TECHNICAL BULLETIN – INFERRED GEOLOGY USSING MMI Ni AND Ce – YILGARN CARTON, W.A.

DECEMBER 2005

Introduction

The Yilgarn Craton of Western Australia is characterized by a number of "greenstone" belts comprising metamorphosed mafic and ultramafic sequences separated by granitic terrains of slightly younger age. As such the distribution of two elements Ni and Ce is of considerable assistance in delineating geology, particularly as outcrop is often limited and where present is subdued by the extent of weathering.

The choice of Ni and Ce is based on selection of a relatively abundant, mobile and extractable element from each of two groups, so-called "compatibles" and "incompatibles" in the earth's crust. Compatibles e.g. Ni, Cr, Mg, Co, V, Fe, Mn, Ca, Sr, P, Ba, and Eu are elements which enter early rock-forming minerals (in a melt) such as olivine, pyroxene, titanomagnetite, etc. The incompatibles (many of them with large ionic radius) such as Cs, Rb, Ce remain in the liquid are "fractionated" and end up in increased concentrations in felsics, granites, syenites, pegmatites etc., and also in many sediments.

In the Yilgarn Craton, nickel is present in soils wherever mafic and ultramafic rocks are present – the levels of MMI Ni which characterize sheet flow ultramafics (Ums) is Ni >2000ppb and adcumulate facies (channel flow ultramafics, Umc) Ni is >8,000ppb in residual/colluvial terrains. Mafic rocks usually have Ni >200ppb but less than 2000pppb with rare earths such as Ce low or absent. Rare earth elements such as Ce are notably absent in mafic and ultramafic rocks with one exception. Ultramafics which have thermally eroded a felsic substrate acquire S (and Ce) and become "fertile" with respect to NiS precipitation. Accordingly the combination of these two elements Ni and Ce can provide a great deal of information regarding lithology, and this can be done from partial digestion/extraction of soil samples as this medium appears to retain a faithful representation of the geochemistry of underlying/surrounding rocks.

Basic Geology and MMI – Western Yilgarn Craton

Below is an aerial photograph of some terrain on the western edge of the Yilgran Craton near Perenjori, showing a synform with banded iron formation (BIF) units and adjacent exposed outcrop/subcrop of ultramafic, mafic and felsic rocks.

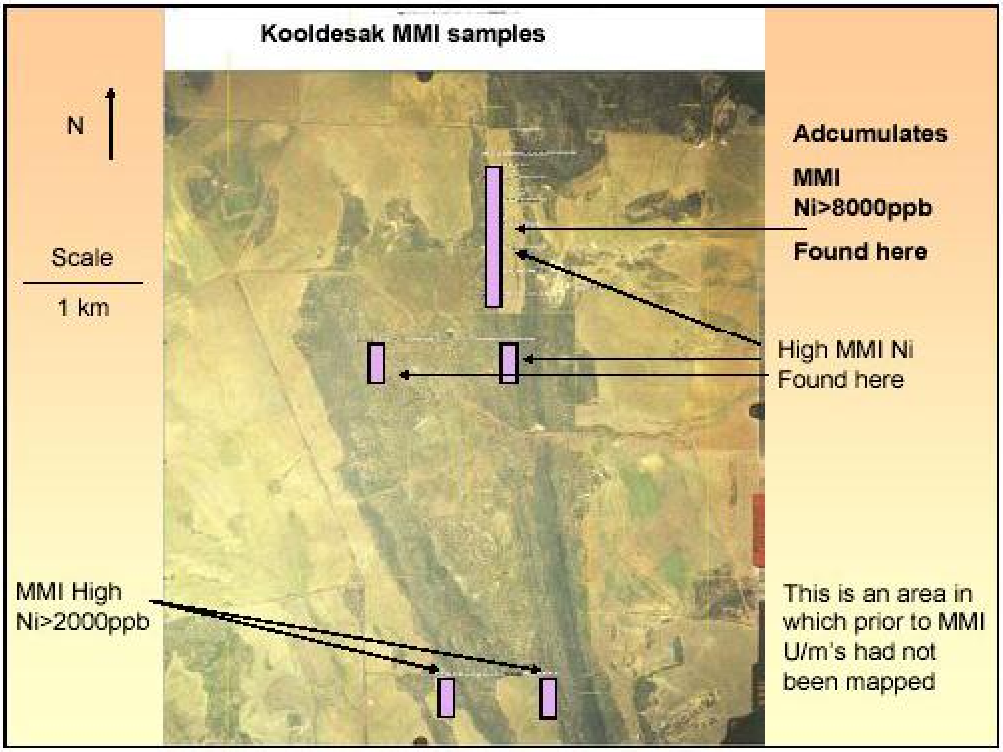

Figure 1. Aerial photograph, Kooldesak.

