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PETROLEUM & MINERALS REVIEW CONFERENCE

18-19 MARCH 1987

COPPER IN AUSTRALIA - PRESENT, PAST & FUTURE

SPEAKING NOTES AND FIGURES

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Today, I'm going to review copper production and resource availability in Australia........Present, Past and Future. Firstly, we will look at the demand and supply situation for copper during 1986, set in a world context, and also look at the factors which affect the viability of some Australian copper producers. Next we will discuss possible future Australian production and copper availability over the next eight or so years from known or identified resources. Finally, we will take a backward glance at Australian copper production since the industry began in 1842 at Kapunda in South Australia, and from this historical base speculate on the possible prospectivity and potential for relatively high grade copper deposits in both proven and less well known basins and fault-bounded troughs within Australia.

In the Western World in 1986, the effect of the fall in oil prices, reductions in the interest rates and the improved pattern of exchange rates significantly improved the prospects of real growth and lower inflation.

As seen from Figure 1, Western World economic growth slowed markedly as a result of the first oil crisis of 1973/4 and the second crisis in 1979/80 to average about 2.1% over the period 1974 to 1982. (The GDP growth rate was actually negative in 1982). Since then, the average growth rate of GDP has risen to 3.6% with a sharp reduction in inflation rates (almost halving) to 4.8%. The forecast growth rate for real GDP in the Western World for 1987 is put at around the same rate as for 1986, namely about 3¼% with a forecast inflation rate for 1987 averaging 3%.

In the case of copper consumption and production, (Figure 2) the rate of growth since 1974 has averaged around 1.3% annually, well below that of the halcyon days of the 60's and early 70's.

In 1986, estimated Western World copper <u>consumption</u> was 7.3Mt (Figure 3), marginally higher than in 1985. However, Western World refined <u>production</u> increased by 1.0% to an estimated 7.4Mt which resulted in a net apparent surplus of refined production over consumption of about 100 000t. World stocks declined in the first half of 1986 but began to rise by year end.

Western World <u>mine</u> production (Figure 4) declined by an estimated 1% in 1986 to 6.4Mt as a result of lower output from almost all major producing countries except Chile and USA where production rose by 2% and 4% respectively. Australia is now the seventh largest Western World producer with about 4% of total production, having displaced the Philippines from this spot in 1984.

In Australia (Figure 5), estimated mine production fell 8% to 239 000t in 1986 despite higher output from Cobar and Woodlawn in NSW, because of decreases in production from Warrego in Northern Territory and from the Mount Gunson mine in South Australia which closed around mid year. However, output from Mount Isa and from Mount Lyell remained at near record levels.

Now, let us pause for a moment and look at this phenomena of rising output in the face of apparent adverse market conditions. Despite the lower price in real terms for copper every year, most copper producers in Australia and many overseas continue to remain in business, although generally at levels of low profitability, for one or more reasons. These factors include increased revenues or decreased costs because of by-product credits, devaluation, increased efficiencies and labour shedding, and decreased unit costs via increased throughput.

For instance, in the case of by-product credits (precious metals), the presence of gold particularly (in relatively minor amounts) has tended to offset decreasing copper revenues because of gold's current high price. At the Warrego mine, NT and Mount Lyell in TAS, the weighted average of the proportional contribution that gold makes to their total revenue (Figure 6) reached almost 50% in the early 1980's and is currently around 25%.

In the case of devaluation, revenues are boosted proportionately when local currencies of major copper producing countries are devalued, although the effective devaluation is somewhat less, being adversely affected by the consequent increase in costs through higher inflation. Figure 7 shows the net devaluation effect on the copper price for the eight major producing countries over the 12 year period 1973 to 1984. Chile and Zaire, for example, averaged a 27% and 13% effective increased copper revenue advantage respectively over the US as a result of devaluation, which, in those countries averaged 140% and 57% per year respectively.

Again, the chronically low prices experienced in the copper industry over the last seven years has necessitated drastic cost-cutting through the introduction of high technology innovations and efficiencies to all phases of the production process, and this is mirrored by an increasing trend in the case of many of the major overseas producers towards production from very low cost surface or oxidised ore-types which are amenable to heap leaching, solvent extraction and electrowinning.

In Australia, producers have lowered unit costs also by increasing throughput. As a result of the fall in price in 1981, lower unit costs have been achieved by a combination of increased ore production (or tonnage milled), and increases in head grades. The rise in output was about 20% in the period 1981-1986 (Figure 6).

The weighted average of copper ore grades for seven major Australian producers during the period 1977-1986 is shown in the top half of Figure 8 while the bottom half shows current and constant dollar copper prices over the same period. There is a suggestion that the price peak of 1979 and 1980 (in real or constant A$) was followed 12 months later by an average reduction in the grade of ore milled while conversely, an increase in average grade has occurred in response to continuing low copper prices in real terms over the subsequent period 1981-1985.

While speaking about prices, it is worth noting that the average US producer price trended downwards from US69.4 cents/lb in January 1986 to US66.5 cents/lb in July at which level it stayed until the end of the year. Nevertheless, the average price during 1986, at US67.4 cents/lb was almost 1% higher than the 1985 average. However, 1986 US copper prices in real terms, were the lowest for over 40 years. Australian copper prices, at an average of $2 113/t for the year, were 2% higher than in 1985, mainly because of the effect of the Australian dollar devaluation. The LME copper price is shown in pounds sterling per tonne for the three years, 1984 to the beginning of 1987 (Figure 9). While the traditional inverse relationship between stock levels and the LME cash copper price obtains for the period up to the end of 1985, the relationship is less obvious in detail during 1986 and may reflect a change in the philosophy of firms as to how they hold and manage stocks.

Well, what about future Australian production in the near to medium term?

If real prices and costs in relative terms don't deteriorate, Australian mine production in 1987 is forecast to remain slightly below the 1986 level before increasing to about 250 000t (Figure 10) in 1988 with the start-up around mid-year of the Olympic Dam project in South Australia where production of 30 000t refined copper annually is planned in the initial phase.

In the longer term, and given that Mount Lyell will now continue past the original closing date of mid-1989 up until around 1994, Australian mine production of copper could increase by up to 50% by the mid 1990's as a result of commissioning of new mines such as Scuddles and Nifty in Western Australia (Figure 5) and/or because of expansion at existing mines (eg Olympic Dam in South Australia), provided relative costs and prices are favourable for their development.

It is worth noting that, as at the end of 1986, Australian Economic Demonstrated resources are about 16Mt of contained copper, about 70% of which resides in the very large Olympic Dam deposit. In fact, most of Australia's economic copper resources lie in the two large Proterozoic deposits at Olympic Dam in SA and at Mt Isa in Queensland.

Now, let us turn the clock back and briefly review Australian copper mine production since its inception.

On the eve of Australia's bicentenary, it may be constructive to consider what implications an analysis of the past 144 years of copper production up until 1986 (Figure 11) could have for future levels and sources of copper output.

To date, Australia has produced about 7Mt of contained copper, which is the equivalent of about one year's western world production. Queensland (Figure 12) has been the largest producer (almost 60% of total) followed by TAS (16%), NSW (10%), SA (9%), NT (3.8%), WA (2%) and Victoria which has produced less than 3 000t or 0.04%. Of the 7Mt produced to date, about 50% has come from the Mount Isa - Cloncurry area and 47% (from about 1953 onwards) from the Mount Isa mine itself, by far the largest single producer. The largest three mines, Mount Isa (about 3.3Mt Cu), Mount Lyell (1.0Mt Cu) and Mount Morgan (0.38Mt Cu), have together produced about 70% of total Australian copper output.

In terms of the geologicial age of the host rocks, the mid-Proterozoic has produced about 52% of past copper production (Figure 13) most of which has come from the Mount Isa mine in the Mount Isa fault trough. A further 16% was produced from the Cambrian, (the early portion of the Phanerozoic) of which Mount Lyell contributed 90% of the output.

In terms of deposit type (Figure 14), the Proterozoic stratabound type of which Rum Jungle (NT), and Mount Gunson and Kapunda in SA are concordant examples, and the Mount Isa copper orebodies, Mammoth, and Duchess in NW QLD and Burra, Blinman, Wallaroo, Moonta, in South Australia are just a few discordant examples, make up the largest proportion (about 65%). When past production is combined with currently identified economic demonstrated resources which of course includes the large Olympic Dam deposit, stratabound deposits clearly represents the single most important deposit type.

The most important metallogenic copper provinces in the past (Figure 15) include the Proterozoic Mount Isa Fault Trough (50%) followed by the Dundas Trough, Tasmania (18%), the Lachlan Fold Belt New South Wales (7%), and the New England Fold Belt which contains the Mount Morgan deposit, Queensland (7%). Overall, 16 basins/blocks have hosted about 50 major mines, each mine having produced in excess of the 4 000t of contained copper cut-off.

However, I consider that Australia's Proterozoic rift basins have the largest potential for further economic stratabound copper deposits and although several of the known rift basins have been substantial producers, some still remain with high potential and have not as yet been exhaustively explored (Figure 16).

The feature of Proterozoic rift basins is their propensity to host relatively high grade large tonnage stratabound copper deposits of the Zambian-Zairean copperbelt type which typically grade plus 3% Cu and plus 50Mt of ore with considerable scope for precious metal (Au, Ag, or PGM, plus or minus cobalt) by-product credits.

Further potential for world class copper deposits exists, I believe, in the "proven" Proterozoic Stuart Shelf area, South Australia and in the Mount Isa Fault Trough in Queensland. By-product precious metal credits could also be expected in both provinces, although within the Mount Isa province, only the eastern or Cloncurry sub-province has had a history of substantial by-product gold credits with copper.

Highly prospective Proterozoic rift troughs or basins in the "unproven" or potential class include the Paterson province and Bangemall Basin, Western Australia, and the McArthur Basin, Amadeus and Birrindudu Basins, in the Northern Territory whose relative prospectivity is premised on the known occurrence there of small but as yet uneconomic Zambian-style copper deposits.

Now, having just completed the foregoing speculation about undiscovered deposits in potential provinces, it may be appropriate to finish an another speculative note; namely, the possibility that a new long-term trend may be identifiable from a plot of historical copper price data which has been adjusted for inflation to reflect long-term trends in real terms (Figure 17).

It is possible that a break in the long-term trend is emerging at about 1980-82 where the trend could conceivably have been reset at a lower level. If this is so, it implies that copper prices in the future, in real terms, may stay around the level of today's prices with only minor fluctuations about the new long term trend line in US dollars. Such a break, and a "resetting" at a lower level has taken place in the past with both copper (Figure 18) and zinc (Figure 19) in the early part of this century and the break in trend at that time appeared to reflect a lowering of costs through technological innovation, particularly via flotation. In the case of copper in 1980-82, such a break may reflect a combination of the impact of technological innovation, international financial adjustments and structural change on the effective unit cost of producing a tonne of copper in each of the seven or eight major producing countries around the world.

