BEASLEY CREEK GOLD DEPOSIT, LAVERTON DISTRICT, WESTERN AUSTRALIA

I.D.M. Robertson[1] and R.N. Carver[2]

[1]*CRC LEME, CSIRO Exploration and Mining, P.O. Box 1130, Bentley, Western Australia*

[2]*GCXPLORE Pty Ltd,67 Chelmsford Rd, Mt Lawley, Western Australia*

LOCATION

The Beasley Creek Au Deposit is approximately 12 km WNW of Laverton at 28º34'S, 122º18'E; Laverton 1:250 000 sheet SH51-02.

DISCOVERY HISTORY

WMC Exploration Ltd discovered the deposit in 1987 using <6 mm soil sampling on a 500 x 40 m grid (Perriam, 1987). The anomaly consisted of 6 samples above 25 ppb Au, including a maximum of 500 ppb and five samples in the 39-58 ppb range. Drilling of the 500 ppb site found gossanous quartz veins in talc-carbonate ultramafic rocks but nothing of ore grade. Drilling 120 m S of the original soil anomaly in an area of gossanous ironstone intersected 7 m at 3.9 g/t Au.

PHYSICAL FEATURES AND ENVIRONMENT

The mineralization lies beneath a low, N-oriented rise, only 3-4 m high (Robertson and Churchward, 1989). The rise has a broad crest with a gentle slope to the W and a steeper slope to the E. The rise is flanked by wash plains, covered by Wanderrie banks with a ribbed texture on air photographs. The wash plains pass to the N and S to broad drainages in which ephemeral streams are incised. The climate is arid with an irregular but mainly summer rainfall, averaging 250 mm per annum. Vegetation is degraded acacia shrubland, mainly sparse *Acacia aneura* and *Acacia linophylla* with a few low shrubs of *Cassia desolata* and *Eremophila* spp.

GEOLOGICAL SETTING

The Beasley Creek Au deposit lies within the Margaret sector of the Laverton Greenstone Belt. There are three major cycles of ultramafic to mafic metavolcanic rocks separated by thin metasediments, including banded ironstone formation, carbonaceous shale and chert (Hronsky *et al.,* 1990). The greenstones are intruded by a variety of pretectonic to syntectonic granitoids, from granodiorite to monzodiorite (Hallberg, 1985). The Au deposit occurs in interflow sediments near the top of the first volcanic cycle (Reddell and Schmulian, 1990). The host is a black shale (Figure 1) enclosed in amphibolitic metabasalts and ultramafic rocks metamorphosed to the upper greenschist facies that have been intruded by dolerite and porphyry.

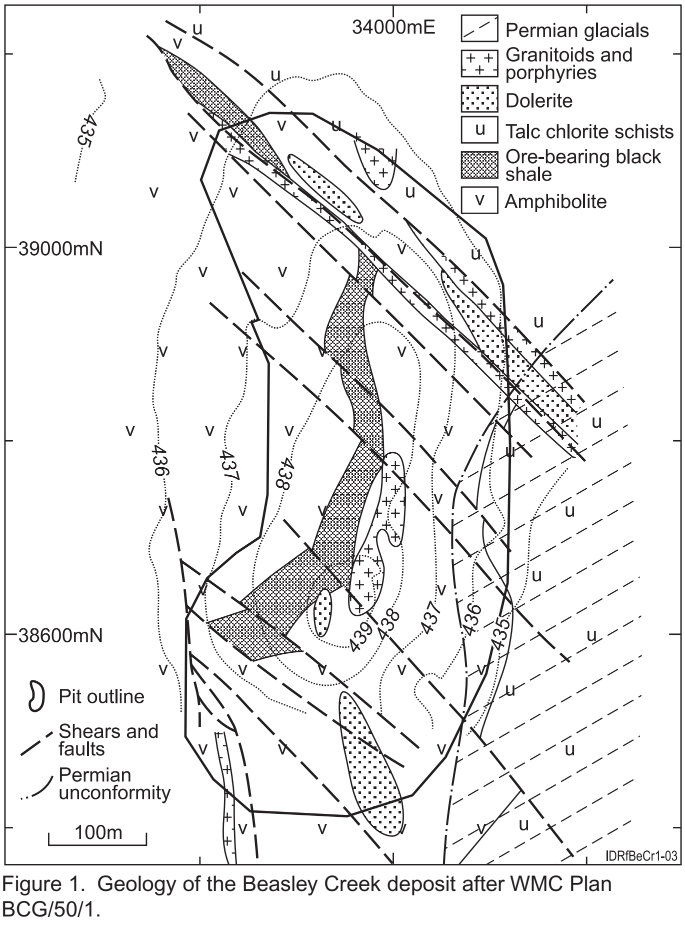

Figure 1. Geology of the Beasley Creek deposit after WMC Plan BCG/50/1.

