Defining Mineral System footprints in the Edmund Basin of the Capricorn Orogen, Western Australia

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The project aims to discover how reflectance spectra measured from the surface of the earth can be utilised in finding mineral footprints of hydrothermal ore deposits concealed by the regolith. The scope is to identify the mineral assemblages at the study area that are characteristic for four schematic domains: 1) unweathered, unaltered bedrock, 2) unweathered altered bedrock, 3) regolith atop unaltered bedrock, and 4) regolith atop altered bedrock.

Prior to fieldwork, reflectance spectra measurements were collected in a laboratory setting (Figure 1) using FieldSpec3™ mineral spectrometer from 552 surface regolith samples, archived by the Geological Survey of Western Australia (GSWA) and the Commonwealth Scientific and Industrial Research Organisation (CSIRO). The acquired VNIR-SWIR reflectance spectra were processed in The Spectral Geologist (TSG™) software using the Multiple Feature Extraction Method MFEM; (Cudahy et al. 2008 and Laukamp et al. 2010) for characterisation of mineral assemblages. This work was carried out to establish the regional and deposit scale variation in the surface mineralogy in general, but also to compare the hyperspectrally derived mineralogy with geochemical analyses undertaken by GSWA to effectively target the fieldwork areas of interest.

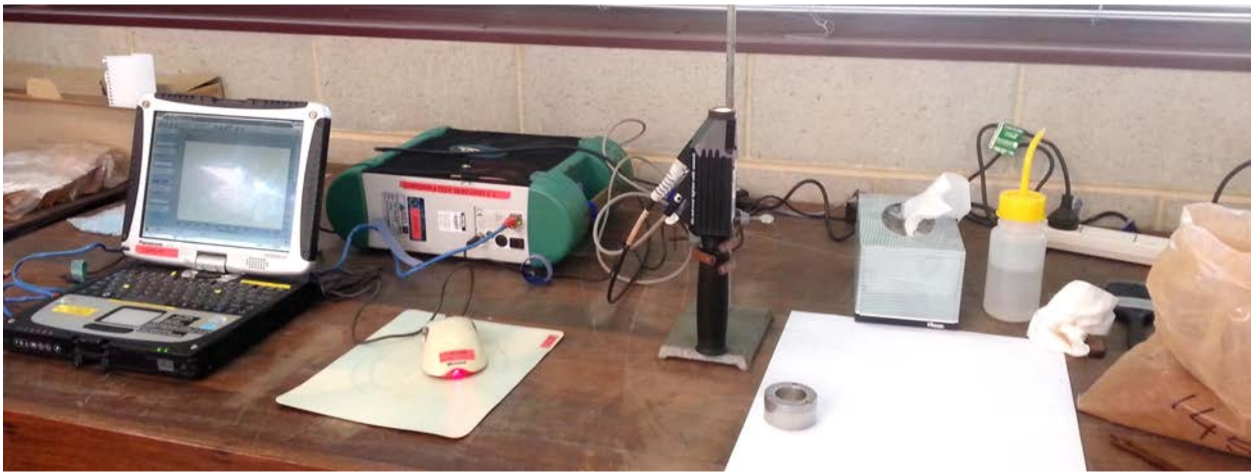

Figure 1. The laboratory setting at the GSWA core library for the reflectance spectra measurements from the archived regolith samples using FieldSpec3™ spectrometer together with sapphire glass container that is located on the paper in the bottom right corner of the photograph (photo: Heta Lampinen).

The TerraSpec 4 Hi-Res mineral spectrometer was used during three weeks of fieldwork from April 20th to May 10th 2015 in the Edmund basin of the Proterozoic Capricorn Orogen in Western Australia. The study area of 60*110 km in size is located 900 km north from Perth, west of the Collier Range National Park and roughly 170 km west from the Great Northern Highway. The study area is designed around the sediment hosted stratiform Pb-Cu-Zn-Ba deposit Abra, discovered at roughly 200 m depth in 1981 by drilling into a magnetic bulls-eye anomaly. Geochemical sampling efforts have so far failed to a find mineralisation footprint around the Abra deposit. Other known base metal mineralisation occurs within the same structural corridor, along the crustal-scale Quartzite Well Fault.

