AUSTRALIAN MINERAL EXPLORATION: OUTLOOK IMPROVING BUT CHALLENGES REMAIN

Lynton Jaques (FAusIMM) & Mike Huleatt
Geocience Australia
CANBERRA ACT

Originally published in The AusIMM Bulletin No5 September/October 2002, pp 36-42.

ABSTRACT

The Australian Bureau of Statistics March quarter data indicate further deterioration in Australian mineral exploration keeping current expenditure levels well below recent levels. Despite this indicators including increased mineral company floats in 2002 on the back of new discoveries, improved gold prices, increased activity especially by juniors, and prospects for improved metal prices in 2003-2004, present the most positive outlook for mineral exploration since 1997. However, a period of sustained increases in metal prices is required for a significant rise in exploration levels. Exploration is focussed in the Yilgarn Craton, the Tanami Province, the Gawler Craton, the Musgrave Province, and the Murray Basin. The Ashburton province is an emerging gold province and much of the Northern Territory is under tenement for diamonds. Discoveries continue to be made but increased greenfields exploration, especially in areas under cover, is needed to exploit Australia's potential. New government geoscience programs, especially regional pre-competitive geophysical surveys, are playing an important role in helping to unlock that potential.

CURRENT STATE OF EXPLORATION

Australian Bureau of Statistics (ABS) quarterly surveys of exploration indicate that Australian mineral exploration expenditure peaked at $1148 million in 1996–1997 and then fell to a 20 year low in real terms in 2001 (Jaques and Huleatt, 2002a). The reasons for this decline, which was accompanied by a major reduction in the number of companies engaged in mineral exploration, are primarily low world metal prices caused by oversupply, poor rates of return on investment, intense competition for risk capital, land access difficulties, and industry consolidation (Jaques and Huleatt, 2002a).

ABS figures indicate that Australian mineral exploration spending in calender year 2001[1] was $665 million, down 2% on 2000. Gold continued to dominate with ~53% of expenditure (63% in 1996-97) followed by nickel, lead-zinc and coal**.** The March 2002 ABS exploration figures showed a further decline with expenditure down almost 10% on March 2001: this is lowest quarterly result since March 1993[2]. ABS estimate in their March quarter report that total mineral exploration expenditure for the financial year 2001-2002 is likely to be around $645 million, down ~6% on 2000-2001.

EXPLORATION HIGHLIGHTS

Despite the reduced levels of exploration last year, additions were made to Australia's resource base for most commodities (Geoscience Australia, 2002). The annual Geoscience Australia overview of Australian mineral exploration (Huleatt *et al.,* 2002) highlights the successes in 2001: these occurred across the continent and ranged from encouraging intersections in grassroots projects to addition of resources at existing deposits.

Discoveries were made in established mining districts and in greenfields provinces. Both are significant as they confirm Australia's high prospectivity and potential for further discoveries. In established mining districts the potential is often at depth, as deep extensions to existing deposits (e.g. Kanowna Belle gold mine). However, near-surface, high-grade ore intersections and deposits continue to be found in districts with a long history of exploration and mining indicating remaining potential.

The potential of greenfields provinces is poorly known as many have only been subjected to reconnaissance exploration or at best have been only intensively explored at surface or shallow depth. This was highlighted by Champion de Crespigny (2002) who pointed to the small number of drill holes below 300m in the Yandal greenstone belt, one of Australia's premier gold districts.

Possibly the most significant recent exploration success was the discovery of Olympic Dam-style copper-gold-uranium mineralisation at the Prominent Hill prospect in South Australia's

[1] Results for calender year 2001 are used as the ABS figures for the 2001/2002 financial year were not available when this article went to print.

[2] March is traditionally a poor quarter for exploration spending due to seasonal climatic conditions and the Christmas holiday period.

Gawler Craton (Figure 1). The discovery had three important implications: 1) it sparked renewed interest in the region for Olympic Dam-style mineralisation, 2) it is a positive result for a junior (Minotaur) – major company (BHP Billiton) joint venture, and 3) brought new confidence to the junior exploration sector and contributed to a change in market sentiment.

