FINDING BLIND OREBODIES: GEOCHEMICAL EXPLORATION FOR LARGE NICKEL-COPPER PGE SULPHIDES ON THE WESTERN GAWLER CRATON

Amy Lockheed & K.M. Barovich

CRC LEME, Department of Geology and Geophysics, University of Adelaide, SA, 5005

INTRODUCTION

The search for ore deposits focuses more and more on concealed deposits. In Australia, where over 70% of the continent is covered with regolith, exploration under cover is an enduring problem. While drill hole sampling is a major regional exploration tool, it is expensive and geochemical sampling can be a desirable alternative, although the regolith geochemical signature of ore bodies at depth is likely to be weak and difficult to interpret.

Mithril Resources, the industry partner in this project, holds tenements in the western Gawler Craton, near Streaky Bay, South Australia. The company's program objective is to discover large nickel sulphide deposits. Their work program is designed to highlight specific mafic igneous bodies and their feeder zones, as these form key targets along with major faults underpinning the magnetic complexes.

GEOLOGICAL SETTING

Outcrop on the western Gawler Craton is limited, so much of the basement has been interpreted from drill hole and aeromagnetic data (Figure 1). Basement rocks of the Streaky Bay area, southwestern Eyre Peninsula, are deformed Paleoproterozoic sedimentary and igneous rocks into which deformed Paleoproterozoic granitoids of the 1630 Ma St. Peter Suite are intruded (Parker 1993). Undeformed Mesoproterozoic Hiltaba Suite Granites and the Gawler Range Volcanics are likely to be the youngest units of the basement. Mafic to ultra-mafic intrusive complexes of unknown stratigraphic position also occur within the basement. They have been intersected in numerous drill holes and are believed to be responsible for at least some of the interesting magnetic and gravity anomalies seen throughout the region. The age of the mafic intrusions is unconstrained. They appear completely undeformed when seen in drill hole chip samples, suggesting they may be related to the ca. 1580 Ma Gawler Range Volcanics (GRV) rather than the ca. 1630 Ma St. Peter Suite, which are extensively deformed felsic to mafic intrusives (WMC 1994).

