Lithotype analysis of hyperspectral imagery collected from drill core for the purpose of rapidly identifying critical mineral deposits in Alberta

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Summary

To help mineral exploration and mining companies rapidly identify rocks linked to ore mineralization, Hyperspectral Intelligence Inc. (HII) has developed a novel method of re-processing hyperspectral imagery data collected by other service providers. This method involves identifying distinct, mappable rock compositions using spectroscopy, where each unique composition is referred to as a lithotype. A lithotype represents a combination of the original lithology, any alteration that has occurred, and mineralization. The main benefit of using HII's Lithotype™ Method is that it identifies distinct rock compositions at a much higher sensitivity level than typical mineral mapping methods, while also producing outputs that allow for the straightforward correlation of distinct compositional units between drill cores. Overall, the lithotype logs produced using HII's Lithotype™ Method allow for faster resource identification.

The analysis presented here, as well as the raw data collection, were performed as part of the Alberta Geological Survey's Mineral Mapping Program, which aims to provide credible open-access geoscience information to better understand Alberta's mineral resource potential.

Methods

Hyperspectral imagery collected from 805 drill cores totaling approximately 51,050 metres were reprocessed for this project. These drill cores were originally drilled to target a variety of commodities and intervals of interest, such as gold, diamonds, lithium brines, uranium, base metals, polymetallic shales, potash, evaporites, kimberlite indicator minerals, titanium, platinum, silver, copper, zinc, lead, oil sands, and zones of potential mineralization or hydrothermal alteration. It should be noted that the target commodity denotes the purpose for which each well was originally drilled and does not necessarily indicate that the commodity is present. The drill cores selected for this project are distributed across the Athabasca Basin, Canadian Shield, and Western Canada Sedimentary Basin within Alberta, and intersect a range of lithologies and stratigraphic intervals from the Precambrian basement, Paleozoic carbonates and evaporites, Mesozoic fine- and coarse-grained siliciclastics, through to Quaternary sediments. Overall, Alberta was divided into eight geographical areas of interest for this study.

The drill core was scanned by Spectrum Geosciences Ltd. between November 2021 and February 2022 for a project under the Alberta Geological Survey's (AGS) Mineral Mapping Program. Hyperspectral imagery was collected from the drill cores using the TerraCore Hyperspectral Core Imaging system, which has three hyperspectral imaging cameras: Visible to

Near-Infrared (VNIR: 400-1000 nm), Short-Wave Infrared (SWIR: 1000-2500 nm), and the Long-Wave Infrared (LWIR: 8000-12000 nm).

The raw data is available on the core data interactive map on the AGS website: Interactive App or Map 014 (https://ags.aer.ca/publication/iam-014), and the processed hyperspectral data and other outputs produced by Hyperspectral Intelligence Inc. for this project will be published on the AGS website once completed.

To re-process this data, HII used several in-house developed tools to accomplish the following:

(1) Data Reduction, wherein data volumes were reduced by >97%.
(2) Library Creation, wherein the VNIR, SWIR, and LWIR imagery was converted to downhole reflectance profile libraries and merged to produce a single spectral library file.
(3) Lithotype Identification, wherein a spectral library was created for each geographical region of interest.
(4) Lithotype Mapping, wherein, the lithotype spectral libraries were used to classify the hyperspectral data from each geographical area of interest to produce spectral logs.
(5) Auxiliary Data Linkage, wherein datasets collected using other sensors (e.g., handheld XRF and Gamma Ray spectrometry) were used to inform the lithotype legend.

Example of Results: Athabasca Basin

Twelve lithotypes were identified in hyperspectral data collected from the 145 drill cores originating from the Athabasca Basin (Figure 1).

A spectral log was produced for each drill core from the Athabasca Basin to show the distribution of the 12 different lithotypes at one-meter depth intervals. These spectral logs allow for the visualization of compositional change along the surface of the drill core.

For the purpose of this project, observations of compositional change were used to create spectral strip logs for a drill core subset. The spectral logs and spectral strip logs for MR-54 are plotted alongside the elemental concentrations of Si, Al, Fe, Mg, K, S, Th, U, and Total Gamma (Figure 2). For MR-54, a lithologic log generated by Orr (1989) was added for reference.

