Gold investigation in the Sungai Luit area, Mengapur Base Metal District, Pahang.

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Abstract: The gold anomaly at Sg. Luit forms part of the Mengapur halo which surrounds an area of copper-molybdenum mineralization. Follow-up geochemical survey was initiated in late 1982. A 40 square kilometre gold anomalous area was delineated. Detailed soil geochemistry, pitting and test geophysical surveys were undertaken over 6 square kilometres of the most anomalous zone.This was later extended for another 3 square kilometres northwestwards.

Geochemical anomaly maps were obtained from residual soil data, chemical analysis of heavy mineral residue from soil and gold colour count of heavy mineral residue. Anomaly maps obtained have indicated the possible occurrence of placer gold within the alluvial plain of the Sg. Luit especially its interfluve with Sg. Burong and Sg. Tekoh. They also indicated that primary gold mineralization probably occurs within the vicinity of Sg. Selangor and Sg. Chembah. Preliminary deep hole hand augering was carried out in two areas, one of which gave an indication of primary gold mineralization at depth.

Primary gold mineralization in the area appears to be structurally controlled rather than lithological. The main trend of mineralization at Mengapur is northeast-southwest. Gold mineralization at Sungai Luit probably follows the same trend. The extent of mineralization and its economic potential is not known as more detailed work needs to be carried out.

INTRODUCTION

An extensive regional reconnaissance geochemical sampling programme was initiated in early 1977 covering large parts of the states of Kelantan and Pahang. This project then known as the Central Belt was carried out by Geological Survey of Malaysia with technical assistance from the Canadian International Development Agency (CIDA). To complement the reconnaissance programme, follow-up investigation was undertaken in Pahang over the Mengapur base metal anomaly which was previously delineated by Lee (in manuscript). Follow-up and detailed investigation up to exploratory diamond drilling indicated the presence of 'skarn-porphyry type' copper molybdenum mineralization over the Mengapur Prospect (Lee & Chand, 1981). This prospect is surrounded by an extensive Pb-Zn-Au-Ag-As-W halo. The gold anomaly at Sungai Luit forms part of this halo. The area of interest occurs at the southern portion of sheet 81, along the upper reaches of Sungai Luit and covering an area of 40 sq km (Figure 1). It is centred on longitude 102° 48'E and latitude 3° 41'N. The area has a low undulating topography with an average relief of about 100 metres above mean sea level. It is well served by timber tracks, which are connected to the Kuala Lumpur-Kuantan trunk road and is about 60km from Kuantan.

HISTORICAL BACKGROUND

Prospecting in the Sungai Luit area dates back to the late eighteen twenties when gold was first discovered. A large chinese mining town was reported to have existed (Savage, 1949); their inhabitants being mainly alluvial gold miners. It was reported in 1940, that 80 dulang washers were panning for gold in the Sungai Luit (Fitch, 1946). The flat country bordering the stream could have been worked for gold as evidenced by the presence of large pits. Blocks
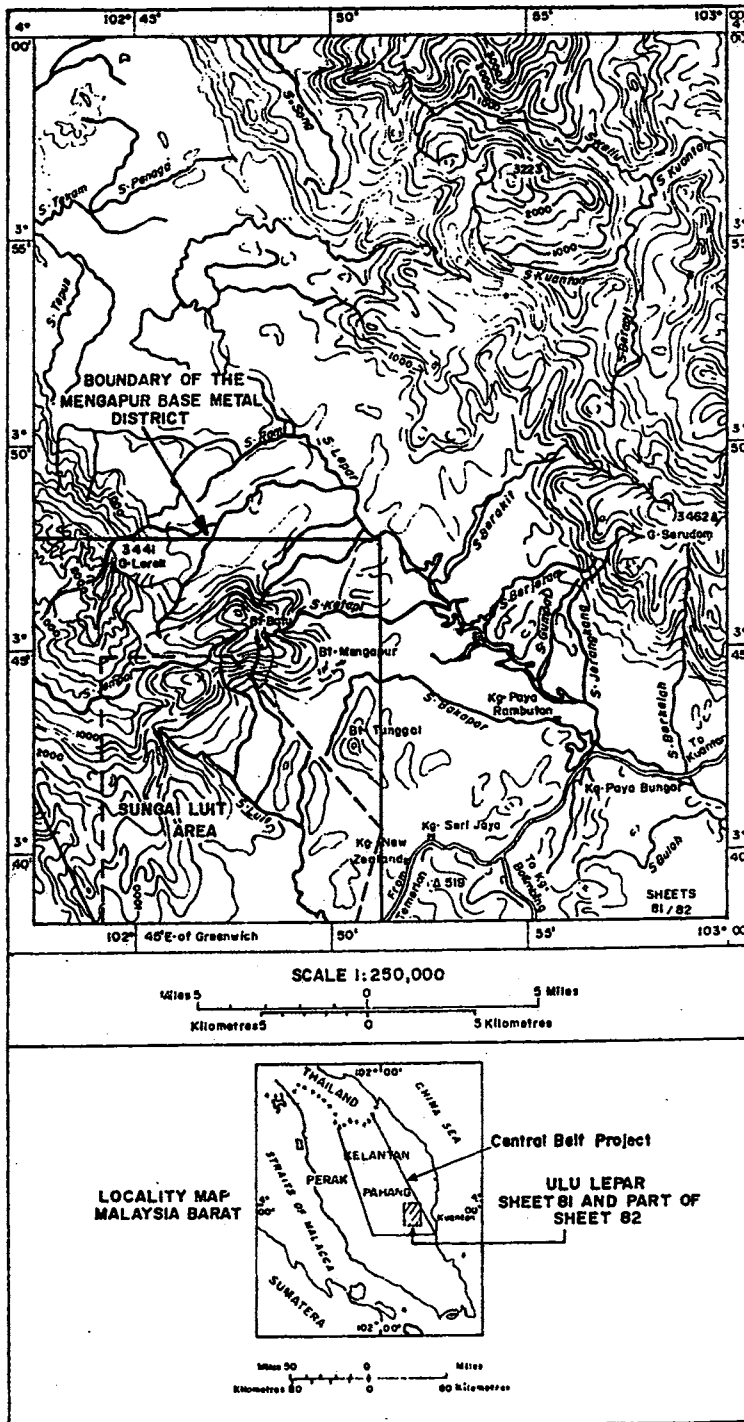
Fig. 1　Location map of the Sungai Luit area, Pahang.

of mixed sulphides were also reported. They consist of pyrite, galena and chalcopyrite and on analysis gave traces of gold and up to 80.4 pennyweights of silver per ton. Ten to fifteen tons of lead concentrates was mined from this area before the mine was destroyed by bandits in 1950.

Two hundred and sixty nine pits were sunk within the drainage of Sungai Kertam which lies just to the south of the Kuantan-Maran highway (Galian Pahang 46/1934). Each pit reached depths of 1 to 2 metres. Most of the gold recovered were fine gold and the area was classified as not mineable for gold.

Mineral Investigation Drilling Unit (MIDU) Project for gold was carried out jointly by the Mines Department and the Geological Survey in 1956. It covered the interfluve of Sungai Luit and Sungai Kertam, an area of approximately 3,640 hectares. Banka drilling was undertaken and 20 holes with a total depth of 202 metres were sunk. The depth of boreholes ranged from 4 metres to 15 metres. Only traces of gold were recovered from the boreholes.

An area lying in the interfluve of Sungai Luit and Sungai Burong was prospected for lead (Fitch, 1946). Ten diamond drill holes were sunk with an average depth of 42 metres. No mineralization of commercial importance was discovered. No gold but only boulders of galena were reported. This area is underlain by quartzite and calcareous shales.

The present area of investigation was geochemically sampled on a reconnaissance scale by Lee (in manuscript) as part of a regional geochemical stream sediment sampling survey - cum - regional mapping programme from 1972 to 1976. An Au-Ag-W-As anomaly, covering an area of 60km^2 was delineated. Further investigation for primary and alluvial/ eluvial gold was recommended.
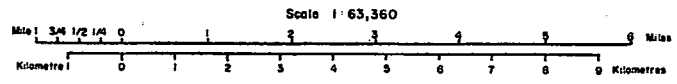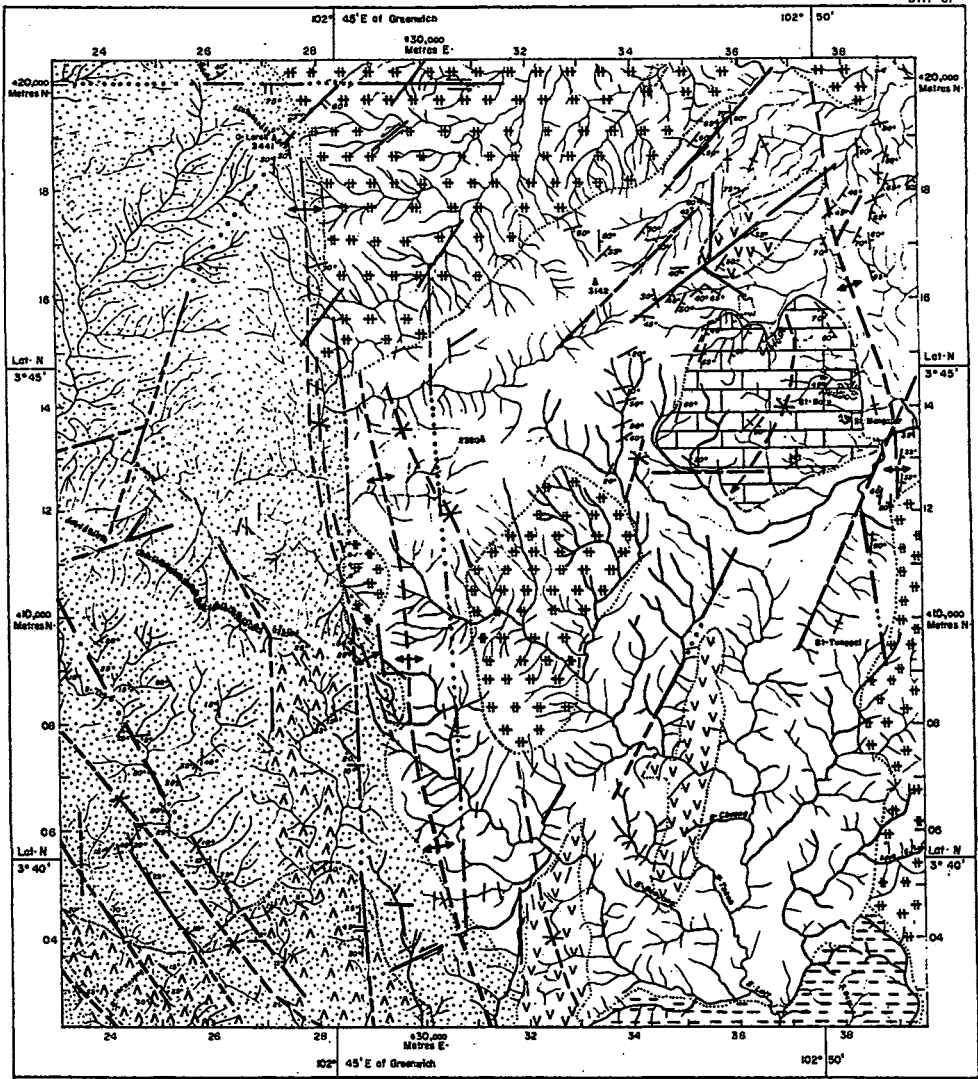
In 1980, an airborne spectrometric and magnetic survey conducted by the Geological Survey of Malaysia covered the Sg. Luit drainage. Spectrometric and magnetic readings indicated the presence of a shallow magnetic basement with predominant NS faulting.

GENERAL GEOLOGY AND MINERALIZATION

The Mengapur base metal anomaly (Lee, in manuscript) lies in an area underlain by a belt of Permian metasediments which had undergone at least two periods of folding and had been intruded by a granodiorite pluton (Figure 2). The Permian metasediments are separated into two distinct facies; a calcareous facies and an argillaceous facies. The younger calcareous facies consists of dark grey limestone interbedded with a shale subfacies.

The argillaceous facies comprises primarily of pelitic hornfels, quartz - sericite phyllite and graphitic slate. Minor interbeds of metamorphosed andesitic, dacitic and rhyolitic tuff occur within the argillaceous unit.

The Permian metasediments were intruded by the Lepar granodiorite which is possibly of Lower Triassic age. This pluton occurs as an elliptical northwest trending body approximately 45 km long and 18 km wide. It is a medium-grained, dark grey, biotite-rich rock ranging in composition from diorite to granite.

