NO.

REPORT
ON
THE MINERAL EXPLORATION
IN
THE EAST JAVA AREA
THE REPUBLIC OF INDONESIA

PHASE I

MARCH 2002

JAPAN INTERNATIONAL COOPERATION AGENCY

METAL MINING AGENCY OF JAPAN

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PREFACE

In response to the request by the Government of the Republic of Indonesia, the Japanese Government decided to conduct a mineral exploration project in the East Java Area and entrusted the survey to the Japan International Cooperation Agency (JICA). The JICA entrusted the project to Metal Mining Agency of Japan (MMAJ) because contents of the survey belong to a very specialized field of mineral exploration.

The survey conducted during this fiscal year is the first-phase of a three-phase project to be compiled in 2004. JICA and MMAJ sent a survey team to the Republic of Indonesia headed by Mr. Osamu MIYAISHI from 18 November to 22 December 2001. The team exchanged views with the officials concerned with the Government of the Republic of Indonesia and conducted a field survey in the East Java Area.

After the team returned to Japan, further studies were made and a report on the first phase of the mineral exploration project was prepared. We hope that this report will serve the development of the Republic of Indonesia and contribute to the promotion of friendly relations between our two countries.

We wish to express our deep appreciation to the officials concerned of the Government of the Republic of Indonesia for close cooperation extended to the Japanese team.

March 2002

Takao KAWAKAMI
President,
Japan International Cooperation Agency

Norikazu MATSUDA
President,
Metal Mining Agency of Japan

SUMMARY

The survey of the first year of the project consisted of analysis of existing data, analysis of satellite images, and geological and geochemical surveys. Analyses of existing data and satellite images covering the East Java area over a total area of 19,000km^2 (project area) were carried out. JERS-1 SAR images were used for photogeological interpretation, the geology and geologic structure of the survey area were studied. Also DEM was prepared from 1:25,000 topographic maps, and a multi-directional light source image, a gradient anomaly image, and an altitudinal dispersion anomaly image were prepared over an area of 5,000km^2 (survey area). Geological and geochemical surveys were carried out over the survey area. A total of 817 sites were selected for geochemical sampling of stream sediments in the survey area of 2,000km^2.

The following conclusions were obtained by the first year survey of the mineral exploration in the East Java area.

The geology of the project area consists mainly of Eocene to Pleistocene volcanic rocks and pyroclastic rocks, and Oligocene-Miocene to Pliocene limestone occurs in the project area. Intrusive bodies of dolerite-diorite, porphyry, and dacite-quartz porphyry were observed. Many gold, copper, lead, zinc and manganese minerals and mineral showings occur in Tertiary volcanic and pyroclastic rocks of the project area.

Many lineaments were extracted from SAR images of the survey area. Most of the lineaments were extracted from the Tertiary volcanic area and this constitutes the dense lineament concentration zones. The predominant directions of the lineaments are; WNW-ESE, NNE-SSW, ENE-WSW, and NE-SW. Also, NW-SE trending lineaments which were difficult to extract by SAR images were extracted by DEM image interpretation. The above dense lineament concentration zones overlap known mineral prospects.

Eleven geochemical districts were identified in the survey area. However, of these, 4 districts are considered to have high mineral potential from the distribution of quartz veins, pyrite dissemination, and alteration minerals on the surface.

Based on the results of the first year survey, it is recommended that the following be carried out as the second year survey of the East Java mineral exploration project. Assess the ore potential and extract targets for further drilling by; detailed geological and geochemical surveys of the survey area and reconnaissance survey of the adjacent areas as listed below.

(1) Geological and geochemical reconnaissance of area to the east and west of the survey area.
The mineral prospects reported in existing information are mainly manganese, while gold, silver, copper, lead and zinc mineral showings are not abundant. Thus it is considered that the ore potential in the areas are not higher than in the present survey area. However, the eastern extension of the mineralization confirmed by the present survey at north of Pule, and the western extension of the known prospect at Selogiri should be confirmed.

(a) Western side: northern half of the area adjacent to the survey area
(b) Eastern side: area adjacent to the survey area

(2) Detailed geological and geochemical surveys of the promising ore prospects in the following districts

(a) Mineral showings and geochemical anomaly zones of Tegalombo-Slahung
(b) Mineral showings and geochemical anomaly zones near Lorog River
(c) Geochemical anomaly zones east of Punung
(d) Geochemical anomaly zones south of Slahung

(3) Geophysical survey, IP electric exploration (about 10km traverse), may be applied when it becomes necessary with extraction of high-ore potential zones by the above (a) to (d) detailed survey.

Fig.1−1 Location Map of the Project Area

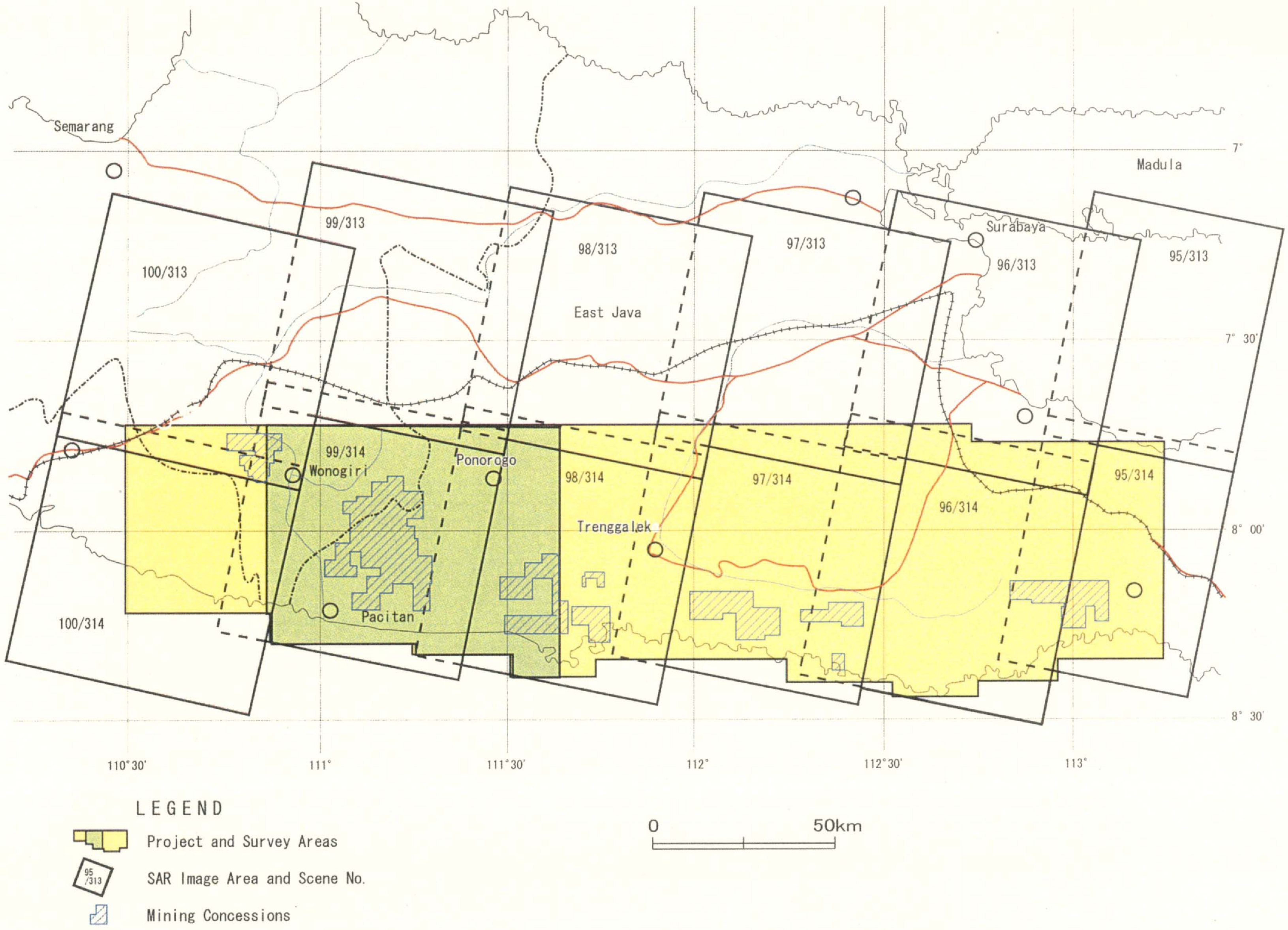

Fig. 1-2 Location Map of the Satellite Image Anlysis Area

CONTENTS

CONTENTS

LIST OF FIGURES AND TABLES

FIGURES

TABLES

LIST of PHOTOGRAPHS

LIST of APPENDIX

LIST of PLATES

PART I

OVERVIEW

PART I OVERVIEW

Chapter 1 Introduction

1 - 1 Objectives of the Survey

In response to the request from the Government of the Republic of Indonesia to conduct mineral exploration, the Japanese Government sent a mission for Scope of Work Consultation to Indonesia in September 2001. And as a result of consultation with the Directorate General of Geology and Mineral Resources of Indonesia, an agreement was reached for cooperative mineral exploration of the East Java area and the Scope of Work was concluded by representative of both Governments in 19 September 2001. The objective of this project is to assess the mineral potential of the area through analysis of existing data, analysis of satellite images, geological survey, geochemical survey, geophysical exploration, and drilling during the three year period from fiscal 2001 to 2003. The counterpart organization in accordance with this Scope of Work is the Directorate of Mineral Resources Inventory.

During the first year of the project, existing data and satellite images for the East Java area extending 19,000km^2 were analyzed. Also geological survey and geochemical survey were carried out over an area of 5,000km^2. The fieldwork was done from 18 November 2001 to 22 December 2001.

1 - 2 Survey Methods

(1) Outline of the survey

The survey of the first year of the project consisted of analysis of existing data, analysis of satellite images, and geological and geochemical surveys. Regarding the examination of existing data, available information concerning geology and mineral deposits were studied, summarized and guidelines and plans for field survey were prepared. JERS-1 SAR images were used for photogeological interpretation, the geology and geologic structure of the survey area were studied, and the relation between the existing data and mineralized zones was considered. Also DEM was prepared from 1:25,000 topographic maps, and a multi-directional light source image, a gradient anomaly image, and an altitudinal dispersion anomaly image were prepared. And lineaments (geologic structure) and intrusive bodies were extracted.

Geological survey and geochemical survey were carried out in the field. Of the 5,000km^2 survey area delineated for geological investigation, areas with mining concessions were excluded for traversing and geological survey covered an area of 2,000km^2 and total length of the survey route amounted to 500km. Stream sediments for geochemical survey were sampled simultaneously with the geological survey. The stream sediments samples were sent from Bandung to XRAL Laboratories, in Canada without drying because of the limited time for the survey and inclement weather. And they were dried at the analytical laboratory.

(2) Work carried out

The total work carried out in the field and in the laboratories is laid out in Tables 1-2 and 1-3.

Table 1-1 Amount of Work

Work	Amount
Existing Data Compilation	Area : 19,000km^2
Satellite Image Analysis	Area : 19,000km^2
Geological and Geochemical Surveys	Area : 5,000km^2 Traverse Area : 2,000km^2 Total Length of Route : 500 km

Table 1-2 Laboratory Tests Carried Out

	Work Items	Amount
Geological and Geochemical Surveys	Observation of thin section of rock samples	50 samples
	Observation of polished section of ore samples	50 samples
	Powder X-ray diffraction analysis	100 samples
	Chemical analyses of rock and ore samples (Elements: Au, Ag, Cu, Pb, Zn, As, Hg, Sb)	100 samples
	Chemical analyses of stream sediments (Elements: Al,Sb,As,Ba,Be,Bi,Cd,Ca,Cr,Co,Cu,Fe,Pb Mg,Mn,Hg,Mo,Ni,P,K,Ag,Na.Sr,Ti,W,V,Zn,Au)	857 samples
	Fluid inclusion measurement (Homogenization temperature and salinity)	5 samples
	Whole rock chemical analysis	20 samples
	Age determination(K-Ar Method)	10 samples

1 - 3 Members of the Survey Team

(1) Mission for Scope of Work Consultation

A Mission for consultation and conclusion of the Scope of Work for mineral exploration in the East Java area was dispatched from November 18 to December 22 2001. The Scope of Work was concluded by Japan International Cooperation Agency, Metal Mining Agency of Japan and General Directorate of Geology and Mineral Resources, Directorate of Mineral Resources Inventory of the Ministry of Mining of the Republic of Indonesia. The members of the above mission are as follows.

[Indonesian Side]

Abdurrohman	(Director, DMRI)
Bambang Setiawan	(Head of Metallic Mineral Division)
Koswara Yudawinata	(Project Manager, DMRI)
Bambang Pardiarto	(Chief of Metallic Mineral Inventory Section)
Aman Sukandar	(Staff in Charge of Foreign Cooperation)

[Japanese Side]

Shigeru YOKOYAMA	(Team Leader, Executive Director of MMAJ)
Kiyoto KUROKAWA	(Energy and Mining Development Study Division, Mining and Industrial Development Study Department, JICA)
Keita KODA	(Deputy Director, Technical Cooperation Division, Mineral Resources Survey Department, MMAJ)
Eishi ENDO	(Deputy Representative, MMAJ Bangkok Office)

(2) Field survey team

Regarding the fist year survey of this project, analysis of existing data and satellite images were carried out from 18 October 2001, and field survey from 18 November to 22 December of the same year. Six scientists from Japan and nine scientists from Indonesia formed the field survey team. Also Deputy Director Koda and Deputy Director Sakata of MMAJ supervised the field survey from 21 to 22 November and 11 to 13 December respectively. Also the Indonesian Project Leader Mr. Bambang Pardiarto participated in the fieldwork from 10 to 13 December.

