BACTERIAL LEACHING AND OTHER TECHNIQUES TO IDENTIFY GOLD UNDERCOVER (N.W. VICTORIA)

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As mining industries move into the 21st century new economic mineral deposits are becoming more difficult to locate. Exploration for major ore bodies is progressing under various depths and types of regolith cover. As this trend in exploration continues, geochemical investigation will play an important role in the success of exploration, particularly in regions of transported overburden and poor geophysical response.

Partial chemical extraction techniques have been widely employed as a geochemical exploration tool. Partial extractions seek to remove part of a mineral phase or phases into solution rather than a specific chemical species that is targeted by selective extraction techniques. Similar techniques used in other studies have had some ability to locate buried ore bodies in specific environments and can provide a rapid and cost effective method for geochemical exploration under regolith cover (Bajc, 1998; Williams and Gunn, 2002). Although previous studies have found the information gained from partial chemical extractions beneficial, they have also concluded that such extractions are of limited use as 'stand alone' procedures (Bajc, 1998).

The use of bacteria in partial extractions of regolith samples has the potential to greatly magnify the geochemical signature imparted on the sample by the underlying mineralisation. The bacteria cause dissolution of only ultra-thin surface layers of mineral particles, so the geochemical signature is not diluted in the sample matrix. The objective of this investigation is to understand the efficacy of bacterial leaching in locating gold mineralisation under regolith in the Stawell goldfield of western Victoria, approximately 230 km northwest of Melbourne. The Bacterial Leach (BL) will also be compared more common techniques including HF acid total digestion (T), weak H_2O_2 leach (HP), H_2O leach, and hydroxylamine hydrochloride leach (HA) analyses.

The study region is situated on the boundary of the Ballarat Trough and Murray Basin and comprises predominantly sandstones, mudstones, shales and slates, with some regions of basalt, overlain by Quaternary alluvial sands, silts, and clays (Douglas and Ferguson, 1976). Recent efforts have been made to explore the region to the NNW of Stawell where potentially gold bearing units occur under a varied thickness of regolith. The regolith cover overlying the mineralised zone at site 1 and 2 is 30-110 m thick. Murray basin alluvial sediments at this location overlie basalt, volcanogenic sediments and psammopelitic rocks. The regolith can be categorised as a thin, uppermost layer (5 m) of weathered soil underlain by up to 40 metres of Loxton/Parilla sands, above Geera clays and a thin layer of saprolite. Site 3 is believed to contain a potentially economic Cu-Au ore body. Analysis of the soils at site 3 was conducted as a blind experiment without prior detailed knowledge of the underlying geology, regolith, or target ore. The regolith thickness generally increases to the north.

Soil sampling was undertaken along traverses across areas overlying known gold ore bodies (Site 1 and 2). Samples were subjected to BL analysis and the results combined in geochemical element suites to predict the underlying mineralisation. The combining of potentially anomalous elements suppresses the background and increases expression, thus enabling recognition of an anomaly where it may have been overlooked in investigations using single elements only. The element combinations are typically necessary given the bacterial mechanisms for non-preferential, incomplete, partial digestion. The element suites in this study used combinations of the following: As, Bi, Cu, Ga, Ge, Ni, Sb, Se, Te, Ti, V and W. No single element anomalies were evident at site 1 and 2. The resulting groupings were subsequently applied to BL results of soil samples of three separate traverses in the vicinity of a suspected buried ore body (Site 3).

An empirical assessment of anomaly expression of the BL over Site 1 and 2 was conducted using hypergeometric statistics (Stanley, 2003). This method requires an orientation survey using prior knowledge of the underlying geology to predicted sites of anomalous response. The following hypergeometric formula relates the probability of the anomalous points and false positives to the successful detection of mineralisation (Stanley, 2003).

$$P(x) = \frac{\binom{a}{x}\binom{t-a}{k-x}}{\binom{t}{k}} \times 100\%$$

a = number of predicted anomalous points
x = number of correct anomalous points
t = total sample points
k = number of anomalous points (true and false)

Hypergeometric statistics allow a rigorous comparison of conventional and new exploration techniques. Site 1 BL significantly predicted mineralisation (*P(x)*<3%) on 2 of the 5 assessed traverses (Figure 1), while Site 2 was successfully predicted with *P(x)*<0.5%). The lower the probability the more successfully the mineralisation is predicted (Stanley, 2003). The results indicate that the BL is providing some beneficial results, but is not consistently identifying the mineralisation under cover.

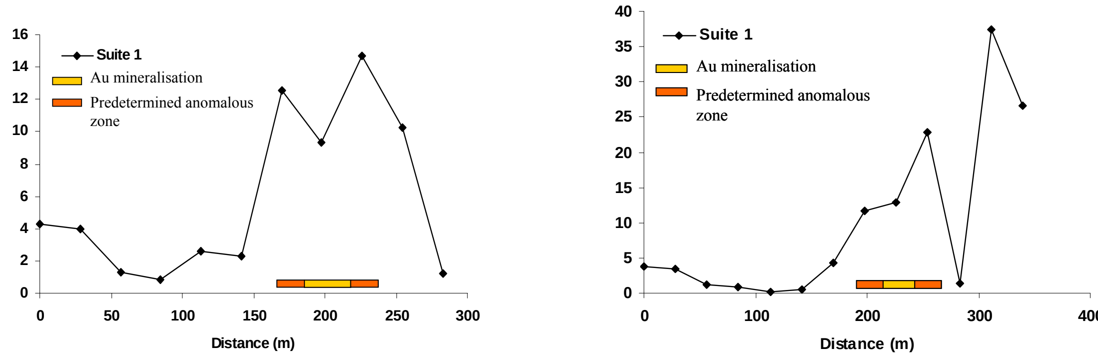

Figure 1. Two successfully predicted traverses from Site 1 using BL.

