THE REPUBLIC OF INDONESIA

REPORT ON THE COOPERATIVE MINERAL EXPLORATION

OF

NOTHERN SUMATRA

CONSOLIDATED REPORT

APRIL 1985

JAPAN INTERNATIONAL COOPERATION AGENCY
METAL MINING AGENCY OF JAPAN

Errata

page and line	error	correct
ix up 22	Mabar river	Mabar River
9 up 4	The intrusion in the late Cretaceous period of the Hatapang granite	The intrusion of the Hatapang granite in the late Cretaceous period
11 up 4	K-Ar rediometric	K-Ar radiometric
11 dawn 16	inthe world	in the world
Fig II-5	Total Fe	Total FeO
Fig II-9	collision nelated	collision related
24 up 7	Silungkaug Formation	Silungang Formation
24 up 18	belong to	belongs to
25 dawn 21	rations	ratio
25 dawn 14	granittoid	granitoid
25 dawn 7	The content of fluorite increases proportionally as the content of florine increased proportionally as the ---	The content of fluorite increases proportionally as the ---
26 up 7	granitoid	granite
Fig III-3	Total Fe	Total FeO
29 dawn 3	Bt. Pionggn	Bt.Pionggu
47 up 4	strage condition	emplacement condition
47 up 5	strage range	emplacement range
47 up 7	boring survey -- boring location	drilling survey -- drilling location
47 up 8	Fig	Fig IV-8
47 up 10	boring survey	drilling survey
Fig IV-8	o Third phase	• Third phase
49 up 14	prodominantce	predominance
48 up 15	Rock Faciesck I	Rock Facies
51 up 6	spread and at Cretaceous	spread at Cretaceous
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Table V-5	Fe/Fe+Ms	Fe/Fe+Mg
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PREFACE

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

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

The Government of the Republic of Indonesia appointed the Directorate of Mineral Resources to execute the survey as counterpart to the Japanese Team.

The survey has been carried out jointly by experts from both Governments.

The collaboration survey for metallic mineral, which lasted three years, consisted of geological, geochemical, and geophysical survey, supported by core drilling and laboratory work.

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

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

April 30, 1985

Prof. Dr. J.A. KATILI

Director General of Gelology
and Mineral Resources,
Ministry of Mines and Energy,
Republic of Indonesia.

Keisuke ARITA,

President,
Japan International
Cooperation Agency,
Japan.

Masayuki NISHIIE,

President,
Metal Mining Agency of Japan
Japan.

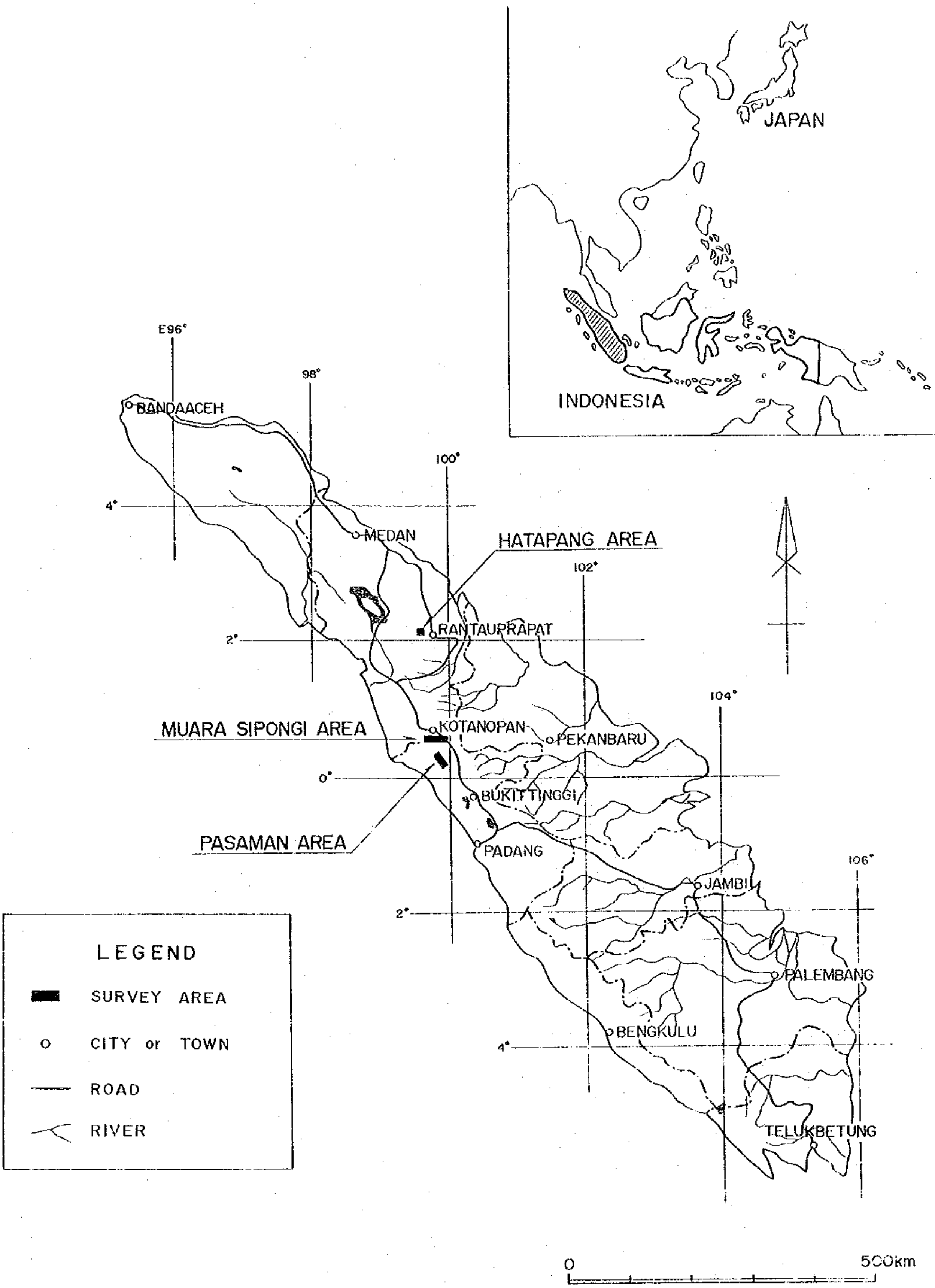

Fig. I-1 Location Map of Survey Areas in Northern Sumatra

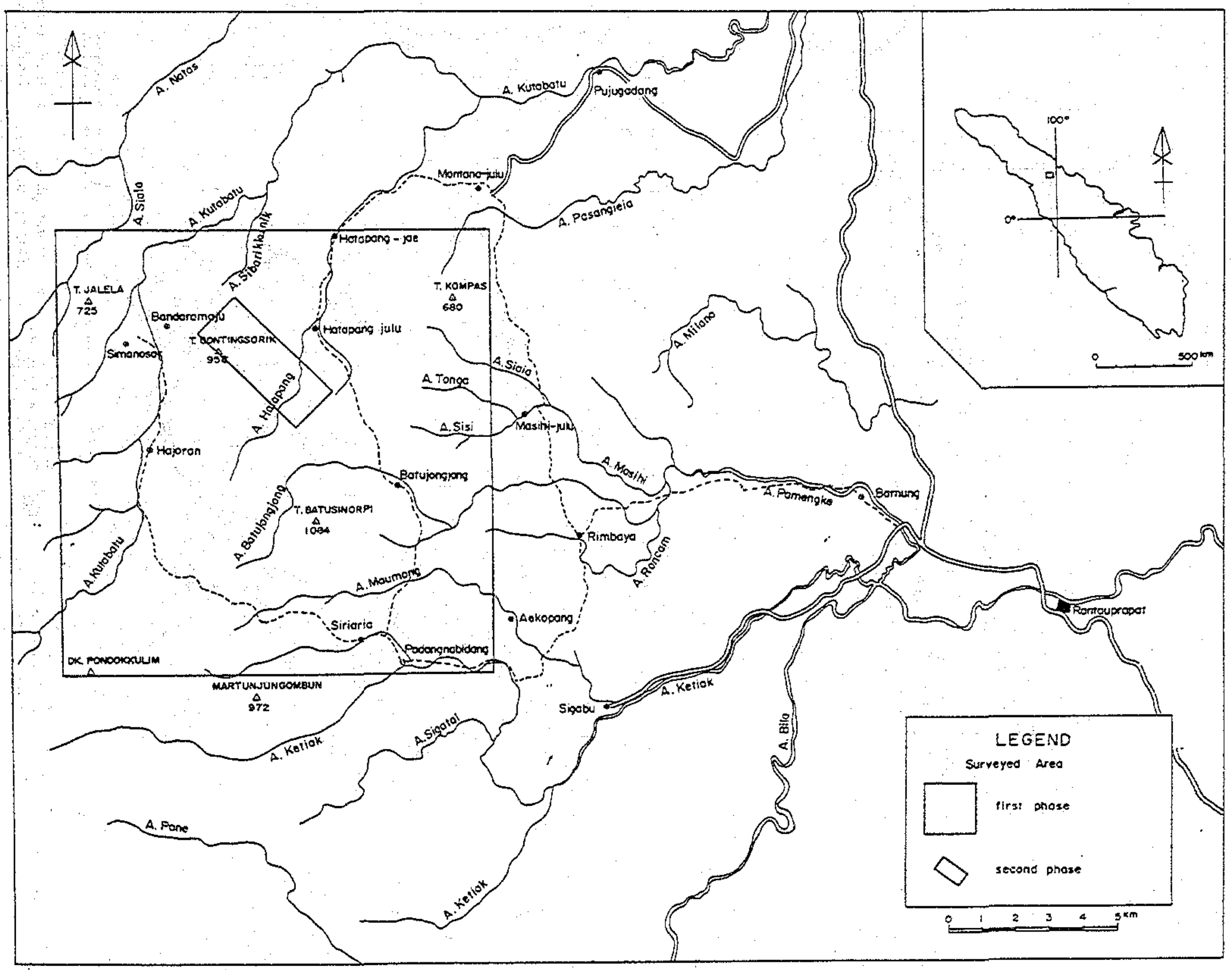

Fig. I-2 Location Map of Hatapang Area

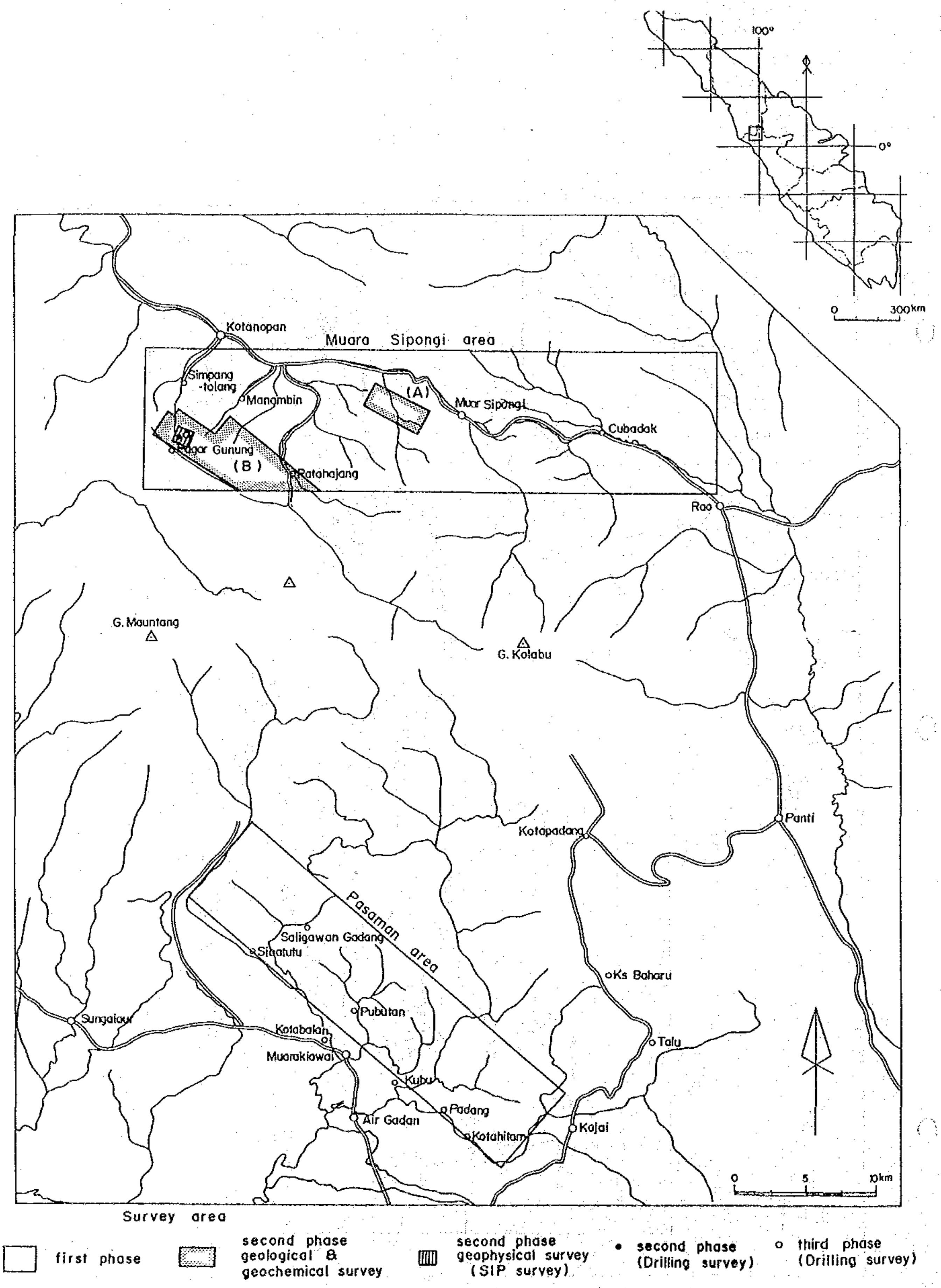

Fig. I-3 Location Map of Muara Sipongi Area and Pasaman Area

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SUMMARY

The government of the Republic of Indonesia requested the Japanese government to conduct the Cooperative Mineral Exploration survey in the Northern Sumatra. In response to the request the Japanese government conducted the geological survey, geochemical survey, geophysical survey (SIP method) and drilling survey from 1982 to 1984.

The results of the surveys are summarized as follows.

1. **Hatapang Area (169 km^2), subject minerals: tin, tungsten.**

The geology of this area consists of Hatapang Formation, the Permian – the Carboniferous, the Palezoic, and adamellite granite (Hatapang granite) was intruded during the later Cretaceous time. The tin-bearing granite with high tin grade of 10 ppm – 98 ppm is recognized in the Hatapang granite.

From the rock facies and age it is considered that the Hatapang granite belongs to the extension of the Phuket zone located at the westernmost area of the Thai-Malaysian-Indonesian tin mineralized zone.

From the distribution of tin, fluorine and lithium in the granite, anomalous areas of tin and fluorine in the stream sediment and consentrating distribution of cassiterite placer in river found by the panning survey, the northern margin area (Hatapang river – Mabar river) and eastern margin area (middle reach of Batu Jongjong River) of the granite were selected as the areas with high possibility of emplacement of tin deposit.

In the datail geochemical survey (soil) conducted at northern margin area of the Hatapang granite a tin and florine anomalous area with the width of 200 m extending 800 m east and west was recognized at the contact between the granite and sedimentary rock at the upper reach of the Mabar river, and this area has the possibility embedding tin deposit if the tin deposit ever exists in the Hatapang area.

2. **Muara Sipongi Area (400 km^2), subject minerals: gold, silver, copper, lead, zinc**

This area is composed of Muara Botung meta-andesite Formation and Patahajang limestone-sedimentary rock – pyroclastic rock Formation, the Permian – the Carboniferans, and the Muara Sipongi granitoids of Jurassic age has intruded in both Formations.

It was made clear that there are the Subunsubun – Bt Pionggu – Si Ayu mineralized zone, gold copper ore deposit (vein type ore deposit and skarn type ore deposit), and Pagar Gunung minerlized zone – Patahajang alteration zone, silver bearing lead zinc ore deposits (skarn type deposit) and the Pagar Gunung mineralized zone was selected as a more promising mineralized zone among them.

It was confirmed by the outcrops and old adits that Pagar Gunung mineralized zone consists of eastern mineralized zone and western mineralized zone (650 m between the zones).

Through the geochemical survey the silver-copper-lead-zinc anomalous areas was recognized extending 1,000 m east and west along the Pagar Gunung mineralized zone from the eastern zone to the western zone. Also, from the existence of 2 anomalous areas (300 m – 400 m extension and 1,000 m extension) by the geophysical survey (SIP method), it is expected that the Pagar Gunung mineralized zone extends more than 1,000 m east and west.

The subsequent drilling survey (14 holes, total length 3,300 m) in the Pagar Gunung Mineralized Zone revealed the following:,

(1) The Pagar Gunung Mineralized Zone is embedded in the Sedimentary Rock and Pyroclastic Rock Members belonging to the Patahajang Formation. In these Members, 4 mineralized zones were found, and the upper 2 mineralized zones (Mineralized Zone I', Mineralized Zone I) are silver-copper-lead-zinc mineralized zone accompanied by epidote and clinopyrozene skarn of Argillaceous Rock Dominance Facies and the lower Mineralized Zone II embedded in the Siliceous Rock and Tuff Facies is (sphalerite) pyrrhotite and pyrite deposits accompanied by the epidote and garnet skarn, and Mineralization III is pyrite mineralized zone accompanied by sericitization. The characteristics of the mineralized zones are as follows.

