MINCOR ZINC PTY LTD
GEORGINA BASIN PROJECT

Combined Annual Report
EL25089 to EL25094 and EL25143

2 October 2007 to 1 October 2008

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Authors:
P.B. GROENEWALD

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JOGMEC
DPI-FM
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1. SUMMARY

The tenements currently comprising the Georgina Basin Project are EL25089 to EL25094 and EL25143. The Annual Reporting period for these tenements is 2 October to 1 October. The tenement schedule is given as Table 1 below.

<table>
<thead>
<tr>
<th>Licence</th>
<th>Name</th>
<th>Grant</th>
<th>Expiry</th>
<th>Blocks</th>
<th>Commitment</th>
<th>Current</th>
</tr>
</thead>
<tbody>
<tr>
<td>EL25089</td>
<td>Arapunya</td>
<td>7/09/2006</td>
<td>6/09/2012</td>
<td>500</td>
<td>$120,000</td>
<td>$77 371</td>
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<td>EL25090</td>
<td>Derry Downs</td>
<td>2/10/2006</td>
<td>1/10/2012</td>
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<td>$120,000</td>
<td>$57 882</td>
</tr>
<tr>
<td>EL25091</td>
<td>Lucy Creek</td>
<td>2/10/2006</td>
<td>1/10/2012</td>
<td>500</td>
<td>$120,000</td>
<td>$78 213</td>
</tr>
<tr>
<td>EL25092</td>
<td>Mt Teitkens</td>
<td>2/10/2006</td>
<td>1/10/2012</td>
<td>500</td>
<td>$120,000</td>
<td>$58 662</td>
</tr>
<tr>
<td>EL25093</td>
<td>Mt Ultim</td>
<td>2/10/2006</td>
<td>1/10/2012</td>
<td>500</td>
<td>$120,000</td>
<td>$67 109</td>
</tr>
<tr>
<td>EL25094</td>
<td>Tarlton Hill</td>
<td>2/10/2006</td>
<td>1/10/2012</td>
<td>495</td>
<td>$120,000</td>
<td>$64 647</td>
</tr>
<tr>
<td>EL25143</td>
<td>Huckitta</td>
<td>2/10/2006</td>
<td>1/10/2012</td>
<td>16</td>
<td>$18,000</td>
<td>$30 974</td>
</tr>
<tr>
<td>TOTAL</td>
<td></td>
<td></td>
<td></td>
<td>3011</td>
<td></td>
<td>$738,000</td>
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</tbody>
</table>

Table 1: Georgina Basin Project Tenement Schedule

The current total expenditure for the Group is $434 858.

Fieldwork was undertaken during the 2007/2008 reporting period to provide preliminary observations of structural features and characteristics of the stratigraphy, stream sediment samples around the interpreted Elkedra shelf, and a detailed gravity survey, to allow more detailed interpretation of the basin. Data studies coupled with the first stage of a numerical model of fluid flow and potential mineralization were completed, as were further studies of selected drill core at the NTGS core library in Alice Springs. An Agreement was entered into with the CSIRO to carry out 3-dimensional numerical modelling of basin fluid flow as part of the 2009 program to better define stratigraphic drill targets.

A Joint Venture agreement was signed with Japan Oil Gas and Metals National Corporation (JOGMEC) on 6th June 2008. This will require expenditure of $2 500 000 during the next reporting period.

2. INTRODUCTION

This investigation by Mincor Zinc Pty Ltd of the mineral potential of the southern Georgina Basin stemmed from the publication of a comprehensive data review by the Northern Territory Geological Survey (NTGS). Mincor Zinc acquired 9 000km² in tenements (ownership transferred from Mincor Resources NL (MCR) to Mincor Zinc Pty Ltd, a wholly owned subsidiary of MCR, on 12/02/2007). This extensive area will allow evaluation of the southern basin margin and adjacent interior as a whole in order to identify the most prospective areas before embarking on a drilling program.
3. REGIONAL GEOLOGY

The Georgina Basin is a broad, northwest-southeast trending, intracratonic depression that is about 1000km long and 500km wide, underlying an area of some 325,000km² of the Northern Territory and Queensland. Approximately 60 percent of the basin area (195,000km²) lies within the Northern Territory (Figure 2).

The basin contains prospective Cambrian and Ordovician marine carbonate and clastic sediments and Devonian continental sediments; the underlying Neoproterozoic (Vendian) clastics are also considered prospective in places. Sediments were deposited in a series of subtidal to supratidal environments over part of an extensive epicontinental shelf. The Palaeozoic sediments progressively thicken in a south-southeasterly direction, rarely exceeding 400 metres in the northern half of the basin and becoming significantly thicker in the southeast (Toko Syncline). The sedimentary sequence of the basin proper appears to have been neither metamorphosed nor intruded by igneous rocks.
The present outline of the Georgina Basin is an erosional remnant of a much larger, early Palaeozoic sedimentary province that once covered much of north central Australia.

