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GEOCHEMICAL PROSPECTING AT TENNANT CREEK, 1964-65

by

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GEOCHEMICAL PROSPECTING AT TENNANT CREEK, 1964-65

SUMMARY

Geochemical investigations have indicated that anomalous concentrations of Co, Mo, Pb, Zn, Ag, Bi, As, Sb, Se, Te, are associated with copper sulphide-gold ores at some mines near Tennant Creek. The primary haloes of As, Sb, and Te have not been investigated, but Cu, Co, Mo, Pb, Zn, Ag, Bi, are known to give at the best only narrow haloes, probably on account of the narrow shear zone control of sulphide mineralization.

Stripped skeletal residual soils and flash flood transported alluvial soils derived from them are present. Surface sampling of the residual soil is reliable in the +180/^{u} and -75/^{u} fractions, but with alluvial soils, auger drilling to below a zone of concretionary lime is necessary to detect copper anomalies. Copper anomalies show in the weathered rock in and immediately below the lime zone, but the lime concretions themselves have only slight and non-anomalous traces of copper even in areas overlying copper sulphides.

Geochemical prospecting failed to reveal an anomaly at the Ivanhoe Mine and an investigation to test the feasibility of detecting mercury haloes is recommended.

Copper geochemical anomalies worthy of further investigation were located at Explorer 13 and Explorer 17.

INTRODUCTION

This report describes selected geochemical and geological investigations carried out by the Resident Geologist seconded from the Bureau of Mineral Resources to the Mines Branch, Northern Territory Administration, Tennant Creek.

The purpose of these investigations initially was to follow up recommendations by P.G. Dunn (1964), but as work progressed, it became apparent that insufficient orientation work had been carried out by previous workers and a brief search of the literature revealed that little or no results have been published on geochemical prospecting in a semi-arid environment subject to cyclonic seasonal rain like Tennant Creek. Consequently, the results of some of the later orientation work arrived too late to be applied to some of the soil surveys.

Most mineral exploration programmes at Tennant Creek have previously been based on geophysical surveys aimed at locating magnetite bodies which are host to most of the sulphide-gold mineralization discovered to date. The geochemical studies described herein were carried out to determine if such studies could achieve the following objectives -

(a) Discriminate magnetic anomalies in terms of potential for sulphide ore minerals.

(b) Locate the portion of a magnetic structure richest in ore metals, which need not be coincident with the centre of the magnetic anomaly.

(c) Locate a significant geochemical soil anomaly indicating a sulphide ore body not associated with a magnetite host.

This report is divided into three parts, Part I deals with general geochemical observations in the primary zone, Part II with the general distribution of metals in the soils, and Part III, in case histories of soil surveys carried out on individual prospects.

PART I

PRIMARY GEOCHEMICAL ASSOCIATION, HALOES AND GEOLOGICAL CONTROL.

Associated minerals and metals in orebodies.

The Peko Mine currently mines about 170,000 t.p.a. of magnetite-chalcopyrite-pyrrhotite-pyrite ore with an average mill-head grade of 5.14% Cu, 2.38 dwts Au/ton, 0.194% Co, 0.28% Bi, with silver production at about 100,000 ozs. per annum. The following minerals are associated with the primary part of the orebody; native bismuth, cobaltite, goethite, wolframite, safflorite, sphalerite, galena, bismuthinite, matildite, tetrahedrite, and arsenopyrite (Edwards, 1955).

The Ivanhoe Mine currently mines 35,000 t.p.a. with an average mill-head grade of about 5% Cu, 4 dwts. Au/ton. Silver production is at 5,500 ozs. per annum. Galena and bismuthinite are associated with the orebody.

The Orlando Mine currently mines about 52,000 t.p.a. at an average mill-head grade of 1.05% Cu, 8.02 dwts. Au/ton with silver production at about 4,000 ozs. per annum.

Bismuth minerals are associated with gold at most gold mines and prospects throughout the field and wolframite is known at Olive Wood (Ivanac, 1954). Bismuth is also won from the Jubilee Mine 6 miles west of Tennant Creek.

It is clear from the above and from Table I that the sulphide phase of mineralization involved the introduction of Cu, Bi, Co, Mo, Pb, Zn, Ag, As, Sb, Te, W, but the relative proportions of these elements, which could be considered as pathfinders, vary greatly from locality to locality. Ni, Sn and V are not in anomalous amounts.

Primary geochemical haloes.

Diamond drill cores from DDH10 at Explorer 5 were spectrographically analysed for Ni, Co, Cu, V, Mo, Pb, Zn, Ag and at Explorer 13 for Ni, Co, V, Cu, Mo, Pb, to investigate the lateral extent of primary leakage haloes of these elements in the wall-rocks.

Explorer 13. Ten-foot half-core samples from DDH1 were collected by P.G. Dunn. Results across a mineralized zone are shown in Plates 3 and 3(A). It is unfortunate that sample cut-offs did not coincide with geological cut-offs, but it is clear that:

(a) Pb, Zn, Mo and Co generally increases in sympathy with Cu in the mineralized zone.

(b) Ni, does not appear to show a significant increase.

(c) V appears to decrease as the sulphophile elements increases. The reason for this is not clear.

(d) There is little or no primary dispersion of ore elements or sought associated metals in wall-rocks - with the possible exception of cobalt.

Explorer 5. Representative quarter-core samples were collected through Warramunga country rock, orebody and barren magnetite. Sample cut-offs coincided with geological boundaries.

Histogram plots for Cu, Bi, Co, Ag, Pb, Ni, Mo and V are shown on Plates 4 and 4(A).

TABLE I.

SOME QUALITATIVE SPECTROGRAPHIC ANALYSES OF ORE IN P.P.M. AND PERCENT

Mine or Prospect	Type of sample	Cu	Ni	Co	V	Mo	Bi	Ag	Pb	Zn	As	Sb	Sn	Te
Peko *	mill head 1964	5%	10-100	100-1000	10	10-100	0.28%	10-100	900	500	0.1%-1%	100-1000	1 - 10	1 - 10
Orlando *	mill head	1.4%	10 - 100	100 - 1000	10	10-100	0.17%	1 - 10	100	100	0.1% 1%	10 - 100	1 - 10	10 - 100
Explorer 5 DDH10	¼ core	3.5%	30	300	2	5	300	3	60	25	n.d.	n.d.	n.d.	n.d.
Explorer 13 DDH1	½ core	5000	20	40	5	500	n.d.	n.d.	700	200	n.d.	n.d.	n.d.	n.d.

* = courtesy of Peko Mines, N.L.

n.d. = not determined.

The following conclusions are apparent:-

(a) Bi, Co, Ag and Pb increase in sympathy with copper

(b) Mo and Ni do not appear to increase significantly

(c) V, as at Explorer 13, shows a decrease - but in this case it may be due to matrix effects in the spectrograph owing to the high sulphide content of samples from 895 feet to 1,079 feet and the almost pure magnetic matrix of samples from 1,079 feet to 1,113 feet.

(d) Excluding the interval from 830 feet to 850 feet, there is only a very narrow lateral copper halo, about 15 feet wide, in the Warramunga country rock on the east side of the lode. There is a slight straight-line build up on logarithmic scale from 744 feet, - but these results are not significant as they are within the background range of Warramunga sediments (see Warramunga sediments below). The high copper values between 830 feet and 850 feet could be the up-plunge primary leakage from a deeper and separate mineralized zone.

(e) None of the associated sulphofile elements analysed appears to be more widely dispersed path-finder for copper than copper itself.

FRESH ROCK GEOCHEMICAL BACKGROUNDS

Warramunga sediments. All samples from DDH1 at Explorer, excluding obviously mineralized and obviously erratic samples were plotted as frequency distribution histograms for Cu, Pb, Mo, Co, Vi and Ni. Smooth curves were drawn through the histograms and are presented on Plate 2.

The curves, apart from those for Ni and V, which in anycase are not pathfinders, show maxima which are sufficiently pronounced to justify the conclusions in Table II.

TABLE II

Element	Approx. Mean background (p.p.m.)	Background Range (p.p.m.)	Remarks
Cu	10	3 - 30	Up to 100 in iron-rich shales.
Co	15	6 - 40	
Ni	28	10 - 160	Highest in iron-rich shales, not diagnostic of mineralization.
V	110	3 - 180	Highest in iron-rich shales along with high Ni, Cu; not diagnostic of mineralization.
Mo	3	0 - 15	Mo 15 p.p.m. probably indicates mineralized zone.
Pb	3	0 - 20	

Ironstone Outcrops. Most outcropping ironstones in the Tennant Creek area have been sampled by McMillan and Debnam (1961) who concluded that ironstones considered to be devoid of copper sulphide minerals gave a background of up to 31 p.p.m. Cu, with other ironstones giving a background up to 200 p.p.m. Similar results have been obtained in the Mount Woodcock area by Dunnet and Harding (in preparation). Highly anomalous ironstone outcrops with greater than 200 p.p.m. Cu are associated with known sulphide lodes at Peko, North Star, Orlando and Cats Whiskers (Dunn (2), 1964).

Similar work was carried out on a small scale concurrently with the investigations described in this report, and the following results are presented for some sulphofile elements which seem to be diagnostic of mineralization.

(a) Mary Lane

Grid Co-ords of Ironstone outcrops	Cu	Co	Zn	Mo	Bi	Pb	Ag	Remarks
15800E/120S	40	25	100	30	20	10	1	Not associated with soil copper anomaly.
* 16000E to 16500E/1150S	370	12	60	20	60	60	n.d.	Associated with soil copper anomaly. Sulphides not known at depth.
(b) Explorer 17 (about 3,000 feet east-south-east of Ivanhoe Mine)								
3300E/570S	600	20	150	70	50	30	n.d.	Associated with copper anomaly overlying mineralized shear zone.
(c) Area 1 (West) Yeaman[2] 1964).								
DDH1 (A)	50	30	n.d.	10	n.d.	10	n.d.	Magnetite body, nil copper, nil gold by assay.

* Arithmetic mean of 17 outcrop samples.
n.d. = not determined.

Lamprophyres. Basic to intermediate dykes and sheets of lamprophyre are known in the Tennant Creek area. These are known to post-date the ironstones (Crohn et.al. 1964) and are not considered to have any close genetic relationship to the sulphide mineralization, but could be intermediate in age between ironstones and sulphides (see Appendices 1 and 2). They are seldom exposed, but accurate geochemical interpretation requires a knowledge of their geochemistry to discriminate high-copper soils derived from such igneous rocks.

Average of 4 lamprophyres in p.p.m. (DDH cores)

Cu	Co	Ni	Mo	Bi	Pb
120	80	490	n.d.	17	33

GEOLOGICAL CONTROL OF SULPHIDE MINERALIZATION

Structural control of sulphide lodes. Crohn et al (op.cit) have noted that most of the important known sulphide occurrences (Peko, Ivanhoe, Orlando, Cats Whiskers) are situated in, or adjacent to, ironstone bodies located on major 090°(T) to 120°(T) trending shear zones. Explorer 5 probably also conforms to similar structural control.

The structures which control the ironstone bodies themselves are discussed by Ivanac (op.cit) and will not be repeated here. Recent underground development has shown that the Peko Mine is essentially an irregular cone-in-cone structure of elliptical horizontal corss-section. The long axis of the ellipse is oriented at 090°, parallel to the major shear zone and the quartz-magnetite, a middle zone of copper/iron sulphide ore and an outer zone of sheared magnetite chlorite schists. The ore zone is defined by the assay cut-offs but sub-economic sulphides in replacement veins and disseminations are present also in the central and outer zones.

Figure 1. Section of mineralized drill core, D.D.H.1(b), Explorer 17. Post-tectonic chalcopyrite and pyrite (light grey) replacing sheared chloritic breccia matrix (black) along shear planes and between grains of pre-tectonic caraclastic magnetite (dark grey). x2 magnification.

A post-mineralization normal fault striking north, dipping 70° to 80° east and with an apparent horizontal dextral displacement of 300 feet, divides the original sulphide lode into the present No.1, No. 1 (Extended), No.2, and No.4 Orebodies.

