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WEST MUSGRAVE PROJECT
Exploration Incentive Scheme Final Report
DAG2016/00680978

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Introduction

Succoth is a recently discovered, low-MgO, taxite-hosted Cu-(PGE-Ni) deposit located in the West Musgrave Province of Western Australia. The deposit is characterised by a new style of magmatic disseminated Cu-PGE-Ni sulphide mineralisation with Cu:Ni ratios of approximately 10:1. The known mineralisation consists of predominantly low grade, disseminated sulphides. Succoth is in the same project area as the giant Nebo-Babel Ni-Cu deposits (Seat et al. 2007) but the two differ significantly in terms of geology and mineralisation.

Since acquiring the West Musgrave Project from BHPB in 2014, Cassini Resources Limited has been working on improving the understanding of the Succoth deposit and the geology of the project area. The Babylon prospect is located at the western end of the Succoth deposit and at present the relationship between the two intrusions is poorly understood. Babylon and Succoth may represent separate co-magmatic intrusions or may have been an originally continuous intrusive body that was structurally offset post-emplacement.

Under the 2016 Industry Drilling Program, Co-Funded Government Exploration Initiative Scheme, the Department for Mines and Petroleum (DMP) approved a contribution of 50% funding to Cassini in the support of Greenfields exploration within the West Musgrave Project (application number: DAG2016/00680978).

Cassini initially proposed two (2) diamond drill holes for a total of 1,350m within Exploration Licence E69/2201 under the Exploration Initiative Scheme targeting Ni-Cu-PGE mineralisation. In September 2016, Cassini reviewed the original proposal and proposed to substitute the initially proposed two diamond holes with a single 800m-900m hole. This change reflected a review of the geological model, in particular the location of the interpreted major N and NNW trending cross-faults which lie close to and sub-parallel with the previously proposed drill holes. The new hole design optimises the intersection angles between the hole, the strike of the mineralised body and the interpreted major faults. The proposed changes were reviewed and approved by the DMP.

In October and November 2016, a single diamond hole (CZD0011) was completed at Babylon prospect. The entire diamond core has been geologically and geotechnically logged, and a series of 104 intervals comprehensively assayed ($\frac{1}{4}$ and $\frac{1}{2}$ core). Only minor disseminated sulphide mineralisation was intersected and the hole was drilled to a final depth of 791.9m. Detailed geological logging and validation was completed in March 2017.

All analytical data and interpretations are included in the Appendix to this report.

Regional Geology

The Musgrave Block is a Mesoproterozoic, east-west trending orogenic belt in central Australia. It comprises a variety of high grade (amphibolite to granulite facies) basement lithologies overprinted by several major tectonic episodes, and intruded by granitoid plutons, layered mafic to ultramafic intrusions of the Giles Complex and mafic dykes (Glikson et al. 1995; 1996; Howard et al. 2009; Smithies et al. 2011 and references therein).

Reviews of the geology of the Musgrave Block are provided by Glikson et al. (1995; 1996, and references therein) and a comprehensive review including recent geochronological data is given in Howard et al. (2015).

Basement

The early tectonic history of the Musgrave Block has proved difficult to define, but there is isotopic evidence for major crust forming events at 1900 Ma and 1600-1550 Ma (Kirkland et al. 2012) and magmatism at ca. 1400 Ma (Howard et al. 2011). The first event with an established tectonic setting was the Mt West Orogeny at 1345-1293 Ma, which resulted in the emplacement of widespread granites of the Wankanki Supersuite and coeval sedimentary and volcanic rocks of the Wirku Metamorphics (Howard et al. 2009). The Wankanki Supersuite granites have formed in the continental arc setting (Smithies et al. 2011) and the Mt West Orogeny represents convergence of the South, North and West Australian Cratons (Myers et al. 1996). The Musgrave Orogeny (ca. 1220-1150 Ma) is characterised by widespread, ultra-high temperature metamorphism and voluminous granitic magmatism of the Pitjantjatjara Supersuite (Smithies et al. 2011).