Fig. 2   General geology of the Mengapur Base Metal District.

Faulting is common and 4 major sets are discernable. The oldest set trends N-S and is traversed by younger NW-SE and NNE-SSW trending wrench faults. The youngest fault in the area, a wrench fault, trends east-west.

The Mengapur base-metal anomaly exhibits four types of mineralization largely associated with a large skarn porphyry system. The system consists of a core of copper-molybdenum surrounded by lead-zinc veins and an outermost annulus of geochemically highs of Au-Ag-Sn. Iron-oxide replacement mineralization occurs within this system, predominantly along the contacts between granodiorite and metasediments as well as over high sulphide zones.

FOLLOW-UP INVESTIGATION STREAM SEDIMENT AND HEAVY MINERAL CONCENTRATE SAMPLING AND TREATMENT

Stream sediments were collected along all major streams draining the area at approximately 500 metre intervals as well as coinciding with stream confluences. They are generally taken from low energy environments within the stream beds. Two samples were collected from each sampling point, one of about 300 gm and another about 50 gm. The smaller sample was collected for Hg analysis.

Heavy mineral stream concentrate sampling was also carried out at approximately 500 metre interval along all major streams. Since effort was concentrated on sampling high energy environment as well as coinciding with stream confluences, it was not always possible to adhere to this sampling interval. The availibility of sufficient amounts of stream concentrates (a sample of about 10 grams is normally required) farther restricts adherence to the desired sampling interval. Efforts were made to pan sediments to a depth of at least about 1 metre and in a high energy environment since in most cases it is not possible to reach the bedrock.

An orientation study was initially conducted to determine the type of pan that should be used to obtain the best recovery for gold. The heavy aluminium *dulang** as well as the Canadian pan were tested. The Canadian pan was found to invariably give a better recovery of gold flakes. Hence, it was extensively used in the panning for stream concentrates.

The stream concentrates collected were dried, bromoformed and weighed (Figure 3). The number of *dulangs* collected was also recorded. The bromoformed concentrates were then magnetically separated. The non-magnetic fraction was preliminarily examined under the binocular microscope. The gold flakes were hand-picked and studied in detail. They were weighed directly using an electronic balance and then fire assayed. Those that are too light to be weighed are dissolved in acid and then analysed for Au using AAS method. The rest of the non-magnetic fraction was then mixed with the other magnetic fractions and analysed for 14 elements. The elements analysed for are Au, Cu, Pb, Zn, Mo, As, Sn, W, Ni, Co, Ag, Bi, Sb and U. The total gold content was then computed in ppm by combining the hand-picked gold flakes (weighed or chemically analysed) with the gold content obtained from analysis of the recombined sample.

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*   A circular, shallow, dish-shaped pan containing closely spaced circular depressions.
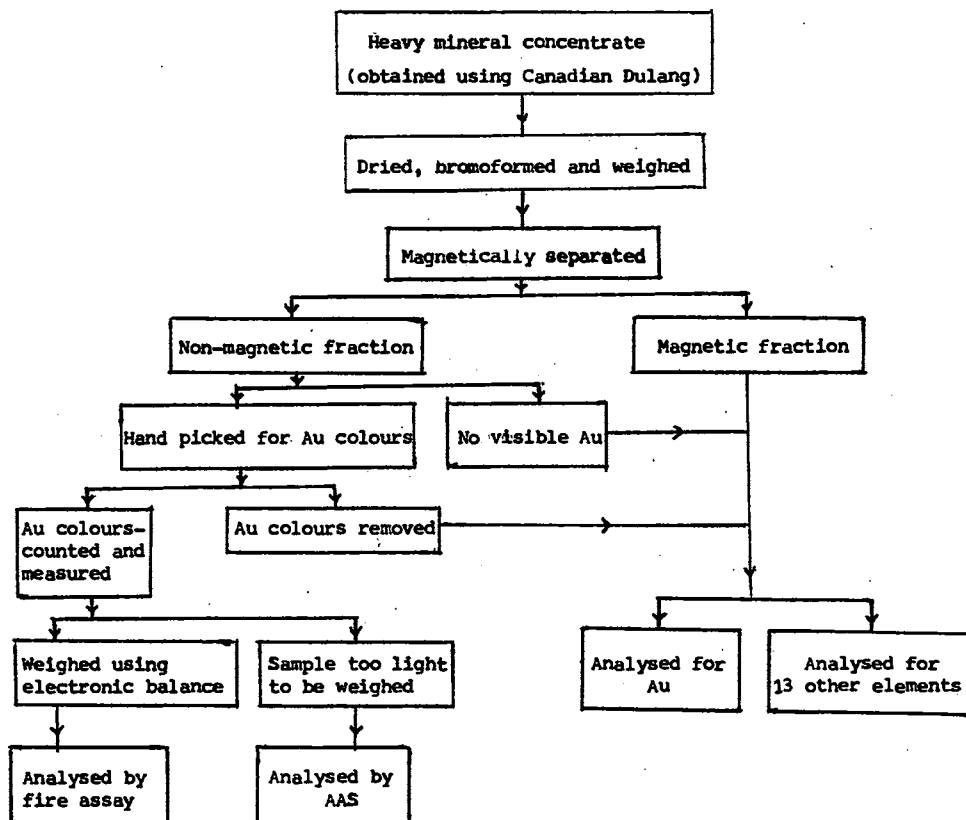   One standard dulang   =   0.00474 cu m or 0.0062 cu yd.

Fig. 3   Heavy mineral concentrate sample preparation

HEAVY MINERAL CONCENTRATE STUDY

(a) Physical characteristics of the gold flakes

Representative samples of gold flakes occurring over the area were studied. Their longest dimension was measured and recorded. A total of 979 gold flakes were measured. Their sizes range from < 3/4 mm to about 5 mm. The gold flakes were categorized into size intervals as shown in Table 1.

From Table 1 it can be seen that 99 percent of the total gold flakes recovered are < 1 mm in diameter and about 63.5 < 1/4 mm in diameter. Gold has been mined previously in the area and the size distribution at the present might not reflect the original size distribution. However, it was found that the gold recovered from Sg. Chuang, Sg. Tekoh and Sg. Benuang contain a fair amount of coarser grained gold flakes. The rest of the area especially that of the upper tributaries of Sg. Luit contain finer-grained gold flakes.

A total of 16 randomly selected samples of gold flakes collected over the area investigated were examined closely under the binocular microscope. The gold flakes can be classified into

TABLE I
SIZE DISTRIBUTION OF GOLD FLAKES.

Size	No. of gold flakes	Percentage present
$< \frac{1}{4}$ mm	622	63.5
$\frac{1}{4} - \frac{1}{2}$ mm	228	23.3
$\frac{1}{2} - 1$ mm	119	12.1
$1 - 2$ mm	9	1.0
$2 - 3$ mm	0	–
$3 - 4$ mm	0	–
$4 - 5$ mm	0	–
> 5 mm	1	0.1

2 groups according to their physical characteristics:-

(i) Gold flakes recovered from upstream areas are generally fine-grained. They are irregular in shape with angular or sharp-pointed edges and their surfaces are generally pitted. This indicates closeness to the source.

(ii) Gold flakes typical of downstream areas are generally flattish with rounded edges and smooth surfaces. Few pits are present. This indicates a distant source.

In some downstream areas, gold flakes may exhibit both of the above mentioned characteristics. This would indicate 2 sources of the gold. The angular flakes from a source nearby and the rounded flakes from a distant source.

Some of the larger gold flakes have greyish-white quartz grains embedded in them. In some cases the quartz grains are rounded in shape and could have got itself embedded in the pits on the surfaces of the Au flakes. Others are angular and could be indigenous with the Au. One gold flake has a greyish square inclusion which could be originally pyrite/galena.

The gold to silver ratio of whole concentrates were calculated and plotted but no conclusive pattern was obtained. The Au/Ag ratio in some cases increases downstream while in others it decreases. The fineness of the gold was determined for a number of samples along a portion of the Sg. Luit. It was found to vary from 940 to 980.

(b) Mineralogical constitutent of the heavy mineral stream concentrates.

Heavy minerals commonly found together with the gold flakes in the stream concentrates are ilmenite, pyrite, zircon, garnet, rutile, leucoxene and cassiterite. Rock fragments are also present. Other minerals present in trace amounts are tourmaline, xenotime, monazite, allanite, topaz, galena and flourite.

GEOCHEMICAL INTERPRETATION

All the geochemical data obtained for both stream sediments and concentrates were statistically treated by graphic means using histograms and reverse cumulative log-probabil-

ity plots for the elements of interest in each sample medium. Partitioning as described by Sinclair (1974), was used to separate the anomalous and background populations. The threshold was taken at the X + 2s level.

(a) Data obtained from stream sediments

Of the 14 elements analysed only 3 show anomalous concentrations correlatable to the occurrence of anomalous gold in the Sungai Luit area, (Figures 4, 5 & 6). Molybdenum in stream sediments shows good correlation with anomalous Au in stream concentrate. The area of coincidence lies along the upper reaches of Sungai Chembah, Sungai Garam, Sungai Tekoh and the north-eastern portion of Timur Oil Palm Estate. Anomalous As concentrations were recorded at Sungai Chembah and the Timur Oil Palm Estate. Tin shows only a slight association at Sungai Chuang and the upper reaches of Sungai Chembah and Timur Oil Palm Estate.

(b) Data obtained from stream concentrates

In the search for gold, heavy mineral stream concentrate is a better medium than stream sediments by virtue of its occurrence as a resistate mineral. It was found that the distribution of Au in stream concentrates shows a good association with As and Ag (Figures 7, 8 & 9) moderate association with Zn, Mo and Pb and a weak correlation with Ni and Sn. It has poor to no correlation with Co, U, W and Cu.

Owing to non-uniformity in the collection of the number of standard dulangs of stream concentrate at each sampling point, all the results for Au were converted to ppm per standard volume of 5 standard dulangs. The distribution of Au in stream concentrates is as shown in Figure 10. The number of colours of Au recovered per standard volume for each locality was also recorded as illustrated in Figure 11.

DISCUSSION

A study of the geochemical data available, showed that in general silt sediments cannot be used reliably in the search for Au since Au occurs as a resistate mineral. The area containing an anomalous concentration of Au covers an area of approximately 40 sq km as shown in Figures 10 & 11. Gold is present in areas underlain by a Lepar diorite stock at the headwaters of Sg. Luit and Permian sediments which consists of carbonaceous slate, sandstone, tuff and minor calcareous sediments.

Figure 11 shows that high concentrations of Au occur within 2 areas i.e. the area drained by Sg. Chembah and its tributaries and that around the Sg. Chuang-Sg. Tekoh area. Two areas of low Au colour count were noted within the Sg. Chembah area. This could possibly be due to previous mining activities.

