NVCL Case Study: South Gawler Craton (MSPD11)

Pt I. Geological Context and Introduction to the Datasets

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Summary

This case study includes a HyLogger data pack for drill hole MSDP11 comprising HyLogger data, geochemistry, and lithology data, as well as a case study report split into several parts. The .tdg file allows full access to the dataset and TSG without a full license and can be accessed through CSIRO's Data Access Portal at https://data.csiro.au/collections. Part I of the case study reporting outlines the geological context of the MSDP11 drill hole, providing the necessary background for interrogating the datasets. It will also provide an overview of the datasets available with the case study. Subsequent parts of the case study will interrogate specific geological questions using this dataset, beginning with Part II. Investigating Skarn Mineralogy. New applications-based sections will be added periodically to the case study and will use the same datasets.

Geological Context

The MSDP11 drill hole is located along the southern margin of the Gawler Range Volcanics (GRV), in South Australia's Gawler Craton, and was drilled as a part of the Mineral Systems Drilling Program (MSDP) (Figure 1). This region of the South Australia is considered an emerging mineral province with evidence of an extensive epithermal province with significant silver mineralization (Wade et al., 2014). The MSDP program was undertaken in 2015-2016 by the Geological Survey of South Australia and was focused on furthering the understanding of the mineral systems which developed during the c. 1590 Ma magmatism in that region. The results of this program are summarized in Fabris et al., 2017.

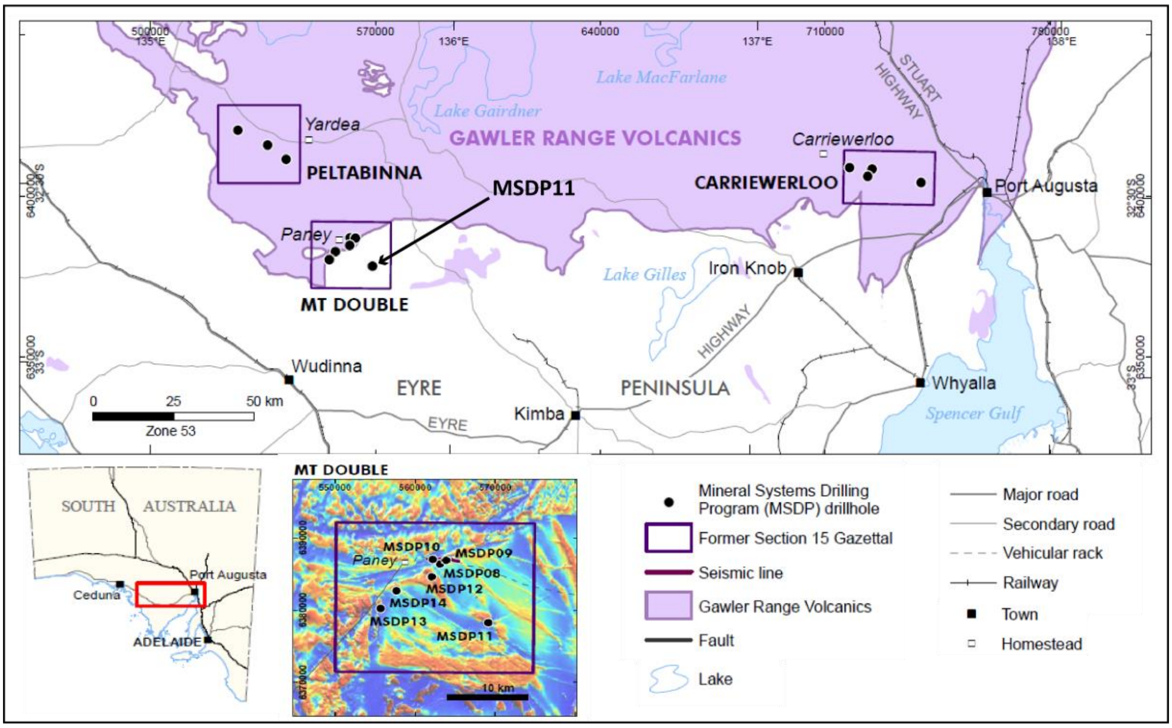

Figure 1. Location of the MSDP drill holes in the Southern Gawler Ranges with a zoomed box showing the drill holes in the Mt Double area (including MSDP11) in relation to residual aeromagnetic data (modified from Fabris, 2017).

