Attack Creek Project, Northern Territory

Summary of exploration activities for 2006, preliminary geological model and proposed exploration strategy

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OM (Manganese) Ltd Exploration

January 2007

Exploration License: EL22786
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1 Introduction

OM (Manganese) Ltd (OMM) explores for manganese and base-metals within three project areas, as part of the Bootu Creek Operation, over sedimentary basins within the Ashburton Province of the Tennant Inlier in the Northern Territory.

The Attack Creek Project is located approximately 73 km north of Tennant Creek along the Stuart Highway and about 62 km south-southwest of the Bootu Creek Project area (Figure 1).

A thorough multidisciplinary exploration study is being undertaken over exploration license EL22786 held by OMM within the area of interest.

1.1 Tenement Details

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Rectangle exclusion at the centre of the Project area, leaving a hole in the tenement coverage of about one graticule, is reserved for local traditional owners cultural usage incorporating a registered heritage site.

1.2 Project Location and Access

The Attack Creek Project is located about 25 km north of Philip Creek Station and 15 km west of the Stuart Highway. The area is accessible via several dirt roads infrequently maintained by the Philip Creek Station (Figure 2).

From the south, 18.5 km north of Three Ways Roadhouse, a dirt road is heading west into the Philip Creek Station house. The station is managed by the owners, Sandy and Kathryn, which should be contacted by phone {(08) 89644710} prior to any site visit using the southern access tracks. Heading through a series of cattle yard gates an array of dirt tracks leads northwest onto the main southern access track which runs for 25 km to the centre of the tenement and further across to the northern portion of the Project area.

From the north, 29.6 km south of the Banka Banka Station house or 60.4 km north of Tennent Creek along the Stuart Highway, a dirt track running southwest through several intersections for 12.6 km leads to the northern end of the Project area climbing in it’s last segment the Short Range Formation sandstone ridge north of the Attack Creek canyon.

Access within the Project area is difficult. There are no maintained tracks east and west of the southern access track and south of the northern access track. There is evidence to old or very local un-used station tracks that may be re-open for future use.

A westward splay off the southern access track leads to the excluded heritage site, which should be avoided from access at all time.
Figure 1. OM Manganese tenement holdings and exploration Projects areas within the Bootu Creek Operation, Northern Territory. Left image shows extent of satellite-borne ASTER spectral study conducted by OM Manganese.

Figure 2. Location of Exploration License EL22786 incorporating OM Manganese Attack Creek Project area over the Tennant Creek 1:250k (SE53-14) map, showing access tracks.
1.3 Previous Exploration Activities

The Attack Creek Project area was previously recognised as prospective for Bootu Creek Mn and base metals mineralisation style as units of the Attack Creek Formation and specifically the contact with the lower units of the Bootu Creek Formation are exposed within a faulted syncline.

However, as only Mn staining is evident within the area compared with obvious massive Mn outcrops within the Bootu Creek Project area, only limited outcrop mapping has been conducted over the Project area to date.

In November 2004 Arnhem Exploration conducted a mapping and sampling survey over the Project area identifying several Fe-rich occurrences with limited associated Mn staining occurrences.

The area is regarded as under explored but still highly prospective due to evidence of Mn mineralisation within favourable lithology.

2 Geological Settings

Three distinct informal provinces are recognised in the Tennant Inlier. These are, from north to south, the Ashburton, Tennant Creek and Davenport provinces. The stratigraphy and the generalized interpreted geological map (Figure 3) are taken from Ferenczi 2001.

2.1 Palaeoproterozoic Basement

A polydeformed succession of greywacke, siltstone and mudstone with interbedded felsic and hematitic shale comprises the Warramunga Formation (1860 Ma), and intruded by syn-orogenic granite and granodiorite as well as by felsic porphyry sills, represents the oldest rocks exposed. This package is overlain by felsic volcanics and volcaniclastics of the Flynn Group (1845-1820 Ma), and is intruded by anorogenic felsic intrusives (granite and porphyry) and lamprophyre. Deformation of the Warramunga Formation during the Barramundi Orogeny produced moderate to tight upright folds with a pervasive, subvertical east-west slatey cleavage and was accompanied by lower greenschist facies metamorphism (from Ferenczi 2001).

I-type granodioritic melts and granitic differentiates (Tennant Creek Suite) intruded the Warramunga Formation and lower parts of the Flynn Group between 1850 Ma and 1840 Ma during the Barramundi Orogeny. Deposition of the volcano-sedimentary Flynn Group and emplacement of the Treasure suite (1830-1825 Ma) followed the Barramundi Orogeny. These mainly volcanic rocks are characterised by predominantly high-K rhyolitic to rhyodacitic lava, felsic tuff and ignimbrites.

2.2 Palaeoproterozoic Sedimentary Basin

Three unconformity-bounded, predominantly cyclic fluvial to shallow marine sandstone, siltstone and carbonate successions (Tomkinson, Namerinni and Renner Groups) overlie the Flynn Group and comprise the Ashburton province (Hussey et al 2001).
2.2.1 Tomkinson Group

The Attack Creek Project area comprises mainly of stratigraphical units of the Tomkinson Group. OMM exploration study suggests that Mn mineralisation is stratigraphically controlled and bound to the contact between the Attack Creek Formation and the basal sandstone unit of the Bootu Creek Formation (Figure 4). An understanding of the host stratigraphy is highly important for the development of an exploration model.

The Tomkinson Creek Group, reaching a maximum composite thickness of almost 11 km, is dominated by thick siliciclastic units that alternate with six mixed siliciclastic-carbonate intervals. Continental flood basalts are present in the lower part of the Tomkinson Group. A recessive sequence of calcareous siltstone and stromatolitic dolololute (Attack Creek Formation, 1730 Ma) is present in the upper part of the group. Along the contact with the overlying predominantly ridge-forming sandstone sequence (Bootu Formation) is a Fe-rich manganiferous horizon within dolomitic siltstone and sandstone (modified after Ferenczi 2001).

2.2.1.1 Hayward Creek Formation

Ridge-forming sandstone units of the Hayward Creek Formation form extensive high ranges. These upstanding outcrops of moderately to sub vertically dipping sandstone are found around the Attack Creek Project area in the axes of northerly and northwesterly plunging, faulted anticlines.
Three mappable sandstone units recognized as the lower, middle and upper sandstone members as, in ascending order, the Manga Mauda, Meerie and Coodna Members are overlayed by the volcanic Whittington Range Member. The four members have a maximum exposed composite thickness of greater than 3.5 km.

Abundant medium to very coarse siliciclastic rocks dominate the Hayward Creek Formation. These are typically quartz arenite and in the Manga Mauda and Coodna Members, sublitharenite is also prevalent. Quartz grains are predominantly fairly clear and free from undulose extinction. They are variably rounded and sorted and are generally quartz cemented, although there is also some interstitial clay. Quartz grains appear to be free from prior overgrowths and are therefore probably first cycle. Variable, though typically minor polycrystalline quartz, chert and lithic grains of metasedimentary and probable volcanic origin are present, as are trace amounts of zircon and white mica.