I will leave you with that thought.

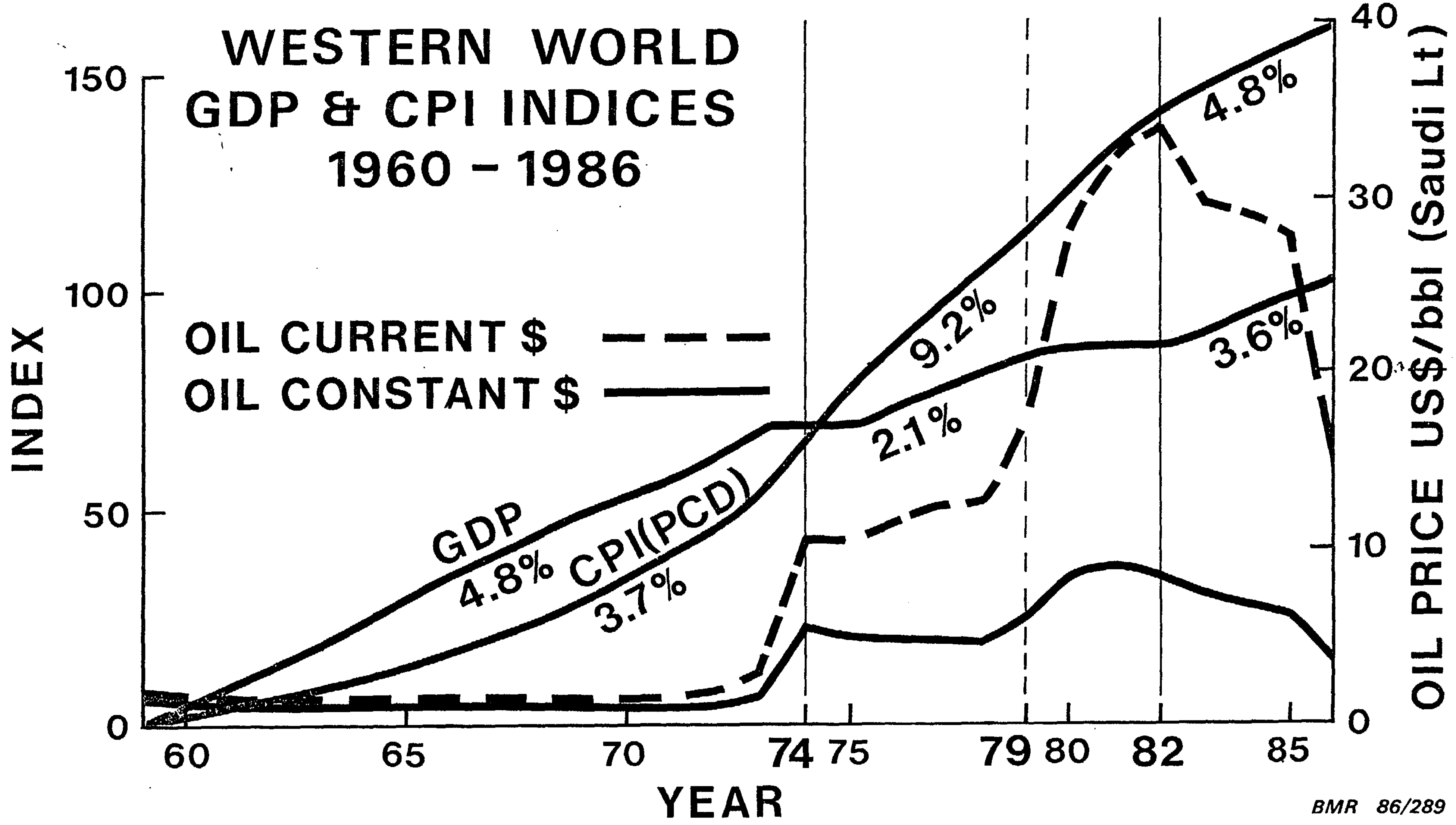

WESTERN WORLD
GDP & CPI INDICES
1960 - 1986
OIL CURRENT $
OIL CONSTANT $
GDP
4.8%
CPI(PCD)
3.7%
2.1%
9.2%
4.8%
3.6%
INDEX
150
100
50
0
60
65
70
74
75
79
80
82
85
YEAR
OIL PRICE US$/bbl (Saudi Lt)
40
30
20
10
0
BMR 86/289

Fig. 1.

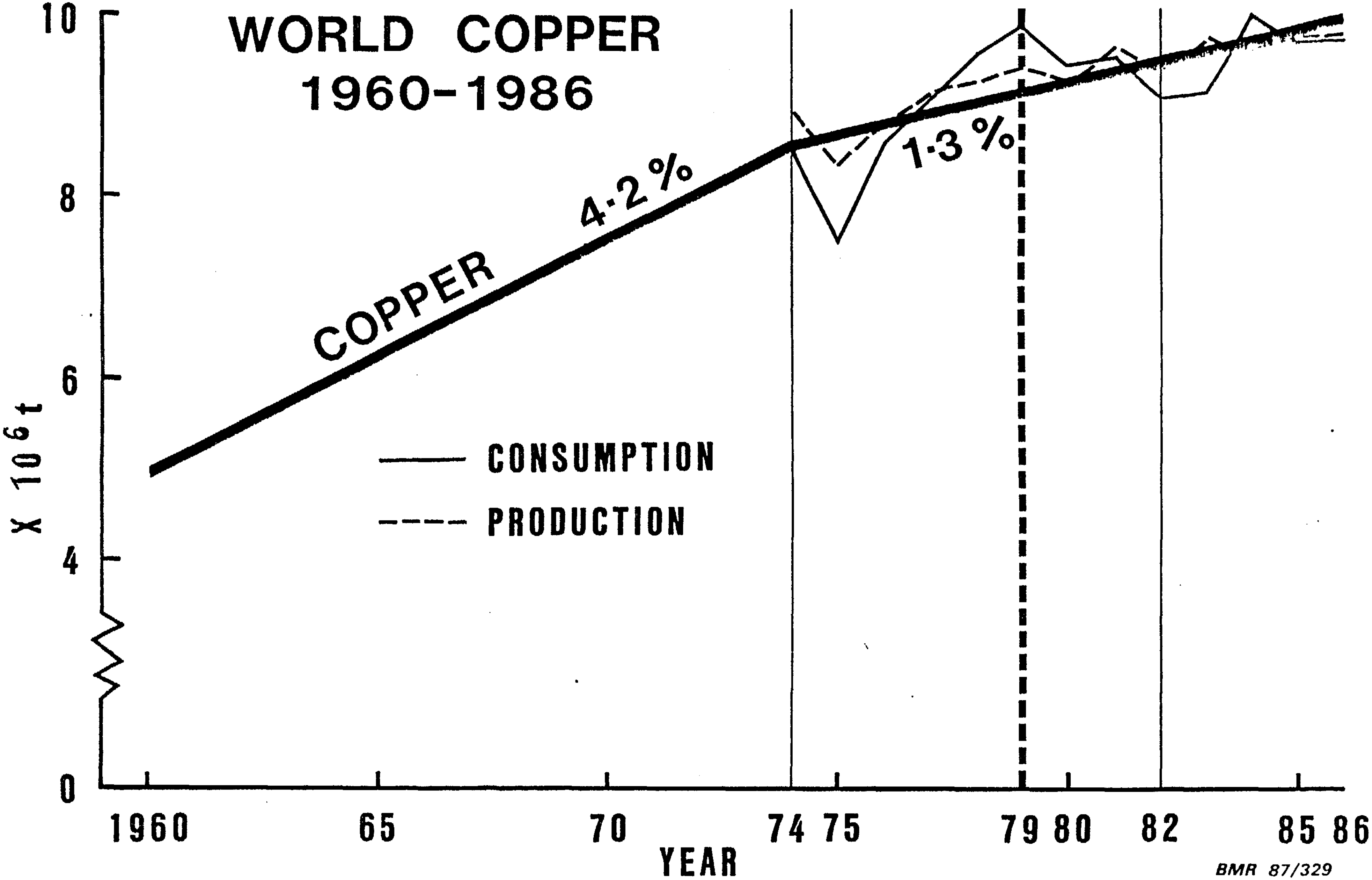

WORLD COPPER
1960-1986
COPPER
4·2 %
1·3 %
CONSUMPTION
PRODUCTION
X 10⁶ t
10
8
6
4
0
1960
65
70
74
75
79
80
82
85
86
YEAR
BMR 87/329

Fig. 2.