EXPLORATION HOTSPOTS

Australia's major mineral provinces such as the Yilgarn Craton, the Mt Isa Inlier, the Curnamona Craton, and central Lachlan Fold Belt in NSW continued to be a focus for exploration. However, several provinces stand out as 'exploration hotspots' with intense coverage of tenements and active exploration programs by many companies (Figure 1).

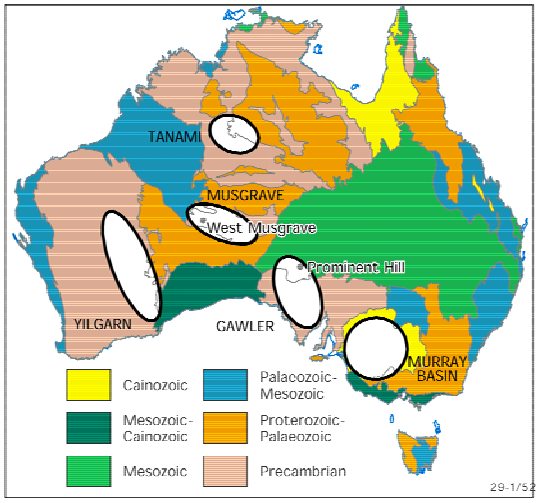

Figure 1: Current mineral exploration 'hotspots' and West Musgrave and Prominent Hill discoveries (see text) in relation to generalised geology.

Yilgarn Craton

The Yilgarn Craton, in particular the Eastern Goldfields, is the most intensively explored region of Australia attracting ~40% of Australian and ~7% of global mineral exploration. This intensity of exploration and the endowment of the Yilgarn means that discoveries continue to be made both near surface and as deep extensions of near-surface deposits. Several recent gold discoveries (e.g. Raleigh, Frog's Leg) are within 25 km of Kalgoorlie.

With the increased focus on deposits under cover, understanding the 3D structure of the prospective corridors is increasingly important. Major orogenic gold deposits in the northeastern Yilgarn are spatially associated with major structures. Geoscience Australia, in collaboration with GSWA and the Predictive Mineral Discovery CRC, recently undertook a deep seismic reflection survey in a transect in the Leonora-Laverton region aimed at defining

the 3D structure of the northern goldfields and comparing it with that determined in a previous transect in the Kalgoorlie region. The recently-released interpretation of the seismic data (Goleby & Korsch, 2002, and accompanying papers), coupled with a structural analysis using potential field data, show both abundant east-dipping shallow and sub-horizontal deep flat structures, with the upper crust characterised by low-angle shears. The crust in both the Kalgoorlie and Northeastern Yilgarn share a number of features including:

- variably reflective upper crust:
- a middle crust composed of numerous, stacked thrust duplexes caused by west-directed imbrication;
- a sub-horizontal lower crust;
- major-east-dipping structures that transect the crust; and
- the containment of greenstones and their intrusive granitoid plutons to a 4-7 km thick layer in the upper crust.

There are also significant differences, notably an absence of major west-dipping structures in the upper crust in the Leonora-Laverton area. Understanding these differences and the controls on gold mineralisation are the subject on ongoing research.

Tanami province

The Tanami gold province has gained importance in recent years with increased gold production (127 t in the past 5 years), particularly from the world-class Callie deposit that now has a resource estimated at greater than 160 t gold (>5 Moz; Kay, 2002). Global gold resources for the province have nearly doubled (88% increase) in the past 5 years. Recent discoveries (e.g. Coyote, Groundrush) and recognition of the potential of the Tanami where only about 20% of the prospective covered areas may have been subjected to modern exploration (Kay, 2002) has resulted in three of the four world's leading gold companies, together with a number of junior companies, exploring large land holdings in the area.

Geoscience Australia and the Northern Territory Geological Survey (NTGS) are supporting exploration in the Tanami – Northern Arunta region through a program including: geological re-mapping (NTGS); geochronological studies; regional syntheses; studies of the mineral potential of mafic-ultramafic rocks; gravity surveys in the Tennant Creek region; and studies of the controls on gold mineralisation in the Tanami.

