REPORT
ON
THE MINERAL EXPLORATION
IN
THE TSAGAAN TSAKHIR UUL AREA, MONGOLIA

PHASE I

FEBRUARY, 1997

JAPAN INTERNATIONAL COOPERATION AGENCY
METAL MINING AGENCY OF JAPAN

REPORT
ON
THE MINERAL EXPLORATION
IN
THE TSAGAAN TSAKHIR UUL AREA, MONGOLIA

PHASE I

FEBRUARY, 1997

JAPAN INTERNATIONAL COOPERATION AGENCY
METAL MINING AGENCY OF JAPAN

Preface

In response to the request of the Government of Mongolia, the Japanese government decided to conduct a Mineral Exploration in the Tsagaan Tsakhir Uul Area Project and entrusted the survey to the Japan International Cooperation Agency (JICA) and the Metal Mining Agency of Japan (MMAJ).

The JICA and MMAJ sent to Mongolia a survey team headed by Mr. Yoichi Takeshita from 29 July to 19 October, 1996.

The team exchanged views with the officials concerned of the Government of Mongolia and conducted a field survey in the Tsagaan Tsakhir Uul area. After the team returned to Japan, further studies were made and the present report has been prepared.

We hope that this report will serve the development of the Project 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 Mongolia for their close cooperation extended to the team.

February 1997

Kimio FUJITA
President
Japan International Cooperation Agency

Shozaburo KIYOTAKI
President
Metal Mining Agency of Japan

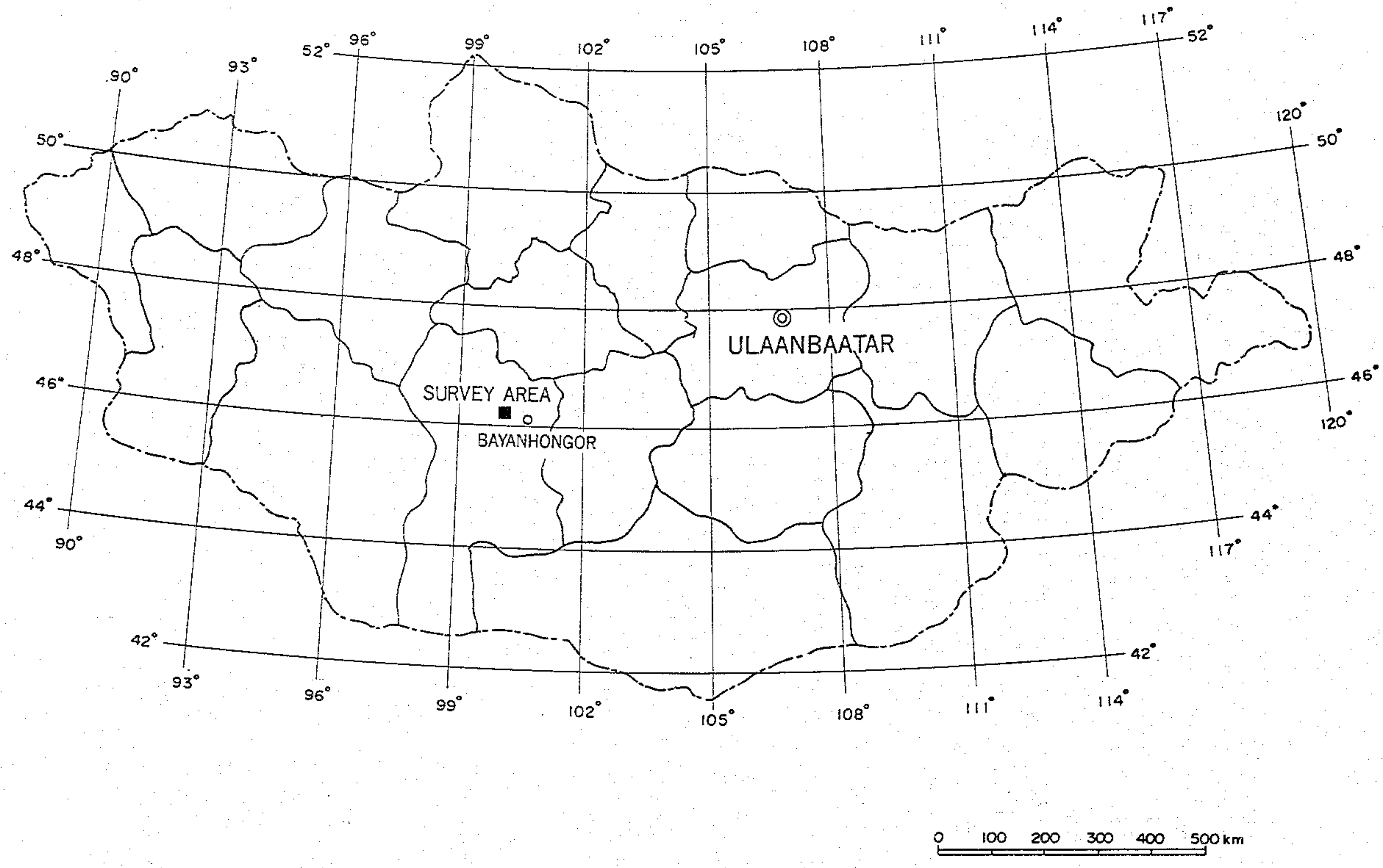


Fig. I-1-1 Location of Survey Area (1)

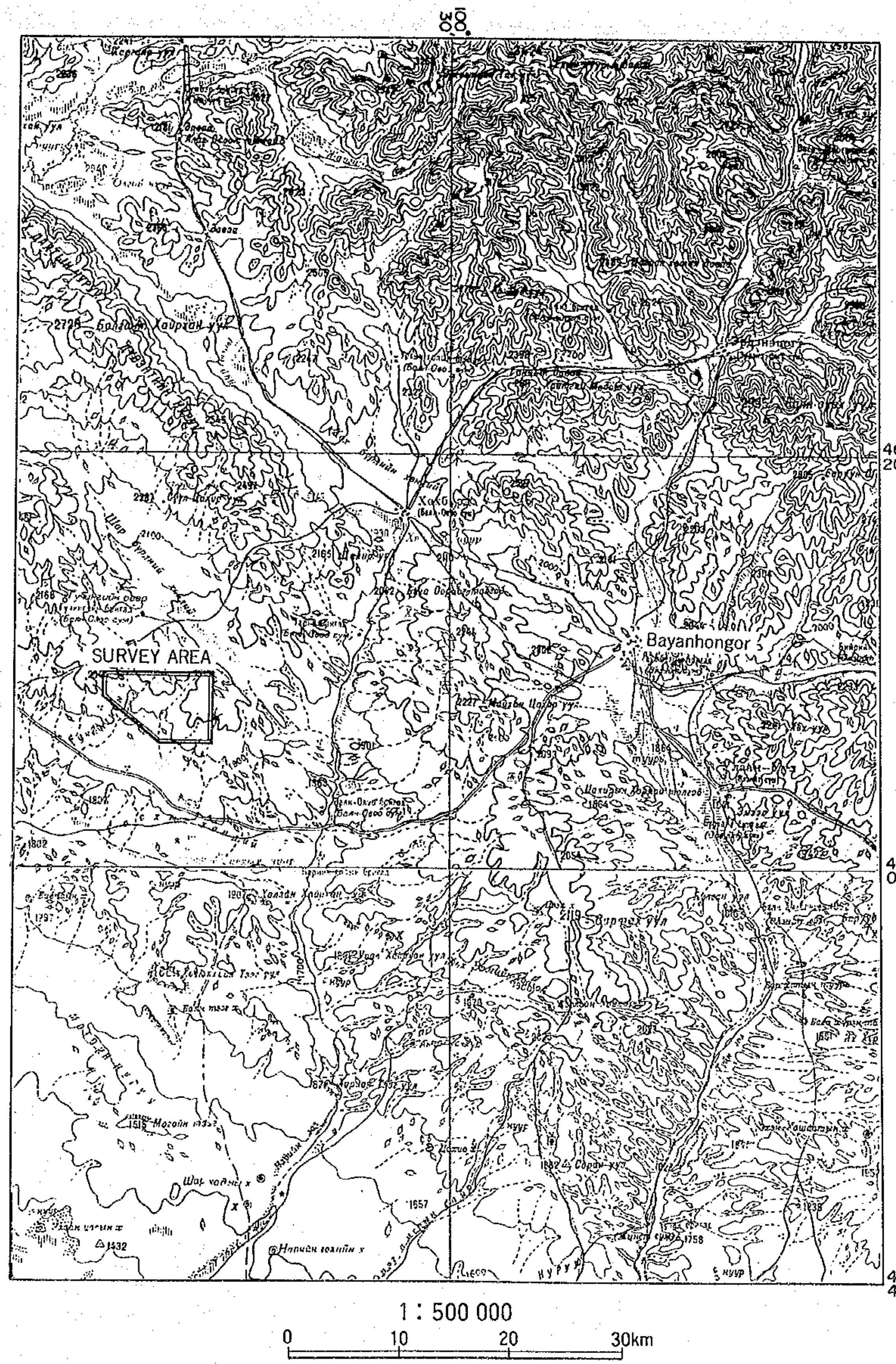


Fig. I-1-2 Location of Survey Area (2)

Abstract

The present investigation including the geological survey, the geophysical survey and the drilling survey has been carried out to clarify the existence of the gold-bearing quartz vein ore deposit in Tsagaan Tsakhir Uul area in Mongolia.

This report summarizes these survey results.

1. Purpose of survey

1) Semi-detailed survey (Area:43 km^2)

To clarify the geology, ore vein, and geological structure of this area.

Particularly to clarify the distribution, directional trend, and scale of quartz vein groups. To study a fissure system from the viewpoint of the relation with the geological structure. To decide a geological detailed area, geophysical survey area, and drilling survey point. To study the period of mineralization by performing the field survey and the radioisotopic dating of rocks and altered minerals.

2) Detailed survey (Area: $10km^2$)

To study the mineralization and its potential of this area by performing quartz vein survey, chemical analysis, ore polished sections and moreover other analyses and tests. To study presence or absence of hydrothermal alteration due to mineralization through the altered clay mineral survey.

3) Geophysical survey (Area: 10.45 km^2)

To two-dimensionally analyze the resistivity structures of shallow to deep portions by the array-type CSAMT method and study the relation with a vein structure.

4) Drilling survey (300m × two holes)

To clarify the continuity of lower part of the vein No. 1 and the vein No. 10 having the most predominant mineralization in accordance with this geological survey and existing data.

2. Survey results

1) Semi-detailed survey

The geology of this area consists of metamorphic rocks, two-mica granodiorite, biotite Adamellite, diorite, and dikes such as amphibolite, quartz porphyry, and lamprophyre. The metamorphic rocks were classified into psammitic gneiss, crystalline limestone, and pelitic gneiss as the result of this survey. The two-mica granodiorite is the host rock of most quartz vein groups. The biotite adamellite is clarified through microscopic observation, which is the existing biotite granodiorite. As the result of dating (K-Ar), this rock shows 384.7±7.8 Ma and the two-mica granodiorite shows 268.1±5.6 Ma. Moreover, from Rb-Sr, it is clarified that diorite and lamprophyre shows 250.4±85.7 Ma and 351.8±236.7 Ma. Furthermore, main quartz vein groups are Nos.1, 2, 3, 5, 6, 7, 8, 9, 10, 14, and 15 which were named by former East Germany. The average vein width ranges from 20 to 30 cm and the maximum vein length reaches 4 km. A quartz vein greatly expands or contracts and moreover, shows a echelon like arrangement. The length of a single quartz vein ranges from tens of meters to hundreds of meters. A quartz vein group consists of the NNW-SSE system, NE-SW system, and E-W system. It is understood that these systems are controlled by the fissure system of the tension fracture (NNW-SSE system and E-W system) and the shear fracture (NE-SE system) in the regional stress field.

2) Detailed survey

Consists of the areas I and II. Ore minerals in a quartz vein include natural gold, chalcopyrite, galena, sphalerite, pyrite, tetrahedrite, covelline, and geothite. These are occurred in a vein like scattered points but no banded or zonal arrangement is observed. Natural gold is generally found in vein pieces in the waste at a old mining site.

Four hundred and forty nine analysis samples including the semi-detailed area were gathered. .

The following are the quartz veins showing an average gold content of more than 1 g/t.

Area	Vein No.	Average width (cm)	Au content (g/t)	Total length (m)
I	1	20.7	21.97	900
II	2	18.9	7.78	1,000
II	3	23.6	6.15	1,000
II	6	26.5	2.55	800
I	10	42.3	10.01	2,800
I	15	10.8	2.43	400

The Au content greatly changes in some intervals of several ten meter more or less.. As the results of the X-ray diffraction on the line samples crossing each vein, and the altered mineral survey by POSAM, the direct relation between an altered mineral and a vein is not clarified. However, altered clay is confirmed from the neighborhood of some veins and the drilling core. As the result of dating (K-Ar) of the altered clay, values of 225.8 to 234.4±4.9

Ma are obtained. It is estimated that the age shows the period of mineralization.