The 1596-1587 Ma Gawler Range Volcanics (GRV) are conventionally split into two main packages, the lower and upper GRV (Allen et al. 2008; Allen et al. 2003). The lower GRV is compositionally variable and includes dacitic to rhyolitic lavas and ignimbrites, tuffs, volcanoclastics and lesser mafics, as well as unnamed felsic volcanics. The upper GRV is dominated by three regionally extensive felsic lava flows. The intrusive counterpart to the GRV is the 1595 – 1570 Ma Hiltaba Suite (Allen et al. 2003). The GRV stratigraphy is described in detail in Allen et al. (2003), Allen et al. (2008), Blissett et al. (1993) and McAvaney and Wade (2015).

MSDP11 was drilled in the Mount Double area where exploration has focused on a curvilinear aeromagnetic anomaly located at the eastern margin of the Pennas Granite (Hiltaba Suite) (Figure 1). Exploration in the region during the late 1980's and early 1990's defined several prospects with anomalous Zn, Pb and Ag, with values of up to 9% Zn, 3.4% Pb and 20g/t Ag in diamond drilling (Robinson et al., 1988). This mineralization is described as stratiform within units of the Hutchinson Group and most consistent in carbonate rich units (Toteff et al., 1995). However, anomalous values are not restricted to those units, and Pb isotope data indicates the presence of syngenetic and remobilised mineralization (Carr and Dean, 1986, Dean, 1993).

Drill Hole Context

MSDP11 was drilled into the stratigraphic units which underly the GRV along its eroded southern margin, and was positioned to test an EM conductor and intense magnetic anomaly (Figure 1, Table 1). Along with drill hole MSDP12, it was sited on potential traps caused by reactive lithologies of the Hutchison Group which are known to host anomalous Zn, Pb and Ag values (Fabris et al., 2017).

Table 1. Drill hole details (Farbis et al., 2017)

Hole	Drill hole number	Easting	Northing	Elevation	Orientation	Hole Diameter	EOH
MSDP11	288777	569173.622	6378227.54	185.391	-50	PQ/HQ/NQ	498.2

MSDP11 was collared in 26.9 m of Cenozoic alluvial gravels and silts before intersecting a number of basement lithologies ranging from porphyries to metadiorites and skarns (Table 2 Summary of the geology log for MSDP11 (from Fabris et al., 2017) Detailed descriptions of the lithologies encountered can be found in Fabris et al., 2017. The intersection of magnetite-rich units and skarn from 320 m accounts for the magnetic anomaly which was targeted and modelled to a downhole depth of 265 m (Ogilvie et al., 2016). The drill hole contains several anomalous, intersections of Ag, Pb, and Zn associated with narrow pyrite-rich intervals, and intersects the skarnified 1790 Ma Hutchinson Group, ending in Augen Gneiss of presumed 2530 Ma Sleaford Complex (Daly and Fanning, 1993). The drill hole also intersects the Hiltaba Suite and several metadioritic units which had not been previously described in the region but appear similar to units of the 1740-1700 Ma Peter Pan Supersuite (Fabris, 2017; Wade and MacAvaney, 2016).

Table 2 Summary of the geology log for MSDP11 (from Fabris et al., 2017)

From [m[]	**To [m]**	**Lithology** (Major)	**Lithology** (Minor)	**Stratigraphic Unit**
0	26.9	Gravel	Silt	Unnamed Cenozoic unit
26.9	77.3	Porphyry		Hiltaba Suite
77.3	138.64	Metadiorite	Metagranite	Peter Pan Supersuite
138.64	144.55	Porphyry		Gawler Range Volcanics
144.55	151.1	Metadiorite		Peter Pan Supersuite
151.1	163.97	Porphyry		Gawler Range Volcanics
163.97	168.11	Metadiorite	Pegmatite	Peter Pan Supersuite
168.11	171.69	Porphyry		Gawler Range Volcanics
171.69	212.6	Metadiorite	Metagranite	Peter Pan Supersuite
212.6	214.89	Porphyry		Hiltaba Suite
214.89	320.82	Metadiorite	Metagranite	Peter Pan Supersuite
320.82	390.6	Skarn	Metagranite	?Hutchison Group
390.6	408.3	Metagranite	Skarn	Peter Pan Supersuite
408.3	439.4	Metadiorite	Metagranite	Peter Pan Supersuite
439.4	445	Skarn		?Hutchison Group
445	455.2	Metadiorite	Metagranite	Peter Pan Supersuite
455.2	480.7	Metagranite	Metadiorite	Peter Pan Supersuite
480.7	498.2	Augen gneiss		Sleaford Complex

