AER/AGS Special Report 129

Alberta Energy Regulator

Index to Hyperspectral Imagery and High-Resolution Photographs for Selected Mineral Core from the Athabasca Basin, Canadian Shield, and Western Canada Sedimentary Basin in Alberta

AGS
ALBERTA GEOLOGICAL SURVEY

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Index to Hyperspectral Imagery and High-Resolution Photographs for Selected Mineral Core from the Athabasca Basin, Canadian Shield, and Western Canada Sedimentary Basin in Alberta

Spectrum Geosciences Ltd. and TerraCore Geospectral Imaging

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Foreword

In November 2021, the Alberta Energy Regulator (AER) / Alberta Geological Survey (AGS) contracted Spectrum Geoscience Ltd. to generate high-resolution photography and depth-associated hyperspectral imagery for 805 drillcore intervals; the total scan length was ~50 970.18 m. This project included drillcore from both the AGS Mineral Core Research Facility (MCRF) in Edmonton, Alberta, and the AER Core Research Centre (CRC) in Calgary, Alberta. Spectrum Geoscience Ltd. subcontracted TerraCore Geospectral Imaging (TerraCore) to provide a custom-built IntelliCore® system for the data.

For each of the 805 core intervals photographed and scanned in this project, the vendor delivered longwave infrared (LWIR), shortwave infrared (SWIR), and visible and near-infrared (VNIR) raw hyperspectral imagery data; true-colour imagery data generated from red, green, and blue (RGB); and two optimized PDF files containing summary core logs of depth-associated hyperspectral data, including imagery and dominant mineral maps, and core photos with RGB true-colour imagery. All of these products are currently available to view and download through the AGS Core Data Interactive Map (https://ags.aer.ca/publications/all-publications/iam-014) and the Alberta Interactive Minerals Map (https://ags.aer.ca/publications/all-publications/iam-001).

This Special Report includes a report on the standard image products, spectral features, and spectral indices of the IntelliCore® system; a summary of TerraCore metadata, including descriptions of the image types and their intended purposes, equipment details, and data collection and processing details; and a digital file with a list of the analyzed core intervals with associated metadata, including geospatial locations, interval depths, scan lengths, geological units intersected, lithologies intersected, and target commodities.

The core intervals analyzed in this project were drilled during previous mineral exploration projects to target a variety of commodities and intervals of interest, including, but not limited to, gold, diamonds, lithium brines, uranium, base metals, polymetallic shale, 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 in the digital file indicates the purpose for which each well/hole was originally drilled and does not necessarily indicate that the commodity is present. The core intervals intersect a variety of lithologies and stratigraphic intervals from the Precambrian basement, Paleozoic carbonate rocks and evaporites, Mesozoic fine- and coarse-grained siliciclastic rocks, through to Quaternary sediments. The core intervals selected for this project are geospatially distributed throughout the province, within the Alberta portions of the Athabasca Basin, Canadian Shield, and Western Canada Sedimentary Basin.

This work was completed under the Mineral Grant provided by the Government of Alberta dated June 22, 2021.

TERRACORE

GEOSPECTRAL IMAGING

Standard Image Products, Spectral Features, and Spectral Indices as seen in INTELLICORE®

Table of Contents

1 INTRODUCTION

This document outlines the explanation and meaning of the standard Products, Spectral Features, and standard Spectral Indices as seen on IntelliCore®. The table below shows the standard Spectral Features and Indices that are processed for every project.

Table 1. Standard Spectral Features and Indices which are processed for all projects.

Standard Spectral Features	Standard Spectral Indices
Albedo	Albedo
D1350:1450	AlOH_H2O
D1360:1410	AlOH_D1400
D1390:1430	AlOH_FeOH
D1440:1510	AlOH_MgOH
D1540:1565	Fe2_silicate
D1520:1580	FeOH_MgOH
D1600:1700	FeOH_AlOH
D1700:1800	H2O_D1400
D1900:2020	H2O_FeOH
D2060:2110	H2O_MgOH
D2150:2190	H2O_AlOH
D2180:2232	MgOH_H2O
D2239:2277	MgOH_AlOH
D2232:2285	MgOH_FeOH
D2270:2298	MgOH1_MgOH2
D2290:2330	serXT01
D2300:2370	serXT02
D2370:2420	
D2370:2400	
D2400:2450	
D1670:1735	
D1735:1780	
W1350:1450	
W1360:1410	
W1390:1430	
W1440:1510	
W1540:1565	
W1520:1580	
W1600:1700	
W1700:1800	
W1900:2020	
W2060:2110	
W2150:2190	
W2180:2232	
W2239:2277	
W2232:2285	
W2270:2298	
W2290:2330	
W2300:2370	
W2370:2420	
W2370:2400	
W2400:2450	
W1670:1735	
W1735:1780	

