Manbarrum Zn-Pb-Ag Project
Burt Range Shelf, Bonaparte Basin, NT

Conference Abstract

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ABSTRACT

In its first six months of operation in the Bonaparte Basin of north-western Australia, Tennant Creek Gold Ltd (TNG) has significantly advanced the resource potential of the Manbarrum Zn-Pb-Ag Project.

TNG successfully completed 62 Reverse Circulation (RC) drill holes for 9,471m on a 50 by 50m grid. Contemporaneously, the company conducted an IP survey which covered selected parts of the tenement holding in the area. Individual ground-gravity traverses were also carried out.

The Sandy Creek Prospect was discovered by Aquitaine Australia in the mid-1970’s. The prospect area was explored by several companies until the late 1990’s. A pre-JORC resource of 3.2Mt @ 4.5%Pb, 2.4%Zn and 15g/t Ag was delineated at the prospect in the early 1980’s by Aquitaine and its partners. The Sandy Creek Prospect was believed to contain primarily structurally-controlled lead mineralisation.

The Sandy Creek Prospect is located in the Burt Range sub-basin of the southern onshore Bonaparte Basin. The mineralisation is hosted in Lower Carboniferous shallow-marine clastic (sandy) dolomite rocks of the Burt Range Formation which unconformably rest on Proterozoic basement and in turn are unconformably overlain by fine-grained carbonaceous siltstones and sandstones of the Upper Lower Carboniferous Milligans Formation.

TNG has been able to demonstrate that the mineralisation is dominated by zinc-lead-silver sulphides replacing the carbonate matrix of the host formation in the form of disseminated and massive sulphides. The morphology of the deposit appears to be controlled by sub-vertical, possibly deformation-induced porosity and by stratigraphic controls, particularly the carbonate-shale contact which forms the hanging wall to mineralisation.

The location of mineralisation at Sandy Creek corresponds closely with a surface (soil) geochemical anomaly and the location of a west-dipping IP (chargeability) anomaly. Regional and prospect-scale gravity data do not provide sufficient detail over the prospect area, however, the data suggest that the mineralisation is situated near the margin of a gravity high (slope).

The major advancements to the project were made by TNG in the areas of geological understanding, mineralisation geometry, mineralisation, and geophysical controls and can be summarised as follows:
• Zinc is the primary economic commodity at the Sandy Creek Prospect with lead occurring on average at a ratio of 20:1. Lead is estimated to constitute about 20% of the deposit (preliminary visual estimates). Base metal intercepts of combined zinc and lead greater than 2 to 3%, show silver values generally exceeding 20g/t.

• The deposit includes a supergene and a primary mineralisation zone with the primary (hypogene) zone dominating the overall mineralisation volume.

• The centre of mineralisation is a sub-vertical pipe-like body with a flat and shallow-dipping top.

• A strong correlation exists between an IP (chargeability) anomaly and the main zinc mineralisation.

• The bulk of the mineralisation is interpreted to be represented by a matrix-replacement style of mineralisation.

• The insight TNG has gained from the discovery of this deposit will be used to effectively guide future exploration.
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1 INTRODUCTION

1.1 Background

Following the successful conclusion of Heritage Clearance negotiations in August 2006, Tennant Creek Gold Ltd (TNG) commenced mineral exploration work at its MANBARRUM Zn-Pb-Ag Project which includes several early to advanced stage exploration targets. Amongst these are the Sandy Creek, Alpha Hill, Winchrope Hill, Ochre mine, Bundaburg, Bore, Browns Hill, Flapper Hill, The Gap, and Beta prospects. Sandy Creek is the most advanced prospect and has had significant historic work completed over it.

Between July and December 2006, TNG completed several field-based exploration programmes which included ground geophysical surveys such as gravity and electromagnetics (IP), the acquisition of high resolution satellite imagery, RC drilling and petrology with most of this year’s field activity focused around the Sandy Creek Prospect.

The core exploration programme completed by the end of 2006 was the RC drilling programme. The analytical results from this programme provide the basis for a resource estimation which is currently underway.

1.2 Location, Access and Infrastructure

The Manbarrum Project located at longitude 129°15'E and latitude 15°20'S, approximately 20km east of the WA-NT border (Fig. 1). The project is about 1¼ hours drive (82km) northeast from the regional centre of Kununurra in WA. The Sandy Creek Prospect is also 10km from the proposed Weaber Gas field pipeline which has been proposed for construction.