Intense silicification and generally poor outcrop have precluded any change to previously interpreted depositional environments. Manga Mauda Member lithofacies are interpreted as largely fluvial. The overlying Meerie Member is interpreted as predominantly shallow marine. The lower sandstone lithofacies of the Coodna Member is considered to be mainly fluvial, whereas the upper sandstone lithofacies was probably deposited in very shallow water environments that may have been locally intertidal. The environment of the basal lithofacies of the Whittington Range Member is interpreted as marginal very shallow water to supratidal.

SHRIMP U-Pb dating of detrital zircons from Meerie Member sandstone indicates a maximum age of 1784 ± 9 Ma. This date is considered to be a very good approximation of the depositional age, given that some sandstone units from the Hayward Creek Formation were clearly derived from contemporaneous felsic pyroclastic rocks and were rapidly deposited with limited reworking.

The Whittington Range Member overlies the Coodna Member and is an interval of mafic volcanic rocks, thinly bedded sandstone and mudstone, and locally evaporitic and cryptomicrobial laminated carbonate rocks. It typically forms recessive valleys. Several small outcrops of weathered, amygdaloidal to massive coarse basalt and dolerite are recognized as part of the Whittington Range Member and its intrusive equivalents.

2.2.1.2 Morphett Creek Formation

The Morphett Creek Formation is a succession of ridge forming sandstone and recessive siltstone and carbonate rocks with an estimated thickness of at least 3000 m. Basal sandstone and conglomerate units of the Morphett Creek Formation sharply overlie the volcanic unit of the Whittington Range Member of the Hayward Creek Formation. Dips within the sedimentary units above and below the volcanic unit are the same. This suggests a concordant relationship between the two formations, despite an inferred period of erosion following extrusion of the volcanic lava.

Four distinct lithofacies were recognized in the Morphett Creek Formation. Although all lithofacies and associations are clearly widespread throughout the Ashburton province, poor outcrop and structural complications typically frustrate efforts to map them in detail. However a mappable contact marked by a distinct morphological change is usually discernible between the second and third lithofacies, approximately in the middle of the formation. The lower two distinct sandstone lithofacies are included in the Kuerschner Member. The overlying Mitty Member consists of a lower mixed siliciclastic-carbonate lithofacies, and an upper predominantly fine to medium sandstone and mudstone lithofacies.
The Morphett Creek Formation is interpreted as representing a transgression from fluvial to very shallow marginal marine settings in the Kuerschner Member to shallow water intertidal and marginal marine to sabkha environments in the overlying Mitty Member. This formation probably represents more or less steady subsidence, following the widespread extrusion of continental flood basalts in the Whittington Range Member at the top of the Hayward Creek Formation.

The Mitty Member is similar to other lithostratigraphic units in HELEN SPRINGS, particularly the Attack Creek and Carmilly Formations (Tomkinson Creek Group), and Carruthers and Shillinglaw Formations (Namerinni Group), and can be difficult to differentiate.

2.2.1.3 Short Range Sandstone Formation

The Short Range Sandstone usually outcrops in bevelled strike ridges dissected by crosscutting creeks that expose almost continuous stratigraphic sections. Outcrops on ridge tops tend to be intensely silicified or are often covered by ferruginous sandy soils and poorly exposed.

The Short Range Sandstone total thickness is 1025m. It is predominantly white, well sorted, fine to coarse, thinly to very thickly bedded quartz arenite. A unique feature of the formation is the presence of minor well rounded red chert grains. Deagan Member sandstone tends to be less texturally and compositionally mature than that of the middle and upper sandstone lithofacies. This corresponds to increased sorting, grain roundness and sphericity upward throughout the Short Range Sandstone. Dispersed, rounded granules and pebbles of quartz and cream to pinkish sandstone occur throughout the formation except in the uppermost units.

Monocrystalline quartz is the principal constituent of Short Range Sandstone rocks. Most quartz grains are relatively clear and undulose extinction is minor, but some grains exhibit polygonal recrystallised domains and others have strain lamellae or a sutured recrystallised tectonic fabric. The Deagan Member has rare, euhedral, embayed quartz grains within recrystallised quartzofeldspathic matrix. Minor amounts of similar quartzofeldspathic grains are present throughout the remainder of the formation and suggest a contribution from a felsic volcanic provenance. Haematitic chert grains, which are characteristic of this formation, are completely recrystallised and are of unknown origin. Trace amounts of well rounded tourmaline, rounded elongate grains of zircon and detrital white mica are present throughout the unit.

2.2.1.3.1 Middle and upper sandstone lithofacies

The Deagan Member is sharply overlain by about 20-50 m of cyclic, medium to very thickly bedded, trough or tabular cross-bedded sandstone containing tabular shale clasts up to 4 cm across, as well as subangular to rounded granules and pebbles of vein quartz and pink or cream sandstone. The sandstone is typically well grainsize-laminated and commonly shows reactivation surfaces, overturned cross-bedding and convolute laminations, indicative of energetic and rapid sedimentation. Individual sandstone units often vary in thickness along strike and occasionally pinch out. They also show local erosional relationships and are in places channel-like. The basal sandstone of the middle lithofacies locally erodes into the uppermost Deagan Member and a disconformity is therefore evident at this stratigraphic level. The relationship is analogous to that at the base of the Deagan Member and suggests that a stepped transgression is expressed in the Short Range Sandstone.
The remainder of the middle lithofacies sandstone consists of cyclic, thinly to medium bedded, fine to coarse quartz arenite. Oscillation and current ripple-marked intervals are common, as are planar, and simple or tabular cross-beds.

The upper sandstone lithofacies is a cyclic, fining- and thinning-upward succession of mainly medium to coarse, thinly to thickly bedded sandstone. The sandstone is often colour laminated (pink, cream and grey) and has large tabular to asymptotic, low angle bidirectional cross-beds. Thinly to medium bedded ripple marked intervals occur throughout this succession and are common near the top. With the exception of the uppermost -50-100 m of section, discontinuous lenticular beds of pebbly and granular sandstone are present throughout this lithofacies. The middle lithofacies is interpreted as predominantly shallow water intertidal facies though locally it may be deltaic or even fluvial given the presence of deformed (overturned) cross-bedding. A gradual deepening is envisioned for the upper sandstone lithofacies but intertidal to subtidal conditions still prevailed. Shallow environments were occasionally repeated throughout the deposition of the Short Range Sandstone as interpreted from the cyclic nature of the succession. The uppermost Short Range Sandstone probably represents shallower tidal flats, which served as barriers to the superseding, quieter lagoonal settings of the Attack Creek Formation.

2.2.1.4 Attack Creek Formation

Exposures of the Attack Creek Formation are generally restricted to carbonate rocks and siltstone in isolated silicified knolls or leached creek embankments. The best outcrops are located in the vicinity of the Bootu manganese mine. The poor quality of outcrop precludes any subdivision.

The lower contact with the Short Range Sandstone is conformable with transitional relationship between sandstone and calcareous siltstone. This contact appears to be sharp and is usually mapped at the base of a dip slope formed by upstanding Short Range Sandstone. The Attack Creek Formation is about 330 m thick in the vicinity of the Bootu mine and about 425 m thick in the Whittington Ranges.