The basin was once contiguous with the Amadeus Basin to the south, but is now separated from it by the Archaean / Palaeoproterozoic Arunta Block. It is not known at present if, or to what extent the Georgina Basin is connected to the Wiso Basin to the west and the Daly Basin to the northwest. The northwest and southwest extremities of the basin are concealed beneath Mesozoic and Cainozoic sediments that mask the actual limits of the basin in these areas. The Davenport Range and the Tennant Creek Block, both comprising deformed Early Proterozoic sediments, provide at least partial separation of the three sedimentary basins.

The basin is fully confined by Archaean to Late Proterozoic metamorphic and igneous rocks. In addition to the structural elements described above, the Georgina Basin is bounded by the Mt Isa Block to the east, while to the north, the basin extends as a thin veneer that overlies the Antrim Plateau Volcanics and the potentially prospective Proterozoic McArthur Basin.

The basin has been deformed by minor to moderate folding and faulting, especially in the south and east, with folding, faulting and local overthrusting along the southern margin. Most of the deformation occurred during the Late Devonian to Early Carboniferous Alice Springs Orogeny. Work by Pacific Oil and Gas has shown that mainly flat lying, Ordovician sediments can conceal and disguise earlier Palaeozoic structures. North of latitude 21°S, the Georgina Basin sequence is gently undulating, with no pronounced folding recognised other than the Lake Nash Anticline which is interpreted to be a supratenuous fold. In the north, faults are recognised only along the basin margin.
The most prominent structural elements in the basin are the Dulcie and Toko Synclines, both of which are asymmetric folds with steep dips on their southwestern flanks; the “GMI” linear which has been identified from gravity and magnetics and is believed to be a basement feature; and the “Jinka Feature”, another gravity-magnetic linear, the surface expression of which occurs in the Lucy Creek-Mt Playford Ooratippra Fault Zones.

In the southern portion of the basin, Late Proterozoic-Early Cambrian sediments are now regarded as basal units; elsewhere in the basin, Middle Cambrian rocks are regarded as basal units.

4. LOCAL GEOLOGY

Figure 3 below, shows the geology of the Georgina Basin surrounding the project area. To the south in grey is the Palaeoproterozoic Arunta Block and north, outside the area shown in the map is the Palaeoproterozoic Tennant Creek Block. The centre of the project area is underlain by the Arrinthrunga Formation, which hosts mineralization at the Box Hole and Trackrider Prospects. In the west, the Dulcie Sandstone crops out in the northwesterly Dulcie Syncline. The eastern third of the project is mainly underlain by the Tomahawk Beds. However, in both the northwest and southeast, there are large areas of younger cover overlying the Georgina Basin.
Davenport Province. This shelf system contains significant thicknesses of carbonates which have been intersected in several deep drill holes. Two holes in particular, Hunt 1 and Baldwin 1 (Figure 3) highlight differences in depth to stratigraphy, for example, in Baldwin 1 the base of the Arthur Creek Formation is at approximately 880m vertical depth whereas in Hunt 1, 23km to the NW, the same contact is at a depth of approximately 345m.

5. ABORIGINAL HERITAGE

Mincor Resources NL executed the final Exploration Deed (with the Central Land Council) in respect of the Georgina Project on 16 August 2007. In recognition of Aboriginal interests in the region, the Deed allows for Heritage Protection Protocols and Compensation for future ground disturbing exploration over the entire project area, irrespective of the presence of a Registered Native Title Claim.

The Registered Native Title Claims principally affect the northern and north-western parts of the project area. The project tenements are affected by the Ooratippra Claim (NTD6043/01) and the Sandover River Claim (NTD6069/01) to varying degrees as follows:

1. EL25090 7% Ooratippra, 93% Sandover River
2. EL25089 7% Ooratippra, 35% Sandover River
3. EL25093 13.6% Sandover River
4. EL25091 21.4% Ooratippra

Tenements EL25092, EL25094 and EL25143 are unaffected by any current Native Title Claims and lie entirely within Pastoral Leases.

Heritage clearances have been obtained through CLC for both major activities in the reporting period: the stream sediment sampling programme, and the detailed gravity survey. For the stream sediment sampling project, a map of the proposed sites was provided to CLC, who then delegated an anthropologist to consult the tribal elders. A meeting was held by the Minco Zinc project manager and the elders at Ampilatwatja. The requested relocation of several sample localities was agreed to and these points were either moved more than 1 km from the site of concern or abandoned. Although Mincor expressed a willingness to employ local indigenous labour for the project, no suitably qualified personnel were provided.

