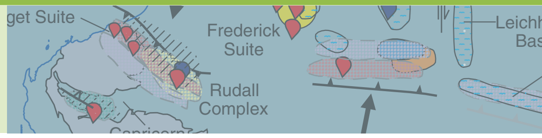
Australian Government
Geoscience Australia

AUSGEO news
ISSUE 88 Dec 2007

Uncovering Proterozoic mineral wealth

Research points to mineral deposit prospects



Geoff Fraser, Narelle Neumann and David Huston

A project synthesising geochronology, geodynamic analysis and tectonic modelling will give the mining industry hints on where to prospect for big, accessible economic mineral reserves.

Much of Australia's mineral wealth comes from deposits from the Proterozoic Eon, 2500 to 542 million years ago (Ma). About 90% of our uranium and lead, 85% of our zinc, and 70% of our copper reserves were deposited in the Proterozoic.

Most of our world-class deposits, such as Broken Hill, Hilton, Mt Isa, McArthur River HYC, Century and Olympic Dam, formed between 1870 Ma and 1550 Ma, a period spanning about a sixth of the Proterozoic. Apart from Olympic Dam, all these deposits were discovered at or near the surface. Between 30% and 50% of the continent contains rocks from this slice of the Proterozoic, but only a few per cent, at best, crops out. If about 5% outcrop has yielded five giant mineral deposits, 95 giant deposits could remain undiscovered in Proterozoic Australia. In most cases, the cover is only in the order of hundreds of metres at most. The challenge is to predict, at successively higher resolution, where undiscovered mineral wealth lies beneath this thin veneer.

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Continental scale

Over the past year, the Proterozoic Synthesis of Australia project has worked to tackle the problem on the continental scale.

We used an understanding of geodynamic processes to predict the location of potential deposits. For example, base metal deposits often occur in developing sedimentary basins, while porphyry copper deposits are often in magmatic arc settings. The project assessed the Proterozoic geodynamic evolution of Australia, and used this to predict regions of mineral prospectivity at the continental scale.

An important component of the project was to compile the evidence underpinning geodynamic interpretations. For the major Proterozoic regions, we compiled and assessed all the available geochronology, and plotted it in a consistent format and time scale to produce a series of time–space graphs (see figure 1 for an example). In contrast to many previously published time–space diagrams, these plots allow easy visual assessment of the quantity and consistency of the available data. The plots are available as thematic layers showing geochronological constraints on sedimentary deposition, magmatic activity, metamorphism and deformation, and mineralising events, along with explanatory notes, in Neumann and Fraser (2007).

Geochronological constraints are critical in comparing the geological history of different crustal fragments in the Australian Proterozoic puzzle. Our compilation highlights