The fluid-inclusion homogenization temperature ranges between 197℃ and 114℃ including those of field samples and the drilling cores (core value: 197℃ to 147℃), which is lower than that of the epithermal gold vein deposit in Japan (240℃ to 180℃, Enjoji and Takeuchi,1976). The point similar to this area is an example (192℃ to 140℃, S.G. Peters & S.D. Golding, 1988) found in the quartz in Devonian granitoids in Charters Towers gold field in Australia.

3) Drilling survey

In case of MJMT-1 (survey of quartz vein No. 10) and MJMT-2 (survey of quartz vein No.1), the quartz veins were captured at the portion approx. 150 m deep from the ground surface respectively. However, both veins are barren veins. Judging from the fact that ore minerals in a quartz vein are distributed like scattered points, the possibilities considered that these minerals could not accidentally be captured by the core.

4) Geophysical survey

The array-type CSAMT method (496 points) was applied to the detailed survey areas I and II and a physical-property test (resistivity measurement) was carried out to field samples and drilling core samples.

As a result, it is found that the planar distribution of analyzed resistivity shows a characteristic corresponding to the vein structure with N-S system. Moreover, it is found as the result of one- and two-dimensional analyses that the sectional structure has a two-layer structure (first layer: 2,000 Ω·m or less, second layer: 2,000 to 10,000 Ω·m or more). However, an extreme difference in resistivity is not found between granodiorite which is the host rock and a quartz vein as the result of the physical property test and moreover, since the quartz vein has a width of tens of centimeters, the relation between a single quartz vein and a resistivity structure is not clarified. It is understood that a high-resistivity zone which has direction of north-south corresponds to a zone having a relatively high distribution frequency of quartz veins in the range of the first layer (depth: 200 to 300 m).

5) Calculation of ore reserves

By the former East Germany, ore reserves were calculated on a total of 8 veins including vein Nos. 9 and 14 in addition to the quartz veins in the above Item 2) and an gold amount of 16.5 t was appropriated (the total length of veins was purposed and the bottom length was assumed as 350 m). In the case of this investigation, ore reserves were approximately calculated by classifying 5 veins excluding the vein No. 15 from those in the above Item 2) into blocks for each grade of gold content, excluding low grade blocks, and assuming the bottom length as 150 m (considering the drilling result). As a result, total amount of gold was calculated as 6.5 tons. The calculated value is the maximum value at present because any mineral symptom is not recognized even at the point of 150 m by drilling.

3. Proposal for second-year investigation

The author proposes the drilling survey for the continuities of lower sides of the quartz vein Nos. 1, 2, 3, and 10 having a high average gold content. The survey purposes to carefully pursue the continuity of each vein at a relatively shallow portion of high grade mineralization of each vein, from the viewpoint that this ore deposit is a small-scale with a small continuity to the lower side in accordance with the results of drilling. Drilling plan will be carried out, that is, the survey point interval of 100 m, two inclined holes of each point (clarify the mineralization at positions of 50 and 100 m deep from the ground surface), and the drilling length of each hole will be 100 to 150 m.

CONTENTS

Figure

※: attached to the end of the report

Table

Appendices

Part I General Remarks

Part I General Remarks

Chapter I Introduction

1-1 Background and purpose of the survey

In later half of 1980s, Mongolia changed its economic system from its conventional socialist planned economic system to a new market economy. Although a number of confusions were induced in political and economic climates, in recent years, its economic climate has been turned to a upward trend due to increased assistance in economy from Japan as well as Western countries.

On the other hand, Mongolia has seen stockfarming as its main industry such that about 30% (about 700,000 people) of its population engage in it, however this country cannot expect this industry to advance aggressively because of its severe natural condition. Thus, a further development of nonferrous metal resources which occupy the first position for obtaining foreign money is one of the most important measures for advancing the market economic system of this country. A typical development of nonferrous metal resource in Mongolia is Erdenet deposit (copper, molybdenum) which is a porphyry copper ore deposit. Although Mongolia has a geologically high potential of nonferrous metal resources, no sufficient exploration has been conducted and future exploration and development have been much expected.

Under this condition, three projects were conducted as resources development cooperative basic surveys since 1991 and Mongolia related agency requested Japan to conduct resource development survey in Tsagaan Tsakhir Uul area which was reputed highly as a domestic gold producing area. In response to this request, Japan dispatched a survey team to that region which stayed from June 3 to June 15, 1996 and took conference about S/W and M/M of 1996 and made agreement thereabouts. A content and purpose of the first year survey indicated in the M/M are geological survey (semi-detailed survey, detailed survey) for Tsagaan Tsakhir Uul area comprising gold bearing quartz vein, geophysical survey, drilling survey, and various indoor tests, with such additional surveys as altered clay mineral survey and trenching survey, for grasping existence of gold deposit in this area and evaluating its potential to contribute to establishment of a survey plan for the next year.

An interim report session and study meeting about its survey results were held in Mongolia and geophysical survey method was instructed through a case of computer analysis on obtained data in accordance with CSAMT method.

1-2 The survey area and the outline on the works of the Phase I

Fig. I-1-1 shows a location of the survey area. The semi-detailed survey area is a section of 43.0km^2 indicated by following coordinates.

(1)	46° 09′ 20″ N	100° 06′ 00″ E
(2)	46° 08′ 20″ N	100° 06′ 00″ E
(3)	46° 06′ 00″ N	100° 09′ 40″ E
(4)	46° 09′ 20″ N	100° 13′ 30″ E
(5)	46° 06′ 00″ N	100° 13′ 30″ E

An outline of the respective surveys conducted in this year is described below.

1. Semi-detailed survey of geology

A 1/10,000 scale geological map and quartz vein distribution diagram were created for the area of 43.0km^2.

2. Detailed survey of geology

Detailed survey areas totaling 10km^2 including area I and area II were extracted in accordance with a result of the semi-detailed survey and existing survey (by ex-East Germany) reference materials, and a 1/2,000 scale geological map and vein quality (Au) distribution diagram were created.

3. Additional survey

Specimens were collected from every 200m grid of the detailed survey area of 10km^2 and altered minerals were identified in accordance with POSAM (Portable Spectro Radiometer for Mineral Identification), to create an altered mineral distribution map.

A trenching survey conducted by ex-East Germany was checked by conducting the same survey again by a scale of 1/100.

4. Drilling survey

Drilling survey for a depth of 300m was carried out to investigate an extension under no.1 and no.10 veins considered to have the most excellent mineralization in accordance with this survey and another survey conducted by ex-East Germany.

5. Geophysical survey

Measuring points were set in intervals of 100m each in a direction perpendicular to an quartz vein and in intervals of 200m each almost in parallel to the vein with respect to geological detailed survey areas and the Array CSAMT method was used for this area.

6. Indoor test

Chemical analysis, thin section of rock, age determination of rock, powder X-ray diffraction, ore polished section, measurement of homogenization temperature of fluid inclusions, and measurement of physical properties of rock and quartz vein, etc. were carried out with respective surveys. Tables I-1-1 and I-1-2 show contents of these surveys and quantities of samples for these purposes.

Table Ⅰ-1-1 Outline of survey works

Survey	Specification				
Geological survey	[Semi-detailed survey]				
	Survey area				$43.0km^2$
	Route line				69.0km
	[Detailed survey]				
	Survey area				$10.0km^2$
	Route line				42.4km
	Additional survey	[Clay mineral survey]			
		Survey area			$10.0km^2$
		[Trench survey]			
		Total length (220 points)			1,540 m
Geophysical survey	Survey lines				49.6km
	Survey point				496points
Drilling survey	Hole No.	Direction	Incline		Length
	MJMT-1	S72° W	-55° w		301.0m
	MJMT-2	N82° E	-74° E		301.7m
	Total 2 holes				602.7m

Table Ⅰ-1-2 Outline of laboratory works

Survey	Item of tests	Quantity
Geological survey	[Semi-detailed survey]	
	① Rock thin section	32 pcs
	② Ore polished section	15 pcs
	③ Chemical analysis (Ore : 9 elements) elements : Au,Ag,As,Hg,Bi,Te,Sb,Se,Mo	46 pcs
	④ Chemical analysis (Rock : 1 2 elements) elements : SiO_2, TiO_2, Al_2O_3, Fe_2O_3, FeO, MnO, CaO, Na_2O, MgO, K_2O, P_2O_5, LOI	13 pcs
	⑤ X-ray diffraction	22 pcs
	⑥ Radioisotopic age determination (K-Ar)	2 pcs
	⑦ Radioisotopic age determination (Rb-Sr)	2 pcs

	[Detailed survey] ① Rock thin section ② Ore polished section ③ Chemical analysis (Ore : 9 elements) elements : Au,Ag,As,Hg,Bi,Te,Sb,Se,Mo ④ X-ray diffraction ⑤ Measurement of homogenization temperature of fluid inclusion ⑥ Radioisotopic age determination (Clay mineral : K-Ar) ⑦ Radioisotopic age determination (Clay mineral : Rb-Sr)	 22 pcs 22 pcs 403 pcs 51 pcs 21 pcs 2 pcs 2 pcs
Geophysical survey	Physical property (Resistivity)	45 pcs
Drilling survey	① Rock thin section ② Ore polished section ③ Chemical analysis (Ore : 9 elements) elements : Au,Ag,As,Hg,Bi,Te,Sb,Se,Mo ④ X-ray diffraction ⑤ Physical property (Resistivity) ⑥ Measurement of homogenization temperature of fluid inclusion	12 pcs 7 pcs 66 pcs 50 pcs 23 pcs 6 pcs

1-3 Member of the survey team

Following members participated in survey planning, negotiation on agreement and the survey to implement this survey.

1. Planning and negotiation

Kenji Nakamura: leader	Director, Technical Cooperation Division, Overseas Activities Department, MMAJ
Katsumi Yokogawa: mining sector	Overseas Inspector, Beijing Office, MMAJ
Tooru Nawata: planning coordination	Energy & Mining Development Study Division,Mining & Industrial Development Study Department, JICA
Masayoshi Kameyama: geology	Technical Cooperation Division, Overseas Activities Department, MMAJ

2. Field survey

Yoichi Takeshita: technical Leader	Dowa Engineering Co., Ltd.
Hiroshi Yokoyama: geological survey	Dowa Engineering Co., Ltd.
Kunio Kimura: geophysical survey	Dowa Engineering Co., Ltd.
Tadashi Nyui: geophysical survey	Dowa Engineering Co., Ltd.
Toyoshi Yosimura: geophysical survey	Dowa Engineering Co., Ltd.
Tatsuhiro Aoyama: drilling survey	Dowa Engineering Co., Ltd.
Takenori Ikeda: drilling survey	Dowa Engineering Co., Ltd.
Tokuzo Nakayama: drilling survey	Dowa Engineering Co., Ltd.
Sadamasa Saito, drilling survey	Dowa Engineering Co., Ltd.

1-4 Terms of the survey

The field survey was carried out in the following steps.

Field survey:	August 5 - October 14, 1996
Geological survey:	August 5 - September 26, 1996
Geophysical survey:	August 26 - October 14, 1996
Drilling survey:	September 8 - October 14, 1996

Interim report session and instruction of computer analysis of geophysical survey results.(Yoich Takeshita, Kunio Kimura) : December 9～22, 1996

Chapter 2 Geographical features of surveyed area

2-1 Location and traffics

Tsagaan Tsakhir Uul area is 550km off Ulaanbaatar, capital of Mongolia, to the west-south west. Road route up to this region measures just 700km and it takes about 14 hours by car.

A national road leading to Bayanhongor located 640km off Ulaanbaatar is paved road in an intermediate length of 450km and a remaining portion is a mountainous road relatively flat. A distance of 60km from Bayanhongor to the survey area takes 1 hour and 15 minutes.

On the other hand, there are air services twice every week from Ulaanbaatar to Bayanhongor, which takes 1 hour and 20 minutes.

2-2 Topography and river system

The survey area is a peneplain having an altitude of 1900m to 2,100m in which metamorphic rocks and granodiorites were eroded and includes Tsagaan Tsakhir Uul mountains having the highest altitude of 2,104m in this area. We can travel to any place by jeep except going around in valleys located locally.

Main river system includes a river flowing in the western portion of this area from the north to the south and another river flowing from the north east to the south west and passing through the central portion to the south. A slight flow amount of water is recognized in only the west river, so that the river is dammed up to provide living water.

Nomads have wells near valleys to ensure drinking water, etc.

2-3 Climate and vegetation

1. Climate

The climate of this area belongs to steppe climate between forest region of the Hanghai mountains and the Gobi Desert. It is the hottest in July in Bayanhongor while its average temperature is 15.9℃ and the lowest temperature is -18.4℃ on average, in January.

The rainfall is 66.4mm max. in July and 1.5mm min. in January while a total amount of the rainfall is 216.3mm.

The wind in this area is relatively strong and the wind speed is about 3m/sec throughout the year.