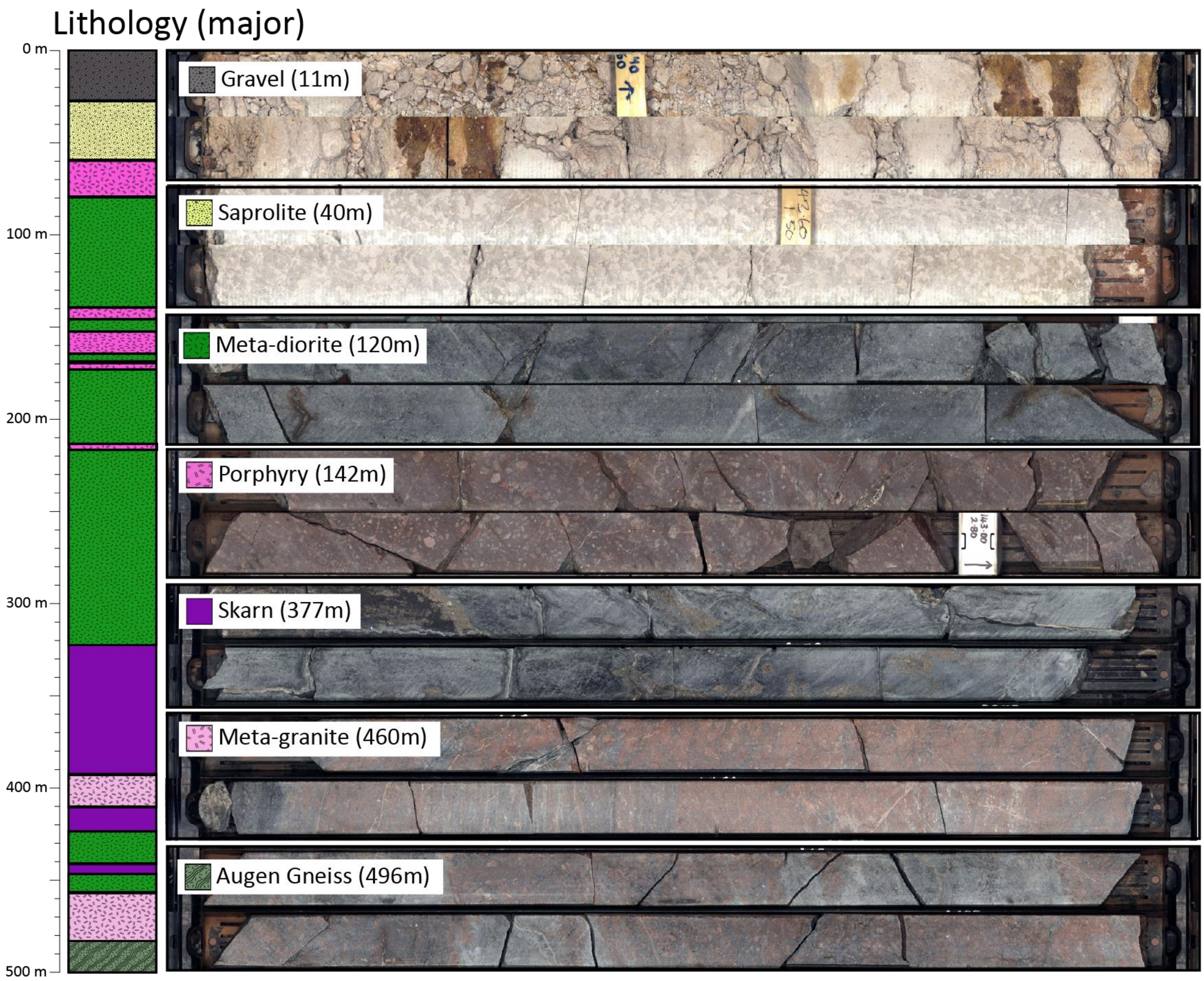

Figure 2 Summary of the lithological Logging (after Fabris et al., 2017) with HyLogger core photos showing the major lithologies

Introduction to the Case Study Datasets

The TSG file in this case study dataset is provided as a .tdg file and includes HyLogger data as well as some imported geochemistry, lithology information (visual logging), magnetic susceptibility and density measurements. To view the HyLogger data, open the file ending in .tdg in TSG8.

