Google image of southern portion of EL 23687 and EL24520 showing the arenaceous sandstone ridges, brown colluvium derived from dolerite (centre) and the extensive black soil plains (left) which surround Lake Woods.

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Summary

The Lake Woods project is located 700 km south of Darwin and 200 km north of Tennant Creek. The project is centred on the Ashburton Range which runs north-south along the eastern margin of Lake Woods, a large seasonal lake. The Stuart Highway passes through the centre of the area. Geologically, the project tenements comprise the Middle Proterozoic Renner Group sedimentary package intruded by pre-Cambrian dolerite on the western side and Cambrian and Cretaceous sediments on the flat open country to the east of the highway. Previous exploration within the district has focused on the potential for diamonds and base metals but has been limited due to poorly developed drainage and widespread alluvial and aeolian cover.

Aircore drilling in 2008 produced samples of an intrusive rock, which were tentatively identified as syenite. Subsequent petrographic work concluded that the ‘syenite’ might represent a phase of a differentiated intrusion, the presence of which has potential economic implications. In 2009 Crossland applied for, and was granted funding by the Northern Territory Government, to carry out a diamond drilling program to obtain core samples for geochemical analysis, petrographic and mineragraphic studies and age dating. Four holes were drilled for a total of 461.6 metres (includes one abandoned hole for 48.3 metres). Sixteen (16) samples were collected for geochemistry and 7.5 kg of drill core was made available for age dating.

Associated activities carried out during the current reporting period consisted of finalising the geological and geophysical modelling prior to the drilling. Following completion of the drilling programme in mid-December, core studies were carried out, which included further thin section preparation, petrographic descriptions, geochemical analysis/assessment and age dating.

As required under the collaborations agreement, a full report of the work conducted was presented to the NTGS in April 2010 (Melville P, March 2010) and drill core was deposited at the NTGS core library in Darwin.

The annual expenditure statement for EL 24520 forms part of this report. It has been forwarded separately.
1 Introduction

Crossland commenced exploration activities in the region in 2004. Diamonds were the target commodity initially, this concept being employed following recommendations by Paradigm Geoscience, which utilised their confidential concepts of target identification. With the increased knowledge gained over several years of exploration, the geological setting of the target area suggested that other deposit types were likely to occur here such as base metals and manganese, potassic evaporates in the Proterozoic sediments and copper-nickel in intrusive complexes.

Geologically the project is located within the Ashburton Province (1400-1700 Ma), which consists of a sequence of unmetamorphosed and weakly deformed, predominantly shallow marine sediments. The oldest rocks that outcrop in the area are Middle Proterozoic evaporitic sandstones and conglomerates of the Renner Group, which form the ridges of the Ashburton Range. A regionally extensive intrusion of what has been previously termed a ‘dolerite’ (NTGS 2001) has recently become the focus of Crossland’s exploration efforts.

Activities over the five years of exploration up to October 2009 included literature research and data acquisition followed by geological reconnaissance and mapping over several seasons; sediment sampling for diamonds and mineralogical determinations, rock chip sampling, laboratory assays, geophysical data processing and modelling (airborne mag), airborne EM (Tempest), air core drilling and subsequent geochemical assays, petrographic work and XRD determinations.

The aircore drilling program conducted in 2008 produced samples of the intrusive rock, which were tentatively identified as syenite. Subsequent petrographic work concluded that the ‘syenite’ might represent a phase of a differentiated intrusion, the presence of which has potential economic implications. In 2009 Crossland applied for, and was granted funding by the Northern Territory Government, to carry out a diamond drilling program to obtain core for geochemical analysis, petrographic and mineralographic studies and age dating.

The on-ground activities for the reporting period were carried out within ELs 23687, 24520 and 27317. No drilling or other ‘on-ground’ activities were conducted on the remaining two licences, however the programme concepts and the results were considered relevant to the project area in entirety and that future work would most likely involve all ground held by Crossland.

Prior to the diamond drilling programme a sacred site survey was carried out by the Aboriginal Areas Protection Authority.