Figure 2, shows the Ni and Ce from an MMI transect across the southern part of the above geology, along with the observed rock types. This is an area in which, prior to MMI geochemistry being undertaken, and despite the degree of exposure, ultramafics had not been mapped (on the 1:250,000 scale).

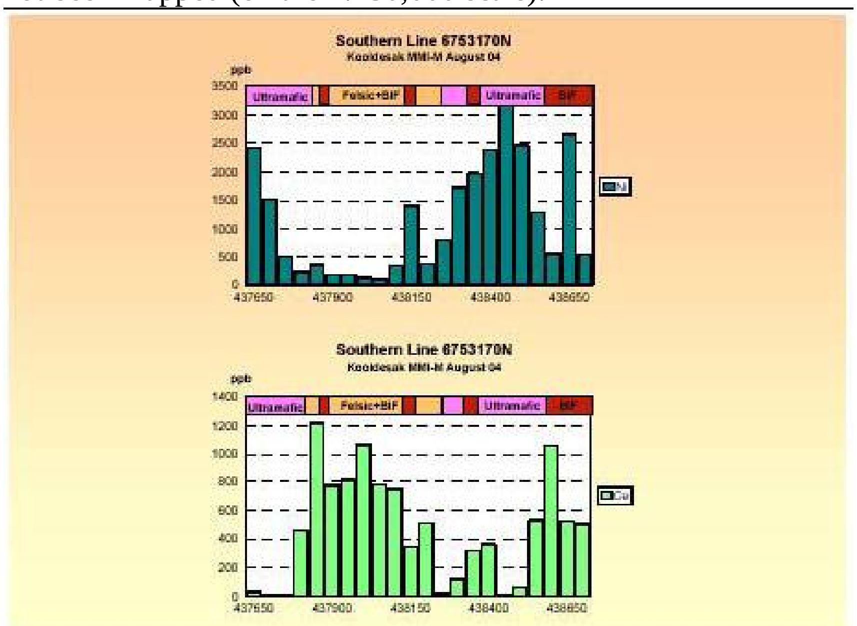

Figure 2. Geology and MMI Ni and Ce geochemistry, line 6753170N, Kooldesak.

The histograms in Figure 2 clearly show the anti-pathetic nature of the Ni and Ce geochemistry in the soils. MMI Ni appears strongly and Ce very weakly in the vicinity of the mapped (sheet flow) ultramafics, whilst MMI Ce is high and MMI Ni is low in the vicinity of the areas marked as felsics and BIF's. Other areas are marked on Figure 1 where MMI Ni soil geochemistry was used to infer the presence of ultramafics, including one, latter confirmed by rock analysis as being adcumulate facies (Ni >8,000ppb).

Inferred Geology and MMI

The very different and diagnostic attributes of these two elements, Ce and Ni, are shown on the following diagram, Figure 3.

