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SOIL SAMPLING AT THE BIG REEF AND TWO MICKS GOLD MINES, FORSAYTH, NORTH QUEENSLAND

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SUMMARY

Geochemical studies along two shear zones in the vicinity of the now abandoned Big Reef and Two Micks gold mines near Forsayth, north Queensland, have demonstrated the potential usefulness of the soil sampling technique in exploration for vein-type gold mineralization in the area. Several gold, lead, copper, and bismuth soil anomalies have been delineated. Some of these anomalies are obviously related to known gold deposits - others possibly indicate previously undetected mineralization although their small size suggests that any associated lodes are probably not of economic significance. There are, however, numerous other fracture zones in the Georgetown-Forsayth area which may contain more important near-surface mineralization so far undiscovered as a consequence of poor outcrop. These deposits are likely to be still fairly small, and expensive exploration programs cannot be justified. However, the analysis of soils for lead and copper affords a cheap, effective, and rapid means of determining the prospectiveness of the most favourable zones.

INTRODUCTION

Object of the investigation

During the 1974 field season a geochemical soil sampling program was undertaken in the area of the now abandoned Big Reef and Two Micks gold mines about 6 km south-southeast of Forsayth, north Queensland (Fig.1). The object of the survey was to assess the usefulness of soil sampling as an exploration technique for gold in the Forsayth region. The Big Reef/Two Micks area was chosen for detailed study because it contained major mineralized structures which had not been prospected over their entire lengths - mining activity was confined to areas of outcrop, and little exploratory driving and crosscutting had been undertaken. Where outcrop was poor the shear zones could be readily traced on aerial photographs and thus appeared well-suited to testing by geochemical means. Also encouraging from a geochemical viewpoint was the fact that the primary ore of the Big Reef and Two Micks mines contained iron, lead, and copper sulphides.

Climate and Relief

The climate is hot with average daily maximum temperatures exceeding 32°C during December and 22°C during July. Average annual rainfall is about 650 mm, most of which falls during the summer months.

The western part of the survey area is relatively flat. To the east of the Two Micks mine the relief is greater but does not exceed about 25 m.

Mining history

The Big Reef mine was one of the largest in the Forsayth area and produced continuously between 1878 and 1893, when lack of capital caused a suspension of operations (Withnall, 1976). It was then worked intermittently until 1934. Total production of the Big Reef mine* was 841225 g of bullion from 25470 tonnes of ore, and 25949 g of gold and 32276 g of silver from 904 tonnes of ore and concentrates (Withnall, 1976).

Little is known of the history of the Two Micks mine. Production is recorded only for 1911 although the reef was known before that date (Geraghty, 1898). The workings are shallow, and only a small tonnage of ore has been extracted.

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* The Tunnel mine is treated here as a part of the Big Reef.

Previous investigations

Mines Administration (Mitchell, 1969) and Western Compass Minerals (no report) have examined the Big Reef mine in recent years. The former company mapped the surface workings, but it appears that no stream-sediment or soil geochemical work has ever been carried out in the vicinity.

GEOLOGY

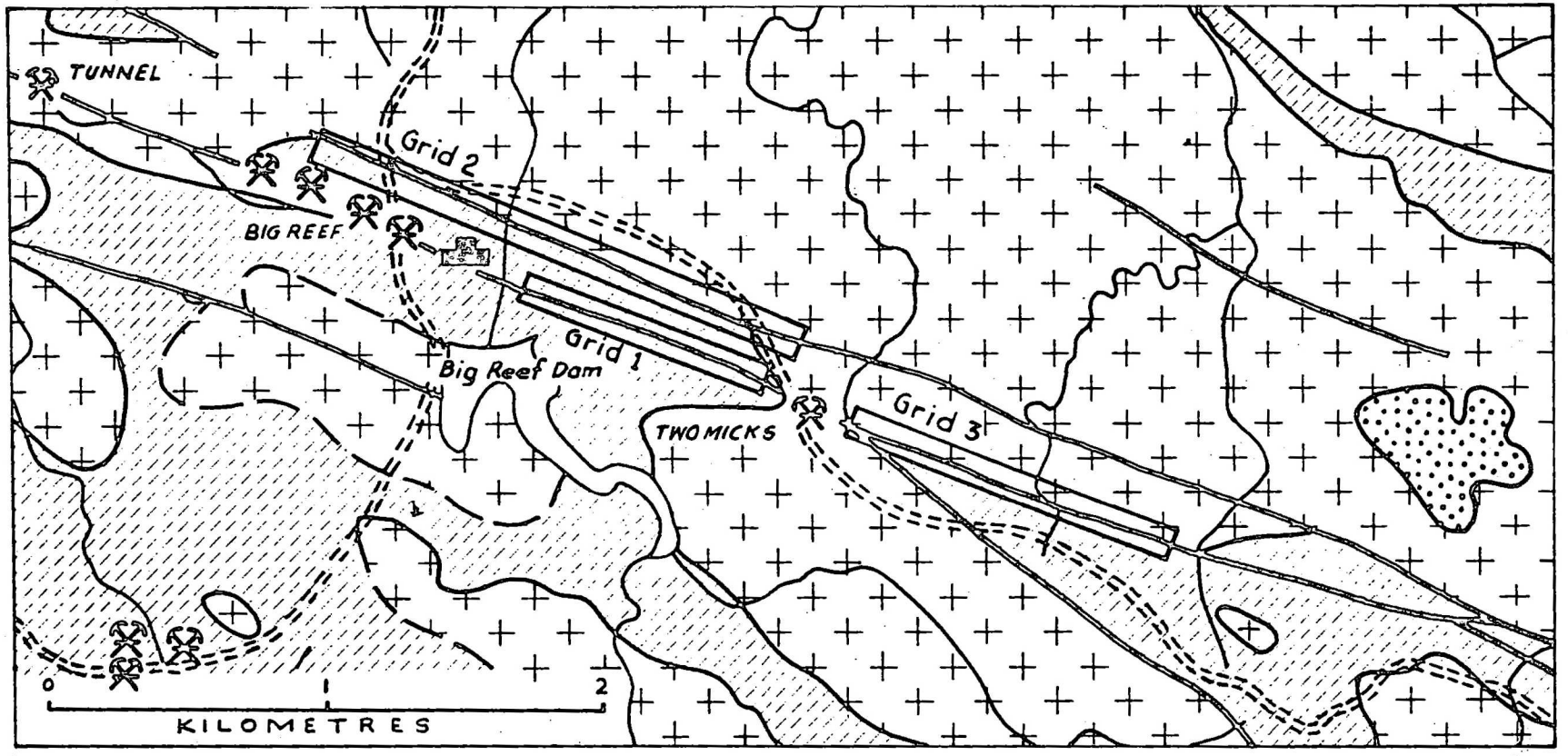
The Big Reef and Two Micks mines are located on a well-defined shear zone (Fig. 1) which can be traced for a distance of about 12 km. The structure cuts both the Forsayth Granite and the Robertson River Metamorphics and in places forms the boundary between these rock units (Bain et al., 1976). It strikes 110° to 115° and has a steep northerly to vertical dip. Generally the shear zone is 2 to 3 m wide but locally it thickens to 6 m.