Indonesian Counterpart Organization: Directorate of Mineral Inventory

Dwi Nugroho S.	(Team leader, geological and geochemical surveys)
Bambang Nugroho Widi	(Geological survey)
Sahat Simanjuntak	(Geological and geochemical surveys)

Wahyu Widodo	(Geological and geochemical surveys)
Iwan Nursahan	(Geological and geochemical surveys)
Moetamar	(Geological and geochemical surveys)
Prima Hilman	(Geological and geochemical surveys)
Wahyu Supriadi	(Geological and geochemical surveys)
Elisa Parkit	(Geological and geochemical surveys)

Field Survey Supervision

Tsuyoshi Sakata	(Deputy Director, Technical Cooperation Division, Mineral Resources Survey Department, MMAJ)
Keita Koda	(Deputy Director, Technical Cooperation Division, Mineral Resources Survey Department, MMAJ)

Japanese Survey Team

Osamu Miyaishi	(Team leader, geological and geochemical surveys)
Masataka Ochi	(Geological and geochemical surveys)
Tetsuo Sato	(Geological and geochemical surveys)
Nobuya Yamamoto	(Geological and geochemical surveys)
Kazuhiro Yamamoto	(Geological and geochemical surveys)
Norio Tsushima	(Geological and geochemical surveys)

1 - 4 Duration of Survey

The duration of survey is was from 18 October 2001 to 15 March 2002 and that of the fieldwork was from 18 November to 22 December 2001.

Chapter 2 Geography of the Survey Area

2 -1 Survey area

During the first year of the project, analyses of existing data and satellite images covering the East Java area over a total area of 19,000km^2 were carried out.

Geological and geochemical surveys were carried out over an area of 5,000km^2 (survey area) delineated by the above analyses within the 19,000km^2 (project area). The eastern part of this survey area is in East Java Province, and the western part in Central Java Province and the area excluding mining concession areas is 2,000km^2.

Table 1-3 Coordinates of Project and Survey Areas

		Latitude(S)	Longitude(E)		Latitude(S)	Longitude(E)
Project	(a)	7° 43.5′	110° 30′	(b)	7° 45.0′	113° 15.00′
Area	(c)	8° 25.18′	110° 30′	(d)	8° 25.18′	113° 15.00′
Survey	(a)	7° 43.5′	110° 52.79′	(b)	7° 43.50′	111° 38.57′
Area	(c)	8° 21.25′	110° 52.79′	(d)	8° 21.25′	111° 38.57′

Note: (a) to (d) show the corners of the project and survey areas

2 - 2 Topography and Drainage

Access: Regular airline was used for trips between Bandung, the seat of DMRI, and Yokyakarta. A member of the team used regular airline from Surabaya to Jakarta on his return trip. Survey equipment was sent for a distance of about 4,000km from Bandung to Yokyakarta by vehicles taking 10 to 13 hours.

Of the roads in the survey area, the major highway joining Wonogiri, Ponorogo, and Pacitan is paved and relatively well maintained. Other roads within the area are narrow and bumpy, but are developed rather densely.

Topography: Many volcanoes with elevation exceeding 2,000m occur in the east to west direction in somewhat southern part of Java Island, and Mt. Semeru in the eastern part of the project area towers 3,676m high. Relatively gently undulating hilly areas exist between these volcanoes. The survey area to the south of this row of volcanoes consists of steep mountainous terrain, but the topography to the east and west of the survey area is relatively flat with gentle relief. The area to the east has limestone karst topography. The area to the north of the volcanic row generally has lower elevation compared to the south, and thus the drainage divide is located southward and the larger rivers drain northward. The major rivers are; Brantas River, Madiun River, and Solo River.

Details of the rivers in the survey area: The drainage of the survey area consists of Solo River system and Madiun River system both of which flow northward into the Java Sea, and many southward-flowing drainage systems. The major southward flowing rivers are; Gridulu River (in the figures, rivers are indicated by K. as abbreviation of Kali), Padi River, Lorok River, Pangguil River, Tembawar River, Konong River, and Nampa River. An artificial reservoir (Waduk Gajah Mungkur) extends over a wide area to the south of Wonogiri.

Also the present survey area extends into the southern half of eastern Java Island where the terrain is steep and rugged although very high mountains do not exist. The major mountains in this part are Mts. Gembes (1,242m high), Rohtawu (1,004m), Sepang (729m), Badud (1,057m), Gede (666m), Gond (875m), and Rampal (818m).

2 - 3 Climate and Vegetation

Climate: Eastern Java is located in the tropical rain forest climate zone, and it is divided into the dry (May – October) and wet (November – April) seasons. The average precipitation is 2,000 ~ 2,500mm and the average monthly temperature ranges between 23 to 32° C (Pacitan). The temperature and precipitation of Malang in the eastern part of the survey area is shown in the table below. The survey was carried out during the wet season, and clear days continued for 5 days at the beginning and the end, but it rained continuously during the 10 days in-between, and the water rose in the rivers.

Table 1-4 Temperature and Precipitation in the Project Area

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Average Temprature(℃)	25	25	25	25	26	25	24	24	25	25	25	25
Monthly Precipitation(mm)	249	272	237	140	59	32	20	28	28	75	164	282

Vegetation: With the exceptions of the parts in the south, the area is cultivated close to the mountain summits and rice fields and farms are developed extensively. There are not many jungles, and the vegetation is generally sparse. Eggplants, pepper, banana, papaya, pineapples, as well as crops such as rice, corn, and casaba are cultivated in the field.

2 - 4 Administrative Districts

As mentioned earlier, the project area extends over 19,000km^2 in the eastern part of Java Island, and administratively it spreads across East Java Province, Central Java Province, and Yokuyakarta Special District. The eastern part of the area for the first year geological and geochemical surveys belong to the East Java Province, and the western part to the Central Java Province (Fig.1-1). Ponorogo Kabupaten (Regency), Trengalek Kabupaten, Madiun Kabupaten, and Magetan Kapupaten belong to the East Java Province and Wonogiri Kabupaten is in the Central Java Province.

Chapter 3 Geology of Project Area

3 - 1 General Geology of the Vicinity of the Project Area

The project area is located in an island arc related to the present subduction of the Australia-India Plate under the Eurasia Plate, and a row of volcanoes occurs in the east-west direction. This volcanic arc overlaps the Tertiary volcanic arc and largely controls the geology and geologic structure of the survey area. East Java is divided into 4 zones, namely from the north southward, Rembang Zone, Kendeng Zone, Central Volcanic Zone, and Southern Mountain Zone. The Rembang and Kendeng Zones consist mainly of post-Oligocene sandstone-mudstone and limestone with intercalation of pyroclastic rocks. The Central Volcanic Zone is composed mainly of post-Pliocene volcanic rocks. In the Southern Mountain Zone, pre-Tertiary metamorphic rocks are exposed at some places and these are overlain by widely occurring Eocene and Oligocene to Pliocene volcanic rocks and limestone units.

The project area spreads across the two southern zones, namely the Central Volcanic and Southern Mountain Zones.

The geology of the survey area is comprised mainly of Eocene to Pleistocene volcanic and pyroclastic rocks, and Oligocene-Miocene to Pliocene limestone occurs in the northwestern to central southern parts. Also the intrusive bodies consist of basalt, andesite, dacite, and diorite.

Table 1-5 Simplified Stratigraphy of East Java

Age	Rembang Zone	Kendeng Zone	Central Volcanic Zone	Southern Mountain Zone
Pleiocene	Alluvium Limestone	Alluviun Limestone	Volcanics Alluvium Limestone	Alluvium, Limstone
Pliocene	Limestone	Limestone Conglomerate, sandstone Volcaniclastics	Volcanics Sandstone, Marl	Volcanics
Late Miocene	Sandstone, Marl	Sandstone Marl Volcanics		Volcanics Limstone
Early - Late Miocene	ClaystoneMarl Limestone	Sandstone Mudstone		Volcanics Limestone
Late Oligocene -Early Micone				Volcanics Limstone
Eocene				Sandstone,Siltstone Limestone
Pre-Tertiary				Shists Limstone

3 - 2 Geology of the Survey Area (Outline of Previous Surveys)

The geology of survey area consists of Tertiary and Quaternary System with basement composed of pre-Tertiary metamorphic rocks mentioned above. The oldest exposed formation in this area is Oligocene volcanic and pyroclastic rocks, and sedimentary rocks. They are called Mandalika Formation and Arjosari Formation respectively. Miocene to Pliocene Series occur widely and they are; Wuni and Semilir Formations consisting mainly of volcanic and pyroclastic rocks, Campurdarat and Wonosari Formations composed mainly of limestone, and Nampol, Jaten, and Oyo Formations consisting mainly of sedimentary units. Also basalt, andesite, and diorite intrusive bodies are exposed. The Quaternary System occurs in the northern part of the area, and it consists of Pleistocene to Holocene volcanic, pyroclastic rocks and unconsolidated sediments. NW-SE and

NE-SW trending faults are predominant in this area.

(a) Stratigraphy

The lowermost units exposed in this area are Arjosari Formation-Dayakan Formation consisting mainly of volcanic and pyroclastic rocks, and Mandalika Formation, Watupatok Formation, Panggang Formation composed of conglomerate and sandstone. These units are correlated to Oligocene and Miocene Series. The overlying Miocene Series are composed of Nglanggran Formation, Semilir Formation, Wuni Formation consisting of volcanic rocks and pyroclastic rocks and Sampung Formation, Jaten Formation, Oyo Formation consisting mostly of conglomerate, sandstone, mudstone and marl, and Campurdarat Formation and Wonosari Formation consisting of limestone.

The igneous activity of the survey area is predominantly andesitic and basaltic, and judging from Oligocene (?) welded tuff in the eastern part, it is believed to have begun as dacitic terrigenous volcanic activities. The distribution of the dacitic welded tuff indicate bimodal activity from Oligocene to Miocene. The stratigraphic division and correlation of the volcanic rocks of the survey area is difficult, and defining lithofacies division for each lithologic distribution area, as was done in the existing geological maps, is believed to be appropriate. Also dolerite, diorite, and porphyry intrusive bodies are exposed in this area. The Quaternary System is widely developed in the northern part and it consists of Pleistocene to Holocene volcanic and pyroclastic rocks (Table 1-5).

(b) Geologic structure

The Tertiary System largely show E-W to ENE-WSW strike with less than 30° dip. Occurrence of gentle and short wavelength fold structure with axes extending in the E-W to ENE-WSW direction is inferred. On the other hand, lower formations appear to be distributed in the northeastern part and the upper units in the southwestern part, and further study is warranted.

Large-scale lateral faults with ENE-WSW~NE-SW trend is dominant and controls the geologic structure of the area. Many quartz veins occur particularly in the vicinity of Karangjero Fault extending along the road connecting Pacitan and Ponorogo, and this may indicate the control of mineralization by this fault. However, many mineralized zones are associated with N-S to NW-SE trending short and small faults and fissures. Also many small NE-SW and NW-SE fault systems occur in the area.

3 - 3 Outline of the Mineral Prospects in the Survey Area

Gold, silver, copper, lead, zinc mineralization is known in this area. Most of them are believed to be of hydrothermal origin, but the possibility of blind porphyry copper deposits should be considered. Also clay deposits associated with volcanic activities and limestone deposits are the main non-metallic deposits.

Gold, silver, copper, lead, zinc, and iron-manganese prospects are known in the survey area. Gold deposits associated with quartz veins are widely distributed from Ponogoro to Pacitan. Seven holes with a total length of 1,005m were drilled jointly by DMR and the Korea Mining Promotion Corporation at Kasihan about 20km north of Pacitan in 1993, and weak copper, lead, zinc mineralization was identified. Their route maps show occurrence of hedenbergite and magnetite and lead and copper oxides and existence of skarn-type ore deposits is a possibility (Table 1-6).

Chapter 4 Results of the Survey

4 - 1 Mineralization Characteristics and Structural Control

(1) Regional geologic structure and distribution of mineralized zones

The survey area lies over the subduction zone of the Australia-India Plate in the Sunda Trench, and the Sunda-Banda Islands continuing from Sumatra through Java, Sunbawa to the west are believed to be under similar geologic environment. The working mines of this region close to the survey area are Gunung Pongkor gold mine and Batu Hijau gold-porphyry copper mine in West Java Province.

The ore deposit of the Gunung Pongkor gold-silver mine is characterized by NW-SE to WNW-SES trending faults and E-W trending fold axes and the host rocks are Tertiary volcanic and pyroclastic rocks. There are 4 major ore veins which are 300 to 1000m long in the strike direction, and less than 300m along the dip, and the average width is 2.5 to 8.0m. The gangue minerals are quartz and adularia, and native gold, argentite, are observed. Alteration is silicification and argillization (sericite, smectite) near the ore deposit. Ag/Au is 1.5~30 (average 9), and heavy metal and As contents are generally low, less than 100ppm. The mineralization is considered to have occurred in 8-9Ma.

The Batu Hijau porphyry gold-copper deposit is located in the southwestern part of the Sunbawa Island in the Sunda-Banda Islands. The host rocks of the ore deposit are Early Tertiary andesitic lava and pyroclastic rocks, and dacite and tonalite. Mineralization and alteration occurred in 3 stages, but the ore minerals are chalcopyrite and bornite in quartz veinlets, and observed alteration minerals are magnetite, sericite, albite, smectite, and kaolin. Mineralization and alteration occurred in a zone more than 1km in width, several kilometers in length and to a depth of 1,000m.

