

FREDDIE WELL Zn-Cu DEPOSIT, MURCHISON DISTRICT, WESTERN AUSTRALIA

M. Cornelius and Raymond E. Smith

CRC LEME c/- CSIRO Exploration and Mining, PO Box 1130, Bentley, WA 6102

LOCATION

The Freddie Well Zn-Cu deposit is located 100 km SW of Sandstone and 430 km NE of Perth and 25 km SW of the Youanmi group of mines (Figure 1) at 28°45'10"S, 118°40'40"E; Youanmi (SH-50-04) 1:250 000 map sheet.

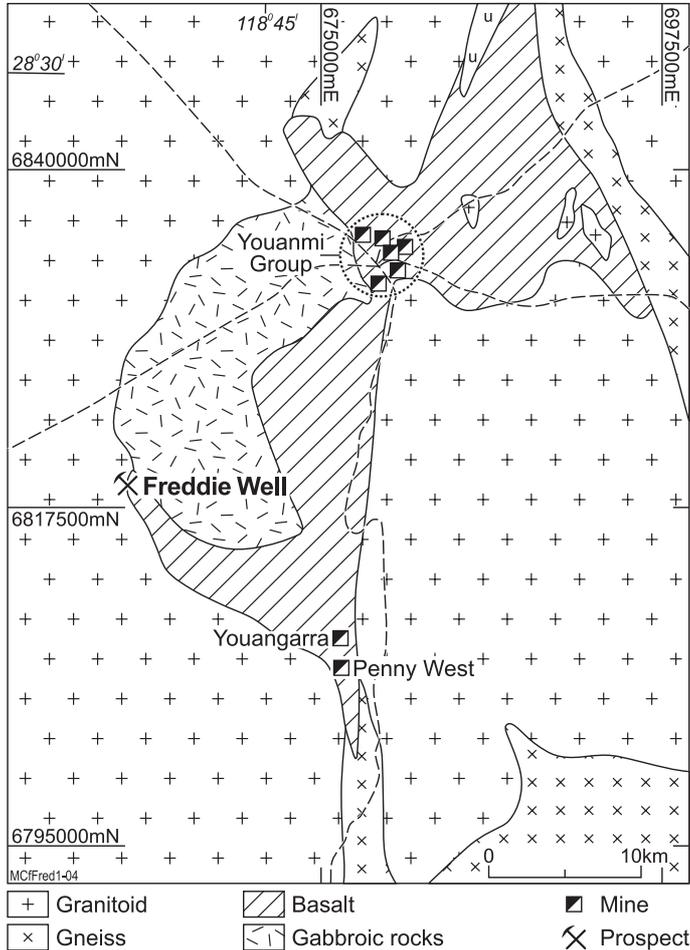


Figure 1. Regional geological setting of the Freddie Well deposit (after Radford and Boddington, this volume).

DISCOVERY HISTORY

The initial discovery was by recognition of the gossan over Zone A (Figure 2). A number of companies investigated the deposit in 1970-1972, including a consortium of Geometals, Carr Boyd, Conwest and Westralian Nickel, Tycho Mining, and Australian Ores and Minerals in 1972 and CRAE in 1974-1976. They used geological, geochemical and geophysical methods. ICI and Newmont ventured into the area with CRAE in 1977. Esso Exploration and Production Australia, in joint venture with Jones Mining, explored the area to the S of the Freddie Well zone in 1982-1983. In 1981-1986, CRAE completed a regional review and geophysical surveys throughout the project area, followed by drilling, mainly targeting Zone D (Figure 2). Eastmet acquired tenure over Zones A and B, and purchased Zone D mineralization from CRAE in 1988 and continued regional work, including soil geochemistry, until 1992. Gold Mines of Australia reviewed all data on Freddie Well in 1993 and estimated the resource. Between 1996 and 1999, Lachlan Resources entered into a joint venture with Base Metals of Australia, and undertook further geophysical work and drilling, mainly at Zones A and B. Subsequently in 2002, Valdera Resources Ltd re-appraised the prospect and conducted further drilling and geochemistry but did not locate substantial economic mineralization outside Zones A, B and D.