At Big Reef two ore shoots were worked. These varied in width up to 1.5 m; one was more than 300 m long, the other about 150 m (Withnall, 1976). Most stoping was carried out in oxidized ore ('brownstone') above a depth of 30 m (Cameron, 1900). Below the oxidized zone (30 m) the lodes became rich in pyrite, galena, and chalcopyrite and the ore could not be successfully treated. Consequently, although the workings extended to a depth of 76 m, production from the lower levels was small.

SAMPLING AND ANALYTICAL METHODS

Sampling techniques

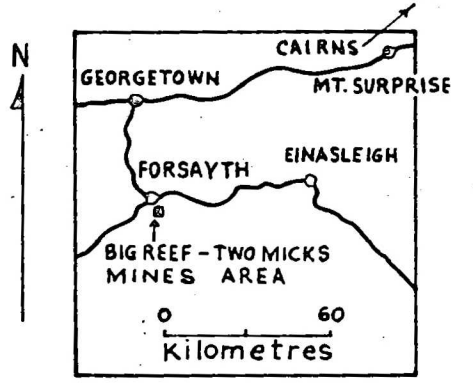
Three rectilinear grids (Fig. 1) were surveyed using a prismatic compass and measuring tape. Grids 1 and 3 were located over the Big Reef/Two Micks shear zone and grid 2 over a parallel fracture about 200 m to the north. Samples were taken every 100 m parallel to the shears and every 10 m at right angles to them. The central site on each cross-line was marked with a star picket and numbered tag. Each sample consisted of about 200 g of material from the B-horizon of the soil profile i.e. at a depth of about 20 cm. A total of 443 samples were collected on the three grids.



CRETACEOUS
MIDDLE ? { FORSAYTH GRANITE
PROTEROZOIC { ROBERTSON RIVER METAMORPHICS

Sandstone, conglomerate
Biotite granite
Mica schist

Geological boundary [where line is broken position is approximate]
Fault, shear zone
Gold mine
Battery site
Soil grid
Road
Creek



Geology by J.Bain (BMR) and I.Withnall (GSQ), 1973.

Fig. 1: Geological map of the Big Reef / Two Micks mines area.

Analytical Techniques

All sample preparation and analytical work was carried out by AMDEL.

The soils were dried and sieved to 80 mesh. They were then digested using hydrochloric and perchloric acids and analysed for copper, lead, zinc, cobalt, nickel, iron, chromium, manganese, molybdenum, and silver by atomic absorption spectrophotometry. Determination of arsenic, tungsten, bismuth, mercury, antimony, selenium, tin, and tellurium was carried out by X-ray fluorescence spectrometry. Gold was determined by atomic absorption following 'aqua regia' (hydrochloric and nitric acids) digestion and organic (DIBK) extraction. The sample weight used for the gold analyses was 2.25 g.

DISCUSSION OF RESULTS

Anomalous gold values have already been noted in soils near gold mineralization in the Forsayth region (Armstrong, 1975). However, gold determinations are difficult to conduct, relatively expensive, and often lack precision owing to sampling errors. There was an obvious need for this study, therefore, to investigate the possibility of using more readily determined elements as a guide to the presence of gold mineralization.

