Republic of Indonesia Report on Geological Survey of West Kalimantan
Jan. 1982

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Japan International Cooperation Agency

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REPUBLIC OF INDONESIA

REPORT ON GEOLOGICAL SURVEY

OF

WEST KALIMANTAN

CONSOLIDATED REPORT

JANUARY 1982

METAL MINING AGENCY OF JAPAN

JAPAN INTERNATIONAL COOPERATION AGENCY

PREFACE

The Government of Japan, in response to a request extended by the Government of the Republic of Indonesia, agreed to conduct an integrated geological survey for mineral exploration and prospecting in West Kalimantan, Indonesia, and commissioned its implementation to the Japan International Cooperation Agency.

The Agency, taking into consideration the important technical nature of the survey work, in turn sought the cooperation of the Metal Mining Agency of Japan to accomplish the task.

The Government of the Republic of Indonesia appointed the Directorate of Mineral Resources to execute the survey as the counterpart to the Japanese team. The survey has been carried out jointly by experts from both countries.

The survey, which lasted three years, consisted of photogeological interpretation, geological survey, geochemical survey and geophysical survey.

This consolidated report hereby submitted summarizes the results of the said survey.

We wish to take this opportunity to express our gratitude to all sides concerned in this exploratory work.

January, 1982

Prof. Dr. J. A. KATILI
Director General,
Directorate General of Mines,
Ministry of Mines and Energy,
Republic of Indonesia

Keisuke ARITA
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President,
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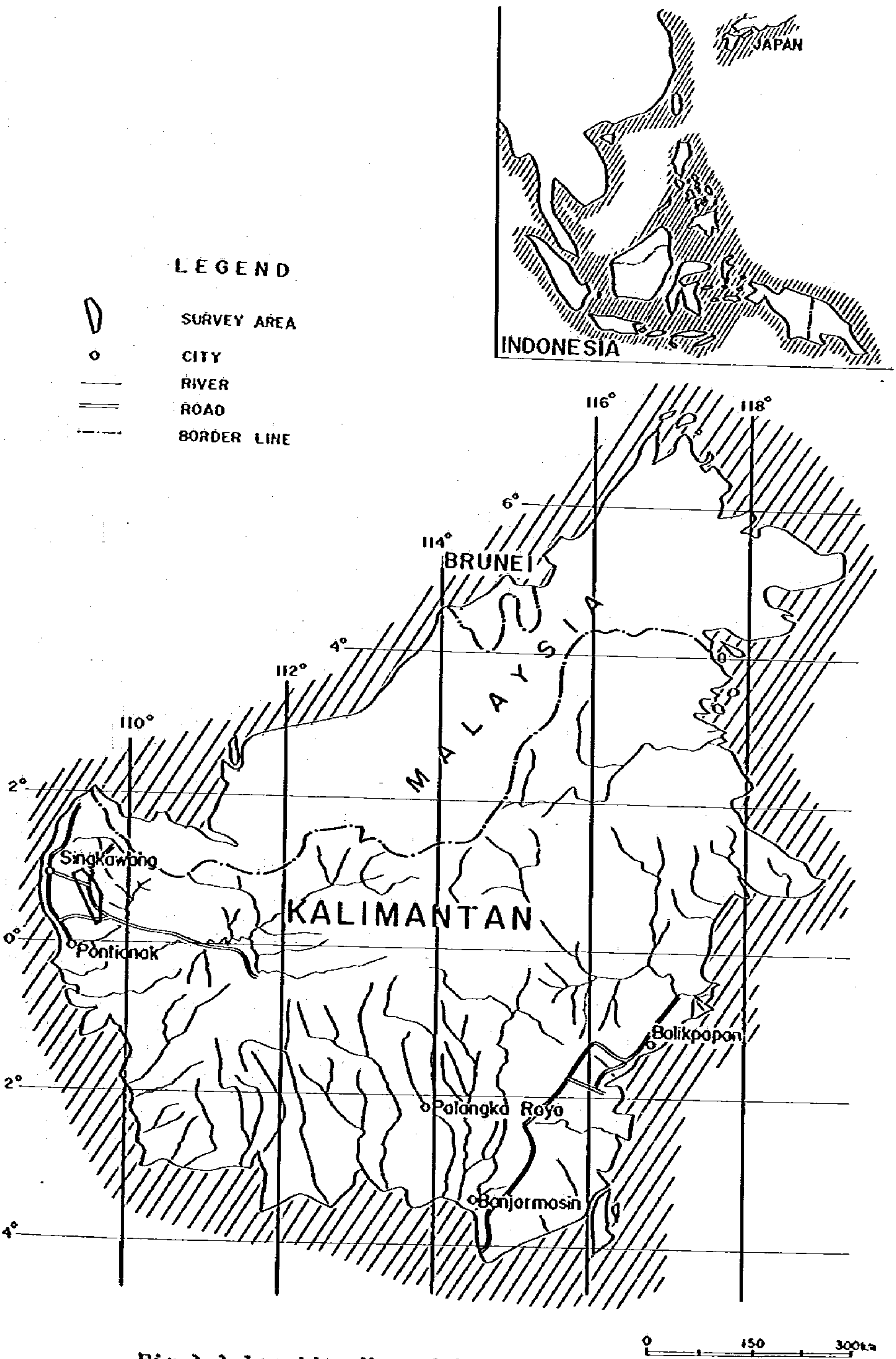

Fig 1-1 Location Map of Survey Area

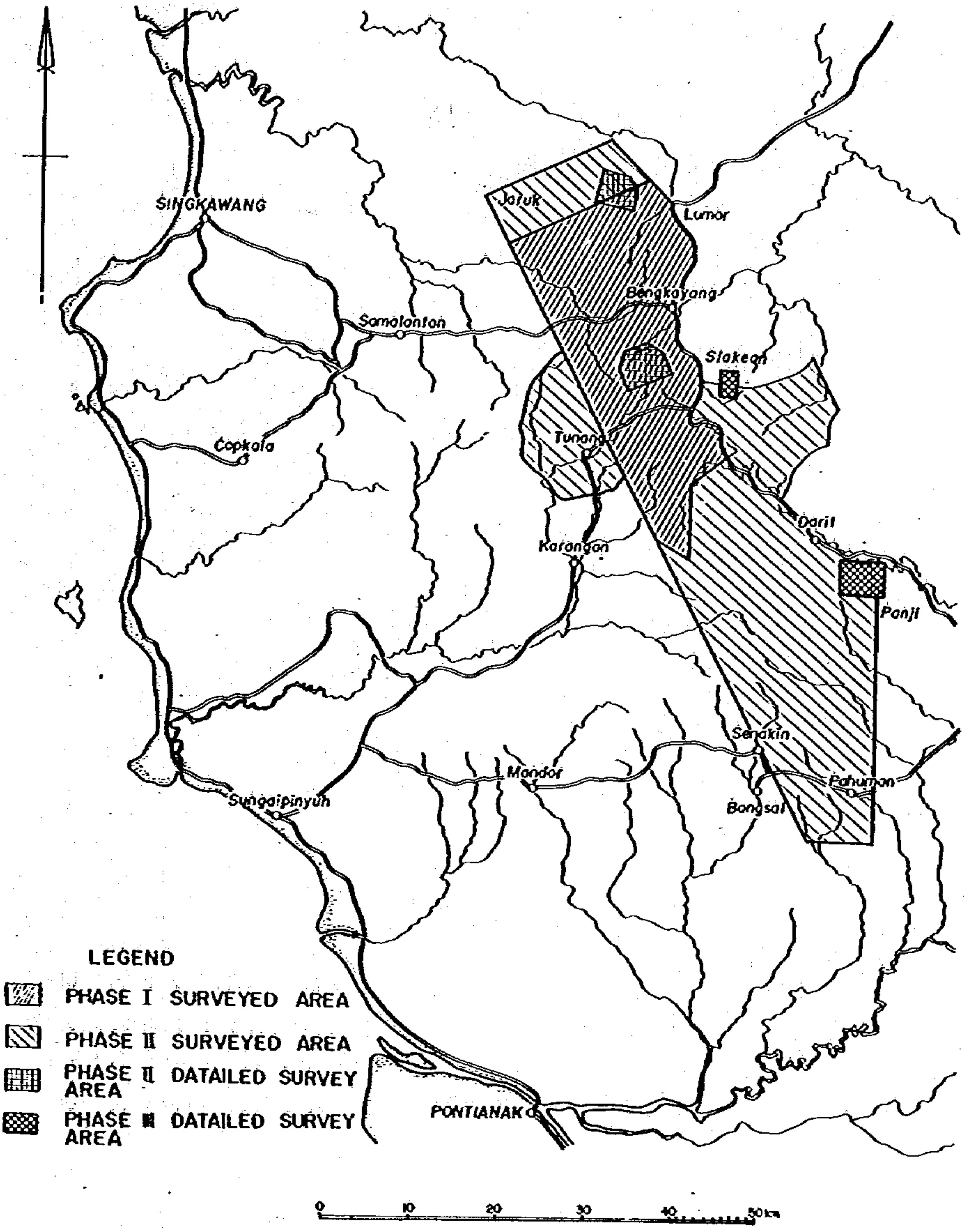

Fig 1-2 Map of Survey Area

Report on Geological Survey of West Kalimantan (Consolidated Report)

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List of Correction

Page	Line	Error	Modification
ii	9	2-5 Instructive Rocks	2-5 Intrusive Rocks
ii	11	2-5-2 Tertiary Instructive Rocks	2-5-2 Tertiary Intrusive Rocks
iii	23	2-2-1 Northern Sedimentary Rock Bloci	2-2-1 Northern Sedimentary Rock Block
x	9	survey were conducted in 4 areas	survey were conducted for 2 years of 1980 and 1981 in 4 areas
28	11	the project area meta-morphism to	the project area, giving thermal metamorphism to

Correction of Error in Table and Figure

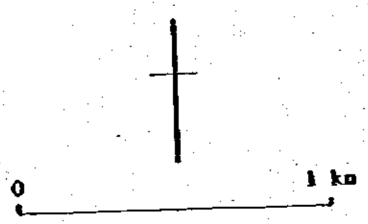
Chart, Map	Error	Modification
Table 1-1	837 862	837 pcs 862 pcs
Table 1-4	Data Processing Aug. 5 - Sep. 15	Data Processing Aug. 25 - Sep. 15
Table 2-2	SccAr $\frac{40\ \text{Rad}/}{9\ \text{m} \times 10^{-5}}$ Aze (m.y.)	SccAr $\frac{40\ \text{Rad}}{\text{gm} \times 10^{-5}}$ Age (m.y.)
Table 4-2	modify the table as attached corrective table	
Fig. 2-7	LEGEND Faulting axis	Folding axis
Fig. 2-24	Magnetite Series/Ilmenite Series in South Area	Magnetite Series/Ilmenite Series in South Asia
Fig. 3-4	(no azimuth and scale)	(put azimuth and scale as attached below) 

Table 4-2 Mean Value and Threshold Value of Reconnaissance Geochemical Survey with Stream Sediment in the Project Area

Block	Element	Mean Value ppm	Standard Deviation (σ) (Logarithmic Value)	M + σ ppm	M + 2σ ppm	Remarks
79/A	Cu	28		64	147	Sedimentary Formation Area
	Zn	71		113	180	
	Mo	1		1	2	
79/B	Cu	32		74	173	Raya Granodiorite Area
	Zn	63		110	193	
	Mo	1		1	1	
80/A	Cu	9	0.340	19	43	Sedimentary Formation Area
	Pb	13	0.214	21	35	
	Zn	59	0.281	114	218	
	Mo	3	0.2097	5	8	
80/B	Cu	21	0.298	43	85	Jirack Formation, Belango Formation Area
	Pb	14	0.276	26	49	
	Zn	32	0.305	65	133	
	Mo	3	0.1913	5	8	
80/C	Cu	18	0.342	43	105	Raya and Selantar Granodiorites Area
	Pb	8	0.332	18	40	
	Zn	25	0.385	60	147	
	Mo	3	0.206	4	7	
80/D	Cu	7	0.370	16	39	Sebiawak Granodiorite Area
	Pb	7	0.286	13	25	
	Zn	10	0.524	34	114	
	Mo	2	0.213	3	6	
80/E	Cu	12	0.326	26	56	Belango Formation Area
	Pb	8	0.229	14	24	
	Zn	25	0.405	63	162	
	Mo	2	0.228	4	9	

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ABSTRACT

This collaboration survey was conducted in west Kalimantan to clarify the actual situation of the geology, stratigraphy, geological structure, igneous activities, mineralizations and their relations for aim of explorating metallic mineral resources in the area. Reconnaissance survey including geological survey, geochemical survey and placer gold panning was conducted for 2 years of 1979 and 1980 in the project survey area extending to 1,500 m^2 and detailed surveys consisting of geological, geochemical and geophysical surveys were conducted in 4 areas (Serantak, Banyi, Selakean and Panji, totalling to 76 km^2) which were selected as the result of the preceding reconnaissance survey.

As the result of the geological survey, the stratigraphy and time correlation of the strata of the project area, which had been considered to belong to the early Mesozoic consisting of sedimentary rocks, volcanic rocks and pyroclastic rocks, have been clarified. Also, the chemical analysis and K-Ar absolute age determination conducted on granitic rocks in the survey clarified the their rock facies, chemical composition, intrusion conditions and age. Some indication of mineralization and existence of some ore deposits were confirmed through the geological survey, as well as their scales and characteristics.

From the survey results, it is concluded that the survey area consists of sedimentary rock strata of the upper Triassic to lower Jurassic, volcanic rocks and pyroclastic rock strata of the middle to upper Jurassic and batholithic Cretaceous granitic rocks (124 to 103 m.y.) and the Tertiary decite and granitic rocks (51 m.y., 27 to 20 m.y.) that intruded into the said strata and that the area belongs to the Cretaceous Magmatic Arc. Mineralization mainly accompanies with the younger igneous activities and mineralized zones and indications of chalcopyrite-molybdenite deposits, gold bearing chalcopyrite-pyrrhotite deposits, gold and silver bearing chalcopyrite-sphalerite-arsenopyrite deposits, manganese ore deposits and alluvial placer gold deposits are observable.

In the reconnaissance, geochemical survey was conducted on stream sediments, and the anomalous areas as interpreted through the geochemical survey coincide with the distribution of the mineralized zones found by the geological survey. From this result, it can be said that geochemical survey of stream sediments is quite effective in selecting promissive and prospective areas of mineralization out of the vast unsurveyed area and that geochemical survey on soils is quite effective in determining the range and condition of mineralized area from the prospective area.

It was also confirmed that the gold panning prospecting is quite effective for reconnaissance of areas which contain gold mineralizations.

Geophysical survey (IP survey) was conducted in the Panji area, the detailed survey area, and an FE anomalous area, though not too prominent, was recognized in the Panji mineralized zone.

Absolute age determination by K-Ar method was conducted to the granitic rocks in the G. Ibu copper and molybdenium mineralization, in addition to the project area, and the result is that the zone is 30 m.y. This confirms that the zone was formed by the calc-alkali rock series igneous activities during the early Tertiary to the Tertiary Miocene, and it is considered that the younger igneous activities brought mineralizations of copper, molybednum, gold, mercury and antimony to west Kalimantan.

PART I

INTRODUCTION

CHAPTER 1 OUTLINE OF SURVEY

1-1 Development of Affairs and Purpose of Survey

A cooperative mineral exploration project in the Republic of Indonesia was conducted in Northwestern Surawesi (1970 ∿ 1974) and in Central Kalimantan (1975 ∿ 1978). Through these two projects, extensive and useful data on the geology and economic geology have been obtained. Moreover, these surveys have contributed effectively to accumulate data on the geology and metallic mineral resources and to improve Projects of the Geological Survey of Indonesia.

The Ministry of Mines and Energy of the Republic of Indonesia re-organized the Geological Survey of Indonesia, and established newly Directorate of Mineral Resources in 1978. Based on the above mentioned beneficial results, the Directorate of Mineral Resources requested a third co-operative project in West Kalimantan area to Japanese Government, through Government of the Republic of Indonesia.

In response to this request, the Government of Japan dispatched a preliminary survey mission headed by Toyo Miyauchi on May 1979. The survey mission conferred with the Staff of Directorate of Mineral Resources regarding the subject area to be surveyed and work program. After a deliberation, it was agreed to perform the co-operative project in an area of 1,500 km^2 covering Gunung Bawang, Bengkayang, Pahuman, and Gunung Raya in West Kalimantan (Fig, 1-1, 1-2). This area prospered in the past as a gold mining area and is known as an area with gold, copper, molybdenum, lead and zinc mineral indications.

The following plan was also agreed on Reconnaissance Survey consisting of photogeological interpretation, geological survey, geochemical survey and gold placer prospecting to be performed in the whole survey area covering 1,500 km^2 in order to interpret geology, geological structures, igneous activities and mineralization and relationship between them and mineralizations. Detailed survey consisting of geological, geochemical and geophysical surveys to be conducted in the extracted promising mineralization areas in order to survey the possibility of exploration by clarifying the scales distributions and properties of these mineralized areas.

1-2 Summary of Survey Operation

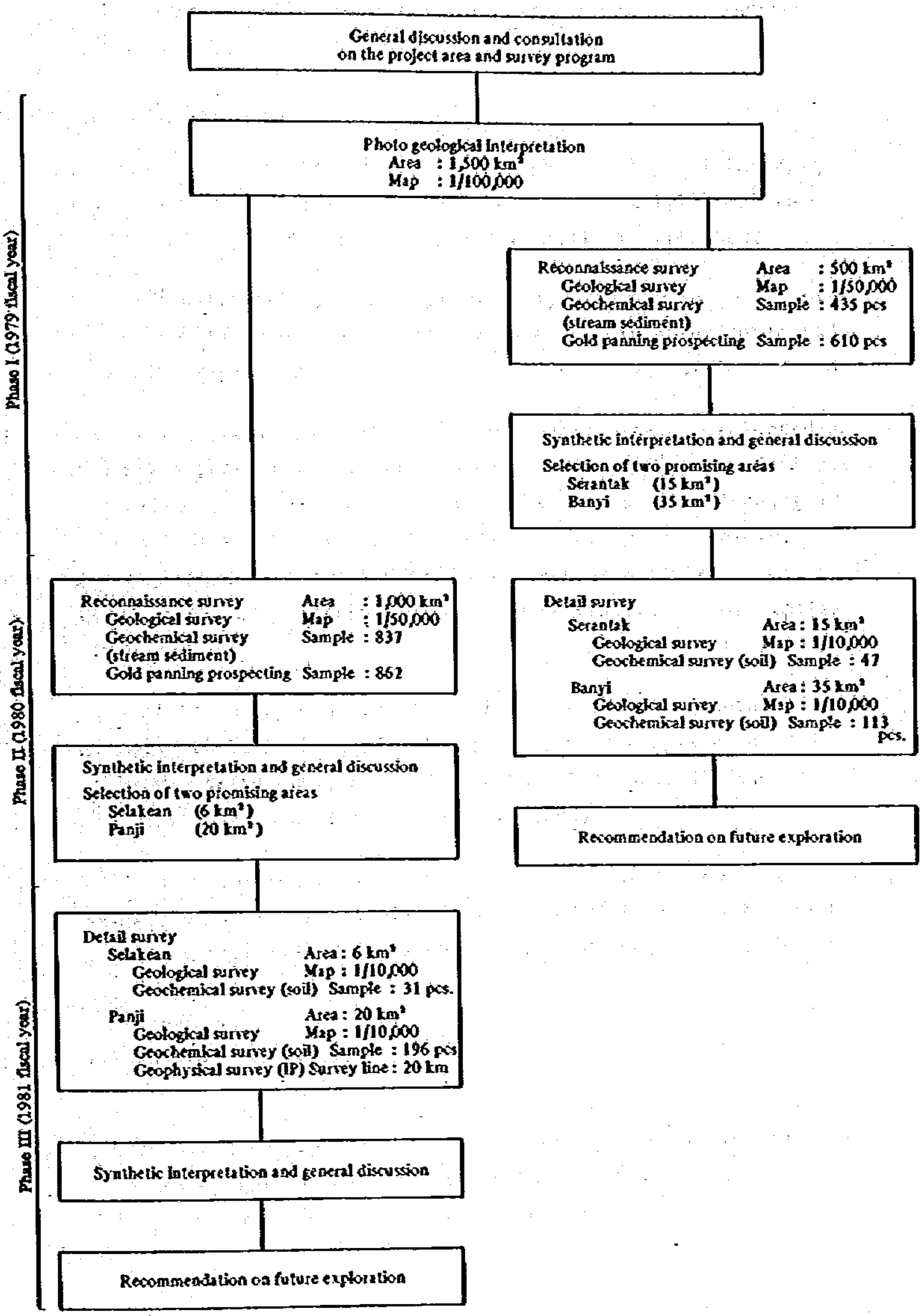
The survey was conducted in collaboration with the Directorate of Mineral Resources, the Republic of Indonesia for three years in 1979 (First Phase Survey), 1980 (Second Phase Survey) and 1981 (Third Phase Survey) in an area of 1,500 km² approximately surrounding in the following coordinated positions.

North latitude	0°51'	East longitude	109°17'
"	1°00'	"	109°25'
"	0°38'	"	109°41'
"	0°15'	"	109°37'
"	0°17'	"	109°40'

The survey had been conducted progressively as shown in Table 1-1, to select promising mineralizations through reconnaissance survey consisting of photogeological interpretation, geological survey, geochemical survey of stream sediments and placer gold prospecting to discuss the possibility of development for the deposits by elucidating the properties, conditions and scales of mineralized zones through detailed survey consisting of geological survey, geochemical survey with soil sampling and geophysical survey (IP Survey).

Prior to the First Phase Survey, the Mineral Exploration Division of Geological Survey of Indonesia (predecessor of Directorate of Mineral Resources) carried out a geochemical reconnaissance survey with stream sediments (sampling density: 1 pcs/5 km²), convering approximately 10,000 km² bounded by the 0° ∿ 1° North Latitude and 109° ∿ 110° East Longitude, the results of which were referred to in determing survey areas for the current surveys.

