No. 40

MALAYSIA

REPORT ON THE COLLABORATIVE MINERAL EXPLORATION OF THE BAU AREA, WEST SARAWAK

PHASE Ⅱ

MARCH 1984

JAPAN INTERNATIONAL COOPERATION AGENCY
METAL MINING AGENCY OF JAPAN

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PREFACE

The Government of Japan, in response to a request from the Government of Malaysia, agreed to conduct a collaborative mineral exploration project with the Geological Survey of Malaysia in the Bau area, West Sarawak, Malaysia. The project is part of a Fourth Malaysia Plan project proposed by the Geological Survey of Malaysia to be implemented by the department with Japanese bilateral assistance. The Government of Japan entrusted the implementation of its assistance to the Japan International Cooperation Agency and the Metal Mining Agency of Japan. This project is designed to be carried out in three phases spaced over three years commencing at the end of July, 1982.

Phase I of the project was completed in February 1983. Based on the results and recommendations of Phase I, Phase II work comprising mainly follow-up geological, geochemical and geophysical surveys in four target areas was accomplished jointly by a Japan Aid team and the staff of the Geological Survey of Malaysia, Sarawak in February, 1984.

This report summarizes the results of Phase II work and also forms a part of the final consolidated report which will be submitted to the Government of Malaysia after completion of the project.

We wish to express our appreciation for the close and mutually beneficial cooperation that exists between the implementing agencies of both the Japanese and Malaysian Governments and to the various organizations, particularly the Japanese Embassy in Malaysia and government departments in Kuching, Sarawak, which have rendered assistance in one way or another during the course of the project.

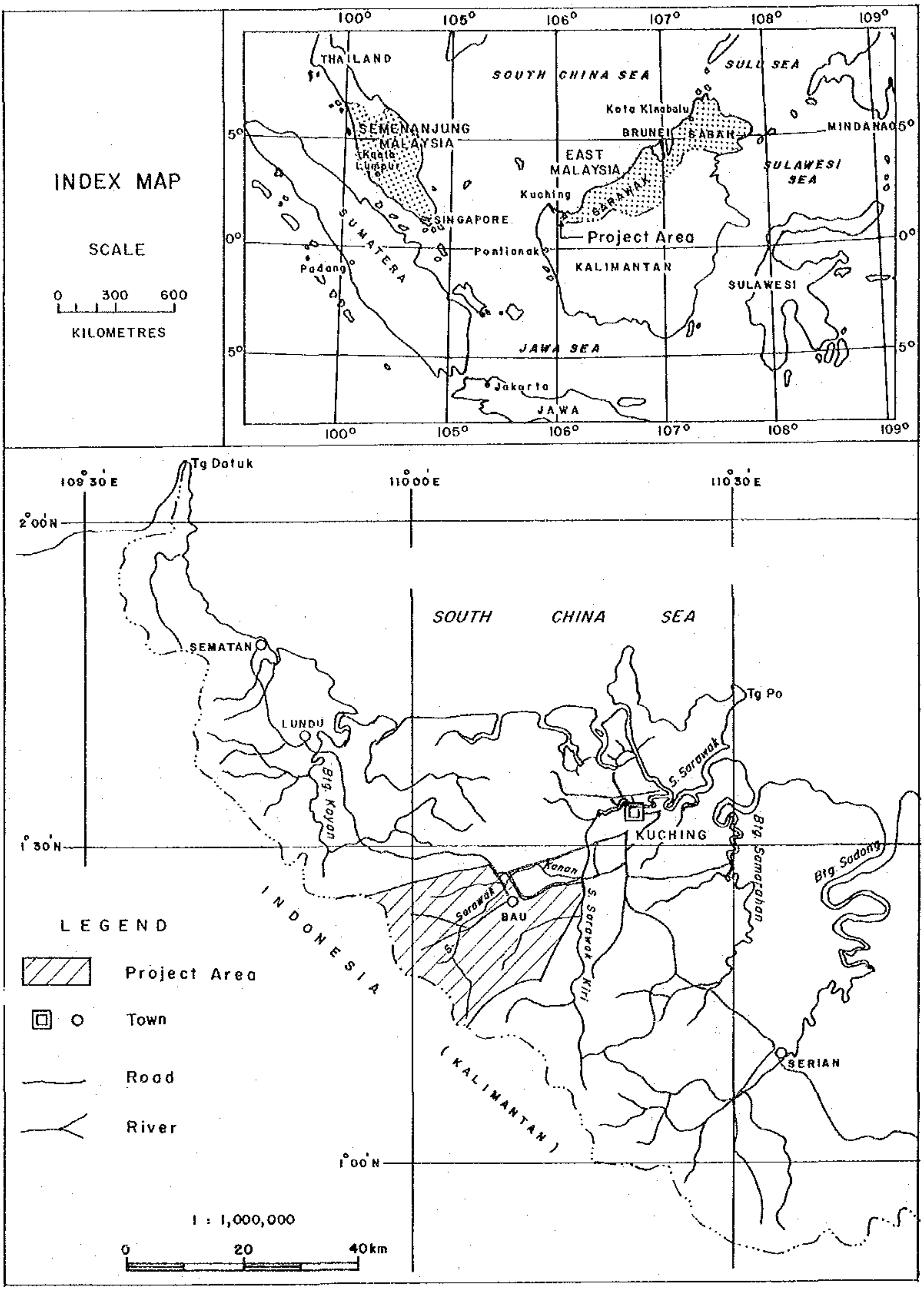
February, 1984

Keisuke Arita
President
Japan International Cooperation Agency

Masayuki Nishiie

Masayuki Nishiie
President
Metal Mining Agency of Japan

D. Santokh Singh
Director-General
Geological Survey of Malaysia



SM 1220/1/83

Fig. 1 Location Map of Project Area

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NOTES

The following Malay and Dayak geographical words are used in the report:

Batang	....	Main river
Pangkalan	....	Jetty
Bukit (Bt)	....	Hill
Arong	....	Valley
Kampung (Kg)	....	Village
Plaman (Plm)	....	New village
Sungai (S)	....	River
Gunung (G)	....	Mountain
Ulu (U)	....	Headwaters of river or surrounding country
Besar (B)	....	Large
Kecil (K)	....	Small
Kanan	....	Right
Kiri	....	Left

ABSTRACT

Phase I of the Collaborative Mineral Exploration Project in the Bau Area which began at the end of July 1982 was completed in February 1983. The results of the work led to a better understanding of the geology and mineralization in the area. Four target areas representing about 13% of the project area were investigated further in Phase II as a follow-up to the recommendations made in Phase I. Detailed studies including geological, geochemical and geophysical surveys in the four areas commenced in May 1983 and were completed in February 1984.

In the Jambusan – Tai Parit area of about 41 km² detailed geological mapping, geochemical rock sampling and investigation of 15 old mine workings and some mineral showings were undertaken. This resulted in the delineation of 4 areas which were considered to merit further exploration work. They include the Seromah North and the Gunung Batu areas where geochemical multi-element 'anomalies' suggest the possibility of Au-Sb mineralization, the Gunung Arong Bakit B, Old Working No. 2 where investigation indicates the presence of a high grade Au ore vein, and the Saburan and Rumoh Old Mine areas where the potentials of finding extensions to the known ore deposits are considered good.

In the Gunung Ropih – Gunung Juala area of about 5 km², detailed geochemical soil survey and geological studies confirms the possibility of Cu-Mo mineralization of the porphyry copper type especially on the SW slope of Gunung Ropih. Characteristics of this type of mineralization were suggested and though hypogene mineralization at the surface was indicated to be low compared to the typical porphyry copper type, the possibility of finding mineralization of economic grade at depth was considered promising.

Semi-detailed geological mapping, and detailed stream sediment and panned concentrate sampling were carried out in the Gunung Api – Sungai Puteh of about 25 km². The work resulted in the demarcation of two small areas where primary gold mineralization of a small scale is considered likely to be found.

The geophysical survey using the spectral induced polarization method undertaken over 6 lines totalling 3.3 line km in the Tai Ton area suggests that the method is suitable in locating and estimating the continuity in depth of stibnite-rich ore veins similar to the type found at the Bidi Old Mine Working.

Based on the results of Phase II, 6 areas were recommended for further exploration work in Phase III to include detailed geological, geochemical and geophysical surveys, and diamond drilling.

GENERAL

CHAPTER 1. INTRODUCTION

1–1 Background of Project

As an impetus to revive mining activities in West Sarawak, particularly in the well known Bau Mining District, the government of Malaysia planned to conduct a systematic mineral exploration programme of the Bau and Lundu-Sematan area under its Fourth Malaysia Plan from 1981 to 1985. This programme is being undertaken with bilateral aid from the Japanese Government and was inaugurated as the "Collaborative Mineral Exploration in Sarawak, Malaysia" in June 1982. The joint effort is to be concentrated in the Bau area and subsequently extended to the Lundu-Sematan area if time and funds permit.

