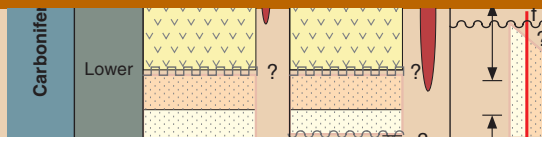
Australian Government
Geoscience Australia

AUSGEO news
ISSUE 94 June 2009

Uncovering Phanerozoic mineral wealth

Geodynamic synthesis points to mineral deposit potential



David Champion, Natalie Kositcin and David Huston

A Geoscience Australia project synthesising geology, geochronology, geodynamic analysis and tectonic modelling will give mineral explorers clearer information on where to prospect across eastern Australia for large accessible economic mineral reserves.

Mineral wealth has been derived from both current and historic mineral deposits related to the Phanerozoic rocks of eastern Australia. These comprise a wide range of commodity types including:

- gold (the Bendigo, Stawell, Hill End, Charters Towers, Beaconsfield, Kidston, Mount Leyshon, Cracow, Pajingo, and Gympie mines)
- copper-gold (the Cadia, North Parkes, Mount Morgan, and Cobar mines)
- base metals (the Rosebery, Hellyer, Lyell, Henty, Thalanga, Balcooma, Woodlawn, Endeavour, and Mount Chalmers mines)
- nickel (the Avebury mine)
- tin-tungsten (the Renison, King Island, Mount Bischoff, Ardlethan, Herberton, and Collingwood mines).

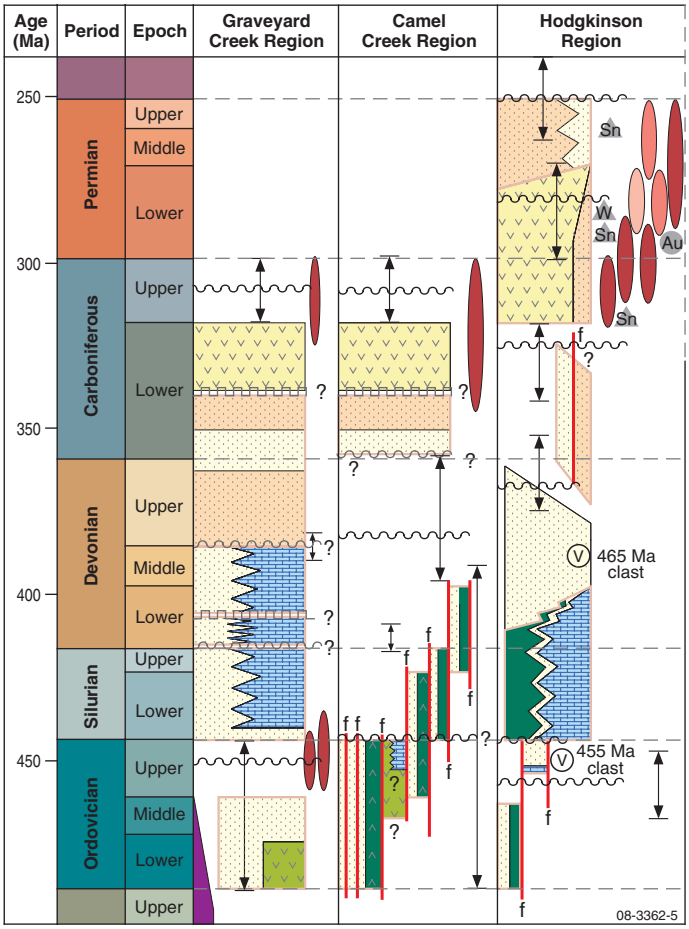


Figure 1. Time–space plot for the north Queensland region. Time-space plots have been compiled for the Lachlan, Thomson, New England and North Queensland orogens, as well as overlying Paleozoic and Mesozoic basins, for eastern Australia.

However, there are significant challenges for explorers in eastern Australia today. These range from developing innovative new approaches or exploration models for the well exposed 'brownfield' regions, such as the eastern Lachlan, and north Queensland, to the challenges of working under cover, for example, in the western Lachlan Orogen and the Thomson Orogen.

Geodynamic synthesis

Over the past year, Geoscience Australia's Phanerozoic Synthesis Project has worked to tackle these challenges through undertaking a geodynamic synthesis of the Phanerozoic of Eastern Australia.

The project's aims were to:

- better understand the tectonic and geodynamic setting of existing mineral deposits within eastern Australia
- provide a predictive capability, within the synthesised geodynamic framework, not just for extending potential regions of known mineralisation but also for potential new styles of mineralisation and commodities.