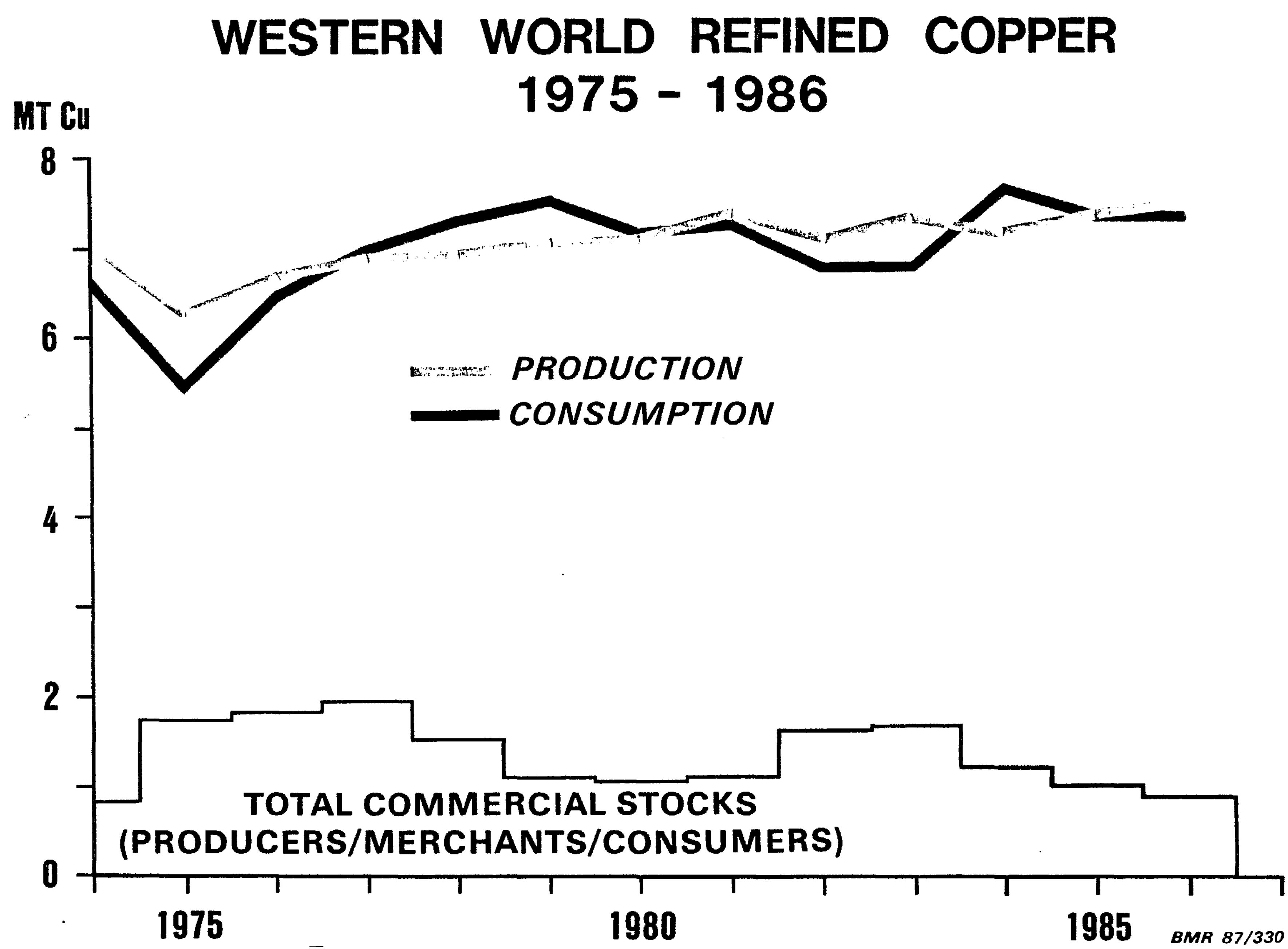

WESTERN WORLD REFINED COPPER
1975 - 1986
MT Cu
8
6
4
2
0
PRODUCTION
CONSUMPTION
TOTAL COMMERCIAL STOCKS
(PRODUCERS/MERCHANTS/CONSUMERS)
1975
1980
1985
BMR 87/330

Fig.3.

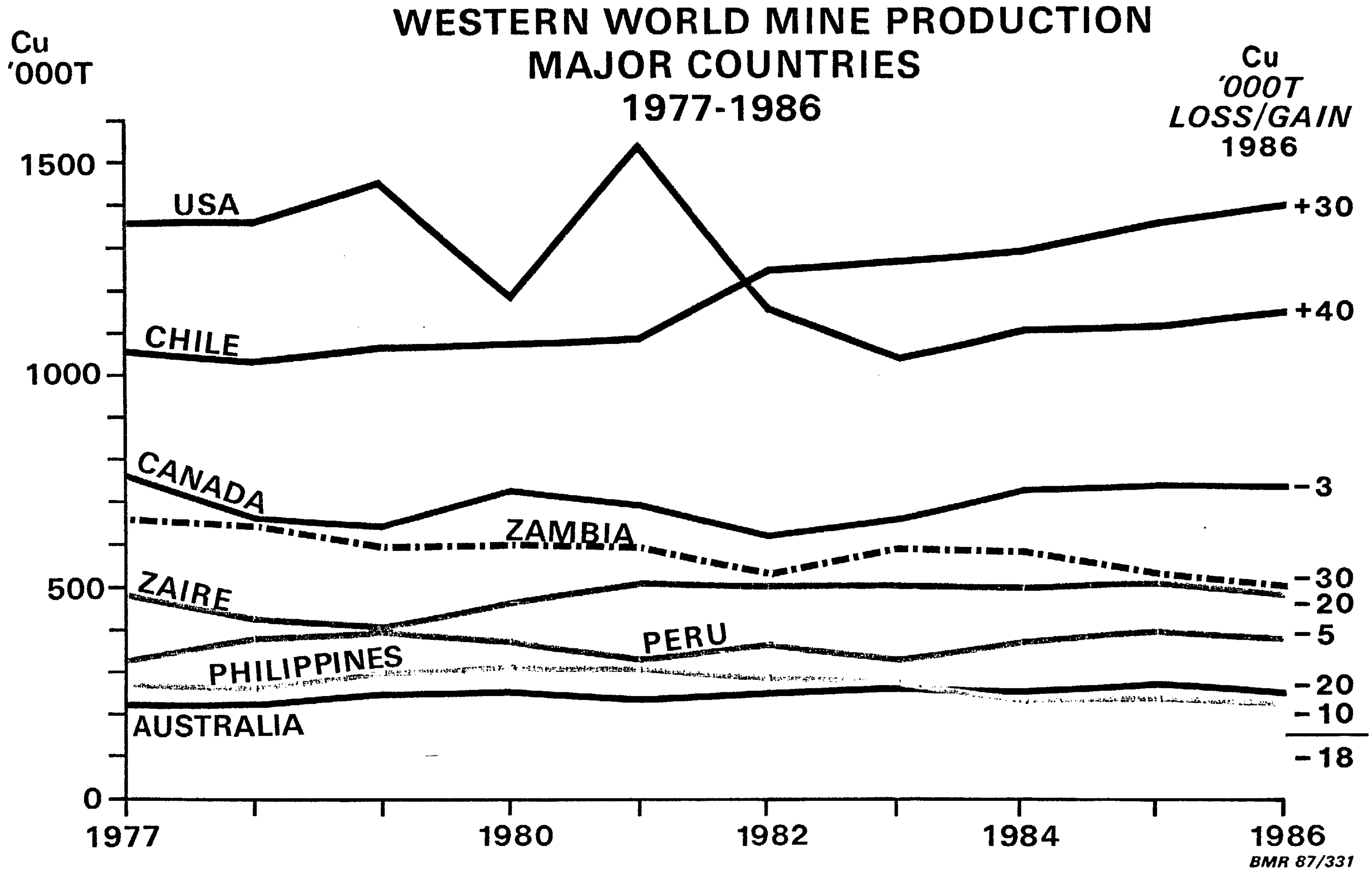

WESTERN WORLD MINE PRODUCTION
MAJOR COUNTRIES
1977-1986
Cu
'000T
Cu
'000T
LOSS/GAIN
1986
1500
1000
500
0
1977
1980
1982
1984
1986
USA
CHILE
CANADA
ZAMBIA
ZAIRE
PERU
PHILIPPINES
AUSTRALIA
+30
+40
-3
-30
-20
-5
-20
-10
-18
BMR 87/331

Fig. 4.

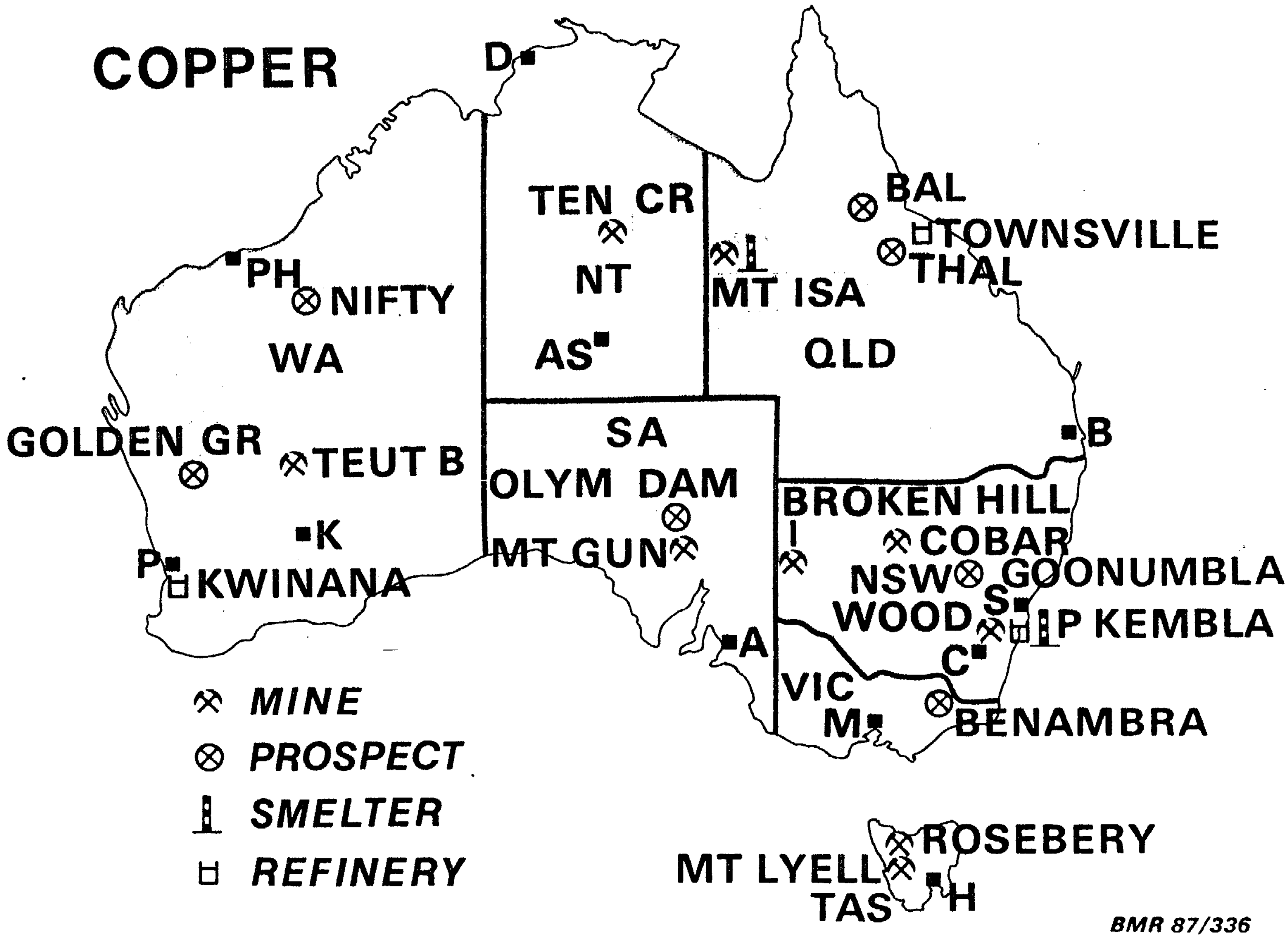

COPPER
D
TEN CR
NT
AS
BAL
TOWNSVILLE
THAL
MT ISA
QLD
PH
NIFTY
WA
GOLDEN GR
TEUT B
K
P
KWINANA
SA
OLYM DAM
MT GUN
A
B
BROKEN HILL
COBAR
NSW
GOONUMBLA
S
WOOD
P KEMBLA
C
VIC
M
BENAMBRA
MINE
PROSPECT
SMELTER
REFINERY
ROSEBERY
MT LYELL
TAS
H
BMR 87/336

Fig. 5.