Kununurra is about 150km north-northeast of the Argyle Diamond mine and about 180km north-northeast of the Sally Malay Nickel mine. Teck-Cominco’s Lennard Shelf zinc-lead operation is located about 600km southwest along the Great Northern Highway.
1.3 Exploration History

References to gossans and surface mineralisation in limestone rocks of the Bonaparte Basin go as far back as the early last century, however serious consideration to the base metal potential of the area was given following the reporting of minor lead and zinc mineralisation in the first onshore oil well drilled by Oil Development NL/Westralian Oil Ltd Spirit Hill No. 1 (Jorgensen et al., 1990, Lee and Rowley, 1991).

Table 1 provides a summary of the companies that were involved in mineral exploration in the onshore Bonaparte Basin; the main exploration strategies employed and major successes.

Table 1. History of base metal exploration in the onshore Bonaparte Basin.

<table>
<thead>
<tr>
<th>Period</th>
<th>Company/JV</th>
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<tr>
<td>1971 - 1986</td>
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<td>Mapping, sampling, IP, grid drilling, EM, aeromagnetic, RC</td>
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<td>• 1973 D-E mineralisation</td>
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<td>Sampling, IP, EM, aeromagnetic, RC drilling, DD drilling; MMI</td>
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<td>TNG</td>
<td>IP, gravity, RC drilling,</td>
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### 1.4 TNG exploration programme

During the 2006 field season TNG completed an RC (Reverse Circulation) drilling programme at Sandy Creek. The programme entailed the completion of 62 drill holes for a total of 9,471m. These holes were drilled on a grid approximately 50 by 50m. The average hole depth was just over 150m.

All holes except one reached drilling target. Initially, the holes were targeted to confirm and determine the extent of historic mineralisation at Sandy Creek, however, as drilling progressed geological controls on mineralisation were recognised and some drill holes redesigned to test extensions to mineralisation. Several drill holes terminated in mineralisation.
2 GEOLOGY

2.1 Basin outline

The Bonaparte Basin is located in north-western Australia, straddling the Northern Territory- Western Australia border and extending offshore north and northwest to the continental margin (Fig. 2). The present gross structure of the basin is that of a V-shaped northwest-pitching syncline. The onshore basin covers approximately 18,000km², about 20% of the combined on and offshore areas (Gunn, 1988; Laws and Brown 1976).

The depositional and structural history of the basin is relatively uncomplicated. Deposition commenced in the Late Cambrian and apart from a depositional interruption during the Late Ordovician to Middle Devonian sedimentation continued to the Holocene. In excess of 15,000m of sediments were accumulated in the deepest part of the basin (Veevers and Roberts 1968).

2.2 Regional Geological Setting

The onshore Bonaparte Basin contains a Cambrian to Permian sedimentary sequence can reach a thickness of 5,000m. The sequence is dominantly Late Devonian to Early Carboniferous age platform carbonates and sandstones. These rocks were deposited in an evolving continental rift system during the Late Devonian followed by thermal sagging and widespread subsidence in the Early and Middle Carboniferous. Marginal clastic rocks and reef complexes interfinger laterally (basinwards) with platform carbonate rocks and fine-clastic rock in the basin.

The southern part of the basin is bounded to the east and west by Precambrian basement. The eastern boundary in the onshore region is faulted against the Sturt Block, while the sediments in the west rest unconformably on the Precambrian Kimberley Block.

The southern part of the basin is strongly controlled by faulting in the northeast-trending Halls Creek Mobile Zone fault system (Gunn, 1988). This fault system is interpreted to be a long-lived and episodically reactivated basement-hosted system that controlled deposition during rifting with sinistral transcurrent and vertical movement. Folding in the basin is insignificant with most folds being drape folds over palaeo-highs. Metamorphism is negligible.

The Pincombe Inlier is an important structural feature in the basin (Fig. 3). It separates the Burt Range sub-basin to the east from the Carlton sub-basin to the west and represents a palaeo-high. The inlier marks the
faulted western margin of the northerly plunging syncline which forms the Burt Range sub-basin.

The Bonaparte Basin has undergone a very similar geological evolution as the Canning Basin in the south Kimberley region. Both basins appear to have been initiated by the same crustal processes and were linked by the reactivated Halls Creek Mobile Zone.