2 Location and Access

The Lake Woods project is located between 700 km and 800 km south of Darwin and 200 km north of Tennant Creek. The Stuart highway passes through the centre of the area and the recently completed North Australian Railway is located 40 km to the west. The Mereenie Gas Pipeline trends north–south through the western section of EL24520. The small community of Elliot lies immediately to the north and the Renner Springs roadhouse is located 40 km to the south.

The western portion of the project area is dominated by ridges of the Ashburton Range which dip west towards Lake Woods. East of the Highway the topography dips eastwards into the plains of the Barkly Tableland where much of the country is open. Access to the area is good with a combination of station tracks, disused stretches of the old Stuart Highway, and good off road conditions into valleys between the sandstone ridges.
The tenements lie on Tandyidgee and Powell Creek Stations owned by Consolidated Pastoral Company and Helen Springs Station owned by S Kidman and Company Ltd. Two native title claims are present within the area covered by the ELs:

- D6038/01 Powell Creek, lodged on 21/06/01, NNTT number DC01/37.
- D6036/01 Tandyidgee/ Powell/ Helen Springs, lodged on 21/06/01, NNTT number DC01/35.

3 Tenure

Title to the tenements is held by Crossland Diamonds Pty Ltd and operated by Crossland Uranium Mines Limited. Details are as follows:

- EL 23687 was granted for a six-year term on 11 June 2003. The tenement was reduced to 16 blocks or 52.1 km² for the final term of the licence, which ended on June 10 2009. Renewal of the licence for a further two years (years 7 and 8) was granted in 2009.
- EL 24520 was granted for a six year term on 3 October 2005. Originally, the licence consisted of 165 blocks or 537.75 km². A reduction to 109 blocks or 356.43 km² took place in 2009 at the end of Year 4.
- EL 25631 was granted on 16 August 2007. The tenement consists of 500 blocks or 1627.23 km². The title was surrendered on 23 August 2010.
- EL 27317 was granted on November 10, 2009. The tenement consists of 8 blocks or 26.03 km². There have been no reductions to date.
- EL 27318 was granted on November 10, 2009. The tenement consists of 1 block or 3.255 km². There have been no reductions to date.

Two SELs have been applied for to cover the current area of the above five licences.

Text Figure 1 on the page 5 shows the location of the projects Exploration Licences.

4 Previous Exploration

Exploration for base metals was undertaken by Aberlour in 1971-1972 and by Lone Pine Gold/NT Gold Mining/Rosequartz Mining during 1988-1990. The latter group undertook geological mapping and limited geochemical sampling but failed to identify any base metal anomalism. Their activities were limited to the Ashburton Range where rock exposure is good. Overall, there has been very limited exploration for commodities other than diamonds in the area.

Ashton Mining Ltd explored the area for diamonds between 1983 and 1991 under exploration licences 4337 and 4345. They collected 75 gravel and 30 loam samples covering most of the western half of the project area at a nominal density of one sample every 1-2 km along drainages. The gravel samples consisted of 40 kg of <4 mm material. Many of the samples were collected from the area between the Ashburton Range and Lake Woods where the land is very flat and the creeks are choked with sand. The eastern half of the area was not sampled because of the lack of drainage. Five of the Ashton samples contained single microdiamonds. Two of the microdiamonds were described as clear, colourless stones while the remainder comprised small irregular cubes of pink-brown and grey colour. Whilst Ashton considered the high concentration of diamonds in this area as interesting they decided to focus on other areas.
in the Northern Territory and relinquished their licences. Aberfoyle Exploration P/L were in JV with Ashton for some of this period.

In the early 1990s CRA Exploration held tenure (EL 7591) over an area totalling 14,800 km², which covered the eastern half of the Lake Woods project area. CRA considered the area prospective for diamonds and flew a detailed magnetic-radiometric survey over an area of 10,900 km². The survey was flown in 1992 at flight line spacing of 300 m and a terrain clearance of 60 m. Of the 53 targets CRA selected for follow-up only one falls within Crossland’s project area and it was explained as a cultural feature. No further work was undertaken by CRA.