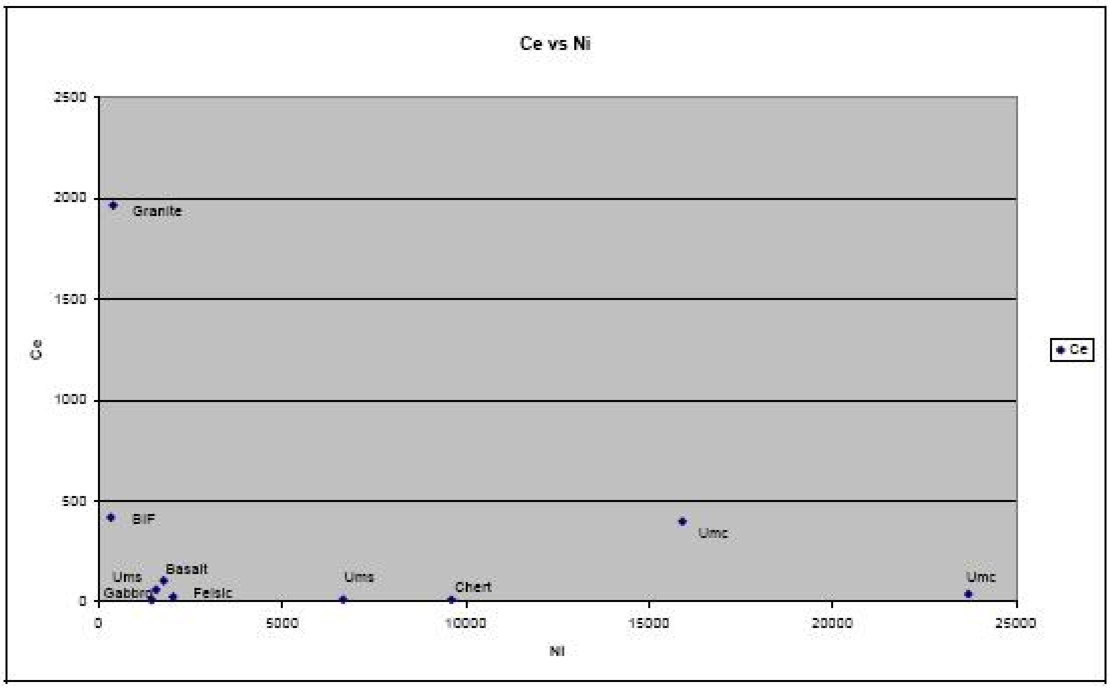

Figure 3. Ni and Ce contents of soils at "classic" rock locations after MMI-M extraction and analysis.

Figure 3 shows the Ni and Ce contents of soils in the vicinity of some chosen "classic" rock locations on the Yilgarn Block. Clearly the ultramafic rocks are aligned along the x (low Ce) axis, and granites and felsics along the y (low Ni) axis. Mafic rocks have both low Ni and low Ce, and are clustered near the origin. With these soils all from "pure" locations, and the sharpness of the MMI technique, there are no soils which plot in the centre of the diagram.

In order to apply the principles to further Yilgarn Craton examples, a scheme was devised which allowed a number of categories to be designed which could be used to delineate soils over some rock types based on these two elements. The following six codes and categories were developed.

Table 1. Categories for delineation of geology from MMI Ni and Ce soil analysis – residual/colluvial terrain, Yilgarn Craton.

Ni	Ce	Code	Assigned Geology
>8000	>30	6	Fertile Umc
>8000	<30	5	Umc
>2000 <8000	<30	4	Ums
>200 <2000	<31	3	Mafic
>200	>30	2	Intrusives/Seds
<201	<31	1	Qz
<201	>30	0	Fel/Gran/Seds

An algorithm was applied in the Excel data spreadsheet to provide a column "Inferred Geology" from the appropriate Ni and Ce data for each sample site. The threshold levels were developed by a little trial and error, but the system is actually very simple once the critical thresholds of 30ppb Ce and 200ppb Ni are established. The thresholds may be locality/regolith dependent.

Application to the Eastern Goldfields

The inferred geology system was applied to an area of the Eastern Yilgarn Craton west of Widgiemooltha, in which detailed MMI analysis for Au, Ag, Ce, Co, Cr, Ni, and Pd was undertaken firstly by Austminex, and then the Redemption Joint Venture, and Focus Minerals. The geology for part of this area, mapped by Dean Goodwin is shown in Figure 4.

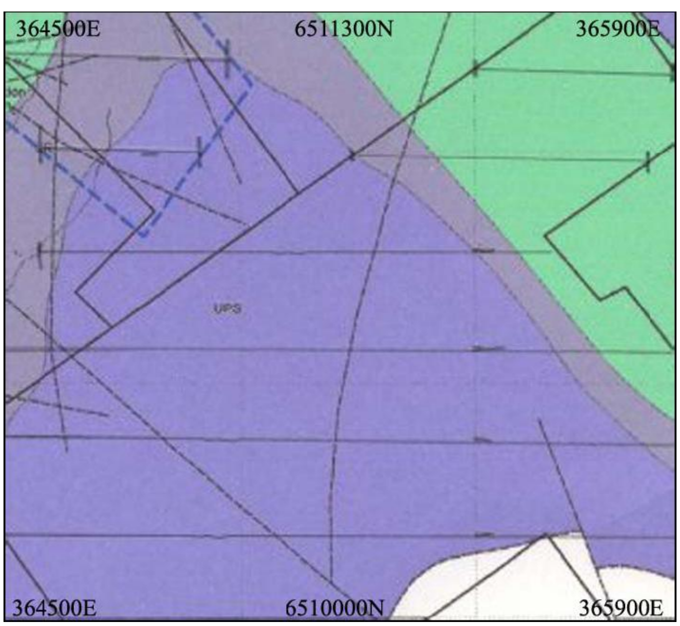

Figure 4. Geology of The Mount SE, Widgiemooltha (after Dean Goodwin).