Spectral Class	Primary SWIR-Active Minerals	Secondary SWIR-Active Minerals	LWIR-Active Minerals
Lithotype 1	Muscovitic Illite		Quartz
Lithotype 2	Muscovitic Illite	Fe^{2+} Bearing	Quartz
Lithotype 3	Muscovitic Illite + Chlorite		Quartz
Lithotype 4	Muscovitic Illite + Carbonate	Fe^{2+} Bearing	Quartz
Lithotype 5	Muscovitic Illite		Quartz
Lithotype 6	Muscovitic Illite		Quartz + Phyllosilicates
Lithotype 7	Muscovitic Illite	Chlorite Alteration + Fe^{2+} Bearing	Phyllosilicates + Quartz
Lithotype 8	Muscovitic Illite	Fe^{2+} Bearing	Phyllosilicates + Quartz
Lithotype 9	Muscovitic Illite	Fe^{2+} Bearing	Phyllosilicates + Quartz
Lithotype 10	Muscovitic Illite + Phengitic Illite	Chlorite + Fe^{2+} Bearing	Quartz + Feldspar
Lithotype 11	Muscovitic Illite		Quartz + Phyllosilicates
Lithotype 11	Carbonate	Muscovitic Illite	

Figure 1. Legend describing the 12 lithotypes identified in drill cores from the Athabasca Basin. The lithotypes are described in terms of their primary and secondary short- and long-wave infrared-active minerals.