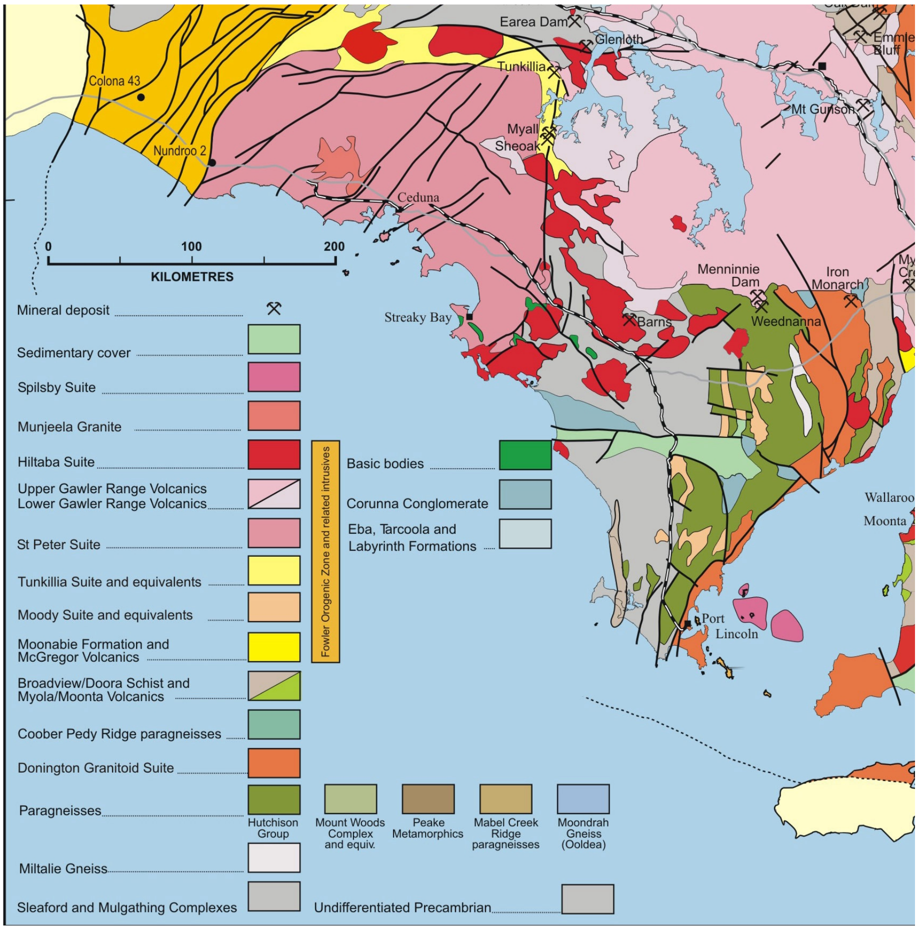

Figure 1: Interpreted subsurface geology of the southern Gawler Craton, South Australia. After Ferris *et al.* (2002).

A complicated stratigraphy of Tertiary and Quaternary sediments covers the Streaky Bay area. Fine to gravelly sands, silts and clays of the Pidinga and Garford Formations are incorporated with and overlain by ferricrete horizons. The Quaternary Bridgewater Formation contains calcareous silts and aeolianites and forms a relatively hard cap over the Tertiary sediments (Rankin & Flint 1991).

Aeromagnetic data interpretation in the Streaky Bay area has delineated over 50 Cu-Ni targets. Limited historical drilling has confirmed the presence of buried mafic/ultramafic intrusions, ranging from ultra-mafic troctolite and peridotite through to mafic gabbro-norite (WMC annual reports). The mafic bodies do not outcrop in this area, and recent air core drilling by Mithril Resources (Mithril Resources *pers. comm.*) has shown that regolith cover varies from about 6 to 80 m. In some locations, drilling encountered up to 6 to 12 m of strongly lithified calcrete, the aeolian Bridgewater Formation. Soil development over calcrete is minimal.

RESULTS

The goal of this project is to undertake an analysis of the behaviour of pathfinder elements through the regolith above the mafic/ultramafic intrusions and evaluate the most successful, rapid and inexpensive means of characterising the intrusions at depth by looking within the top two to three meters of regolith. Mithril Resources has made available base and some trace element data at two metre intervals throughout a set of shallow RAB drill holes over targeted anomalies. These data are available for use in this project.

Depth profile plots and drill hole logs were used to separate the stratigraphy into four relatively distinct zones down to basement. The calcareous sediments of the Bridgewater Formation generate the uppermost zone observed in the stratigraphic profile. The 6 to 12 m of carbonate-rich, fine-grained sediments form a hard calcrete cap over the sands and clays of the Tertiary Garford and Pidinga Formations, which creates an obvious contrast between the units. The sands, silts and clays of the 6 to 50 m of Garford and Pidinga Formations constitute the next two identified members in the profile. 2 to 18 m thick ferricrete horizons occur in both, commonly throughout the Garford Formation and as a capping of the Pidinga Formation. Clean quartz and clay grains, most likely of the Pidinga Formation, are often located directly beneath the Fe-rich zone. This unit is the hardest to define, as it is visually difficult to determine its top, where the oxidised zone finishes, and its base, where the weathered basement sediments commence. The final division of the profile contains weathered and fresh basement.

The majority of the conclusions in the study were achieved using data from 26 of the 53 holes drilled, covering an area of approximately 24 km^2. These particular holes were selected for two reasons: 1) they are concentrated within an area located near a strong magnetic anomaly; and 2) the area displays a diverse lithological basement including ultramafics, gabbros, granitoids and felsic gneisses. Depth plots and ratios of the transition elements are shown with simple graphing techniques used to express the behaviour of geochemical signatures throughout the profile and to display any correlation between basement rocks and the regolith. Comparisons of data from areas with similar and different lithology were made to delineate any common patterns, which could possibly be used to identify the basement rock type.

Given the significant difference in basement lithology of the target bodies (mafic to ultramafic) versus the variably magnetic felsic to intermediate St Peter Suite granitoids, pathfinder elements including Ni, Cu, Cr, Mn and V, which are elevated in mafic to ultra-mafic rocks, were targeted. These elements were plotted against depth throughout the regolith profile. Changes in values were easily observed and distinguishing features could be interpreted. There was no discernible anomaly in any elements throughout the calcrete of the Bridgewater Formation. Pathfinder element abundances are uniformly low, which is to be expected, as the sediments are up to 75% carbonate, and any basement detrital signature is highly diluted. But in the majority of holes, an abrupt increase in these element values occurred at the base of the calcrete or a few metres deeper within the Tertiary sediments of the oxidised zone that was described earlier (Figure 2). The rise in abundance occurred in most elements such as Ni, Cu and Cr, but was most prominent in V. This pattern is reflected in the plots for the basement saprolitic material.

