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Drillhole report for LBD1, Birrindudu Basin, 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™ rapidly measures reflectance spectra and also captures continuous high-resolution digital colour imagery of drill cores in their originaletrays. The 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. The 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 (lithology logs, petrography, scanning electron microscopy (SEM) data, assay data) was sourced from Jones (2009).

REGIONAL GEOLOGY

The following description is derived from Jones (2009). LBDI is located within the Birrindudu Basin (Figure 1), which contains Paleoproterozoic sandstone, mudstone and shallow water evaporitic carbonate rocks of the Limbunya Group. The Limbunya Group is 1250 m thick and consists of cyclic, hypersaline carbonate and siliciclastic rocks.

It unconformably overlies the poorly exposed Inverway Metamorphics. Cutovinos et al (2002) describe the Inverway Metamorphics as comprising quartz muscovite schists and metasandstones (intersected in LMDH130). Exposed rocks from the Inverway Metamorphics comprise steeply dipping, brown muscovite quartz schist, with grey to reddish-grey acid volcanics and minor siltstone. Concordant quartz veins are common and form massive, 2–4 m thick reefs of white quartz that cut through both the schist and volcanics.

LBD1 was drilled to test a bull’s-eye magnetic anomaly, which was interpreted to be a basic body associated with the Antrim Plateau Volcanics. A syncline forms the dominant structural feature with the surface expression of a magnetic anomaly occurring near the core of the syncline. The oldest exposed rocks in Proto’s project area are micaceous sub-litharenites, siltstone and mudstone of the Farquharson Sandstone of the Limbunya Group. To the south, the Cambrian Antrim Plateau Volcanics lie in contact with the Blue Hole Formation. The surface is mainly covered by Cainozoic ferruginous duricrust cover with subordinate Quaternary alluvium, colluvium and black soil plains.

LOGGED GEOLOGY

Logged geology in Jones (2009) interpreted that LBD1 intersected three main geological units:

a) sediments of the Limbunya Group;

b) metamorphosed sediments of the Inverway Metamorphics; and

c) basaltic sills intruding the Inverway Metamorphics.

The Limbunya Group occurs from surface down to 322 m. Metamorphosed sediments of the Inverway Metamorphics occur from 322 m to 751 m (end of hole). Throughout the Inverway Metamorphics are a number of magnetic basaltic sills ranging in thickness from a few centimetres up to 50 m.

Proto has interpreted that LBD1 intersected five separate units of the Limbunya Group including the Mallabah Dolostone, Amos Knob Formation, Pear Tree Dolostone, Margery Formation and the Stirling Sandstone. Overall, the Limbunya Group rocks were unmetamorphosed and bedding where present was flat-laying. At 322.8 m the geology changes to red oxidised...
mudstones, breccias and basalts and below this point the rocks are metamorphosed and bedding where present is not perpendicular to the long core axis as it had been throughout the Limbunya Group. This change is interpreted to represent an erosional unconformity and suggests that the Inverway Metamorphics were uplifted and exposed prior to deposition of the Limbunya Group sediments. From 322.8 m to 751 m (end of hole) metamorphosed sediments of the Inverway Metamorphics are intruded by highly magnetic basaltic sills. Petrographic results suggest the basaltic sills are also strongly metamorphosed. The presence of oxidised basalt just below the interpreted erosional unconformity also suggests that the basalts are older than the overlying Limbunya Group. No basalts were logged in the Limbunya Group.

Overall, the drillhole was unmineralised except for a zone between 384.25 m to 397.8 m. Vugs are present in this 13.55 m wide zone of siliceous metamorphosed dolomites and they contain pyrite-chalcopyrite crystals. The highest one metre half core assay results returned are: 0.224 g/t Au (381–382 m); 0.058% Co (389–390 m); 0.071% Cu (387–388 m) and 0.03% Ni (389–390 m). The maximum values of 49.64% Fe, 10.93 ppm U and 275 ppm V were all recorded in the interval 337–338 m, which is just below the logged unconformity between the Limbunya Group and Inverway Metamorphics.