These multi-disciplinary studies are using the high quality aeromagnetic database for the region to develop a new regional framework for exploration (Crispe *et al.,* 2002; AGES, 2002). A new 400 m line spacing aeromagnetic and radiometric survey in the western Tanami (Billiluna-Lucas areas) has recently been flown by the Geological Survey of Western Australia, and a major new crustal seismic transect is being considered.

The gold systems in the Tanami region are diverse, hosted by a variety of lithologies, and formed over a range of physico-chemical conditions and depths with The Granites goldfield and world-class Callie deposit formed at the shallowest crustal depth (Wygralak *et al.,* 2001). Recent dating suggest that there may be more than one mineralising event.

Gawler Craton

The discovery by Minotaur Resources of significant Olympic Dam-style copper-gold-uranium mineralisation at their Prominent Hill prospect, half way between Olympic Dam and Coober Pedy (Figure 1) refocussed attention in the potential of the northeast Gawler Craton to host iron oxide copper – gold deposits. The original drill intersection that included 107m @ 1.94% Cu and 0.65 g/t Au was described as the best Cu-Au greenfields intersection seen in South Australia since the Olympic Dam discovery (Heithersay, 2002). The discovery was made testing a discrete gravity anomaly that is partly coincident with a well-defined magnetic anomaly. Hematite-magnetite alteration systems are widespread and visible in regional government aeromagnetic and gravity data. Large areas of the northeast Gawler Craton are now under tenement and a number of prospects with large iron-oxide systems are being actively explored.

Geoscience Australia and the Office of Minerals and Energy Resources South Australia are undertaking an integrated multi-disciplinary study of the Olympic Cu-Au province that extends 500 km along the eastern margin of the Gawler Craton to determine controls on the distribution and formation of deposits. Three major centres of magmatic and hydrothermal activity have been recognised – Mount Woods in the north, the Olympic Dam area, and the Moonta-Wallaroo-Roopena area in the south. The distribution of the ~1590 Ma high-level Hiltaba Suite granites (and co-magmatic Gawler Range Volcanics) is controlled by extensional structures with the plutons elongated NE-SW in inferred dilational jogs within a regional conjugate dextral transcurrent fault system. Mineralisation may be controlled by NE

to ENE-trending, normal faults that define the margins of the dilational jogs (Direen *et al.,* 2002). Systematic changes in mineralisation and alteration assemblage along the province are related to crustal level with higher grade and more extensive Cu–Au±U mineralisation generally associated with relatively oxidised and lower temperature breccia-hosted haematite-rich systems that involved interaction with surficial fluids (Skirrow *et al.,* 2002).

Musgrave Province

The mafic-ultramafic rocks of the Proterozoic Giles Complex of the Musgrave Ranges straddling the borders of WA, SA and the NT has long been considered prospective for Ni, Cu, PGEs, V and Ti. They had seen little exploration in recent years until the discovery in May 2000 by WMC Ltd of significant Ni-Cu-PGE sulphide mineralisation at its Babel and Nebo prospects. Limited information is available and no resource estimates have been released. However, similarities in geological setting, and the style and tenor of mineralisation have prompted comparisons with the world-class Voisey's Bay deposit in Canada. Large areas of the Giles Complex and surrounding areas are now under tenement or application. Exploration is being assisted by new government 200-400 m line spacing aeromagnetic and radiometric surveys of the Musgrave Ranges in SA and the NT. A new 400 m line-spacing aeromagnetic and radiometric survey of the parts of the western areas of the Giles Complex (Scott, Cooper areas of WA) is currently being flown.

Murray Basin

The Murray Basin is emerging as a major mineral sands province following the discovery, mostly in the last five years, of over 200 heavy mineral deposits containing more than 80 Mt of coarse grained ilmenite, rutile and zircon (Oakes, 2001). These deposits differ from the fine-grained WIM 150 deposits (4900 Mt @ 2.8% heavy minerals) found in the 1980s. Primary targets are strandline deposits within a latest Miocene - Pliocene marine sand sequence (Loxton - Parilla Sands). The beach deposits are sub-parallel and range from 200-1000 m in width, up to 10 km in length and typically contain 2-4% heavy minerals with 15-30% rutile, 8-24% zircon and 40-60% ilmenite. The deposits are variably magnetic and some of the strandlines and deposits were found using 200-400 m line-spacing regional aeromagnetic data flown by the Victorian Geological Survey (Dickson, 1999).

