MONS CUPRI Cu-Zn-Pb DEPOSIT, PILBARA, WESTERN AUSTRALIA

P. Collins[1], B. Hooper[2] and M. Cornelius[3]

[1]*Dept of Applied Geology, Curtin University, GPO Box U1987, WA 6845*

[2]*Straits Resources Ltd, P.O. Box 1641, West Perth, 6872 Western Australia*

[3]*CRC LEME, c/- CSIRO Exploration and Mining, P.O. Box 1130, Bentley, WA 6102*

LOCATION

The Mons Cupri deposit is about 120 km E of Karratha and 4 km SW of Whim Creek (Figure 1) at 20°52'50"S, 117°48'20"E; Roebourne 1:250 000 map sheet (SF 50-03).

DISCOVERY HISTORY

Copper mineralization has been known at Mons Cupri since at least 1897, when it was mined for supergene Cu. However, only 442 t of Cu were produced before its closure in 1917. Soil and stream sediment geochemical surveys have been undertaken by several explorers since 1970 to establish its geochemical signature, including the regolith, gossan and Hg in the atmosphere 1 m above the ground (Smith, 1980). Results are, however, likely to be affected by contamination from early mining.

PHYSICAL FEATURES AND ENVIRONMENT

Mons Cupri is within part of an 85 km long, arcuate range of low hills that generally are 80-120 m above sea level and attain a maximum elevation of about 160 m (Figure 1). To the N, there is a vast, flat plain of transported regolith that reaches a maximum elevation of 25-30 m where it laps onto the range and is of variable thickness (<50 m). The area has a semi-arid climate with mean daily minimum and maximum temperatures of 26-39°C (January) and 13-27°C (July). The average annual rainfall is about 310 mm, falling in summer from thunderstorms and cyclones. As there are only about 25 rain days per year, the regolith above the water table is dry for most of the time. The mean annual evapotranspiration is about 350 mm but the potential evapotranspiration is about 1700 mm. Thus, vegetation is sparse and restricted to drought resistant grasses and shrubs.

GEOLOGICAL SETTING

Mons Cupri is on the southern flank of the Mt Brown Felsic Volcanic Centre that is a domed pile of felsic volcanic rocks 15-25 km^2 in area that spreads across the NE trending Archaean Whim Creek volcanic belt. About 1000 m of rhyolitic-dacitic volcanic rocks, that are conformably overlain by up to 500 m of fine- to coarse-grained felsic volcaniclastic and epiclastic rocks, make up the Mons Cupri Volcanics (Smithies, 1998; Collins and Marshall, 1999). The felsic volcanics are conformably overlain by at least 200 m of the W-dipping Rushall Slate, that has infilled a small depocentre on the S flank of the volcanic pile (Collins and Marshall, 1999). These formations are unconformably overlain by up to 2000 m of basaltic and ultramafic volcanic and intrusive rocks of the Louden Volcanics and tholeiitic basalt-andesite lavas of the Negri Volcanics (Smithies 1998; Collins and Marshall 1999).

The Mons Cupri deposit occurs in the upper parts of the Mons Cupri Volcanics (Figure 2) where there is about 600 m of massive, coarse-grained agglomerate that flanks a massive feldspar-phyric dacite-rhyolite domal extrusive or intrusive body. The agglomerate contains angular to rounded boulder-sized fragments of the adjacent massive rhyolite, with some granitoid and amygdaloidal basalt clasts. Along strike from Mons Cupri, the agglomerate grades into matrix- and clast-supported cobble to boulder conglomerate with interbedded tuff and siltstone. The upper section of the formation grades into a poorly sorted, layered package of vitric, crystal and lithic tuffs, tuffaceous sandstone, shale and chert that underlies the Rushall Slate.

REGOLITH

The Mons Cupri area was originally covered by part of a vast, gently undulating, Cretaceous-Tertiary peneplain that is generally referred to as the Hamersley Surface (Campana *et al.,* 1964; Hickman, 1983). Subsequent erosion has completely removed this peneplain and its underlying weathered profile, leaving a range of hills that outcrop as the Whim Creek volcanic belt. Although the Mons Cupri area is in an erosional regime, the gossanous, oxidized zone of the Mons Cupri deposit is one of the few remnants of the palaeoweathered profile. The hills are covered by a thin, discontinuous, residual soil which grades into locally-derived gravels and sand as colluvial sheetwash and talus on the lower flanks of hills. Silt, sand and gravel have accumulated in modern drainages. To the NW, NE and SE of the belt lie Quaternary floodplains of alluvial sand, silt and clay with gilgai surfaces in areas of expansive clays. Outwash fans of colluvial gravel, sand and silt fringe the hills.