In the Succoth area, the dominant basement lithologies are amphibolite to granulite facies mafic meta-volcanic rocks (the View Hill amphibolite) and less commonly felsic meta-volcanic rocks which have locally been observed associated with thin sulphidic chert horizons. All of these lithologies, are interpreted to form part of the Wirku Metamorphics (1345-1293 Ma), which have been metamorphosed during the long-lived Musgrave Orogeny (ca. 1220-1150 Ma).

The Giles Event (Ngaanyatjarra Rift)

The long-lived Giles Event (1085-1040Ma; Howard et al. 2011; 2015) also called the Ngaanyatjarra Rift by Aitken et al. (2013), has only been recognised in the Musgrave Block. This large-scale event, apparently initiated through renewed movement along trans-lithospheric faults, was associated with emplacement of major mafic-ultramafic Giles Suite layered intrusions (Bell Rock, Blackstone, Jameson-Finlay), voluminous gabbros and granitoids, and extrusion of a 5 km thick package of Bentley Supergroup bimodal volcanic rocks in the Palgrave Cauldron area west of Babel (Smithies et al. 2013). This event has been ascribed to generation of magmas associated with crustal thickening, delamination and gravitational collapse of the crustal column, followed by asthenospheric ascent and ponding of mafic melt at the crust–mantle interface, rather than a mantle plume (Aitken et al. 2013). Both the Nebo-Babel and Succoth mineralisation are associated with mafic chonoliths that were emplaced during this event. Partitioned, but locally intense ductile deformation, is now recognised as occurring penecontemporaneously with emplacement of Giles Event magmatic rocks (Howard et al. 2009; Aitken et al. 2013) and has modified the present day geometry of the Succoth mineralised intrusion in particular. Swarms of dolerite and rarer troctolite dykes are abundant in the West Musgraves (Godel et al. 2011; Howard et al. 2015) and are of several generations including syn-Giles Event (e.g. Alcurra Suite) and post-Giles dykes e.g. Kullal (ca. 1000 Ma) and Gairdner dyke Suites (827-824 Ma).

The Petermann Orogeny

Following the emplacement of the mafic dyke suites, a major intercratonic event, the Petermann Orogeny, occurred at ca. 570-530 Ma (Scrimgeour et al. 1999, Camacho and McDougall, 2000), producing widespread mylonitic fabrics within major shear zones throughout the Musgrave Block (Camacho et al. 1997). The degree of deformation and metamorphism in layered intrusions decreases from east to west (e.g. Glikson et al. 1996), and in the Nebo-Babel and Succoth areas the Petermann Orogeny may have reactivated earlier structures and resulted in N-S brittle faulting.

Co-funded Drilling Program

Project Summary

The disseminated mineralisation at Succoth/Babylon prospects is Cu dominated. Massive sulphides are rare and are either chalcopyrite-rich or pyrrhotite-rich, the latter containing significant pentlandite (1-3 wt% Ni). Succoth/ Babylon PGE data are utilised in chondrite-normalised PGE plots for disseminated, Cu-rich mineralisation and massive Cu-Ni sulphides. Massive sulphides from Succoth/Babylon show markedly different patterns, as well as far higher Ni:Cu ratios, when compared to the disseminated mineralisation.

Given that Succoth/Babylon mineralisation is magmatic in origin, there are two fundamental processes that could result in Succoth-type Cu-PGE mineralisation. Partial melting of primitive mantle can result in mafic magmas with Cu > Ni and a PGE signature enriched in PPGE relative to IPGE owing to the presence of two discrete PGE phases in the mantle source; the PPGE-rich liquid phase preferentially being carried by the migrating melt phase. Alternatively, given the presence in the same terrane of both Cu-Ni (Nebo-Babel) and Cu-rich mineralisation there also exists a strong potential for a sulphide melt to have fractionated into separate Cu- and Ni-rich melts, as is invoked to occur on a large-scale in the Norilsk-Talnakh system, Russia, in the offset orebodies at Sudbury, and at No. 24 orebody at Jinchuan. Fractionation and migration of a Cu-rich melt from a Ni-Cu-PGE sulphide parent can result in identical metal ratios to those seen in Succoth. This current exploration model for Succoth and Babylon implies presence of a Ni-rich orebody somewhere nearby.