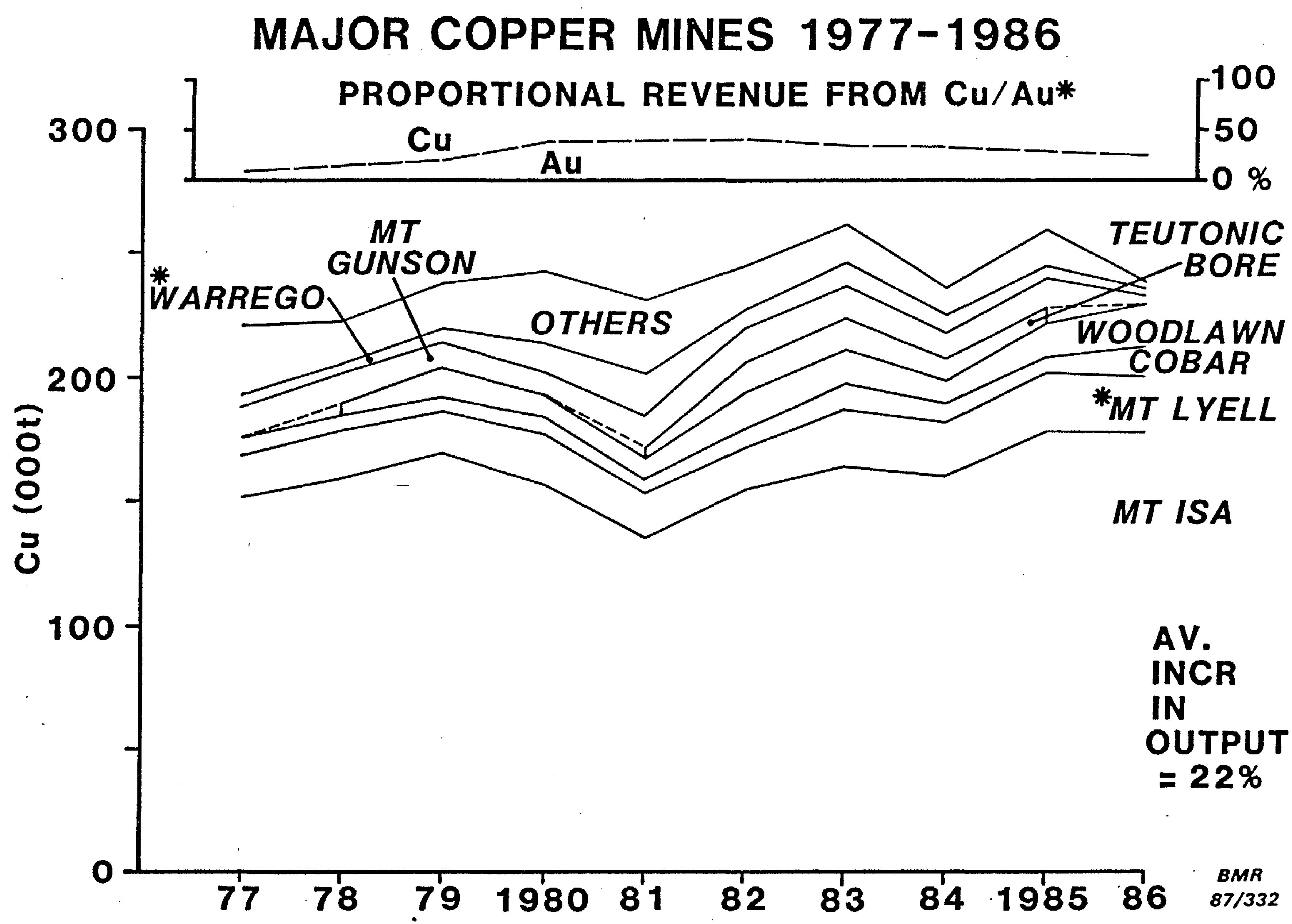

MAJOR COPPER MINES 1977-1986
PROPORTIONAL REVENUE FROM Cu/Au*
Cu
Au
100
50
0 %
300
200
100
0
Cu (000t)
*WARREGO
MT GUNSON
OTHERS
TEUTONIC BORE
WOODLAWN
COBAR
*MT LYELL
MT ISA
AV. INCR IN OUTPUT = 22%
77
78
79
1980
81
82
83
84
1985
86
BMR 87/332

Fig. 6.

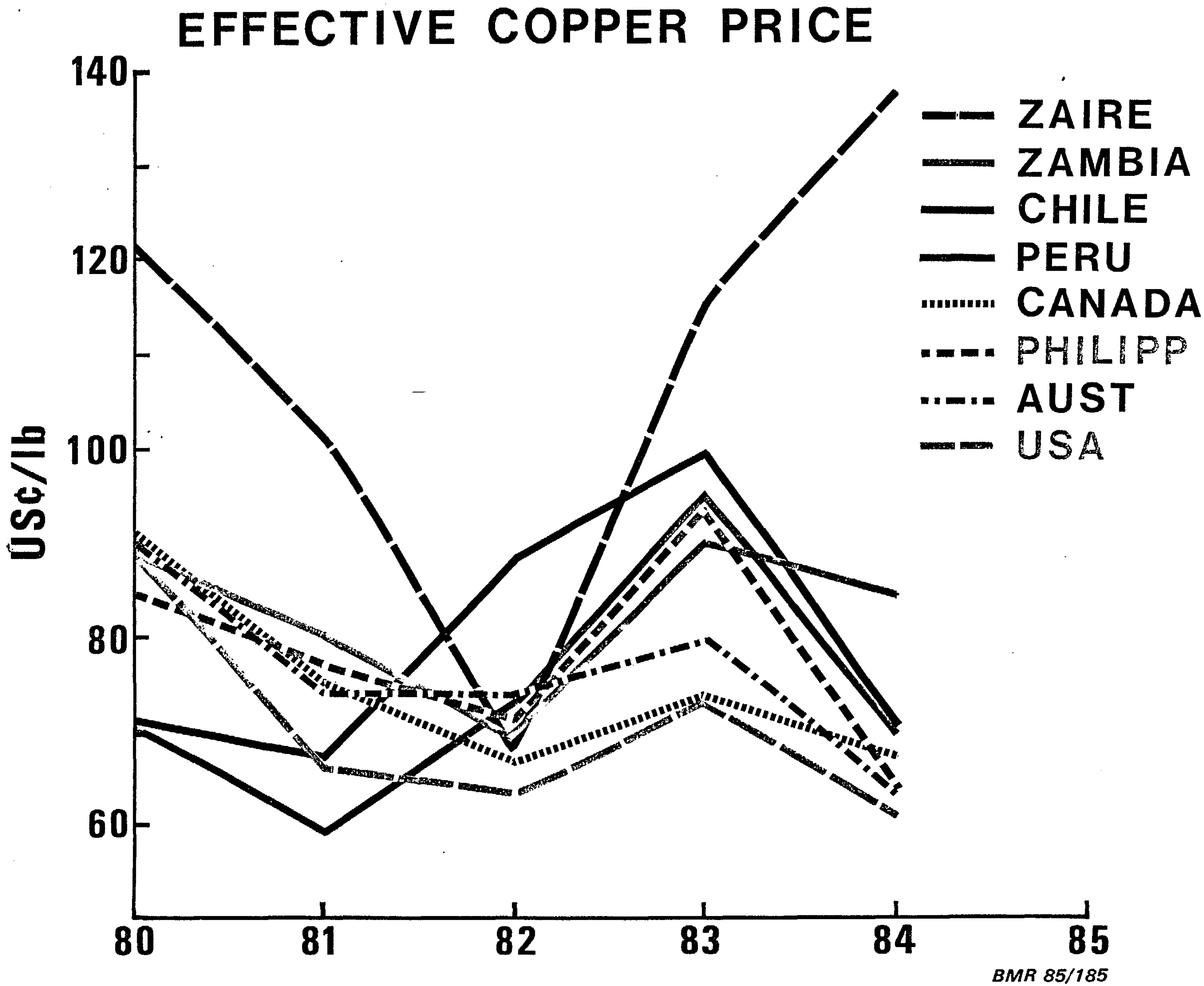

EFFECTIVE COPPER PRICE
140
120
100
80
60
USc/lb
ZAIRE
ZAMBIA
CHILE
PERU
CANADA
PHILIPP
AUST
USA
80
81
82
83
84
85
BMR 85/185

Fig. 7.

AVERAGE ORE GRADE (%Cu) AND COPPER PRICES 1977-1986

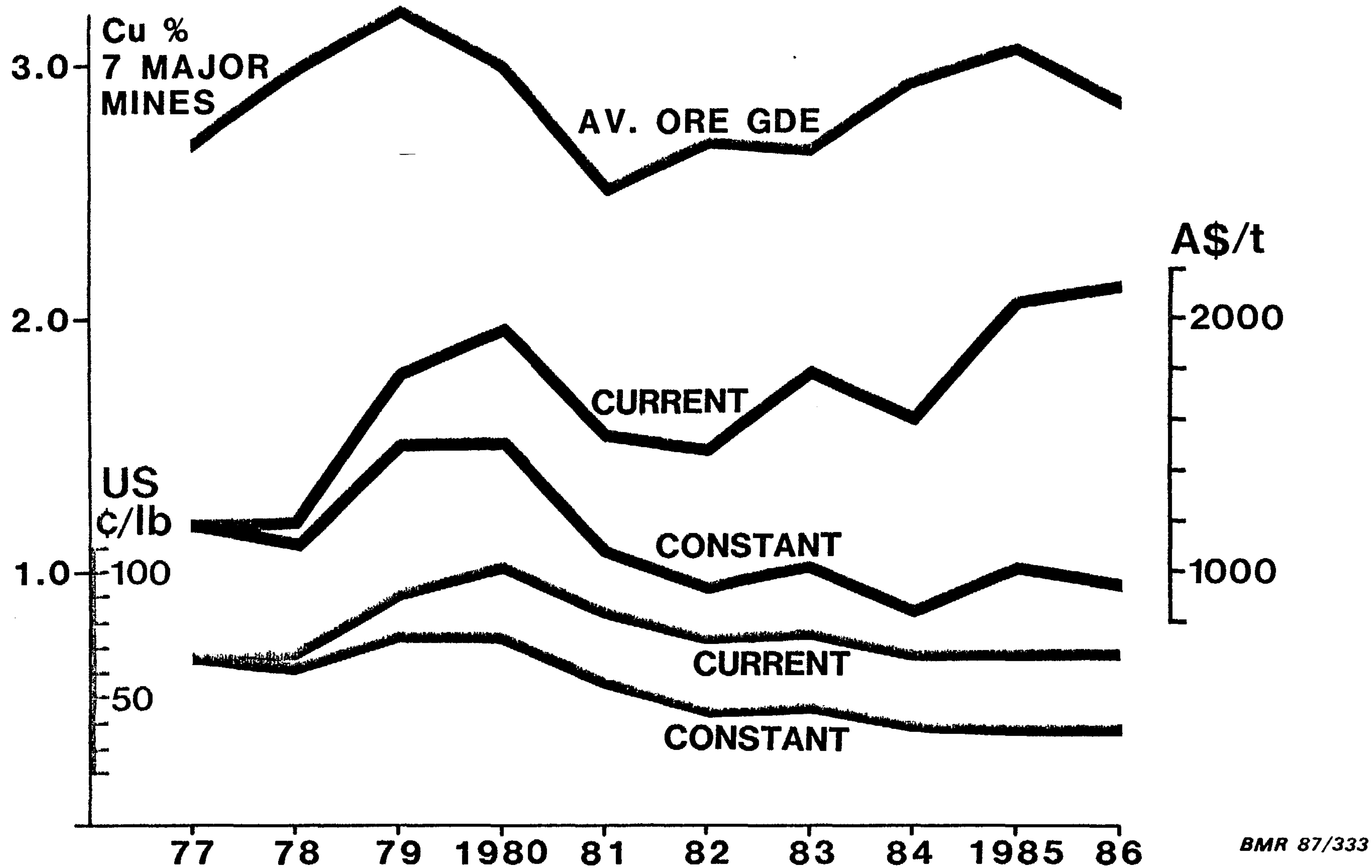


Fig. 8.

