Identifying potential mineral resources using digital imagery

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Abstract: A total of one hundred and twenty three gold-bearing mineral deposits in the Charters Towers area west of Townswille, Queensland, Australia were initially classified into four named and unnamed separate vein styles, with different trends and alteration patterns, a breccia-style deposit and placer gold deposits. The area has vein deposits in Ordovician and Silurian granitoids and breccia-style in the Carboniferous volcanics. In this paper a modeling of these deposits is described using geological mapping, landscape analysis and digital imagery (Landsat TM and geophysics) to improve the classification and identification of possible new target for exploration.
Keywords: Mineral Exploration, Digital Imagery, Clay-alteration.

1. Introduction

The movement of mineralized fluids through a rock mass causes significant changes to rock mineralogy and chemistry and the level of magnetic minerals. Almost all air-borne and satellite imaging techniques don't directly model mineralization, but instead identify broad areas of alteration associated with the passage of mineralizing fluids.

This paper adopts a step-wise approach to model mineral deposits using landscape evolution connected to a geological framework. In this concept, areas of hard rock mineralization (erosional landscapes) are identified and modeled differently from remnant (laterite) and depositional (alluvial/colluvial) landscapes. This model is used as a predictive tool to identify areas of clay-alteration that are potential new target areas for mineralization.

The area of study is small and is centred on the Ordovician, Silurian and Carboniferous rocks in the Charters Towers area west of Townswille, Queensland, Australia (Fig. 1).

The purpose of this research was to integrate remotely sensed data and geoscience attribute data in a digital enviroment to improve the classification of mineralization and to identify additional areas for exploration.

2. Approach and Methodology

Prior to modeling, a database of characteristics of mineralized areas [1] [2] was assembled from point-collected attributes obtained from field collected geological and mineral occurrence mapping [3] [4].

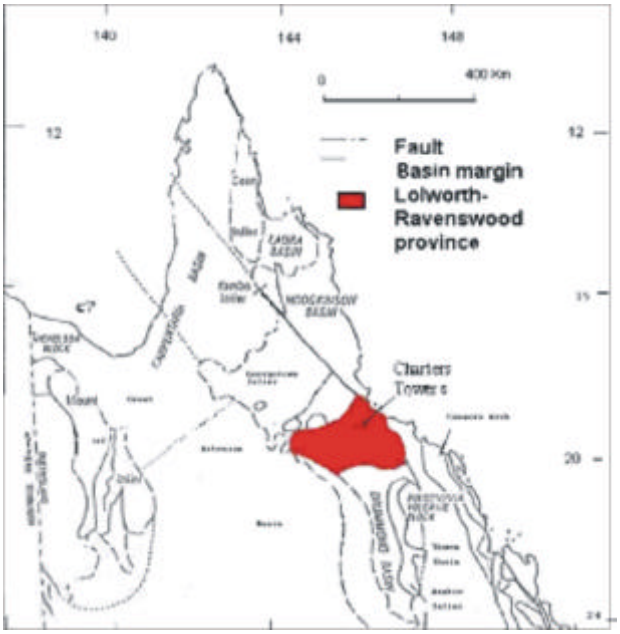

Fig. 1: Locality map of Study area.

A systematic approach is developed to identify and classify mineral resources (using an established geological framework and Landsat TM airborne geophysics data) and to identify new targets for exploration. We specifically wished to identify areas of

clay-alteration, and adopted the following approach to do this:

- Developed a Landsat "clay-ratio" algorithm
- Identified a threshold "clay-ratio" image [TCR]
- Used this TCR to map intense clay altered areas
- Digitized intense clay altered areas
- Prepared a Potassium (K) ratio image
- Prepared a Potassium vs. Thorium scattergram
- Prepared a K vs. magnetics scattergram
- Mapped the significant anomalous features of the scattergrams against geological units and mineralized lodes

In modeling mineral deposits that occur in bedrock it is important to differentiate residual soil on weakly weathered bedrock (erosional terrain) from alluvial-colluvial deposits (depositional terrain) and lateritic deep weathering profiles (remnant terrain).