Major indices (temperature, rainfall, wind speed) of Bayanhongor and Ulaanbaatar are shown below.

Table Ⅰ-2-1 Major climatic indices

1) Mean monthly temperature (°C)

	Jun.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Bayanhogor	-18.4	-16.8	-7.9	1.0	9.3	15.0	15.9	14.4	7.9	-0.8	-10.8	-17.4
Ulaanbaatar	-26.1	-21.7	-10.7	0.5	8.3	14.9	17.0	15.0	7.6	-1.7	-13.7	-24.0

2) Mean monthly precipitation (mm)

	Jun.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Bayanhogor	1.9	3.2	4.5	9.3	15.2	33.8	66.4	54.5	16.4	7.1	2.6	1.5
Ulaanbaatar	1.5	1.9	2.2	7.2	15.3	48.8	72.6	47.8	24.4	6.0	3.7	1.6

3) Mean monthly wind velocity (m/second)

	Jun.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Bayanhogor	2.8	2.8	3.0	3.8	3.9	3.1	2.8	2.7	3.0	3.0	3.2	2.9
Ulaanbaatar	0.9	1.4	2.3	3.4	3.7	3.4	2.6	2.4	2.3	1.9	1.3	0.8

2. Vegetation

There are almost no bushes in this area, which is covered entirely with low grass which is feed for cattle.

Chapter 3 Existing geological information of survey area

3-1 Outline of previous works

Before this area was geologically surveyed by ex-East Germany in 1970s which drew up 1/25,000 scale geological maps ($80km^2$), 1/5,000, 1/2,000 scale ore vein (quartz) maps and dug three shaft ,(total 80m) and trenching survey (212, total 1390m).

Further, although they have carried out the geophysical survey (resistivity method) and drew up some VES curves and section of resistivity by schlumberger method, plan of resistivity by pole-dipole method, however, the positioning information is lacked.

They have recorded 55 quartz veins including the north-west extension of this area. The quartz veins direct to NNW-SSE, NE-SW and W-S. Major veins continue intermittently over several Km with a width of 10cm-1m and an extension of several hundred meters as a unit.

Ore reserves of eight veins considered to have an excellent mineralization (nos.1, 2, 3, 6, 9, 10, 14, 15) as a result of chemical analysis of sampling specimens were calculated so that it was made evident that the grade of crude ore (gold) was 20.78g/t, the amount of crude ore was 730,000t, and a reserve of gold (metallic amount) was 16.5t. This calculation is on an assumption that the surface mineralization continues up to underground of 300m - 350m.

3-2 General geological features around survey area

The circumference of the survey area consists of metamorphic rocks, quaternary basalt covering metamorphic rocks which distributed around the position 15 km west of the base camp to form a tableland. The granodiorite serving as the host rock of mineralization in this region has a scale of 8 km in the zonal direction and 10 km in the meridional direction intruded into metamorphic rocks. Quartz vein groups were formed around the center of those rocks.

3-3 Geological positioning of survey area

Mongolia is geologically located on the fold belt (additional belt on the south edge of Angara plate) formed in Palaeozoic era and Mesozoic era, surrounded by Precambrian cratons such as Siberian massif (Angara plate) in the north and Sino-Korean massif, Tarim massif (Cathaysia plate) in the south. This area belongs to Bayanhongor mineral deposit sector (gold).

3-4 Brief history of mining industry of survey area

Chinese people mined the high grade outcrops of gold vein around in the 12th to 15th centuries.

Chapter 4 Synthetic study of survey results

4-1 Geological structure, mineralization characteristic and mineralization control

1. Geological structure and ore vein structure

In this area, metamorphic rocks, biotite Adamellite, two-mica granodiorite, diorite, quartz porphyry, and lamprophyre are distributed. Speaking of the general structure of these rocks, metamorphic rocks has the NW-SE system, diorite has two intrusive directions of the NW-SE and NE-SW systems, quartz porphyry has the N-S system, and lamprophyre has the NE-SW system. Moreover, the confirmed fault structure is the NE-SW system.

A quartz vein group consisting of tens of stripes is classified into three directions of the NNW-SSE system, NE-SW system, and E-W system.

Radioisotopic dating of these igneous rocks are 384.5±7.8 Ma (K-Ar) for adamellite rock, 268.1±5.6 Ma (K-Ar) for granodiorite, 250.4±85.7 Ma (Rb-Sr) for diorite, and 351.8±236.7 Ma (Rb-Sr) for lamprophyre. Moreover, a radioisotopic dating of 225.8 to 234.4±4.9 Ma (K-Ar) is obtained for altered clay of a quartz vein which is considered to show the period of mineralization. Rb-Sr age has a narrow range of an isotopic composition ratio and a large error, no preferable isochron is obtained. As the result of field observation, it is found that lamprophyre penetrates major quartz vein and quartz porphyry. Moreover, quartz porphyry may be cut by a quartz stringer. Furthermore, it is considered that diorite cuts major quartz vein (No.10) while it may be cut by a quartz vein. From the results of the above dating and field observation, the generation sequence of igneous rock and quartz vein in this area is estimated as shown below.

Lamprophyre ························	Permian period downward
Diorite and quartz vein(mineralization) ····	Permian period
Quartz porphyry ·····················	Permian period
Granodiorite ························	Permian period
Adamellite ·························	Devonian period

That is, it is understood that rock bodies and quartz veins other than adamellite are generated in almost same period. From the above mentions, it is estimated that the structures of the above-described rock bodies and quartz veins were also controlled by a fissure system formed in the same stress field.

That is, it is considered that a stress worked on this region from the E-W direction at the time of intrusion or immediately after the intrusion of granodiorite, the shear fracture of the NE-SW system and the tension fracture of the NNW-SSE system or N-S system and the E-W system were formed.

The quartz vein controlled by the shear fracture of the NE-SW system is represented by the quartz vein No. 5 with a maximum vein width of 50 m. Microscopic observation of this vein shows the relict texture of crushed granodiorite, therefore No.5 have possibility of an altered vein receiving a strong silicification and intimates the presence of a shear zone.

The result of the survey implements by the former East Germany shows that this vein was formed along a fault. In the present survey result, however, a fault along No. 5 is not confirmed. Quartz porphyry and quartz vein groups other than No.5 were controlled by the tension fracture and do not have the evidence of receiving a shear. And the echelon-like arrangement generally observed shows a feature of the tension fracture.

2. Features of mineralization

1) Properties of quartz vein

Quartz veins in this area are classified into three systems of <1> NNW-SSE/50-90° W, <2> NE-SW/60-80° NW, and <3> E-W/70-80° N from the viewpoint of their directional trends.

The continuities of these systems are 1 to 4 km for the system <1>, the maximum of 1 km for the system <2>, and hundreds of meters for the system <3>. These veins include a case in which a single quartz vein repeats expansion and contraction and intermits and a case in which a single quartz vein temporarily disappears and thereafter, a new vein appears by laterally deviating from the position of the single quartz vein by several meters to tens of meters.

Moreover, an end of a single quartz vein may be branched to two or three veins or deteriorated by finely forming an echelon-like arrangement.

2) Properties of mineralization

a) Occurrence of ore minerals in field

Natural gold and sulfide mineral may be observed in a zone having a high gold content of chemical analysis. Particularly, by carefully searching a waste sample of a quartz vein at the old mining sites, they are found without exception. In this case, natural gold and sulfide mineral are hardly confirmed in the same sample.

Moreover, they are hardly found in a zone with a low gold content. Though banded or zonal arrangement is not recognized in quartz vein.

b) Occurrence of ore minerals through microscopic observation

Ore minerals confirmed through microscopic observation of polished sections consist of natural gold, chalcopyrite, galena, sphalerite, pyrite, and tetrahedrite as primary minerals and covelline and goethite as secondary minerals. Moreover, altaite, tellurium sulfide mineral, or tellurium oxide mineral may be recognized.

Natural gold: Has a normal grain size of 0.01 to 0.05 mm and a maximum grain size of 0.3 ×1.0 mm in irregular shaped, and most frequently independently recognized between quartz grains or along a crack of quartz, contained in chalcopyrite, or rarely accompanied to tetrahedrite. Chalcopyrite: Associated with galena or pyrite or accompanied by tetrahedrite. Chalcopyrite is frequently alternated with covelline or goethite secondarily. Galena: Occurred between quartz grains or in chalcopyrite. Sphalerite: Occurred in tetrahedrite or combined with chalcopyrite. Pyrite: Recognized in most samples, occurred between quartz grains, or accompanied chalcopyrite or contained in chalcopyrite, and alternated with goethite in most cases. Tetrahedrite: Occurred between quartz grains or may be accompanied by pyrite or galena. Covellinc: Secondarily replaced to chalcopyrite or tetrahedrite. Goethite: Mainly replaced to pyrite.

c) Outline of result of chemical analysis of ores (9 elements)

Chemical analysis was carried out for such nine elements (449 samples) as Au, Ag, As, Sb, Hg, Bi, Te, Se, and Mo. Among these elements, however, most of Hg, Bi, Te, Se, and Mo show a detection limit or lower.

Au: The content shows a high value of tens of ppm at old mining site without exception but it is generally lower than the above value in the case of outcrops.

Ag: Corresponds to Au in many cases and Au/Ag shows approx. 5/1 in these cases.

As: Corresponds to or not to Au or Ag depending on the case. The maximum content is 94 ppm.

Sb: Relatively preferably corresponds to Au and may correspond to Ag and As. The content is tens of ppm at most and the maximum content is 400 ppm.

Hg: The content may show 500 to 1,700 ppb in a range of the vein No. 1 a high gold grade. But it is not certainly that a sample of high gold grade have high Hg mercury content.

Te: The content incidentally show 20 to 40 ppm. Te may correspond to a high grade gold.

Bi: Most Bi shows a detection limit or lower. The content incidentally shows 10 to 60 ppm but it does not correspond to a gold grade. Se and Mo: Exceeds a detection limit at a maximum of 44 ppm for 5 samples of Mo. From the above results, mainly Sb followed by Ag and As can be considered as a indicating elements for the gold survey.

d) Average content of Au for each vein

The average Au content, scale, and direction of major quartz veins are shown below.

Area	Vein No.	Direction	Avr. width	Avr Au content(g/t)	Total length(m)
II	1	NNW-SSE	20.7	21.97	900
II	2	NNW-SSE	18.9	7.78	1,000
II	3	NNW-SSE	23.6	6.15	1,000
II	3′	NNW-SSE	22.8	0.92	800
II	6	NNW-SSE	26.5	2.55	800
I	7	NNW-SSE	12.6	0.03	750
I	7′	NNW-SSE	8.5	0.19	± 500
I	8	NE-SW	15.3	0.27	1,500
I	9	NNW-SSE	26.6	0.71	3,000
I	9′	NNW-SSE	17.8	0.21	400
I	9″	NNW-SSE	13.0	0.26	400
I	10	NNW-SSE	42.3	10.01	2,800
I	14	NNW-SSE	19.7	0.10	400
I	15	NNW-SSE	10.8	2.43	400
I	16～23	NNW-SSE	13.2	0.66	>1,500

As shown above, vein Nos. 1, 2, 3, 6, 10, and 15 show an average Au content exceeding 1 g/t and they are belong to the NNW-SSE system. They have a large fluctuation every range (tens to hundreds of meters = approximately single vein).

3) Alteration

The alteration related to forming of a quartz vein is hardly recognized in the host rock contacting a vein. However, quartz vein contains sometime altered clay minerals such as sericite, chlorite, or calcite. As the result of X-ray diffraction of samples (interval of 50 m) crossing each of the veins No. 1, 2, and 3 and the No. 9 and 10, chlorite was detected from all samples but the correlation between a quartz index and a quartz vein position was not recognized. Therefore, chlorite is not directly related to forming of a quartz vein but it is considered that chlorite is formed due to regional alteration.

Moreover, as the result of the altered mineral survey by POSAM, chlorite, montmorillonite, and (sericite) were detected. Among them, sericite cannot be distinguished from muscovite which is a rock-forming mineral. The distribution of clay minerals almost coincides with geological classification. The area distributed metamorphic rock forms a chlorite and montmorillonite zone, the diorite area forms a chlorite zone, and most of the granodiorite area forms a (sericite) zone but a chlorite and montmorillonite zone locally appears, however, any relation with a vein is not recognized.

4) Homogenization temperature of fluid-inclusion

The homogenization temperature of fluid-inclusion was measured on 27 samples of major field quartz veins and drilling cores. The samples were gathered from the central portion of the veins in the case of outcrops and drilling cores, and from waste quartz vein which natural gold or sulfide minerals are recognized in the case of old mining site. No flow structure is recognized in quartz veins. In general, the grain sizes of inclusions are generally small, which ranges between 2.5 and 10 μm and most inclusions are oval or polygonal. There are many inclusions consisting of two phases of vapor and liquid in addition to those consisting of only liquid phase. Most inclusions have a vapor-liquid volume ratio of 2 to 5%. Measurement was performed through a television monitor by enlarging inclusions up to 2,000 times because the grain size of the inclusions is small. The measured temperature distribution of some samples shows two peaks but that of most samples shows a normal distribution. Average values of measurement results are shown below.

