December 1988.

APPENDIX

Ten Year Summary

The following summary of data is provided as a record of the last ten years of survey results. To obviate possible distortions that may occur due to the different number and composition of respondents from year to year, percentage figures have been used wherever possible rather than dollar figures.

	1978-79	1979-80	1980-81	1981-82	1982-83	1983-84	1984-85	1985-86	1986-87	1987-88
Number of Responses	80	95	122	130	122	118	121	130	121	**113**
Total Revenue ($ Million)	5347	7161	7858	8640	10083	11000	13859	15055	16338	**17571**
Percentage of Total Revenue (%)										
Supplies, Depn., Govt Services, etc	51.4	49.1	53.1	60.0	57.2	58.3	61.2	59.8	60.0	**56.4**
Labour, Group Tax and Payroll Tax	22.3	20.6	23.5	25.5	24.6	23.1	20.1	20.2	19.7	**18.0**
Direct Taxes	12.1	14.3	10.5	7.0	8.0	7.6	7.1	8.2	8.0	**9.0**
Shareholders	10.1	12.3	8.7	2.1	3.8	4.2	4.6	3.7	4.1	**10.1**
Lenders	4.1	3.7	4.2	5.4	6.4	6.8	7.0	8.1	8.2	**6.5**
	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	**100.0**
Profit and Taxes										
Net Profit ($ Million)	539	879	665	177	379	462	640	557	669	**1772**
Income and Resource Taxes ($ Mil)	637	1028	822	604	808	837	1000	1229	1315	**1579**
Balance Sheet										
Total Assets ($ Million)	8370	10868	14748	19760	23599	25401	27662	28640	29168	**30593**
Share of Total Assets				Percentages						
Shareholders' Funds	38.3	45.6	46.8	45.1	42.3	43.2	40.6	36.9	37.0	**43.5**
Borrowings	37.2	31.2	32.7	37.6	40.9	40.4	43.2	47.1	44.1	**38.0**
Other Liabilities	24.5	23.2	20.5	17.3	16.8	16.4	16.2	16.0	18.9	**18.5**
	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	**100.0**
Fixed and Deferred Assets	69.8	69.9	72.9	74.3	73.7	72.8	70.7	71.3	71.6	**71.2**
Other Assets	30.2	30.1	27.1	25.7	26.3	27.2	29.3	28.7	28.4	**28.8**
	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	**100.0**
Effective After-Tax Return on Year-End Funds Employed:										
Exploration and Mining	13.0	13.9	6.5	2.6	5.2	4.5	6.6	9.6	9.0	**8.5**
Smelting and Refining	8.6	10.5	8.2	2.9	1.1	3.5	2.4	0.3	1.4	**13.3**
Total	11.2	12.9	7.0	2.7	3.9	4.2	5.3	6.7	6.9	**9.7**
Effective After-Tax Return on Year-End Assets:										
Exploration and Mining	9.4	10.6	5.1	2.2	4.2	3.8	5.5	7.9	7.3	**7.1**
Smelting and Refining	6.7	8.2	6.5	2.4	0.9	3.0	2.0	0.3	1.1	**9.9**
Total	8.5	9.9	5.5	2.2	3.3	3.5	4.5	5.6	5.6	**7.9**
Resource Based Taxes & Income Taxes as % of Operating Profit Before Resource Based Taxes:										
Exploration and Mining	55.4	56.1	59.8	76.6	61.0	65.3	55.6	50.8	52.7	**49.8**
Total Survey	52.8	53.9	56.3	72.0	65.6	63.0	58.3	56.6	58.4	**46.3**
Net Profit Return on Average Shareholders' Funds	17.8	21.5	10.9	2.2	4.1	4.4	5.7	5.1	6.4	**14.7**
Effective After-Tax Return on Average Funds Employed	11.7	13.9	8.1	3.4	4.3	4.4	5.5	6.7	6.8	**10.0**
Effective After-Tax Return on Average Assets	8.9	10.6	6.4	2.8	3.6	3.7	4.6	5.7	5.6	**8.2**
Percentage Export Sales to Total Sales	67.9	68.2	70.0	73.0	77.7	78.4	79.3	81.2	78.2	**75.7**
Debt to Equity Ratio	0.97	0.68	0.70	0.83	0.96	0.94	1.07	1.27	1.19	**0.88**

Queensland mineral development: current progress and the future outlook

B M Dobbyn

Queensland Department of Mines

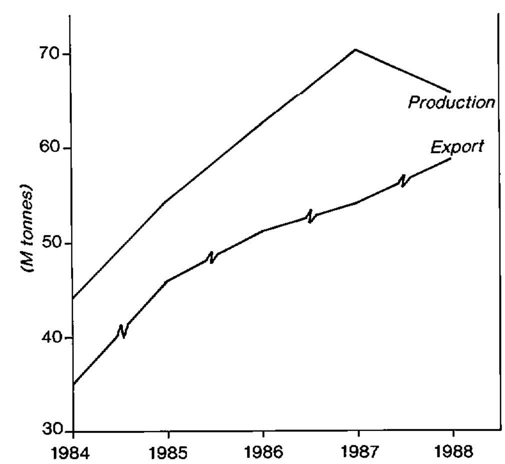
QUEENSLAND MINERAL INDUSTRY 1988

The Queensland mining industry whilst still strong, experienced some changing fortunes in 1987-88, particularly the major income earners such as Coal, Crude Oil and Natural Gas.

The value of Queensland mineral production fell below the previous year by 6.4% to $3 901 Million, reflecting a 4.4% reduction in coal production and a 19.7% reduction in the value of coal produced, together with a 9.9% reduction in crude oil production and a 21.0% reduction in value.

Value of Mineral Production 1984–1988

Coal Production and Export 1984–1988



Coal continued as the State's major mineral and energy commodity in economic terms (55%) and the industry was disadvantaged by domestic cost pressures, industrial disputes and low prices - together with unfavourable exchange rate movements.

Crude oil price reductions, coupled with the strengthening Australian dollar and climatic effects during the year, contributed to reduced crude oil production and returns on production.

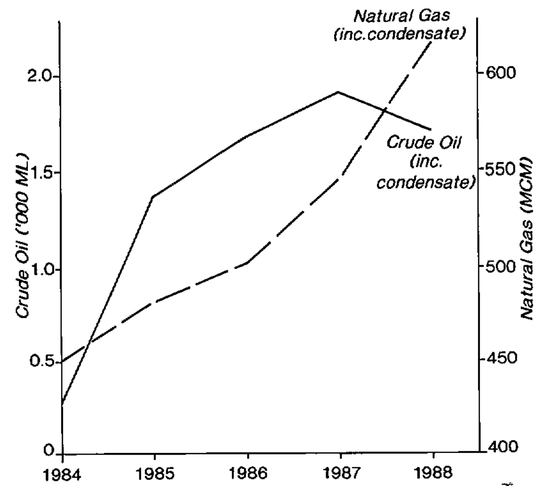
Natural gas production increased by 13.4% to 619 616 MCM but value of production fell by 10.4%, mirroring the drop in crude oil price.

Base Metals showed a mixed performance with Copper (+38.5%) and Lead (+32.2%) showing improved earnings over the previous year, and Zinc (-14.3%) and Nickel (-9.2%) experiencing reduced earnings.

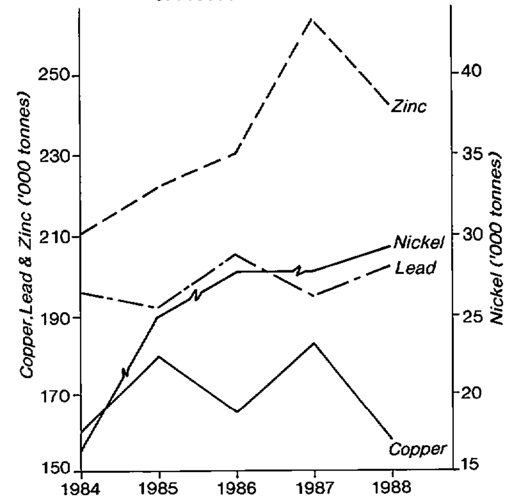
Mount Isa continued to be the State's only significant producer of Copper, Lead and Zinc although the Gold/Copper operation at the Selwyn/Starra mine came on line in mid 1988 and is expected to produce 10 000 tonnes per annum of contained copper.

While Nickel content of ore mined rose by 5.5%, the production of ore and the value of production fell by 4.4% and 9.2% respectively below the 1986-87 figures.

Crude Oil and Natural Gas Production 1984–1988



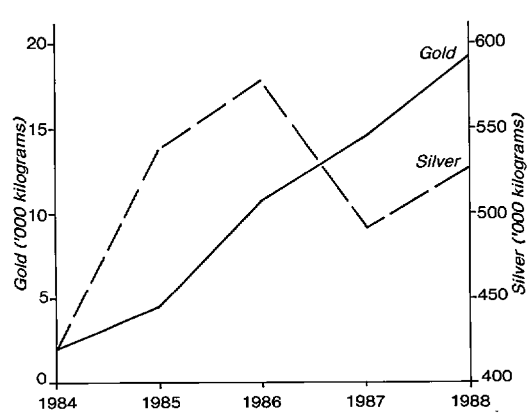
Significant Base Metal Content of Production 1984–1988



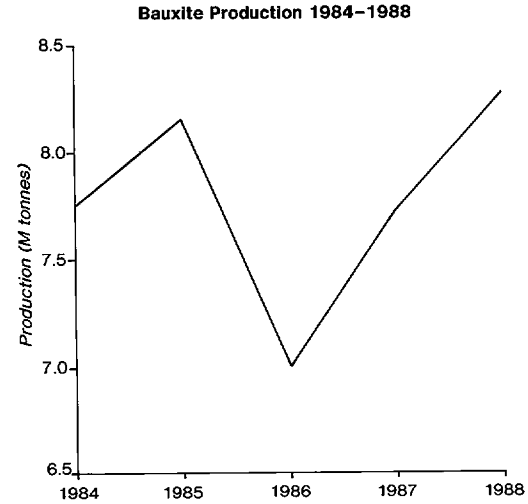
Both Gold and Silver experienced significant increases in production. Increase in silver production (+7.1%) followed as a result of increased lead production at Mount Isa, while gold production rose by 45.9% because of a continuing high level of activity in mining to reduce the impact of the gold tax in 1991 and in response to relatively high and stable gold prices.

Substantial gold production occurred at Kidston, Mount Leyshon, Red Dome and Pajingo together with the commissioning of mines at Selwyn/Starra, Croydon, Ravenswood, Wirralie and Horn Island.

Precious Metals Content of Production 1984–1988



Bauxite Production 1984–1988



Bauxite production at Weipa rose by 7.2% with buoyant prices increasing the value of production by 13.0% over that of 1986-87.

Improved market conditions for the Queensland Bauxite and Aluminium industry resulted from low stock levels and stronger world demand.

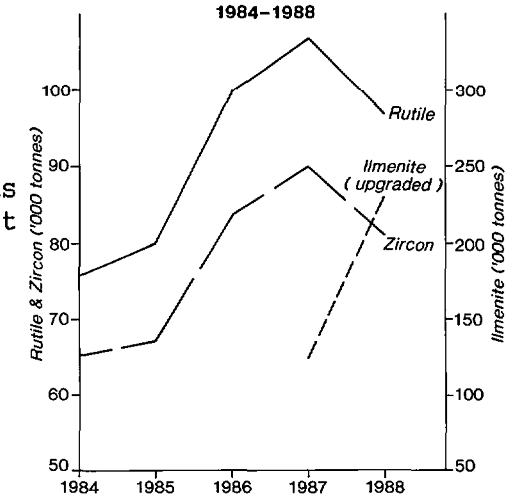
Rutile, Zircon, Ilmenite and Monazite were separated from heavy mineral sands mined by Consolidated Rutile Ltd at North Stradbroke Island and by Currumbin Minerals Pty Ltd at Coolangatta.

In addition ilmenite was upgraded by Consolidated Rutile Ltd at its plant at Pinkenba.

While all mineral sand commodities enjoyed buoyant pricing, the value of rutile concentrate produced decreased by 9.7% due to a decrease in production of 11.4%. Zircon and ilmenite concentrates rose in value by 51.1% and 117.4% respectively.

New developments in the Queensland mineral sands mining industry are expected to take place over the next few years, expanding the activities of companies on the central and southern coast of Queensland to take advantage of high prices. Emotive reactions to conservation issues which commonly result in the misuse of powers and legislation by the Federal Government have in many cases frustrated attempts by the industry and the Queensland Government to broaden the production base in an industry that for some time has had an exemplary record in land rehabilitation.

Mineral Sands Concentrate Production 1984–1988



CHANGES IN PERSPECTIVE

Stanford Research Institute in a report commissioned by the Queensland Government, has identified several fundamental conditions that have emerged during, or as a result of, changes in the world economy and which will have important impact on the global economic environment in the next decade or two, namely:

- slowdown in world economic growth;
- saturation in material consumption;
- increasing barriers to trade;
- increasing importance of the financial dimensions of economic activity; and
- changes in the Asia/Pacific region.

The Queensland Government has acted to effect the changes necessary to bring about a strong industrial economy by adopting a "market facilitation" strategy that encourages the private sector to act in new ways.

Whilst the mining and mineral processing sector is already acting to improve its overseas competitiveness, new investment in large scale mining projects will probably require a combination of lower infrastructure and service costs, and improved productivity of capital and labour.

Additional smaller-scale opportunities include development of reserves of industrial minerals such as magnesite, silica sands, phosphate rock, kaolin and magnetite, downstream processing of natural gas, and expansion of advanced materials and high-value products such as gold, gemstones and rare earths.

The Queensland Department of Mines has taken steps to enchance its services to the industry by:

- the review of mining legislation and the introduction in 1989 of the Mineral Resource Act to replace the current Mining Act;
- an improved and streamlined administration of title-processing, including the use of a comprehensive computerised Mining Tenures Data Base in 1989;
- the provision of regional offices for more efficient, on-the-spot client consultation; and
- the establishment of performance-oriented and market-driven Program Management within the Department in 1987.

These steps, together with a policy of targetted assistance to developers, are expected to provide industry with a positive climate for investment in exploration for - and exploitation of resources.

Encouragement is given, in particular, to proposals that include the further processing of minerals, where this processing can be seen to add value to the mineral resource as mined.

Likely projects in the next five years include the upgrading of ilmenite via the synthetic rutile or titanium slag route to add value to the State's significant resources of low-grade mineral sand; the establishment of satellite industry, such as caustic soda and sodium cyanide manufacture, consequential to the supply of natural gas to Gladstone; and the further processing, perhaps to the full extent of magnesium metal production, of the State's magnesite resources at Kunwararra and Yaamba, near Rockhampton.

Needless to say, the ability of companies to commit to further processing is dependent on a variety of external influences such as:

- market opportunities;
- impact of the Developing Countries;
- availability of technology; and
- world pricing of commodities.

It is not the intention of Government to intrude into areas which are more properly market-led or initiated. However, the encouragement of entrepreneurial skills within industry, together with the provision of positive investment climate by means of:

- providing assistance in the enhancement of market-driven research and development;
- assisting in the cost-competitiveness of Queensland industry by containing infrastructure costs to industry;
- establishment of reasonable transport costs and maintaining a healthy industrial climate;
- a rational balance between development and conservation issues, leading to a planned and efficient use of Crown land;
- ensuring pricing policies, taxation and other Government charges provide adequate compensation to the community while not impacting unfavourably on the total tax burden of Industry; and
- providing industry with speedier access to land for development purposes,

remain strategic goals of the Queensland Government.

FUTURE PROJECTS AND OUTLOOK

Exploration activity in 1987-88 remained high. Applications received for authorities to prospect totalled 1 226, 4 more than the previous year, while current mining leases totalled 3 634 - slightly down on the previous year.

However, there was a 2% increase in area held under lease, and the number of mining lease applications received increased from 672 in 1986-87 to 898 in 1987-88.

Changes in Federal government policy to facilitate offshore mineral exploration are expected to generate interest, particularly in the territorial sea (to 3 nautical miles).

COMMODITY PROSPECTS

COAL. With stocks low, spot prices for coal are expected to continue to firm, with improved prospects of increased contract rates. Existing coking coal contracts preclude further price gains until the next round of negotiations this year. Prospects will depend to a large extent on the exchange rate of the Australian dollar.

Modest increases in Queensland output are expected due to mine expansion at Cook, Goonyella Cleanskin Pit and Blair Athol collieries, productivity improvement and a more favourable industrial climate.

Significant proposed and potential mining projects currently being evaluated include:

- a $100 Million development of a second longwall mine at German Creek Southern Colliery (Capricorn Coal Management Pty Ltd), which is expected to produce 1.2 M tonnes per annum from 1991;
- the Ensham Project (A.Q.C. Pacific Pty Ltd - Bligh Coal Limited/Idemitsu Qld Pty Limited/Allied Queensland Coalfields Ltd/Pacific Coal Pty Limited and Others J.V.) where a feasibility study has been conducted for development of open-cut reserves of thermal and soft coking coal (210 M tonnes);
- Gordonstone (Denham Coal Associates - Anaconda Australia Inc./Kennecott Explorations (Australia) Ltd/Suncorp/Lend Lease Resources Pty Ltd J.V.) where proven reserves of coking coal (580 M tonnes) have been investigated for an underground longwall mine proposal;
- a proposal to mine semi-anthracite at the Dawson Valley Mine, Baralaba (Baralaba Coal Pty Ltd/Phoenix Oil & Gas J.V.) at a rate of 300 000 tonnes per annum which is based on proven reserves of 133 M tonnes;
- the Clermont Project (Clermont Coal Mines Ltd - Esso Australia/ Mitsubishi Development Pty Ltd J.V.) involving open-cut mining of thermal coal at an initial rate of 6.6 M tonnes per annum by 1990.

OIL/NATURAL GAS. Crude oil prices are expected to continue to be affected by the threat of excess supply from members of OPEC. This will also have implications on development of natural gas and shale oil reserves as crude oil replacements.

Use of natural gas as a chemical feed stock has the advantage of lessening the dependence of development on crude oil pricing. The future of shale oil production in Queensland, on the other hand, will depend on an improvement in world oil prices or a reduction in production costs, or both.

Petroleum exploration in 1987-88 continued the trend towards recovery apparent in the previous year, with 153 wells being drilled, including 93 exploration wells. Activities continued to be concentrated in the Eromanga/Cooper Basins and adjacent areas, although drilling activity in the

Surat and Surat/Bowen Basins also increased. A small percentage of exploration was over the onshore Carpentaria Basin and investigation of methane drainage from coal beds in the Bowen Basin. Stratigraphic drilling of bores was carried out by the Department of Mines in the Eromanga Basin (2), the Carpentaria basin (1.5) and the Laura Basin (1).

Queensland is expected to attract almost 50 percent of on shore exploration activity in Australia. Operators are now considering exploration in high-risk geologically complex "traps" and stratigraphic drilling by the Department of Mines in 1989/90 will be concentrated in the north Eromanga Basin. Future activities of the industry will be controlled by overall ranking of prospects and projects and continuing low oil prices would tend to restrict exploration to low-cost on-shore areas.

Natural gas pipeline development within Queensland is proceeding and will escalate over the next decade. Looping of the Roma to Brisbane line has commenced and the State Gas Pipeline will link the wells at Wallumbilla and North Denison to the Queensland Alumina refinery at Gladstone this year. A proposal to extend this trunk line from the Gladstone city gate to Rockhampton is in a prefeasibility stage and is being assessed by the Interdepartmental Committee on Natural Gas.

M.I.M. Holdings Limited have sought Expressions of Interest for the supply of natural gas to Mount Isa. This may involve the construction of a trunk line from the south-west Queensland gas fields, which would become a focus for further exploration and proving of reserves in the State's western region, as well as making for supply of gas to other potential consumers such as Queensland Phosphate Limited's project at Phosphate Hill.

A project to utilise methane drained from coal beds in the Bowen Basin is being actively developed by North Queensland Energy, a joint venture between Elders Resources and Curtain Bros. The venturers are hopeful for a commercial operation by 1991 servicing the north and west of the State.

PRECIOUS METALS. Gold production now represents about 10% by value of the Queensland minerals and energy sector. The industry has undergone major expansion due to new technology, buoyant prices and tax exempt status.

The fall in the $A price of gold prices, due to the strengthening of the US dollar, declining inflationary prospects and strong world supply, is expected to continue, while the full effects of the gold tax in 1991 are yet to be assessed. In spite of these negative factors, exploration for gold continues to account for 50 percent of exploration expenditure in Queensland and 80 percent of current Authorities to Prospect for minerals.

Kidston and Mt Leyshon mines are expected to continue to be among the top ten Australian gold mines, with Pan Australian Mining Ltd boosting production at Mt Leyshon from 2 500 kg per annum to 3 700 kg per annum this year, using a technology change from heap leaching to C.I.P.

Significant gold prospects in the exploration or evaluation stage include:

- Belyando, where Ross Mining N.L. are preparing for open cut mining with treatment on an adjacent site in 1989;
- Camel Creek, an open cut operation with heap leaching, planned for 1989 by Golden Ant Mining Ltd;
- a multi-operation project by North Queensland Resources N.L. involving the Disraeli, Reward, Highway East, Joe's Delight, and Hadleigh Castle prospects in the Charters Towers area;

- projects involving the redevelopment of past mines at Gympie (B.H.P. Minerals/Gympie Eldorado Gold Mines Limited J.V.) and North Arm (Valdora Minerals); and
- the Yandan project (Western Mining Corporation Ltd), involving open cut mining near the Suttor River.

Silver production continued to be chiefly associated with Base Metal and gold operations, rather than a primary mining target. Almost all (98%) of Queensland silver production is a result of lead/zinc operations at Mount Isa and it is expected that silver production levels will continue to mirror levels of production of these other metals.

A continuing industrial demand for silver will assist in offsetting oversupply but substantial rises in price are not expected in the short term.

BASE METALS. Prices for Copper are expected to continue to fluctuate, under the combined effects of consumer demand, stock levels resulting from increased activity at existing operations and also the commissioning of new mines and the emergence of new technology such as Isasmelt.

Lead production is forecast to increase by 2% over the 1987/88 level but will be offset to some extent by rising stock levels.

Increased interest in Western Zinc by Communist countries and a close balance between production and demand are expected to maintain firm prices for zinc in the short term.

Significant Base Metal projects being investigated or evaluated include:

- The development, by MIM Holdings Limited, of the Hilton silver/lead/zinc deposit north of current operations, with plans for full scale mining in 1989 and a dedicated concentrator and Isasmelt in 1990, expected to lift MIM lead production by 10% and zinc by 25%;
- the Thalanga, west of Charters Towers, project (Pancontinental Mining Limited/Outakumpu Oy J.V.), where copper/zinc/lead/ silver/gold reserves will be mined and treated in 1989/90; and
- the Balcooma project, north of Charters Towers, (Triako Resources Limited), where the company plans mining and treatment of a copper/lead/zinc ore in two concentrators at a total rate of 0.85 M tonnes per annum.

Nickel prices, following significant escalation in 1988, have eased and are expected to dampen demand in 1989 leading to a 3 percent reduction in Western World nickel consumption. Even so, there appears to be interest from China in possible sources of Queensland nickel for export.

While there are as yet undeveloped resources of lateritic nickel near Mount Garnet (Southwest of Cairns) and in the Marlborough/Mount Etna area near Rockhampton, the only producing mine at Greenvale has a limited life expectancy of only a few years due to dwindling reserves. Recent activities have involved a $200 million upgrading of the Yabulu treatment plant to treat imported ores.

BAUXITE, ALUMINA AND ALUMINIUM. Over this decade the world aluminium industry has undergone massive restructuring with closures of high-cost smelting capacity and has slashed its cost structure to maintain its existence in what has become a more volatile market with changing trade patterns, the emergence of unaffiliated producers and increasing emphasis on further processing of primary metal.

The industry is optimistic on future prospects but warns of the strongly cyclical nature of the industry and the risks of substitution of aluminium by other materials as a result of continuing very high prices.
There is a possibility of one further Australian greenfields project late in the 1990's, but initial plans appear to be for expansion of existing capacity to allow for an expected average 2 percent increase in consumption over the remainder of the century. Plans have been announced to expand production at the Boyne Island Smelter and the Gladstone Alumina Refinery.

MINERAL SANDS. The Queensland mineral sands mining industry is expected to expand over the next decade to a large scale integrated industry including

- rutile production;
- zircon production and possible further processing; and
- ilmenite upgrading to either or both of synthetic rutile and titanium slag.

R.Z. Mines (Newcastle) Pty Ltd and Strategic Minerals Corporation N.L. are completing a full feasibility study of the mining, mineral separation and further processing of mineral sands deposits in the Byfield area north of Yeppoon. This operation would produce 600 000 tonnes per annum of ilmenite, which would be upgraded by smelting to titanium slag or via the sulphate route to synthetic rutile, within the next five years.

Mineral Deposits Ltd has completed a feasibility study of a proposal to mine and process reserves in the Agnes Water region south-east of Gladstone. Forecast annual production rates from this area are 20 000 tonnes rutile, 25 000 tonnes zircon and 150 000 tonnes ilmenite, with commencement possible within two years.

State resources in Central Queensland could be augmented by the exploitation of deposits lying within the Commonwealth acquired land at Shoalwater Bay. Recent proposed changes to Federal legislation may pave the way for possible access to such areas by the mining industry through joint State/Federal co-operation.

OTHER MINERALS. Magnesite. Two large deposits of magnesite have been identified in Central Queensland at Kunwararra (Queensland Metals Corporation N.L./Pancontinental Mining Ltd/Radex Heraklith Gr J.V.) and at Yaamba (Peabody Australia Pty Ltd/Beloba Pty Ltd/Southern Pacific Petroleum N.L./Central Pacific Minerals N.L./Shell Company of the Australia Ltd J.V.).

The Kunawarra deposit (550 M tonnes) is expected to provide feed for a variety of products ranging from sintered to caustic calcined magnesia at production rates of 150 000 tonnes per annum and 25 000 - 80 000 tonnes per annum respectively.

The initial stage of the operation would see calcining by 1990 with possible progression to smelting to magnesium metal in Gladstone by 1992-93.

The Yaamba deposit (460 M tonnes) is expected to be developed in 1991 and the intention is to market 100 000 tonnes per annum of raw magnesite and 40 000 tonnes of calcined and dead burned magnesia per annum.

Both projects would benefit from a ready supply of natural gas for the calcining/burning operations.

Kaolin. Significant Queensland Kaolin deposits are located at Weipa and at Skardon River on Cape York Peninsula.

The Comalco operations at Weipa, which mine deposits underlying the bauxite layer, are planning for continuing and possible expanding resource exploitation to the paper-coating industry at a production level of 500 000 tonnes per annum within 10 years.

The Skardon River deposit, 85 km north of Weipa, is being evaluated by Venture Exploration N.L. Final market strategy and a decision to develop are expected this year - the return per tonne of processed material being very dependent on the whiteness grade available.

Gemstones. The Queensland Government has sought Expressions of Interest in exploration for sapphire and other gemstones in part of Departmental Area 1D in the Clermont Mining District. If this area is released, it is expected that the mining and processing bases for these commodities will be significantly expanded.

Interest has been encouraging, with 31 applications being received by the Department of Mines.

Expansion of the processing base will be dependent on the securing of additional resources and overseas markets for Australian cut stones.

Phosphate. Queensland Phosphate Limited is currently finalising evaluation of a project to pipe 590 000 tonnes per annum sulphuric acid from Mt Isa to their mining leases at Phosphate Hill where it is proposed to mine and treat 1.2 M tonnes per annum of phosphate rock, producing 215 000 tonnes per annum of high analysis phosphate fertilisers and 167 000 tonnes per annum phosphoric acid to produce 213 000 tonnes per annum of ammonium phosphates.

Factors affecting a decision to proceed include those involving cost structure, such as removal of the fertiliser bounty, low cost fuel and competitive freight rates.

Tin. The collapse of the international tin market in 1985 has resulted in the closure, scaling down and rationalisation of many sections of the tin industry in Queensland, with production in 1987/88 of 330 tonnes of contained tin. Pending a significant lift in tin prices, further decline in production can be expected this year.

However, the North Broken Hill Ltd/Shell Company of Australia Ltd J.V. at Collingwood, south of Cairns, may have a feasible proposal in the next few years to mine and treat cassiterite ore and produce 7 500 tonnes of tin concentrate over six to seven years.

Silica Sand. Production of Silica Sand in 1987/88 was 1.30 M tonnes. Following the unjustified intervention by the Federal Government, the proposal to mine and export high quality Silica Sand at Margaret Bay has been withdrawn by the proponents.

The expanded operations at Cape Flattery (1.4 M tonnes per annum by 1994), together with possible expansion of ACI's North Stradbroke Island activities remain as Queensland's only significant silica sand projects unless a more rational and balanced attitude on conservation issues can be engendered in Canberra.

Building Stone

In Queensland, renewed interest in the use of natural stone - granite, marble, sandstone, and slate as building material has resulted in increased exploration to identify stone resources, the reopening of several historic sources, the upgrading of existing processing facilities, and proposals from a number of companies to establish new quarries and processing facilities in eastern Queensland by the mid 1990's.

The major Sandstone sources, located between Helidon and Toowoomba and at Stanwell via Rockhampton, have been quarried for building purposes for over 100 years. The sandstone is used for external and internal cladding, landscaping purposes and more recently for tiles (some reportedly for export). Production during 1987/88 was 2 129 tonnes.

Marble is mined only in the Chillagoe district in North Queensland, but small deposits are also known in the Gladstone hinterland and Warwick-Stanthorpe districts suitable for production of chip. Chillagoe marble is exported in block form and several companies are currently undertaking feasibility studies into quarrying and processing of marble blocks for slab and tile manufacture. Production during 1987/88 was 12 280 tonnes.

Granite is quarried in small quantities at Gracemere near Rockhampton, Charters Towers and Mount Isa. The Australian demand for granite products has grown to over 400 $000m^2$ per year, with domestic supply meeting less than 50 percent of this demand. Potential export markets to Taiwan, Japan, U.S.A. and Italy also exist for granite blocks and possibly tiles, slabs and billets. As a result, several companies are investigating granite resources throughout the State; feasibility studies are nearly completed for a multi-million dollar tile processing facility in southeast Queensland.

New South Wales minerals: towards the early nineties?

F W Cook

New South Wales Department of Minerals and Energy

Any comment on the New South Wales minerals industry outlook for the first part of the next decade necessarily derives from the industry's present state. The reality is that a sound multifaceted basis for expansion exists and optimism is felt particularly for the future of the gold and coal sectors.

The following current status report, therefore, will set the scene for later discussion on the geoscientific, commercial, economic and marketing issues likely to impact on the New South Wales industry in the next three years, and will also supply the framework for some meaningful projections.

STATUS REPORT

Mineral exploration

Private sector exploration expenditure in New South Wales for f1987/88 (Table 1) showed a 36% increase over the f1986/87 level, arresting the protracted decline noted in annual private expenditure totals over the period from f1981/82. Of the commodity categories, **GOLD**, which grew by over 76%, was the prime performer and the indications are that **BASE METALS** exploration is recovering. **COAL** exploration spending declined by around 10% in 1987/88 due mainly to the impacts of general market decline and the emphasis by the existing mines on consolidation.

Statistical dissections of New South Wales exploration expenditure are also available for geographic spread and technical activity over the past three years. The trends evident in these statistics are not surprising with the Lachlan region recording the bulk of the increase in exploration expenditure during f1987/88 with much of that being on gold (Figure 1). New England also showed improvement, but to a lesser extent. Of the technical activities, geology, geochemistry, drilling and engineering studies recorded major increases with, surprisingly, spending on geophysics remaining static.

Mineral production

Production value of minerals from New South Wales over the last 3 years in current terms is shown in Table 2.
The outstanding performers in f1987/88 were **GOLD** (up 300% on the 1986/87 value) and **GEMSTONES** (up 88%). The performance of these minerals, logically, is linked to prevailing strong commodity prices and resultant induced output expansion. **BASE METALS** (up 35%) and **HEAVY MINERAL SANDS** (up 23%) also showed pleasing increases in production value for the same reasons. **SILVER** concentrates value peaked in f1986/87 due mainly to (the near depleted) supergene ore output from the Elura mine.

TABLE 1. NEW SOUTH WALES MINERAL EXPLORATION PRIVATE EXPENDITURE $ million

	f1985/86 actual	f1986/87 actual	f1987/88 actual	f1988/89 f1989/90 qualitative forecast
TYPE OF MINERAL				
Copper, Lead, Zinc, Silver	17.05	12.56	13.70	increase
Gold	17.52	18.14	32.03	increase
Mineral Sands	1.48	1.40	1.53	major increase
Tin, Tungsten	2.10	0.09	0.00	nil
Other Metallics	0.50	1.59	2.60	static
Coal	11.83	11.09	9.93	static
Construction Materials	0.08	0.54	np	increase
Diamonds	0.63	0.76	np	decline
Other Non-metallics	0.69	1.38	3.87	major increase
TOTAL	51.79	47.59	64.48	increase
GEOGRAPHIC REGION				
New England	4.95	5.40	8.28	major increase
Lachlan	22.07	21.28	34.40	major increase
Western-Broken Hill	10.86	6.71	8.49	minor increase
Sydney/Gunnedah/Bowen Basin	12.28	11.83	11.09	minor decline
Other (inc GAB,CMB,MurrayB)	1.63	2.36	2.20	minor increase
TOTAL	51.79	47.59	64.48	increase
TECHNICAL ACTIVITY				
Geology	11.14	8.25	14.76	
Geophysics	2.41	3.92	3.59	
Geochemistry	3.07	3.35	5.57	
Drilling	14.26	12.75	16.77	
Other (inc engineering sts)	8.92	5.74	9.88	
Overheads	11.99	13.58	13.90	
TOTAL	51.79	47.59	64.48	increase

TABLE 2. NEW SOUTH WALES VALUE OF MINERAL PRODUCTION $ million P = Preliminary

	f1985/86 actual	f1986/87 actual	f1987/88 actual	f1988/89 f1989/90 qualitative forecast
MINERAL GROUP				
Coal	2299.00	2612.00	2000.00 P	increase
Base Metals Concentrates	311.66	335.00	453.70 P	major increase
Heavy Mineral Sands	29.80	42.60	52.20 P	major increase
Silver Concentrates	0.20	28.30	22.80 P	minor decline
Gold Concentrates	7.17	30.80	92.70 P	major increase
Construction Materials	316.23	304.80	328.70 P	increase
Opals and Sapphires	19.21	29.80	55.90 P	major increase
Limestone	18.80	20.30	21.10	static
Clays	16.30	19.80	20.60 P	static
Other Minerals	11.75	13.60	15.50 P	minor increase
TOTAL VALUE OF PRODUCTION	3030.12	3437.00	3063.20 P	increase

TABLE 3. NEW SOUTH WALES MINERAL ROYALTIES $ million

	f1985/86	f1986/87	f1987/88
MINERAL GROUP *			
Coal	115.90	132.64	95.80
Base Metals	0.80	0.48	3.10
Heavy Mineral Sands	0.81	1.16	1.73
Gold, Silver	0.05	0.13	0.78
Opals, Sapphires	0.15	0.17	0.20
Limestone	0.45	0.46	0.65
Clays	0.14	0.10	0.13
Other Minerals	0.16	0.14	0.12
TOTAL ROYALTY	118.46	135.28	102.51

* Construction materials royalties are levied by the Department of Lands

The aggregate **COAL** production level fell during f1987/88 to 63.9 million tonnes of saleable coal (down 13% from the previous year) with a preliminary valuation of around $2 billion (down 23%). The fall in output was due to mine closures and industrial disruptions. However, coal export levels were generally maintained by running down stocks. The output tonneage has imcreased 7% in the first half of f1988/89 relative to the same period in f1987/88, and, combined with the impact of price increases, the production value too is recovering.

Currently, the only **PETROLEUM** production from New South Wales sedimentary basins is associated with coal mining in the Southern Coalfields. **METHANE** is drained from the coal measures in two mines (Westcliff and Appin) to fuel gas turbine electricity generators.

Royalty revenue
Royalty collected in f1987/88 ($102.5 million) showed a decline of 24% over the preceding year, mostly reflecting the 20% royalty concession to the major contributor, the coal industry (Table 3).

OPERATIONAL OUTLOOK - THE MEDIUM TERM

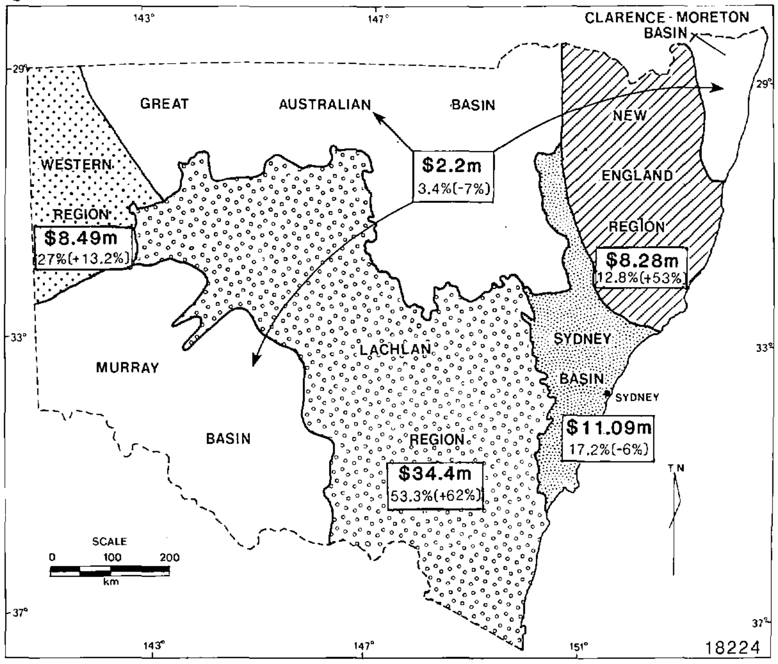
Discussion here will centre on the mineral developments which will have major impact on the performance of the New South Wales minerals industry in the medium term.

The high growth rate in recent years, albeit from a low base, in New South Wales **GOLD** production, has continued throughout c1988 (preliminary estimates place output at around 5,700 kg). Existing producers are operating at, or above, design capacity and four significant new mines have commenced production in the last twelve months. For the record, one mine (Cowarra Creek) suspended production late in 1988 pending further exploration results and the very efficient New Occidental tailings re-treatment project at Cobar headed by Ranger Resources will cease production in March, 1989, upon exhaustion of its ore reserves.

The details of the four new gold producers are recorded below. Refer to Figure 2 for locations. Drake (Mt Carrington Mines Ltd) poured its first gold in July, 1988, and is now producing near its designed rate of 420 kg (13,900 oz) pa. Mineral Hill (Triako Resources Ltd/Cyprus Mines Corp) poured its first gold in November, 1988. The mine is now commissioned and is producing gold at a rate of 780 kg (25,000 oz) pa, as well as 1600 tonnes pa by-product copper.

London-Victoria (BHP Gold Mines Ltd) commenced production in December, 1988, and is building-up its production towards design capacity of 300,000 tpa to deliver 780 kg (25,000 oz) pa of gold.

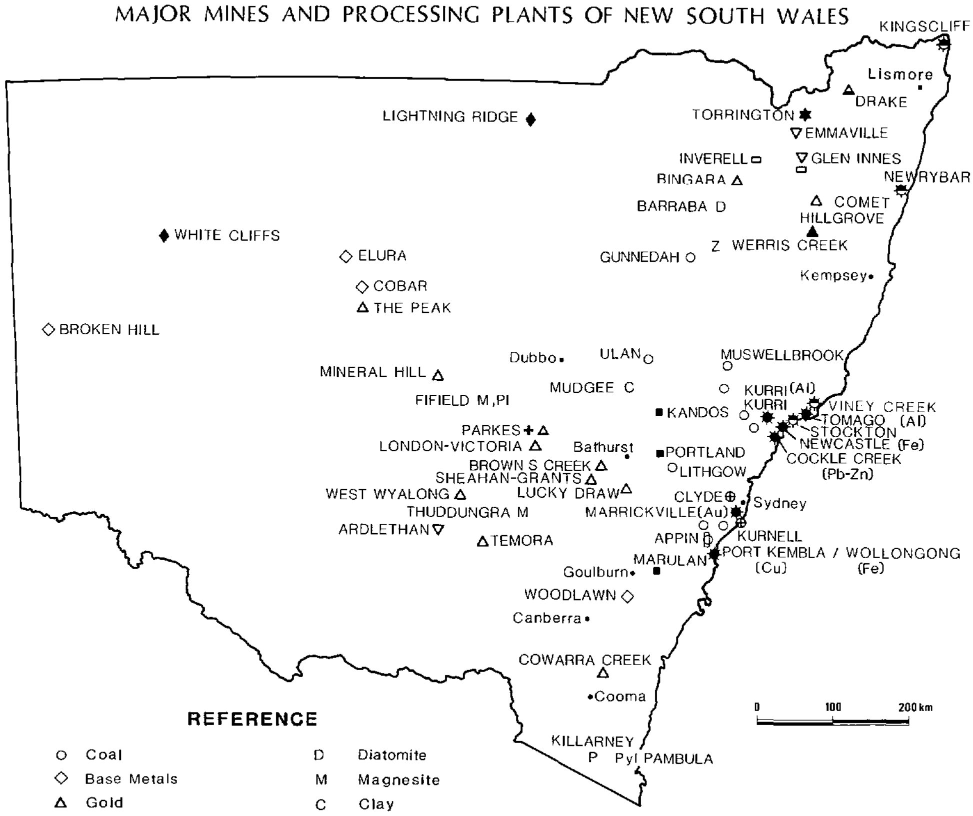
Figure 1: PRIVATE N.S.W. EXPLORATION EXPENDITURE BY REGION 1987/88



Private expenditure by region, with %age of state total and trend (±) relative to 1986/87 regional expenditure

FIGURE 2: MAJOR MINERAL RESOURCES

MAJOR MINES AND PROCESSING PLANTS OF NEW SOUTH WALES



REFERENCE

O	Coal	D	Diatomite
◇	Base Metals	M	Magnesite
△	Gold	C	Clay
▲	Gold-Antimony	Pyl	Pyrophyllite
✲	Mineral Sands	P	Peat
▽	Tin	✱	Topaz
▲	Gold-Silver	+	Copper Prospect
♦	Opal	✸	Smelter (Al,Cu, or Pb-Zn or Au)
▭	Sapphire		Steelworks (Fe)
■	Limestone	⊕	Oil Refinery
Pl	Platinum	▯	Methane Drainage
Z	Zeolite	•	City

Note. Numerous construction materials quarries around Sydney are not plotted.

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Lucky Draw mine (Renison Goldfields Cons. Ltd), near Oberon, produced its first gold in January, 1989. This deposit was a virgin discovery in 1985 following creative airborne geophysics interpretation combined with regional rock-chip sampling. At capacity, the mine will treat 500,000 tpa for an annual gold yield of around 680 kg (22,000 oz).

The Comet mine near Armidale of Mt Gipps Ltd is expected to be producing gold in late 1989 at a rate of 510 kg (16,400 oz) pa and a number of smaller gold operations could commence production in about a year including Alpine and Mayday (Epoch Mines N.L.) in the Cobar region, Golden Rise (Neilsen) and Caloola (Ajax Joinery Pty Ltd/Goldrim Mining (Aust.) Ltd in the Bathurst area, and Calarie (BHP Gold Mines Ltd) at Forbes.

One of the success stories of the New South Wales mining industry in 1988 is the Woodlawn **BASE METALS** mine now operated by Denehurst Ltd. Under Denehurst's tight management and inventory control and with staff numbers at 40% of former levels, this mine is operating profitably, treating 505,000 tpa of underground sulphide ore. The process has been simplified and control is stricter, resulting in improved recovery and reduced costs. Research into tailings re-treatment and the technology of direct metal production are on-going and the company anticipates expanding production from these sources in the medium term. The Elura mine (North Broken Hill Peko Ltd) near Cobar is also investigating metallurgical and mine expansion options to improve efficiency, productivity, output and ultimately, profitability. Benefits should accrue in the medium term.

In the **HEAVY MINERAL SANDS** sector the three major producers have continued to operate at full capacity during the last year. All have active exploration programmes and some plans to pursue incremental expansion exist, particularly at the Currumbin Minerals Ltd mine at Kingscliff. A potential new producer (Australmin Holdings Ltd) has advanced plans to recommission a separation plant at Woodburn to treat the Newrybar orebody.

An exciting new development in the **INDUSTRIAL MINERALS** sector is the **ZEOLITE** production by the Mt Gipps Ltd/J. M. Stephens Pty Ltd joint venture at Werris Creek. This resource was identified through a research programme conducted by the Geological Survey of NSW. Zeolites are complex aluminosilicate minerals widespread in acid to intermediate pyroclastics and have properties useful in agricultural and industrial applications.

Other Industrial Minerals which have shown tangible production expansion during the year are **DIMENSION STONE**, **DIATOMITE** and **CLAYS**. However, **LIMESTONE** output tonneage has declined.

Boom conditions are being experienced in the **GEMSTONES** sector with **OPAL** and **SAPPHIRE** exploration and production activities thriving. Some significant changes incorporating sophistication throughout an integrated exploration, production, processing and marketing stream are expected in the next few years in this sector.

Calendar year 1988 has been a watershed year for the New South Wales **COAL** industry and the mine-closure scenario of recent years is now exhibiting signs of a substantial turn-around. No further closures have been effected since June 1988 and the Avon mine (Avon Colliery Pty Ltd) has been re-opened. The Vickery mine (Kembla Coal and Coke Pty Ltd) has now been issued a lease and small scale mining is continuing. Across the state, 71 mines are currently operating.

On the industrial relations front, considerable progress has been achieved in negotiations between coal companies and the unions to reach agreements governing working conditions. Around 60% of New South Wales mines have achieved agreement on restructuring. Important productivity gains are now being experienced as a result of the restructuring of working practices.

TECHNICAL DEVELOPMENTS AND PROJECT EXPANSIONS - THE LONGER TERM

Of prime significance, particularly in the longer term into the 1990's, are the following major projects.

The Peak **GOLD** project (CRA Ltd), located 9 km south of Cobar could be producing gold by early 1992 at a rate of around 2900 kg (90,000 oz) pa. Most of the gold, silver and subordinate base metals mineralization is located between 420m and 580m below surface in five lenses on or adjacent to the faulted contact between the Chesney Formation and the Great Cobar Slate, both of Devonian age. The metallurgy of the indicated resource (4 mt at 6.8 g/t Au) is simple and exploration at present is being directed at completion of a 510m exploration shaft of production dimensions.

Any go-ahead decision by North Broken Hill Peko Ltd on the Parkes **GOLD/COPPER** project will deliver a significant gold output in the early years of mining of greater than 1550 kg (50,000 oz) pa and, at a later stage, copper production which may be of strategic importance as a feedstock to the ER&S Company Port Kembla copper smelter, now being rebuilt.

Exploration on a number of smaller gold projects is showing pleasing progress. These include Brackins Spur near Armidale (Mt Gipps Ltd), Glendale (Climax Mining Ltd) near its (with Cyprus and Arimco) Sheahan-Grants mine, Forest Reefs as a possible satellite development for Browns Creek (BHP Gold Mines Ltd), Bumbaldry (Lachlan Resources N.L./Cluff Resources Pacific Ltd), Adelong (Pan Australian Mining Ltd/ MIM) and New

Cobar (CRA Ltd). Further down the track, some interesting results are also expected from gold exploration programmes being carried out by leading explorers in the Parkes region.

Although no mine developments are imminent, the Fifield **PLATINUM** province explorers are committing major expenditure on longer term strategic exploration. The programmes include sophisticated geophysical studies in conjunction with the Geological Survey of New South Wales. The Survey has been closely involved in processing and modelling the gravity and magnetics data available over the Alaskan-type intrusives identified near Fifield.

Exploration for **HEAVY MINERAL SANDS** is now being directed at three quite different targets in New South Wales; the traditional present day dune systems, the inland Tertiary deposits in the Murray Basin and the near-offshore continental shelf placer deposits. It is expected that reserves, amenable to mining in the environmentally sensitive coastal regions, will be identified soon as a result of the present concentration of exploration activity. The longer-term inland and off-shore targets will require the perfection of exploration, mining and (accepting Victoria's WIM 150 project as analogous) metallurgical techniques, before discovery and commercial production of any resources could be contemplated.

A renewed enthusiasm for **COAL** industry development is emerging in New South Wales with a number of mining projects being canvassed for development as demand becomes available. Marketing and development studies are being resumed and leasing approvals for several projects are advanced.

The most promising projects, all in the Hunter Valley, can be ranked into two groups with Group A projects ranking closer to development at this stage.

Group A; Bulga (Elders Resources), Hunter Valley No 2, (Coal and Allied Ltd), Camberwell (Toyota/Southland Mining), United (Agip/Exxon/ Miners Federation) and Mt Arthur South (Elcom/Ampol/Picon).
Group B; Dartbrook (Shell/others), Glendell (RGC/Dalgety) and Mitchells Flat (Pacific Copper Ltd).

The improved industry outlook is supported by the equipment and infrastructure investments already in place to service any expanded production. Investment in longwall mining equipment has placed the surviving underground mines in more competitive positions. Coal transportation and ship-loading facilities in the Hunter Valley currently have surplus capacity which can quickly absorb export expansion when it materialises. Sophisticated computer co-ordination of mining, rail transportation, coal-loader and shipping movements into the Port of Newcastle has enabled a great variety of brands of coal to be delivered to the port stockpiles for blending, if required, and then for export according to customer specifications.

On the international coal market scene, some important developments in competitor strategies, involving Canada and the USA in particular, are being critically monitored. On the other hand, the Chinese export strategy appears to have fallen behind target and Poland has reduced exports. It is believed that export markets for New South Wales producers may develop in traditional European producing countries such as West Germany and the United Kingdom.

Studies are underway in the Southern Coalfields to test the feasibility of methane production in several other coal mines. In addition, conventional exploration of the Sydney/Gunnedah/Bowen Basins by several companies is addressing the longer term possibility of methane drainage from unmined or unmineable coal measures using vertical wells and hydrofraccing techniques.

COMMERCIAL DEVELOPMENTS OF MAJOR IMPACT

The merger of Peko-Wallsend Ltd and North Broken Hill Holdings Ltd to form North Broken Hill Peko Ltd (North) was finalised in early 1988. Subsequently, North has proposed transfer of ownership of coal and other assets to Elders Resources NZFP Ltd as consideration for cancellation of Elders shares in North. The impact of these complex corporate rationalisation activities is still unclear.

The combining of the **ZINC** and **LEAD** interests of North Broken Hill Peko Ltd and CRA Ltd to form the assets of the new (soon to be listed) public company Pasminco Ltd is expected to provide considerable benefits to the New South Wales lead and zinc mining and smelting sectors. Apart from strengthening the positions of the Pasminco products on world markets, benefits will be felt through efficiency of exploitation of the Broken Hill base metals resources. Increased productivity and possibly longer mine life are likely to come from mining of lower grade and more inaccessible ores, improvement of pillar extraction and the blending of management style and technical expertise at the mines. Economies should flow to Pasminco's smelters and refineries, particularly the Cockle Creek facility near Newcastle, through precision in feedstock sourcing.

Rationalisation of the ownership of mines and projects in the New South Wales **COAL** industry by substantial Australian companies and Japanese interests is likely to give greater stability to the industry and help create opportunities for the benefits of economies of scale to be attained.

Elders has acquired the Saxonvale mine, the adjacent Bulga project and has an option to take up a 19.9% interest in Oakbridge Ltd in a substantial diversification into coal. Bond Corporation Holdings Ltd has bought The BHP Co Ltd's Macquarie Collieries to strengthen its Hunter Valley coal exposure.

The Shell Company of Australia Ltd now owns majority equity in the Drayton mine and The Exxon Corporation has total ownership of the Lemington mine as well as major interests in the Ulan mine and the United project. Idemitsu Kosan Company Ltd has purchased Muswellbrook Resources Ltd which owns the Muswellbrook mine and adjacent authorisations.

Base-metal miner Denehurst Ltd has acquired the Metropolitan colliery in the Southern Coalfields in a significant diversification of its business interests.

ECONOMIC POLICY AND MARKETING INFLUENCES

The New South Wales Government's royalty concessions to the coal industry continue to play a significant role, along with the industry's own restructuring moves, in pursuing the objective of placing the industry on a profitable footing.

In the New South Wales Minerals Processing Development Strategy, there is recognition that there must be a re-assessment of Australia's traditional role as a major supplier of ores, concentrates and semi-processed mineral products to overseas processing plants. The Strategy has been structured to promote downstream processing in the state and a strong policy commitment by the Government is in place to help processors gain long term market growth.

Apart from the long-standing processing activities of steelmaking, base metals and aluminium smelting and petroleum refining, several initiatives are undergoing investigation or development in NSW including manganese processing (BHP), silicon metal production feasibility based on a quartz gravel resource at Cowra (Pancontinental Mining Ltd), fused silica, gold refining, titanium metal production, ceramic-grade alumina powders production and industrial minerals upgrading.

Through the administration of opal and sapphire exploration and mining tenure, the state is now placing more emphasis on company commitment to domestic processing and marketing of gems. As a result there has been significant new involvement by mineral exploration companies in long term sophisticated exploration of the state's gem fields. It is noted also that the traditional producers are now adopting more transparent marketing strategies.

Strong demand for Dimension Stone by the building industry has triggered a vigorous resource assessment programme by the Geological Survey of NSW of high-quality materials in the state. It is hoped that a major degree of substitution of foreign sourced materials will result.

The discouraging petroleum exploration and production (except for methane drainage) outlook for New South Wales continues to be governed by international market forces, rather than any negative assessment of the prospectivity of the state's basins. Similarly, any resumption of NSW tin production will depend on depletion of the International Tin Council's stocks.

A most profound impact in the medium term relating to economic policy will emanate from the Commonwealth Government's decision to tax gold mining income from 1992. Some incentive now falls on current and prospective producers to pursue distorted development plans which could compromise optimum resource extraction, in order to maximize gold output prior to the tax introduction date.

CONCLUSIONS

The technical outlook for the New South Wales minerals industry continues to be outstanding, with increased exploration spending and output value levels forecast. Advanced thinking is likely to deliver a steady stream of new mining projects in both traditional and previously unrepresented commodities (for example, zeolites and platinum).

From the economic and commercial viewpoints the impacts of global market forces are being met by the participants in the New South Wales arena and the New South Wales Government as challenges to be answered by sensitive combination of expertise and policy to ensure continued reliable supply of the quality products to the users.

The merger at an almost unprecedented level to provide international marketing strength in the zinc and lead sectors is not seen as solely defensive but as being a credible move by Pasminco Ltd's sponsors to capture increased market share. Synergies will also allow New South Wales to benefit from enhanced zinc and lead resource extraction.

Rationalisation in the coal industry is a logical outcome after the rigours of the international market over the last six years. Productivity improvement, supply reliability and customer satisfaction through the provision of precise brand specification by blending, are impressive achievements likely to flow from the recent restructuring in the New South Wales coal sector.

It is concluded too, that the pursuit of the benefits of further processing of the nation's and the state's mineral output through technical developments, must be accompanied by vigorous international marketing initiatives to secure markets for the processed products in competition with existing overseas suppliers who will be most unlikely to relinquish unwillingly their market share. Present and future minerals processing plants established in New South Wales should seek also to import feedstocks from the Pacific Basin and elsewhere to help attain economies of scale.

Victorian mineral developments in progress and prospect

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Introduction

Victoria was the major gold producer in the world in the 1850's and 1860's. The prosperity which was created by mining gave rise to the roads, railways, museums, libraries and the spectacular nineteenth century and Federation architecture of Victoria, as well as contributing to the general prosperity of the State and country. The towns founded on gold mining are now among the State's major regional economic centres and best tourist attractions.

Victoria's mineral wealth has also constituted an important aspect in the development of Australia. In addition to gold, Australia's biggest petroleum fields were discovered in the Gippsland Basin offshore from Victoria in the 1960's. Together, these two events have made a significant contribution to the Australian nation, without which the Australian economy and present day society would undoubtedly be different.

Victoria also has extensive resources of brown coal, a large oil and gas industry and important quarrying activities supplying the construction industry.

Figure 1 shows the value of Victorian gold mining and quarrying industry production from 1982 to 1988.

Despite Victoria's comparative advantages in terms of endowment of natural resources and availability of infrastructure, exploration and mining development has lagged compared to elsewhere in Australia.

Industry perceptions

The mining industry in Victoria sees several barriers to the development of the industry. These include:

- the time consuming mechanism of obtaining approvals for the exploration, development and mining stages adds considerably to the risk, cost and uncertainty of establishing a mining operation. The time required to negotiate Victoria's complex and lengthy approval procedures seems unfortunately to be longer than in other States. These costs and delays are borne by the industry prior to commencement of development and in many cases occur several years prior to commencement of operations

- Victoria is relatively closely settled with many mineral deposits and prospective areas being located near population centres. Close settlement makes access to land more difficult, gives rise to community concerns and can create added challenges in managing an exploration program, development project or mine. Close settlement can have advantages for mining companies with lower infrastructure costs and a ready pool of local skilled labour

VALUE OF VICTORIAN GOLD MINING AND EXTRACTIVE INDUSTRY PRODUCTION 1982-88

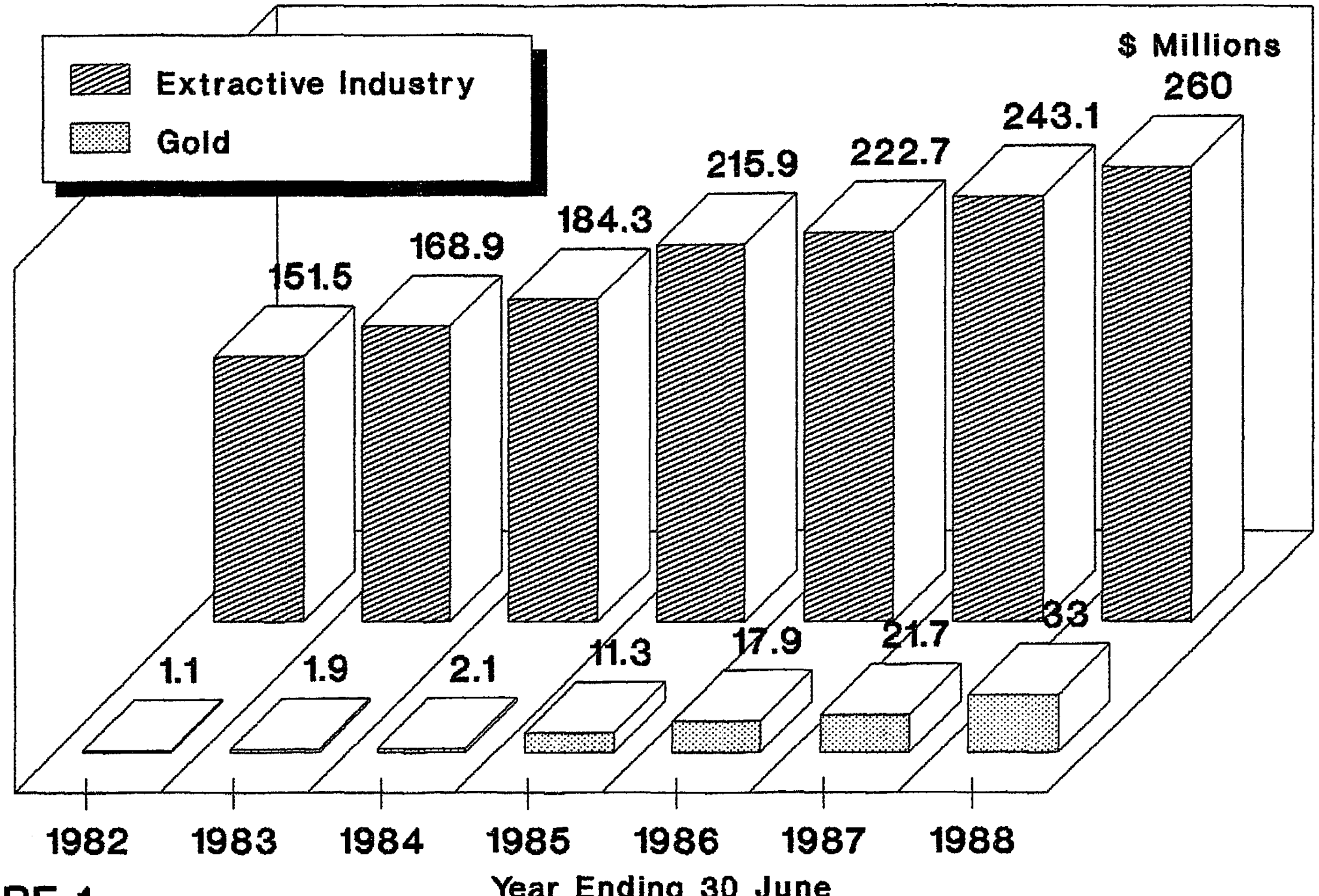


FIGURE 1

1988 production is estimated

- the increasing environmental management controls and restrictions on mineral exploration, development projects and mining operations

Government recognition

The Victorian Government is committed to the goal of creating a strong economy and an equitable society with a better quality of life for all Victorians. The Government's Economic Strategy, Social Justice Strategy and Conservation Strategy are designed to lead Victoria into the 1990's by providing a clear direction and identifying the steps which must be taken to ensure a better future. Mining is an industry which directly affects all three of these strategies. Mining has the potential to contribute considerably to the Victorian economy and to develop a new prosperity in regional Victoria. DITR is committed to the responsible development of the State's mineral resources in the interests of the people of Victoria.

The Department understands the concerns of the mining industry and broader community, and has initiated several changes which are designed to assist growth of the Victorian Mining Industry through an improved operating climate and internal efficiencies.

These initiatives include:

- review of the Mines Act
- review of the Extractive Industries Act and Regulations
- establishment of an Environmental Unit
- appointment of more mining inspectors and a review of the Mining Inspectorate
- computerization of the geological records system (GEDIS)
- major project facilitation
- a review of the need for economic skills within the Minerals Group
- review of the role, capabilities and skills required of the Geological Survey

Review of the Mines Act

In recent times, both the mining industry and the community have sought changes to the Mines Act 1958 to provide for the requirements of an expanding mining industry in a contemporary society concerned with social and environmental issues.

The provision of an effective administrative framework consistent with the responsible development of Victoria's mineral resources is essential for the realisation of the State's mineral potential. This requires a clear, logical and consistent overall framework of law and regulation.

In mid 1987, the Minister for Industry, Technology and Resources announced that a comprehensive review of the Mines Act would be undertaken. During February 1988, the Minister announced that a Ministerial Working Group comprising representatives from the Departments of Industry, Technology and Resources, and Conservation, Forests and Lands, and the Ministry for Planning and Environment, with Mr Michael Arnold as chairman, would oversee the review. Project milestones achieved include:

- February 1988 release of an Issues Paper - "Review of the Mines Act 1958, Issues for Public Consultation"

- 280 written submissions were received by the 30 June 1988 deadline for comments on the issues paper

- December 1988 release of an Options Paper - "Review of the Mines Act 1958 - Options for Change". The closing date for submissions is 31 March 1989

It is intended to have the legislation ready for the Spring Session 1989.

Review of the Extractive Industries Act and Regulations

The current regulations that control the operation of hard rock quarries, and sand, clay and gravel pits, are recognised as being highly prescriptive and lacking in appropriate discretionary powers for inspectors to give direction on specific aspects of quarrying practice.

It is intended that the Act be amended to provide for discretionary powers. The regulations will be changed to align with more practical means of control. In essence, codes of practice with respect to various technical aspects of quarrying practice will be developed (eg use of explosives, use of electricity) in consultation with industry. Such codes will essentially contain the equivalent technical provisions of the present regulations. Concurrently, a less voluminous set of regulations will be developed which will address non technical issues such as application requirements, and duties and responsibilities of employees and managers.

It is further proposed that an Extractive Industries Board be constituted that will consist of both permanent term appointments and specialist temporary members where appropriate. The Board's constitution will be flexible enough that the current functions of the former Quarry Manager's Board and Extractive Industries Advisory Committee can be continued along with other functions involving advice to the Minister on relevant extractive industry matters.

The proposed amendments will assist in developing more responsible self regulation within the industry and provide for a higher profile for the industry whereby industry matters can be more responsibly and successfully addressed.

The Interdepartmental Committee having the task of preparing an Extractive Industries Strategy Plan for the greater Melbourne area is expected to complete its Final Report during early 1989.

Establishment of an Environmental Unit

The Mines Act whilst maintaining the ultimate power of determination with respect to mining tenements also devolves some measure of decision making to other legislation. This has resulted in an unwieldy process for handling decisions on tenement applications where environmental and conservation matters need to be considered. In the past, poor performance with respect to management of environmental matters on the part of some in the mining industry has not helped this position. The Minerals Group therefore needs to develop a higher level of environmental expertise specific to the mining industry and its performance. Such an approach is essential for the compatible pursuit of the Government's Economic, Social Justice and Conservation Strategies.

The Environmental Unit will provide the necessary expertise and service required. The Unit will consist of six persons with the full range of the mining orientated multi-disciplinary skills required. The Unit will co-ordinate and liaise with the current Inspectorate, the industry, other Government Departments, planning authorities at all levels, and interest groups.

Review of the Mines Inspectorate

It is planned that more mining inspectors be appointed. A review of the mining inspectorate is currently being undertaken to rationalise its operation to ensure that the Unit can meet the increased requirements that will be imposed upon it by the changing demands of an expanding minerals sector.

The review will be directed at such matters as the scheduling of inspectors, the method of inspection and the development of technical and interpersonal skills so as to liaise more effectively with all interested parties. While the occupational health and safety function is the principal role of the inspectorate, the regional location of the inspectorate often ensures that the Mines Inspector provides the initial DITR focus on many issues. The interface with the new Environmental Unit will be carefully examined so that effective liaison will be achieved.

An essential thrust of the inspectorate role in the future will be:

- Proactive - establishment of inspectorial techniques to attend to potential trouble spots before they arise
- Reactive - establishment of more effective inspectorial scheduling to eliminate current problems

"GEDIS" computer system

During September 1988, the Mnister for Industry, Technology and Resources announced the allocation of $1 million for the first stage of a computer-based mining information system. This system is known as "GEDIS" - Geological, Exploration and Development Information System.

When operational during early 1990, Stage 1 of GEDIS will provide a more effective mining titles management system with integrated tenement and a land-use computer aided mapping capability. Stage 1 will also provide menus and indexes of data sources for BOREDATA, MINEDATA, extractive industry materials, geological mapping and geophysical information. Current project status is that an evaluation of tenders is being completed. Four suppliers tendered for the provision of hardware and software as a suitable development "platform".

Study of the economic potential of the mining industry

The thrust of the Government's economic strategy is towards the responsible promotion of growth, investment and the creation of wealth and jobs. The Mining Industry has not grown to the extent considered possible and as part of economic strategy initiatives various specific measures were proposed to encourage growth. Beforehand, it was felt desirable to try and find out whether growth in the mining industry in the State was likely to occur given that the commercial and legislative climate was favourable. To this end Professor Brian Mackenzie, a well known Canadian mining academic from Queens University, Ontario, who also has had experience in Australia, was asked to undertake a broad economic study of the mineral development potential of the State of Victoria. In order to do this, Professor Mackenzie compared the Appalachian region of Canada with Victoria, which are geologically similar. He then proceeded to examine the most promising possible Victorian mineral developments in the light of the Canadian experience.

While the geological analogy and the application of Canadian methodology he chose could be open to some minor criticism in detail, fundamentally it provides a reliable means of estimating the order of magnitude of the investment that could occur following successful exploration and mining development in Victoria provided that the investment climate was propitious.

Having studied 16 selected current Victorian exploration and mining projects, he found that 12 of these had the economic potential of proceeding to development under existing conditions. On the basis of these 12 developments he calculated that in 1987 Australian dollars there could result in the following (figures rounded):

- $350 million dollars of new investment
- $6100 million dollars of sales revenue
- $3500 million dollars of wages and salaries and other production costs
- $530 million dollars of what he calls economic surplus or new wealth
- 22,000 person years of direct employment

While these figures are encouraging, they do of course contain an element of supposition. However, on the credit side the report does not take adequate account of the 'multiplier factor' associated with job creation and income generation which is strong in the mining industry.

Major project facilitation

The Minerals Group Major Mining Projects Facilitation Unit has responsibility for facilitating development of major mining projects. Projects currently being assisted include:

- Heavy Minerals at Horsham - Wimmera Industrial Minerals Pty Limited
- Base Metals at Benambra - Macquarie Resources Limited
- Gold at Bailieston - Bond Gold Australia Pty Limited

Progress during 1988 and plans for 1989 are discussed under industry developments.

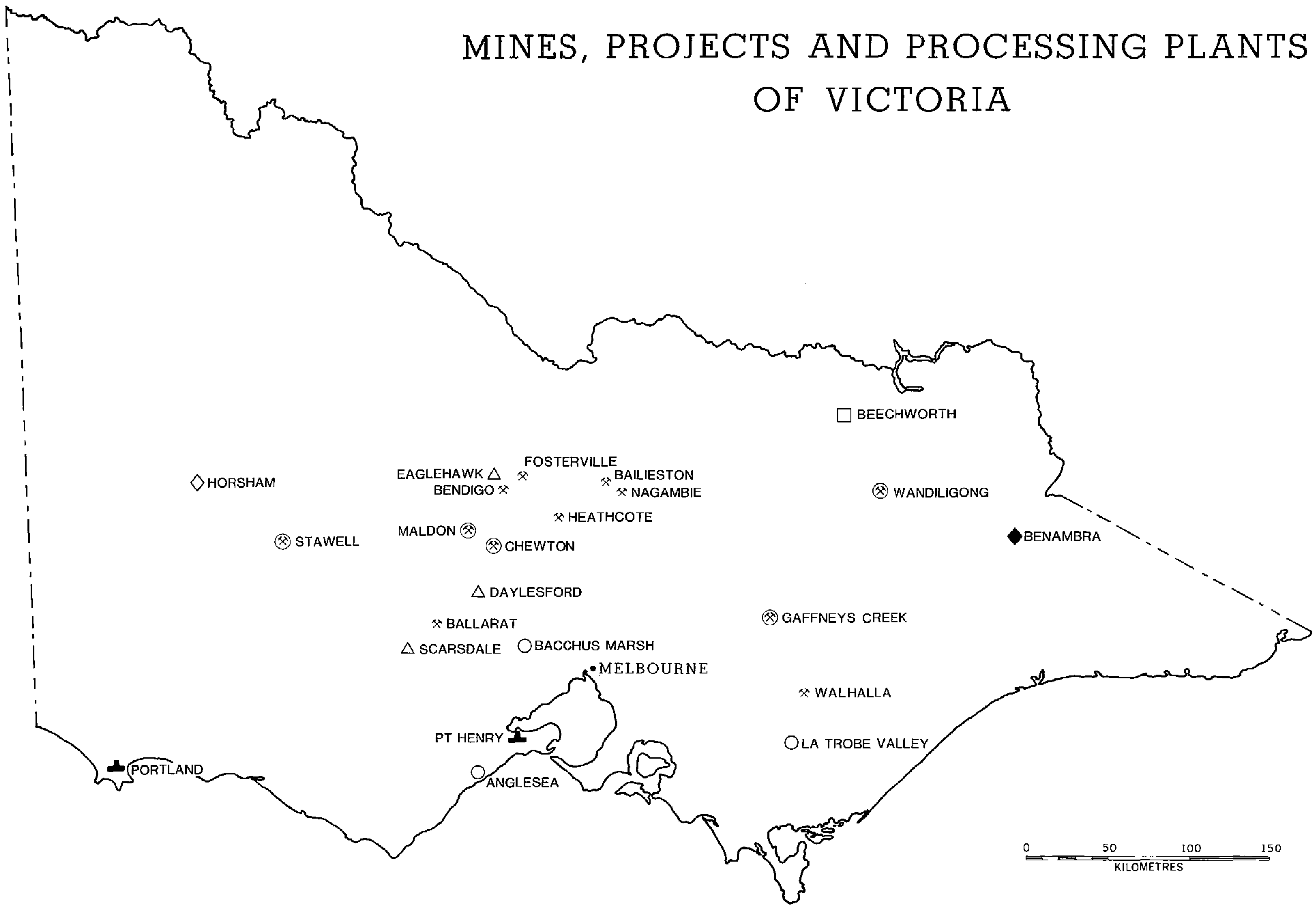
Industry developments

Figure 2 shows the locations of mines, projects and processing plants of Victoria.

Gold producers

Western Mining Corporation - Stawell. This WMC managed joint venture operation of Great Boulder Holdings Limited/Central Norseman Gold Coporation Limited, derived ore from three sources - open cut, underground and from old tailings dumps. Gold production in 1987-88 was 33,134 ounces. Exploration for gold in the Stawell area is ongoing.

MINES, PROJECTS AND PROCESSING PLANTS OF VICTORIA



Copper-Zinc Project	◆	Gold Mine	⊗
Heavy Minerals Project	◇	Gold Tailings Operation	△
Gold Project	⚒	Brown Coal Mine	○
Feldspar Project	□	Aluminium Smelter	┻

FIGURE 2

Triad Minerals NL - Maldon. Open cut mining at Union Hill Maldon and CIP ore treatment at the nearby Porcupine Flat processing plant is now well established. Gold production from plant commissioning until 30 June 1988 was 3,635 ounces. Gold production in the September quarter 1988 was 2920 ounces. The life of the project will be dependent upon successful exploration for external sources of ore within the Maldon Goldfied. This goldfield was Victoria's second largest producing field. Treatment of any external sources of ore is proposed at the Porcupine Flat plant.

Bendigo Gold Limited - Daylesford, Scarsdale, Eaglehawk. This company and its wholly-owned subsidiary, Bendigo Gold Associates Pty Limited operates three CIP plants for the purpose of treating gold mine tailings. A total of approximately 800,000 tonnes of tailings is currently available for treatment at the three sites. Gold production in 1987-88 was 4378 ounces. Further tailings may become available that could prolong the operation beyond the three to four years currently envisaged.

Broken Hill Holdings Limited - Gaffneys Creek. Operations at the A1 Mine have seen a variable production through the gravity separation plant which has a capacity of a 500 tonnes per day. A CIP plant was constructed during 1988. Mill head grade varies substantially with some throughput averaging in excess of 30g/t. Production for 1987-88 was 3432 ounces of gold.

United and Commercial Holdings Limited - Wandiligong. Operations at the Williams United Mine at Wandiligong near Bright produced 1328 ounces of gold in 1987-88. Underground operations have been temporarily suspended.

Newmont Australia Limited - Chewton. The Wattle Gully Gold Mine is currently on a care and maintenance basis. Surface exploration is being undertaken in the Fryerstown area. The mine produced 951 ounces of gold in the year to June 1988 and 1177 ounces in the September quarter 1988.

Advanced projects

Bendigo Gold Limited - Fosterville. Bendigo Gold's mining lease application covers the Fosterville Fault Zone approximately 30 km east of Bendigo. The exhibition period for public comments on the Environment Effects Statement and planning scheme amendment closed on 1 March 1989. The project will involve a series of small open cuts and both conventional CIP and heap leaching treatment methods are envisaged. Planned gold production is 30,000 ounces per annum from 300,000 tonnes of ore grading 2.7 g/t over an anticipated mine life of 5 - 10 years. Scheduled commencement of production is mid 1989.

Perseverance Mining Pty Limited - Nagambie. Exploration in this little known goldfield commenced in April 1985. Ore reserves were delineated during 1987 and Perseverance's Mining Lease was issued in January 1989. Heap leaching technology will be used. Planned gold production is 40,000 ounces per annum from an ore throughput of 1 million tonnes grading 1.2g/t. First gold production is scheduled during May - June 1989. Seven -10 million tonnes grading 1.2 g/t gold have been delineated.

Bendigo Mining NL - Bendigo. An Environment Effects Statement was recently completed by Bendigo Mining for the Deborah Reef Project at Bendigo. The proposed operation involves further development of the Central Deborah Reef by means of a new shaft or decline, underground crushing and grinding, and transportation of a slurry via a pipeline to a treatment site 2.8 km away. The public exhibition period for EES concluded in March 1989. Proposed annual production is 30,000 ounces of gold.

Bond Gold Australia Limited - Bailieston. Bond Gold's project will entail mining of a series of discreet open cuts in the vicinity of the historic mining area of Bailieston. Treatment proposals involve heap leaching possibly utilising a re-usable pad construction and pressure emitter (drip feed) application of solution spray. Approximately 7.5 million tonnes grading of 1-2g/t have been outlined for a project having a mine life of about six years. An EES is to be completed during March.

Gwalia Group/New Holland Mining NL - Heathcote. This joint venture project has delineated approximately 150,000 tonnes of ore at 3.9 g/t gold. An exploratory winze and drive is now being developed at Hirds Prospect to reconcile bulk sampling results with earlier diamond drilling results. It is aniticipated that an underground resource will be defined.

Alluvial gold prospects. Significant alluvial gold resources are known to exist throughout Victoria: in the Ovens Valley - in excess of 250,000 ounces gold has been outlined by BHP and others; Buckland River - in excess of 100,000 ounces of gold delineated by Meekathara Minerals; Ashton Mining has outlined a resource of 600,000 ounces at Landsborough.

Western Mining Corporation - Bendigo Gold Project. Western Mining Corporation's Mining Lease was granted by the Minister for Industry, Technology and Resources in August 1987. The company's Environment Effects Statement was released in December 1987. During 1988 panel hearings into the project were held in May and June, with the Panel Report being completed in July. The Minister for Planning and Environment's assessment of the Panel Report was completed in November 1988. WMC has undertaken underground development work at the Williams United and Carshalton Shafts. The proposed underground development adjacent to the Spring Gully Reservoir was not approved.

Wimmera Industrial Minerals Pty Limited - Horsham Heavy Minerals Project. In December 1985, CRA Exploration Pty Limited and the Victorian Government jointly announced the discovery of "WIM 150", a substantial mineral sand deposit at Drung South, near Horsham. In 1987 a CRA subsidiary company, Wimmera Industrial Minerals Pty Limited was established to develop the 'WIM 150' deposit and to evaluate other discoveries.

On 11 January 1988, CRA Limited announced reserves for the deposit: Proven in situ reserves exceeding one thousand million tonnes at over three per cent heavy minerals have been established in the primary exploration area. The proven reserves are part of a larger resource estimated at 4,900 million tonnes averaging over two per cent heavy minerals.

Reserves of individual contained heavy minerals in the primary exploration area are of the order of:

Rutile and anatase	3 400 000 tonnes
Leucoxene	4 600 000 tonnes
Ilmenite	12 500 000 tonnes
Zircon	5 100 000 tonnes
Monazite	580 000 tonnes
Xenotime	170 000 tonnes

During 1988 pilot plant testing of ore commenced under a Development Lease. Up to 20,000 tonnes of ore will be treated as a preliminary study into mineral recovery through flotation and to test market suitability. In January 1989 an Environment Effects Statement was released for a Demonstration Project. The EES and mining lease application within the Development Lease area will allow for larger scale testing under the Demonstration Project. The purpose of the Demonstration Project is for the mining and treatment of about one million tonnes of ore over two years to:

- establish the suitability and competitive potential of WIM 150 mineral concentrates in world markets
- scale-up and optimise the flotation technology development by the Company for mineral recovery
- obtain further data on WIM 150 geology, hydrogeology, and a range of related issues
- assist in planning for commercial mining operations
- continue studies over a range of environmental issues to enable preparation of an EES to accompany applications for commercial mining
- upgrade certain WIM 150 minerals to enhance market value

The Demonstration Project will also provide a range of data for subsequent use in an EES to cover possible commercial mining.

Macquarie Resources Limited - Benambra Base Metals Project. In December 1987, Macquarie Resources released an Environment Effects Statement for the Benambra Project covering copper-zinc deposits at Wilga and Currawong. Following the granting of project environmental and planning approvals in December 1988, a mining lease covering 4691 ha is expected to be granted during early 1989. Macquarie plans to mine at a maximum rate of 450,000 tpa ore, starting at the Wilga deposit and bringing ore from the Currawong deposit on-stream in project year two. A final feasibility study decision on the project is expected during June 1989. Surface diamond drilling at the Currawong deposit for additional geological and metallurgical information was undertaken earlier this year. Initial geological results were encouraging.

Ballarat Goldfields Limited - Ballarat East Gold Project. Mining Lease 1158 was granted on 5 October 1988 by the Minister for Industry, Technology and Resources to provide for Ballarat Goldfields redevelopment of the Ballarat East Goldfield. The company exhibited an Environment Effects Statement, conducted a public education campaign and participated in a public hearings process which culminated in September 1988 with the Minister for Planning and Environment granting planning and environmental approval for the project. Surface development works commenced in January 1989. A feature of the mine development will be the blind boring of a shaft. A large concrete pad has been poured to support a Zeni shaft boring rig. This rig will bore a 4 metre diameter shaft to about 320 metres depth. Boring and shaft installation works are scheduled for completion during mid 1989. The earliest that the mine could be producing gold is September 1990.

ACI Feldspar - Beechworth. This proposal relates to the production of a high grade feldspar product by open cut mining of granite and subsequent flotation treatment. The product will be used in glass making and will substitute for feldspar currently being imported. Anticipated production will be 20,000 tonnes feldspar from 50,000 tonnes fresh clean granite extracted. Significant quantities of weathered granite will need to be extracted as stripping. This material will be crushed and used for road aggregate if planning approval is gained.

Conclusion

The Department of Industry, Technology and Resources sees 1989 as being a year of great promise for the Victorian Mining and Quarrying Industries. The framework of a new mining law will be prepared and other initiatives implemented to assist the growth of the Victorian mining and quarrying sectors. The challenge for government and the mining industry is to achieve the commissioning of new mines.

Review and outlook for South Australia

R G Nelson

South Australian Department of Mines and Energy

PETROLEUM

1. Exploration The exploration outlook for oil and gas in South Australia remains bright, despite a reduction in the number and area of PELs under tenure and mandatory relinquishment in 1989 of parts of PELs 5 and 6 and of PEL 8 in toto.

The actual number of PELs dropped from 16 in 1987 to 14 in 1988 with a corresponding reduction in areas under tenure of 15.5% to 325 497 km^2. The total amount of seismic shot for 1988 remained reasonably constant at 4473 km onshore and 726 km offshore. A total of 71 exploration and appraisal wells was drilled (cf 59 in 1987). Total expenditure for 1988 was $51.2 million for gas and $38.1 million for oil.

Three major areas have emerged as the focus of exploration endeavours. These are the Otway Basin (both onshore and offshore), the Eromanga Basin over the margins of the underlying Cooper Basin sequence, and a broad area centred on 26°30'S and 141°E containing an Upper Triassic sequence provisionally assigned to the Cooper Basin.

In addition, during 1989 SADME will produce data packages and interpretations aimed at promoting the Bight Basin and the potential for oil in Cambrian reservoirs distributed widely throughout the state.

1.1 Otway Basin

a) Onshore: The Katnook 1 and 2 gas discoveries in the Robe-Penola Trough are potentially the most important gas discoveries in South Australia since Gidgealpa in 1963. Both wells are in PEL 32 with Ultramar (Australia) Inc. as operator. They are located about 10 km southwest of Penola and about 45 km north of Mount Gambier. Katnook 1 was cased and suspended on 20/1/88 as a new field gas discovery after testing gas at 172.75 MCm/day (6.1 MMCFGD) from a sand 1880-1885m KB. The sand, in the basal part of the Early Cretaceous Eumeralla Formation, also produced minor condensate and traces of fluorescence which gave encouragement for future oil discoveries in the area. Katnook 1 reached a total depth of 2520m KB in the Early Cretaceous Pretty Hill Formation.

After acquisition and interpretation of 90 km of infill seismic, Katnook 2 was located 700m to the northeast as an updip appraisal of the Katnook 1 well and was programmed to drill to a total depth of 3500m with all deeper levels being new exploration targets. Two deep seismic reflectors in the Pretty Hill Formation were to be investigated as potentially oil-bearing sandstone reservoirs. The prime objective of Katnook 2 was to provide the basis for a local supply centred on Mount Gambier as the regional centre.

The well spudded on 1/12/88 and 2 weeks later tested a small gas flow of 0.34 MMCFGD in a Eumeralla Formation sand at 1557-1563m KB, 300m higher than the reservoir in Katnook 1. The primary target ("Katnook Sand") was intersected lower than the prognosed depth and at the gas-water contact mapped in the No. 1 well. It was wet. Drilling continued into the Pretty Hill Formation. Good reservoir sands were encountered at 2864m KB which on test flowed 14.9 MMCFGD and up to 109BPD condensate. The test flow through a half-inch choke was a South Australian record. Further drilling has revealed a gas column of over 600m with no indication of a gas-water contact. Possible net pay thickness could exceed 100m.

SAGASCO has completed a feasibility study which indicates that supplying local markets in the Southeast of SA is viable. However, there now remains the possibility that the South Australian portion of the Otway Basin could supply incremental gas to the Adelaide market medium term, providing 300-400 BCF of gas can be proven. There are a number of undrilled structures adjacent to Katnook within PEL 32 whose prospectivity has been considerably upgraded by the Katnook 2 discovery.

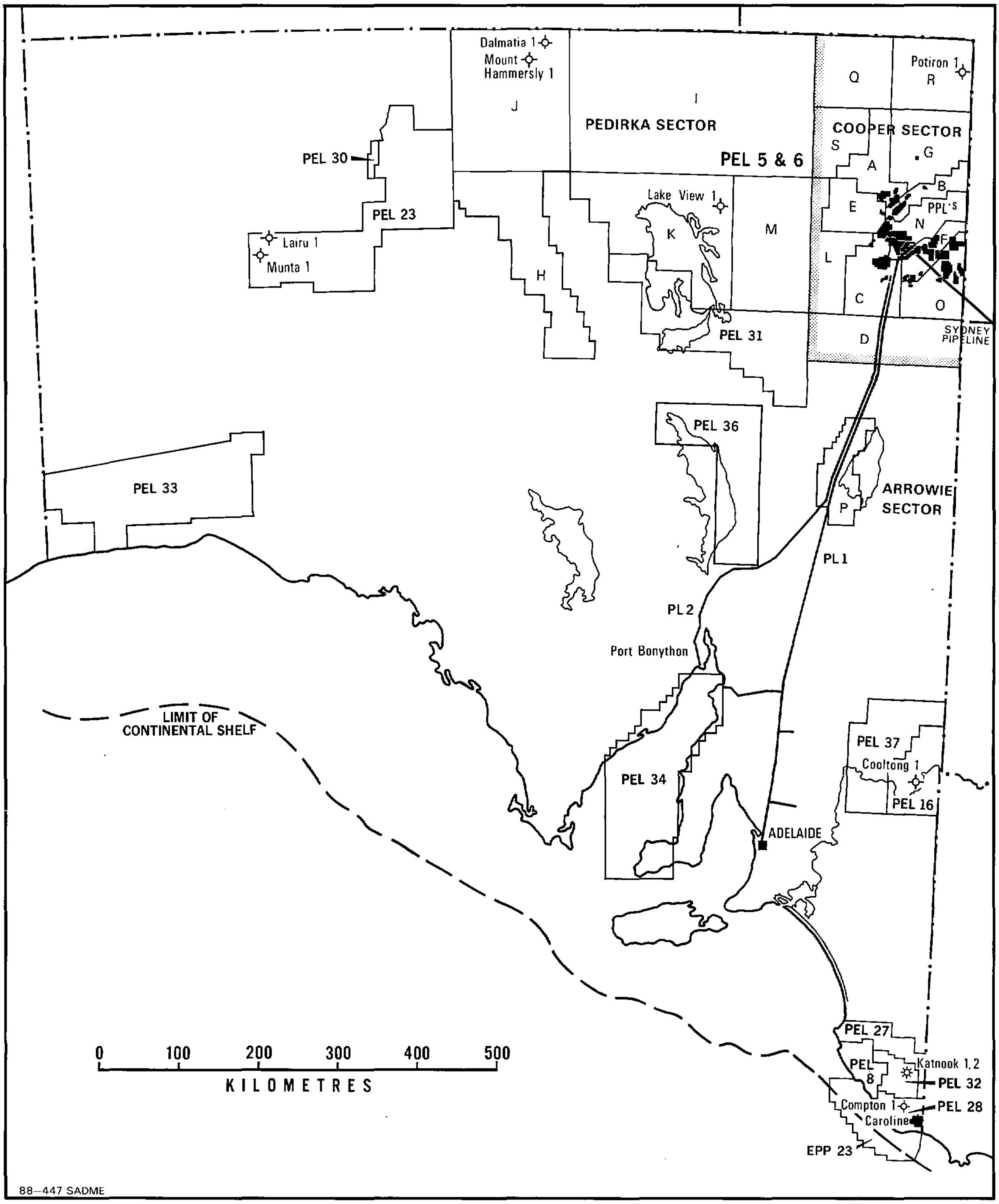
b) Offshore: The only two offshore petroleum permits in waters adjacent to South Australia are in the Otway Basin. EPPSA23 was granted to a consortium headed by Cultus Petroleum NL in 1987. A further area (EPPSA24) was granted, again to a group headed by Cultus Petroleum NL, in 1988. A well is to be drilled in late 1989 on a structure delineated by 1988 seismic surveys in EPPSA23.

1.2 Cooper Basin Permian Margins Significant oil discoveries were made during 1988 in the Lake Hope Block of PELs 5 and 6 where Jurassic sediments overlie the margins of the Cooper Basin Permian sequence and where there are no barriers to hydrocarbon migration from the Permian sources into the overlying Jurassic reservoirs. Elsewhere, barriers are provided by seals, such as the Triassic Nappamerri Formation siltstones.

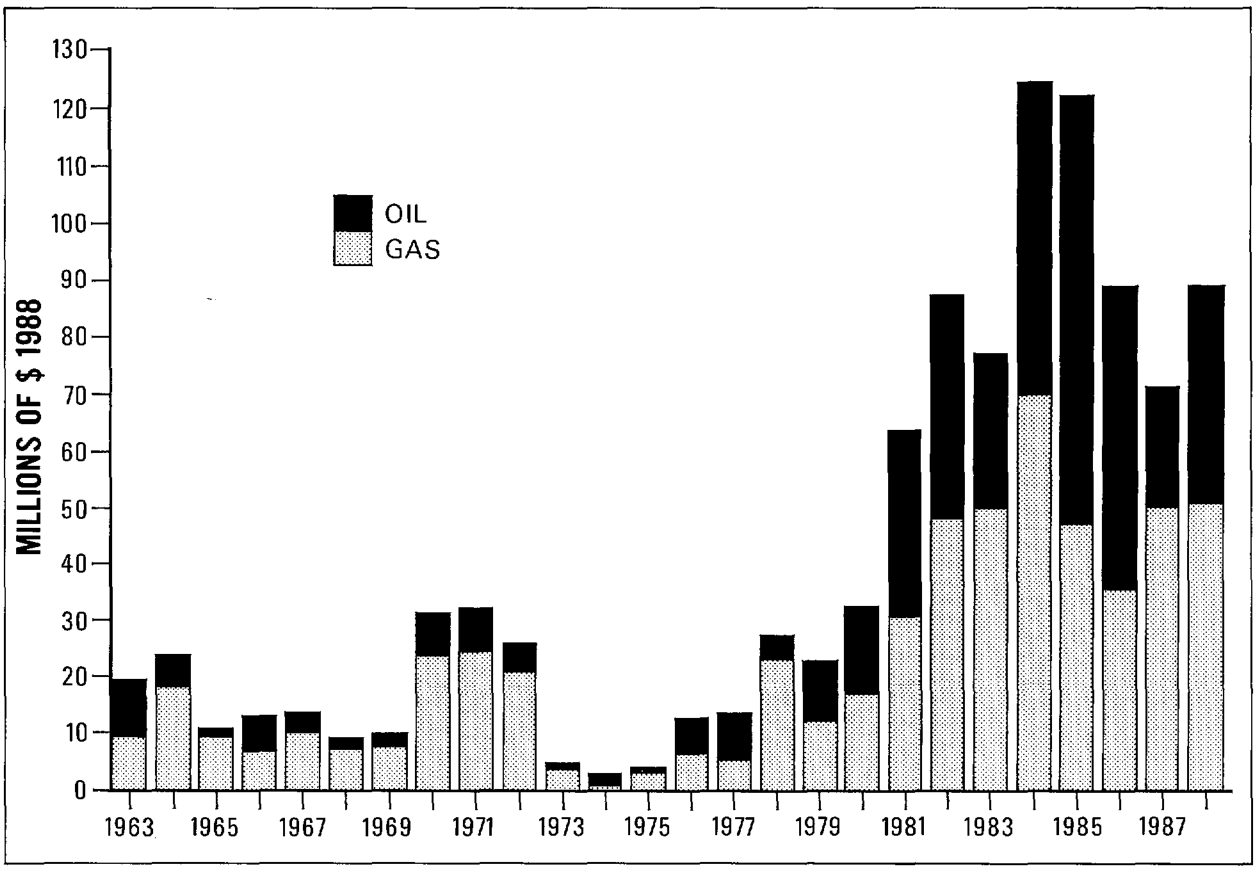
Proven oilfields in the Lake Hope block now include the Sturt, Sturt East, Tantanna and Taloola fields with indicated recoverable reserves at present of approximately 3.0 MMBBL. A new exploration programme began in the area in February, which also extended into the neighbouring Murta and Patchawarra southwest Blocks. Meanwhile, a pipeline has been laid to link the new fields with the existing oil-gathering system at the Gidgealpa Field.

The Lake Hope discoveries were instrumental in Santos' adding 7.5 MMBBL pf reserves for 1988 - the most successful year for SA oil discoveries since 1984.

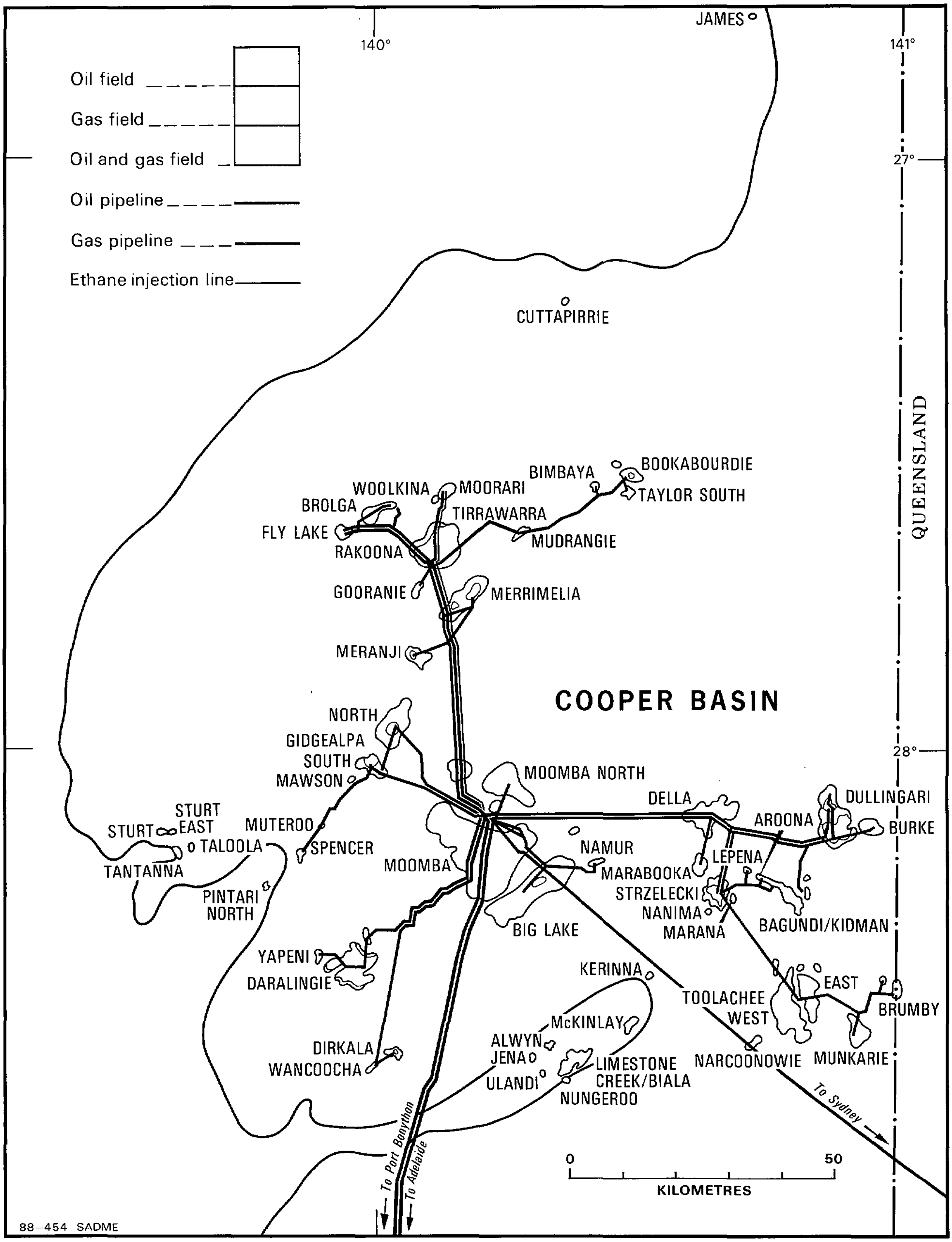
1.3 Upper Triassic Sequence A wide area of Upper Triassic rocks extending through parts of the Patchawarra East and Haddon Blocks in the northeast corner of PELs 5 and 6 and the Aquitaine 'B' Block in Queensland ATP 259P is provisionally assigned to the Cooper Basin. However, this unconformity-bounded sequence is likely to represent a different depositional phase from both the Cooper and Eromanga Basins, possibly more akin to the Simpson Desert Basin which yielded the Poolowanna 1 oil discovery. Santos is referring to this unit informally as the Lamdina Formation (R S Heath, pers. comm 1989). Oil shows have previously been recorded in this formation at Cook 1 and Potiron 1. A new oil discovery with major oil flows has been made in James 1 in the Patchawarra East Block of PELs 5 and 6, about 150 km northeast of Moomba. Two drill stem tests between 2301m and



Oil and gas exploration tenements held ,1988



South Australian annual exploration expenditure, ($1988)



Producing oil and gas fields in the Cooper Basin.

2338m flowed 1400 and 1810 BOPD respectively in what is essentially a sandstone sequence 210m thick unconformably overlying the Cambrian Kalladeina Formation.

Although the structure is bald of Permian sediments, Cooper Basin source rocks on the flanks are believed to have supplied updip Upper Triassic reservoirs, the accumulated oil interpreted to be biodegraded and water-washed condensates of Permian origin.

Santos is carrying out seismic surveys and has programmed several wells in 1989 to explore this sequence. Individual structures are numerous, but small, and the distance from oil-gathering systems downgrades their current economic potential. However, the economics of production may change in the near future if multiple and/or larger discoveries warrant the laying of a pipeline.

2. Development and Production

2.1 Oil The Cooper/Eromanga Basins continued to supply South Australia's oil and condensate production. Four new fields were discovered in 1988. The largest oilfield remains the Permian Tirrawarra Field, with original reserves in place of 107 MMSTB. The Tirrawarra field continues as Australia's most significant miscible gas field. This field is showing particularly good performance, with gas breakthrough not reducing oil relative permeability. The other Permian oilfields with light, highly volatile oils remain candidates for miscible gas floods. Enhanced oil recovery using injected natural gas or ethane as a miscible flood is underway in two such fields. At the end of 1988, a total of 6 injector wells were operating in the 2 fields.

The Jurassic and Lower Cretaceous oilfields, which are lower vapour pressure fields, are producing very satisfactorily. Various options are being reviewed for secondary and tertiary recovery. One field is currently under waterflood and one field is under test for a future waterflood.

Crude oil discovered during 1988 totalled 7.5 MMSTB, compared to 0.5 MMSTB in 1987, resulting in a cumulative total of 99.4 MMSTB discovered reserves to December 1988. Crude oil production for 1988 was 8.5 MMSTB (8.6 MMSTB for 1987 for a cumulative total of 45.5 MMSTB). Four oil development wells were drilled during the year, and five new fields were brought on-line for a total of 31 fields on-line for 1988.

2.2 Gas Seven new gas fields were discovered during 1988 in PELs 5 and 6 (10 in 1987) adding an extra 228 BCF to give a cumulative 4431 BCF of sales gas discovered (Santos' estimates). Sales gas produced for 1988 amounted to 170.4 BCF (total cumulative production to date being 2014 BCF).

A total of 26 fields were on-line as of December 1988, producing from 238 wells.

2.3 Energy Minerals Production The total value of hydrocarbons produced in SA during 1988 dropped by $53.1 million compared to 1987, yielding $657.6 million. Significant reductions in the value of LPG, condensate and crude oil were, however, offset by an increased value of sales gas produced by 18.8% to $302.0 million.

COAL

1. Background Unlike New South Wales and Queensland, South Australia does not possess large quantities of low cost black steaming coal suitable to meet electricity needs. The coal mine at Leigh Creek and the natural gas from the Cooper Basin, which currently provide 98% of our power station requirements, have limited proven reserves. The "energy crisis" of the late 1970's and the risk of gas shortage for any further gas fired power station developments prompted substantial exploration for coal to fuel South Australian power stations.

   Exploration activity in the 6 year period from 1977-1982 resulted in substantially more coal being discovered than had been found in the previous 90 years.

   The SA government, in recognition that there was uncertainty regarding future choice of fuel for the State's power generation industry, established a number of committees to consider all of the available options.