A regolith map of the study area was generated from air photo interpretation to highlight areas of residual, erosional and depositional terrains. Only the erosional terrain had significance in the modeling of mineralized lodes associated with outcropping geological units. Regolith units were generated from the geology map of the area.

The clay-ratio algorithim (i.e. ratio of Landsat TM image bands 5 and 7) produced a ratio image which, when mapped to previously known areas of clay-alteration, yielded a 'threshold' image ratio that could eliminate signatures from the vegetation cover (dry grasses and trees [6]. Dry plant material has lingo-cellulose absorption features at 2.09 and 2.34 μm [5]. These absorption features may significantly influence the capacity to identify areas of clay using the standard band clay ratio 5/7 in Landsat TM data. In areas which have significant vegetation cover it is necessary to find the threshold value on the 5/7 ratio image and produce a new image to show only clay altered areas of the outcrop rock unit and omit areas of alluvium, colluvium or over deep weathering profile.

Geophysical imagery is also used to map clay-altered areas, with clay alteration evident from the potassium ratio image (potassium image [red], potassium/thorium image [green], and potassium/uranium image [blue]). This approach is supported by statistical analysis (correlation cluster variation) of K vs. Th, and K vs. magnetics.

3. Results and Discussion

A new image was generated using a threshold on ratio image (5/7 ratio > 2) and a color composite image (see Fig. 2) was prepared using the new image, Landsat bands 4 and 7. Used in conjunction with airborne radiometric images (K ratio and K vs Th) and scattergrams of K vs magnetics (MAG), (Fig. 3), we are able to clearly delineate areas of clay-alteration that have mineralization potential. Importantly we are also able to interpret a history of mineralization in the different aged lithologies. The magnetic features of the Ordivician and Silurian to Devonian granitoids are different and reflect a different history of the movement of fluids through these units. The very low magnetic values of the Mount Leyshon trend reflects the Late-Carboniferous to Early Permian reverse polarization.

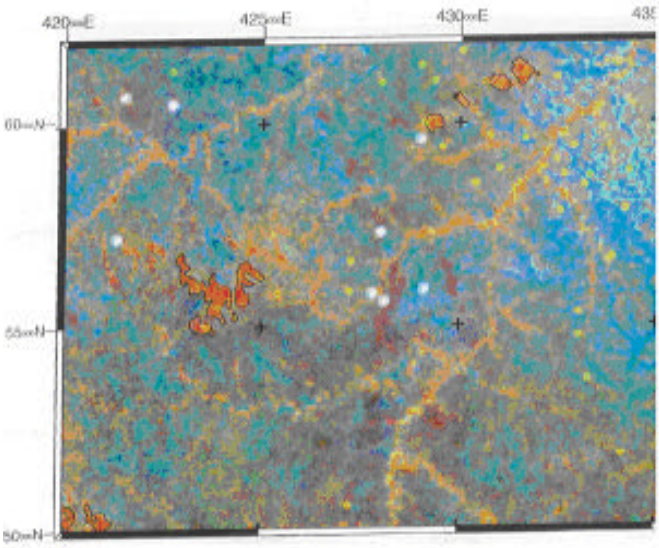

Fig. 2: A color composite image (5/7,4,7 -rgb) clay alteration areas digitized.