2 SWIR SPECTRAL FEATURE IMAGES IN INTELLICORE®

Spectral feature images in IntelliCore® will show under the feature extraction section for each camera. The sub-section is where depth or wavelength mean images can be selected for viewing. The digital data (downhole reports) for spectral features will show on the reports menu as depth and wavelength mean reports.

2.1 Depth Mean

These are presented as a series of images rainbow scaled from blue (low values) through to red (high values). Note that these can also be accessed down-hole using the feature extraction dashboard and appear under the depth mean column.

2.1.1 D1350:1450 (D1400)

Is related to the hydroxyl ion (OH^-), which is most strongly seen in aluminous minerals such as sericite, illite, kaolinite and clays (Al-smectite and nontronite). It is less well developed in ferromagnesian minerals such as amphibole, biotite, and chlorite. As such, it would be expected to be greatest in the oxide zone, in the argillic altered zone, and with quartz-sericite alteration.

2.1.2 D1900:2020 (D1950)

Is related to water. This water can either be bound in a mineral structure or be unbound water along fractures or as fluid inclusions – these two types can be discriminated on the basis of the wavelength. Unbound water is of little importance; however bound water content is really useful for both separating mineral species and as a proxy for temperature. The greater the number for this Feature, the more bound water is present. In general, as temperature increases, the amount of bound water will decrease – this holds true for clay and mica minerals, where the progression with increasing temperature is:

- Smectite (high water) – interlayered smectite/illite – illite-sericite (low water).
- At very high temperatures, sericite can be highly muscovitic and contain no water. Therefore, this Feature (along with the water/AlOH and water/MgOH ratios) can be used as a temperature proxy, and to vector towards high or low temperature zones.

2.1.3 D2150:2190 (D2165)

Records information chiefly about kaolinite, dickite, pyrophyllite, and alunite. In the case of pyrophyllite and alunite this is the main absorption feature, while in kaolinite and dickite a secondary feature on the flank of the AlOH absorption (see D2200) is recorded. The depth of this absorption is related to the amount of kaolinite or dickite present, and in kaolinite may also provide a measure of the crystallinity of that phase.

2.1.4 D2180:2230 (D2200)

Records the depth of the AlOH absorption feature present in clay (Al-smectite, illite and kaolinite) and sericite; it also occurs in minerals typical of advanced argillic alteration such as alunite and pyrophyllite. The higher the number of this feature, the greater the presence of AlOH bearing minerals.

2.1.5 D2232:2285 (D2250)

Records the depth of the Fe^{2+}-OH absorption. This is absent to very weakly developed in amphibole, weakly developed in biotite, moderately developed in epidote, and strongly developed in chlorite and in general this feature is a good proxy for chlorite abundance. When viewed together with D2300 in chlorite, this can provide mineralogical information – chlorites with a high degree of Al substitution have a high value of D2250 relative to the D2300 index.

2.1.6 D2290:2330 (D2300)

Also records the MgOH absorption, but across a very narrow wavelength range. This has been done to extract the main hydrocarbon absorption which occurs at ~2310nm, and which (in the absence of magnesian minerals such as talc, tremolite etc.) can be used as a proxy for hydrocarbon presence and relative abundance.

2.1.7 D2300:2370 (D2350)

Records the MgOH absorption in ferromagnesian minerals (mainly amphibole, biotite, epidote, and chlorite), as well as the CO_3 absorption in carbonate minerals. The greater the value of this feature, the greater the amount of ferromagnesian or carbonate minerals that are present. This feature is used in conjunction with the wavelength position to determine ferromagnesian and carbonate mineralogy and chemistry.