In the search for primary Au, Boyle (1979) has emphasised the importance of the age old method of using the number of gold colours recovered from soil, eluvium and weathered residuum in locating primary Au sources. Consequently it would follow that areas drained by streams containing a high occurrence of gold colours would indicate closeness to its primary source.
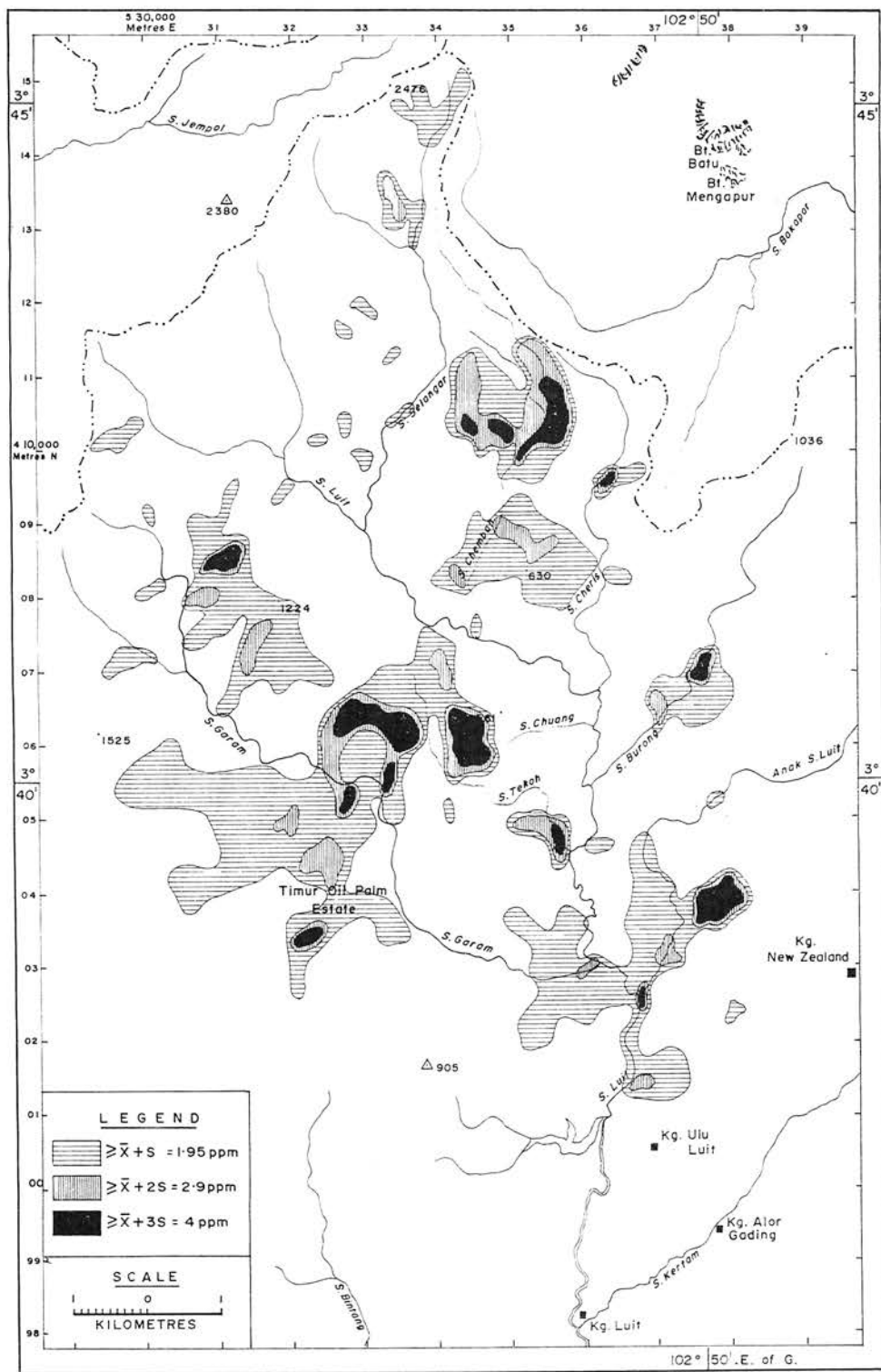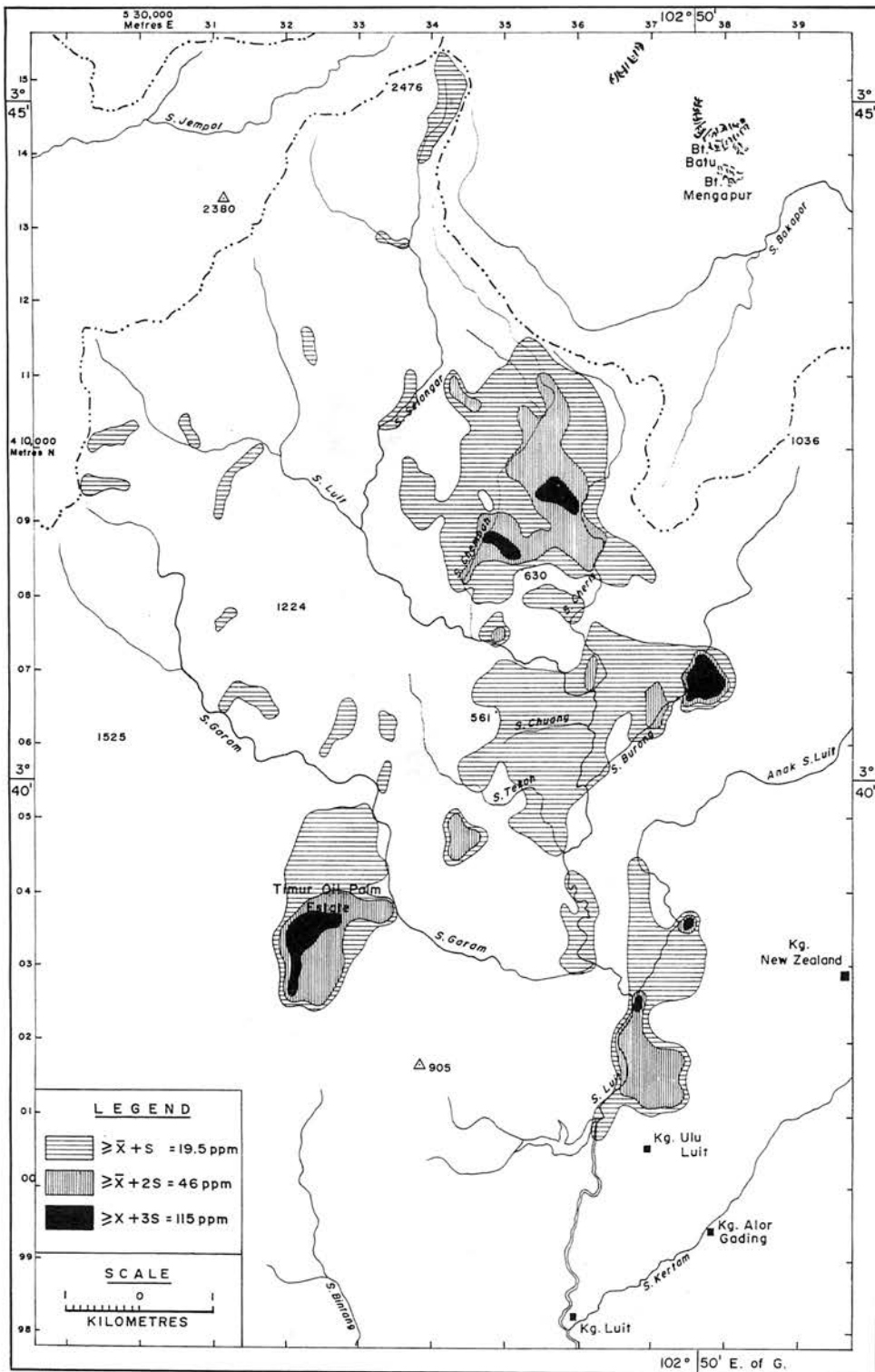
Fig. 4   Molybdenum in stream sediments.

Fig. 5   Arsenic in stream sediments.

LEGEND

≥X̄ + S = 8·3 ppm
≥X̄ + 2S = 19 ppm
≥X + 3S = 45 ppm

SCALE

1   0   1
KILOMETRES

S. Jempol

2475

2380

Bt.
Batu
Bt.
Mengapur

S. Bakapor

1036

S. Selangor

S. Luit

S. Shembam

630

S. Chartis

1224

S. Garam

561

S. Chuang

S. Tekoh

S. Burong

Anak S. Luit

1525

Timur Oil Palm
Estate

S. Ganan

Kg.
New Zealand

905

S. Luit

Kg. Ulu
Luit

Kg. Alor
Gading

S. Binlang

S. Kerlam

Kg. Luit

102° 50' E. of G.

Fig. 6   Tin in stream sediments

Fig. 7   Gold in stream concentrates

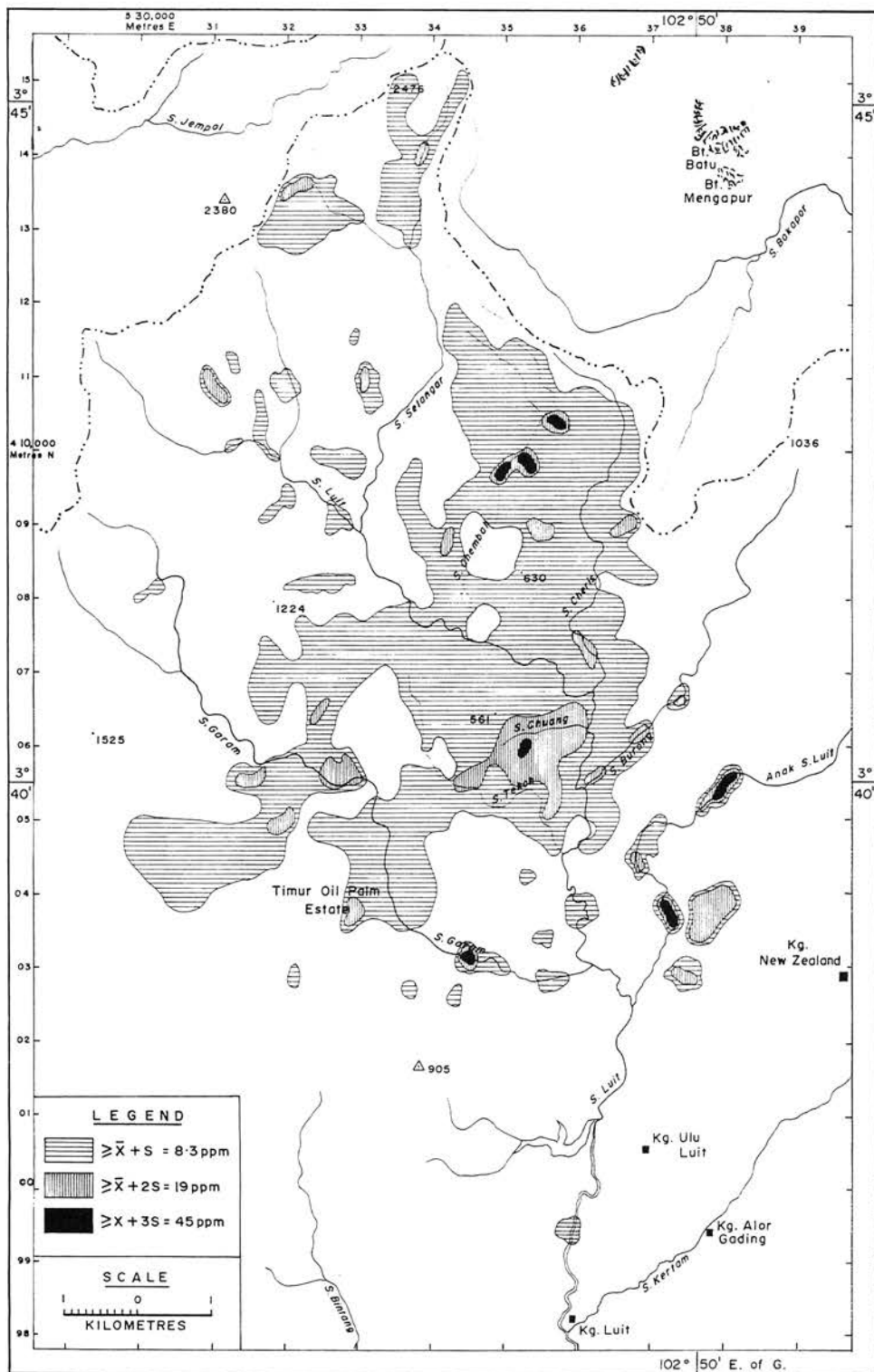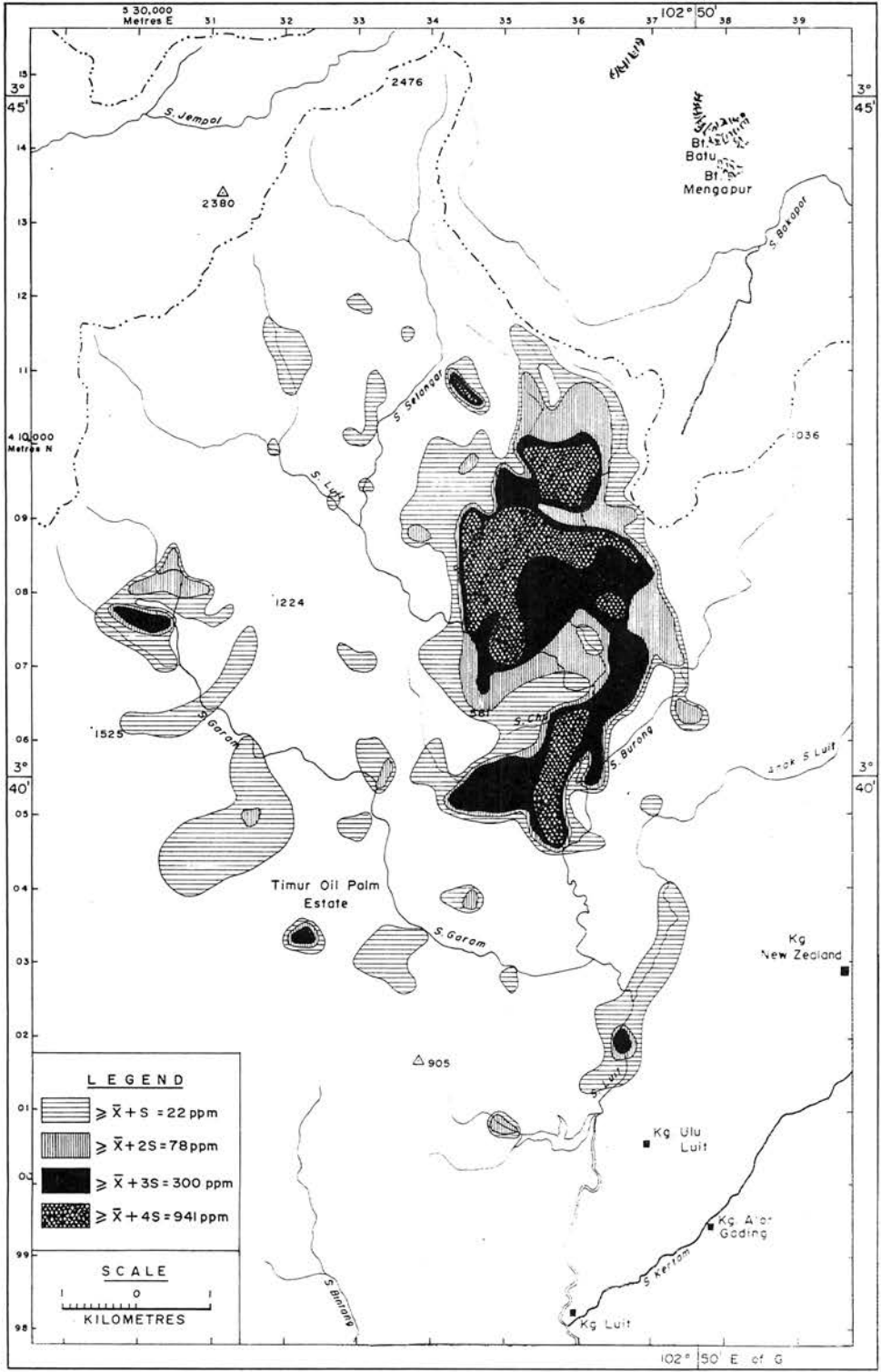Fig. 8   Arsenic in stream concentrates.