The joint exploration programme is divided into 3 phases – Phase I : August 1982 to March 1983, Phase II : May 1983 to March 1984 and Phase III : May 1984 to March 1985. Though bilateral aid became available only in August 1982, initial work by the Geological Survey of Malaysia, Sarawak, including acquisition of past information, design and planning of programme, upgrading of laboratory facilities and partial geochemical sampling fieldwork was already in progress from 1981 to early 1982. Phase I which involved geochemical and geological surveys over an area of 540 km^2 and a semi-detailed geological survey over 70 km^2 in the Bau area, was completed in March 1983. The main objective of Phase I was to delineate areas with good potentials for ore deposits including areas of possible lateral and vertical extensions of known ore deposits. Based on the results, areas of good economic mineral potentials were recommended for follow-up work.

1–2 Results and Recommandations of Phase I

The main results of Phase I work may be summarized as follow:

(i) The known ore deposits are classified as epithermal vein type and may be grouped as Au-Sb deposits in the Bau Limestone, Cu-Pb-Zn deposits in quartz porphyry stocks and near their contacts and Hg deposits in shale and sandstone of the Pedawan Formation.

(ii) The major known deposits of chiefly Au and Sb were emplaced in the NE to ENE fold crests in WNW to NW and NNW to N faults and subsidiary fractures, and are mainly located near the major NNE fault on the W side of the alignment of Tertiary intrusive stocks. Known Cu-Pb-Zn ore deposits were emplaced in joints in a Tertiary stock and in NE fractures in limestone adjacent to its contact. Known Hg ore deposits were formed in NE faults in shale and sandstone.

(iii) Results of the geochemical survey shows good correlation with the geology and the distribution of known ore deposits. Four broad zones of metal enrichment and 19 anomalous areas may be delineated.

(iv) The overall Phase I results suggest the possibility of finding new economic ore deposits and extensions to known ones in (a) the limestone area around Paku, Bau, Krokong, Kampung Poak, Kampung Seromah and Jambusan for Au-Sb ore deposits, (b) the alignment of Tertiary stocks from Gunung Juala to Gunung Baran for Cu-Pb-Zn ore deposits and from Gunung Ropih to Gunung Api for Mo, Ag and Au ore deposits, and (c) the area N and E of Gunung Tegora for Hg ore deposits.

Based on the results, five areas were recommended for immediate follow-up work in Phase II. They are:

(i) The Jambusan-Tai Parit area of about 50 km^2 was recommended for detailed geological mapping and geochemical soil and rock sampling.

(ii) The Gunung Ropih-Gunung Juala area of about 5 km^2 for detailed geochemical soil sampling.

(iii) The Tai Ton area of about 20 km^2 for geophysical survey and exploration drilling.

(iv) The Gunung Api-Sungai Puteh area of about 25 km^2 for detailed geological mapping, detailed geochemical stream sediment and panned concentrate sampling and possibly detailed geochemical soil sampling in smaller target areas.

(v) The Tegora area for detailed geological mapping, detailed geochemical stream sediment sampling and possible soil sampling of smaller selected areas.

1–3 Outline of Present Investigation (Phase II)

1–3–1 Areas Investigated

Based on the recommendations of Phase I work and the subsequent meeting between officials of the Japanese and Malaysian governments, the following areas representing about 13% of the total area investigated during Phase I were agreed to for follow-up work in Phase II (Fig. 2).

(i) The Jambusan-Tai Parit area of about 41 km^2, for detailed geological mapping and geochemical rock survey.

(ii) Gunung Ropih-Gunung Juala area of about 5 km^2 for detailed geological mapping and geochemical rock survey.

(iii) Gunung Api-Sungai Puteh area of about 25 km^2 for semi-detailed geological mapping, and detailed geochemical stream sediment survey and panned concentrated sampling.

and (iv) The Tai Ton area for Spectral Induced Polarization Survey over 6 lines totalling 3.3 km in length.

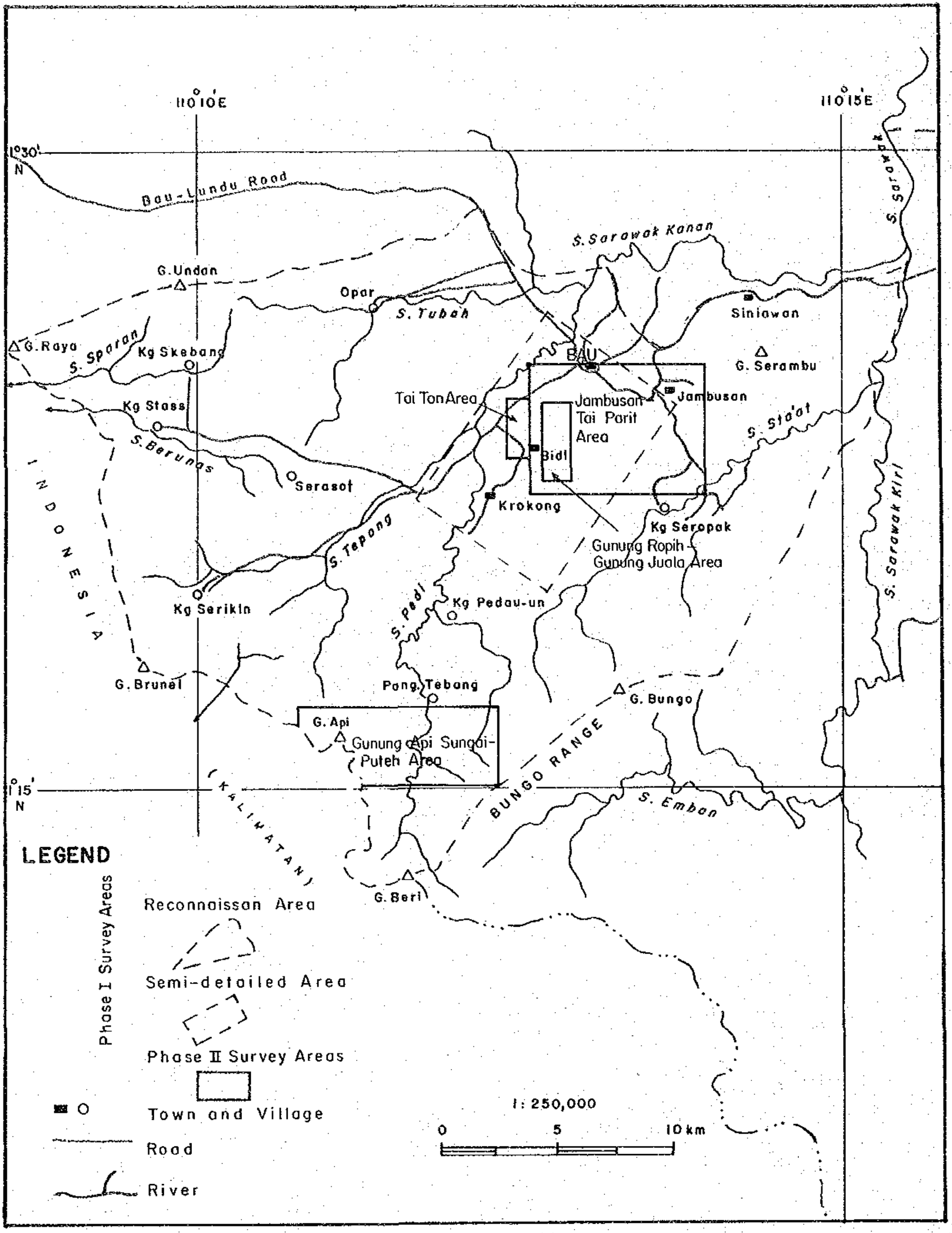

Fig. 2 Location Map of Phase Ⅱ Survey Area

1–3–2 Purpose and Method

The Jambusan – Tai Parit Area

The main objective in the area is to study in detail particularly the Au-Sb mineralization and geology with a view to finding possible new ore deposits and extensions to known ones for further exploratory work. For this purpose, detailed mapping was undertaken along preselected routes and rock samples both mineralized and unmineralized were collected for analysis. Several old mine workings were mapped in detail and rock and ore samples taken for geochemical analysis.

Gunung Ropih – Gunung Juala Area

Detailed soil sampling on a grid pattern of 25 m x 100 m and 25 m x 50 m was undertaken in this area as a follow-up to the geochemical anomalous values for Cu, Pb, Zn, Mo, W, Au and Ag and the encouraging geological field observations obtained during Phase I. The samples were dried, sieved and analysed for 6 elements including Cu, Pb, Zn, Mo, Au & Ag. Some mineralized rock samples were also collected for chemical analysis.

Gunung Api – Sungai Puteh Area

Follow-up detailed stream sediment and panned concentrate sampling, and semi-detailed geological mapping were undertaken primarily to explore further the anomalous values for Au and Ag detected in stream sediment and panned concentrate samples during Phase I.

Tai Ton Area

Spectral Induced Polarization Survey was carried out over 6 lines totalling 3.3 km in this area. The lines were orientated across known mineralized veins near the old Tai Ton Mine, the Kusa Mine and the Bidi South old workings. This survey was undertaken mainly to ascertain the applicability of the method in detecting mineralized veins and their extensions in depth.

