

Using Deposit-scale Alteration and Geochemical Signatures to Explore for Analogue Deposits: a Case Study From the Mt Wright Gold Project, Queensland

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ABSTRACT

Both Short Wavelength Infrared (SWIR) spectral and multi-element (ME) analysis of drill samples are proven and cost-effective (but not necessarily routine) techniques for characterising certain alteration types, pathfinder elements, and their distributions in and around ore deposits. The understanding obtained from these methods can easily be transferred to regional and/or near mine exploration, so that similar styles of mineralisation can be targeted and/or identified. Short Wavelength Infrared spectral data from drill holes around the Mt Wright gold deposit, in north Queensland, highlight subtle variations in sericite chemistry, both within the ore zone at least several hundred metres into the surrounding wallrock. By modelling the distribution of different alteration types in 3D, a better understanding of the nature of the alteration is obtained, and drill holes that do not intercept the orebody can be placed in a spatial context relative to the overall mineralised system. As such, SWIR spectral data is ideally suited to the drilling phase of exploration when targeting Mt Wright-style mineralisation. Multi-element however, reveals that the pathfinder element signature extends no more than approximately 50m beyond the edge of the orebody. Compared to the SWIR results, it appears that ME analyses may be better utilised in surface geochemical methods during the early stages of exploration for this style of deposit.

INTRODUCTION

The Mt Wright gold deposit (Total Resource ~ 1 Moz @ 3.3g/t), is hosted within an approximately 200x60 m wide, vertical, breccia pipe, located in northeast Queensland, Australia (Fig. 1). The deposit is characterized by a series of overprinting, structurally-focused rhyolite intrusions and hydrothermal breccias, hosted within the Ordovician Millaroo Granite (Furniss, 1998). Mineralisation of the complex (~305 Ma) occurred subsequent to, but essentially coeval with the final rhyolite brecciation stage (Perkins and Kennedy, 1998), and is characterized by pyrite-marcasite (after pyrrhotite) veining and intense sericite alteration. The pipe itself is weakly mineralized at surface (approx 0.2-0.5 g/t), but grades increase with depth and average around 4 g/t between 500-800m below the surface (Fig. 2). Development of the underground mine began in 2006, with the first ore trucked to the nearby Ravenswood plant in early-mid 2007.

The small and low-grade surface expression of the deposit makes exploring for analogues difficult, particularly where outcrop is poor. As such, characterizing the alteration and geochemical signature is important so that surface and/or drill samples in areas of interest can be compared to those associated



Figure 1: Map of Queensland, Australia, showing approximate location of Mt Wright.

with this style of mineralisation. To achieve this, a combined Short Wavelength Infrared (SWIR) spectral analysis and multi-element (ME) study was conducted. The results of this investigation are already being applied to regional exploration.

METHODS

An ASD (Analytical Spectral Devices) TerraSpec® was used to collect SWIR spectra from a combination of RC chips and diamond core. Approximately 5000 spectra were obtained from 19 drill holes, with the chips/core analysed at either 1 or 2 metre intervals (the collection of this data took about one week). The spectral data was processed in The Spectral Geologist Pro® software (TSG), where four major mineral groups/assemblages were identified:

- Sericite-illite
- Kaolinite-illite
- Sericite-chlorite
- Chlorite

Samples within the sericite-illite group were then split into four sub-sets based on the wavelength ranges of the 2200nm absorption feature (Fig. 3). The resulting seven “mineral groups” were plotted on down-hole drill traces in the software package MineSight 3D® and iso-surfaces for the different “classes” were digitized (using 50m level plans) to visualize the alteration mineral distribution in 3D.

Several of the above drill holes were selected for multi-element (ME) analysis. Samples were taken at 2-3m intervals, within and adjacent to the ore zone, with sampling intervals gradually increasing up to 20m approximately 150-200m away from the mineralization. Where possible, samples in the wallrock avoided veining and other small-scale (non representative) features. All samples were submitted to ALS Chemex and analysed for 48 elements using method ME-MS61 (four acid digest with combined ICP-MS/AES analysis).

ALTERATION MINERALOGY WITHIN AND ADJACENT TO THE MT WRIGHT DEPOSIT

The SWIR spectral data appears to indicate that there is some zonation of the alteration mineralogy within and adjacent to the deposit. In particular:

- 1) The upper portion of the rhyolite breccia pipe is dominated by short wavelength (<2201 nm) white mica alteration, whereas the lower part is characterized by sericite in the (2201-2203 nm) range (Fig. 4);
- 2) In the surrounding Millaroo Granite, the kaolinite-illite mineral group (plus minor long wavelength sericite) forms an annulus around the pipe (Fig. 5);
- 3) Pervasive sericite-chlorite alteration exists beyond the kaolinite-illite halo, in the Millaroo Granite.