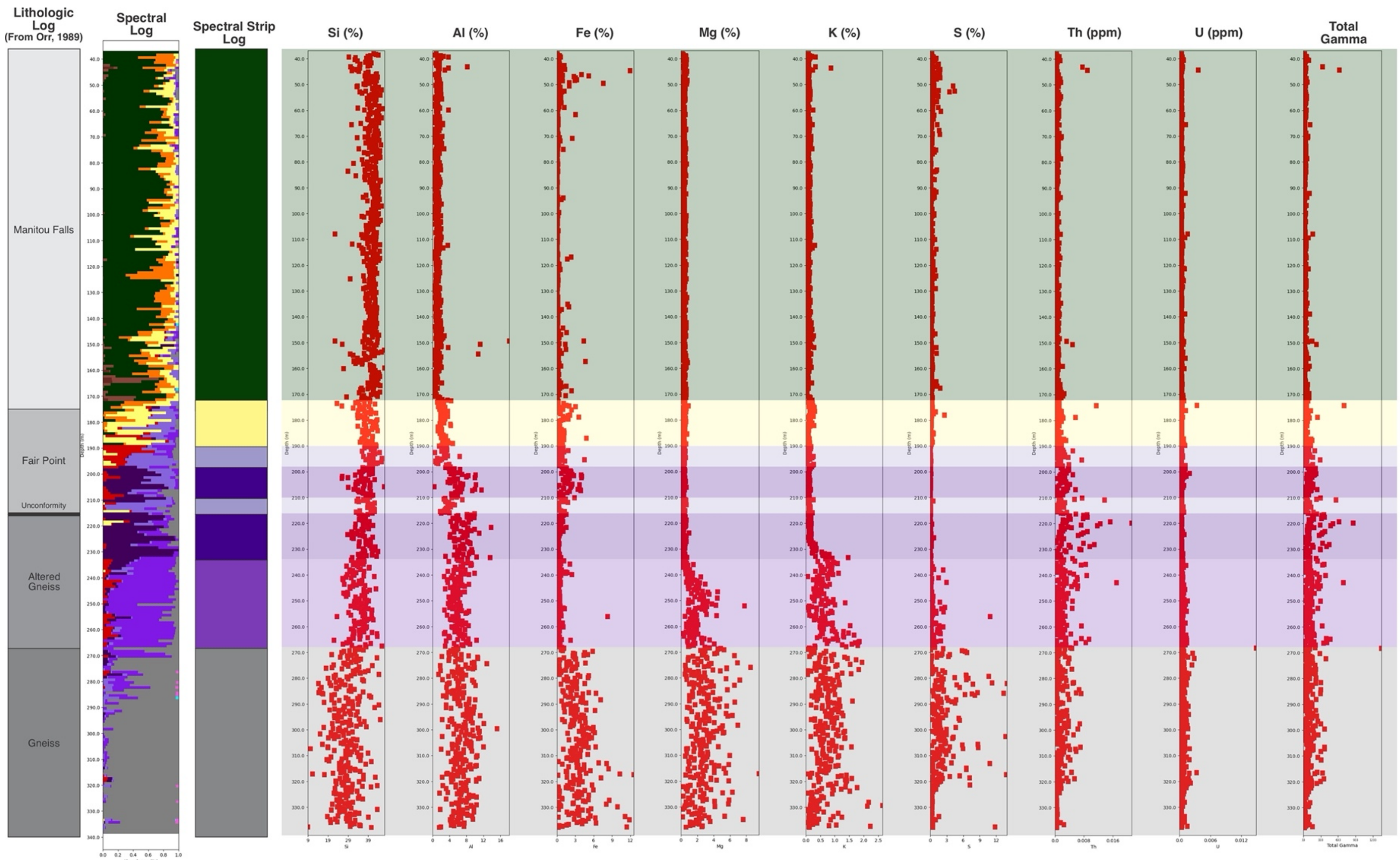

Figure 2. Spectral log for MR-54 at one meter depth intervals plotted alongside elemental concentrations (from handheld XRF) for Si, Al, Fe, Mg, K, S, Th, and U. The lithotype legend is provided in Figure 1. The lithologic log for MR-54 was published in Orr (1989). The spectral strip log was created visually using the abundance and distribution of the different lithotypes.

Discussion

To demonstrate how spectral strip logs can be used as a tool for advancing the understanding of a region, a cross-section produced through the Maybelle River trend (after Post et al., 2003) was re-generated using the outputs of the Lithotype^{TM} Method. In total, eight different compositional units were labelled in these strip logs, which are referred to as Unit A through H (Figure 3).

Reproducibly identifying the different compositional units in this area is important for targeting uranium mineralization. This can be difficult using only visible drill core logging methods because both the sedimentary rocks of the Fair Point Formation and the basement rocks have been extensively altered and fragmented in some locations. However, using the spectral logs produced using the Lithotype^{TM} Method, different compositional units are easier to observe, and it is possible to start developing various subsurface representations (e.g., Figure 4).

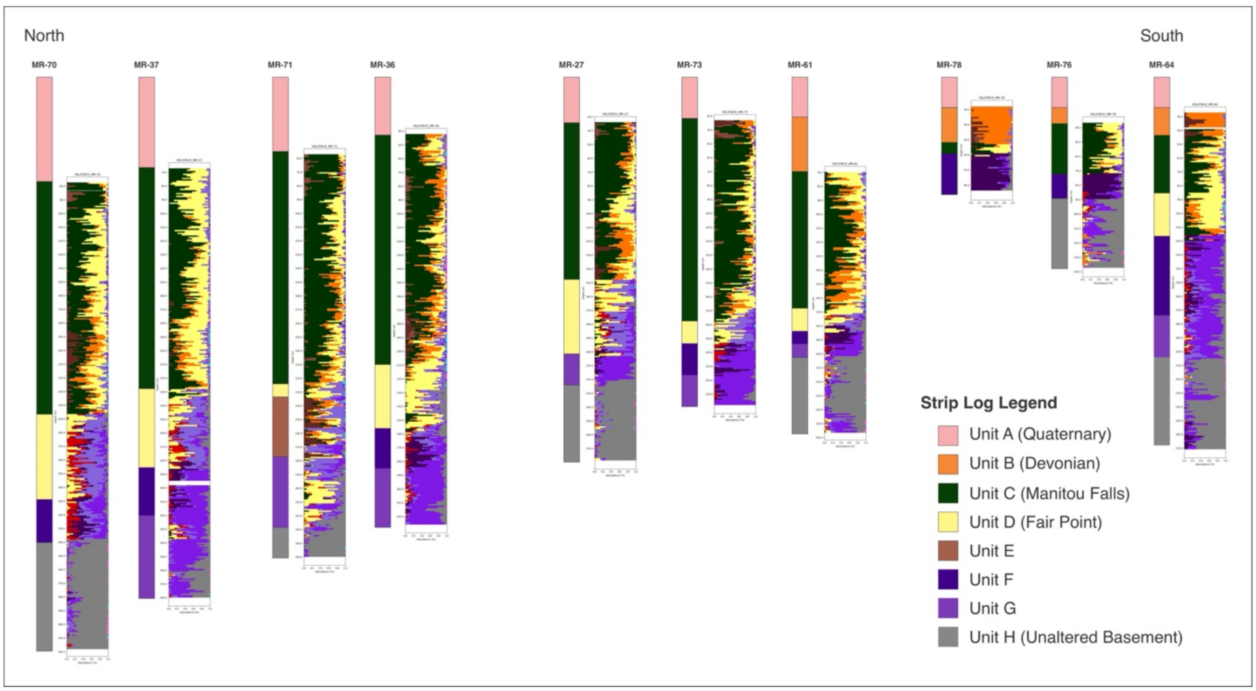

Figure 3. Cross section through the Maybelle River trend (after Post et al., 2003) showing spectral logs and spectral strip logs to provide an example of how units can be correlated between drill cores. The strip log legend is generic to avoid introducing bias or unintentional errors because Units E, F, and G are logged differently in different publications. The lithotype legend is provided in Figure 1.

