REPORT ON THE MINERAL EXPLORATION IN THE UUDAM-TAL AREA MONGOLIAN PEOPLE'S REPUBLIC

(PHASE I)

FEBRUARY 1992

JAPAN INTERNATIONAL COOPERATION AGENCY

METAL MINING AGENCY OF JAPAN

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РЕЗЮМЕ

В последние годы Монгольская Народная Республика открыла двери своей экономики для западных стран и проводит политику по форсированию привлечения капиталов и техники из этих стран.

В отношении технического сотрудничества с нашей страной в области горной промышленности до сего времени были выдвинуты многочисленные призывы. На это японское правительство направило два раза, в августе 1990 года и в марте 1991 года, группу проектно-выборочного исследования. В итоге исследовательская группа и Государственный геологический центр МНР достигли договоренности по поводу проведения исследований с 1991 года и было заключено рабочее соглашение S/W (Scope of Work), датированное 16 мартом 1991 года.

Целью исследования является выяснение ситуации с рудными месторождениями путем определения геологической обстановки Уудам Тал, района на юго-востоке МНР с площадью примерно 500 тыс. кв. км.

В текущем году, в первом году, определяющем 1991 финансовый год, как стартовый, японская сторона сформировала выездную исследовательскую группу в составе пяти человек и отправила ее на место с 18 июня по 8 октября 1991 года.

На месте исследования было установленно семь следующих районов: район Дорнод, включающий многочисленные залежи руд металлов серебра, свинца, цинка, район Тумуртыйн Овоо с залежами цинковых руд типа скарн, район Нухут-Даваа с залежами вольфрама типа грейзен, район

Хар-Айраг с редкими в мире залежами плавикового шпата, район Лугийнгол с залежами редких земель типа карбонатит, район Цагансубурга со вторым в Монголии месторождением меди типа порфир и также район Улзийт с залежами редких земель типа карбонатит, стронция, плавикового шпата и многочисленными золотыми жилами.

Исследования включают компиляцию уже имеющихся данных, геологические исследования и анализ съемок со спутника.

За компиляцию данных отвечал преимущественно руководитель группы. Взаимодействуя с монгольскими представителями, был проведен сбор и систематизация материалов, имеющихся в хранилище данных Государственного геологического центра в Улан-Баторе, по металлам, неметаллам и ресурсам каменного угля.

Что касается геологических исследований, то четверо исследователей, взаимодействуя с местными организациями монгольской стороны, провели выездные исследования основных существующих рудников и известных рудных месторождений, входящих в районы исследования, указанные на карте местонахождения районов объектов исследования.

При анализе съемок со спутника трое исследователей в Японии, используя цветные фотосъемки MSS и данные TM CCT проводили геологическую расшифровку фотоматериалов и экстрагирование дегенерирующих поясов.

В результате исследований признано что каждый из районов: Дорнод, Тумуртыйн Овоо, Цагансубурга и Улзийт является многообещающим в качестве объекта продолжения исследований.

В районе Дорнод уже проведены довольно большие по объему исследования и по крайней мере можно сказать, что открыты рудные месторождения, сопровождающие обнаруженные во время воздушной магнитной разведки магнитные аномалии и рудные выходы на поверхность. Однако допускается возможность, что подземные залежи многих металлов остались не обнаружены, и в дальнейшем, начав с широкой гравитационной разведки, необходимо осуществить программу разведки подземных рудных залежей.

Кроме того рудные месторождения в районе Цав по своему объему, качеству, условиям местности и другим моментам являются наиболее возможными для наибольшей разработки. Поскольку рудная разведка этих месторождений уже достаточно продвинулась, желательно в дальнейшем использовать их в качестве объекта подробных исследований, предпослав этому разработку рудников.

В районе Тумурстыйн Овоо маловероятно открытие новых месторождений в результате широкотерриториальных исследований, но есть достаточно смысла задуматься о разработке уже известных месторождений. В отношении этих месторождений Монголия уже определила курс их самостоятельного развития, но для непосредственного их освоения в виде рудников необходимы, наверное, общие расчеты экономической целесообразности, прежде всего предусматривающие процесс выбора месторорждения.

Подробное исследование золотого месторождения Огон-Овоот в районе Улзийт привлекает внимание быстрым экономическим эффектом. К тому же в области, начиная с этого района и до района Цагансубурга на востоке, есть и кроме этого еще много золотых месторождений.

Дальнейшая задача видится в следующем: наряду с проведением отдельных выездных исследований по этим месторождениям с выяснением их характера, вести поиск новых месторождений, проводя ряд исследований на основе методов дистанционного обднаружения и широкотерриториальной физической разведки.

Также стало ясно, что в Монголии есть важные данные, касающиеся исследований, осуществленных ранее.

Для того, чтобы исследования в этой стране проходили гладко и эффективно желательно и далее изучать эти проблемы и эффективно их использовать.

Опираясь на вышеизложенные результаты предложен план исследований на второй год.

PREFACE

In response to the request of the Government of Mongolian People's Republic, the Japanese Government decided to conduct a Mineral Exploration in the Uudam-Tal 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 Mongolian People's Republic a survey team headed by Mr. Eitaro Sato from June 18 to October 8, 1991.

The team exchanged views with the officials concerned of the Government of Mongolian People's Republic and conducted a field survey in the Uudam-Tal 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 for 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 Mongolian People's Republic for their close cooperation extended to the team.

February, 1992

Kensuke YANAGIYA
President
Japan International Cooperation Agency

Gen-ichi FUKUHARA
President
Metal Mining Agency of Japan

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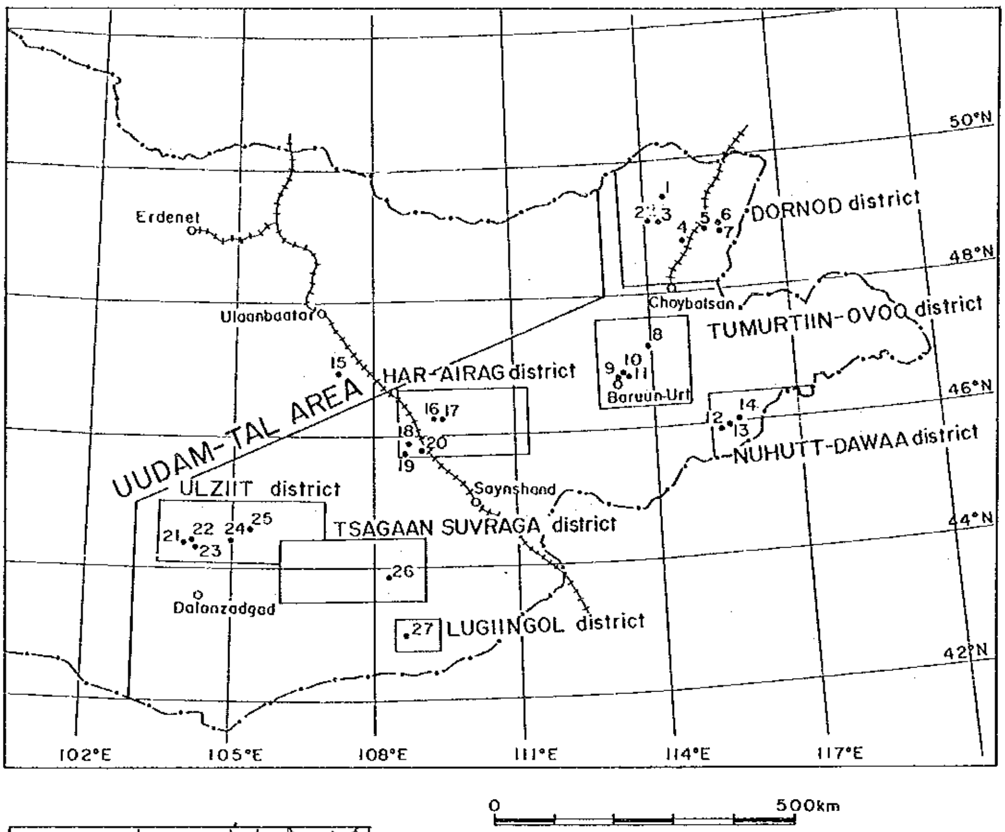
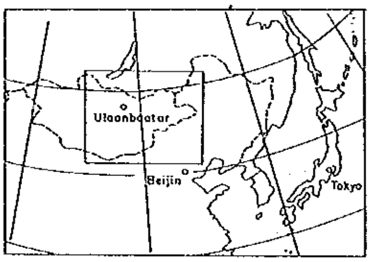




NAME OF DISTRICTS AND ORE DEPOSITS

DORNOD district
1 Tsagaan-Chuluut Hudak
2 Ulaan
3 Mardai
4 Delger-Munh
5 Tsav
6 Salhiit
7 Bayan-Uul

TUMURTIIN-OVOO district
8 Arin-Nuur
9 Tumurtiin-Ovoo
10 Salaa
11 Salhiit

NUHUTT-DAWAA district
12 Yuguzer
13 Tsentr
14 Nuhutiin-Tsagaantolgoi

HAR-AIRAG district
15 Chol-Tsagaan-Del
16 Adag
17 Bor-Undur
18 Maihanta
19 Tsagaantakhilch
20 Hongor

ULZIIT district
21 Mushgia-Hudak
22 Olon-Ovoot
23 Bayan-Hoshoo
24 Dugshih
25 Onh

TSAGAANSUVRAGA district
26 Tsagaansuvraga

LUGIINGOL district
27 Lugiingol

Fig. I-1-1 Location map of the Uudam Tal Area

Summary

Technical cooperation with our country in the field of mining has often been requested from the Mongolian People's Republic in the past. The government of Japan dispatched project finding missions on two occasions, August 1990 and March 1991, at the request of the Mongolian government.

The purpose of these surveys is to determine the potential of existing mineral deposits by clarifying the geological conditions in the Uudam-Tal area in the southeastern part of the Mongolian People's Republic.

During the first year of this agreement MMAJ organized a mission consisting of 5 members who were dispatched to the field from June 18th to October 8th, 1991.

Seven areas were selected to be surveyed: the Dornod district which contains silver, lead and zinc deposit zones; the Tumurtiin-Ovoo district which is an area of skarn type zinc deposit zones; the Nuhut-Dawaa district which is an area of greisen type tungsten deposit zones; the Har-Airag district which is one of the best fluorite deposit zones in the world; the Lugiingol district which contains carbonatite type rare earth deposits; the Tsagaansuvraga district, the second best porphry copper deposit zones in Mongolia; and the Ulziit district which contains carbonatite type rare earth deposits, strontium and fluorite deposits, and many showings of gold occurrence.

The surveys entail data compilation, geological survey and satellite image analysis. The mission leader collected and organized data upon metallic, non-metallic and coal resources in the data room at the State Geological Center in Ulaanbaatar with the cooperation of the Mongolian liaison.

Four geologists carried out a field survey of the major existing mines, known deposits and mineral showings in the survey area shown on the location map, with the cooperation of the local Mongolian staff.

The satellite image analysis was conducted by three members of the mission working in Japan. Color printed MSS images and CCT/TM data were used in a photo-geological interpretation to determine alteration zones.

As a result of these survey districts such as Dornod, Tumurtiin-Ovoo, Tsagaansuvraga and Ulziit were found to have potential and be worthy of future surveys.

In the Dornod district, a considerable number of surveys have already been conducted including airborne magnetic surveys. Deposit outcrops have been mapped from anomalies associated with these surveys, but there is a possibility that blind polymetallic deposits remain undiscovered. Therefore, in the future it will be necessary to conduct a program of surveys for these blind deposits, starting with a regional gravity survey. Among deposits in this district, the Tsav deposit seems, from its ore reserves, grades and location, to have the most potential for future development. The exploration of this deposit has already reached an advanced stage. Assuming that future development of this mine is to be conducted, it is desirable that a detailed survey of the deposit be concluded.

There is little possibility of finding new deposits by regional surveys in the Tumurtin-Ovoo district, but development of deposits in this area is worthy of consideration. The government of Mongolia has already decided to develop this district but a feasibility study, to include ore dressing processes, must be completed before proceeding with the actual development.

A detailed survey of gold deposits in the Ulziit district at Olon-Ovoot is worthy of attention from the point of view of quick economic effects. There are many other additional showings of gold occurrence in areas stretching from this district to the Tsagaansuvraga district in the east. It would be advisable to conduct a field survey of each of these showings to clarify their character. A series of surveys to find additional new deposits should be conducted at the same time. These surveys should include remote sensing analysis and a regional geological survey.

It was found that there was a huge amount of data from the previous surveys in Mongolia.

In order to promote smooth and effective surveys in this country, this data should be further studied and used effectively.

Plans for further surveys in the second year of this agreement have been proposed from the results described above.

Part Ⅰ GENERAL REMARKS

Chapter 1 Introduction

1-1 Survey background

The Mongolian People's Republic has recently opened the door of their economy to western countries and is now pursuing a policy which promotes the introduction of funds and technology from these countries. The Mongolian government has approached our government positively and private companies are also taking a strong interest in development of the resources of Mongolia. Technological cooperation with our country, in the field of mining, was desired and a written request for surveys to develop rare earth deposits in the Mushgia-Hudak area was submitted in October, 1989. The first project finding mission was dispatched at the request of the Mongolian government and the possibility of cooperative surveys fro copper, lead zinc and rare earth minerals was confirmed.

A second project finding mission dispatched in March of 1991, following three additional requests for assistance from Mongolia during February of 1991. The goal of this mission was to investigate the feasibility of surveys which had previously been proposed and to discuss specific survey items with their Mongolian counterparts. This resulted in the survey mission and the State Geological Center of the Mongolian People's Republic agreeing upon the commencement of a survey program in 1991 and a Scope of Work (S/W) dated March 16th, 1991 was signed. The surveys which were agreed upon were begun 1991 and were conducted according to this Scope of Work.

The purpose of these surveys was to determine the potential of mineral deposits in the Uudam Tal area of the Mongolian People's Republic. This was accomplished by geological investigation of the area, satisfying all four of the requests submitted by the Mongolian parties.

1-2 Purpose and outline of activities during the first year's surveys

The area which was surveyed during the first year of this program is shown in Figure I-1-1. This is the Uudam-Tal area which occupies an area of 500,000km^2 in the southeastern part of the MPR. The survey area was bounded by the southeastern border of the MPR, a line from the boarder north to a point at 45°00'N, 103°00'E, a diagonal line to a point 48°00'N, 113°00'E and a line north from the latter point to the border. Due to the vastness of the survey area and the wide variety of mineral occurrence in the area, specific areas of interest had to be chosen.

The following seven districts were selected to be surveyed.

1. The Dornod district: a polymetallic district covering an area of 33,000km^2 in which silver, lead and zinc minerals occur associated with igneous activity of Jurassic to Cretaceous Period.

2. The Tumurtiin-Ovoo district: a skarn district of 33,000km^2 in which zinc minerals are associated with Early Jurassic igneous activity.

3. The Nuhut-Dawaa district: a greisen type metallogenic district covering 7,000 km^2 with occurrences of tungsten and molybdenum mineralization.

4. The Har-Airag district: one of the best fluorite districts in Mongolia covering 40,000km^2. The mineralization is associated with Mesozoic igneous activity and the mines of Bor-Uudur and Agag are being worked.

5. The Lugiingol district: vein shaped carbonatite rare earth deposits occurring with alkaline rocks of Permian to Triassic Priod in an area of 3,300km^2.

6. The Tsagaansuvraga district: the second largest porphyry copper district in Mongolia covering 20,000km^2 with many deposits and prospects formed in Early or Middle Carboniferous Period.

7. The Ulziit district: a district in the southern Gobi desert of 20,000km^2 in which there was repeated carbonatite, fluorite, strontium and rare earth mineralization from Silurian to Late Jurassic Period.

The purpose of the first year's surveys was a geological study of the deposits in the Uudam Tal area of the Mongolian People's Republic. Specific elements of the program of study and the purpose for each are as follows:

1. Compilation of existing data: collection, organization and analysis of a large amount of data held by the Mongolian authorities, to determine the current state of mining activity in the study area. This included summarizing past and current surveys of the area, listing existing mines and development projects in the area, and a tabulation of ore showings in the area.

2. Geological surveys: to investigate active mines, known deposits, and ore showings in the survey area, to study the conditions under which mineralization occurred and to investigate the geological environments in which the mineralization occurred.

3. Satellite image analysis: to study the regional geological structure of the survey and to locate alteration zones by spectral analysis of light reflected from the ground in the areas of known ore deposits.

The first year's survey activities are outlined as follows (Table I-1-1):

1. Data compilation: The mission leader, with the cooperation of the local authorities, compiled background information in the data room of what was formerly called the "International Geological Center Building" at the State Geological Center of the Mongolian People's Republic in Ulaanbaatar from June 21st to October 6th, 1991. During this period, four other members of the mission were also engaged in this work for a total of 60 man-days. Their activities included collection and organization of data relating to metallic and non-metallic mineral and coal resources in the area. Specific information obtained by this research team included data on the following topics:

a. information on known deposits and areas of ore showings

b. a list of past surveys and surveys currently in progress

c. information on exisiting mines and mine development porjects

d. statistics on domestic production, importation and exportation of resources

2. Geological Surveys: Field surveys were conducted and data was collected and confirmed, as necessary, in the following areas:

a. The Dornod district; the Dornod exploration sites and the polymetallic deposits at Tsav and Ulaan

b. The Har-Airag district; the Choir exploration sites and the fluorite deposits at Tsagantakhilch, Maihanta, Hongor, Bor-Undur, Adag and Chol-Tsagaan-Del

c. Tsagaansuvraga district; the Tsagaansuvraga copper deposit

d. Ulziit district; the Geology Company's exploration site, the Mushgia-Hudak rare earth deposit, the Olon-Ovoot gold deposit and the Bayan-Hosho strontium deposit.

Four members of the survey mission, with the cooperation of the Mongolian staff, performed studies at the major existing mines, known ore deposits, and at sites where mineralization is indicated within the survey area. These studies began with location of the study areas and confirmation of the geology and mineralization in each area. Important outcrops were then sketched and photographed and rock samples were taken for laboratory studies. The environments of the areas of mineralization were also analyzed. An outline of laboratory work performed is presented in Table I -1-2.

An optimum survey route was determined from the background information which was provided by the Mongolian team. A geological route map was then drawn from air photos and topographic maps which were drawn at a scale of 1:100,000. At each study area along the survey route, detailed observations were made and recorded as accurately as possible. Imporatant outcrops were also sketched at an appropriately reduced scale and photographed in color. The precise locations of the study areas were determined by GPS measurements. The results of these studies were then analyzed with the cooperation of the Mongolican team in Ulaanbaatar and geological maps of each study area were then prepared in accord with the superintendent's instructions.

3. Satellite Image Analysis: The remote sensing team, working in Tokyo, determined the distribution of geological units, the location of alteration zones and lineaments within the study area by photo-geological analysis of color printed MSS images and TM CCT data. The TM CCT data were at a scale of 1:200,000 and the MSS images were at a scale of 1:500,000 and 1: 100,000. The MSS images were used to produce larger mosaic images.

The larger scale MSS images at a scale of 1:500,000 were used to determine lineaments and the distribution of geological units in the study area. The images which were employed in this process are presented in Table II -2-1 and the area covered by these images is shown in Figure II -2-1. The results of the photo-geological analysis were reviewed and correlated with geological structure, the distribution of known ore deposits and the location of areas where mineralization is indicated by use of a composite analysis map.

Alteration zones around known deposits were identified by spectral analysis of light reflected by the earth. False color images (color prints at a scale of 1:200,000) were made by combining TM CCT data from two color bands (2,3,4 and 4,5,7). The data which was used in this process is listed in Table II -2-2 and the scales of these data area shown in Figure II -2-2.

The reflected spectra of rock samples collected during the field survey were also measured. From these measurements the proportional arithmatic processing appropriate for the identification of the alteration zones was determined. An alteration zone extraction map was then prepared form the results of this work.

1-3 Organization of survey mission personnel

1. Survey planning and negotiations teams

a) Japanese staff

Hiroshi SHIMIZU	Metal Mining Agency of Japan (MMAJ)

Kyoichi KOYAMA	Metal Mining Agency of Japan
Toshio SAKASEGAWA	Metal Mining Agency of Japan
Mitsuhiro WADA	Chinese Division, Asian Bureau, Ministry of Foreign Affairs
Shinji IKEDA	Mining Division, Board of Resource Energy, Ministry of International Trade and Industry
Kazuyuki MURAKAMI	Metal Mining Agency of Japan
Hideya METSUGI	Metal Mining Agency of Japan
Takeshi SHIROMIZU	Japan International Cooperation Agency

b) Mongolian stuff

G. BATTSENGEL	Director, United Nations and Western Countries, Ministry of International Trade and Industry
L. NASANBUYAN	Ministry of International Trade and Industry, (Japanese Division)
Z. BARAS	Head, National Geology Center
J. TSEND-AYUSH	National Geology Center
B. AMARSAIHAN	National Geology Center
T. RENCHINDORJI	Geology Company
SH. BAASANDORJI	Geology Company

2. Field survey teams

a) Japanese stuff

Eitaro SATO	(Leader, existing data compilation) Mitsui Mineral Development Co.,Ltd
Akeo ONISHI	(geological survey, existing data compilation) Mitsui Mineral Development Co.,Ltd
Kiyoshi NAKAMURA	(geological survey, existing data compilation) Mitsui Mineral Development Co.,Ltd
Hideo SUZUKI	(geological survey, existing data compilation) Mitsui Mineral Development Co.,Ltd
Shigeyuki YAMASAWA	(geological survey, existing data compilation) Mitsui Mineral Development Co.,Ltd

b) Mongolian stuff

J. TSEND-AYUSH	(Organizer, existing data compilation) National Geology Center
D. BATBOLD	(geological survey) Geology Company
K. ENKHTUPUSHIN	(geological survey) Geology Company
BAYAR-SAIHAN	(geological survey) Dornod exploration site
SH. BAASANDORJI	(geological survey) Person in charge, Geology Company
D. GARAMJAV	(geological survey) Geological Institute

3. Satellite image analysts (in Japan)

Koji YASHIRO	Mitsui Mineral Development Co.,Ltd
Kazuhiro ADACHI	Mitsui Mineral Development Co.,Ltd
Hidehisa WATANABE	Mitsui Mineral Development Co.,Ltd

Table I-1-1 Dispatchment of survey mission

1. Specification

Contents of survey	Number of geologist	Term of dispatchment
1) Data compilation		
Responsible engineer	1 geologist	105 days
Geologist	4 geologists	15 days each
2) Geological survey		
Field survey	4 geologists	60 days each
Field analysis	4 geologists	7 days each
	Total	433 days

2. Performance

Number of geologist		Depperture		Arrival	Term of dispatchment
Responsible engineer	1	June 18	~	Oct. 8	113 days
Geologist	3	June 18	~	Sept. 16	91 days each
Geologist	1	July 1	~	Sept. 16	78 days
				Total	464 days

Table I-1-2 Lavoratory work

Testing items	Quantity Specified	Dornod	Tumurtiin -Ovoo	Nuhutt-Davaa	Har-Airag	Lugiin -gol	Tsagaan-suvraga	Ulziit	Performance Total
1. Thin sections	80	26	14	4	3	8	7	20	82
2. Polished sections	50	19	16	1	0	1	11	4	52
3. Whole rock chemical analysis	50	17	5	2	2	7	6	12	51
4. Ore analysis	370	82	45	12	29	7	90	120	385
1) Polymetallic vein and skarn (Cu, Pb, Zn, Ag, Au, Mo, W)	(100)	62	32	10	0	0	0	0	104
2) Porphyry copper (Cu, Mo, Ag, Au)	(100)	0	13	0	0	0	90	0	103
3) Auriferous quartz vein (Au, Ag)	(90)	18	0	0	0	0	0	74	92
4) Carbonatite and Apatite rock (TREO, Sr, Ba, P, Y)	(30)	0	0	0	0	7	0	26	33
5) Fluorite ore (CaF_2, SiO_2, $CaCO_3$, Fe_2O_3,)	(30)	0	0	2	29	0	0	0	31
6) Strontium ore ($SrSO_4$, $BaSO_4$, $CaSO_4$, Fe_2O_3,)	(20)	2	0	0	0	0	0	20	22
5. X-ray diffraction	100	25	12	5	9	6	19	26	102
6. Dating	30	10	3	0	0	7	3	7	30
1) K-Ar Method (whole rock)	(5)	2	0	0	0	1	0	2	5
2) K-Ar Method (mineral)	(20)	4	2	0	0	6	3	5	20
3) Pb-Pb Method (mineral)	(5)	4	1	0	0	0	0	0	5
7. Fluid inclusion test	10	3	0	1	2	1	0	7	14
8. Fossil identification	1	0	0	0	0	0	1	0	1

Chapter 2 Geography of the Survey Area

2-1 Location and access

1. Location

The survey area is called the Uudam Tal area, which means "a vast plain" in the Mongolian language. It is located in the southeastern part of the Mongolian People's Republic and has a width of 300 to 400 km and a length of 1,200km, covering an area of 500,000km^2. Within the Uudam Tal area there are six administrative districts. These are the Aimags of Hentii, Dornod, Subaatar, Dundgovi, Dornogovi and Umnugovi (Fig. I-2-1).

