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Geochemical studies around the Tekka Area, Perak, Peninsular Malaysia

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Abstract: This paper is concerned with the application of some geochemical methods to the establishment of certain multi-mineralic veins at Tekka which suboutcrop beneath a residual soil cover.

Soil samples, collected along three traverses on Tekka Hill, were analysed for tin, arsenic, cold-extractable and total fluoride, tungsten, copper, lead and zinc. The arsenic, cold-extractable and total fluoride and tungsten anomalies that were established correlate very well with the tin ones, and so these elements may well be useful pathfinders for tin deposits both at Tekka and in similar areas elsewhere. Determination of the fluoride content of soils as an aid to the search for suboutcropping mineral deposits has never before been investigated in Malaysia. The encouraging results obtained at Tekka give good reason for thinking that it could be usefully employed for this purpose, particularly if the rapid and economical cold-extractable method of analysis is employed.

Work at Tekka has also demonstrated that soil conductivity measurements facilitated the tracing of suboutcropping stanniferous sulphide deposits there, and so the use of this technique should be further investigated should mineralisation similar to that at Tekka occur elsewhere.

INTRODUCTION

After the detailed geology, structure and mineralogy of the mineralised vein swarms at Tekka were established, a geochemical study was carried out at Tekka Hill to ascertain the dispersion patterns of a selected number of elements and the search for similar stanniferous suboutcropping veins of the same kind.

Various elements were tested, namely As, W, Cu, Pb and Zn, while fluoride analysis and soil conductivity measurements were introduced for the first time in Malaysia to establish their possible role as pathfinders for the Tekka type of mineralisation.

GEOCHEMICAL SOIL SURVEY

Details of study

A geochemical soil survey was carried out on the western and south-west portions of Tekka Hill. Soil samples were collected from the B-horizon at points 50 feet (15.24 m) apart along three traverses (Fig. 1). The soils were also sampled at various depths from four soil profiles, and further samples were collected from the B-horizon at various distances from a mineralised vein.

In the laboratory, the soils were analysed for tin, arsenic, cold-extractable and total fluoride, tungsten, copper, lead and zinc, and soil conductivity measurements were also carried out. For analysis the minus-80-mesh (B.S.S.) fraction of the oven-

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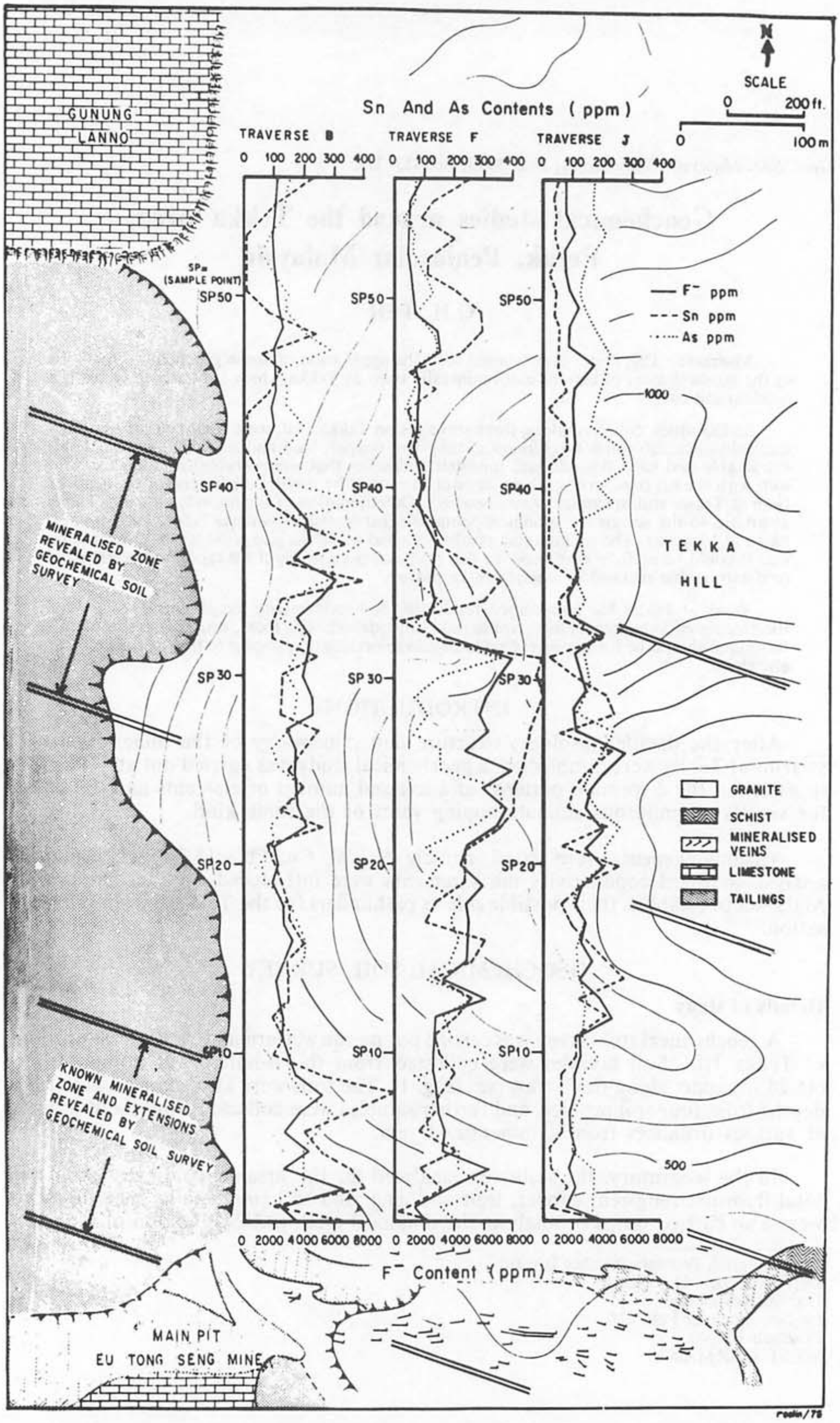

Fig. 1. The fluoride tin and arsenic content of the minus–80–mesh fraction of B–horizon soil samples from Tekka Hill, Perak (after Teh et. al. 1975).

dried sample was used. Published analytical procedures were used and were modified, where necessary, to obtain optimum results from the Tekka soils.

Even though tin is the only metal of economic interest, the distribution patterns, in the soils, of the other associated elements were investigated to see if they might facilitate the search for suboutcropping tin deposits at Tekka. It was felt that the results of this study might assist others planning geochemical surveys for the search for suboutcropping tin deposits elsewhere in Malaysia.

THE ANALYTICAL ASPECT

Tin Analysis

The wet, colorimetric method of Stanton (1966, pp. 81–84) was used.

Arsenic Analysis

Stanton's modified Gutzeit method was employed for the determination of arsenic (1966, pp. 44–47).

Tungsten Analysis

The zinc dithiol method of Stanton (1970, pp. 59–60) was selected for the determination of tungsten.

Cooper, Lead and Zinc Analyses

Copper, lead and zinc were determined by Atomic Absorption Spectrometry (A.S.S.).

Detailed accounts of the analytical procedures and reagents appear in Teh (1976).

Fluoride Analysis

During recent years the development of analytical methods in which selective ion electrodes play a key role has permitted a number of elements (fluorine, sulphur, chlorine etc.), of considerable interest to the applied geochemist, to be determined fairly simply and rapidly, over considerable concentration ranges. This prompted the present investigation, which was to consider the possibility of using fluorine as a pathfinder element for primary, suboutcropping tin deposits in Peninsular Malaysia.