To evaluate which elements might be the most useful as pathfinders, Pearson product moment correlation coefficients between gold and all the other elements determined during the survey were calculated (Table 1). Coefficients were computed for both raw and logarithmically transformed data to cover the possibilities of the elemental distributions following either normal or lognormal patterns.

Lead, copper, bismuth, mercury, and silver show statistically significant correlation with gold. The usefulness of mercury and silver as pathfinders is doubtful, however, as high values for these elements occur only near the old Big Reef battery site (Fig. 5). It seems likely that mercury has been artificially introduced during amalgamation and that silver, while it occurs in the ore, is only concentrated to easily detectible levels in soils by human intervention. Gold, lead, copper, and bismuth, then, are the only elements useful in the detection of gold mineralization in the Big Reef/Two Micks mines area, and the following discussion is limited to these four.

Element	r (raw data)	r (log data)
Cu	0.70*	0.43*
Pb	0.70*	0.44*
Zn	0.08	0.09
Co	-0.09	-0.09
Ni	-0.07	-0.11
Cr	-0.02	0.05
As	-0.07	-0.04
W	0.12	0.10
Bi	0.48*	0.32*
Hg	0.69*	0.40*
Sb	-0.05	-0.05
Se	0.02	0.03
Sn	0.11	0.02
Te	0.09	0.00
Mo	0.00	0.03
Ag	0.69*	0.33*
Fe	-0.06	-0.13
Mn	-0.01	0.02

Table 1: Pearson correlation coefficients (r) between gold and the other elements determined. Asterisks indicate positive correlations that are significant at the 99% confidence level.

Geochemical thresholds for gold and its pathfinder elements

Gold

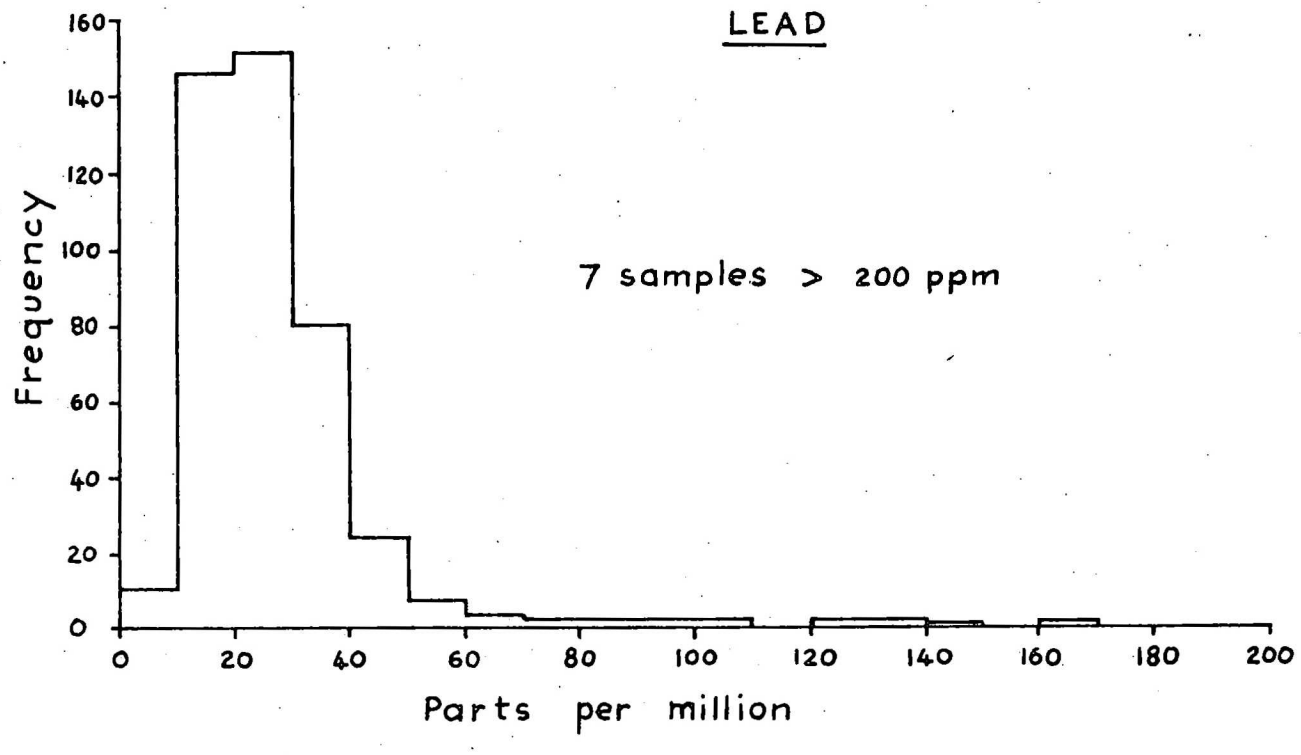
Gold was detected in too few samples for a geochemical threshold to be statistically defined but any gold value of 0.1 ppm or greater would appear to be anomalous. The fact that meaningful geochemical patterns emerge when soils are analysed for gold (Figs. 4-6) suggests, but by no means proves, that the element has largely been dispersed in colloidal form by some chemical process. If the gold was present solely in coarse particulate form, large sampling errors would probably have destroyed any orginal geochemical continuity. Sporadic high gold values in samples not enriched in any other element (Figs. 4 & 5) may indicate occasional occurrences of particulate gold, however.

