Part I

GENERAL DISCUSSION

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Chapter 1 Introduction

1.1 Circumstances for starting the survey

Since 1990, the Mongolian government has been proceeding with a shift from the planned economy to the market economy, opening a door of its economy to Western countries and enforcing its policy to accelerate introduction of required funds and techniques. The main industries of the country are livestock farming, mining and light industries. Concerning the mining industry the Erdenet mine which is one of the world's largest porphyry copper and molybdenum deposits, and their concentrates earn a large percentage of total export income of Mongolia

The basic survey for developing mineral resources in Mongolia conducted by Japan International Cooperation Agency (JICA) and Metal Mining Agency of Japan (MMAJ) was commenced in FY 1991 and it has been enforced in the following five areas till FY 1997 (Figure I-1-1).

- Uudam tal area (survey of developing mineral resources):	FYs 1991 to 1993
- Tsav area (survey of developing local areas):	FYs 1992 to 1995
- Altan tal district (regional survey of mineral resources):	FYs 1994 to 1995
- Uudam tal area (follow-up survey and aftercare):	FY 1995
- Tsagaan tsakhir uul area (survey of developing mineral resources):	FYs 1996 to 1997

Upon enactment of the New Mining Law in 1997 in accordance with the world standards, Mongolia has been promoting prospecting and development of mines through introduction of foreign funds, allowing the mine development with 100% foreign funds. Under these circumstances, Mineral Resources Authority of Mongolia (MRAM) (changed to the Ministry of Trade and Industry, Mineral Resources Authority of Mongolia, in September, 2000 accompanying the government office reorganization as a result of change in political power) estimated the basic surveys for mineral resources conducted in previous years and requested the Japanese government to conduct a regional survey of the central north area where potential of copper, gold and other mineral resources was expected (Public Communication No. 449). The Mongolian side expects to use the result of this project as a basic data for promoting exploration and development of mineral resources based on the foreign investment.