The strongest evidence for Ni-rich mineralisation within the Succoth mineralised complex is at the Babylon prospect with intersections of 1.96% Ni where Ni-rich mineralisation occurs as xenoliths in late dolerites. This model implies presence of Ni-rich massive sulphides at depth within the Babylon prospect.

The above proposed model implies sulphide liquid fractionation and is supported by the existence of Ni-rich sulphide mineralisation. As part of the 2016 exploration programme, a single diamond drill hole was designed to test stratigraphy at much deeper levels compared to any previous drilling. At the completion of the first hole, a high-powered down-hole EM survey would be completed to test for any EM conductors, which may represent massive sulphides.

Methodology

A single diamond drillhole (CZD0011) was completed for 791.9 metres within Exploration Licence E 69/2201 at the Babylon Prospect between the 29th October and the 18th November 2016.

- Diamond coring was from surface.
- Orientation marks were done every run once in competent ground.
- PQ3 size core was drilled from surface to 132.2 m down hole depth, following by HQ2 (chrome barrel) down to 491.5 m, and finally NQ2 (chrome barrel) was completed to the end of hole (791.9 m).
- A REFLEX EZ-TRAC gyroscope orientation shoots were completed approximately every 15 m. Stated accuracy is $\pm 0.35^\circ$ in azimuth and $\pm 0.25^\circ$ in inclination.
- The entire diamond core has been geologically and geotechnically logged.
- Selected intervals (a total of 104) were assayed for a comprehensive suite of elements.
- A summary log with main lithological units has been completed in 2016 and a more detailed log with the benefit of assay data was completed in March 2017. Minor disseminated sulphide mineralisation was intersected. The hole has been cased with 4 mm PVC for subsequent down-hole EM survey.
- The drill core has been transferred from Cassini's West Musgrave Camp to Perth for submission to the WA Geological Survey core library. All of the data and interpretations are presented in this report.

Assay Methods

Whole rock geochemistry was undertaken on quarter core samples (for PQ diameter core) and on half core samples (for HQ2 and NQ2 diameter core) cut on an Almonte core saw, and submitted to Bureau Veritas (Ultra Trace), Canning Vale, Western Australia. The analytical suite consisted of a combination of fused bead X-ray fluorescence (for whole rock elements Al, Ba, Ca, Cr, Fe, K, Mg, Mn, P, Si, S, Ti, V and Zr), four acid digest (hydrochloric, nitric, hydrofluoric and perchloric acid) followed by an ICP-AES and ICP-MS finish (for Co, Cu, Zn, Ni, Na, As, and Nb), and fire assay with a silver secondary collector and ICP-MS finish for Pt, Pd and Au. Loss on ignition (LOI) was measured gravimetrically at 1000°C. The analytical suite utilised a 12:22 flux for XRF fused bead production, consisting of 31.5% lithium tetraborate, 58.5% lithium metaborate and 10% lithium nitrate. Internal standards and blanks were inserted by Cassini contract geologists.

Results

GEOLOGY

Results of the 2016 West Musgrave Project co-funded diamond drill programme within Exploration Licence E69/2201 are in Appendix 1. These results include: summary geological, alteration and structural logs, and collar and survey files. Plan and cross section views of the drill hole are given in Figure 1 and 2.

Based on the most recent logging of CZD0011, the summarised geology is as follows:

0 – 6 metres: Surficial unconsolidated and weakly cemented **sands**.

6 – 19.8 metres: Variably calcrete-cemented **pisolithic material** and pebble-sized **rock fragments**.