![Regional tectonic setting of the Bonaparte Basin.](image)

**Figure 2.** Regional tectonic setting of the Bonaparte Basin.

### 2.3 Local Geology

The Manbarrum Project area is located along the eastern margin of the Burt Range sub-basin (Figs 3). Late Devonian and younger sedimentary rocks rest unconformably above basement rocks. The sediments strike broadly northeast and dip at about 30° to the northwest with minor displacement from north-northeast trending faults.
2.3.1 Stratigraphy

At Sandy Creek, the stratigraphic subdivisions show broad similarities with Sorby Hills, although local variation is likely to have occurred (Lee and Rowley, 1991, Jorgensen et al., 1990). The stratigraphy of the broader Sandy Creek area is described in terms of lithological units distinguished during recent RC drilling. In principle, a layer of transported material up to 15m thick covers the entire area. It has been deposited on a layer of weathered clayey sediments which is commonly 25 to 30m thick. This layer is interpreted to be a residual of the underlying sedimentary sequence. A transitional zone of 1 to 3m separates the weathered from
the unweathered material. Unweathered rock formations included the interbedded sandy and shaly carbonaceous siltstones of the Milligans Formation (Clm in Fig. 4); a quartz-sandy dolomite (Clb2 in Fig. 4) and silty dolomite (Clb1 in Fig. 4).

A preliminary comparison with the Sorby Hills stratigraphy suggests that the "quartz-sandy dolomite" unit can be correlated with the Upper Burt Range Formation (Gooseneck Member) of the Lower Carboniferous and the "silty dolomite" with the Middle Burt Range Formation (Knox Siltstone Member) of the Lower Carboniferous.

Figure 4. Simplified stratigraphic column of the Burt Range sub-basin.
2.3.2 Structure

The recent RC close-spaced drilling suggests that the basement block underlying the Sandy Creek area is a relatively stable and moderately northwest-tilted block. However, minor faults and fractures may have affected the area. Up to 10m wide intervals of oxidised rock chips have been observed amongst fresh rock which may suggest weathering along faulted zones. In addition, litho-stratigraphic correlation of bore hole data suggests that the stratigraphy at Sandy Creek is offset by an east-striking and north-dipping normal fault (Fig 5). The displacement is interpreted from the offset in the up-dip projection of geological boundaries. An apparent lateral offset in the order 40 to 50m is interpreted.

It is also possible that strike-slip or oblique-slip movement in basement-hosted structure transposed as minor, oblique-trending fracture sets into the overlying sedimentary cover. Such faults would have minimal vertical movement however would be able to create significant permeability in the cover sequence.

Future work is expected to shed further light on the significance of faults as controls on sedimentation and stratigraphy.

2.4 Mississippi Valley-type (MVT) Mineralisation of the Bonaparte Basin – Sandy Creek

Until recently, MVT mineralisation in the onshore Bonaparte Basin has generally been associated with the Sorby Hills deposit (Lee and Rowley, 1991; Jorgensen et al., 1990; Ringrose, 1989), although MVT mineralisation was discovered at almost the same time at Sandy Creek. Both occurrences have remained the only significant sub-economic occurrences of MVT mineralisation discovered in the Bonaparte Basin. TNG’s recent work has substantially increased the resource potential at Sandy Creek.

2.4.1 Mineralisation

The Zn-Pb-Ag mineralisation at Sandy Creek is irregularly distributed below the contact between the Milligans Formation shaly and sandy siltstones units and the underlying quartz-sandy carbonate rocks. This contact forms the hanging wall to the known mineralisation. No zinc-lead mineralisation penetrated into the overlying shales. Shales acted as seal to the mineralising brine. Cross and long section representation of the mineralisation (using 1% cut off) suggests that mineralisation occurs as steeply dipping high grade pods as well as stratabound layers sub-conformable with stratigraphy (Figs. 5/6/7).
Figure 5. Simplified solid geological map (cover removed) of the Sandy Creek area following the completion of drilling in 2006 (red dots). Green and blue dots are historic drill holes. Contours represent %m intervals.

The mineralisation includes a near-surface zone of supergene mineralisation which is predominantly sphalerite (zinc mineral) oxide with locally high grade galena (lead mineral) in a clay matrix. The oxide mineralisation is estimated to represent 20% of the total metal content.
Figure 6. Representative geological section for the Sandy Creek Prospect (section 8,297,050N). Mineralisation is interpreted at 1% ZnEq (zinc equivalent) cut off and mineralised intervals at a minimum length of 2m. ZnEq is calculated at a Zn:Pb ratio of 3:1.

Figure 7. North-south long section for the Sandy Creek Prospect (section 520,630E). Mineralisation is interpreted at 1% ZnEq (zinc equivalent) cut off and mineralised intervals at a minimum length of 2m. ZnEq is calculated at a Zn:Pb ratio of 3:1.
Dominant ore minerals are coarse-grained sphalerite (zinc) and galena (lead) at a Zn:Pb ratio that varies from 1:10 to 30:1 within the mineralised zone. In the sulphide zone the Zn:Pb ratio ranges from 1:5 to 30:1 with a global average for the deposit being at about 20:1 indicating a strong zinc bias.