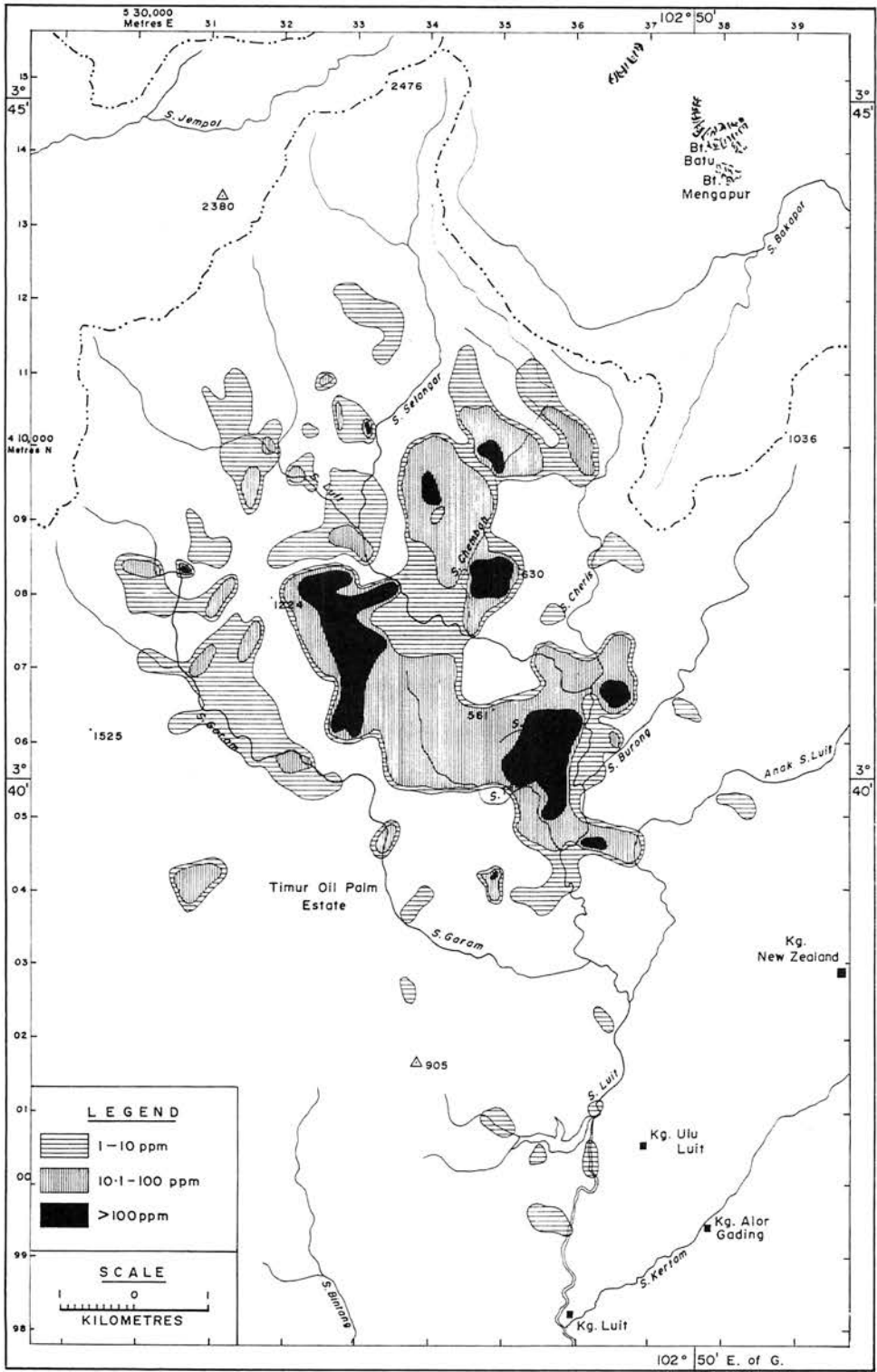Fig. 9   Silver in stream concentrates.

Fig. 10   Distribution of gold in stream concentrates in ppm per 5 standard *dulangs*.
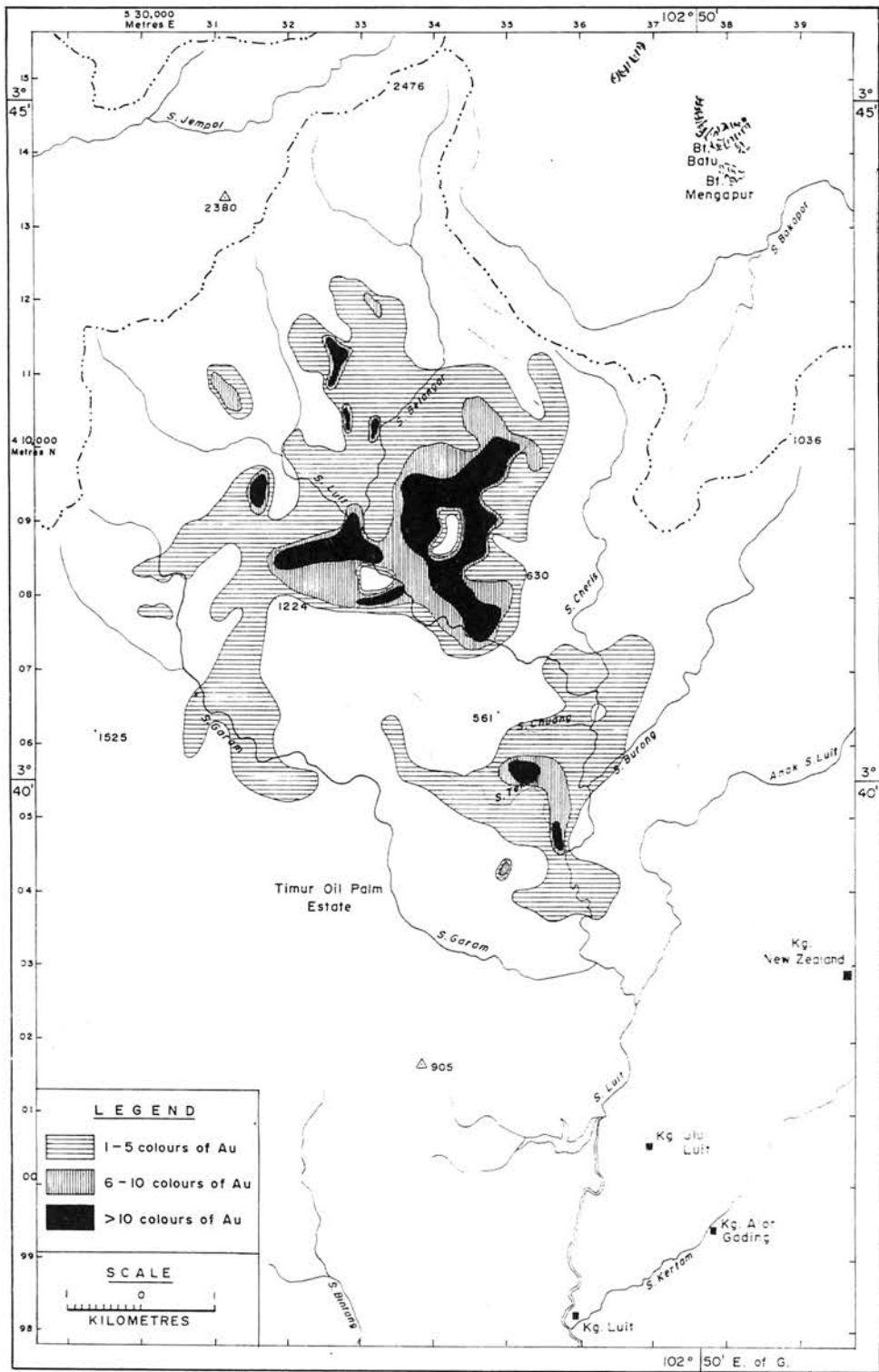
Fig. 11 Distribution of gold in stream concentrates in colours of gold per 5 standard *dulangs*.

In view of the high colour counts, further detailed investigation was undertaken. This phase involves soil sampling, pitting etc, with the base line of the soil grid as shown in Figure 12. This would provide effective coverage for both the areas of high Au occurrence.

DETAILED INVESTIGATION

For detailed investigation, an area of 6 sq km was chosen from the 40 sq km delineated during the follow-up stage (Figure 12). This phase of investigation includes (i) soil sampling (ii) pitting (iii) detailed geologic mapping and (iv) preliminary geophysical survey.

The baseline was orientated at 330° for preliminary VLF geophysical and detailed investigation. It extended northwestwards for 5 1/2 kilometres from the confluence of Sungai Tekoh with Sungai Luit. Cross lines were cut at 100 metre interval and they extend for 1 km on either side of the baseline.

(a) Soil sampling

Soil samples were collected from A, B and C horizons. They were collected from the A and B horizons at 50 metre intervals on a rectangular grid and the C horizon at 400 metre intervals along a triangular grid.

Soil samples collected from the A and C horizons were analysed for 14 elements (Ag, As, Cu, Co, Fe, Hg, Mo, Ni, Mn, Pb, W, U, Zn and Au). Soil samples from the B horizon were similarly analysed except for Au. Samples collected during the later part of the survey were also analysed for Bi and Sb.

Soil samples for Hg analysis were collected separately and sent in a moist state to the laboratory where they were air-dried and sieved through an 80 mesh screen prior to analysis. The other soil samples were subjected to soil sample preparation as shown in Figure 13. They were initially dried in an oven at not more than 55°C. Twigs/pebbles were then removed. The soil aggregates were broken up using a wooden mallet and sieved through a 10# sieve. The sieved portion was homogenised and then split into 2 fractions. One fraction weighing at least 30 gms was analysed for Au by fire assay method. The remainder was sieved (80#), homogenised and split. A portion of this was retained at Kuantan office for storage and colorimetric analysis of Sn, W and As while the remainder was sent to Ipoh for determination of the other elements. Mercury was determined by the cold-vapour atomic-absorption method.