The geology map shows, to the south east of The Mount, a relatively simple sequence (from SW to NE) of ultramafic (peridotite), tremolite and thence mafic (high mag basalt). The inferred geology map, based on MMI Ni and Ce, of the same area to the south-east of The Mount is shown in Figure 5.

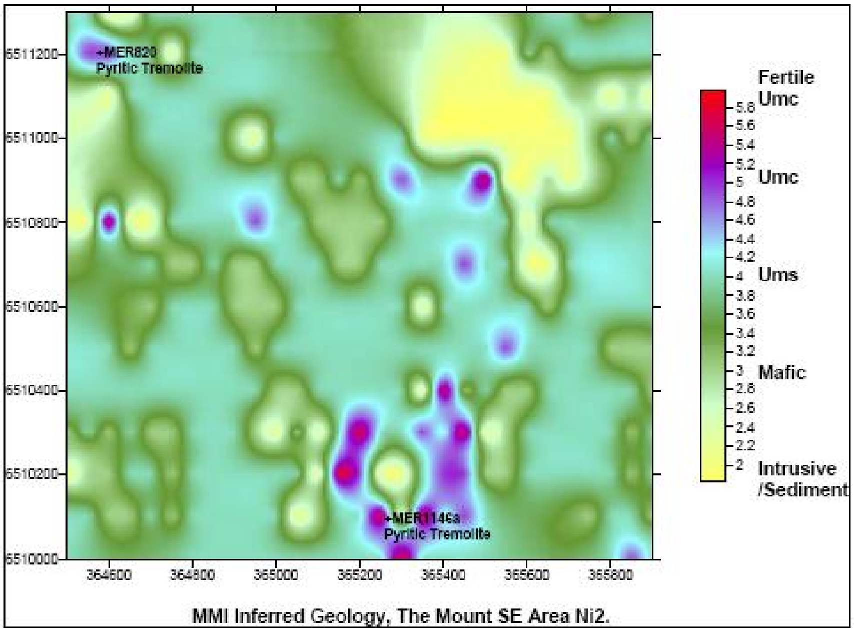

Figure 5. Inferred geology at The Mount, near Widgiemooltha, eastern Goldfields.

Both maps agree on the position of the major boundary between ultramafic and mafic, running NWSE. The Inferred geology map however suggests two corridors of adcumulate ultramafics trending NW-SE within the peridotite (Ups) unit. Subsequent ground inspection provided rock samples of a diagnostic pyritic tremolite some 1km apart on the most south westerly of these. Pisolitic ironstones were noted on the basal contacts in the areas marked and shown as "fertile Umc". The inferred geology also suggests relatively large areas which are not simply mafic or ultramafic. These are coded as "2 = Intrusives/sediments", based on their Ce content along with Ni in soil. Two examples of the rocks obtained from these areas are shown in Figure 6(a) and 6(b).

Figure 6(a). Rock sample 867R.

Figure 6(b). Rock sample 871R.

Although slightly different, both rocks are clearly pale coloured and contain quartz and feldspar. These have come from an area which has no mapped rocks other than mafics and ultramafics. It is believed they are late stage felsic/porphyry intrusives – possibly related to fractionation or differentiation during cooling. A second example, related to a gold mineralization event is shown in Figure 7.

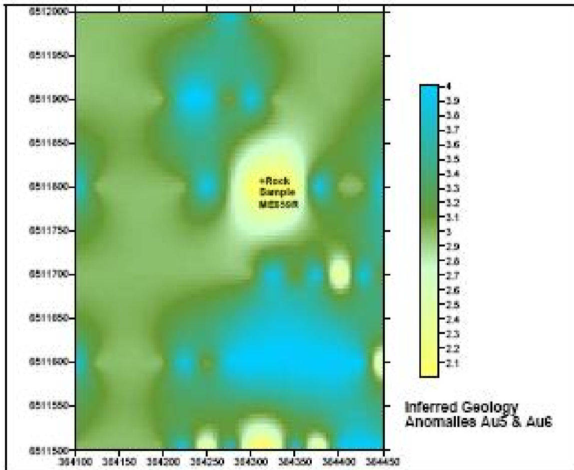

Figure 7(a). Inferred geology, Au5&6.