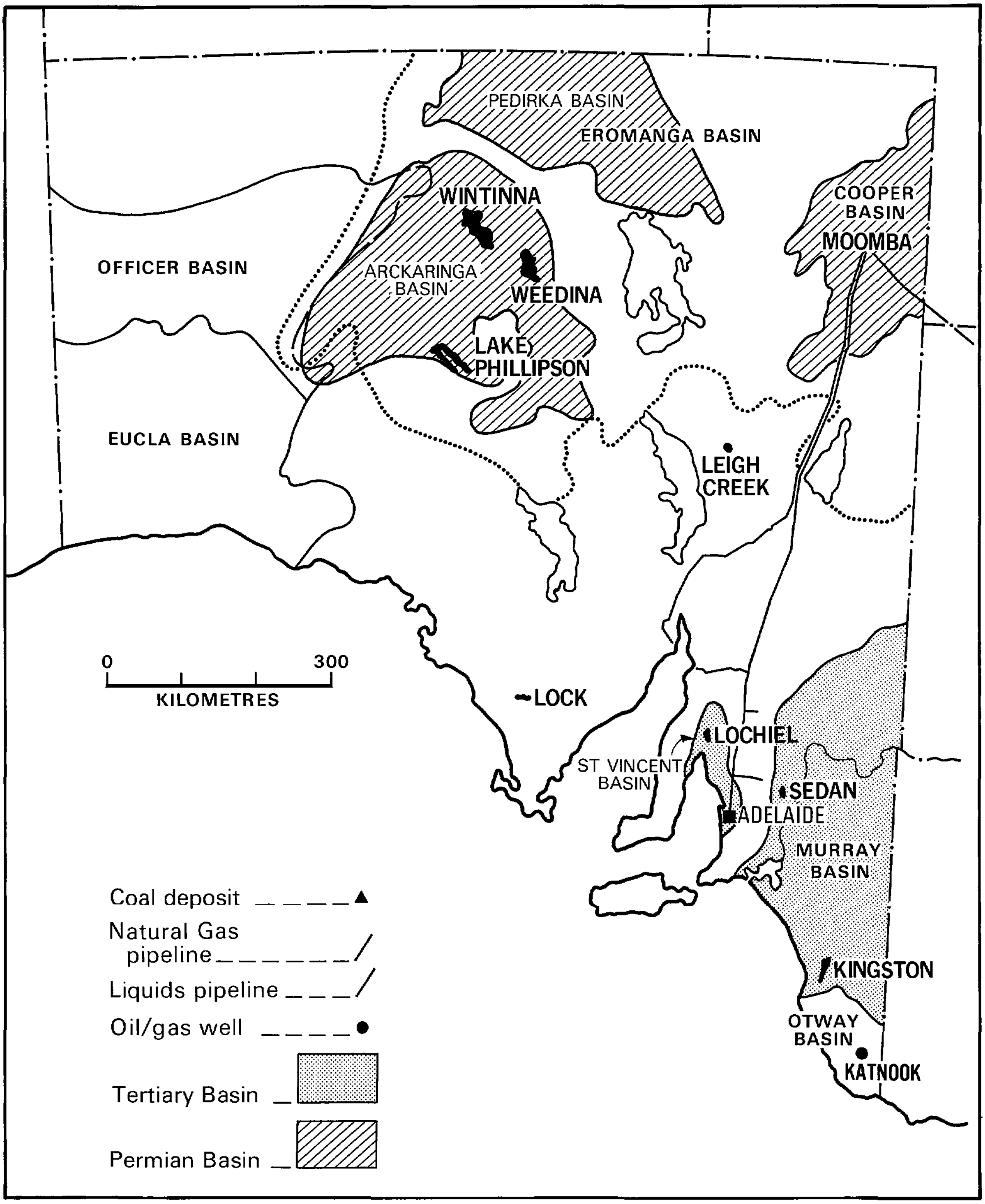
   The first such committee was the Advisory Committee on Future Electricity Generation Options. This committee considered all possible energy options available for electricity generation, including local coal, imported black coal, natural gas, wind, solar, nuclear power and interconnection of the electricity grid with Victoria. The committee recommended that South Australia should, in the future, primarily rely on the development of its own coal resources for new power station developments.

   The Government accepted this recommendation and in 1984 appointed the Future Energy Action Committee, who invited the licensees of the Kingston, Lochiel, Sedan and Wintinna (see Fig 4) to submit proposals to supply coal to the Electricity Trust of South Australia (ETSA).

   The Lochiel and Sedan coalfields were considered to be the two most favoured for development and should be progressed to the next level of detailed technical assessment. The committee recommended that the Kingston and Wintinna deposits should be considered further if it could be shown that the economics of coal supply from these deposits could be substantially improved. ETSA has excavated a trial pit at Lochiel to upgrade geotechnical and hydrological parameters and to obtain a 2000 tonne coal sample for combustion purposes.

   In 1987, the Management Review Committee was established by the to coordinate a joint study by SADME, ETSA and CSR of the Lochiel and Sedan coalfields. The study, which was concluded in December, 1988, confirmed the findings of the earlier FEAC Committee and recognised that both Lochiel and Sedan are viable alternative sources of fuel for mine-site 500 MW pulverised-fuel power stations.

2. Leigh Creek South Australia has only one operating coal mine located 550 km north of Adelaide at Leigh Creek. The coal is mined by ETSA using open-cut mining methods. It is expected that coal mining will continue at Leigh Creek to the year 2025, supplying coal to both the present 240 MW Thomas Playford B Power Station and the adjoining new 2 x 250 MW Northern Power Station at Pt Augusta (see Fig 4) as well as a new 250 MW unit (NPS3) currently due for completion in 1996.



Location of the major coal deposits in South Australia

3. Electricity Demand Present planning is based on all future base load generating plant being coal fired. The development of the South Australian power station following NPS3 is dependent on a number of factors, the most important of which are the load and energy forecast and future gas supply. The current assessment indicates an earliest use date of 2001 for the first unit following NPS3. Use of a local coal unit in 2001 would require finalisation of selection of a coalfield by 1991 or 1992. The commitment and construction lead time for a coal fired power station is 7 to 8 years.

4. Outlook for Coal South Australia coals offer the best long term option for the State's energy supply, mainly because of their abundance. All of the coal deposits currently under consideration for development have uncertainties associated with combustion technology or the economics of supply. Mining evaluations and coal utilisation research are being actively progressed by both Government and private industry to ensure selection of the best option for the State. New deposits like Weedina (which was discovered since FEAC was established) along with some of the earlier discovered deposits such as Bowmans (see Fig 4) combined with the use of new technology such as Circulating Fluidised Bed Combustion and the gasifying of lignites for combined cycle power generation, may yet prove to be serious contenders.

5. Low Grade Coal Technology Consulting Services SAGRIC International has established consultancy services in low-grade coal technology to commercialise South Australian expertise and facilities in resource evaluation and utilisation. SAGRIC International is the technology transfer company of the South Australian Government, with established contacts in UN and World Bank organisations.

MINERAL RESOURCES

1. Exploration

1.1 General: Total expenditure on mineral (including coal) exploration reported in the calendar year 1988 was $9.6 million, which is 24% down on the 1987 total of $12.6 million.

Throughout the State, metal exploration remained steady, comprising 56% of total expenditure. Coal exploration was down by 44% (21% of total); diamond down by 69% (6% of total); and uranium down by 19% (5% of total). Expenditure on exploration for a variety of non-metallic mineral commodities was steady, comprising 12% of total.

With reference to specific commodities, exploration expenditure on gold rose by 36% to $2.25 million, while expenditure on the search for heavy mineral sands rose marginally to $0.75 million.

The area held under Exploration Licences increased by 9% to about 214 000 km^2, while the total number of licences remained steady However, drilling reported by companies was down considerably (a total of only 67 000m of core and non-core drilling compared with 110 000m in 1987).

Gold and base metal exploration was focussed principally on the Tarcoola, Coober Pedy, Stuart Shelf, Olary and Yorke Peninsula regions, while the Murray Basin remained the principal target for active heavy-mineral sand exploration.

1.2 Notable Developments

a) Heavy Mineral Sand Exploration: Exploration for heavy-mineral sands in South Australia has intensified in recent years, from no exploration in 1985, to 14 ELs and a total expenditure of $0.65 million in 1987, and to 24 licences and a total expenditure of $0.75 million in 1988. The stimulus has been from the discovery of the CRA WIM 150 deposit near Horsham (Vic) and the limitations being placed on exploration on the eastern Australia seaboard.

In the Murray and Eucla Basins, the principal targets are coastal strandlines of Tertiary age. Approximately 50 beach ridges are preserved in the Murray Basin over a distance of 100 to 300 km from the coast; some are up to 100 km long. Recent SADME mapping and geological investigations have led to the recognition of three stranded coastal dunes on the northern and eastern margins of the Eucla Basin, adjacent to the Nullabor Plain. The largest of those, the Ooldea Range, has a length of about 650 km.

In the SA portion of the Murray Basin, exploration is being carried out by Aberfoyle Resources Ltd, Burmine Ltd, TC Pacific Resources Pty Ltd and Demis Ltd. BHP has explored parts of the southeastern Ooldea Range and other licences are under application over much of the Ooldea and adjacent Barton Ranges.

b) Lead-Zinc Potential: An information package summarising South Australian lead-zinc prospects has been prepared by SADME. The package was prepared from approximately 950 SADME and company reports and is designed to encourage exploration for lead-zinc-silver to provide feedstock for the Broken Hill Associated Smelters at Port Pirie. Prospective geological settings have been established in four major geological provinces:

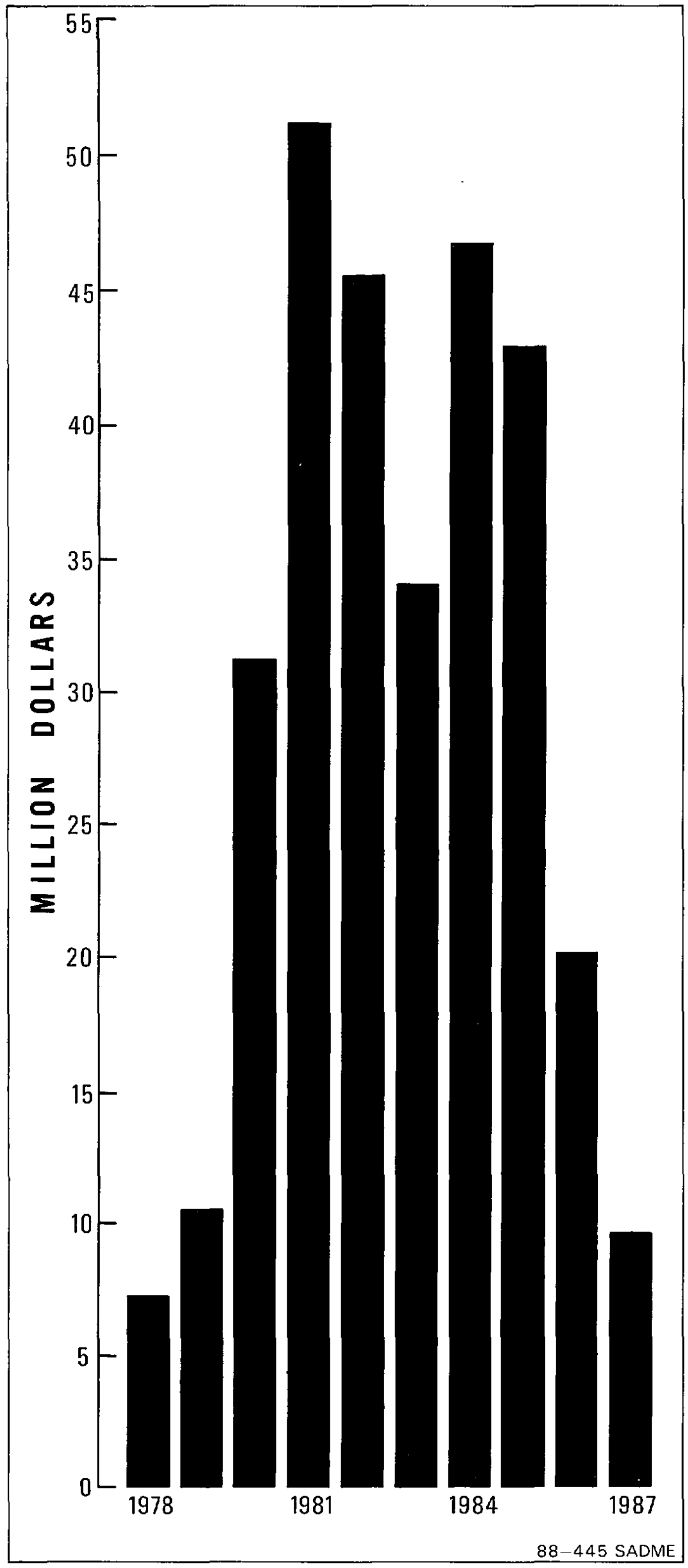
- Gawler Craton
- Adelaide Geosyncline and Stuart-Spencer Shelf
- Willyama Inlier and Curnamona Cratonic Nucleus
- Kanmantoo Trough

A regional airborne geophysical survey of the west-central portion of Eyre Peninsula has been completed. This summary comprised 87 000 km of flight lines ranging from regional (1-2 km spacing) to detailed coverage (250-500 m in areas of high prospectivity). Total magnetic intensity, 256-channel spectrometric and VLF-EM measurements were made. This joint SADME/BMR project is providing valuable information on an area of the prospective Gawler Craton where outcrop is limited. Production of final contour plans will be completed during 1989. SADME's Geophysics Branch will also coordinate a comprehensive programme to provide interpretation of the data for publication.

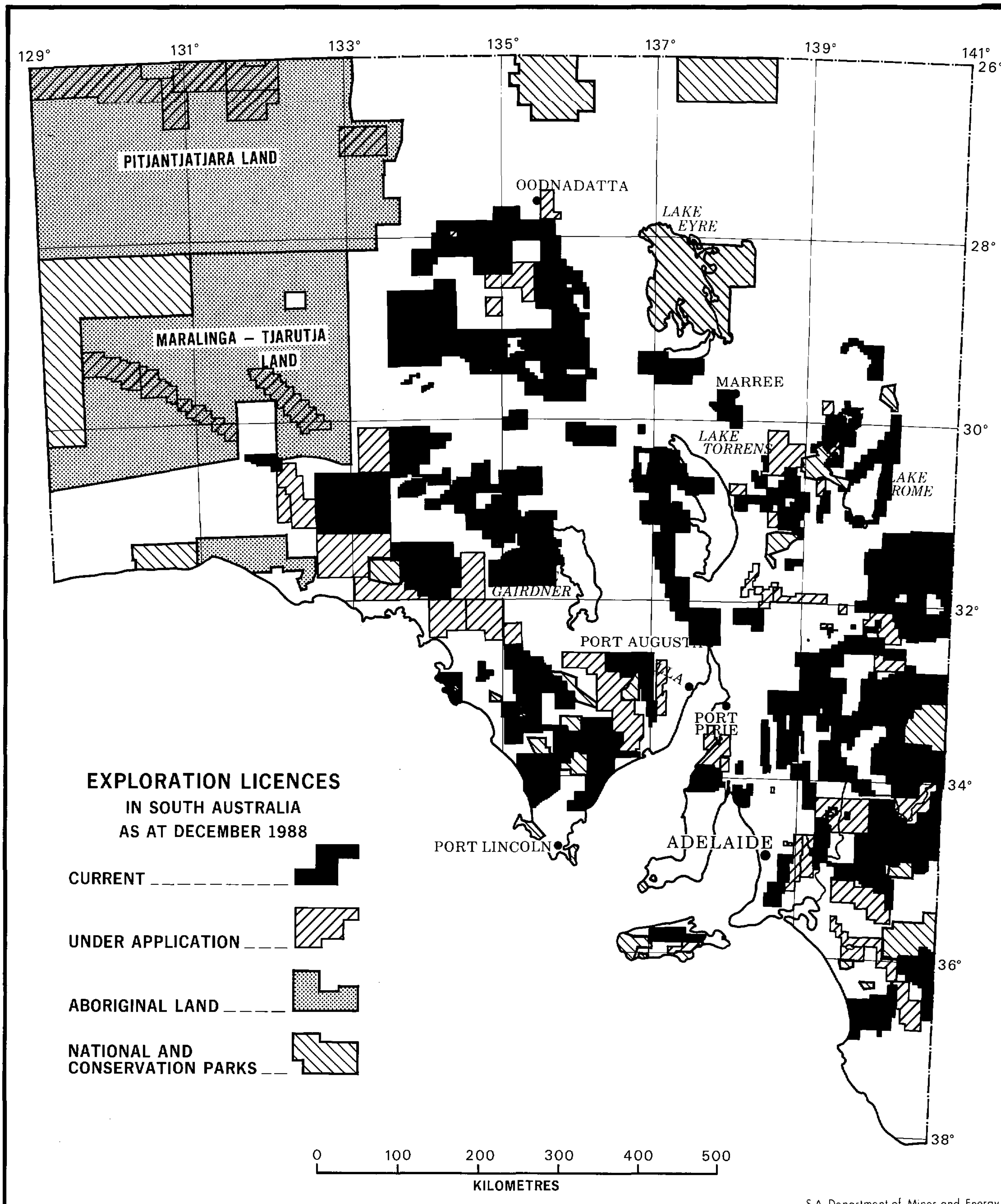
c) Kimberlitic Rocks: Knowledge of the number and distribution of Kimberlitic bodies in South Australia has increased in the last decade during exploration for diamonds and base metals. Intrusives are known in the following areas:

- Terowie-Whyte Yarcowie
- Carrieton-Eurelia
- Port Augusta
- Mulgathing

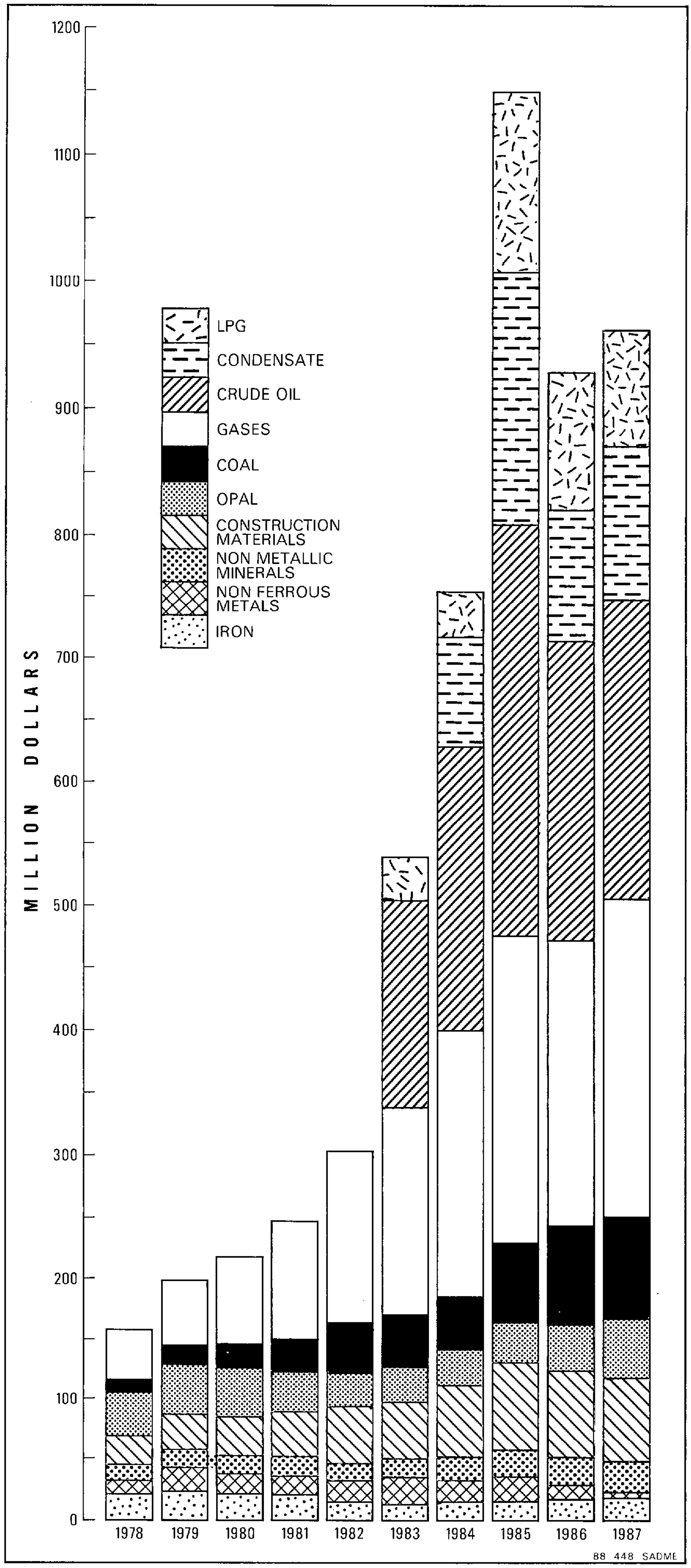
Many of these are phlogophite-bearing and it is considered that there may be potential to locate a source of vermiculite, which is an



Company expenditure on exploration in South Australia



Exploration Licences in South Australia as at January 1, 1989.



Value of South Australian mineral production.

alteration product of phlogophite or biotite mica. At present, all South Australian and most Australian vermiculite requirements are imported.

2. Production The value of mineral (other than petroleum) production in 1988 is expected to increase compared to 1987 due to the initial production of cathode copper and uranium oxide from Olympic Dam and copper cement from leaching operations at Mount Gunson by Adelaide Chemical Co. The outlook for 1989 is for further major increases as Olympic Dam goes into full production of copper, uranium oxide, gold and silver, together with copper concentrates as Moonta Mining NL brings Poona on-stream.

Mineral production in South Australia in the calendar year 1987 was comparable with that of the previous year in terms of tonnage and/or volume. Coal production from Leigh Creek increased by 3.0% and $2.43 million to a level of $84 million following increased consumption by ETSA for power generation at Port Augusta. Production of iron ore by BHP Co Ltd was up 1% and the value of sales increased correspondingly to $18.0 million. However, following cessation of mining operations at Mount Gunson in June 1986, there was no copper production in 1987. Metal production, in general, remained at about $22 million. Non-metallic and industrial minerals ($25 million) generally maintained steady production rates, although significant increases were noted in barite production (up 51.3%) and magnesite production (up 41.7%). The output and value ($69 million) of construction materials was marginally down due to reduced road-making requirements by Government authorities. Estimated value of opal production was up by $11.2 million to $50 million due to an increase in output from Mintabie, now well established as the world's largest producer of precious opal.

3. Development

3.1 Olympic Dam: The town of Roxby Downs was firmly established and had a population of 1850 by the end of 1988. Initial planning allows for a population expansion to 4000. Authorization to operate the plant was granted at the end of September and the Olympic Dam project was officially opened on 5th November 1988.

Total resource is estimated at 2000 million tonnes, with probable ore reserves of 450 million tonnes. The annual mining programme now calls for the processing of 1.5 million tonnes of ore which will produce 1900 tonnes of uranium oxide, 43 000 tonnes of copper, 27 000 oz of gold and 560 000 oz of silver.

Underground development to the end of 1988 totalled:

- 31.5 km of driving (increasing at rate of 800m/month)
- 3.8 km of raise boring
- 0.5 km of shaft sinking
- 3.1 km of declining.

Other major works completed underground during 1988 include:

- two truck-loading stations
- development of future production stoping areas.

On the surface, construction of the full-scale metallurgical plant was completed and production commenced. The first section of the refinery came on-line in early September with copper cathode production commencing in mid September.

All the electrolytic copper production has been sold under long-term contracts to British and German fabricators and in Australia. The copper will be sold under ruling prices on the London Metals Exchange.

About 60% of uranium output has been committed. A long-term contract with Kansai Electric Power Co of Japan was signed in June and followed signing of contracts with nuclear power generating authorities in the UK, Sweden and South Korea.
Gold and silver will be sold on a spot basis on world markets.

3.2 Poona Copper Gold Project: Stripping of overburden using elevated scrapers has exposed the Poona lode extension at a depth of 7m. Some oxidised ore has been stockpiled; native copper stringers have been found in the zone of supergene enrichment. The in situ undiluted ore reserve has been estimated at about 180 000 tonnes (averaging 7.1% copper and 2.0 g/t gold) above a 2% copper cut-off grade. Production at the rate of 5000 tonne contained copper per year started in February 1989, with a first shipment of direct smelting copper ore from Wallaroo.

The deposit is an extension of the Poona lode which was mined in the 1860s and was discovered from detailed follow-up of a SIROTEM geophysical anomaly.

3.3 Mount Gunson: Golden Shamrock N.L. subsidiary, Adelaide Chemical Co, is engaged in recovering remnant oxidised copper ore at Mount Gunson. The ore body consists predominantly of atacamite in quartzite with minor malachite and cuprite. The ore, with a nominal head grade of 1.5% copper, is mined from the Main Open Cut and several smaller deposits. High-grade copper cement is produced by leaching to provide feedstock to the Burra copper oxide plant.

3.4 Tarcoola Blocks Mine: Tarcoola Gold Ltd installed a headframe and winder at the main shaft and carried out an underground exploration programme to assess reserves for the Wards and Imperial reefs and the 3rd mine level of the old workings.

3.5 Middleback Ranges Iron Ore: BHP is embarking on a new $40 million mining development at the Iron Duke deposit in the Middleback Ranges to ensure maintenance of supplies of high grade (+ 60% Fe) ore for at least 25 years. Production is programmed to commence in March, 1990.

Six pits currently operating in the Iron Baron region are nearing exhaustion and mining there will finish during 1990. Development of the Iron Duke deposit is being undertaken by the Kinhill-Baulderstone-Roche joint venture. Output from this deposit is planned at 1-1.5 million tpa. Iron Monarch, the other BHP mining operation in the Middleback Ranges, produces over 0.5 million tpa of high-grade lump ore.

The second stage of a feasibility study involving the mining of a trial pit in the Iron Princess orebody north of Iron Knob has been completed. A draft mining proposal for the orebody is to be submitted in March, 1989. It is anticipated that 1 million tpa can be extracted over a 5 year period.

3.6 Port Pirie Rare Earths: SX Holdings Ltd intends to build a plant for treating rare earths at Port Pirie. The project proposed will be phased in over 5 years:

Stage 1: Yttrium extraction from imported ionic clay 100 tpa yttrium oxide

Stage 2: Production of a bulk concentrate La, Ce, Pr, Nd and 99.5% pure oxides of samarium, europium and gadolinium.

14.5 tpa bulk concentrate.

Sm_2O_3 3 tpa
Eu_2O_3 0.1 tpa
Gd_2O_3 4.5 tpa

Stage 3: Monazite/xenotime cracking plant 2000-10 000 tpa monazite.

3.7 Adelaide Brighton Cement Ltd: ABC Ltd is in the final stages of a study into further upgrading the preheater kiln at its Birkenhead cement works into a precalcifier kiln. This development will make the Birkenhead works the largest in Australia and is expected to double the present preheater kiln capacity from 500 000 to 1 200 000 tpa.

At the same time, consideration is being given to increasing production of limestone from the company's Rapid Bay quarry, 80 km south of Adelaide. Export of the limestone to interstate centres would necessitate upgrading of present wharf facilities to cater for 30 000 tonne ships.

3.8 Uley Graphite: Pilot plant testing of graphite at Uley by Solution Mining N.L. began and is continuing. It is proposed to produce an up-graded product for world-market assessment. The feedstock is obtained from the Mikirra graphite deposit, 23 km southwest of Port Lincoln.

Australia currently imports all its natural graphite requirements (about 1500 tpa).

3.9 Granite building stone: At least a dozen new quarry sites for granite building stone are expected to be subjected to development to supply increased Australian demand for quality cladding material. The new Parliament House in Canberra makes considerable use of South Australian stone.

Mineral development in progress, and prospects, Western Australia

L C Ranford

Geological Survey of Western Australia

Petroleum and Mineral Production in 1987/88

The 1987/88 value of Western Australia's mineral production was $6 945.6 million, an increase of 17% over the previous year (Table 1). This increase was due to continued expansion of gold mining, and significant increases in the value of nickel, mineral sands, alumina, coal and petroleum products. Changing commodity prices positively affected mineral sands and nickel, and had a detrimental effect on the value of iron ore production. Diamond production was reduced by 6% from the peak levels of 1986/87, and its value was reduced by 13%, reflecting the lower quality products which came entirely from the Argyle AK1 pipe.

Mineral Exploration

Expenditure on mineral exploration was $466 million during 1987/88, an increase of 44% on that of the previous year, and an amount which constitutes 58% of total expenditure on mineral exploration in Australia. Gold exploration accounted for 78% of the expenditure figure in Western Australia, compared to 74% in 1986/87. Such a high level of gold exploration in 1987/88 is unlikely to be sustained in the coming year, in view of the demise of many of the smaller exploration companies after the November 1987 stock exchange crash and the sharp drop in the Australian dollar price of gold. Of 98 new mining proposals processed by the Department of Mines during 1987/88, 69 were for new or expanded gold mining operations, 6 for mineral sands operations, 3 for iron ore mines and 2 for nickel mining operations.

Petroleum Exploration

Petroleum exploration activity increased slightly in 1988 with 33 new field wildcat (NFW) exploration wells being commenced (Figure 1) compared to 31 in 1987. The greater part of the exploration drilling, during 1988, occurred in the Carnarvon Basin (14 NFW wells) and the Canning Basin (11 NFW wells). This resulted in two discoveries, both in the Carnarvon basin, during the year:

- a gas/condensate discovery at Echo 1 in the Mungaroo Formation on the Rankin Platform
- a gas/oil discovery at Yammaderry 1 in the Barrow Group.

Seismic-survey activity increased in 1988 with a total of 21 831 line km of seismic reflection data being required compared to 15 091 line km in 1987 and included 19 656 km offshore and 2 175 km onshore.

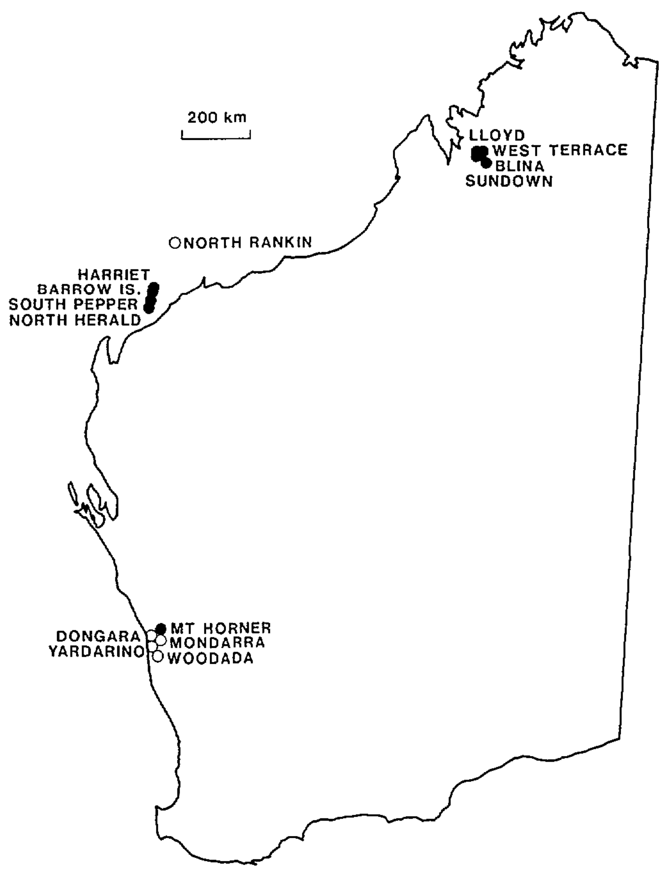


Figure 1: New field wildcat wells commenced in 1988

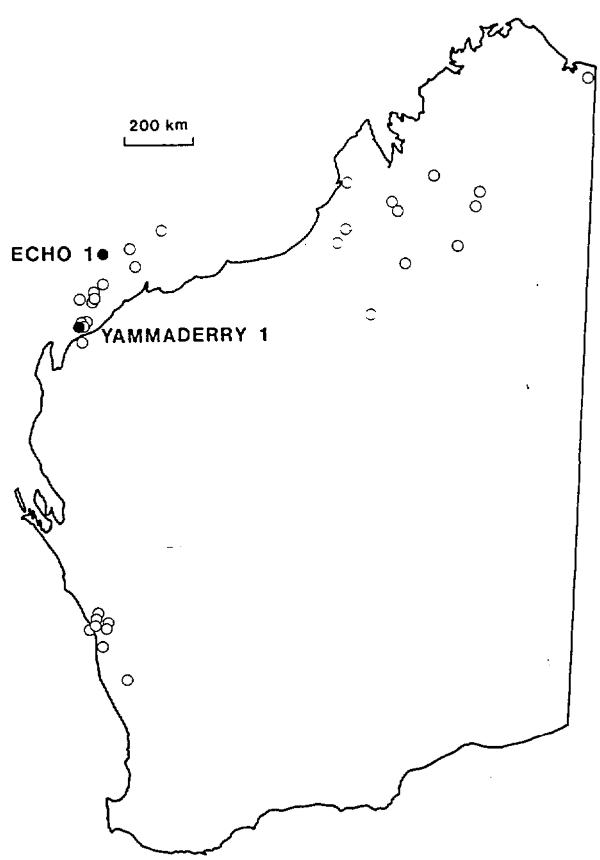


Figure 2: Petroleum producing fields - December 1988

Based on permit commitments, exploration drilling activity in 1989 is expected to be higher than in 1988. Onshore, 39 exploration wells are projected with a further 11 exploration wells offshore. This is a somewhat more optimistic forecast than made by APEA which expects a maximum of 36 wells to be drilled in Western Australia in 1989. Again, based on permit commitments, seismic surveying onshore is expected to increase with 3 825 line km as against 2 175 line km being recorded in 1988. Offshore seismic acquisition is expected to decrease significantly in 1989 with approximately 10 000 line km being acquired, including two major 'spec' surveys, compared with 19 656 line km acquired in 1988.

Petroleum Production and Development

Ten oilfields (Figure 2) were in production in December 1988 - Barrow Island, Harriet, North Herald, South Pepper, Mount Horner, Dongara, Blina, Lloyd, Sundown and West Terrace. Five gasfields were producing in 1988 - Dongara, Yardarino, Woodada, Mondarra, and the giant North Rankin Field.

Development drilling activity increased in 1988, with 17 development/extension wells being drilled as against 9 wells in 1987. A significant increase in reserves was demonstrated in the Bambra structure with the discovery of an 11 m hydrocarbon column in Bambra 3, drilled by Bond Petroleum in TL-1 located in the Barrow Sub-basin near the Harriet Field. This discovery may raise the Bambra structure to economic status. Wapet's Saladin-7 extension test extended the area of the Saladin Field and recorded a flow of 1 720 kL of 49.2 API oil per day. Development drilling also occurred on the Mount Horner Field (Barrack Energy), Barrow Island (Wapet), the South Pepper Field (WMC), and the North Rankin Field (Woodside).

Onsite construction of production facilities for the Saladin Field began in March 1988, and will continue into 1989 with production planned to commence in June 1989 at a rate of 6 200 kL per day. The Talisman Field is expected to come into production in 1989, with production of oil from the Talisman 1 well; to date no projected production rates have been released. Design of the Goodwyn A platform by Woodside is expected to begin in early 1989, and up to 10 production wells are planned for the North Rankin Gasfield over the next two years. The $3.5 billion LNG export phase of the North West Shelf project is scheduled to commence operation late in 1989.

Gold Production and Developments

In 1988 an additional 33 significant gold mines (annual production exceeding 100 kg gold) were brought into production, and these contributed about 36 000 kg to the State's total annual gold output (Table 2). Another 45 new gold mines could commence production in 1989, contributing up to 36 000 kg to the State's gold production (Table 3). However, indications are already emerging that these may not all proceed to development on account of the declining gold price.

Two new major gold mines were opened in 1988: Hedges and Junction. Alcoa's Hedges mine is adjacent to Boddington (Worsley) and is situated on the same zone of laterite-hosted gold mineralization. The treatment plant at Hedges is designed to treat 2 million tonnes per annum. WMC's Junction deposit, about 35 km southwest of Kambalda, has large ore reserves (Table 2) and

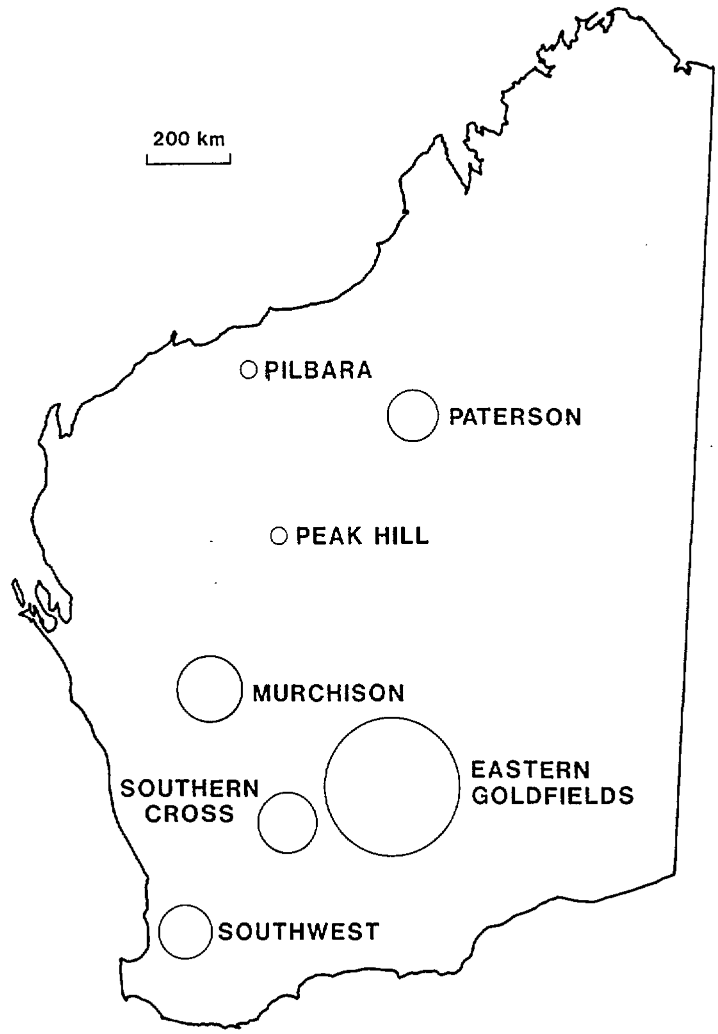


Figure 3: Gold production in 1987/88

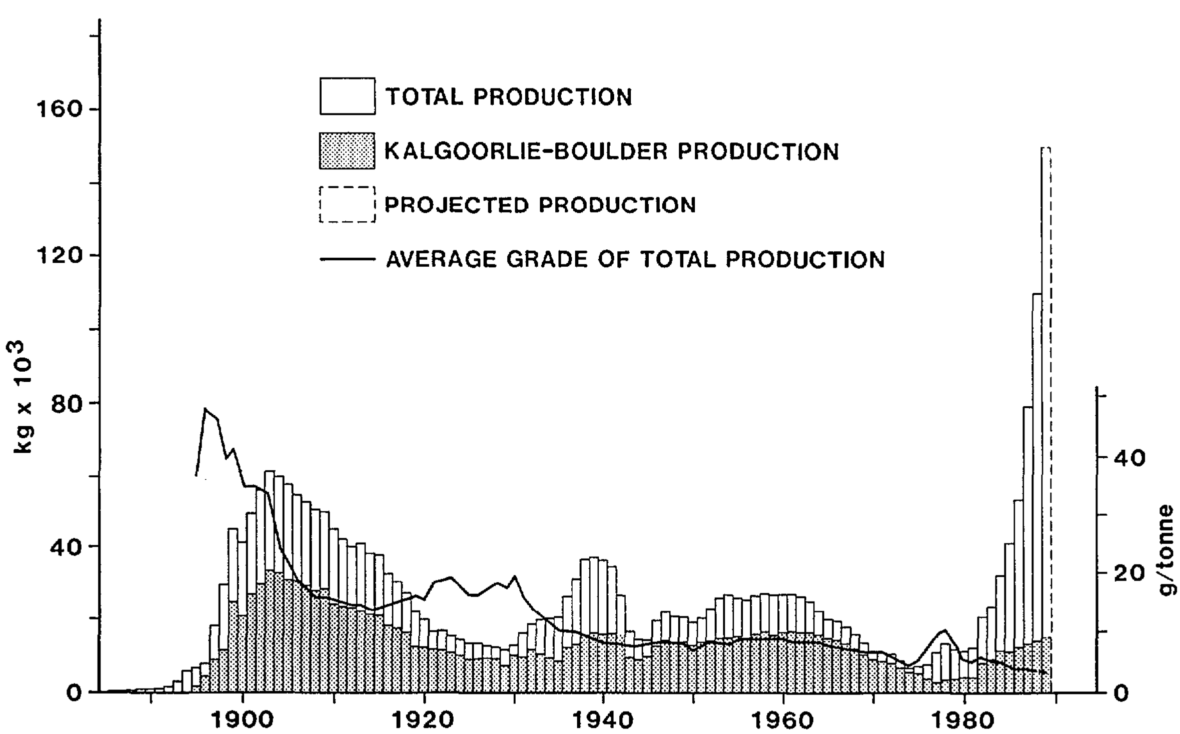


Figure 4: Gold production in Western Australia

will be a major contributor to the 2.5 million tonne per annum throughput of the St Ives mill.

Western Australia's total gold production in 1988 (Figures 3 & 4) was about 110 t and could conceivably reach 150 t in 1989 if all proposed developments were to proceed. Gold has now overtaken iron ore to become the State's most important mineral commodity in terms of value of production. Major new gold mining developments now on program include Big Bell, with the first pour having taken place in February 1989, and the Big Pit at Kalgoorlie, planned to produce between 15 000 and 30 000 kg gold annually from 1991 onwards. Granny Smith, to the south of Lancefield, Mt Hope (Bounty) in the Forrestania area, Labouchere and Rothsay both in the Murchison, are other major new projects scheduled for development over the next year or so. Apart from the new mines coming into production, many of the existing mines are planning major expansions. Boddington is progressively increasing gold production by 6 000 kg from the original design to achieve 12 330 kg in 1989, and Telfer is aiming at annual production of 9 330 kg in 1989 (an increase of 3 000 kg over 1987/88), and 12 440 kg in 1990. A new treatment plant and rationalisation of production between Marvel Loch and Southern Cross should lift production by about 2 000 kg in 1989, and plant expansions are also occurring at Mt Magnet, Meekatharra, Southern Cross, Jubilee, New Celebration, Lancefield and Mt Gibson.

Unless the gold price increases markedly over the next twelve months, production will probably peak in 1990 and this will be accompanied by a greater concentration of production in the hands of a small number of large-scale miners. In 1987/88 about 50% of Western Australia's gold production was associated with 10 of the State's 600 recorded producers.

Iron Ore Production and Developments

Iron ore production increased by 22% in 1988 but its total value decreased slightly compared to 1987 (Table 1). Throughout most of the 1980s the world steel industry has experienced a recession. However, there are now firm indications of a significant improvement in the demand for steel, with the first redress of the price imbalance for five years; the negotiated 15% rise being recently concluded with Japanese steelmakers for 1989/90.

The development of more production sites may be feasible in the Hamersley Iron Province in the early 1990s. Construction work has commenced at the 200 Mt Channar deposit (Figure 5) and is scheduled for completion at the end of 1989; the eventual production rate will be 10 Mt per annum. Crushed ore will be transported from the mine to Paraburdoo using a 21 km overland conveyor. Separate sales of Marra Mamba ore by Mt Newman give the potential for increased production levels, and development of the Mesa 'K' deposit at Pannawonica will provide additional resources of 67 Mt 'blendable' pisolitic ore for the Robe River partners. Production from McCameys Monster has moved a step closer, with ongoing development to produce 0.75 Mt per annum (after processing) of lump ore from scree material from early 1989. The main development of McCameys (which contains up to 2 000 Mt of 60+% Fe iron ore) could occur after 1991. The 2 Mt per annum Marillana Creek (Yandicoogina) project will go ahead, subject to a satisfactory environmental report, whilst the Goldsworthy partners are ensuring their long term future in the North Pilbara, with the development based largely on the Nimingarra deposit.

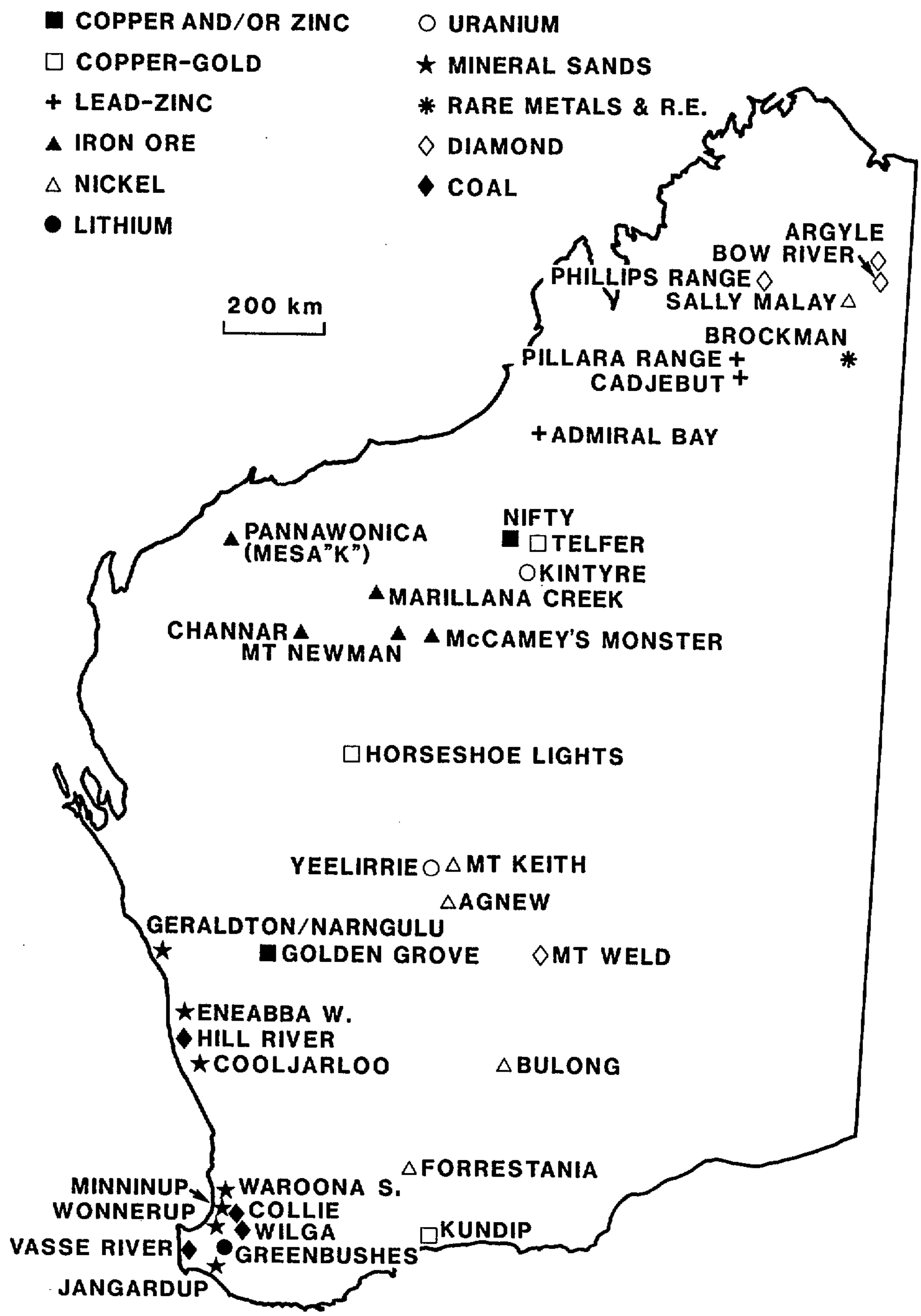


Figure 5: Active mineral projects (except gold) in 1988

Mineral Sands Production and Development

The mineral sands industry is undergoing rapid expansion following substantial price increases for ilmenite and zircon. New mines are planned for Wonnerup, Cooljarloo and Jangardup. New mines have been established at Waroona South and Minninup, and new treatment plants have been constructed at Rockingham (zirconia plant) Narrigulu/Geraldton and Capel. The Cooljarloo mineral sands project, inland from Cervantes, will incorporate a $300 million fully integrated downstream processing complex. The plan calls for mining, mineral separation, a synthetic rutile plant and a titanium dioxide pigment plant. Another large deposit has recently been identified at Eneabba West where a 150 Mt resource is reported to contain about 4% heavy minerals; feasibility studies are examining the possibility of mining in 1990. This could be accompanied by another concentrator and synthetic rutile plant based on the Eneabba deposits.

Western Australia produces about 30% of world's ilmenite, 40% of the world's zircon and 50% of the world's monazite. The State's large resources of mineral sands, coupled with steadily increasing world demand, are expected to lead to further development during the 1990s. Apart from increased mining, there is considerable potential for additional processing, including production of synthetic rutile, titanium dioxide pigment, titanium tetrachloride, titanium metal, zirconia and zirconia products. There is also scope for the processing of monazite to individual rare earth elements of high purity, and the production of magnets, phosphors, and ceramics etc derived from them. However, there is a significant environmental lobby which could influence development of the industry and is already affecting exploration over much of the prospective Scott Coastal Plain on the south coast.

Diamond Production and Developments

The Bow River diamond mine commenced production in 1988 and the feasibility of further alluvial diamond extraction from large deposits in the Argyle area is being examined. Demand for good quality gem diamonds is more buoyant now than for several years and the Argyle alluvial deposits contain a higher percentage of such stones than does the primary pipe deposit.

A renewed interest in diamond exploration is being shown in the State, following the announcement of another significant find in the Phillips Range of the East Kimberley region, where pilot plant testing is due to commence shortly.

Base Metal Production and Developments

Substantial increases in prices over the past 2 years have resulted in renewed interest in base metal exploration in Western Australia. Improved prices have resulted in the long-awaited go-ahead decision for the development of zinc-copper-silver Scuddles mine at Golden Grove and the commencement of zinc-lead mining at Cadjebut in the Pillara Range southeast of Fitzroy Crossing. Copper is also being recovered as a significant by-product of gold mining at Horseshoe Lights, Telfer and Kundip (Ravensthorpe).

Other Pillara Range deposits, similar to Cadjebut, such as Pinnacles, Prices Creek and the large Blendevale deposit are still being tested and could follow Cadjebut into production during the 1990s. Total resources for the Pillara Range base metal deposits exceed 25 million tonnes at a grade of 11-12% combined lead and zinc.

The Admiral Bay lead-zinc-copper mineralization in the Canning Basin is also being actively explored as a long term potential development. The mineralization is low grade and occurs within a 500 metre thick zone below a depth of 1 200 metres; however, it includes some high-grade zones and mineralization extends over a strike length in excess of 20 km. No mining plans have yet been announced for the Nifty copper deposit, in the East Pilbara, but a moderately sized open-cut operation may be imminent, given the improved price for copper.

The increased nickel price has led to a decision on the re-opening the Agnew nickel mine by its new owners (WMC). In addition, interest is being shown in the development of mines at Sally Malay, Forrestania, Radio Hill and Bulong; interest has also been re-kindled in the 290 million tonne low-grade nickel deposit at Mt Keith.

Uranium Exploration

Exploration for uranium continued at a cost of about $15 million per annum in 1988. Western Australia's two largest uranium deposits, Yeelirrie and Kintyre, currently have combined U_3O_8 resources estimated to be worth over $2 500 million at current prices, and if the State's other known deposits are included Western Australia's total U_3O_8 resources amount to almost double this figure. Should there be a change in the Commonwealth Government's policy several of the Western Australian deposits might be developed into mines at relatively short notice.

Rare Earths and Minor Metals Exploration

Metallurgical tests have commenced on material from the Mt Weld rare earths deposit near Laverton. Reserves have recently been upgraded to 15.2 million tonnes grading 11.2% lanthanides and yttrium oxides at a 5% cut-off, or 1.31 million tonnes grading 23.6% at a 20% cut-off. The higher grade material would be competitive with heavy mineral sand products, and subject to satisfactory tests results and mining approvals etc, mining could commence in 1990 at a rate of up to 20 000 tonnes per annum. The phosphate potential of the Mt Weld deposit has been adversely affected by the appreciation of the Australian dollar, and plans for fertilizer production have been deferred.

The Brockman rare earth and polymetallic deposits, southeast of Halls Creek could commence production in 1991, subject to satisfactory metallurgical test results and subsequent feasibility study The main products will be zirconium, niobium and yttrium, and the plant will probably process 300 000 tonnes of ore per annum.

At Greenbushes, in the Southwest, production of spodumene concentrates has been increased to over 100 000 tonnes per annum, making this one of the largest lithium mining operations in the world. Extensive hard rock resources of 23 million tonnes are reported to occur, with zones of higher grade ore within the total figure.

Platinum-group element (PGE) exploration continued at a relatively high level of ativity in 1988, with some 40 companies holding prospects within

Western Australia. There are no immediate plans for development, but interesting intersections have been recorded from the Panton Sill and Lamboo Sill in the East Kimberley, the Munni Munni Complex in the West Pilbara and at Yarawindah Brook near New Norcia.

Coal Resources and Development Plans

CRA has reported coal resources of 700 million tonnes export quality steaming coal at Vasse River and about 450 million tonnes of steaming coal at Hill River. Detailed conceptual mine and power station plans for use of open-cut resources of 100 million tonnes of coal at Hill River have been completed; the power station would have four 250 MW generators operating for at least 30 years.

Plans are also well advanced for a possible new power station at Collie, using coal from ground held by Griffin and Western Collieries. South of Collie, exploration is continuing across the Wilga and Boyup Coalfields where resources are estimated to exceed 300 million tonnes.

TABLE 1

WA MINERAL PRODUCTION 1987/88

Commodity	Quantity	Value Aus $ M	% Value Change
Alumina	6.1 Mt	1 183.0	+8
Coal	3.7 Mt	151.0	+7
Diamond	30.2 Mcts	248.2	-13
Gold	90.5 t	1 843.8	+42
Iron Ore	95.2 Mt	1 867.2	-1
Mineral Beach Sand Concs			
Ilmenite*	1.1 Mt	133.9	+70
Leucoxene	11 Kt	4.6	-10
Monazite	10 Kt	7.0	-17
Rutile	85 Kt	51.2	+11
Zircon	367 Kt	97.1	+72
Nickel Concentrate+	389 Kt	391.7	+48
Petroleum Products			
Condensate	1 140.5 ML	169.9	+222
Crude Oil	1 932.6 ML	304.4	+16
Natural Gas	3 629.2 Mm^3	320.5	+15
Salt	5.5 Mt	107.2	0
Silver	12.7 t	2.3	+15
Tantalite Concentrate	133 t	5.7	+36
Tin Concentrate+	434 t	2.9	-41
Others	-	54.0	+43
		6 945.6	+17

*Includes reduced and upgraded ilmenite products

+Products are taken through to metal and/or matte forms by the operators prior to sale

TABLE 2

PRINCIPAL GOLD DEPOSITS COMMENCING PRODUCTION IN 1988

		Ore Reserve Mt	Grade g/t	Fine Gold kg pa
1.	Beasley Creek	2.10	2.0	1050(b)
2.	Bellevue (Underground)	1.39	8.6	2000
3.	Blue Funnel	0.99	3.1	480
4.	Bronco South	0.25	1.5	350(b)
5.	Caledonian	1.51	3.9	750(b)
6.	Callion	?	ca. 8.0	780
7.	Catherwood	0.33	4.1	?400(b)
8.	Comet	1.03	4.8	606
9.	Davyhurst-Gt Ophir	0.83	2.5	662
10.	Gibraltar (Yaloginda)	?	4.0	620
11.	Golden Kilometre	3.50	5.5	2560
12.	Golden Valley (Frasers)	1.00	ca. 6.0	ca.1000
13.	Hedges	8.00	2.1	3577
14.	Higginsville (Poseidon S)	1.50	2.5	1240
15.	Hopes Hill	4.35	2.4	2180
16.	Junction	10.00	3.2	1700(b,c,d)
17.	King of Creation - Craigiemore-Wedge	2.43	2.7	1350
18.	Kings Cross	0.09	3.1	266(s)
19.	King Solomon	0.07	2.3	157(s)
20.	Kohinoor	0.22	11.3	265
21.	Kundip	0.13	11.1	870
22.	Mt Corlac/Rona Lucil	0.94	2.6	?500(b)
23.	Mt Morgans	3.50	5.3	1280
24.	Parker Range	0.36	1.4	315(s)
25.	Peak Hill	3.00	3.5	1800
26.	Redeemer	3.80	3.5	2000(b,c)
27.	Scotia	1.30	7.0	?(b)
28.	Talbot	0.27	3.0	?(b)
29.	Transvaal	0.45	2.7	1500(b)
30.	Tuckabianna	4.21	3.1	1866
31.	White Flag	1.53	3.4	1244
32.	Wiluna West Lode	1.47	3.6	1000(b)
33.	Wombola	0.13	2.6	330

(b) Production bulked with that from other deposits, and consequently variable.

(c) 1988 production reflects mill capacity rather than mining rate.

(s) Small deposit, production figure approximates to total known reserves.

(d) Total additional annual production of new Kambalda-St Ives operations will be approximately 2200 kg pa.

TABLE 3

POSSIBLE GOLD PROJECTS, 1989

		Fine Gold kg pa
1.	Bannockburn	750
2.	Badgebup	680
3.	Baneygo-McKenzie Well-Reichelt Find	900
4.	Bayleys	1500
5.	Big Bell	ca. 5000
6.	Binduli	?
7.	Bounty	1840
8.	Brittania	(b)
9.	Bullabulling	1750
10.	Bulong	140
11.	Burbanks	?
12.	Carbine	?
13.	Central Norseman Tailings	?
14.	Darlot	1060
15.	Forrestania (Mt Holland etc)	1300
16.	Glendower/Evelyn Molly	640(s)
17.	Gold Hill	800
18.	Golden Dragon	?
19.	Golden Valley (Kanowna)	460
20.	Great Lady	230
21.	Gullewa (Monarch)	590
22.	Halcyon	620(b)
23.	Iron Stirrup	?
24.	Jasper Flat	?
25.	Johnson Range	400
26.	Kaltails	1400
27.	Kanowna Deep Leads	1250
28.	King of the Hills (Mt Edon)	900
29.	Labouchere	2500
30.	Lady Bountiful Extended	400
31.	Mossbecker	500
32.	Mt McClure	1200
33.	Murrin Murrin	200
34.	Panglo	1000
35.	Patricia-Jeans	600
36.	Randalls	480
37.	Revenge	(b)
38.	Riverina	500
39.	Rothsay	2000
40.	Three Mile Hill	1400
41.	West Black Flag	1000
42.	Wilgeena	190
43.	Wiluna North Lode	?400(b)
44.	Yaloginda (Romsey etc)	580
45.	Yundamindera	480

(b) Production bulked with that from other deposits, and consequently variable.

Northern Territory mining production 1988, and outlook 1989

C A Mulder

Department of Mines and Energy, Northern Territory

The gross value of minerals, oil and gas, produced in the Northern Territory during the financial year 1987-88 was $1 250 million, representing a 14.2 percent increase over the previous year and constituting about 17 percent of the Territory's total product.

Total expenditure on mineral exploration increased by 74 percent to $48.8 million.

The total value of minerals produced increased by 11 percent to $ 1 033 million and the total value of hydrocarbons rose by 32 percent to $ 217 million.

Uranium oxide - with a 33 percent share in the total mineral value produced - continued to be the most valuable commodity in the Northern Territory, followed by bauxite/alumina (32 percent), gold (20 percent), manganese (11 percent), zinc, lead, copper, tin, silver, and construction materials (4 percent).

The Ranger and Nabarlek mines in the Alligator Rivers region produced together 4 425 tonnes of uranium oxide, an increase of just 0.5 percent over the previous year. Ore stockpiles at Nabarlek have now been completely depleted but Queensland Mines is carrying out intensive exploration in project areas adjacent to the mine.
Energy Resources of Australia Ltd (ERA), the owners of the Ranger mine, have announced plans to increase the production of uranium oxide by 50 percent to 4 500 tonnes by the year 1991 and to 6 000 tonnes per year by 1992. ERA continued exploration in the mine project area and have now also published reserves of 22.1 million tonnes at an average grade of 0.3 percent U_30_8 for No 3 orebody.

The enormous combined reserves of uranium at Jabiluka and Koongarra remain undeveloped, as a result of the current "three-mine policy" of the Commonwealth Government. Uranerz Australia Pty Ltd is carrying out exploration in the western part of Arnhem Land after having reached an agreement with the Aboriginal Custodians.

Nabalco Pty Ltd produced from its mine on Gove Peninsula 5.7 million tonnes of bauxite in 1987-88, 3.5 million tonnes of which were further processed to extract 1.4 million tonnes of alumina. Bauxite production increased by 18.6 percent and the production of alumina remained the same compared to 1986-87. Current ore reserves are estimated at 177 million tonnes of bauxite.

Gold production increased by 38 percent to 10 426 kg. The most significant increase on exploration expenditure was on gold which increased in 1987-88 by 64 percent to $32.6 million. There were 13 operating mines, 8 in the Pine Creek Geosyncline, 3 in the Tennant Creek Inlier, and 2 in the Granites-Tanami Block. The largest individual producer was the Granites Mine with 2 729 kg, followed by Pine Creek Gold, (2 489 kg) and Cosmo Howley (885 kg). North Flinders Mines Ltd, the operators at The Granites mine, have recently made significant discoveries of more gold prospects in the area.

The Coronation Hill Joint Venture (CHJV) has established in the conservation zone of the Kakadu Stage 3 area 3.41 million tonnes of ore grading 5.58 g/t gold, 0.24 g/t platinum, and 0.82 g/t palladium. Subject to approval by relevant Government bodies and Aboriginal Custodians, construction work will start in July 1989 and processing of ore in January 1990. Expected initial annual production will be of the order of 1 500 kg gold, 30 kg platinum, and 26 kg palladium. CHJV has also been given permission by the Commonwealth Government to assess a new platinum and palladium prospect at El Sherana also located within the Conservation Zone.
Total demonstrated economic reserves of gold stand (as per Aug. 1988) at about 136 tonnes, valued at over $ 2.4 billion.

Production of 1.9 million tonnes of refined manganese by Gemco on Groote Eylandt represented a 23 percent increase over the previous year. The mine has reserves of 200 million tonnes of recoverable ore.

The Woodcutters Mine continued the production of lead and zinc concentrates and of silver. The mill has been upgraded and can now process a throughput of 180 000 tonnes of ore per year produced entirely from underground operations. An exploration program in the immediate mine area is underway to extend the open-ended orebody of 1 million tonnes of more than 20 percent combined lead-zinc and 140 g/t silver.

The Territory Government is still having negotiations with Mount Isa Mines Ltd in an effort to find ways to economically develop the huge zinc-lead-silver deposit at McArthur River.

Peko Mines produced over 1 500 tonnes of copper during the fiscal year 1987-88. The production of this element will return to a significant level when the Gecko mine in Tennant Creek re-opens sometime in the first half of 1989.

Reconnaissance exploration for diamonds in a broad east-west belt through the middle of the Territory remains at significant levels.

The outlook for the mining industry in the Northern Territory is indeed healthy. Uranium exploration around Nabarlek and in the Ranger Project Area is continuing. Gold exploration expenditure has more than doubled in 1987-88 and is likely to increase further. Exploration for gold in the Pine Creek Geosyncline and the Tennant Creek Inlier is intense and exploration results in the Alligator River region and in the Granites-Tanami Block prove very encouraging. There are eight gold projects in an advanced feasibility stage and four of these (Woolwonga, Coronation Hill, Arltunga, and Union Reef) are likely to be brought into production in 1989, or early next year.

The results of exploration at Coronation Hill have also shown that potential for economic deposits of platinum group elements exists.

Expected 50 percent increases in production capacity at Ranger (uranium) and Groote Eylandt (manganese) and the resumption of copper mining at Gecko will further boost the mineral product.

To help create an attractive investment climate for the mining industry, a bill containing over 100 amendments to the Mining Act 1982 is before the Legislative Assembly for debate. The new Act will make it easier to operate, through the removal of anomalies and red tape, and it will also result in quicker issuing of titles whilst also providing explorers and miners with a more secure title.

Protracted delays in acquiring access to land for exploration and mining form a major stumbling block to progress in mineral resource development. However, the NT Government is making every effort to alleviate these problems.

The positive results of negotiations between Aboriginal Custodians and North Flinders Mines (The Granites), Uranerz (Arnhem Land), Otter Exploration NL (Tanami), as well as the progress being made by the Tanami Joint Venture towards a negotiated agreement with the Central Land Council, may be taken by explorers as encouraging signs of improving access to Aboriginal Land.

Despite low oil prices, petroleum exploration in the Northern Territory and Administered Waters was at record levels during 1988. Of the 33 petroleum wells drilled 20 of these were offshore. Indications for the near future are that exploration for hydrocarbons will continue at this high level with at least, an average of 14 offshore petroleum wells per year being drilled for the next three years.

The major reason for such an exploration boom results from the recent success in the Timor Sea region where development of two fields is currently in progress. The combined production of the Jabiru Field and Challis Field, which comes on line in mid-1989, is estimated at approximately 80 000 BOPD. This, along with good hydrocarbon indications in Oliver-1, Montara-1, Skua-3, and Cassini-1 encouraged competitive bidding for permits in the Ashmore-Cartier Islands area during a recent bidding round. The award of these permits has provided a further boost to the continuity of exploration and development in the Timor Sea Region.

Future work in the Bonaparte and Arafura Basins is also expected to continue at an accelerated level. Permit areas with a similar rifted-margin setting as that of the Ashmore-Cartier Island region were taken up in 1988 and two new areas to the north of the Petrel field will be released in 1989.

Ongoing appraisals of the Petrel gas field produced encouraging results with an 800 000 m^3/day gas flow from the Petrel-4 well.
Upstream facilities such as a pipeline between the Petrel field and Darwin, a liquefied petroleum gas plant and new port facilities are currently under consideration.

The recent success in negotiations with the Indonesian Government over the disputed Timor Gap area should also prove beneficial to future exploration and development in the region.

Exploration onshore has predominately occurred in areas previously considered to have low potential due to the relative old age of the rocks. Ten exploration permits have been issued in the last two years in the Middle Proterozoic McArthur Basin, Late Proterozoic-Early Palaeozoic Georgina Basin and Early Palaeozoic Bonaparte Basin. Although no significant finds have been located in these areas to date, the structural and stratigraphic data obtained have provided invaluable facies information and new ideas on play concepts, allowing better exploration strategies to be utilized.

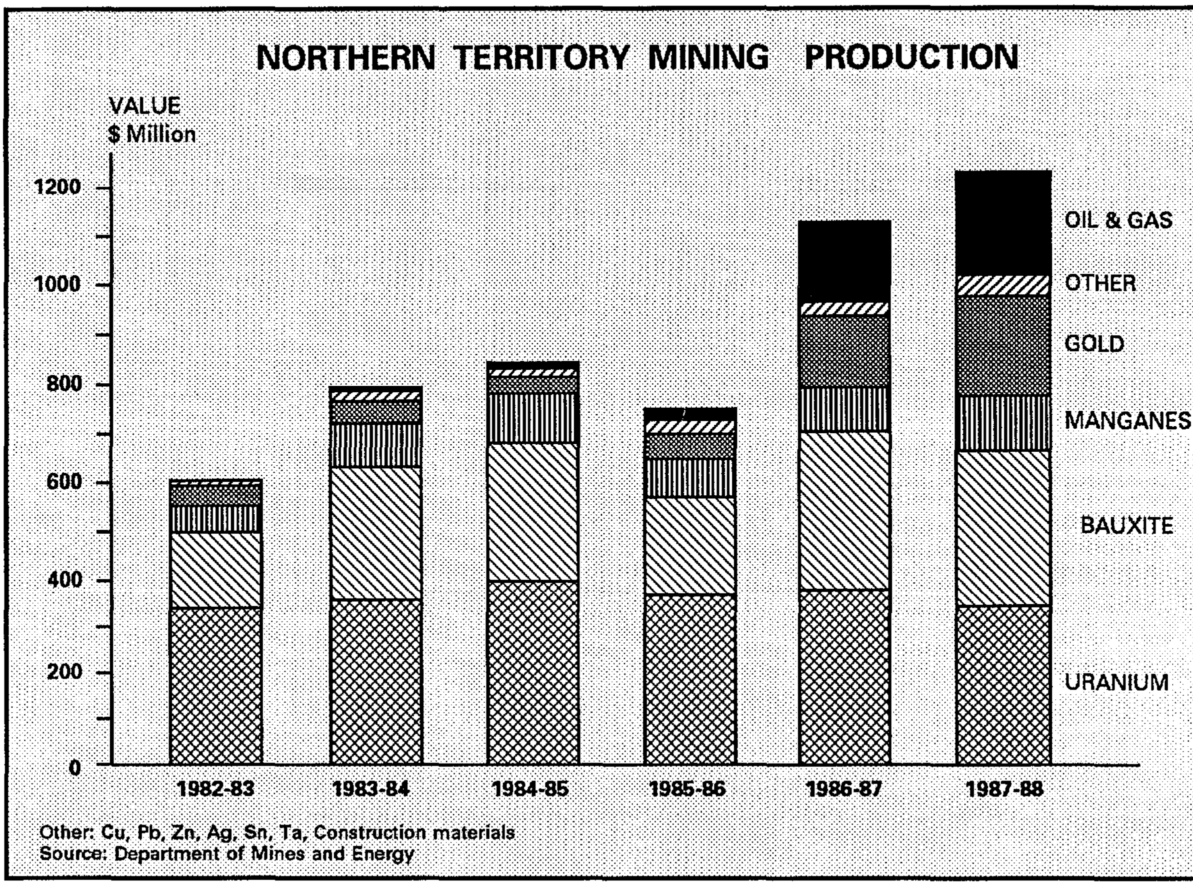
Onshore, the Palm Valley and Mereenie gas fields of the Amadeus Basin are in the forefront of development. The recent completion of the major gas pipeline from Alice Springs to Darwin has created new opportunities including:

i) 25 km spur line and gas fired power station for the Cosmo Howley mine.

ii) feasibility studies into the construction of a pipeline and station for the Gove area.

iii the supply of reticulated gas to business groups and new housing developments in the Darwin area.

Presently an investigation is being conducted into the running of a pipeline between Alice Springs and Moomba. This would have the potential of linking both the Amadeus and the Bonaparte gas reserves with the rest of Australia.



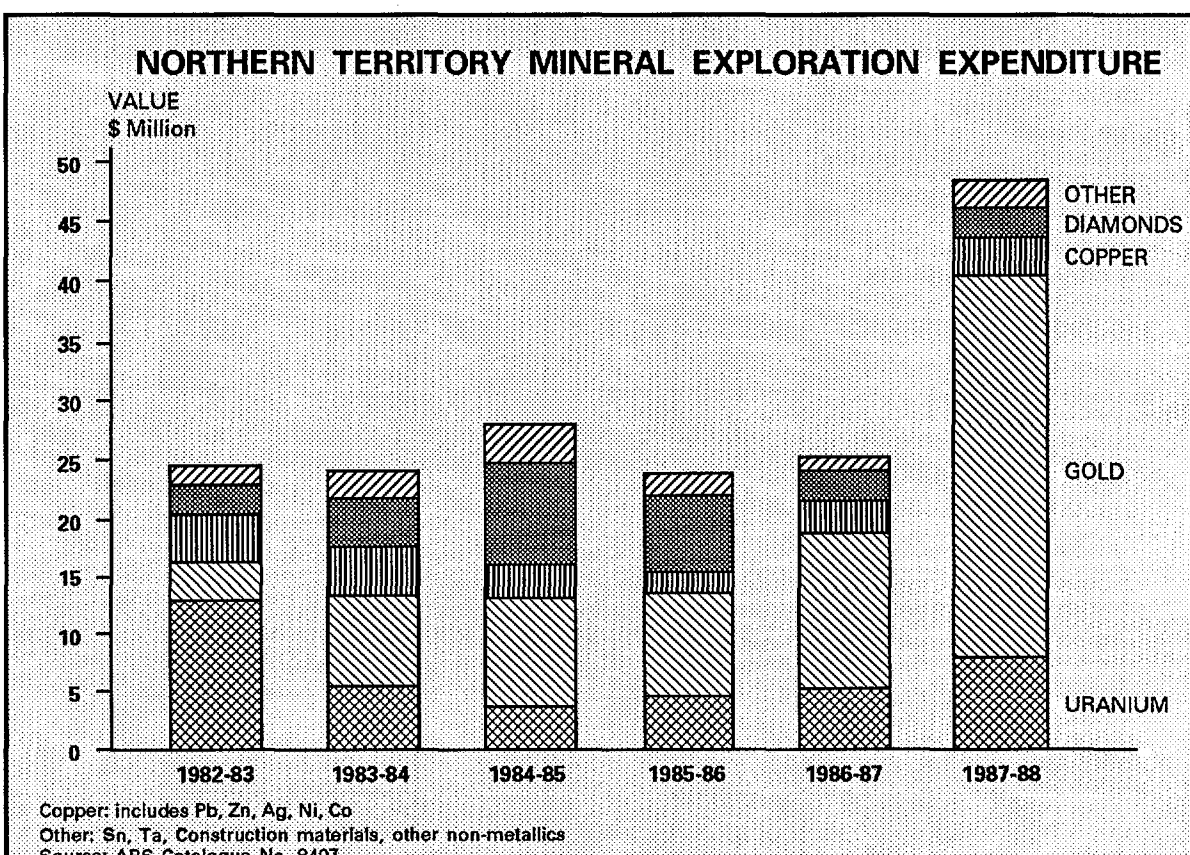


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Figure 1

MINES AND MINERAL PROSPECTS IN THE NORTHERN TERRITORY

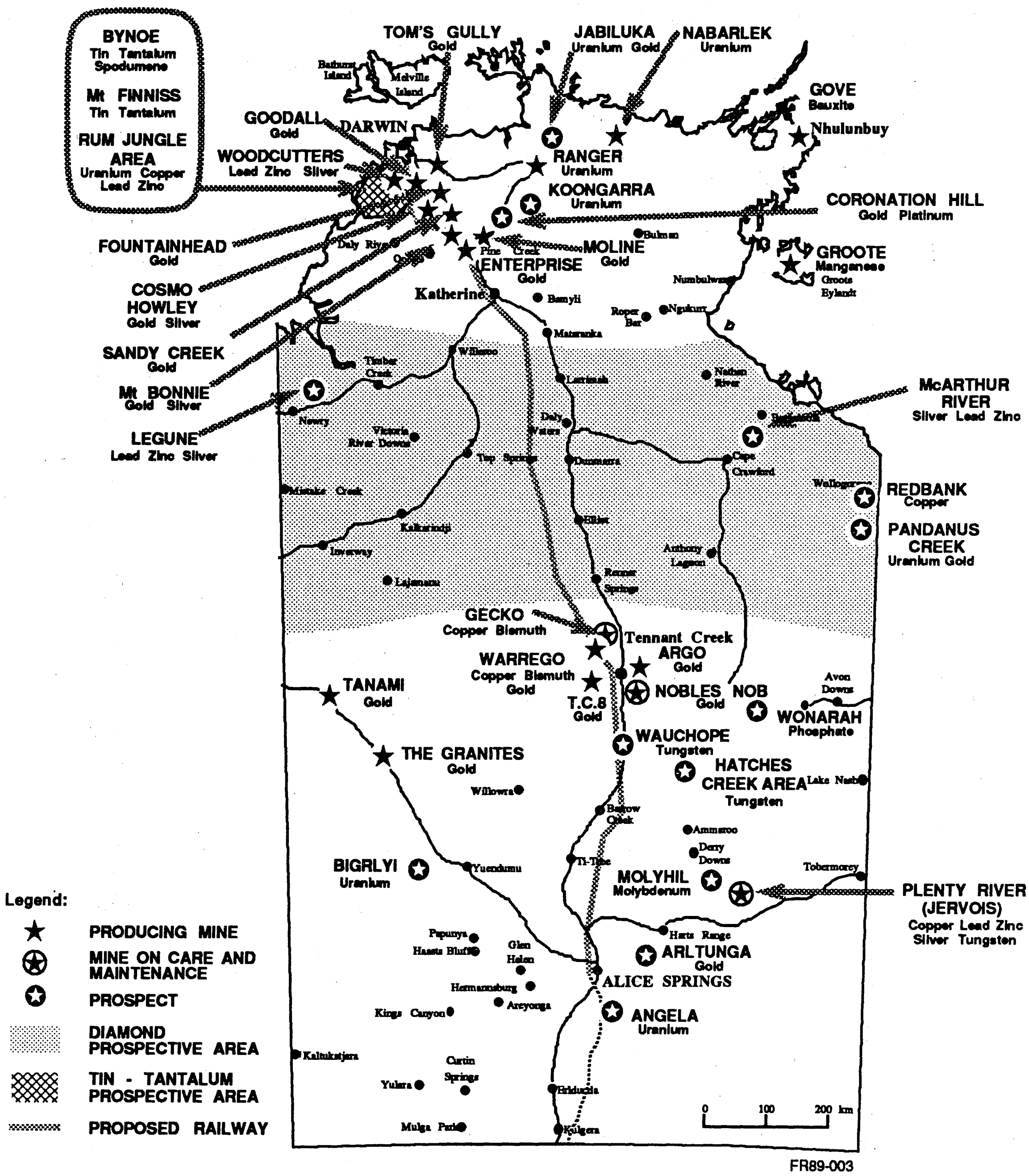


Figure 2

OIL AND GAS FIELDS IN NORTHERN TERRITORY AND ADJACENT AREAS

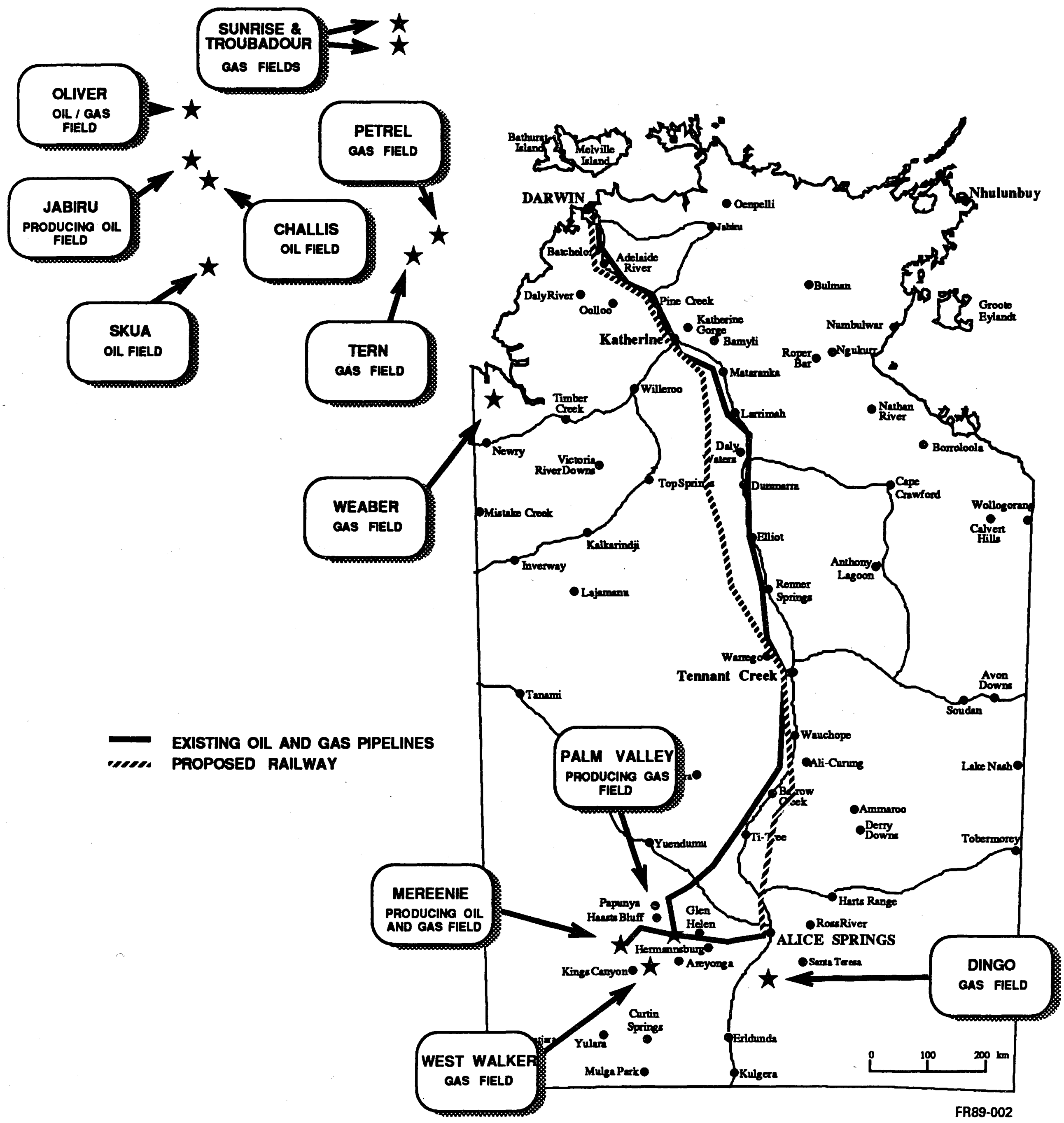
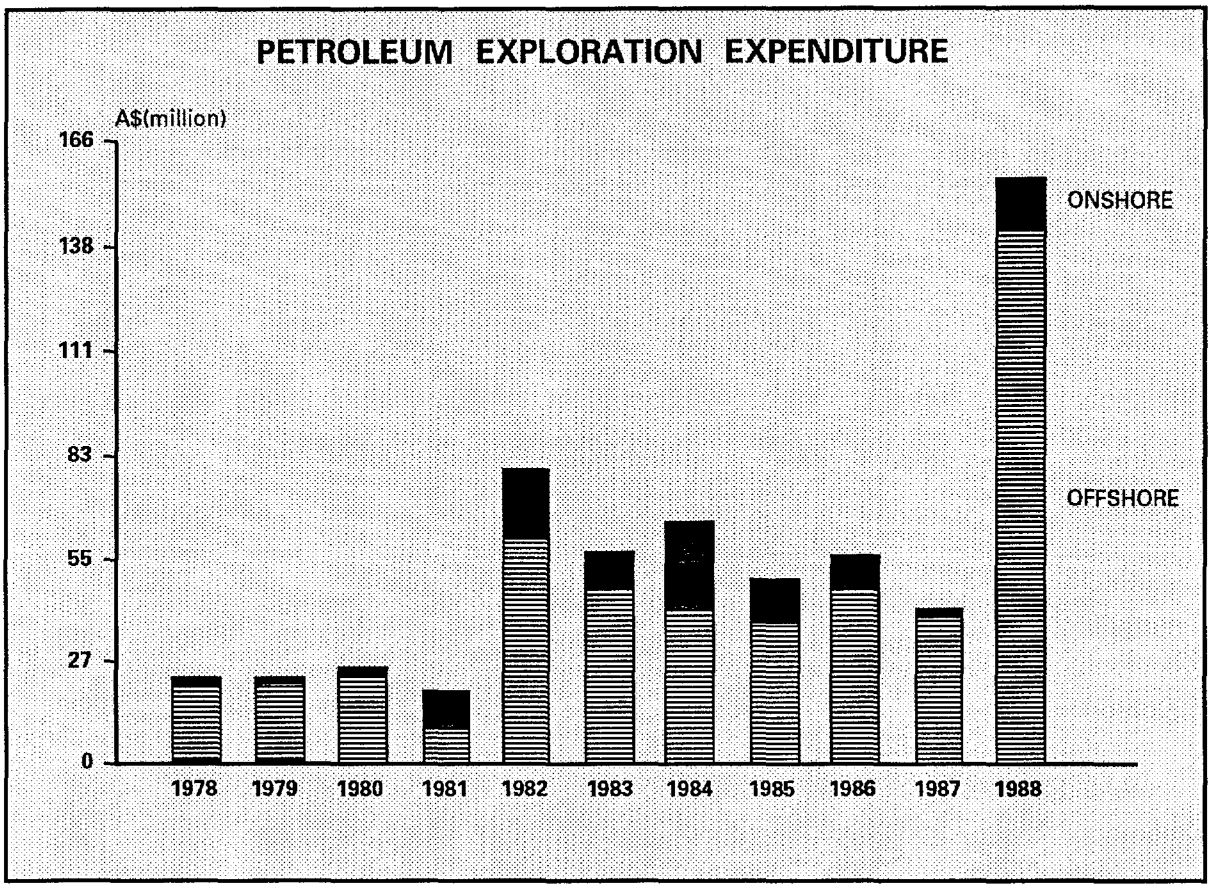


Figure 3



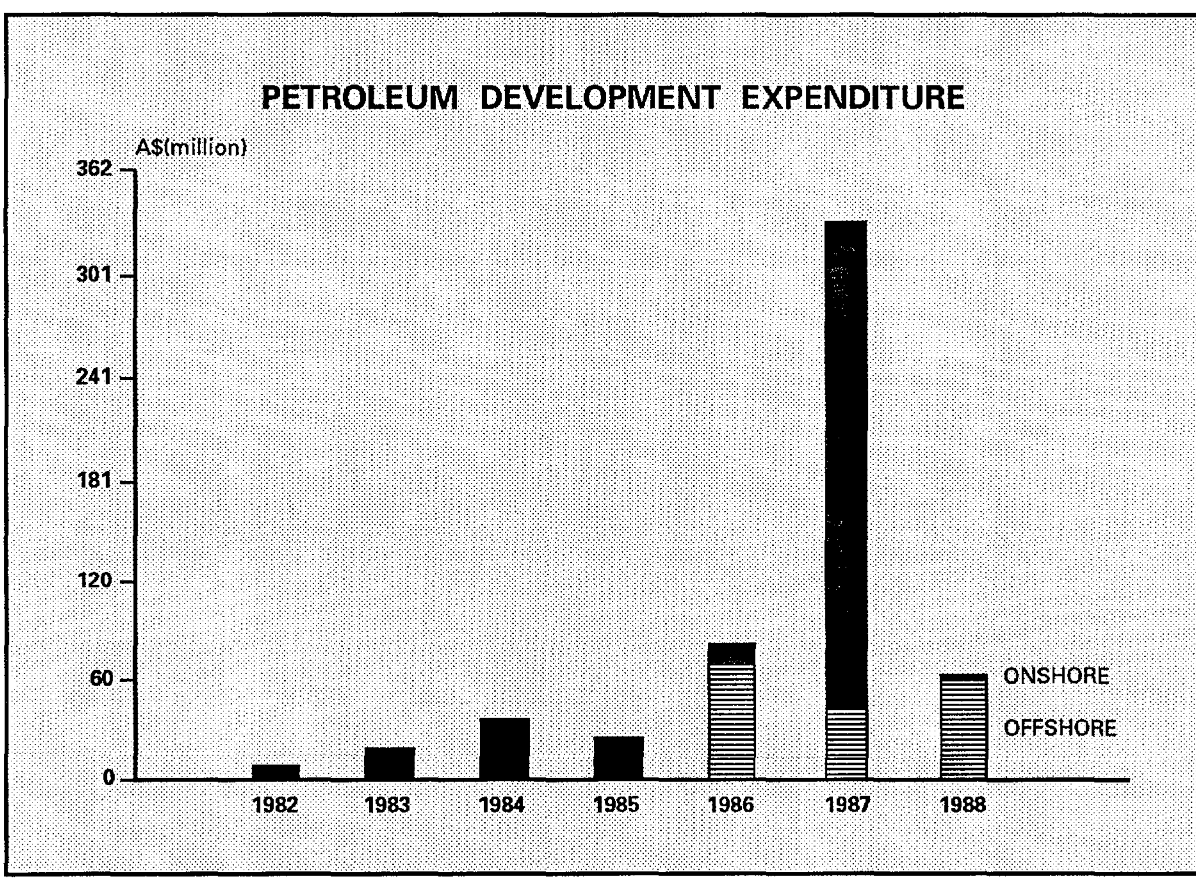


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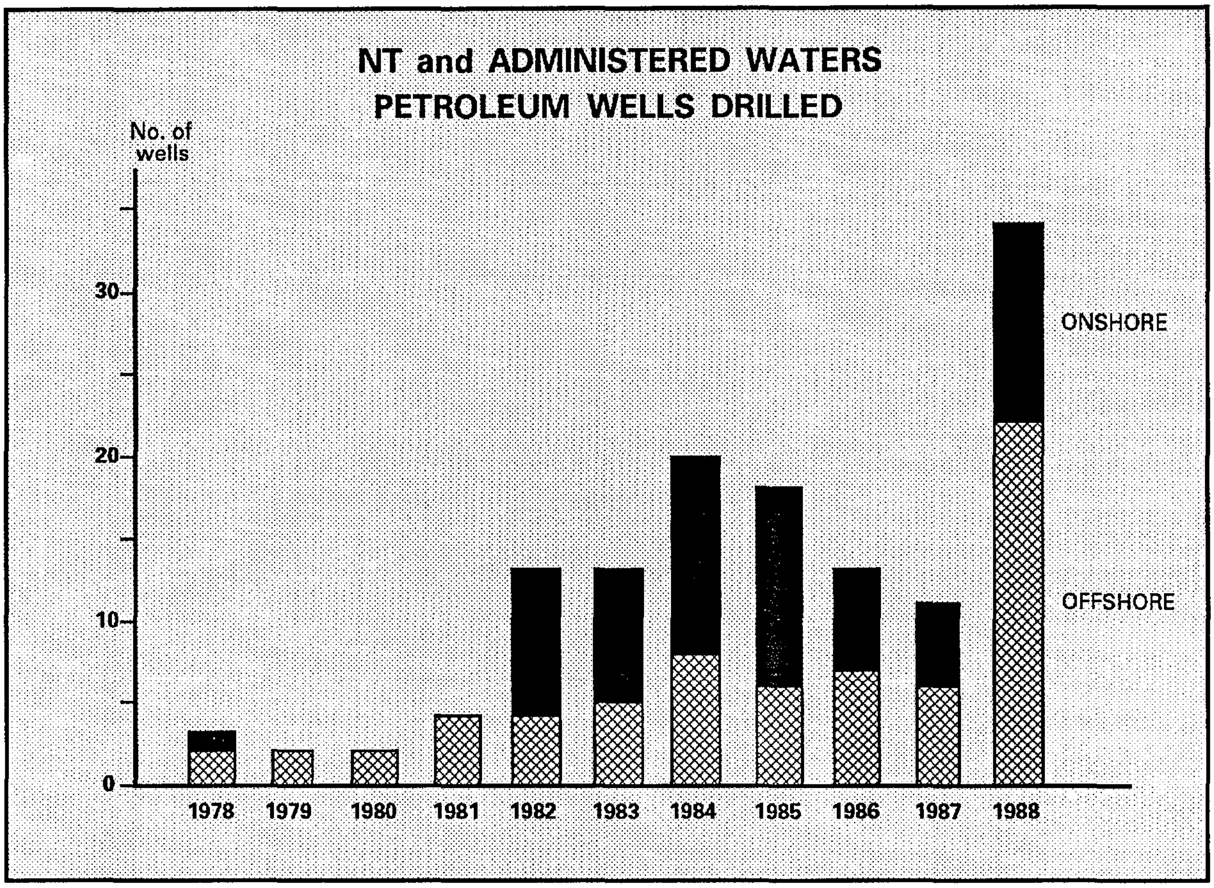
Figure 4


NT and ADMINISTERED WATERS
PETROLEUM WELLS DRILLED
No. of wells
30
20
10
0
ONSHORE
OFFSHORE
1978
1979
1980
1981
1982
1983
1984
1985
1986
1987
1988

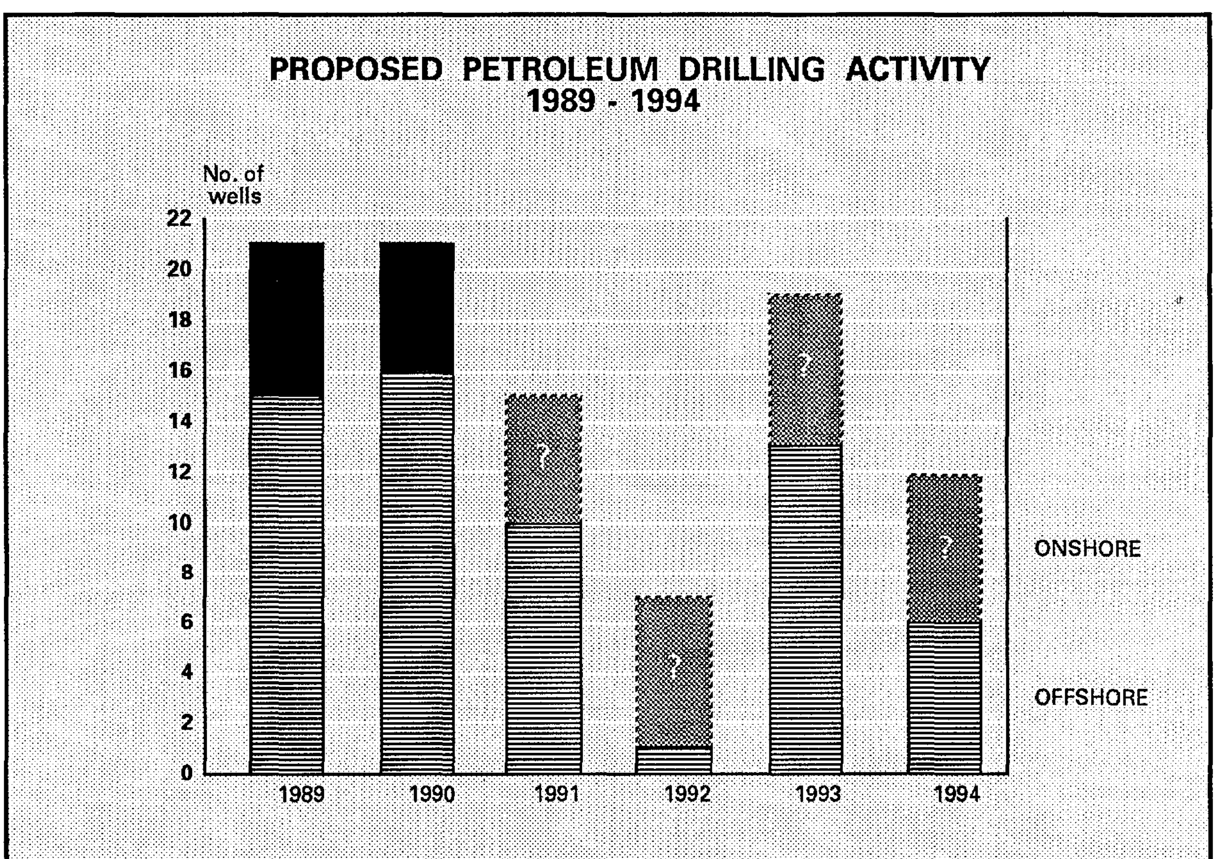

PROPOSED PETROLEUM DRILLING ACTIVITY
1989 - 1994
No. of wells
22
20
18
16
14
12
10
8
6
4
2
0
?
?
?
?
ONSHORE
OFFSHORE
1989
1990
1991
1992
1993
1994
FR89-001

Figure 5

Table 1 Northern Territory Gold Production and Reserves

Mine	Operator	Production 1987-88 (grams)	Demonstrated Reserves Tonnes ore	Av. Grade (g/t)	Gold (kg)
The Granites	North Flinders Ltd	2,729,157	2,280,000	6.18	14,090
Pine Creek	Pine Creek Goldfields Ltd	2,489,234	10,600,000	2.17	28,620
Warrego (incl. Argo)	Peko Wallsend Ltd	1,229,525	5,100,000	1.00	5,100
Cosmo Howley	Dominion Gold Ops Pty Ltd	885,000	2,230,000	2.23	4,973
TC8	Cuprex Ltd	746,217		NA	
Tanami Gold	Harlock Pty Ltd	687,974	1,550,000	1.50	2,325
Nobles Nob	Australian Development Ltd	651,017	280,000	22.00	6,160
Mt Bonnie	Zapopan Consolidated NL	365,570	90,000	3.50	315
Moline	Pacific Goldmines	267,572	2,300,000	3.13	7,199
Goodall	Western Mining	98,940	4,300,000	2.40	10,320
Fountainhead	Zapopan Consolidated NL	96,943	2,250,000	0.74	1,665
Small Producers		73,968		NA	
Chinese Howley	Metana Minerals NL	63,855	2,520,000	0.09	226
Sandy Creek	Territory Resources NL	41,459	1,548,000	0.72	1,114
	Total Production:	**10,426,431**			
Jabiluka	Pancontinental Mining Ltd	-	1,100,000	10.70	11,770
Tom's Gully	Carpentaria Gold Pty Ltd	-	450,000	6.70	3,015
Woolwonga	Dominion Gold Ops Pty Ltd	-	2,110,000	2.78	5,866
Coronation Hill	BHP Minerals Ltd	-	4,850,000	4.31	20,903
Howley Alluvial	Metana Minerals NL	-	3,900,000	0.60	2,340
White Range	White Range Gold	-	465,000	6.00	2,736
Union Reef	Mineral Horizons NL	-	1,900,000	1.69	3,211
Peko Tailings	Peko Wallsend Ltd	-	3,400,000	1.20	4,080
					136,028

Note:
Production is over fiscal year 1987-88
Demonstrated reserves are as at Aug. 1988

Table 2 Northern Territory - Metal mineral production and reserves, other than gold

Mine	Commodity	Proved Ore Reserves	Average Grade	Production 1987-88
Ranger	Uranium	10.5Mt	0.3 % U_3O_8	3274 t U_3O_8
		22.1 Mt (probable)	0.3 % U_3O_8	
		3.2 Mt (possible)	0.3 % U_3O_8	
Nabarlek	Uranium	Stockpiles exhausted	-	1151 t U_3O_8
Jabiluka	Uranium	53.26 Mt	0.39 % U_3O_8	-
	Gold	1.1 Mt	10.7 g/t	-
Koongarra	Uranium	3.55 Mt	0.346 % U_3O_8	-
Coronation Hill	Gold	3.41 Mt (proven	5.58 g/t Au	-
	Platinium	and probable)	0.24 g/t Pt	-
	Palladium		0.82 g/t Pd	-
Nabalco	Bauxite	250 Mt	51 % Al_2O_3	5.7 Mt 3.5 Mt bauxite used to produce 1.4 Mt alumina
Gemco	Manganese	197 Mt	50 % Mn	1.9 Mt manganese concentrate
Woodcutter	Lead	1 Mt	7.1 % Pb	22,950 t Pb-conc.
	Zinc		14.4 % Zn	36,089 t Zn-conc.
	Silver		140 g/t Ag	1.2 t Silver
McArthur River	Zinc-Lead-Silver	227 Mt	9.2 % Zn	-
			4.1 % Pb	-
			41 g/t Ag	-
Gecko	Copper	Not available		-

Some economic effects of declining Australian oil production

Barry Naughten, Lindsay Hogan & Barry Jones

Australian Bureau of Agricultural and Resource Economics

Crude oil has been, and is expected to remain, a major source of Australia's primary energy. Until 25 years ago, Australia was totally dependent on imports for its crude oil requirements. However, since the discovery and development of the Bass Strait oil fields in the 1960s, domestic crude oil production has provided the major share of Australia's requirements.

Australian production peaked in 1985-86 and is likely to continue to fall over the 1990s (Department of Primary Industries and Energy 1988). With Australian demand for petroleum products expected to rise over the 1990s, the growing shortfall in domestic crude oil supplies will need to be met by substantially increased oil imports.

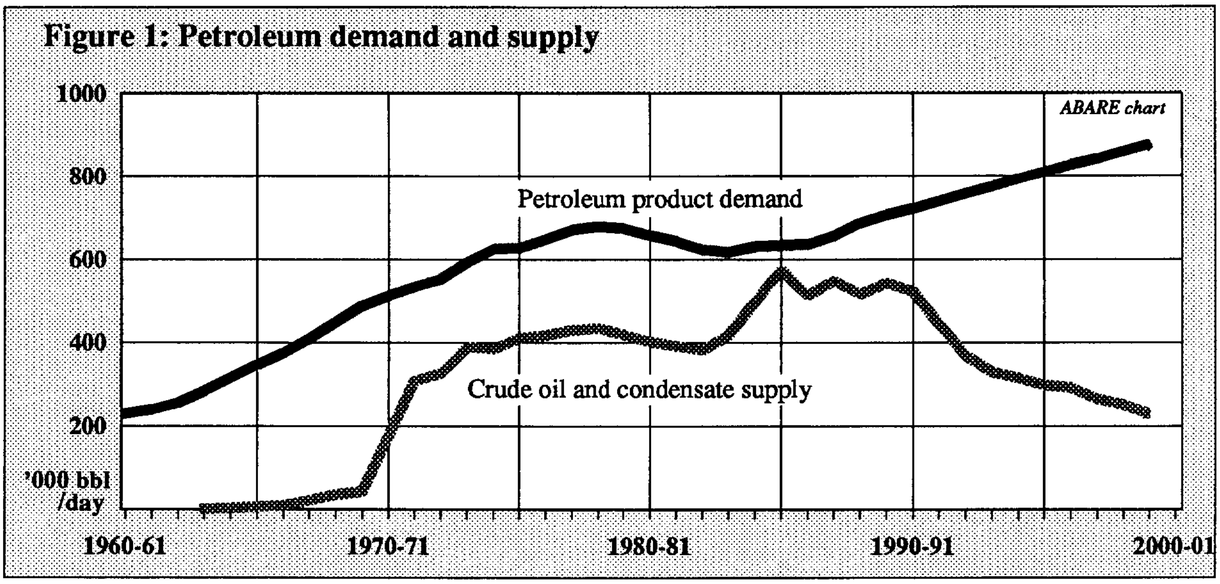
The development of the domestic crude oil industry since the 1960s has had a major impact on the Australian economy. In particular, economic growth has been higher than it would otherwise have been, in some years adding as much as half of one per cent a year to annual growth in gross domestic product (Folie and Ulph 1981, p.94). The expected decline in production will similarly have an impact on the economy. In addition to effects on economic growth, declining oil production will adversely affect Australia's trade and debt position at a time when reduction of our large current account deficit and stabilisation of the foreign debt burden are key objectives of macroeconomic policy. The oil industry argues that these effects could be decreased by reducing taxation of the oil industry to encourage domestic crude oil exploration and production (Orchison 1988; Esso Australia Ltd 1988).

This paper provides an outline of the macroeconomic implications of the decline in crude oil production and an indication of the size of the effect on the economy, with particular attention given to the problem of the external balance. Although detailed consideration of issues relating to the forms and level of taxes on oil production are outside the scope of this paper, it is clear that reductions in oil industry taxation will have implications beyond the industry. We briefly consider how these may affect macroeconomic policy objectives, including external rebalancing.