Lead

The distribution of lead in the soils of the Big Reef/Two Micks area is shown in histogram form in Figure 2. The histogram is positively skewed and this suggests that the lead distribution has lognormal affinities. Confirmation of lognormal tendencies is obtained when a cumulative frequency plot for lead is constructed on log-probability paper (Fig. 3). The fact that two intersecting straight lines result, indicates that the lead distribution can be closely approximated by two lognormal populations - one background and the other anomalous. The discontinuity between the two lines can be used as a threshold value for distinguishing anomalous from background samples. Thus, a lead level of 50 ppm or greater is probably anomalous and worthy of closer examination.

Copper

The copper results are more difficult to interpret than those for lead. Again the histogram is positively skewed (Fig. 2) but the log-probability cumulative frequency plot is undiagnostic as no rectilinear segments or sharp breaks are observed (Fig.3). An arithmetic probability diagram (not shown) proves to be even less informative. Given the strong association of lead and copper in the Big Reef ore (page 2), and the comparable mobilities of the two elements under normal conditions, any soil high in lead is also likely to be high in copper. It is



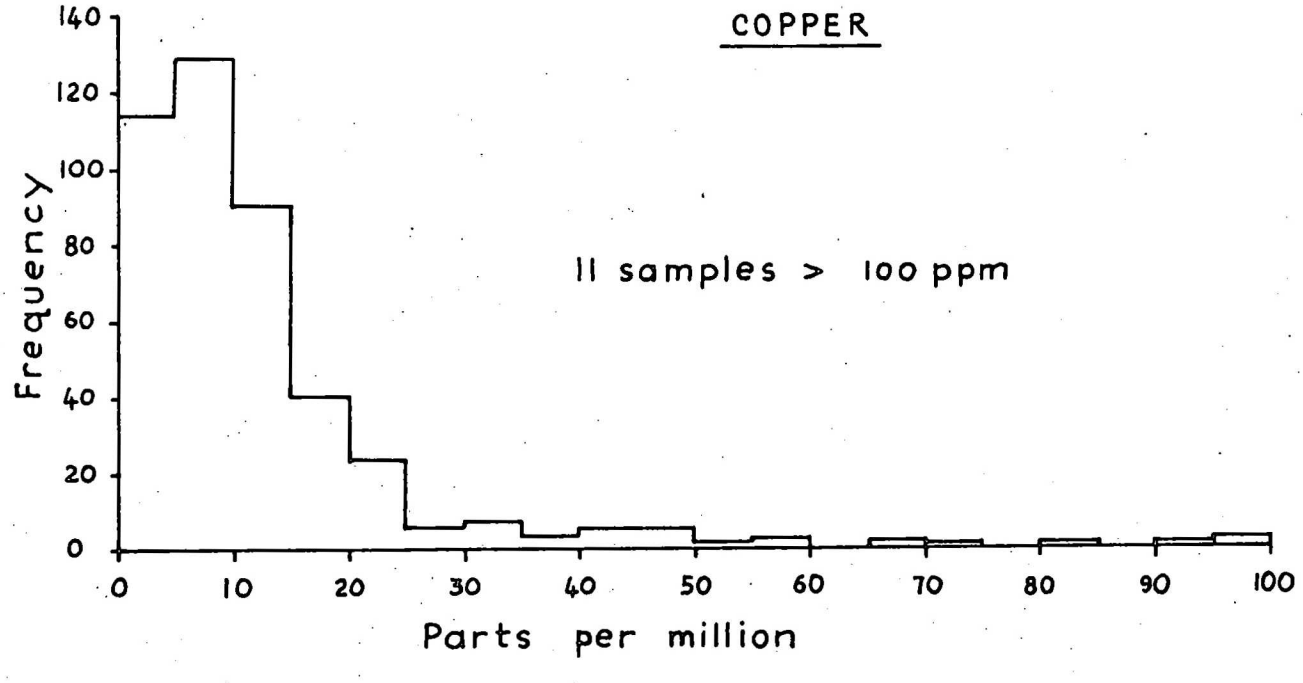


Fig. 2: Histograms for lead and copper in the soils of the Big Reef / Two Micks mines area.