A. *Cold-extractable fluoride*

The method for determining cold-extractable fluoride, which was designed by Pluger and Friedrich (1972), was tested and found to be satisfactory. A detailed account of the procedures and reagents appear in Teh, Fung and Hosking (1975) and Teh (1976).

Initial laboratory work was performed on one of the soil samples (F2) to determine the best medium for cold-extractable fluoride analysis. The results indicate that the treatment by 0.01N HCl was the best (see Table 1) and this was similar to that suggested by Pluger and Friedrich (1972).

Replicate cold-extractable fluoride analysis, using this treatment, was then performed on three soil samples (B1, B5 and B14) to test the validity of the method when dealing with local soils. The results (Table 2) show that the relative standard deviation percentages are acceptable for applied geochemical work.

TABLE 1

A comparison of the quantities of fluoride extracted from portions of a minus-80-mesh, B-horizon soil sample (from Tekka) by various leaching agents. (The analysis was made by the fluoride-sensitive electrode method.)

SOIL SAMPLE	SOLUBLE F^- CONTENT (p.p.m.)			
	10^{-3}N NaOH	Water	Buffer	10^{-2}N HCl
F2	7.18	7.80	5.90	14.3

TABLE 2

Standard deviation for replicate fluoride analysis of Tekka soils effected by a fluoride sensitive electrode following a 10^{-2}N HCl leach.

Sample	Mean Value, p.p.m.	n	Standard Deviation p.p.m.	Relative Standard Deviation %
B1	14.92	5	0.85	5.7
B5	5.54	5	0.34	6.1
B14	8.02	5	0.45	5.6

B. *Total-fluoride*

Initially, in an endeavour to determine the total fluoride content of the soils under examination, the total fluoride method of Pluger and Friedrich (1972) was employed, but this was abandoned as replicate analysis with international standard rocks suggested that only c. 60–70 per cent of the total fluoride was extracted (Teh, Fung and Hosking, 1975).

So, the writer's attention was turned to the method of Kesler, van Loon and Bateson (1973) and this, after certain minor modifications, provided acceptable results (Table 3), with the international standards being analysed. A detailed account of the analytical procedure appears in Teh, Fung and Hosking (1975).

C. *Initial Laboratory Work*

Initial laboratory work was carried out to ascertain the minimum amount of ammonium citrate buffer required for the soil samples (F15 was tested) without considerably affecting the ionic strength of the buffer. This was prompted by the large amount of ammonium citrate (45 gm) suggested by Kesler, van Loon and Bateson.

Various amounts of ammonium citrate were used (15 gm, 25 gm and 45 gm) and tests were made with the international standards (Table 4 and Fig. 2). The results indicate that 25 g of ammonium citrate buffer was sufficient for the Tekka soils.

TABLE 3

Comparison of results from two analytical procedures for total fluoride using the selective ion electrode

Sample	Literature Values (p.p.m.)	Method of Kesler, van Loon, Bateson (using ammonium citrate buffer)			Method of Pluger and Friedrich (using citric acid & disodium hydrogen phosphate)		
		Writer's mean (p.p.m.)	Standard deviation (p.p.m.	n	Writer's mean (p.p.m.)	Standard deviation (p.p.m.)	n
(i) USGS–GSP–1 Granodiorite	3900, 3800 4000, 3700	3907	481	6	2185	139	5
(ii) CRPG–GA Granite	440, 487 500	588	88	8	229	28	5

(i) Flanagan, F.J. (1969). US Geological Survey Standards-II. First compilation of data for the new U.S.G.S. rocks. Geochem. et Cosmochimica Acta Vol. 33, pp. 81–120.

(ii) Roubault, M., de La Rouche, H. and Govindaraju, K. (1968). Report (1966–1968) on geochemical standards: Granites GR, GA, GH, Basalt BR, ferriferous Biotite Mica-Fe; Phlogopite Mica-Mg. Sciences de la Terra, Tome XIII, no. 4, pp. 379–404.

TABLE 4

The results of experiments carried out to ascertain the minimum amount of ammonium citrate required when analyzing Tekka soil samples for their fluoride content by a selective ion electrode method.

Sample	Amount of Ammonium citrate (gm.)	Electrode Potential mV			$=E_1-E_3$ mV	Fluoride content by calculation (p.p.m.)
		25 ml. sample solution E_1	+1 ml. *Standard F^-solution E_2	+2 ml. *Standard F^-solution E_3		
Sample	45	60.0	53.9	46.5	13.5	12621
F15	25	64.7	58.8	51.1	13.6	12150
	15	68.8	61.7	53.6	15.2	10810
USGA-GSP-1	45	89.7	84.4	76.6	13.1	3937
Standard	25	95.3	90.0	82.0	13.3	3867
GA	45	141.6	114.7	94.1	47.5	517
Standard	25	147.3	120.3	99.6	47.7	496

*Standard F^- solution contains 96.14 p.p.m. F^-

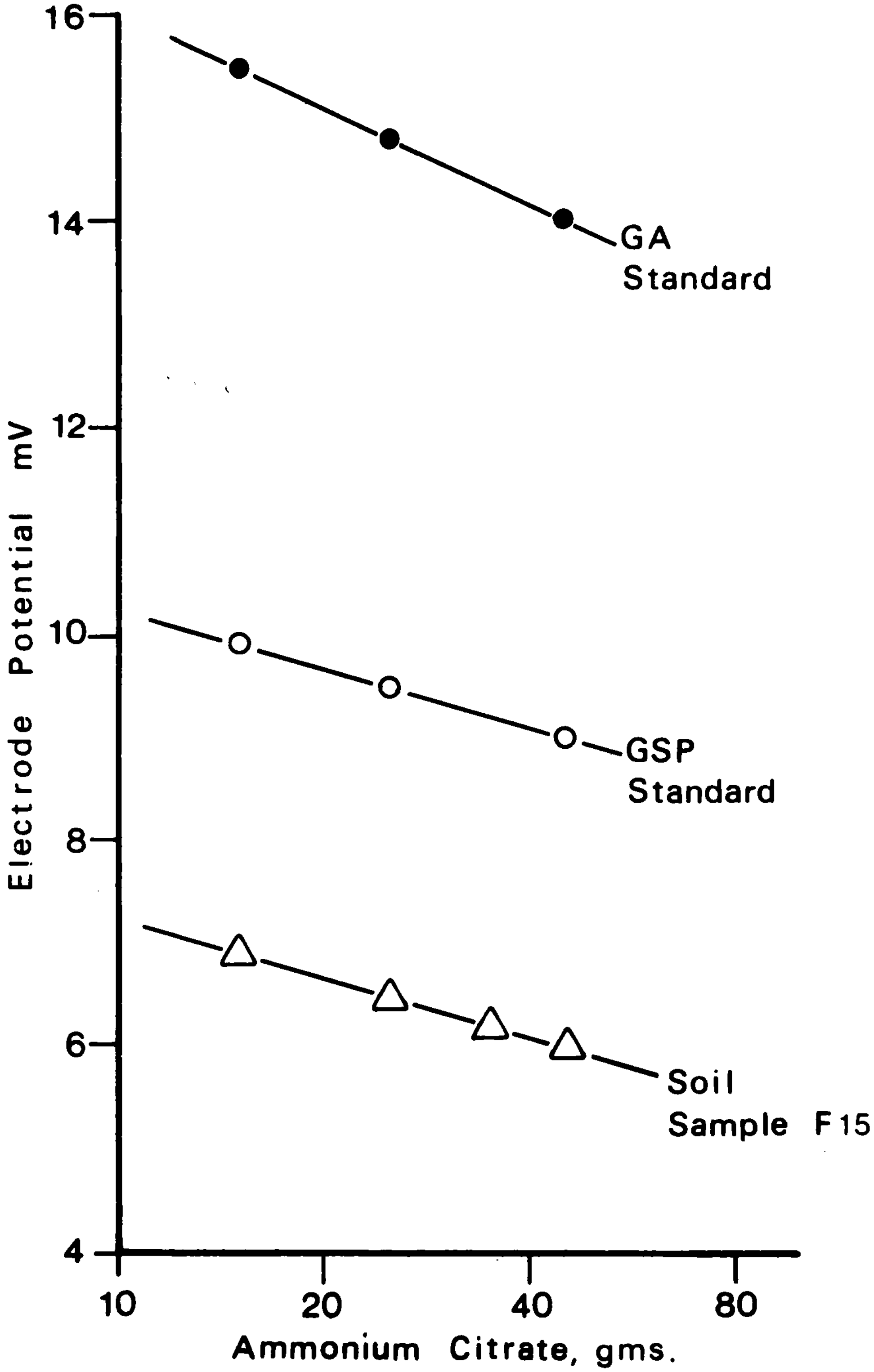

Fig. 2. Effect of various amounts of Ammonium citrate buffer on electrode potentials of solutions of various fluoride concentrations.