1–3–3 Project Personnel

The following personnel from the Geological Survey of Malaysia, Sarawak and the Metal Mining Agency of Japan were involved at the professional level in the execution and report preparation for Phase II of the project:

Malaysia (Geological Survey of Malaysia, Sarawak)

Mr. Victor Hon (Geologist, Leader, Overall Works)

Mr. Dorani bin Johari (Geologist, Geological and Geochemical Surveys, Report)

Mr. Paul Ponar Sinjeng (Geologist, Geological and Geochemical Surveys, Report)

Mr. Wan Zawawie bin Wan Akil (Geophysicist, Geophysical Survey, Report)

Mr. Charles Chin (Geochemist, Chemical Analysis)

Mr. Pang Suh Cem (Geochemist, Chemical Analysis)

Japan (Metal Mining Agency of Japan)

Mr. Mitsuo Yasunaga (Geologist, Leader, Overall Works)

Mr. Hirofumi Taniguchi (Geologist, Geological and Geochemical Surveys)

Mr. Ikuhiro Hayashi (Geologist, Geological and Geochemical Surveys, Report)

Mr. Atsumu Nonami (Geologist, Geological and Geochemical Surveys)

Mr. Susumu Sasaki (Geophysicist, Geophysical Survey)

Mr. Tomio Tanaka (Geophysicist, Geophysical Survey)

Mr. Kazuto Matsukubo (Geophysicist, Geophysical Survey)

1–3–4 Work Schedule

Phase II work commenced in May, 1983 with fieldwork in the follow-up areas and ended in February, 1984 with the printing of the final report. Details of the work schedule is as shown in Table 1. Details of the coverage, type of samples collected and tested are also shown in Table 2.

Table 1 Work Schedule of Phase II

Contents	Location	Duration	Area km^2	Length of Route Traversed km
Preparation of Topographic Maps (1/5000, 1/10000)		Before Project Survey	70	
Preparation and Orientation		May 11 – May 19, 1983		
Geochemical Soil Survey (Rock sampling)	Gunung Ropih – Gunung Juala	May 20 – Aug. 10, 1983	5	25.0
Semi-detailed Geological Survey (stream sediments and panned concentrates sampling)	Gunung Api – Sugai Puteh	Jun. 6 – Jun. 25, 1983	25	76.0
Detailed Geological Survey and Geochemical Survey (rock)	Jambusan – Tai Parit	Jun. 26 – Aug. 6, 1983	41	153.6
Geophysical Survey	Tai Ton	Aug. 29 – Oct. 15, 1983		3.3
Data Processing Interpretation and Report Preparation (in Malaysia)		Oct. 3 – Jan. 21, 1984		
Printing of Report		Jan. 22 – Feb. 10, 1984		

Table 2 Number of Tested Samples

	G. Api – S. Puteh Area	Jambusan – Tai Parit, G. Ropih – G. Juala and Tai Ton Areas	Others	Total
Thin Section	4	25		29
Polished Section		27		27
K-Ar Dating			2	2
X-ray Diffractive Analysis	3	38		41
Chemical Analysis of Whole Rock	6	8	6	20
Chemical Analysis of Rock Samples		493	493	
Chemical Analysis of Soil Samples		1019		1019
Chemical Analysis of Ore Samples				
Au, Ag		201		201
Au, Ag, Sb		20		20
An, Ag, Cu, Pb, Zn		6		6
Au, Ag, Cu, Mo		15		15
Panned Concentrate Samples	212			212
Stream Sediment Samples	255			255
SIP Test Samples		20		20

CHAPTER 2. GEOGRAPHIC INFORMATION

2–1 Location and Accessibility

The Jambusan-Tai Parit, the Gunung Ropih-Gunung Juala and the Tai Ton areas of Phase II are located near Bau Town which is easily accessible by 43 km of paved road from Kuching. Except for the rugged limestone hills, access into the various parts of the areas present little difficulties and is usually by means of gravel road and footpaths.

The Gunung Api-Sungai Puteh area is however, not accessible by road but may be reached on foot within 3 hours from Kampung Kaman. Except during the dry season, the area is usually also accessible by long boats via Sungai Pedi.

2–2 Topography and Drainage

Four distinct topographic land forms which closely reflect the underlying geology may be distinguished in the areas under investigation. These unclude: (i) rugged limestone hills, (ii) alluvium-covered limestone flats, (iii) low undulating hills and (iv) steep sloped hills. The Jambusan-Tai Parit and the Tai Ton areas are dominated by the picturesque karst topography formed by the Bau Limestone with cliff bound karst towers rising to as high as 300 m. Limestone also forms alluvium-covered flats commonly adjacent to karst towers. Intervening low undulating hills are underlain by shale and minor sandstone of the Pedawan Formation. The steep-sloped hills of Gunung Ropih and Gunung Juala consist of Tertiary intrusive stocks. In the Gunung Api-Sungai Puteh area these intrusives also form steep-sloped hills whereas surrounding undulating hills are underlain chiefly by shale and minor sandstone of the Pedawan Formation.

The Jambusan-Tai Parti area is drained by tributaries of the Sungai Sarawak Kanan. Drainage density is very low and streams are often underground in the limestone area. Flooding is frequently experienced during the wet season in the limestone flat areas.

Tributaries of Sungai Pedi and Sungai Sarawak Kiri drain the Gunung Api-Sungai Puteh area. Streams in this area are more evenly distributed and are largely controlled by faults and the regional ENE bedding strike.

2–3 Climate and Vegetation

The climate is typically that of a humid, tropical lowland characterized by very heavy rainfall, a uniform temperature and a high relative huidity. The NE monsoon period of the Landas Season from November to February brings heavy rain while the SW monsoon for April to August is milder and locally considered as the dry season. The mean annual rainfall is about 4,200 mm and temperature is uniform throughout the year ranging from a minimum of 22.9°C to maximum 32.8°C.

Except for the limestone hills, most of the area is covered by secondary forest in various stages of regrowth. The vegetation of the limestone hills consists mainly of stunted trees and it has remain intact mainly because the hills are unsuitable for cultivation. Shifting cultivation of padi is widespread and only a very minor proportion of the area is being used for permanent agriculture, settlement and mining.

CHAPTER 3. GENERAL GEOLOGY

The project area is situated in West Sarawak which forms part of the West Borneo Basement. The basement is the exposed part of the Sunda Shield and is built up of Palaeozoic and Mesozoic rocks. It was tectonically active throughout the Palaeozoic, Mesozoic and Tertiary up to Miocene time. Ever since, it has been a stable area.

The project area is underlain by rocks of pre-Late Jurassic to Tertiary age which form the large ENE trending Bau Anticline. The core of the anticline consists mainly of the Bau Limestone and the pre-Late Jurassic Jagoi Granodiorite. The flanks of the anticline is formed mainly by the Pedawan Formation. (Fig. 3 and Fig. 4)

3–1 Stratigraphy

The Serian Volcanics of Late Triassic age occur only as two small inliers near Batu Kitang and in the uppermost reaches of Ulu Sungai Siniawan. They consist chiefly of aphanitic to amygdaloidal andesite. The Formation is unconformably overlain by the Bau Limestone which has been previously mapped as Late Jurassic to Early Cretaceous. During Phase I, the Bau Limestone has been informally subdivided into a lower bedded 'black limestone' facies and an massive 'grey limestone' facies. The former is found mainly along the margins of the Jagoi Granodiorite and in small areas southeast of Bau town. Chiefly sandstone and conglomerate locally form the base of the formation at the margin of the Jagoi Granodiorite, west of Gunung Krian and in the upper reaches of Ulu Sungai Siniawan.

The Pedawan Formation consists of a moderately to steeply dipping sequence of predominantly shale, mudstone, siltstone and sandstone with subordinate tuff, tuffaceous sediments and limestone and rare conglomerate. The formation accounts for the major part of the project area and is estimated to be in the order of 4,500 m thick. It overlies conformably the greater part of the Bau Limestone but possible localized unconformity between the two formations is not ruled out. In many places the base is observed to interfinger with of the Bau Limestone. From past data, it is known that the Pedawan ranges in age from late Jurassic to Late cretaceous. The Kayan Sandstone of clean white quartzose sandstone and some conglomerate of possibly Late Cretaceous to Tertiary age overlies unconformably the Pedawan Formation near the NW and SE margins of the project area.