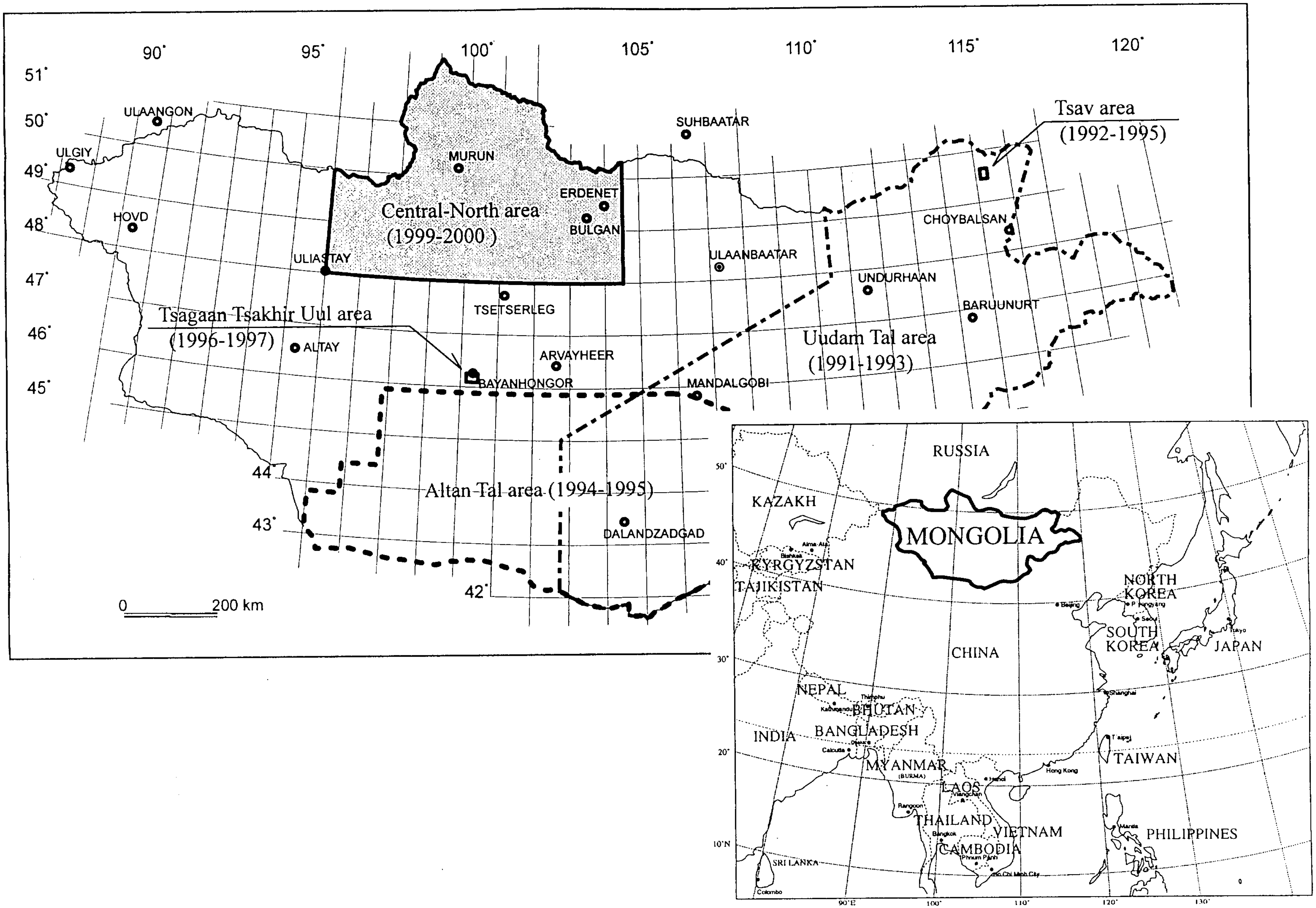


Fig. I-1-1 Location map of the past and present projects in Mongolia

1.2 Outline of the survey

1.2.1 Purpose of the survey

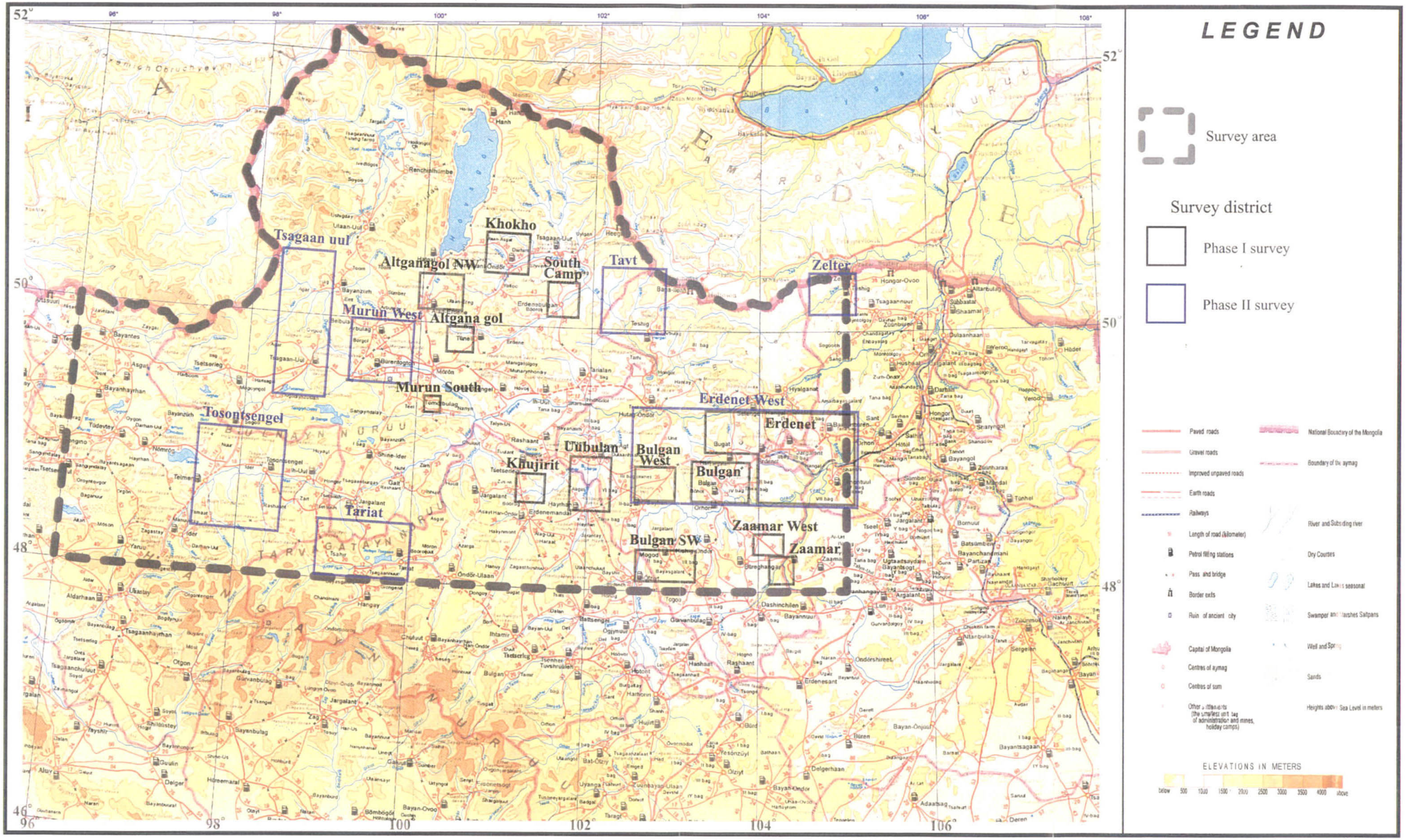
The purpose of this survey on the central north area of Mongolia is first to conduct the analyses of existing data and satellite images as well as the ground truth (reconnaissance field survey), to execute an integrated analysis of the acquired data, and then to efficiently extract promising areas for mineral deposits out of the whole area.

1.2.2 Survey area

The area covered by this survey is located in the northern part of Mongolia. It ranges from 97° 00′ E to 104° 30′ E of longitude in the E-W, and from the southern limit of 48° 00′ N of latitude to the northern limit of the border between Mongolia and the Russian Federation in the N-S, covering approximately 200,000 km^2 (Figure I-1-1). Geography of the area is roughly divided into two parts, i.e. the steppe in the South and mountainous/forestry area in the North. The Erdenet mine (a porphyry copper and molybdenum deposit) whose operation started in 1978 is included in the southeastern part of the survey area.

