Porphyry deposits: genetic models using hyperspectral imagery data of drill core for exploration and mining applications

Ekaterina Savinova[1], Ronell Carey[2]

1.

Senior Spectral Geologist, Corescan Pty Ltd, Ascot, WA, 6104, Australia. Email: Katerina.savinova@corescan.com.au

2.

Interpretation Services Manager, Corescan Pty Ltd, Ascot, WA, 6104, Australia. Email:

Ronell.carey@corescan.com.au

Keywords: Porphyry, hyperspectral, alteration, VIS-SWIR, clay

Introduction

The identification of alteration minerals and their chemical composition calculation, along with characterisation of mineral textural relationships, can be effectively completed with the use of hyperspectral drill core imaging. Successful interpretation of hyperspectral drill core imagery, in combination with geological, geochemical and geophysical inputs, can lead to an expansion of current mineral resources, optimisation of mine processes, as well as future delineation of new green-field districts. In most ore deposits, alteration minerals are related to the chemistry of the mineralising fluids and are easily identifiable by spectral characteristics in the VIS-SWIR wavelength range. These include minerals such as mica-, amphibole-, carbonate-, chlorite-, iron oxide-, kaolinite-, smectite-, sulfate- and tourmaline-species.

High resolution hyperspectral images, such as those collected by the Corescan multi-sensor platform, assist in capturing a higher amount of pure mineral pixels and enhance the interpretation of mixed pixels by having access to spectral data from neighbouring mineral grains. Additional advantages of 2D hyperspectral imaging include characterisation of texture and mineral associations.

Methods

Detailed mineralogy for the investigation of alteration domains and chemical variations in a case study porphyry system were acquired using an automated hyperspectral core imaging system. The scanning measurements were performed with the Corescan HCI-3 custom built unit. The HCI-3 operates across the VIS and SWIR bands from 450—2,500nm at a spectral resolution of ~4nm and a spatial resolution of 500µm, resulting in ±150,000 spectra per meter of imaged drill core. The spectrum of each pixel is spatially referenced to the depth of the drill hole and tied to high resolution photography (50µm) and laser profiler (200µm), both effectively assisting with logging and description of the core and calculating pseudo-RQD, respectively. The reflectance spectral signatures are compared to an amalgamated reference spectral library (USGS) that consists of over 1,000 separate minerals and mineral sub-species. Also, the spatial referencing of the spectra allows for detailed comparison with other downhole geological information such as geochemical and geophysical datasets.

Discussion

Large Cu porphyries may have an orebody that extends over several kilometres and the surrounding alteration halo is often 10 – 20 times larger. Categorisation and insight into the spatial relationships of alteration zones can serve as important vectors in ore deposit exploration. Hyperspectral imaging of drill core assists in porphyry mineral characterisation by highlighting veining and other textures associated with the formation of the ore deposit. On a micro-scale, it allows for the identification and understanding of cross-cutting relationships, paragenesis and vein alteration envelopes that may not otherwise be apparent. On a regional scale, hyperspectral imagery is well suited to characterise alteration domains that can illuminate previously unknown mineralization vectors and expose underutilised variations in mineral compositions. These spectral datasets can be readily applied to porphyries in exploration and mining (Figure 1).