Table 1·1 Flow chart of Exploration Survey Program



The development of survey and summary of each phase survey are described below.

1-2-1 The First Phase Survey

Prior to the First Phase Survey, photogeological interpretation was conducted in the whole area covering 1,500 km^2 in order to interpret outline of geology and geological structure.

101 airphotographs of approximately 1/50,000 in scale, provided by Directorate of Mineral Resources, were interpreted and photogeological map was compiled in scale of 1/100,000.

The northern part of the whole project area was selected as the first phase reconnaissance area, covering 500 km^2. Geological survey, geochemical survey of stream sediments, and placer gold prospecting were conducted in order to clarify the geology, stratigraphy, geological structures, igneous activities, mineralized zones, and distribution and characteristics of mineralizations.

Field survey was conducted from July 1979 to October 1979 as shown in Table 1-2, of which results were compiled in Geological Map (1/50,000), Maps of Geochemical Anomaly (1/50,000) and Map of Placer Gold Distribution (1/50,000).

The result of first phase survey was interpreted to extract two areas (50 km^2 in total) of Serantak and Banyi located as the promising mineralized zones where detailed survey was to be performed in the next phase survey.

1-2-2 The Second Phase Survey

The Second Phase Survey consists of reconnaissance survey and detailed survey. Following the first phase of the collaboration survey for exploration of metallic mineral resources conducted to cover 500 km^2 in West Kalimantan, the second phase reconnaissance survey was conducted to cover the rest of 1,000 km^2 in the central and southern parts of the same region, consisting of the geological survey, geochemical survey with stream sediments and placer gold prospecting. The results of work were compiled to Geological Map (1/50,000), Map of Geochemical Anomaly (1/50,000) and Map of Placer Gold Distribution (1/50,000) of the whole project area, together with the first phase survey results. As the result of reconnaissance survey, the geology, geological structures, igneous activities, mineralizations, etc. became clear in this area which occupies the central portion of West Kalimantan.

Two areas (50 km^2 in total) of Serantak and Banyi selected as promising mineralized zones as the result of first phase reconnaissance survey were determined as detailed survey areas.

(1) Serantak Area

The massaive copper bearing pyrrhotite ore deposits and the gold bearing quartz veins were distributed in this detailed survey area of 15 km^2.

(2) Bayni Area

A hydrothermal alteration zone accompanied by the pyrite dissemination was found, centering at S. Banyi, around where the mineralizations were sporadic, such as many of chalcopyrite-gold-quartz veins, molybdenite-chalcopyrite dissemination, in the area of 35 km^2.

Prior to conducting the detailed survey, topographic maps of 1/5,000 in scale were compiled, using airphotographs.

The detailed survey was conducted, consisting of geological survey and geochemical survey with soil sampling. The results of work were compiled to Geological Map (1/10,000) and Map of Geochemical Anomaly (1/10,000), exploring the geology, geological structures, igneous activities, relationship among mineralizations and characteristics of mineralized zones in these areas.

Outline of the second phase reconnaissance survey and detailed survey is shown in Table 1-3.

1-2-3 The Third Phase Survey

Two promising mineralized areas, Selakean and Panji, covering 26 km^2 in total, located by the third phase reconnaissance survey, were selected for the detailed survey in the third phase.

(1) Selakean Area

Gold-chalcopyrite-sphelerite-arsenopyrite ore veins were distributed in this area of 6 km^2.

(2) Panji Area

Chalcopyrite dissemination area and torunaline-quartz mineralization were recognized in granodiorite in this area of 20 km^2.

Topographic maps of 1/5,000 in scale were compiled, using airphotographs, for the detailed survey consisting of geological survey and geochemical survey with soil sampling. The results of work were summarized in Geological Map (1/10,000) and Map of Geochemical Anomaly (1/10,000), exploring the geology, geological structures, relationship among igneous activities and mineralizations, existence and scale of mineralizations. Geophysical survey (IP Survey) was also conducted in Panji mineralization in order to explore its scale and characteristics in an area of 2 km × 1.8 km, along the survey line of 20 km.

Outline of the third phase field survey is shown in Table 1-4.

1-3 List of Members

The members engaged in the consultation and fieldworks for each phase survey are as follows.

Table 1-2 Outline of Field Survey in Phase I (1979)

	Survey area	Survey period	Area km²	Survey route km	Sample pcs
Reconnaissance survey Photogeological interpretation	Whole area	July 9 – Aug. 9	1,500		
Geological survey	North area	Aug. 6 – Sep. 28	500	583	
Geochemical survey	North area	Aug. 6 – Sep. 28	500		435
Gold panning prospecting	North area	Aug. 6 – Sep. 28	500		610
Data processing	North area	Sep. 29 – Oct. 27			

Table 1-3 Outline of Field Survey in Phase II (1980)

	Survey area	Survey period	Area km²	Survey route km	Sample pcs
Reconnaissance survey Geological survey	Central & South area	June 3 –* Aug. 15	1,000	819	
Geochemical survey	Central & South area	June 3 – Aug. 15	1,000		873
Gold panning prospecting	Central & South area	June 3 – Aug. 15	1,000		862
Detail survey Geological survey	Serantak & Banyi	Aug. 16 – Sep. 13	50	165	160
Data processing		Sep. 13 – Oct. 12			

* include preparatory survey

Table 1-4 Outline of Field Survey in Phase III (1981)

	Survey area	Survey period	Area km²	Survey route km	Sample pcs
Detail survey Geological survey	Selakean & Panji	June 8 –* Aug. 25	26	179	
Geochemical survey	Selakean & Panji	June 8 – Aug. 25			227
Geophysical survey	Panji	July 8 – Aug. 24		20	
Data processing		Aug. 5 – Sep. 15			

* include preparatory survey

Phase I (1979)

(a) Planning and Consultation

Indonesia	Japan
Dr. Prof. J.A. Katili Director General Directorate General of Mines Ministry of Mines and Energy	Toyo Miyauchi Metal Mining Agency of Japan
Ir. Salman Padmanagara Director Directorate of Mineral Resources	Takashi Ono Agency of Natural Resources and Energy Ministry of International Trade and Industry
Ir. P.H. Silitonga Directorate of Mineral Resources	Hisamitsu Moriwaki Japan International Cooperation Agency
Ir. Yaya Sunarya Directorate of Mineral Resources	Nobuhisa Nakajima Metal Mining Agency of Japan
	Katsuhiko Ozawa Japan International Cooperation Agency

(b) Survey Team

Indonesian Team

Leader

Ir. Yaya Sunarya	(D.M.R.)

Member

(Geological and Geochemical Survey)

Ir. Koswara Yudawinwta	(D.M.R.)
Subandi Widasaputra	(")
Idik Sumpena	(")
Tatto Sudharto	(")
Simpwee Soeharto	(")
Deddy T. Sutisna	(")
Johnny R. Tampubolon	(")
Danny Z. Herman	(")
Yan Soalon Manurung	(")
Zulkifli	(")

(Assistant)

A. Muchsin	(")
Wachyu Ili	(")
Moe'tamar	(")

Japanese Team

Leader

Sakae Ichihara	(M.M.A.J.)

Member

(Geological and Geochemical Survey)

Sakae Ichihara	(M.M.A.J.)
Nobuhisa Nakajima	(")
Katsumi Hayashi	(")
Atsushi Takeyama	(")
Atsumu Nonami	(")
Daizo Ito	(")

(Photogeological Interpretation)

Susumu Takeda	(M.M.A.J.)

Phase II (1980)

(a) Planning and Consultation

Indonesia		Japan	
Ir. Salman Padmanagara Director	(D.M.R.)	Hisamitsu Moriwaki	(J.I.C.A.)
Ir. P.H. Silitonga	(")	Tadao Inoue	(M.M.A.J.)
Ir. Yaya Sunarya	(")	Kyoichi Koyama	(")
		Nobuhisa Nakajima	(")
		Yutaka Okano	(")

(b) Survey Team

Indonesian Team		Japanese Team	
Leader		**Leader**	
Ir. Yaya Sunarya	(D.M.R.)	S. Ichihara	(M.M.A.J.)
Member		**Member**	
(Geological and Geochemical Survey)		(Geological and Geochemical Survey)	
Ir. Koswara Yudawinata	(D.M.R.)	Sakae Ichihara	(M.M.A.J.)
Subandi Widasaputra	(")	Fukio Kayukawa	(")
Tatto Sudharto	(")	Kiyohisa Shibata	(")
Simpwee Soeharto	(")	Atsushi Takeyama	(")
Johnny R. Tampubolon	(")	Susumu Takeda	(")
Danny Z. Herman	(")	Yasushi Komoda	(")
Sukmana	(")	Hirofumi Furuta	(")
Yan Soalon Manurung	(")		
(Assistant)			
A. Muchsin	(")		
Wachyu III	(")		
Moe'tamar	(")		

Phase III (1981)

(a) Planning and Consultation

Indonesia		Japan	
Ir. Salman Padmanagara Director	(D.M.R.)	Kyuzo Tadokoro	(M.M.A.J.)
		Shozo Sawaya	(")
Ir. P.H. Silitonga	(")	Kyoichi Koyama	(")
Ir. Yaya Sunarya	(")	Kenji Sawada	(")
		Kazuhiko Uematsu	(")

(b) Survey Team

Indonesian Team		Japanese Team	
Leader		Leader	
Ir. Yaya Sunarya	(D.M.R.)	Sakae Ichihara	(M.M.A.J.)
Member		Member	
(Geological and Geochemical Survey)		(Geological and Geochemical Survey)	
Simpwee Soeharto	(D.M.R.)	Sakae Ichihara	(M.M.A.J.)
Johnny R. Tampubolon	(")	Terumi Ishikawa	(")
Danny Z. Herman	(")	Hirotaka Nishimoto	(")
Sukmana	(")		
(Assistant)			
Moe'tamar	(")		
M. Rachmat	(")		
(Geophysical Survey)		(Geophysical Survey)	
Nanang Sunarya	(")	Kenichi Nomura	(")
Drs. Gusti Hidayat	(")	Akihiko Chiba	(")
Immanuel M.F.	(")	Kazufumi Yoshimura	(")
Eddy Kurnia	(")		
W. Soeparmin	(")		

D.M.R.: Directorate of Mineral Resources

M.M.A.J.: Metal Mining Agency of Japan

J.I.C.A.: Japan International Cooperation Agency

CHAPTER 2 OUTLINE OF SURVEY AREA

2-1 Location and Accessibility

The project area is situated in Northwestern Kalimantan as shown in Fig. 1-1 and Fig. 1-2, approximately bounded in the following coordinated points of longitude and latitude.

North	latitude	0°51'	and	East	longitude	109°17'
"	"	1°00'	and	"	"	109°25'
"	"	0°38'	and	"	"	109°41'
"	"	0°51'	and	"	"	109°37'
"	"	0°71'	and	"	"	109°40'

As regards its administrative division, this area belongs to Mempawah District and Sambas District of West Kalimantan Province.

The domestic Garuda round-trip air flights (F-28) are nationally operated twice a day between Pontianak and Jakarta, Capital City of the Republic of Indonesia, taking approximately one hour for one way. The time differential is one hour in advance between the Java island and the Kalimantan island.

The project area is accessible by two routes, i.e. north and south route. The north route starting from Pontianak, runs 145 km northward along the seaside road to Singkwang, the second biggest city in West Kalimantan and reaches Bengkayang where the base camp was set for the survey in north part, the major location at the north part of the survey area, further 75 km eastward from Singkawang. There is a paved road further northward to Sarawak from Bengkayang, and it takes about 5 hours by car to reach from Pontianak to Lumar, most northern place of the project area.

The southern part of the survey area is accessible by a paved or gravel road up to Darit running eastward from Sungaipinyuh on Pontianak-Singkayang road, via Mandor, Pahuman and Sidas, and the total distance is approximately 120 km. This south road was recently paved as a link of road construction running to the east region of Kalimantan, under the Colombo Plan Assistance currently rendered by the Government of Australia, having a good comfortable road up to Darit to facilitate an case of arriving at Darit even by a passenger car. However, the road between Darit and Bengkayang is still kept unpaved, hard in passing through even by a four wheel driven car.

The major roads are well conditioned for traffic as above. However, nothing but the mountain roads and trails are dependable to the survey site from these major roads, through which the survey equipment, camping materials and foods can only be transported by labors.

The ferry boats transport passengers, cars and goods to cross S. Kapuas running at the north of Pontianak, but if it is in congestion, a long time waiting is enforced.

2-2 Geographical Features, Vegitation and Climate

The north part of this project area is characterized by a mountain range with Gunung Bawang the highest, 1,490 m above the sea level, while the central part by a mountain range extending east-westward, consisting of Gunung Pandan Kecil and Gunung Genting Bakilok of around 1,000 m high. However, the project area is generally characterized by low land or plains with elevation ranging from 100 to 500 m above the sea level.

Owing to the high temperature and a high humidity, the survey area being located nearly on the equator, the tropical plants have luxuriantly grown, forming a tropical forest zone. While there is not much of short vegitation under the tropical forest zone in the mountain region, bushes and grasses are very dense in the plains, especially the dense growing of bushes at the trace left after slashing-burning agriculture, and therefore, many is difficult to enter into the field, except for the areas along a road, a trail and a river.

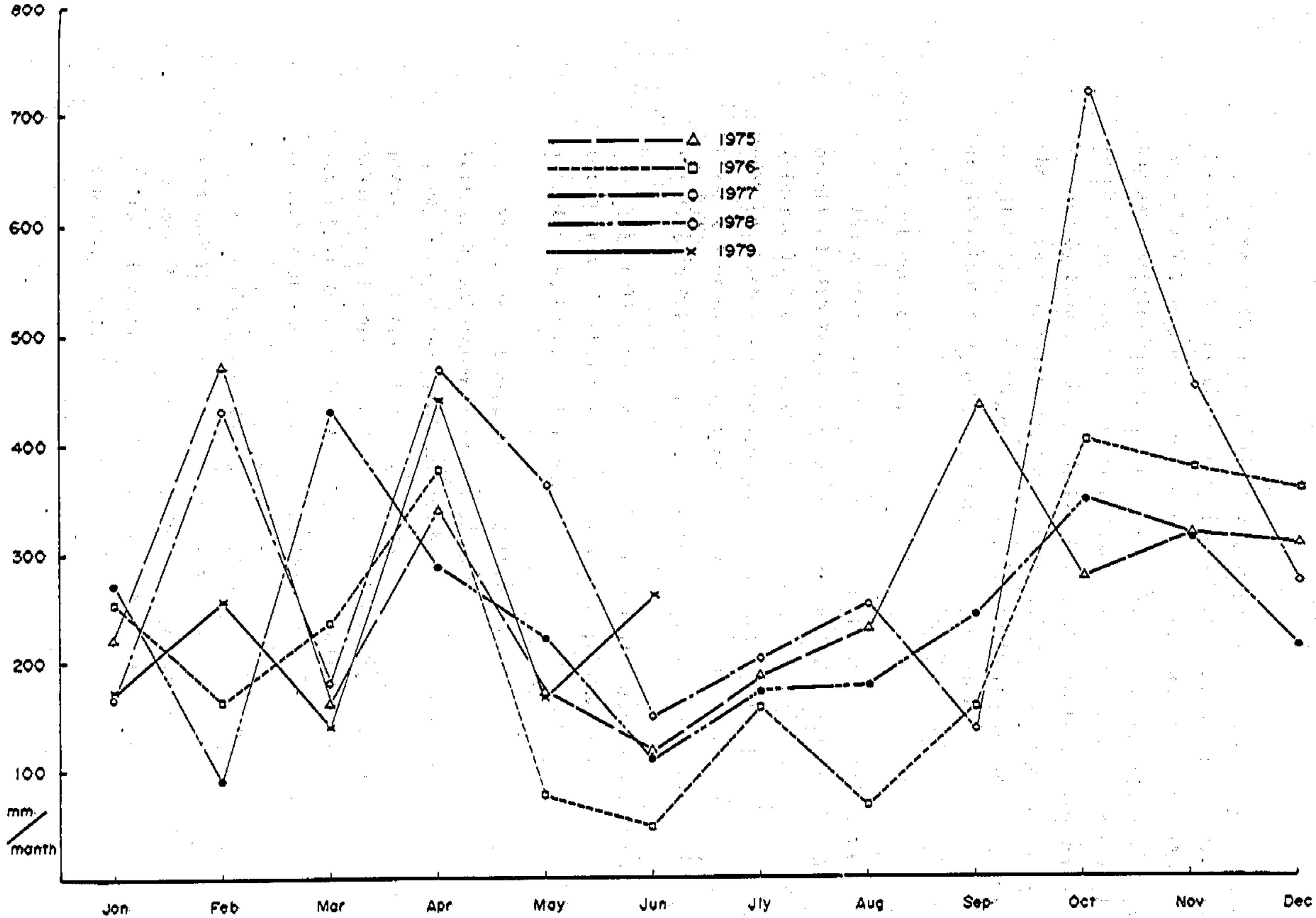


Fig 1-3 Precipitation at Bengkayang

Owing to the survey area being situated nearly on the equator, the climate is characterized by the so-called tropical climate having a high temperature and a high humidity. Fig. 1-3 gives the annual precipitation record of 1975 ∿ 1979 at Bengkayang, according to which the dry season is from June to August. The mountain region, such as G. Bawang and others, has a very high humidity even during the dry season, being covered by thick clouds and having a plenty of rainfall. Accordingly, the temperature in the region is so low at night that it requires a sleeping bag at the camp.

2-3 Circumstances of Survey Area

The administrative divisions in the Republic of Indonesia is organized with Propinsi (Province), Kotamadia (City) or Kabupaten (District), Kacamatan (Country), and Desa or Kampung (Village), to each of which a Gubernur (Governor), Bupati (Chief of District), Camat (Chief of Country), Kepala Desa or Kepala Kampung (Chief of Village) is appointed, respectively, to govern the responsible area.

West Kalimantan Province (Propinsi Kalimantan Barat) covers a total area of 146,760 km^2 and has a total population of 2,372,516 inhabitants, based on 1977 census.

The northwest area of West Kalimantan Province, covering Kota Pontianak, Kabupaten Pontianak and Kabupaten Sambas included in the survey area of this project, has been highly developed since the past. 60% or 1,411,647 inhabitants of the total population of West Kalimantan Province are living in these three areas covering 25% of total West Kalimantan area, where the majority of population concentrates at the plain area along the coast line.

Especially, many Chinese immigrants have lived in the plain area and along the coast line since the past, and they are occupying more than 60% of total population in Singkawang where is the central city for them. Besides them, there lives other tribes such as Dayak, Malay, Java and Sunda and so forth.

This area is well known that the gold products have been traded since the 13th century, and the placer gold mining had been flourished at Mempawah, Nontrado and Bengkayang, where have all been known as "Chinese District" since the mid-18th century. The gold mining has, however, rapidly inclined since the mid-19th century, and at present, no more than a small scale gold mining can be seen by some local inhabitants only during a spare time out of their agricultural work.

Agricultural products are at present their major products, especially harvesting rubber and pepper. Dayak people in the survey area still cultivate land by slashing-burning agriculture, even today.

No fierce animal is living, except the venomous snakes (green snake, cobra, etc.) having a hazardous poison, with which the survey members have been greatly bothered and afflicted, together with leaches, a poisonous plant called jeratan and some infections deseases from river water. Also, as the area is in the tropics, malaria is a common disease.

CHAPTER 3 PREVIOUS SURVEY

Geological reconnaissance survey in West Kalimantan had been performed by Dr. Molengraaff (1900), Dr. Wing Easton (1904) and Dr. Loth (1920), during the period of Dutch colonation. The geological maps of 1/100,000 scale have been compiled by Dr. Wing Easton, covering West Kalimantan area to include the survey area of this project.

Further, the surveys for West, Southwest and Central Kalimantan areas had been performed by Dr. Krol (1920) and Zeijlmans Van Emmichoven (1935, 1938 and 1939), reporting the results and compiling the geological maps of 1/250,000 scale.

Dr. Bemmelen has summarized these results into Geology of Indonesia (1949), describing the geological stratigraphy, geological structures and economic geology of Kalimantan.

The subsequent analyses of geological structures in West Kalimantan and Northwest Sarawak, including Malaysian Sarawak, had been performed by Dr. Katili (1965 ∿ 1973, 1980 ∿ 1981), Dr. Haile (1968 ∿ 1973), Dr. Pupilli (1973), Dr. Hatchison (1973 & 1975) and Dr. Hamilton (1978), from the Plate Tectonics points of view.

The alluvium placer gold had been mined in Panembahan of Mandor, Sambas and Bengkayang, so-called "Chinese District", on the ore deposits of West Kalimantan, during the period from the 18th century up to the first half of the 19th century. The surveys and prospectings on the primary gold deposits at Lumar, Senturu and Bengkayang, the copper ore deposits around Mandor and the molybdenite ore deposits at G. Bawang and Benaul had been conducted, but no detailed data and information had been published. At present, no more than a small scale mining at the alluvium placer gold deposits is being operated by local inhabitants.

In 1970, the Mineral Exploration Division of Geological Survey of Indonesia conducted the metallic mineral resource exploration survey in West Kalimantan covering approximately 10,000 km^2 bounded by the 0° ∿ 1°

North Latitude and 109° ∿ 110° East Longitude to include Pontianak, Singkawang, Bengkayang and Mandor, with the geochemical survey by sampling at a rate of one stream sediment per about 5 km^2, and the geochemical anomalous area has been discovered at several locations.

The detailed survey of copper and molybdenum mineralized zones at Gunung Ibu was conducted during the period of 1974 ∿ 1978 under technical cooperation rendered by the Government of Belgium for following up the above reconnaissance geochemical survey, and the current survey continued by the Directorate of Mineral Resources, the Republic of Indonesia, the survey including the detailed geological and geophysical surveys, drilling exploration and the alluvium placer gold prospecting is at present continuing over the geochemical anomalous areas and over the placer gold are at Sambas as well.

