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Drillhole report for CHDDH102, Pine Creek Orogen, 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 lithological logs were sourced from Eupene (2003) with some checking against BHP (1985).

REGIONAL GEOLOGY

The following description is derived from Carville et al (1990).

Coronation Hill is located within the South Alligator Valley, which is part of the Pine Creek Orogen (Figure 1). The South Alligator Valley is a northwest-trending fault-bounded valley where downfaulted Palaeoproterozoic sediments (such as the Mundowie Sandstone, Koolpin Formation, Coronation Sandstone, Pul Pul Rhyolite, Kurrundie Sandstone and Plum Tree Volcanics) are unconformably overlain by Palaeoproterozoic Kombolgie Subgroup sediments.

A quartz-feldspar porphyry noted from mapping and within drillholes intrudes into the Proterozoic sediments at Coronation Hill. The quartz-feldspar porphyry varies in colour from off-white to deep purple (depending upon the hematite alteration intensity). The porphyry is generally altered to a quartz-sericite assemblage.

Hydrothermal alteration has affected all rock types below the Coronation Sandstone. Volcaniclastic units show alteration to an assemblage of chlorite, sericite and quartz. An oxidising stage which has oxidised pyrite to hematite and introduced hematite (as earthy and specular hematite) discolours the quartz-feldspar porphyry. The hematite intensity ranges from absent to pervasive.

Valenta (1991) noted that uranum mineralisation ‘occurs in chloritic zones which alter quartz-feldspar porphyry’. However, Carville et al (1990) noted no spatial relationship between alteration and mineralisation. Different rock types have responded to the alteration in different ways, but there is no apparent zoning of alteration around mineralisation.

LOGGED GEOLOGY

Logs from CHDDD102 show that the near-surface khaki siltstone overlies an alternating sequence of carbonaceous shale (‘chert black shale’) intruded by quartz-feldspar porphyry. Between 64.85 m to 211.18 m, the quartz-feldspar porphyry intrudes sediments logged as either ‘chert black shale’ or ‘tuffaceous siltstone’. From 211.18–311.75 m, sedimentary breccias are the dominant logged unit, with a small 40 cm interval of quartz sandstone at 260.14 m. Quartz porphyry, quartz-feldspar porphyry and sedimentary breccias are logged to 410.55 m. From 410.55–700.4 m (end-of-hole) the logged geology consists of dolomite, dolomite breccia and smaller zones of ‘sedimentary breccia’.

OTHER WORK (PETROGRAPHY, GEOCHEMISTRY)

Eupene (2003) has digitised the geology and assays into a Microsoft Access database. The original sample numbers and sample intervals were not cited. The assays from this
work are noted here as a general guide to mineralised zones within CHDDH102. From this database, anomalous gold assays (>0.1 ppm Au_avg) from CHDDH102 are as follows:

- 8 m @ 0.36 ppm Au from 278 m
- 18 m @ 0.47 ppm Au from 322 m
- 4 m @ 0.1 ppm Au from 348 m
- 8 m @ 0.19 ppm Au from 372 m
- 32 m @ 3.00 ppm Au from 408 m
- 6 m @ 1.17 ppm Au from 464 m
- 2 m @ 1.41 ppm Au from 484 m
- 16 m @ 8.82 ppm Au from 496 m
- 2 m @ 1.5 ppm Au from 666 m

No uranium assays were recorded in the database for CHDDH102, however the database is likely to be incomplete.

**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 2011 will also be available via the NVCL Database ([http://nvcl.csiro.au/](http://nvcl.csiro.au/)). Please request the TSG data using Unique key ID plus Hole ID (ie, 7963293_CHDDH102) from NTGS.

**General mineralogy**

There is a general zonation of mineralogy based on lithology; the lower dolomite unit has almost 100% dolomite response from HyLogging (Figure 2). The upper part of the hole is more variable, comprising chlorite and white micas, with minor zones of gypsum. Aspectral responses around 50 m

![Figure 1. Location of drillhole CHDDH102. Background map is NT Geological Regions map.](image-url)
Figure 2. Mineralogy summary in CHDDH102; looking downhole from left to right (depth along X axis). The bottom of the hole is dominated by dolomite (reddish brown colour) which is the Proterozoic Koolpin Fm dolomite. Above the dolomite, the hole is a mixture of Mg chlorite (light brown); FeMg chlorite (light blue), illitic muscovite (yellow brown) and muscovite (yellow).
and 120 m highlight logged zones of carbonaceous / black sediments, which have low reflectivity.

**Spatial patterns in mineral distribution**

The scanning of CHDDH102 was part of a larger programme of scanning drillholes and mineral mapping within the Coronation Hill deposit. To determine whether there are mappable mineral zones within sections of Coronation Hill, some of the comments on mineral distribution refer to minerals found in adjacent holes to CHDDH102.

