Republic of Indonesia

Report on Geological Survey of West Kalimantan

Feb. 1981

Japan International Cooperation Agency

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REPUBLIC OF INDONESIA

REPORT ON GEOLOGICAL SURVEY OF WEST KALIMANTAN

PHASE II

FEBRUARY, 1981

JAPAN INTERNATIONAL COOPERATION AGENCY
METAL MINING AGENCY OF JAPAN

PREFACE

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

The agency, taking into consideration the importance of the technical nature of this survey, sought the cooperation of the Metal Mining Agency of Japan in order to accomplish the contempleted task.

The Government of the Republic of Indonesia appointed the Directorate of Mineral Resources to execute the survey as counterpart to the Japan team. The survey is being carried out jointly by experts of both Governments.

This year's survey was for the second phase survey, consisting of geological survey, geochemical survey, detailed geological survey and detailed geochemical survey, for metallic mineral exploration, based on the results of the first phase survey.

This report submitted hereby summarizes the results of the second phase of surveys, and it will also form a portion of the final report that will be prepared with regard to the result to be obtained by the survey.

We wish to take this opportunity to express our gratitude to all sides concerned in the execution of the said second phase survey.

February 1981

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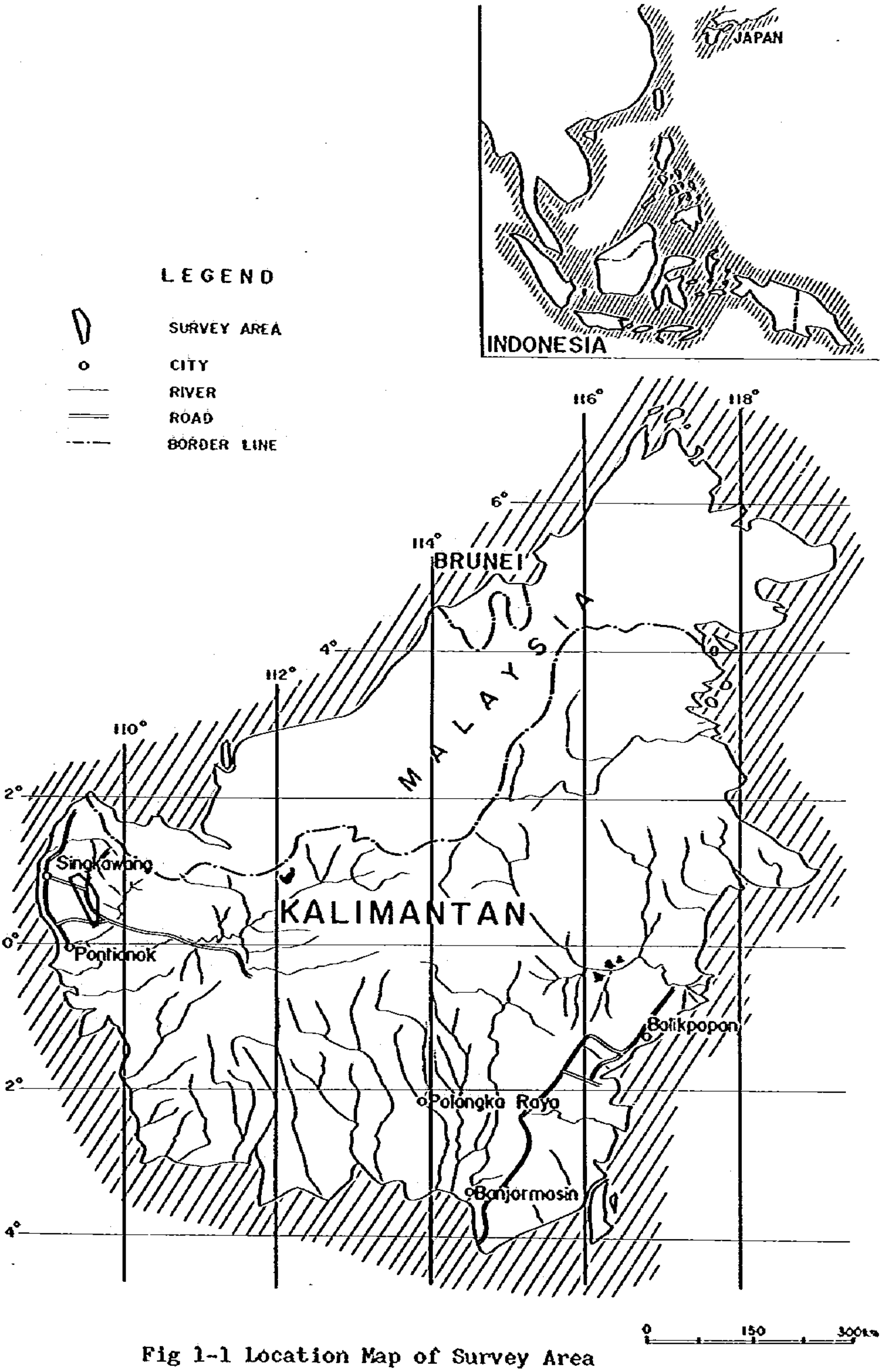

Fig 1-1 Location Map of Survey Area

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ABSTRACT

Following the first phase of the collaboration survey for exploration of metallic mineral resources conducted to cover 500 km^2 in West Kalimantan, the Republic of Indonesia, the second phase reconnaissance survey was conducted to cover the rest of 1,000 km^2 in the same region, consisting of the geological, survey, geochemical survey and placer gold prospecting.

Further, an elucidation has also been attempted on the mineralized zones through the detailed geochemical survey with soil sampling conducted for two areas (50 km^2 in total) of Serantak and Banyi located as the promising mineralized zones in the first phase survey.

The interpretation has been made on the survey result collected through the surveys of geology, geological structure, igneous activities and mineralizations covering total project (1,500 km^2), together with the results of the first phase survey, leading in many new findings. They are briefly summarized as follows.

The geology in the survey area consists of Upper Triassic - Lower Jurassic sedimentary rock formations and Jurassic andesite, dacite and their pyroclastic rocks, into which the batholith of Middle Cretaceous granodiorite has been extensively intruded at the southern survey area, giving a contact metamorphism to both of them.

The stocks of tonalite and dacite in the Early-Middle Tertiary age were found successively intruding along the structures trending NW-SE and NE-SW.

The absolute age dating resulted in 114 - 103 m.y. for the batholith of granodiorite, 98 - 95 m.y. for the quartz diorite, 51 m.y. for the dacite and 27 - 20 m.y. for the tonalite.

The mineralized zones of copper, molybdenum and gold are distributed inside and around the dacite and tonalite sotcks intruded during the period of Early-Middle Tertiary age, disclosing the relationship between the younger igneous activities and the mineralizations.

Panji copper dissemination area and Selakian copper-lead-zinc-bearing ore deposit were the promising mineralizations, among all other mineralized zone found through the reconnaissance survey.

Through the detailed survey, copper-molybdenum-bearing quartz veins were found at the upperstream of S. Banan in Serantak area. This mineraliz-

ed zone is located at the north of Takap - Sirih molybdenite zone found through the first phase survey, both being same mineralized in the Sirih tonalite group. It is assumed that the Sirih tonalite are generally accompanied by the molybdenite mineralization as well as the existence of anomalous Cu-Mo area found in the north of Sirih tonatile area through the geochemical reconnaissance survey.

Banyi mineralized zone shows an obscure zonal arrangement, such as, from center to outer, the barren tourmaline zone, molybdenite zone, pyrite zone and gold (copper) zone. Especially, the shear zone along S. Banyi is accompanied by the sericite chlorite argillized alteration with the pyrite-bearing veinlets, but no content of gold and copper is found, and the mineralization might be classified as the pyrite mineralized zone.

Thirteen (13) anomalous areas, such as Cu, Mo and Zn, have been found through the geochemical survey performed in the reconnaissance survey, over which any mineralized zone or such an indication was overlapped, proving that the geochemical survey with the stream sedimentals was very effective for extraction of mineralized zones in the reconnaissance survey area.

Their good relationship with the mineralized zones has also been revealed through the geochemical survey with soil (Cu and Mo) sampled in the detailed survey, proving the effectiveness to find the distributions and zones of mineralizations in the detailed survey..

The results of surveys jointly conducted in this area and Central Kalimantan area have proved that the igneous activities of island arc and calc-alkalic type have occurred during the period from Early to Middle of Tertiary age, and the mineralizations of copper, molybdenum, gold, mercury and antimony have been widely brought into Kalimantan as well.

PART I

INTRODUCTION

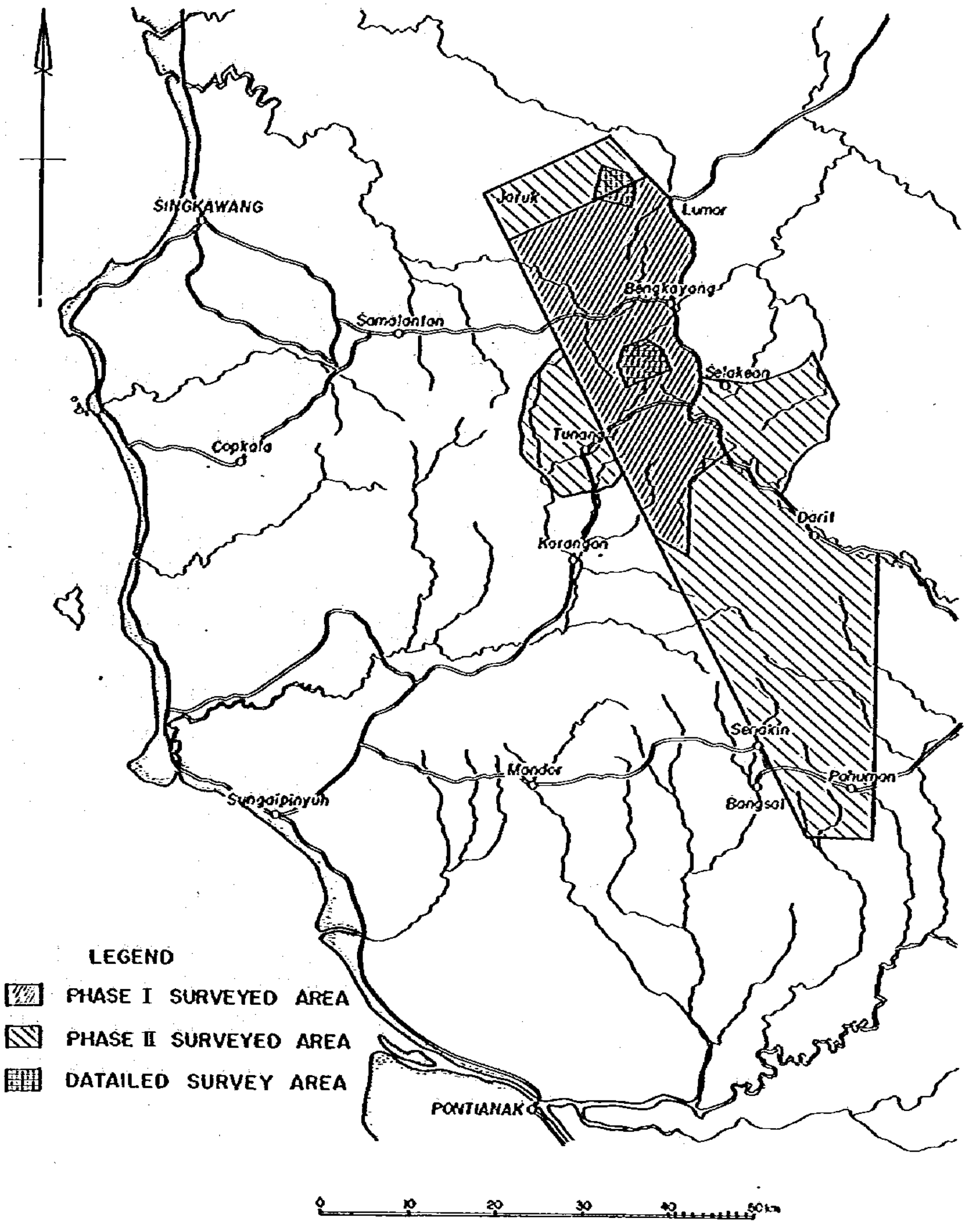

Fig 1-2 Map of Survey Area

CHAPTER 1 INTRODUCTORY REMARKS

The second phase survey of cooperative metallic mineral exploration project in West Kalimantan of the Republic of Indonesia was conducted under the following program.

(1) The finding of promising mineralized areas has been carried out through the reconnaissance survey consisting of geological survey, geochemical survey with stream sediments and placer gold prospecting, as same as in the first phase survey, over the area of 1,000 km^2, excluding the area of 500 km^2 surveyed during the first phase survey period, among the whole project area of 1,500 km^2 (see Fig. 1-2).

(2) The exploration of mineral deposits has been carried out through the detailed survey consisting of geological and geochemical surveys with soil sampling over 50 km^2 at the two promising mineralized areas, i.e. Banyi mineralized area and Serantak - Sungai Banan mineralized area, both found in the reconnaissance survey area (500 km^2) of first phase.

Seven (7) geologists from Japan (Metal Mining Agency of Japan) and thirteen (13) geologists and surveyers from the Republic of Indonesia (Directorate of Mineral Resources) have been engaged in this survey, commencing on 3 June, 1980. This field survey has been completed on 12 October, 1980, with the cooperation of gevernmental authorities in the Province, cities, and villages of West Kalimantan, in addition to cooperations rendered by the Ministry of Mines and Energy and Directorate of Mineral Resources of the Republic of Indonesia.

The results of the survey have been compiled into the preliminary geological maps by the geologists of both teams at the base camp in the field, and after the rocks, ores and geochemical samples collected for the chemical analyses and laboratory test have been analyzed, examined and interpreted both in Japan and in the Republic of Indonesia, the final geological maps and the geochemical analysis maps have been compiled and then summarized in this report.

CHAPTER 2 OUTLINE OF SECOND PHASE INVESTIGATION

2-1 Reconnaissance Survey

2-1-1 Survey Area

The area subject to this collatoration survey covers 1,500 km^2 to include G. Bawang, Bengkayang, G. Raya, Darit, Paphuman and Senakin in the northwest area of West Kalimantan, the Republic of Indonesia, of which the first phase survey has completed over 500 km^2 to include G. Bawang, Benkayang and G. Raya, leaving the area of 1,000 km^2 for the second phase survey.

Because the mineralized area were expected to exist in the north area of G. Bawang and the west area of Tunung through the results of study performed in the first phase survey, by mutual consultation with both sides before starting the second phase survey, the survey area has been changed more or less to include the above-mentioned two areas, while to exclude the east area of Darit and the eastsouth area of Bengkayang, where the sedimentary rocks are mostly distributed, as an equivalent area to the above addition (Fig. 1-2).

2-1-2 Method and Amount of Survey

(1) Geological survey

The geological survey has been conducted mainly along the rivers, using the topographic maps of 1/20,000 in scale enlarged from those of 1/50,000 in scale provided by the government of Indonesia, and the geological maps of 1/50,000 in scale have been prepared, covering the total survey area of 1,110 km^2 and the total surveyed route length more than 800 km. Accordingly, the total survey area for both the first and second phases covered 1,645 km^2. In addition, for all areas where a mineralized zone or its showing was found, sketch maps of ore deposits have been appropriately prepared.

(2) Geochemical survey

Keeping pace with the geological survey, sampling of stream sedimens, using 80 mesh sieve, was carried out at each river and creak. These samples were divided into two groups, each being held by Japan and Indonesia. The total number of samples reached 897, including the spare samples, and were sent to Japan for chemical analyses of Cu and Mo. 837 samples were analized in the assay laboratory. While, the chemical analyses of Pb and Zn were performed by the Indonesian laboratory. These assay analysis results were used for the geochemical interpretation.

(3) Placer gold prospecting

Bengkayang and Lumar areas in the project region were very well known as the placer gold prospecting and mining place in the past. Even at present, some local inhabitants are mining the placer gold in a small scale. Because the good relationship between the distribution of placer gold and the mineralized areas was recognized from the results of first phase survey, the placer gold prospecting was also applied again by panning work at the same places where the geochemical sampling was conducted, covering 862 locations.

2-2 Detailed Survey

2-2-1 Survey Purpose

Two promising mineralized areas, Serantak and Banyi, covering 50 km² in total, were located by the geological and geochemical reconnaisance survey of the first phase, and the invetigation of mineralizations was conducted in detail, consisting of geological and geochemical surveys, in order to explore the geology, geological structures, igneous activities, relationship among the mineralizations, scale and characteristics of mineralized zones in these areas.

2-2-2 Survey Area

The following two areas were selected for the detailed survey in the second phase, where the distribution of mineralized areas was recognized in the study of the geological and geochemical surveys performed in the first phase.

(1) Serantak area

The massive copper-bearing pyrrhotite ore deposits and the gold-bearing quartz veins were distributed in this area of 15 km².

(2) Banyi area

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

2-2-3 Method and Amount of Survey

(1) Compilation of topographic maps

The topographic maps of 1/5,000 in scale were compiled, using the air-photographs of approx. 1/40,000 in scale provided by the government of Indonesia, covering Serantak area of 20 km^2 and Banyi area of 56 km^2 totaling to 76 km^2. These maps were used for the detailed geological and geochemical surveys, and further, as the original topographic maps to compile the geological maps of 1/10,000 in scale.