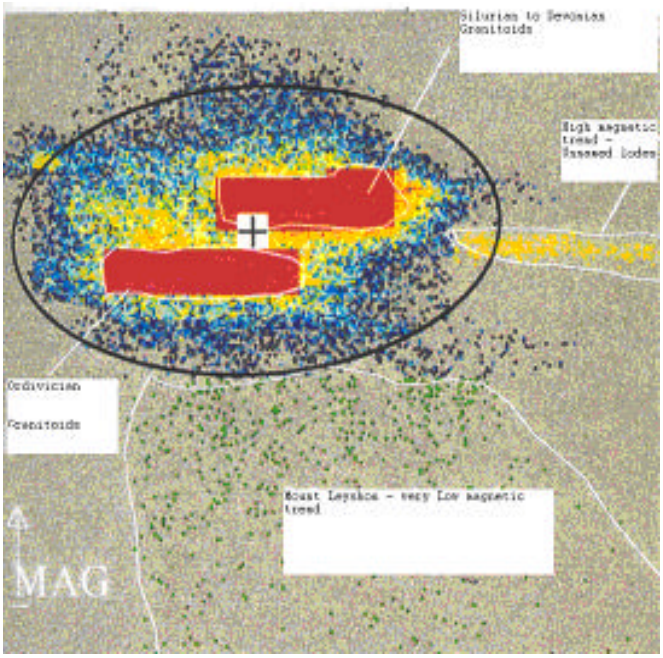

Fig 3: Mag vs K Scattergram.

In the K vs Th scattergram the location of anomalous areas of Th or K (outside the 90% data envelope) were

shown to coincide with deep weathering, unnamed or Ravenswood lodes, Charters Towers lodes and areas of Mount Leyshon style of mineralisation (Fig. 4).

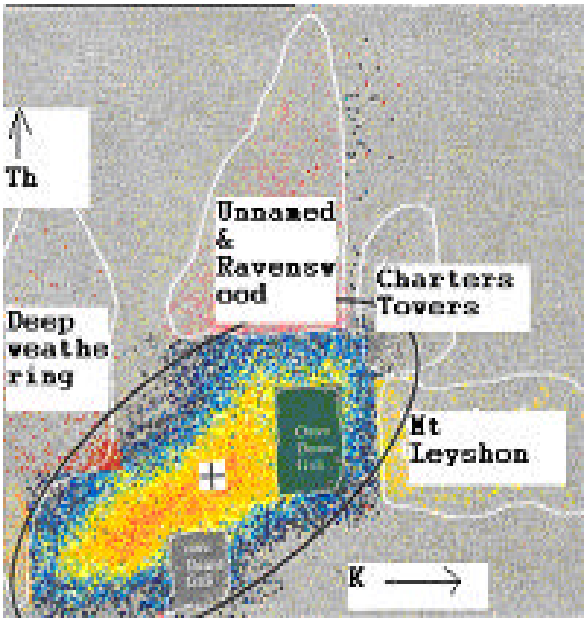

Fig 4: Th vs K Scattergram.

4. Conclusions

Alteration and mineralization in the Charters Towers region has occurred in the two main styles of hard rock mineralization. These styles are (i) localized and related to either narrow vein mesothermal deposits of Ordovician, Silurian or Devonian age, (ii) large areas of beccia-related disseminated mineralisation.

The major findings of the research are that:

(i) In this region, weathering processes involved the destruction of K and enchancement of Th in ferric oxides in residual weathering profiles.

(ii) The anomalous areas of Potassium and Thorium in the scattergrams were shown to be coincident with the location of lodes that reflected different ages and styles of mineralisation.

(iii) The combination of field data and satellite and geophysical digital imagery showed a range of consistent features that were important in identifying the attributes of alteration and mineralisation.

(iv) The K vs MAG scattergram identified variations in magnetic features of the different intrusive units.

(v) The Th vs K showed that styles of mineralisation in this area could be identified and distinguished and that new areas for exploration based on this data were likely, particularly in zones with 'intense clay' signatures, high 'K' alteration, and higher magnetic signatures. The vein systems gave more subtle patterns in modeling than the Mount Leyshon mineralisation.

(vi) The Charters Towers lodes were generally high in K, but no alteration pattern could be determined for the other mesothermal vein systems.

The Carboniferous Mount Leyshon event was characterised by 'intense clay' alteration, 'very high K' values, 'moderate Th' and 'very low' magnetic values. The mesothermal-epithermal vein systems had no significant 'intense clay" or K alteration, and showed varying levels of Th anomalism. It is postulated that overprinting by the later event Mount Leyshon mineralizing event creates locally higher K values and variable magnetic values in these mesothermal vein systems.

Acknowledgement

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