(b) Pitting

Pitting was carried out along the soil lines on a square grid at 200 metre interval as shown in Figure 12. Each pit measured 30cm x 30 cm x 60 cm (depth).

All the soil recovered from the pits were put into sugar sacks or *ambongs** and soaked overnight in nearby streams. The soaked soil was then put into large basins and the soil aggregates broken up. Clay in suspension was allowed to flow out while the heavier particles

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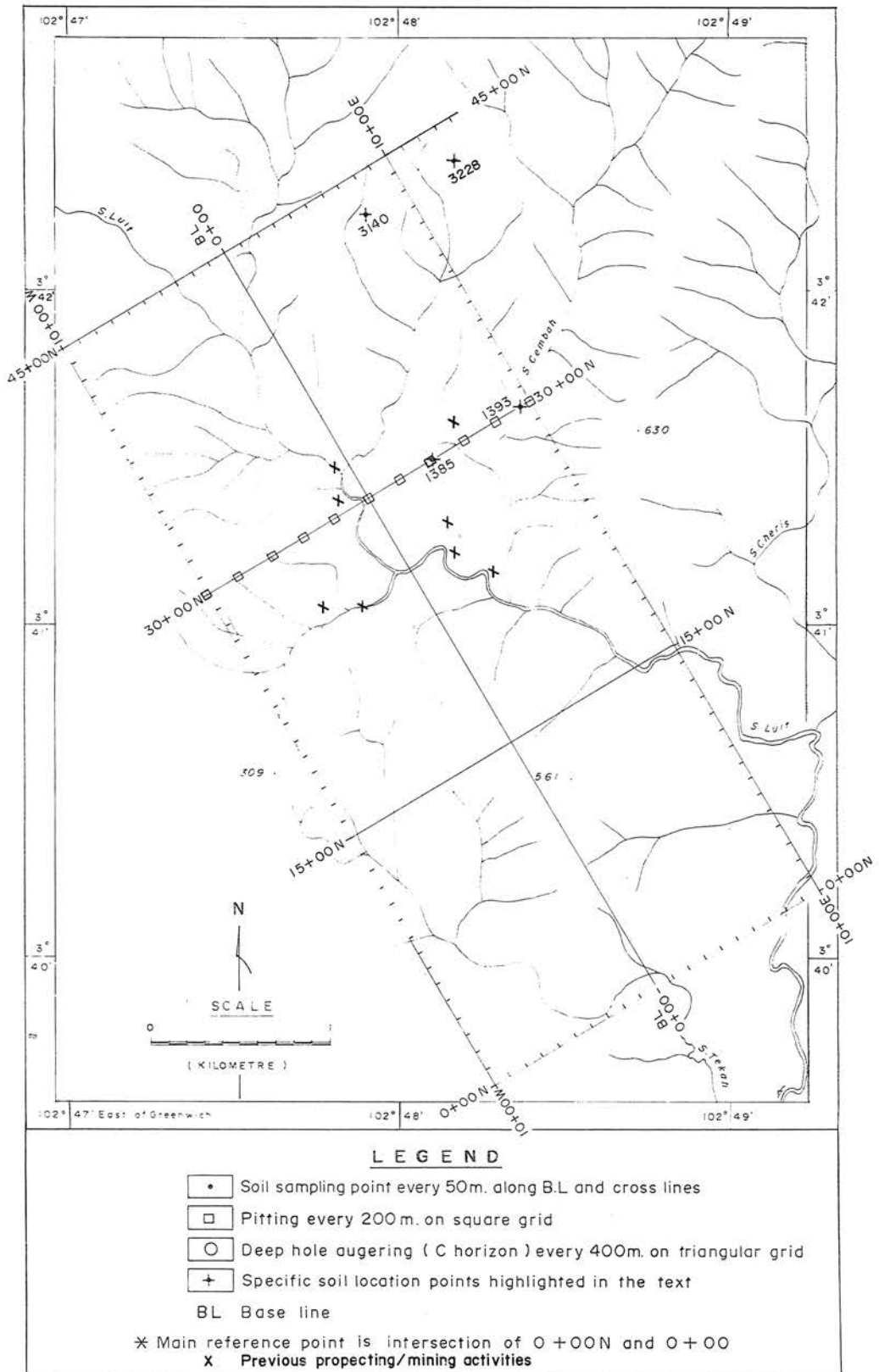* A rectangular metallic (zinc coated) container, measuring 30 cm x 30 cmx 50 cm.

Fig. 12 Soil grid plan of Sungai Luit area, Pahang.

Sample collected

↓

Dry

↓

Remove twigs /pebbles

↓

Break up lumps with
wooden mallet.

↓

Sieve through 10#
if necessary

↓

Homogenise and split

Send to Ipoh
for Au assay
(100g, at least 30g)

Sieve, 80#
Homogenise, split

Send to Ipoh
for analysis
of other
elements.

Grind for colouri-
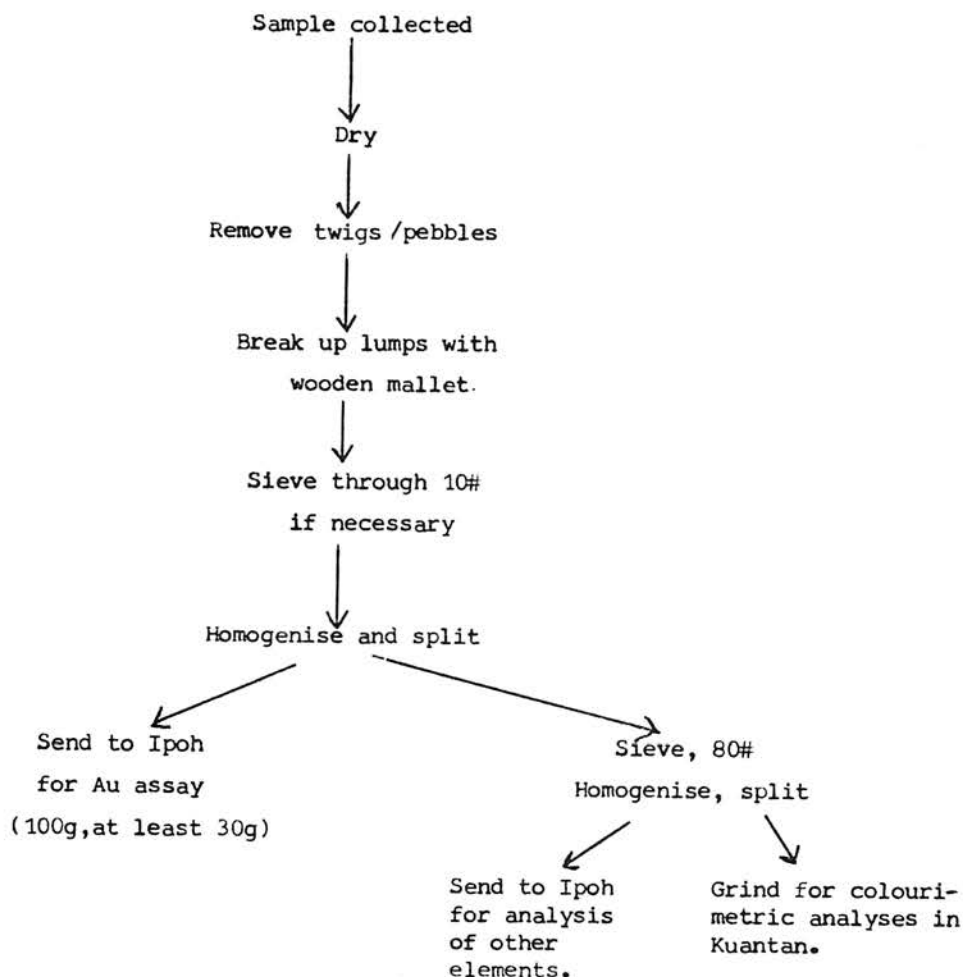metric analyses in
Kuantan.

Fig. 13   Soil sample preparation.

retained. Care was taken to make sure that all the soil aggregates were completely broken up. The residue remaining inside the basin was then panned using the Canadian *dulang*.

An attempt was made to recover at least 8gms of heavies from each sampling point. In areas where only a small amount of heavies was recovered, two to four pits of the same dimension were dug. The heavies recovered were subjected to a similar treatment as that carried out for stream concentrates recovered during the follow-up stage.

(C) Detailed geologic mapping

Detailed geologic mapping was carried out along the soil grid especially along streams draining the area. Rocks as well as vein quartz and limonite samples encountered were collected and petrographically studied. Selected samples were analysed for Pb, Cu, Zn, Co.

Ni, Fe, Mn, Ag, Mo (by AAS method), U (Fluorimetry), Au (by AAS or fire assay) and Sn, W, As (colorimetry). The geologic boundary did not differ much from that mapped by Lee (in manuscript). A number of highly pyritised rocks were encountered in the field. They were chemically analysed as well as crushed and panned. Chemical analysis revealed that they contain 0.01-0.02 ppm Au and no visible Au colours were recovered from the panned samples.

The Au content of the diorite rock was found to vary from 0.01 to 0.14 ppm with an average of 0.06 ppm. The carbonaceous slate contain 0.01 to 0.13 ppm Au with an average of 0.02 ppm. The Au content of rhyolitic tuff varies from 0.01 to 0.07 with an average of 0.04 ppm. The Au content of the diorite was highest followed by the tuff and finally carbonaceous slate. Vein quartz and limonite samples were also analysed but they gave a value of 0.01 - 0.02 ppm Au.

(d) Geophysical survey

A preliminary geophysical survey involving magnetic and VLF methods was carried out along the soil grid by the geophysical division of the survey. The equipment used were the MBS-2 and G-816 magnetometers and VLF-EM 16 receiver. The EM survey was carried out with respect to the transmitting station in Japan (240°).

A total of 21 E-W traverse lines with a 100 metre spacing between the lines was covered. The spacing between stations along each traverse line was 25 metres. The area covered includes only the southern 2 sq km of the area presently under detailed investigation.

Results from this geophysical survey carried out indicated that the northeastern quadrant of the area is magnetically more responsive than the rest of the survey area. This could be due to the presence of a shallow suboutcropping basic body. It also confirmed the existence of a major N-S fault.

PRESENTATION OF RESULTS

Geochemical results for soil samples collected from the A, B and C horizons were plotted directly. However, those obtained for heavy mineral residue from soil were converted to mgm per cubic metre before they were plotted.

All the geochemical data obtained were similarly statistically treated as discussed previously. Statistical levels obtained for the various elements from the A and B horizons and heavy mineral residue from soil are as shown in Tables II & III respectively.

The multielement anomalies obtained from soil samples for the A and B horizons were rather erratic and difficult to interpret. The raw geochemical data was thus subjected to moving average treatment (of non overlapping blocks) of Choke *et al.* (1979). The most suitable block size was determined to be 175 sq km (Figure 14). The resultant multielement residual map obtained for the A horizon is as shown in Figure 15. The multielement residual map for the B horizon is similar to that of the A horizon.

Geochemical results obtained from analysis of whole heavy mineral soil residue were converted to mgm per cubic metre and then plotted and statistically treated. The individual

TABLE 2
STATISTICAL PARAMETERS DERIVED FROM CUMULATIVE LOG-PROBABILITY PLOTS[1] OF
SOIL SAMPLES OBTAINED FROM A AND B HORIZONS.

Elements	Detection Limit	$\bar{x}$		$\bar{x}+s$		$\bar{x}+2s$		$\bar{x}+3s$	
		A hor.	B hor.	A hor.	B hor.	A hor.	B hor.	A hor.	B hor.
Cu	1	2.9	3.7	8.8	11.2	28	34	95	110
Pb	1	7.8	11.5	22.5	28	66	72	210	185
Zn	1	5.6	6.8	15.5	24	42	83	120	310
Mo	0.5	3.0	3.5	5.1	6.4	8.8	12.0	16	22.5
As	5	12	11	22	21	42	42	80	87
* Sn	10	2.7[2]		9.6[2]		35		140	
* W	4	2.1[2]		3.9[2]		7.5		15	
* Ni	1	0.52		2.1		8		35	
* Co	1	1.15		3.3		9.5		30	
* Ag	0.1	0.022[2]		0.062[2]		0.18		0.54	
Fe%	1%	1.17%	2.39%	2.8%	3.4%	4.6%	5.0%	7.6%	7.8%
Mn	1	6.8	8.7	25	30	90	102	370	380
Au	0.002	0.0025	–	0.0048	–	0.0095	–	0.0195	–
Hg	0.02	0.062	–	0.10	–	0.16	–	0.27	–
U	0.5	0.15[2]	0.15[2]	0.28[2]	0.32[2]	0.54	0.54	1.05	1.05

$\bar{x}$ = mean, s = standard deviation.
* Statistical parameters for these elements are the same for both soil horizons.
[1] Values are in parts per million (ppm) unless otherwise stated.
[2] Extrapolated value – below detection limit.