The above two ore deposits differ in type, but are both associated with Tertiary island arc activities, and the geologic environment of East Java such as NW-SE, ENE-WSW trending fault system, E-W fold structure, predominance of andesite – namely calc-alkali rock series, and the features are characteristic to the wider region.

(2) Mineralization

Mineralization confirmed by geological and geochemical surveys of the area was mainly that of gold, silver, lead, copper, and zinc. Small-scale manganese mineralization was also observed.

The gold, silver, copper, lead, zinc mineralization occurred as quartz veins containing chalcopyrite, galena, and sphalerite. In the existing mining concessions, chalcopyrite and sphalerite occur together with quartz and skarn minerals. Geochemical survey showed gold, silver, copper, lead, zinc as well as low molybdenum geochemical anomalies. The major mineralization zones are concluded to occur in the following districts within the survey area.

(a) Tegalombo-Slahung district: quartz vein zones between Ponorogo and Pacitan

(b) South of Slahung district: gold, silver, zinc geochemical anomaly zones

(c) Lorog River district: gold, silver, copper mineralized and altered zones

(d) East of Punung district: geochemical anomaly zones west of Kebonsari known gold prospect

(e) North of Pule district: northern extensions of the Candi quartz veins and silicified rocks of Pule known gold prospect

(f)Wonocoyo geochemical anomaly zone: geochemical anomaly zones in the lower reaches of Konong River

Aside from the above, mineral showings of the following 6 districts were confirmed by reconnaissance of the known mining concessions.

(g) Kasihan Prospect

(h) Quartz veins and Candi silicified rocks near Pule

(i) Selogiri gold deposit

(j) Kebonsari gold deposit (Punung gold deposits)

(k) G.Gembese silicified rocks

(l) Gold mineralization in the northern part (Randusari)

(1) Geologic horizon of the mineralization (and host rock)

The geology of the survey area is mainly composed of Oligocene to Miocene volcanic and pyroclastic rocks, and Pliocene limestone, and the northern part consists of Quaternary volcanic rocks. Predomiant volcanic rocks are basaltic, andesitic, and dacitic volcanic and pyroclastic rocks and coarse-grained rocks. Some of the tuff and tuffaceous sandstone has bedded structure.

Mineralization mainly occurs in the Oligocene to Miocene volcanic and pyroclastic rocks, while alteration affected even Pliocene intrusive dacite. Also Pliocene limestone in the southern coast abuts against dacite intrusive body, and thus is considered to be younger than the dacitic intrusion.

On the other hand, copper, lead, and zinc occur associated with skarn minerals in Kasihan. It is inferred that the mineralization occurred in zones deeper than epithermal deposits, and Miocene holocrystalline rock (diorite) is the host rock of the quartz veins. Also it is clear that this holocrystalline rock is related to the mineralization. Therefore, these mineralization activities are believed to go back to Miocene.

(2) Distribution of ore deposits and structural control

The geologic structure of the survey area is characterized by ENE-WSW and NW-SE trending fault systems and fold structure with ENE-WSW to E-W direction. This is harmonious with the results of lineament interpretation. This also is harmonious with the N-S compressional field of Java Island after Tertiary.

Quartz veins accompanied by gold, silver, copper, lead, zinc mineralization occur widely, particularly from Ponogoro to Pacitan (Telalombo-Slahung district, zone south of Slahung, Lorog River district). An ENE-WSW trending large-scale left-lateral fault and NW-SE trending right lateral fault occur near the above, while the direction of the quartz veins are mostly N-S. This can be interpreted to be extension fractures in an N-S compressional field. The alteration zone extends in the N-S direction almost parallel to the extension of the veins.

Thus it is considered that the mineralization of the survey area occurred quite harmonious with the stress field under the influence of regional tectonic movement.

(3) Related igneous rocks

Igneous rocks which are inferred to be related to mineralization, such as diorite, dolerite (basalt), andesite (porphyry), and dacite (quartz porphyry) occur in the survey area. Namely dacite is exposed and altered in prospects (a) and (b), and dacite and diorite - dolerite are exposed and altered in prospects (c) to (d). Quartz porphyry, diorite or dacite occur in the vicinity of Kasihan, Kebonsari, Selogiri, and Pule of the known prospects. The ages of these intrusive bodies are, 18.1Ma for the dacite exposed at (a), 22.8Ma for the diorite at the upper reaches of Lorog River and 17.3Ma for the dacite near Pule. On the other hand, the age of the dacite in the western part (east of Pacitan) is 4.8Ma. In other words, dacite with the exception of that in the west shows Miocene age and the age of mineralization is estimated to be almost the same as that of intrusion. Also in the west, pyrite dissemination and quartz vein floats are observed and the dacite is believed to be related to mineralization. Intrusive bodies are generally circular to oval and although not very clear, some of the basalt intruded in the N-S to NE-SW direction.

(4) Alteration zoning

The distribution of altered minerals in the survey area indicate that the alteration of the major mineral prospects are sericite, and sericite-smectite and chlorite-smectite mixed-layer clay minerals are predominant in the vicinity and neutral alteration.

On the other hand, kaolin mineralscharacterizing acidic alteration are detected to the east of Pule and in the southeastern part. Although these have limited distribution, it is possible that they were developed overlapping the sericitic alteration zone in the mineral prospects.

(5) Mineralization environment

The quartz veins of this survey area can be divided into 2 groups from the homogenization temperature and salinity of the quartz (1 sphalerite) samples. One group has homogenization temperature of under 250° C with 3% NaCl equivalent salinity, and these are considered to be the product of epithermal mineralization. The other group has somewhat higher temperature at 250~300° C with lower salinity of 1.6~2.3% NaCl equivalent. The higher temperature group occurs near diorite exposures and is exposed in lower elevation of Nagram River. Thus it is possible that these quartz veins are exposed at localities deeply dissected and contain minerals formed at high temperatures.

As mentioned earlier, the ore deposits at Kasihan and other known mining concession 20km northeast of Pacitan contain contact metasomatic type copper, lead, and zone deposits associated with skarn minerals (grossular, hedenbergite, etc.,) aside from quartz veins. Quartz diorite and dacite are exposed in the vicinity.

Although most of the quartz veins in the survey area did not show gold grade sufficiently high to mine economically, some samples from the known prospects showed 10g/t and thus the occurrence of gold-bearing veins can be anticipated in the survey area with similar geologic conditions. Particularly zones with gold geochemical anomalies, although not very high, can be the targets for gold exploration.

From the above, it is concluded that the mineralization of the area is generally epithermal gold, silver, copper, lead, and zinc, and that deeper parts are exposed in some localities.

Although strong indication of copper, lead, and zinc mineralization could not be confirmed on surface, chalcopyrite in quartz veins, and secondary copper oxides and galena and sphalerite occur widely. Molybdenum geochemical anomalies are observed to the east of Punung, west of Ponorogo, and along the Lorog River, and the zone east of Punung is adjacent to gold, silver anomalies to the west and is interesting.

(6) Regional structural control: geology and ore deposits outside of the survey area

Tertiary igneous rocks extend eastward and westward from the survey area for this year, and mineral prospects with these volcanic rocks as host rocks are known. Therefore mineralized zones similar to those in the present survey area can be expected in these areas. Gold mineralization similar to the Selogiri deposit can be expected on the western side. Mineral prospect north of Pule is expected to continue westward. However, to the east, the distribution of the Tertiary rocks become narrower in the north-south direction and effective exploration will be limited in the western part because of the large amount of Tertiary limestone.

4 - 2 Potential of Ore Deposits

Geochemical anomalies were detected at 54 localities of the survey area. However, the anomalies occur concentrated in the following 7 districts and of these, 3 districts (1) ~ (3) are considered to have high potential from the distribution of quartz veins, pyrite dissemination, and alteration minerals on the surface. Geochemical anomaly zones in (7) are also believed to have high potential from existing data.

(1) Mineral showings of Tegalombo-Slahung district : Au anomalies were detected at 2 localities, Ag anomalies at 4 localities, and Cu and Pb anomalies were detected at 1 locality. Quartz veins are best developed in this prospect and sericitic alteration is observed. The maximum gold content of quartz vein samples is only 1.1g/t Au (rock chip). Also a 35cm-wide quartz vein containing chalcopyrite shows 2.2% Cu, but its gold grade is low. A 1.6m-wide and a 1.9m-wide quartz veins both contain only 0.1g/t Au. The homogenization temperature of fluid inclusions are low for both veins at 186° C and 210° C (salinity of 1 sample was 3.2%).

(2) Mineral showings to the south of Slahung: Ag anomalies were detected at 4 localities and Zn anomalies at 2 localities. This mineralized zone overlaps the sericitie-mixed layer clay alteration zone and the mineralized zone is inferred to extend in the N-S direction. Although pyrite dissemination is well developed on the surface, the Au grade at 3 localities was lowest at 42 and 56ppb.

(3) Mineral showings of Lorog River: Two alteration zones extending in the N-S~E-W and N-S directions at the lower and upper reaches of the Lorog River both overlap Au-As geochemical anomalies. Sericite-mixed layer clay minerals are observed at the alteration zones. Of these kaolin minerals occur at the downstream zone and this is observed to be related to mineralization.

A 10cm-wide pyrite-clay vein contain chalcopyrite and the Cu grade is 6.9%. Also white-argillized and pyrite disseminated quartz porphyry intrusion is observed in this prospect.

(4) Punung geochemical anomaly zone: A gold, silver, molybdenum, lead showings occur to the west of Kebonsari Prospect. Mixed-layer clay minerals occur as alteration minerals.

(5) North of Candi-Pule Prospect: N-S trending quartz veins and silicified rocks occur in the mineral prospects of Candi and Pule. A sample from Candi silicified rocks and from Pule vein exposure showed gold content of 4.4g/t and 1.2g/t respectively. An As geochemical anomaly and Cu anomaly were detected to the northeast of these prospects. Also kaolin and other minerals indicating acidic alteration were detected.

(6) Wonocoyo Prospect (geochemical anomaly zone): Au and Ag anomalies occur along the Konong River. Floats of quartz veins have low gold content (58ppb).

(7) Kedungwedi River Prospect: This is a known prospect, but it could not be located during the present survey. A small gold working area is located to the east and this was confirmed. Au geochemical anomaly was detected in 1 sample and acidic alteration zone occur in the area.

The mineral prospects of the known mining concessions as well as the above are summarized in Table 1-6.

Table 1-6 Major Mineral Showings and Geochemical Anomaly Zones

Mineral Showings and Geochemical Anomaly Zones	Main Commodities	Structural Control	Mineralization	Alteration	Geochemical Anomaly
(a)Tegalombo-Slahung	Au,Cu	Qtz Veins : ENE-WSW	Abundunt Qtz veins 35cm@2.2%Cu 20cm@1.1g/tAu	Sericite	Au,Ag, Cu,Pb,Zn,As
(b)South of Slahung	Au	Qtz veinlets : N-S dominant	Abundunt Qtz veinlets 20cm@56ppbAu	Sericite Mixed-layer mineral	Au,Ag, Zn,As,Hg
(c)K. Lorog	Au,Cu	Stockwork: NE30° E and NW55°	Argillic zones 10cm@Cu6.9%	Sericite Mixed-layer Kaolin	Au, Cu,Zn,Mo,As
(d)East of Punung	Au	Not confirmed (lineament:NW-SE)	Float of Qtz	– (Chlorite)	Au,Ag, Pb,Mo,As,Hg
(e)North of Pule	Au	Not confirmed (lineament:NNE-SSW)	Float of Qtz (1.6g/t Au)	Kaolin	Ag,Cu,Zn, Mo,As,Hg
(f)Wonocoyo	Au	Not confirmed (lineament:NW-SE)	Float of Qtz (58ppb Au)	– (Chlorite)	Au,Ag,Mo
(g)K.Kedungwedi	Au,Cu	Not confirmed (lineament:NW-SE)	Float of Qtz (1.1%Cu, 0.6g/tAu)	–	Au

(Within Existing Concessions)

Mineral showings and Geochemical Anomaly Zones	Commo Dities	Structural Control	Mineralization	Alteration	Geochemical Anomaly
(h)Kasihan Prospect	Cu,Pb,Zn	Qtz vein and Breccia dyke (N-S)	Qtz Vein (Width:30cm 1.1%Zn)	Skarn Mixed-layer mineral	-
(i)Near Pule and Candi	Au	Vein(N-S) Fault(NW-SE)	Qtz Vein (Width:1m : 1.2g/tAu) Silicified zone (Width:1m : 4.4g/tAu)	Sericite Kaolin Chlorite	-
(j)Selogiri Deposits	Au	Fault (N-S)	Qtz Veinlets Width:5-40cm×Length 500m, 2.0g/tAu	Chlorite	-
(k)Kebonsari Deposits (Punung Deposits)	Au	NW-SE	Qtz stockwork:0.7g/tAu Chalcopyrite,Qtz Vein Width:25cm,2.4%Cu	Sericite	-
(l)G. Gembes Silicified zone	Au	Fault?(NE-SW)	Width:0.6m Silicified zone : 10.9g/tAu	Mixed-layer mineral, Chlorite	-
(m)Upstream of K. Kedungwedi	Au	Vein(NNW-SSE?)	Acive mining(Underround) Ore dump : 11.8g/tAu	Sericite Mixed-layer mineral	-

Chapter 5 Conclusions and Recommendations

5 - 1 Conclusions

During the first year of the mineral exploration project in East Java, existing documents and information on geology and mineral resources of the project area were analyzed, satellite images were analyzed and interpreted, and geological and geochemical surveys were carried out. And the following results were obtained.