Data acquisition included two methods of reflectance spectra collection. The primary one was by using the contact probe provided in the sponsored equipment package, and the other by using a viewing probe. Sampling setups for the two probes are shown in Figure 2. Data collection was carried out in two person team for safety and efficiency (Figure 3).

Figure 2. Viewing probe setup on the left and contact probe on the right. GoPro camera was attached to both probes in time-lapse and video -mode to provide continuous record of sampling (photos: Vaclav Metelka).

Figure 3. The reflectance spectra sampling team; on left associate professor Dr Vaclav Metelka and on right PhD candidate Heta Lampinen from University of Western Australia, Centre for Exploration Targeting (photo: Crystal LaFlamme).

Field reflectance spectra were collected from selected locations that are situated across the Abra deposit area, Quartzite Well Fault and over diamond core drilling sites that have been scanned with a VNIR-SWIR-TIR hyperspectral drill core scanner (HyLogger) by GSWA or analysed with TerraSpec3 by Abra

Mining Pty Limited. The sampling profile length ranged from 500 to 3000 meters and spacing of measurements 20 to 40 meters depending on the terrain and vegetation. Altogether 21 contact probe measurement profiles, resulting in 1315 reflectance spectra data points, additional to the surface dataset measured at GSWA's core library, were collected. In addition to contact probe measurements, 409 measurements from 10 profiles using the viewing probe – a probe utilising sunlight instead of internal light source – were also completed. Regolith samples were also collected from the surface as shown in Figure 4, for the XRD analysis.

Figure 4. Collection of regolith samples along reflectance spectra profiles (photo: Heta Lampinen).

The preliminary results of the data analysis have been presented at the Goldschmidt 2015 in Prague 16th to 21st of August 2015 and at the SEG-CODES "World-Class Ore Deposits" conference in Hobart 27th to 30th September 2015. The poster presentations are shown in Figure 6 and are available on request.