Field quartz vein:	165℃ to 118℃
Core quartz vein	197℃ to 147℃
(150 m or more deep from the ground surface):	
Field barren vein:	137℃ to 114℃

The homogenization temperature tends to rise for core samples and lower for a barren vein. As a whole, however, the value is lower than that of epithermal gold vein deposit in Japan (240℃ to 180℃, Enjoji and Takeuchi, 1976). As a region similar to this region, there is an example (192℃ to 140℃, S.G. Peters & S.D. Golding) in the gold contained quartz vein of Devonian granitoids in Charters Towers gold field in Australia, which almost coincides with the value of core sample in this area. In any case, because the homogenization temperature relates to the pressure condition when a quartz vein is formed or the salt concentration of an inclusion, it is necessary to synthetically study these factors.

4-2 Relation between drilling result and mineralization

According to the results of the present survey and the past survey (former East Germany), the drilling for lower part survey was executed for 300 m on the vein Nos. 1 and 10 with the most predominant mineralization respectively. As a result, a quartz vein was captured nearby a position 150 m deep from the ground surface in each case but the captured veins were barren. However, in the west vein of the quartz vein No. 10 of MJMT-1, very small amounts of galena and sphalerite (diameter of 1 mm respectively) were observed. Judging from the property of the mineralization in this area, however, the possibility is left that the mineralization of gold was not obtained incidentally.

4-3 Geophysical survey result and vein structure

The array-type CSAMT method (496 points) was applied to the geological detailed areas I and II and a physical property test (resistivity measurement) was applied to a field sample and a drilling core sample.

1. Area I

In this area, two-mica granodiorite is distributed in the west part, metamorphic rocks (psammitic gneiss) are distributed in the east part, and diorite is distributed in the southeast marginal part. The quartz vein Nos. 9 and 10 ranging from the north to south in the east part and the quartz vein Nos. 7 and 8 in the southwest part are distributed.

1) Plan of one-dimensional analysis

It is clarified that a resistivity distribution shows the N-S direction corresponding to a mineral vein. The N-S structure is confirmed up to the vicinity of a position at a depth of 500 m. At a shallow portion, zones showing 2,000 to 5,000 Ω·m, 5,000 to 10,000 Ω·m, and 10,000 Ω·m or more are arranged like stripes at widths of 100 to 300 m. The number of zones of 2,000 to 5,000 Ω·m decreases for a deeper position and the zones of 5,000 to 10,000 Ω·m and 10,000 Ω·m or more are distinguished. Moreover, a stripe width increases.

2) Section of one-dimensional analysis

There is a high-resistivity zone continuing from the north part to the south part. The width of the zone is 300 m or more. Though the zone extends up to the outside of the area in the north and south parts, the boundary at the east side of the zone in the central parts almost coincides with the geological boundary between two-mica granodiorite and metamorphic rocks and the metamorphic rocks have a low resistivity. The boundary at the west side of the high-resistivity zone is present in two-mica granodiorite from north to south. Moreover, a high-resistivity zone in the NNW-SSE direction is recognized in the two-mica granodiorite in the southwest part of the area. However, a difference with the surrounding region is not recognized in the resistivity of diorite in the southeast part of the area.

3) Section of two-dimensional analysis

A relatively flat two-layer structure is shown as a whole. There is a boundary at a depth of 200 to 300 m. The upper first layer shows a resistivity of 2,000 Ω·m or less and the lower second layer shows a resistivity of 2,000 to 10,000 Ω·m or more. Because most of the distributed rock bodies are two-mica granodiorite, it cannot be considered that different rock bodies are present at the both sides of the boundary surface. As the result of the drilling (MJMT-2) when drifting this rock in the area II, the portion up to approx. 220 m deep from the ground surface is considerably altered and the portion deeper than the above portion is relatively fresh, therefore, it is estimated that the two-layer structure of resistivity is divided due to the difference between degrees of alteration.

4) Resistivity structure and vein structure

As the result of the physical property test, it is found that there is not any extreme difference between two-mica granodiorite which is the host rock and a quartz vein {quartz vein: 4,300 to 17,100 Ω·m, granodiorite (field sample: 660 to 11,900 Ω·m, drilling core: 6,200 to 11,900 Ω·m)} and moreover, the width of the quartz vein is 10~50cm. Therefore, the relation between a single quartz vein and a resistivity structure is not clarified. However, from the one-dimensional cross section, it is found that all of the distribution regions of the quartz vein Nos. 9, 10, and 14 through 23 are included in the high-resistivity zone extending from north to south as shown in Fig. I-4-1. The distribution region of the quartz vein No. 7 is included in the high-resistivity zone in the two-mica granodiorite in the southeast part of the area. From the above results, it is understood that the N-S high-resistivity structure in this area corresponds to a zone with a relatively high distribution frequency of quartz veins.

2. Area II

In this area, two-mica granodiorite and the quartz vein Nos. 1, 2, 3, 5, and 6 are distributed .

1) Plan of one-dimensional analysis

Though a N-S resistivity structure is observed, it is not remarkable compared to the area I.

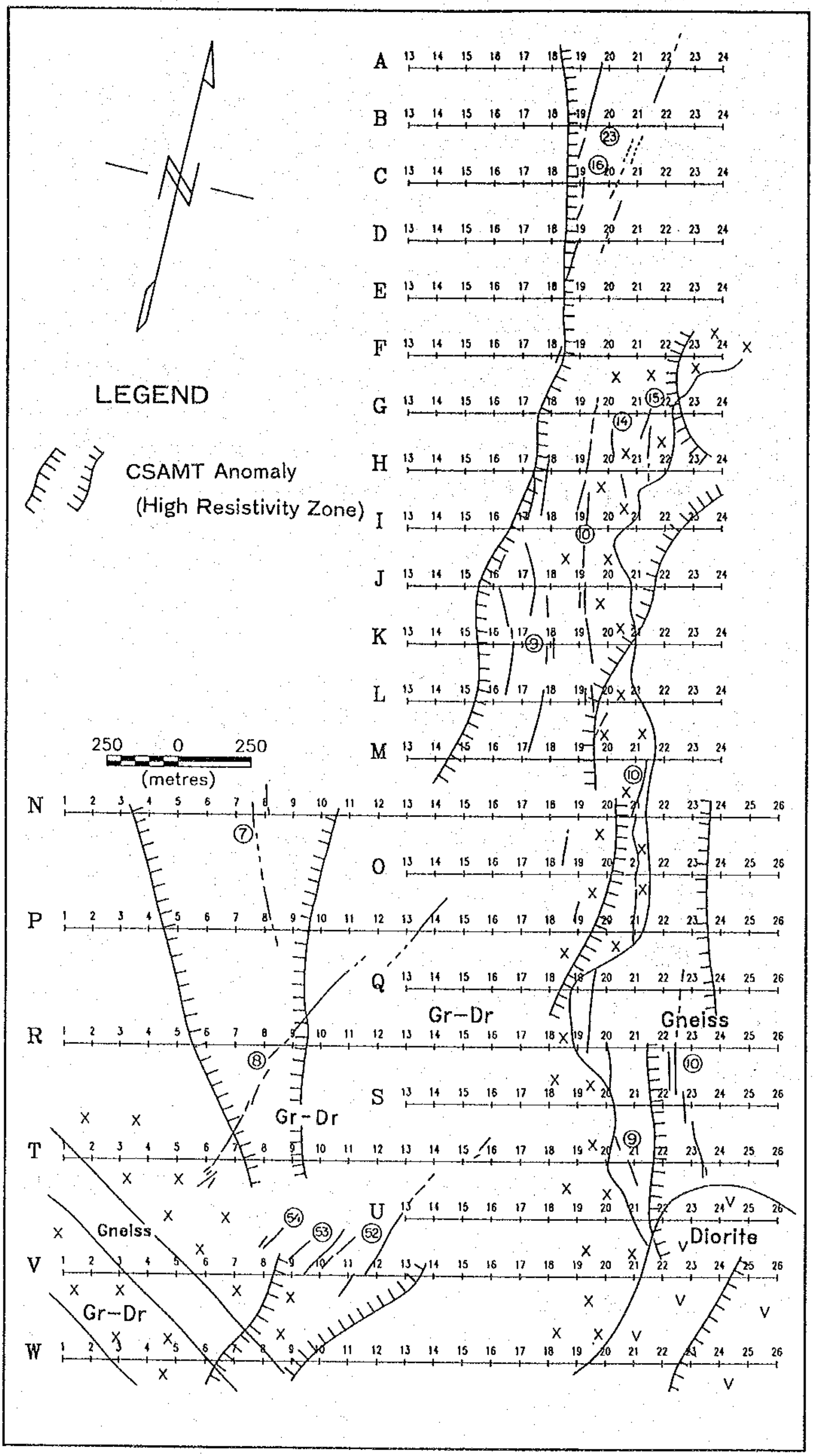


Fig. I-4-1 Results of Comprehensive Analysis of Geophysical Survey (Area I)

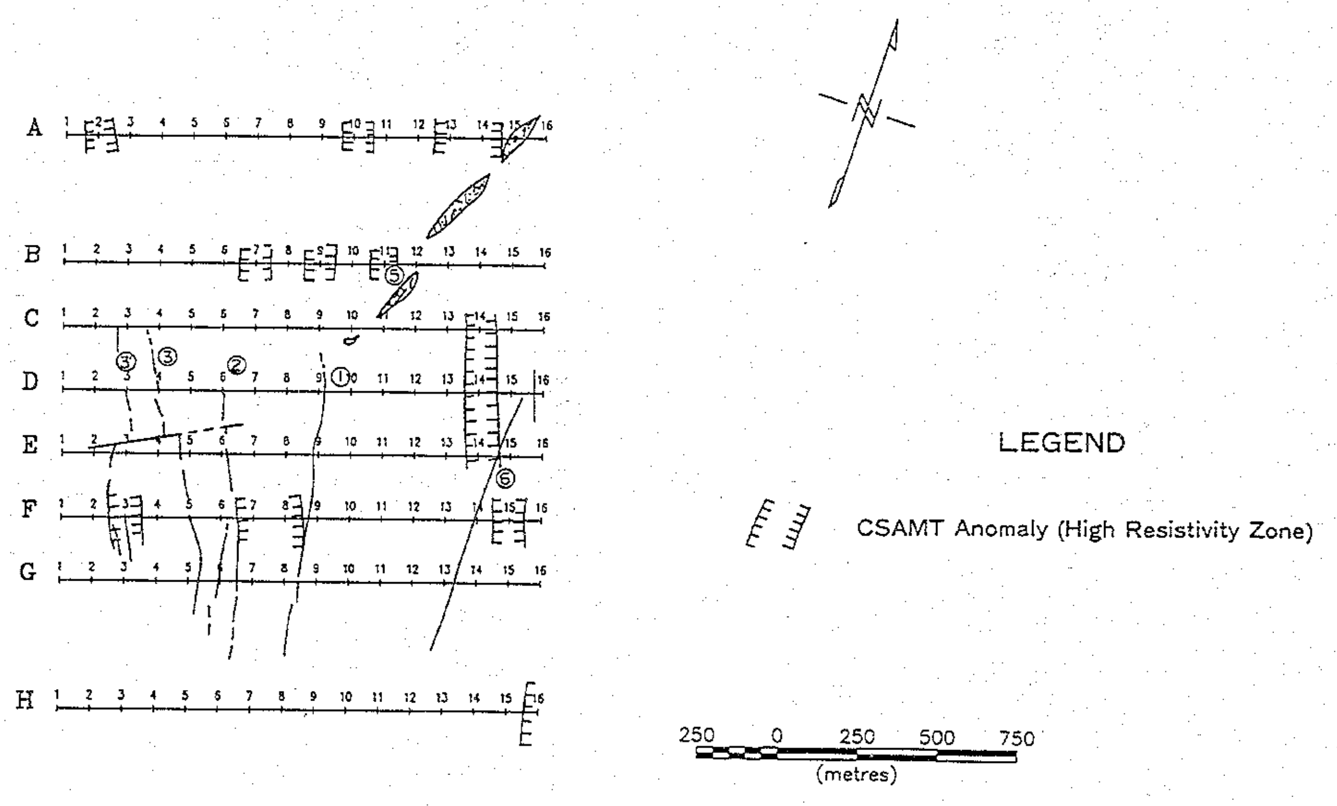


Fig. I-4-2 Results of Comprehensive Analysis of Geophysical Survey (Area II)

2) Section of one-dimensional analysis

Though a N-S high-resistivity zone connected to three lines (such as Line-E) is observed in the central east part of the area, it is not related to a vein structure.

3) Section of two-dimensional analysis

Though this area also shows a two-layer structure, its boundary depth differs in each lines. The first layer has a resistivity of 50 to 2,000 Ω・m and the second layer has a resistivity of 2,000 to 10,000 Ω・m. The boundary depth between the first and second layers on the line (Line-D) nearby the drilling MJMT-2 almost coincides with the depth of boundary between and an altered zone fresh zone and its depth is 250 m.