3–2 Igneous Rocks

The oldest intrusive rock in the area is the Jagoi Granodiorite which forms two mountain

Fig. 3 Geological Map of the Project Area

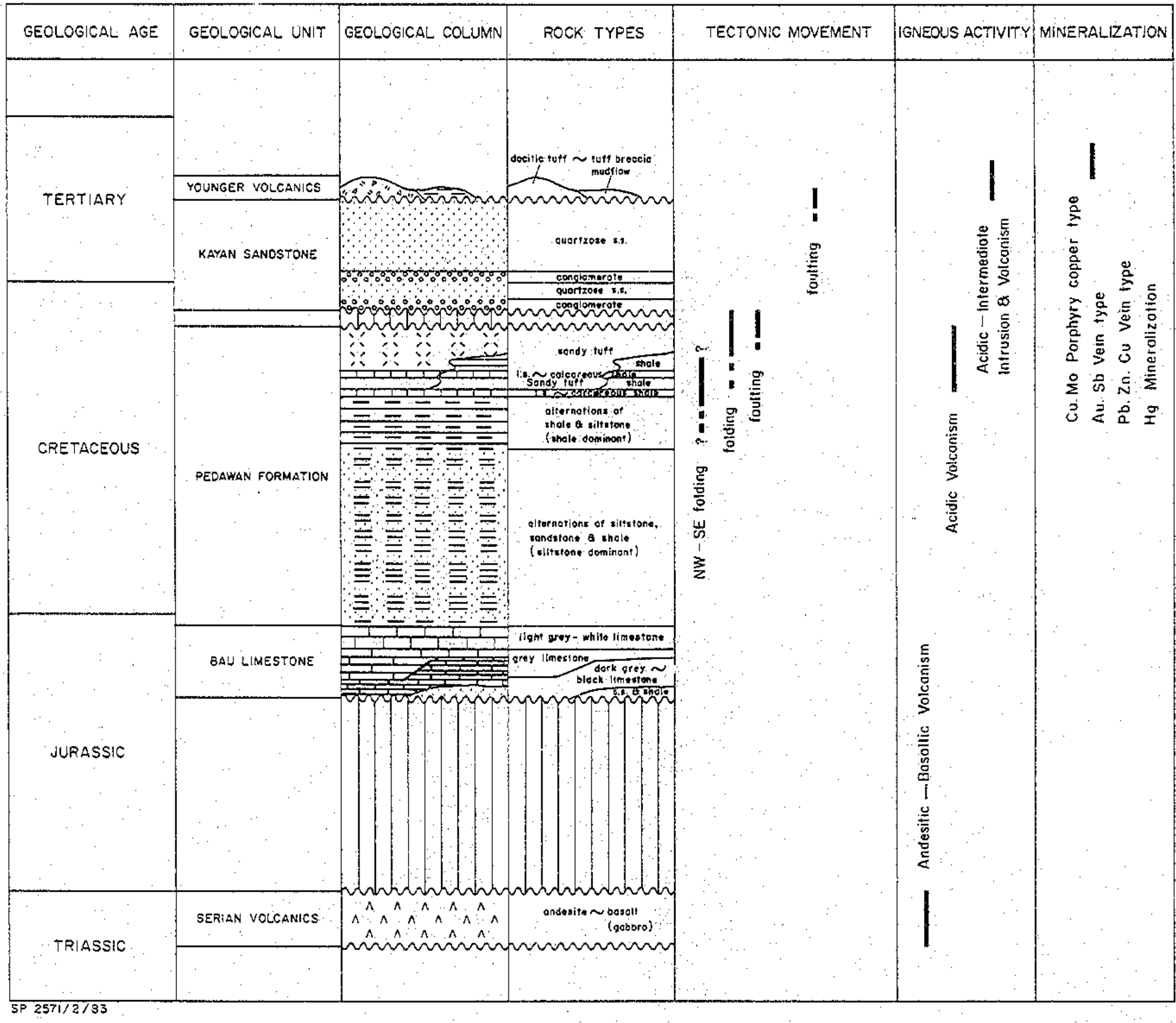

Fig. 4 Stratigraphy and Geological Activities, Bau Area

ranges on both sides of the Serikin valley. The medium to coarse grained granodiorite is overlain unconformably at its margins by the Bau Limestone but its relation to the Upper Triassic Serian Volcanics described earlier is not known. A K/Ar whole rock date gave an age of 89.8 + 3.6 m.y. and two K-Ar dates of hornblende from the intrusive gave ages of 123 + 15 m.y. and 192 + 10 m.y. (Table 3). The first two ages are obviously too young as the Bau Limestone is Late Jurassic to Early Cretaceous. The third one which places the emplacement of the Jagoi Granodiorite at the boundary of the Lower Jurassic and Upper Triassic is more acceptable.

The Tertiary intrusives are the youngest group of rock found in the project area and consist mainly of quartz porphyry and dacite stocks, dikes and sills. Normative mineralogy of 18 samples show that most of these rocks are granodioritic in composition. Quartz porphyry stocks occur mainly in the limestone area and are chiefly hydrothermally altered. Alteration include chloritization, sericitization and in places epidotization. The dacite stocks occur mainly in the south and were also intensely altered. The stocks are believed to have been emplaced at a relatively shallow depth as is evident from occurrence of associated, extruded volcanic breccia and tuff, and possible lava flow found at Gunung Begah, Sungai Da'an and the Bau Hill. Numerous dikes and sills similar in composition to the stocks occur in the area and they also suffered intensive alteration. They were emplaced mainly in faults and in the limestone area appear to be mainly apophyses of the stocks.

Two K-Ar dates of the intrusive stocks gave ages of 10.8 m.y. and 11.2 + 0.8 m.y. which place them in the upper part of Miocene or Pliocene.

3–3 Structure

The ENE Bau Anticline largely governs the present distribution of the various rock units in the area. This anticline was produced under a compression stress field with its principal stress axes directed from the NNW and SSE. The same stress field also produced small-scale congruent folds in the Pedawan Formation. 4 sets of faults may be distinguished in the area, a WNW to W, a NE to E, a NNE and a NW to N set. Dikes were emplaced mainly in the NW to N faults which being tensional are more open. NNE faults are larger and though tight were apparently suitable channels for mineralizing solutions. The NE to E set are mainly reverse strike faults parallel to the regional strike of the Pedawan which controlled largely the elongated shapes of the intrusives in the southern part of the area. The NNE alignment of the intrusive stocks is thought to might have been controlled by a tectonic line such as a major boundary or a fracture zone in the underlying basement rocks.

Table 3 K-Ar Age Determination of the Jagoi Granodiorite

	Sample No.	BRO 110		BRO 111		* JR0040	
	Coordinates X Y	89820 4763		89808 4800		89865 4700	
	Rock Name	Granodiorite		Granodiorite		Granodiorite	
	Unit Name	Older Intrusive		Older Intrusive		Older Instrusive	
Analysis	Material	Hornblende		Hornblende		Whole Rock	
	K %	0.40	0.42	0.37	0.38	2.20	2.20
	$^{40}Ar_{rd}$%	28.0	19.7	52.6	50.1	78.2	82.5
	$^{40}Ar_{rd}$, SCC/g x 10^{-5}	0.194	0.204	0.289	0.300	0.772	0.803
	Isotope Age (m.y.)	123 ± 15		192 ± 10		89.3 ± 3.6	

* Data from Phase I Work

Determination by Teledyne Isotopes, New Jersey, U.S.

3–4 Mineralization

Many small old mine workings and some mineral showings are found in the area. They occur mainly in the area from Bau to Krokong, around Bukit Pangga and Jambusan, and in the Gunung Tegora and Bukit Saha (Gading) areas and were formed chiefly along the crest of the Bau Anticline and NNE alignment of Tertiary intrusives. Many are located at the intersection of these two prominent structures. The ore deposits are mainly of the epithermal fissure-filling vein type and their sites of deposition are largely structurally controlled. There is little doubt that mineralization in the project area is closely related to the Tertiary intrusives which may also be the source.

Based on the metals mined and mineral assemblages, the known ore deposits may be divided into 3 groups.

(i) Gold-Antimony Ore Deposits. Most of the ore of known old workings and present mines fall within this group and were/are mined mainly for gold and in a few cases for antimony. They occur as quartz/calcite or calcite-quartz veins, lens-shaped, which in some cases contain calc-silicate minerals. Gold and stibnite are the minerals of interest and associated metallic minerals include common pyrite, arsenopyrite, native arsenic and subordinate sphalerite, galena, chalcopyrite, orpiment, realgar, marcasite and rare sulfosalts. These ore bodies were emplaced mainly in limestone along NNE to NE and NNW to NW fractures and are generally small.

(ii) Gold-bearing Cu-Pb-Zn Ore Deposits. Ore minerals are mainly galena, sphalerite, chalcopyrite, pyrite and arsenopyrite with minor amounts of stibnite, gold and sulfosalts. Quartz and calcite are the common gangue minerals. They occur as small veins along fractures in the Tertiary stocks and in limestone immediately adiacent to the intrusives.

(iii) Mercury Ore Deposits. The ore minerals include cinnabar, native arsenic, arsenopyrite and occasionally native mercury. Gangue minerals consist of quartz, calcite, barite, fluorite and talc. The ore deposits occur in brecciated to highly sheared zones in shale and sandstone of the Pedawan Formation.

Metal contents of stream sediment samples indicate 4 broad zones of metal enrichment in the project area: a zone in the limestone area surrounding the Tertiary stocks 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 mild Ag and Mo enrichments occur, a zone of Hg enrichment in the Pedawan Formation stretching from Gunung Tegora in a northeasterly direction as far as Gunung Sta'at and a zone of U enrichment almost completely restricted to the Jagoi Granodiorite.

PRESENT INVESTIGATION

PART I GEOLOGICAL AND GEOCHEMICAL SURVEYS

CHAPTER 1 JAMBUSAN – TAI PARIT AREA

1–1 Geological Survey

1–1–1 Geology

The Jambusan – Tai Parit Area is underlain by rocks of the Late Triassic Serian Volcanics, Late Jurassic Bau Limestone, Cretaceous Pedawan Formation, and Neogene Tertiary acidic intrusive stocks and dykes (Fig. I–1 and I–2)

Serian Volcanics

The Serian Volcanics is exposed as a small patch in the uppermost tributaries of Ulu Sungai Siniawan. It consists of a two-pyroxene andesite, dark green in colour, with an aphanitic to partially amygdaloidal texture. The formation is inferred to be unconformably overlain by the Bau Limestone.