Surface alteration of all exposures has been extensive. Carbonate rocks are intensely silicified. Outcrops are dominated by thinly to thickly laminated and, less commonly, massive dolostones and dolomitic intraclast breccias. These are typically green or grey and are predominantly neomorphosed to microsparites and intrasparites. Parallel or wavy laminations are the most common sedimentary feature, which near the top of the formation are interpreted as cryptomicrobial laminites. Very thin beds of ripple cross-laminated, fine to very fine sandstone and laminated siliciclastic siltstone occur in places within the dolostones. Intraformational conglomerate, rip-up clast breccias and slump breccias commonly form laterally persistent thin beds.

The contact with the overlying Bootu Formation is placed at the base of the first laterally persistent sandstone in an upward dolostone to sandstone transition. In places the boundary is sharp and concordant. To the south of the Bootu manganese mine, the base of a laterally persistent, thinly to thickly bedded, medium to granular sandstone interval marks the top of the Attack Creek Formation. This sandstone is up to about 5 m thick and displays a locally erosive base on underlying carbonate rocks.

The base of the Bootu Formation is represented by thin to medium ripple marked Sandstone. Several thin beds of green friable siltstone occur within the carbonate lithofacies. These were interpreted as possible tuffites, although zircon separated from one of these siltstone intervals in drillcore varied from euhedral, magmatic growthzoned grains to clear rounded grains that are probably detrital. Despite Pb-loss, all zircons appear to be older than about 1700 Ma and
represent a heterogeneous population. SHRIMP U-Pb age of the youngest zircon is 1752 ±26 Ma. This represents the best estimate of the maximum depositional age of this rock.

The Attack Creek Formation was probably deposited in a protected shallow marine environment starved of significant siliciclastic input. There is evidence for intertidal settings and the presence of intraclast breccias, pisolites and oncolites may indicate reworking after periodic exposure and consolidation. The occurrence of intraformational slump breccias and ripup clast breccias probably indicates occasional more energetic conditions.

2.2.1.5 Bootu Creek Formation

The Bootu Formation is an upstanding unit dominated by a relatively homogeneous succession of sandstone that includes intervals of granular to pebbly sandstone and conglomerate, and minor amounts of siltstone, mudstone and carbonate rocks. The most distinguishing feature of this formation is the apparent homogeneity and extensive thickness of uniformly medium to very thickly bedded sandstone.

The exact thickness of the Bootu Formation is unknown but is inferred to be at least 2000 m. Outcrop of Bootu Formation is mainly confined to a faulted, northwest trending synclinal structure about 13 km northeast of Banka Banka homestead, where it forms an extensive low relief plateau. Rock units on this plateau tend to be intensely silicified and are often covered by ferruginous sandy soils. As a result, there is typically only limited exposure of the middle to upper parts of the formation.

The lowermost 150-250 m of the Bootu Formation is variably exposed and typically forms a series of lower relief strike ridges below the main area of outcrop. The lowermost units form a distinct lower lithofacies and host the abandoned Mucketty manganese mine and other manganese occurrences. This lower lithofacies is a cyclic, mixed siliciclastic-carbonate succession that represents the transition from the underlying, carbonate dominated Attack Creek Formation to the sandstone lithofacies of the Bootu Formation.

The base of the Bootu Formation is placed at the base of the first laterally persistent sandstone in a cyclic, dolostone to sandstone transition. This sandstone is poorly to moderately well sorted, medium to granular and locally pebbly, and is about 5 m thick. It ranges from calc-litharenite or sublitharenite to quartz arenite. The sandstone has a sharp concordant and locally erosive contact with underlying carbonate lithofacies of the Attack Creek Formation and is planar, tabular or trough cross-bedded. It also exhibits localised overturned cross-bedding and convolute laminations.

Most sandstone towards the base of the Bootu Formation contains tabular shale clasts and subangular to rounded metasedimentary clasts. The latter are predominantly of sandstone but also include minor amounts of siltstone and carbonate. Graded bedding is sometimes present. A manganese-enriched interval of laminated to thinly bedded siltstone and mudstone occurs just below a laterally persistent sandstone unit, which is about 50 m above the base of the Bootu Formation. The manganese enrichment is at a similar stratigraphic and appears to be stratiform. Manganese stained domical and bulbous stromatolites occur about 3 m above the main Bootu mine manganese mineralisation. Overlying manganese stained, thinly bedded sandstone and siltstone exhibit shallow water ripple marks, desiccation features and halite pseudomorphs.

The upper 100-150 m of the lower lithofacies contains two major coarsening- and thickening-upward sandstone cycles. The sandstone consists mostly of thinly to medium bedded sublitharenite to quartz arenite that has planar, tabular, trough and ripple cross-strata. It also has
locally abundant desiccation features and halite pseudomorphs, and rare domical stromatolites in
the lower parts. Some siltstone and fine sandstone interbeds exhibit current lineations and tool
marks, and the more recessive intervals may be due to a higher mudstone and/or lithic content.
The contact with the overlying dominant sandstone lithofacies is placed where bedding becomes
medium to thick and units are medium to coarse. This contact is transitional, coincides with the
appearance of scattered pebbles and cobbles and approximates the beginning
of the upstanding low relief plateau.

The remainder of the formation is dominated by thinly to very thickly bedded, fine to very
coarse, moderately to well-sorted quartz arenite and sublithic arenite. Although not mapped, it
can be differentiated into a middle and upper lithofacies. The middle lithofacies forms the
majority of the unit and is at least 1350 m thick in the vicinity of Looa Creek. Minor granular to
cobble conglomerate and poorly sorted sublithic arenite are also present in the middle lithofacies.
Most conglomerate clasts are of well-rounded cream to pinkish quartzite and less common white
vein quartz. Ripple marks are present in some intervals throughout and are very common in the
upper lithofacies sandstones. Most cross-bedding is bidirectional, simple or tabular and concave
upward. Some meter-thick, concave cross-beds with large tabular weathered out mud clasts that
are indicative of rapid sedimentation are present in the middle lithofacies.

In general, most sandstone is finer and more thinly bedded in the upper lithofacies of the Bootu
Formation. The finer sandstone is usually interbedded with red-brown mudstone and siltstone
and is typically well rippled. Desiccation features are common. The remaining sandstone appears
to be a lateral equivalent and consists of planar or tabular cross-bedded, medium-bedded quartz
arenite, or medium to thick trough cross-bedded pebbly sublitharenite. The upper lithofacies is
about 100-200 m thick.

The contact with the overlying Carmilly Formation is gradational. Sandstone units fine and thin
upward to be sharply overlain by laminated mudstone and dolostone, which contain thin
intervals of thinly bedded sandstone in their lower part.

Typically, sandstone of the Bootu Formation consists of >90% monocrystalline quartz, <10%
chert and <5% lithic grains. Most quartz grains are milky, Some quartz shows deformation
lamellae or recrystallised domains indicating a metamorphic provenance. Other quartz grains
contain green, brown and blue-grey tourmaline, muscovite or fluid inclusions that are indicative
of a high-level igneous or hydrothermal origin. Rounded to fractured euhedral tourmaline and
zircon are common accessory heavy minerals.