2.1.8 D2370:2420 (D2390)

Records the secondary MgOH absorption, which is only present in strongly magnesian minerals. It is best developed in amphibole, biotite, and unless the Mg content is high generally absent from chlorite and epidote.

2.2 Wavelength Mean

These are presented as a series of images rainbow scaled from blue (low values) through to red (high values). Note that these can also be accessed down-hole using the report button and selecting wavelength mean reports.

2.2.1 W1350:1450 (W1400)

Records the wavelength of the hydroxyl absorption. This varies with mineralogy from ~1380nm (ferromagnesian minerals), through ~1400nm (AlOH minerals including clays) to ~1450nm (sulphates and unbound water).

2.2.2 W1900:2000 (W1950)

Records the wavelength position of the water absorption and is the key discriminator between bound and unbound water. As a rule of thumb, values of below 1920 represent water bound in phyllosilicates while values above 1920nm represent unbound water. In general, unbound water in quartz occurs between 1920 and 1940, while that in feldspar is between 1940 and 1960. Very high values (1980 and above) could represent water in chlorite.

2.2.3 W2150:2190 (W2165)

Records information about the wavelength position of the ~2165-2180nm absorption, which occurs at longer wavelengths in dickite than kaolinite and can therefore be used as an index to separate those two minerals.

2.2.4 W2180:2230 (W2220)

Is the wavelength of the AlOH absorption, and a reflection of mineral chemistry for illite and sericite. Values of below 2200 reflect highly aluminous chemistries (paragonitic), 2200-2210 are typical potassic or muscovitic chemistries, and values above 2210 indicate Si-rich chemistry accompanied by Fe and Mg in the mineral structure (phengitic). In porphyry systems, mineralization is normally associated with potassic or phengitic compositions while paragonitic compositions are more commonly an indication of a high sulphidation environment or lithocap. Tracking variation of this feature extraction across the entire orebody may therefore provide an exploration vector by looking for changes to longer wavelengths associated with potassic or phyllic alteration.

2.2.5 W2232:2285 (W2250)

Records the wavelength of the Fe^{2+}-OH absorption. Low values (<2250nm) are related to magnesian compositions, becoming increasingly iron-rich to longer wavelengths (and especially >2260nm).

2.2.6 W2290:2330 (W2300)

Records the wavelength position the Mg-OH absorption, but across a very narrow wavelength range. This has been done to extract the main hydrocarbon absorption which occurs at ~2310nm, and which (in the absence of magnesian minerals such as talc, tremolite etc.) can be used as a proxy for hydrocarbon composition.

2.2.7 W2300:2370 (W2350)

Is the wavelength of the MgOH absorption. This provides discrimination between ferromagnesian minerals, with values below 2325 representing amphibole, 2325-2335 biotite, and above 2335 chlorite or epidote. In the presence of carbonates, this feature can be used to distinguish between carbonate minerals, specifically dolomite and calcite.

2.2.8 W2370:2420 (W2390)

Is the wavelength of the secondary MgOH absorption. This is only used in mixtures where separation of ferromagnesian minerals using other criteria is difficult, and the addition of this information may permit a mineral ID to be made.

2.3 Summarized table for Feature Extractions

Numerical data is provided for each of the feature extractions below, but images are not created without special request. These feature extractions can form the basis for advanced processing images.

Table 2. Summarized feature extractions and corresponding images.

Wavelength Mean	Depth Mean	Feature Image	Minerals
W1350:1450	D1350:1450	D/W 1400	OH feature
W1360:1410	D1360:1410		OH doublet dickite/kaolinite
W1390:1430	D1390:1430		OH doublet dickite/kaolinite
W1440:1510	D1440:1510	D/W 1450	OH doublet alunite
W1540:1565	D1540:1565		Clinozoisite/epidote
W1520:1580	D1520:1580		Sulphates/zeolites
W1600:1700	D1600:1700		OH in sulphates
W1700:1800	D1700:1800		OH in sulphates
W1900:2020	D1900:2020	D/W 1950	Interlayer/interstitial water
W2060:2110	D2060:2110		Talc
W2150:2190	D2150:2190	D/W 2165	Kaolinite/dickite feature
W2180:2232	D2180:2232	D/W 2200	Al-OH
W2239:2277	D2239:2277		Biotite/Chlorite
W2232:2285	D2232:2285	D/W 2250	Fe-OH
W2270:2298	D2270:2298		Fe-OH
W2290:2330	D2290:2330	D/W 2300	Amphibole/Hydrocarbons
W2300:2370	D2300:2370	D/W 2350	Mg-OH/CO3
W2370:2420	D2370:2420	D/W 2390	Biotite/Amphibole

