NIFTY COPPER DEPOSIT, GREAT SANDY DESERT, WESTERN AUSTRALIA

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LOCATION

The Nifty Cu deposit is located in the Great Sandy Desert of Western Australia, 200 km ESE of Marble Bar and 65 km W of Telfer at 21º39'36"S, 121°34'12"W (Figure 1); Paterson Range 1:250 000 map sheet (SF51-06).

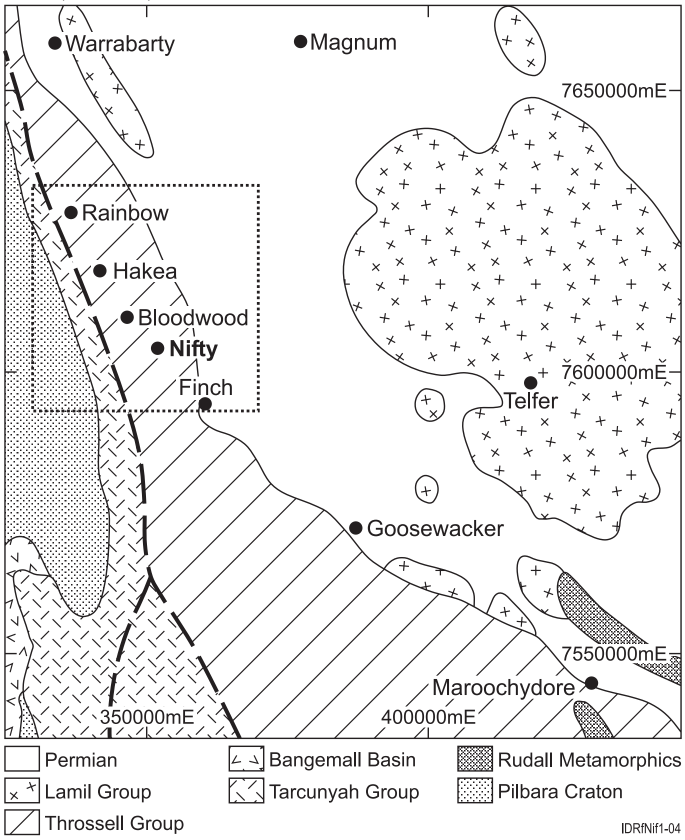

Figure 1. The location of Nifty and other deposits in relation to the Paterson regional geology after Bagas and Lubieniecki (2000).

DISCOVERY HISTORY

WMC Resources Ltd discovered Nifty in 1980 by using regional ironstone sampling and reconnaissance geology. Malachite staining of an outcrop and Cu-anomalous ironstones from dune swale reconnaissance sampling were the initial indicators (Figure 2). This was followed by lag sampling on a 500 x 50 m grid that detected a 2.5 x 1.5 km Cu-Pb anomaly. Secondary Cu mineralization was intersected in percussion drilling in mid-1981, with high-grade primary ore (20.8 m at 3.8% Cu) discovered in 1983.

PHYSICAL FEATURES AND ENVIRONMENT

WNW trending seif dunes up to 30 m high and 0.1-1.5 km apart are the dominant geomorphological feature (Chin *et al.*, 1982). The intervening sandy swales contain minor scattered rock outcrops, lateritic gravel and colluvium. On the dunes and in the swales, spinifex (*Triodia* spp.), shrubs, grasses and some small trees, including *Eucalyptus*, *Melaleuca*, *Acacia* and *Hakea* spp., stabilize the sand. The climate is semi arid, with an annual mean rainfall of about 310 mm, falling mainly between November and March, associated with thunderstorms and cyclones. The mean daily temperatures ranges are 11-25ºC in July and 26-41ºC in January.