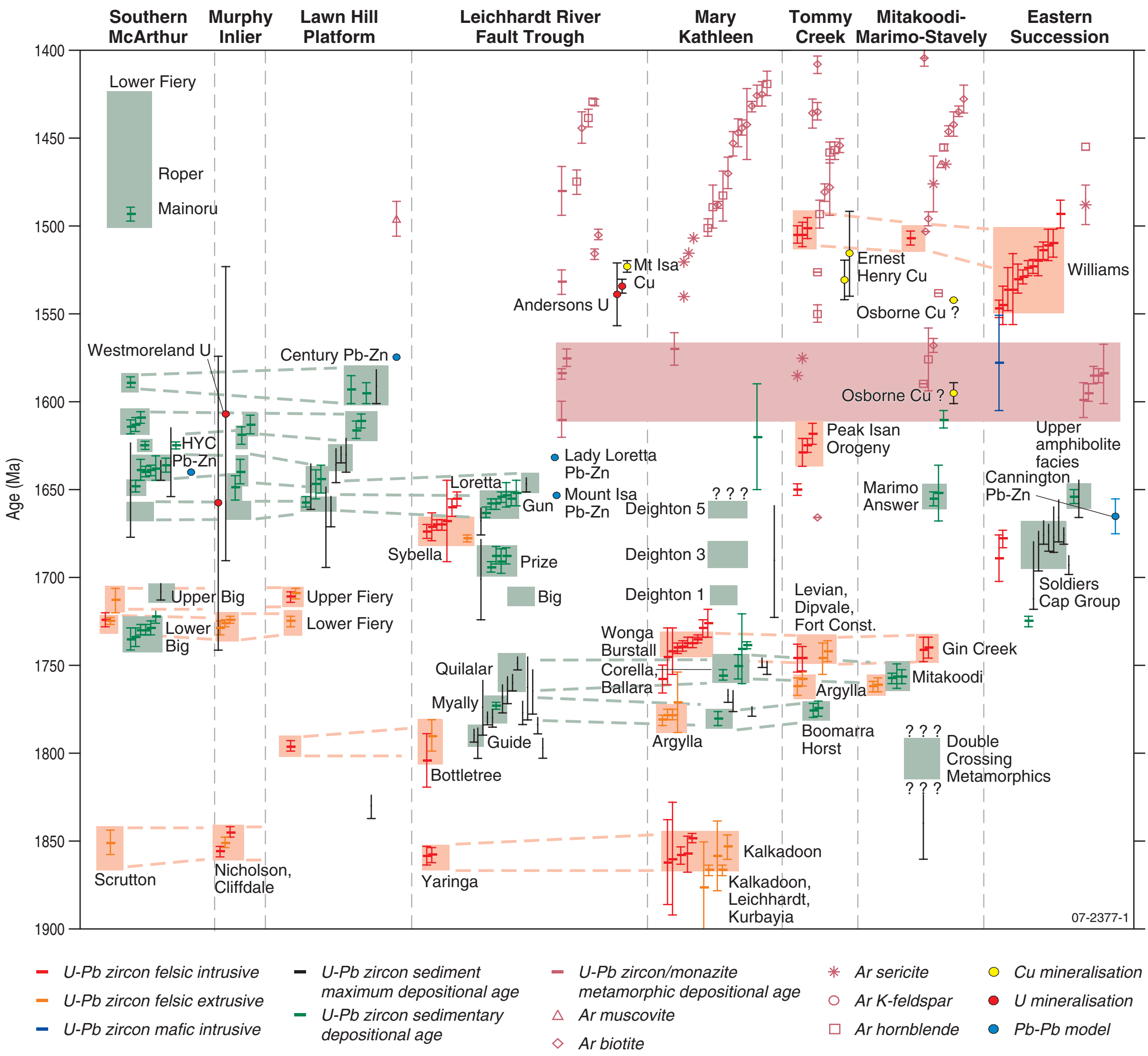

Figure 1. Time–space plot for the Mount Isa Inlier and southern McArthur Basin showing the abundance of geochronological data underpinning our understanding of the stratigraphic and magmatic evolution of the eastern margin of the North Australian Craton. All available radiometric ages and their uncertainties are plotted and coded by colour and symbol according to the geochronological method and geological interpretation. Coloured overlays highlight periods of geological activity, with green indicating sedimentation, red, magmatism and pink, metamorphism.

the wide variation in the quantity and quality of geochronological constraints for different Australian Proterozoic inliers, and for different aspects of their evolution. For example, the abundance of data for the Mt Isa region and Curnamona Province allows a relatively detailed stratigraphic framework to be erected, in contrast to the relatively few stratigraphic age constraints available for the Gawler Craton. As well as indicating levels of confidence that can be attached to age-based geological correlations, this information can also be used to guide future dating work, both within Geoscience Australia and by external researchers.

Reviews of earlier models

As part of the project, we held a series of workshops in collaboration with colleagues from the state and Northern Territory geological surveys to review and summarise the geological evolution of particular Australian Proterozoic regions.

