No. 13

REPORT
ON
THE MINERAL EXPLORATION
IN
THE ALTAN-TAL AREA, MONGOLIA

(PHASE I)

MARCH 1995

JAPAN INTERNATIONAL COOPERATION AGENCY
METAL MINING AGENCY OF JAPAN

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PREFACE

The Government of Japan, in response to the request of the Government of Mongolia decided to conduct a mineral exploration in the Altan-Tal area, Mongolia and entrusted the survey work to the Japan International Cooperation Agency (JICA). JICA, considering the importance of technical nature of the survey work, in turn, sought the cooperation of the Metal Mining Agency of Japan (MMAJ) to accomplish the work.

MMAJ concluded the scope of work (S/W) with Ministry of Energy, Geology, and Mining after discussion on the survey.

The survey work in the survey area will be carried out within a period of two years commencing from 1994.

Metal Mining Agency of Japan dispatched the survey mission consisting of four members to Mongolia from September, 1994 to November, 1994.

The survey work in Mongolia was carried out successfully with cooperation of the Mongolian Government authorities and MONGEO Co., Ltd.

This report summarizes the result of the survey work carried out in 1994 and also forms a part of the final consolidated report which will be submitted to the Government of Mongolia after completion of the survey work.

We wish to express our deep appreciation to the officials of the Government of Mongolia concerned for their close cooperation extended to the survey mission.

March, 1995

Kimio Fujita
President
Japan International Cooperation Agency

Takashi Ishikawa
President
Metal Mining Agency of Japan

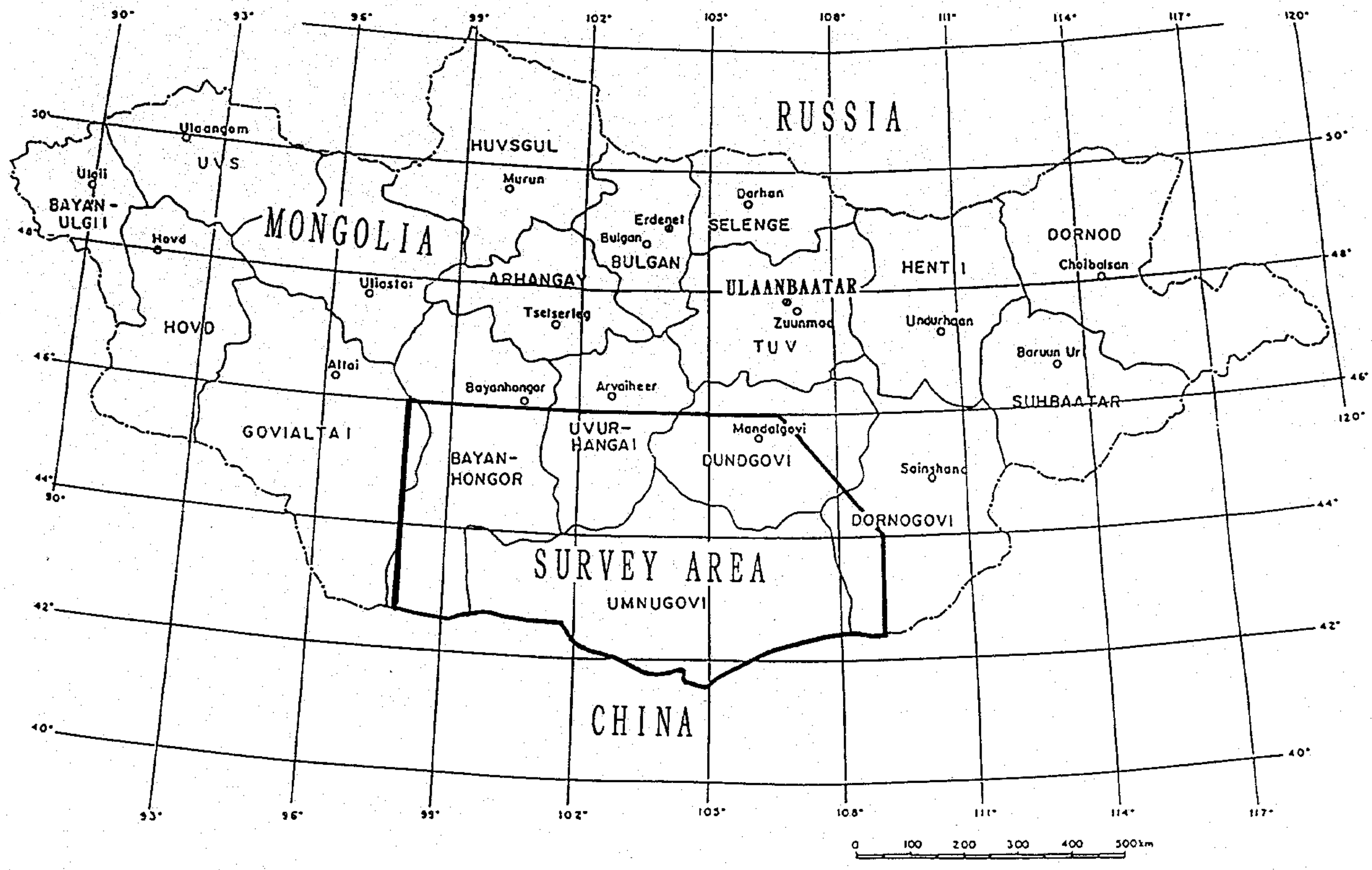

Fig. I-1-1 Location Map of Survey Area

Отчет

Результат первых лет обследования, проведенного с августа 1994 года по февраль 1995 в соответствии с охватом работ по обследованию по минеральным ресурсам в области Алтантал, Монголия за два года с 1994 по 1995 год, завершенного 29 июля 1994 года описан в этом отчете.