Mineralized zone	Emplacement Horizone	Ore mineral and skarn mineral
Mineralized Zone I'	Argillaceous Rock Predominance Facies (20 m)	Gold bearing silver chalcopyrite, galena sphalerite epidote (clinopyrozene) (especially gold content is high)
Mineralized Zone I	Argillaceous Rock Rock Predominance Facies (20 m ~ 30 m)	Silver-bearing (chalcopyrite) galena sphalerite epidote (clinopyrozene)
Mineralized Zone II (consisting of 6 ore horizons)	Siliceous rock and tuff facies (30 m ~ 60 m)	(sphalerite), pyrrhotite, pyrite (the higher the deposit, the richer in sphalerite), epidote garnet (clinopyrozene)
Mineralized Zone III	Same as above (10 m)	Massive pyrite, sericitization (horizon thickness)

( ): thickness of the horizone

(2) The Mineralized Zone I' was newly found by the drilling survey and has good grade, namely thickness of 110 cm, grade of gold 0.41 g/t, silver 195 g/t, copper 1.25%, lead 1.31% and zinc 9.85%(MJI-13). The mineralized zone captured by the MJI-14 drilling has a higher gold grade of 1.63 g/t than other mineralized zones, although it is a drag ore (width 20 cm).

(3) The Mineralized Zone I was confirmed to extend more than 1,200 m east and west with alternately rich part and poor part and its average thickness ang grade are 60 cm – 100 cm, silver 165 g/t – 12 g/t, copper 0.84% – 0.28%, lead 3.44% – 1.59% and zinc 7.56% – 1.29%.

(4) The Mineralized Zone II consists of 6 ore sub-zones and partially contains zinc (maximum 6.94%) but generally the ore grade for silver, copper, lead and zinc is low like the Mineralized Zone III.

(5) The mineral contents of the main mineralized zones are as follows:

The Possible ore reserve is expected about 800,000t, average thickness of 0.88 m and grade of silver 68 g/t, copper 0.45% lead 1.20% and zinc 4.60% calculating based on the above results.

Drill Hole No.	Drill Depth (m)	Width (m)	Au g/t	Ag g/t	Cu %	Pb %	Zn %
Mineralized Zone I							
MJI-3	53.70 ~ 54.30	0.60	<0.1	62.0	0.14	3.44	1.29
MJI-4	122.00 ~ 122.60	0.60	<0.1	42.0	0.30	2.50	4.48
MJI-5	190.40 ~ 192.60	2.20	<0.1	27.7	0.28	0.17	3.73
MJI-6	61.70 ~ 62.70	1.00	<0.1	20.3	0.08	1.60	2.47
MJI-9	150.40 ~ 151.40	1.00	<0.1	164.6	0.82	1.69	7.52
MJI-12	75.10 ~ 76.10	1.00	–	23.9	0.48	0.02	7.56
MJI-14	141.65 ~ 142.35	0.70	–	12.0	0.04	1.59	1.47
Mineralized Zone I'							
MJI-13	23.10 ~ 24.20	1.10	0.41	195.0	1.25	1.31	9.85
MJI-14	38.30 ~ 38.50	0.20	1.63	94.0	0.90	6.48	3.84
MJI-14	39.10 ~ 39.80	0.70	–	32.0	0.11	2.24	1.58
Mineralized Zone II							
MJI-5	241.40 ~ 242.20	0.80	<0.1	13.0	0.05	0.60	2.03
MJI-II	195.15 ~ 195.40	0.25	<0.1	0.9	0.05	<0.01	6.94

3. Pasaman Area (200 km^2), subject mineral: chrome

The ultrabasic rock body with the scale of 8 kn NS by 4 km EW is accompanied by some amount of dunite but mostly consists of harzburgite. This harzburgite contains 0.2 – 0.5% of Cr_2O_3. The chrome mineral contained in the rock is chromium spinel because the Cr_2O_3 grade of mineral is 27% – 47% whereas the Al_2O_3 content is high at 40% – 20%. It is not good quality for chrome ore. It is a small possiblity to find chromite ore deposit valued economically.

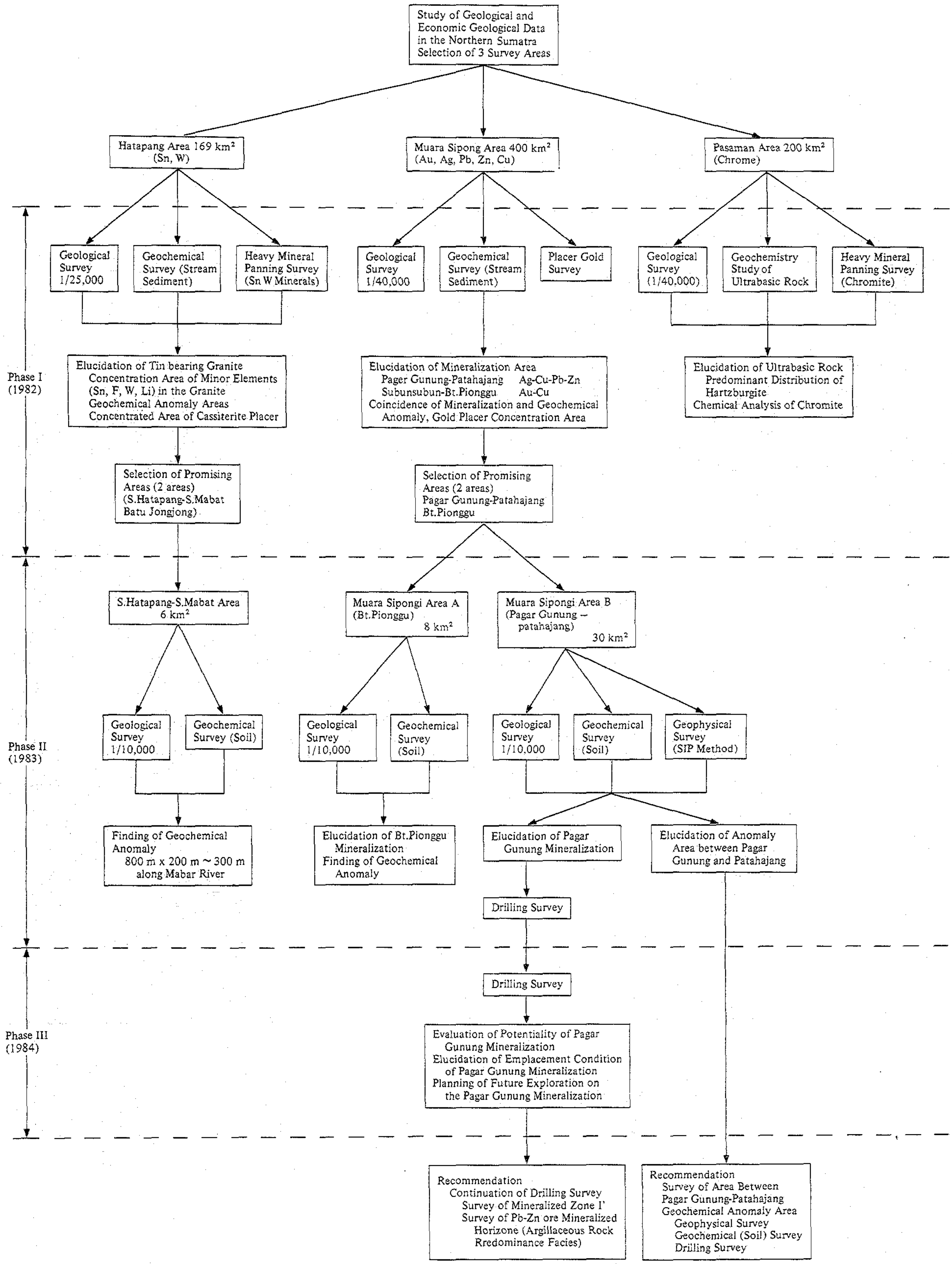


Table I-1 Flow Sheet of Selection of Promising Area through Survey

PART I

INTRODUCTION

CHAPTER 1 OUTLINE OF SURVEY

1-1 Survey Areas and Survey Objectives

Of the mineralized areas distributed in the Northern Sumatra of Indonesia, the following 3 areas were selected and the possibility of emplasement of ore deposits was surveyed by elucidating the relations among the geology, geological structure, igneous activities and mineralization in these areas.

The survey areas were as follows, (Fig. I-1);

(a) Hatapang Area
This areas is situated approximately 2°10′ North Latitude by 99°37′ East Longitude and covers an area of 169 km² (13 km x 13 km), and tin and tungsten were the subject minerals of the survey. (Fig. I-2)

(b) Muara Sipongi Area
This area covers 400 km² and is bounded by the following coordinates (40 km EW x 10 km NS).;

North latitude	0°30′	East longitude	99°38′
″	0°40′	″	99°38′
″	0°30′	″	100°02′
″	0°40′	″	100°02′

Gold, silver, copper, lead and zinc were the subject minerals of this survey. (Fig. I-3)

(c) Pasaman Area
This area is situated approximately at 0°13′ North latitude by 99°53′ East longitude and covers an area of 200 km² (7 km x 30 km), and chromite was the subject mineral of this survey. (Fig. I-3)

1-2 Survey Methods and Survey Amount

The survey was conducted for 3 years from 1982 through 1984.

The survey methods and survey amount by year are shown in Table I-2.

1-3 Survey Period and Survey Members

The preliminary survey and agreement negotiation survey was conducted from July 6, 1982 to July 20, 1982.

The survey members are as follows.

Leader	Shozo Sawaya (MMAJ)
Members	Masahiro Nagai (Agency of Natural Resources and Energy, MITI)
″	Ken Nakayama (MMAJ)
″	Tadaaki Ezawa (JICA)

The Indonesian members are as follows.

Prof. Dr. J. A. KATILI	– Director General Directorate General of Mires *Ministry of Mines and Energy* DIRECTORATE OF MINERAL RESOURCES
Ir. Salman PADMANAGARA	– Director ;
Drs. DJUMHANI	– Chief. Exploration Services Division
Drs. Juliar THAIB	– Chief, Geochemistry Division;
Ir. P. H. SILITONGA M. Sc	– Chief, Metallic Minerals Exploration Division;
Ir. SUBANDORO	– Acting Chief, Exploration Geophysics Division;
Ir. SUBANDORO	– Chief, Volcanogenic Minerals Section;
Dra. Ellya DAMAN	– Mineral Chemistry Laboratory;
Dra. RATNAWIDURI S	– Chief, Foreign Technical Cooperation Sub Setion.

The survey period and survey memebers by year are shown in Table I-3.

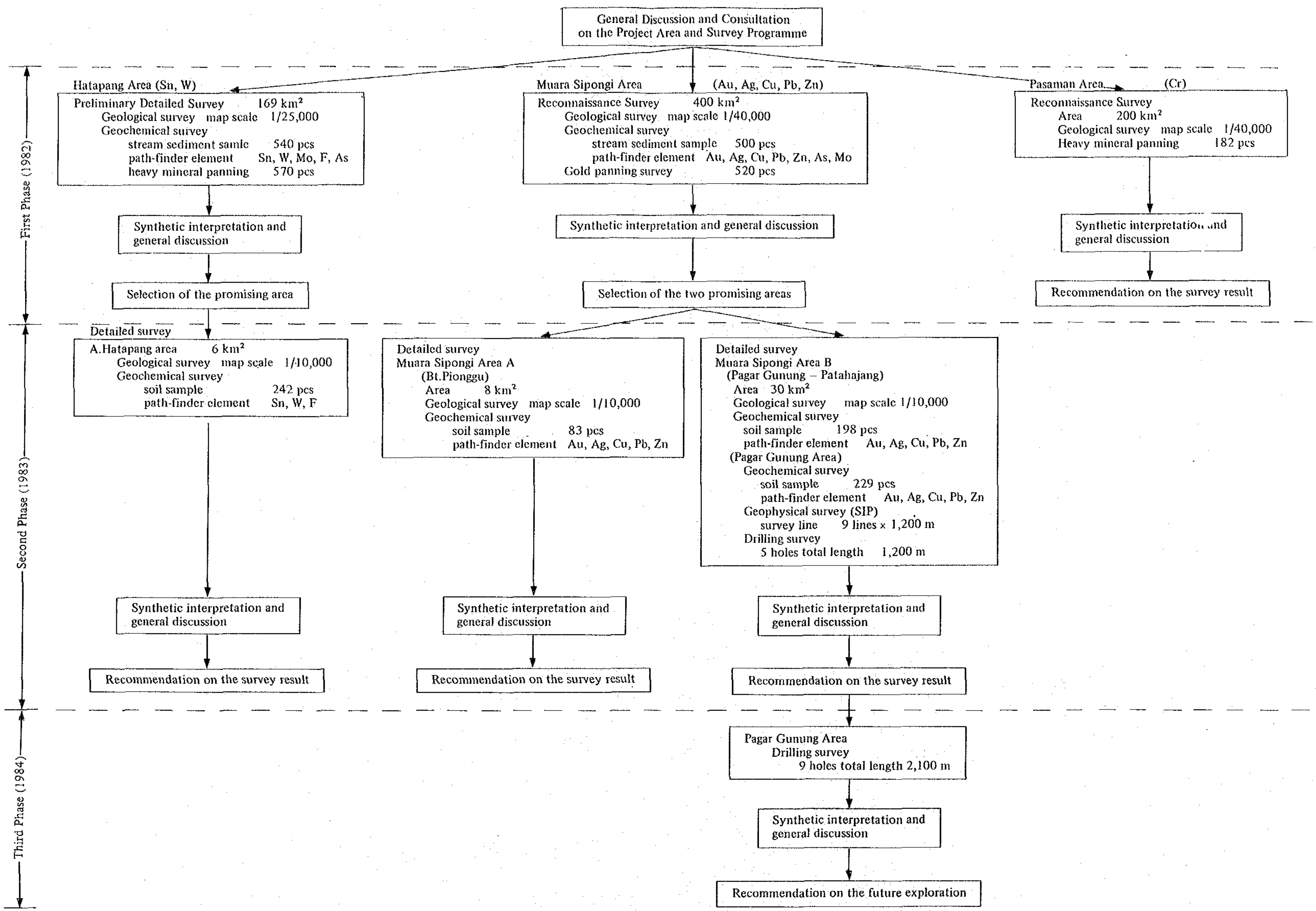


Table I-2 Flow Sheet of Survey in Northern Sumatra

Table I-3 Survey Schedule, Term, and Members

Year	Survey	Survey Period	Survey Members	
			Japan	Indonesia
Phase I (1982)	Survey Programing & Negotiation		Ken Nakayama	P.H.Silitonga
	Geological Survey Geochemical Survey Data Processing	Aug. 24, 1982 Nov. 6, 1982 Nov. 7, 1982 Dec. 6, 1982	Sakae Ichihara Hideo Suzuki Haruo Watanabe Osamu Miyaishi Mitsuru Suzuki Ikuya Hamada	Yaya Sunarya Surjono Yan S.Manurung Adin Simbolon Deddy T.Sutisna Johnny R.Tampubolon Danny Z.Herman Sukmana Hotma Simangunsong Zulkifli Wahju III M.Mamat
Phase II (1983)	Survey Programing & Negotiation		Makoto Ishida Ken Nakayama Jiro Osako Takahisa Yamamoto Shigeo Wada	P.H.Silitonga
	Geological Survey Geochemical Survey Data Processing	May 30, 1983 Aug. 16, 1983 Aug. 17, 1983 Oct. 15, 1983	Sakae Ichihara Hideya Kikuchi Tetsuo Sato	Yaya Sunarya Surjono Koswara Yudawinata Soebejo Jonny R.Tampubolon Danny Z.Herman Hotma Simangunsong Wahju III Atun Suryana M.Mamat
	Geophysical Survey	May 30, 1983 Aug. 13, 1983	Masao Yoshizawa Tomio Tanaka Masatane Kato	Marino Rachmat Setiawan Empon Ruswandi Manasal Hutagalung W.Suparmin Asngari Suparno
	Drilling Survey	Nov. 2, 1983 May 10, 1984	Koichiro Daimaru Yukio Kawamura Isamu Nakayama Tatsuo Sawaguchi	Yaya Sunarya Surjono Deddy T.Sutisna Johnny R. Tampubolon Danny Z.Herman Saksono Suratman Bany Johan Encep Sudjana Bambang Wahono Moe'tamar M.Mamat
Phase III (1984)	Survey Programing & Negotiation		Makoto Ishida Ken Nakayama Takashi Kamiki	P.H.Silitonga
	Drilling Survey	June 25, 1984 Mar. 23, 1985	Sakae Ichihara Yukio Kawamura Mitsuo Sasaki Masazo Hâga	Yaya Sunarya Deddy T.Sutisna Madtuhi Tono Hardyan Supratono Ruhiat Kisman Bany Johan M.Mamat

CHAPTER 2 PREVIOUS SURVEY

During the period of Dutch colonization, surveys were conducted in northern Sumatra by Schürman (1930), Bemmelen (1932, 1939), Westerveld (1947), Van der Marel (1941, 1947, 1948), and Druif (1932, 1934, 1939), mainly in the Aceh, Medan, and Toba areas. The geology, geological structures, and mineral resources of these areas are covered comprehensively by Bemmelen in his *Geology of Indonesia* (1949). Geological maps have also been compiled in 1/1,000,000 and 1/250,000 scale.

The first integrated geological survey of all of northern Sumatra was conducted from 1975 through 1980 by a cooperative team composed of members from Indonesia (GSI · DMR) and Great Britain (IGS). The team performed regional geological and geochemical surveys. The project shed light upon the geology and geological structure of northern Sumatra and resulted in the discovery of a number of areas containing ore deposits. The results of the survey have been published in the form of a series of 1/250,000 scale geological maps by the Geological Research and Development Center (formerly the Geological Survey of Indonesia) of the Ministry of Mines and Energy.

Extensive research involving investigation of the geological structure of northern Sumatra from the standpoint of the plate tectonics theory has been published by Katili (1968 – 1982), Hamilton (1978), Cameron (1980), and others. These efforts have resulted in an ever-increasing clarification of the history of the geological tectonics of northern Sumatra.