Results also show that on the addition of this amount of ammonium citrate the pH does not require further adjustment to pH 6.

Replicate fluoride analysis were performed on soil samples F15, F19, F27 and F30. The results show that the relative standard deviation is within acceptable limits (Table 5).

TABLE 5

Standard deviation for replicate fluoride analysis when using a fluoride sensitive electrode and a sodium hydroxide fusion, (with ammonium citrate buffer).

Soil sample	Mean value p.p.m.	n	Standard deviation p.p.m.	Relative standard deviation p.p.m.
F15	12075	8	1164	9.6
F19	8331	10	332	4.0
F27	2778	10	289	10.4
F30	1231	10	44	3.6

Soil Conductivity measurements

Secondary dispersion of mobile elements from in situ ore-deposits into neighbouring rocks and overlying soil may be due to an electrochemical mechanism which is also responsible for the generation of self-potential currents (Govett, 1975). Put in another way, the result of the operation of this mechanism is an abnormal proportion of ions dispersed in water within the zone of an electrical field around the ore-body. This zone is characterised by an anomalous conductivity that can be measured.

At Tekka, as noted earlier, there are sulphide-rich stanniferous veins, hence it is a suitable area for testing the possibility of using anomalous conductivity measurements as a means of locating the suboutcropping portions of such deposits.

Analytical procedure

The procedure of Govett (1975, pp. B29–B30) was utilised to obtain a series of measurements of soil conductivities. 0.5 g portions of minus-80-mesh B-horizon soil samples from Traverses B and F were stirred for 1 minute on a magnetic stirrer in 50 ml of deionized water. Conductivity measurements were then made by means of a Philips laboratory conductivity meter PW9501/01, a dip-type conductivity cell and a conductivity bridge.

GEOCHEMICAL ANALYSES OF SOIL SAMPLES FROM TRAVERSES

Three traverses, namely B, F, and J, were chosen for the geochemical soil survey on Tekka Hill. They run in a N–S direction on the western and south-western slope and are 400 feet (c. 122 m) apart. (See Fig. 1). This survey was in part an orientation one, but it was also conducted to locate, at the outset, further suboutcropping mineralisation similar to that exposed at the mine pit. Soil samples from the B horizon were collected from each sample point by means of a hand auger. A team of four was involved in the sample collection which took 2 days to accomplish.

Choice of sampling interval

The sampling interval was chosen as 50 feet (15.24 m). However, a test was run between sample points F27 to F31 with sample intervals of 16.3 feet (c. 5 m) to test the suitability of the initial sampling interval.

The result of this test is displayed in Fig. 3. The closer sampling interval invesitgated established, in detail, an anomalous tin zone between sample points F27 to F31, but applying the 50-foot sampling interval the same anomalous zone was established but not as precisely. Since this geochemical soil survey was only concerned with picking up anomalous zones indicating suboutcropping mineralisation and not with the 'internal' pattern of each anomaly, the sampling interval of 50 feet was considered to be adequate, as it was thought that by its employment anomalous zones of importance would not be missed, and of course, it would speed up sample collection.

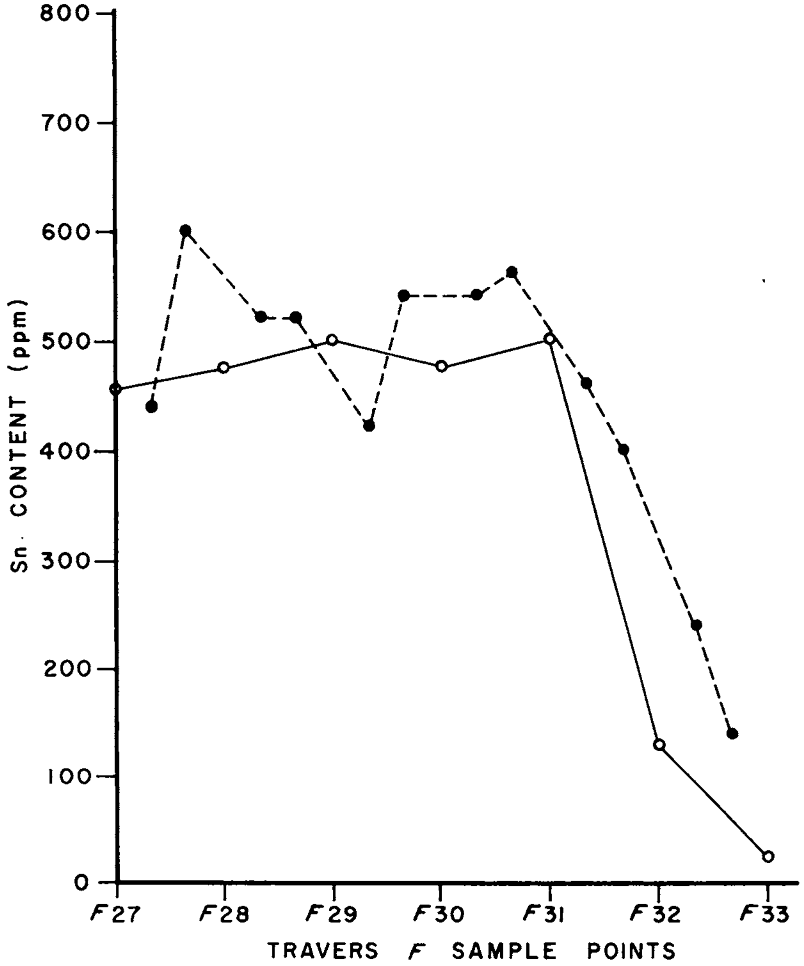

Fig. 3. Graphs justifying the choice of sampling interval of 50 feet (15.24 m) for the collection of samples along traverses B, F and J on Tekka Hill, Tekka, Perak.

Size-fraction analysis

In the laboratory the initial samples, collected at depths of 15 cm (c. 0.5 ft), 30 cm (c. 1 ft) and 60 cm (c. 2 ft) from Soil Profile I, were separated into various size fractions of plus 20-mesh (B.S.S.), minus 20-mesh to plus 80-mesh and minus 80-mesh and analysed for Sn, total F^- and cold-extractable F^-.

The results of the analyses are shown in Table 6 and indicate that the minus-80-mesh fraction for samples taken at 60 cm from the surface is the most appropriate one for study since it contains the highest concentrations of recoverable Sn, total F^-, and cold-extractable F^- content.