4) Resistivity structure and vein structure

Though the vein Nos. 1, 2, and 3 (intervals of 100 to 150 m) are relatively densely distributed, they do not show the characteristic high-resistivity structure like the area I and do not capture a vein structure.

4-4 Idealized model of mineralization

Figure I-4-3 shows a idealized model of mineralization.

Stage I: Idealized model of mineralization Granodiorite intruded into metamorphic rocks in around Permian period. After they were solidified, the shear fracture and tension fracture were formed in a E-W stress field. Mineral vein deposit and quartz porphyry probably due to the post-magmatism of granodiorite were formed by being controlled by these fractures. The precipitation temperature of gold is 120 to 200℃ in terms of the inclusion homogenization temperature. However, precipitation temperature produced a difference of elevation every vein or depending on a vein extended section due to the pressure condition at a precipitation portion or the salt concentration of a hydrothermal solution.

Stage II: Tilting motion and erosion

After a mineral vein was formed, it was tilted due to tilting motion and exposed to the ground surface due to erosion. The quality of a mineral state also produced the difference by reflecting the difference of elevation between precipitation temperature sections.

4-5 Potential of mineral deposit existence

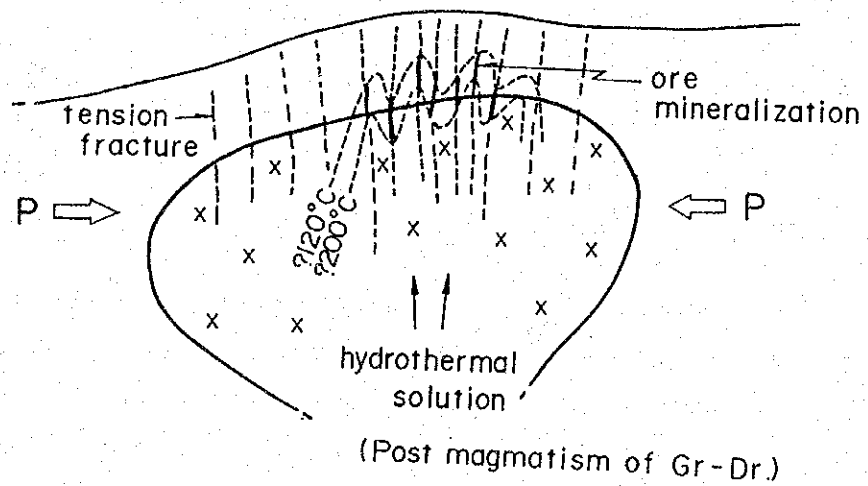
Though the quartz veins of this area consist of tens of veins, only vein Nos. 1, 2, 3, 6, and 10 can potentially be evaluated at present. The mineralization and scales of them are listed below again.

Vein No.	Avr. vein width(cm)	Avr. gold content(g/t)	Total vein length(m)
1	20.7	21.97	900
2	18.9	7.78	1,000
3	23.6	6.15	1,000
6	26.5	2.55	800
10	42.3	10.01	2,800

These quartz veins have a large fluctuation every section (tens to hundreds of meters) and moreover, the continuity of the lower part of a predominant mineralization cannot be estimated only according to the results of the two drilling holes executed in this fiscal year. However, a gold content was calculated on trial in order to use it as a criterion of the future development and scale.

As the calculation method, the above five veins were divided into blocks every section in which the qualities were relatively well arranged, low-quality blocks were excluded, and the length to the lower side of a vein was assumed as 150 m. The calculation results are shown in Table I-4-1. The gold content reached 6.5 t. When considering that no mineral symptom is found at a position 150 m deep from the ground surface as the result of drilling, the value of 6.5 t is the maximum value. On the other hand, former East Germany calculated for eight veins including the vein Nos. 9, 14, and 15 in addition to the above 5 veins and a gold amount of 16.5 t was appropriated. In the case of this calculation, the total length for each vein is purposed and the downward length is assumed as 350 m.

I Stage : Gr－Dr Intrusion
and Mineralization (Permian ?)



II Stage : Removement, Errosion
→ Recent

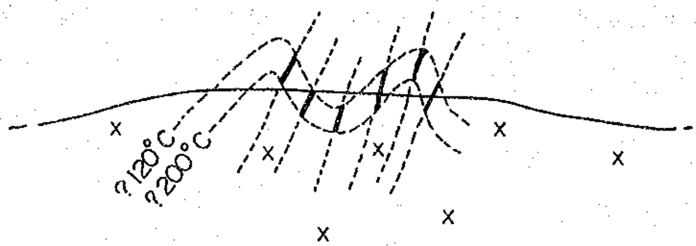


Fig. I－4－3 Idealized model of mineralization

Table I-4-1 Result of ore reserve(Au)calculation

No. of vein	Block range	Thickness (m)	Length (m)	Depth (m)	Volume (m^3)	Specific gravity	Weight (t)	Gold content (g/t)	Metal content (kg)	
1	No. 4 ～ 16	0.20	230	150	6,900	2.6 *	17,940	14.53	260.7	* same value with old east Germany
1	14 ～ 26	0.22	330	150	10,890	2.6	28,314	32.68	925.3	
1	27 ～ 30	0.25	90	150	3,375	2.6	8,775	5.70	50.0	
1	31 ～ 32	0.10	40	150	600	2.6	1,560	5.55	8.7	
	Sub total		690		21,765		56,589	22.00	1,244.7	
2	No. 36 ～ 53	0.29	440	150	19,140	2.6	49,764	8.21	408.6	
2	59 ～ 77	0.10	400	150	6,000	2.6	15,600	10.37	161.8	
2	80 ～ 81	0.10	80	150	1,200	2.6	3,120	376.90	1,175.9	
	Sub total		920		26,340		68,484	25.50	1,746.3	
3	No. 85 ～ 93	0.25	220	150	8,250	2.6	21,450	9.00	193.1	
3	119 ～130	0.21	260	150	8,190	2.6	21,294	17.58	374.3	
	Sub total		480		16,440		42,744	13.27	567.4	
6	No. 149～155	0.13	260	150	5,070	2.6	13,182	3.93	51.8	
6	158～163	0.28	150	150	6,300	2.6	16,380	4.07	66.7	
	Sub total		890		11,370		29,562	4.01	118.5	
10	No. 319～330	0.35	400	150	21,000	2.6	54,600	12.28	670.4	
10	348～352	0.40	200	150	12,000	2.6	31,200	12.86	401.2	
10	366～376	0.50	200	150	15,000	2.6	39,000	18.15	707.8	
10	377～382	0.45	110	150	7,425	2.6	19,305	56.75	1,095.6	
	Sub total		910		55,425		144,105	19.95	2,875.0	
	Total	0.225	3,890	150	131,340	2.6	341,484	19.19	6,551.9	

Chapter 5 Conclusion and recommendation

5-1 Conclusion

The following conclusion is obtained from the present investigation results .

1) The geology of survey area consists of a) metamorphic rocks, b) biotite adamellite, c) two-mica granodiorite, d) diorite, and e) quartz porphyry f) lamprophyre. Item b) was intruded in Devonian period and item c) was intruded in Permian period and both serve as the host rock of quartz veins.

2) A quartz vein consists of tens of stripes and consists of the NNW-SSE system, NE-SW system, and E-W system. Veins predominant in mineralization and scale belong to the NNW-SSE system. In the case of the average of four veins among these veins, the vein width is 20 to 40 cm, the gold content is 6 to 22 g/t, and the length is 900 to 2,800 m. The extended distance of them is equal to the total length in which a single quartz vein continues while repeating expansion and contraction or being arranged like an echelon. The mineralization of every section in the single quartz vein greatly fluctuates.

3) Ore minerals include natural gold, chalcopyrite, galena, tetrahedrite, and moreover slight tellurium minerals (e.g. sulfide mineral and oxide mineral). They are closely related to each other. Their occurrence is like scattered points but a striped or banded structure is not recognized.

4) It is considered that mineralization relates to post-magmatism of two-mica granodiorite and it is controlled by a fissure system formed under a regional stress condition at that time.

5) The precipitation temperature of gold estimated from the homogenization temperature of fluid-inclusion is lower than a expected temperature.

6) As the result of drilling of two holes in this fiscal year (the vein Nos. 1 and 10 are purposed), no mineral symptom is detected except that a very small amount of sulfide minerals (galena and sphalerite) is confirmed in the west vein of the vein No. 10 at a position 150 m deep from the ground surface. However, judging from the characteristic of occurrence of ore minerals in this area, the possibility is also left that mineral symptom cannot be detected even in a mineralized zone by core samples.

7) The one-dimensional analysis plane in the geophysical survey (array-type CSAMT) shows a N-S resistivity structure harmonious with a major vein structure up to a depth of approx. 500 m. A high-resistivity zone in the structure may correspond to a zone of a quartz vein with a relatively high distribution frequency.

8) Potential cannot be evaluated only by the mineralization of the ground surface and the drilling results of two holes. However, as the result of calculating the amount of gold of five veins (Nos. 1, 2, 3, 6, and 10) with predominant mineralization (when assuming a length to the lower side of a vein as 150 m), the gold amount comes to 6.5 t.

5-2 Recommendation for the Phase II

According to the investigation results in this fiscal year, the author proposes to apply drilling survey to the vein Nos. 1, 2, 3, and 10 whose mineralization is predominant on the ground surface. According to the drilling results in this fiscal year, purpose to confirm the continuity at a relatively shallow portion of each vein from the viewpoint that the mineral vein deposit in this area is a small-scale mineral deposit with a small continuity to the lower side of a mineral symptom portion. Survey will be performed for the high grade sections (blocks) under the following conditions in principle, interval between survey points: 100 m, number of holes at each point: 2 (holes), drifting depth:100 to 150 m/hole, and ore intersection depth: positions 50 m and 100 m deep from the ground surface. Evaluate mineral vein deposit through these surveys and study future development method and scale.

Part II Details of the Survey

Part II Details of the Survey

Chapter 1 Semi-detailed survey of geology

1-1 Survey method

A root map was prepared by using a 1/10000 topographic map. For positions of performing various analyses and gathering test samples, the latitudes and longitudes were identified by GPS (global positioning system).

1-2 Geology

With respect to geology of this area, metamorphic rocks and granodiorite assumed to belong to the latter period of proterozoic occupy more than 90% entirely this area except distributions of the quaternary system. There are distributed diorite, and such dykes as amphibolite, quartz porphyry and lamprophyre etc.

Quartz vein, main objective of the survey consists of ten rows.

Fig. II-1-1 shows a geological map of this area, Fig. II-1-2 shows a geological profile, and Fig. II-1-3 shows schematic geological column, and Fig.II-1-4 shows location of test samples.

1.Metamorphic rocks

The metamorphic rocks are distributed in the west, south and east of this area and penetrated by granodiorite and other rocks. They comprise the following three kinds of rocks.

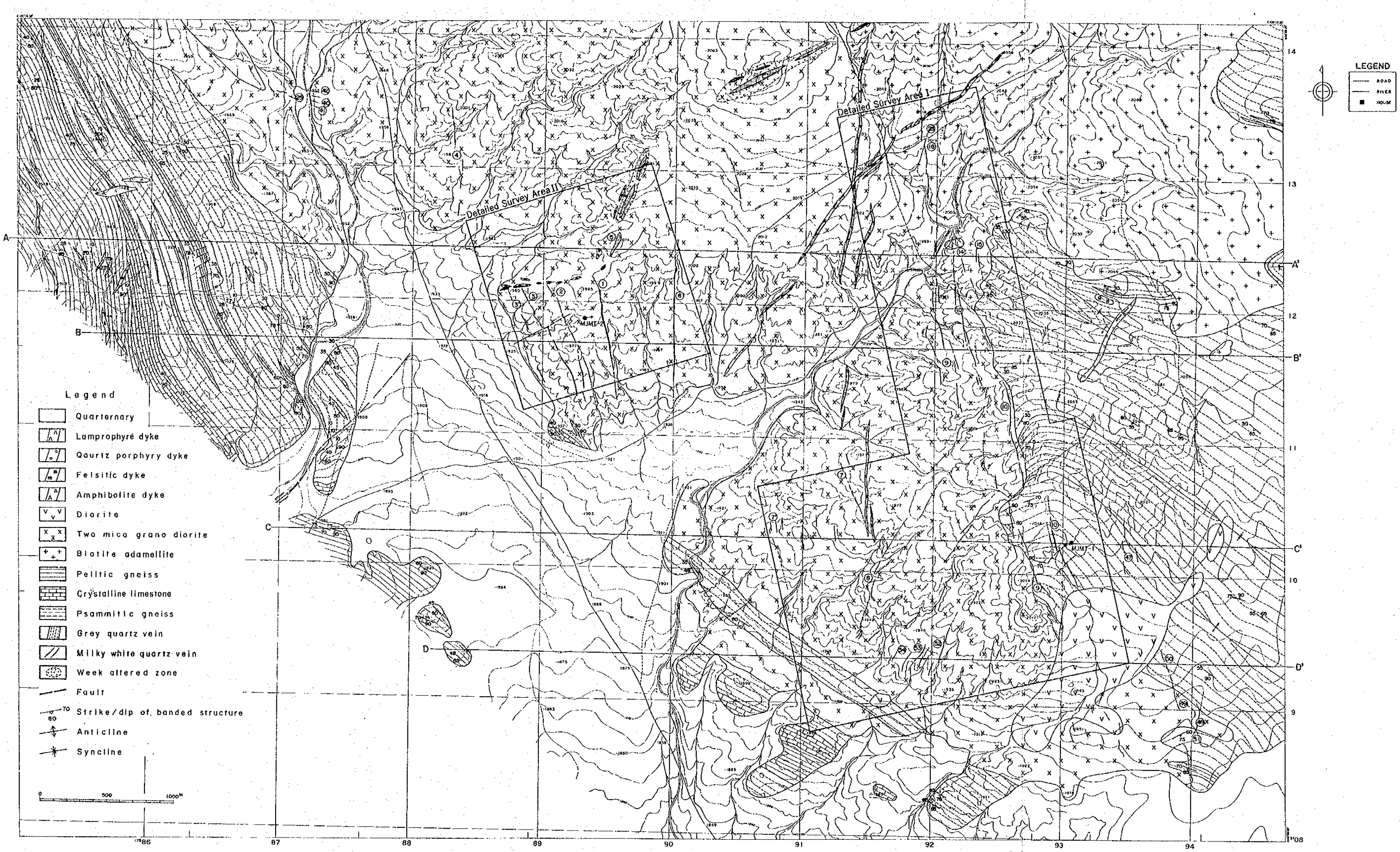
* Psammitic gneiss
* Crystalline limestone
* Pelitic gneiss