The location data for the intended gravity survey was provided to CLC in July. After discussion of the techniques used in the gravity survey and an explanation that only a cursory stop would be made at each point, and there would be no associated ground disturbance, it was agreed that the survey could proceed without consultation with the elders. Mincor Zinc did undertake to avoid all the places that were considered sensitive in the stream sediment survey consultation.

6. EXPLORATION
The first aspect of exploration addressed has been the numerical modelling of fluid flow potential in order to constrain the most likely areas of mineralization. This is being done by staff of the mining division at CSIRO. For this work, all available geophysical data, comprising the regional airborne palaeomagnetic and gravity surveys, were compiled and formatted. A geological compilation for the southern Georgina Basin was also provided. The first aspect of the modelling (Appendix I) has involved analysis of the basin in terms of the five fundamental aspects of mineralization, as follows:

- the geodynamic history,
- the basin architecture
- fluid sources and reservoirs
- fluid pathways and drivers
- mechanisms of metal deposition

Commencement of stage 1 of the modelling involved the generation of magnetic and gravity “worms” (propagation of geophysical boundaries in depth) using specialized algorithms developed by the CSIRO. This was delayed because such an extensive study area had not been completed previously and required expansion of the computational power. Nonetheless, worming of the magnetic and gravity data has been completed. This processed data was then studied and interpreted by Dr Barry Murphy of the PMD*CRC, a specialist in geophysical interpretation using “worm analysis” (Appendix II).

Concurrently, a detailed geological interpretation of the southern Georgina Basin commenced, including the generation of multiple interpreted cross sections across the basin using stratigraphic control from earlier oil exploration drill holes. This will be included in the next phase of the CSIRO study where a series of test models will be developed and deformational and fluid flow scenarios trialed. Using this work, the project will progress to a higher level of sophistication with the building of 2 and 3-dimensional models.

The ultimate aim is to identify target areas and depths within the Georgina Basin tenements where metaliferous brines are most likely to have been concentrated and orebodies precipitated. To this end, all of the data provided by the NTGS has been reviewed. At least three diamond drillholes are anticipated in the next year to clarify the regional stratigraphy and controls on structural features.

The 2008 field season comprised stream sediment sampling, studies of structural characteristics, checking of stratigraphic detail, and a detailed gravity survey. The stream sediment sampling has involved the collection of 350 samples from stream confluences, mainly in the Arapunya and Lucy Creek area around the Elkedra shelf (Figure 4). Samples were taken from a depth of 5 cm in active creek channels, sieved to less than 300 µm and submitted for analysis in 60 g aliquots. Results are awaited. The gravity survey was designed to allow direct extension over Mincor Zinc’s project area of NTGS commissioned gravity surveys to the south. A total of 2,392 sites were measured on a 2km by 2 km grid (Figure 6) in the period 13 September to 2 October 2008. Final results will be available in the next reporting period. A series of stratigraphic drill holes that will be drilled along the Elkedra Shelf zone have been planned and site clearance from the CLC is still awaited.
drilling will be completed once the detailed results of the numerical modelling exercise are known. The Elkedra shelf zone and the Tarlton area are most likely target areas for initial follow-up.

Figure 4: Map of the stream sediment sample localities in the first assessment of the area proximal to the Elkedra Shelf.

Figure 6: Map of the sites at which gravity was measured in the helicopter supported detailed gravity survey.
CONCLUSIONS AND RECOMMENDATIONS

The Georgina Project is highly conceptual in nature and target generation within the tenement area depends partly on numerical modelling of potential fluid flow in a structural framework that must be progressively developed using progressively more detailed geophysical methods. Prospectivity is substantial for Pb and Zn mineralization, principally MVT type within Mincor’s project area. The detailed gravity work currently in progress should allow identification of any structures with significant basement penetration. The studies of the physical and geochemical characteristics of stratigraphic units will allow recognition of likely levels at which mineralization may be generated by fluid flow through these structures. Once this is achieved, electromagnetic studies should allow identification of shallow level conductors.

The program of stream sediment sampling geochemical (taking local conditions into account for each area) is intended to identify any potential surface expression of the mineralization. In view of the potential that there may be only minor seepage from concealed mineral systems, it is imperative that this geochemical study be undertaken with all possible consideration of local characteristics. Chemical analyses will be performed at part per billion sensitivity and statistical interpretation will address aspects such as geomorphologic location and stratigraphic situation for all sites.

A program of diamond drilling to depths of c. 600 m will be undertaken to further develop the understanding of the structural characteristics. These drill holes will be located once the structural controls provided by the detailed gravity study have been attained. Shallow RC drilling is to be done in areas indicated by the stream sediment sampling.
APPENDIX I
STAGE 1 OF MODELLING: 5 QUESTIONS ANALYSIS

Question 1 - What is the geodynamic history?