Data from the selected drill holes were separated in relation to the stratigraphic divisions mentioned above. Transition element ratio plots were produced to allow for further examination of the geochemical behaviour of particular elements throughout the profile. Comparisons were made between the regolith plots and the results of the basement data. The Bridgewater calcrete and Pidinga sands and clays showed inconsistent patterns in the distribution of data for rocks of differing lithology. The oxidised zone plots, however, displayed distinct patterns linked to varying basement rock types (Figure 3). At specific limits of data values it is possible to predict a mafic basement.

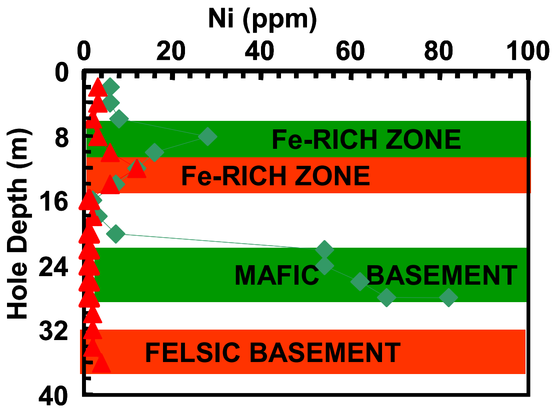

Figure 2: Ni concentration vs. drill hole depth plot for two drillholes. Green points represent Ni data over a gabbroic basement; red triangles represent Ni data over felsic basement. Note the substantial Ni enrichment in the ferruginous zone of the regolith profile over mafic basement.

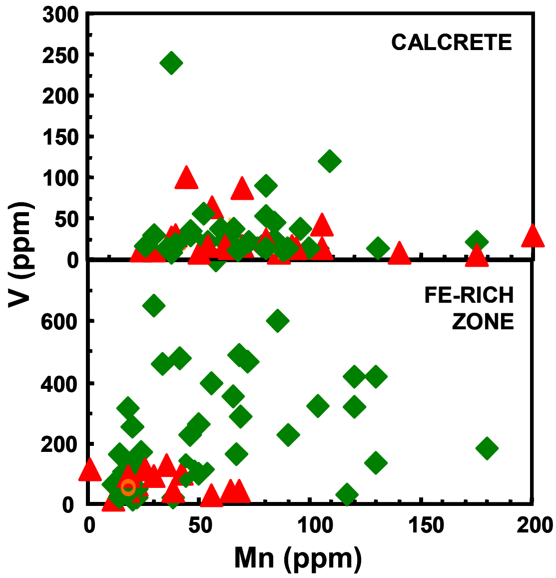

Figure 3: Mn vs. V for calcrete layer and Fe-rich zone. Green diamonds represent samples over mafic basement; red triangles represent samples over felsic basement.

Unfortunately, sampling of the oxidised zones requires expensive and time-consuming air core drilling through up to twelve metres of calcrete, and in places the sands of the Pidinga Formation. More detailed geochemical analyses of the calcrete layers in the 26 holes was undertaken to try to establish a method of pinpointing basement lithology from the calcrete. Absolute abundances of pathfinder elements are too low in the calcrete to be useful in distinguishing differences in basement lithology. This is not surprising, as the Bridgewater Formation in this area is up to 75% carbonate. Although rare earth element (REE) abundances are also quite low, the REE patterns from the calcretes in the 26 holes show that subtle differences between mafic and felsic basement lithology can be discerned. We suggest the detrital component of the Bridgewater Formation reflects fragments derived from in situ weathering of the basement, and incorporated within the aeolian Bridgewater carbonate material.

CONCLUSIONS

While calcareous sediments of the Bridgewater Formation may contain subtle geochemical indicators of the differences in basement lithology, it is not adequate evidence to confidently predict basement lithology for drilling. Below the calcrete, within the oxidised zone, the geochemical anomalies are large enough to confidently conclude whether basement is mafic or felsic.

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