TABLE 6

Size fraction analyses using the samples at depths of 15 cm, 30 cm & 60 cm from the surface, from Soil Profile I, Tekka, Perak

Sample	Sn (p.p.m.)	Total F^- (p.p.m.)	Cold Ext. F^- (p.p.m.)
plus-20-mesh			
15 cm	88	3150	7.4
30 cm	96	2700	6.5
60 cm	168	1750	6.4
minus-20 to plus-80-mesh			
15 cm	340	4100	9.2
30 cm	88	4000	8.3
60 cm	112	2780	6.0
minus-80-mesh			
15 cm	300	8100	13.5
30 cm	92	4900	10.2
60 cm	340	3450	9.3

Results of the Tekka orientation survey

Approach to the interpretation of the results

The results of the geochemical soil survey were plotted as profile curves. On inspection of these profiles curves, it was obvious that they displayed a dispersion pattern reflecting the strike of the mineralized zone exposed in the mine pit (Fig. 1).

The lognormal distribution pattern (Ahrens, 1957) appears to be the one most applicable to the results of this geochemical survey. This was evident in the plots when the concentrations of the various elements were scaled logarithmically. The cumulative frequency plots for cold-extractable F^-, total F^-, Sn and As are approximated by straight lines (Fig. 4A–D), indicating that the populations are lognormally distributed. An outline of the procedures of the graphical representation by simple statistical treatment of the geochemical data is given in Lepeltier (1969).

Background and threshold values

The background and threshold values (b and t respectively) are read directly on the graph as the abscissae of the intersections of the distribution line with the 50% and 2.5% ordinates respectively (Fig. 4).

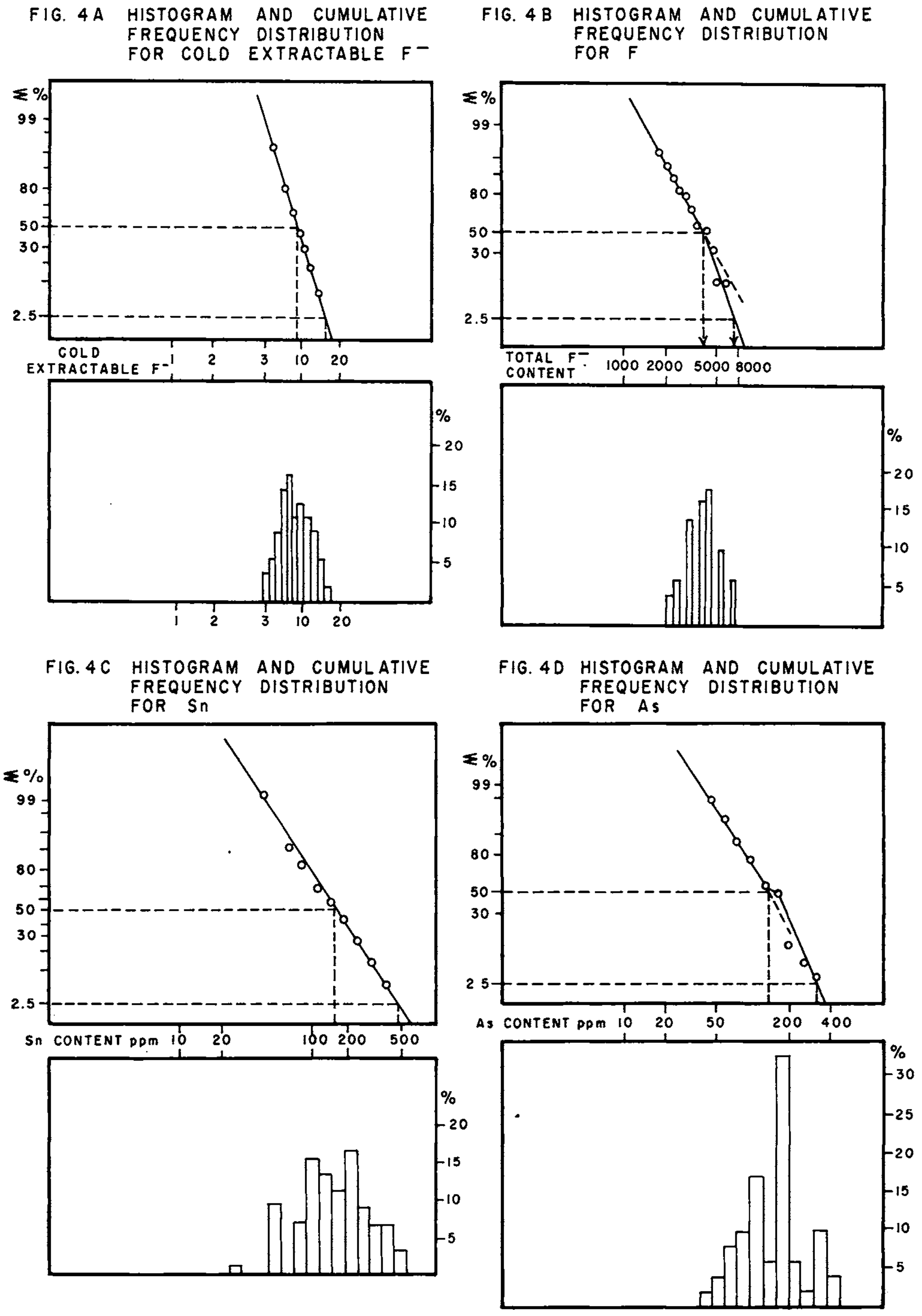

FIG. 4A HISTOGRAM AND CUMULATIVE FREQUENCY DISTRIBUTION FOR COLD EXTRACTABLE F⁻

FIG. 4B HISTOGRAM AND CUMULATIVE FREQUENCY DISTRIBUTION FOR F

FIG. 4C HISTOGRAM AND CUMULATIVE FREQUENCY DISTRIBUTION FOR Sn

FIG. 4D HISTOGRAM AND CUMULATIVE FREQUENCY DISTRIBUTION FOR As

Fig. 4. Histogram and cumulative frequency curves for cold-extractable F⁻, total F⁻, Sn and As

Table 7 lists the background and threshold values of the elements determined from Tekka Hill in B-horizon soil samples.

TABLE 7

Background and threshold values of the elements determined in B-horizon soil samples from Tekka Hill, Tekka, Perak

Element	Background, b (ppm)	Threshold, t (ppm)
Tin	160	460
Arsenic	135	320
Tungsten	32	115
Total Fluoride	4000	7200
Cold-extractable fluoride	9.2	15.0
Copper	280	580
Lead	580	1200
Zinc	135	280

Distribution of geochemical anomalies

For tin, the geochemical soil survey revealed an anomalous zone bounded by sample points B21 to B38 along Traverse B, sample points F19 to F32 along Traverse F and sample points J19 to J31 along Traverse J (see Fig. 1).

The anomalous zones of arsenic, tungsten, total and cold-extractable fluoride are very similar to that of tin (Figs. 1, 5 & 6).

Copper, lead and zinc anomalies are spatially closely related to one another, and the anomalous zones for these three elements lie between sample points B34 to B47 along Traverse B and sample points F14 to F27 and F46 to F54 along Traverse F (Fig. 7). The anomalous zones along Traverse B and that between F14–F27 are probably related to that of tin (see Fig. 1). These anomalous copper-lead-zinc zones are also substantially wider than that of tin. The results show that in the Tekka Hill environment zinc is the most mobile, copper has intermediate mobility, whilst lead is the least mobile. The anomalous zone between F46 and F54 probably indicates a suboutcropping sulphide-rich area.