- The Georgina Basin is an intracratonic sedimentary basin that covers a large area (~330,000 square kilometers) and experienced multiple tectonic events through a period of about 500 million years from the Neoproterozoic to the late Paleozoic (ca. 850-350 Ma).

Sequence of major geological events

<table>
<thead>
<tr>
<th>Age</th>
<th>Geological period</th>
<th>Tectonic features</th>
<th>Related tectonic event</th>
<th>Principal stress orientation</th>
<th>Structural products</th>
<th>Other notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;65 Ma</td>
<td>Cenozoic</td>
<td>Discrete drainage systems</td>
<td>None???</td>
<td>Unknown</td>
<td>Terrestrial Cenozoic deposition - scattered distribution</td>
<td></td>
</tr>
<tr>
<td>&lt;251 Ma to &gt;65 Ma</td>
<td>Mesozoic</td>
<td>Formation of Mesozoic basins</td>
<td>Intra-cratonic extension??</td>
<td>Unknown</td>
<td>The northwest areas of the Georgina basin are overlain by the mesozoic basins - unclear margin here</td>
<td>corresponding sedimentary rocks</td>
</tr>
<tr>
<td>&lt;350 Ma to &gt;298 Ma</td>
<td>mid-late Carboniferous</td>
<td>Orogenic deformation</td>
<td>The Mount Eclipse Movement of the Alice Springs Orogen</td>
<td>ENE-WSW shortening</td>
<td>Minor reactivation of older Alice Springs Orogeny structures in the Southern Georgina Basin</td>
<td></td>
</tr>
<tr>
<td>&lt;410 Ma</td>
<td>Devonian</td>
<td>Orogenic deformation and siliciclastic foreland development</td>
<td>The Pernjara Movement of the Alice Springs Orogen</td>
<td>ENE-WSW contraction</td>
<td>Most intense deformation visible in the southern Georgina Basin; the formation of present structural margin of the southern Georgina Basin due to thrusting of basement over Neoproterozoic-Ordovician rocks; siliciclastic foreland deposition (&gt;650 m)</td>
<td>possible mid-Devonian igneous intrusion as inferred from a U-Pb crystallization age of 390 Ma for a niobian rutile (no intrusion of notable size is seen in the region).</td>
</tr>
<tr>
<td>&lt;450 Ma</td>
<td>Ordovician - before Devonian</td>
<td>Orogenic deformation and siliciclastic foreland development</td>
<td>The Rodingan Movement of the Alice Springs Orogen (ref. 1 &amp; 4), associated with convergent subduction at SE Australian margin</td>
<td>NNE-SSW contraction or shortening (Geody. Fig. 6)</td>
<td>Deformation mostly confined to the eastern-central Arunta region; unclear deformation fabrics in the southern Georgina Basin, but could be due to overprinting of later deformation or other factors</td>
<td>Metamorphosed Cambrian rocks of the Irindina package to granulite facies</td>
</tr>
</tbody>
</table>

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<table>
<thead>
<tr>
<th>Time Interval</th>
<th>Event</th>
<th>Stage</th>
<th>Notes</th>
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</thead>
<tbody>
<tr>
<td>480 to &lt;450 Ma</td>
<td>Ordovician</td>
<td>Siliciclastic platform development</td>
<td>Larapinta event (ref. 1) - intracratonic extension</td>
</tr>
<tr>
<td>&lt;550 Ma</td>
<td>Cambrian to Ordovician</td>
<td>Platform development (early); non-deposition and erosion (southern Georgina; 518-511 Ma); Resumed platform development (later)</td>
<td>the Cambro-Ordovician Delamerian Orogeny in areas southeast of Georgina (ref. 1 &amp; 4)</td>
</tr>
<tr>
<td>From ~550 Ma</td>
<td>Early Cambrian</td>
<td>Major plate reorganization</td>
<td>Petermann Orogeny (ref. 1 &amp; 4)</td>
</tr>
<tr>
<td>~850 Ma to &gt;550 Ma</td>
<td>Neoproterozoic</td>
<td>Initiation of Georgina Basin as part of the Centralian Superbasin</td>
<td>Rifting associated with the onset of the break-up of Rodina (ref. 1, 2, 3 &amp; 4)</td>
</tr>
</tbody>
</table>