The structure of the Ivanhoe, Orlando, Cats Whiskers and Explorer 5 orebodies are simpler than Peko. Ivanhoe appears to be a case of sulphides replacing the sheared margin between hard magnetite and chlorite schists, complicated by penecontemporaneous movement (McNeil, pers.comm.) Orlando orebody is essentially emplaced in a shear zone which contains little magnetite (Crohn et al. op.cit.). Cats Whiskers appears to be a replacement down the centre of a sheared ironstone body, and Explorer 5 is a replacement of an original roughly triangular prism of magnetite plunging east-south-eastwards at 60°.

Paragenesis of sulphides and ironstone. Edwards (op.cit.) concluded that the ironstone emplacement at Peko was virtually complete before the introduction of sulphides.

Figure 1 is a section of core from DDH1 (B) at Explorer 17. The major ore phase of sulphide mineralization, consisting of chalcopyrite, pyrite and gold, has replaced the sheared magnetite-chlorite schist along shear planes and along cracks in the magnetite. The magnetite is cataclastic and obviously pre-dates the shears along which the ore sulphides were introduced. However, an earlier generation of chalcopyrite is also present and consists of bleb-like inclusions about 0.25mm. across, located entirely within the magnetite grains. There is no evidence that the chalcopyrite in these bleb-like inclusions entered along cracks or crystallographic planes in the magnetite grains and therefore must date from the initial crystallization of the magnetite. These observations may explain Dunnet's (1965) conclusion at North Star that, on statistical grounds, there are copper populations present in the ironstone which are not related to the ore-type sulphide mineralization.

Subsurface and photogeological studies indicate that the Explorer 17 Shear Zone strikes east-south-east and is probably continuous with the shear zones recorded at the Ivanhoe Mine to the west and the Mary Lane Mine to the east-south-east.

Mineragraphic study of cores from Lone Star shows that magnetite grains in a magnetite/chlorite shear zone are cataclastic and pre-tectonic, while the chlorite is syntectonic, and related to shearing. Yeaman [1] (1964) has shown that the copper values in the magnetite chlorite schist zone in DDH3 at Lone Star tend to be highest where shearing is most pronounced.

At Peko however, skeletal idioblastic magnetite crystals have been observed. (K. Wright, pers.comm.) which must be post-tectonic. On the other hand, occasional blebs of chalcopyrite in massive magnetite have been observed mesoscopically in cores from elsewhere in the field (DDH1 Burnt Shirt, and others), which appear not to have entered the magnetite epigenetically during or after shearing.

Crohn (op.cit.) has observed lamprophyre dykes intruding ironstone at the Caroline Mine. Sheared lamprophyre containing chalcopyrite on shear planes was observed below the main sulphide intersection at Explorer 17 DDH1(B) (see appendix). If the chalcopyrite in the sheared lamprophyre is the same generation as that in the mineralized intersection higher up the hole, it follows that the magnetite is separated in time from the ore mineralization by a period of lamprophyre intrusion.

PART II

DISTRIBUTION OF METALS IN SOILS

Climate

The following synopsis of climatological figures for Tennant Creek is included since soil formation is largely a function of temperature and rainfall. These figures were obtained from "Northern Territory Statistical Survey, 1964" (Comm.Bur.of Census and Stat., Canberra), and from the Post Master, P.M.G., Tennant Creek.

Rainfall. Recorded annual rainfall varies between 5 inches and 17 inches, but is most often between 10 inches and 14 inches. Most of the rain falls in a few days during the intensely hot months of January to March although freak rainstorms can occur at any time of the year. Precipitation of 3 inches to 4 inches per day from cyclonic disturbances is not uncommon during the summer season. The greatest recorded daily rainfall is 9.22 inches (February) and the greatest monthly rainfall is 16.95 inches (March).

This heavy, short, seasonal cyclonic precipitation frequently results in flash flooding which may extend up to 100 miles (e.g. March, 1965).

Temperature. Maximum recorded shade temperatures range from 110°F between November and February to 36°F in June and July. Six consecutive weeks of above-century maximum shade temperatures (equivalent to 150°F to 155°F ground sun temperature) were recorded during January and February, 1965.

Wind. The prevailing wind direction between September and June is easterly with strong south-easterly winds between June and September. No quantitative figures for wind velocity were obtained, but the strongest winter winds were estimated at about force 5 on the Beaufort scale and these are thought to be the bearers of most of the aeolian "bulldust".

Local wind vortices of considerable energy ("whirly willies") can occur during the period of intense summer heat. These have been known to cause damage to property and frequently will carry a column of dust to an altitude of 500 feet above ground level.

Soil evolution and topography.

As shown in the foregoing paragraph, the climate is hot, semi-arid and subject to cyclonic summer cloudbursts. The summer ground temperature is extremely high resulting in surface soil dessication, destruction of humus and sparse vegetation cover. The predominantly argillaceous nature of the underlying Warramunga geosynclinal sediments also contributes to the loose, easily eroded soil, - with the result that the finer fractions of the top soil are quickly and easily stripped from the higher ground, mainly by flash flooding, and to a minor extent by wind action, and are washed into low-lying areas. These areas of extraneous soil accumulation form extensive alluvial flats which quickly become impassable to wheeled vehicles and horses with the onset of the rains. These flats have been termed "bulldust" by local inhabitants, but it is proposed here that they could be called "alluvial" and the term "bulldust" reserved for aoelian accumulations of fine loess or parna.

An old peneplained erosion surface stands about eighty feet above the level of the plains (see photo 1) and the remnant mesas of this old peneplain are probably the ultimate source of most of the alluvial material.

Significant accumulations of aeolian "bulldust", or parna, are formed in the more arid regions towards Alice Springs but are much less important at Tennant Creek and none were recognized during the survey.

Photo 1. View from Nobles Knob looking north-east. Remnant mesas standing 80 feet above present plane level.

Photo 2. Stripped skeletal residual soil covered with quartz pebbles, spinifex and light snappy gum flora. Orlando Road, near Mary Lane.

Photo 3. Transported shallow alluvial soil, Explorer 17.
Compare vegetation with photo 2.

TABLE III

SIZE ANALYSES (W+ %) OF VARIOUS SOIL TYPES, SAMPLE DEPTH = 8 INS.

	Sample grid location	+ 475/u gravel and grit.	-475/u + 180 Contains sand and hair-like roots	-180/u + 75/u silt	- 75/u clay	Remarks
MARY LANE	16250E 650S (background	56% (mainly ½"-¼"pebbles)	11.5%	24%	8.6%	1
	16250E 1150S (Cu anomaly peak)	62% (mainly ½" ¾ ¼" pebbles)	10%	18.2%	8.8%	1
EXPLORER 17 Line 3400E	1300S	29%	19.5%	38%	11.4%	2
	1100S	25.4%	21.6%	39%	15.7%	2
	600S (anomaly peak)	25%	23%	38.2%	14%	2
	500S	26.7%	23.5%	38.2%	11.4%	3
EXPLORER 13 Line 2600W	400N	18	19.4%	46.5%	14.7%	3
	600N	14%	17.5%	48%	18%	3
Aeolian parna-"bulldust"	N.T.A. District Office.	0	0	100%		

Note: Relative proportion of sand/silt/clay is about the same in all types, i.e. approximate 1/1.75 to 2/.5 to 8), the main difference being in the +457/u size (grit and gravel).

Remarks (Table III)

(1) Location - Mary Lane.

Stripped skeletal residual soil on gently sloping ground. Grey-brown with large number of coarse sub-angular quartz pebbles, - probably represents a compressed remnant "A" horizon impressed on a remnant "B" horizon stone layer. Depth to weathered bedrock;- 0 to 2 feet. Vegetation consists almost solely of spinifex clumps and snappy gum.

(2) Location - Explorer 17.

Probably alluvial, formerly considered to be residual mature type (see below). Red-brown, calcareous soil, poorly developed horizons, very low organic content (hair-like roots only), weathered bedrock at 5 feet. Open vegetation, taller and more varied tree population, no spinifex.

(3) Location - Explorer 13.

Alluvial soil - formerly considered to be largely aeolian in origin, but an 18% gravel fraction, most of which was angular to sub-angular, is clear evidence that much of the material is not of aeolian origin.

Vegetation is denser than at Explorer 17 and there is a wider variety of eucalypt species. See photos 2, 3, and 4.

These alluvial areas, previously termed "bulldust", are typified by the presence of active and numerous ant beds. A "tide mark" six inches above the base of the ant beds indicated the depth of flash flood run-off water which accumulated there in March 1965.

Soil profiles and secondary metal distribution. *

Stripped skeletal residual type (Mary Lane). This type of soil is located on hill slopes and are freely drained. Soil depth is shallow (about 0 to 18 inches), and horizons are poorly developed. The "A" horizon is often missing and in places the "C" horizon is exposed.

(a) Metal distribution according to fraction size.

The area was originally grid auger drilled (see Part III) and a weathered bedrock copper anomaly at 10 feet depth was established at 16250E/1150S, and was considered to be related to anomalous ironstone outcrops near this location (see Part I "ironstone outcrops" above). Samples were subsequently collected at 8 inch depth from one anomalous and one non-anomalous station and size analysed (see Table III), and the $+475/^{u}$; $-475/^{u}$ to $+180/^{u}$; $-180/^{u}$ to $+75/^{u}$; and $-75/^{u}$ fractions were then analysed by emission spectrograph for Cu, Pb, Zn, Ag, V and Mo.

Although it may be considered hazardous to draw conclusions from only two sample stations, the following observations emerge (see Plate 5).

(i) Of the sulphophile elements sought which are associated with Tennant Creek mineralization, only Cu and Pb show significant contrast.

(ii) Cu shows contrast in all fractions, the silt $(-180/^{u} + 75/^{u})$ size showing the poorest contrast.

(iii) Pb does not show contrast in the silt fractions, but shows good contrast in the sand $(-475/^{u}$ to $+180/^{u})$ and clay $(-75/^{u})$ fractions.

The absence of contrast of Pb in the silt fraction is puzzling, but could be due either to difficulties inherent in the emission spectrograph method or to the presence of much silt sized extraneous parna in the sample.

* The profiles described in this paper can be compared with those described by Harding (1965) from Aeromagnetic Ridge (north of Peko road).

(b) Metal distribution according to depth (-180/^{u} material).

A vertical profile across the peak of anomaly 16250E/1150S is shown on Plates 9 and 10. The anomaly is slightly transposed southwards near the surface, probably as a result of surface water flow. There is no marked variation in the width of the anomaly relative to sample depth, which suggests that secondary processes were not important in the present distribution of metal values. It seems more probable that the anomaly is an example of an oxidised primary halo undergoing active erosion, although cold extractable studies would be necessary to confirm this.

<u>Alluvial (shallow) bulldust soil - Explorer 17.</u> A significant anomaly was located at 3400E/600S in weathered bedrock by auger drilling to 10 feet depth, and subsequent diamond drilling indicated that it was related to a low-grade copper-iron sulphide occurrence at depth (see Part III).

Soil samples were subsequently collected at 8 inch depth and were submitted to size analyses and emission spectrograph analyses for Cu, Pb, Zn, Ag, V and Mo. However, in these shallower samples no contrast could be detected in any element in any size fraction (see Plate 6). The -180/^{u} (approx. -80 mesh B.S.S.) fraction of samples from 5 feet depth was then analysed spectrographically and it was found that one sample (600S) gave 10 x background (= 1,000% contrast). The soil horizon from which this material came is uncertain, owing to the mixing action of the auger, but it was more pallid than either the underlying weathered bedrock or overlying surface soil. It is probably the upper part of the "C" horizon. On Plate 6 (bottom), these results are compared with weathered bedrock samples from 10 feet depth (-180/^{u} material). In vertical profile, it therefore appears that there is no anomalous copper in the surface transported soils, a narrow (one point) anomaly at 5 feet depth in leached residual soil <u>in situ</u>, and a 100 ft. wide anomaly in weathered bedrock at 10 feet depth. In the absence of cold extractable studies, it is impossible to say if the widening of the anomaly at 10 feet depth is due to secondary lateral dispersion, or it if represents the leached oxidised portion of a primary halo.

<u>Deep red-brown and yellow-brown soils, originally of alluvial origin - Explorer 13). Plates 7 and 13.</u> A significant copper anomaly, related to copper sulphides in ironstone at depth, was located by auger sampling to about 30 feet depth on Line 2600W at Explorer 13.

The "A" zone is considered to be of alluvial origin on account of texture and size analyses. It is red brown in the upper five feet and yellow brown below five feet. The "B" zone varies in thickness between one and five feet and consists of ferruginized rock fragments in the upper parts. The ferruginous zone passes with depth into a zone of lime concretions and opal, - which probably implies locally high alkalinity. This lime zone passes gradationally downwards into the "C" zone of bleached weathered bedrock fragments.