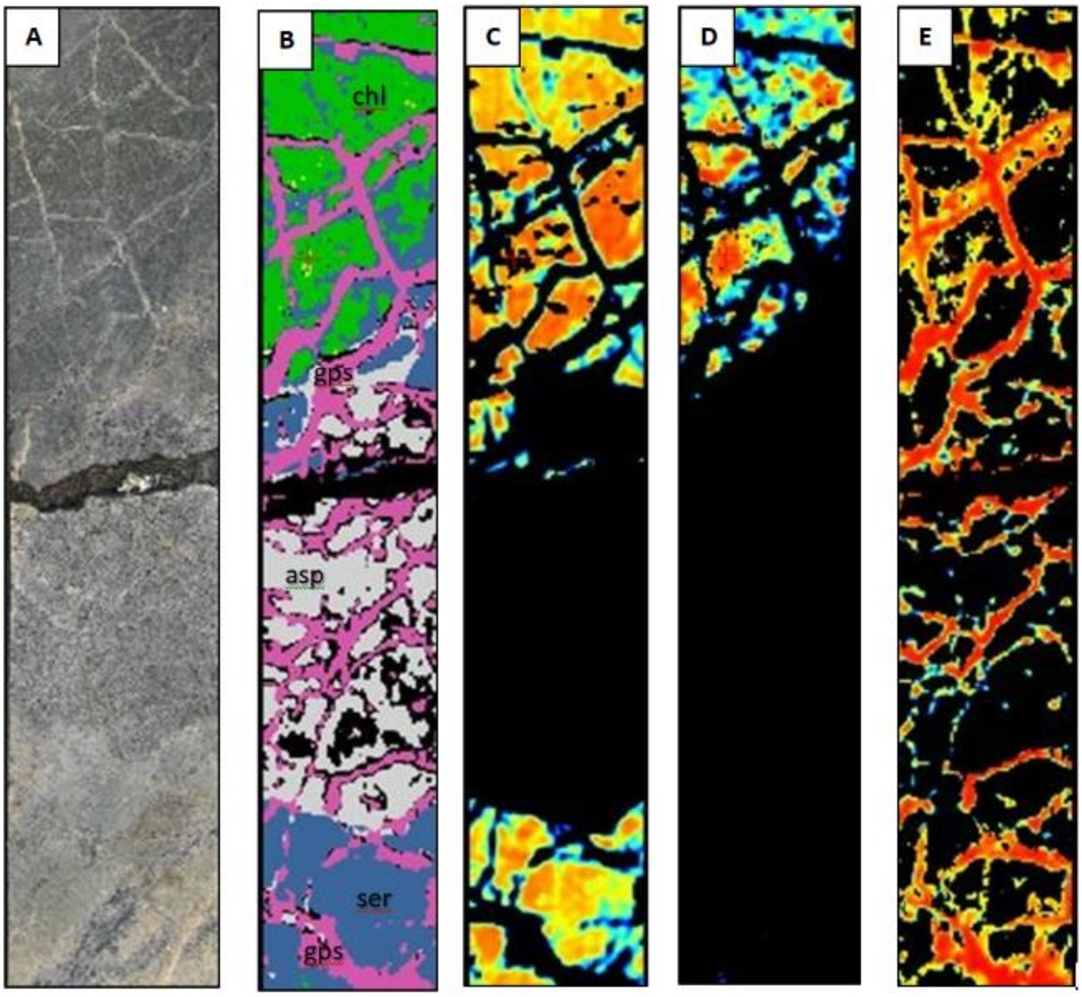

Figure 1. A) Core photography at 50µm; B) Mineral class map that is a visual summary where all interpreted minerals are designated a unique colour; chl = Chlorite, gps = Gypsum, asp = Aspectral (match for unaltered feldspar or silicification), ser = Sericite; C) Sericite spectral match; D) Chlorite spectral match; E) Match for gypsum veining.

It is common practice to base geological models on observations in drill core and geochemical analysis, and these datasets successfully define rock type distribution and structural domains (Figure 2). However, hydrothermal alteration domains and metal zoning in relation to the intrusion are often hard to characterise visually and geologists rely on relatively expensive and time consuming methods (XRD, interpretation of thin sections, etc.) to assist with this task. Analysis and interpretation of continuous hyperspectral imagining data, acquired on average at ~500 µm spatial resolution, provide a highly sampled account of rock surface mineralogy at relatively fast speeds.

Observations made on a micro-scale are often mirrored on a regional scale and are invaluable in determining the geological evolution of a deposit type. For example, white mica compositional changes on a regional scale may include shifts from muscovite to phengite while on micro-scale, distinct veining events are recognised where white mica changes outwards from muscovite to phengite. In addition, with systematic hyperspectral imagery we are able to characterise alternating separate intervals of white mica-chlorite mixtures, as well as mineral composition and crystallinity variations. Other commonly described features include abundant gypsum veining and inferred altered feldspar zones, intervals dominated by kaolinite-dickite-pyrophyllite-alunite, segments with tourmaline and sections where the main alteration minerals are amphibole, biotite and/or carbonate. Segmenting drill holes into their main alteration mineral components allows for the classification of an area into well understood alteration zones as proposed by Sillitoe (2010) or Lowell and Guilbert (1970).

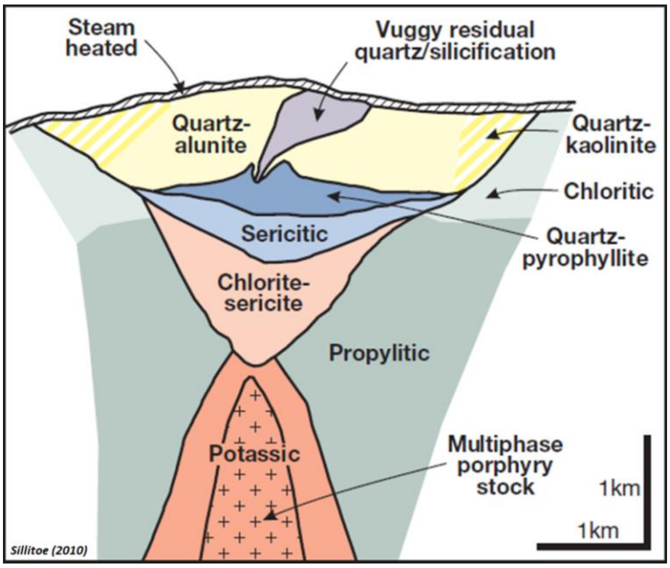

Figure 2. Simplified schematic of alteration-mineralization zones in a non-telescoped porphyry Cu system (R. Sillitoe, 2010).

References

Lowell, J.D., Guilbert, J.M., 1970. *Lateral and Vertical Alteration-Mineralization Zoning in Porphyry Ore Deposits*; Economic Geology, v. 65, pp. 373-408.

Sillitoe, R.H., 2010. *Porphyry Copper Systems*; Economic Geology, v. 105, pp. 3-41.