Window of opportunity

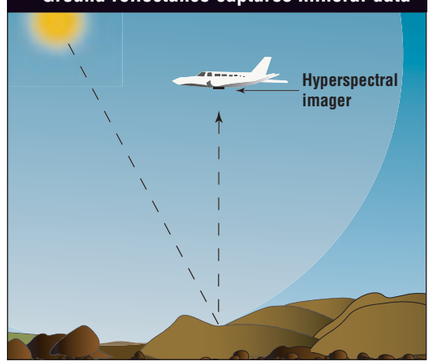
Mapping our weathered landscape: from left, Peter Hausknecht (HyVista), Dennis Gee (Cooperative Research Centre for Landscape Environments and Mineral Exploration), Tom Cudahy (CSIRO) and Scott Halley (Placer Dome)

Airborne hyperspectral mapping systems developed in Australia can provide vital clues to the geology that lies beneath our weathered landscape. **David Cohen** reports

To the naked eye, Australia is a vast, sunburnt landscape of weathered rock, soil and sand.

To a geologist this weathered blanket, called the regolith, covers two-thirds of the landscape and obscures the fresh underlying rock that potentially contains significant mineral deposits, presenting a major challenge for mineral exploration.

Ground reflectance captures mineral data



Surface geochemical sampling techniques and geophysical data have helped see through the regolith – but how well has the surface been mapped, especially when point sampling and interpolation techniques have been relied on for existing published geological/regolith maps?

Would measurement of the mineralogy for every point on the ground produce more accurate geological maps?

Geologist Tom Cudahy, of CSIRO Exploration & Mining, and geophysicist Peter Hausknecht, of airborne hyperspectral acquisition company HyVista, believe so and think it's achievable through a new generation of Australian-designed and developed airborne hyperspectral sensing technologies.

Hyperspectral remote sensing involves measuring the wavelength spectrum of sunlight reflected by the Earth's surface from the sky, in many narrow contiguous spectral bands, ranging from the visible to mid-infrared parts of the electromagnetic spectrum.

Because minerals absorb electromagnetic energy (light) by atomic and molecular processes, specific minerals can be identified and their quantity measured according to the nature of the absorption bands observed in the reflected spectrum.

The results can look like a mass of squiggly lines, as each pixel has a full spectrum of information. After processing, the image can look like an impressionist painting with swathes of deep reds, greens and electric blues. But each colour and line has mineralogical significance.

Australia has been a world leader in the development and application of spectral sensing technologies for more than 20 years. But hyperspectral sensing has been taken up largely by explorers outside Australia, in well-exposed geological environments such as the United States, Africa, South America and China.

Acceptance in Australia has been disappointing and the regolith has often been cited as the reason. However, the few geoscientists using hyperspectral sensing systems in Australia are discovering a host of minerals even within the most deeply weathered environments.

"A weathered landscape comprises a diverse suite of minerals, most of which cannot easily be measured in hand sample by the field geologist," Dr Cudahy said.

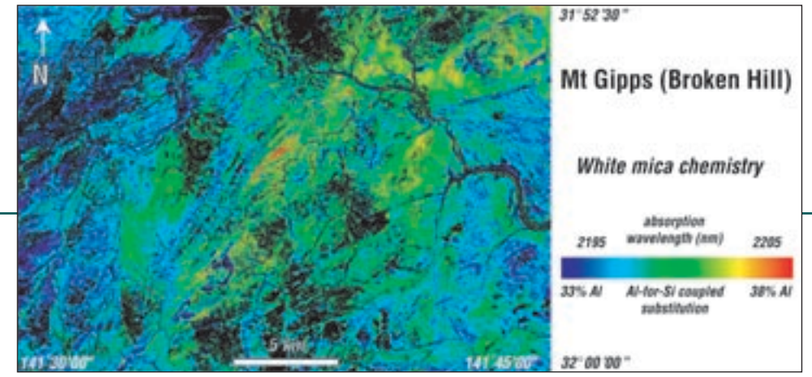
"Hyperspectral sensing measures the abundances of these minerals, and in many cases their chemistries and crystal structure.

