



## Erratum

## Hematite/maghemite trace element geochemistry in base metal exploration

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## ABSTRACT

Fe-oxide micro-concretions are examined as a possible sampling medium in geochemical exploration for base metal mineralisation. Samples were extracted from loose, partly transported regolith overlying the Hillside Fe-oxide–Cu–Au deposit (Rex Minerals Ltd., South Australia) along two traverses across the deposit, using a rare earth magnet. Fe-oxide minerals in the magnetic separates are maghemite (25–35 wt.%) and hematite (15–40 wt.%). Results of the chemical analysis are compared to the bulk regolith composition. Combined content of Cu + Pb + Zn + Ni of the magnetic mineral separates of up to 1300 ppm is compared to 150 ppm in the bulk sample. Electron Microprobe and Laser Ablation ICP-MS analyses of the Fe-oxide phase in the petrographically complex Fe-oxide rich micro-concretions revealed base metal contents of > 3000 ppm Ni + Cu + Zn (average 490 ppm) indicating the selective accumulation of base metals in this phase. A Manhattan distance cluster analysis was performed on the bulk regolith and magnetic separate samples to determine geochemical affinities of elements within the sample types. Based on this a base metal index (Cu + Pb + Zn + Ni) was generated and used to identify positions of base metal anomalies. The results clearly reproduce the established anomaly and demonstrate the viability of using magnetically separated mineral fractions of regolith as a geochemical sampling medium.

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## 1. Introduction

Maghemite or magnetic hematite is a common minor constituent of soils in arid and semi-arid climate zones. The formation of maghemite in these environments is not understood in all detail but it may form through excessive heat e.g. burning of organic material during bush fires (Anand and Gilkes, 1984, 1987; Schwertmann and Fechter, 1984), precipitated from fluids present in the soil (Fine and Singer, 1989), via oxidation of magnetite (Mullins, 1977; Schwertmann and Taylor, 1989) or through dehydration of lepidocrocite (–FeOOH) or goethite (Cudennec and Lecerf, 2005). Maghemite has been demonstrated to be an important carrier of trace elements in soils (Chittleborough et al., 1984; Shidu et al., 1978, 1980). The capacity of maghemite to incorporate elevated amounts of trace elements into the crystal structure of  $\gamma\text{Fe}_2\text{O}_3$  was demonstrated by de Oliveira et al. (2000) and linked to the magnetic behaviour of the mineral. Due to this trace element accumulating capacity, maghemite formed through authigenic processes within the regolith has potential to incorporate trace element signatures of the growth environment and may preserve trace elements inherited from the magnetite precursor.

While the importance of maghemite as a source of trace element nutrients in soils has been well demonstrated (e.g. da Costa et al., 1999), minimal use of this characteristic has been made for the potential identification of geochemical signatures in mineral exploration. McQueen and Munro (2003) analysed Fe-rich surface lag for trace elements and concluded that increases in the Fe as well as the Pb, As, Sb, Bi and Ba contents in the lags were largely due to prolonged exposure to surface weathering and not necessarily indicative for underlying mineralisation.

In this study we analysed the magnetically extractable mineral fraction of loose regolith material overlying the Hillside Iron Oxide Cu–Au (IOCG) deposit, South Australia. Sampling specifically targeted Fe-oxide aggregates in the regolith profile to depths of up to 1 m. In contrast to the approach by McQueen and Munro (2003) this different sampling approach is shown to provide a suitable medium for use in geochemical exploration. Another advantage of this sampling medium in geochemical exploration is its ubiquitous availability in arid and semi-arid soils and the relative ease of extraction from the soil using a hand held REE magnet.

This project develops a methodological approach for the use of magnetically extractable mineral fractions or magnetic separates, in geochemical exploration for mineral deposits under cover. It demonstrates that trace element signatures of these mineral fractions provide a unique signal of underlying mineralisation with a high spatial reliability. The approach uses geochemical analysis of bulk samples and mineral separates as well as electron probe and laser ablation

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micro-analysis, to determine the major and trace element compositions of samples at variable spatial resolution and analytical detection limits.

### 1.1. Location

The Hillside IOCG (Iron Oxide Copper Gold) deposit in South Australia is a recent discovery of this type of mineralisation by Rex Minerals Ltd. with a maiden resource estimate of 100 Mt at 0.7% copper and 0.2 g/t gold. Mineralisation is hosted by the Mesoproterozoic Wallaroo group and spatially associated with the Pine Point fault zone in the eastern margin of the Gawler Craton. Geological cross correlation of the mineralisation with the host rock sequence suggests a timing of mineralisation shortly after emplacement of the nearby Curramulka Gabbro ( $1589 \pm 5$  Ma, Zang et al., 2007), a member of the Hiltaba magmatic suite. Mineralisation at Hillside comprises an early stage of magnetite + quartz followed by a pyrite + chalcopyrite sulphide stage associated with intense hematite (+epidote + allanite) formation. The Hillside area is unconformably overlain by Tertiary limestones and blanketed by several 10s to > 100 m of transported, mainly

aeolian cover with local occurrences of calcrete nodules. The area within which mineralisation occurs is under agricultural usage for growing cereals, the average rainfall of the region is 503 mm/a.