**Carbonates**

Dolomite is the dominant carbonate and also the dominant mineral within CHDDH102, particularly in the logged dolomite intervals from 444 m (Figure 3). The TSA-assigned ankerite and siderite were a bad fit, partly influenced by the Fe response in the visual near infrared, so were turned off and recalculated. There are minor dolomite occurrences uphole from the dolomite lithological units; the dolomite in these upper units occurs as gash veining / infill (sometimes with quartz or gypsum) for example at 325 m (Figure 4).

**Talc**

Small zones of talc are found within the lower dolomite, with the most notable concentration around 643 m (Figure 4). The talc appears to be an alteration overprint (Figure 5) and is fairly localised and not spatially associated with mineralisation.

**Chlorite**

Lithological control on chlorite distribution in CHDDH102 (Figure 6) can be noted by the concentration of chlorite in the tuffaceous siltstone units (72–92 m; and 158–202 m) and the sedimentary breccia below the dolomite (682–700 m). Chlorite is absent within the quartz-feldspar porphyry units above 211 m and there is minimal chlorite within the dolomite (530–681 m). Chlorite is present in the quartz-feldspar porphyry units below 211 m and is a significant hydrous mineral in the quartz-feldspar porphyry logged between 368–390 m. There is a composition change within the quartz-feldspar porphyry logged at the top of the hole compared with units logged below 322 m.

Chlorite composition appears to become more maghnesian with depth; changing from FeMg chlorite (intermediate chlorite) to mainly magnesium chlorite from around 322 m to end-of-hole. As the magnesium chlorite spreads across different lithologies, this suggests that it may be an alteration feature, rather than a lithological feature.

**White micas**

The white mica distribution is mostly lithologically controlled; with notably the quartz-feldspar units above 322 m comprising illitic muscovite, with lesser muscovite and phengite (Figure 7). As previously mentioned with the chlorite distribution, the quartz-feldspar porphyry below 322 m is mineralogically different to the units above. The quartz-feldspar porphyry unit from 311–322 m has a higher proportion of illitic muscovite than quartz-feldspar porphyry units higher up-hole.

**Aspectral response**

The strongest aspectral response is within the logged intervals of ‘chert black shale’ and ‘black carbonaceous siltstone’ towards the top of the hole (Figure 8). This aspectral response highlights the effect of carbonaceous material within the drill core (which adversely affects reflectivity). Other smaller aspectral intervals may reflect silification (eg, in Figure 7; the coincident plots of Quartz_H2O and aspectral response may indicate quartz zones) and this is likely to be in the mineralised sedimentary breccia zone around 418 m.

**Tourmaline / Fe tourmaline**

In a previous program of measuring spectral reflectance, a Coronation Hill drillhole (CHDDH49) gave a Fe tourmaline response both above and below the mineralisation zone. In order to test whether this is a mappable feature at Coronation Hill, close attention was paid to the TSA-assigned Fe tourmaline (and tourmaline) response. However, the TSA-assigned tourmaline group responses are quite noisy and a poor match. There was no spectral match against an Fe tourmaline spectrum from CHDDH49 (brought in using the Auxmatch scalar) in CHDDH102.

**NH illite / NH alunite**

In CHDDH100, TSA assigned muscovite + NH alunite, with NH alunite being the secondary (minor) mineral in the mineral mix. The spectra has characteristic NH4 absorptions at 1912 nm, 2013 nm and 2112 nm plus a minor inflection at 1554 nm. The TSA mineral mix needs validating by another method (such as XRD) as NH illite is not currently within the TSA spectral library so the mineral identification has some uncertainty. TSA did not assign any spectra in CHDDH102 with NH alunite as part of the mineral composition. A check of the spectra in CHDDH102 (using auxmatch of spectra from CHDDH100, plus scalars to check for NH4 absorptions) did not indicate any NH illite / NH alunite within CHDDH102.

**Hematite / iron oxide alteration**

Hematite alteration of the quartz-feldspar porphyry is well - documented (Carville et al 1990) and appears to be quite extensive from the HyLogger results. The TSA library does not have a comprehensive list of iron oxides, so Figure 9 shows the TSA-assigned goethite-hematite response (Figure 9; Row 2) but also shows FeOx intensity and core colour (Row 3 of Figure 9). A hematite response that was found in another NTGS drillhole (LBD1) is also matched against the CHDDH102 spectra (Row 4 of Figure 9). Results indicate:

a) FeOx alteration seems quite pervasive throughout CHDDH102 and while the upper units of quartz-feldspar porphyry have a strong FeOx response, locally strong FeOx responses are indicated in other rock types;

b) Sedimentary breccias have high FeOx response, with FeOx being within breccia clasts and also within the matrix;

c) There are two ‘LBD1 hematite’ zones which also correspond to a reddish intensity colour in the FeOx intensity plot (Figure 9) from 165–90 m (tuffaceous siltstone) and around 440 m (sedimentary breccia).
Figure 3. CHDDH102 mineral summary, showing logged geology (top row); carbonate distribution (Row 2) and talc distribution (Row 4). Gold assays (in relation to carbonate, talc and logged geology) are shown in Row 3.
Figure 4. a) Example of dolomite infill at 325 m (uphole from main dolomite unit in CHDDH102). b) Spectral response for dolomite at 325 m.