PHYSICAL FEATURES AND ENVIRONMENT

The prospect is just E of a subdued scarp that marks the edge of an

undulating plain, comprising a mantle of soil, sand, lateritic gravel and duricrust. The immediate prospect area consists of low hills and gullies. The dominant vegetation of the district is mulga (*Acacia aneura*), poverty bush (*Eremophila*) and turpentine (*Eremophila* spp.). The area is not currently used for grazing and is largely natural bushland. The climate is semi-arid with long, hot, dry summers and short, cool winters. The mean daily temperature range is 22-38°C in January and 7-19°C in July. The mean annual rainfall of 240 mm falls mainly during May-July but local thunderstorms or depressions may bring rain in January-March; the mean annual evaporation is 2600 mm.

GEOLOGICAL SETTING

The Freddie Well prospect lies in the E Murchison Mineral Field of Western Australia, at the SW margin of a metamorphosed layered gabbroid complex, approximately 20 km in diameter (Figure 1). A NNW-striking, zone up to 500 m wide of foliated and lineated quartz-sericite-(chlorite-feldspar) schist (Figure 2) is interposed between the Youanmi gabbroid complex to the E and largely laterite covered granitoid rocks to the W (Marston, 1979). The eastern margin of the felsic schist is sulphidic and contains a number of pods and semi-continuous horizons of rutilated, gahnite-bearing, blue quartz-rich rock, known informally as 'freddite', that appears to be a recrystallized chert or BIF, and forms a low ridge in the northern part of the prospect. This rock changes facies along strike into banded quartz-magnetite rock and also contains lenses of massive sulphides, mainly pyrrhotite, pyrite and sphalerite, with or without magnetite. Up to 50% sphalerite with minor chalcocopyrite occurs in some of these lenses. Above the sulphides are

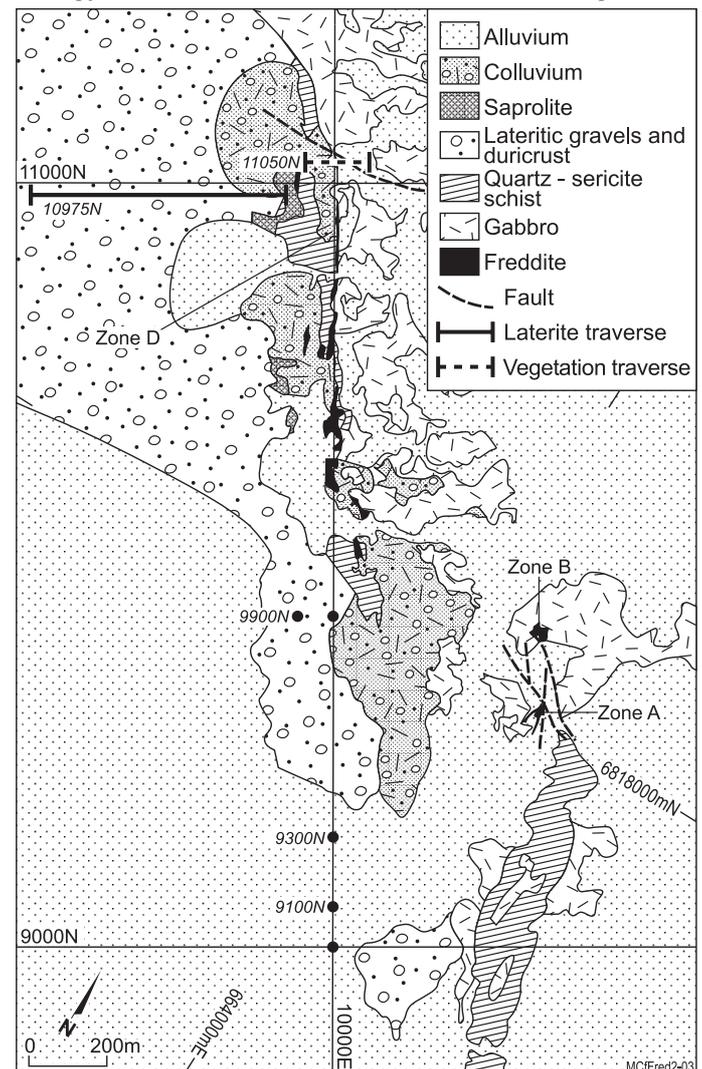


Figure 2. Deposit geology and location of sample traverses (after Valdera Resources Limited, 2002).