GEOLOGICAL SETTING

Nifty lies within the Palaeoproterozoic to Neoproterozoic Paterson Orogen (Williams, 1990; Williams and Myers, 1990). The Paterson Orogen is bounded to the W by the Archaean Pilbara craton, to the N and NE by the Canning Basin and, to the E, by the Proterozoic Officer Basin. The Orogen consists, from the base, of the Rudall Complex, the Yeneena Supergroup and the Tarcunyah Group (Figure 1). The Yeneena Supergroup has an upper member, the Lamil Group, and a lower member, the Throssell Group. The Nifty Cu deposit is hosted by folded, carbonaceous, dolomitic shale of the Broadhurst Formation of the Throssell Group. The deposit stratigraphy was established from diamond drilling (Norris, 1987) and local outcrop mapping during exploration. The mine stratigraphy has been simplified to four members; footwall beds, Nifty member, pyrite marker bed, and hangingwall beds (Anderson *et al.*, 2001). The footwall beds consist of thinly laminated carbonaceous pyritic shale, micaceous and chloritic siltstone and minor light-grey dolomitic mudstone. The lower Nifty member consists of 40-70 m of dolomitic mudstone interbedded with carbonaceous shale, variably overprinted by quartz-dolomite alteration. Individual beds are typically 1-2 m thick. This is overlain by a grey-black chloritic shale (1-4 m) with distinctive quartz-dolomite spots which are pseudomorphs after evaporite rosettes. The upper unit (25-60 m) is lithologically similar to the lower unit. The pyrite marker bed (1.5-22 m) is blue-black carbonaceous shale with abundant framboidal pyrite. The hangingwall beds that form the core of the Nifty syncline are thinly laminated, dark grey to black, pyritic, carbonaceous silts and shales.

MINERALIZATION

Primary

The Nifty deposit is a structurally-controlled, chalcopyrite-quartz-dolomite replacement of carbonaceous and dolomitic shale (Anderson *et al.*, 2001). Hydrothermal alteration is zoned and grades from a pyrite-quartz-chalcopyrite-galena-sphalerite overprint on beds of carbonaceous and pyritic shale through interbedded, banded hydrothermal quartz-dolomite and unaltered shale beds to silicified dolomitic shale with black quartz in the centre of the orebody.

During regional compression, fluids were expelled along a thrust into the dolomitic and carbonaceous shale of the Nifty member. Hot, saline, reduced, mildly acidic Cu-bearing hydrothermal fluids reacted with carbonaceous and dolomitic shales of the Nifty member, precipitating Cu where the pH increased. Primary resources are 109.7 Mt @ 1.4% Cu at a 0.4% Cu cut-off (Straits Resources Ltd., 2001).

Secondary

Weathering has modified the mineralization to depths of 200 m. At 100-200 m, primary chalcopyrite is replaced by supergene chalcocite. In the oxide zone (0-100 m), Cu occurs as malachite, cuprite, azurite and native Cu. It has also migrated horizontally up to 400 m into weathered hanging wall shales, producing the shale-hosted secondary Cu mineralization (Figure 3.) The total resources of secondary mineralization are 38.6 Mt @ 1.1% Cu (Straits Resources Ltd., 2001).

REGOLITH

Regionally, drilling indicates weathering has reached 80-100 m before

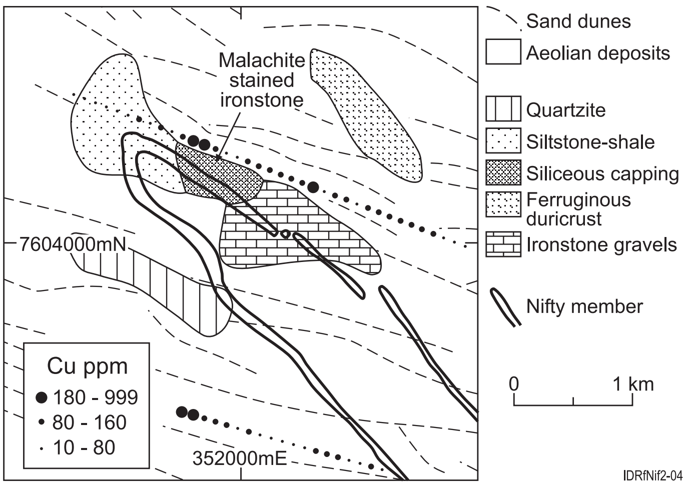

Figure 2. Local geology at Nifty, showing locations of the discovery samples.