The Australian Oil Market: 1960-2000

. Supply

The pattern of liquid petroleum supply and demand in Australia from 1960-61 to 1999-2000 is illustrated in figure 1. Prior to the mid-1960s, Australia relied almost totally on imported crude oil. However, since the discovery and development of the Bass Strait fields in the middle to late 1960s, Australian crude oil production has accounted for a large share of domestic requirements, peaking over the period 1984-85 to 1986-87. Bass Strait has been the major oil producing area, accounting for about 88 per cent of total



crude oil production in Australia (Australian Minerals and Energy Council 1987).

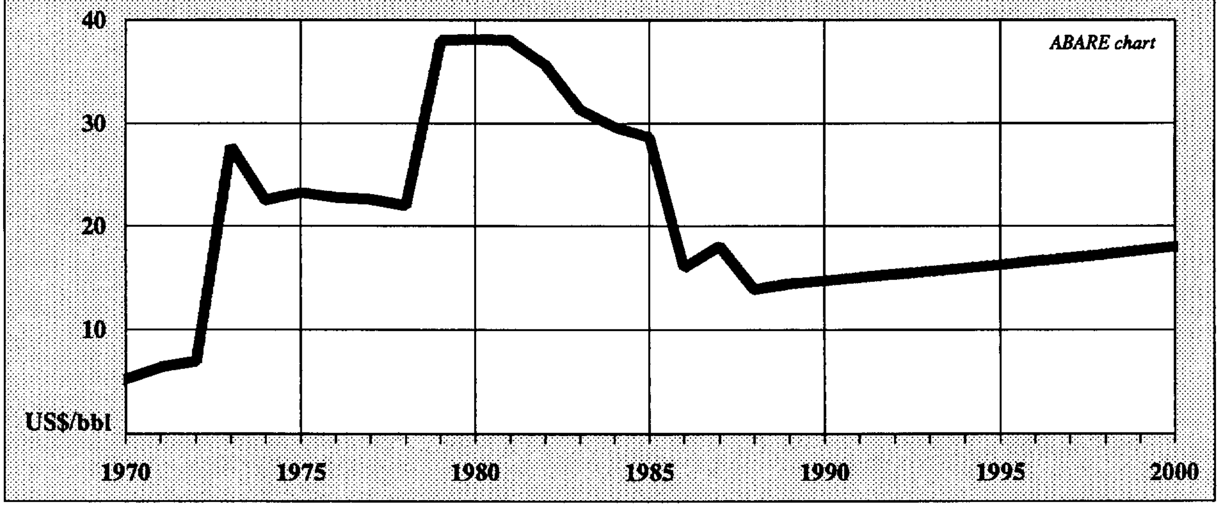
As the large Bass Strait fields are depleted, Australia's crude oil production is projected to decline steadily from its peak of 199 million barrels in 1985-86 to about 79 million barrels in 2000 (ABARE 1989). This outlook includes forecasts of production from currently producing fields, plus the possible contribution from both identified but undeveloped fields and as yet undiscovered petroleum resources assessed as having a 50 per cent probability of occurrence.

. Price

The price of crude oil relative to prices of other products, particularly manufactured goods, fluctuated widely between the early 1970s and the mid-1980s. Real oil prices increased by over 300 per cent during 1973-74 and by a further 200 per cent during 1979-80 (figure 2). As a consequence, crude oil exploration and production in non-OPEC countries increased markedly and growth in world oil consumption moderated. There were increased efforts both to gain efficiencies in the use of crude oil and to substitute alternative energy sources for crude oil, placing downward pressure on prices. During the first half of the 1980s, OPEC oil production was reduced significantly to support price levels. In late 1985, OPEC announced it would defend an (unspecified) market share rather than price. As a result, real oil prices declined by over 50 per cent during the first half of 1986 and have remained relatively weak since that time.

The price of crude oil, denominated in US dollars, averaged less than US$14 a barrel in 1988, and is projected by ABARE to rise only gradually to US$18 by 2000. This projection is well below the levels of the late 1970s and early 1980s in real terms. The trend reflects a moderate projected increase in world consumption of petroleum products and a forecast decline in non-OPEC crude oil production as a proportion of world requirements (excluding centrally planned economies).

Figure 2: World real oil price



In Australia, the adoption in 1975 of import parity pricing, whereby domestic oil prices are based on the cost of imported oil of a similar quality, together with the sharp rises in international oil price in the 1970s, resulted in a moderation of the use of petroleum products (figure 1). This was most apparent following the second oil price shock. Overall, the importance of crude oil in Australia's total energy use has declined significantly, from over 50 per cent in the 1970s to 39 per cent in 1985-86.

. <u>Imports and self-sufficiency</u>

Taking into account projected changes in both real income and real oil prices, domestic demand for petroleum products is expected to increase at an annual rate of about 2.2 per cent over the 1990s. The demand for refinery feedstock is projected to rise at around 2.0 per cent a year. The consequent growing excess of domestic demand over domestic supply of crude oil will be satisfied through increased net imports. Net petroleum imports are assumed to rise from 9 million barrels in 1985-86 to about 200 million barrels in 2000. This implies that Australia's self-sufficiency will fall from 96 per cent in 1985-86 to around 28 per cent in 2000. The cost of net imports of crude oil in 2000 is forecast to be about $4900m (in 1988 Australian dollars). This compares with a crude oil net import bill of $500m in 1988.

Although Australia's level of crude oil self-sufficiency is expected to decline rapidly over the remainder of the century, it should be noted that levels of oil self-sufficiency in themselves exhibit little relationship to economic performance. Figure 3 shows that self-sufficiency levels in some major industrialised countries vary widely both between countries and over time. There is no obvious link between levels of self-sufficiency and national economic performance. While rapid changes in self-sufficiency levels, as have occurred in Australia and the United Kingdom in recent years and as is projected for Australia in the next decade, do have substantial economic impacts in terms of adjusting to changing circumstances, the cases of the Federal Republic of Germany and Japan demonstrate that strong economic growth can be sustained with very low levels of indigenous oil production.

Figure 3: International oil self-sufficiency ratios

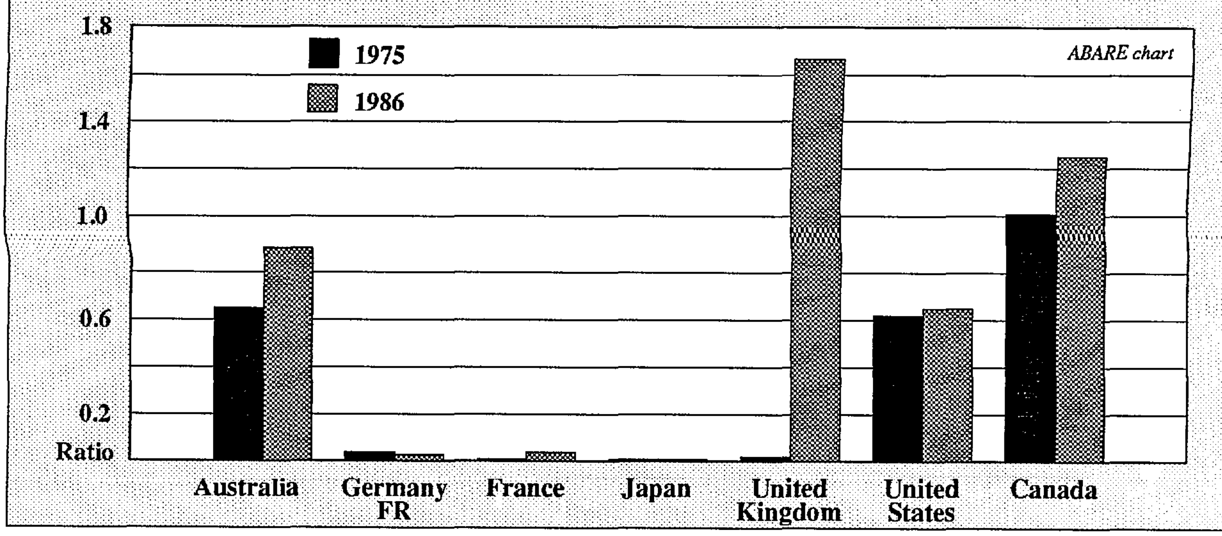


Figure 4: Australia's current account deficit as a share of gross domestic product

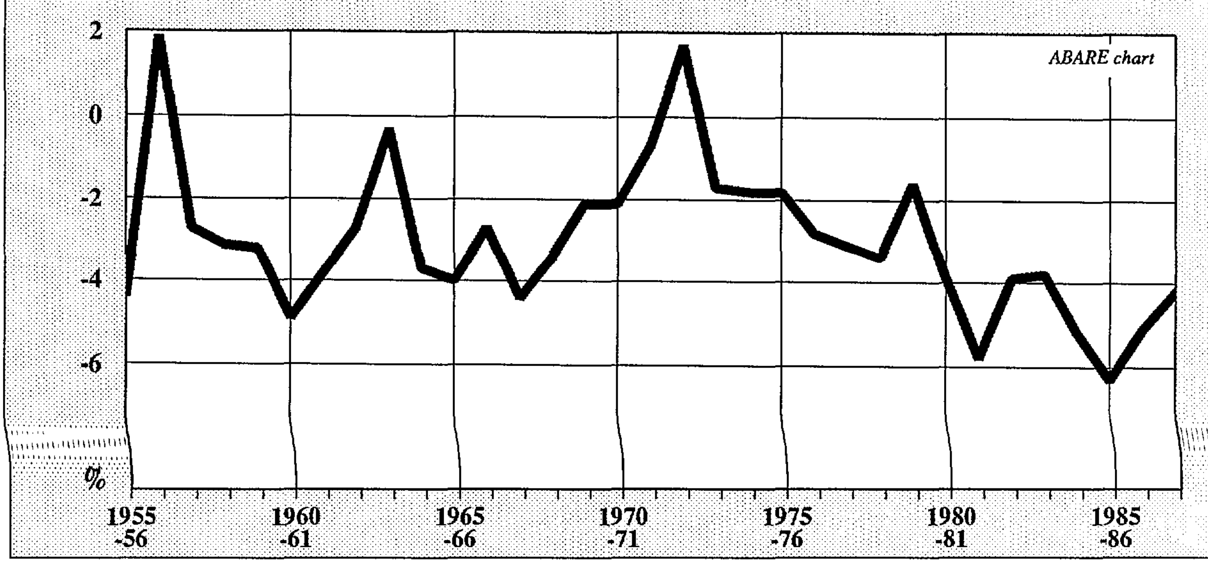
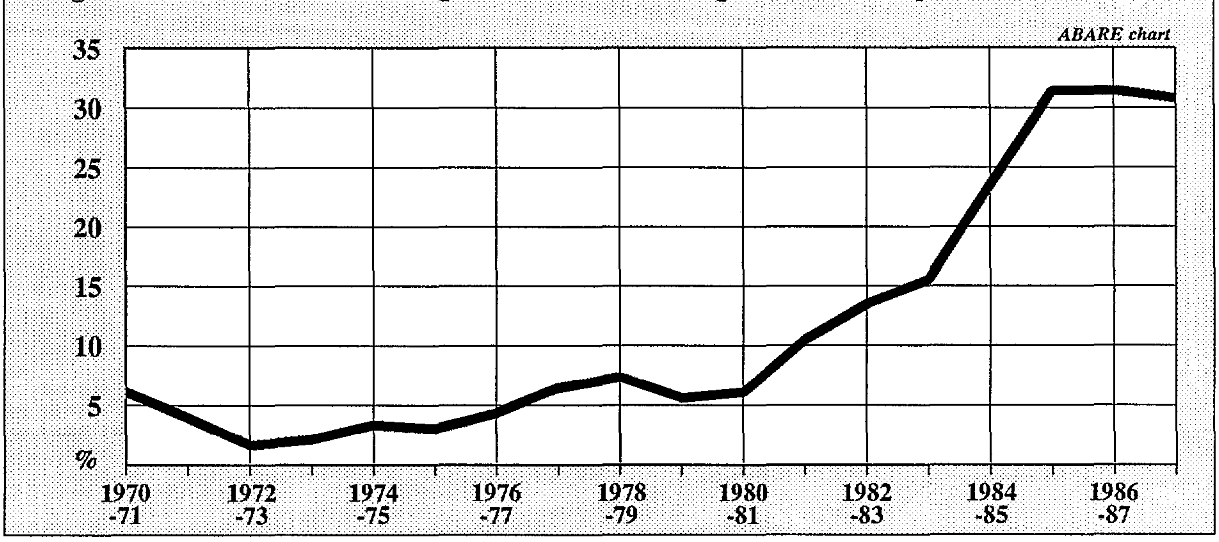


Figure 5: Australia's net foreign debt as a share of gross domestic product



Australia's Current Account Deficit

A major feature of the Australian macroeconomic environment during the 1980s has been the emergence of an historically large current account deficit, peaking at 6 per cent of gross domestic product in 1985-86 (figure 4). This contrasts with an average of 2 per cent between 1960-61 and 1979-80. The current account deficit as a share of gross domestic product has declined since 1985-86. It is estimated to be 4 per cent of gross domestic product in 1988-89 (Hogan, Thorpe and Kirby 1989).

Australia's net foreign debt as a share of gross domestic product has also increased significantly, from 6 per cent in 1980-81 to nearly 32 per cent in 1986-87 (figure 5). This rise largely reflects the strong net capital inflows of recent years (equal in magnitude to the current account deficits) and a sharp increase in the share of capital in the form of debt, rather than equity, financing. The proportion of debt financing in Australia's net capital inflow has increased from about 40 per cent in the 1970s to an average of over 75 per cent in the 1980s.

Since much of Australia's debt is denominated in foreign currencies, the substantial depreciation of the Australian dollar between late 1984 and mid-1986 also contributed to the rise in net foreign debt. The appreciation of the Australian dollar since mid-1986 resulted in a slight fall in the ratio of net foreign debt to gross domestic product to around 30 per cent in 1987-88.

The reduction of the current account deficit to a level consistent with a stabilisation or gradual decline in Australia's net foreign debt is an important objective of economic policy. Such a current account deficit is likely to be of the general order of magnitude of 1-2 per cent of gross domestic product (Hogan, Thorpe and Kirby 1989). To achieve this, the trade balance will need to be somewhat stronger than occurred historically to offset the rise in the net income deficit associated with the increased costs of servicing Australia's foreign debt. This medium term objective of economic policy is well recognised in the debate on the future of the Australian oil market (Australian Minerals and Energy Council 1987).

The increase in crude oil imports resulting from declining crude oil production will, other things being equal, add to Australia's current account deficit. The value of imports of crude oil and condensate in the year 2000 is forecast to represent about 7 per cent of the total value of exports of goods and services. While this is considerably higher than the proportion in recent years, the recent experience is historically atypical (table 1). For example, in 1960, before the start of indigenous oil production, crude oil imports represented 9.3 per cent of total exports of goods and services and at the oil price peak around 1980 the proportion had been as high as 5.4 per cent.

Increasing crude oil imports will also reduce the net contribution of the energy and mineral resources sector to total exports. However, the significant expansion of the resources sector since the early 1960s and the expected further growth in exports to 2000 means that when increased oil imports are taken into account the contribution of net minerals and energy exports will still be much greater than during the 1960s (table 1).

The major economywide effects of the depletion of Australian crude oil supplies can be analysed using both conceptual and quantitative models of the economy. Here, a simple conceptual model will be outlined first. Some

Table 1: OIL, ENERGY AND RESOURCE SECTOR EXPORTS AS PROPORTIONS OF TOTAL EXPORTS OF GOODS AND SERVICES

	Crude oil		Energy		Total resource sector	
Year	Gross imports	Net exports	Excl. net oil exports	Incl. net oil exports	Excl. net oil exports	Incl. net oil exports
	%	%	%	%	%	%
1960	-9.3	-9.3	0.5	-8.8	8.8	-0.5
1970	-5.9	-5.9	3.7	-2.2	26.1	20.2
1975	-4.8	-4.8	7.4	2.6	32.4	27.6
1980	-5.4	-5.4	14.6	9.2	29.5	24.1
1988	-2.5	-0.8	11.3	10.6	35.3	34.5
1992	-3.8	-2.7	10.9	8.2	36.8	34.1
2000	-7.0	-6.5	14.0	7.4	35.5	29.0

Sources: Norton and Garmston (1984); Australian Bureau of Agricultural and Resource Economics.

indicative results from two simple quantitative models are then presented. More detailed analysis is outside the scope of this paper, but forms the basis for work in progress.

Theoretical Analysis of the Economywide Effects of an Oil Boom and Decline

The general equilibrium model developed by Swan (1955) and Salter (1959) is the simplest such model that can be used to analyse the economywide effects of declining crude oil production for a small open economy such as Australia's. It also provides a useful framework for analysing Australia's current account deficit. The medium to long term adjustments required in response to a change in the economy are emphasised in the model. Monetary considerations are ignored in the model; however, such considerations are relatively more important in the short term.

An outline of the Swan/Salter model and its application to Australia's recent and prospective macroeconomic environment, particularly with reference to the large current account deficit, is given in O'Mara (1988). The model distinguishes two classes of goods and services - traded (import competing and exports) and non-traded (most services). The key relative price in the model is the price of non-traded goods relative to the price of traded goods: that is, the real exchange rate. A fall in the relative price of non-traded goods is a real exchange rate depreciation.

Since the model originated as a mode of analysing a small economy such as Australia's, it is assumed that the terms of trade - that is, the price of exports relative to the price of imports - is determined in the world economy. It is due to this simplifying assumption that export and import competing goods can be treated together as belonging to the traded goods sector. In the model, inputs (such as labour) flow between the traded and non-traded goods sectors in response to changes in the real exchange rate. Domestic demand for each class of goods is assumed to be determined by aggregate domestic demand and the real exchange rate.

The Swan/Salter model has formed the theoretical basis for several studies of a resources sector boom (see, for example, Corden and Neary 1982; Neary and van Wijnbergen 1985). In this paper, however, the emphasis of the analysis is on the decline of an industry, rather than a boom.

The Swan/Salter model indicates that the discovery and exploitation of a natural resource such as crude oil (a traded good) leads to an appreciation of the real exchange rate and a fall in the output from other export and import competing industries to a level below that which would otherwise have occurred. This is the phenomenon known as the 'Gregory effect' or 'Dutch disease'. In the Australian case, for example, a mineral boom is postulated to lead to a contraction of the agricultural sector and the rest of the mining sector. In an economy with a relatively large manufacturing sector, a contraction of this sector (sometimes referred to as 'deindustrialisation'), is another possible important effect (Gregory 1976; Snape 1977; Corden and Neary 1982; Neary and van Wijnbergen 1986). However, despite this contraction elsewhere, national income is higher as a result of the exploitation of the natural resource.

The direction of adjustment of the economy to declining domestic crude oil production and increasing net oil imports is basically the reverse of the adjustment to an increase in crude oil supplies. Relative to what it would otherwise be, the productive capacity of the economy declines and total national income decreases. As a result of a decline in domestic expenditure associated with declining income from oil, there arises an excess supply of (deficiency of demand for) non-traded goods. Given that the price of traded sector goods is by assumption fixed (in foreign currency terms) there is a consequent fall in the price of non-traded goods relative to traded goods. That is, there is a real depreciation of the exchange rate. This relative price change eliminates the excess supply of non-traded goods, releasing inputs to the traded goods sector, which expands. This tends to reduce any existing trade deficit by both import substitution and export expansion. The above mechanism depends on domestic expenditure declining in line with the reduced income available from oil production. If this does not happen, an external deficit will occur or an existing deficit will be exacerbated.

Implications of Declining Crude Oil Production for the Australian Economy

An industry detailed, economywide model is required to identify the effects on particular industries of the decline in crude oil production. However, some indication of the extent of the broad economic effects resulting from declining oil production can be gained by using much simpler quantitative models consistent with the above theoretical framework. Two such models have been used. First, an expanded and updated version of a model developed by Folie and Ulph (1979) was used to investigate the extent to which the real exchange rate adjusts to an increased oil import bill. Second, a model developed by EPAC (1986, 1988) was used to quantify the impact on the growth in gross domestic product in the medium term when external rebalancing is a primary policy objective and when a decline in net oil trade is considerable.

The extent of the required real depreciation is sensitive to assumptions made about factors such as future indigenous oil production, world oil prices and domestic oil demand growth. The depreciation could be expected to lead to an expansion of the other traded goods industries. It would also increase the domestic price of crude oil, thus depressing demand, stimulating exploration and improving the economic viability of alternative or synthetic fuels, with the end result of some increase in self-sufficiency. Such second-round effects obviously need to be considered in detailed modelling of the effects of declining oil production. Some indication of the size of the effects can be gained by using simple models.

Table 2 gives an indication of the size of the depreciation required under a wide range of assumptions about oil prices, future oil production, petroleum demand and the response of the export sector to the depreciation. The model used to obtain these results is along the lines of that used by Folie and Ulph (1979, p.89). The notion involved is straightforward: an increase in oil imports in excess of a base year proportion will tend to cause a trade deficit. The indicated real depreciation is that required to restore the trade balance through its effect on the values of imports (negative) and exports (positive). The model indicates a real depreciation of 7.6 per cent is required over the period to 2000 in a case incorporating the Bureau's base case assumptions for oil prices, production and domestic demand growth but in which only a modest response from the tradeable sector is assumed: specifically, that there is an induced decline in imports but no enhancement to exports. Allowing for a modest response from aggregate exports of goods and services to the lower value of the Australian dollar reduces the apparent required depreciation by about 2 percentage points, to 5.4 per cent.

If we take into account not only the increased oil imports but also the partially offsetting forecast increases over the period to 2000 in exports of other petroleum and energy related commodities, the apparently required real depreciation is reduced further, to around 0.5 per cent in the base case.

There is another reason for broadening the perspective to encompass a wider range of energy related commodities. Changes in the world price of oil will also affect the value of exports of other energy commodities. For example, higher world crude oil prices will increase Australia's oil import bill, despite some induced decline in demand and a possible increase in supply. However, such a price rise will also increase the value, and possibly the volume, of exports of liquefied natural gas (LNG), steaming coal and other forms of energy because of the link between the price of oil and other energy forms and the possible substitution by consumers away from higher priced oil. This offsetting increase in energy exports will reduce the depreciation required as a result of the oil price increase.

The effect of declining oil production on the medium term problem of external rebalancing can also be modelled simply, to provide some indicative results. For this purpose, a small quantitative model developed by the Economic Planning Advisory Council (1986, 1988) has been used. This model is addressed explicitly to the medium term rebalancing problem and includes an important adjustment role for both domestic expenditure and the real exchange rate. Given a trade balance target (in this case as at 1991-92), the model indicates the permissible rate of growth in gross national expenditure where imports and exports are assumed to be influenced by given rates of real depreciation and a given 'underlying' growth rate is assumed for exports. Two cases were examined: the actual case, in which declining net oil trade is included in aggregate exports, and the hypothetical case in which the underlying growth in exports reflects no decline in net oil exports from its historically high value at the commencement of the period of analysis (1986-87).

Table 2: DEPRECIATION DUE TO DECLINING CRUDE OIL PRODUCTION REQUIRED OVER THE PERIOD 1988-2000(a)

Assumptions	Energy commodities included: Crude oil and condensate	Total petroleum	All energy commodities
	%	%	%
Base case(b)	5.4	3.8	0.5
Variations			
Export elasticity zero	7.6	5.2	0.6
Export elasticity 1.3	2.8	1.9	0.3
World crude oil price $A5 a barrel higher(c)			
- price transfer, petroleum only	5.9	3.8	0.5
- price transfer, all energy	5.9	3.8	-0.3
Slower GDP growth(d)	5.0	3.2	-1.1
Lower petroleum demand(e)	4.8	3.2	0.1
Higher oil production(f)	3.7	2.1	-0.7

(a) The formula used to derive the required depreciation is given by:

$$1+d_t = [1+(m_t-m_b)]^{1/a}$$

where d_t is the required depreciation; a is the combined elasticity of import and export responses to a change in the real exchange rate = 0.8 + 0.3 = 1.1; m_t is the proportion of crude oil imports in total imports in 2000 = 0.070; m_b is the proportion of crude oil imports in total imports in the base year (1987-88) = 0.026. (b) Average economic growth of 3 per cent a year; average Australian crude oil import prices of US$17.50 (1988 dollars) in 2000; crude oil production declines to 79 million barrels by 2000; net crude oil imports rise to 204 million barrels by 2000; price elasticity of demand for aggregate imports of goods and services = 0.8; price elasticity of demand for aggregate exports of goods and services (terms of trade corrected) = 0.3. (c) The two cases presented here assume that higher prices for crude oil will mean higher prices for other forms of energy. The first case assumes that only prices for other forms of petroleum rise; the second assumes that coal prices rise as well. (d) Assumes economic growth for Australia is half of that in the base case from 1992 onwards. (e) Assumes petroleum product demand growth of half that in the base case from 1992 onwards. (f) Assumes crude oil production of 129 million barrels by 2000.

Using the model, it was found that the rate of feasible growth in gross domestic product from 1986-87 to 1991-92 was reduced by about one half of a percentage point a year by the increase in oil imports forecast over the period. This is a rough indicator of the size of the loss in national income caused by the decline in oil production expected over that period.

General versus Oil Industry Specific Adjustment Mechanisms and Policy Responses

The foregoing consideration of the consequences of oil industry contraction illustrates the operation of general adjustment mechanisms. These will in general have policy implications. For example, fiscal policy has an obvious role in restraining expenditure consistent with the fall in national income resulting from the decline in oil production. To achieve an appropriate adjustment to the real exchange rate, there may also be an important role for incomes policy, as has been seen in recent years (the Prices and Incomes Accord). Of the recent analyses of oil industry contraction, Ulph and Folie (1981) concluded in favour of such general adjustment mechanisms rather than policy interventions directed at the oil industry in an attempt to restrain the rate of decline in oil self-sufficiency. Their position was that general mechanisms minimise the burden of adjustment by spreading it across the economy (1981, p.87).

A more rigorous argument along these lines is provided by Corden under the heading of the 'theory of domestic divergences' (1980, p.9). The implication of the argument is that oil industry specific policies, for example a tariff on oil imports, could be justified where government had adopted a policy of oil self-sufficiency. However, while such an objective was more widely countenanced ten years ago, at a time when there was much greater concern about OPEC's share of world oil production and the consequent risk of physical supply shortages, it has negligible support today, either from government (Department of Primary Industries and Energy 1988, para. 5.28) or industry (McGill 1986, p.37). Given the rejection of a self-sufficiency objective, economic theory suggests that oil or energy industry specific policies are only warranted where there is evidence of the market failing to provide the necessary signals for the efficient allocation of resources.

Despite these considerations in favour of general mechanisms of adjustment, some studies of the economywide consequences of Australian oil industry contraction have concluded in favour of oil (or energy) industry specific assistance. Brain and Schuyers (1981, p.272) concluded in favour of energy industry specific responses on the basis of premises which included the view that the real exchange rate is relatively ineffective as a mechanism of general adjustment. The National Institute of Economic and Industry Research (cited in Australian Minerals and Energy Council 1987, pp.22-6) supports this view on the ineffectiveness of the real exchange rate as a general mechanism of adjustment, although its view on the relative merits of general versus energy industry specific adjustments is less clear cut.

The primary concern in this paper is with the economywide consequences of oil industry contraction, including those for employment and the current account. Even if oil industry contraction is a major contributor to external account pressures, it does not follow that intervention in this industry is appropriate in the absence of an oil self-sufficiency objective or of evidence of market failure. This conclusion is independent of the view taken on the effectiveness of the real exchange rate mechanism (in the light of relevant elasticities and the context of external debt) for two reasons. First, there are other general adjustment mechanisms. Second, industry specific interventions, if required, may be more effectively directed to industries other than oil. Even if there is evidence of market failure in the oil or energy industries, it is still necessary to consider the full range of effects of the proposed remedies, including their economywide effects.

Indeed, the effects of oil industry specific measures could damage the achievement of macroeconomic objectives. For example, concessions or assistance to a particular traded goods industry, such as the oil industry, could put upward pressure on gross national expenditure, thereby jeopardising the attainment of external balance; they could also put upward pressure on the real exchange rate or require increased taxes elsewhere in the economy, thereby penalising other traded goods industries. In either case, the economy may not be operating at its full productive capacity.

The need to improve our understanding of such issues provides some of the motivation for the use of more industry detailed, economywide models. This will also enable identification of those industries that will gain and those that will lose as a result of oil industry decline, taking into account the general adjustment mechanisms brought about by the decline.

Concluding Comments

The Australian economy has benefited from the indigenous production of crude oil which commenced in the 1960s and peaked in the mid-1980s. Both national income and domestic expenditure have increased more rapidly than they would otherwise have done. To the extent that the real income accruing from the increase in domestic crude oil production has been invested rather than consumed, the productive capacity of the Australian economy is now greater than it would otherwise have been.

The forecast continuing decline in crude oil production over at least the period to 2000 will retard growth in national income. There has for some years been a debate in Australia over the best mechanisms to adjust to this situation, with some analysts and commentators favouring general adjustment mechanisms and others advocating measures specific to the oil or energy industries. These arguments must be evaluated against the current central economic policy concern to reduce the current account deficit to a level consistent with the stabilisation or gradual decline of Australia's net foreign debt.

Given that it is the balance of payments effect of increased oil imports which is of prime concern, the appropriate policy response would appear to have to be directed to that objective and not the oil industry. Theoretical analysis suggests policy responses to facilitate general adjustment: notably a restraint of domestic expenditure to match the decline in oil revenue and possibly measures in support of real exchange rate adjustment, such as through incomes policy. Any microeconomic policy affecting the oil industry, including taxation and property rights allocation, must take into account any evidence of market failure, and the community's ownership of the resource. However, given the size and importance of the industry in determining macroeconomic outcomes, attention must also be paid to the economywide impact of these measures.

References

ABARE (Australian Bureau of Agricultural and Resource Economics) (1989), 1989 Outlook for Australian Mineral Resource Exports to 2000, AGPS, Canberra.

Australian Minerals and Energy Council (1987), Report of the Working Group on Alternative Fuels, AGPS, Canberra.

Brain, P.J. and Schuyers, G.P. (1981), Energy and the Australian Economy, Longman Cheshire, Melbourne.

Corden, W.M. (1980) 'Trade Policy and Economic Welfare,' Oxford University Press.

___ and Neary, J.P. (1982), 'Booming sector and de-industrialisation in a small open economy', Economic Journal 92(December), 825-48.

Department of Primary Industries and Energy (1988), Energy 2000: A National Energy Policy Paper, AGPS, Canberra.

Economic Planning Advisory Council, (1986), External Balance and Economic Growth, Council Paper No. 26, Office of EPAC, October.

___ (1988), Australia's Medium Term Growth Potential, Council Paper No. 30, Office of EPAC, March.

Esso Australia Ltd (1988), When Will the Wells Run Dry?, Sydney (booklet).

Folie, G.M. and Ulph, A.M. (1979), Self-Sufficiency in Oil: An Economic Perspective on Possible Australian Policies, CAER Paper No. 6, University of New South Wales, Sydney.

Gregory, R.G. (1976), 'Some implications of the growth of the mineral sector', Australian Journal of Agricultural Economics 20(2), 71-91.

Hogan, L., Thorpe, S. and Kirby, M. (1989), Australian and world macroeconomic developments and prospects. ABARE paper presented at the National Minerals and Energy Outlook Conference, Canberra, 15-16 March.

McGill, S. (1986), Transcript of comments in Energy 2000 Conference Proceedings, Canberra, 3-4 September, pp.36-7.

Neary, J.P. and van Wijnbergen, S. (1986), 'Natural resources and the macroeconomy: a theoretical framework', Natural Resources and the Macroeconomy, Basil Blackwell, Oxford.

Norton, W.E. and Garmston, P.M. (1984), Australian Economic Statistics, 1949-50 to 1982-83: I Tables, Reserve Bank of Australia, Occasional Paper No. 84, Sydney.

O'Mara, L.P. (1988), Exchange rates and agriculture: a macroeconomic view from down under! ABARE paper presented at the December 1988 meeting of the International Agricultural Trade Research Consortium, San Antonio, Texas, 14-16 December.

Orchison, K. (1988), Facing the crude reality of falling liquid fuel self-sufficiency. APEA (Australian Petroleum Exploration Association) address to a luncheon meeting of the Committee for the Economic Development of Australia, Brisbane, 9 May.

Salter, W.E.G. (1959), 'Internal and external balance: the role of price and expenditure effects', Economic Record 35(71), 226-38.

Snape, R.H. (1977), 'Effects of mineral development on the economy', Australian Journal of Agricultural Economics 21(3), 147-56.

Swan, T. (1955), 'Longer run problems of the balance of payments' in H.W. Arndt and W.M. Corden (eds.) (1963), The Australian Economy: A Volume of Readings, Cheshire, Melbourne, pp.284-95.

Ulph, A.M. and Folie, G.M. (1981), 'An economic analysis of oil self-sufficiency in Australia', Journal of Business Administration 12 (Spring) 1-25 (reprinted in P.J. Lloyd (ed.) (1984), Mineral Economics in Australia, George Allen and Unwin, Sydney.)

Australia's gas supply and demand to the year 2030

P N Greenhalgh & J C M Jones

The Australian Gas Association

1. INTRODUCTION

Of particular interest to the gas industry and its customers are continuity of natural gas supplies and their cost. Like other utilities and public services, planning of gas supply requires a long term view, not only to provide a basis for the industry to initiate the necessarily large, long lead time investments in facilities and infrastructure, but also to provide a basis for the industry's customers, both existing and potential, to evaluate the competing sources of energy and to plan their investments accordingly.

It is against this background that The Australian Gas Association (AGA) maintains a continuing review of natural gas supply and demand in Australia. The most recent study results were released in October 1988 (references 1 and 2) updating the previous reports released in 1985.

This paper highlights some of the principal features of the 1988 review of supply and demand and identifies some associated policy issues.

The time frame of the review is out to 2030, although the most important gas supply investments are likely to be required over the period 2000 - 2015.

2. DEMAND FOR NATURAL GAS

In 1987-88, natural gas accounted for some 17% of Australia's primary energy demand, compared with 45.5% for coal and 38% for petroleum products.

2.1 Approach to Forecasting

A "base" forecast of natural gas demand to 2010 was obtained from gas utilities on the basis of:

- average growth rate of the GDP of 2% pa; and
- constant real prices for competing fuels and electricity.

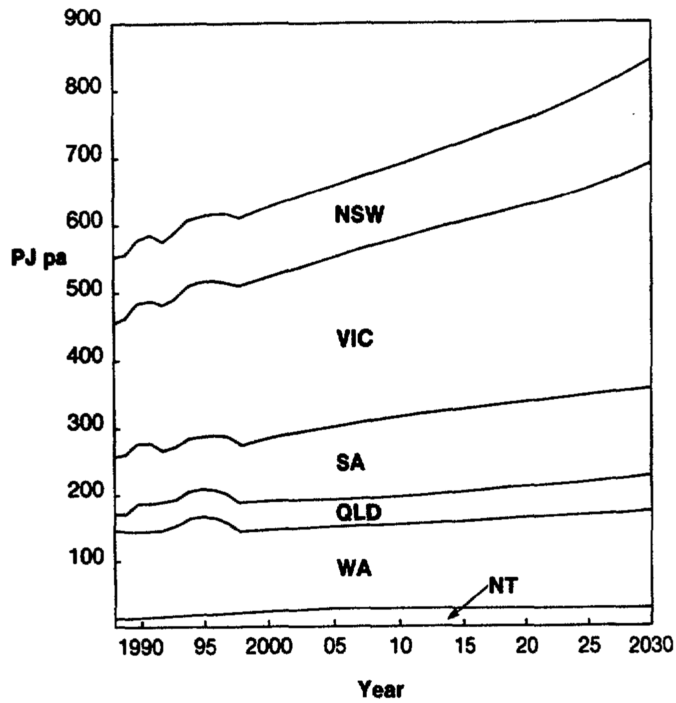
An "adjusted base forecast" was then developed to correspond more realistically to an expected increasing trend in real gas prices, assumed for study purposes as 1% pa from 1990 onwards. The adjustment was made to accord to a price elasticity of about -0.8 applied to domestic, commercial and industrial demand. Demand by bulk customers, ie those having individual contracts with suppliers, was assumed to be unaffected by this price effect.

Beyond 2010, it was assumed that:

- residential demand would grow at 1% pa;
- commercial/industrial demand would grow at 2% pa; and
- there would be no growth in bulk demand.

The adjusted base forecast out to 2030 is displayed in Figure 1.

FIGURE 1: ADJUSTED BASE FORECAST OF DEMAND FOR NATURAL GAS



Source: The Australian Gas Association

2.2 Possible Additional Demands for Gas

The adjusted base forecast does not include any new major markets for gas. Three of these possible future markets are discussed below.

- Natural Gas Vehicles - NGV's

  The most promising applications of NGV's are large trucks and urban buses. Work by the National Institute of Industrial and Economic Research, commissioned by the AGA, suggests that up to 70 PJ pa of natural gas in compressed or liquefied form could be used by NGV's by 2000.

- Development of Further Major Petrochemical Plants

  Gas can be used as feedstock in the production of chemicals such as methanol, ammonia and urea. Such industries are already major users of natural gas in Australia. A typical plant to meet export requirements would use up to 20 PJ of gas per annum.

- Power Generation

  Notwithstanding the higher cost of natural gas as a fuel compared with coal, generation of electricity using gas turbines has some significant offsetting advantages. These may be summarised as follows.

GAS TURBINE	V	COAL/STEAM TURBINE
. Lower captial cost		. Higher captial cost
. Higher fuel cost		. Lower fuel cost
. Quick start-up		. Slow start-up
. Short construction		. Long construction
. Small increments		. Large increments

It is likely that up to 300 PJ pa of fuel would be required for new generating plant by 2010 to replace plant at the end of its economic life and to accommodate continued modest growth. This demand would be met by either coal (in steam turbine stations) or by natural gas fuelled gas turbines. Either method has similar thermodynamic efficiencies. An estimated build up to such a demand from New South Wales, Victoria and South Australia is shown in Table 1.

TABLE 1: POSSIBLE MARKET FOR FUEL FOR NEW POWER STATIONS OPERATIONAL FROM 2005.

	FUEL REQUIREMENTS, PJ		
YEAR	NSW	VIC	SA
2005	-	110	11
6	-	130	13
7	18	142	14
8	72	153	16
9	114	160	17
10	120	160	20

Source: The Australian Gas Association.

3. SUPPLY OF NATURAL GAS

3.1 Sources of Supply

Table 2 displays the most recent information on proved and probable gas reserves issued by the Bureau of Mineral Resources. It shows that Australia has over 85,000 PJ of gas reserves which, with the highest of the demand forecasts and currently envisaged exports of LNG, would be sufficient to 2050 and beyond. The only difficulty would be the remoteness of over 80% of the reserves, in the North West, from the major demand centres in the southern and eastern States (Figure 2).

TABLE 2: AUSTRALIAN PROVED AND PROBABLE RESERVES OF SALES NATURAL GAS.

BASIN	PROVED AND PROBABLE RESERVES, PJ (a)
Adavale	23
Amadeus (b)	385
Amadeus & Bonaparte (c)	351
Bass	301
Bonaparte (b)	4,492
Bowen	244
Browse	24,448
Carnarvon	42,438
Cooper/Eromanga	3,851
Gippsland	9,240
Otway	18
Perth	195
Surat	73
TOTAL	86,059

Notes:

(a) Proved and probable, being the sum categories of 1 and 2 by the traditional petroleum industry classification.
(b) Category 2 only.
(c) Category 1 only.

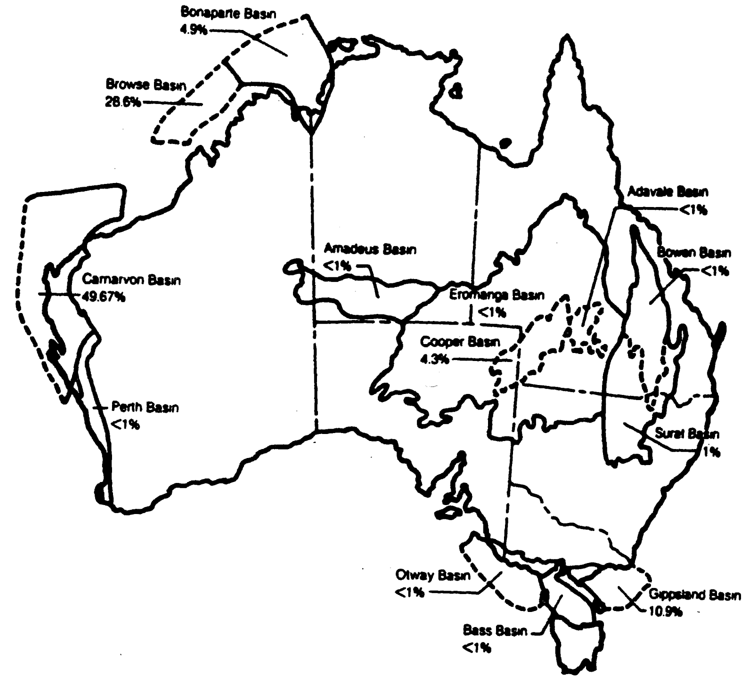
Source: Bureau of Mineral Resources, Geology & Geophysics, Australia's Petroleum Reserves & Resources as at 31 December 1987, August 1988.

3.2 Pipelines

Australia already has a number of long pipelines carrying gas from remote sources to capital cities (Figure 3). A feature of the current network is that all States except New South Wales and South Australia have their own independent source of supply. New South Wales and South Australia are effectively interconnected through their common source at Moomba in the South Australian part of the Cooper Basin. Figure 3 also displays possible future pipeline links that would effectively interconnect all capital city markets and make available the major reserves from the North West.

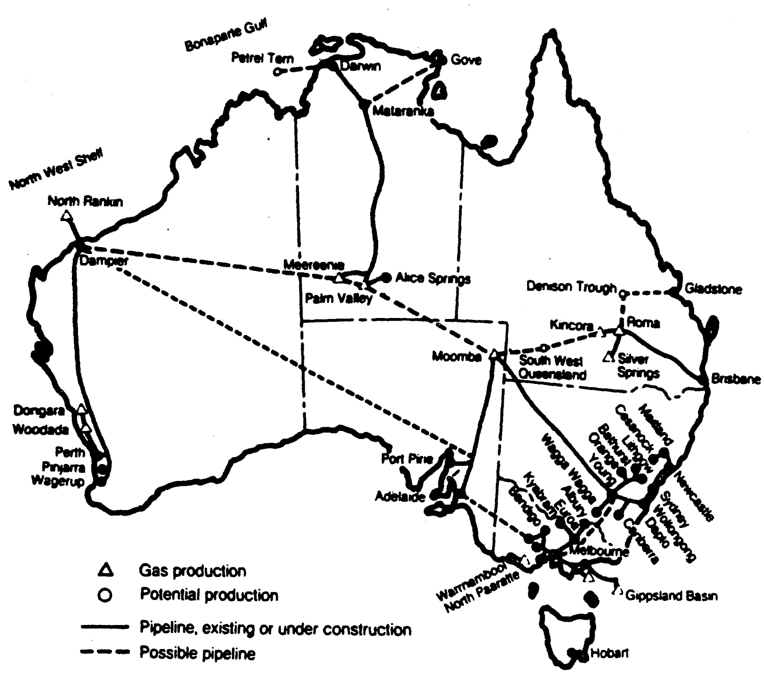
The cost of transporting gas by pipeline is significantly affected by economies of scale. This is illustrated by Figure 4. The main reason for these economies is the scale effect inherent in the flow of fluids in pipes.

FIGURE 2: LOCATION OF NATURAL GAS RESERVES



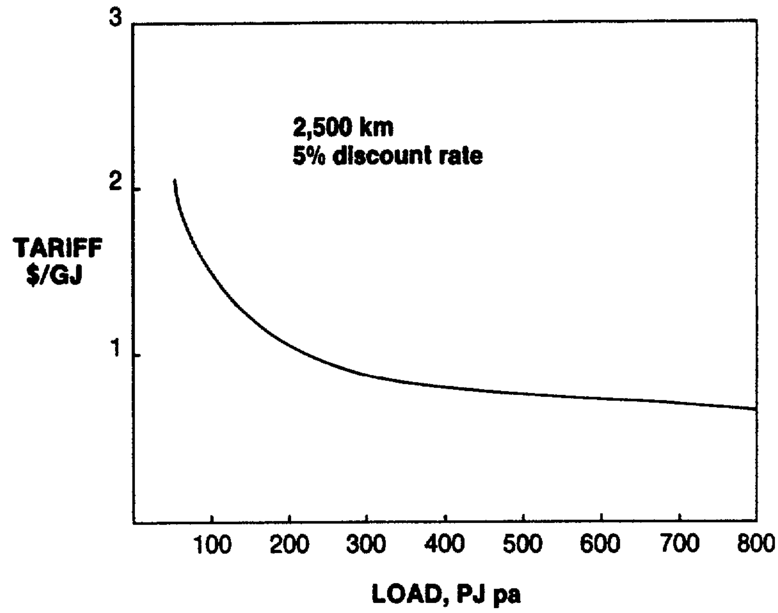
Source: Department of Primary Industries & Energy, Energy 2000 - A National Energy Policy Paper, 1988.

FIGURE 3: AUSTRALIAN NATURAL GAS PIPELINE NETWORK



Source: Department of Primary Industries & Energy, Energy 2000 - A National Energy Policy Paper, 1988.

FIGURE 4: INDICATIVE TOTAL PIPELINE COST EXPRESSED AS A TARIFF

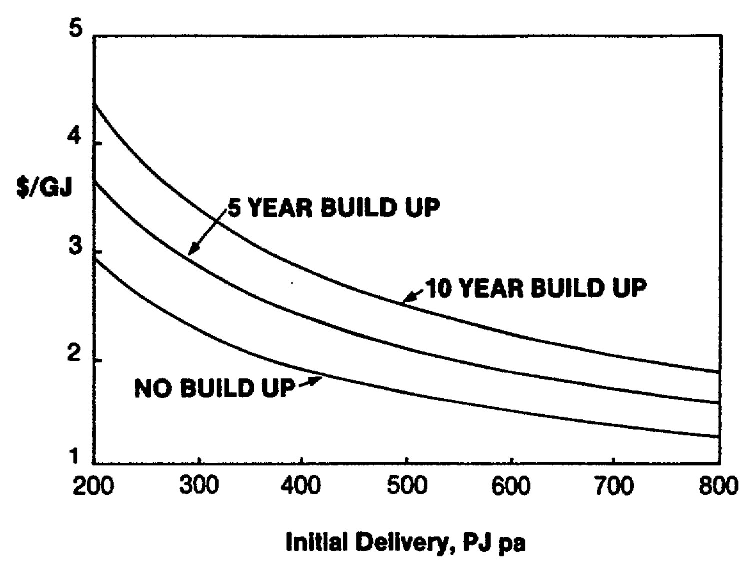


Source: The Australian Gas Association

4. PRICES OF NATURAL GAS

The cost of gas ex-plant (corresponding to wellhead for onshore supplies and the onshore delivery point for offshore supplies) is also subject to significant economies of scale. This arises from the capital intensive nature of gas extraction from reservoirs with set up and plant costs less than proportionately dependent on production. These economies of scale are reflected in the indicative ex-plant prices for gas from the North West displayed in Figure 5, postulated by producers for the purposes of the AGA study.

FIGURE 5: INDICATIVE EX-PLANT PRICES FOR NATURAL GAS FROM THE NORTH WEST



Source: The Australian Gas Association

Also shown is the effect on gas price of a phased take-up of demand, over periods of 5 and 10 years, illustrating the economic advantage of taking up as quickly as possible a given level of supply.

The ex-plant price corresponding to an initial production (and take-up) of 500 PJ pa from the North West together with the price ranges for current sources of gas (allowing a real price increase over the period of the study) form the basis of Table 4 which indicates the corresponding city gate gas prices.

TABLE 4: INDICATIVE CITY GATE PRICES OF NATURAL GAS - SOUTHERN AND EASTERN STATES.
1987-88 $'s

		PRICE/TARIFF/COST, $/GJ		
MARKET	SOURCE	Ex-Plant(a)	Pipeline	City Gate
NSW	Cooper	1.60-2.32	0.70	2.30-3.02
	Gippsland	1.90-2.32	0.72	2.62-3.04
	North West	1.69	1.10	2.79
VIC	Gippsland	1.90-2.32	0.14	2.04-2.46
	North West	1.69	1.10	2.79
SA	Cooper	1.60-2.32	0.30	1.90-2.62
	Amadeus	1.50-1.83	1.01	2.51-2.84
	Gippsland	1.90-2.32	0.66	2.56-2.98
	North West	1.69	1.10	2.79
QLD	Surat/Bowen	2.50-3.05	0.40	2.90-3.45
	Cooper/Eromanga	2.00-2.44	1.07	3.07-3.51
	North West	1.69	1.98	3.67

Note:(a) Range of ex-plant prices correspond to an increase of 1%pa from 1990 from current sources.

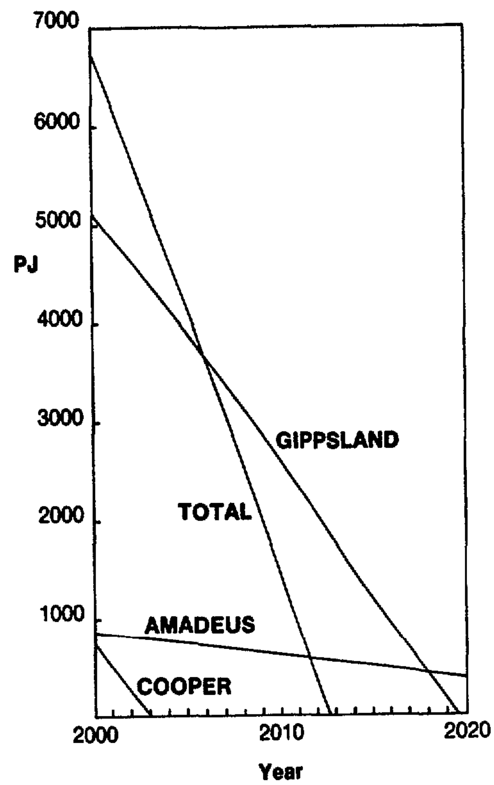
Source: The Australian Gas Association.

The city gate prices include a pipeline transportation component, also indicated. This Table shows that city gate prices for Sydney and Adelaide would be lower for gas from the North West than the corresponding prices for gas from Moomba (Cooper Basin). For Melbourne, which currently enjoys lower gas prices principally because of the lower pipeline cost from the Gippsland Basin, gas from the North West would cost more.

5. SOME POSSIBLE OUTCOMES

Figure 6 illustrates the depletion of current sources of supply, excluding the North West, that would eventuate if no interconnections took place. Also shown is the depletion of all sources of supply combined. These graphs emphasise the need to interconnect current sources of supply to enable a quick take-up of supplies from the North West. Without simultaneous depletion of this kind, take-up of supplies from the North West could be spread over up to ten years.

FIGURE 6: EXPECTED DEPLETION OF CURRENT NATURAL GAS RESERVES EXCLUDING THE NORTH WEST



Source: The Australian Gas Association

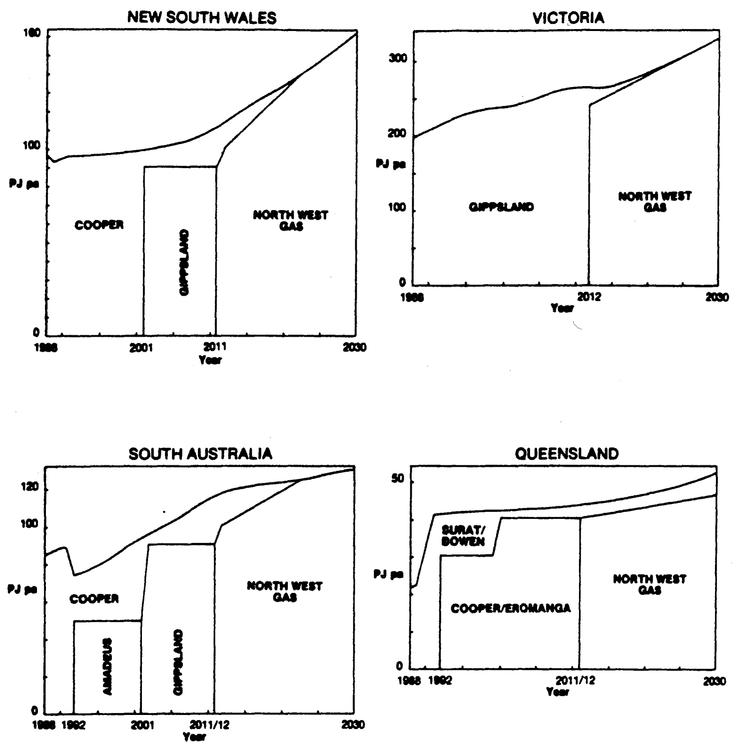
5.1 Scenario 1 - Simultaneous Depletion

Scenario 1 was defined as corresponding to unrestricted supply from the Gippsland Basin to New South Wales and South Australia, as well as the interconnection of the Amadeus and Queensland Cooper (Cooper/Eromanga) sources. Depletion of the combined sources would be expected to occur in 2011/12, at which time a 500 PJ pa supply from the North West would be brought on stream. The schedules of supply to the four southern and eastern States are illustrated on Figure 7. Figure 8 displays the demands corresponding to scenario 1 and compares them to the adjusted base forecasts. The differences between the curves are due to price elasticity effects.

The curves illustrates the enhanced demand following lower prices in New South Wales and South Australia when the supplies from the North West come on stream. For Victoria, the opposite effect is illustrated.

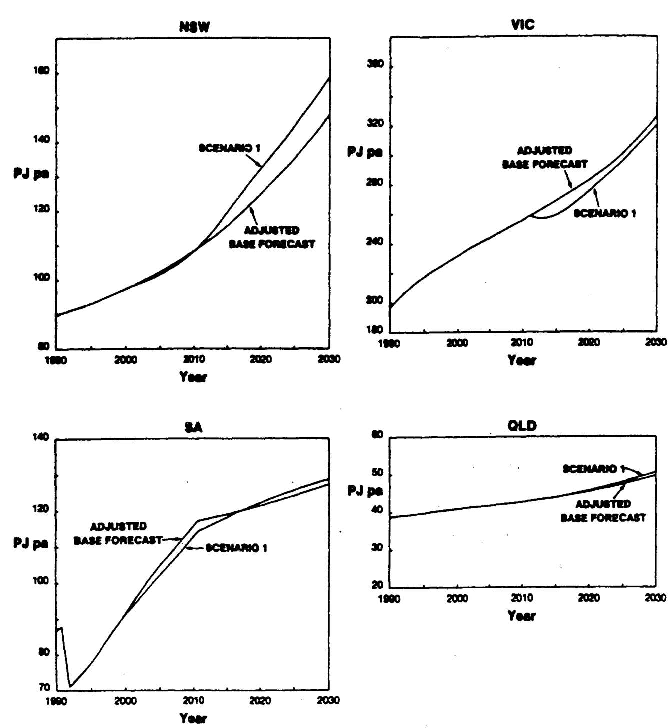
FIGURE 7: SCHEDULE OF NATURAL GAS SUPPLY - SOUTHERN & EASTERN STATES - SCENARIO 1

Illustrative Only



Source: The Australian Gas Association

FIGURE 8: NATURAL GAS DEMANDS - SCENARIO 1.



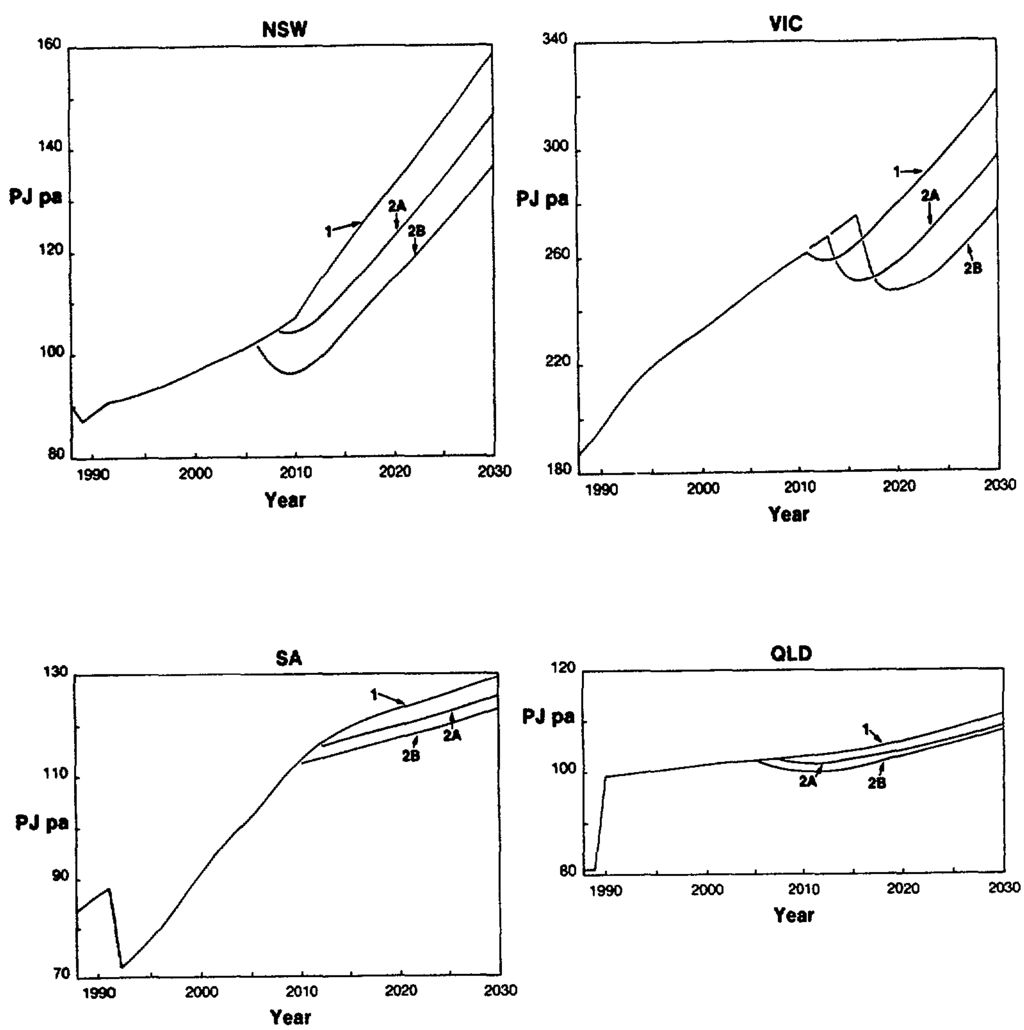
Source: The Australian Gas Association

5.2 Scenarios 2A and 2B - Non-Simultaneous Depletion

Scenarios 2A and 2B were postulated to illustrate the effect of a phased take-up of gas from the North West resulting from restrictions on supplies from the Gippsland Basin to other States. Scenario 2A corresponds to a five year interval between New South Wales, South Australia and Queensland being connected to the supply from the North West and Victoria being connected. Scenario 2B corresponds to a ten year interval.

Figure 9 illustrates that everybody would be worse off with an outcome which does not achieve simultaneous depletion. The longer the build up period, the higher the price of the gas with demand depressed accordingly. Victorian consumers enjoy a short term advantage arising out of the increased duration of cheaper supplies from the Gippsland Basin but when these finally deplete they become worse off than they would under Scenario 1 because the full economic potential of the economies of scale for supplies from the North West would not have been realised.

FIGURE 9: NATURAL GAS DEMANDS - SCENARIO 1, 2A, 2B.



Source: The Australian Gas Association

6. A POSSIBLE OPPORTUNITY - Scenario 3

Given the economies of scale available in production and transport of natural gas, there are incentives for seeking new markets for gas. Of the three possibilities outlined previously, gas fired power generation is the most readily achievable. Both the technology and the markets are already in place.

If the additional gas demand of 300 PJ pa given in Table 2 is superimposed on Scenario 1 (simultaneous depletion) further economies of scale can be achieved. This is illustrated in Table 5 which compares the gas prices payable under scenario 1 with those payable if demand is increased by 300 PJ pa (Scenario 3). All consumers under Scenario 3 pay about 60c/GJ less than they would under Scenario 1, as a result of a reduction in city gate price from \$2.79/GJ to \$2.23/GJ. The price to an electricity generation authority would be a few cents above \$2.23/GJ. An even more competitive city gate price of \$2/GJ could be offered for electricity generation if the saving to other consumers were reduced to some 45c/GJ, revenue to the gas supplier remaining unchanged.

TABLE 5: NATURAL GAS CONSUMER PRICES, SCENARIOS 1, 3, 3*, 2020

1987-88 DOLLARS

SELLING PRICES, \$/GJ

SCENARIO	Residential		Commercial/Industrial	
	NSW	VIC	NSW	VIC
1 (a)	9.94	6.70	4.58	3.73
3 (b)	9.35	6.11	4.00	3.15
3* (c)	9.49	6.25	4.14	3.29

Notes:

(a) Simultaneous depletion, forecast demand. City gate price \$2.79/GJ.
(b) Simultaneous depletion, forecast demand plus 300 PJ pa. City gate price \$2.23/GJ.
(c) As Scenario 3, but with a special price to electricity authorities of \$2/GJ at city gate. Total revenue as for Scenario 3.

Source: The Australian Gas Association.

Under this scenario, designated 3* on Table 5, these consumers would still be better off than they would be in absence of the additional gas demand for electricity generation. Clearly, there would be considerable scope for a range of negotiated prices for supply of gas to electricity generation authorities. The price would be influenced by the location of the power station with respect to large diameter pipelines and by the provisions necessary to meet peak demands in excess of long term pipeline delivery capabilities. A price of gas close to \$2/GJ would be very competitive for peak and possibly intermediate load generation.

7. CONCLUSIONS

This brief overview of the investigations undertaken by the Australian Gas Association demonstrates:

- there is sufficient gas in Australia to meet all foreseen demands to 2050, and probably beyond as new discoveries continue to be made;
- gas production and transport offers significant economies of scale over the parameter range applicable to Australia; and
- these economies of scale provide strong incentives to develop new markets for gas including use of gas as a vehicle fuel and in gas turbine power generation.

The principal policy implications are:

(1) Victoria currently enjoys a comparative advantage arising from its relative proximity to a large gas resource. Pooling of this resource with those from the Cooper/Eromanga and Amadeus Basins would bring forward the time at which Victoria would need to draw on the more expensive (to Victorian consumers) gas from the North West. The achievement of simultaneous depletion would, in practice, probably be imperfect because both demand and supply (reserves) cannot be predicted perfectly - particularly over the long periods required by infrastructure provision for natural gas. The arguement that is most likely to convince policy makers to work towards simultaneous depletion is that of the superior long term economic benefits accruing from economies of scale.

So long as commercial and long term economic incentives are reinforcing rather than in conflict, there is no reason to suppose that the play of market forces would not lead to an outcome close to the economic ideal. The role for governments is to ensure that short term considerations and anti-competitive outcomes do not inhibit the achievement of this ideal.

(2) Recent comprehensive public inquiries in New South Wales and Victoria have demonstrated convincingly that natural gas at a price between \$2/GJ and \$3/GJ delivered to gas turbines is strongly competitive with conventional coal fired power stations, at least for peak power. The AGA study has demonstrated that such a price could be achieved applying normal commercial criteria. However, the provision of electrical generating capacity is subject to a number of considerations other than the generic one considered in the AGA study. For example both the Electricity Commission of New South Wales and the State Electricity Commission of Victoria draw a high proportion of their fuel from large Government owned coal mines with sufficient capacity, in some cases, to supply several generations of power stations. The long term total opportunity costs of not using these resources should be included in a decision between coal and gas as a power station fuel.

Finally, while it remains generally true that inter fuel competition is largely resolved by economics, the environmental impacts of combustion products are attracting increased interest - including the Greenhouse Effect. Much of the associated comment has confused the complex causes and effects of atmospheric pollution and has lacked discrimination between what will happen and what might happen as a result. One outcome is certain - the concentration of carbon dioxide in the atmosphere is increasing almost exponentially. From this point of view, natural gas is the cleanest of the carbon based fuels. It generates about half the amount of carbon dioxide per unit of combustion heat than coal and this fraction can drop to about one quarter when account is taken of the thermodynamic losses between the raw fuel and final consumption of heat. These aspects are explained in the March 1989 issue of the Australian Gas Journal published by the AGA.

References

1. The Australian Gas Association, Gas Supply & Demand Study, Second Participants' Report. October 1988. Obtainable from the Association for $200, postage paid.

2. The Australian Gas Association, Gas Supply & Demand Study, Second Public Report. November 1988. A condensed summary of the Participants' Report, obtainable from the Association for $10, postage paid.

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Development of marginal fields

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INTRODUCTION

By proceeding with the development of five new fields in Bass Strait Esso and BHP are meeting a challenge facing the entire oil industry in Australia: how to produce from smaller and more difficult oil and gas reserves in an environment of declining oil production and economic uncertainty.

The remaining discovered fields to be developed have reserves that are only a small proportion of those developed from the early discoveries in Bass Strait, such as Kingfish, containing over 1 billion barrels of oil, and Halibut, with about 700 million barrels.

With small reserves and low prices, new fields are only economically viable if they can be developed and operated inexpensively. Government take, particularly secondary taxation, is a development cost burden which marginal projects often cannot carry, even after development costs have been reduced through innovative engineering. The five new developments which are underway follow on from technical studies and the significant change made to the fiscal environment in Bass Strait when the Commonwealth Government, in June 1987, provided excise exemption for the first 30 million barrels (4770 ML) of production from certain offshore projects. Shown in Figure 1 is the location of the five new developments - Whiting producing to Snapper, Seahorse and Tarwhine producing to Barracouta and Perch and Dolphin producing to Shore.

The search for low cost development methods for these projects has been especially difficult because of several factors which are peculiar to Bass Strait:

- Weather conditions can be severe and the cost of building structures to withstand these conditions is high. Installation costs are expensive because there are no weather windows during the year when good conditions can be expected.

- Because Bass Strait is relatively isolated from the rest of the industry, drilling and other major equipment is not readily available and is costly to mobilise. Lack of competition among contractors often results in high fabrication and floating spread rates (approximately twice those for the Gulf of Mexico, for example).

- Industrial relations problems take their toll in Bass Strait. A dispute in 1988 involving McDermotts derrick barge DB101 delayed mobilisation for more than five months.

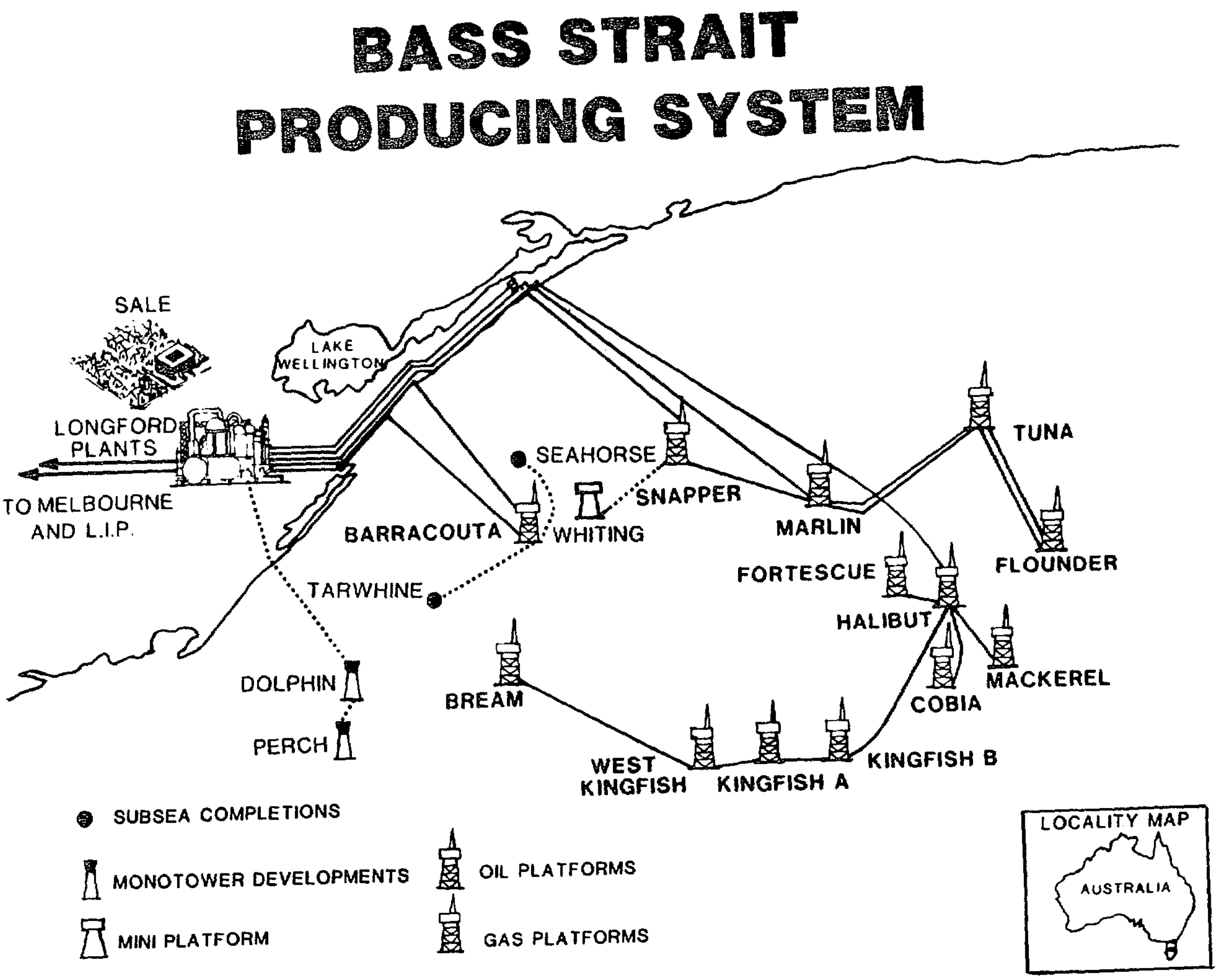
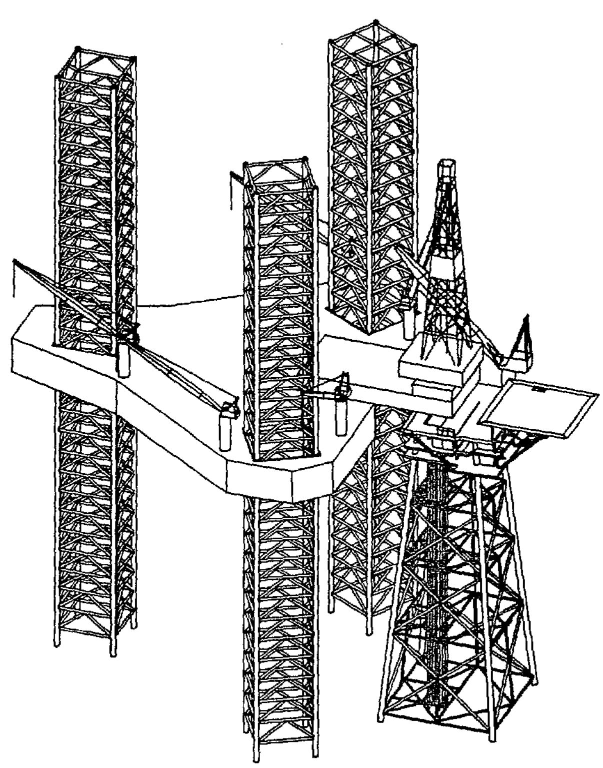


FIGURE 1



WHITING

FIGURE 2

In 1988 Esso/BHP spent $8 million on the development and analysis of new concepts for small field development. These concepts include remotely operated mini-platforms, a floating production system, satellite wells to existing platforms and single-well structures. Some of these innovations will be used in the five new developments. Reserves in these new fields total 51 million barrels (8110 ML) at a total development cost of around $320 million.

WHITING

The Whiting field was discovered in 1983, lying 14 km from the Snapper platform. The field contains total crude and condensate reserves of 21 million barrels (3340 ML) and gas reserves of 100 million million SCF (2830 billion cubic metres) located in multiple oil and gas reservoirs.

Development of Whiting calls for five wells: four single completion wells drilled in the Whiting East area and one single completion well drilled in the Whiting West area. Wireline recompletions and simultaneous production of oil and gas enable development of all the commercial reservoirs with high recovery factors and the minimum number of wells.

Whiting was perceived as an ideal candidate for an unmanned mini-platform development because of the small but good quality reservoirs, the availability of a gas zone for artificial lift gas and the proximity to a second generation host platform, Snapper. This technology is not novel in many other oilfields around the world but represents a significant breakthrough in development options for small reserves in Bass Strait.

The Whiting jacket will be located in 53 m of water and constructed as a conventional four leg structure with a 12 m x 14 m leg spacing at deck level. The 1200 tonne jacket has been designed for a derrick barge lift installation and will be supported by four drilled and grouted insert piles.

Although the mini-platform can accommodate a workover rig, development drilling would necessitate a larger and more costly platform to accommodate a full drilling rig. As a cost saving alternative it was decided to use a jack-up rig to drill the five development wells. This is the first time a jack-up rig has been used in Bass Strait and it is depicted in Figure 2 operational at Whiting.

Whiting will be unmanned and remote operated, relying on Snapper to function as a host platform. Minimal facilities will require low personnel attendance and Whiting oil and gas will be transported to Snapper via individual 200 mm and 250 mm pipelines. The total budgeted cost is $150 million. Production is scheduled to commence in mid 1989 at an initial rate of 12 000 BOPD (1.9 ML/D).

SEAHORSE & TARWHINE

The Seahorse and Tarwhine fields lie close to the existing Barracouta platform located some 24 km offshore in 43 m of water. With combined reserves of just 11 million barrels (1750 ML), their development clearly required a break from Bass Strait tradition to achieve economic viability.

SEAHORSE & TARWHINE SUBSEA COMPLETIONS SYSTEM OVERVIEW

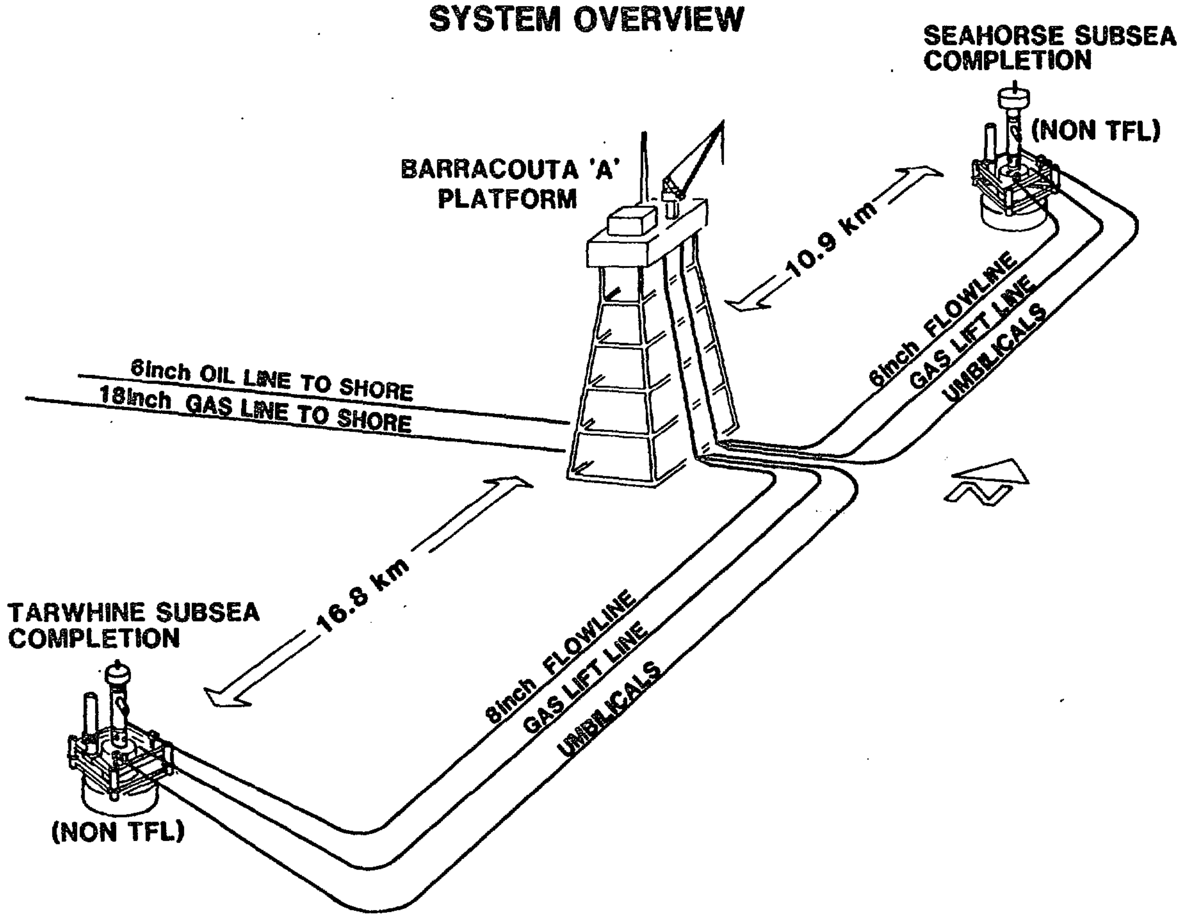


FIGURE 3

PERCH & DOLPHIN MONOTOWER DEVELOPMENT

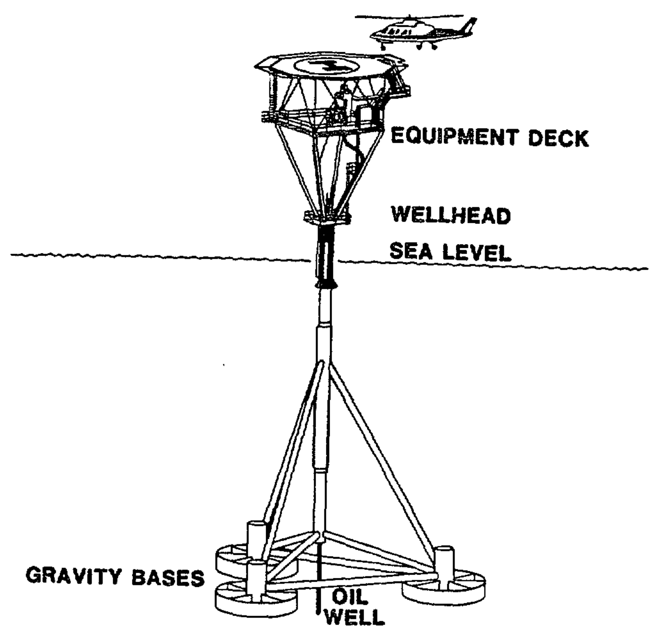


FIGURE 4

The discovery well for the first of these fields, Seahorse No. 1, was suspended in 1978 due to the small reserves size, estimated at just 4 million barrels (640 ML). This existing exploration well will be re-entered and completed with a single tubing string utilising a subsea completion located 11 km north of Barracouta. Oil will flow from the two hydrocarbon zones at around 1500 m subsea via a 150 mm insulated flowline laid on the seafloor to Barracouta.

Similarly development of the Tarwhine field will also use a suspended exploration well and will be completed with a single tubing string. Oil from this field, which is located 17 km south west of Barracouta, will flow to Barracouta via a 200 mm insulated flowline.

In both cases, the the Christmas trees will be located on the seafloor using technology that is now well established in Australia and elsewhere in the world as depicted in Figure 3. Production will be controlled remotely from the host platform, Barracouta A.
Barracouta is a manned platform and will support common receiving facilities for both fields. This will include control, separation, pumping and compression facilities, plus provision for gas lift. Existing pipelines from Barracouta will transport the oil and gas to shore for further processing at Longford.

The total cost of the Seahorse and Tarwhine project, not including the original drilling of the exploration wells, is $88 million. Production is planned to commence at the beginning of 1990 with an initial rate of around 8 500 BOPD (1.4 ML/D).

PERCH & DOLPHIN

Perch and Dolphin are located in the south west corner of the Gippsland Basin somewhat distant from the other Bass Strait developments. Their location dictated a different approach when considering development alternatives.

Perch lies 25 kilometres offshore in a water depth of 42 m. It was discovered in 1968 and contains 13 million barrels (2070 ML) of oil in one production zone.

The Dolphin field, discovered in 1967 lies nearby, 22 km offshore in 38 m of water and contains an estimated 6 million barrels (950 ML) of hydrocarbon reserves located in one highly productive zone.

The optimisation of Perch and Dolphin developments exemplifies the work required to identify the best, low-cost alternatives for small fields.

A total of over 140 options for the development of these and the three other new fields in Bass Strait were initially considered. For Perch and Dolphin the options were narrowed down to three fundamental options which were evaluated in some detail.

One option involved sub-sea completions, similar to the Seahorse and Tarwhine hardware, connected via a pipeline directly to the Longford onshore processing plant. This option was ruled out because of the high capital expenditure involved in installing very long flowlines, gaslift lines and control lines to each well.

Another approach involved the use of a floating production system. This system relied on subsea wellheads producing to a tanker, and was initially considered attractive because of its ability to be used to produce additional fields in the area at minimum cost. A similar system is currently operated by BHP to produce the Jabiru field. The Bass Strait proposal differed from the Jabiru system in that it was not intended to be dedicated to one field. It would have rotated between several fields to share the development costs to allow optimum production cycles.

The third option involved a very simple minimum platform structure at each field and the construction of a pipeline connected directly to the Longford processing plant. This approach offered the advantages of very low operating costs, relying on an unmanned monotower and remotely operated production.

The last two options attracted similar capital costs, and the choice lay in a comparison of the flexibility of the floating production system with the much lower operating costs of the unmanned monotower/pipeline system.

Analysis of the alternatives finally indicated that a gravity based, single well structure development was the most attractive because of its marginally lower investment cost and very much lower operating costs.

A gravity based monotower will be erected on each field with a pipeline stretching 10 km from Perch to Dolphin and then 37 km to Longford.

A single well will be drilled on each field using a jack-up rig which will be positioned above the monotowers. The two fields can be developed with single wells because of their small, high quality reservoirs.

Although piled towers have been used extensively overseas and in Australia, the gravity based monotowers are a novel solution for developing small Bass Strait fields. The monotowers can readily house one or two wells. The gravity base has been selected over a conventional piled alternative because the expensive barge-assisted installation time is greatly reduced compared with the installation time involved in constructing the alternative conventionally piled structure. Bass Strait calcareous soils are ideally suited to gravity bases.

The steel structure base will weigh approximately 600 tonnes and in addition approximately 1400 tonnes of iron ore ballast will be installed in the gravity foundation pods. The topside deck, including facilities and helideck, will weigh approximately 200 tonnes, which gives a total weight of around 2200 tonnes. Figure 4 shows the Perch/Dolphin configuration.

The topsides are very small with a deck area of 10 m x 10 m located immediately below the helipad. There will be very little process equipment on board, consisting only of a test separator to enable individual well tests and chokes to control production. The production will be routinely controlled from Longford with infrequent visits to the monotowers by personnel for well testing and maintenance.

The production flowline to shore will be a 300 mm line and in addition there will be a 100 mm gas lift line to carry gas from Longford to the offshore oil fields.

CONCLUSION

The analysis, development and evaluation of various options and proposals to suit each field development has provided an opportunity for much professional development and learning. It has been necessary to adjust to a changing environment both in technological and economic terms.

Knowledge, both from within and without the organisation, is an important resource. Through its parent company Exxon, Esso Australia has access to a fund of experience collected worldwide including Exxon Production Research Company located in Houston, Texas. The inclusion of experienced personnel from overseas affiliates in our study task forces ensured cross fertilisation of ideas.

Esso is currently involved in active exploration of Bass Strait. With the experience gained from small-field developments already underway in Bass Strait, Esso is well placed to identify low-cost solutions for future development of discoveries.

In Bass Strait we also see additional reserve opportunities through incremental development of existing fields. As new reserve opportunities become smaller and more difficult to develop, our existing fields can be expected to become increasingly more attractive as sites for yielding additional reserves. Opportunities for increased oil recovery are envisaged through infill drilling, attic recovery and gas injection projects and secondary recovery mechanisms such as miscible flooding projects.

Potential for further development in Bass Strait is clear, both through further development of the existing resources in Bass Strait and through exploration.

With Australia able to supply only 25 per cent of its own oil needs by the year 2000, the need to develop this potential is pressing. However such development is enormously expensive and will depend on a number of factors.

Extensive feasibility studies will be required before further development of existing resources becomes possible. Continuing technical evaluation and innovation will be necessary to make new developments technologically and economically possible.

A supportive economic environment will also be essential if such projects are to be feasible. Apart from a stronger price outlook, government take is also a critical issue. Substantial potential exists for incremental production from old oil fields. These however are subject to overall government taxes totalling 88 percent at the margin. These extremely high government take levels will significantly affect the development of these reserves which also involve high investment and technical risk.

The industry will need as much encouragement as possible in developing additional reserves in Bass Strait. This area has seen over twenty years of exploration and development, and the outlook is for reserves that are one, or two, orders or magnitude smaller than the early giants, but nevertheless will provide a potentially substantial and important addition to Australias declining reserve base.

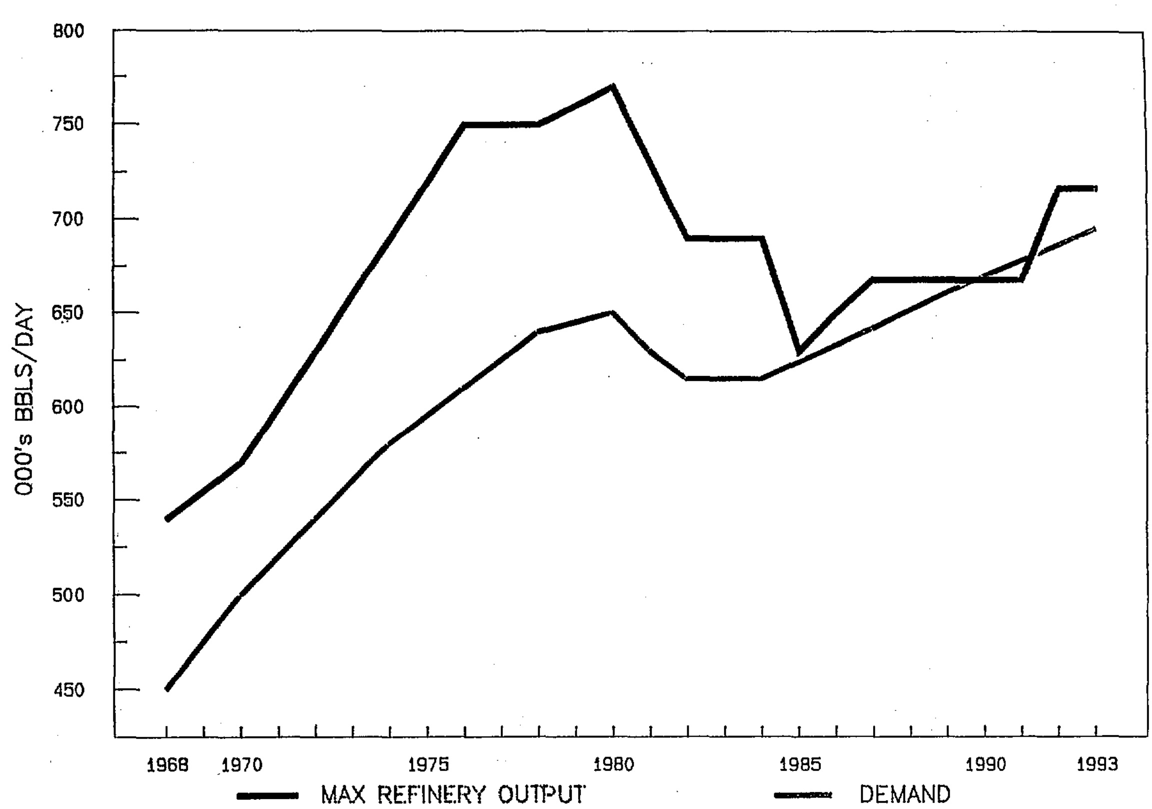
Refining since deregulation - new Asia Pacific linkages

P J West

BP Australia

The refining industry in Australia is generally an efficient one - certainly by regional standards. It is isolated from markets other than the local Australian market. As a result, the industry has developed to largely match the Australian market demand.

AUSTRALIAN OIL SUPPLY/DEMAND



The Australian oil industry import / export balance during the financial year 1987 / 1988 indicates the balanced position between product imports / exports. There is in the order of 10% of total production exported and about 10% of total requirements imported. These imports and exports reflect geographic opportunities and production skews.

AUSTRALIAN INDUSTRY IMPORT / EXPORT BALANCE 1987 / 1988

(UNIT MILLIONS M3)

	GASOLINE	JET	DIST.	F.O.	AVGAS	LUBES	TOTAL
IMPORTS	0.9	0.2	0.7	1.1			2.9
EXPORTS	0.4	0.4	0.8	0.8	0.1	0.2	2.7
NET IMPORTS / (EXPORTS)	0.5	(0.2)	(0.1)	0.3	(0.1)	(0.2)	0.2

The allocation of indigenous crude oil to refining / marketing companies from 1965 to 1988, lead Australian refiners to also tailor their equipment to use the enforced crude oil to satisfy the market. The removal of this allocation by deregulation at the start of 1988 has been a very significant event for the refining (and producing) industry.

1988 A TIME OF TRANSITION

Transition was initially very smooth in logistical terms as most refiners and producers negotiated deals whereby oil movements were similar to those prior to deregulation. Both parties were coping with a new commercial environment. As they became more comfortable, the different opportunities were identified and explored. By mid 1988 the industry was comfortable with the new environment, and by end 1988 the industry was exploring and adventuring beyond the customary boundaries of crude oil purchases and sales. Australian crude was no longer primarily for Australia. Refiners were recognising the opportunities for "best buys" in the market. Most people are aware of the general volatility of oil prices over the years. What isn't quite so obvious is the distortion in relative values of different feedstocks (and products). The costs of particular crude oils vary one from another :- for example because one Indonesian crude oil is suitable for use by Japanese utility companies and another is not, the relative price will vary according to Japanese utility demands. Refiners are now becoming more flexible and faster on their feet to take advantage of these opportunities.

1989 A TIME OF CHANGE

The preliminary skirmishes and sometimes extended negotiations are gone as the players have become more educated and aware of the commercial relativities and opportunities of the other party. The market has become free in a more literal sense :-

1. Lots more players (including major trading houses)

2. A much bigger playground

3. New rules

There has been a further decline in South East Australian production and new production in the North West Australian region. Exports have been decreasing from the South East and increasing from the North West. Other producers are following in the footsteps of the Gippsland producers in seeking out and developing offshore markets. New initiatives such as the BHP acquisition of the refining trading company PRI have impact on the industry. On balance for 1989 the industry recognises the real market value of crudes as established by commercial means and market competition. Commercial relationships are well established between producers and refiners.

SOUTH EAST ASIAN INTERACTION

Under the allocation scheme there was some rationalisation of distribution of Australian crude via refinery crude oil exchanges. However, now that refiners are purchasing more selectively the distribution of crude has been adjusted by import / export balance.

Australia is more clearly a part of the South East Asian crude oil balance than before. Indonesia is almost equidistant for most Australian refineries to the crude oil available from the North West Australian and Timor Sea fields. With cabotage, it is necessary to use Australian Flag Shipping to use the distant Australian crude oil, therefore unless a refiner has available surplus Australian Flag Shipping, he will be more inclined to purchase Indonesian crude oil. Many Australian crudes are now reported on wire services. Refineries in Singapore include Australian crudes in their processing contracts now that they are available and at times attractive.

EXPORTS

Many of the previously regulated crude oils (Cooper Basin, Jackson, Barrow) have been exported during 1988 to Pacific rim destinations (Japan, Singapore, New Zealand).

PRICING

Deregulation created a problem with respect to pricing of Australian crude oil. Gippsland quotations on APPI and Platts were a primary reference. To many small producers this was the only yardstick by which they could price their crude. Major refiners and producers have looked beyond Gippsland and a wide variety of pricing mechanisms have been put in place. These are constantly being reviewed as circumstances and relativities change.

PRICE RISK

Refiners have learnt to use hedging mechanisms to hold exposure to oil price changes at more constant levels. In the regulated environment supplies were predominantly from local sources and all significant competitors saw the same cost or benefits of oil price changes. Varied mechanisms now for pricing, and different exposures for long and short haul crudes, create a price risk.

IMPORTS

Feedstock imports have increased since deregulation as a result of crude slate optimisation by some refiners. BP at Kwinana has had the most dramatic change. Other issues such as the reduced production of Gippsland crude oil and the Caltex dispute in early 1988 also have had an impact on that increased import.

New concepts for petroleum exploration in Australia

Peter J Davies, Trevor Powell, Michael A Etheridge, Marita Bradshaw, David Falvey, Phillip Symonds, Neville Exon, Barry Willcox, David Heggie & Paul Williamson

Bureau of Mineral Resources, Geology & Geophysics

Introduction

Oil may be found in old basins with new ideas
It may be found in new basins with old ideas
It may be found in new basins with new ideas
But
It is unlikely that it will continue to be found in old basins with old ideas.

The history of Australian petroleum exploration is one of largely being driven by prevailing fashions, i.e. known play exploration. Most present day explorers are searching for oil and gas in predominantly established low cost areas. Drilling the simple structures in the Surat, Bowen, Cooper and Eromanga Basins is continuing with "old ideas in old basins". New directions are necessary. In order to be more successful explorers, we must develop a geater concentration on innovative play concepts, take greater risks and drill more holes(R.A.Laws 1988).

Finding more petroleum demands integrated sedimentary basin analysis aimed at understanding the development of prospectivity in the Australian sphere. The Australian continent and continental margin includes between 70 and 80 different sedimentary basins, and an integrated analysis of each is a two fold process comprised of:

. Construction of a three dimensional genetic geological model documenting how the sedimentary basin formed, filled with sediment, compacted and matured.

. Extraction of the predicted subsurface conditions of source, maturation, migration, reservoir, trap and seal from the geological model and definition of the potential for the occurrence of an effective petroleum system within the basin.

The above two processes are best achieved through an organized integrated approach. The essential facets of such an integrated analysis are shown in Figure 1 and demand substantial expertise in at least seven major disciplines i.e. structure, gravity/magnetics, thermetrics/modelling, seismic interpretation, sediment facies analysis, palaeontology and geochemistry. It is axiomatic that such expertise be interactive throughout the development of the genetic model. Essentially, model development is concerned with two mega processes i.e. Basin Formation and Basin Fill. Maturation, migration and entrapment are a consequence of both.
Mindful of the needs for new innovative exploration plays, scientists of the Bureau of Mineral Resources have been active in defining new concepts of both basin formation and basin fill and understanding the interaction of both in developing new scenarios for finding petroleum.

Basin Formation

Australian basins have formed through two prime tectonic processes, i.e. extension and compression.

Extensional tectonics in basin formation in Australia.

Extension of the continental lithosphere, a process increasingly recognized as involving shear along one or more shallow dipping detachment faults, has two main structural consequences:

. the development of asymmetric basins or half grabens. This geometry has now been shown to dominate in the Bass Strait Basins, on most other parts of the Australian continental margin, in the Canning Basin and in a number of Proterozoic rifts.

. the development of transfer faults to accommodate along strike variations in basin geometry. The effects of the transfer faults are to induce substantial compartmentalization in basin architecture.

The consequences of the above are that in the early stages of basin evolution the primary distribution of reservoir and source facies is controlled to a very large degree by the mechanics of the detachment process and this may vary from one basin to another and along the same margin. Depositional environments will be variable with facies changing suddenly over relatively short distances. The further maturation and migration of hydrocarbons are influenced by and predicted by the detachment model (Etheridge etal 1988).

The first test by BMR of the extensional model of basinal formation has occurred in the Fitzroy Trough of the Canning Basin. Previous idealized interpretations of the Fitzroy Trough show down to trough normal faults bounding both sides of the trough and hence a structural symmetry. In contrast, studies by Drummond etal(1988) show the Fitzroy Trough to have a marked assymetric half graben structure, with one side a hinge zone or flexure and the other side bounded by normal faults. Further, the sense of assymetry switches several times at transfer faults along the length of the trough. This radically new interpretation has implications for resource exploration because of the way it influences basin fill and the late stage restructuring of the basin(Drummond etal 1988).

Applying and extending these principles to the southern margin of Australia, Willcox and co-workers has unravelled a very complex multi-extensional and transtensional history for the Great Australian Bight and Sorell Basins. The recognition that late-stage wrenching is superimposed on transfer faults markedly upgrades the petroleum potential by providing a mechanism for petroleum migration and entrapment during the period of thermal maturity. Structuring of similar age provides the anticlinal traps that harbour the giant Gippsland Basin fields. Further, the recognition of pre-Cenomanian fault bocks related to both a post rift marine and syn rift lacustrine source, and a basin margin play incorporating drape of the Neocomian section over fault blocks sourced by late Jurasic to Neocomian shales, adds substantially to the exploration interest in the area.

Compressional tectonics in Basin Formation in Australia

Little attention has been accorded the effects of compression in the formation of Australian basins beyond recognizing that the northern margin of Australia is to some degree a compressional margin. More recently Davies etal(1988) and Pigram etal(1988) recognized that the middle Oligocene(30My) collision of the Australian craton with a complex subduction system to the north resulted in the development of a foreland basin that extended from the Coral Sea to the Indian Ocean. Six stages in this evolution have been recognized(Table 1). Its affects were:

. to produce a major basin of deposition across the northern margin of Australia with a carbonate platform developed updip from coeval basinal sediments.

. to raise the maturity of otherwise shallow Cretaceous source rocks that had formed on the northern margin of the Australian craton and which are immature further south on the craton.

. to drive fluids out of the clastic depocentre towards the south by tectonic or sedimentary loading. Such fluids would likely be hot and carry metals and hydrocarbons.

. to produce a series of reservoirs, both carbonate and clastic, in en echelon lines across the northern margin. Such reservoirs would act as sponges to the southward migrating fluids.

. to produce a fine grained clastic seal overlying the reservoirs.

Foreland basins are currently amongst the most sought after exploration targets. From a petroleum exploration potential viewpoint they are considered to be very forgiving basins i.e. almost anything goes. Prudoe Bay and the Alaskan North Slope testify to the excitement that they generate.

The above delineated ideas for the evolution of the northern margin of Australia are yet to be adequately tested. Seismic data collected from the Fly Platform already substantiates many of the ideas outlined above.

An important effect of collision is the compressional reactivation of existing extensional structures. This can influence structuring, facies distribution, and the timing of migration, and thus play a key role in play development at shallower levels within a basin. In Australia, mid-Tertiaary reactivation has been critical in the development of some of our major fields in the Gippsland basin and the North West Shelf, creating traps at the time of peak oil generation.

Basin Fill

The deposition of packages of sediments, either as sources or reservoirs, together with enclosed basinal fluids are the result of the interaction of tectonic history, eustatic sea level, climate, biological productivity, water chemistry, and the temporal relationships of the palaeoenvironment. The distribution, quality and composition of source, reservoir and seal are a complex sum of all of the above interacting variables.

The Problem of Source

A prerequisite for the occurrence of petroleum is a petroleum source rock. Such source rocks can be of both marine and non marine origin and their location is becoming increasingly important for the selection of areas for future exploration. Finding sources occurs in two ways (1) through the analogue method, (2) through new lateral thinking.

Graben development in the Jurassic coincident with a period of high sea level created environments conducive for the generation of source rocks in many parts of the world, for example in the North Sea and off Eastern Canada. In both cases, sources were deposited in deep water troughs comparable in age and structure to the Lewis Trough, the Vulcan Graben and the Malita Trough on the Northwest Shelf. The geometry of these troughs together with the high sealevel induced oxygen depleted deep water produced environments ideal for the preservation of sediments which in the North Sea contain 10% organic carbon. A source rock interval of similar richness has not yet been intersected on the Northwest Shelf(source rocks are usually around 2-3%) which may reflect either insufficient exploration or a different combination of palaeogeographic conditions persisting off Northwest Australia. Identifying and plotting sequential palaeogeographic time slices thus becomes an essential and powerful part of the analogue method in locating new potential source rocks. It allows the identification of analogues of a particular set of circumstances in a different time slice. For example, in North West Australia, the Early Triassic was a period of high sealevel. Palaeogeographic maps of the Northwest Shelf indicate a number of places where early Triassic basal transgressive sands are sealed by overlying marine shales which may provide a hydrocarbon source facies(Bradshaw etal 1988). Such a play has yet to be fully tested.

Oil is currently produced in Australia in the Eromanga and Surat Basins from fluvial lacustrine sources. Extension of this play should be made to the Clarence -Morton Basin in northeast New South Wales. Mature oil prone coals and carbonaceous shales identical to those in the Eromanga occur proximal to the widespread sandstone reservoir. Such a play has yet to be tested.

The Ordovician is a period of time which saw the proliferation in the global oceans of an alga named ***Gloecapsomorpha prisca.*** This alga forms the source for many of the Palaeozoic oils of North America, for example in the Williston basin, and in basins in the Baltic. The same alga has been located in the Goldwyer Formation of the Canning Basin and the Horn Valley Siltstone of the Amadeus Basins. Careful recent work has indicated that the Horn Hill Formation is slightly older than the Goldwyer Formation and now two intervals of enhanced source rock quality have been recognized in both basins. The search for reservoirs must now begin in both basins.

On a global basis Proterozoic and Cambrian sediments do not coincide with the maxima of petroleum occurrences. Such sediments are nevertheless widespread over large parts of northern and central Australia. In the Proterozoic of the McArthur Basin five potential source rocks have been identified, while the Middle Cambrian of the Georgina Basin is comprised of alternating cycles of limestone reservoirs and organic rich(8%) shales. The volume of such potential alone demands that it be seriously studied.

The problem of the Timing of Generation

Understanding the timing of source rock maturation and the generation of petroleum is an essential and key process in basin analysis made possible through the technique of burial and thermal geohistory analysis(Falvey and Deighton 1982). The method involves analysis of a sedimentary section through a process of progressive backstripping of chronostratigraphic units and a calculation of decompacted thickness of the underlying section. The backstripped section is plotted as a function of geological time relative to an estimated sea-level height and an interpreted palaeo-water depth.

