they were mined out open pits which are flooded. Outline of these workings are compiled in Appendix 1 based on previous data. Only two of the principal mine workings are described in this chapter.

3–1–25–1 Tai Parit Mine

The Tai Parit mine, the biggest in West Sarawak, is located immediately south of Bau town. The deposit was mined for gold by the Borneo Company from 1898 to 1921 during which time a total of 15,371 kg of gold was extracted from approximately two million tonnes of crude ore. The opencast mine is now flooded.

The ore deposit is inferred to occur as elongated, massive and/or network bodies with N50°E to N70°W trends in limestone of the Bau Limestone at the contact with the Pedawan Formation. The deposit consisted mainly of calcite-quartz veins containing native gold with a small amount of arsenic minerals. The physical control of this mineralization may be considered to be the Tai Parit Fault but details are not clear.

3–1–25–2 Bukit Young Mine

This mine is situated just southwest of Bau town, and was mined by the Bukit Young Mining Company from 1955 to 1979.

A total of 68 kg of gold from about 85,000 tonnes of crude ore with an average grade of 8.5 g/t Au was produced. The working is also flooded at present.

The deposit consists mainly of NNE–SSW trending quartz-calcite veins formed in limestone near the contact with the Pedawan Formation. Ore minerals are gold with stibnite and native arsenic and rare galena. The deposit appears to be controlled by a NE–SW trending fault immediately adjacent to the deposit.

3–2 General Characteristics of Mineralization

The general characteristics of mineralization in the project area may be summarized as follows:

1) On the basis of the metals mined in the past and mineral assemblages, the ore deposits in the Bau area can be roughly divided into gold-antimony deposits, gold-bearing copper--lead-zinc deposits and mercury deposits. The main ore minerals of each group are as follows:

(i) Gold-antimony ore deposits

Gold, stibnite, native arsenic, pyrite and arsenopyrite are common ore minerals of this group. Subordinate minerals include sphalerite, galena, chalcopyrite, marcasite and some sulfosalts. Gangue minerals are mainly quartz and calcite, and calc-silicate minerals in some ore bodies.

(ii) Gold-bearing copper-lead-zinc ore deposits

Ore minerals are mainly galena, sphalerite, chalcopyrite, pyrite and arsenopyrite with minor amounts of stibnite, gold and sulfosalts. Quartz and calcite are common gangue minerals. Calc-silicate minerals are absent.

(iii) Mercury ore deposits

Cinnabar, native arsenic, arsenopyrite and occasionally, native mercury are common with gangue minerals, such as calcite, barite, fluorite and calc.

2) The known ore deposits occur mainly in the area from Bau to Krokong, around Bt. Pangga and Jambusan, and in the Gading and Tegora areas. No significant mineralization is known in the western and southeastern parts of the Bau area, and in the Jagoi Granodiorite.

Most of the ore deposits are formed along the crest of the Bau Anticline and the NNE trending alignment of Tertiary intrusives. Numerous ore deposits are localized at the intersection of these two prominent major structures around the Bau town area. The majority of the gold-antimony ore deposits occur in limestone along fractures and joints trending NNE to NE. These fractures and joints are consistent with the direction of faults and dykes developed throughout the limestone area. Thus it can be said that the most favourable sites for ore deposits are fractured zones adjacent to faults and dykes in limestone. Gold-bearing copper-lead-zinc ore deposits occur along fractures and/or joints in the Tertiary intrusive stocks and in limestone immediately adjacent to them. They occupy approximately the centre around which gold-antimony ore deposits are distributed.

Mercury ore deposits occupy the brecciated or highly sheared zones in shale and sandstone of the Pedawan Formation, near small intrusive stocks.

3) Most ore deposits are of the epithermal, fissure-filling vein type. A few however, occur also in closely fractured or shattered zones in limestone as lenticular shaped ore bodies formed by local replacement of the host rock. Economic contact metasomatic ore deposits to-date have not been found in the area.

Copper mineralization of the porphyry copper type was recognized for the first time to occur in the G. Ropih area, one of the Tertiary intrusive stocks. Work carried out so far however, indicated that the mineralization is sub-economical.

4) Generlly, the ore deposits are small, although relatively larger deposits such as the Tai Parit, which produced more than 2 million tonnes of crude ore (about 15 tonnes of gold), and the Tai Ton B, with a vein measuring more than 350 m long, are also known.

3–3 Preliminary Assessment of Old Mine Waste and Tailing

During the 1900's, when mining activites in the Bau Mining District reached their peak, the Borneo Company set up two central gold treatment plants. One plant was at Bau to treat ores from the Tai Parit, the Batu Bekajang and other nearby mines. The other plant was at Bidi, to treat ores from mines in the Tai Ton, Bidi and Krokong areas. Tailings from these two plants were dumped in the low-lying areas around the plants and in disused opencast workings, as in Bidi. Later on, some of the tailings of these dumps were treated for Au although the proportions were very small.

Small tailing dumps are also found at Saburau, Tai Ton, Boring and Krokong.

Samples of the tailings from Saburau, Tai Ton, Bidi and Krokong were collected by the Anglo-Oriental (Malaya) Limited in the early 1950's and were analysed for gold by the Malayan Geological Survey, giving the following results:

Saburan area	5.43 g/t Au
Tai Ton area	0.31 g/t Au
Bidi area	0.93 g/t Au
Krokong area	0.78 g/t Au

The tailing dump at Bidi, estimated to be around 1 million tons, was investigated by the Department of Mines, Federation of Malaya. Samples were collected by bangka-drilling and analysed, giving the following results:

Drill hole No. 1	0 ~ 5.18 m	1.86 g/t Au
Drill hole No. 2	0 ~ 7.92 m	1.24 g/t Au
Drill hole No. 3	0 ~ 17.37 m	2.02 g/t Au
Drill hole No. 4	0 ~ 1.2 m	1.55 g/t Au

During Phase I of this project, samples from the tailing dumps at the old Bau Airstrip and the Southwest End of Tai Parit Lake were systematically callected on a grid pattern using the hand anger. The weighed average gold content was calculated for each anger hole and the overall average grade and tonnage estimated by block averaging.

Old Bau Airstrip : Average Au grade = 2.01 g/t

Total reserve of Tailing Dump = 261,160 t

(S.G. of tailings = 1.6)

Southwest End of Tai Parit Lake: Average Au grade = 0.77 g/t

(Reserves not calculated)

Based on the investigations above and past information the average Au grades of probable economical tailing dumps in the Bau Mining District vary between 1.24 to 2.02 g/t except for the Saburan tailings which probably average around 5.0 g/t Au. The total reserve of the dumps is conservatively estimated to be not less than 1,000,000 t. It should be pointed out that except for the tailing dump at the Old Bau Airstrip, others occur at scattered smaller dumps which are presently difficult to relocate because of secondary vegetation regrowth. A detailed ground survey including a study of past records, consultation with local people of probable locations of these dumps and augering would be required to assess their grades and reserves realistically.

PART Ⅲ GEOCHEMICAL SURVEY

CHAPTER 1. GENERAL REMARKS

Geochemical surveys using three sample media, namely, stream sediments, soil and rock were employed during the various exploration stages of the project. The strategy of the geochemical survey adopted follows closely the normal sequence – an initial reconnaissance stream sediment survey succeeded by more detailed follow-up surveys using stream sediments, soil and/or rock in progressively smaller target areas.

Geochemical stream sediment survey is the most suitable technique for obtaining information on a broad area. This method was used during Phase I of the project. Both stream sediment and panned concentrate samples were collected at preselected sampling sites. The reconnaissance stream survey was followed up by detailed geochemical stream sediment, panned concentrate, soil and lithogeochemical surveys during Phase II in smaller selected target areas. Detailed stream sediment and panned concentrate sampling were undertaken in the Gunung Api-Sungai Puteh area, detailed soil sampling in the Gunung Ropih-G. Juala area and a semi-detailed lithogeochemical survey in the Jambusan-Tai Parit area which is underlain by limestone with no soil development. As further follow-up work in the areas delineated by Phase II work, detailed soil and panned concentrate sampling in the Sungai Sinyi-Sungai Matung area, and detailed lithogeochemical sampling in the Seromah North and Gunung Batu area were undertaken.

The goechemical methods employed in this project played prominent roles in deciding and selecting potential target areas for further follow-up work in each succeeding phase of the project. As the project area is a well-documented gold mining district, project efforts placed emphasis on the exploration for gold. Because of the mode of gold dispersion and the limitation of the analytical method used, analysed gold values in themselves are not very effective and reliable in exploring for the metal. Associated path finder elements such as Sb, As and Mn, and physical estimation of gold grains in panned concentrate samples instead, were heavily relied upon.

Most of the geochemical samples collected during the project were analysed for various selected elements in the laboratory of the Geological Survey of Malaysia, Sarawak. Analytical data were statistically treated and interpreted.

CHAPTER 2. PHASE I GEOCHEMICAL SURVEY

2–1 Outline of Work

Reconnaissance geochemical survey including geochemical stream sediment and panned concentrate sampling of active stream sediments was carried out during Phase I over the whole project area of 540 km^2.

The work was initially started independently by the staff of the Geological Survey of Malaysia in March, 1982 and later continued jointly with a Japanese aid team. Field sampling work was completed by October 1982. A total of 663 stream sediment samples were collected giving a sampling density of 1.2 samples per km^2. Except for the limestone area around Bau town, all other samples were collected from sites in mostly 1st or 2nd order streams, pre-selected on a 1:50,000 topographic base map. At each site, a minimum of about 20 g of wet-sieved, –80 mesh stream sediment sample was collected in a plastic bag. Relevant information pertaining to each sample site including among others, the sample number, the geographic coordinates, elevation, rock type, vegetation and possible source of contamination was recorded on a standard field coding form. At most sample sites, panned concentrate samples were also obtained by hand panning known volumes of sediments measured with 5ℓ wooden boxes. Wooden pans (dulangs) were used in panning and ideally sediments were panned until about 15 to 20 g of heavy minerals were obtained. The sample was collected in a small plastic bag. In the manner described, 454 panned concentrate samples were collected over the project area giving a sampling density of 0.84 sample/km^2.

In the laboratory, the stream sediment samples were air-dried and analysed for Au, Ag, Sb, Cu, Pb, Zn, Fe, Mn, As, Mo, Hg, Ba, W and U. The panned concentrate samples were air-dried, bromoform separated and the heavy fractions counted for gold grains under the binocular microscope.

Statistical methods including the Sinclair's graphic method (1974) of deriving meaningful statistical levels and multivariate analysis techniques were applied to treat and interpret the stream sediment analytical data. The analytical data for each element classified according to the derived statistical levels were presented on a 1:100,000 drainage map of the project area. Factor scores for all the samples using factor 1 and 2 were also plotted on a similar scaled maps.

For the panned concentrate samples, the counted number of gold grains for each sample was calculated to a standard 50 ℓ volume of stream sediments. The calculated results were then arbitrarily devided into 4 classes and plotted also on a 1:10,000 scaled drainage map.

2–2 **Results**

The distributions of the analysed elements in stream sediments samples and the results of multivariate analyses suggest that 4 broad zones of metal enrichment exist in the project area: a zone in the limestone area around Bau Town where Au, Sb, W and As enrichments occur, a zone along the NNE alignment of Tertiary intrusives particularly from Gunung Juala to Gunung Baran where Cu, Pb and Zn, and minor Mo and Ag enrichments are found in close association, a zone of Hg enrichment stretching from Gunung Tegora in a northeasterly direction to as far as Gunung Sta'at and a zone of U enrichment almost completely confined to the area underlain by the Jagoi Granodiorite. By combining the drainage catchment areas of the various samples which are anomalous for various elements, 19 anomalous areas may be delineated in the project area (Fig. III–1, Fig. III–2, Table III–1).

Results of the gold grain counts of panned concentrate samples show three main areas where samples with gold grains are clustered in the Jambusan area, the Gunung Ropih Tertiary intrusive area and the Gunung Api Tertiary intrusive area. 6 samples in the Jambusan area contain 27 to 175 gold grains per 50 ℓ stream sediments, 2 samples in the Gunung Ropih area 27 and 28 gold grains and 2 samples in the Gunung Api area, 27 and 56 gold grains. Outside these 3 areas, gold grains mainly less than 10 per 50 ℓ stream sediments were also detected in a few samples from the Bt. Pangga, Gunung Tabai and Gunung Juala area. In other areas, samples with detected gold grains are singly located and are generally from streams draining the Tertiary intrusives. At many sampling locations, gold grains were observed in panned concentrate samples but not detected in the stream sediment samples. This is probably due to the mode of occurrence of gold and the small amounts of sample used in analysis. The reverse situation is also true in some cases which suggest the possibility that gold most probably occurs as very fine particles which were not retained in the panned concentate samples.