The survey area was bounded by the southeastern border of the MPR, a line from the boarder north to a point at 45°00'N, 103°00'E, a diagonal line to a second point at 48°00'N, 113°00'E and a line north from the latter point to the boarder.

2. Access

Ulaanbaatar can be reached by express train from Beijing in 30 hours or by regular train in 40 hours. As of October, 1991, however, a flight from Beijing to Ulaanbaatar was available with a flight time of one hour and 50 minutes.

The terrain between Ulaanbaatar and the survey area is a vast desert steppe at an elevation of 1,000 to 1,500m. This region is easily accessible by motor vehicles, but most of the roads are not hard surfaced and can only be traveled at speeds of about 40 kph. For this reason it is advisable to travel by domestic airlines to all areas except Har Airag, which is close to Ulaanbaatar. The domestic flight schedules from Ulaanvaatar to cities in the survey area are as follows:

To	Daily flights	Flight time
Choibalsan	1 or 2	1 hr 25 min
Barn-Urt	2	1 hr 25 min
Dalanzadgad	2	1 hr 40 min

(The times shown are one way flight times)

In the rural survey area, while the roads are little more than tracks, the terrain is a flat and four wheel drive vehicles can be driven almost everywhere. The area is a desolate desert steppe, however, with no food, water or shelter and it is necessary to travel in groups.

2-2 Topography and drainage

1. Topography (Fig. I-2-2)

The survey area is a vast plain called the Mongolian Highland at an elevation of 700 to 1,500 m. Influenced by the balance between the amount of precipitation and evaporation, the northern part of the area is steppe, and the southern part is desert. The lowest point in the survey area is Lake Khuh which is in the northeastern part of the area at an elevation of 560m. The highest point of the survey area is in the southwest. It is a peak in the mountains of Gurvan-Saihan which has an elevation of 2,825m.

Topographically, the survey area can be divided into five regions. These are the Dornod Plain in the north, the Gobi Lowland which extends southwest from the plain, the East Mongolian Highland to the north of the Gobi Lowland, the Dariganga Highland which is south of the Gobi Lowland and the Gobi Altai Mountains in the southwest of the survey area.

The Dornod Plain has the lowest mean elevation of these regions. It is a vast plain which lies at an elevation of 600 to 1,000 m with scattered post-erosional hills. These low hills have peak elevations of only 1,000 to 1,200m.

The Gobi Lowland is a low zone in structure with a width of 30 to 150km, extending to the southwest from the Dornod Plain. It is a desert zone at an elevation of 900 to 1,000m, with scattered remanent hills at an elevation of 1,000 to 1,200m.

The East Mongolian Highland is a gently rolling plain with scattered remanent hills. It has an approximate width of 300km, a length of 800km and an elevation of 1,000 to 1,500m. The hills in this region have elevations of 1,500 to 1,700m. The northwest half of this region is adjacent to Hentii, Altai and the Gobi Altai Mountains and higher elevations are found here than in the southeastern potion of the region.

The Dariganga Highland is at an elevation of 1,000 to 1,200 m and scattered remanent hills have elevations of 1,500 to 1,700 m in this region. It is located southwest of the Dornod Plain and south of the Gobi Lowland and is covered with extensive plateau basalt.

The Gobi Altai Mountains are located in the southwest end of the East Mongolian Highlands. They are composed of several mountain ranges, such as the Gurvan-Saihan, the Ih-Shanhai, etc. These mountains have elevations which range from 1,700 to 2,800m and trend from west-norht-west to east-south-east through this region. They are cut by the Gobi Lowland which runs through the area from southwest to northeast and they disappear further to the east.

2. Drainage (Fig. I-2-3)

The majority of the drainage in the survey area is in Dornod and Hentii Aimags upon the Dornod Plain. It consists of the Ulz, Galin, Kherlen and Halhin Rivers, all of which are blind rivers flowing into inland lakes in Mongolia, China and Russia. There are a few large rivers with permanently flowing water in the southern part of the East Mongolian Highland, but most of these flow into the Gobi Lowland and disappear.

2-3 Climate and vegetation

1. Climate (Table I-2-1)

Average annual temperatures in the survey area range from a low of −1.6°C in the city of Choibalsan to a high of 3.9°C in Dalanzadgad. The highest average monthly temperature is 23.2°C in Sainshand during the month of July and the lowest is −21.3°C in Choibalsan in January. During the course of a year temperatures in this area can show a range of 80°C, with the highs of 45 to 47°C occurring in the Gobi desert and lows of −43°C in the city of Choibalsan.

The survey area is arid both in the steppe and in the desert with generally higher precipitation in the north than in the south. The annual precipitation ranges from a high of 246 mm in Choibalsan to a low of 100 mm in the Gobi area. The precipitation in this area is seasonal occurring primarily in the form of rain. The rainly season lasts from May to September with the peak rainfall in July. The winter is a dry season with only a few millimeters of precipitation per month.

The wind is generally strong throughout the year in this area. The strongest winds are observed in the Gobi desert during the months of March, April, May and November. There are 40 to 50 days of sand storms each year, during these months. The weather conditions in the Gobi are very severe during the summer when hot winds are accompanied by temperatures above 40°C.

2. Vegetation

The vegetation in the survey area is largely controlled by the balance between the amount of precipitation and evaporation. On the Dornod Plain and in the northern part of the East Mongolian Highlands, the precipitation is high during the summer but the temperature is low and there is little evaporation. Due to the low evaporation, there are few trees but relatively tall grass and thick ground vegetation forming a steppe.

The annual precipitation is generally low and temperatures are very high in the Gobi area. As a result, the Gobi Highland, which is quite dry, is a rock desert and the lowland is barren desert with sand hills. The intermediate zone between the highlands and lowlands is a semi-arid steppe with short grass and little vegetation. Trees are, on the whole, very scarce here and only short trees which are unique to the Gobi Desert are found. These trees are sparse but gregarious and are called Gobi trees. They are found at oases and on lowlands of the desert which occasionally become damp.

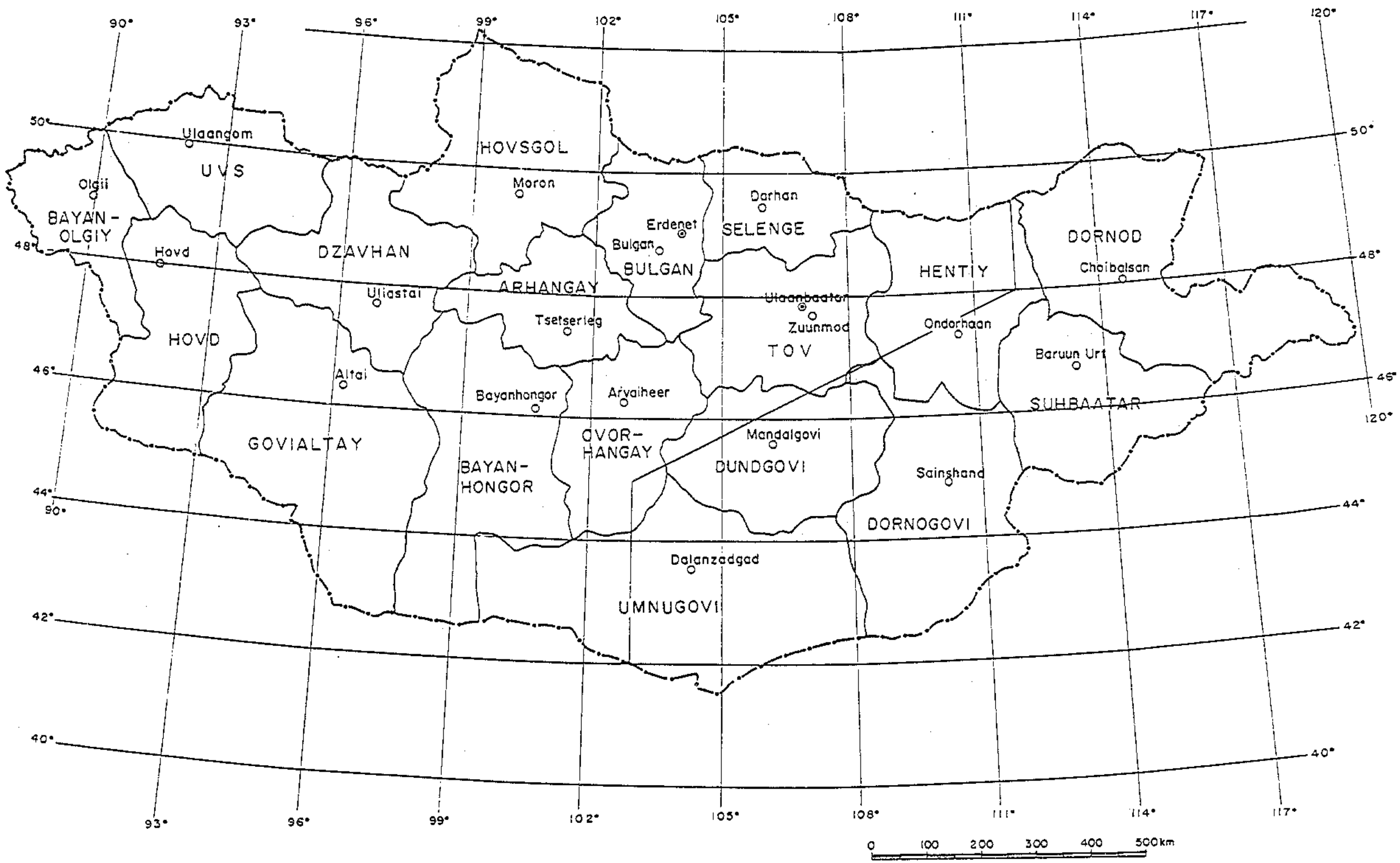


Fig. I-2-1 Administrative division

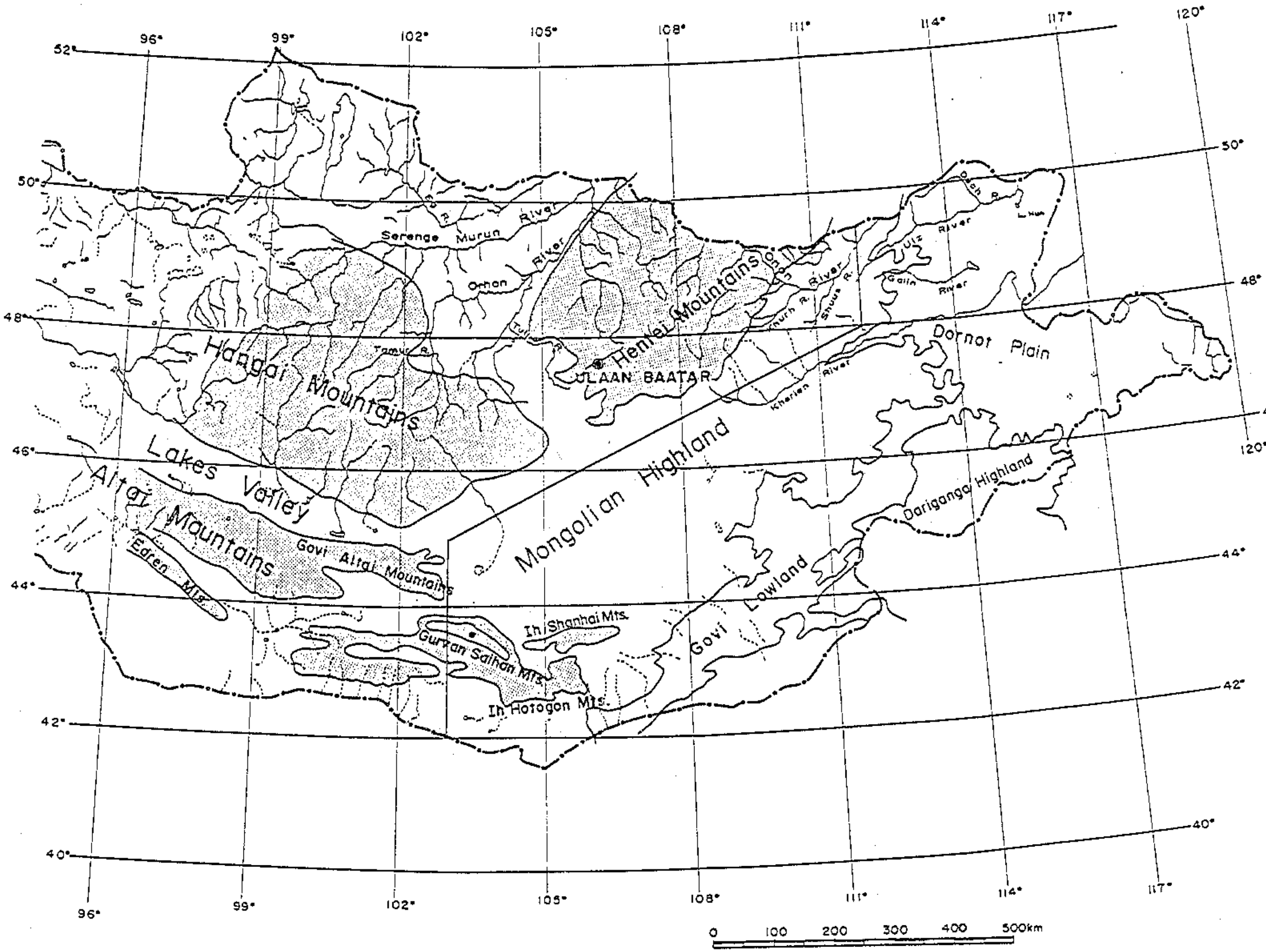


Fig. I-2-2 Geographical features

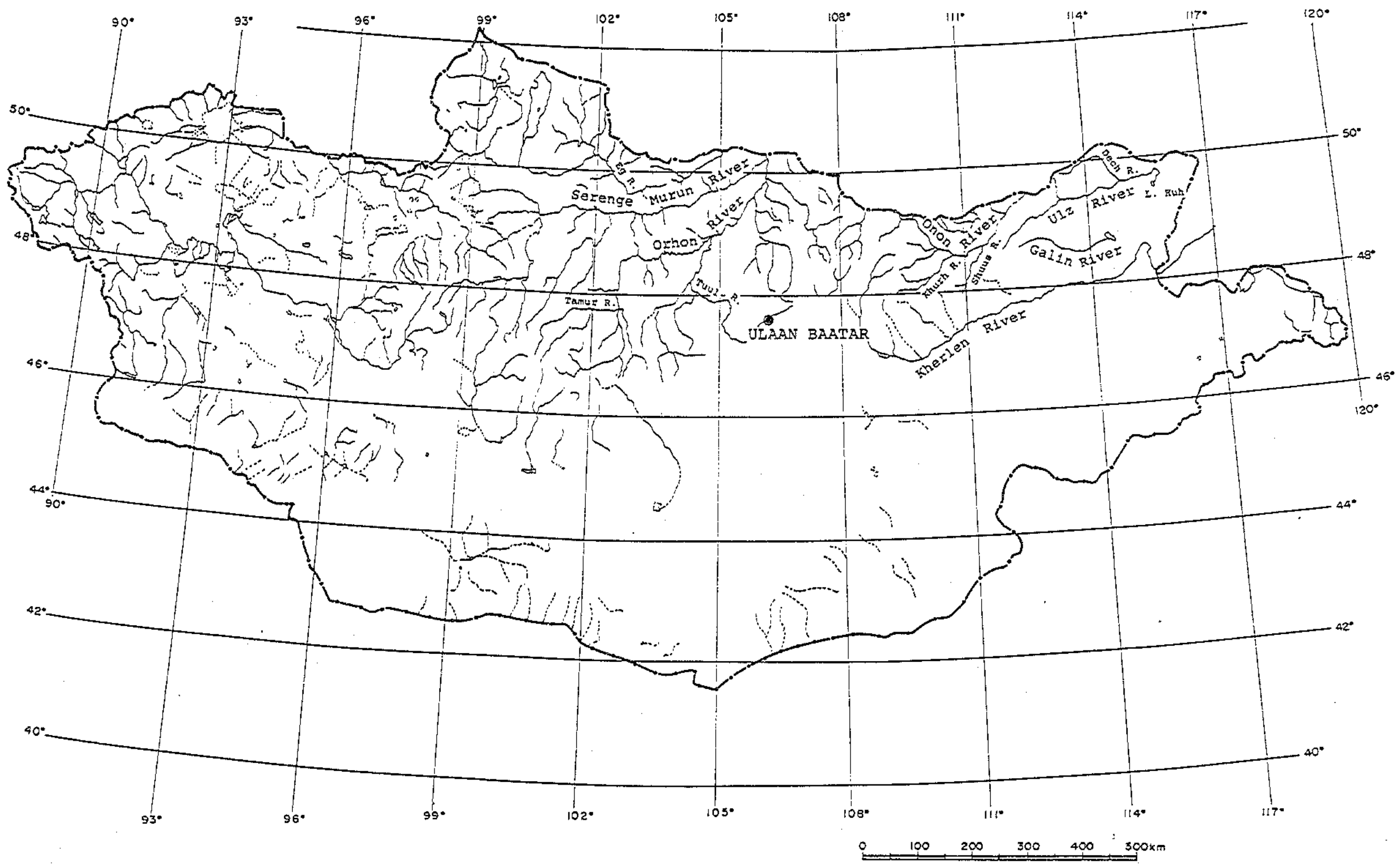


Fig. I-2-3 Drainage systems

Table I-2-1 Major climatic indices of the area

Mean Monthly and Annual Temperature (°C)

Meteorological station	*Mean Monthly*												*Annual average*
	Jan.	*Feb.*	*March*	*April*	*May*	*June*	*July*	*Aug.*	*Sept.*	*Oct.*	*Nov.*	*Dec.*	
Altai	−18.9	−17.0	−8.9	−0.5	6.9	12.6	14.0	12.7	6.3	−1.8	−10.8	−16.9	−1.8
Arvaiheer	−15.5	−13.9	−6.6	1.4	8.5	14.2	15.4	14.0	8.4	1.2	−8.2	−14.1	0.4
Baruun Urt	−21.5	−18.6	−8.5	2.9	11.2	17.4	19.9	17.9	11.2	1.3	−10.1	−18.9	0.4
Bayanhongor	−18.4	−16.8	−7.9	1.0	9.3	15.0	15.9	14.4	7.9	−0.8	−10.8	−17.4	−0.7
Bulgan	−21.3	−19.2	−9.5	0.8	8.6	14.7	16.3	14.4	7.5	−1.3	−11.4	−19.2	−1.6
Choibalsan	−21.3	−18.8	−9.1	2.4	11.1	18.0	20.6	18.2	10.7	1.8	−10.5	−18.9	0.4
Dalanzadgad	−15.4	−12.2	−3.2	6.1	13.6	19.4	21.2	19.5	13.2	4.8	−5.8	−14.0	3.9
Hovd	−25.4	−20.8	−7.3	3.8	11.5	17.5	18.9	16.9	10.4	1.3	−10.1	−20.3	0.3
Mandalgov'	−18.0	−15.3	−7.0	2.7	10.6	16.9	18.8	17.2	10.3	1.8	−8.3	−16.8	1.1
Mörön	−23.8	−19.7	−8.3	1.5	9.1	15.7	16.9	14.7	7.8	−1.2	−12.3	−21.5	−1.8
Ölgii	−17.8	−15.2	−6.4	1.9	8.9	14.8	14.5	14.6	8.3	−0.1	−9.1	−16.3	−0.2
Öndörhaan	−23.2	−20.2	−9.5	2.3	10.4	16.8	18.8	16.8	9.7	0.6	−12.2	−21.1	−0.9
Sainshand	−18.4	−14.8	−4.7	5.9	14.0	20.6	23.2	21.1	13.8	4.3	−7.5	−16.5	3.4
Sühbaatar	−23.3	−19.6	−8.0	3.3	10.5	17.2	19.1	16.6	9.8	0.5	−10.0	−19.9	−0.3
Tsetserleg	−15.6	−14.1	−6.9	1.1	8.1	13.3	14.7	13.1	7.4	0.2	−8.4	−14.1	0.1
Ulaanbaatar	−26.1	−21.7	−10.8	0.5	8.3	14.9	17.0	15.0	7.6	−1.7	−13.7	−24.0	−2.9
Ulaangom	−33.0	−30.2	−19.0	−0.2	11.1	17.7	19.2	16.9	10.0	0.1	−11.3	−26.8	−3.8
Uliastai	−23.1	−21.2	−11.3	0.3	7.9	14.1	15.4	13.7	7.1	−1.4	−13.9	−21.6	−2.8
Zuunmod	−20.5	−18.4	−9.9	0.1	7.9	13.8	15.4	13.7	7.4	−0.7	−11.1	−18.9	−1.8

Note: Mongolia's climate is sharply continental. Throughout the year, there are 250 sunny and 9–23 cloudy days. The duration of the period with a mean daily temperature higher than 0°C lasts about 170–190 days, increasing to the south and south-east up to 200–215 days.

