

Application of soil geochemistry to the detection of Sb-Au mineralization in the Buffalo Reef Area, Kuala Medang, Pahang

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Abstract: Surface and underground prospecting for gold deposits carried out during the early 1930s in the Buffalo Reef area uncovered N-S trending lenses composed of quartz and stibnite, located in metamorphosed argillaceous sediments. Since then, extensive surface and some underground mining activities have been carried out for gold and antimony. A ridge and spur soil geochemical survey was carried out in areas that have not been disturbed by such activities. The survey lines were oriented approximately E-W, perpendicular to the regional structure and reported lodes in the area and samples were collected at an interval of 10 m. The minus 80 mesh fraction of the samples were analyzed for antimony and arsenic. The results which were then plotted on a map, indicated the presence of a significant zone of soil anomaly with a N-S trend. A trenching programme across this zone was then embarked upon and this revealed the presence of a prominent gossanized gold-stibnite-quartz style of mineralization.

INTRODUCTION

Soil geochemistry is an important exploration tool and is very widely used, particularly in areas of deep residual cover and sparse outcrops. In every successful soil survey, there is a unique combination of sampling pattern, sampling procedure, choice of sample preparation and analysis as well as an interpretation method, that ultimately delineates an area for detailed follow-up work.

Even in well prospected areas, new surveys of a local scale, analyses of different elements and other parameters with more advanced interpretative techniques prove to be useful (Thornton and Howarth, 1986). In Malaysia, the soil surveys are generally carried out after some work on a reconnaissance level, and in combination with other geochemical exploration methods (Lee and Weber, 1984; Chu and Singh, 1984; Ong and Lee, 1986). In these soil surveys, about 4 to 14 elements were analysed in order to delineate an area for follow-up work.

The Buffalo Reef area is located in the Kuala Medang District, about 55 km to the north of Raub in Pahang and was previously studied by Richardson (1949). The northeastern part of this area has a record of mining activity that dates back to the early part of this century while the central and southern parts are relatively unexplored. The northeastern part was first prospected for gold in 1900 but during the 1970s antimony, which occurs in the form of stibnite within gold bearing veins, was the main product exploited from this area.

The geology and mineralization of this area were studied and based on this study, a plan was formulated to explore the central and southern parts for a similar kind of mineralization.

GEOLOGY

The Buffalo Reef area is located at the boundary of the Bentong and Raub Groups (Fig. 1). The western highlands is underlain by conglomerates belonging to the Bentong Group. The conglomerates contain rounded clasts with diameters up to 10 cm and 30 to 40% of arenaceous matrix. They form massive outcrops with ill defined stratification.

The rocks from the Raub Group are exposed to the east of the highlands occupied by the conglomerates. The lithology of this group within the Buffalo Reef area consists mainly of phyllite, together with subordinate amounts of tuffaceous rocks and limestones. The tuffaceous materials are interbedded with the phyllite and they are both highly weathered. The limestones are found beneath a cover of alluvium.

The lowlands to the east of the Raub Group is largely covered by alluvial, colluvial and eluvial materials, which have been strongly disturbed by mining. The Raub Group underlies these superficial deposits.

The bedding of the rocks within this area generally strikes between 340°N and 350°N, and dip between 65°-75° towards the east. Most of the quartz veins are parallel to the bedding. This approximately N-S trend is similar to the regional structural trend.

MINERALIZATION

Surface mapping and trenching of the Buffalo Reef area has revealed the presence of N-S trending parallel mineralized zones marked by quartz veins which carry significant gold values. On a regional basis, these N-S trending zone can be correlated to the Selinsing mine in the south, and probably the gold mineralized Cheroh felsite dike as well as the

lode channels in Bukit Koman, Raub. These veins are interpreted to have originated as a regional discontinuous deep N-S fracture system tapping mineralizing fluids from below (Yeap, 1991).

The mineralization in the Buffalo Reef area is represented by several lines of small discontinuous gold and sulphide bearing quartz lenses. The quartz lenses in a single line may have a maximum width of about 50 cm and can be traced over a distance of