The soil conductivity profile curves are also spatially closely related to the Cu, Pb, and Zn anomalies (see Fig. 7). The anomalous Cu-Pb-Zn zone between sample points B35 and B45 is associated with shortwavelength and high-amplitude peaks (between 150 x 10^{-6} mhos) and adjacent troughs (about 50 x 10^{-6} mhos) whilst that between F8 and F18 is associated with similar peaks (averaging 150 x 10^{-6} mhos) and troughs (about 25 x 10^{-6} mhos). The small peak between sample points F52–F54 may have some significance in view of the intense Cu-Pb-Zn highs in its vicinity and because of slightly anomalous tin values between sample points F47–F50. Tin, as discussed in earlier, is present in the sulphide-rich veins, as cassiterite and stannite, and thus this anomalous zone may well be a surface reflection of a suboutcropping swarm of such veins.

The relationships between the concentrations of tin and those of arsenic, tungsten, total fluoride and lead, were analysed graphically by correlation diagrams (see Fig. 8). The coefficient of correlation has been derived by means of simple statistical calcula-

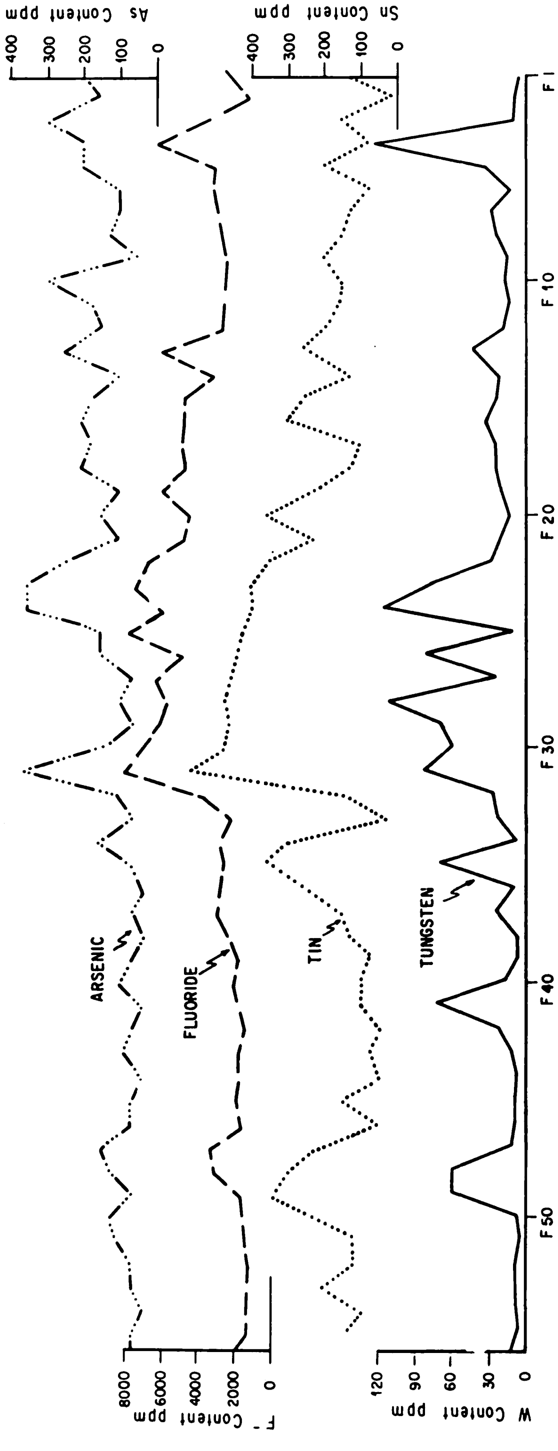

Fig. 5. Relationship of tungsten content with that of tin, fluoride and arsenic of the minus-80-mesh fraction of the B-horizon soil samples from traverse F, Tekka Hill, Perak.

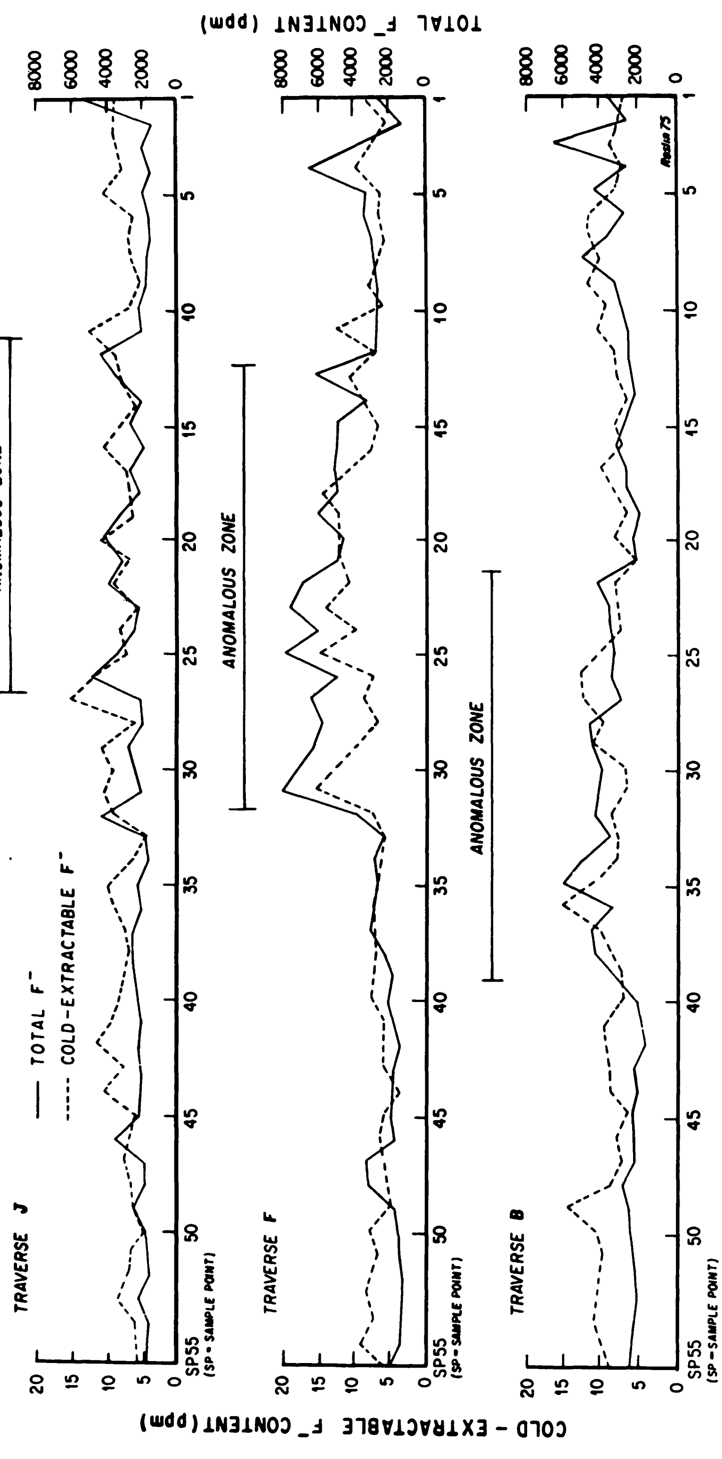

Fig. 6. The total and cold-extractable fluoride content of the minus-80-mesh fraction of B-horizon soil samples from Tekka Hill, Perak.