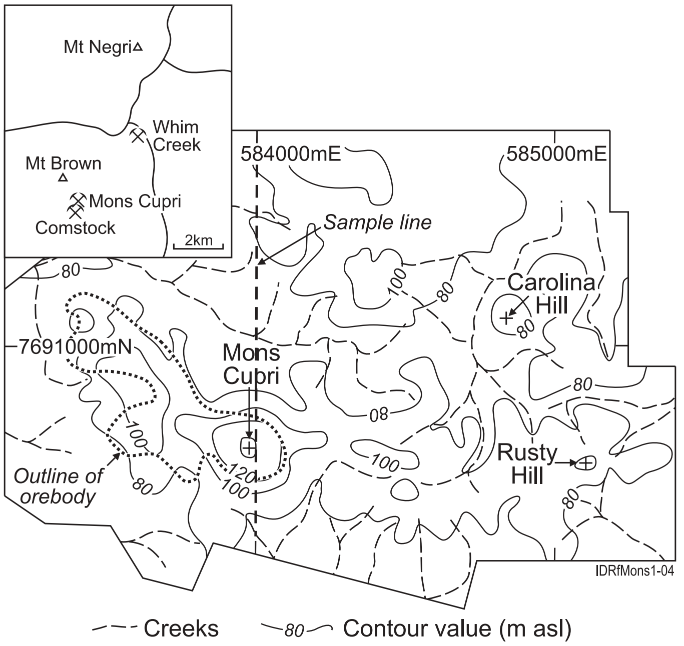

Figure 1. Location and topography of the Mons Cupri area.

MINERALIZATION

This VHMS deposit consists of an ovoid lens (250 x 400 m in plan;

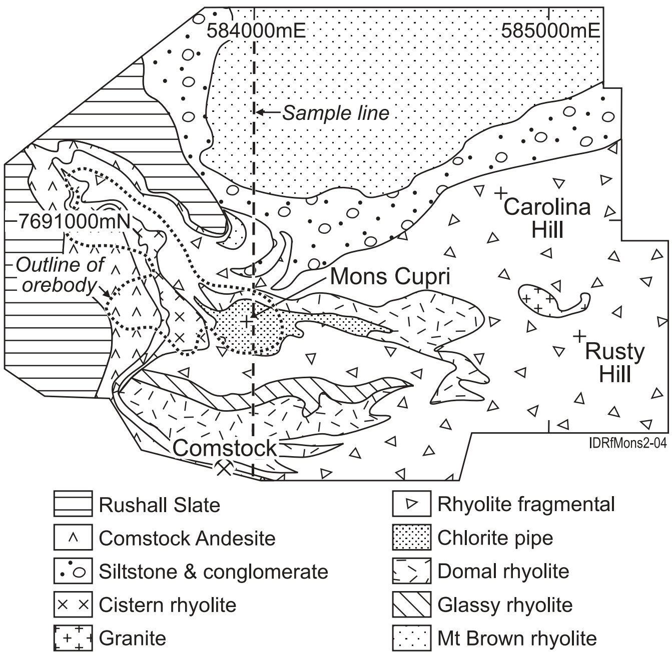

Figure 2. Geology of the Mons Cupri area (after Smith, 1980). All rock units are part of the Mons Cupri Volcanics, except Rushall Slate, Comstock Andesite and Granite.