Other areas

The Ashburton Province is emerging as a new gold province with discoveries of the Paulsens and Waugh deposits, and an operating mine at Mount Olympus. These discoveries have stimulated a significant uptake of tenements by both majors and juniors. The high grade and style of the mineralisation has prompted comparisons with Carlin-type deposits.

Much of the Northern Territory is under title for diamonds with 3 global diamond explorers and 5 junior companies active following the release of large areas of new 400 m line-spacing aeromagnetic data by the NTGS (AGES, 2002).

The Kimberley region is an area of active exploration with nickel, PGE and base metal targets in the Halls Creek Orogen, and diamond in the North Kimberley. Interesting gold occurrences have recently been reported from the North Kimberley region.

OUTLOOK IMPROVING BUT EXPLORATION LEVELS STILL DOWN

The ABS March quarter data indicate a continuing deterioration in exploration expenditure. However, there are signs that suggest the outlook for exploration is improving, stimulated primarily by higher gold prices in recent months. There has been a distinct improvement in market sentiment toward the resources sector as demonstrated by the significant increase in the number of mineral resource companies listing on the Australia Stock Exchange (ASX). Also the Australian Gold Council's Explorers Index (Figure 2) ended its downward trend in November as gold prices began to improve and Prominent Hill was discovered. However, indicative of the uncertainty of the recovery the index has eased since May, reflecting the global market downturn.

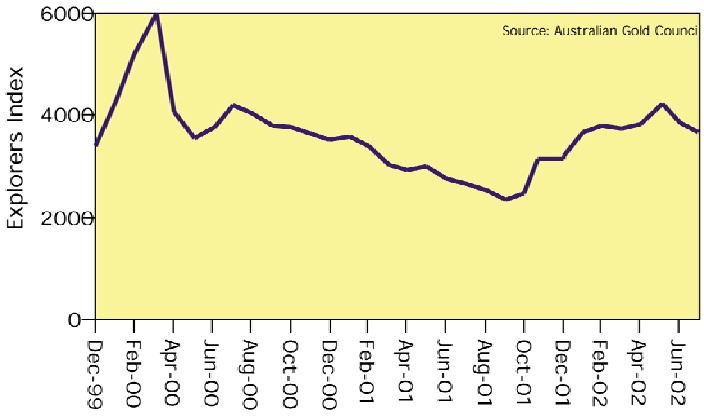

Figure 2: Australian Gold Council Explorers Index for the period since December 1999. Source Australian Gold Council. (www.australiangold.org.au/investors)

Gold price as an indicator of future exploration levels

Gold is the major target of Australian mineral exploration and, from 1983-84 on, changes in gold spending have, with the exception of 1995-96, determined the level of national exploration spending (Figure 3). Broadly, gold exploration spending has followed the gold price with a lag of 12-18 months (Figure 4). If this pattern holds, the improved 2002 gold price should precede higher exploration spending in 2003. With ABARE's forecast of a still higher price in 2003 (Maurer *et al.,* 2002) increased exploration spending can also be expected in 2004 (Figure 4). Further, the Australian Gold Council/Deloitte Touche Tohmatsu 2002 Gold Investment Survey predicts a 25% increase in gold exploration spending in 2002-2003.