The area (1,500 km^2) subject to this project was planned, referring to the existing information of mineralized zones, especially the results of the above-mentioned geochemical and reconnaissance surveys.

PART Ⅱ

GEOLOGICAL SARVEY

CHAPTER 1 GENERAL GEOLOGY OF WEST KALIMANTAN

West Kalimantan, including the survey area of this project, is situated in the northeastern marginal part of Sundaland which forms the southern end of the Asian Continent, as shown in Fig. 2-1. West Kalimantan, including Malaysian Sarawak and southwest Kalimantan, can be geologically divided into the following three regions, as shown in Fig. 2-2.

(1) Central Kalimantan Area (Schwaner Mountain)

This region has become craton after sedimentations repeated during the period from Palaeozoic age to early Mesozoic (Triassic) age and receptions of orogenic movement incidental to the old granitic rock intrusions.

(2) Northern and Southern Side Region of Schwaner Mountain

The region where the thick sedimentary rocks of flysh type, the acidic and intermediate volcanic rocks and their pyroclastic rocks, extruded during the period from Late Triassic age to Jurassic age, have first extensively been distributed, and subsequently, upheaved and received the granitic intrusions during Cretaceous age. Especially, at the south side of Schwaner mountain, the acidic and intermediate volcanic group (Matan Complex by Dr. Bemmelen, 1939 & 1949) has extensively been distributed, being affected by the contact metamorphism (propylitization, sericitization, silicification, etc.) by the granitic batholithes intruded during Cretacous age. In the northern side of the Schwaner mountain, similar andesite, dacite and their pyroclastic rocks (Jirak and Belango Formations taken up in this survey) are extensively distributed and intruded by granitic rocks during the Cretaceous age.

Most of the granitic batholith in the northern area of the Schwaner mountain are tonalite and granodiorite of the calc-alkali rock series, but in the southern area granitic rocks of alkali rock

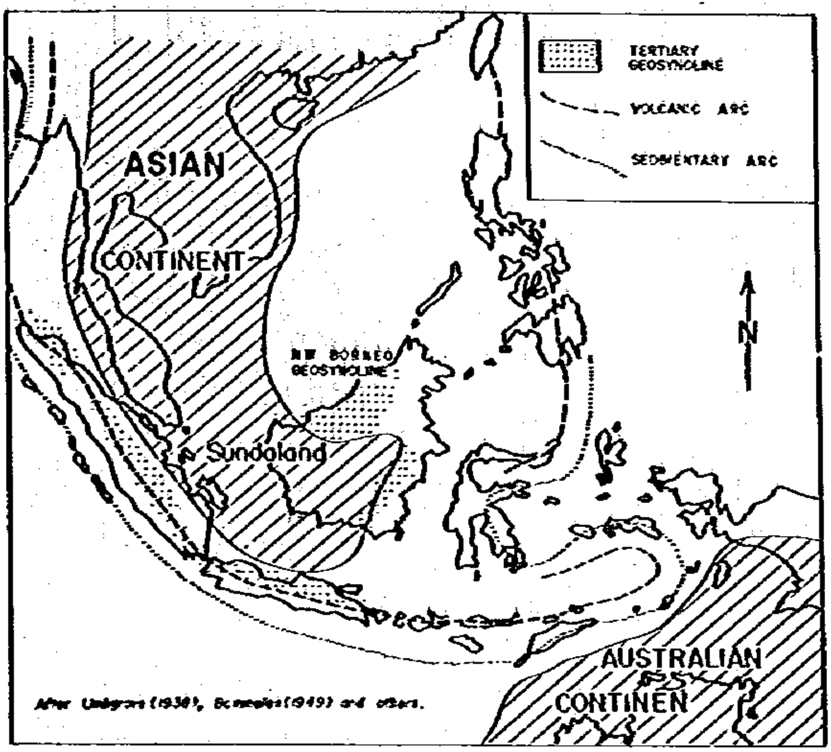


Fig. 2-1 Map of Sundaland

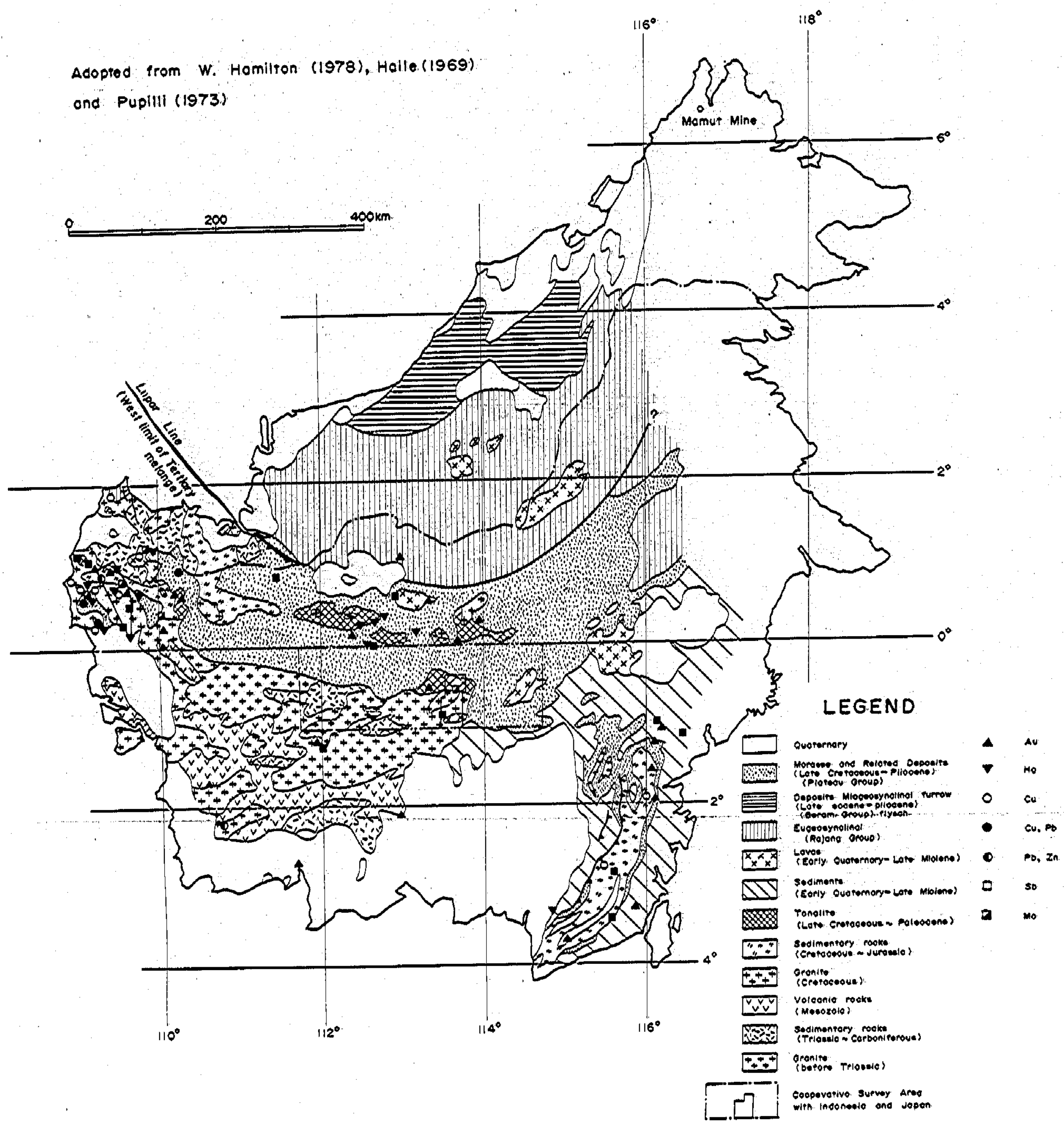


Fig. 2-2 Geological and Metallic Mineral Distribution Map of Kalimantan

series consisting of monzonite or sometimes riebeckite granite are observable (A. Sudradjat 1975, BATAN, 1975). Hamilton (1978) points out possibility that such a distribution of granitic rocks of the calc-alkali and alkaline rock serieses would be caused by subduction of plate from the north.

At the north side of Schwaner mountain, the recent survey has revealed that many granitic rocks and dacite have been intruded by the igneous activities during the period from Late Cretaceous age to Early Miocene age.

Further, the Plateau Group are extensively distributed, centering at the upperstream of S. Kapuas and consisting of the molasse sediments brought from the northwest Borneo geosyncline during the period from late Cretaceous age to middle Miocene age.

(3) Malaysian Sarawak Area

At north of Lupar Chert-Ophiolite zone, extending over 250 km along the boundary between Kalimantan of Indonesia and Malaysian Borneo, thick geocynclinal sedimentary strata have been deposited, such as Rajang Group consisting of abyssal argillaceous rock, greywacke, radiorarian chert and Baram Group consisting of sandstone, shale and limestone, with both Groups resulting by the Northwest Borneo Geosynclinal movement during the late Cretaceous through Tertiary (Haile 1969). The Rajang Group is accompanied with ophiolite, radiralian chert and limestone, and folding and imbricate structure are recognized in the Group. Hamilton (1978) regards the Group as "mélange".

With the geological characteristics as above, the Sundaland in Kalimantan area centered at the area having the palaeozoic metamorphic rocks and gneissose granitic rocks in the Central Kalimantan, Schwaner mountain, is cored with a cratonized stable continent under the igneous activities during the period from Carboniferous age to Triassic age. It is, subsequently, thought that it has grown southeastward and northward by the stepped land additions during Mesozoic age, being followed from the above. Further, the granodiorite batholithes have intruded during middle Cretacous age.

Both Rajang and Baram groups have been deposited through the northwest Borneo geosynclinal movement over an extensive area at the east and north sides (chiefly at Malaysian Sarawak) of Sundaland, which is bordered from Sundaland by Lupar Chert-Ophiolite zone.

From the plate techtonics points of view, this Lupar Chert-Ophiolite line, as well as Rajang Group thought as a mélange, is considered to indicate a zone where the oceanic plate of south China sea had subducted south-westward under the continental plate of Kalimantan during the period of northwest Borneo geosynclinal movement. (Katili, 1973 ∿ 1981; Hamilton, 1978; Hatchioson, 1973 ∿ 1975; and Haile, 1973).

As West Sarawak and West Kalimantan at the south side of Lupar-Ophiolite zone, i.e. the north and east side of Sundaland, the acidic and intermediate calc-alkalic volcanic rocks extruded and plutonic rocks intruded during the period from end of Cretaceous age to Miocene age have been confirmed through the absolute age dating and the geological survey recently conducted in collaboration between governments of the Republic of Indonesia and Japan. Namely, Raea diorite (Central Kalimantan to upperstream of S. Kahayan, JICA-MMAJ-GSI, 1978), Sirih and Banyi tonalites, Serantak dacites (Bengkayang-Lumar area, West Kalimantan, JICA-MMAJ-DMR, 1979), etc. are well known, and many can be exampled that their younger igneous activities have accompanied the mineralizations of Au, Cu, Mo and so on.

Viewing the geological structures in West Kalimantan from the plate tectonics points of view, there is a very high potential where the younger igneous rocks can be distributed into other areas. For the metallic mineral exploration, some mineralizations of Cu, Mo. Au, Sb, Hg, Pb and Zn extensively distributed in the area of West Kalimantan are inferred to relate to the younger igneous activites during the period from Early Tertiary age to Miocene age.

CHAPTER 2 GEOLOGY IN THE PROJECT AREA

2-1 Outline

Stratigraphy and igneous rocks in the project area have been clearly divided into sedimentary rocks (Bengkayang Group) of upper Triassic to lower Jurassic age, volcanic and pyroclastic rocks (Jirak and Belango Formations) of Jurassic age, Cretaceous granitic rock batholith, Paleogene volcanic and pyroclastics (Serantak Formation), Tertiary granitic rock intrusions and Quaternary, as a result of new discovery of ammonite fossils correlative with lower Jurassic and absolute age determination of igneous rocks by K-Ar method during the survey, as shown in Fig. 2-3, 2-4, 2-5, 2-6.

Namely, the Bengkayang Group had been correlated with the upper Triassic by previous survey of Wing Easton and at el, but it have been correlative with the upper Triassic to Lower Jurassic since ammonite fossils indicating the lower Jurassic were found from top horizon of the Group. Granitic rocks are classified into old granitic rocks dated from 124 m.y. to 95 m.y., and dacite intruded in the Paleogene is dated as 51 m.y. by K-Ar absolute age determination. Volcanic and their pyroclastic rocks that are extensively distributed in the project area can be correlated with Jurassic, since these rocks unconformably overlie Bengkayang Group, and have been intruded by Cretaceous granitic rocks (G. Sebiawak and G. Raya Granitic rocks).

The names of Formations and rocks used in this report are newly given according to the names of the place, mountain or river where these Formations and rocks are extensively distributed.

2-2 Sedimentary Rocks

2-2-1 Bengkayang Group

Bengkayang Group are distributed at the north part of the project area, and thick stratum consisting of sandstone, mudstone and siltstone. The Group is divided into the following formation from upper Formation to lower;

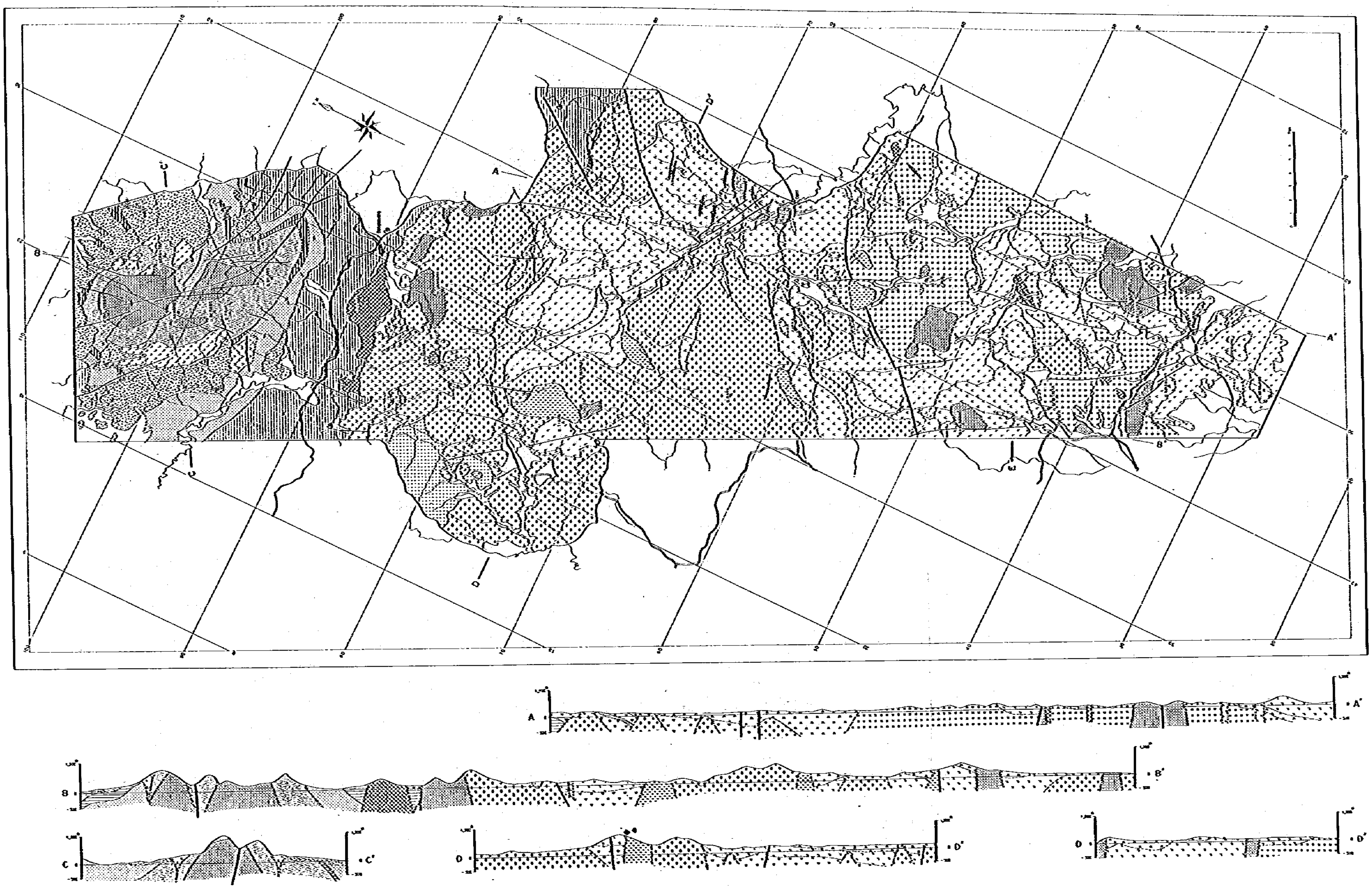


Fig. 2-3 Geological Map of the Project Area

LEGEND

Quaternary
- Gravel, Sand

Tertiary

Serantak Formation
- Dacitic pyroclastic rocks
- Serantak Dacite

- Quartz porphyry 2
- Granodiorite 4
- Sirih, Banyi Tonalite
- G.Panandan Quartz gabbro, Dolerite

Cretaceous
- Tiang Quartz Diorite
- G.Selantar Granodiorite
- G.Raya Granodiorite
- G.Sebiawak Granodiorite

Triassic ~ Jurassic

Belango Formation
- Red Mudstone
- Andesitic rocks (Andesite lava, Andestic tuff and tuff breccia)
- Dacitic rocks (Dacite, Dacitic tuff)

Jirak Formation
- Red Mudstone
- Andestic tuff and Tuff breccia
- Andesite lava

Bengkayang Group
- Sungaibetung Formation
- Riampelaya Formation
- Kalung Formation
- Banan Formation

- Fault
- Anticlinal axis
- Synclinal axis

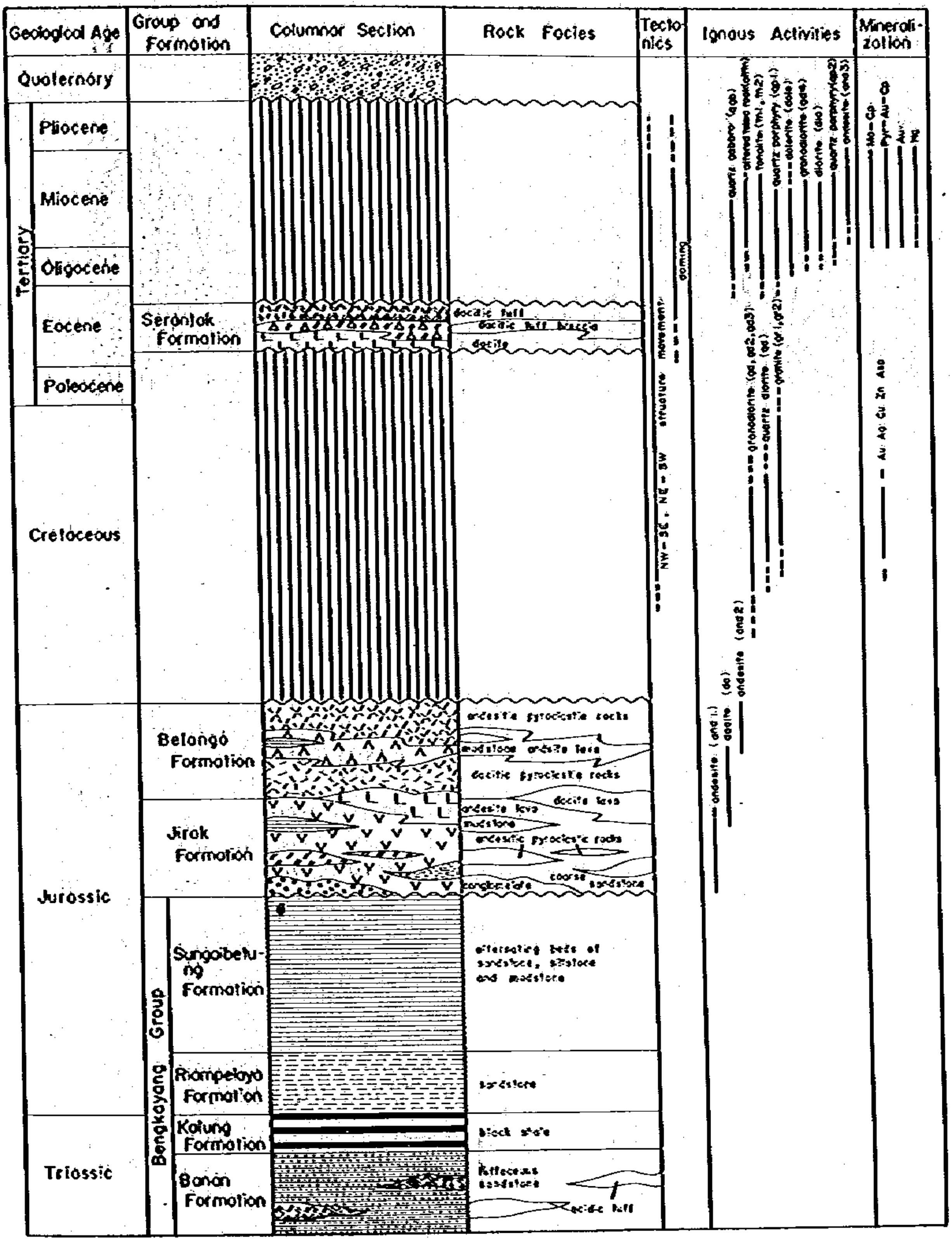
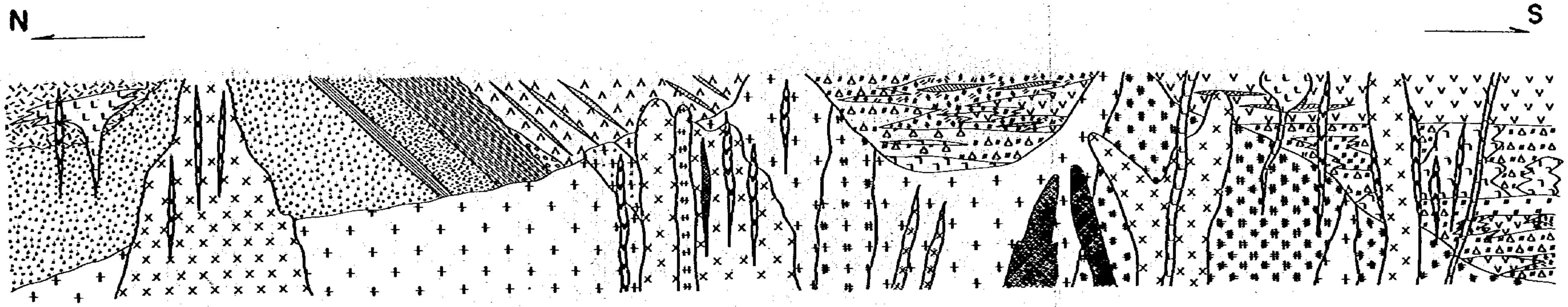


Fig. 2-4 Generalized Stratigraph of Survey Area



- Selantak Formation
- Belongo Formation (andesitic lava and pyroclastics)
- Belongo Formation (Dacitic lava and pyroclastics)
- Jirak Formation
- Bengkayang Group:
  - Sungaibelung F.
  - Rianpelaya F.
  - Kalung F.
- Banan F.

