BEHAVIOUR OF GEOCHEMICAL PATHFINDER ELEMENTS DURING WEATHERING AND PEDOGENESIS IN SE AUSTRALIA

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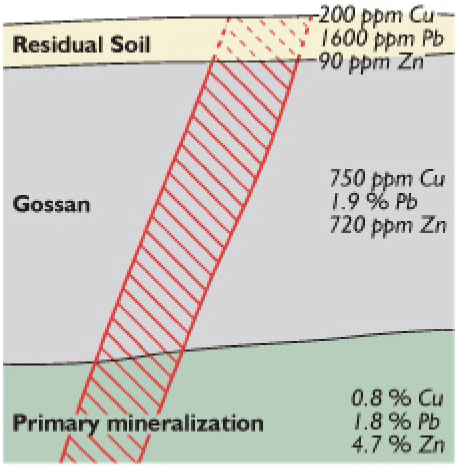

Figure 1: Selected element abundances in regolith at Wagga Tank, Cobar NSW.

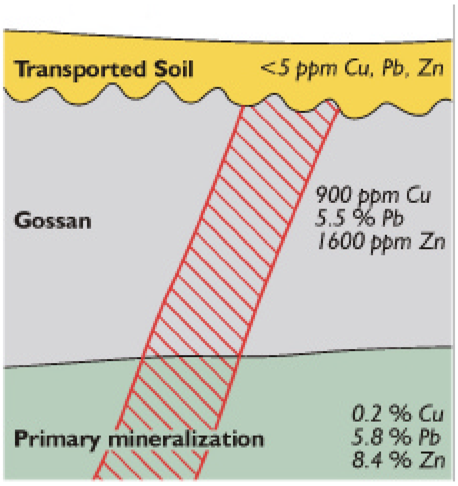

Figure 2: Selected element abundances in regolith at Elura, Cobar NSW.

During weathering of Pb-Zn-Cu-As-Ag-bearing sulfide deposits, Cu, Zn and Ag are usually regarded as highly mobile and As and Pb as relatively immobile. Thus the gossans and residual soils above such mineralization are Pb- and As-rich but comparatively Cu-, Zn- and Ag-poor. At Wagga Tank, in the semi-arid Cobar district of western New South Wales, these latter elements are depleted by several orders of magnitude in the surficial materials (Figure 1).

On weathering of the sulfides, Cu and Zn are preferentially concentrated in the goethite structure whereas Pb is commonly concentrated in the hematite structure. Percentage amounts of Cu and Zn may also be incorporated in Pb-rich alunite-jarosite group minerals, which persist through further weathering. Consequently, because all these minerals are present in the subcropping gossan, their contained base metals were preserved up the regolith profile and were available to be incorporated into the soils, with the coarse (hematite-rich) and magnetic (maghemite/hematite-rich) soil fractions being particularly Pb-rich. However, further north at Elura, although base metals are again preserved in subcropping gossanous material, the soils over the deposit are developed in transported material and may give no indication of the underlying mineralization (Figure 2). Here the soils are dominated by fine material which tends to be goethitic and Zn rich but, because of the lack of Pb and the known mobility of Zn relative to Pb, uncertainty exists about the significance of Zn as a potential pathfinder for base metal mineralization in this highly weathered environment.

Furthermore, in the Cobar region (and throughout SE Australia), many apparently residual soils are actually hybrid soils, composed of residual soil and variable amounts of aeolian material (which is not visually obvious). The presence of aeolian material, characterised by abundant –63 µm sized material, can dilute any geochemical signature present in fine soil material. Thus, in areas with unknown amounts of aeolian or other transported material, the coarse soil fraction (commonly containing residual fragments) represents a better sampling medium than the finer, more clay-rich soil fraction.

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OBJECTIVE

To follow the distribution of base metals during the weathering of Zn-rich mineralization and to understand how elemental abundances in different soil fractions can be used during mineral exploration in the semi-arid region of NSW, Australia.

INTRODUCTION

The use of soil samples for mineral exploration depends upon an understanding of chemical processes which occur during weathering and the soil formation processes. During weathering of Pb-Zn-Cu-As-Ag-bearing sulfide deposits, Cu, Zn and Ag are usually regarded as mobile and As and Pb as immobile. Thus gossans (highly weathered ferruginous rock derived from the original sulfides) above such mineralization are Pb-and As-rich but comparatively Cu-, Zn- and Ag-poor. This trend to depletion of Cu and Zn relative to Pb is developed even further in residual soils above mineralization *(Figure 1)*. However, if the soil has formed in transported material there may be no anomalous base metals in it i.e. no indication of underlying mineralization *(Figure 2)*.

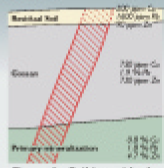

Figure 1. Soil in residual material above mineralization

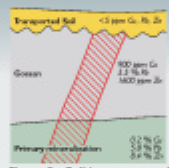

Figure 2. Soil in transported material above mineralization

SAMPLES

Unweathered and saprolitic rock and soil samples from profiles through the regolith at Wagga Tank and Elura *(Figures 3, 4 & 5)* have been studied.