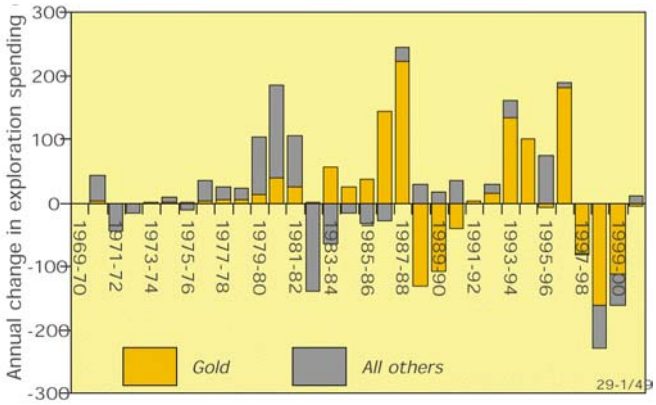

Figure 3: Annual change in total mineral exploration and gold exploration expenditure (millions dollars) by year. Changes in gold exploration spending have dominated exploration spending since 1983-1984. Data from Australian Bureau of Statistics quarterly reports of exploration expenditure.

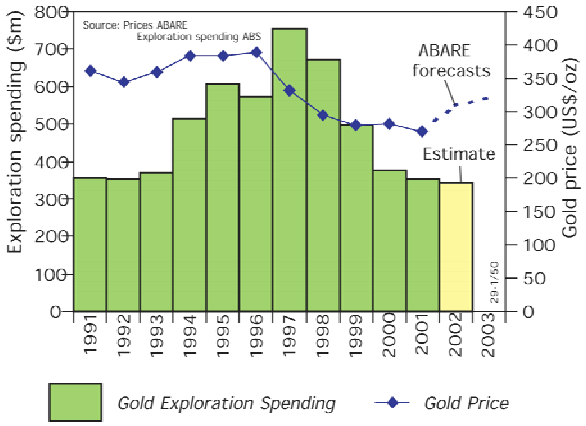

Figure 4: Australian gold exploration expenditure (ABS) versus gold price (ABARE). Note the 1-2 year lag in mineral expenditure increases compared with the increase in the gold price.

The outlook for base metals is also improving but is dependent on global economic recovery. Substantial growth in metal demand in the next 10 years, mostly from China and the former Eastern bloc countries, has been predicted and significant price rises for base metals forecast in 2003-2004 (Lennon, 2002; Maurer *et al.,* 2002). ABARE predicts a significant growth in production and export earnings for the Australian minerals and energy sector in 2002-03 on the back of improved prices but also suggests that a sustained period of higher prices is needed before there is significant increase in expenditure in exploration (Hogan, 2002).

Increase in mineral floats

A further positive indicator for improved levels of exploration is the increase in the number of new mineral exploration companies listing on the ASX. Although market confidence has fallen somewhat since May, the number of new listings to date is the highest since 1996. Those companies that have listed sought funds of just under $100 million and most achieved their target or were oversubscribed albeit with a relatively narrow investor base. A further 9 floats targeting $36 million are pending. If all are successful, the number of IPOs listed in 2002 will be the highest since 1994 (Figure 5).

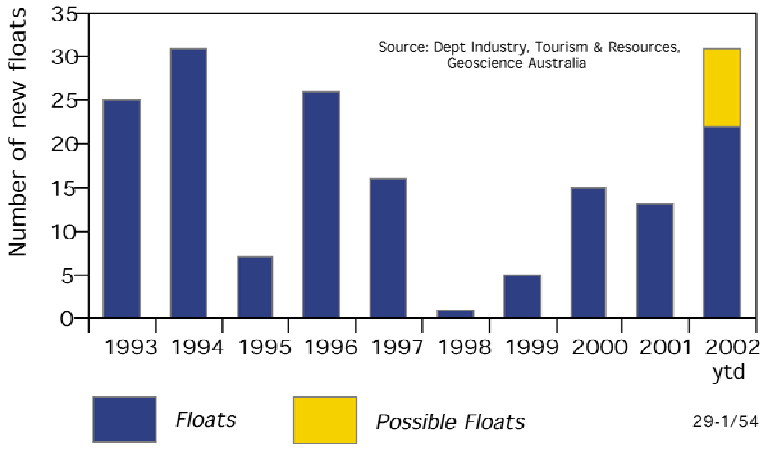

Figure 5: *Number of mineral resource floats (Initial Placement Offers) on the Australian Stock Exchange in the past decade. Data complied by Department of Industry, Tourism and Resources and Geoscience Australia from public sources.*

These companies will have a positive impact on exploration but, important as their capital raisings are for the capital-starved junior sector, the average size of individual raisings is small (~$4 million) and the total raised falls well short of that required to restore exploration

spending to average historic levels. As noted in the recent KPMG review of Australian capital markets, floats of this size are too small to attract support from institutional investors.

