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EXPANDING our knowledge of Mt Isa *to a third dimension*

Australian researchers have been working together to interpret the geology and prospectivity of the Mount Isa Western Succession.

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Since March 2002, a collaborative project to improve our understanding of the 3D crustal architecture and mineral systems of the Mount Isa Western Succession has engaged researchers from Geoscience Australia, universities, industry and other government agencies. The project has been carried out under the auspices of the Predictive Mineral Discovery Cooperative Research Centre (*pmd**CRC).

The project gave high priority to building of a 3D structural model of the Mount Isa region, incorporating stratigraphy, major unconformity surfaces, fault geometries, basin shape and mineral deposit locations. Complementary investigations into the geodynamic setting, origin and timing of events that may have influenced or controlled fluid flow in the region helped the researchers achieve:

- a comprehensive and internally consistent 3D interpretation of basin architecture and regional structure that allows mineral alteration patterns to be better understood in terms of fault geometries, sequence stratigraphy and other potential fluid pathways
- better understanding of the geological and tectonic processes that controlled and influenced basin geometry and fluid flow
- improved temporal constraints on the timing of these processes and the events that gave rise to them.

The project built on previous Geoscience Australia successes with NABRE (North Australian Basins Resource Evaluation) and external partners, such as the AMIRA P552 Fluid Flow Modelling project. It involved collaboration with the Queensland Department of Natural Resources, James Cook University, Melbourne University, the University of Western Australia, CSIRO, and two exploration companies currently active in the region, Xstrata Copper and Zinifex. The University of Newcastle provided further geological input and analytical data on a contractual basis.

Following a 12-month confidentiality period, the results of the project became publicly available from 30 April 2006 and are currently being prepared for publication.

As might be expected of such a richly endowed mineral province, the Mount Isa region in northern Australia (figure 1) has long been the subject of intense geological research and exploration activity. There is a diverse range of opinion about its regional structure, tectonic evolution and metalliferous potential. This makes mineral exploration more difficult and fraught with uncertainty, because there is rarely the time or resources to fully assess the wide range of interpretations.

Despite such uncertainties, tectonic setting and its role in controlling crustal architecture and the pattern of fluid flow are widely perceived to be important factors in the formation of ore bodies and their metallogeny. The difficulty for exploration companies is that the Western Succession, like so many other Proterozoic terranes in northern Australia (including the Eastern Succession), has been substantially modified by later deformation and post-depositional processes. The original tectonic setting and basin architecture are no longer obvious, and there is ongoing uncertainty about the age of mineralisation, its relationship to major structures, and whether these structures first became active before or after mineral deposition.

Marrying basin analysis with regional structural studies was deemed the most effective means of differentiating between pre-, syn- and post-depositional fault movements, although this is seldom enough to narrow the range of potential exploration targets. Details of possible source rocks and traps are also required.

More importantly, the researchers thought it desirable to have all elements of the mineralising system brought together in a single 3D representation, permitting better visualisation of the problem and more effective discrimination between competing geological interpretations. The 3D environment provides a much less forgiving test bed for subsurface geological interpretation than was ever possible from traditional 2D geological maps and cross sections.

Successful exploration now demands a more integrated approach to the problem of target selection, requiring an understanding of the entire mineralising system. This has been the guiding philosophy and visionary goal behind the current research program:

… through a better understanding of the geological controls on existing sediment-hosted Pb–Zn–Cu deposits in the Western Succession derive the key geological parameters that will increase the predictive ability of the exploration industry to locate blind or as yet undiscovered mineral deposits beneath cover elsewhere in northern Australia.

Project scope

The previous Geoscience Australia NABRE study in the Western Succession largely concentrated on elucidation of basin architecture in the Calvert (1730–1670 Ma) and Isa (1670–1595 Ma) superbasins. (See the event chart of Neumann et al for a more detailed geochronology of these two structural entities.)

