GEOCHEMICAL DISPERSION IN THE REGOLITH OF THE CSA AREA, COBAR, NEW SOUTH WALES

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INTRODUCTION

The CSA Copper Mine is located in the Cobar District of New South Wales, approximately 12 km north of Cobar (Figure 1). Effective geochemical exploration for base metal deposits in the CSA area has been hampered by limited knowledge of the regolith controls on element dispersions in the different regolith-landform settings found throughout the area. Understanding the regolith-landform controls on the geochemical dispersion pathways is important to help understand and interpret existing geochemical data and plan and interpret new geochemical surveys.

Geochemical and mineralogical data indicate that iron oxides, particularly hematite and goethite, are major hosts for base metal pathfinder elements including Cu, Pb, Zn, Ag, As, Bi, Cd, Hg, Se, Te and Tl in the regolith of the CSA area. Other secondary minerals are also likely to be important, particularly in the gossans formed from weathering mineralisation. Understanding how the different pathfinder elements behave during formation of the ore weathering profile and subsequent dispersion in the regolith can help in developing appropriate and robust geochemical exploration models in the CSA area.



Figure 1: Location of the CSA Copper Mine in western NSW. Also showing the extent of study area surrounding the CSA Mine (rectangle).

GEOLOGY, MINERALISATION AND REGOLITH SETTING

The CSA Cu±Pb-Zn deposit occurs within the Cobar mineral field on the eastern margin of the Cobar Basin. It is hosted in rocks of the Cobar Supergroup. The Cobar Supergroup is comprised of Early Devonian basinal sediments, including shallow and deep marine facies, which are now largely confined to north-trending synclines. The CSA area is dominated by interbedded turbiditic siltstones, sandstones and mudstones of the Nurri and Lower Amphitheatre Groups within the Cobar Supergroup. The CSA deposit lies stratigraphically near the top of the CSA Siltstone and just below the Biddabirra Formation.

Mineralisation at the CSA deposit is made up of four main ore systems, all of which strike approximately

north and dip steeply to the east, sub-parallel to cleavage. The mineralisation occurs as structurally controlled, epigenetic vein-complexes containing massive sulphide bodies. These are composed predominantly of chalcopyrite, cubanite, pyrrhotite and sphalerite with minor quantities of galena, together with abundant quartz veins and some pyrite. The sulphides and quartz are hosted in intensely cleaved chloritic siltstones. The mineralisation forms many sub-parallel ore lenses that typically extend up to 100 m along strike and range in width up to 20 m. They plunge steeply with vertical dimensions up to several hundreds of metres.

The CSA area has a landscape of moderate to low relief with a wide variety of regolith materials and landforms. Regolith-landforms are dominated by areas of colluvial sheetwash deposits and alluvial sediments, with rare outcrops of slightly weathered bedrock (saprock). The area is extensively masked by red-brown residual soils with extensive accumulations of surface lag consisting of lithic gravels, quartz fragments and ferruginous pisoliths. Gossans have been identified throughout the area but most are found close to the CSA mineralisation.

REGOLITH GEOCHEMISTRY

Geochemical associations in the weathering profiles around the CSA deposit show progressive change between different regolith materials. Sampling and analysis of these materials has shown that Fe-oxides/oxyhydroxides are important hosts for base metal pathfinder elements. Patterns that have been identified in the element correlations indicate Cu, Pb, Zn, As, Bi, Cd, Co, Cr, Hg, Mo, Sb, Se, S, Te and Th are the most useful elements for identifying anomalous areas around the CSA deposit (Table 1). These elements and their associations are best represented in gossan, aircore samples and lithic and ferruginous angular lag.

In surface lag, gossan and aircore samples, the association of Cu–Pb–Sb±Zn-Bi-Se shows the strongest relationship with the abundance of Fe. The elevated Fe content has a direct relationship to the amount of goethite and hematite in all of the samples. Aside from the target elements (Cu, Pb, Zn) other elements (including Ba, Bi, Cd, Hg, Se, Te and Tl) are variably useful as pathfinders for the identification of base metals anomalies in the CSA area.

Saprock geochemistry around the CSA deposit has provided numerous well-defined multi-element geochemical anomalies, which include combined Cu and Zn anomalies. Detailed analysis of the saprock geochemistry suggests that Zn is particularly mobile and has been widely dispersed by chemical

and mechanical processes. Copper and Cd give the clearest definition of mineralised zones. Arsenic has a limited distribution over the main mineralised zone, but it is particularly enriched around the western gossan system. Lead is enriched in the Western mineral system, with a limited distribution over the Eastern mineral system. Bismuth, Sb, Hg and Zn generally show an even distribution over the QTS North mineralisation and the surrounding area.

