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GOING FOR GOLD in the Eastern Yilgarn

New 3D maps of Australia's premier gold province are now available.

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The Late Archaean granite–greenstone terranes of the Eastern Yilgarn Craton host the majority of Australia's world-class gold deposits.

High-resolution gravity, magnetics, geological and geochemical maps make up most of the large amount of data available on the region, augmented by high-quality deep seismic reflection profiles and covered by a range of teleseismic studies. These data have now been integrated into a set of new 3D maps at a range of scales (Blewett & Hitchman 2006).

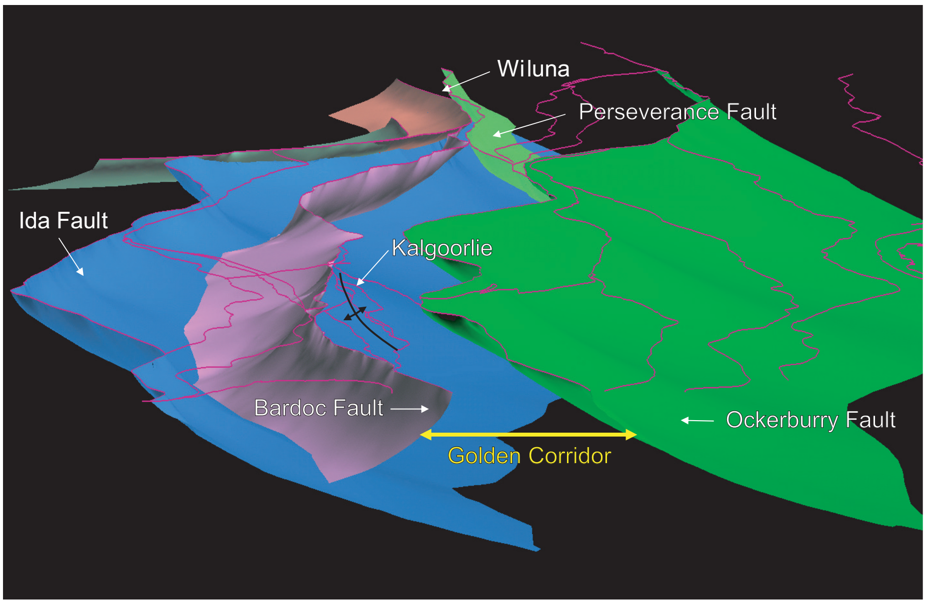
This project was conducted at Geoscience Australia as part of the Predictive Mineral Discovery Cooperative Research Centre's Y2 project. Results from this work are now free of confidentiality protection and are available as Geoscience Australia Record 2006/05.

Imaging the architecture

The philosophy of the Y2 project was to consider mineral systems in terms of five key parameters: geodynamics; architecture; fluid drivers and pathways; sources of fluids and metals; and depositional mechanisms.

Understanding the architecture of a system at a range of scales is essential for effective area selection and targeting. Development of this understanding includes defining and mapping the geometry of pathways for fluid flow, the components involved in fluid focusing, and the ultimate trapping mechanisms. The architecture is best elucidated by 3D maps.

A recurring feature of the Eastern Yilgarn 3D maps at a range of scales is the spatial relationship between domes or anticlinoria and larger gold deposits in the region. As these architectural elements are an essential contributing factor to the endowment of this region, mapping them helps improve predictive discovery.



▲ **Figure 1.** Perspective view looking north from above the 'Golden Corridor' defined by the west-dipping Bardoc Fault and the east-dipping Ockerburry Fault.

Terrane scale

The architecture of the eastern half of the Kalgoorlie Terrane is an elongate anticlinorium from Kambalda to Plutonic, with culminations (below deposits) and intervening depressions. This 'Golden Corridor' is over 700 kilometres long and contains a large proportion of the known gold in the Yilgarn Craton (figure 1). Regional 3D geological maps are therefore likely predictors of favourable tracts of country at the broadest scale.

Semi-regional scale

Domes are defined at several levels within the upper 10 to 15 kilometres of the present crust. The base of the greenstone has been mapped from 0 to 7 kilometres thick, with a dome-and-basin topography to this surface. Coincident with the spacing of the gold deposits at the surface, the wavelength of the dome apices of the greenstone base is typically around 35 kilometres.

Beneath the greenstone base, the felsic upper crust is dominated by sets of strong seismic reflections that are interpreted as shear zones, now altered by fluid flow during orogenesis and mineralisation. These reflections are openly folded into a series of stacked domes of ever decreasing wavelength upwards towards the greenstone base.