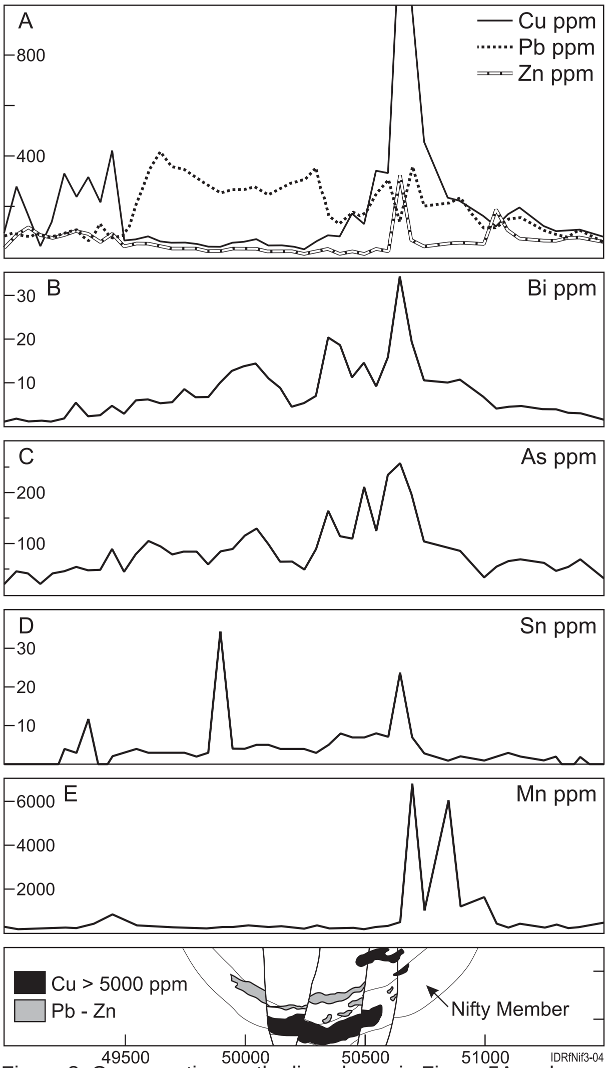

Figure 3. Cross section on the line shown in Figure 5A and geochemical profiles (local coordinates).

the carbon oxidation front is reached in the black shales. In the Nifty Syncline, the drilling indicates thicknesses of up to 25 m of lateritic duricrust and ferruginous saprolite overlying mottled and pallid saprolite.

Although there is outcrop at Nifty, elsewhere sand dominates the surface and outcrop is rare. Much of the aeolian sand is mixed with minor amounts of ferruginous granules. In areas of low relief, colluvial loams occur in places. The outcropping areas have associated thin skeletal soils. The discovery samples were collected on, and adjacent to, a unit mapped as siliceous ironstone after dolomite (Chin *et al.*, 1982; Figure 2).

REGOLITH EXPRESSION

Regional sampling

Ferruginous lag pebbles (2-10 mm) were collected for regional reconnaissance. Sampling is difficult in sand-dominated terrain. A variant on the lag sampling technique was developed, involving screening sand and using the 2-6 mm size fraction (Carver *et al.*, 1985).

The geology as of 1980 (Paterson Range 1:250 000 sheet), the positions of the ferruginous lag traverses and the malachite stained ironstone that contributed to the discovery are shown in Figure 2. The regional Cu threshold is 80 ppm. Both reconnaissance traverses have many samples above threshold with the maxima adjacent to the siliceous ironstone outcrop of the mineralized Nifty member. The Fe contents of samples varied widely (2-50%), requiring normalization of the data to Fe. The normalization (M_N) to a nominal 30% Fe was by M_N = M35/(F+6), where M is Cu, Pb, Zn or As (ppm) and F is the % Fe content. This empirical formula compensates for statistical artefacts at very low Fe contents caused by a

