The GSWA HyLogger™: rapid spectral analysis and its application in detecting mineralization

by

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Introduction

HyLogging™ is a new, highly automated system designed by CSIRO to determine drillcore mineralogy using rapid reflectance spectroscopy. The resulting data, coupled with simultaneous acquisition of high-resolution digital photographs of scanned core, can provide new insights into host-rock and alteration mineralogy, vectors to mineralization, objective determination of lithostratigraphic units and their boundaries, and refined inputs to resource block modelling and geometallurgical characteristics. All mineralogical and image data are stored on a central database, which can be accessed using the internet.

The GSWA HyLogger™, which was installed in July 2009 at the Carlisle Core Library, is one of seven machines in Australia that together make up the AuScope National Virtual Core Library (NVCL) consortium. This is a collaborative Federal and State project which aims to provide drillcore mineralogical and image data in a standard format.

Since the installation of the HyLogger in July 2009, about 7000 m of mineral and petroleum core have been scanned, and the data successfully processed.

Methodology

Drillcore is scanned in its original trays and requires minimal preparation, other than being dry and clean. Required metadata include hole location and depth.

The HyLogging system comprises an integrated suite of spectroscopic, imaging, lighting, and materials handling tools that enable core to be scanned semi-automatically. Scanning is carried out using a computer-controlled table that continuously moves the core in a zigzag path beneath the scanner at a rate of approximately one metre every 30 seconds.

The HyLogger currently uses a CDI silicon-array grating spectrometer for the visible near-infrared (VNIR) wavelengths (380 to 1000 nm), and a Fourier transform infrared (FTIR) spectrometer for the shortwave-infrared (SWIR) wavelengths (1000 to 2500 nm). Both spectrometers measure radiance that is converted to spectral reflectance in relation to a Spectralon standard. The raw spectrometer instantaneous-field-of-view is 8 mm in diameter. The imaging system is a digital three-colour (red, green, blue) area-array camera used in a line-scan mode with a resolution of 0.1 mm. The system constructs a continuous image of the core, frame by frame, as the tray passes underneath. The system incorporates a laser profilometer used to measure the physical condition of the core every 0.1 mm as well as fractures and breaks to assist in geotechnical assessment and for control of other aspects of the system. The spectrometer, image, and profilometer data are captured simultaneously during a single traverse of the core tray.

Depending on core diameter and tray size, one tray can be scanned in three to five minutes, meaning that more than 500 m of core could be measured in one day, though a more typical output is 300 m.

Software and processing

The HyLogging hardware is complemented by special CSIRO-developed software ‘The Spectral Geologist’ (TSG-Core™) for the analysis, mineralogical interpretation, and simultaneous visualization of the spectral, image, and mineralogical data. Identification of minerals is made using an updated version of ‘The Spectral Assistant’ (TSA™) algorithm, along with estimates of their relative proportions and an interpretation error.

Pre-processing of data imported into TSG-Core includes trimming imagery to reduce dataset size, applying masks to hide non-geological materials, depth logging, checking and editing erroneous classifications, creating new numeric scalars to highlight additional mineralogical properties of the core, and importing external information, such as lithological logs and assays. The TSG-Core process results in a series of numeric and graphic logs and output products that can be printed, converted to PDF files, or placed into the NVCL relational database. The processed dataset is about 3 megabytes/metre whereas the size of the raw dataset is about 5–7 times greater. Raw (non-TSG) data, referred to as Level 0, are archived, whereas the processed (TSG) data

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are referred to as Levels 1–5 depending on the stage of the processing applied.

A free version of TSG (TSG-Viewer) is available for examining previously processed datasets from www.thespectralgeologist.com.

Targeting minerals

The current version of the HyLogger is suited to the recognition of iron oxides, sulfates, hydroxyl- and carbonate-bearing minerals (Table 1). It is not designed for ore minerals, although some massive phases can be mapped.

A next-generation system, which will involve the addition of a thermal infrared (TIR) spectrometer (wavelengths from 6000 to 14000 nm), is designed for the detection of non-OH-bearing silicates, such as feldspar, pyroxene, olivine, garnet, and quartz.