OTHER WORK (PETROGRAPHY, GEOCHEMISTRY)

Proto selected ten petrographic samples, 147 assay samples (at one metre intervals) and 23 samples taken

![Figure 1. Location map of drillhole LBD1. Background map is NT Geological Regions map.](A10340.w)
for whole rock, trace element and platinum group element analysis. One petrographic sample (493.6 m) of fine-grained basalt intruding carbonate was selected for examination by SEM techniques. Results from these samples are in Jones (2009) and some results are referenced with the HyLogger results (below). As part of an exercise in validating HyLogger results, 12 samples were sent for X-ray diffraction (XRD) and petrographic analysis and are reported in Purvis (2010).

**HYLOGGER RESULTS**

The core was scanned by the HyLogger 2–7 in Darwin. HyLogger specifications and raw data specifications in Mason and Huntington (2010). Level 1 processed TSG data can also be requested (available for viewing using TSG Viewer – http://www.thespectralgeologist.com/) and in 2011 will also be available via the NVCL Database (http://nvcl.csiro.au/). Please request the TSG data using unique key ID plus hole ID (ie; 7853531_LBD1) from NTGS.

**General mineralogy**

Comments about the mineralogy are made on a ‘User Class’ dataset, which is a dataset that has masked out spurious spectral results (such as from core markers, tray edges, noisy spectra and results which had a poor match to minerals in the TSG library). From this User Class dataset, muscovite is the dominant mineral but combined carbonate minerals (calcite, dolomite, ankerite, siderite) comprise a greater proportion of the mineralogy (Figure 2). Intermediate chlorites are most common of the chlorites. Kaolinite / dickite comprise around 10% of the minerology, within two specific zones in the hole. LBD1 has a notably high ‘aspectral’ component (roughly 11%). The aspectral response is common through most of the hole, but there are four main areas of aspectral response; these are discussed below.

**Spatial patterns in mineral distribution**

The mineralogical domains correspond well to the logged stratigraphic and lithological intervals. There are changes in both mineralogy as well as composition of carbonates and micas at different parts of the hole.

**Carbonate Group**

Carbonate minerals show both spatial and compositional zonation to the logged units (Figure 3). Dolomite in the upper part of the drillhole is constrained to the carbonate-bearing units of the Limbunya Group (Mallabah Dolostone, Amos Knob Formation, Pear Tree Dolostone and Margery Formation). The dolomite abruptly ceases at the contact between the Margery Formation and the Stirling Sandstone. Minor siderite is found in the Stirling Sandstone, but this unit is dominantly muscovitic. Dolomite is the dominant mineralogy between 385 m and 420 m, which is logged as ‘silicified carbonate sandstone to mudrock’ in the Inverway Metamorphics.

From 421 m, the dominant carbonate species changes from dolomite to calcite. There is a notable calcite domain between 528–595.3 m which corresponds with the logged ‘carbonate-rich metasedimentary rock’ within the Inverway Metamorphics. Checking of the carbonate response assigned by the TSA library by plotting the carbonate spectra by absorption wavelengths shows that there are two distinct carbonate populations; dolomite (2320 nm) and calcite (2340 nm), validating the TSA classification of two different carbonate species (Figure 4).

The lower dolomite in the Inverway Metamorphics (385–420 m) is geochemically different from the upper dolomite units logged in the Limbunya Group sediments (Figure 5). Assay data from the lower dolomite indicate weakly anomalous Au, Cu and Mn, whereas the upper dolomite has unremarkable assay results.

Results from the HyLogger can illustrate different generations of calcite within LBD1 (Figure 6). Fe-poor calcitic breccia at 515.5 m has a different spectral response and textural relationship to the ferroan calcite vein that crosscuts the calcitic breccia at 515.2 m. The integration of the imagery with the spectral response gives information about timing relationships which may be otherwise not apparent.

**Chlorite Group**

Intermediate (FeMg) chlorites are the most dominant chlorite group and are grouped in two main zones; 415–540 m and 593–743 m (Figure 3). These zones are logged as variable metasediments of the Inverway Metamorphics and basaltic sills. The zone between the two chlorite groups (approximately 540–593 m) is dominantly calcite ‘carbonate-rich metasedimentary rock’.