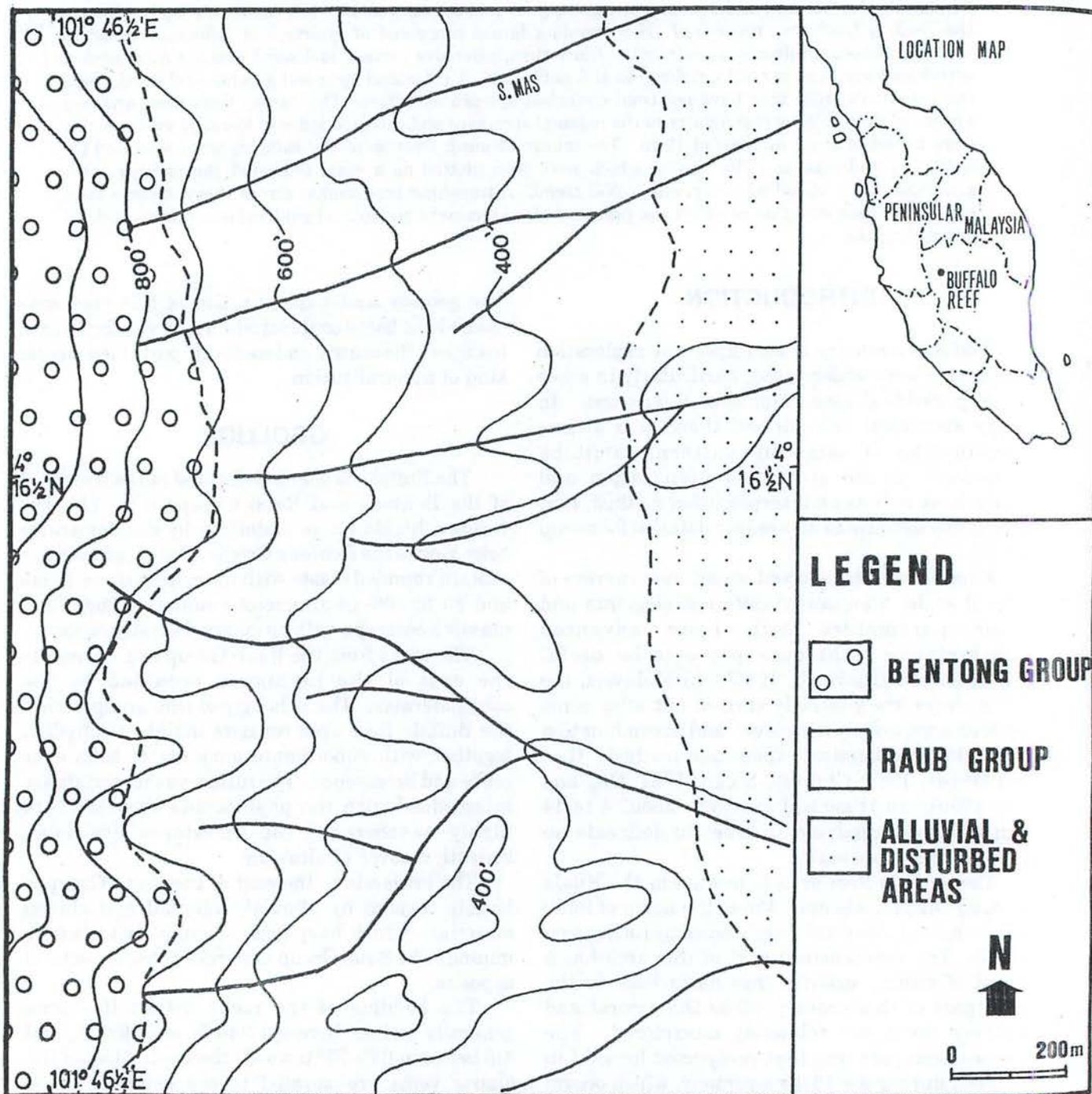


Figure 1. Sketch map showing the distribution of the Bentong and Raub Groups as well as the alluvial and disturbed zones in the Buffalo Reef area, Kuala Medang, Pahang.

50 to 60 metres, the most. Pinching and swelling occurs vertically as well as horizontally. The veins also tend to swarm where the width of a swarm zone may extend up to 20 m. Generally, the veins in the centre of a swarm tend to be thicker, though the quartz lenses may not necessarily be located at the centre of a swarm, or even within a swarm zone.

The veins here have a trend of 340°N and generally dip steeply to the east, parallel to the bedding. Vertical veins are also common. Conjugate veins, with an average thickness of 5 to 7 cm are also found in some lines of mineralization.

Under the microscope, the ore is observed to be generally coarse. The most common minerals in un-oxidized ores are quartz and stibnite. Early quartz are commonly replaced and veined by second generation quartz and stibnite. Gold is found as replacement or as veinlets together with stibnite, cutting quartz. The size of gold ranges from about 145 microns to 5 microns. Gold in the oxidized ores are associated with antimony ochre. Some of the handspecimens are vuggy in nature due to the weathering out of sulphides.

GEOCHEMICAL SOIL SURVEY

The Approach

There is a marked lack of outcrops in the central and southern, previously unexplored part of the Buffalo Reef area, as it is covered by thick residual soil. Therefore, it was decided that a geochemical soil survey is best suited to detect the presence of mineralization here. Given the nature of the mineralization in the northeastern part of this area, where gold is intimately associated with stibnite and arsenopyrite, and the fact that arsenic has been proven to be a useful pathfinder for gold (Rose *et al.*, 1979), the soil samples were analysed for only two elements; arsenic and antimony.

The samples were not analysed for gold because this would entail the collection of a minimum of 500 g of soil per sampling site, in a country where the precise relationship of the soil profile to gold mineralization is at best, unknown. Furthermore, the variation of gold content in sub-samples for the analysis generally produces misleading results, making it very difficult to draw any conclusions for follow-up work (Thornton and Howarth, 1986). Besides, the analysis of gold would not be economically practical compared to the analysis of arsenic and antimony, for an exploration programme of this scale.

Sampling and Analysis

A ridge and spur soil survey was carried out in the central and southern parts of the Buffalo Reef

area. The location of the survey lines are shown in Figure 2. The survey was generally restricted to areas underlain by rock types from the Raub Group as geological records indicate that mineralization is absent or very poor within the conglomerates from the Bentong Group.

The sampling interval was set at 10 m as the width of a vein swarm in the northeastern part is known to extend up to 20 m. Sampling points were fixed using a hip-chain and a compass. Eight survey lines were laid approximately E-W, perpendicular to the veins, and a total of 322 samples were collected.

Soil samples were collected from horizon B, at a depth of 30 to 45 cm, with the aid of a hoe (changkul). The soil in contact with the metal head of the hoe were carefully discarded and only the central uncontaminated portions were collected. About 30 g of soil was collected at each sampling site and placed in labelled plastic bags.

The soil samples were air dried and disaggregated in the laboratory. They were later separated using a nylon sieve, where the minus 80 fraction was retained for analysis. Arsenic and antimony were analysed using the Gutzeit Head method and the hot acid digestion — AAS method, respectively.

Results and Interpretation

The results of the soil analysis for arsenic and antimony were used to produce cumulative probability plots and contour maps. A computer was utilized to generate the contours, where the kriging method was applied, using arbitrary coordinates with intervals of 50 m and origins located in the south east corner of the map.

The threshold value was set at the 95th percentile for this survey, where the values of arsenic and antimony are 30 ppm and 20 ppm, respectively. This value was selected because it furnished the largest cluster of anomalies and the least number of isolated highs, when the data were plotted on the map and contoured. The contour intervals were based on the natural break of data observed on the cumulative probability plots, at the 95, 97.5 and 99th percentile (Fig. 3 and Table 1).

Using these plots, a significant zone of arsenic and antimony anomaly was recognized as highlighted in Figure 4. A three dimensional surface representation of the values are shown in Figure 5. This overlapping zone trends N-S and is located at the eastern part of the area surveyed. It has a minimum combined length and width of 400 m and 100 m, respectively.