19.8 – 156.6 metres: Medium-grained to coarse-grained **meta-leucogabbro**, similar to and probably genetically related to a meta-anorthosite unit present in Succoth where it is termed the ICR Unit. This unit is more magnesian and is incipiently joint-plane weathered down to 39 metres. It is cross-cut by numerous late dolerite dykes and at 144.7 to 144.9m is cross-cut by a well-zoned felsic pegmatite. Rare xenoliths of felsic volcanic rocks are present.

156.6 – 177.1 metres: Fine-grained, chlorite-altered and fractured **dolerite**.

177.1 – 221.8 metres: A medium-grained **mela-troctolite to peridotite** unit (with MgO up to 22 wt%) which appears to be relatively late-stage e.g. a dyke, and has a faulted upper contact.

221.8 – 246.8 metres: A sharp contact between the ultramafic unit and the **meta-leucogabbro** is present at 221.8m. The meta-leucogabbro near this contact is weakly mineralised with disseminations and wisps of chalcopyrite. This narrow, mineralised interval (222 – 225.15 m downhole) includes the peak Cu and Ni assays in the drill hole, 1 metre at 0.80% Cu, 0.11% Ni, 242 ppb Pd and 127 ppb Pt from 222 m.

246.8 – 259.6 metres: **Dolerite** body, veined, fractured and chlorite altered. Veins mainly calcite and zeolites. Some xenolithic blocks of meta-leucogabbro present.

259.6 – 262.1 metres: Medium-grained **meta-gabbro**.

262.1 – 264.3 metres: **Dolerite** with some intermixed meta-gabbro.

264.3 – 292.1 metres: **Meta-gabbro** unit generally coarse-grained to medium grained. Cross-cutting dolerite dykes are present.

292.1 – 315.1 metres: Large body of fine-grained (locally medium-grained) **dolerite**.

315.1 – 328.0 metres: Coarse-grained to medium-grained **meta-gabbro** unit with increasing felsic influence down-hole in the form of patches and partly-resorbed xenoliths of felsic meta-volcanics.

328.0 – 329.5 metres: **Dolerite**.

329.5 – 340.75 metres: **Amphibolite** to **intermediate** pre-Giles country rock. Medium-grained and locally orange-brown altered.

340.75 – 354 metres: Glomerocrystic (plagioclase) **dolerite**.

354 – 417.95 metres: Medium- coarse-grained **meta-gabbro** unit interspersed with fine-grained cross-cutting dolerite.

417.95 – 432.2 metres: Foliated **amphibolite**, fine-grained to medium-grained (1 mm).

432.2 – 496 metres: Sheared contact with strongly foliated and gneissic-textures **meta-gabbro**.

496 – 496.4 metres: **Dolerite**.

496.4 – 499 metres: **Intermediate Gneiss** unit.

499 – 500.1 metres: **Meta-gabbro** unit.

500.1 – 528.5 metres: Fine-grained **dolerite** with medium-grained (1 mm) core zone.

528.5 – 602.9 metres: Variably-foliated **meta-gabbro** unit, medium- to coarse-grained, with cross-cutting dolerites.

602.9 – 605 metres: Sharp contact with **felsic meta-volcanic** unit. This unit grades imperceptibly into the felsic gneiss unit below.

605 – 613 metres: **Felsic gneiss**.

613 – 614.25 metres: **Felsic meta-volcanic** unit with some quartz veining.

614.25 – 614.85 metres: **Dolerite**.

614.85 – 615.4 metres: **Felsic gneiss**.

615.4 – 633 metres: Fine-grained **dolerite** with medium-grained (1 mm) core zone.

633 – 646.75 metres: Vari-textured to taxitic **meta-gabbro** unit. A trace of chalcopyrite was noted in this unit.

646.75 – 666.0 metres: Fine-grained **dolerite** with medium-grained (1 mm) core zone.