In 1999 the NTGS flew the South Lake Woods Survey at a line spacing of 400 m and a flying height of 60 m. This survey covers most of the project area, and when combined with the earlier CRAE survey, full coverage has been achieved.
Figure 1. Lake Woods Tenement Location Plan
5. Geology

5.1 Regional Geology

The Lake Woods project area is located in the southeast corner of the NTGS 1:250,000 Geological Map Series Beetaloo sheet SE 53-6 (Folder Figure 2). Geologically it is within the Ashburton Province (1400-1700 Ma), which consists of a sequence of unmetamorphosed and weakly deformed, predominantly shallow marine sediments. The Ashburton Province overlies the Warramunga Province, which is deformed by the Tennant Orogeny (1850 Ma) and intruded by granites of the same age. The Ashburton Province is in turn, overlain by Palaeozoic sediments of the Georgina and Wiso basins to the east and west respectively. Based on the magnetic patterns, both the Wiso and Georgina Basins are probably represented in the project area.

The oldest rocks that outcrop in the tenements are Middle Proterozoic evaporitic sandstones and conglomerates of the Renner Group, which form the ridges of the Ashburton Range. The sequence is intruded by a sill of consisting of ‘dolerite’ and the newly determined alkali syenite/gabbro (1295+-14 Ma). The intrusive rocks have been shown to be more widespread than past mapping suggests as they tend to be susceptible to intense weathering and therefore recessive.

The Renner Group is designated as Mesoproterozoic in age and unconformably overlies the Namerinni and Tompkinson Creek Groups south of the tenement area near Renner Springs. It is divided into five formations, namely the Gleeson, Baralandji, Powell, Wiernty and Jangirulu. Conformably overlying the Jangirulu Formation are the Lake Woods Beds. Within the latter, recent mapping by J Seeley (2008) has identified several cycles of deposition, in which similar lithologies are repeated three or four times from east to west over a distance of 20 km. This conformable bedded sequence comprises quartz arenite, hematitic quartz arenite, arkosic sandstone, dolomitic siltstones and grey shales.

5.2 Project Geology

The project area is centred on the Ashburton Range which forms a gentle, north plunging anticline with a near north south axis running parallel and immediately east of the Stuart Highway. Mapping by Crossland personnel has resulted in the following observations and interpretations.

5.2.1 Lake Woods Beds

5.2.1.1 Stratigraphic setting and depositional environment

Conformably overlying the Jangirulu Formation of the Renner Group are the Lake Woods Beds, which underlie most if not all of the mapped portions of the tenement area. There are at least five recognisable lithologies exposed from east of the Stuart Highway through to Lake Woods in the west. There appears to have been several cycles of deposition in which similar lithologies are repeated three or four times from east to west over 20 kilometres. The conformable bedded sequence comprises quartz arenite, hematitic quartz arenite, arkosic sandstone, dolomitic siltstones and grey shales. A substantial dolerite sill was intruded into the sedimentary sequence and is exposed in western parts of the area. The stratigraphic sequence was adequately covered by mapping along east-west traverses normal to the clearly defined structural trends of the area (see the front cover of this report).
Folding is not evident within the tenement. Strikes taken on the full lithological sequence across the region are consistent and within the range 340° to 360° degrees. Dips are consistently to the west, however, the angle decreases westwards to become almost flat lying. Immediately west of Stuart Highway exposures of quartz arenite dip west at 50° to 60° degrees. In central parts of the area dips decrease form 40° to 20° degrees and reduce to 10° degrees or less in the most westerly outcrops.

The overall structure west of the highway is suggestive of a gentle warp since exposures examined within five kilometres to the east have low angle westerly dips. Several road cuttings 20 to 25 km to the south have exposed quartz arenite with low angle dips to the east. If these rocks are a southerly extension of the Lake Wood Beds then a possible anticline is present. North and immediately east, satellite imagery shows a shallow syncline centered about 370000 E and 8020000 N with an axial trend of 340° and parallel to structures west of the highway.