This zone of anomaly was interpreted to represent either a new area of mineralization, or a continuation of the mineralization in the

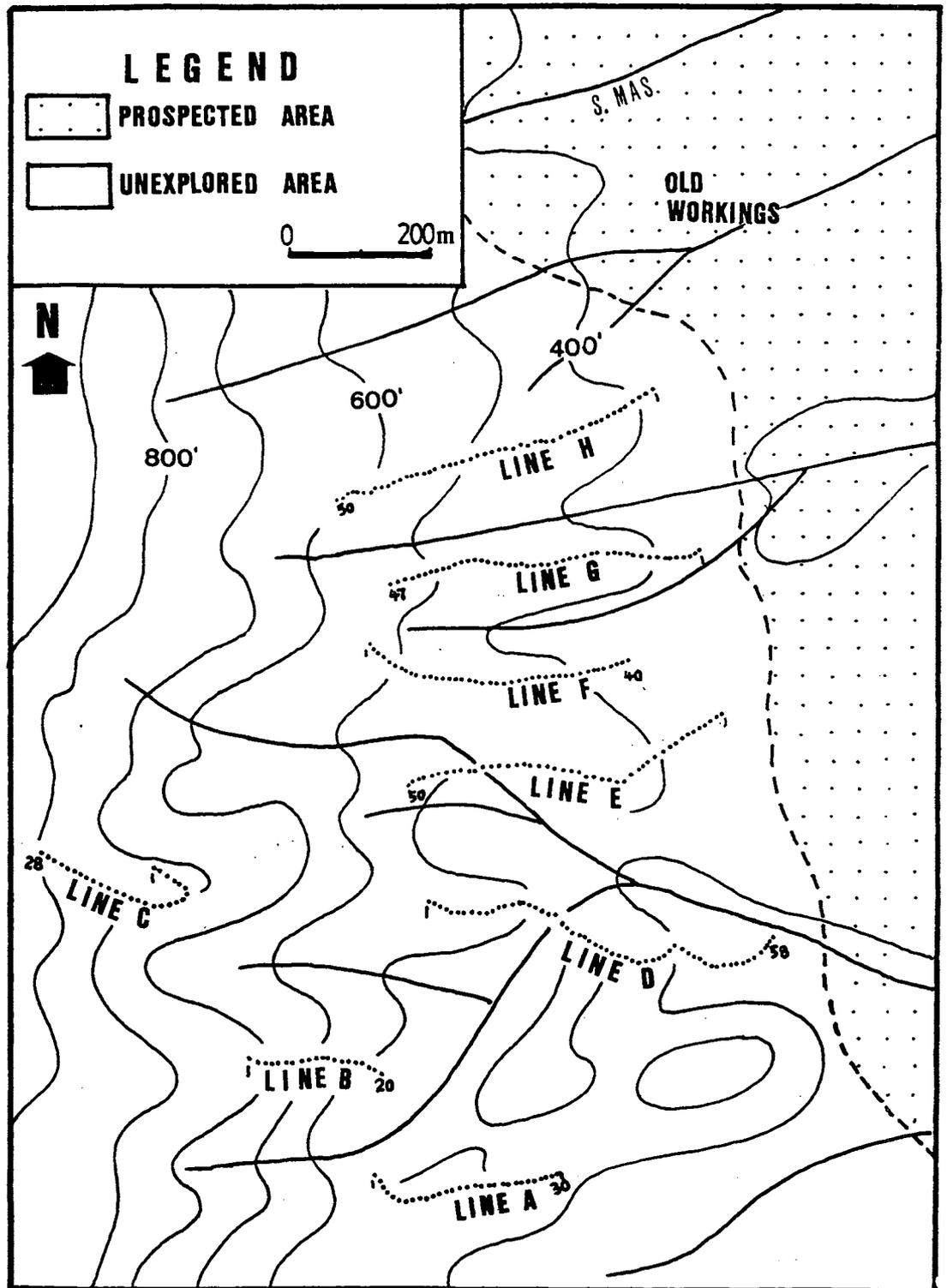


Figure 2. Sketch map showing the location of the geochemical soil survey lines concentrated mainly in the central and southern parts of the Buffalo Reef area.