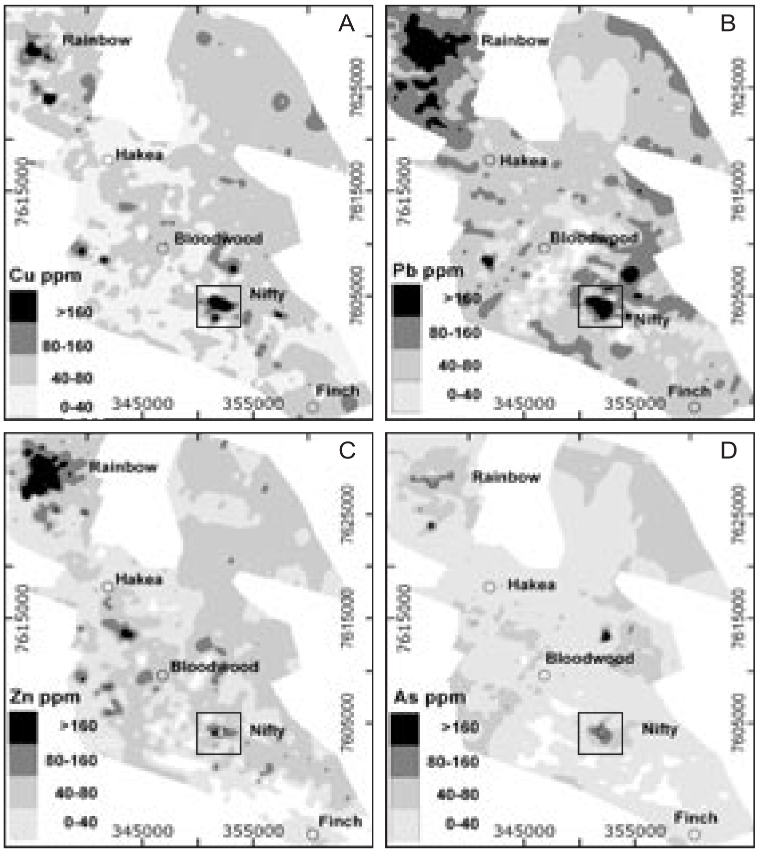

Figure 4. Regional lag geochemistry of Cu, Pb, Zn and As (data normalized to 30% Fe).

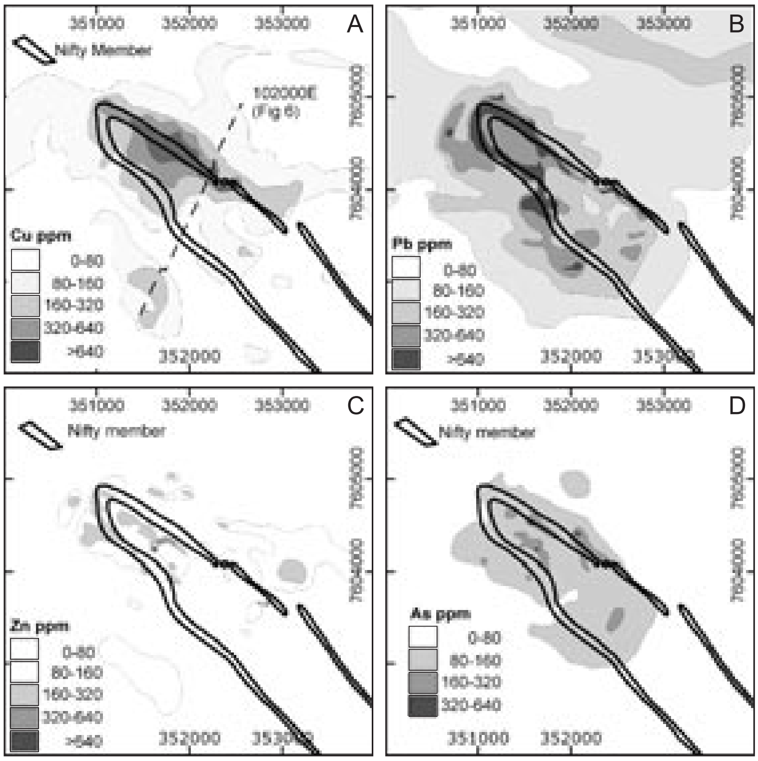

Figure 5. Lag geochemistry (50 x 500 m) of Cu, Pb, Zn, As (data normalized to 30% Fe).

combination of large multiplication factors, poor analytical precision near the detection limit (5-10 ppm) and the reporting interval (5 and 10 ppm). The effect of this normalization on the two most anomalous samples is illustrated in Table 1.

The regional distributions of Cu, Pb, Zn and As around Nifty are shown in Figures 4A-D. These are from reconnaissance ironstones supplemented with 500 x 50 m grid samples that have been sub-sampled to 500x500 m. At this regional scale, Nifty can be seen to be strongly anomalous in Cu and Pb. There is a well-defined As anomaly, but the Zn anomaly is weak. Regionally, Nifty rates second to the Pb-Zn-dominated Rainbow anomaly in the NW of the area. However, economic mineralization has yet to be found at Rainbow.