Level of exploration activity

There are a number of signs of renewed exploration activity, including tenement applications and areas under title or application in several jurisdictions. Current levels of Australian mineral exploration expenditure (~$650-680 million pa) are about 25% below the long-term and recent decade historic averages (Table 1). The under-investment is particularly

Annual exploration expenditure	Mean expenditure per year (2001 dollars)
Mean Australian mineral exploration expenditure 1970-1979	$675
Mean Australian mineral exploration expenditure 1980-1989	$1010
Mean Australian mineral exploration expenditure 1990-2001	$906
Mean Australian mineral exploration expenditure 1970-2001	$866
Mean Australian gold exploration expenditure 1980-1989	$386
Mean Australian gold exploration expenditure 1990-2001	$516

Table 1. Mean annual Australian mineral exploration expenditure by decade. Data from ABS quarterly surveys of exploration expenditure and adjusted for inflation.

pronounced for gold (currently ~$350 million pa) compared to expenditures in the last decade and is a concern for the industry given that Australian gold production has fallen by ~10% since peaking at 314 t in 1997 (Close, 2002).

In 2001 nearly 80% of individual companies had Australian exploration budgets less than $4 million (US$2 million) and only about 7 had budgets of more than $25 million (Metals Economics Group, 2001). Therefore, although the junior sector plays a major role in Australian mineral exploration and greater proportions of the exploration budgets of larger companies are being spent through juniors, any significant lift in overall exploration spending requires increased exploration commitment from the larger companies. Recent announcements by several global gold majors indicate that gold exploration budgets will rise.

THE FUTURE: OPPORTUNITES AND CHALLENGES

Australia's substantial mineral endowment, and continuing discovery of a wide range mineralisation types in different terranes highlights the under-explored nature and potential of these provinces. Coupled with low discovery costs, especially for gold, these provide compelling reasons for continued exploration in Australia (Jaques & Huleatt, 2002b). These favourable features have attracted most of the world's largest mining and exploration companies to Australia and most are now engaged in exploration, either in their own right or in joint ventures.

Despite extended and sometimes extensive exploration, much of the country has only been explored at a reconnaissance level or to shallow depths even in well-explored areas. Exploration of greenfields areas is still at a relatively low level and large areas of the more remote, buried frontier provinces remain under-explored. Discovery of new resources beneath regolith cover represents a major challenge.

The regional semi-detailed pre-competitive aeromagnetic and gravity data provided by Geoscience Australia and State and Northern Territory geological surveys provide a firm basis for exploration but important areas remain to be flown to modern standards. Following the implementation of the Commonwealth Spatial Data Access and Pricing Policy of 2001 this data is now largely provided either free over the Internet or at low cost. The release of such modern, high quality, regional pre-competitive datasets has been shown to result directly in greater uptake of exploration licences and expenditure by companies and to lead to discovery of new resources. New airborne geophysical exploration technologies, notably improved AEM systems and new airborne gravity gradiometry system (FALCON™) are providing new capability to overcome 'the tyranny of depth' (PMSEIC, 2001). These, coupled with regional gravity surveys and crustal seismic reflection surveys and new visualisation software, are helping to build 3-D models of the crust that assist the continued discovery of new resources to sustain the Australian mineral sector into the future.

ACKNOWLEDGMENTS

We thank our Geoscience Australia colleagues Dean Hoatson, Russell Korsch, Yanis Miezitis and Roger Skirrow, and Lisa Melville and John Willis (DITR Resources Division) for helpful comments on the draft of this paper, Wendy Vantol for assistance with the manuscript

preparation, and Chris Fitzgerald for drafting the figures. Publication is with the permission of the Chief Executive Officer, Geoscience Australia.