These studies placed less emphasis on the older underlying Leichhardt Superbasin (1790–1740 Ma) even though it was recognised that major faults dating from that period had the potential to exercise an important control on the geometry and location of future, successor basins. The new study was consequently directed at improved understanding of the architecture of the older Leichhardt Superbasin and how this interacted with younger basins to produce the distribution of sedimentary facies and magmatic rocks preserved in the Western Succession today.

Particularly important in this context was an attempt to recognise rock sequences that may have served as potential source and trap rocks for metals. No less important was a study of fault geometry and distribution, and how these may have influenced fluid flow and the migration of mineralising fluids through the rock pile.

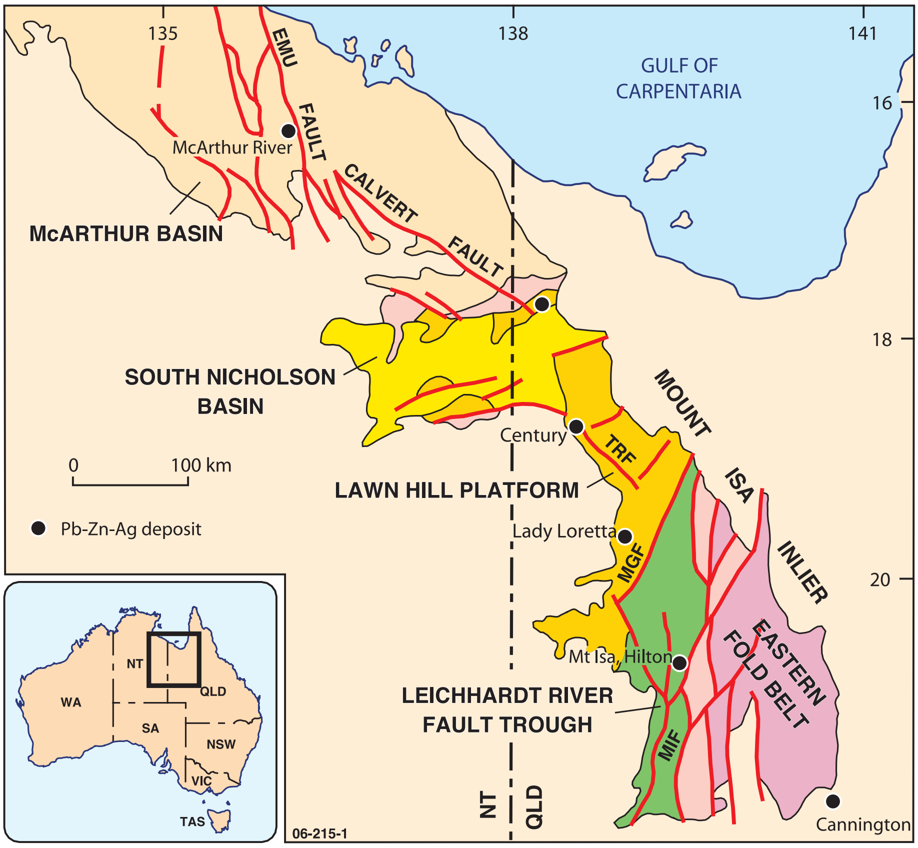

Figure 1. Study area in relation to major tectonic elements in the Mount Isa region.