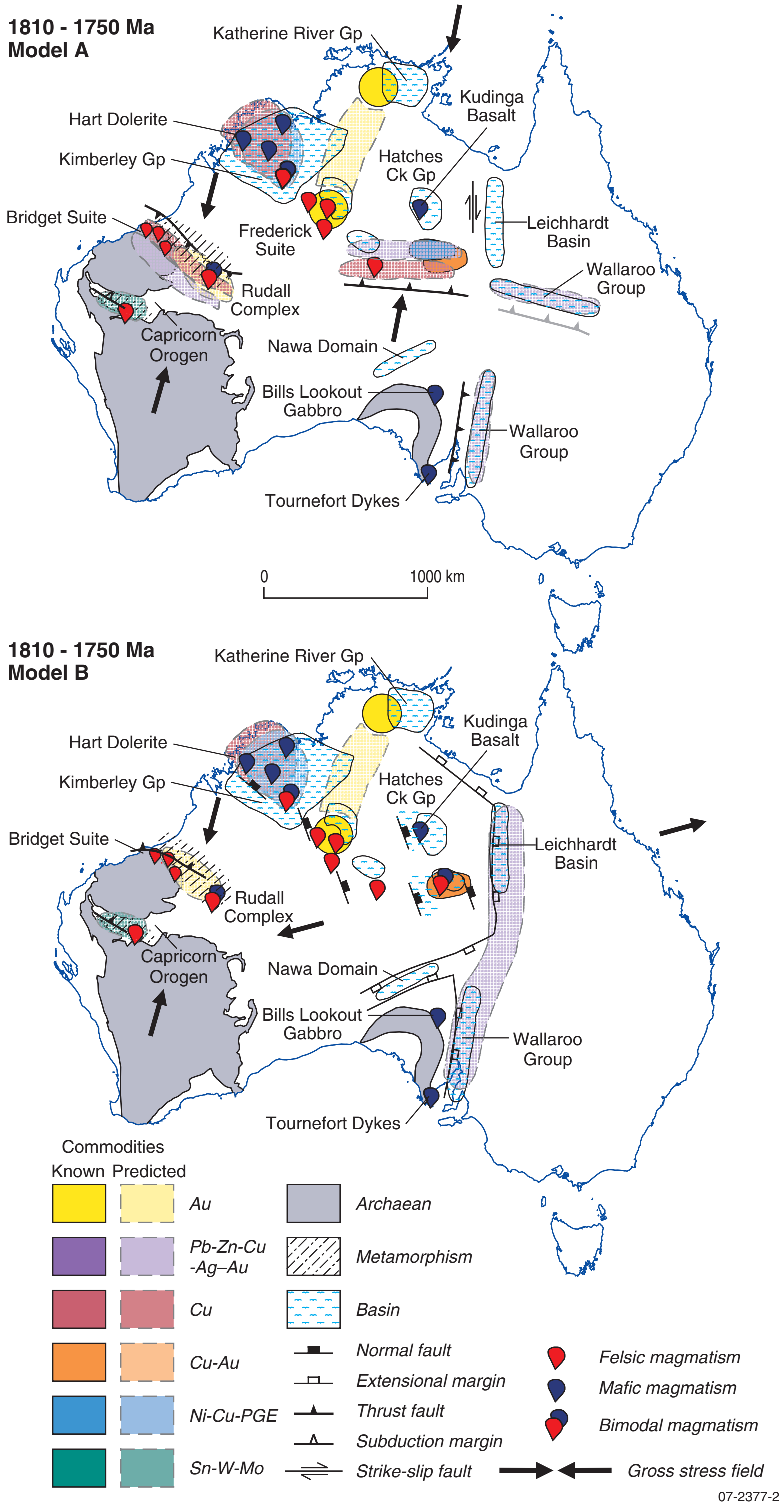

Figure 2. Alternative geodynamic models for Proterozoic Australia for 1810 Ma to 1750 Ma, with known and predicted mineral commodities shown as coloured overlays. Note the contrasting predictions of mineral prospectivity in the two models along the eastern margin of both the North Australian and South Australian cratons, along the southern margin of the North Australian Craton, and along the margin between the North Australian and West Australian cratons.

We also reviewed previously published tectonic models for Proterozoic Australia and the evidence on which they were based. The review traced the development of tectonic interpretations over the past 20 years, ranging from the 'ensialic' model of Etheridge et al (1987) invoking largely vertical addition to the crust, to a series of recently published models dominated by plate tectonic-style, horizontal accretionary tectonics.

There is an apparent inconsistency between recently published models that infer a long-lived, convergent, accretionary margin along the southern edge of the North Australian Craton (for example, Giles et al 2004, Betts and Giles 2006, Wade et al 2006) and others that infer a long-lived east-facing extensional margin along the eastern edges of the North Australian and South Australian cratons (Gibson et al, in press). The contradictions arise partly from workers having experience in different parts of Proterozoic Australia and partly from contrasting tectonic interpretations of the same geological evidence.

Implications for explorers

Since the tectonics is open to interpretations with differing implications for minerals systems, we have not presented a single model for the tectonic evolution of the Australian Proterozoic. Instead, we present two contrasting end-member models for five time intervals between 1870 and 1550 Ma. We present the models as a series of diagrams showing major geological features and inferred geodynamic setting, with coloured overlays depicting predicted mineral commodities based on associations between mineral systems and geodynamic processes.

Prediction of mineral prospectivity conducted at the continental scale provides a first-order guide to area selection for mineral exploration. Examples of these diagrams are shown in figures 2a and 2b. They illustrate how different end-member geodynamic models lead to significantly different predictions of mineral prospectivity in particular regions. See Fraser et al (2007) for the full series of the diagrams and explanatory notes, along with a review of published tectonic models and known metallogenic events for Proterozoic Australia.

For more information

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> "Geochronological constraints are critical in comparing the geological history of different crustal fragments in the Australian Proterozoic puzzle"

Related websites/articles

Proterozoic Synthesis Project
www.ga.gov.au/minerals/research/national/geodynamics/proterozoic_synthesis.jsp

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