1.2.3 Survey methods

In the first year, the existing data were collected and analyzed. While the information on the geology and deposits of the area surveyed was collected and compiled, the points for the ground truth were extracted on the basis of the prepared mosaic images and geological interpretation of SAR data obtained by JERS-1. Since a wide range of approximately 200,000 km^2 was covered by the survey, the district was divided into two parts, the east and west to 100° east longitude, and our ground truth was conducted on the part east to. 100° east longitude in the initial year, and the survey on the part west to 100° east longitude was conducted in the second year. However, Tavt. and Zelter districts ,whose survey was unavailable in the initial year because of access problem, were covered by our survey of the second year. Further, a follow-up survey was enforced in the second year on the Erdenet West district which was considered to be promising as a result of the survey enforced in the initial year.



Road map of Mongolia (1999)

Fig. I-2-1 Site map of the central north area

(1) Analysis of existing data

The data and drawings of the geological surveys and prospecting of mineral resources conducted by Mongolia alone or jointly with the former USSR and East European countries was listed. Our analysis was conducted in the first year to select the prospects which were considered as important.

(2) Analysis of satellite images

Mosaic images will be prepared from SAR data obtained by JERS-1, geologically analyzed and interpreted together with the existing data. Geological structures related to generation of deposits such as lineament and circular structure will be acquired on the SAR image and used to help extract promising areas for occurrence of deposits. In the first year, the image of the entire area was prepared and image analysis was conducted for the part east to 100° east longitude, and in the second year, image analysis was conducted on the part west to 100° east longitude.

(3) Ground truth

Based on the results of analyses of existing data and satellite images, ground truth (reconnaissance geological survey) is conducted to grasp geology and alteration style of the selected mineral occurrences/points. In addition rock chip, ore, and stream sediment samples collected were supplied for laboratory tests. The results of laboratory tests with field observations might be used for the integrated analysis.

1.2.4 Organization of the survey mission

(1) Analysis of existing data and conducting ground truth

(1-1) Japanese side:

Ken Nakayama (Japan Mining Engineering Center for International Cooperation - JMEC)
Ikuhiro Hayashi (JMEC)
Hajime Hishida (JMEC)
Haruhisa Morozumi (JMEC)
Takayoshi Murakami (JMEC)

(1-2) Mongolian side:

Dambiisurengiin Bold (Mineral Resources Authority of Mongolia - MRAM)
Chadrabaliin Gerelkhuu (MRAM)

Baatariin Ochirkhuyag (Geological Information Center of MRAM)
Sengeegiin Munhkbaatar (Geological Information Center of MRAM)
Renchindorjin ENKHSAIKHAN (Geological Information Center of MRAM)

(1-3) Analysis and processing of satellite images

Masahiko Nono: Analysis and report preparation (JMEC)
Yoshiaki Shibata: Image production, analysis and report preparation (JMEC)
Tadashi Yamakawa: Data processing and image production (JMEC)
Motomu Goto Data processing and image production (JMEC)

(1-4) Integrated analysis and report preparation

Ken Nakayama (JMEC)
Ikuhiro Hayashi (JMEC)
Hajime Hishida (JMEC)
Haruhisa Morozumi (JMEC)
Takayoshi Murakami (JMEC)
Naoyoshi Murakami (JMEC)

(1-5) Repot the result to the Mongolian counterpart

Ken Nakayama (JMEC)
Naoyoshi Murakami (JMEC)

1.2.5 Duration and contents of the survey

(1) Phase-I survey

(1-1) Analysis of existing data and conducting ground truth

June 30 (Wed.) - September 3 (Fri.), 1999

Table I-1-1 Record of the ground truth (Phase-I survey)

Item		Number
Observed sites	:	80
Samples obtained	: Rocks and ores	276
	: Stream sediments	18

(1-2) Analysis of satellite images

June 22 (Tue.) - October 15 (Fri.), 1999

Data processing, mosaic image production and analysis of SAR image obtained by JERS-1

(1-3) Laboratory test, integrated analysis and report preparation

September 6 (Mon.), 1999 - March 16 (Wed.), 2000

Table I-1-2 Laboratory test (Phase-II survey)

Item		Number of samples
Microscopic observation		
Thin section		69
Polished thin section		9
Polished section		4
X-ray diffraction		41
Geochemical analysis		
Ore	(23 elements)	3
Rock Chip	(28 elements)	181
Rock	(XRF: 47 elements)	36
Pan Concentrate	(17 elements)	17
Fluid inclusion (Homogenization Temperature and Salinity)		7
EPMA		5
K-Ar dating		6
Stable isotope		
$\delta^{18}O$		5
$\delta^{34}S$		7

(1-4) Outline of the results of Phase-I survey

Geology of the district covered by the survey was found to consist of multiple micro continents and island arcs formed or accreted during the time from the Precambrian to the Lower Mesozoic, influenced by several ogenic movements, and deposits were formed as a result of active igneous activities which occurred from the Upper Paleozoic to the Mesozoic. With regard to mineralization, it is important to consider the relations between the lineament in the NW-SE system and the lineament in the N-S system. The tendency was noted where granitic rock were intruded, and mineralization of porphyry type copper, epithermal type gold and skarn type lead-zinc were identified.

On consideration of the result of ground truth together with laboratory test, a total of 17 mineral occurrences and points were selected as promising. Since the promising mineral occurrences/points occurred in Erdenet, Bulgan, Bulgan West districts, these three districts were determined as having potentials of deposit existence.

