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Drillhole report for MURD002 Murphy Inlier, Northern Territory: National Virtual Core Library NTGS Node: HyLogger 2–7

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Drillhole report for MURD002, Murphy Inlier, Northern Territory: National Virtual Core Library NTGS Node: HyLogger 2–7.


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INTRODUCTION

The National Virtual Core Library (NVCL) is a collaborative research infrastructure project funded by the Commonwealth Government’s ‘National Collaborative Research Infrastructure Strategy (NCRIS)’ within the Department of Innovation, Industry Science and Research. The project is one component of the earth sciences platform managed through AuScope Ltd and implemented by CSIRO and all State and Territory geological surveys.

The NVCL project has the goal of progressively building a high-resolution hyperspectral and digital image of earth materials and properties for the upper one to two kilometres of the Australian continent, and facilitating world-class geoscience research. The HyLogger instrument rapidly measures reflectance spectra and also captures continuous high-resolution digital colour imagery of drill cores in their original trays. HyLogger 2-7 is a ‘Version 2’ HyLogger instrument, and is the seventh machine built by CSIRO. Further information about the HyLogger (specifications and capabilities) is within Mason and Huntington (2010).

The Northern Territory Geological Survey (NTGS) is producing a record of HyLogger results for each drillhole that is scanned from the NTGS core facility collection. The HyLogger data is presented with reference to other known information, such as logged geology and assays (if available). If the hole was submitted to the government by a company, then the additional drillhole information provided in this report (coordinates, geological logs, assays, additional data) was sourced from the relevant company statutory reports. NTGS makes no assurances on the accuracy or quality of the lithological logs, assays, etc and further information should be sourced from the relevant company report. This report does not validate company-supplied data, but is referenced to give context to the HyLogger results.

For this report, the additional data (lithological logs, assay data) was sourced from the Bondi Mining company report (Esser 2009).

REGIONAL GEOLOGY

The following description is derived from Esser (2009).

The oldest rocks in the region are the Palaeoproterozoic Murphy Metamorphics, which form the basal unit of the Murphy Inlier, and consist of isoclinally folded greenschist facies metasediments; typically quartz-feldspar-mica schists and gneiss with minor graphitic units. The Murphy Metamorphics form the core of the ‘Murphy Tectonic Ridge’ and only outcrop in the Northern Territory portion of the inlier.

The northern margin of the Murphy Inlier is unconformably overlain by the Westmoreland Conglomerate, which is the oldest unit in the Palaeoproterozoic Tawallah Group, and marks the base of the southern portion of the McArthur Basin.

The Seigal Volcanics lie conformably on top of the Westmoreland Conglomerate and consist of massive and amygdaloidal tholeiitic basaltic lavas with minor interbedded siltstones and sandstones. A thin shale bed is commonly found at the base of the Seigal Volcanics and marks the hiatus between deposition of the Westmoreland Conglomerate and the start of volcanism.

Structurally, the region is cut by a dominantly northwest-trending series of faults and joints paralleling the Calvert Fault. Possible north-northwest-trending extensions of the Emu Fault also pass through the west side of the region under the Phanerozoic cover. A second set of northeast-trending faults can also be seen paralleling the structural trend of the Murphy Tectonic Ridge. Both sets of faults commonly consist of high angle normal and reverse faults whose intersection appears to form structural blocks displaying horizontal movement and/or tilting. Lateral movement is also common in the northwest-trending structures. Numerous mafic, commonly doleritic, dykes parallel the faulting and are thought to be coegenetic with the Proterozoic volcanics of the Tawallah Group.

LOGGED GEOLOGY

The following description is derived from Esser (2009).

MURD002 (Figure 1) was part of a regional exploration drilling program designed to test a shallow eU3O8 anomaly and a major northwest-trending fault at the UCI9 target.

Logged lithologies in MURD002 include:

a) Cenozoic fine-grained mudstone (now clay) and chert to a depth of 10 m;

b) medium-grained quartzites of the Westmoreland Conglomerate to 54 m;

c) a coarse-grained, anorthite phric gabroic dyke to 202.25 m;