Large exposures of quartz arenite show well preserved ripple marks, mud cracks and cross bedding. These are common features seen throughout the area and the best examples of which crop out along the old highway. Based on the consistency of the ripple morphology throughout the stratum, provenance appears to have been from the southwest.

The environment of sedimentary deposition for a large proportion of the observed rock types is considered to be intertidal shallow water with a paleoclimate that probably remained arid for lengthy periods prior to a new sedimentary cycle. The inter cycle arid climate is substantiated by the presence of fossil mud cracks and by probable laterite formation. The laterite occurs as intraformational or interbedded ferruginous breccias and its possible origins are discussed in a later section.

Finer grained sediment types such as dolomitic siltstone or mudstone together with grey shales were deposited on a marginal platform or in slightly deeper waters of an evolving basin.

### 5.2.1.2 Sedimentary Rock Types

- **Quartz arenite**
  
  Quartz arenites are the most common visible rocks to crop out throughout the project area. They comprise white to grey massive or bedded indurated flaggy sandstones, resistant to weathering, and forming north-northwest striking ridges. Essentially they are quartz-rich sandstones, in which rounded quartz grains have overgrowths and are cemented by colloidal silica. In metamorphic terms the rock is quartzite, however in the absence of any regional metamorphism, quartz grain cementation is primarily a function of the diagenetic process and induration.

  Individual beds of quartz arenite vary in thickness from a few centimeters to greater than five metres and extend laterally for tens of kilometres; these major lithological horizons can be traced along strike for over 80 km on satellite imagery.

  Columnar jointing caused by the contact effect of the sill is a distinctive feature of the arenite immediately overlying the intrusion (Photo 1). Another contact-related phenomenon can be seen in thin section, where the quartz grain component of the arenite has been ‘welded’ to form a quartzite.
Hematitic quartz arenites with ferricrete and breccia development are interbedded with the quartz arenites; these ferruginous arenites are laterally extensive and display similar current bedding and ripple structures to the arenites (Photos 2 and 3). Iron oxide acts as part of the cement within the arenite and most probably is dominated by hematite. Several origins are proposed as possible sources for the abundant iron oxides present in these rocks.

- One is that weathering and dissolution of ferromagnesian minerals in the sill produced iron-rich solutions that percolated down joints and fractures in the underlying arenite and recrystallised as a ferruginous cement.
- Periodic deposition of iron oxide precipitated from seawater during sandstone accumulation.
- The ‘breccias’ could have been formed by the fluidity of evaporate minerals in the contact dolomitic siltstone that were subsequently weathered to form a spongy limonitic breccia matrix.

- **Dolomitic siltstone and shale**

Dolomitic mudstones or siltstones are found in the south central part of the surveyed area bordered by ridges of the resistant arenites. These recessive softer sediments crop out at the head of a broad valley and are largely covered by colluvium. Downstream from the outcrops the valley is 1.5-2 km wide with extensive alluvial flats and a sand filled drainage system.

The outcrops of dolomitic siltstone are confined to small dendritic drainages imposed on thick colluvial cover and only two or three small exposures enabled strike and dip readings to be taken. Beds strike 340°-350° with westerly dips of 45°-50° indicating that the dolomitic and shale sequence conformably overlies arenites to the east and underlies the arenaceous rocks immediately west of the outcrops.

Soft dolomitic sediments and shales are easily weathered, which accounts for their lack of exposure. In all outcrops they are particularly friable and easily crumble into powder or small fragments. Gypsum crystals form within exposed dolomitic siltstone layers (Photo 4) and in accumulated piles of eroded dolomitic material in creek beds. Gypsum crystals are common in shales and aeolian sands where there is a source of calcium and sulphur. Sulfurous acid produced during weathering of iron sulphides is a possible source of sulphur for gypsum production. While no visible pyrite was seen during mapping of the outcrops the overlying grey shale may indicate euxinic facies-type deposition with reducing conditions that may have enabled the growth of syngenetic pyrite or deposition of anhydrite. More probably, the gypsum formed during sedimentation or diagenesis of the sediment, and could have been accompanied by other evaporite minerals.