(2) Detailed geological survey

The detailed survey on geology, geological structures, mineralizations and hydrothermal alteration zones was carried out at the rivers and roads, using the topographic maps of 1/5,000 in scale. The survey area consisted of Serantak area of 15 km^2 and Banyi area of 36 km^2, totaling to 51 km^2 and the geological maps have been compiled with 1/10,000 scale.

(3) Geochemical survey

Sampling of soils for the geochemical survey was performed from B-horizon, selecting three (3) sampling points per km^2 where having no influence and no contamination from the rivers. These soil samples collected were dried in the sun at the camp, screened through a 80 mesh sieve and divided to two packs, one to Japan and another to the Directorate of Mineral Resources of Indonesia, for chemical analyses in the assay laboratory. The total number of samples reached 175, including the spare samples, of which 160 samples were sent to Japan for the chemical analyses of Cu and Mo elements in the assay laboratory.

2-3 Report

In addition to the discussions made one after another at the survey fields or camps on the survey results, either in the reconnaissance or detailed survey, the compilation work of preliminary geological maps and others were performed at the base camp and in the Directorate of Mineral Resources, after completion of field survey. Data processing and interpretation were carried out and the comprehensive study was made in Japan. Thus, these studies and conclusions were summarized in this report. In addition, the laboratory analyses and observations were made on the samples collected through the reconnaissance and detailed surveys, respectively, as follows.

101 samples for petrographic microscopic examination; 24 samples for ore microscopic examination; 56 samples for ore chemical analysis; 5 samples of granitic rocks for determination of their absolute age; 11 samples of igneous rocks for complete analysis; and 10 samples for X-ray diffraction analysis.

2-4 Survey Team and Schedule

2-4-1 Survey Schedule in Indonesia

The second phase survey was carried out in accordance with the following schedule.

Period covered	15 May, 1980 to 10 February, 1981

Of the total period covered the survey period in the field was as follows.

Departure of advance party and preparatory work	3 June, 1980 to 22 June, 1980
Departure of main party and mobilization to the survey area	23 June, 1980 to 1 July 1980
Reconnaissance survey	2 July, 1980 to 15 August, 1980
Detailed survey	16 August, 1980 to 4 September, 1980
Demobilization and return of main party to Japan	5 September, 1980 to 13 September, 1980
Data processing in Indonesia and return of survey team leader to Japan	13 September, 1980 to 12 October, 1980

2-4-2 Survey Team

(1) Planning and consultation

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

(2) Survey members

Indonesian Team		Japanese Team	
Leader:		Leader:	
Ir. Yaya Sunarya	(D.M.R.)	Sakae Ichihara	(M.M.A.J.)
Members:		Members:	
Ir. Koswara Yudawinata	(D.M.R.)	Fukio Kayukawa	(M.M.A.J.)
Subandi Widasaputra	(D.M.R.)	Kiyohisa Shibata	(M.M.A.J.)
Tatto Sudharto	(D.M.R.)	Atsushi Takeyama	(M.M.A.J.)
Simpwee Soeharto	(D.M.R.)	Susumu Takeda	(M.M.A.J.)
Johny R. Tampubolon	(D.M.R.)	Yasushi Komoda	(M.M.A.J.)
Danny Z. Herman	(D.M.R.)	Hirofumi Furuta	(M.M.A.J.)
Sukmana	(D.M.R.)		
Yan Soalon Manurung	(D.M.R.)		
A. Muchsin	(D.M.R.)		
Wachyu III	(D.M.R.)		
Moe'tamar	(D.M.R.)		
M. Rachmat	(D.M.R.)		

(Note): D.M.R. : Directorate of Mineral Resources, the Republic of Indonesia

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

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

CHAPTER 3 PREVIOUS SURVEY

Geological reconnaissance surveys 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 and Central Kalimantan areas had been performed by Dr. Krol (1920) and Dr. Zeylmans Van Emmichoven (1931 ∿ 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 and geological structure of Kalimantan.

The subsequent analyses of geological structures in West Kalimantan and Northwest Sarawak, including Sundaland and Malaysian Sarawak, had been performed by Dr. Katili (1965 ∿ 1973), 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 Gunung 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 alluvinum 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 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, a survey including the detailed geological and geophysical curveys, drilling exploration and the alluvium placer gold prospecting is at present continuing over the geochemical anomalous areas and over the placer gold area at Sambas as well.

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

CHAPTER 4 OUTLINE OF SURVEY AREA

4-1 Location and Accessability

The project area covering 1,500 km^2 is located at the northwest part of West Kalimantan, the Republic of Indonesia. (See Fig. 1-1)

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.

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 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, Capital of West Kalimantan Province, runs 145 km northward along the seaside road to Singkawang, the second biggest city in the same province, and reaches Bengkayang, 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 where the base camp was set for the survey in the north part.

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, Paphuman 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 ease of arriving Darit even by a passenger car.

However, the road between Darit and Bengkayang is still kept unpaved, hard in passing through even by a jeep.

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 across S. Kapuas running at the north of Pontianak, but if it is in congestion, a long time waiting is enforced.

4-2 Circumstance 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 (Governer), 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 the Chinese-Indonesians are occupying more than 60% of total population in Singkawang where is the central city for them. Besides them, there lives another 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 centrury, and the placer gold mining had been flourished at Hampavah, Montrado and Bengkayang, where have all been well known as "Chinese District" since the mid-18th centruy.

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 infectious diseases from river water. Also, as the area is in the tropics, malaria is a common disease.

4-3 Climate and Vegitation

Owing to the survey area to be located nearly on the equator, the climate is characterized by the so-called tropical climate having a high temperature and a high humidity with a plenty of rainfall. Fig. 1-3 gives the annual precipitation record of 1975 ∿ 1979 at Bengkayang, according to which the total annual precipitation reaches up to 2,900 ∿ 3,850 mm, the monthly record showing 100 ∿ 200 mm even during the dry season from June to August, while reaching 300 ∿ 350 mm during the rainy season from September to May. (Fig. 1-3)

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.

Owing to the high temperature with a high humidity in general, the tropical plants have luxuriantly grown, forming a tropical forest zone. There is not much of short vegitation under the tropical forest zone in the mountain region, but 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 very difficult to enter into the field, except for the areas along a road or a river.

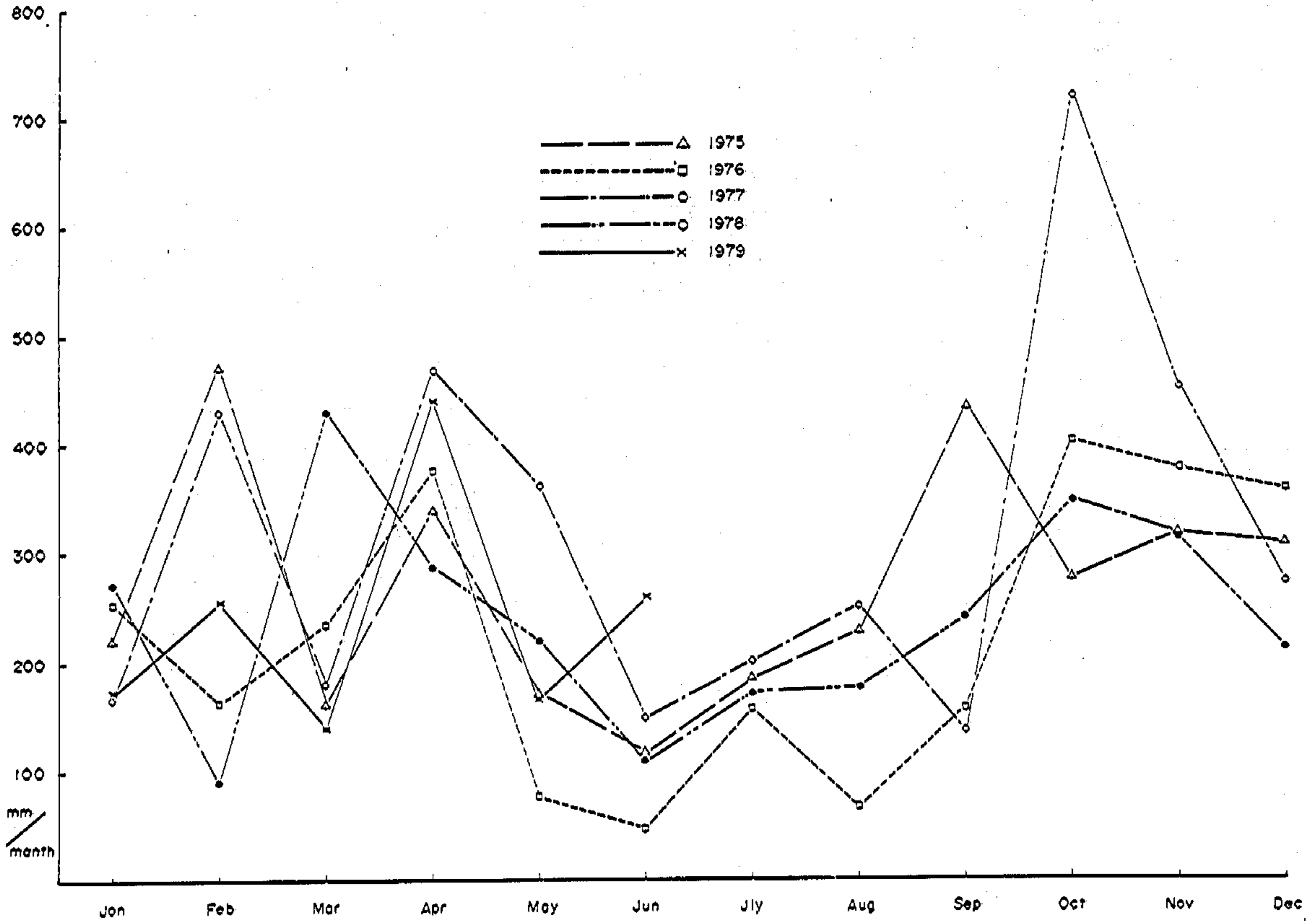

Fig 1-3 Precipitation at Bengkayang

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PART Ⅱ

GENERAL DISCUSSION AND CONCLUSIONS

CHAPTER 1 GENERAL DISCUSSION

The second phase survey consists of reconnaissance survey (geological and geochemical surveys, and placer gold prospecting, covering 1,000 km^2) and the detailed survey (geological and geochemical surveys, covering 50 km^2) over the Serantak and Banyi mineralized zones, resulting in the acquisition of many new data and information on the geology and ore deposits in the survey area, together with the advancement in interpreting the relationship among the geology, geological structures and ore deposits.

1-1 Geological Outline of Survey Area

The reconnaissance geological survey has been completed over the total area of 1,500 km^2 assigned to this project, resulting in the clear interpretation on the geology in this area. Consequently, this area can broadly be classified into the following geological epoches, through which the geological structures, igneous activities and mineralizations in this area can be characterized.

(1) Thick flysh sedimentary rocks were deposited during the period from Late Triassic age to Early Jurassic age.

(2) Extrusion and depositions of andesite, dacite and their pyroclastic rocks in Jurassic age.

(3) Intrusions of granodiorite batholith during Middle Cretaceous age.

(4) Intrusions of dacite and tonalite, andesite dykes and deposits of dacitic pyroclastic rocks during Tertiary age.

Beginning with the sandstone deposits accompanied by a little of acidic tuff, Upper Triassic - Lower Jurassic sedimentary rocks (Bengkayang Group), consisting of sandstone, siltstone and mudstone, has been rythmically accumulated as the normal thick sedimentary rocks (flysh type).

Two species of ammonite fossil at the Lower Jurassic Toarcian stage were discovered on the upper formation of th Bengkayang Group. This ammonite fossils are correlated with those of Tethys fauna, belonging to the same fossil fauna group as those in the Europe and Toyora Group in Japan, and the yieldings in this area were very important for a comparion among these Tethys fauna formations.

The andesite, dacite lavas and their pyroclastic rocks (Jirak and Belango Formations), generated during the period from Middle-Jurassic age before Cretaceous age, were widely deposited. Basal conglomerate was partially overlain on Bengkayang Group unconformably. The igneous rock group (Matan Complex by Dr. Bemmelen, 1949) having an extensive distribution at south of Schwaner mountain range (southwest Kalimantan) has conventionally been compared with the Upper Triassic group, but it may be correlated with the Jirak and Belango Formations determined as Jurasic age in this survey.

In the southern part of this survey area, the granodiorite has intruded at both Gunung Raya and Gunung Sebiawak as a large scale batholith, giving the contact metamonphism (serictitization, silicification, and epidotization).

The granodiorite is chiefly representative in the rock facies, however, the quartz diorite and granite are recognized as stocks or dykes. The K-Ar absolute age dating dated as 114 - 103 m.y. for granodiorite and 98 - 95 m.y. for quartz diorite, resulting in an intrusion during Middle-Cretaceous age.

Sirih and Banyi Tonalites as the younger granitic rocks, are widely distributed as stocks in the survey area. The K-Ar absolute age dating dated as 27 - 20 m.y. for these tonalites, resulting in an instusion during the period from Oligocene age to Miocene age.

Before the tonalite has intruded, the dacite (51 m.y. by the K-Ar absolute age dating) associating with dacitic pyroclastic rock deposits (Serantak dacite and dacitic pyroclastic rocks) has similarly intruded, which are all assumed consistently to be a series of formations during the younger igneous activities.

The granitic rocks intruded through the igneous activities from Cretaceous age up to Miocene age belong to calc-alkalic rock series equivalent with those of Japanese Island-arc in terms of the chemical compositions.

Also, these tonalite intrusive rocks can be classified into the magnetite granite series generally accompanied by the porphyry copper ore deposit, based on the classification of Dr. Ishihara (1977), as the results of opaque mineral examinations under microscope.

1-2 Outline of Geological Structure

West Kalimantan, including the survey area, is situated in the Cretaceous Magmatic Arc continuing from the east part of Malaysia to the central and southwest areas of Kalimantan through the project area, and also at the south area of Lupar-Chert - Ophiolite zone running along the south boundary of Northwest Borneo geosyncline (Tertiary age) as well as continuing around the boundary between Kalimantan and Malaysian Sarawak.

The major geological structure in the project area is, therefore, characterized generally by those of series trending toward NW-SE, caused by both the Cretaceous Magma Activity and the northwest Borneo geosyclinal structural movements. Namely, the older structure (anticlinal and synclinal axes) seen in both Bengkayang Group and Belango Formation is of NW-SE direction. Also, the direction of granodiorite batholith intruded during Cretacous age, the anticlinal axis of dome structure intruded by Sirih tonalite, the andesite dykes and faults are of NNW-SSE direction.

Besides the above, the structural directions of NNW-SSE, and NEE-SWW can be inferred from the alignment of quartz diorite, younger tonalite and dacite stocks intruded into the Cretaceous granodiorite batholith, and the shear zones accompanied by faults and mineralizations. They could be the structural lines caused by the block movement in the Cretaceous granodiorite batholithes.

1-3 Characteristics of Mineralization

Mineralizations in the survey area are divisible as follows.

(1) Chalcopyrite-molybdenite quartz vein (Sirih tonalite)

(2) Mineralized zones consisting of tourmaline, chalcopyrite molybdenite, pyrite and gold (Banyi tonalite and G. Raya granodiorite)

(3) Gold- and copper-bearing pyrrhotite ore deposits (Serantak dacite)

(4) Chalcopyrite disseminated zones (Banyi-type tonalite at Panji)

(5) Copper, lead and zinc bearing arsenopyrite ore vein (Jirak group at Selakean area)

(6) Manganese ore deposits (Serantak dacitic pyroclastic rocks)

(Note): Items in parentheses show the country rocks embedded ore deposts.

Besides the above, the pyrite disseminated zones accompanied by the silicification and argillization, as well as the areas accompanied by a little of chalcopyrite dissemination were discovered at many locations. Also, the pyrrhotite dissemination was sometimes found in the fine grained tuffaceous rocks of Banan Formation in Bengkayang Group which is the lowest formation in this project area.

These mineralizations are related to the younger igneous activities (acidic plutonic activity - hypabyssal igneous activity and volcanic activity during the period from Late Cretaceous age to Early Miocene age, i.e. Serantak dacite, Sirih tonalite and Banyi tonalite).

In addition to the molybdenite quartz vein of S. Takap and S. Sirih already known in the Sirin tonalite through the first phase survey, the other mineralizations of similar type were newly found at the upperstream of S. Banan in the Sirih tonalite extended further northward and distributed up to Gunung Buwah Obah. It was also revealed to have a possibility of distributing new molybdenite quartz veins, because the anomalous areas of molybdenum and copper were discovered through the geochemical survey conducted in this area.