outcrops of boxwork gossans with characteristic geochemical signatures (Smith *et al.*, 1976). The close association of 'freddite' with felsic volcanic rocks suggests a volcanic exhalative origin for the silica and base-metal sulphides (CRA Exploration, 1976; Sargeant, 1978; in: Stewart *et al.*, 1983). To the N, the mineralization is terminated by faults. The mineralized horizon remains to be tested along strike to the S under the lateritic sandplain and alluvium (Smith *et al.*, 1976).

REGOLITH

Weathering penetrates <5 m in areas of outcrop and subcrop. Sulphides at the A Zone, for example, occur at about 10-12 m depth. Resistant lithologies (gabbro and dolerite) are fresh at outcrop (Figure 2) whereas some of the felsic schists are weathered. In gullies and small depressions, colluvial soil appears to be several metres thick whereas, on low hills and ridges, soil cover is thin (50-200 mm). The lateritic mantle (pisolitic and nodular duricrust and gravel with overlying sand) is preserved as an undulating plain SW of D Zone. Lateritic gravel is thin along the edge of a gentle erosional scarp, overlying residual clay, and thickens to the SW. South of A and B Zones, colluvial and alluvial cover thickens and covers a partly preserved, partly eroded lateritic profile.

MINERALIZATION

The sulphide mineralization consists of the D zone (Figure 2) and two smaller zones, A and B, approximately 1500 m to the S. The aggregate mineral resource totals approximately 800 000 t at 9.5% Zn (Valdera Resources, 2002). Zone D consists of two parallel, steeply dipping shoots 8 m apart, both about 120 m long and 5-6 m wide. The main

sulphides are pyrrhotite, pyrite, sphalerite and chalcopyrite, in some cases associated with magnetite. The geochemical composition of the sulphides from diamond core is: high Zn and Fe, subordinate Cu, anomalous Cd, In, Ag, Mo and Mn; erratic Sn, W, Ga and Co; detectable Sb and Bi, and low Pb and Ni; As is almost absent (Smith *et al.*, 1976).

REGOLITH EXPRESSION

Stream sediments

Active channels dissect the immediate area around the mineralization and stream sediment geochemistry shows that Zn and Cu anomalies can be detected for about 500 m downstream. The <75 μm fraction appears to be optimal for the detection of Zn and Cu; the concentrations of other pathfinder elements are low (Ag 0.5 ppm, Sn 5 ppm and W 20 ppm) and have not been fully assessed (Smith *et al.*, 1976). The use of stream sediment geochemistry is restricted by the limited extent of active drainage.

Soil

Soils in erosional landform regimes are generally residual, derived from saprolite and fresh rock. They are thin (1-2 m) red-brown and loamy with fine carbonate material and concretions beneath the top 50 mm. Soil samples were taken from 50-100 mm depth. In mineralized areas, soils show prominent Zn and Cu anomalies of 2000-3000 ppm Zn and Cu. Although all fractions showed prominent anomalies, the <75 μm fraction appeared to show the best compromise of anomaly width and magnitude. Concentrations of pathfinder elements are low but are generally best in the 0.6-2.0 mm fractions. Silver and Sn show weak anomalies (about 5 ppm) that coincide with the main Zn and Cu peaks.