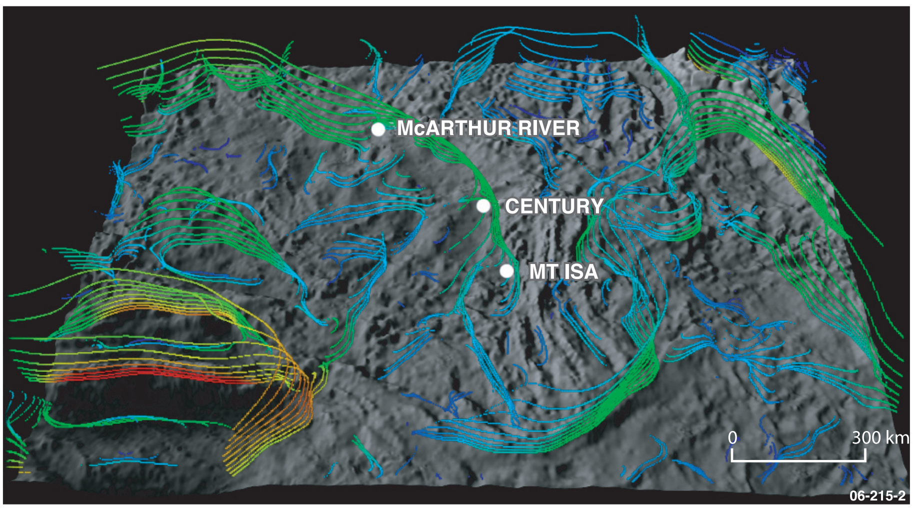

Figure 2. Gravity response upwardly continued from 66 to 220 kilometres to produce the 'Barramundi worm' as determined by Hobbs et al (2000). Note major Pb-Zn mineral deposits located along the trace of this feature which is thought to represent a continent-scale boundary between crustal blocks of contrasting density.

Only part of the Western Succession was investigated in detail, with the bulk of the research being conducted in the northern part of the Leichhardt River Fault Trough and the southern part of the Lawn Hill Platform (figure 1). As such, the study area straddled the Mt Gordon Fault Zone, a prominent geophysical and geological feature (figure 1), as well as a significant length of the 'Barramundi worm' (figure 2). The latter had already been identified in upwardly continued regional gravity datasets (Hobbs et al 2000), and appeared to serve as an important locus for several mineral deposits at Century and Lady Loretta (figure 1). The Century Pb–Zn deposit formed part of a PhD project carried out at James Cook University under the banner of the *pmd**CRC.

Objectives, organisation and deliverables

To achieve its visionary goal, the project was set up to deliver:

- 3D Gocad model of basin architecture
- improved understanding of the geodynamic setting and crustal architecture
- more tightly constrained space–time plot and event chart
- metamorphic map and improved diagenetic/burial history for region
- timing and age of fault movement with respect to depositional and post-depositional histories and related mineralisation
- pilot study in use of remote sensing as a means of determining the distribution of particular mineral species or parageneses (e.g. muscovite- versus phengite-dominated rocks) or alteration styles (e.g. silicification) associated with mineralisation (see article by Oliver and van der Wielen in this issue of *AusGeo News*).

To meet its objectives, the project was managed as a series of modules with specific outcomes and deliverables. These included:

- **3D basin architecture** underpinned by interpretation of the potential field data (gravity and aeromagnetics) and structural analysis undertaken in a number of key localities (e.g. Bull Creek, Barr Hole, Mellish Park, Lake Julius). Construction of the 3D Gocad model (figure 3) is at the core of this module, although it also incorporated a study of faults that may have been active at critical times during basin formation and subsequent inversion and evolution. The geometry and age of these faults were determined through a combination of structural cross-sections, map patterns and field studies. Thermobarometric data (Kubler indices and white mica b dimensions) were employed to constrain the depth of tectonic burial and related metamorphic history of the basin.
- **3D isopach map and identification of sedimentary depocentres** to constrain basin shape and the location of growth faults (figure 3). This module combined mapped sedimentary thicknesses obtained from the 1:100 000 sheets with sequence stratigraphy of detailed measured sections obtained from many of the same key localities used to constrain the deformational history. In view of the detailed work previously undertaken by NABRE (Southgate et al 2000) on the Calvert and Isa supersequences, the focus of this module was on the older underlying units (Myally and Quilalar supersequences) that formed the original rift template.
- **Mineral index maps and numerical modelling** were employed to assess the extent and degree of fluid flow accompanying basin formation and its subsequent inversion. A critical component of this module has been the processing of remotely sensed LANDSAT, ASTER, HYPERION and radiometric data to identify the possible footprints of fossil hydrothermal systems. Large numbers of PIMA analyses were undertaken in support of this module, in order to properly calibrate and ground-truth the remotely sensed data. Cross-referencing with the results of module 1 has been carried out to ascertain whether there is any relationship between the inferred hydrothermal hotspots and regionally significant structures such as faults, stratigraphic boundaries or high-strain corridors. As a test of how basin architecture and fault geometry may have controlled or influenced fluid flow and paleo-temperatures during basin inversion, a number of numerical simulations were run in Flac3D, based on simplified geological models.

