BACKGROUND & INTRODUCTION

Uranium deposits in the form of carnotite, a potassium uranyl vanadate, formula K2(UO2)2V2O8.3H2O occur in calcitized drainage channels on the northern half of the Yilgarn Craton, Western Australia. The largest of these, is at Yeelirrie, but other deposits at Lake Way, Nowothanna and Lake Maitland were investigated and drilled in the 1970’s.

A number of other palaeo-drainage channel deposits have come under consideration since. The genesis of carnotite uranium deposits was described by Mann & Deutscher (1978). Uranium derived from the weathering of granitoid rocks, along with potassium is transported in the neutral to alkaline groundwaters to a point in the drainage system where a source of vanadium derived from clays beneath the valley calcrete (which is also deposited from these carbonate rich waters), provides a chemical “trap”. The olive to yellow coloured mineral carnotite is deposited on the calcrete and in the clays to provide low-grade, near surface enrichments. The deposits are usually tabular, relatively recent, and commonly show the “dis-equilibrium” radiometric phenomenon associated with very young uranium deposits which are out of equilibrium with their daughter products (Levinson, 1974). Along with scintillometry, groundwater geochemistry and soil geochemistry is used to delineate the carnotite enrichments.

LOCATION & GEOLOGICAL SETTING

Magna Mining’s Badja uranium prospect is approximately 30km south of the town of Yalgoo, in the Murchison Province of Western Australia. The 1:250,000 geological image for this area is shown in Figure 1.

This map shows a 30km long drainage system with granitoid rocks at the eastern (headwaters) end, and the Cagacaroon Hills, a mafic and BIF complex on the downstream (western) end. This drainage system enters the larger Salt River palaeodrainage system to the south of Cagacaroon Hill.
**SURFICIAL GEOLOGY, SOILS AND SAMPLING POSITION**

Four target areas were selected for MMI sampling within the drainage system, as shown on the Earth Google image in Figure 2.

The outline of the palaeodrainage system is clearly evident. In general soils within this drainage system consist of partly transported material, particularly in the east. In the west, the white-green colour of the in-situ surficial calcrete is evident as two separate pods. Samples were taken at 400 x 400m intervals at a depth of 10-25cm.

**MMI SAMPLING, ANALYSIS AND RESULTS**

Fourteen elements Ag, As, Au, Ca, Cd, Ce, Cu, Fe, Ni, Pb, Th, Ti, U and Zn were analyzed after MMIM extraction. Surfer images for all elements were generated for each of the target areas. Only those pertinent and relevant to uranium exploration will be discussed here. The uranium image for the entire drainage system is shown in Figure 3 below.

Clearly target areas 3 and 4 have the highest uranium concentrations in soil. In particular, within target area 4 a value of 23,000ppb U after extraction was obtained at 451902mE 6831003mN, and numerous values in excess of 1,000ppb U were obtained in both target area 3 and target area 4. Highest Th values were not coincident with these highest soil U values, and maxima in scintillometer values did not exactly coincide with highest soil U values.
INTERPRETATION

In addition to the individual Surfer plots for each element, an Inferred Geology map, using the elements Ca, Ce, Ni, Fe and Ti was constructed (see Technical Bulletin TB20). The Inferred geology map is shown in Figure 4.

The inferred geology map shows, for the eastern portion of the drainage system (Target area 1) that weathering granitoid substrate is prevalent. Within target area 2 the inferred geology picture is not coherent, with many “undifferentiated” samples. This is a result of the highly transported nature of the soil samples in this area. However within target areas 3 and 4, large coherent areas with high Ca, suggestive of calcrite are evident. Target area 3 has an area of approximately 1.5sqkm of above 3,000ppb U, and target area 4 approximately 2sq km with U greater than 3,000ppb. The latter has one MMI sample with 23ppm U. Figure 5 highlights a problem associated with disequilibrium in U systems as young as this. Gamma ray spectrometer readings were taken every 100m on the same sample lines as used for the MMI sampling (i.e. lines 400m apart). Figure 5 shows gamma ray spectrometry highs plotted onto the same image as the MMI U contours.

Clearly the high values from gamma ray spectrometry are not coincident with the MMI soil geochemistry highs. In general they are further “down stream”. Uranium gamma ray spectrometry is based on gamma ray emissions from Bi214, a daughter product. To reach that daughter product uranium must first decay through thorium. Th230 has a half-life of 80,000 years meaning that parent uranium must be in residence for 80,000 year for thorium (and consequent daughters) to reach 50% of their secular equilibrium values, and for 10 half lives (800,000 years) to reach 99.9% of their secular equilibrium. Thorium, unlike uranium is not mobile. When uranium is dissolved and moves down catchments such as this, two things happen. Thorium (and its consequent daughters) is left behind in the source (granite) areas giving a falsely high impression (from gamma ray spectroscopy) of the amount of uranium around weathering granites. Secondly, uranium when it is deposited in a sink area needs 800,000 years for the full secular equilibrium with its daughter products to be re-established. Gamma ray spectrometry therefore infers a lower than true amount of uranium in a sink area if it is younger than 800,000 years. It can be concluded from Figure 5, that much of the uranium within the anomalous soil zones is younger than this date and has not had time for daughter products (e.g. Bi214) to build to secular equilibrium values. It can also be inferred that the oldest uranium is to the west (down-stream) and that the uranium deposit is younger to the east (upstream).
CONCLUSIONS

Location of uranium mineralization in the Badja project drainage system has been facilitated by MMI extraction and analysis. The exact relationship between highest MMI soil uranium values and grade must await infill sampling and drilling. Inferred geology carried out in conjunction with uranium analysis has distinguished between source and sink areas for uranium and provided a geochemical outline in accordance with accepted principles for genesis of carnotite in calcreted drainage systems.

REFERENCES


Mann, A.W. and Deutscher, R.L. 1978. Genesis principles for the precipitation of carnotite in calccrete drainages of Western Australia. Econ. Geol., 73, 1724-1737.

ACKNOWLEDGEMENTS

Magna Mining and in particular Kim Gardner are thanked for permission to utilize this data for a case study.

CONTACT INFORMATION

Email us at minerals@sgs.com
www.sgs.com/mmi