Emission spectrograph analyses of sized fractions gave no contrast in samples collected at 8 inch depth.

Histograms for copper in 180/^{u} material, determined by emission spectrograph, are shown on Plate 7.

Copper is distributed as follows:

(a) In the "A" zone (between 0 and 20 feet) no contrast was noted between samples from areas overlying background and anomalous weathered bedrock.

(b) In the ferruginous layer copper is enriched with respect to both background and anomalous weathered bedrock, but this could be due to a secondary enrichment by co-precipitation with iron hydroxide. There are insufficient data to state confidently if this represents enrichment of background metal or a significant anomaly.

(c) In the lime fragments, copper is always very low(=10 p.p.m. at 1,000N) over the anomaly but there is significant contrast in the copper content of rock fragments from this layer and from the underlying layers.

Ivanhoe Mine geochemical orientation survey - copper profile. Weathered bedrock in the vicinity of the Ivanhoe Mine was sampled, at the same time as Explorer 13, on a sample spacing of 400 feet x 100 feet. Weathered bedrock is shown to be present at 15 feet depth from auger cuttings and from exposures in the ventilation shaft 10 feet east of 675N/716W. It can be seen that there is no obvious geochemical anomaly (Plates 8 and 13) on line 716W, which at 675N is vertically above the west end of the vertically dipping orebody 8 feet to 15 feet wide and assaying 5% Cu/5 dwts Au per ton. Histograms throughout each auger hole were plotted (Plate 8), but the highest value obtained, (25 p.p.m. Cu at the bottom of hole 675N) is within the background range.

It therefore appears that geochemistry using copper as an indicator is not a wholly reliable tool at Tennant Creek and the evidence does not support P.G. Dunn's (op.cit.) conclusion that the Ivanhoe orebody is marked by a 50 p.p.m. anomaly.

Harding (1965) working on an extensive area north of the Peko road (Aeromagnetic Ridge) discovered many small, spotty mono-metal anomalies which are apparently not related to sulphides at depth, but were more probably related to minor local accumulations in the soil profile.

Biological effects on metal redistribution.

Oxidation and water table levels. Evidence from bores indicates that the standing water level in the vicinity of Tennant Creek is generally about 180 feet. Warramunga sedimentary rocks are generally oxidised to between 200 feet and 300 feet, but sulphide lodes are frequently oxidised and leached considerably below this level.

Vegetation. (See Plates 2, 3 and 4). Apart from drought-resisting shrubs and grasses, the vegetation consists largely of various small, stunted species of eucalypt up to 15 feet high, such as snappy gum. These trees probably have root systems in deep alluvial soils stopping at the lime zone . They therefore do not draw nutriment from the water table nor can they draw from moisture in the anomalous bedrock because of the intervening lime zone, but depend on local near surface soil moisture whenever rain happens to fall. For most of the year, transpiration of these sclerophyllous species is practically dormant.

Root systems, especially where soil cover is thin, probably spread laterally rather than vertically. The low rainfall and high evaporation account for the sparsity and xerophytic nature of the vegetation. Consequently, trash formation is negligible and when it does occur, it is quickly dispersed by winds or oxidised under the hot summer sun.

The nature of the vegetation, which is a function of climate, thus fails to provide the mechanism for the formation of epigenetic surface soil anomalies, even where flash flood stripping is not active. In other parts of the globe which enjoy a more humid climate, surface soil anomalies generally form through secondary dispersion by botanical agencies. (Tooms and Jay, 1964).

Antbeds. Antbeds from the vicinity of the Explorer 13 copper anomaly and the surrounding background area were sampled by Professor H.E. Hawkes, since white ants are known to draw the soil for the construction of their nests from considerable depth. No contrast in copper content was indicated, which must show that the building material must be derived from above the zone of lime concentration.

Antbed sampling therefore is not a satisfactory technique in geochemical prospecting at Tennant Creek.

CONCLUSIONS TO PARTS I AND II

Pathfinders.

Spectrographic analyses of mill heads and diamond drill intersections in the Tennant Creek mining field show that economic copper/gold mineralisation was accompanied by varying amounts of other metals which may have potential use as pathfinders. These metals are: Pb, Zn, Ag, Bi, Co, Mo, As, Sb and Te.

Primary Haloes.

Of Cu, Pb, Co, Mo and Bi; Cu shows the widest lateral spread in Warramunga rocks, but even this amounts to only a few tens of feet. An apparent halo in some ironstones could be spurious and due to an earlier phase of copper mineralization (see below). A geochemical programme aimed at locating the remnants of a weathered primary leakage halo within the zone of weathering therefore requires considerable luck, or close sample spacing of 50 feet or less.

The spreads of As, Sb, and Te have not been investigated, but they could show considerably greater lateral spread owing to their higher volatility, and these are being investigated at time of writing (Dec., 1965).

Structural control and paragenesis

Sulphide ore replaced pre-existing magnetite breccia bodies which, in turn, were replacements of sedimentary rocks at favourable stratigraphic/structural loci along earlier shear zones. The ore mineralization followed shearing which brecciated the magnetite, and this shearing may, in places, represent re-activation of the shear zones which originally controlled the emplacement of the magnetite. The shearing which controlled the ore strikes 090° to 120° and the primary leakage of metals will be most pronounced in this direction. An earlier, and economically unimportant, generation of copper minerals occurs as microscopic bleb-like inclusions in magnetite; it appears to be of the same age as the magnetite.

There is a possibility that the magnetite emplacement is separated in time from the ore mineralization by a period of lamprophyre intrusion.

The events may be summarized in chronological order as -

1. Shearing
2. Emplacement of magnetite, with minor chalcopyrite inclusions, by replacements of sediments.
3. Possible period of lamprophyre intrusion.
4. Major shearing along east-west to east-south-east axes, possibly by reactivation of (1).
5. Major sulphide/gold mineralization of economic importance where shearing (4) has brecciated magnetite (2), with minor post-tectonic recrystallization of magnetite.

If (3) is too early and if the lamprophyre intrusion did not occur until after (5), a third shearing with minor remobilization of sulphides is implied.

Soil types and secondary dispersion.

The hot, semi-arid climate with seasonal, but unpredictable, cyclonic rain and flash floods results in stripped skeletal residual soils over sloping and high ground with extensive alluvial deposits, up to at least 30 feet thick, of local provenance in low lying areas. These different soil types may be recognised by their size analyses, contrasting flora , white ant activity and geomorphological features. The alluvial soils are underlain in places where they are well developed by ferruginised bed-rock, which in turn is underlain by a zone of lime concretions.

It is impossible, in the absence of cold extractable metal determinations to state with confidence to what extent secondary dispersion has occurred. A vertical profile of an anomaly in the stripped residual soil does not exhibit much lateral variation with respect to soil horizon and depth, suggesting the anomaly is an oxidized primary halo undergoing active erosion, and that secondary dispersion in the horizontal direction is unimportant.

In the alluvial soils, geochemical anomalies do not form, and their absence could be explained by the inter-relationship of climate with vegetation and the inability of the xerophytic vegetation to draw metal-enriched nutrient from below the lime zone which in places caps the bedrock.

An anomaly at Explorer 17 was one sample point wide in weathered bedrock at five feet depth and 100 feet wide at 10 foot depth. It is impossible to state confidently if this is an oxidised primary halo undergoing vertical leaching or if the apparent widening of the anomaly is due to lateral secondary dispersion possibly with vertical leaching superimposed.

The 250ft. width of the anomaly at Explorer 13, which is an area of drainage accumulation, suggests that lateral secondary dispersion is effective in this area. The anomaly at this locality is in weathered bedrock below a concretionary lime zone, which is overlain in turn by thick alluvium.

Choice of sample material

(a) Alluvial covered areas. Auger drilling to sample weathered bedrock is necessary. The zone of concretionary lime, if present, should be penetrated and lime fragments should be excluded from the sample material.

A few exploratory auger holes should be drilled in alluvial areas to obtain soil profile information and to decide on the optimum sample depth before embarking on an extensive prospecting programme. The need for deep augering to weathered bedrock with attendant high costs could render a programme uneconomic.

(c) Ironstone outcrops. Chip sampling of ironstone outcrops provides a valuable supplement to grid soil sampling, particularly where ironstones protrude above possibly alluvial overburden which would show no anomaly even if a mineralized zone is present (e.g. Explorer 17).

Good contrast between background and anomalous ironstones has been noted at Mary Lane where they show good correlation with areas of background and anomalous soils.

Interpretation of ironstone results, however, should be done with caution (see below).

Interpretation and choice of pathfinders.

(a) Soils and sedimentary rocks.

(i) Any copper analysis above 30 p.p.m. should be regarded as "possibly anomalous".

(ii) A copper anomaly accompanied by high V ($>$ 50 p.p.m.) and high Ni ($>$ 40 p.p.m.) is probably spurious and due to iron-rich sediments, but a Cu "high" coinciding with a V "low" should be regarded as a very encouraging indication of copper sulphide mineralization.

(iii) The absence of elements associated with the sulphide mineralization (Pb, Ag, Zn, Co, Bi, Mo) does not in itself detract from the significance of a Cu anomaly (e.g. Explorer 17).

(iv) High copper values accompanied by high Ni, Pb, Co and Bi probably indicate basic igneous intrusions (lamprophyres) and not sulphide mineralization (e.g. Mary Lane).

(b) Ironstone outcrops.

High copper by itself may not necessarily be significant, since mineragraphic evidence suggests that high copper by itself may indicate merely the early, and economically unimportant, chalcopyrite generation which dates from the crystallization of the magnetite.

The 800 p.p.m. Cu in magnetite below the footwall of the Explorer 5 orebody is not accompanied by anomalous amounts of metals with which the copper is associated in the sulphide zone. There are insufficient data to decide if this 800 p.p.m. Cu in the magnetite represents either a laterally spreading primary halo of copper associated with the ore mineralization or a high concentration of the earlier but economically unimportant copper generation.

In general, only copper need be analysed initially if a copper orebody is sought. The associated sulphide elements (Co, Pb, Zn, Ag, Mo, Bi) are unreliable as pathfinders as they do not in every case, give a coincident anomaly of detectable contrast. These, and other elements (Ni, V) need be sought only to aid the interpretation of results.

Reliability of geochemical prospecting

Although significant copper anomalies were detected at Explorer 13 and Explorer 17, no copper anomaly was found at 25 feet sample spacings to 30 feet depth (weathered bedrock) above the Ivanhoe orebody. Geochemical prospecting using copper as an indicator therefore cannot be considered wholly reliable. In addition, the cost for drilling 30 feet auger holes at 5/- per foot makes the sample collecting cost of £7.10.0 per sample prohibitive for covering large areas.

More volatile pathfinders, such as As, Sb, and Te, which are known to be present in the Peko and Orlando ores in anomalous amount (see Table I) may be expected to give a primary leakage halo wider than Cu. Hg might also be associated with the sulphide lodes, and could give a very wide primary halo; secondary upward leakage through transported soils might also be detectable at shallow depth. Such a secondary leakage has been detected through 30 feet of transported lake sediments at Cordero, Nev., (Hawkes and Williston, 1962).

Mercury orientation studies are therefore recommended, especially as the hot, dry climate would tend to favour secondary migration of this metal.

PART III

CASE HISTORIES OF INDIVIDUAL PROSPECTS

Results of investigations described in Parts I and II were not available when some of these investigations were carried out, so that current interpretations differ from some which were made at the time.

Mary Lane: (Plate 14 and 15) (MGR 188000E/2544000N)

This area was selected because of its situation on a major west-north-west trending shear zone, the occurrence of minor copper minerals at the surface, and a series of slight I.P. anomalies obtained during a contract survey carried out by McPhar's Limited on behalf of Australian Development N.L.

Investigation. The area was auger drilled at the request of Australian Development N.L. on a spacing of 100 x 250 feet to weathered bedrock (about four to five feet). Several samples consisted of dark green biotitic material derived from lamprophyres which gave high Cu, Ni, Pb, Co results.