**Kaolin Group**

Kaolin group minerals (Figure 7) are found in two main zones; 0–51 m (which highlights the regolith and depth of weathering) and 305–330 m (which indicates a paleoregolith). The kaolinite in the near-surface regolith has fairly shallow water absorption features around 1910 nm and in the OH doublet around 1397 nm and 1415 nm, appearing to resemble a moderate to high degree of crystallinity. The paleoregolith has dickite (305–316 m) above a mixed dickite/kaolinite zone (316–330 m). XRD samples have been taken to validate the dickite response, with results indicating that dickite was ‘highly likely’ but difficult to conclusively show, given that there may be some kaolinite also present (see Additional Data). The dickite occurs just above the logged unconformity (323 m).

**White Mica Group**

White micas show compositional and spatial variation within LBD1 (Figure 8). Phengite is dominant from 41 m to around 221 m, corresponding with the more carbonate-rich units of the Limbunya Group. From 211 m, muscovite becomes dominant, which coincides with the start of the silty and sandy units of the Stirling Sandstone. There is a trend in the change in the 2210 nm wavelength from around 180 m to around 311 m, indicating a composition change from Fe/Mg to Al-rich with depth (Figure 8). However, the Al-rich composition is also affected by the kaolin group minerals around the logged unconformity (305–330 m).
Figure 2. Dataset Overview/Hole Summary of LBD1 showing core imagery (column 1), logged geology (column 2), mineral groups (column 3); colour legend for mineral groups (column 4), main minerals (column 5) and colour legend for minerals (column 6).
Figure 3. Carbonate and chlorite mineralogy plotted against Logged Geology.
Figure 4. Differentiating carbonate mineralogy by absorption wavelengths. There appears to be two separate carbonate populations; dolomite (centred around 2320 nm) and calcite (centred around 2340 nm).

Aspectral Response

An aspectral response generally indicates spectra with no diagnostic absorption features within the HyLogger wavelength range. In ‘The Spectral Geologist’ software, an aspectral result can be returned due to noisy spectra (resulting from low reflectance; such as in melanocratic lithologies) or rocks with no minerals containing structural OH, H2O and/or CO3.

In LBD1, aspectral responses are clustered into four main zones (Figure 9). Zones A and B have a different spectral response compared with Zones C and D. Zone B has a notable Fe absorption response at 875 nm and a double peak (752 nm and 980 nm). However, the SWIR spectrum is ‘flat’, which gives an aspectral response. Zone A is logged as sediments; Zone B is within the paleoregolith zone at the top of the Inverway Metamorphics whilst Zones C and D are basalts (ie; with no hydrous mineralogy).

XRD analysis of the Zone B sample (Appendix 1) indicates that the sample is hematite, with the SWIR response ‘swamped’ by cronstedtite, kaolinite and other phases. The clayey hematite assayed at 49.64% iron, 10.93 ppm uranium and 275 ppm vanadium.

FeOx Alteration

Figure 10 shows the TSA-assigned FeOx mineralogy in LBD1. However, XRD analysis, combined with assay data shows that there are more Fe-rich intervals than just in the top 40 m regolith zone of LBD1. The clay-rich hematite identified from XRD analysis at 333.7 m is common between 295–374 m. Maximum Fe assays for LBD1 of 49.64% Fe for 337–338 m confirm the Fe–rich mineralogy of this interval, which spans the unconformity between the Inverway Metamorphics and the Limbunya Group. The FeOx alteration in this interval is most common with kaolin group minerals or within the ‘aspectral’ zone.

Comments regarding HyLogger validation

Twelve core samples from LBD1 were subject to independent XRD analysis and petrography for the purposes of validating the TSA-assigned mineralogy from the HyLogger scanning. The report (Purvis 2010) and associated correspondence is in Additional Data. The results were incorporated into a paper presented at the Australian Earth Science Convention (AESC) (Green et al 2010) and also at an NTGS-specific presentation at the AESC (Additional Data). Validation results from LBD1 data include:

a) TSA-assigned ‘opal’ (53.1 m) gave an XRD result of ‘quartz dominant’ and petrographic description of ‘cryptocrystalline and microcrystalline quartz lenses of chalcedony’. The ‘opal’ response was not opal sensu stricto, but did highlight siliceous mineralogy.

b) TSA-assigned dolomite (389 m; 402.3 m) and calcite (547.3 m) were confirmed by XRD and petrography.

c) TSA-assigned dickite (328 m) was unable to be verified using petrography (earthy hematite clouds, interstitial material) but ‘kaolinite or dickite’ were indicated. Initial XRD results indicated ‘subdominant kaolinite’ with further testing indicating dickite as ‘highly likely’ (Additional Data).