"These laboratory-grade quantitative data can then be incorporated into more sophisticated mineralogical models of regolith stratigraphy and alteration zones to yield even higher level map products from which geologists can extract value."

The technology is being put to the test in the deeply weathered environment of the Eastern Goldfields around Kalgoorlie.

"Critical for this region is the detection of muscovite, especially its chemical variations," Dr Cudahy said. "The muscovite chemistry appears to be sensitive to the oxidation state of fluids associated with Archaean gold mineralisation. Mixing of these fluids causes gold to precipitate while producing large gradients in muscovite chemistry."

Placer Dome has been building up libraries of regional muscovite chemistry patterns around the Yilgarn gold deposits based on field spectral measurements taken from samples at the bottom of fresh rock drill core. The regolith was considered too much of a problem for remote detection.



Breaking through the regolith: A seamless map of white mica chemistry, masked for vegetation and kaolin (black areas), and based on 16 flight-lines of HyMap images

Placer Dome's Scott Halley says: "But now airborne hyperspectral systems like HyMap (see below), and more accurate processing methods coming out of CSIRO and HyVista, can map 'fresh' white mica chemistry that closely matches the patterns detected on the ground, even in places like Kalgoorlie.

"This is invaluable new data for us and potentially transforms our thinking of how we should be exploring in the regolith."

Another example is the Kimberley region of Western Australia, which before a recent airborne hyperspectral survey was not considered prospective for hydrothermal gold mineralisation.

The airborne data revealed a suite of previously unrecognised hydrothermal alteration minerals across large parts of the region. Primary gold was also found and exploration companies quickly took up much of the available exploration ground.

"The capacity to see mineral systems not recognised before is why this technology is so powerful," Dr Hausknecht said.

CSIRO and HyVista are working with Australian mapping agencies and explorers to deliver a new series of accurate mineral map products, especially alteration and regolith mineral abundance maps, derived from remote sensing data at scales from 1:25,000 to 1:250,000.

Mike Donaldson, from the Geological Survey of Western Australia, said: "This new hyperspectral technology has the potential to significantly add to geological understanding of this country by providing spatially comprehensive mineral abundance maps that complement current mapping techniques and geological map products."

Dr Cudahy said that no matter how inaccessible, rugged or environmentally sensitive the landscape, hyperspectral sensing can measure and map every point on the ground to reveal accurately what is exposed at the surface and to provide vital clues to what lies beneath.

"The challenge now is for explorers to begin asking the right questions of the hyperspectral data because there is a wealth of geological information waiting to be revealed," he said.

'Keg' holds key to new mapping technology

The HyVista technology, HyMap (pictured), that produces high-definition hyperspectral images, looks like a small yellow beer keg.

It sits in a light aircraft, such as a Cessna 404, pointing through a hole in the floor just inside the back door, with a human operator along for the ride to check data.

About one metre high, 60 centimetres wide and weighing about 120 kilograms, it sits on a specially stabilised platform at a survey altitude of 3,000 to 10,000 feet. It measures 126 wavelengths of reflected light for every three to ten-metre diameter pixel on the ground.

Important alteration minerals, such as muscovite, chlorite, hematite and kaolinite, have distinctive spectral signatures that can be measured directly using high signal-to-noise hyperspectral sensing systems such as HyMap.

The mineral results can be seamlessly stitched into maps according to customer needs. For example, white mica chemistry for every pixel over 300 square kilometres of exposed regolith in the Mt Gipps area near Broken Hill can be measured, mapped and provided as a product in 1:25,000 scale map format or as a 20 square centimetre postage stamp (see figure above).

It takes one to two days' flying time to acquire the data at a cost of $25 to $35 a square kilometre plus processing charges to deliver these mineral maps.

LINK

A regional HyMap survey conducted by the Geological Survey of New South Wales is available at:

www.minerals.nsw.gov.au/minfo/75/pdfs/new_products.pdf

HyVista: ***www.hyvista.com***

HyMap: ***www.intspec.com***

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