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Application of Hyperspectral Methods in Hydrothermal Mineral System Studies

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Hyperspectral infrared reflectance spectra are used to identify abundances and compositional differences of mineral groups and single mineral phases. 3D mineral maps are derived from surface (airborne and satellite sensed) and sub-surface (drill core) mineralogical data and integrated with geological, geochemical and geophysical datasets, enabling a quantitative mineral systems analysis.

The Western Australian Centre of Excellence for 3D Mineral Mapping is working on a variety of mineral deposits to showcase the emerging applications of hyperspectral techniques in mineral system studies. Applied remote sensing technologies comprise hyperspectral airborne surveys (HyMap) covering 126 bands in the visible and shortwave infrared, as well as satellite-based multispectral surveys (ASTER) featuring 14 bands from the visible to thermal infrared. Drill cores were scanned with CSIRO's HyLoggingTM systems, which allow a fast acquisition of mineralogical data in cm-spacing and thereby providing statistically significant datasets. Building on procedures developed for public Australian geosurvey data releases for north Queensland, Broken Hill and Kalgoorlie (http://c3dmm.csiro.au), the ultimate goal is to develop sensor-independent scalars based on the position, depth and shape of selected absorption features in the visible-near (VNIR), shortwave (SWIR) and thermal infrared (TIR), which can be applied to a wide range of mineral deposit types.

In the Rocklea Dome Channel Iron Ore deposits of the Pilbara (Western Australia) for example, hyperspectral drill core data were processed into 3D mineral maps to delineate major ore zones by identifying various ore types and possible contaminants. Vitreous (silica-rich) iron ore was successfully separated from ochreous goethitic ore, with both of them requiring different metallurgical processing. The silicified vitreous iron ore as well as outlined carbonate-rich zones are presumably related to overprinting groundwater effects. The hyperspectral mineral mapping of contaminating, carbonate- or clay-rich zones helped to better constrain the ore zones and the genesis of the mineral system.

Airborne hyperspectral data covering about 2500 km2 were obtained from the Eastern Goldfields Superterrane (Yilgarn Craton, Western Australia), which is highly prospective for Archean Au as well as komatiite associated Fe-Ni sulphide mineralisation. In this project hyperspectral airborne data allowed not only the remote mapping of mafic and ultramafic rocks, which are among the main host rocks for Archean Au deposits in the study area, but also the remote mapping of hydrothermal alteration patterns and various geochemical signatures related to the structurally controlled Au mineralisation down to a 4.5 m pixel size. We can reconstruct fluid pathways and their intersections with steep physicochemical gradients, where Au deposition presumably took place, by combining hyperspectral remote sensing with hyperspectral drill core data in 3D mineral maps. White mica mineral maps as well as mineral maps based on the abundance and composition of MgOH and FeOH bearing silicates are the main products for a semi-quantitative assessment of the key alteration minerals in this project.

In the southern Selwyn Range, Mount Isa Inlier, Queensland, hyperspectral mineral maps, such as "ferric oxide abundance", "white mica abundance" and "white mica composition", were integrated with geophysical

datasets (total magnetic intensity, ternary radiometric imagery). The integration of the datasets enabled us to construct a comprehensive fluid flow model contributing to our understanding of iron-oxide Cu-Au deposits in this region, identifying the source, pathway and depositional sites, which are in good accordance with known deposits.

3D mineral maps derived from hyperspectral methods can distinctly improve our understanding of mineral systems. The advantages of hyperspectral techniques over conventional exploration methods include: (1) the fast and cost efficient acquisition of both surface and sub-surface mineralogy, (2) objective mineral mapping compared to subjective drill core logging by various geologists, (3) the production of a great variety of geoscience products, which can be extended or reassessed with improving knowledge about the mineral system.