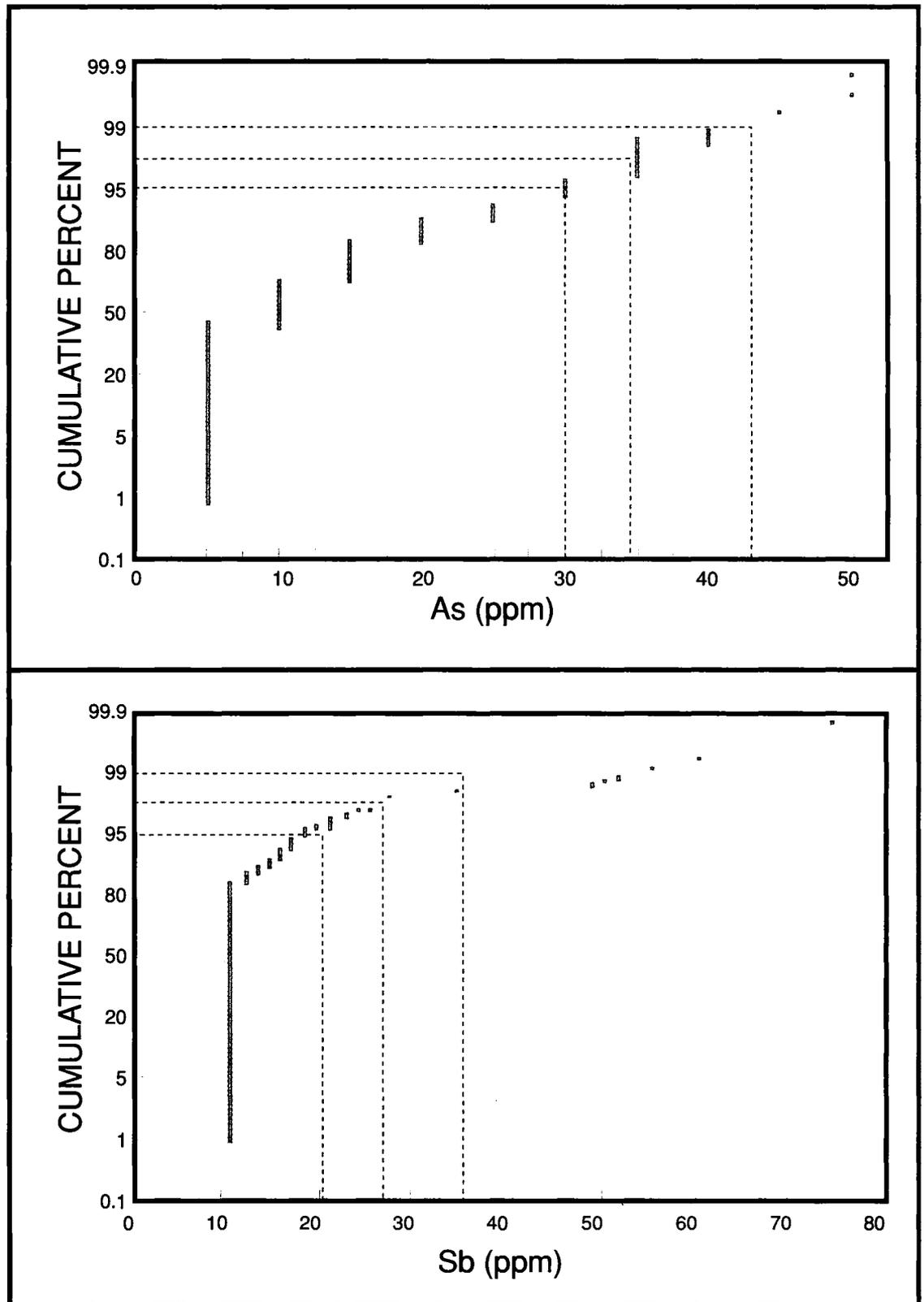


Figure 3. Cumulative probability plots for arsenic (A) and antimony (B), showing the natural break of data at the 95, 97.5 and 99th percentiles, which were used to define contour intervals.

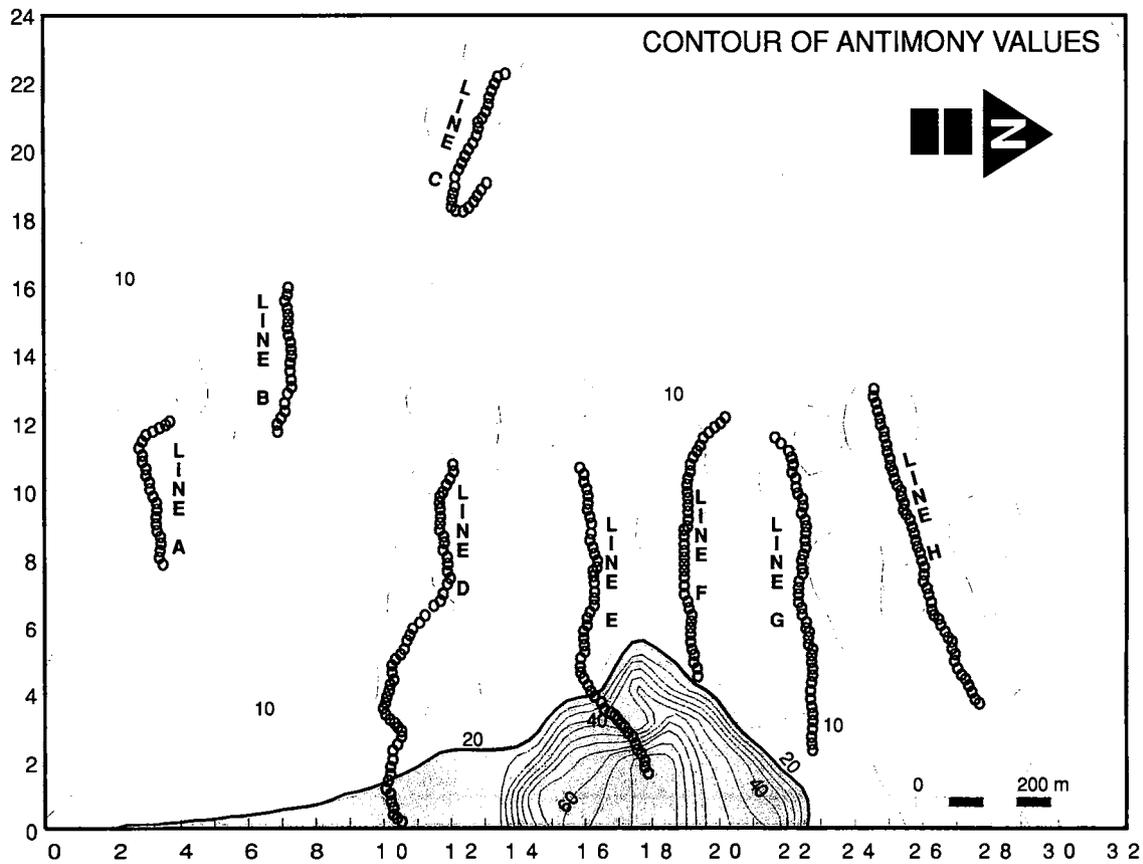
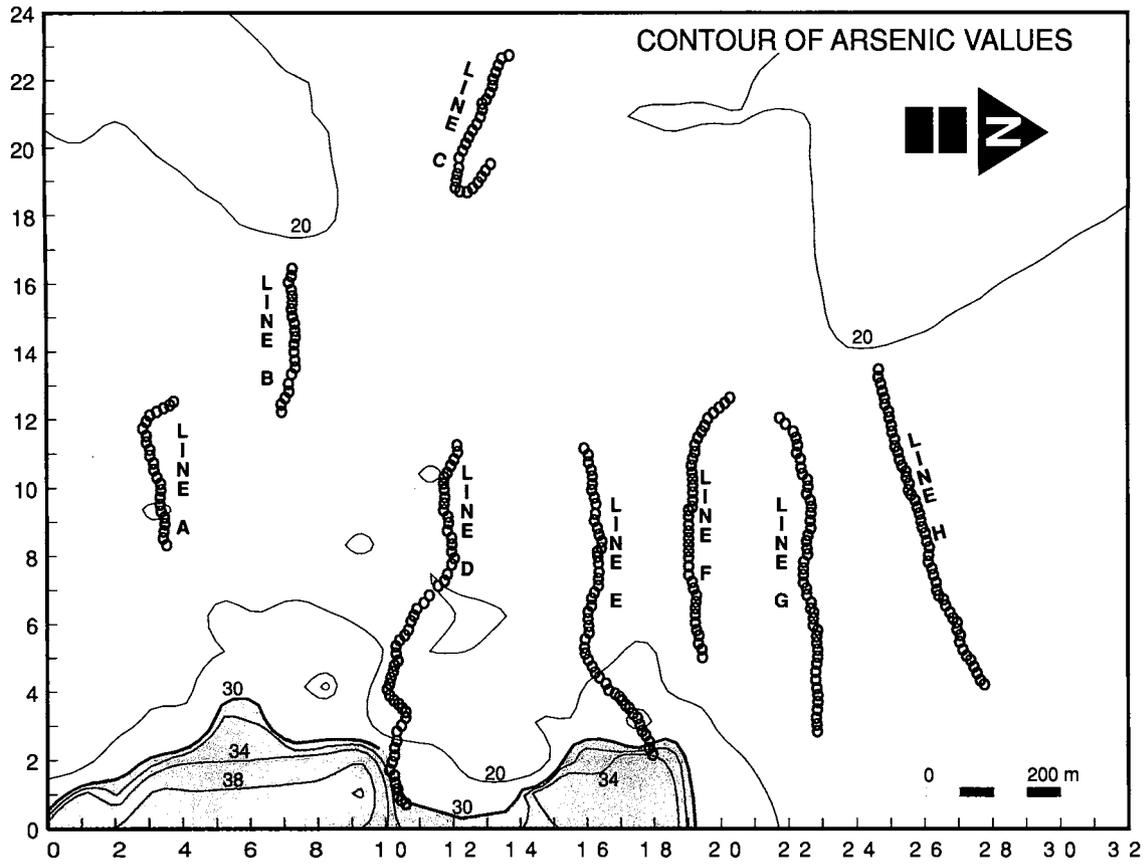