The occurrence and close association of manganese and graphitic units is noteworthy and may be
related to the shallow water saline depositional environments of the Bootu Formation. Hypersaline brine pools can result in decaying organic matter and reducing conditions. This may have led to primary manganese precipitation. Alternatively, manganese-enriched, oxidised basin fluids may have migrated along Bootu Formation sandstone units and reacted with reduced units (graphitic shales).

2.2.1.6 Carmilly Formation

The Carmilly Formation is the uppermost unit of the Tomkinson Creek Group, and is a recessive,
mixed siliciclastic and carbonate sequence that conformably overlies the Bootu Formation. It is
approximately 750 m thick but the exact thickness of the formation in this region is uncertain
due to fault complications. The preserved stratigraphic level at the top of the unit also varies due
to an angular unconformity between the Carmilly Formation and the overlying Jeromah
Formation.
Figure 4. Geological map of the Attack Creek Project area extracted from Tennant Creek 1:250k SE53-14 geological map (Donnellan et al 2001). **Legend:** Tenement boundaries in green polygons, Ironstone and disseminated Mn in siltstone and sandstone in red polygons, prospective contact between Attack Creek Formation and Bootu Creek Formation in black line. For further information refer to text on proposed geological model and exploration strategy in this report.

Three distinct lithofacies are identified in the type area. The lower lithofacies is a recessive, mixed siliciclastic-carbonate interval that is transitional with the overlying middle lithofacies. The middle lithofacies is a 70-150 m thick upstanding sandstone interval, which typically forms a prominent strike ridge in the middle of the formation. This is overlain by another recessive, mixed siliciclastic-carbonate interval (EtY3) which is distinct from the lower lithofacies.

The Carmilly Formation consists of cream to maroon siliciclastic mudstone, greenish grey and cream to white or pinkish-tan, predominantly fine to medium sandstone, and variably silicified dolostone and chert. The carbonate lithofacies is of thinly bedded dolostone that ranges from predominantly laminated to massive. It typically forms distinct cryptomicrobial dolostone intervals, which contain biohermal stromatolites and wavy- or parallel-laminated boundstone and dololaminites. These are locally associated with evaporite pseudomorph-bearing sandstone units and chertified evaporite 'beds'.

The base of the Carmilly Formation is exposed along several kilometers strike length. Basal units are typically of recessive chert, laminated dolostone or cream to maroon mudstone. The lower lithofacies consists of thinly bedded and laminated silicified dolostone (chert) and cream to
greengrey or maroon mudstone and sandstone. Chert and fine to medium sandstone intervals form small, low relief rises or rounded strike ridges whereas the siltstone/mudstone-dominated intervals are more recessive. Intervals of chert, dololaminite, and domical and bulbous stromatolites are interbedded with minor, well sorted, current and oscillation ripple marked, very fine to medium sandstone in the lower parts. These units pass upward into a more siliciclastic succession comprising intercalated planar bedded, parallel- and cross-laminated sandstone and mudstone. This interval is often prolifically rippled marked and desiccated. Most sandstone units at this level have a distinctive grey appearance when weathered.

The middle lithofacies of the Carmilly Formation is mostly composed of cream to white or pinkish-tan sandstone. This sandstone consists mostly of intensely ripple marked, well sorted, thinly to medium bedded, fine to medium quartz arenite. Current and interference ripple marks are common throughout. Several slightly less resistant intervals of finer and more thinly bedded quartz arenite occur in this lithofacies. Desiccation features are abundant in some horizons, as are intraformational tabular shale clasts. Evaporite pseudomorphs (mostly after halite) are present in some intervals, particularly near the top. Voids after probable nodular anhydrite pseudomorphs occur in the uppermost part. This upstanding sandstone interval displays gradational contacts with adjacent units and separates an underlying predominantly fine siliciclastic succession from an overlying more dolomitic (microbial/evaporitic) succession.

The upper lithofacies is dominated by cream to buff weathering, laminated to thinly bedded mudstone, calcareous siltstone and minor dolostone. Thin layers of nodular chert, enterolithic chert (anhydrite) and pseudomorphs after halite and probable gypsum (now replaced by silica) are also present. The stromatolitic bioherms and boundstones that occur in the upper lithofacies tend to show a cyclic relationship with ripple cross-laminated, evaporite pseudomorph-bearing sandstone and planar laminated mudstone. These bioherms tend to be of lower relief and are more domical in character than those in the lower lithofacies, suggesting slightly more energetic shallow environments.

Carmilly Formation sediments conformably overlie shallow marine to deltaic or fluvial facies of the uppermost Bootu Formation and represent a gradual, though in part cyclic, shift to lower energy, protected lagoonal and marginal marine settings. Relatively energetic intertidal settings are inferred for the middle lithofacies, which represents either large protective sand barriers or a shoreface. The upper lithofacies is interpreted as being characteristic of deposition in a sabkha environment. Units in the upper lithofacies show an overall shift towards more protected hypersaline conditions, although periodic intervals of higher energy, marked by intensely ripple marked, thinly bedded sandstone are common.

The contact with the overlying Jeromah Formation is sharp and erosional. A subtle regional angular relationship is evident between these formations and there is typically a sudden change in lithology and bedding characteristics, although locally, this is not obvious and the contact can be difficult to distinguish. The units above the unconformity are typically medium to thick, tabular or trough cross-bedded sandstones, pebbly sandstones and conglomerate.

2.2.2 Namerinni Group

The Namerinni Group is an alternating sandstone, siltstone and carbonate succession with a maximum total thickness of about 2800 m. This Group is divided into, in ascending order, the Jeromah, Carruthers, Shillinglaw and Willieray Formations (Figure 3).

The Mesoproterozoic Renner Group unconformably overlies all formations of the Namerinni Group. A subtle angular unconformity with the underlying Tomkinson Creek Group is
recognised where Namerinni Group rocks are in general finer and the sandstones are less mature and more lithoclast-rich than those in the upper Tomkinson Creek Group (from Hussey et al 2001).

2.3 Structural Deformation

The structure of the Ashburton province (from Hussey et al 2001) is dominated by north-northwesterly, north-northeasterly and northeasterly trending faults, and by less significant northwesterly trending faults. These tend to form elongate fault block geometries. Most of the faults appear to be subvertical and both normal and reverse senses of movement are documented, although some faults are rotational. Moderate to low angle faults have been identified, but these are rare.

The Proterozoic rocks of the Ashburton province typically show low to moderate bedding attitude, although beds can range from subhorizontal to subvertical and rarely may even be locally overturned adjacent to faults. In general, most folds display open to moderate interlimb angles and lack pervasive axial planar cleavages, although associated conjugate fracture cleavages are sometimes evident. Tight to isoclinal folds are present but these tend to be developed in or adjacent to major fault zones.

The earliest major period of folding produced regional northwest trending map-scale anticlines and synclines that are restricted to the Tomkinson Creek Group. Regional aeromagnetic data suggest that these folds continue beneath the Georgina Basin in east.

It is proposed that this earliest folding event generally produced more open fold styles and that the tight, northwesterly trending folds have been enhanced by northwesterly faults. The open fold geometry is evident in the general distribution of Short Range Sandstone outcrop as well as in several mappable synclines within the region. The absence of a well developed axial planar cleavage also suggests that this folding event was not intense and occurred at a relatively high crustal level.