- Andesite Dyke
- Quartz Porphyry
- Diorite Dyke
- Younger Granodiorie
- Dolerite Dyke
- Sirih, Banyi Tonolite
- Padan Quatz Gabbro
- Granite I. 2.
- Tiang Quartz Diorite
- Raya Gd.
- Sebiawak Gd.
- Selantar Gd.

Fig. 2-5 Schematic Geological Profile

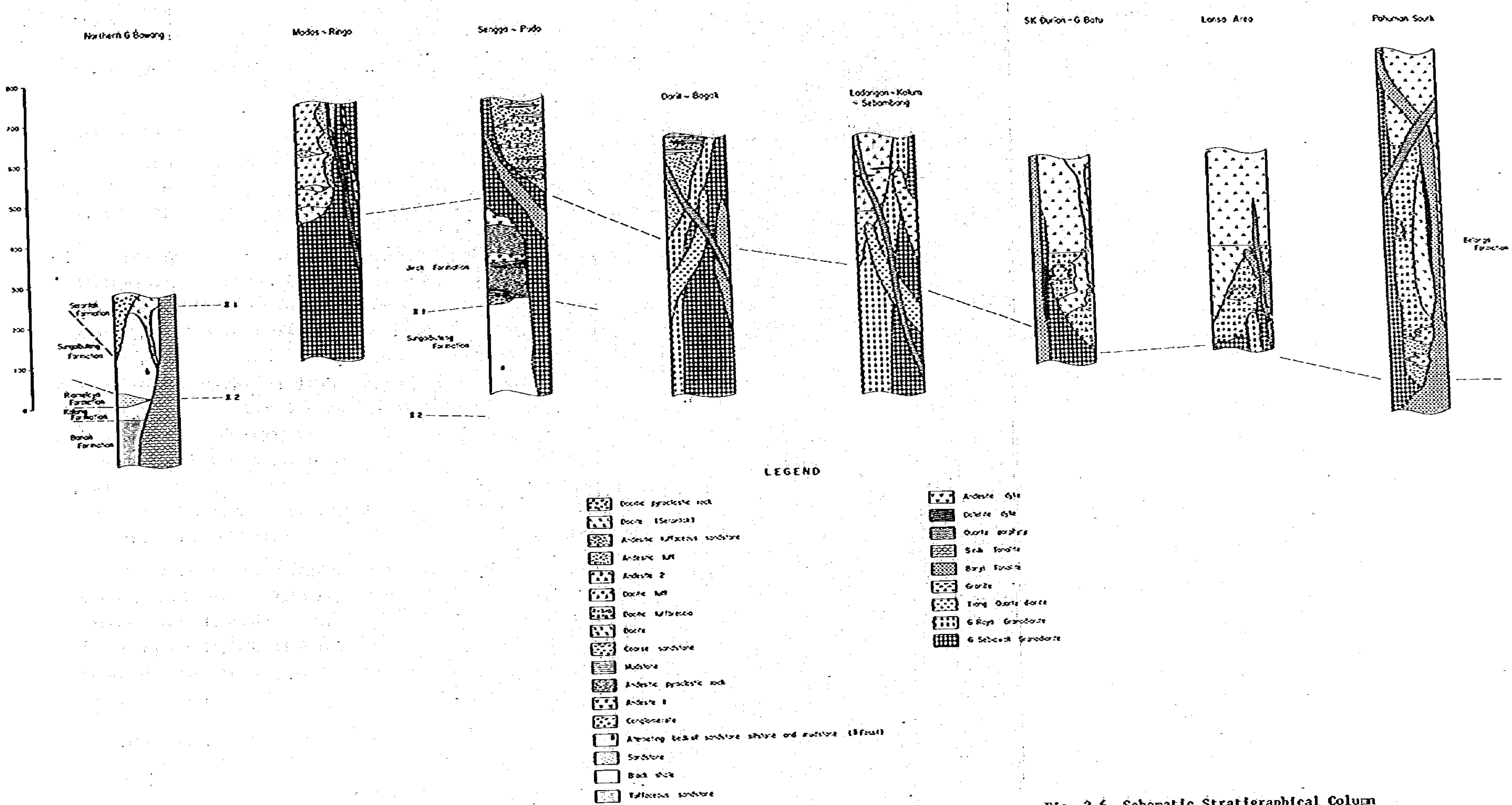


Fig. 2-6 Schematic Stratigraphical Column

Upper	Sungaibetung Formation	:	alternated beds of sandstone, mudstone and siltstone
	Riampelaya Formation	:	sandstone
	Kalung Formation	:	black sandstone, shale
Lower	Banan Formation	:	tuffaceous sandstone, fine acidic tuff

(1) Banan Formation

Distribution: This Formation is distributed mainly in area of the G. Buwah Obah, G. Bawang and G. Mahamnd mountains. The type locality is at S. Banan and S. Sirih.

Rock facies: The Formation consists of hard medium-grained (tuffaceous) sandstone, intercalating with fine acidic tuff and black sandstone. Fine tuff is continuously distributed and traceable. Tuffaceous sandstone consists of fragments of dacite, andsite, chert, mudstone and fragments of plagioclase and quartz in siliceous matrix. Epidote, chlorite and some biotite are contained as altered mineral showing hornfels alteration caused by intrusion of Sirih tonalite. The grey fine-grained tuff is accompanied with quartz particles and resembles rhyolite in appearance, but under a microscopic observation it mainly consists of fine-grained quartz and plagiodase fragments, smaller than 0.3 mm, contained some epidote.

According to the record of survey in the past, the acidic volcanic rocks of the Triassic system in the west Kalimantan and Sarawak areas is characteristics of Keratophyre, but after analysing chemically the fine tuff (80RG-200) sampled at east side of G. Serantak, it was found not containing much sodium to be regarded as Keratophyre.

Thickness: 1,500 m or more

Stratigraphic correlation: According to the existing data and information (Dr. Wing Easton, 1904 and Dr. Zeylmans Van Emmichoven, 1938) about West and Southwest Kalimantan, this Formation is classified into the Upper Triassic series, being known to accompany the acidic and intermediate volcanic rock complex (Matan complex determined by Dr. Bemmenlen, 1948, called Serian Formation under the stratigraphic correlation table of Pupilli, 1973).

This tuffaceous sandstone Formation was determined of the Upper Triassic series, referring above information.

(2) Kalung Formation

Distribution: The type locality is situated at the upstream of S. Raya from the Kalung village, and the Kalung Formation is distributed overlieing conformably the Banan Formation surrounding the mountain area of G. Bawang and B. Mahmud.

Rock facies: This rock is a dark black hard fine grained sandstone and shale, having an evidently graded bedding. According to the microscopic observations, these rocks consist of quartz, feldspar, calsite, silicate minerals, and some hornblende, showing slight holnfels.

Stratigraphic correlation: The Kalung Formation conformably overlies the Banan Formation and is also conformably overlain by the Riampelaya sandstone Formation. However, the Riampelaya Formation is thinned out at east of G. Serantak, and the Formation is overlain directly by the Sungaibetung Formation.

Thickness: 100 to 150 m at the thickest part, but in some places the Formation becomes very thin.

(3) Riampelaya Formation

Distribution: Its type locality is situated at the upstream of S. Raya and S. Selayu, and the Formation overlies the Kalung

Formation conformably. This Formation is unconformably overlain by the Tertiary Serantak dacitic pyroclastic rocks at S. Ledo and S. Sansak, north of G. Buwah Obah.

Rock facies: The Riampelaya Formation consists of light grey medium to coarse grained sandstone and conglomerate containing pebble of black shale is deposited on the Kalung Formation at upperstream of S. Kalung and S. Semade. Under a microscopic observation, the rock is slightly tuffaceous sandstone accompanied by sands of andesite and dacite.

Thickness: 300 to 0 m.

(4) Sungaibetung Formation

Distribution: Its type locality is on the road between Bengkayang to Lumar and area of the Bengkayang and Sungaibetung areas. The Formation is also distributed in the plain area of S. Taban and S. Mayun in southeast of Bengkayang.

Rock facies: This Formation is flysh type sedimentary rocks, consisting of alteranted beds of fine grained sandstone, black or gray mudstone and siltstone. It shows a clear bedding and increases mudstone upward. At S. Taban and S. Mayun, the Formation intercalates fine tuffaceous sandstone in its most upper horizon.

Fossil: Ammonite fossils were discovered during this survey from the mudstone of middle to upper horizone in the Sungaibetung Formation. The fossils were discovered in the following four places and appraisable fossils were found at the first two places:

Kampung Marikar	1.5 m to the west (Specimen No. 79 RD-7, 79 RL-2)
Bengkayang	0.5 km to the east (Specimen No. 79RD-54)

North of Lumar

Confluent of S. Taban and S. Mayun

These fossils is not under good preservation condition and coeffective identification is not obtainable, but Dr. Hirano, assistant professor of Waseda University, identified and reports as follows (H. Hirano, S. Ichihara, et al, 1981) (Photo -1):

Specimen No. 79 RD-54

Harpoceras (s. str.) sp.

Material: An internal mould and external cast of a quarter whorl

Diagnosis: Strong curvature of ribs at the inner one third of the flanks.

Comparison: Similar to *Harpoceras capellinii FUCINI* (Fucini, 1904) found in Italy, *Harpoceras mulgravium* YOUNG & BIRD (Buckman, 1909) found in England, *Harpoceras falcicostatum* FUCINI (Fucini, 1904) found in Italy, and *Graphoceras* found in England and south France. The preservation condition is not good and at present there are only two specimens and the name was given as *Harpoceras* (s. str.) sp.

Specimen No. RD-7 Rℓ-2

Dactylioceras (orthodactylites) sp.

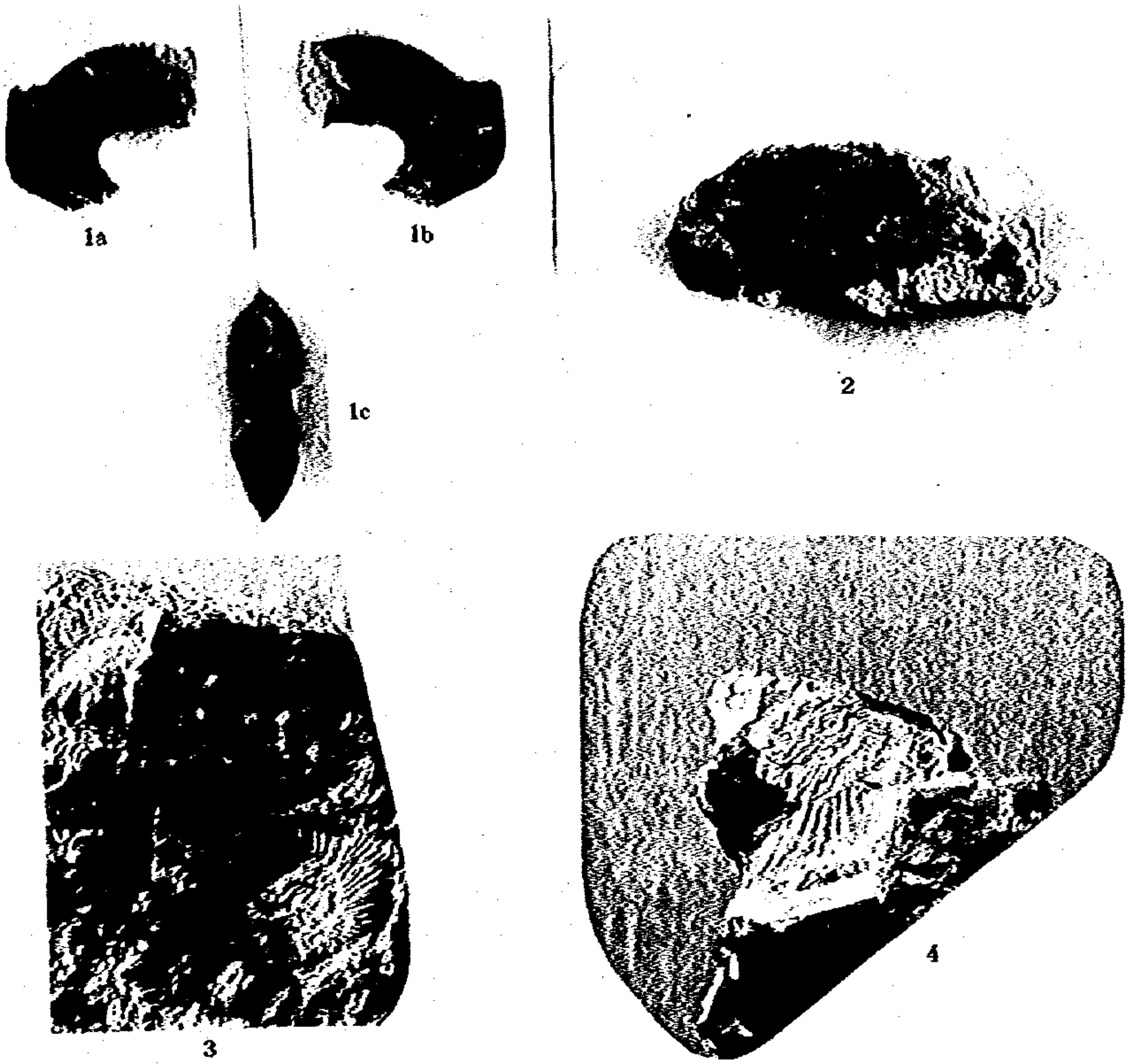
Material: Unfavourable preserved five specimens.

Diagnosis: Mostly simple, fine and somewhat prorsiradiate ribs, and moderate to involute volution.

Comparison: Similar to *Dactylioceras (orthodactylites) semicelatoides* MUABENGE (Muabenge, 1957) found in south France and *Dactylioceras (orthodactylites) tenuicostatum* (YOUNG & BIRD) (Schmidt-Effing, 1972) found in Spain.

Age: The Jurassic Lias Toarcian stage

In West Kalimantan, there is a record of Krans (1896) discovering *Harpoceras radians* REINECKE in the north of G. Bawang, but exact location of the discovery is not certain. Our discovery is the first case of having the exact discovery position data.



1a-c *Harpoceras* (s. str.) sp.

Location: An exposure of 0.5 km eastward from Bengkayang West Kalimantan

Horizon : An upper part of the Sungai-betung Formation of the Bengkayang Group

a. A left flank; b. A right flank; c. A venter

2-4 *Dactylioceras (orthdactylites)* sp.

Location: An exposure of 1.5 km westward of Kampung Marikar West Kalimantan

Horizon : upper part of the Sungai-betung Formation of the Bengkayang Group

2. A right flank; 3. A right flank; 4. An external cast of the left flank

(H. Hirano, S. Ichihara at el (1981) Lower Jurassic Ammonite from West Kalimantan Province, Republic of Indonesia Bulletin of the Geological Research and Development Center Indonesia No.4 March)

Photo-1 Photographs of Ammonite Fossil

Up to present, fossils have been found only in the two types of *Harpoceras* (s, sr) sp. and *Dactylioceras Corthodactylites* sp., both of which indicate the lower Jurassic (Lias Toarcian stage). They seem to belong to the Tethys system as the fossil fauna. The same ammonite fossils have been found in the Toyora Group in Yamaguchi Pref. of Japan and the discovery of the fossils in West Kalimantan is very significant as it connects the Tethys system sedimentry rock formations between the Mediterranean Sea area and Japan.

Stratigraphic correlation: The Sungaibetung Formation was determined to be the lower Jurassic because of the discovery of the ammonite fossils.

Thickness: 2,000 m or more.

2-3 Volcanic Rocks and Pyroclastic Rocks

Strata, consisting of andesite, dacite and their pyroclastic rocks, are extensively distributed from the central to southern project area. Since these Formations overlie unconformably the Sungaibetung Formation with thin basal conglomerate, and have been intruded by Cretaceous granitic rocks, they are correlative with Jurassic. These strata are divided into two Formations, depending upon their rock facies, namely lower stratum consisting of predominantly andesite and andesitic pyroclastic rocks and is called Jirak Formation, and upper stratum is dominant dacite and dacitic pyroclastic rocks and is named Belango Formation through the reconnaissance geological survey.

In the northern part of the survey area, around G. Serantak, G. Bawang and G. Buwah Obah, the dacitic pyroclastic rocks overlies unconformably the Bengkayang Group. Since the dacitic intrusive rocks, that are considered to be related with the dacitic pyroclastic rocks, was determined as 51 m.y. through K-Ar method, the Formation was correlated with early Tertiary pyroclastic rocks and named as the Serantak Formation.

2-3-1 Jurassic Volcanic Rocks and Pyroclastic Rocks

(1) Jirak Formation

Distribution: The Jirak Formation is distributed in the southern areas of Bengkyang to Sungaibetung, southeastern area of Bengkayang and western area of G. Tiang.

Rock facies: The Jirak Formation consists of andesite and andesitic pyroclastic rocks. A thin conglomerate stratum partly presents in the unconformable on the Sungaibetung Formation, indicating unconformity between the two series. Also, a thin bed of fine-grained red tuff containing hematite is intercalated in the southeastern area of Bengkayang.

The conglomerate is composed of pebbles of sandstone and shale of 2 to 5 mm diameter and the material of matrix is andesitic tuff. Andesite is compact massive rock and its phenocrystal plagioclase has been sericitized, and ground mas has also been altered to aggregation of chlorite, carbonate and iron oxide with plagioclase lath, quartz by chloritization, sericitization and carbonitization.

The andesitic pyroclastic rock consists of tuff, lapilli tuff and tufaceous sandstone. These rocks consist of andesite pebbles, plagioclase of having its part altered to epidote, mineral clasts of chlorite and others in matrix consisting of plagioclase, epidote, chlorite, quartz and iron mineral. Most rocks were intruded by the G. Raya granodiorite in the Cretaceous and were altered by the contact metamorphism.

Stratigraphic correlation: Jirak Formation overlies unconformably on Sungaibetung Formation, partly having a basal conglomerate beds. Also, at the west and south sides, this Formation has been intruded by G. Raya granodiorite during Middle Cretaceous age, thus being affected by contact metamorphism. With this, this Formation is correlative with the Upper Jurassic system.

(2) Belango Formation

Distribution: The Belango Formation is sporadically distributed in center to southern area of the project area as the roof pendant of the Cretaceous granitic rock batholith. The type locality is alongside the road between Bagak-Darit to Bengkayang and in the Pahuman area.

Rock facies: The Belango Formation consists of dacite, dacitic pyroclastic rocks, andesite, andesitic pyroclastic rocks.

The dacitic pyroclastic rock that occupies the major portion of the Belango Formation is a massive rock with no bedding, and the rock consists of dacitic and andesitic breccia, plagioclase, quartz and hornblende, fragments of aggregate epidote in matrix consisting of fine quartz, sericite and clay mineral. In some parts of the dacitic pyroclastic rocks where strong contact metamorphism has taken place by intrusion of granitic rocks, sericite (polytype $2M_1$) is found as altered mineral by argillization, and in some places where the dacitic rock contacted the G. Tiang quartz diorite, andalusite is found. There is a record of boulders of welded tuff in the Medan village.

The andesitic volcanic rock and its pyroclastic rock consist of andesite, andesitic tuff, tuff breccia, and thin stratum of reddish brown tuffaceous mudstone. The andesitic rocks are massive rocks of dark grey and they consists of phenocrysts of plagioclase, and colored mineral (maybe hornblende) that has been altered to chlorite, and matrix consisting of plagioclase laths, fine prismatic hornblende and iron mineral. The andesitic tuff consists of fragments of andesite and plagioclase, secondary sericite, chlorite, epidote and occasionally quartz. In the Panji area, where the survey was conducted in details, the rock is characterized quartz andesitic rock, containing many quartz in its matrix, not silicificated andesite.

In the Darit area, thin stratum of reddish tuffaceous mudstone containing hematite are intercatated, and is folded with the folding axis of S53E and plunge of 18°SE.

Stratigraphic correlation: G. Raya granodiorite has intruded into Jirak Formation and Belango Formation, and direct contact part between both Formations is not observable and not clarifying the relationship. However, the Belango Formation was determined to be an upper Formation in consideration of mutual positions of the two, strike and dip of the stratum, etc.

2-3-2 Tertiary Dacitic Pyroclastic Rocks

In the areas around G. Serantak, G. Bawang and G. Buwah Obah mountains, dacitic pyroclastic rocks are extensively distributed overlying the Bengkayang Formation unconformably, and it is named as the Serantak Formation.