Figure 4. Contour maps of the arsenic (A) and antimony (B) values. The thick contour lines represent the threshold level; 30 ppm for arsenic and 20 ppm for antimony.

Table 1. The threshold level and basic sub-divisions of the arsenic and antimony values that were used to produce the contour maps.

Classes (percentile)	Arsenic (ppm)	Antimony (ppm)
< 95 (Threshold value)	< 30	< 20
97-97.5	30-34	20-25
97.5-99	35-42	26-34
> 99	> 43	> 35

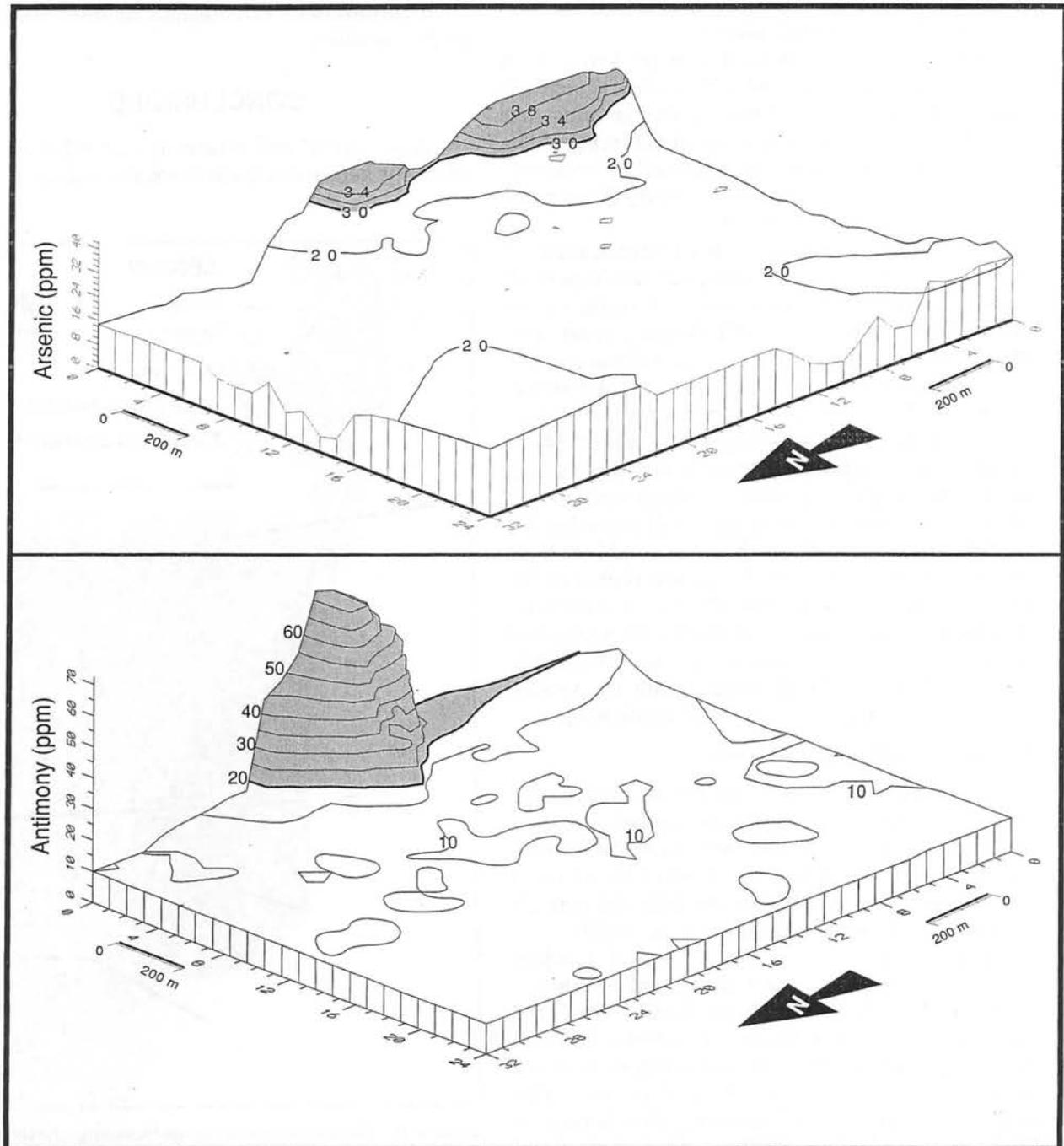


Figure 5. A three dimensional surface representation of the arsenic (A) and antimony (B) values. The threshold level is marked by thick lines.

northeastern part that has been displaced by a fault. Based on this, a trenching programme was embarked upon to confirm the presence of mineralization below the geochemical soil anomaly.