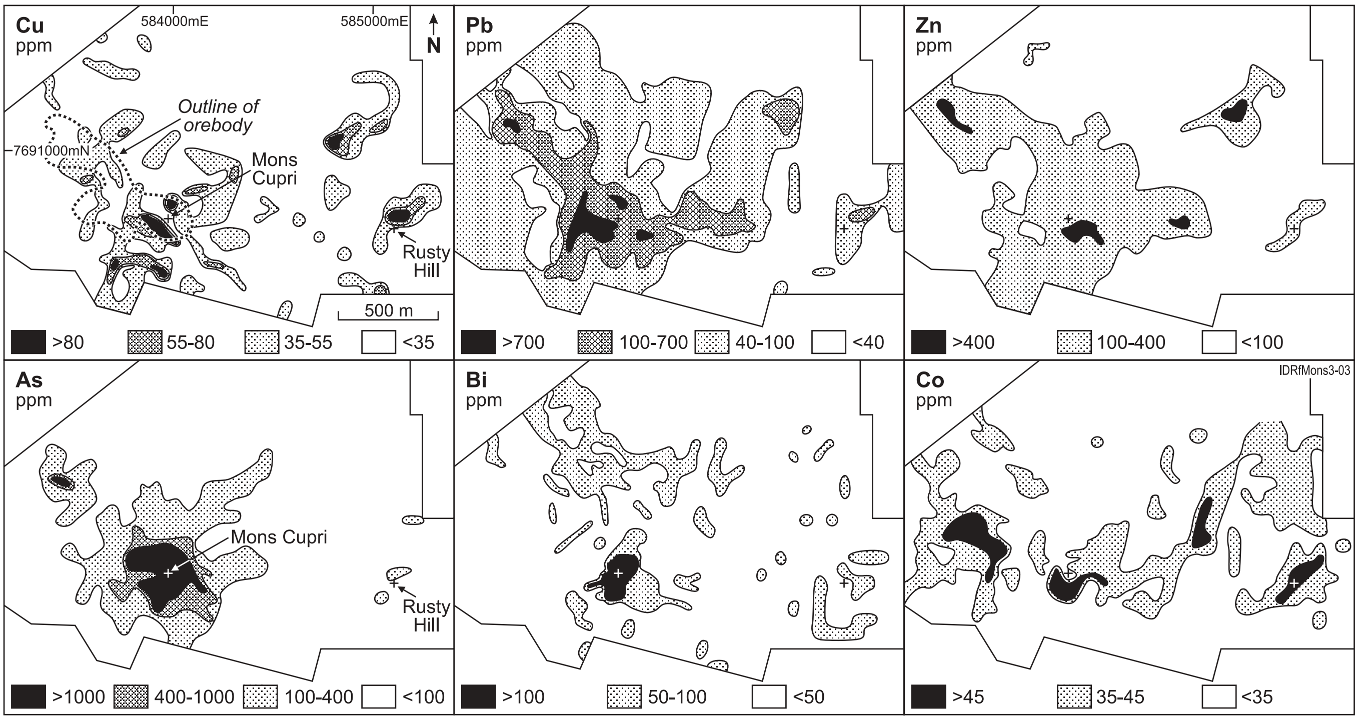

Figure 3. Detailed Cu, Pb, Zn, As, Bi and Co soil geochemistry (<75 μm) by Australian Inland Exploration Co Inc 1971 (after Smith, 1980.

3-15 m thick) of stratiform Zn-Pb-Cu sulphides that caps a stockwork zone, dominated by veined and disseminated Cu-sulphides and enclosed within a heterogeneous chlorite-carbonate-sericite alteration zone (Miller and Gair, 1975; Collins and Marshall, 1999). The stockwork zone contains up to 15 Mt at 1% Cu and the stratabound zone has an estimated 1 Mt at 5.3% Zn, 3% Pb, 1.0% Cu and 56 g/t Ag (Collins and Marshall, 1999). There is an oxide reserve of 4 Mt at 0.75% Cu (Straits, 2003) and an in situ resource of 10.9 Mt at 0.6% Cu.

The proximal stratiform lens consists of bands of fine- to medium-grained pyrite, sphalerite and galena, with minor chalcopyrite and tetrahedrite that are interbedded with tuffaceous sandstone, siltstone and chert at the top of the Mons Cupri Volcanics (Miller and Gair, 1975; Smithies, 1998). As the host sequence has a westerly dip, the stratabound lens is overlain by Rushall Slate (Collins and Marshall, 1999), except for a small outcrop of gossan (Smith, 1980). Underlying stockwork mineralization consists of an anastomosing network of chalcedonic quartz and carbonate veins (10-100 mm thick) with chalcopyrite and minor sphalerite and galena. It is confined to a funnel-shaped alteration zone that narrows from about 250 m across, near the palaeosurface at the top of the Mons Cupri Volcanics, to about 20 m wide at depths of 300 m. The upper 30 m of the stockwork zone is a dense network of crustiform, chalcedonic quartz-chalcopyrite veinlets that also traverse the stratabound ore (Miller and Gair, 1975).