This TSG file was generated by the HyLogger-3 system during analysis of the core at the Geological Survey of South Australia using the method described by Schodlock et al., 2016. Reflectance spectra were collected over the visible-to-near-infrared (VNIR 380– 1000 nm), short-wave infrared (SWIR 1000– 2500 nm) and thermal infrared (TIR 6000– 14 500 nm) wavelength ranges and high-resolution (0.1 mm pixel) digital colour photographs of core were obtained concurrently using a built-in line-scan camera. The reflectance spectra were automatically resampled to 8 nm spectral sampling and 8 mm spatial resolution by The Spectral Geologist software.

The results discussed Part I of this case study are primarily based on TSA (The Spectral Assistant) outputs which are derived in the TSG software (e.g. Figure 4). TSA is an algorithm for automated spectral unmixing which uses its training library to match the spectrum against a single mineral or model a simulated mixture of 2-4 minerals that most closely resembles that of the input spectrum (Berman et al., 2011). TSA mineralogy outputs are one of the most common outputs derived from hyperspectral data using TSG and for this dataset has been derived using expert input and domain knowledge. The SWIR and TIR spectral ranges are sensitive and diagnostic for different mineral groups, and so the SWIR and TIR TSA result are complementary and should be considered together (Figure 3).

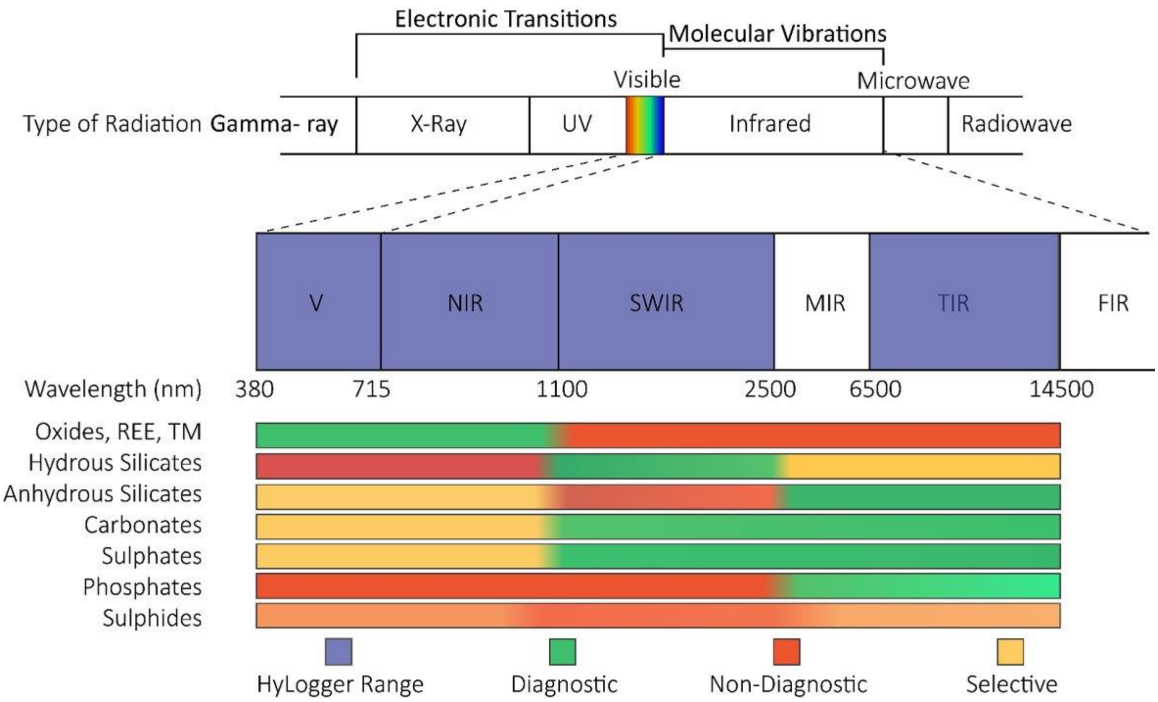

Figure 3 Summary of the Hylogger spectra range and the mineral groups for which the VNIR, SWIR, and TIR are diagnostic, non-diagnostic, and selective.