Follow-up Trenching

A total of five trenches, trending approximately E-W, and five test pits were laid over and to the west of the zones of arsenic and antimony anomalies. The trenches and test pits have an average depth of about 5 m and their locations are shown in Figure 6. Generally, these trenches cut the B horizon, but highly weathered bedrock (C horizon) were reached in several places.

The trenches revealed the presence of a prominent main vein zone with a strike length of about 70 m and several discontinuous veins that are diffused over a wider area in the south. The zone of gold and stibnite mineralization swells out from about 10 m in the north to nearly 50 m in the south, over a length of 120 m.

In the north, there are at least 3 thick silicified zones, up to nearly 3 m across, but this tapers off to a single zone of only about 2 m thick, in the south. The southern part of this zone, apart from the main vein, consists of less than a dozen parallel discontinuous veins, with a maximum thickness of about 7 to 10 cm, diffused over a width of 50 m.

The veins here generally strike about 340°N and dip steeply to the west, though some are vertical. However, a majority of the veins have inconsistent orientations due to displacement by soil creep (Fig. 7).

The weathering of iron bearing sulphides have resulted in the formation of a gossan that caps the veins as shown in the profile (Fig. 7). This material is sometimes up to about 6 m thick over a length of 25 m. It is also found enclosing some of the less weathered veins located lower within the profile, indicating an on going process of weathering.

Surficial Dispersion Pattern

The terminology that is used in the explanation of surficial patterns is purely descriptive. Patterns that develop more or less directly over the bedrock are said to be superjacent, as distinct from lateral patterns that are displaced to one side and entirely underlain by barren rock (Rose *et al.*, 1979).

Superjacent patterns are typical of residual overburden unless there is a directional movement, as in the case of the Buffalo Reef area. Here, the zones of arsenic and antimony anomalies were found to be displaced to the east and south-east of the actual zone of mineralization (Fig. 6). The dispersion of arsenic and antimony in B horizon of the soil seem to be towards the north-east, east and south-east directions, away from the actual mineralization (Figure 8).

Topographically, the zone of anomaly and the actual zone of mineralization is located midway of a slope (Fig. 9). Therefore, this lateral displacement of the Sb and As anomalies could be due to dispersion, where the combination of weathering and gravity creep has caused a distortion, resulting in the formation of a well developed fan, extending downslope from the zone of mineralization (Fig. 10).

The soil which moved down the slope by slow lateral creep under the influence of gravity and produced this laterally displaced anomaly, also caused the creeping of veins. This has resulted in their inconsistent orientations as observed in the trench profiles.

CONCLUSIONS

A successful and relatively cost effective ridge and spur geochemical survey was conducted in the

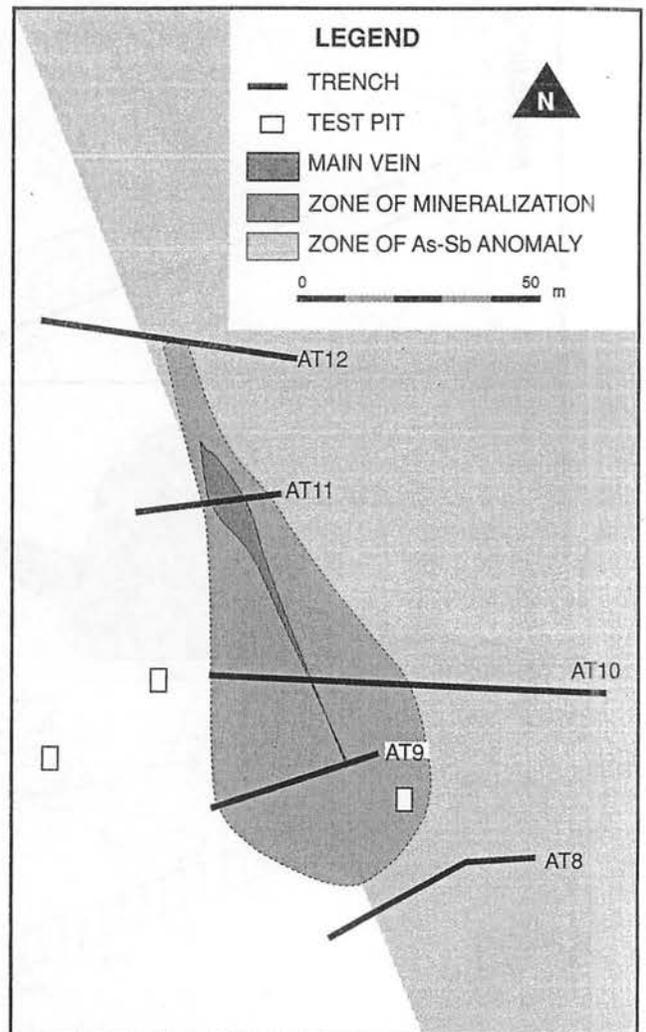


Figure 6. Sketch map showing the location of the trenches and three of the five test pits. The zone of arsenic and antimony soil anomalies are displaced to the east of the zone of mineralization.