REGOLITH EXPRESSION

Mons Cupri hill is the exposed oxidized portion of the cupriferous stockwork mineralization and is essentially a network of gossans capping a supergene zone (Smith, 1980). Weathering extends to a depth of about 75 m below surface, with the present water table at about 20 m. Deeply weathered parts of the stockwork vein and alteration zone in the Mons Cupri Volcanics have siliceous veinlets with malachite and minor azurite but no secondary Zn or Pb minerals have been identified (Smith, 1980). This is reflected in variable enrichment in Cu and low levels of Pb and Zn in the gossanous stockwork zone in comparison with the primary sulphide mineralization (Table 1; Smith, 1980).

The stratabound lens dips beneath the Rushall Slate and has been 'protected' from much of the palaeoweathering; most of it is below the level of oxidation (Collins and Marshall, 1999). In comparison with the host felsic volcanics, the stratabound primary sulphide ore is strongly enriched in Cu, Pb, Zn, Ag, As, Bi, Co, Mo, Ni, Sb and Sn (Table 1), and therefore all these elements should be effective indicators for Mons Cupri style stratabound mineralization. Where the stratabound lens crops out as a small gossan on the W flank of Mons Cupri hill, it is strongly enriched in Pb and Ag (up to 30% Pb, 305 g/t Ag) and is markedly depleted in Zn (Table 1). Other elements enriched in the primary ore (ie, As, Bi, Mo, Sb, Sn, and Au) are also expected to be enriched in the gossan. An underlying supergene zone is enriched in Cu, slightly depleted in Pb and Ag and markedly depleted in Zn (Smith, 1980; Chisholm, 1983).

In the 1970s, there were several soil, stream sediment and rock chip geochemical surveys in the Mons Cupri area, including a detailed soil geochemical survey over Mons Cupri on a 30 x 60 m grid (Chisholm, 1983). This soil survey (Figure 3) revealed strong Cu, Pb, Zn and Bi anomalies and less pronounced Co and As anomalies (Smith, 1980). The Cu and Bi anomalies coincide with exposed Cu mineralization, whereas a Co anomaly is slightly offset on the S flank of Mons Cupri hill (Smith, 1980). A Pb and As anomaly located to the W of the main Cu-Bi anomaly is attributed to the Pb-rich gossan equivalent to the stratabound ore on the W flank of Mons Cupri hill. A Zn anomaly is located to the SE of Mons Cupri and apparently is not coincident with the main Cu-Bi anomaly (Smith, 1980). An orientation survey to test Hg in soils, following testing of Hg in the atmosphere, showed that anomalous Hg generally correlates with mineralization but several Hg highs are not directly related to base metal sulphides (Chisholm, 1983).

During 2000, soil samples were collected on N-S lines 500 m apart at a 100 m interval throughout an area of about 24 km^2 that included Mons Cupri and the nearby Whim Creek deposit. One grid line, at 584000mE (AMG), passed over the footwall stockwork and alteration zone, perpendicular to its elongation (Figure 2). Samples were analysed for Cu, Pb, Zn, Ag, As, Sb, Bi, Mo, Te, Ni, Au, Hg and Cr after extraction with Regoleach (Table 2), and profiles of analytical data for key elements are presented in Figure 4. Regoleach is a proprietary technique developed by ALS Laboratories and is one of the stronger digests used for partial extractions. This survey reflects only the soil geochemical signature of the cupriferous footwall stockwork veining and alteration zone since the stratabound ore does not outcrop near this sample line.

The footwall zone of the Mons Cupri deposit has a pronounced multi-element soil geochemical anomaly (Figure 4) that is characterised by: -

(i) Pronounced enrichment in Cu, Bi, Ag, Mo and Au and moderate enrichment in Pb, which coincides with the stockwork zone and is consistent with the findings of a detailed survey by Smith (1980);

(ii) No enrichment in Zn, which is to be expected from the extremely low Zn content of gossanous stockwork ore; and

