RECOGNITION OF BURIED GOLD ORE BODIES IN WESTERN VICTORIA BASED ON SOIL BACTERIAL LEACHING AND OTHER CHEMICAL LEACH ANALYSES

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New economic mineral deposits are becoming more difficult to locate as mining industries move into the 21st century. Exploration for major ore bodies is progressing under various depths of regolith cover. As this trend in exploration continues, geochemical investigation will play an important role in the success of exploration, particularly where there is a lack of geophysical responses and in areas of transported overburden.

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 deeply buried ore bodies in specific environments and can provide a rapid and cost effective method for geochemical exploration under regolith cover (Bajc 1998, Williams & Gunn 2002, Watling *pers. comm.* 2003). Although previous studies have found the information gained from partial chemical extraction beneficial, they have also concluded that such extraction is of limited use as a 'stand alone' procedure.

The use of bacteria in partial extractions of regolith samples has the potential to greatly amplify 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 preliminary 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 (Figure 1). The bacterial leach will also be compared to more common techniques including total digestion, weak acid (Mehlich I) and weak H_2O_2 leach analyses.

Figure 1: Location of Stawell, Victoria.

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 & Ferguson 1976). Recent efforts have been made to explore the region to the north of Stawell where potentially gold-bearing units occur under a varied thickness of regolith. The regolith ranges in thickness from approximately 5 m to 130 m, with depth to bedrock increasing to the north. Exploration of the Stawell and Ballarat zones of the Victorian gold province in these regions of regolith cover is of great interest as it has the potential to identify gold ore bodies of comparable size to those already worked.

Initial soil sampling was undertaken along a traverse across an area of regolith overlying a known gold ore body. Samples were subjected to bacterial leach analysis and the results used to develop geochemical element suites to predict the underlying mineralisation. The resulting groupings were subsequently applied to results of bacterial leaching of samples of three separate traverses in the vicinity of a suspected buried ore body (site 2). The regolith cover overlying the mineralised zone at site 1 is approximately 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 approximately 40 m of Loxton/Parilla sands, above approximately 60 m of Geera clays and a layer of saprolite. The Geera clays include layers incorporating more than 50% shell fragments at depths of approximately 50 m and 100 m. Site 2 is believed to contain a potentially economic Cu-Au ore body. Analysis of the soils at site 2 was conducted as a blind experiment without prior detailed knowledge of the underlying geology, regolith, or target ore.

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The shape of the buried ore body determined from the bacterial leach data for site 1 was quite similar for each of the geochemical suites. This pattern is expected since certain elements are used in all derived groupings. The ore body geometry possibly reflects fault zones, as well as zones of mineral depletion that can be characteristically adjacent to those of enrichment (Figure 2.). There is a likely presence of a Cu-Au ore body in the vicinity of site 2 (Dugdale *pers. comm.* 2003). When applied to the site 2 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. The Cu data from the third traverse also indicates an anomaly in this region (Figure 4). Interestingly, soil pH values for the third traverse of site 2 were lower than at 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 bacterial leach.

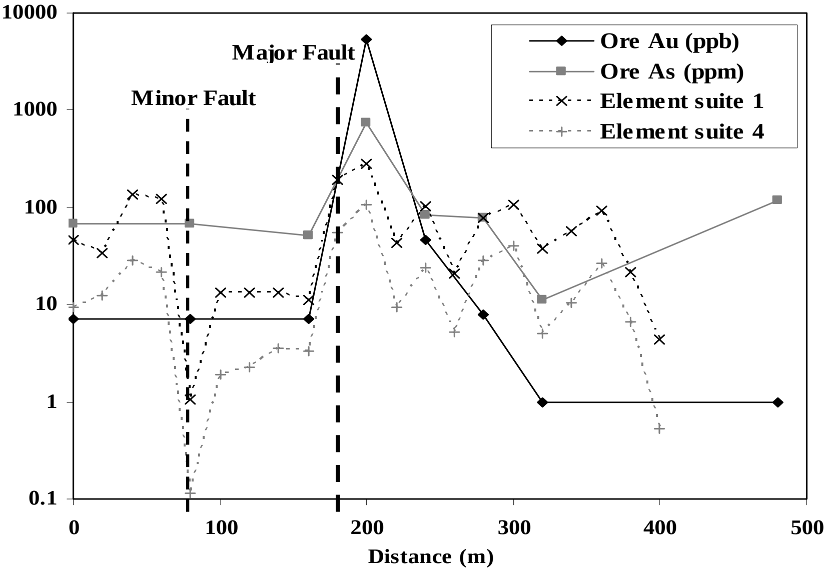

Figure 2: Selected geochemical suites developed for site 1 with Au and As concentrations from the underlying mineralised zone.