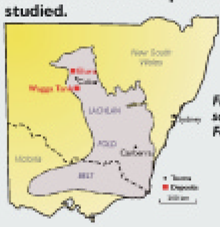

Figure 3. Location of sample sites, Lachlan Fold Belt SE Australia

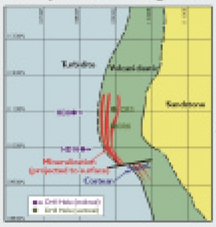

Figure 4. Location of drill hole and costean samples, Wagga Tank

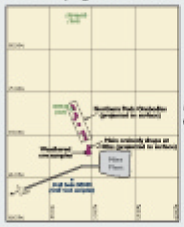

Figure 5. Location of samples, Elura

METHODOLOGY

Rock → Crush -75 μm →
- Electron microprobe analysis (trace elements in Fe oxides) (alunite-jarosite compositions)
- X-ray diffraction
- HCl/HNO$_3$/HF/HClO$_4$ Dissolution → ICP (Al, Fe, Mn, Ca, Na, K, Ti, P, S, Cu, Pb, Zn, Zr); ICP-MS (Ag, As, Cd, Sb)

Soil → Sieving → +2mm; -2 +1mm; -1mm +500μm; -500 +250μm; -250 +125μm; -125 +63μm; -63μm → Test for magnetic component → chemical analysis/XRD

RESIDENCE OF BASE METALS AND MINOR ELEMENTS IN GOSSANS

Hematite from gossanous material at Wagga Tank has higher Pb but lower Cu, Zn and SO$_3$ contents than co-existing goethite *(Table 1)*. The Pb-rich alunite-jarosite minerals, with the general formula $AB_3(XO_4)_2(OH)_6$, in such material may contain high abundances of As, S and P as well as high Cu and Zn contents. Although not as abundant as the Fe oxides these minerals tend to be stable under further weathering.

Similar base-metal rich Fe oxides and alunite-jarosites occur at Elura.

	As ppm	Cu ppm	Pb %	Zn ppm	SO$_3$ %	P$_2$O$_5$ %
Whole rock	-	2400	2.6	520	-	-
Hematite	7000	240	1.0	250	0.34	0.03
Goethite	4800	5800	0.22	3000	0.80	<0.01
Plumbogummite	<100	160	37.0	2000	2.58	22.3
Hinsdalite	2.36%	3300	26.6	1300	5.95	11.0
Beudantite	8.25%	6600	26.1	280	14.0	0.76

Table 1. Base metal and minor element contents in gossans at Wagga Tank

RESIDENCE OF BASE METALS IN SOILS OVER MINERALIZATION

Residual soil

- Pb is strongly concentrated into coarse soil fraction above mineralization. Strong coherent anomaly *(Figure 6)*.
- Zn is only poorly retained in coarse soil fraction. Weak geochemical response above subcropping mineralization *(Figure 7)*.
- No Zn anomalism evident in fine soil fraction *(Table 2)*.

Transported soil

- Zn is concentrated in fine soil fractions. Even background is higher than in residual soil over mineralization.
- The lack of Pb with anomalous Zn reflects the high mobility of Zn during weathering and/or high local backgrounds in the rocks and casts doubt on the potential of Zn in the fine soil fraction as a pathfinder for mineralization.
- Aeolian material in the region also concentrates in the fine soil fraction.

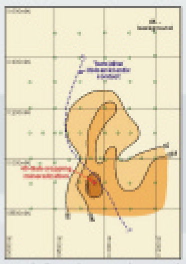

Figure 6. Distribution of anomalous Lead (ppm) in 1-2mm soil samples, Wagga Tank

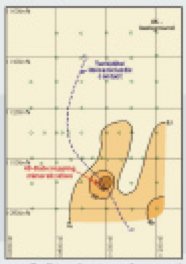

Figure 7. Distribution of anomalous Zinc (ppm) in 1-2mm soil samples, Wagga Tank

CONCLUSIONS

During the weathering of polymetallic sulfide orebodies in the Cobar district, Cu, Pb and Zn are preferentially concentrated into the Fe oxides and alunite-jarosite group minerals, which persist into the soils.

- Sieving of soils indicates that the coarse fraction is Pb and As rich and the finer material may be more Zn (and Cu) rich.
- In residual soils highly anomalous Pb contents are retained, especially in the coarse hematitic fraction.
- In the soils developed in transported material, the transported (including aeolian) component may dilute any Pb signature originally present.
- In areas with an unknown amounts of aeolian and other transported material, the coarse material (consisting of both residual fragments and neo-formed Fe segregations) represents a more reliable sampling medium than the finer, more clay-rich soil fraction, despite the possibly higher Zn and Cu contents in the latter.

Table 2. Features of soils in residual and transported material

Soil Type \ Location	Wagga Tank Residual		Elura Transported	
Coarse (1-2 mm) %	>5 (bauxite + lithic frags)		<2	
Fine (-63 μm) %	<40		>50	
	Mineralized	Background	Mineralized	Background
Pb in coarse (ppm)	1000	20	65	45
Pb in fine (ppm)	50	10	36	33
Zn in coarse (ppm)	79	12	120	51
Zn in fine (ppm)	12	12	468	79

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Editor's note: Keith Scott's poster (reproduced above) was awarded 'Best Poster' prize at the 17th International Soil Science Conference in Thailand, August 2002.