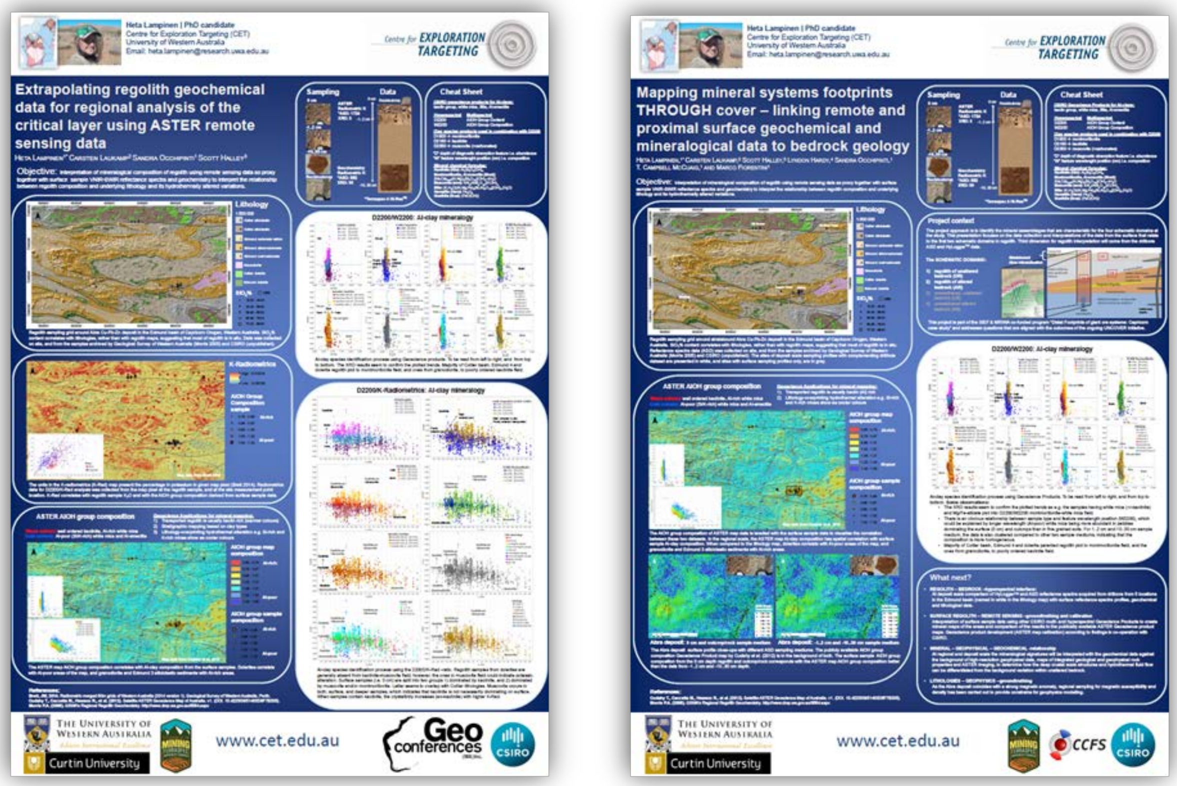

Figure 5. Poster presentations in the Goldschmidt 2015 (left) and SEG Hobart 2015 (right) conferences.

A spatial comparison of geochemistry from regional 4*4 km state regolith dataset by the GSWA and lithology, carried out prior to data collection in laboratory and field, already showed that abundances of major oxides, SiO_2 and K_2O in particular, correlate with bedrock lithologies rather than regolith landforms, suggesting that large parts of regolith is in situ. Preliminary results too, through data analysis that is now underway in the deposit scale, illustrate encouraging associations between the reflectance spectra, multispectral remote sensing Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) data, and geology in both regional and deposit scale datasets.

The Al-clay species identification process at the regional scale has already been carried out using the CSIRO's precompetitive Geoscience product scripts D2200 and W2200 that enable the definition of the abundance and composition of Al-clays by following the depth (D) of the absorption feature at 2200 nm wavelength and the shift of the absorption feature between shorter and longer wavelength that indicates compositional change of aluminium in Al-clays through Tschermak's substitution. For identifying the kaolin group (D2160), white micas (D2350), and Al-smectites a combination of the product base scripts were used, and the resulting mineral composition plots are shown in Figure 6. Based on the results, the majority of surface regolith in the Edmund basin is kaolinite and white mica. Collier basin depositional packages, Edmund depositional package 4 and dolerite compose of kaolinite and white mica, but contain also montmorillonite (Al-smectite), whereas regolith atop granodiorite is dominated by poorly ordered kaolinite. Potential hydrothermal alteration identifiers in mineral spectra in regolith samples were observed from the results, e.g. in situ white micas in regolith over dolerites (Figures 6 and 7), but further processing is required.