It is proposed that this unit acted as a pathway for the intrusion, causing assimilation of the sediment into the magma. The varied composition of the dolomitic and evaporitic-type sedimentary assemblage is likely to have compositionally affected the margins of the intrusive body.
5.2.2 Intrusive Rocks

An extensive sill-like intrusion is located on the western flank of the anticline, forming a pronounced escarpment. It is highly weathered in outcrop and has limited cliff-face exposures over some ten kilometers, beyond which it remains covered by the sediments or is obscured by thick alluvium and colluvium in the valley floor and sides (Photo 5).

In the 1980’s the intrusion was noted by personnel involved in drainage sediment surveys, who were sampling for diamonds, but little importance was attached to it. During government mapping of the Helen Springs sheet (Hussey et al 2001), the presence of dolerite intruding the Lake Woods beds was noted but only mentioned in passing in the explanatory notes. It appears that the composition, the lateral extent and thickness of the sill and its regional setting went largely un-noticed until the 2008 drilling programme results were assessed and integrated with the government aeromagnetic data. This led to a reinterpretation by Crossland’s consultants. Magnetics show the intrusion to have a potential strike length in excess of 50 km (Figure 4). Petrographic studies and XRD identifications carried out at ANU, Canberra (Seeley, 2009) determined that samples of the intrusive consisted of a “complex quartz-bearing alkali syenite with a mineralogy and texture derived from un-mixing during differentiation” (Seeley, 2009).

Further scrutiny of the magnetics suggested that a strong and complex magnetic signature located immediately west, as well as to the east of the project boundary, could represent a previously unknown volcanic/sub-volcanic terrane. It was suggested that the syenite/gabbro could be related to this terrane with a consequent increase in the prospectivity of the region.
The data shows a typical volcanic-terrane magnetic signature. The interpreted volcanics may be an unrecognised more easterly extension of the Early Cambrian Antrim Plateau Volcanics, which cover vast areas of the western and northwestern Northern Territory or alternatively, a previously unknown older volcanic field.

![Photo 2.](image)

**Photo 2.** The photo shows the contorted contact between gypsiferous sediment (pale) and the overlying hematitic quartz arenite beds.

## 6 Structure

Structure within the tenement area is relatively simple comprising an asymmetrical anticline with a small warp on the western flank limb. The anticlinal axis is located immediately east of the Stuart Highway and has a gentle NNW plunge.

The conformable bedding sequence trends $340^\circ$ for the most part with dips of $50^\circ$ - $60^\circ$ immediately west of the anticlinal axis. Bedding dips decrease to $10^\circ$-$20^\circ$ in the most westerly exposures of arenaceous rocks. In the south of the area the stratigraphic sequence undergoes flexure as the strike of the bedding swings from $340^\circ$ to $020^\circ$.

Based on satellite image interpretation and field mapping there is little evidence of normal, reverse or strike slip faulting within the project area.
Photo 3. Ferruginous layered and brecciated sandstone

Photo 4. Gypsiferous dolomitic sediment
7. Economic Geology

No known mineralised occurrences are present within the tenements. Historically, the regional emphasis has been directed towards exploration for base metals and diamonds but this has been hampered by poorly developed drainage systems combined with widespread colluvial cover. The Renner Group was apparently correlated with sediments in the McArthur Basin, which host the McArthur River base metal deposits; however more recent mapping has shown that the correlated units belong to the older Tomkinson Creek Group, which is in unconformable contact with the Renner Group. Favourable rocks in the former contain uneconomic occurrences of Pb-Zn-Cu sulphides. The Bootu Creek Manganese deposits occur in the Bootu Formation, which is included within the Tomkinson Creek Group.