In 1970, the Overseas Resources Development Co., Ltd. conducted surveys on the metallic mineral resources of the Kotanopan – Muara Sipongi areas of the southern Tapanuli region, which have long been known for their gold, coppear, lead, and zinc ore deposits. Also known, among others, are the zinc ore mineralized zones of the Rokop region, the porphyry copper deposits (Tangse) and tin-tungsten mineralizations (Hatapang) discovered by the Indonesian – British Cooperative Survey team. P.T. Tambang Timah of Indonesia, Rio Tinto Group is now conducting surveys and prospecting works on the Tangse porphyry copper deposits.

CHAPTER 3 GEOLOGICAL OUTLINE OF NORTHERN SUMATRA

From 1975 through 1980, the Indonesian – British Cooperative Survey team conducted an integrated geological survey over a wide expanse of northern Sumatra covering some 190,000 km^2. The results of this survey have been reported in numerous research papers, and new material continues to be published in the form of a series of 1/250,000-scale geological maps. The following outline of the geology of northern Sumatra is based on these materials. (Fig. I-4)

The oldest strata known to exist in northern Sumatra are Tapanuli Group, the Permian – the Carboniferous, which is made up of the Kluet Formation which is intercalated with thin layers of mudstone and siltstone in quartz arenite; the Bohorok Formation, composed of unsorted conglomerate wacke (pebble mudstone) which is comtemporaneous heterotopic facies interfingered with the Kluet Formation and the Alus Formation which accompanies mainly limestone which covers the Kluet Formation. These are distributed in the Barisan Mountains and their eastern environs.

The Upper Permian – Triassic system Peusangan Group, which overlies the Tapanuli Group, is made up of the Silungkang Formation composed of semi-continental basic volcanic rock and Fusulina lime-stone, and the Kualu Formation composed of Triassic limestone, radiolarion chert, wacke sandstone, and siltstone. Kualu Formation overlies unconformably the Tapanuli Group and the Silungkang Formation.

The Silungkang Formation is distributed along the Takengkan tectonic line in central Aceh as well as in the Muara Sipongi region, and is correlative with the Silungkang Formation found south of the Equator (Silitonga, Kastowo; 1975). The Kuala Formation is distributed within the slopes of the Barisan Mountains from Rantauprapat to Parapat.

Woyla Group the Upper Jurassic-Cretaceous is made up of wacke, slate, and linestone in its lower member; basic an intermediate volcanic rock in its upper member and opholite, consisting of ultrabasic rock and radiolarian chert regarded as products of a marginal sea. They are distributed in the Ache and Natal regions.

During the Cenozoic era there was periodic volcanic activity, during which most of the sedimentary basins were formed. Among these basins are the Central Sumatran Basin, the North Sumatran Basin the Northwest Ache Basin, and the West Sumatran Basin. In the Pleiocene epoch there were eruptions of large quantities of Toba tuff, mainly in the Toba subsidences where a great deal of magma had been discharged in the rift valleys that were formed by geoanticlinal movement. This Toba tuff is distributed over a wide area.

Igneous activity involved the intrusion of granitoid rocks during the Palaeozoic era, the Triassic period, the Jurassic-Cretaceous period, and the Tertiary era, resulting in copper, lead, and zinc replacement deposits by Jurassic granitoid rock, tin and tungsten mineralization by Cretacious granites and porphyry copper deposits by Tertiary intrusion.

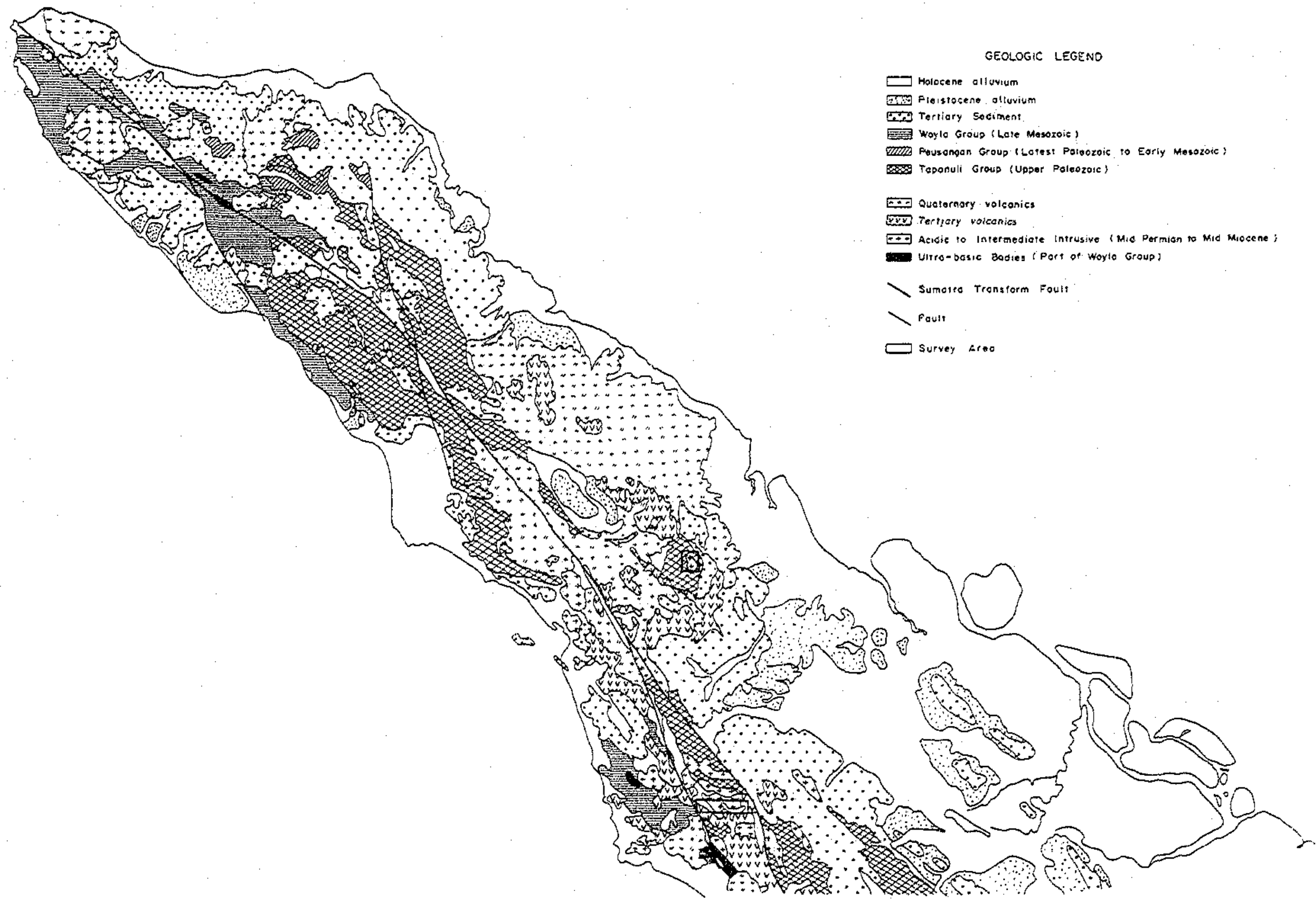


Fig. I-4 Geological Map of North Sumatra (DMR/IGS)

CHAPTER 4 CONDITION IN THE SURVEY AREA

The Sumatra Traverse Road runs 880 km between Medan in North Sumatra Province and Padang in West Sumatra Province, connecting the three survey sites and making them easily accessible to none another (Fig. I-1).

The Hatapang site is reached by means of the Sumatra Transverse Road via Rantauprapat which lies 285 km south of Medan. The site's base camp, Hatapan Julu, is reached by four-wheel-drive vehicle as far as Monton Julu 916 km) and by foot for the remaining 8 km to the Hatapang base camp.

The Sumatra transverse Road runs along the northern border of the Muara Sinpongi site; this survey area can also be reached from Kotanopan to Patahajang and from Batas to Limau Manis on unpaved roads. Muara Sipongi is situated 631 km from Medan, while Padang lies 249 km from Muara Sipongi.

Pasaman is accessible by car via the Trans-Sumatra Road by travelling from Panti, 50 km to the south of Muara Sipongi, in the direction of Air Bangis on the West Sumatran Coast for 90 km as far as Air Gadang, Muara Kiawai. At Air Gadang, a ferry is boarded to cross the Pasaman River. The ferry may inoperable during low-water periods, however, thereby hindering the transport of vehicles and machines.

While the above-mentioned main roads can be used to reach the town or village nearest to each of the survey areas, human labor is required to transport the various pieces of survey equipment, camping gear, food supplies and other necessary articles over the footpaths and mountain roads that lead into the actual survey sites.

Hatapang is located in North Sumatra Province, Muara Sipongi in North Sumatra and West Sumatra and West Sumatra Provinces, and Pasaman in West Sumatra Provinces, and Pasaman in West Sumatra Province; each is under the executive juristiction of its respective Provincial Government.

The survey sites are all middle and high altitude areas – 200 m – 1,500 m above sea level – lying within the Barisan Mountain Rage which runs longitudinally, like a spine, up the western part of the Island of Sumatra. Low and middle altitude areas, particularly those lying along main rivers, have already been extensively developed; they contain towns and villages and are largely cultivated, mainly with rice. There are also extensively developed plantations of coconut palms which are grown for their oil. Mountain and upland areas are covered with dense tropical rain forest, and travel by means other than road, mountain path, and river is difficult.

The region's climate is tropical with high temperatures and high humidity. The dry season lasts from May to August and the rainy season from August to April, according to past precipitation records. Data for Kotanopan shown monthly rainfall to be 83 – 168 mm during the May – August dry season and 196 – 284 mm during the September – April rainy season. Average monthly rainfall is 147 mm. Rainfall is heaviest during the months of October and November when 300 mm have been recorded.

While temperatures remain consistently high in the lower altitudes, the higher regions experience falling temperatures at night, making the use of sleeping bags a necessity. Tigers and monkeys inhabit the forests, and fresh tiger tracks were discovered at Pasaman. The lowland areas are also home to numerous mountain leeches and poisonous grasses, and malaria is common.

PART II

HATAPANG AREA

CHATPER 1 GEOLOGY

1-1 Geological Outline

The geology of the survey area consists of Permian and Carboniferous pebbly sandstone and mudstone Formation (Hatapang Formation). The intrusion in the late Cretaceous period of the Hatapang granite caused thermal alteration in the Hatapang Formation resulting in hornfels in the periphery of 1 km – 2 km of the intrusive rock stock. The Hatapang Formation is correlative with the Bohorok Formation of the Indonesian-British Cooperative Survey.

By the volcanic activity in Toba which produced a big caldera of Lake Toba from the late Tertiary time through the early Quarternary time, the pyroclastic rock (Toba tuff) was sedimentized around the Lake Toba, uncomformably covering the Hatapang Formation and Hatapang granite along the rivers, north of the survey area. Fig. II-2 generally shows the stratigraphy, igneous activities, geological structure and mineralization of the survey area.

1-2 Geology

1-2-1 Sedimentary Rock and Pyroclastic Rock

(1) Hatapang Formation

It is compoased of shale (siltstone and mudstone) and fine-grained sandstone having poorly sorted breccia and sub-breccia. Under the microscope, poorly sorted siltstone containing grains (0.1 mm – 0.3 mm) of quartz and feldspar in the silt matrix is observed and partially pebbly mudstone and siltstone containing breccia and sub-breccia of granite, sandstone and mudstone (0.5 mm – 2 cm) and quartz, feldspar fragments are also recognized. A field survey in the downstream Batu Jongjong River found tuffaceous rocks suggesting that the Hatapang Formation may contain a certain amount of pyroclastic rock. The sandstone and mudstone have the interfinger relations.

This Formation has been intruded by the Hatapang granite during the late Cretaceous time, and within 1 – 2 km from the contact the stratum has undergone thermal metamonphism and many biotite, muscovite and quartz were formed in the hornfels rock.

(2) Montong Julu Formation

This Formation is distributedat the Montong River in the northeast corner of the survey area but the distribution range is narrow. It consists of green sandstone and uncomformably covers the Hatapang Formation and is uncomformably covered by the Toba tuff bed in the Jampalan River and also from the agglomerate of the rock, it was classified as the Tertiary.

(3) Toba Tuff Formation

The Formation is distributed along the lower reaches of the Kota Batu River and Hatapang River and their tributaries in the northern part of the survey area, and forms small plateaus in some places. It is made of pale green dacite tuff and vitric crystal tuff which contains biotite and quartz fragments which do not contain so much of lithic fragment. In some parts of the Pangalan River, in the upper reaches of the Kota Batu River, volcanic conglomerate exists being accompanied by shale and granite pebbles. The tuff has derived by the volcanic activities in Toba during the later Tertiary ~ early Quaternary time.

1-2-2 Granites

(1) Hatapang Granite

It is distributed as oval sheped, stock with the scale of 6 km EW by 8 km NS in the central part of the survey area encompassing the upper reaches of the Kota Batu, Hatapang and Batu Jongjong River. Around the intrusive rock, many dike and small stock of the same type of biotite granite are distributed.

The Hatapang granite is classified into the following 3 types from its rock texture and component minerals.

(a) Porphyritic – Equi-granular Biotite Granite

Porphyritic biotite granite with large feldspar phenoxryst is main Hatapang granite and distributed in the central, eastern and southern parts of the stock. At the western margin of the stock becomes qui-granular and especially along the Kota Batu River. The microscopic examination reveals that both rocks consist of plagioclase, potassium feldspar, quartz and biotite as main rock-forming minerals and are generally accompanied by topaz, fluorite, and zircon as accessory. By the more analysis, they are classified as adamellite, containing almost equal quantities of plagioclase and potassium feldspar.

(b) Fine-Grained (Two mica) Granite

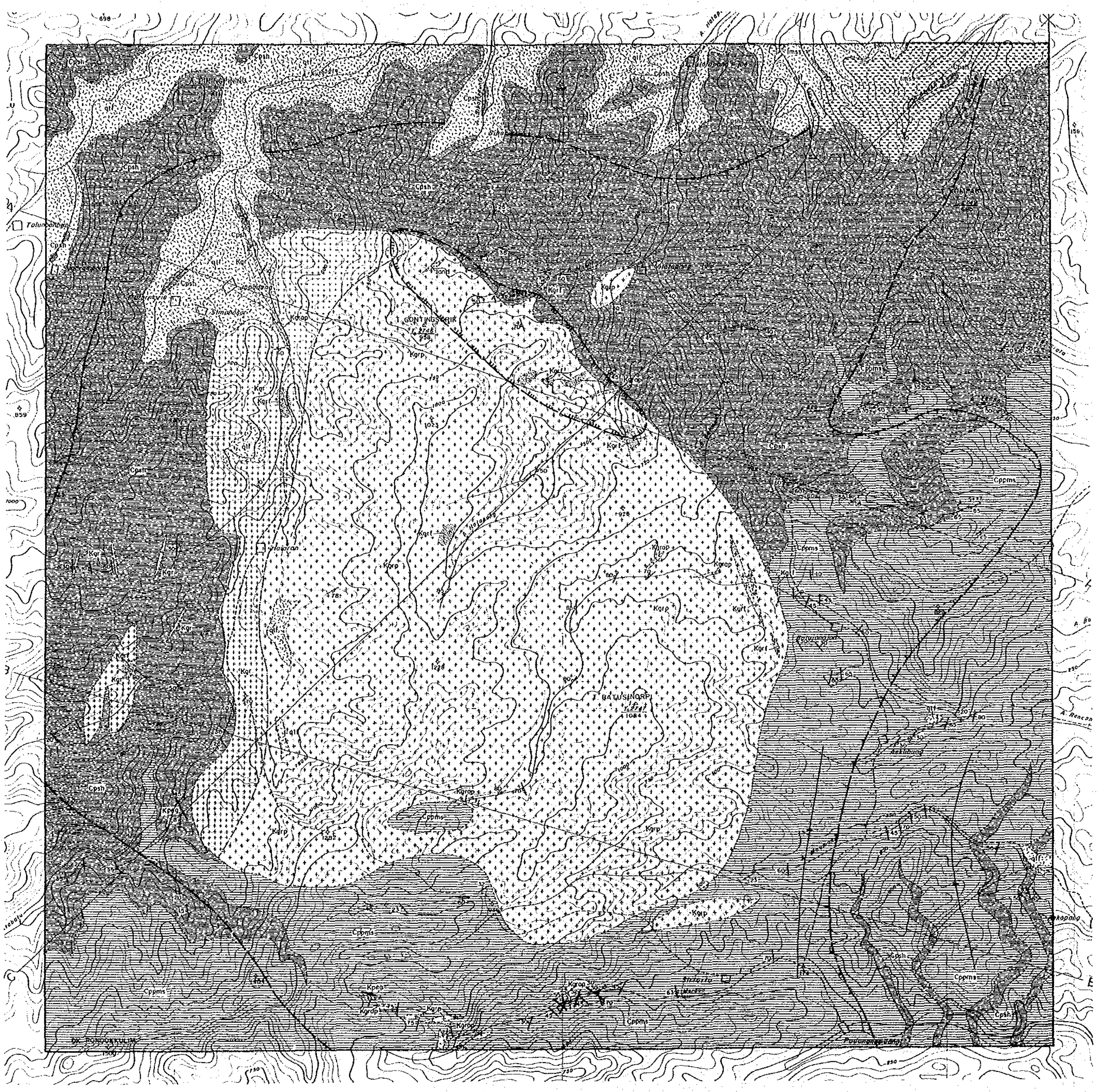
The rock is distributed in the northern and eastern parts of the Hatapang granite, in the upper reaches of the Hatapang River, north of Hajoran on the Kota Batu River. This rock has intruded as dikes or in irregular forms in the porphyritic granite – equi-granular granite and sometimes looks like the irregular portion of the Porphyritic and equi granular granite suggesting that the intrusion took place at the later stage of the time. The grenite is accompanied by muscovite, and as described later, it contains more tin as a minor element than the porphyritic and equi grained granites. The observation under the microscope reveals that its main rock-forming minerals are plagioclase, potassium feldspar, quartz and biotite, being accompanied by muscovite, topaz and fluorite. As a result of the mode analysis, it is also classified as granite (adamellite).