666.0 – 710.5 metres: Dark-grey, foliated, medium to coarse-grained mafic to intermediate **meta-gabbroic** unit.

710.5 – 728.4 metres: Fine-grained, foliated **amphibolite**.

728.4 – 787.3 metres: Coarse to medium-grained vari-textured **meta-gabbro**. Probable intercalations with felsic units near the lower part of the intersection.

787.3 – 791.9 metres: Fine-grained **dolerite**.

This sequence is interpreted to represent pre-Giles country units (e.g. amphibolite, felsic gneiss, felsic meta-volcanics, intermediate gneiss), which have been intruded by Giles Event (leuco-) gabbro (-norite) and subsequently metamorphosed. We interpret the metamorphism to have occurred during the Giles Event. Later cross-cutting igneous rocks are represented by dolerites and the ultramafic unit, although some dolerites are probably pre-metamorphic and show signs of ductile deformation and foliation development. Examples of typical rock textures are given in Figures 3 to 6.

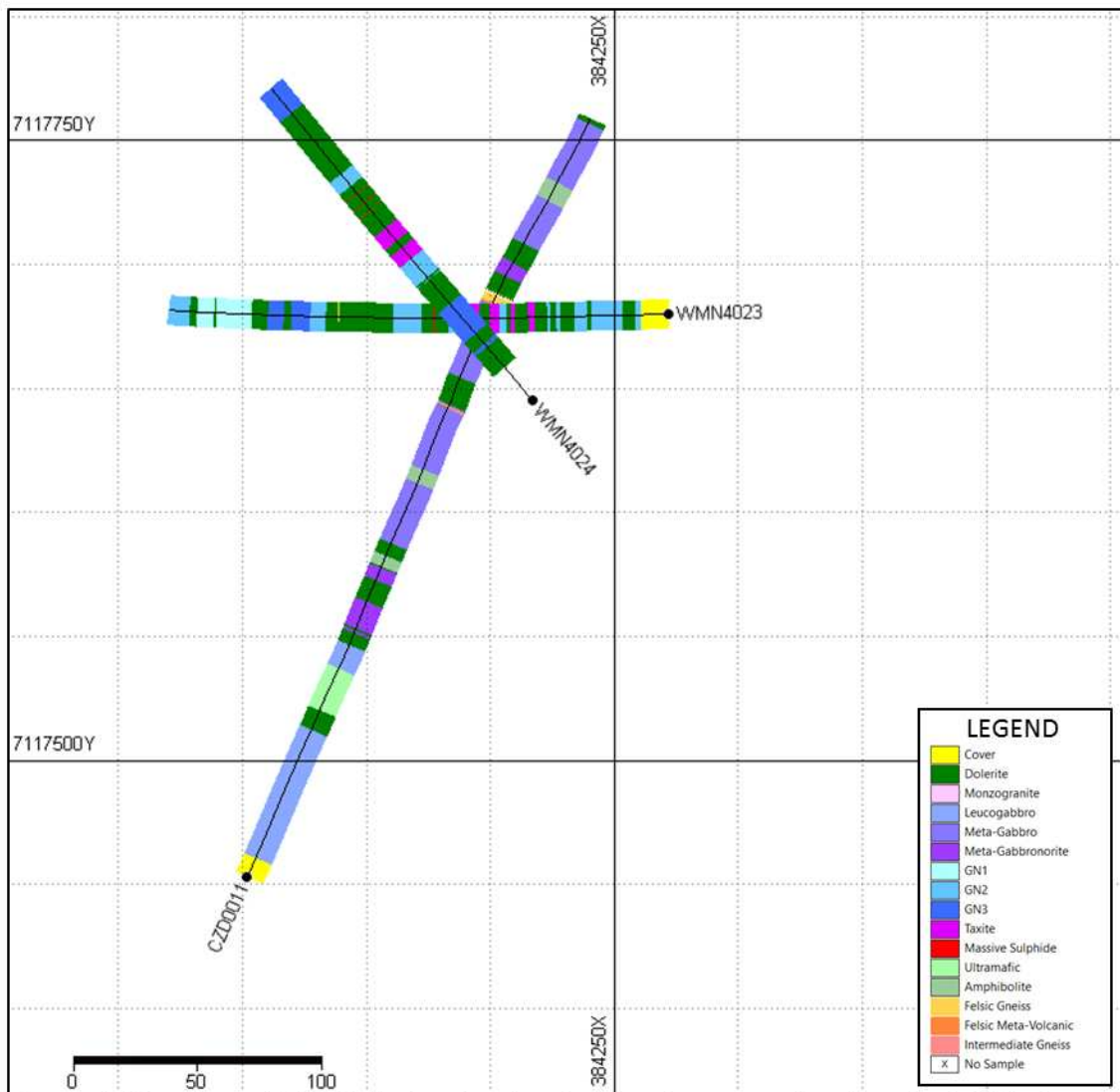


Figure 1: Plan view of CZD0011 showing downhole geology as well as historical drill holes WMN4023 and WMN4024. Codes GN1, GN2, GN3 are Cassini internal codes for specific Giles Event meta-gabbronorites.