These major northwest trending folds clearly predate the prominent faults in the region. North-northwesterly trending faulted synclines and anticlines are superimposed on earlier folds in the Tomkinson Creek Group, whereas anticlines, synclines, homoclinals and asymmetric folds are present in the Namerinni and Renner Groups. These latter folds have notably shorter wavelengths, are often more intensely developed locally, and are clearly related to faulting rather than regional folding. There is often a dramatic steepening in bedding attitudes towards the northerly trending folds. Fold geometries and localized cleavage development (typically on the western side of major north-northwesterly trending faults) generally suggest reverse movement on steeply easterly dipping faults. Quartz dissolution and white mica growth are common in these high strain zones within a dominantly brittle regime. Quartz veins are not a common feature in the region, but do occur in these zones. Open folds are present in the Renner Group. These may likewise be related to fault block movements. Outcrops of Renner Group show conjugate sets of fracture orientations that suggest horizontal east-west compression orthogonal to the major faults.

Significant structuring of the Ashburton province is evident prior to the deposition of the Renner Group. Minor tilting also appears to have occurred before deposition of the Namerinni Group but the limited exposure of this contact precludes an adequate understanding. Apparent shifts in palaeocurrent directions and variations in unit thicknesses suggest that there has been variable subsidence and extension throughout the Ashburton province during this interval.
3 Summary of exploration Activities Taken Through 2006

3.1 Satellite-Borne Spectral Study

3.1.1 Introduction

OM Manganese commenced a satellite-borne ASTER spectral study over the area in an attempt to identify possible Mn mineralisation targets, Fe-rich zones, prospective stratigraphical units and contacts, and prospective structures.

The Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) can be considered to be the geological successor to Landsat TM. The ASTER satellite is onboard one of NASA’s Earth Observing Satellite systems, Terra, which was launched in 1999.

The ASTER instrument collects data in 14 bands (Table 1) together with one stereo, backward-looking band. The ASTER instrument consists of three separate instrument subsystems, with each subsystem operating in a different spectral region and having its own telescope: the visible and near infrared (VNIR), the SWIR, and the TIR. It has a mixture of spatial resolutions, ranging from 15 m in the visible part of the spectrum to 30 m in the SWIR, to 90 m in the TIR. Like SPOT it has a 60 × 60 km swath width, but is on the same orbit as Landsat TM, but with a half-hour delay.

<table>
<thead>
<tr>
<th>Band number</th>
<th>Wavelength (µm)</th>
<th>Resolution (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Band 1</td>
<td>0.52 to 0.60 (visible green)</td>
<td>15</td>
</tr>
<tr>
<td>Band 2</td>
<td>0.63 to 0.69 (visible red)</td>
<td>15</td>
</tr>
<tr>
<td>Band 3</td>
<td>0.76 to 0.86 (near infrared)</td>
<td>15</td>
</tr>
<tr>
<td>Band 4</td>
<td>1.60 to 1.700 (shortwave infrared)</td>
<td>30</td>
</tr>
<tr>
<td>Band 5</td>
<td>2.145 to 2.185 (shortwave infrared)</td>
<td>30</td>
</tr>
<tr>
<td>Band 6</td>
<td>2.185 to 2.225 (shortwave infrared)</td>
<td>30</td>
</tr>
<tr>
<td>Band 7</td>
<td>2.235 to 2.285 (shortwave infrared)</td>
<td>30</td>
</tr>
<tr>
<td>Band 8</td>
<td>2.295 to 2.365 (shortwave infrared)</td>
<td>30</td>
</tr>
<tr>
<td>Band 9</td>
<td>2.360 to 2.430 (shortwave infrared)</td>
<td>30</td>
</tr>
<tr>
<td>Band 10</td>
<td>8.125 to 8.475 (thermal infrared)</td>
<td>90</td>
</tr>
<tr>
<td>Band 11</td>
<td>8.475 to 8.825 (thermal infrared)</td>
<td>90</td>
</tr>
<tr>
<td>Band 12</td>
<td>8.925 to 9.275 (thermal infrared)</td>
<td>90</td>
</tr>
<tr>
<td>Band 13</td>
<td>10.25 to 10.95 (thermal infrared)</td>
<td>90</td>
</tr>
<tr>
<td>Band 14</td>
<td>10.95 to 11.65 (thermal infrared)</td>
<td>90</td>
</tr>
</tbody>
</table>

Table 1. ASTER wavelength bands (from Gozzard, 2006)

Because of its higher spectral resolution and configuration when compared to Landsat TM for example, especially in the SWIR and TIR parts of the spectrum, ASTER is able to map a range of minerals. In the SWIR it is able to discriminate alunite, pyrophyllite, kaolinite, illite–muscovite–sericite, and MgOH–carbonate minerals (Figure 5).

In the TIR it can discriminate feldspar, quartz, carbonate, amphibole, and clay. However, the discrimination of these mineral assemblages requires sophisticated processing to remove temperature and atmospheric effects from the data.

At 15 m resolution the VNIR data are currently the best resolution multispectral data available commercially from a satellite, with the exception of the 4 m resolution IKONOS data and the 70
cm resolution DigitalGlobe image products. Compared to the single panchromatic 15 m band of Landsat TM ETM+, the ASTER VNIR data have a better spectral resolution.

The SWIR data consists of six bands. Band 4 has a similar wavelength to Landsat TM band 5 and is located where most types of materials have maximum reflectivity. Bands 5 to 9 cover a region where many OH-bearing minerals and carbonate minerals have absorption features. Bands 5 to 8 approximately cover the wavelength limits of Landsat TM band 7.

![Figure 5. Distribution of ASTER and Landsat bands (from Gozzard, 2006)](image)

Minerals of interest to the exploration of hydrothermal Mn and base-metals mineralisation within the Attack Creek Project area that can be identified in the SWIR region include:
- Mg-OH minerals and carbonates — major components of lithological units associated with mineralisation. Landsat TM cannot discriminate these minerals
- alunite–pyrophyllite — significant because they can define areas of argillic alteration. Landsat TM cannot discriminate these minerals
- kaolin-group minerals — also significant because they are useful in helping to define argillic alteration and in mapping regolith
- illite–muscovite–smectite — common minerals in the surficial environment and useful for mapping regolith. They are also associated with both phyllic and argillic alteration

ASTER TIR bands, which measure radiance in the 8.1 – 11.7 µm wavelength region, are the only available multispectral thermal-imaging data available, apart from airborne systems, and although they only have a resolution of 90 m, are useful for identifying surface silicification, silicilastic units and possibly chert breccia units.

3.1.2 Work Completed

One ASTER scene, collected on 9th September 2000, covering the entire extent of the Attack Creek Project area was sourced out for OMM by Geoimage Pty Ltd, an imagery specialist consultancy based in WA.

Product processing included:
- VNIR and SWIR data merged and orthorectified to SRTM DEM and MDA satellite base at 15m resolution
- TIR data orthorectified to same base but at 90 m resolution
- Calibration for local crosstalk by estimating a spectral end member for the crosstalk contamination and then removing it
Atmospheric calibration by estimating gains for each ASTER band to make data values compatible with the expected theoretical atmospheric spectrum in the case of VNIR and SWIR data and with the expected blackbody response, in the case of ASTER TIR data.