(c) Aplite

Fine-grained white aplite is recognized as dikes in the upper reaches of the Kota Batu River and along the peripery of the Hatapang River in the Hajoran area. It is fine-grained and equi-granular and contains plagioclase and quartz as main rock-forming minerals but almost none of biotite and muscovite, and is accompanied by fluorite and sphane.

(d) Pegmatite

Pegmatite veins accompanied by tourmaline are distributed in the periphery of the granite stock and accompanying the small granite stocks.



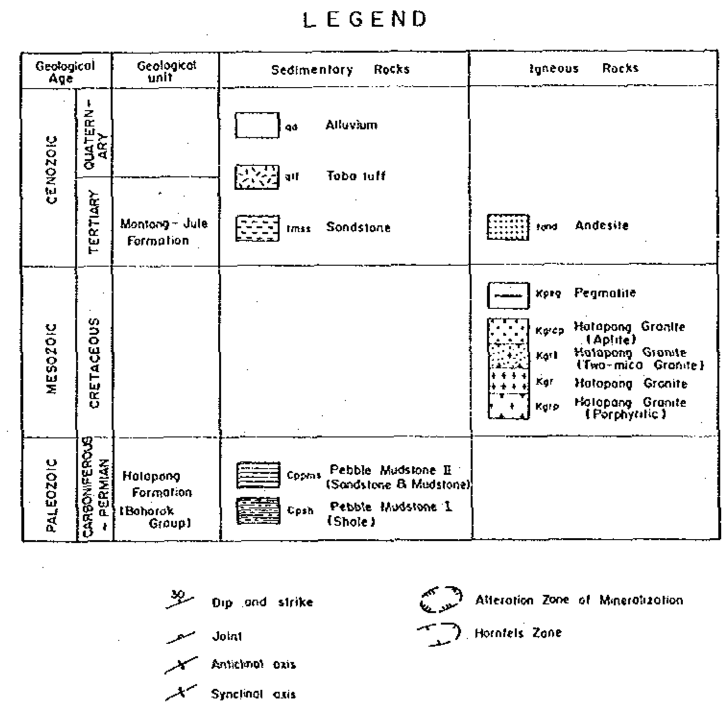


Fig. II-1 Geological Map of Hatapang Area

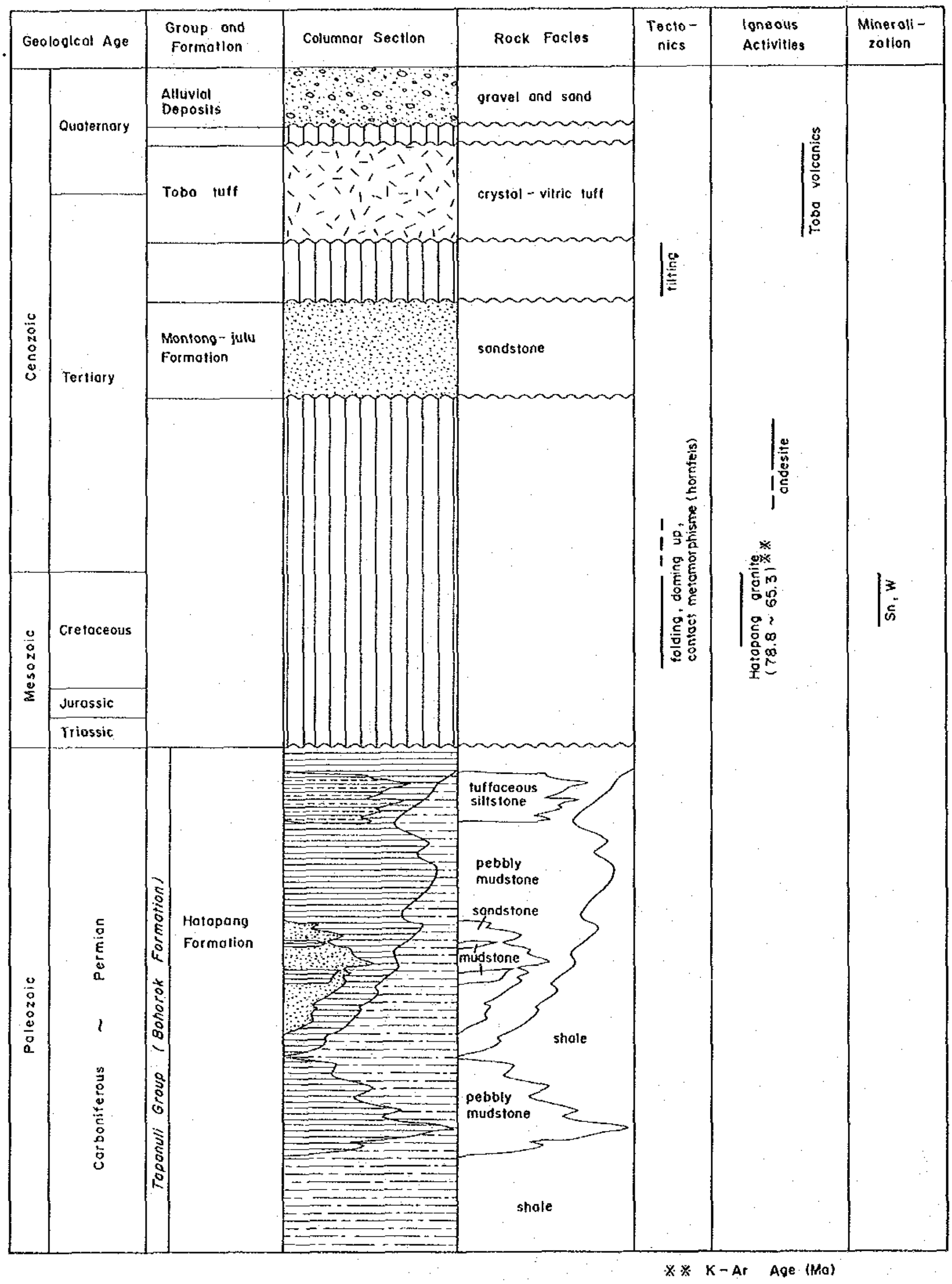


Fig. II-2 Generalized Stratigraphy of Hatapan Area

CHAPTER 2 CHARACTERISTICS OF HATAPANG GRANITE

2-1 Time of Intrusion

In order to determine the intrusion time of the Hatapang biotite granite, the age determination was made using the K-Ar rediometic method. One sampl (CR-7) was selected from Hatapang Julu, one (ED-1) from the upper reaches of the Batu Jongjong river (both were porphyritic biotite granite) and one (AR-6) from aplite and the age determination was performed on the biotite in the first two cases and on the whole rock in the last because it contained no biotite of hornblende. (Table II-1)

Table II-1 Age of Hatapang Granite through K-Ar Radiometric Method

No.	Sample No.	Locality	Rock Name	Mineral or Rock	^{40}Ar rad (sec./gm x 10^{-5})	^{40}Ar rad (%)	k %	Age (Ma)
1	AR-6	S. Manungal	Aplite	whole Rock	1.09 1.10 1.10	85.7 86.4	4.25 4.25	65.3 ± 2.6
2	CR-7	A. Hatapang	Granite	biotite	2.37 2.33 2.47	83.8 81.3 83.6	7.52 7.63	78.8 ± 3.2
3	ED-1	A. Batu Jong jong	Granite	biotite	1.73 1.79	76.0 80.1	5.79 5.83	76.2 ± 3.0

As a result of the determination, the porphyritic biotite granites were 78.8Ma and 76.2Ma and the aplite 65.3Ma, indicating the Late Cretaceous in age. The magnetic susceptibility of the Hatapang granite is very low at 17 – 1 x 10^{-5} SI units and it is classified to be of the ilmenite series granite.

2-2 Chemical Composition

31 samples were collected, as uniformly distrubiting as possible, from the Hatapang granite stock and the main elements (SiO_2, TiO_2, Al_2O_3, Fe_2O_3, FeO, MnO, MgO, CaO, Na_2O, K_2O, P_2O_5, BaO and Loi) and minor elements (F, Cl, Li, W, Sn, and Mo) were assayed. The samples collected included 12 samples from fine-grained (two-mica) granite. 17 samples from porphyritic biotite granite, a samples from aplite, and a sample from pegmatite.

Table II-2 shows the results of the analysis and the ratios of the normative minerals calculated from the analysis results. For reference the average values of the tin granites inthe world (Stemproskovor 1974, Hoskins 1979) and the average values of the minor elements of the tin bearing granite (Tischendorf 1977, Hoskins 1979) are also shown.

2-2-1 Main Chemical Composition

The Hatapang granite contains 73% – 77% SiO_2 and is an acidic granite to have the differentiation index of more than 92 (percentage of the normative minerals such as quartz, orthoclase and feldspar), indicating that it is a highly differentiated granite.

The Hatapang granite is plotted in the granite (adamellite) region on both the triangle relationshp diagram of the normative minerals, quartz-(plagioclase + albite) – potassium feldspar and the relationship diagram of the mode minerals, quartz-plagioclase-potassium feldspar (Fig. II-3, II-4). On the M – F – A relationship diagram, it is almost differentiated and gathered in the alkali (Na_2 + K_2O) corner (Fig. II-5).

On the K_2O-Na_2O–CaO diagram, this rock has low content of CaO and is gathered near the K_2O-Na_2O line (Fig. II-6).

The Hatapang granite shows similar values to the average grade of the world tin bearing granites (by Stemproskovor).

2-2-2 Trace Element Composition

(a) Tin

The tin content of the Hatapang granite was determined to be from 1 ppm to 98 ppm. The content was divided into 3 grade classes, 1 ppm – 7 ppm (21 samples), 1 ppm – 23 ppm (7) and 59 ppm – 98 ppm (3). Since the tin content in normal granites is 1 – 8 ppm according to Tischendorf (1977), the Hatapang granite samples containing 10 ppm or more of tin are considered to represent an anomalous value. Fig. II-7 shows the distribution of the anomalous value of tin which exists around the Hatapang River at the northern margin of the Hatapang granite and its tributaries and also in the middle reaches of the Batu Jongjong River. The tin content of 10 ppm or more is often found in the fine-grained two mica granite.

(b) Tungsten

Most of the tungsten values are in the range of 12 ppm to 22 ppm showing high back-ground, and especially high values of 170 ppm and 198 ppm were found in the region of the Batu Jongjong and the anomalous values are distributed in the center of the Hatapang granite stock, south of the anomalous area of tin (Fig. II-7).

(c) Fluorine

Except 2 samples, all the samples showed high fluorine contents ranging from 1,500 ppm to 5,000 ppm in comparison with the normal granites (250 ppm – 1,500 ppm, Tischendorf 1979). According to Tischendorf, the tin granite shows the fluorine content of 3,750 ppm ± 1,500 ppm, and from this point of view, the Hatapang granite showed the similar value as the tin bearing granite.

No particular correlation has been found between the flurine and tin contents, but as shown in Fig. II-8, in the correlation between fluorine and CaO contents, the fine-grained granite with higher content of tin in comparison with the porphyritic biotite granite tends to show high back ground content of fluorine. The areas to show the fluorine content of 4,000 ppm or more are situated at the northern margin of the Hatapang granite (upper reaches of the Hatapang River) and in the center (upper reaches of the Batu Jongjong River) (Fig. II-7) and the former corresponds to the anomalous area of tin and the latter to the anomalous area of tungsten.

(d) Lithium

Minimum 45 ppm and maximum 350 ppm are shown, and if the equi-content contour is drawn, the areas to show the lithium content of 150 ppm or more are situated at the northern margin of the Hatapang granite and they correspond to the areas of high tin content. (Fig. II-7)

Table II-2 Chemical Compositions of Hatapang Granite

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
	Sample No.	AR-10	BR-4	BR-16	BR-18	CR-7	CR-13	CR-21	ED-1	ER-15	ER-45	ER50	ER-55	ER-57	ER-58	FR-14	FR-16
	Rock Name	C-Gr	C-Gr	C-Gr	C-Gr	C-Gr	C-Gr	C-Gr	C-Gr	C-Gr	C-Gr	C-Gr	C-Gr	C-Gr	C-Gr	C-Gr	C-Gr
Chemical Composition	SiO_2	73.94	77.55	75.82	75.73	75.30	74.26	75.46	76.05	76.37	75.48	75.54	76.17	75.33	76.23	75.42	76.85
	TiO_2	0.07	0.09	0.08	0.01	0.09	0.20	0.06	0.10	0.07	0.07	0.06	0.09	0.13	0.06	0.06	0.12
	Al_2O_3	12.91	12.64	12.95	13.49	13.12	13.62	12.81	12.40	12.98	13.09	13.46	13.75	12.96	12.78	13.42	12.34
	Fe_2O_3	0.16	0.24	0.12	0.01	0.18	0.28	0.20	0.12	0.19	0.18	0.14	0.17	0.32	0.16	0.23	0.40
	FeO	0.94	0.86	1.22	0.58	1.08	1.15	1.15	0.94	0.72	1.01	0.79	0.36	1.15	0.94	0.72	1.01
	MnO	0.03	0.03	0.03	0.02	0.04	0.03	0.02	0.01	0.01	0.04	0.01	0.01	0.04	0.03	0.04	0.02
	MgO	0.10	0.09	0.10	0.02	0.10	0.26	0.11	0.06	0.08	0.11	0.01	0.09	0.17	0.08	0.08	0.11
	CaO	0.61	0.25	0.80	0.44	0.73	0.94	0.70	0.79	0.75	0.71	0.60	0.19	0.72	0.73	0.77	0.32
	Na_2O	3.75	3.24	3.57	3.83	3.55	3.55	3.97	3.46	3.77	3.67	4.03	2.88	3.14	3.75	3.77	2.71
	K_2O	4.77	5.24	5.12	5.20	5.14	4.92	5.28	4.62	4.85	5.17	4.75	5.82	5.22	4.50	4.98	4.98
	P_2O_5	0.02	0.02	0.02	0.02	0.02	0.02	0.01	0.02	0.02	0.02	0.02	0.02	0.01	0.02	0.02	0.02
	BaO	0.01	0.01	<0.01	<0.01	<0.01	0.01	<0.01	0.01	<0.01	<0.01	0.01	<0.01	0.01	<0.01	0.01	0.01
	LOI	0.82	0.69	0.84	0.58	0.68	1.09	0.83	1.06	0.74	0.78	0.79	1.11	0.91	0.74	0.90	0.93
	Total	98.14	100.96	100.69	99.95	98.97	100.34	100.62	99.65	100.57	100.35	100-21	100-67	100.11	100.03	100.42	99.82
	F ppm	3350	1500	4650	2100	3850	4900	4650	3250	2650	4550	350	1600	1900	3350	3350	620
	Cl ppm	200	<400	500	400	100	100	500	200	400	300	300	400	500	400	400	300
	Li ppm	190	125	185	45	225	135	190	130	35	160	95	50	100	185	125	85
	W ppm	21	24	12	33	18	17	17	170	20	6	15	22	12	13	16	9
	Sn ppm	1	1	2	3	5	10	3	5	2	5	4	2	6	23	7	2
	Mo ppm	1	1	1	8	1	1	1	2	1	1	1	3	1	1	1	1
C.I.P.W Norm	q	33.79	37.46	32.73	32.19	32.54	32.88	30.09	35.86	33.74	31.98	32.12	36.46	34.56	34.88	32.23	40.63
	or	28.19	30.97	30.26	30.73	30.38	29.08	31.2	27.3	28.66	30.55	28.07	34.4	30.85	26.6	29.43	29.43
	ab	31.71	27.4	30.19	32.39	30.02	28.33	33.57	29.26	31.88	31.04	34.08	24.36	26.55	31.71	31.88	22.92
	an	2.9	1.11	3.84	2.05	3.49	4.53	1.55	3.79	3.59	3.39	2.85	0.81	3.51	3.49	3.69	1.46
	c	0.52	1.23	0.13	0.81	0.44	1.12	0	0.32	0.21	0.22	0.65	2.42	0.86	0.46	0.48	1.96
	di	0	0	0	0	0	0	1.63	0	0	0	0	0	0	0	0	0
	hy	1.86	1.58	2.39	1.07	2.09	2.46	1.31	1.68	1.33	2.02	1.29	0.68	2.26	1.81	1.37	1.72
	mag	0.23	0.35	0.17	0.14	0.26	0.41	0.29	0.17	0.28	0.26	0.2	0.25	0.46	0.23	0.33	0.58
	il	0.13	0.17	0.15	0.02	0.17	0.38	0.11	0.19	0.13	0.13	0.11	0.17	0.25	0.11	0.11	0.23
	ap	0.5	0.05	0.05	0.05	0.05	0.05	0.02	0.05	0.05	0.05	0.05	0.05	0.02	0.05	0.05	0.05
	ol	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	hm	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Total	99.38	100.32	99.91	99.45	99.44	99.24	99.77	98.62	99.87	99.64	99.42	99.6	99.32	99.34	99.57	98.98
	Q+Or+Ab	93.69	95.83	93.18	95.31	92.94	90.29	94.86	92.42	94.28	93.57	94.27	95.22	91.96	93.19	93.54	92.98
	D.I.	94.27	95.52	93.26	9584	9346	90.98	95.08	93.71	94.40	93.91	94.82	95.60	92.59	93.81	93.94	93.94
	Age (Ma)					78.8±3.2			76.2±3.0								