Mean Monthly Precipitation (mm)

Meteorological station	*Jan.*	*Feb.*	*March*	*April*	*May*	*June*	*July*	*Aug.*	*Sept.*	*Oct.*	*Nov.*	*Dec.*	*Total yearly*
Altai	1.2	1.8	6.7	9.9	14.1	28.9	44.4	42.2	14.8	7.6	3.3	2.0	176.9
Arvaiheer	0.9	1.8	4.2	8.8	17.1	40.6	91.7	61.9	17.9	4.8	2.8	1.7	254.2
Baruun Urt	2.2	1.7	3.3	7.0	13.7	31.1	57.0	42.1	23.2	5.8	2.7	1.9	191.2
Bayanhongor	1.9	3.2	4.5	9.3	15.2	33.8	66.4	54.5	16.4	7.1	2.6	1.5	216.3
Bulgan	1.4	2.1	3.9	9.4	24.5	57.1	101.0	77.9	30.2	11.4	3.6	1.8	324.3
Choibalsan	1.9	2.4	3.0	6.7	14.8	40.8	75.7	59.4	27.1	8.2	3.3	2.7	246.0
Dalanzadgad	1.1	1.5	2.8	5.6	11.2	23.9	33.5	34.6	12.4	2.9	1.9	1.1	132.5
Hovd	1.6	1.2	1.7	5.4	13.1	17.7	34.5	27.6	9.6	3.2	1.5	2.1	119.0
Mandalgov'	0.7	1.4	2.0	3.3	10.2	33.0	46.5	45.6	14.1	3.8	1.8	1.4	163.8
Mörön	1.5	0.9	2.1	6.4	13.8	46.2	70.1	60.6	22.3	6.2	2.5	1.9	234.5
Ölgii	0.8	0.6	1.2	4.3	10.9	23.5	33.8	15.4	12.2	2.2	0.9	1.3	107.1
Öndörhaan	1.8	2.6	4.7	7.4	15.8	47.0	73.3	58.9	29.5	7.3	3.7	2.2	254.2
Sainshand	0.7	1.4	1.3	4.2	10.4	19.6	34.9	27.0	9.8	4.3	1.5	1.0	116.1
Tsetserleg	2.5	3.7	5.9	17.4	32.5	68.5	90.9	76.0	27.7	11.2	6.0	2.3	344.0
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	233.0
Ulaangom	2.2	2.1	3.5	4.2	7.1	23.2	36.0	27.2	14.0	4.5	7.7	3.6	135.3
Uliastai	2.6	2.6	5.6	9.6	15.0	33.8	65.2	42.1	21.9	8.0	4.9	5.7	217.0
Zuunmod	1.4	2.1	3.8	8.9	14.4	49.8	83.8	64.8	29.6	6.0	3.6	2.6	270.8

Note: Precipitation is extremely irregular according to different seasons of the year. During the coldest months (October–March) just 8–10 per cent of the total annual precipitation falls and 67–78 per cent during the three summer months (June–August). The lowest precipitation is in January and the highest in July.

Mean Monthly and Annual Wind Velocity

Meteorological station	*Mean Monthly*												*Annual average*
	Jan.	*Feb.*	*March*	*April*	*May*	*June*	*July*	*Aug.*	*Sept.*	*Oct.*	*Nov.*	*Dec.*	
Altai	2.7	3.0	3.4	4.3	4.4	3.8	3.0	3.0	3.1	3.5	3.5	2.8	3.3
Arvaiheer	2.8	3.1	3.6	5.0	4.8	4.0	3.3	3.1	3.4	3.5	3.5	3.0	3.6
Baruun Urt	3.0	3.2	3.6	4.9	4.8	4.4	3.4	3.1	3.5	3.4	4.9	3.1	3.8
Bayanhongor	2.8	2.8	3.0	3.8	3.9	3.1	2.8	2.7	3.0	3.0	3.2	2.9	3.1
Bulgan	0.6	1.7	2.3	3.0	3.0	2.6	2.1	1.9	2.2	2.1	2.0	1.7	2.2
Choibalsan	3.8	4.1	4.5	5.4	4.5	4.1	3.5	2.2	3.7	4.0	4.0	4.3	4.1
Dalanzadgad	3.0	3.5	4.4	5.6	5.6	4.4	4.0	3.6	3.7	3.4	3.8	3.1	4.0
Hovd	0.9	1.3	2.0	2.7	2.8	2.3	1.8	1.7	1.8	1.9	1.7	1.0	1.8
Mandalgov'	3.9	4.2	4.4	5.5	5.8	4.9	4.2	3.7	3.9	3.6	4.0	4.0	4.3
Mörön	1.0	1.4	2.2	3.3	3.2	2.1	1.7	1.6	1.7	1.7	2.1	1.4	1.9
Ölgii	2.4	2.9	2.5	3.2	3.5	3.2	2.5	2.9	2.6	2.9	3.3	2.1	2.8
Öndörhaan	3.4	3.3	3.9	4.8	4.8	4.0	3.7	3.3	3.5	3.5	3.3	3.4	3.7
Sainshand	3.8	4.0	4.7	5.7	5.8	5.0	4.1	3.8	4.0	3.9	4.1	4.2	4.4
Sühbaatar	1.7	1.9	2.4	3.2	3.4	2.8	2.3	2.4	2.5	1.7	2.3	2.2	2.4
Tsetserleg	2.4	2.5	2.8	3.5	3.3	2.4	2.1	2.0	2.4	2.6	2.8	2.5	2.6
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	2.2
Ulaangom	0.8	0.9	1.1	1.7	2.3	2.1	1.6	1.5	1.5	1.5	1.3	0.9	1.4
Uliastai	1.2	1.2	1.6	2.6	2.7	2.5	2.3	2.2	2.5	1.7	1.2	1.1	1.9
Zuunmod	1.7	2.2	2.8	3.6	3.7	2.8	2.3	2.0	2.5	2.3	2.5	2.1	2.8

Note: The mean annual wind velocity varies from 2–3 metres per second over a large part of the country's territory to 5 metres per second in the extreme south-east. Throughout the course of the year, it is calm, which is one of the essential peculiarities of the wind regime.

Chapter 3 General Geology

3-1 Outline of past surveys and brief history of mining

The record of resource surveys and development in Mongolia traces back to the the beginning of gold mining in the 11-12th centuries. Early in the1800's, gold mining was started by gold traders in the Altai and south Hangai, early in the 1900's, "Mongolor", a Russian-Mongolian company was founded, and gold mining began in the northern part of the Hentii hills. Though there have been many changes since then, alluvial gold mining has become the core of mining in the country until the middle of the 1970's.

Upon the Russian Kabariam's discovery of tungsten veins in a part of the Yuguzer deposit during his survey for water resources in 1939, a modern geological survey began in the survey area. Following this, from 1942 to 1943 geological surveys were conducted by the Soviet Union around the Yuguzer deposit, and in 1943 mining was commenced at the deposit. In 1954, geological survey at a scale of 1:200,000 was started at the Har-Airag district. Until Yuguzer mine was closed, the main activity was the exploration of the Nuhut-Dawaa district. The Soviet Union also discovered the Bor-Undur deposit in the same year, and since then the survey of fluorite resources at the Har-Airag district as well as mining at the Nuhut-Dawaa district has become active.

In 1964, the Tsagaansuvraga deposit (Cu) was discovered by local people, and the following year, in 1965, a survey over a wide area around the Tsagaansuvraga deposit began. In 1966, Hungary and Mongolia entered into a cooperative survey at the Tumurtiin-Ovoo district, where tungsten deposits such as Salaa, Salhit, etc., were discovered and in 1967, Arin-Nuur deposits (Cu, Mo) were also discovered. Since then geological surveys by COMECON countries led by the Soviet Union have been carried out very intensively on the area covering the whole Uudam-Tal area. From 1971 to 1972, the Soviet Union conducted a geological survey around Tsagaansuvraga deposit, and discovered a number of copper ore showings. In 1972, the Mardai (U) and Lugiingol deposits (REE), in 1974, the Tumurtiin-Ovoo deposit (Zn) were discovered and the development of the Hongor deposit (fluorite) was commenced. In 1975, the Tsav and Bayan-Uul deposits (Ag, Pb, Zn), in 1976, the Bayan-Hoshoo deposit (Sr), in 1978, the Chol-Tsagaan-Del deposit (fluorite) were discovered, and in 1980, a mining at the Marudai and Chol-Tsagaan-Del deposits was started. Thus resource surveys in the Uudam-Tal area in Mongolian People's Republic expanded rapidly from 1964 on, and most of the deposits presently known were discovered during the ten years until 1970. Since then a follow-up survey was conducted on the each deposit, and mining was started at some deposits such as Marudai, Bor-Undur, Chol-Tsagaan-Del and Adag. However, many mineral showings were investigated only intermittently up to now.

Surveys conducted by various kinds of geological survey groups with the cooperation of COMECON countries are generally large scale and systematic. Usually at the beginning of surveys, airborne magnetic survey was conducted, and at the same time a geological map over a wide area at a scale of 1:500,000 was made. They are followed by a geological survey over a wide area at a scale of 1:200,000 mainly by systematic geochemical exploration and aerial photo analysis. If some mineral showings are found, further detailed surveys are conducted, and at the same time, by using various methods, such as γ-ray spectrum method, IP method, pitting, trenching, diamond drilling and tunneling are conducted for a period of two or three years in most cases.

These survey reports (in Russian) are strictly kept, with serial numbers on their back, at a library in the former International Geological Center building in Ulaanbaatar, and their total number is said to be more than 6,000.

3-2 General geology around the survey area (Fig. I-3-1, Fig. I-3-2)

Mongolia is located in the fold belt called Mongolian geosyncline between Siberian platform block and Sino-Korean block. The sedimentation of the "geosyncline" took place from the Precambrian to the Paleozic and these sedimentary rocks have undergone the orogenic movements in Baikalian (latest Proterozoic), Caledonian (early Paleozoic) and Hercynian (late Paleozoic). The composing rocks are gneiss, schist, phyllite, crystalline limestone, sandstone, shale, siltstone, limestone, such volcanic rocks as basalt, rhyolite, which folding intensively and forming an arc convexly with a southern aspect, are distributed outside the Siberian block. These sediments are intruded by granite of various ages since the Proterozoic. From north Mongolia to Da Xing An Ling, the igneous activity lasted to the Mesozoic Era, and the volcanic and granitic rocks of Jurassic to Cretaceous ages (Yenshan period) are widely distributed. In the Gobi district, serpentinized ultrabasic rocks supposed to be ophiolite are distributed sporadically along a major tectonic line parallel to the fold axis.

In the east side of the fold belt, there is a block called Dong Bei para-platform (Breya block), and in the south side, another one called Sino-Korean block, both being Precambrian. All the three basins, Junggar (or Dzungar), Tarim and Tsaidam are underlain by the Phanerozoic formations of several tens of km thick, but in the depth there exist crystalline metamorphic basement rocks. Between these basins, the mountains of Altai, Tenshan and Kunlun composed of metamorphic rocks of the Hercynian Period run from east to west.

In the Gobi district there are some inland sedimentary basins in addition to the above, and many coalfields are formed.

Mongolian fold belt is considered to be an accretionary zone to the Siberian plate by the subduction of oceanic plate in Paleozoic Era (Parker and Gealey, 1985).

3-3 Geological situation of the survey area

The survey area is located in the fold belt, formerly called the "Mongolian geosyncline" on the southern or southeastern margin of the Siberian block. The geology consists of, from the oldest, the Middle Proterozoic Group on the southwestern part of the Hai-Airag district, the Paleozoic Group distributed widely on the whole area and the Jurassic System distributed in the southeastern part of Dornod, around Choir and from the southern part of the Har-Airag district to the the Gobi area. These strata have undergone orogenic movements in the Baikalian (latest Proterozoic), the Caledonian (early Paleozoic) and the Hercynian (late Paleozonic), and were intruded by granite of various ages since Proterozoic. In the Dornod district in the east, the igneous activity lasted to Mesozoic, and the volcanic and granitic rocks of the Jurassic to Cretaceous (Yenshan period) are widely distributed.

The Middle Proterozoic System, covered uncomformably by the Paleozoic and Mesozoic groups, is exposed like a fenster in an oval area of the 80km east-west and 30km north-south at the southeastern part of the Har-Airag. It consists of gneiss, schist, crystalline limestone and gneissose granite intruding into these rocks, and forms the country rock of the fluorite deposits at Hongor, Maihanta, etc. In the Dornod district, in addition to those, gneiss and schist supposed to be the Proterozoic (?) are distributed at the Tsav deposit in the northwestern and eastern parts.

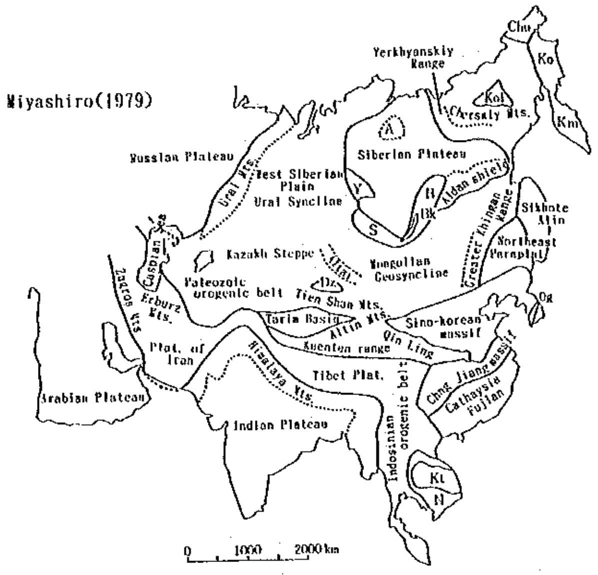
The Paleozoic, found widely in the whole area, consists of schist, phyllite, sandstone, shale, siltstone, limestone, chert and volcanic rocks of Silurian to Permian ages, intensively folding and forming an arc convexly with a southern aspect outside the Siberian block. In the Gobi district,serpentinized ultrabasic rocks are distributed sporadically along a major tectonic line parallel to the fold axis.

These sediments are intruded by granites of various age since the Paleozoic, and forms the country rock of the skarn deposit in the Tumurtiin-Ovoo and the gold showings in the Ulziit district.

The Mesozoic, distributed widely in the Gobi district, consists of the volcanic and granitic rocks of Jurassic to Cretaceous ages (Yenshan Age), and the sediments of inland sedimentary basins of Cretaceous Period accompanied by coal measure. In the Dornod district volcanic and granitic rocks of Jurassic to Cretaceous ages are distributed widely and the polymetallic deposits consisting of silver, lead and zinc are accompaned by these rocks.

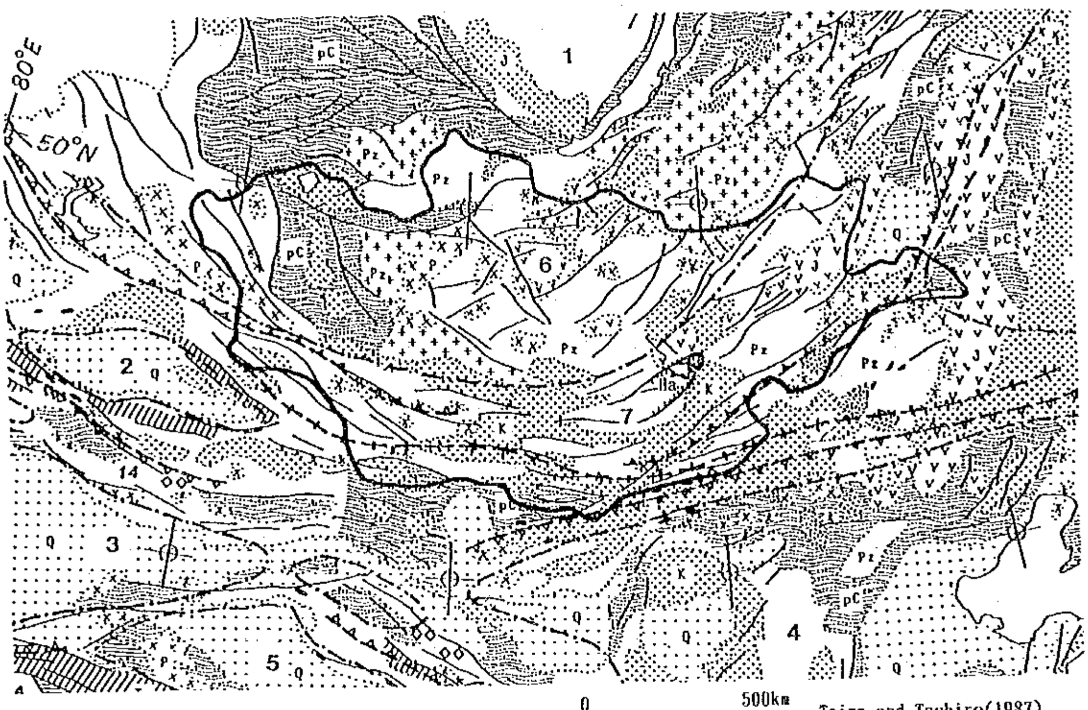
The survey area is the area where igneous activities had most actively repeated since the Paleozoic in Mongolia, and contains most of the major mineralized zones in association with them.

Miyashiro(1979)



LEGEND

A: Anabar Plateau
B: Baikal Mts.
Bk: Lake Baikal
Chu: Chukotskiy Pen.
Dz: Dzungaria Basin
Km: Kamchtka Pen.
Ko: Koryak Mts.
Kol: Kolyma massif
Kt: Kontum massif
N: Hersinian ologenic belt
Og: Ogcheon Geosyncline
S: Sayan Mts.
Y: Yenisei Mts.



Taira and Tashiro(1987)

L E G E N D

Sedimentary rocks

- Quaternary(Nonmarine)
- Palaeozoic(Sedimentary and Metamorphic Rocks)
- Nonmarine Sedimentary Rocks

pC: Precambrian
Pz: Paleozoic
P : Permian
J : Jurassic
K : Cretaceous
Q : Quaternary

Igneous rocks and metamorphic rocks

- Tertiary igneous rocks (chiefly volcanic rocks)
- Mesozoic volcanic rocks
- Permo-Mesozoic Granitic Rocks
- Paleozoic Igneous Rocks
- Precambrian and Early Paleozoic Basement Rocks
- Ophiolites
- Blue Schists
- Har-Airag Block(middle Proterozoic) gneiss, crystalline schist, marble, gneissose granite

- Fault
- Approximate Location of Ancient subduction zone
- Approximate Location of suture zone
- Approximate boundary of continental blocks

1 Siberian Block
2 Junggar Block
3 Tarim Block
4 Sino-korean Block
5 Tsaidam Block
6 Sajany AFB(Early Paleozoic)
7 Altay-Hinggan AFB(Late Paleozoic)

Fig. 1-3-1 Geological setting of the area

EONOTHEM	ERATHEM	SYSTEM	SERIES	MPR	DORNOD	NUHUT-DAWAA	TUMURTIIN-OVOO	HAR-AIRAG	LUGIINGOL	TSAGAANSUVRAGA	ULZIIT	GEOCHRONOMETRY Ma BP	MAGNETO-STRAT.
PHANEROZOIC	CENOZOIC	QUATERNARY	HOLOCENE	Q_{IV}	grey sand-pebble	grey sand-pebble	grey sand-pebble	grey sand-pebble	grey sand-pebble	grey sand-pebble	grey sandstone, conglomerate	(0.01)	BRUNHES
			PLEISTOCENE UPPER	Q_{III}									
			PLEISTOCENE MIDDLE	Q_{II}									
			PLEISTOCENE LOWER	Q_{I}								1.8	MATUYAMA
		NEOGENE	PLIOCENE UPPER / LOWER	N	P-N mixed colored terrigenous	P-N mixed colored terrigenous	P-N mixed colored terrigenous				P-N mixed colored terrigenous	3.3(3.27), 5.3(4.8)	GAUSS, GILBERT
			MIOCENE UPPER / MIDDLE / LOWER									6.5, 11(11.3), (15), (16.2), 10(21)	
		PALEOGENE	OLIGOCENE	P	clay-silt, gravel-sand	clay-silt, gravel-sand	clay-silt, gravel-sand				clay-silt, sand-pebble	23(23.7), 27(30), (36.5)	
			EOCENE									34(40), 30(43.9), 45(52), 53(57.8)	
			PALEOCENE									59(62.3), 65(64.4)	
	MESOZOIC	CRETACEOUS	UPPER	K_2		red bed-terrigenous-carbonate	red bed-terrigenous-carbonate	red bed-terrigenous-carbonate	red bed-terrigenous-carbonate	red bed-terrigenous-carbonate	red bed-terrigenous-carbonate	65(64.6), 83, 88, 88, 91, 95	NORMAL
			LOWER	K_1	basalt, molasse andesite rhyolite, granite / granodiorite	molasse, (coal bearing) mixed colored clay-silt, gravel-sand	molasse, coal rich, granite, granodiorit	dacite, rhyolite	molasse, continental	molasse(marine and continental)	alkali lava with carbonatite	107(112), 114, 118, 120, 120(115), 135(140)	MIXED
		JURASSIC	UPPER	J_3	molasse(marine & continental)	granite, granodiorite	basalt, andesite		trachybasalt trachyandesite		alkali lava with carbonatite	139, 144, 157	
			MIDDLE	J_2	graite, granite porphyry			andesite, dacite, rhyolite				159, 170, 175, 180	MAINLY NORMAL
			LOWER	J_1			granite					186, 196, 201	MAINLY MIXED
		TRIASSIC	UPPER	T_3	molasse, terrigenous sed							205, 210, 220, 230	MAINLY NORMAL
			MIDDLE	T_2	greywacke, flysh							235, 240	REVERSE
			LOWER	T_1								250	
	PALEOZOIC (UPPER PALEOZOIC)	PERMIAN	UPPER	P_2	P_1 - P_2 dacite, rhyolite		monzonite, granite, granosyenite	andesite, dacite, rhyolite	syenite / granodiorite, granite	alkali granite	andesite, rhyolite	255, 260	
			LOWER	P_1		geosynclinal sediments			rhyolite, monzonite	sandstone, mudstone,	dacite, granite rhyolite,	270, 280	
		CARBONIFEROUS	UPPER SUBSYSTEM: STEPHANIAN (D GZHELIAN, A KASIMOVIAN), WESTPHALIAN (D, C, B, A MOSCOVIAN)	C_3		granite, granodiorite, andesite, dacite, rhyolite,		andesite, dacite, rhyolite	basalt, andesite	alkali granite / sandstone, mudstone quarz-monzonite	andesite, dacite, rhyolite	290, 300, 310	MAINLY REVERSE
			UPPER SUBSYSTEM: NAMURIAN (BASHKIRIAN, SERPUKHOV)	C_2		andesite, dacite, rhyolite			granodiorite	basalt, andesite	granite, granodiorite	325	
			LOWER SUBSYSTEM: VISÉAN, TOURNAISIAN	C_1				molasse, continental marine,	siliceous shale	basalt, andesite	granodiorite, granite	(342), 355	MIXED
		DEVONIAN	UPPER	D_3	terrigenous	jasper quartzite terrigenous	green schist, black schist, terrigenous, tuff, limestone flysh	sandstone, congromerate	granodiorite, graywacke, flysh, tuff, terrigenous	basalt, andesite	jasper, terrigenous graywacke, flysh, tuff, granite	375	
			MIDDLE	D_2	D_{1-2} terrigenous limestone					terrigenous limestone			MAINLY REVERSE
			LOWER	D_1								390	
	(LOWER PALEOZOIC)	SILURIAN	PŘIDOLÍ								terrigenous	410	MIXED
			LUDLOW				granodiorite				molasse(coal rich)	424	REVERSE
			WENLOCK	S_2			?					428	
			LLANDOVERY	S_1							red bed carbonate	438	
		ORDOVICIAN	UPPER: CINCINNATIAN ASHGILL									446	MAINLY NORMAL
			UPPER: CHAMPLAINIAN CARADOC									(454)	
			LOWER: LLANDEILO-LLANVIRN, ARENIG, TREMADOC									455(473), 470, 490, 510	MIXED
		CAMBRIAN	UPPER										MAINLY REVERSE
			MIDDLE									(523)	NORMAL
			LOWER		green shale, black shale	?			terrigenous (greywacke, flysh, tuff		?	530, 550	MAINLY REVERSE
PROTEROZOIC	NEO-PROTEROZOIC		TERMINAL PROTEROZOIC NEOPROTEROZOIC III, CRYOGENIAN, TONIAN	R_3 C_1 Pz_3	green schist, black schist, granite, granodiorit		?	limestone	terrigenous graywacke, flysh, tuff	granodiorite, granite		570(540), 650, 850, 1000	
	MESO-PROTEROZOIC		STENIAN, ECTASIAN, CALYMMIAN	Pz_2				crystalline schist, phyllite				1200, 1400, 1600	
	PALEO-PROTEROZOIC		STATHERIAN, OROSIRIAN, RHYACIAN, SIDERIAN	Pz_1								1800, 2050, 2300, 2500	
ARCHEAN												4000	

Fig-I-3-2 Schematic Stratigraphic Column of the Uudam-Tal Area

Chapter 4 General Comments on the Survey Results

4-1 Geological structure and features of mineralization

1. Geological structure

The survey area is located in the fold belt, formerly called Mongolian geosyncline in the south-southeastern margin of Siberian block. The sediments of the "geosyncline" of the Precambrian to Paleozic have undergone orogenic movements in Baikalian (latest Proterozoic), Caledonian (early Paleozoic) and Hercynian (late Paleozoic).