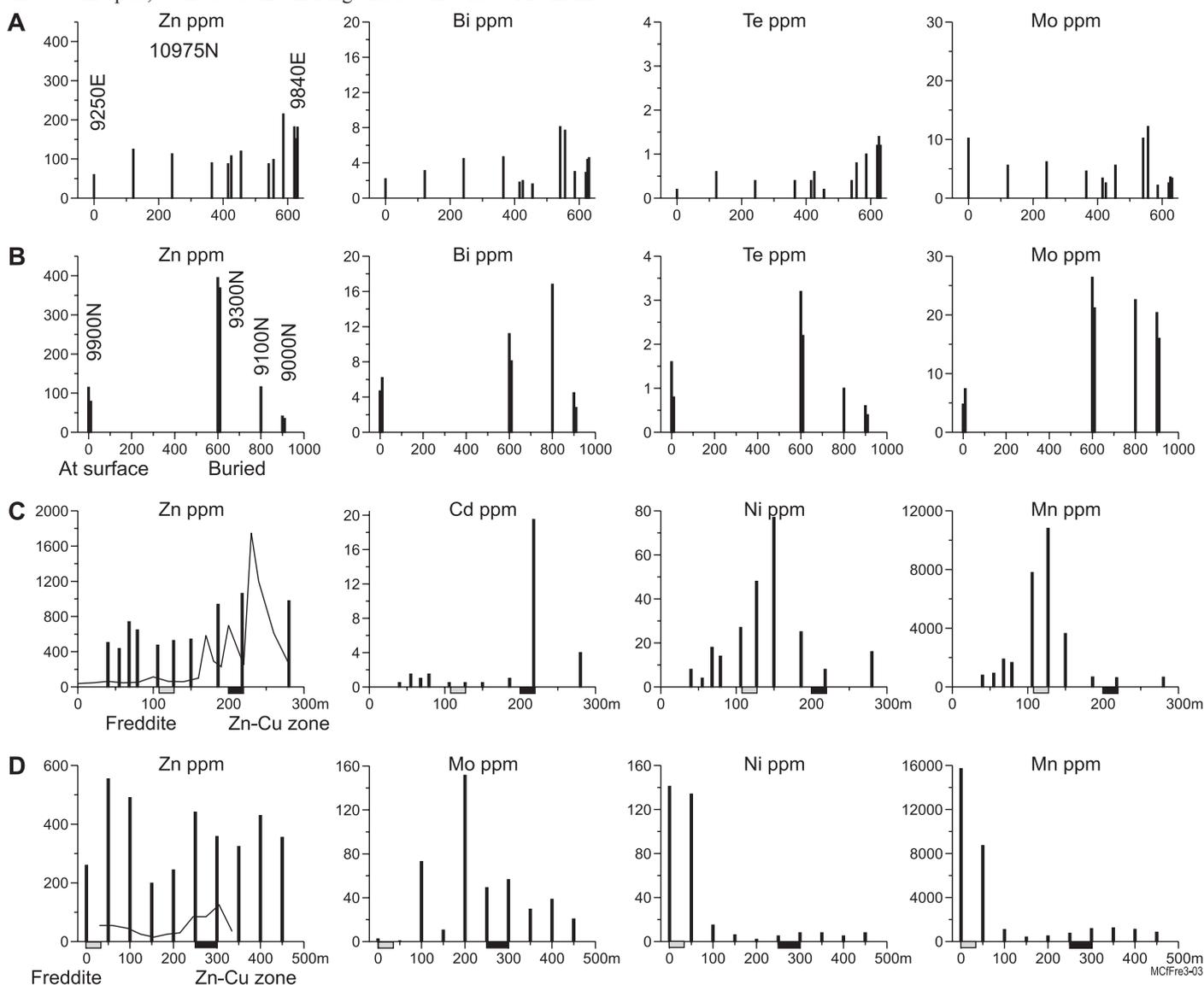


Figure 3. A. Element concentrations in lateritic nodules along 10975mN. B. Element concentrations in lateritic gravel along 10000mE. C. Element concentrations in ashed acacia twigs along 11050mN (Zn in soil as fine line). D. Element concentrations in ashed mulga twigs along 9000mN (Zn in soil as fine line).

There is an erratic, narrow anomaly in W, peaking at about 40 ppm in the <75 µm fraction. Cadmium, In and Mo show barely detectable anomalies (Smith *et al.*, 1976; Butt and Zeegers, 1992).

Gossan

Gossans formed on base metal sulphides show high Zn (500-20000 ppm) and Cu (200-2500 ppm) concentrations with anomalous Ag (10 to >40 ppm), Cd, In and Sn. Manganese concentrations are less than 1000 ppm, Mo and W concentrations are erratic. In contrast, gossans formed on magnetite shoots show moderately high V (to 1500 ppm) and Cr (to 1200 ppm) concentrations but lack the pathfinder suite of the gossans on base metal sulphides (Smith *et al.*, 1976).