		17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	Average of Tin Granite of the world, according to Stemproskvor (1974)
	Sample No.	FR-20-2	AR-16	AR-24	BR-20	BR-22	BR-24	CR-11	CR-18	CR-20	CR-24	DR-10	DR-14	DR-25	AR-6	AR-17	
	Rock Name	C-Gr	F-Gr	F-Gr	F-Gr	F-Gr	F-Gr	F-Gr	F-Gr	F-Gr	F-Gr	F-Gr	F-Gr	F-Gr	Ap	Peg	
Chemical Composition	SiO_2	76.21	77.18	77.35	75.80	74.79	75.43	75.64	75.22	74.99	75.26	75.24	75.07	73.48	73.62	75.26	73.02
	TiO_2	0.27	0.03	0.03	0.06	0.02	0.03	0.05	0.04	0.07	0.02	0.04	0.07	0.02	0.01	0.01	0.21
	Al_2O_3	10.96	12.58	13.10	12.90	14.62	13.60	13.57	13.62	13.33	13.39	13.47	13.28	15.77	14.93	13.77	13.90
	Fe_2O_3	0.89	0.10	0.16	0.17	0.20	0.15	0.07	0.28	0.20	0.26	0.21	0.44	0.07	0.11	0.22	0.78
	FeO	2.74	0.79	0.79	1.15	0.50	0.86	0.79	0.86	0.86	0.86	0.94	0.94	0.72	0.22	0.50	1.34
	MnO	0.07	0.01	0.03	0.03	0.01	0.03	0.03	0.05	0.02	0.06	0.07	0.03	0.02	0.01	0.02	0.05
	MgO	0.28	0.10	0.02	0.09	0.02	0.06	0.02	0.06	0.14	0.02	0.05	0.06	0.01	0.06	0.09	0.52
	CaO	0.61	0.43	0.13	0.73	0.39	0.56	0.19	0.27	0.75	0.61	0.63	0.79	0.83	1.04	0.30	1.24
	Na_2O	2.01	3.04	3.78	3.57	4.26	3.92	4.03	4.19	4.15	4.77	4.56	3.83	5.27	5.72	2.06	3.28
	K_2O	4.80	5.59	4.94	4.91	4.60	4.55	4.21	4.28	5.20	4.17	4.19	5.07	3.15	4.05	7.81	4.57
	P_2O_5	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	
	BaO	<0.01	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	
	LOI	1.29	0.58	0.54	0.94	0.66	0.67	0.59	0.59	0.77	0.76	0.68	0.83	0.66	0.91	0.56	
	Total	100.16	100.46	100.9	100.18	100.1	99.89	99.22	99.49	100.51	100.22	100.11	100.45	100.03	100.71	100.63	
	F ppm	3300	2500	1650	4900	2900	3600	1750	2250	4500	5000	4550	4450	6050	4300	1950	(3,700 ± 1,500)*
	Cl ppm	600	400	<300	500	300	200	100	200	500	100	200	300	300	200	300	
	Li ppm	285	100	230	135	85	125	150	295	145	385	350	195	125	20	70	(200 ± 100)*
	W ppm	12	16	26	23	198	27	40	26	20	18	28	19	18	1	30	(7 ± 3)*
	Sn ppm	4	3	17	4	3	13	98	18	11	91	57	17	5	3	2	(30 ± 15)*
	Mo ppm	1	1	1	1	1	1	1	1	1	1	1	1	2	1	3	(4 ± 2)*
C.I.P.W Norm	q	42.68	36.49	35.62	34.5	31.28	33.33	35.1	33.25	28.86	29.65	30.6	31.09	28.48	22.88	32.33	32.13
	or	28.37	33.04	29.2	27.84	27.19	26.89	24.88	25.29	30.73	24.64	2476	29.96	18.62	23.94	46.16	27.27
	ab	17	25.71	31.97	30.19	36.03	33.15	34.08	35.43	35.1	40.34	38.56	32.39	44.57	48.37	17.42	27.79
	an	2.9	2	0.52	3.49	1.8	2.65	0.81	1.21	2.39	2.82	3	3.79	3.99	3.11	1.36	6.12
	c	1.4	0.8	1.35	0.65	1.97	1.26	2.09	1.65	0	0	0.34	0.11	2.23	0	1.43	1.22
	di	0	0	0	0	0	0	0	0	1.03	0.07	0	0	0	1.63	0	0
	hy	4.9	1.66	1.39	2.22	0.8	1.66	1.43	1.57	1.15	1.46	1.78	1.5	1.3	0.36	1.05	3.01
	mag	1.29	0.14	0.23	0.25	0.29	0.22	0.1	0.41	0.29	0.38	0.3	0.64	0.1	0.16	0.32	1.16
	il	0.51	0.06	0.06	0.11	0.04	0.06	0.09	0.08	0.13	0.04	0.08	0.13	0.04	0.02	0.02	0.46
	ap	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.5	0.5	0.5	0
	ol	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	hm	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Total	99.1	99.95	100.39	99.3	99.45	99.27	98.63	98.94	99.73	99.45	99.47	99.66	99.38	99.8	100.14	99.16
	Q+Or+Ab	88.05	95.24	96.79	92.53	94.5	93.37	94.06	93.97	94.69	94.63	93.92	93.44	91.67	95.19	95.91	87.19
	D.I.	88.85	95.29	96.41	93.18	95.02	94.06	95.37	94.98	94.95	95.15	94.42	93.76	92.24	95.38	95.78	8793
	Age (Ma)														3±2.6		

C-Gr: Coarse Grain Granite
F-Gr: Fine Grain Granite

Ap: Aplite
Peg: Pegmatite

* Specialized Granites Proposed Average Content (ppm) by Tischendorf (1977)

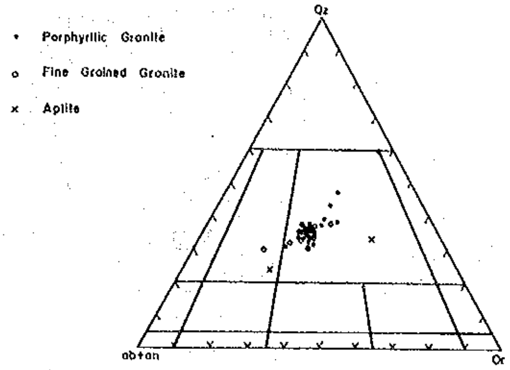


Fig. II-3 Normative Quartz-Plagioclass-Orthoclase Diagram for the Hatapang Granite

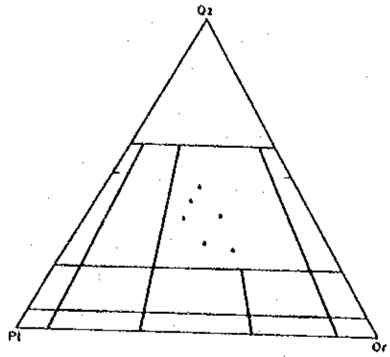


Fig. II-4 Modal Quartz-Plagioclass-Kalifeldspar for Hatapang Granite

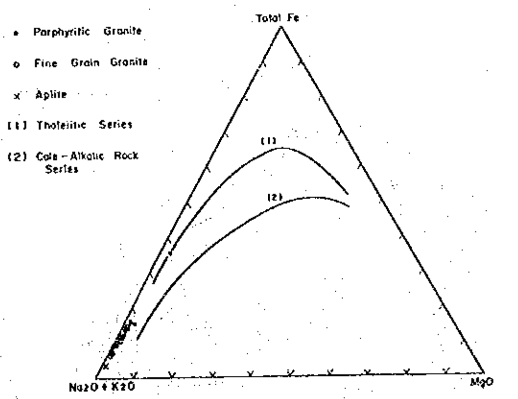


Fig. II-5 F-M-A Diagram for Hatapang Granite

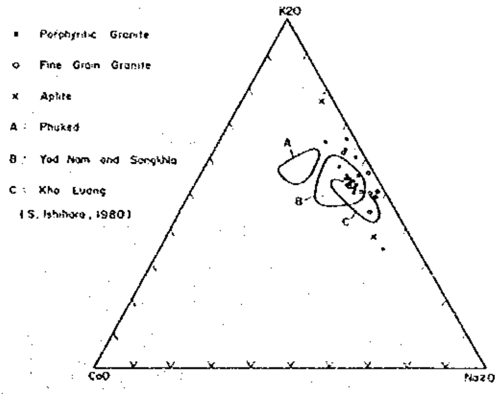


Fig. II-6 Cao-K_2O-Na_2O Diagram for Hatapang Granite

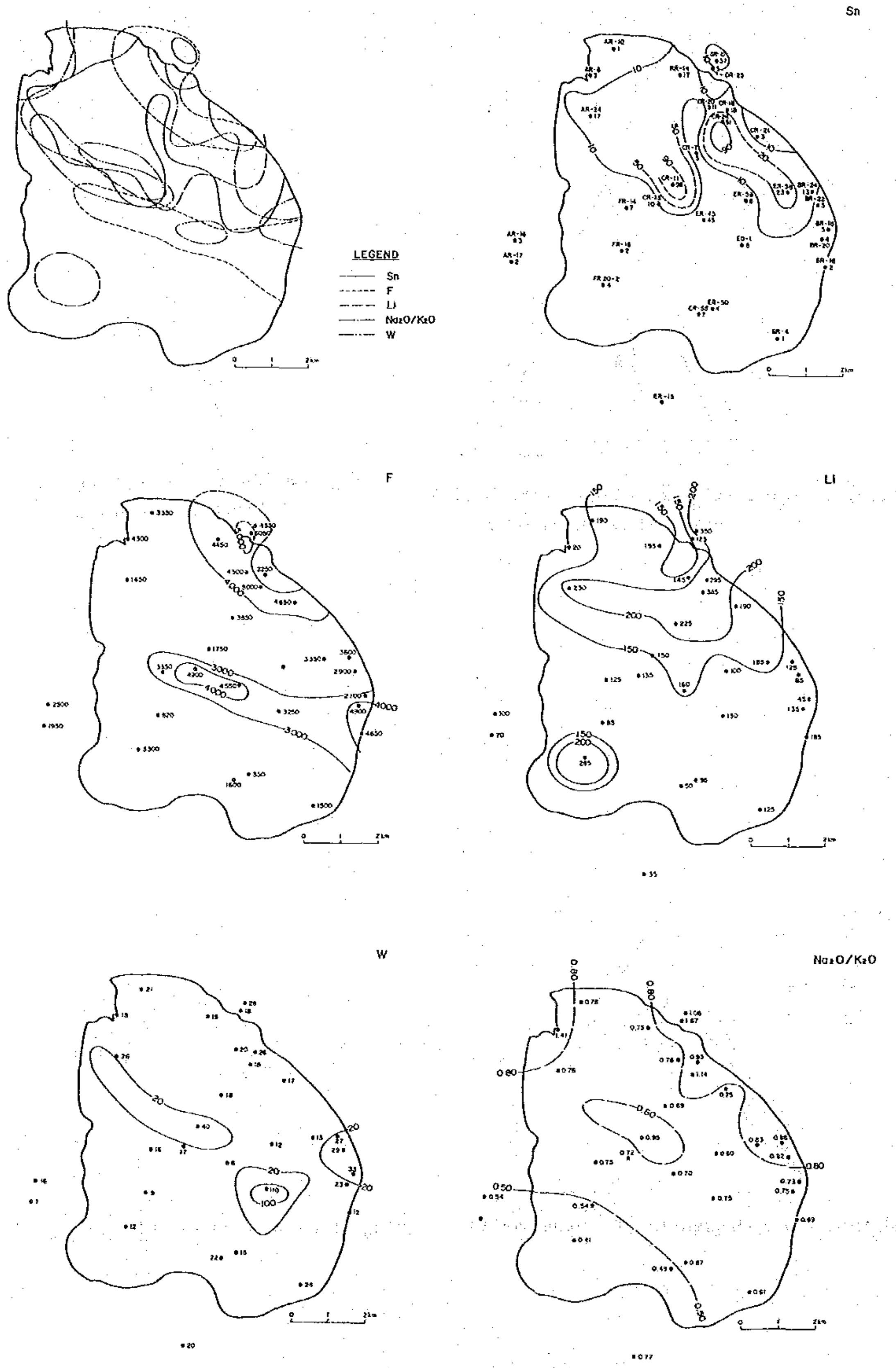


Fig. II-7 Distribution of Minor Element (Sn, W, F, Li) and Na_2O/K_2O in Hatapang Granite

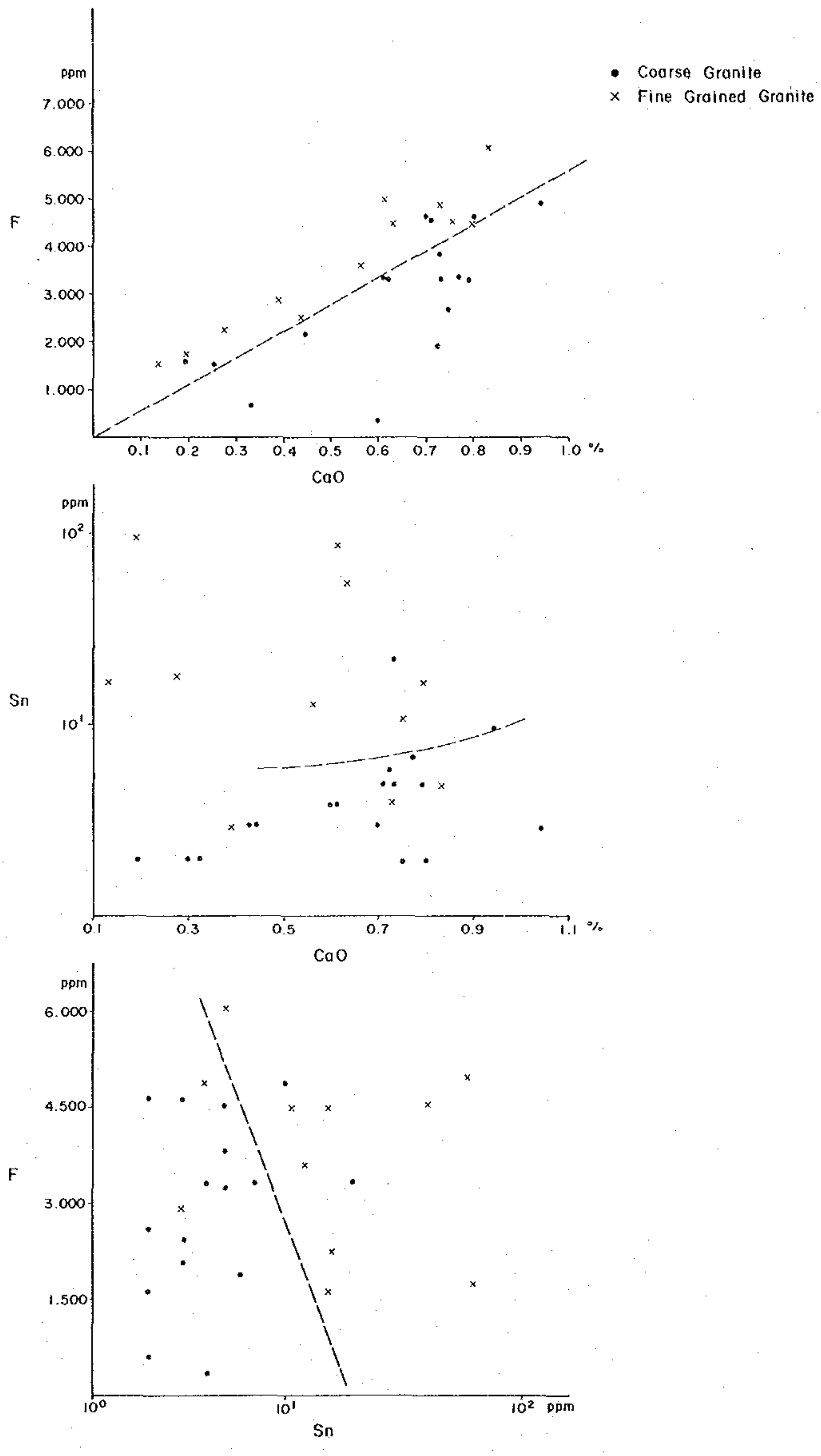


Fig. II-8 Cofficient of Correlation of Tin and Fluorine Contained in Hatapang Granite

2-2-3 Characteristics of Hatapang Granite

From the age determination, magnetic susceptibility and chemical composition described above, the characteristics of the Hatapang granite are summarized as follows.

(1) It is highly differentiated acidic rock with the SiO_2 content of 73% – 77% and differentiation index of 92% or more.

(2) The granite is identified adamellite by the modal analysis and norm analysis.

(3) The chemical composition is similar to the world average grade of the tin bearing granite (Stemproskovor 1974).

(4) The contents of tin, tungsten, fluorine and lithium are similar to the values of the tin bearing granite suggested by Tischendorf (1977).

(5) Anomalous values of tin, fluorine, lithium and Na_2/K_2O ratio of the Hatapang granite stock are densely distributed at the northern margin (upper reaches of the Hatapang River) and east-north margin (middle reaches of the Batu Jongjong River).

(6) The age determination by the K-Ar method showed the age of 65 – 78Ma and it is considered to be an intrusive rock of the Late Cretaceous time.

(7) The result of the magnetic susceptibility measurement suggests high possibility of the ilmenite series granite accompanied by tin mineralization.

In consideration of the fact that of the Thai-Malysian-Indonesian tin mineralization zones, the zone to show the Late Cretaceous time is in the Phuket zone located at the westernmost margin (Mitchell 1976, P. Nutalaya et al) and the granite in that zone is porphyritic biotite granite (adamellite or monzonitic granite) having the phenocryst of the potassium feldspar (Ishihara et al 1979) and judging from the characteristics of the Hatapang granite such as age, rock facies, chemical composition and minor element and its location, it is highly possible that the Hatapang granite is in the southern extension of the tin granite zone in the Phuket region. The relations are shown in Fig. II-9.