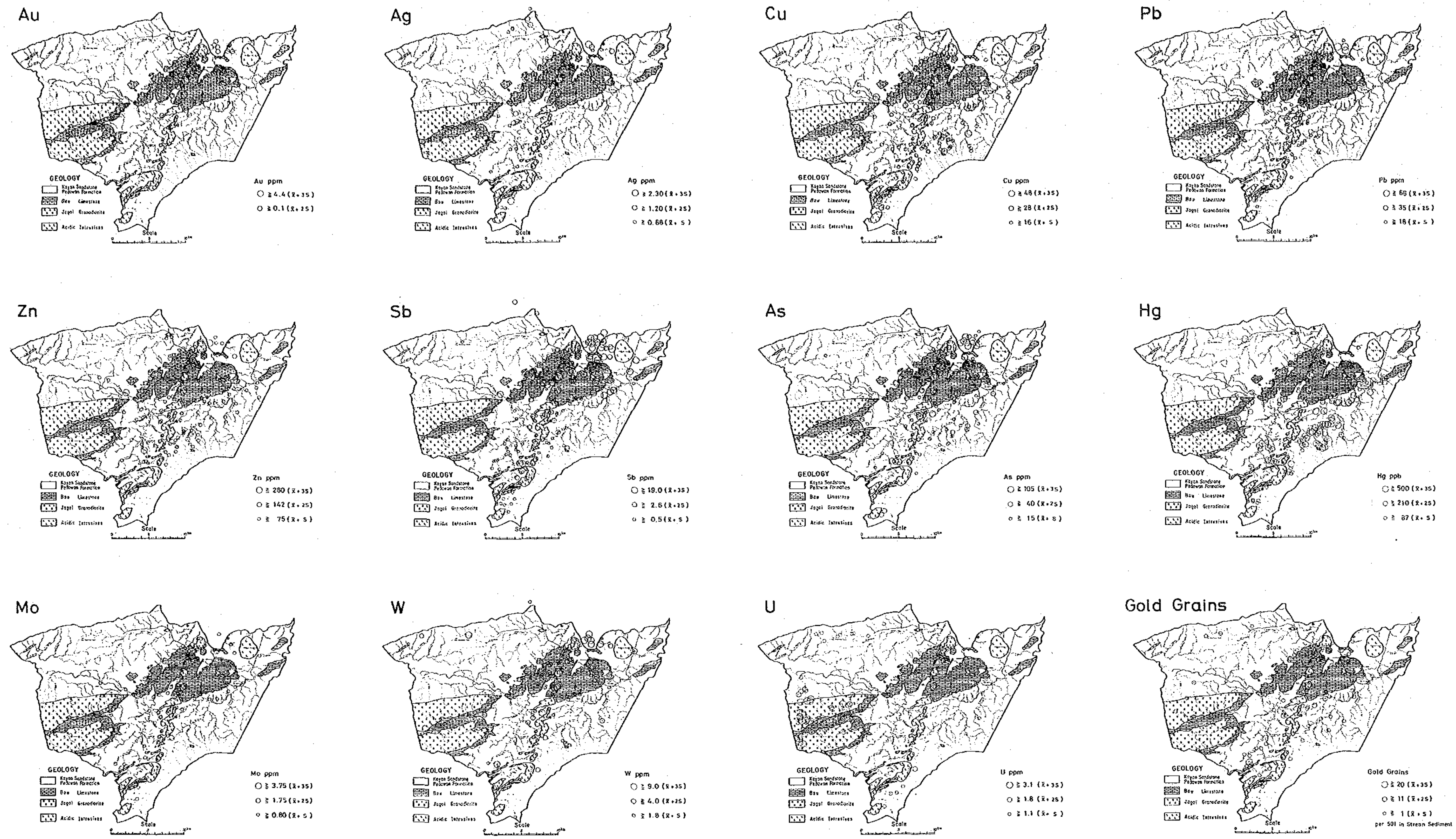
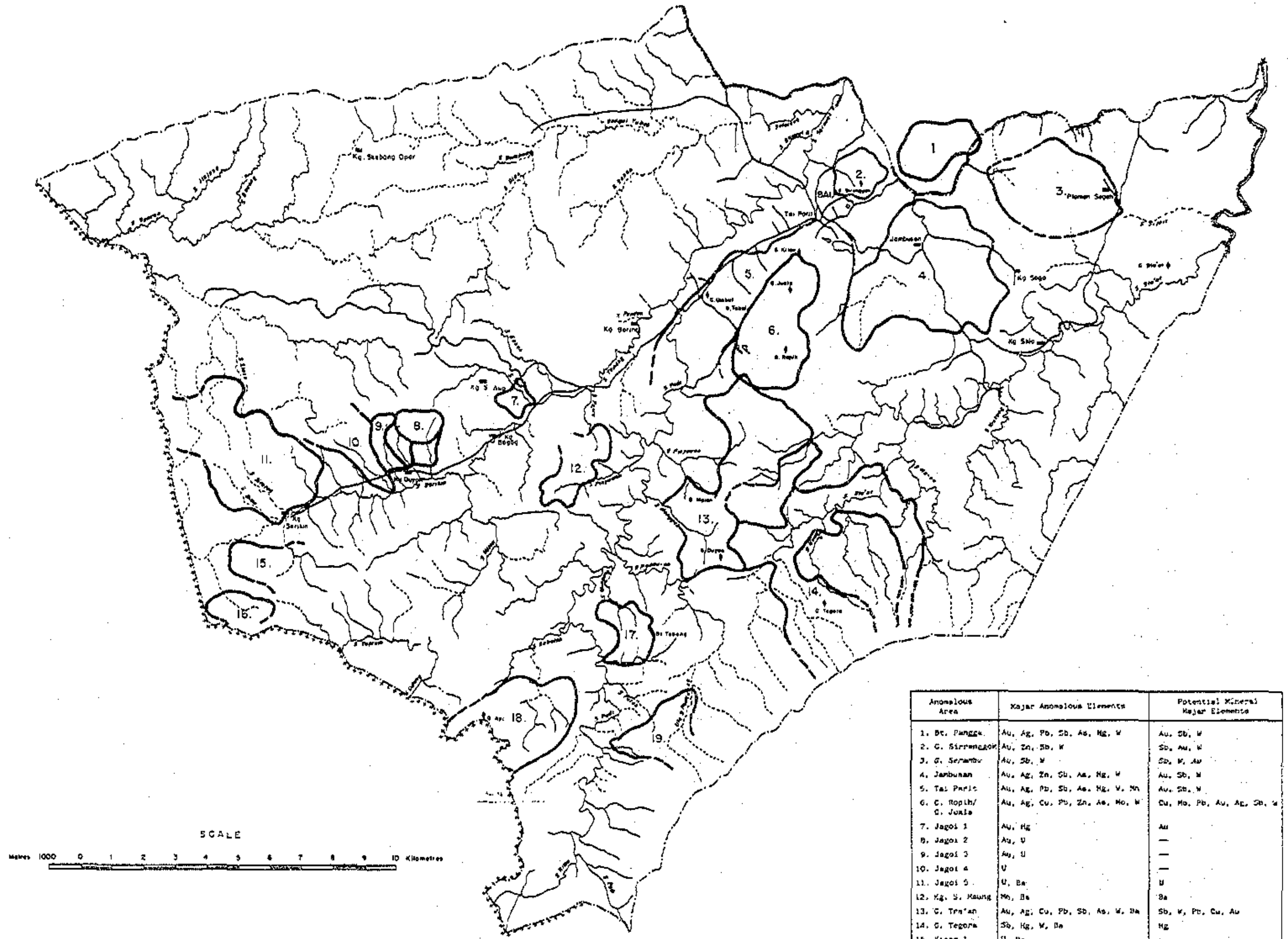


Fig. Ⅲ-1 Distribution of Elements in Stream Sediments, Bau Area



Anomalous Area	Major Anomalous Elements	Potential Mineral Major Elements
1. Bt. Pangga	Au, Ag, Pb, Sb, As, Hg, W	Au, Sb, W
2. G. Sirenggok	Au, Zn, Sb, W	Sb, Au, W
3. G. Serambu	Au, Sb, W	Sb, W, Au
4. Jambusan	Au, Ag, Zn, Sb, As, Hg, W	Au, Sb, W
5. Tai Parit	Au, Ag, Pb, Sb, As, Hg, V, Mn	Au, Sb, W
6. G. Ropih/ G. Juala	Au, Ag, Cu, Pb, Zn, As, Mo, W	Cu, Mo, Pb, Au, Ag, Sb, W
7. Jagoi 1	Au, Hg	Au
8. Jagoi 2	Au, U	—
9. Jagoi 3	Au, U	—
10. Jagoi 4	U	—
11. Jagoi 5	U, Ba	U
12. Kg. S. Maung	Mn, Ba	Ba
13. G. Tra'an	Au, Ag, Cu, Pb, Sb, As, W, Ba	Sb, W, Pb, Cu, Au
14. G. Tegora	Sb, Hg, W, Ba	Hg
15. Kisam 1	U, Ba	—
16. Kisam 2	U, Ba	—
17. Bt. Tebang	Sb, As, Hg	Hg
18. G. Api	Au, Ag, Hg, W	Au
19. S. Puteh	Au, Ag, Cu, Sb, Mo	Au, Ag, Cu?, Mo?

Fig. Ⅲ-2 Geochemical Anomalous Areas and Mineral Potential, Stream Sediment Survey, Bau Area

Table Ⅲ-1 Geochoemical Anomalous Areas, Bau Area

Name of Anomalous Area	Approximate Areal Extent of Catchment of Anomalous Samples Km²	Anomalous Samples: Anomalous Element	Anomalous Samples: No. of Samples	Anomalous Samples: Range of Values	Anomalous Samples: Total No. of Samples	Geology	Remarks	Priority
1. Bt. Pangga	3.3	Au Sb W As Ag Hg Pb Zn	6 10 5 8 2 5 3 1	0.2–3.7 ppm 18.8–10,640 ppm 15–62 ppm 41–7952 ppm 1.9–4.9 ppm 328–984 ppb 153–459 ppm 872 ppm	10	Underlain mainly by the Bau limestone, small Tertiary intrusive stocks, sills and dikes. Two major faults in area.	Heavily prospected and several old Sb & Au workings in the area. Samples are contaminated to varying degrees. Two stone quarries on the S edge of limestone hill and one operating mine in the SE corner of the area. Potential for other Sb and Au deposits in the area and also for W mineralization	Recommended for follow-up work by means not affected by geochemical contamination.
2. G. Sirenggok	2	Sb Au W As Zn Mo Ba	7 2 3 1 3 1 1	4.8–7480 ppm 2.4–7.7 ppm 4–5 ppm 516.0 ppm 149–309 ppm 2.0 ppm 360 ppm	8	Underlain by Tertiary intrusive stocks and mainly shale and limestone of the Pedawan Formation and the Bau limestone. Hydrothermally bleached, pyritized intrusion breccia especially near contact of intrusive in the SW margin.	Area heavily prospected in the past. One small old working near S margin of intrusive. Potential for Sb, Au	Recommended for follow-up work by means not affected by geochemical contamination.
3. G. Serambu	9	Sb W Au Ag Zn Mo	5 2 1 1 1 1	2.8–34.0 ppm 8.11 ppm 0.2 ppm 1.3 ppm 169 ppm 3.6 ppm	6	Underlain by Tertiary intrusive and shale and sandstone of the Pedawan Formation.	No known old workings in the area. Potential for Sb, W and Au mineralization.	Recommended for follow-up work.
4. Jambusan	13	Au Sb W As Ag Hg Cu Zn	14 26 11 24 2 17 1 4	0.5–5.7 ppm 3.8–1592.0 ppm 12–110 ppm 40–215 ppm 1.4, 6.0 ppm 213–15,700 ppb 51 ppm 150–340 ppm	39	Underlain by the Bau Limestone and shale and some sandstone of the Pedawan Formation. Some Tertiary dikes and sills.	Heavily prospected and many small old Sb & Au workings in the area. Anomalous values reflect the mined area. All samples are geochemically contaminated to varying degrees. Potential for other Au and Sb and for W deposits in the area. Gold > 10 grains per 50 ℓ sediments detected in 6 panned concentrate samples.	Recommended for immediate follow-up work by means not seriously affected by geochemical contamination.
5. Tai Parit	> 9	Au Sb As W Ag Hg Cu Zn Pb Mn	14 18 21 10 4 4 1 2 11 4	0.3–9.1 ppm 3.3–612.0 ppm 48–1270 ppm 4–450 ppm 1.3–5.7 ppm 246–4790 ppb 30 ppm 350,910 ppm 36–165 ppm 746–19,000 ppm		Underlain by Bau Limestone, shale and minor sandstone of the Pedawan Formation and argillaceous limestone, shale and sandstone of the Krian Member and small stocks, dikes and sills, hydrothermally bleached and in cases pyritized. Important faults include the Tai Parit, Krian, Johara and the Gumbang faults.	Heavily prospected and many old workings located in the area. All samples are contaminated to varying degrees. The heavily prospected and mined area for Sb and Au are shown by anomalous values for these elements and As in the samples. The area is also anomalous for W Potential for other Au and Sb and for W deposits exists in the area.	The area is recommended for immediate follow-up work by means not seriously affected by geochemical contamination.
6. G. Ropih/ G. Juala	6.5	Cu Mo Pb Zn Au Sb W As Ag Ba	16 6 11 4 13 11 13 13 7 1	29–174 ppm 2.8–5.8 ppm 37–740 ppm 146–545 ppm 0.5–61.2 ppm 6.1–157 ppm 4–13 ppm 41–353 ppm 1.2–7.6 ppm 385 ppm	25	Underlain by Tertiary intrusive porphyry stocks, dikes and/or sills and the Bau Limestone. NNE Faults and NE to NW and radial fractures. Igneous rocks mostly hydrothermally altered.	Heavily prospected and several old Sb and Au workings in the G. Juala area. A few known small veins of massive sulphides, mainly galena, sphalerite, pyrrhotite and pyrite in this area. Samples contaminated. One old working known in the G. Ropih area. Cobble-size floats of massive pyrite found in stream draining the S part of the intrusive. Little geochemical contamination. Potential for Cu, Mo, Au & W mineralization in the G. Ropih area and for other Cu, Pb, Ag, Au & Sb occurrences in the G. Juala area. Gold > 10 grains/50 ℓ of sediments detected in 5 panned concentrate samples.	Recommended for immediate follow-up work.
7. Jagoi 1	1	Au Hg	2 3	0.5, 0.8 ppm 258–1570 ppm	3	Underlain mainly by the Bau Limestone and the Jagoi granodiorite. Some small Tertiary dikes occur in the area.	A gold occurrence known in the area.	Not recommended for follow-up work.
8. Jagoi 2	2.0	U Au	4 1	3.0–4.2 ppm 0.8 ppm	4	Underlain mainly by Jagoi granodiorite.	Anomalous values for U probably reflect the higher U content of the granitic body.	Not recommended for follow-up work.
9. Jagoi 3	2.5	Au U	3 1	0.8 ppm 3.3 ppm	3	Underlain mainly by the Jagoi granodiorite and by the Bau Limestone along its S contact. Some small Tertiary dikes occur within the area.	No known mineralization or working known in the area.	Recommended for follow-up work.
10. Jagoi 4	>2.5	U	3	2.0–3.0 ppm	3	Underlain mainly by the Jagoi granodiorite intrusive.		Not recommended for immediate follow-up work.
11. Jagoi 5	9.5	U Ba	24 2	1.8–9.0 ppm 2.2, 385 ppm	24	Underlain mainly by the Jagoi granodiorite intrusive.	No known mineralization in the area. Anomalous values probably reflect the higher U content of the granitic body.	Recommended for follow-up work by a rapid scintillometer survey.
12. Kg. S. Maung	>2.5	Ba Ag Mn	4 2 4	350–370 ppm 1.2, 1.3 ppm 1090–1920 ppm		Underlain by shale, mudstone and some sandstone of the Pedawan Formation.	Potential for Ba mineralization.	Recommended for follow-up work.
13. G. Tra'an	13	Au Sb W As Ag Hg Ba Cu Pb	2 8 5 4 3 1 3 3 4	0.6–1.3 ppm 3.1–18.9 ppm 5–11 ppm 75–140 ppm 3.7–34 ppm 1160 ppm 345–360 ppm 29–35 ppm 43–143 ppm	20	Underlain by Tertiary intrusive stock and shale and sandstone of the Pedawan Formation. Minor limestone and some dikes and sills.	Small old workings for Au and Sb near S. Monggak and G. Ngian. Also placer gold occurrence known at S. Gunong Dran draining the S slope of G. Tra'an. Gold > 10 grain/50 1 sediments detected in 3 panned concentrate samples. Area has potential for Sb mineralization outside known localities of stibnite old working. Possibility of base metals especially Pb mineralization at G. Tra'an and the N part of G. Ngian. Potential for Au especially in the S part of G. Tra'an. Potential for W mineralization in the G. Duyan area.	Recommended for follow-up work.
14. G. Tegora	18	Hg Ba Cu Zn Sb W	26 3 1 2 2 2	251–105,000 ppb 345–3280 ppm 50 ppm 156,166 ppm 2.9, 3.7 ppm 4, 7 ppm	26	Underlain by shale, mudstone and sandstone of the Pedawan Formation. Minor igneous dikes and sills and thin calcareous beds.	Old Tegora Mercury Mine near G. Tegora. Potential for Hg mineralization outside the old mine area.	Recommended for immediate follow-up work.
15. Kisam 1	>1.3	U Ba	4 3	2.6–5.2 ppm 300–385 ppm		Underlain by the Jagoi granodiorite.	Anomalous values probably reflect the higher U and Ba contents of the granitic body.	Recommended for follow-up work by a rapid scintillometer survey.
16. Kisam 2	1	U Ba Mn	3 3 1	2.6–4.6 ppm 350–480 ppm 860 ppm	3	Underlain by the Jagoi granodiorite.	Anomalous values probably reflect the higher U and Ba contents of the granitic body.	Recommended for follow-up work by a rapid scintillometer survey.
17. Bt. Tebang	2	Hg As Sb Zn	6 3 2 1	396–114,642 ppb 189–710 ppm 64.4, 76.9 ppm 309 ppm	6	Underlain by Tertiary intrusive porphyry and shale and some sandstone of the Pedawan Formation.	Old Gading Mercury Mine near Bt. Tebang. All samples contaminated by mining.	Not recommended for follow-up work.
18. G. Api	5	Au W Ag Hg	1 1 1 2	0.5 ppm 15 ppm 2.8 ppm 214, 258 ppb	5	Underlain by Tertiary intrusive stock and shale and sandstone of the Pedawan Formation.	One old mine working for Au reported in the area. Gold > 10 grains/ 50 1 detected in 4 panned concentrate samples from the area. Potential for Au mineralization.	Recommended for immediate follow-up work.
19. S. Puteh	2.5	Au Sb Ag Cu Mo	1 2 2 1 1	19.8 ppm 2.8, 4.0 ppm 2.2, 8.3 ppm 34 ppm 1.8 ppm		Underlain by hydrothermally altered, Tertiary intrusive stock, volcanic breccia and volcanic-mud flow deposit, and shale and sandstone of the Pedawan Formation.	Gold reported to occur in S. Puteh. Potential for Au and Ag mineralization.	Recommended for immediate follow-up work.