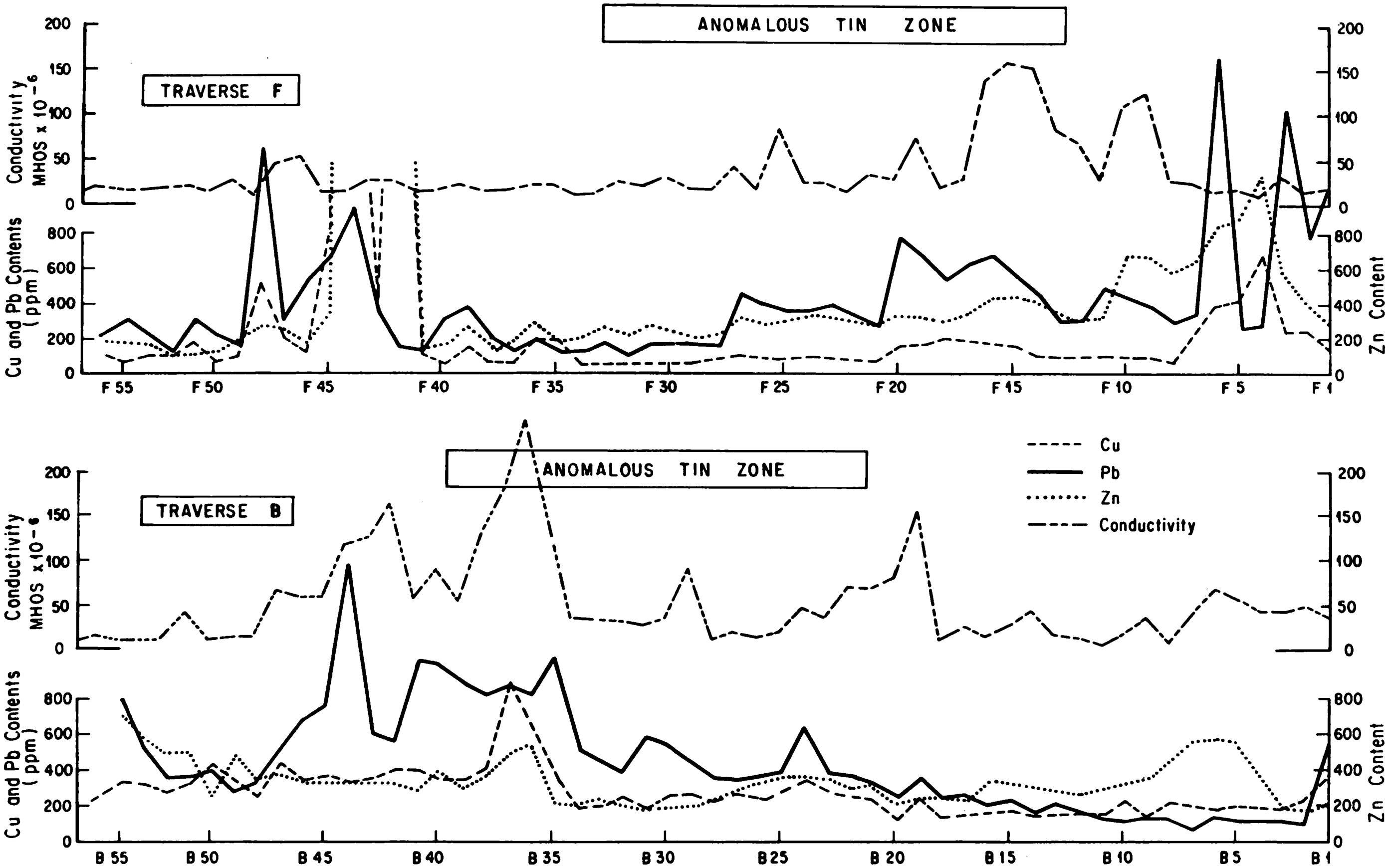

Fig. 7. The copper, lead and zinc content and soil conductivity measurements of the minus–80–mesh fraction of the B–horizon soil samples from Tekka Hill, Perak.

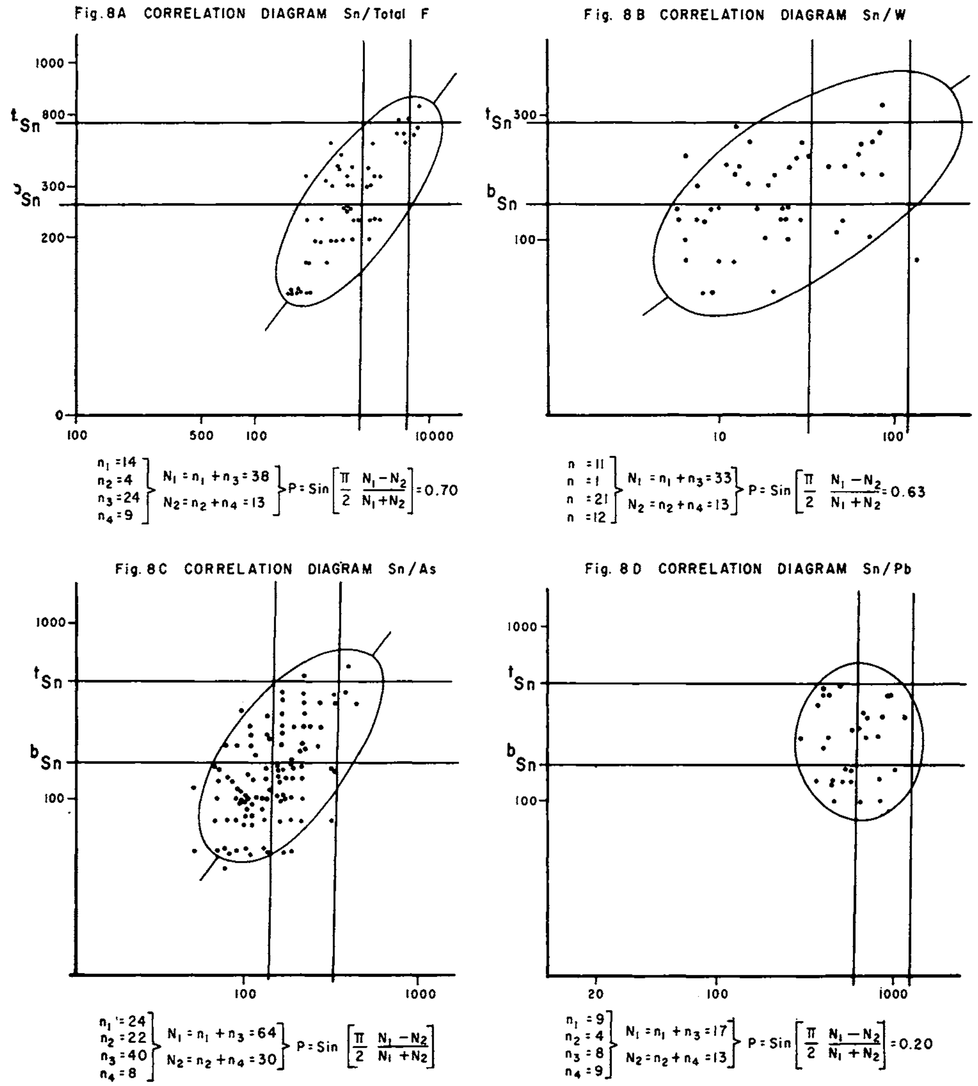

Fig. 8. Correlation diagrams for Sn/Total F^-, Sn/W, Sn/As, and Sn/Pb.

tions using the method of Lepeltier (1969). The other element relationships that have been examined are displayed graphically as correlation clouds in full log coordinates in Fig. 8.

It is of particular interest to note that over the anomalous zones, total and cold-extractable fluoride show good correlation (Fig. 6).

Figs. 8A, 8B & 8C show fairly good correlation between the concentrations of tin and those of total fluoride, tungsten and arsenic. The correlation clouds are broad elongated ellipses.

Table 8 shows the correlation coefficients and main axis slopes of correlation clouds of the various pairs of elements. The results show that in the soil samples analysed, the concentrations of tin vary more-or-less sympathetically with those of total fluoride, tungsten and arsenic. Hence, for the Tekka area, total fluoride (and, indirectly, cold-extractable fluoride), tungsten and arsenic may be used as pathfinder elements for tin.