Bau Limestone

The Bau Limestone is widely distributed in the area, covering more than half of it. It consists mainly of thick reef limestone showing black to dark brownish grey, dark grey to brownish grey and grey to light grey colours. Limestone in the area was classified by its colour tone into a LI (black to dark brownish grey), LII (dark grey to brownish grey) and LIII (grey to light grey) type. Colour differences probably reflect variations in composition and within short distance indicate similar stratigraphic limestone levels.

The LI type is widely distributed in the flat and appears to be dominant in the lower part, LIII type in the middle and LIII type in the upper part of the formation.

Rare, thin siltstone and sandstone beds occur intercalated with the Bau Limestone in the flats around Kampung Seromah, and in the west and east of the Batu Bekajang Lake. They are traceable for about 4 km in the flats W of Kampung Seromah, with a E-W strike and a southerly dip.

The age of the Bau Limestone is estimated to be Late Jurassic based on foraminifera found in the formation by previous workers.

Pedawan Formation

The Pedawan Formation is found mainly north of the Jambusan and Ah Onn roads, around Batu Bekajang Lake, south of the Seromah road, and in the upper tributaries of Sungai Rumoh around Gunung Tangan and Bukit Sakawing, and south of Jambusan.

The formation consists of interbedded shale, siltstone and sandstone beds. In places, the siltstone and fine-grained sandstone contain carbonaceous laminae.

The contact between the formation and the underlying Bau Limestone has not been ob-

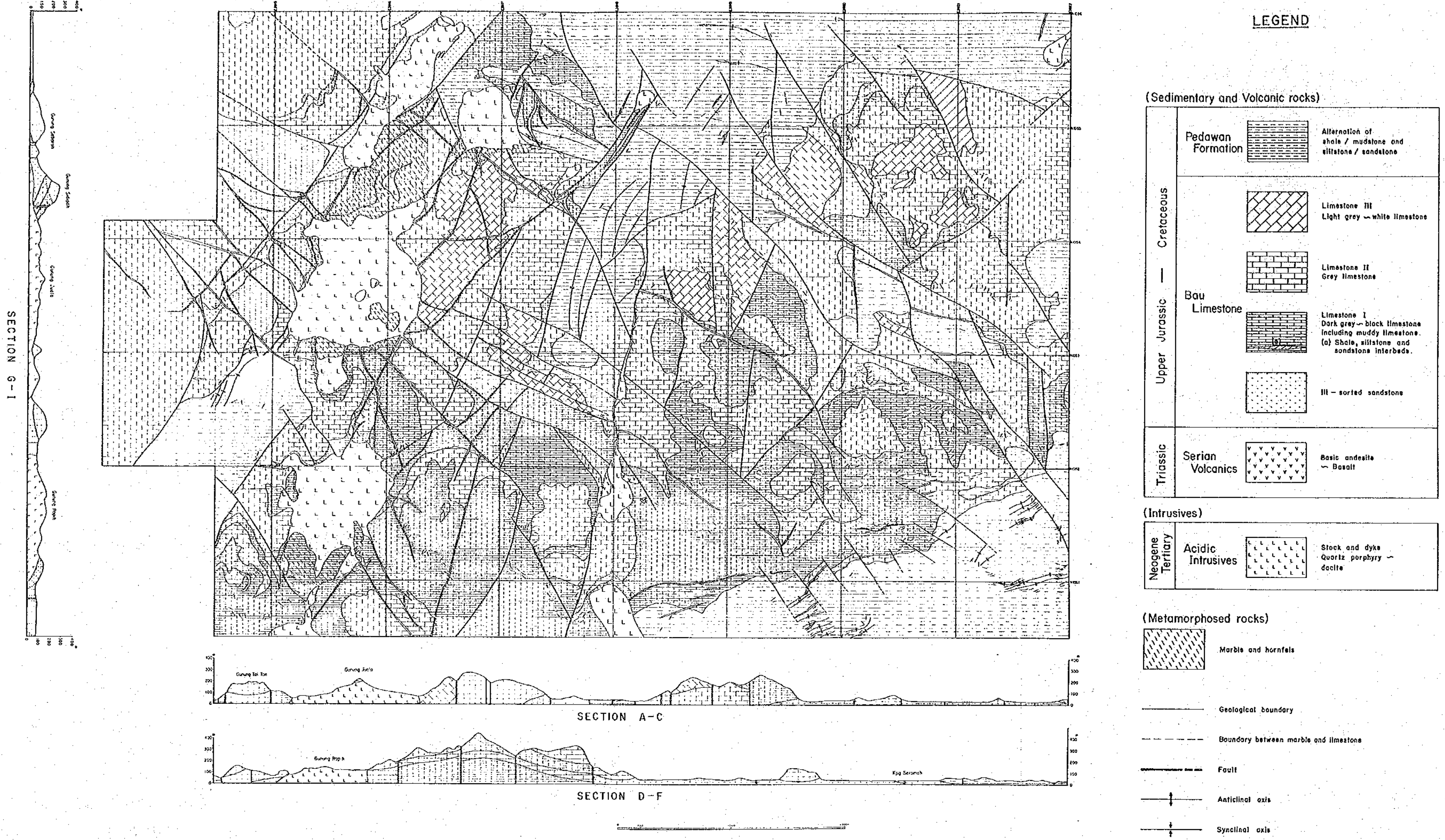

Fig. I-1 Geological Map of Jambusan-Tai Parit Area

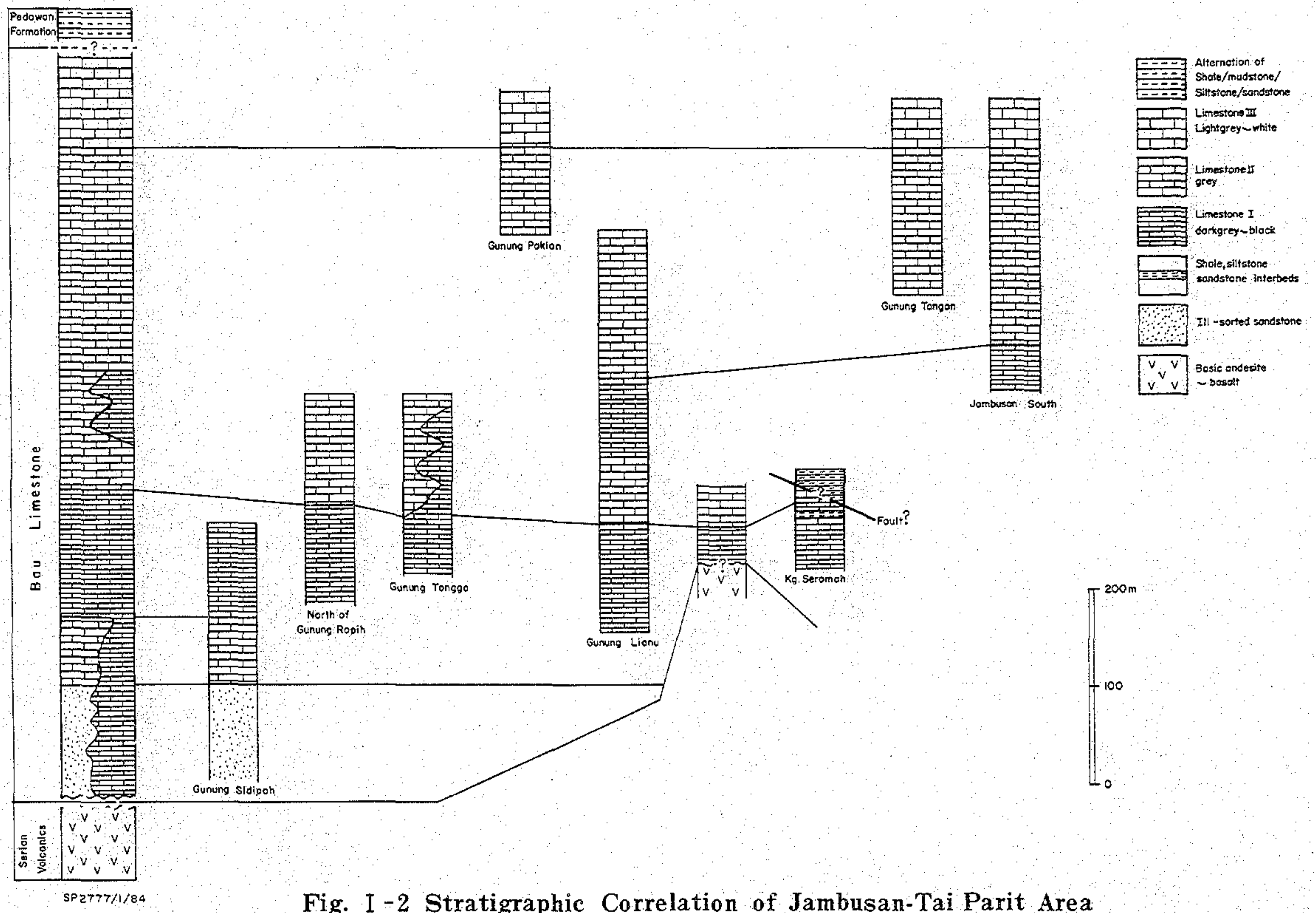

Fig. I-2 Stratigraphic Correlation of Jambusan-Tai Parit Area served in the field. Their relationship is however, inferred to be an angular unconformity(?) over most of the area surveyed. This inferrence is based on the fact that the underlying Bau Limestone dips 20° to 30° whereas the contact appears to be nearly horizontal as indicated by the distribution, shape and topography of both formations.