Iron and Mn oxides/oxyhydroxides are widely distributed in the near-surface regolith in the CSA area. Most target and pathfinder elements in saprock samples show positive correlations with Fe and Mn indicating that the oxides/oxyhydroxides of these elements are important hosts to the majority of the target and pathfinder elements in the saprock. The Fe and Mn oxides/oxyhydroxides occur as thin laminations in veins and on cleavage planes in the saprock. The concentration of Cu, Pb, As, Bi and Sb, in particular, can be related to the high percentage of hematite and goethite recognised in the aircore saprock samples. Hematite and goethite have the ability to scavenge and concentrate Cu, Pb, As, Bi and Sb (McQueen & Munro 2003). Figure 2 shows the pathways by which these elements may be incorporated into goethite and hematite during weathering.

Gossans from the CSA area are characterised by a strong positive correlation between Pb, Sr and S. This suggests that sulfates of the alunite-jarosite group, previously identified by Trueman (1972), may be important hosts for Pb and Sr in the gossans. Lead will substitute for K, and Sr for Al in members of this mineral group. In the primary mineralisation Sr is hosted in calcite, which is intimately associated with chalcopyrite in the M lens mineralisation in the QTS North mineral system (Figure 3).

Table 1: Common element associationsderived from correlation matrices (1369samples) of analysed elements in regolithsamples from the CSA area.

Ag - Cd - Hg
As - Fe - Pb - Se
Cu - Pb - Zn - Fe - Se - Bi - Sb
Cd - Cu - Hg - Zn
Co - Pb - Zn
Fe - Th - P
Fe – Pb
Sr – Pb

Bulk lag samples from the CSA area generally show elevated levels of Pb, As, Sb, and in some cases Ag (in the more ferruginous fractions) and Cu and Zn (typically in the lithic fractions) relative to regional background levels. There is a well-defined positive correlation between the abundance of Fe and hematite and the trace elements Pb, As and Sb. This is related to a previously recognised weathering-controlled fractionation of these elements during surface maturation of the lag (McQueen & Munro 2003). Copper and Zn show a strong negative correlation with Fe and hematite abundance, except in lag derived from gossanous outcrops. A lag sample collected near an outcropping Pb-Zn gossan associated with the Western mineralisation shows very distinct geochemical characteristics with anomalous concentrations of Pb (330-3,100 ppm), As 61-510 ppm), Bi (7-77 ppm), Cu (100-690 ppm), Zn (150-540 ppm) and Ag (0.3-3.1 ppm) in the different lag fractions (lithic and ferruginous).



Figure 2: Connectagram showing mineral host pathways through the weathering profile from primary ore minerals to secondary and gossan minerals.

Geochemical signatures recognised in soil samples show little resemblance to the underlying saprock geochemistry. Soils sampled in close proximity to the gossans in the Western mineral system have higher concentrations of Cu, Pb, Zn, As and Bi. The concentration of these elements can be attributed to the erosion of the gossans above the Western mineral system and mechanical addition of the ferruginous material to the soil. Pathfinder element signatures emanating from the underlying geology have been strongly diluted by the thin cover of residual soil in this area due to large quantities of introduced aeolian sediment in the soil.

CONCLUSIONS

The regolith of the CSA area consists of a red-brown soil containing ferruginous pisoliths overlying transported regolith or *in situ* saprolite/saprock with scattered outcropping saprock and gossans. Detailed geochemical investigation of the regolith materials within the upper weathering profile around the CSA Mine indicates that there has been significant leaching of metals and dispersal of the remaining geochemical signatures into Fe oxides/oxyhydroxides. Hematite and goethite are major hosts to the major pathfinder elements, including Cu, Pb, Zn, As, Sb and Ag. Alunite-jarosite group minerals are important hosts from Pb and Sr. Well defined saprock-hosted base metal anomalies are reflected by Cu, Pb, Zn, Ag, Cd and Se. However As, Ba, Hg and Mn appear to be depleted in the saprock. The base metal anomalies have limited lateral dispersion, possibly due to the low permeability of the surrounding, thinly bedded, interbedded siltstones and sandstones.

The fractionation and dispersion of pathfinder elements from the primary ore to outcropping gossan and eventually into surface lag accumulations demonstrates that regolith processes have a strong influence and control on base metal element dispersion and accumulation in the regolith. Iron oxides and oxyhydroxides have been recognised as important hosts for the major base metal elements in the saprock.

Major pathfinder elements, including Pb, Cu, Cd and Sb, have limited chemical mobility within the regolith, due to the formation of stable secondary host minerals for these elements. Copper shows small characteristic dispersion halos around known zones of mineralisation in the CSA area. Zinc is particularly mobile and has been widely dispersed, probably by chemical and mechanical processes.

Strongly ferruginised materials, including lag and gossans, which have had prolonged exposure on the surface have an abundance of hematite and maghemite. With the increased Fe and hematite content there has been an increase in Cu, Pb, As and Co contents.



Figure 3: Location of the CSA Mine and surface projections of mineralisation zones.

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