The area was contoured by P.W. Crohn at 100 p.p.m. level for Cu, Pb, Ni (Plate 15). It can be seen that these contours enclose most of the lamprophyre cuttings. A small Cu anomaly between 1600E/1100S and 1650E/1100S (referred to later as Cu Anomaly 16250E/1150S) remains after eliminating the results due to those lamprophyres. This remnant Cu anomaly was found to coincide with a few small ironstone and porphyry outcrops. It was noted the other ironstone outcrop at 15800E/120S was not associated with a soil anomaly and the two sets of ironstones contrast markedly in trace element content (see Part I).

The 100 p.p.m. areas were then angle wagon drilled by Australian Development N.L. to test the sub-surface attitude of these areas. The areas interpreted as lamprophyre were discarded and again Cu Anomaly 16250E/1150S remained, which appeared to have a 70° northerly dip, with an apparent W.N.W. plunge direction.

DDH2 was drilled by the Mines Branch, N.T. Administration but only barren porphyry and barren Warramunga sedimentary rocks were intersected. Although core recovery was poor, no traces of ore minerals were observed in drill water or sludge.

DDH1 had previously been drilled to test a weak shallow I.P. anomaly, which appeared to coincide with high Pb, Ni, samples collected by P.G. Dunn on line 1700E (op.cit.) This hole also failed to encounter any evidence of mineralization, and it is now considered that the anomalous auger samples in this area were derived from lamprophyric material.

Conclusions and recommendations. Wagon drilling, confirmed by diamond drilling, indicates that the anomalous zone is small and has no depth extent of interest. Further exploration of the area is not warranted.

Explorer 13 (Plate 13) (M.G.R. 176400E/2548500N)

Investigation. The area was investigated at the request of Geopeko Limited.

Auger holes were drilled in June-July, 1964, to weathered bedrock (15 to 35 feet) at a spacing of 200 feet x 100 feet, except for line 3500W, which was drilled only into the A horizon and which should therefore be disregarded. A marked copper-zinc anomaly was found associated with, but off-centre from, a major magnetic anomaly, suggesting that the main concentration of copper may not be at the centre of the body responsible for the magnetic anomaly.

The general location of the copper anomaly is probably correct, but a number of discrepancies became apparent when further samples of weathered bedrock from this area were analysed in 1965.

Line 2600W	Cu in p.p.m. 1964	1965
1000N	150	250
900N	800	100
800N	500	120
600N	150	25

These discrepancies are probably due to:

(a) variable proportions in sample material of secondary lime, weathered bedrock and ferruginized rock fragments.

(b) matrix effects as a result of the high lime contents of some of the samples.

The magnetic anomaly with which the Cu anomaly is associated has been drilled on line 2400W by Geopeko Limited, and weakly mineralized magnetite was intersected (Plates 3 and 3A).

Conclusions and recommendations. It is noted that samples from above the Ivanhoe orebody (Plate 13) did not give an anomaly.

It is possible that some of the anomalous copper is due to exotic secondary re-precipitation by circulating groundwater probably under alkaline conditions, as indicated by secondary lime and silica deposition. However, the distribution of the anomaly, eccentric from the magnetic anomaly, suggests that previous diamond drilling may not have entered the more copper-rich part of the structure.

The following are recommended:

(a) Check bottom-of-hole weathered bedrock material from below the lime zone for copper by atomic absorption spectrometry on lines 2800W, 2600W, 2400W, 2200W from 400N to 1,000N.

(b) Recontour results of (a)

(c) determine the attitude of the copper anomaly in depth (30 to 150 feet) by limited wagon-drilling. The holes should be angled at -60° and arranged to give a complete N-S section across the anomaly peak. Wagon drill samples should be collected at five foot intervals and analysed by atomic absorption spectrometry.

(d) select a deep diamond drilling target if warranted.

Explorer 17 (Plates 11 and 12) (M.G.R. 177700E/2548300N).

Investigation. This area was investigated at the request of Geopeko Limited. Bottom of hole (10 to 15 feet) auger samples were collected at a spacing of 400 feet x 100 feet, followed up by intermediate lines at 200 feet spacing. In the vicinity of the linear E.S.E.-striking magnetic features, supplementary samples at 50 feet intervals were collected.

Copper values were contoured and, as at Explorer 13, an anomaly was found to be associated eccentrically with the deep, linear E.S.E. striking magnetic feature defined by the 400 gamma contour between 1600E/100N and 3500E/600S. The 100 p.p.m. Cu contour correlated with red-brown weathered hematitic slate cuttings, which could be readily distinguished from the normal buff, grey or brown weathered phyllitic Warramunga sedimentary rocks. This belt of red slates includes several quartz magnetite and hematite outcrops between 2600E and 3400E, and coincides with a photogeological linear feature which passes into the Mary Lane Shear to the E.S.E. and into the Ivanhoe Mine to the west.

Surface (6 inch depth) sampling showed no anomalous results but sampling at 5 feet and 10 feet depth did show a copper anomaly centred on line 3400E.

DDH1, drilled by the Mines Branch, N.T. Administration, was designed to test the copper anomaly at depth, but had to be abandoned at 130 feet because of drilling difficulties.

DDH1(B) was subsequently drilled from a collar at 3460E/462S on an azimuth of 203.5° (Grid), inclined at -75°, and to a length of 651 feet. Low grade disseminated primary copper/iron sulphides were encountered between 444 feet and 539 feet, corresponding to an average vertical depth of 460 feet below 600S. The sulphide minerals are associated with a (magnetite-bearing) shear zone which had an apparent northerly dip of -84° in a vertical plane parallel to 203.5° (Grid); an orthogonal projection shows this dip closely approximates the true dip (Appendix 1).

Conclusions and recommendations. The success of DDH1(B) in finding chalcopyrite at depth indicates that Cu Anomaly 3400/600S is derived from a mineralized zone, and it is recommended that the centre of the magnetic structure at 3200E/550S should be drilled before the prospect is abandoned.

P. Crohn's speculation that the Mary Lane Shear Zone partly controlled the localization of mineralization at Ivanhoe appears to be confirmed, and further geochemical and detailed ground magnetic or low-level aeromagnetic prospecting of the entire length of this photo-linear feature, between Red Bluff and the Lone Star Mine, is clearly warranted.

ACKNOWLEDGEMENT

The writer is indebted to the geological staffs of Geopeko Limited and Australian Development, N.L., for their co-operation in carrying out the programme. The writer also wishes to thank Professor H.E. Hawkes for much stimulating discussion and encouragement. Thanks are also due to Mr. M. Collins, Post Master at Tennant Creek Post Office, for some climatological figures.

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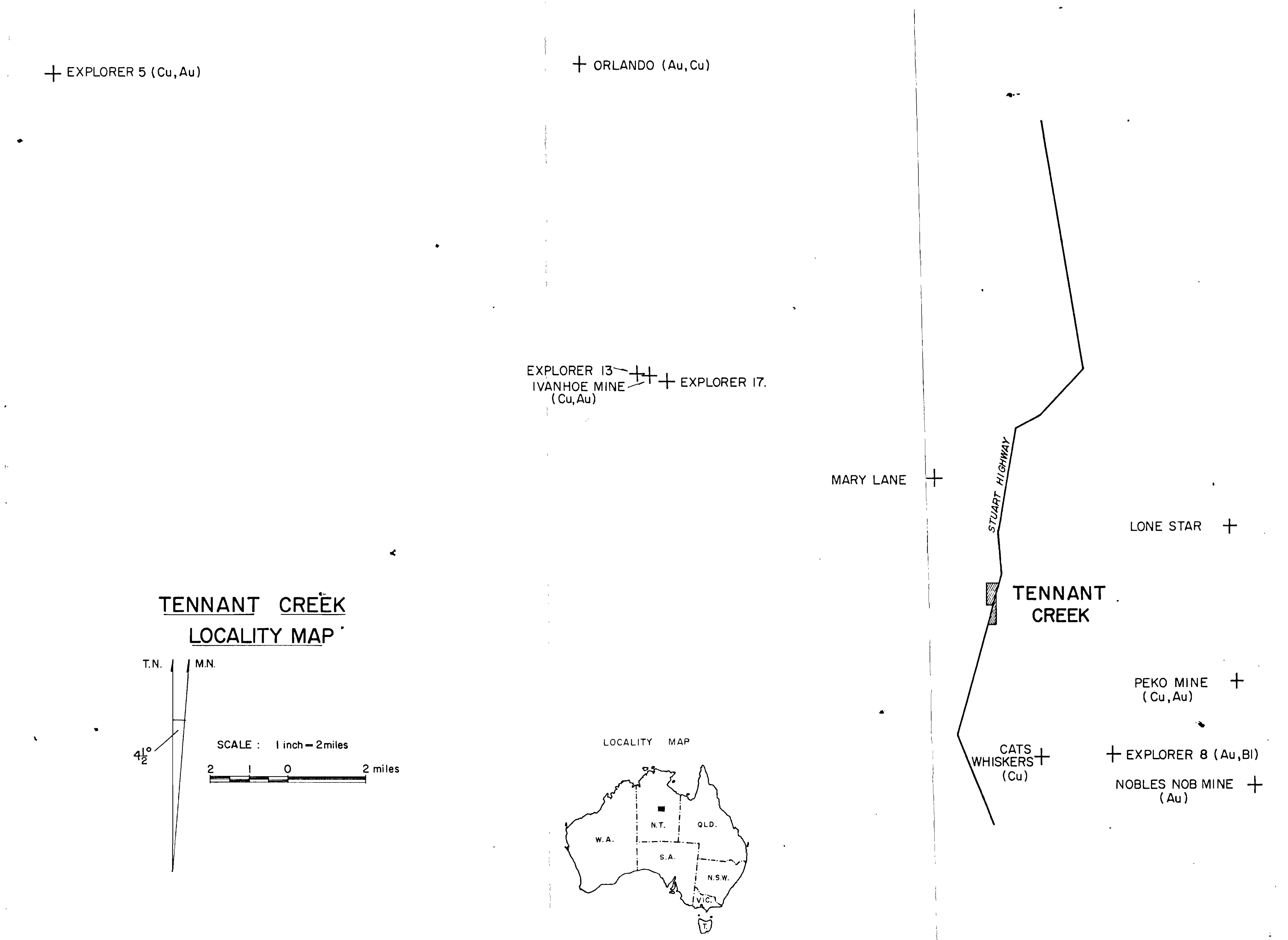