(iii) A strong As anomaly and low level Ag, Co, Ni, Sb anomalies on the

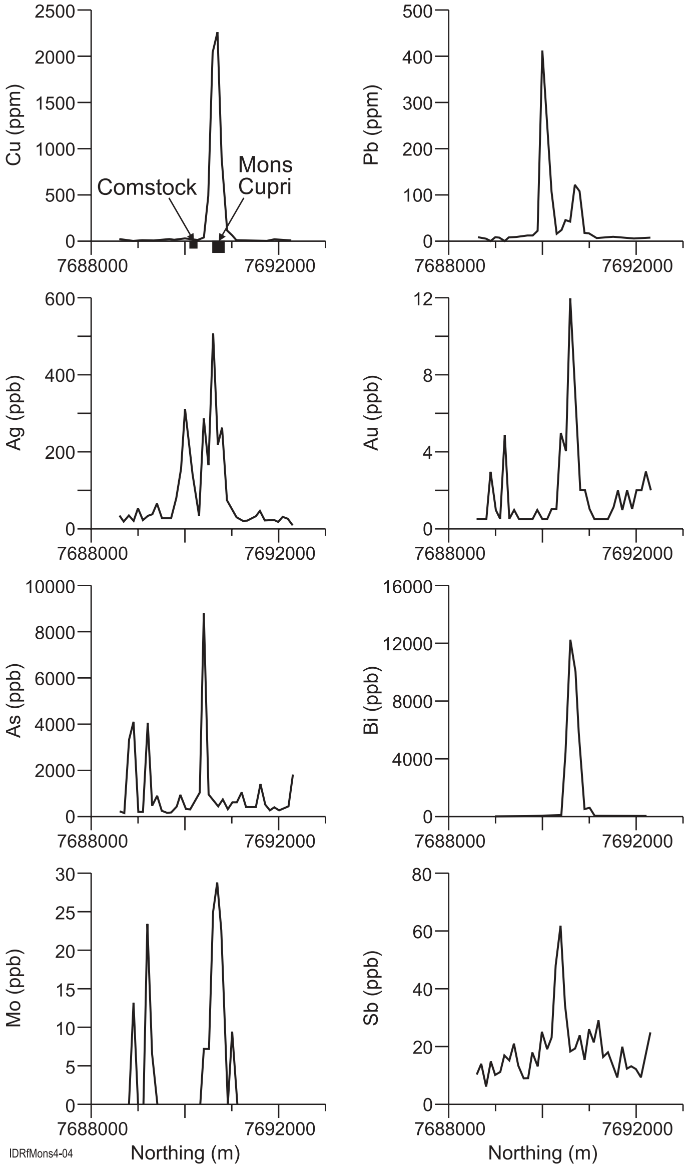

Figure 4. Regoleach analysis of soil samples along line 584000mE which passes over the Mons Cupri stockwork mineralization and over epigenetic vein-style Pb mineralization at Comstock.

southern shoulder of the main Cu-Bi anomaly.

The Cu-Bi anomaly over Mons Cupri is a broad but distinct spike, with little dispersion except, possibly, on the N flank where the anomaly extends 100-200 m beyond the stockwork-alteration zone (Figure 4). This limited dispersion is partly an artefact of wide-spaced sampling but is attributed mostly to limited dispersion in an immature elluvial-colluvial soil.

Another distinct anomaly, about 500 m S of Mons Cupri, coincides with the position of the Comstock Ag-Pb lode deposit that is hosted by an andesite body within the Rushall Slate. The strong Pb and Ag anomaly with a less pronounced Zn anomaly (Figure 4) is consistent with the primary mineralogy of this lode (see Collins and Marshall, 1999).

In summary, the most effective pathfinder elements for a Mons Cupri-type, footwall stockwork deposit are Cu, Bi, Ag, Au, Mo and Pb and possibly As and Sb in eluvial-colluvial soils, but with limited dispersion away from the deposit. The gossanous oxide ore is characterised by abundant Cu and anomalous Ag, Co, Pb and Zn in comparison with the host felsic volcanics. The most effective pathfinder elements for the stratabound component of a Mons Cupri-type deposit are Pb and Ag and, to a lesser extent, Zn and Cu in soils and gossan. Several other elements such as As, Au, Bi, Mo, Sb and Sn also should be effective indicators.

REFERENCES

Black, S.J., 1999. Genesis of the Whim Creek sediment-hosted volcanogenic massive sulphide deposit. Honours thesis, Curtin University of Technology, Perth, 152pp. (unpublished).

Campana, B., Hughes, F.E., Burns, W.G., Whitcher, I.G. and Muceniekas, E., 1964. Discovery of the Hamersley iron deposits: Proceedings, Australasian Institute of Mining and Metallurgy, 210: 1-30.

Chisholm J. 1983. Summary report Mons Cupri project West Pilbara Western Australia. Unpublished report Elf Aquitaine Aust. Pty. Ltd.

Collins, P.L.F., Hooper, B. and Cornelius, M., 2004. Whim Creek Cu-Zn-Pb deposit, Pilbara, WA. (this volume).