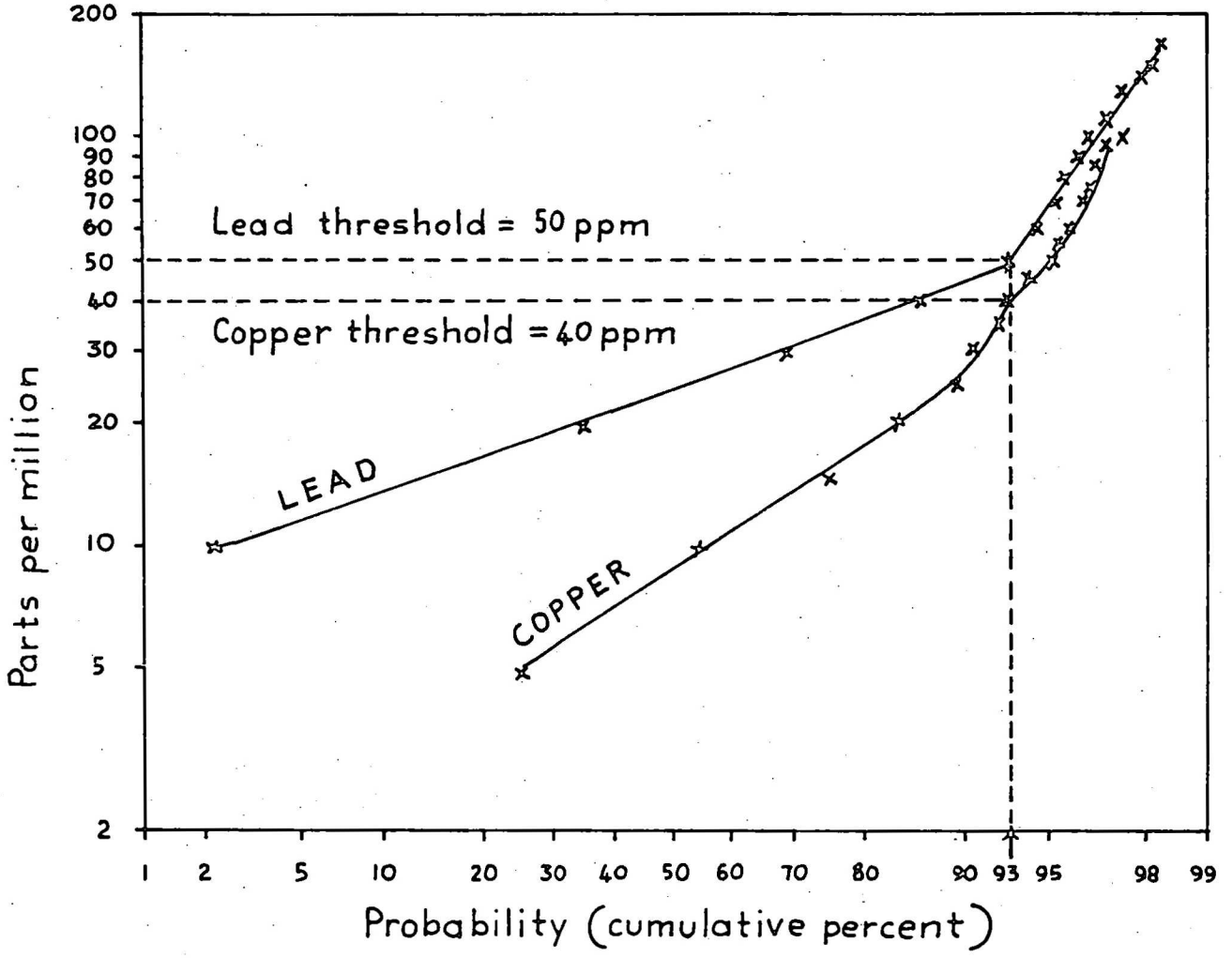


Fig.3: Log-probability cumulative frequency diagrams for lead and copper in the soils of the Big Reef / Two Micks mines area .

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plausible to assert, therefore, that the percentage of samples anomalous in copper is the same as the percentage anomalous in lead. It is on this premise that the interpretation shown in Figure 3 is based. When this procedure is adopted a threshold value for copper of 40 ppm is obtained.

Bismuth

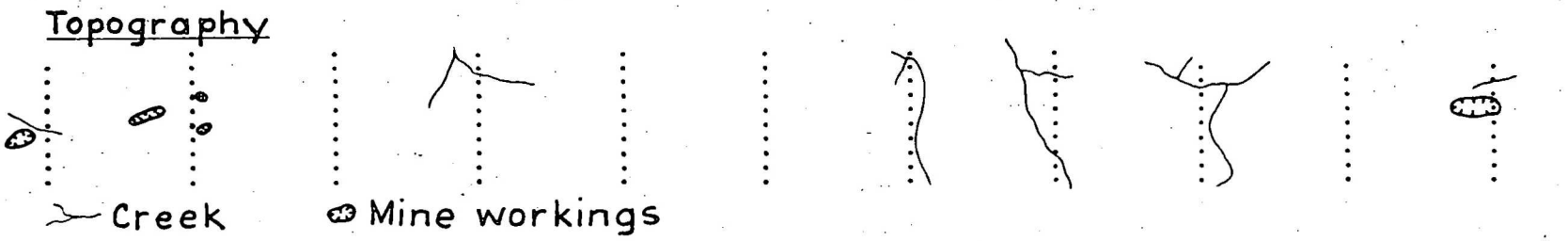
Bismuth, like gold, was detected in relatively few samples and statistical analysis of bismuth values is not possible. A minimum value of 6 ppm would appear realistic for distinguishing soils anomalous in bismuth, however.