CHAPTER 3. PHASE II GEOCHEMICAL SURVEY

3–1 Outline of Work

Based mainly on the recommendations of Phase I work, follow-up geochemical survey work during Phase II was undertaken in 3 areas, the Jambusan-Tai Parit area, the Gunung Ropih-Gunung Juala area and the Gunung Api-Sungai Puteh area. The Jambusan-Tai Parit area has been heavily prospected and mined in the past. In order to avoid as far as possible geochemical contamination due to old mine workings and prospecting pits and because of the lack of soil development over limestone which underlies most of the area, a lithogeochemical survey was undertaken over the area. A total of 493 limestone chip samples were collected along preselected routes in an area of approximately 29 km^2 giving a sampling density of 17 samples/km^2. In the laboratory, the samples were crushed, rolled and quartered, and ground to about −100 mesh and analysed for 11 elements including Au, Ag, As, Sb, Cu, Pb, Zn, Mo, Fe, Mn and Hg. The analytical results of each element was trend analysed using the method of De Geoffroy et al (1968) with some modification. The trend value and anomaly component for each element obtained at each sample site were contoured and presented as tend surface and anomaly surface maps on a scale of 1:20,000.

In the Gunung Ropih-Gunung Juala area covering approximately 1.6 km^2, a geochemical soil survey was carried out. Using steel gauge angers, 1019 soil samples, each weighting about 800 g were collected in polythene bags from the B horizon along previously prepared lines. The lines were oriented E–W and spaced 100 m and 50 m apart. The sampling interval along each line was 25 m. The samples were dried, crushed lightly, rolled and quartered, sieved to −80 mesh and analysed for Au, Ag, Cu, Pb, Zn and Mo. Simple statistical analysis, factor analysis and trend analysis were used to process and interpret the analytical data and treated data are presented on 1:10,000 scaled maps of the area.

Detailed follow-up stream sediment and panned concentrate sampling were carried in the Gunung Api-Sungai Puteh area of about 25 km^2. A total of 255 stream sediment samples were collected giving a sampling density of 10.2 samples per km^2. At each preselected sample site, about 20 g, −80 mesh, wet sieved, stream sediments were collected in a polythene bag. The samples were air-dried and analysed for Au, Ag, Cu, Pb, Zn, As, Sb, Hg, Mo and W. The analytical data was statistically treated according the method of Sinclair (1974) and presented on 1:25,000 drainage maps of the area.

At most stream sediment sample sites, panned concentrate samples were also collected with the dulang from known volumes of sediments. A total of 212 samples were collected and those containing gold were further panned and examined under the binoculars in the laboratory to separate out the gold. Each sample of gold grains was then weighed. All panned concentrate samples including these from which gold grains had been separated out were then bromoformed and the heavy fractions rapidly examined under the microscope. The distribution of gold grains in the samples are presented on a 1:25,000 drainage map of the area.

3–2 Results

The following general observations may be drawn from the trend analysis of the analytical data of the lithogeochemical survey of the Jambusan-Tai Parit area:

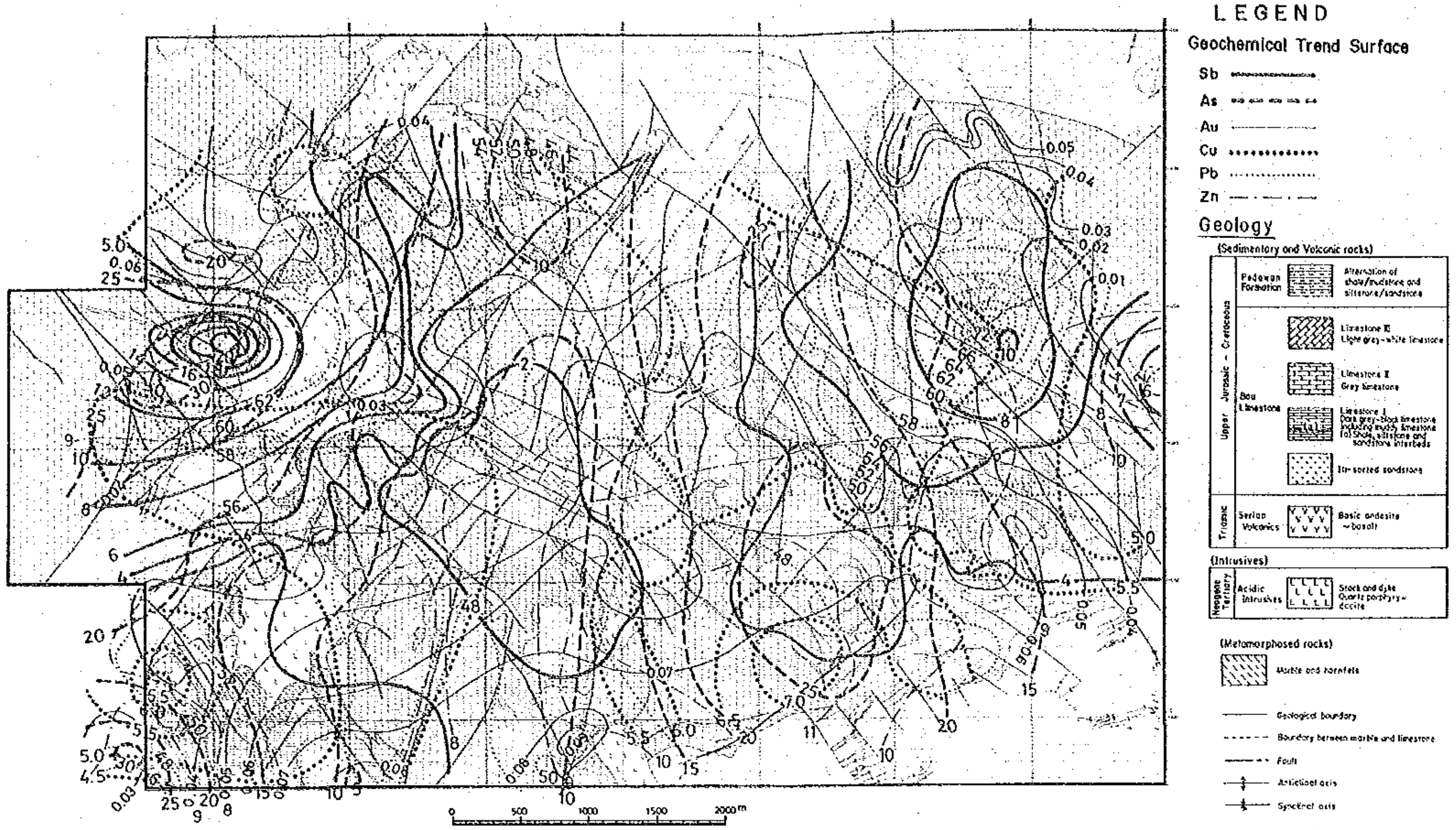
i) The trend surface for mercury divides the area into two distinct zones, an eastern zone of high mercury background and a western zone of low mercury background (Fig. III–3).

ii) The trend surfaces of the 11 analysed elements generally show a low metal zone of about 1 km wide stretching from Gunung Ropih in a northeasterly direction.

iii) Superimposition of the anomaly surface maps for As, Sb, Hg and Mn shows good overlapping of 'high anomalies' in three areas-The Gunung Krian-Gunung Badug area, the Gunung Batu area and the Seromah North area. The Gunung Krian-Gunung Badud area coincides with the area where most old mine workings for Au and Sb are located. The other two areas are therefore, considered important and merit further exploration with for possible Au and Sb mineralization (Fig. III–4).

From the distribution patterns of the analysed elements in soil samples from the Gunung Ropih-Gunung Juala Area and from factor and trend analyses of the data, three zones of metal enrichments may be broadly outlined in each intrusive a near central zone of Cu–Mo enrichment overlapped marginally and successively by zones of Pb–Zn and Au–Ag enrichments.

Anomalous values for Cu account for about 45 % of this data. Four large anomalies, two NW and S of Gunung Juala and two SW and E of Gunung Ropih may be identified. The anomalies cover areas measuring approximately 100,000 m^2, 200,000 m^2, 250,000 m^2 and 100,000 m^2 respectively. Anomalous values for Mo account for about 2.5 % of the data and form clusters of small anomalies in the SE part of Gunung Juala and in the SW and E parts of Gunung Ropih. 45 % of the data for Pb are anomalous forming a large anomaly in the northern part of Gunung Ropih and the southern part of Gunung Juala. The highly anomalous parts of the anomaly in the former area has a pronounced WNE trend. Anomalous Zn values form small scattered anomalies mainly in the S part of Gunung Juala and the N and SE parts of Gunung Ropih. Anomalous values for Au and Ag are erratically distributed around the margins of both the intrusive stocks of Gunung Ropih and Juala (Fig. III–5).



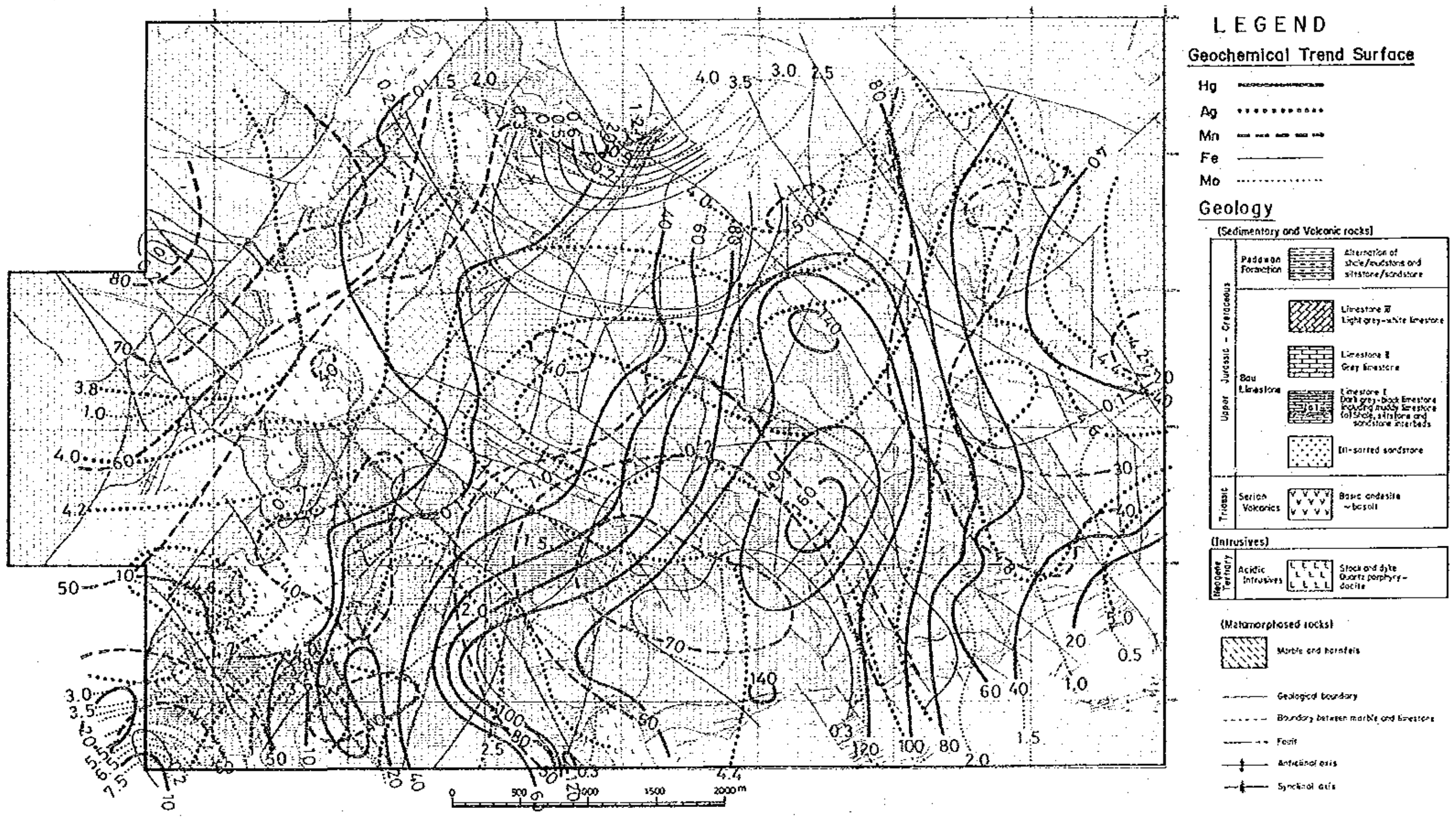


Fig. Ⅲ-3 Combined Trend Surface Map, 11 Elements, Jambusan-Tai Parit Area

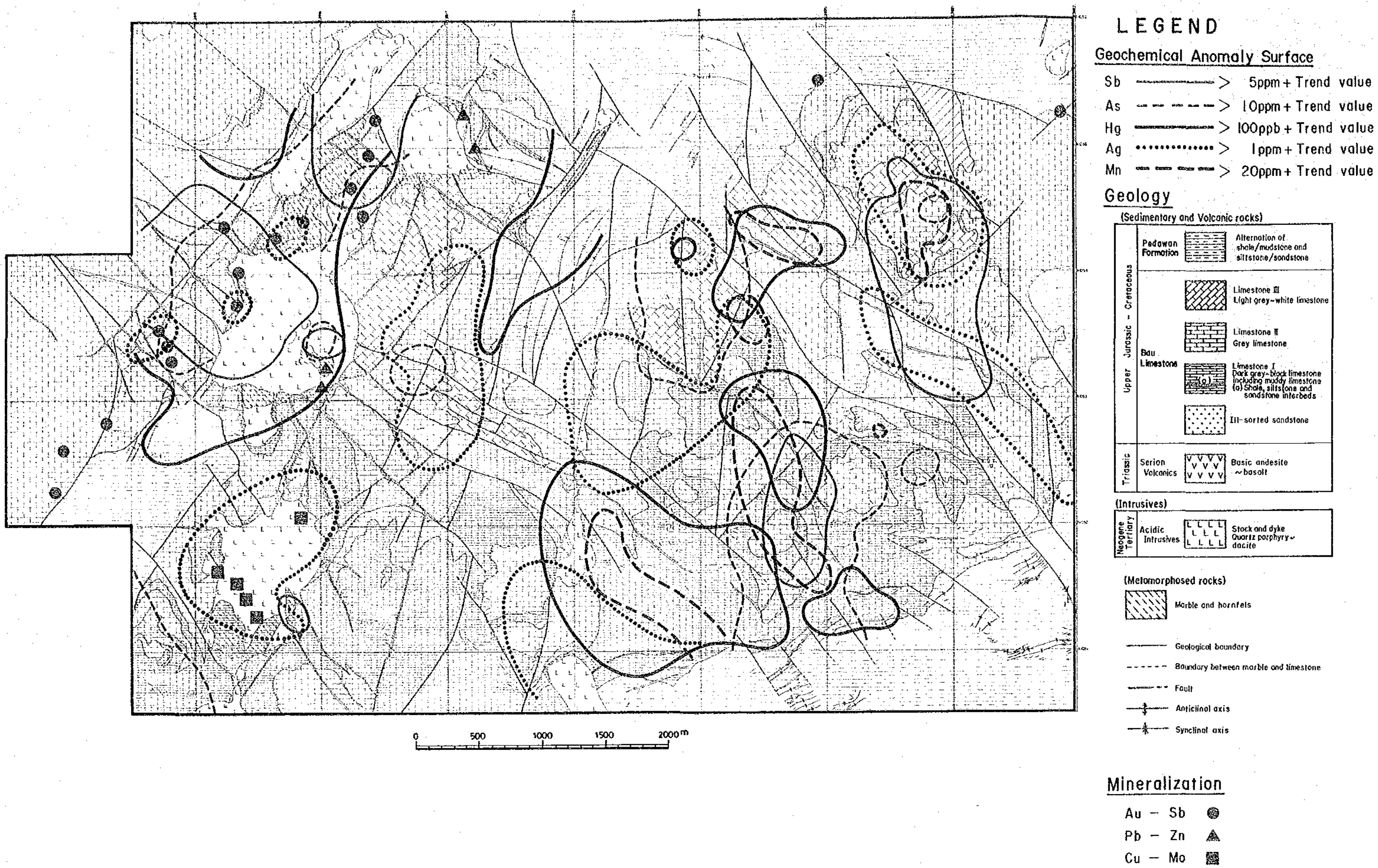


Fig. III-4 Combined Anomaly Surface Map, Sb, As, Hg, Ag and Mn, Jambusan-Tai Parit Area