**KEY FEATURES OF THE GEODYNAMIC HISTORY**

- **Long period of basin development since the break-up of Rodina**, involving multiple rifting and extensional events with different extensional orientation and settings.
- **Two different main extension directions** (NE-SW and NW-SE) led to the development of rifting/normal faults of different orientations. This is important for fault development and reactivation in later stages.
- **Platform development in Cambrian led to the deposition of platform carbonate sequence, separated by a period of non-deposition and erosion** (? any evidence for cast formation, as this will have significant perm & porosity implications at certain stratigraphic levels, look for evidence in core). The presence of uplift associated with the Cambro-Ordovician Delamerian Orogen southeast of the Georgina Basin during platform development could mean higher hydraulic head in the southeast margin/parts of the Georgina Basin.
- **Long periods of basinal extension and sedimentation mean favorable conditions** for the development of basinal fluids and brines.
- **Dextral transpression along the Paterson Orogen-Petermann Orogen-Tasman Line** would probably lead to more intensive structural activities in the areas near the present southern margin of the Georgina basin than in the northern margin before the extended period of platform development.
- **The Alice Springs Orogeny is the most important event that led to the inversion of the Georgina Basin**. It is probably in this event that the Georgina Basin became a discrete basin entirely separated from other basins in the original Centralian Superbasin. In particular, intensive thrusting and associated deformation at the southern margin of the Georgina Basin led to most deformation belts here in the Basin and also led to elevated basement here. This also means higher hydraulic head for
the fluid circulation at the southern margin and more important fault reactivation and rock deformation here;

- The change of shortening (contraction) directions during the Alice Springs Orogeny could be very significant. The earlier orogenic contraction is dominated by NNE-SSW shortening (although deformation fabrics in the Southern Georgina Basin are unclear), and this switched to ENE-WSW shortening in later stages. This switch could lead to very different behaviours of earlier inversion structures (e.g. faulting and fault reactivation) in later stage;

- **Structural inversion during the Alice Springs Orogeny is potentially most important for migration and focusing of mineralizing fluids in the Georgina Basin.**

**GEODYNAMIC ISSUES FOR NUMERICAL MODELLING INVESTIGATION**

- Reactivation of pre-existing rifting faults and deformation/damages in the basin sequences (in particular, platform carbonate units) and associated fluid transport patterns, as a response to the earliest phase of the Alice Springs Orogeny
- Mechanical and hydrological effects of stress switch in later stages of the Alice Springs Orogeny
- Mechanical and hydrological effects of potential hydraulic head associated with topographic uplift (southern or southeastern margin) before present-day erosion.

**Question 2 - What are the key aspects of the architecture?**

- Up to 2.2km of Cambrian Georgina basin sequences plus Neoproterozoic basement
- Thickness and lithologies of the Neoproterozoic sequences below the Georgina Basin Carbonates are not well understood.
- Depth to Palaeoproterozoic basement DTM (digital terrain map) not always consistent with drill core observations of Paleoproterozoic granitoids (ie Palaeoproterozoic granitoids cannot intrude Neoproterozoic sediments as indicated by section & depth to basement interpretation).
- Neoproterozoic glacial sequences (tillites) including black shales, arkoses and feldspathic sandstones
- Early extensional fault architecture - it is important to identify the early extensional fault architecture so that we can identify the most favorably oriented faults for later reactivation.

**Question 3 - What are the fluid sources and reservoirs?**

- Can the Neoproterozoic sequences be a source for base metals?
  - what is the Neoproterozoic lithologies/stratigraphy, are there any volcanics or intrusives?
- Is Palaeoproterozoic basement the only potential source of mineralising fluids and base metals?
- The NTGS interpreted a crustal source for the Pb on a mixing line between 1800-500 Ma with original Pb at 1800 and remobilisation at <500Ma (Alice Springs Orogeny age); 420-280 Ma mineralization age according to Dunster et al. (2007 - NTGS Report DIP 007)

**Question 4 - What are the fluid pathways and drivers?**

- Alice Springs Orogeny most likely dominant fluid driving mechanism........
o Fault architecture is likely to be of primary importance to fluid movement/pathways within the basin sequence as much of the sequence exhibits relatively low permeability (particular vertical permeability) except where it is deformed, fractured or faulted.
o implications for fluid sources.....
o implications for fluid pathways based on architecture, major basement fault dips and displacements, basement fault propagation into Georgina basin sequences etc......
o Thermal-related fluid drivers?..... Basement intrusives and or radiogenic heat sources
o Topographic relief at the southern margin of the basin associated with the Alice Springs Orogeny as a fluid driver?.....
o The role of basin sequence seals and permeable units influencing fluid flow patterns:
  ▪ fluid flow localisation during seal breaching
  ▪ fluid accumulation or lateral flow below seals in blind faults etc
o The role of unconformities (base of Neoproterozoic and base of Cambrian) in localising strain and fluid flow etc

- Harts Range granulites are the same age sediments as the Georgina and Amadeus basin. So these have been buried, cooked and exhumed very quickly, during a significant tectonothermal event.
- 504-513Ma Kalkarindji flood basalts in central NW Georgina basin, evidence for an early Alice Springs equivalent thermal/volcanic event in the Nth Georgina Basin region (? nature of this thermal event, and impact on Southern Georgina Basin, where are the associated dykes etc?)