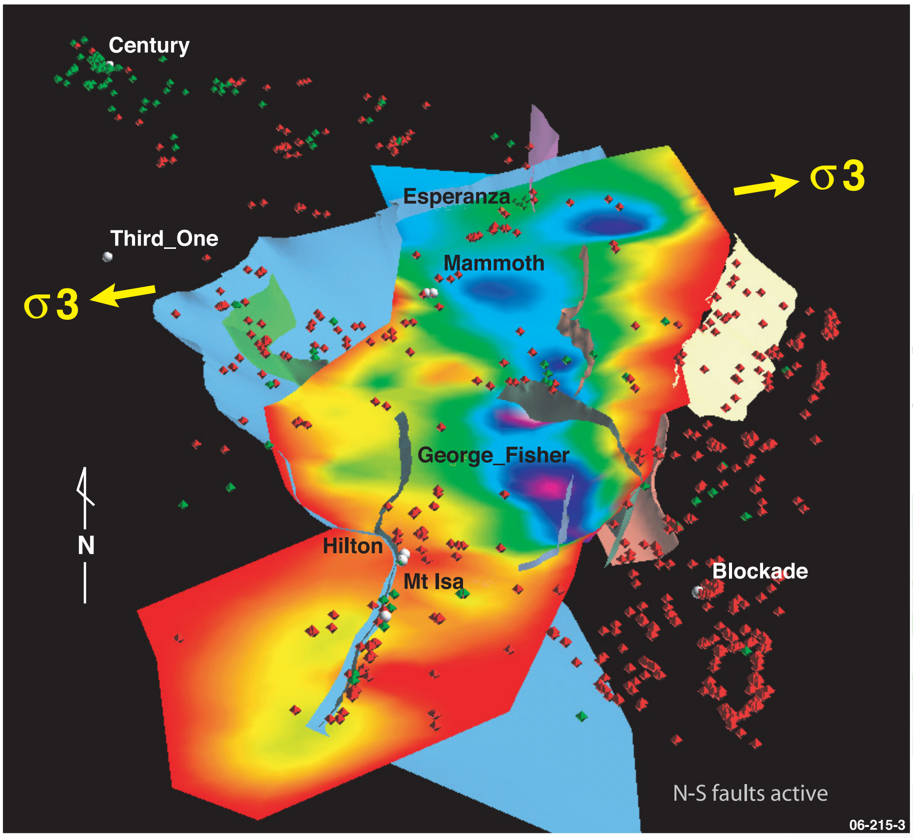

Figure 3. Isopach map for Myally-age sediments (1770-1780 Ma) combined with mineral occurrences (red = Cu; green = Pb-Zn) and major basin-bounding faults in the Mount Isa region.

- **An extended and revised space–time and event plot** was necessitated by improved chronostratigraphic control on the age of sedimentary deposition (see the article by Neumann in *AusGeo News 78*), as well as a better understanding of the present-day 3D basin architecture and the kinematic framework that gave rise to this architecture. Particularly important in this regard is a large component of U–Pb SHRIMP dating of detrital zircon populations from different parts of the stratigraphy. The results of this work provide important constraints on depositional ages, as well as the provenance of the sediments. Several granites from the Sybella Batholith were also selected for zircon analysis to refine their ages in relation to both the depositional history and the tectonic evolution of the basin.

References

1. Neumann NL, Southgate PN, Gibson GM & McIntyre A. In press. New SHRIMP geochronology for the Western Fold Belt of the Mount Isa Inlier: developing a 1800–1650 Ma event framework. Australian Journal of Earth Sciences.
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