REGOLITH

The weathered Archaean rocks at Beasley Creek have been partly stripped (Robertson and Churchward, 1989). This is indicated by the absence of a lateritic duricrust over all but the eastern flank of the rise (Figure 2). The ferruginous duricrust contains numerous vermiform voids lined with yellow-brown clay and gibbsite. Sporadic outcrops of gossanous (in part) ironstone overlie both the ore-bearing black shale and metadolerites. Calcretes are abundant near the top of the rise. A shallow, dish-like channel of Permian fluvioglacial sediments is exposed in the eastern margin of the mine pit (Robertson *et al.,* 1996) and its saprolites overlap those of mafic and ultramafic Archaean rocks (Figure 1).

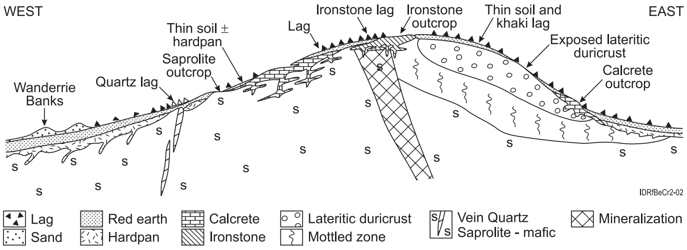

Figure 2. Regolith geology model for Beasley Creek.

The mineralization and much of its host have been intensely weathered to spongy, massive or colloform goethite and hematite, with relicts of sericite, and some Mn oxides (lithiophorite, cryptomelane). The depth of weathering reaches >230 m near mineralization but country rocks 400 m away are weathered to only 40 m (Robertson, 1991). Deep weathering around the mineralization was probably caused by shearing and acidity from oxidizing sulphides. At depth, the saprolite is green, passing upward to brown and its upper part is patchily cemented by calcrete and coarse gypsum, which extend at least 75 m E of the mineralization. The water table lies at about 16 m depth and the water is potable.

Soils on the plains on either side of the rise are relatively deep (0.3-0.5 m), acidic and underlain by hardpanized colluvium-alluvium. On the rise, the soil is thin (0.1-0.2 m), colluvial, alkaline and gives way downwards to hardpanized saprolite, calcrete and ironstone (Figure 2). The soils consist of (i) a coarse fraction (>700 µm) of quartz and ferruginous granules, (ii) an intermediate fraction (75-700 µm) largely of reddened aeolian quartz, (iii) a fine fraction (<75 µm) of quartz silt, and (iv) a very fine fraction (<4 µm) of clay and Fe oxides (Robertson, 1999).

The soil on the hill and wash plains has been worked by wind and sheetwash, removing the fines. This has left a variety of lag types, each related to its substrate. The saprolite on the rise has a buckshot lag of black granules and lithic fragments with larger lumps of ironstone near ironstone outcrops. Lag on the duricrust consists of red or brown granules of ferruginous clay, and khaki to light-brown ferruginous nodules and granules with cutans. Lag developed on the colluvial-alluvial wash plains is generally finer and consists of quartz and all the above types but cutans are largely abraded.

MINERALIZATION

The weathered mineralization is hosted in a N-striking phyllitic black shale, some 15-40 m thick, which dips E at 45° and Au is associated with ferruginous zones within it. Prior to mining, proven and probable ore reserves (all in the weathered zone) were 2.1 Mt at 2 g/t Au. Gold at 70-80 m depth consists partly of xenomorphic primary grains (Ag to 48%) and partly of high-fineness secondary grains. Above 60 m depth, there are only euhedral secondary grains and above 20 m a second generation of irregular, rounded, weakly corroded secondary grains occurs (Freyssinet and Butt, 1988).

REGOLITH EXPRESSION

Gossan and ore zone

Robertson and Gall (1988) investigated diamond core from drilling that intersected the mineralized ferruginous horizon near surface and penetrated the footwall (DDH BCD1). Gold mineralization was marked by anomalous Pb, W and As with erratic increases in Be, Zn, Sb and Co. The envelope for As slightly exceeds that of Au. Tungsten is restricted to the ore zone.