Data-driven atmospheric effects correction by finding a water vapour spectrum in an image and then unmixing it.

Data supplied by Geoimage:
- Raw original Aster data (zipped HDF Format)
- 9 band VNIR and SWIR merged orthorectified data (zipped ERMapper format)
- 5 band TIR orthorectified data (zipped ERMapper format)
- Data supplied as UTM Zone 53, WGS84 Datum (equivalent to GDA94)
- Various ECW enhancements (MapInfo format)

Unfortunately the product supplied by Geoimage is poor and does not meet our standards and expectations. The raw and processed datasets were passed to Resource Potentials, a Perth based geophysical and geological consultants, for assessment reprocessing, recalibration and re-enhancement.

Identified issues with the Geoimage product:
- Processing the raw dataset from Level 1A to Level 1B by Geoimage using in-house software was incorrect and unnecessary as Level 1B is readily available commercially to purchase.
- Atmospheric calibration and crosstalk correction had to be preformed by Resource Potential using their software.
- Scene selected has high coverage of fire burnt area including a live fire locally dispersing heavy smoke. It is impossible to conduct spectral analysis over area covered with fresh days-old burnt vegetation.
- TIR dataset is unusable, as area covered by this dataset does not match area covered by VNIR an SWIR dataset. This is possibly due to originally corrupted raw dataset or corruptions occurred during Geoimage processing.

It is highly recommended to pursue Geoimage to deliver a usable TIR dataset, as it is crucial for the exploration in a variable silica environment.

Data supplied from Resource Potentials:
- Processed and calibrated VNIR and SWIR dataset
- Standard band ratio enhanced images as GeoTIFs and MapInfo TAB files (in order of their proven exploration value):
  - Vegetation masked true colours
  - Ferrous iron
  - Mg (OH) abundance
  - RGB image of ferric iron (red), Al (OH) abundance (green), Mg (OH) abundance (Blue), and band 2 (greyscale) as background
  - Ferrous silicate
  - Dolomite
  - Al (OH) abundance
  - Landsat equivalent to TM 742
  - Landsat equivalent to TM 541
  - Ferric iron

Image quality after applying vegetation masking was preserved and with the absence of higher resolution images used as a base map for orientation and geological mapping. Furthermore, as
Mn and Ironstone outcrops are dark-black, using this image it is possible to identify insitu and scree of highly disseminated Mn and Ironstone occurrences larger than one 15 m pixel size, counting for most of the known occurrences to date (Figure 6).

It is recommended to create and apply a vegetation mask over other enhanced images to reduce confusion between geology and vegetation.

![Figure 6] The vegetation-masked true-colour ASTER image on the left highlighted all Ironstone and Mn occurrences larger than the size of one 15m pixel and to a high extent morphological and geological contacts (2 km between crosses). Enlargement of the area bound by the red rectangle on the right shows mineralised locations tested in the field marked as red polylines (2 km between crosses). For information regarding image overlays refer to Figure 4.

Mapping for ferrous iron spectral signature proved useful in identifying Ironstone and disseminated Mn in siltstone and sandstone though not as distinctive as within the Bootu Creek Project area, as surface expressions of mineralisation here are not as intensive. Dolomitic units of the Attack Creek Formation show here a distinctly high ferrous iron signature suggesting a possible alteration signature and a possible association with base-metals mineralisation. Further investigation into the mineralogical and geochemical composition of these dolomitic units is planned. This enhancement also highlights structures mainly were indicative units are spatially displaced.

Mapping for Mg (OH) abundance and for dolomite spectral signature identified the entire Attack Creek Formation dolomite unit within the Attack Creek Project area (Figure 8) with mixed results identifying dolomitic-siliclastic units.
Figure 7. The ferrous-iron enhanced ASTER image on the left (A) highlights ferruginous dolomite unit of the Attack Creek Formation and its geological contacts with the Short Range Formation and the Bootu Creek Formation. Ironstone and disseminated Mn occurrences are also highlighted (B) but not as distinctively as within the Bootu Creek Project area (C).

Figure 8. Mg(OH) enhanced ASTER image on the left and dolomite signature enhanced ASTER image on the right highlight dolomitic units within the Attack Creek Formation at the northern portion of the image within the Attack Creek Project area.
Figure 9. Landsat 742 equivalent ASTER enhancement on the left highlights geological contacts and structural contacts within the Attack Creek Project area. For comparison, on the right, a newly processed re-gridded regional magnetic image (RTP tilt) of the same area showing in red a north-south axial-plain parallel structure across the Tomkinson Group.

3.1.3 Recommendations for advanced interpretations

- Obtain spectral signature from ASTER dataset of Fe-Mn-rich mineralised outcrops of the Bootu Creek Mineralisation style, ferruginous dolomite, ironstone, dissolution zones, marker beds, and apply ASTER classified mapping over entire dataset. These targets can now be identified and sampled directly from the dataset using accurate GPS located field observation waypoint.
- Obtain spectral signature from GPS located rock samples collected in the field and apply ASTER classified mapping over entire dataset. The spectral signature can be obtained through CSIRO using preferably the ASD system if it is available or, if not, the PIMA mobile devise.
- Adjust thresholds values to standard and advanced enhancements according to field mapping and observations.
3.2 Geological Reconnaissance Fieldwork

3.2.1 Introduction

Between the 27-28 November 2006, OMM conducted a 2 days preliminary reconnaissance survey within the Attack Creek Project area with the objectives to:

- Evaluate the exploration potential for Mn mineralisation
- Test targets derived from the ASTER spectral study and evaluate its value as an exploration tool over the Project area
- Advanced the geological understanding of Mn mineralisation style
- Establish an understanding of the physiography of the Project area for further planning of logistical aspects of future exploration activities

3.2.2 Participants

- Amit Eliyahu – Geological consultant
- Guy Pickerin – Field assistant contracted through Arnhem Exploration

3.2.3 Logistics

- Field vehicle and field gear were hired from Arnhem Exploration
- Meals and accommodations were supplied by Bootu Creek Minesite

3.2.4 Conclusions

- The area was recognised as prospective and under-explored
- Using maps derived from ASTER enhanced images the one Mn mineralised outcrop was successfully identified, adding 3 new disseminated Mn Mineralised zones and identifying the highly prospective contact between the basal unit of the Bootu Creek Formation and the dolomitic Attach Creek Formation (Figure 10).
- ASTER products are highly effective as an exploration tool over the Project area and should be further advanced before the next field geological mapping campaign starts
- A new database of correlating GPS located geological field observations, rock-chip and grab samples, and field photography is being established to advance the geological understanding of the Project area (Figure 11 and Appendix A)
- A total of 19 rock-chip samples were collected for geochemical analysis, petrological study and spectral signature study. Results of these studies will be published separately once available.
- Mineralisation style within the Attack Creek Project area shares similarities with the Bootu Creek Mineralisation Style
- Mapped and unmapped tracks were recorded and tested for accessibility
Figure 10. One known Mn mineralised outcrop (A) was successfully identified, adding 3 new Mn Mineralised occurrences (red). Targets B and C are disseminated Mn to Mn staining in Fe-rich siltstone while target D is Ma staining in ironstone after sandstone.