TABLE 8

Correlation coefficient, and main axis slope of correlation cloud of various pairs of elements

Elements	Correlation coefficient	Main axis slope of correlation cloud
Tin/total fluoride	0.70	38°
Tin/tungsten	0.63	50°
Tin/arsenic	0.54	37°
Tin/lead	0.20	0°

Table 8 shows the poor relationship between tin and lead (Fig. 8D). The low correlation coefficient, and an axis which parallels the tin ordinate, show that the two elements are almost separated spatially and that the tin anomaly is more marked than the lead ones.

SOIL PROFILES

The soils collected for geochemical analysis were derived, essentially, from the weathering of the granitic parent material. The profiles of the soils of Tekka Hill consist generally of 3 principal horizons, namely the A, B and C. Based on the type of profile and characteristics of each soil horizon, the residual soils present in the Tekka area are classified as members of the Rengam Soil Series by the Soil Science Division, Ministry of Agriculture, Malaysia.

The Rengam Soil Series is a mature soil with well-developed soil profile. A detailed description of a typical profile in the Tekka area appears in Teh (1976).

Four soil profiles were sampled on Tekka Hill. They all fall on a straight line, striking N–S, with Soil Profile I at the lowest elevation and Soil Profile IV at the highest (see Fig. 9). At each of the four sites soil samples were collected at depths of 1ft (c. 30 cm), 2 ft (c. 60 cm), 3 ft (c. 90 cm), 4 ft (c. 120 cm), 5ft (c. 150 cm) and 6ft (c. 180 cm).

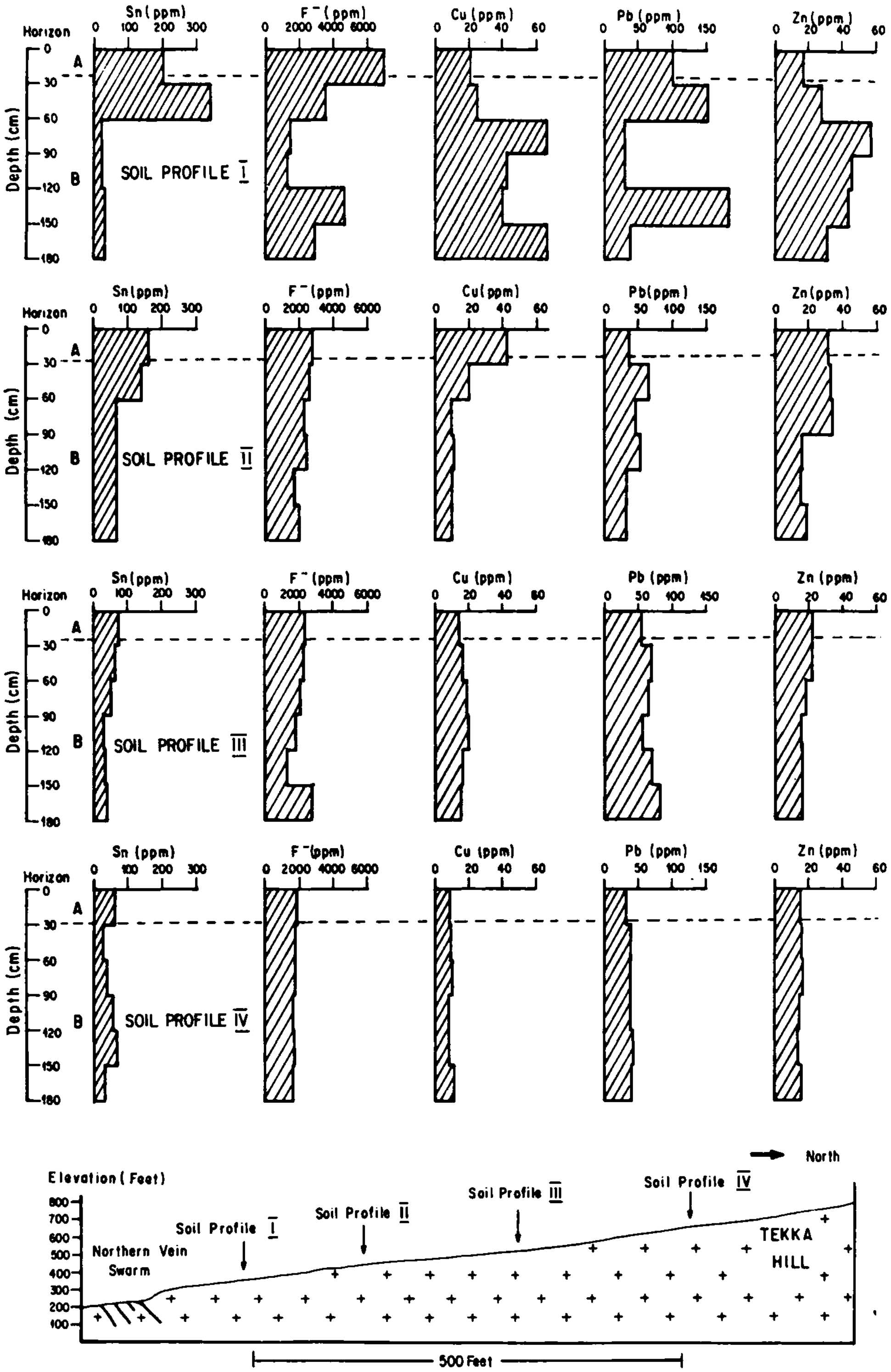

Fig. 9. Diagram indicating the variation in the correlation of certain elements with depth in the Tekka soils. The minus-80-mesh (B.S.S.) fraction was analysed.

In the laboratory, the oven dried, minus-80-mesh size fraction was used for analysis. The results are shown in Fig. 9.

Distribution of certain elements in the profiles

Fig. 9 shows that from Soil Profile I to Soil Profile IV, the profiles generally indicate a gradual decrease in concentration of all the elements investigated from surface to a depth of 180 cm. And also the gradual accumulations of the mobile Cu, Zn and F^- downslope. Zn appears to be more mobile than Cu, and Cu in turn is more mobile than F^-. Further, soluble elements, and those incorporated or absorbed on clays and colloids, are liable to be removed from the A-horizon, whereas those contained in resistant and comparatively dense primary minerals, which may by particularly abundant in Profiles I and II as they are near the northern vein swarm, are probably enriched in that horizon. The immobile elements, Sn and Pb, are concentrated within the first 60 cm of the profiles and show a general depletion with increasing depth. The distribution of high Sn and Pb values may also be related to the distances of the profiles from the vein swarm. Soil Profile I, the nearest to the veins has the highest concentration of Sn and Pb, whilst Soil Profile IV, the farthest, has appreciably lower Sn and Pb concentrations. Soil creep, although slight because of the vegetation cover, may nevertheless, have modified somewhat the dispersion of all the elements, but particularly Sn and Pb, which are largely present as insolubles in the soil'

This profile study has demonstrated that by investigating the vertical metal distribution along a series of profiles lying on the same direction as the traverses from which the samples for the overall geochemical survey are to be collected, permits a better appreciation and interpretation of the overall metal distribution pattern. It has also established that at Tekka the concentrations of metals in samples taken from the B horizon, and at depths of 60 cm from the surface, do not differ significantly from those provided by samples down to depths of 180 cm; thus one can accept that at Tekka there is no need to collect samples below 60 cm.

THE WIDTHS AND INTENSITIES OF SPECIALLY INVESTIGATED ANOMALIES IN THE SOILS OVER A MINERALISED VEIN AT TEKKA

Generally as a mineralised vein is weathered its liberated components are incorporated into the overlying soil where they tend to be dispersed laterally by mechanical, chemical, and biochemical means, and in such a way that an element-anomalous zone is generated which is considerably wider than the parent ore deposit.