The Banyi mineralized zone consists ot zonal arrangements dividing roughly into barren tourmalinized zone, chalcopyrite-molybdenite mineralized zone, argillized zones (sericite - chloride - quartz) accompanied by the pyrite along Banyi river, and gold mineralized zone, in order from center to outer. A little alteration was discovered in the chalcopyrite and molybdenite minnalized zones, indicating the weak mineralization even at the surface outcrops, but it was proved that the mineralizations along Banyi river were remarkable in the argillization, such as sericites, chlorites, etc., being accompanied only by the pyrite, and indicating no content of Cu and Au in the results of chemical analysis of these samples. The shear in these zones occurs along S. Banyi affecting a strong hydrothermal alteration in it, through which it could be a kind of pyrite halo where the pyrite is the main ore mineral with no content of Au and Cu.

The Panji mineralized zone newly discovered in this survey contained the chalcopyrite in the veinlets in the Banyi type tonalite.

The Selakean mineralized zone was distributed at the east part of this project area. The copper, zinc and gold bearing arsenopyrite ore deposits were embedded in Jinak andesite Formation, locating away from the tonalite stocks, together with the gold and copper bearing pyrrhotile ore deposits around the Serantak dacite.

1-4 Relationship Among Geological Structures, Igneous Activities and Mineralizations

The mineralizations in this area proved the relationship with the activities of younger acidic igneous rocks from Late Cretaceous age to Early Miocene age, such as Serantak dacite and Sirih and Banyi tonalite, which are distributed as stocks.

These acidic igneous rocks have been intruded, being controlled by the NE-SW structural line of block movement occurred in the Cretaceous granodiorite batholithes (G. Raya granodiorites, etc.) as well as by the general structural line of NW-SE. The mineralized zones were also embedded in the fissures and shear zones in these structural lines.

1-5 Correlation between Geochemical Survey Result and Mineralized Zones

The geochemical survey with stream sediments was conducted in the reconnaissance survey area (1,000 km^2), resulting in 4 locations of anomalous areas mainly with Mo, 3 locations mainly with Cu, 4 locations mainly with Cu-Mo and 2 locations mainly with Pb and Zn, totaling to 13 locations.

Nothing special was, however, found in the correlation among Mo, Cu, Zn and Pb with each other, but a little between Pb and Zn.

The Mo anomalous area was especially well correlated with the molybdenite mineralized zone distributing in the Sirih tonalite, as same as the results of first phase survey.

No molybdenite mineralization was confirmed yet in the G. Buru and G. Buwah Obah molybdenite anomalous area through this survey, but a new molybdenite mineralization is expected to be discovered in this area, from the results of this survey.

The Cu anomalous area was discovered in the Panji mineralized zone newly found through this survey, where the Mo anomolous area co-existed as well. These anomalous areas are very important to coincide with the Panji mineralized zone.

The Zn anomalous area was coincided with the Selakean mineralized zones, being accompanied by the Cu and Mo anomalies. It is noticeable that anomalous area is inferred to indicate Selakian mineralized zone representing zinc-copper bearing arsenopyrite deposit were recognized in the other anomalous areas of Cu, Mo, Zn and Pb, respectively.

An anomalous area of either Cu or Mo was found through the geochemical survey with soil samples collected in the detailed survey area, ranging in a good correlation with those of mineralization outcrops. Through the results of thes surveys, the sampling of stream sediments in the reconnaissance survey as well as sampling of soils in the detailed survey proved very effective and useful to investigate and locate the mineralized zones in this area.

CHAPTER 2 CONCLUSIONS AND FUTURE PROGRAM

2-1 Conclusions

Following the first phase survey, the second phase survey was conducted with the detailed survey (geological survey and geochemical survey) to evaluate the two mineralized zones (Serantak and Banyi areas, 50 km^2 in total) located from the first phase survey, as well as to continue the reconnaissance survey (geological and geochemical surveys) with the purpose to locate the prospective mineralized zones, in addition to investigate the geology, geological structures and mineralized zones in the area (1,000 km^2) remained from the first phase survey.

The conclusions resulted from the second phase survey are as follows.

(1) The geology and geological structures were clarified of the total area (1,500 km^2) subject to this project, i.e. both the stratigraphy and their age were clarified of the formations consisting of the sedimentary rocks, volcanic rocks and pyroclastic rocks.

For the igneous activities, the granodiorite batholith extensively distributed in the project area and the granitic rocks intruded into the batholith were specifically classified into the granodiorites and quartz diorites intruded during Middle Cretaceous age and the tonalites intruded during the period from Eocene age to Early Meocene age, through the geological survey and K-Ar absolute age dating.

For the geological structures, the general structural direction of NW-SE was confirmed in West Kalimantan. Also, the structural line of NE-SW was assumed in the block movement structures found in the granodiorite batholith.

It was also assumed that the younger igneous rock intrusions were confined from these geological structures and provided the places for miniralization.

(2) Based on the chemical analyses and the absolute age dating with the plutonic rocks newly added from this survey, the rock facies classification through the microscopic examinations and the results of comprehensive study made together with the results from the first phase survey, the granites in this area were classified into two categories in terms of age.

Namely, the granodiorites of G. Raya type extensively distributed as batholith in this survey area were dated as 114 - 103 m.y., the quartz diorites of Tiang type were the Middle Cretaceous intrusives during a period 98 - 95 m.y. and the dacites of Serantak type and the tonalites of Sirih and Banyi type, both being distributed as the instrusives during a period 51 - 20 m.y., from which they were all verified to be caused by the igneous activity during a period from Middle Cretaceous age to Early Miocene age.

Judging either one from the results of chemical analyses, they all belong to the igneous rocks near to the calc-alkalic rock series of island arc type similarly in Japan.

According to the results of microscopic examinations with the opaque minerals sampled, they are all classified into the magnetite series granite predominant with the magnetite (common in the porphyry-copper ore deposits, according to the classification of Dr. Ishihara).

(3) Several mineralized zones were newly discovered in the reconnaissance survey area. Of them, noticeable were both the Panji chalcopyrite mineralized zone and the Selakian copper and zinc bearing aresenopyrite mineralized zone to be further investiged in the future.

In the detailed survey area, the mineral conditions and characteristics were clarified on the Banyi mineralization. A new chalcopyrit-molybdenite mineralized zone was also found at S. Banan area, which is thought of a northward extension of Sirih-Takap mineralized zone.

Judging from the mineralizing conditions, such as number, width, scale and grade of the ore veins, it seems to be not potentially embedding the molybdenite veins. However, because of the facts that an extensive distribution of tonalites embedding the molybdenite veins was found at the north of this mineralized zone through the reconnaissance survey and that a Cu-Mo anomalous area was discovered around the tonalites through the geochemical survey, a possible bearing of new molybdenite mineralized zone can be expected at north of Sirih Tonalite stock.

(4) For the investigation techniques to locate the mineralized zones in a wide area through a reconnaissance survey, the geochemical survey collecting the stream sediments was applied in this survey area. Also, in order to investigate the mineralized area distribution in the

detailed survey area, the geochemical survey sampling soils was applied in a subgrid system. Both methods disclosed the anomalous areas indicating an existence of mineralized zone, from which they proved very effective to the reconnaissance and detailed surveys, respectively.

(5) In the central and west parts of Kalimantan where the collaboration survey between Japan and Republic of Indonesia has been conducted, the copper, bolybdenum and gold mineralizations have been recognized in the survey areas, clarifying them to be derived from the igneous activities during Early Tertiary age.

Besides the above, the copper and molybdenite mineralizations, i.e. Gunung Ibu copper-molybdenite mineralization and Paloh copper mineralization, incidental to the same granitic rocks are well known in West Kalimantan, but any of these mineralized zones is assumed to relate to the younger igneous activities. Also, many other mineralizations are extensively distributed, such as Hg, Sb and so forth, but they are assumed as a link with those during the same era. They are not yet completely surveyed and interpreted.

The results obtained from the cooperations metallic mineral exploration survey in the central and west parts of Kalimantan will provide the very useful and fundamental data and information to investigate and interprete the mineralized zones in the Kalimantan area.

Viewing from these data and information, many mineralized zones of Cu, Mo, Pb, Zn, Hg and Sb extensively distributed in the Kalimantan area are very possible to relate to the younger igneous activities as same as those in the West Kalimantan.

2-2 Future Program

The mineralized zones in this survey area consist of those related to the igneous activities intruded during Tertiary, such as tonalites, dacites, etc. Many mineralized zones and indications have been recognized throughout both the first and second phase surveys. Further, the actual conditions of two minealized zones located from the first phase survey have been clarified by the second phase survey, discovering many new metalliferous veins as well.

The future program and issues are described hereunder, based on the interpretations and evaluations made on the results of project survey.

(1) Many mineralized zones and mineral indications are found in the recconnaissance survey area, among which both the Panji copper disseminated zone and the Selakean copper, lead and zinc mineralized zone are very noticeable. Especially, in the Panji area where the entire mineralization could not be clarified through the reconnaissance survey due to the poor conditions of exposure, the detailed geological survey, geochemical survey with soil sampling and geophysical survey (I.P. survey) may prove very effective in order to clarify the extensions of this mineralization.

Also, if the old trenches collaped at present are cleaned up to confirm the mineral conditions and the mineralization is hopefully expectable for the Selakean mineralized zone. Considerations should be given to the future detailed survey.

(2) Molybdenite mineralization was newly found at S. Banan of Serantak area of detailed survey area, situating at the northward extension of Takap - Sirih molybdenite quartz veins found through in the first phase survey.

These mineralizations were distributed in the Sirih tonalite which were confirmed through the reconnaissance survey to further extend up to G. Buwah Obah in the north area. Also, the Mo and Cu anomalous areas were recognized around them through the geochemical survey with stream sediments. Thus, a possible expectation can be held for finding a new metalliferous vein even in the Sirih tonalite around G. Buwah Obah.

Further, for the Banyi mineralizations, zonal arrangements of barren tourmalinization, copper - molybdentite mineralization, pyrite mineralization incidental to the sericite - chlorite alteration and gold - copper mineralization could be considered as a zonal arrangement.

Among the above, since Cu, Mo, Au, etc. were rarely found in the Banyi pyrite mineralized zone accompanying the specially strong alteration, along Banyi river, it is considered as the pyrite halo, having a poor bearing of ore minerals.

(3) For the mineralizations in the area of West Kalimantan, the interpretation has already been made to relate to the younger igneous activities of calc-alkalic rock series intruded during Early Tertiary age, through the collaborated metallic mineral resource survey in this project in addition to the survey already conducted in Central Kalimantan.

There are many mineralized zones and indications of Au, Hg, Sb and others in addition to Cu and Mo in West Kalimantan, as shown in Fig. 3-2. For examples, Gunung Ibu copper-molybdenite mineralization, Paloh copper mineralization, mercury mineralizations at upper stream of S. Kapuas, antimony mineralization around the boundary between Malaysia and Borneo, etc. are said to relate to the similar younger igneous activities (Taylor and Hatchison, 1978).

Referring the results of this survey to these mineralizations, to extend the study over the geology, geological structures and igneous rocks and the survey over the exploration of ore deposits, especially to clarify the correlation of these mineralizations with the younger igneous activities in the area of West Kalimantan, which were considered to have been generated, because the oceanic plate of northwest Borneo has, during Early Tertiary age, subducted under Sundaland of continental crust, means to geologically position the mineralizations in this area and their neighboring areas, providing the very important fandamental data and information for interpreting the ore deposit bearing conditions not only in the project area, but also in Kalimantan.

It is recommended to further continue the survey and interpretation on the mineralized zones currently known, based on the results of this survey.

PART Ⅲ

RECONNAISSANCE SURVEY

CHAPTER 1 OUTLINE OF SURVEY AREA GEOLOGY

1-1 General Geology in West Kalimantan

The west area of Kalimantan, including the survey area of this project, is situated at the eastern surrounding of Sundaland, making part of the south end of Asian continent (Fig. 3-1).

West Kalimantan island, including Malaysian Sarawak and southwest Kalimantan, is geologically divided into the three regions as follows.

(1) Central Kalimantan (Schwaner mountain)

The region having a cratonized stable block, after sedimentations repeated during the period from Palaeozonic age to Early Mesozoic (Triassic) age and reception of orogenic movement incidental to the older granite intrusions.

(2) North and south areas 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.

At the north side of Schwaner mountain, the recent survey has revealed that many granitic rocks 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 consisiting 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

Lupar Chert-Ophiolite zone exists, extending over 250 km around the boundary between Kalimantan belonged to Indonesia and Malaysian Sarawak. At its north, the thick geosynclinal sedimental formations have been deposited, such as Rajang Group consisting of the flysh sedimentary formation and Baram Group consisting of sandstone and limestone sedimentary formations, formed by the northwest Borneo geosynclinal movement during the period from Late Cretacous age to Tertiary age (Haile, 1969) (Fig. 3-2).

Rajang Group consists of the ophiolite, radioralian chert and limestone, being considered as melange by Dr. Hamilton (1978).

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 south-eastward and nothward 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 melange, is considered to indicate a zone where the oceanic plate of south China sea has subducted south-westward under the continental plate of Kalimantan, during the period of northwest Borneo geosynclinal movement. (Hamilton, 1978; Hatchison, 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 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

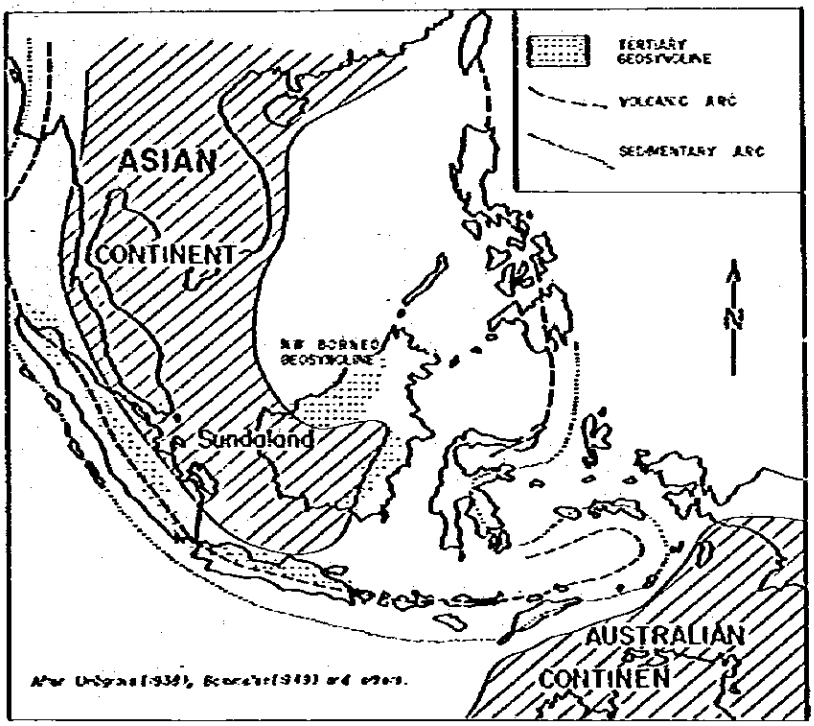

Fig 3-1 Map of Sundaland

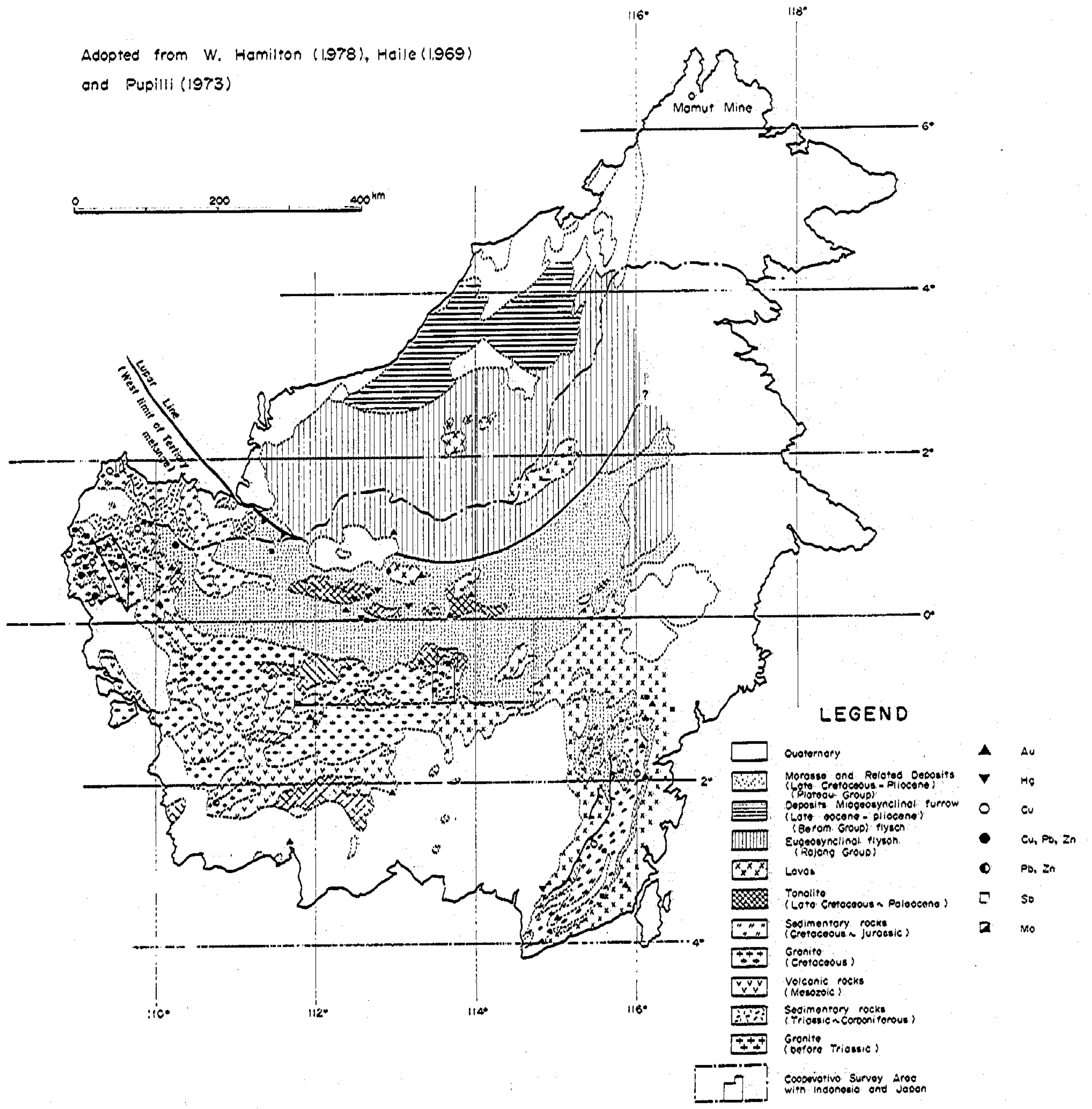

Fig 3-2 Geological and Metallic Mineral Distribution Map of Kalimantan

survey recently conducted at a collaboration between 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 techtonics 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 minerelizations 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.