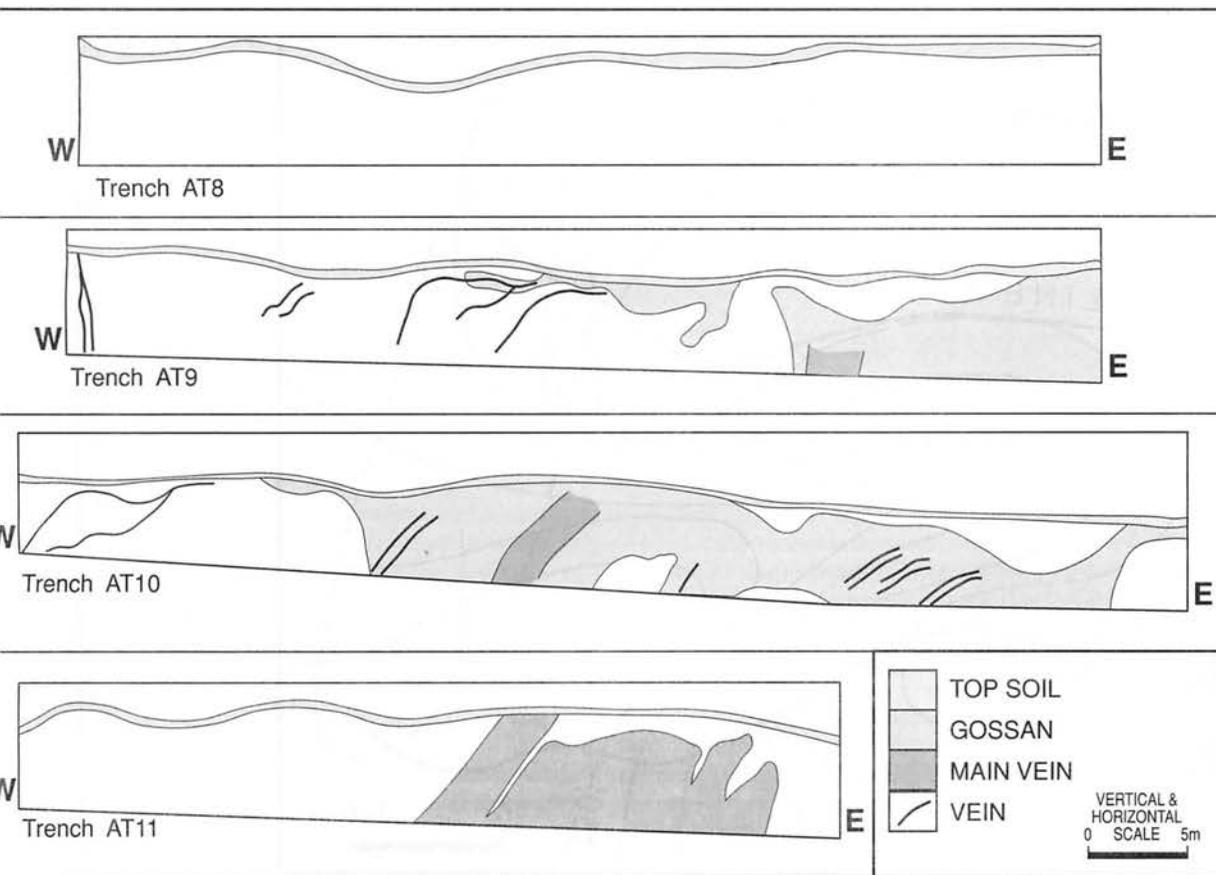


Figure 7. The profile of trenches AT8, AT9, AT10 and AT11. The veins in trenches AT9 and AT10 are capped by goossan and have inconsistent orientations due to slow lateral creep under the influence of gravity, unlike the veins AT11.

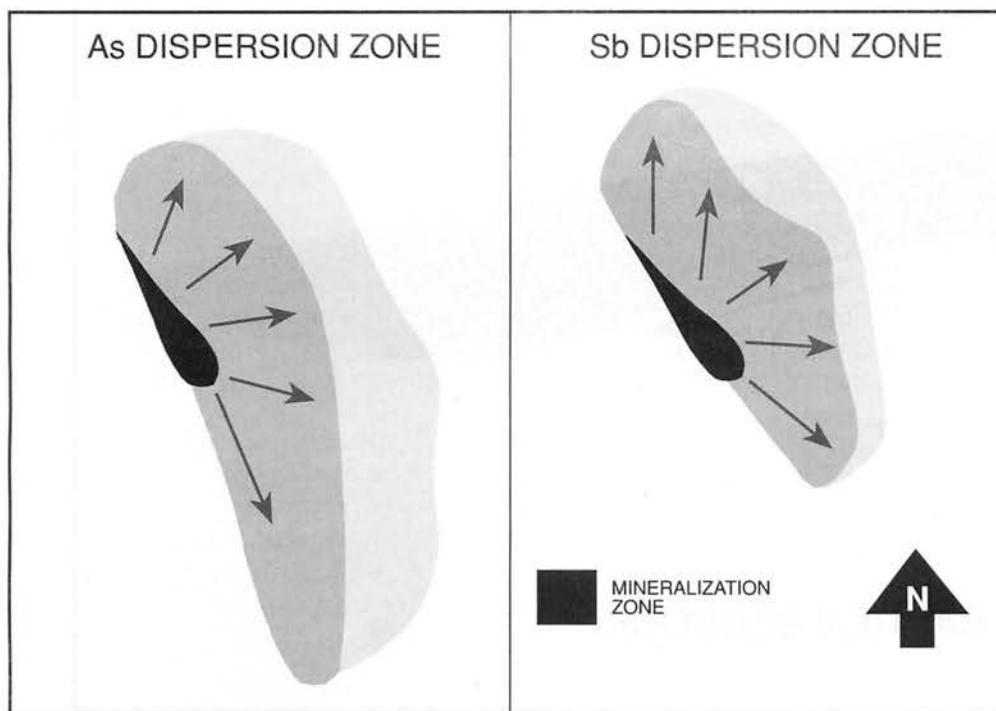


Figure 8. An illustration of the arsenic and antimony dispersion zones relative to the zone of mineralization. The arrows indicate the directions of dispersion.