The output provides a quantitative picture of an evolving basin, which is a vehicle for calculating the temperature history of appropriate horizons. Various algorithms can then convert these time-temperature functions into maturity indices, such as vitrinite reflectance and estimates of potential oil generation.A typical heat flow history may be derived from a knowledge of the major plate tectonic events occurring during basin subsidenc, such as rifting and continental breakup. A further variable in the equation is an estimate of palaeo-seabed or land surface temperature. This is the T-zero for all temperature calculations at depth and can be estimated by knowing palaeo-latitude (from global reconstructions) and palaeo-water depth.

The method is routinely applied in all offshore basin studies in BMR. It has led to an understanding of the history of the petroleum generation in the Bass, Otway and North Perth Basins and on the Exmouth Plateau. It is important to note that in all cases consideration of variable heatflow and seabed temperature has had a major impact on estimates of the timing of peak oil generation.

Reservoirs - What, Where and How?

Most petroleum in Australia has been found within, or is being persued within, sandstone bodies of fluviatile and/or deltaic origin. The top and intra Latrobe plays in the Gippsland Basin represent alluvial sands, point bar deposits, and back barrier/barrier bar deposits. The Late Triassic to Early Jurassic of the Vulcan Graben and the Early Cretaceous Pretty Hill Sandstones of the Otway Basin have formed in similar environments. In the Goodwin Fields/Rankin Trend fields, major pulses of coarse clastics form the reservoirs. In the Patchawarra Trough of the Cooper basin of South Australia the Permo-Triassic paludal and lacustrine sediments with fluvial sandstones form the main play.

In spite of the above, and the co-occurrence of many of these sandstone reservoirs with rift scenarios, it is surprising how little about "rift-fill" is applied during exploration. Syn rift sedimentation in extensional basins is highly variable. Rapid and sudden facies variations occur within basins and sequences frequently cannot be correlated between adjacent basins(Etheridge etal 1988). However, structural control imposes some order on this apparent chaos. Some continuity of facies occurs along the strike of the basin,i.e.braided alluvial systems flowing along the basin floor, alluvial fans derived from the hinged margin and turbidite fans derived from most rivers entering lakes are often extensive potential reservoirs. Local highly variable alluvial fans, fan deltas, braid deltas and gravity flows form proximal to transfer faults emanating from the faulted margin and landslides from the cliffs formed by the boundary faults form discrete local reservoirs. Modern studies suggest that on the basis of sorting and porosity development braided streams are likely to form better reservoirs than fan deltas. For this reason the ends of basins and the floor proximal to hinged margins will be the most prospective, particularly when they occur near depocentres adjacent to boundary faults and therefore up-dip from the best lacustrine source rocks.

In Australia, sandstone bodies of origin different from fluvial and deltaic facies, together with other non clastic rocks like limestones, have received little attention as potential reservoirs.

Deep water sandstones which act as reservoirs have recently been discovered in many parts of the world, either as deep sea fan deposits or as turbidites. Both the North Sea Brae and Frigg Fields are large submarine fan deposits of early Tertiary age. The Tertiary oil of the Ventura and Santa Barbara Basins and the gas in the Grimes Field in California occurs in turbidite reservoirs. Exploration in similar environments in Australia has been very limited. Only in the Dampier Sub Basin south of the Rankin Platform have these lessons been applied where the Early Cretaceous Flag Sandstone at Harriet Field has been interpreted as a prograding submarine fan complex. What chances that the new find at North Rankin is also a fan complex. In this context it should be noted that in the Grimes Field in California seismic studies were unable to identify the sandstone lobes within the fan complex.

50% of the world's petroleum occurs in carbonate rocks. However, in Australia, the development of carbonate plays has been largely neglected. The consequence of this is that Australian carbonate provinces have been generally underexplored: at best, limited and sometimes inappropriate play concepts have been applied. Bahamman and Persian Gulf models are not the global answer to interpretation of carbonate environments. They are not for example applicable to the interpretation of the growth and evolution of carbonate rocks in the Great Barrier Reef Province, the largest carbonate province currently existing on earth. Instead the northeast Australian margin defines a different model of reef platform evolution resulting from processes dominated by plate tectonics, sealevel and high energy. Such a combination of processes with attendant products can be shown to have occured many times in the geological past and particularly in the Australian region. The attendant products are significantly different to conventional model predictions and therefore vital in understanding the possible distribution of petroleum. The major reservoir types have been determined from a detailed knowledge of reef biology and biochemistry, sedimentology, geophysics, plate tectonics, structural geology, palaeoclimate and palaeo-oceanography. Three principal inter-relations determine the type of reservoir produced:

(1) Plate position and sealevel will interact to determine whether temperate or tropical reservoirs develop. The facies and porosity variation within both types will be radically different. If, as in Australia, the craton moves from a temperate to a tropical climate then the temperate reefs will form the base on which future tropical reefs will grow. Such a scenario occured in the development of the Miocene subsurface reefs in the Gulf of Papua (Figure 4). As a consequence of the northward

motion of the Australian plate in the Cainozoic, temperate algal reefs first grew and formed the base for later multiple phases of high energy tropical reef growth. Identification and delination of the separate build-up types is essential in exploration strategy.

(2) Climate and paleo-oceanography will determine whether coral reefs or algal reefs develop. This is especially vital in understanding possible relations between reservoir and source. Tropical reefs are essentially externally sourced whereas tropical green algal reefs may provide both source and seal. In Australia such reefs have received scant attention and this may represent a very serious exploration error as such features in the south west of the USA are estimated to contain 8 billion barrels of recoverable oil. Similar features have not been reported from Australian basins but with a greater emphasis on high resolution seismic analysis, and the predictive criteria published in Davies etal (1988), such features should be discovered.

(3) Structure, sealevel and climate will determine the geometry and extent of reservoirs and their relationships to source and seal. Large reef systems frequently develop along the margins of a rift basin, along which petroleum prospectivity will be determined by the timing of growth in relation to the structural evolution of the rift basin. Reefs are most likely to grow in two structural/time related situations:

- On fault blocks, early in basin evolution and therefore in a regime of high subsidence. Their structural position controls their shape which is usually atoll or pinnacle and the impinging energy and adjacent slopes will determine the size of leeside drape environments of high porosity. Such reefs are often encased in onlapping basinal sediments and sealed by prograding fluvioclastics. The Pandora Reef is an example of such a prospect defined by BMR and successfully drilled in 1987 by the International Petroleum Corporation. One drill hole so far has has defined 900ft of hydrocarbon pay with 25% porosity containing 3TCF of recoverable gas.

  Other examples of this mode of growth are seen in the Fitzroy Trough of the Canning Basin.
- On hinge boundaries reefs can grow at any stage during basin development. During the early high subsidence phase of basin development backstepping reefs will form in contrast to the later stages of slow subsidence when prograding reefs will form. Different facies and porosity distribution will characterise these types(Table 2).

In defining prospectivity it is therefore essential to know the relations between growth and structure, and nowhere is this more apparent than in the Canning Basin where two phases of reef growth have been identified. The earliest phase is a backstepping phase formed during a rapid relative rise in sealevel and this is replaced by a prograding reef phase formed during a period of slow sea level change. The earliest phase of growth occured on fault blocks and structurally controlled hinge lines. The identified relationship of reservoir facies type and structure(Drummond etal 1988) and the successful drilling of a fault controlled pinnacle reef off northeast Australia (Davies etal 1988) should encourage future exploration in the Canning based on the ideas generated from within the BMR in the past three years.

Where there's a Drill there's a Way

Recent scientific drilling of the Exmouth Plateau by the Ocean Drilling Program in August 1988 did not find oil. It did find a new reservoir.

Site 764 of Leg 122 of the Ocean Drilling Program cored 200m of Upper Triassic reef complex off the northern margin of the Exmouth Plateau. In spite of extensive previous industry drilling, reefs of this age had never previously been discovered in this area. Mapping of similar Upper Triassic reefs and shelf carbonates now identified on seismic sections(Exon etal 1989), together with the earlier reported occurrence of reefal carbonates in eastern Indonesia, Timor and in Papua New Guinea extends the probability of Upper Triassic reef facies being discovered elsewhere on the Northwest Shelf and defines a new exploration target for the whole of the region.

Petrologic examination of the reef and perireefal sequence together with interpretation of the logs indicates that the high porosity grainstones and coquinas associated with the reefs were deposited in a high energy tropical environment and form excellent reservoirs. Scientists working on the Triassic reefs have indicated that their seismic character is similar to that of the Neogene reefs off northeast Australia(Davies etal 1988) which appear to form an excellent analogue for their Triassic counterparts.

Space Age Exploration

The search for new and better ways of assessing prospectivity and exploring for hydrocarbons has prompted BMR's Division of Marine Geosciences to enter into a joint research program with Transglobal Exploration and Geoscience of California aimed at defining the presence, nature and composition of sub seafloor accumulations of hydrocarbons and the maturity and type of source rocks from which gas seeps are derived. The relationship between the maturity of potential source rocks and the molecular and isotopic signal in seeps is the objective of the program. Further, when tied to high resolution seismic studies, information and ideas on migration pathways and trapping mechanisms will be generated. This will be achieved through a state of the art program of continuous underway analysis of light hydrocarbons and carbon dioxide in sea water, in conjunction with bottom sampling and geochemical analysis and high resolution seismic and sidescan sonar.

This program will provide basic data and maps of light hydrocarbon distributions in potential prospective areas both on a local and a regional scale. Such data may provide direct evidence of the presence of gas seeps, the nature of the seep(thermogenic or biogenic), and if thermogenic the possible type of accumulation(gas, condensate or liquid) that supports the seep. It is thus a relatively inexpensive method of defining the presence and distribution of mature source rocks. The first program using these techniques has just been completed in the Gippsland and Bass Basins. Similar programs are planned for the Northwest Shelf in 1989/90.

Conclusions

BMR aims to provide both the understanding by which future petroleum can be found and the best data and ideas with which industry can explore effectively and successfully. Some of the innovative thinking outlined above will hopefully reduce risks, make exploration more attractive, increase the number of successful holes drilled and provide energy security again for Australia.

References

Bradshaw,M.T., Yeates,A.N., Beynon,R.M., Brakel,A.T., Langford,R.P., Totterdell,J.M., and Yeung,M., 1988, Paleogeographic evolution of the North West Shelf Region, In, Purcell , P.G. and R.R. (Eds.), The North West Shelf, Australia: Proceedings of Petroleum Exploration Society, Australia Symposium, Perth.

Davies, P.J., Symonds, P.A., Feary, D.A. and Pigram, C.J., 1988, Facies Models in Exploration - The Carbonate Platforms of Northeast Australia. APEA Journal, V.28 (Part 1), 123 - 143.

Davies, P.J., Symonds, P.A., Feary, D.A. and Pigram, C.J., 1989, The evolution of the carbonate platforms of Northeast Australia. SEPM Special Publication 44 (In Press).

Drummond, B.J. Etheridge, M.A., Davies, P.J., and Middleton, M.F., 1988, Half-graben model for the Structural Evolution of the Fitzroy Trough, Canning Basin, and Implications for Resource Exploration. APEA Journal, V.28 (Part 1), 76 - 87.

Etheridge, M.A., Symonds. P.A. and Powell, T.G., 1988, Application of the Detachment Model for Continental Extension to Hydrocarbon Exploration in EXtensional Basins. APEA Journal, V.28(Part 1), 167 - 189.

Exon, N.F, Williamson, P.E, and ODP Leg 122 Shipboard Scientists, 1989, Ocean Drilling Program finds Triassic reef play off North West Australia. Oil and Gas Journal (In Press).

Falvey, D.A. and Deighton, I., 1982, Recent advances in burial and thermal geohistory analysis. APEA Journal, 22, 65-81.

Laws, R.A., 1988, Geological significance of recent discoveries and developments in Australia and Papua New Guinea. APEA Journal, V.28(Part 2), 59 - 66.

Pigram C.J., Davies, P.J., Feary, D.A. and Symonds, P.A., 1989, Tectonic controls on carbonate platform evolution in Southern New Guinea: Passive Margin to Foreland Basin. Geology (In Press).

Table 1. Stages in the evolution of the foreland basin between Australia and New Guinea. The foreland basin will in fact be diachronic towards the west i.e. the ages will become young in that direction.

Phase 1	Cretaceous to Palaeocene	Pre Collision	Organic rich and Siliclastic sediments
Phase 2	Eocene to Early Oligocene	Neo Collision	Temperate carbonates
Phase 3	Middle Oligocene	Collision Foreland Basin formed.	Deep water clastics Temperate shelf carbonates.
Phase 4	Late Olig.to Middle Mioc.	Proximal infill. Distal Platform	Clastics Tropical carbonates Reefs.
Phase 5	Mid. Mio.to Early Plioc.	Southward Migration of Basin and Platform	Clastic sediments bury buildups.
Phase 6	Late Plioc. to Recent	Platform demise	Clastic sediments seal platform.

Table 2. Gross characters of reefs formed during backstepping and prograding scenarios.

Backstepping Reefs	**Prograding(Advancing) Reefs**
1. Dominated by backward retreating facies.	1. Dominated by forward prograding facies.
2. Reef facies underlain by lagoonal facies.	2. Reef facies overlain by lagoonal facies.
3. Framework facies relatively thin.	3. Framework facies thick.
4. Preservational potential of back facies is high.	4. Preservational potential of backreef facies is low.
5. Forereef facies subordinate.	5. Forereef facies dominant.
6. Reefs discrete, especially as ribbons along hinge strike.	6. Reefs form huge platforms - greater expanse of reefs.
7. Reservoirs likely to be simple.	7. Reservoirs stacked and complex.

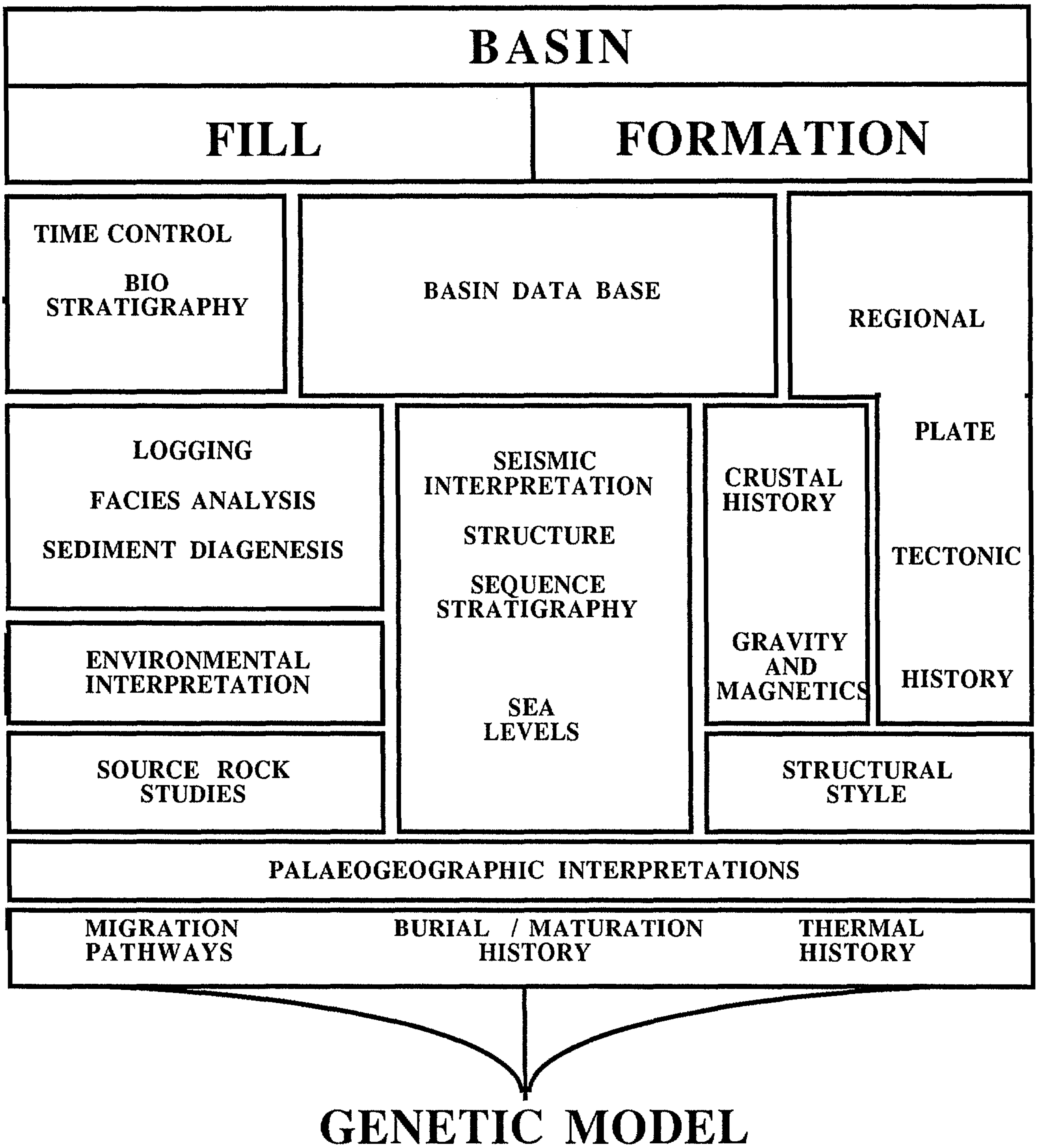


Figure 1. Tasks involved in an integrated basin analysis program leading to the development of a genetic useful to exploration.

Fuel demand for electricity generation - the case of Japan

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The structure of demand for fuels for electricity generation in Japan has changed significantly since the end of the Second World War. These changes have accompanied the rise of Japan as a major economic power and reflect structural adjustments in the economy in response to higher oil prices in the 1970s and policy decisions aimed at strengthening energy security including reliability of supply of fuels. As Japan has few domestic energy resources it has had to meet domestic demand for energy largely from imports.

Japan is the major market for Australian fuel exports, buying about $1.0b in 1988, and accounting for about 35 per cent of Australia's total fuel exports. Currently about half of Australia's steaming coal exports and a third of Australia's uranium exports go to Japan.

Australia is a major supplier of Japanese requirements of fuels, primarily of coal and uranium. In calendar year 1987 Australia supplied 69 per cent of Japan's steaming coal imports. Australian exporters have long term contracts for the delivery of uranium to several Japanese electricity utilities. In October this year Australia will begin to export LNG (liquified natural gas) from the North-West Shelf in Western Australia to Japanese electricity and gas utilities. On the basis of currently contracted volumes Australia will supply about 10 per cent of Japanese LNG consumption in 1990 and about 15 per cent after 1995.

Although some Australian steaming coal is consumed in the Japanese industrial sector, all the uranium and most of the forthcoming LNG exports will be consumed in the generation of electricity. The value of Australian fuel exports to Japan could rise to $2.3b by 1995 (in 1988 dollars). Future developments in this market are therefore of major significance for Australia.

Structure of the Japanese Electricity Industry

The ownership structure of the electric power industry in Japan and contributions to output in 1987 are shown in table 1. Most electricity is generated by nine regional electricity utilities - the Hokkaido, Tohoku, Tokyo, Chubu, Hokuriku, Kansai, Chugoku, Shikoku, and Kyushu Electric Power Companies - each of which is independent and privately owned and holds exclusive retail sales rights within its service area (Electric Power Information Center 1987). These nine utilities are also responsible for the transmission and distribution of electric power for almost all public supply throughout Japan.

The nine major utilities produced approximately 74 per cent of total electricity generation in Japan in 1986. The balance of Japan's electricity

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All years quoted in this paper are Japanese fiscal years unless stated otherwise. Fiscal year 1988 is 1 April 1988 to 31 March 1989.

output is produced by wholesale utilities, including the Electric Power Development Co. Ltd, the Japan Atomic Power Co., 33 public power generating enterprises, 21 joint venture power companies, several minor generating companies, and non-electric industrial firms. Unless stated to the contrary, the statistics referred to in this paper refer to fuels consumed or electricity generated by these Japanese utilities and exclude electricity produced by non-electric industrial firms.

The electricity industry in Japan started with the establishment of the Tokyo Electric Lighting Company in 1887. In 1939 the Japan Electric Power Generation and Transmission Company was founded as a nationwide electricity wholesale company, and in 1942 regional distribution companies were established, taking over the businesses and facilities operated by the then hundreds of electric utility enterprises. Following a further reorganisation in 1948 and again in 1951 the present nine regional electric utilities were established.

Table 1: ELECTRIC POWER GENERATION AND SALES AND DISTRIBUTION SYSTEM IN JAPAN IN 1986(a)

Electric utilities and firms	Generation		Sales and distribution	
	Amount	Share	Amount	Share
	GW.h	%	GW.h	%
9 major regional utilities(b)	499 962	73.92	516 073	85.75
Okinawa Electric Power Co.	3 209	0.47	3 683	0.61
Others				
Electric Power Development Co.	31 674	4.68		
Japan Atomic Power Co.	14 747	2.18		
31 local government utilities	7 556	1.12		
2 local government utilities(c)	444	0.06		
4 joint thermal power companies(d)	6 227	0.92		
15 joint thermal power companies	36 426	5.39		
Sumitomo Kyodo Karyoku	1 265	0.19		
Electricity sold outside the regional utilities distribution system			17 983	2.99
Subtotal	601 510	88.93	537 739	89.35
Non-electric, industrial firms	74 842	11.07	64 070	10.65
Total	676 352	100.00	601 809	100.00

(a) Japanese fiscal year 1 April 1986 to 31 March 1987. (b) The nine major utilities also distribute power generated by the Electric Power Development Co., the Japan Atomic Power Co., all local government utilities, and four of the joint thermal power companies. (c) Hokkaido and Kanagawa prefecture government owned utilities sell part of their output outside the regional utilities distribution system. (d) Electric utility and non-electric joint ventures. Four joint companies sell some power through the regional utilities distribution system.
Source: Japan Petroleum and Energy Trends (1988, p.4).

Figure 1: Japanese electricity network

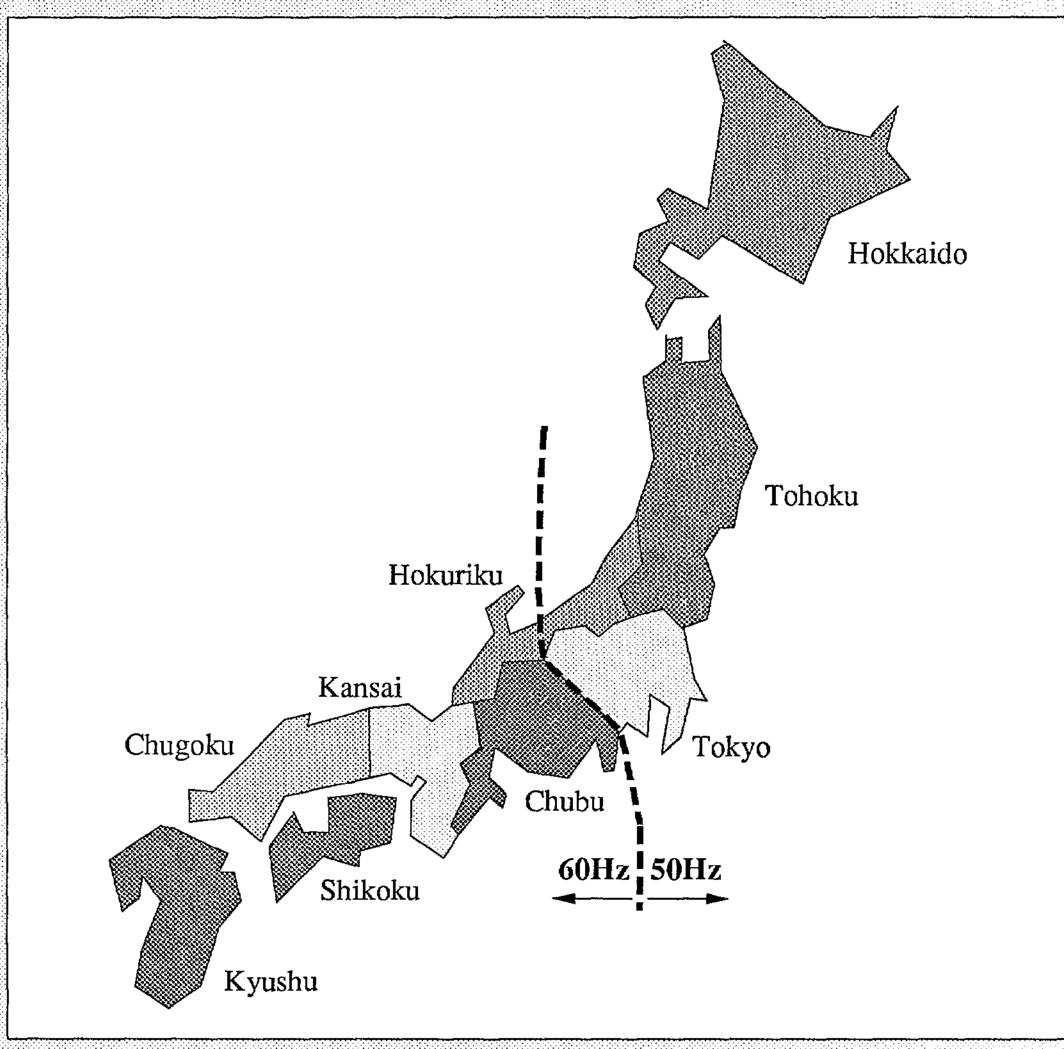
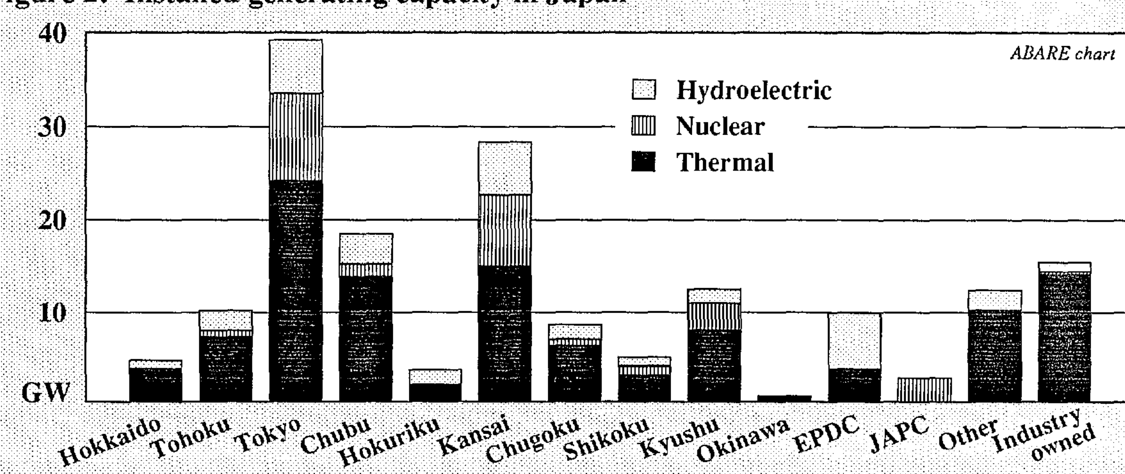


Figure 2: Installed generating capacity in Japan



The Japanese electricity grid (figure 1) consists of two parts: the 50 Hz power system of eastern Japan and the 60 Hz power system of western Japan. The interconnection allows only a very small exchange of power between the two otherwise separate parts. This limits the extent to which utilities in one part can sell power to utilities in the other part. The development of the two separate frequency zones reflects the disparate origins of the industry. Within each frequency zone electricity is sold between utilities to compensate for fluctuations in demand and to cover emergencies.

The major electricity utilities use various combinations of generating facilities - thermal, nuclear and hydroelectric (figure 2) - and hence different utilities consume different mixes of fuels. The way fuels are used varies as well: some utilities use coal and oil for generating middle and peak load electricity; other utilities use these fuels for generating base load requirements.

Fuel Consumption by Power Utilities

Strong economic growth and electricity demand in Japan have resulted in a tenfold increase in electrical power generation (table 2) between 1955 and 1987. Most of this expansion of the Japanese electricity sector took place in the 1960s, when annual growth of generation averaged 12 per cent. After 1970 average annual growth slowed to 3.6 per cent and from 1980, to 3.2 per cent.

Table 2: ELECTRICITY GENERATION IN JAPANESE UTILITIES

Year(a)	Thermal	Nuclear	Hydro	Total
	TW.h	TW.h	TW.h	TW.h
1955	16.7		48.5	65.2
1960	57.0		58.5	115.5
1965	115.0	0.025	75.2	190.2
1970	274.9	4.61	80.1	359.6
1971	290.8	8.0	86.8	358.6
1972	331.1	9.5	87.9	428.5
1973	330.3	9.7	66.0	406.0
1974	299.4	19.7	78.7	397.7
1975	309.6	25.1	79.3	414.0
1976	332.3	34.1	82.1	448.4
1977	366.0	31.7	70.3	468.0
1978	369.1	59.0	68.9	497.0
1979	373.7	69.3	78.6	521.6
1980	346.9	82.0	85.1	514.1
1981	352.2	87.2	83.7	523.1
1982	343.3	101.8	77.3	522.5
1983	361.0	113.1	81.4	555.5
1984	378.3	133.2	70.6	582.2
1985	363.8	159.0	81.2	603.9
1986	354.6	167.3	79.5	601.5
1987	379.0	186.6	74.6	640.1

(a) Japanese fiscal year: 1955 fiscal year is 1 April 1955 to 31 March 1956. Figures for the years up to and including 1972 include non-utility production, which in 1973 constituted 15 per cent of thermal generation, almost 100 per cent of nuclear generation and 7.8 per cent of hydroelectric generation, amounting to 13.7 per cent of total generation.
Source: Electric Power Information Center (1987).

The growth in total generation, however, conceals important differences in the rates of growth of the three different technologies used by the electricity generation sector: thermal (using coal, gas and liquid fuels, mainly crude oil and heavy oil), nuclear power and hydroelectric power. About 75 per cent of the total growth in electricity generation since 1973 has been supplied by nuclear power. Electrical output from hydroelectric stations dominated supply until the mid-1960s, but has remained static since that time. Generation from thermal plants rose strongly until the early 1970s, at an average annual rate of about 20 per cent. However, between 1973 and 1987 growth in thermal generation has averaged only 1.0 per cent a year. Nuclear electricity generation has increased dramatically since it first made a contribution in 1965. Between 1973 and 1987 nuclear electricity has averaged an annual rate of growth of about 23.5 per cent.

Although overall thermal power output has grown slowly since the early 1970s (production peaked in 1979, then levelled off and has fallen since 1984), there have been considerable changes in the mixes of fuels consumed in thermal electricity generation (table 3). Oil consumption rose strongly until 1979, but since then has declined. Consumption of coal, mainly from

Table 3: FUEL CONSUMED BY JAPANESE THERMAL POWER STATIONS

Year(a)	Total oil	Heavy oil	Crude oil	Naphtha	LNG	Coal
	ML	ML	ML	ML	kt	kt
1955	307	307				7 211
1960	4 956	4 956				16 600
1965	12 505	11 786	719			20 073
1970	41 885	34 646	7 239		367	18 821
1971	45 892	34 896	10 996		714	13 873
1972	56 059	37 460	18 599	164	676	10 663
1973	66 426	42 825	23 601	2 240	1 379	8 318
1974	57 712	34 681	23 031	2 802	2 475	7 339
1975	58 665	35 999	22 666	2 439	3 326	7 179
1976	64 532	38 622	22 175	3 735	3 920	7 771
1977	68 464	41 953	22 726	3 785	5 703	8 136
1978	64 294	40 532	21 389	2 373	8 936	7 729
1979	60 556	39 699	18 527	2 330	11 708	8 385
1980	50 497	35 689	13 432	1 376	12 987	9 776
1981	49 709	34 377	14 334	998	13 227	12 188
1982	45 535	31 045	13 742	748	13 358	14 821
1983	45 301	29 744	15 002	555	15 332	17 714
1984	40 286	25 987	13 920	379	20 791	20 569
1985	34 272	21 079	12 830	363	21 634	22 627
1986	32 226	18 711	13 126	388	21 949	21 869
1987(e)	33 670	na	na	na	22 780	23 310

(a) Japanese fiscal year: 1955 fiscal year is 1 April 1955 to 31 March 1956.
(e) Estimate. LNG Liquified natural gas.
Sources: Electric Power Information Center (1987); Japan Petroleum and Energy Trends (1988).

domestic mines, rose in the late 1950s and early 1960s, before declining with the increase in oil consumption in the 1970s. Coal consumption began to rise again after 1975 when new coal fired capacity was constructed.

Four stages in the development of the Japanese electricity sector can be identified. In the early years after the war, Japan relied heavily on domestic fuel sources, such as hydroelectric power and local coal. By 1960 these fuels accounted for over four-fifths of fuel requirements for electricity generation. The reliance on domestic fuels reflected a low level of energy consumption per person and a relatively unsophisticated industrial structure. Foreign exchange shortages also limited the scope for purchasing imports.

In the 1960s there was a shift to a second stage characterised by marked dependence on imported oil. By 1973, about two-thirds of Japan's total primary fuel requirement for electricity generation were supplied by imported petroleum. The rapid growth in reliance on imported oil was due to strong economic growth driving demand for electricity. The availability of cheap oil on world markets and the limited domestic fuel supplies meant that imported oil was the economic choice.

A move away from dependence on imported oil marked the shift into the third stage of fuel consumption in Japan, which is characterised by a diversification of fuel sources - into nuclear, coal and LNG. This change was triggered by the first oil shock in 1973 and was strongly reinforced by the second shock in 1979.

The Japanese electricity sector may be entering a fourth stage in its development - one characterised by multi-fuel generating systems that give utilities considerable flexibility in deciding on optimum fuel consumption patterns in the shorter term. This is likely to have important implications for forecasting and is discussed later in this paper.

. Government policy

The oil shocks of the 1970s had a profound affect on Japanese energy policy. Government policy changes initiated in the 1970s and strengthened in the 1980s were designed to reduce the country's dependence on oil, to increase the security of its energy supplies and to cut the cost of its industrial energy bill in order to retain international competitiveness. The effect of these policies has been to reshape the fuel requirements of electric generating capacity in Japan and as a consequence enable oil to be gradually replaced by nuclear power, LNG and coal.

The range of instruments used by the Japanese government to achieve its policy objectives were described by Perkins (1985). They range from indicative forecasts of energy demand and supply* to specific laws. Within the context of the overall objective of reducing the country's dependence on oil, addressed in the 1962 Petroleum Industry Law (revised in 1978), and the 1973 Petroleum Supply and Demand Optimisation Law, the government has passed two major laws which have a direct impact on the electricity sector: the

* The process involved in developing these forecasts is described by Perkins as 'consensus planning, as the indicative targets finally produced are a compromise of what is considered economically and politically desirable from a national perspective, and what is commercially feasible in the view of private industry' (Perkins 1985, p.31).

1980 Law Concerning the Promotion and Development of Alternative Energy Sources (the Alternative Energy Law) and the 1979 Law Concerning the Rationalisation of Energy Use (the Conservation Law). One of the primary objectives of the Alternative Energy Law is to achieve a diversification of sources of electric power generation. The Alternative Energy Law also directs the Minister for International Trade and Industry to develop and publicise target levels for electricity generation from alternative energy sources. These targets have been incorporated in the Ministry's long term demand and supply outlooks released in 1983 and, most recently, in 1987. The objective of the Conservation Law is to promote maximum energy conservation without affecting economic growth, social welfare or employment (Perkins 1985).

It is clear that through the application of policy instruments the Japanese government has been effective in reshaping the mix of generating capacity and in promoting energy conservation, thereby directly affecting consumption of individual electricity fuels.

Forecasts of Electricity and Fuel Demand

Long range forecasts of electricity supply and demand are prepared by the Supply and Demand Committee of the Electric Utility Industry Council, which is an advisory body to the Minister for International Trade and Industry. The Electric Utility Industry Council normally updates its forecasts at the same time as the Overall Energy Council, also an advisory body to the Minister, updates its long range energy supply and demand forecasts (table 4). The forecasts by the two Councils provide authoritative official long term forecasts (Japan Petroleum and Energy Weekly 1987). The most recent Electric Utility Industry Council forecast was released in October 1987 and contains forecasts for 1995, 2000 and 2005.

Each April, the Ministry publishes an update of the rolling ten-year plan for electricity facilities which is drawn up by the Central Electric Power Council. The April 1988 plan contains forecasts for 1992 and 1997. The 1988 forecasts are based on the assumption of an electricity consumption growth rate of 2.4 per cent a year between 1987 and 1997. This is made up of a strong 3.8 per cent growth rate in the residential and commercial sectors (due to increased use of domestic appliances and strong construction activity) and a weaker 1.2 per cent growth in the industrial sector (due to a decline in growth of energy intensive industries, particularly steel making). Economic growth is assumed to average 4.0 per cent a year over the period.

The Central Electric Power Council is forecasting a 27 per cent increase in both generating capacity and electricity output over the period 1987-97 (table 5). The steady decline in thermal power output since 1984 is expected to be reversed, and thermal output is forecast to increase by 11 per cent over the decade to 1997. This modest turnaround is due mainly to the expected 50 per cent increase in electricity output from coal fired power stations, and should occur despite a reduction in the proportion of LNG thermal output and a fall of 16 per cent in electricity generated from oil fired stations. Thermal generation's share of total electricity generation will fall, as nuclear's share increases.

Nuclear electricity generation is forecast to contribute most of the growth in generation over the period 1987-97. By 1997 nuclear capacity is expected to have grown by 67 per cent over 1987 levels. Hydroelectric capacity is expected to grow by 17 per cent, while generation from hydroelectric stations is expected to grow by 27 per cent.

Table 4: FORECASTS OF ELECTRICITY GENERATION IN JAPAN(a)

Fuel	1987(b) Amount	1987(b) Share	1992(c) Amount	1992(c) Share	1995(d) Amount	1995(d) Share	1997(c) Amount	1997(c) Share	2000(d) Amount	2000(d) Share	2005(c) Amount	2005(c) Share
	TW.h	%	TW.h	%	TW.h	%	TW.h	%	TW.h	%	TW.h	%
Nuclear	187	29	222	32	265	35	296	38	348	40	425	45
Hydro	75	12	90	13	97	13	97	12	106	12	115	12
Thermal												
Oil	na		144	20	110	15	121	15	95	11	70	7
LPG	na		(e)		3	-	(e)		3	-	(f)	-
LNG	na		155	22	164	22	161	21	164	19	155	16
Coal	na		67	10	92	12	90	12	118	14	160	17
Other	na		17	3	25	3	17	2	34	4	30	3
Subtotal	379	59	381	55	375	50	397	50	395	46	415	43
Total	640	100	693	100	760	100	783	100	868	100	955	100

(a) Japanese fiscal years: fiscal year 1987 is 1 April 1987 to 31 March 1988. (b) Source: Agency of Natural Resources and Energy (1988). (c) Central Electric Power Council April 1988 forecast (Japan Petroleum and Energy Trends 1988). (d) Electric Utility Industry Council October 1987 forecast (Japan Petroleum and Energy Weekly 1987). (e) Included with 'other'. (f) Included with 'oil'. LPG Liquified petroleum gas. LNG Liquified natural gas. (-) Negligible amount.

Table 5: MAIN FEATURES OF THE CENTRAL ELECTRIC POWER COUNCIL FORECAST(a)

Item	Unit	Nuclear	Hydro	Thermal Oil	Thermal LNG	Thermal Coal	Total
Installed capacity							
1987 estimate(b)	GW	28	35	49	31	11	159
Additional capacity by 1997(b)	GW	19	6	-4	12	8	42
Percentage increase	%	67	17	-9	40	75	27
Electricity generation							
1987 estimate(b)	TW.h	185	76	144	133	60	613
Additional generation by 1997(b)	TW.h	111	20	-23	28	30	169
Percentage increase	%	60	27	-16	21	50	27
Thermal fuel consumption							
1987 estimate(b)	(c)			33.7	22.8	23.3	
Additional consumption by 1997(b)	(c)			-5.5	4.6	10.3	
Percentage increase	%			-16	20	44	

(a) Figures rounded. (b) Japanese fiscal year: fiscal year 1987 is 1 April 1987 to 31 March 1988. (c) Oil consumption in GL; coal and liquefied natural gas consumption in Mt.

The Central Electric Power Council forecasts that coal consumption will rise by 10.3 Mt in the decade to 1997, LNG consumption will rise by 4.5 Mt over the same period, and oil consumption will decline by 5.5 GL.

Review of past official forecasts indicates that they have not been reliable, reflecting the 'compromise' nature of the forecasts (Japan Institute of Energy Economics 1988). The accuracy of the current Central Electric Power Council and Electricity Utility Industry Council forecasts will be affected by new developments in the Japanese power sector. First, electricity utilities will have increased flexibility in their fuel planning because of the diverse mix of generating capacity. Moreover, an increasing proportion of thermal plants will be multi-fired (that is, able to use more than one type of fuel). In these circumstances suppliers will have more flexibility to respond to short term price fluctuations and supply constraints, by fuel substitution.

The effect of increased nuclear capacity in the 1990s will be to firmly establish nuclear power as the predominant fuel for generating base load electricity. For some utilities (for example, Chugoku and Hokkaido) new nuclear generation capacity will replace coal or supplement it as the main base load fuel. Coal will be increasingly used together with oil and LNG as a middle load fuel. New coal fired capacity being built by utilities that already have nuclear capacity (for example, Kyushu, Chugoku and Tohoku) can be expected to enhance their range of fuel sources for meeting medium load demand.

Structural adjustment of the Japanese economy directly affects electricity demand. Many of the energy intensive industries, which typically make up base load demand, are no longer expanding. In the 1987 Ministry of International Trade and Industry report, 'Twenty First Century Energy Vision', many new industries are seen to be 'information intensive' rather than energy intensive. Increasingly, growth in demand for electricity will come from the residential and commercial sectors (demand from these two sectors exceeded demand from the industrial sector for the first time in 1987). These factors affect the shape of the daily load curve, which is expected to become more peaked. Accordingly, demand will increase for middle and peak load power, generated mainly by smaller, less efficient power stations burning liquid fuel and more expensive gaseous fuels, and from hydroelectric stations.

A further issue is that environmental concerns in Japan are likely to become more important than has been the case in the past, and are likely to influence the choice of fuels to be consumed. Fossil fuel consumption could be affected by concern over acid rain and the greenhouse effect, and nuclear power growth by emerging public disquiet over safety. In response to public pressure, utilities have been turning to cleaner, though more expensive, fuels. Tokyo Electric, for example, burns LNG to reduce emissions in heavily builtup Tokyo.

In deciding how to invest in new generating capacity to meet expected electricity demand, the Japanese utilities consider a range of factors. These include government policies, the structure of tax and other government financial incentives and disincentives, the costs of power generation from different fuels and the choice of generating technology, and security of supply.

Additional uncertainties affecting the forecasts include the future rate of growth of the Japanese economy and electricity demand, and the future path of energy prices, particularly oil prices. Changes in the electricity tariff rate structure, as utilities act to moderate the increased 'peaky' shape of the load curve, can be expected to affect demand for thermal fuel.

Strong electricity growth in Japan in 1987 and 1988 raises doubts about the value of the latest Central Electric Power Council rolling ten-year forecast, which expected electricity demand to grow over the decade to 1997 at an average rate of only 2.4 per cent a year. Even if demand were to fall to the forecast growth rate over the rest of the forecast period, the forecast would still underestimate total demand by about 8 per cent in 1997. The Japanese Institute of Energy Economics (1988) is projecting electricity demand to grow at 3.1 per cent. This growth rate is similar to that experienced over the period 1980-87.

There are a number of factors which point to a higher rate of growth in electricity demand than projected in the official forecasts. These include strong economic growth as a result of expansion of the domestic sector, a limit on further energy conservation savings, positive demand effects from low energy prices and further strong growth in Japanese service industries. It has been estimated (Kimura 1989) that if electricity demand were to grow at 3 per cent with 1987 as a starting point, demand in 2000 could surpass the official projection by 11 GW of required generating capacity.

Higher growth in electricity demand could be expected to lead to demand for fuel for electricity generation higher than that reported in the official forecasts. The growth of nuclear capacity in relation to overall demand growth will be a key determinant of development in demand for thermal fuels. The current official forecast expects nuclear power to contribute 40 per cent of total power generation in 2000. However, the Institute of Energy Economics (1988) does not expect this to be reached: it assumes nuclear power will contribute only 34 per cent in 2000, and expects that increase in thermal generation will make up the difference.

According to the latest Electric Utility Industry Council forecast, 53 GW of nuclear capacity will be installed by 2000. This figure comprises the 28 GW in operation, 12 GW under construction and 6 GW approved for construction, together with a further 7 GW not yet approved. If this additional 7 GW is not approved for environmental or other reasons, nuclear capacity will reach only 46 GW in 2000. The further development of nuclear power may also be delayed if estimates of the cost advantages over coal prove to have been incorrect, as suggested by Perkins (1987).

Kimura (1989) has calculated that the shortfall in the official forecast of generating capacity for 2000 could be 18 GW. This is made up of the 7 GW of the as yet unapproved nuclear capacity, and 11 GW further shortfall if demand growth averages 3 per cent rather than 2.4 as forecast. According to Kimura, if half this shortfall is covered by the construction of additional coal fired plants, demand for steaming coal for power generation could reach 55-60 Mt in 2000. The 1988 Central Electric Power Council rolling ten-year forecasts project demand for steaming coal for electricity generation in 1997 at 33.6 Mt. Consumption in 1987 was estimated to have been 23.3 Mt.

If thermal output is to be expanded, coal will have to be price competitive with oil and LNG. As Japanese utilities now use a range of fuel types and have plants which can use more than one fuel it can be expected that demand for individual fuels will be affected by relative price changes, as utilities can switch between fuels in response to short term market factors.

Implications for Australian Exports

The Japanese market for steaming coal is expected to grow over the short to medium term at a higher rate than that indicated by official forecasts. Anti-nuclear and environmental concerns could slow the nuclear program and stimulate thermal power generation, particularly using LNG, in the 1990s, thereby opening market opportunities for Australian suppliers additional to the present North-West Shelf contracts.

For Australia to maintain its dominant market share in steaming coal in the Japanese power sector, export prices will have to remain competitive with other thermal fuels and compete with other supplies, particularly from new projects in Indonesia and China. Exports of Australian uranium are expected to be stable over the short to medium term, in line with long term contracts that are currently in place. However, further uranium sales to Japan can be expected.

Strong growth in demand for steaming coal in Japan may not be accompanied by strong price increases. Coal prices are presently competitive with oil and LNG, and will need to remain competitive to maintain coal's share in the mix of thermal power generation. The demand for particular thermal fuels can be expected to be more price sensitive than in the past, due to the increased flexibility in fuel substitution available to utilities. This development can be expected to be reflected in more flexible fuel supply arrangements in future.

Environmental concerns over emissions from the burning of fossil fuels are likely to favour substitution of LNG for oil and coal over the medium term. A postponement of the start of construction of new nuclear power stations, for whatever reason, would have a significant effect on primary fuel consumption only after the mid-1990s.

References

Agency of Natural Resources and Energy, Ministry of International Trade and Industry (1988), in Thermal Coal Imports by Japanese Power Utilities, Marabeni Corporation, December, Tokyo, p.7.

Electric Power Information Center (1987), Electric Power Industry in Japan 1987, Tokyo (and previous issues).

Institute of Energy Economics (1988), Fifteen years since oil crisis: how shall we face new era of challenge? A paper presented to the 21st Symposium on Energy Economics, December 1988.

International Energy Agency (1988), Energy Prices and Taxes, 1st Quarter 1988, OECD, Paris (and previous issues).

Japan Petroleum and Energy Trends (1988), Japan Petroleum and Energy Trends, 1 April, pp.2-6.

Japan Petroleum and Energy Weekly (1987), Japan Petroleum and Energy Weekly, 12 October, pp.3-8.

Kimura, T. (1989), 'A review of coal demand outlooks for Japan', Energy in Japan, Bi-monthly Report 95, 32-5.

Ministry of International Trade and Industry (1983), Long Term Energy Supply and Demand Outlook and Future Energy Policy, Tokyo.

___ (1987), The Twenty First Century Energy Vision - Entering the Multiple Energy Era, Tokyo.

Perkins, F. (1985), Japan's Energy Policies - Their Evolution and Implementation, Japan Institute of Energy Economics, Tokyo.

___ (1987), The Impact of Falling Oil Prices on Comparative Electricity Generation Costs in Japan: Implication for Japanese-Australian Energy Trade, Japan Institute of Energy Economics, Tokyo.

Liquefied natural gas market prospects

J G Pullar

Woodside Petroleum Ltd

In September, the Prime Minister will officially open Australia's first large scale LNG plant on the Burrup Peninsula, near Karratha, Western Australia. This event will celebrate the birth of a major new export industry for Australia.

Of course, natural gas has been available in Australia for many years. But LNG will be an entirely new export commodity for this country... and since LNG exports from the North West Shelf Project alone will represent a significant component of Australia's future balance of trade and exchange revenue, it is appropriate that we understand more about the LNG industry and its future prospects.

Before considering the market prospects for Australian LNG, let us briefly review the history of the LNG industry and the development of the North West Shelf Project in order to gain some understanding of the complexities of the LNG trade.

Background:

The North West Shelf LNG Project is the first LNG project in the world to be developed without a substantial Government interest. The six participants in the LNG phase: Woodside Petroleum Ltd; BHP Petroleum (North West Shelf) Pty Ltd; BP Developments Australia Ltd; Chevron Asiatic Limited; Japan Australia LNG (MIMI) Pty Ltd; and Shell Development (Australia) Proprietary Limited each have a one sixth interest. Woodside Petroleum Ltd. is Operator of the Project on behalf of the other Venture Participants.

With the commencement of LNG exports to Japan, Australia will be supplying LNG to eight major Japanese electricity and gas utilities: Tokyo Electric; Chubu Electric; Kansai Electric; Chugoku Electric; Kyushu Electric; Tokyo Gas; Osaka Gas; and Toho Gas. Between them, these utilities serve the power requirements of 90 million Japanese people and a big proportion of Japan's major industries.

Deliveries of LNG to Japan are scheduled to reach a plateau of six million tonnes a year from 1994.

Though the LNG concept is relatively simple in itself, requiring the conversion of natural gas from a vapour to a liquid, the process is complex and as a result the commercial production of LNG is a relatively new industry. It is only 30 years since the first trial cargo... and only 25 years since the first commercial cargo was delivered from Algeria to the UK.

LNG production and transport is a unique industry, requiring substantial investment by both producers and purchasers. Perhaps it is little wonder, therefore, that in 24 years there have been only 10 large-scale commercial LNG plants built around the world, refer to Figure 1.

To undertake such an investment requires special commitments by buyers and sellers alike. The producers must ensure they can provide a safe, reliable supply over a long period. This requires substantial gas reserves -- usually enough to service a 20 year contract -- and complex facilities, including transport from the plant to the Buyers facilities.

Buyers must satisfy themselves of long term levels of demand so as to commit to take an agreed annual quantity for the life of the contract. Apart from these commitments and the extensive financial commitments of both parties, there must be a high degree of mutual understanding and trust between the parties.

In reviewing the history of the LNG trade, it is notable how the success or otherwise of LNG markets have generally reflected very closely the strength of commitment and mutual understanding between the parties involved in various projects.

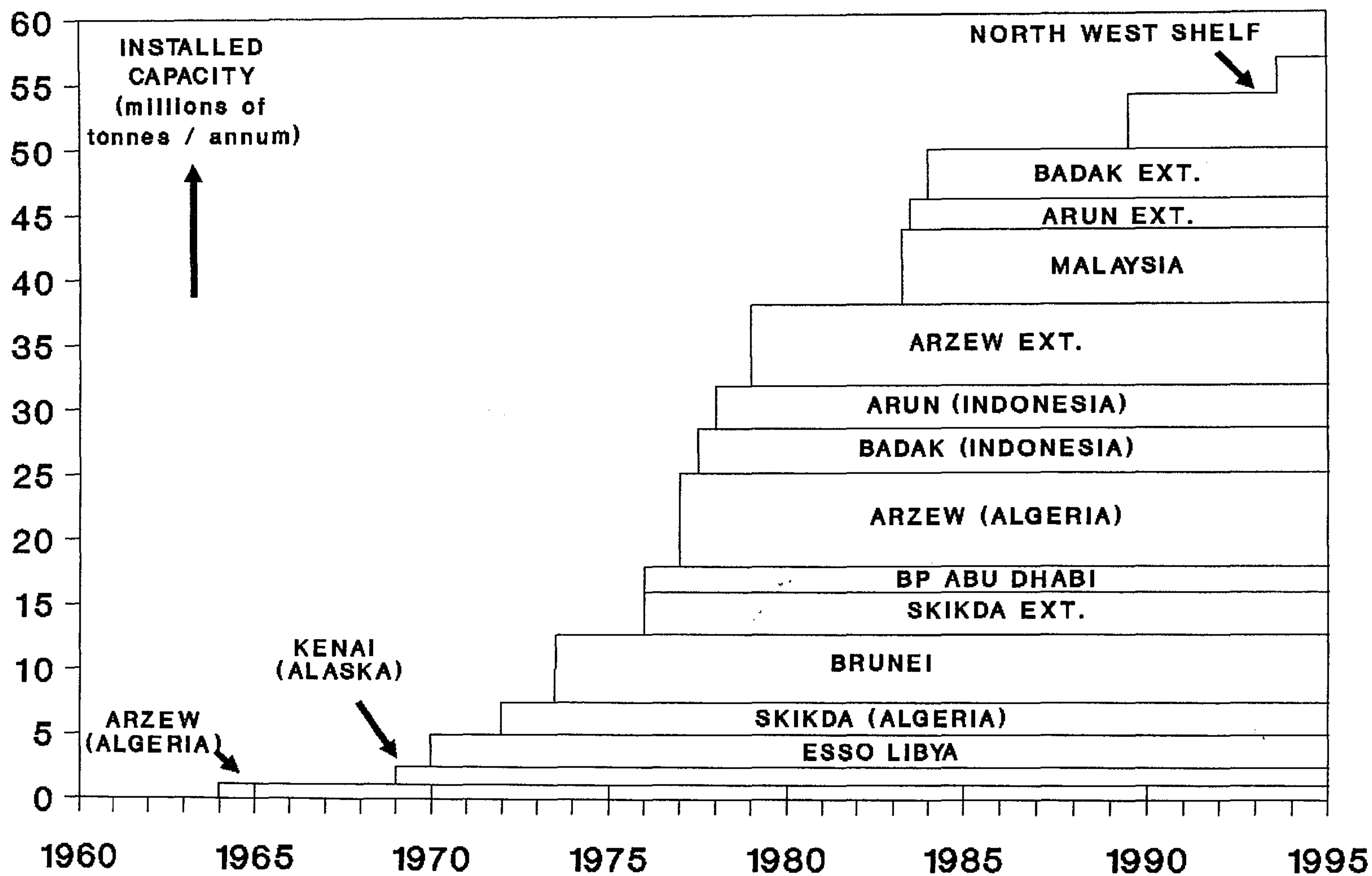
In Europe, the industry grew very rapidly in the late 1960s and 1970s. However, it reached a plateau at the end of the 1970s and only recently have there been developments which will lead to further growth in the European-based LNG trade. The plateau coincided with the reduced growth in energy demand which followed the oil price rises of the 1970s and competition with oil, coal and natural gas -- including, more recently, natural gas from the USSR.

But an important contributing factor was the failure of LNG producers and suppliers to agree to terms for additional supplies. The Algerian producers were conducting negotiations with a number of countries, but were unable to agree to terms for supplies from facilities they already had available.

At the same time, Nigeria was seeking a market for LNG in either Europe or the US. Uncertainty over government requirements, together with increasing development and transport costs, severely handicapped the producers' efforts to offer LNG on a competitive basis.

The US market, which had been developed in the 1970s with supplies from Algeria, virtually collapsed in the early 1980s with competition from local natural gas supplies and fuel oil. Disagreements and legal action over take-or-pay obligations effectively strangled growth of LNG supplies into the US -- until recently, when the outlook for natural gas demand and supply has lead to renewed interest in LNG imports.

OVERVIEW OF LNG PROJECTS



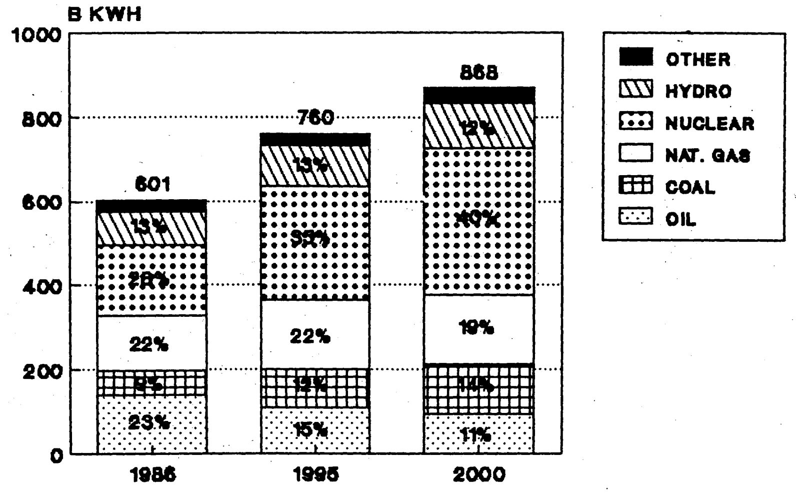
Woodside Petroleum Ltd./February 1989

YEAR

FIGURE 1

FIGURE 2

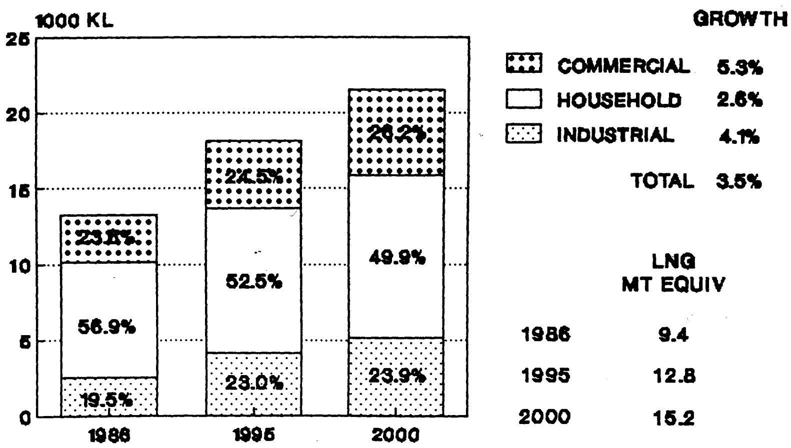
JAPAN - ELECTRICITY GENERATION
PRIMARY FUEL SOURCE



SOURCE: MITI (1987)

FIGURE 3

TOWN GAS DEMAND FORECAST
(BY CONSUMER TYPE)



SOURCE: MITI (1987)

NOTE: MISC USERS INCLUDED IN COMMERCIAL

By contrast, the LNG story in Japan is one of outstanding success. Supplies commenced in 1969 and have grown steadily to reach 29 million tonnes in the calendar year 1988 - making Japan the largest market for LNG in the world. Throughout that period, LNG has been supplied from six projects in five different countries with cargoes being delivered on schedule to individual buyers. This success has been achieved through mutual understanding between producers and the public utility buyers -- and through the total commitment of both sides to the sales and purchase agreements made between them. Such agreements have been honored completely, despite significant fluctuations in energy prices and an ever-changing outlook for Japanese energy demand.

A unique feature of the LNG industry is the closed loop nature of sales and purchase arrangements, and the substantial investment required in facilities by both producers and purchasers. In the case of the North West Shelf, where we have had to produce natural gas from exceptionally deep water, in a cyclone-prone region remote from established construction facilities and a skilled labor force, the costs were substantial.

The facilities required to provide LNG over the build-up period and for 14 years at 6 million tonnes per annum from the North West Shelf are currently estimated at $9.8 billion. In addition, approximately $1 billion will be invested in the seven LNG carriers required to transport the LNG from Australia to Japan.

This investment -- which is the largest investment ever made by private enterprise in Australia and currently among the largest in the world -- has required the participation of some of the largest resource companies. The LNG Project has brought together Shell, BHP, Chevron, Mitsui, Mitsubishi and BP. As an indication of the size of the project in cost terms, it is worth noting that at the time of their commitment, the North West Shelf Project represented each participant's largest single investment anywhere in the world.

Woodside -- with the largest participant interest in the North West Shelf Project and a one-sixth interest in the LNG phase of the Project -- has financed its participation from shareholder funds and a project loan of US$1.65 billion from a syndication involving some 60 of the world's leading banks.

Such enormous investments -- not to mention the extraordinary risks involved -- are generally beyond the capability of even the largest companies. Therefore, joint venture arrangements have come to form an essential part of LNG projects. These arrangements -- together with the structures and agreements necessary to protect each company's interest and their individual taxation and fiscal positions -- are extremely complex and take considerable time to put into place. Consequently, substantial lead times have to be allowed for negotiations between buyers and sellers, even before they can think about making a start on construction.

On the buyers' side, there is significant investment in facilities to receive, store and process the LNG. The gas companies have to store and then regasify the LNG before they can put it into their distribution networks, and power companies have to invest in storage and power generation facilities. For the North West Shelf Project, some of the Japanese buyers are able to use existing facilities and facilities shared with other utilities. However, investment in new facilities is still estimated to be in excess of $6 billion.

With such a level of investment required by all parties associated with an LNG project, and the complex arrangements that have to be entered into before a project can commence, it is not surprising that there are only 10 such projects in the world at this time.

Because of the huge costs and long-term commitments involved in the sale of LNG, there are significant differences between the LNG trade and, say, the trading of crude oil.

Before considering investment in an LNG development, access to the best market opportunities is paramount. Firm and predictable sales commitments must be locked into place at prices which can support massive capital investments and at the same time be competitive with other energy sources. In addition governments play a role in setting the right sort of environment for investors.

In the trading of crude oil, the supplier usually has flexibility to respond to changes in the market. If prices fall or collapse he can curb production, and even shut down in the extreme case. He has control over supply and can make investments based on relatively short term oil price assumptions.

In the long term LNG market, no such flexibility exists. Operating under 20 year take-or-pay contracts, the prime obligation is delivery. The seller accepts the long term obligation to ensure a reliable supply, and the buyer is committed to purchase. Hence the relationship between buyer and seller is totally different, obligations are deeper, the commitment greater.

Another key difference between the LNG and the oil trade is the importance of the shipping arrangements. With the oil trade shipping is readily available on a charter basis and generally represents less than 10 per cent of the delivered cost of the product. Because of the closed loop nature of the contracts shipping is an integral part of any LNG project. The ships are dedicated to the project and are expected to last for the full period of the contract. The arrangements can be either on a delivered or FOB basis. The high cost of the vessels and the need to ensure safe reliable operations results in the shipping costs representing a much larger proportion of the cost of the final delivered product than is the case for crude oil.

It is against this background that we must assess the future market prospects for LNG, particularly if we are to consider markets which offer potential for further developments within Australia.

Because of the importance of the shipping cost in the final delivered cost of LNG and because this is influenced by the distance between that plant and the Buyers terminal, the most attractive markets for LNG supplies from Australia are obviously in countries located in the Pacific Basin.

Japan:

When discussing markets for LNG, obviously the focus of attention must be Japan .... as already mentioned the largest single market in the world today.

28.3 million tonnes of LNG was imported into Japan in fiscal year 1987. Power generation accounted for 77 per cent of the total with gas utilities and Nippon Steel accounting for 21 per cent and 2 per cent respectively.

The electricity utilities introduced LNG as a result of the need to find a clean burning fuel to replace, in part at least, coal and oil to reduce air pollution to meet the requirements of stringent legislation introduced into Japan in the sixties and seventies. At the same time the Japanese government had as an objective the need to diversify Japan's energy supplies by type and source.

LNG was originally introduced as a base load fuel however increasingly it has become an intermediate fuel with nuclear and coal meeting the major part of the utilities base load requirements. In 1986 the power utilities used 21.9 million tonnes of LNG which represented 22 per cent of their fuel requirements.

In a 1987 report on Japans future energy requirements the Ministry for International Trade and Industry (MITI) forecast that increasingly Japan would look to nuclear and coal to supply its electricity requirements, refer to Figure 2. Nuclear would increase from 28 per cent in 1986 to 40 per cent in the year 2000 and coal would increase from 9 per cent to 14 per cent for the same period. At the same time oil would decline from 23 per cent to 11 per cent.

LNG requirements were forecast to increase from 21.9 million tonnes to 27.5 million tonnes in the year 2000 but the proportion of total energy used would decline from 22 per cent to 19 per cent.

A more recent study published by the Institute of Energy Economics (IEE) in 1988 which takes account of the 4.8 per cent growth in energy demand in Japan in the fiscal year 1987 predicts LNG use for power generation will grow to 28.6 million tonnes by the year 2000.

End use gas consumption is forecast by MITI to grow at an average of 3.5 per cent, refer to Figure 3. Residential sales which represent 56.8 per cent of gas consumed are predicted to grow at a rate of 2.6 per cent per year. Higher rates of growth are forecast for the Commercial and Industrial sectors which are expected to grow at 5.3 per cent and 4.1 per cent per annum respectively. The demand for LNG by the gas utilities is expected to increase from 5.8 million tonnes in 1986 to 9.4 million tonnes in the year 2000.

The Japanese gas industry has developed over more than a hundred years, and there are today 248 separate gas companies, ranging from the very small to the three major utilities responsible for a major proportion of total gas sales. Originally mainly supplying low calorific value town gas manufactured from coal, they now make use of a wide range of gas-making feedstocks, including not only coal but also coke, crude oil, locally produced natural gas, kerosene, naptha, LPG and LNG.

Because of this diversity of feedstocks, there is still today a wide range of types of gas distributed to the public, most of them with calorific values which are less than half that of natural gas. The introduction of LNG imports has made it possible to convert gas distribution systems from these low-calorific-value gases to natural gas, an operation which is economically attractive since more than double the energy can be delivered through a given system. An existing investment thus acquires a greatly increased revenue potential at relatively modest cost.

This expansion of the natural gas distribution network combined with an increasing use of gas for residential and commercial space heating, a large new market for gas fueled air conditioning and further penetration of the large industrial energy market would suggest if anything that the MITI forecasts could be regarded as conservative.

MITI's 1987 forecast demand projects total LNG demand to be 37.9 million tonnes by the year 2000. When the power generation volumes are revised to take account of the growth of demand in the fiscal year 1987 then LNG demand would amount to approximately 39 million tonnes by the year 2000.

With public concern in Japan over the future of nuclear energy and the greenhouse effect increasing noticeably it is possible that energy use could shift dramatically in the future away from nuclear and coal to other sources such as LNG, hydro, solar etc.

In the case of nuclear power the current total capacity amounts to 40 million KW of which 28 million KW is in current operation and 12 million KW planned. Of this, 6 million KW are in the preparatory stage. The official Government forecast is based on a target of 53 million KW for the FY2000. Due to anti-nuclear movements however, the current lead times of 12 years is becoming longer and the IEE believe that the official target will not be met by FY2000. Should delays occur, then around 10 million KW could be lost and accordingly there would be further shortfalls in the supply. In the case of a 20 million KW shortfall it means that the power utilities would need a further 20 power plants each of a million KW capacity. It will be necessary for the power companies to decide which energy or power sources would be taken to meet the demand.

If nuclear capacity were reduced by 10 MKW in 2000 and the volume shared between coal and LNG, demand for LNG in 2000 would increase by approximately 5.5 million tonnes to 44.5 million tonnes.

With current contractual commitments of 36.4 million tonnes per annum... assuming existing contracts will be extended there is a potential surplus demand of 4.0 million tonnes per annum in 1995 increasing to 8.4 million tonnes by 2000 assuming the nuclear programme is curtailed, refer to Figure 4

JAPAN - LNG DEMAND PROJECTIONS
MITI 1987 FORECAST

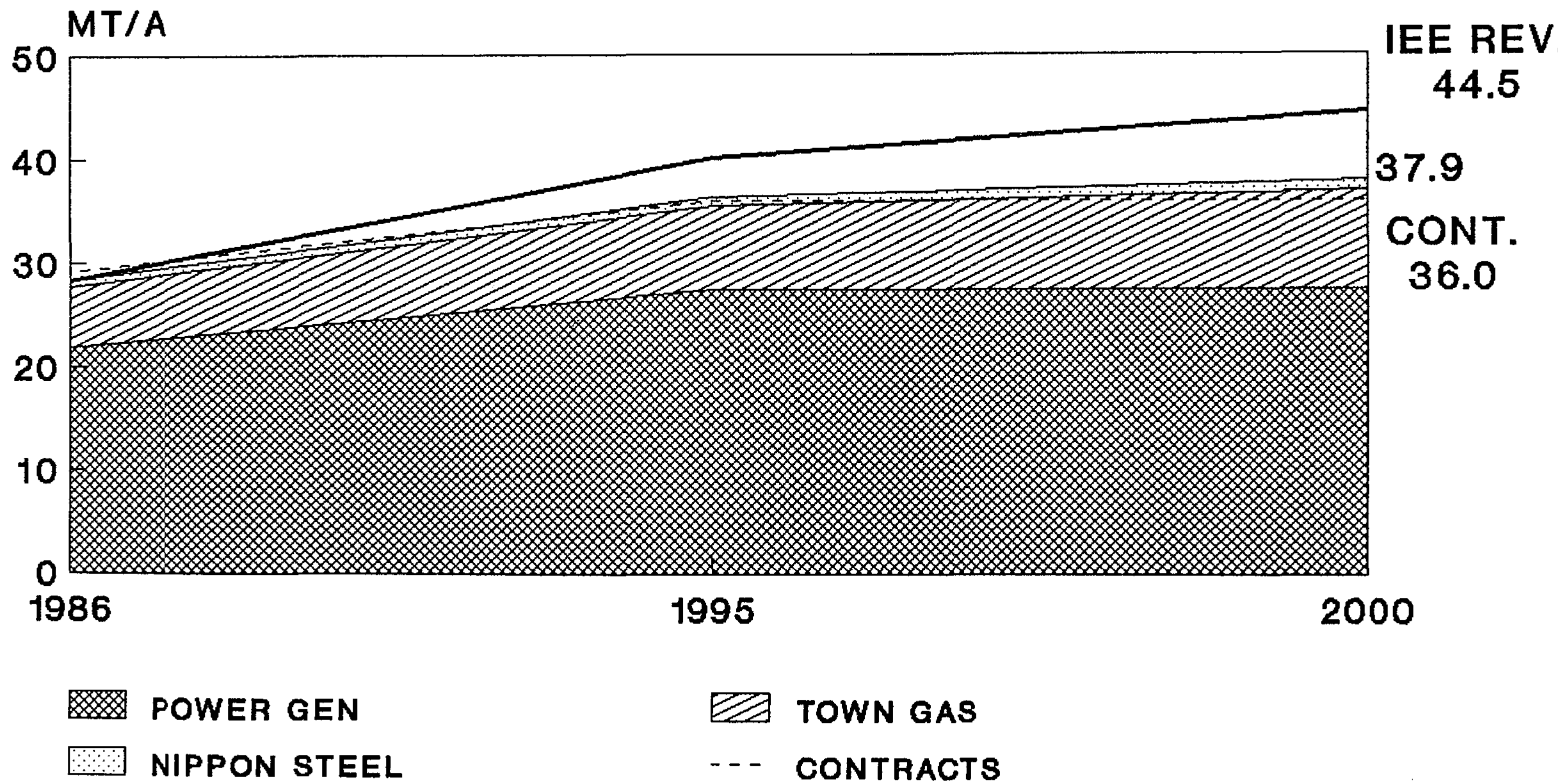


FIGURE 4

South Korea:

Following the introduction of LNG to South Korea in 1986 the demand for natural gas has grown dramatically. City gas load represented approximately 9 per cent of the 2 million tonnes of LNG imported per year. With industrial and residential sales showing high levels of growth it is expected that the city gas load could double to approximately 360,000 tonnes - or 20% of total LNG imports by 1990. Further growth will be limited until the existing transmission grid is extended to supply all the country's major urban-industrial areas. Currently of the nineteen city gas utilities operating in South Korea only seven receive natural gas. The others use mainly LPG and naptha as feedstock.

Residential customers account for over 95 per cent of total customer numbers, however industrial gas use, which has grown by more than 50 per cent per year is more than three times residential gas demand. A further expansion of the national transmission grid to large industrial users in Pusan and Ulsan will see this rate of growth maintained in the 1990's.

Currently LNG is used to fire two thermal power stations however the Korean Electric Power Corporation plans to reduce the proportion of LNG it uses for electricity generation. Small peak shaving plants could be converted to gas firing if the government prevents other fuels being used for environmental reasons.

To meet this rapid increase in demand the Korean Gas Corporation is known to be negotiating for an additional one million tonnes of LNG for 1992 and it is expected to increase the import level to at least four million tonnes per annum by 1995. Further extensions of the national grid and an increase in the number of city gas companies using natural gas could see demand for LNG increase to six million tonnes by the year 2000.

Taiwan:

First deliveries of LNG from Indonesia are due to commence early in 1990 however it already appears that demand is likely to exceed the 1.5 million tonnes per annum contract level. On current demand forecasts Taiwan could easily accommodate an additional 300,000 tonnes in the first year (1990) and approximately 600,000 tonnes in 1991.

Environmental considerations may dictate a drastic lowering of pollution levels over the next five or ten years, necessitating the conversion of power stations from coal and oil to natural gas. Increasing opposition to Korea's ambitious nuclear programme may also become a significant factor in favour of LNG.

It is quite likely, therefore, that a further 2 million tonnes per annum will be negotiated no later than 1994. By then demand could again exceed supply and a second terminal would be necessary. Essentially, the requirement for LNG in Taiwan will be between two and three million tonnes in 1995, rising to between three and six million tonnes per annum by the year 2000.

India:

Currently, no LNG is imported into India. However, the Gas Authority of India is preparing a feasibility report for importing LNG mainly for the purposes of increasing power generation capacity. Existing indigenous gas resources are currently used mainly for power generation and fertiliser production. It is planned that in the future power generation will have priority on existing resources and any future imports of LNG. Since mid-1987 discussions have taken place between India and Indonesia on the possible sale of two million tonnes of LNG per annum.

USA:

Declining natural gas production and reserves, together with increasing demand, indicate that the US will soon require a substantial increase in LNG imports, or natural gas via pipeline from reserves in Alaska, Canada and Mexico.

There is a great reluctance by LNG sellers to invest heavily in LNG projects for the US. The legal and political complexities of long term energy imports may mean that only Algeria will find the US to be an attractive proposition, since it has large uncommitted production capacity originally developed for US buyers. Nigeria may be successful if costs can be contained through the use of existing LNG vessels and the acquisition of existing terminals on the east coast and the Mexican Gulf.

With three reasonably large receiving terminals in place, the US east coast and the Mexican Gulf area are well placed to receive substantial additional LNG imports. The west coast is geographically convenient for Australia, but is unlikely to have the necessary facilities in the near future to receive imports.

Hong Kong and Singapore:

In the past both cities have been reported as planning to import LNG.

With Singapore's recent execution of a pipeline project with Malaysia it is doubtful that it will become an importer of LNG in the near to medium future.

Since 1977 Hong Kong's gas demand has been supplied exclusively from gas manufactured from naptha. Recently the Hong Kong and China Gas Company announced plans to nearly double the existing production capacity by the end of 1991.

Although the distribution system installed by the Hong Kong and China Gas Company has been designed to take natural gas when available it is unlikely that imports of LNG to Hong Kong would be considered until the late 1990's.

LNG Supply Sources:

A review of market prospects would not be complete without a brief review of the LNG supply sources.

For the Pacific Basin there are currently six supply sources from five countries, refer to Table 1. Each of these projects commenced operation as a base load plant with 20 year supply contracts for quantities ranging between 1 million and 6 million tonnes per annum. In the case of Indonesia the original production levels have been increased by additional contracts for both long term and more recently short term supplies.

TABLE 1

EXISTING PACIFIC BASIN LNG PROJECTS

	SOURCE	MARKET	START-UP	DURATION (Years)	PLATEAU VOLUME (mtpa)
Kenai	Alaska	Japan	1969	20+15EXT	1.0
Brunei	Brunei	Japan	1972	20	5.0
Abu Dhabi	Abu Dhabi	Japan	1977	20	2.2
Badak I	Indonesia	Japan	1977	23	4.0
Arun I	Indonesia	Japan	1978	23	3.7
Bintulu	Malaysia	Japan	1983	20	6.0
Arun II	Indonesia	Japan	1983	20	3.3
Badak II	Indonesia	Japan	1983	20	3.2
Arun III	Indonesia	South Korea	1986	20	1.9

This recent development of short term contracts to utilise spare capacity and to meet short term increases in demand is a feature which will have to be taken into account when considering where the increase in demand for LNG in the Pacific Basin will be supplied from in the future.

With the existing projects in Indonesia, Brunei, Malaysia and Australia all understood to have spare capacity capable of development it is likely that the increased demand forecast for around 1995 or earlier will be supplied from expansions of these projects. A recent contract between Algeria and Japan also raises the possibility of additional supplies from there, although the ability of Algeria to be competitive is likely to be constrained once they have utilised their surplus shipping capacity. It is therefore likely that new base load capacity will not be able to penetrate the LNG market until the late 1990's.

At that time depending on the energy price outlook it is likely that economics and market requirements will dictate that any new projects have a production capacity of 2 to 4 million tonnes. Really large projects such as Alaska's Prudhoe Bay and Qatar's North Field may have to wait to the 21st century unless they can successfully negotiate contracts with a number of buyers in more than one market, refer to Table 2. An unknown of course is whether Government to Government arrangements may influence the earlier development of such projects.

TABLE 2

PROFILE OF FUTURE PACIFIC BASIN LNG PROJECTS

	SOURCE	MARKET	START-UP	DURATION (Years)	PLATEAU VOLUME (mtpa)
UNDER CONSTRUCTION					
North West Shelf	Australia	Japan	1989	20	5.84
Badak III	Indonesia	Taiwan	1990	20-25	1.5-4.5
PROPOSED					
North Field	Qatar	Japan	1995+	20	6.0
India 1	Indonesia	India	1995+	20	2.0
Yukon Pacific	Alaska	Japan/ Korea/Taiwan	1995+	20	7.0-14.0
Thailand 1	Thailand	Japan	2000+	20	3.0
Petrel	Australia	Japan	2000+	20	2.3
Sakhalin	USSR	Japan	2000+	20	3.0

Source: Petroleum Intelligence Weekly Vol XXVIII No 4 (January 23 1989)

Summary:

In summary, the market potential for Australian LNG looks very promising.

Depending on your view of economic world growth and the potential impact of public concern for the environment and the development of nuclear energy additional LNG demand could be between 6 to 14 million tonnes in 1995 increasing to between 15 and 30 million tonnes by the year 2000, refer Table 3.

With the US West Coast and India representing approximately 33 per cent of the additional demand in the year 2000 and with neither currently importing any LNG the upper range of this projection should be treated with a deal of caution.

TABLE 3

PREDICTED DEMAND FOR ADDITIONAL LNG IMPORTS
(additional to current known contractual commitments)
(million tpa)

	1995		2000	
Country	Conservative	Optimistic	Conservative	Optimistic
Japan	2.0	4.0	4.0	8.0
Korea	2.0	3.0	3.0	6.0
Taiwan	2.0	3.0	3.0	6.0
India	-	2.0	2.0	4.0
US West Coast	-	2.0	3.0	6.0
	6.0	14.0	15.0	30.0

For Australia the challenge will be to secure a significant proportion of any additional demand. As explained it is likely that additional demand prior to 1995 will be met from expansions or extensions of existing projects.

In this regard the North West Shelf Project will be competing with existing suppliers. Price will of course be an important factor and the terms offered by the North West Shelf will have to compete with new arrangements entered into recently between other LNG producers and Japan. The main feature of these arrangements is increased flexibility offered to the Buyers.

Also of significance will be the reliability of supply. As already mentioned the existing suppliers of LNG have established an impressive record of providing cargoes on schedule without exception. As a minimum the North West Shelf Project will have to perform in a similar manner if it is to be considered for additional LNG cargoes or contracts.

For greenfields development projects the challenge is even greater. To be successful in securing a place in the market in the mid to late 1990's will require enormous commitment from all involved. The North West Shelf Project started as a concept in late sixties and early seventies with negotiations only getting underway seriously in the early eighties. Nine years later as a result of the determination of the developers and investors and the commitment of the Buyers, successive governments, unions and financiers, LNG supplies are about to commence. New projects will require a similar dedication and commitment if they are to be successful.

The challenge is before us. It has been met with the North West Shelf Project and I am sure it can be met again and as a result I predict that Australia will secure a share of the market potential in the Pacific Basin and that LNG will be one of Australia's main export earners well into the 21st century.

Uranium market prospects

George Littlewood

Canning Resources Pty Ltd

1. Introduction

A review of the prospects for uranium markets at this conference is especially timely, since the Australian Labor Party is in the midst of reviewing its uranium policy, which has governed the domestic uranium industry for more than six years. The connection between uranium markets and politics - domestically and internationally - is inescapable. To a much greater extent than other minerals, the evolution of supply, demand and price factors is shaped greatly by political policies, in producing and consuming countries alike. Far from being an exception to this rule, Australia is a prime example of it.

An interaction of politics and markets has certainly occurred in the last decade and will assuredly persist for the next. What happens to the market beyond the turn of the century is much less predictable, although the signals will be clear within the next few years, as a consequence of the very long lead times for nuclear power programmes and, to a lesser extent, green-fields uranium mines.

Before looking forwards, a brief glance backwards will be instructive. In summary, uranium markets exhibited a period of excessive over supply in the late seventies and early eighties but - in production and consumption terms - this period ended in 1984 (after allowing for reprocessing). It has been followed by a period of hiatus - still with us - which is characterised by high inventories, erratic spot price behaviour and prospects of, but few commitments to, new uranium mines. The signs are that the end of this period of hiatus is in sight, with the fundamentals of supply, demand and prices moving into a period of greater stability and predictability, at least until the end of the century.

2. The Period of Over Supply

A common criticism of the uranium industry - especially by those who seek to make political arguments that Australia's uranium policy should not be relaxed - has been that it has been hopelessly wrong in projecting supply and demand in the past, and therefore current projections should be treated as suspect. It is important therefore to look at the factors which generated the over supply, which persisted for more than a decade, up to 1984. It will be found from this examination that the future picture is far different from that which applied in the 1970s.

Extra confusion is sometimes added by comparing estimates based on differing criteria and data collected in different ways. OECD and Uranium Institute figures are based on information submitted by members. Other, commercial forecasters are freer to superimpose judgements based on a continuous interaction with the market and collectively their projections fall within a much narrower range. For consistency of approach, Nukem figures are used in this paper.

The historic relationship between supply and demand is illustrated in Figure 1. Demand projections compiled in the late 1960s and the 1970s reflected high expectations for a rise in the share of nuclear energy in the total electricity mix and were also based on electricity demand growth rates which proved to be exaggerated. Two oil shocks, recessions and energy conservation programmes caused significant downward adjustment in forecast electricity growth rates. This is illustrated in Figure 2.

Driven largely by these sharp declines in predicted growth rates - but also by public acceptance problems in the United States, centred around the Three Mile Island incident - almost half of the 254 reactors ordered during the 1970s in the United States were subsequently cancelled. Adjustments on the supply side were slow in coming. Spurred on by high expectations for growth in demand for uranium, new mining capacity was commissioned especially in the United States. The supply pipeline was further clogged by contractual arrangements between the utilities and the US Department of Energy, which then had a monopoly of uranium enrichment capacity. Many utilities became locked into what, in the early stages, were effectively take or pay enrichment contracts and considered it more advantageous to obtain uranium for enrichment and stockpile the enriched material, rather than cancel contracts.

A combination of these factors caused uranium supply to increase far beyond requirements, as illustrated by Figure 1. By the time that the demand and supply lines crossed over, more than 140 000 tonnes of uranium had been accumulated in inventories, then roughly four years of forward cover which, on a rule of thumb basis, was double normal industry practice.

It is tempting to imagine that these vastly over stated projections - albeit for reasons understandable in hindsight - were mistakes perpetrated overseas and not copied domestically. The fact that this wasn't the case is illustrated by Figure 3 which has been extracted from the Second Fox Report, published in 1976. Not surprisingly, Australia shared the general euphoria and a huge upsurge of exports in uranium from Australia was predicted. Significantly, the Fraser Government uranium policy which flowed from the Fox inquiry - sequential development of new uranium mines and a Federal Government set and controlled floor price - were conceived in those heady days. The current ALP policy - a restricted number of mines, plus continuation of the floor price policy - while adopted largely for internal ALP political reasons is also an outcome of the Fox view of the market place.

3. The Period of Hiatus

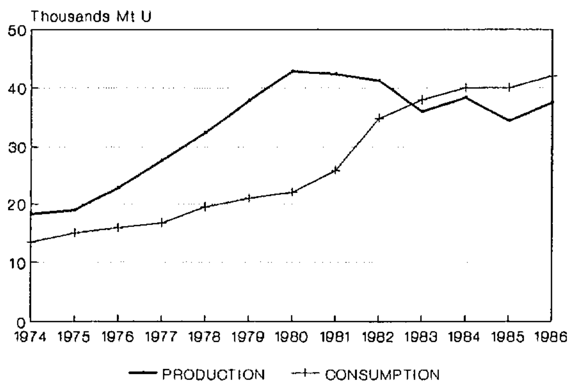
As Figure 1 illustrates, while supply outstripped demand, demand itself grew consistently during the period of over supply. In this decade, growth rates have averaged 9.5 per cent per year - significantly ahead of the growth rates for most other mineral commodities. By 1984 demand exceeded supply, after accounting for reprocessing. Then commenced what might be described as the period of hiatus, a main feature of which has been the spectre of large quantities of inventories overhanging the market.

The inventory overhang has had a number of important impacts on market behaviour. Firstly, it has had a dramatic impact on US uranium production which has fallen from 15 500 mt U tonnes in 1980 to a current 5000 tonnes, as a consequence of high cost capacity being shut down. Unless substantial price increases occur, much of this capacity has gone forever. Secondly, the period of hiatus has been marked by a growing disparity between uranium prices realised through long term contracts and those achieved in the spot market.

At the end of 1988, the Nuexco Exchange Value - often used by the industry as a spot market price - was quoted at US$11.75/lb U3O8. To put that into perspective, in December 1978 the Exchange Value was US$43.25/lb (1978 dollars) - and has never reached that level since.

Nukem reports that the spot market accounted for only 9.7 million lbs U3O8 in 1988 (3731 mt U) - less than 10 per cent of reactor feed requirements. Furthermore, 1988's spot market volume was 13 per cent less than 1987's and 41 per cent below 1985's volume which was the largest recorded so far this decade.

HISTORICAL SUPPLY/DEMAND

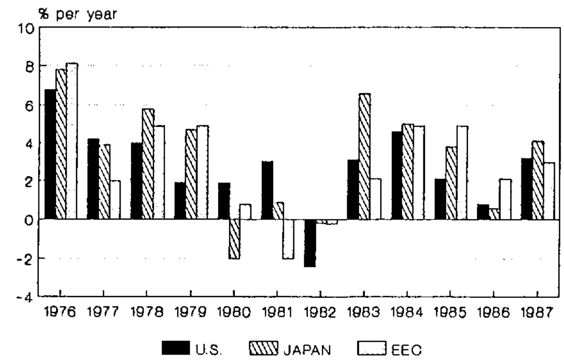


Source: Nukem

FIGURE 1

ELECTRICITY PRODUCTION

Growth Rates



Source: Nukem

FIGURE 2

SECOND FOX INQUIRY

Projections for Uranium Production

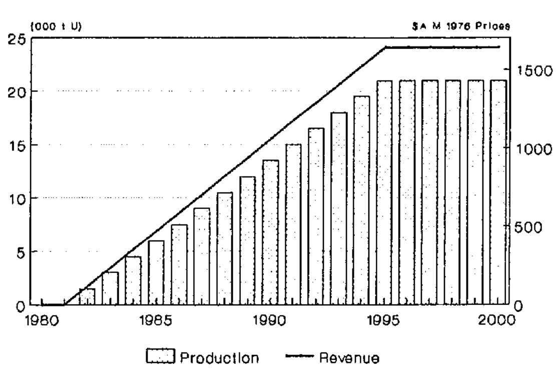


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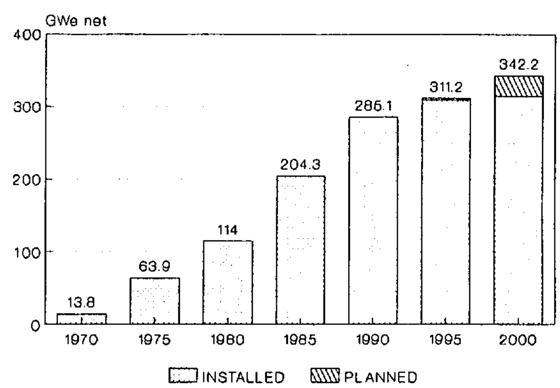
FIGURE 3

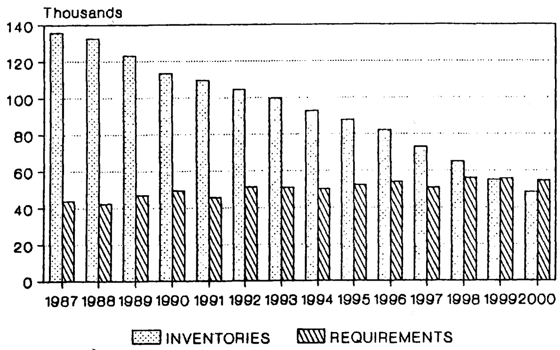
INSTALLED NUCLEAR CAPACITY



Source: Nukem

FIGURE 4

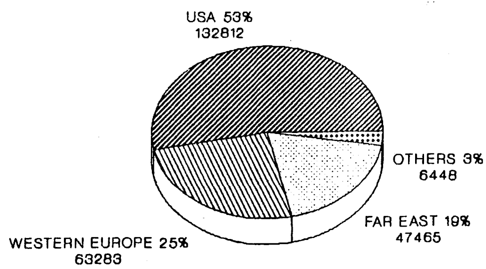
INVENTORY DEVELOPMENT
NATURAL URANIUM (MT U)



Source: Nukem NDS 12/88

FIGURE 5

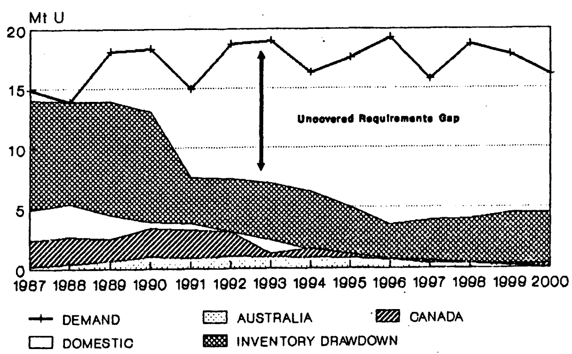
WORLD UNCOVERED DEMAND
1987-2000 Cumulative
Mt U



Source: Nukem NDS 12/88

FIGURE 6

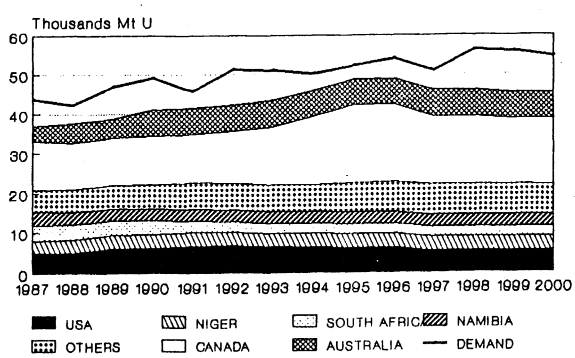
USA SUPPLY/DEMAND
Uncovered Requirements



Source: Nukem NDS 12/88

FIGURE 7

SUPPLY/DEMAND
Total Capability



Source: Nukem NDS 9/88

FIGURE 8

Remembering that 1988 spot prices were the lowest ever both in US dollars and in the buying currencies of the major nuclear utilities, the low volume actually traded on spot markets suggests that the market is not as influenced by spot prices as might at first be assumed.

The fact is that the majority of uranium consumed by nuclear utilities is purchased under long term contracts made directly with producers on commercial terms which inevitably take into account the cost of producing yellowcake, not the price of unwanted inventory. That is not to say that long term contracts are immune from competition, whether it be from spot market opportunities or other, lower cost producers. But it is vital that a continuous supply of uranium is available to fuel reactors and buying behaviour reflects this, by placing far more reliance on long term arrangements than spot markets. Contract prices vary from region to region but range from the mid US$20.00s to above US$30.00s in some cases.

It would be most unwise to base conceptions on the way the market might move in the 1990s on the behaviour of spot prices in the last year or so during the hiatus period. While the spot market must have some influence on expectations of longer term contract prices, to base government policies and investment decisions on spot market behaviour would be unjustified.

4. <u>A Return to Greater Stability</u>?

As pointed out earlier, demand continued to grow strongly in the 1970s and the 1980s, during the period of over-supply. While projected growth rates for the rest of the century are now down to an average annual rate of around 2.5 per cent, the key fact is that they are now far more predictable than has been the case for the last two decades. This is a function of the long lead times for the licensing, constructing and commissioning of nuclear reactors which, outside of France, are of the order of a decade.

Until the turn of the century, it is now very much a case of "what you see is what you get". More than 90 per cent of the reactor capacity which will be in operation by the turn of the century is either built or being built, as illustrated by Figure 4.

The growing demand will be met from four types of sources - inventory draw down, reprocessing of used uranium fuel, mines currently in operation and new mine capacity, whether from expansions to existing mines or green-fields mines.

The timing of the end of the current period of hiatus is likely to be governed largely by the draw down of excessive inventories. The likely pattern of inventory development is illustrated by Figure 5.

To understand the impact of the inventory position, it is important to remember that inventory levels vary significantly from region to region. The inventories of some Japanese utilities represent a forward cover of four or five years of demand, and the Japanese seem willing to carry relatively high levels of uranium stocks and treat them as a quasi-domestic source of fuel. At the other extreme, most US utilities currently seem content to live on virtually a hand to mouth basis. European norms tend to be in the area of two years. Also, what has happened in the past may not be a necessarily sound guide as to what will occur in the future. Taking all these factors into account, inventories are likely to be at a more commercially acceptable level from the early 1990s onwards.

Since, as shown in Figure 6, 53 per cent of uncovered demand for the period 1987-2000, is accounted for by US utilities, what happens and when in that market area is of great significance. As shown Figure 7, a very substantial fall occurs in the US inventory position in the early 1990s - once again pointing to the possible start of a period of more stable supply/demand conditions.

Another factor which must be taken into account in looking at fundamental supply/demand relationships for the 1990s is the contribution which is likely to be made by reprocessing of used fuel. Nukem estimates place this at around eight per cent of demand. Most likely this figure will not be reached, for a variety of reasons. However, even if it is, a significant gap still exists for most of the 1990s between production from existing and announced expansions and consumption, less reprocessing.

Clearly, much of this gap will be filled by planned expansions to existing capacity but there is still room - amounting to several thousand tonnes per year - for new projects. Both in Australia and Canada there are potential developments which could fill that gap. The question is which particular projects will do so. The answer, as always in uranium, is as likely to be as much a matter of politics as of business investment decisions - an issue which is addressed in the next section of this paper.

However, given the predictability of demand for the 1990s, the working down of inventories to commercially acceptable levels and a clearer picture of the supply side, the 1990s are likely to be far more stable than the last 15 years. Prices during this period should continue to be governed by supply/demand relationships, rather than by inventory trading through the spot market.

5. Beyond 2000?

Projecting uranium markets beyond the early part of the next century is, to put it mildly, a hazardous business and the wildly astray predictions made in the 1970s provide a cautionary tale for would be forecasters. The scope for widely different outcomes is graphically illustrated by the 1987 OECD "Yellow Book" which projects a range of between 875GWe and 2160GWe of nuclear capacity in the year 2025! However, one thing is clear - within the next few years early signs will appear, given the decade plus lead time for new nuclear reactors.

So far, the signs are that there is more likely to be upside, rather than downside, potential. Public acceptance of nuclear programmes in the US and Canada is growing, the greenhouse issue has - to some extent - recommitted the nuclear option and, particularly in the United States narrow, and in some cases last summer non-existent, margins between grid capacity and peak demand mean that new base load capacity must be committed for fairly soon. Realistically, the choice is between nuclear and coal. While there are no market implications which need to be considered now, there are certainly pressing policy considerations, as far as Australia's domestic uranium producing industry is concerned.

6. The Implications for Australia

As observed earlier, uranium and politics are mixed inextricably and nowhere is this more the case than in Australia. How, then, are the market factors dealt with earlier likely to be influenced by political policies in Australia - and visa versa. The answer lies in two parts - the short term and the long term.

Firstly, a quick look backwards. The following table illustrates changing supply over the last 14 years.

Table 1

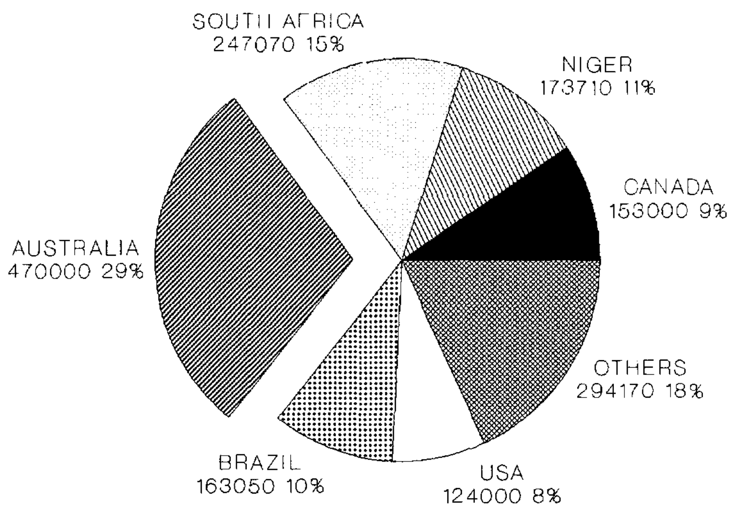
Country	1975	1980	1985	1987
		Metric Tonnes U		
Australia	0	1561	3251	3711
Canada	3564	7149	10879	12435
France	1854	2650	3149	3350
Namibia	0	4039	3385	3544
Niger	1306	3616	3180	2967
South Africa	2489	6148	4885	3965
United States	8276	15507	3958	4946
Others	1424	2160	1863	2079
Total	18913	37891	34550	36997

These figures speak for themselves. Namibia's arrival as a player in 1976-77 is in part attributable to Australia's decision to go down the Royal Commission route (the Fox Inquiry) and thereby delay the building of Ranger and Nabarlek until 1980. Canada's dramatic emergence as the uranium giant reflects its strong commercial orientation to the nuclear business, exemplified by the commissioning, in 1983, of the big Key Lake mine in Saskatchewan - done while Australia seemed to think that there were few untapped opportunities in the uranium market. The United States, on the other hand, has (not without a few protests) let the market take its course.

The most telling comparison, however, is between Australia and Canada, as shown in Figure 9. While Australia has around 10 per cent of markets and 30 per cent of low cost resources, Canada has almost exactly the reverse. The difference in export income is around $600 million annually. It is hard to see how the bulk of this disparity can be accounted for in any other way than the outcome of policies adopted by successive governments in Australia, in imposing floor prices not responsive to market levels and, by various means, limiting output.

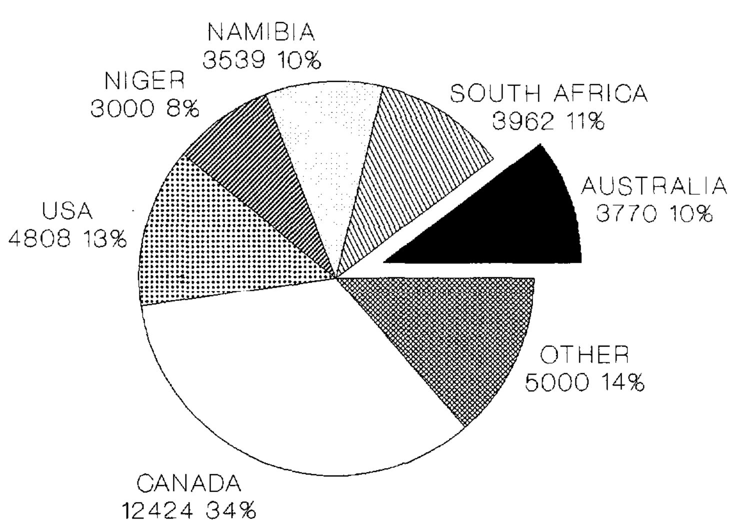
In the short term (ie the first half of the 1990s) there will be modest opportunities in the market place for additions to capacity and new projects. Those most likely to succeed are expansions to existing competitive capacity (eg the announced 1500 tonnes expansion at Ranger) and small, new projects which can find niches in the market place. From an Australian perspective, these niche opportunities stem from the fact that Australia is currently under represented in the market place and

URANIUM RESOURCES
RAR low cost category (Mt U)



Source: BMR 12/87

MARKET SHARES 1987
Metric Tonnes U



Source: Nuexco #235 3/88

FIGURE 9

customers have shown a very clear desire to diversify supply sources for security reasons - not only by geographical regions but by mines within those regions.

However, Australia will not realise its true potential while it labours under the current restrictive policies. Australia's poor market-share, especially when compared with Canada, is evidence of that. Why should customers, whose natural propensity is to spread their supply sources for security reasons, make themselves unduly hostage to domestic policies? The evidence is that they are preferring the lesser of two evils - placing more and more of their eggs in the Canadian supply basket, despite the growing dominance of that producer. The Canadians are poised to develop several new projects and unless Australia reconsiders its policies we are very likely to once again be shut out of market growth, as occurred when Key Lake was developed.

These considerations can be compared with the view, taken in the Federal Government's "Energy 2000" policy paper, which assumes that Australia will capture one third of uncommitted

WOCA demand in the period to the year 2000. This assumption is based on the premise that each of the three main producing areas - the African countries, Canada and Australia - will share the pie equally. But why assume that this is - or should be - the limit of Australia's ambitions? Given market concerns about Canada's growing dominance and South African sanctions, why not aim higher? To adopt an assumption that the business will be shared equally is unsound from a marketing perspective and foreshadows the unfortunate possibility of turning into a self fulfilling prophesy.