3 LWIR SPECTRAL FEATURE IMAGES IN INTELLICORE®

Due to thermal hyperspectral imaging being a relatively new application, feature extractions in this wavelength range still under development. Below is a list of feature extractions TerraCore utilizes, and an example of what the extraction may be used to measure. Ultimately, because mineral signatures vary so widely in the LWIR, feature extractions can be used for multiple minerals, or a specific mineral may be measured by multiple feature extractions.

3.1 Peak-Height Mean

These are presented as a series of images rainbow scaled from blue (low values) through to red (high values). Note that these can also be accessed down-hole using the feature extraction dashboard and appear under the depth mean column.

3.1.1 PH76000 – 11900

Measures the intensity of the strongest peak across the LWIR spectrum.

3.1.2 PH8000

Measures the intensity of features associated with silica and sulphate-bearing minerals.

3.1.3 PH9000

Measures the intensity of features associated with silica.

3.1.4 PH9600

Measures the intensity of features associated with alkali feldspars, AlOH minerals, and MgOH minerals.

3.1.5 PH9800

Measures the intensity of features associated with plagioclase feldspars, AlOH minerals, and MgOH minerals.

3.1.6 PH11200

Measures the intensity of features associated with dolomite.

3.1.7 PH11300

Measures the intensity of features associated with calcite.

3.2 Peak-Wavelength Mean

These are presented as a series of images rainbow scaled from blue (low values) through to red (high values). Note that these can also be accessed down-hole using the report button and selecting wavelength mean reports.

3.2.1 PW76000 – 11900

Measures the wavelength position of the strongest peak across the LWIR spectrum.

3.2.2 PW8000

Measures the wavelength position of features associated with silica.

3.2.3 PW9000

Measures the wavelength position of features associated with silica.

3.2.4 PW9600

Measures the wavelength position of features associated with alkali feldspars, AlOH minerals, and MgOH minerals.

3.2.5 PW9800

Measures the wavelength position of features associated with plagioclase feldspars, AlOH minerals, and MgOH minerals.

3.2.6 PW11200

Measures the wavelength position of features associated with dolomite.

3.2.7 PW11300

Measures the wavelength position of features associated with calcite.

4 SWIR SPECIFIC SPECTRAL INDICES IN INTELLICORE®

Spectral index images can be found under spectral indices section in IntelliCore®. The sub-section menu is where the various indices can be selected for display. The downhole data for spectral indices can be selected from the report button in IntelliCore®. Due to the LWIR being a fairly new technology, no standard spectral indices are available at present.

4.1 AlOH:H20 (inverse index is H20:AlOH)

Is the ratio between D1950 and D2200 and provides a simpler means of evaluating bound water content with aluminous phyllosilicates.

4.2 AlOH:D1400

Is the ratio between the D2200 and D1400 absorption features, and so provides a simple discriminator between areas of predominantly AlOH alteration (sericitic, argillic) and sulphates or ferromagnesian minerals.

4.3 AlOH:FeOH (inverse index is FeOH:AlOH)

Is the ratio between the D2200 and D2250 absorption features, and so provides a simple discriminator between areas of predominantly ferromagnesian alteration and AlOH alteration.

4.4 AlOH:MgOH (inverse index is MgOH:AlOH)

Is the ratio between the D2200 and D2350 absorption features, and so provides a simple discriminator between areas of predominantly ferromagnesian alteration (potassic, Na-Ca) and AlOH alteration (sericitic, argillic).