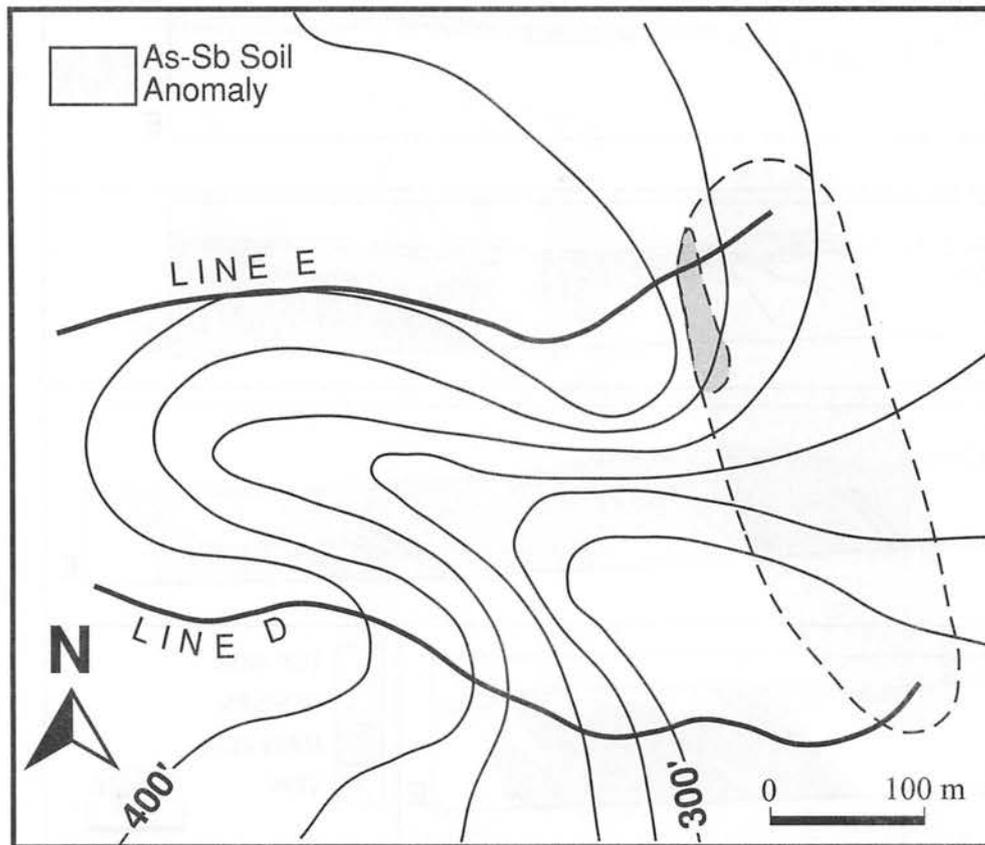


Figure 9. Diagram showing the combined zones of arsenic and antimony soil anomalies, located midway of a slope. The area of the soil anomaly is at least 10 fold that of the actual zone of mineralization.

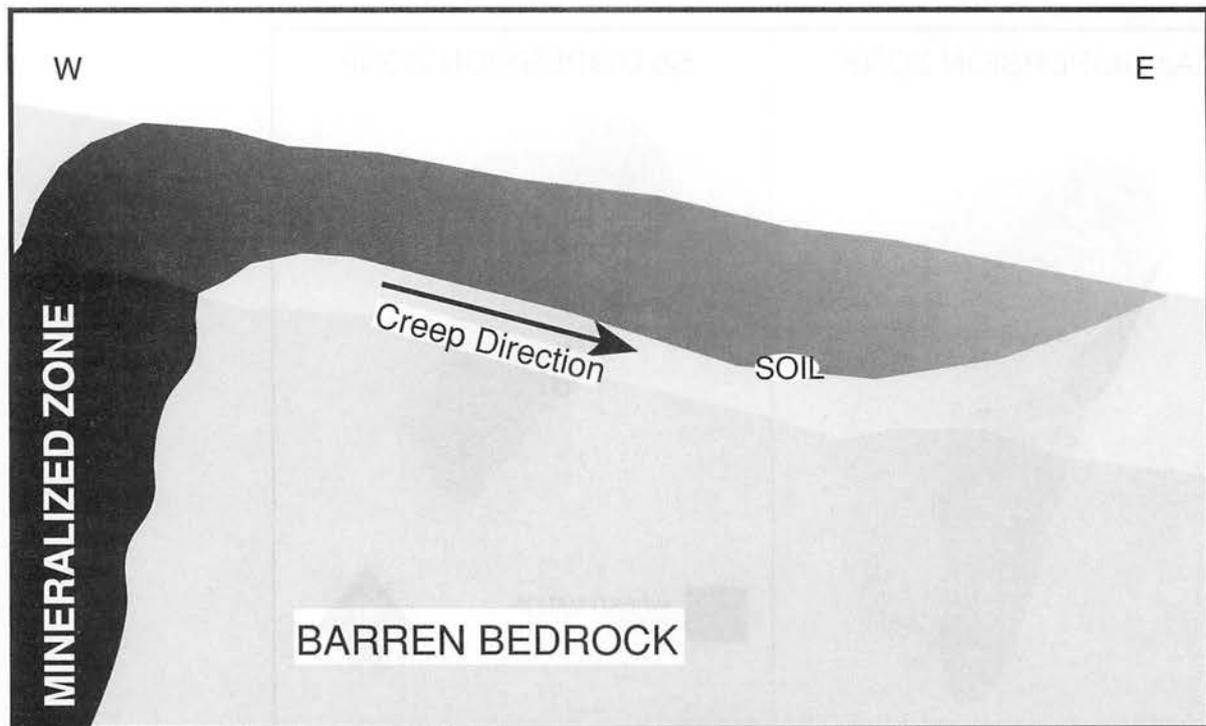


Figure 10. A schematic E-W section of the geochemical soil anomaly showing the formation of a well developed fan extending downslope from the mineralization under the influence of gravity.

southern and central parts of the Buffalo Reef area. Based on the nature of the mineralization in the northeastern part of the area, the soil samples were analysed only for arsenic and antimony. The results of the analyses clearly delineated an overlapping N-S trending zone of arsenic and antimony anomaly, which was subsequently trenched across to reveal a significant zone of gold and stibnite mineralization. The extensive dispersion of arsenic and antimony was crucial in the discovery of this mineralization, where the zone of anomaly was at least 10 fold in area compared to the actual mineralized zone.

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