Acidic Intrusives

The Neogene Tertiary acidic intrusives, mainly quartz porphyry, are located in the western part of the area. Two of the larger intrusive stocks form Gunung Ropih and Gunung Juala and are described in detail under the Gunung Ropih – Gunung Juala Area. The other smaller stocks are located at Gunung Kolong Bau, Bukit Batu Bekajang, and south of Gunung Lianu.

Most of the stocks are very strongly weathered and probably altered, and fresh rock exposures are rare. The extent of the intrusive stocks has been largely mapped by the distribution of yellowish brown soil containing quartz grains, and floats of intrusive rocks.

Dikes mapped in the field mostly as dacite, branch out from the Gunung Ropih and Gunung Juala stocks and fill fault zones that had developed in the intruded limestone. The dikes of one to ten meters wide, extend from a few hundred meters to 2 km in strike length. Most of the dikes in the limestone are argillized and form gorges, being less resistant than the intruded limestone. Dykes in the Pedawan Formation are indistinguishable topographically because they are as resistant to erosion as the Pedawan Formation.

1–1–2 Metamorphism and Alteration

Marble is developed only around the larger intrusive stocks especially in the vicinity of Gunung Bau and Gunung Arong Bakit between the Gunung Juala and Gunung Kolong Bau stocks, and south of Gunung Juala and Gunung Ropih. On the eastern and the western sides of the intrusive alignment, marble is only scarsely observed. Skarnitization is observed only as rare calc-silicate lenses of up to several cm thick near the boundary of the intrusive bodies. The skarn minerals are mainly garnet and epidote.

The intrusive stocks of Gunung Juala and Gunung Ropih show silicification, sericitization and potash alterations which are described in detail under the Gunung Ropih – Gunung Juala Area. Other stocks and dikes mostly suffered only argillization, but it is difficult to distinguish whether this is due to hydrothermal alteration or weathering.

1–1–3 Structure

The main geological structures in the Jambusan – Tai Parit area are faults with general trends of approximately NE-SW and NW-SE. In the NW half of the area the NE-SW trending faults are dominant whereas in the SE half, the NW-SE faults are dominant. In the NW half, the Tai Parit fault is one of the NE-SW trending faults with a strike extension of greater than 5 km. The fault passes through the Tai Parit lake, the old Saburan mine and the Rumoh mine. The NE-SW faults control the distribution of the Bau Limestone and Pedawan Formation, and they are parallel to the general axial trends of the folds developed in the Pedawan. NW-SE faults, found about 200 to 400 m apart are commonly observed near Gunung Juala and Gunung Ropih. They were originally open fractures which had developed because of the NW-SE compressional stress but most were later filled by dikes. The strike extent of these NW-SE trending faults in some cases reaches a few kilometers. In between two neighbouring NW-SE faults, N-S trending faults are occasionally observed.

1–2 Geochemical Survey

The Jambusan – Tai Parit Area has been heavily prospected and mined in the past. Preliminary work during Phase I suggested the possibility of finding new deposits particularly for Au and Sb in the area. To avoid as far as possible 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 programme was recommended as part of the follow-up work. During the present survey, a total of 493 limestone samples were collected over the area and analysed for 11 elements.

1–2–1 Sampling and Analysis

A total of 493 limestone chip samples were collected along geologically surveyed routes in the area underlain by limestone. Sampling covered an area of approximately 29 km^2 giving an overall sampling density of 17 samples/km^2. The routes traversed were mainly along valleys and foothills such that coverage is uneven with low sampling densities particularly in rugged limestone hill and limestone flats areas. The samples were crushed, rolled and quartered, and ground to about -100 mesh. Each was analysed for 11 elements including Au, Ag, As, Sb, Cu, Pb and Zn, Mo, Fe, Mn and Hg by the laboratory of the Geological Survey of Malaysia, Sarawak according to the procedure outlined in Appendix 1.

1–2–2 Data Treatment

The procedure of smoothing geochemical data based on trend analysis used by De Geoffroy et al *(1968) with some modification was applied to the analytical data of the 493 limestone* samples collected over the area (Fig. I–3). The trend values and anomaly components obtained

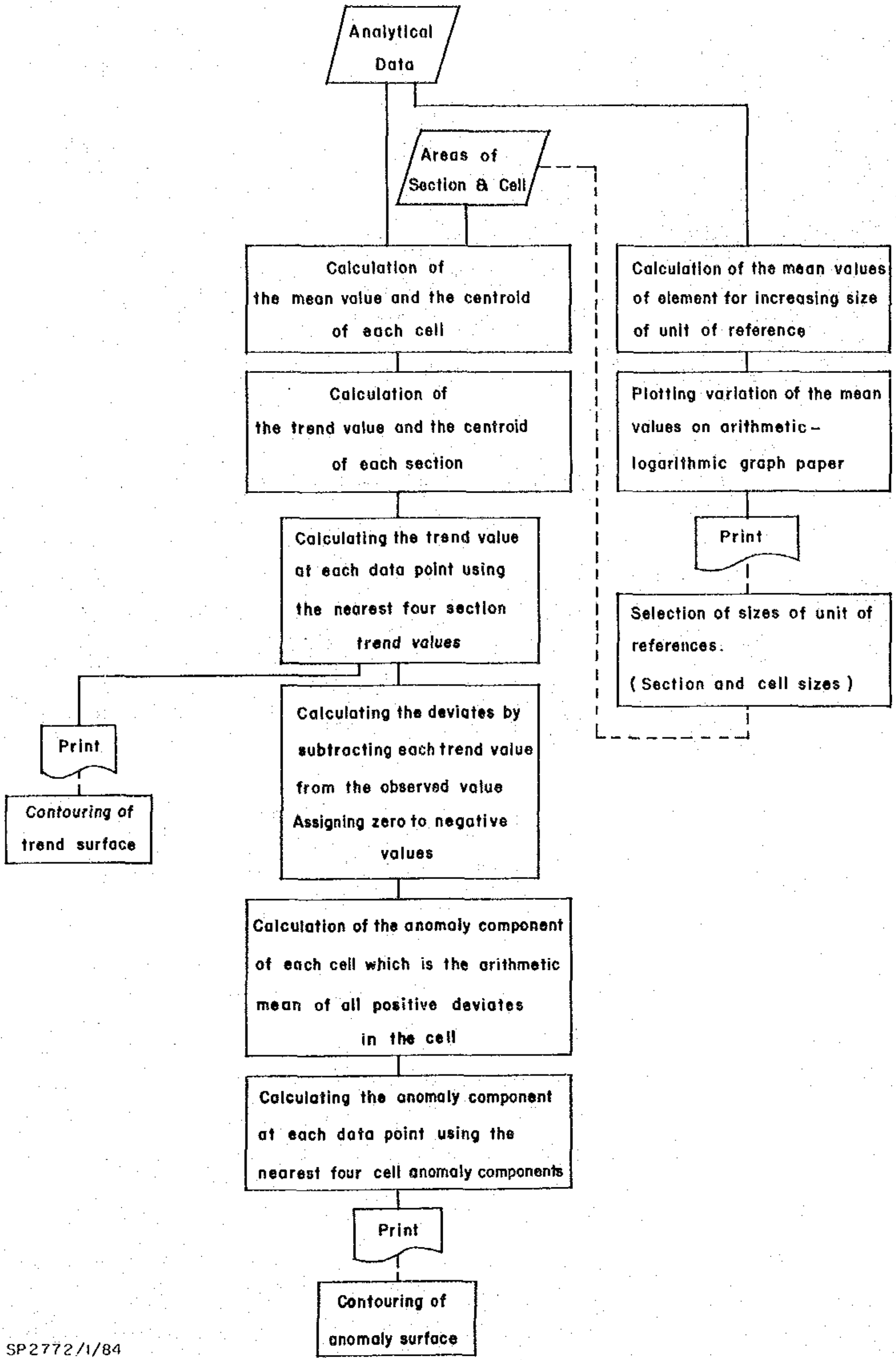

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Fig. I -3 Flow Chart of Trend Analysis

were contoured to produce trend surface and anomaly surface maps. From the anomaly surface maps, it is possible to delineate anomalous areas of interest which in many cases may be correlated with known mineralization in the area. New areas of interest should represent target areas for further exploration work.

The method involves:

i) The selection of units of reference (sizes of squares) for each element analysed. These units of reference referred to as the cell and section represent the local and regional conditions respectively. The selection is done by plotting the mean value of the element of interest of all samples in the unit of reference against increasing size of unit of reference plotted on a logarithmic scale. Cell and section sizes are determined from inflexion points on the graph obtained (Fig. I–4).

ii) Calculation of the trend value and anomaly component. The mean value or trend value for each element of all samples in each section is calculated and plotted at the centroid of the section. This section is moved by a distance of one side of the section both laterally and vertically over the area surveyed and their mean values and centroids calculated and plotted. Mean values and centroids of sections are computed from the mean values and centroids of cells within each section. The trend value at each sample point is then computed from the four nearest trend values of sections. All positive deviates of data are then calculated by subtracting the trend values at the data points from the original data values. The anomaly component for each cell is then computed as the arithmetic mean of all positive deviates occurring within each cell (all negative deviates were assigned a value of zero). The anomaly component of each data is subsequently calculated using the four nearest cell (Davis, 1972) anomaly components.

iii) Plotting the Trend Surface and Anomaly Surface Maps. These are obtained by contouring the trend values and anomaly components of all data points obtained on 1:20,000 scaled topographic maps of the area for every element analysed.