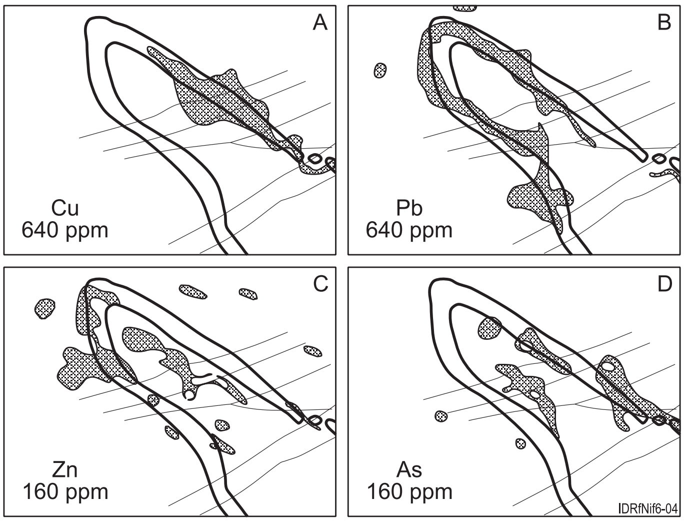

Figure 6. Summary of zoning in Cu, Pb, Zn and As shown by lag sampling (data normalized to 30% Fe).

Detailed lag sampling

The surface geochemistry, based on 500 x 50 m lag sampling normalized to 30% Fe, closely reflects the mineralization (Figures 5A-D); the strong Cu anomaly in the N limb of the syncline and the 640 ppm contour indicates the Nifty open pit. Copper mineralization is confined to the Nifty member in the fresh rock but the secondary ore blanket in the hanging wall shales occurs to the S of the Nifty member and this direction of dispersion is reflected in the surface geochemistry. There is a clear termination of highly anomalous Cu, Pb and As about 2 km SE from the nose of the syncline. This position is marked by an offset in the Nifty member, indicating the mineralization is truncated by a NE trending fault. Lead is the most anomalous element in the lag; it is sourced from the pyrite marker bed, which lies stratigraphically above the Nifty member. Lead is extensively dispersed above 160 ppm, forming a broad regional anomaly. Above 320 ppm, Pb is closely confined to the pyrite marker bed. The As distribution is similar to that of Pb. In the fresh rock, Zn and Pb occur at similar concentrations. In the lag, Zn has been significantly leached, producing weaker anomalies than Cu and Pb. The greatest Zn anomalies occur in the core of the syncline and on the SW side of the syncline nose. These zoning patterns are summarized in Figure 6.

Samples from traverse 102 000 mE (Figure 3A) were analysed for a broad suite of elements. The profiles show Cu to be strongly anomalous on the N limb of the syncline associated with the Nifty member and the secondary shale-hosted mineralization. Lead is broadly anomalous over the width of the syncline. Arsenic and Bi show similar distributions reaching a maximum over the Nifty position but remaining anomalous to the S over the hangingwall. Tin gives narrow peaks over the Nifty member on both limbs of the syncline. Manganese peaks strongly over the Nifty mineralization but is at background levels over the hangingwall and the Nifty member on the S limb of the syncline. It is not known whether this reflects primary rock composition or the effect of weathering.

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TABLE 1
DISCOVERY LAG

Cu (ppm)	Cu_N (ppm)	Pb (ppm)	Pb_N (ppm)	Zn (ppm)	Zn_N (ppm)	Fe (%)
115	188	165	271	100	164	15.30
190	185	225	219	230	224	29.90

_N is normalized element

SAMPLE MEDIA – SUMMARY TABLE

Sample medium	Indicator elements	Analytical methods	Detection limits (ppm)	Background (ppm)	Threshold (ppm)	Max anomaly (ppm)	Dispersion distance (m)
2-6 mm ferruginous granules sieved from sand	Cu	AAS	5	40	160	11900	2000 x 500
	Pb		5	40	160	9500	2000 x 1200
	Zn		5	40	80	8300	1000 x 500
	As		5	40	80	600	2000 x 800
	Bi		0.1	2	5	35	1000
	Sn		1	4	8	32	200

AAS - after HNO_3/$HClO_4$ digestion