**Legend:** Stratigraphic contact prospective for disseminated Mn mineralisation of the Bootu Creek Style is marked by a thin black line. Mn mineralised occurrences zones marked by red polygons. Tenement boundaries marked by green polygons. Scale is 1km between crosses.

Figure 11. Access to Project area is limited with large silicified beds (C) and densely vegetated areas. Images A and B looking northwest and southwest respectively from Short Range Sandstone ridges across a plain of dolomitic siliciclastics and dolomites of the Attack Creek FM to low ridges of the Bootu Creek FM. Prospective contact along the eastern-centre portion of the Project area showing Mn staining is relatively accessible from the southern access track (D). Large manganiferous ironstone outcrop targeted using ferrous iron and true colour ASTER enhancement maps (E).
4 Geological Model

4.1 Introduction

The proposed geological model for Mn mineralisation within the Tomkinson Group covered by the Attack Creek Project area is based on preliminary study of observations and data collected in the field combined with OMM proposed geological model for Mn and base-metals mineralisation within the Ashburton Province of the Tennant Inlier.

The geological model for the region identifies massive regional-scale hydrothermal systems within paleoproterozoic sedimentary basins over an area of approximately 11,000 km² within the Ashburton Province. Characterising these hydrothermal systems is a work in progress, crucial for the understanding and further development of the exploration efforts and interpretation of collected data.

Based on field observations and preliminary mineralogical, geochemical, and geophysical evidence the genetic models for mineralisation are suggested to be subtypes of Sedimentary Exhalative (SEDEX) Mineralisation Style (Figure 12).

Subtypes of SEDEX deposits include those that formed below but near the seafloor. These deposits, either individually or collectively (district-wide), may show characteristics of both seafloor deposition and epigenetic features typical of Mississippi Valley-type (MVT) deposits (Goodfellow et al 2006).

SEDEX deposits are typically tabular bodies composed predominantly by combinations of Zn, Pb Ag, with several subtype variations of which Sedimentary Mn and Sedimentry Cu best match the Bootu Creek Mn and Cu mineralisation styles respectively.

Figure 12. Sedimentary basin architecture for SEDEX deposits. Green rectangle highlights possible geological environment for Bootu Creek Mineralisation Style.
4.2 Mn Mineralisation Style

Based on very limited work conducted to date, surface evidence to Mn mineralisation within the Attack Creek Project area is very poor showing typically primary Mn staining and low degree of dissemination within sand and silti lithologies, and secondary dendritic growth of Mn oxides within fine carbonatic and siliclastic lithologies. Medium to fine quartz grains are commonly preserved, as are primary beds and textures. The higher levels of mineralisation seems to be stratigraphical controlled bound to the same contact favourable for Mn and base-metals mineralisation within the Bootu Creek Project area.

In places surface enrichment of iron oxide formed a series of low dark ironstone hills suggested to be similar to the black ironstone ridges and knolls marking the near-surface location of the Mn horizon at the Bootu Creek Project area. These occurrences are possibly derived from in-situ weathering and surface enrichment of an iron-rich halo to Mn mineralisation.

Carbonaceous siltstone, silty dolomite and dolomite have been identified immediately below the inferred manganiferous horizon commonly hosting manganese dendrites along bedding and within fractures.

At a regional scale, a clear stratigraphic control is evident over the manganese deposits in the Bootu Creek and Attack Creek areas. In both locations the manganiferous horizon is bounded to the base of the Bootu Formation indicating a regional distribution of the mineralising event. The basal sections of the host units both contain interbedded sandstone, dololutite and dolomitic siltstone. Both host units overlie dominantly carbonate-mudstone sequences.

Surface and subsurface (meso- and microscopic) observations indicate at the Bootu Creek Project area that the manganese is epigenetic. Siltstone, sandstone and stromatolitic dololutite are mineralised; pervasive replacement of the former is common and leads to the formation of stratabound tabular massive manganese ore. Massive manganese oxide replacement of the stromatolitic dololutite bed at the abandoned Mucketty mine suggests that Mn mineralisation is not syn-sedimentary.

The facies change described above over approximately 15 km of strike from siliclastic rocks to a bed of stromatolitic dololutite within the Bootu Creek Project area may represent a geomorphological continuum to a deeper marine environment further to the southwest with the development of carbonatic platform of massive stromatolitic to siliclastic dolomites facies of the Attack Creek Formation within the Attack Creek Project area.

Exploration for both Mn and base-metals mineralisation within the Project area should follow the geological and exploration models for Bootu Creek Mineralisation Style for the obvious similarities indicated above.

Possible mechanism for mineralisation at Bootu Creek and Attack Creek Project areas suggests that metals might have been leached from sediments and basic volcanics within the Hayward Creek Formation. Under the SEDEX model the ultimate traps for the metals carried under oxidized conditions are reduced sub-basins with an unlimited supply of H2S in the ambient water column (Figure 12). However, for the Bootu Creek Mineralisation Style it is suggested that metals were transported as metal-rich brines under reducing and slightly acid conditions within marine sandstone aquifers such as the Bootu Formations. The generation of low temperature (60-100ºC) Mn and trace metal fluids may have been related to basin dewatering. Manganese oxides, iron oxides and trace metals would have been precipitated when the brine encountered a redox
barrier (alkaline and oxidising conditions). Dolomitic siltstones in basal sections of the host formations may have provided the appropriate chemical environment for this to occur.

Structural deformation within the Attack Creek Project area is relatively simple with consistent shallow dipping sedimentary beds within open folds. However, the area lacks a comprehensive structural interpretation towards a possible reconstruction of paleoproterozoic surfaces and understanding the structural controls over mineralisation.

Figure 13. Disseminated to stained Mn mineralisation within shallow dipping siltstone (A and B) and sandstone (C). Massive ironstone with Mn staining and possible dissolution textures making ridge (D). Mn dendrites within laminated shaly and silti dolomite along the basal units of the Attack Creek FM close to the contact with the Short Range FM (E). Ferruginous silti dolomite making the majority of the attack Creek FM (F and G) can be clearly identified by ASTER enhancement for ferrous iron, Mg(OH) and dolomite (Figures 7 and 8). Stromatolitic dololutite as bedded intervals within the Attack Creek FM (H and I). Chert Breccia along north-south fault zone (J) as marked in Figure 9.
4.3 **Recommendations for further work**

- Structural interpretation of newly re-grided regional magnetic datasets
- Field Structural mapping
- Mapping lithologies using spectral mapping of ASTER datasets and newly re-grided regional radiometric datasets
- Petrological studies of selected rock samples from Mn mineralisation zones and host siliclastic and dolomitic lithologies.
- Field geological mapping for Bootu Creek Mn and base-metals Mineralisation Style, un-mineralised dissolution zones, dolomitic lithologies and main structures. As no significant mineralisation is present along a relatively well exposed upper Attack Creek Formation units and basal Bootu Creek Formation units, exploration along the eastern limb of the syncline should focus on base-metals while exploration within the western side of the syncline and along the main north-south fault should focus on both Mn and base-metals mineralisation.
- Geophysical properties study of samples from the mineralised zone, footwall and hanging wall, dolomite, and dissolution zones. Recommended properties to study are:
  - Mass (density and porosity) for potential gravity surveys
  - Inductive (mag k/induction coil and EM conductivity.) for electromagnetic and magnetic field surveys
  - Galvanic electricity properties for Resistivity and Induced Polarity surveys, and possibly useful for interpretations of EM survey
- If mapping and remote sensing studies identify base-metals anomalies and areas under cover with potential Mn mineralised zones Hoist-EM survey should be considered to identify conductive bodies under cover, potential structures related to mineralisation and lateral offsetting of conductive bodies, and to model for bedding dips, unit repetitions due to possible thrusting and folding, and possible hidden poorly conductive vertical bodies
5 Exploration Strategy

The exploration strategy for the next two years is based on the proposed geological model and collective experience from previous exploration work conducted both over the Attack Creek Project area and the Bootu Creek Project area.