The project used the 'Five Questions' methodology adopted by the Predictive Mineral Discovery Cooperative Research Centre (pmd*CRC : Barnicoat 2008). It clearly targeted the first of the 'Five Questions', namely, constraining and understanding the regional and local geodynamic environment as the first step in delineating mineral systems.

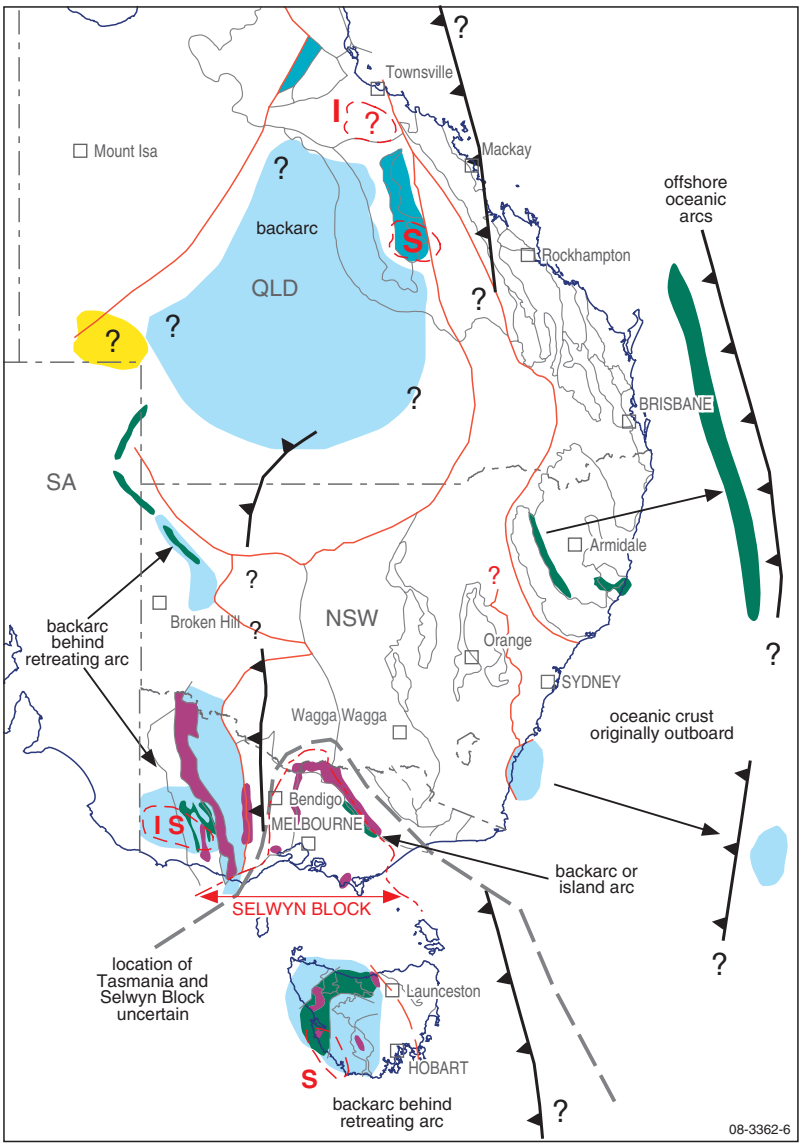


Figure 2a. Interpreted tectonic environment of eastern Australia for the Early to Middle Cambrian Delamerian cycle (ca. 520 to 490 Ma). Interpretation based on synthesis of published geological data and tectonic models.

To achieve this, Geoscience Australia's research team synthesised geological data on a regional, largely orogenic basis, focussing on the eastern states of Australia particularly the belt of Paleozoic and early Mesozoic rocks that run from Tasmania to north Queensland. The synthesis involved the compilation of available published and unpublished state geological survey data, as well as data from general scientific literature. In addition, discussions were held with relevant state geological survey scientists and other key researchers of eastern Australian geology. All data was captured in Geoscience Australia's PROVINCE and EVENTS databases and used to produce time-space-event plots for each region of eastern Australia. This was undertaken to summarise regional geology to allow comparison between regions, and to identify geological events and geodynamic cycles within and between regions. An example of a time-space-event plot is shown in figure 1.

One important outcome of the project was the realisation that there are broadly contemporaneous orogenic events recorded in all of the orogens of eastern Australia. These have been previously recognised (such as the 'stages' described by Scheibner and Basden (1998) and Korsch and Harrington (1981) in New South Wales and the New England

Orogen, respectively) or used (for example, Glen (2005)) to define tectonic cycles for all the Tasmanides. The research team followed the latter approach, documenting the geological syntheses and tectonic interpretations for each region and for all of eastern Australia on the basis of the Delamerian, Benambran, Tabberabberan, Kanimblan and Hunter-Bowen Tectonic Cycles. The models are presented as a series of diagrams showing major geological features and the inferred geodynamic setting for each cycle (see figure 2a).