The rocks consist of gneiss, schist, phyllite, crystalline limestone, sandstone, shale, siltstone, limestone and such volcanic rocks as basalt, andesite, rhyolite which folding intensively and forming an arc convexly with a southern aspect, are distributed outside the Siberian block. These sediments were intruded by granite of various ages since Proteorozoic.

In the survey area, the igneous activity lasted to Mesozoic Era, and the volcanic and granitic rocks of Jurassic to Cretaceous Period (Yenshan period) are widely distributed. In the Gobi area, serpentinized ultrabasic rocks supposed to be ophiolite are sporadically distributed along a major tectonic line parallel to the fold axis.

In the Gobi district there are some inland sedimentary basins of the Mesozoic (mostly Cretaceous Period) and many coalfields are formed.

From the above mentioned circumstances, Mongolian fold belt is considered to be an accretionary zone to the Siberian plate by the subduction of oceanic plate. However there are many problems to be solved, such as the geological situation of the Middle Proterozoic System in the Dornod, Hai-Airag districts.

2. Features of mineralization

In the survey area, various metallogenic provinces with different geological environments are distributed, such as polymetallic deposit zone mainly consisting of silver, lead and zinc, accompanied by hydrothermal auriferous quartz veins (Dornod district), greisen type deposit zone mainly consisting of tungsten and molybdenum (Nuhut-Dawaa district), skarn type zinc deposit zone with magnetite and garnet (Tumurtiin-Ovoo district), fluorite deposit zone (Har-Airag district), carbonatite type rare-earth deposit zone accompanied by alkaline rocks (Lugiingol district), porphyry copper deposit zone (Tsagaansuvraga district), polymetallic zone consisting of carbonatite type rare-earth deposit zones accompanied by alkaline rocks, fluorite deposit , auriferous quartz veins and porphyry type gold deposit (Ulziit district).

As a result of this year's survey, at least it was found and confirmed that the polymetallic deposit in the Dornod district was formed since Jurassic-Cretaceous Period, the skarn deposit in the Tumurtiin-Ovoo district was formed since Jurassic Period, the carbonatite deposit in the Lugiingo district was formed in Triassic Period and porphyry copper deposit in the Tsagaansuvraga district was formed in Carboniferous Period. Also it was confirmed that in the Ulziit district, there were igneous activities during a long range from Devonian to Cretaceous Period. These facts, by specifying the periods various kinds of mineralization, shows the possibility of inspecting or constructing the history of structural development of this area from the study of mineral deposit, and attracts attention as a future subject.

3. Structural control of mineralization

Each mineralization of the seven districts mentioned above found in the survey area forms a striking metallogenic provinces, and their distribution are localized. To clarify the reason, it is necessary to clarify tne age of mineralization of each district and the nature of magma of ralated igneous rocks, and to study based on the history of structural development in this area.

As for structural control of mineralization in each district, as every deposit in the survey area belongs to epigenetic or similar type deposit, it is considered to be possible to locate accurately the mineralized zone by clarifying the relation between deposits and ① related igneous rocks, ② fractures possible to be passages for ore-forming fluid, ③ country rocks appropriate for mineralization, ④ the alteration of country rocks and the homogenization temperature of fluid inclusions. However, many of these points remain to be future subjects.

4-2 Potentials of the existence of ore deposits

1. Dornod district

The geology of this district is composed of granite and volcanic rocks from Jurassic to Cretaceos Period, accompanied by abundant polymetallic deposits (argentiferous lead-zinc deposits) such as Tsav, Ulaan, Muhar.

Concerning this district, various survey works such as geological survey at a scale of 1:200,000, airborne magnetic exploration, geochemical exploration were carried out mostly by the Soviet Union since 1971, and the deposits mentioned above were confirmed as a result of such follow up survey works as γ-spectra survey, trenching, diamond drilling, tunneling, etc., conducted for the anomalies extracted from those surveys.

On the other hand, these deposits are non magnetic bodies except the skarnized zone of the Ulaan. Muhar is a blind deposit and Tsav and Ulaan are supposed to be also the blind deposits which are not eroded so much. Therefore, large potentiality for non magnetic polymetallic blind deposits is expected, and it is possible that these type deposits have been possibly overlooked by the surveys up to the present.

2. Tumurtiin-Ovoo district

The geology of Tumurtiin-Ovoo district is composed of Devonian, Permian and Cretaceous Systems and Permian to Jurassic granites intruding Paleozoic, and with the acidic igneous activities from late Paleozoic to early Mesozoic, high temperature-type deposits were formed, such as the skarn-type zinc deposits of Tumurtiin-Ovoo, Salhiit, etc., greisen type molibdenum deposit of Arin-Nuur, tungsten- quartz vein of Slaa, etc.

All these deposits are exposed on the surface or shallow seated. Since COMECON countries usually conduct airborne magnetic exploration in their early period, magnetic anomaly suggesting the presence of magnetite-type skarn deposits were almost extracted. In addition, as the skarn deposits are localized to the contact zone between igneous rocks and limestone or dolomitic sedimentary rocks, it is easy to limit the target. Therefore, there is a little possibility of remaining of large scale deposits undiscovered here.

The largest Tumurtiin-Ovoo deposit has comparatively big scale and higher grades, and is considered to be worth studying its development. However, as the xenoblock of Palaeozoic rocks which contains deposits are small and limited, little space is remained for exploration around. Other deposits such as Salhiit are generally of low grades and have weak mineralization.

3. Nuhut-Dawaa district

The geology of Nuhut-Dawaa district is composed of Ordovician sandstone, schist and biotite granite which intruded in Trissaic to Jurassic Period. With these acidic igneous activities, greisen type tungsten-molybdenum-beryllium deposits such as Tsentr, Yuguzer, etc., and many other greisen type tungsten-molybdenum deposits, tungsten-bearing quartz veins, or pegmatite type beryllim deposits were formed, and form metallogenic province of a rare metal.

In this district during a long time since 1942 up to early 1980's, exploration activities were energetically conducted applying the methods of geochemical exploration,airborne magnetic exploration, gravity exploration, radioactivity exploration, IP method, trenching, drilling, tunnelling etc. As a result, the nature of its mineralization became clear, and even low grade, small scale mineral showings with poor continuity were surveyed in detail. Accordingly there is a little possibility of new large scale and high grade deposits to be discovered at this district in the future.

4. Har-Airag district

The geology of Har-Airag district is composed of various kinds of gneisses, schists, crystalline limestone of Proterozoic Era, rhyolite of Carboniferous Period, granite, granite pophyry, granodiorite porphyry of Permian Period, basalt, quartz porphyry, aplite, aplitic granite of Cretaceous Period, etc., and in these rocks many fluorite deposits are formed such as Bor-Undur, Adag, Har-Airag, Hongor, Hajyuu-Ulaan,etc. The largest deposit is Bor-Undur which has the ore reserves of more than 20 million tons, and the total amount of fluorite resources in the Har-Airag district is reported to be 50 million tons.

In this district, by COMECON countries' energetic survey works up to the present, the survey for mineralized outcrops was at least completed, and a large number of mineral showings were found out. The fluorite resources of this district are considered to be possibly more abundant, but concerning main showings detailed surveys have already been conducted, and the discovery of new large-scale deposits can scarcely be expected.

5. Lugiingol district

The geology of Lugiingol district is composed of shale, sandstone of Late Permian Period and Lugiingol alkaline complex of Triassic Period intruding into them. The deposit is a vein type carbonatite deposit mainly with the light rare earth metals as La, Ce, etc. accompanied with alkaline complex.

Concerning the Lugiingol carbonatite deposit, details have become clear by the survey works up to the present. It is small scale, low grade and has less possibility to be developed. In addition, promising alkaline complex are not found in the vicinity.

6. Tsagaansuvraga district

The geology of the Tsagaansuvraga district is composed of Middle to Upper Devonian and Lower Carboniferous Series and Carboniferous to Early Permian granite-syenite intruded into them. Accompanied with acidic igneous rocks of Carboniferous to Early Permian Epoch, in the area of about 300km E-W×about 60km N-S, many porphyry type deposits and showings such as Tsagaansuvraga, Nalinhuduk, Harmagtai, Ih-Shanhai, Duchin-Hural and others are distributed, and the district forms a porphyry copper belt which is the second largest one in Mongolia, next to Erdenet mine.

Concerning the Serven-Suhait deposit (with the ore reserves of 240 million tons, Cu 0.53% and Mo 0.018%), a main deposit in this district, intensive exploration works has been carried out by diamond drilling and tunnels. As a result it has become obvious that it is low grade, with poor pyrite and poor secondary enrichment. The results of check analysis of ore piles conducted by this survey show their low grades. Very few room is remained for exploring this deposit.

As for the other mineral showings distributed in this district, there are showings of gold-bearing copper such as Harmagtai, Ovootu-Hira,etc., For these showings, checking and evaluation are necessary, as well as the survey for alteration zones.

7. Ulziit district

The geology of the Ulziit district is composed of Upper Silurian to Lower Devonian schist and granite, granite-diorite of Late Carboniferous to Permian Period, syenite-syenite porphyry, rhyolite and gabbro, etc. of Cretaceous Period, and accompanying with them, Mushgia-Hudak (REE) Bayan-Hoshoo (Sr), Bayan-Ovoot (fluorite), Olon-Ovoot (Au) and many gold showings including Dugsih, Onh, Bayan-Bor-Nuruu are formed. Thus, in this district the igneous activities have occurred repeatedly in various times, with which many gold showings are formed in the whole area as well as carbonatite, fluorite,and other deposits.

Among these, the Olon-Ovoot gold deposit and many gold showings such as Dugsih, Onh, Bayan-Bor-Nuruu were discovered by the geological surveys at a scale of 1:200,000 conducted from 1979 to 1982, but have been left without any follow-up surveys up to the present. By this survey, Olon-Ovoot deposit was confirmed to be mesothermal auriferous quartz vein, but from existing information, porphyry type gold deposits around the granite body, hot spring type or epithermal and other different types of gold deposits are expected along the major tectonic line.

4-3 Past surveys and future development

The survey works which have been carried out in the survey area up to the present, have been conducted by various international geological survey teams with the cooperation of COMECON countries, led by the Soviet Union, since mid. 1940's. The methods of those surveys have a series of the following stages:

① Geological survey at a scale of 1:500,000

② Geological survey at a scale of 1:200,000: the area to be surveyed is several ten thousands square km

- Geological survey: in addition to a photo-geological survey as the main method, *geological survey and sampling for geochemical exploration, airborne magnetic* exploration and systematic geochemical exploration are jointly used. Usually most of the deposits and mineral showings are detected at this stage of surveys.

- Geochemical exploration: along traverse lines with an interval of several hundred meters, the samples are collected regularly or randomly, and multicomponent semi-quantitative analysis by means of emission spectrograph analysis and mineralogical analysis are conducted.

- Airborne magnetic exploration: airborne magnetic map at a scale of 1:500,000 is made.

③ Geological survey at a scale of 1:100,000: in addition to a photo-geological survey as a main method, geological survey and systematic geochemical exploration survey are jointly used, but this survey are applied not often.

④ Geological survey at a scale of 1:50,000: the area to be surveyed is several thousands square km. It follows the geological survey at a scale of 1:200,000 and 1:100,000. At the same time surveys by γ-ray spectrum method, IP method, etc. are often applied together.

⑤ Geological survey at a scale of 1:10,000 : conducted around specific mineral showings. The area to be surveyed is less than several hundreds square km. During this stage, many trenching works and some of diamond drilling works are started.

⑥ Geological survey at a scale of 1:2,000: a map of ore deposit based on trenching, etc.

The characteristic feature is that at the early stage of the survey works, generally airborne magnetic exploration and a huge number of geochemical exploration are jointly used. Trenching and pitting are the most popular exploration methods, and energetic surveys are conducted including diamond drillings. Therefore it can be considered that in Mongolia at the stage of completing the geological survey at a scale of 1:200,000, the survey of searching mineral deposits and showings with magnetic anomalies and outcrops seems to be almost completed. However, the exploration for non magnetic blind deposits remains to be a subject of future survey.

In Mongolian People's Republic, some mines such as the Erdenet mine (copper), the Bor-Undur mine (fluorite) etc. have already been developed by these surveys, and there exist some deposits which have not yet been developed but have been explored to the later stages.

As for the mineral exploration of this Project in Mongolian People's Republic, it seems to be necessary to collect the further information of past surveys and geology of the survey areas in the future, considering those circumstances mentioned above, and at the same time, it may be necessary to consider the methods of the surveys which will be more adequate to the survey stage and to the features of geology and deposit of each district.

The surveys necessary in the future in Uudam-Tal area are considered to be two types: the survey following and exceeding the past survey works and the supplemental survey for their incomplete parts.

Chapter 5 Comments

5-1 Proposed survey exceeding the results of past survey

The survey works following and exceeding the results of past surveys are to develop ore deposits which seem to have brighter prospects in the future among the past surveys taken up as promising and explored to the later stage. The deposits to be surveyed are Tsav, Ulaan, Tumurtiin-Ovoo, etc. As for the polymetallic deposits of Tsav, Ulaan, etc. in the Dornod district, it seems to be the best plan to transfer technology at first through the survey and development of the Tsav deposit which has a higher grades and a reasonable scale of deposit, and then to start the survey of other deposits. As for the Tumurtiin-Ovoo deposit, Mongolia decided to develop it by itself and started to strip the overburden, but it seems necessary to support Mongolia in a mineralogical study with a perspective of refining process in the future.

5-2 Proposed survey supplementing the imperfect parts of past survey

The examples of surveys supplementing the imperfect parts of past surveys are ① an exploration of blind polymetallic deposits in the Dornod area, ② an evaluation survey of gold showings in the Ulziit district, ③a structural analysis survey by remote sensing analysis and gravity exploration in the Tsgaansuvraga and Ulziit districts.

The exploration of blind polymetallic deposits in the Dornod area is the exploration of non magnetic polymetallic deposits in volcanic rocks areas.

It is pointed out by surveys and studies that the epithermal deposits in volcanic rocks areas are often accompanied with the center of volcanic activities or caldera structures. (for example, Kubota, 1991). Volcanoes of old geological time related to the exploration of epithermal vein type deposits do not retain their original shapes in most cases because of burying, erosion or deformation, but the center of these volcanic activity and caldera structures can sometimes be detected clearly by gravity exploration over a wide area (Fig.I-5-1, Fig. I-5-2). Therefore in Dornod district, it is considered to be worth of conducting works over wide areas including Tsav and Ulaan deposits as models in the beginning stage of exploration.

The surveys of the gold deposits at the Ulziit district are divided into ① the survey of the Olon-Ovoot deposit, ② evaluation survey of known mineral showings and ③ a structure survey to obtain new deposits.

Concerning the Oln-Ovoot deposit, it is necessary to make the vein map and assay map as a basis of development and evaluation, for which detailed geochemical exploration should be conducted, and there will be a possibility of confirming the extension of mineralized zones towards horizontal and vertical directions by CSAMT method or IP method aiming at the hallo of disseminated pyrite zone around auriferous quartz veins.

In the Ulziit district, igneous activities occurred repeatedly from Devonian to Cretaceous, then different types of gold deposits might have been overlapped. As the location and the outline of many gold showings in the Ulziit district have already become clear, focussing on these indications, it is necessary to conduct a series of surveys consisting of ore analysis, vein mapping, alteration zone survey, measurement of homogenization temperature of fluid inclusion, mineralogical study, etc., to clarify the mineralization type of each showing, and at the same time to evaluate the possibility of the finding of deposits. There is also a major tectonic line passing through this district, and it may be important as the place of ore formation. Therefore, it is also an important task at the early stage of exploration to infer the location of the tectonic line covered with detritus by remote sensing and geophysical exploration over a wide area.

5-3 Application of remote sensing

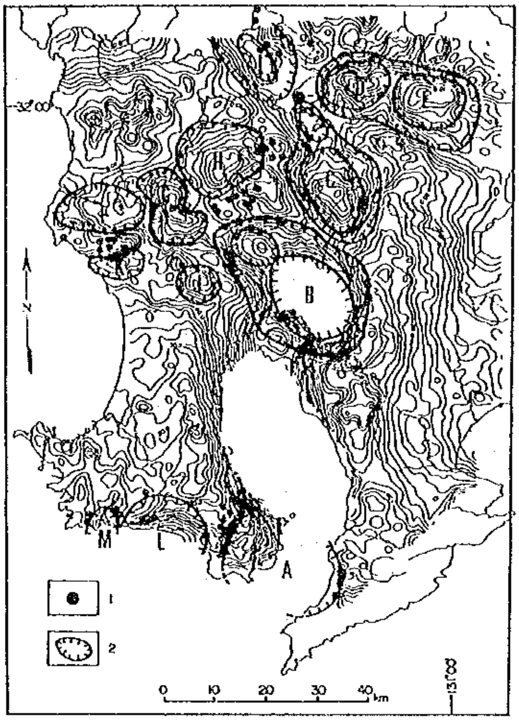
As a result of this year's survey, analysis and interpretation were difficult in the Dornod district because of dense vegetation, but the major structure was interpreted in the Gobi area with aparse vegetation.

On the other hand, concerning the extraction of altered zones, by reasons that

① most of argillization zone of porphyry copper type deposits and showings were eroded out, and

② many deposits in the survey area, such as carbonatite, vein type polymetallic deposits, pipe-shaped or stockwork polymetallic deposits, etc. are not accompanied by large scale alteration zones,

it was difficult to find out hydrothermal alteration zones on the satellite image. However, in the Gobi area, bedding, faults, intrusive bodies such as alkaline complex, etc. were clearly recognized. Therefore it is considered to be effective to conduct remote sensing method together with geological survey for the confirmation of rock facies and airphoto interpretation in order to understand the geological structure.



L E G E N D

1: Gold ore deposit
2: Assumed depression
A: Ata
B: Aira
C: Anraku
D: Kakutou
E: Kobayashi
F: Senndai
G: Iriki
H: Miyanojyou
I: Ookuchi
J: Yaeyama
K: Kushikino
L: Ei
M: Makurazaki
Contour line: 2 mgals interval

Fig. I-5- 1 Map showing a relation between low Bouguer anomaly and gold ore deposits in south Kyusyu (Kubota, 1991)

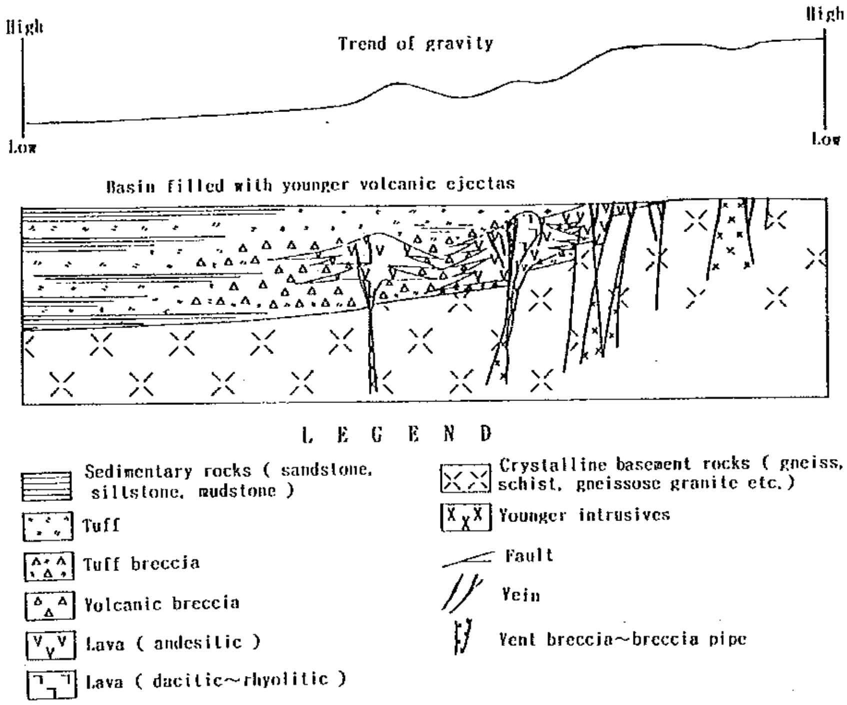


Fig. I-5- 2 Volcanic depression model in relation to gold ore formation (Kubota, 1991)

Chapter 6 Conclusion and Recommendations

6-1 Conclusion

Based on this year's results, the each district was evaluated from the viewpoint of the possibility of future development of the known deposits (Table IV-1-1).

As a result, the following districts can be considered to be promising among the district in Uudam-Tal area:

1. Dornod district: vein type polymetallic deposits in Tsav, stockwork skarn deposit in Ulaan

2. Tumurtiin-Ovoo district: Tumurtiin-Ovoo zinc deposit

3. Ulziit district: Olon-Ovoot gold deposit and showings around the deposit.

Next, the each district was evaluated from the viewpoint of the possibility of finding new deposits in future. As a result, the following districts were selected:

1. Dornod district: all the polymetallic deposits in the Dornod district are considered to be blind deposits. It is also possible that the whole area can be a zone of blind polymetallic deposit as the area is widely covered with volcanic rocks of Jurassic to Cretaceous Period.