Saprolite

The host lithology is marked by elevated Al, Fe, Ba, Ce, Cr, Ga, Mn, Ni, Rb, V and Y. Apart from Au, the mineralization is marked by elevated Ag, As, Cd, Cu, Pb, Sb, W and Zn. The lateritic duricrust and mottled zone are weakly enriched in Ag, Nb and W, and are strongly enriched in the pathfinders As, Bi, In, Pb, Sb, W and Sn. Cobalt, Zn and Cu are depleted near surface (Robertson, 1991).

Regional soil and lag

Although the discovery was made by sampling <6 mm soil (Figure 3A), this sandy soil is known to fail to detect some promising locations due to dilution by aeolian material. This site has been investigated by multi-element orientation studies by WMC and CSIRO. The soil grid was resampled for 2-6 mm lag (Figure 3B). The ratio of the lag/soil percentiles increases from 2 at the 50th percentile to 7 at the 97.5th percentile, demonstrating aeolian dilution (Table 1). The difference between soil and lag Au signatures is most evident at Beasley NW (Figure 3).

TABLE 1
STATISTICAL COMPARISON OF LAG AND SOIL

Type	25%ile	50%ile	75%ile	90%ile	97.5%ile	Contrast (97.5/50)
Lag	1	4	16	56	400	100.00
Soil	1	2	6	23	69	34.50

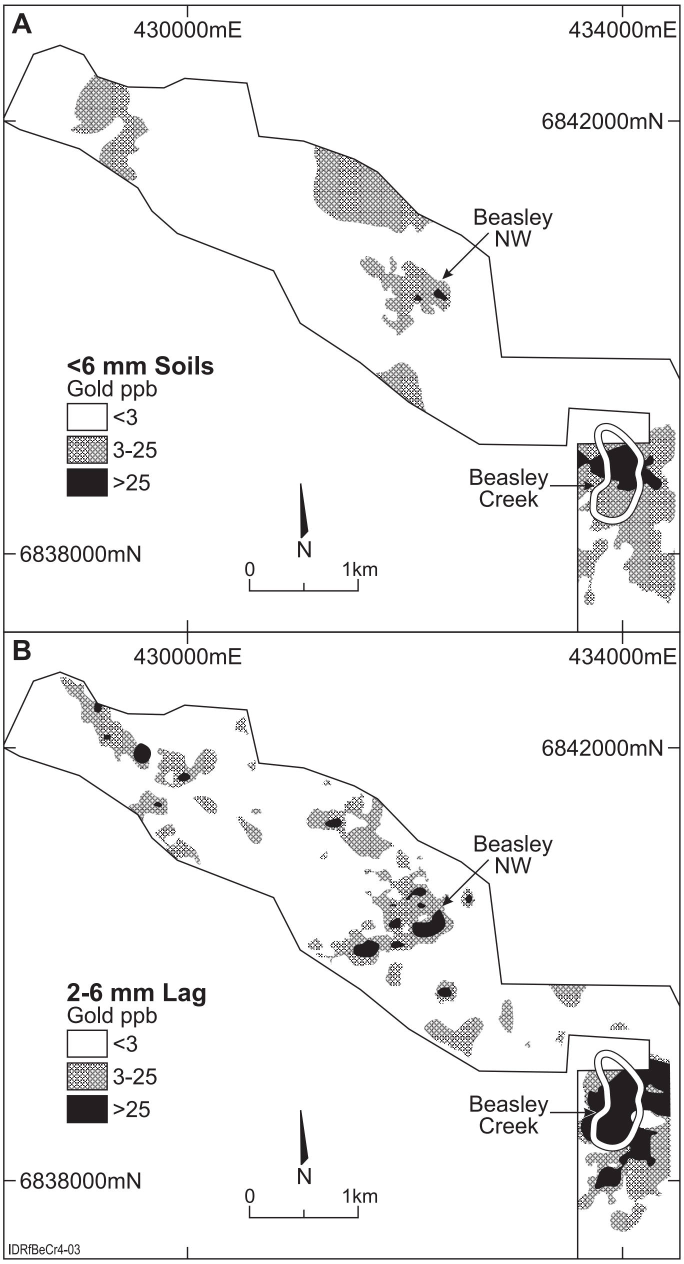

Figure 3. Regional distribution of Au in soils and lags from WMC data.