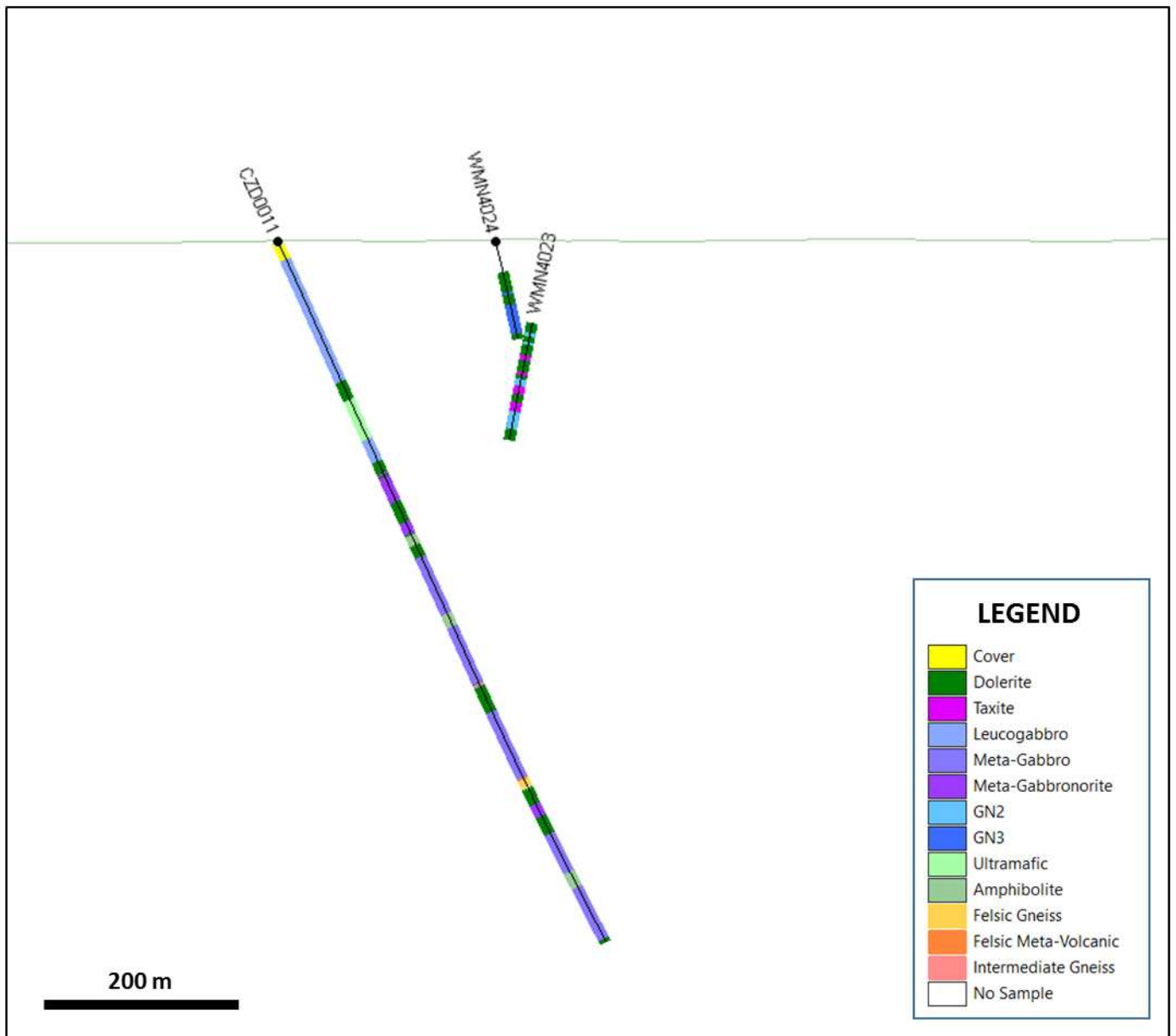


Figure 2: Oblique northwest-looking section showing downhole geology in CZD0011. Codes GN2 and GN3 are Cassini internal codes for specific Giles Event meta-gabbroonorites.



Figure 3: Coarse-grained meta-leucogabbro at 221.8 metres down hole showing blocky plagioclase habit and minor wispy chalcopyrite.



Figure 4: Typical peridotite at 206.5 metres showing flow-alignment of blocky plagioclase crystals in a finer-grained ground mass of olivine and minor clinopyroxene.



Figure 5: Typical medium-grained meta-gabbronorite at 261 metres.



Figure 6: Sharp intrusive contact preserved between felsic meta-volcanic (left) and meta-gabbro (right) at 602.9 metres. Note truncation of quartz veins in the former.

STRUCTURE

Structural measurements on CZD0011 were carried out by Grant Osborne of Geosborne Pty Ltd. A full report is included in the appendix to this report, and this work is summarised here. A total of 95 structural observations (93 measurements) were obtained from the drill hole. The majority of the core was marked with an orientation line along the top of the core, but orientation data was missing locally in zones of shears or faults where the orientation tool failed due to incompetent core. Data was collected using the CoreMap orientation device which permits direct observation of planar and linear fabrics whilst the core is held in the exact orientation of the drill hole at each depth. Only the contact, foliation and fracture datasets contained enough readings to be statistically valid.