Imaging results

Core tray images (Figure 11) and a hole mosaic image (Appendix 2) are available as jpeg files. The jpeg resolution of the core tray images is set at 4000 pixels per metre (approximately 6.4 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 (12 Mb file size). The whole of hole image can also be seen in Figure 2.
Figure 5. Plot of LBD1 carbonates with assays. Dolomite found within the Limbunya Group sediments (towards the upper part of LBD1) is geochemically different to the dolomite found below the unconformity within the Inverway Metamorphics. The lower dolomite (below the unconformity) has anomalous Cu, Au and Mn.
Figure 6. Different generations of calcite in LBD1. Top plot shows Fe-poor calcite, while the bottom plot shows Fe-rich calcite vein that cross-cuts the Fe-poor calcite. Differentiating the calcite by Fe content can highlight different generations of calcite.
Figure 7. Kaolin group minerals in LBD1. Bottom plot shows kaolin group minerals grouped in the regolith (top part of LBD1) and also the paleoregolith along the unconformity separating the Inverway Metamorphics from the overlying Limbunya Group sediments.
Figure 8. White mica distribution in LBD1. Row 1 is logged stratigraphic units. Row 2 shows the change in white mica composition down the hole, with phengite dominant in the Margery Formation, Pear Tree Dolostone and Amos Knob Formation, but muscovite dominant in the Stirling Sandstone. Row 3 shows that there may be more than one white mica population present; the main population appears to be centred around 2209.5 nm with a smaller population at 2205 nm. Row 4 shows that there is decreasing Al content in the white micas going downhole to the unconformity.
Figure 9. Aspectral zones in LBD1. (a) Shows that the aspectral response is mainly clustered into four zones. Closer examination of these zones indicates that the aspectral response also varies between these zones. Zone A [(b) and (d)] has a different spectral response to Zone B [(e) and (f)] between 1400–2400 nm. (d) and (e) highlight the differences between the core at the two sites.

CONCLUSIONS AND/OR FURTHER WORK

Results from HyLogging LBD1 are summarised below:

1. The distribution of kaolin group mineralogy highlighted both the regolith (near surface) and paleoregolith (on the unconformity between the Limbunya Group and the Inverway Metamorphics)
2. There are two different carbonate populations within LBD1; dolomite is dominant in the Limbunya Group sediments and the upper part of the Inverway Metamorphics, whilst calcite is dominant in the carbonate-rich metasediments of the Inverway Metamorphics. However, the change from dolomite to calcite is not at the logged unconformity (322 m) but at 415 m (within the logged Inverway Metamorphics)
3. The unconformity between the Inverway Metamorphics and overlying Limbunya Group sediments is logged at 322 m, which corresponds with a distinct mineralogy change (kaolinite and dickite on the paleoregolith; dominant mineralogy changes from muscovite to “aspectral”; “aspectral” response interpreted as being from ‘non-typical’ hematite clays). However, there is also a distinct mineralogy change at around 415 m, which is not highlighted from the geology summary. Carbonate mineralogy changes from dolomite to calcite; chlorites are recognised but the geology summary indicates Inverway Metamorphics metasediments. The detailed log notes a change from ‘silicified carbonate sandstone’ to ‘sedimentary breccia’, but the HyLogger results indicate that this boundary is perhaps more geologically significant than currently recognised
4. There are four main domains of aspectral response. Zone B (around 333 m) showed an aspectral response in the short-wave infrared but Fe$^{2+}$ ramp in the visual near infrared. XRD results indicated that the sample is a hematitic clay (hematite + kaolinite + gypsum + monohydrocalcite + cronstedtite + plumbogummite). Further work will include searching for analogues, with the aim of understanding the geological processes that formed the hematitic clay.
5. The HyLogger imagery shows colour domains relating to changes in mineralogy / lithology (Figure 2; whole hole
Figure 10. FeOx minerals in LBDI. Top row is logged stratigraphic units. Row 2 has TSA-assigned hematite and goethite, which coincides with the regolith zones (with kaolin group minerals near top of hole). Row 3 shows FeOx intensity with core colour, this indicates that the FeOx minerals are more widely spread throughout LBDI than just the top 40 m of the hole. In particular, there is a zone of FeOx alteration from around 215–385 m which also coincides with a deep reddish brown core colour. XRD results on LBDI at 333.7 m indicated a clayey hematite that is not in the TSA library. When matching the spectral response for this clayey hematite through LBDI, there is a zone delineated from 295–374 m (row 4). This clayey hematite is within the paleoregolith of the Inverway Metamorphics.
mosaic). High resolution imagery delineates carbonate / basalt contacts (Figure 11: tray pic) and different generations of calcite (Figure 5).