Dark samples, small particle sizes, organic matter, coatings, and complex mixtures pose challenges for automated interpretation systems and can lead to TSA errors (Clark, 2004). Tools are provided to identify and edit these errors.

Applications for exploration

A goal of the HyLogging methodology is to improve the objectivity of drillcore logging, and increase the amount, quality, and value of information obtained from what is seen as an expensive type of exploration activity. Other exploration benefits (Huntington, 2007) include understanding:

- Signatures of mineralized environments — alteration types and zones
- Characteristics of primary rock types
- New vectors to mineralization
- Indicators of weathering regimes and processes
- Indicators of chemistry and temperature
- Metallurgical and geotechnical properties
- Differences between transported and residual materials in regolith.

The goal of the AuScope NVCL project is to make this new type of mineralogical drillcore information widely available for all forms of Earth science research and to unlock previously unrecognized information in the many public core libraries around Australia.

Petroleum core

Using the HyLogging methodology for petroleum core is a new direction for GSWA. Recently acquired spectral data for several kilometres of petroleum core from the Canning Basin has provided information about lithostratigraphic unit boundaries, porosity, and water content, which will assist in exploration targeting.

Case study (Minnie Springs molybdenum mineralization)

The Minnie Springs molybdenum–copper prospect is located in the Ti Tree Shear Zone, which cuts granitic rocks of the Minnie Creek batholith in the Gascoyne Province of Western Australia (Pirajno et al., 2008). Two mineralization styles are present: disseminated molybdenite in potassic-altered granite, and molybdenite-bearing quartz veins and veinlets hosted in sericitized foliated granite.

Table 1.TSA mineral database

	Group of minerals	*Mineral*
VNIR spectrometer		
	Iron oxide	Hematite, goethite, jarosite
SWIR spectrometer		
	Kaolin	Kaolinite WX (well-crystalline), kaolinite PX (poor-crystalline), dickite, nacrite
	White mica	Muscovite, phengite, paragonite, illitic muscovite, illitic phengite, illitic paragonite
	Smectite	Montmorillonite, nontronite
	Other AlOH	Pyrophyllite, gibbsite, palygorskite, diaspore
	Chlorite	Mg-bearing chlorite, Fe-bearing chlorite, intermediate Mg/Fe chlorite
	Dark mica	Biotite, phlogopite
	Mg clay	Incorporating saponite, hectorite, sepiolite
	Amphibole	Hornblende, tremolite, actinolite, reibeckite
	Serpentine	Serpentine (antigorite, chrysotile, lizardite)
	Other MgOH	Talc, brucite
	Sulfate	Jarosite, Na-bearing alunite, NH-bearing alunite, gypsum
	Epidote	Epidote, clinozoisite, zoisite
	Silicate	Prehnite, topaz, opal
	Tourmaline	Tourmaline, rubellite
	Carbonate	Calcite, dolomite, magnesite, ankerite, siderite

SOURCE: modified after Huntington et al. (1997)