TABLE 3
STATISTICAL PARAMETERS DERIVED FROM CUMULATIVE LOG-PROBABILITY PLOTS[1] OF
HEAVY MINERAL RESIDUE SOIL.

Elements	$\bar{x}$	$\bar{x} + s$	$\bar{x} + 2s$	$\bar{x} + 3s$
Cu	1.2	5.3	25	125
Pb	18	68	260	1100
Zn	5.2	20	78	330
Mo	0.44	1.5	4.9	17.5
As	3	15	76	430
Sn	14	59	250	1200
W	0.44	1.5	5.1	18.5
U	29 $\mu g/m^3$	100 $\mu g/m^3$	350 $\mu g/m^3$	1350 $\mu g/m^3$
Ni	0.24	0.95	3.8	17
Co	0.13	0.61	2.9	15.5
Ag	15 $\mu g/m^3$	62 $\mu g/m^3$	265 $\mu g/m^3$	1250 $\mu g/m^3$
Au	0.37	1.9	9.5	50

(1) Values are in mg/m^3 unless otherwise stated.
$\bar{x}$ = mean; s = standard deviation

anomaly maps obtained for all the 14 elements were not subjected to moving average treatment as the anomalies obtained were readily interpreted. The resultant multielement anomaly map obtained for heavy mineral residue from soil is as shown in Figure 16. Two other geochemical anomaly maps were also produced from data obtained for heavy mineral residue from soil. Figure 17 shows the distribution of colours of gold recovered per pit while Figure 18 shows the geochemical anomaly map for Au contoured at $\bar{x} + s$, $\bar{x} + 2s$ and $\bar{x} + 3s$ levels.
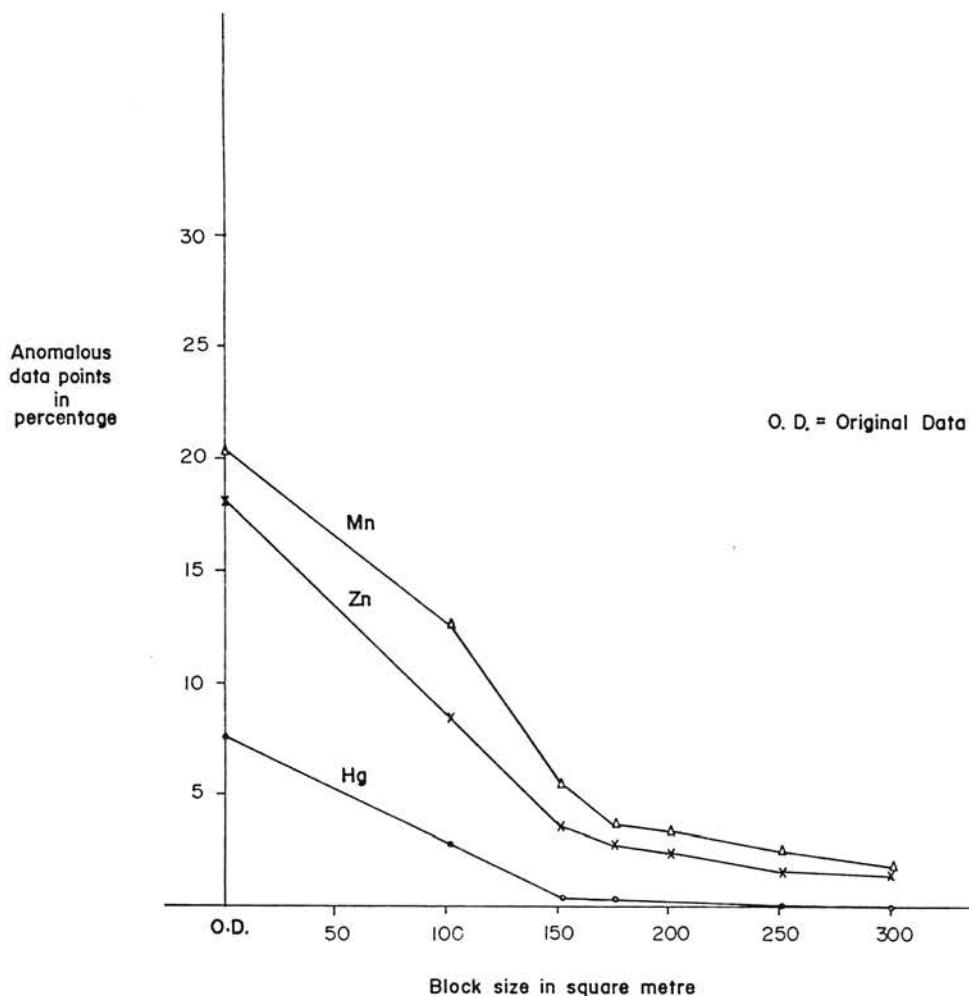
Fig. 14   Variation in percentage of anomalous data points as a function of block size.

DISCUSSION

In general, there is a very close similarity between results obtained from soil (Figure 15) and that obtained from heavy mineral residue of soil (Figure 16). The area sampled can be divided broadly into 2 main anomalous areas one occupying the southern portion of the grid and the other towards the north. A smaller anomaly occurs to the east of the southern anomaly; this anomaly is of minor importance and is not described.

The southern anomaly occupies the central and eastern parts. This anomaly can be separated into 2 parts; the main anomaly extends from Sg. Luit to Sg. Tekoh while another is confined to the floodplain of Sg. Luit. The main anomaly is attributed to the presence of Sn, Ag, Pb and As mineralization. Boulders of galena with minor amounts of Ag have been recorded to occur at the interfluve of Sg. Luit and Sg. Burong (Fitch, 1946). Ten diamond drill holes sunk over the area revealed the absence of galena thus implying that the source of the galena is located farther upstream (Unpublished G.S. Files). To the east and along the flood plain of Sg. Luit, there is overlapping of this main anomaly with further upstream the Sg. Luit. A number of anomalous gold values was recorded along the flood plain of the Sg. Luit. Both the residual soil and heavy mineral residue anomaly maps show that the eastern portion of
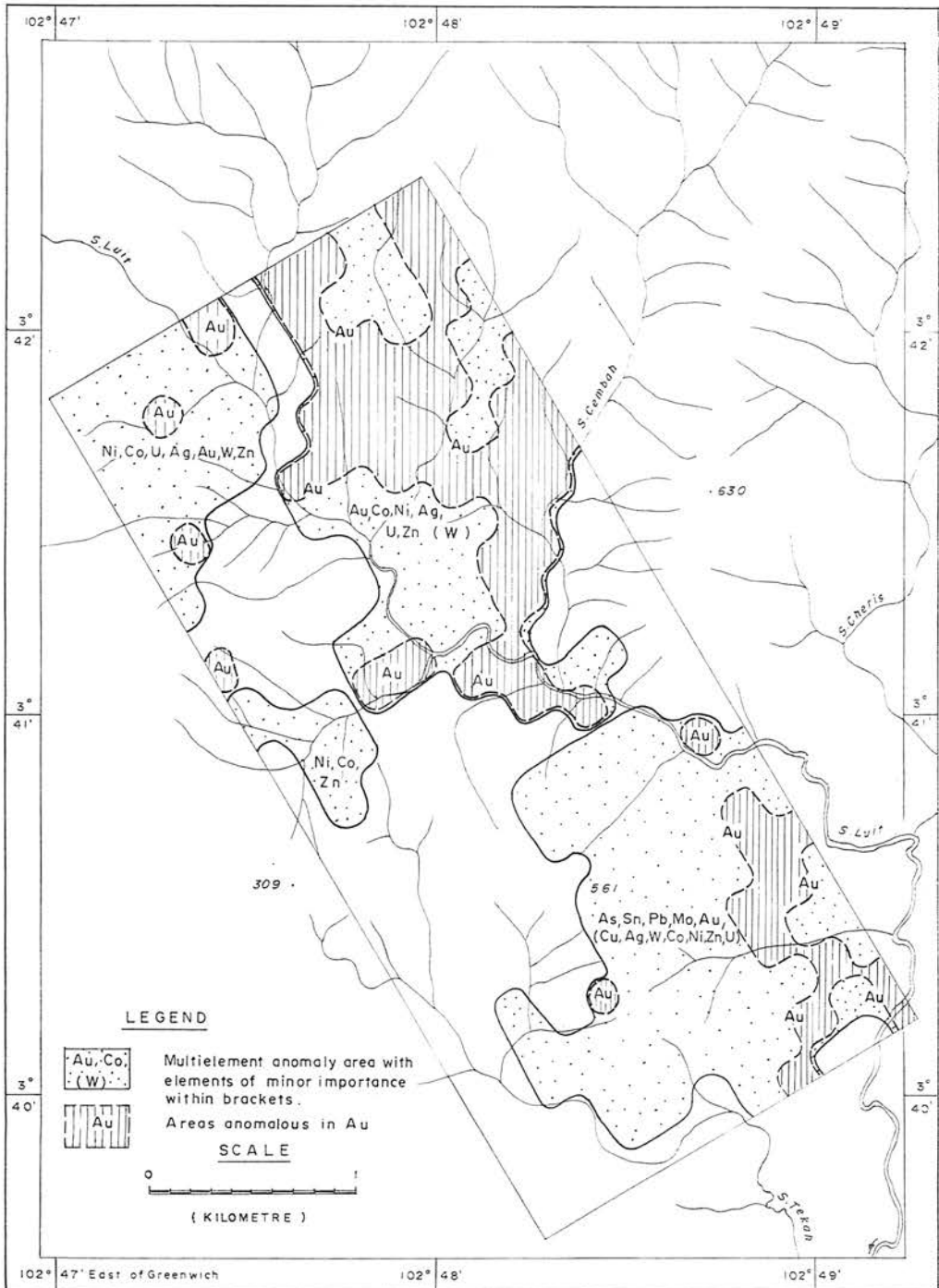
Fig. 15   Multielement residual soil map of 'A' horizon.

Fig. 16   Multielement heavy minerals from soil.

the anomaly which lies in the flood plain of Sg. Luit is anomalous in Mn, Zn, Co, Ni, U and Au. The area upstream is more anomalous in these elements. This implies the downstream dispersion of these elements.

Soil (Figure 15) and heavy mineral residue from soil (Figure 16) show that the northern anomaly is anomalous in Fe, Mn, Ni, Co, Zn and Cu with minor amounts of Pb, Hg, As, Ag and Au. This area is underlain by a diorite stock which accounts for the presence of anomalous Co, Ni, Fe and Mn. The scavenging action of Fe and Mn could have contributed to the greater dispersion of these elements farther downstream along Sg. Luit. The disparity of anomaly outlined in Figures 15 and 16 is probably attributed to the highly disturbed nature of this area caused by previous prospecting and mining activities.

When Figures 17 and 18 were compared it was found that areas demarcated as containing anomalous amount of Au coincide with the areas of high gold colour count. As an approximation, 2 to 9 colours of Au corresponds to the anomalous 9.5 to 50 mg/m³ Au ($\geq \bar{x}$ + 2s) recovered from soil; and greater than 9 colours corresponds to the highly anomalous values of ≥ 50mg/m³ ($\geq \bar{x}$ + 3s)

The close similarity between the two maps is attributed to two factors. The size of the gold colours recovered is more or less uniform. This is evident from the study on 979 gold flakes recovered from the area, 86.8% of which had their longest dimension measuring < ¹/₂ mm in diameter. Secondly, most of the gold occurs as free visible gold and are not incorporated within sulphides. Where these conditions are satisfied, the search for Au can be carried out by recording the colours of gold recovered and contouring the data obtained without having the heavy mineral concentrates analysed for Au.

The map that is easiest to use for delineating anomalous areas in the station is that showing the distribution of gold colours recovered per pit. However, it should be kept in mind that the area is highly disturbed owing to previous prospecting and mining activities.

Two areas with high concentration of gold colours recovered were delineated from the map showing the number of gold colours recovered per pit (Figure 17). These two areas were tested for its primary gold potential by undertaking deep soil augering at 10 metre interval across them. Deep hole augering was carried out for 400 metres from station 81/EL/1385 to 1393 and from station 81/EL/3140 to 3228 (Figure 12). Soil samples were collected at depths of 1 ¹/₂ metre interval until a maximum depth of 10 metres. However, owing to the presence of abundant laterite most of the holes reached only 2 to 3 metres. Soil samples were analysed for 17 elements: Cu, Pb, Zn, Mo, As, Sn, W, Ni, Co, Ag, Fe, Mn, U, Bi, Sb, Au and Hg. Distribution of the various elements in the profile along the 2 traverse lines were drawn.