Anomalies delineated by the survey

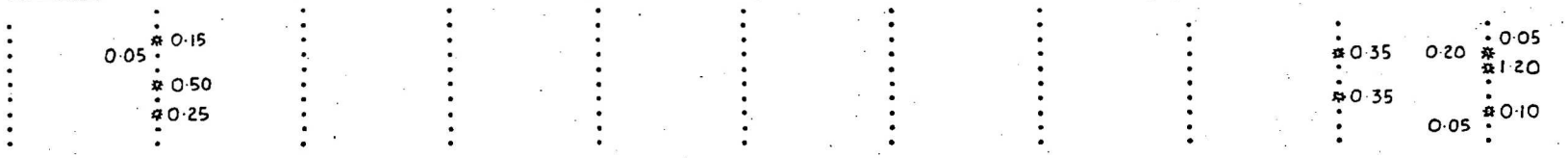
Gold, lead, copper, and bismuth results for the three soil grids are shown in Figures 4-6. Anomalous values (defined using the threshold values established in the previous section) are indicated by asterisks. The more important anomalies are emphasized in Figure 7 which highlights those samples enriched in two or more of the four 'critical' elements. Of the nine anomalies that emerge, four (anomalies 1, 2, 4, and 7) can be confidently attributed to known mineralization or significant previous mining activity. The fact that mercury was detected at anomaly 5 also suggests mining contamination. The remaining anomalies possibly indicate new lodes. Anomaly 8 is the most interesting from an economic viewpoint. Anomaly 6 is difficult to evaluate as it lies on a grid extremity and little can be said about its areal extent. It probably deserves closer scrutiny, however. Anomalies 3 and 9 are confined to a single sample and would appear to be of little consequence.

CONCLUSIONS

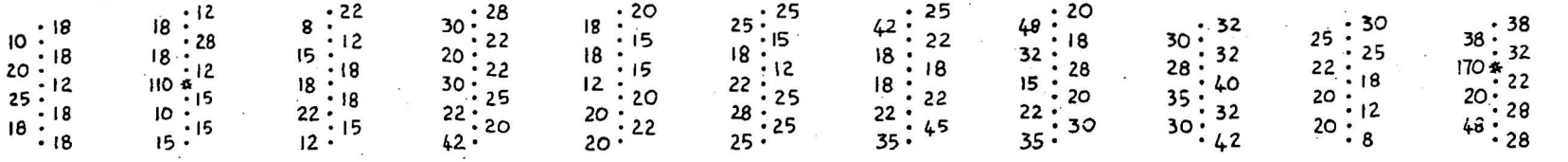
In the Big Reef/Two Micks mines area a number of gold, lead, copper, and bismuth soil anomalies have been outlined. Some of these are obviously related to known gold deposits, others may indicate previously undetected lodes. These latter anomalies are small and any associated mineralization is unlikely to prove of economic significance. The fact that anomalous zones were delineated, however, indicates that soil sampling is potentially capable of locating more important deposits in other areas.



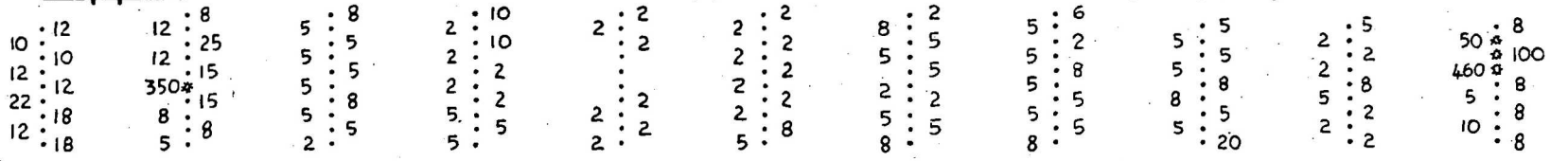
Gold — where no value shown gold was not detected (<0·05 ppm)



Lead



Copper — where no value shown copper was not detected (<2 ppm)



Bismuth — where no value shown bismuth was not detected (<4 ppm)

Fig. 4: Analytical results — grid 1. All values are in ppm.

0 100 200
Metres

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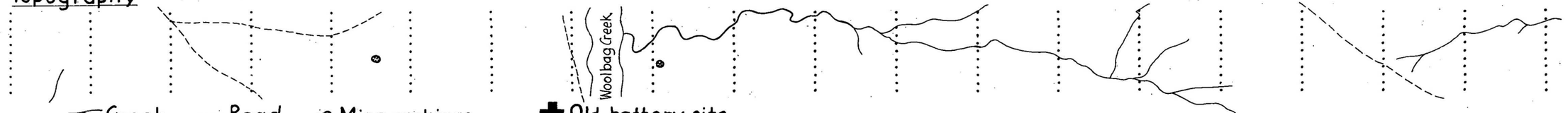
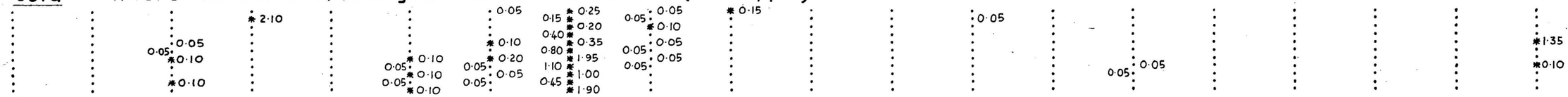
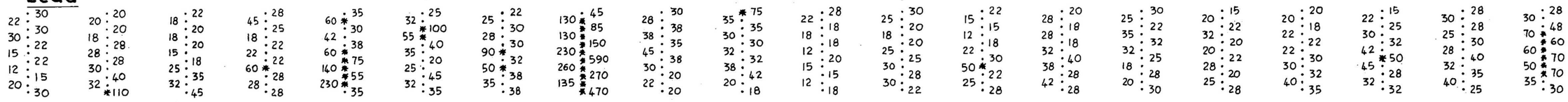
Topography