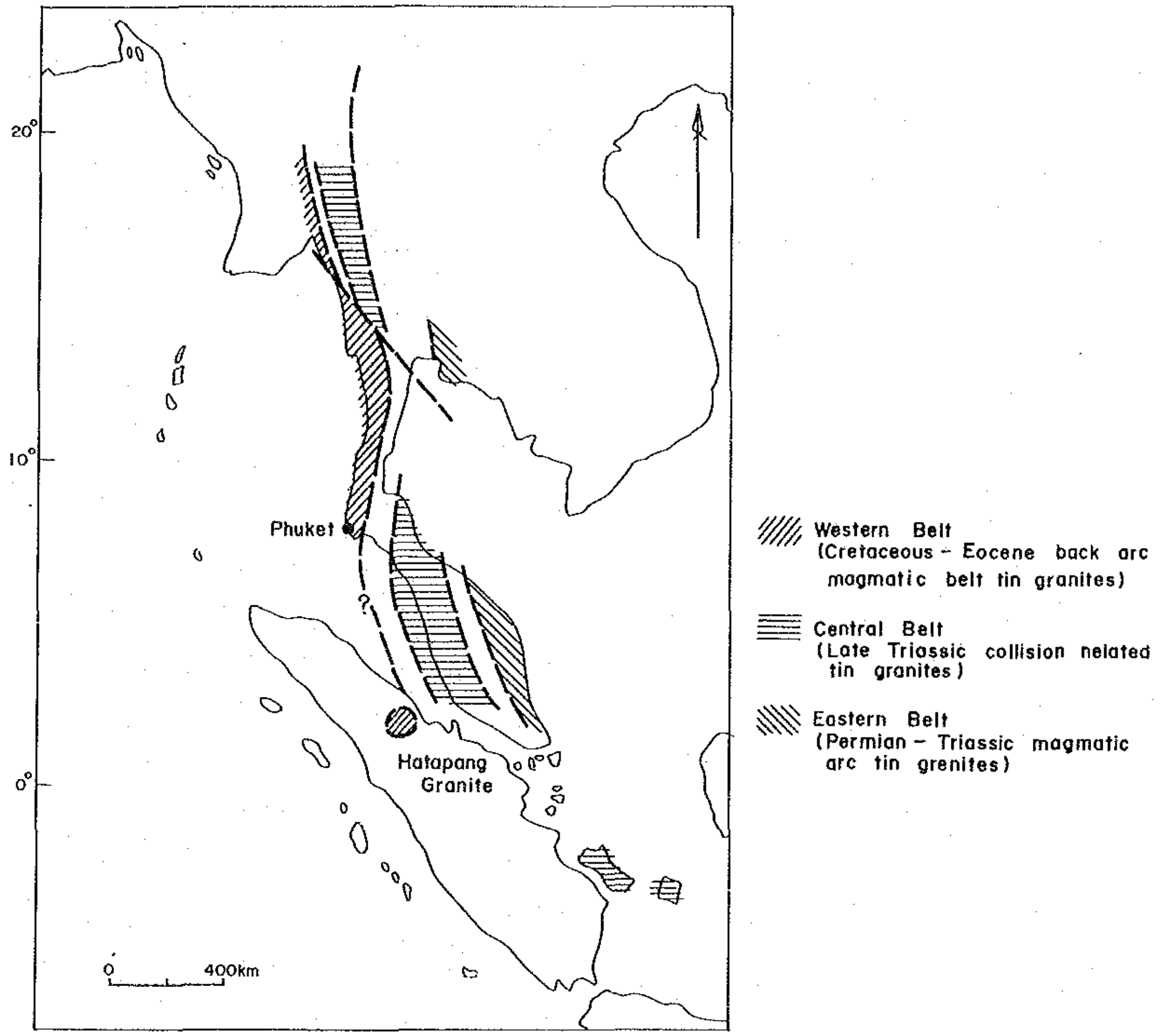


Fig. II-9 Possible Relationship with Hatapang Granite and Tin Granite of the Southeast Asia (modified from Mitchell 1979)

CHAPTER 3 GEOLOGICAL STRUCTURE

Due to the intrusion of the Hatapang granite, the Hatapang Formation shows a dome structure. That is, the hatapang Formation dips 30 – 70° on the outer side of the intrusive rock body at the western, southern and southeastern sides of the Hatapang granite with the exception of localized distrubance in the structure. At the northeastern side, however, the Hatapang Formation does not form the dome structure, its strike being N60° – 80°E with a dip of 30° – 60° SE. This suggests that although the Hatapang granite has been intrued forcefull to push up the Hatapang Formation into the dome structure, it was stoped intrusion at its northeastern side. It is infered that the stoping intrusion caused the fact that tin-rich, fine-grained granite and quartz veins exist, the contents of pneumatolytic minor elements such as fluorine and lithium are rich and tin and tungsten mineralization is distributed in the area along the northeastern part. In the area of 1 – 2 km around the main stock of the Hatapang granite small dikes of the same granite are distributed, indicating the possibility that the main stock of the granite is extended toward the lower side way.

CHAPTER 4 MINERALIZATION

4-1 Tin and Tungsten Placer Ore Survey

By panning the stream sediment, the placer survey of tin ore (cassiterite) and tungsten ore was conducted. The samples collected by panning of 40ℓ capacity (2 x 20ℓ plastic buckets) at each sampling point were separated and detected contained mineral at the Directorate of Mineral Resources in Bandong and the weight of the each heavy mineral such as tin ore (cassiterite) and tungsten was measured. As a result, as shown in Fig. II-12, the cassiterite placer is densely distributed around the upper reaches of the Hatapang River and middle reaches of the Batu Jongjong River.

4-2 Mineralized Zones

As a result of the geological survey, mineralization, although weak, was recognized in the upper reaches of the Hatapang River, the Mabat River region, its tributary and in the middle reaches of the Batu Jongjong River. All the zones correspond to the concentrating distribution areas of cassiterite found by the heavy mineral placer survey.

(1) Mabat River Region

Many quartz veins are distributed in an area 2,500 m EW by 1,000 m SN along the boundary between the Hatapang Sedimentary Rock Formation and the Hatapang granite in the region of the Mabat River (Fig. II-10). These quartz veins are accompanied by hematite stains and tourmaline, fine-grained two-mica granite with some content of tin is distributed, and weak sericite argillization zone is recognized. The maximum values obtained by the analysis of 8 samples taken from the quartz veins (including 1 boulder sample) were 630 ppm for tin and 410 ppm for tungsten in maximum value. The weak argillization zone is accompanied by the 2M type sericite (or muscovite) with good crystallinity, but no strong greisen alteration was recognized.

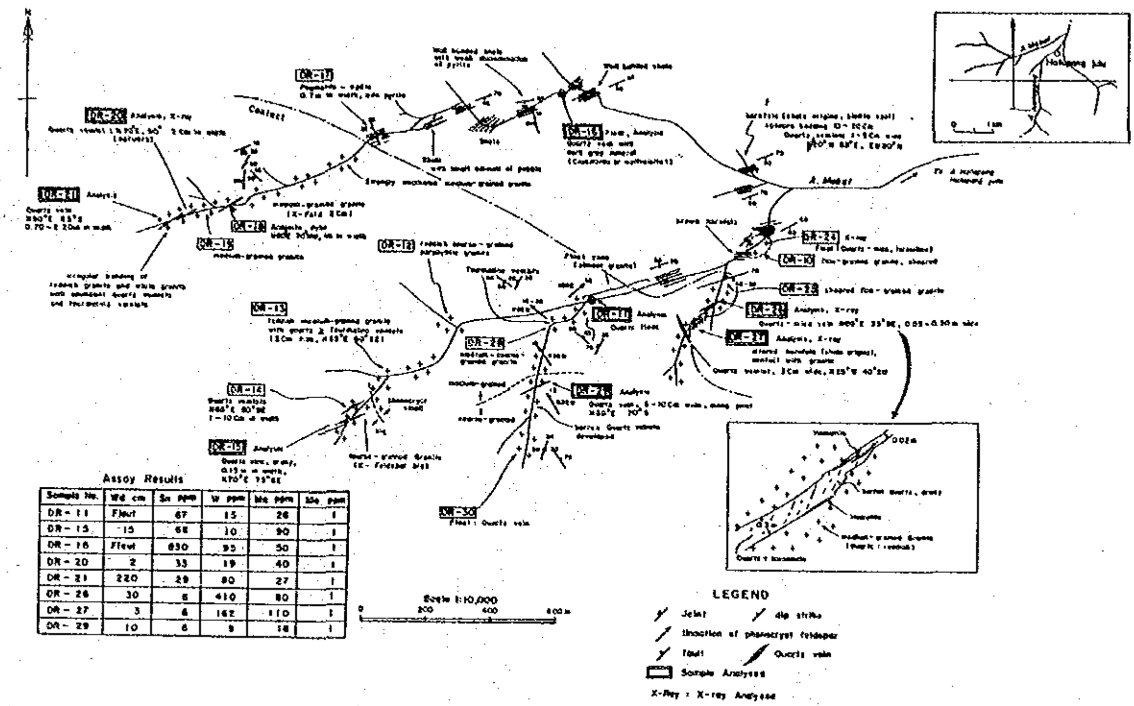
(2) Upper Reaches of Hatapang River

Eight quartz veins were found within a space of 20 m along a tributary of the Hatapang River, some 4 km upstream from the village of Hatapang Julu, and 2 veins were subjected to analysis and Sn 0.83% from the vein width 10 cm and Sn 0.06% from the vein width 15 cm were obtained. (Fig. II-11)

(3) Middle Reaches of Batu Jongjong River

Quartz veins and fine-grained granite dikes increase in number in an area of 200 m on the hornfels side of the Hatapang granite contact area. The quartz veins are accompanied by tourmaline. The fine-grained granite is intruded like an inhomogeneous part in th dikes or coarse-grained granite, and in the survey by the Directorate of Mineral Resources (1981), cassiterite dissemination was found.

As aforementioned, the distribution of fine-grained granite and quartz veins containing tin, concentrating distribution of minor element (Sn, F, Li) and high ratio of Na_2/K_2O in the Hatapang granite stock, intrusion form of granite (stoping intrusion), concentrated distribution of cassiterite placer and Sn and F anomalous areas found by the geochemical survey to be described later, suggest that the upper reaches of the Hatapang River, its tributary region and middle reaches of the Batu Jongjong River may be the most promising tin mineralization zone area in the Hatapang Area.



Assay Results

Sample No.	Wd cm	Sn ppm	W ppm	Mn ppm	Mo ppm
DR-11	Fleut	67	15	26	1
DR-15	15	68	10	90	1
DR-16	Fleut	830	95	50	1
DR-20	2	33	19	40	1
DR-21	220	29	80	27	1
DR-26	30	6	410	80	1
DR-27	3	6	162	110	1
DR-29	10	6	9	18	1

Fig. II-10 Tin Mineral-showing in Mabat River, Hatapang Area

	Sn ppm	W ppm	Mn ppm	Mo ppm
CR-4	8 300	32	573	6
CR-14	685	111	740	1
CR-24	91	18	-	1

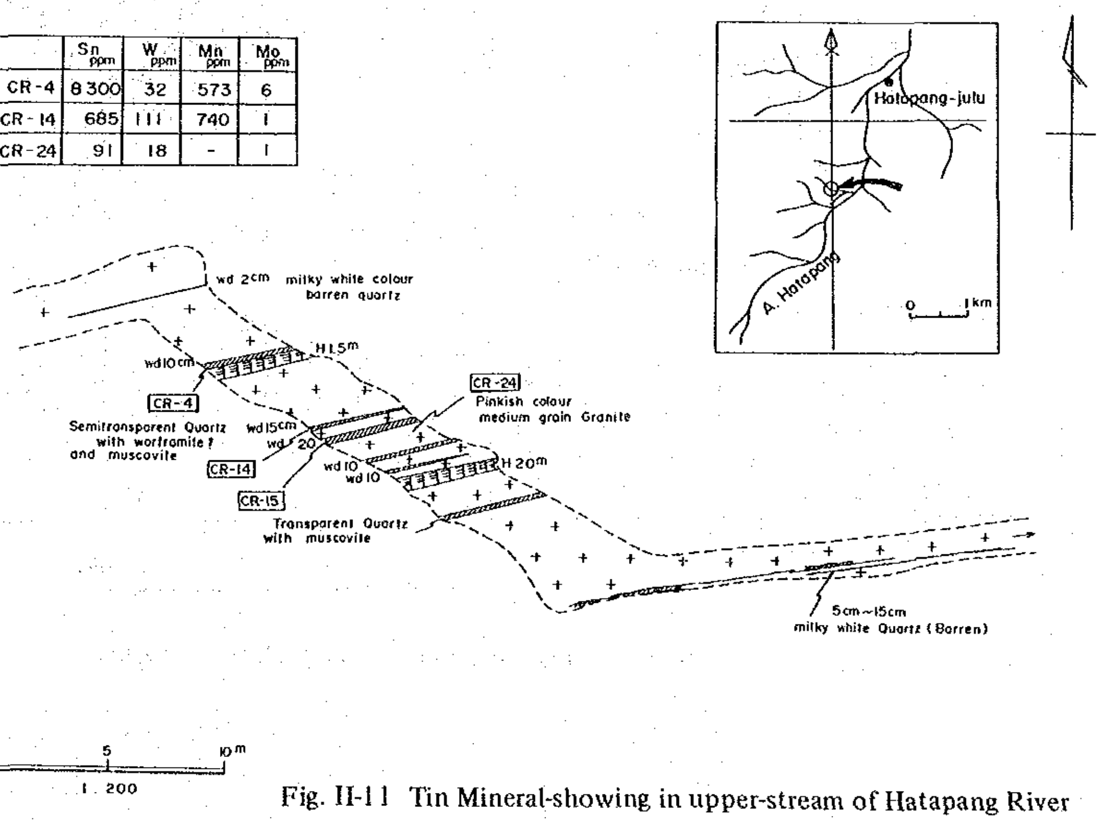


Fig. II-11 Tin Mineral-showing in upper-stream of Hatapang River

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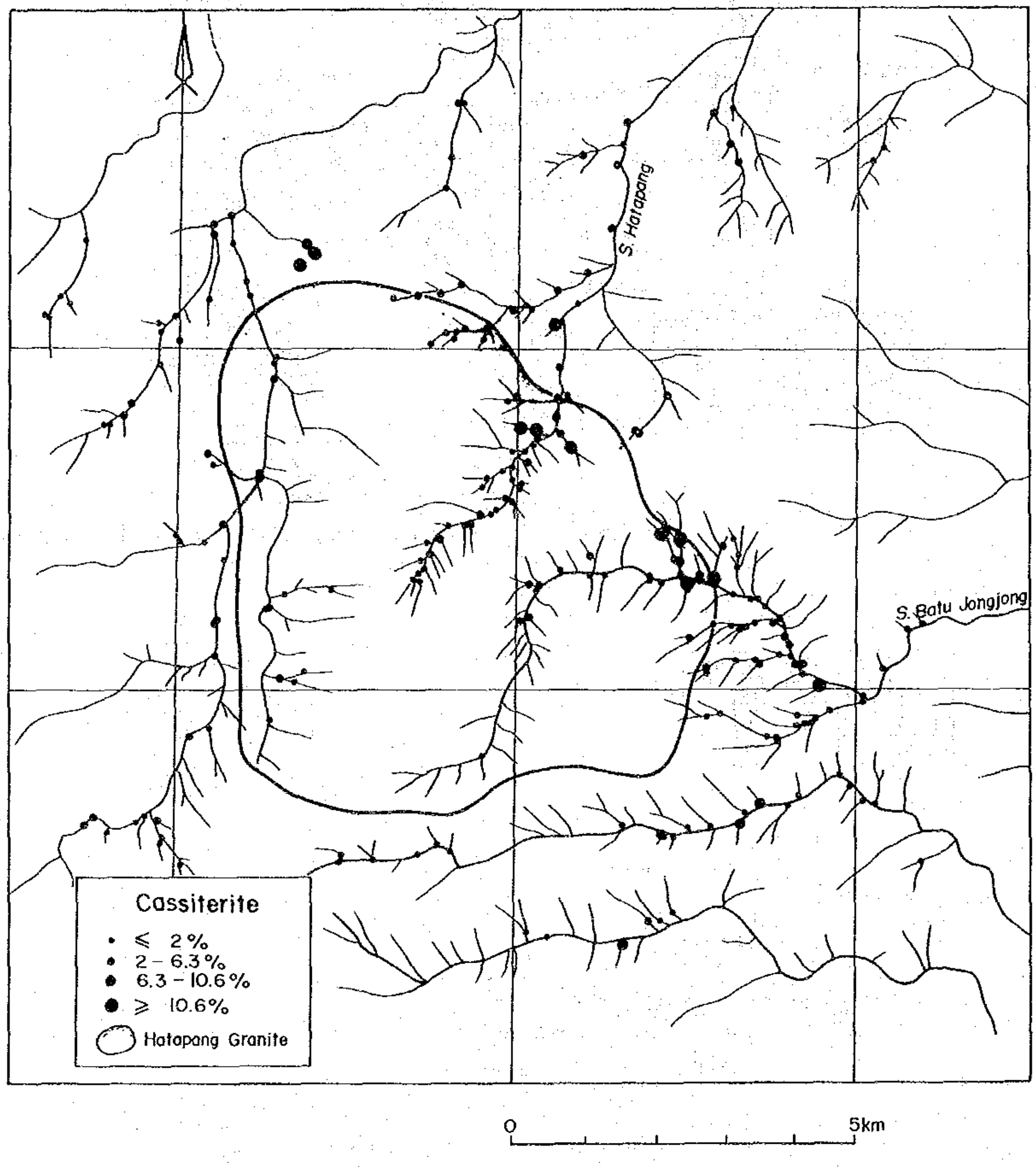


Fig. II-12 Distribution of Cassiterite Placer in the Hatapang Area

CHAPTER 5 GEOCHEMICAL SURVEY

5-1 Geochemical Survey on Stream Sediment

5-1-1 Sampling

In the first phase survey, stream sediments were sampled at the density of 4 samples per km from the main rivers centering on the Hatapang granite. The collected samples totaled 571 pieces.

5-1-2 Path-fiinder Elements

In order to trace the tin and tungsten mineralization, 5 elements including tin, tungsten, fluorine, arsenic and molybdenum were selected and analyzed.