1-2 Outline of First Phase Investigation

The geology at the north part of the first phase survey area ($500\ km^2$ to include G. Bawang, Benkayang and G. Raya) is summarized as follows.

1-2-1 Geology

(1) Mesozoic sedimentary rocks, volcanic rocks and pyroclastic rocks

The Bengkayang Group has been deposited from the top as follows. are extensively distributed from the north mountain region of Gunung Bawang - Gunung Mahmud up to the plains of Benkayang - Sungaibetung.

The Bengkayang Group is deposited from the top as follows.

Sungaibetung Formation	:	Alternated beds of sandstone, silstone and mudstone
Riampelaya Formation	:	Sandstone
Kalung Formation	:	Black shale
Banan Formation	:	Tuffaceous sandstone, sandstone

The ammonite fossils are found at the top horizon of Sungaibetung Formation to indicate the Lower Jurassic series. Covering the Bengkayang Group unconformably, both the Jirak Formation consisting of andesite and andesitic pyroclastic rocks and the Belango Formation consisting of andesite and decitic pyroclastic rocks are distributed.

(2) Cretaceous granodiorite

The granodiorite and quartz diorite are extensively distributed at the south area, intruding into Bengkayang Group, Jirak Formation and Belango Formation.

The K-Ar absolute age dating indicates the granodiorite to be during Middle Cretaceous age.

(3) Younger tonalite

The Sirih and Banyi tonalites intruded during the period from Oligocene age to Early Miocene age are distributed at both the mountain region of Gunung Bawang - Gunung Mahmud and the area of S. Banyi.

(4) Tertiary dacite and dacitic pyroclastic Formations

The Serantak dacites and dacitic pyroclastic rocks are extensiverly distributed around the mountain region of Gunung Bawang.

(5) Quaternary

The quaternary system consisting of unconsolidated pebble, sand and silt are distributed along the rivers in the plains.

1-2-2 Mineralization

The pyrite-bearing molybdenite quartz veins are distributed in the Sirih tonalite; the pyrite, molybdenite, chalcopyrite, mineralizations and gold-bearing quartz veins in the Banyi tonalite; and the gold-bearing pyrrhotite ore deposits around the Serantak dacitic stocks.

Based on the close relation of these mineralizations with the above-mentioned younger igneous rocks intruded during the period from Obligocene age to Miocene age, these mineralizations are clarified to be caused by these younger igneous activities.

1-3 Geological Outline of Second Phase Survey Area

Based on the results of first phase survey, the geology of second phase survey area is classified into the Upper Triassic - Lower Jurassic sedimentary rocks, Jurassic Volcanic rocks and their Pyroclastic rock formation, Middle Cretaceous granitic rocks, pyroclastic rocks, Tertiary volcanic rocks, pyroclastic rocks and Intrusives, and Quaternary system.