(1) Geological and geochemical survey results

Many gold, copper, lead, zinc prospects and geochemical anomaly zones were confirmed in Tertiary volcanic and pyroclastic rocks of the survey area. For these mineral prospects, distribution of the quartz veins, filling temperatures of the fluid inclusions, pyrite dissemination, nature and distribution of alteration minerals, relation with geologic structure, and the results of geochemical survey were examined. It was concluded from these results that; (a) gold and copper potential is the highest at the prospect in the vicinity of Tegalombo-Slahung, followed by (b) the gold, silver, and copper geochemical anomaly zones to the south of Slahung, (3) geochemical anomalous zones near the Lorog River in the eastern part of the study area, and (4) the geochemical anomaly zones to the east of Punung.

Chalcopyrite and sphalerite are often observed in the quartz veins of this area, but the geochemical anomalies of heavy metals are low. And in this general trend, copper anomalies have been detected in the Tegalombo Prospect, and the mineral potential for gold and copper is high. The prospect to the east of Punung has molybdenum anomalies and it arouses interest despite its weak content.

(2) Mineral potential of the study area

Tertiary volcanic and pyroclastic rocks are distributed to the east and west of the survey area, but their distribution is not as wide as in the survey area. Also the mineral prospects reported in existing information are mainly manganese and gold, silver, copper, lead, zinc, mineral showings are not abundant. Thus it is considered that the ore potential is higher in the survey area within the potential area. However, the eastern extension of the ore prospect discovered by the present survey at north of Pule, and the western extension of the known prospect at Selogiri should be confirmed.

5 - 2 Recommendations

Based on the above-reported results of the first year survey, it is recommended that the following be carried out as the second year survey of the East Java mineral exploration project. Assess the ore potential and extract targets for further drilling by; detailed geological and geochemical surveys of the survey area and reconnaissance and detailed survey of the adjacent areas as listed below. Also it is recommended that panning be used effectively for efficient extraction of geochemical anomaly zones.

(1) Geological and geochemical reconnaissance of area to the east and west of the survey area.

a. Western side: northern half of the area adjacent to the survey area (40km×25km)

b. Eastern side: area adjacent to the survey area (50km×20km)

(2) Detailed geological and geochemical surveys of the promising mineral showings

a. Mineral showings and geochemical anomaly zones of Tegalombo-Slahung (5km×12km)

b. Mineral showings and geochemical anomaly zones near Lorog River (6km×10km)

c. Geochemical anomaly zones east of Punung (5km×14km)

d. Geochemical anomaly zones south of Slahung (5km×12km)

(3) Geophysical Survey may be applied when it becomes necessary with extraction of high-ore potential zones by the above a to d of the detailed survey. IP electric exploration is concluded to be most appropriate since pyrite dissemination is expected in the epithermal and porphyry copper ore deposits in this area.

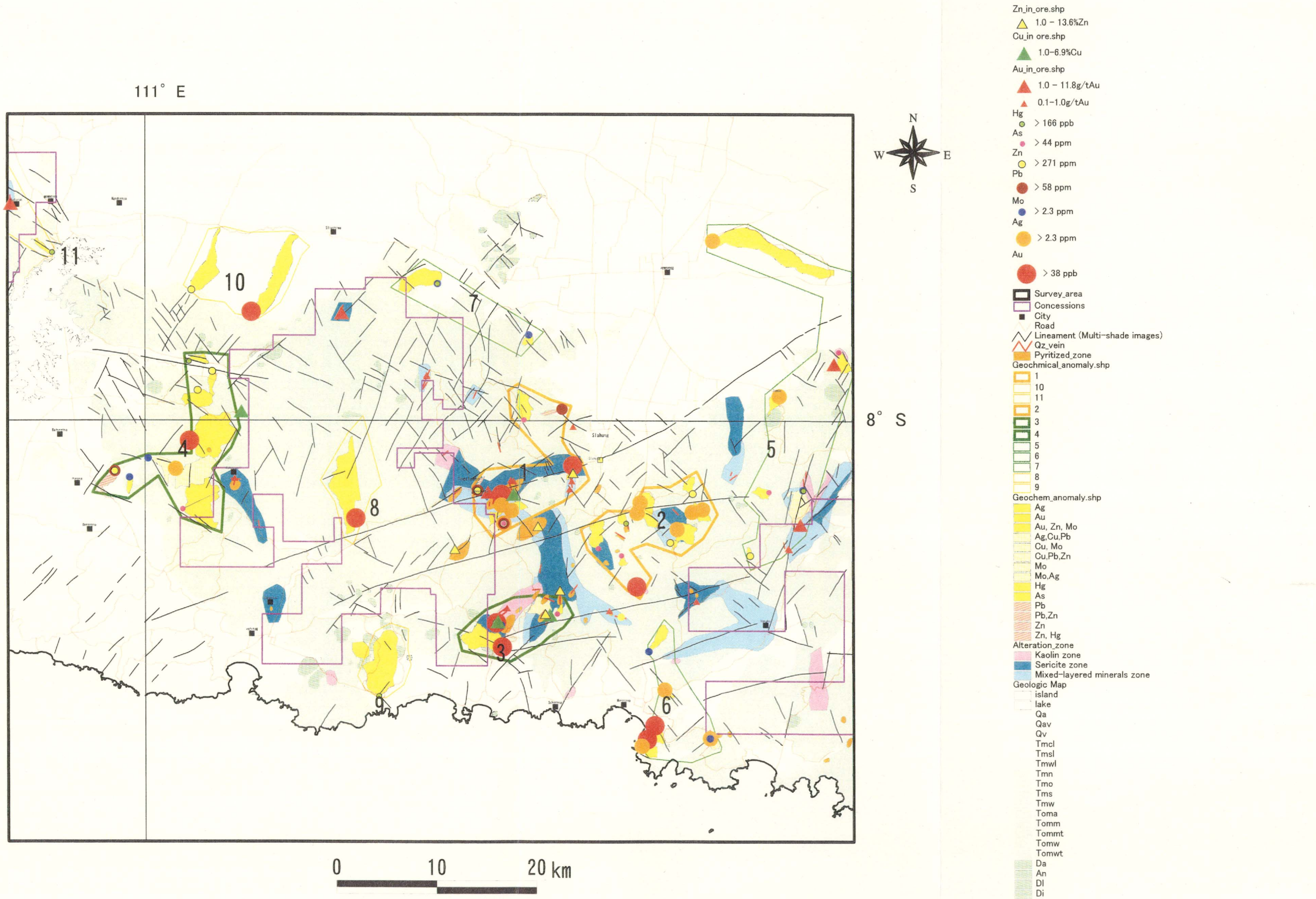

Fig.1-3 Compilation Map of the Survey Area

PART II

DETAILED DISCUSSION

PART II

DETAILED DISCUSSION

PART II DETAILED DISSCUSSIONS

Chapter 1 Analyses of Existing Data

1 - 1 Existing Geological Information

Existing geological information of the project area is shown in the list of references. And the major ones are laid out in Table 1-1. Sites for geochemical sampling were determined by the analysis of existing data. The area delineated for present-year survey was considered to have particular importance within the total study area.

Table 2-1 Major Mineralization Occurrences Based on Existing Data

No.	Name	Commodity	Geology	Mineralization	Previous Work
1	Selogiri	Au	Andesitic tuff Microdiorite	Quarzrz vein:3 main veins,5-40cm wide,500m long,cp,gn,sp	Shallow drilling Test pitting
2	Kebonsari	Au	Dacite-andesite breccia	Quartz stockwork, 25cm wide, cp,gn,sp	Test pitting Drilling(5holes,820m)
3	Petung-sinarang Burungkah	Au	Andesite-basalt	Quartz stockwork and veins, Silicification, sp,py,gn	Tunneling Drilling(9 holes,492m)
4	Kasihan Kobasari	Cu,Pb,Zn	Andesite breccia	Cu,Pb-Zn skarn(Cu porphyry) Quartz vein,cp,sp	Drilling (Year1991-94:7 holes, 1,005m. (Year1996-98:5 holes, 499m)
5	G. Mas, Selogiri	Au	Andesite-basalt	Quartz stockwork and veins	Trenching
6	Pulung	Au	Andesite(lava,tuff)	Quartz vein and veinlets	-
7	Tegalombo	Au	Dacite Andesite, Andesite breccia	Vein along the andesite dyke	-
8	G. Domasan, Slahung	Cu,Zn	Andesite breccia	Quartz vein	
9	K. Gondang Panggul	Ag	Dacite	Quartz vein	-

Note: Py:pyrite cp:chalocpyrite, sp:sphalerite, gn:galena

1 - 2 Outline of Geology of the Survey Area

The geology of the survey area is composed of pre-Tertiary basement (Cretaceous System and older units), Eocene to Pleistocene volcanic and pyroclastic rocks, Oligocene to Pliocene sedimentary rocks, Oligocene-Miocene-Holocene limestone, and Oligocene to Pleistocene intrusive bodies. Also gold, silver, copper, lead, zinc mineralization is known in this area. The mineralization is generally considered to be epithermal activities, but the possibility of buried blind porphyry copper mineralization should not be ignored. Also clay deposits associated with volcanism and limestone are the non-metallic deposits of this area (Fig. 2-1).

The stratigraphy of this area is as follows:

(a) Panggangrui Formation (Tomp): This unit occurs widely in the northern part of the survey area. It consists of basaltic to andesitic lava and pyroclastic rocks. Sandstone is intercalated. This unit interfingers with Watupatk Formation, and is correlated to the upper part of the Mandalika Formation. This is an Oligocene to Miocene marine formation.

(b) Dayakan Formation (Tomd): This unit occurs near G. Gembes in the northern part of the survey area. It consists of alternation of sandstone and mudstone.

(c)Watupak Formation: This formation occurs in the northern part of the survey area. It consists of basaltic lava and pyroclastic rocks. Sandstone, mudstone, chert are intercalated. It interfingers with Panggang Formation, and is correlated to the upper part of Mandalika Formation. The upper part interfingers with Semilir Formation. It is more than 500m thick.

(d)Semilir Formation: This formation occurs in the northern part of the area. This unit consists of tuff and sandstone and mudstone alternation. The lithofacies of the tuff varies significantly namely it is dacitic, andesitic, and basaltic. The bedding is generally clear. The lower part of this unit interfingers with Panggang Formation, Dayakan Formation, and Watupak Formation while the upper part is a transition zone to Nglangglan Formation. In the southern part, this is correlated to the upper part of Ajosari Formation, and is believed to be Upper Miocene Series. The unit is more than 750m thick.

(e)Nglangglan Formation: This unit consists of basaltic to andesitic lava and pyroclastic rocks.

The pyroclastic rocks are composed of alternation of volcanic breccia and sandy tuff (sandstone). This is believed to be shallow marine sediments. It is correlated to the upper part of Mandalika Formation. The unit is about 500m thick.

(f)Sampung Formation: This formation is distributed occurs as small unit in the northern part of the area. It consists of calcareous sandstone, marl, and limestone. Conglomerate occurs in some parts. It is correlated to Arjosari Formation and is considered to be upper Lower Miocene. This is a shallow marine sediment. It is 150m thick.

(g) Wonosari Formation: This formation consists mainly of reefal limestone, calcarenite with intercalation of conglomerate and marl. It is correlated to Upper Miocene to Pliocene Series. It is contact with andesite, but is not metamorphosed.

(h) Quaternary volcanic rocks: These rocks are distributed in the northern part of the area and are mainly composed of andesitic lava and pyroclastic rocks. The Quaternary volcanic rocks are divided into 12 units in the Ponorogo Quadrangle map, and the thickness is indicated to be more than 2000m. The Quaternary System is not surveyed in detail during the present project and thus this is shown as one unit in the geological map. Those unconformably overlying the Tertiary System are called Lawu Lahar and is a mixture of basalt, andesite and pumice, and volcanic ash.

(i) Quaternary System: Alluvium is distributed mainly near Ponorogo, Wonogir, and along the rivers in the southern part. It consists of gravel, sand, and mud.

1 - 3 Outline of Ore Deposits of the Survey Area

(1) Outline of mineralization

Showings of gold, silver, copper, lead, zinc, and iron-manganese are known in the survey area. Gold mineralization associated with quartz veins is widely distributed particularly in the zone from Ponorogo to Pacitan. Seven holes with a total length of 1,005m were drilled by joint exploration of DMR and Korea Mining Promotion Corporation in 1993 at a mining concession 20km northeast of Pacitan, and confirmed weak copper, lead, and zinc showings. Their route maps show the occurrence of hedenbergite, magnetite, lead and copper oxide minerals, and occurrence of skarn deposits are anticipated.

(2) Mineral prospects

Forty mineral prospects are known in the survey area. Of these, 3 are gold prospects, 13 are copper, lead, zinc prospects, and 24 manganese and iron/titanium prospects. Gold mineralization is associated with quartz veins in dacite or andesite. Details regarding width and reserve are not known. On the other hand, a DMRI material (DMR, 2000) contains descriptions of 10 Au-(Cu) prospects and the Au potential of the survey area is deemed to be high. Those of Selogiri and Kebonsari are being developed and mined, although of small scale, and they warrant particular mention. The quartz veins of Selogiri are said to be 5-40cm wide, but are more than 500m long in the strike direction. The Au-Cu deposit of Kasihan is inferred to be Au-Cu porphyry copper type deposit, and 7 holes totaling 1000m in length were drilled by DMR together with Korea Mining Promotion Corporation during 1991 to 1994. Manganese deposits are all small and none are said to be mined presently. The manganese orebodies occur as lenses at the border between Tertiary tuff and limestone. The Fe/Ti deposits are placer and/or residual deposits.