Lateritic mantle

In the vicinity of the Freddie Well deposit, SW of D Zone, lateritic gravel and duricrust are preserved at surface (Figure 2). Sampling along 10 975mN (Figure 3A) extends 740 m and ends approximately 150 m W of the main mineralized zone which is in erosional terrain with no lateritic mantle preserved. Despite the distance from mineralization, several elements increase in concentration towards the eastern end of the traverse (Zn ≤180 ppm, Bi ≤8 ppm, In ≤3.5 ppm, Mo ≤12 ppm, Te ≤1.4 ppm, Cl, Hg, REE, S and Sn). This could be due to dispersion from the gossan or a response to base metal mineralization hosted by the 'freddite' sequence, extending 100-150 m W of the main mineralized zone.

Lateritic gravel is also preserved at surface at 9900mN and under 1-10 m of colluvium and alluvium intersected by auger and percussion drilling SE of Zones A and B, 1.7-2.0 km (9 000mN-9 300mN) S of D Zone. Buried lateritic, ferruginous gravel contains concentrations of Bi ≤17 ppm, In ≤1.4 ppm, Mo ≤26 ppm, Te ≤3.2 ppm and Zn ≤395 ppm (Figure 3B). This geochemical signature is particularly significant if the lateritic gravel is residual, as the generally well-preserved cutans suggest. It could indicate the continuation of the mineralized horizon along strike from D Zone and, potentially, massive sulphide mineralization beneath transported and residual regolith.

Vegetation

The use of biogeochemistry for base metal exploration was tested in a pilot study using *Acacia spp.*, the most common larger plant in the area. *Acacia* shrubs grow to several metres and may be suitable for a biogeochemical survey in areas of medium thick transported cover (<20 m) because of their deep roots that could penetrate cover and reflect the chemical composition of the residual regolith beneath. At the nearby Penny West Au deposit, hairline rootlets occur at least 30 m below surface (Radford and Boddington, this volume).

Bark and non-woody twigs of approximately 2-3 m tall acacia shrubs with similar bark and leaf characteristics were sampled along two traverses. The northern traverse, 11 050mN, (Figure 3C) intersects the mineralized sequence associated with D Zone. The southern traverse, (9000mN; Figure 3D), is approximately 2 km S and intersects the interpreted southern strike extension of Zones A and B beneath a depositional area (1-10 m of colluvium-alluvium on a partly preserved residual profile).

Along 11 050mN, ashed twig samples show two element associations: in the E is a strong Mn and Ni anomaly that coincides with a low ridge formed by 'freddite'. Approximately 100 m to the W, Cd and W concentrations show sharp peaks, Zn concentrations also peak but the amplitude is less and the anomaly broader. Ashed bark samples clearly outline a multi-element anomaly associated with the 'freddite' ridge expressed by high Mn, Ni, Pb, Li, Bi and S concentrations, but show only a weak response in Cd over the main mineralized zone 100 m further to the W.

The traverse along 9000mN was planned to intersect the buried southern extension of bedrock mineralization, extrapolated from drilling and soil geochemistry at Zones A and B to the N. Ashed twig samples show no clear element signal in the centre of the traverse with the exception of Mo. However, at the W end of the traverse, W, Fe and, in particular, Mn and Ni concentrations are strongly elevated. This signature resembles that on 'freddite' along the northern traverse. Ashed bark shows a similar pattern. Manganese, Ni, W, Li and Zn concentrations peak at

the western end of the traverse, generally at lower levels than in ashed twigs. The only element that peaks in the center of the traverse is Mo.

The biogeochemical signatures of acacia shrubs along both traverses appear to be closely related to bedrock. Whilst they offer little advantage in areas of residual soil, lateritic gravel or duricrust at surface, they appear to hold promise as a surface sample medium in areas of cover; this requires further study.