4.5 Fe2 Silicate

Is the ratio between the reflectance values at 1200 and 1600nm. Iron-bearing minerals, including iron oxides (but not magnetite which is a spectral), iron carbonates (ankerite or siderite) and ferromagnesian minerals, have an absorption between 800 and 1000nm. Values >1 reflect the presence of iron-bearing minerals, while values <1 reflect their absence. The greater the value, the greater the proportion of iron-bearing minerals; in general, very high values (<1.3) relate to the presence of siderite.

4.6 H2O:MgOH (inverse index is MgOH:H2O)

Is the ratio between D1950 and D2350 and works along the same principle as water/AlOH. High values of this ratio will reflect areas of smectite (either Mg-rich saponite or Fe-rich nontronite) formed by weathering of primary phyllosilicate minerals, and with both being trioctahedral smectites these will reflect transition as opposed to oxide material. Low values will reflect high formation temperatures, and this ratio could provide a proxy for temperature distribution across the deposit.

4.7 H20:D1400

Is the ratio between D1950 and D1400 and can indicate the presence and relative abundance of water in minerals which respond with a 1400 feature (ferromagnesian minerals, sulphates, and clays).

4.8 H20:FeOH

Is the ratio between D1950 and D2250 and can indicate the presence of water in ferromagnesian minerals. High water content may result from mineral mixtures with smectites and sulphates.

4.9 FeOH:MgOH (inverse index is MgOH:FeOH)

Records the ratio between the Fe^{2+}-OH and MgOH absorptions. Given that the Fe^{2+}-OH absorption is best developed in chlorite, this can be used as a proxy for chlorite abundance; however, where chlorite is Al-rich (such as in minerals like sudoite) the Fe^{2+}-OH absorption becomes very deep and may exceed the Mg-OH absorption in magnitude. Values of >0.8 therefore can be used to map out Al-rich chlorites.

4.10 MgOH1:MgOH2

Records the ratio between the two MgOH absorptions (2340 and 2390). A higher value of the MgOH2 feature can help discriminate between biotite and chlorite. Varying values of this ratio may also indicate alteration of chlorite after biotite.

4.11 Ser_XT01 and 02

Records the width of the AlOH absorption using slightly different methods but provide similar information. As AlOH bearing minerals become more crystalline (generally reflecting higher temperature, but also in some cases the effects of pH) so the AlOH absorption becomes narrower. Therefore, higher values for this index record more crystalline micas such as muscovite/sericite, grading down to illite, illite-smectite and Al-smectite at lower values.

5 LWIR SPECIFIC SPECTRAL INDICES IN INTELLICORE®

5.1 D8200-8500

This index captures information related to quartz intensity, based on the first quartz Reststrahlen peak relative to the trough between the quartz peaks. High values for this index indicate greater quartz intensity.

5.2 D8900_D8200

This is a ratio between the two main quartz Reststrahlen peaks. As the particle size of quartz decreases, so the 8200 peak increases relative to the 8900 peak and so lower values for this index may reflect finer quartz/silica particle sizes and so indicate (for example) silicification or the presence of silica cement.

5.3 D10300_D9700

An index aimed at mafic minerals, and specifically amphibole (via D10300) and chlorite (D9700). Amphibole is often partially retrogressed to chlorite, which can be hard to identify by eye and which has potential geological and geometallurgical importance. High values for this index (where amphibole is present) denote unaltered amphibole, and lower values indicate retrogression to chlorite.

5.4 5.4 D9750_10700

Designed to capture retrogression of pyroxene or olivine to chlorite, but in the opposite sense to the previous index. In this case, high values will indicate more significant chlorite retrogression where pyroxene or olivine is present.

6 SPECTRAL INDICES COMMON TO BOTH SWIR AND LWIR IN INTELLICORE®

6.1 Max Wavelength

Returns the wavelength at which the maximum reflectance occurs. Useful for broad mineralogical discrimination, for example in the SWIR for identifying biotite-rich spectra (peak occurs around 2000nm) and in the LWIR for separating broad mineral groups based on this value.

6.2 Max Intensity

Records the maximum reflectance for each pixel, which is analogous to the albedo. Especially useful in the SWIR to determine the presence of dark phases that cause a reduction in reflectance such as fine-grained sulphides, graphite, dark oxide minerals (especially spinels) etc.