To investigate dispersion of this type at Tekka a northward-dipping mineralised vein was selected and soil samples from the B-horizon were collected at various distances on either side of it (Fig. 10).

The oven dried, minus-80-mesh fractions were analysed for Sn, Cu, Pb, Zn and total F^-.

Fig. 10 shows the relationship between the spread of the analysed, essentially vein-derived components in the soil and the width of the mineralised vein where it is exposed.

Dispersion pattern

Fig. 10 shows that the mobile elements, namely Cu, Zn and F^-, are dispersed laterally but to a more marked extent to the right of the mineralised vein, which

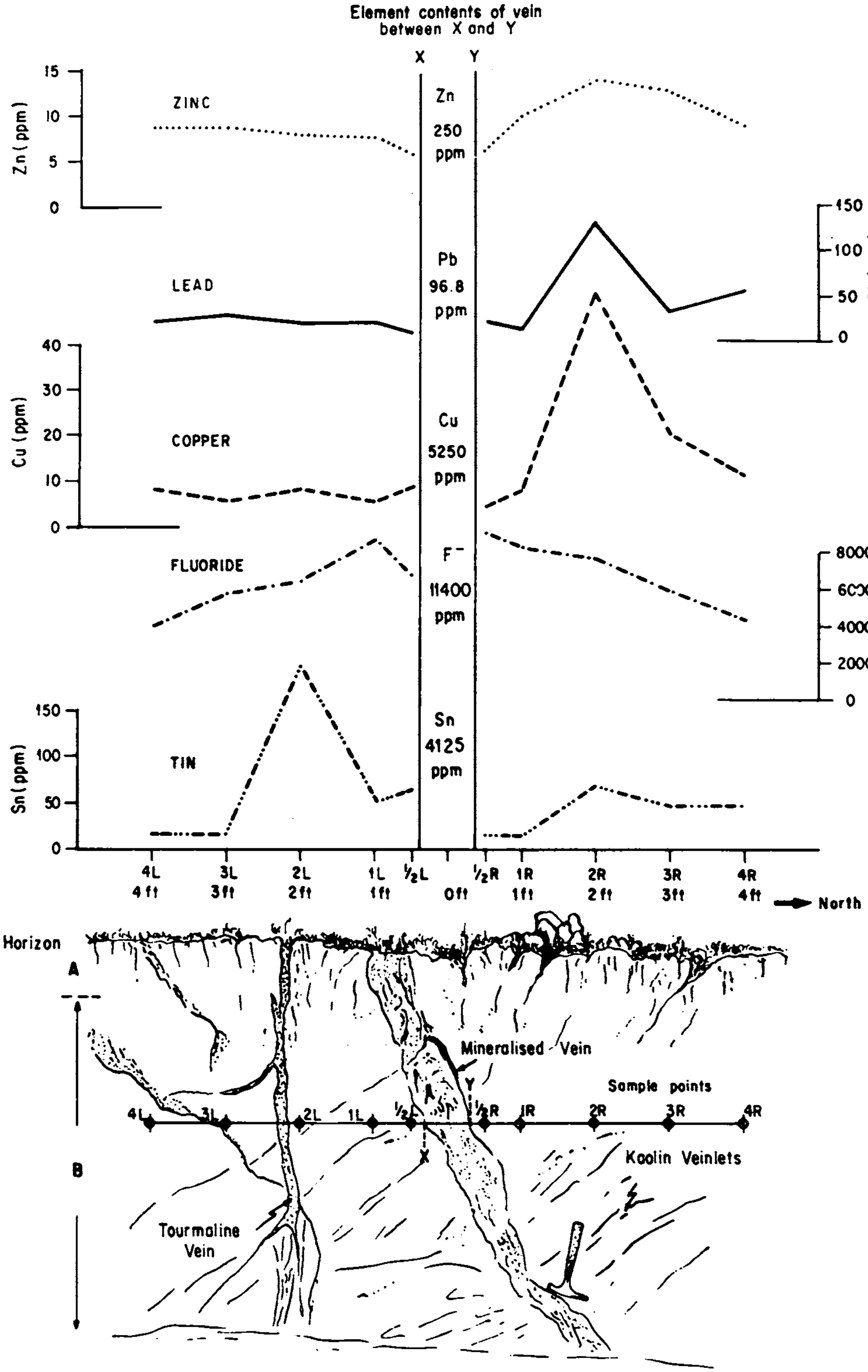

Fig. 10. A diagram indicating the nature of the lateral dispersion of certain 'ore-elements' in the soil adjacent to a mineralised vein of Tekka, Perak.

suggests that either the hanging-wall side of the vein was the more heavily mineralised initially and/or that to the right of the vein, escape routes (fractures) for the more mobile elements were better developed. The locally high Sn and F^- values to the left of the vein may be, at least in part, due to deposition of Sn and F^- there during the development of the tourmaline veinlet (see Fig. 10). The less mobile elements, namely Sn and Pb, give more intense and sharper anomalies than do the mobile ones and, in particular, the Zn and F^- anomalies are wider, weaker and flatter. Perhaps, it is not surprising that the Sn, Cu, Zn and F^- contents of the vein are appreciably higher than those of the related soils, but it is surprising that in the case of Pb the reverse is true. The marked enrichment of lead in the soil may be in some way be due to the element becoming fixed as a relatively insoluble mineral or minerals, but a satisfactory explanation for this phenomenon has not been found.

The study has shown that associated with this vein, which is only 8 in. wide, there is a dispersion halo that is almost 7 feet across. The results of this study have facilitated the interpretation of the Tekka geochemical results generally in that they have provided a better understanding of the relationships between anomalous concentrations of metals in the soils and their parent suboutcropping veins.

CONCLUSIONS

The results of the geochemical orientation soil survey on Tekka Hill confirm that geochemical methods of prospecting are useful tools in the location of suboutcropping tin and possibly other deposits there. The survey also showed that:-

1) If a 50-feet (15.24 m) sample interval is adopted, significant anomalous zones will not be missed there.
2) The B-horizon of the mature residual soil has the maximum concentration of the ore-elements investigated.
3) Analysis of the minus-80-mesh (B.S.S.) fraction of the soils provides the optimum results.

Besides locating suboutcropping ore bodies, the analytical data also provided information concerning the relationships between the various elements investigated. Thus, it was established that arsenic, tungsten, total fluoride and cold-extractable fluoride are relatively good pathfinders for tin, whilst copper, lead and zinc are not associated with tin in a manner of value to the geochemical prospector.

That determination of the fluoride distribution in the soil might also, on occasion, help in the search for suboutcropping tin (and other) deposits has been demonstrated, for the first time in Malaysia, by the writer. He has also shown that at Tekka the distribution of cold-extractable F^- in the soils correlates very well with those of total F^- and of Sn. As the cold-extractable fluoride determination can be carried out very quickly, and even conducted on the spot, it has obvious attractions.

It was also shown that soil conductivity measurements vary more-or-less sympathetically with the anomalous Cu-Pb-Zn zones in the soils and so suggest that at Tekka and elsewhere, in Malaysia, where Tekka-type mineralisation occurs, soil conductivity measurements alone, or better, in conjunction with geochemical investigations of the type discussed in this paper, might provide a useful means of tracing etc., suboutcropping mineral deposits.

Soil profile analysis has confirmed that B horizon samples are those that are best-suited for the survey and that samples taken at about 60 cm below the surface provide the most useful result. Studies of the lateral dispersion of elements from a mineralised vein have indicated that haloes may develop in the soils which are 10 times the width of the veins, and confirm that the mobile Cu, Zn and total F^- give wider, weaker spreads than the comparatively immobile Sn and Pb which provide traces of intense sharp peaks.

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