TENNANT CREEK

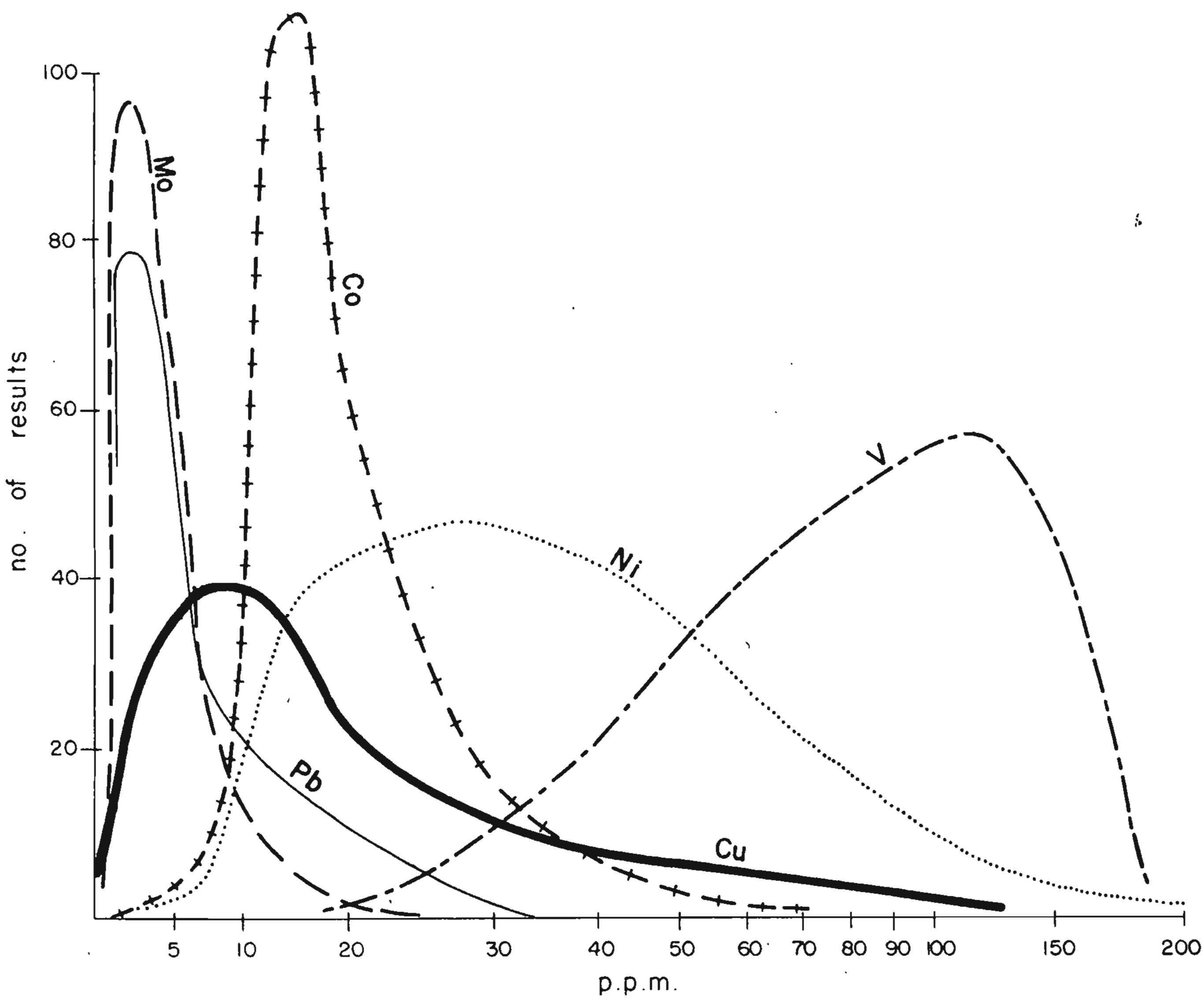
LOCALITY MAP

E53/A14/111

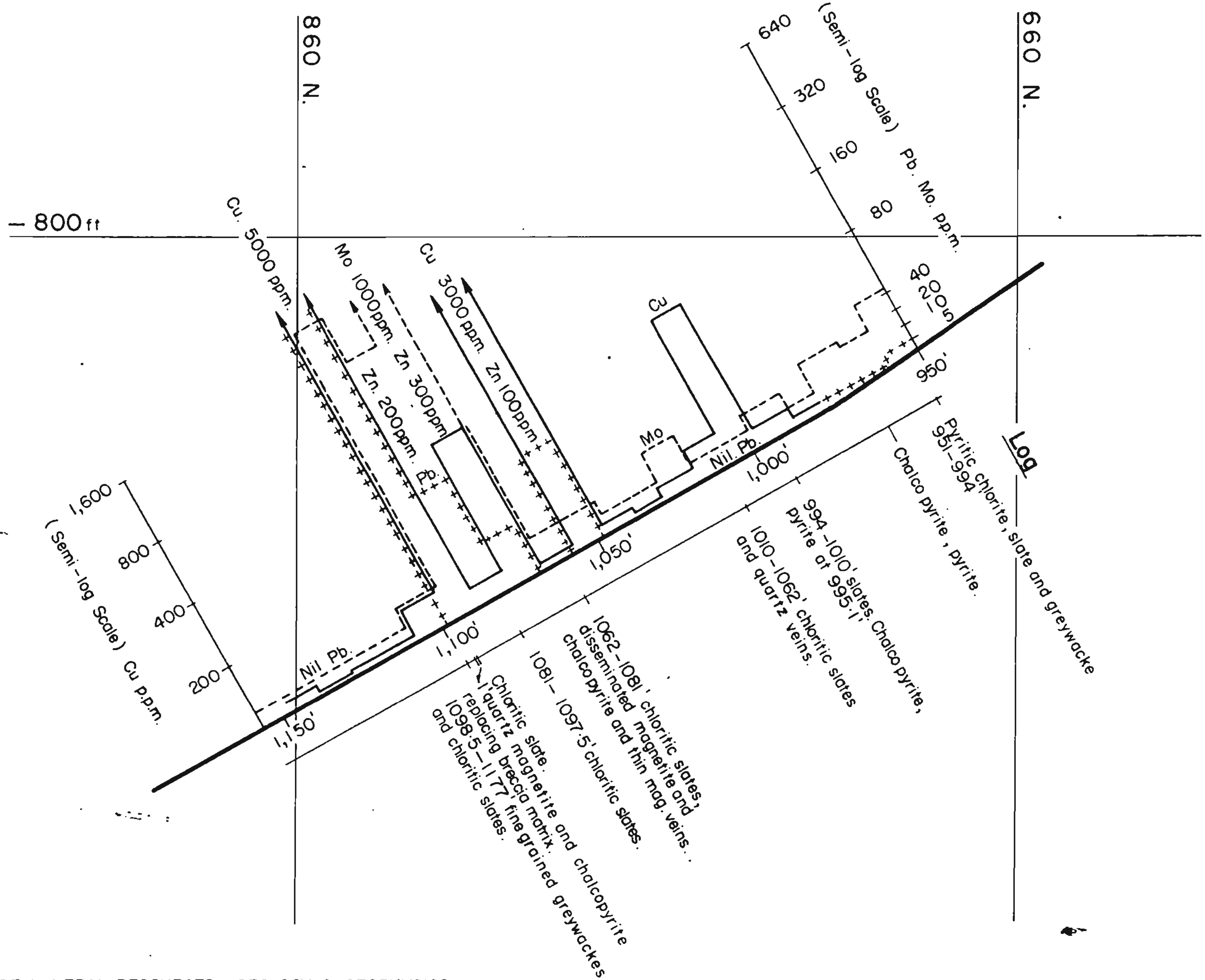
TENNANT CREEK

POPULATION DISTRIBUTION OF Cu, Co, Ni, V, Pb, Mo

UNMINERALIZED ROCK, EXPLORER. 13, D.D.H.I.



E53/A14/112



TENNANT CREEK

EXPLORER 13

D.D.H.I. 950ft. — 1,150ft.

GEOCHEMICAL HISTOGRAM

Cu ....——————
Pb ....+ + + + +
Mo ....– – – – – –

SCALE: 1 inch = 40 feet

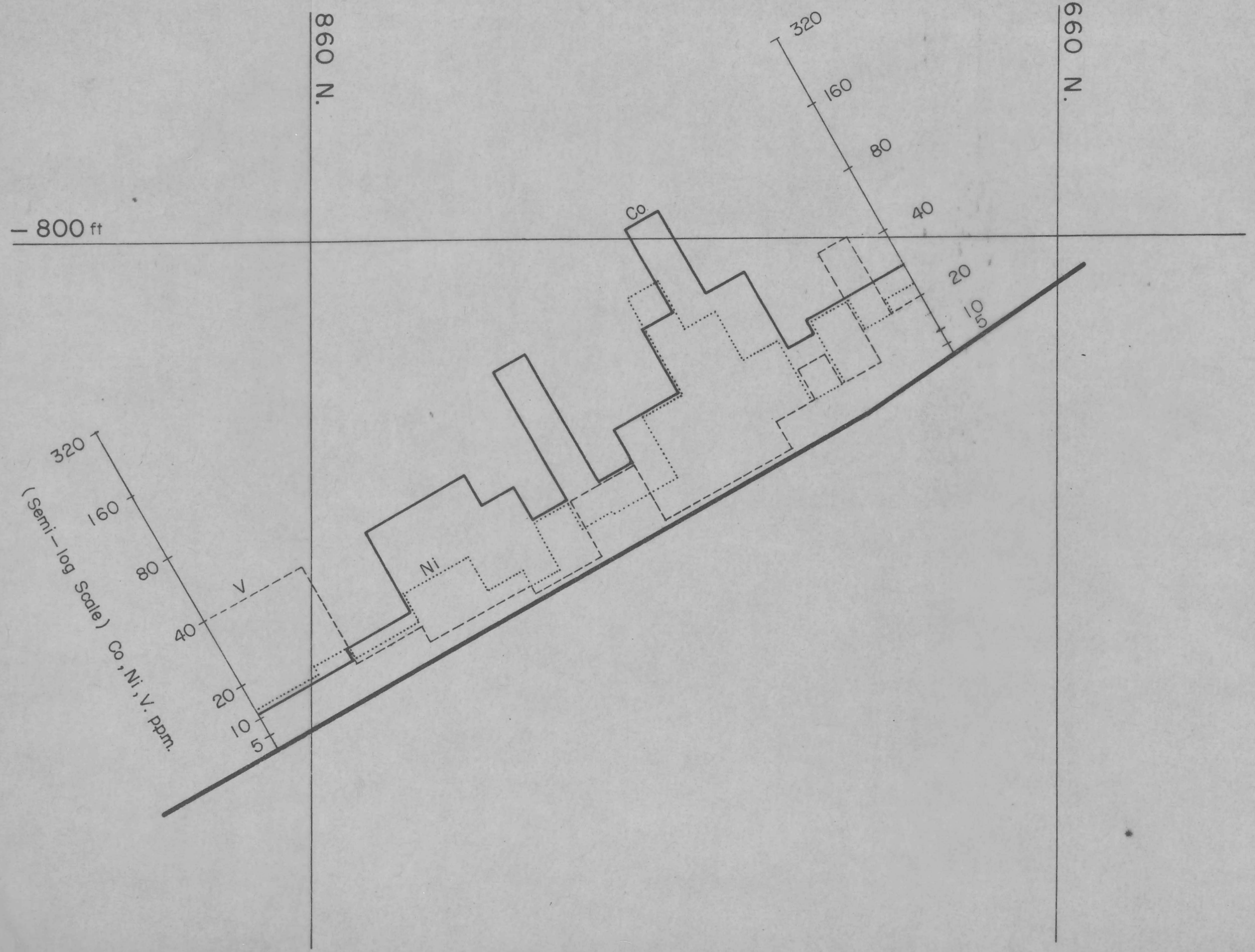
40 20 10 0 40 FEET

E53/A14/113

PLATE 3.

BUREAU OF MINERAL RESOURCES, GEOLOGY & GEOPHYSICS

TO ACCOMPANY RECORD 1965/234



GEOCHEMICAL HISTOGRAM

Co .... ———
Ni ....
V .... – – – –

(TO OVERLAY PLATE 3)

E53/A14/114

PLATE 3 (A)

BUREAU OF MINERAL RESOURCES, GEOLOGY & GEOPHYSICS

TO ACCOMPANY RECORD 1965/234

TENNANT CREEK

EXPLORER 5

D.D.H. 10, 744 ft.-1,113 ft.

GEOCHEMICAL HISTOGRAM

Cu .... ———
Bi.... -------
Co ....+++++
Ag.... ....