6.3 Spectral Variance

A measure of the overall variance from the full spectral mean for each pixel. This essentially records the "flatness" of a spectrum, in featureless and dark materials this value will be low as opposed to high values where pixels contain distinct and definite absorptions/peaks. This can therefore be used as a measure of confidence, where variance is low mineral identifications may be less reliable.

6.4 Min Wavelength

Records the wavelength at which the minimum reflectance occurs. In the SWIR often related to specific absorption features (Al-OH, Mg-OH etc.) or to the presence of iron, which when present has a large charge transfer feature at ~800-1200nm and so values of ~1000-1200nm often reflect the presence of iron. In the LWIR may record the Christensen feature at which scattering starts.

6.5 Min Intensity

Records the lowest intensity in a pixel. Require for other spectral calculations but not especially useful on its own.

7 GRIDDED FEATURES

Gridded features are very similar to regular feature extractions, except that the spectrum is zoomed into a very specific wavelength range before normalization of the spectrum. This allows for the detection and measurement of weaker features. The gridded features pertain to the same minerals and wavelength regions as the normal feature extractions listed above, and can be performed on the following features as standard:

- Grid W2250
- Grid D2250
- Grid D2165
- Grid W2165
- Grid D2200
- Grid W2200

Additional gridded features can also be created upon request.

8 PRODUCT DESCRIPTIONS

The descriptions below are for the various image products found on IntelliCore®. These can be accessed by selecting a camera, a section, and the appropriate subsection.

8.1 False Colour Composite

Composed of 3 bands selected from the infrared wavelength range. Highlights textural information.

8.2 RGB

High resolution (typically 0.15 mm pixels), natural colour photograph of dry drill core/sample.

8.3 Core Mask

Mask used to extract relevant (i.e. from the core) spectral data from areas of extraneous data (e.g. core tray or scanning table).

8.4 Enhanced Image

False colour image highlighting areas of spectral variation. Here colours are not assigned any particular interpretation, however, different colours indicate regions with specific spectral characteristics.

8.5 Albedo

Image illustrating areas of highest and lowest reflectance. Warm colours show high reflectance, while cold colours show areas of low reflectance. This data can give an indication of core quality.

8.6 Multisom / SOM Borehole Image / BH SOSO

Maps classes of different colours based on spectral variation. The number of classes is defined during processing. The classes are assigned to rainbow colour pallet to highlight spectral and textural variation in the image. The default number of classes derived from the data is 20. This can be done a box level (Multisom) or a borehole level (SOM Borehole Image). The 20 classes can then be given a mineral classification by a spectral geologist.

8.7 Unmasked Auto Dominant Map

Unsupervised matching technique with a library that includes tray material (cardboard, plastic, etc.). This map is an early product intended to identify mineral types and major lithologic or mineralogic changes.

8.8 Auto Dominant Map

Unsupervised matching technique performed once core masking has occurred. The core mask ensures that matching is only performed on the sample and not the core box. This map is an early product intended to identify mineral types and major lithologic or mineralogic changes.

8.9 Borehole Mineral Map

Maps classes of different colours based on spectral variation. Each class is interpreted by a spectral geologist and assigned a mineral/mineral mixture name, for which a legend is generated.

8.10 Dominant Mineral Map (Borehole SOM V1)

Maps classes of different colours based on their match to an external spectral library. Mixtures may be present, but the matching identifies the dominant mineral.

8.11 Fenix RGB

Displays the image utilizing the red, green, and blue bands from the spectral camera.

Appendix 1 – TerraCore Metadata Summary

Image Descriptions and Intended Purpose

RGB: True Colour

Description: High resolution natural colour photograph of dry drillcore or sample.

Purpose: Selected as it provides a true colour image or rendition of the drillcore sample.

VNIR: False Colour Composite

Description: The image provides a natural colour image for the visible near-infrared (VNIR) data. The 3 VNIR spectral bands selected for this image are Red: 650 nm, Green: 532 nm, Blue: 485 nm.

Purpose: Selected to provide true colour data from the spectral data across the VNIR wavelength range (400–1000 nm).

SWIR: False Colour Composite

Description: False Colour Composite Image generated using a combination of bands from the Shortwave Infrared (SWIR) camera. The 3 SWIR spectral bands selected for this image are Red: 1940 nm, Green: 2200 nm, Blue: 2340 nm.