Resolving Australia's policy position becomes of even more crucial importance, when considering the longer term - and it is the longer term which Australia should be addressing. A nation which possesses 30 per cent of the world's low cost uranium resources sells itself short if it does not take the long view, certainly one that stretches beyond the middle of the next decade.

Potential benefits beyond the turn of the century may seem a long way off, but if allowance is made for the long lead times which are characteristic of the nuclear business, now is the time to be considering Australia's' future in the uranium market place.

Allowance for long lead times is also crucial from a policy perspective. For more than a decade Australia has sent some very clear - if unpalatable - signals to the market place on price and volume. If our full potential is to be realised, some equally clear signals, foreshadowing a fundamentally different attitude, must be sent before the market will be convinced. Some time may be required for the message to be heard, understood and taken into account in purchasing strategies. This is especially so in the United States, which accounts for more than half the cumulative uncovered demand between 1987 and 2000.

The current ALP review is not only timely - its completion before the end of the year (as intended by the Review Committee) is crucial. Australia has yet another chance to earn a larger place in the market, more commensurate with its resources. As always, it will be politics, as well as markets, which will determine the outcome.

The greenhouse effect: some implications for Australian energy production and trade

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The potential climate change has two distinct sorts of implications for energy policy. It will lead to international pressure to change the present pattern of fuel use, with special emphasis on reducing the rate of combustion of hydrocarbons. More directly, it will change the pattern and level of demand for some forms of energy, most notably space heating and cooling.

Increasing temperatures will have a significant effect on both total electricity demand and winter peak demand in southern parts of Australia. Demand for space heating is strongly associated with ambient temperature, and domestic hot water use is also influenced by temperature. Use of electricity for summer cooling is likely to increase in Queensland, the Northern Territory and South Australia. The effects on peak demand are significant.

Australia faces severe problems of adjustment if there is international pressure for reduced use of hydrocarbons, as structural factors largely determine our very heavy use of transport fuels. While more effective use of public transport is possible, our urban structure imposes serious limitations on our flexibility. International pressure to reduce hydrocarbon use and these limitations together constitute a significant force for fundamental change. Although there are formidable obstacles to the task of either reducing energy use or replacing fossil fuels by other energy sources, the changes to the climate now being predicted are highly likely to stimulate a serious attempt to alter the current pattern of energy use.

The effect on trade will be strongly determined by international reactions to the prospect of climate change. In the short to medium term, there are likely to be moves to use gas or even fuel oil instead of coal to reduce carbon dioxide production. Prospects for coal exports could therefore be significantly reduced by any international moves to scale down the rate of producing carbon dioxide. While some pro–nuclear activists have argued that a boom in uranium sales could result, this does not appear a likely outcome. If environmental concerns trigger different attitudes to energy supply and use, this is unlikely to benefit a technology with the serious environmental problems seen by the public to be associated with nuclear power.

1. Introduction

This paper is predicated on the expected climate changes predicted[1] as a consequence of the increased atmospheric concentration of carbon dioxide and other "greenhouse" gases. Of the anticipated changes in climate, the most obvious short–term effects on direct energy use will be those arising from the predicted increase in mean temperatures of 2–3^{0} C. However, other anticipated changes, such as rising sea level and more frequent weather extremes[2], may be more influential in producing public acceptance of the need to change the pattern of energy use. Both improved efficiency of fuel use and increasing emphasis on the use of renewable energy are likely to be stimulated by growing awareness of the consequences of the current rate of combustion of hydrocarbons.

2. Direct changes in Australian energy use

Water heating has been estimated[3] to account for about 35% of domestic energy consumption in Australia, while another 35% goes on space heating and cooling. The total use of energy for domestic purposes varies significantly between States[4], as does the allocation of this energy between end–uses,as shown by Tables 1 and 2 respectively.

TABLE 1: RESIDENTIAL ENERGY CONSUMPTION, 1979–80

State	Total (PJ)	GJ Per head
Victoria	101	26.2
N.S.W.	79	15.5
Queensland	25	11.4
S.A.	22	16.7
W.A.	21	17.0
Tasmania	12	27.9

TABLE 2: RESIDENTIAL ENERGY CONSUMPTION BY END–USE, 1979–80

State	Space heating and cooling	Water heating	Other
Tasmania	50%	30%	20%
Victoria	50%	25%	25%
South Australia	35%	30%	35%
New South Wales	30%	35%	35%
Western Australia	25%	35%	40%
Queensland	15%	45%	40%
AUSTRALIA	35%	35%	30%

It is clear from Tables 1 and 2 that there is a relationship between climate and the proportion of domestic energy used to modify the internal temperature. It is also clear from Table 1 that the total domestic energy use varies significantly between States[5]. Combining the data from these two tables, taking account of the inefficiencies of production of end–use energy, gives the primary fuel use per head for various purposes[6]. The data are displayed in Table 3.

TABLE 3: PRIMARY FUEL USE FOR DOMESTIC PURPOSES PER HEAD (GJ)

State	Space heating and cooling	Water heating	Other	TOTAL
Tasmania	15.0	9.0	6.0	30
Victoria	21.0	10.5	10.5	42
South Aust.	11.2	9.6	11.2	32
N.S.W.	10.5	12.3	12.3	35
W.A.	7.0	9.8	11.2	28
Queensland	3.7	11.1	9.9	25

Table 3 shows clearly the effect of climate on energy use for space heating or cooling, with the primary fuel use per head in Victoria double that of South Australia and New South Wales, three times that of Western Australia and about six times that of Queensland. The apparently anomalous low figure for the State of Tasmania is due to the use of hydroelectricity in that State rather than thermal generation, with its much greater demand for primary fuel.

It should be noted that more recent data is available for some states. For example, 1983 data for N.S.W. show that space heating has declined to about 26% of residential energy use[7], compared with 30% in 1979–80. Recent Victorian data also show a drop in the importance of space heating to about 40% of residential energy use[8], with water heating now about 33% and other uses some 27%. In the case of Victoria, the picture is further complicated by very large differences in energy use between three categories of dwelling. Those with both gas and electricity appear from official statistics to use about twice as much residential energy as those with off–peak electricity, which in turn appear to use about twice as much as the dwellings which only have day–rate electricity[9]. Some of these differences are undoubtedly accounted for by the failure of the statistics to include the heat value of wood as a fuel. Since wood is the main heating source for about 13% of homes in N.S.W. and Victoria, about 17% of those in the A.C.T. and 54% of those in Tasmania[10], an inability to account for this fuel is a very significant error.

The effect of climate change is, however, likely to reduce the current fuel demand for space heating in the cooler states, especially Victoria. The impact on the overall fuel use in the State will be relatively small, however, since domestic energy use amounts to less than 12% of the total energy demand of the State[11]. Temperature data suggests the order of magnitude of savings in energy; since the average minimum temperature for Melbourne is 2° C lower than the figure for Adelaide[12], it might be expected that a temperature increase of 2° would reduce the Victorian space heating demand per head to something like the figure for South Australia. Similarly, the average minimum for Brisbane is 2° higher than the figure for Sydney[13], so the New South Wales figure might drop to something like the Queensland value. Of course, these are crude estimates, because the populations of these States are not all living in the respective capital cities, and heating demand is not simply related to the average temperatures. Nevertheless, such a change would drop the fuel needed for domestic space heating by a total of about 80 PJ, equivalent to about 15% of domestic energy use or about 3% of total national energy use. This would not be a trivial change.

Climate change may also have a significant effect on the load structure of the electricity industry, however, since the system peak in such states as New South Wales and Victoria occurs in the early evenings of cold winter days. The load at 6 p.m. on a cold winter day is typically about 10% greater than the load during the working day[14]. If the demand for space heating were reduced by climate change, the load peak would be expected to be significantly smaller, giving the State Electricity Commission a more satisfactory system load. Coulter estimated the change in the winter electricity demand as 200MW per Celsius degree at 6pm in Sydney[15]. Thus a temperature increase of 2–3° would reduce the system peak in that state by about 500MW.

The demand for domestic hot water is, as shown by Table 3, much less closely linked to climate. Thus climate change will have less effect on the demand for hot water than it will have on the need for space heating. There is, however, an association between ambient temperature and hot water use, as shown by a recent study of domestic hot water use in Victoria[16]. The evidence does not suggest significant changes in energy use for domestic hot water are likely to result from climate changes of the sort envisaged.

There will probably be increased electricity demand in states in which the system peak occurs in summer. In South Australia, for example, the system peak occurs in the summer, due to the use of air conditioning[17]. Higher average temperatures will inexorably increase this demand for energy to moderate the climate, although the magnitude of the increased energy demand could be expected from the above tables to be rather smaller than the effect on the Victorian peak. An increasing seasonal asymmetry in the South Australian system would certainly increase the benefits of linking the State with the Victorian grid, which has usually had surplus capacity at that time of the year. There will also be increased energy use in refrigeration and freezers, as the energy required for heat pumping is simply proportional to the temperature difference maintained between the interior and the exterior. The total energy use in this area is most significant in warmer States such as Queensland, in which refrigeration is a major domestic electricity user. All these changes will also be reflected in the energy demand of commercial and other offices, for which data are not readily available.

3. <u>Pressures for changes in carbon dioxide production</u>

The production of carbon dioxide and other greenhouse gases is undoubtedly an international problem which cannot be solved by any one nation acting alone. The Bruntland Report[18] suggested the need for "a four–track strategy":

- improved monitoring and assessment of the evolving phenomena;
- increased research to improve knowledge about its origins, mechanisms and effects;
- the development of internationally agreed policies for the reduction of the causative gases; and
- adoption of strategies needed to minimise damage and cope with the changes.

Hardin has argued[19] that international agreement on such issues is unlikely. In crude economic terms, the marginal benefit to a nation from reduced combustion of hydrocarbons is clearly less than the marginal cost, since the benefits are shared equally with the other nations of the globe, whereas the costs are all localised. The history of attempts to limit acid precipitation by controlling the emission of sulphur dioxide is not an encouraging story, and tends to support Hardin's gloomy prognosis. However, the recent convention to protect the ozone content of the atmosphere by limiting the emission of chlorofluorocarbons suggests that there is some hope of reaching international agreement to combat serious environmental problems, even if the motives for agreement may be mixed[20]. It is worth noting that these compounds also contribute to climate modification, so it could even be claimed that there is already international agreement to address at least one aspect of the problem. In the words of the Bruntland Report[21]:

> **"Nations urgently need to formulate and agree upon management policies for all environmentally reactive chemicals released into the atmosphere by human activities, particularly those that can influence the radiation balance on earth. Governments should initiate discussions leading to a convention on this matter."**

There are two possible broad approaches to reducing the rate of production of carbon dioxide. One approach would be to expand the use of fuels which are not carbon–based; the obvious leading contenders to fill the role would be renewable energy sources and nuclear power. The alternative broad approach would be to reduce total energy use by conservation measures of various kinds.

The two approaches are, of course, not mutually exclusive. A case could certainly be made for using energy much less wastefully than we do at present, regardless of the fuel being used. In terms of the supply options, it has been claimed[22] that renewable energy could be scaled up to provide an amount equivalent to current global energy consumption. Renewable sources provide about 21% of world energy use, mainly through hydropower (6%) and biomass (15%, predominantly as fuelwood or wastes), and are reported to be growing in their use by more than 10% per annum[23].

A key to greater use of renewable energy is the research effort needed to develop the technologies needed. Data are available on research funding for a range of OECD countries, both in absolute terms and as a proportion of the total government expenditure on energy–related R&D[24]. The Australian R&D effort in renewable energy is relatively weak compared with some countries, despite our notable successes in this area; we spend about half the amount per head of the average for all the member countries of the International Energy Agency. However, it should be noted that the percentage of our government energy R&D effort going to renewables is higher than the average for OECD countries.

A 1983 analysis[25] of the total Australian energy research budget commented on the extraordinary emphasis on nuclear energy, especially given that there are no serious plans to use nuclear power in Australia; recent ABS data[26] shows that the total government expenditure on research related to nuclear energy is still almost double the total amount spent on all forms of solar, biomass, wind, geothermal and ocean thermal energy. The Australian government recently agreed to spend an extra $5 million over the next five years on research into renewable energy and conservation, in return for an agreement by the Democrats to pass the Resource Rent Tax legislation in the Senate. Diesendorf has argued[27] that a variety of renewable energy technologies, including solar hot water and grid–connected wind farms, are now economically competitive with conventional forms of energy. He argues that the spread of these technologies is impeded by institutional barriers and the low level of research support. A 1984 survey showed solar domestic hot water to be competitive in most parts of Australia, despite the claims of some electricity authorities[28].

Nuclear electricity is the other possible large–scale alternative to the combustion of fossil fuels. The climate of opinion toward nuclear power, however, had been soured by the economic problems of the industry before the accidents of Harrisburg and Chernobyl. A recent analysis[29] suggested that the non–fuel operating costs of U.S. reactors have increased by a factor of four since 1980. The international picture is that nuclear power supplies about 15% of all electricity, or about 2% of total primary energy. On the bright side for the industry, there are now over 350 reactors operating and another 140 planned, and the growth of nuclear power in the last twenty years has been quite impressive. On the negative side, there has been a significant move away from earlier enthusiasm for nuclear power since the Chernobyl accident[30].

> **"Following Chernobyl, there were significant changes in the nuclear stance of certain governments. Several – notably China, the Federal Republic of Germany, France, Japan, Poland, United Kingdom, United States and the USSR – have maintained or reaffirmed their pro–nuclear policy. Others with a 'no–nuclear' or 'phase–out' policy (Australia, Austria, Denmark, Luxembourg, New Zealand, Norway, Sweden – and Ireland with an unofficial anti–nuclear position) have been joined by Greece and the Philippines. Meanwhile Finland, Italy, the Netherlands, Switzerland and Yugoslavia are re–investigating nuclear safety and/or the anti–nuclear arguments, or have introduced legislation tying any further growth of nuclear energy and export/import of nuclear reactor technology to a satisfactory solution of the problem of disposal of radioactive wastes."**

Both renewable energy sources and nuclear power could be used to reduce considerably the carbon dioxide burden resulting from the combustion of fossil fuels for electricity generation. A simple calculation suggests that the burning of coal and lignite in Australia for electricity production yields over 100 million tonnes of carbon dioxide each year; even a 10% substitution would be a considerable achievement.

It is also possible, as mentioned above, to seek to reduce the production of carbon dioxide by lowering the rate of use of energy. Such a conservation policy can be an alternative or complement to replacing the burning of fossil fuels by nuclear power or renewable energy. This general approach is sometimes opposed by those who argue that the rate of use of energy is closely linked to the overall performance of the economy or the rate of economic growth. It should be noted that energy use per unit of economic output has now been falling steadily for fifteen years. By 1981, overall energy use per unit of GDP in non–communist countries was 85% of the 1971 value[31], and since then the decline has continued so that energy use per unit of GDP in Japan, as an extreme example, is now 70% of the value fifteen years ago[32]. Australian energy use could probably be reduced by 30% without lowering the standard of living.

4. A possible Australian response

If there should arise a need or desire to formulate an Australian approach to reducing fuel use, the strategy would have to be based on a comprehensive understanding of current fuel use. The two dominant areas of fuel use in Australia[33] are transport (27%) and fuel industry conversion losses (33%). One possible approach would be to concentrate efforts, at least initially, in these two sectors which together account for about 55% of all energy use.

In terms of electricity generation, it should be more widely recognised that the thermodynamic price for the convenience of electricity is the very low thermal efficiency of using hydrocarbon fuels. The overall efficiency of thermal electricity generation in Australia[34] is below 30%. In other words, more than 70% of the carbon dioxide production from the electricity industry is associated with the generation of waste heat. An appreciation of this leads to the obvious conclusion that electricity should, as a general rule, be directed to applications for which other energy sources are inappropriate, such as lighting and powering appliances. The use of electricity for such purposes as space heating and the supply of domestic hot water is not only thermodynamically absurd, but also a very low priority if measured in terms of useful return per unit of carbon dioxide produced.

In theory, it is possible to obtain useful energy from the heat produced in electricity generation, and this is done in practice in some European countries. The recent Australian practice has been to build large power stations in locations remote from any possible markets for the heat, so it is not possible even in principle to make use of this energy. There is a limited potential for industry to expand the present level of generating electricity and process heat in a co–generation system, but this will have little impact on the overall electricity system.

The historical practice of the electricity authorities has been to invest in the generating capacity which would be needed to meet inflated demand forecasts, and to subsequently seek by various means to increase demand to make use of the generating capacity. Any serious attempt to reduce the combustion of hydrocarbons would necessarily include a review of these wasteful activities. Since the electricity industry is nominally under public control, such a review is possible in principle, if difficult in political practice. It is perhaps worth noting that a review in N.S.W. has caused a revision of both the expansion plans and the planning procedures of that state's Electricity Commission. This event is also a reminder that another problem is the organisation of the industry along State boundaries, making it possible for inefficient practices to be justified by arguments of State chauvinism. It is also worthy of note that the response of electricity authorities to the failure of demand growth to meet their inflated forecasts has, in general, been simply one of adjusting the exponent in their forecasts, rather than recognition that the forecasts are fundamentally flawed by being based on the discredited belief that exponential growth in demand is either an organic feature of society or a necessary component of economic growth.

In terms of transport use, the emphasis should be on road transport, which accounts[35] for 77% of all transport energy – more than three times as much as rail, sea and air put together. There have been some attempts to improve the fuel economy of road vehicles, and by 1986 the average fuel economy of cars[36] had been improved to equal the figure for 1963. While there are opportunities for further technical improvements to the performance of cars, it should be recognised that the wasteful emphasis on car transport is an inevitable result of our geography in general and our urban structures in particular. Newman and Kenworthy have shown[37] the clear relationship between urban form and transport fuel use. Motor spirit use per head in Australia is about double the level for typical countries of western Europe and about four times the figure for Japan. If it is a long–term aim to reduce the production of carbon dioxide and other greenhouse gases from transport fuels, serious attention needs to be directed to urban planning.

The celebrated sprawl of Australian cities may have been a pardonable luxury when fuel was plentiful and there was little concern for the effects of its use. To continue to plan on the basis of perpetuating the current profligate use of the private car can no longer be justified. As an extension of this point which makes a relatively small contribution to the overall problem but has important symbolic value, society will undoubtedly move in time to restrict activities which constitute gratuitous combustion of hydrocarbon fuels. Not only do we, for example, fuel vehicles and drive them round in circles to see which one is fastest, we also find people willing to pay money and even fly inter–state to watch the spectacle. It would be hard to imagine a more pointless way of changing the climate.

The remaining important policy choice is whether the pattern of energy use should be changed by government fiat or by means of economic incentives. In general, those who have faith in markets tend to support the use of economic incentives, while those who do not believe in the nineteenth–century framework of neo–classical economics are unlikely to believe that significant change will be achieved equitably through the guidance of an invisible hand. As an example of a recent attempt to alter fuel use by economic means, import parity pricing of oil appears to have influenced demand for oil, especially as a fuel for space heating. The policy is clearly inequitable, however, as low–income groups in outer suburbs use more fuel and thus are disproportionately affected by the price rise. It is clearly absurd even in principle to attempt to influence domestic use of electricity by economic means, since typical consumers do not have accurate information about either the rate of electricity use by particular appliances or the charges per unit for electricity.

As a further complication, any serious attempt to use economic pressures to change fuel use would necessarily involve a more sophisticated approach to economics than the current convention of basing prices on the short–term costs of supply, taking no account of either depletion or environmental degradation. A pricing policy designed to inhibit the adverse environmental effects of fuel use would have to be derived from an accurate long–term costing of those effects; such a practice would have the effect of making fossil fuels more expensive than they currently are, and this would in turn have the sort of equity problems mentioned above. Such an approach might promote equity between generations at the expense of equity between different contemporary social groups. Given the absence of a defensible intellectual framework for an economic approach, there are clear advantages in achieving policy objectives by legislative action, however distasteful that may be to the supporters of the presently–dominant ideology. Examples of the sorts of legislative actions which have been taken in other countries to reduce the use of fuels range from lowering speed limits to prohibiting private cars in specified city areas and specifying minimum fuel economy standards.

5. <u>Impact on trade in energy minerals</u>

The international ramifications of the greenhouse effect are likely to impact on Australia's trade in minerals. If there are pressures to reduce the scale of production of carbon dioxide, the Australian export coal industry will presumably suffer to some extent. That will not be a trivial consideration, as coal is currently Australia's largest single export commodity. On the other hand, there may be trade gains in two areas. Australia has large quantities of uranium, and the moral qualms about its export now appear to have been swept aside by concern about the balance of trade. If nuclear power enjoys a revival in fortunes as a substitute for electricity derived from fossil fuels and the current permissive government policies are continued, Australia may derive increased export earnings from uranium. It has recently been argued by pro–nuclear activists[38] that increased export of uranium would not only be economically beneficial but would also "improve living standards internationally and contribute to an amelioration of the Greenhouse Effect". As argued above, however, if environmental concerns are seen as being so important as to persuade governments of northern hemisphere countries to conclude an international agreement to limit production of carbon dioxide, the response in unlikely to be a move toward the energy technology which has raised a higher level of environmental concern than any other.

Australia has developed quite sophisticated technologies for harnessing renewable energy; most notable are solar water heaters and photovoltaic cells. As for nuclear power and uranium, a world–wide trend toward the use of renewable energy would provide expanded export markets for these products. For the reasons discussed above, a move toward increased use of renewable energy is probably more likely than a revival for nuclear power. Despite the withdrawal of the previously generous tax incentives, wind power continues to be installed in California. Countries such as the Philippines have invested heavily in renewable energy, with U.S. companies so far the main beneficiaries. Given the sophisticated technologies developed in Australia, in many cases with the assistance of government funding through the NERDD Programme, there would be some virtue in more serious study of the increased opportunities for export resulting from international concern about possible changes to the global climate.

5. Conclusion

Climate change is a global problem, which no nation or province can address alone. The global impact demands a global response. With a clear need for co–operation, there can be no justification for continuing to allow crucial aspects of energy planning to be based on boundaries drawn by nineteenth–century colonial bureaucrats. The imperative of concerted international action will bring with it a need for local co–ordination.

Some changes to the current pattern of energy use will flow from the predicted climate changes. Increasing temperatures should reduce the size of the winter peak demand for electricity in New South Wales and, to a lesser extent, Victoria, while the summer peak demand in South Australia can be expected to increase. Increases in electricity use for refrigerators and freezers can be expected, especially in warmer parts of Australia.

More significant changes are likely to result from pressures to moderate the production of greenhouse gases. Since the majority of Australian energy use is concentrated on the activities of electricity generation and road transport, these would be the obvious sectors on which to concentrate in any concerted move to reduce the rate of burning hydrocarbons. The present practices which might most productively be modified are the wasteful use of thermal electricity to produce low–grade heat and the level of use of cars.

Neither change could be accomplished without significant attitudinal change to facilitate the necessary political programme. It should be recognised that attitudes to energy supply and use options are much more complex than the traditionally–assumed dichotomy between technocrats and environmentalists. All but the most zealous environmentalists enjoy some of the comforts of our contemporary life–style, and most technocrats have some concern for the natural world. A coherent approach to changing the present pattern of energy use in a fundamental way should be based on a more thorough understanding of the complex social role of energy and the consequently complex mixture of attitudes among the population.

The two broad options to reduce the emission of greenhouse gases are renewable energy and nuclear power. Given current social attitudes toward the other by–products of nuclear energy, it is more likely that the concern will be reflected in the form of increased support for renewable energy technologies. An important element in expanding the use of renewable energy will be the development of a sophisticated economic framework, taking account of depletion and broad environmental effects of energy use. A simplistic economics based on extraction costs will be seen by future generations as a stage of intellectual development comparable to the pre–scientific era. The holistic approach, now common in thinking about environmental matters, must also pervade our social and economic systems. The Bruntland Report summarised concisely the dimensions of the future world energy task, and the sort of approach needed if it is to be tackled satisfactorily:

"Energy is not so much a single product as a mix of products and services, a mix upon which the welfare of individuals, the sustainable development of nations, and the life–supporting capabilities of the global ecosystem depend. In the past, this mix has been allowed to flow together haphazardly, the proportions dictated by short–term pressures on and short–term goals of governments, institutions and companies. Energy is too important for its development to continue in such a random manner. A safe, environmentally sound and economically viable energy pathway that will sustain human progress into the distant future is clearly imperative. It is also possible. But it will require new dimensions of political will and institutional co–operation to achieve it." [39]

References

1 World Meteorological Organisation, Report of the International Conference on the Assessment of the Role of Carbon Dioxide and of Other Greenhouse Gases in Climatic Variation and Associated Impacts, Villach, Austria, 9–15 October 1985, WMO No. 661 (Geneva: WMO/ICSU/UNEP, 1986)
2 Ibid
3 National Energy Advisory Committee, Report No. 13: Energy Conservation in Buildings (Canberra: AGPS, 1980)
4 Ibid
5 Department of Resources and Energy, Energy Demand and Supply Australia 1960–61 to 1982–83 (Canberra: AGPS, 1984)
6 Australian Bureau of Statistics, Pocket Year Book Australia No. 71 (Canberra: ABS, 1986)
7 Energy Authority of N.S.W., N.S.W. Energy Model (Sydney: 1983)
8 Department of Industry, Technology and Resources [Victoria], Study of Home Energy Conservation (Melbourne: 1987)
9 Ibid
10 Australian Bureau of Statistics, National Energy Survey Household Appliances, Facilities and Insulation 1985–86, Cat. No. 8212.0 (Canberra: 1987)
11 Department of Resources and Energy, op cit
12 Australian Bureau of Statistics, op cit (reference no. 6)
13 Ibid
14 National Energy Advisory Committee, Report No. 19: Electricity in the Australian Energy Market (Canberra: AGPS, 1983)
15 G.Coulter, Impact of climate change on the electricity generation industry in New South Wales, paper to conference "Greenhouse 87", Melbourne (1987)
16 K.Guthrie, Domestic Hot Water Consumption Patterns and Quantities, paper to Victorian Solar Energy Council seminar "Designing Water Heaters for Today's Market", Melbourne (1987)
17 Electricity Trust of South Australia, Annual Report (Adelaide: ETSA, 1986)
18 World Commission on Environment and Development, Our Common Future, (Oxford: Oxford University Press, 1987), p. 176
19 G.Hardin, The Tragedy of the Commons, Science 162, 1243–48 (1968)
20 J.Farman, What hope for the ozone layer now?, New Scientist 116, 50–54 (1987)
21 World Commission on Environment and Development, op cit, p.177
22 D.Deudney and C.Flavin, Renewable Energy: The Power to Choose (London: W.W. Norton, 1983)
23 World Commission on Environment and Development, op cit, p.192
24 Department of Primary Industries and Energy, private communication (1987)
25 I.Lowe, Who Benefits from Australian Energy Research?, Science and Public Policy 10, 278–284 (1983)
26 Australian Bureau of Statistics, Research and Experimental Development All–Sector Summary Australia 1984–85, Cat. No. 8112.0 (Canberra: ABS, 1987)
27 M.Diesendorf, Non–Technical Barriers to Renewable Energy, paper to Annual Conference of the Australia and New Zealand Solar Energy Society, Canberra (1987)

28 I.Lowe, D.E.Backhouse and M.Sheumack, The Experience of Solar Hot Water Systems, Search 15, 165–167 (1984)
29 Energy Economics ......
30 World Commission on Environment and Development, op cit, p.187
31 Australian Science and Technology Council, Australia's Role in the Nuclear Fuel Cycle (Canberra: AGPS, 1984)
32 M.Diesendorf, private communication of IEA statistics (1987)
33 Department of Resources and Energy, op cit
34 Ibid
35 Ibid
36 G.Evans, Ministerial Press Release (Canberra: 1986)
37 P.W.G.Newman and J.R.Kenworthy, Transport and Urban Form in Thirty–two of the World's Principal Cities, paper to International Symposium "Transport, Communication and Urban Form", Melbourne (1987)
38 D.R.Ebeling, The Nuclear Fuel Cycle in Australia, Institution of Engineers, Australia (1988)
39 World Commission on Environment and Development, op cit, p.202

The changing North Asian steel industries: raw materials challenges and opportunities

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The structure and location of the world steel industry has undergone considerable change during the past twenty years, particularly in the Pacific region, notably in Japan and the newly industrialising countries of North Asia. In the 1950s and 1960s Japanese manufacturing was dominated by labour intensive activities. By the late 1970s Japan had achieved pre-eminence in a wide range of capital intensive manufacturing activities. A great deal of this industrial base was metals and energy intensive. In particular, Japan rapidly built up a steel industry that became the Western world's largest. However, from the late 1970s the Japanese economy began to undergo changes that resulted in a reduction of the metals and energy intensity of its manufacturing industry. The Japanese economy is now under strong and sustained pressure for further change, with Japanese steel production and consumption likely to decline.

With their currently lower wages and rapidly improving quality control, newly industrialising countries such as the Republic of Korea and Taiwan are gaining a comparative advantage in steel production over Japan. This shift in comparative advantage, as well as rapid economic growth in China, have important implications for the pattern of Pacific trade in coking coal and iron ore and for the price formation process. Competitiveness between suppliers to these markets will also affect the pattern of trade in raw materials.

Historically, steel making technology has had a marked effect on the demand for coking coal and iron ore. It is apparent that cost efficiency in steel production will continue to have a major impact on the patterns of steel production and trade. Important new technologies are being developed which have the potential to progressively change those patterns and affect the nature and timing of steel industry investment.

Technology in Steel Making

Steel producers are continuously seeking ways to reduce the cost of steel making through improved production techniques. There are two main ways that technological innovations have influenced the steel industry - by fundamental changes in the method of steel production and by the introduction of modified production techniques aimed at reducing the cost of raw material inputs, for example, pulverised coal injection.

The blast furnace is the most widely used steel production method, accounting for about 74 per cent of world steel production. Japanese steel makers using blast furnaces have endeavoured to reduce costs using various cost cutting measures, mainly focused on energy inputs into the steel making process. However, the evidence suggests that in spite of large fluctuations in input prices, input substitution has been limited. After falling during the 1960s and 1970s, use of coking coal in place of oil in blast furnaces rose in the early 1980s because of higher oil prices (figure 1), but since

1970 the ratio of coking coal use to pig iron production has fluctuated within a narrow range, 0.7-0.83. Unless there are dramatic changes in relative fuel prices, the coal to pig iron ratio is unlikely to change significantly during the next ten years and the principal cost cutting measures will continue to be directed at substituting cheaper coals for hard coking coal.

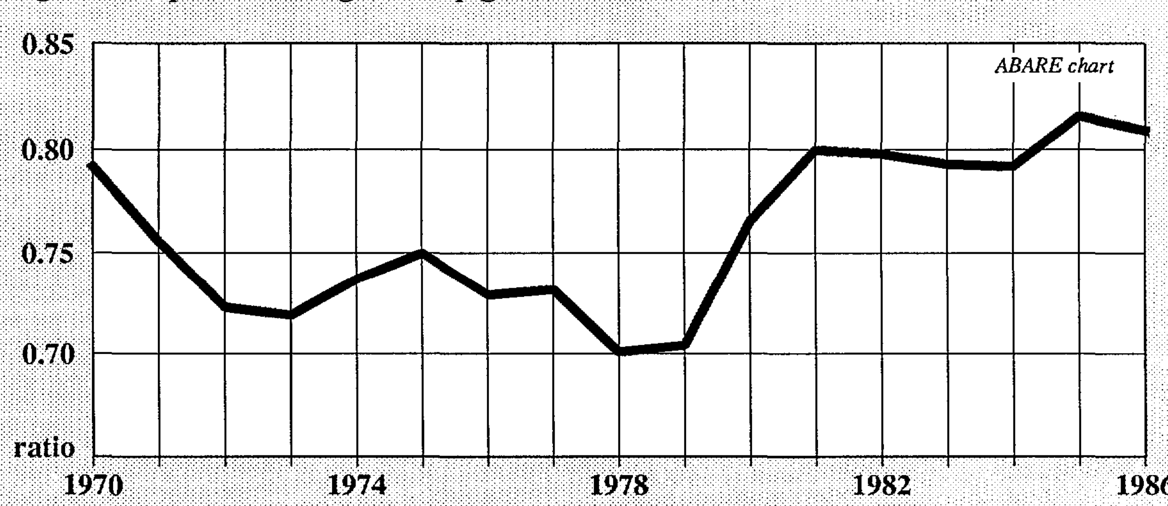
The main techniques used to substitute cheaper, lower grade coals for hard coking coal are blending, pulverised coal injection and, to a lesser extent, formed coke. Pulverised coal injection allows up to 20 per cent of hard coking coal to be replaced by soft coking or non-coking coal. Formed coke can be manufactured using up to 70 per cent non-hard coking coal, but technical difficulties inhibit its commercial application. These methods do not change the overall quantities of coal required for pig iron production, but they change the quality composition of coal inputs and hence reduce the cost.

As steel producers substitute cheaper coals for hard coking coals the price of hard coking coal is expected to ease, reducing the price premium. However, the overall quantities of coal used in the steel making process are not expected to change significantly on account of technical innovations in blast furnaces.

There are two other methods of producing steel - the electric arc furnace and a new process being developed, known as smelting reduction. Electric arc furnaces generally use scrap steel as raw material, eliminating the requirement for both coking coal and iron ore, although direct-reduced iron ore (sponge iron) can also be used as raw material. As electric arc furnace production increases its share of steel making capacity some loss of iron ore and coking coal markets is expected, although there is the possibility that increased production in electric arc furnaces will lead to increased use of sponge iron.

Smelting reduction is the most recent steel production innovation and is a form of intensive smelting which eliminates or greatly reduces the need for coke. To date, only one smelting reduction facility (in South Africa) is operating on a commercial basis, and this method is not expected to account for a significant proportion of world steel output until after the year

Figure 1: Japanese coking coal to pig iron ratio



2000. The gradual introduction of smelting reduction technology beyond 2000 will further ease demand and prices for coking coal.

Demand for Raw Materials

North Asia will continue its growth as a major steel producing region and a major destination for iron ore and coking coal exports into the next century. Even though Japanese steel production and consumption are likely to decline, demand for steel and steel making raw materials is set to continue to expand strongly in China, the Republic of Korea and Taiwan (Crowley, Nagle and Porter 1988).

For the OECD group of countries, economic growth is expected to remain moderate during the next ten years, with Japanese gross domestic product projected to grow by 3.5 per cent a year on average. The long term rates of economic growth for Korea and Taiwan are likely to be about 5 per cent a year, and for China around 7.5 per cent. Economic growth in these countries is expected to be amongst the strongest in the world.

The Japanese Ministry for International Trade and Industry expects world steel production to increase during the next ten years, and Japan's output to fall. Total Japanese steel production is forecast to fall to around 90 Mt in 1995 (Research Institute of the Japanese Ministry for International Trade and Industry, personal communication, November 1988) and to around 85 Mt in 2000, despite the Japanese steel industry producing at well above expected levels in 1987 and 1988, at 105 Mt (ABARE 1989). The strong recent performance of the Japanese industry reflects a mix of expansionary fiscal policies and a boom in the construction industry.

Apart from losses of export markets for some steel products, domestic markets are also likely to contract in the short to medium term. Important steel using industries are moving offshore and the sharply increased competitiveness of steel imported from other Asian suppliers will displace a portion of domestic sales. Like other Japanese industries, the steel industry is expected to continue the trend toward products of higher value added (Porter, Nagle and Jones 1988).

The expected reduction in Japanese steel output, as well as the use of more efficient blast furnaces and of electric arc furnaces, will reduce Japanese demand for iron ore and coking coal. Electric arc furnace output accounted for about 25 per cent of total steel output in 1981 and 30 per cent in 1987. This is forecast to rise to around 35 per cent in 2000. Steel production from Japanese blast furnaces is forecast by ABARE to be around 55 Mt in 2000, compared with 69 Mt in 1987.

On the basis of slightly improved ratios of consumption of coking coal and iron ore to crude steel output, Japanese coking coal and iron ore imports are forecast to be about 48 Mt and 90 Mt, respectively, in 2000, compared with 64 Mt and 122 Mt in 1987.

Korea and Taiwan have much to gain from Japan's shift away from steel production. With their lower wage costs and export oriented trade and development policies, they are well placed to take advantage of the reduced competitiveness of the Japanese industry and increase production capacity in order to export to Japan and to markets that Japan may lose.

Korea was the world's eleventh largest producer of crude steel in 1987, with production of about 17 Mt. The sixth five-year plan includes further expansion of the Kwangyang steel complex and encouragement of the production of special steels (Government of the Republic of Korea 1986). According to the Korean Institute for Economics and Technology, steel demand in Korea is expected to rise almost 50 per cent to around 24 Mt in 1990 and to 35 Mt by 2000 (McCulloch 1987). Korea's steel production is forecast by ABARE to be around 30 Mt in 2000, with production from blast furnaces to be about 20 Mt. Accordingly, coking coal and iron ore imports are projected to rise to about 16 Mt and 30 Mt, respectively, in 2000, from 9 Mt and 17 Mt in 1987.

In Taiwan, steel production and consumption are also forecast to expand rapidly. Taiwan's crude steel production in 1987 was about 5.8 Mt, of which 34 per cent was produced using electric arc furnaces. Expansion programs are planned over the period to 1995, to double annual capacity to about 12 Mt, with electric arc furnaces producing about 3.5 Mt of this total. Taiwan's Council for Economic Planning and Development forecasts domestic steel demand in 1995 at 11.5 Mt, leaving little room for exports (Metal Bulletin 1987). Taiwan's steel production from blast furnaces is forecast by ABARE to reach around 10 Mt in 2000, with coking coal and iron ore imports at 8 Mt and 15 Mt, respectively, compared with 3 Mt and 5 Mt in 1987.

China has achieved strong economic and industrial production growth over recent years, and its economy is expected to continue to grow strongly. This economic growth and particularly the expansion of its industrial base and infrastructure will lead to strong demand for steel. By the year 2000, crude steel production is targeted to rise to around 80 Mt, compared with production of 56 Mt in 1987 (Johnson and Clark 1987). Johnson and Clark project crude steel consumption to be around 110 Mt in 2000.

Although China is a large producer of minerals, it remains a net importer of iron ore. China has large reserves of iron ore and coal but most of these reserves tend to be of relatively low quality and are predominantly located in the remote western regions of the country, well away from industrial centres. Transport infrastructure deficiencies make it difficult and expensive for China to develop its domestic mining sector. Although China's coal industry is likely to be developed further to support steel production (discussed later in the paper), substantial iron ore imports are expected. Higher quality imported iron ore can be delivered to seaboard steel mills more cheaply than local ores. Iron ore imports are therefore likely to increase with the forecast strong growth in steel production and consumption. According to some estimates (Johnson and Clark 1987), Chinese import demand for iron ore in 2000 will more than double, to between 30 Mt and 40 Mt, compared with around 12 Mt in 1987.

Supply of Raw Materials

In the North Asian market, both price and other factors determine the competitiveness and, in turn, the market shares of suppliers of coking coal and iron ore. The main factors determining market shares are the landed cost of raw materials at the market and raw material quality.

However, factors such as the reliability and reputation of suppliers, and supply diversification policies, are also important. The Japanese government has placed a high priority on security of supply and has actively encouraged importers to diversify sources of supply. Procurement policies of purchasers of raw materials for steel making are designed to achieve a balance between the two objectives of supply security and cost minimisation.

The Japanese Ministry for International Trade and Industry and other government agencies have encouraged importers of raw materials to coordinate purchases. It appears that the Japanese steel mills do exercise some degree of buyer power in the coking coal market by acting as a single buyer (Anderson 1987). The lead negotiating firm acting for the Japanese steel mills and dealing with Australian and US coal suppliers is Nippon Steel Corporation, while South Africa and Canada are assigned Nippon Kokan K.K. In the Pacific market, procurement policies have had a significant effect on prices and quantities of coking coal and iron ore traded.

. <u>Coal</u>

The representative costs for the major coking coal exporting countries, Australia, the United States and Canada, for typical coal quality available from these countries in 1986 are shown in table 1. Australia had the lowest mine operating cost, with Queensland coal at $18.2/t (International Energy Agency 1988). Next is New South Wales at $20.7/t, followed by Canada at $22.3/t. The Appalachian mines in the United States, which produce higher quality coking coals than the other producers, have the highest mine operating costs of the countries examined, at $34.5/t. Transport and handling costs for the United States and Canada were double those for Australia.

It is important to note that the cost of shipping coal to export markets is a major component of the cost of imports (table 2). For example, ocean freight accounts for almost 20 per cent of the cost of Queensland coal in Europe and 14 per cent in Asia. In general, the high cost of shipping coal compared with the value of the product has the effect of segmenting the world coking coal market into regional markets, the most important of which are the Pacific and Atlantic Basins. Variations in freight rates have important implications for the competitiveness (and profitability) of the competing exporters. When freight rates are high, Australian coal becomes less competitive on the European market.

Of the new entrants in the Pacific market, only China is considered to have the potential to supply coking coal (Calarco 1988). The Chinese coal market

Table 1: COKING COAL COSTS IN 1986

Source	Mine operating	Transport handling	Total operating	Capital recovery	Total
	US$/t	US$/t	US$/t	US$/t	US$/t
Australia					
Queensland	18.2	9.1	27.3	11.0	38.3
New South Wales	20.7	8.7	29.4	7.6	37.0
United States					
Appalachia	34.5	18.0(a)	52.5	5.0	57.7
Canada	22.3	17.2	39.5	13.0	52.5

(a) Contract rates negotiated between the shipper and the carrier are available at less than this rate.
Source: International Energy Agency (1988).

Table 2: COKING COAL COSTS, INCLUDING FREIGHT, IN 1986

Source	Operating	Freight(a) Asia	Freight(a) Europe	Costs including freight Asia	Costs including freight Europe	Capital recovery
	US$/t	US$/t	US$/t	US$/t	US$/t	US$/t
Australia						
Queensland	27.3	4.5	7.0	31.8	34.3	11.0
New South Wales	29.4	5.0	7.5	34.4	36.9	7.6
United States						
Appalachia	52.5	8.5	4.5	61.0	57.0	5.0
Canada	39.5	4.5	8.5	44.0	48.0	13.0

(a) Source: National Coal Council (1987).

is complex, with a host of problems. A detailed analysis of the Chinese coal market was undertaken by the International Energy Agency in 1986 (Doyle 1987). With the expected expansion of Chinese steel making capacity, coal requirements are also expected to increase, although at a somewhat slower rate, given expected improvement in coking rates. China's coking coal requirements are projected to be around 75-85 Mt, depending on steel output, in 2000, compared with 60 Mt in 1985. With the increase in demand from the Chinese steel industry the domestic coking coal market is destined to remain tight (Doyle 1987). In these circumstances, China is not expected to become a significant exporter of coking coal during the next twelve years.

. <u>Iron ore</u>

Using 1984 data, the World Bank (1986) has carried out a study of comparative operating costs of some major iron ore producers who represent about 67 per cent of market economy production (tables 3 and 4). Operating costs cover labour, transport and handling and energy. The study covers the United States (Minnesota), Canada (Quebec and Labrador), Australia (Pilbara), Brazil and West Africa. Although data for India were not available in the World Bank study its operating costs are thought to be slightly higher than Australia's.

Several broad conclusions can be drawn from the study. First, operating costs as a proportion of total costs for all producers were similar (between 71 per cent and 79 per cent). Second, although the individual cost categories are generally also similar in proportion to total costs, there were three important exceptions: in Brazil, labour costs are low (7 per cent compared with 22-25 per cent for other producers) and transport and handling costs are high (28 per cent compared with an average of 17 per cent for the others); and in the United States where hard low grade ores are mined, energy costs are high (16 per cent compared with an average 7 per cent for others). Third, Australia and Brazil, the biggest producers of sinter feed, are the lowest cost producers. Brazil's costs were slightly lower than those of Australia, while the United States and Canada were the highest cost producing regions. With the addition of freight rates (the other major component of costs), Australia becomes the lowest cost supplier to the Asian market while Brazil remains the lowest cost supplier to Europe. West African

Table 3: IRON ORE COSTS (SINTER FEED) IN 1984

Source	Mine operating	Transport handling	Total operating	Capital recovery(a)	Total
	US$/t	US$/t	US$/t	US$/t	US$/t
Australia	9.4	3.0	12.4	2.4	14.3
Brazil	7.0	3.9	10.9	3.2	14.1
West Africa	11.5	3.2	14.7	3.2	17.9

(a) Includes depreciation, amortisation and interest.
Source: World Bank (1986).

Table 4: IRON ORE COSTS INCLUDING FREIGHT (SINTER FEED) IN 1984

		Freight(a)		Costs including freight		
Source	Operating	Asia	Europe	Asia	Europe	Capital recovery
	US$/t	US$/t	US$/t	US$/t	US$/t	US$/t
Australia	12.4	5.5	7.6	17.9	20.0	2.4
Brazil	10.9	8.0	5.3	18.9	16.2	3.2
West Africa	14.7	na	4.9	na	19.6	3.2

(a) Average of spot iron ore freight rates for 1984 from Bolis and Bekkala (1987). na Not available.

producers, who have high operating costs, are more competitive than Australia in Europe. West African producers export very little ore to the Asian market.

The World Bank cost study predates the opening of the Carajas mine in Brazil. Carajas is the world's largest iron ore mine with output of 25 Mt in 1987 and a potential capacity of 35 Mt a year. The extent of existing or planned capacity in the major exporter countries is expected to deter the entry of new suppliers into the market.

Outlook for Raw Material Supply Costs

Because of the extent and nature of its coal reserves, Australia is expected to remain a highly competitive supplier of coking coal. Barnett (1987) forecasts that in 2000 Australia will remain the lowest cost producer of coking coal. He projects that Australia will export about 46 Mt of hard coking coal in that year, with the operating costs of the marginal mine around US$35/t to US$39/t (1986 dollars).

Canada is expected to be a higher cost producer of coking coal than Australia in 2000. In order to assess prospects for Canadian coals in international markets, Jamieson (1986) produced a series of supply projections for metallurgical coal at various price levels indicative of the cost of mining Canadian coking coal. At higher prices the incentive to produce coking coal increases. With the price at US$60/t, the older western Canadian mines would produce about 12 Mt a year (1986 dollars). At a price of US$63.8/t the south-east British Columbia and Alberta mines would become viable and would increase production to about 18 Mt a year.

Schulz (1988) projects that US production costs will remain constant in real terms in the northern and southern Appalachians, while those in the central Appalachians will increase by around 20 per cent in real terms between 1983 and 2000. He forecasts only slight real cost increases for US export coal.

On the basis of these forecasts and ABARE's projections for real exchange rates it appears that Australia will remain the most competitive supplier of coking coal to the Pacific market, followed by Canada and the United States.

For iron ore Australia's position as a low cost producer is likely to be maintained for the foreseeable future, with production remaining centred on the Pilbara region's extensive high grade, low cost ore reserves. Brazil's operating costs are now likely to be slightly above those shown in table 3 as a result of the commissioning of the Carajas mine.

The competitive rankings of Brazil and Australia in the two major markets, Japan and Europe, are expected to remain unchanged. Australia and Brazil are expected to increase their market shares in North Asia.

Freight rates in the early 1980s were substantially below their long term declining trend because of slack demand and low ship building costs. However, in 1987 shipping space was limited and as a result freight rates generally rose. Shulz (1988) forecasts that if oil prices rise only moderately and with continued economy gains made in operating costs, freight rates will remain around their long term trend so that supplying countries that are closer to consuming countries should be at an advantage.

Projected Trade Flows of Raw Materials in the Pacific Market

Australia is the major supplier of coking coal and iron ore to all the markets in the region (tables 5 and 6). Australia's main competitors are Brazil and India for iron ore, and Canada and the United States for coking coal.

The outlook for coking coal and iron ore trade flows in the region in 2000 is shown in tables 7 and 8. The figures in these tables are indicators of orders of magnitude of changes to Pacific trade. They are not detailed projections of coking coal and iron ore demand in North Asia. Such forecasts await detailed modelling of the market.

Although figures for the trade flow projections are based on a number of assumptions such as forecasts of blast furnace steel production by country and supply costs, the general trend in the Pacific trade for steel making raw materials is for a contracting though more competitive market for coking coal and an expanding competitive iron ore market.

Japan is expected to remain the largest buyer of coking coal (importing around 48 Mt in 2000) and thereby continuing to have a major influence on prices. The Republic of Korea and Taiwan are forecast to become increasingly important in the coking coal trade, importing about 16 Mt and 8 Mt, respectively. However, because their demand is expected to remain smaller than Japan's they are likely to continue to follow Japan as the price

Table 5: PACIFIC TRADE IN COKING COAL IN 1987

Importer	Australia Amount	Australia Share	Canada Amount	Canada Share	United States Amount	United States Share	Total imports
	Mt	%	Mt	%	Mt	%	Mt
Japan	29.0	44.7	15.4	24.1	9.0	13.9	63.9
Korea, Rep. of	3.6	38.8	3.0	31.6	2.0	23.5	9.2
Taiwan	2.4	75.1	0.6	18.8	0.2	6.1	3.2
Total	35.0		19.0		11.2		76.3

Exporter columns: Australia, Canada, United States.

Sources: International Energy Agency (1988); Association of Iron Ore Exporting Countries (1987); Financial Times (1988).

Table 6: PACIFIC TRADE IN IRON ORE IN 1987

Importer	Australia Amount	Australia Share	Brazil Amount	Brazil Share	India Amount	India Share	Total imports
	Mt	%	Mt	%	Mt	%	Mt
Japan	43.0	35.2	27.0	22.1	20.0	16.4	122.0
Korea, Rep. of	6.0	36.8	4.7	28.1	3.0	17.9	16.7
Taiwan	3.6	70.1	1.3	26.0			5.1
China	7.5	60.9	4.0	31.9	0.3	2.4	12.3
Total	60.1		37.0		23.3		156.1

Sources: International Energy Agency (1988); Association of Iron Ore Exporting Countries (1987); Financial Times (1988).

Table 7: PROJECTIONS TO THE YEAR 2000 FOR THE PACIFIC TRADE IN COKING COAL

Importer	Australia Amount	Australia Share	Canada Amount	Canada Share	United States Amount	United States Share	Total imports
	Mt	%	Mt	%	Mt	%	Mt
Japan	25	52	10	21	6	12	48
Korea, Rep. of	8	47	5	33	3	20	16
Taiwan	6	75	1	12	1	12	8
Total	39		16		10		72

Table 8: PROJECTIONS TO THE YEAR 2000 FOR THE PACIFIC TRADE IN IRON ORE

Importer	Exporter: Australia Amount	Exporter: Australia Share	Exporter: Brazil Amount	Exporter: Brazil Share	Total imports
	Mt	%	Mt	%	Mt
Japan	36	40	24	28	90
Korea, Rep. of	11	38	8	27	30
Taiwan	9	60	5	33	15
China	18	51	14	40	35
Total	74		57		170

leader, and also to maintain policies to diversify suppliers. Imports of metallurgical coal into the North Asian region are expected to decrease from 76 Mt in 1987 to around 72 Mt in 2000, with China maintaining self-sufficiency. A fall in regional demand will create challenges for Australian coking coal exporters. Because there are expected to be adequate supplies of coking coal on the international market in 2000, Korea and Taiwan will not have to bid aggressively to satisfy their demand, but to a large degree will be able to procure supplies from present suppliers to the Japanese market.

For the iron ore trade a different story emerges. Although increased demand for iron ore in Korea and Taiwan (up 13 Mt and 10 Mt, to 30 Mt and 15 Mt, respectively) is expected to partly offset reduced Japanese demand (down 32 Mt to 90 Mt), the possible entry of China as a buyer in the international iron ore market (importing as much as 35 Mt in 2000) will have implications for both prices and quantities traded. If China and the newly industrialising countries become significant purchasers of iron ore and bid on a competitive basis, Japan's market power may be reduced, resulting in both quantities traded and prices increasing. Future strong demand for iron ore is expected to provide the Australian export industry with significant opportunities for development.

Conclusions

Changes in steel making technology are not expected to have a marked effect on the quantities of raw materials demanded to the year 2000, although there will be increasing substitution of cheaper coals for hard coking coal and consequently a reduction in the price premium for hard coking coal.

For the North Asian iron ore and coking coal markets as a whole, the volumes and sources of imports are not expected to change substantially during the next ten years. Japan's demand for coking coal and iron ore is expected to fall. This fall in Japanese demand will be offset by increased demand from China, the Republic of Korea and Taiwan in the case of iron ore, and for coal will be partially offset by demand from Korea and Taiwan.

With Japan forecast to remain the dominant importer of Pacific coking coal, it will remain the price leader and key negotiator with suppliers, and so will continue to have considerable power over price in a market where demand is easing. To a large extent freight rates will determine the degree of segmentation of the world coking coal and iron ore markets and thus the degree of Japan's monopsony (single buyer) power in the Pacific market. The adequacy of supplies will also be an important factor in allowing Japan to retain its market power.

The outlook for iron ore trade flows to Japan, Korea and Taiwan is similar to that forecast for coking coal, but the price formation pattern is expected to change. China will become an increasingly important North Asian steel producer. If China buys large quantities of iron ore on the international market and bids on a competitive basis for supplies, the buying pattern of other North Asian countries will also become more competitive. Such a development could have benefits for Australian iron ore suppliers through increased prices and quantities traded.

For Australia to maximise its market share for coking coal and iron ore in North Asia, new trading relationships must be forged at a time when there will be intensive competition from other suppliers and strong diversification policies in consuming countries.

References

ABARE (1989), 1989 Outlook for Australian Mineral Resource Exports to 2000, AGPS, Canberra.

Anderson, D. (1987), An Analysis of Japanese Coking Coal Procurement Policies: the Canadian and Australian Experience, Centre for Resource Studies, Queen's University, Kingston, Canada.

Association of Iron Ore Exporting Countries (1987), Iron Ore Statistics, 2/1987, Geneva.

Barnett, D.W. (1987), 'The cost and availability of Australian coal', in D. Barnett, V. Calarco, and G. McCloskey, World Coal Outlook, Macquarie University, Sydney.

Bolis, J.L. and Bekkala, J.A. (1987), Iron Ore Availability - Market Economy Countries, Information Circular 9128, US Bureau of Mines, Washington DC.

Calarco, V.J. (1988), World Coal Outlook: Past, Present and Future, Macquarie University, Sydney.

Crowley, P.T., Nagle, W. and Porter, D. (1988), Long run adjustment in the Japanese steel industry: implications for Pacific coking coal and iron ore trades. An ABARE paper presented at the AJRC/MITIRI Workshop on Adjustments in the Japanese Steel Industry, 10-11 November.

Doyle, G. (1987), China's Potential in International Coal Trade, International Energy Agency, Coal Research, London.

Financial Times (1988), ICR Coal Statistics Yearbook, Financial Times Information, London.

Government of the Republic of Korea (1986), The Sixth Five-Year Economic and Social Development Plan: 1987-1991, Seoul.

International Energy Agency (1988), Coal Information 1988, Organisation for Economic Co-operation and Development, Paris.

Jamieson, E.D. (1986), The Cost and Availability of Canadian Coal, International Energy Agency, Coal Research, London.

Johnson, C.J. and Clark, A.L. (1987), 'China's minerals future: 1985-2005', Natural Resources Forum 11(2), 111-26.

McCulloch, R. (1987), 'Rapid growth leaves room for two-way trade', Metal Bulletin Monthly 197, 49-52.

Metal Bulletin (1987), 'Taiwan plans steels trade set-up', Metal Bulletin 7158, 23.

Nagle, W.A. (1988), 'Metal and mineral markets in China', Resource Trends September 1988, pp.56-64.

Porter, D., Nagle W. and Jones B. (1988), Changing demand for minerals in North Asia. An ABARE paper presented to the BMR and ABARE Petroleum and Minerals Outlook Conference, Canberra, 16-17 March.

Shulz, W. (1988), Energy in Europe - Energy Policies and Trends in the European Community 10, Commission of the European Communities, Directorate-General for Energy, Brussels.

National Coal Council (1987), Improving International Competitiveness of US Coal and Coal Technology, Arlington, Virginia.

World Bank (1986), Iron Ore: Global Prospects for the Industry, 1985-95, Industry and Finance Series, vol. 12, Washington DC.

Commercial links with China - potential and constraints

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Mr. Chairman, Ladies and Gentlemen,

I'm very pleased to have been given this opportunity to outline, to the Conference, some of the aspects concerning the development of commercial links with China.

My presentation will be concentrating on two aspects. These are, firstly, the potential and secondly the constraints mitigating against that potential.

As a preface to my observations on this topic, I should first explain that I'm wearing my hat as the President of the Australia China Business Co-operation Committee.

This is a Committee, administered by a secretariat within the Confederation of Australian Industry, which comprises an assembly of around sixty Australian companies who have already established commercial links with China.

Our objective is to develop Australian business with China by the establishment of an informal network, whereby Australian firms can learn from each other's experiences in China.

Each year, we also arrange a forum for senior executives from both countries to discuss common issues. Last year this was held in Beijing and this year it will be held in Perth in April.

The term "potential" is a term which has been in vogue now for many years when describing China. No doubt Marco Polo used an equivalent word to describe the opportunities he saw during his travels in the 14th century.

The simplest view of China's potential is their huge population and their current standard of living.

There are varying estimates of China's population but it's probably pedantic to argue whether it's 1.1 billion or 1.2 billion even though the difference is 100 million people. This is about six times Australia's total population so I can understand why the actual population is often used to describe how potential is seen. This has given rise to a lot of wishful thinking in the past such as:

"If each Chinaman (and woman) wanted a pair of woollen socks, what a benefit that would be for the Australian wool industry."

I am familiar with a more quantitative approach which compares the consumption per capita of steel. Steel is a useful commodity to compare because it is a basic material used in construction and consumer goods and thus its consumption illustrates the general state of an economy.

The following table illustrates this approach.

	PR China	Taiwan	South Korea	Australia	USA
Population (million)	1100	19.6	42.1	16	245
Apparent Finished Steel Consumption (million tonnes)	63.9	9.0	14.8	5.3	87.9
Apparent Finished Steel Consumption per capita (kg)	58	459	352	327	359

Table 1: Net apparent steel consumption per capita in PR China compared with other countries. (Source: International Iron and Steel Institute estimates for calendar year 1988.)

(Note: Net apparent steel consumption is the sum of a country's finished steel production plus imports minus exports divided by the population.)

The gap between 58 kg for China and the other countries quoted illustrates the task ahead for China's Iron and Steel industry.

It also illustrates the opportunity for the balance of the world's steel industry to become involved not only in the export of steel products into China, but in the actual development of China's domestic industry to meet the ambitious targets set.

These targets are shown on the next table.

	1949	1957	1960	1979	1983	1987	1988	2000
Raw steel production (million tonnes)	0.16	5	18	34	40	56	59	70

Table 2: Historical and planned future raw steel production in China (million tonnes). (Source: Ministry of Metallurgical Industry, Beijing.)

Another aspect of the potential existing for this particular industry lies in the import by China of better quality raw materials. This is of particular relevance to Australia's minerals and energy industries. Although China has abundant proven reserves of iron ore recently estimated at 49 billion tonnes, most of this is of poor quality, averaging between 30% and 38% Fe. It would be a comparatively easy technical exercise to replace some of this lower grade domestic iron ore with higher grade Australian ore. This would greatly improve the production efficiency of Chinese blast furnaces to enable them to exceed their officially planned targets.

Unfortunately, achieving this will not be so simple as it is not merely technical issues which need to be addressed - I'll be covering this in more detail when I cover the constraints.

I might add that some of the modern plant installed, for example, at Baoshan, is already operating on a diet of high grade raw materials mainly from Australia, but also from Brazil and India.

Both these countries are strong competitors for China's iron ore imports, and the Australian industry has a real challenge in the future to retain and, hopefully, to expand our current share of this market.

A few moments ago I mentioned one opportunity which, technically, would be a relatively easy matter to finalise for both the benefit of the Chinese steel industry and the Australian iron ore industry. I alluded to constraints inhibiting this opportunity. However, even in some of the constraints present, there are opportunities emerging.

Specifically, this observation applies to the ability of the Chinese infrastructure to handle a substantially greater quantity of iron ore shipped into ports, handled across wharves and transported to steelworks.

I attended a conference recently in Beijing organised by the Pacific Economic Co-operation Committee. One of the speakers was Mr. Jin Lin from the Ministry of Metallurgical Industry in Beijing. He also discussed this constraint and went further to comment that "China will need to import as much iron ore as possible from overseas. The tonnage of imported iron ore by the year 2000 will be entirely dependent on the degree of co-operation between China and Pacific countries. The finance could be provided by co-operation between Australia and (the) World Bank or other credit organisations to help build and expand the handling capacity of harbours or specialty ore docks in China, in order to increase Chinese import iron ore tonnages by the year 2000."

I would add that the transport system between the wharves and steelworks needs to be addressed also. Anyone who has visited China recently and noticed the traffic congestion on inadequate roads servicing major port facilities would probably have drawn the same conclusion.

There is potential, therefore, for Australian firms to participate in the expansion of all this infrastructure i.e. ports, wharves, stevedoring and transport.

These observations have been drawn from my own knowledge of BHP's iron ore exporting industry, however, I believe that the same observations could be made for other industries and other commodities.

For example in the petroleum exploration industry, China is looked upon as today's frontier, and the people prospecting as pioneers.

Vast potential is seen in the remote areas such as the Tarim Basin and the Qaidam Basin in the north west where very little exploration using modern techniques has been carried out. We think there may be some oil there, but finding it and then moving it to the markets reveals considerable infrastructural shortcomings.

CSR, as our operating partner in a consortium drilling for oil on Hainan Island can quote from nine years experience in China. At times they found this to be somewhat plagued with constraints due to a number of factors:

- there were few ground rules to guide either side. These were developed from first principles by negotiation with local and central authorities;

- there were, and still are, numerous levels and arms of government;

- there was considerable confusion as to the respective roles played by the various levels and arms of government;

- communications, particularly for on-shore based operations, were almost non-existent;

- any regulations which could be identified were often subject to change with little or not notice. This particularly applied to the tax regime;

- the management of foreign currency exchange can only be described as unique with a three tiered system of exchange. First of all there is the official exchange rate which is tied to the U.S. dollar at 2.8 yuan to the dollar. Secondly, there is the quaintly Chinese concept of government approved unofficial money exchange centres where the going rate for a US dollar varies from day to day. Recently, these conversion rates have been up to six yuan to the dollar. Thirdly, there is the black market for currency at which even higher rates can be obtained;

- in more recent years, inflation has become a considerable problem. It is currently running at around 20%, largely caused by the central government's price reform policies taking effect.

- there was little understanding of the principle of copyright which complicated the training process for Chinese workers;

- there was an expectation, if not ambition, on the Chinese side that they would retain total control over day-to-day administration of drilling operations despite their knowledge of modern techniques still being in the learning phase.

These constraints, however frustrating they may be to the outsider, continue nevertheless to be part of the Chinese business environment. Furthermore, the constraints themselves give rise to additional opportunities.

The most obvious one is in the area of communication.

Great advances have been made in the past in telecommunications. A few years ago, placing a telephone call overseas from an office or hotel room in China was a particularly frustrating exercise.

First of all one had to find the exchange, and an operator who was willing to co-operate and able to understand what was required. Then there would often be a long wait for a line to become available. When a connection was finally made it was often so faint that both parties had to shout to be heard. Often the conversation would be accidentally terminated, by either persons unknown or equipment failure just when it reached its most important stage.

It is encouraging, therefore, to see the priorities that the Chinese have accorded the humble telephone, because international direct dialling has well and truly arrived in a number of major Chinese cities. That is not to say that the system is now faultless, but it illustrates what can be achieved and the potential for further development in this area.

The important principle I've attempted to illustrate in this address is that the potential and constraints affecting business decisions in China should not be considered in isolation. Many of the constraints themselves give rise to other opportunities, as mentioned earlier.

However, there are a number of constraints from which not even the most optimistic person could extract opportunities.

Included in this number are:

- cross ministry conflicts and rivalries. If more than one ministry is involved in a negotiation, there are often difficulties in reaching agreement to which all ministries feel equally committed. This is related to the problem of "loss of face" by the personnel in one ministry if personnel in another ministry are perceived as undertaking a more prominent role in the negotiations;

- a similar problem exists between actual departments within ministries;

- the confusion in roles and responsibilities of the various levels and agencies of government. I have often seen examples where a provincial organisation will claim to have authority to undertake transactions requiring foreign exchange, only to be thwarted at the last moment by one of the central authorities imposing some unanticipated restriction. In the final analysis, of course, it is the central authority who prevails;

- a sometimes inflexible attitude whereby up to 80% of product from some joint ventures is required to be exported. This guidelines is often applied regardless of any import replacement considerations;

- a growing tendency for some elements of the bureaucracy to accept "kickbacks". The authorities have pinpointed this problem and are cracking down hard to prevent it spreading;

- their complicated system of foreign exchange management. This was explained in greater detail earlier.

Summing up, therefore, developing business in China is not for the faint hearted or for those who want a quick return on their investment.

It is a country which requires a long term approach.

My image of China's potential as a market is of the pot of gold at the end of the rainbow - it appears no closer as you proceed towards it. However in this process, other opportunities will emerge which we should be flexible enough to recognise and develop to mutual benefit.

It is a country in close proximity to Australia and in a rapidly developing region, so will no doubt become even more important to us as the years go by.

I'm not aware of very many success stories for foreign firms in China, but BHP's experience has been encouraging. China has been a customer of ours since 1891 so we must have done something right.

TABLE 1

	PR CHINA	TAIWAN	SOUTH KOREA	AUSTRALIA	USA
POPULATION (MILLION)	1100	19.6	42.1	16	245
APPARENT FINISHED STEEL (MILLION TONNES)	63.9	9.0	14.8	5.3	87.9
APPARENT FINISHED STEEL CONSUMPTION PER CAPITA (KG)	58	459	352	327	359

Net apparent steel consumption per capita in PR China compared with other countries.

TABLE 2

	1949	1957	1960	1979	1983	1987	1988	2000
RAW STEEL PRODUCTION (MILLION TONNES)	0.16	5	18	34	40	56	59	70

Historical and planned future raw steel production in China (Million tonnes).

CONSTRAINING FACTORS

- FEW GROUND RULES
- MANY LEVELS AND ARMS OF GOVERNMENT
- CONFUSION OF ROLES
- POOR COMMUNICATIONS
- REGULATION CHANGES WITH LITTLE OR NO NOTICE
- MULTI TIERED FOREIGN EXCHANGE SYSTEM
- INFLATION IS INCREASING
- COPYRIGHT DIFFICULTIES
- EXPECTATIONS OF CONTROL WITHOUT FULL UNDERSTANDING
- INTER-MINISTRY RIVALRIES
- INTRA -MINISTRY RIVALRIES
- PROVINCIAL VERSUS CENTRAL CONTROL
- IMPORT REPLACEMENT NOT ALWAYS SEEN AS LEGITIMATE METHOD OF F.E. CONTROL
- CORRUPTION IS GROWING

New materials - new Australian Industries

T Biegler

CSIRO Division of Mineral Products

This paper addresses the question of what business opportunities new materials might provide, in which industry sectors those opportunities are likely to arise, and how the emergence of new materials might affect the business of the resource sector. New materials will offer new business opportunities, but overnight revolutions in opportunities for the major resource-based products should not be expected. Any competitive advantage for Australian business will need to depend and build on strengths in marketing and technology. The advantage provided by a local mineral resource is a minor factor. The chemical industry seems more likely than the minerals industry to take up the new materials business opportunities.

What Are New Materials?

New, or advanced, materials are in the public eye. One has to go no further than a headline in the Australian Financial Review (1) just a few days before the deadline for this Conference to see that this is a high-profile topic. The headline said "Advanced materials 'exciting'" and the article referred to applications of new materials in electrical and electronic engineering. The new materials included superconductors, new semiconductors, high-power magnets, ceramics, electroactive polymers, glassy metals and many types of sensors. To this catalogue of new materials can be added a range of plastics, metal alloys, and composite materials such as fibre-reinforced plastics or metals.

In defining the term new materials, it is hard to get much further than the meanings of the two words themselves. A more extended definition would go something like "materials recently or currently emerging from the research and development stage that have properties allowing them to replace 'conventional' materials in existing functions or perform a completely new function". Most often we are talking about materials that, through some technological advance, can perform better at, or extend, the limits at which present materials are useable. Temperature, corrosion and abrasion are typical of the conditions that limit structural materials. Alloying, fibre-reinforcement, structure control, new chemical compounds are typical means of achieving new limits. Rarely are the new materials cheaper than those they replace, although they can occasionally become so with volume production.

In the Government arena, the Federal Department of Industry Technology and Commerce has nominated New Materials Technology as a priority area and research grants are awarded annually on a competitive basis through the IR & D Board's Generic Technology Grants Scheme. In addition, at least three states (New South Wales, Victoria, and Western Australia) have promoted new materials as a target for local industrial development. Not surprisingly, these Government priorities reflect similar activities on the international scene.

Some Considerations for a "New Materials Business"

- New materials tend to displace traditional materials at the margin and hence work their way into the market in niche applications where existing materials are performing at their limit, and probably not very well.

- New structural materials are likely to displace traditional materials in an evolutionary rather than revolutionary manner.

- Sometimes revolutions occur, usually in the things the community wants to do. The space program is an example. Conventional materials simply could not do many of the jobs and new ones had to be developed.

- A successful new materials business should be driven by market forces, not by new technology. However, if the investment is made with hopes of long-term returns, a business based on new applications and new functions might eventually be successful.

- There is a lot of added-value in a processed new material. There is also a lot of added cost.

New Materials and the Minerals Sector

Ultimately, of course, the starting material for any inorganic product comes out of the ground. It has therefore been natural for the minerals sector to take an interest in developments in the new materials field, especially when new technology suggests major and high volume new applications.

The best example of a sudden technological stimulus is probably the discovery in 1986 of the new range of "warm" super-conducting ceramics containing rare-earth elements, coming as it did only three years after the announcement of a new generation of high energy-density magnets containing the rare-earth element neodymium. These developments created a buzz of interest amongst the minerals community, especially as Australia is a major supplier of the unprocessed minerals which lead to the rare-earth chemicals.

The prospects for further processing of rare earth minerals and of vertical integration from mining to final processing of such minerals in Australia have been widely canvassed (see, for example, ref. 2). So far, the major development has been the decision of an existing producer, Rhone-Poulenc Chimie Australia Pty Ltd, to set up processing facilities in WA although progress has been affected by the conclusion (3) of the WA Environmental Protection Authority that the second of the two proposed stages is not environmentally acceptable. The Australian minerals sector is being cautious about getting into this business, presumably in recognition of the barriers to entry into a complex market and technology, and the difficulties associated with fitting such an operation into their existing businesses.

An earlier example of mineral industry interest in new materials was stimulated by bullish projections in the early 1980's for markets of up to 40,000 tonnes per year of new engineering ceramics for diesel engine components. Markets of this magnitude for mineral-based products would clearly be attractive to the minerals sector and account for the extensive consideration of vertical integration in the industries producing the mineral raw materials.

In 1987, the Basic Metals Industry Council reported (4) on the scope for the further processing of Australian minerals. The study was carried out in line with Government policy to encourage further downstream processing of Australian minerals. While the BMIC's conclusions are not explicitly directed at processing by the minerals sector, one can easily read into them that there are some opportunities for existing mineral businesses to carry out further processing of raw materials. The prospects that could be considered as relating to new materials include gallium, which is a constituent of the important semi-conductor gallium arsenide, lithium (for lithium-aluminium alloys, lithium carbide), monazite (the source of rare earth elements) and zirconia. In three of these cases (gallium, monazite, zirconia), commercial developments are already underway and these are all being undertaken by chemical companies.

Who Gets Into New Materials Businesses?

New materials (and one must remember that these are as diverse as old materials) generally fall into the category of elaborately transformed manufactured products. For a number of reasons they seem more likely to fit comfortably within the chemicals or manufacturing business rather than the minerals industry. Even at the raw material or feedstock front end of the new materials business, the producer needs to deal with a large number of small volume customers each with individual specifications. The demands on technical services are high. As well, there is a major requirement for strong marketing skills and a broadly based marketing network for customers widely dispersed internationally. A commodities business may well have difficulty in adapting to this mode of operation.

Another factor determining the appropriate type of business is the volume of material being processed. Statistics for the advanced ceramics business provide a useful context for this discussion. The total advanced ceramics business is estimated currently to be around $5 billion per annum, split roughly 4:1 between electronics and structural applications. The electronics applications include substrates, sensors, and capacitors. The raw materials used to formulate these products represent a value of about $250 million and the total quantity of materials involved is in the order of 100,000 tonnes. A big slice of this quantity is ceramic-grade alumina, and many other mineral-based products go to make up this highly segmented market. The projected growth rates for various segments of the advanced ceramics business are mostly in the 10-20% per annum range, which of course is part of the attraction as a growing new business.

While the concept of vertical integration in the minerals industry has an attractive ring to it, the hard truth seems to be that there is minimal competitive advantage in the ownership of a convenient mineral resource. The quantities of individual raw materials needed for the business are too small to have a major influence on the location of the downstream processing activity. There will, of course, be exceptions to this generalisation. One might arise where the minerals company can see the possibility of holding a monopoly or similar dominant position by exploiting a unique mineral resource, but this will be a rare occurrence.

Companies already in the ceramics and chemical companies entering advanced ceramics dominate this business, and set it firmly in the chemicals area. A recent article on emerging technologies in the 1990's (5) describes how the Japanese chemical and allied industries are carrying out research and development in electronics and new materials in order to compensate for the decline in growth rates of their traditional businesses and in an effort to capitalise on new scientific ideas in new business areas. The Ministry of International Trade and Industry of Japan, MITI, has selected fine structural ceramics, functional polymers, composite materials and amorphous alloys for national development as basic technologies. R & D in these areas has been an important activity in recent years for virtually all of the major Japanese chemical firms. A 1986 list (6) of US companies actively participating in advanced ceramic R & D activities includes W.R. Grace, Allied Chemical, Dow Chemical, Union Carbide, American Cyanamid, and other traditional chemical corporations. While there are a few resource companies active in this area, it seems reasonable to conclude that the advanced ceramics business is mainly being taken up by the chemicals industry.

One could cite two examples supporting the view that, for Australian mineral resource-based companies, advanced material products based on minerals are not a good fit to their existing businesses. Some years ago, Australian Minerals Consolidated Ltd, a mineral sand miner, operated a zirconia production facility at Bow, New Hampshire, but they sold this business in 1983. Nilcra Ceramics Pty Ltd, a joint venture between Nilsen Sintered Products Pty Ltd (a ceramics firm) and CRA, was sold in 1988. It is no coincidence that both of these operations now belong to the ICI Australia Advanced Ceramics business unit.

Turning to current Australian research, a glance at the three rounds to date of the IR & D grants given in 1987 and 1988 under the New Materials Technology banner shows how diverse the field really is, with topics such as optical fibres, ductile ceramics, superconducting ceramics, metal coatings, new welding technology and bio-implantable plastics. While many of these are indeed exciting topics, it seems fair to say that resource businesses would have difficulties in seeing either opportunities or threats arising from the research being supported under this scheme.

CSIRO and New Materials Research

A wide range of new materials research is being carried out in CSIRO, including advanced ceramics, new refractories, new magnets, "warm" superconductors, new electronic materials, processing of rare earth ores, and production of titanium diboride for metallurgical applications. The CSIRO Division of Materials Science and Technology has an extensive program devoted to advanced ceramic materials, including structural ceramics, sensors, and refractories. Perhaps the best known CSIRO work relates to the discovery of structural ceramics based on partially stabilised zirconia. Commercial developments of this discovery have related to production of the ceramic itself and of the ceramic powder precursor materials. These commercial developments have occurred over recent years, with both powder production and ceramic parts manufacture now being carried out by the ICI Advanced Ceramics business unit. The processes utilise the technology developed in collaboration with CSIRO.

Threats to Traditional Materials

From the above, it is hard to conclude that new materials provide a significant threat to traditional materials, particularly those that are the products of the minerals industry. There will be some nibbling away at the edges of the market and some effect on growth rates, but wholesale displacement by entirely new materials is a somewhat remote possibility. Of course, the continuing process of replacement of one metal by another, one alloy by another, or of metals by plastics and vice versa will continue, but these examples do not fall into the category of the new materials considered in this paper.

Conclusions

New materials have created and are creating new Australian industries. While these industries use raw materials emanating from the minerals sector, they utilise only small fractions of the total mineral production or, sometimes, raw materials whose total absolute production is rather small, for example gallium. The new businesses created so far have all been within the chemical industry. The new business opportunities for the mineral industry itself seem to be rather slim, but on a happier note, the threats to traditional materials, that is the output of the traditional minerals businesses, also seem small.

Acknowledgement

In preparing this paper, I was greatly helped by discussions with Dr. G. Barnett of ICI Advanced Ceramics and Dr. H.N. Sinha of the CSIRO Division of Mineral Products.

References

(1) The Australian Financial Review. February 8, 1989, p.39.

(2) Materials Australasia Vol. 19, No. 4, May 1987 (special issue devoted to Prospects for Rare Earths).

(3) Proposed Rare Earth Treatment Plant, Pinjara, Western Australia, Report and Recommendations. Environmental Protection Authority, Perth WA, Bulletin 352, September 1988.

(4) Scope for further processing of Australia's minerals: a tripartite view. Basic Metals Industry Council, October 1987.

(5) Emerging Technologies in the 1990's. S. Takaoka, Chemistry International, Vol. 8, No. 5, 1986 p.5.

(6) Advanced Ceramics. Report No. 3/86, Office of Industrial Innovation, Department of Regional Industrial Expansion, Canada.

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Traditional materials: the challenge for base metals

Stephen Mallyon

M.I.M. Holdings Limited

Traditional materials. This is certainly an appropriate description for the major base metals. The description "traditional materials" is a complement to the longevity and usefulness of the properties that have made base metals an important component of man's technological development and advancement. The challenge for base metals in a world of competing materials is not a circumstance which has emerged only recently. Changing markets and demand patterns are two aspects of the basic challenge that has continually confronted and been overcome by these traditional materials, the base metals. In order to gain an appreciation for the current market position of base metals, it is most instructive to consider the development of these markets throughout time.

History of Development of Base Metals

Base metals have been familiar to and worked by man since he first sacrificed his cave-dwelling, nomadic existence for a more-settled life that evolved from the advancement of early agricultural methods. Ever since these early times the development of efficient and effective base metal and agricultural industries has been a central theme in the story of man. The interdependence of these two basic industries has long been recognised as the following biblical quote from Deuteronomy 8:9 testifies.

"A prosperous land, a land where you will eat bread without stint, a land whose stones are iron and from whose hills you will dig copper"

That copper was one of the first metals to be employed by man cannot be challenged. The discovery of complete copper smelting installations of several periods from the fourth millenium B.C. to Roman times demonstrates that the knowledge of extracting metal from its ores was known from very early times. However, even before smelting techniques were developed, early man probably looked upon native copper as a sort of malleable stone that could be easily hammered into shape. In whatever manner it was first discovered, copper's bright and pleasing appearance was a great attraction to primitive man; he found that it was ductile enough to beat into almost any shape that he required and that in the process it became hard enough to be sharpened into weapons or to be fashioned into other implements of lasting quality. It is not clear at what stage man realised that copper is virtually indestructible, but he knew that whatever he made was made to last.

With copper and tin being found near to each other in many parts of the world, bronze, an alloy of these two metals, began to be produced; at first accidentally, but later under some sort of scientific control which varied the constituents of the alloy to suit the purpose for which they were required. Bronze could be sharpened and was hard enough to retain a cutting edge so that it could be used for hunting and war weapons and the manufacture of construction tools. This long-lasting material brought the dawning of the Bronze Age which is generally regarded as phase two of the Metal Age, after copper.

While copper and bronze were at the forefront of the Metal Age, lead, one of the oldest metals used by man, was proceeding to develop its own applications. The earliest known specimen of lead, dating from 5000 B.C., is a spinning bobbin found in the USSR. In 400 B.C., Egyptians and Sumerians used lead sulphate for make-up, and the Pharaohs' artisans used lead in glazing pottery. Lead writing tablets have been dated to this era as well as sling projectiles, charms and other decorative items. The Chinese minted lead coins in 300 B.C. Lead was used in bridge construction throughout Asia Minor to protect and anchor iron and bronze fasteners.

Scanning this list of uses for lead from several thousand years ago reveals just how many applications have reduced or eliminated their usage of lead. Nonetheless, there is still a healthy demand for lead in the modern world where consumption rates now total over five million tonnes annually. This total consumption level equates to a rate of around one kilogram per person per year for every person in the world, and this rate is probably little different to the rate prevailing three thousand years ago.

After lead, copper and tin, zinc is the next major base metal with a long history. A few zinc artifacts dating back to 500 B.C. have been found in Europe. Nonetheless, zinc was not widely used during these early times, and it was not until one of the earliest examples of metal substitution occurred that zinc usage became widespread. The importance of bronze has already been mentioned, but as long as two thousand years ago, brass, an alloy of copper and zinc, was beginning to contest markets with its harder cousin, bronze. This contest has endured for two thousand years until today the relative roles of bronze and brass have reversed to such an extent that little bronze in used in comparison to the abundant usage of brass.

These four traditional metals have not only been witnesses to man's development through the ages, but have played an important role in promoting that development from a rudimentary agriculturally-based society into the modern society that we know today. Although base metals have been important to man throughout this period, it has really only been since the Industrial Revolution that demand for base metals has soared. This explosion in demand has been a result of the important role played by base metals in an industrially-based society as well as the rapid growth in population over the last 150 years.

A Century of Base Metals

From 1850 through to 1950 there was a rapid advancement in man's scientific knowledge that revolved around utilising the natural environment to improve living conditions. Machinery was developed to carry out the tasks of many workers. Electricity was discovered. The multitude of electrical-based inventions that followed was the beginning of the modern history of the base metals. The rapid development of machinery and technology during this period brought with it a requirement for materials able to withstand greater tolerances of stress, malleability and workability.

The early Industrial Age not only boosted demand for the traditional materials of the time, but led to the development of materials which would eventually compete these traditional materials in many end-use markets. Two of these new materials were the metals aluminium and nickel.

Aluminium is the second most abundant element in the Earth's crust after silicon, yet it is a comparatively new metal that has been produced in commercial quantities for less than 100 years. Alumina, the oxide of aluminium was recognised in the latter part of the eighteenth century, but a commercially sound method of reducing the oxide to the metal was not developed until 75 years later. This development was an electrolytic process which was only possible following the successful harnessing of electrical power. The irony in this development is that aluminium has now effectively replaced copper in the high-voltage transmission of electrical power.

Indeed, the strong growth of aluminium markets over the past 30 years has been largely at the expense of other base metals and traditional materials. For example, aluminium has replaced a significant part of the steel, tin and glass beverage container market, has penetrated the wood and steel markets in residential, industrial and commercial construction, and is increasing its share in the castings market in competition with zinc and iron.

Nickel is another metal that has assumed much greater importance since the Industrial Revolution. Nickel's greatest value is in alloys with other elements, where it adds strength and corrosion resistance over a wide range of temperature. This has made nickel vital to the iron and steel industries and the subsequent development of the chemical and aerospace industries.

Current Uses for Base Metals

Where standards of living are high today, so is the consumption rate of base metals. Consumption of refined copper in the Western World has grown from less than half a million tonnes at the beginning of the twentieth century to over eight million tonnes today. Zinc consumption for the world has grown from around one million tonnes in 1920 to more than six million tonnes today. The total consumption of the major base metals is greater than at any previous time in history. In 1987, the total consumption and production of the major base metals each exceeded 40 million tonnes for the first time ever.

Table 1: World Production and Consumption of the Principal Non-Ferrous Metals in 1987

	Production		Consumption	
	(Mill.t)	% Growth 1987	(Mill.t)	% Growth 1987
Aluminium	16.33	+ 4.7	17.20	+ 4.9
Copper	10.18	+ 3.0	10.43	+ 3.6
Zinc	7.02	+ 3.1	6.86	+ 1.8
Lead	5.63	+ 3.1	5.62	+ 1.3
Nickel	0.78	+ 4.0	0.85	+ 10.4
Tin	0.20	-	0.23	-
TOTAL	40.14	+ 3.7	41.19	+ 3.6

Growth in demand for metals has by no means been uniform. Over the post-war period the growth in copper consumption from one year to the next has ranged from a high of 22% down to a low of -18%. This variability in consumption rates can lead to misleading conclusions if too much emphasis is placed on the short-term trends. Indeed, over the last few years most forecasts for growth in demand for base metals have been extremely conservative, and recent record consumption rates have exceeded most expectations. This situation has created the tight market balance that we see in most base metals today with the subsequent result that metal prices have been bid up to levels higher than most people would have anticipated. The magnitude of the growth rate for base metals since the recession in the early years of this decade is shown in Table 2.

Table 2: Growth Rates in Base Metal Consumption 1982-87

	Growth Rate (%p.a.)
Aluminium	4.6
Copper	3.3
Zinc	3.8
Lead	2.3
Nickel	6.8
Tin	3.1

Although base metals enjoy a wide variety of applications, it is generally in one or two areas where the dominant properties of the metal can best be utilized. The largest use of copper is in electrical equipment and supplies, lead is mostly used in battery applications, the largest use of zinc and nickel is in corrosion protection, aluminium is used in applications such as the transport and packing industries where light weight is desirable, while tin is mostly used in solder and tinplate.

In the debate on substitute materials, copper is often presented as the candidate with the most to lose in any development of new materials. The claim that potential demand for copper will decline in certain applications is undoubtedly true: but this is not a new or unusual phenomenum for copper. Ever since copper helped produce the first tonne of aluminium these two metals have competed for marketshare. The use of aluminium in high voltage overhead power transmission lines has already been mentioned, but copper is still preferred for underground lines and dominates the smaller gauge wire market. Radiators for cars is another area where copper and aluminium compete vigorously. This market competition between copper and aluminium is not the only challenge that has confronted copper. In telecommunications (and this area is particularly relevant in view of the current discussions concerning fibre optics) copper has already conceded considerable tonnages because of technological advances. These advances have encompassed substitution such as microwave communications and fibre optics as well as improvements in the use of copper through such techniques as multiplexing. Yet, despite all this competition, copper has still managed to maintain positive rates of growth.

This positive growth rate for copper demand is the result of its multitude of uses. Although the largest use of copper is in electrical equipment and supplies, other desirable properties in copper ensure its usefulness in other applications. Copper is widely used in the production of non-electrical industrial machinery and parts, household and commercial air conditioning equipment and farm machinery. Construction uses include roofing, down spouts, gutters, nails, rivets, soldering coppers, welding torch tips, screws, glass and metal seals, and heating and cooling tubing. Copper is an exceptionally good material for building because of its durability and resistance to corrosion and all weather conditions to which it is exposed in a normal environment.

In the automobile industry, copper is used in many ways in addition to a myriad of electrical and electronic applications. these uses include copper alloys in radiators, brake linings and tubes, air-conditioning gaskets, bearings, bushings, carburettors and oil lines.

Copper alloys are used in the manufacture of corrosion-resistant vessels and tanks, saltwater piping, shipboard condenser intake systems, propeller shafts, aircraft parts, steam and water lines. Copper-nickel alloys are particularly well-suited to marine environments because of copper's resistance to biofouling. Miscellaneous uses of copper include chemicals and inorganic pigments. Copper chemicals are used extensively in agriculture, medicine, and as wood preservatives. Copper is also used extensively in watches, clocks, microscopes, projectors and many types of gauges. Copper, brass and bronze are popular materials in kitchen utensils, bathroom fittings, jewellery, furnishings and decorative items. In addition to being easy to maintain, the attraction of copper is that it can be extruded, drawn, stretched, spun, bent, rolled or worked in many other ways.

Lead is another of the traditional metals that is supposedly moving out of fashion. Environmental and health concerns have pushed lead out of a number of applications such as petrol additives, water piping, paints and some solders. On the positive side, however, growing power requirements have seen strong demand for lead-acid batteries to store electric energy. Although there are many technologies being studied as alternatives to the lead acid system, these technologies are presently uneconomic for any large-scale application.

Apart from the traditional use of lead-acid batteries in motor vehicles, these batteries are developing applications in markets which require a source of standby electrical energy for emergency lighting, telephone or other communication systems, or where voltage control is extremely critical. Large lead-acid batteries are being developed and scaled-up to cater for peak power loads in commercial and industrial applications. Traction batteries are being increasingly used in electric vehicles such forklifts and airport vehicles. In underground coal mines in the US, battery-driven equipment is competing with diesel-powered equipment as average seams that are mined become thinner, restricting operational head-room and air circulation.

Modern technologies also bring some benefits for the traditional materials. Lead is the most impervious of all common metals to x-rays and gamma radiation as it provides the most compact, highest density protection. For this reason lead is widely used in leaded glass windows and as sheet in walls of hospital x-ray rooms as well as in both portable and permanent structures containing nuclear material.

In contrast to such metals as iron, aluminium, copper and lead, the importance of zinc can be easily under-estimated because zinc tends to lose its identity in end products. Uses for zinc are based on a number of properties, mainly its low melting point which facilitates shaping by casting, its high electro-chemical activity whereby zinc provides cathodic protection for iron and steel products, and its ability to alloy readily with copper to make brass, imparting characteristics of workability at low temperatures, corrosion protection, and attractive finishes. In other uses for zinc, zinc oxide is a widely used compound mainly because of its opacity to ultraviolet light and high refractive index.

Outlook for Base Metals

There are several reasons why producers of base metals need not despair the future. Both the short and long history of base metals amply demonstrates the ability of these metals to compete in a world of advancing technology. This competitiveness is derived from the desirable properties of base metals in meeting the specifications necessary in modern materials. The diversity of end-use applications developed for the base metals ensures continuing markets in the future. Although alternate materials and technologies have been eroding some of the traditional applications for base metals, this erosion has taken many place over many decades.

One measure of the extent of this erosion is derived by calculating the intensity of use for the metals. The intensity of use for a metal is normally calculated as metal demand per unit of gross national product or some other macroeconomic variable such as industrial production. The intensity of use for each of the older base metals, copper, lead, zinc and tin, has been declining throughout the post-war period while the intensity of use for the newer base metals, aluminium and nickel, has stabilized after rapid growth in the years up to 1970. The intensity of use for copper based on this measure is shown in Figure 1. It is this declining trend which has generated much discussion regarding the outlook for base metals. The decline in intensity of use has largely been attributed to the impact of substitute materials as well as other factors such as miniaturization of metal components.

The decline in metal consumption per unit of economic output, however, masks another trend which is relevant to the metal industries. This trend measures the metal consumption per person. Copper has again been chosen to display this trend in Figure 2. The chart reveals that copper consumption per person has not varied much outside a range of 2.5-2.7 kilograms. The figures for copper consumption per person still show a strong correlation with general economic conditions with the exceptionally high figures in 1973 and 1979 related to booming economic conditions and the low readings in 1975 and 1982-83 related to recessions.

Another interesting aspect of these per capita consumption figures is that they include consumption levels for nations at widely different stages of economic development. Figure 3 shows the copper consumption per person for a number of selected countries. Despite a consumption rate of around 2.6 kg per person for the world as a whole, the developed countries of the EEC, Japan, North America and Australia have consumption rates far in excess of this average. Developing countries such as China and India have the potential to boost copper consumption significantly as the development of infrastructure and industrialization proceeds.

INTENSITY OF USE - COPPER

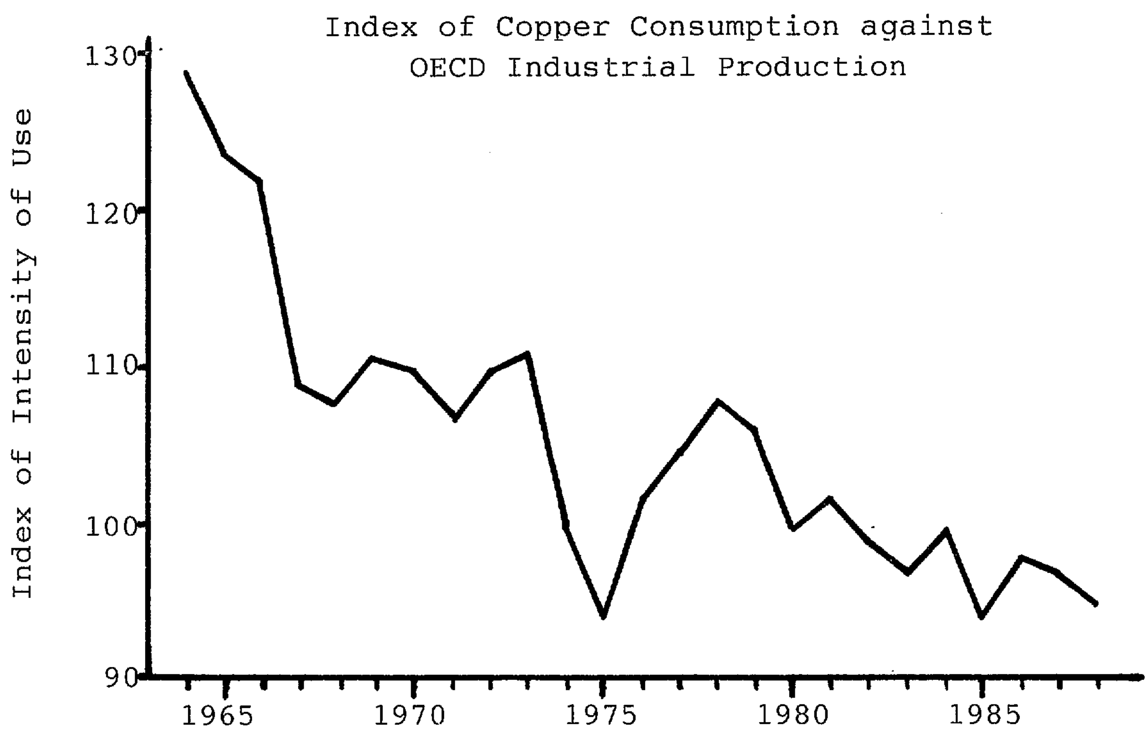

Figure 1

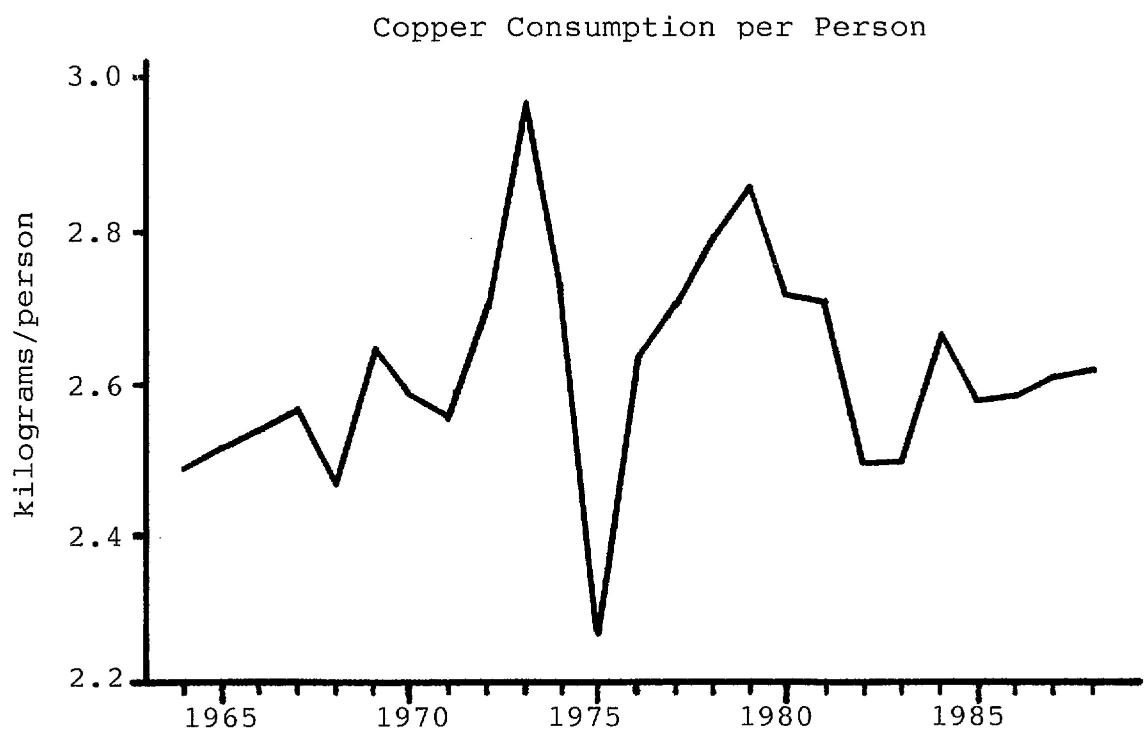

Figure 2

INTENSITY OF USE - COPPER

1987 Consumption per person

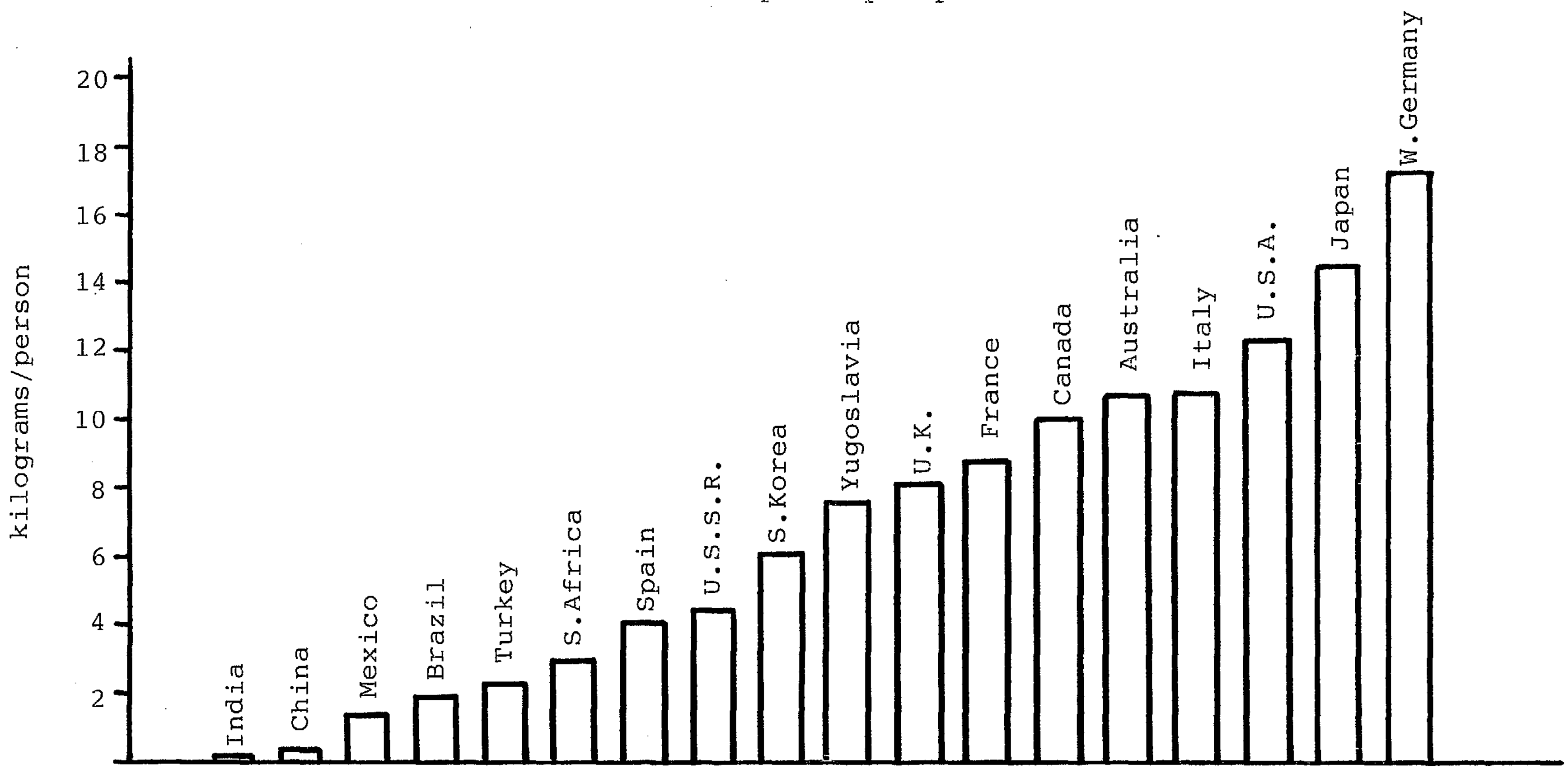

Figure 3

However, before this latent potential can be realized there countries will have to lift their general economic output so that these development projects associated with the early stages of industrialisation can be financed and maintained. An example where this economic growth has occured is South Korea where copper consumption per person has grown some 60% over four years to 6.1 kg per person.

Adequacy of Supply

Most base metals have an economic reserve base that would satisfy anticipated demand for around 50 years. The prospect of the world running out of mineral resources was the subject of a report by the Club of Rome where it was concluded that the world may not be able to continue its present rate of growth because of the exhaustibility of resources. However, this conclusion overlooks the geological nature of mineral reserves and the ingenuity of man.

First, the reserve base is generally defined as the resource that is mineable under present conditions of technology and reasonable economic returns. The reserve base has long been maintained around current levels through a programme of exploration that seeks to ensure a replemishment of reserves. Further, if a critical or useful mineral was viewed as being scarce, the price for that mineral would be bid to such a level where sub-economic deposits would enter the reserve base.

Even with a high price on the mineral, the reserve base may still be considered inadequate. This is the point where man's ingenuity comes to the fore. There are several ways in which an inadequate reserve base may be overcome.

1. Enhanced technology to improve the economic recovery of the reserve.
2. More recycling of the mineral to take advantage of the existing resource.
3. Development of substitute materials.

For the base metals, the impact from this last point will largely depend on the relative economics of the substitute material and the metal which it seeks to displace.

Conclusion

Base metals have played an important role in man's development over many centuries. While the actual application for the metal has changed over time, consumption rates have continued to grow as a result of an improvement in general economic well-being for an expanding population.

The challenge for base metals is to continue developing new uses which utilize the unique properties of these traditional materials. Aggressive research and development is a prime requisite for continued growth and there must be a strong commitment to ensure that materials and process technology do not remain static. Provided the base metal producers remain inovative, markets will be created which allow for the continual evolution of base metal applications alongside other technological advances.