20 10 0 60ft
SCALE 1 inch-60 feet

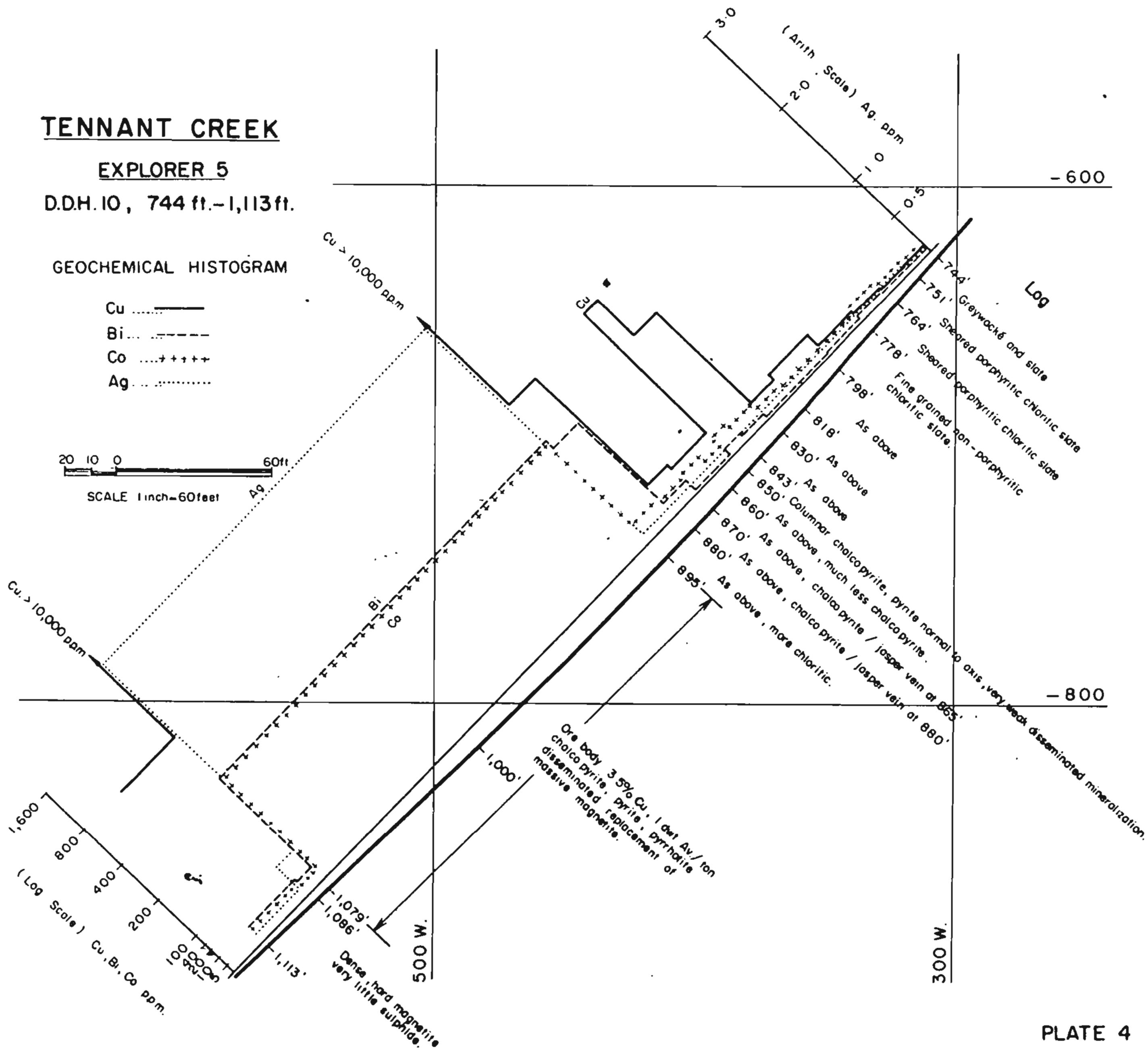


PLATE 4

E53/A14/115

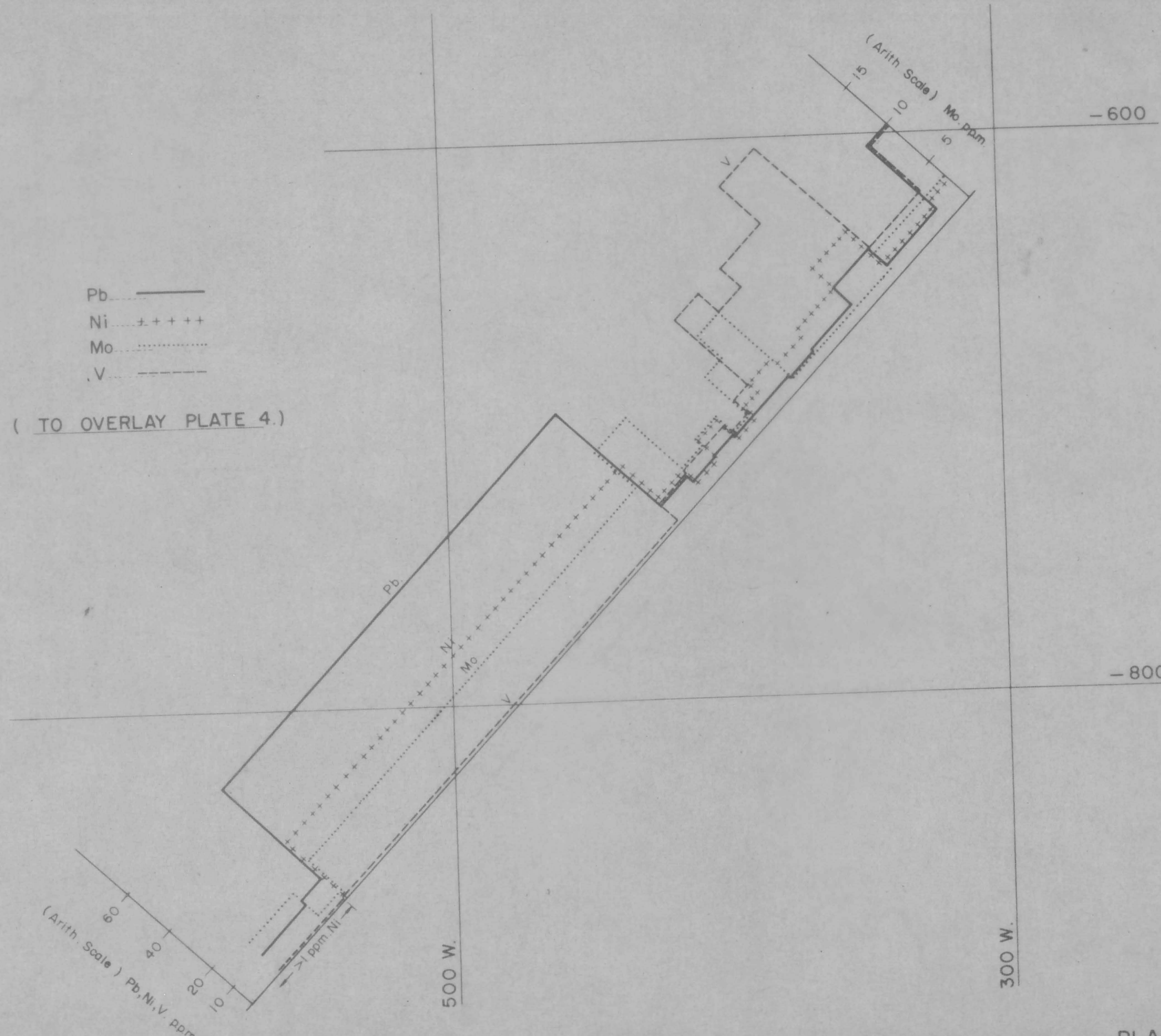


PLATE 4 (A)

E53/A14/116

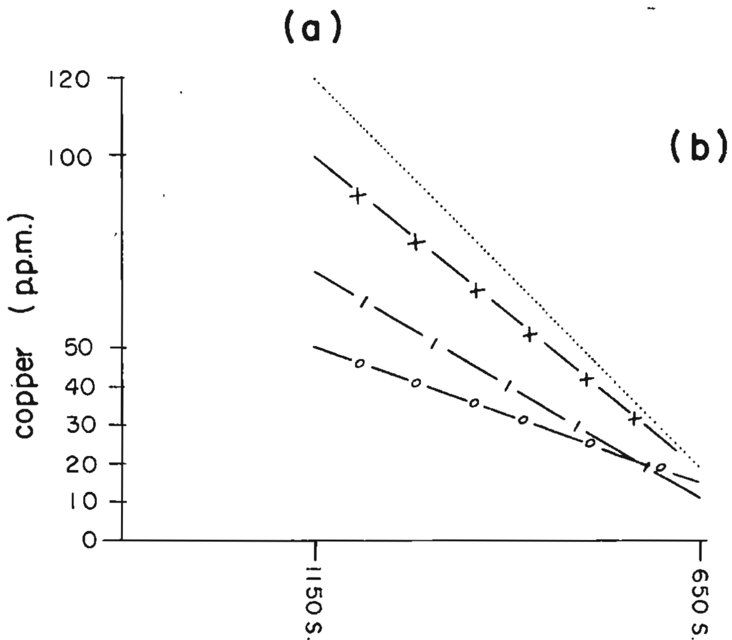
TO ACCOMPANY RECORD 1965/234

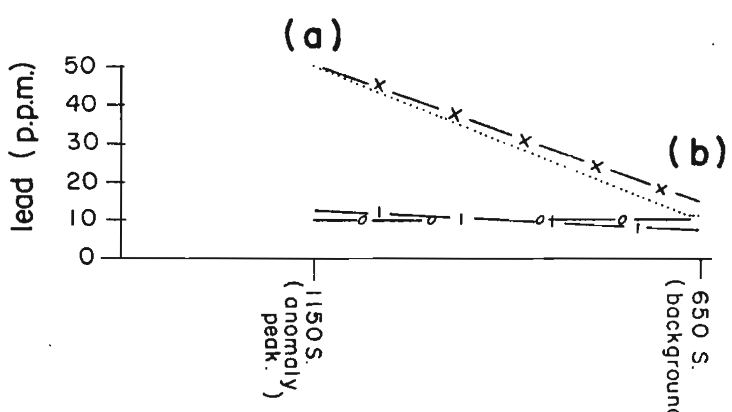
BUREAU OF MINERAL RESOURCES GEOLOGY & GEOPHYSICS

MARY LANE

LINE 16250E

fraction	% contrast Cu.	% contrast Pb.
—I—I—I = +475µ	600	150
—x—x—x = −475µ +180µ	500	330
—o—o—o = −180µ +75µ	330	0
.... = −75µ	600	410





SIZE ANALYSES (wt.%)

	+475µ	−475µ +180µ	−180µ +75µ	−75µ
1150 S. (anomaly peak)	62	10	18·2	8·8
650 S. (background)	56	11·5	24	8·6

Distribution of copper and lead according to sample fraction size.
(a) = anomalous (b) = background.

Soil details : freely drained, immature, residual, hill slope.
Sample depth : 8 inches.

E53/A14/117

EXPLORER 17 Line 3400 E. Horizontal Scale: 1 inch = 100 feet.