1) Psammitic gneiss

This rock is located in the lowest horizon of the metamorphic rocks and distributed in the west, south and east. Its stratum thickness is assumed to be more than 2km.

According to field observation, this rock is generally grayish white and indicates uniform grain structure of quartz, plagioclase, muscovite and biotite (depending on cases), apparently showing a texture of holocrystalline acidic igneous rock. Generally there exists bedding plane of several tens cm - several m thick and there are generally observed banded structures almost parallel to them. Further, segregation quartz vein of several cm - 10cm in width parallel to these structures are also noticed.

This rock does not have a characteristic of being easy to break as crystalline schist along its schistosity plane.



CARTOGRAPHY 1996
PHOTOGRAPHY 1983

Fig. Ⅱ-1-1 GEOLOGICAL MAP OF SEMI-DETAILED AREA

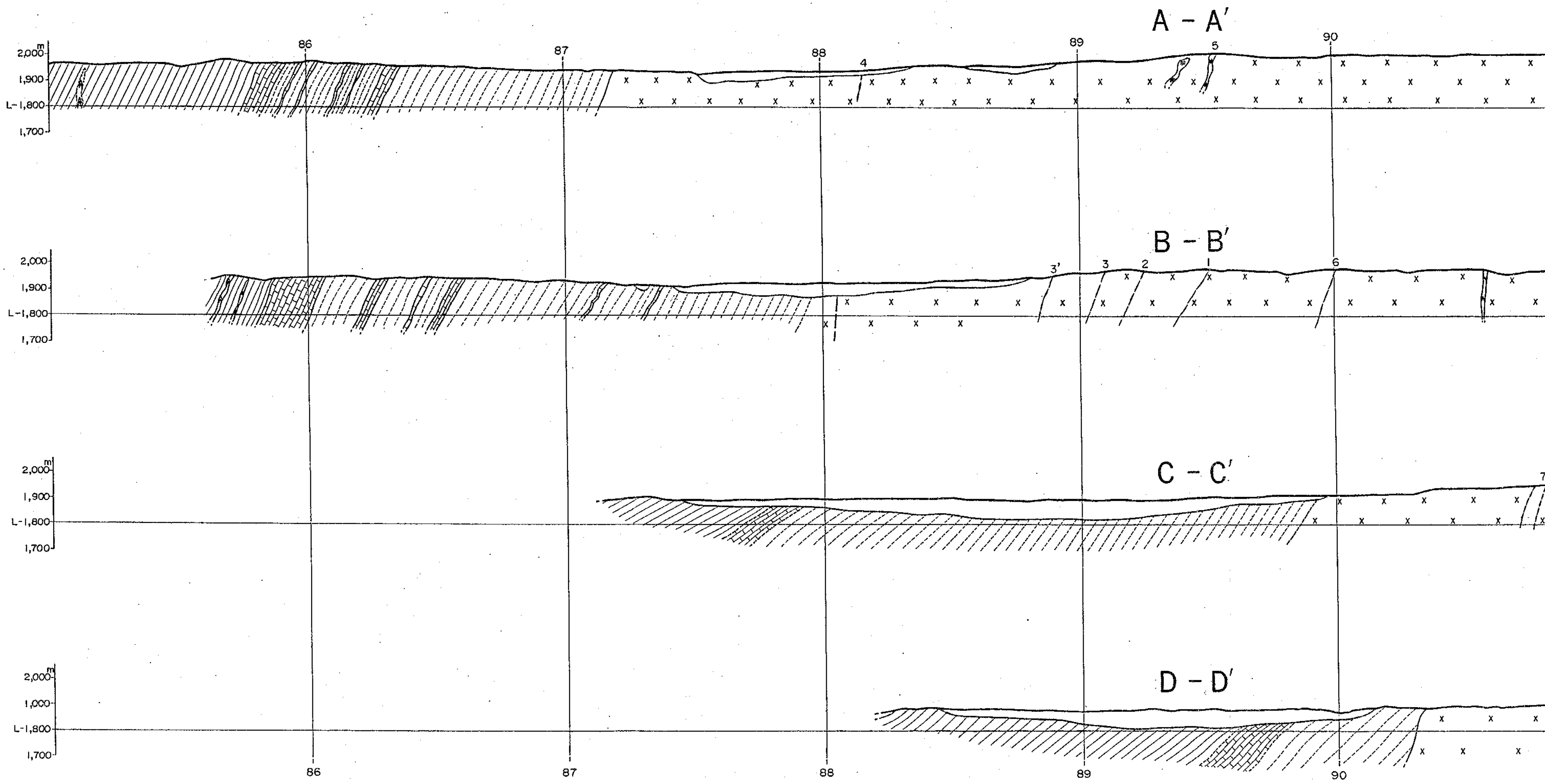
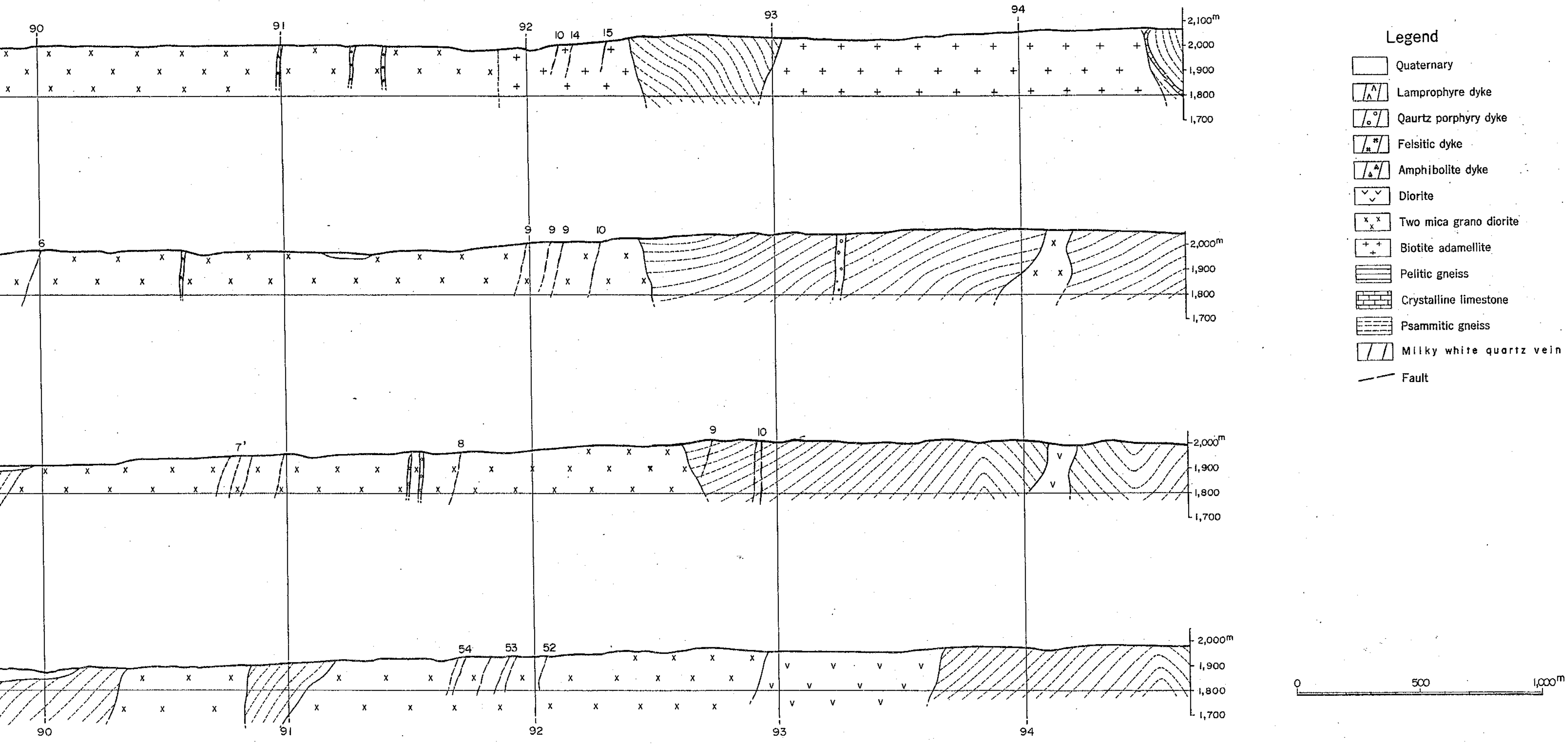
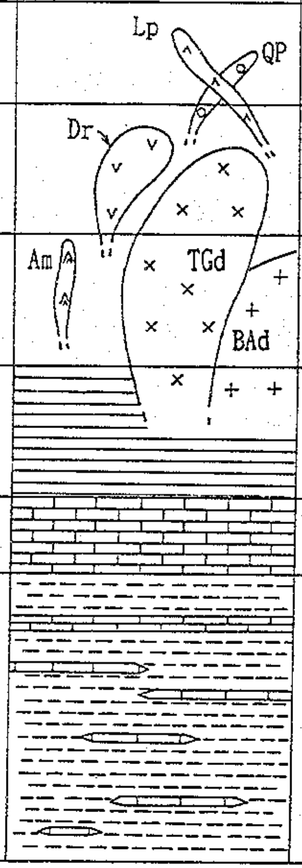