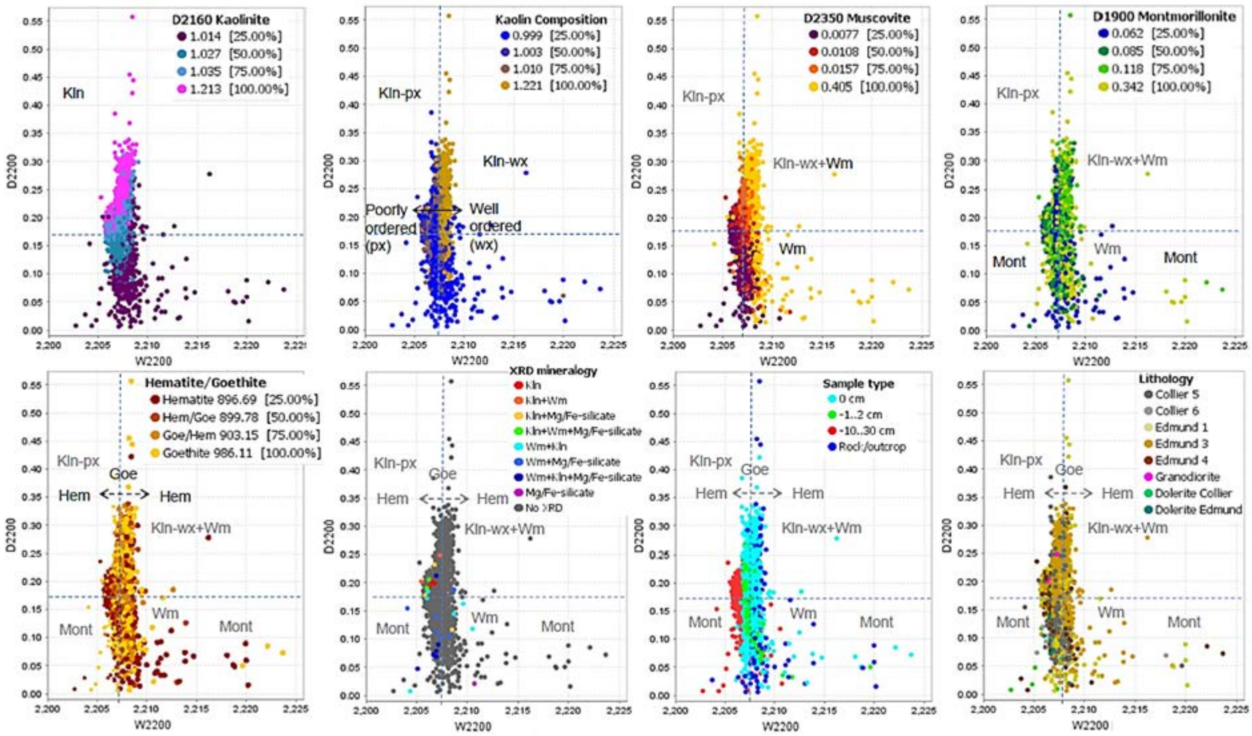

Figure 6. Al-clay species identification process plots using CSIRO's Geoscience products D2200/W2200, in combination with products targeting specific Al-clay minerals. "D" designates the depth of diagnostic absorption feature i.e. abundance, and "W" feature wavelength position (nm) i.e. composition. Plots are to be read from left to right and from top to bottom.

Comparison of regolith geochemistry and remote sensing data shows that radiometrics correlates with K_2O % of geochemistry and reflectance spectra derived from surface sample data. Radiometrics potassium-% (K-Rad) was extracted from the coordinates of the archived regolith samples and on-site measurements. The radiometric potassium-% and Al-abundance Geoscience product D2200 were used in combination for Al-clay species identification. The presence of white micas is suggested by high K contents and high values in the AlOH composition (D2200) that are supported by the XRD analysis. Regolith samples overlying dolerite seem largely absent of kaolinite and muscovite; however, some that plot in the muscovite field could indicate potassic alteration (Figure 7).