(3) Brief description of the mining concessions of the survey area

The mining concessions of the survey area are shown in Figure 1-3, and they are owned by enterprises such as; Kud. Selogiri, PT. Mega Budi Manganis, Kud Akur, PT. Sumber alam Peleng, PT. Keikan Perdana, PT. Triprasetya Pujiraharja, PT. Miracle, PT. Nomsantido, PT. Rotal Indotama, PT. Everlastika, PT. Timah Investasi Mineral.

(a) Kud Selogiri: Gold deposit associated with N-S trending pyrite-quartz veins (less than 10cm wide) in andesite. There are at least 2 veins and the strike length is said to be 2km, and the present working length is about 300m. The host rock is strongly disseminated by pyrite and is sericitized and chloritized. Presently the mining is carried out at 20~40m below surface by shaft and adit. Individual bonanza extends along the dip and does not appear to extend in the strike direction. The vein-grade is said to be several tens to several hundreds g/t. The ores are ground by small mill after hand picking and the gold is recovered by amalgam method. According to DMR data, 5 holes with total extension of 820m were drilled, but the results are not shown. The reserves (gold content) are calculated to be 206kg.

(b) PT. Mega Manganis: A manganese deposit outside of the survey area at Tulunganga.

(c) Kud Akur: It is also called Kebonsari after the village name, and also Punung after the sub-district name. The main deposit is stockwork gold consisting veinlets of less than 1cm wide. The host rock is andesitic tuff breccia, but 10cm-wide quartz veins containing pyrite and chalcopyrite also occur in this deposit. Gold grade is low and that of the presently mined ores is less than 1g/t Au. Oxidized zone occurs to 10m depth and this zone is said to have several g/t Au.

The ores are ground by small mill after hand picking and gold is recovered by amalgam method.

(d) PT. Sumber Alam Peleng: Quartz veinlets containing sphalerite are said to occur in andesite and dacitic porphyry. Gold grade is low and past exploration was not active.

(e) PT. Keikan Perdana: Skarn-type copper, lead, zinc deposits related to andesite lava and pyroclastic rocks and quartz porphyry intruded into limestone occur in the Kasihan district where this concession exist. Gold grade of the ores is generally low. Sphalerite and chalcopyrite-bearing quartz veins are the main ore in at least 2 outcrops. Drilling was conducted in 1994, it is not worked at present.

(f) T. Prasetya Pujiraharja: This is described to be in Gunung Mas district, this is a gold deposit accompanying quartz and pyrite in andesitic-basaltic lava and pyroclastic rocks. Nine holes with a total extension of 482m were drilled, and the reserves are 5.6 million tons at 1.89g/t (DMR data). It appears to have been worked in small scale up to around 1996. This area was not surveyed.

(g) Miracle: This is located to the east outside of the survey area. This consists of gold-bearing quartz veins in propylitized volcanic rocks. The maximum width of the veins is 35cm, maximum grade 2.9g/t Au, 87g/t Ag. Mining concession has expired.

(h) Nomsantindo: This is located to the east outside of the survey area. Gold mineralization is anticipated from quartz veins and silicified pebbles. But the gold content of the pebbles is low.

(i) Royal Indotama: This is located to the east outside of the survey area. Gold mineralization is observed in chalcedonic quartz-pyrite veins to stockwork within andesite, dacite and limestone. Maximum width and grade is 2m and 1.8g/t Au. Mining concession has expired.

(j) Everlastika Jaya: This is located to the east outside of the survey area. This is characterized by pyrite dissemination in rhyolite. Mining concession has expired.

(k) Timah Investasi Mineral (TIM): This covers a wide area outside of the survey area to the east. This is presently at the stage of regional survey.

Table2-2 Correlation of Geologic Units

		1408-3 SURAKARTA	1508-1 PONOROGO	1507-4 PACITAN	1508-2 MADIUN	1507-5 TULUNGAUNG	1508-3 KEDIRI	1507-6 BLITAR	1608-1 MALANG	1607-4 TUREN	1608-2 PROBOLINGGO	1607-5 LUMAJANG
Qa	Alluvium & Quarternary deposits	Qa Alluvium	Qa Alluvium Qaf Alluvium, Fan Deposits	Qa Alluvium	Qa Alluvium	Qa Alluvium	Qa Alluvium Qt Terrace Deposits	Qa Alluvium	Qa Alluvium Qt Terrace Deposits	Qal Alluvium and Coastal deposits Qas Swampand River Deposits	Qa Alluvium	Qa Alluvium Qc Coastal Deposits
Ql	Quarternary limestone										Ql Coral Limestome	
Qs	Pleistocene Sedimenatary Rocks	Qb Baturetno Formation Qt Older Alluvium		Qpk Kalipucang Formation	Qpnv Notopuro Formation Qpk Kabuh Formation		Qpnv Notopuro Formation Qpk Kabuh Formation Qpp Pucangan Formation		Qpw Welang Formation Qpj Jambang Formation Qpk Kabuh Formation			
Qhv	Quarternary (Holocene) volcanics	Qvm Merapi Volcanic Rocks Qvl Lawu Volcanic Rocks	Qlla Lawu Lahar Qvcl Condrodimuko Lava Qval Anak Lava Qvl Lawu Volcanics				Qd Kelud Debris Qvlh Laharic Deposits Qvk Young Kelud Volcanics Qv(n,p) Upper Quarternary Volcanics Qhvp Young Parasitic Volcanics	Qvlh Laharic Deposits Qvk Kelud Volcanics Qptm Tuff	Qvs Tengger Volcanic Sands Qvb Bromo Volcanics Qtt Cemaratiga Debris Qv(n,p) Upper Quaternary Volcanics Qvtm Malang Tuff	Qlv Avalanche deposits Qlks Lava Qls Lava Qlk Lava Qptm Tuff Qpvb Volcanics Qvs Volcanics Qvk Volcanics	Qvl Lamangan Volcanic Rocks Qvll Lamangan Lava Qtt Cemeratiga Debris	Qlks Lava Qls Lava Qvs Semeru Volcanic Rocks Qvk Karangduren Volcanic Dune
Qpv	Quarternary (Pleistocene) volcanics		Qvw Wilis Volcanics Qvjl Jobolarangan Lava Qvsl Sidoramping Lava Qvjb Jobolarangan Breccia Qvtt Tambal Tuff Qvbl Butak Lava Qvbt Butak Tuff Qvjt Jobolangan Tuff		Qav Argokalangan Morphocet Qas Sedudo Morphonit Qp Pawonsewu Morphonit Qpg Gajahmungkur Morphonit Qj Patukbanteng-jeding Morphocet Qjt Tanjungsari Morphonit Qjn Ngebel Morphonit Qjd Dangean Morphonit Qjk Klotok Morphonit	Qpwv Wilis Volcanic Rocks	Qpvp Old Parasitic Volcanics Qpkb Kawa-Butak Volcanics Qpva Young Anjasmara Volcanics Qpat Old anjasmara Volcanics Qpvk Old Kelud Volcanics	Opvk Old Kelud Volcanics Qlk Parasite Andesitic Lava Qpkb Butak Volcanics	Qvtr Rabano Tuff Qvt Tengger Volcanics Qvaw Arjuna-Welirang Volcanics Qpv Middle Quaternary Volcanics Qp Lower Quaternary Volcanics Qpat Old Anjasmara Volcanics	Qvt Volcanics Qvj Volcanics Qpkb Lava	Qvt Tengger Volcanic Rocks Qva Argoporo Volcanic Rocks Qpvt Old Tengger Volcanic Rocks Qvp Pandak Volcanic Rocks Qvtr Rabano Tuff	Qvt Tengger Vocanic Rocks Qvj Jembangan Volcanic Rocks Qvl Lamongan Volcanic Rocks Qvab Argopuro Breccia Qvat Argopuro Tuff
Qi	Quarternary intrusives				Qppr Parang Andesite Intrusive Qpp Punjul Andesite Intrusive							
Tns	Neogene (Miocene-Pliocene) sediments	Tmo Oyo Formation		Tmo Oyo Formation								
Tms	Miocene sediments	Tmn Nampol Formation Tmss Sambipitu Formation Tmj Jaten Formation	Tmcs Cendono Formation	Tmn Nampol Formation Tmj Jaten Formation	Tmj Jaten Formation	Tmn Nampol Formation Tmj Jaten Formation		Tmn Nampol Formation		Tmn Nampol Formation		
Tnl	Neogene (Miocene-Pliocene) limestones	Tmpk Kepek Formation Tmwl Wonosari Formation	Tmwl Wonosari Formation	Tmwl Wonosari Formation	Tmwl Wonosari Formation	Tmwl Wonosari Formation		Tmwl Wonosari Formation		Tmwl Wonosari Formation	Tpl Leprak Formation	
Tml	Miocene limestones		Tmal Sampung Formation	Tmcl Campurdarat Formation		Tmcl Campurdarat Formation		Tmcl Campurdarat Formation				Tmp Puger Formation
Tmv	Miocene volcanics	Tmng Nglanggran Formation Tmw Wumi Formation Tms Semilir Formation	Tmn Nglanggran Formation Tms Semilir Formation	Tmw Wuni Formation Tms Semilir Formation	Tmw Wuni Formation	Tmw Wuni Formation		Tmw Wuni Formation		Tmw Wuni Formation		
Tni	Neogene intrusives	Tpdi Pendul Diorite	Tm (a b d) Intrusive Rocks	Tomi Intrusive Rocks	Tomi Intrusive Rocks	Tomi Intrusive Rocks		Tomi Intrusive Rocks		Tomi Intrusive Rocks		Tmid Intrusive Rocks
Toms	Oligocene-Miocene sediments	Tomk Kebobutak Formation	Tomd Fayakin Formation	Toma Arjosari Formation		Toma Arjosari Formation						
Tomv	Oligocene-Miocene volcanics	Tomm Mandalika Formation	Tomw Watopatok Formation Tomp Panggand Formation	Tomw Watopatok Formation Tomm Mandalika Formation	Tomm Mandalika Formation	Tomm Mandalika Formation		Tomt Tuff member of Mandalika Tomm Mandalika Formation		Tomt Tuff member of Mandalika Tomm Mandalika Formation		Tomm Mandalika Formation
Tps	Paleogene sediments	Tew Gamping Wungkal Formation										
pTm	Pre-Tertinary rocks	KTm Metamorphic Rocks										

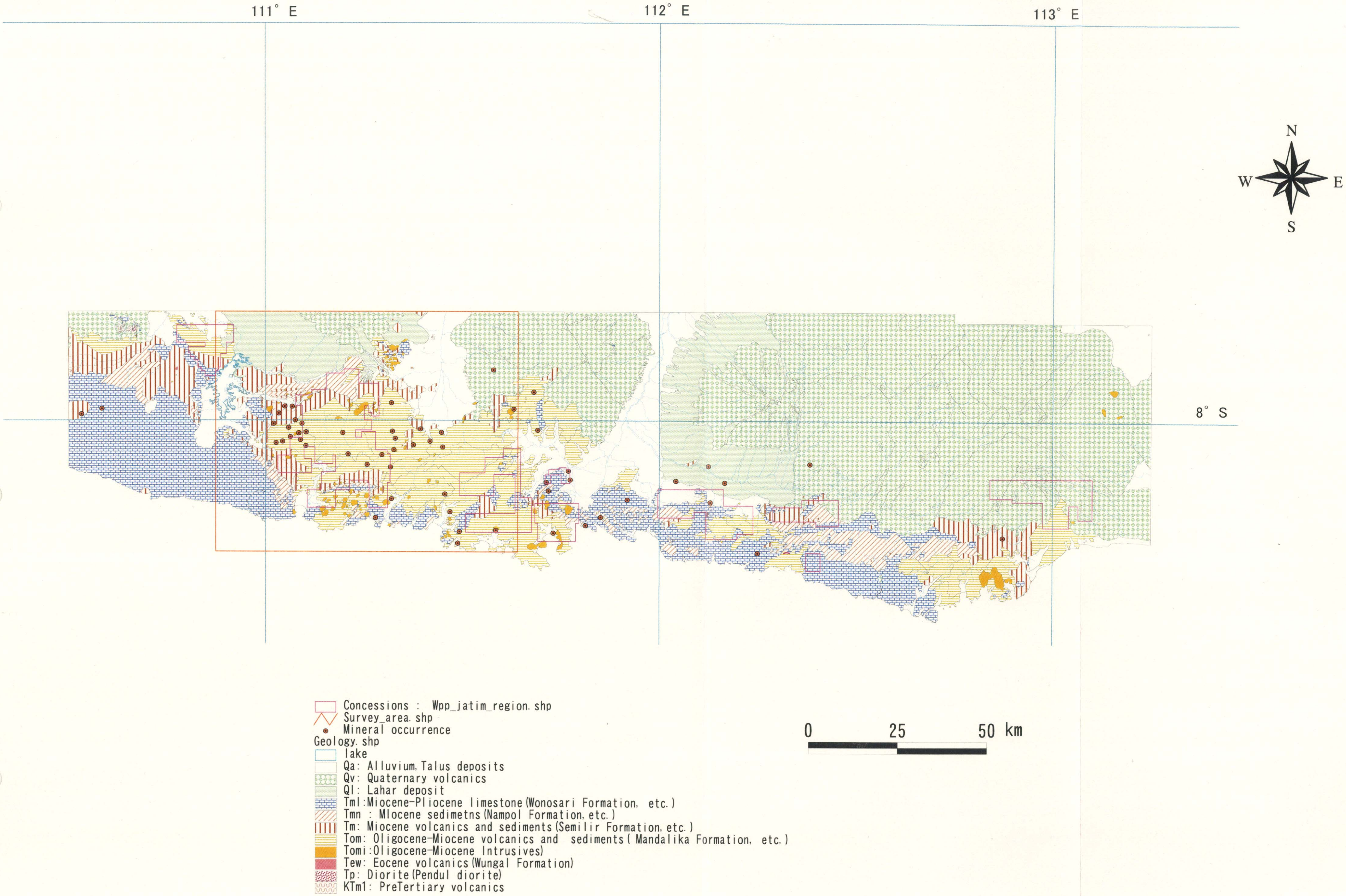

Fig.2-1 Compilation Map of Existing Data

Chapter 2 Satellite Image Analysis

2 - 1 Method of Survey

The project area is covered by 12 scenes of JERS-1 SAR data, and photogeological interpretation was carried out using 1:500,000 mosaic images prepared from these data. DEM (Digital Elevation Model) was used for topographic analysis of the survey area. The images produced from DEM consisted of multi-shade image, altitudinal-dispersion anomaly image, and slope image. Mainly lineament and intrusive igneous bodies were extracted from these images.