(2) Phase-II survey

(2-1) Conducting ground truth

June 17 to (Sat) - August 12 (Sat), 2000

Ground truth

Table I-1-3 Record of the ground truth (Phase-II survey)

Item		Number
Observed sites	:	37
Samples obtained	: Rocks and ores	276
	: Stream sediments	18

(2-2) Analysis of satellite images

June 14 to (Wed) - October 13 (Fri), 2000

Data processing, mosaic image production and analysis of SAR image obtained by JERS-1

(2-3) Laboratory test, integrated analysis and report preparation

August 14(Mon), 2000 - March 23 (Fri), 2001

Table I-1-4 Laboratory test (Phase-II survey)

Item		Number of samples
Microscopic observation		
Thin section		81
Polished thin section		41
Polished section		
X-ray diffraction		159
Geochemical analysis		
Ore	(23 elements)	10
Rock Chip	(28 elements)	220
Rock	(XRF: 47 elements)	13
Pan Concentrate	(17 elements)	16
Fluid inclusion (Homogenization Temperature and Salinity)		11
EPMA		0
K-Ar dating		7
Stable isotope		
$\delta^{18}O$		8
$\delta^{34}S$		2

(2-4) Report of the result to the Mongolian counterpart
March 4 (Sun) – March 9 (Fri), 2001

(4) Outline of the results of Phase-II survey

Like the part covered by our survey conducted in the initial year, geology of the part west to 100°east longitude consists of accretionary prism and magma arc of the Riphean to the Lower Mesozoic. As a result of the existing data analysis, Tariat, Tsagaan uul, Tsosontsengel and Murun West districts were selected whose potentials of gold and copper deposit existence were considered as high. In the part east to 100° east longitude, Zelter and Tavt districts were selected. Upon examination of the ground truth and laboratory test results, Naranbulag mineral occurrence in Tosontsengel district and Ereen and Teshig mineral occurrences in Tavt district were extracted as promising mineral occurrences. On the other hand, in Erdenet West district which was considered as promising from the results of the survey conducted in the initial year and a follow-up survey was enforced, existence of lithocap was reconfirmed as a sign of the surface and shallow features of porphyry system in Tsagaan chuluut, Mogoin gol 2 and

Danbatseren mineral occurrences and a possibility where highly sulfidation type gold deposit and porphyry copper/molybdenum deposits might exist at deep was determined. It was also reconfirmed that epithermal gold deposits might exist in Tsookher mert prospect in Erdenet West district and Oyuut khonkhor prospect in Bulgan West district.

Chapter 2 Geography of the Survey Area

2.1 Location and traffics

The survey area is located in the northern part of Mongolia with its western limit and eastern limit at 97° 30' E and 104° 30' E of longitude respectively, and with southern limit at 48° 00' N of latitude and northern limit of the border between Mongolia and the Russian Federation, covering approximately 200,000 km^2 (see Figure I-2-1). The rectilinear distance from the capital of Ulaanbaatar and the southeastern end of the surveyed area is approximately 180 km.

The eastern and northern parts of the area extend over aimag (Provinces) of Bulgan and Khuvsgul respectively, while its southern and western parts extend over aimag of Arkhangai and Zavkhan respectively. Five major cities in the area are Bulgan (population: 13,000; Bulgan aimag) and Murun (population: 28,000; Khuvsgul Province), Tsetserleg (population:18,000; Arkhangay aimag), Tosontsengel (population: 10,000; Zavkhan aimag) which are capitals of the respective aimag, and Erdenet (population: 65,000; Bulgan aimag) which is a mining city.

Access to the area can be performed by railway or air route from Ulaanbaatar. However, because of their limited routes, people prefer to going there by car in most cases. Almost all the main roads connect to cities, towns and villages of the survey area are not paved and rough. Therefore, it is necessary to move by four-wheeled vehicles. Depending on topographical features and road conditions, around 70-80 km/hour may be available in some places. However, usually 30-50 km/hour is available in almost every place. If many gravels and rocks are placed on the road or if it is muddy right after rainfall, we are forced to drive there at 30 km/hour or less. Although network of roads connect to local cities, towns and villages has been developed, almost every road is not well maintained. Therefore, arrival time with given distance is difficult to estimate.

One of the problems for transportation by vehicles is crossing rivers. The western part of the survey area mainly consists of mountains with forests where many rivers are running. Although a bridge is provided at a point where main road and big river is crossing, most of them are made of wood and excessively damaged. In some places a bridge has been washed away because of flood and the road is impassable (for example, east of Tsagaan uul town, northern part of the area). No bridge is provided for middle to small-scale river. When a river was swollen, our vehicle used for the survey could cross it only through traction by a truck made in Russia. An accident once occurred near Tavt; a four-wheel drive vehicle was washed by water flow, inundated, and was towed by a large-scale heavy machine. Sufficient preparation for vehicle parts is required since it is almost difficult to obtain them in rural districts.

The main trunk roads are as follows:

- Ulaanbaatar → Zaamar (200 km, 5 hours) → Bulgan (100 km, 3 hours)
- Ulaanbaatar → Darkhan (200 km, 5 hours) → Erdenet (50 km, 2 hours)
- Erdenet → Bulgan (100 km, 3 hours)
- Bulgan → Selenge (250 km, 6 hours) → Murun (100 km, 3 hours)
- Ulaanbaatar → Tsetserleg (400km, 11 hours)

A railway has been constructed from Ulaanbaatar to Erdenet via Darkhan, and its operation is once a day. A regular flight is available from Ulaanbaatar to Murun, and from Ulaanbaatar to Tosontsengel through a year.