Detailed soil and lag

Figure 4A shows the distribution in the discovery data of Au in soil in a 1 km^2 area around the deposit. Although Au is elevated over the mineralization (25-75 ppb), detailed sampling by WMC showed that the soil anomaly maximum lies 100-200 m to the E of the ore subcrop (Figure 4B). The NW trends in the data were attributed to structures with this trend. Arsenic (Figure 4C) shows poor contrast in the soil with a broad area of 20-40 ppm; the peaks (40-80 ppm) are also offset to the E. The distribution of Au and As in lag (Figures 4D and 4E) is similarly offset E as the soil but with twice the abundances. Similar anomaly offsets of As and Au to the E in both lag and soil were noted by Robertson (1996a) and were attributed to the asymmetric development of lateritic duricrust on the eastern side of the deposit, in which these elements have been chemically dispersed. The distribution patterns of Cu (Figure 4F), Zn and Sb in the lag showed improved targeting of the mineralization.

Coarse lag (10-50 mm) gave strong but rather spiky anomalies that accurately target the mineralization. The fine lag gave a smooth, weaker but broader dispersion halo (Figure 5). The magnetic (about 40%) and non-magnetic (about 60%) components of the lag gave similar Au anomalies but the non-magnetic lag component was far more successful for the pathfinders As, Zn and Cu (Figure 6). The lag contains gossan fragments, enriched in Au, As, Cu and Zn that are all non-magnetic. As non-magnetic lag predominates, removal of the magnetic fraction, prior to analysis, is not worthwhile and the total lag sample should be analysed. (Robertson, 1996a)

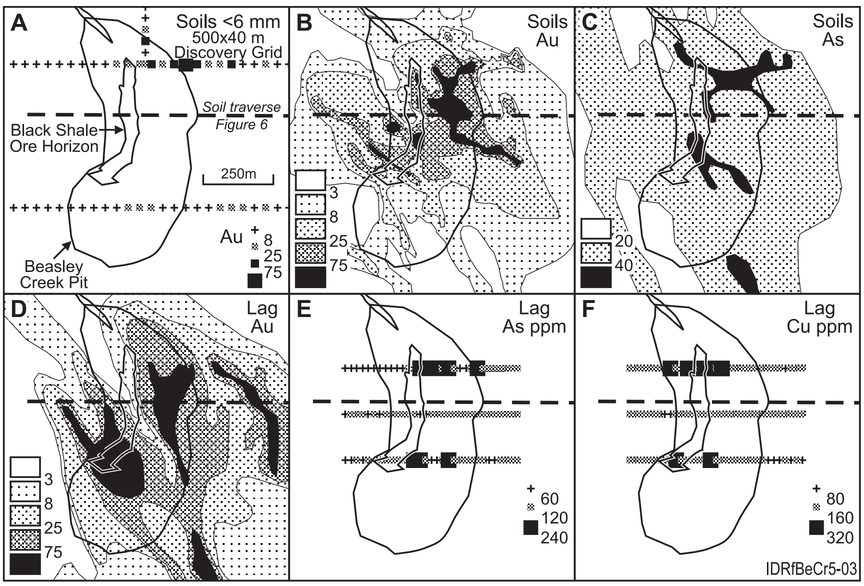

Figure 4. Detailed distribution of Au, As, Cu, Zn in soil and lag from WMC data.

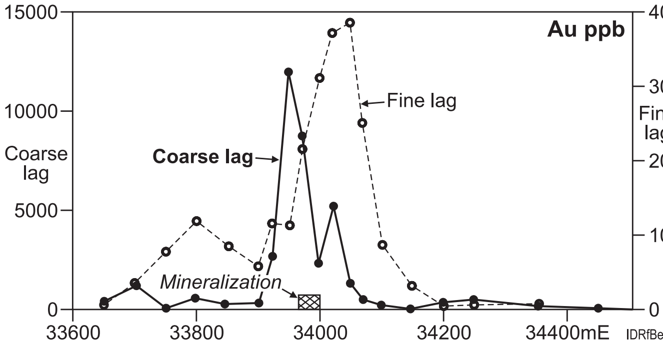

Figure 5. Comparison of dispersion of coarse and fine lag. Mineralization as hatched block.