The most recent interpretation of the geological setting of the Target Area suggests that deposit types likely to occur in this geological environment include base metals in the Palaeozoic sediments, copper-nickel in intrusive complexes, stratabound manganese similar to the Bootu Creek deposits, and diamonds within sub-cropping intrusive pipes. Sedimentary phosphate deposits are also a possibility in this type of environment.

Assuming that the subsurface magnetic signature does represent an igneous province, then two possible economic scenarios are proposed:

- a southeasterly extension of the Cambrian Antrim Plateau Volcanics (Kalkarindji Continental Flood Basalt Province). The Antrim volcanic terrane is comparable to a number of other continental flood basalt terrains around the world, all of

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**Photo 5.** View of the syenite sill capped with sandstone
which are associated with world class mineral deposits particularly Ni-Cu, Cr and PGE’s.
• a discrete alkaline igneous complex. Alkaline complexes around the world are associated world class deposits of Cu, Au, REE’s Ti, P and diamonds.

8 Exploration Activities

8.1 Introduction
The principal field activity for the year was a diamond core drilling program carried out between the 27th November and 10th December 2009. The drilling was accompanied by some additional field outcrop mapping to aid in correlating the drill hole results with surface observations. Four holes were drilled for a total of 461.6 metres (includes one abandoned hole for 48.3 metres). Seventeen (17) samples were collected for geochemistry and 7.5 kg of core was made available for age dating. Offsite activities involved descriptive petrographic work on the nature of the intrusive rocks, geochemical analysis of the core and assessment of the chemistry and age dating.

8.2 Drillhole Planning
On the basis of the initial research carried out by the company’s consultants, it was proposed to drill three holes into and through the intrusion, firstly to determine its relationship with the intruded rocks, secondly to acquire samples for petrography, chemistry, mineral content and age dating and thirdly to ascertain if there were indicators of economic potential resulting from a more detailed understanding of the intrusion.

The main points/issues derived from the initial phase of research were included in the Collaborations Application document (Melville Paul M, March 2009). That report also contained a lengthy chapter, which looked at the exploration strategies and models that could apply to the type of situation envisaged at Lake Woods.

Drill hole locations were determined on the basis of:
• geophysical interpretation of magnetic anomalies in relative proximity to the surface trace of the sill,
• a shallow depth to the anomalies and
• Results of an AAPA Sacred Site survey and ease of access to the proposed drill sites.

Folder Figures 3 to 6 comprise a group of images, which illustrate the drillhole locations and their positions relative to the magnetics interpretation.

The three holes were positioned at the following optimum locations. Location coords are in GDA 94 (Zone 53).

• LWDDH1 - 359649E  8012518N (EL 27317). Sited on a mag high, which is one of several that form an elongate arc of mag highs, presumably tracing the edge of the layered intrusion.
• LWDDH2 - 355836E  8013012N (EL 24520). Sited due west of hole 1 in a magnetically flat area. Useful for comparison with the magnetically complex zone on which holes 1 and 3 are located.
• LWDDH3 - 358965E  8014899N (EL 23687). The immediate area is rather complex magnetically. The hole tested the strong linear mag feature that defines the margin of the complex mag domain to the west and the smooth mag domain to the east. This feature
may be a separate intrusive along the domain boundary and independent of the more flat
dipping synenite.

All holes were drilled vertically. See Figures 3 and 5 for the hole positions relative to the
tenement boundaries and to the geophysical features.

8.3 Results and Interpretation

The drill hole locations correlate with target areas that were selected to test geophysical
anomalies exhibiting differing magnetic signatures. The following descriptions and discussion
as to the size of the sill, its composition, mode of emplacement, age and the economic
implications are based on the results of field observations and interpretation of the drill logs,
chemical analyses, petrography and age dating. All drill hole/drill core data can be found in
Appendices 1 to 5.