Table 2-3 SAR Image Acquisition Date

No.	Path	Row	Acquisition Date	No.	Path	Row	Acquisition Date
1	95	314	1995.07.12	7	98	313	1995.06.01
2	96	313	1995.03.03	8	98	314	1995.06.01
3	96	314	1995.03.03	9	99	313	1995.06.02
4	96	315	1995.03.03	10	99	314	1995.06.02
5	97	313	1995.03.04	11	100	313	1995.04.20
6	97	314	1995.03.04	12	100	314	1995.04.20

2 - 2 Results of SAR Image Interpretation

The project area is covered by 12 scenes of JERS-1, SAR data, and the results of image interpretation are reported below.

(1) Division of geologic units

The geology of the project area is composed mainly of, according to existing geological maps, pre-Tertiary basement schists, Tertiary volcanic rocks and limestones, Quaternary volcanic rocks and unconsolidated sediments, and Tertiary intrusive bodies. These were divided into 19 geologic units by image interpretation. Of these units, the Tertiary volcanics are divided into 4 divisions (Ttf, Ttl, Tl, Tv) (Fig. 2-3, Table 2-4).

The above were judged to be correlated to Tertiary volcanic rocks because of the following nature, namely; sedimentary structures are almost non-existent and features characteristic to volcanic rocks such as complex and intricate resistance to weathering are observed, and the distribution coincides well with that of the geological maps. This volcanic rock area is divided by lithofacies as follows;

(a) rocks with high resistance to weathering (predominantly massive rocks such as lavas), (b) rocks with intermediate resistance to weathering (mixture of lavas and pyroclastic rocks), (c) rocks with low resistance to weathering (predominantly pyroclastic rocks). Also (d) dark gray unit with rough texture (Tv) has higher relief compared to other units, occurs isolated, and has bowl-shaped summit. Therefore these are easily distinguished from other units by these characteristics.

(2) Lineaments

Many NW-SE continuous faults and intersecting NE-SW faults are shown in the western part of the survey area in geological maps. Our present interpretation did not reveal NW-SE trending lineaments. The reason for this is believed to be the inability to clearly read the eastern slope because of foreshortening related to the direction of radiation (east looking). Extraction of NW-SE lineaments was particularly difficult. Other lineaments extracted from the images are mostly similar to those described on existing geological maps.

The predominant systems of lineaments interpreted and extracted in the whole survey area tend to be NNW-SSE, NW-SE, NE-SW, and N-S. Lineaments trending in the NNW-SSE, NNE-SSW, and NE-SW directions are predominant in the part the west of Tulungagung in the central part of the survey area. High density occurrences of lineaments are found in the 4 districts of; (a) western part of Tulungagung, (b) southwastern part of Ponorogo, (c) western part of Worogiri, (d) southeastern part of Worogiri. The 4 high-density lineament zones all are in the Tertiary volcanic rock area. Most of the known mineral prospects are distributed in these zones, and immediately above or near the extracted lineaments. Many Tertiary intrusive bodies are also extracted in these zones. High lineament density, development of intrusive bodies, and known mineral prospects overlap in the above 4 zones, and therefore, these are considered to be highly promising districts.

On the other hand, many NE-SW, NNE-SSW, WNW-ESE trending lineaments were extracted to the east of Tulungagung, and high-density zones are relatively concentrated in (e) eastern part of P. Sempu district, (f) western part of P. Sempu district, and in (g) G. Mahameru district. Of these zones, (e) and (f) zones are in Tertiary volcanic area, and the relation with mineralization should be considered after examining past survey data. Regarding the (g) zone, it is located within Quaternary volcanic area.

(3) Circular structures

Circular to semi-circular structures were extracted at 5 localities in Tertiary volcanic rocks in the western part of Tulungaggung. The size of most of these structures is 2~3km in diameter with a maximum of 5km.

Table 2-4 Photogeologic Units Classified by SAR Images

Unit	Photo-characteristics		Morphologic Expression				Superficial Cover	Probable Lithology (Correlation with Published Geologic Map)
	Tone	Texture	Drainage		Rock Resistance	Bedding	Cultivation	
			Pattern	Density				
Qa	light gray	very fine	meandering	very low	very low	none	partly intense	Unconsolidated sediments composed of ash, gravel, sand, silt and clay (Holocene : Recent alluvial deposits)
Qv4	gray	rough	parallel	low	high	massive	none	Quaternary volcanic rocks; mainly lava flow (Qpva)
Qv3f	light gray	fine	parallel	low	low	horizontal	partly sparse	Quaternary volcanic flow and fall ; mainly pyroclastic deposits (Qvm, Qlla)
Qv3l	gray	rough	radial	medium	high	massive	none	Quaternary volcanic rocks; mainly lava flow (Qvaw, Qvl)
Qv2p	dark gray	rough	radial	low	very high	massive	none	Quaternary volcanic rocks; mainly lava flow ; parasitic volcano
Qv2f	light gray	fine	parallel	low	low	horizontal	partly sparse	Quaternary volcanic flow and fall;mainly pyroclastic sediments (Qav)
Qv2l	gray	rough	radial	medium	high	massive	none	Quaternary volcanic rocks; mainly lava flow (Qj, Qvk, Qvt and Qp)
Qv1p	dark gray	rough	radial	low	very high	massive	none	Quaternary volcanic rocks; mainly lava flow ; parasitic volcano
Qv1f	light gray	fine	parallel	low	low	horizontal	partly sparse	Quaternary volcanic flow and fall ;mainly pyroclastic sediments (Qvtm, Qvf, Qvll)
Qv1l	gray	rough	radial	medium	high	massive	none	Quaternary volcanic rocks ;mainly lava flow (Qpkb, Qvs, Qp)
Tl2	dark gray	coarse	multi-basinal	high	low	gentle	rare	Limestone with karst topography (Tmwl)
Tl1	gray	fine	Sub-multi basinal	medium	low	partly bedded	partly sparse	limestone with other sedimentary rocks (Tmcl, Tmsl)
Ttf	light gray	fine to medium	sub-dendritic	high	moderate	partly bedded	partly sparse	Mainly pyroclastic rocks with other sedimentary rocks (Toma, Tmj, Tomm, Tomd, Tms)
Tlf	dark gray	medium	sub-dendritic	medium	moderate to high	partly bedded	rare	Volcanic rocks ; lava flow with pyroclastic rocks (Tomv, Tmw, Tmm,Toma, Tmj Tomm, Tomd, Tms)
Tv	dark gray to gray	coarse	sub-dendritic	medium	moderate to high	massive	rare	Mainly volcanic lava flow (Tomv, Tmw, Tmm)
Ps	dark gray	rough	sub-parallel	high	high	massive	none	Sedimentary rocks of high resistance (KTm: Pre-Tertiary metamorphic rocks)
TD	light gray	fine	sub-parallel	low	high to moderate	massive	none	Intrusive rocks with independent domes (Tomi, Tmi)

2 - 3 Results of image interpretation by DEM

Of the whole area, topographic analysis was carried out using DEM (digital elevation model) for the survey area. The used images are; multi-shade image, altitude-dispersion anomaly image, and slope image. The results of interpretation can be summarized as follows.

(1) Geologic units

The geology of the survey area was divided into the following 7 units by DEM image interpretation.

Quaternary unconsolidated sediments (Qa); resistance to weathering extremely low.

Quaternary volcanic rocks (Qv); topographic characteristics of young volcanoes are clearly distinguished.

Tertiary limestones (Tl) ; karst topography.

Tertiary sedimentary rocks (Tms); resistance to weathering low.

Tertiary volcanic rocks (Tv); complex features intricately mixed.

Intrusive bodies (D1, D2); high relief, summits isolated and bowl shaped.

(2) Lineaments

(a)G. Pudi~ G. Gembel district

(b)West of G. Sepang district

(c)Northwest of G. Rohtawu district

(d)East of Baturetno district

Also it is noted that many NW-SE trending lineaments which were difficult to extract by SAR images were extracted by DEM image interpretation.

(3) Circular structure

For the present DEM image interpretation, three types of images, namely multi-shade image, altitude-dispersion image, and slope image are used. From multi-shade image, relatively large circular structure in the order of 2~ 3km in diameter were extracted, and from the altitude-dispersion and slope images, relatively small ones less than 2km in diameter were extracted. The circular structures in these images are oval to arc shaped and are interpreted as protrusion or depression topography isolated from the topography of the vicinity. The extracted structures are in Tertiary volcanic rock area, and all of them show domal type or protruding type with the exception of the collapse type of 3 structures near the Wonocoyo Village. The occurrence of these dome-type structures agree well with that of intrusive bodies in existing geological maps. All of these, with the exception of the dome-type and collapse circular structures mentioned later, are classified as intrusive igneous bodies (D1, D2). Four circular structures continuous in the NNE direction were extracted to the north of Wonocoyo Village. There are, however, no description of intrusive bodies in this area in existing geological maps. The genesis of these structures is considered to be the existence of buried blind intrusive bodies and lava domes, and these 4 structures were classified as dome-type structure.

(4) Fold structure

As in the case of SAR image interpretation, repeated development of anticline and syncline structures with ENE-WSW trending axes were extracted in the central part of the survey area, and structures considered to be anticlinoriums were found in 3 localities. Also an anticline with WNW-ESE axis is observed in the Tertiary volcanic rocks (Tv) to the northwest of Pacitan.

2 - 4 Discussions

From photogeologic viewpoint, it is not so easy to establish a detailed stratigraphy and to comprehend macroscopic structure of the survey area due not only to massive Tertiary strata but also to dense vegetation cover and cultivation. Nevertheless some important structural implication was obtained in the survey area through the present interpretation as described below.

(1) Major Lineament

The interpretation revealed that a major lineament was located along the Melikan River with ENE-WSW trend. This lineament is the longest one that extends from a foothill side of a volcano on the east to the north of Pacitan on the west. It has an extension of more than 60 kilometers and crosses the central part of the survey area. The lineament considerably controls major structure of the survey area since the area can be divided into two main geologic provinces (the Northern and Southern Bocks) by the lineament. The Melikan River does not run so straightly and many meandering patterns can be seen along the middle part of the main stream. The lineament strongly implies a left lateral strike slip fault because of drag patterns in short streams that flow into the Melikan River.

Some other parallel lineaments to the above major one are also observed along the Tempran and Gede Rivers in the Southern Block. On the eastern end of the survey area, an N-S trending lineament was observed and it can be also in fault contact with the Block mentioned above.

(2) Major Folds

Any conspicuous folds were not found in the Northern Block of the survey area through the photogeologic interpretation. Two convexly curved main streams, on the other hand, were clearly observed along the downstream part of the Ngrendeng River in the Southern Block. The curves repeatedly show convex patterns towards west. They are photogeologically so called "drainage anomalies" and strongly imply to form representative subsequent streams of plunging folds in the Southern Block. Thus two folds with ENE-WSW trending axes can occur near the Ngrendeng River and adjacent parts. The consequent streams in those curves flow diversely into subsequent streams without any contradiction. Similar anomalies can be also observed near the Nglerp River to the east of the Ngrendeng River.

The above results of interpretation should be verified in the field and may help when mapping in view of the regional structure of the survey area as well as examining relationship with metallic mineralization.

(3) Difference between the results of DEM image and SAR image interpretation

Satellite data interpretation was carried out for the survey area by DEM and SAR images. Both results show similar results regarding geologic unit division and lineament extraction. The following differences and characteristics were pointed out for interpretation of these images, and it is felt that understanding the nature of these images would be very effective in using them for acquiring geologic information of vegetated areas.