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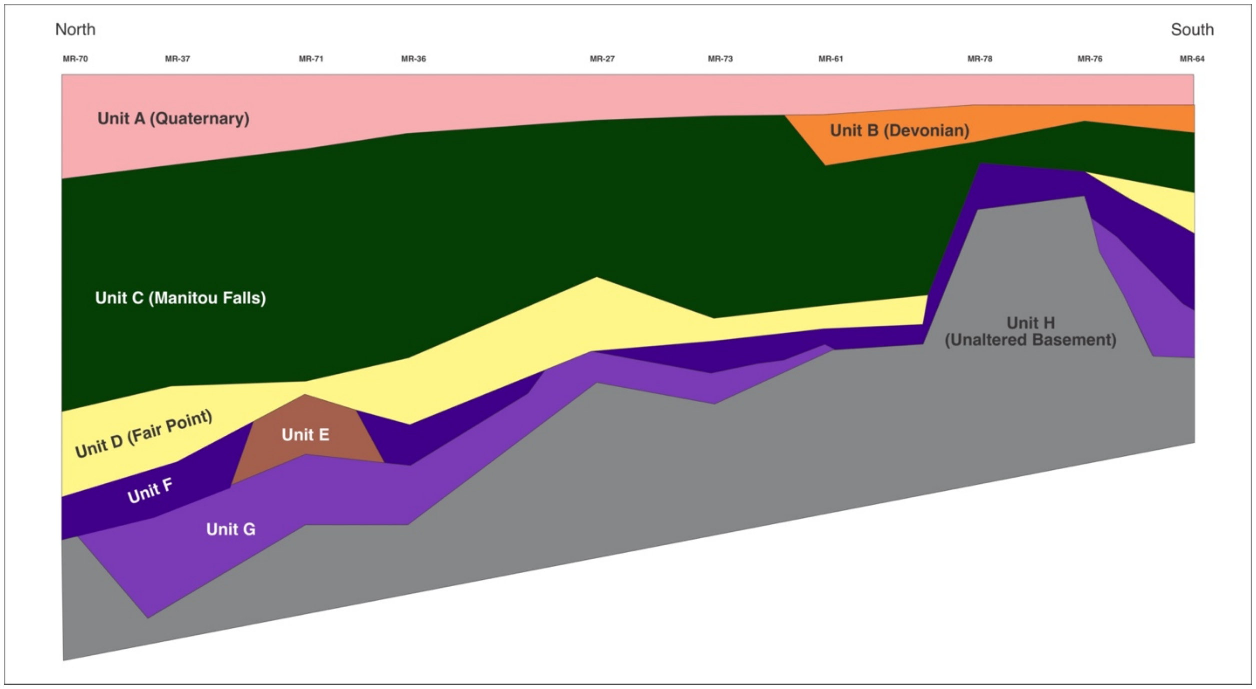

Figure 4. Cross section through the Maybelle River trend showing one possible subsurface interpretation derived using the spectral strip logs generated using the Lithotype™ Method.

Discussion

The primary goal of the Alberta Geological Survey's Mineral Mapping Program is to provide credible open-access geoscience information to help understand Alberta's mineral resource potential. Although the spectral logs produced using the Lithotype™ Method are reproducible and can be validated using auxiliary data, it is the responsibility of the qualified geologist working on an exploration project to ensure that the results of all data sources have been reviewed and considered. As a result, it is strongly suggested that the spectral logs generated using the Lithotype™ Method be used in combination with other data sources to validate and critique the spectral results, with the goal of ensuring that all outputs are robust and reproducible.

To assist with this task, HII has provided its deliverable files to the AGS in a variety of output formats and file types, allowing downstream users to have several options when it comes to further analysis, presentation, and use of the generated outputs.

References

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