COPPER PRICE AND STOCK LEVELS

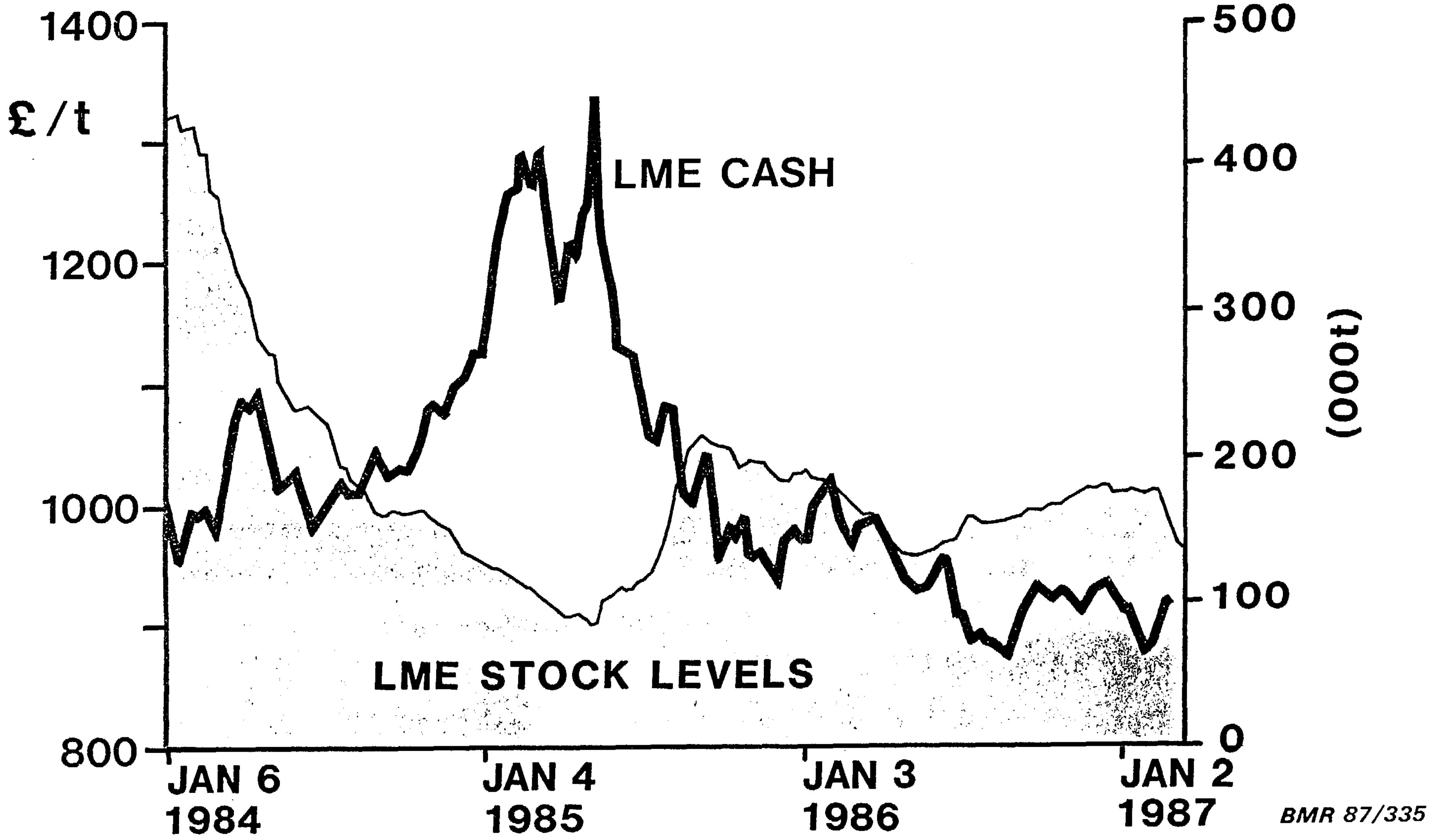


Fig. 9.

FORECAST AUSTRALIAN MINE PRODUCTION

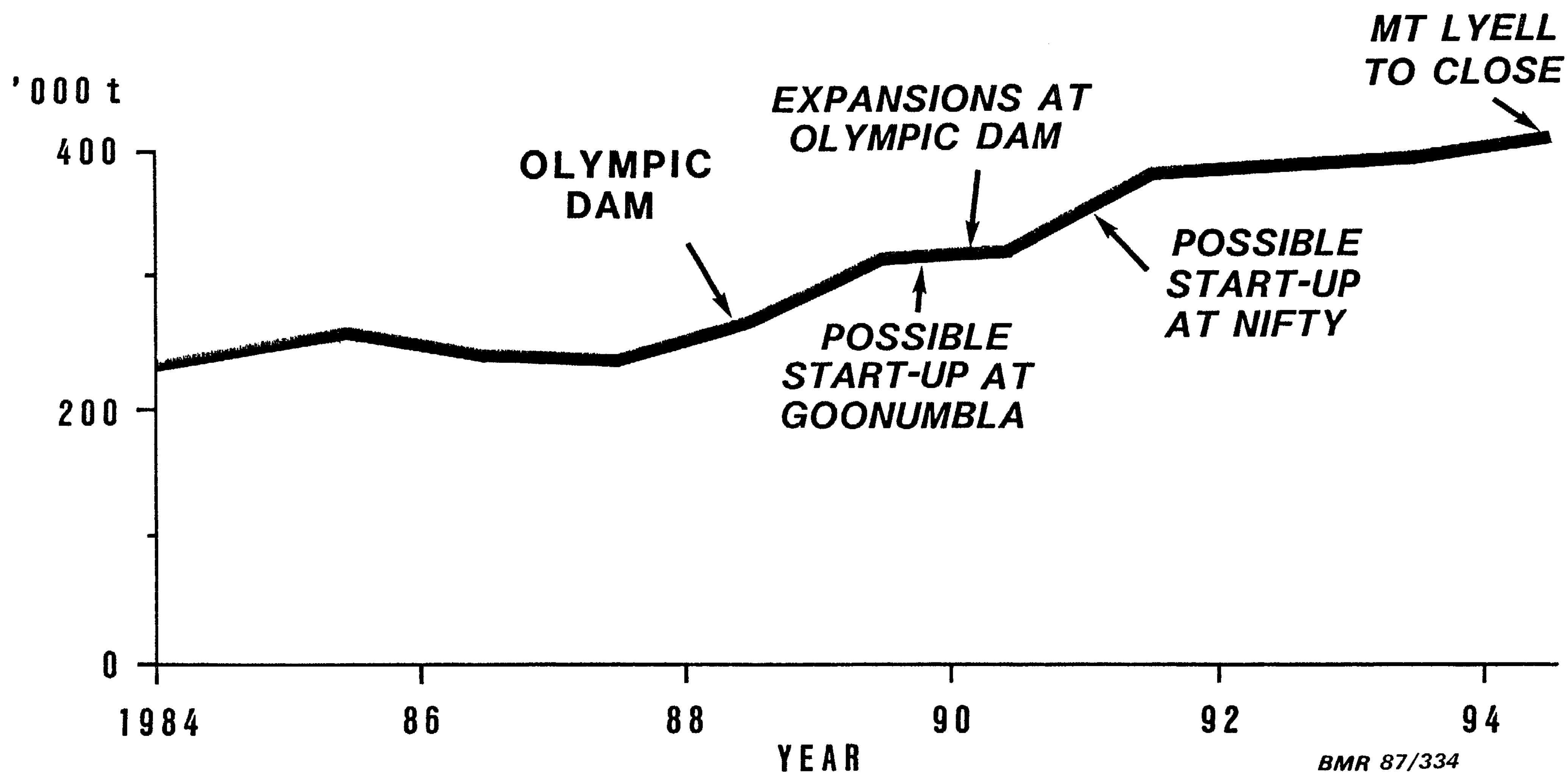


Fig. 10.

AUSTRALIAN COPPER MINE PRODUCTION
1842-1986

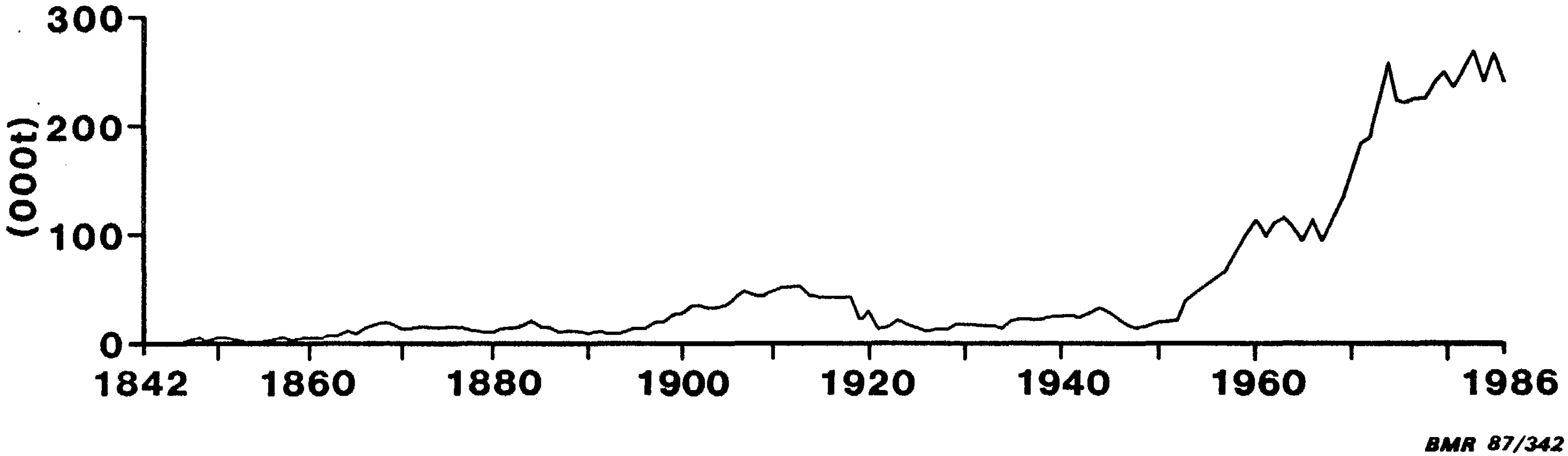


Fig. 11.