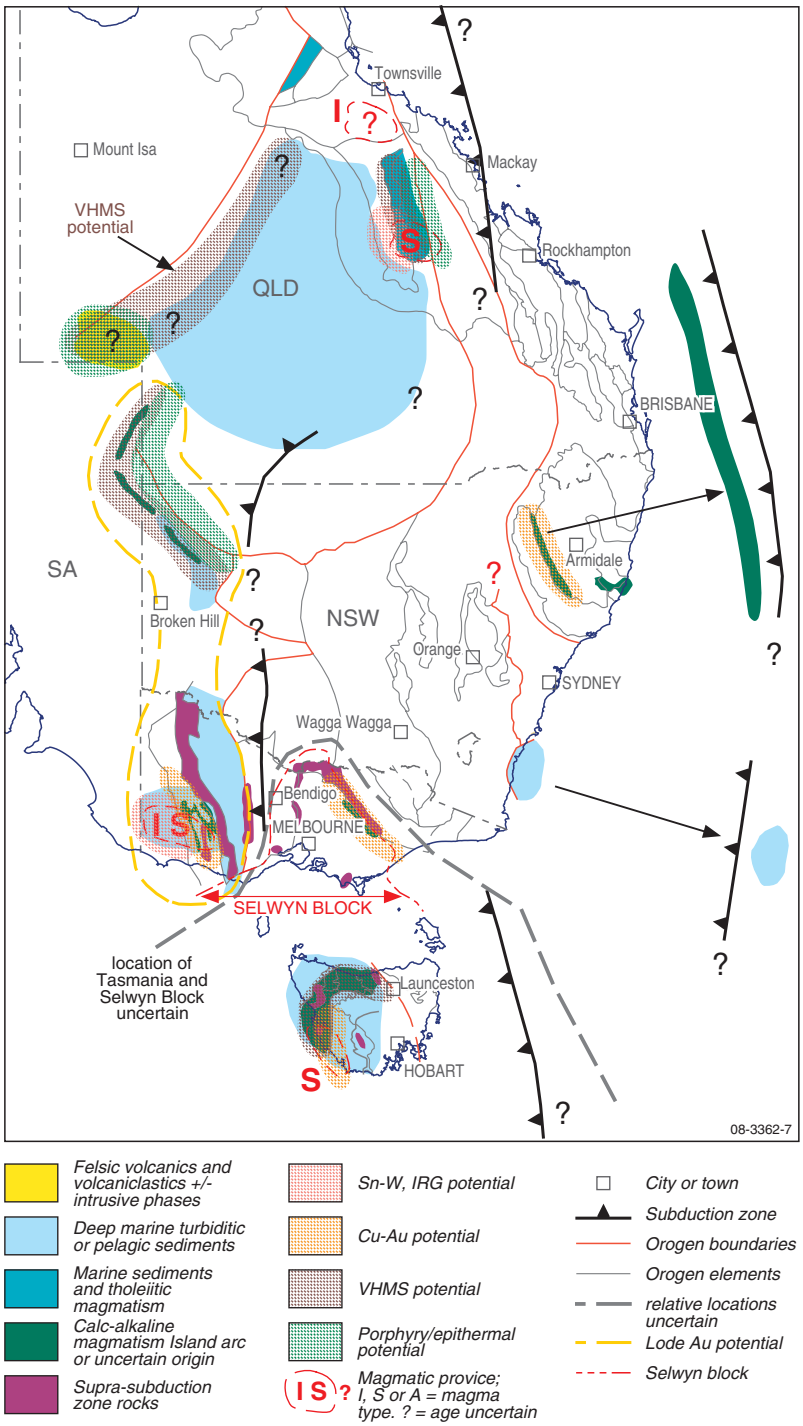


Figure 2b. Simplified mineral potential map of eastern Australia for the Delamerian cycle based on the interpreted geodynamic regime (figure 2a), the distribution of known mineral deposits, and the relationship between geodynamic setting and mineral deposits.

Known and potential mineralisation

The new geodynamic synthesis provides the geodynamic framework to both constrain known mineralisation and provide a predictive capability for potential mineralisation. To better understand the geodynamic setting (and spatial relationships) of existing and historic mineralisation within eastern Australia, a review of significant Phanerozoic mineral deposits was compiled. This was used to help delineate possible extensions of such mineralised belts based on the geodynamic interpretation. The research team also used this geodynamic synthesis to predict areas for potential new deposits (see figure 2b). Base metal deposits, for example, often occur in developing sedimentary basins, while porphyry-related deposits are often in magmatic arc settings. These conclusions are presented as a series of diagrams using coloured overlays to depict predicted mineral commodities, based on associations between mineral systems and geodynamic processes for each orogenic cycle (see figure 2b). Prediction of mineral prospectivity at the eastern Australian scale will provide a first-order guide to area selection for mineral exploration.