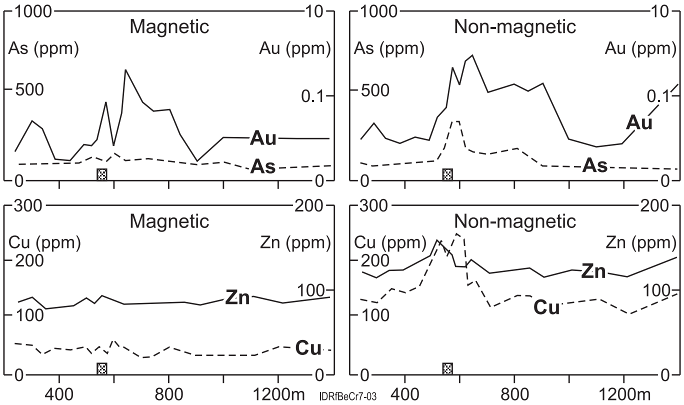

Figure 6. Goechemical comparison of magnetic and non-magnetic components of the fine lag for Au, As, Cu and Zn. Mineralization as a hatched block.

Three soil size fractions (710-4000, 4-75 and <4 µm) were compared to the complete soil (Robertson, 1999). The largely aeolian sandy material (75-710 µm) was discarded. The 710-4000 µm fraction consists largely of black goethite- and hematite-rich nodules, red to yellow ferruginous clay granules, minor quartz, calcrete and, close to mineralization, minor gossan fragments. It gives the best response and the distributions of As, Au, Cu, and to a lesser extent Cd, Sb, W and Zn are related either to mineralization or to dispersion in the lateritic duricrust (the broader target). These results are closely comparable to the fine lag, which is derived from this. Gold gives a 600 m-wide E-offset dispersion of >20 ppb, locally reaching 200-300 ppb. The black shale host is indicated by maxima in Ba and Mn. The 4-75 µm fraction is significantly less effective than the <4 µm fraction due to dilution by aeolian silt. The <4 µm fraction indicated the host shale by an increase in sericite and the mineralization is indicated by anomalies in Au, As, Cd and Cu.

The Beasley Creek mineralization has a strong Au anomaly in lag and the soil coarse fraction that covers 0.3 km^2 above a threshold of 8 ppb. For As, there is a broad regional anomaly of similar extent (30 ppm) but the contrast is poor with little internal detail. From the discovery history and the Au distribution, the Au anomaly as a whole should be the drill target and not the more restricted Au maxima (>75 ppb). Surficial sampling is effective on the rise, where the residual profile is thinly covered, but ineffective on the surrounding colluvial-alluvial plains.

REFERENCES

Freyssinet, P. and Butt, C.R.M. 1988. Morphology and geochemistry of gold in a laterite profile, Beasley Creek, Laverton, Western Australia. CSIRO Division of Minerals and Geochemistry, Perth, Restricted Report Number MG60R, 14 pp. (Reissued as Open File Report 6, CRC LEME, Perth, 1998).

Hallberg, J.A., 1985. Geology and mineral deposits of the Leonora - Laverton Area, Northeastern Yilgarn Block, Western Australia. Hesperian Press, Perth.

Hronsky, J.M.A., Perriam, R.P.A. and Schmulian, M.L. 1990. Lancefield gold deposit, Laverton. In F.E. Hughes (Editor) Geology of the Mineral Deposits of Australia and Papua New Guinea. The Australasian Institute of Mining and Metallurgy, Melbourne. pp 511-517.

Perriam R.J. 1987. The Beasley Creek Prospect: Discovery and Status at 30/6/87, Internal WMC Memorandum.

Reddell, C.T. and Schmulian, M.L. 1990. Windarra nickel deposits, Laverton. In F.E. Hughes (Editor) Geology of the Mineral Deposits of Australia and Papua New Guinea. The Australasian Institute of Mining and Metallurgy, Melbourne. pp 561-566.

Robertson, I.D.M. 1991. Multi-element dispersion in the saprolite at the Beasley Creek Gold Mine, Laverton, Western Australia. CSIRO Division of Exploration Geoscience, Perth, Restricted Report Number 152R Volumes 1 & 2, 128 pp. (Reissued as Open File Report 26, CRC LEME, Perth, 1998).

Robertson, I.D.M. 1996a. Ferruginous lag geochemistry on the Yilgarn Craton of Western Australia; practical aspects and limitations. Journal of Geochemical Exploration 57: 139-151.