AUSTRALIAN COPPER MINE PRODUCTION BY STATE 1840-1986

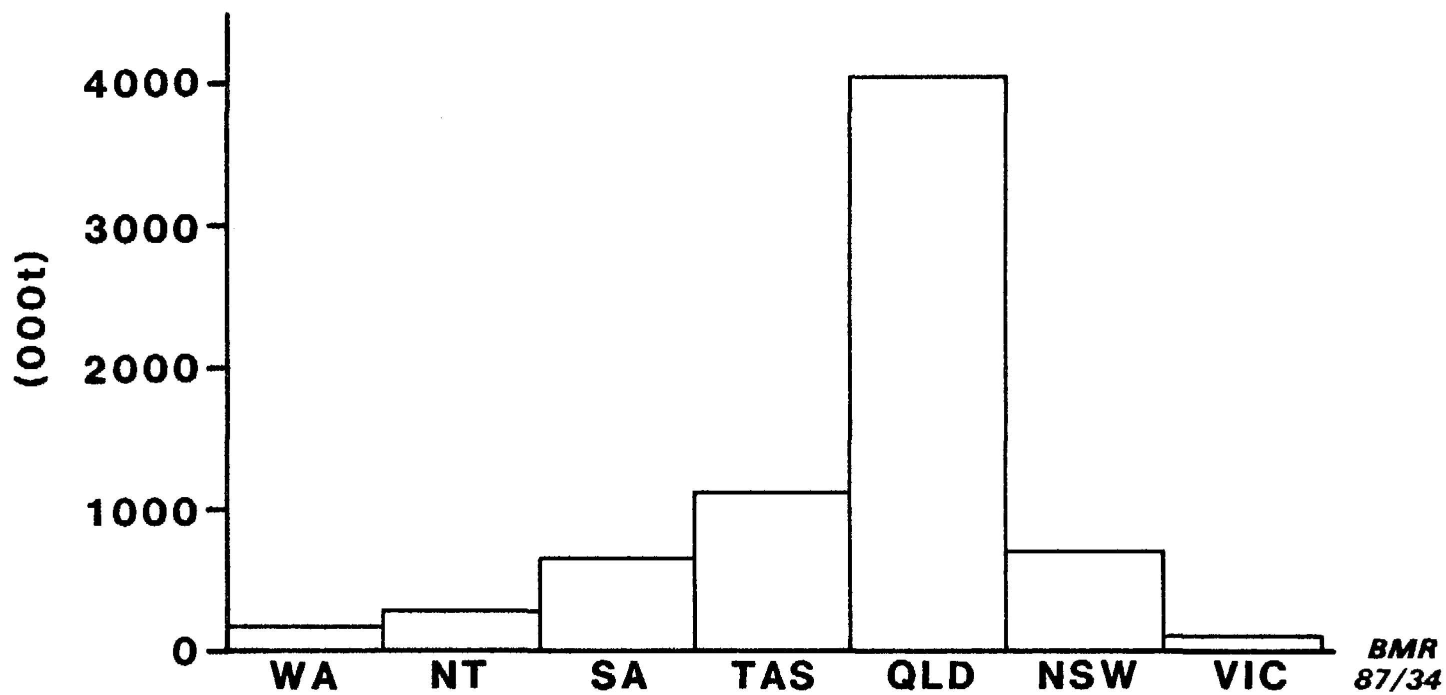


Fig. 12.

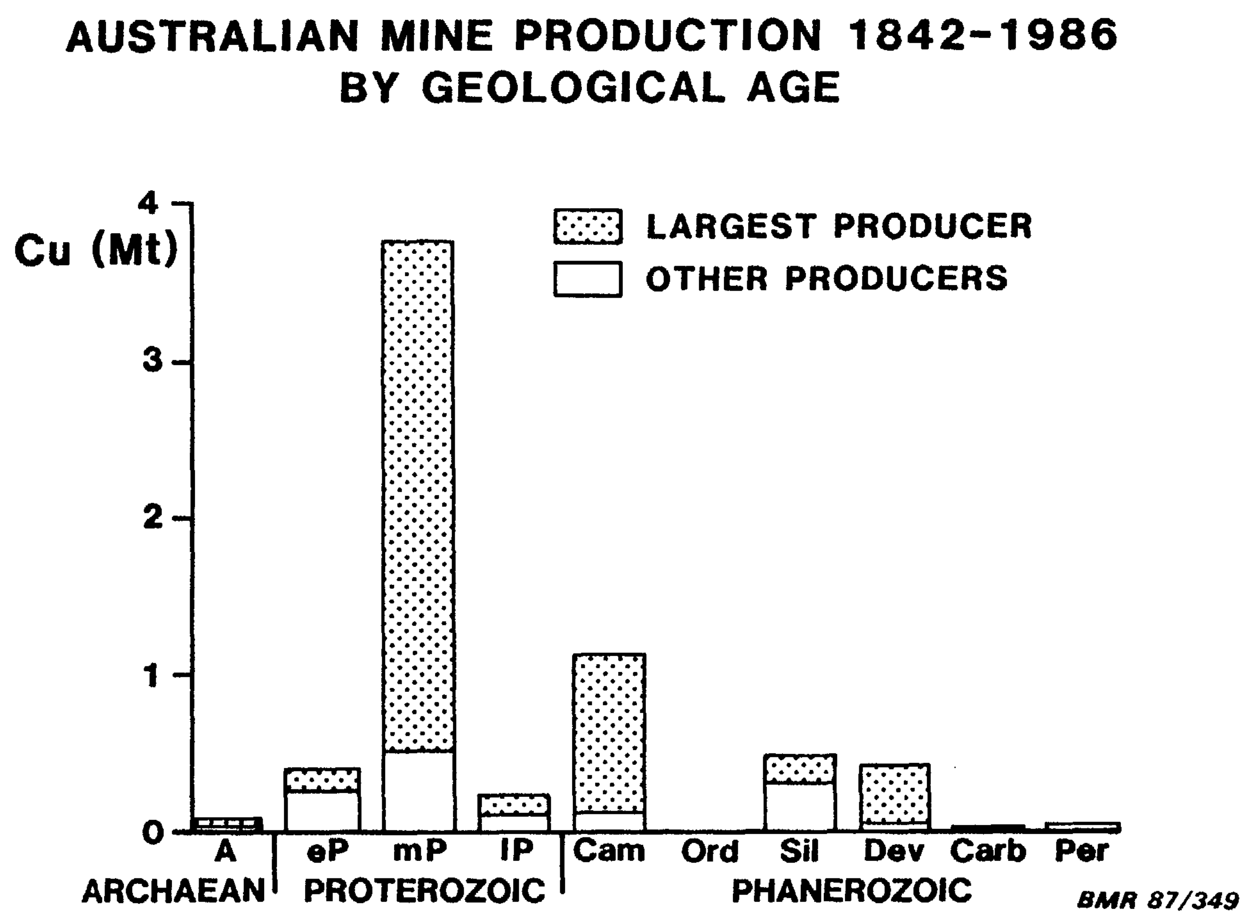

AUSTRALIAN MINE PRODUCTION 1842-1986
BY GEOLOGICAL AGE
Cu (Mt)
4
3
2
1
0
LARGEST PRODUCER
OTHER PRODUCERS
A
eP
mP
lP
Cam
Ord
Sil
Dev
Carb
Per
ARCHAEAN
PROTEROZOIC
PHANEROZOIC
BMR 87/349

Fig. 13.