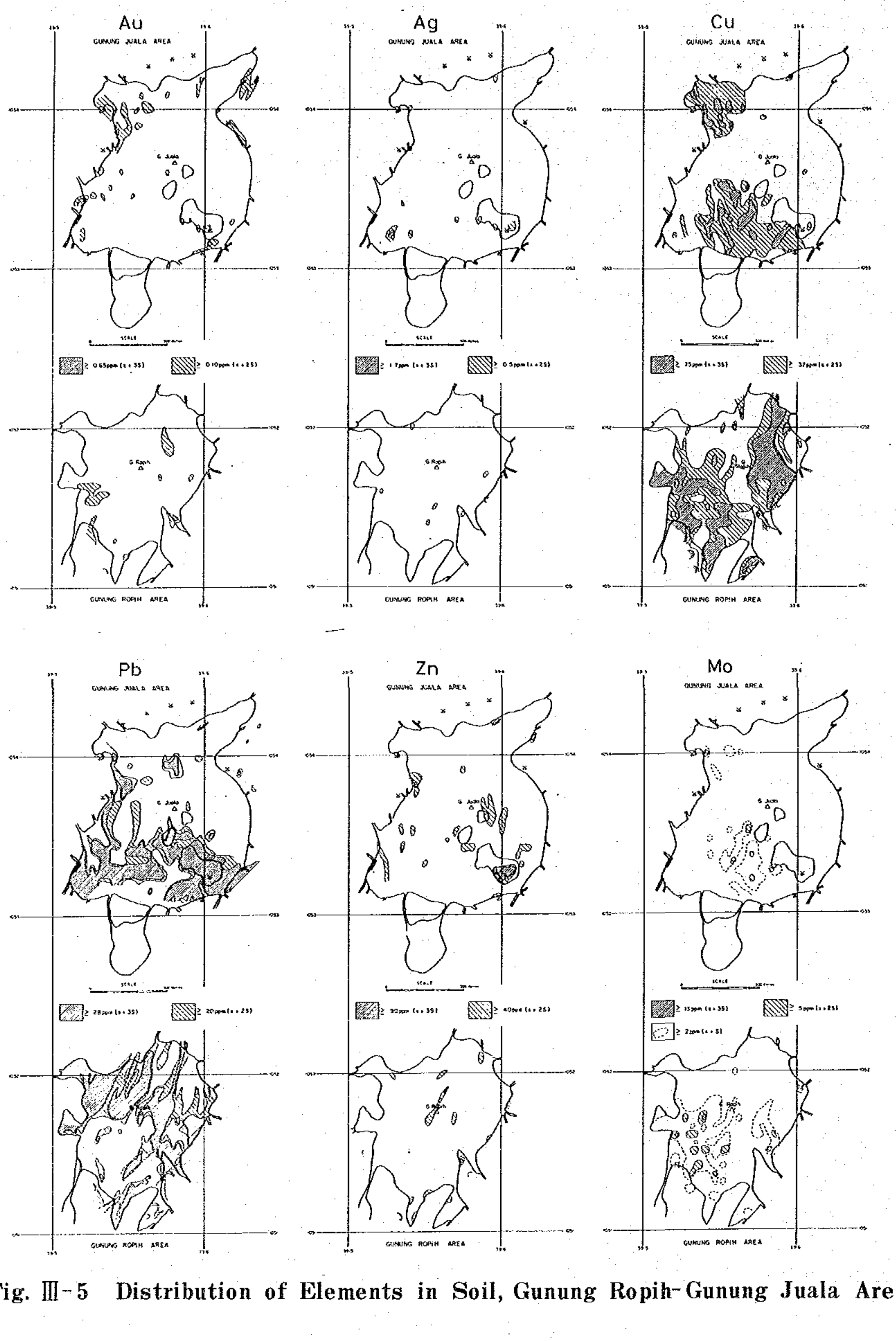


Fig. III-5 Distribution of Elements in Soil, Gunung Ropih-Gunung Juala Area

Factor analysis shows that factor 1 and high factor 1 scores are correlatable with the anomalous distributions of Pb and Zn, factor 2 and high factor 2 scores with the anomalous distributions of Cu and Mo, and factor 3 and high factor 3 scores with anomalous distributions of Au and Ag. Trend analysis generally also show that the anomaly highs for the six elements show the same elemental association and distributions as indicated by factor analysis and statistical treatment.

No distinct contiguous anomalies could be delineated from the results of the geochemical stream sediment survey in the Gunung Api-Sungai Puteh area. Anomalous values for most of the elements appear to be mainly singly scattered. As shown in Table III–2, Au, Ag, As, Sb, Mo and W are bimodally distributed with 11 samples accounting for the anomalous population for Au, 20 samples for Ag, 9 samples for As, 59 samples for Sb, 16 samples for Mo and 49 samples for Mo.

Table III–2 Statistical Parameter of Metal Contents, in Stream Sediments, Gunung Api-Sungai Puteh Area

Element	Population	Proportion (%)	Nos. of Samples used in Statistical Treatment	x (ppm)	$x+s$ (ppm)	$x+2s$ (ppm)	$x+3s$ (ppm)
Au	Anomalous	4.5	11	0.51	0.8	1.25	2.0
	Background	95.5	240	0.145	0.23	0.375	0.64
Ag	Anomalous	8.0	20	5.6	6.8	8.3	10.0
	Background	92.0	227	0.41	1.35	4.6	15.5
Cu	Anomalous	–	–	–	–	–	–
	Background	100	249	15.0	22.2	28.2	36.2
Pb	Anomalous	–	–	–	–	–	–
	Background	100	252	13.7	18.7	23.7	28.7
Zn	Anomalous	–	–	–	–	–	–
	Background	100	252	56.1	80.5	104.5	128.5
As	Anomalous	3.5	9	64	68	72	76
	Background	96.5	245	8	19.6	48	124
Sb	Anomalous	23.5	59	5.5	7.6	10.6	14.7
	Background	76.5	194	1.95	4.7	11.7	28.2
Hg	Anomalous	–	–	–	–	–	–
	Background	100	252	22.5	70.0	212	664
Mo	Anomalous	6.5	16	5.2	5.9	6.8	7.8
	Background	93.5	237	0.8	2.2	6.0	16.5
W	Anomalous	19.5	49	15	21	30	44
	Background	80.5	204	2.1	7.4	25	87

From the results of the panned concentrate sampling, it is observed that gold was physically detected in more samples than chemically in the stream sediment samples. Out of the 212 panned concentrate samples, gold was observed in 30 (~ 15 %) (Fig. III–6). From the tributaries of Sungai Pedi, 12 samples contain gold grains – 1 sample from a stream just north of Kampung Tringos Baharu contains 0.292 g/t, 1 from Sungai Matung 1.890 g/t, 1 from a stream just southwest of Pangkalan Tebang 0.376 g/t, and others have values ranging from 0.014 g/t to 0.068 g/t. 18 samples from Sungai Sebuloh and its tributaries contain gold grains – 2 samples from Sungai

Pad contain 0.130 g/t and 0.268 g/t, 1 from a tributary of Sungai Sinyi, 0.411 g/t, 1 sample from Sungai Sinyi 0.663 g/t and others have values ranging between 0 g/t and 1 g/t. Abundant cinnabar was observed in the samples from Sungai Seripoh Kecil. Subordinate amounts of cinnabar and realgar commonly observed in panned concentrate samples containing gold grains.

Based on the results of the geochemical survey, it is concluded that gold and possibly mercury mineralizations are of potential economic importance in the area. Two small areas with potential for primary gold mineralization are indicated, the Sungai Sinyi and the Sungai Matung Areas. The source of the placer gold found in these areas are most porbably mineralized quartz veins in the Pedawan Formation near the contacts of intrusive dikes and in fault zones. Probable bedrock mercury mineralization in the Sungai Seripoh Kecil area is indicated by anomalous values for Hg in stream sediment samples and abundant cinnabar in panned concentrate samples from the area.

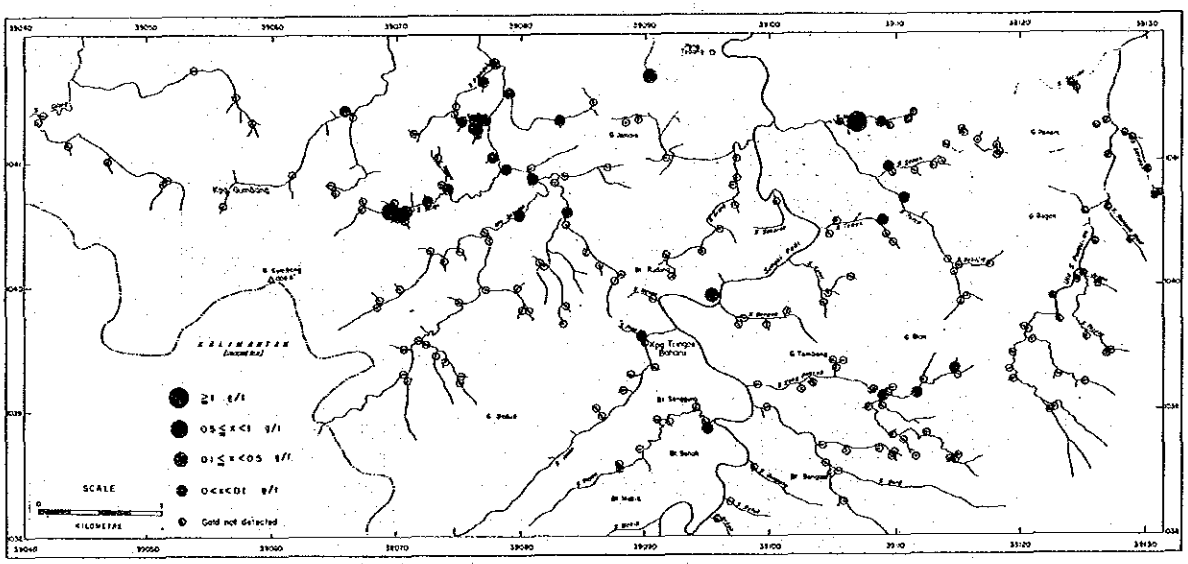


Fig. Ⅲ-6 Distribution of Gold in Panned Concentrate Samples, Gunung Api-Sungai Puteh Area

CHAPTER 4. PHASE III GEOCHEMICAL SURVEY

4–1 Outline of Work

Further follow-up work was undertaken during Phase III in the Seromah North, Gunung Batu, Sungai Sinyi and Sungai Matung areas. In the Seromah North and Gunung Batu areas the multi-element 'anomalies' indicated by the lithogeochemical survey undertaken during Phase II were investigated further by detailed channel lithogeochemical sampling. Channel rock chip samples were collected at between 50 m to 100 m intervals along preselected routes, At each sample site, information pertaining to the colour type of limestone, structure and the number and thicknesses of calcite veins/veinlets over 1 m or more of the outcrop sampled, was recorded. In this manner, a total of 34.9 km traverse were made and 423 channel rock chip samples collected. The samples were analysed for Au, Ag, Sb, As, Hg and Mn and the results statistically treated according to the method of Sinclair (1974) and presented as contoured 1:50,000 scaled maps. Au values were arbitrarily classified and also presented as a contoured map of the same scale.

In the Sungai Sinyi and Sungai Matung areas, detailed geochemical panned concentrate and geochemical soil sampling, and trenching were carried out as a follow-up to the anomalous amounts of placer gold found by panning of stream sediments and the favourable field observations obtained in these areas during Phase II. Stream sediments at regular intervals along the main streams were systematically panned and counted for gold grains in order to trace the soruce of the alluvial gold. At places, the alluvium and the soft, weathered bedrock outcrops were crushed, sampled and panned and any gold grains observed, counted. A total of 296 panned concentrate samples were collected. 897 geochemical soil samples were also collected in both areas on a grid pattern of 100 m x 25 m. These samples were analysed for Au, Ag, As, Sb, Hg and Mn after drying, grinding, quartering and rolling. The analytical results were statistically treated and presented in the same manner as those of the Seromah North and Gunung Batu areas.

120 m of trenches were also dug in the middle reaches of Sungai Matung where gold grains are anomalously concentrated in the steam sediments and geological observations indicated possible bedrock mineralization. Panned concentrate of the weathered, bedrock, clay and alluvium in the trenches were simultaneously carried out to detect possible gold mineralization.

4–2 Results

Analytical results of the lithogeochemical samples from the Seromah North area show As, Sb, Mn, Ag and Hg background values higher than those from the Gunung Batu area. In the former area, anomalous values for As, Sb and Mn show good correlation and are mostly concentrated along a NE zone parallel to a fault in the northwestern part of the area (Fig. III–7). Though these values do not form a continguous anomaly, the trend of the anomalous zone is apparent from the distribution of the values higher than background. Higher class values of 0.2 ppm Au are also concentrated along this zone which is underlain chiefly by limestone of the black, dark grey to dark brownish grey and light grey colour types. Another smaller zone enriched in As and Sb parallel to a NW fault just north of the central part of the area may also be distinguished. The distribution of calcite veinlets appears to be also somewhat correlatable with the two anomalous zones. Calcite veins thicker than 10 cm in particular are confined to the NE zone. The anomalous zones suggest possibility for Au and Sb mineralization.

As, Sb and Mn values also show good correlation in the Gunung Batu area (Fig. III–8). Anomalous values for these elements appear to form an ENE tending zone in the northwestern part of the area. In particular, anomalous values for Mn show up as an extensive anomaly while those for As and Sb form narrow zones chiefly on the northwestern side of a major ENE fault underlain chiefly by limestone of the grey to brownish grey and light grey colour types. The distribution of calcite veinlets appears to bear no relationship to the elemental distributions. It is concluded that an As– Sb–Mn enriched zone trending ENE exists in the northwestern part of the Gunung Batu area, NW of a major ENE fault and that this zone may have some potential for Au and Sb mineralization.

The results of the panned concentrate sampling and trenching indicate that the placer gold found in the stream sediments in both areas originated from alluvial bank deposits of gravel, sand and clay. From the geochemical soil survey however, probable primary sources of the alluvial gold particularly in the Sugai Sinyi area may be delineated.

In the Sungai Sinyi area, the primary source was traced by panned concentrate sampling to a wide, swampy area of gravel, sand and clay in the upper reaches of Sungai Sinyi. A distinct anomaly for As and high Au values just SE of the swamp into which streams draining the anomaly flow, were obtained by the geochemical soil survey. It is clearly indicated that this anomalous area underlain by the Pedawan Formation and an intrusive dacite dike is the most likely primary source of the alluvial gold found in Sungai Sinyi. Gold grains detected in panned concentrate samples from the lower reaches of Sungai Mud most probably also originated from this source, the gold being transported there by Sungai Sebuloh which drains the SE part of the anomaly.

In the Sungai Matung area, it was initially thought that the placer gold originated from the sheared shale and quartz veinlets along a fault parallel to the river. Panned concentrate sampling of the weathered bedrock also indicated such a possibility. However, the trenches dugged in the area and panning of the weathered bedrock, alluvial sand and clay in these trenches suggest that the gold may have been derived from the alluvium. Rare gold grains detected in some panned concentrate samples of the bedrock might have been the result of contamination by gold grains sinking into cracks in the bedrock from the overlying alluvium. A possible primary source of the placer gold is detected by the geochemical soil survey to be in the upper reaches of Sungai Matung around the contact of the Pedawan Formation with the intrusive dacite stock. This possible source even if present, is suggested to be of very small extent.