There are also several scalars discussed in the later parts of this case study (e.g, 2200D). Scalar is the term used by TSG to refer to any set of calculated values related to loaded spectral data. The scalars applied are pre-written, well-established, and in most cases published scripts for spectral parameters which probe the position or depth of a given spectral absorption feature. Batch system scalars commonly use a 3-band polynomial fit, while the User Scalars employ a Multiple Feature Extraction Methods for their outputs so are much more restrictive. Details of the scalars name, application, as well as references are included the explanatory notes of the report in which they are used, there is also a master sheet of scalars that can be accessed at the link in the additional resources section at the back of this report.

The TSG file also includes some of the geochemistry data compiled by GSSA as a part of the MSDP project. Geochemistry can be found under the scalars as imported numeric logs. The lithology data is captured as class scalars. The remainder of the relevant data for the drill hole is included as .csv files in the case study data pack, which can then be used to create new numerical scalars in TSG and may be used in future sections of this case study.

Downhole Summary

The most basic hyperspectral output from HyLogger datasets is the downhole mineralogy summary. This is displayed on the summary screen in TSG and provides an overview of the downhole hyperspectral mineralogy as derived from the TSA algorithm, and can be binned at different sizes. Figure 4 shows the TSA derived downhole mineralogy for MSDP11 along with the major lithologies and whole rock geochemistry assays for MgO, Zn, and Ag showing the regions of anomalous metal content.

The TSA outputs in Figure 4 are split into SWIR and TIR mineralogy and represent spatial plots of the User SWIR and User jCLST results binned at the 1 m scale. Using only this summary plot, the major lithologies and contacts can be distinguished based on changes in the downhole spectral mineralogy. For instance, the porphyry units and meta-granites can be distinguished from the meta-diorites by an increase in the TIR reported plagioclase in the porphyries and an increase in K-feldspar in the meta-granites. In addition to distinguishing major rock types from the downhole summary, it is also possible to investigate mineralogical heterogeneity and alteration within a given unit. This may be important when considering sampling procedures, or even correlating stratigraphy using marker units. An example is the heterogeneity within the metadiorite in which there are significant variations in dark mica and amphibole content.

Perhaps the most heterogeneous and distinct unit is the ~60 m of skarn at 320 m depth. This unit has a strong invalid or aspectral signature in the SWIR due to the abundance of magnetite, and both the TIR and SWIR show a strong signature indicative of amphibole minerals. There is also a significant amount of sulphate reported in the skarn unit (e.g., 360-380 m). This is often indicative of weathering of sulphides on the surface of the core. Using the TSG summary screen, interesting sections of the drill core identified in the hyperspectral mineralogy can be further investigated in the context of the core photography by using a floater screen showing the linescan to, for instance, confirm that the sulphate signature in the TSA results is the result of the presence of sulphide weathering (Figure 4). For instructions on how to do this, refer to the instructional video titled “Introduction to working with HyLogger Data in The Spectral Geologist (TSG)”.

This skarn unit is also MgO rich with respect to the rest of the stratigraphy, and this is reflected in the abundance of serpentine and amphibole reported in the hyperspectral mineralogy. Anomalous metal contents (Zn, Ag) are observed in several parts of the stratigraphy including the skarn unit. The hyperspectral mineralogy of this skarn unit will be interrogated in more detail in Part II of this case study.