Rock facies: The Serantak Formation consists of fine grained dacitic tuff, lapilli tuff and partially tuff breccia.

Also, there are crystal tuff in which quartz and plagioclase fragments are observable in the matrix consisting of fine-grained quartz and plagioclase, sericite and tuff breccia having dacitic breccia.

In the downstream of S. Holo and S. Bekuan, the fine-grained tuff is partially altered to white clay. The white clay was detected as halloysite or poor crystaline kaolinite through an X-ray analysis. The clay is product by weathering.

Stratigraphic correlation: Since the Serantak dacitic tuff unconformably overlies the Bengkayang Formation in S. Bejuan Besal and by referring to the results of the K-Ar age determination of the Serantak dacite, this Formation is correlated with the Tertiary Oligocene. However, a possibility is still remained that this Formation resulted from dacite volcanic activities in more younger period when younger volcanic activities are recognized at surrounding area, and this determination must be reviewed further while referencing to the geology of the northern area.

2-4 Quaternary Sediments

The Quaternary sediments consisting of unconsolidated sand and gravel are observable along the major rivers in the project area.

2-5 Intrusive Rocks

The G. Sebiawak granodiorite, G. Raya granodiorite and G. Selantar granodiorite which are the members of the Cretaceous intermediate - acidic plutonic batholith distributed extensively in Central - West Kalimantan are distributed in the center and south part of the project area. Stocks and dykes of granite and quartz diorite have successively intruded in the batholith. In north part and some south part of the project area, Tertiary igneous rocks, such as Sirih and Banyi tonalites, Pandan quartz gabbro, Serantak dacite, dolerite and andesite are distributed.

2-5-1 Cretaceous Granitic Rocks

(1) G. Sebiawak Granodiorite

Distribution: The Cretaceous granitic rocks are extensively distributed in the area from Darit to Pahuman, in the southern part of the project area. They have roof pendants of Belango Formation and have been intruded by the Banyi type tonalite.

Rock facies: The S. Sebiawak granodiorite has large crystals of quartz and plagioclase and is easily distinguishable from G. Raya granodiorite since the quartz is conspicuous for phenocryst under weathering. The rock has color index of 5∿10%, and coarce grained porphyritic texture, being near granitic rock facies.

The major components are quartz, plagioclase are maximum 3∿4 mm in size. The Sebiawak granodiorite is plotted in more granitic field than G. Raya granodiorite, resulting comparison of normative mineral calculated from chemical analysis. Sometimes, the Sebiawak granodiorite contains dioritic autolith.

In contrast with G. Raya granodiorite, the G. Sebiawak granodiorite is more porphyritic and has much roof pendant of Belango Formation. This fact infers that G. Sebiawak granodiorite is more shallow intrusion than G. Raya granodiorite.

Age of intrusion: Absolute age determination result by K-Ar method indicated that the G. Sebiawak granodiorite is 124 ± 8 m.y. and it has intruded during the early Cretaceous.

(2) G. Raya Granodiorite

Distribution: The G. Raya granodiorite is a batholithic granodiorite that is distributed extensively occupying the center part of the project area metamorphism to the Jirak and Belango Formations. Small stocks of the G. Raya granodiorite are sporadicaly distributed in the summit and around of G. Gamarabak in the G. Gamarabak mountain in the G. Sebiawak granodiorite.

Rock facies: The G. Raya granodiorite has medium grained equigranular texture and is composed of hornblende and biotite with color index range of 7 to 20%. The rock facies varies by the location, from the granodioric to tonalitic and sometimes to quartz dioritic characteristic.

Tonalitic parts of the G. Raya Granodiorite is distributed in the S. Empawang and S. Madas areas of the eastern and central parts to the Bangkek village area. The color index of this part is in the range of 15 to 20%, and the part has equigranular fine to medium grained texture, consisting of plagioclase, quartz, hornblende and small amount of biotite.

The granodiorite part has a medium grained equigranular, and the major components are plagioclase, quartz, hornblende and biotite, being accompanied with orthoclase. Dioritic rocks having a color index of 40%, which seems to be autolith, is distributed in a small scale.

Age of intrusion: The K-Ar absolute age determination indicates that the G. Raya granodiorite is 114 to 103 m.y., intruding during middle Cretaceous age.

(3) G. Selantar Granodiorite

Distribution: The G. Selantar granodiorite is distributed in the S. Sebumbung area, the western part of the survey area. It has intruded in the Jirak andesitic Formation and has been intruded by the quartz diorite and Serantak type dacitic rocks.

Rock facies: The G. Selantar granodiorite is a coarse grained porphyritic biotite hornblende granodiorite having the color index of 10% and less. It consists of large amount of Jirak andesite xenolith, and plagioclase and quartz occur as large porphyritic crystals. Through a microscope, phenocrysts consisting of plagioclase, quartz, hornblende and biotite of up to 3 mm in the size are observable in the groundmass consisting of plagioclase, quartz, hornblende and biotite of up to 0.3 mm.

Age of intrusion: Since the G. Selantar granodiorite was intruded by the Tiang type quartz diorite and Serantak type dacite, and has the Jirak andesitic xenolith, the G. Selantar granodiorite has intruded during the Cretaceous, the same stage of the G. Raya granodiorite intrusion.

(4) Tiang Quartz Diorite

Distribution: The type locality of Tiang quartz diorite is G. Tiang, and it is distributed in many place, namely Kelampe, Kulumi, Tembawang Bordong, and Bayu, as small intrusive stock.

Rock facies: The Tiang quartz driorite is hornblende quartz diorite having the color index of 20 to 30% and dark grey, fine to medium grained holocrystalline texture. The main components are plagioclase, quartz and hornblende, and some of the Tiang quartz diorite contain common augite and orthopyroxene.

Age of intrusion: The Tiang quartz diorite has intruded into the G. Raya granodiorite and G. Sebiawak granodiorite. Its age, 98.6 ∿ 95 m.y., was determined through the K-Ar method.

(5) Granite

Granite has intruded into the G. Raya granodiorite and G. Sebiawak granodiorite as the dike, but the contacting part has not been confirmed yet. The granite is a pinkish leucoratic biotite granite and is regarded to be the youngest intrusive rock among the Cretaceous intrutions.

2-5-2 Tertiary Intrusive Rock

(1) Pandan Quartz Gabbro

Distribution: The Pandan quartz gabbro is distributed in G. Pandan, northwest of Bengkayang, and also in G. Kelan as small stock.

Rock facies: The Pandan quartz gabbro is dark green with color index of 50% or more and has a coarse grained holocrystalline to porphyritic texture. The major components are plagioclase, hornblend, quartz and common augite, in the order of the quantity accompanied by small amount of orthopyroxene.

Age of intrusion: The Pandan quartz gabbro has intruded into the contact zone between Sungaibetung Formation, Jirak Formation and G. Raya granodiorite. Since doleritic basic rock dykes have intruded into the G. Raya granodiorite and G. Sebiawak granodiorite, and the quartz gabbro has a porphyric texture partially, the quartz gabbro can be considered as a hypabyssal intrusive rock, and was determined to be a younger intrusive rock.

(2) Tonalite

Distribution: The type locality is distributed in the G. Buwah Obah - G. Bawang - G. Mahmud mountain areas for the Sirih tonalite and that for the Banyi tonalite in the S. Banyi area. Several small stocks, similar to Banyi tonalite have intruded at Pahuman area, locating at southern part of the project area.

Rock facies: The tonalite has medium grained holocrystalline texture with the color index of about 10%. The major components are of plagioclase, quartz, biotite, and hornblende and a small amount of orthoclase. Some of the biotite have altered to chlorite, epidote or carbonate. Chalcopyrite-molibdenite quartz veins and pyrite disseminations with sericite alteration are embedded in the tonalite.

Age of intrustion: The tonalite has intruded into the Bengkayang Formation and the Cretaceous granitic rocks. K-Ar age determination on Sirih tonalite and Banyi tonalite indicated 20 m.y. and 27 m.y. respectively, showing Tertiary Oligocene to early Miocene.

(3) Serartak Dacite

Its type locality is distributed in the east side of G. Serantak and phenocrysts of plagioclase and quartz are very prominent. Under microscopic observation Phenocrysts of quartz, plagioclase and of small amount of biotite are in the groundmass which consists of fine-grained quartz, biotite and chlorite. Dikes and stocks having the phenocrysts of plagioclase and quartz are recognized in many places of the survey area, and their rock facies are quite similar, thus regarded Serantak type dacite. Its age was determined 51 m.y. by the K-Ar method in the S. Banan area, and also Serantak dacite has been intruded by the Sirih tonalite.

2-6 Geological Structure

The Cretaceous granitic rocks in the project area is distributed, being controlled by the general direction of WNW-ESE of the Cretaceous Magmatic Arc (Katili 1973) which connects the south part of Indochina Peninsula to West-Central Kalimantan through the Natuna and Andaman Islands. However, sedimentary rock area, distributing Bengkayang Group of upper Triassic to lower Jurassic series, in the northern part of the project area and Cretaceous batholith area (G. Sebiawak and G. Raya granitic rocks) in the Central to south project area have different structural geological characteristics, depending on geological situation (Fig. 2-7).

2-6-1 Northern Sedimentary Rock Area

In the northern sedimentary rock area, the Bengkayang Group forms a domed anticlinal structure with an axis of anticline of N30°W, centerring in the Sirih tonalite, caused by the intrution movement during the middle Tertiary, and faults, andesite dykas and molybdenite quartz veins or small foldings in the area and adjacent area of Sirih tonalite are in the harmonious direction of N30°W to the anticlinal structure.

At places away from the Sirih tonalite, the synclinal and anticlinal structures of the N60° ∿ 90°E axis exist in the Sungaibetung Formation of the Bengkayang Group, observed on the road from Bengkayang to Lumar. This synclinal and anticlinal structures are regarded as the older folding formed before intrusion of Sirih tonalite.

2-6-2 Granodiorite Batholith Area in Central to Southern Part

The E-W folding and fault in Belango Formation existing in the vicinity of Darit are old structure, same as the N60° ∿ 90°E fold structure in the Bengkayang Group. They run in the same direction as the general intrusion direction of the Cretaceous granodiorite (G. Sebiawak and G. Raya granodiorite) and are regarded to be the results of the older batholith intrusion.

The younger tonalite (Banyi tonalite and others) intruding in the granitic batholith are distributed as stocks in the Banyi (south of Bengkayang) and Senakin-Pahuman areas. The younger tonalite in the Banyi area has intruded in the contact part of the Jirak Formation-Bengkayang Group and the G. Raya granodiorite batholith, assuming tectonic line of N60°∿90°E strike in this contact part.

Several Banyi type tonalite stocks have intruded into the G. Sebiawak granodiorite in Senakin-Pahuman area. A fault of the N30°E strike runs in this area, same as the northern sedimentary rock area, so that it is regarded that the intrusion of the younger granitic rocks is subjected to the structure.

There is a fault zone striking N60°E cut by the above mentioned younger fault of N30°W system in the adjacent of the contact line of the G. Sebiawak granodiorite and G. Raya granodiorite in south of Darit. These faults surround the G. Raya granodiorite together with the infered tectonic line that controlled intrusion of the younger intrusive rocks in south of Bengkayang and the N60°E strike fault in south of Darit, and these faults are regarded as an old tectonic lines formed by block movement of the G. Raya granodiorite. There are not many roof pendants of the Jirak and Belango Formations in the western area where the G. Raya granodiorite is distributed and mineralization is also scarce in this area. This fact suggests that G. Raya granodiorite had been lifted by block movement, eroded and has exposed its deep part, resulting in poor mineralization.

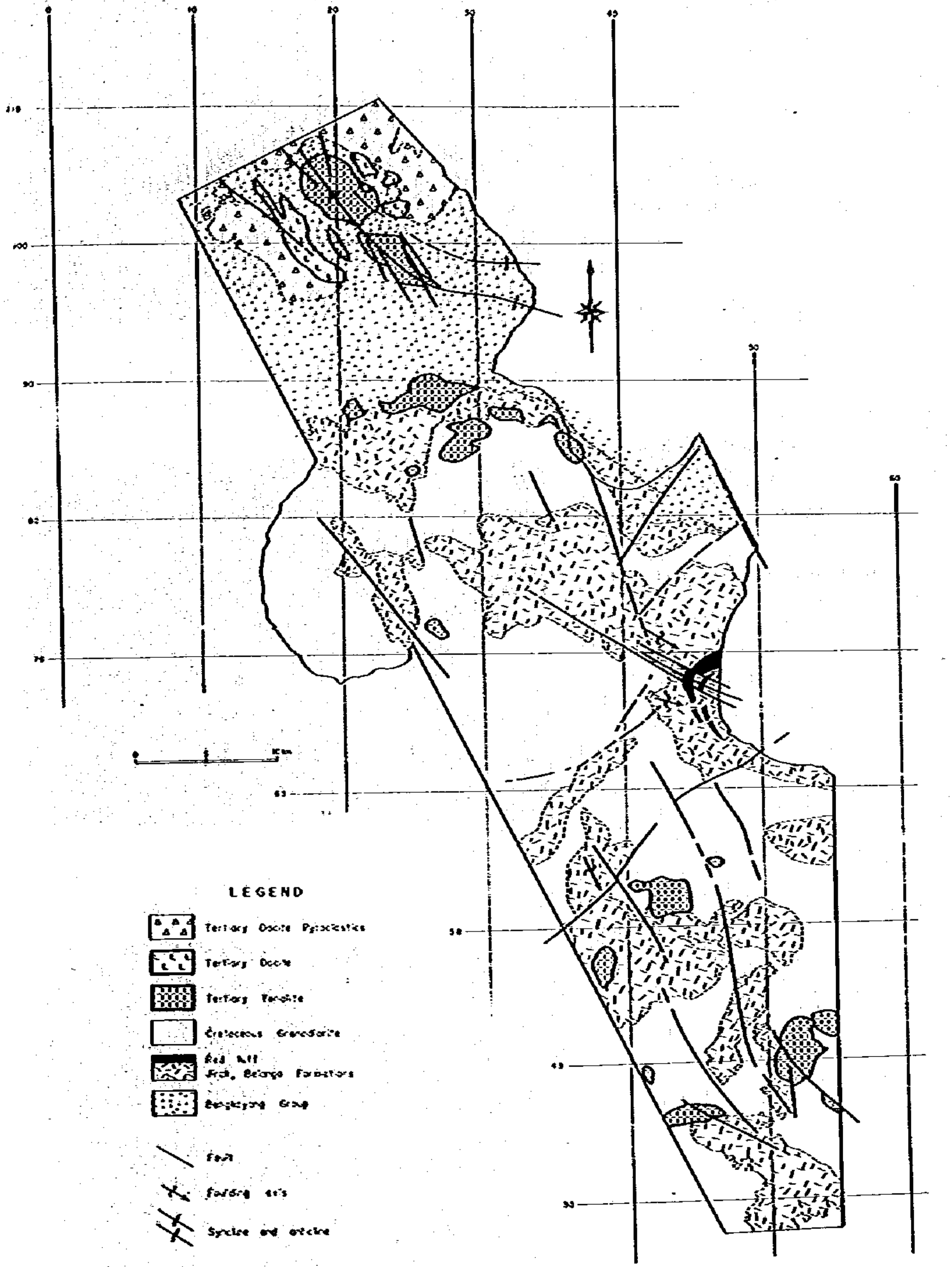
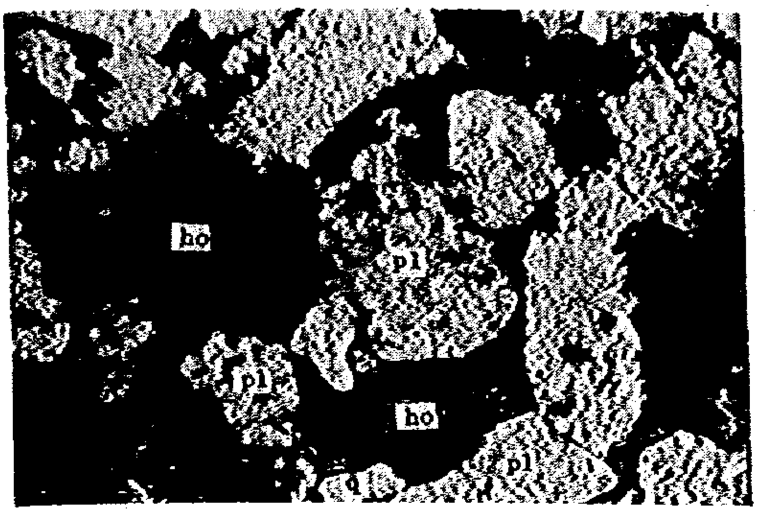