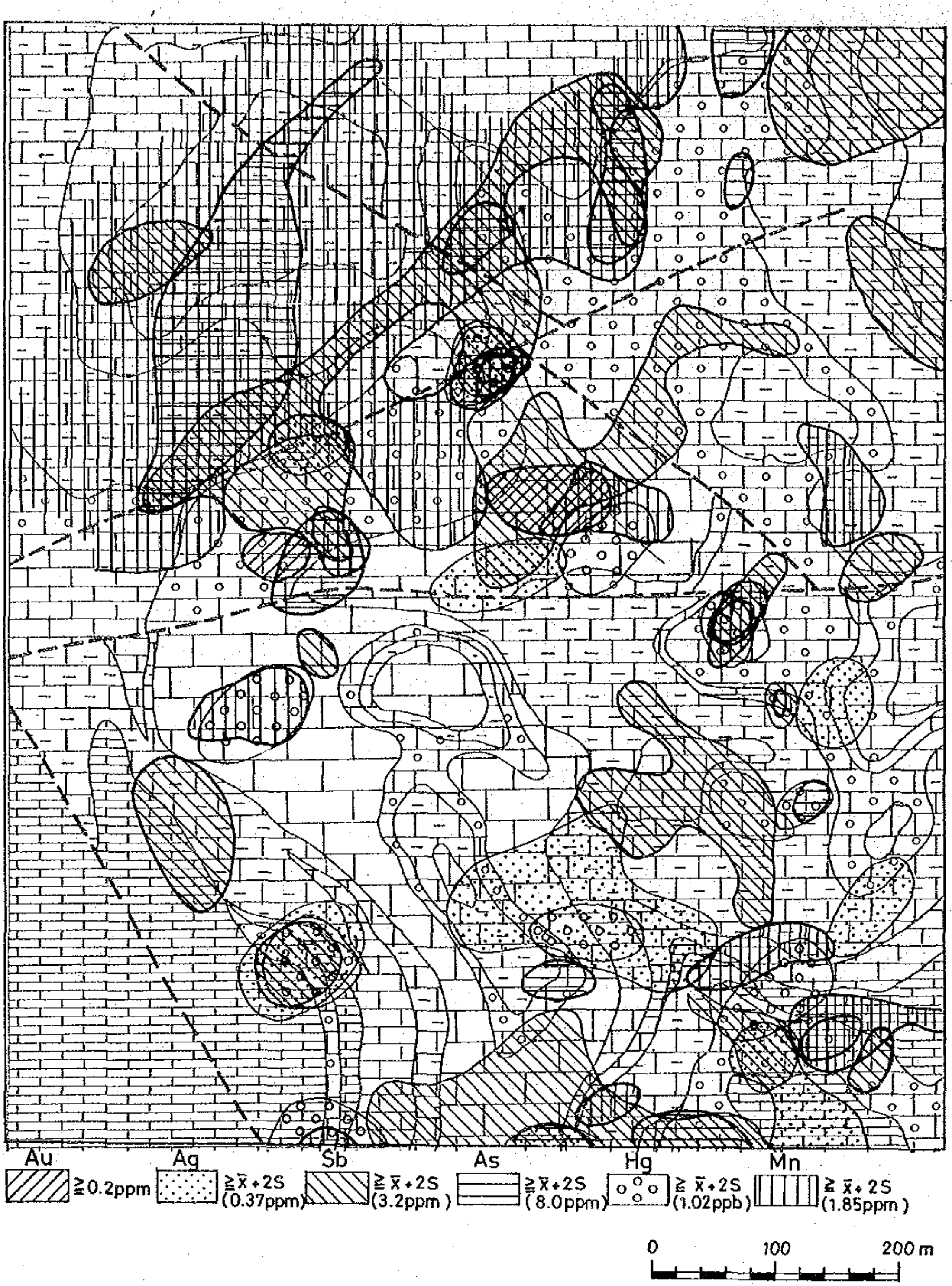
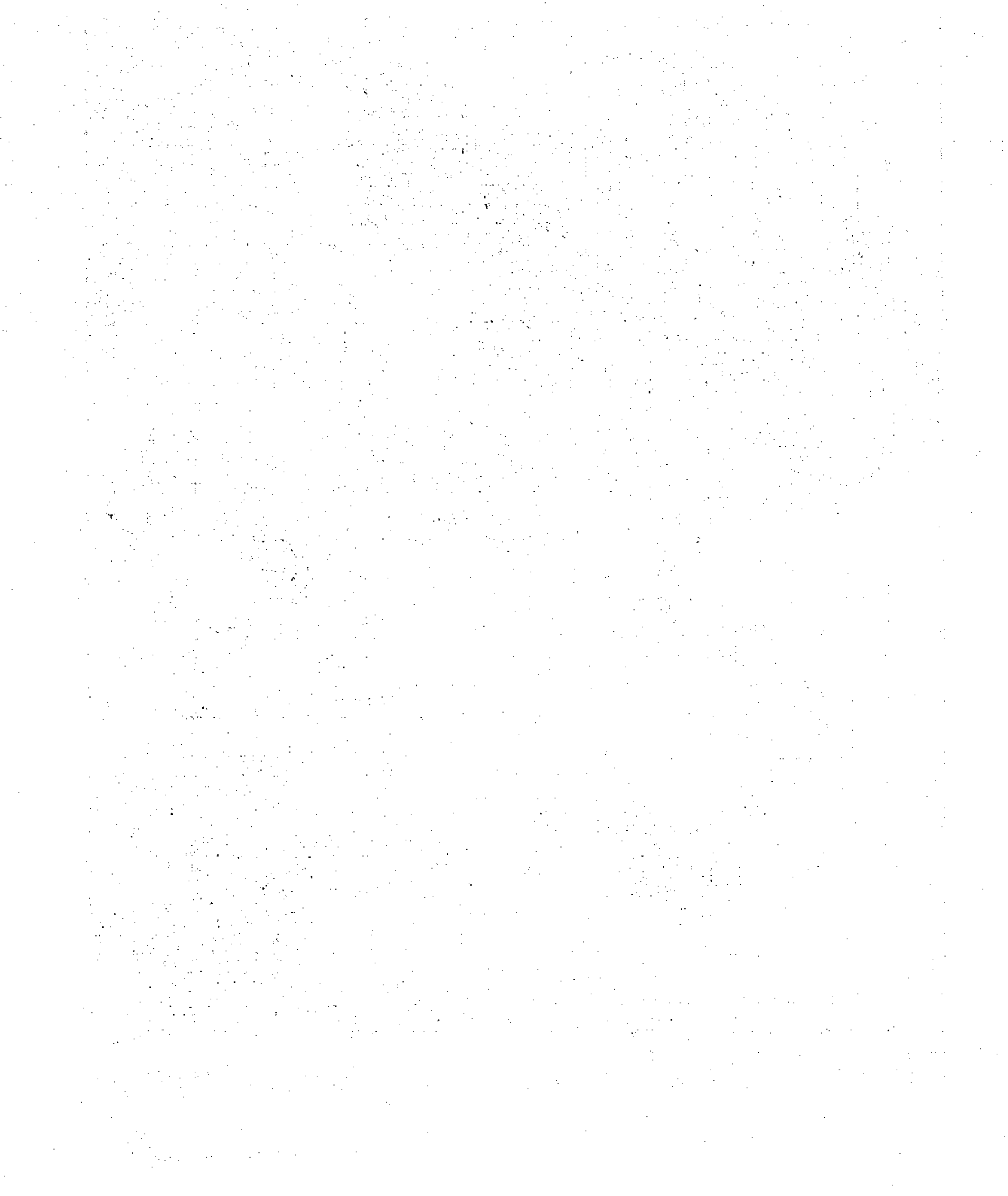


Fig. Ⅲ-7 Geochemical Anomalies, Lithogeochemical Survey, Gunung Batu Area



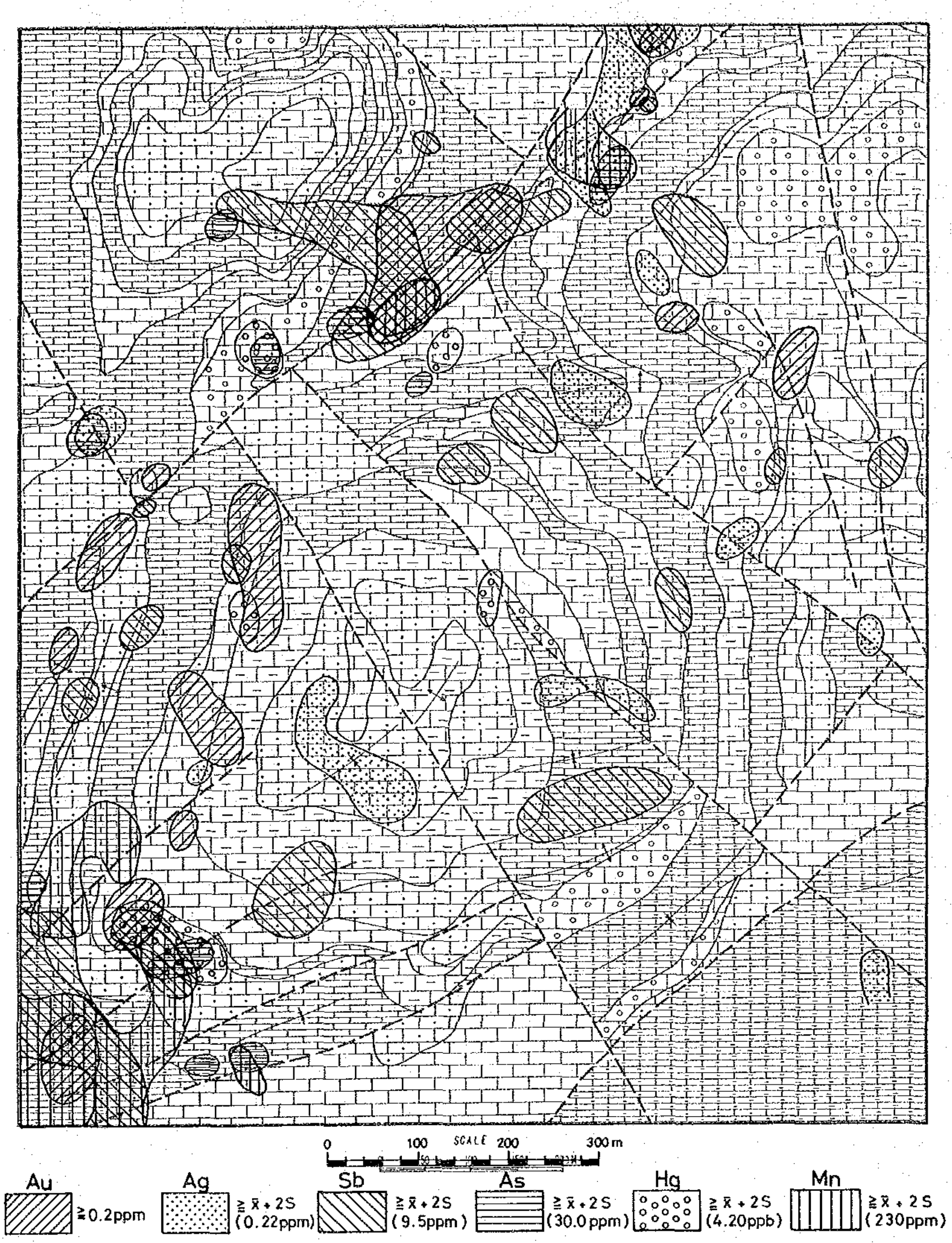


Fig. Ⅲ-8 Geochemical Anomalies, Lithogeochemical Survey, Seromah North Area

PART IV GEOPHYSICAL SURVEY

CHAPTER 1. GENERAL REMARKS

Three methods of geophysical survey, the Spectral Induced Polarization (Spectral IP), Induced Polarization (IP) and Magnetic Survey were used during the project in small selected areas.

The Spectral Induced Polarization survey was undertaken over a few known old mine workings which consist mainly of quartz-calcite veins containing stibnite, arsenopyrite, native arsenic and gold during Phase II. The objective was to examine the applicability and suitability of the method in detecting Au and Sb-bearing quartz-calcite veins and their continuity with depth. The results of the survey, indicate two relatively small but strong to very strong Spectral IP anomalies over the Bidi ore deposit. Mineralization as an ore vein containing abundant stibnite and rare arsenopyrite is also indicated to continue in depth dipping towards the east over one anomaly. The other anomaly indicates a similar type, near-surface ore body which dips to the west.

During Phase III, an IP survey using the dipole-dipole method and a ground magnetometer survey were conducted simultaneously over the Gunung Ropih area where Cu–Mo mineralization of the porphyry copper type was suggested by Phase I and Phase II work. The primary aim of the surveys was to study the extent of mineralization and hence, to indicate suitable sites for exploration drilling Analysis of overall data suggested that three general types of FE anomalies exist in the area, a surface roof-shaped anomaly slightly elongated along the ENE direction with a maximum FE value of 9.8 % which is widely distributed above a depth of about 100 m in the central part of the area, a deep anomaly with an E–W trend and a maximum FE value of 8.0 % which is observed about a depth of 200 m or more in the north-central part of the area, and a shallow to deep anomaly with a maximum FE value of 8.4 % which is observed in the southwestern part of the area. Several sites based on the results of the geophysical surveys were recommended for drilling exploration.

CHAPTER 2. SPECTRAL INDUCED POLARIZATION SURVEY

2–1 Outline of Work

The Spectral IP Survey was conducted over the Tai Ton B, Bidi and Bidi South ore deposits which consist mainly of gold-bearing, quartz-calcite veins containing chiefly rare to abundant stibnite, arsenopyrite and native arsenic. Six lines with a total length of 3.3 km were surveyed over the three areas. Figure IV–1 shows the locations of these survey lines.

The dipole-dipole configuration with an electrode spacing of 50 m and electrode spacing factor of n=1–5, was employed. During the survey, a configuration of up to 8 current electrodes, consisting of sheets of aluminium foils, was used in order to reduce the contact resistence. Copper sulphate porous pots were used as potential electrodes.

A Geotronic FT–4 transmitter and a GDP–12/2GB data processor were used. The generator was powered by a ZMG–5 petrol-engine and generated a maximum power of 3.0 kw.

2–2 Results of Spectral IP Survey

2–2–2 Laboratory Measurements

A total of 27 superficial rock and ore samples were collected for laboratory measurements of resistivity, spectral responses of magnitude, phases and percentage frequency effect. The results of the measurements are shown in Table IV–1 and Table IV–2.

There is a strong contrast in the IP properties betweeen some of the ore and rock samples. The ore samples with metallic ore minerals show a high negative raw phase and low resistivity, but the limestone samples, the host rock of the ore deposits, and calcite ore samples show high resistivity and low IP effect. If there exists an ore deposit of the type similar to that of the Bidi ore deposit which contains abundant metallic ore minerals it may be expected that low resistivity and high IP effects would be observed. The results also indicate that the resistivity and the IP effect tend to increase and decrease respectively as the content of calcite in the ore samples increases. It is considered that the sulphide minerals such as stibnite and arsenopyrite cause high IP effects.

2–2–3 Field Measurement

All measurements obtained in the field were presented as spectral IP pseudosections, phase spectral diagrams, magnitude spectrum diagrams, cole-cole diagrams and raw phase diagrams.

The characteristics of the spectral IP of the spectra between 0.125 Hz and 8Hz of the ore deposits surveyed can be classified into five types as shown in Table IV–3. Type I shows a very strong spectral IP anomaly and it may be considered to be caused by a large amount of sulphide minerals on the basis of the results of the laboratory measurement. Type II is a very weak anomaly caused by a small amount of sulphide minerals with abundant calcite. Types III, IV and V correspond to non-mineralized rock.