Figure 5. Occurrence of talc in CHDDH102 as blebs within the lower dolomite unit.

hematite response seems to be from a brick red hematite in the matrix. While the hematite response is similar, the logged rock types are different; 

d) Zones of hematite and silicification (Figure 10) may be present at around 279 m and 418 m, where there is a coincident high Quartz_H2O and FeOx intensity response. This is coincident with gold mineralisation at around 418 m, but not with stronger gold mineralisation in the dolomite at 499 m.

Imaging results

Core tray images (Figure 11) and a hole mosaic image (Appendix 1) are available as jpeg files. The jpeg resolution of the core tray images is set at 5000 pixels per metre (approximately 9 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 (14.5 Mb file size).
Figure 6. Chlorite distribution CHDDH102 (middle row) compared with logged lithology (top row) and Au assays (bottom row). The chlorite composition changes from FeMg chlorite (blue) to Mg chlorite (brown) going downhole.
Figure 7. White mica distribution in CHDDH102 (middle row) compared with logged geology (top row) and Au assays (bottom row). The dominant mica is illitic muscovite.
Figure 8. Aspectral response in CHDDH102 (Row 2) is concentrated in the ‘chert black shale’ units (coloured hot pink in Row 1). Carbonaceous units have a low reflectivity. Row 4 (quartz,H₂O) delineates fluid inclusions in quartz. The lower ‘chert black shale’ unit has a coincident quartz,H₂O and aspectral response, which may indicate silicification or quartz-rich zones.
Figure 9. FeOx alteration in CHDDH102. Second row shows the TSA-assigned goethite and hematite occurrences in CHDDH102, while Row 3 shows the FeOx alteration intensity (coloured by rock colour). Row 3 shows areas of FeOx alteration that are not in the TSA library, while Row 4 shows the occurrence of a hematitic clay that was found in another hole (LBD1).
Figure 10. a) Plot of FeOx intensity, with Quartz_H2O and gold assays. The coincident zones of Quartz_H2O, FeOx intensity may indicate zones of hematisation and silicification with variable Au mineralisation.
CONCLUSIONS AND / OR FURTHER WORK

There is a mineralogical difference between the quartz-feldspar porphyries within CHDDH102; with the change in mineralogy at 322 m. There are two possible explanations – the mineralogy change could show differences in alteration around 322 m and/or the logged quartz-feldspar porphyry units belong to separate generations and are not the same. Valenta (1991) noted that there are likely to be multiple generations of quartz-feldspar porphyry at Coronation Hill due to cross-cutting relationships with the diorite unit. Further work examining textural differences may clarify the reason for the mineralogical differences between the quartz-feldspar porphyry units.

FeOx alteration is widespread and not just confined to the quartz-feldspar porphyry units. There is a coincidence of FeOx, silicification and mineralisation in the sedimentary breccia at around 412 m but not in the higher grade mineralisation within the dolomite at 499 m.

Mineral occurrences noted in other Coronation Hill holes (such as Fe tourmaline in CHDDH49 and NH4 illite in CHDDH100) were not observed in CHDDH102, although CHDDH102 had a more magnesian composition downhole, with talc alteration within the dolomite.

REFERENCES


GLOSSARY

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>AIOH</td>
<td>Aluminium hydroxide.</td>
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<tr>
<td>CCD</td>
<td>Charge coupled device.</td>
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<tr>
<td>FTIR</td>
<td>Fourier transform infrared spectrometer.</td>
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<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>NH4</td>
<td>Ammonium cation. An NH4 mineral is a mineral that contains the ammonium cation. In terms of spectral response, the NH4 cation has characteristic absorptions at 1912 nm, 2013 nm, and 2112 nm. Other absorptions features can diagnose the type of ammonium mineral.</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>SEM</td>
<td>Scanning Electron Microscopy is a type of electron microscope that images the sample surface by scanning it with a high energy beam of electrons, giving information on sample composition and other properties. SEM results may be used to validate mineral identification by the HyLogger.</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>
</tr>
<tr>
<td>SWIR</td>
<td>Shortwave infrared (light). Nominally covering the range 1000–2500 nm.</td>
</tr>
<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>
</tr>
<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>
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<tr>
<td>XRD</td>
<td>X-Ray Diffraction - an analytical technique that reveals information about the crystallographic structure, physical properties and chemical composition of a sample. It is based on observing the scattered intensity of an X-ray beam hitting a sample and measuring the scattered angle and wavelength or energy.</td>
</tr>
<tr>
<td>λ</td>
<td>Lambda – Often used as a symbol for wavelength of light.</td>
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Appendix 1. Hole Mosaic of CHDDH102, with Trays 1–5 on top row; Trays 6–10 on second row etc until end of hole.