Fig. 2-7 Geological Structure Map in the Project Area



Sample No.: 79RB-1

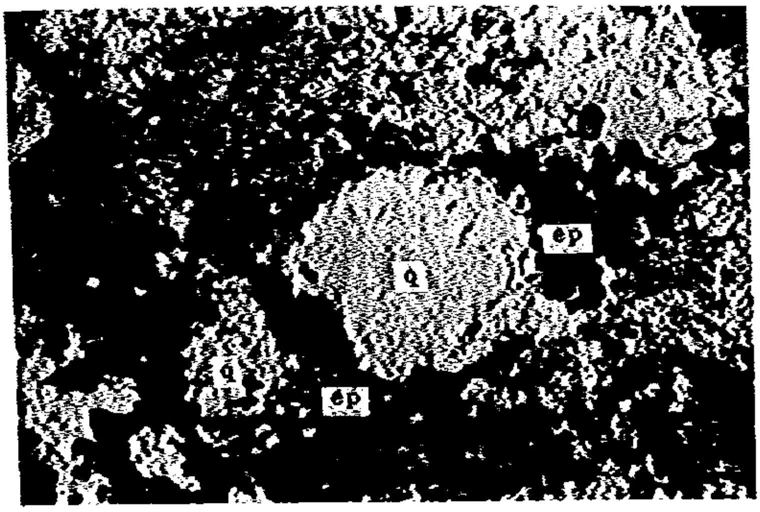
Locality : S.Ledo

Rock Name : Tuffaceous sandstone

Formation : Banan Formation

qt : quartz
pl : plagioclase
ho : Hornblende

0 0.5 mm



Sample No.: 79RB-19

Locality : S.Ledo

Rock Name : Fine tuff

Formation : Banan Formation

q : quartz
r.f.: rock fragment (andesite)
ep : epidote

0 0.5 mm

Sample No.: 79RB-62

Locality : S.Raya

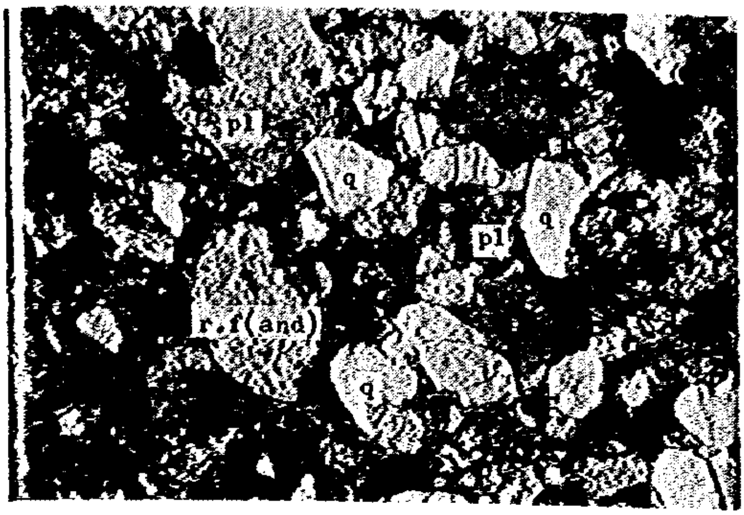
Rock Name : Fine Sandstone

Formation : Kalung Formation

quartz, clay, Fe mineral

0 0.5 mm

Photo-2 Microphotographs of Thin Section



Sample No.: 79RB-60

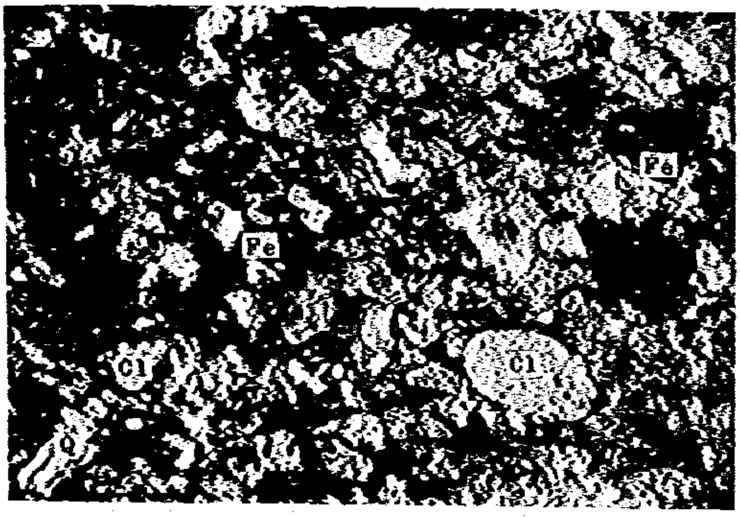
Locality : S.Raya

Rock Name : Sandstone

Formation : Riampelaya Formation

q : quartz
pl : Plagioclase
r.f.: rock fragment
and : andesite fragment

0 0.5 mm



Sample No.: 80RB-60

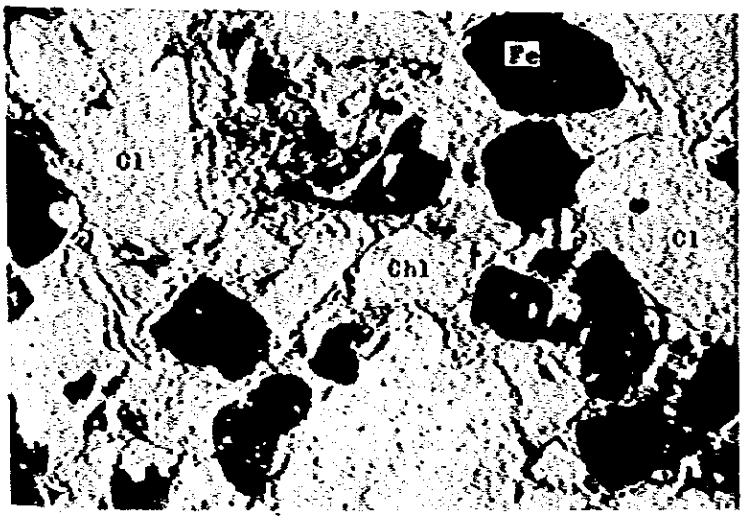
Locality : S.Sibat

Rock Name : Sandstone

Formation : Sungaibetung Formation

Q : quartz
Fe : iron mineral
Cl : clay

0 0.5 mm



Sample No.: 80RB-92

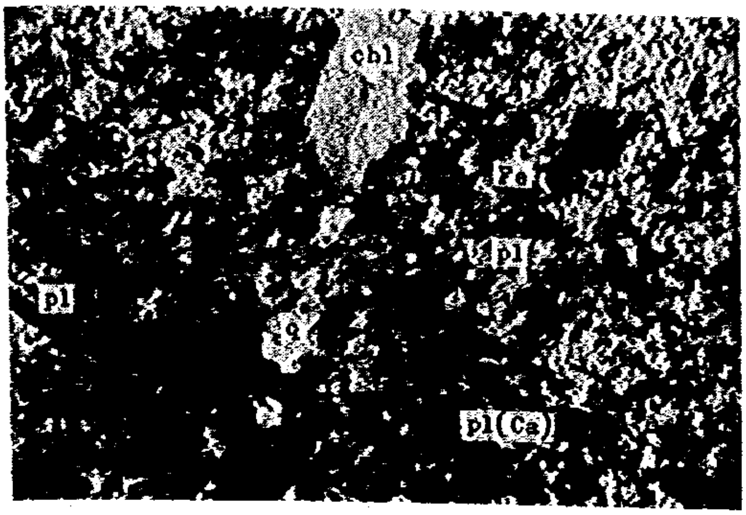
Locality : S.Tithtaring

Rock Name : Conglomerate

Formation : Jirak Formation

Fe : iron mineral
Chl : chlorite
Cl : clay mineral

0 0.5 mm



Sample No.: 79RD-11

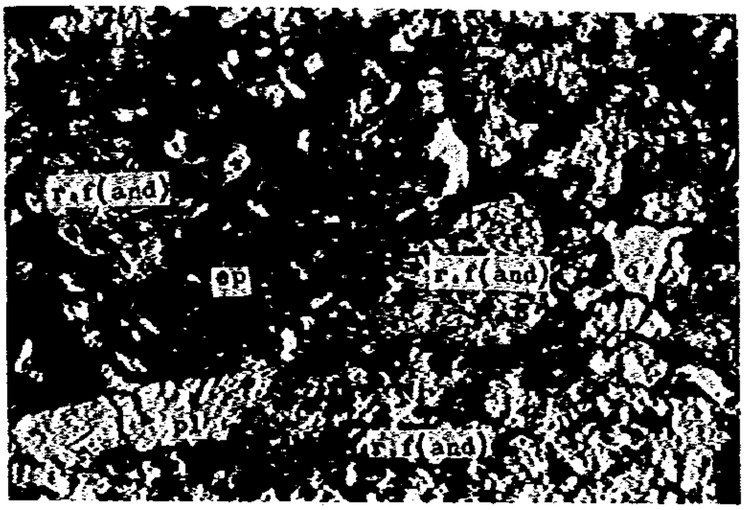
Location : S.Moroi

Rock Name : Andesite

Formation : Jirak Formation

q : quartz
pl : plagioclase
chl : chlorite
Fe : iron mineral
ca : calcite

0 0.5 mm



Sample No.: 79RD-23

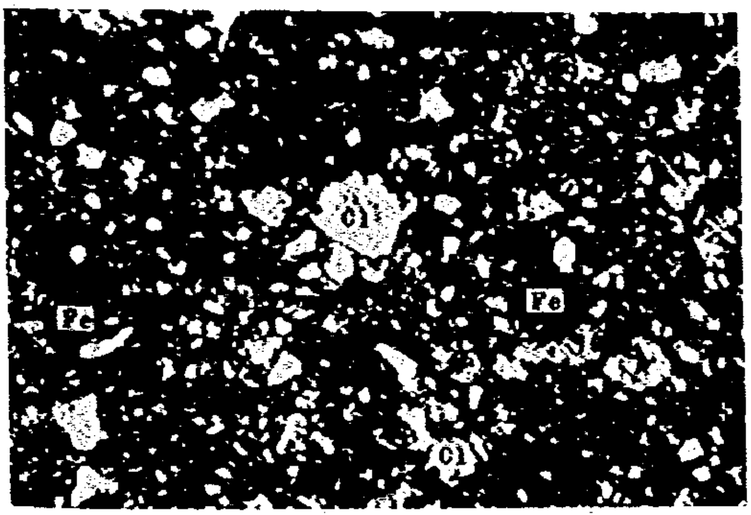
Location : S.sebalau

Rock Name : Andesitic tuff

Formation : Jirak Formation

q : quartz
pl : plagioclase
ep : epidote
r.f.: rock fragment
(andesite)

0 0.5 mm



Sample No.: 80RB-93

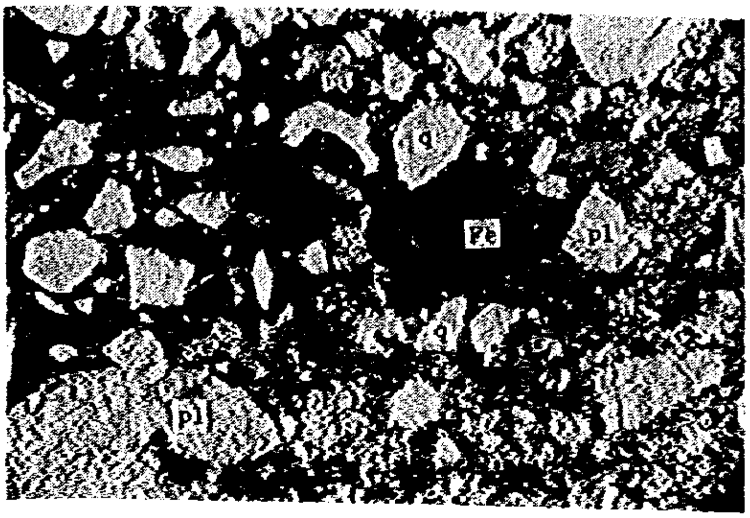
Location : S.Tithtaring

Rock Name : red tuffaceous
rock

Formation : Jirak Formation

Cl : clay
Fe : iron mineral

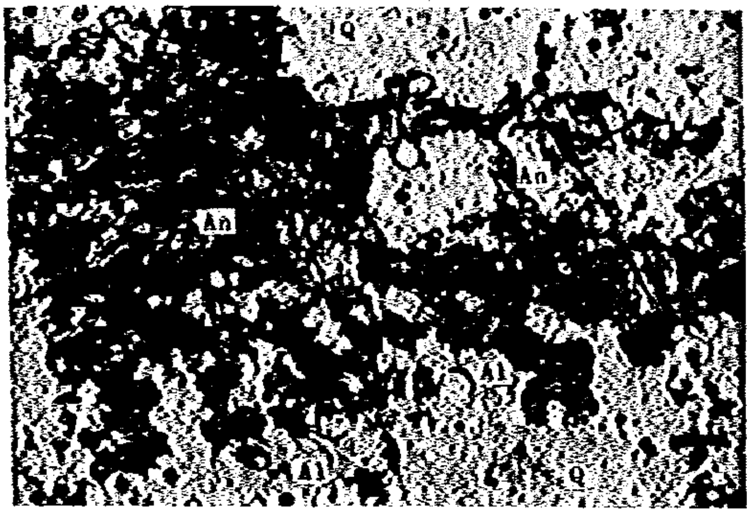
0 0.5 mm



Sample No.: 79RF-8
Locality : S.Kersik
Rock Name : Dacitic crystal tuff
Formation : Belango Formation

q : quartz
pl : plagioclase
Fe : iron mineral

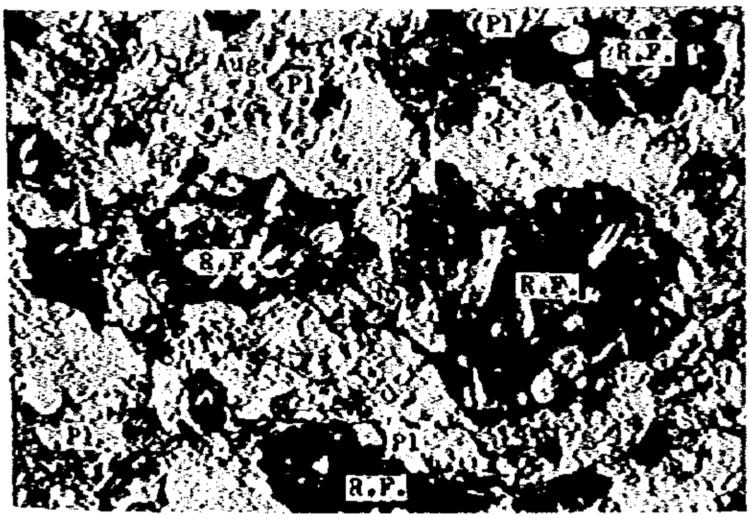
0 ____ 0.5 mm



Sample No.: 80RA-200
Location : Bt Tiang
Rock Name : Dacitic tuff
Formation : Belango Formation

Q : quartz
An : andalusite
Al : alunite

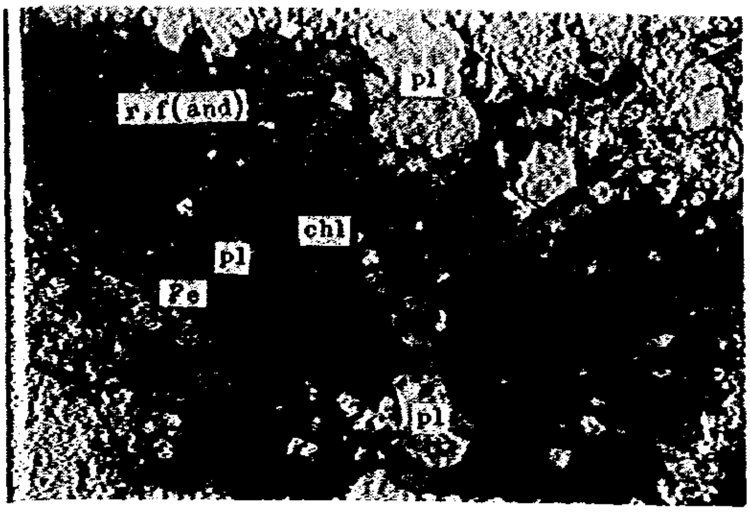
0 ____ 0.5 mm



Sample No.: 80RB-64
Locality : S.Lelandang
Rock Name : Andesitic tuff
Formation : Belango Formation

Pl : plagioclase
Aug : augite
R.F.: rock fragment

0 ____ 0.5 mm



Sample No.: 79RA-33

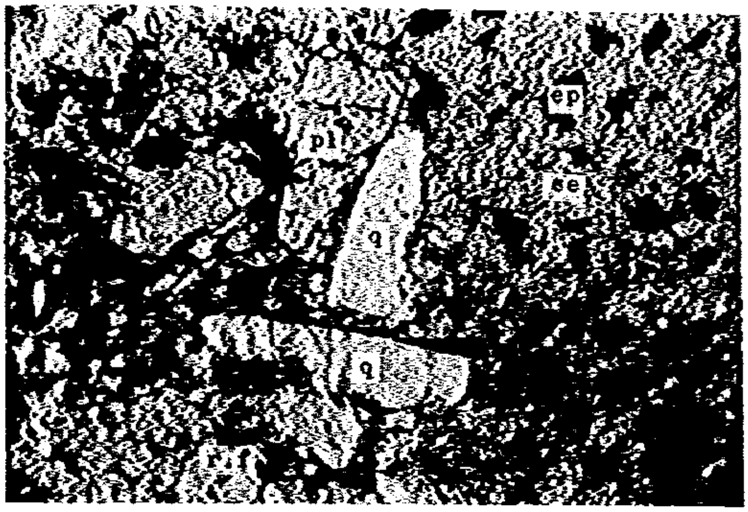
Locality : S.Semoa Tapang

Rock Name : Tuff breccia

Formation : Serantak pyrocrastics

pl : plagioclase
chl : chlorite
Fe : iron mineral
r.f.: rock fragment
and : andesite

0 ________ 0.5 mm



Sample No.: 79RB-52

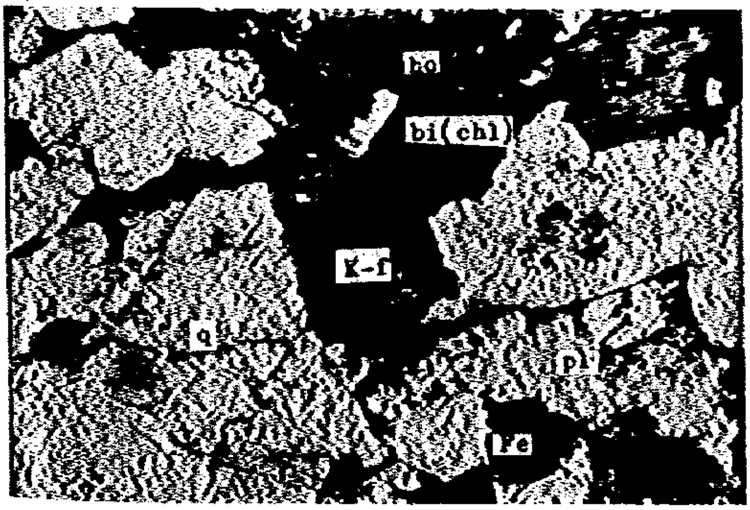
Locality : S.Lumar

Rock Name : Lapilli tuff

Formation : Serantak pyrocrastics

q : quartz
pl : plagioclase
ep : epidote
se : sericite
r.f.: rock fragment

0 ________ 0.5 mm



Sample No.: 79Rp-19

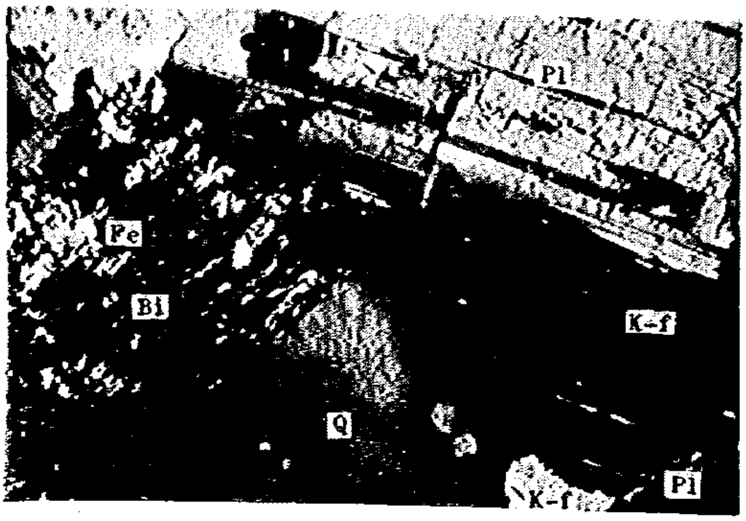
Locality : S.Bala

Rock Name : Granodiorite

Group : G.Raya Granodiorite

q : quartz
pl : plagioclase
ho : hornblende
k-f : potassic feldspar
bi : biotite
chl : chlorite
Fe : iron mineral

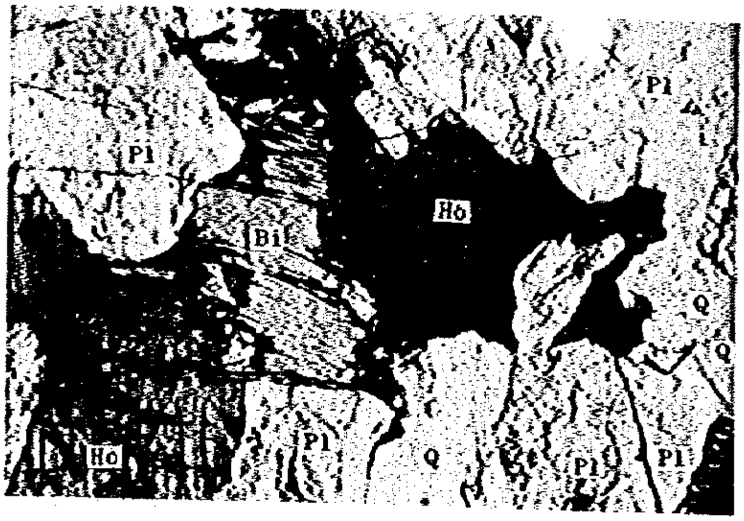
0 ________ 0.5 mm



Sample No.: 80RE-21
Locality : S.Radek
Rock Name : Granodiorite
Group : G.Sebiawak Granodiorite

Q : quartz
Pl : plagioclase
Bi : biotite
K f : potassic feldspar
Fe : iron mineral

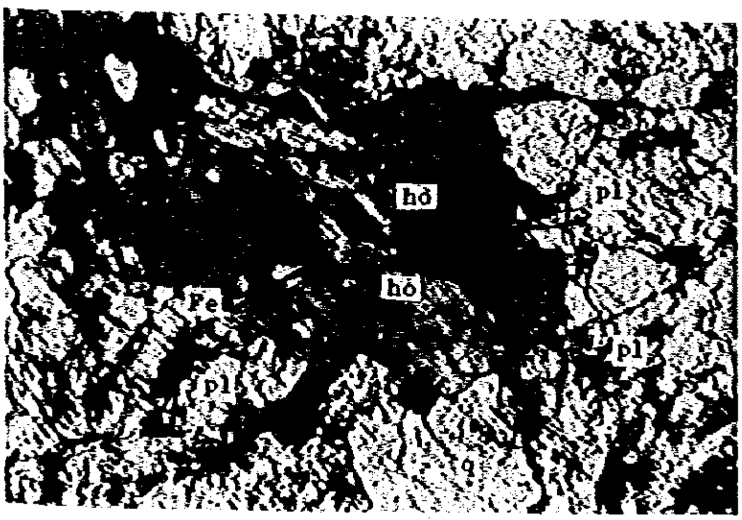
0 0.5 mm



Sample No.: 80RA-61
Locality : S.Bebale
Rock Name : Granodiorite
Group : G.Raya Granodiorite