Over the Bidi ore deposit, Type I anomalies were detected between stations No. 4 and No. 6 on Line B and No. 4 and No. 5 on Line C together with low resistivities of less than 2,000 Ωm and a high negative raw phase of less than −40 mrad (Figure IV−2). The Bidi ore deposit (old mine workings) of quartz-calcite veins contain abundant stibnite, arsenopyrite, native arsenic and gold. The trend of the anomalies is consistent with that of the veins. The anomalies also indicate the ore bodies are of limited lateral extent. The ore body probably continues in depth between stations No. 4 and No. 6 on Line B with an easterly dip. On Line C between stations No. 4 and No. 5, the ore body is indicated to be shallow, no deeper than 100 m with a westerly dip.

Two type II anomalies were recognized in depth at station No. 3.5 on Line A and No. 5.5 on Line F with a relatively low resistivity and low phase of between −20 and −10 mrad. The former anomaly is located over an old mine working of the Tai Ton A ore deposit. Previous data suggest that the deposit consists mainly of calcite with a little stibnite and arsenic minerals. The other anomaly is located over a flooded mine working of the Bidi South ore deposit. The ore in this working appears to be very similar to that of the Bidi ore deposit. The characteristics of the anomaly may indicate the existence of weak mineralization containing a small amount of sulfide minerals. The Tai Ton B ore deposit which consists of a very thick calcite vein did not give any distinctive response in general.

From the above-mentioned results, it may be concluded that the mineralization of the Bidi ore deposit at places probably extends in depth but those of the Tai Ton A and Bidi South ore weak and shallow. The Tai Ton B deposit may be extremely poor in sulphide minerals and did not give any distinctive spectral IP response.

Table Ⅳ-3 Classification of Spectral IP Data

	Type I	Type II	Type III	Type V	Type V
Phase Spectrum (0.125–8 Hz)	Peak near 1 Hz or flat	Flat or right-side-up	Right-side-up (its slope is greater than type II)	Negative coupling	Right-side-up (its slope is very large)
Magnitude Spectrum (0.125–8 Hz) and its slope	Right-side-down	Right-side down	Almost flat	Right-side down	Right-side down
	Large	Small		Small	Small
Cole-Cole Diagram (0.125–8 Hz) and length of horizontal curve	Left-side-down or flat	Flat	Flat	Downward curve	Upward curve
	Long	Short	Very Short		
Raw Phase at 0.125 Hz	High (more than − 40 mrad)	Low (−10 mrad to −20 mrad)	Very Low (less than −10 mrad)	Very Low (−10 mrad to 10 mrad)	Ver Low (less than −10 mrad)
Coupling type	Normal	Normal	Normal	Negative	Normal (partially negative)

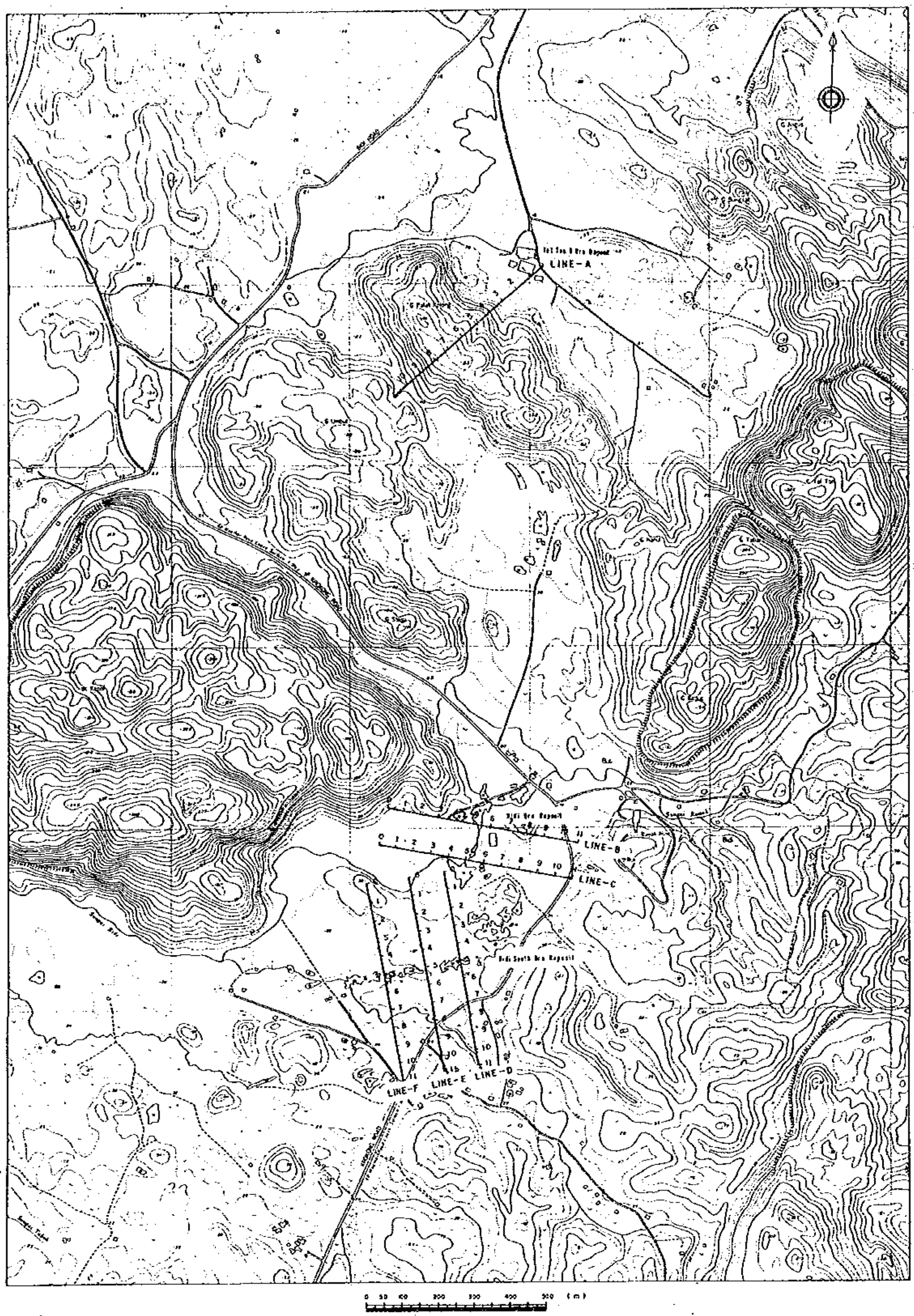


Fig. Ⅳ-1 Spectral IP Survey Lines

Table Ⅳ-1 IP Properties of Ore and Rock Samples

No.	Sample No.	Resistivity (Ohm-m)	Raw Phase (-mrad)	3pt Decoupled (-mrad)	P.F.E. (%)	Rock name	Sample Location
1	AR-0084	37	660	691	129	Stibnite rich, native arsenic ore	Tai Ton A Ore Deposit
2	AR-0032d	52	609	655	107	Py-Sb-calcite ore	G. Tongga ore Deposit
3	Bidi-2	27	532	551	94.6	Stibnite, native arsenic ore	Bidi Ore Deposit
4	AR-0008	292	313	300	55.7	Py-Sb-calcite ore	G. Krian Ore Deposit
5	Bidi-1	1570	194	193	30.4	Stibnite bearing arsenic, calcite ore	Bidi Ore Deposit
6	AR-0069d	1930	52.1	49.7	8.2	Sarabauite and stibnite ore	Lucky Hill A Ore Deposit
7	A-10	12800	2.62	2.18	0.41	Limestone	Tai Ton B Ore Deposit
8	A-7.5	16400	2.1	1.95	0.29	Limestone	Tai Ton B Ore Deposit
9	A-6	24300	2.03	1.86	0.33	Limestone	Tai Ton B Ore Deposit
10	A-3.5	15100	6.74	6.61	0.95	Limestone	Tai Ton B Ore Deposit
11	B-4	5060	8.44	6.6	1.29	Limestone	Bidi Ore Deposit
12	B-5	7100	2.26	1.32	0.41	Limestone	Bidi Ore Deposit
13	B-7	16900	1.73	1.76	0.27	Limestone	Bidi Ore Deposit
14	C-5.5	15400	3.92	4.23	0.5	Limestone	Bidi Ore Deposit
15	C-7.5	17500	0.59	-0.13	0.32	Limestone	Bidi Ore Deposit
16	D-0.5	32500	0.29	-0.08	0.98	Limestone	Bidi South Ore Deposit
17	D-1	14100	1.79	1.74	0.2	Limestone	Bidi South Ore Deposit
18	D-2.5	15000	1.3	1.46	0.15	Limestone	Bidi South Ore Deposit
19	D-5	22300	2.1	1.66	0.31	Limestone	Bidi South Ore Deposit
20	E-3.5	13400	0.91	0.91	0.18	Limestone	Bidi South Ore Deposit
21	E-5.5	20200	1.56	1.67	0.22	Limestone	Bidi South Ore Deposit
22	F-0	29000	2.77	3.08	0.39	Limestone	Bidi South Ore Deposit
23	F-1.5	16900	1.18	1.7	0.19	Limestone	Bidi South Ore Deposit
24	F-3.5	15600	0.43	0.8	0.03	Limestone	Bidi South Ore Deposit
25	B-5.5	8400	3.07	2.55	0.4	Calcite	Bidi Ore Deposit
26	A-6.3	11600	4.37	2.63	0.58	Calcite	Tai Ton B Ore Deposit
27	AR-0055	11800	10.7	10	1.4	Quartz Porphyry	Bidi Ore Deposit

Table Ⅳ-2 Characteristics of Ore and Rock Samples

	Ore	Rock (Limestone, Calcite, Quartz porphyry)
Resistivity	Low (30 to 2,000Ωm)	High (more than 5,000Ωm)
Raw Phase (0.125 Hz)	More than -50 mrad (-52.1 to -660 mrad)	Less than -11 mrad
Phase Spectrum	Flat or decreases slowly as the frequency increases.	Increases as the frequency increases.
Magnitude	Decreases as the frequency increases. When the raw phase at 0.125 Hz is large, its slope becomes large.	Flat
Cole-Cole Diagram	When the raw phase at 0.125 Hz is large, curve starts from (0.7, -0.7) showing a slope of 45°. As the raw phase become small, curve starts near (1,0) and its slope becomes almost flat.	Concentrates near (1.0)

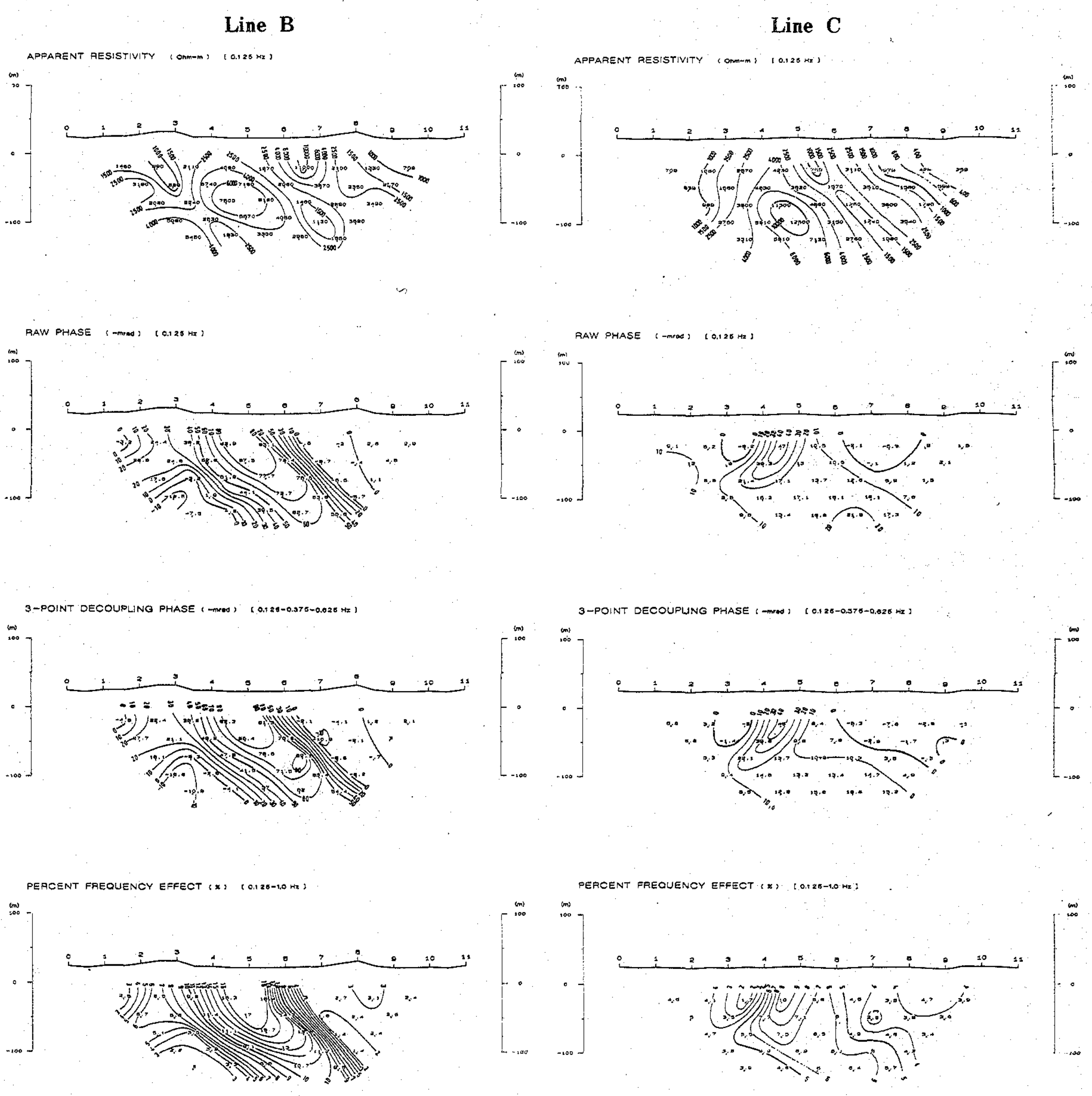


Fig. Ⅳ-2 Spectral IP Pseudo-Sections of Line B and Line C

CHAPTER 3. INDUCED POLARIZATION SURVEY

3–1 Outline of Work

During Phase III in the Gunung Ropih area, eight lines with a total length of 9.9 km, five lines running N32°E and 3 E–W with a line spacing of 100 m were surveyed by the IP method using the frequency domain (Figure IV–3). The dipole-dipole array with an electrode spacing of