2. Ulziit district-Tsagaansuvraga district: it is known that in the Ulziit district-west Tsagaansuvraga district, a number of gold-silver showings are distributed. It is assumed from the records and this survey result that there are several types of gold mineralization, such as mesothermal gold deposits and porphyry type deposits.

6-2 Recommendations for the second year's survey

1. It was found that, in Mongolia, there are enormous data concerning the surveys conducted in the past. In order to carry out the survey more smoothly and effectively in this country, it is necessary to collect further the information concerning the past surveys and the geology of the future survey area, and based on them, to consider the way of development work according to the survey stage, geological conditions and the features of deposits at each district.

2. As for the Uudam-Tal area's survey, it is desirable to promote the surveys of Olon-Ovoot gold deposit aiming the early development of profitable mines, and at the same time, to conduct survey to evaluate a large number of gold showings distributed in the area of about 300km E-W×about 60km N-S from the Ulziit district to the Tsagaansuvraga district. The applicable methods are

a) to prepare basic maps such as vein maps, assay maps on the surface of the Olon-Ovoot deposit,and at the same time to confirm horizontal and vertical extension and the structure of veins by geophysical exploration method,

b) to conduct a series of surveys of ore analysis, vein mapping, alteration zone survey, the homogenization temperature measurement of fluid inclusion, mineralogical study, etc. and to evaluate the possibility of finding of mineral deposits,

c) to assume the tectonic line covered with detritus by satellite image analysis and gravity survey, and then to extract the promising area ,

d) to determine the mineralization age of the deposits as igneous activities in this area occur repeatedly from Devonian to Cretaceous Period and there is a possibility of overlapped gold mineralization, and

e) to conduct remote sensing analysis including geological survey in order to correlate with the results of photo-geological interpretation and extraction of alteration zones by satellite image analysis.

3. On the other hand, in the Dornod district, there is a possibility of existence of blind polymetallic deposits in the area covered widely with volcanic rocks of Jurassic to Cretaceous Period, so regional gravity survey should be conducted.

4. As for the deposits at an advanced stage of exploration, among those extracted to be surveyed in the future, such as the polymetallic deposits of Tsav, Ulaan, etc and the Tumurtiin-Ovoo zinc deposit, it is desirable to conduct the advanced surveys (basic surveys for development). Specifically, it seems to be the best plan to transfer technology at first through the survey and development of the Tsav deposit which has a high grade, a reasonable scale and lower risk, and then to start the survey of other deposits.

Part II PARTICULARS

Chapter 1 Main Deposits

This chapter details the major deposits and the mineral indication areas in the survey area, based on material provided by the Mongolian People's Republic and a local geological survey. The ★ mark indicates the deposit to which the local surveys were conducted.

1-1 Dornod district

The Dornod district is located at the northeastern end of Mongolia. In administrative district terms, it is an about 33,000km^2-area in the northern part of the Dornod Aimag. This district has a relatively good infrastructure, with a railway (narrow gauge) which connects the Siberian Railway and Choibalsan, the capital of the Aimag, through the center of the region. It also has a branch line running off this north-south line in an east-west direction from Chingis-Khaan to Mardai. The 48-passenger Antonov airplane departs twice a day from Ulaanbaatar to Choibalsan city, the southernmost part of the district. The flight takes about one and half hours one way.

The major climate index of the Dornod district is as follows:
Amount of solar radiation; Annual solar radiation is 4,500MJ/m^2~4,800MJ/m^2.

The annual average temperature; 0.3°C~−1.5°C.
Monthly average temperature*; the highest month is July with 20.6°C, the lowest month is January with −21.3°C
Temperature range is between −46.7°C and 40.1°C*.

Precipitation*; annual precipitation: 246mm
Monthly average precipitation; maximum month is July with 75.1mm, and minimum month is January with 1.9mm.

Relative humidity; monthly average: January 70~80%, April 35~40%, July 48~55%, October 47~50%.

Wind velocity*; monthly average; January 3.8m/sec., April 5.4m/sec., July 3.5m/sec., October 4.0m/sec.
(Notice) *: * indicates the Choibalsan city's results.

The elevation of the district is 560m~1,300m, the lowest in Mongolia. Most parts of this district are made up of gentle, hilly areas 700~900m above sea level. As this district has an adequate precipitation in summer, it has relatively thick steppe. The average temperature of this district is −21~−23°C in January, and 19~21°C in July, and the annual average temperature is about −2°C. As for Choibalsan, the highest record of temperature is 40.1°C and the lowest is −46.7°C.

In this district, gneiss and schist, formed during Proterozoic and Palaeozoic eras and various igneous rocks, formed during Jurassic to Cretaceous periods are widely distributed. Hydrothermal polymetallic deposits (Tsav, Ulaan, Muhar, Bayan-Uul, Salhiit, Delger-Munh deposits etc.), auriferous quartz vein (Tsagaan-Chuluut Huduk), and uranium deposit (Mardai) were formed in relation to the intermediate~acidic igneous activity in the Mesozoic era (Fig. II-1-1).

1-1-1 Tsav deposit★ (Fig. II-1-2)

1. Location and transportation

Location : Longitude 115°20'16" East, Latitude 48°55'27" North, Elevation 770m above sea level. In administrative division terms, the deposit is located in the Choibalsan Sum in the Dornod Aimag.

The railway (narrow gauge) that connects the Siberian Railway and the capital of the Aimag, Choibalsan runs 1.5km west of the deposit. There is a road for trucks (gravel road) from the deposit to the Havirga station about 16km southwest from the deposit. It is about 125 km from Choibalsan to the Tsav deposit, about three and a half hours by car via the dirt road, which runs along the above-mentioned railway through the steppe.

2. Topography

The lowest point around the deposit is the swampy area (689m), about 10km south of the deposit, while the highest is at Khuf Tolgoi hill (846.3m), about 5km east southeast of the deposit. This district is, a hilly zone which consists of buried valleys and small hills, 100m~150m higher than the valleys. As the valleys have no running water, automobiles can drive almost anywhere.

3. Climate

The major climate index around the Tsav deposit is as follows: Annual solar radiation is 4,700MJ/m^2, annual average temperature is 0.6°C, and annual precipitation is 246mm. This area belongs to the steppe climatic zone. Because the elevation of the deposit area is the lowest of the area, the climate of this area is relatively mild despite its high latitude, with about 120 frostless days annually. As this area has sufficient precipitation in summer, it is covered with a comparatively thick steppe with a height of 50~70cm.

4. Geology and deposit

(1) Mineralization

This deposit contains silver, lead, and zinc with a small amount of copper.

It occurs as quartz vein with miscellaneous minerals.

Ore minerals are mainly of galena and sphalerite with a small amount of chalcopyrite, tetrahedrite and marcasite. Minor minerals are argentiferous tetrahedrite, miscelleneous silver ore, pyrargyrite, etc. Secondary minerals are cerussite, anglesite, smithsonite, covelline, etc. The gangue minerals consist of quartz, calcite, fluorite, rhodochrosite, clay minerals and other related minerals.

(2) Type of deposit

Vein type.

(3) Ore reserves and grades; (calculated in 1987)

Classification*	Ore reserves	Pb (%)	Zn (%)	Ag(g/t)
C_2	3,894,000t	6.96	5.89	304.09 (average width of vein 1.06m)
P_1	3,786,000t	5.84	3.40	138.46 (average width of vein 1.11m)
C_2+P_1	7,680,000t	6.41	4.66	222.46 (average width of vein 1.08m)

*(Notice) Accuracy classification of ore reserves after the Soviet-type category. A, B, C_1, C_2, P_1, P_2 is the order from the highest accuracy to the lowest. Corresponding to the Japanese standard, A to proved ore reserves, C to possible ore reserves, and P to prospective ore reserves, respectively.

(4) Size of deposit

About 10 veins are present in 2km×3.5km area. The length of the No.4 vein is 2,500m, and the No. 3 vein, 3,500m, which is the longest. The width of the veins varies from 0.2m to 3.0m and the average width of the vein is 1.08m. The major veins are the No. 4, No. 8, No.2 and No.1 vein. The No. 4 vein occupies 60% of the total ore reserves and it is the most dominant at 200m to 300m below the surface.

(5) Structure of the deposit

Strike: N-S in the northern part but it gradually changes to N25°W~N55°W in the southern part.

Dip: 55°~85°E: the dip decreases toward the west.

(6) Country rock

Gneiss and schist formed during Proterozoic and Paleozoic eras and granite, granodiorite, granite porphyry, andesite, and basalt etc. formed during Jurassic and Cretaceous periods.

The results of the potassium-argon dating are as follows: schistose granite (whole rock): 163±8Ma, Ditto (biotite): 161±8Ma, monzodiorite (hornblende): 156±8Ma, granite porphyry (whole rock): 140±7Ma. There was only a little difference between these results and the estimated values by the Mongolian side.

(7) Structual control

This deposit is in the "Havirga complex", an upheaval block enclosed by two fault systems, E-W~N60°W system and N10°E~N-S system. It is assumed that the strike of the pre-mineralization fissure: N-S~N55°W, and the strike of post-mineralization fissure: N40°W, N70°W, or E-W, etc. The amount of dislocation is not estimated.

(8) Related igneous rocks

This deposit is considered to be related to the Late Jurassic "Havirga complex" which consists of granite porphyry, granodiorite, monzonite and so on. Ages of the ore minerals by Pb-Pb method are 109.3 Ma, 116.1 Ma, 131.0 Ma and so on, suggesting the Early to Middle Cretaceous mineralization.

(9) Alteration

The wall rock is slightly white-argillized along the vein. Country rocks of the deposit suffered widely a propylitic alteration, mainly chloritization.

5. Water supply

Water is available from the marshes situated about 5km northwest and southwest of the deposit where the groundwater level is shallow.

6. Hydrology

The amount of water flowing out from the tunnel is $15m^3$ (at July 1991). Groundwater level is nearly the same as tunnel level, 160m below the ground surface.

7. Discovery and history

1975 The USSR discovered the outcrop of the No.2 vein, by a geological survey at a scale of 1:200,000 and a γ-ray spectrum survey at a scale of 1:25,000.

1981 The USSR conducted a detailed geological survey at a scale of 1:50,000 and 1:25,000, geochemical exploration (100m×25m interval), geophysical exploration (IP method: 4.5km, electromagnetic exploration to a depth of 125m deep, length of traverseline 35km). Trenching was also carried out.

1982 The USSR conducted gravimetric exploration and electric exploration as well as drilling.

1983 The DORNOD exploration office in Mongolia began to conduct survey works (By the cooperation of Mongolia and USSR).

1985 The DORNOD exploration office conducted geological surveys and geochemical exploration at a scale of 1:10,000 (By the cooperation of Mongolia and USSR).

1985~86 The DORNOD exploration office carried out trenching and drilling works (By the cooperation of Mongolia and USSR).

1988 No.14 vertical shaft sinking (By the cooperation of Mongolia and USSR).

1986~89 The DORNOD exploration office conducted a detailed survey, and drew up a report (By the cooperation of Mongolia and USSR).

1990 No.15 vertical shaft sinking (By the cooperation of Mongolia and USSR).

Past exploration works		Total until 1987	Total during 1988~91	Cumulative total
Trenching		10,494.9m^3	approx. 10,000m^3 at 320 points	approx. 20,000m^3
Drilling	136holes	25,757.6m	314 holes 14,500m	450holes 40,257.6m
Analysis sample	boring	3,879pcs	Until 1991, total 12,000 pcs of samples will be analyzed.	
	trenching	1,992pcs		
	rock samples for geochemical exploration	7,217pcs		
	trenching	1,992pcs		
	soil samples for geochemical exploration	14,152pcs		

The cumulative total cost of the exploration up to 1987 was 14,373,177 Tugriks.

8. Mining operation
   (1) Owner of enterprise: MONGOLIAN PEOPLE'S REPUBLIC, DORNOD Company
   (2) Employees
   60 Russian contract-technicians (30 employees×2 shifts). All the jobs related to the underground work are conducted by Russians. The Mongolians conducted borings using 3 machines from the surface.

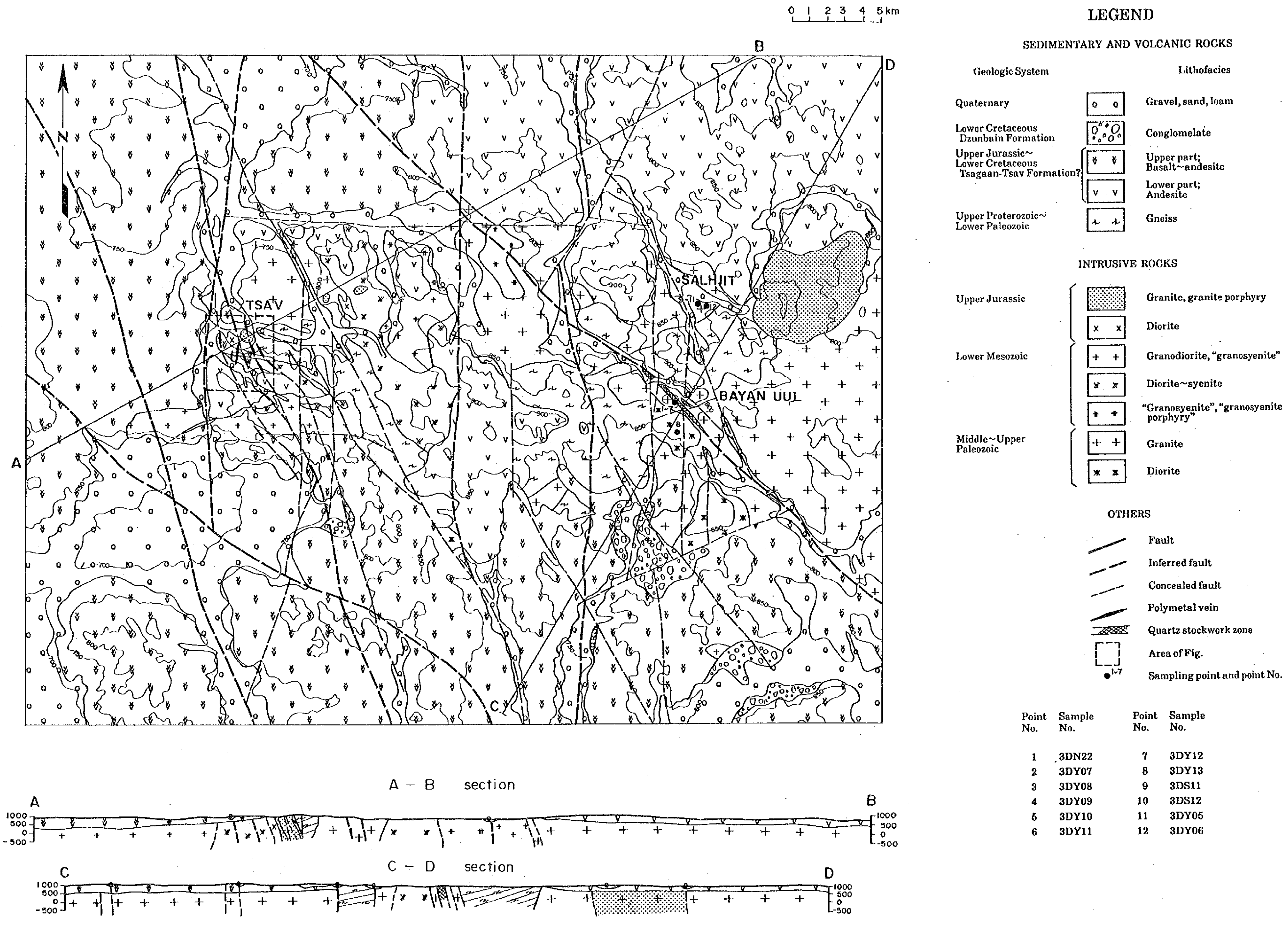
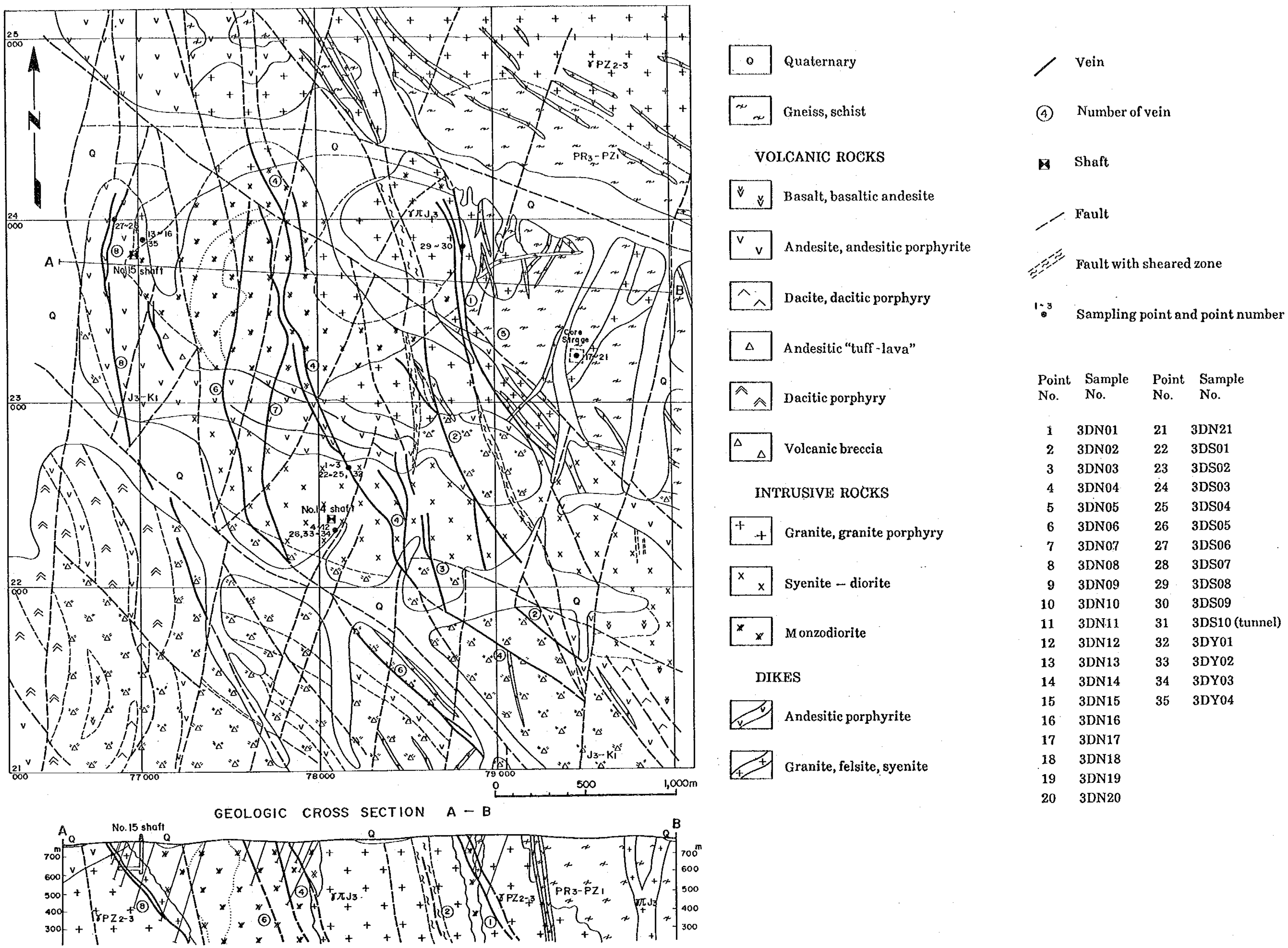


Fig. II-1-1 Geological map of Tsav-Bayan Uul



Point No.	Sample No.	Point No.	Sample No.
1	3DN01	21	3DN21
2	3DN02	22	3DS01
3	3DN03	23	3DS02
4	3DN04	24	3DS03
5	3DN05	25	3DS04
6	3DN06	26	3DS05
7	3DN07	27	3DS06
8	3DN08	28	3DS07
9	3DN09	29	3DS08
10	3DN10	30	3DS09
11	3DN11	31	3DS10 (tunnel)
12	3DN12	32	3DY01
13	3DN13	33	3DY02
14	3DN14	34	3DY03
15	3DN15	35	3DY04
16	3DN16		
17	3DN17		
18	3DN18		
19	3DN19		
20	3DN20		

Fig. II-1-2 Geological map of Tsav ore deposit

(3) Scale of production

Exploration has not been conducted yet.

(4) Mining method

The No.4 and No.8 veins have been explored by drift using leg-drill at EL+628m. Vertical shaft ∅ =4.8m (cross section area=20m²).

(5) Transportation method

Wasted rock is carried from the tunnel, by means of a $1m^3$-mine-car and a hoist with $2.53m^3$ bucket.

(6) Others

Electricity Diesel generator 350kw×3

Hoist motor 70kw (hoisting ability 2.5t)

Compressor 8 atm., $25m^3$×3

Support Main adits are coated by concrete. Drifts are supported by wooden-frames.

1-1-2 Ulaan deposit ★ (Fig. II-1-3, Fig. II-1-4)

1. Location and transportation

Location: Longitude 114°05'12" East, Latitude 49°05'12" North, Elevation 1,159m above sea level. In administrative division terms, the deposit is located at Dashbalbar Sum in Dornod Aimag.

The railway (narrow gauge) that connects the Siberian Railway and the capital of the Aimag, Choibalsan runs about 90km east of the deposit. From this line, there is a branch line that runs to Mardai, that is about 11km east of the deposit.

The Ulaan Mine is about 230km from Choibalsan city via Haviruga, traveling by car on a dirt road.

2. Topography

The elevation of major rivers around the deposit are from 800m to 850m above sea level. The maximum elevation is Mt. Khugnu's (1,131.7m), about 1.9km east-south-east of the deposit. Topographically, it is of a hilly zone which is made up of buried valleys and small hills, 150m~200m higher than the valleys. Four-wheel drive automobiles can travel almost anywhere. The valleys around the deposit are relatively abundant in water. A fault-line scarp has formed at the north side of the deposit, therefore the topography around the deposit is relatively steep.

3. Climate

The major climate index around the Ulaan deposit is as follows: Annual solar radiation is $4,700MJ/M^2$, annual average temperature −1°C, and annual precipitation is 246mm. This area belongs to the steppe climatic zone.

Because the elevation around the deposit is the lowest in MPR, the climate is relatively mild for its high latitude, about 120 frostless days annually. As this area has sufficient precipitation in summer, a relatively thick steppe, 50~70cm in length is formed.

4. Geology and deposit

(1) Mineralization

The minerals of this deposit are of silver lead and zinc with small amounts of copper. The ore is classified into three types of mineral assemblage. 1. quartz-fluorite-sulfide. 2. quartz-epidote-sulfide. 3. epidote-actinolite-sulfide. Sphalerite is the most dominant mineral with a small amount of pyrrhotite and pyrite. A small amount of calcite, chalcopyrite, arsenopyrite and covellite are observed under the microscope.

(2) Type of deposit

Stockwork type ore that fills breccia pipe. Skarnization is recognized at a depth.