**Question 5 What are the metal depositional mechanisms?**

- Box Hole has silicified siltstone above Galena rich mineralisation, with the mineralised zone also being silicified. What is the significance of this?
  o Possible higher level MVT-style vug-hosted mineralisation style?
- It is clear from the limited core observations to date that the sulphide mineralisation within the dolostones and limestones is closely associated with stylolites, and in particular with tensile re-opening of relatively flat stylolites with pyrite and other sulphides being deposited on the re-opened stylolite surfaces as well as in blebs in the host rock.
  o these features were most commonly observed just below significant horizons of fine silts and shales possibly indicating that these shales are important in providing an upper seal to a system allowing for fluid pressures to build beneath the seal and drive tensile failure along the weaker stylolitic bands thus creating the space for the initiation of sulphide mineralisation.
  o Once this reaction commences it is possible that the acid generation may continue to create open space thus acting as a positive feedback to the mineralisation process.....
- Quite complex double-plunging folds with limbs up to 45 degrees proximal to Box Hole? — has this district undergone anomalously high strain deformation compared with other regions in the Georgina basin? Is this significant to the elevated base metals in this area?
APPENDIX 2

STRUCTURAL ARCHITECTURE OF THE GEORGINA BASIN, NORTHERN TERRITORY, FROM INTERPRETATION OF AEROMAGNETIC AND GRAVITY GRADIENTS
Structural architecture of the Georgina Basin, Northern Territory from interpretation of Aeromagnetic and Gravity gradients

By: Fractore Pty Ltd
Contact: F. C. (Barry) Murphy
cm@fractore.com
October 2008

For: Mincor Resources N. L.
Attn: Bruce Groenewald
Introduction

Mincor Resources N. L. commissioned Fractore P. L. to undertake an interpretation of aeromagnetic and gravity data over the Georgina Basin block of tenements in the Northern Territory. The objective was to interpret a fault architecture from the regional potential field data and to compare this against existing interpretations (SEEBASE, 2002). This contributes to a broader project with CSIRO to construct a 3D geological model and to undertake numerical simulations of a range of field-based scenarios to determine prospectivity of the area. The basin is being explored for carbonate-hosted ZnPbAg massive sulphide deposits and the existing deposits, though small, show evidence for sulphide replacement and cavity fill with affinities to both Mississippi Valley-type (MVT) and Irish-type deposits. The size of the Georgina tenement block approximates that of the Irish Carboniferous basin. The basin is situated to the north of the Proterozoic Arunta inlier and it comprises a relatively flat lying to gently folded sedimentary succession up to 2 km (or more?) in thickness; this is in turn overlain by surficial cover in places (Figure 1).

The geodynamic setting involved multiple stages of intra-continental rifting (Neoproterozoic; Cambrian, Ordovician), punctuated by orogeny and related foreland basin sedimentation. Most of the basin volume in the southern Georgina region was formed by foreland loading during (and after) the early Cambrian Petermann Orogeny (SEEBASE, 2002). The basin developed over a heterogeneous basement whose varying rheology may be important in determining fluid flow during subsequent inversion (Alice Springs Orogeny, Carboniferous-Permian). The preservation of the Georgina Basin, as an erosional remnant of the broader scale Neoproterozoic Centralian Superbasin (Officer and Amadeus Basins) is attributed to the basement terranes in this region being rigid and resisted inversion (SEEBASE, 2002).

Fault control on the localisation of carbonate-hosted deposits, though less evident for MVT’s, is viewed as an important element of the hydrothermal system as they are likely to behave as pathways for fluids that have been flushed through the basement. Metal deposition is generally related to mixing and cooling of fluids with contrasting salinities, temperature and redox potential, as seen in Irish-type systems (Everett et al. 1999; Wilkinson et al. 2003). The most common drivers of fluid flow in such systems are thermally induced convection and topographically influenced expulsion, which can be in tandem with extensional (Oliver et al., 2006) or compressional deformation (Murphy et al., in press). The Alice Springs inversion created a topographic front to the south that may have driven fluids from highlands down through basement and subsequently being focussed into faults within the basin (see Zhang, TWiki page). Analogous genetic models are applied in the Irish-type deposits (Hitzman and Beaty, 1996; Murphy et al. in press).