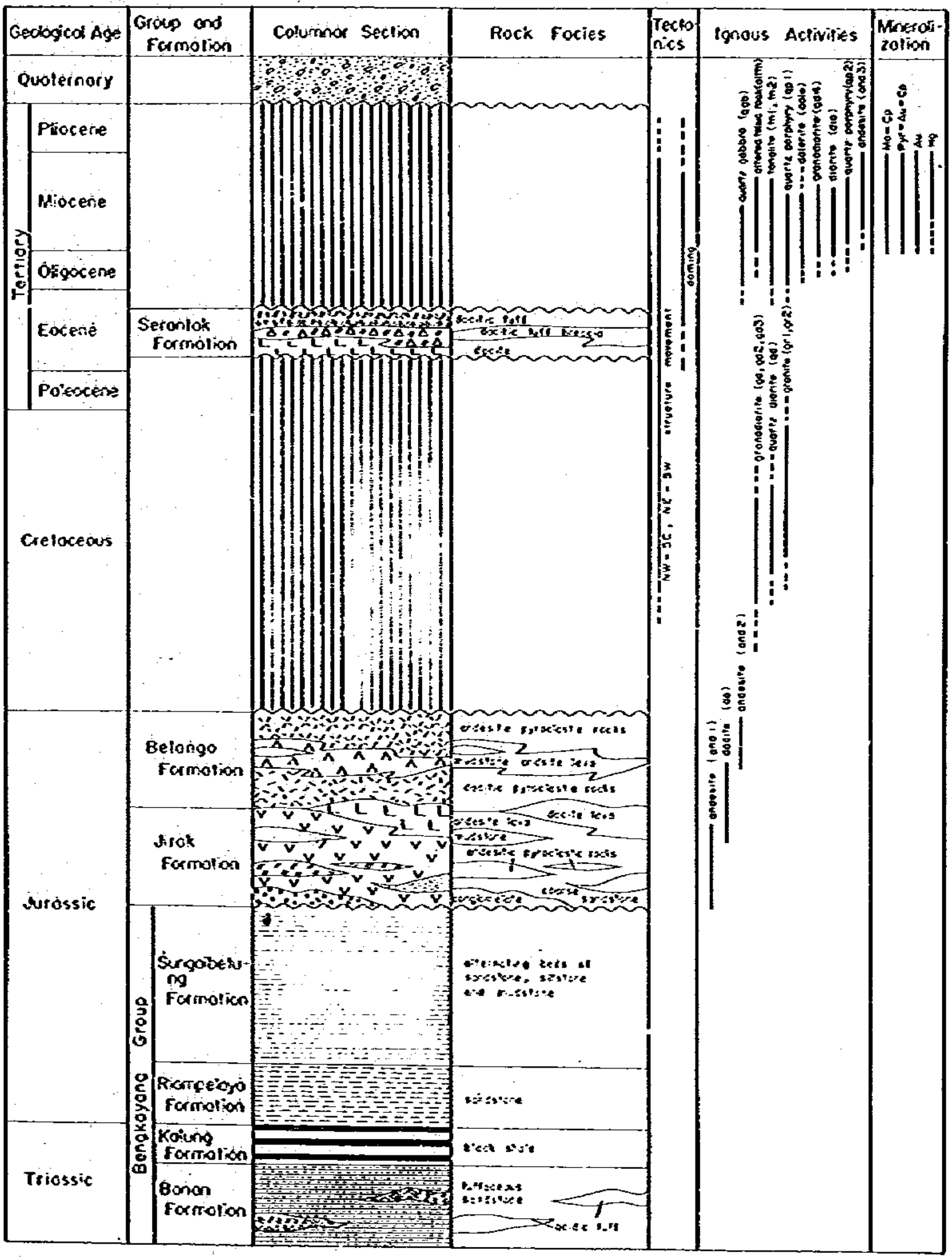

Fig 3-3 Generalized Stratigraph of Survey Area

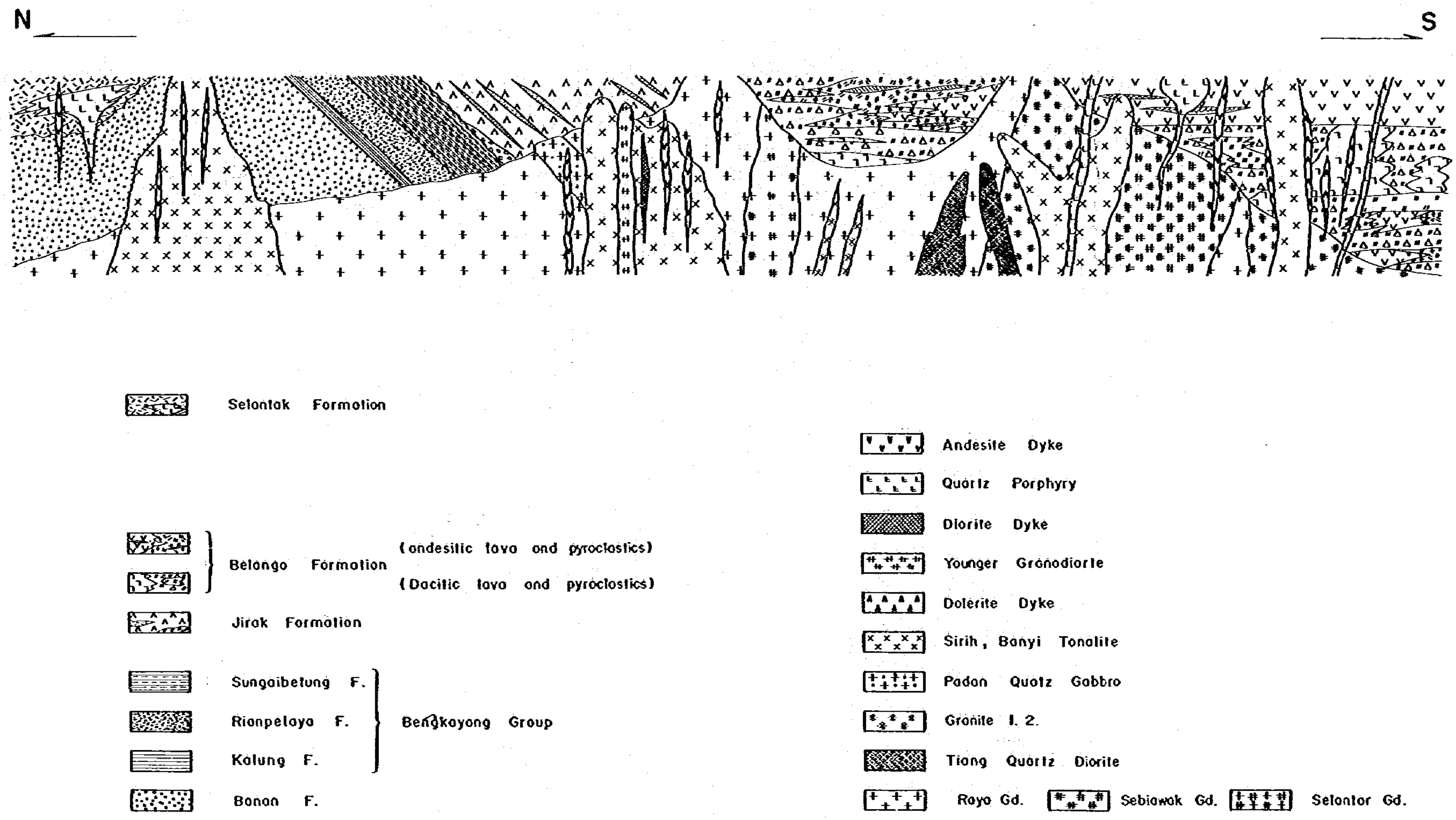

Fig 3-4 Schematic Geological Profile

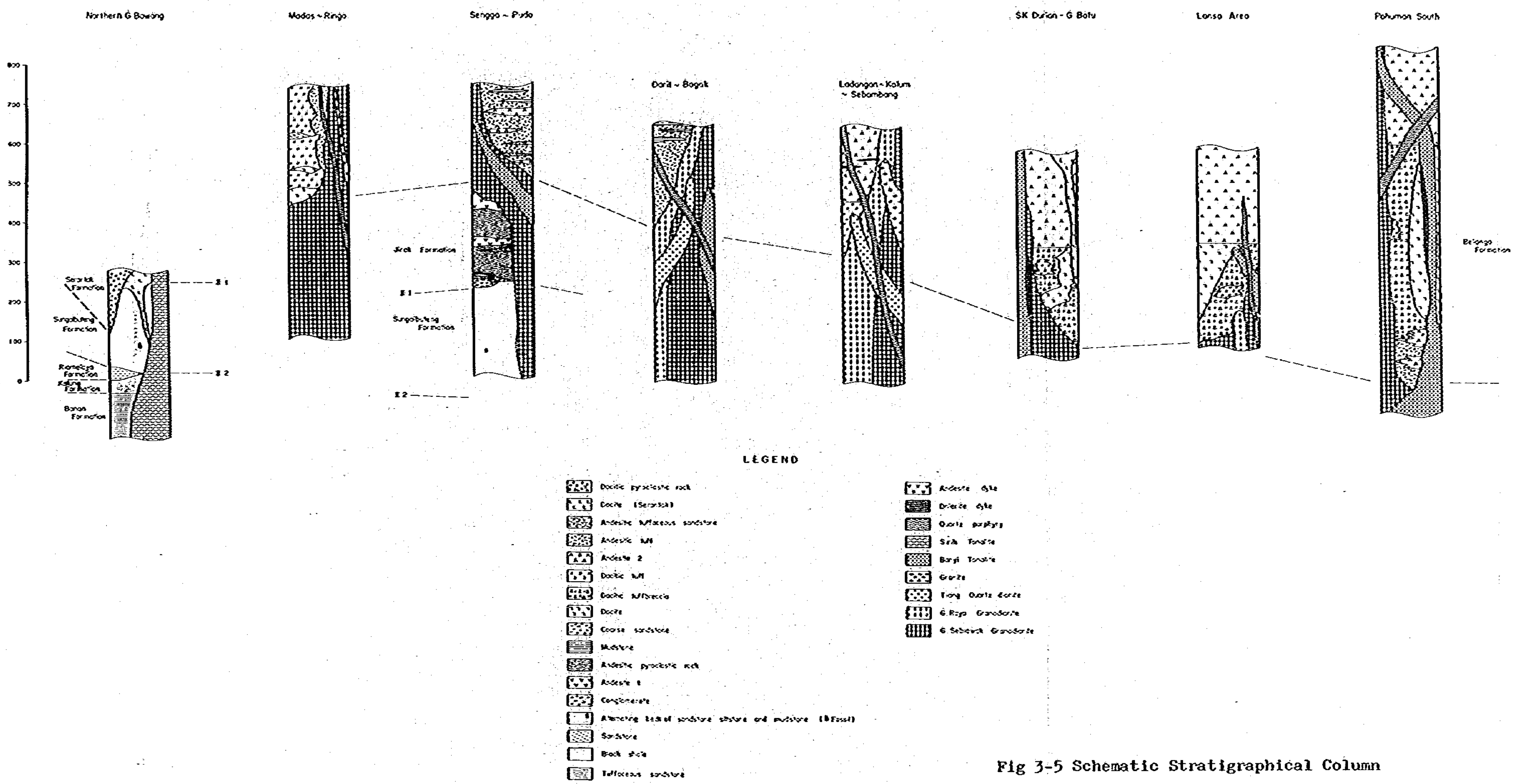

Fig 3-5 Schematic Stratigraphical Column

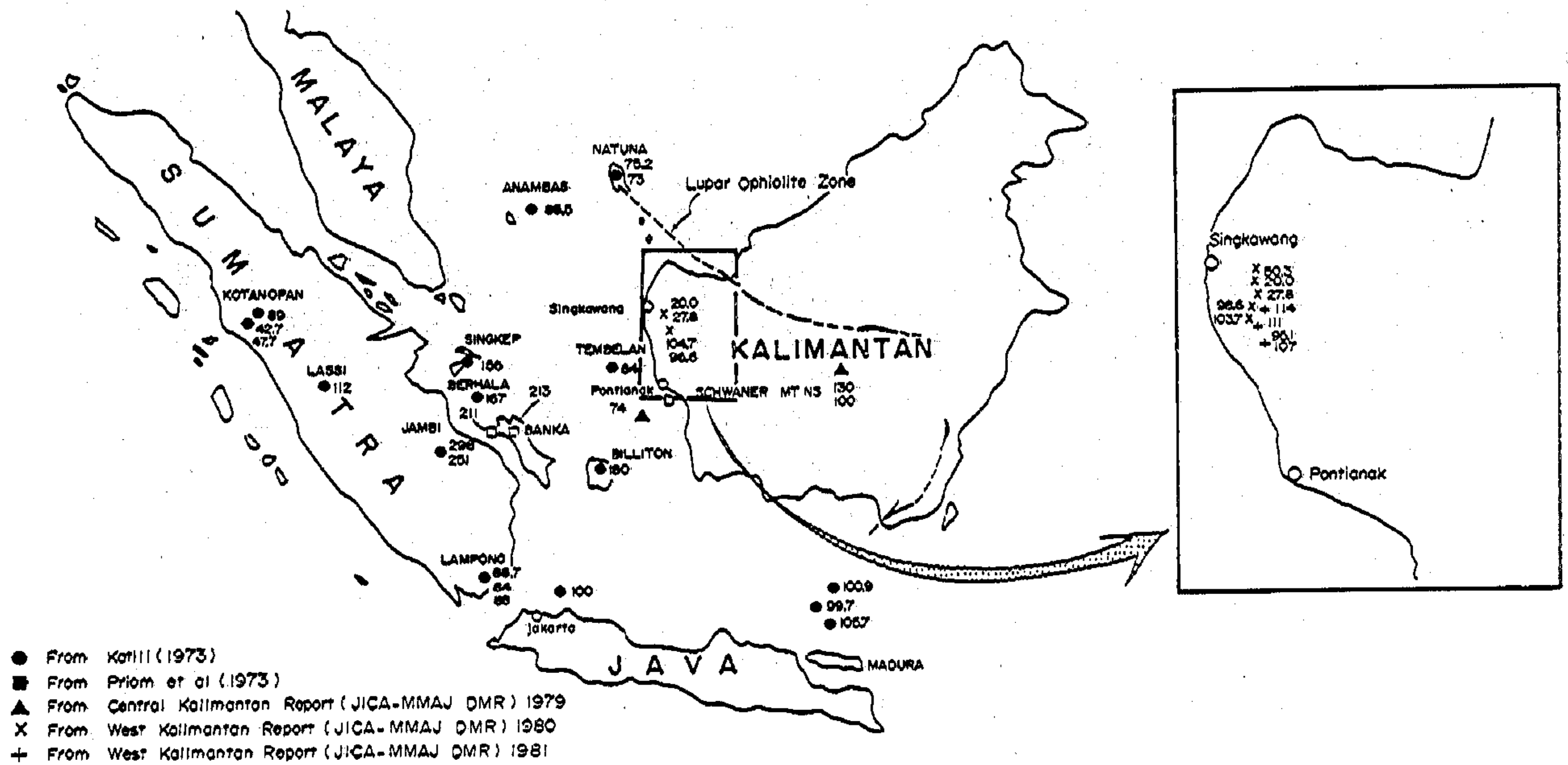

Fig 3-6 Absolute Age of Granitoid Rocks in Kalimantan

The names used for formation and igneous rocks in this report are made in a combination with those of place, river or mountain where the said formation or igneous rock is dominantly exposed of, in order to avoid the same from being confused in any existing books and other literatures. Some use the same names in the first phase survey, while the others are given new names in the above manner.

1-3-1 Upper Triassic - Lower Jurassic Sedimentary Rocks

Based on the stratigraphic classification applied in the first phase survey, the older sedimentary rock formations consisting of tuffaceous sandstone, hard black shale, fine grained sandstone, sandstone, siltstone and mudstone from the lower bed and being extensively distributed from the east side of Bengkayang to the north side of Gunung Bawang, was classified as Bengkayang Group and named as follows.

Bengkayang Group: Sungaibetung Formation
Riampelaya Formation
Kalung Formation
Banan Formation

These Formations were correlated with Upper Triassic - Jurassic System under the surveys of Dr. Wing Easton (1904) et al. However, owing to a discovery of ammonite fossils to correlate with the Lower Jurassic System Lias Series Toarchian stage at the upper horizone of Sungaibetung Formation through the first phase survey, Bengkayang Group was correlated with Upper Triassic - Lower Jurassic System.

The fragments of identical ammonite fossils were also found in the Sungaibetung Formation at the southeast part of Bengkayang in this second phase survey.

Owing to the intrusion of Tertiary tonalite rocks into the Bengkayang Group at the northest end of mountain range from Gunung Bawang to Gunung Mahmud in this survey area, the Bengkayang Group was domed up, showing a dome structure and undergoing the thermal metamorphism at the lowest formation.

1-3-2 Jurassic Andesite, Dacite and Dacitic Pyroclastic Rocks

(1) Jirak Formation

This Formation consisting of andesite, andesite pyroclastic rocks and unconformably overlying the Sengaibetung Formation in Bengkayang Group is distributed at Gnung Selakean in the survey area.

The fine grained congomerate bed unconformably overlies in part, where the tuffaceous siltstone and sandstone are also existed and intercalated into the Formation.

This Formation was named Jirak Formation, together with the andesite lava extensively distributed in the Tiang area at the west side of this survey area.

This Formation is partly affected by the thermal metamorphism due to the intrusion of G. Raya granodiorite.

(2) Belango Formation

This Formation is extensively distributed to the south area of Pahuman village and to the west side of Gunung Tiang in addition to the area along the road between Bengkayang and Darit, the west slope area of Gunung Tiang, the south area of this survey area, and the area from Pejambonsari village to around Gombang village.

This Formation consists of the dacitic pyroclastic rocks containing lava, tuff, tuff breccia and partly andesite lava in the lower horizon and andesite in the upper horizon intruded by the G. Sebiawak granodiorite and altered with thermal metamorphism due to the intrusions of G. Raya granodiorite and G. Sebiawak granodiorite.

1-3-3 Cretaceous Plutonic Rocks

At the south area occupying two-third of total survey area to include the first phase survey area, the biotite hornblende granodiorite of batholith type extensively intruded during Mesozoic Middle Cretaceous age are widely distributed, into which the quartz diorite and granite have intruded in the form of stocks or dykes.

The granodiorite is classified into the medium grained biolite hornblende granodiorite, coarse grain granodiorite and prophyritic granodiorite. They are named the G. Raya granodiorite, G. Sebiawak granodiorite and G. Selantar granodiorite, respectively.

1-3-4 Dacitic Lava and Pyroclastic Rocks

The dacitic stocks and lavas having coarse grained quartz and plagioclase phenocrysts are distributed around G. Bawang, accompanying the tuff breccia, lapilli tuff and tuff.

The identical dacitic stocks have intruded into the Bengkayang Group at Sansak, Jirak Formation at Gunung Semalo, G. Raya granodiorite at the east side of Tiang Aping, porphyritic granodiorite at Kulampe, Belango Formation at Kalumi and Gunung Batu and Gunung Sebiawak granodiorite.

The detailed survey at S. Banan area in the second phase survey has proved that Sirih tonalite has intruded into Serantak dacite, as explained in a later section, and the K-Ar absolute age dating has determined the dacite as pre-Sirih tonalite. Thus the descriptions for relationship of both rocks in the first phase survey report are accordingly to be corrected.

1-3-5 Younger Plutonic Rocks

The tonalite identical to the Sirih tonalite has intruded at Gunung Buwah Obah at the north side of Gunung Bawang. Also, the tonalite accompanying copper mineralization are distributed at Panji at the south side of Darit. They are regarded as same age as Sirih tonalite intruded during the period from Oligocene age to Miocene age.

Further, the tonalite stocks similar to Banyi tonalite, but accompanying no mineralization, are distributed at Kayuaga village, Gunung Belakan, Gunung Sematuh and Gunung Seburuh.

The dorelite dykes are found at several areas, e.g., the dykes intruded into the faults cutting G. Raya granodiorite at S. Tikalang and the stocks around Gunung Samarade at the west side of Pahuman, running toward NE-SW direction and accompanying the tonalite at Ngadan village.

Also, the diorite dykes are distributed around Palehaloan at the west side of Pahuman and it has intruded into G. Sebiawak granodiorite, striking NE-SE.

In addition, there are many small dykes, such as andesites and quartz porphyries which have intruded into G. Raya and G. sebiawak granodiorite and Belango Formation. One of them distributing around Pahuman is large scale vein.

1-3-6 Quaternary

Quaternary system is distributed at the plain areas along rivers consisting of unconsolidated pebbles, sand and silt.

CHAPTER 2 STRATIGRAPHY

2-1 Sedimentary Rocks (Bengkayang Group)

Mesozoic sedimentary rocks are distributed at the north side of Gunung Bawang and at the southeast side of Bengkayang, among the areas of this survey. These sedimentary rocks belong to Bengkayang Group, as classified in the first phase survey.

Bangkayang Group consists of tuffaceous sandstone, black shale, sandstone containing pyroclastic materials, very thick alternated beds of sandstones, musdstone and siltstone, from the lower formation, i.e., the sedimentary formation beginning from the sandstone sedimentation accompanying pyroclastic rocks of Late Triassic up to the alternated formations of sandstones and mudstones of Early Jurassic age. This Group is divided into four Formations, i.e. Banan Formation, Kalung Formation, Riampelaya Formation and Sungaibetung Formation from the lower Formation. The Group is characterized like Flysh type sedimentary rocks, showing rhysmical sedimentation with thick sandstones and siltstones.

2-1-1 Banan Formation

(1) Distribution

This Formation is distributed to the upperstreams of S. Bukuan, S. Molo and S. Bejuan, centering at the mountain range of Gunung Buwah Obah, Gunung Bawang and Gunung Mahmud.

It forms a dome structure with the thermal metamorphism due to the intrusion of Sirih tonalite.

(2) Rock facies and lithology

This Formation has a dark grey, hard medium grained (tuffaceous) sandstone, intercalating with fine grained tuffaceous sandstone and the coarse grained tuff, sometimes hard black shale, laid partly at Gunung Serantak, S. Molo, S. Bejuan and S. Bekuan.

The rhyolite sheet, containing quartz phenocryst, is found at the east slop of Gunung Serantak.

From the microscopic observation, it consists of the fragments of dacite, chert, mudstone, andesite, quartz, and plogioclase, more than 0.5 mm in size and the matrix chiefly composed of quartz grains.

Epidote and calcite occur as the altered minerals. The fine grained felsitic rocks (RA-18) are very siliceous, consisting of the fine grained quartz, plagioelase, dacite and andesite fragments.

Table 3-2 gives the results of chemical analysis examined on the siliceous tuff (RG-200), a member of this felsic rock, connecting to the copper-bearing pyrrhotite ore deposits on the east slope of Gunung Serantak. According to this, it is a rhyoritic tuff having a plenty of silica content. The fine grained siliceous tuffs similar to this rock (RG-200) are partly mineralized with pyrrhotite dissemination.

(3) Thickness: Approximately 1,500 m or more

(4) Fossil: Not discovered

(5) 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 igneous 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.

2-1-2 Kalung Formation

(1) Distribution

This Formation was confirmed of the distribution around Sirih tonalite rocks and overlay conformably Banan Formation, through the first phase survey. The Formation continues at the north side of Gunung Bawang, i.e. extensively distributing at S. Bendah, S. Holo and S. Kalangan.

(2) Rock facies and lithology

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, feldspare, calsite, silicate minerals, and some hornblende, showing weak holnfels.

(3) Stratigraphic correlation

This Formation has overlay comformably on Banan Formation. This is also, overlain conformably by Riampelaya Formation, but Riampelaya Formation thins out at the east side of Gunung Serantak, being directly overlain by Sungainbutung Formation.

A fact that this Formation has been overlain in an angular unconformable relationship by Serantak dacitic pyroclastic rock Formation was observed at S. Bejuan Besar. Kalung Formation could be regarded as an upper bed of Banan Formation, because Banan Formation intercalates with similar shale in it, but it was named Kalung Formation, the same as in the first phase survey.

(4) Thickness: 100 m

(5) Fossil: Not discovered

2-1-3 Riampelaya Formation

(1) Distribution

This rock is extensively distributed at the west area of Gunung Bawang, thining out it at the northeast side of Gunung Bawang and at the east side of Gunung Serantak.

(2) Rock facies and lithology

This rock is light grey, medium-fine grained sandstone.

(3) Thickness: 0 ∿ 300 m

(4) Fossil: Not discovered

2-1-4 Sungaibetung Formation

(1) Distribution

This rock is distributed around the north of Lumar and along the rivers of S. Toban and S. Mayun, as the top formation of Bengkayang Group.

Owing to thining out of Riampelaya Formation, at the north of Lumar, this is deposited directly on Kalung Formation. This is distributed at a lower zone along the rivers of S. Taban and S. Mayun, being overlain unconformably by the andesitic pyroclastic rocks of Jirak Formation in a small distribution.

(2) Rock facies and lithology

This Formation is normal sedimentary rock consisting of the alternating beds of fine grained sandstone, grey mudstone and siltstone. It shows a clear bedding at the north of Lumar, increasing the mudstone upward.

This Formation consists of the alternated formation of light grey ∿ brown fine grained sandstone, grey ∿ dark grey mudstone and siltstone and its bedding is well developed along the rivers of S. Taban and S. Mayun, increasing the tuffaceous fine grained sandstone upward.

The Formation strikes E-W ∿ N50°W and dips 30° ∿ 50°S, showing a monocline structure. A thin layer of tuffaceous shale is partly intercalated.

According to the microscopic observation, the sandstone consists of brown iron hydroxide mineral, argillized pebble (sericitized and kaolinized) in matrix consisting of sericitized or kaolinized lath-shaped plagioclase small quantity of quartz, and tuffaceous materials.

The matrix contains silicate minerals and sericite, and the fine grained matrix contains quartz (0.07 mm) and a little of iron minerals. This Formation also contains partly tuffaceous materials in where many iron oxide veinlets of 0.5 mm in width are existed.

(3) Fossil

Ammonite fossil fragments were found in the mudstone near the joint between S. Mayun and S. Taban. These fossil fragments cannot be determined owing to the poor preservation, but were identical with the sample 79-RL-2 *Dactylioceras (Orthodactylites)* sp. (Jurassic Lias Toarcian stage) collected and examined from the same Formation in the first phase survey.

Further, it is known to produce the fragments of ammonite fossils in this Formation at the north side of Lumar, but nothing was found available to be identified.

(4) Stratigraphic correlation

Because the ammonite fossils were discovered and both the rock facies and lithology are well identical with those at Sungaibetung Formation in the first phase survey, this Formation is correlated with Sengaibutung Formation of Early Jurassic age.

(5) Thickness: 2,000 ∿ 5,000 m

2-2 Volcanic and Pyroclastic Rocks

2-2-1 Jirak Formation

(1) Distribution

This Formation is distributed at the west area of S. Taban and at the south area of Pudo village, among all others in this survey area, unconformably lying over Sungaibutung Formation. It consists of conglomerate, andesite and andesitic pyroclastic rocks.

Conglomerate is distributed as the basal conglomerate at Titiaring village, around where the grey sandstones are exposed. Above it, an alternated beds of 3- or 4-layers andesitic lava and andesitic pyroclastic rocks are overlaid.

This Formation strikes nearly N-S to E-W, and dips 20° ∿ 30°S and has been intruded by G. Raya granodiorite. Jirak Formation is also distributed at Tiang and Kalumpe areas at the west side of this survey area, chiefly consisting of andesitic lava.

This Formation has been overlain by Belango Formation at the west side of Gunung Tiang and intruded by G. Raya granodiorite.

(2) Conglomerate

This rock has a brown or dark green color, and consists of pebbles of sandstone and shale of 2 ∿ 5 cm in diameter in the andesitic tuff matrix. The tuffaceous sandstone is distributed around this conglomerate, partly intercalating a thin layer of red siltstone.

The thickness of the conglomerate and sandstone bed is as thick as 10 to 30 m.

According to the microscopic observations of conglomerates, the component pebbles are strongly chloritized rocks, quartzite and andestic rock framents of more than 25 mm in grain size, including quartz and iron minerals as well.

The matrix consists of fine grain quartz, siliceous minerals, chlorite clay and iron mineral, with a ratio of 5 to 1 between pebble and matrix.

Besides the above, the red siltstone consists mostly of the matrix cementated by iron hydroxide and the clastic rock fragments almost argillized, sericitized and kaolinized, of less than 0.15 mm in grain size.

(3) Andesite

This rock is visually grey or black colored fine grain, compact and massive.

The phenocrystic was altered by carbonitization and chloritization. They also have a strong magnetic susceptibility and contains a pyritic dissemination. Both the lavas and the pyroclastic rocks are alternatively deposited for 3 or 4 beds, but each lava has no continuating distribution.

Upon the microscopic observations, the andesite lava consists of plagioclase (1.4 mm in length), hornblende (less than 0.5 mm in length) and small quantity of iron minerals as phenocryst in ground mass containing a little of plagioclase, iron minerals and siliceous mineral, and plenty of lath shaped hornblendes. This hornblende could be the secondary products altered by thermometamorphism.

(4) Andesitic pyroclastic rocks

This consists of tuff, lapilli tuff, tuff breccia and tuffaceous sandstone.

At the south side of Pudo village, the grey ∿ fine green lapilli tuff or tuff breccia is exposed. In the swamp at the west side of Takatong village, both the alternated beds of fine grey lapilli tuff and the medium grained tuffaceous sandstone crop out at 1.0 ∿ 1.5 m in thickness.