All calculations were done by a desk top computer. Plotting of values on maps and contouring were manually carried out.

1–2–3 Results of Trend Analysis

Trend and anomaly surfaces for the various elements analysed are shown in Maps I–2 – I–23. The trend surface for each element represent its regional background variation whereas the anomaly surface represent its local variation above the background over the area. High local variations may be correlated to known mineralization or indicate possible mineralization of the element. In describing the anomaly surface for each element, all areas above the zero value are

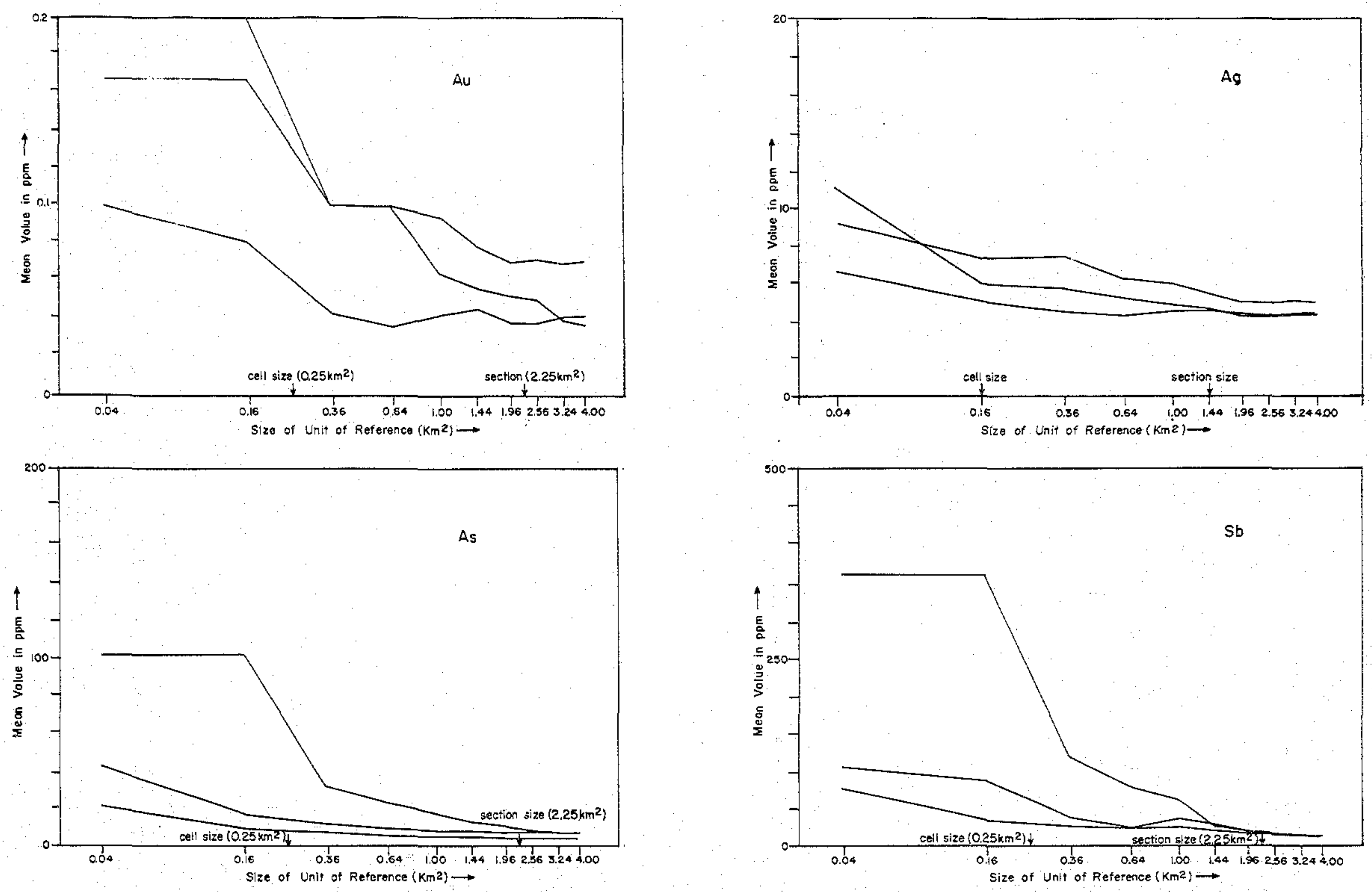

Fig. I-4-1 Selection of Cell and Section Sizes, Jambusan-Tai Parit Area (1)

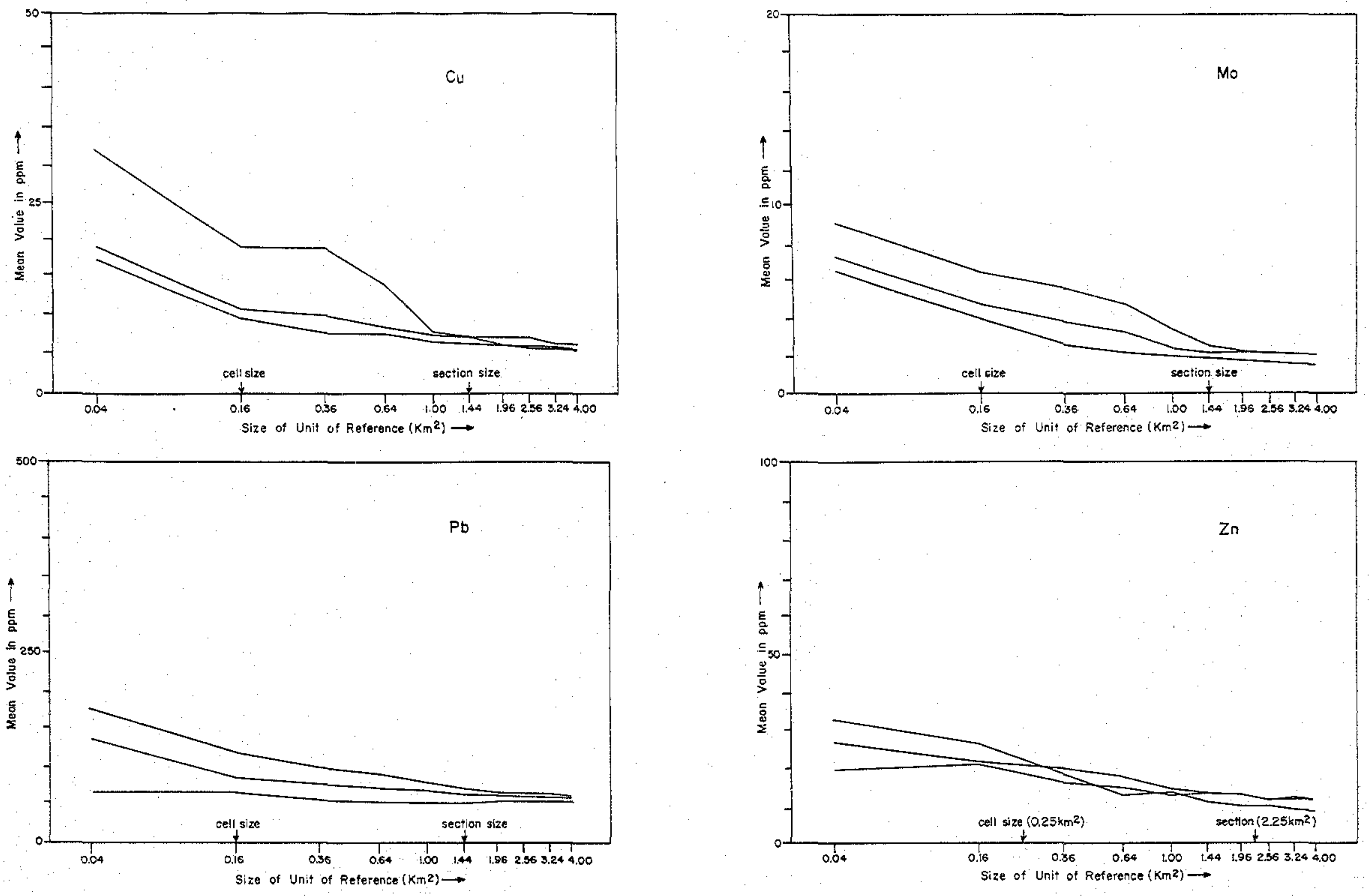

Fig. I-4-2 Selection of Cell and Section Sizes, Jambusan-Tai Parit Area (2)