Robertson, I.D.M. and Churchward, H.M. 1989. The pre-mining geomorphology and surface geology of the Beasley Creek Gold Mine, Laverton, WA. CSIRO Division of Exploration Geoscience, Perth, Restricted Report Number 26R, 38 pp. (Reissued as Open File Report 9, CRC LEME, Perth, 1998).

Robertson, I.D.M. and Gall, S.F. 1988. A mineralogical, geochemical and petrographic study of the rocks of drillhole BCD1 from the Beasley Creek Gold mine - Laverton, Western Australia. CSIRO Division of Minerals and Geochemistry, Perth, Restricted Report Number MG67R, 47 pp. (Reissued as Open File Report 7, CRC LEME, Perth, 1998).

Robertson, I.D.M., 1999. Origins and applications of size fractions of soils overlying the Beasley Creek gold deposit, Western Australia. Journal of Geochemical Exploration 66: 99-113.

Robertson, I.D.M., Koning, A.E., Anand, R.R. and Butt C.R.M. 1996. Atlas of transported overburden. CSIRO Exploration and Mining Restricted Report 296R. 122p. (Reissued as Open File Report 87, CRC LEME, Perth, 2001).

TABLE 2
SAMPLE MEDIA - SUMMARY TABLE

Sample medium	Indicator elements	Analytical methods	Detection limits (ppm)	Background (ppm)	Threshold (ppm)	Max anomaly (ppm)	Dispersion distance (m)
Gossan	Au	INAA	0.005	-	-	46	
	As	INAA	5	-	-	1270	
	Sb	INAA	5	-	-	9	
	W	INAA	10	-	-	25	
	Cu	XRF	10	-	-	930	
	Zn	XRF	5	-	-	410	
	Cd	ICP/MS	5	-	-	3	
Saprolite	Au	INAA	0.005	0.014	0.088	8	
	As	INAA	2	3	10	1760	
	Sb	INAA	0.5	0.23	0.37	12	
	W	INAA	2	3	5	13	
	Cu	XRF	5	155	230	570	
	Zn	XRF	5	110	170	330	
	Cd	ICP/MS	0.1	0.07	0.33	1.5	
WMC lag 2-6 mm	Au	GFAA	0.001	0.002	0.025	9	600
	As	ICP	5	30	60	220	
	Cu	ICP	5	50	120	245	
	Zn	ICP	5	50	120	270	
	Sb	ICP	1	0.5	2	250	
	Bi	ICP	0.1	0.3	1.0	2.8	
CSIRO Lag 10-50 mm	Au	INAA	0.005	0.008	0.02	12	100
	As	INAA	2	100	200	1000	100
	Sb	INAA	0.2	1.0	1.5	4	
	W	INAA	5	<5	6	8	
	Cu	XRF	5	100	150	600	100
	Zn	XRF	5	130	200	300	
CSIRO Lag 0.5-10 mm	Au	INAA	0.005	0.01	0.02	0.900	700
	As	INAA	2	80	100	300	100
	Sb	INAA	0.2	3.5	4	6	100
	W	INAA	5	<5	5	10	
	Cu	XRF	5	100	150	220	200
	Zn	XRF	5	70	90	120	100
WMC soil <6mm	Au	GFAA	0.001	.002	0.025	0.860	400
	Au	GFAA	0.001	.002	0.008	0.860	800
	As	ICP	1	10	30	58	400
CSIRO soil 710-4000 µm	Au	INAA	0.005	0.006	0.010	0.200	
	As	INAA	2	50	75	170	
	Sb	INAA	0.5				
	W	INAA	2	3	4	7	
	Cu	XRF	5	100	125	180	
	Zn	XRF	5	60	75	90	
	Cd	ICP/MS	0.05	0.1	0.2	0.6	
CSIRO Soil <4 µm	Au	INAA	0.005	.020	0.030	0.250	
	As	INAA	2	20	30	60	
	Sb	INAA	0.5				
	W	INAA	2	2	?	?	
	Cu	XRF	5	75	75	125	
	Zn	XRF	5	100	110	130	
	Cd	ICP/MS	0.05	0.1	0.2	0.4	

ICP/MS after HF/$HClO_4$/HNO_3/HCl digestion ICP and Graphite furnace AAS after $HClO_4$/HNO_3 digestion