The distribution of Au in the soil profile along traverse line 81/EL/1385 to 1393 (see Figure 19) shows that only 2 values exceeded 0.01 ppm Au. In general over most areas, Boyle (1979) has reported the threshold of Au for soil to be 0.01 ppm. From the Au analysis carried out on soil samples from the A horizon, the threshold was 0.0095 ppm which is close to 0.01 ppm. The below threshold values of Au recorded at lower levels along the soil profile indicated that the high Au colour count over the area (from shallow pitting) was the result of previous prospecting and mining activities and not likely due to primary Au mineralization at depth.
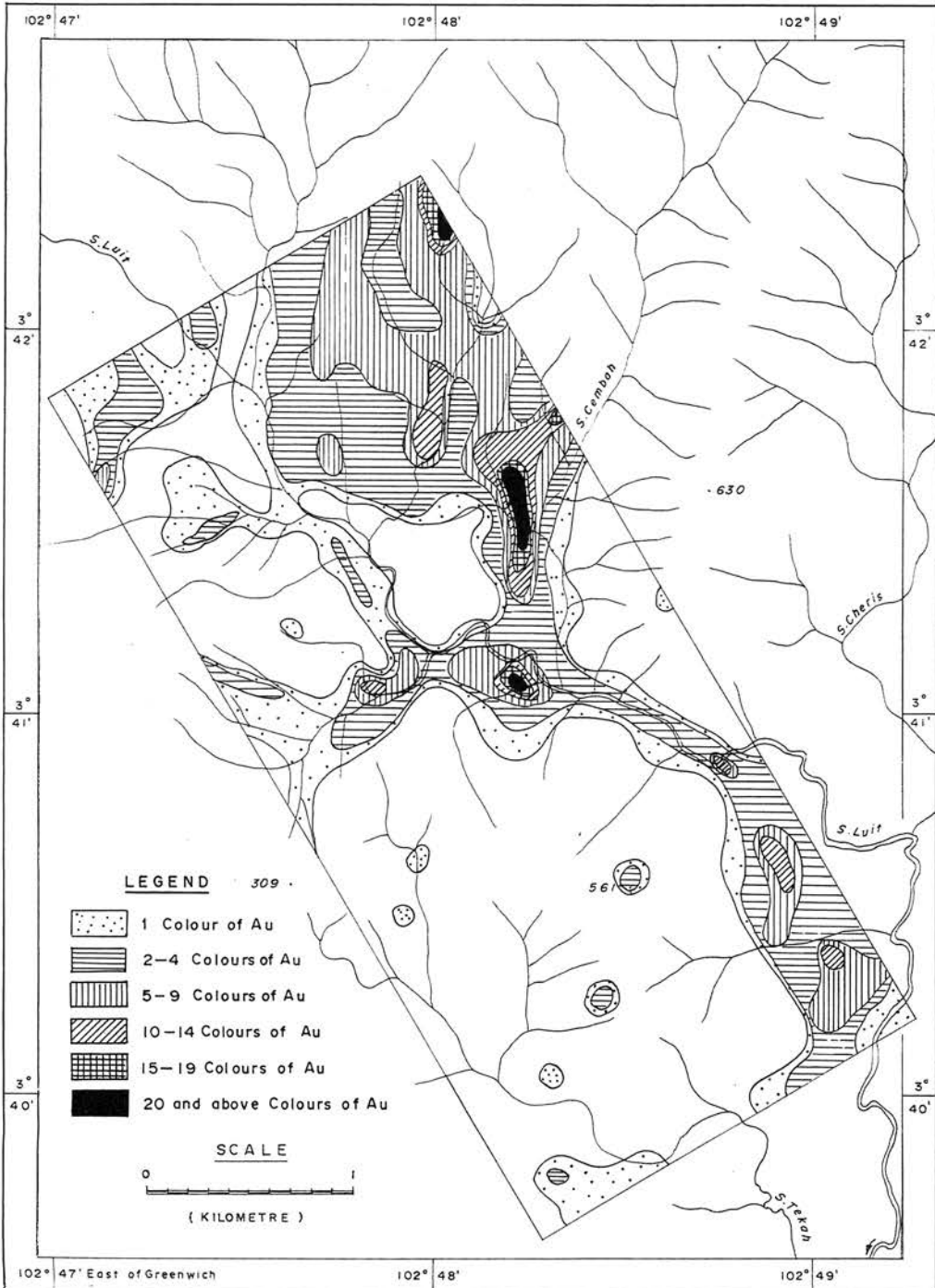
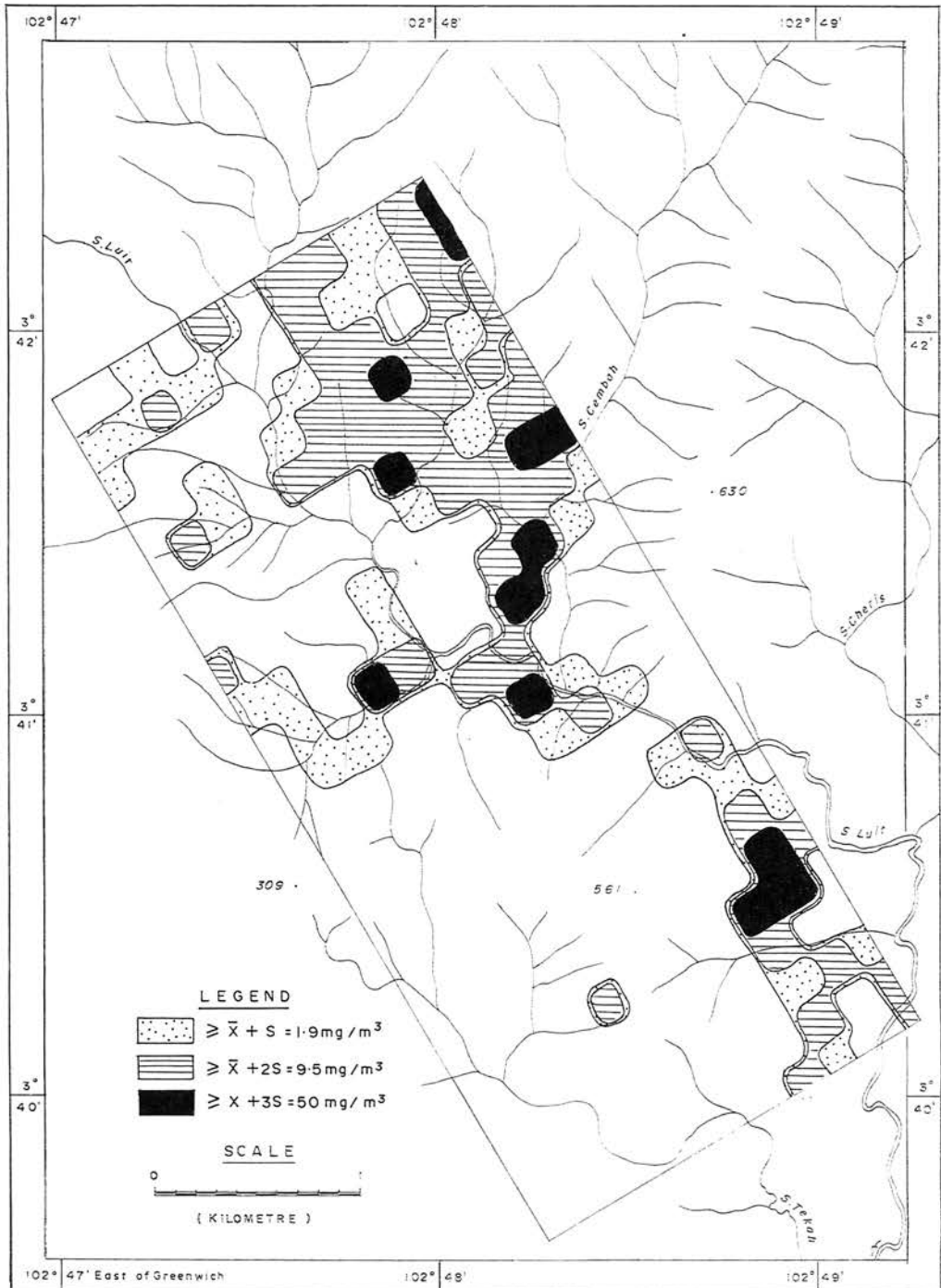Fig. 17   Map showing colours of Au recovered per pit.
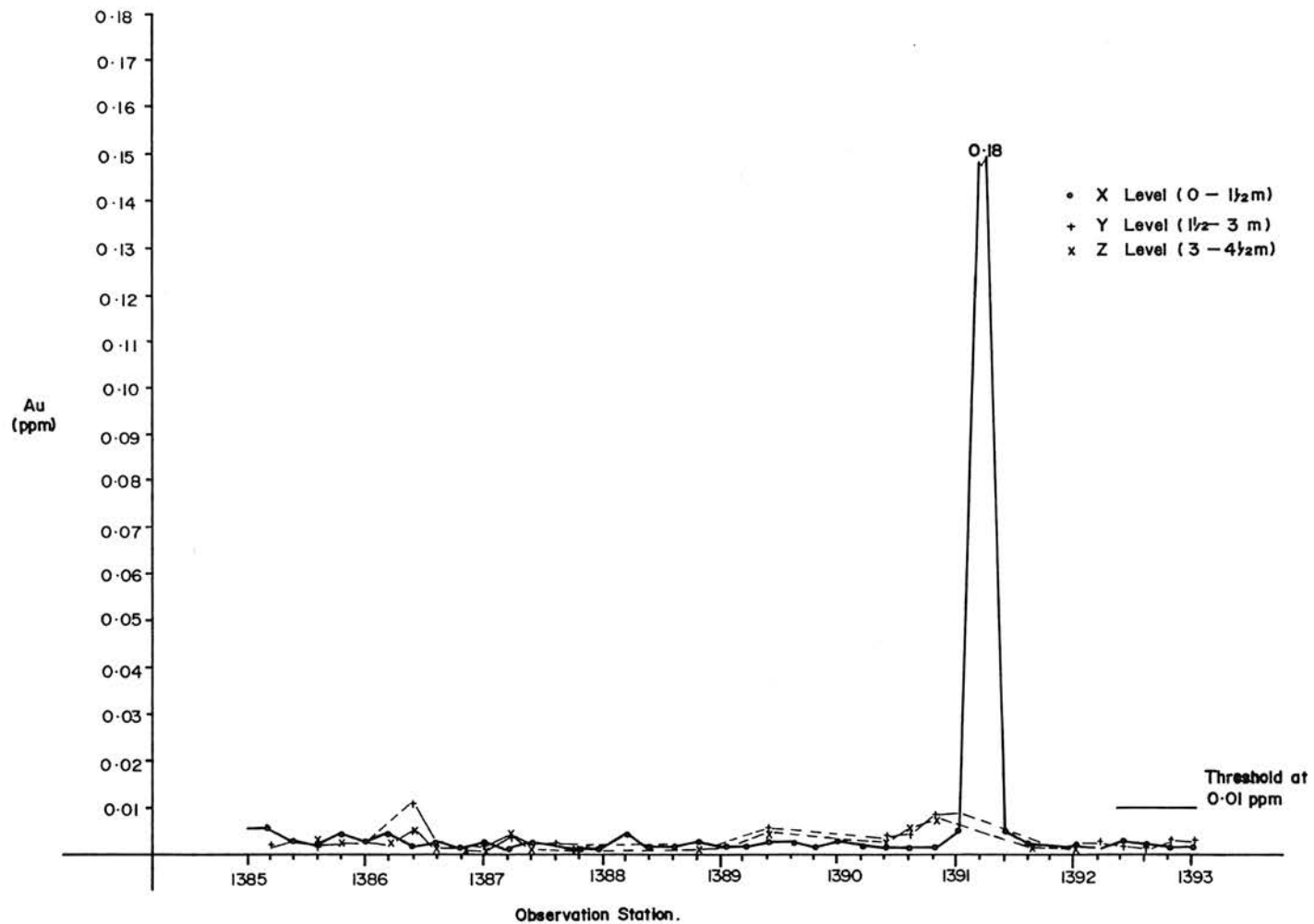
Fig. 18   Gold in heavy minerals from soil.