Contact data comprised two types; contacts between dolerites and other lithologies (n=32) and contacts between pegmatite and other lithologies, with no contacts between pegmatite and dolerite observed. The average dip of the dolerite was 62°/156°, and two of the five felsic intrusives (pegmatites) also had this orientation. The remaining felsic intrusives dipped approximately 30°/336° and 90°/210°, and this orientation was also measured on a dolerite dyke. It may be, or not, significant that the dolerite and pegmatite are orthogonal to each other (88° interplanar angle). The dolerite orientation is parallel to the Barrow Range Cavenagh Corridor and this suggests it may have intruded parallel to the regional foliation of the pre-Giles Complex wall rocks which are also known to dip to the SE.

The majority of the 27 **foliation measurements** were taken in foliated Giles Intrusive Complex rocks as only 34m of the hole (4%) intersected wall rocks (felsic meta-volcanics or amphibolite). The average dip of the foliation was well constrained at 59°/198°, at an angle of 56° to the orientation of drill hole CZD0011 (dipping 65° towards azimuth 022°).

The 22 **fracture measurements** were distributed around the margin of the stereonet with a mean orientation of 87°/345°. Steep fracturing is common suggesting the fractures developed during an extensional phase, possibly related with relaxation along the Barrow Range Cavenagh Corridor during NW-SE extension (=Late Rift 2 stage of Aitken et al, 2013).

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