Under microscopic, lithic fragments of tuff can not be identified, because of their hard alteration. The tuff consists of crystal fragments of plagioclase and chlorite partly epidotized, being contained in the matrix comprising of plagioclase, chlorite, calcite and iron minerals, and the clastic structure is common.

Under microscope, the tuffaceous sandstone was altered strongly and consists probably of plogioclase fragments in the matrix. The matrix was completely argillized to secicite and kaoline.

(5) Stratigraphic correlation

Jirak Formation overlies unconformably on Sungaibetung Formation, partly having a basal conglomerate beds. Also, at the west and south sides of this Formation, 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.

2-2-2 Belango Formation

(1) Distribution

In addition to its distribution along Darit road running between Bagak and Benkayang via Darit, this Formation is intermittently distributed southward from around Ladangan village and from around Gomban village to Pahuman village, at the central part of this survey area, further extending at the south side of Pahuman village.

It covers approximately 5 km at the north side of Darit road up to Sempuan, and approximately 3 km at the south side of Darit road, in a near zontal form.

Further, at the south side of central survey area, it continues down to the south side of Pahuman village with a width of about 10 km, being intruded at many locations by G. Sebiawak granodiorite of Cretaceous age.

A relatively wide range of its distribution is at the area along Darit road, at the area of Sebangbang village - Pejambonsari village - Gomban village - Sabaro village, and at the south area of Pahuman village.

(2) Rock facies and lithology

This Formation consists broadly of dacitic volcanic rocks and andesitic volcanic rocks. No clear boundary between these two kinds of rocks can be observed at the area along Darit road, being assumed in a relationship of transition or interfinger. While, at the area covering from center to south of this survey area, a relatively clear boundary is observed between these two. The andesitic volcanic rocks oberlie the dacitic volcanic rocks, partly having the intercalation of thin andesitic volcanic rocks at the south of Pahuman.

Namely, both kinds of rocks are distributed horizontally at north, while at the south part of the survey area, the depositional relationship between both beds is relatively very clear so as that the dacitic volcanic rocks partly having the intricalation of thin andesitic volcanic rocks underlie the andesitic volcanic rocks.

a) Dacitic volcanic rocks

This consists of dacitic lava and tuff breccia.

Dacite lava: In addition to two-layer distribution extending to E-W around Adong and Padang Pio at the north side of this survey area, it has a fairly extensive distribution, centering at Gombang village at south. Further, the small distributions crop out at the east side of Ganteng village and at the south side of Panuman village.

This rock has a greenish blue grey or dark grey color, and is compact and hard, with a clear porphyritic texture. The phenocrystic minerals consist of hornblende and botite in addition to quartz plagioclase.

The dacite around Pandang Pio is much crystalized in the groundmass, partly showing the rock facies like quartz porphyry as well. The rocks around Comban village have a dark green color and are hard, presenting the porphyritic complex of epidote crystals in addition to the phenocrysts of plagioclase and quartz having 2 or 3 mm in size.

Dacitic pyroclastic rocks: This is chiefly composed of tuff breccia, partly including tuffaceous mudstone and tuff.

In addition to a distribution of tuff breccia along Darit road between Sepuan and Tapang at south, it has an extensive distribution from Sebambang village to south of Pahuman village at south, occupying a majority of dacitic valcanic rocks.

The rocks distributed along Darit road at north show light grey or greenish grey in the matrix, having a massive but no-bedding. The breccia comprises of dacite and andesite, many being of 1 cm in size, containing the fragments of plagioclase, quartz, hornblende, epidote, etc. as well. Also, since the boulders of welded tuff are scattered at small swamps at north of 1 km away from Medang village, the welded tuff could be partly distributed around this area. The welded tuff has a grey or dark grey color, transitioning into the tuff breccia.

The distribution from southern Sebandan village to south of Pahuman village consists of tuff and tuff breccia, the latter occupying a majority. The tuff breccia contains many dacitic and andesitic breccia of 1 cm in size, having a grey or greenish grey color with the compact and hard lithology.

Under microscope, the result revealed to have many clastic fragments of quartz and feldspares as large as 1 or 2 mm in size, in addition to the contents of andesitic and dacitic breccia or tuff breccia.

The matrix comprises of fine granular quartz and sericite, and clay minerals. According to the results derived from the X-ray diffractive analyses of RE-68 thermal metamorphic rocks, the very good crystallized sericite of $2M_1$ type were detected, proving that they have undergone a strong thermal metamorphism by G. Raya granodiorite.

Further, the tuff breccia of hard lithology and greyish green color, including the dacitic breccia of 1 or 2 cm in size are exposed at the area from Pejambonsan village to its south-eastward. The tuff crops out chiefly at the upperstream of S. Sengan at 2 or 5 km northwest of Combang village, having yellow or white fine grains. The tuff breccia around this area include the intercalation of dark green muddy tuff as well.

The dacitic tuff around west of Gunung Tiang are distributed at the west middle hill of Gunung Tiang at east of Kp. Tikalung, consisting of lapilli tuff. Under microscope (RA-77), the result revealed the dacitic breccia (0.5 mm in size), crystal fragments of plagioclase and quartz in the matrix of secondary biotite and quartz.

Especially, the dacitic tuff in contact with Tiang quartz diorite at west slope of G. Tiang contain andalusite, quartz and alunite as the thermometamorphic products due to the intrusion of Tiang quartz diorite.

b) Andesitic volcanic rocks

This consists of andesite lava, andesitic tuff, tuff breccia, sandstone and redish brown mudstone.

Andesite lava: This is distributed along the rivers of S. Lapit and S. Selamdang, at north of the survey area. In the area from center to south, this rocks are distributed at the area from Timpang village to Mangun village, at the area from around Pekatan village to Bidi village, and on the summit at west of Lansa village. Around Pahuman village, it is distributed at around Gunung Sinabung and Padang village and on the summits of Gunung Sema and Gunung Sebilang, having the phenocryst of plagioclase and hornblende with a dark green or dark grey color and undergoing the chloritization and epidotization.

Under microscope, the result revealed the composition of 1 mm size plagioclase (partly changed to epidote and sericite), and phenocryst of hornblende (chloritized) and natrix which consist of lath-shaped plagioclase and fine prismatic hornblende and iron minerals.

Andesitic tuff breccia and tuff: In addition to a exposure of tuff breccia along Darit road, it is also distributed a little at Pahuman village. The tuff is prominently exposed eastward around area along Darit road, in which sandstone and mudstone are intercalated. The tuff breccia has a greyish green or dark grey color.

Under microscope, the result revealed that the lithic fragments contain mostly andesite, showing commonly affects of alterations mostly into chlorite, epidote, sericite, clay and limonite, and the matrix contains many sericite, chlorite and clay. Where not so much altered, the clastic fragments of plagioclase are observable.

The tuff was affected by a strong alteration into chlorite and epidote as well. Under microscope, the result revealed that it is of lithic tuff consisting of plagioclase contained large quantities of breccia (1 mm in grain size) of andesite, crystal fragments of plagioclase and augite epidotized, and the matrix comprises of clay minerals, such as chlorite, other plagioclase and iron minerals.

Sandstone has a loess color, fine grained tuffaceous texture with a relatively good consolidation. Mudstone has substantial hematites through weathering, showing a redish violet color.

Stratigraphic correlation: No direct contact between Belongo Formation and can be observed with Jirak Formation due to the intrusions of G. Raya granodiorite and not good exposure, so that a correlation between these two Formations is unceratin whether to be in the conformity or not.

2-3 Serantak Dacite and Dacitic Pyroclastic Rocks

(1) Distribution

This distribution is made to cover Bengkayang Group in the plain area at the northern surrounding of Gunung Bawang and Gunung Buwah Obah mountains, as pyroclastic rocks of Serantak dacite.

(2) Rock facies and lithology

This consists of fine granular dacitic tuff and lapilli tuff. Under microscope, the observation result revealed the crystal tuff consisting of clastic fragments of quartz and plagioclase in the matrix of fine grained quartz, plagioclase, titanite and sericite.

Fine grained tuff is partly argillized into white clay at the downstreams of S. Molo and S. Bekuan. According to the X-ray diffractive analyses, it is determined to be a halloisite or poorly crystalline kaolinite.

(3) Stratigraphic correlation

It is determined of Tertiary system, as it is in a close contact with Serantak dacite. It covers Kalung Formation of Bengkayang Group unconformably. Referring to the K-Ar aboslute age dating of Serantak dacite, it is determined of Oligocene series, but a possibility still remains to be a formation from the younger dacitic igneous activity. Re-investigation is required in this regard.

2-4 Quaternary Sediments

Quaternary sediments consist of unconsolidated gravel, sand, silt, etc., and are distributed along the rivers of S. Menyuke, S. Lang and S. Perabe, at the lower land at south of Pahuman.

2-5 Classification of Granitic and Instrusive Rocks

2-5-1 Age Dating

For the purpose to clarify the age of intruding the plutonic rocks in the survey area, sampling is made to select 3 samples from G. Raya granodiorite widely distributed in this second phase survey area, 1 1 samples from Tiang quartz diorite intruded into the above, and 1 sample from Serantak dacite distributed at north of this survey area, totaling to 5 rock samples, for which the K-Ar age dating is carried out. Table 3-1 gives the results, together with the same derived from the first phase survey (4 rock samples).

According to the results, the G. Raya granodiorite ranges in 114 ∿ 107 m.y., showing the nearly same age of Middle Cretaceous age with that derived from the samples (G. Raya granodiorite; 103 m.y.) in the first phase survey.

Also, the quartz diorite from east of Kp. Sikocek dated as 95 m.y., similarly resulting in the same with that of Tiang quartz diorite in the first phase survey. The dating resulted from G. Raya granodiorite is well recognized the intrusion of nearly same age, viewing from the points of tolerance range, but the tendency shows slightly older with the granodiorite from Sehalcian and Parikap villages, i.e. 114 m.y. and 111 m.y., respectively, being followed by the granodiorite from Gunung Gamarabah, 107 m.y., and the newest, 103 m.y., with the same from Gunung Bintawa in the first phase survey. Accordingly to the normative diagram to be mentioned later, the slightly older granodiorite from Selakean village and Parikap village are plotted in the tonalite side, as compared with the slightly younger granodiorite from Gunung Gamarabah are done in the granite side.

The dacite stocks or lava are distributed around Gunung Bawang at north of this survey area, however, being included in the Serantak dacite in this report. 51 m.y. is resulted with this decite from the K-Ar absolute age dating, as Eocene series of Paleocene.