Table 2-5 SAR Images and Images Produced from DEM

Interpretation	DEM images	SAR images
Geologic unit division	somewhat unclear	clearer
Lineament extraction	Many lineaments are extracted by linear features	Difficult to extract NW-SE lineaments due to fore-shortenings
Circular structure extraction	Extracted only by oval to arc shaped or depression topography	Extracted only by Rock resistance to weathering
Folding extraction	Extracted by drainage pattern	Extracted by geomorphology and by drainage pattern

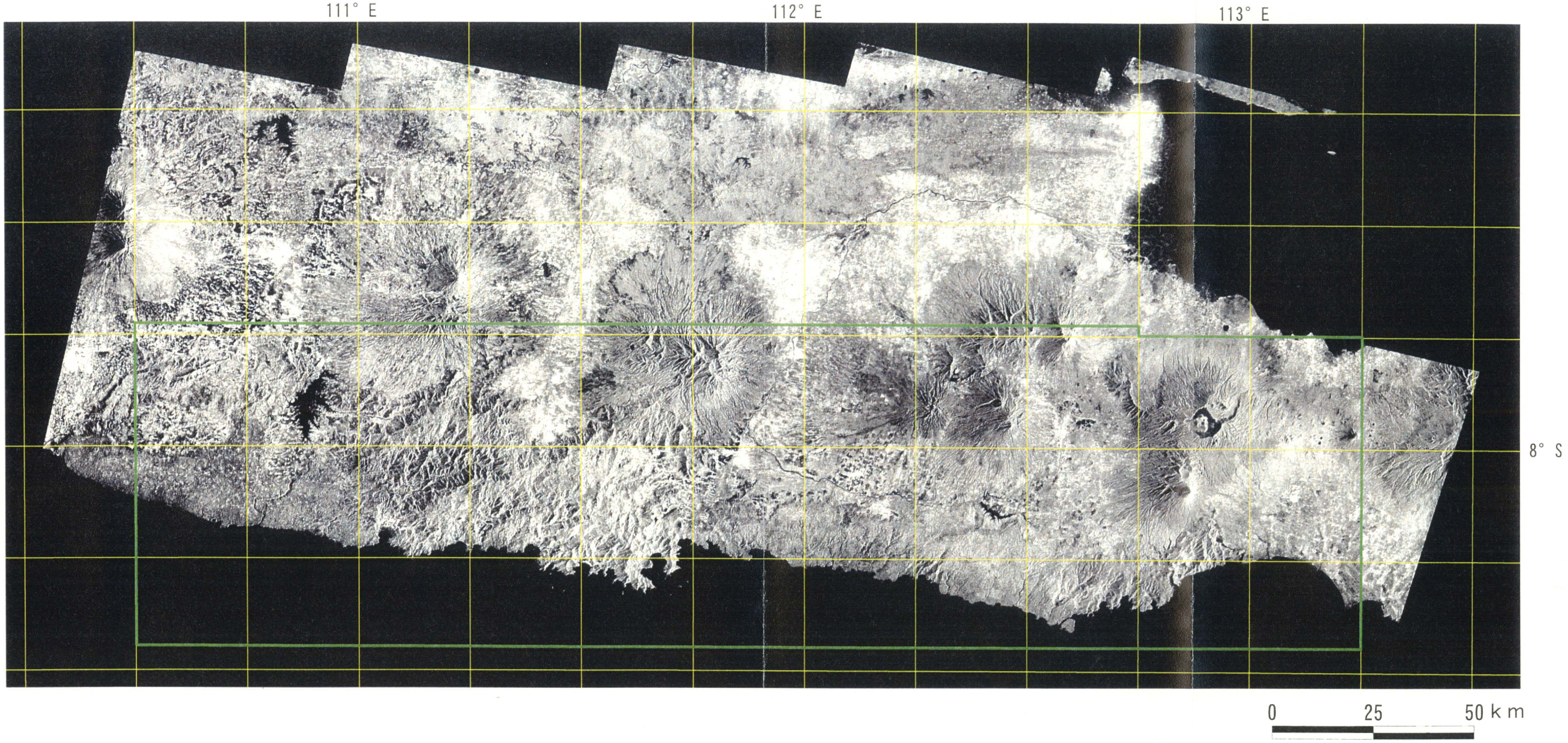