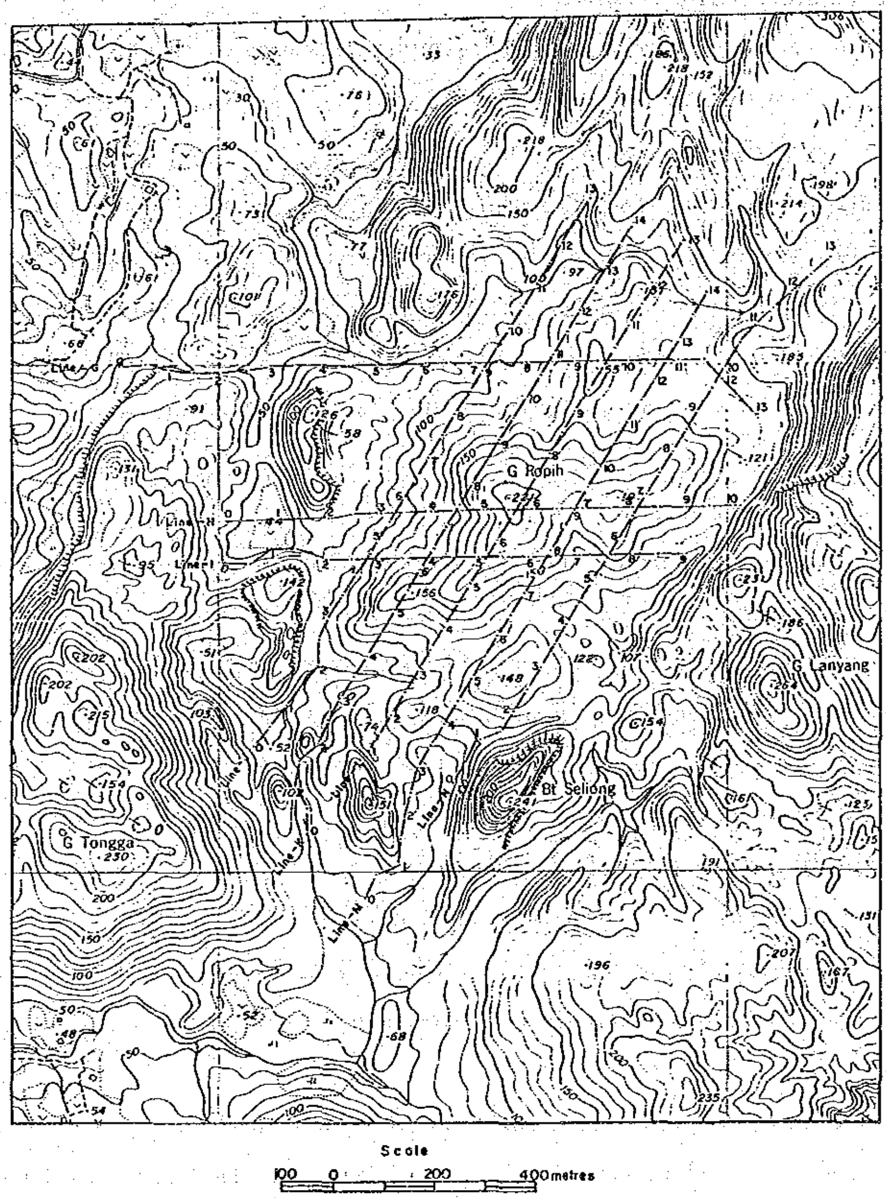


Fig. IV-3 IP Survey Lines, Gunung Ropih Area

100 m and an electrode spacing factor of n=1–5, was employed. To reduce the current electrode contact resistence, large quantities of salt water were applied to the aluminium foil current electrodes. Copper sulphate porous pots were used as potential electrodes. A Chiba CH–T7802 IP transmitter and 2 Chiba receivers, CH–T7801 and CH–7802, were used. The generator was powered by a Geotronics–421 petrol-engine which can generate a maximum power of 3.0 kw.

3–2 Result of IP Survey

3–2–1 Laboratory Measurements

Twenty three comparatively fresh rock samples consisting of 10 limestone samples and 13 intrusive rock samples were collected for resistivity, percentage frequency effect, specific gravity and magnetic susceptibility measurements.

Generally, limestone shows high resistivity and specific gravity, low magnetic susceptibility and average PFE values. The intrusive rock shows low resistivity and specific gravity, high magnetic susceptibility and high PFE values. The limestone shows resistivity values ranging from 2523 to 150818 ohm-m and a mean specific gravity value of 2.7. The intrusive rock has resistivity values of about 1,000 ohm-m and its specific gravity varies from 2.12 to 2.73.

3–2–2 Field Measurements

The results of the field measurements are processed and presented as pseudo-section profiles and contoured plan maps.

Apparent frequency effect and apparent resisitivity values range from –3.0 % to 9.8 % and 44 to 24,800 ohm-m respectively. FE values of more than 4.0 % are classified as highly anomalout. The apparent resistivity values are classified into three groups:

Low resistivity : less than 250 ohm-m
Moderate resistivity : 250 – 1,000 ohm-m
High resistivity : more than 1,000 ohm-m

Figure IV–4 shows the distribution of the high FE anomalous values and apparent resistivity corresponding to levels of approximately 100 m (n=1), 200 m (n=3) and 300 m (n=5) below the surface.

Three prominent FE anomalous zones occur in the central and north central parts of the area and in the southwestern parts of the Lines J, K and L. The main roof-shaped anomalous zone in the central part covers a wide extent, is well-developed at level n=1, and is separated from the deeper north central anomaly which is well developed at n=3 and n=5 by narrow FE lows. The southwestern anomalous zone is clearly observed at n=1 and n=2 levels but decreases in size towards depth and its further extension with depth is not known due to insuffcient data.

The results of the apparent resistivity show in general a low resistivity area surrounded by high resistivity zone in the same manner as the intrusive rock is surrounded by limestone. There are however some small resistivity highs within the intrusive area. The plots of the apparent resistivity maps for n=1, 3 and 5 all show some small apparent resistivity highs which are probably due to the silicified parts of the intrusive rock. The extensive resistivity low areas for n=1, most probably indicate the distribution of the overburden. Those obtained for n=3 and 5 cover smaller areas and most likely correspond to the altered clayey or brecciated parts of the intrusive rock. Resistivity lows show different trends at every level. The resistivity lows for n=3 are separated by a moderate resistivity zone trending E–W. The more extensive resistivity low for n=1 forms a broad NNE zone whereas the resistivity lows for n=3 are small with no apparent trend.

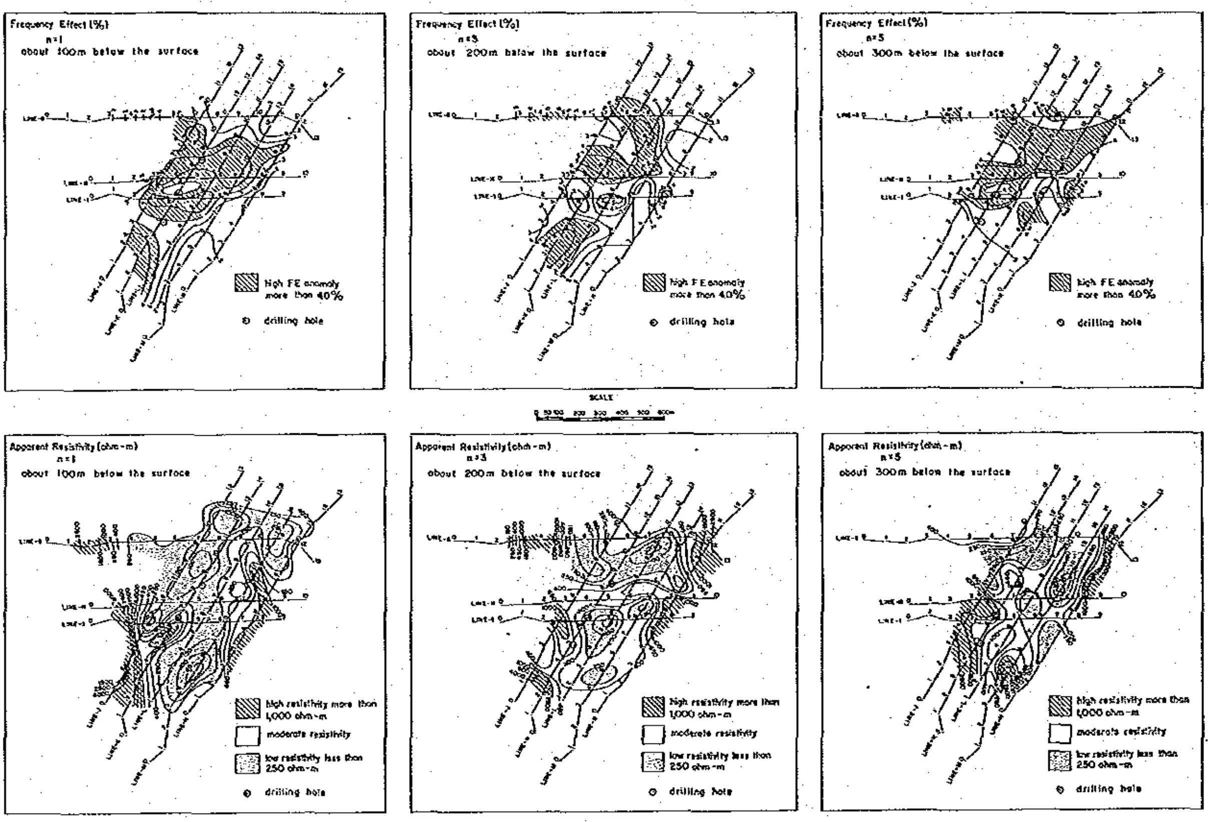


Fig. Ⅳ-4 Contour Maps of Frequency Effect and Apparent Resistivity, IP Survey, Gunung Ropih Area

CHAPTER 4. MAGNETIC SURVEY

4–1 Outline of Work

A magnetic survey employing total magnetic field measurement was conducted along the same lines, simultaneously with the IP survey. Two portable Proton Magnetometers, Model G–816 were used, one at the base station and the other in the field. Readings were taken along the survey lines at 50 m intervals. Readings were also recorded regularly with the other magnetometer at the base station to monitor the diurnal variations.

23 rock samples were also collected in the field and measured in the laboratory for their magnetic susceptibilities.

4–2 Results of Magnetic Survey

4–2–1 Laboratory Measurement

The mean values of the magnetic susceptibility and percentage frequency effect of the limestone are 40.0 x 10^{-6} e.m.u. per cm^3 and 2.0 % respectively. However, those of the intrusive rock are generally variable, ranging from 33.0 x 10^{-6} to 726.0 x 10^{-6} e.m.u. per cm^3 in magnetic susceptibility and 1.2 to 5.0 % in P.F.E.

4–2–2 Field Measurement

Magnetic values range from 334 to 827 gammas. Generally, the area can be divided into a magnetic high zone, in the south and magnetic low zone in the north. The small variations in magnetic values in the two zones are due to small local disturbances of the earth's magnetic field which arises from small local changes in magnetization or magnetization contrast. The general magnetization contrast, though small, between the northern and southern zones suggests that the intrusive rock may be composed of two different units.

The magnetic highs detected in the central and southern margin of the area gave extremely high values in comparison with ordinary values for quartz porphyry, and are similar to that of sample WR516 which is highly pyritized. It is inferred that the magnetic highs may be caused by mineralization accompanied by magnetite, pyrrhotite and pyrite (Figure IV–5).

PART V EXPLORATION DRILLING

CHAPTER 1. GENERAL REMARKS

Based on the geophysical results and taking into account the results of the geochemical soil survey and geological observations including alteration studies, three vertical holes, MJM-1, MJM-MJM-2 and MJM-3 with a total depth of 692.8 m, were drilled in the western and south western slopes of the Gunung Ropih (Figure V–1) in order to confirm that Cu–Mo mineralization exist at depth and to study the mechanism of mineralization.

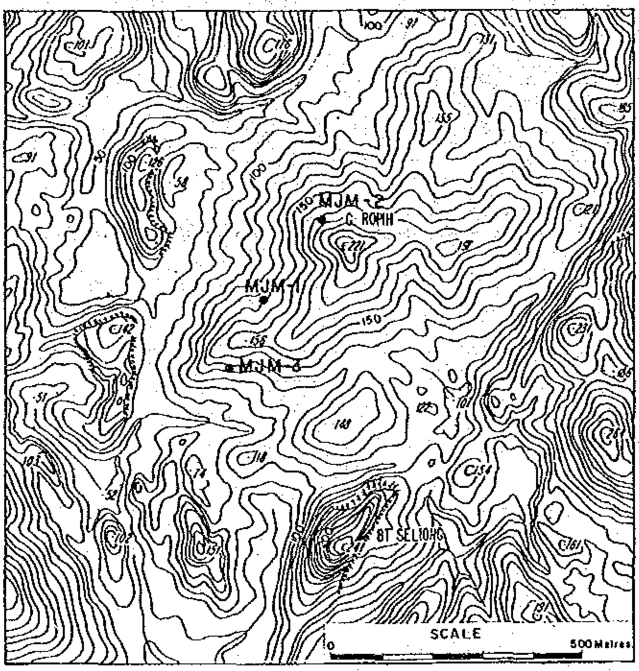


Fig. V-1 Location of Drill Holes, Gunung Ropih Area

The drilling work was conducted between July 27 and November 5, 1984 by 3 Japanese drillers and three assistants of the Geological Survey of Malaysia, Sarawak, using a Long Year L-34 drilling machine and the wireline method. The drilling operation was done daily in two shifts of 12 hours per shift.

No. of Hole	MJM-1	MJM-2	MJM-3
Location	Station 6.5 of IP-Line K	Station 8.3 of IP-Line K	Station 5.0 of IP-Line K
Drilling Period	Aug. 15 – Sept. 10	Sept. 24 – Oct. 5	Oct. 15 – Oct. 29
Depth of Hole	241.30 m	250.50 m	201.00 m
Average Core Recovery	86.82 %	98.44 %	73.78 %
Lithology	Quartz porphyry	Quartz porphyry	Quartz porphyry
Mineralization	Disseminations of chalcopyrite, pyrite and pyrrhotite with rare molybdenite from 139 m to 190 m. (0.18 % Cu)	Weak disseminations of pyrrhotite and pyrite	Disseminations of chalcopyrite, pyrite, pyrrhotite and rare bornite between 50 and 114 m. (0.23 % Cu)

Details of the lithology of the drill holes and analytical results for Cu and Mo are shown in Figure V–2 and Appendix 4.

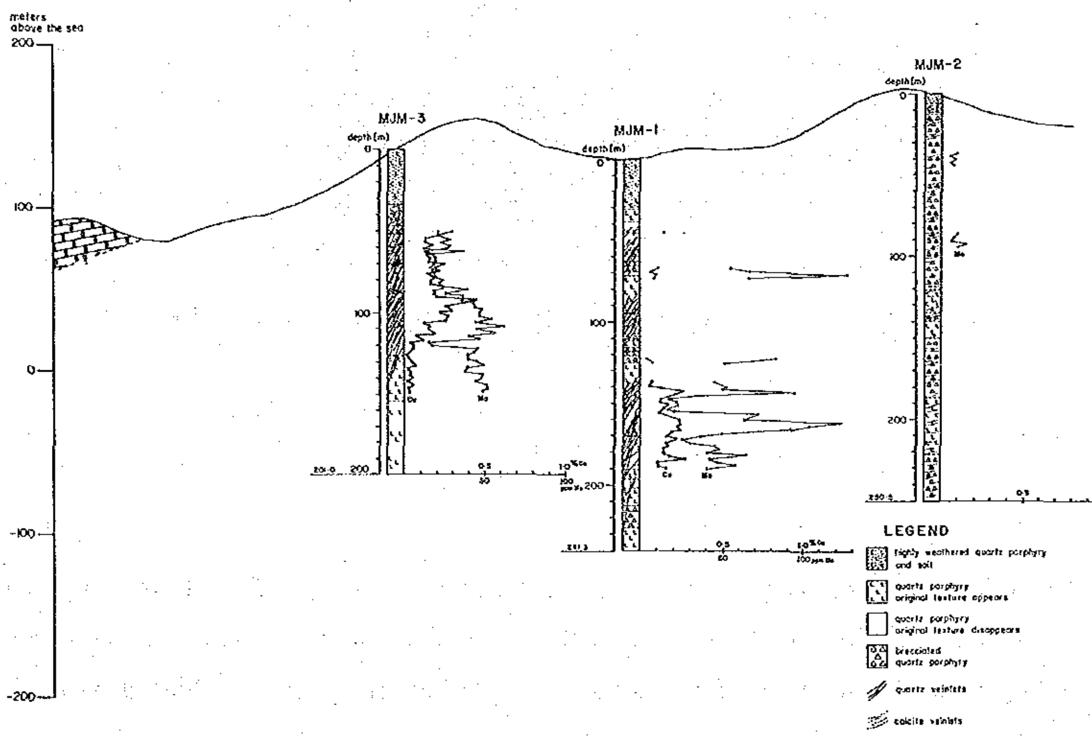


Fig. V-2 Cu and Mo Contents, Drill Holes MJM-1, MJM-2 and MJM-3, Gunung Ropih Area

CHAPTER 2. RESULTS OF EXPLORATION DRILLINGS

2–1 Drill Hole MJM-1 (Depth Drilled: 241.3 m)

Drill hole MJM-1 intersected acidic intrusive rock, probably quartz porphyry, which is highly silicified, brecciated and contains abundant quartz veinlets. The original texture of the intrusive rock has been obliterated by intense silicificaiton mainly in the form of quartz veinlets which appear to occur independent of the cracks produced as a result of brecciation. Silicification is the predominant form of alteration but chloritization and sericitization are also common except for the shallower part, above a depth of 31 m, which is intensely kaolinised and forms the overburden.