Although we may be near the end of the golden age of growth in base metal markets, these metals will still have an important and complementary role in the development of applications for new and existing materials. The outlook for growth in base metal consumption remains good.

Black coal resources: the foundation for the industry

M B Huleatt

Bureau of Mineral Resources, Geology & Geophysics

Introduction

The Australian black coal industry is only able to exist because it has a firm foundation of high quality resources. These resources, however, present the industry and governments with two distinct challenges. The first is to improve overall resource recovery and the second is to ensure that exploration and development is sufficiently well advanced to support the projected growth in domestic consumption and exports.

A brief resume of Australia's resources is given and is followed by a discussion of each of the challenges. Discussion of the first challenge will concentrate on the need to increase coal recovery rates, particularly in underground mines, and how this might be achieved. This will be examined from the resource scientist's point of view and will be based on the need to responsibly manage future production of a finite, non-renewable energy resource.

The second challenge will examine a selection of potential mines, from both New South Wales and Queensland, that are available to meet future demand. It will show that, from the selected projects alone, Australia will be well able to meet future increases in demand.

Resources

Australian black coal resources are located primarily in New South Wales and Queensland. The principal deposits in those states occur in the Sydney and Bowen Basins. Smaller, but important resources, occur in Tasmania, South Australia and Western Australia. A summary of current BMR resource estimates is given in Table 1.

BMR estimates that economic demonstrated resources total just over 70 billion tonnes in situ, of which almost 50 billion tonnes are considered to be economically recoverable. Although most resources are bituminous in rank there are semi-anthracites and sub-bituminous coal. In addition some very low volatile bituminous coal is produced. The only coal that is not well represented among Australia's resources is anthracite. An important feature of the resources is that bituminous coal is predominant and the international coal trade is very largely composed of coal of this rank.

Australia's resources are of moderate size on a world wide basis. Leading resource nations, USA, China and USSR, have resources between two and five times greater than Australia's. These countries are also leading coal producers but almost all their output is for domestic consumption, leaving only a small proportion available for export. Australia, in contrast, is a relatively small consumer and has a substantially greater production capability than required to meet domestic demand. That extra capability is the basis for Australia's position as a premier coal exporter. There is no evidence to suggest that there will be a major reversal of this position. A large proportion of Australia's resources will, therefore, be available for export. While Australia's identified resource levels are more or less in line with those of South Africa they are considerably greater than those of Canada and Colombia, two major competitors.

Table 1: Australian Economic Demonstrated Black Coal Resources

(million tonnes)

	In Situ	Recoverable
A Total Resource		
Queensland	35 410	25 080
New South Wales	33 500	23 700
Tasmania	530	250
South Australia	150	150
Western Australia	740	480
	70 330	49 660
B Open Cut Resources		
Queensland	12 762	11 486
New South Wales	13 900	12 600
Tasmania	25	22
South Australia	150	150
Western Australia	25	390
	27 270	24 648
C Underground Resources		
Queensland	22 648	13 596
New South Wales	19 600	11 100
Tasmania	505	224
South Australia	-	-
Western Australia	307	92
	43 060	25 012

The First Challenge

Most will be aware of, and other papers in this volume will undoubtedly highlight, the importance of coal to the national economy. What is too often forgotten is that the coal industry is based on coal resources. NO RESOURCES NO INDUSTRY! Coal is a non-renewable resource and this fact confers a responsibility on governments and industry to ensure that resources are developed and worked in a manner that maximises the life of the resource. Current production rates suggest a resource life of

200–300 years for existing economic resources. If it could be demonstrated beyond doubt that after that time an acceptable alternative form of energy or the current inferred and/or subeconomic coal resources will be available in required quantities there would be no need to be concerned about increasing resource recovery rates. The availability of acceptable alternatives is yet to be demonstrated and proving of other coal resources cannot be taken for granted. Therefore, it is in the nation's long term interest that recovery rates be maximised.

The in situ resource estimates in Table 1 are for coal at or above 600 metres depth. There is coal below 600 metres but it is currently considered to be uneconomic. Of the coal above 600 metres some 27 billion tonnes are mineable by open-cut methods. The remaining 43 billion are amenable to underground mining only. It is, therefore, essential to the future of the industry to maintain efficient open-cut and underground mining sectors.

Of the in situ resource, BMR estimates that about 50 billion tonnes are economically recoverable. Some 20 billion tonnes are expected to be left in the ground given current technology and commercial conditions. What benefits might flow from being able to recover all or at least part of that 20 billion tonnes? If all of it could be mined, prepared and sold on the international market it would raise export revenue in excess of $650 billion at current prices. This should immediately raise three questions: 'Why will it be left in the ground?', 'Can Australia afford to leave it in the ground?' and 'How can more of it be recovered?'.

The first question is relatively simple to answer. Given existing mining technology and coal prices the coal cannot be won economically while maintaining a safe, efficient operation and adhering to statutory requirements.

The second is answered with a further question. Can Australia afford to ignore coal with the potential to earn $650 billion?

The third question is not as easily resolved because it involves a renewed commitment to research and development programs relating to mining technology and methodology aimed specifically at increasing resource recovery, while continuing research into other aspects of the industry such as improving productivity, preparation and safety. In all cases continuity of programs up to and including the in-pit demonstration phase is essential if full benefits are to be derived from such programs.

Funding of projects likely to give a quick return on investment may be attractive economically but in terms of responsible resource use projects likely to give longer term results are also needed. There needs to be a balance between long term and short term payoff projects. Projects aimed at increasing recovery rates will provide both long and short term pay-offs. Short term pay-offs will accrue to coal producers by factors such as increased revenue from a given block of coal, deferment of investment needed to develop new mines to replace those whose resources are worked out and the retention of experienced workers especially if the replacement mine is in a different coalfield. The major long term payoff will come in the form of a substantial increase in resource life.

Open-cut mines achieve high resource recovery rates, often in excess of 90% of the in situ resource; however, the depths to which open cuts can operate are limited. Most underground mines achieve recovery rates of between 50 and 60%. With over 60% of the total in situ resource amenable only to underground mining it is important that recovery rates from underground operations be increased and that appropriate research and development be carried out to enable this to be done.

In most underground operations any coal left in an area after mining ceases will be sterilised and therefore permanently lost. Most coal not mined is left for one or more of the following reasons. It may be left to support mine openings to allow safe and orderly withdrawal of men and equipment to new areas. It may be left to fulfill statutory requirements such as the protection of surface structures. It may be left because the seam is simply too thick for existing technology to mine the whole seam. The successful re-introduction of longwall mining has helped improve recovery rates but the problem of satisfactory recovery of resources from thick seams remains.

Figures (Table 2) from the Joint Coal Board (JCB) (1988) help bring this latter problem into focus. For example, in the Southern District over 18% of production came from seams over 5 m thick. The seams worked in the District were up to 12.0 m thick but the maximum thickness worked was only 3.4 m. So in that district some operations left at least 8.6 m of coal in the ground. There may be good reasons for not taking the whole seam, e.g. parts of the seam may be of a quality too poor to produce a saleable product or the coal left may be needed to improve roof conditions in the mine. However, that coal may also be of acceptable quality but available technology does not permit its recovery and it will most likely be sterilised.

Table 2: Percentage Production from different Seam Thicknesses in Underground Coal Mines

New South Wales, May 1987

Seam thickness	Singleton-North West	Newcastle	West	South
<1.0 - 3.99 m	65.4	81.4	80.6	78.4
4.0 - 4.99 m	7.0	5.4	-	3.2
>5.00 m	27.6	13.2	19.4	18.4
Thickness range worked (m)	2.4 - 8.8	1.4 - 7.1	1.8 - 11.0	1.8 - 12.0
Maximum thickness worked (m)	4.2	3.8	3.5	3.4

Source: Joint Coal Board

Implementation of increased R&D programs aimed at increasing resource recovery should ideally start immediately because the longer the delay the smaller the future benefits. It is impossible to accurately estimate the value (in terms of potential export revenue) of coal affected in this way each year. However, if the 1987 underground raw coal production of about 56 Mt is taken and using an underground recovery rate similar to BMR's estimate for all in situ underground resources it is possible to get some indication of the value of that coal. Based on these assumptions it is estimated that, on average, mining 56 Mt from the in situ underground resource would entail leaving some 40 Mt of coal in the ground. Based on export steaming coal prices that coal would be valued at at least $1.3 billion. While this is not a definitive figure it does serve to highlight the potential value of coal not currently being recovered and the importance of concentrating some effort into improving recovery rates. This is, of course, a long term benefit but as already discussed improved recovery rates also have short term benefits such as allowing the deferment of investment in replacement mine capacity.

At current production rates Australia's demonstrated resources will last for between 200 and 300 years, but it is unrealistic to expect that output will remain at current levels for the next three centuries. Energy requirements will continue to grow and a reduction in the present resource life of coal will occur unless an alternative fuel(s) is utilised. It remains to be seen, however, whether ultimately there will be any restriction on growth in coal demand.

Despite possible substitution of coal by other energy forms it is prudent, in the interests of responsible resource management, to improve coal recovery levels. Not only will it increase the overall use of a non-renewable resource but it has potential financial rewards. R&D will not bear fruits overnight so the longer the delay in increasing commitment to it the greater the reduction in eventual returns.

It is pertinent to ask what the chances of success would be if there was an increased research program into resource recovery. Basically the chances appear to be very good. Although the initial introduction of longwall mining in Australia was disastrous its successful re-introduction is increasing coal recovery in the working sections of the seams in which it is used. The original equipment was not suitable for Australian conditions but further research and development resulted in the successful re-introduction of the method. Continuing research into this technology is likely to further improve its operation.

However longwall mining has not improved vertical resource recovery to any great extent despite allowing greater lateral recovery. Thick seams are successfully mined overseas and it may be possible to adapt those technologies to Australian conditions. To avoid a repeat of the longwall saga the techniques must be thoroughly investigated, tested and modified as required. Hence the need to direct research and development to this area. The fact that thick seams are mined overseas suggests that with appropriate research and development the thickness of coal mined in Australia could be increased and it is likely that, given the appropriate encouragement, substantial improvements can be made to Australia's rate of resource recovery.

Improving recovery rates, particularly in underground mines is part of the challenge faced by the coal industry and governments in Australia. There is no doubt that Australia has the expertise, industry and research organisations to meet the challenge.

If Australian coal is going to meet the challenge ahead it is also important that investigations of the chemical and physical properties of coals continue. Advances in coal utilisation technology continue to increase the breadth of application for individual coals. A prime example of this is the increasing use of lower rank coals by the steel industry.

It is reasonable to assume that technological advances will continue and the specifications for required coals will change. To take full advantage of these advances a detailed knowledge of Australian coal properties will be necessary. Just how important such knowledge is is illustrated by the example of attempts, some years ago, to establish Australian coking coal in the European market.

Buyers were sceptical that Australian coals could make coke comparable to that made from European coals. The basis for their scepticism was the high inertinite content of Australian coals. Inertinite is a microscopic organic component of coal which, in European coals, shows little plasticity or agglomerating tendency (both desirable properties) during coking. Consequently too high an inertinite content would render the coal unsuitable for coke making.

Many Australian coking coals have inertinite contents ranging from 30% to over 50%. Some have less than 30% but all make good coke. Inertinites in Australian coals do not hinder the manufacture of good coke and a detailed knowledge of their resource enabled suppliers to counter the European scepticism. Fortunately the Australian suppliers were able to overcome the consumers prejudice and tap the European market. Persistent pressure from government and industry has resulted in the good coking properties of Australian high inertinite coals being specifically acknowledged in the Economic Commission for Europe's International Codification System for Medium and High Rank Coals which was published in 1988.

Responsibility for obtaining such detailed knowledge of coal in an existing lease area rests with the leaseholder. However, governments must continue to ensure the maximum availability of information on the properties of coals on crown land. This, in conjunction with a knowledge of technological advances in utilisation, will help achieve an efficient mine development program.

If the first challenge is to be met and the benefits flowing from Australia's resources maximised research programs should include a significant component aimed at improving resource recovery.

The Second Challenge

Successful research programs will benefit mines to be developed in the future as well as those currently in operation. It is the potential for future development that will be examined below.

Prior to the decision of the Coal Industry Tribunal in 1988 regarding operational and working conditions it was estimated that Australia's saleable coal production capacity was about 167 Mt/year (Huleatt, 1988). Full implementation of the Tribunal's decision would increase this by 10-15% to about 184-192 Mt/year.

If the established trend in domestic consumption continues by the year 2000 domestic demand should be about 60 Mt/year.

Various organisations have prepared forecasts of future Australian coal exports. Some of these are given in Table 3. These projections, together with that for domestic consumption, indicate that new production capacity will be required over the next decade. In addition new mines will be developed to replace capacity as old mines have to close.

Table 3: Some Projections of Australian Black Coal Exports in 2000 (million tonnes)

	Steaming	Coking	Total
World Coal Study (1980)	85.0	85.0	170.0
Dept Primary Industries & Energy (1987)	69.8	57.2	127.0
Australian Bureau of Agricultural & Resource Economics (1989) (Base Case)	85.0	72.0	157.0
Coal Resources Development Committee New South Wales (1988) (Base Case)	102.0	58.0	160.0

The following discussions examines possible future mines, and hence the availability of additional resources, that might be used to meet the demand for new production capacity. It should be stressed that in the projects referred to the degree of exploration of resources in each project area differs. In all cases more detailed testing will be required before production commences. It should also be stressed that those projects referred to are not the only ones available for future development and they have been chosen simply to illustrate the number and variety of projects that could be developed.

Examination of these projects is from a resource/technical aspect only. Commercial aspects are not considered.

Queensland

In terms of economic demonstrated resources Queensland could supply sufficient coal to meet all Australia's increased domestic and export demand well into the next century. The principal resource area is the Bowen Basin with smaller though still large resources in the Surat, Blair Athol and Wolfang Basins.

Bowen Basin. Large undeveloped resources of high quality coking and steaming coal are present and coals of both types are currently produced.

Of four proposed coking coal mines, Gordonstone, Poitrel, Daunia and Hail Creek all could also produce steaming coal. Although possible products from these mines would be similar to those now being produced from other mines in the Basin, only Gordonstone will work a seam now being mined elsewhere (German Creek seam). These projects could add 10 Mt/year of coking coal to the State's production.

Substantial undeveloped steaming coal resources, with chemical and physical properties similar to coals now mined, are present in the basin. Development of two of the more advanced deposits, Ensham and Baralaba would add some 3 Mt/year to the State's production. Other steaming coal projects, which if developed would add over 18 Mt/year to the State's capacity, are Winchester South, Theodore, Daunia, Poitrel and South Walker.

Wolfang Basin. To the east of Blair Athol a major steaming coal resource occurs in the Wolfang Basin in a geological sequence dominated by one major seam which is up to 30 m thick. Despite having an overburden which includes basalt and possible high water volumes, the resource could support an open cut mine with a capacity of about 10 Mt/year.

Surat-Moreton Basin. In the State's south, substantial resources of steaming coal are present in the Ipswich-Toowoomba-Miles region. There is currently only limited production, near Ipswich. Although regarded primarily as steaming coals many are suitable for conversion to liquid fuels. A characteristic of these coals is their very high volatile matter content.

Ten principal deposits, with resources exceeding 3300 Mt, could support mining operations. It is estimated that over 20 Mt/year of capacity could be brought on stream if needed. These coals may be somewhat disadvantaged by the fact that none are currently mined or used, and so are not known in the market place.

Queensland Potential. These reasonably well explored resources could add some 10 Mt/year of coking coal and over 50 Mt/year of steaming coal to the State's capacity if developed. Given the acceptability of Bowen Basin coals in the international market and the advantage of existing infrastructure, prospects for new developments are high. Surat coals may encounter some difficulties not because of their quality but because of the advantages held by other coals which have proven record in the market.

New South Wales

Economic demonstrated resources in New South Wales could also meet all Australia's new coal demand into the twenty-first century. Most potential lies in the Newcastle and Hunter coalfields of the Sydney Basin and in the Gunnedah Basin. The attractiveness of many of these resources is that either steaming or coking coal can be produced from the same raw coal. Also many potential mines would be based on seams already successfully marketed.

Sydney Basin - Newcastle Coalfield. Possible projects include Bellbird which would mine the Greta seam, and the Ironbark operation in the Tomago Coal Measures. Both Greta and Tomago coals have coking and steaming applications. Total capacity from these projects could be 4 Mt/year.

Sydney Basin - Hunter Coalfield. The Hunter Coalfield is the largest producing area in the State and along with the Newcastle field is Australia's principal source of soft coking coal. Numerous possible mines in the Hunter field aim to mine the Wittingham Coal Measures. Four of the main projects, Hunter Valley No. 2, Mount Arthur South, Mitchell's Flat and the United Collieries Joint Venture, will work coals in the Jerry's Plains Subgroup. Mines currently working that unit include Hunter Valley No. 1, Wambo, Warkworth, Mount Thorley and Saxonvale.

Four more possible mines, including two in the Glennies Creek area, Rix's Creek and Glendell will work the Vane Subgroup. Existing mines working this unit include Liddell State and Howick.

Development of these projects would add some 23 Mt/year to Australia's production capacity.

Gunnedah Basin. The Gunnedah Basin is a northerly extension of the Sydney Basin and currently supports two mining operations. Both high volatile coking and steaming coals are produced. Three projects have potential for development, Vickery, Boggabri and Maules Creek. From the technical aspect successful testing of coals from recent trial mining at Vickery is most important because all three projects would work seams not currently mined. Development of all three could add over 10 Mt/year to total production capacity.

New South Wales Potential. The projects discussed above could add over 37 Mt/year to Australia's production capacity. In addition there are other resources in the State that could support operations, e.g. the Oaklands Basin coal and the Southern and Western Coalfields. Those coals included in the 37 Mt estimate have some advantage in that either coking or steaming coal or both could be produced and they would in most cases come from seams that have been accepted by the international market.

Australian Potential

There is no question that Australia has the resources and potential mining operations to meet future demand although many deposits being investigated will require further exploration to provide sufficient detailed knowledge of the resource to support planning and development of mining operations. Those projects referred to could add almost 100 Mt/year to Australia's coal output if developed and in many cases they would mine seams already accepted in the market.

It can be concluded that exploration to date has established a satisfactory store of resources from which the industry can take up the challenge. Exploration, however, needs to continue in order to define more clearly those lesser known resources that occur throughout the country, particularly to ensure that competing land uses do not sterilise substantial resources.

Conclusion

There can be no doubt that Australia's coal resources and potential mining operations provide a substantial foundation to enable the industry to continue and to expand. However, although resources are adequate to meet possible demand for over 100 years, a substantial portion of the resource is not recoverable with existing technology. From the responsible resource management point of view it is desirable that the recovery rate be increased and this will necessitate implementation of specific research programs.

References

Australian Bureau of Agricultural and Resource Economics, 1989, 'Long Term Outlook for Resource Exports', National Minerals and Energy Outlook Conference, Canberra, 15-16 March 1989.

Coal Resources Development Committee, 'NSW Coal Export Demand Forecasts 1987-2000', Department of Energy, Sydney.

Department of Primary Industries and Energy, 1987, 'Forecasts of Energy Demand and Supply Australia 1986-87 to 1999-2000', Australian Government Publishing Service, Canberra.

Huleatt, M.B., 1988, 'Australian Coal in 2000: It Will Meet the Challenge', Asia-Pacific Coal Trade Workshop: The Dynamics of Expanding Supply, East-West Center, Honolulu, 29-30 September 1988.

Joint Coal Board, 1988, 'Black Coal in Australia 1986-87', Joint Coal Board, Sydney.

World Coal Study, 1980, 'Future Coal Prospects', Bellinger Publishing Company, Cambridge, Massachusetts.

Some issues in domestic transport costs

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Most of Australia's 100 million tonnes a year exports of coal are transported by government owned and operated railways. Governments have used their monopoly position on the transport of export coal to charge freight rates that on average exceed costs by a factor of three. The resulting reduction in mining industry profitability causes the industry to be much smaller than is required for an efficient allocation of the nation's resources. The paper goes on to discuss some options for moving to a more satisfactory set of arrangements for the supply and pricing of rail freight services to the coal industry in particular and to bulk products in general.

1. Importance of Rail Freight Costs

Rail freight rates represent a significant component of the seaboard (or f.o.b.) price received for Australian export coal. Domestic transport costs are further increased by costs incurred by the mine to the railway and by port charges. Data from a sample of mines for the years 1985 and 1986 indicate average rail freight charges of $12.98 per tonne, or 21.4% of the f.o.b. price, for Queensland coal and $7.80 per tonne, or 14.6% of the f.o.b. price, for NSW coal (Table 1). Given the fall in f.o.b. prices since then, the percentage of rail freight costs of the export price is somewhat greater in more recent years.

Table 1 Importance of Rail Freight Charges to the Export Coal Industry, 1985-86

	f.o.b. price	Rail Freight Charge	
	$/t	$/t	% f.o.b. price
Queensland Coal:			
average	60.65	12.98	21.4
range		6.52 to 17.05	10.8 to 28.1
NSW Coal:			
average	53.32	7.80	14.6
range		2.85 to 13.11	5.30 to 4.68

Source: prices from Joint Coal Board (1985-86)
charges from Easton (1988).

2. Current Situation

The negotiation of coal mining licenses between private mining companies and the state governments of Queensland and NSW generally required concurrent negotiation of an agreement for the transport of the product to the seaboard. In the majority of cases the mines have been required to use the government railways on the terms and conditions set by the government.

Two type of pricing arrangements have been followed by the state governments. Queensland opted for a two-part tariff: one, at the outset mining companies financed necessary capital works (including new railway infrastructure, upgrading of existing infrastructure and rolling stock) by an up-front payment; and second, companies paid an operating charge per tonne of product transported. NSW, by contrast (and except for the Ulan mine), makes a single per tonne charge to cover both capital and operating costs.

A common characteristic of the freight rates set by the two states is that the rates charged exceed costs by a very wide margin. Table 2 shows data compiled by Easton (1988) for a sample of mines. Certainly one can dispute the precise estimates of current railway freight costs, especially those related to capital costs. In Freebairn and Trace (1988), we report an extensive evaluation of the Easton numbers. Despite various differences of opinion, we conclude that the average total cost calculations by Easton are about right, and in general err in the direction of overestimating costs. The Easton numbers indicate an average excess charge of $7 per tonne for Queensland coal, or 11.5% of the 1985-86 f.o.b. price, and $5 per tonne for NSW coal, or 9.3% of the f.o.b. price.

Table 2 Estimates of Rail Freight Paid, Costs Incurred in Providing Rail Freight and Magnitude of Over-Charging for Export Coal

	Queensland 1985	NSW 1986
Total export tonnage (million)	47.2	40.7
Tonnage of mines included in survey (million)	42.0	15.4
Payment by survey mines ($/t)	9.99	7.80
Estimated cost ($/t)	3.03	2.84
Estimated excess charge ($/t)	6.96	4.96

Source: Easton (1988)

The magnitude of the excess charge varies widely from mine to mine. As a generalisation, it tends to be greater for mines opened more recently (in part reflecting higher coal prices and government expectation of higher rents to be exploited at the time contracts were negotiated) and for mines more distant from the port.

Escalation clauses promise even greater excess charges in the future. Most contracts include clauses specifying that freight charges will rise according to an index of fuel prices, wage rates and steel prices. The index is applied to the total freight charge, both the part representing costs of supply and the excess charge. No allowance is made for gains in productivity. While there has been flexibility in the application of the escalation formulae, such as freezing it during recent falls in export prices, such is not automatic and requires considerable lobbying.

The way in which contracts specify the effects of tonnage variations on freight rates reflects an average cost philosophy. That is, small tonnages mean higher freight rates per tonne. By contrast, an economic perspective based on marginal cost pricing suggests lower rates for smaller tonnages, especially when many costs can be regarded as fixed.

Finally, productivity of the state operated railways leaves much to be desired. Easton (1988) and Freebairn and Trace (1988) suggests gains of perhaps as much as $1 per tonne are available.

To conclude, the current arrangements for the supply and pricing of rail freight to the export coal industry are far from satisfactory and departs from what would be expected under a commercial environment.

3. Adverse Effects of Current Arrangements

The current arrangements for the domestic transport of Australian coal have adverse effects for the coal industry itself and for the allocation of scarce national resources. Excessive freight rates directly reduce industry profitability. In turn, industry investment, employment and production is much less than is consistent with the best use of the nation's scarce resources. In addition, the wide variation of excess charges from one mine to another causes distortions in the development of the coal industry itself.

Table 3 provides an indicative picture of the likely effects of a $7 a tonne reduction in rail freight rates (or a combination of reduced freight rates and port charges) on the industry over the 1990s. The increase in profitability induces a significant expansion of the industry with total production rising by over 40 million tonnes a year by the end of the century. The larger industry is estimated to increase national economic efficiency by about $140 million a year - a measure of the greater social value of labour, capital and other resources moving from elsewhere in the economy to the export coal industry. The large drop in state government revenues (the net effect of the loss of excess charges and small increases in royalty and payroll tax receipts) indicates an important barrier to achieving change.

Table 3 Estimated Effects of a $7.00 per tonne reduction in Rail Fright Rates Paid by the Australian Coal Industry

	Early 1990s	Mid and Late 1990s
Increased production (million tonnes)		
- coking coal	10	21
- steam coal	12	23
Lower seaboard prices ($/t)		
- coking coal	2.0	3.0
- steam coal	0.3	0.4
Increased exports ($million)	1000	2500
Higher mining industry pre-tax profits ($million)	700	1000
Lower state government revenues ($million)	700	1000
Higher federal government revenues ($ million)	400	600
Net national efficiency gain ($million)	75	140

All dollar terms are in constant 1986 Australian dollars.

Source:Freebairn (1988)

4. Reform Options

There are two levels at which changes for a better future might be contemplated; the area of ownership of railways for the transport of coal and other minerals; and adoption by the government railways of commercial principles in setting freight rates.

An underlying reason for the present unsatisfactory arrangements is the legislated monopoly position of government railways. A key requirement is to open-up the scope for competition, including from other modes of transport and from privately owned and operated railways. Privatisation could take the form of complete private ownership as exemplified by the Pilbara iron ore industry. Alternatively, it might take a half-way house strategy in which the government continues to own and maintain the railway infrastructure but the private sector owns and operates the rolling stock.

The general philosophy of continued government ownership and operation of the railways, but setting freight rates to mimic a competitive commercial environment, is to set rates which (a) return to railways the (social) opportunity cost of resources needed to provide the service and (b) at the same time indicates to the mine investors the social marginal cost of changes in tonnage transported. Because of the decreasing cost structure of most railway operations a two-part tariff is suggested. The first part tariff would represent an access charge (either as an up-front capital contribution or an agreed fixed annual charge) to cover the fixed cost of the track and associated infrastructure. In the case of multi-use lines, consideration of relative capacity to pay would be given to assessing the share of unattributable costs of jointly used infrastructure allocated to particular users. The second part tariff would represent a per tonne of product transported charge to cover the annual capital costs of rolling stock, usage sensitive track maintenance costs, train operating costs and marginal congestion costs (if relevant).

References

Easton, E. (1988), 'Charges and Costs of Rail Transport of Coal, Lead and Zinc Concentrate: Summary', Centre of Policy Studies Research Report B17, Monash University.

Freebairn, J.W. (1988), 'Consequences of Adopting Commercial Rail Freight Rates', Centre of Policy Studies Research Report B16, Monash University

Freebairn, J.W. and Trace, K. (1988), 'Principles and Practice of Rail Freight Pricing for Bulk Minerals', Centre of Policy Studies Research Report B15, Monash University.

Joint Coal Board (1985-86), Black Coal in Australia, 1985-86, Sydney.

Realistic expectations of change

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I have been asked to present a paper about realistic expectations of change.

Workers in the coal mining industry have the reputation of being obstinate in their resistance to "change". The resistance is remarked upon because it is always assumed that "change" is unquestionably to the benefit of the industry and therefore is a good thing for the workers as well. The word itself is a word to conjure with. Governments and coal companies have been putting it in a phrase - "the need for change" - and have been pressing the phrase for so long now that the Coal Industry Tribunal adopted it as the threshold question in the Industry Restructuring Case. Therefore, I assume that I have been asked to tell you all how much change can realistically be expected of mineworkers as a consequence of the Restructuring Case Decision.

During the case, all the parties agreed that the industry needed to be changed, but differed as to what direction change should take.

The Government and the Coal Associations put the simplistic position that the industry was caught in a classic price cost squeeze. Coal prices continued to fall in Australian dollar terms. They said that the price Australia received for its coal exports was determined by the export market and could not be influenced by Australian producers. Hence, they argued, we could only affect the other side of the equation. We had to become more efficient, they said. The world market was forcing "change" upon us.

The Coal Associations used the word "change" to mean a reduction in labour costs per tonne by way of attacking working conditions. The Miners Federation understood only too well what the word presaged for mineworkers if the Commonwealth Government and the Coal Associations' views were accepted - compulsory weekend work, the end of the 35 hour week, longer shift lengths, an end to the Christmas shutdown and work rosters which include forced overtime. The four panel roster, for example, requires an average of seven hours overtime per week, bringing the compulsory average hours of work from 35 per week to 42.

We argued strongly that the answer to the industry's problems was not a continuation of cost cutting and government deregulation in which the burden fell solely on the workers in the industry. Controls on investment decisions and the prevention of price cutting between Australian exporters are the fundamental changes the industry requires. Such matters are outside the jurisdiction of the Tribunal and much of what the Queensland Coal Association sought was granted, although the all out approach of the NSW Coal Association was rejected.

Indeed, the real cause of demands for change in the workplace is the restructuring of ownership and market shares in the industry. Mineworkers are being asked to facilitate and pay for struggles between corporations for control of the profits to be made from coal mining in Australia and on a world scale. Some sections of the industry have been wound down or closed permanently while others are emerging stronger than before.

The change in market shares has resulted from the decision of the Hawke Government to abandon export price controls in September, 1986. When this action was taken, it was asserted that this would increase export tonnages and assist the balance of payments without redistributing tonnages among producers. In fact, Hawke wrote to the Federation putting this view. Of course, this has not been the case and it was never intended to be so. Australian coal companies have deliberately forced the price down in competition with each other in order to win tonnage increases or at least stable tonnages in a declining market. They set prices so low that many mines could not continue and were forced to attack working conditions and/or close operations.

The coal companies are not united on this issue. Some benefit at the expense of others. The companies which supported deregulation the most strongly were those which had large, low cost operations, high capital investments and high stocks and excess capacity. There are many companies which privately support export controls and regulation because it is their operations that suffer under the export free-for-all.

It is clear that deregulation through this process redistributed export tonnages within the Australian coal industry. This has been reflected in an increase in the proportion of the export tonnages going to open cuts and particularly the Central Queensland open cuts. The Advisory Committee of the Australian Coal Consultative Council reported that for the 30 weeks to 23rd January 1988, Queensland exports were up by 19.7% compared with the same period the year before. NSW exports were up by only 2.9%. Saleable production increased marginally in this period, but NSW production declined by 5.9%. Moreover, stocks were down 57.4% in Queensland but only down 28.6% in NSW.

Underground and West Moreton operations in Queensland were wound down in this period. This means that the large increases in export tonnage coming from Queensland must have come overwhelmingly from Central Queensland open cuts dominated by BHP-Utah, MIM, CRA and CSR - the greatest proponents of deregulation of export controls.

Of the 10 mines that closed in NSW since deregulation, 8 have been undergrounds. These account for much of the reduced production coming from NSW. There has been a very clear restructuring of the industry in favour of the large corporations which control large operations.

At the Tribunal, all of these issues were canvassed. The Federation cited the price cutting activities of Australian exporters as the cause of the low prices and declining profitability which companies were asking the Tribunal to offset by ordering changes in work patterns. Mineworkers had already suffered for the price cuts with their jobs and removal of working conditions at mine level. However, this is only part of the reason for mineworkers' resistance to the changes introduced in the Restructuring Case.

A regime of low prices also leave small coal companies open to takeovers. Following the industry crisis over the past two years which included a run of losses and negative returns on shareholder funds, most small to medium companies traditionally involved in the coal mining industry were in a vulnerable position for take-overs. Many are deciding to cut their losses by selling their operations and assets. According to the Coopers and Lybrand survey of the NSW industry in 1987-88, the overall loss was $151m and the return on shareholders' funds was -9.9%. This was the worst result ever.

Moreover, many smaller to medium sized companies who have come through the troubles of the last few years are not in a position to invest in order to take advantage of the new systems of working introduced in the Restructuring Decision. They have had relatively low revenues and have high debt to equity ratios. The Federation argued during the case that the changes being proposed were not likely to help such mines.

Large companies with money to spend, such as the international energy companies, Australian based conglomerates and Japanese trading houses, are being welcomed in as new partners or new outright owners. In Queensland most ownership changes appear to be in the area of undeveloped reserves or new projects, with the exception of Agip and Arco.

It is significant that many of the new entrants to the industry are companies which either use or market coal on the international market (for example: Idemitsu, Ube, Sumitomo, Nissho Iwai, Agip, Exxon). This would suggest an optimistic view of the coal trade over an extended period and weakens to some extent the credibility of Japan's threat to move away from Australian coal and toward US coals. It is also important to recognise that much of the take-over activity is designed to facilitate further package sales of operations and assets. The most likely area for more activity is in the Hunter Valley, and particularly around R.W. Miller and Coal and Allied.

The strategy of the Coal Associations and the Federal Government with regard to deregulation of coal exports to allow the dominance of large companies over smaller operators, the continued inaction over the industries troubles in the export area, and the continued attack on working conditions and hours of work have all facilitated, by design or otherwise, a period of profits and growth in the coal industry based on fewer, larger operations owned by a handful of large corporations. Many of the joint marketing and development proposals put forward in the National Coal Authority policy will now become a reality within large corporations which will increasingly dominate the industry.

A summary of the restructuring in the coal industry would have to be:

1. Price cutting to enable established low cost large corporate producers to win higher tonnages.

2. Price undercutting forcing mine closures to enable the large companies to pick up additional contracts.

3. A regime of low export prices which puts small coal companies in a weak financial position and leaves them open to takeovers.

4. A coal industry dominated by a small number of large corporations.

This restructuring is about the interests of individual corporations, not the interests of the coal industry. It is mineworkers who pay for the interests of these successful companies. We have already paid with the loss of over 4000 jobs and reductions in earnings in 1987. We are being asked to pay again by the introduction of six and seven day rosters and erosion of conditions. The Restructuring Case is part of the strategy to rationalise ownership and control in the industry. Attacks on working conditions allow existing large producers to continue to increase their share of both Australian exports and world coal exports. They also allow corporations to expand or initiate their role in the coal industry on the basis of highly profitable operations.

The coal industry between 1985 and 1989 is the classic example of an industry in cathartic crisis and reconstruction based on concentration of capital, devaluation of assets, a rationalisation of operations and a revised approach to production and marketing which utilises productive capacity and economies of scale at a higher level.

Against this background, it is hardly realistic to expect mineworkers to accept the changes invoked by the Restructuring Case at all. The Case was not about industry viability, but about corporate competition and it is the mineworkers and their families who pay. They pay with their jobs, their earnings and their working conditions.

Coal industry - accepting the challenge: new marketing challenges

John Doherty

Clutha Limited

The black coal business has one objective - to maximise the return on its investment. It is not concerned with market share, it is concerned with market profitability. Maximum profitability permits all the other admirable, proper, and altruisitic achievements to be attained in the form of being a good employer, being a 39% taxpayer, being a significant contributor to the repayment of Australia's excessive international private debt and being able to generate real fixed capital investment in coal to the progressive benefit of this nation.

There are several key factors which coal businessmen carry in their minds as important. The number one factor is price, number two is the yield of saleable coal from raw coal and three more relate to production volume and cost, and transport.

There is nothing proportionately more sensitive to our business than price. It is clearly recognised by buyers who work actively and collectively to minimise it. It is occasionally used against us by our competition in oversupplied markets but such market habits should not deflect the marketer from being responsible for making the major contribution to coal company profitability.

Price is however a derivative of perceived supply/demand imbalance and the best price in all the circumstances is not easily predetermined and defended in the current manner of selling international coal. The world coal business is huge and long standing but remains secretive by comparison with other commodities, possibly because internationally traded coal is less than 10% of total world coal production and a tiny proportion of total traded energy, but more likely because buyers and sellers have not yet had available to them any instantaneous view of the market measured by supply and demand tonnages and the price range at which they might be cleared.

Delayed information on a few markets is published by Coal Journals many days or weeks after the transaction is complete. The lack of current information between participants, and particularly sellers, means that the price imperative derived from the supply/demand imbalance operates more in favour of the buyer than the seller.

New marketing challenges include introducing new ideas on information flow on current volume and price changes in the industry to allow sellers to be better equipped to make judgements on the revenue maximisation equation for their companies. The challenge will always be to achieve a fair price and a reasonable volume distribution obtained on a level playing field of information.

This paper makes comment upon

i) the last ten, mostly dismal years for coal company shareholders, but great years for market share enthusiasts.

ii) yet another estimate of the trend of demand and supply for internationally traded seaborne coal to the turn of the century, recognising that even estimating one year out is hazardous.

iii) some thoughts that future marketers might keep in mind to enable them to pick up a portion of the several dollars per tonne the industry is often accused of leaving on the table throughout the business cycle of coal.

Introduction

The Australian black coal industry produced 136 million tonnes of saleable coal in 1987/88 and exported 75% (102 million tonnes) of that production. Australia has the highest ratio of exports to domestic consumption, 3.0, of any country; its major competitors in the international seaborne trade, USA and South Africa, hold ratios of 0.1 and 0.3 respectively. The challenging issues facing the marketing of Australian coal lie in dealing with the volatile, aggressive and competitive international energy market. Marketing of coal in the domestic environment is important but not representative of the same challenges and uncertainties as the international scene, nor it is a buffer to variable international sales.

Australian domestic consumption is rising steadily, principally for supplying the increasing electricity demand in NSW and Queensland, but supported by steel and cement.
An important feature of international business, namely currency, does not appear to play a role but nevertheless domestic prices are related to effective export returns over time except where long term power station supply contracts exist. Many producers would choose to operate entirely within the long term domestic market but opportunities are logistically few. The challenge for Australian coal is the challenge of the international scene where the driving force remains a prediction of good growth for at least one more investment cycle combined with a competitive resource base (iii).

The incentive to deal in the higher risk international environment attracted new investment to the industry over the last decade, to the financial chagrin of most investors. $800 million dollars of Australian coal company shareholders funds were disclosed as losses over those years and substantially more were hidden in the many joint venture operations which supported much of the growth in production through the 1980's. In retrospect, the world wide investment in coal in the last 10 years was proportionately the largest single development ever seen in the industry and predicated upon the seemingly insatiable estimates of demand for coking and steaming coal between 1985 and 2000. The existing industry in 1978 questioned such high rates of growth but they were brushed aside in the wish by banks to fund and engineers to build the biggest and best coal mines. Marketers were appointed by the tens to serenade the potential customers. The optimisitic and positive marketing challenges of 1980 turned finally to desperation as business lost impetus with economic recession, too much coal chased too few customers, and worse still, oil and gas prices returned to coal competitive levels.

Nevertheless Australia's brief foray into the shoals of volume at any cost, in defiance of the first law in any Economics textbook, brought forth substantial and beneficial changes in the scale of things including the ubiquity of Australian coal and its marketers. For example:

a) Australia increased its exports of coking and steaming coal from 40 million tonnes in 1978 to 101 million tonnes in 1988 comprising 55 million tonnes of coking coal and 46 million tonnes of steaming coal. The country disposes of its coal to more than 35 countries and overtook the USA as the world's largest exporter in 1984 a position it still retains.

b) Australia has the installed productive capacity in mines and infrastructure to increase production of coal by about 20% over the next two years as companies take advantage of the additional production time made available under the recent decision by the Coal Industry Tribunal. The CIT's decision was a prescription to increase the cash cost per tonne of producing coal and to utilise existing capital over a greater number of hours per year - 'benefits' which can be obtained by increasing employment, spending more cash and changing the shift patterns of mine workers. Labour costs per tonne of production are expected to increase at least 16% by mid year.

c) Australia has constructed a greater size and diversity of coal transport and loading infrastructure than any other country e.g. South Africa, Colombia and China each have one coal loader suitable for Cape Size vessels, Canada has two, USA has three, Australia has five. Incremental expansion of most of the existing Australian facilities is available should the demand so require.

d) As best can be judged, using selected exchange rates, Australia's existing and new mine FOB costs remain competitive with all the actual and projected players in the supply side of the export steaming coal business (vide Barnett - The Cost of Export Steam Coal - What Role New Players, 3rd Pacific Rim Coal Conference (iii)).
Australian coking coal will remain the most competitive in the world scene.

Characteristics of the seaborne trade that emerged in parallel to the Australian developments over the ten years include:

a) volume - an increase in the volume traded from 160 million tonnes (62% coking) in 1978 to 280 million tonnes (50% coking) in 1987 and an expectation that 1988 will reveal 285 million tonnes with a revitalisation of coking coal to 52%. Overall the average growth rate was 6% but quite variable between years and within qualities.

b) price - the same price in US dollars for coking coal in 1979 and 1989 but an increase of 25% in the US dollar price of steaming coal over the same 10 years. A steady decline of the real Australian dollar price for both, regardless of exchange rate. Variations up and down occurred in between.

c) a turning point, for the worse, in the coal business cycle in October 1982 and again, perhaps for the better, in October 1987 indicating a repeat of a 7 or 8 year cycle, somewhat shorter than earlier expectations.

d) a stagnation in total world coal trade from 1985 to 1988 which led to aggressive competition and a permanent decline in the land based trade as high cost traditional cross border suppliers in Europe reduced their activity.

e) Australia's share of the total seaborne trade increasing from 40 mtpa (25%) to 100 mtpa (35%) effectively placing Australia in a price determining position in world markets, a position which has not been used to the detriment of any customer.

f) two new supplying countries emerging, Colombia and China. The latter, despite the fanfare and optimism, has done little to advance its position but marketing activities in 1987 did a great deal to disrupt further an already unstable pricing framework.

g) the completion of all major capital investment in seaborne traded coal production and little new investment foreshadowed at current prices; a decline in Polish coal exports because of a lack of investment in their high cost mines and an announcement that their exports will cease in 2000; reductions in some highly subsidised domestic production throughout Europe, (excluding Germany), and Japan.

h) Japan's long term contracts altered to share reduced demand except in selected cases where the legalities of the contracts were dominant and above market prices were continued to avoid legal action.

i) a demonstration for Australian producers that increasing volume in an oversupplied market by marginal pricing of sales is not financially prudent as the average price moves quickly to the marginal price and total export revenue declines as volume increases.

The Next 11 Years - Supply/Demand

March 1989

There is a view within the export industry that a near balance exists between supply and demand for seaborne traded coal. Any short term supplies must be obtained from the USA where a large production resource exists and from which shortages can be met, if needs be at the expense of higher prices. The supply industry is not yet convinced that the transition to non USA supply shortfall is other than short term and thus the market barometer might be perceived as 'change' moving to 'fair'.

1990 to 2000

The market barometer is strengthening to 'fair' although 'stormy' will interrupt the wish for smooth sailing at some stage.

The two broad categories of traded coal, coking and steaming, do not face the same demand characteristics and it remains convenient to subdivide predictions into these two classifications. There will always be overlap of qualities but commercial classification is determined by whether coal is entering the metallurgical industry or the heat raising industry rather than any precise quality distinction.

Future steaming coal demand

The growth predicted for steam coal has been a basis for optimism and investor retention of interest in an otherwise poorly performing industry. There is physical and planning evidence to support the early 1990's as an era requiring more steaming coal, principally for electricity production. The higher rates of growth assume general world trade countinues to expand; lower rates assume some down turn, which would also reflect in coking coal demand.

All forecasters (i) are predicting strong steaming coal demand into the 1990's with annual growth rates 7 to 8% p.a. up to 2000. These forecasts contrast with stagnation of the steam coal trade in 1987 and 1988 in tonnage terms although prices moved upward significantly at the end of 1988 showing support for a return to growth. The result of these changes is likely to see an increase of demand from a 1988 level about 140 mt to 160 mt in 1990. The author however sees less optimism and prefers the next ten years demand growth of 6% in the first half declining to 5% in the second half. The estimates have been drawn with modifications from an analysis completed by the Australian Coal Report (vi)in 1988 after an examination of primary energy requirements and economic growth projections of individual countries crosschecked against the existing plans for new power plants, conversion from oil to coal of existing plants and industrial boilers.

The declining domestic coal production capacity in Europe and Japan is an additional feature of the 1990 demand which has not revealed itself in the past.

STEAM COAL DEMAND FORECAST - SEABORNE TRADE
(million tonnes)

Import area	1990	1995	2000
Western Europe	80	103	134
Japan	29	40	54
Other Asia	40	53	58
Africa	7	9	12
Other	4	7	12
	160	212	270

The absolute increases in demand over the next five years are approximately equal between Asia and Europe. These two growth markets will allow a better balance of trade between the natural supply/demand regions of the world as governed by the cost of seafreight. The market distortions created by the anti South African movement from 1986 onward diminished the returns for both Australia and South Africa. The parties who benefited were the northern hemisphere consumers who transferred even more of the wealth of the suppliers to them as each supplier inefficiently competed for tonnage in his most distant consuming area. Australia needs to be careful to avoid her self interest being lost by supporting expensive idealogical positions, the cost of which is not being shared by those who are the most vocal.

South Africa is an important player in the future supply of steaming coal, as is China. One can conjecture about their real supply by estimating an increase or no increase from a specified date and thus produce alternative supply schedules e.g. Calarco (ii). The differences between inclusion or omission of their new capacity can be significant over 10 years, amounting to 35 million tonnes. The ability to competitively supply seems to be a suitable criterion to adopt for South Africa as it clearly has the uncommitted resource and organisational capacity. China's internal needs are likely to dominate demand, her costs are not competitive and thus tonnage estimates presume attainment by government decree.

New supply sources will appear in Indonesia and Venezuela to add to existing suppliers, all of whom are likely to expand at the right price level with the exception of Poland whose exports are declining to zero after 2000.

All countries in the following supply schedule are competitive suppliers of steam coal and operate on commercial lines with the exception of China. It is reasonable to assume that China will clear her coal at market price and not disturb the worlds' commercial arrangements. The USA may remain the highest cost supplier and be in more of a swing position than other countries. It is the USA resource which protects consumers against absolute shortage of coal.

STEAM COAL SUPPLY FORECAST - SEABORNE TRADE
(million tonnes)

Country	1990	1995	2000
Australia	52	62	74
USA	24	24	39
South Africa	42	55	65
Canada	5	10	12
Colombia	13	18	28
Poland	9	9	4
Indonesia		7	14
Venezuela		7	14
China	10	15	15
Others	5	5	5
	160	212	270

Future coking coal demand

The medium term demand outlook, 1989 to 1992, indicates little growth for the world's coking coal market, with demand increasing by a marginal 5 to 10 million tonnes only. Even the longer term outlook is very modest with the demand by the year 2000 increasing by approximately 15 to 25 million tonnes.

The demand for steel in the OECD economies is no longer increasing and steel production in those countries is declining in the face of low cost steel imports. Only the newly industrialising countries, such as South Korea, Taiwan, India, China and Brazil, project increased steel production, which will replace higher cost capacity in the OECD.

The markets for coking coal are changing and previous geographic advantages, such as the USA had in Europe, are disappearing. The seaborne coking coal trade is expected to benefit as a greater percentage of the world's coking coal consumption will be open to competition, e.g. the West German ban on coking coal imports to protect the domestic industry will become less important with reduced steel production in that country.

Australian exporters will have the opportunity to gain greater market share by securing new tonnage sales to expanding steel producers and by continuing to replace higher cost US coal.

The rapid growth during the last five years of weak coking coal consumption in the Japanese coking coal market is not a permanent threat to the better quality coking coal exports. The greater part of those sales to the Japanese represents the excess production of prime coking coal in an oversupplied market, with the Japanese steel mills prepared to lower their coke quality requirements in the face of cost pressure, excess blast furnace capacity and increasing coking times.

The change in the market for coking coal is the growth in coal for blast furnace pulverised coal injection. The use of PCI coal directly reduces the coke consumption and has gained increasing world wide acceptance. PCI coal will continue to gain market share, but the greater use of PCI will require higher quality coke in the blast furance, which strengthens the market position of prime coking coals.

Alternative steel making technologies will continue to develop but in most countries they will not be competitive with the established blast furnace steel making route. Electric steel making has gained increasing market share, but is limited by the availability of steel scrap. The conventional coke based steel making plants will continue to dominate the industry.

Imports of coking coal by region are estimated to be as follows.

COKING COAL DEMAND FORECAST - SEABORNE TRADE
(million tonnes) incl. PCI

Region	1990	1995	2000
Japan	70	69	69
Europe + Mediterranean	50	55	55
Other Asia	16	20	25
Latin American	14	17	21
Total	150	161	170

Available new supply of prime coking coal at commercially justified prices appears to be limited to Australia and the USA. No other country has the ability to compete on commercial grounds and is unlikely to contribute simply on the basis of foreign exchange needs alone, e.g. Russia, Poland or China. The supply sources for meeting the increased coking coal demand are forecast as follows:

COKING COAL SUPPLY FORECAST - SEABORNE TRADE
(million tonnes)

Country	1990	1995	2000
Australia	55	60	66
USA	49	50	55
Canada	26	28	28
South Africa	4	5	5
Poland	7	5	3
China	3	5	5
USSR	6	8	8
	150	161	170

Summary

The forecasts of total demand for seaborne coal in 1995 total 373 million tonnes. 1995 is a year within the construction horizon for new mines and infrastructure provided 1989/1990 demonstrates a solid upward price movement in US dollars and real Australian dollars. Australia's proportion of supply is 33% at 122 million tonnes. This is an attainable figure from the existing mines working more days per annum and about three new mines. Australia's production prospectivity is greater than this and additional new mines can take up shortfalls from an uncertain South Africa and delayed development in Indonesia and Venezuela.

The total figures disguise the change in balance of coal qualities. The real growth is in steam raising coals. The new development required will be in steaming coal mines but almost no new coking coal mines - only an increase in annual output from existing mines.

Competing Fuels

The principal fuels competing with coal are oil, gas and uranium. Gas and uranium are in abundance but oil is considered to have medium term limitations. Competition from coal liquefaction or oil shale is not presently important.

Uranium has many advantages of an ideal fuel for electricity production. It is a dense energy medium, comparatively cheap to buy and fissure, expensive in terms of capital cost and reprocessing. The safety characteristics of the nuclear reactor are well understood. The spectacular growth of nuclear power generation in some countries e.g. France, Japan, Switzerland, Sweden, Taiwan, etc, is a credit to the foresight of their governments. Other countries have been less concerned or deeply enmeshed in environmental restraints reinforced temporarily by the Cherbonyl melt down. However, the nuclear fuel cycle has now displaced coal as the base load cycle for future electricity production in many countries. A major displacement of coal may still be a generation away, and is assisted by community inability to accept the realities of the uranium cycle. The anti nuclear lobby and the coal industry are uncomfortable bed fellows but temporarily have the same vested interest.

Natural gas is a fuel in abundant supply but not necessarily cheap to develop. Current arrangements tie its price to oil but such volatility will not be accepted by customers. Nevertheless whilst it may never be a strong price competitor for coal there is a rigidity in seaborne supply arrangements which will ensure it is burnt even when it has no economic advantage. Gas will impinge on base load operations because of its logistical inflexibility.

Oil remains the fuel of principal concern to coal in the next five years. Oil fired boilers and cement plants are in profusion. Appropriate price shifts can easily encourage increased oil consumption to the detriment of coal. It did seem for some years that oil prices would never again press down on oil but eventually the law of supply and demand broke the back of the selling cartel.

Historical data since 1890 shows that the coal prices are driven down every 15 years or so by oversupply of energy with oil being the bogey. The coal industry has good reason to be apprehensive about oil for five to ten years. Oil above US$20 per barrel is comforting.

The quest for reduced use of fossil fuels as prognosticated by the dangers of the greenhouse, acid rain and ozone depletion phenomena is likely to provide exciting debate in political and environmental lobbies in the next ten years.

The limited long term information available on the phenomena allows much mud slinging and coal needs to avoid it all sticking. The industry must and will help itself on these issues of radiative gases lest inaction reveals itself in a deteriorating competitive position.

New Marketing Challenges

Australia and Competing Exporters

Australia has a coal industry with the following advantages:

- high quality black coal deposits close to the deep sea ports.
- excellent mining conditions.
- good rail infrastructure.
- a diversity of ports; coal loaders which rate among the world's best.
- excellent mining conditions.
- a range of competitive FOB costs for existing and future coal mines.

The natural advantages of close proximity to the sea are matched by the Colombian, Venezuelan and Indonesian projects. Except for the Colombians these projects are only at their development stage.

The world's large exporters, such as the U.S.A., South Africa, Canada and China are at a disadvantage in more than one way. Good rail infrastructure in Australia is not matched by any other nation although the freight rates charged by government owners may be. China is still developing its transport facilities, South Africa is dependent on a single rail route to Richard's Bay from which port over 90% of export tonnage is shipped.

The US industry has high freight charges from railroads, which do not depend on coal for their livelihood. The Canadian industry is concentrated in the coking coal sector and only the older established mines can survive in current market conditions, while the new projects require prices up to 40% higher than 1989 market prices to survive. All coal haulage is over long distance.

The Logistical Position of Australia

Australian coal markets can be divided into three categories:

a) nearby markets, principally on the western rim of the Pacific, where Australia is generally the largest supplier, due to a combination of competitive production and freight cost advantage, e.g. Japan, Korea, Taiwan, Hong Kong.

b) distant markets, principally Europe and other Mediterranean countries, plus Latin America. In these markets Australia's relatively low FOB costs are offset by a freight disadvantage.

c) Australia-dominated markets in which a combination of port limitations in the importing countries and freight advantage gives Australia a substantial landed cost advantage. These markets include India/Pakistan/Iran for coking coal; and some of the ASEAN countries and small South Pacific markets for steaming coal.

There is no reason to expect that Australia's current penetration of Asian markets (around 60% overall) is likely to diminish. The freight disadvantage in more distant markets incurred by the Australian industry compared with South Africa, Colombia and USA will impose limitations on overall market penetration, although in particular instances, Australian suppliers will achieve higher levels of sales due to customers' purchasing policies and quality requirements.

Nevertheless, given circumstances likely to prevail in the marketplace during the review period, the present reducing trend in Australia's penetration of European coking and steaming coal markets is expected to level out at 20% in 1990 but increase to near Mediterranean and Latin America.

Pricing In The New Marketing Challenge

The principal marketing challenge to the producer is the profitable clearing of the volume of production to a series of customers located as close to the source of production as possible. However in a rising market where all customers diversify their supplies by customer, state and country, one finds that the volume problem is not the key - it is price.

All consumers of coking coal, swiftly being followed by steaming coal, are very well informed on supply characteristics, suppliers strengths and weaknesses and the overall position of the market. The Japanese raw material procurement policy has been in operation for 30 years and is the quintessential strategy for ensuring monopsonistic market control. Anderson (iii) has analysed these procurement policies and their effectiveness in the control of Canadian and Australian long term supplies. Australian marketers are now able to draw upon long experiences in the industry to see how they might improve their collective position in the Japanese market as it effectively determines the entire Asian pricing structure. European consumers note the annual evolution of pricing in the Asian trade and use the results as a guide to determining their attitude to Australian sellers.

Australia has swung away from Europe as market demand has firmed. This change allows a return to the concept of Asian FOB pricing to European markets just as USA producers often sell European FOB price to Asian customers. Australia set itself a difficult position years ago when some suppliers introduced the concept of treating Europe as a market having to be supplied on a CIF basis at the same price as the lowest alternative. Such moves at times of desperate oversupply are understandable but for suppliers to offer such unnecessary competitiveness in a firm market, when the alternative base load supplier is the USA, shows a lack of profit maximisation.

Judgement of market condition is the primary asset of a marketer. The current one sided position of selling coal where there is a significant lack of immediate information to the seller leads to the need to occasionally lose a customer or some tonnage in a negotiation to provide an estimate of just how firm the market is. For over 10 years Australian marketers have found difficulty in being firm with customers in order to test the market although the next two years could see a change as suppliers reexamine their revenue maximisation strategies.

A significant development in coal market maturation would be the provision of an immediate information source on supply/demand imbalance and a price index on levels needed to clear the market. Examples abound of similar markets of which the most obvious are the Stock Exchange and FOREX markets. However there are hundreds of others in such coal analogues as oil and aluminium to finance mortgages, agricultural grains, meats, etc. The essence of these spot, and future markets is the rapid display of information to buyer and seller. As a result bid/offer differences are less, markets broaden, there is reduced dependence on uncertain long term relationships of price to quality and demand and all parties have more flexibility with reduction of uncertainty and risk, be it in spot or long term business.

Marketers of coal are now generally aware that Bain Refco (vii) and Barlow Jonker (vi) are establishing an international computer screen trading system for spot steaming coal. The system will be offered to all eligible producers, consumers and traders and will provide an important real time index of spot price and price trend. The larger the volume traded the more valuable the price index, such that, like oil and aluminium, the index is likely to be used in long term contracts and thus avoid the long drawn out annual negotiations on steam coal. The Australian Government export control policy would surely be aided if a reference price were independently available. It would be the fair market price at a point in time and, in principle, should be the price for which automatic export approval would be granted.

The computer screen trading of spot steaming coal is likely to evolve into a futures market, then into coking coal and ultimately be the mechanism for all long term contract price setting. It will not be necessary to trade on the screen to obtain its benefits. All the traditional personal relationships can be maintained, indeed strengthened, by removing the difficult broad margin price debate. Instead marketers can deal with premiums, discounts, quantity and quality. Marketers would have less need to wander the world of customers so frequently, their regular presence is often a danger to themselves by suggesting oversupply, even if there is none.

Challenges For The 90'S

The Australian coal marketer's individual and collective challenges in the 1990's are

- to develop strategies for pricing steaming and coking coal, to return real Australian revenue to 1979 levels, particularly in Asia where the majority of the coal is sold on Japanese based pricing settlements.

- to determine whether a European customer can reasonably expect to pay a higher C & F price for the benefits of diversifying his purchase to Australia.

- to observe that the pricing push is likely to come from the quickly growing steaming coal business rather than coking coal. Both marketing segments should work together to ensure customers do not continue to dominate the market in both up and down phases as they have done in the 80's.

- to individually develop a diversity of markets in happy juxtaposition with other suppliers to give the buyer alternatives and decrease exposure of the seller.

- to be as fully informed as possible on the state of market demand in relation to supply by utilising the screen coal trading system (q.v.) as a component of marketing activity.

- to reinstate more balanced contract terms in those contracts which were varied to the sellers' disadvantage in the early 80's.

- to understand that the marketing of a non renewable resource, where the next tonne costs more to produce and the market is substantially price inelastic in the medium term, is not best dealt with financially on the basis of seeking competition destruction through the low price mechanism. Such policies as were pursued have demonstrated that the companies adopting them reduced their own profitability and all other suppliers simply met the market. Substantial losses to Australian national income occur when such policies ensue.

- to realise that the world's largest seaborne seller of coal is watched closely by all other countries and none will depress the price in times of difficulty much below whatever Australia's price is and that Australia may well be required to act as the second swing supplier to the USA and actually reduce production rather than reduce price to unstable levels. There is nothing novel or heretical in this approach. Many other industries reduce production in such circumstances e.g. the JSI, our best customer, varies steel output to assist in price stabilisation. Volume at all costs is a recipe for economic failure.

- to recognise the political and emotive overtones in the concern about greenhouse, acid rain and ozone reduction phenomena and be prepared to pass accurate information to customers on coal's position in contribution to radiative gas production.

- to note that the United States dollar remains the world's measure of energy value and where contracts may be written in other currencies that such should not be to the ultimate detriment of their Australian revenues despite their apparent attractiveness.

- to caution new corporations entering the business that new coal cannot be assumed to take the present price if it moves the supply/demand balance too far and that patient penetration of the market leads to sensible pricing and sensible contracts.

References

i) - Krupp Energiehandel, 1987 forecast 7-8% (10-11Mt) growth pa in 1988-1990.

- Calarco (November 1987) forecast 4.5% pa growth in 1986-2005, with a 22% growth in 1986-1990 (averaging 7.6 Mtpa in 1986-90)

- the US Energy Information Agency (April 1988) forecast a 3.6% pa growth to 2000 in its mid-case forecast, involving a 39% growth to 1995 (averaging 8.4 Mtpa in 1986-95).

- the IEA Coal Information 1988 forecasts OECD steam coal imports will grow 20% in 1986 - 90 (averaging 5.2 Mt pa) and 35% (averaging 8.7Mt pa) in 1990-1995.

ii) David L. Anderson An Analysis of Japanese Coking Coal Procurement Policies. The Canadian and Australian Experience. Centre for Resource Studies, Queen's University, Kingstone, Centario 1987, pp 222.

iii) Donald W. Barnett The Cost of Export Steam Coal - What Role New Players? Macquarie University, NSW 2109, Australia pp.23.

iv) Simpson, Spence and Young, Shipping brokers, London and Sydney - various statistical material.

v) Sinclair Knight & Partners, Consulting Engineers, Sydney. Various demand supply matrices prepared by Mr. V. Calarco and data from the MICAS cost analysis programme.

vi) Australian Coal Report & Barlow Jonker Pty Ltd 44 Margaret Street, Sydney. Various publications.

vii) Bain Refco Ltd, 225 George Street, Sydney. Private communication, 2/12/88.

International coal industry protectionism: the case of the United Kingdom

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In response to the declining competitiveness of their coal industries and increased energy security concerns following the sharp oil price rises in the 1970s, several industrialised countries now provide high levels of assistance to their coal industries. In particular, the United Kingdom, the Federal Republic of Germany, France, Belgium, Spain and Japan support high cost domestic producers. In 1987, total hard coal production in these countries was around 240 Mt, equal to 71 per cent of world hard coal trade in that year. Production costs are high in these countries compared with those of the major coal exporters, and much of their production would not be competitive at world prices. Estimates of the assistance provided to coal producers in these countries have been published recently by the International Energy Agency (1988a).

The insulation of large domestic markets from import competition constitutes a major barrier to growth in world coal trade. The extent of liberalisation of protected European markets and the pace at which such reform proceeds have important implications for the world coal trade outlook and the process of price formation.

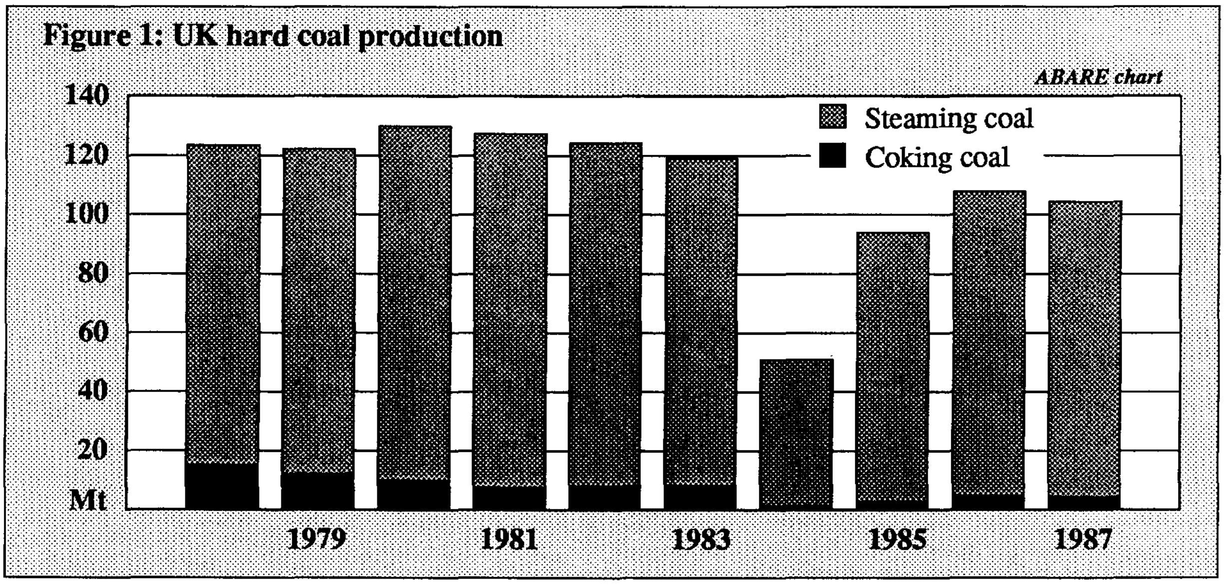
In this paper, results of research on the UK steaming coal industry, the largest of the protected markets, are presented. The research on the UK is part of a broader study of coal protectionism in major trading countries.

The UK Coal Industry

Since the mid-1950s successive UK governments have heavily subsidised domestic coal production and provided protection against import competition, first from cheap oil imports and later from imported coal (Turner 1985). Despite this assistance the UK coal industry has had a long history of financial losses.

In 1987 the UK industry produced 100 Mt of steaming coal and 4 Mt of coking coal (International Energy Agency 1988a), with around 85 per cent of production coming from underground mines. Almost all coal produced in the United Kingdom is produced by a state owned monopoly, the British Coal Corporation. The UK electricity sector is dominated by the Central Electricity Generating Board, also a state owned monopoly. The Board is British Coal's largest customer, accounting for 80 per cent of British Coal's steaming coal sales in 1987 (Prior and McCloskey 1988). The Board buys over 90 per cent of its steaming coal requirements from British Coal.

Compared with the production costs of the major coal exporters, UK costs are high and a large part of current production would be unprofitable at world prices. To maintain production at the current level, British Coal receives a substantial amount of assistance from a number of measures including input subsidies, deficiency payments and domestic purchasing quotas (International Energy Agency 1988a). The latter, the major form of assistance, takes the



form of a non-contractual agreement, known as the 'joint understanding', which governs British Coal's sales of steaming coal to the Central Electricity Generating Board (International Energy Agency 1988a). Under the agreement the Board purchases coal from British Coal at prices substantially above import parity. The average price paid by the Board to British Coal in 1987 was £42/t (US$69/t), compared with an average cif import price of US$41.44/t paid by other EC countries.

In response to declining competitiveness and heavy financial losses, the UK coal industry has undergone considerable structural change over the past decade. UK production has fallen from 130 Mt in 1980 to 104 Mt in 1987 (figure 1). The momentum of adjustment accelerated sharply following the 1984-85 coal strike, partly in response to decreased union power (Edwards 1988). Employment in underground mines has declined from 159 000 in 1983 to 87 000 in 1987. Substantial productivity gains and cost reductions have been achieved by workforce reductions, improved management practices, rationalisation of existing mine capacity - involving closing high cost mines, extending low cost mines and developing new mines - and by increased capital investment.

Measured productivity increased from an average of 2.5 t per worker per shift in 1984 to around 4 t per worker per shift in 1987 (Prior and McCloskey 1988). A significant proportion of this was undoubtedly due to the shedding of surplus, unproductive labour rather than increased worker productivity. While significant advances have been made, UK productivity is still low in comparison with the major coal exporting countries. Output per worker per shift in Australian underground mines was around 14 t in 1987 and around 35 t in opencut mines (Joint Coal Board 1988).

Average costs of production declined from £44.50/t in 1985-86 to £40/t in 1986-87. However, costs increased to an average of £41.50/t in 1987-88 (Prior and McCloskey 1988). Available operating costs data at the mine level for UK underground mines for 1982 and 1986 are presented in figure 2. Cost data for 1986 are also presented in 1981-82 prices. By way of comparison, cost data for Australian steaming coal production are presented in figure 3. Between 1981-82 and 1986, UK average costs increased from £36.82/t to £40/t. This represents a decline in real terms of around 12 per cent. Australian average operating costs, by comparison, declined in real terms by 25 per cent between 1983 and 1986.

Figure 2: UK mine operating costs

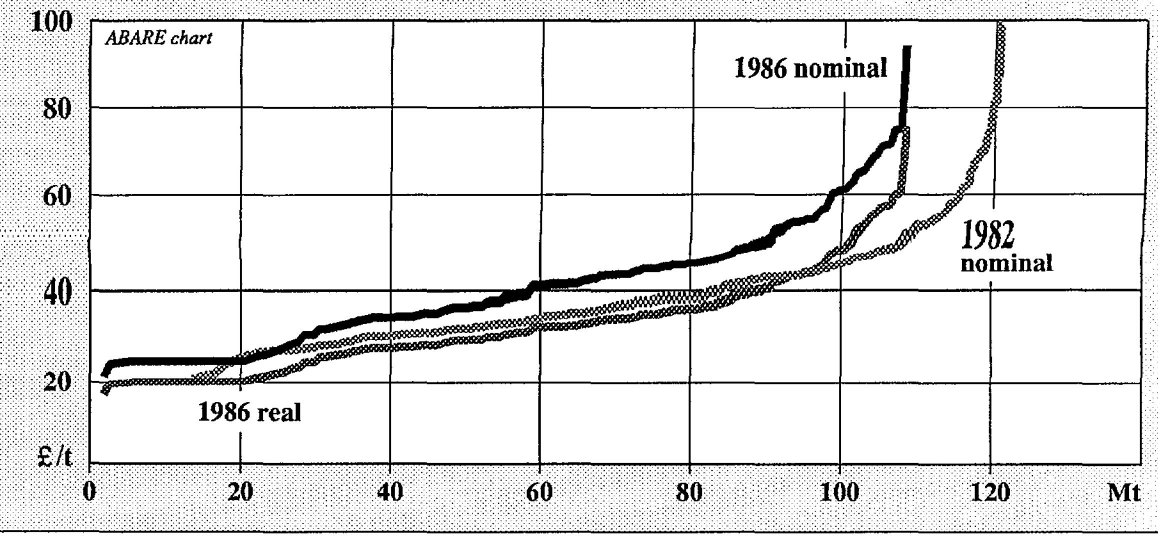


Figure 3: UK and Australian mine operating costs in 1986

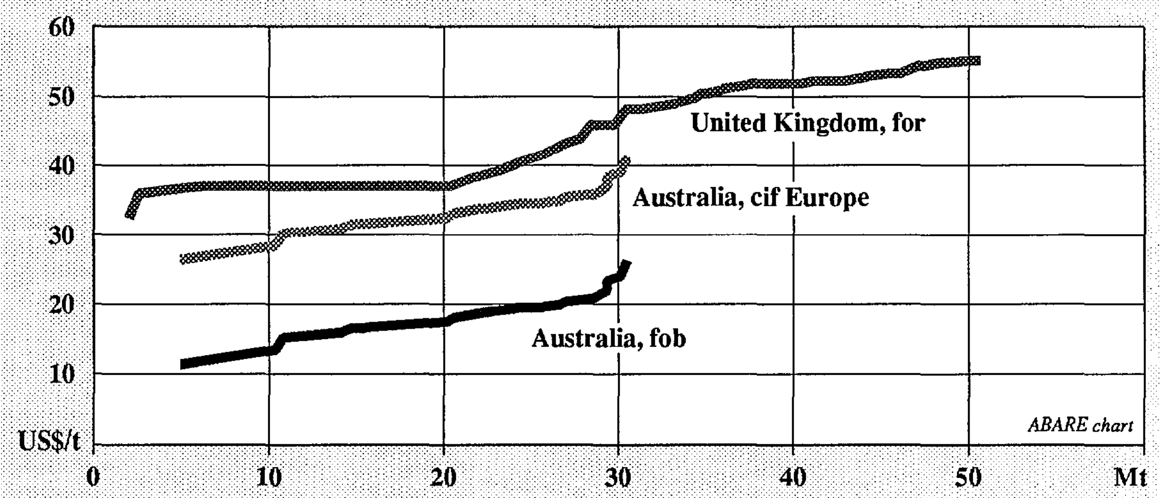
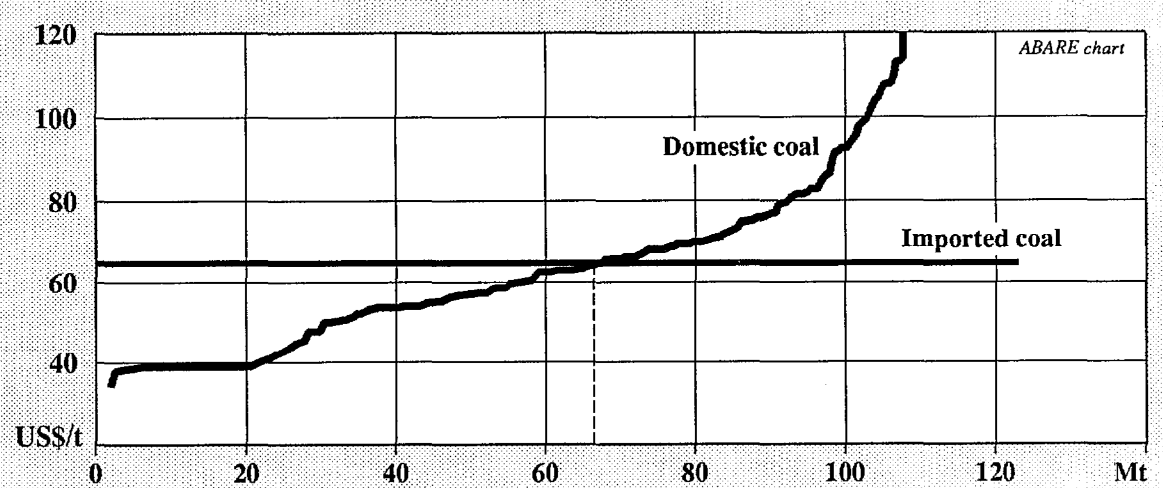


Figure 4: Cost of delivered coal in the United Kingdom in 1986

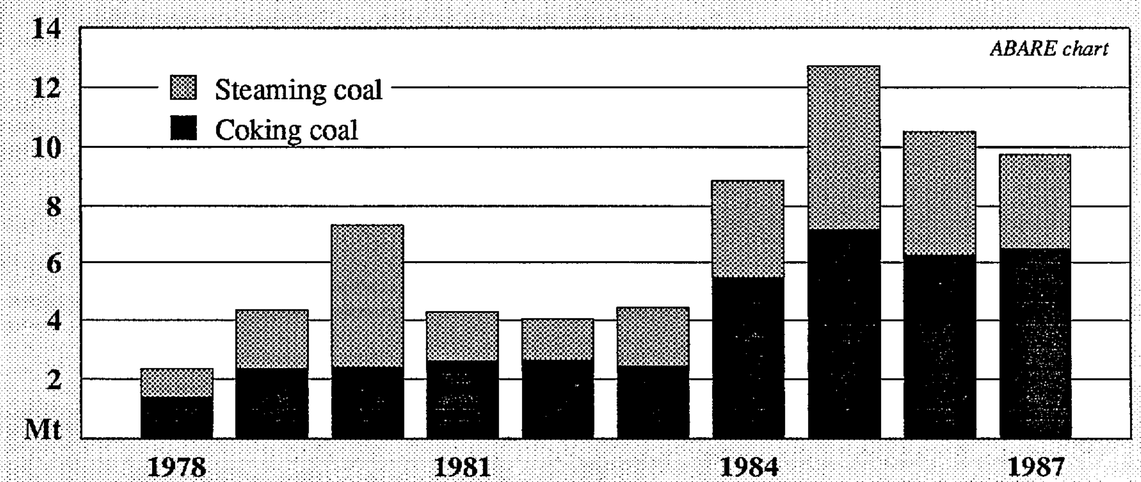


It is possible to obtain an estimate of how much of British Coal's output would have been competitive in a free market in 1986, the most recent year for which we have detailed cost information. In 1986 the average cif import price of steaming coal in Europe from all sources was US$45/t. At present, a large part of UK imports have to be transshipped from Rotterdam on relatively small ships because the United Kingdom does not have the port facilities to receive the large scale vessels used in international coal trade. Adding US$20/t for transshipment and delivery to inland power stations, the estimated delivered cost of steaming coal is around US$65/t. Note that many power stations, particularly those situated on the Thames, could obtain coal at a much lower delivered cost than this. Estimated delivered costs from domestic and imported sources are compared in figure 4, assuming an average delivery cost in the United Kingdom of US$2/t for domestic production. This comparison suggests that in the absence of assistance only about 66 Mt of British Coal's production, out of a total steaming coal production of about 103 Mt, would have been profitable in 1986. In a free market, the United Kingdom would have been importing around 37 Mt of steaming coal. In 1986 the United Kingdom imported only 4 Mt of steaming coal (figure 5).

This estimate is approximate and it is assumed that port facilities exist to handle this import demand. Available estimates indicate that UK import capacity is currently only around 20 Mt a year and most of these ports are unable to accept large vessels. However, if the United Kingdom had port facilities to accept large scale vessels, transshipment costs could be avoided and UK importers would face similar import prices to those paid by European consumers. In this case, an additional 16 Mt of UK production would have been uncompetitive in 1986. The poorly developed import facilities of the United Kingdom are to a large extent a legacy of protectionist policies.

A number of prospective developments have placed the future of the UK coal industry under considerable uncertainty. The UK government has announced an end to deficiency payments to British Coal and is insisting that British Coal achieve full financial independence by the end of this financial year (1988-89). For British Coal to make a profit at current (high) domestic prices, further mine closures and a further reduction in UK output may be required. More importantly, the UK government has announced its proposals for privatising electricity production (Secretary of State for Energy 1988). It is unlikely that current or future UK governments would enforce the 'joint understanding' on private electricity producers.

Figure 5: UK hard coal imports



Further, the European Community plans to implement a common European market in electricity by 1992. The United Kingdom already imports a small amount of electricity from France via a cable under the English Channel. If the 1992 proposal is implemented, the UK electricity sector will face increased competition from relatively cheap foreign sources of electricity. In this competitive environment, the profitability of a privatised UK electricity sector would depend on access to steaming coal at the lowest possible price.

British Coal argues that a significant proportion of the UK coal industry could compete in the longer term with imported steaming coal (British Coal 1986; Edwards 1988). It points to productivity increases and unit cost reductions that have been achieved over the past few years and the prospects for further cost reductions. British Coal also argues that the current low steaming coal prices are not sustainable in the longer term because the pound is currently overvalued and because major exporters are not earning market rates of return on investment at existing prices. Further, strong growth in world demand for steaming coal over the next decade will result in increased steaming coal prices. British Coal also argues that significantly increased UK coal imports would place upward pressure on world prices, reducing gains to importers. Since many UK mines are extremely deep and if closed could not be profitably reopened, British Coal argues that the UK government and the UK electricity sector should take a longer term perspective on the relative costs of using domestic as opposed to imported coal. British Coal has indicated its intentions to enter into long term contracts with electricity producers.

Consider the following scenario. Assume that the UK electricity sector is privatised at some time in the near future and that the choice between competing fuels and between domestic and imported coal supplies is entirely market determined. To simplify matters assume that British Coal continues its virtual monopoly on UK coal production. The outlook for UK coal imports will depend on the growth in UK coal demand, on relative movements in UK production costs and delivered import prices and on future government assistance policy. These factors are discussed in the next three sections of the paper.

The Outlook for UK Coal Demand

In 1987 the UK electricity sector accounted for around 85 per cent of total UK steaming coal demand. Electricity demand is assumed to depend on the level of real income and electricity prices. In the short run, changes in electricity demand are assumed to be fairly unresponsive to changes in electricity prices (that is, the price elasticity of demand is low in the short run). In the long run, empirical estimates suggest a price elasticity of demand of about unity (that is, a 1 per cent fall in price will result in a 1 per cent increase in demand). The income elasticity of demand for energy in a developed economy such as the United Kingdom is estimated to be around 0.7. Assuming an average rate of growth in real gross domestic product per person of around 2.5 per cent, and for the moment holding real energy prices constant, UK electricity demand is projected to increase at an average annual rate of 1.75 per cent over the next decade.

The share of coal fired capacity in total electricity generating capacity was around 61 per cent in 1986 (see table 1). In 1986, 67 per cent of total electricity production was derived from coal fired stations (see table 2). Fuel prices to UK power stations are summarised in table 3 for the period 1978 to 1986. Over that period, even though UK steaming coal prices were considerably above import parity, coal remained competitive with oil and

Table 1: SHARES OF FUELS IN UK ELECTRICITY GENERATING CAPACITY

Year	Coal	Oil	Gas	Nuclear	Other
	%	%	%	%	%
1986	61	22	0	11	6
1990	56	21	0	18	5
1995	56	22	0	17	5

Source: Based on data reported in International Energy Agency (1988b) and on unpublished sources.

Table 2: SHARES OF FUELS IN UK ELECTRICITY PRODUCTION

Year	Coal	Oil	Gas	Nuclear	Other
	%	%	%	%	%
1973	62	26	1	10	1
1978	65	18	1	13	3
1986	67	10	1	20	2
1987	71	8	1	18	2

Source: International Energy Agency (1988b).

Table 3: PRICES PAID FOR FUEL FOR ELECTRICITY GENERATION
On a heat equivalent basis

	Heavy fuel oil			
Year	Including tax	Excluding tax	Natural gas	Steaming coal
	£/t	£/t	£/t	£/t
1978	51.81	45.85	38.66	39.08
1979	59.27	52.71	46.50	45.04
1980	89.33	81.32	56.18	56.64
1981	112.40	104.14	119.63	66.59
1982	114.01	105.83	107.95	71.53
1983	125.78	117.60	109.13	75.59
1984	157.58	149.43	109.34	76.17
1985	173.55	165.40	129.20	81.26
1986	102.71	94.56	116.13	82.29

Source: International Energy Agency (1988c).

gas. The share of coal in total generating capacity would probably have been lower if the Central Electricity Generating Board's fuel choice had been unconstrained. The average share of coal for the industrialised European economies, excluding the United Kingdom, was only 26 per cent, even though coal prices over the period were on average lower than in the United Kingdom. Ideally, the implications for fuel choice in electricity generation of a removal of all distortions in relative fuel prices should be considered. In such a situation, the share of coal would likely decline, even with imports at world prices. This is beyond the scope of the present paper, but it is an issue to be addressed in the Bureau's ongoing research.

Assuming that average real coal prices paid by UK authorities are likely to decline because of increased import competition, it is likely that the rate of utilisation of coal fired plants will remain near capacity. Two new coal fired power stations, West Burton and Fawkes, are proposed for completion by 1995, which will raise coal fired capacity by 3.6 MW a year. Taking into account planned additions to oil and nuclear capacity (International Energy Agency 1988b, p.I.155), the share of coal in total generating capacity would be around 56 per cent by 1995. On this basis, steaming coal demand in electricity generation is projected to increase by an average rate of 1.7 per cent a year over the period to 1995. Assuming a similar rate of increase for industrial uses, UK demand for steaming coal is projected to be around 115 Mt in 1995, compared with 100 Mt in 1987.

Lower UK coal prices due to policy reform and continued problems with nuclear power may result in a higher share of coal in total capacity, and stronger growth in steaming coal demand. However, increased environmental concerns may result in a decline in both the utilisation of existing coal fired capacity and reduced investment in coal fired capacity. Environmental concerns may increase the attractiveness of natural gas.

<u>The Outlook for World Coal Prices</u>

The outlook for world steaming coal production, demand and prices is presented in ABARE (1989). Taking into account expected oil price movements and a projected small decline in the share of coal in electricity generation, an annual rate of increase in demand of 2.8 per cent is projected. This suggests that world demand for steaming coal, excluding demand from centrally planned economies, will be around 1700 Mt in 1995, 28 per cent above that in 1987.

The very large economically viable reserves of steaming coal suggest that long run supply is highly responsive to changes in price. Over time, increases in input prices and depletion effects will tend to raise production costs. Productivity increases due to changes in labour practices, improvements in mining techniques and investment in new, improved capital will decrease unit costs. Over the past decade, productivity improvements have outweighed depletion effects, with the result that real operating costs have fallen in the major exporting countries (Barnett 1985; Long 1986). In this study the conservative assumption that average costs will remain constant in real terms has been made. Most of the increase in production over the next decade will come from large scale capital intensive mines embodying the most recent technology and having relatively low operating costs. Marginal production costs are therefore likely to increase only moderately.

Estimates of supply elasticities for major coal producing countries have been obtained by fitting linear supply functions to available published cost data. The estimated supply functions indicate that a 5 per cent increase in real steaming coal prices, compared with those prevailing in 1986, would be required to induce the necessary supply to satisfy the projected increase in steaming coal demand. Assuming that freight rates remain constant in real terms, the Rotterdam real price of steaming coal in 1995 is projected to be around US$47.25/t, compared with US$45/t in 1986.

The Outlook for UK Production Costs

Major determinants of the future viability of the UK coal industry are the extent of further cost reductions that can be achieved in existing mines, the extent to which production from existing low cost mines can be extended and the scope for developing new low cost mines.

British Coal aims to achieve productivity growth of over 40 per cent during the period 1985 to 1990, with unit cost reductions of a similar magnitude (Prior and McCloskey 1988). The projected productivity increases are based on further mine closures, continued investment in new and existing low cost mines and the introduction of a six day working week. It is assumed that a six day week would increase output at constant average costs by around 15 per cent.

Extraction costs rise sharply with increased mine depth. A high proportion of UK mines are old and relatively deep. As an indication of the severity of depletion effects in the UK industry, mine level costs data for 1981-82 and for 1986 indicate that of the 32 mines with operating costs above £55/t in 1986, 16 had operating costs below £40/t in 1981-82.

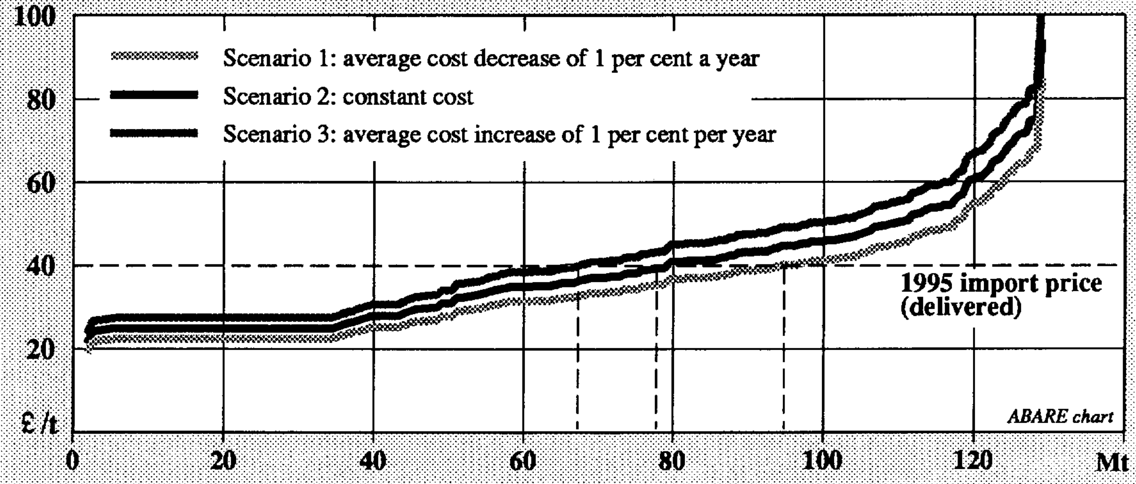
This suggests that substantial investment and technological improvements will be required simply to maintain existing costs. British Coal is continuing to make losses (British Coal 1988), so that more high cost mines are likely to be closed over the next year or so. British Coal may have difficulty raising the funds necessary to finance the continuing large scale investment program necessary to both maintain current production levels and costs. The continuation of low profitability is likely to constrain British Coal's ability to invest substantially in upgrading existing capacity, with the result that British Coal may have to channel its investment funds into its lowest cost mines. This may result in a substantial contraction in the number of operating mines in the United Kingdom.

In 1986-87, underground production was 88.7 Mt and opencut production was 14.6 Mt (Prior and McCloskey 1988). Expansion of the lower cost, profitable opencut sector would significantly reduce British Coal's average costs. However, the opencut sector faces major environmental constraints which may limit future output (Grimshaw and Smith 1988). In this analysis a small increase in opencut production to about 16 Mt in 1995 is assumed.

New mine developments likely to come on stream involve a total of around 16 Mt a year (Prior and McCloskey 1988). The Selby complex, designed to produce around 12 Mt at an average cost of around £25/t, is expected to be fully operational by 1995. The only other new mine expected to be completed before 1995 is Ashfordby, with a potential capacity of around 3.6 Mt. In addition to new mines, major expansion programmes are currently underway which should add around 3 Mt of capacity at an average cost of around £30/t (Prior and McCloskey 1988).

In the absence of a necessary, detailed analysis, three scenarios for UK operating costs are assumed: an average rate of decrease of 1 per cent a

Figure 6: UK coal supply scenarios



year (scenario 1), constant average costs (scenario 2) and an average rate of increase of 1 per cent a year (scenario 3). The resulting UK supply schedules are presented in figure 6. The continued poor profitability of the UK industry, strong depletion effects and relatively limited resources (in comparison to the major exporting countries) suggest that scenario 3 is the most likely.

Potential UK Imports

The analysis of the outlook for world steaming coal demand and production indicates a 1995 cif import price for steaming coal at Rotterdam of US$47.25/t (in 1986 dollars). Inland rail freight rates in the United Kingdom should decline sharply as increased import volumes would allow more favourable rates to be negotiated. Therefore, a transshipment and inland delivery cost of US$15/t to inland power stations has been assumed. Assuming an average exchange rate between the pound and the US dollar of 1.55, the delivered import price to inland UK power stations is projected to be around £40/t (US$62/t) in 1995.

Projected UK imports under the three scenarios are presented in table 4. Assuming no relocation of UK power plants, and in the absence of assistance to the UK coal industry, UK imports would be 17 Mt under scenario 1, 35 Mt under scenario 2 and 49 Mt under scenario 3. While it is not likely that import capacity will be sufficient to meet the high import figures by 1995, the potential cost savings provide a very strong incentive to invest in import infrastructure. Further, there are strong economic incentives to

Table 4: UK COAL IMPORTS IN 1995

US$/£	Scenario 1	Scenario 2	Scenario 3
	Mt	Mt	Mt
1.55	17	35	49
1.60	18	37	51
1.50	11	27	41

locate new power plants on coastal sites. In a competitive electricity market, plants at coastal locations are likely to have a large cost advantage compared with inland power stations. Therefore, in the longer term a gradual relocation of UK power stations to coastal areas would be expected.

While the 'joint agreement' is unlikely to be imposed on a private electricity sector, it is possible that future UK governments will provide direct budgetary assistance to the UK coal industry to facilitate 'adjustment'. While this is unlikely to ensure the continued existence of unprofitable mines in the long term, it will have the effect of slowing the required adjustment in the UK industry and will slow the rate of growth in UK imports. The costs of continued assistance to high cost mines in an effort to ameliorate adjustment costs is likely to be high. Alternative policy options should be explored.

Implications for World Trade

UK consumption of steaming coal is large relative to the existing world trade in steaming coal. Liberalisation of the UK market would provide a significant stimulus to the development of world coal trade. Any increase in world prices as a result of increased UK imports is likely to be confined to the very short term, given the high responsiveness of world steaming coal supply to changes in price and the small share of UK demand in total world demand for steaming coal.

Australia's potential share of the UK market will depend largely on the cost competitiveness of Australian coal. Australia was one of the lowest cost suppliers of steaming coal to the European market in 1987 and supplied 24 per cent of UK steaming coal imports and around 20 per cent of European steaming coal imports. ABARE's analysis of the supply outlook for the major steaming coal suppliers suggests that South Africa, Australia, the United States and Colombia will supply most of the future UK demand. Given relative fob costs, provided that freight rates do not increase substantially, Australia should maintain its share of the UK market on the basis of relative delivered costs. While South Africa is likely to be the lowest cost supplier to the UK market, supply diversification policies and politically motivated restrictions on imports of South African coal would tend to favour Australia. Should freight rates increase significantly, however, Australian coal will be less competitive in the UK market.

Increased exposure to import competition is likely to result in a significant contraction of the UK coal industry and increased imports. The rate of increase in imports will be determined by investment in coal ports in the United Kingdom. Under all scenarios considered, a large viable UK industry would survive liberalisation. The surviving industry may be an important factor in undermining coal protectionism in other European countries. Free trade in electricity between EC members ideally requires common taxes and subsidies on fuel and other inputs to electricity generation. Significant reductions in UK assistance would add increased impetus to the achievement of reduced assistance to other European coal industries.

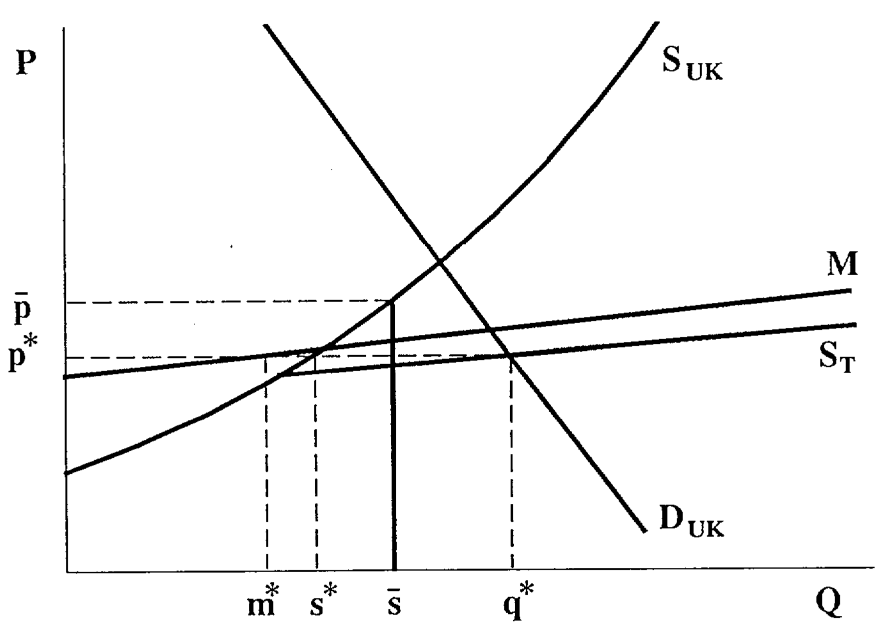
Appendix

ANALYTICAL FRAMEWORK

The basic framework of analysis is shown in the following diagram. The UK coal supply schedule is denoted by S_{UK}. The supply schedule indicates the quantity of coal that the UK coal industry could profitably supply at each price. The position of the supply curve at a point in time depends on factors such as productivity, input costs, geological conditions and the stock of capital. The slope of the curve depends on resource availability, the range of costs across existing mines, and on the proportion of fixed and variable factors of production. The UK demand schedule is denoted by D_{UK}. The demand schedule indicates the quantity of steaming coal demanded by electricity producers and industrial users at each price. The position of the schedule depends on the price of substitute fuels, on the stock of coal fired generating capacity and on the demand for electricity, which in turn is assumed to depend on the level of real income (real gross domestic product) and the level of electricity prices relative to the general price level.

UK electricity demand can be met either from domestic production or from imports. The supply of imported steaming coal to the United Kingdom is denoted by the schedule M. UK import supply is equal to the difference between the demand for and supply of steaming coal in the rest of the world. If the United Kingdom were a small country, in the sense that changes in UK supply and demand had minimal impacts on world price, then import supply to the United Kingdom would be infinitely elastic; changes in UK import demand would not affect world prices. For the moment it is assumed that the import supply schedule is positively sloped. The position of the schedule and hence the price of a given quantity of imports will depend on demand and supply conditions in the rest of the world.

Total supply of thermal coal to the UK market is equal to the sum of domestic plus imported supplies, and is denoted by S_T. The free market price in the United Kingdom is determined by the intersection of the demand and



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total supply schedules and is equal to p*. At p*, total demand for steaming coal is equal to q*, domestic production is s* and imports are equal to the difference between q* and s*. In a free market, domestic consumers pay the same price for domestic coal and imported coal.

The joint understanding between British Coal and the Central Electricity Generating Board has the effect of fixing domestic supply at $\bar{s}$ and restricting exports to q* - $\bar{s}$. Domestic producers are able to obtain a price higher than the price of comparable imported coal. Notice that since $\bar{s}$ is less than total demand, demand greater than $\bar{s}$ and any incremental demand can be met at the import price. Domestic production in the United Kingdom is greater than it would be in the absence of this contract.

The Supply of Imports to the United Kingdom

In this section the import supply function and its likely position in 1995 are estimated. Indexing coal exporting countries by 'j' and coal importing countries by 'i', define the UK import supply function as:

$$(1)\quad M_{UK} = \sum_j [s_j(p^*, c^*) - D_j(p^*, p_o^*, y_j)] - \sum_i [D_i(p^*, p_o^*, y^*_i) - S\ (p^*, c^*)]$$

where p* denotes the world price (delivered to Rotterdam), p_o^* denotes the price of other fuels (mainly oil), y denotes real income, and c denotes productivity and geological factors which affect supply costs. Consider the slope of this function,

$$(2)\quad \frac{dM_{UK}}{dp^*} = \frac{1}{p^*}\ [(\sum_j \epsilon_j s_j + \eta_j\ D_j) + \sum_i (\eta_i\ D_i + \epsilon_i s_i)],$$

where the ϵ represent elasticities of supply with respect to price in the rest of the world and the η represent elasticities of demand. In equation (2) it is assumed that the effects of changes in world price of steaming coal on aggregate real incomes are sufficiently small to be ignored. World supply and demand data, excluding centrally planned economies, are summarised in table 5. For present purposes, and without introducing serious bias, it can be assumed that elasticities of demand are similar in all countries. Estimates of supply elasticities are obtained by fitting linear supply functions to available published costs data for South Africa, Australia and the United States the major potential suppliers to the UK market (table 6). These estimates relate to the long run. For the short run, much lower supply and demand elasticities are assumed. The assumed parameter estimates are summarised in table 2. Expressing equation (2) as an elasticity of import supply gives:

$$\eta s \equiv -\ (\frac{dM_{UK}}{M_{UK}}\ /\ \frac{dp^*}{p^*}) = \frac{[\Sigma_j(\epsilon_j s_j + \eta_j D_j) + (\Sigma_i \eta_i D_i + \epsilon_i s_i)].}{M_{UK}}$$

Table 5: WORLD STEAMING COAL PRODUCTION AND CONSUMPTION IN 1986 Excluding centrally planned economies

Region	Production	Consumption
	Mt	Mt
United States	657	629
Canada	9	12
Western Europe	74	150
Australia	79	37
South Africa	160	112
India	140	140
North Asia	38	103
Rest of world	47	42
Supply from centrally planned economies	21	-
Total	1 225	1 225

Source: International Energy Agency (1988b).

Table 6: LONG RUN SUPPLY PARAMETERS USED IN SIMULATIONS(a) Operating costs, fob

Country	a	Average cost	b	Marginal cost	Elasticity of supply
United States	38	40	0.006	42	10
Australia	17	23	0.15	29	2.4
South Africa	15	17.5	0.03	20	4.2
Canada	30	34	0.9	38	4.7
Colombia	20	21	2.0	38	2.1

(a) Linear supply curves of the form $p = a + bq$ are fitted to 1986 data. The high cost 'tail' of the supply curves for individual countries are eliminated by this method. It is assumed, in effect, that these mines will go out of production in the longer term.
Sources: Estimates are based on data in International Energy Agency (1988b) and ABARE Australian mine level costs data.

Assuming a long run elasticity of demand of 0.8 for all countries (similar to an estimate used by Freebairn 1988) and using our estimated long run supply elasticities, a long run estimate of η_s of around 2000 is obtained.

This implies that a 10 per cent increase in UK coal imports would in the long run increase world prices by only around 0.005 per cent. If the United Kingdom were importing 50 Mt of steaming coal, a 10 per cent increase in UK coal imports would increase world prices by only 0.06 of a per cent. It follows that in the long run the United Kingdom is a price taker on world markets.

In the short run the high fixed component of mine costs and the long development phases of coal mines limit the responsiveness of coal supply. Moreover, the demand for coal is likely to be unresponsive in the short term as substitution possibilities are limited by existing generating capacity and technological considerations. Assume that the short run supply elasticity is, say, one-fifth of the long run supply elasticity: that is, it takes five years for supply to fully adjust to a price change. Assume demand elasticity in the short run is 0.15. The short run elasticity of import supply facing the United Kingdom is therefore equal to around 400. In this case a 10 per cent increase in coal imports would raise world prices by around 0.025 per cent.

The United Kingdom is too small in relation to total world production and consumption and world supply is too responsive for changes in the United Kingdom to have a significant impact on world prices.

References

Australian Bureau of Agricultural and Resource Economics (1989), 1989 Outlook for Australian Mineral Resource Exports to 2000, AGPS, Canberra.

Barnett, D. (1985), The Supply of US Thermal Coal Exports to 2000, International Energy Agency Coal Research, London.

British Coal (1986), The Coal Industry: Memorandum 2, in UK House of Commons Energy Committee Report, Her Majesty's Stationery Office, London.

___ (1988), Report and Accounts, 1987-88, Her Majesty's Stationery Office, London.

Edwards, M. (1988), Operations review - an overseas experience. Paper presented at the 1988 Australian Coal Conference, Gold Coast, 17-21 April.

Freebairn, J. (1988), Consequences of Adopting Commercial Rail Freight Rates, Centre for Policy Studies, Monash University, Melbourne.

Grimshaw, P. and Smith, M. (1988), 'Open cut coal mining in Britain', Mining Magazine July, pp.44-55.

International Energy Agency (1988a), Third Coal Review, Organisation for Economic Cooperation and Development (OECD), Paris.

___ (1988b), Coal Information 1988, OECD, Paris.

___ (1988c), Energy Prices and Taxes: 1st Quarter 1988, OECD, Paris.

Joint Coal Board (1988), Black Coal in Australia 1986-87, Sydney.

Long, R. (1986), The Availability and Cost of Coal in South Africa, International Energy Agency Coal Research, London.

Prior, M. and McCloskey, G. (1988), Coal on the Market: Can British Coal Survive Privatisation, Financial Times Information, London.

Secretary of State for Energy (1988), Privatising Electricity, Her Majesty's Stationery Office, London.

Turner, L. (1985), Coal's Contribution to UK Self-Sufficiency (2nd edition), Policy Studies Institute and Royal Institute of International Affairs Joint Energy Program, Energy Paper No. 9, London.

Gold: sustainable growth?