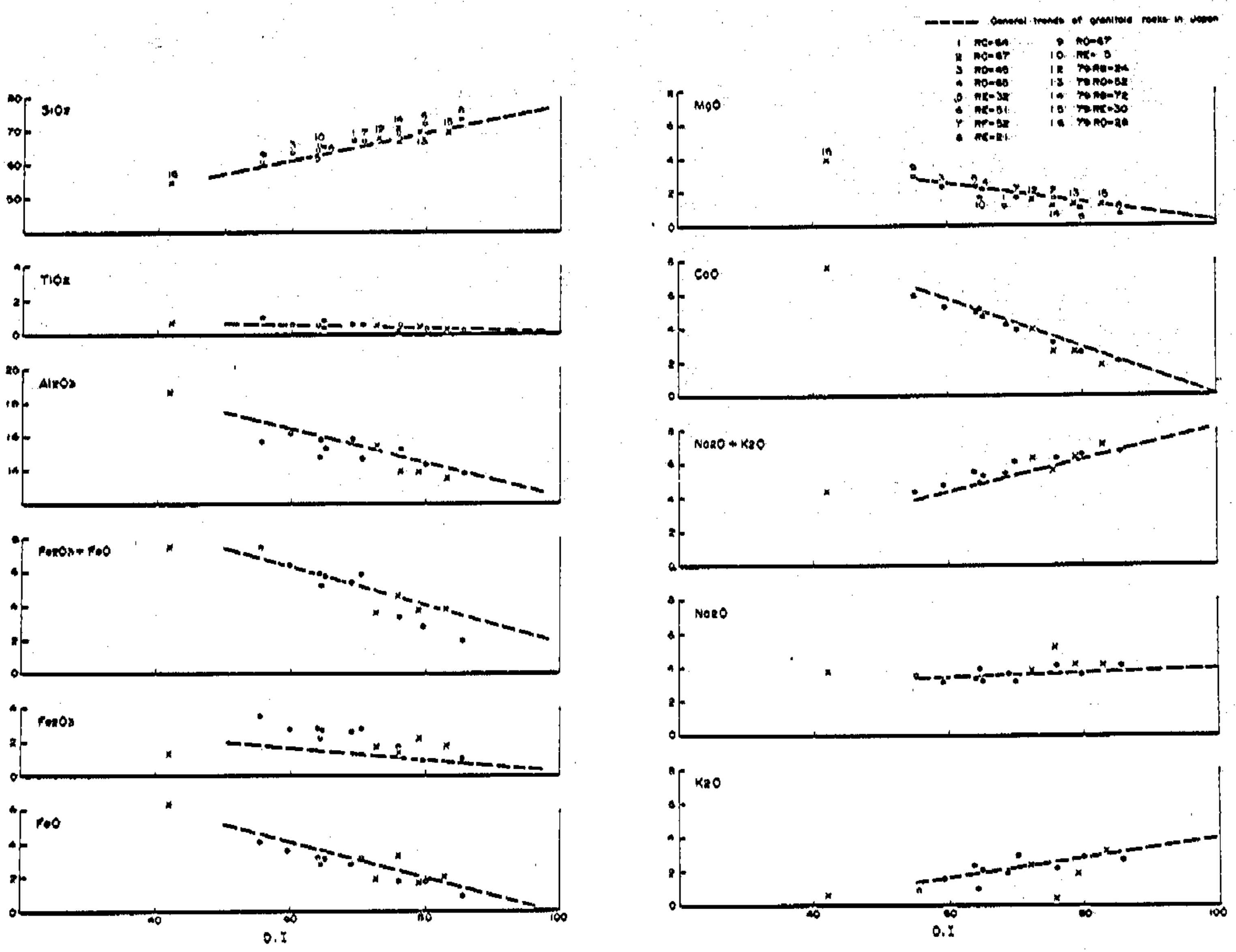

Fig 3-7 Variation Diagram of Granitoid Rocks

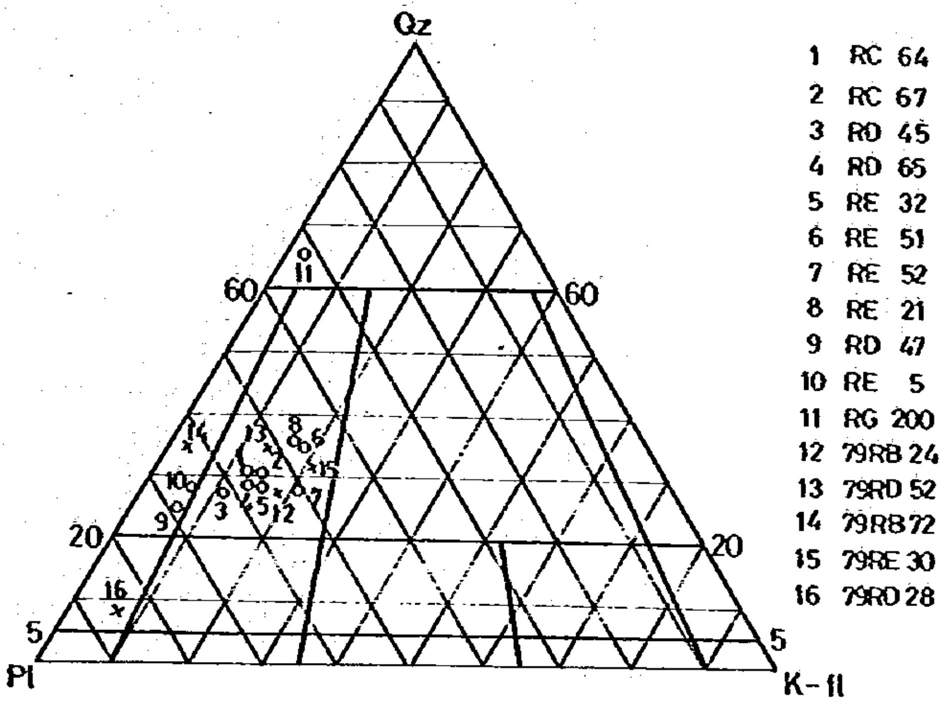

Fig 3-8 Normative Q-Pl-K·Fl Diagram of Granitoid Rocks

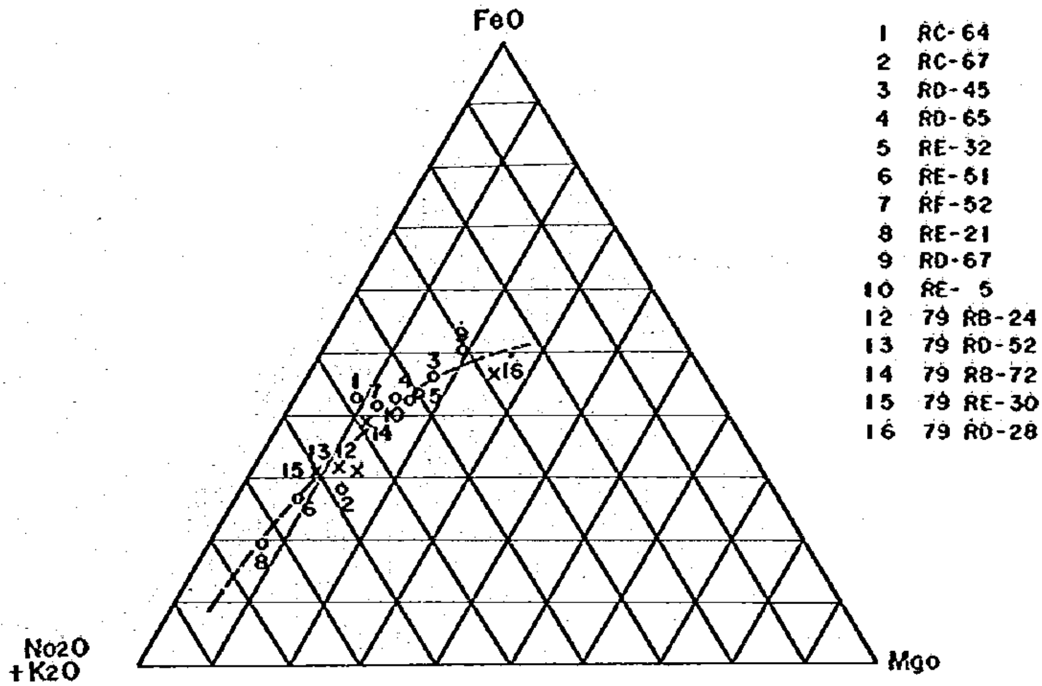

Fig 3-9 M-F-A Diagram of Granitoid Rocks

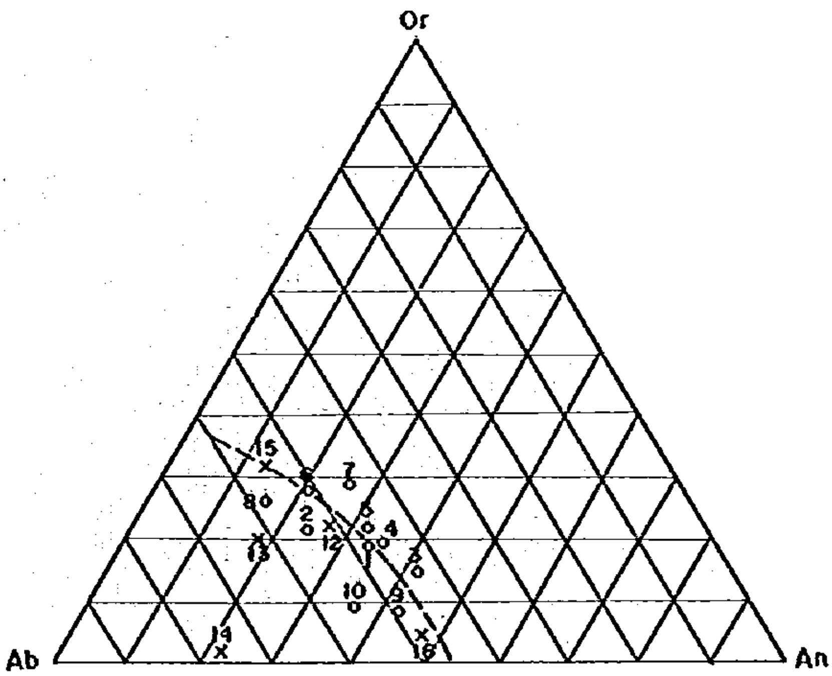

Fig 3-10 Normative Or-Ab-An Diagram of Granitoid Rocks

Table 3-1 Result of K-Ar Age Determination

No.	Sample No.	Locality	Rock Name	Mineral or Rock	$sccAr^{40Rad}$/gmx10-5	Ar^{40Rad}%	K%	Age(m.y.)
1	79-RB-24	S. Bamua	Sirih Tonlite	Hornblende	0.213 0.223	48.3 48.9	2.80 2.79	20.0±1.0
2	79-RD-52	S. Boni	Banyi Tonalite	Hornblende	0.126 0.137	30.1 43.9	1.20 1.21	27.8±1.4
3	79-RE-50	S. Sakung	Tiang Quartz Diorite	Hornblende	0.367 0.354	73.3 70.0	0.90 0.93	98.6±4.9
4	79-Rp-19	S. Bala	G. Raya Granodiorite	Hornblende	0.225 0.215	62.9 45.0	0.53 0.53	103.7±5.2
5	80-RA-31	S. Molo	Serantak Dacite Porphyry	Whole rock	0.061 0.062	43.1 50.5	0.30 0.31	51.3±2.6
6	80-RC-64	S. Empawang	G. Raya Granodiorite	Whole rock	0.702 0.722	86.9 89.7	1.56 1.56	114. ±6
7	80-RD-45	Kp Parikap	G. Raya Granodiorite	Whole rock	0.572 0.586	87.0 88.6	1.28 1.31	111. ±6
8	80-RD-67	S. Serape	Tiang Quart Diorite	Whole rock	0.267 0.280	66.7 70.5	0.72 0.72	95.1±4.8
9	80-RF-52	G. Gamarabak	G. Raya Granodiorite	Whole rock	0.968 1.01	90.8 92.3	2.30 2.30	107. ±5

The constants for the age calculation are: $\lambda_\beta = 4.962 \times 10^{-10} yr^{-1}$, $\lambda e = 0.581 \times 10^{-10} yr^{-1}$, $K^{40} = 1.167 \times 10^{-4}$ atom per atom of natural potassium.

Table 3-2 Chemical Composition of Gronitoid Rocks

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
	Sample No.	RC-64	RC-67	RD-45	RD-65	RE-32	RE-51	RF-52	RE-21	RD-67	RE-5	RG-200	79-RB-24	79-RD-52	79-RB-72	79-RE-30	79-RD-28
	Location	S.Enpa-vang		Kp.Pari-kap (S. Dapahan)	North Kp. Emang	North kp. Seliat	North kp. Emang	G.Gamana-bak	Kp. Kayuaga	S.Serape	Kp. Sampur-anch	G.Seran-tak	S.Banua	S.Banyi	G.Seran-tak	S.Peben	G.Pandan
	Rock Name	Gr.dio	Gr.dio	Gr.dio	Gr.dio	Gr.dio	Gr.dio	Gr.dio	Gr.dio	Qtz Dio	Qtz Dio	ac ff	Tn	Tn	dac	Gr.	Qtz Gab
Chemical Composition	SiO_2	66.43	69.39	63.57	65.17	64.46	71.26	66.11	73.56	60.92	65.29	77.03	67.31	69.26	70.11	69.82	54.37
	TiO_2	0.50	0.43	0.56	0.63	0.60	0.33	0.42	0.28	0.87	0.54	0.18	0.48	0.47	0.35	0.40	0.63
	Al_2O_3	15.86	15.02	16.11	15.08	14.68	14.17	14.49	13.77	15.77	15.80	7.80	15.45	13.94	13.91	13.53	18.69
	Fe_2O_3	2.51	1.61	2.76	2.63	2.78	0.93	2.79	0.97	3.41	2.18	2.04	1.66	2.16	1.46	1.80	1.21
	FeO	2.79	1.79	3.54	3.13	3.09	1.89	3.10	0.98	4.07	2.94	1.21	1.91	1.66	3.22	2.04	6.23
	MnO	0.11	0.10	0.14	0.12	0.12	0.09	0.10	0.06	0.16	0.14	0.06	0.06	0.05	0.05	0.06	0.13
	MgO	1.07	1.47	2.28	2.09	2.23	0.98	1.67	0.67	2.78	1.59	1.09	1.61	1.20	1.35	1.17	3.93
	CaO	4.21	3.12	5.27	4.72	4.96	2.59	3.82	2.02	5.95	5.20	6.58	3.99	2.63	2.65	1.80	7.59
	Na_2O	3.51	4.06	3.14	3.25	3.22	3.54	3.21	4.11	3.46	3.93	1.40	3.84	4.19	5.32	4.02	3.78
	K_2O	1.98	2.28	1.59	2.01	2.24	2.88	2.99	2.65	0.83	0.95	0.37	2.40	1.95	0.27	3.12	0.63
	H_2O^+	0.65	0.48	0.46	0.70	0.82	0.72	0.88	0.42	1.17	0.70	1.98	0.93	1.68	1.04	1.86	2.50
	H_2O^-	0.18	0.15	0.21	0.19	0.25	0.20	0.24	0.19	0.19	0.15	0.26	0.19	0.36	0.05	0.12	0.36
	P_2O_5	0.15	0.14	0.17	0.11	0.16	0.13	0.13	0.09	0.27	0.20	0.07	0.12	0.09	0.11	0.09	0.08
	Total	99.95	100.04	99.80	99.83	99.61	99.71	99.95	99.78	99.85	99.61	100.07	99.95	99.64	99.89	99.83	100.13
C.I.P.W. Norm	Q	27.18	27.94	23.39	24.89	23.48	31.94	24.79	34.13	20.50	24.91	55.76	24.6	30.2	29.3	28.5	5.8
	Or	11.69	13.47	9.40	11.85	13.24	17.03	17.64	15.69	4.90	5.62	2.17	14.5	11.7	1.7	18.4	3.9
	ab	29.67	34.34	26.58	27.47	27.21	29.94	27.16	34.76	29.26	33.24	11.85	33.0	35.7	44.6	34.1	32.0
	an	19.89	14.55	25.03	20.64	19.00	12.02	16.30	9.46	25.06	22.67	13.91	17.8	11.4	12.2	8.1	32.0
	C	0.66	0.54	0.04	-	-	0.83	-	0.67	-	-	-	-	0.7	0.4	0.6	-
	Wo	-	-	-	-	-	-	-	-	-	-	4.18	-	-	-	-	-
	Wo (di)	-	-	-	0.86	1.92	-	0.75	-	1.13	0.77	3.44	0.5	-	-	-	1.9
	en (di)	-	-	-	0.59	1.21	-	0.51	-	0.70	0.42	2.71	0.3	-	-	-	0.1
	fs (di)	-	-	-	0.20	0.58	-	0.18	-	0.36	0.32	0.34	0.1	-	-	-	0.1
	en (hy)	2.66	3.66	5.67	4.61	4.34	2.44	3.54	1.67	6.21	3.53	-	3.7	3.0	3.3	2.9	9.6
	fs (hy)	2.42	1.42	3.55	2.56	2.03	2.33	2.69	0.65	3.15	2.64	-	1.5	0.5	4.1	1.7	9.4
C.I.P.W. Norm	mt	3.63	2.34	4.01	3.82	4.02	1.34	4.05	1.41	4.95	3.17	2.96	2.3	3.2	2.1	2.5	1.9
	il	0.96	0.82	1.06	1.20	1.14	0.62	0.80	0.53	1.65	1.03	0.35	0.9	-0.9	0.8	0.8	1.2
	ap	0.37	0.34	0.40	0.27	0.37	0.30	0.30	0.20	0.64	0.47	0.17	0.3	0.7	0.3	0.3	2.0
	Total	99.13	99.42	99.13	98.96	98.54	98.79	98.81	99.17	98.51	98.79	97.84	99.5	98.0	98.8	97.9	99.9
	Q+Or+ab	68.54	75.75	59.37	64.21	63.93	78.91	69.54	84.58	54.66	63.77	-	72.1	77.6	75.6	81	41.7
	D.I.	69.14	76.19	59.89	64.88	64.48	79.87	70.37	85.24	55.48	64.55	-	72.5	79.2	76.5	82.7	41.7
	Group	G.Raya	G.Raya	G.Raya	G.Raya	G.Raya	G.Raya	G.Raya	G.Sedian	Tiang	Tiang	Banan F.	Sirih	Banyi	Serantak	Gr.1	Pandan
	age (my)	114±6		111±6				107±5		95±4.8			20.0±1.0	27.8±1.4	51.3±2.6		

Abbrebation: Gr.dio: Granodiorite Qtz dio: Quartz diorite Tn: Tonalite Qtz-gab: Quartz gobbro Gr: Granite
Ac ff : Acidic tuff dac : Dacite

The granodiorite batholith extensively distributed in West Kalimantan is clarified the intrusion of Middle Cretaceous age, as shown in Fig. 3-6, even from the results of K-Ar age dating for the Central Kalimantan and so forth.

While, this K-Ar absolute age dating has proved that Serantak dacite, Sirih tonalite rocks, Banyi tonalite, all being accompanied by the mineralizations, have been intruded from the igneous activities during the period from Paleocene age to Miocene age.

2-5-2 Chemical Compositions

The chemical anslyses are made on the samples of plutonic rocks distributed in this survey area, giving in Table 3-2 the analysis results and the weight ratio of norm minerals calculated from such analytic values.

Further, in the same table, the analytic value in the first phase survey, are given for granite (grl), tonalite, quartz gabbro, and dacite of younger igneous rocks for the reference purpose, which their distribution could not found in the second phase survey area.

Through these analytic results, most samples contain SiO_2 ranging from 62% to 70% and belong to intermediate igneous rock. But sample of RE-21 and RE-21 are slightly acidic, while RD-67 is slightly basic, namely tonalitic rock.

In comparison with Japanese granitic rock (Aramaki et al 1972), Al_2O_3 value is ploted below the line of the average content, while Fe_2O_3 a little above level from the average value (total of FeO and Fe_2O_3 is nearly similar). But the slope of the average line of these igneous rock is closely similar to that of Japanese granitic rocks.

Fig. 3-8 gives the correlation diagram of quartz, plagioclase and potasic feldspar on the basis of norm minerals, calculating from the results of chemical analyses. According to it, G. Raya granodiorite is classified into the granodiorite group under the IUGS classification, but its distribution covers an extensive range, being divided into a group slightly near to the tonalite (hereinafter called "A-group") and another group near to the granite (hereinafter called "B-group").

Looking at the locational distribution of each group, A-group prevails over Selakean and Parikap regions, while B-group over all other regions, tending to be widely distributed within the G. Raya granodiorite batholith.

As previously mentioned in the absolute age dating, A group could be of slightly older intrusion as compared to of B-group.

In M-F-A correlation diagram (Fig. 3-9), the G. Raya granodiorite shows the differentiating route similar to the volcanic rocks of calc-alkalic rock series. Further, the Sirih tonalite, Banyi tonalite, Serantak dacite and Pandan quartz gabbro are all on the same alignment. As a consequence from the chemical analyses of granitic rocks extensively distributed in the survey area and the examinations made on the chemical compositions of them, like as above, SiO_2 is increasing, but FeO^+ is decreasing, in the older grinitic rocks (Middle-Cretaceous age) and the younger grainitic rocks (Eocene age - Miocene age; accompanying a mineralization within the survey area) are both advanced in the differentiation, and their differentiating lines shown the trend similar to those of volcanic rocks of calc-alkalic rock series. From this, both granitic rocks are inferred to be differentiated from the magma source of identical calc-alkalic rock series.

2-5-3 Classification by Opaque Minerals

The Au-Cu-Mo mineralized zones accompanied by the granitic rocks are well known in the west area of Kalimantan. Also, the tin ore minealized zones are distributed from Malay Peninsula to the east area of Sumatra Island. In order to clarify the correlation between these mineralized zones and the granitic rocks, the classification of granite series by opaque minerals is worked out, i.e. the granitic rocks can be divided into two series of magnetite and ilmenite, depending upon the contents of magnetite and ilmenite, respectively, and it is said that the tin ore deposits relate with the ilmenite series granitic rocks, while the porphyry copper deposits with the magnetite series granitic rocks (By Dr. Ishihara, 1977):

The first phase survey was made on the Sirih and Banyi tonalites which belong to the younger granite series accompanying the mineralizations, examining the opaque mineals (magnetite and ilmenite)

Table 3-3 S Type/I Type of the Granitoid Rocks

	$K_2O:Na_2O$	(MOD) Al_2O_3/Na_2O+K_2O+CaO	Norm C%
RC-64	I	I (1.03)	I (0.66)
RC-67	I	I (1.01)	I (0.54)
RD-45	I	I (0.97)	I (0.04)
RD-65	I	I (0.95)	I (-)
RE-32	I	I (0.88)	I (-)
RE-51	I	I (1.04)	I (0.83)
RP-52	I	I (0.93)	I (-)
RE-21	I	I (1.03)	I (0.67)
RE-67	I	I (0.78)	I -
RE-5	I	I (0.93)	I -
79-RB-24	I	I (0.96)	I -
79-RD-52	I	I (1.01)	I (0.71)

contained in the samples collected and trying to classify them in the granitic rock series. As a result from the above, it was revealed that the opaque minerals in the both tonalites consist of rich magnetites and a little of ilmenite, being classified into the magnetite series granitic rocks as defined by Dr. Ishihara.

The same examinations were conducted on the G. Raya granodiorites intruded during Cretaneous age (RC-64, RC-67, RD-45, RD-65, RE-21, RE-32, RE-51 and RF-52) and on the Tiang quartz diorite (RD-67 and RE-5) to observe the opaque minerals through a microscope.

Under microscope, it was resulted in all cases to have very many magnetites as compared with a few ilmenite, both being classified into the magnetite series granitic rocks.