### 1.2. Sampling

Two sample sets were collected from the Hillside exploration site shown in Fig. 1. The first set of samples (SET1) was collected from 10 locations along a traverse that followed a main road, which crosses the northern extent of the well established Hillside Cu–Au anomaly. Sampling was done with a shovel at depth intervals of 0–20 cm, 20–30 cm and 30–50 cm. The second set of samples (SET2) was collected from 11 locations crossing the southern section of the Hillside Cu–Au anomaly in a NW–SE direction. Sampling was done using a percussion drill-corer fitted with individual 1 m length PCV core tubes. Cores were collected at a spacing of approximately 200 m along the mid-point of an erosional rise, marked by a drainage depression to the north and the hill-top to the south. The transect intersected known mineralised zones and included areas beyond the known mineralisation.

Soil descriptions were recorded in the field and back in the laboratory, prior to drying. Samples of SET1, which were reasonably dry when collected, were further air dried in the laboratory. The soil cores of SET2 had a higher moisture content due to rainfall prior to collection and required drying in an oven at 105 °C. SET2 samples were then passed through a nylon sieve, to remove the >2 mm components.

The dry samples were split using a sample splitter, with one fraction used for bulk sample analyses and the other for extraction of magnetic minerals. Magnetic minerals were separated by hand using a Nd rare earth magnet.

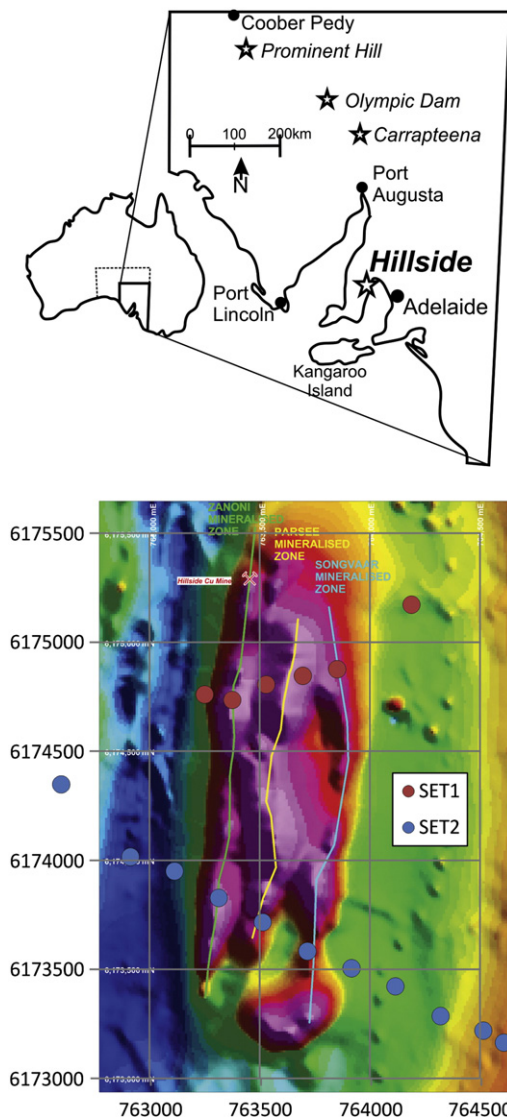


Fig. 1. Location of the Hillside IOCG deposit in South Australia and sample locations of SET1 and SET2 on the Hillside exploration site.

A1: 4 - 14cm  
fine sandy, red to dark brown  
calcareous sand and soil

B1: 23 - 49cm  
fine sand to clay, calcareous,  
poorly sorted, locally  
containing carbonate mottles  
and nodules

BK: 8-54cm  
fine sand to clay, locally  
indurated and calcareous,  
increasing content of  
containing carbonate mottles  
and nodules to depth

C: 0 - 25cm  
greenish, highly weathered  
saprolite

B2: 0-40cm  
red brown clay, carbonate  
mottles and nodules  
conglomeratic

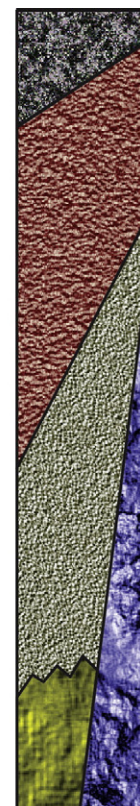


Fig. 2. Schematic stratigraphic column of the soil and regolith sampled.

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