Fig. 2-2 SAR Mosaic Image of the Project Area

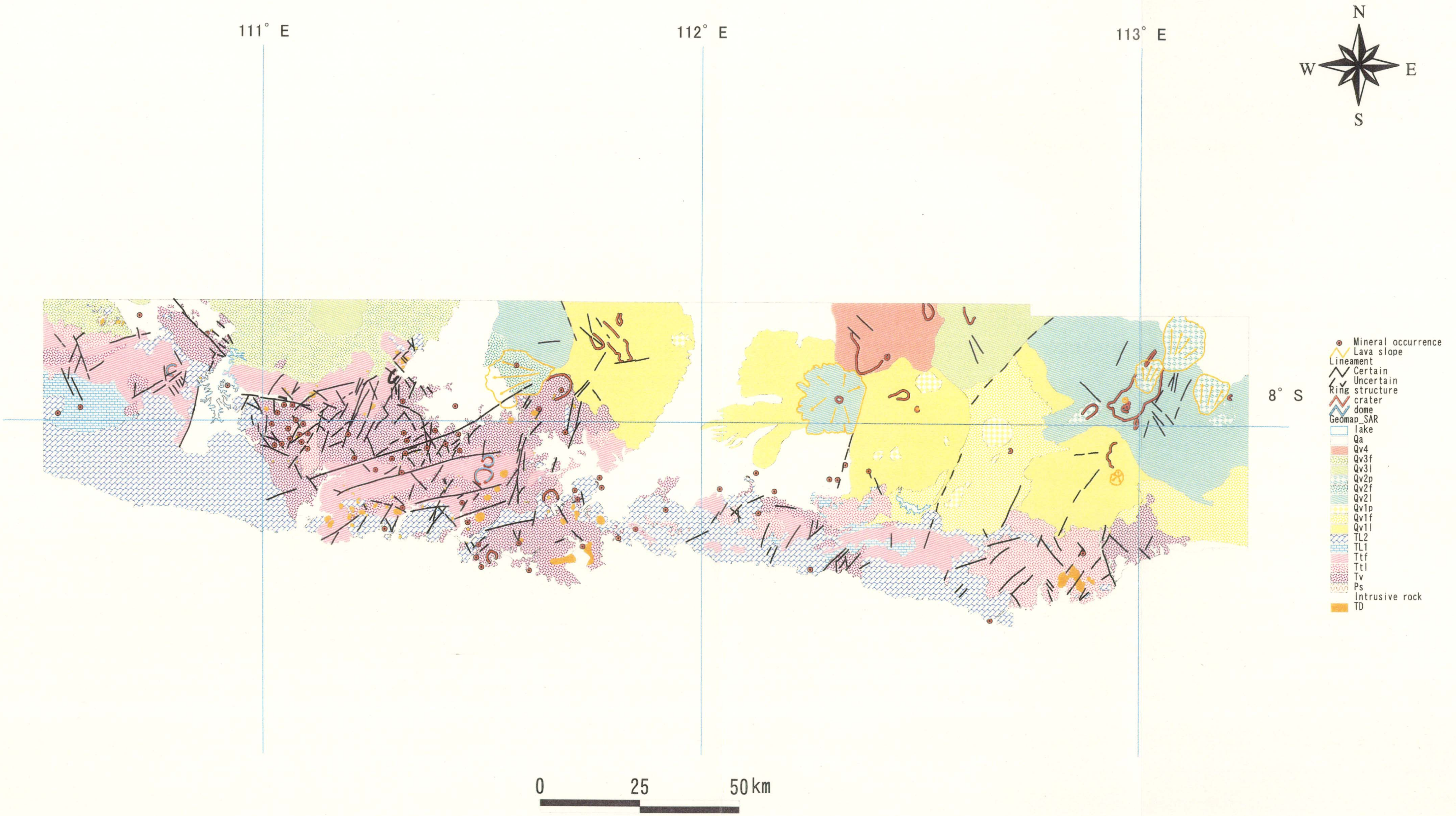

Fig.2-3 SAR image Analysis of the Project Area

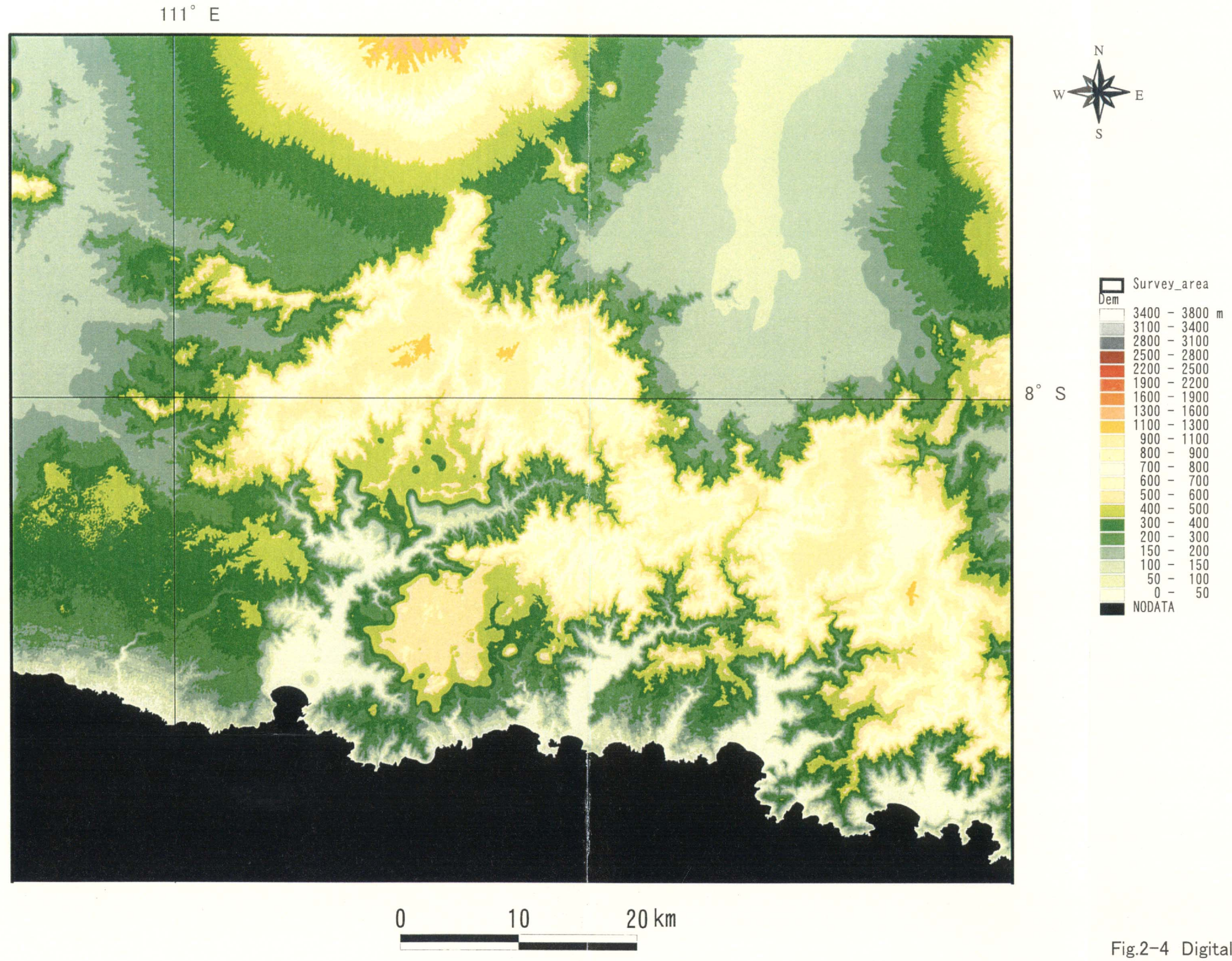

Fig.2-4 Digital Elevation Model of the Survey Area

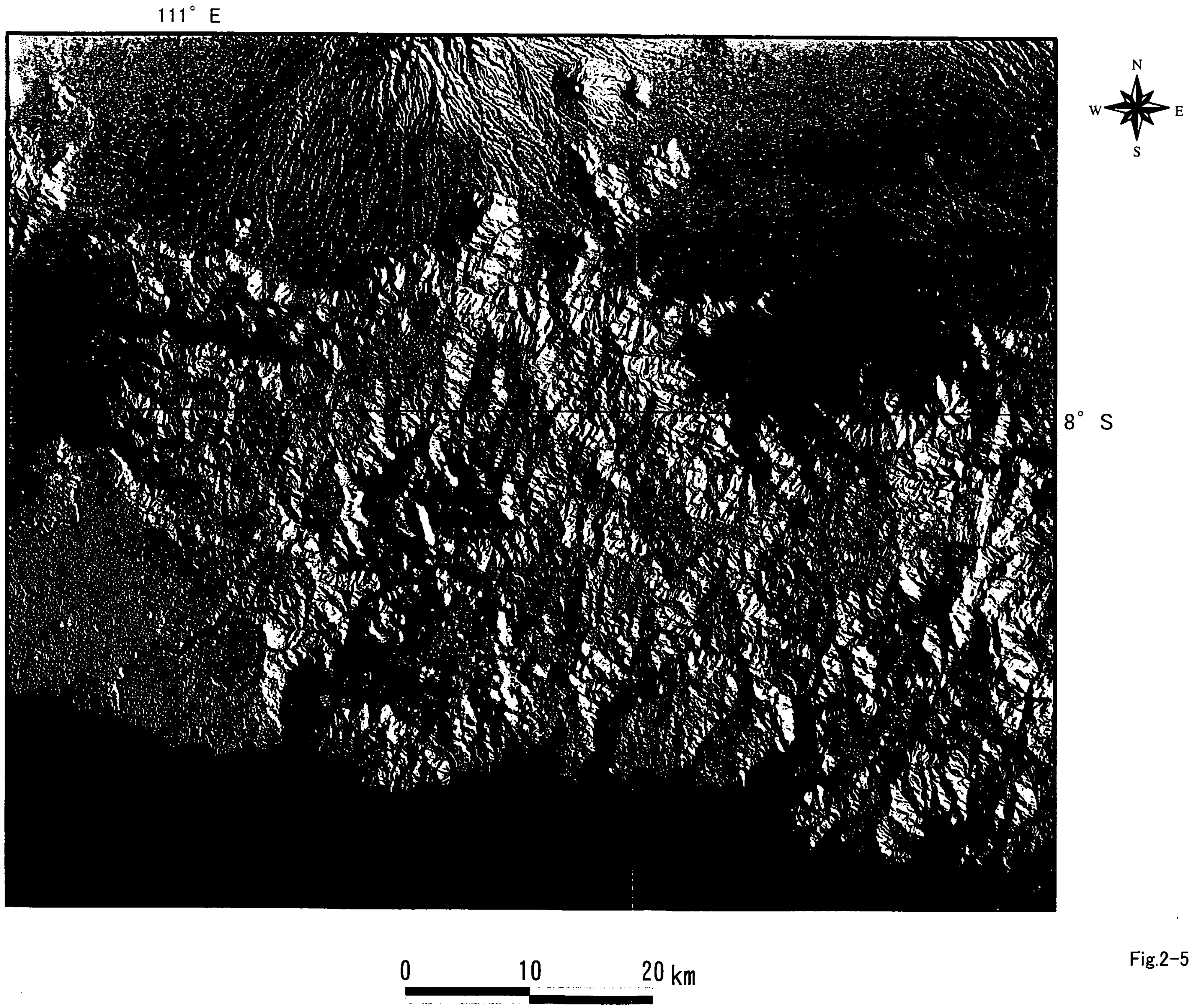

Fig.2-5 Shade Image by Multi-directional Light Sources

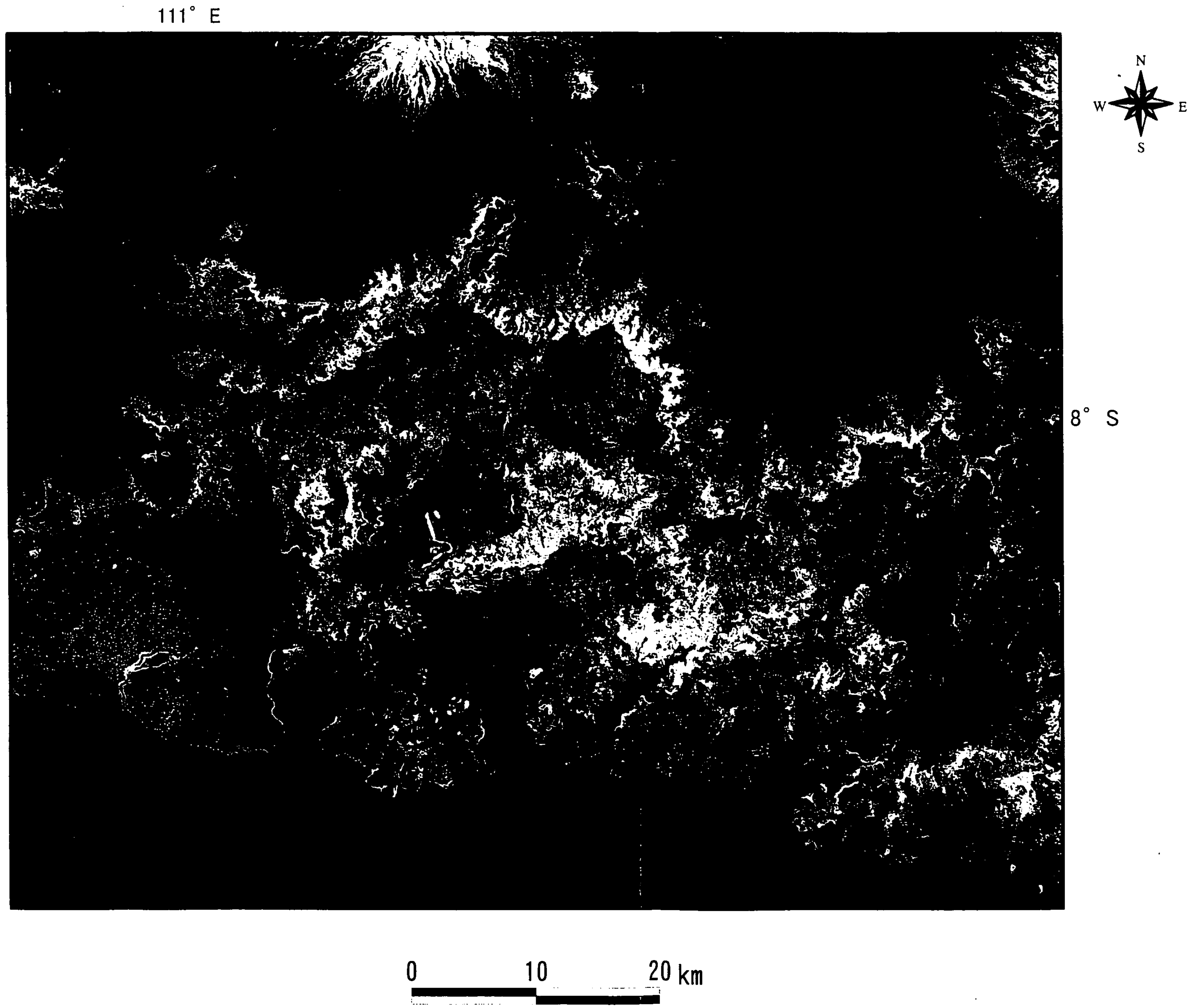

Fig.2-6 Slope Image

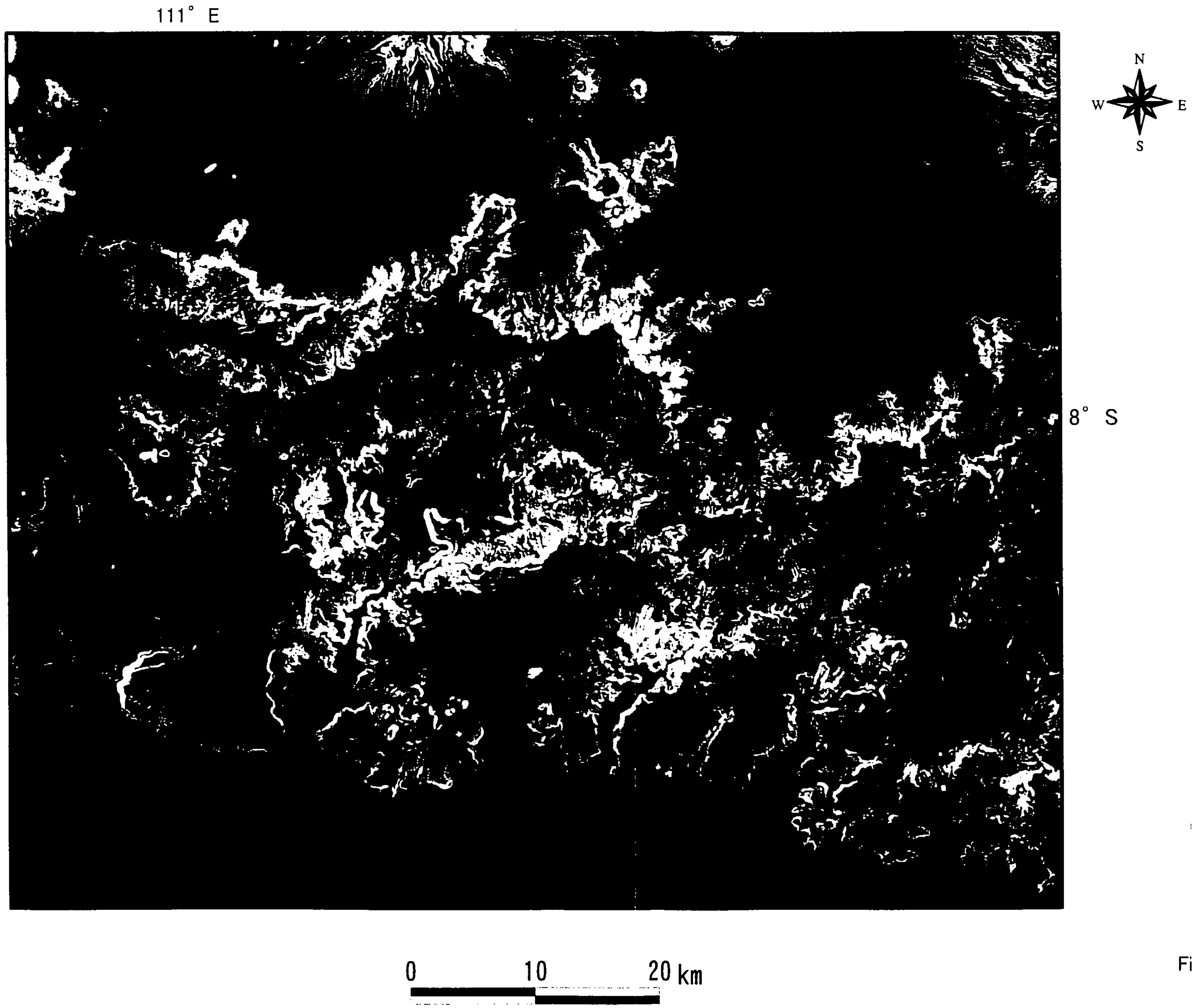

Fig.2-7 Anomaly Image of Altitudinal Dispersion

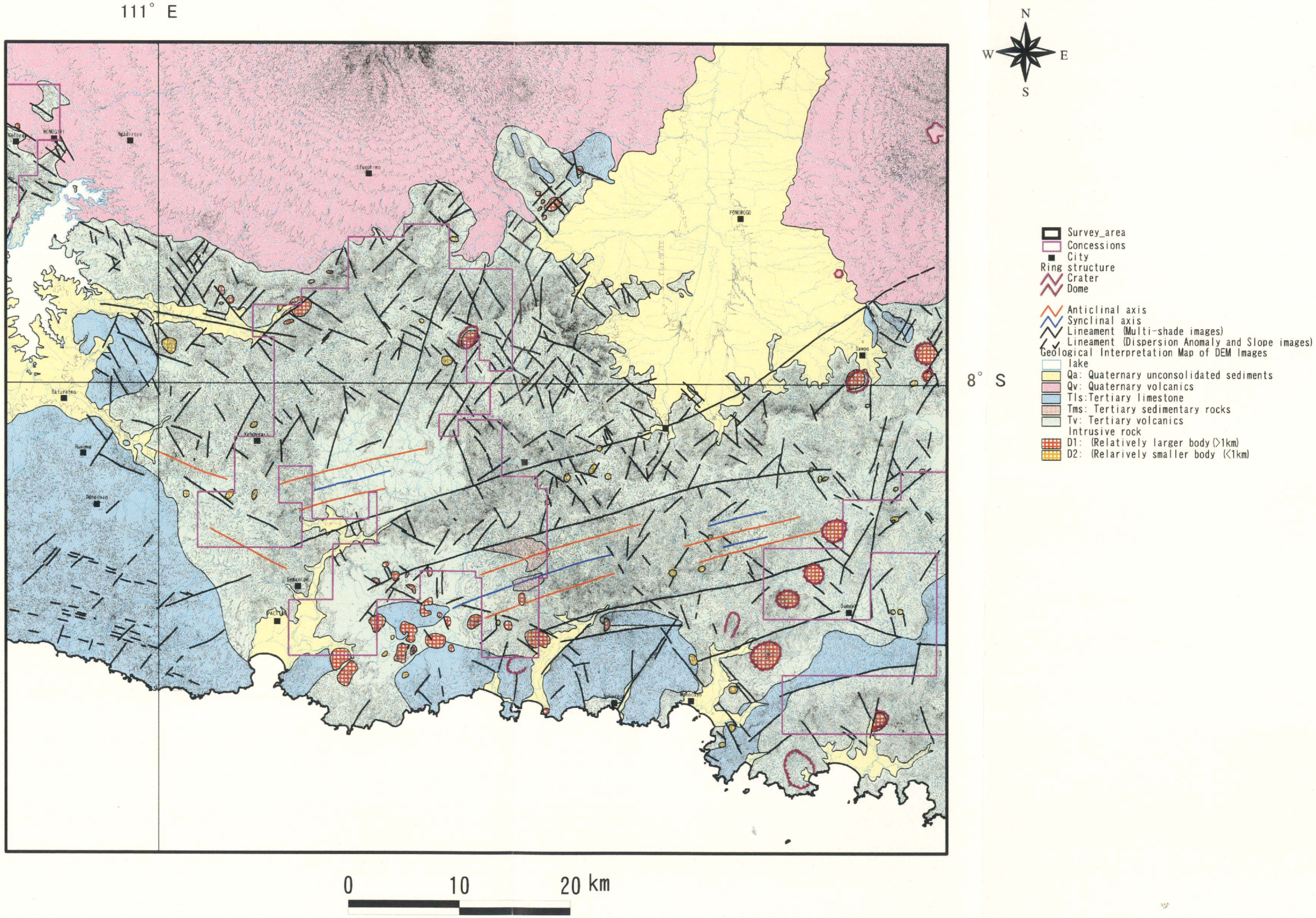

Fig.2-8 Extracted Lineaments of the Survey Area