In addition, just for reference purpose, if a trial is made to classify these samples of granitic rocks collected through this survey, in accordance with S-type (sedimentary type) and I-type (igneous type) under the classification of Dr. Chappell and Dr. White (1,974 and 1,977, respectively), all fall into I-type (See Table 3-3).

For instance, they have pointed out that the granitic rocks of S-type are accompanied by the tin ore deposits, as the results of investigation conducted on the tin ore deposit of Lachlan in the south-east of Australia.

2-6 Older Granitic Rocks

This consists of G. Raya granodiorite, G. Sebiawak granodiorite, G. Selantak granodiorite, granite (gr1) and granite (gr2).

2-6-1 G. Raya Granodiorites

(1) Distribution

This rock is extensively distributed over a majority of central region in the survey area, whereat Jirak and Belango Formation remain as loof pendants on the G. Raya Granodiorite. Around Gunung Gamarabak at south, the small distribution of G. Raya Granadiorite is exposed.

(2) Rock facies and lithology

This rock shows a medium, equi-granular texture, having hornblende and biotite as the colored minerals with the color index of 7 ∿ 20%.

The magnetic susceptibility tested by pen magnet in field showed medium in general, and the rock facies changes, ranging in those of granodiorite, quartz diorite and tonalite, depending upon their locations sampled.

According to the results of microscopic observations of granodiorites, they show a coarce equi-granular texture, and the main constituent minerals consist of hypautomorphic plagioclase, xenomorphic quartz, hornblende and biotite, potashic plagioclase filling interstitial parts among other minerals.

A little quantity of iron minerals, hypersthene and zircon are contained as the accessory minerals.

A sort of dioritic facies is distributed in a small range around S. Karuk and Empadang, with the color index of 25 ∿ 40% in dark grey and a fine grain, having a strong magnetic susceptibility check by pen magnet in field. It is chloritized and/or epidotized. This rock facies and granodiorite facies are intergradational.

A part of tonalitic facies is distributed over the area from Gunung Bintaw and Gunung Raya for Bongkek village and at the area along S. Enpawang at north and S. Mada.

This rock facies has a color index of 15 ∿ 20% and a fine or medium equi-granular texture, chiefly consisting of plagioclase, quartz and a little quantity of biotite, with a weak or medium magnetic susceptibility check by pen magnet in field.

Under microscope, the result revealed a fine or medium equi-granular texture, consisting of a plenty quantity of plagioclase showing a hypautomorphic zonal structure, a medium quantity of quartz, hypautomorphic hypersthene, a little quantity of hornblende and augite, besides which the xenomorphic potashic feldspar, iron minerals and biotites are observable as well.

(3) Time of intrusion

This rock dated as 114 ∿ 103 m.y. during Middle-Cretaceous age, resulting from the K-Ar absolute age dating.

2-6-2 G. Sebiawak Granodiorite

(1) Distribution

This rock is extensively distributed from center to south in this survey area, having Belango Formation as a loof pendants and intruded at many locations by Banyi tonalites.

(2) Rock facies and lithology

This rock has a color index of 5% and a coarce grained porphyritic texture, presenting a near granite rock facies.

Much of quartz has a grain size of 0.3 ∿ 0.8 mm. It features that quartzes in weathered rocks is conspicuous, because of residuary from weathering in the fields.

Under microscope, the result revealed that the main constituent minerals consist of plagioclase, quartz, hornblende, biotite and orthoclase.

Plagioclase is hypautomorphic, having a grained size of approximately 3.5 mm with a zonal structure. Quartz is xenomorphic, having a grained size of approximately 4 mm. Hornblende is hypautomorphic, having a grained size as large as 1.5 mm. Biotite is hypautomorphic, having a grained size below 1 mm, with a partial chloritization. Orthoclase is xenomorphic, having a perthite texture.

The iron minerals, zircon and apatite are contained as the accessory minerals.

2-6-3 G. Selantar Granodiorite

(1) Distribution

This rock is distributed at the area along S. Sebumbung at west of this survey area. Intruding into Jirak andesite Formation and intruded by the small stocks of quartz diorite rocks and small Serantak type dacite stocks.

(2) Rock facies and lighology

This rock is a sort of coarce grained porphyritic biotite - hornblende granodiorite with a color index of 10%.

It contains large crystals of plagioclases, quartz with a porphynitic texture and plenty quantities of Jirak andesite xenolith.

Under microscope, it was observed to include the phenocrysts of plagioclase, quartz, hornblende and biotite of 3 mm at maximum in size, in the groundmass of quartz, plagioclase, hornblende and biotite below 0.35 mm.

A few of titanites are contained as the accessory mineral.

(3) Time of intrusion

This has intruded during the same Cretaceous age with those at Gunung Raya, because it has been intruded by Tiang quartz diorite and Serantak dacite and has the xenolith of andesite of Jirac Formation.

2-6-4 Tiang Quartz Diorite

(1) Distribution

This has intruded during the same Cretaceous age with those at Tembawang Bordong village and at south of Baya village.

(2) Rock facies and lithology

This rock has a color index of 20 ∿ 30% in dark grey, with a medium equi-granular texture, being classified in the hornblende quartz diorite, an aboundance with quartz and hornblende, containing plagioclase as well. Also, a little quantity of pyrite and chalcopyrite disseminations are distributed at some places.

Under microscope, the result revealed to have a granular texture, and the main constituent minerals consist of plagioclase, quartz and hornblende, while the accessory minerals include iron minerals, epidote, chlorite and titanite.

Plagioclase is hypautomorphic, having a grained size of approximately 2 mm, with a partial epidotization. Quartz is xenomorphic, having a grained size of 0.7 mm, with a myrmekitic texture as well. Many of hornblendes has a small crystal with approximately 1 mm in grain size and a partial epidotization.

(3) Time of intrusion

This has intruded into both G. Raya and G. Sebiewak granodiorite, showing 95 ± 4.8 m.y. resulted from the K-Ar absolute age dating, which is a little newer than those of above granodiorite, but sure to have been intruded during Middle Cretaceous age.

The first phase survey dated 98.6 ± 4.9 m.y. to the identical quartz diorite samples exposed at Gunung Tiang, under the K-Ar absolute age dating, as nearly same as above.

2-6-5 Granite (gr-1)

(1) Distribution

This rock is distributed as a small dyke around the upperstream of S. Sebunbung at west of this survey area as well.

(2) Rock facies and lithology

This is a leucocratic biotite granite of medium grain in white, having a color index below 5%. According to the microscopic observations of samples (79-FR-30) collected at the upperstream of S. Sebumbung in the first phase survey, the main constituent minerals are plagioclase, orthoclase, quartz and biotite, while the accessory minerals are opaque minerals and apatite.

(3) Time of intrusion

This is distributed as a dyke intruding into G. Selantar granodiorite at the strike of N30°E.

2-6-6 Granite (gr-2)

(1) Distribution

A small scale distribution is found around Emang village at northwest of this survey area and around Sampuraneh village at center.

(2) Rock facies and lithology

This rock distributed around Emang village is a biotite granite having a color index of 1 ∿ 3% in pink color and a medium equigranular texture, consisting of a plenty quantity of potashic feldspar, quartz, plagioclase and fine grained biotite.

The rock distributed around Sampuraneh village is a horblende granite having a color index of 1 ∿ 3% in pale pink color and a medium porphyritic texture, containing the phenocrysts of quartz, potashic feldspar, plagioclase and hornblende in the groundmass consisted of the same minerals.

Also, only a few quantity of pyrite dissemination is observed.

For both of them, no magnetic susceptibility under a pen magnet examination can be seen.

(3) Time of intrusion

It is assumed that this rock intruded into both G. Raya and G. Sebiawak granodiorite, however, no such a contact is confirmed yet.

2-7 Tertiary Intrusive Rocks

2-7-1 Banyi Type Tonalite

(1) Distribution

The distribution is found as a large or small stock in the villages of Panji, Tajur, Kayuaga, Datt and Tempara, and on the mountains of Gunung Belakang and Gunung Sematuk at about 3 km east of Pahuman village.

(2) Rock facies and lithology

This rock in general has a color index of 30 ∿ 40% with a medium or coarse equi-granular texture. The main constituent minerals are chiefly quartz, plagioclase, hornblende and biotite. The magnetic susceptibility tested by pen magnet in field is strong.

The result under microscope observations revealed to have a granular texture, chiefly consisting of plagioclase, quartz and hornblende, with the accessory minerals of a little quantity of iron minerals and apatite in addition to biotite.

2-7-2 Diorites

(1) Distribution

The distribution is found as a small dyke at Panji at east of this survey area, at east of Pahuman and around Asong village.

(2) Rock facies and lithology

This is a diorite having a dark grey color with a medium grained equi-granular texture, aboundant in hornblende, being disseminated by a little quantity of pyrite. The magnetic susceptibility tested by pen magnet in field is strong.

(3) Time of intrusion

It is inferred the nearly same with that of Banyi tonalites.

2-7-3 Quartz Porphyry

(1) Distribution

The rocks are distributed around east of Pahuman village, Kabatin village and at west of Gunung Sematuk. The rocks around east of Pahuman intruded into G. Sebiawak granodiorites, while those around Kabatin village and at west of Gunung Sematuk intruded into the andesitic tuff breccia of the lowest Belango Formation.

(2) Rock facies and lithology

This has a greenish grey color with conspicuous phenocrysts of quartz and plagioclase. When weathered, the plagioclase turns to white, the quartz appearing conspicuously. There is relatively a few of colored minerals and a minor crystal of hornblende.

The observations under microscope (RC-27) resulted as follows.

The plagioclase and augite of hypautomorphic - idiomorphic to show a zonal texture in general, and the hornblende fairly chloritized are contained in the groundmass consisting of lath-shaped plagioclase, hornblende, iron mineral, epidote and a minor quantity of apatite.

2-7-4 Dorerite Dykes

(1) Distribution

This rocks and known with the three distributions, such as at west of Gunung Raya, around Bagak village and two rows around Boyong village at about 3 km northwest of Gombang village.

The dykes around Gunung Sampape show in a form of small stocks, while others are small dykes having the strikes at N-S or NE-SW.

(2) Rock facies and lithology

This has a dark green color with a medium granular texture. The main constituent minerals are hornblende and pyroxene, including almost none of plagioclase.

Both hornblende and pyroxene are altered into epidote to a fair extent. The dolerite (RA-65) distributed at west of Gunung Tiang consists of plagioclase, pyroxene and a minor quantity of small biotitic crystals, including a very few of quartz.

Since the dyke at southwest of Boyong village is accompanied by Banyi tonalite and intruding into Gunung Sebiawak granodiorites, it is inferred that the rocks were intruded, following to the tonalite.

2-7-5 Andesite Dykes

(1) Distribution

Many distributions of small dykes at 1 ∿ 3 m in width are found at various locations within the survey area.

(2) Rock facies and lithology

There are two types, i.e. a massive fine granular andesite dyke and a slightly coarce granular dyke having a phenocryst of plagioclase.

The result derived from the observations under a microscope revealed to have a minor quantity of plagioclase and augite phenocryst in the groundmass consisting of lath-shaped plagioclse, augite, chlorite, iron ores, calcite and a minor quantity of quartz.

CHAPTER 3 GEOLOGICAL STRUCTURE

The intrusive direction of Cretaceous granodiorite distributed in this survey area was greatly confined by the general structural trend (NW-SE) of Cretaceous magmatic activity (Cretaceous Magmatic Arc by Katili, 1973) continuing from east of Malaysian Peninsula to Central Kalimantan via West Kalimantan. Viewing from the geological characteristics in this survey area, however, a respectively different feature of geological structure can be observed between the sedimentary rock area where Bengkayang Group (Upper Trassic - Lower Jurassic) at north is widely distributed and the Cretaceous granodiorite batholith area at south.

3-1 Northern Sedimentary Rock Area

In the northern sedimentary rock area, Bengkayang Group has an anticlinal dome structure, being caused by Sirih tonalite intrusion during Middle Tertiary. Faults, dykes, ore veins and small folding axes, which are referred by projection of the strike and dip of bedding planes on Schmidt's net, have also a trend (NW-SE) harmonious with this anticlinal dome structure.

At the place being away from Sirih tonatile, the anticlinal and syclinal structures trending E-W were observed along the road between Bengkayang and Lumar in Bengkayang Group where the structure before intrusion of Sirih tonalite is still remaining.

3-2 Southern Granodiorite Batholith Zone

There are two structural trends in the southern granodiorite batholith zone, i.e. NE-SW trend forming a contact between the sedimentary rocks and the granodiorite batholithes, and NW-SE trend faults running at south of Darit. Either one is the fault trend formed before intrusion of quartz diorite, and the oldest structural trend after intrusion of granodiorite divided this area into three blocks. The folding of E-W trend seen in Belango Formation in Darit area is also formed generated during this period.

Quartz diorite, Sirih tonalite and Serantak dacite intruded as stocks in the granodiorite batholith, are aligned in the two directions of NNW-SSE and NE-SW trend. The faults and folding axes referring from the projection of strike and dip on bedding planes in Belango Formation on Schmidt's net have also the same direction with those of above both structural trends. The mineralized zones are also coincided with these structural trends. Since these structural trends relate to the intrusive rocks and the mineralizations, they are inferred the tectonic lines being caused by the deep fissures continued to be active until Middle-Tertiary in the granodiorite rocks as Fig. 3-11 shows.

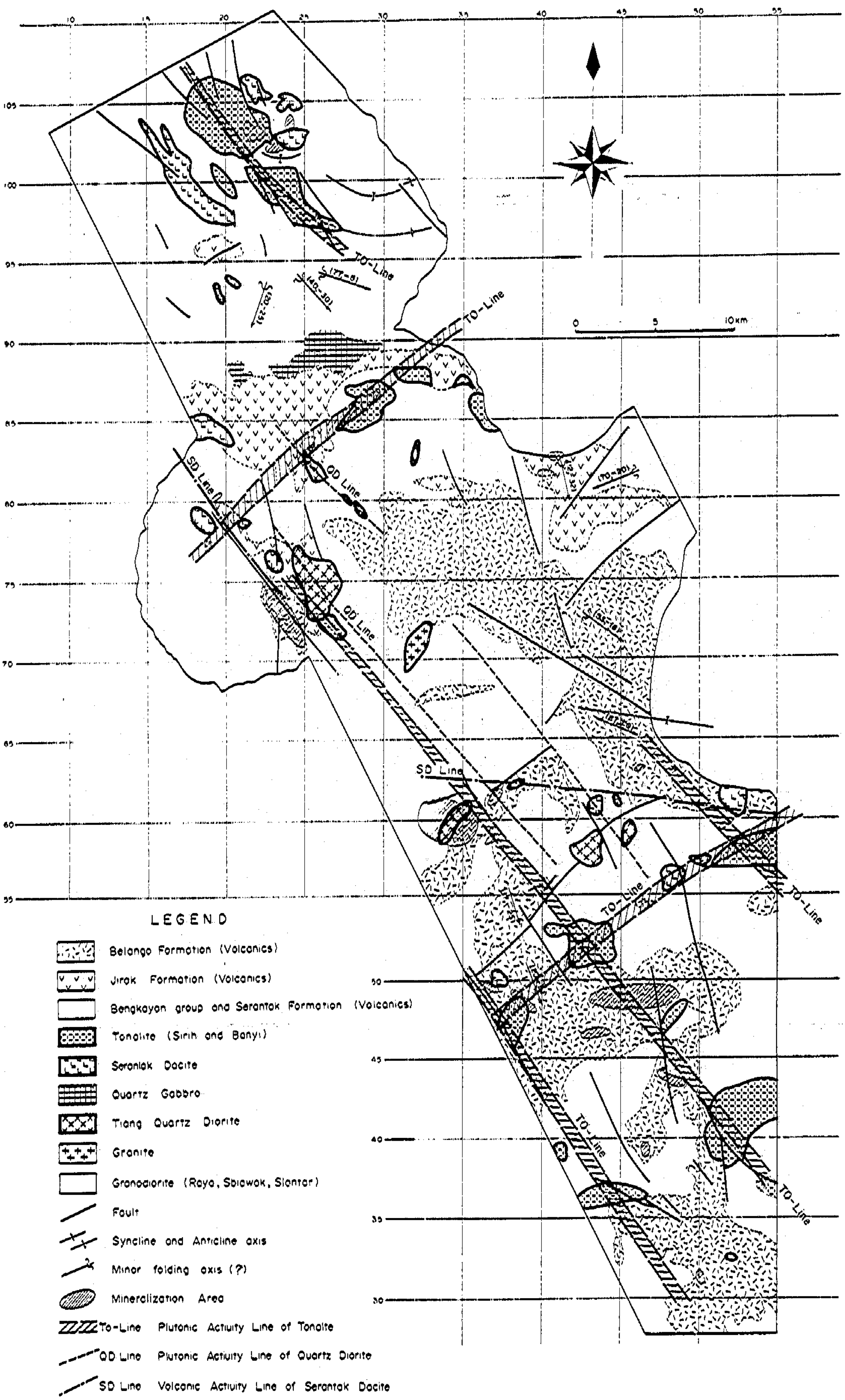

Fig 3-11 Outline of Geological Structure in Survey Area