Further work is planned, as the geology intersected in LBD1 has implications for the known stratigraphy in the area. Further work may include age dating (to determine the age of the basalt sills) and interpretation of the results within the regional geology context.

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>
</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>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>Scalar</td>
<td>Any set of imported or calculated values associated with spectral data loaded in TSG</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>
</tr>
<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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Hi Jon,

Glad to have helped. Yes, let's stay in touch with this. I have not seen this spectral shape before but it appears that Erick has seen something similar in the past. However, no XRD was done for the samples he saw.

I have attached a screen grab of the XRD pattern for your interest. Looking at the pattern again, they may well also be small amounts of Al-silicates (e.g., chlorite?) present. Again, further analysis would confirm this (or not). I agree there is unlikely to be sufficient cronstedtite (i.e., ferrous iron) to have such a dramatic effect on the spectra. What about the presence of gypsum?

Cheers,

Martin

Hi Martin.

You're a champion! This is so impressive and thanks so much for running this quickly. Very interesting. One would suspect the ferrous iron as swamping other SWIR active minerals but you did suggest only a trace of Cronstedtite which does not sound quite enough? As you say an XRF analysis would be the next thing to do. I will suggest this to Belinda in the NTGS and Lena at GSWA. This is a great little collaboration and I thank you for this. I think you said you'd never seen this spectral shape before? Is that correct? Why it covers such a wide depth interval in two widely separated regions is still to be understood.
Hi Jon,

A couple of things:

Firstly, I passed on the data stick to Tim this morning.

Secondly, I have managed to run the iron 'ore' sample LBD1 on the XRD. Very interesting results! A qualitative interp is as follows with phases reported as major, minor and traces abundances:

Hematite (major)
Kaolinite, gypsum, monohydrocalcite (minor)
muscovite (white mica), cronstedtite, plumbogummite (trace)

Monohydrocalcite = CaCO3.H2O
Cronstedtite = Fe22+Fe3+(Si,Fe3+)O5(OH)4
Plumbogummite = PbAl3(PO4)2(OH, H2O)6

Another phase with a very weak/broad diffraction peak at 8.76A (11.72 degrees 2-theta) was detected (in trace amounts) but could not be identified.
Plumbogummite or minerals of the plumbogummite group (e.g., ???) are not uncommon in iron ore deposits and have been described in association with the Pilbara iron ores. Cronstedtite is a ferrous and ferric bearing phase of the kaolinite-serpentine family. The ferrous iron may explain the large SWIR ramp you described for the spectra (as well as the SO4/PO4 phases?), and may explain why kaolinite is not being detected in the SWIR (is being swamped by other phases).

The kaolinite is consistent with the (other?) initial results you mentioned. There was no magnetite detected by XRD and this was confirmed using a magnetic (ie no magnetic material was observed/attracted).

To be really sure of the mineral identification, I would recommend SEM or microprobe analysis of a polished thin-section of this material or at least bulk XRF chemistry.

Hope this helps. Cheers....

******************************************************************************

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Appendix 2. Hole mosaic of LBD1, with Trays 1–10 on top row; Trays 11–20 on second row etc until end of hole.