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History of Gold Production

Evidence of gold mining goes back for over 5000 years, the early mining consisting mainly of simple alluvial and eluvial operations in what is now Iran. The gold was used in its naturally occurring condition for ornamental and decorative purposes. Several estimates of the cumulative world production have been made, the most likely being 110 000 tonnes to the end of 1988 (Gold: World Supply and Demand, 1982; also, Milling-Stanley 1987). The accelerating rate of production is significant: in over 5000 years, until 1900, an estimated 25% of the total was produced; however, with advances in exploration, mining and treatment methods, the remaining 75% has been produced in the last 88 years. An estimated 90% of all gold mined is still available as jewellery and ornaments, coins, gold bars, etc.

Australia's Gold Mining Industry

Since the start of Australian gold production, there have been three peaks of output in the industry (Fig. 1). The first was immediately after the discovery of gold, when easily mined, rich, alluvial and eluvial deposits in Victoria and New South Wales yielded high returns from 1852 to 1860. The second was from 1899 to 1908, when Victoria's production coincided with high output from Western Australia. The third, minor peak was from 1931 to 1941 because of a resurgence of gold mining in the 1930s depression. The present upsurge in production started in 1981 and has already passed the previous record annual production of 119 tonnes in 1903, with an estimated output of 152 tonnes in 1988 (Figs 1 and 2). The main reason for the great increase in production was the 'discovery' of new economic resources, mostly in deposits which had been abandoned as uneconomic many years ago. The economics of exploiting such deposits changed for the following reasons:

- The large increase in the price of gold in the late 1970s.
- Greatly improved mining equipment, transport, and blasting materials, which have lowered costs.
- The realisation that deposits which in the past were mined selectively as individual lodes or small groups of lodes could be mined profitably as a whole using modern open-pit mining methods.

AUSTRALIAN MINE PRODUCTION OF GOLD

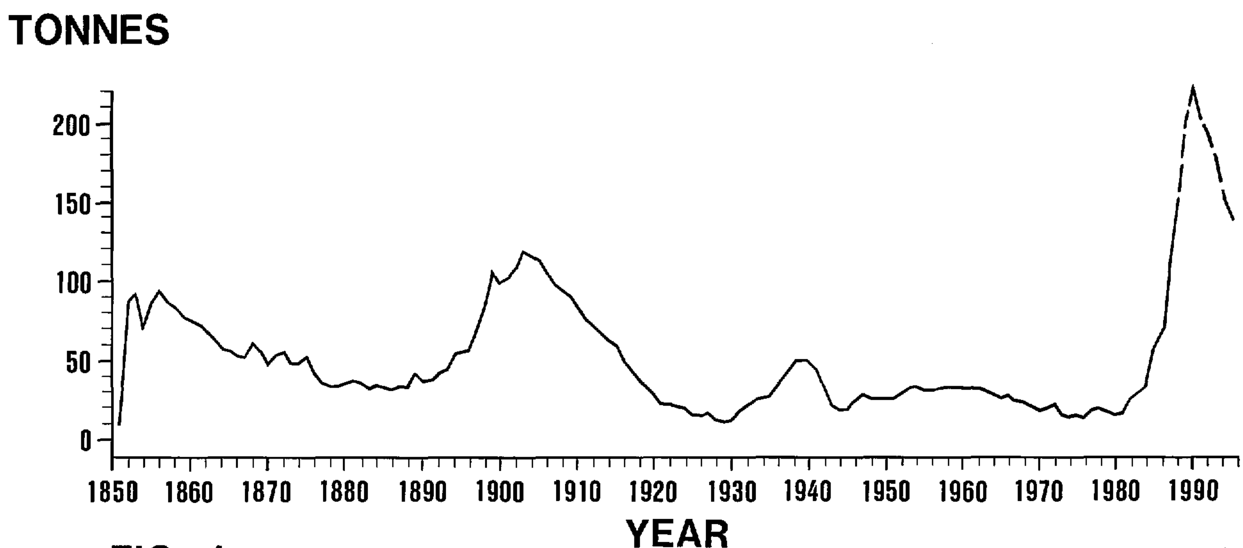

FIG. 1

AUSTRALIAN GOLD PRODUCTION AS A PERCENTAGE OF WORLD OUTPUT

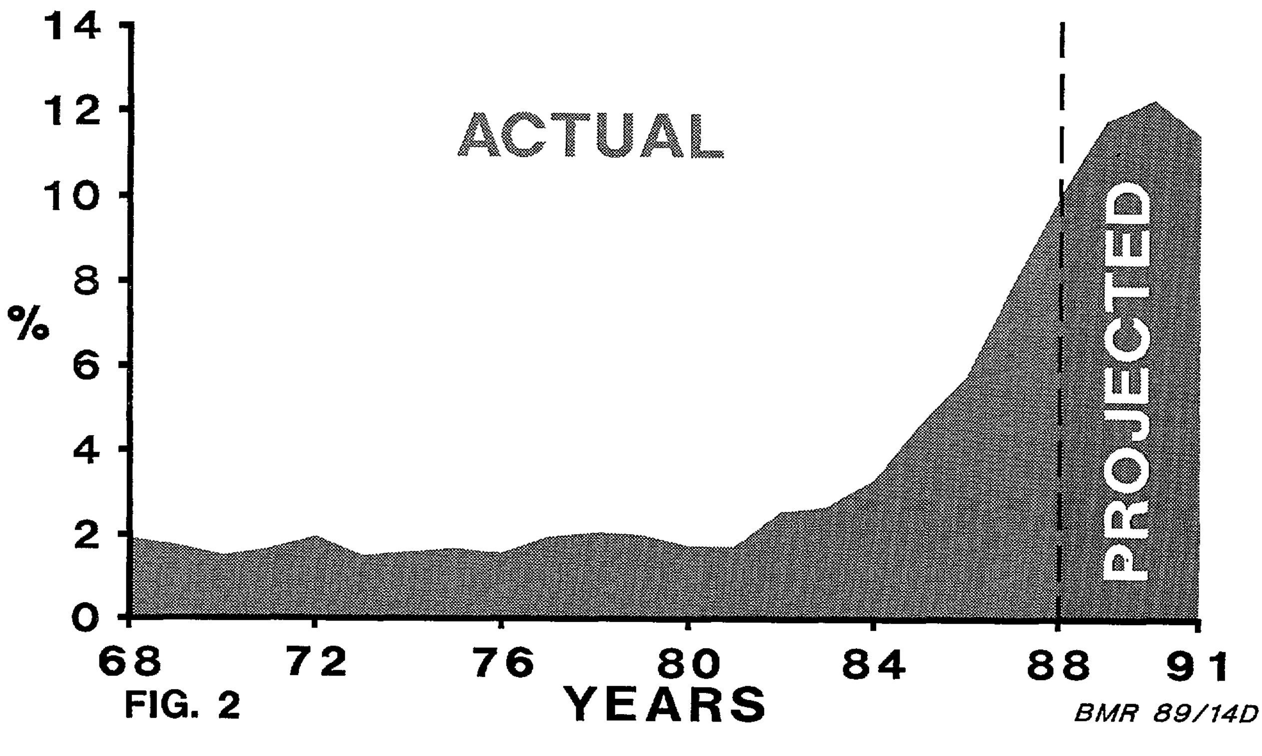

FIG. 2

- Improved treatment technology such as the carbon-in-pulp method of extracting gold which has allowed the economic treatment of ore considered too low-grade in the past. Carbon-in-pulp technology has also allowed efficient extraction of gold from oxidised ore. The success of carbon-in-pulp technology is well illustrated by the fact that numerous tailings dumps have been, and are being, re-treated to extract gold left behind by previous treatment.

- The use of heap-leach technology which has allowed the economic extraction of gold from very low-grade ore without fine crushing. This method of processing has been largely responsible for the rapid growth of the United States gold mining industry.

- The development of modern rapid geochemical analytical techniques, allowing economical delineation of small differences in the gold content of ores.

- The availability of gold loans which made finance for developing mines readily available to miners. The loans provide the option of higher financial gearing to Companies and, because they are provided at an agreed gold price, partially eliminate the risk of a downturn in the price of gold for the duration of the loans.

Other factors which encouraged exploration were:

- The favourable gold price compared with the low prices of many other mineral commodities in the mid 1980s.

- The low capital cost of gold treatment plant compared with plant to treat many other metallic ores.

- The comparative simplicity of marketing gold compared with most other mineral commodities.

- The tax-free status of gold mining.

Australia's Future Gold Production

Assuming that the economics of gold production remain constant in real terms, BMR's projections of future output, from known gold resources and on present and planned capacities, indicate that Australian annual gold production will peak in 1990-91 at about 220 tonnes, and thereafter will decline. This forecast assumes the opening of about 40 new mines, now in development or in advanced stages of exploration, during this period and allows for the closure of about 130, mostly small, mines (over 170 mines were operating in 1988) because of exhaustion of economic resources. This projection, shown in fig 1, does not allow for future gold discoveries.

Will new discoveries allow Australia to sustain the current level of gold production or, after attaining a peak output in 1990-91, will there be a steady decline to pre-1980 levels? The answer lies in a number of factors.

Price of Gold. There is no reliable way of predicting the future price of gold; proof of this difficulty is provided by the widely differing projections made by analysts in the past. While the price of gold is influenced by a demand/supply relationship, a number of factors make gold price movements different from those of most other mineral commodities. Annual production and sales of gold are only a small percentage of the total stocks of gold, reducing the effect that new supply has on price. Because of gold's monetary role, exchange rate and inflation rate movements are important determinants of gold prices, especially in the short term, as are price movements in other precious metals, crude oil, and other commodities.

Milling-Stanley (1988) estimated that in 1987 total gold supply, including sales from the Eastern Bloc, net official sales and recycling of scrap, amounted to 2008 t. Many countries are actively exploring for additional reserves and expanding present capacity; several countries such as Papua New Guinea, Philippines, Indonesia and Brazil are on the verge of becoming important producers. Projections by The Gold Institute (1988) indicate that total world mine annual production of gold will rise by about 16% in aggregate to a total of about 2100 t by 1991.

Demand for gold is generally of two types - fabrication demand and investment. Demand for fabrication in 1987, including its use for manufacture of jewellery, electronics, dentistry, coins and medals, and other uses, amounted to 1589 t, leaving an estimated surplus of 419 t to be taken up for investment or bar hoarding. Use of gold for fabrication, especially for jewellery and by the electronics industry, has been strong in all parts of the world except Africa, total demand increasing by 68% from 1980 to 1987 (Milling-Stanley, 1988). Future gold demand, which is a major determinant of the price of gold, depends mainly on the broad economic outlook, that is, strong economic growth will encourage demand for gold for fabrication and equally, economic growth and rising inflation will encourage demand for investment (Etheridge, 1984). Gold is perceived as a hedge against inflation and as an insurance during depression. Perhaps the most encouraging indication of gold's value for investment is that during the past six or so years, the world price of gold has not been subject to the wild fluctuations caused by political upheaval during the first few years after the price was decontrolled in 1968. While some doubt must be cast on the world's long term capacity for absorbing the increasing gold production at current price levels, over the next three to five years the price of gold is likely to remain stable if gold is primarily regarded as a store of value, a more tangible currency than paper money. These influences affect the world price of gold, which is quoted in US dollars. The price received by Australian producers is determined by the exchange rate of the Australian dollar against the United States dollar.

To sum up, assuming that the world economy remains sound, demand for gold for fabrication should continue to expand, and demand for investment and bar hoarding should remain strong for perhaps another five years.

Maintaining low costs of production. Between 1900 and 1983 the Australian gold mining industry was able to increase mining efficiency from a rate of 200 to 1540 tonnes of ore per man-year. In the same period gold production per man-year increased from 4.5 kg to 71.5 kg, despite a fall in average grades treated, from 24 g/t to 4.8 g/t (Brodie Hall, 1984). Although data are not available it is likely that productivity has further increased since 1983. To continue the improvement in efficiency, will require continued research and development. Examples of recent advances made by research to reduce costs of production are improvements to the heap-leach method, carbon-in-pulp and the discovery that gold ore can be processed with saline ground waters, typical of most parts of the interior of Australia.

Taxation. The tax-free status of the Australian gold mining industry is due to end in 1991. The reintroduction of taxation may increase costs on at least parts of the industry, but there may be positive effects as well. For example, offsetting deductions will be available, and introduction of imputation on dividends from gold mining shares will lessen the impact of corporate tax.

Discovery of additional resources. In 1980, Australian economic demonstrated resources of gold were estimated by BMR as 332t. Eight years later, after an output of 529t, the estimate is 1378t. In 1988 alone, 13 new discoveries of gold mineralisation at or near known ore deposits were announced and resources were increased at numerous operating mines; the largest increase published during the year was for Telfer mine, WA, where the previous year's estimate of contained gold was doubled, from 41.6 t to 90.2 t. The success of exploration reflects increased exploration expenditure. Between 1980-81 and 1987-88, annual expenditure on private exploration for gold in Australia increased fivefold in constant dollars, to $581 million; in 1987-88 gold accounted for 73% of the total private sector exploration expenditure for minerals other than petroleum and oil shale.

In the past 20 years, many discoveries of gold have been made in Australia. In addition, known ore which was considered uneconomic in the past has been successfully exploited using modern mining and treatment technology. Exploration successes include delineation of additional ore at known orebodies, discovery of separate orebodies close to known deposits, and discovery of new deposits, either in recognised goldfields or in areas previously unsuspected of hosting gold mineralisation. Most of Australia's increased gold production has come from mineralisation not regarded as ore in the past or from extensions of ore found during development and mining of reopened deposits. Several of the new discoveries are types that cannot be matched with types of known orebodies in the rest of the world.

Discoveries of new geological types of gold deposits are a bonus to the mining industry because they provide conceptual models for future exploration for that type of deposit. Olympic Dam, about 500 km north-northwest of Adelaide, is a very large copper-uranium-gold deposit of a type not known elsewhere in the world. Similar mineralisation has been found elsewhere in the region but is not economic. Boddington, about 140 km southeast of Perth, is a lateritic deposit, overlying an Archaean greenstone basement. Although little is known of the genesis of the deposit, it appears to be a type new in Australia and perhaps, in the world. The discovery of Boddington led directly to the discovery of the adjoining deposit, Hedges. The presence of gold mineralisation in laterite overlying greenstones is considered highly significant because this geological combination occurs over vast areas in Western Australia. Coronation Hill, about 220 km southeast of Darwin, is a hydrothermal deposit in interbedded acid volcanics and clastic sediments. The ore contains gold and platinum-group metals and in places, uranium. Although the origin of the Coronation Hill deposit is not fully understood, it is believed to be unlike any other known gold deposit; mineralisation in the nearby El Sherana mine and, perhaps, other parts of the region may have a similar origin. Jabiluka, about 230 km east of Darwin, is primarily a uranium deposit similar to others of the Alligator Rivers uranium province, but a medium-sized gold orebody occurs within the uranium ore. Other new discoveries such as Pajingo, 50 km southeast of Charters Towers, Qld; Starra, about 150 km southeast of Mount Isa, Qld, and Temora, 15 km north of Temora, NSW, although not unusual types, have greatly enhanced the prospectivity of the areas in which they were found; Telfer, about 400 km southeast of Port Hedland, WA, is not a new type of deposit (it is in fact geologically similar to some Victorian and some other Western Australian gold deposits) but was the first gold discovery of this type in the region, possibly indicating the presence of a new gold province.

The remarkable rate of success achieved by exploration companies in the past ten years is likely to continue, albeit perhaps at a slower rate, despite the fact that most of the comparatively easily found gold deposits have been discovered. Future exploration for less easily discovered, mostly subsurface, deposits will require the most advanced technology and will be expensive. Nevertheless, many parts of Australia are still regarded as highly prospective for gold by the mining industry, and the accumulation of geological knowledge acquired from previous exploration and from systematic geological investigations by BMR and State geological surveys will facilitate the search.

The most prospective region in Australia is probably the Yilgarn Block, WA, where vast areas of greenstone, host rock to the Golden Mile deposits of Kalgoorlie, are still untested, or have received only cursory attention, because they are partly or wholly covered by thin superficial soils. Other prospective regions are the Pine Creek Geosyncline and Tennant Creek areas, NT, eastern Queensland, and eastern New South Wales. The resumption of mining at the previously highly productive Bendigo goldfield and at Stawell may indicate the start of more active exploration and mining in Victoria which was, for a period, Australia's leading gold-producing state. Although Tasmanian gold production is almost entirely a by-product of base-metal mining, Tasmania is also prospective for gold mineralisation as such.

Conclusion

Past peaks of gold production in Australia were mainly the result of discoveries of easily mined gold or favourable prices. The reasons for the present, much higher production level, are far more complex, including the lowering of costs of production by advanced mining and treatment technology and a sustained favourable price range, which led to a favourable reassessment of many abandoned deposits, and, with improved exploration techniques, successful exploration for less easily discovered ore. Whether Australia can maintain a high level of production will depend partly on a favourable gold price level, partly on continued advances in mining and treatment technology to reduce costs, but above all, on successful exploration. Australian geoscientists have made enormous advances in the understanding of the geology of Australia and in the processes of ore genesis. Exploration techniques are constantly being improved, and a variety of geological, geophysical, remote-sensing, and geochemical methods is used to identify prospective geological environments and deposits within them. Easily discovered deposits exposed at the surface were found 100 years ago or more, less easily discovered deposits mostly in the last 40 years; future challenge lies in discovery of the hidden, more difficult to find orebodies to supply gold in the future. The Australian gold mining industry has the technical expertise to sustain the current rate of gold discovery. Although the production rate will probably decline within the next five years as the many small open-pit mines reach the end of their economic life, output is unlikely to return to the 1980 level of 17 t/year; it is more likely to remain above 80 t/year to the end of this century.

References

Brodie Hall, L., 1984 - Opening Address. Proceedings of AusIMM Regional Conference, 9-11 October 1984, Kalgoorlie.

Etheridge, W.A., 1984 - The Economics of Gold. Proceedings of AusIMM Regional Conference, 9-11 October 1984, Kalgoorlie.

Gold: World Supply and Demand, 1982. Australian Mineral Economics Pty Ltd, Sydney.

Milling-Stanley, G., 1988 - Gold 1988. Consolidated Gold Fields PLC, London.

World Mine Production of Gold 1987--91, The Gold Institute, 1988, Washington DC.

Aluminium: issues in world price formation

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One of the major areas of interest in the analysis of primary commodity markets is the way in which prices are determined, especially in international trade. There are two main reasons for this interest: primary commodities are of particular importance to the trading patterns of a number of countries, and their prices are frequently highly volatile in the short to medium term. For a country such as Australia, where around 80 per cent of total export revenue is derived from primary commodities, this issue of international price formation is fundamental to the future health of the economy. Short and long term fluctuations in commodity prices will affect the balance of payments and, through this, the direction of economic policy.

There has been an abundance of research into the factors influencing commodity prices and the dynamic mechanisms at work in these markets. However, a number of factors inhibit the general application of conventional economic theory to certain mineral commodity markets. For example: many mineral markets deviate from the perfectly competitive form of other commodity markets; international market prices are difficult to determine for some minerals due to transfer pricing practices; and mineral exploitation is based on imperfect knowledge about the extent and grade of deposits.

As well as being of central interest to Australia, the aluminium market provides an ideal opportunity to examine the types of pricing mechanisms employed under various market structures and the main factors affecting the formation of prices. ABARE has developed a model of the world aluminium market to quantify the influence of these factors on the aluminium price in the short term.

Price Formation in the Aluminium Market

The structure of most metal markets may be categorised as oligopolistic. That is, there are a number of large producers in the market, none of which is necessarily dominant. It is the extent to which this group of large producers seeks to control the market which determines the type of pricing mechanism which operates.

In such markets there is generally a 'producer price', set or administered by the largest producer or by agreement among the major producers, and a free market price. The free market price is generally determined on one of the major commodity exchanges, such as the London Metal Exchange or the New York Commodity Exchange, or through spot market contracts.

The aluminium market is oligopolistic by nature, although this has been changing over the past fifteen years. Historically, aluminium production has been dominated by six major companies: ALCOA, Alcan, Reynolds Metals, Kaiser Aluminum (all United States), Pechiney (France) and Alusuisse (Switzerland). However, the dominance of these firms has been declining over time, with their proportion of total production coming down from 80 per cent in 1958 to 60 per cent in 1973, and to 35 per cent in 1987 (Banks 1979, p.71 and ABARE estimates).

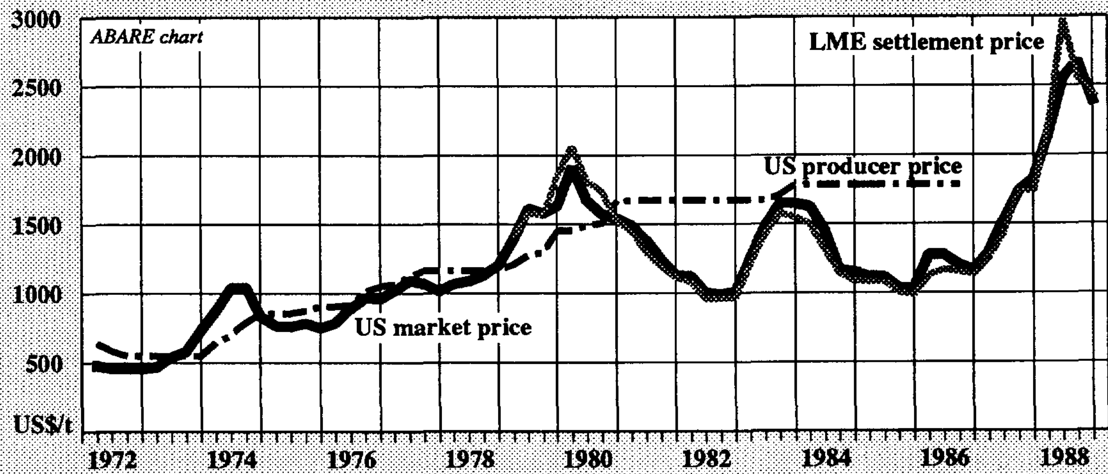
The aluminium market also has a high degree of vertical integration, from the mining of bauxite through to the production of finished aluminium products. One or more of the six major companies have been involved in virtually all of the major aluminium projects of international significance in the market economy countries. According to the US Bureau of Mines they accounted for around 34 per cent of bauxite mining capacity and 55 per cent of alumina refining capacity in 1984 (US Bureau of Mines 1985, p.10). In addition to these multinational firms, there are about fifty other firms whose aluminium operations are more restricted in scope but which accounted for about 26 per cent of bauxite, 12 per cent of alumina and 25 per cent of metal production capacity in 1984.

The history of price formation in the world aluminium market has been broadly in line with this evolving market structure. In the 1950s and 1960s, the major US producer and exporter, Alcan, set a price for aluminium ingots. The other major producers followed this price which became known as the producer price. The producer price was changed only periodically and was rarely adjusted downwards. Meanwhile, the US free market price was the price at which most transactions outside the major producers took place. As this competitive fringe was very small in this period, the free market price was generally the same as the producer price. This was a time of strong growth in the demand for aluminium and saw increased penetration of markets at the expense of other materials such as steel and glass. The control over the price exercised by the major producers led to greater stability in the aluminium market than in many other non-ferrous metal markets.

In the early 1970s, this tight control began to wane. The nationalisation and expansion of bauxite mining capacity in some of the more outward looking and nationalistic of the developing countries weakened the control of the major companies over supplies of bauxite. In addition, the existing aluminium producers could not effectively exclude anyone wishing to produce aluminium. Firms such as Hydro Aluminium (Norway), with access to large financial, technical, bauxite and energy resources, began to establish themselves in the industry. The number of state owned companies and companies in which the state has a decision making role also increased. This expanding fringe of competitive producers established prices for short and long term contracts outside the pricing system established by the major producers, and thereby increased the competitive pressures on the major companies.

In response to these pressures, the London Metal Exchange (LME) began trading aluminium ingot contracts on the forward market in October 1978. Trading activity increased significantly within a short period and the LME price quickly became the free market price for ingot sales in Asia, Europe, South America and the Middle East. Most contracts in these regions are written using the LME price as the base price, with a small premium for quality and reliability and an allowance made for exchange rate changes and transport charges. The US free market price was immediately arbitraged to the LME price and the two have moved together ever since. The producer price became increasingly irrelevant and has not been quoted since 1986. This can be seen in figure 1 which traces the history of the various aluminium prices since 1972. The producer price displayed little movement from the end of 1980 to 1986, while there was considerable variation in the free market price.

Figure 1: Aluminium prices



In undertaking this analysis of the aluminium market, considerable attention has been given to the industry's long history of producer pricing - a pricing mechanism which has not been evident in relation to the world aluminium market for some years. An understanding of the producer pricing mechanism and the process by which free market pricing evolved is very important in developing an understanding of the process of price formation in this market and in the markets for several other metals, such as lead and zinc, where the two pricing mechanisms co-exist with neither being completely dominant. The evolution of the aluminium industry provides a very good example of the effect of market structure on the type of pricing mechanism employed.

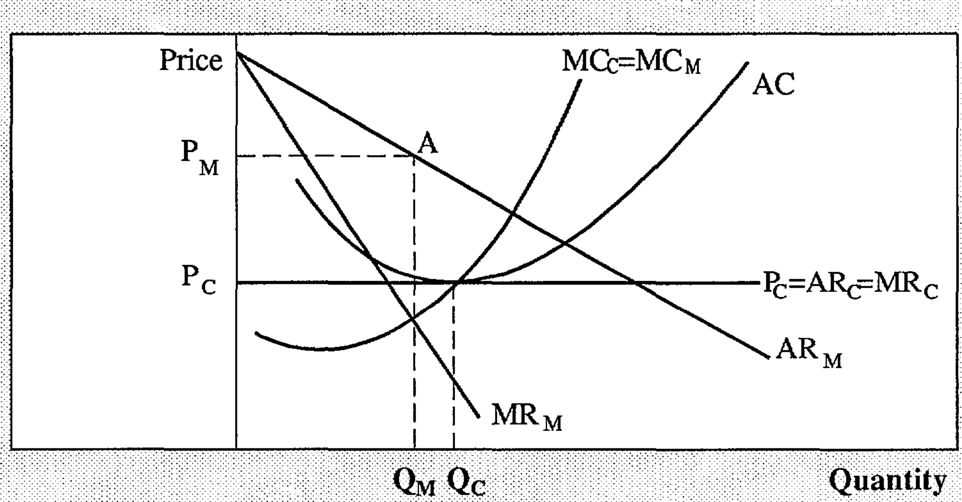
The type of market structure reflects the degree of non-competitive behaviour displayed by the participants in the market. Broadly speaking, this non-competitive behaviour can be either 'strong' or 'weak', with the latter being more prevalent in metals markets. In the 'strong' form of non-competitive behaviour, there is open or implicit collusion to restrict production in order to raise prices. Such cartels have been largely unsuccessful in the long run. The aluminium industry has not seen this degree of overt market manipulation. Rather, the major six producers were faced with very little competition in the 1950s and 1960s, because of their control of bauxite deposits and the economies of scale achieved through the vertical integration of the mining, refining and production stages. This led to a stable market and continued price competitiveness of aluminium with respect to other materials. With the aluminium market expanding, there was no requirement for an organised attempt to restrict production to gain greater returns. This may be classified as the 'weak' form of non-competitive behaviour.

In this weaker form of non-competitive behaviour, there is no active collaboration to raise prices. However, firms do not actively compete against one another for sales in a manner which would result in lower prices. There is generally competition between major producers for contracts but with an implicit understanding to withhold excess production from the free market (either the terminal metal exchanges or the spot market). Since most metal is traded under medium to long term contracts, trading on the free market is often fairly thin, so significant sales may depress the free market price. This may result in producers who trade on the free market actually losing revenue. If the producers are fairly large, withholding production from the free market will generate higher profits in the short term than under a competitive market structure. But in the longer term it will only do so if all or most other producers also adopt the strategy. In the face of significant costs of entry to the industry, this pattern tends to be self-reinforcing as producers learn the value of the withholding response in keeping new entrants at bay. Such behaviour is often characterised as acting 'in the interests of the industry' in comments in trade journals and output from industry organisations.

In examining the process of price formation under this weak form of non-competitive behaviour, two extreme cases and an intermediate case can be identified. If, on the one hand, the producers do not collude to set any price and all metal is sold on the free market, the market would then function like any other competitive market. This can be seen in figure 2 which represents the two extreme cases for an individual firm. Under perfect competition, the firm faces a given market price (P_C) and will produce the amount Q_C. This is determined by the intersection of the price and the marginal cost curve for the firm (MC_C). This type of market structure is not often seen in metals markets, although zinc is perhaps the closest example.

The opposite case is where the producer price is dominant and the free market price is either nonexistent or arbitraged to the producer price. The major producer or producers will choose the quantity and price that maximise profits or joint profits and may be characterised as a monopoly. This is represented in figure 2 by the downward sloping demand (D) and marginal revenue (MR_M) curves. The producer will choose the quantity Q_M, which results from the intersection of the MR_M and the marginal cost curve (MC_M), and the price P from point A on the demand curve. In times of increasing demand, such a price strategy requires the condition that consumers can obtain further quantities of the metal at the current producer price. This was the case with the aluminium industry until the early 1970s: as capacity continued to expand to keep pace with the growth in demand, the producer rice was rarely adjusted. However, since the price is set non-competitively, without frequent reviews of the price this condition may not always be guaranteed. In periods when an industry is operating at levels close to full capacity at the producer price, an increase in demand will result in a shortage of metal. Additional quantities of metal will then be obtainable only on the free market or from fringe producers. This will lead in general to some interaction between the producer price and the free market price and

Figure 2: Pricing under perfect competition and monopoly



that is the intermediate, and for the aluminium market, the most interesting case.

This intermediate case cannot be analysed within the framework of figure 2. While the resulting price will lie somewhere between P_c and P_m, the actual level and process of adjustment to that level will depend on such factors as the balance of market power between the major producers and the competitive fringe, and the state of the market as reflected in the level of stocks and capacity utilisation. As noted earlier, the aluminium market has been characterised by this type of interaction between producer price and free market price since the early 1970s. From around 1972 to 1978, the free market price became more volatile and fluctuated around the producer price rather than merely following it. With the introduction of LME contracts for aluminium in 1978, the free market price was determined primarily by the state of the market while the producer price became increasingly irrelevant. In terms of figure 2, this may be thought of as a movement over time of the price from P_M toward P_C.

Within this intermediate case, there are two elements: the influence of the free market price on the producer price and that of the producer price on the free market price. The first of these is relatively straightforward. If the producer price is significantly above the free market price, producers will come under pressure to reduce their price, either through the fear of losing sales to the free market or through actual sales losses. While a producer may receive a premium over the free market price for such things as reliability of supply and consumer loyalty, such a premium may not be sustainable if it is too large or continues for too long.

If the producer price is below the free market price, producers are likely to respond quite differently. Such a situation will occur when there is a shortage of metal at the producer price and consumers are forced onto the free market to obtain supplies. Supplies to the free market come from smaller producers outside the major companies, secondary producers, occasional sellers such as centrally planned economies and merchants reselling from major producers. In the short term, there is likely to be little pressure on producers to increase their price. The shortage may be temporary, if the concomitant rise in the free market price is sufficient to relieve the excess demand. However, while it may be expedient for producers to be seen to be behaving in the interests of an orderly market by not immediately raising prices, the loss of profits will be more difficult to bear the longer the free market premium persists.

The second element of the intermediate case - the influence of the producer price on the free market price - is more complex. The effects depend on the state of the market with respect to stock levels, excess demand or supply and the yield expected from holding stock. Consider first the case where producers can fulfil all their orders at the current producer price. Excess metal sold on the free market will therefore be at a slight discount to the producer price due to the excess supply. The size of this discount depends on the extent of the excess supply. In conditions of continuing inventory buildup, this discount will be increasing. The free market price will therefore be determined by the magnitude and persistence of the excess supply.

Consider the case where the market moves from excess supply to excess demand at the current producer price. The free market price rises to clear this excess demand. What will determine the free market price is the expected yield from holding the marginal units of stock (which must cover the transaction and storage costs of holding) and the opportunity cost of purchasing a unit of metal in the current period rather than in the next period.

In this case, the free market price depends primarily on expected future market conditions and the extent of the excess demand as reflected in the change in stocks.

The difference between the producer price and the free market price may serve as an indication of the extent of excess demand or supply. Figure 3 shows this relationship for the two aluminium prices over the period 1972 to 1981 together with the ratio of stocks to consumption. The relationship between the price difference and the stocks to consumption ratio is clear. When stocks are higher as a result of excess supply, the producer price is consistently above the free market price. Conversely, in times of excess demand, the free market price is at a premium to the producer price.

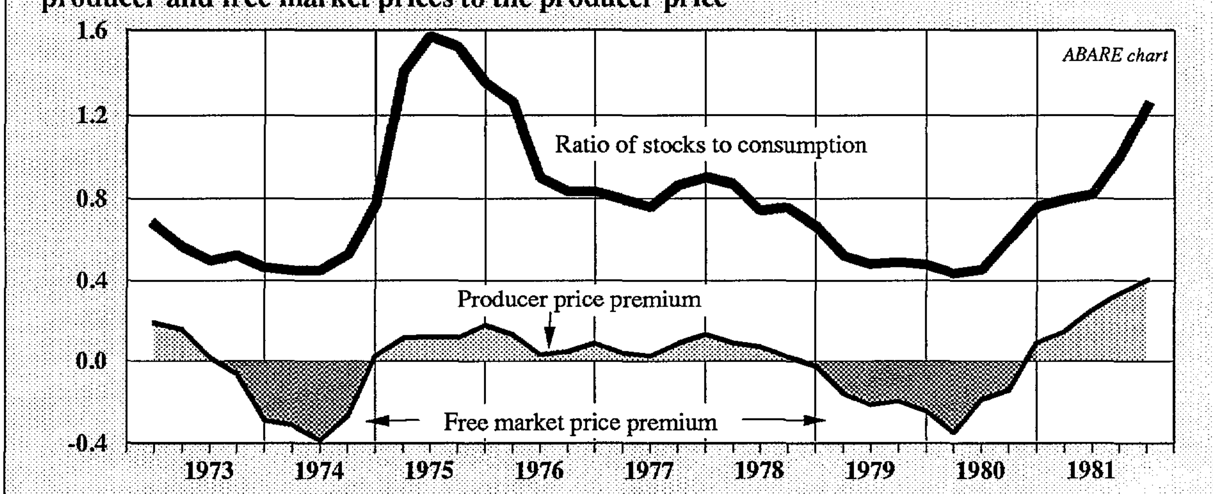
The introduction of aluminium contracts on the London Metal Exchange in 1978 also introduced another factor into the determination of the free market price. Whereas before, stocks were held purely for transactions and precautionary purposes, trading on the forward market meant that stocks could now be held for speculative purposes. One of the main purposes of the Exchange is to enable 'hedging' to take place. Hedging involves transferring the risk of unfavourable price movements from producers and consumers of metal commodities to speculators. In determining the free market price or the exchange price, the opportunity cost of the speculators' funds and the expected return from buying aluminium stocks must now be taken into account. However, as noted above, it is precisely these fundamental market conditions which determine the free market price in the absence of commodity speculation.

Modelling the World Aluminium Market

As a first step in quantifying the determinants of aluminium prices, ABARE constructed a model of the world aluminium market to examine the process of price formation. A summary of the model structure, results and data sources is given in the appendix.

The key point of interest for aluminium is the determination of the free market price since the introduction of LME contracts. As already discussed,

Figure 3: Ratio of stocks to consumption and ratio of the difference between producer and free market prices to the producer price



changing market conditions provide the impetus for adjustment to the free market price. The model results confirm the strong association between changes in the stocks to consumption ratio and the free market price, and the focus of the free market on short term market conditions. The responsiveness of the free market price to market conditions, even in the absence of perfectly free competition, is evidence of the declining power of the major producers. By basing both short and long term contract prices on the LME market price, consumers and producers have reached a stage where changes in the LME price transmit meaningful signals on the current and expected state of the market.

As discussed, the producer price is set with an eye to the free market price. The large producers take the free market price as indicative of the state of the market, and may adjust their price up or down at different speeds depending on whether or not there is excess demand. The model results confirm that the large producers adjust their price faster when the free market price is below the producer price. That is, in times of excess supply, producers are more sensitive to the market conditions and react to the perceived threat posed by the low free market price by lowering their price faster than they would increase their price when supplies are short and the free market price is high.

Finally, the results show that although changes in industrial production as a whole will lead to a commensurate change in aluminium demand, in the short term at least, both supply and demand are not very responsive to changes in price. Exogenous shifts in either supply or demand will therefore result in proportionately much greater changes in price than in quantities demanded or supplied.

Conclusion

The evolution of the pricing structure in the aluminium market before the introduction of LME contracts for aluminium in 1978 provides a useful illustration of the concepts which govern the behaviour of most metals markets. In modelling the interaction between the producer price set by the major exporters and the free market price over the period 1973-79, it was found that the producer price adjusted toward the free market price at a faster rate when there was excess supply in the market. In contrast, it was found that the free market price, both before and since the introduction of the LME contracts, responded primarily to the short term state of the market, namely the rate of change in aluminium stocks. The demise of the producer price in the early 1980s and the subsequent dominance of the LME price as the market's reference price may be seen as the final steps in the transition of the aluminium market from an oligopolistic structure to a more competitive one.

The simulation results, together with the events of 1988, provide some useful insights to the short term future of the aluminium market. The high prices and strong growth in consumption in 1988 have prompted widescale reactivation of smelter capacity, particularly in the United States. The buildup of stocks late in the year and early in 1989 can be expected to exert downward pressure on the price in 1989. This inventory buildup should continue through the coming year, given the slow responsiveness of supply and demand to price changes in the short term.

Appendix

SUMMARY OF ALUMINIUM MARKET MODEL

Model structure

As with most standard commodity market models, the model of the aluminium market summarised here consists of equations explaining consumption, production and price with an identity ensuring market clearance. Labys (1973, 1975), Labys and Pollak (1982) and Wagenhals (1984) provide surveys of commodity market models; examples of aluminium market models include Hojman (1981, 1984), Smithson, Anders, Gramm and Maurice (1979) and Fisher and Owen (1981). The model was estimated using quarterly data over the period 1979(1) to 1987(4). Estimation methods used were ordinary least squares and two-stage least squares which are available on the TROLL econometrics package.

As an adjunct to the model, an equation explaining the adjustment of the producer price in the earlier period, 1973-79, was also included. This is perhaps only of historical interest with regard to the aluminium market, but it illustrates the interaction between the producer and free market prices discussed above. Quantification of the interaction may also be useful in examining other metal markets, such as lead and zinc, where the two pricing mechanisms co-exist with neither being completely dominant.

Consumption. The aggregate consumption of aluminium was explained by the previous period's level of consumption and lags of industrial production and the effective real price of aluminium. The effective real price is the free market price adjusted for changes in the US real effective exchange rate. The adjustment ensures that account is taken of the different rates of inflation and exchange rate changes with respect to the US dollar in consuming countries. Equation (1) below details the parameter estimates and basic diagnostics. The semi-logarithmic form of the equation allows straightforward aggregation of the quantities and linear decomposition of relative prices (Ghosh, Gilbert and Hughes Hallett 1987, p.30). Other variables that were considered and then dropped, as they proved to be statistically insignificant, included the prices of copper and steel (considered as substitutes) and a linear time trend (as a proxy for technological change).

Production. Aggregate production is explained by lags of the effective real price of aluminium and the level of production, and by the lagged change in the level of stocks. A linear time trend and quarterly dummy variables were also included to account for technological change and seasonal patterns in production, respectively. Equation (2) details the parameter estimates for the production equation.

Free market price. The equation explaining the free market price may be thought of as an inverse stock demand equation. As such, the free market price depends only on current market conditions and is determined independently of the producer price. The free market price will adjust until holders of stock are satisfied with the return obtained on holding those stocks. The free market price is therefore a function of the previous quarter's free market price, of current and lagged values of the ratio of stock to consumption, and of the US real effective exchange rate. While there is a strong case for the rate of interest to be included as a measure of the opportunity cost of holding stocks, in this case such a variable was not statistically significant when tested. The US real effective exchange rate was included to account for the effects, on trade and stockholding in producing and consuming countries, of relative changes in inflation and exchange rates between the United States and major industrial countries (Chu and Morrison 1984, 1986; Sapsford 1988). Equation (3) details the parameter estimates for the free market price equation.

Market clearance. The market clearance is ensured using an identity reconciling consumption, production and changes in stocks (equation 4). Consumer stocks are not reported and so are assumed to be negligible and to take the form of a statistical discrepancy. Data for net imports from centrally planned economies, on the other hand, are reported. However, as the amount is relatively minor, its effects on price determination are not modelled explicitly. The variable is thus treated as a datum in the identity.

Producer price. It is assumed that the producer price ceased to be actively quoted about a year after the introduction of the LME contract. The sample period for this equation therefore ran from 1973(4) to 1979(4) and corresponds to the period when the power of the major companies to control the price declined dramatically. The producer price was modelled as a function of industry costs and with regard to the state of demand. The latter is represented by the difference between the producer price and the free market price and by an expected demand variable defined as the four-quarter sum of consumption (Ghosh et al. 1987, pp.66-8). Equation (5) details the preferred producer price equation. The parameter estimates for various measures of industry costs, such as the real oil price and interest rates, were not statistically significant and were thus not included in (5).

Estimated equations

List of variables:

C	Consumption
S	Producer stocks (at end of period)
P	Production
FP	Free market price (US market price until 1978(4) then LME price)
REER	US real effective exchange rate
USWHPI	US wholesale price index
PP	US producer price
IP	OECD industrial production index
FP*	Adjusted free market price (= FP.(REER/USWHPI))
T	Time trend
NM	Net imports from centrally planned economies
CS	Consumer stocks
YC	Four-quarter sum of consumption
Q1	Dummy variable for first quarter

The figures in brackets in the equations refer to t-statistics. All equations passed tests for the presence of autocorrelation and heteroskedasticity, correct functional form and normality of the residuals. Simulations were also carried out to validate the system. Results of these tests are not reported here due to space constraints.

(1)
$$C_t = \underset{(8.1)}{6454.0} + \underset{(12.3)}{0.183}\, C_{t-1} + \underset{(6.7)}{0.774}\, C_{t-4} + \underset{(6.6)}{30.419}\, IP_t - \underset{(-4.8)}{23.011}\, IP_{t-4}$$
$$- \underset{(-5.7)}{574.9} \ln FP^*_{t-3} - \underset{(5.0)}{363.9} \ln FP^*_{t-6} - \underset{(-3.3)}{8.697}\, T.$$

$R^2 = 0.94.$ $F(7,29) = 60.1.$ $DW = 1.69.$ $h = 0.9.$

Estimation: ordinary least squares; period: 1979(1) to 1987(4).

(2) $$P_t = -1411.8 + 0.827\ P_{t-1} + 253.5\ \ln FP^*_{t-1} + 3.264\ T$$
$$\quad\quad (-3.3) \quad (18.4) \quad\quad (4.0) \quad\quad\quad (3.3)$$
$$- 0.173\ (S_{t-3} - S_{t-4}) - 72.112\ Q1.$$
$$(-3.7) \quad\quad\quad\quad (-3.9)$$

$R^2 = 0.96$. $F(5,30) = 139.9$. $DW = 1.5$. $h = 1.4$.

Estimation: ordinary least squares; period: 1979(1) to 1987(4).

(3) $$\ln FP_t = 2.78 + 0.829\ \ln FP_{t-1} - 0.708\ (S_t/C_t) + 0.616\ (S_{t-1}/C_{t-1})$$
$$(2.9) \quad (9.6) \quad\quad (-5.2) \quad\quad (3.8)$$
$$- 0.318\ \ln REER_t.$$
$$(-2.5)$$

$R^2 = 0.91$. $F(4,31) = 75$. $DW = 2.2$. $h = -0.8$.

Estimation: two-stage least squares; period: 1979(1) to 1987(4).

(4) $$S_t \equiv S_{t-1} + P_t - C_t + NM_t - (CS_t - CS_{t-1}).$$

(5) $$\ln PP_t = 1.62 + 1.024\ \ln PP_{t-1} - 0.306\ [\max(\ln PP_{t-1} - \ln FP_{t-1}, 0)]$$
$$(2.0) \quad (41.5) \quad\quad (-2.1)$$
$$- 0.274\ [\min(\ln PP_{t-1} - \ln FP_{t-1}, 0)] - 0.188\ \ln YC_{t-1}.$$
$$(-4.4) \quad\quad\quad\quad (-1.9)$$

$R^2 = 0.99$. $F(4,33) = 672$. $DW = 2.16$. $h = 0.7$.

Estimation: ordinary least squares; period: 1973(1) to 1979(4).

Data

The consumption, production and stocks data are at the primary aluminium level. That is, secondary aluminium (obtained from scrap recycling) and wrought aluminium and aluminium alloys are excluded. Stocks refer to producer and exchange stocks. No data are available for stocks held by consumers. The data cover the Western world plus Yugoslavia but exclude the remaining centrally planned economies. The source for the data was World Bureau of Metal Statistics (1988).

The aluminium price data were obtained from Metallgesellschaft (1987) - the US producer price and US market price were as quoted in Metals Week for 99.5 per cent pure aluminium ingots. The LME price was also for this grade of aluminium and was converted from pounds sterling to US dollars using average quarterly exchange rates.

The real effective exchange rate for the United States was obtained from Morgan Guaranty Trust Company (1988), and the source for the US wholesale price index and interest rates was the International Monetary Fund (1988).

References

Banks, F.E. (1979), Bauxite and Aluminium: An Introduction to the Economics of Nonfuel Minerals, D.C. Heath and Company, Lexington, Massachusetts.

Chu, K. and Morrison, T.K. (1984), 'The 1981-82 recession and non-oil primary commodity prices', Staff Papers, International Monetary Fund 31, 93-140.

___ and ___ (1986), 'World non-oil primary commodity markets: a medium-term framework of analysis', Staff Papers, International Monetary Fund 33, 139-84.

Fisher, L.A. and Owen, A.D. (1981), 'An economic model of the US aluminium market', Resources Policy 7, 150-60.

Ghosh, S., Gilbert, C.I. and Hughes Hallett, A.J. (1987), Stabilizing Speculative Commodity Markets, Clarendon Press, Oxford.

Hojman, D.E. (1981), 'An econometric model of the international bauxite-aluminium economy', Resources Policy 7, 87-102.

___ (1984), 'The economics of bauxite and aluminium: distributed lags and new econometric estimates', Resources Policy 10, 177-89.

International Monetary Fund (1988), International Financial Statistics, vol.41, Washington DC (and previous issues).

Labys, W.C. (1973), Dynamic Commodity Models: Specification, Estimation and simulation, D.C. Heath and Company, Lexington, Massachusetts.

___ (1975), Quantitive Models of Commodity Markets, Ballinger, Cambridge, Massachusetts.

___ and Pollak, P.K. (1982), Commodity Models for Forecasting and Policy Analysis, Croom Helm, London.

Metallgesellschaft (1987), Metal Statistik, Metallgesellschaft AG, Frankfurt (and previous issues).

Morgan Guaranty Trust Company (1988), 'LDC debt reductions: a critical appraisal', World Financial Markets, 30 December, pp.1-13.

Sapsford, D. (1988), 'Internationally traded primary commodities: a model of price determination', Applied Economics 20, 439-52.

Smithson, C.W., Anders, G., Gramm, W.P. and Maurice, S.C. (1979), World Mineral Markets: An Econometric and Simulation Analysis, Mineral Policy Background Paper 8, Ontario Ministry of Natural Resources, Ontario.

US Bureau of Mines (1985), Mineral Facts and Problems, 1985 Edition, US Department of the Interior, Bureau of Mines Bulletin 675, Washington DC.

Wagenhals, G. (1984), 'Econometric models of mineral markets: uses and limitations', Natural Resources Forum 8(1), 77-86.

World Bureau of Metal Statistics (1988), World Metal Statistics, October, London (and previous issues).

High-technology metals - can Australia supply them?

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Introduction

The last 30 years or so have seen a great increase in the use of what are now being called 'new materials', 'advanced materials', or 'high technology materials'. These are materials that exhibit greater strength, higher strength/density ratios, greater hardness, and/or one or more superior thermal, electrical, optical or chemical properties when compared with traditional materials. Because of these superior properties, many of the uses of these materials are in applications not known 30 years ago - the so called high technology applications. A common feature is the association of these applications with the technology intensive industries, such as defence, aerospace and electronics.

The term 'high technology' is imprecise, and is used in different ways in various contexts. This paper does not attempt to define it. It generally has connotations of use of materials with properties superior to those of the traditional materials used in the past, commonly coupled with advanced, highly specialised fabrication and manufacturing techniques. The term has come to be applied to the material as well as the application. This paper discusses a number of metallic elements to which the term 'high technology' has been applied.

It is important to note that many common metals have high technology uses. Copper, for example, is a constituent of high-temperature superconducting materials. However, the high technology uses are a very minor part of total consumption, although they commonly require metal with a much greater purity than that needed for the more traditional uses.

For another group of metals, high technology applications represent the only or major use. This paper focuses on a selection of these, viz gallium, germanium, hafnium, indium, the rare earths group (RE), scandium, selenium, tellurium, thallium and yttrium. It discusses some features of the selected group, and considers the implications of these features for Australia's potential to become a source of supply of the metals.

Some features

The metals discussed have several characteristics in common:

- except for the rare earths, they are used only in small amounts - annual demand for many is only a few tens of tonnes;
- many of their uses require a very high degree of purity (99.9999% is not uncommon) even though the metal may be used as an alloy, and the nature and content of the impurities themselves may be controlled very closely;
- most form only a very small proportion of the ores from which they are obtained - the content commonly is measured in parts per million;
- consequently, they are rarely mined on their own account - mine production is a by-product of the mining of other metals, and therefore, the quantity mined each year is independent of the demand;

- the amount extracted during processing of the primary mineral commodity depends on the demand for the by-product; its recovery may not be economic so it is left in the wastes (tailings, slags, drosses, etc) resulting from extraction of the main commodity. Even if the by-product commodity is separated, it is usually necessary to extract only part of the content from the wastes to obtain sufficient quantities to satisfy demand;

- wastes from the processing of other minerals therefore represent a substantial resource of many of the metals discussed in this paper;

- it follows from the two preceding points that availability of many of these metals depends more on the relation of the metal's separation cost to its price, than on the metal's geological resources. An illustration that the limitation on availability of these metals is commercial rather than geological is given by the Darling Range bauxites: these have been mined for 25 years for alumina production, but only recently has plant been constructed to extract the gallium from the bauxite.

Geological Occurrence

The metals discussed in this paper occur geologically as minor constituents in a variety of ores of common minerals that are produced in large quantities. All are mined only as a by-product of these other commodities; consequently their availability depends largely on whether their price justifies separation from the ore or mineral.

Rare earths occur in some varieties of alkaline igneous rocks and in some kinds of uranium deposits. They occur also in the mineral monazite which is a minor constituent of the heavy mineral sands suite (predominantly rutile, ilmenite and zircon). Hafnium and yttrium also occur in heavy mineral deposits: hafnium is contained in zircon, and yttrium in monazite. Yttrium is also contained in xenotime, a minor constituent of the heavy mineral sands suite, and commonly accompanies rare earths in some alkaline igneous rocks.

Several of the metals discussed here, including selenium, tellurium, germanium and indium, occur in minute quantities (usually <100ppm) in a variety of base metal ores. Tellurium and selenium occur primarily in copper ores. Thallium and germanium occur predominantly in zinc ores, and are also a very minor constituent of some coal deposits. Indium is found in zinc ores and, less commonly, in tin and tungsten ores. Gallium occurs in bauxite (50-60ppm), which is the main source, as well as in zinc ores. Scandium occurs primarily in ores of tungsten, uranium and phosphorous.

Supply, demand and uses

The world and Australian supply positions and uses of these metals are set out below. The United States Bureau of Mines (USBM) is the source of most of the world data.

Because, in monetary terms, their importance is small, reliable information on Australian production and consumption is lacking; many are not identified separately in trade statistics because the quantities involved are small, or data is not published because only a few firms are involved. A further difficulty is that many are imported for use in Australia as part of manufactured or semi-manufactured products, so the actual quantity of a particular commodity used in Australia cannot be ascertained even if trade statistics are available.

Gallium: This metal is used, primarily as gallium arsenide, in semiconductors, light emitting diodes, and other electronic devices. Current world demand, expected to increase by at least 20% over the next few years, is in line with production at about 30-50 t/year. The chief producers of gallium are France, the Federal Republic of Germany and Japan. A plant at Pinjarra, south of Perth, will begin production early in 1989. Australian trade data is unavailable.

Germanium: Estimated world refinery production is 80 t/year, excluding Zaire. Europe is a major source of germanium, where it is extracted as a by-product of base metal refining. In Australia there is no known recovery of this metal.

Hafnium: World production is about 90 t/year. Australia has about half the world resources contained in zircon. The main sources of hafnium are USA, France and Japan with no known Australian production, trade or consumption. The metal is used in control rods for nuclear reactors, in high strength oxidation resistant alloys and, increasingly, in carbide cutting tools.

Indium: Estimated world refinery production is 44 t, the main sources being USA, Canada, Europe and Japan. No production, processing, trade or consumption has been recorded in Australia. Indium has a variety of electronic and electrical applications.

Rare earths: In 1987, recorded world mine production was 35 000 t of contained rare earth oxides (REO). Rare earths have a variety of uses in catalysts, metallurgy, ceramics, and electronics. Australian production in 1987 was 7 688t REO in 12 800t of monazite concentrate; the main producers were Associated Minerals Consolidated from Eneabba and Capel areas in WA (66%), Westralian Sands Ltd from Capel (11%) and Cable Sands Pty Ltd from Waroona and Minnimup Beach in WA (7%). Australian exports were 10 491 t of monazite in 1987, all to France, but in past years some was exported to USA and Malaysia. No imports were recorded and monazite is not currently consumed in Australia.

Scandium: Scandium is used predominantly in laser crystals. World production is estimated at 50 kg/year. Main mine producers are China, USA and USSR. No Australian production is recorded and no trade or consumption data is available.

Selenium: World refinery production is about 1100 t but this excludes production in the USA, centrally planned economies, and some market economy countries; Japan, USA and Canada are the main sources. BMR estimates that about 40 t of selenium is recovered in an intermediate form from products of copper refining and smelting in Australia. Selenium is used in electronics (principally as a photoreceptor), in glass making, and as a pigment.

Tellurium: World refinery production is estimated at 95 t (excluding USA, centrally planned economies, and some market economy countries) with USA, Canada, Japan, and Peru the main sources. It is used mainly as an alloying element in steels and copper, and also in catalysts and in infrared optics. Data on production, consumption and trade in Australia are not available.

Thallium: World mine production is about 14 t. Europe and North America are major sources. Australian consumption and trade data are not available. Thallium has a variety of uses in electronics, and is used also in corrosion resistant alloys, glassmaking, and pharmaceuticals.

Yttrium: Yttrium has a variety of uses in electronics, and is used also in catalysts and ceramics. World mine production of contained yttrium oxide is about 680 t/year, major sources being Australia, Malaysia, Brazil and USA. Australian production of xenotime, which contains about 30% Y_2O_3, is approximately 40 t/year; producers are Cable Sands Pty Ltd and Associated Mineral Consolidated Ltd from mineral sand deposits in the south west of Western Australia. Yttrium may also be extracted from monazite concentrate, of which Australia produced 12 800 t in 1987. Export statistics not available but all production is known to be exported, probably to France and USA. Australian consumption and import levels are not known.

Australian resources

Little quantitative data is available on resources of these metals in Australia, and even qualitative information is sparse. Quantitative data on Australian resources are available for only hafnium, rare earths, and yttrium. All these currently are mined in Australia - hafnium in zircon, rare earths in monazite, and yttrium in monazite and xenotime, all constituents of heavy mineral sands. Resources of hafnium, rare earth oxides and yttrium oxide contained in mineral sands are shown in Table 1.

In addition to the resources listed in Table 1, large but unquantified resources of hafnium, rare earths, and yttrium are known to exist in other mineral sand deposits which currently are the subject of feasibility studies, and the current high level of exploration for mineral sands in Australia is likely to add to these resources. Resources are also known in hard rock deposits: the Brockman deposit has proved and probable resources of more than 9 Mt of ore containing 0.075% heavy rare earth oxides, and 0.124% yttrium oxide; the Mount Weld deposit has indicated resources of 15.40 Mt containing 11.2% rare earth and yttrium oxides; both these deposits contain a number of other metals such as niobium, tantalum and zirconium. Other potential sources of rare earths in the long term include the copper-gold-uranium deposit at Roxby Downs, which potentially is a very large resource, and a number of uranium deposits, particularly in the Mount Isa region and the Olary district in South Australia.

Most of the other metals considered in this paper are known to occur in various mineral deposits in Australia. From information available to it, BMR believes Australia probably has substantial resources of gallium, germanium, indium, scandium, selenium, tellurium and thallium. All these are present in orebodies currently being mined for other mineral commodities, although data on the content is sparse. Gallium occurs in bauxite, of which Australia has very large resources. Scandium occurs in some uranium deposits. The host deposits for the remaining metals are principally the ores of zinc or copper. While Australia does not have large economic resources of these metals, they are adequate for the medium to long term, and the geological potential for discovery of additional deposits is high. As pointed out earlier, separation of these commodities depends on their price and, consequently, the demand for them. It is unlikely that lack of resources would prevent Australia becoming a producer of these commodities if commercial circumstances were favourable.

Processing in Australia

Although it has abundant resources of materials containing the metals discussed in this paper, there has been little processing of them in Australia beyond the mine production stage. However, during the 1980s, a trend towards downstream processing of material developed as companies, encouraged by government, sought to add value to product and maximise financial returns.

In the field of rare earth minerals, three project proposals are currently active although two are subject to development of appropriate methods of radioactive waste disposal. The proposals are:

- Currumbin Minerals proposed in 1987 to build an RE plant at Lismore, NSW, but its application was not approved because of radioactive waste disposal problems.

- Rhone Poulenc's proposed monazite processing plant at Pinjarra, WA, received approval for Stage I (which involves leaching monazite in caustic soda to produce a mixed hydroxides solid) but Stage 2 was not approved. This stage converts RE hydroxides to RE salts and produces radioactive thorium hydroxide and ammonium nitrate waste.

- SX Holdings announced a proposal to build an RE processing plant at Port Pirie, SA, using non-radioactive raw materials imported from China as feedstock.

With regards to the other metals, Rhone Poulenc has completed the construction of a 50 t/year gallium extraction plant near Alcoa's alumina refinery at Pinjarra, WA. The used liquor from the alumina refinery is to be piped to this new plant and returned after extraction of the gallium.

Crude selenium is recovered during base metal smelting and refining at Port Kembla and at Newcastle and is exported for further processing. Domestic and imported crude materials are treated in Sydney and commercial grade selenium produced.

The Townsville copper refinery (capacity 175 000 t/year) recovers precious metals from anode slimes. Although the slimes contain small amounts of tellurium the company does not recover it. Recycled slimes are stored on site so they may be treated for tellurium in the future, depending on the economic viability.

Future prospects

Technology involving the use of the metals discussed here is advancing rapidly. Several have high growth rates, and the USBM forecasts similar rates until the end of the century. However, because the current demand is small, the quantities involved are not large. For example, the USBM estimates United States industrial demand for germanium in 1986 as 38t (and total world demand as 80 t); it forecasts an average annual growth rate of 5.4% from 1983 to 2000, representing a cumulative United States demand over that period of 990 t.

The technological advances can also lead to changes in demand for particular metals, and even substitution of one metal in the group by another. Examples are development of a magnet alloy containing the rare earth neodymium which has much better magnetic characteristics than an alloy containing another rare earth, samarium; and substitution of germanium-bearing semiconducting materials by gallium-bearing materials.

These changes in demand mean that any medium to long term forecasts of growth rates must be treated with extreme caution.

Although quantitative information is lacking, Australia's resources of the metals being discussed are probably able to satisfy any likely future demand. This, taken with the high growth rates forecast for some of the metals, raises the question of the extent to which Australia could benefit economically by the extraction and refining of the metals.

Several points are relevant here.

- Uses of most of the metals require a high degree of purity. Although the high purity form of the product may have a high unit value, the unit value of the form in which the metal is first extracted from the ore is much less. Because of this and the small quantities involved, the value of any likely level of mine production would have little impact on the Australian economy, especially in comparison to the contribution which would result from the value added by processing to the high grades.

- Worldwide, processing of each metal to the refined stage, and even beyond, is in the hands of only a few firms, who generally have proprietary rights to the processes they use. Development of a processing operation in Australia is therefore likely to involve participation by overseas interests unless other commercially competitive processing technologies are developed. A comparison can be made with the construction of alumina refineries and aluminium smelters in Australia in the 1960s. The companies holding the various bauxite leases each established joint arrangements with one of the world major aluminium groups, partly in order to get access to the latest refining technology.

- Even though the unit value added by processing mine production to refined metal may be large, the quantities involved are small, so the total added value may not be large. We can take germanium as an example again: annual world production of refined metal is 80 t; if a price in Australian dollar terms of $1500/kg is assumed, the annual value of the total world refined metal production is $120 million. If a refinery were to be built in Australia, it could expect to provide only part of the total world production. But even if the figure of $120 million for world refined metal production is compared with the value of Australian mine production of other mineral commodities, it is exceeded by the current value of Australian mine production of 15 commodities; and, of course, value is added to mine production of many commodities by smelting and refining.

- The value added to a quantum of refined metal by using it in some form of manufacturing process is likely to be even greater than the value added by refining, but this aspect is not discussed here.

- There is little or no current demand for these metals in Australia as an input to a manufacturing process, so most or all production would have to be exported.

- Because of their high unit values and the small quantities involved, the costs of transporting from one country to another material processed to an intermediate stage are only a small part of the overall refining costs. That is, there would not be any great cost advantage in siting refining facilities close to the extraction plant.

These points suggest that possession of resources of these metals would not give Australia any great competitive advantage in development of refining facilities; such development would face several commercial hurdles, and the direct economic benefit is not great. There could of course be indirect benefits such as those resulting from the import of technology.

Conclusion

To summarise, demand for the metals discussed here is growing rapidly, although substitution resulting from the rapid technological development which characterises their applications can affect growth trends even in the medium term. Many applications require a high degree of purity, and refining to this purity represents high added value. However, the quantities involved are small, and the total value of production of the share of world markets of any of the metals that Australia might acquire is not large in relation to production of many of the other minerals now produced in Australia. Although data is sparse, Australian resources of these metals probably are adequate for likely requirements, and any proposal to develop processing facilities in Australia would not be limited by lack of geological resources.

TABLE 1
RESOURCES OF HAFNIUM, RARE EARTH OXIDES AND YTTRIUM OXIDE (kt)

Commodity	Demonstrated		Inferred
	Economic	Paramarginal	
Hafnium	157	64	22
Rare Earth Oxides	243.1	434.4	36.2
Yttrium Oxide	5.9	54.7	8.7

Mineral sands - a value adding success story

Peter W Cassidy

AMC Mineral Sands Ltd

INTRODUCTION

Australia's mineral sands exports have grown in value from $125 millions in 1978 to an estimated $489 millions in 1988. In 5 years time, the export value is expected to have grown to about $900 millions. Although part of the reason for this growth pattern is price, "value adding" by means of downstream processing is also a major contributor. The mineral sands industry is a value adding success story.

MINERAL SANDS INDUSTRY

The major naturally occurring commercial mineral sands products are rutile, zircon, ilmenite and monazite.

Rutile is a detrital mineral and typically containing 95-97% titanium dioxide. When found in economic concentrations, rutile is recovered and consumed as feedstock for the chloride route titanium dioxide industry and in the production of titanium metal and welding rod electrodes.

Zircon has a theoretical composition of ZrO_2 67.2% and SiO_2 32.8%, however in reality it always contains small amounts of hafnium and other inclusions such as magnetite, rutile, iron and alumino-silicates. Zircon's high melting point, low thermal expansion coefficient and high refractive index combine to make it an attractive raw material for use in refractories and ceramics and as a foundry sand.

Ilmenite with typical TiO_2 dioxide contents ranging from 45-65%, is the most common form of titaniferous mineral. Since the early to mid 1900's ilmenite has traditionally been consumed as feedstock for the sulphate route titanium dioxide pigment process, and more recently as feedstock for synthetic rutile production.

Monazite is a rare earth thorium phosphate typically containing from 55-65% combined rare earth oxides. Major current and projected end uses of monazite derivatives include catalysts, metallurgy, glasses, ceramics, electronics and permanent magnets.

The history of mineral sands mining in Australia began in 1934 at Byron Bay on the east coast of Australia, where Zircon-Rutile Limited and Metal Recoveries Limited were the first commercial enterprises engaged in the mining and recovery of "black sands". The first Australian mineral sands mining followed some two decades after the US National Lead Company's development of the most important application for the industry. In 1916, the company, now known as NL Chemicals, developed technology for the use of titanium dioxide, instead of toxic lead oxide, as pigment for paints. The titanium dioxide pigment market segment has been the major consumer of titaniferous minerals, and hence the main determinant of the health of the mineral sands industry, to the present day.

Demand for beach sands grew rapidly, driven first by the growing usage of titanium dioxide pigment, then by the need for titanium metal and alloys for welding electrodes and later through the developing usage of zircon in refractories for steel production. During the period from 1934 to the present, there have been over 50 heavy mineral producers active at some stage on the east coast of Australia, peaking at almost 30 companies operating simultaneously in 1956. Subsequent rationalisation of the industry has resulted in only four companies mining and processing mineral sands on the east coast of Australia today.

Mining and processing of mineral sands commenced in Western Australia when the Capel deposit south of Bunbury was brought into commercial production in 1956. These deposits were mined for primary ilmenite, which could be digested directly in sulphuric acid as the first step in production of titanium dioxide pigment. This differed from mining on the east coast which was operated to recover rutile and zircon, and where the high chrome content ilmenite initially had very limited sales outlets. By the mid 1970's continuing exploration efforts had identified extensive rutile, zircon, monazite and ilmenite deposits in the Eneabba, Jurien Bay and Gingin areas north of Perth. Assisted by the reduction of mineral sands mining activity on the east coast, these areas soon became a major focus and today lead production, not just in Australia but throughout the world.

The current major mineral producers located in Australia are shown in Figure 1.

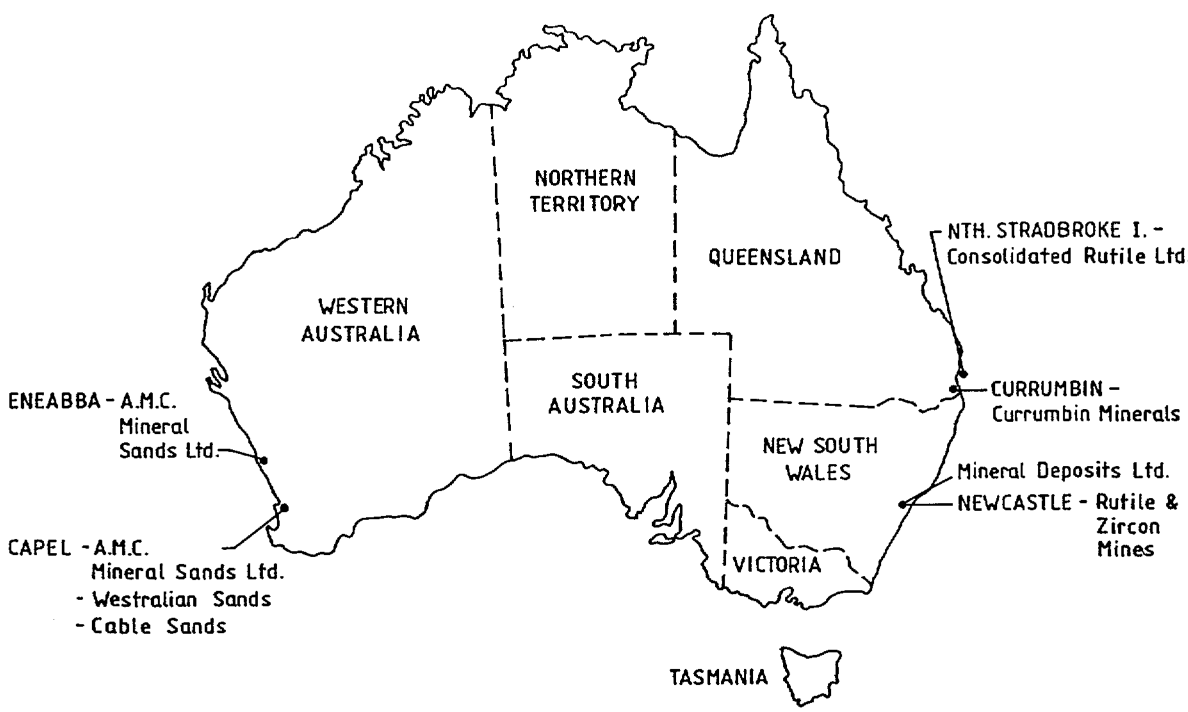

Figure 1. Current Australian Mineral Sands Producers

Aided by the development of downstream processing, the Australian mineral sands industry is emerging as a very significant export earner and, whilst not in the same league as coal, iron ore, gold and alumina is, as shown in Figure 2, nonetheless very significant to the Australian economy and continuing its rapid growth.

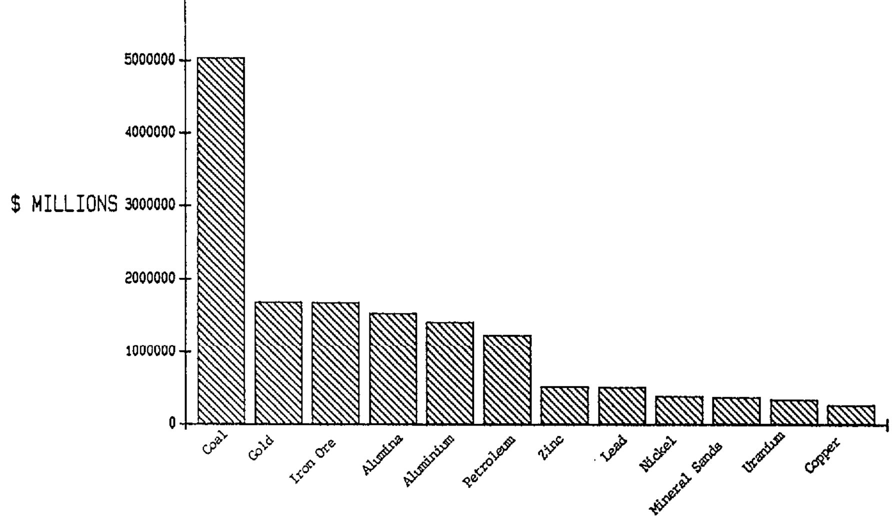

Figure 2. Major Australian Mining Sector Exports - 1987

Elsewhere in the world mineral sand producers are located in Sierra Leone, South Africa, USA, Canada, Norway, India, Ceylon, Brazil and Malaysia. As set out in Figure 3, Australia in 1989 is expected to contribute a very significant part of the western world's production of rutile, zircon, ilmenite and monazite.

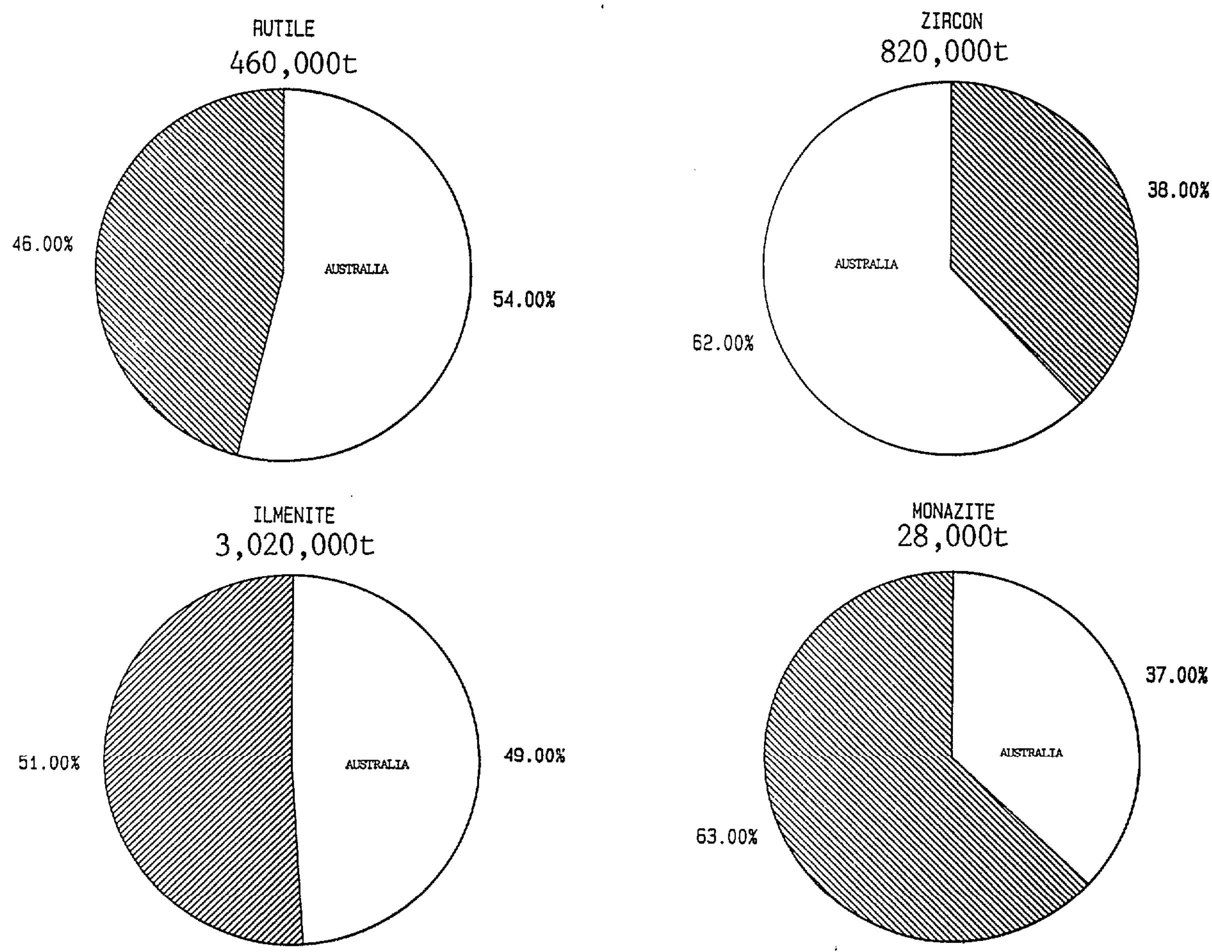

Figure 3. Australia's 1989 Portion of Estimated Western World Mineral Sands Production

VALUE ADDING

Ilmenite The first significant value adding to Australian mineral sands domestically came in the 1960's with conversion of ilmenite into titanium dioxide pigment at plants located in Burnie, Tasmania and Australind in Western Australia. The sulphate route process used by both these plants involves the dissolution of ilmenite into concentrated sulphuric acid and eventual precipitation of purified titanium dioxide which is further refined into pigment. The combined capacity of these two plants peaked at about 70,000 tonnes per annum of pigment in 1988.

Conversion of ilmenite into titanium dioxide pigment adds significant value to the final product. Ilmenite valued at say $80-85 per tonne is converted into pigment valued at about $ 1.00 per lb, an increase of about 12 times in value.

Rutile Technical and environmental pressures have resulted in significant changes to the titanium dioxide pigment industry over the past 20 years. The alternative route to titanium dioxide pigment, the chloride route process, has grown at the expense of the sulphate route and is now almost exclusively the route selected for expansion of the industry. With the exception of E I du Pont & Nemours high TiO_2 ilmenite feedstock plants in the USA and Mexico, the preferred feedstocks for chloride route plants are rutile, synthetic rutile and 80-85% TiO_2 slags.

The chloride route process is based on the chlorination of high TiO_2 feedstocks in fluid bed reactors at temperatures of 800-1000°C. Titanium tetrachloride is separated from other volatile chlorides, burnt to titanium dioxide in oxygen and further refined to pigment.

In Western Australia, SCM Chemicals have converted their Australind sulphate route plant to a 70,000 tonnes per annum chloride route plant which is now being commissioned. The Cooljarloo Joint Venture Partners are also planning the construction of a 54,000 tonnes per annum chloride route plant at Kwinana in Western Australia with project completion expected in early 1991. These plants are expected to use natural rutile and/or synthetic rutile as feedstocks with value added between feedstock and pigment of approximately four times and five times respectively.

Synthetic Rutile The production of 92% TiO_2 synthetic rutile has and is set to continue to be a major success story for value added activities in the Western Australian mineral sands industry.

The process employed for the production of synthetic rutile in Australia is based upon direct reduction of the iron content of 60% TiO_2 ilmenite feedstock to the metallic state using a sub-bituminous coal as the source of both fuel and reductant. The metallic iron component of the reduced ilmenite is then removed by an electrochemical aeration or rusting process in dilute ammonium chloride solution.

The value added effect of synthetic rutile production is to take approximatley 1.7 tonnes of ilmenite feedstock valued at $80-85 per tonne and convert it into a product with a value of about $500 per tonne, equivalent to a four fold increase in export revenue earnings.

The first Australian synthetic rutile plant was commissioned in 1969 by Western Titanium Ltd (now part of Renison Goldfields Consolidated Ltd's mineral sands division AMC Mineral Sands Ltd) at Capel in Western Australia. This plant had a nominal capacity of 10,000 tonnes per annum of synthetic rutile. In 1974 a larger plant of 30,000 tonnes per annum capacity was commissioned at Capel. These two plants are operating today, but technological improvements to the process and de-bottlenecking have increased the combined capacity to 60,000 tonnes per annum of synthetic rutile.

The poor business environment of the mineral sands industry through the late 1970's and early 1980's resulted in the next Australian plants not being seen until 1987. That year, both AMC and Westralian Sands Ltd commissioned plants in Western Australia. The AMC plant located at Geraldton (Figure 4) is rated at 112,500 tonnes per annum capacity and is the world's largest synthetic rutile plant. WSL's plant is located at Capel and is rated at 100,000 tonnes per annum.

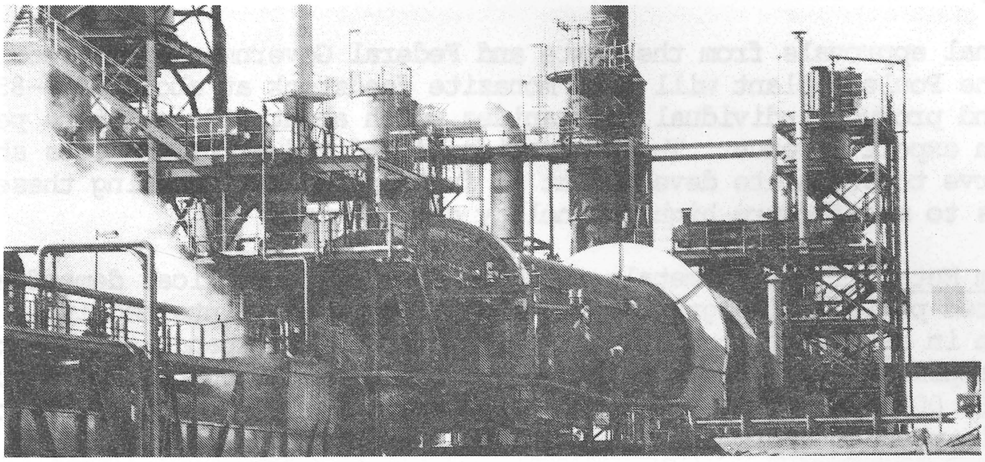

Figure 4. AMC's Geraldton Synthetic Rutile Plant

Product from the four synthetic rutile plants in Western Australia is used as feedstock for titanium dioxide pigment and titanium metal production in the USA, Japan and Europe and, later this year, also in Western Australia. Australia dominates world production of synthetic rutile with 240,000 tonnes forecast for 1989, 58% of world production.

The mineral sands industry believes that strong growth in synthetic rutile production, as a substitute for natural rutile, will be underwritten by a rapid world-wide growth in chloride route pigment operations. Australia, particularly Western Australia, is well placed to take advantage of this continuing avenue for value adding opportunities.

Zircon Until recently, the Australian downstream processing of zircon sand had been restricted to milling for applications that include refractories, ceramics and foundries. This situation has changed with the commissioning of ICI Australia's newly formed Z-Tech division plant at Rockingham in Western Australia. This plant will have the capacity to produce up to 750 tonnes per annum of high purity zirconia and zirconium chemicals. Zirconia products will be produced in a patented two stage process, plasma arc dissociation of zircon followed by chemical leaching. Final product purities of up to 99.99% ZrO_2 will be aimed at supplying rapid growth potential applications such as ceramic engine parts and electronic ceramics. Value adding in 1989 terms would see zircon sand at, say, $600 per tonne ($0.20 per lb of contained ZrO_2) being upgraded to $8.00-10.00 per lb of zirconia or 40 to 50 times.

Monazite Some 20 years ago, rare earth oxides were produced in Australia from the processing of monazite. Since 1972 however, Australian monazite production has been exported for processing in the USA and Europe. From time to time, consideration was given to processing of monazite in Australia by mineral sands producers but no significant progress was made. In 1986, Rhone Poulenc Chimie announced plans for a monazite cracking plant located at Pinjarra in Western Australia. The proposal was for a multi-stage process to yield a range of mixed and individual lanthanides to meet forecast strong demand for high purity products. This project is capable of consuming up to 15,000 tonnes per annum of monazite, about Australia's total production rate, making it the second largest rare earth facility in the world.

When final approvals from the State and Federal Governments are received the Rhone Poulenc plant will take monazite feedstock at about $825-850 per tonne and produce individual lanthanides worth about $100 millions per annum in export revenue. The production of individual lanthanides should also serve to stimulate development of further industries using these products to manufacture high technology components.

Titanium Metal Titanium metal, although subject to cyclical demand and associated periods of significant overcapacity, has maintained its position in aerospace applications and continued to expand in industrial market applications. The possible value adding of A$700 per tonne rutile into US$5.00-6.00 per lb titanium sponge continues to be a possibility in Australia when an appropriate market and business opportunity arises.

THE FUTURE

The market for mineral sands products is expected to remain strong at least through calendar 1989 and the high level of exploration activity in the industry reflects the bullish outlook. A number of companies in Australia and overseas have announced plans for expansion of mineral sands operations. Most of those in Australia relate to production of natural minerals with no significant value adding but there are important exceptions.

In Western Australia, AMC has announced feasibility studies into the development of the Eneabba West resource and an associated 125,000 tonnes per annum synthetic rutile plant. Decisions on these projects are expected in mid-1989.

The Cooljarloo Joint Venture partners have started construction of a mine and mineral processing operation at Cooljarloo in Western Australia. Plans for a 130,000 tonnes per annum synthetic rutile plant and a 54,000 tonnes per annum pigment plant as a fully integrated downstream processing project have already been announced and are well advanced. The current schedule calls for commissioning of the mine and processing plant by the end of 1989 with the synthetic rutile plant and pigment plant on stream by late 1990 or early 1991.

In Victoria, CRA Ltd is evaluating a heavy mineral resource at Wimmera. Part of the evaluation involves consideration of downstream processing of the titaniferous minerals to titanium dioxide pigment in Australia. Operations are planned to begin in the early to mid 1990's.

Value adding to Australian mineral sands products is well set to continue into the 1990's and beyond with scope existing for exploration success to provide further opportunities. However, overseas competition remains severe and Australia's industry continues to monitor with concern proposed future developments within Madagascar, Brazil, South Africa and Canada. Value adding and downstream integration, coupled with cost efficient operations, provide a powerful combination for Australia's mineral sands companies to maintain their competitive position in the world wide industry.

Resources, research and exploration - a basis for sustained growth?

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Introduction

There can be little doubt that global demand for mineral and petroleum resources will continue to grow, although there will be changes in the demand for individual commodities as a result of technological advances, substitution or environmental concerns.

In spite of the legitimate long term concerns about the overall limits to growth imposed by the availability of resources (as well as by the environmental impact of resource usage) there is little evidence that the supply of economically competitive mineral deposits is being exhausted. For particular deposit types, new deposits continue to compete successfully in their grade-tonnage relationships with earlier developments; and new deposit types continue to be discovered. Notable examples of the latter in Australia include the Kambalda type nickel deposits, the Northern Territory (unconformity-related) uranium deposits, the Olympic Dam copper deposit and the Argyle (lamproite-related) diamond deposit. Moreover new mining and processing technologies have increased the range of economically competitive deposits.

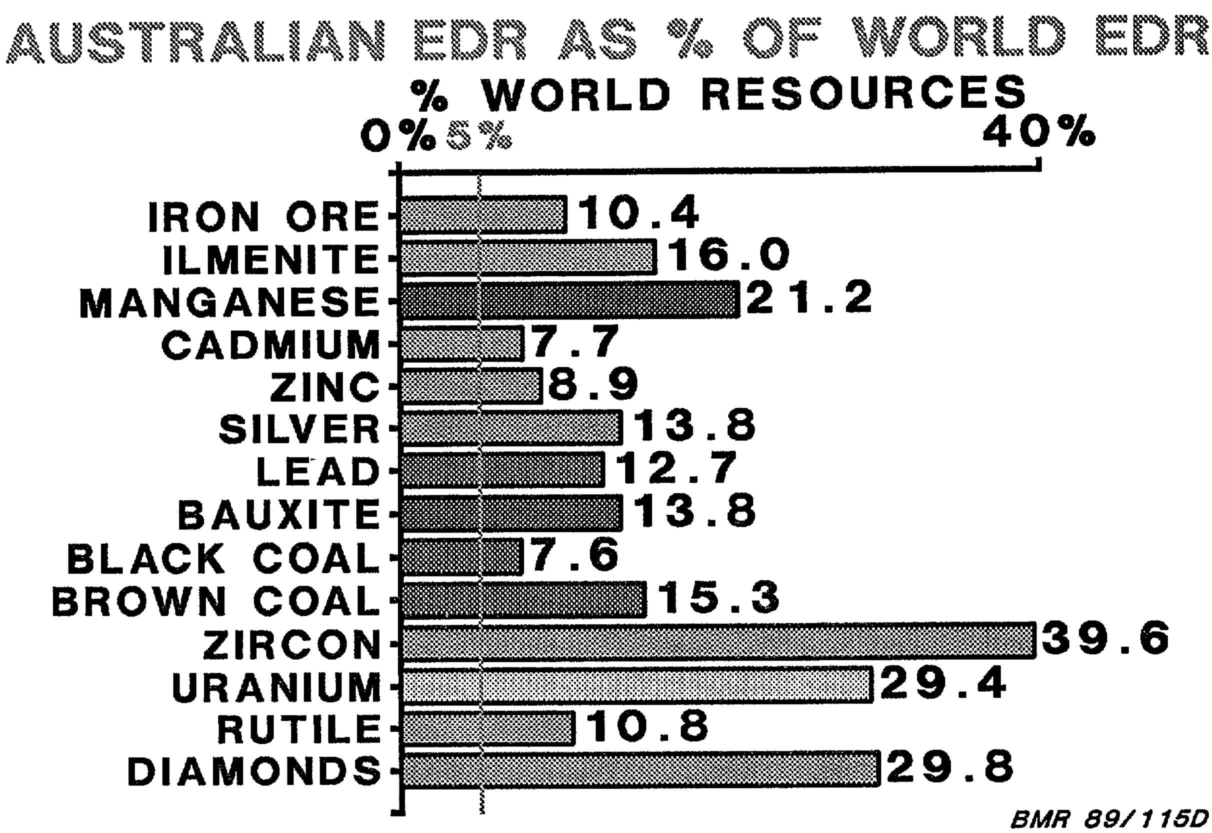
The challenge for the next few decades therefore is to maintain or increase Australia's share of the market by maintaining supply from new economically competitive deposits (ie. preferably deposits in the lowest cost quartile). In that context, the purpose of this contribution is to outline Australia's basic resource potential and to indicate some basic requirements for the continued realisation of that potential.

Australia's current resource base

Fig 1 shows Australia's approximate share of economic demonstrated resources (EDR) of a number of major mineral commodities. Taking Australia's 5% share of the world's land area as a general indicator it is clear that Australia has a particularly large share of several of these commodities, notably zircon, uranium and diamonds (although the gem component of the resources is only about 5%).

Bauxite, coal and iron ore, Australia's main mineral exports, fall into an intermediate group where Australia has substantially more than its areal share of EDR, but where Australia's main competitors also have very large resources.

At the other extreme there are a number of commodities where Australia has less than its areal share. Although Australia is the world's third largest producer of nickel and fifth of gold, our economic demonstrated resources of both of these are less than 5% of the world total. It should be noted however that Australia's nickel resources are mainly sulphide ores, whereas a substantial part of the world resources are relatively high cost laterite ores.



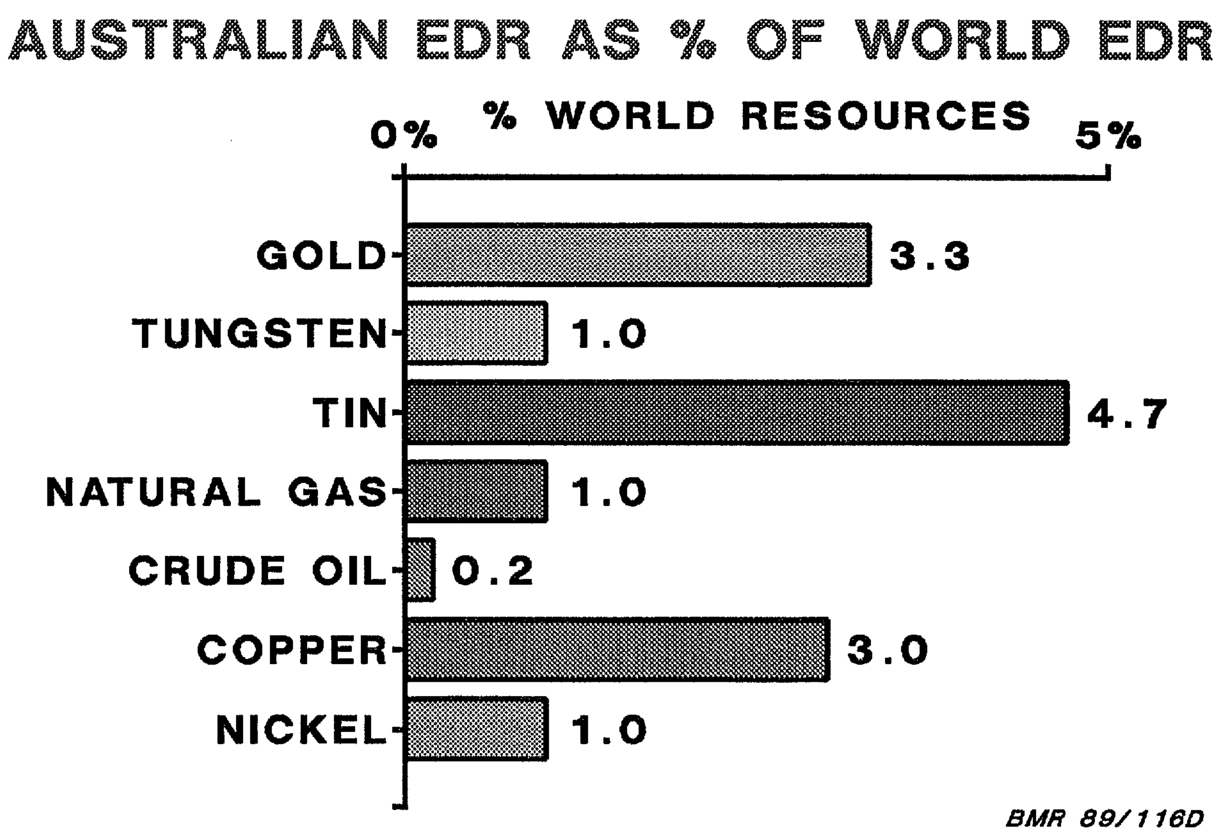


Fig 1. Australia's share of economic demonstrated resources for a number of major mineral commodities. Note that comparisons of resource levels between countries need to be made with caution because of different definitions of what constitute a resource, and differences in comprehensiveness of the data.

Australia is also a major importer of a number of the commodities where it lacks its areal share of economic demonstrated resources. Notable amongst these are crude oil, mineral fertilisers and elemental sulphur. At present the increasing need to import crude oil is the largest negative factor in the overall outlook.

According to the petroleum self-sufficiency median demand scenario published in the Energy 2000 National Energy Policy paper, Australia's self-sufficiency will most likely decline from present levels of about 85% in 1989 to somewhere between about 30 to 60 percent of demand in 2000. This scenario includes an estimate of production from undiscovered fields by BMR based on the current level of knowledge and historical evidence.

Evidently therefore the net value of the mineral industry to Australia can be increased by attempting to meet these current deficiencies as well as by increasing the value of exports.

The ratio of the currently economic demonstrated resources to the current annual mine production (the R/P ratio) provides a general indicator of the adequacy of the resource, and of the current resource constraints on potential growth. For black coal, iron ore and bauxite the R/P ratios are 286, 166 and 91 respectively, and there are evidently no quantitative restraints on potential growth in these industries.

These commodities, and the alumina extracted from bauxite, are mostly sold under long term contracts, with prices negotiated between seller and buyer. Continued growth in these industries will be dependent on marketing arrangements, and on the Australian producers remaining cost-competitive with producers in other countries.

The economic demonstrated resources of most of Australia's other export commodities are adequate to support production at current levels for at least twenty years. Nickel and gold are notable exceptions to this generalisation (see below).

It should be emphasised however that this situation is not a reason for complacency. Given the long lead time from the initiation of exploration to the beginning of production, it is necessary continually to discover new economically competitive deposits to maintain the resource base and to meet changing economic conditions and specifications for individual commodities (fig 2). In the case of the Olympic Dam deposit the knowledge base for exploration and the exploration strategy itself were developed several years before the discovery in 1975, and production did not begin until 1988. Thus the present relatively favourable situation with respect to copper resources is a result of long term programs of knowledge acquisition and exploration.

The low R/P ratio for gold reflects the current high production rate. Gold production from known deposits is expected to reach peak output in 1990-92, thereafter declining to a level of about 80t/year, a level expected to continue until 2000.

The remarkable rate of success in discoveries of gold achieved by Australian companies is directly related to expenditure on exploration. In 1980 BMR estimated Australian economic demonstrated resources of gold as 332t. Eight years later, after an output of 529t, the estimate is 1378t. In this period, annual expenditure on private exploration for gold in Australia increased fivefold, in constant dollars; in 1987-88 this proportion had increased to 73% of the total.

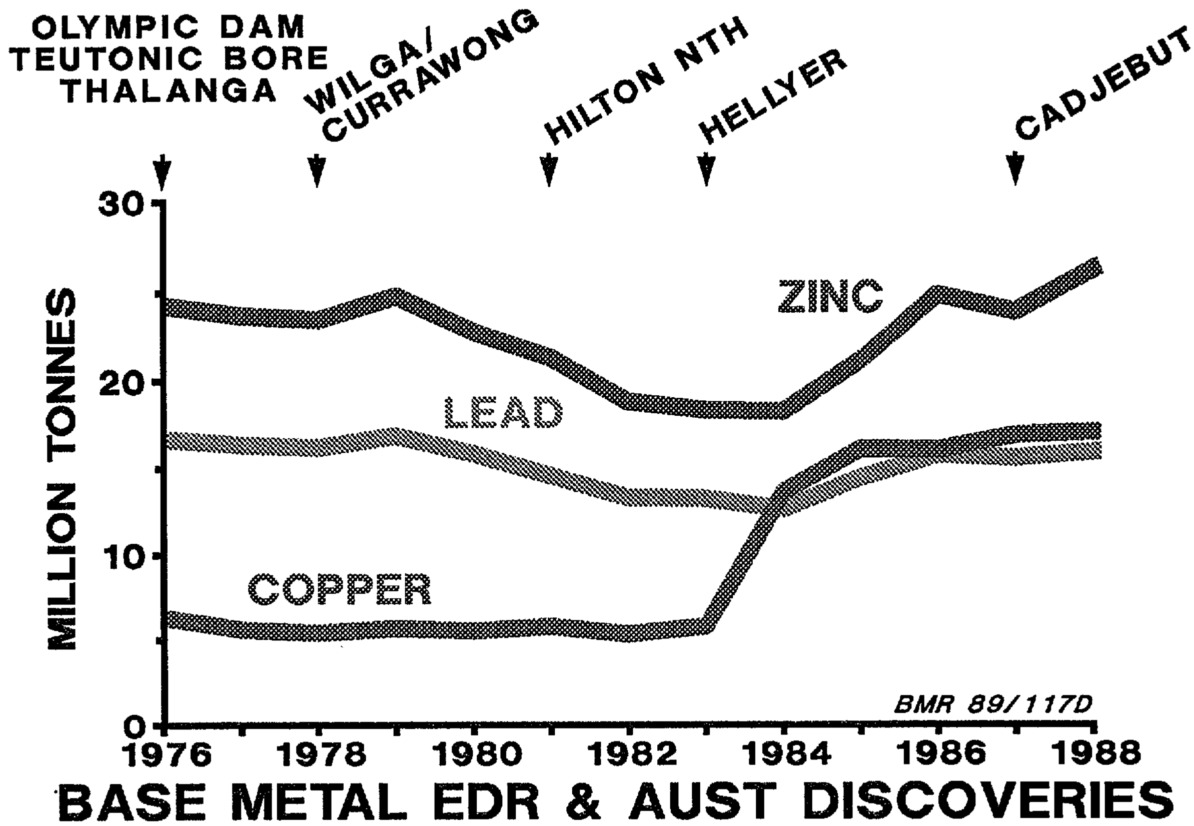


Fig 2. Changes in economic demonstrated resources of copper, lead and zinc in relation to discovery of deposits. Note in particular that the discovery of the Olympic Dam deposit in 1975 is not reflected in EDR until 1984, and production from this deposit did not begin until 1988.

Australian gold mines presently operating or in the development stage with resources large enough to continue mining to 2000 are: Telfer, WA; Boddington, WA; Kambalda Mines, WA; Big Pit or alternatively Giant Pit in the Kalgoorlie-Boulder area, WA; Mount Charlotte, WA; Norseman, WA; New Celebration, WA; Mt Gibson, WA; Reedy, WA; Lancefield, WA; Big Bell, WA; Granny Smith, WA; Kidston, Qld; Mt Leyshon, Qld; Red Dome, Qld; Starra, Qld; Mt Rawdon, Qld; Pajingo, Qld; Olympic Dam, SA; Rosebery, Tas; Hellyer, Tas; Stawell, Vic; and Bendigo, Vic. Overall, Australia's inferred resources of gold are of similar magnitude to the economic demonstrated resources.

There may appear to be some cause for concern as to adequacy of mineral sand resources. The ratios of economic demonstrated resources to production of ilmenite, rutile, zircon and monazite are 38, 44, 32 and 19. Economic demonstrated resources of ilmenite have increased by 21% over the last 12 years, but resources of rutile and zircon, the other major mineral sand products, have increased by only 5% and 1%. However, quantitative data is not yet available for some large deposits currently being tested; and the current high level of exploration in many parts of Australia suggests that further deposits will be found.

Another paper has pointed out that economic demonstrated resources of lead and nickel have decreased over the last 12 years - ie. additions to this category have not kept pace with mining. Economic demonstrated resources of zinc have increased over the period, but only because of recent additions. Economic demonstrated resources of copper increased substantially in the mid 1980s but this was largely the result of delineation of resources at Olympic Dam. It might be noted also that most of the economic demonstrated resources of copper are in two deposits, Mount Isa and Olympic Dam.

Inferred and subeconomic resources of nickel are several times the economic demonstrated resources, and the recent large increase of nickel prices could well lead to some of the subeconomic resources being reclassified as economic. However, economic demonstrated resources of lead and zinc, providing R/P ratios of about 34, comprise a large proportion of their respective total resources.

So while Australia is well endowed with resources of some of the major mineral commodities, such as bauxite, coal and iron ore, the adequacy of resources of some other commodities such as mineral sands and base metals is less assured.

As indicated above the maintenance of the resource base at present levels has been the result of a continuing high levels of exploration. It has often been pointed out that most surface deposits have now been discovered and that future discoveries will depend on more sophisticated exploration programs designed to locate concealed deposits. The evidence of Australia's basic resource potential suggests however that such exploration effort will be rewarded.