Q : quartz
Pl : plagioclase
Ho : hornblende
Bi : biotite

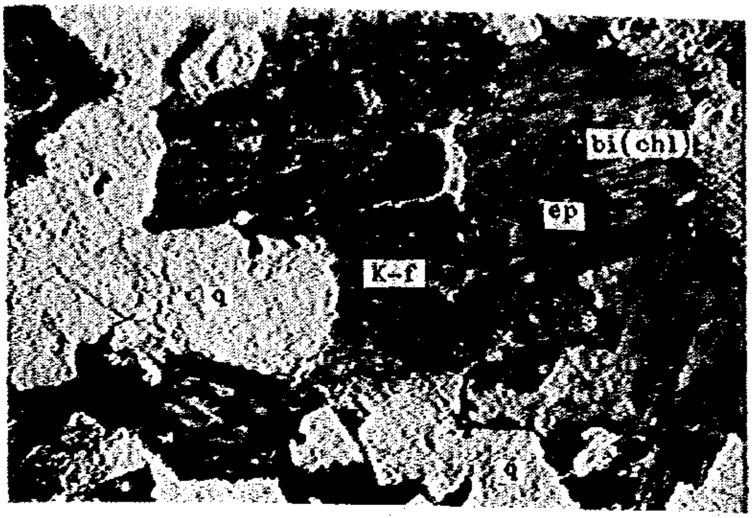
0 0.5 mm



Sample No.: 79RE-50
Location : S.Pehem
Rock Name : Quartz diorite
Group : Tiang quartz diorite

q : quartz
pl : plagioclase
ho : hornblende
Fe : iron mineral

0 0.5 mm



Sample No.: 79RP-32

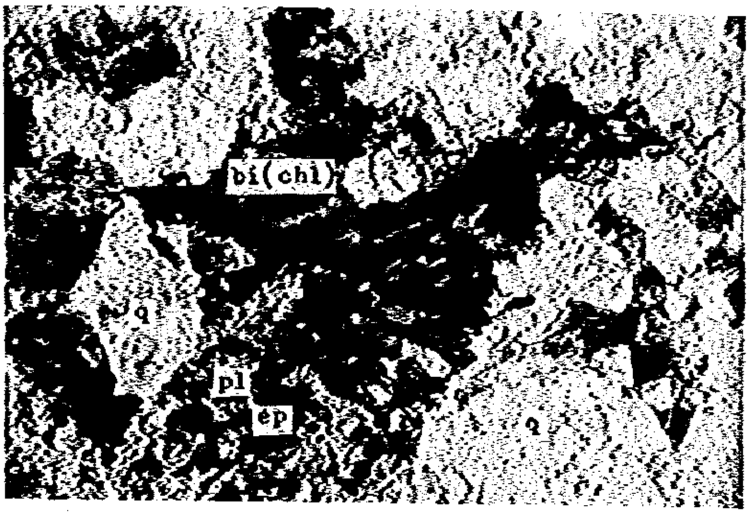
Locality : S.Sembuang

Rock name : Granite

Group : Granite

q : quartz
ep : epidote
k-f : potassic feldspar
bi : biotite
chl : chlorite

0 ——— 0.5 mm



Sample No.: 79RE-30

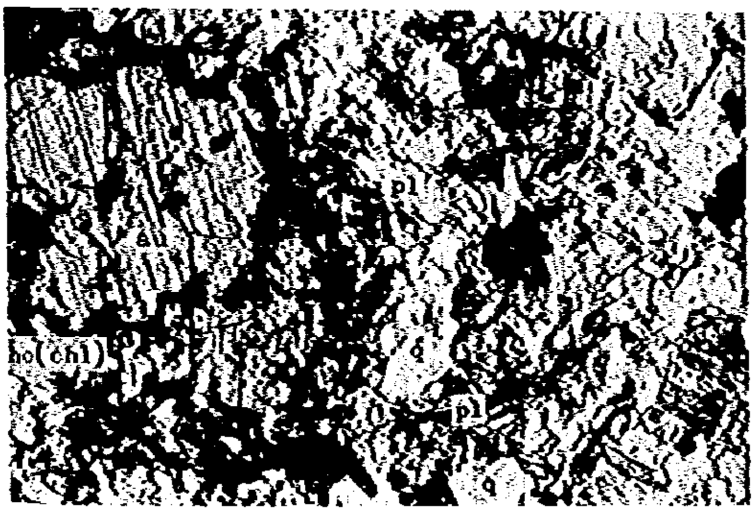
Locality : S.Sakung

Rock Name : Granite

Group : Granite

q : quartz
pl : plagioclase
ep : epidote
bi : biotite
chl : chlorite

0 ——— 0.5 mm



Sample No.: 79RD-18

Locality : G.Kelan

Rock Name : Quartz gabbro

Group : Pandan Quartz gabbro

q : quartz
pl : plagioclase
ho : hornblende
chl : chlorite
au : augite

0 ——— 0.5 mm

Sample No.: 79RB-24

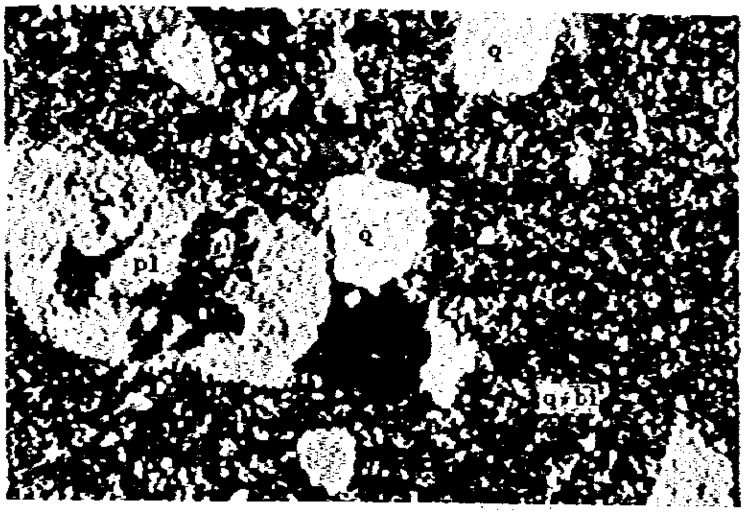
Locality : S.Bamua

Rock Name : Tonalite

Group : Sirih Tonalite

q : quartz
pl : plagioclase
k-f : potassic feldspar
bi : biotite

0 ____________ 0,5 mm



Sample No.: 79RB-10

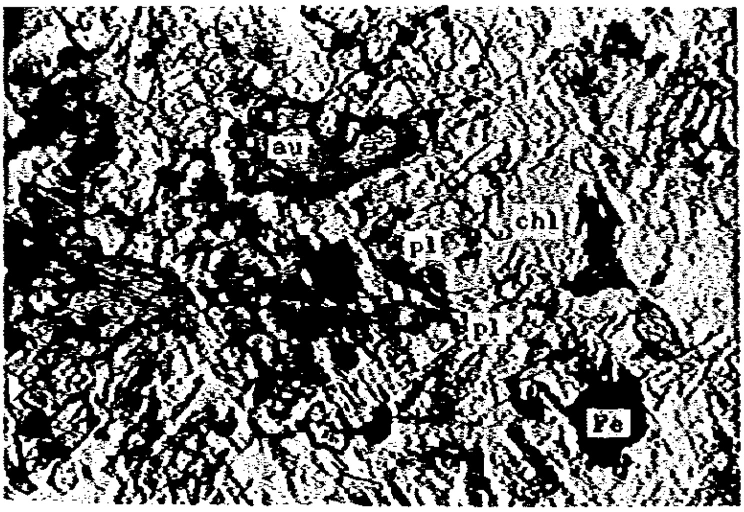
Locality : S.Bamua

Rock Name : Dacite

Group : Serantak Dacite

q : quartz
pl : plagioclase
bi : biotite

0 ____________ 0,5 mm



Sample No.: 79RC-27

Locality : S.Cebol

Rock Name : Dolerite

pl : plagioclase
chl : chlorite
au : augite
Fe : iron mineral

0 ____________ 0,5 mm

CHAPTER 3 CHARACTERISTICS OF GRANITIC ROCKS

3-1 Distribution of Granitic Rocks in Kalimantan

There is a granitic batholith extending in the NWW∿SEE direction in the scale of 500 km long and maximum width of 150 km from Central Kalimantan to West Kalimantan (Fig. 2-19). The batholithic granitic rocks are thought to be in the Cretaceous (Granitic) Magma Arc formed by the Cretaceous subduction (Katili 1973, 1981) and it is situated in a part of the Jurassic and Cretaceous Granitic and Volcanic Terrain (Hamilton, 1978) that surrounds the Sundaland and connects from the South China Sea and South Indochina Peninsula through Kalimantan, Sumatra, to Malaysian Peninsula (Fig. 2-8). In this project, chemical analysis and absolute age determination were conducted on the granitic rocks distributing from Benkanyang to Pahuman of the project, in order to study characteristics of these granitic rocks.

In this project, the granitic rocks are classified in the order of ages as shown below.

Cretaceous granitic rocks
- G. Sebiawak granodiorite
- G. Raya granodiorite
- G. Selantar granodiorite
- Granite (dyke)
- Tiang quartz diorite

Younger (Tertiary) granitic rocks
- G. Pandan quartz gabbro
- Sirih and Banyi tonalite
- Serantak dacite

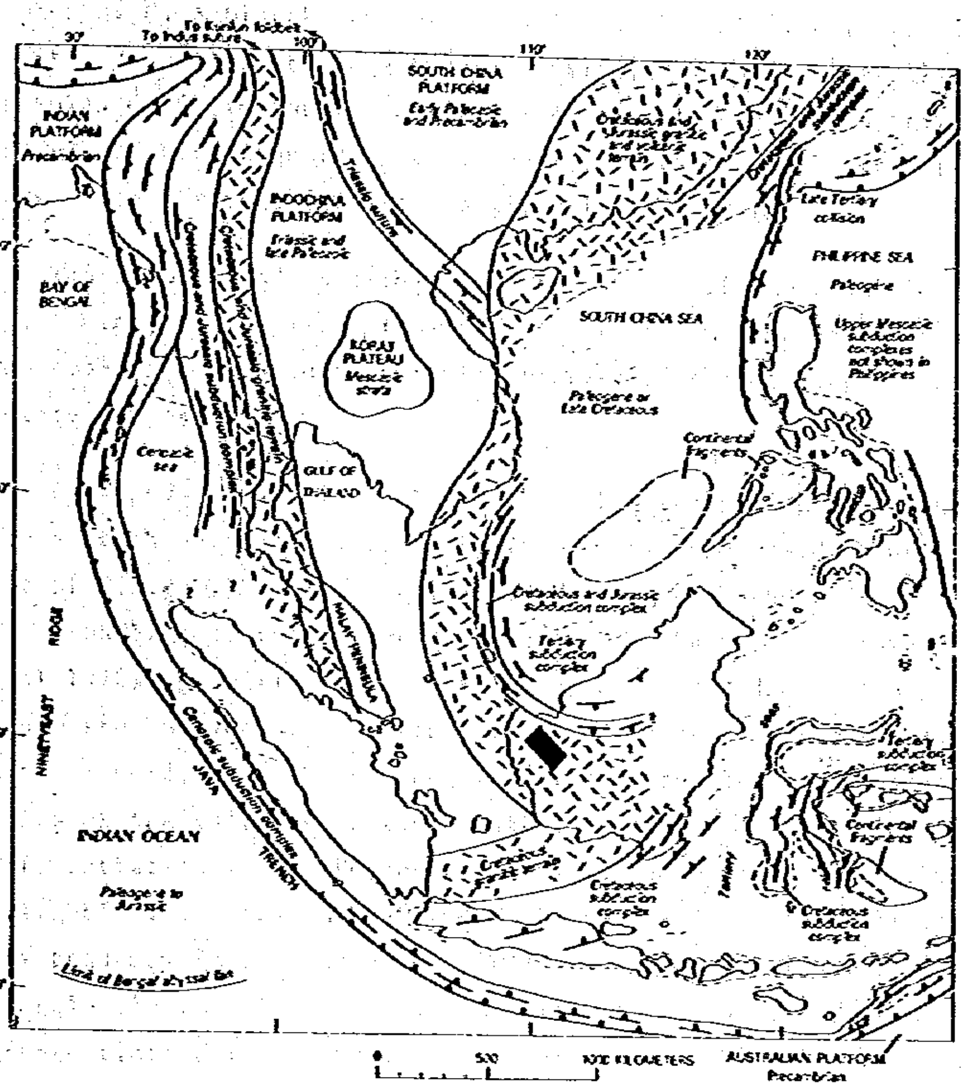


FIGURE 31.—Mesozoic and selected Cenozoic tectonic elements of southeast Asia and Indonesia. Positions and shapes of many elements were very different at the time they formed. Symbols within subduction complexes show dominant direction of thrusting, barbs on overriding side. Based on interpretations in this report south of 10° N.; north of 10° N., interpreted freely from many sources.

Fig. 2-8 Mesozoic and Selected Cenozoic Tectonic Elements in South Asia and Indonesia by Hamilton

3-2 Chemical Composition of Granitic Rocks

24 rocks samples were chemically analyzed during three years to review the chemical composition of the granitic rocks in the survey area. Selected assay samples are 24 samples, namely 2 samples of G. Sebiawak granodiorite, 10 samples of G. Raya granodiorite, 3 samples of Tiang quartz diorite, 3 samples of granite, 2 samples of Sirih-Banyi tonalite, 1 sample of Serantak dacite, 1 sample of Pandan quartz gabbro and 2 samples of G. Ibu granitic rocks. The analysis results are given in Table 2-1.

The results indicate that the SiO_2 values of the granitic rocks in the project area range from 54% to 75%, or in a broad range of from sub-basic to acidic, but the majority of them belong to intermediate composition.

Fig. 2-9 shows a tendency of variation indicating relationship between each oxide and differentiation index (expressed as Qz + Ab + Or of C.I.P.W.) of the specimens. Marking with the average variation line of the Cretaceous granitic rocks in Japan (Aramaki et al 1972), granitic rocks in the project area indicate linear change similarly along the tendency of Japanese granitic rocks. In other words, the chart shows that the differentiation characteristics of the calc-alkali rock series, namely with increasing with differentiation index (following magmatic evolution), SiO_2 value straightly increases but FeO and Fe_2O_3 values decrease in linear. This tendency is also crearly expressed by the FeO^*-(Na_2O + K_2O)-MgO Triangle Diagram (Fig. 2-10), that is, with the prograss of magmatic differentiation (increase of Na_2O + K_2O), the FeO^* value continuously decreases following calc-alkali rock series course. Additionally, graphs of SiO_2-FeO^*/MgO and FeO^*-FeO"/MgO Diagram (Fig. 2-11) for classification of igneous rocks into the tholeitic and calc-alkali rock series, show that the granitic rocks in the project area have typical differentiation of the calc-alkali rock series.

Table 2-1 Chemical Composition of Constitution Mineral of Granitic Rocks in Project Area

Sample No.	79RP-19	79RF-20	80RC-64	80RC-67	80RD-45	80RD-65	80RE-32	80RE-51	80RF-52	79RQ-59	81RX-53	81R2-24
Rock Name	Gr. dio	Gr. dio	Gr. dio	Gr. dio	Gr. dio	Gr. dio	Gr. dio	Gr. dio	Gr. dio	Gr. dio	Gr. dio	Gr. dio
Location	S. Pala	S. Semba-ang	S. Empa-wang	Kp.Perudu	Kp.Parikap S. Dapahan	North Kp. Emang	North Kp. Seliat	North Kp. Emang	G.Gamana-bak	S. Setona	Panji	G. Kader (Napal)
SiO_2	69.26	69.63	66.43	69.39	63.57	65.17	64.46	71.26	66.11	65.13	71.75	68.97
TiO_2	0.41	0.40	0.50	0.43	0.56	0.63	0.60	0.33	0.42	0.57	0.42	0.48
Al_2O_3	14.26	14.14	15.86	15.02	16.11	15.08	14.08	14.17	14.49	14.34	13.41	14.36
Fe_2O_3	1.42	1.82	2.51	1.61	2.76	2.63	2.78	0.93	2.79	3.02	1.22	1.78
FeO	2.37	1.91	2.79	1.79	3.54	3.13	3.09	1.89	3.10	2.73	2.30	2.56
MnO	0.07	0.09	0.11	0.10	0.14	0.17	0.12	0.09	0.10	0.11	0.15	0.10
MgO	1.11	1.07	1.07	1.47	2.28	2.09	2.23	0.98	1.67	2.00	0.82	1.38
CaO	3.35	2.81	4.21	3.12	5.27	4.72	4.96	2.59	3.82	4.73	2.66	3.99
Na_2O	3.56	3.95	3.51	4.06	3.14	3.25	3.22	3.54	3.21	2.79	3.75	3.39
K_2O	2.40	2.42	1.98	2.28	1.59	2.01	2.24	2.88	2.99	1.85	2.03	1.60
P_2O_5	0.09	0.09	0.15	0.14	0.17	0.11	0.16	0.13	0.13	0.08	0.09	0.10
$H_2O(+)$	1.17	1.27	0.65	0.48	0.46	0.70	0.82	0.72	0.88	2.26	0.95	0.88
$H_2O(-)$	0.23	0.36	0.18	0.15	0.21	0.19	0.25	0.20	0.24	0.34	0.17	0.24
Total	99.70	99.96	99.95	100.04	99.80	99.83	99.61	99.71	99.95	99.95	99.62	99.83
q	29.6	29.3	27.18	27.94	23.39	24.89	23.48	31.94	24.79	28.0	34.30	31.62
or	13.9	14.5	11.69	13.47	9.40	11.85	13.24	17.03	17.64	11.1	12.02	9.46
ab	29.9	33.6	29.67	34.34	26.58	27.47	27.21	29.94	27.16	23.6	31.72	28.68
an	15.9	12.8	19.89	14.55	25.03	20.64	19.00	12.02	16.30	21.1	12.63	19.14
c	0.1	1.3	0.66	0.54	0.04	-	-	0.83	-	-	0.41	0.04
he	-	-	-	-	-	-	-	-	-	-	-	-
wo } di	-	-	-	-	-	0.86	1.92	-	0.75	0.6	-	-
en } di	-	-	-	-	-	0.59	1.21	-	0.51	0.4	-	-
fs } di	-	-	-	-	-	0.20	0.58	-	0.18	0.1	-	-
en } hy	2.8	1.2	2.66	3.66	5.67	4.61	4.34	2.44	3.64	4.6	2.04	3.43
fs } hy	2.6	3.6	2.42	1.42	3.55	2.56	2.03	2.33	2.69	1.7	2.61	2.62
mag	2.1	2.6	3.63	2.34	4.01	3.82	4.02	1.34	4.05	4.4	1.76	2.57
il	0.8	0.8	0.96	0.82	1.06	1.20	1.14	0.62	0.80	1.1	0.80	0.91
ap	0.3	0.3	0.37	0.34	0.40	0.27	0.37	0.30	0.30	0.3	0.20	0.24
Total	98.0	99.0	99.13	99.42	99.13	98.96	98.54	98.79	98.81	97.0	98.49	98.71
q+or+ab	73.4	77.4	68.54	75.75	59.37	64.21	63.93	78.91	69.54	62.7	78.04	69.76
D.I.	74.9	78.2	69.14	76.19	59.89	64.88	64.48	79.87	70.37	64.6	79.24	70.67
Group	G. Raya	G. Raya	G. Raya	G. Raya	G. Raya	G. Raya	G. Raya	G. Raya	G. Raya	G. Raya	G.Sebiawak	G.Sebiawak
age m.y.	103.7±5.2		114±6		111±6				107±5		124±8	

Abbreviation: Gr. dio: Granodiorite, Q_z dio: Quartz diorite Ton: Tonalite,
Q_z Gab : Quartz gabbro, Gr: Granite.

	Sample No.	79RE-30	79Rn-32	79RF-32	79RE-50	80RD-67	80RE-5	79RB-24	79RD-52	79RD-72	79RD-28	QD-1	GD-1	80-RG-200	81-RY27
	Rock Name	Gr	Gr	Gr	Qz dio	Qz dio	Qz dio	Ton	Ton	dac	Qz Gab	Qz dio	Gr. dio	ac.ff.	and ff.
	Location	S.Pehen	S.Semade	S.Sembuan	S.Pehen	S.Serape	Kp.Sempur-anch	S.Banua	S.Banyi	S.Serantak	G.Pandang	G.Ibu	G.Ibu	G.Serantak	S.Kader2
Chemical Composition	SiO_2	69.82	69.39	74.77	59.78	60.92	65.29	67.31	69.26	70.11	54.37	62.13	63.59	77.03	71.77
	TiO_2	0.40	0.49	0.20	0.63	0.87	0.54	0.48	0.47	0.35	0.63	0.75	0.59	0.18	0.42
	Al_2O_3	13.53	13.62	13.03	16.03	15.77	15.80	15.45	13.94	13.91	18.69	16.84	16.09	7.80	12.77
	Fe_2O_3	1.80	1.62	0.85	2.81	3.41	2.18	1.66	2.16	1.46	1.21	2.87	2.44	2.04	2.08
	FeO	2.04	2.04	1.09	4.81	4.07	2.94	1.91	1.66	3.22	6.23	3.19	2.71	1.21	2.49
	MnO	0.06	0.06	0.03	0.08	0.16	0.14	0.06	0.05	0.05	0.13	0.12	0.11	0.06	0.05
	MgO	1.17	1.07	0.45	3.29	2.78	1.59	1.61	1.20	1.35	3.93	2.51	1.92	1.09	0.33
	CaO	1.80	2.14	1.51	6.92	5.95	5.20	3.99	2.63	2.65	7.59	5.36	4.63	6.58	7.03
	Na_2O	4.02	4.23	4.05	3.00	3.46	3.93	3.84	4.19	5.32	3.78	3.89	3.96	1.40	1.41
	K_2O	3.12	2.66	2.64	1.06	0.83	0.95	2.40	1.95	0.27	0.63	1.23	2.15	0.37	0.39
	P_2O_5	0.09	0.08	0.00	0.09	0.27	0.20	0.12	0.09	0.11	0.08	0.20	0.16	0.07	0.15
	$H_2O(+)$	1.86	2.11	0.93	1.52	1.17	0.70	0.93	1.68	1.04	2.50	0.79	1.28	1.98	0.86
	$H_2O(-)$	0.12	0.23	0.29	0.12	0.19	0.15	0.19	0.36	0.05	0.36	0.18	0.21	0.26	0.27
	Total	99.83	99.74	99.84	100.14	99.85	99.61	99.95	99.64	99.89	100.13	100.06	99.84	100.07	99.96
C.I.P.W. Norm	q	28.5	28.2	36.9	18.0	20.50	24.91	24.6	30.2	29.3	5.8	19.09	19.48	55.76	47.30
	or	18.4	15.6	15.6	6.1	4.90	5.62	14.5	11.7	1.7	3.9	7.29	12.69	2.17	2.28
	ab	34.1	35.7	34.1	25.2	29.26	33.24	33.0	35.7	44.6	32.0	32.92	33.50	11.85	11.90
	an	8.1	9.7	7.5	27.3	25.06	22.67	17.8	11.4	12.2	32.0	24.84	19.78	13.91	27.39
	c	0.6	0.3	0.8	-	-	-	-	0.7	0.4	-	-	-	4.18	-
	he	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	wo (di)	-	-	-	2.6	1.13	0.77	0.5	-	-	1.9	0.19	0.91	3.44	2.82
	en (di)	-	-	-	1.5	0.70	0.42	0.3	-	-	0.1	0.13	0.59	2.71	0.76
	fs (di)	-	-	-	0.9	0.36	0.32	0.1	-	-	0.1	0.05	0.27	0.34	2.08
	en (hy)	2.9	2.7	1.1	6.7	6.21	3.53	3.7	3.0	3.3	9.6	6.12	4.19	-	0.05
	fs (hy)	1.7	1.7	0.9	4.5	3.15	2.64	1.5	0.5	4.1	9.4	2.41	1.92	-	0.17
	mag	2.5	2.3	1.2	4.2	4.95	3.17	2.3	3.2	2.1	1.9	4.16	3.54	2.96	3.01
	il	0.8	0.9	8.5	1.2	1.65	1.03	0.9	0.9	0.8	1.2	1.42	1.12	0.35	0.80
	ap	0.3	1.0	-	0.3	0.64	0.47	0.3	0.7	0.3	2.0	0.47	0.37	0.17	0.35
	Total	97.9	98.1	98.6	98.5	98.51	98.79	99.5	98.0	98.8	99.9	99.09	98.36	97.84	98.91
	q+or+ab	81.0	79.5	86.6	49.3	54.66	63.77	72.1	77.6	75.6	41.7	59.30	65.67	-	-
	D.I.	82.7	81.0	87.8	50.1	55.48	64.55	72.5	79.5	79.2	41.7	59.84	66.76	-	-
	Group	Granite	Granite	Granite	Tiang Q.D.	Tiang Q.D.	Tiang Q.D.	Efrih Ton	Banyi Ton	Serantak	G.PandanQG	G.Sijanguk	G. Raya	Banan F	Belango F *
	age m.y.				98.6±4.9	95±4.8		20±1.0	27.8±1.4	51.3±2.6		30.3±1.5	30.4±1.5		

* strong hornfelsic alteration.