5-1-3 Analysis of Analysis Data

(1) Correlation between Path-finder elements

As shown in Table II-3, the correlation among the path-finder elements is remarkably noticed among the tin, fluorine and tungsten, but almost none is recognized between arsenic and molybdenum and among molybdenum, tungsten and fluorine.

Table II-3 Correlative Coefficient of Geochemical Path-Finder Element through Geocl Survey in Hatapang Area

	F	W	Mo	As
Sn	0.5590	0.6918	-0.0412	0.1967
F		0.7340	0.2930	0.0705
W			0.0017	0.0248
Mo				0.0963
As				

(2) Anomalous Areas

As a result of the statistical processing, the average grade (M), standard deviation (S.D.) and threshold values (M + S.D.) and (M + 2 x S.D.) of each path-finder element were calculated,

Table II-4 Anomalous Value of Path-Finder Elements through Geochemical Survey in Hatapang Area

	Min. Value ppm	Max. Value ppm	Mean M ppm	S.D.	M + S.D.	M + 2 x S.D.
Sn	1	3,100	24	0.3676	174	1284
F	110	2,000	433	0.2812	827	1581
W	1	1,800	23	0.9198	192	1594
Mo	1	4	1	0.1080	1	2
As	2	59	7	0.2572	12	22

(Population 540)

and the threshold values (M + S.D.) and (M + 2 x S.D.) were made Grade 2 anomalous value and Grade 1 anomalous value respectively, and the areas adjacent 2 points or more of these were made anomalous areas. (Table II-4)

The minimum and maximum values, mean value (M), standard deviation (S.D.) and threshold values (M + S.S.) and (M + 2 x S.D.) of each Path-finder element are shown in Table II-4.

(1) Tin Anomalous Areas

Grade 1 anomalous areas (maximum value 3,700 ppm) are found at a point 2 km upstream from the village of Hatapang Julu along the Hatapang River and in its western tributary. In the neighborhood of the maximum value point, quartz veins (width 10 cm Sn 0.83%) are distributed. Grade 2 anomalous areas are found in the range of 4 km EW by 1 km SN including the Mabat river, a tributary of the Hatapang river, upper reaches of the Kotahong River and Batu Jongjong River.

These anomalous areas are situated at the northern margin and eastern margin of the Htapang granite stock and correspond to the areas with high content of tin, fluorine and lithium found by the analysis of the granite, areas with high Na_2O/K_2O ratio, concentrating distribution areas of tin placer found by the panning survey and the areas where many tin-rich fine-grained granite and quartz veins are distributed. (Fig. II-13)

(2) Fluorine Anomalous Areas

Grade 2 anomalous areas of fluorine almost correspond to the anomalous areas of tin and tungsten. (Fig. II-13)

(3) Tungsten Anomalous Areas

Grade 2 anomalous areas of tungsten are distributed in the upper reaches of the Batu Jongjong River and the Hatapang River.

The dense distribution area of the tungsten of the Hatapang granite tends to appear in the center of the granite stock, in comparison with the concentrating distribution area of tin, and this tendency was also recognized in the geochemical survey. (Fig. II-13)

(4) Arsenic and Molybdenum Anomalous Areas

Asenic anomalous areas are distributed at the northeast and southeast outer margins of the Hatapang granite rock. It is difficult to obtain the anomalous areas for molybdenum because the most of the analyzed values are low at 1 ppm to 2 ppm, but if the distribution of 2 ppm (11% of whole) is taken into consideration, anomalies are scattered at the periphery of the Hatapang granite stock. Since the arsenic and molybdenum have low correlation with the tin, tungsten and fluorine and their distribution areas are also different from those of the tin, tungsten and fluorine, their anomalous areas seem to be related to the contact alteration given to the Hatapang Formation by intrusion of the Hatapang granite. At the present moment, no molybdenum mineralized zone is discovered.

5-2 Geochemical Survay on Soil (Detailed Survey)

5-2-1 Sampling

Geochemical survey on soil was conducted in the area of 6 km^2 (1.5 km ∠ 4 km) in the upper reaches of the Hatapang and Mabat Rivers which were extracted as promising tin mineralied zone by the first phase survey.

The sampling was made at the intervals of 70 m along 11 measurement lines (N 45° E direction, measurement line interval 400 m). The total number of samples was 242 pieces.

5-2-2 Path-finder Elements

3 elements including tin, tungsten and fluorine to indicate the tin and tungsten mineralization were analyzed.

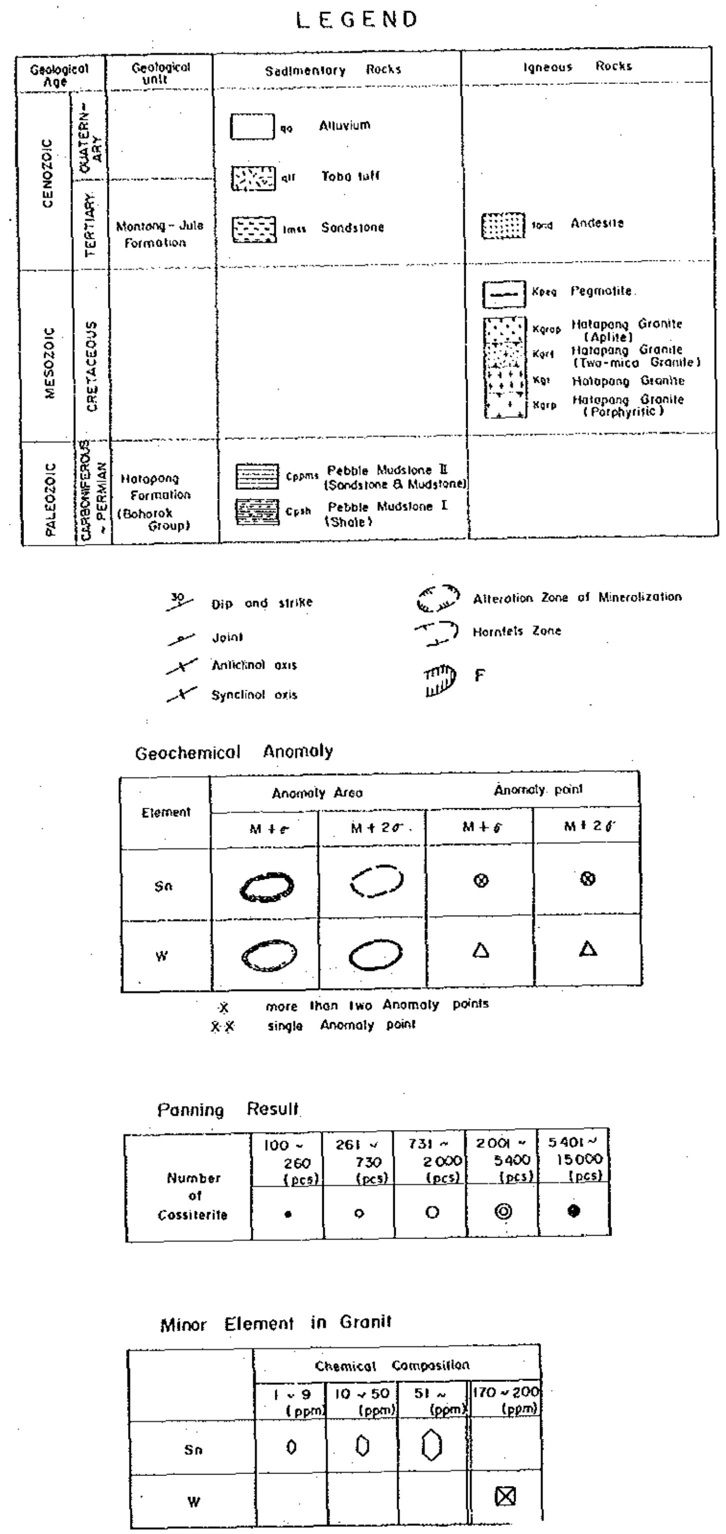


Fig. II-13 Distribution of Geochemical Anomaly Areas in Hatapang Area

5-2-3 *Analysis of Assay Result*

(1) Correlation among Elements

As shown in Table II-5, the correlation among the tin, tungsten and fluorine is good.

Table II-5 Correlative Coefficient of Geochemical Path-finder Elements through Geochemical Survey in the Hatapang River-Mabat River Area

	W	F
Sn	0.585668	0.554423
W		0.538544

(2) Anomalous Areas

The mean value (*M*), standard deviation (*S.D.*) and threshold values (*I*) (*M + S.D.*) and (*II*) (M + 2 x S.D.) of each Path-finder element are shown in Table II-6. The analysis was made separately for the Hatapang granite and Hatapang Formation (hornfels).

Table II-6 Anomalous Value of Path-finder Elements through Geochemical Survey in the Hapapang River-River Area

	Max. ppm	Min. ppm	Mean ppm (M)	S.D.	M + S.D.	M + 2 x S.D.	M + 3 x S.D.
Sn	860	2	35	0.377205	ppm 85	ppm 203	ppm 484
W	350	1	25	0.481666	76	231	
F	2,700	300	1,086	0.187131	1,671	2,572	

(Total Area) Population 242

	Max. ppm	Min. ppm	Mean ppm (M)	S.D.	M + S.D.	M + 2 x S.D.	M + 3 x S.D
Sn	860	6	41	0.334251	ppm 90	ppm 193	ppm 418
W	350	7	40	0.238737	69	119	207
F	2,700	300	-1,165	0.171989	1,730	2,572	

(Granite Area) Population 177

	Max. ppm	Min. ppm	Mean ppm (M)	S.D.	M + S.D.	M + 2 x S.D.	M + 3 x S.D
Sn	150	2	24	0.427971	ppm 64	ppm (171)	ppm
W	65	1	7	0.557983	26	(95)	
F	2,200	380	899	0.201293	1,428	(2,271)	

(Hornfels Area) Population 65

The content tendency of tin, tungsten and fluorine along the 11 measurement lines YA to YK *(400 m interval) from the east is shown in Fig. II-15. Of the* path-finder elements, the mean value for fluorine is 1,163 ppm for the Hatapang granite stock and 899 ppm for the Hatapang hornfels Formation. The content is high at the contact between both rocks and especially in the Mabar river region (measurement lines YJ – YI) the mean value of fluorine (1,165 ppm) showed an anomalous value. In the Hatapang granite stock, the background of fluorine tends to be higher in the Sosopan River and Mabar River region (YD – YJ, more than 900 ppm) than the upper reaches of the Hatapang River (YA – YC, 500 ppm – 900 ppm). It seems that the distribution frequency of the quartz vein and fine-grained granite which was found by the detailed geological survey is higher in the western area (Sosopan River, Mabar River) than eastern area (Hatapang River region).

(a) Mabat River and Mabar River Middle Reaches
Grade 2 anomalous areas of fluorine are found in the scale of 800 m EW by width 200 – 300 m in the middle reaches of the Mabat River – Mabar River. These areas are overlapped by Grades 1 and 2 anomalous areas of tin and Grade 2 anomalous areas of tungsten. In these anomalous areas along the Mabar River, quartz veins (width 10 cm, copper 0.18%) accompanied by the dissemination of chalcopyrite was recognized (Fig. II-14).

(b) Upper Reaches of Hatapang River
Grade 2 anomalous area exists in the scale of 500 m EW by width 200 m and this area is overlapped by the anomalous area of tungsten.

(c) Other
In addition to the above 2 anomalous areas, small anomalous areas are distributed in the intermediate area Sosopan River and its tributary.

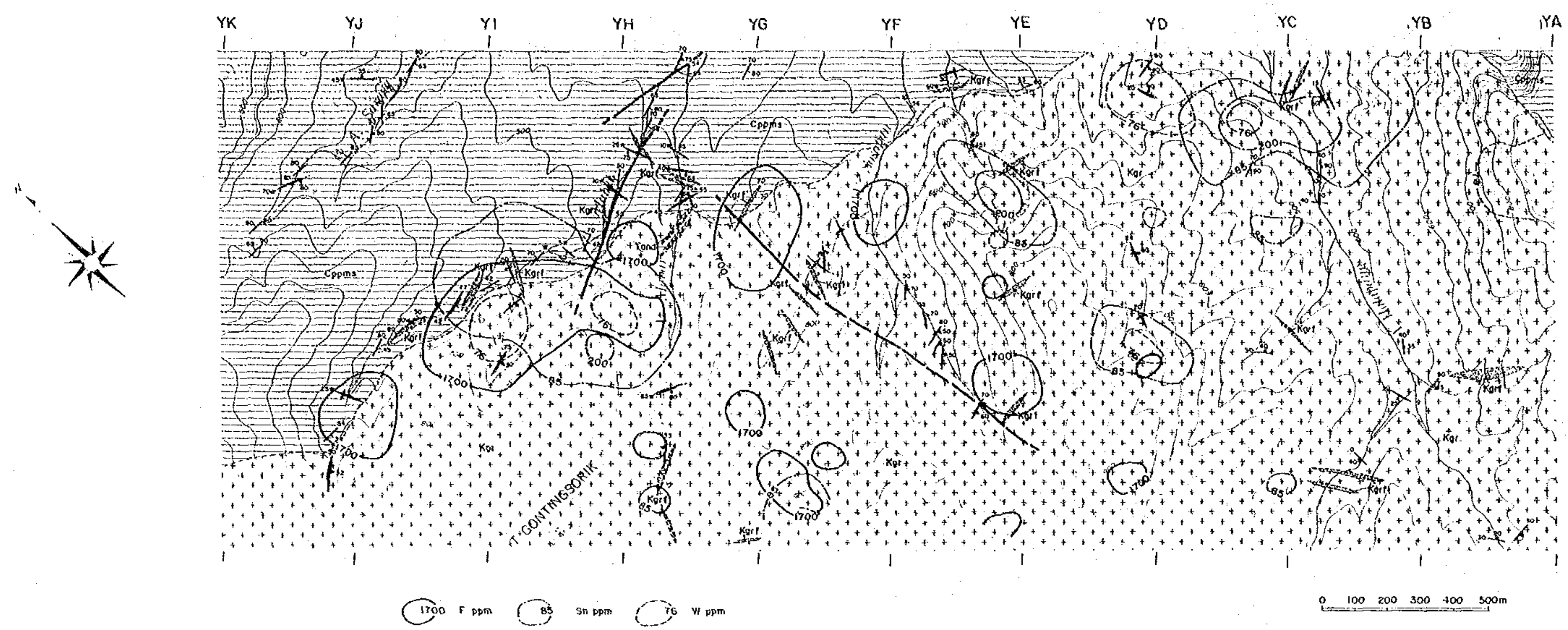


Fig. II-14 Distribution of Geochemical Anomaly areas in Mabat River-Hatapang River Area

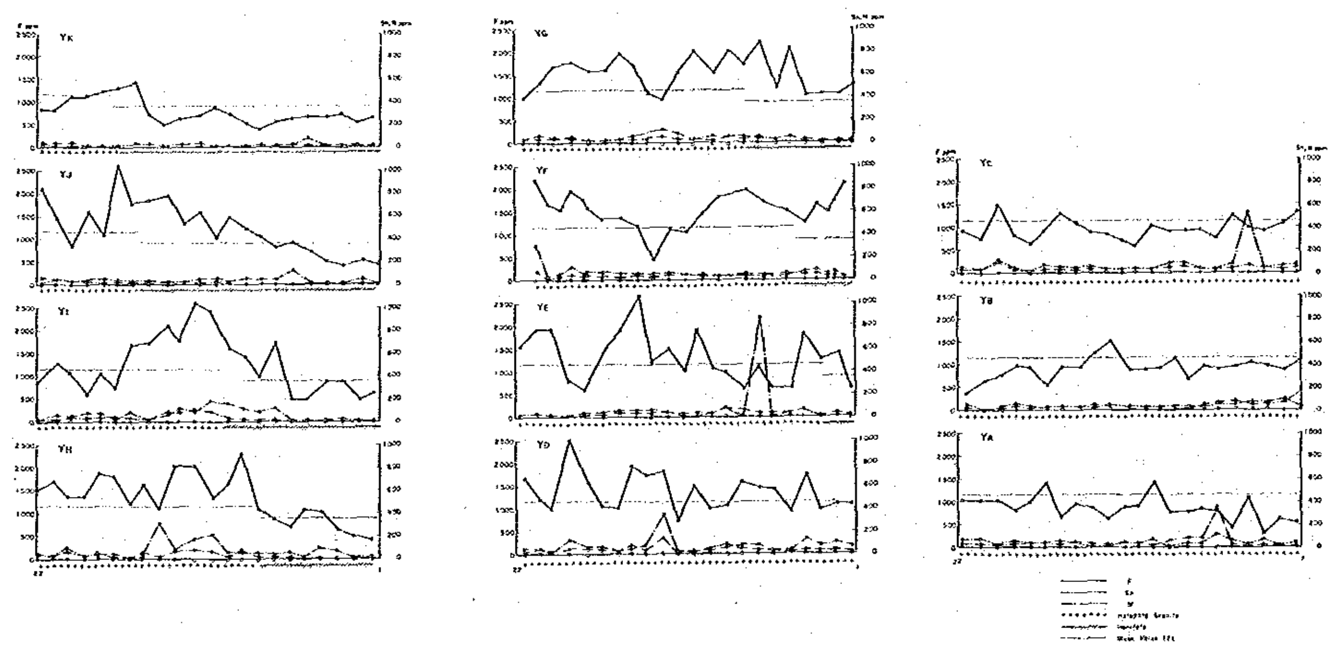


Fig. II-15 Geochemical Tendency of Each Survey Lines in Mabat River-Hatapang River Area

PART III

MUARA SIPONGI AREA

CHAPTER 1 GEOLOGY

1-1 Geological Outline

In the first phase geological survey (reconnaissance survey), the Muara Sipongi Area was geologically divided as follows.