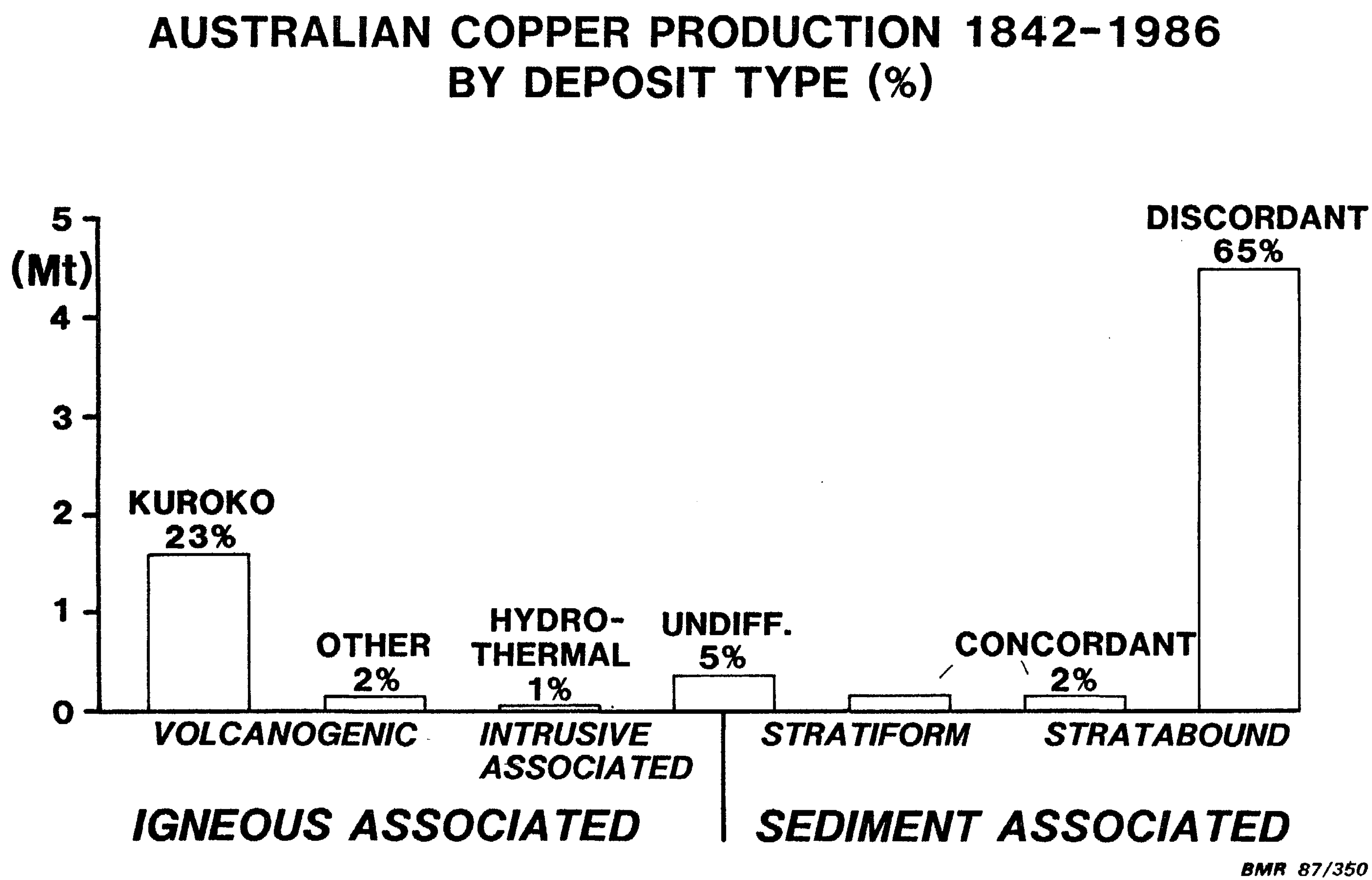
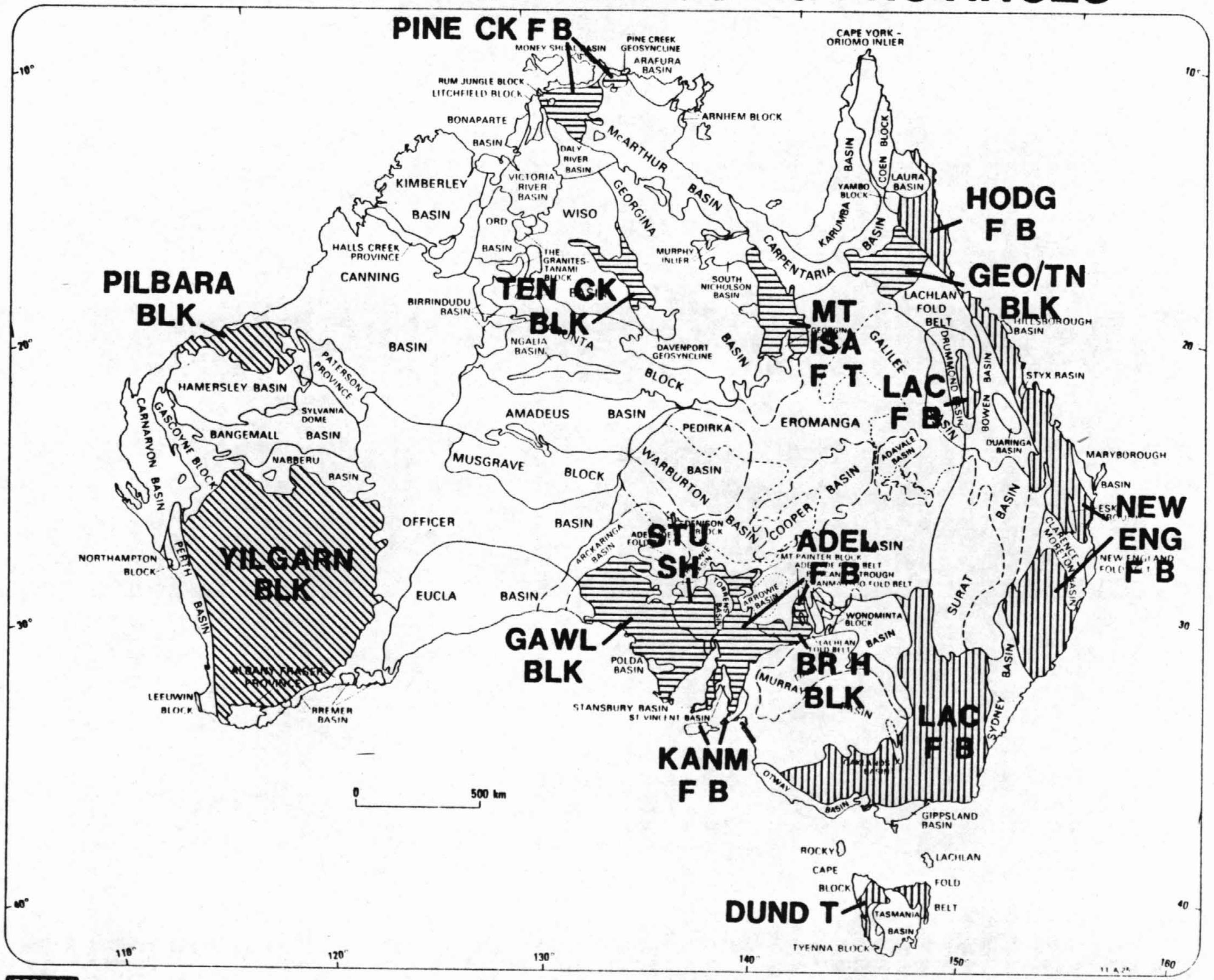

AUSTRALIAN COPPER PRODUCTION 1842-1986
BY DEPOSIT TYPE (%)
5
(Mt)
4
3
2
1
0
KUROKO
23%
OTHER
2%
HYDRO-
THERMAL
1%
UNDIFF.
5%
CONCORDANT
2%
DISCORDANT
65%
VOLCANOGENIC
INTRUSIVE
ASSOCIATED
STRATIFORM
STRATABOUND
IGNEOUS ASSOCIATED
SEDIMENT ASSOCIATED
BMR 87/350

Fig. 14.

MAJOR COPPER PRODUCING PROVINCES



ARCHAEAN

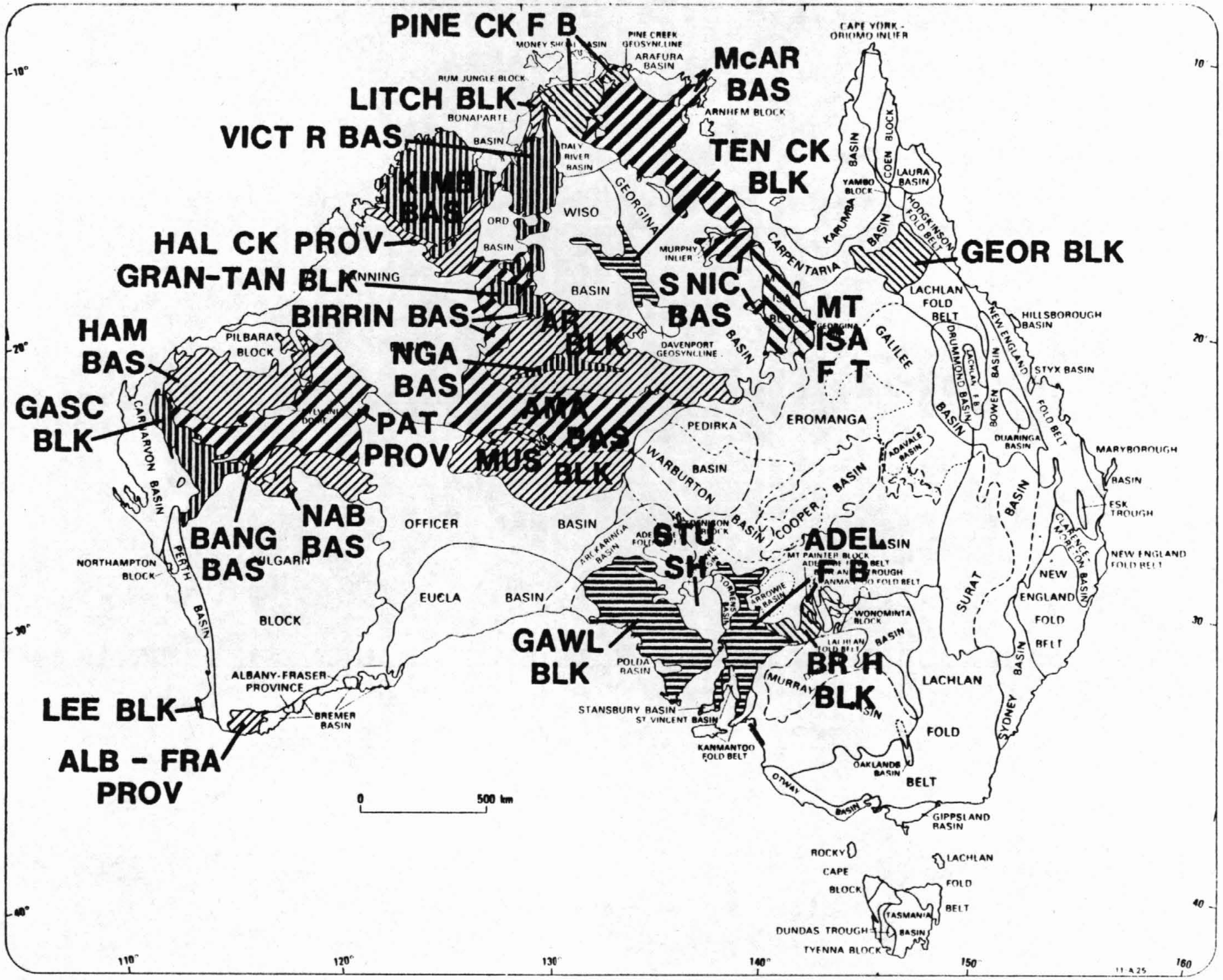
PROTEROZOIC

PHANEROZOIC

BMR 87/346

Fig. 15.

POTENTIAL PROTEROZOIC COPPER PROVINCES



POTENTIAL		HIGH		MODERATE		LOW
PROVEN		LARGE		MEDIUM		SMALL

BMR 87/347

Fig.16.

