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Modelling geochemical indices from hyperspectral reflectance spectra—applications for exploration and mining

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Hyperspectral reflectance spectra can provide valuable information for characterisation of potential resources by objective identification of mineral assemblages throughout the exploration and mining process. Traditionally, hyperspectral sensing in the visible and infrared wavelength regions is used to map alteration footprints in hydrothermal systems (e.g. argillic, sericitic, propyllitic) and to vector towards a resource.

This paper aims to demonstrate examples of modelling geochemical indices from hyperspectral data, using case studies from the exploration through to the mining stage. One example case study is from the Western Australian portion of the Bight and Eucla Basins, where Cretaceous and Cenozoic sediments cover a vast area of Precambrian crust. As part of the Eucla basement stratigraphic drilling program conducted by the Geological Survey of Western Australia, GSWA, (Spaggiari & Smithies, 2015), hyperspectral reflectance spectra were collected from drill core using a HyLogger3 located at GSWA's drill core library in Carlisle, Western Australia. The HyLogger3 (Schodlok, et al. 2016) provided valuable information about this underexplored area. Combined acquisition of visible-near, shortwave and thermal infrared data allowed the characterisation of most major rock forming minerals, such as carbonates as well as hydrous and anhydrous silicates. The hyperspectrally-derived mineralogy exhibited distinct changes in chlorite/biotite and amphibole abundances and their composition between metabasalts intruded by adakites and within the respective lithologies.

A Partial Least Squares (PLS) regression method, within The Spectral Geologist (TSG) software (https://research.csiro.au/thespectralgeologist/), was applied to model geochemical indices from hyperspectral data by using geochemical analyses (XRF provided by GSWA) for calibration. Three geochemical indices, that are commonly used to characterise basement lithologies, were modelled: 1) the Mg# (Mg/(Mg+Fe); Miyashiro, 1975), 2), Aluminium saturation index (Al_2O_3/(Na_2O+K_2O+CaO); Zen, 1986) and 3) SCFM (SiO_2/(SiO_2+CaO+FeOtot+MgO; Walter & Salisbury, 1989). The example from the Bight and Eucla Basins showed that modelled geochemical indices allow a more detailed characterisation of basement rock types, potentially revealing information critical for exploration, which would have been missed by conventional, sparse geochemical sampling. Furthermore, scalars developed for modelling geochemical indices in one drill core could in many cases be successfully applied to other drill cores from the same geological province.

The approach presented here can be used to I) advance stratigraphic correlation of basement and cover rocks based on objective drill core mineralogy, II) map intensity of weathering of basement, and III) map mineralogical and physicochemical gradients potentially related to hydrothermal systems. Already during the exploration stage, different ore domains can be inferred from the mineral assemblages interpreted using the hyperspectral data (e.g. sulphide vs oxidised zones).

Every metre of drilled core could drive the decision to investigate a selected area further or to continue working elsewhere. Therefore, extracting as much geoscientific information as possible from drill cores during early greenfields exploration stage is imperative. Companies can save costs on expensive analytics and improve targeting for future sampling by recognising the potential for extrapolating expensive geochemical data to the thousands of hyperspectral measurements acquired from drill holes in a matter of days.