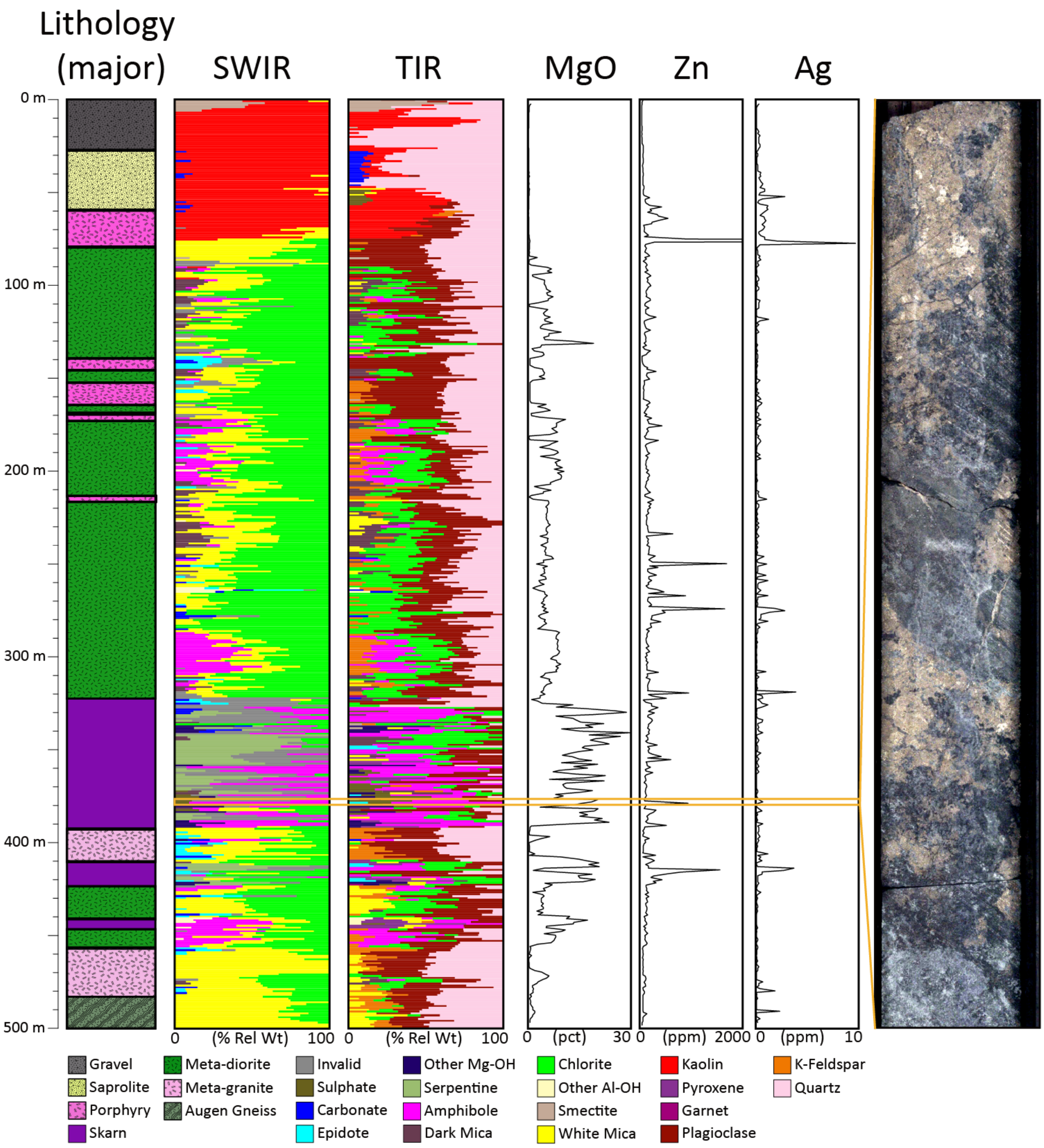

Figure 4 Summary of the major lithologies (after Fabris et al., 2017), TSA-derived hyperspectral mineralogy by mineral group, and selected goechemical assays for MSDDP11 (highest value for Zn plot off the scale) with a core photo from the sulphate-rich intersection of skarn.

Acknowledgments

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Furthermore, we'd like to acknowledge all those hard working people that collect and process the NVCL data on a day to day basis, helping to 'uncover the mineralogy of the top two kilometres of the Australian continent', and particular, the HyLogging team at the Geological Survey of South Australia for creating this dataset.

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Additional Resources

AuScope Discovery Portal
http://portal.auscope.org/

Instructional Videos

"How to download TSG Files from the Auscope Discover Portal"
https://www.youtube.com/watch?v=Oh_YAxEpLeo&t=115s

"Introduction to working with HyLogger Data in The Spectral Geologist (TSG)"
https://www.youtube.com/watch?v=u-SjA2_J3RQ&t=71s

Recorded Webinars

"The National Virtual Core Library – Building a Continental-Scale drill core database"
Carsten Laukamp, Monica LeGras and Jessica Stromberg – CSIRO Covideo Conference
https://www.youtube.com/watch?v=AlcIqAGc9U4&t=4s

"Mineral composition trends in hydrothermal mineral systems inferred from reflectance spectra"
Carsten Laukamp – CSIRO Covideo Conference
https://www.youtube.com/watch?v=IEvxn6o0imk&t=110s

"UK SGA Chapter: AuScope Workshop with CSIRO Scientists"
Jessica Stromberg and Carsten Laukamp – NVCL Online Workshop
https://www.youtube.com/watch?v=JuXg5if170M

Other TSG Materials
https://research.csiro.au/thespectralgeologist/support/downloads/

CSIRO Spectral Reference Library
http://mineralspectrallibraries.csiro.au/

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