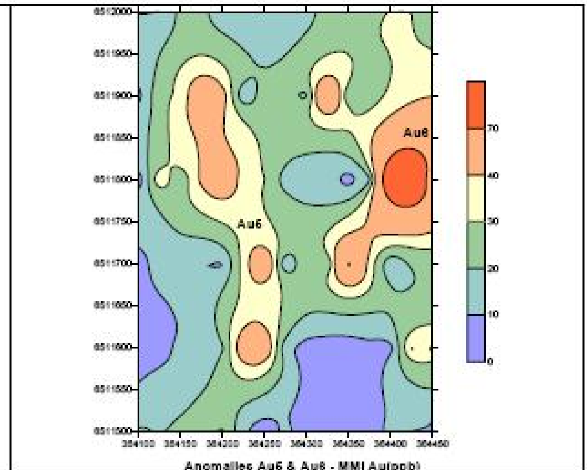

Figure 7(b). MMI Au, anomalies Au5&6.

In this particular case, high MMI gold values occur either side of the soils with inferred geology coded = 2 (Intrusives/sediment) – in excess of 100ppb to the east. The rock sample ME659R was obtained after sampling and interpretation. Again it is a pale coloured, in this case fine grained - probably a late intrusive porphyry. Figure 8 shows a photograph of this rock.

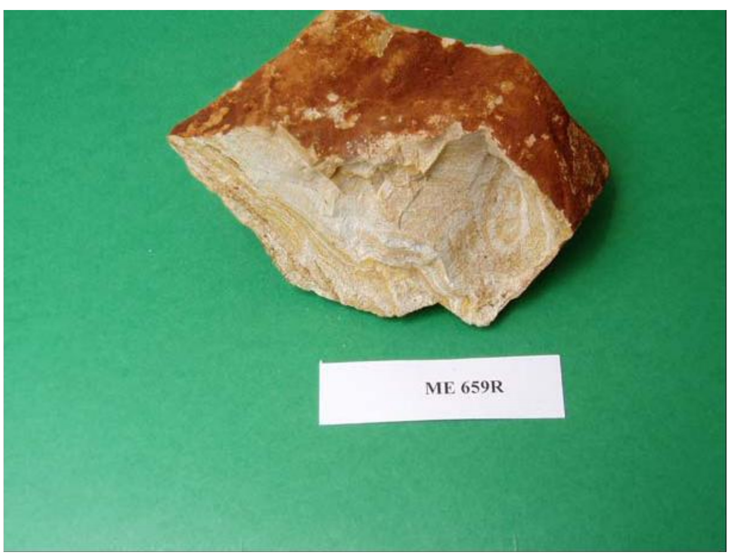

Figure 8. Photograph of rock sample ME659R.

No intrusives were mapped – outcrop at this location is poor. The soils over this unit have much lower MMI Au – 7ppb Au, than soils over the adjacent (altered) mafics. This unit has had an influence on gold distribution and may have played a part in producing or enhancing mineralization in the adjacent mafics.

Conclusions

Inferred geology techniques developed from observations and sampling on one side of the Yilgarn Craton have been successfully transferred and implemented into a survey approximately 1000km away. In general, the mapped geology has been confirmed, but greater detail added only in part due to the better sampling density. Some rock types not identified in the geological mapping exercise have been delineated by the MMI soil geochemistry.

Using just these two elements, it is not possible to distinguish categorically some rock types. For example, both sediments and felsics have high Ce content. Sediments in particular, due to their wide variations will always require special attention, and the appropriate elements to do so maybe applicable only to specific sediment units in specific localities. The BIF unit at Kooldesak is noted to have high Th Sc, V and Ti, as well as high Ce. This will be pursued in forthcoming work.

The transfer of technology here has been on the same basic (Yilgarn Craton) geology, and for minor changes in regolith. Application of this model to the same geology under alluvial cover would require changes to the threshold levels. It was noted in connection with Figure 3 that “mixtures” of soils will plot in the centre of the diagram, can be identified, and potentially can be handled, providing the end members can be identified and characterized. Application of this technique to other geological terrain types will require further investigative and developmental work. Orientation over known rock outcrops to obtain the relevant elements and thresholds required for diagnostic purposes are considered appropriate.

Acknowledgements

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