REFERENCES

- Butt, C.R.M. and Zeegers, H. 1992. Regolith exploration geochemistry in tropical and sub-tropical terrains. Handbook of exploration geochemistry, 4. Elsevier, Amsterdam, 607 pp.
- CRA Exploration Pty Ltd, 1976-1975 annual report of mineral claims, Freddie Well zinc-copper prospect, East Murchison Goldfield, Western Australia. CRA Exploration Pty Ltd, Company report (unpublished).
- Marston, R., 1979. Copper mineralization in Western Australia. Geological Survey of Western Australia, Mineral Resources Bulletin 13.
- Radford, N. and Boddington, T., 2003. Penny West Gold Deposit, Youanmi, WA. CRC LEME webpage <http://www.crcleme.org.au/>
- Sargeant, D.W., 1978. Annual report on Pincher Hill prospect, Youanmi area, Western Australia. Newmont Pty Ltd, Company report (unpublished).
- Smith, R.E., O'Connell, A.M. and Edwards, R.G., 1976. Freddie Well Zn-Cu deposit. In: Smith, R.E., Butt, C.R.M and Bettenay, E. (editors) Superficial mineral deposits and exploration geochemistry, Yilgarn Block, Western Australia: XXV International Geological Congress, Excursion guide 41C, 44-50.
- Stewart, A.J., Williams, I.R. and Elias, M., 1983. Youanmi, Western Australia, 1:250 000 Geological Series. Geological Survey of Western Australia, Explanatory Notes SH/50-4.
- Valdera Resources Limited, 2002. Prospectus 2002 (unpublished).

SAMPLE MEDIA - SUMMARY TABLE

Sample medium	Indicator elements	Digest	Analytical method	Detection limits (ppm)	Minimum value (ppm)	Maximum value (ppm)	Dispersion distance (m)
Mulga twigs, ashed (N=20)	Zn	Ashing followed by 4-acids	ICP-OES	1	199	1060	100
	Cd		ICP-MS	0.5	<0.5	19.5	<10
	Mo		ICP-MS	0.2	<0.2	151	<10
	Mn		ICP-OES	1	400	15700	<10
	Ni		ICP-OES	1	2	141	<10
Stream sediments (N=60)	Zn	N/A	XRF	5	48	982	500
	Cu		XRF	5	52	185	500
Gossan (N=29)	Zn	N/A	XRF	5	87	22000	N/A
	Cu		XRF	5	72	2351	
	Pb		XRF	5	<5	28	
	Mn		XRF	5	32	981	
	Co		XRF	10	20	464	
	As		XRF	10	<10	12	
	Sb		XRF	5	5	18	
	Bi		XRF	10	<10	10	
	Cd		XRF	5	<5	26	
	In		XRF	5	<5	63	
	Mo		XRF	10	<10	49	
	Ag		OES	0.1	<0.1	8	
	Sn		XRF	5	<5	29	
	Ge		XRF	2	<2	5	
Ba	XRF	10	<10	764			
W	XRF	10	<10	46			
Soil (N=122)	Zn	N/A	XRF	5	43	>3000	300
	Cu		XRF	5	33	>1500	300
	Ag		OES	0.1	<0.1	2	50
	Sn		XRF, OES	5.1	<5	<5	50
	W		XRF	10	<10	40	50
Lateritic gravels and duricrust (N=20)	Zn	4 acids	ICP-OES	1	30	395	500
	Bi		ICP-MS	0.1	1.6	16.8	200
	Te		ICP-MS	0.2	0.2	3.2	200
	Mo		ICP-MS	0.2	2.2	26.4	100
	In		ICP-MS	0.02	0.36	3.48	200
Mineralization in fresh rock (N=51)	Zn	N/A	XRF	5	113	570 000	N/A
	Cu		XRF	5	236	38000	
	Pb		XRF	5	<5	282	
	Mn		XRF	5	73	2731	
	Co		XRF	10	<10	1030	
	As		XRF	10	<10	<10	
	Sb		XRF	5	<5	13	
	Bi		XRF	10	<10	16	
	Cd		XRF	5	<10	1023	
	In		XRF	5	<5	152	
	Mo		XRF	10	<10	104	
	Ag		OES	0.1	<0.1	80	
	Sn		XRF	5	<5	178	
	Ge		XRF	2	<2	21	
Ba	XRF	10	<10	94			
W	XRF	10	<10	879			