8.3.1 Petrography of the Sill

The top of the sill is seen in core from a shallow depth in hole LWDDH01. The intrusive rock
textures have been preserved from weathering by the overlying sand and other material. The
feldspathic section comprises large pink orthoclase crystals and smaller crystals of plagioclase
(Photo 6). In thin section the orthoclase crystals have halos of spectacular intergrowths of
myrmekite, perthite and microcline as well as graphic intergrowths. The ferromagnesian
minerals are profoundly altered to hornblende, chlorite and biotite with expulsion of abundant
opaque iron. Some relict pyroxene is evident.

Considerable visual changes in both composition and texture occur toward the middle of the sill. Pink orthoclase is no longer present and ophitic textured pyroxene(s) enclose laths of
plagioclase as the dominant mineral phases (Photo 7). The rock type closer to the middle of the
sill is essentially an alkali gabbro of possible essexite or lherzolite composition. Sections of
core indicate some crystal fractionation has occurred further complicating identification. It was
hoped to get more definitive information on mineral composition and hence the original rock
type from the middle of the sill but the degree of alteration caused by assimilation is
problematic. However, some thin sections show a very mafic rock with ophitic texture in which
bronzite and possible diappライト enclose altered orthoclase and small unaltered
plagioclase laths. A few granules of possible olivine show typical alteration to opaques along
fractures and margins. Principal accessory minerals are apatite and baddeleyite (zirconium
oxide), which occur throughout. Interestingly zircon is not present. The presence of
baddeleyite is interesting in that it is often associated with alkaline igneous complexes such as
carbonatite and layered intrusions of lower crustal/upper mantle derivation, such as the
Bushveld and Stillwater Complexes. Magnetite is thought to be the most abundant of the
magnetic components of the sill.

8.3.2 Proposed Origin and Composition of the Magma

The possibility of a lower crustal-upper mantle origin for the intrusive material could suggest
that the magma was generated proximal to the diamond/graphite stability field, which could
account for the presence of microdiamonds in the streams draining outcrops of the sill. An
original composition for the intrusion could have been lherzolite or alkaline gabbro.

The greatest complication in determining a composition for the primary magma results from the
total assimilation of a thick sediment (siltstone/dolomitic siltstone) sequence by the magma
during passive emplacement. In the Ashburton Ranges, siltstone sequences are estimated to be
100-300 m thick and are interbedded with similar thicknesses of quartz arenite. The only
exposed contact-related effect caused by the intrusion is the unique hexagonal and octagonal jointing in the overlying quartz arenite unit, extending twenty to thirty metres above the sill.

Photo 6. LWDDHO1 @ 61 m showing pink orthoclase, shiny biotite and altered pyroxenes.
Photo 7. LWDDH03 @ 25.2 m showing acicular hornblende after pyroxene, orthoclase, plagioclase and biotite.

8.3.4 Chemistry and Mineralogy

Sixteen samples collected from drill hole LWDDH01 were sent to ALS laboratories for analysis. See Appendix 3 for the tabulation of these results correlated with the sample depths. Several different methods of analysis were used, which are summarised below.

- Au, Pt, Pd: Lab method code PGM-MS24 – FA then ICP-MS finish using a 50 g sample. Detection limit 0.001-1 ppm.
- Ag, Ba, Ce, Co, Cr, Cs, Cu, Dy, Er, Eu, Ga, Gd, Hf, Ho, La, Lu, Mo, Nb, Nd, Ni, Pb, Pr, Rb, Sm, Sn, Sr, Ta, Tb, Th, Ti, Tm, U, V, W, Y, Yb, Zn and Zr: Lab method code ME-MS81 for Rare Earths and Trace Elements. Variable detection limits. Results in ppm.
- As, Bi, Hg, Sb, Se: Lab method code ME-MS42 for ultra-trace level method, 4 acid near-total digestion. Variable low levels of detection. Results in ppm.
- Ag, As, Cd, Co, Cu, Mo, Ni, Pb, Zn: Lab method code ME-4ACD81, fusion with lithium metaborate. Low detection level. Results in ppm.
- SiO2, Fe2O3, CaO, MgO, Na2O, K2O, Cr2O3, TiO2, MnO, P2O5, SrO, BaO: Lab method ME-ICP06, fusion with lithium metaborate. Results in %.
- There were also specific analyses for Carbon, Sulphur and LOI