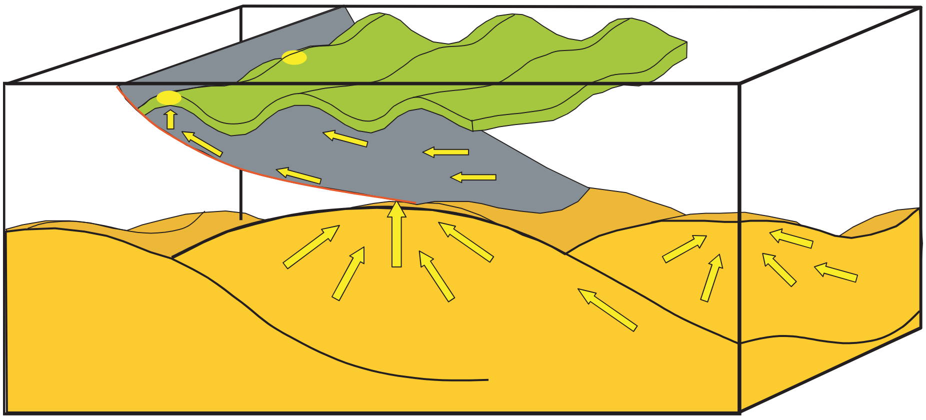
The stacked domes are interpreted to provide an efficient pathway for focusing orogenic fluids into the apex of the domes at higher structural levels (figure 2; yellow surface). 'Breaching' faults (figure 2; grey surface)occur near the apex of many domes, forming pathways for the dome-focused fluid to migrate to progressively higher structural levels for subsequent trapping (mineral deposit formation).

Camp scale

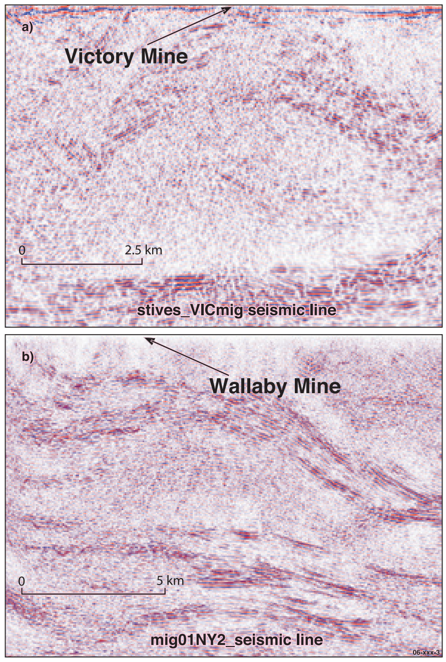
The upper 10 kilometres of the seismic data defines a recurring geometry for many of the gold deposits of the region (e.g. St Ives, Wallaby, Kanowna Belle), with deposits located close to the apices of broad open domes, imaged as high-amplitude reflections that are interpreted as shear zones (figure 2; green surface, figure 3).

These domed reflections are close to, or define, the greenstone base, which is folded over a felsic (granitic) laccolith. At depths between ~6 and ~8 kilometres beneath the domes, there is an equally strong set of planar sub-horizontal reflections. The region between the high-amplitude reflections is interpreted to be occupied by granite, due to its featureless seismic character and gravity modelled low density.

The timing between the folding and doming and granite emplacement is unclear. If the granites are late syn-folding, then magmatic fluids may have contributed to the fluid flux and mineralisation. If they are pre-folding, rheological contrasts may have influenced local stress fields and also explain the local endowment. Both pre- and syn-magmatic factors may be important.



▲ **Figure 2.** Schematic model (from Henson et al 2005) of fluid focusing towards mineral deposits (yellow dots) above a series of stacked domes with decreasing wavelengths (black horizontal lines) upwards.