The Basic Potential

In broad terms, Australia's mineral deposits and mineral potential falls into three categories. Mineral deposits are traditionally associated with hard-rock mining in the basement provinces and most early discoveries were in this category (fig 3). These were the deposits that made Australia a leading producer in the latter years of the nineteenth century. The basement provinces can themselves be divided into three broad categories of distinctly different geological age, with the oldest in the west and the youngest in the east (fig.3). The second category of mineral deposits comprises those hosted in the sedimentary basins overlying the basement provinces while the third category comprises those obtained from the regolith, the highly variable veneer of superficial deposits and weathered bed-rock which overlies both the

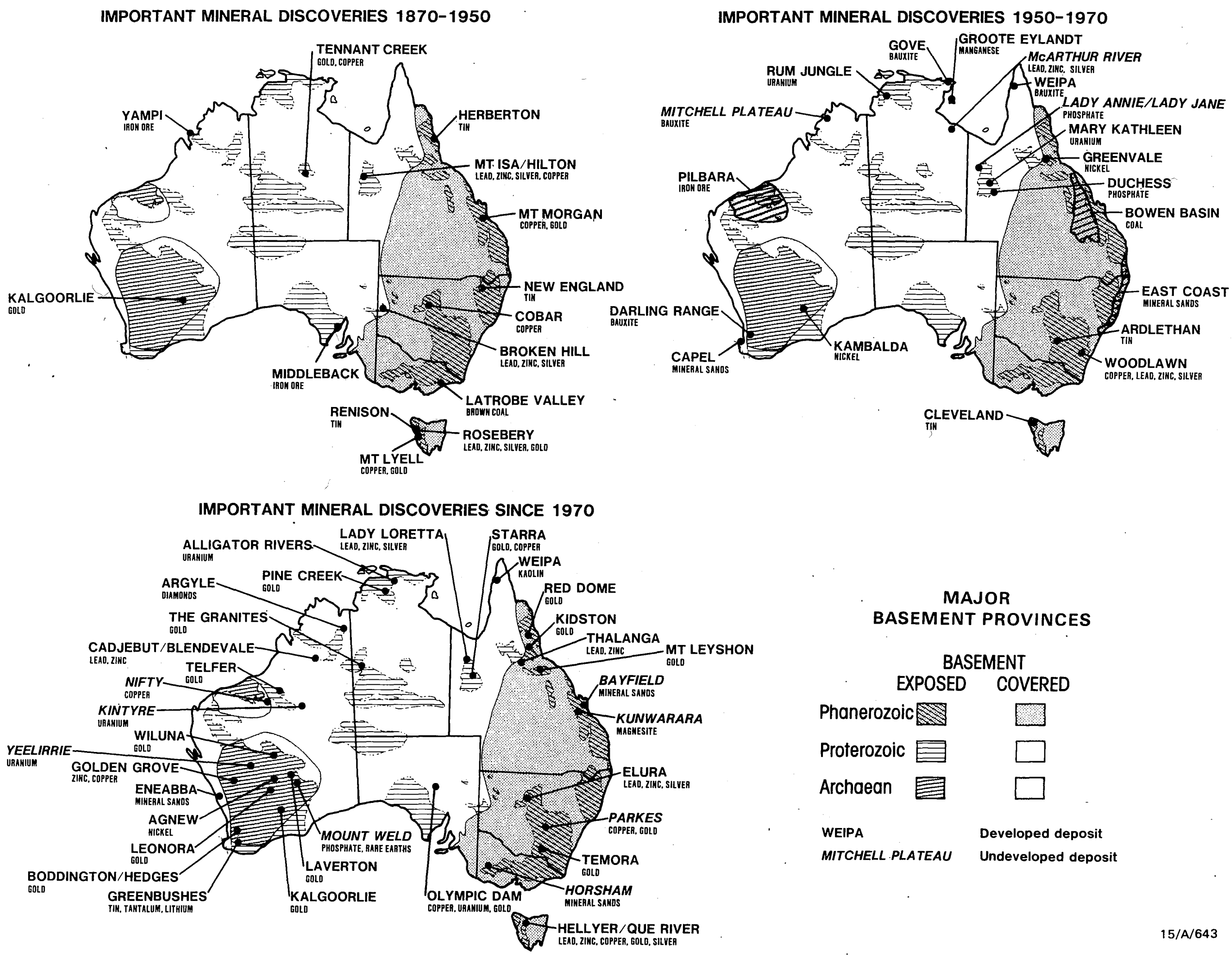


Fig 3. Important mineral discoveries in Australia during the periods 1870-1950, 1950-1970 and since 1970.

basement provinces and the sedimentary basins. Sedimentary and regolith deposits were particularly important in a succession of mineral discoveries in the 1950s and 1960s that again made Australia a major force in world mineral supply and the mineral industry a major contributor to the Australian economy. These included mineral sands on the east and west coasts, bauxite from the regolith in northern Australia and the Darling Range, iron ore in the Pilbara (although these deposits had been recognised in the nineteenth century), manganese at Groote Eylandt, phosphate rock in northern Australia and recognition of the extent of the coal deposits of the Bowen Basin. The first major discoveries of petroleum in the Gippsland Basin were also made in this period.

From the mid-1960s there was a substantial growth of the scientific exploration capacity of Australian companies, making use of the national geoscience knowledge base, of a wide range of techniques and of developing concepts of mineral deposit genesis and occurrence in relation to stratigraphy and tectonics. A progressive melding of basic geological science and exploration geology has occurred so that the empirical element in exploration has progressively been reduced. The result of this changed approach was that the rate of discovery in the 1970s was not only maintained but increased. Some of the new finds, such as Olympic Dam and Elura were blind deposits, and many, such as Telfer and Golden Grove, were greenfields discoveries (fig.3).

The discoveries have been concentrated in the basement provinces. However in the regolith, laterites containing economic gold concentrations, such as Boddington and Hedges, have been recognised as important exploration targets; and many gold deposits, particularly in Western Australia have been economic only because they are in the weaker rock of the weathered zone, which can be mined at low cost.

Thus Australia's mineral potential is the result of the particular combination of basement provinces, sedimentary basins and regolith that make up the near surface of the continent. Australia is endowed with a particularly wide range of productive mineral deposit environments, although it lacks the typical geologically young associations of the Pacific rim, which are found in Papua New Guinea and Melanesia, and which contain a significant proportion of global copper, molybdenum, chromium and gold resources.

The basement provinces within Australia offer high potential for a range of different deposit types. The old western province has particular potential for gold and nickel, the central province for further discovery of its remarkable large base metal deposits and uranium, and the eastern province for a range of metallic deposits including gold and tin. Importantly the advances in geoscientific knowledge over recent years have enabled the characteristics of particular deposit types to be better defined in relation to their geological environments so that exploration effort can be better focussed with increased chance of success. The advances in exploration concepts have been accompanied by advances in exploration techniques so that we can be confident that new competitive deposits will continue to be discovered if the exploration effort and the effort to enhance the knowledge base are maintained.

In relation to future research requirements, the main need has recently been identified as larger province multidisciplinary studies, undertaken over several years and involving expertise in such areas as geochronology, geochemistry, remote sensing, sedimentology and geophysics. Results of such studies need to be in the public domain for the use of all explorers and require cooperation between BMR and the State Geological Surveys. The ultimate aim of such studies would be to construct large, integrated databases of which updated geological maps and reports would form an important component.

Within these studies, regional study of the regolith will be particularly important, in recognition of the fact that the regolith is a significant barrier to the discovery of the concealed deposits in the bed-rock beneath.

Other research studies in more direct support of industry are also required and Australia has developed particularly effective means for developing such studies through the Australian Mineral Industries and Australian Petroleum Industries Research Associations (AMIRA and APIRA).

Australia's petroleum potential deserves special comment since Australia's level of petroleum self-sufficiency is expected to decline rapidly over the next few years.

An objective view of petroleum potential is vital for future planning, but the uncertainties inherent in estimates of resources must also be recognised.

In 1988 BMR published its most recent estimate of Australia's petroleum potential (Table 1). These estimates reflect an opinion of prospectivity based on established and foreseeable concepts of Australian geology and petroleum occurrence. At the average expectation level these estimates represent a conservative but realistic view of petroleum potential for the continent. Such figures are appropriate for government planning. However in any given basin there is a small but significant chance of a very much larger potential that is expressed at the 5% or even lower probability level, which is the target for exploration. The fact that a large but speculative potential exists in many regions reflects our uncertainty and lack of knowledge in unexplored or lightly explored basins. It is highly unlikely that such speculative potential will be realised in all basins but there is a significant chance it may be achieved in one or more cases. There are many spectacular cases in the history of petroleum exploration where this has proved to be the case (eg. Pratt, 1952). The concept is clarified for Australia by the question "What would have been the estimates of resource potential of the Gippsland Basin prior to exploration?". The resource potential that ultimately became productive reserves, would probably have occurred at the 5% level or less in a pre-exploration estimate of potential. Clearly a low average potential should not by itself be an inhibition to exploration. Development of new geological concepts resulting from research and exploration may well result in the identification of resources that existed previously at the 5% probability level. It is useful therefore to critically examine the precepts upon which current views of prospectivity are based.

The sedimentary basins of the eastern, western and southern margins of the Australian continent were formed as a consequence of the separation of Australia from adjacent continental land masses by sea floor spreading. Such passive margin basins are frequently considered to have low prospectivity - a perception which in part is based on the poor results obtained from the Atlantic margin of North America. Like all generalisations it is an oversimplification. Rifting processes which precede sea-floor spreading frequently result in conditions favourable for the deposition of petroleum source rocks. The associated thermal regime, where accompanied by appropriate burial during subsidence of the continental margin in the post-rift phase is appropriate for petroleum generation. Structural models of continental margin formation developed at BMR assist in the identification of such circumstances. Australia's three major petroleum basins - Gippsland, Barrow-Dampier and Bonaparte - follow this scenario and call into question generalised assumptions regarding the low prospectivity of passive margins.

TABLE 1 : ASSESSMENT OF UNDISCOVERED PETROLEUM RESOURCES BY REGION AND AT VARIOUS PROBABILITY LEVELS

	Crude Oil $kLx10^6$ ($BBLx10^6$)			Condensate $kLx10^6$ ($BBLx10^6$)			Sales Gas m^3x^9 (ft^3x10^{12})		
	95%	Average	5%	95%	Average	5%	95%	Average	5%
Eastern Australian Onshore Basins	10 (60)	30 (200)	80 (500)	4 (25)	8 (50)	15 (100)	25 (0.9)	50 (1.8)	90 (3.3)
Southern Coastal Margin Basins	20 (140)	90 (560)	210 (1340)	2.5 (15)	11 (70)	27 (170)	12 (0.4)	35 (1.3)	75 (2.6)
Central Australian Basins	0 (1)	10 (60)	40 (250)	0.1 (1)	1 (8)	4 (25)	1 (0.03)	10 (0.3)	30 (1)
North-eastern Margin Basins	0 (0)	50 (320)	160 (1000)	0 (0)	3 (20)	11 (70)	0 (0)	8 (0.3)	30 (1)
Northern & Western Margin Basins	40 (280)	245 (1540)	500 (3200)	55 (350)	190 (1200)	440 (2800)	240 (8)	640 (23)	1300 (45)

Similarly the Lower Palaeozoic and unmetamorphosed Proterozoic Basins of the continent itself are regarded as of low prospectivity for petroleum and have received minimal exploration considering their size. However Lower Palaeozoic basins have been prolific producers of oil in North America and very large reserves are indigenous to Upper Proterozoic rocks in Oman and on the Siberian Platform of the USSR. Recent BMR work has identified viable petroleum source rocks in the Middle Proterozoic of the McArthur Basin, Cambrian of the south Georgina Basin and Ordovician of the Amadeus and Canning Basins. The source beds in the latter case are identical in type to those which source Ordovician oils in North America. The petroleum potential of these basins is highly speculative but cannot be ignored.

Consideration of petroleum source rock distribution and the processes of hydrocarbon generation and migration offer a different approach to the assessment of petroleum potential of sedimentary basins compared with the methods currently used. Quantitative estimates of the amounts of petroleum generated may be a direct route to the measurement of the ultimate potential of sedimentary basins.

Clearly perceptions of petroleum potential change with time. The realisation of Australia's ultimate potential will depend upon the maintenance of exploration based upon further development of concepts of petroleum occurrence through the application of geological research, and through the collection of new data in research and exploration programs.

Conclusion

There are strong grounds for confidence that Australia's resource base for most mineral commodities can be maintained or enhanced.

This will be achieved however only if vigorous exploration programs are pursued based on a comprehensive up-to-date knowledge base. In the words of Roy Woodall of Western Mining Corporation, "Towards AD 2000 our role will certainly be to increasingly use all the skills of the research scientist to discover new resources to replace those being mined and used by society today ...".

While Australia's potential in most mineral commodities is high in a global context, this is not true for crude oil, where the largest global resources are geographically restricted. However the conditions for crude oil generation have been realised in a number of Australian basins and there are good grounds for optimism that significant resources remain to be discovered. The realisation of the potential however will again depend on the development of the knowledge base and on an informed and active exploration program. In relation to the overall balance of minerals trade this remains the highest priority.

Acknowledgments:

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References

Pratt, W.E., 1952, Toward a Philosophy of oil-finding. Bull. Amer. Assoc. Petrol. Geolog. 36, 2231-2236

Woodall, A., 1987, The Role of Mineral Exploration towards 2000 AD. Keynote Address at "Exploration 87" Conference, Toronto, Canada, Sept 28, 1987

Implications of international trade arrangements: natural resource-based trade issues in the Uruguay round

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1. Introduction

The current Uruguay Round of multilateral trade negotiations under the auspices of the GATT provides a unique opportunity to address the problems of trade protectionism which have increased substantially in the 1980s and distorted access to world markets for a number of natural resource-based products.

Protectionist issues of particular concern to Australia affecting resources include tariffs, including tariff escalation, subsidies, market reservations and other quantitative restraints. One issue which has emerged is the impact of production and other subsidies on several commodities of key interest to Australia. There are dangers that the effects of these distortions on, for example, the coal trade will continue and could be repeated in other areas unless tighter rules concerning production subsidies and other distortions are negotiated in this Round.

Our resources and energy industries are efficient and competitive. However, our exports face a range of barriers and distortions, particularly in the coal, steel and aluminium sectors, as indicated by the following examples.

Coal

Subsidies and other support measures assisting coal production in a number of EC countries and Japan distort world coal trade and contribute to the current world oversupply of coal.

EC member state coal support policies comprise a range of measures, including: production subsidies; price supports; grants to offset losses, stockpiling, rationalisation and pension costs; export subsidies; regulations governing coal/energy use; and market reservations for domestic coal. The cost of these programs has more than doubled in a number of countries over the past five years as prices for internationally traded coal have declined markedly in real terms.

In the FRG, annual official coal subsidies have risen by more than 75% in the past four years (Table 1). Subsidies to the FRG coal industry alone exceeded the value of Australia's global coal exports in 1987/88. In Japan, annual direct coal production assistance has more than doubled between 1984/85 and 1987/88 (Table 2).

Table 1:
Assistance from Federal and State Budgets for German coal (in DM million)

Assistance measures	1980	1984	1988 (target)
1.1 coking coal subsidies	1,633.1	1,707.1	3,462.3
1.2 stocking of hard coal	114.7	125.0	107.5
1.3 investment assistance	631.7	190.3	-
1.4 old burdens/pit closures	395.2	179.0	219.4
1.5 company-specific measures	226.5	238.5	339.9
1.6 social measures	261.3	236.1	357.1
Sub-total	**3,262.5**	**2,676.0**	**4,486.2**
2. electricity production fund (coal levy)	2,038.8	2,198.0	4,800.0
3. coal research and processing	521.9	314.1	120.7
4. other assistance, not restricted to hard coal	222.3	490.4	482.4
Total	**6,045.5**	**5,678.5**	**9,889.3**

(Source: FRG Federal Ministry of Economics)

Table 2:
Assistance from Budget for Japanese Coal (in US dollars, millions)

Assistance measures to current production	**1982/83**	**1984/85**	**1987/88** (pr.est)
Grants Sub-total	101	113	179
Price support			
e) on sales to electricity producers and non-ferrous industries	101	344	974
f) on sales to iron and steel, coke and gas-coke producers	93	148	177
Sub-total	194	492	1,151
Assistance measures not Benefiting Current Production			
Sub-total	382	428	743
Total of all assistance measures	**677**	**1,033**	**2,073**

(Source: IEA)

While it is acknowledged that steps are being taken by some countries, including FRG and Japan, to wind back and in some cases eliminate subsidised production, the pace generally has been far too slow and competitive producers like Australia have been faced with diminishing and/or negative returns leading to the scaling down of their own production and industry investment.

Despite cutbacks in subsidised production in the FRG, the intensity of production subsidies has grown dramatically.

Table 3:

FRG Growth in Coal Subsidies

YEAR	DM/t of Saleable Coal (excl. small mines)	DM/Employee (excl. small mines)
1980	64.50	29,591
1984	65.36	30,086
1988 (est.)	130.00	63,275

(Source: FRG Federal Ministry of Economics)

Our own estimates suggest that prices of domestic coal per tonne compared with imported coals are on average higher by approximately 150% - 250% in several European countries and Japan.

Steel

World trade in steel is highly regulated and distorted by a plethora of trade barriers and other assistance measures including tariffs, subsidies, market reservations, quantitative restrictions, licensing, "voluntary" export restraints, import price trigger mechanisms with associated threats of dumping or countervailing duties actions, use of technical standards and certification as access barriers, government ownership practices involving output prices not related to production costs.

Voluntary export arrangements (VERs) and orderly marketing arrangements (OMAs) have proliferated rapidly in the 1980s as the principal means of regulating world trade in steel. More than 60 per cent of world steel trade is now estimated to be controlled under these agreements. The main importers, the EC and the USA, use VERs and OMAs to protect their own markets.

The expiry in September 1989 of the VERs into the USA could provide a catalyst for more intensive consideration of resources trade issues in the Uruguay Round. There is a danger, however, that the US might pursue steel issues outside the context of the Round and seek bilateral rather than multilateral solutions.

Aluminium

Aluminium trade is distorted by many of the same forms of market access barriers and subsidies, eg tariffs, with higher tariffs applied to more highly processed aluminium products; non-tariff measures including subsidies, import licensing and quotas, government ownership practices involving output prices not related to production costs.

Such distortions similarly affect trade in other minerals and metals including copper, nickel, zinc, etc.

2. Negotiating Arrangements in the Uruguay Round

Punta del Este Mandate

The Uruguay Round negotiations were launched at the GATT Ministerial Meeting in Punta del Este, Uruguay, in September 1986 (and are to be concluded within four years from that date). The negotiations are to seek trade liberalisation in all areas and improved trade rules. Fourteen negotiating groups were established to consider issues relating to world trade in goods and one group to consider trade in services. The Natural Resource-based Products Group (one of these fifteen groups) was set up with the following specific mandate:

> "Negotiations shall aim to achieve the fullest liberalisation of trade in natural resource-based products, including in their processed and semi-processed forms. The negotiations shall aim to reduce or eliminate tariff and non-tariff measures, including tariff escalation."

Role of the NRBP Group

On paper the Natural Resource-based Products Group has primary responsibility for the consideration in the Round of minerals trade issues together with forestry and fisheries issues. However there are major differences between key participants on the scope and nature of the Group's work and its role in relation to other negotiating groups.

Product coverage is a particularly vexed question: the negotiating mandate is wide and non-limiting but a number of countries want product coverage limited to those resources covered by previous GATT studies undertaken from 1982 to the commencement of the Round (non-ferrous minerals - aluminium, copper, lead, nickel, tin and zinc - forestry and fisheries products) and have been reluctant to see other resources included. However since coal and ferrous minerals and metals trade is subject to major distortions, Australia proposed at the outset that product coverage should include energy (particularly coal) and ferrous minerals and metals (including steel). The United States and some others have supported the inclusion of energy-based products, but the EC and Japan remain opposed. Following protracted negotiations, in June 1988 agreement was reached, without prejudice to any decision on ultimate coverage for the negotiations, that the GATT Secretariat could begin work on background studies of trade problems in a wider range of products, including energy (coal) and ferrous minerals and metals (including steel).

There are also different views on where the substantive negotiations affecting resources trade should take place. Several countries want these negotiations contained within broader generic negotiations covering tariffs and non-tariff measures, while others have indicated that they will consider NRBP issues only in the NRBP Group. Australia remains flexible on where NRBP issues might be negotiated substantively in the Round but considers that the issues are more likely to receive maximum prominence and exposure in the mandated NRBP Group.

Lindsay Duthie, Australia's Special Trade Representative to the EC, has been Chairman of the Natural Resource-based Products Group since the beginning of the Round.

Other Relevant Groups

Other negotiating groups of particular relevance for resources issues include the Tariffs, Non-Tariff Measures (NTMs), Subsidies (often referred to as the generic Groups) and Trade Related Investment Measures (TRIMS) Groups. The negotiating mandates of these Groups are as follows

- Tariffs: Negotiations shall aim, by appropriate methods, to reduce or, as appropriate, eliminate tariffs including the reduction or elimination of high tariffs and tariff escalation. Emphasis shall be given to the expansion of the scope of tariff concessions among all participants.
  Chairman: Lindsay Duthie

- Non-Tariff Measures: Negotiations shall aim to reduce or eliminate non-tariff measures, including quantitative restrictions, without prejudice to any action to be taken in fulfilment of the rollback commitments.
  Chairman: Lindsay Duthie

- Subsidies: Negotiations on subsidies and countervailing measures shall be based on a review of relevant Articles of the GATT and Code on subsidies and countervailing measures with the objective of improving GATT disciplines relating to all subsidies and countervailing measures that affect international trade. A negotiatiating group will be established to deal with these issues.
  Chairman: Michael Cartland (Hong Kong)

- Trade-Related Investment Measures: Following an examination of the operation of GATT Articles related to the trade restrictive and distorting effects of investment measures, negotiations should elaborate, as appropriate, further provisions that may be necessary to avoid such adverse effects on trade.
  Chairman: Tomohiko Kobayashi (Japan)

Australia continues to press issues relevant to natural resources in each of these negotiating Groups in parallel with our efforts in the NRBP Group.

3. Preparation for the Negotiations

Australia's approach for the resources negotiations has been developed in close consultation with the Trade Negotiations Advisory Group (TNAG), industry organisations and key resource exporters. On-going consultations are maintained with these organisations and companies, eg through meetings with the AMIC Trade Committee and TNAG and through informal contact. We attach high importance to input from industry in developing our negotiating proposals and to the co-operative role industry can play in furthering Australia's interests in the negotiations.

4. Australia's Objectives and Approach

Our key objective is to achieve a more favourable international framework for Australian resource-based trade through reduced market barriers and other trade distortions.

Our overall approach is underlined by the fact that over 40% of Australia's tangible exports are resource-based products and that major distortions pervade trade in a number of these key products. Improvements in areas of the resources trading environment could have a proportionately large impact on Australia's trading performance.

Key areas of interest are coal and steel and non-ferrous minerals and metals which are subject to significant trade distortions, eg aluminium, copper, zinc, nickel, lead and tin.

As a starting point, Australia proposed that the negotiations on minerals, energy, forestry and fisheries products from crude production through to the primary processed stage should be aimed at achieving the phased elimination within ten years of the end of the Round of all tariffs and non-tariff measures, including subsidies and other support measures affecting market access, complemented by tighter rules on the use of production subsidies.

Our approach has been to have the key issues in resources trade (tariffs, subsidies and other non-tariff measures) addressed on a comprehensive basis, and to identify ways of achieving cuts in overall levels of protection applying to specific commodities.

5. Australia's Strategy

Australia's approach to the negotiations is predicated on the fact that some of the major issues such as the problems of production subsidies and specific sector issues such as coal and ferrous metals are relatively new in GATT negotiations. There is therefore not a long history of development work on these issues. In addition, the development of widespread support for Australia's proposals, in particular relating to certain key issues such as coal, is hindered by the small number of GATT members with major export interests.

Our strategy has three main elements:

(i) to highlight the similar and often integrated forms of protectionist measures which permeate a wide range of resource-based products with combinations of support systems varying between countries and between products, eg we are developing a list of non-tariff measures applied to our key resource exports in major markets which will be submitted when NRBP negotiations resume

(ii) to generate coalitions of support for our proposals within key resource exporting countries

(iii) to draw attention to the costs of protectionism, eg on coal in the EC and Japan.

Each of these elements is being pursued at a number of levels - at the political level through Government to Government representations and Ministerial contact; at the officials level through submission of papers and proposals in the Geneva based negotiations processes, with contact groups of like-minded countries, regional groupings and bilateral discussions; and at the business level through corporations participating in international conferences and industry to industry contacts.

Some of the new issues are beginning to capture the interest of other international organisations. For instance Australia was instrumental in having the International Energy Agency examine the level of protectionism in coal by assessing the Producer Subsidy Equivalent values for individual IEA countries. We are also seeking to have the OECD undertake work on subsidies and related measures on non-fuel mineral trade. Nevertheless it is apparent that in the time remaining in the Uruguay Round, Australia will also need to contribute its own rigorous analytical work on the problems of production subsidies and other support systems if we are to influence others as to the importance of addressing these issues in the negotiations. In this regard the current work by ABARE on the costs of coal protectionism and trade distortions in major world coal markets is particularly timely.

Too often, however, we have been told by some other participants, including some with vested interests, that perhaps resources issues are matters for future negotiations - not this Round. We strongly reject this.

6. Attitudes of Key Participants

GATT negotiations are based on consensus. The attitudes of individual countries or small groups of countries can therefore be critical in moving the locus of discussion or influencing the pace of negotiations.

In the case of resources issues there have been surprisingly few countries which have played an active role in bringing forward issues and developing proposals.

- USA: Has not played a strongly activist role in this Group. Has supported the inclusion of energy issues in the negotiations and has generally been supportive of our objectives on coal. Issues of concern to the US include dual pricing, certain export restrictions, subsidies, government ownership practices and tariffs and non-tariff measures. However, the US position to date has been that subsidies could be addressed in the Subsidies Group and that tariffs and non-tariff measures could be handled in broader request/offer negotiations.

- EC: In the early stages of the Round focussed largely on supply side issues. Issues of concern to the EC include high tariff rates, double pricing, quantitative export restrictions/export taxes. Wants NRBP negotiations confined to NRBP Group. Has opposed expansion of product coverage to include coal and steel issues.

- Japan: Has been largely negative towards Australia's approach - wants to exclude energy issues from negotiations. Has supported EC call for examination of certain supply side issues.

- Chile: Attaches a high priority to early substantive negotiations. Interests are principally non-ferrous minerals and metals, has opposed the inclusion of energy and ferrous minerals and metals.

- Canada: Has advised Australia that it shares our objectives for NRBP outcomes but has adopted a different strategy. Wants substantive negotiations to take place in generic groups, eg Tariffs, Non-Tariff measures Groups: has led a move to ensure that negotiations on resources are not separated from broader market access negotiations and do not include supply access issues.

- African Countries: Are seeking a narrow focus on specific commodities of interest to them and seek price stabilisation and preferential arrangements.

7. Assessment of the Negotiations

The Uruguay Round has now reached the half way mark. Progress on NRBP negotiations has been slow. The Report adopted by Ministers at the Mid-Term Review Meeting in Montreal in December was little more than a re-statement of the Punta del

Este negotiating mandate and an agreement to continue negotiating. However, there are some positive aspects of the Report for Australia: negotiating options have been kept open - in particular for product coverage; the Group now has an agreed mandate to consider energy (coal) and ferrous metals issues without prejudice to any decision on ultimate product coverage for negotiations; and agreement that participating countries provide as much relevant trade and barrier data as possible by 31 March 1989.

However, failure to reach agreement on a number of key issues including agriculture at the Montreal meeting has resulted in the negotiations for all Groups being placed on hold. Participants will meet again at the beginning of April in an attempt to resolve this impasse in the four outstanding areas. Once this is achieved the negotiations process is expected to resume for all Groups as soon as possible.

A number of resource exporting countries are growing impatient with the pace of work in the NRBP Group. In addition to Australia's efforts to achieve a high profile for these issues, Chile, supported by some other Latin American countries, has attempted to inject a sense of urgency into the proceeedings. We are strengthening our efforts to work for a more receptive environment for the NRBP negotiations and to ensure that the issues of key importance to us, including coal and steel, continue to be given high exposure and consideration.

The need to consider trading arrangements on steel to follow the conclusion in September this year of the current VRA arrangements in the USA may prove a catalyst for injecting a higher level of activity and interest in resource-based issues. However there is a danger that this important single issue may overshadow efforts on other resource-based issues of equal or greater importance to Australia.

During the early part of this year, we will be seeking to develop closer co-operative efforts with countries which have shared interests on specific issues and to raise the level of debate on the costs of protectionism in some of the key resource consuming countries. In this regard we hope to be able to draw on the ABARE coal study to highlight the costs of coal trade protectionism to the domestic economy of the provider of protection and to the need for solutions to be found in the context of the Uruguay Round.

8. Role of Industry

On-going consultations with Australian industry are an integral part of developing our approach to the negotiations. However, we would like to see even greater involvement of the Australian mining sector in the resources negotiations particularly through

- providing hard evidence of trade

distortions/barriers

- drawing the attention of overseas industry counterparts and of customers in key countries to the costs of protectionism and to "sell" the basic objectives of Australia's proposals on resource-based issues. In our view this should assist the process of developing coalitions of support in ensuring that these issues are addressed effectively in the Round.

9. Conclusion

While there are still major hurdles and roadblocks in the NRBP negotiations to be overcome, the outlook from Australia's viewpoint is not completely negative. Despite attempts by certain countries to limit product coverage to non-ferrous minerals and metals and forestry and fisheries products, negotiating options have been kept open and the Group now has an agreed mandate to consider energy (coal) and ferrous metals (steel) issues with agreement that the Secretariat undertake background studies on problems in trade in an extended range of products, including coal and steel.

We continue to underline the importance of these issues to Australia and to emphasise that the outcomes on resources trade will have a major influence on our own contributions to trade liberalising efforts.

However, the degree of success or otherwise of resources negotiations in the Uruguay Round will largely depend on the willingness of our trading partners to accept that these are issues which must be addressed in this Round.

Mineral exploration outlook: targets, commodities and concepts

Neil Herriman,

CRA Exploration Pty Ltd

Abstract.

Urban Australian society, inclusive of many in Government, appears to believe that the mining industry is no longer relevant to its way of life and can be written off as a sunset industry. In reality the industry plays a critical role in every individual's standard of living and the generation of new wealth for the nation.

Society also has an image that ore deposits are ubiquitous and are easy to discover. However data shows that only 1 in about 300 exploration programmes result in an economic discovery; with a 75% chance that the discovery will only yield a lower than average return. Even at average return the level of profitability would hardly be likely to attract the rational investor who would be better off putting his money safely into long-term bonds.

The motivating factor for continued investment in exploration is the 25% chance that a discovery will yield an above average return; and a small (5%) chance that it will be a significant discovery. For a large company (such as CRA Ltd) a significant discovery would be a mining operation that could add 5% to the company's annual turnover, and operate in the lowest quartile in terms of the cost of production.

Despite the odds, it can be argued that exploration has been too successful in its discoveries, resulting in a boom/bust cyclicity in the level of exploration activity; with a periodicity of about 10 years. This cyclical pattern strongly indicates that the recent boom, focussed almost exclusively on gold, has now peaked and exploration activity will contract up to the mid-1990's before the start of another up-turn. Such a period of contraction will represent a window of opportunity for those few companies with the foresight, stamina and commitment to maintain a consistent level of exploration funding. Exploration focus will be multi-commodity and targets will be World-class.

Comparison with other countries, of similar geology, strongly suggests that Australia has still to realise her full mineral potential, including such World-class deposits. However the history of exploration shows that, if such potential is to be achieved, then explorationists and researchers alike must

increasingly develop an innovative approach based on an open-mind, lateral thinking and multiple working hypotheses. They must not be blinded by the limits of present knowledge. Ready access to geotechnical data is a key requirement for such an approach. To quote a successful explorationist:

"Discovery consists of seeing what everyone has seen and thinking what nobody has thought" (Richards 1986).

Introduction: The Role of The Mining Industry in Society.

Some two and a half million years ago early Man discovered that certain fine grained rocks could be shaped or split to produce a very sharp edge. By using such "tools" he was able to significantly increase the efficiency of the work he had to do to exist. Life was no longer totally dominated by the need to survive. He now had spare time on his hands which he could devote to "recreation" and self-expression through art and religion. This new freedom would have been envied by those groups of people who neither had access to the right rock-material nor the necessary skills to work it, but had other items of value which could be exchanged. Thus a trade developed based on "lithoculture" (c.f. agriculture). This was the start of the mining industry as we know it today, and its critical role in the development of our way of life is recognised by the way we have defined the progress of civilisation through such terms as Stone Age, Bronze (alternatively Chalcolithic or copper) Age, Iron Age and the Nuclear Age.

However, today the web of civilisation has progressed so far from its roots and become so complex that urban man appears to have lost sight of the primary importance of lithoculture to his way of life. This is particularly so in our Australian society, which is the most urbanised in the world and where Government actions in regard to industry restructuring strongly suggest that the mining industry is to be written off as a sunset industry (1).

Yet history shows that a healthy and prosperous mining industry is critical to our way of life, standard of living, employment, national self-sufficiency, the generation of new wealth and our balance of trade.

The mining industry is made up of three interdependent stages: exploration, development and production; of which exploration is the single most important (2). Minerals can only be produced, and income generated, if ore deposits are first successfully located. Thus the effectiveness or otherwise of exploration has a profound effect on the health of the industry as a whole and its ability to generate new wealth for the nation. However, it is important to note the time that is involved between the commencement of initial exploration and the start of production, which can often be in the order of 15 years or more. A healthy future for the mining industry is therefore very dependent upon healthy mineral exploration now.

Successful Exploration: The Odds.

It has been said that mineral exploration has been too successful in the discovery of new resources, thus reducing the incentive for further exploration (2,3). From a local perspective new ore discoveries have played a major part in Australia's historical development and have rescued virtually every State at least once from economic depression (4). It is therefore not surprising that the general public have come to believe that orebodies are easy to find and are lying around everywhere, at call, just waiting to be stumbled over. However it is of concern when such a perception is also held by some in Government, and when they propose a national auction bidding scheme for the granting of mineral exploration licences based on this supposition (5).

Although rocks are ubiquitous, stone-age Man did not use any ordinary rock-type to make his tools. Rather his quarries were restricted to only those limited outcrops where geological events had exposed the most suitable fine grained "flinty" rocks; and where work could be carried out with the greatest economy of effort.

As Bailly noted (6), "natural occurrences that become mineral resources are man-perceived, man-made and definable only in human terms".

Similarly today, although trace amounts of metals are ubiquitous throughout the Earth's crust, those areas where metals are concentrated, to the extent that they might represent possible economic targets, are rare and are randomly distributed according to the vagaries of geological process. It is the localisation of rare geological events, and not such man-made considerations as national park boundaries, that dictates the localisation of an ore deposit.

A study of U.S. exploration, 1942-1967, showed that 52 mineable propositions were discovered as a result of 17,000 exploration programmes. That is to say, the chances of an economic discovery resulting from any one programme was 1:300 (7). Pretorius quoted similar odds (8); and in a study of Canadian exploration Boldy estimated the odds at between 1:100 and 1:1500 (9).

A major study of Australian exploration discovery statistics for the period 1955-1978, by Mackenzie and Bilodeau (10), showed that of 100 mineral deposits discovered, only 43 could be considered potentially economic, pre-tax (Fig.1). Furthermore, given the high risk of exploration in the first place, the average rate of return for these discoveries, of only 11% would hardly be likely to attract the rational investor. After taking the tax regime into account these figures become even less

INFLUENCE OF TAX & METAL PRICE ON DISCOVERY OF ECONOMIC ORE DEPOSITS, 1955 - 78
(out of 100 possible discoveries)

	Lower Limit Prices	Expected Value Prices	Upper Limit Prices
Number Economic Discoveries:			
Potential	24	43	69
After-Tax	14	33	58

(After Mackenzie & Bilodeau, 1983)

Figure 1

INDUSTRY TAX BILLS

INDUSTRY	INCOME SUBJECT TO TAX (% OF TOTAL)	TAX PAID AS % OF TAXABLE INCOME	TAX PAID AS % OF TOTAL INCOME
MINING	21.72	46.97	10.20
AGRICULTURE / FORESTRY	11.07	44.48	4.92
MANUFACTURING	7.51	37.14	2.79
FINANCE	13.72	19.5	2.67
HEALTH	9.51	39.01	3.7
ENTERTAINMENT	9.10	44.7	4.07

Source: The Weekend Australian Jan. 21-22, 1989

Figure 2

attractive. The number of economic deposits discovered is reduced to 33, and the average rate of return is reduced to only 9%. In other words the effects of Government taxation on the mining industry, which is the highest taxed of any industry in Australia (Fig.2), is to reduce the number of economic deposits by approximately 25%.

The study also clearly demonstrated the sensitivity of the discovery economics to varying metal price conditions; with the number of economic discoveries (after tax) varying from 14 to 58 according to whether metal prices were at lower or upper limits for the period of study (Fig.1).

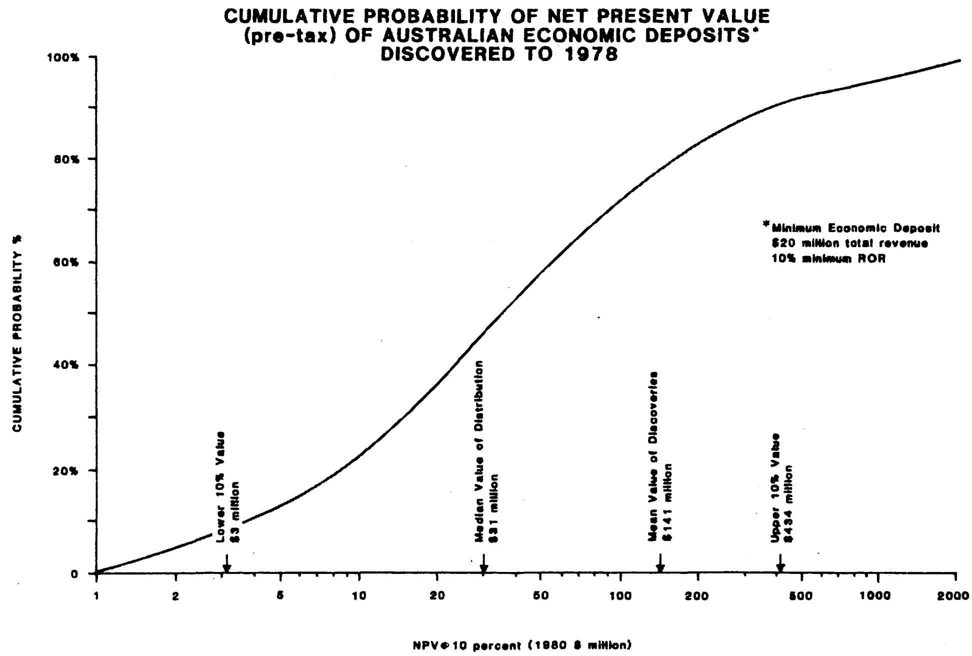
It is also worth noting that the study showed that any unexpected delays between exploration and mine production caused a significant fall-off in the average return and a systematic erosion of the expected value of the discovery. This effect is well understood by many in industry who have experienced such delays over environmental issues; and is certainly clearly understood by those lobby groups who deliberately adopt such delaying tactics. However it does not appear to be recognised by some in Government who believe that much exploration work is "excessive" and "premature" and propose legislation in order to delay exploration and production decisions (5).

Given that, on average, exploration is only marginally economic and would hardly encourage the rational investor (without considering the effects of taxation, metal price uncertainties and unexpected delays) why is it that companies still continue to explore?

Beating the Average: World Class Targets.

The mean value of the deposits evaluated by Mackenzie and Bilodeau was $141 million (1980 dollars) (Fig.3). Given the discovery of an economic deposit there is a 75% chance that it will yield a lower than average return. On the other hand there is a 25% chance that it will yield an above average return; and a small (5%) chance of a $1,000 million discovery or better. It is this thought that, despite the odds, any exploration programme may lead to a significant, or World-class discovery, that is the great motivator for continued investment in mineral exploration.

As an exploration target, the essential characteristics of a World-class mineral deposit are its high grade combined with large size, convenient shape and clearly defined ore zones, easily treatable ore together with valuable by-products, and a good location (11) (Fig.4). Expressed another way, the contained metal content of a World-class orebody will be capable of making a notable impact on the level of World sales; and can be extracted at a production-cost which is in the lowest quartile by world standards.



After Mackenzie & Bibolesu, 1983

Figure 3

WORLD - CLASS ORE DEPOSIT

· CHARACTERISTICS ·

HIGH GRADE

+

LARGE SIZE

CONVENIENT SHAPE

DEFINED ORE-ZONES

EASILY TREATABLE ORE

VALUABLE BI-PRODUCTS

GOOD LOCATION

(After Richards, 1986)

Figure 4

As a major mining company, CRA Ltd would consider an orebody capable of adding >5% to its cash flow as being an attractive exploration target (Fig.5). The impact of this additional annual production capacity, as a percentage of present World sales, is listed in Fig.6 for a range of metals. It should be noted that any significant discovery which would add more than 10% to present world production must be considered an unwise target as it is likely to ruin the market!

Exploration Cycles and Commodity Prices: A Multi-Commodity Approach.

As noted by Anon (20) and Cook (3), modern exploration has been too successful, resulting in a marked cyclicity in the levels of Western World exploration activity.

Increased metal prices have attracted increased exploration activity which has consistently led to increased discovery, over-supply, and decreased metal price. In turn, this has reduced the incentive for exploration and made the high-cost producers uneconomic, thus reducing supply and stimulating the start of another cycle.

This cyclicity is clearly seen in the levels of Australian exploration expenditure over the last 24 years (Fig.7); with a periodicity of approximately 10 years between troughs. This data also strongly suggests that we are at or, more likely, just past a peak in exploration activity and we can therefore expect to see a continuing down-turn until the mid-1990's.

The most notable feature of this last exploration "boom" is that it has been almost totally dominated by expenditure on gold exploration. Exploration expenditure on other commodities has continued on a downhill slide since the peak of the "resources boom" in 1981. Nor has this single-minded commodity focus been restricted to Australia. It has been a World-wide trend (based on data for USA, Canada, South Africa and Australia) with over 70 cents of every exploration dollar being devoted to gold (Fig.8). As a result, Western World gold mine reserves and resources are on the increase, reflecting the success of exploration (Fig.9). Therefore if gold behaves as other commodities, then we can expect a downwards re-adjustment in the future price of gold.

However of more concern from an industry perspective is the lack of sustained exploration for other commodities, and particularly those that have been able to command high prices in recent times. Mine production has increased without replacement of depleting reserves. This trend is clearly illustrated by Western World reserve figures for copper, lead and zinc (Figs. 10,11 and 12).

Given such trends, reflecting the inter-relationship between fluctuating exploration activity, discovery success rates, and

SIGNIFICANT DISCOVERY CRITERIA FOR MAJOR MINING COMPANY (e.g. CRA Ltd)

CAPACITY TO ADD 5% TO SALES

i.e. ANNUAL PRODUCTION>$A250 million (1988)

EQUIVALENT TO ANNUAL PRODUCTION CAPACITY OF

500,000oz GOLD

3,000 Tonnes U_3O_8

100,000 Tonnes COPPER

200,000 Tonnes ZINC

2.5 million ct. GEM DIAMONDS

5 million Tonnes COAL

10 million barrels OIL

Figure 5

SIGNIFICANT DISCOVERY CRITERIA AS PROPORTION OF PRESENT WORLD SALES/PRODUCTION

	%
GOLD	1
IRON ORE	1.4
COPPER	1.5
ZINC	4
DIAMOND	6
NICKEL	6
URANIUM	8
PLATINUM	8
MANGANESE	23
MOLYBDENUM	42
CHROMIUM	55
VANADIUM	55
BERYLLIUM	100

Figure 6

EXPLORATION EXPENDITURE, AUSTRALIA (1965 - 1987)

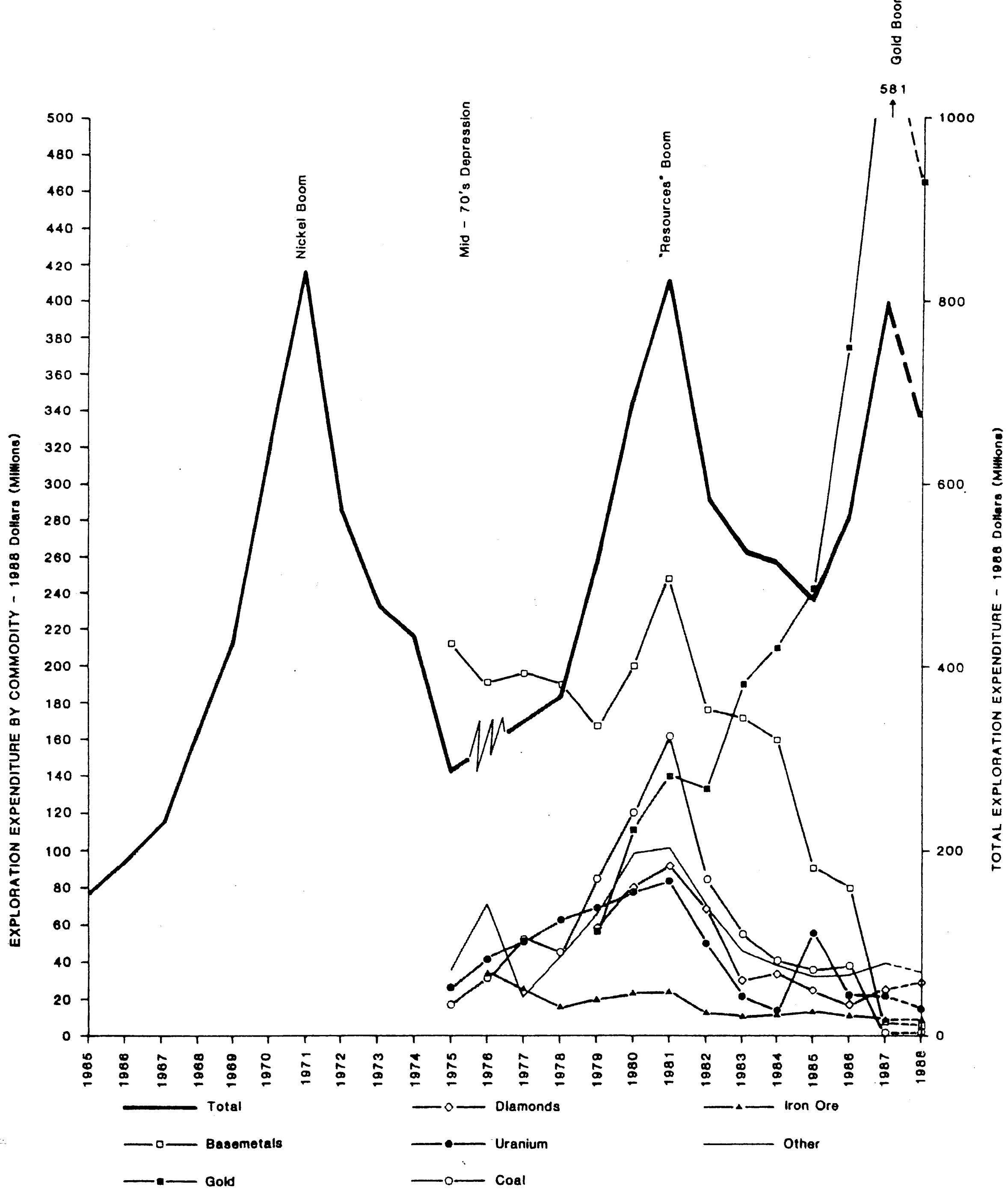


Figure 7

"WORLD" EXPLORATION EXPENDITURE 1970 - 87 by TYPE

% SPENT ON Au, PGM's - Cu, Pb, Zn, Ni - U - OTHER

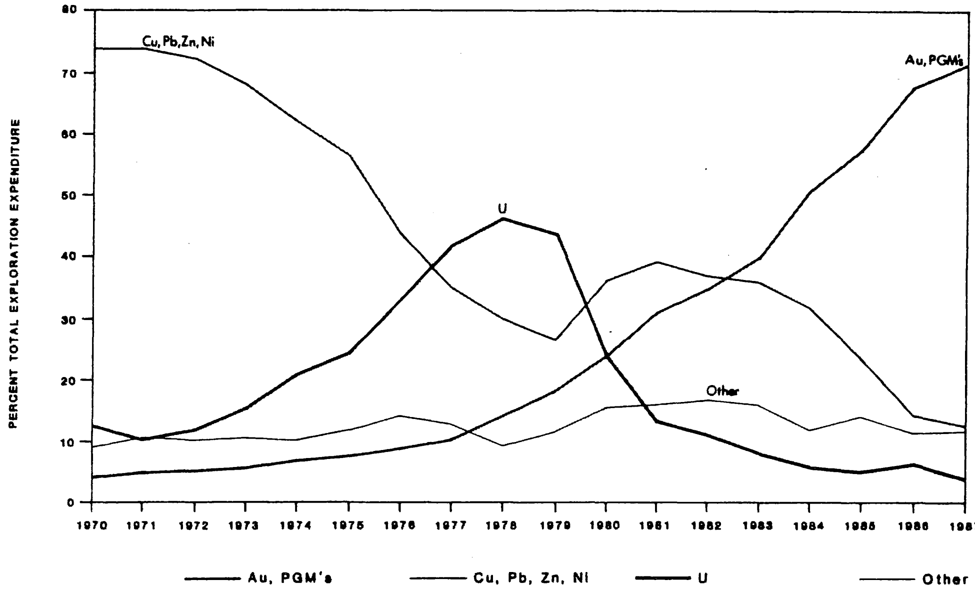


Figure 8

GOLD RESERVES AND RESOURCES (W. WORLD)

1970 - 1987

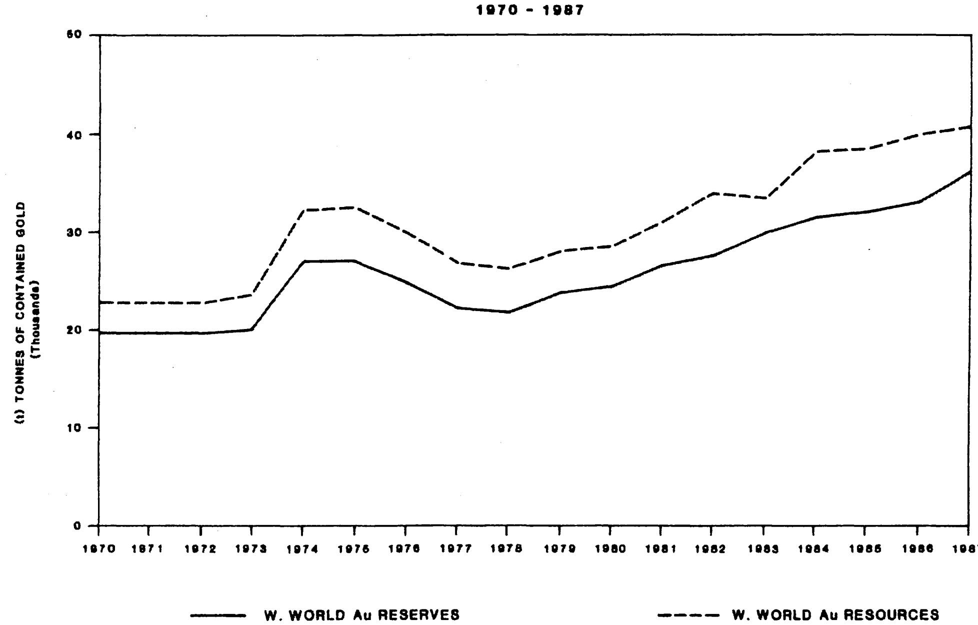


Figure 9

COPPER RESERVES AND RESOURCES (W. WORLD)

1970 - 1987

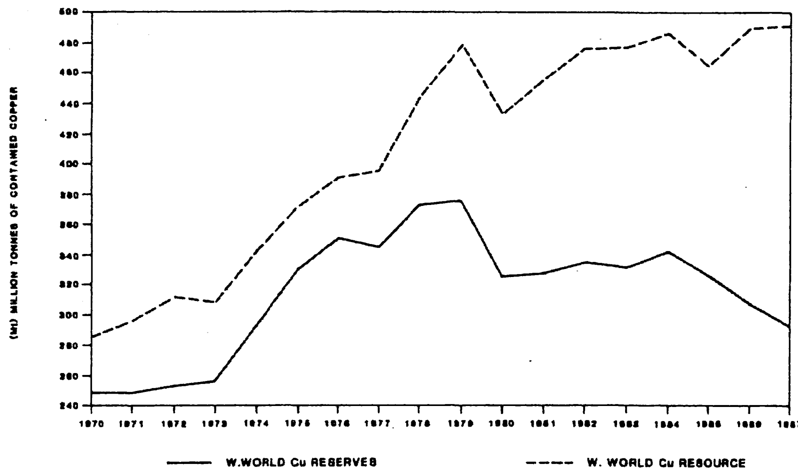


Figure 10

LEAD RESERVES AND RESOURCES (W. WORLD)

1970 - 1987

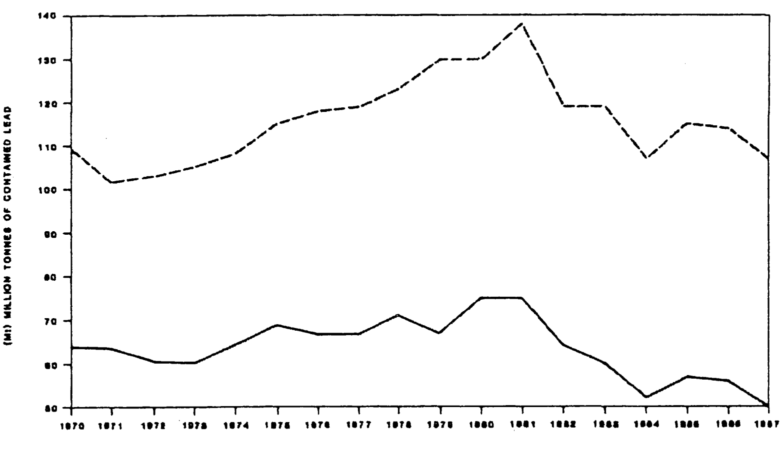


Figure 11

ZINC RESERVES AND RESOURCES (W. WORLD)

1970 - 1987

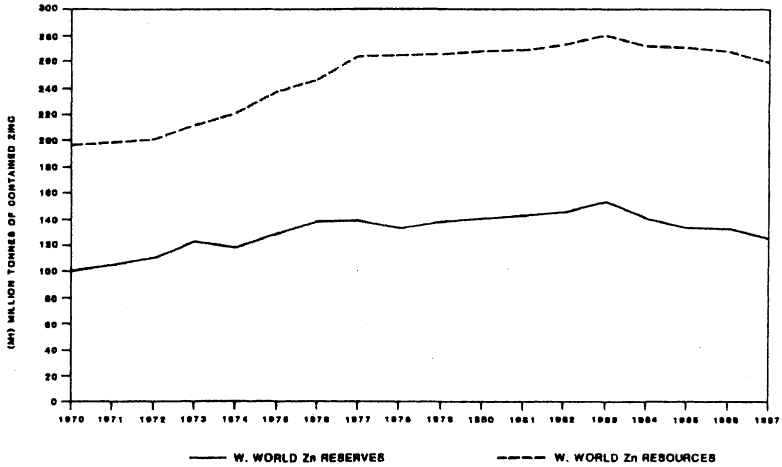


Figure 12

fluctuating metal prices, then the messages are clear. First, maintenance of a consistent level of exploration funding over the long term will create windows of opportunity during the troughs in the cycle, when most competitors will either have reduced funds, or none at all.

Secondly, if industry is to sustain reasonable levels of profitability over the long-term, it is imperative that it reduces its exposure by maintaining a multi-commodity focus in its exploration (Fig.13).

Fig.14 summarises the predicted long-term outlook for a range of major mineral commodities, based on the ratio of existing reserves relative to projected demand.

Finally, the cyclicity has a major message for University undergraduate intake programmes.

The Potential for New Discoveries: Unit Regional Values.

In his analysis of mineral discoveries made during the 40 years prior to 1986, Cook (3) notes that 166 were significant and 70 were World-class. Of these, 9 World-class deposits were discovered in Australia (i.e. 13%). What is the potential for discovering further significant ore deposits in Australia?

If there is any validity in the idea that ore deposits are formed as a result of geological processes, then any two regions of sufficiently large a sample area, and with similar geology, should theoretically contain similar mineral resources per unit area: i.e. they should have similar Unit Regional Values (12). Using this approach, Pretorius (8) compared the relative effectiveness of past exploration, to 1971, between the USA, Canada, South Africa, New Zealand and Australia. Results showed that Canada had produced 2x, New Zealand 3x, South Africa 12x, and the USA 36x the value of Australian mineral production per unit of area. Although the base data used is now out-dated, subsequent discovery history suggests that these relativities are still valid.

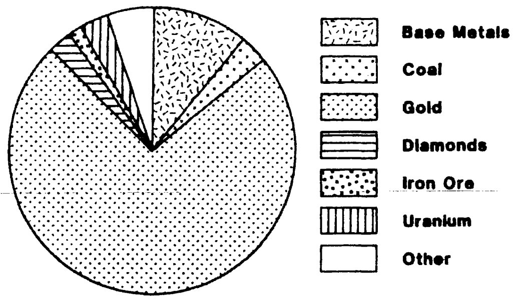
As Pretorius concluded, Australia's real mineral potential has in no way been realised when compared to that of South Africa and the U.S. There remain enormous opportunities for further exploration discoveries.

What then do we, who are involved in or associated with exploration, have to do to realise Australia's full mineral potential?

Realising Australia's Mineral Potential: Unconventional Thinking.

Numerous excellent papers have been written addressing the need to improve exploration success, and all have emphasised the

AUSTRALIA 1987 - 88



EXPLORATION EXPENDITURE

Figure 13

MAJOR MINERAL COMMODITIES

(ANNUAL PRODUCTION GREATER THAN $US 2.5 BILLION)

	ANNUAL PRODUCTION $US BILLION	STATIC RESERVE LIFE (YEARS)	RATIO IDENTIFIED RESERVES TO CUMULATIVE PRIMARY DEMAND 1987-2000	OUTLOOK FOR EXPLORATION
Aluminium	24	237	13.0	Poor
Copper	17	40	2.6	Good
Diamond	4	15	1.0	Good
Gold	21	25	2.5	Good
Iron Ore	17	132	9.0	Poor
Lead	3	28	2.4	Moderate
Nickel	4	67	3.5	Moderate
Phosphate	5	Very large	5.0	Moderate
Platinoids	3	125	10.0	Poor
Silver	3	18	2.1	Poor
Sulphur	7	24	1.2	Good
Uranium	3	64	3.2	Good
Zinc	6	25	1.6	Good

Figure 14

requirement for first-class management, highly qualified but practically-oriented staff, clear yet flexible planning, a willingness to take risk and, last but by no means least, an open-mind and innovative thinking. In this paper I would like to restrict my remarks to this last point.

The Australian mining industry, and particularly exploration, has long recognised the importance of R & D to its future prosperity, operating as it does in an internationally competitive environment. Funding of projects co-ordinated by the Australian Mining Industries Research Association (AMIRA) has shown a significant and consistent increase since the late 1970s, long before the Government introduced the 150% R & D tax "carrot" (Fig.15), and for a number of years now the CSIRO Division of Exploration Geoscience, with industry's support, has in fact achieved the target recently set by Government, of >25% industry funding. As well, exploration companies provide direct support to numerous university research projects; either financially or in material/logistical support.

A major proportion of this external research is focussed on studying ore-types which are presently considered to be economic exploration targets. Such research has an important contribution to make in exploring for extensions to known ore deposits, or for further deposits in established mining fields, and in improving our knowledge of ore-geology and exploration technology in general.

However, history suggests that it may have only limited application in improving our exploration for, and discovery of, new types of World-class deposit and new mineral fields. In fact, if the limitations of such research are not recognised, its results may even detract from our ability to make such new, major discoveries.

In the 24 years following the first discoveries of gold and copper in central Queensland during the mid-1800s, many prospectors passed over an iron-capped hill, which was "contemptuously known as the Iron Mountain", without giving it much thought as it was totally dissimilar to the auriferous quartz reefs and alluvials that had been discovered up to that time (13). In 1882, the Morgan brothers and Sandy Gordon, who were "too ignorant to share the miner's prejudice against ironstone" invited a Dr. Robertson ME, FGS, FRGS, to inspect this Ironstone Mountain and assess its potential as a possible copper deposit. Dr. Robertson recorded that there was a "complete absence (of copper) from the stone, ... there was iron in it, there might be gold in it, but certainly there was no copper". After Robertson's departure, the syndicate stayed on to collect samples for assay - something no-one else had bothered to do before! Thus was discovered the giant Mt. Morgan copper-gold deposit.

Similarly, it wasn't until 1883, seven years after the first

AMIRA - FUNDED EXPLORATION RESEARCH

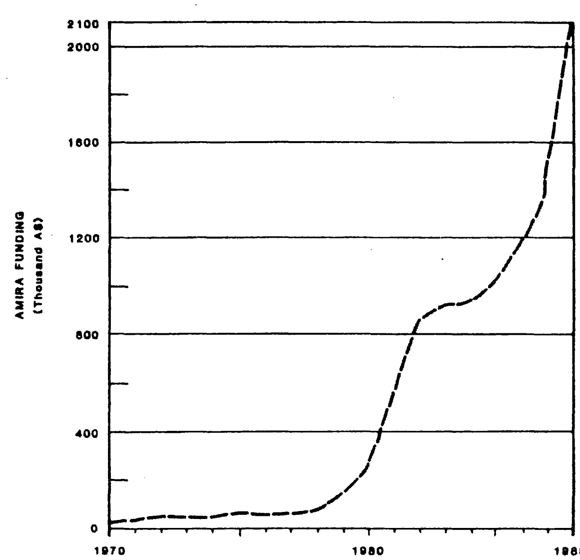


Figure 15

APPLICATION OF GEOLOGICAL OBSERVATIONS, ASSOCIATIONS & THEORIES TO THE VARIOUS STAGES OF EXPLORATION

EXPLORATION STAGE	FACTUAL OBSERVATIONS (Maps, reports)	NATURAL ASSOCIATIONS (Ore-patterns, Non-genetic models)	THEORIES (General geologic concepts, Genetic models)
Area selection	MAJOR	MAJOR	MAJOR
Tenement exploration	MAJOR	MAJOR	MODERATE
Target appraisal-surface	MAJOR	MAJOR	MODERATE
Target appraisal-subsurface	MODERATE	MODERATE	MINOR

(Modified after Bailly, 1981)

Figure 16

discovery of silver in Western NSW, that Broken Hill was first pegged by Charles Rasp. The hill had been recognised as gossan by many of the earlier cornish miners who had prospected over this area. However, as Blainey records (4), the iron hat was enormous compared to gossans associated with known ore deposits of the time and its lode and geological environment were also different. Luckily Rasp, whose knowledge of geology was limited to that learnt from a guidebook on prospecting, was unaware of these differences. [In fact he believed it to be a tin deposit]. Thus it was left to a man ignorant of the "facts" to discover a truly World-class ore deposit.

Such lessons are not restricted to the mineral industry alone. Levorsen (14) noted that most of the oil provinces had been discovered contrary to orthodox geological opinion prevailing at the time, and Pratt (15) relates how the giant Kuwaiti oil-fields were rejected by the large petroleum companies because their "knowledge" of the Iranian fields across the Gulf clearly indicated that there was "no oil in Arabia". It was left to a small company who did not know this fact, to make the discovery. As Pratt concluded: "where oil is first found ... is in the minds of men ... when no man any longer believes more oil is left to be found, no more oil fields will be discovered ...".

In the late 1970's there was a widely held opinion that there were no longer any significant orebodies left to be found in outcrop in Australia. As the 1978 ASTEC Review of the BMR noted: "the majority of large ore-bodies outcropping at the surface, or close to the surface, have now been discovered ... future discoveries will need increasingly to rely on sophisticated research".

Since that statement was made CRA Exploration has discovered the World-class Argyle diamond deposit, the WIM 150 heavy minerals deposit and the Kintyre uranium deposit; and of discoveries made by competitors, Boddington gold and Coronation Hill PGM - gold deposits come to mind. All were at, or close to surface, and all were in some significant way atypical of established ore deposit models as "known" prior to their discovery.

In a review of 20th century uranium discoveries Gableman (16) observed that new and larger types of ore deposit have been consistently discovered, not as a result of exploration based on accepted target models, but as a result of pioneer prospecting in "unfavourable" areas. He went on to note that the scientific understanding of ore deposits has followed, rather than led, exploration in a series of step-wise increments. The discovery of a new ore-type gave rise to a period of intense study and the generation of a new target-model. However this was followed by a period of stagnation when knowledge was considered to be complete with virtually no anticipation of the next new discovery-stage.

Thus it is not the generation of geological knowledge itself that limits our vision of new exploration opportunities, but rather that tendency to believe that our knowledge is complete.

If Australia's mineral potential is to be fully realised then I believe that both explorationists and researchers alike must avoid being blinded by the limits of present knowledge. Rather, they must maintain an open mind, recognising that there is no such thing as proof in science ... only disproof (17). The principle of Multiple Working Hypotheses is as important to scientific advancement today as it was when first proposed almost a century ago - by a geologist (18,19).

The corollary of such a philosophy is that the documentation of, and ready access to, basic geological data is as important as its interpretation and the generation of a new theory, if not more so (Fig.16). It constitutes the building blocks for lateral thinking and the generation of alternative multiple hypotheses. Without access to such data exploration opportunities are limited. As Richards so eloquently put it (11):

"discovery consists of seeing what every one has seen and thinking what nobody has thought".

Conclusion: Mineral Exploration Outlook.

In attempting to gaze into the misty depths of the oft misused crystal ball and predict the future outlook for mineral exploration I am reminded of President Truman's observation that "the only thing new in the World is the history (we) don't know: the only thing that changes is the names (we) give things".

Present exploration activity, World-wide, is almost exclusively focussed on gold as the prime target; and many arguments have been put forward that gold has a mystique of its own and will not react to the laws of supply and demand as do other ordinary commodities. Such arguments do have a certain amount of validity. However my perception of the future is that the same cyclical pattern of "boom and bust", which has characterised past exploration activity, will similarly apply in the future.

The evidence strongly indicates that the recent exploration "gold boom" has now peaked and future levels of exploration activity will continue to decline to a low-point in the mid-1990s, reflecting the loss of speculative interest, the impact of additional production from recent discoveries, and a gold price hovering around a "floor". The exploration industry will undergo a period of rationalisation and contraction, with many companies falling by the way-side.

However, for the more far-sighted companies, this period of contraction can alternatively represent a significant window of opportunity through decreased competition, the freeing up of land under title and take-over opportunities. Sustained levels of exploration funding, first-class management and staff, an aggressive approach and innovative thinking directed towards the discovery of multi-commodity World-class targets will be the hallmarks of the successful few.

The overall outlook is then expected to steadily improve in the latter half of the 1990's, reflecting an increasing demand for new resources, covering a wide range of commodities, in order to replace depleted reserve stocks.

The crystal ball also reveals an ominous dark cloud which casts a shadow over the above scenario: exploration, and the mining industry in general, have a major communication problem.

Contrary to public perception, and that of at least some sections of Government, exploration and mining are not a sunset industry. They continue to compete very successfully in the international market-place, with negative levels of Government assistance. Rather than focusing policy decisions solely on the weaknesses in the national economic base, Government should also be building on the strengths. If exploration is to be able to realise the window of opportunity that lies ahead then it is imperative that Governments, their advisors, and the general public, gain a more realistic understanding of the exploration process, the risks involved and its fundamental role in the generation of new national wealth.

Compared to large regions of similar geology elsewhere in the World, the major part of Australia's true mineral potential is yet to be discovered. The key to unlocking this wealth will be innovative (unconventional) thinking, the avoidance of being blinded by the limits of present knowledge, and the use of multiple working hypotheses based on ready access to basic geotechnical data.

However a major issue for the future is the increasing amount of land (presently 32.6% of Australia) where exploration is either restricted or totally excluded. Although Government is now beginning to recognise the importance of first assessing the mineral potential of such areas before legislating on exploration access, it is strongly argued that such access is never denied and "the keys thrown away". Any such assessment of mineral potential can only be made in the context of the limits set by our present knowledge of ore-deposits. History has consistently shown that such knowledge is, at best, very limited.

References.

(1) May, J., 1989 Science and Technology in Mining: Getting the Balance Right. The Mining Review, January. p21-23. Australian Mining Industry Council, ACT.

(2) Anon., 1984 Towards Successful Exploration. Mining Journal, Vol.303, No.7777. p157-159.

(3) Cook, D.R., 1986 Analysis of Significant Mineral Discoveries in the Last Forty Years and Future Trends. Mining Engineering, February. P87-94.

(4) Blainey, G., 1969 The Rush That Never Ended. A History of Australian Mining. Melbourne University Press (2nd ed.). 389p.

(5) Anon., 1988 Assistance to Mining: Some Issues and Preliminary Analysis. Industries Assistance Commission Discussion Paper, June. AGPS, Canberra.

(6) Bailly, P.A., 1981 Today's Resource Status - Tomorrow's Resource Problems: The Need for Research on Mineral Deposits in Studies in Geophysics. Mineral Resources: Genetic Understanding for Practical Applications. p21-32. National Academy Press, Washington D.C.

(7) Bailly, P.A., 1976 Mineral Exploration Trends and Prospects. Semicentennial Seminar on Exploration Geophysics. Colorado School of Mines.

(8) Pretorius, D.A., 1973 The Role of the Economic Geology Research Unit in Mineral Exploration in South Africa. EGRU Information Circular No.77. University of Witwatersrand, Johannesburg, South Africa.

(9) Boldy, J., 1977 (Un) Certain Exploration Facts From Figures. CIM Bulletin, May. p86-95.

(10) Mackenzie, B.W. & Bilodeau, M.L., 1983 A Study of the Economics of Mineral Exploration in Australia. Australian Mining Industry Council Seminar, July. AMIC, Canberra.

(11) Richards, S.M., 1986 Management of Exploration in Management and Economics of Mining Operations. Proc. Western Australia School of Mines Annual Conference, Oct. p19-24. Kalgoorlie, Western Australia.

(12) Griffiths, J.C. & Singer, D.A., 1971 Unit Regional Value of Non-Renewable Natural Resources as a Measure of Potential Development of Large Regions. Geol. Soc. Aust. Sp. Pub. No.3. p227-238.

(13) Kerr, J., 1982 Mt. Morgan: Gold, Copper and Oil. Diamond Press, Brisbane. 247p.

(14) Levorsen, A.I., 1943 Discovery Thinking. Bull. AAPG. Vol.3, No.7. p887-928.

(15) Pratt, W.E., 1952 Towards a Philosophy of Oil-Finding. Bull. AAPG. Vol.3, No.12. P2231-2236.

(16) Gableman, J.W., 1988 Conventional and Unconventional Uranium Deposits. Ore Geology Reviews, Vol.3, No.1-3. p1-11.

(17) Popper, K.R., 1959 The Logic of Scientific Discovery. Basic Books, New York. 41p.

(18) Chamberlin, T.C., 1898 The Method of Multiple Working Hypotheses. Journal of Geology, Vol.5. p837-848.

(19) Platt, J.R., 1964 Strong Inference. Science, Vol.146, No.3642. p347-353.p

1989 base metals prices outlook

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THE RECENT PAST

Metal prices in calendar 1988 were somewhat better than most forecasters predicted at the beginning of the year. Indeed it was noticeable, even remarkable how much initial forecasts were progressively revised upwards as the year unfolded, in response to the actual firming trend in market prices, and as the world economy continued its strong growth.

In general, and with the benefit of hindsight, the better than forecast price performance by metals (excluding gold and silver) can be attributed to:

Demand - Better than anticipated

(a) On the demand side, a continuation of reasonably strong economic growth in the OECD consuming nations. In 1988 OECD growth rates were around 5%, and fairly evenly spread, whereas expectations at the start of the year were that some cooling off, even decline in economic activity and in metal demand would become apparent by mid-year. That did not occur and, in fact, metals demand appeared to be just as strong in the second half as it was in the first half of 1988.

(b) The newly industrialised countries (NIC's) and Japan enjoyed even higher growth rates, with, for example, the strong economies and production base of Korea and Taiwan more than compensating for the less vigorous growth (as compared with earlier years) in Japan.

(c) Much of the growth in the NIC's was in "investment" rather than "consumption" areas with a consistent proportionally higher demand for metals for this purpose.

(d) The USSR and China came further in from the cold and moved closer to a market integration, in terms of metal demand, with Western economies.

Supply - Tight constraints continued: While demand for metals worldwide grew faster than expectations, the supply side continued to lag.

(a) The lacklustre price performance of base metals between 1982 and 1986 resulted in a decline in the attraction of committing exploration funds to this sector.

(b) In strong contrast, from 1980 until mid 1988, gold offered a more exciting exploration target.

(c) Apart from managements' unwillingness to seek new base metal investments, constrained earnings and cash flows restricted the ability of companies to fund exploration and development programs.

(d) Large borrowings commonplace within the industry, needed to be serviced in terms of both interest and capital, thus further limiting cash availability for new investment.

(e) In a beleaguered cash situation and with tight operating margins, mining company management attention was more directly focused on improving efficiencies, increasing productivity, lowering costs and workforce shedding rather than on production expansion.

(f) Until the last year or so, following the take-off in metal prices, there was a consensus perception that metals would continue to be in oversupply, which, when coupled with expectations of low profitability, meant anticipated rates of return were insufficient to justify new investment.

(g) Base metals, in fundamental rate of return terms, suffered badly in comparison with gold, both in USA and Canada, but especially in Australia, where cash profit margins were not uncommonly around 50% of sales revenue.

(h) For many institutional investors, the base metals sector was viewed as being cyclical with little or no inbuilt growth prospects. Hence, with many companies having considerable (but since 1986 reducing) debt, there was little incentive for mining companies to contemplate investment in a new development or expansion to be financed by equity.

The net effect of continuing firm demand, coupled with the consequences of the relative lack of new investment in productive capacity over the previous 6 - 8 years resulted in a significant supply shortfall in all base metals from 1986 through 1988. The flowthrough impact on terminal metal prices on the LME and Comex surprised everyone.

The $64 billion question is - how long will these buoyant metal prices last and what levels could they reach over say the next two years?

WORLD ECONOMIC SCENARIO

The world economic scenario in 1988 was notable for the resounding manner in which the performance confused and confounded the economic bears who had, by and large, expected signs of a significant or even considerable slackening in economic activity. It just didn't happen and many are now forecasting a similar scenario to occur in 1989, but twelve months later than initially expected.

Ord Minnett Securities' economist/strategist, Geoff Warren, expresses his view of the world economic outlook as follows:

What chance a recession in 1989? The "consensus view" on the world economy in 1989 presently looks for a slow-down in growth over the course of the year but not the emergence of recession. Whilst we do not reject this view out of hand, we also suggest that the prospect of recession emerging over the course of 1989 cannot be lightly dismissed. The consensus view appears to be based on the absence of some of the forces usually required to precipitate a recession, such as tight monetary or fiscal policies or identifiable major shocks. In addition, inflationary dangers are not yet poignant enough to demand a slamming on of the monetary brakes. Consensus also places inflation as unlikely to become a major problem until well into 1989 (if at all), by which time it would be too late to induce a substantial weakening in growth during 1989.

An alternative view can be based on the notion that the world economy is sufficiently unstable at present that merely the **absence** of stimulative policies is enough to permit a recession to develop. Such a view could rest on the notion that the world economy is presently "overstretched", so that some form of retrenchment is in fact the **natural** state of affairs. Accordingly, a recession need not be induced as is presumed under the consensus view referred to above, but can simply emerge once the driving force of stimulative Government policies is withdrawn.

For this alternative view to hold water, one has to be able to identify areas of over-extension or dislocation in the world economy which are sufficiently substantial to command a recession. Most of the relevant factors stem from overuse or abuse of stimulative demand-side policies (i.e., monetary and fiscal policy). In simple terms, such policies are aimed at buoying total spending in the economy by either (a) the Government spending more than it collects, or (b) giving people the opportunity to borrow (against future income) at a hopefully attractive interest rate. Problems arise when the process becomes excessive in the sense that either the supply side of the economy cannot bear the additional demand (which may be reflected in rising inflation) or economic units become **over-extended**, which is typically reflected in **over-indebtedness**. With supply side constraints being of concern but not yet pressing, any immediate problem areas are related to over-extension/over-indebtedness. Specifically, there is the global rise in indebtedness and decline in savings ratios as circumstantial evidence of unsustainably high levels of demand, and the very size of the US twin deficits is hard evidence that the US economy in particular is over-extended.

What **evidence** is there to support the prospect of recession unfolding in 1989? **Firstly**, economic statistics no longer paint a picture of unambiguous strength in the world economy as they were doing some months ago. Although it is not possible at this stage to distinguish between the prospects for recession as against merely a slow-down, it can no longer be said that the world economy contains enough momentum to rule out a substantial softening in the next 3 - 6 months. **Secondly**, if the thesis of over-extended spending levels supported by borrowings is correct, then any retrenchment process should be first detected in a deceleration in credit creation and/or monetary growth, which should then be closely followed by diminishing demand growth. There is some evidence that this is occurring in the US and UK, with US monetary aggregates over the 3 months to November 1988 growing at annualised rates of only 0.7% for M1, 2.8% for M2 and 4.4% for M3, and some softening becoming detectable in UK lending figures. Notably, these are the two major countries where spending appears most over-extended. **Thirdly**, the action in financial markets has been consistent with an implicit forecasting of a deflationary recession rather than an ongoing growth scenario. This is seen, for example, in the lacklustre performance of equity markets, the low valuations placed on cyclical stocks, the lack of upward movement in long term interest rates despite a tightening of monetary policy, and the poor performance of inflation hedges like gold and other commodities since mid-year.

Although the above is sufficient to support the notion of recession unfolding during 1989 as a **possibility**, it is far from a certainty. There is also some evidence which questions (but not refutes) the alternative view put above. **Firstly**, it is only in the US and UK where circumstances **command** spending retrenchment, and where there is also some evidence that this process may have begun. For other major countries, the need for imminently lower spending and debt levels is less clear and less pressing. Indeed, in Japan active monetary stimulus and high credit creation/monetary growth continues at some pace amid attempts to support the US$. **Secondly**, the resilience of the world economy after the sharemarket crash does not seem consistent with any inherent weakness, even allowing for the sharp and immediate post-crash easing of monetary policy. One would have thought such a psychological shock could have done more damage if the world economic structure was truly vulnerable. **Thirdly**, despite deterioration of the Savings and Loans Industry problems in the US, there has been no significant, broad-based escalation in bad debt problems over the last year (although delinquencies remain at high levels). This is not consistent with increasing over-indebtedness.

Is a Recession "Inevitable"? A further related issue is whether a recession will inevitably occur sometime within the next couple of years. Although "inevitable" is perhaps too strong a word, we nevertheless believe that a recession is highly probably within this time frame. On a superficial level, it is contended that economic and market cycles are endemic to the system, representing a shift from excess in one direction to excess in the other. The most relevant excesses currently identifiable in the world economy (as touched on in the discussions above) mainly relate to overuse or stimulative demand-side policies, particularly monetary policy. The ability to maintain stimulative policies for much longer is becoming increasingly capped by supply-side constraints such as industrial capacity utilisation, commodity markets and labour markets which are all closing in on their physical limitations. A problem with such excesses is that once the upward momentum is lost, there can be a tendency for the process of retrenchment to act as an accelerator in the opposite direction. In the current instance this could be manifested in an escalation of bad debts in the financial sector and **further** expansion of the US budget deficits as growth weakens. This might actually work to propagate and exacerbate the process of weakness in the economy as reactive measures are taken. Looking at the world economy in this fashion the key issue is when and not whether a recession will emerge.

An argument that recession need not occur could be based on the notion that growth will settle down to levels consistent with the underlying non-inflationary sustainable growth rate as determined by growth in productive capability. This is generally estimated at around 2.5% per annum. Whilst this is possible, in an historical context this would be a rare occurrence. The probability of the world economy settling down to a stable moderate growth path is arguably a function of the degree of excess and distortion in the world economy: the greater the excess and distortions, the greater propensity for instability in a downward direction. We believe that the chances of avoiding a recession sometime in the next couple of years is low. Anything from a growth recession (of say 1% growth) to depression is possible.

A Strong Economy in 1989? The one prospect not yet considered is that of a strong world economy in 1989 (i.e., growth in excess of 3.5%). Given that the statistics are already indicating a slow-down in the pace of growth, that global policy settings have overall moved from stimulative towards midly restrictive, and that supply-side constraints are beginning to emerge, we view this as a low probability outcome. If it was to eventuate, the inflation risk in the world economy would escalate. The likely response of monetary authorities should then be to tighten policy, which would then harbour a cyclical downturn in the usual fashion at a later stage (probably in 1990).

Other Factors. The above analysis assumes no shocks to the world economy. The major area of danger at the moment would be a loss of confidence in the US economy which would increase the risk of recession considerably. With US political and economic parameters in a post-election state of flux, the risk of such a shock is not insignificant. A further risk is that of a crash in Japanese asset markets. We doubt this will occur until monetary policy is tightened in Japan, which is not in prospect in the near future. Nevertheless, if it did occur, it could be significant if it resulted in financial instability and a drying up of liquidity generation in Japan because of effects on collateral and confidence.

METALS OVERVIEW

By and large in 1989 we expect base metal prices to soften from 1988 levels, although the falls will not be uniform. For example, we anticipate tin will improve in price, while lead and zinc have less downside than, for example, nickel. Because the supply side is still in most cases the more volatile input, and since stock levels are mostly still tight, any interruptions to supply, along the lines of what happened for example to copper and zinc in 1988, could result in a blow-out in spot prices over short periods of time. Such spikes could be short-lived.

Despite some softening, we do not expect prices for any of the metals to fall back to the disaster levels of pre-1986. Even allowing for a slow-down in economic activity in 1990, metals prices next year should be comfortably above 1986 levels and with the exception of lead, measurably higher than in 1987. In 1990 tin, nickel and zinc prices should be substantially above those of 1987.

The wild card in the pack could be the return of inflation and/or inflationary expectations. Should this occur it would add both speculative potential and volatility to metals generally. Copper and nickel probably have the greatest scope for speculative volatility over the next twelve months.

In the following metal price forecasts, we have confined our analysis to the LME traded base metals. For example, iron ore and mineral sands have not been specifically covered, but both appear subject to the same price determinants in 1989 of reasonably firm economic growth (but slowing down in the second half) and generally insufficient capacity worldwide. The 1989 outlook for other non-precious metals generally is therefore still positive.

ALUMINIUM

The pace of aluminium consumption growth appears to be slowing from the heady levels of 1987 - early 1988, and this slow-down in the rate of growth should continue into 1989 and 1990.

Capacity rates are currently around 96%, while annual capacity (mainly Brazil) could increase by only 650,000 tonnes over the next two years.

Provided the world economy does not lose too much momentum, consumption should be around 14.2 - 14.3 million tonnes in 1989 and 1990, up some 12% and 4% on 1986 and 1987 respectively.

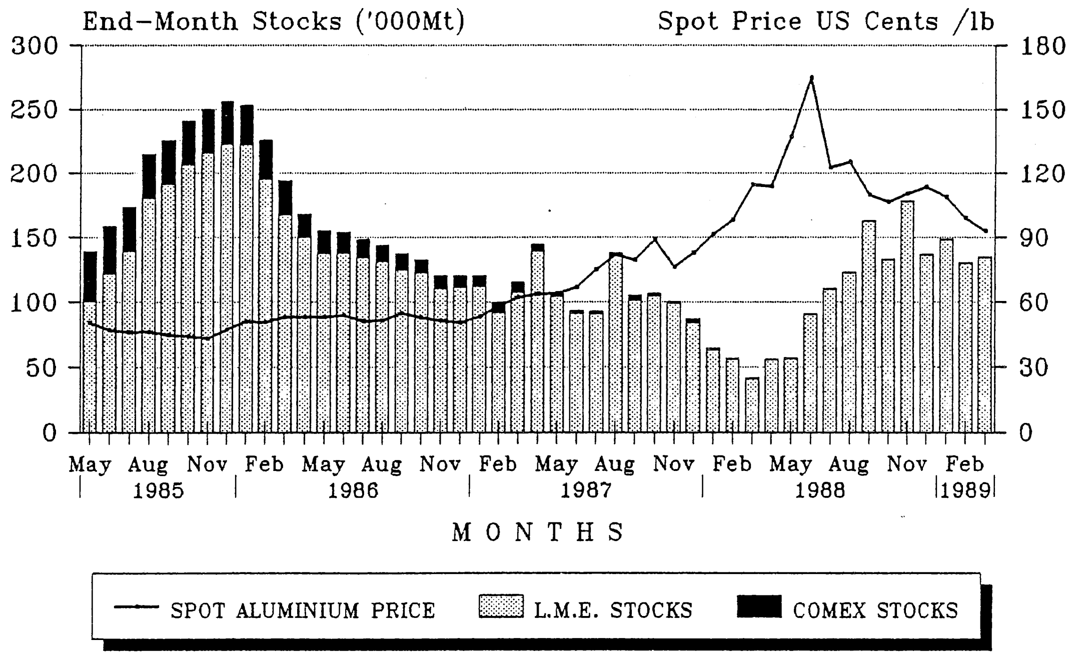
If there are no production disruptions, it should give the opportunity for some stockpile replenishment, but this will not be of major proportions. Stock levels could remain between 5 to 6 weeks consumption.

Forecast prices in US cents per pound are:

	Actual			Forecast		
	1986	1987	1988	1989 1st Half	1989 2nd Half	1990
Average	52c	71c	117c	95c	85c	80c

Note that the 1989 forecast at 90c is 27% above the 1987 average and it is 23% below that of 1988. Current price 10.3.89 is 99c.

ALUMINIUM LME-COMEX STOCK : PRICE TREND
May 1985 - March 9th 1989
ORD MINNETT MINING RESEARCH



COPPER

In 1988 demand was particularly strong in Western Europe and Japan, although part of this strength was attributable to rebuilding of fabricator downstream inventories. For 1989 and 1990 demand should be close on a par with 1988 levels at around 8.2 - 8.3 million tonnes.

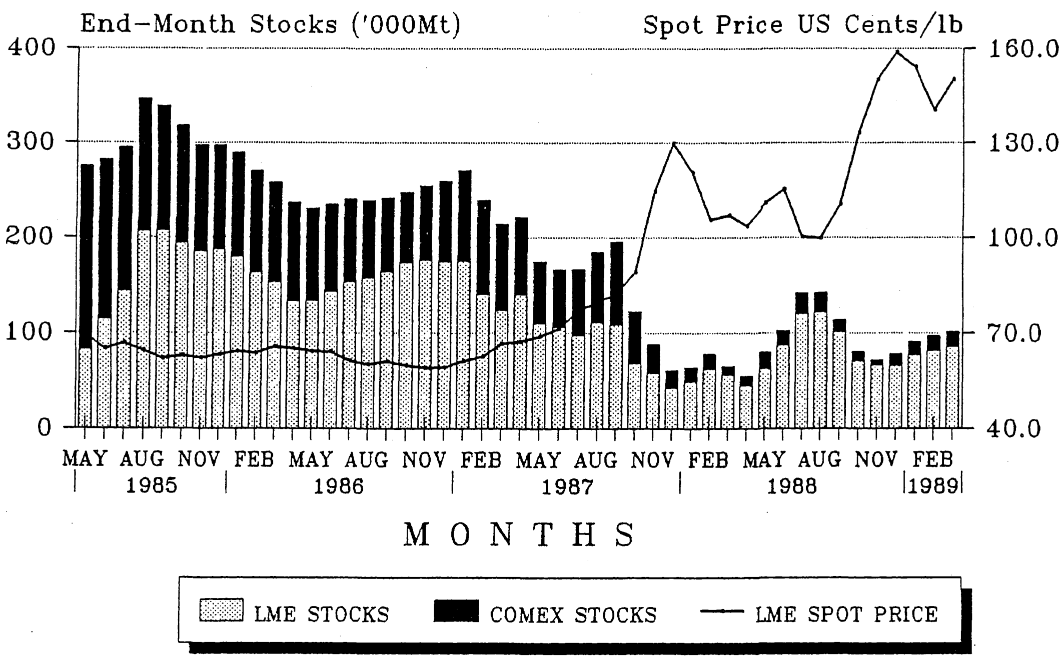
Despite high prices, producers have been slow to respond by increasing production. Strike action in Canada and Peru had a significant impact on output in 1988. Mine capacity utilisation is around 88%. Overall mine output in 1988 was below that of 1987, resulting in stock levels declining to a critical level of 3 - 4 weeks consumption.

Forecast prices in US cents per pound:

	Actual			Forecast		
	1986	1987	1988	1989 1st Half	1989 2nd Half	1990
Average	62c	81c	115c	140c	100c	85c

Note that the 1989 forecast at 120c is 48% above the 1987 average and 4% above that of 1988. Current spot price (10.3.89) is 145c.

COPPER LME-COMEX STOCK : PRICE TREND
May 1985 - March 9th 1989
ORD MINNETT MINING RESEARCH



LEAD

Lead has been the least exciting metal over the last two years, having enjoyed its big price lift in late 1986 - early 1987. As a consequence of the early move, refined production was able to match the increased demand and stockpiles have stayed stable at a little over 5 weeks consumption. From here on, most growth should come from the Asian NICs, but consumption in 1989 and 1990 should not vary much from the 4.3 million tonnes of 1988.

Secondary production has been stimulated by higher prices and now accounts for almost 50% of refined production.

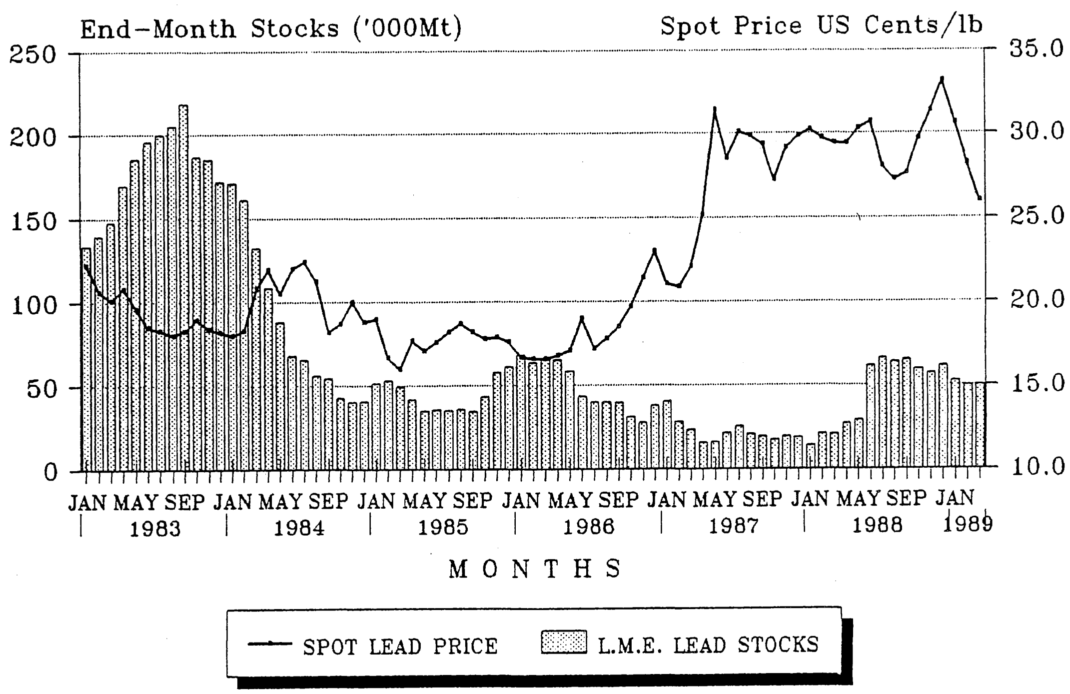
At present supply and demand fundamentals are closely in balance, with present prices sufficient to maintain the equilibrium. In 1990/91 a number of new lead/zinc mines will come on stream in Canada, Alaska and Australia. In the meantime, declining production costs and expansion of co-product zinc supplies should ensure a gentle drift in market quotes.

Forecast prices in US cents per pound:

	Actual			Forecast		
	1986	1987	1988	1989		1990
				1st Half	2nd Half	
Average	18c	27c	29.7c	27.5c	25.5c	25.5c

Note that the 1989 forecast at 26.5c is 2% below that of 1987 and 11% below that of 1988. Current spot price (10. 3.89) is 26.5c.

LEAD L.M.E. STOCK : PRICE TREND
January 1983 – March 9th 1989
ORD MINNETT MINING RESEARCH



NICKEL

The year 1988 was exceptional for nickel, but demand is now past its best and likely to decline as scrap begins to replace virgin metal. For 1989 finished consumption may well be about the same as 1988 at 650,000 tonnes.

Production, however, continues to move rapidly ahead as industrial disputes and technical difficulties are overcome. Of all the metals, nickel has the biggest statistic shortfall of supply versus demand, and stocks at between 6 and 7 weeks consumption are not really at a consumers' comfort level.

Substitution and consumer resistance to prices above $7.50 per pound could well see consumption in 1989 below 1988 levels, but the production side has little elasticity to compensate for unexpected supply side interruptions.

While the price trend should be firmly down, the path will not be a smooth one and short term fluctuations could be similar to those experienced in 1988.

Barring unduly harsh supply side disruptions, the price in the fourth quarter of 1989 could be down some 45% from present levels to $4.50 per pound.

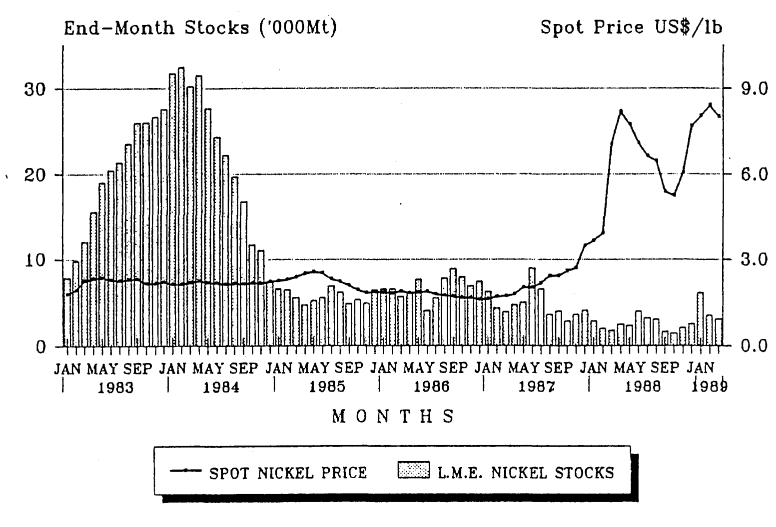
The year 1990 could see prices average $3.50 per pound, which, although down 55% from first half 1989 forecast averages, will still nevertheless be up 100% on the 1986 average.

Forecast prices in US cents per pound:

	Actual			Forecast		
	1986	1987	1988	1989		1990
				1st Half	2nd Half	
Average	176	221	625	775	475	350

Note that the 1989 average at 625 cents is 182% above that of 1987 and is is the same as 1988. Current spot price (10.3.89) is 810c.

NICKEL L.M.E. STOCK : PRICE TREND
January 1983 - March 9th 1989
ORD MINNETT MINING RESEARCH



TIN

Refined consumption in 1989 is forecast around 173,000 tonnes, some 12% above 1986 levels, with USA being the main geographic area of growth. The increase in the price of aluminium has restored much of tin's competitive edge in the can market.

After 2-1/2 years of essentially sideways price movement, the market is now showing very positive signs of the three year progressive reduction in the stockpiles (some 61,000 tonnes) overhung from the ITC collapse three years ago.

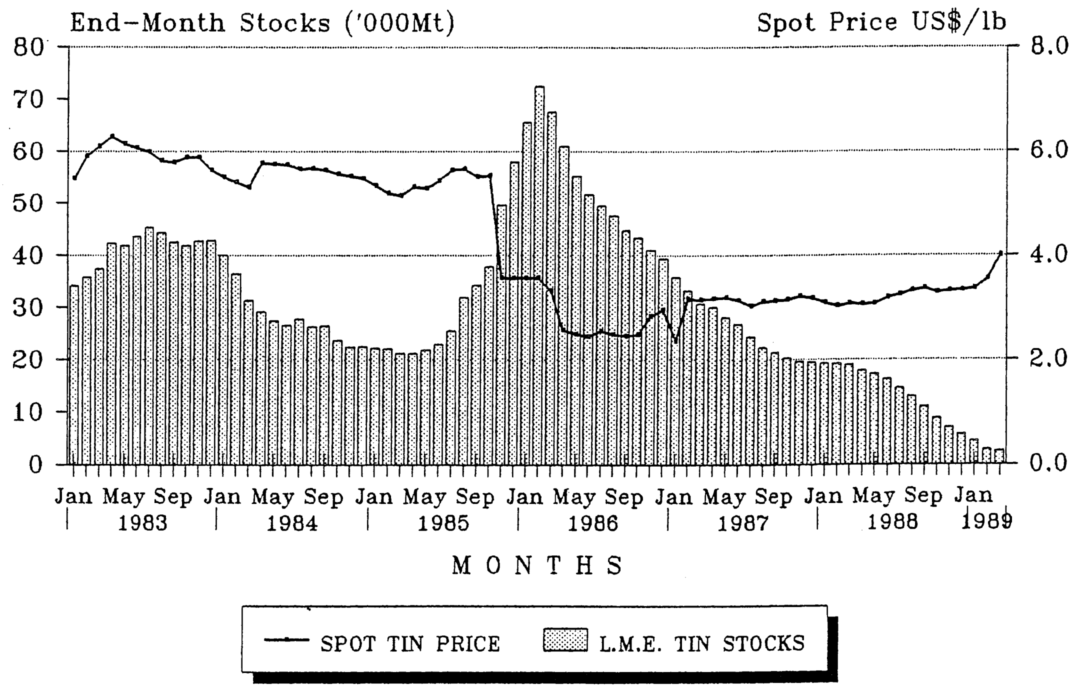
Stockpiles are around 4 - 5 weeks consumption and non-socialist world production will need the stimulus of higher prices if major shortages are to be averted over the next two years. Some 180,000 tonnes of mine production will be needed to ensure a reasonable supply/demand balance, or 35,000 tonnes above 1987 levels.

Forecast prices in US cents per pound are:

	Actual			Forecast		
	1986	1987	1988	1989		1990
				1st Half	2nd Half	
Average	2.80	3.05	3.32	370	430	450

Note that the 1989 forecast at 400c is 31% above the 1987 average and it is 20% above that of 1988. Current price 10.3.89 is 402c per pound.

TIN L.M.E. STOCK : PRICE TREND
January 1983 - March 9th 1989
ORD MINNETT MINING RESEARCH



ZINC

In 1989 demand for zinc could exceed 5.3 million tonnes, up 8.6% from 1986 levels. Japan and USA seem likely to continue to be the high growth rate areas. The strength in demand will continue to test producers' ability to supply refined metal.

Supply continues to be the dominant factor in the supply/demand equation, and actual and anticipated strikes in Europe, North America and South America have resulted in stockpile levels declining to most uncomfortable levels (for consumers) at below five weeks consumption.

The imbalance is not likely to be corrected until the new wave of major zinc projects come on stream later in 1989.

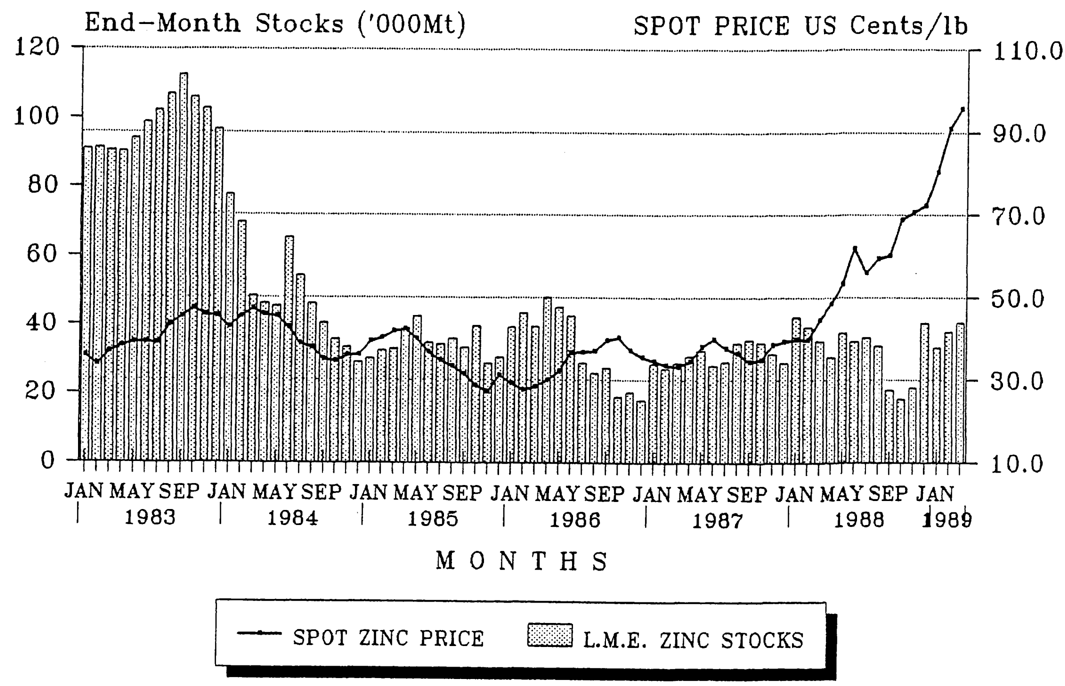
In 1989 the refined zinc market will, in our view, continue to be extremely tight. In 1989, as new mines begin contributing to production, zinc prices should start to drift back.

Forecast prices in US cents per pound:

	Actual			Forecast		
	1986	1987	1988	1989 1st Half	1989 2nd Half	1990
Average	34c	36c	56c	85c	65c	55c

Note that the average price for 1989 at 75c per pound is 108% above the 1987 average and it is 34% above that of 1988. Current price 10.3.89 is 93c.

ZINC L.M.E. STOCK : PRICE TREND
January 1983 - March 9th 1989
ORD MINNETT MINING RESEARCH



GOLD

Because of its very nature as a currency and inflation hedge, as well as a haven to combat political uncertainty, gold often does not necessarily reflect simple supply/demand equations.

Nevertheless, the increasing world production of gold is something which the market found difficult to absorb in 1988, and 1989 is likely to continue this trend. In 1989 lack of Central Bank intervention, lower investment demand and a sound economic outlook point to a lacklustre price picture. But 1990 could see an improving outlook as the world economies enter a more difficult phase, which could place strain on the US$. Some support could come from the return of inflationary expectations, but this should be a supporting rather than a significant uplifting force.

For 1989, in the absence of no major shocks to the world's monetary system, we foresee an average price of US$380 per ounce, or very close to existing levels. The year 1990 should see an average price not too far removed from this level, but watch the trend of US excess money supply growth.

SILVER

Since mid-1988 silver inventories have begun to rise again. Although the price profile for gold and silver have diverged at specific periods during the past, we see no reason to expect, in the likely 1989 and 1990 economic/monetary/gold scenario, that prices will, on average, vary significantly from present levels of around $5.85 per ounce.

SUMMARY

A pause in economic expansion will put some pressure on base metal prices in 1989, but inventories are not expected to return to excessively high levels. In some cases, for example zinc and tin, stock to consumption ratios could still be tight well into the second half.

In the foreseeable future we can only concur with the viewpoint expressed by Mr. John Ralph, Chief Executive of CRA Limited, following release of record 1989 profit results.

He said the traumas of the decade between 1975 and 1985 (attributable to major slumps in demand caused by the two oil shocks being superimposed on excess capacity caused by earlier over-optimism) were an aberration in the history of mining and the metals business is now back in a stable growth phase for at least a decade and possibly longer. Furthermore, although the price rises (in 1988) will be hard to sustain, fundamentals are now the best they have been since 1972 and stability has returned to the markets.