There were no indications of significant anomalous base or precious metals or PGE. The whole rock analysis (‘oxides’) generally reflect the nature of the rock type, the mineralogical variation of the different phases of the intrusion and the overprinting effect of the alterations observed.
There was one spurious value noted in sample No.146116 (collected bottom of hole) of 28.2 ppm Se over a ‘background’ of <1 ppm in all other samples collected. It does however correlate with an anomalous Cu value of 496 ppm and a geochemical relationship of these two elements in this environment is possible. The presence of finely disseminated sulphides was noted in the core from 124 m, being described as pyrite or possibly arsenopyrite. There is a marginal increase in arsenic over this interval, with the values between 5 and 10 ppm against a ‘background’ of <1 ppm. The presence of visible arsenopyrite should produce much higher levels than the maximum of 10 ppm. A ‘anomalous’ carbon analysis of 0.88% correlates with carbonate vein in sample No.146107.

It is not obvious from a visual scrutiny of the analyses that there has been a dramatic variation in the chemistry or mineral composition of the intrusion’s margins due to assimilation of sedimentary material, especially material that is rich in carbonate (dolomite) and sulphur (gypsum derived). The presence of a pink, feldspar-rich ‘syenite’ at, and adjacent to the upper contact is especially noticeable in the core. This distinctive feldspar component correlates with core samples containing up to 3.5 times K₂O content (approx 2.2 %) compared with samples from other intervals. It has been suggested that the presence of the K-feldspar could be a result of assimilation of the intruded sediment (Seeley 2010), however he also suggests that it could also be a primary feature of the magma. If the former, then what is the potassium source in the sedimentary pile. Could it be sourced from clays derived from the breakdown of older potassic feldspar, or possibly potassic evaporitic minerals dissolved from near surface but present in the sediments at depth?

8.3.5 Age of the Intrusion

A 7 kg sample of core from the central portion of the sill in hole LWDDH03 was submitted for age determination to the Australian National University in Canberra. The work was undertaken by Dr. Mark Fanning of ANU. The sample is No.73501 and was taken from the interval 73.39 to 73.88 m.

A standard heavy mineral separation performed on this rock sample did not yield any zircons. However, a small number of baddeleyite (ZrO₂) grains were observed in the heavy mineral concentrate. A dozen or so of these grains were hand picked and mounted in an epoxy SHRIMP mount together with grains of a reference baddeleyite from the Phalaborwa carbonatite, South Africa, which has an age ~2060 Ma as published by Heaman and Le Cheminant (1993). U-Pb analyses were carried out at ANU in February 2010 using SHRIMP II. The U/Pb ratios have been calibrated relative to the Phalaborwa reference grains. As noted by Wingate and Compston (2000) crystal orientation effects in baddeleyite have a major influence on the 206Pb/238U ratios determined by ion probe. However, the 207Pb/206Pb ratios and ages are robust and are used to determine the crystallisation age for Precambrian baddeleyite.

From the current data set the best estimate for the crystallisation age of the scarce baddeleyite grains recovered from the sample is $1295 \pm 14$ Ma.

A full account of the dating methodology is contained in Appendix 5.
Photo 8. Close up of the upper contact of the sill showing the conformably overlying quartz arenite.
9. Conclusions

Most of the questions regarding the physical and mineralogical properties of the intrusive body have been largely resolved by the data assessment derived from the drilling program. The principal question that remains unanswered is ‘what is the potential for the discovery of economic mineral deposits in a geological setting associated with this type of intrusive body’? There was no indication in the drill core of mineralisation or alteration related to a mineralising episode. Regional exploration (geophysics followed by drilling) outside the boundaries of the company’s current tenements would be required to determine the prospectivity of the interpreted volcanic terrane to the west.
10. Bibliography


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Various Crossland and Paradigm Annual Reports to NTDME