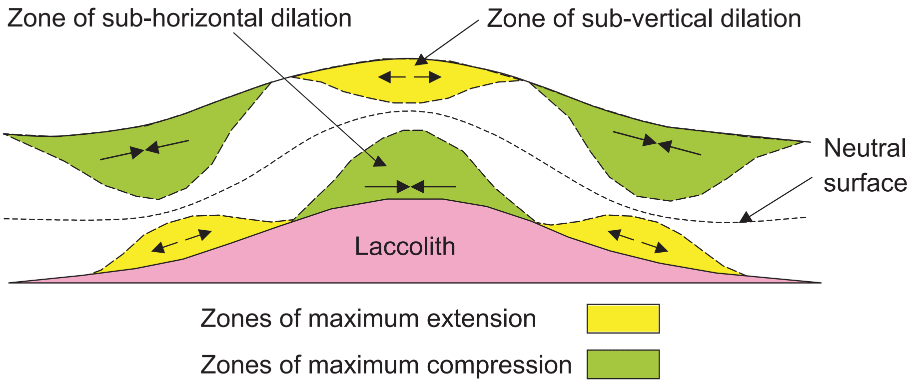


▲ **Figure 3.** Seismic reflection lines (3A, 3B) across the Victory and Wallaby gold deposits showing both located above the apex of domes. The muted regions between the strong reflectivity is interpreted as a granite laccolith. The diffuse zone cross cutting the strong reflectivity at the Victory gold mine (3A) is mapping swarms of porphyry dykes that are likely sourced from the laccolith (dome) at depth.

Deposit scale

The precise location of gold deposits within domes may depend on the local stress mode with respect to the 3D neutral surface of the domes (figure 4). Extension or dilation dominates the outer arc, leading to vertical extension veins and granite or porphyry dykes.

Compression dominates the inner arc, causing flat-lying extension veins and granite or porphyry sills. More space (dilation) occurs in the outer arc, so if the depth of erosion is below the neutral surface of the domes, endowment and prospectivity may be reduced.



◀ **Figure 4.** Variation in local stress field above and below 'a neutral surface' within an anticline/dome. The yellow highlighted zones are areas of maximum dilation (and likely fluid flow) in the outer arc where dykes and steeply dipping veins develop. In the inner arc the green-coloured areas define maximum compression where sills (and sub-horizontal veins) develop. The model suggests that the structural level is important, e.g., if a location is eroded below the neutral surface then the dome apex may be a region of maximum compression not dilation.

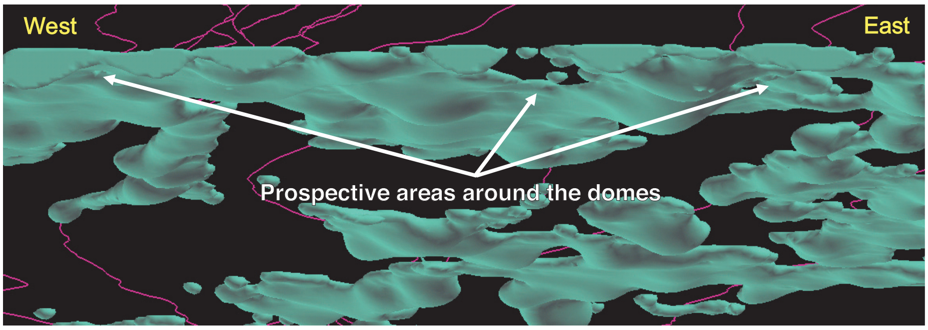


Figure 5. Perspective view looking north from underneath the geologically constrained gravity inversion model (green volume), showing the undulous nature of this surface. Purple lines are the regional fault traces on the Earth's surface.

Gravity tools

Seismic reflection data were used extensively in this project to construct the 3D maps. These data were very effective in defining domes and predicting their occurrence and geometry. However, such data are not available everywhere, so what does the explorer use in the seismic-absent regions?

One of the datasets available over much of Australia is gravity. In a region like the Yilgarn Craton, the greenstones are essentially dense and overlie a less dense felsic (granitic) substrate. The densities of these two main rock types are different enough to be mapped easily by gravity data.

Geologically constrained inversions of the base of the granite–greenstone interface reveal a complex dome-and-basin architecture to this surface. The geometry of the greenstone base established from the gravity inversion matches very closely with the interpretation of this interface in the seismic reflection data (figure 5).

This means that regional inversions of the gravity data effectively map the prospective domes in regions where seismic data are not available. This could be used as a first-pass exploration targeting tool in this province and elsewhere.

Conclusion

Domes occur at a range of scales and are linked in time and space with world-class gold deposits. The 3D mapping of the architecture of these domes is improving area selection, targeting and predictive capacity.

More details and scientific outcomes from the project are available on DVD (Geoscience Australia Record 2006/05).

References

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2. Henson PA, Blewett RS, Champion DC, Goleby BR, Cassidy KF, Drummond BJ, Korsch RJ, Brennan T & Nicoll M. 2005. Domes: the characteristic 3D architecture of the world-class lode-Au deposits of the Eastern Yilgarn. James Cook University Economic Geology Research Unit Contribution 64:60.

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