(3) Ore reserves and grades; (ore reserves were calculated in 1987)

Classification*	Ore reserves	Pb (%)	Zn (%)	Ag(g/t)
$B+C_1+C_2$	68,100,000t	0.95	1.90	49
P_1	25,000,000t	?	?	?
Total	93,100,000t			

(4) Size of deposit

The area of this deposit is 425m×200m. This deposit is composed of nine ore bodies within a vertical breccia pipe. The average width of the ore bodies is 10m~50m with the maximum width of 70m and 80m. The elevation of the outcrop is EL 1,100m, and it has been confirmed by boring that mineralization is continuous more than 1,200m below the surface.

(5) Structure of the deposit

This deposit is breccia pipe type emplaced in rhyolite. The ore grade gradually increases toward the periferal zone of the pipe, and it is a so-called chimney type. The boundary between the pipe and host rocks is clear. The dip of each ore body is very steep, being 85°~90°, along the outer wall of the pipe.

(6) Country rock

Jurassic to Cretaceous rhyolites are exposed around the deposit.

(7) Structural control

Ulaan deposit is located between the Muhar fault and the East Muhar fault, both of which are trending in N30°W~N33°W and 500m apart. The ore deposit is cut by the Muhar fault on its southwest side and runs partly along the Muhar fault.

(8) Related igneous rocks

Not obvious. The age of the ore measured by the Pb-Pb method is 170.1Ma, indicating Middle Jurassic.

(9) Alteration

Alteration minerals such as epidote and actinolite formed in association with skarnization are found in the ore excavated from the tunnel. The country rock (felsite) is widely feldspathizated by potassium feldspar.

5. Water supply

The small valley near the deposit has an abundant amount of water.

6. Hydrology

The underground water-table is 20m~50m below the surface. The spring line is about 950m above sea level.

7. Discovery and history

1971 The USSR began exploration with an air-borne magnetic survey.

1973 The USSR discovered the deposit by the magnetic anomaly. After the discovery, it has continuously excavated by trenching and boring.

1979 USSR conducted the supplementary exploration.

1984~1986 USSR conducted the detailed survey.

tunnel	2 levels	1,400m

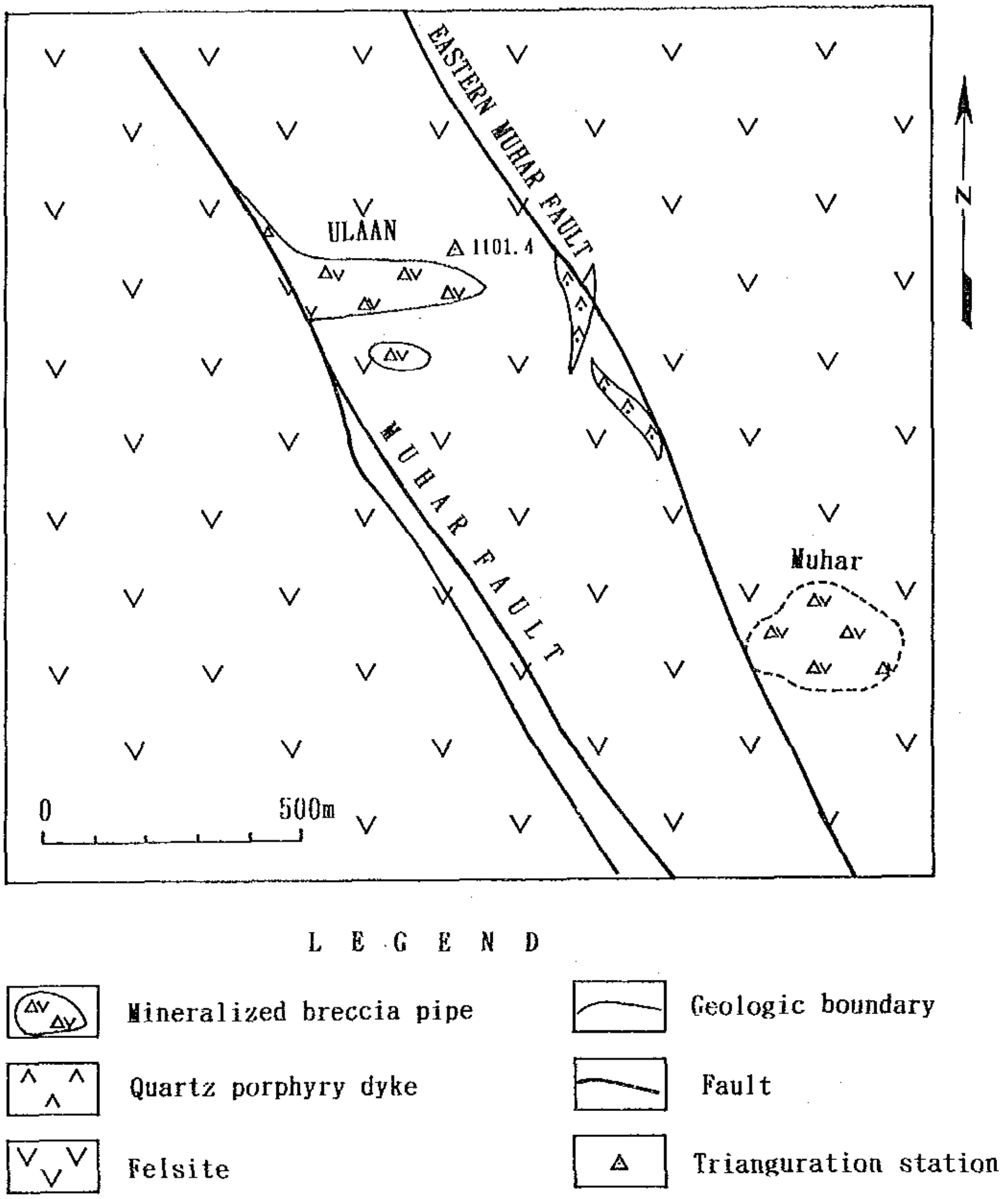
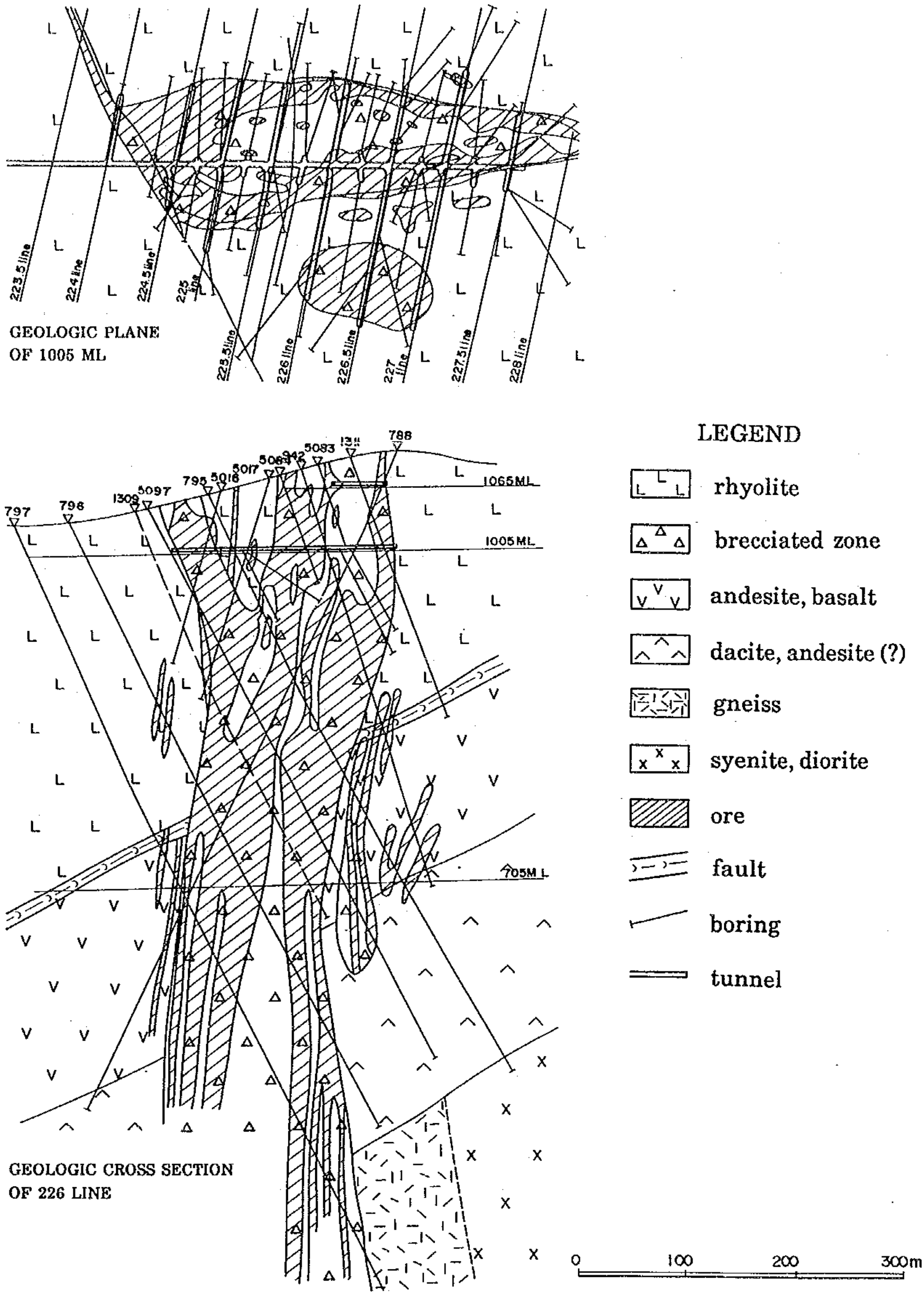


Fig. II-1-3 Geological map of Ulaan and Muhal



Modified from the data offered by MPR

Fig. II-1-4 Geological map of the Ulaan ore deposit

boring	250 holes	about 11,000m
	longest hole	1,200m

8. Mining operation

None. Work ceased after the above-mentioned exploration had been completed. All the equipment has been removed.

9. Others

(1) Size of adit: 2.5m×2.5m. A considerable part of the adit is excavated without support.

(2) The results of the ore dressing test conducted by USSR are as follows:

	Pb(%)	Zn(%)	S(%)
Grade of concentrates	60	40	56
Recovery percentage	85.9	86.2	

1-1-3 Muhar deposit (Fig. II-1-3, Fig. II-1-5)

1. Location

About 1.2km southeast of the Ulaan deposit. The deposit is located at the east side of East Muhar fault. Geologically, it is a part of the Ulaan deposit. In administrative division terms, it is located in the Dashbalbar Sum in the Dornod Aimag.

The railway (narrow gauge) that connects the Siberian Railway and the capital of the Aimag, Choibalsan runs about 90km east of the deposit. From this line, a branch line runs to Mardai, about 11km east of the deposit. There is a dirt road from Havirga to the Muhar deposit. It is about 230km from Choibalsan city to Ulaan Mine, taking about six and half hours by car via a dirt road.

2. Topography

The elevation of the major rivers around the deposits varies from 800m to 850m. Mt. Khugnu is the highest point being 1,131.7m above sea level, about 700m south of the deposit. Topographically, it is a hilly zone which consists of buried valleys and small hills, 150m~250m higher than the valleys. Four-wheel drive automobiles can travel almost anywhere. The valleys around the deposit are relatively abundant in water. A fault-line scarp has formed at the north side of the deposit, therefore the slope around the deposit is relatively steep.

3. Climate

Same as Ulaan deposit

4. Geology and deposit

(1) Mineralization

The deposit consists of silver, lead, and zinc. Geologically, it is assumed to be similar to the Ulaan deposit.

(2) Type of deposit

Stockwork type ore deposit that fills breccia pipe

(3) Ore reserves and grades: (calculated in 1987)

Classification*	Ore reserves	Pb (%)	Zn (%)	Ag(g/t)
$C_2+P_1+P_2$	25,500,000t	0.63	3.40	113

(C_2: 9,800,000t, P_1: 3,700,000t, P_2:12,000,000t)

(4) Size of deposit

The cross-section is 300m E-W×200m N-S at EL+700 level. This deposit is blind breccia pipe, plunging southwest with 75°~80°dip. The surface elevation of the deposit is about 1,030m to 1,100m. This deposit is recognized by boring from approx. 200m below the surface (EL600m) to 400m or more below the surface.

(5) Structure of deposit

This deposit is assumed from the results of 15 borings to be made up of several ore bodies, which are parallel to the breccia pipe.

(6) Country rock

In the district the Jurassic to Cretaceous "felsite" (acidic volcanics) is widely exposed.

(7) Structural control

The deposit is located in the block east of the East Muhar fault with strike of N30°W~N33°W.

(8) Related igneous rocks

Not obvious.

(9) Alteration

Not obvious.

5. Water supply: The small valley near the deposit has an abundant amount of water.

6. Hydrology

The underground water-head is 20m~50m below surface. The spring line is about 950m above sea level.

7. Discovery and history

1971: The USSR began exploration with an air-borne magnetic survey. After that, it is not clear except that it was explored at the same time as the Ulaan deposit. More than 15 drillings were applied with the maximum length being 800m.

8. Mining operation

None. Work ceased after the above-mentioned exploration had been completed. All the equipment has been removed from the site.

1-1-4 Bayan-Uul deposit ★

1. Location and transportation

Location: Longitude 115°41'16" East, Latitude 48°54'11" North, Elevation 920m above sea level. In administrative division terms, the deposit is located at the Choibalsan Sum in the Dornod Aimag.

The railway (narrow gauge) that connects the Siberian Railway and the capital of the Aimag, Choibalsan runs 37km west of the deposit. As for the 150km distance between Choibalsan and the Bayan-Uul deposit, there is a dirt road available. It takes about four hours by car through the steppe.

2. Topography

The major rivers around the deposits are 800m~820m above sea level. The unnamed mountain is the highest point being 932.6m above sea level and is located in the central part of the mining area. A small number of marshes are seen in the valleys. However, four-wheel drive automobiles can travel almost anywhere.

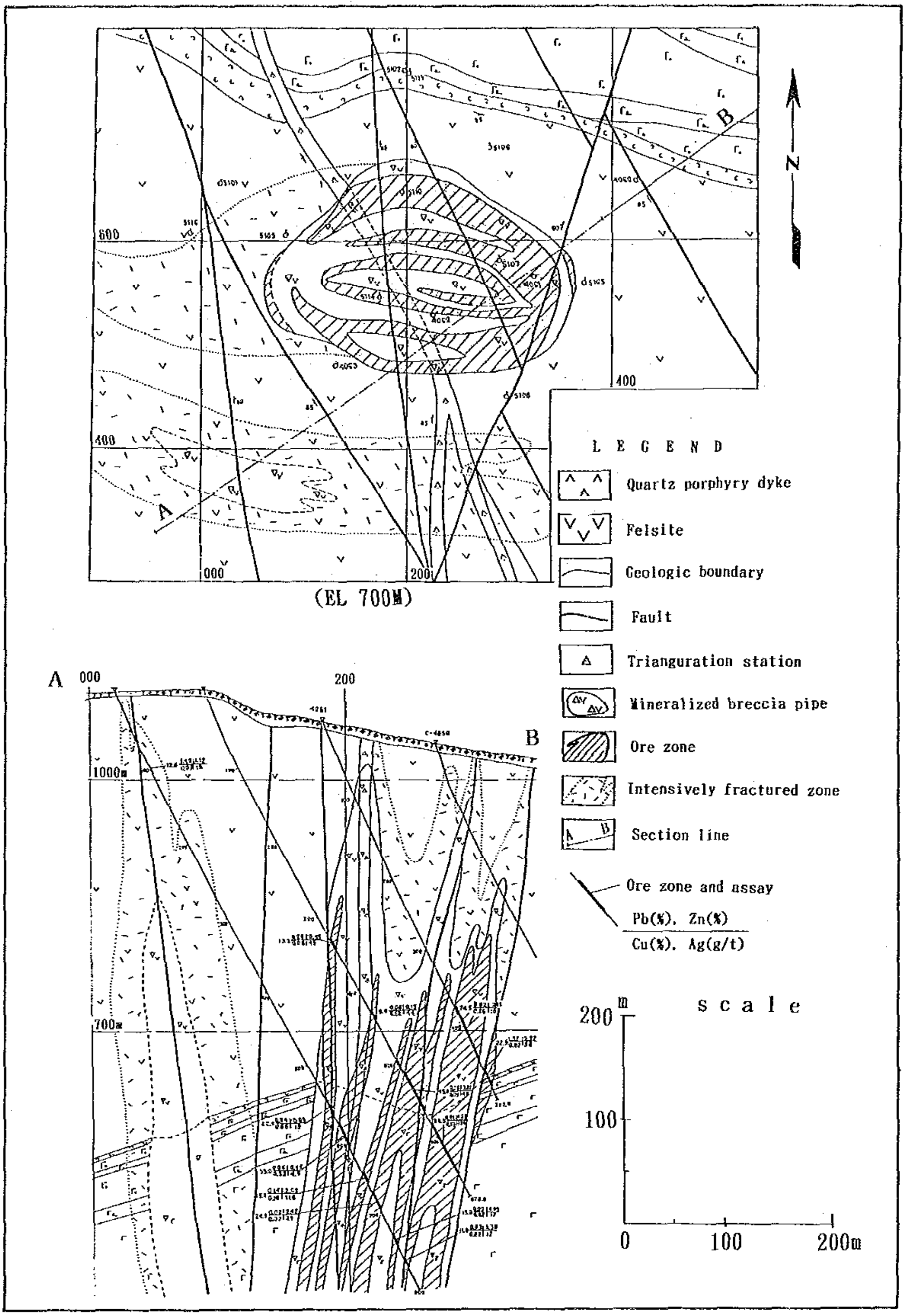


Fig. II-1-5 Geological profile of the Muhar ore deposit

3. Climate

Same as Tsav deposit

4. Geology and deposit

(1) Mineralization

The deposit contains of silver, lead, and zinc. It occurs as a quartz vein with miscellaneous minerals. The ore consists of sphalerite, chalcopyrite, pyrargyrite, stibnite, bismuthinite, electrum, etc. The gangue consists of quartz and clay minerals.

(2) Type of deposit

Vein type

(3) Ore reserves and grades; (ore reserves were calculated in 1987, $P_1 + P_2$)

Classification*	Ore reserves	Pb+Zn (%)	Cu (%)	Ag(g/t)	Au(g/t)	Mo(%)
Ore body I	30,465,000t	1.0	0.10	80.0	0.3	0.03
Ore body II	30,645,000t	2.0	0.13	80.0	0.3	0.03

(4) Size of deposit

This deposit consists of a large stockwork silicified zone and quartz veins. The length of the stockwork of silicified zone is 5,700m, and the width is about 60m. In this zone, there is a quartz vein whose total length is 1,700m with a width of 5m, while another one whose length is 1,700m has a width of 13m. The mineralization of these quartz veins were confirmed by boring to a depth of 300m below the surface.

(5) Structure of deposit

Strike: N45°W, Dip: 80°NE

(6) Country rock

It consists of the latest Paleozoic granite, the Mesozoic diorite and others.

(7) Structural control

This deposit is formed along the Bayan-Uul fault (N45°W system) and its derived fissures.

(8) Related igneous rocks

Not obvious.

(9) Alteration

Silicification, pyritization

5. Water supply

A small number of swamps are seen near the valley. It is assumed that the groundwater level around the deposit is shallow.

6. Hydrology

Not obvious.

7. Discovery and history

1975	The USSR conducted a geological survey at a scale of 1:200,000, and this deposit was discovered together with the Tsav deposit at the same time. After the discovery, geophysical and geochemical explorations were conducted on this deposit as well as the Tsav deposit.
1984~1986	Detailed surveys by boring and trenching were conducted mostly by Mongolian.

1988~1991 Geochemical and geophysical explorations were conducted by the cooperation of Mongolia and USSR. At present, the report on these surveys is being drawn up.

Past exploration works: boring 15,000m~20,000m

8. Mining operation
   None.

9. Others.
   In the 1991 report, it was suggested that a detailed survey should be conducted.

1-1-5 Salhiit deposit★

1. Location and transportation
   Location: Longitude 115°41'01" East, Latitude 48°57'37" North, Elevation 732m above sea level. In administrative division terms, the deposit is located in the Choibalsan Sum in Dornod Aimag.
   The railway (narrow gauge) that connects the Siberian Railway and the capital of the Aimag, Choibalsan runs 28km west of the deposit. From the sealed road that is parallel to the railway there is a dirt road running to the deposit. It is about 130km from Choibalsan city to Salhiit deposit, about 4-hour drive by car through the steppe.

2. Topography
   Topographycally, this deposit area is a hilly zone which is made up of buried valleys and small hills, about 100m higher than the valleys. The highest point of the deposit (939.6m) is situated at a nameless hill about 3 km southeast of the Salhiit deposit, and the lowest at a valley located on the north of the deposit (840m). A small number of swamps are seen in the valleys. However, four-wheel drive automobiles can travel almost anywhere.

3. Climate
   Same as Tsav deposit

4. Geology and deposit
   (1) Mineralization
   The ore of this deposit contains silver, lead, and zinc. It occures as calcite-quartz vein with galena, sphalerite and chalcopyrite.
   (2) Type of deposit
   Vein type
   (3) Ore reserves and grades
   They have not been thoroughly calculated yet. Silver content of the vein is 15g/t at the outcrop.
   (4) Size of deposit
   The width of the vein: 1m (boring), 3~4m (trenching, stockwork vein zone)
   (5) Structure of deposit
   Strike: N35°~40°W, Dip: 80°NE
   (6) Country rock
   It consists of the Precambrian to Cambrian schist, the Carboniferous to Permian granodiorite and diorite, and the Jurassic andesite and granite.

(7) Structural control
This deposit occurs along the fissure with strike of NW-SE.

(8) Related igneous rocks
The Jurassic granite.

(9) Alteration
Silicification

5. Water supply
Not obvious.

6. Hydrology
Swamps are seen in the valley. It is assumed that the groundwater level is shallow.

7. Discovery and history
1988 This deposit was discovered when a geological survey at a scale of 1:50,000 was conducted.

1989 Trenching and boring were conducted.
Past exploration works:
trenching 30 places (Mongolia, the USSR)
boring 20 holes (the USSR) It is reported that only 1 or 2 holes hit the ore vein.

Geophysical and geochemical explorations (Mongolia)
The results were not satisfactory, therefore the survey was stopped.

8. Mining operation
None.

1-1-6 Delger-Munh mineral ore showing ★

1. Location and transportation
Location: Longitude 114°48'21" East, Latitude 48°46'58" North, Elevation 917m above sea level. In administrative division terms, the deposit is located at the Gurvanzagal Sum in Dornod Aimag.

The railway (narrow gauge) that connects the Siberian Railway and the capital of the Aimag, Choibalsan runs 20km east of the deposit. From the sealed road that is parallel to the railway there is a dirt road running to the deposit. It is about 90km from Choibalsan city to the Salhiit deposit, about 3-hour car drive through the steppe.

2. Topography
The elevation is lowest at the swamp (738m) which is located about 6km northwest of this mineral indication area, and highest at Mt. Delger-Munh (967.3m), about 3km southeast of the area. Topograhically, it is a hilly zone which is made up of buried valleys and small hills that are 100m~200m higher than the valleys. A small number of swamps are seen in the valleys. However, four-wheel drive automobiles can travel almost anywhere.