The main objectives are:
- Identify Mn and/or base metals mineralised zones
- Define drilling targets or
- Downgrade Project prospectively and surrender the ground

In order to upgrade known Mn mineralisation occurrences to drilling targets level and to generate new drilling targets a comprehensive mapping effort is to be conducted using remote sensing and field mapping methods.

5.1 Advanced spectral mapping

- To be completed by the end of March 2006 through Resource Potentials
- Obtain thermal bands (TIR) for ASTER and complete dataset processing
- Obtain spectral signature from ASTER dataset of Fe-rich Mn-stained mineralised outcrops, dolomite, ironstone, dissolution zones, marker beds and chert breccia, and apply ASTER classified mapping over entire dataset. These targets can now be identified and sampled directly from the dataset using accurate GPS located field observation waypoint.
- Obtain spectral signature from GPS located rock samples collected in the field and apply ASTER classified mapping over entire dataset. The spectral signature can be obtained through CSIRO, preferably using the ASD system if it is available or, if not, the PIMA mobile devise.

5.1.1 Estimated costs for spectral study

- One Level 1B ASTER scene over the Project area: $110
- Processing and enhancement of dataset: 3 days * $600/day = $1,800
- Obtaining spectral signature from rock samples at CSIRO: 1day * $125/day = $125
- Total for spectral study (1/07): $2,035

5.2 Magnetic and radiometric regional study

- To be completed by mid April 2006 through Southern Geoscience (SGC)
- Re-gridding of regional magnetic and radiometric over the Tennant Creek 1:250k sheet area
- Conduct a regional structural and alteration study over the Tennant Creek region targeting for hydrothermal fluid conducts possibly associated with Bootu Creek Mn-Mineralisation Styles, and general MVT, SEDEX, Sedimentary Cu and Sedimentary Mn deposits

5.2.1 Estimated costs for Magnetic and radiometric regional study

- Cost for re-gridding processing and enhancing regional datasets (1/07): $2,000
- Cost for interpreting datasets: waiting for a quote
5.3 Petrological study

- Study the geochemical and mineralogical properties of Mn mineralisation, footwall and hanging wall material, and alteration including silicification styles to identify indicative pathfinding characteristics of stratigraphy for the small scale drilling interpretations and the regional scale exploration
- Study the mineralogy and textures associated with Mn mineralisation to establish characteristics of primary hydrothermal mineralisation and enriched / depleted / contaminated supergene related mineralisation to define better down dip potential
- Submit selective samples for thin sections, polished sections, XRD and possibly SEM study
- Contract a consultant petrologist or establish a research project with UWA at an honour or MSc levels
- Examine the value in drilling one deep research RC hole across prospective contact into footwall

5.3.1 Estimated costs for Petrological study

- Contracting Janet Muhling (1/07): 5 sections * {$45/section (prep) + $150/section (analysis)} + $400 reporting = $1,375

5.4 Field mapping

- To commence at end of drilling program around the beginning of June
- Map Attack Creek Project area for Bootu Creek Mn and base-metals Mineralisation Style, un-mineralised dissolution zones, dolomitic lithologies and main structures.
- 10 fieldwork days of targeted geological mapping at 1:20k scale over stereo aerial photos (if available from NTGS) or purchased archived IKONOS images

5.4.1 Estimated costs for field mapping

- Geologist: 10 days * $700/day = $7,000
- Field assistant: 10 days * $450/day = $4,500
- Vehicle and gear hire: 10 days * $120 = $1,200
- Accomodation: Bootu Creek Camp and camping
- Food: provided by Bootu Creek Camp
- Total for field mapping (2/07): $12,700

5.4.2 Acquisition of IKONOS scenes

- Archive data available through Geoimage
- Costs for 316 km² of archive 1-metre colourised data plus processing:
  - Data: $3,955
  - Freight from USA: $198
  - Orthorectification: $1,903
  - ECW compression & reprojection (usually not required): $348
  - ECW compression only: $330
  - Total for IKONOS scenes (compression only): $6,386
5.5 EM surveys

• Incorporate a hand-held EM survey with first stage field mapping and consider a full ground EM survey as a follow-up over selected known occurrences to define spatial distribution of potential mineralised bodies

• Providing a successful completion of first stage mapping, conduct a geophysical properties study by end of August 2007 of samples from the mineralised zone, footwall and hanging wall, dolomite, chert breccia and dissolution zones using 5 brick to fist size grab samples. Study is available through Southern Geosience (SGC) conducted by Don Emerson of Systems Exploration in NSW.
  - Properties to study are:
    ▪ Mass (density and porosity) for potential gravity surveys
    ▪ Inductive (mag k/induction coil and EM conductivity.) for electromagnetic and magnetic field surveys
    ▪ Galvanic electricity properties for resistivity and Induced Polarity surveys, and possibly useful for interpretations of EM survey

• Identify areas with poorly exposed prospective lithologies to examine the possibility of small-scale ground EM or IP survey to be conducted after the field mapping before the end of the 2007 field season.

• Assuming the Project hasn’t been downgraded by end of 2007 field season, an airborne EM survey over the Attack Creek Project area should be considered for an execution around May 2008 to identify conductive bodies under cover, potential structures related to mineralisation and lateral offsetting of conductive bodies, and to model for bedding dips, unit repetitions due to possible thrusting and folding, and possible hidden poorly conductive vertical bodies.

• Delineate new drilling targets from subsequent interpretations of EM data

5.5.1 Estimated costs for EM surveys

• Hand held survey (1/07): 4 days * $1,400/day (geologist, fieldy, vehicle, gear) = $5,600
• Geophysical properties study (2/07): 5 samples * $275/sample = $1,375
• EM ground survey: waiting for a quote
• IP ground survey: waiting for a quote
• Helicopter borne EM survey (1/08):
  - VTEM: $155/line km
  - Skytem: $127/line km
  - GPX: $104/line km (2006 price, waiting for a quote)
• Fix-wing airborne EM survey (line km):
  - Tempset: $110/line km

Minimum prospective area within Project area is approximately 61 km² with an estimated 600 line km at 100 m line spacing (Figure 15). Total cost estimated for a Helicopter borne EM using Skytem quote would be $76,200.
Figure 15. Proposed coverage for an airborne Hoist EM survey over the Attack Creek Project area (red polygon).
6 Reference


## Appendix A

Geological Information Database for the Attack Creek Project Area

**DRAFT – partial table**

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