Implications for explorers

The geology and tectonic development of the Tasmanides of eastern Australia has been the focus of numerous studies (Murray 1986, Coney 1992, Gray and Foster, 2004, Scheibner and Basden, 1998, VandenBerg and others 2000, Li and Powell 2001, and Glen 2005). Results of this research are two-fold. Firstly, there is a general consensus that since Rodinian-break-up in the Late Neoproterozoic, eastern Australia has been a convergent margin alternating between extensional and convergent orogenic cycles, and accretionary growth, continuing through to the Mesozoic. Secondly, there has been the recognition that the current make-up of Paleozoic to early Mesozoic eastern Australian provinces represents a potential amalgamation of terranes that may originally have been some distance apart.

Additional uncertainty revolves around actual tectonic reconstructions, such as the actual positions and number of subduction zones/magmatic arcs, best exemplified in debate over the Ordovician and Silurian of the Lachlan Orogen (for example, Gray and Foster 1997). This has a number of important implications for mineral exploration. Obviously there is significant potential for (continental and island) arc and back-arc related mineralisation in eastern Australia. However, the present-day locations of such zones can be complex, may be poorly understood, may be non-continuous (such as remnants of the Macquarie and Calliope island arcs), and perhaps be in areas not previously considered. A good example of the latter is the poorly exposed and understood Thomson Orogen (north-western New South Wales and western Queensland). Recent seismic and geological data along the southern margin of the Orogen suggest that it may once have been an east-west oriented accretionary convergent margin (for example, Glen and others 2007), significantly increasing its potential for arc and back-arc related mineralisation.

These results will shortly be released as a Geoscience Australia Record which will report on the following outputs:

- Geological summaries and time-space-event plots (Part 1)
- Interpreted geological and geodynamic synthesis for eastern Australia (Part 2)
- Interpreted mineral potential, along with a compilation of known mineral deposits (Part 3).

For more information

phone Dave Champion on +61 2 6249 9215
email david.champion@ga.gov.au

References

Barnicoat AC. 2008. The Mineral Systems approach of the pmd*CRC. In: New Perspectives: The foundations and future of Australian exploration. Abstracts for the June 2008 pmd*CRC Conference. Geoscience Australia Record 2008/09.

Coney PJ. 1992. The Lachlan belt of eastern Australia and Circum-Pacific tectonic evolution. In: The Paleozoic Eastern Margin of Gondwanaland: Tectonics of the Lachlan Fold Belt, Southeastern Australia and Related Orogens. Tectonophysics, 14: l–25.

Glen RA. 2005. The Tasmanides of eastern Australia. In: Terrane Processes at the Margins of Gondwana. Geological Society of London Special Publication 246:23–96.

Glen RA, Poudjom-Djomani Y, Korsch RJ, Costello RD & Dick S. 2007. Thomson-Lachlan seismic project - results and implications. In: Mines and Wines 2007 Extended Abstracts. Australian Institute of Geoscientists Bulletin 46.

Gray DR & Foster DA. 2004. Tectonic review of the Lachlan Orogen, southeast Australia: historical review, data synthesis and modern perspectives. Australian Journal of Earth Sciences 51:773–817.

Korsch RJ & Harrington HJ. 1987. Oroclinal bending, fragmentation and deformation of terranes in the New England Orogen, eastern Australia. In: Terrane Accretion and Orogenic Belts. American Geophysical Union Geodynamics Series 19:129–139.

Li ZX & Powell CMcA. 2001. An outline of the palaeogeographic evolution of the Australasian region since the beginning of the Neoproterozoic. Earth-Science Reviews, 53: 237–277.

Murray CG. 1986. Metallogeny and tectonic development of the Tasman Fold Belt system in Queensland. Ore Geology Reviews 1:315–400.

Scheibner E & Basden H. 1998. Geology of New South Wales: synthesis. Vol 2. Geological evolution. Geological Survey of New South Wales.

VandenBerg AHM, Willman CE, Maher S, Simons BA, Cayley RA, Taylor DH, Morand VJ, Moore DH & Radojkovic A (eds). 2000. The Tasman Fold Belt in Victoria. Geological Survey of Victoria, Special Publication.

Related websites

Predictive Mineral Discovery (pmd*CRC)
www.pmdcrc.com.au/RESprograms.html