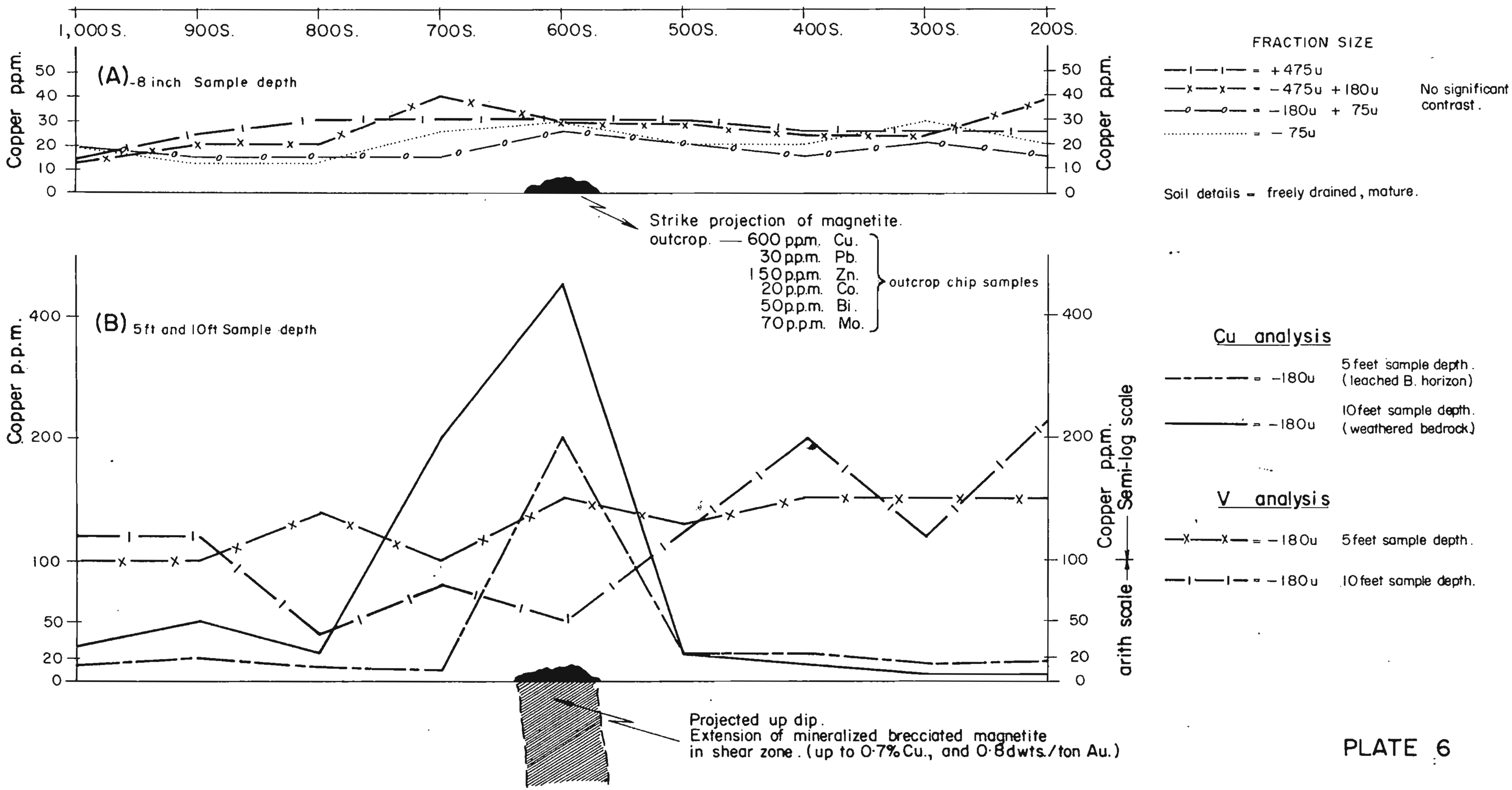
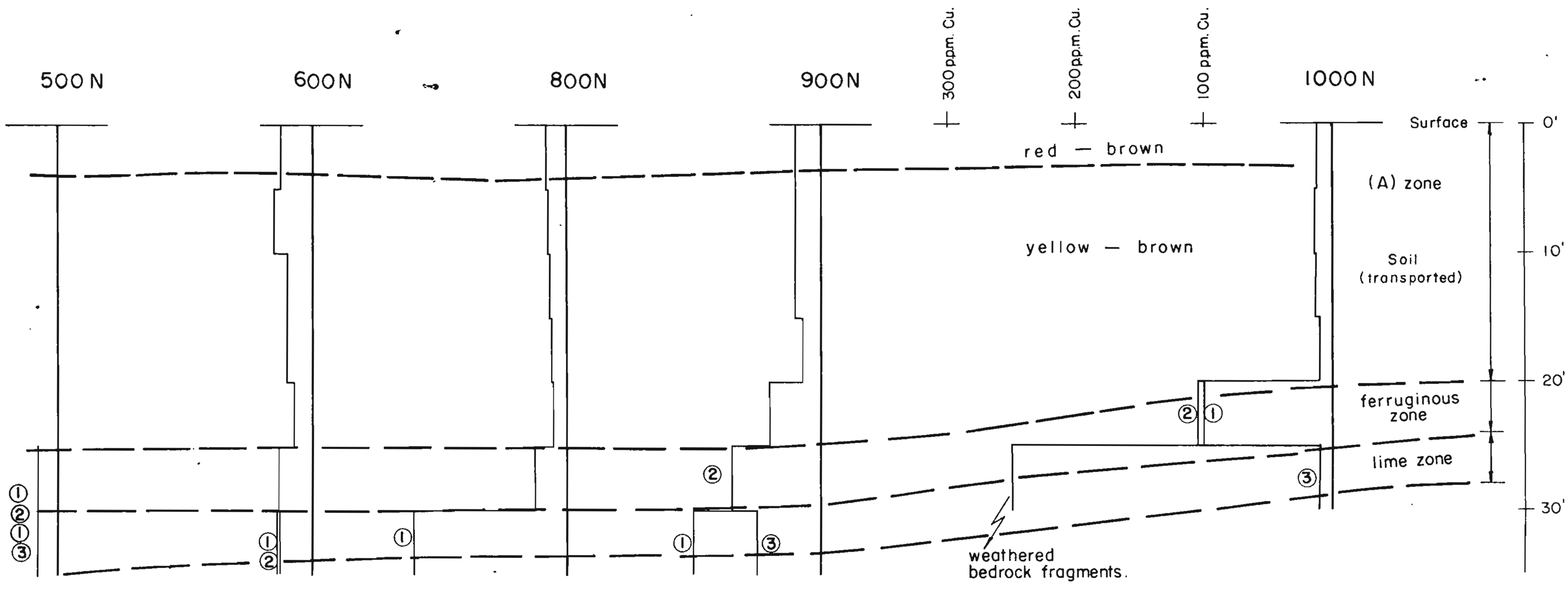


PLATE 6



LEGEND

① Total sample analysis.
② Ferruginous fragments analysis.
③ Lime fragments analysis.

Horizontal scale : 1 inch 100 p.p.m. Cu.
Vertical scale : 1 inch 10 feet.
No topographic scale horizontally

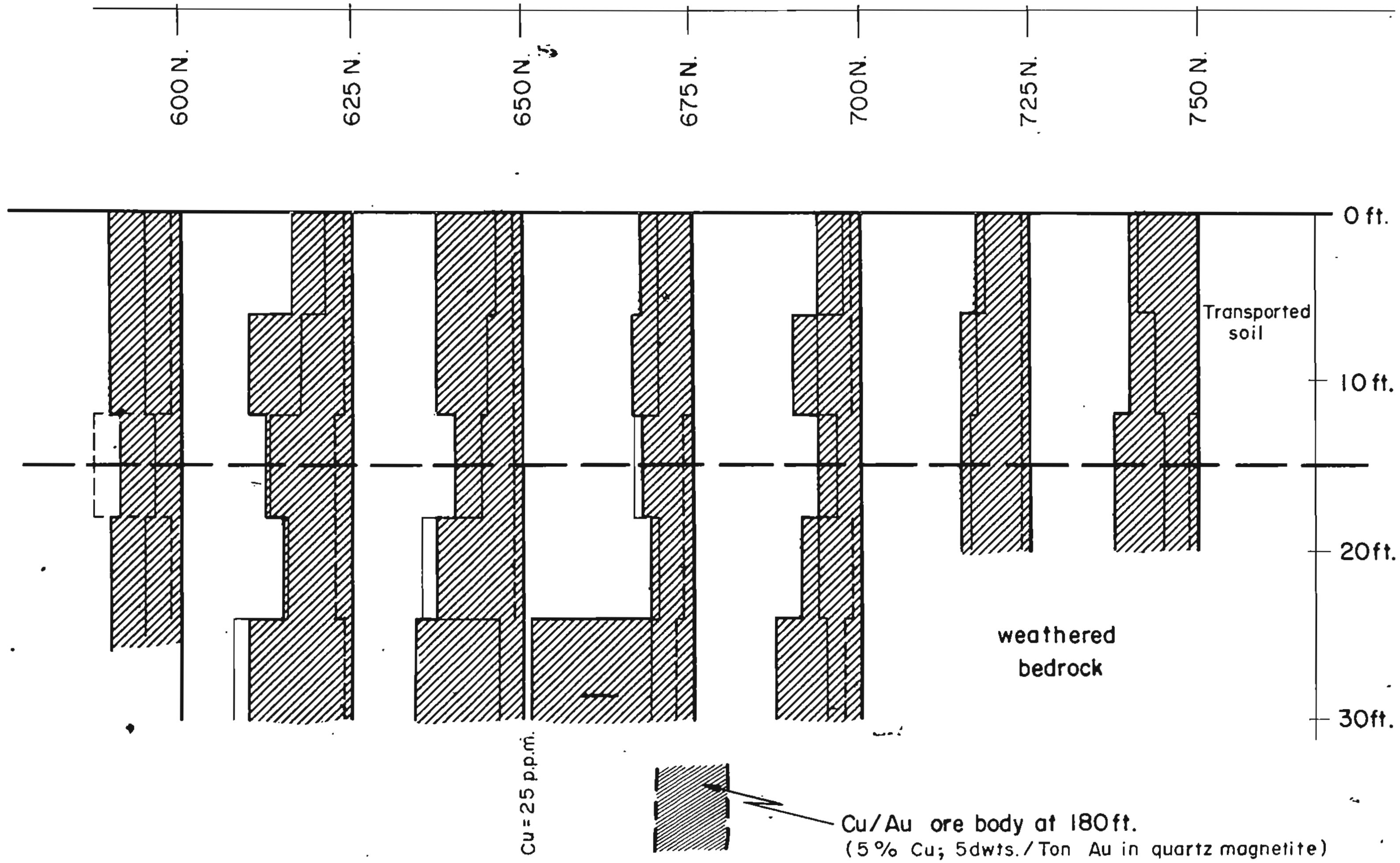
EXPLORER 13

Line 2600 W.

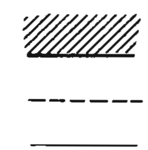
Copper distribution histograms.

(Sample material not sized)

PLATE 7.



TENNANT CREEK
IVANHOE MINE
GEOCHEMICAL HISTOGRAM
Cu, Co, Bi
line 716 W.

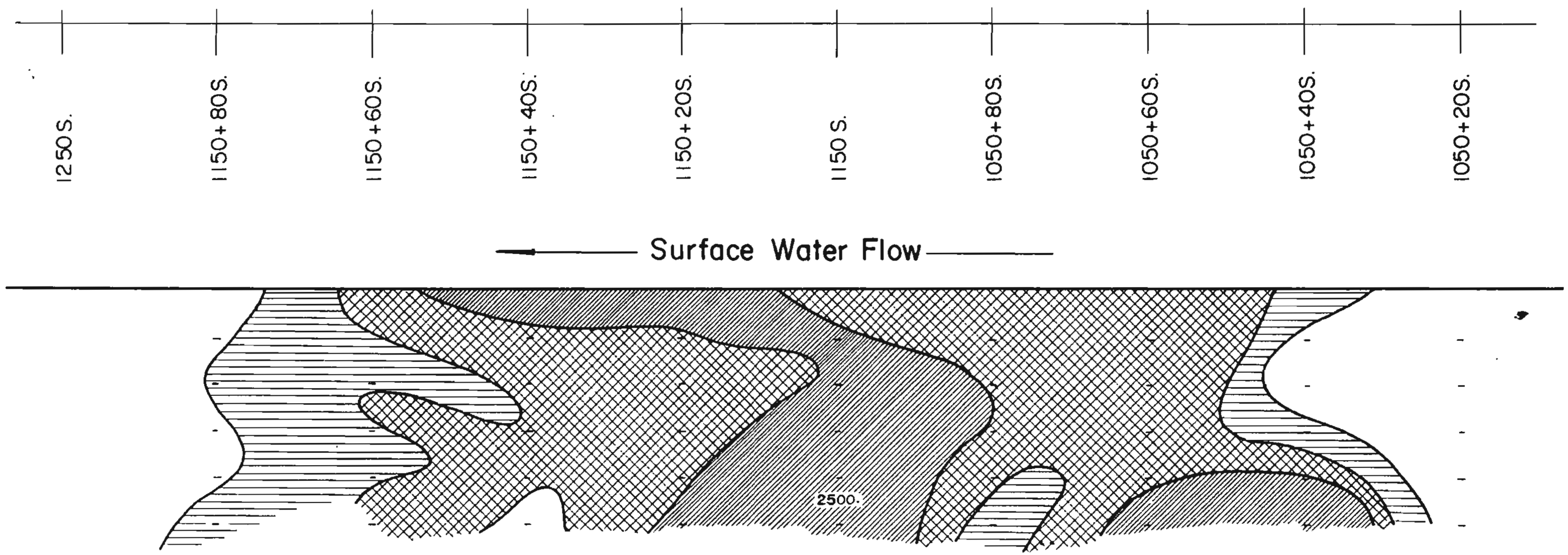


Horizontal scale : 1 inch = 25 feet.

Vertical scale : 1 inch = 10 feet.