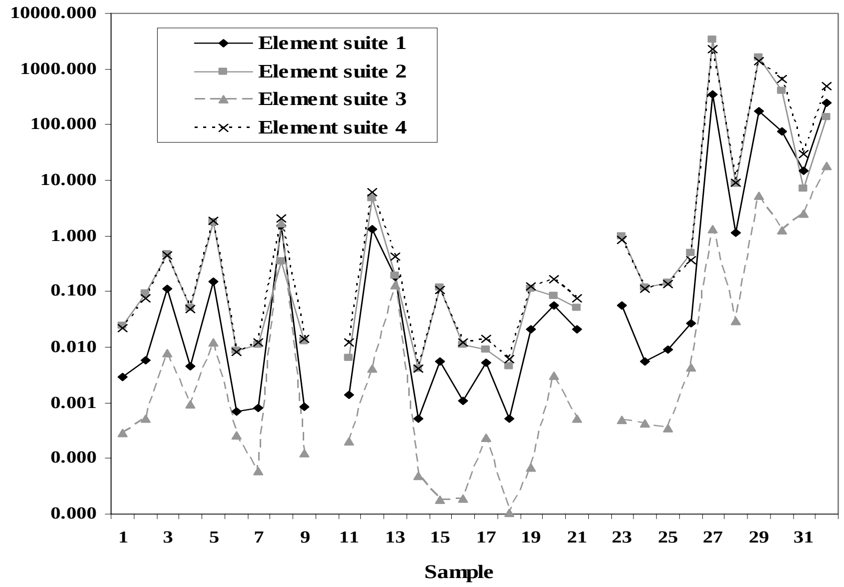

Figure 3: Geochemical suites applied to site 2.

The element suites in this study used combinations of the following: As, Bi, Cu, Ga, Ge, Ni, Sb, Se, Te, Ti, V and W. These were determined routinely in the bacterial leachates and other partial extractions using a Quadrapole ICP-MS in the School of Applied Chemistry, Curtin University of Technology. The combining of results for potentially anomalous elements suppresses the background and increase expression, thus enabling recognition of an anomaly where it may have been overlooked in investigations using single elements only.

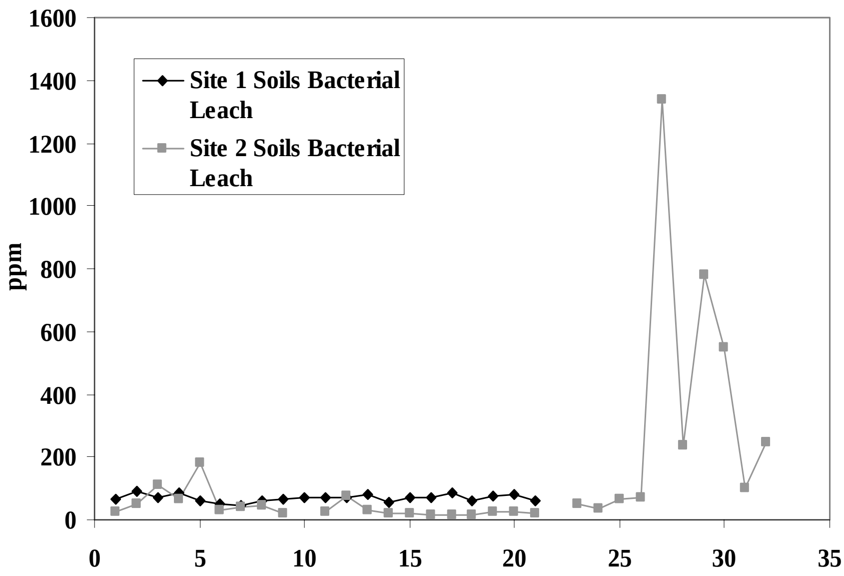

Figure 4: Cu concentrations from the Bacterial Leach of soil samples from sites 1 and 2.

Arsenic is often associated with gold and can be an effective indicator element. The halo thickness of As in the Victorian goldfields is estimated by Phillips & Hughes (1996) to be 80 m to 100 m, with concentrations 10-30 times the baseline or background concentration. Although there are some elevated As levels associated with the higher gold contents in the ore body used in this study, this trend is not reflected to any significant degree in the soils and regolith cover. The samples from each of the four traverses did not show highly elevated As contents reflecting a geochemical halo. Arsenic soil concentrations of < 400 mg kg^{-1} estimated from the bacterial leach experiments represent values that are common for many soils in the Stawell region.

Further investigation of the soils was undertaken using HF acid total digestion, a weak acid nutrient leach (Mehlich I), and a weak hydrogen peroxide leach to compare the results of these chemical extractions with those of the bacterial treatment. Reproducibility of data from the laboratory methodology was excellent for all methods based on replication of samples; however, field replicates were not used in this preliminary study. Reproducibility from a field sampling aspect has therefore not yet been determined. The results from the bacterial leach were different to the total dissolution analysis, weak acid leach, and weak hydrogen peroxide leach for a number of elements.

The results of bacterial leaching experiments have allowed for identification of possible areas of buried mineralisation that were not apparent through other chemical partial extractions. However, the success of the experiments in locating actual buried Au ore bodies is yet to be verified. The bacterial leaching provided significantly different geochemical information than the other chemical partial extraction techniques, although whether it 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, such as in the goldfields of western Victoria.

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