Quartz veinlets occur abundantly at depths of about 40 m to 110 m and 140 m to 200 m. Below 200 m, however, they gradually decrease in abundance and no quartz veinlets are observed near the bottom of the drill hole.

These quartz veinlets are informally classified into two types, namely micro-veinlets which are thinner than 1 mm and veinlets which are thicker than 1 mm. The former is earlier than the latter.

Veinlets of skarn composed mainly of andradite, chlorite, epidote, wollastonite, quartz and calcite, are also found as irregular streaks throughout the entire core section. They were produced later than the quartz veinlets as they are found filling cracks which cut the quartz veinlets.

Ore minerals observed in this hole are composed mainly of chalcopyrite and pyrite, a small amount of pyrrhotite and rare bornite, chalcocite (?), molybdenite and sphalerite (?). Most of these minerals are very fine-grained, less than 1 mm across, particularly chalcopyrite and molybdenite which are mostly about 0.1 mm across. In general, chalcopyrite associated with pyrite occurs dominantly where quartz veinlets are intensely developed. Microscopically, however, chalcopyrite is disseminated more in micro-cracks than in the quartz veinlets themselves. The larger chalcopyrite grains especially are associated more with andradite filling the cracks.

Pyrrhotite is disseminated in micro-cracks below the depth of 150 m and is frequently accompanied by pyrite and chalcopyrite. Rare spots of bornite in the intrusive itself is observed at about the 50 m depth. The boundaries of some bornite grains are probably oxidized to dull black chalcocite. Rare sphalerite is observed at a depth of about 70 m, together with veinlets containing andradite.

The average grades of Au, Cu and Mo of the main mineralized parts of the drill hole are as follows:

Depth (m)	Au (g/t)	Cu (%)	Mo (ppm)	Remarks
43.4 – 45.0	tr.	0.15	27	Silicified intrusive rock, highly brecciated, rare bornite
65.0 – 73.0	tr.	0.15	79	Silicified intrusive rock with patches of skarn minerals, chalcopyrite and pyrite
121.0 – 125.0	tr.	0.06	68	Silicified intrusive rock, rare quartz veinlets with dissemination of chalcopyrite and pyrite
137.0 – 145.0	tr.	0.17	59	Silicified intrusive rock, quartz veinlets with chalcopyrite and pyrite
160.0 – 190.0	tr.	0.19	57	Silicified intrusive rock, quartz veinlets with pyrrhotite, chalcopyrite and pyrite
228.0 – 230.0	tr.	0.13	55	Highly silicified and brecciated intrusive rock, chalcopyrite, pyrrhotite and pyrite, rare quartz veinlets

The average grades of the major mineralized section between a depth of 139 m and 190 m are trace Au, 0.18 % Cu and 55 ppm Mo.

2–2 **Drill Hole MJM-2 (Depth Drilled: 250.5 m)**

The section intersected by MJM-2 is also composed of quartz porphyry, which is mostly brecciated. However, this hole differs greatly from MJM-1 even though it is only 200 m away. It is characterized by argillization, mostly kaolinitization, rather weak silicification and the absence of quartz veinlets.

The cracks are generally filled by calcite in place of quartz. However, the distribution of calcite veinlets are rather patchy and discontinuous.

Ore minerals observed consist of abundant pyrrhotite and pyrite, a small amount of galena, sphalerite and malachite and rare chalcopyrite. Pyrrhotite, of about 1 mm across, is equally disseminated in the rock and along the cracks accompanied by calcite. Most of the pyrite occurs with calcite in the cracks and some are also disseminated in the rock itself. It is observed commonly at a depth of about 100 m, rarely around the 150 m depth and commonly near the bottom of the drill hole. Galena and sphalerite grains are about 1 to 5 mm across and are closely associated with calcite in the shallow part to about the 70 m depth and below 200 m. Malachite stains some rock fragments which are sub-rounded and fringed with fine-grained pyrrhotite. Such fragments are not so abundant but they are observed in many places. Rare chalcopyrite occurs as disseminations of very fine grains only around the 40 m and 90 m depths accompanied by pyrite.

The analytical results of the core in which a little chalcopyrite is observed are as follows:

Depth (m)	Au (g/t)	Cu (g/t)	Mo (ppm)
35.0 – 45.0	tr.	tr.	7
85.0 – 95.0	tr.	tr.	10

2–3 Drill Hole MJM-3 (Depth Drilled: 201.0 m)

This section of drill hole MJM-3 is composed of a similar acidic intrusive rock, intensely silicified with a considerable amount of quartz veinlets. It is similar to drill hole MJM-1 though brecciation of the rock is not extensive.

Besides intense silicification, sericitization and chloritization are commonly observed. Sericite mainly replaces feldspar phenocrysts. Most of the chlorite occurs as replacement of hornblende phenocrysts though some occur as veinlets filling cracks. Quartz veinlets are dominantly developed above the 130 m depth. They are roughly classified into two types in the same way as those of drill hole MJM-1. Skarn veinlets consisting of andradite, chlorite, epidote, wallastonite, quartz and calcite are also observed filling cracks.

Ore minerals are composed predominantly of chalcopyrite and pyrite, a small amount of pyrrhotite and hematite and rare bornite and malachite. Chalcopyrite and pyrite occur as disseminations of very fine grains in quartz veinlets and in cracks. Chalcopyrite also occurs as rare, irregular streaks of 5 mm width, associated with chlorite filling cracks at a depth of 107.5 m. Pyrrhotite is disseminated along cracks around a depth of 70 m to 90 m and 160 m to 180 m. Hematite forms a banded structure with quartz and chlorite.

Rare bornite occurs as disseminations of very fine grains in the country rock about a depth of 160 m and rare malachite is observed in argillized rock at a depth of 90 m to 95 m.

The average grades of the main mineralized part containing quartz veinlets are as follows:

Depth (m)	Au (g/t)	Cu (g/t)	Mo (ppm)
50.0 – 114.0	tr.	0.23	31

PART VI

CONCLUSION AND RECOMMENDATION

CHAPTER 1. CONCLUSION

The conclusions of the work carried out over 3 years (Phase I – Phase III) in the Bau Area may be summarized as follows:

Phase I

i) The known ore deposits and mineral occurrences in the area may be classified as of the epithermal vein type genetically related to the acid igneous activity of Miocene age. They may be further grouped as Au–Sb deposits in the Bau Limestone, Cu–Pb–An deposits in stocks of quartz porphyry and limestone adjacent to the stocks and Hg deposits in the shale and sandstone of the Pedawan Formation. No deposits are known to occur in the Kayan Sandstone, the Jagoi Granodiorite and the Serian Volcanics.

ii) The emplacement of the ore deposits was structually and to same extent lithologically and its subsidiary folds with NE to ENE axial trends, the NNE alignment of Tertiary intrusive stocks, the NE–SW (including NNE–SSW) and NW–SE faults, and subsidiary joints and fractures with the same trends in limestone. Most of the Au–Sb deposits occur as veins filling faults and fractures and replacing the host rock. The major known deposits were emplaced in NW faults and fractures. They are mainly located near the intersection of the ENE Bau Auticline and the NNE alignment of tertiary intrusives near the major NNE fault on the western side of the alignment of intrusives. Some of the deposits replaced selectively argillaceous limestone and were emplaced parallel to the bedding planes. The known Cu–Pb–An ore deposits were emplaced in joints in a Tertiary stock and in NE fractures in limestone just adjacent to the contact. The known mercury ore deposits were in NE faults in shale and sandstone of the Pedawan Formation.

iii) The general distribution of known ore deposits and mineral occurrences shows good correlation with the results of the geochemical stream sediment survey. 4 broad zones of metal enrichment may be delincated from the results of the geochemical survey; a zone in the limestone area around Bau town where Au, Sb, W, and As enrichments occur, a zone along the NNE alignment of Tertiary intrusives particularly from G. Juala to G. Barau where Cu, Pb and Zn, and minor Ag and Mo enrichments are found in close association, a zone of Hg enrichment stretching from G. Tegora in a northeasterly direction to G. Sta'at and a zone of U enrichment within the Jagoi Granodiorite. 19 anomalous area may also be delincated by combining the anomalous values obtained and the catchment areas of the anomalous stream sediment samples. The panned concentrate samples show three main areas where samples with gold grains are clustered, the Jambusan area, the G. Ropih Area and the G. Api Area.

iv) In general, from the results of the Phase I work, the possibility of finding new economic ore deposits and extensions to old ones may be retricted to the following areas:

a) The limestone area around Paku, Bau, Krokong, Kg. Poak, Kg. Seromah and Jambusan for Au–Sb ore deposits,

b) The alignment of Tertiary stocks for Cu–Pb–Zn, Mo, Ag and Au deposits. In particular, abundant mineralized floats and extensive alteration observed in the G. Ropih stock supported by geochemical anomalous values for Cu and Mo, indicated the possibility of finding a porphyry copper type of mineralization in this area. Favourable geological observations and the geochemical survey including panned concentrates samples also indicated good potentials for finding Au and Ag mineralization in the S. Puteh and G. Api areas.

c) The area to the North and East of G. Tegora for mercury ore deposits.

v) It is estimated that there exists not less than 1 million tonnes of old mine tailings in the Bau Mining District with grades ranging from 1.2 to 2.0 g/t Au. The largest tailing dump at the old BAu Airstrip was assessed to have a reserve of about 261,000 tonnes with an average Au grade of 2.01 g/t.

Phase II

i) Results of the detailed investigation of some of the old mine workings show that gold ore veins in marble with calc silicates and/or quartz as the principal minerals contain the highest gold grades. The study also indicates good possibilities of finding further extensions of the gold ore veins in three of the old mine workings, the Arong Bakit, Saburan and Rumoh old mine workings.

ii) The lithogeochemical survey of limestone in the Jambusan–Tai Parit area shows good overlapping of the high anomaly surfaces for As, Sb, Hg and Mn in three areas. Since one of these areas coincide with the area in which most old mine workings for Au and Sb are located, the other two areas, the Seromah North and the G. Batu areas are indicated to have good potentials for Au and Sb mineralizations.

iii) Detailed geochemical soil and geological surveys in the G. Juala–G. Ropih area confirm the occurrence of Cu–Mo mineralization in the southern part of the G. Ropih stock and the possibility of the mineralization to be of the porphyry copper type.

iv) The geophysical survey using the spectral induced polarization method in the Tai Ton area indicate that the Bidi ore deposit at places continues at depth. The survey also show that the method in suitable for detecting and estimating the shape and continuity in depth of ore bodies similar to that of the Bidi ore deposit which contains abundant sulphide minerals such as stibnite and arsenopyrite, and arsenic. Only very weak SIP anomalies however, could be detected over veins such as the calcite vein of Tai Ton B deposit which are poor in sulphide minerals.

v) The detailed geochemical stream sediment, geological and panned concentrate surveys, particularly the latter in the G. Api–S. Pulih indicate two small areas of possible primary gold mineralization – the S. Sinyi and S. Matung areas. The source of the placer gold found in these areas is suggested to be most probably quartz veins in the Pedawan Formation near its contacts with intrusive dikes and stocks and in fault zones in the formation.

Phase III

i) The results of the detailed lithogeochemical survey in the Seromah North and Gunung Batu areas indicate three anomalous zones of metal enrichment. In the Seromah North area, two anomalous zones enriched in Au, Sb, As and Mn are recognised, a NE zone in the northwestern part of the area and a minor NW zone just north of the central part. These zones are fault related and particularly the NE zone holds possibility for Au and Sb mineralizations. Plots of calcite veinlets/veins in limestone also show that most of the thicker veins encountered are located within this zone. A minor As–Sb–Mn enriched zone trending ENE is indicated in the northwestern part of the G. Batu area. Since Au is known to be associated with As, Sb and Mn, it is inferred that this zone may also have some potential for Au and Sb mineralizations.

ii) Detailed mapping and rock sampling in the Arong Bakit area show that the gold ore vein of the old working No. 2 extends along strike for a distance of about 71 m with an average thickness of 4.3 m. The average grade of the ore is calculated to be 6.3 g/t Au and 10.2 g/t Ag. Assuming a down-dip extension of equal to and half the strike length, ore reserves available are 55,800 and 27,000 tonnes respectively. Assuming a cut off mineable grade of 10 g/t Au, the high grade section of the vein with a strike length of 26.4 m and average thickness of 5.1 m may be calculated to contain an average ore grade of 14.7 g/t Au and 21.4 g/t Ag. Based on similar assumptions of down-dip extensions, the corresponding reserves are 9,200 and 4,600 tonnes.

iii) In the Sungai Sinyi area, the probable primary source of the placer gold occurring in stream sediments has been traced by panned concentrate and geochemical soil surveys to an anomalous area in the upper reaches of Sungai Sinyi. Similar work in addition to trenching in the Sungai Matung area, indicated that the primary source of the placer gold found in the area may be located in the upper reaches of river. The source if present, is however, indicated to be of very small extent.

iv) Drilling results in the Gunung Ropih area prove that subeconomical disseminated Cu mineralization of the porphyry copper type exists in the southwestern part. Two of the holes drilled intersected disseminated Cu mineralization with an average grade of about 0.18% Cu between a depth of 139 m and 190 m in one hole and 0.23% Cu between a depth of 50 m and 114 m in the other hole. By correlation of the results of the various work undertaken in the area including geological mapping, geochemical soil survey and IP and magnetic surveys, it may be inferred that areas with moderate to high FE, accompanied by silicification and little or negative magnetic contrast, have potential for disseminated Cu mineralization. Areas of low resistivity within a wider high resistivity zone in the intrusive and showing the above characteristics is indicated to be the best areas.

CHAPTER 2. RECOMMENDATION

Based on the results of the work undertaken during the project period, the following follow-up work are recommended:

i) The northwestern part of the Seromah North area should be followed up by very detailed mapping and channel sampling of the extensions of the thick calcite veins found in this area to explore for Au and Sb mineralizations.

ii) The areas underlain by marble immediately west and north of the Gunung Juala intrusive should be further followed up by very detailed mapping and rock sampling in order to explore for gold ore veins similar to that of the Old Working No. 2 of the Gunung Arong Bakit area.

iii) The anomalous area for Au and As in the upper reaches of Sungai Sinyi should be followed up initially by detailed geochemical soil survey to delineate the extent of the open-ended anomaly. Trenching and exploration drilling should follow to confirm bedrock Au mineralization.

iv) Further exploration drilling is recommended in the southern and eastern parts of the Gunung Ropih area to examine the extent and grade of Cu mineralization.

v) Geochemical anomalous areas delineated during phase I of the project not followed-up yet should be further explored. These areas include the Bt. Pangga, G. Sirrenggok, Serambu, Jagoi 3, Jagoi 5, Kg. S. Maung, G. Tra'an, G. Tegora, Kisam 1 and Kisam 2 areas. The metals of interest in these aeas include Au, Sb, W, Pb, Hg, Ba and U.

vi) The Tai Ton area which is covered by alluvium should be further explored by geophysical method(s) in order to study the geology and possible Au and Sb mineralizations beneath the alluvium.

vii) The geophysical anomaly detected in depth over the Bidi ore deposit should be further explored by the spectral or conventional IP method on the northern side in order to determine the northern limit of the anomaly. This should be further followed up by drilling.

viii) Most of the known old workings and present mines for Au and Sb operated very near surface deposits. The possibility of larger deposits with higher grades at deeper levels cannot be ruled out. Detailed geological mapping and sampling to be followed by exploration drilling are required at most of the old working and present mine sites to explore for possible Au and Sb mineralizations at depth.

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