Fig. 19 Distribution of Au in the soil profile along traverse line 81/EL/1385 – 81/EL/1393.

However, the distribution of Au in the soil profile from station 81/EL/3140 to 3228 gave very encouraging prospect for the occurrence of primary Au mineralization at depth. Anomalous concentrations of Au were recorded along this traverse line from station 81/EL/ 3145+40m to 3228 (Figure 20). This anomalous area probably extends farther eastwards and measured at least 100 metre in width. The highest Au content recorded was 1.15 ppm and this was at the Y level i.e. from a depth of $1^1/2$ to 3 metres. Within this area the Au content varied from 0.012 to 1.15ppm. From these results it was found that Au is closely related to As (Figure 21). Gold has no correlation with Bi. Gold mineralization in the Sg. Luit area indicates that it is of the gold-quartz type. The area underlain by this Au anomaly is traversed by numerous quartz stringers. The only element which is most closely related to it is As. Search for primary Au mineralization should be made for dilatant zones nearby (open fissures, faults, shear zones, drag fold etc.) in which the Au and gangue elements have been concentrated.

Geologically this area is very favourable for Au mineralization. It lies in an area of sedimentary rocks intruded by a small stock-like intrusive of diorite to the NW. These type of environment is known to contain most of the largest lode mining districts (Boyle, 1979).

CONCLUSIONS AND RECOMMENDATION

1. The best medium to use in the search for gold in the Sg. Luit area is heavy mineral residue of soil. Untreated data from soil gave a rather erratic picture and interpretation difficult. For better interpretation the soil data had to be subjected to moving average treatment.

A contoured map showing the number of gold colours recovered per pit gave equivalent results from the assayed heavy mineral residue obtained from soil. Hence, colour count is preferred as it is cost-effective.

2. From a study of heavy mineral residue of soil it was found that elements which have a similar pattern of distribution with Au are Ag, Zn and Cu. However, results from soil profile show that As is most closely correlated to Au.

3. The largest area of anomalous Au concentration occurs at the northeastern portion of the area under investigation. It is open ended to the northeast, hence, more detailed work should be carried out in order to close the anomaly. Gold was analysed only for the A horizon. Soil samples from the B horizon should also be analysed for Au over selected areas.

4. Gold in the Sg. Luit area occurs mainly as free Au and is not locked up in the crystal lattices of sulphides. About 99% of the Au flakes are less than 1 mm in diameter. However, most of the Au colours are visible. The amount of flour Au present is negligible. This suggests that the Au has originated from primary veins and lodes. The variable fineness of the Au (940-980) further supports its origin from primary veins and lodes (Boyle, 1979). Sporadic Au mineralization occurs throughout the Sg. Luit area as evident from the various anomaly maps. The area is underlain by tuff and carbonaceous slate of Permian age as well as diorite. Locally all the rock types are highly pyritised especially along fissures and fractures within the various rocks. It is highly probable that some of these fissures and fractures contain Au mineralization.
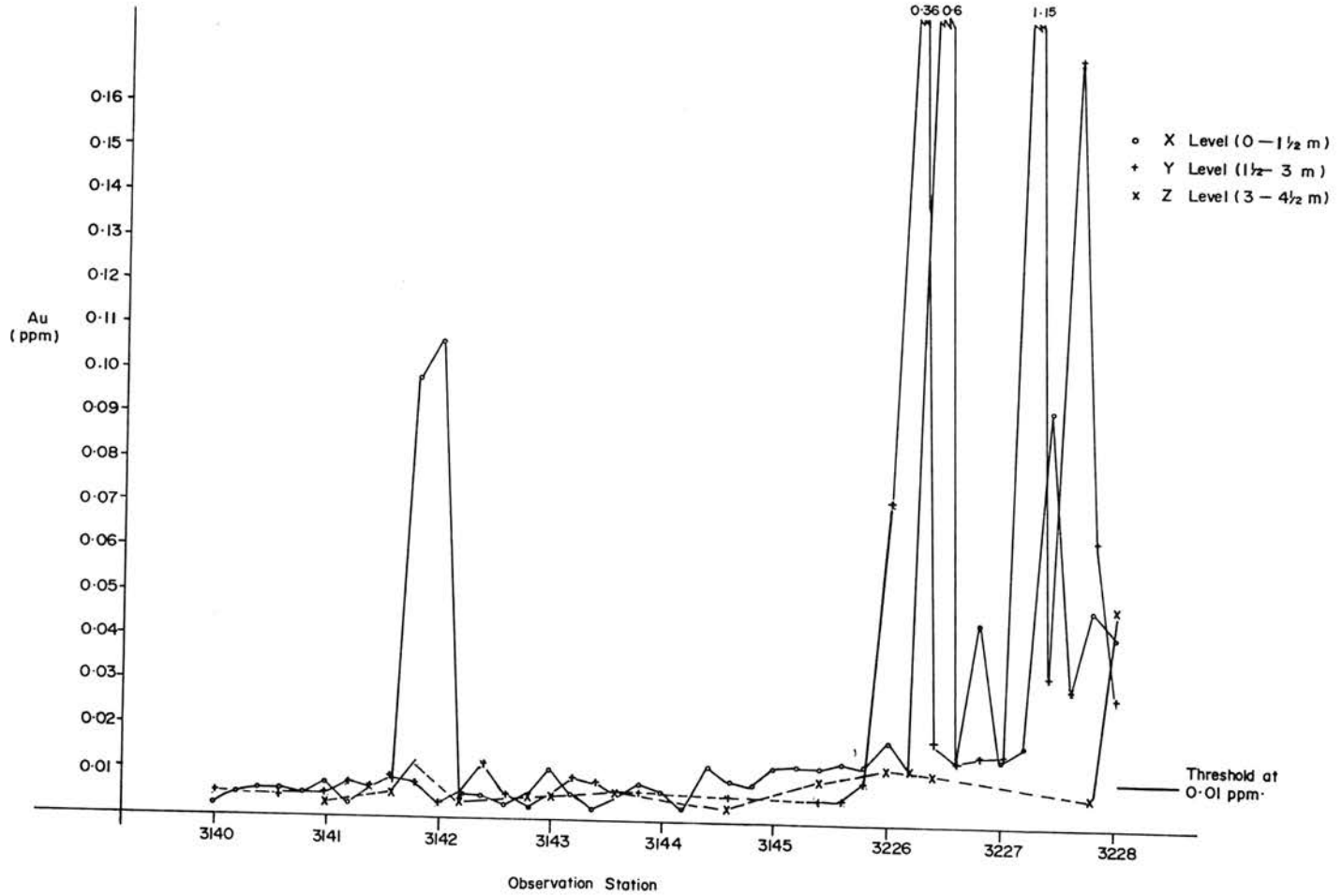
Fig. 20 Distribution of Au in the soil profile along traverse line 81/EL/3140 — 81/EL/3228.
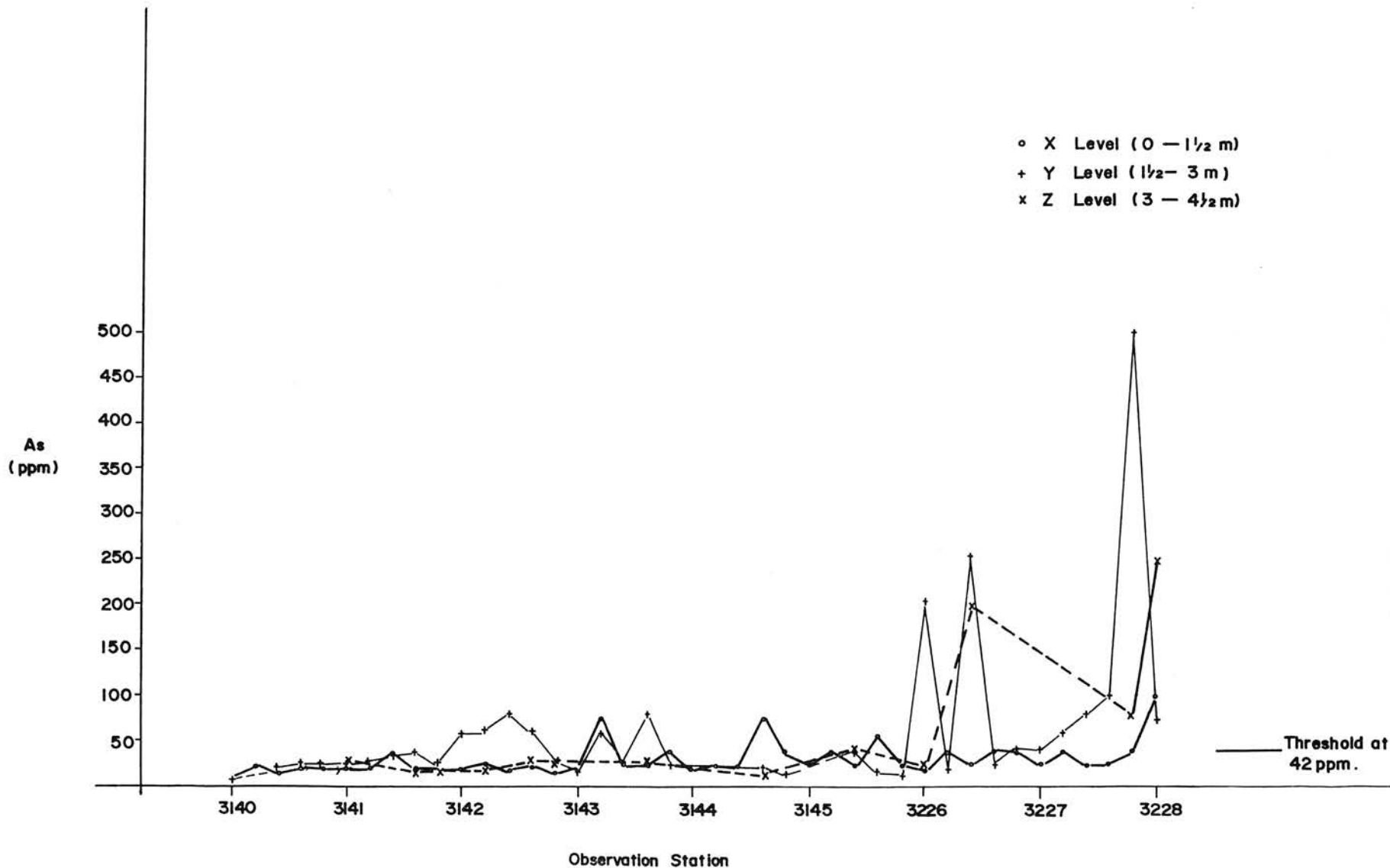
Fig. 21 Distribution of As in the soil profile along traverse line 81/EL/3140 — 81/EL/3228.

5. The highest gold value recorded from pitting was 556 mg/m and this is equivalent to 0.28 gm/ton. This is rather low. However, it is to be noted that pitting was carried out only to a shallow depth of 60 cm.

There is thus a strong possibility of the occurrence of placer Au in economic quantity in the lower reaches of Sg. Luit especially within the interfluve area of Sg. Luit with Sg. Tekoh and Sg. Burong. The thickness of alluvium in this area is about 10 metres. Banka drilling should be carried out within this area to determine its potential for placer Au.

6. Deep hole hand augering was carried out along traverses cutting across two areas containing the highest number of Au colours recovered. A majority of the holes could penetrate only 2 to 3 metres owing to the presence of hard laterite.

Promising results indicating the possible presence of Au mineralization was returned from the northermost anomalous area. Since the anomaly is open-ended, the actual extent cannot be determined at this stage until further work has been carried out over the area. Banka drilling should subsequently be undertaken.

This area of highest Au mineralization is underlain by carbonaceous slate which lies between the diorite stock to the northwest and tuff to the southwest. A distinct fracture (probably a fault) runs along the Sg. Chembah which lies close to the contact between tuff and carbonaceous slate. The highest anomalous gold results are obtained within the area drained by Sg. Chembah and its tributaries thus implying that Au mineralization in the Sg. Luit is fracture controlled. The source of gold mineralization is speculative and could have originated from the volcanic rocks within the area and remobilized by the intrusion of the diorite stock. Gold mineralization is probably associated with auriferous quartz veins and massive sulphides. A similar geological setting has been reported in the Sok Prospect (Chu, 1983); metamorphosed carbonaceous sediments and sulphides bearing (esp. pyrite) metavolcanic and metamorphosed volcaniclastic rocks may be important sources of the Au.

ACKNOWLEDGEMENTS

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