Buses also run on main roads. However, because of their irregular time schedule, it is difficult for foreigners to use them. In addition to vehicles and buses, Mongolians also use cattle for their transportation.

2.2 Topography

Figure I-2-2 shows topography of the survey area.

Average level of Mongolia is 1,580 m above the sea level. While the lowest point is 552 m, the highest point is 4,506 m on Mt. Berukha, the highest mountain in the Altai Mountains. The national land is roughly divided into two parts, that is Khangai, north of Mongolia consisting of forests, rivers, lakes and fertile plateaus, and Gobi, south of Mongolia consisting of steppes where less than 50% of the area is vegetated and deserts. The survey area belongs to Khangai. The southeastern part consists of the Khangai Mountains whose level is 2,000 m to 4,000 m above the sea level, and the northern part close to the border with Russian Federation is steep Khuvsgul Mountains. In contrast, the central to eastern parts of the survey area consist of hills with gentle slopes and flat steppes.

Topographical characteristics of the area are described below.

Khuvsgul Mountains constitute a district on the eastern extension of Sayan Mountains ranging from Russia. Lake Khuvsgul, one of the most eminent picturesque places in Mongolia, is situated in the central part of the mountains which are 2,000 to 3,500 m above the sea level.

Khangai Mountains consist of Khangai Range, Tarvagatai Mountains and Bulnai Mountains, whose level is 2,000 to 4,000 m above the sea level.

Orkhon-Selenge River Basin is a drainage basin with the Selenge river running in the northern central part of Mongolia (which flows into Lake Baikal located in Russian Federation) and Orkhon River as its branch. The district is one of the most eminent places for stock raising in Mongolia.

2.3 Drainage system

Figure I-2-2 shows a drainage system of the survey area.

The Selenge River which runs through the survey area is the largest river in Mongolia having a lot of branches. The Selenge river runs through vast basins of Selenge and Orkhon crossing the border with Russian Federation and flows into Lake Baikal. From Lake Baikal it diverge into rivers called Angara and Yenisey, and they flow out into the Arctic Ocean. The total length of the extended basin of Yenisey, Baikal and Selenge is almost 5,540 km.

Orkhon gol, a branch of the Selenge river running through the southeastern part of the survey area, joins the Selenge river at the point approximately 50 km to the south of the border with Russian Federation.

Lake Khuvsgul is the second largest lake in Mongolia, whose area (2,760 km^2; 125 km $\times$ 30 km) is approximately four times as large as that of Lake Biwa, Japan. The depth of the deepest point of the lake is 262 m. Being a fresh water lake with exceedingly high transparency, the lake is one of the most popular places to tourists for its picturesque scenery. The lake and its vicinity are designated as a national park. Compared with the eastern part of the survey area, more lakes and swamps develop in the western through southwestern parts.

2.4 Climate

Figures I-2-3 and I-2-4 show the average temperatures of a year and annual precipitation of the survey area, while Tables I-2-1 and I-2-2 and Figures I-2-5 and I-2-6 show temperatures and precipitation in every month of a year in Ulaanbaatar, Murun and Bulgan.

As a characteristic of the climate in Mongolia, difference in temperatures is conspicuous because of its continental climate. Hot summer season is short, and it is chilly in winter. The northern part of Mongolia where the survey area is situated belongs to the sub-polar zone of cool temperate zone as a climate division. The steppe in the central part has a dry climate and Gobi in the southern part has a desert climate. Annual precipitation of the capital Ulaanbaatar