Quaternary
Tertiary andesite
Tertiary dacite tuff Formation
Permian – Carboniferous Sedimentary rock and Pyroclastic rock Group
  Patahahajang Limestone and Clastic rock Formation
  (Bt Tanjung limestone Formation)
  Muara Botung Meta Andesite Formation
  S. Ranya Clastic rock Formation

The Muara Sipongi Granitoids batholith of the Jurassic is distributed at the central part of the survey area and the intrusion has intruded in the Muara Botung Formation and Patahajang Formation.

The S. Ranya Formation is correlative with the Kluet Formation of the Tapanuli Group subjected to the Indonesian-British Cooperative survey and the Muara Botung Formation and Patahajang Formation with the Silungkang Formation of Peusangan Group.

1-2 Sedimentary Rock and Volcanic Rock of the Permian and the Carboni ferous

1-2-1 S. Ranya Formation

The Formation is the lowest formation of the survey area and consists of coarse-grained quartz arenite sandstone distributed centering on the Ranya River at the easternmost end and intercalates the fine-grained sandstone and siltstone show clear bedding.

The quartz grains of the arenite sandstone has been slightly recrystallized, having undergone contact alteration due to the intrusion of the porphyritic biotite granite (adamellite).

1-2-2 Muara Botung Meta-Andesite Formation

It is widely distributed along the Botung River in Muara Botung village, and besides, it is widely distributed to the Bubungan River, south of Limau Manis village in the east and from the Si Ayu River to the north-eastern Pagar Gunung region in the west.

It consists of dark green massive andesite lava, and partially the andesitic pyroclastic rock is distributed in the upper reaches of the Muara Botung River and Sipongi River, and the conglomeratic andesitic tuff containing andesite conglomerate is distributed in the upper reaches of the Cubadak river.

The andesite lava is hard and massive with hornblende phenocryst. Microscopic observation reveals that it is meta-andesite with plagioclase altered into sericite, colored mineral phenocrysts altered into epidote and chlorite in the groundmass consisting of plagioclase and clay minerals. At the contact with the granitoids, pyrite is usually disseminated.

1-2-3 Patahajang Formation

The Formation is distributed in Pagan Gunung, westsouth of the survey area and in the southern part of Ranjau Batu (along the Cubadak River). The Formation in the southern part of Ranjau Batu consists of white limestone, calcareous siliceous rock, sandstone, shale and siliceous shale, and the siliceous rock is tuffaceous rock.

Around the upper reaches of the Cubadak River, thin layers of conglomerate are intercalated between the Formation amd Muara Botung meta-andesite Formation. The white and massive limestone is accompanied by limestone conglomerate and it has undergone recrystalization and became saccharoidal at the contact with the Muara Sipongi grandoitoids. The Formation distributed in Patahajang and Pagar Gunung is composed of sandstone and shale alteration of strata having grade bedding and intercalates pale green tuff and limestone.

This Formation was surveyed in the second phase, it is mentioned in detail later.

For these older sedimentary rock and pyroclastic rock, the data to determine the age such as fossil have not been obtained, but they are compared with the Silungkaug Formation of the Peusangan Group (Katili 1969, Silitanga 1975) dominant in the volcanic rock and limestone which are characteristically distributed inthe Sumatra Island, on basis of the Indonesian-British cooperative survey.

1-3 Tertiary Dacitic Tuff Formation

This Formation is commonly found unconformably overlying the older sedimentary rock, volcanic rock and granitoids is along the southern marginal survey area, namely the southern area of Pagar Ganung to Patahajang, in the upper reaches of the Muara Botung River and Cubadak River and in the southern part of Rao. It consists of pale green dacitic tuff, dacitic lapilli and tuff and the microscope observation reveals that the vitreous matrix is accompanied by rock fragments, pumice, quartz, feldspar and mica fragments.

This Formation belong to the Neogene pyroclastic rock which is widely distributed in the Northern Sumatra.

1-4 Tertiary Andesite

Black colored andesite is distributed in the northeastern area of Cubadak and Tolang. It is fresh pyroxene andesite having plagioclase, small amount of common pyrozene and quartz phenocryst in the matrix mainly consisting of plagioclase, overlying the Muara Botung mata-andesite. It is also confirmed by the Second phase survey that the fresh pyroxene andesite is distributed at the mountain top of Pagak Gunung – Simpang Opat.

1-5 Quaternary

The river sediment consisting of unconsolidated pebbles, sand and silt is distributed in the Rao lowland area and in the major river basins.

1-6 Intrusive Rocks

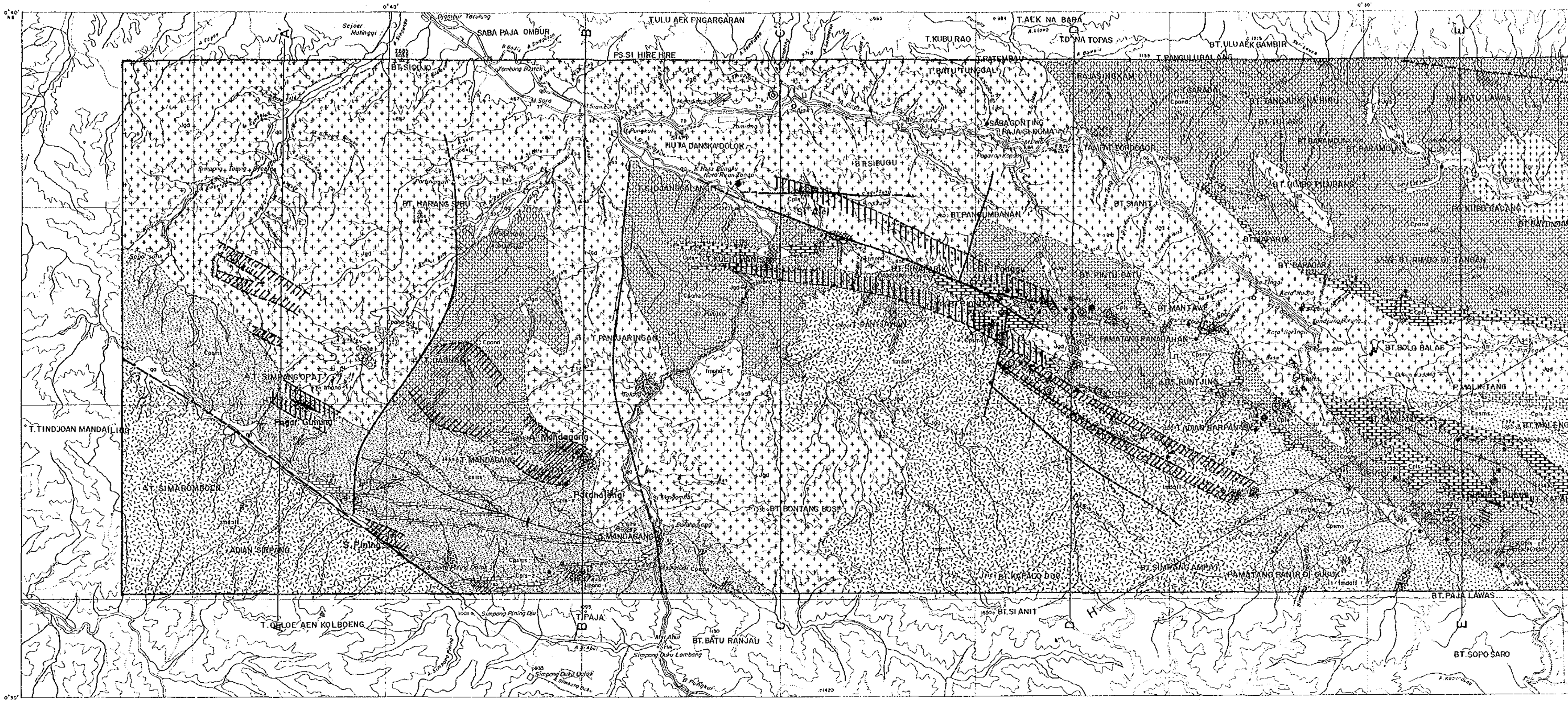
The intrusive rocks are granodiorite which is distributed as a batholith extending N 60 W in the center of the survey area and is distributed as small stocks and veins at the periphery. It mainly consists of quartz diorite and is generally called Muara Sipongi Granitoids. For these granities of the Jurassic was determined the age by using the K-Ar radiometoric method.

It was confirmed by the second phase survey that mylonitized muscovite grandoirite (mylonite) are distributed in the northern part of Pagar Gunung, and they are considered to be older intrusive rocks than the Muara Sipongi granitoids. In addition, there are Bt Ruruk Raru granite remarkably accompanied by large plagioclase phenocnyst quartz porphyry and andesite dikes which are distributed in the northern part of Rao and in the upper reaches of the Ranya River.

1-6-1 Muara Sipongi Granitoids

The rock are widely distributed over an area 2 – 5 km wide and over 20 km long from Kotanopan through Muara Sipongi and into the southern part of Cubadak.

The granitoid betholith consists mainly of holocrystalline medium grained grandodiorite. At the Periphery of this batholith (Bt. Pionggu, Pagar Gunung) stocks and dikes of quartz diorite and diorite are distributed. The microscopic observation reveals that the granodiorite is equigranular holocrystalline and the main rock-forming minerals are quartz, plagioclase and horn-



LEGEND

Geological Age		Geological unit	Sedimentary Rocks	Volcanic Rocks	Intrusive Rocks
CENOZOIC	QUATERNARY		qa Alluvium		
	TERTIARY			tmdat BT. Pocncehan Dacitic tuff	tmand-2 Andesite tmand-1 Andesite
MESOZOIC	CRETACEOUS ~ JURASSIC				Kgr BT. Ruruk Raru Granite Kpor Plagio Quartz Porphyry Jgd Muara Sipongi Granodiorite
PALEOZOIC	PERMIAN ~ CARBONIFEROUS	Patahajan Formation	Cpls-2 Limestone Cpams Clastic Rock	Cpand M. Batang Andesite and Pyroclastic Rocks	
		BT. Tanjang Formation	Cpls-1 Limestone Cpss Sandstone		
		S. Ranya Formation	Cpqs Quartz Sandstone		

- Dip and structure
- Joint
- Fault confirmed
- Fault inferred
- Anticlinal axis
- Synclinal axis
- Folding axis

- Pyrite disseminated zone
- Silicified zone
- Skarn alteration
- Metalliferous vein, Ore bed
- Malachite stain

- Silicification zone
- Skarnization zone

Fig. III-1 Geological and Mineralized Zone Map of Muara Sip

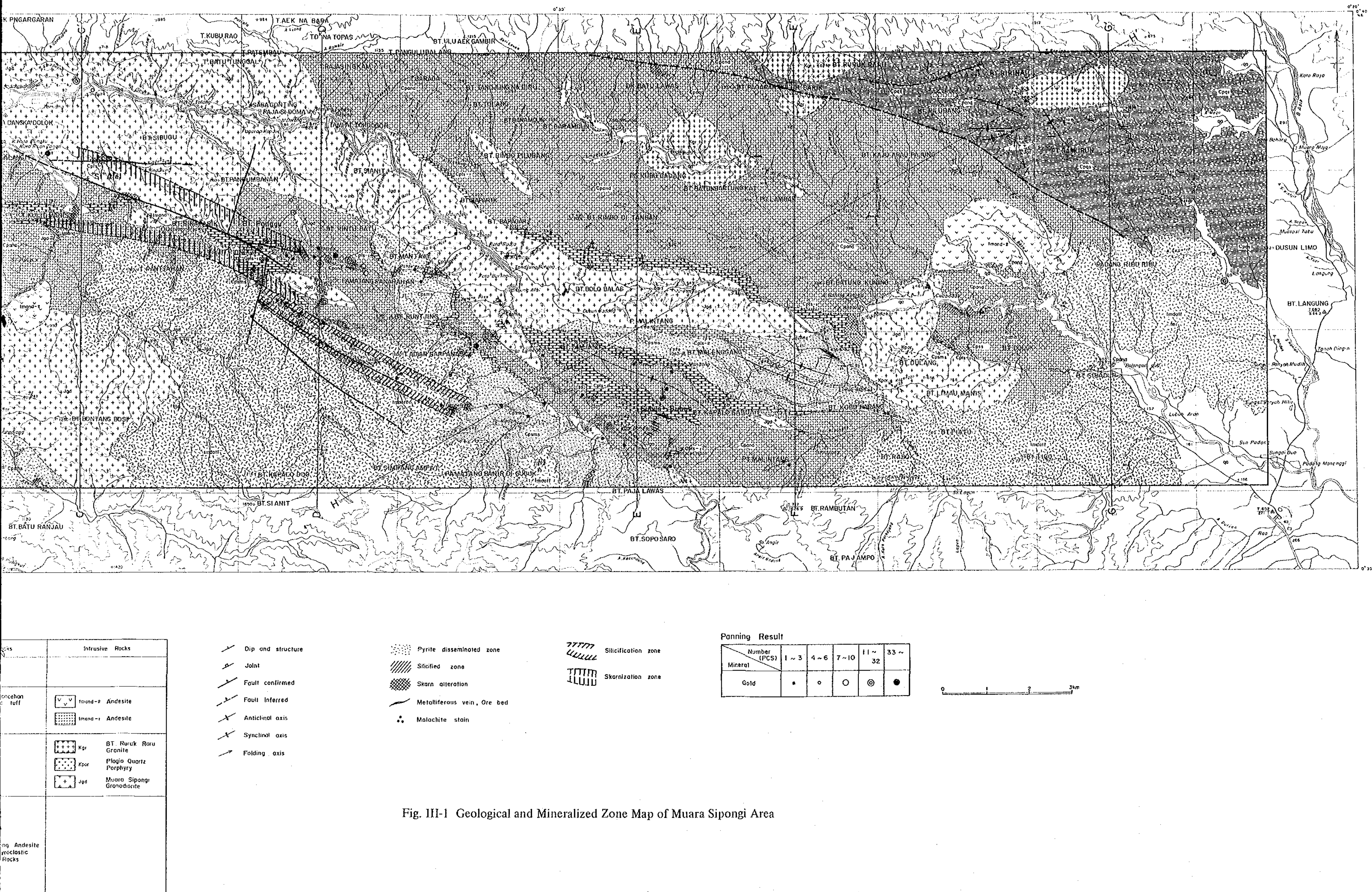


Fig. III-1 Geological and Mineralized Zone Map of Muara Sipongi Area

blende being accompanied by small amount of biotite and potassium feldspar. The quartz diorite is a slightly basic granitoid containing a small amount of quartz but almost none of the potassium feldspar, and the mineral composition includes, like the granodiorite, the plagioclase, hornblende, quartz and a small amount of biotite, being accompanied by some amount of pyroxene.

As a result of the age determination using the K-Ar method of the Muara Sipongi granitoids (2 granodiorite samples and one quartz diorite sample), it is in the range of 182 – 142 Ma as follows, indicating the age of the Jurassic time.

Table III-1 Age of Muara Sipongi Granitoids through K-Ar Radiometric Method

Sample No.	Location	Rock Name	Mineral measured	^{40}Ar rad (sec/gm x 10^{-5})	^{40}Ar rad (%)	K (%)	Ag (Mg)
BR-213	Tanjang Ala	Granodiorite	Hornbende	.214 .217	39.8 40.2	37 38	142 ± 7
ED-3	A.M.Botung	Quartz-Diorite	Hornbende	.106 .108 .111	28.3 17.4 20.6	16 16	166 ± 20
FR-226	Barlan	Granodirite	Hornbende	.302 .314 .323	48.6 51.5 41.3	42 42	182 ± 7

20 samples as to be uniformly distributed in the Muara Sipongi granoitoid batholith and the accompanying quartz diorite stocks, were selected and main components and miner element (fluorine, chlorine) were analyzed and the results and normative mineral ratios are shown in Table III-2.

Of these samples, 10 samples are intermediate with the content of SiO_2 62% – 70%, 7 samples are slightly basic at 53% – 62% and the remaining 3 samples are basic at 43% – 53%.

In the triangle diagram of quartz – plagioclase (anorthite and albite) – potassium feldspar based on the normative mineral ratios, the granites are classified into granodirite, quartz diorite in accordance with the granite classification of IUGS. (Fig. II-2).

Of them, the granitoids distributed from Subunsubun mineralized zone to Bt Pionggu mineralized zone and Si Ayu skarn mineralied zone and also in Pagar Gunung – Patahajang mineralized zone are classified into tonlite and quartz diorite from the mode mineral rations.

In the tendency diagram (Fig. III-4) of the relationship between the main component analysis values and differentiation index (perentage of normative minorals of quarty, orthoclase albite) all the components show almost a linear relationship and it is very similar to the tendency of the granites of the Cretaceous in Japan (Aramaki 1972), although the content of Al_2O_3 and FeO is lower and the content of Fe_2O_3 is slightly higher.
Al_2O_3 and FeO is lower and the content of Fe_2O_3 is slightly higher.

The difference in the content of Al_2O_3, FeO and Fe_2O_3 from the Japanese granites is also recognized with the granittoids in West Kalimantan (MMAJ.JICA/DMR 1979 – 1981) and this seems to be the characteristics of the Jurassic and Cretaceous granites in Indonesia.

In accordance with the FMA triangle diagram (Fig. III-3) of 3 components MgO – (FeO + Fe_2O_3) – (Na_2O + K_2O) prepared in order to investigate the tendency of the differentiation of the granitoids, the differentiation of calc-alkalic rock series is shown and the Muara Sipongi granitoids are classified as calc-alkalic rock series granitoids of the island arc.

The Muara Sipongi granitoids were found to contain 70 ppm – 380 ppm of fluorine and 100 ppm – 700 ppm of chlorine. The content of fluorine increases proportionally as the content of fluorine increases proportionally as the content of SiO_2 increases (the content is higher for acidic granites), but chlorine shows no such tendency. But the granitoids which showed particularly high values (400 – 700 ppm) tend to be distributed in the neighborhood of a mineralized zone. The granitoids found near Cubadak village are tonalite and a few chalcopyrite is disseminated in them.

As a result of approximate measurement of the magnetic susceptibility of the Muara Sipongi