Fig. II -1-2 GEOLOGICAL PROFILE OF SEMI-



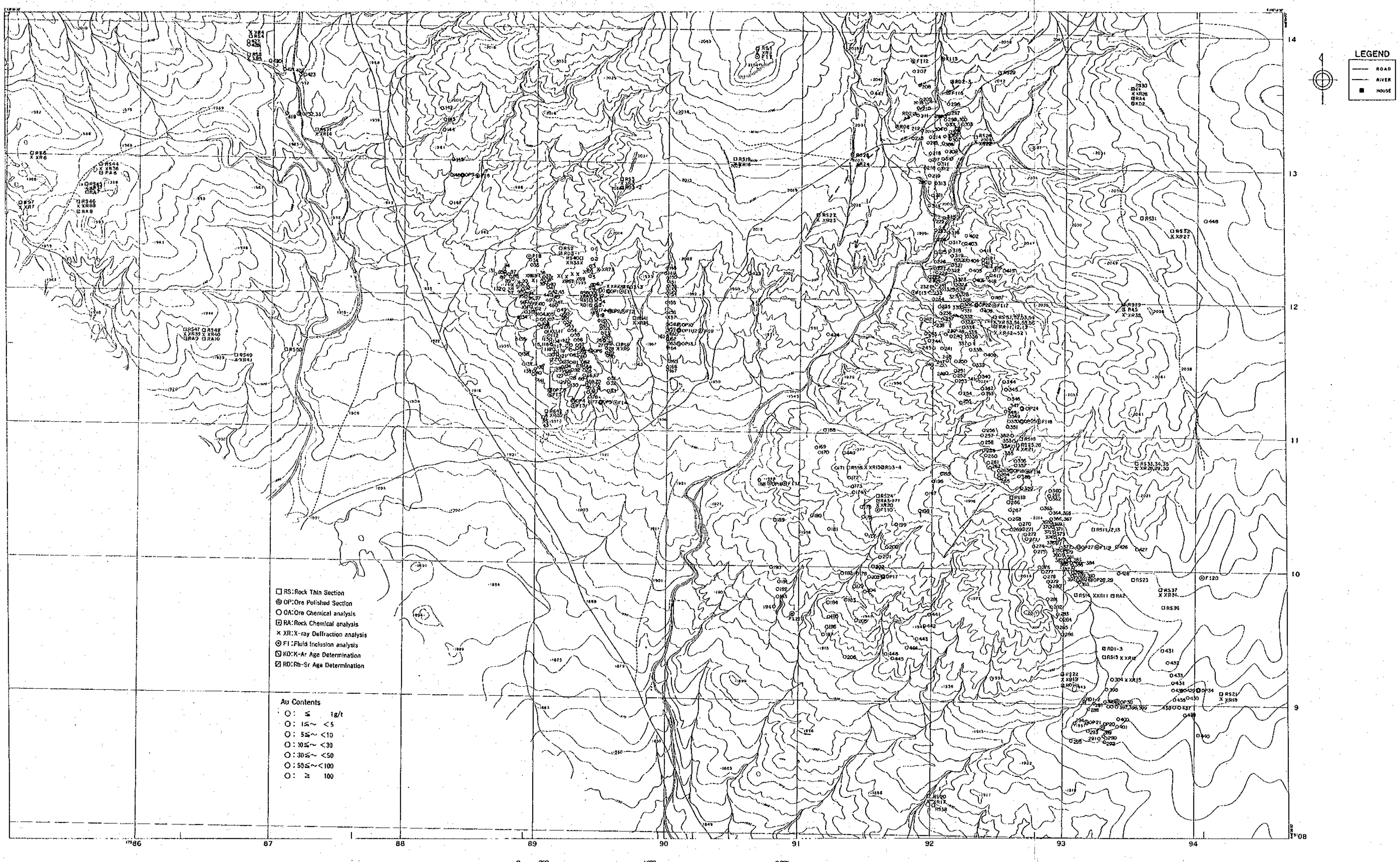
L PROFILE OF SEMI-DETAILED AREA

Geological time		Metamorphic rocks	Geological column	Thickn. (m)	Ore mineraliz.	Rock facies	Age determ. by K-Ar, Rb-Sr
Cenozoic	Quarternary			> 50		Gavel, Sand, Silt	
	Tertiary						
Mesozoic	-100×10⁶ y. -200						Cl of Q.V.: 225.8~234.4 ±4.9 Dr:250.4 ±85.7 TGd:268.1±5.6
Upper paleaozoic	-300						
Middle~Lower paleaozoic	-400 -500						BAd:384.7±7.8
Late Proterozoic		Pelitic gneiss		> 700		Layered 、Schistose ~gneissose st. occured chlorite, muscovite, biotite, garnet	
		Crystalline limestone		max250		Saccharoidal structure	
		Psammitic gneiss		>2,000		Gneissose structure occured muscovite, biotite, augite, garnet localy folded intercalated crystalline limestone	



QP:Quartz porphyry Lp:Lamprophyer Am:Amphibolite Dr:Diorite BAd:Biotite adamellite TGd:Two mica granodiorite
Cl:Clay st.:structure Thickn.:Thickness determ.:determination

Fig. Ⅱ-1-3 Schimatic geological column



CARTOGRAPHY 1996
PHOTOGRAPHY 1983

Fig. Ⅱ-1-4 LOCATION MAP OF TEST SAMPLES

Observation of thin section no.50, 53 with a microscope (see Table II-1-2) indicates that this rock comprises quartz, plagioclase and potassium feldspar together with a small amount of muscovite and biotite, and sometimes apatite. This indicates gneissose structure. This rock sometimes has a combination of quartz, plagioclase, augite, biotite, potassium feldspar, sphene, and opaque mineral. The same X-ray analysis (no.55) (see Table II-1-3) as for the thin section no.53 indicates that large amounts of quartz, potassium feldspar and plagioclase are contained as well as slight amounts of chlorite and sericite.

Granodiorite (adamellite: described later) of small grain - medium grain having a width of several m to 10m frequently penetrates irregularly near a boundary between this rock developed in the east area and the biotite/muscovite granodiorite described later in an interval of several hundred m in width, such that some places indicate migmatite-like faces mixed with this rock.

2) Crystalline limestone

This kind of the rock was developed mainly in the west and south of this area and distributed so that it is sandwiched by psammitic gneiss. The number of layers of this rock totals more than 10 in the west area. The thickness of the layers is several m to about 250m and thin layers of them are lens shaped and insufficiently continuous. The layers having a thickness of 250m max. are neatly covered with pelitic gneiss located above in the west area. This rock was not developed aggressively in the east area so that there are distributed only thin beds having a thickness of several m in some places.

According to field observation, this rock is grayish white crystalline limestone, and unexceptionally there can be recognized black opaque minerals having a diameter of less than 1mm.

Observation with a microscope (thin section nos.31, 43, 47) indicates saccharoidal limestone or marble and coarse-grained crystalline calcite occupies more than 95% the composition accompanied with a small or minute amount of quartz, opaque minerals (iron oxide?), muscovite, apatite and so on.

3) Pelitic gneiss

This rock is also distributed mainly in the west and south of this area. This rock is situated on the top horizon of metamorphic rocks in the west area and has a thickness of more than 700m. In the south area, psammitic gneiss covers the top of this rock having a thickness of about 200m.

According to field observation, this rock is black to dark grayish black and bedding plane and schistosity plane are excellent, and to be broken likely platy form as the same with crystalline schist. Often large crystals (1cm max. in dia.) of garnet are observed, and indicate that it was placed in an environment having high temperatures and high pressures.

Observation with a microscope (no.46) shows that this rock may be green schist, or muscovite-chlorite-quartz schist. The composition minerals are muscovite-chlorite-quartz-amphibole-biotite-opaque mineral and very ununiform. In X-ray diffraction (no.38) for the same specimen as thin sections, a minute amount of plagioclase is detected as well as large amounts of quartz, chlorite and sericite.

2. Granodiorites

The granodiorites are distributed from the central area to the north west - north - north east area and penetrate metamorphic rocks. They comprise the following two rocks, which are not clarified the relation of each other. It is difficult to search a boundary partly because there are no continuous outcrops.

* Biotite/muscovite granodiorite
* Biotite granodiorite (muscovite containing biotite adamellite)

1) Two mica granodiorite

The biotite/muscovite granodiorite is distributed from the central area to the north - north west. In the south portion of this area in accordance with a distribution of many floats, it is estimated that two mica granodiorite exists in psammitic gneiss in a form of dike like rock having a width of about 200m and harmony with its structure.

This rock is grayish white, medium-coarse grained holocrystalline rock, comprising mainly quartz and plagioclase, accompanying a small - medium amount of biotite and muscovite. Sometimes, pink potassium feldspar is accompanied. With naked eyes, almost no alteration is noticed except a part contacting quartz vein.

Observation with a microscope (thin section nos.8,40, 41) indicates medium equigranular texture. This rock comprises mainly quartz and plagioclase, accompanying a small - medium amount of muscovite, biotite and potassium feldspar. All the three specimens are excessively altered and in some cases, plagioclase and biotite are altered and in other cases, only plagioclase is selectively altered. A small vein of epidote is noticed in no.40.

In X-ray diffraction for specimens (nos. 8, 33, 34) corresponding to the thin sections, this rock shows almost uniform reflective pattern, consisting of a small amount of muscovite and potassium feldspar as well as a large amount of quartz and plagioclase. Biotite cannot be confirmed because it overlaps muscovite of their peaks.

2) Biotite granodiorite (muscovite containing biotite adamellite)

This rock is distributed in the north east area. As described, a boundary between this rock and the biotite/muscovite granodiorite is not clear.

Although this rock is grayish white, a degree of whiteness is slightly higher than biotite/muscovite granodiorite. In a slightly weathered portion near the center of the distribution area, banded structure of NW-SE system which is harmonious with a structure of psammitic gneiss, not seen in its fresh portion can be uniformly observed.

With the naked eyes, this rock consist of quartz, plagioclase and potassium feldspar, biotite often accompanying a small amount of muscovite.

Observation with a microscope (thin sections nos.26, 29, 32) indicates coarse equigranular texture. This rock consist of mainly quartz, potassium feldspar and plagioclase, accompanying a medium amount of biotite. A small - medium amount of muscovite is also noticed in nos.26 and 32. No.32 contains more potassium feldspar than plagioclase, clearly indicating microcline structure.

This rock is officially called as discribed abore muscovite containing biotite adamellite. In X-ray diffraction (nos. 22, 27) for specimens corresponding to the thin sections nos. 26, 32, the same mineral as in observation with a microscope can be recognized. Particularly, micas found are biotite (reflection at peak 2θ = 17.7A) and in no.27, potassium feldspar and plagioclase indicate the same reflective peaks.

Only no.22 is highly altered, so that epidote, quartz, sericite, opaque mineral (iron sulfide) and clay mineral are formed.

Granodiorite frequently penetrating psammitic gneiss near a boundary between psammitic gneiss and two mica granodiorite in the east area described previously is not biotite/muscovite granodiorite as a result of observation with a microscope (no.10) but biotite adamellite. If this number of small size biotite adamellite is the same as that contained in a main body, biotite adamellite in the main body is older than biotite/muscovite granodiorite, which can be assumed to be cut by the former. An existence of the previously described banded structure supports this assumption.

3. Diorite

Three bodies of diorite are distributed in the north west and south east. A rock body in the south east is the largest scale, which is a stock like having a width of 0.8km extending by 2.0km from the north east to the south west. This rock is estimated to penetrate a south edge of quartz veins nos.9, 10. On the other hand, south edge of this rock is cut by several small size sterile quartz veins.

This rock is dark green - dark gray and its edge portion is fine grained and its center portion is homogeneous, medium-coarse grained, semi-holocrystalline texture. Plagioclase and mafic minerals can be observed as phenocryst.

Observation with a microscope (thin section nos. 14, 15, 22) indicates coarse-grained holocrystalline texture, These comprise mainly plagioclase, hypersthene, and amphibole, accompanying a small amount of augite, quartz, potassium feldspar, biotite, apatite and opaque mineral (iron oxide). Although no.15 is violently altered, the other two are fresh, that is, so altered that can be neglected.

In X-ray diffraction (nos.11, 12,19) for the same specimens as the thin sections, the compositions are plagioclase, hypersthene, amphibole and biotite, accompanied with a small amount of quartz. In no.12 observed to have been altered under observation with a microscope, a medium amount of chlorite and a small amount of sericite are detected.

4. Dyke rocks

Dyke rocks include amphibolite, pegmatite, quartz porphyry, felsitic rock and lamprophyre.

1) Amphibolite

Amphibolite is distributed mainly in metamorphic rocks and was developed especially in pelitic gneiss in the west area. This rock has a variation of directivities such as N-S system, NE-SW system and NW-SE system and generally intercepts gneissose structure. This rock is not extended profoundly in width direction, having a width of several m - about 10m. The rock vein is often divided regularly indicating boudinage or sometimes showing a protruded topography formed by differences in erosion with surrounding pelitic gneiss.

This rock is dark green, medium and homogeneous, and comprising mostly amphibole. No schistosity and gneissose structure can be recognized.

Observation with a microscope (no.6) indicates porphyroblast structure, comprising mainly amphibole accompanying garnet (2mm in diameter), quartz, opaque mineral, and plagioclase. This is a regional metamorphic rock indicating garnet amphibole phase. Its original rock may be basaltic mafic rock.

In X-ray diffraction (no.6) with the same specimen as the thin section, this rock comprises a large amount of amphibole, a small amount of quartz and plagioclase and a minute amount of chlorite.

2) Pegmatite

This rock is also distributed very frequently in metamorphic rocks depending on areas. It has generally a width of less than 1m, no continuity and no constant directivity. This rock comprises mainly quartz, plagioclase and potassium feldspar. The single crystal of potassium feldspar is sometimes more than 1cm in diameter.

The pegmatite is not described in the geological map because of its small scale.

3) Quartz porphyry

This rock is developed in mainly the central area, penetrating biotite/muscovite granodiorite. Several rock groups having a width of 2-10m are in line to each other with a relatively continuity in the N-S system and sometimes intercepted by sterile quartz small veins.

This rock is pale greenish gray, fine grained-aphyric and sometimes fine grained quartz and plagioclase are observed. Observation with a microscope (no.24) indicates that it is medium-grained holocrystalline, comprising mainly plagioclase and quartz accompanying a small amount of potassium feldspar. Although it seems that there exits mafic minerals, its name is not clear. Almost all minerals except quartz were altered by a strong alteration.

In X-ray diffraction (no.20) for the same specimen, this rock comprises quartz and a medium amount of plagioclase, accompanying a small amount of potassium feldspar. Additionally, a medium amount of sericite is detected.

4) Felsitic rock

This rock is distributed in parallel to quartz vein no.5, consist of several bodies having the irregular shaped and arrangement as echelon like. With the naked eyes, it is pale gray, fine grained-aphyric, siliceous. This is considered to have been formed at the same period as no.5. No thin section was created.