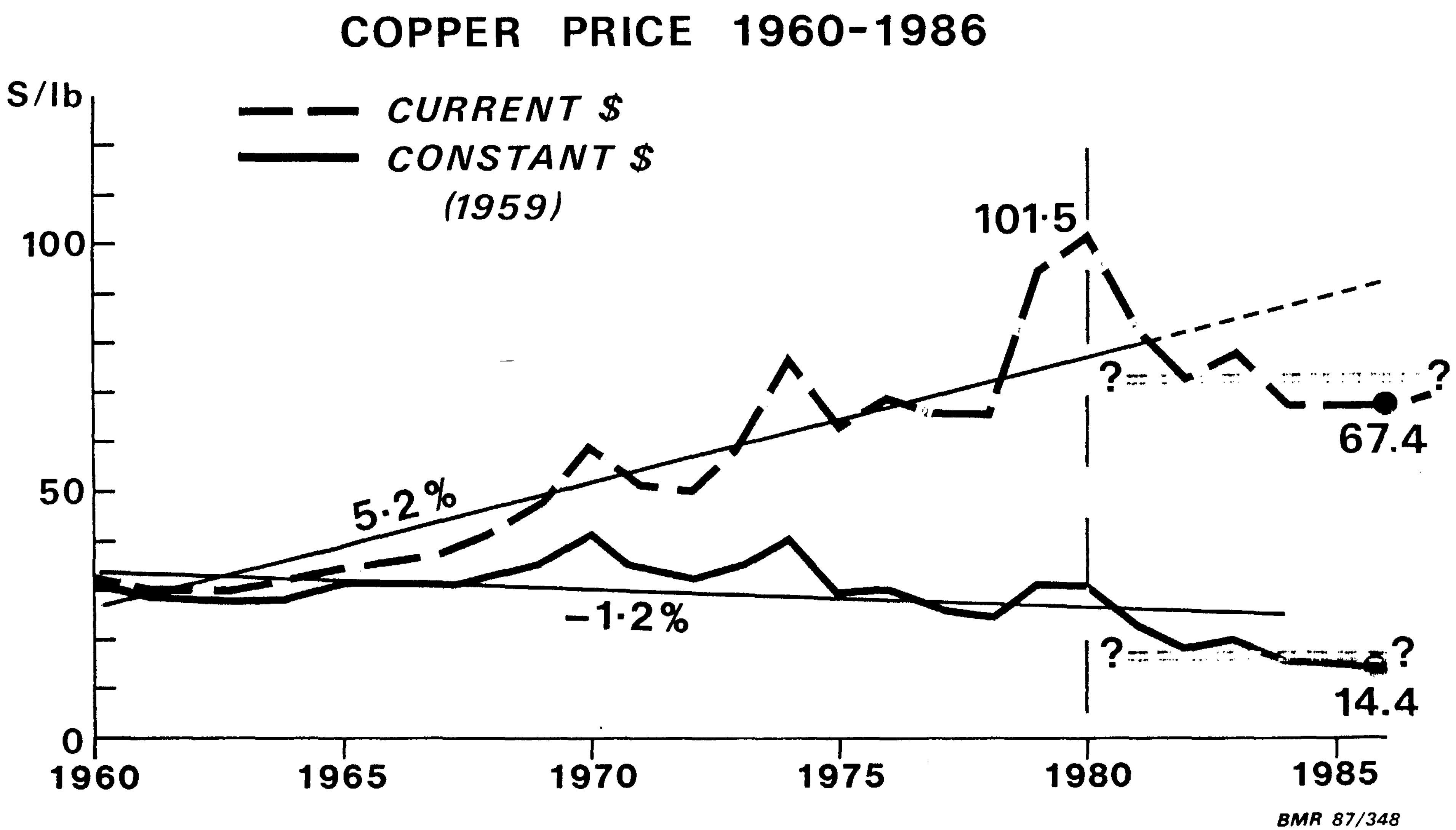

COPPER PRICE 1960-1986
S/lb
CURRENT $
CONSTANT $
(1959)
100
50
0
101·5
5·2%
−1·2%
?
?
?
?
67.4
14.4
1960
1965
1970
1975
1980
1985
BMR 87/348

Fig. 17.

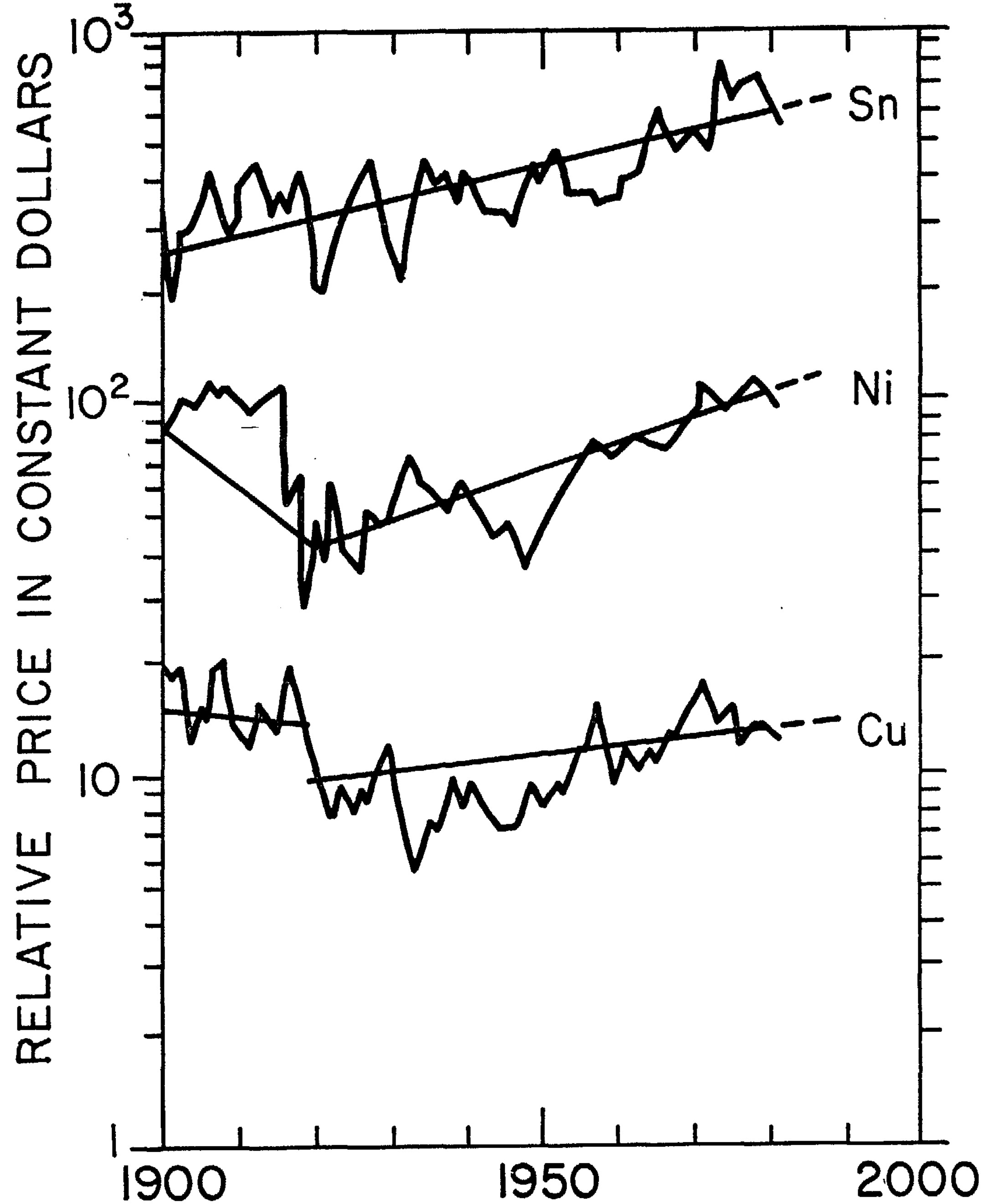

RELATIVE PRICE IN CONSTANT DOLLARS
10^3
10^2
10
1
1900
1950
2000
Sn
Ni
Cu

Fig. 18.

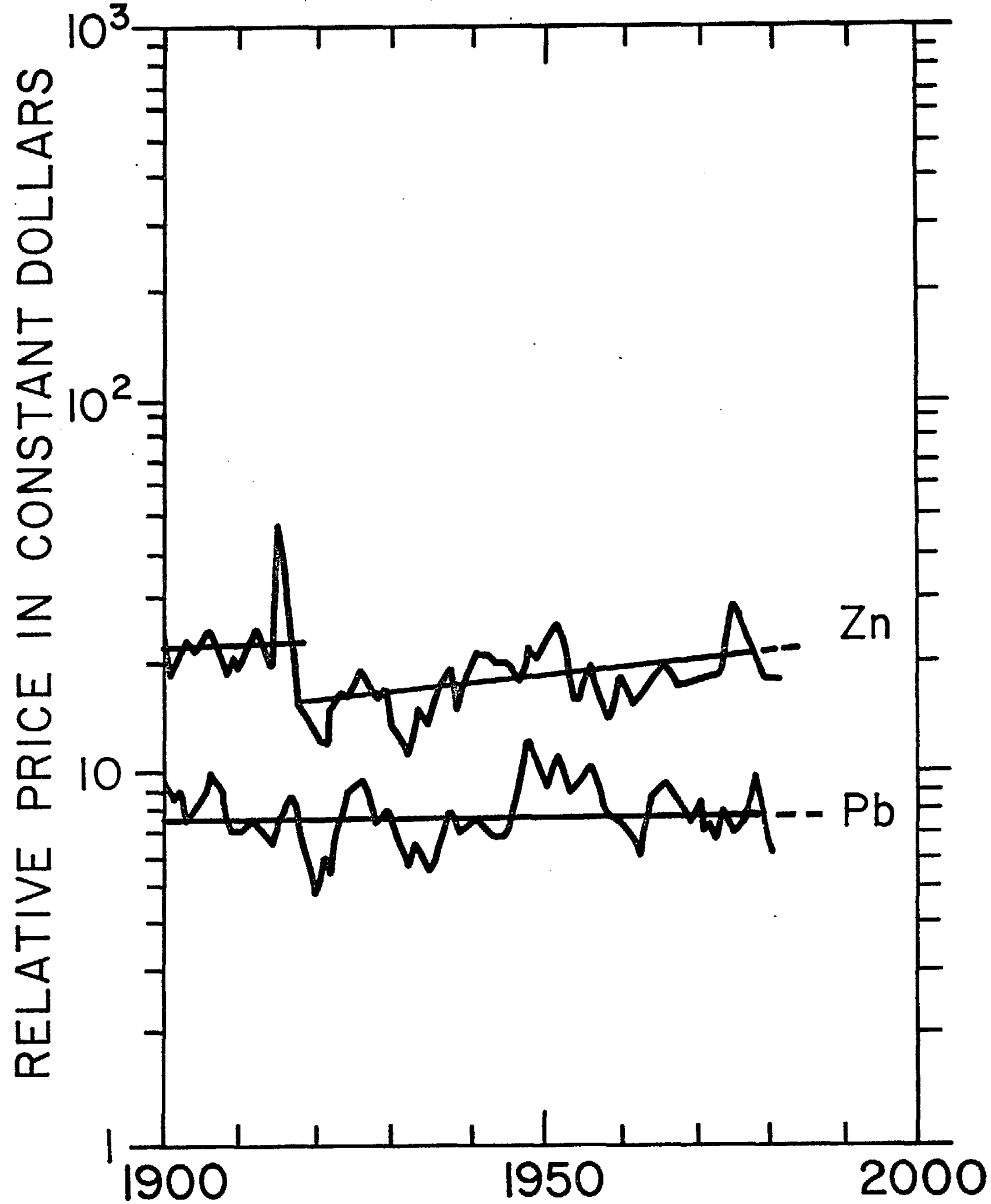

RELATIVE PRICE IN CONSTANT DOLLARS
10^3
10^2
10
1
1900
1950
2000
Zn
Pb

Fig. 19.