Collins, P.L.F. and Marshall, A.E., 1999. Volcanogenic base metal deposits of the Whim Creek Belt. In: K.M. Ferguson (Editor) Lead, zinc and silver deposits of Western Australia. Mineral Resources Bulletin 15, Geological Survey of Western Australia, pp 44-72.

Hickman, A.H., 1983. Geology of the Pilbara Block and its environs. Bulletin 127, Geological Survey of Western Australia, 268 pp.

Miller, L.J. and Gair, H.S., 1975. Mons Cupri copper-lead-zinc-silver deposit. In: C.L. Knight (Editor), Economic Geology of Australia and Papua New Guinea - 1. Metals. Monograph 5, Australasian Institute of Mining and Metallurgy, pp. 195-202.

Pike, G., 2001. The facies architecture of two contrasting volcano-sedimentary successions from the Archaean Whim Creek Belt, North Pilbara Terrain. Western Australia; the intra-continental arc-related Whim Creek Group and plume-related, continental rift-hosted Bookingarra Group. PhD thesis, Monash University, Melbourne, 465pp. (unpublished).

Smith, A.M., 1980. Mons Cupri Cu-Pb-Zn-Ag deposit, Pilbara Block, W.A. Journal of Geochemical Exploration.12: 168-171.

Smithies, R.H., 1998. Geology of Sherlock 1:100 000 sheet. 1:100 000 Geological Series Explanatory Notes, Geological Survey of Western Australia, 29 pp.

Straits 2003. Straits Resources Annual Report for 2003.

TABLE 1

INDICATOR ELEMENTS IN GOSSAN, PRIMARY SULPHIDES AND HOST ROCKS

Element	Mons Cupri Volcanics (a) ppm		Altered Mons Cupri Volcanics (b) ppm		Stratabound ore (c) (ppm)		Stockwork ore (c) (ppm)	
	Ave	Max	Ave	Max	Primary Ave/Range	'Gossan' Ave/Range	Primary Ave/Range	'Gossan' Ave/Range
Cu	21	94	13	15	10000	750-35300	8400	500-30000
Pb	25	158	26	31	26700	25500-307500	800	100-1000
Zn	48	850	45	62	63600	2100-2800	2400	100-600
Ag	-	<0.5	-	<0.5	70	20-305	10	-
As	3	8	8	16	800-3000	-	-	-
Au	-	<0.005	-	-	0.01-4.43	-	-	-
Ba	845	1211	816	1077	<800	-	-	-
Bi	<1	1	<0.1	0.1	40-1000	<23	-	-
Co	4	5	-	-	3000	-	-	-
Cr	<1	2	-	<1	200-400	-	-	-
Mo	1	2	1	1	150-400	-	-	-
Ni	5	9	6	8	2000	-	-	-
Sb	1	2	4	5	400-800	130-600	-	-
Sn	2	3	2	2	200-300	4-25	-	-
Ti	2760	3120	3000	3180	2	-	-	-

(a) Source: Pike (2001); 12 samples of spherulitic dacite and 8 samples of feldspar-phyric dacite; Black (1999); 2 samples of fragmental rhyolite.

(b) Source: Pike (2001); 3 samples of sericite altered spherulitic dacite.

(c) Source: Smith (1980) and Chisholm (1983, unpublished data).

(-) = data not available

TABLE 2
SAMPLE MEDIA - SUMMARY TABLE

Sample medium	Indicator elements	Analytical method	Detection limit (ppm)	Background (ppm)[1]	Threshold (ppm)[1]	Max anomaly Stockwork[2] (ppm)	Dispersion distance (m)
Soil	Cu	Regoleach		15	75	2270	100
(colluvial-	Pb	Regoleach	0.01	7	40	123	
alluvial	Zn	Regoleach		12	75	15/na	
	Ag	Regoleach		0.03	0.2	0.509	
	As	Regoleach		0.3	1.55	8.79	
	Bi	Regoleach	0.005	0.045	0.33	12.3	100
	Sb	Regoleach	0.005	0.009	0.035	0.062	
	Mo	Regoleach	0.01	<0.01	0.04	0.029/na	
	Te	Regoleach	0.005	<0.005	0.02	0.012/na	
	Ni	Regoleach		22	58	140	
	Co	Regoleach		10	34	40	
	Au	Regoleach	0.001	0.002	0.005	0.012	
	Hg	Regoleach	0.005	0.014	0.068	0.027/na	
	Cr	Regoleach		22	66	84	

[1] Background and threshold based on complete soil survey

[2] Directly over footwall stockwork zone

na = Not anomalous but depleted at this point