

Application of hyperspectral analysis to mapping Precambrian hydrothermal alteration systems in Australia

Matilda Thomas^{1,2}, Adrian Brown², Malcolm Walter², and Thomas Cudahy^{2,3}

¹*Geoscience Australia, GPO Box 378, Canberra ACT 2601*

²*Australian Centre for Astrobiology, Macquarie University, NSW, 2109*

³*CSIRO Division of Exploration and Mining, ARRC, 26 Dick Perry Ave Technology Park, WA 6102*

Hydrothermal mineral assemblages typically display certain spectral characteristics due to vibration of the hydroxyl (OH⁻) anion in the near infrared (Hunt, 1979). These properties allow detection by satellite-borne infrared spectrometers (Rowan *et al.*, 1977). Hyperspectral equipment, such as the Australian-built HyMap airborne system and the PIMA II field spectrometer, collect detailed spectral information, often in contiguous wavelengths, which can be analysed and interpreted for making detailed mineralogical and alteration maps (Cocks *et al.*, 1998). Two Precambrian hydrothermal systems, well suited to testing remote sensing of hydrothermal systems are described here: one at Mount Painter in the Flinders Ranges in South Australia, comprising one of the world's largest hydrothermal deposits; and one in the North Pole Dome in the Pilbara region of Western Australia.

Mt Painter, Flinders Ranges

Analysis of air- and ground-gathered short-wave infrared hyperspectral measurements were used in combination with conventional field mapping of hydrothermal alteration at Mt Painter Inlier. Airborne hyperspectral data defines the spatial distribution of end-member assemblages occurring as primary minerals and as products of weathering and alteration. Field spectral measurements and thin-section analyses, were used to verify the mineral maps and calibrate the airborne data. The main zone of alteration, coinciding with the Paralana Fault Zone, contains kaolinite, muscovite, biotite, and K-feldspar. A minor spectral difference associated with a ring-like feature around Mt Painter, possibly containing halloysite, is interpreted to represent a separate hydrothermal system. Remote sensing of alteration at Mt Painter shows that hyperspectral imaging produces accurate maps of the distribution of alteration minerals and can be used to interpret different stages and fluid evolution of a system (Thomas & Walter, 2002).

North Pole Dome, Pilbara Craton

In October 2002, as part of collaboration between the CSIRO and the Australian Centre for Astrobiology, a hyperspectral visible-near infrared (VNIR) dataset was collected from the North Pole Dome in the Pilbara Craton, using the HyMap instrument. The North Pole Dome is a granite covered by greenstones of the Warrawoona Group (Van Kranendonk, 2000). In an effort to understand the hydrothermal activity, remote mineral mapping and ground surveys using a PIMA spectrometer have been carried out. The results of the latest fieldwork include mapping of two temporally dissociated, Archaean hydrothermal events, described in detail in Brown *et al.*, (2004). Hydrothermal activity at the Dome is thought to have played an important part in mediation of a possible biosphere hosting the earliest known life on Earth.

References

- Brown, A. J., Walter, M. R. and Cudahy, T. J. (2004) Remote Mapping of Earth's Earliest Biosphere: Hyperspectral Imagery of the Pilbara Craton and applications for finding niches for life on Mars, in *International Journal of Astrobiology*, pp. 16-17, Special Supplement 1 - Abstracts from the Astrobiology Science Conference 2004, NASA Ames Research Laboratory, Mountain View, CA.
- Cocks, T., Janssen, R., Stewart, A., Wilson, I. and Shields, T. (1998) The HyMap Airborne Hyperspectral Sensor: The System, Calibration and Performance. *1st EARSeL Conference*, 37-42.
- Hunt, G. R. (1979) Near infrared (1.3-2.4 μ m) spectra of alteration minerals - potential for use in remote sensing. *Geophysics*, 44, 1974-1986.
- Rowan, L. C., Goetz, A. F. H. and Ashley, R. P. (1977) Discrimination of hydrothermally altered and unaltered rocks in visible and near infrared multispectral images. *Geophysics*, 42, 522-535.
- Thomas, M. and Walter, M. R. (2002) Application of Hyperspectral Infrared Analysis of Hydrothermal Alteration on Earth and Mars. *Astrobiology*, 2 (3), 335-351.
- Van Kranendonk, M. J. (2000) Geology of the North Shaw 1:100 000 Sheet, Geological Survey of Western Australia, Department of Minerals and Energy, Perth, WA.