The BL geochemical suites respond similarly over the traverses, which is expected since certain elements are used in all derived groupings, however suite 1 provided the best results in the form of higher contrast anomalies and fewer false positives. The BL also possibly indicates fault zones at Site 2, as well as zones of mineral depletion that can be characteristically adjacent to those of enrichment (Figure 2).

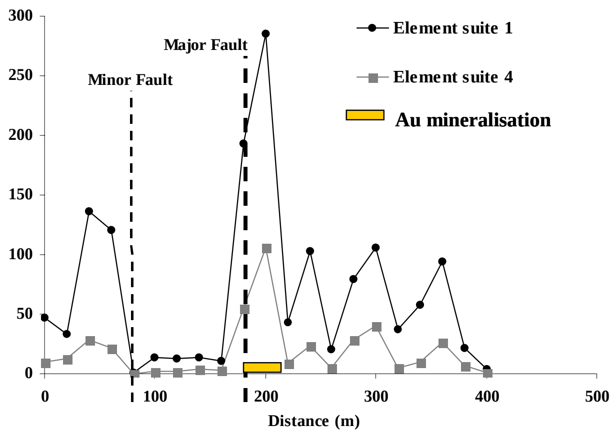

Figure 2. Geochemical suites developed for Site 2 with underlying mineralised zone and faults.

There is a potential presence of a Cu-Au ore body in the vicinity of site 3 (J. Dugdale, SGM, pers. comm., 2003). When applied to the site 3 soils, the geochemical suites provide similar results. There is, however, a distinctive zone at the end of the third traverse (samples 23-32) of very different chemistry (Figure 3). Unfortunately, this region has not yet been drilled to assess the underlying geology and, in turn, the effectiveness of the element groups. Single element data, particularly Cu, from the third traverse also indicates an anomaly in this region from all analytical techniques (Figure 4). Interestingly, soil pH values for the third traverse of site 3 were lower than the other locations, perhaps indicating that soil pH may provide an indication of underlying geology, a change in regolith, or influence factors that may affect the proficiency of the BL. Future research on the influence of soil properties and anomaly expression will be required to better understand the BL and other techniques in this region.

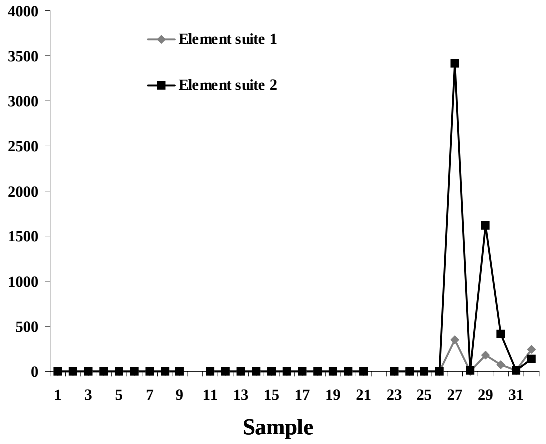

Figure 3. Site 3 BL element suite responses.

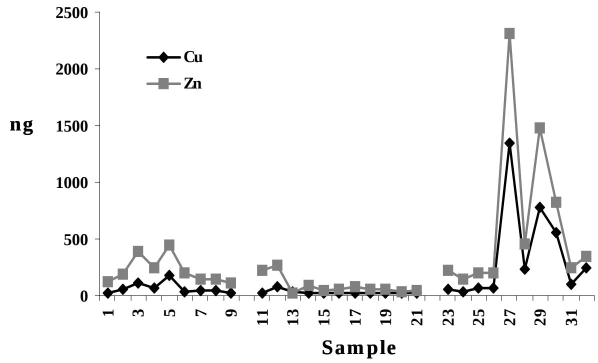

Figure 4. Site 3 BL responses for Cu and Zn.

Further investigation of the soils was undertaken using the previously mentioned leaches (T, HP, H_2O and HA) to compare the results of these chemical extractions with those of the bacterial treatment. Comparing the responses for elements based on the various leach treatments by correlation and principle component statistical analysis indicated that the BL was most similar to the HA leach. The HA specifically targets the amorphous Mn oxide phases and implies that the BL may be slightly selective towards the same phases. The H_2O and HP leach were also very similar in their responses for these soils.

The results of BL experiments have allowed for identification of possible areas of buried mineralisations that were not apparent through other chemical extractions. However, the success is inconsistent. The BL significantly provided different geochemical information than the other techniques, although HA was similar. In traverses where single element anomalies occurred the other techniques would have also worked. Whether BL has superior qualities as an individual 'stand alone' technique is yet to be determined. Bacterial leaching, nevertheless, is likely to be a beneficial tool in future geochemical exploration in areas of regolith cover.

REFERENCES:

Bajc, A.F. 1998. A comparative analysis of enzyme leach and mobile metal ion selective extractions: case studies from glaciated terrain, northern Ontario. J. Geochem. Expl. 61:113-148.

Douglas, J.G. and Ferguson J.A. (Eds). 1976. Geology of Victoria. Spec. Publ. Geol. Soc. Aust. 5. Graphics Services, Adelaide.

Stanley, C.R. 2003. Statistical evaluation of anomaly recognition performance. Geochemistry: Exploration, Environment, Analysis. 3:3-12.

Williams, T.M. and Gunn A.G. 2002. Application of enzyme leach soil analysis for epithermal gold exploration in the Andes of Equador. Appl. Geochem. 17:367-385.

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