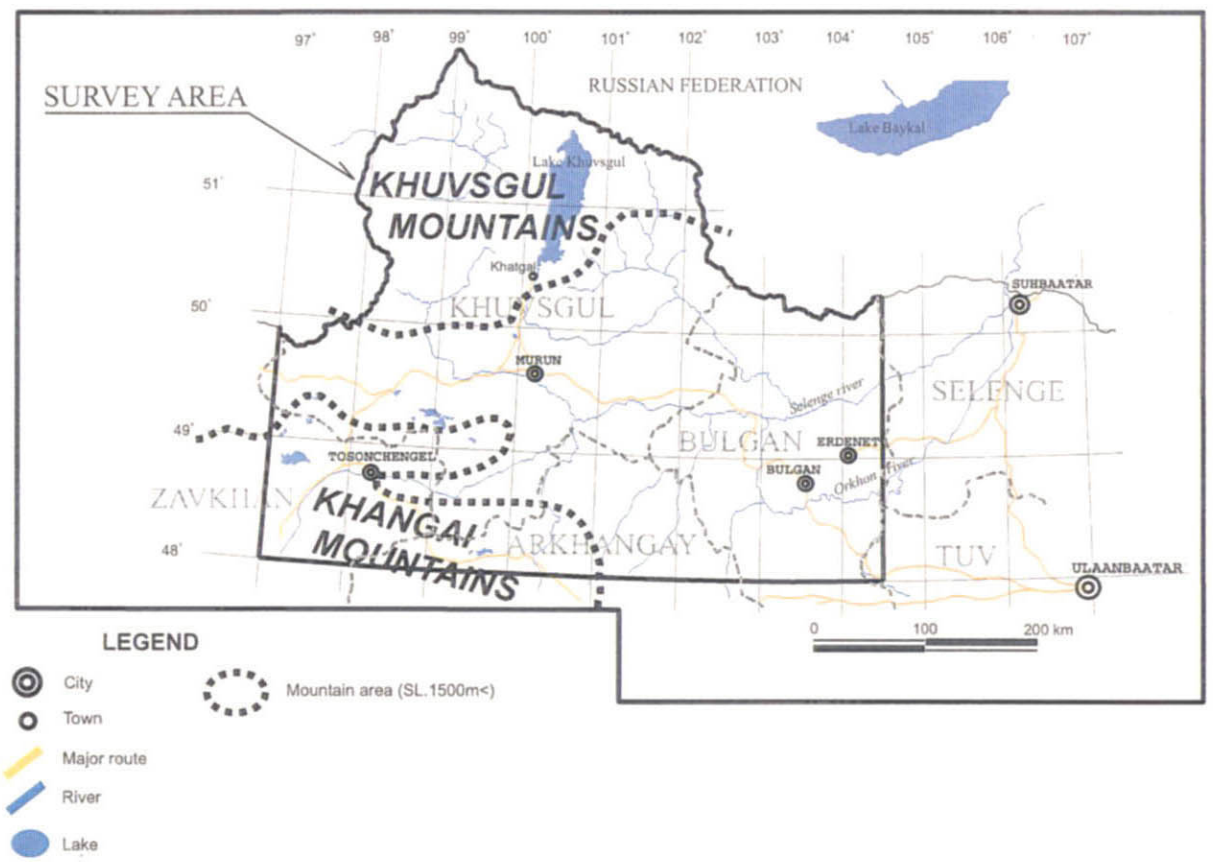


Fig. I-2-2 Relief map of the central north area

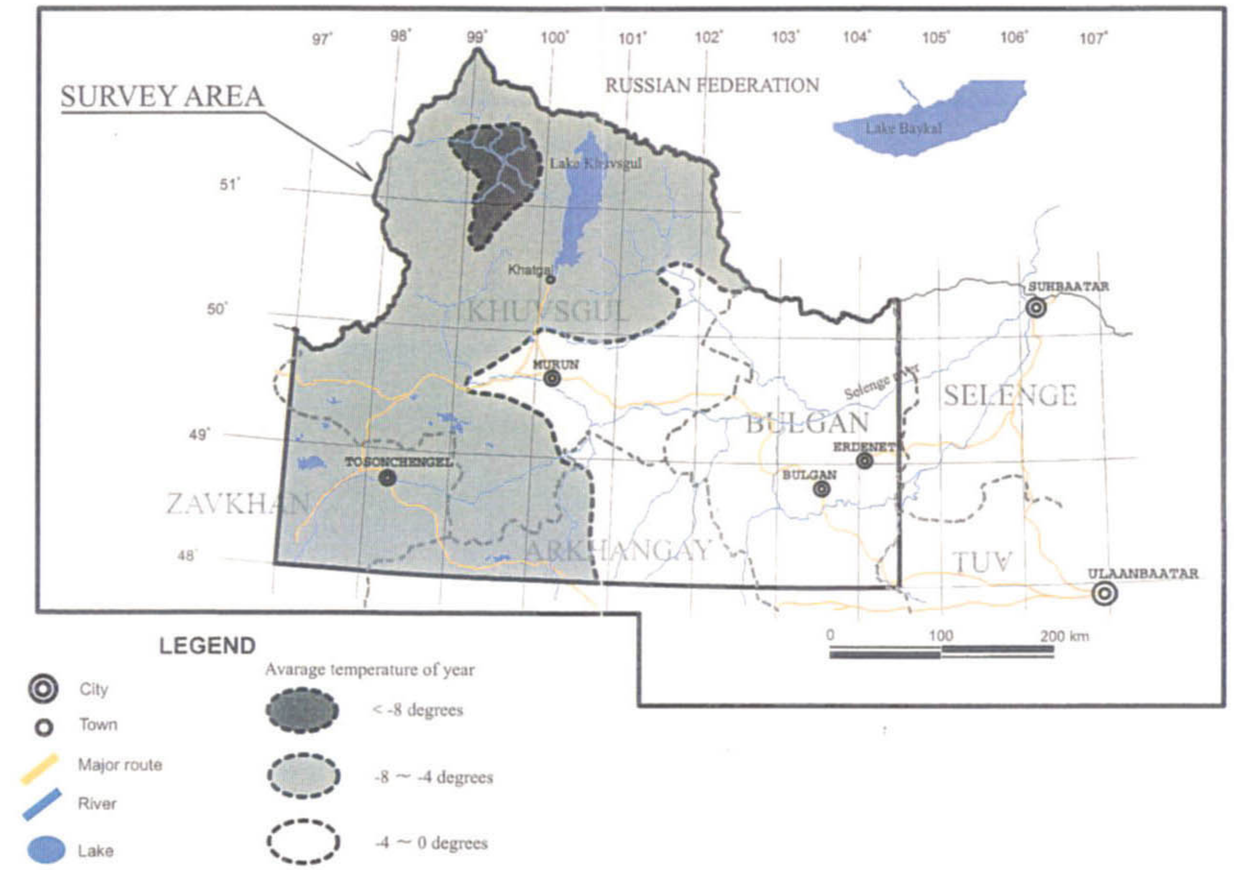


Fig. I-2-3 Mean temperature in the central north area

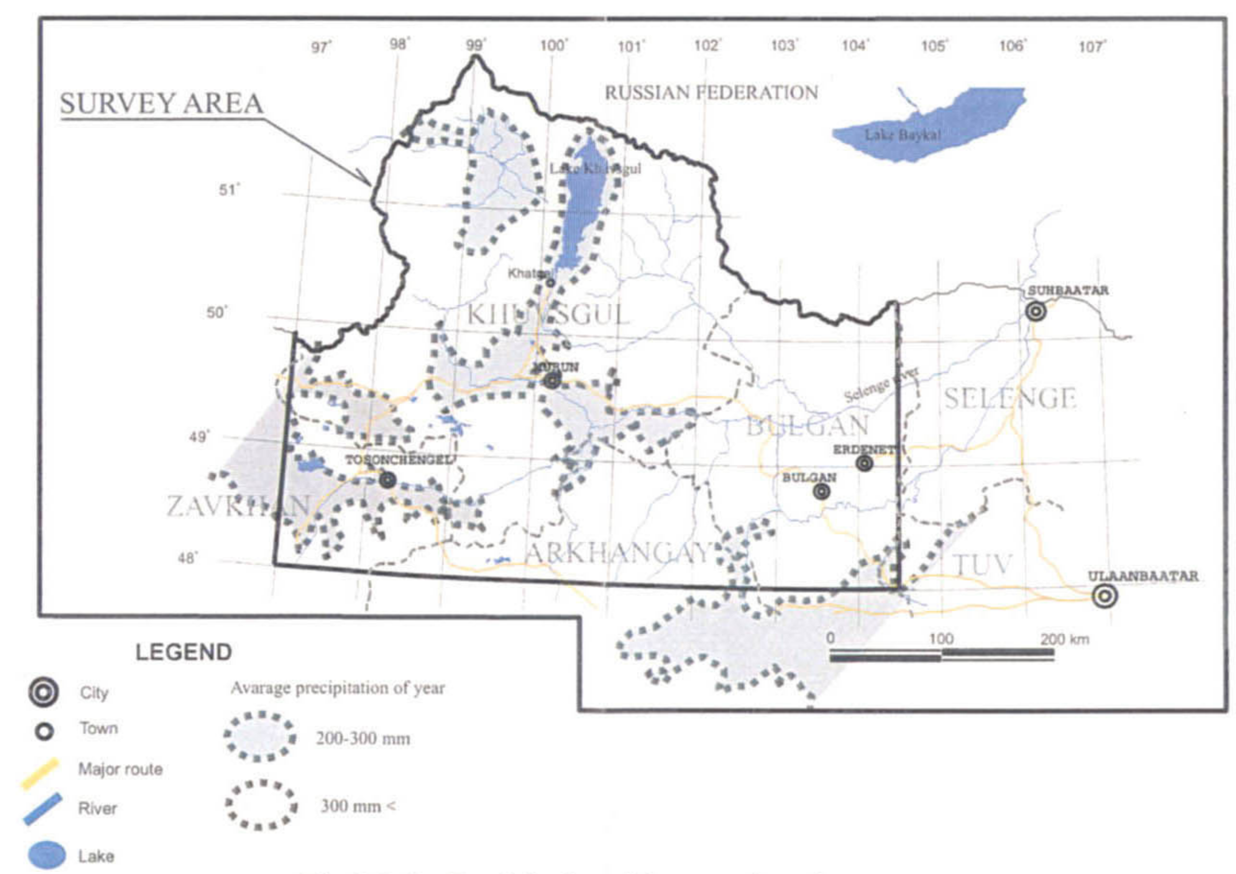


Fig. I-2- 3 Precipitation of the central north area

Table I-2-1 Mean monthly and annual temperature (℃) of major province centers in the central north area

Province center	January	February	March	April	May	June	July	August	September	October	November	December	Average
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
Murun	-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
Ulaanbaatar	-26.1	-21.7	-10.8	0.5	8.3	14.9	17	15	7.6	-1.7	-13.7	-24	-2.9