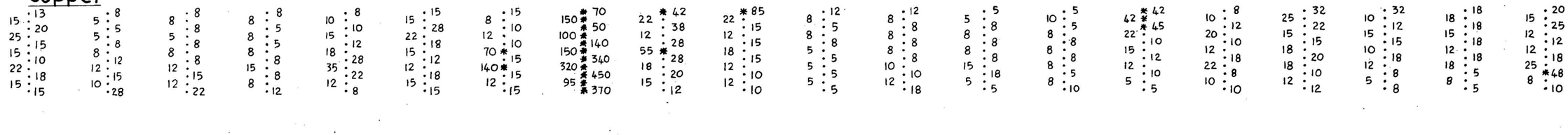
Gold — where no value shown gold was not detected (< 0.05 ppm)



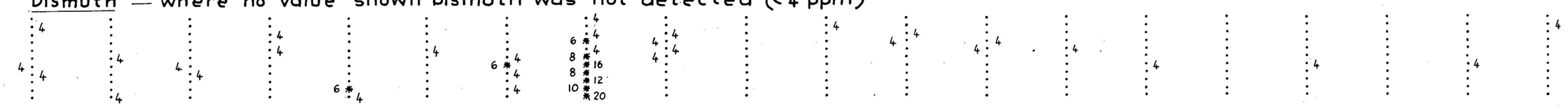
Lead



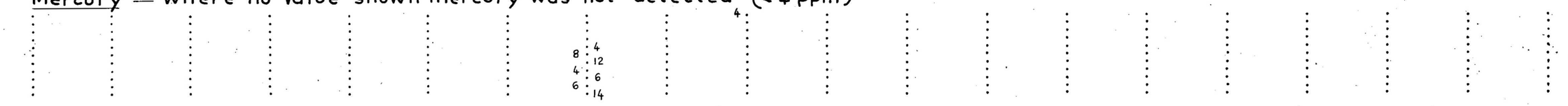
Copper



Bismuth — where no value shown bismuth was not detected (< 4 ppm)



Mercury — where no value shown mercury was not detected (< 4 ppm)



Silver — where no value shown silver was not detected (< 1 ppm)

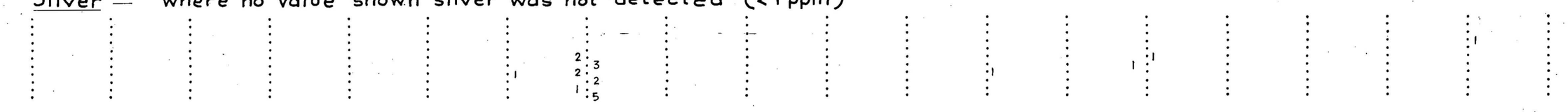


Fig. 5: Analytical results-grid 2. All values are in ppm.

0 100 200 300
Metres

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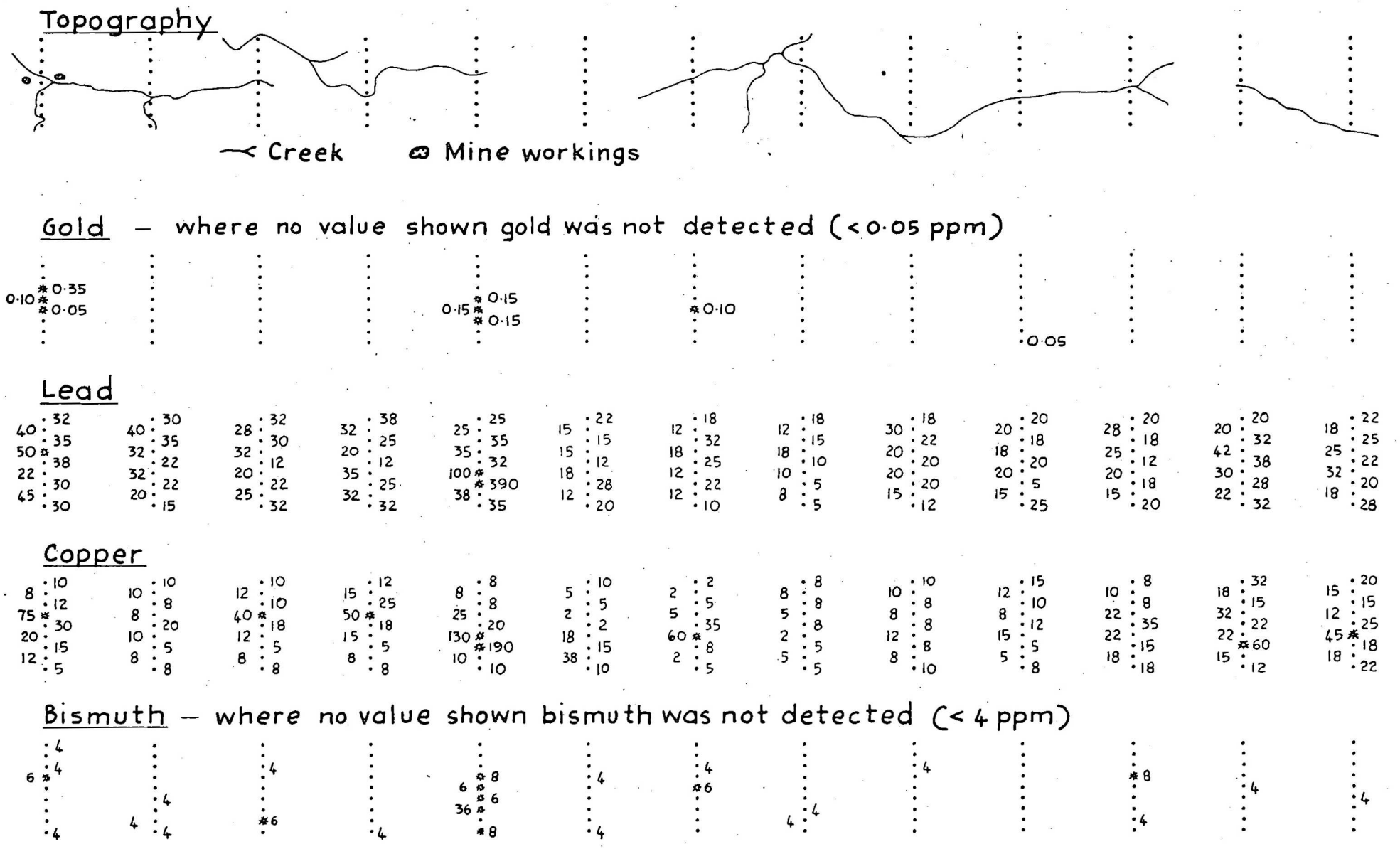