3. Climate
Same as Tsav deposit

4. Geology and deposit

(1) Mineralization

The ore of this deposit contains silver, lead, and zinc (?). It occures as a quartz vein with galena. In addition, arsenopyrite and pyrites are seen. A little amount of cerussite and anglesite are seen as secondary minerals.

(2) Type of deposit

Not obvious. (Vent-filling pipe-shaped deposit at the center and vein type deposits at srroundings are expected.)

(3) Ore reserves and grades

They have not been calculated yet, as the exploration was not sufficient.

(4) Size of deposit

Not obvious.

(5) Structure of deposit

Not obvious.

(6) Country rock

Andesite, shale, sandstone, and conglomerate (unknown age)

(7) Structural control

Not obvious.

(8) Related igneous rocks

Not obvious.

(9) Alteration

Silicification, epidotization, argillization, etc.

5. Water supply

Swamps are seen near the valley. It is assumed that the groundwater level around the deposit is shallow.

6. Hydrology

Not obvious.

7. Discovery and history

198? The USSR discovered this mineral indication area and conducted a detailed survey.

1989 Geophysical exploration was conducted. IP anomaly was 15%, being higher than that of Ulaan (12%).

1991 Mongolia commenced geological survey at a scale of 1:50,000, drawing up a exploration map on a scale of 1:10,000, and boring. The depth of the boring hole was 492m as of July 22nd, 1991.

8. Mining operation

None.

1-1-7 Tsagaan-Chuluut Huduk deposit★

1. Location and transportation

Location: Longitude 113°25'00" East, Latitude 49°28'00" North, Elevation 860m above sea level. In administrative division terms, the deposit is located at the Bayandun Sum in the Dornod Aimag.

The branch line of the railway (narrow gauge) that connects the Siberian Railway and the Choibalsan city runs to Mardai, 60km southeast of the deposit. From the sealed road that is parallel to the branch line there is a dirt road running to the deposit. It is about 270km from Choibalsan city to the Tsagaan-Chuluut Huduk deposit, about 7-hour journey by car through the steppe via Mardai.

2. Topography

This deposit area consists of flat land, 790m~900m above sea level along the Ulz River and mountains, about 300m higher than that. The Tsagaan-Chuluut Huduk deposit is located at the southern foot of the mountains near the left side of the Ulz River. The highest part of this area is at Mt. Hanan (1,131.7m), about 8 km north-north-west of the deposit, while the lowest is the area alongside the Ulz River (790m~800m). Major rivers have abundant running water, and the valleys have well-developed swamps. The mountains are relatively steep, therefore the area a car can travel is limited.

3. Climate

The major climate index around the Tsagaan-Chuluut Huduk deposit is as follows: The Annual solar radiation is 4,600MJ/m^2, annual average temperature is $-1°C$, and annual precipitation is 246mm. This area belongs to the steppe climatic zone. As this area has sufficient precipitation in summer there is a relatively thick steppe, 50~70cm in length.

4. Geology and deposit

(1) Mineralization

The ore of this deposit consists of placer gold in the valley and stockwork quartz veins containing visible gold on the back mountains. Vein quartz is highly oxidized and leached. Native gold occurs as electrum with shape of hair, indefinate, quadrilateral, etc. As secondary minerals, limonite (goethite) is found.

(2) Type of deposit

Alluvial gold deposit (placer gold)

(3) Ore reserves and grades

First layer	approx. 450,000~650,000m^3, Au 0.6 g/m^3
Second layer	approx. 2,000,000m^3, Au 1.8g/m^3

The total amount of gold is estimated to be about 4t.

(4) Size of deposit

First layer	1~1.5m×50m×9,000m (approx. 1,800,000m^3)
Second layer	2m×100m×over 10km (approx. 2,000,000m^3)

(5) Structure of deposit

Quartz vein: Strike: N35°~40°W, Dip: 80°NE

Alluvial gold deposit:

First layer	approx. 1m below the surface	flat
Second layer	approx. 17m below the surface	flat

(6) Country rock

Alluvial sediments. Auriferous stockwork quartz vein is emplaced in the Proterozoic gabbro and granodiorite and the Triassic to Jurassic granite.

(7) Structural control

This deposit occurs in the alluvial sediments along the creeks.

(8) Related igneous rocks

Auriferrous quartz veins in the Proterozoic gabbro and granodiorite and aurifeous quartz veins and stockwork quartz veins in the the Triassic to Jurassic granite are considered to be the origin of alluvial gold. K-Ar ages are 154±8Ma for granite porphyry (Late Jurassic) and 156±8Ma for monzodiorite (hornblende), nearly the same age with granite around Tsav.

5. Water supply
   Water is abundant in the small valleys. Wells are present near the deposit.

6. Hydrology
   Water is abundant in the valleys.

7. Discovery and history
   1973 This deposit was discovered by the geological survey at a scale of 1:200,000.
   1991 Placer gold deposit has been explored by about 270 people by pitting, boring and blanket sluicing. Production is scheduled to commence in 1992.

8. Others
   Silicification, sericitizattion, and pyritization are observed in the host rock of auriferous stockwork quartz vein.

1-1-8 Mardai deposit★

1. Location and transportation
   Location: Longitude 114°21'30" East, Latitude 49°06'20" North, Elevation 900m above sea level. In administrative division terms, the deposit is located at the Dashbalbar Sum in the Dornod Aimag.
   The branch line of the railway (narrow gauge) that connects the Siberian Railway and the Choibalsan city runs to the deposit. The roads for trucks run parallel to the line. It is about 200km from Choibalsan city to the Mardai deposit, about 5 hour car ride through the steppe.

2. Topography
   Topographically, the deposit area is a hilly zone which is made up of buried valleys and small hills, 150m~250m higher than the valleys. The elevation is highest at the Mt. Dzurhut Ovoot (1,071.0m) which is located about 1.7km southeast of this deposit, and lowest at the valley located on the west of the deposit (860m). Four-wheel drive automobiles can travel in this area except the swamps along the major valleys.

3. Climate
   Same as Ulaan deposit.

4. Geology and deposit
   (1) Mineralization
   The ore of this deposit contains uranium. It occurs as coffinite, uraninite, etc.
   (2) Type of deposit
   Stockwork type~vein type.
   (3) Ore reserves and grades
   Not obvious. Not open to the public as it is of national importance.
   (4) Size of deposit
   Not obvious. (Size of the pit is 200m×400m×30m depth)
   (5) Structure of deposit
   Strike: NW-SE, Dip: 10°~15°NE

(6) Country rock

Rhyolite, andesite, basalt and their pyroclastic rocks (welded tuff and tuff: K-Ar age, 135~150Ma), conglometate and sandstone formed during Late Jurassic to Cretaceous Period.

(7) Structural control

Not obvious.

(8) Related igneous rocks

The Late Jurassic to Cretaceous volcanic rocks (?)

(9) Alteration

Not obvious.

5. Water supply

Not obvious.

6. Hydrology

Running water can been seen at the valleys, therefore it is assumed that the groundwater level around the deposit is shallow.

7. Discovery and history

1972 This deposit was discovered by air-borne γ-ray survey.

1980 The USSR began underground mining.

8. Mining operation

Open cut mining: Stripping has been completed, and mining has just begun. It is scheduled that mining be conducted to a depth of 100m.

Underground mining : Mining has been completed, and then the mine was closed.

(Amount of ore already exploited : approx. 25%)

9. Others

(1) Name of mine : DORNOD Uranium Mine (USSR jurisdiction)

(2) Number of employees : 100 (Russian)

1-2 Tumurtiin-Ovoo district

The Tumurtiin-Ovoo district is located in the Suhbaatar Aimag, eastern part of Mongolia, and has an area of about 16,000km^2.

The 48-passenger Antonov airplane departs several times a day from Ulaanbaatar to Baruun-Urt city, the capital of the Aimag. The flight takes about 85 minutes one way. The major transportation in this area is by car through the steppe.

Topographically, this district is located at the area where the Govi lowland, which is situated between East Mongolian Highland on the north and Daringanga basalt plateau on the south, is in contact with Dornod plain on the east. This area is a hilly zone, 900m~1,100m above sea level.

The climatic index varies considerably within the district. The annual average temperature; 1°C~5°C. Annual frostless days; 120~140. The highest and the lowest temperatures; 40.8°C and −41.4°C. The annual precipitation is higher in the southern part and lower in the northern part, ranging from 90mm to 175mm. The southern part is desert, and the central to the northern parts belong to the semi-desert to steppe zone. It is particularly windy from March to June and in November with about 30~50 sandstorm days annually.

The geology of the district is composed of the Devonian, Permian and Cretaceous Systems, and the Permian to Jurassic igneous rocks which intruded into them. Various deposits of high temperature type such as skarn-type zinc deposits at Salhiit, Tumuritiin Ovoo, etc., greisen-type molybdenum deposits at Arin-Nuul, quartz veins containing tungsten at Salaa, etc occur in association with the acidic igneous activity during the latesct Palaeozoic to Early Mesozoic Periods.

1-2-1 Tumurtiin-Ovoo deposit★ (Fig. II-1-6)

1. Location and transportation

Location: Longitude 113°19'29" East, Latitude 46°47'44" North, Elevation 1,135m above sea level. In administrative division terms, the deposit is located at the Suhbaata Sum in the Suhbaata Aimag. It is 18km from the capital of the Aimag to the deposit, about 40 minutes through the steppe by car.

2. Topography

The elevation of the major valleys aruond the deposit varies from 1,030m to 1,060m. The maximum elevation is Tumurtiin-Ovoo hill (1,139.4m) where the outcrops of ore deposit exist.

Topographically, the area around the deposit is hilly zone which is made up of buried valleys and small hills, 100m higher than the valleys. As the valleys have no running water, four-wheel drive automobiles can travel almost anywhere.

3. Climate

The major climate index of the Tumurtiin-Ovoo district is as follows:
Amount of solar radiation; Annual solar radiation is 5,100MJ/m^2.

The annual average temperature; 0.4°C.

Monthly average temperature*; the highest month is July with 19.9°C, the lowest month is January with −21.5°C

Temperatures range from −40.1°C to 39°C.

Precipitation*; annual precipitation: 191.2mm

Monthly average precipitation; the highest month is July with 57.0mm, and the lowest month is January with 2.2mm.

Relative humidity; monthly average : January 60~70%, April 30~40%, July 40~50%, October 40~50%.

Wind velocity*; monthly average; January 3.0m, April 4.9m, July 3.4m, October 3.4m. (per second)

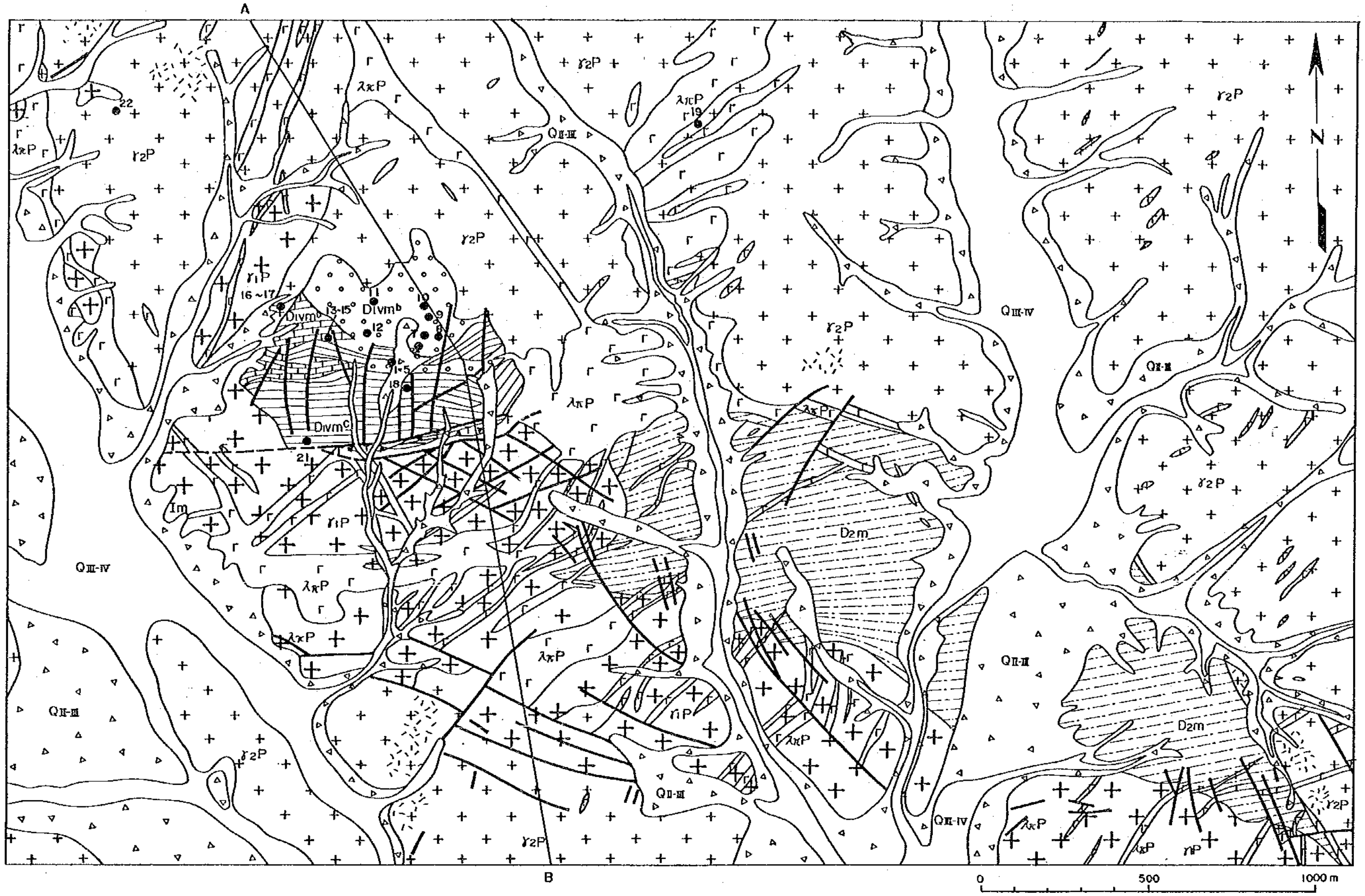
This area is highlands, about 1,000m above sea level, located between Mongolian Govi and the DORNOD plain. It's steppe length is short. It is relatively mild with about 120 frostless days annually, and windy for three consecutive months from April to June and November with about 30 sandstorm days annually

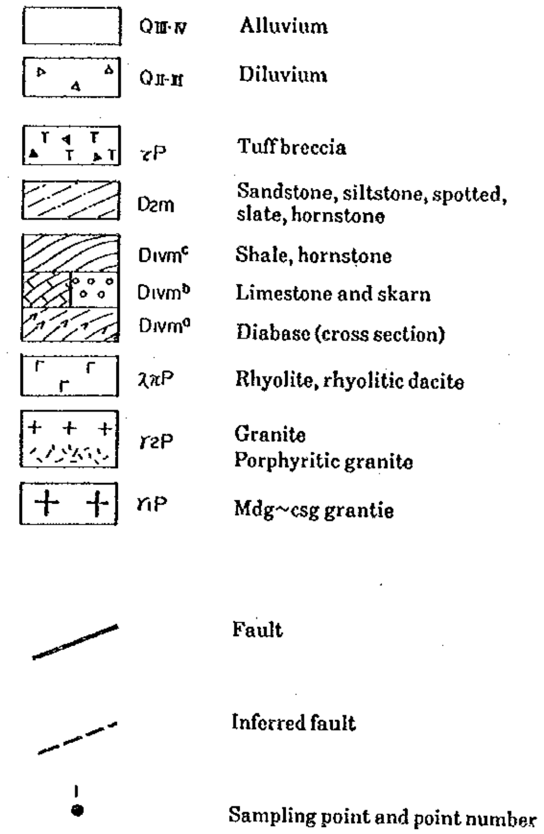
(Notice) *: * indicates the Baruun-Urt city's results.

4. Geology and deposit

(1) Mineralization

The ore of this deposit contains zinc. It occurs as garnet skarn ore with a large amount of magnetite iron ore. Ore minerals are magnetite, hematite, sphalerite, chalcopyrite, pyrite, stibunite etc. Sphalerite occurs as small veinlets within skarn and





Point No.	Sample No.	Point No.	Sample No.
1	3TN01	16	3TS28
2	3TS14	17	3TS29
3	3TS15	18	3TS30
4	3TS16	19	3TS31
5	3TS17	–	–
6	3TS18	21	3TY02
7	3TS19	22	3TY04
8	3TS20		
9	3TS21		
10	3TS22		
11	3TS23		
12	3TS24		
13	3TS25		
14	3TS26		
15	3TS27		

GEOLOGIC CROSS SECTION A–B

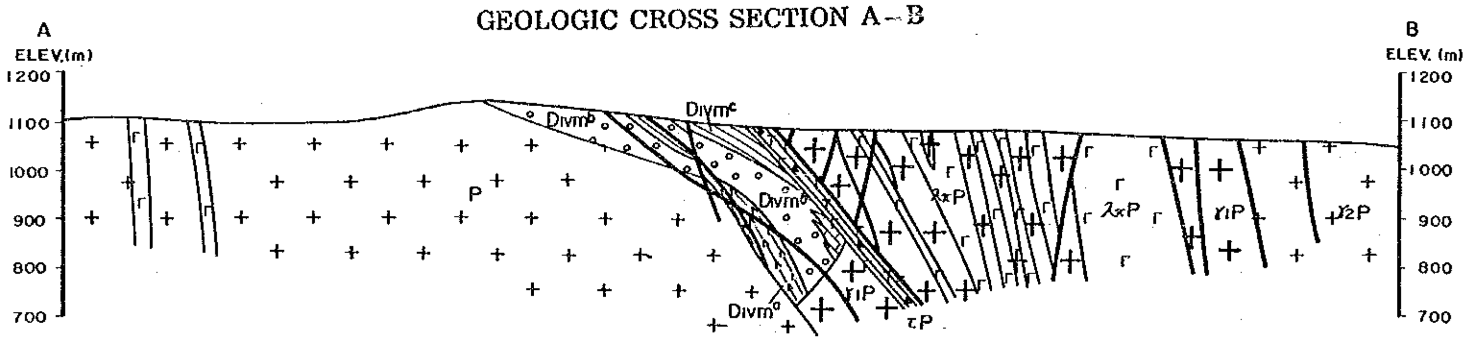


Fig. II-1-6 Geological map of Tumurtiin-Ovoo

magnetite, or as disseminated ores.

(2) Type of deposit

Massive type and/or lenticular skarn type.

(3) Ore reserves and grades; (Cut off 3.0%)

Ore reserves (t)	Classification	Zn (%)	Zn metal content(t)
6,810,000	$B+C_1$	12.04	820,000
7,689,000	$B+C_1+C_2$	11.5	885,300

(4) Size of deposit

Length 600m, width 300m, thickness 5m~40m.

(5) Structure of deposit

Strike: E-W, Dip: 18.4°N (calculated results).

(6) Country rock

The Silurian to Devonian sedimentary rocks and the Late Palaeozoic to Early Mesozoic acidic intrusive rocks intruding the sedimentalry rocks. The ore body is intruded by small dikes of porphyry and dioritic porphyry that have flow structure.

(7) Structural control

The deposit is of skarn-type by replacement of Devonian limestone and is controlled by size and structure of the limestone xenoblock. This xenoblock plunges toward south with 10 to 70° dip, in average 50°.

(8) Related igneous rocks

It is considered that the skarnization is related to the Late Palaeozoic and Early Mesozoic acidic intrusive rocks.

Regarding to abundant magnetite, there are two opinions whether related with the skarnization or of by sedimentary origin. The stage of zinc mineralization is considered to be related with small-size dikes of alkaline rocks at the latest stage of acidic igneous activity. However, presence of such a kind of alkaline rocks is not confirmed as yet. So, aforementioned theory remains only as an assumption.

(9) Alteration

Skarnization (magnetite-garnet skarn)

5. Water supply

1,230m^3/d of spring water is available at Dund Urt, 14km southeast of the deposit and Bayan Gol, 9 km east-south-east of the deposit.

6. Hydrology

As a result of the Hydrology survey from the Mongolian side, it is assumed that the amount of spring water from boring is 0.4~0.6m^3, the amount of the spring water in the tunnel is 1.5m^3, and open pit is 5~15m^3/h.

7. Discovery and history

1973 The survey group by the cooperation of East Germany and Mongolia conducted regional magnetic exploration.

1974 When the survey group by the cooperation of East Germany and Mongolia was conducting magnetic exploration, it was confirmed that zinc mineral existed in the magnetite.

1975~1976 The survey group by the cooperation of East Germany and Mongolia conducted a preliminary exploration.

1977~1979 The survey group by the cooperation of East Germany and Mongolia conducted a detailed survey (1980 Report).

Geological survey at a scale of 1:50,000

Boring 110holes 30,000m~40,000m

(Ore reserves were calculated based on 46 holes (8,476m) of boring in 1979)

1979 Technological F/S was conducted.

1980 Ore reserves and grades were ratified by the National Ore Resources Examining Committee.

1989 The final F/S was conducted only by the Mongolian side.

1990 Mongolian Ore Public Corporation (Mongolia, Erdene Co. Ltd.) was given permission to develop. It has been employing a consulting company to carry out the stripping. As well, Japanese and Canadian consulting companies are preparing an F/S.

Past exploration works

trenching many

boring 113 holes, Cumulative length 30,000m~40,000m, (50m×50m interval)

tunnel vertical shaft 70m (1), tunnel 1,051.6m (1,030m above sea level)

8. Mining

(1) Owner of enterprise

Mongolian Public Corporation of Mining (Mongol Erdene Corporation)

(2) Employees

Soviet contract-technicians has been conducting stripping at present.

(3) Scale of production

Exploration have not been conducted yet. (Only boring and tunnel exploration has been conducted.)

(4) Mining method (plan): Open cut mining, Stripping has been commenced at the production of crude ore is 300,000t/y (crude ore 1,000t/d) aiming at commencing mining in 1994. It is considered that ore reserves that are not workable by open cut mining are impossible to exploit, with the life of the mine estimated to be 25 years.

(5) Transportation method :

Not obvious.

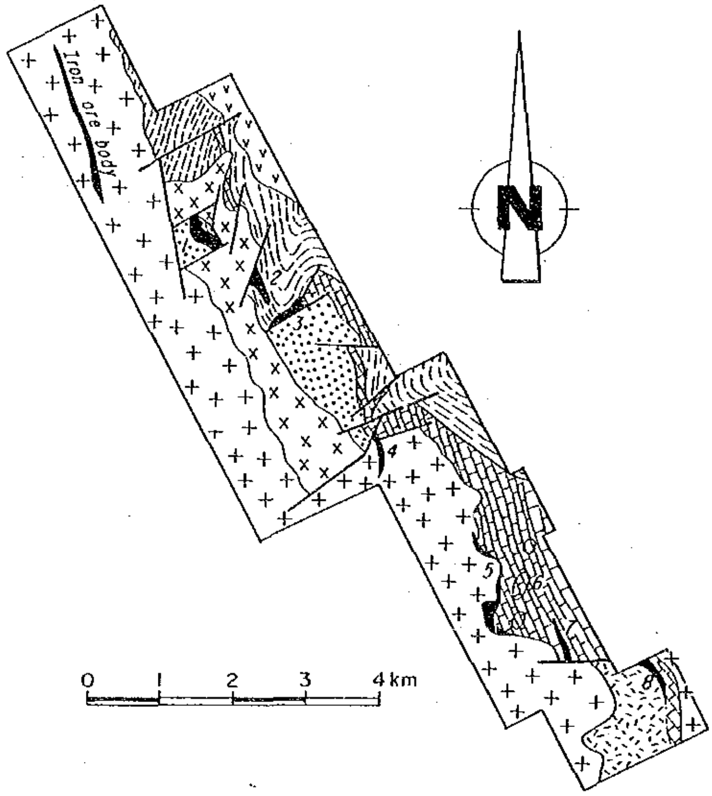
(6) Others

Ore from the surface to about 30m below is oxidized. Results of ore dressing test by East Germany is as follows: Recovery rate: 81.8%, Grade of concentrate : Zn 52.5%.