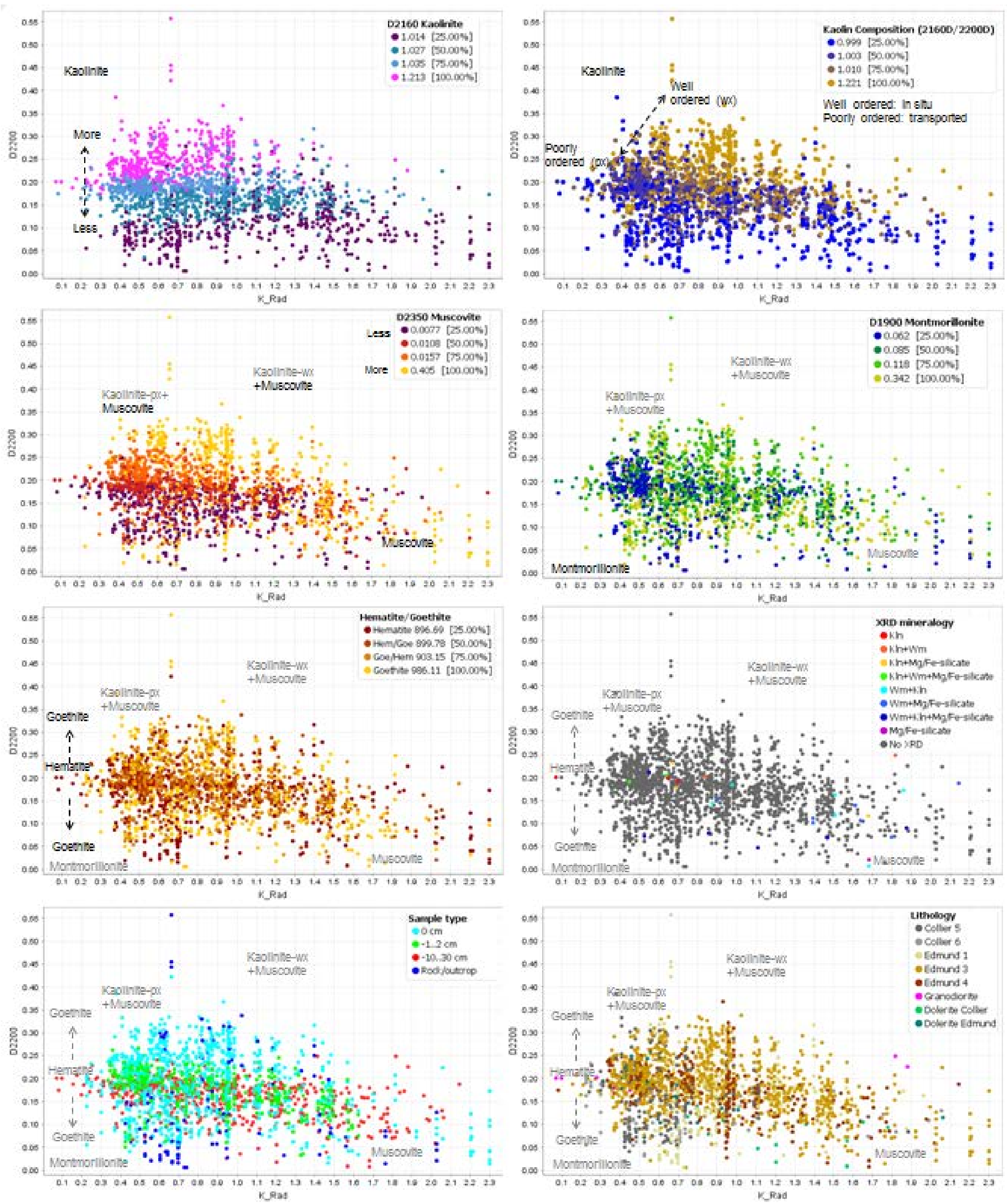

Figure 7. Al-clay species identification process using the 2200D/K-Rad –ratio and their comparison to sample type, XRD results and lithologies.

This new high resolution dataset acquired from surface profiles suggests that mineral assemblages and changes in mineralogical composition detected from the reflectance spectra can be used to map the compositional variation of regolith landforms in the study area and potentially provides insights into bedrock composition. Detailed results of further analysis in both regional and deposit scale will be submitted for publishing in a journal paper later on in 2016.

The project is part of the SIEF & MRIWA co-funded program “Distal Footprints of giant ore systems: Capricorn case study” and addresses questions that are aligned with the outcomes of the ongoing UNCOVER initiative. We would like to thank Students in Mining TerraSpec Instrument Program for the generous support of the critical field component of this study and for the technical assistance throughout our work.

If you are interested in following the research project outcomes and publications contact: heta.lampinen@research.uwa.edu.au

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