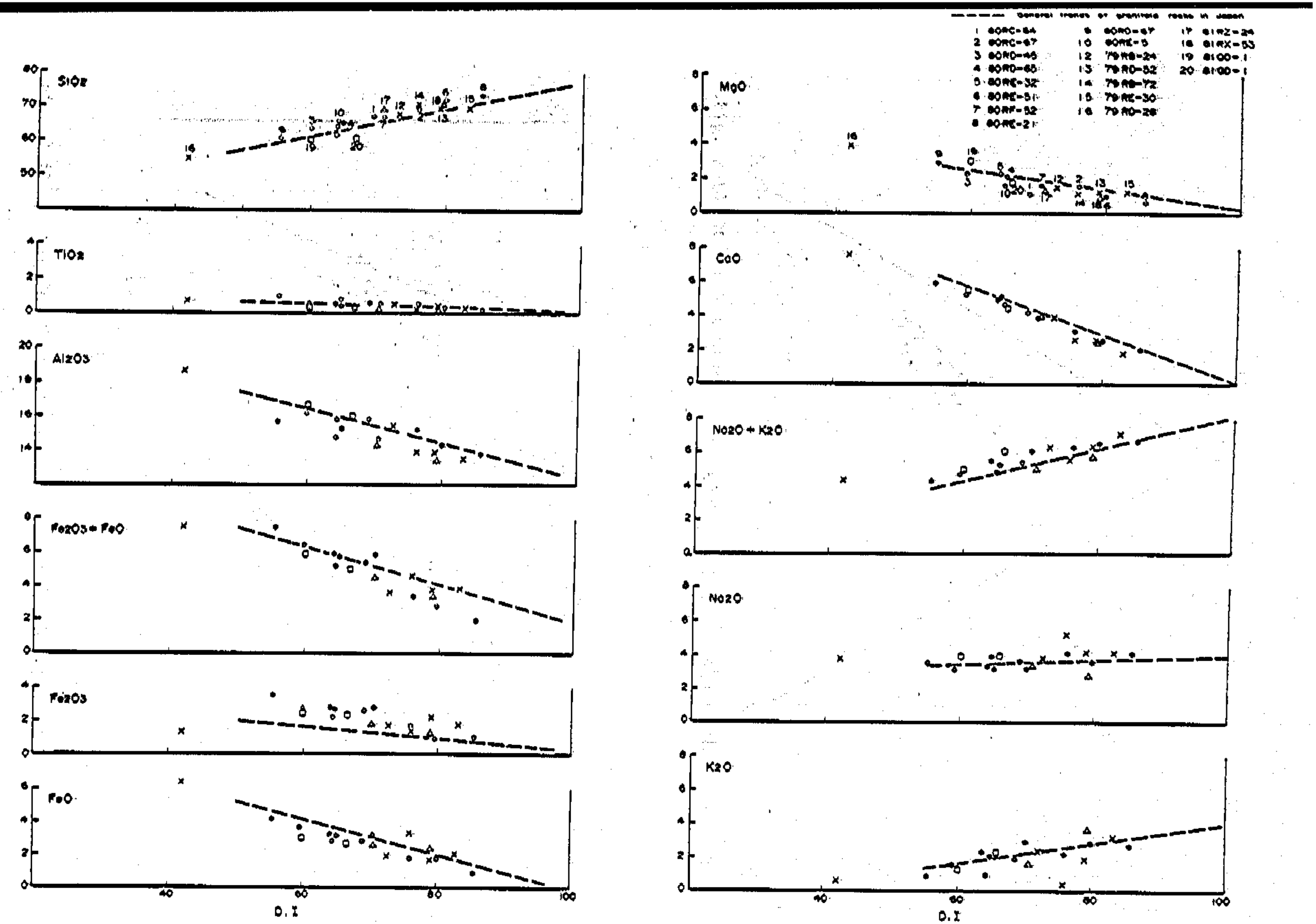


Fig. 2-9 Variation Diagram of Granitic Rocks in the Project Area

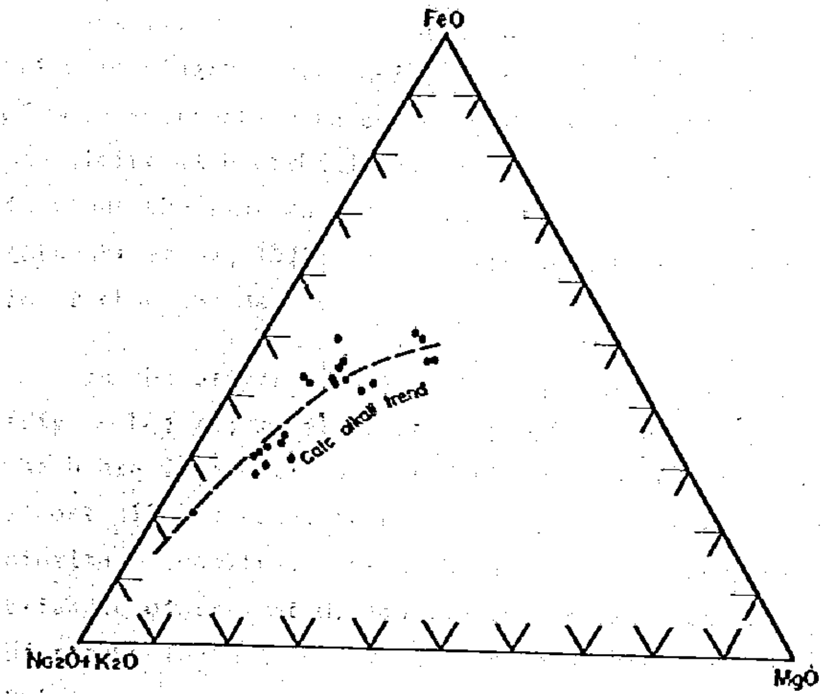


Fig. 2-10 M - F - A Diagram of Granitic Rocks in the Project Area

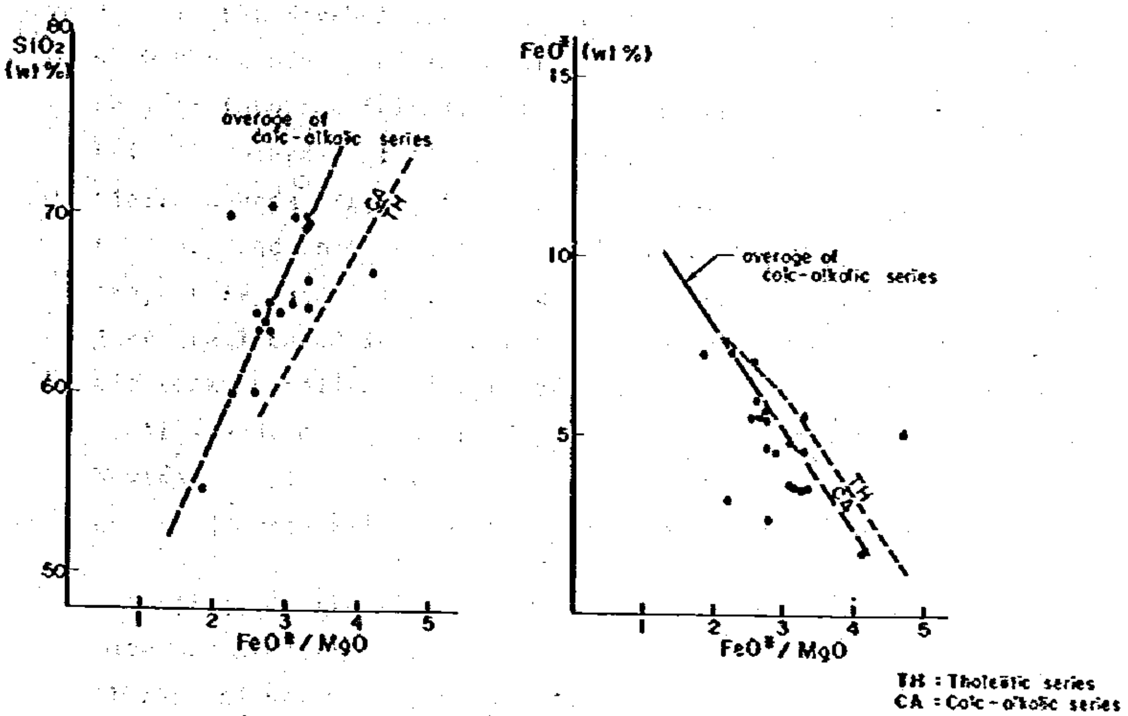


Fig. 2-11 SiO_2-Fe*/MgO Diagram and FeO*-FeO/Mgo Diagram of Granitic Rocks in the project Area

Indicated in the normative orthoclase - albite - anorthite triangle diagram (Fig. 2-13) is the trend of changing from field of much anorthite with scarce orthoclase field of scare anorthite and albite with orthoclase. The tendency shown in the diagram is about the same as the average trend of Japanese granitic rocks (Aramaki et al, 1972), though the amount of orthoclase is slightly lower than the Japanese.

In the diagrams of normative quartz - plagioclase - orthoclase (Fig. 2-12) and modal quartz - plagioclase - orthoclase (Fig. 2-14), which are frequently used for classification of granitic rocks, almost all the granitic rocks are plotted in the range of granodiorite - tonalite. The modal quartz - plagioclase - orthoclase triangle diagram of G. Ibu granitic rocks from the T. Suhanda data of the Geological Survey of Indonesia with cooperation of the Belgium Government conducted on the G. Ibu granitic rocks (they belong to the same bathlith of the granodiorite of this project) is also given in this report (Fig. 2-15), and the relation shown in the diagram indicates about the same tendency.

In the North American Continent, the granodiorite batholiths show the tendency of increasing K_2O (Potash feldspar) contents as they go into the inland. Fig. 2-17 is prepared based on the triangle diagram of quartz - plagioclase - potash feldspar in Sierra Nevada (Prosnell & Bateman, 1973) as an example of this tendency and in it the tendency line of the granitic rocks of this project is marked in the diagram. The granitic rocks of this project are located in the northern marginal part of Kalimantan granitic rock batholith and form of tonalite-granodiorite of having small amount of potash feldspar. When it is referred to the Sierra Nevada example, its trend seem to be correspond with the prominent quartz diorite region of the Sierra Nevada west marginal part.

Also, in the case of the Kalimantan granitic batholith, monzonite and alkali granitic rocks are reported by A.S. Sumartadipura (1976) and BATAN Report in the south margin from the center of the

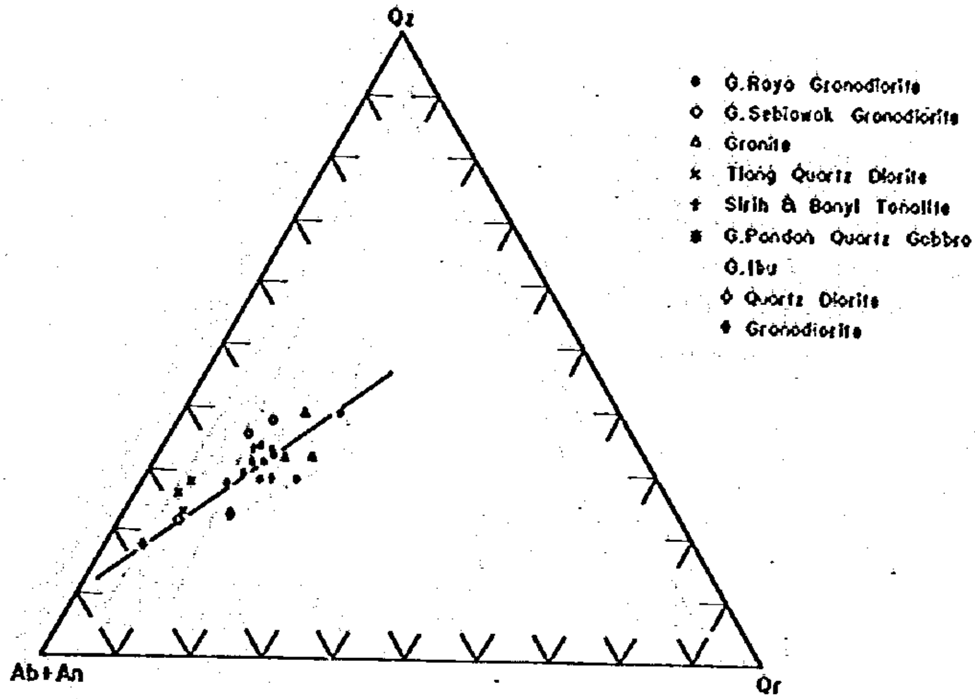


Fig. 2-12 Normative Qz-Pl-Or Diagram of Granitic Rocks in the Project Area

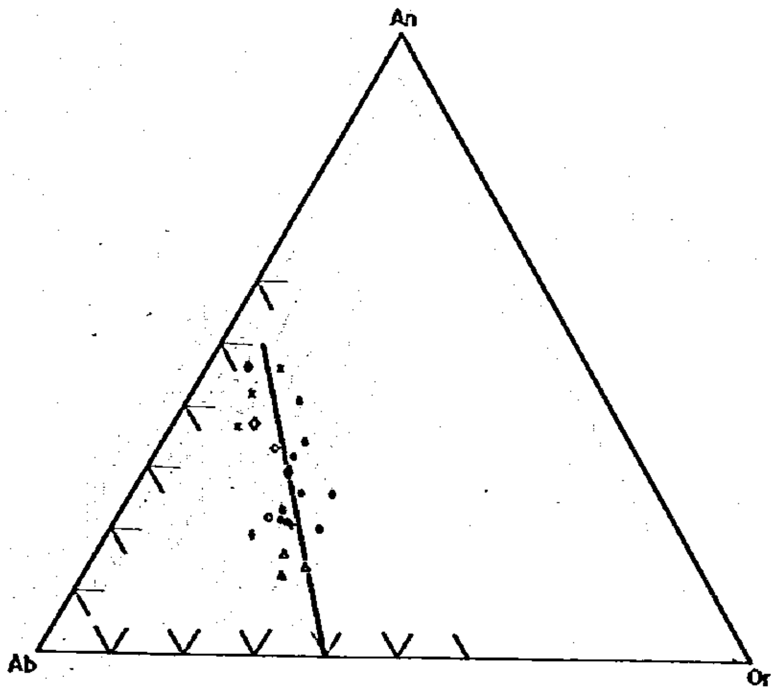


Fig. 2-13 Normative An-Ab-Or Diagram of Granitic Rocks in the project Area

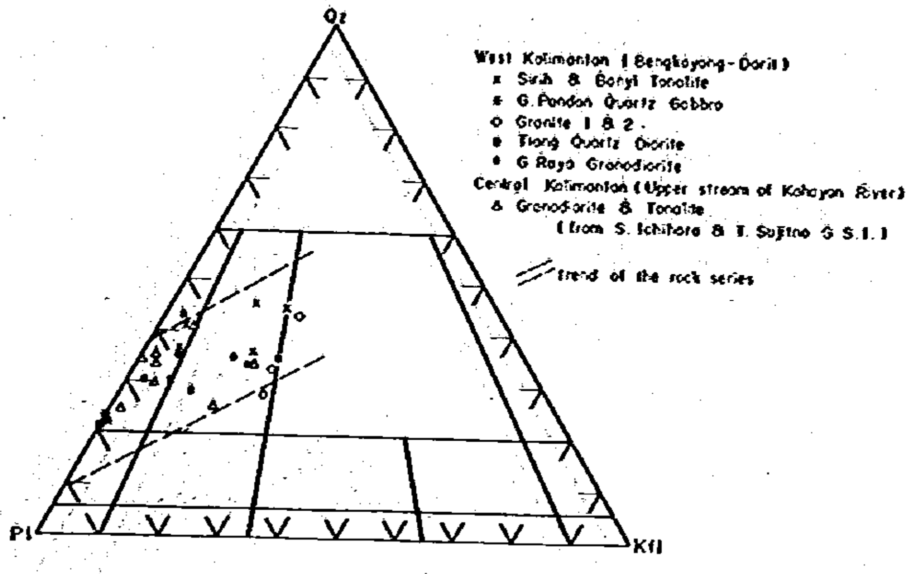


Fig. 2-14 Modal Qz-Pl-Kfl Diagram of Granitic Rocks in the Project Area

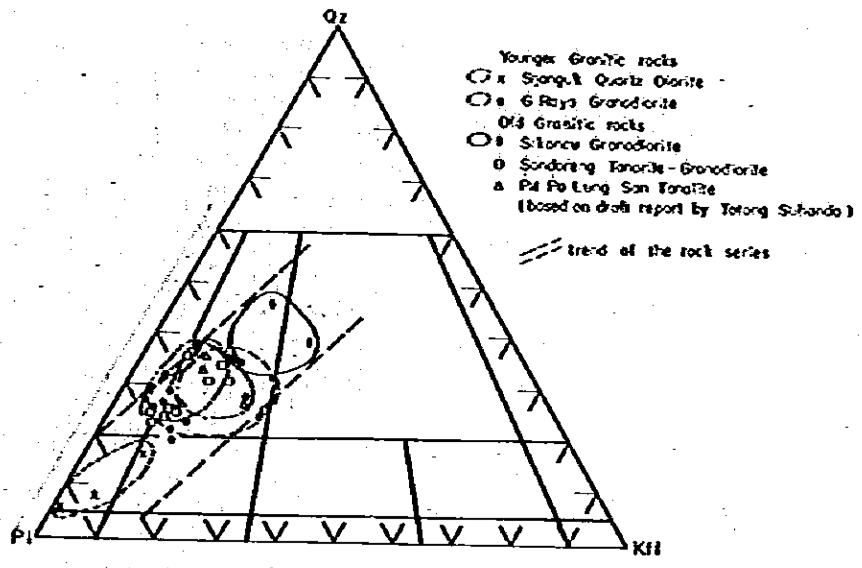


Fig. 2-15 Modal Qz-Pl-Kfl Diagram of Granitic Rocks in G.Ibu Area

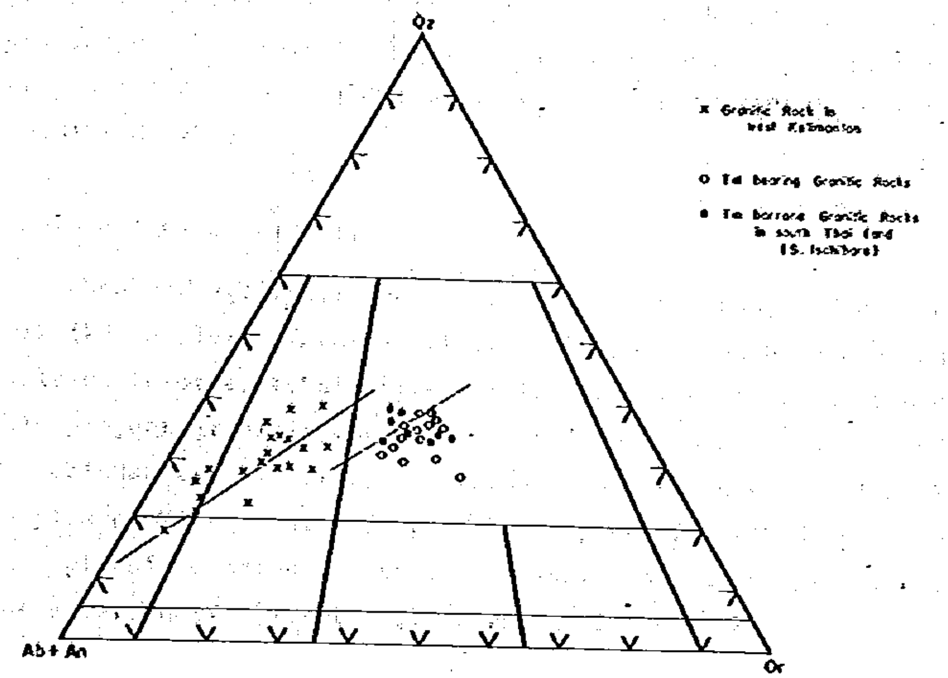


Fig. 2-16 Normative Qz-(Ab+An)-Or Diagram of Granitic Rocks in the Project Area and South Thailand

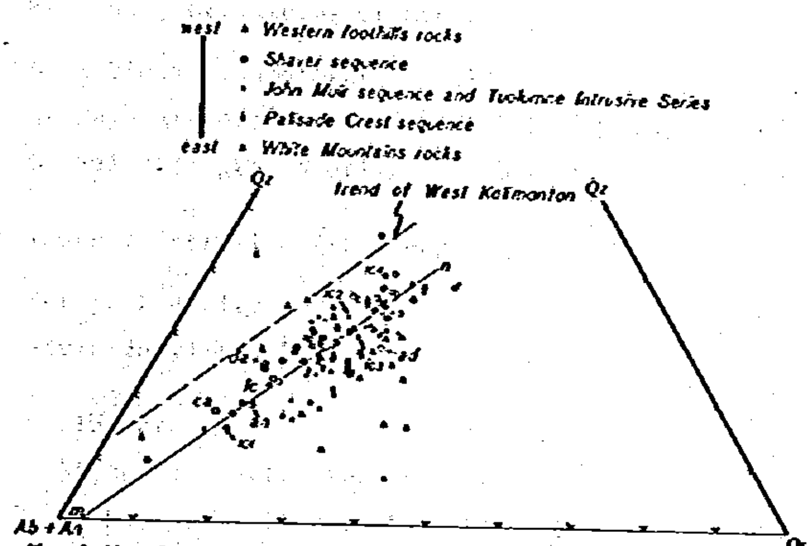


Fig. 2-17 Normative Qz-(Ab+An)-Or Diagram of granitic Rocks in Sierra Nevada by Presnell & Batemen