Purpose: Selected to provide image data across the SWIR wavelength range (1000–2500 nm). The image colours highlight textural information in the drillcore due to spectral contrast between the selected bands in the false colour composite. The specific bands are selected to highlight spectral contrast resulting from Mg-Fe-phyllosilicates, carbonates, Al-phyllosilicates, and OH-bearing minerals.

LWIR False Colour Composite

Description: False Colour Composite Image generated using a combination of bands from the Longwave Infrared (LWIR) camera. The 3 LWIR spectral bands selected for this image are Red: 8600 nm, Green: 10000 nm, Blue: 11800 nm.

Purpose: Selected to provide an example of image data across the LWIR wavelength ranges (8000–12000 nm). The image colours highlight textural information in the drillcore due to spectral contrasts in the data. The bands used in the false colour composite were selected to highlight variations between felsic, phyllosilicate-rich, mafic and carbonate materials in the images.

SWIR: Enhanced Image

Description: False colour image highlighting areas of spectral variation. Here colours are not assigned any particular interpretation; however, different colours indicate regions with specific spectral characteristics. These images are generated using a decorrelation stretch across 3 contrasting spectral bands for the SWIR wavelength region (1000–2500 nm). The decorrelation stretch is related to principal component analysis in that both techniques are projection methods and extract key characteristics from the input dataset. These methods uncover relationships between the different variables. In the case of the decorrelation stretch, three bands are selected from the multispectral image, and the relationships between the spectral responses in these bands are revealed in the decorrelated output. These relationships are further emphasized by applying a contrast stretch to the extracted features. The result is a colourful composite image, where the visual colour separation allows for better feature discrimination.

Purpose: Selected as these images highlight textural contrast across the drillcore samples. While the colours do not relate to specific minerals in the images, they provide a good indication of changes in the spectral signatures and highlight rock and mineral variations across the drillcore.

LWIR: Enhanced Image

Description: False colour image highlighting areas of spectral variation. Here colours are not assigned any particular interpretation; however, different colours indicate regions with specific spectral characteristics. These images are generated using a decorrelation process across 3 bands for the LWIR wavelength region (8000–12000 nm). The decorrelation stretch is related to principal component analysis in that both techniques are projection methods and extract key characteristics from the input dataset. These methods uncover relationships between the different variables. In the case of the decorrelation stretch, three bands are selected from the multispectral image, and the relationships between the spectral responses in these bands are revealed in the decorrelated output. These relationships are further emphasized by applying a contrast stretch to the extracted features. The result is a colourful composite image, where the visual colour separation allows for better feature discrimination.

Purpose: Selected as these images highlight textural contrast across the drillcore samples. While the colours do not relate to specific minerals in the images, they provide a good indication of changes in the spectral signatures and highlight rock and mineral variations across the drillcore.

SWIR: Dominant Mineral Map

Description: Mineral map generated using a matching technique against a reference library compiled by TerraCore from publicly available libraries (ASTER Spectral Library (Baldridge *et al*., 2009), United States Geological Survey Spectral Library (Kokaly *et al*., 2017)). The spectrally dominant mineral is displayed for every pixel in the image. These mineral maps are generated across the SWIR region and display minerals that can typically be detected across this range.

Purpose: The dominant mineral map provides an indication of the mineralogy across the drillcore samples. Minerals readily characterized in the SWIR region includes phyllosilicates, clays, carbonates, hydroxides, including selected sulphates, inosilicates, cyclosilicates, sorosilicates and oxides.

LWIR: Dominant Mineral Map

Description: Mineral map generated using a matching technique against a reference library compiled by TerraCore from publicly available libraries (ASTER Spectral Library (Baldridge *et al*., 2009), United States Geological Survey Spectral Library (Kokaly *et al*., 2017)). The spectrally dominant mineral is displayed for every pixel in the image. These mineral maps are generated across the LWIR region and display minerals that can typically be detected across this range.

Purpose: The dominant mineral map provides an indication of the mineralogy across the drillcore samples. Minerals readily characterized in the LWIR region includes inosilicates, nesosilicates, tectosilicates, carbonates, sulphates, including selected phosphates and phyllosilicates.