5) Lamprophyre

This rock is NE-SW system distributed from the central area to the north east. It has a width of 10m max. and wide continuity. In the north east, this is branched to two or three and have echelon like arrangement. Nos.9, 10 system veins are intercepted by this rock.

This is dark bluish black, fine-grained , fine-textured and apparently looks fine-grained basalt.

Observation with a microscope (no.27) indicates that it is fine-grained holocrystalline, containing small size olivine, augite and amphibole as phenocryst. Its ground mass comprises mainly potassium feldspar and amphibole, accompanying a small amount of augite and opaque minerals. This rock was subjected to quite strong alteration, producing chlorite, calcite, and quartz. Additionally, it contains a small amount of quartz xenolith.

In X-ray diffraction (no.23) for the same specimens, a medium amount of chlorite, a small amount of plagioclase and fine amounts of amphibole, quartz and calcite are detected.

5. Quartz vein

Although a group of quartz veins confirmed in this survey is shown in a geological map of Fig. II-1-1, this is shown in Fig.II-1-3 as a quartz vein distribution map to stress the quartz veins. Vein numbers in the same figure indicating individual veins are the same as those used by ex-East Germany.

The survey carried out by ex-East Germany shows 55 veins including the north west area out of this area. In this survey, all the veins in this area were confirmed except small size veins nos.26, 27, 28 in the north west and additionally, branch veins of the north veins (nos.16 - 23) of the no.9 system and no.3', 7' were newly confirmed. As a vein out of the survey area, nos. 13, 30-39 and 44-46 exist.

The veins in these area are divided to the following three systems depending on directivity.

Directivity		Vein No.
(1) NNW-SSE system	···········	Nos.1, 2, 3, 3', 6, 7, 7', 9, 10, 14, 15, 6-23
(2) NE-SW system	···········	Nos.5, 8, 52, 53, 54
(3) E-W system	···········	Nos.25, 40, 41, 42

Of them, all veins having an excellent mineralization belong to (1) system.

On the other hand, ex-East Germany classified those veins to the following three types depending on the directivity of the veins and their accompanying ore mineral.

	Directivity	Vein No.	Accompanying ores
Type 1	NW system(out of the survey area)	Nos.30-39,40-46	Cu, Pb, Zn
Type 2	NNW system(partly E-W, NW system)	Nos.1-4, 6-10, 14-23, 25, 27-29, 40-43, 47-51	Cu, Pb, Bi, Au
Type 3	NE system	Nos.5, 13	Cu, Pb

Characteristics of the quartz veins in this area will be described below. Ore mineral will be described in batch in a chapter about detailed survey.

1) Quartz vein of NNW-SSE system

(Nos. 1, 2, 3, 3', 6, 7, 7', 9, 10, 14, 15, 16-23)

The quartz veins of this system are milky white and distributed within all detailed survey areas described later except in small size nos. 4, 47-51. Most of the veins penetrate granodiorite and part of them penetrate psammitic gneiss.

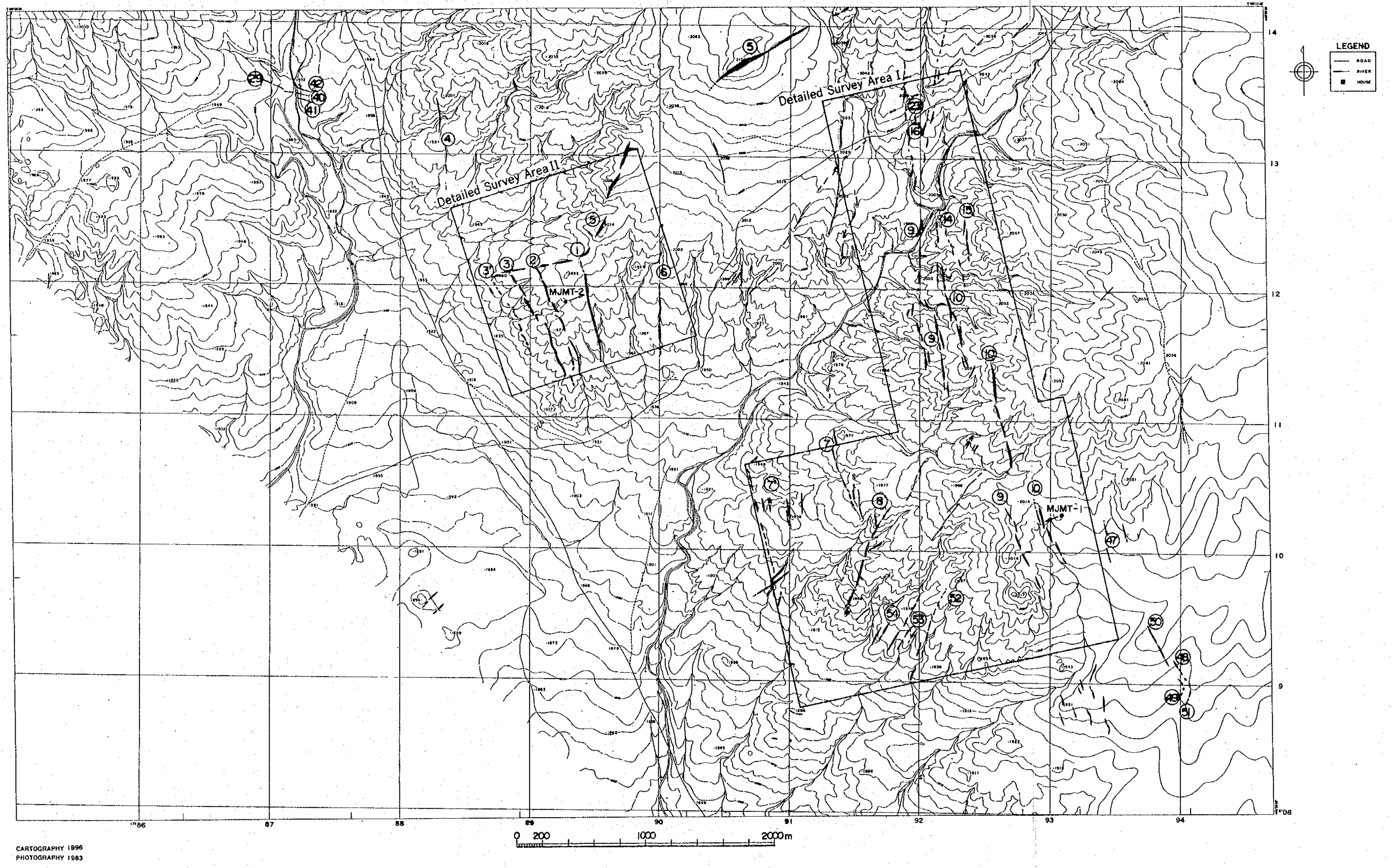


Fig. Ⅱ-1-5 Location of Quartz Vein

An average width of the major veins (nos. 1, 2, 3, 6, 7, 9, 10) is 20-30cm and their maximum width is 110cm (no.10). It is a characteristic of the quartz vein that it is continuous and generally it extends by 1km - several km. However, most single veins extend by several tens m - several hundred m. In some cases, it continues while an interruption is repeated and in other cases, some veins run in parallel to each other with a distance of several m - several tens m with arrangement of echelon. Nos. 1, 2, 3, 6 veins (detailed survey area II) almost belong to the former and nos. 9, 10 veins (detailed survey area I) almost belong to the latter.

Nos.14, 15 are a small size parallel vein of no.10 and nos.16-23 are north extension vein of no. 9. Outcrops of portions having an excellent mineralization of nos. 1, 2, 3, 6, 9, 10 have been mined. Their mining depths can be estimated to be only less than 10m judging from amounts of waste heap and three survey shafts of no.1 (vein confirmed entering at about 18m deep of every shaft).

2) Quartz vein of NE-SW system (Nos. 5, 8, 52, 53, 54)

Quartz veins of this system are milky white except that no.5 indicates grayish white, and penetrate granodiorite.

Typical no.5 vein is distributed around Tsagaan Tsakhir Uul and contains irregular lens shaped single veins measuring several tens m to several hundreds m, disposed in line. The total extension in this area is about 4km. The vein width is far larger than other veins and 50m max. in Tsagaan Tsakhir Uul.

According to a result of observation with a microscope (thin section no.3), it is estimated that its original rock was granodiorite comprising quartz, potassium feldspar, plagioclase, muscovite and so on. The original rock was crushed once and successively subjected to a strong silicification. Currently, it comprise almost totally quartz and a quite small amount - minute amount of potassium feldspar, plagioclase and muscovite are recognized.

In X-ray diffraction (no.3) for the same specimens, a minute amount - small amount of plagioclase and a minute amount of potassium feldspar and sericite are detected.

That is, a possibility that no.5 is all an altered vein different from the other quartz veins is high.

No.8 has the second largest extension, in which single veins having a width of 5-20cm and measuring several tens m in length extend intermittently totaling about 1km. At the south west end, this is branched to several veins. After that, this veins are pinch out.

Nos. 52-54 comprise five or six veins parallel to each other, which single veins having a width of 5-10cm extend over several hundreds m with an insufficient continuity.

3) Quartz vein of E-W system (Nos. 25, 40, 41, 42)

This system is a small vein distributed in the north west area. It has a width of several cm to 10cm and is lack of continuity. There is found a mining ruins at part of a outcrop of no.41.

4) Scale of quartz veins

The scales of main quartz veins, confirmed by this survey shows Table II-1-1.

Table II-1-1 Scales of main quartz veins

No. of Q.V.	Direction	Mean width (cm)	Total Length(m)	Remark
1	NNW-SSE	20.7	900	
2	NNW-SSE	18.9	1,000	omit parallel vein
3	NNW-SSE	23.6	1,000	omit parallel vein
6	NNW-SSE	26.5	800	
7	NNW-SSE	12.6	750	omit parallel vein
8	NE-SW	15.3	1,500	omit parallel vein
9	NNW-SSE	26.6	3,000	omit parallel vein
10	NNW-SSE	42.3	2,800	
16 ~23	NNW-SSE	13.2	> 1,500	omit parallel vein

5) Relation between no.5 vein and nos. 1, 2, 3 veins

No. 5 and nos. 1, 2, 3 are approximate to each other at their north ends. Their back-and-forth relationship is not clear. Although ex-East German people estimated that the latter was intercepted by the former, this was not made evident in this survey despite trenching survey conducted to make sure. The following assumptions are possible.

a) Nos. 1,2,3 are cut by no. 5. However no cut tip is found.
b) Nos. 1,2,3 strike no. 5 so that it vanishes.
c) Nos. 1,2,3 naturally vanishes where they come near no. 5.
d) Nos. 1,2,3 are branches of no. 5.

If we dare to make a conclusion about that, (3) is most acceptable. As for back-and-forth relation, it is estimated that no. 5 was formed after or at the same period.

6) Relation between quartz vein and dykes

The back-and-forth relation of quartz vein and dykes is described in 1-3 and 1-4. This can be summarized as follows. The quartz vein no. 23 (north extension of no. 9) is cut by lamprophyre. Nos. 9, 10 may be cut by diorite. On the other hand, this rock is cut by small size veins (NNW system). Also there is quartz porphyry cut by small size veins (NNW system).

6. Quaternary

This is considered to be mainly river deposit, widely distributed from the central area to the south. This comprises poorly sorted sub-round gravel, sand, and silt.

7. Geological structure

1) Structure of metamorphic rocks

The metamorphic rocks distributed from the west to the south have a monoclinic structure having a strike to NW and inclined to SW at 60° to 85° . Pelitic gneiss higher in horizon has increased gradient.

Although the metamorphic rocks in the east area have basically a strike of the same NW system as the west area, it forms a folding structure in which anticline and syncline having a gradient of 65° to 90° are repeated. Part of the axis of fold is mildly bent by an influence of intrusion of granodiorite.

2) Fault

In the metamorphic rocks in the west area, a fault of NE-SW system (slippage to the left) exists having a horizontal transition amount of several hundreds m estimated from a deviation of distribution of pelitic gneiss. That location coincides with a valley topography and a disturbance occurs in the structure (strike) of metamorphic rocks around the fault. Although there is a possibility that the north east extension of the fault is continuous with the quartz vein no. 5, this is not clear.

Ex-East Germany estimated that extensions of this fault and no. 5 vein were the same fault, which intercepted nos. 1,2,3 veins and no. 5 was a vein intruding into the fault. Because there is a possibility that the no.5 vein is altered vein of granodiorite subjected to crushing, it cannot be denied that the no. 5 is a fault.

Although an existence of the fault was not testified by a survey around no. 5, its trace may have been erased by silicification.

All small size faults belong to NE-SW system, in which transition of crystalline limestone and quartz vein by about 10m can be recognized.

8. Structural control of the quartz vein

According to a survey by former East Germany, the type 1 (NW system , outside the area) are in the contact point of granodiorite and migmatite and type 2 (NNW system) runs in the contact