The wavelength variation around 2200 nm is important as this feature is controlled by the substitution of Fe and Mg for Al in the sericite structure (Herrmann et al., 2001). Muscovites (low

Fe, Mg) exhibit absorption around 2200 nm, whereas phengites (high Fe, Mg) display absorption around 2210(+) nm. Therefore the wavelength of the absorption feature is a function of pH, as muscovites form in more acidic environments relative to the neutral-alkaline conditions required for phengites. As such, the variation in the wavelength of the 2200 nm feature essentially maps a pH gradient within the hydrothermal system. In this case, the pH of the fluids may have some relationship to grades (i.e. precipitation of gold) within the pipe.

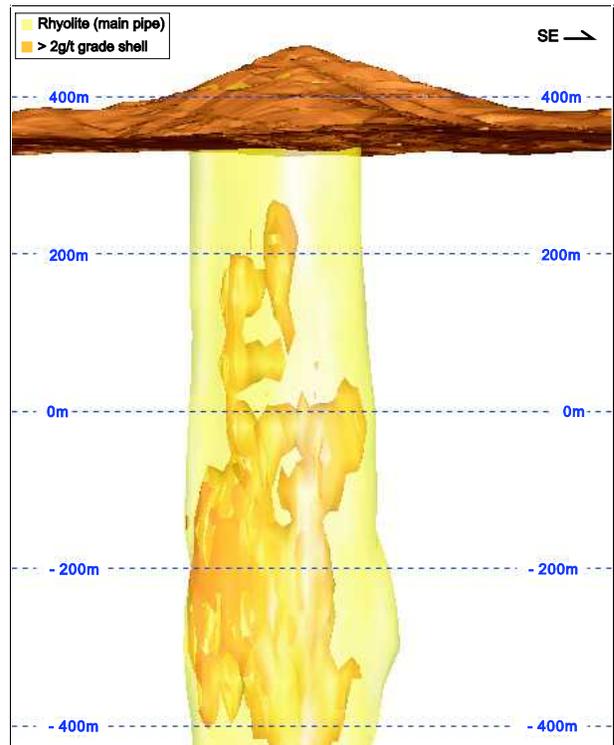


Figure 2: Screen shot from Minesight 3D (looking NE), showing > 2 g/t (Au) grade shell and outline of rhyolite breccia at Mt Wright. Elevations are in metres above sea level.

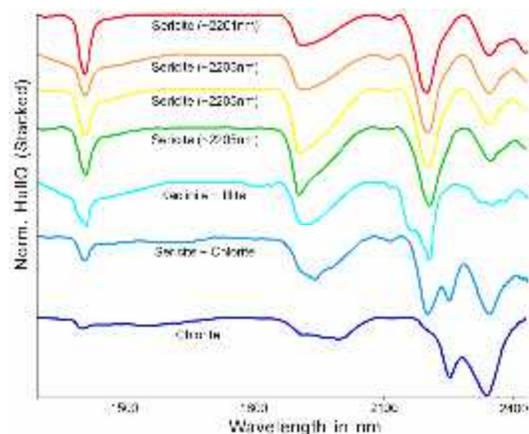


Figure 3: Typical SWIR spectra for different “mineral classes”, highlighting the subtle shift in the wavelength of the 2200 nm absorption feature in the sericite. Example spectra for mixed kaolinite-illite and sericite-chlorite as well as chlorite-only samples are also shown.