HOLE SPECIFICATIONS

<table>
<thead>
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<th>Hole ID</th>
<th>MURD002</th>
<th>Unique Identifier</th>
<th>785325</th>
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<td>Geological Terrain</td>
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<td>Total Depth</td>
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<tr>
<td>Latitude_GDA94</td>
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<td>Longitude_GDA94</td>
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</tr>
<tr>
<td>94MGA_Easting</td>
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<td>94MGA_Northing</td>
<td>8038216</td>
</tr>
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</tr>
<tr>
<td>Dip</td>
<td>-60°</td>
<td>Azimuth</td>
<td>208.1 (True)</td>
</tr>
<tr>
<td>Logged By</td>
<td>Bondi Mining</td>
<td>Logged Report Ref</td>
<td>CR2009-0953</td>
</tr>
<tr>
<td>Start Core Depth</td>
<td>101.5 m</td>
<td>End Core Depth</td>
<td>556.1 m</td>
</tr>
<tr>
<td>Date HyLogged</td>
<td>8 March 2010</td>
<td>HyLogged By</td>
<td>Darren Bowbridge</td>
</tr>
<tr>
<td>Date of HyLogger Report</td>
<td>16 September 2010</td>
<td>HyLogger Report Author</td>
<td>Belinda Smith / Jon Huntington</td>
</tr>
</tbody>
</table>
d) highly silicified Westmoreland Conglomerate quartzites to 385.4 m;
e) a coarse-grained gabbroic dyke to 541.25 m; and
f) silicified Westmoreland Conglomerate quartzites to the end of hole at 556.1 m.

Logged alteration in this hole includes:

- hematisation within the upper Westmoreland conglomerate unit;
- hematisation, and chlorite alteration in the upper anorthite phyric gabbro;
- intense silicification, minor clay alteration, and hematisation within the intermediate Westmoreland Conglomerate;
- strong brick red hematisation and associated carbonate veining / brecciation, and chloritisation of the lower gabbro; and
- intense silicification and hematisation in the lower Westmoreland Conglomerate.

Brick red hematisation and calcite veining is coincident with notable anomalism in eU/O values within the lower altered gabbro. Chalcocite copper mineralisation was clearly visible in the carbonate veins in the intensely hematitic zones of the lower gabbro.

**OTHER WORK (PETROGRAPHY, GEOCHEMISTRY)**

Bondi Mining reported that MURD002 intersected ‘significant’ uranium and copper mineralisation in the lower gabbro. The copper mineral is dominantly chalcocite, which is up to 30% in narrow bands several centimetres wide and often strongly fractured to brecciated. The mineralised interval included 99 m at 1260 ppm Cu and 14.2 ppm U between 405 to 504 m, including 2 m at 1% Cu and 85 ppm U from 447 m.

**HYLOGGER RESULTS**

The core was scanned by the HyLogger 2–7 in Darwin. HyLogger specifications and raw data specifications are in Mason and Huntington (2010). Level 1-processed TSG data can also be requested (available for viewing using TSG Viewer – [http://www.thespectralgeologist.com/](http://www.thespectralgeologist.com/) ) and in late 2011 will also be available via the NVCL Database.
Please request the TSG data using Unique key ID, plus Hole ID (ie, 7853525_MURD002) from NTGGS.

**General mineralogy**

Figures 2 and 3 summarise the downhole mineralogy in MURD002. The spatial patterns clearly reflect the two main logged units within the drillcore:

- gabbro units (101.5–202.25 m; then 385.4–541.25 m) alternating with
- quartzites from the Westmoreland Conglomerate (202.25–385.4 m; then 541.25 m to EOH).

The Bondi Mining report summary recorded ‘intense silification, quartz-sericite alteration and minor clay alteration’ within the upper Westmoreland Conglomerate unit. The spectral response indicates that the ‘sericite’ is dominantly muscovite. The gabbro units show a mix of chlorites, phengite, muscovite, with the upper gabbro unit indicating more magnesian mineralogy (Mg clays, Mg chlorite and amphiboles) compared with the lower gabbro unit.

The FeOx response is mainly restricted to the Westmoreland Conglomerate quartzites (202–385 m) which was logged as ‘hematisation in the upper Westmoreland unit’. Intervals in the lower gabbro noted as ‘strongly hematitic’ don’t show as hematitic in the VISNIR response. However, the core colour intensity plus the FeOx intensity (from the FeOx intensity scalar) indicates a wider interval of Fe response (Figure 4). The Fe response could be due to FeOx alteration or due to the presence of Fe-rich minerals (such as Fe chlorites and phengite). The lower part of the upper gabbro shows the least amount of FeOx alteration (approximately 139–202 m).

**Spatial patterns in mineral distribution**

As mentioned above, the mineralogical domains reflect the alternating logged lithologies of gabbro and quartzites (Figures 2–6). The quartzite units (202–385 m; 541–556 m) indicate muscovite (2199 nm AIOH wavelength) with possible minor paragonite (Figure 5). There is little to differentiate the two quartzite units; there is an indication of minor kaolinite in the lower quartzite. The two gabbro units seem mineralogically different to each other. The upper gabbro unit has indications of MgOH minerals, such as Mg chlorite, Mg clays and hornblende, which are absent in the lower gabbro unit (Figure 6). The logged geology notes a change at around 135 m, from a leucogabbro (101.5–135 m) to a gabbroic dyke (135–199.3 m). The HyLogger results show a mineralogy change at around 133 m, changing from Fe-chlorite to Mg chlorite (Figure 6).