Geochemical scale : 1 inch - 20 p.p.m. (Cu, Co, Bi)

PLATE 8



LEGEND

200 p.p.m. to 500 p.p.m. Cu

500 p.p.m. to 1,000 p.p.m. Cu

> 1000 p.p.m. Cu

TENNANT CREEK MARY LANE

LINE 16250 E. COPPER PROFILE

HORIZONTAL SCALE 20 10 0 20 feet

VERTICAL SCALE 10 5 0 10 feet

PLATE 9

BUREAU OF MINERAL RESOURCES, GEOLOGY & GEOPHYSICS

E 53/A14/121

TO ACCOMPANY RECORD 1965/234

1250 S.	1150+80S.	1150+60S.	1150+40S.	1150+20S.	1150 S.	1050+80S.	1050+60S.	1050+40S.	1050+20S.
	150	500	1500	1550	1000	800	800	400	50
	200	400	900	800	1000	600	600	150	80
	150	600	500	700	2000	1000	500	200	100
	150	250	600	700	2500	500	600	400	100
	250	500	100	1200	2500	400	2000	1500	150

← Surface Water Flow

TENNANT CREEK
MARY LANE

LINE 16250E.
COPPER PROFILE

HORIZONTAL SCALE 20 10 0 20 feet

VERTICAL SCALE 10 5 0 10 feet

PLATE 10


PLATE 11
TENNANT CREEK
EXPLORER 17
GEOLOGICAL MAP
200 100 0 200 ft.
SCALE : 1inch-200feet
LEGEND
Quartz - magnetite.
Red, brown ferruginous slate.
Weathered Warramunga sediments (brown and buff siltstone and slates).
from auger cuttings
Photo linear feature (Mary Lane Shear ?).
1,000 E.
2,000 E.
3,000 E.
4,000 E.
5,000 E.
500 N.
500 S.
1,000 S.
1,500 S.
M.N.
600 ft. to Ivanhoe Mine
Silty slate with iron rich veins
Ironstone
D.D.H.I. (B) -75°
D.D.H.I. (abandoned) -62°
Quartz haematite / magnetite
Highly magnetic
Brecciated
Red haematite slate
Brown phyllite with ferruginous veining
Haematite jasper
Ferruginous (ironstone)
Quartz haematite
Ferruginous slate
Iron enriched slate
Ferruginous siliceous slate
Ferruginous (ironstone ?)
Grey slate, iron bands
Purple grey slate

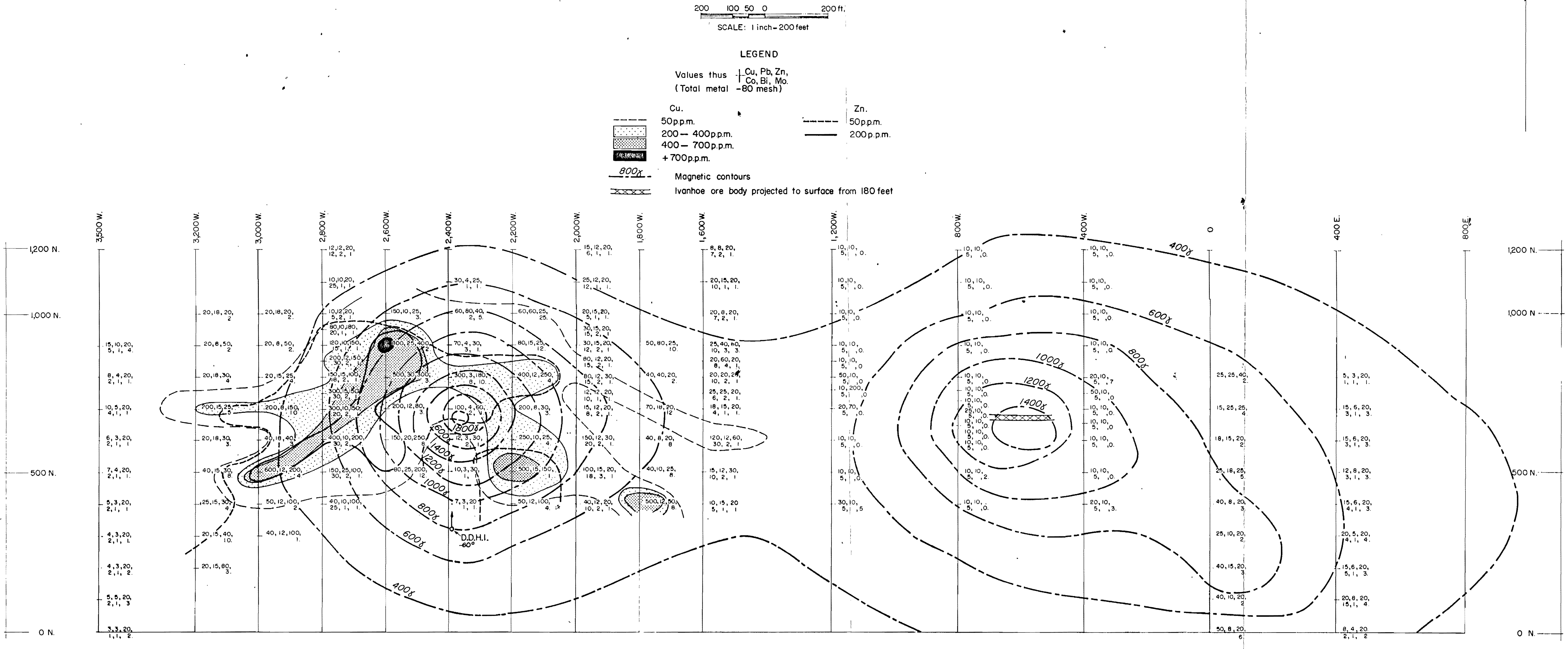
PLATE 12

BUREAU OF MINERAL RESOURCES, GEOLOGY & GEOPHYSICS

E53/A14/125

TO ACCOMPANY RECORD 1965/234

TENNANT CREEK
EXPLORER 13 and IVANHOE MINE
GEOCHEMICAL MAP, C-zone soils



APPENDIX 1.

EXPLORER 17, LOG OF DIAMOND DRILL HOLE NO. 1 (B).

By W.S. Yeaman.

Collar co-ordinates: 3,460E/462S (Geopeko geophysical grid).

Course: Azimuth 203.5° (Grid). Inclination - 75°.

Depth: 651 feet.

Purpose: To test primary zone below Cu. Anomaly 3400E/600S and eastern extension of the axis of Magnetic Anomaly 3,150E/500S.

Result: Very low-grade disseminated chalcopyrite and pyrite, believed to be the down dip extension of the surface geochemical anomaly, was intersected between 444 feet and 539 feet. No gold or copper assays of economic grade were encountered.

Surveys:

250'	Tro Pari,	dip 78°	azimuth	220°M
315'	" "	" 74°	"	215°M
375'	" "	" 70°	"	212°M
430'	" "	" 68°	"	211°M
451'	Acid etch (corrected)	" 68.5°		-
550	Tro Pari,	" 65°		209°M

Note on Drilling Technology

The first 190 feet was drilled by 4¼" dia. Halco dry percussion hammer drill in 1½ shifts with a Holman Rotair/Rolls Royce Compressor delivering 600 c.f.m. This was done to obviate clay in the oxidised zone swelling when in contact with drilling water from conventional diamond drilling, thus preventing the placing and eventual removal of NX casing. The technique was very successful. The use of split inner-tube core barrels effected almost 100% core recovery below the oxidised zone.

Interval	Recovery	Description of Core
0' - 190'	0	Hammer drill hole (by Australian Development N.L.)
NX Core		
190' - 262'	62	Pink and lemon oxidised silty slate. Bedding/core axis = 12°. Cleavage/core axis = 12°. Bedding/cleavage angle measured on face normal to core axis = 30°. The trace of the intersection of bedding and cleavage forms a faint lineation parallel to the core axis.
BXM Core		**BX casing wedge at 284 feet for azimuth correction.**
280'		**Base of Oxidation**
262' - 285'	20	Coarse to fine-grained impure greywacke. Graded bedding at 265' indicates either (a) bedding vertical with younging to the south or (b) bedding inverted and dipping about 55° to south. Solution (a) considered most probable and agrees with the geophysical interpretation.

285'	-	306'2"	10'2"	Alternating 2" bands of greywacke and slate. Bedding/core axis = 26°. Bedding/cleavage still = 30° on core end.
306'2"	-	346'	39'10"	Massive, coarse greywacke.
346'	-	358'	12'	Chloritic slate with rounded quartz porphyroblasts up to ¼" long and showing cerebral structure with minute chlorite inclusions radially arranged near the periphery of the crystals. Such a structure has been termed "porphyroidal" by J. Elliston, who considers it to indicate crystallization from a hydrated colloid.
358'	-	362'	4'	Chloritic slate.
362'	-	373'	11'	Sheared greywacke with quartz porphyroblasts similar to those above developed in shear planes.
373'	-	391'	18'	Highly sheared chloritic slate. Shearing is along bedding planes at 26° to core axis. Less sheared greywacke 387' - 387'6".
391'	-	393'	2'	Medium grained greywacke.
393'	-	401'	7'	Alternating greywacke and chloritic slate. Bedding/core axis = 29° Cleavage/core axis = 24°.
<u>AXM Core</u>				<u>AX casing wedge at 401' for azimuth and dip correction.</u>
401'	-	444'	42'6"	Fine grained greywacke with moderately well developed idioblastic <u>pyrite</u> cubes of about ⅛" side, growing along sheared bedding planes at 435 feet. Pyrite must be post-tectonic.
				<u>MINERALIZED ZONE INTERSECTED</u>
444'	-	459'	15'	Sheared chloritic slate with quartz porphyroblasts containing chlorite inclusions (as above). Sparsely disseminated chalcopyrite and pyrite replacements in slate and surrounding cataclastic magnetite grains. Pyrite usually shows good cubic idiomorphism. Magnetite is dispersed throughout core as grains up to ½" long. Magnetite clearly crystallised before shearing and the sulphides post-shearing. Chalcopyrite richest at 444'6", 449'6" to 453'. Barren grey jaspery silica from 448' to 449'.
459'	-	494'	32'	As above, very little sulphide or magnetite, apart from 481' - 481'6", where there is a band of magnetite breccia with fragments up to ½" long.

494'	-	511'	16'	As above, quartz porphyroblasts becoming larger and more numerous down the hole. Sulphides at 499' - 500', 503' - 504'.
511'	-	533'	22'	Sheared porphyroblastic sedimentary rocks.
533'	-	539'	5'6"	Pink feldspathic intrusive rock with minor biotite and chlorite, probably minette lamprophyre (Pontifex, pers. comm). This rock has been sheared similarly to the sediments and chalcopyrite plates are on the sheared faces. There are also thin stringers (⅛" wide) containing chalcopyrite and pyrite. If these sulphides are the same generation as those in the magnetitic sections higher up, this igneous rock indicates the maximum age for the sulphide mineralization.
539'	-	564'	20'	Chloritic slates and medium grained grey-wacke.
564'	-	651'	81'	Chloritic slates and fine to medium-grained greywackes. Occasional graded bedding indicates younging is probably to the south, assuming that the bedding strikes E.S.E. and dips almost vertically. Bedding/core axis = 36^{o} at 574'.
651'				End of Hole.

ASSAY RESULTS - EXPLORER 17 - HOLE 1

Assayed by Peko Mines N.L.

	Sample	Interval	Cu%	Au dwts/long ton
F	632	444' - 449'	0.04	0.04
	633	449' - 454'	0.75	0.03
	634	454' - 458'	0.5	0.10
	835	458' - 462'	0.1	0.05
	636	462' - 466'	0.05	0.06
	637	466' - 470'	0.15	0.80
	638	470' - 474'	0.15	0.20
	639	474' - 478'	0.2	0.07
	640	478' - 482'	0.1	0.10
	641	482' - 486'	0.1	0.15
	642	486' - 490'	0.2	0.30
	643	490' - 494'	0.2	0.08
	644	494' - 498'	0.15	0.07
	645	498' - 502'	0.3	0.15
	646	502' - 507'	0.25	0.20

APPENDIX 2

LAMPROPHYRE FROM EXPLORER 17, D.D.H. 1 (B) TENNANT CREEK

by

W. Oldershaw

R 65060258

A four-inch length of one-inch diameter bore core from D.D.H. 1 (B) at Explorer 17, three-quarters of a mile east of Ivanhoe Mine Tennant Creek, was submitted by W.S. Yeaman for petrographic examination. The handspecimen is a fine-grained red rock containing flakes of chlorite 0.25 inches long. The specimen is cut by veins of quartz and of chlorite 0.1 inches thick, and contains black, polished slickensides.

Under the microscope the rock is seen to consist of wispy masses of penninite 5 mm long set in a matrix of euhedral ~~crystals of~~ orthoclase 1 mm long, irregularly-shaped grains of orthoclase, and interstitial quartz. The penninite is crowded with granules of hematite, and probably represents altered biotite. Some orthoclase crystals occur in sub-variolitic, or sheaf-like, masses. The orthoclase is fresh, but the cleavage planes are extensively stained with limonite. Cryptoperthite is common. Quartz occurs as irregularly shaped interstitial grains comprising about 5 percent of the rock. Hematite and apatite are accessory.

The rock is a biotite lamprophyre, or a minette. These are commonly regarded as differentiates from acid igneous rocks.