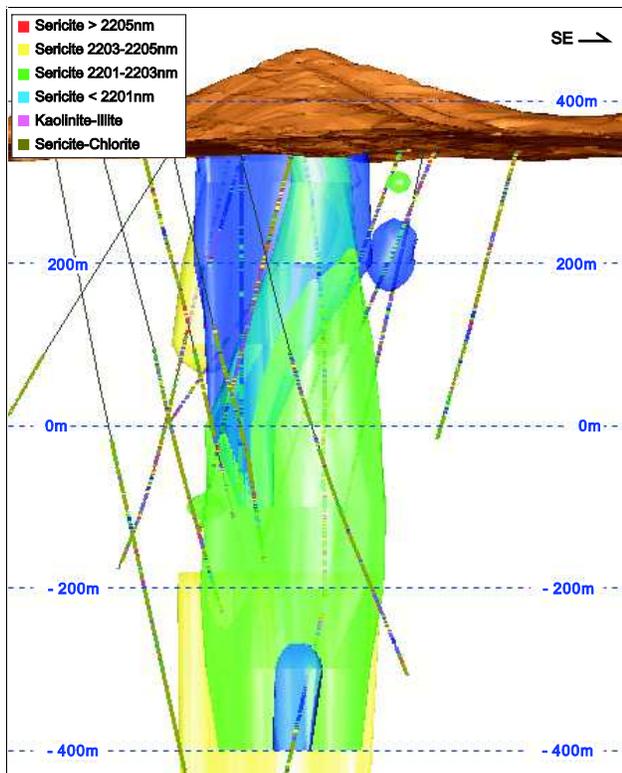


Figure 4: Screen shot from Minesight 3D (same view as Figure 2), showing modelled distributions of different sericite wavelength groups (blue: <2201 nm; green: 2201-2203 nm; yellow: 2203-2205nm). The shorter wavelength sericite appears to be more dominant in the upper parts of the rhyolite breccia, with the wavelength gradually increasing with depth. Longer wavelength sericite (>2203 nm), has a patchy distribution outside the main pipe, but may become more prevalent at depth. Drill holes from which SWIR spectral data was collected are also plotted.

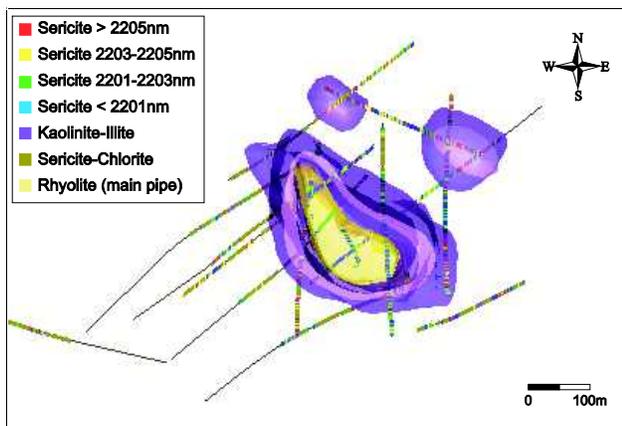


Figure 5: Screen shot from Minesight 3D (plan view), with modelled kaolinite-illite halo (purple) surrounding rhyolite breccia. Drill holes from which SWIR spectral data was collected are plotted.

The origin of the kaolinite-illite halo is uncertain. It extends from the margins to the orebody into the surrounding granite for a distance of ~50m. The width of the zone appears to decrease with depth, and is much less apparent at ~700m below the

surface (possibly a function of decreased data density at depth). The kaolinite is associated with steep fractures/faults, previously interpreted to have formed during late weathering (Furniss, 1998). However, due to the inferred depth of formation, the kaolinite may be of hydrothermal origin.

The extent of the sericite-chlorite alteration within the Millaroo Granite has not yet been determined (also due to lack of drilling outboard from the deposit), although a drill hole ~1km away from the rhyolite breccia, still displays this style of alteration. From the data available, there appears to be some patchy zonation to the wavelength of the sericite 2200 nm absorption feature with longer wavelength (i.e. more phengitic) mica being more common closer to the orebody. More follow-up work is required.

The presence of patchy sericite alteration to the north-east of the pipe is attributed to other brecciated zones within the Millaroo Granite. These smaller zones can be mineralized (e.g. 17,000 oz @ 5 g/t extracted from an outcropping satellite deposit), but are all interpreted to be related to the larger system.

MULTIELEMENT DATA

By combining the ME and SWIR data for a representative drill hole through the deposit, it can be seen how constrained the geochemical signature of the deposit is (Fig. 6). Apart from small-scale vein-related and/or lithological variations within the granite, enrichment of the pathfinder elements is essentially constrained within the pipe and surrounding kaolinite-illite halo (i.e. within 50m from the edge of the deposit). The ore zone is also totally sodium depleted, reflecting the total sericitisation of the feldspars within the rhyolite breccia.

Elements including Bi and Sb are clearly enriched within the ore zone, highlighting the presence of sulphide minerals. Elevated W exists within both the kaolinite-illite halo and the pipe, whereas Li appears to be enriched only within the kaolinite zone (possibly substituting for K or Mg in the associated illite).

IMPLICATIONS FOR EXPLORATION

As the detectable ME alteration zone only extends up to 50m out from the edge of the rhyolite breccia, the use of pathfinder elements is limited in exploration for similar deposits. However, ME analyses of rhyolite and/or brecciated samples from outcrop and/or drilling is important to establish if comparable chemical signatures exist to those at Mt Wright. Geochemically, a “near-miss” during a drilling campaign would be difficult to recognize if the drill hole passed more than 50m away from a similar orebody. As such, systematic ME sampling of holes that do not intercept mineralization could be a useful, but not necessarily a cost-effective procedure.