**White Mica Distribution**

White mica distribution in MURD002 is shown in Figures 7 and 8. The white mica distribution appears to have two distributions; the main muscovite / paragonite distribution centred around 2199 nm and a smaller population of phengite centred around 2216 nm (Figure 7). The main muscovite / paragonite micas are almost exclusively found within the quartzite units of the Westmoreland Conglomerate (Figure 8) which contrasts with the longer wavelength illitic muscovite, illitic phengite and phengites within both gabbro units. It is also worth noting that apart from the illitic phengite mapped at the gabbro / quartzite contacts, the lower gabbro contains illitic phengite (within the zone coincident with elevated Cu and U; approximately 405–485 m). The upper gabbro does not have this illitic phengite away from the gabbro/quartzite contact.

**Carbonate Distribution**

Esser (2009) noted chalcocite copper mineralisation within the carbonate veins. The logs note “gabbro that has been intensely veined by antitaxial veining – blown apart….drusy and sigmoidal”. Figure 9 shows that there is one interval of dolomite that corresponds with the logged carbonate interval with mineralisation from 409–410 m, with the dolomite being notable in this interval of what is otherwise phengite or FeMg chlorite.

**Imaging results**

Core tray images (Figure 10) and a hole mosaic image (Appendix 1) are available as jpeg files. The jpeg resolution of the core tray images is set at 4000 pixels per metre (approximately 5 Mb file size per tray) to allow zooming in on the image without losing resolution. The hole mosaic image has a resolution of 1000 pixels per metre (37Mb file size). The whole of hole image can also be seen in Figure 3 and Appendix 1. The colour changes reflect the different lithologies, with the Westmoreland Conglomerate contrasting against the gabbro units. It is also interesting...
Figure 3. MURD002 from the TSG ‘hole’ screen; this summary screen is available as a pdf file, upon request. Column 1 is the hole mosaic; Column 2 shows the logged geology taken from Bondi Mining logs. Column 3 shows the dominant mineral down the hole. Column 4 shows the Fe Oxides identified in the VNIR spectrum.
Figure 4. Fe intensity and Fe Oxides (hematite and goethite) in MURD002. Top plot is logged lithology. Fe Oxides plot only in the quartzites of the Westmoreland Conglomerate (Plot 2) however the FeOx intensity (Plots 3 and 4) is throughout much of the drillhole. Plot 3 shows the FeOx intensity with TSA-assigned Fe Oxides. The grey colour (Other) represents spectra that do not match the hematite and goethite in the TSA library (‘Not In Library’ etc) but still have an Fe response in the VNIR. Plot 4 shows the SWIR mineral response for the FeOx intensity. There are no Fe-rich mineralogies within the quartzite units (which are dominantly muscovite and paragonite) that may explain the FeOx intensity. Within the lower gabbro is Fe chlorite and phengite, which may partly contribute to the FeOx response.
Figure 5. Hole summary (downhole from left to right), showing lithology in top row (dark purple = gabbro; pale mauve = quartzite). White micas show dominantly muscovite in quartzite units while the lower gabbro has a mix of muscovite and phengite (plus illitic muscovite and illitic phengite). Chlorites are absent from the quartzite, while Fe Oxides show most strongly in the middle quartzite unit.
Figure 6. Hole summary showing logged lithology in top row and distribution of magnesian mineralogy within the upper gabbro unit. Amphiboles, Mg clays and Mg chlorite are concentrated in the upper gabbro.
Figure 7. White mica population distribution in MURD002. There appears to be two populations of white mica centred around 2198 nm (muscovite) and a smaller 2217 m (phengite) population.
Figure 8. White mica distribution downhole of MURD002. The quartzite is dominantly muscovite-rich, with the main quartzite unit from 203–385 m being of relatively uniform composition and distribution. The contacts of the middle quartzite unit with the upper and lower gabbro is characterised by illitic phengite, and lesser phengite. The lower gabbro unit has a concentration of phengite associated with the strongly altered, mineralised portion (405–485 m) whereas the upper gabbro has no phengite other than on the contact. The phengite in the lower gabbro is irregularly distributed, with sharp zones of no white mica at 499–511 m.
Figure 9. (a) Distribution of carbonate minerals within MURD002. The most notable interval of dolomite around 409–410 m in the lower gabbro unit corresponds with anomalous Cu and U assays. (b) Core imagery from this interval.
to compare the gabbro units; the upper gabbro unit seems more melanocratic than the lower gabbro unit. The lower gabbro unit does not seem to have the uniformity of colour, which may reflect variable alteration noted in logging.