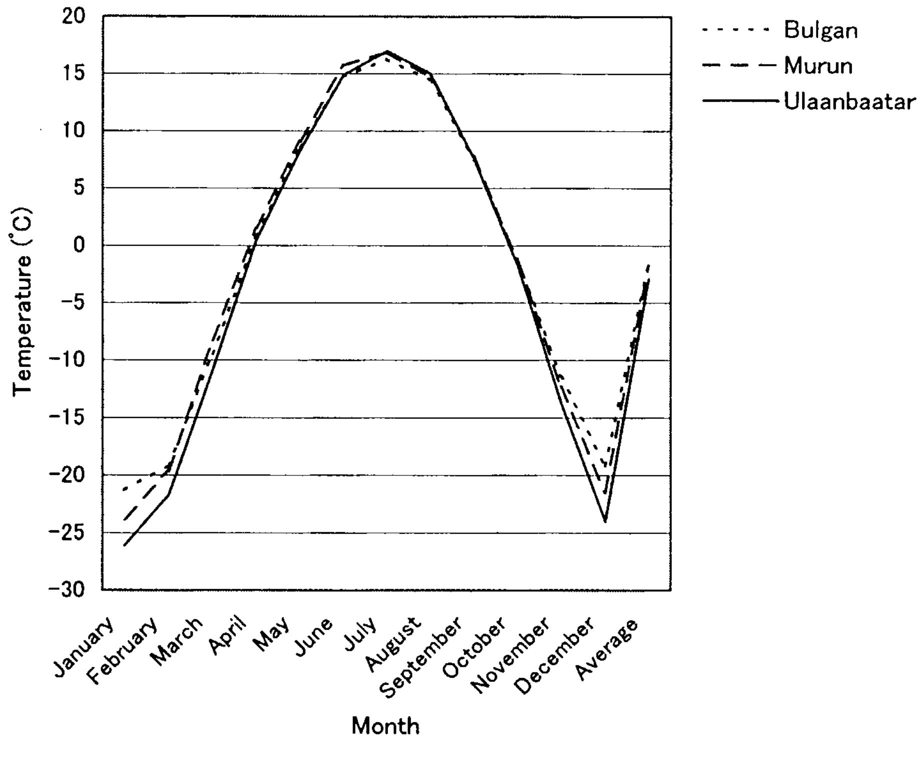


Fig. I-2-5 Temperature of major proveince centors in the central north area

Table I-2-2 Mean monthly and annual precipitation (mm) of major province centers in the central north area

Province center	January	February	March	April	May	June	July	August	September	October	November	December	Average
Bulgan	1.4	2.1	3.9	9.4	24.5	57.1	10.1	77.9	30.2	11.4	3.6	1.8	19.5
Murun	1.5	0.9	2.1	6.4	13.8	46.2	70.1	60.6	22.3	6.2	2.5	1.9	19.5
Ulaanbaatar	1.5	1.9	2.2	7.2	15.3	48.8	72.6	47.8	24.4	6	3.7	1.6	19.4

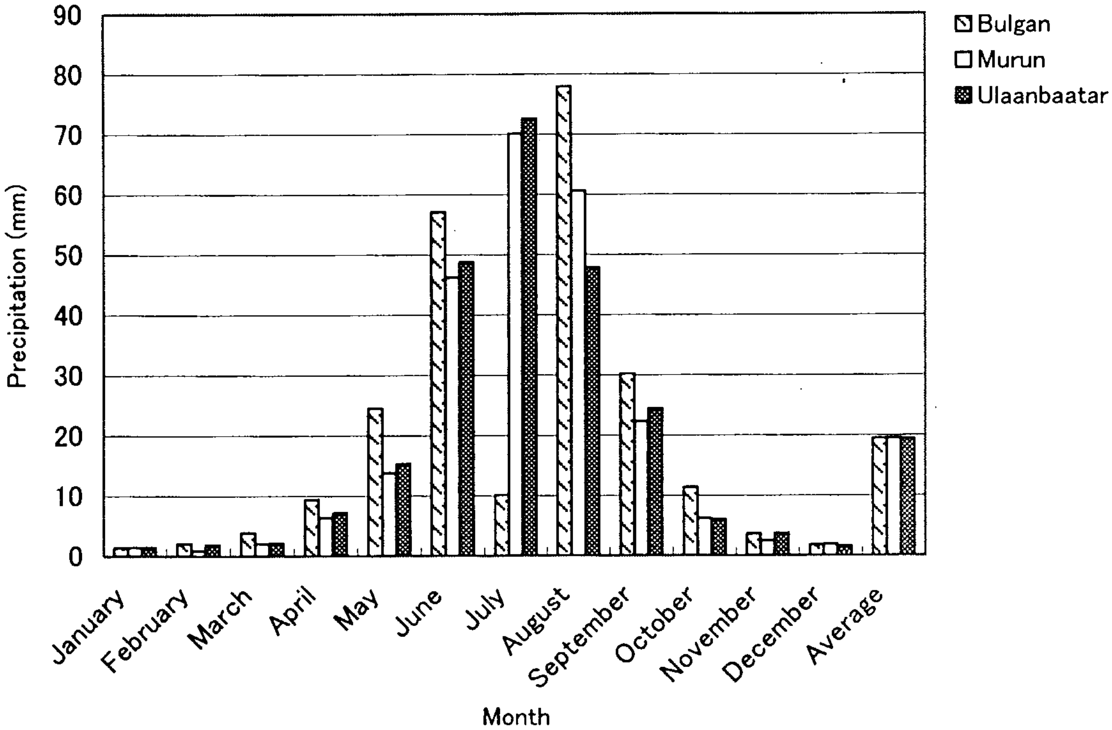


Fig. I-2-6 Precipitation of major province centers in the central north area is less than one sixth of that of Tokyo. Both yearly and daily differences in temperatures are large, and the average temperatures of summer and winter are 15℃ and 20℃ minus zero respectively. The central to southeastern parts of the survey area have climates similar to that of Ulaanbaatar. The vicinity of Khuvsgul nuur and mountains in the western and southwestern parts of the survey area have colder climates compared with those of its central to southeastern parts.

2.5 Vegetation

On the hills and places with relatively low level in the southern to central parts of the survey area, low trees and plants grow in summer. In particular, while the dry southern slopes constitute a steppe because of much sunshine in summer, conifers grow on the wet northern slopes. A lot of conifers are clustered in Khuvsgul Mountains of the northern part and Khangai Mountains of the southeastern part of the survey area as well as in the ridge with high level. The plains and hills in Selenge-Orkhon Basin in the eastern part of the survey area is the most famous place for stock raising where large-scaled grain fields develop in summer.