Multi element data may have more use in early-stage exploration, particularly soil geochemistry. As a large proportion of the terrain surrounding Ravenswood/Mt Wright has thin residual cover, the existence of a buried deposit of similar type is possible. Soil sampling programs in the area now include the pathfinder elements that are expected to be anomalous in-line

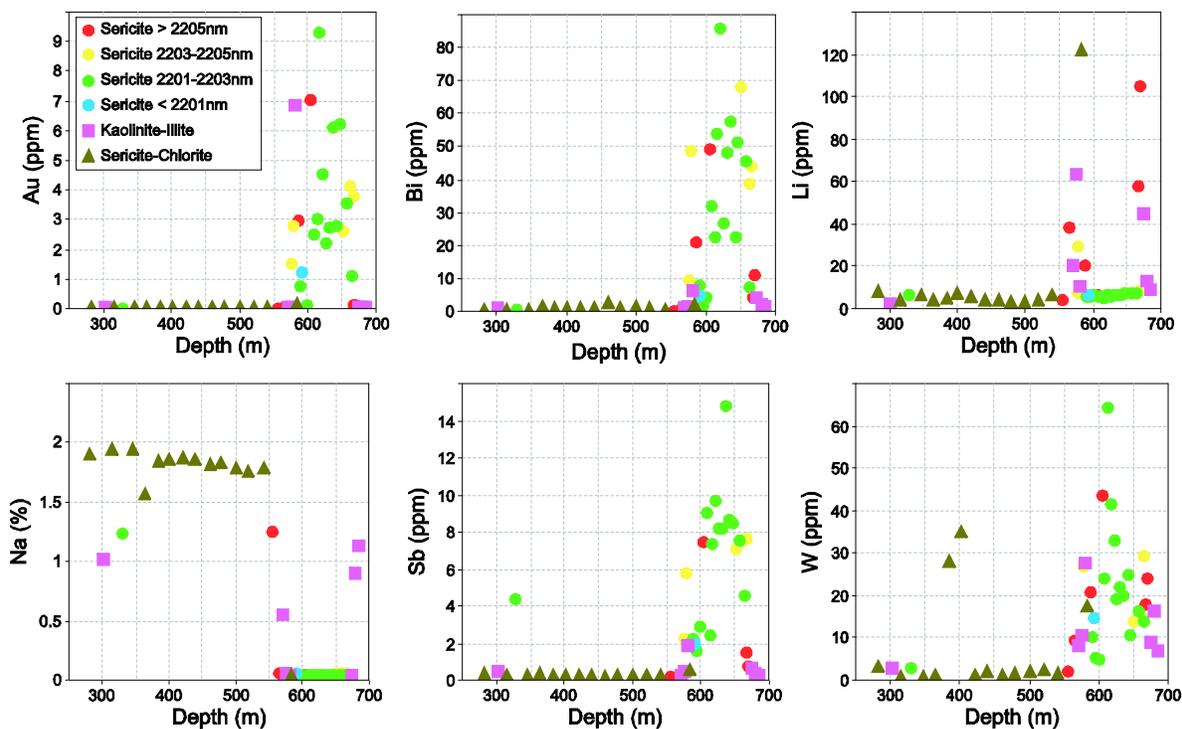


Figure 6: Plots of selected element profiles for one of the drill holes intercepting the orebody at Mt Wright (approx. 500m below surface). Colours represent different mineral classes determined by SWIR spectral analysis. In addition to Au, the ore zone is enriched in Bi, Sb and W, and depleted in Na. The periphery of the orebody, including the kaolinite-illite halo is enriched in Li, and has elevated W relative to the more distal wallrocks.

with the ME data obtained from drill samples, and soil orientation surveys around Mt Wright.

In contrast, the collection of SWIR data from rock chips and drill samples (potentially during a drilling program) appears to be both an economical and potentially invaluable technique in exploring for similar deposits. In the case of drill samples, the alteration mineralogy could be used to determine where a particular hole is spatially, relative to known mineralisation. This process would be relatively straight forward when viewing the data in 3D modeling software. As such, drill samples from previously abandoned hydrothermal breccia-type prospects will be analysed with the ASD TerraSpec in order to understand the chemistry of the systems and why no significant mineralisation was located. The results (combined with selective ME sampling) will be used to re-evaluate their prospectivity.

CONCLUSIONS

Short Wavelength Infrared spectral and ME analyses have been extremely useful tools in characterizing the alteration style of the Mt Wright deposit. The use of SWIR data has highlighted subtle changes in the chemistry of the Mt Wright system that are related to gold distribution/precipitation (within the pipe) and can be used as a vector to ore in the surrounding alteration halo. Knowledge of the constrained ME footprint has changed the approach in exploring for similar deposits, particularly soil sampling programs. Due to the success of this study, the

methods described here are being implemented on other deposits/prospects in the area and in regional exploration.

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