Fig. 6: Analytical results – grid 3. All values are in ppm.

0 100 200
Metres

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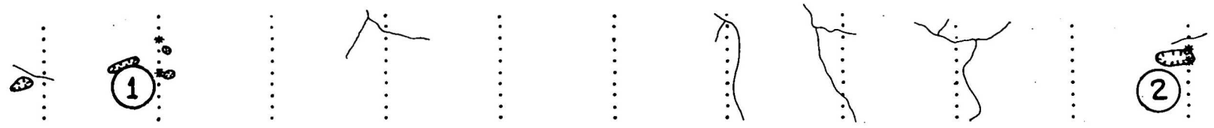
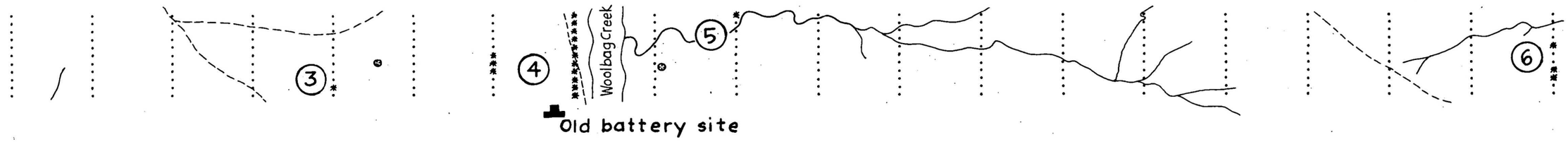
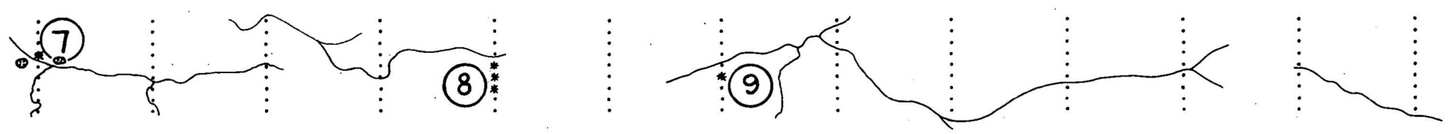
Grid 1



Grid 2



Grid 3



0 100 200 300
Metres

Creek. ---- Road. Mine workings. (1) Number by which anomaly referred to in text.

Fig. 7 : More significant anomalies delineated by the survey. Asterisks indicate samples anomalous in two or more of the following elements – gold, lead, copper, and bismuth.

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During any future survey of this type lead and copper determinations would probably suffice and analytical costs could be kept to about $1 per sample. Any areas where soils contain 50 ppm or more of lead and 40 ppm or more of copper should be set aside for follow-up work. Considerably more expensive and less precise gold and bismuth determinations could not really be justified during the initial stages of the exploration program.

Although the gold deposits of the Forsayth region are not large, a modest mining operation might be possible if several reefs were worked concurrently and the ore treated at a central mill. A combination of additional reserves in previously worked ore shoots and new reserves in as yet undetected lodes would probably be needed to sustain such an operation. As few of the mines were worked systematically below the water table the presence of the former is likely, the discovery of new shoots will depend on the availability of cheap, reliable exploration methods. Although geophysical techniques may prove useful in certain applications (Wilson, in prep.), these methods are relatively expensive. In addition, interpretation is hampered by the abundant graphite that occurs in the Forsayth area. Geochemical soil sampling appears a more attractive proposition for detecting near-surface mineralization.

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