Hyperspectral Mapping of an Ancient Hydrothermal System

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Hydrothermal deposits have been suggested as locations of high importance in the search for fossilized forms of ancient biota on Earth [Walter and Des Marais, 1993; Farmer and Des Marais, 1999]. They occur where spatially confined warm (50^{O}) to hot (500^{O}) fluids are in disequilibrium with their host rocks [Piranjo, 1992]. By the action of such a system, solutes can be concentrated to form ores at certain horizons within or on the surface of a rock body. Such concentrations may be developed where a drop in temperature, pressure, or alteration of the permeability or chemistry of the host rocks created conditions suitable for the solute to be precipitated from the hot fluid.

It has been suggested by many researchers that alteration of host rock in hydrothermal systems typically produces halos of chlorites and white micas [Yang et al., 2000; Cudahy et al., 2002]. Hydrothermal systems can therefore be characterized by layered horizons of altered rocks which are able to be detected using hyperspectral remote sensing surveys [Huntington, 1996]. Such a survey has recently been carried out in the ancient Pilbara craton of Western Australia. The target of this survey was the North Pole Dome, a 600 sq. km region of the Pilbara which underwent alteration by a shallow marine low temperature hydrothermal system [Nijman et al., 1998; Van Kranendonk, 2000]. The survey was conducted over a half day period using the Hymap instrument [Cocks et al., 1998].

The North Pole Dome is home to many stromatolite horizons and has featured in many papers on the subject [eg. Walter, 1980; Hoffman et al., 1999]. The opportunity to correlate stromatolite horizons and alteration mineral occurrences is a primary future objective of this project.

The ancient age of the Archean rocks of the North Pole Dome makes them a compelling analog for similarly aged parts of the Martian surface. Hydrothermal deposits are postulated to explain many observed features on Mars [eg. Gulick, 1998]. Remote surveys of proposed Martian hydrothermal deposits may be conducted in the near future and comparison to terrestrially-sourced alteration mineral maps will be desirable. The collection, examination and interpretation of such terrestrial data sets has now begun.

The initial results of this survey will be presented including:

- initial maps of the alteration zones surrounding the North Pole Dome,
- initial assessments of geological processes causing rock alterations,
- possible linkages with known stromatolite horizons, and
- proposed further research for this data set.

References

Cocks, T. Jenssen, R., Stewart A., Wilson, I., Shields, T., 1998. The Hymap™ airborne hyperspectral sensor: the system, calibration and performance. *Presented at 1st EARSEL Workshop on Imaging Spectroscopy*, Zurich, October 1998.

Cudahy T.J., Wilson J., Hewson, R., Okada, K., Linton, P., Harris, P., Sears, M., Hackwell, J.A., 2002. Mapping Porphyry Alteration at Yerington, Nevada, using Airborne Hyperspectral VNIR-SWIR-TIR Imaging data. *(in press)*

Farmer, J.D. and Des Marais, D.J., 1999. Exploring for a record of ancient Martian Life, *Journal of Geophysical Research 104*, no. E11, p. 26977-26995.

Gulick V.C., 1998. Magmatic intrusions and a hydrothermal origin for fluvial valleys on Mars. *Journal of Geophysical Research 103*, no. E8, p. 19365-19387.

Hoffman, H.J., Grey, K., Hickman, A. and Thorpe R., 1999. Origin of 3.45 Ga coniform stromatolites in the Warrawoona Group, Western Australia. *Geological Society of America, Bulletin 3*, p 1256-1262.

Huntington, J.F., 1996. The role of remote sensing in finding hydrothermal mineral deposits on earth. *In Evolution of hydrothermal ecosystems on Earth (and Mars?)*. Wiley, Chichester (Ciba Foundation Symposium 202) p. 214-235.

Nijman, W., de Bruijne, K.C.H. and Valkering, M.E., 1998. Growth fault control of Early Archean cherts, barite mounds and chert barite veins, North Pole Dome, eastern Pilbara, Western Australia. *Precambrian Research 88*, p. 25-52.

Pirajno, F., 1992. *Hydrothermal mineral deposits: principles and fundamental concepts for the exploration geologist*. Springer-Verlag, Berlin.

Van Kranendonk, M.J., 2000. *Geology of the North Shaw 1:100 000 Sheet Western Australia Geological Survey, 1:100 000 Geological Series Explanatory Notes, 86p*. Department of Minerals and Energy, Western Australia.

Walter, M.R., Buick, R., and Dunlop, J.S.R., 1980. Stromatolites, 3400-3500 Myr old from the North Pole area, Western Australia. *Nature 284*, p. 443-445.

Walter M.R., and Des Marais, D.J., 1993. Preservation of Biological Information in Thermal Spring Deposits: Developing a Strategy for the Search for Fossil Life on Mars. *Icarus 101*, p. 129-143.

Yang K., Huntington, J.F., Browne, P.R.L., Ma, C., 2000. An infrared spectral reflectance study of hydrothermal alteration minerals from the Te Mihi sector of the Wairakei geothermal system, New Zealand. *Geothermics 29*, p. 377-392.