1-2-2 Salhiit deposit★ (Fig. II-1-7)

1. Location and transportation

Location: Longitude 113°30'05" East, Latitude 46°48'02" North, Elevation 1,074m above sea level. The deposit is located 16 km east of Tumuritiin-Ovoo. In administrative division terms, the deposit is located at the Suhbaatar Sum in the Suhbaatar Aimag. There is a dirt road running 27km from the capital of the Aimag, Baruun-urt to the deposit, about one-hour journey by car through the steppe.



(from D. Ayush, E. E. Petrenko, 1972)

LEGEND

- Cretaceous
  - Acidic effusive rock
  - Intermediate effusive rock
- Early~Middle Devonian
  - Clayey shale and siliceous shale
  - Carbonate rock
  - Sandstone and shale
- Jurassic
  - Granite porphyry and granodiorite porphyry
- Permian
  - Leucocratic granite
- Fault
- Zn mineralized zone and number
- Geochemical anomaly

Fig. II-1-7 Geological map of Salhiit

2. Topography

Elevation of major small valleys near the deposit are between 990m and 1,020m above sea level. The highest point is the nameless hill (1,106.2m) located at about 2km west of the deposit. Topographically, it is a hilly zone which is made up of buried valleys and small hills, 150m~250m higher than the valleys. As the valleys have no running water, automobiles can travel almost anywhere.

3. Climate

Same as Tumurtiin-Ovoo deposit

4. Geology and deposit

(1) Mineralization

The ore of this deposit contains zinc. It occures as magnetite-garnet-rich skarn. Additionaly, there are some ore showings in association with brecciated quatzite. Ore minerals are sphalerite and small amount of chalcopyrite, galena and tungsten.

(2) Type of deposit

Massive and/or lenticular skarn deposit.

(3) Ore reserves and grades

Ore reserves	Zn (%)	Zn metal content (t)
approx. 920,000t	6.4%	58,000t

(4) Size of deposit

Below-mentioned eight ore zones exist within a range of length 12km×width 300~800m, along the contact of the Devonian sedimentary rocks and Permian to Jurassic granite, granite porphyry and granodiorite porphyry.

Name	Length(m)	Thickness(m)	Grade	Remarks
1st zone	600	15~150		located at the northwestern end
250	20~30	Zn<3%		located at the northwestern end
2nd zone	800	50~300	Zn<2.5%	western wing of the syncline
	100~200	6~20	Zn 2~6%	Max. Zn=2%
	200	130	Zn0.1%	south wing of the syncline
3rd zone			Zn0.01%~3%,	Cu <1%
4th zone	600	20~70	Zn0.01~0.1%,	max. Zn 1~2%
5th zone	1,400	30~150	Zn1~1.4%,	max. Zn 2~3%
6th zone	3 geochemical anomaly zones within the area of 0.2km^2.			exist (Zn 0.01~0.02%)
7th zone	Fracture zone in skarn and quarzite		Zn < 0.1%	
8th zone	350	30	Zn<8%,	Cu+Pb<0.6~2%
	150	18	Zn<4%	

(5) Structure of the deposit

The shape of the each ore bodies is complicated, controlled by fold structure of the Devonian sedimentary rocks, the structure of limestone, the structure of the contact between the Devonian sedimentary rocks and intrusive rocks, and faults. Ore bodies are generally arranged in N40°W direction along the general trend of the contact between Devonian sediments and Permian to Jurassic intrusive rocks.

(6) Country rock

Silurian to Devonian sedimentary rocks, Devonian to Jurassic intrusive rocks and

Cretaceous extrusive rocks.

(7) Structural control

The ore bodies are arranged in N40°W direction along the boundary between the Devonian sediments and the Permian to Jurassic granite, granite porphyry and granodioritie porphyry and the locations are within 1km from intrusive rocks.

(8) Related igneous rocks

Skarnization is considered to be related to the Late Paleozoic to Early Mesozoic acidic intrusive rocks.

(9) Alteration

Skarnization (magnetite-garnet skarn), silicification.

5. Water supply

There is no river. Spring water of 1,230m^3/d is available at Dund-Urt, 15km southwest of the deposit and Bayan-Gol, 9km southwest of the deposit.

6. Hydrology

Not obvious.

7. Discovery and history

1966	Hungarian geological survey group (B. Yanchiki and others) discovered the deposit.
1968~1972	The survey group by the cooperation of East Germany and Mongolia conducted various surveys including trenching and boring.

1-2-3 Salaa deposit★

1. Location and transportation

Location: Longitude 113°26'06" East, Latitude 46°48'49" North, Elevation 1,070m above sea level. In administrative division terms, the deposit is located at the Suhbaatar Sum in the Suhbaatar Aimag.

There is a 19km dirt road running from the capital of the Aimag, Baruun-Urt to the deposit, about 40 min. by car through the steppe.

2. Topography

Elevation of major small valleys near the deposit are between 1,040m and 1,060m above sea level. The highest point is Mt. Bor (1,155.5m) located about 2 km northeast of the deposit. Topographically, it is hilly zone consists of of buried valleys and small hills, 100m higher than the valleys.

3. Climate

Same as the Tumurtiin-Ovoo deposit

4. Geology and deposit

(1) Mineralization

The ore of this deposit is wolframite bearing, quartz vein containing small amount of molybdenite.

(2) Type of deposit

Quartz vein

(3) Ore reserves and grades; (C_2)

Ore reserves WO_3 (%)

approx. 170,300t 1.35%

(4) Size of deposit

There are 12 quartz veins whose length is 100m~400m, width is 0.35m~1.2m, with the maximum width being 3.3m.

(5) Structure of deposit

Strike: NW-SE, Dip: 25°~60°NE

(6) Country rock

It consists of the Early and Middle Devonian terrigenous carbonate rocks, the Permian volcanic and granitic rocks, the Permian to Jurassic granitoids (Salaa Block, the mother rock of deposits in a strict sense; 205Ma) and the Middle to Late Cretaceous granitoids. As for intrusive rocks, they are made up of fine-grained granite, aplite and quartz porphyry formed in the Late Jurassic Period, and diorite, diabase and kersantite etc. formed in later age.

(7) Structural control

Associated with a big crushed zone by fault striking NW-SE, NE-SW with dip of 25°~60°E~NE. The structure of this deposit is the same as that of intrusive rocks.

(8) Related igneous rocks

Dike-formed intrusive rocks since Jurassic.

(9) Alteration

Greisenization is partially seen.

5. Water supply

There is no river. 1,230m^3/d of Spring water is available at Dund-Urt, 13km south of the deposit and Bayan-Gol, 5km southwest of the deposit.

6. Hydrology

Not obvious.

7. Discovery and history

1966: The geological survey group (By the cooperation of Hungary and Mongolia) discovered the deposit.

1966: After the discovery, various surveys including trenching and boring were conducted, and mined by open cut mining and underground mining.

1-2-4 Arin-Nuur deposit★

1. Location and transportation

Location : Longitude 113°57'31" East, Latitude 47°13'44" North, Elevation 1,006m above sea level. It is located about 75km northwest of the Baruun-Urt city. In administrative division terms, the deposit is located at the Suhbaatar Sum in the Suhbaatar Aimag. There is a dirt road running from the Baruun-Urt city (population 16,000) to the mine. It is about 100km from the Baruun-Urt city to the Arin-Nuur deposit, and it takes about two and a half hours by car through the steppe.

2. Topography

Elevation of major small valleys near the deposit are about 900m above sea level. The highest point is the Mt. Sharga Tolei (1,025.0m) located about 0.5 km northeast of the deposit. Topographically, it is a hilly zone which is made up of buried valleys and small hills, 100m higher than the valleys.

3. Climate

Same as the Tumurtiin-Ovoo deposit

4. Geology and deposit

(1) Mineralization

The ore of this deposit contains copper and molybdenum. It occurs as greisen ore containing chalcopyrite and molybdenite. Greisen is composed of quartz and sericite with calcite and potassium feldspars. Ore minerals are pyrite, chalcopyrite, molybdenite and small amount of galena, magnetite and ilmenite. Tetrahedrite, chalcocite, cassiterite and wolframite are rarely found. Limonite, jarosite, covelline and malachite are prominent in oxidized ore.

(2) Type of deposit

Massive greisen. There are 4 ore zones.

(3) Ore reserves and grades; (C_2)

Ore reserves (t)	Mo (%)	Cu (%)	Mo metal content (t)
24,100,000	0.107	0.06	25,810

(4) Size of deposit

1st zone

No. 1 ore body 400m×700m×depth 30m~100m (lenticular type , dip 40~50°NE)

No. 2 ore body thickness less than 20m×depth 20m~30m (vein-type , dip 20~30°E)

2nd zone

thickness less than 40m×length of 500m. Quartz veins are developed in the greisen.

3rd zone

thickness 100m×length 500m. Greisen plunges steeply to NE.

4th zone

Not obvious. It consist of greisen and quartz vein.

(5) Structure of deposit

Strike: NW-SE, Dip: 25°~60°N

(6) Country rock

It consists of the Permian coarse-grained granite, and the Jurassic to Cretaceous biotite granite, granite ~ syenite granodiorite. Aplite, pegmatite, granite porphry, granodiorite porphyry, and lamprophyre occur as pre-mineralization dikes and albitophyre and porphyrite occur as post-mineralization dikes. Greisenized granite is the most important as host rock of copper-molybdenum mineralization.

(7) Structural control

The structure of the deposit is controlled mainly by fractures. The strike of the major fractures are parallel to the contact of the Permian sediments and the Jurassic granitoids with fracture zones of 10-15m width and dip of 80°NW.

(8) Related igneous rocks

The Cretaceous granite porphyry and granodiorite porphyry (?).

(9) Alteration

Microclinization, albitization and greisenization from the margin to the center.

5. Water supply

There is no river. There is an oasis in the Arin-nuul village, about 4km north of the deposit.

6. Hydrology

Not obvious.

7. Discovery and history

1967: B. Yantyuki, a Hungarian geologist and others discovered this deposit.

After the discovery ~ 1970s: The survey group by the cooperation of East Germany and Mongolia conducted various surveys including trenching and boring, and mined by open cut mining and underground mining.

1-3 Nuhut-Dawaa district

The Nuhut-Dawaa district is located in the Erdene-Tsagaan Aimag, eastern part of Mongolia occupying an area of about 7,000km².

The 48-passenger Antonov airplane flies once a day from Ulaanbaatar to Baruun-Urt city, the capital of the Aimag. The flight takes about 85 minutes one way. It takes about six to seven hours by car through a path in the steppe from Baruun-Urt to Nuhutt-dawaa.

As for topography, this district has a gentle hilly topography which has an elevation of 900m~1,200m and located in the northern end of the Dariganga Highland.

The climatic index varies as follows. The annual average temperature; 0°C~1°C. Annual frostless days; 105~115. The highest and the lowest temperatures; 39.0°C and −41.4°C (Baruun-Urt). The annual precipitation is 230mm~270mm, therefore this district is covered by a relatively thick steppe. It is particularly windy on three consecutive months from April to June and November having more than 40 sandstorm days annually.

As for geology, this district consists of Ordovician sandstone and schist, and biotite granite intruded from Triassic to Jurassic time. Accompanied with these acidic igneous activity, many greisen type deposits of tungsten, molybdenum and berylium like Tsentr, Yuguzer, etc., quartz vein containing tungsten and pegmatite type deposit of berilium and a mineralized zone of rare metals are formed.

1-3-1 Yuguzer deposit ★ (Fig. II-1-8)

1. Location and transportation

Location: Longitude 115°24'02" East, Latitude 45°54'27" North, Elevation 1,181m above sea level. In administrative division terms, the deposit is located in the Erdene-Tsagaan Sum in the Suhbaatar Aimag. The deposit and the old mine site are located about 205km southeast of Baruun-Urt city, the capital of the Aimag, and adjacent to the eastern part of Erdene-Tsagaan village.

It is about 250km from Baruun-Urt city to the Yuguzer deposit, taking about six hours by car through the steppe via the dirt road.

2. Topography

Elevation of major valleys near the deposit are about 1,060m above sea level. The highest point is the hill where the outcrop of the deposit is present (1,160.2m). This district is a gentle hilly zone which consists of buried valleys and hills, 100m higher than the valleys. At the river side of Jyaran river and Khuishiin river which flow western side of deposit, some part forms very steep cliff.

3. Climate

The major climate index around the Yuguzer deposit is as follows.
Amount of solar radiation; Annual solar radiation is 5,200MJ/m².

Temperature; annual average temperature; 0.5°C.
Monthly average temperature*: the highest month is July with 19.9°C, and the lowest month is January with −21.5°C.
Temperatures range from −40.1°C to 39°C.

Precipitation*; annual precipitation: 191.2mm.
Monthly average precipitation; the highest month is July with 57.0mm, and the lowest month is January with 2.2mm.

Relative humidity; monthly average : January 47%, April 37%, July 47%, October 45%.

Wind velocity*; monthly average; January 3.0m/sec., April 4.9m/sec., July 3.4m/sec., October 3.4m/sec.

This deposit is located where Dariganga Highland and DORNOD plain meet. The area around the deposit is a highland about 1,000m above sea level, and steppe is covered by low grass. The temperature is relatively mild, with about 110 frostless days annually. It is particularly windy for three consecutive months from April to June and November with about 40 sandstorm days annually.
(Notice) *: * indicates the Baruun-Urt city's data.

4. Geology and deposit

(1) Mineralization

This deposit contains tungsten, molybdenum, beryllium, and bismuth. It mainly occurs as greisen, and partially quartz vein. Molybdenite is found in addition to wolframite. Wolframite is column-shaped, and disseminated in quartz and muscovite.

(2) Type of deposit

Massive and/or vein type greisen deposit and quartz vein. As for the ore reserves, greisen occupies 90%, and molybdenum-bearing quartz vein occupies 10%.

(3) Ore reserves and grades; (C_2)

Ore reserves	WO_3 (%)	Mo (%)
approx. 21,580,000t	0.197	0.056

In addition, there are BeO 41,000t (average grade 0.08%), and Bi 5,140t (average grade 0.132%).

(4) Size of deposit

There are greisen deposits whose area are 1.5km^2 and several meters to 150m (average width is 66m) thick and 45 quartz veins whose width are several cm and length are less than 100m. There are 12 greisen deposits, among them, the No. 4 ore body, the largenst one, whose length is 1,450m, width 82m to 900m, and average thickness 8.9m, occupies 90% of the ore reserves.

(5) Structure of deposit

The deposit was formed by greisenization at the top of biotite-granite dome of late Triassic to Jurassic age, and its shape is just like a convex contact lens swelled upward. The boundary between schist which is the cap rock, and greisenized biotite granite is sharp. Greisenization is the strongest at the top of dome and gradually gets weak to the deep place and increases the inclination towards circumference.

The strikes and dips of the major deposits are as follows.

No.1 Ore body. Strike: N40°E, Dip: 5~55°NW
No.2 Ore body Strike: N30°E, Dip: ~50°SW
No.3 Ore body Dome-shaped, Dip is not obvious.

(6) Country rock

Biotite granite intruded during Triassic and the beginning of Jurassic Period.

(7) Structural control

The deposit is the greisen formed at the top of the biotite granite dome intruded during Triassic to Jurassic Period. (thickness: several m~150m, average 66m). Distribution of greizen is controlled by the dome of biotite granite. The boundary between greizen and Ordovician sandstone and schist which are the cap rock is quite obvious.

(8) Related igneous rocks

Biotite granite formed during Triassic to the beginning of Jurassic Period.

(9) Alteration

Greisenization and silicification are dominant. The greisenization is developed at albitization zone~feldspathization (potassium feldspar) zone at the top of the biotit granite dome with zinnwaldite. The minerals consist of topaz, zinnwaldite, quartz, berezite (a kind of replaced products composed of quartz, sericite, pyrite, etc.), argillite (a kind of rock which is dark grey or green in color, and consists of plagioclase, quartz, lepidolite, topaz, muscovite, beryl, cassiterite, wolfromite, pyrite and a small amount of molybdenite and chalocopyrite), quartz and kaolinite.

5. Water supply

There are wells and rivers at Chonogol, 2km west of the deposit.

6. Hydrology

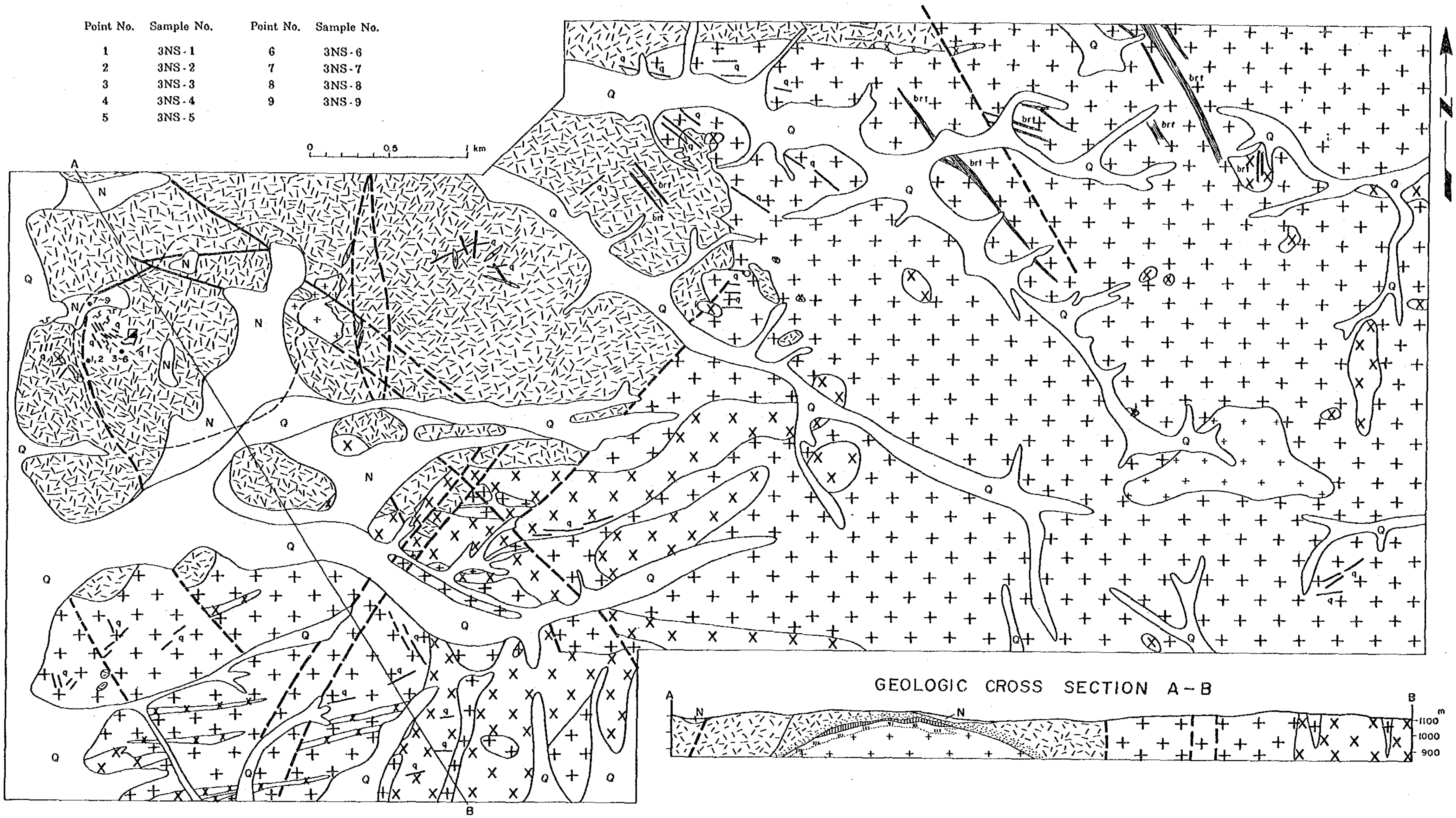
Amount of water emanation in the tunnel is 30~50ℓ/min.

7. Discovery and history

In the past, mining activity in the Nuhut-Dawaa district was conducted with priority given to the Yuguzer deposit, and at the same time developping other ore showings and the deposit. Therefore, the followings show not only the history of Yuguzer deposit but also other ore showings which shall be mentioned later.

1938	The USSR began to conduct geological surveys.
1939	Kabariam, a Russian, discovered the tungsten vein (a part of the Yuguzer deposit) when exploring for water resources.
1942~1943	The USSR began to conduct a geological survey at a scale of 1:10,000 and 45 quartz veins that contained wolframite and scheelite are discovered. While conducting these surveys, the Batgui ore showings (W) were discovered.
1943	Working at the Yuguzer mine began.
1954	The USSR discovered ore showings of Mo, W, and Be (SaihanUul, Tsagaan Uul) when making map at a scale of 1:200,000.
1956	Working at the Yuguzer mine was suspended.
1957	The USSR conducted various surveys including pit, trenching, and boring in such mineral showing areas as Saihan-Uul, and Tsagaan-Uul etc.
1969	The Bayan-Hairast deposit was discovered. The grade, WO_3 3.6 % is confirmed by pits (By the cooperation of Mongolia and USSR).
1970	Mapping at a scale of 1:25,000 (By the cooperation of Mongolia and USSR). Evaluation of small-sized mineral indication was conducted around the skarn greison mineral showing in Bayan-Hairast.

Point No.	Sample No.	Point No.	Sample No.
1	3NS-1	6	3NS-6
2	3NS-2	7	3NS-7
3	3NS-3	8	3NS-8
4	3NS-4	9	3NS-9
5	3NS-5		



LEGEND

- Q — Quarternary
- N — Neogene
- Middle ~ Late Jurassic: Granite porphyry
- Early ~ Middle Jurassic: Leucocratic granite
- Late Triassic ~ Early Jurassic: Leucocratic porphyritic granite
- Carboniferous: Biotite granite, biotite-hornblende granite
- Ordovician(?): Metamorphic rocks derived from shale, sandstone and siltstone
- Hornfels(cross section)
- Greizen(cross section)
- Ore body of Mo, W(cross section)
- brf — Zone of argillization, chloritization and "beresitization" bearing fluorite and sulphide
- Quartz vein
- Fault
- Inferred fault
- Zone of upper greizenizated layer
- Shaft
- Adit
- Sampling point and number

Fig. II-1-8 Geological map of Yuguzer