Faults can juxtapose rocks units that contrast in density and/or susceptibility and therefore result in gradient changes in the potential field (gravity, aeromagnetics). Consequently, an emphasis is placed here on interpretation of the gradient data and an automated technique, termed “worms” (Hornby et al. 1999), was applied to detect their positions and strength. The superiority of this method is that it reduces ambiguity and makes for a more robust, repeatable interpretation. It is recognised that changes in the gravity and magnetic fields relate to a range of geological sources, not
only to faults, both in the basement and in the basin, and a discrimination of such sources was not attempted here. Rather, the gradients were evaluated with an emphasis on interpreting the fault framework. The interpretation also seeks to account for faults that do not have an associated gradient contrast across them, but are inferred from their effects on subjacent gradients (such as offsets and linear breaks in the gradient field). This follows methods developed through the pmd*CRC and applied in other mineralised terrains, such as gold provinces of the Yilgarn in Western Australia (Bierlein et al. 2006) and Western Victoria (Murphy et al. 2006) and to volcanic hosted massive sulphide deposits in Tasmanian (Murphy et al. 2004).

Figure 1: Regional scale maps of a) mapped geology and exploration tenements (Mackay, 2007) and b) interpreted basement elements (SEEBASE, 2002).
Data Inputs

The primary data are open file aeromagnetics from the Northern Territory Geological Survey (Figure 2a) and the Bouguer gravity sourced from Geoscience Australia’s GADDS web site (Figure 2b). A key part of the analysis performed here is the application of edge detection methodology, termed “worms”. The worm data are used in conjunction with more conventional image analysis techniques, such as high pass filters and sun angles. Worms are derived from wavelet-based algorithms that yield an above ground point data set at different upward continued heights. These points map the positions of gradient changes in the potential field (see Hornby et al. 1999; Archibald et al. 1999, Holden et al. 2000). The worm data were generated using CSIRO’s algorithm with two representations, MAX being the position of maximum gradient, and EFVD being the position of the effective first vertical derivative of the gradient. Worm maps shown here for the aeromagnetics (Figure 3) and gravity (Figure 4) are colour coded by the upward continued height, where blue is low level and red is high level. The points that comprise these images coalesce, visually, as “worm sheets” and their above ground 3D shape can mirror image the below ground geological contacts. In effect, the dip direction of a worm sheet may be used to infer the dip direction of the associated contact. Long wavelength gradients (i.e. those that persist to high levels of upward continuation) usually reflect the presence of deep seated geological contrasts, such as major faults or shear zones, while the high frequency (low level) gradients represent shallow sourced contacts. The gradients rely on the existence of a density or susceptibility contrast due to juxtaposition of a range of natural sources at different depths, such as granitoids, faults, dykes and stratigraphic elements. The data were further processed using Fractore’s Geoscope software (Murphy and Russell-Head, 2006) to yield images and vector lines for subsequent GIS analysis. In particular, images of height migrated data were used to discriminate significant gradients, i.e. features that are more depth extensive. The aeromagnetics was transformed into a pseudogravity (psg) format and upward continued over 7 levels from 260m to 16640m height. This data was interpreted at the 520m height level, omitting the lowest level which is dominated by high frequency effects. The gravity was interpreted at the lowest, 867m height level and was upward continued over 7 levels to 55467m.
Figure 2: Regional potential field data a) Total magnetic intensity image and b) Bouguer gravity image. Black box surrounding each image represents the broader region of the processed worm data sets. Red outlines are the tenement block.
Figure 3: Aeromagnetic worms at regional a) and b) and tenement scales c) and d) where a) and c) are coloured by height of upward migration (blue = low level, green to red = higher level worms; MAX data), and b) and d) of height migrated image (white elements have greater height persistence).
Figure 4: Gravity worms at regional a) and b) and tenement scales c) and d) where a) and c) are coloured by height of upward migration (blue = low level, green to red = higher level worms; MAX data), and b) and d) of height migrated image (white elements have greater height persistence).
**Interpretation**

The focus has been to extract the fault-related gradients, with an emphasis on imaging their strike length. Long strike length faults are a proxy for deeper penetrating and potentially mineralising faults. Line interpretations were made at 1:1,000,000 scale for the aeromagnetics and gravity respectively (Figures 5 and 6). These data were digitised and processed in a GIS platform to yield strike length images where the longer elements are represented by warmer colours.

The aeromagnetics is dominated by a system of NW trending structures in the southern Georgina Basin (Figure 5a). A second less pronounced set is ENE to NE trending, at a broadly conjugate orientation to the NW trend. Thirdly, a strong north-south orientation is locally developed in the central region of the tenements.

The gravity shows a similar distribution of trends with varying strike lengths. There is partial overlap in positions with aeromagnetic gradients, while in other regions there is none. East-west trends appear more evident and the north-south trend in the central region of the tenements is again emphasised.

There is a similar range of length parameters between each of these interpretations. A single data set was processed whereby the gravity and aeromagnetic length values were combined (Total Length; Figure 7). This shows a coherence of structural features. A relative timing is apparent where the early formed north-south trend appears truncated by the NW set. The ENE-NE set mainly cross cuts the NW trend but is in places truncated against NW trends; this may be due to reactivation phenomena.