The sulphide content is variable ranging from very fine, sparsely disseminated grains of pyrite-marcasite-sphalerite-galena to spongiform aggregates through to massive polysulphide aggregates completely replacing the host rock (Figs 8/9). Open space filling by colloform, textured, rhythmically banded sphalerite-marcasite and coarse euhedral marcasite is also evident. Minor fine veins of crystalline barite are associated with some sulphides.

Figure 8. Photograph of sandy dolomite core specimen (historic drilling). Mineralisation occurs as vein network and disseminated mineralisation (core 4.3cm wide).
Figure 9. Micro-photograph shows colloform sphalerite with minor interlayered galena (Mc = marcasite, Sp = sphalerite, black minerals = galena, view = 1mm).

The mineralogy and sulphide textures are consistent with other MVT deposits, i.e., epigenetic replacement of carbonated host rocks. Textures include vein and cavity infilling, colloform overgrowths and rhythmic banding of sulphides (Fig. 9). Although currently difficult to construct, a possible paragenetic sequence would be: Pyrite-marcasite + sphalerite replacement of host rock with later marcasite-sphalerite overgrowths and cavity infilling. Minor galena is associated with later sphalerite.

2.4.2 Metal content distribution

Contour maps of cumulative mineralised intervals above 0.5%ZnEq and cumulative weighted average grade times interval length illustrate the pod-like nature of the deposit as well as the widespread stratabound component of it (Fig. 5). The diagram also illustrates a north-northeast trend in the mineralisation which may be related a fracture system in the host carbonate unit. An interpreted east-trending normal fault suggests that faulting may have continued during the Late Carboniferous giving way to fluid conduits in the basin margin.
2.4.3 Element associations

Bore hole samples were analysed for zinc, lead, silver, copper, cadmium, arsenic, iron and sulphur. Graphic down hole geochemical logs highlight various element association that are common with other MVT deposit. Zinc and lead have a moderate to good positive correlation within the zinc-dominated parts of the deposit. Silver is more enriched in galena although the bulk of the silver is associated with high grade zinc. Iron sulphides are strongly associated with zinc sulphides.

2.4.4 Alteration

Pervasive silicification is evident in some chips, replacing the calcareous portion of the rock and hosting fine botryoidal clusters of sphalerite. Other textural features include possible allochens (ooids) in MRC016 (120-128m).

2.4.5 Geophysics

Of the three geophysical techniques – IP, gravity and seismic – utilised in exploration of the project area IP (chargeability) appears to be the most useful detection tool. Figure 10 shows the distribution of mineralisation projected onto the -85m IP depth slice. This displays a close spatial association between IP chargeability and mineralisation. The chargeability response is likely to relate to mineralisation, particularly marcasite and pyrite below the base of oxidation.

Gravity and seismic data density at the prospect scale is not sufficient to draw conclusions to the controls of mineralisation at Sandy Creek. However, both gravity and seismic suggest a complex basin margin geometry with basin margin parallel and orthogonal trending offsets in the basement.
3 CONCLUSIONS

Major advancements to the project were made by recent TNG exploration in understanding mineralisation geometry, mineralisation, and geological and geophysical controls. These can be summarised as follows:

- Zinc is the primary economic commodity at the Sandy Creek Prospect with lead occurring on average at a ratio of 20:1. Lead is estimated to constitute about 20% of the deposit (preliminary visual estimates) pending the resource estimation.
The deposit includes a supergene and a primary mineralisation zone with the primary (hypogene) zone dominating the overall mineralisation volume.

The centre of mineralisation is a sub-vertical pipe-like body with a flat and shallow-dipping top, open to the north, south, west and at depth.

A strong correlation exists between an IP (chargeability) anomaly and the main zinc mineralisation.

The bulk of the mineralisation is represented by a matrix-replacement style of mineralisation.

The insight TNG has gained from the discovery of this deposit will be used to effectively increase the resource and enhance the chance of further discoveries in the licence area and the region..

The information in this report that relates to Exploration Results, Mineral Resources or Ore Reserves is based on information compiled by Neil Biddle, who is a Member of The Australasian Institute of Mining and Metallurgy. Neil Biddle is a Director of Tennant Creek Gold Limited. Neil Biddle has sufficient experience which is relevant to the style of mineralisation and type of deposit under consideration and to the activity which he is undertaking to qualify as a Competent Person as defined in the 2004 Edition of the ‘Australasian Code for Reporting of Exploration Results, Mineral Resources and Ore Reserves’. Neil Biddle consents to the inclusion in the report of the matters based on his information in the form and context in which it appears.
4 References