CONCLUSIONS AND/OR FURTHER WORK

The HyLogged mineralogy reflects both broad-scale lithological changes (between gabbro and quartzites) as well as identifying differences between the upper and lower gabbro units, as well as the heterogeneity of the upper gabbro unit. Further examination of these mineralogical domains may give a greater understanding of the nature of the gabbro units intersected in MURD002.

The lower mineralised portion of the gabbro is characterised by longer wavelength (phengitic) white micas, plus a zone of dolomite–hosted chalcocite. The interval has FeOx alteration, but not the hematite or goethite within the TSA library.

REFERENCES

## Glossary of acronyms and technical terms commonly used in HyLogging spectroscopy.

<table>
<thead>
<tr>
<th>Acronym</th>
<th>Definition</th>
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<tbody>
<tr>
<td>Albedo</td>
<td>Normally applied to the mean broadband brightness of a spectrum over a specified wavelength range. A white or altered sample will commonly have a high albedo, whereas a graphitic rock will have a very low albedo.</td>
</tr>
<tr>
<td>AlOH</td>
<td>Aluminium hydroxide.</td>
</tr>
<tr>
<td>CCD</td>
<td>Charge coupled device.</td>
</tr>
<tr>
<td>FTIR</td>
<td>Fourier transform infrared spectrometer.</td>
</tr>
<tr>
<td>HgCdTe</td>
<td>Mercury Cadmium Telluride used in infrared detectors.</td>
</tr>
<tr>
<td>HQ</td>
<td>Shorthand for hull quotient (a type of background corrected spectrum).</td>
</tr>
<tr>
<td>IFOV</td>
<td>Instantaneous field of view (of an instrument).</td>
</tr>
<tr>
<td>InSb</td>
<td>Indium antimonide – used in infrared detectors.</td>
</tr>
<tr>
<td>LN₂</td>
<td>Liquid nitrogen.</td>
</tr>
<tr>
<td>MCT</td>
<td>Mercury Cadmium Telluride used in infrared detectors.</td>
</tr>
<tr>
<td>MgOH</td>
<td>Magnesium hydroxide.</td>
</tr>
<tr>
<td>MIR</td>
<td>Mid infrared.</td>
</tr>
<tr>
<td>nm</td>
<td>Nanometre, being one billionth of a metre. A HyLogger 2 operates between 380 and 2500 nm.</td>
</tr>
<tr>
<td>Ref</td>
<td>Abbreviation for reflectance.</td>
</tr>
<tr>
<td>SNR</td>
<td>Signal-to-noise ratio.</td>
</tr>
<tr>
<td>SRSS</td>
<td>Standardised residual sum of squares (TSA’s measure of mineral identification error). Low SRSS values are more reliable than high ones. The current ‘bad’ threshold is 1000.</td>
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<tr>
<td>SWIR</td>
<td>Shortwave infrared (light). Nominally covering the range 1000–2500 nm.</td>
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<tr>
<td>TSA</td>
<td>‘The Spectral Assistant’ – CSIRO trademarked algorithm that uses training libraries of pure spectra to match an unknown spectrum to a single mineral or to identify a mixture of two minerals. Part of the TSG software package.</td>
</tr>
<tr>
<td>TSG</td>
<td>‘The Spectral Geologist’ – CSIRO-developed specialist processing software, designed for analysis of field or laboratory spectrometer data.</td>
</tr>
<tr>
<td>TIR</td>
<td>Thermal infrared (light). Nominally covering the range 6000–14000 nm.</td>
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<tr>
<td>um or µm</td>
<td>Micrometre (formerly micron), being one millionth of a metre. A HyLogger 2 operates between 0.38 and 2.5 micrometres.</td>
</tr>
<tr>
<td>Vis</td>
<td>Visible (light). The human eye is nominally sensitive between 390 and 750 nm.</td>
</tr>
<tr>
<td>VNIR</td>
<td>Visible near infrared (light). Nominally covering the range 380–1000 nm.</td>
</tr>
<tr>
<td>wvl</td>
<td>Abbreviation for wavelength, found in TSG scalar names.</td>
</tr>
<tr>
<td>λ</td>
<td>Lambda – Often used as a symbol for wavelength of light.</td>
</tr>
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Appendix 1. Hole mosaic of MURD002, with Trays 1–5 on top row; Trays 6–10 on second row etc until end of hole.