REFERENCES

AGES, 2002. Annual Geoscience Exploration Seminar (AGES). www.dme.nt.gov.au/ntgs/conferences/Ages2002/AGES_info.htm.

Champion de Crespigny, R. 2002. Australia: the view from down-under. Prospectors and Developers Association of Canada Annual Convention, Trade Show and Investor's Exchange. http://www.pdac.ca/pdac/pub/papers/2002/index.html

Close, S.E. 2002. Australia's gold industry beyond 2000 – Changes and challenges. AUSIMM Bulletin May/June **3**, 12-16

Crispe, A.J., Vandenberg, L.C., Hendricks, M.A., Dean, A.A., Cross, A.J. & Smith, J.B. 2002. Tectonic setting and magmatism in the Tanami Region. Geological Society of Australia Abstracts, **16**, 165.

Dickson, T.W. 1999. A history of exploration for heavy minerals in the Victorian section of the Murray Basin. *In* Stewart, R (ed.), *Murray Basin Mineral Sands*. Extended Abstracts. Australian Institute of Geoscientists Bulletin **26,** 34-41

Direen, N.G., Lyons, P., Jagodzinski, E.A., Milligan, P.R., & Skirrow, R.G. 2002. A first-generation 3D-model of the crustal architecture of the north-eastern Gawler Craton and implications for Olympic Dam-style mineral systems. Geological Society of Australia Abstracts, **67**, 61.

Geoscience Australia, 2002. Australia's identified mineral resources.

Goleby, B.R. & Korsch, R.J. 2002. Northeastern Yilgarn seismic workshop, August 2002. Workshop Notes. Geoscience Australia.

Heithersay, P. 2002. Prominent Hill discovery – URN 1: The best Cu-Au intersection in 25 years. *MESA Journal*, **24,** 4.

Hogan, J. 2002. Minerals and energy: Overview of the outlook for 2002-03. Australian Commodities, June quarter 2002 **9 (2),** 335-339.

Huleatt, M.B., Jaques, A.L., & Towner, R. 2002. Australian mineral exploration: A review of exploration for the year 2001. Geoscience Australia.

Jaques, A.L., & Huleatt, M.B. 2002a. Australian mineral exploration: analysis and implications. *AusIMM Bulletin,* **Jan-Feb (1),** 45-52.

Jaques, A.L., & Huleatt, M.B. 2002b. Exploration costs – prospects Australia figures well. *AusGeo News,* **64,** 3-7.

Kay, B. 2002. The Tanami: Australia's best gold frontier? Paper presented at Australia's "Exploration Hotspots" Conference, 1-2 May, 2002, Sydney.

Lennon, J. 2002. The changing landscape for the world minerals industry. http://www.pdac.ca/pdac/pub/papers/2002/index.html

Maurer, A., Peel, M., Simms, A,. & Berry, P. 2002. Minerals Outlook for 2002-03. *Australian Commodities,* June quarter 2002, **9**(2), 347-364.

Metals Economics Group, 2001. *Corporate Exploration Strategies, 2001.* Metals Economics Group, Halifax.

Oakes, G. 2001. The Murray Basin mineral sands province: first steps towards the emergence of a new world-class source of titanium minerals and zircon. Paper presented at Mining 2001, Melbourne.

PMSEIC. 2001. Australia's mineral exploration. Paper presented to the Prime Minister's Science, Engineering and Innovation Council, Canberra, June 28. http://www.ga.gov.au/pdf/RR0029.pdf

Skirrow, R.G., Bastrakov, E., & Raymond, O.L. 2002. Alternation and mineralisation settings in the Olympic Cu-Au Province, Gawler Craton, South Australia. Geological Society of Australia Abstracts, **67**, 73.

Wygralak, A.S., Mernagh, T.P., Fraser, G., Huston, D.L., McInnes, B., Crispe, A., & Vandenberg, L. 2001. Gold mineral systems in the Tanami region. New insights from NTGS-AGSO research. *Geoscience Australia Research Newsletter.* **34** 2-9.