The regional gravity worms of Australia (Figure 8) provide a somewhat different context for the regional scale features that impact on the Georgina Basin. Figure 8a shows the major high level/deep seated gradients. The arcuate east-west to NW trending gradients in the Arunta Block appear truncated eastwards by a major NNE gradient extending from South Australia through the Northern Territory. Figure 8b is a more detailed map of the region showing the high level (black) and lower level gradients (green). The regional NNE gradient is more segmented at this scale and is cut by the NW gradients in the southern Georgina Basin that cause a rotation to more northerly trends through the central parts of the tenement block. These features are considered to be crustal scale boundaries. Intersections and offsets of such features may be loci for focussing fluid flow.

At the tenement scale, a preliminary analysis of fault intersections was made, using the line interpretations (Figures 5 and 6). The intersections were determined using overlapping buffers. The length values of the intersecting lines in the overlap regions were weighted (by 1000) and added back to the original length grids for the aeromagnetic and gravity data sets (Figure 9). Warmer colours reflect regions of longer strike length intersections. The inference is such regions may have a higher fracture density and a higher potential as pathways for mineralising fluids. A next step may be to evaluate such regions in the context of past exploration results. It is notable that the Box Hole prospect lies close to an interpreted major intersection in the gravity data.
Figure 5: Aeromagnetic interpretation showing a) line interpretation, b) regional scale strike length image of fault-related gradients, c) TMI image with interpreted fault lines superimposed and d) strike length image at tenement scale.
Figure 6: Gravity interpretation showing a) line interpretation, b) regional scale strike length image of fault-related gradients, c) Bouguer image with interpreted fault lines superimposed and d) strike length image at tenement scale.
Figure 7: Strike length image of fault-related gradients from combined aeromagnetic and gravity interpretations, a) regional and b) tenement scale.
Figure 8: Regional gravity worms of Australia showing a) high level gradients (red) and major metal deposits (blue) and b) high (black) and lower level (green) gradients.
Figure 9: Strike length intersection images of a) aeromagnetic and b) gravity lines.
Comparison of the interpreted fault frameworks shows similar patterns although differing in positions of key features. The SEEBASE (2002) image of depth to basement and interpreted fault lines (Figure 10a) indicates a wide range of structures of varying time of generation. A series of north-south fault lines (red) across which the depth to basement varies are considered early formed. Other SEEBASE structures are shown in yellow, green, blue and black lines of varying types. The magenta coloured lines (Figure 10a) are interpreted from the combined strike length interpretation (Figure 10b). There is some correlation with the SEEBASE features, especially the major north-south structure through the central region of the tenement block. Yet, other north-south SEEBASE features to the west are not identified in the strike length analysis. This may be because these features have short strike extent, being early formed and are more disrupted by later features, however there are few gradients of this orientation that correlate with these SEEBASE features. The NE trending faults are well represented in both interpretations (Figure 10 and b).

The interpreted fault lines are overlain on the digital elevation model (Figure 11). Changes in elevation across some of these faults suggest recent (Neotectonic) displacements.
Figure 10: Comparative frameworks from a) SEEBASE (2002) and b) combined strike length image. Interpreted faults from this study are shown in magenta. All other fault lines are from SEEBASE.
Conclusions

The potential field data reveals a dominant set of NW trending faults along the southern Georgina Basin. An orthogonal set of NE trending faults intersects these. Both sets of faults are interpreted to have influenced developed of the basin and probably originate from Proterozoic basement structures. Early formed north-south trending faults are evident in the central parts of the tenement block. Intersections of these different trending faults provide opportunities for focusing hydrothermal fluid flow both during extension and subsequent inversion. There are a number of such potential intersection regions within the tenement block. A ranking of these could be undertaken in relation to failure under the applied stress implicated in the Alice Springs Orogeny and using strike length attributes may be a useful filter to apply in this ranking.

The dip directions and depth extents of the major faults need to be constrained for subsequent modelling. The worm data does not however provide a unique solution in this regard, as there are varying apparent dip directions inferred along individual fault segments. Seismic data would provide a key input to determining these parameters.

Parallels in the basin setting with respect to the Irish and MVT zinc provinces are evident, with intracratonic rift development and subsequent inversion. A number of contrasts are apparent with the Irish basin which a) was founded on an ancient suture zone where oceanic crust was consumed, b) had an elevated geothermal gradient, and c) there was a substantial depocenter (the South Munster Basin is over 10km thick) as an implied brine factory that supplied of enormous volumes of metal bearing fluids. The existence of a similar source region supplying fluids to the southern Georgina Basin is inferred to the south where the greatest inversion related strains are concentrated.
References


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