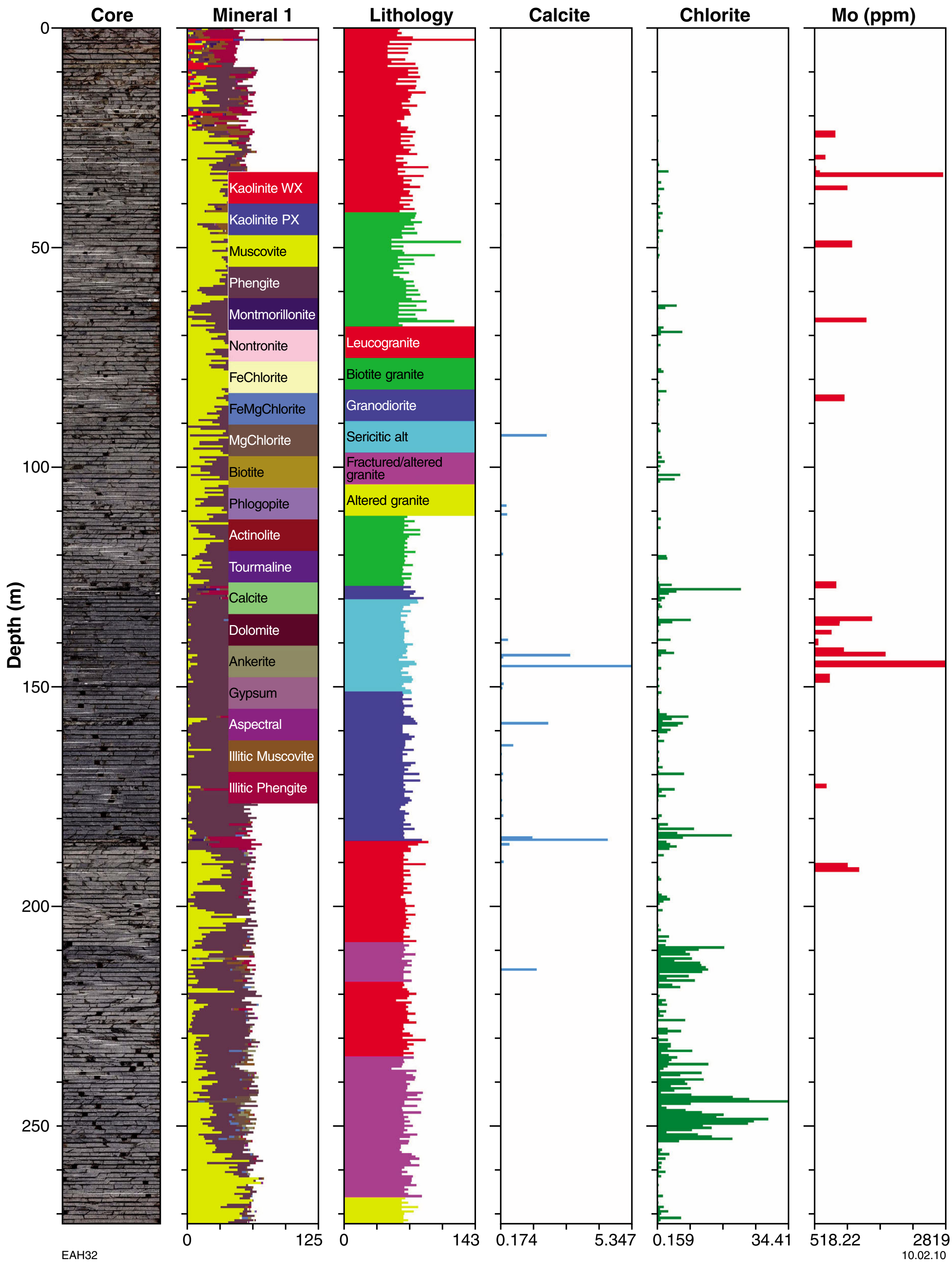

Figure 1. TSG graphic logs for drillhole MSD 2 (counts per 0.5 m core)

Three drillholes (118 m, 272 m, and 150 m depth, respectively) from the Minnie Springs prospect were scanned by the HyLogger. White mica, chlorite, and kaolinite were identified as the dominant minerals in the system, with calcite as a common secondary mineral in veins (Fig. 1). Minor minerals include tourmaline, zoisite, epidote, amphibole, nontronite, and montmorillonite. Subtle changes in the chemistry and crystallinity of muscovite/phengite/illite or Fe–Mg/Mg chlorite reflects varying physico-chemical properties. The pervasive development of low-Al phengitic white mica and chlorite reflects a low-temperature Fe–Mg-rich alteration environment that probably overprinted an early stage of sericitic (muscovite) formation. These sericitic and propylitic alteration assemblages are spatially associated with quartz–pyrite–molybdenite veins that are tracked by illitic phengite and calcite. The higher temperature potassic alteration is the earliest hydrothermal event in the system.

Conclusion

Considerable value can be added to drillcore information using HyLogger technology, which offers rapid and objective analysis, resulting in data that can be processed to indicate areas of mineralization or mineralization-related alteration. Provision of these data from a centralized database through the internet results in wider utilization of information and communication to a much broader community.

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