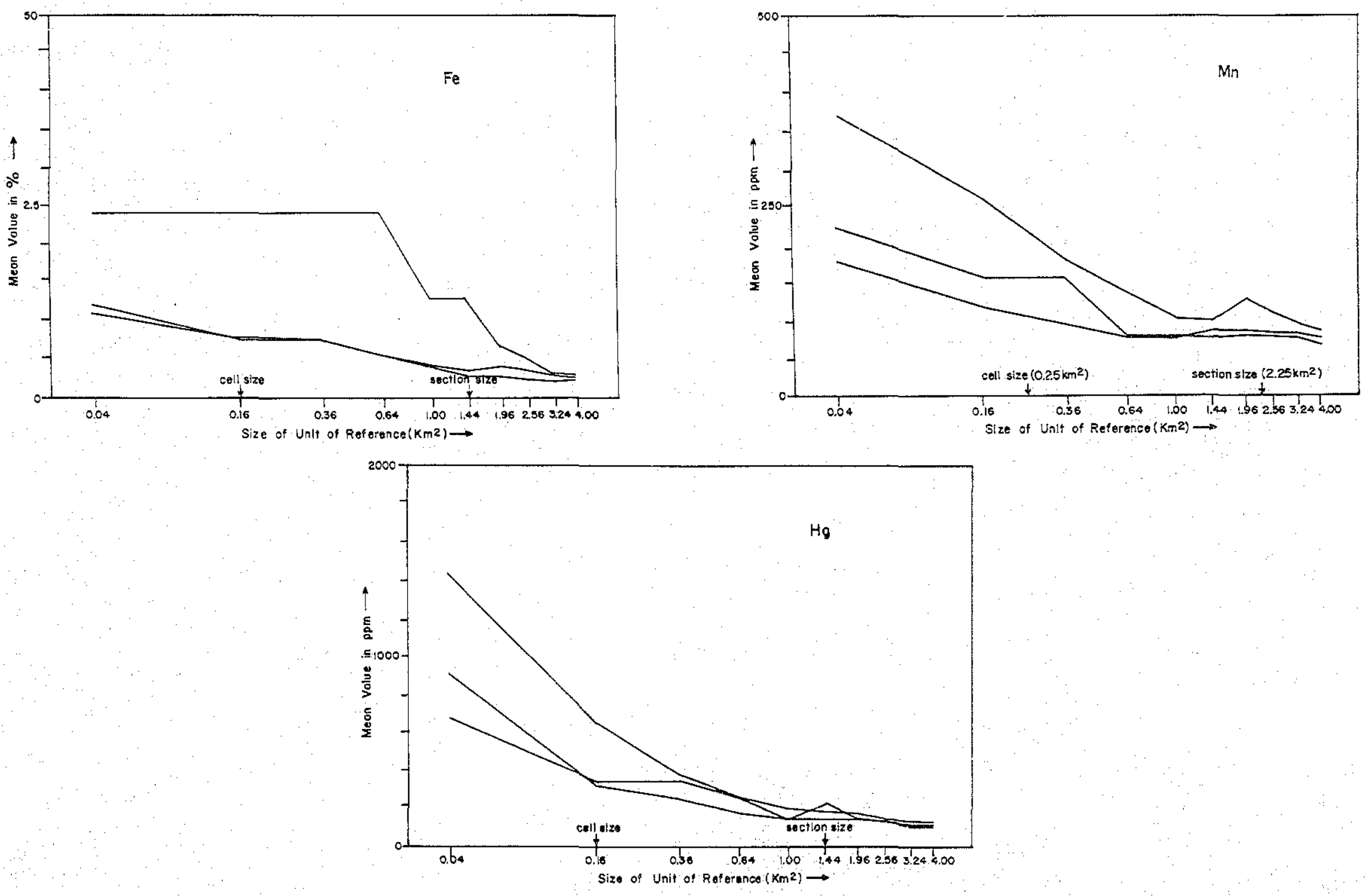

Fig. I-4-3 Selection of Cell and Section Sizes, Jambusan-Tai Parit Area (3)

arbitrarily considered anomalies for that element but only relatively high anomalies are discussed.

Gold (Au). Au content of the samples ranges from trace (< 0.1 ppm) to 0.2 ppm but most are analysed to contain trace and 0.1 ppm Au. The trend surface varies from trace to a high of 0.09 ppm. There are generally three areas of high backgroound trend surface: the NW and NE parts of the area where old mining activities for Au are mainly located and a broad high trend area to the south. The anomaly surface has a highest value of about 0.06 ppm. The 'high anomalies' appear to be eratically scattered and probably represent only analytical inconsistency.

Silver (Ag). Ag values range from 0.4 to 16.3 ppm but most samples analysed between 3 to 4 ppm. The trend surface varies from a low of about 2.74 to a high of 5.92 ppm. There are three general broad areas of high background trend, two towards the NW and SW parts and a broader area in the W part of the area. The anomaly surface shows 'high anomalies' of up to 3 and 6 ppm near Gunung Ropih and Gunung Batu.

Copper (Cu). Copper values range from 2 to 32 ppm with most below 10 ppm. The trend surface varies from about 4.5 to 7.0 ppm with high trend areas just W of Kampung Seromah and S of Gunung Ropih. A small' high anomaly' of up to 10 ppm shows up SW of Gunung Batu in the anomaly surface map.

Lead (Pb). Lead values range from 16 to 540 ppm with most between 40–50 ppm. The trend surface varies from 46 to 72 ppm and shows two high areas, one centering around Gunung Juala and the other just south of Gunung Batu. The anomaly surface reveals only small scattered anomalies of about 5 to 10 ppm.

Zinc (Zn). Zinc values range from 2 to 72 ppm with most below 20 ppm. The trend surface varies from 7 to 11 ppm with a broad higher trend area just W of Kampung Seromah. The anomaly surface shows a few small anomalies of up to 20 ppm SE of Gunung Jebong, just NE of Gunung Tangan, N of Kampung Seromah and just W of Gunung Juala.

Molybdenum (Mo). Molybdenum values range from trace (< 0.5 ppm) to 14.9 ppm with most below 4.0 ppm. The trend surface varies from about 1.0 ppm to 7.5 ppm with two higher trend areas just SW of Gunung Ropih and N of Gunung Tangan. The anomaly surface shows small scattered anomalies of up to 4.0 ppm with 4 'high ones' of up to 3.0, 3.5, 4.0 and 3.0 ppm SW of Gunung Ropih, N and W of Gunung Tangan and SE of Gunung Jebong.

Arsenic (As). Arsenic values range from trace (< 0.5 ppm) to 510.0 ppm with most below 30 ppm. The trend surface varies from about 5 to 30 ppm with three general high trend areas NW of Kampung Seromah, from Gunung Krian to Gunung Ropih. The anomaly surface show three areas of 'high anomalies' of up to about 40, 50 and 40 ppm, just NW of Kampung Seromah, around Gunung Tangan and from Gunung Krian to Gunung Tai Ton.

Antimony (Sb). Antimony values range from trace (< 0.5 ppm) to 360.0 ppm with most below 10 ppm. The trend surface varies from about 2 to 22 ppm with higher areas around Gunung Batu and from Gunung Krian to Gunung Badug. The anomaly surface shows anomalies of up to 70, 30, 10 and 5 ppm around Gunung Arong Bukit, Gunung Batu, Gunung Krian and just NW of Kampung Seromah.

Mercury (Hg). Mercury values range from trace (< 25 ppb) to 1451 ppb with most below 100 ppb. The trend surface varies from about 10 to 160 ppb and divide the area into two with the eastern half showing a high trend surface centering around the area just NW of Kampung Seromah. The anomaly surface shows two distinct 'high anomalies' of up to about 1200 and 700 ppb just NW of Kampung Seromah and near Gunung Batu.

Manganese (Mn). Manganese values range from 9 to 401 ppm with most between 10 and 50 ppm. The trend surface varies from 40 to 80 ppm and shows two large high trend areas, W of Kampung Seromah and from Gunung Krian to Gunung Badug. The anomaly surface shows 'high anomalies' of up to 120, 100, 80 and 160 ppm, W of Kampung Seromah, E and W of Gunung Tangan and around Gunung Juala.

Iron (Fe). Iron values range from trace ($< 0.1\%$) to 2.4% with most values below 0.4%. The trend surface varies from 0.1 to 1.2% with a broad high W of Kampung Seromah and N of Gunung Tangan. The anomaly surface shows three 'high anomalies' of up to 1.0, 1.2 and 0.6% just W of Kampung Seromah, N of Gunung Tangan and around Gunung Juala.

1–2–4 Discussion

From the results of the trend analysis, the following general observations may be made:

(i) The trend surface for mercury divides the area surveyed into two distinct zones; an eastern zone of high mercury background and a western zone of low mercury background. One of the possible reasons for this may be attributed to the occurrence of the intrusive stocks in the western part of the area which can be postulated to have driven off an appreciable amount of mercury during their emplacement. Another plausible reason could be that mercury was introduced in the eastern zone some distance away from the main igneous activity. A combination of both phenomena may also be the cause of the high trend to the east.

(ii) The trend surfaces of the 11 elements show for most elements a general low metal zone of about 1 km wide trending NE from Gunung Ropih.

(iii) Superimposition of the anomaly surface maps for As, Sb, Hg and Mn shows good overlapping of the 'high anomalies' in three areas: the Gunung Krian – Gunung Badug area, the Gunung Batu area and the Kampung Seromah North Area (NW of Kampung Seromah) (Map