SWIR: Dominant Mineral Map Graph

Description: Graph displays a count of the pixels from the SWIR mineral map as a percentage log. The interval spacing for the graph is at 1cm. The depth measurements displayed on the graph (in metres) are the mid-point values for the 1cm interval.

LWIR: Dominant Mineral Map Graph

Description: Graph displays a count of the pixels from the LWIR mineral map as a percentage log. The interval spacing for the graph is at 1cm. The depth measurements displayed on the graph (in metres) are the mid-point values for the 1cm interval.

Equipment Details

TerraCore System

Data were captured using a TerraCore Hyperspectral Core Imaging system with multiple cameras to facilitate capture of drillcore tray images simultaneously in a single scan cycle

RGB Camera

Camera Make & Model: TVI VISION PRIIMUS 4096QT

Wavelength Range: Visible

Spectral Bands (collected): 3

Spectral Bands (actual): 3

Spatial resolution (pixel size): 0.1 mm

Light Source: LED illumination

VNIR Camera

Camera Make & Model: SPECIM FX10

Wavelength Range: 400–1000 nm

Spectral Bands (collected): 93

Spectral Bands (actual): 112

Spectral resolution: 5.5 nm (mean)

Spatial resolution (pixel size): 0.45 mm (resampled to 1.13 mm)

Light Source: Halogen lamp illumination

SWIR Camera

Camera Make & Model: SPECIM SWIR3

Wavelength Range: 1000—2500 nm

Spectral Bands (collected): 288

Spectral Bands (actual): 251

Spectral Resolution: 12 nm

Spatial resolution (pixel size): 1.13 mm

Light Source: Halogen lamp illumination

LWIR Camera

Camera Make & Model: SPECIM OWL

Wavelength Range: 8000—12000 nm

Spectral Bands (collected): 100

Spectral Bands (actual): 288

Spectral resolution: 100 nm

Spatial resolution (pixel size): 1.13 mm

Light Source: Thermal heating bar illumination

Data Collection and Processing Details

Location

All hyperspectral data collection took place at Spectrum Geosciences facilities in Calgary, Alberta between November 2021, and February 2022.

Data Processing

Data Correction: System corrections are applied to all camera image data using the white and dark reference files acquired at the time of each core tray image file. Data are subset to active wavelength range and filtered converting data from radiance to reflectance.

Data Preparation: Core trays are extracted as the region of interest in the image data. Core masks are generated to isolate core from background tray material. Depth points, core loss and missing core are recorded and associated to the image data for depth registration of the imagery.

Spectral Processing: Spectral drillcore image data are matched to the appropriate spectral range reference libraries. Best correlated minerals are assigned to each individual image pixel.

Product Generation: Hyperspectral Image Cubes are BIL format (Band interleaved by line) with associated ENVI compatible header files. Product images are JPG and PNG, and numerical downhole data is CSV formats.

QA/QC Process

Data Evaluation: Camera operation is reviewed daily with all tests completed and passed before data acquisition begins. Image data are reviewed for image quality, focus, geometry, and completion during the acquisition process.

Processed Data Review: Spectral data products are reviewed to ensure accuracy of corrections and generation of spectral products.

Core Mask Review: Auto generated core masks are reviewed and edited to ensure only core material is selected for the spectral analysis.

Depth Segment Review: Depth assignments to the drillcore are reviewed to ensure they fall within acceptable values. Depth units (m/ft), core loss and missing core are taken into account in the depth registration.

Interpretation Review: Spectral mineral matches are reviewed, evaluated, and edited by subject matter experts.

Data Product Review: Data products generated are reviewed against the image data for accuracy and completeness

References

Baldridge, A M., Rivera, G., Hook, S.J., Grove, C.I., 2009. The ASTER spectral library version 2.0. Remote Sensing of Environment 113, 711–715.

Kokaly, R.F., Clark, R.N., Swayze, G.A., Livo, K.E., Hoefen, T.M., Pearson, N.C., Wise, R.A., Benzel, W.M., Lowers, H.A., Driscoll, R.L., and Klein, A.J., 2017, USGS Spectral Library Version 7: U.S. Geological Survey Data Series 1035, 61 p.