Основной задачей обследования является найти золотое месторождение или отложение в обследовании, описанном ниже, путем синтетическного анализа результатов, полученных от сбора, компиляции, анализа и оценки, имеющихся данных, интерпретации сателлитных отображений и настоящего обследования породы, сопровождаемого геологическим обследованием.

Преследуется также цель передать технологию монгольским коллегам в ходе осбледования.

Район проведения обследования называется "Алтантал, площадь его составляет 330 тыс. кв. километров и он ограничен по линии 98° восточной долготы, 46° северной широты, по линии, соединяющей пересечения 46° северной широты и 106° восточной долготы и 44° северной широты и 109° восточной долготы, по линии 109° восточной долготы и границы между Монголией и Китаем. Настоящее обследование породы в 1994 году было проведено в восточной половине к востоку от 103° восточной долготы обследуемой области.

Топографически обследуемая область может быть разделена на 3 района, а именно район Гови Алтайских гор, занимающих западную и южную часть обследуемой области, подошвы долины Гови юговосточной части к востоку Гови Алтайских гор и центральных и северовосточных частей Восточного Монгольского нагорья.

Область обследования гелогически расположена в складке пояса между блоком сибирской платформы к северу и Китайско-Корейским блоком, формально называемым "Монгольская Геосинклиналь". Гелогически область обследования состоит из старейшей Протерозойской группы, которая распространяется спорадически в направлении к востоку и западу в северной части области, Палезойской группы и Мезозойской группы, распространяющейся широко по всей области и Третичной системы Кайнозойской группы, распространяющейся в северной части области. Эти напластования подверглись орогеническим движениям в

Байкальском (позднейший Протерозойский), Каледонийском (ранний Палеозойский), Херцинианском (поздний Палеозойский) периодах и были подвержены вторжениям гранитных скал различных эр, начиная с позднейшей Протерозойской.

В обследоваемой области вулканические активности наиболее активно повторялись в Палеозойской и Мезозойской, особенно в Палеозойской, и отложения руды формировались в зависимости от распространения вулканической активности. Особенно, в области найдено много признаков отложений руды порфирной меди, которые формировались в близкой связи с вулканической активностью от поздних Каменоугольных до Пилейских.

Результаты сбора, анализа, интерпретации сателлитных отображений и действительного обследования породы были собраны следующим образом.

(1) Сбор и анализ имеющихся данных.

В результате сбора, комипиляции и анализа, имеющихся данных по геологическому обследованию, геохимической разведке, геофизической разведке, бурению и так далее по отложениям руды и признакам руды золота серебра, меди, свинца и цинка в области обследования было выбрано 10 обещающих областей, где имеется много признаков руды, содержащей золото или руды, в которой предполагается, что должна быть золотая масса. (Смотри рис. II-I-4.)

Вне этих 10 областей, области - Нараджин Худук - Цагаонсубрага, Их Шанхай, Хармагтай и Байян Гови как будто возможны как обещающие области золота и меди, а области Олон Овоот и Байянхонгар кажутся возможными, как обещающие области признаков золота. Кроме эти 6 областей, четыре области, за исключением областей Байян Гови и Байянхонгар, расположенных в области действительного обследования породы к востоку от 103° восточной долготы.

(2) Интерпретация сателлитного отображения

Тридцать три места действия, ТМ отображений Ландсата, покрывающих всю область обследования, были интерпретированы, и были выбраны зоны изменения пород по сложению и составу и очертания в сателлитном отображении.

Выбранные зоны изменения пород по сложению и составу, которые показали некоторый цвет в сателлитном отображении, оказались такими, как область Шутен или область Их Шанхай; всего их насчитано 96 областей в области всего обследования и 47 областей в восточной части области, обследованной при действительном обследовании породы.

В восточной части области обследования к востоку от 103° восточной долготы преобладают две продольных структуры, а именоо с северовостока по направлению на восток-северовосток и запад-северозапад, которые простираются на большое расстояние.

В сателлитных отображениях были ясно наблюдены структуры от кривых до круглых в области Шутен, области к юговостоку от области Шутен, области Ханбод и в области на юг-юговосток от Луус.

Хотя близкая связь между зонами изменения пород по сложению и составу и линейностью в сателлитных отображениях не ясна, очертания в восточном и западном направлении являются доминантными в областях №43 и №44, по направлению на востоко-северовосток в областях Шутен и Их Шанхай и по направлению на восток и запад в областях №23, 24 и 25.

В результате действительного обследования породы для выбранных зон изменения пород по сложению и составу сделано заключение о возможности выбора признаков руды, сопровождаемых силисифицироваными и глинистыми зонами покрывающими площадь более нескольких сотен квадратных метров, однако, кажется вероятно трудным отобрать порфирную медь и признаки руды пластового типа, сопровождаемые небольшими зонами изменения пород по сложению и составу. Тем не менее, предполагается полезным обследовать выбранную зону изменения породы по сложению и составу, в качестве ключа для поисков эпитермальных месторождений золота.

(3) Действительное обследование породы

64 области, отделенные из 45 областей кроме 47 областей, выбранных из анализированных сателлитных отбражений восточной половины области обследования к востоку от 103° восточной долготы, были обследованы на местности. В 24-х областях из этих 64 областей не было отмечено ни силисифицированием, ни глиистостью.

Из оставшихся в зоне из 64 областей при действительном обследовании породы были найдены признаки руды эпитермального месторождения золота (№5 = Шутен), признаки руды, которые могут быть признаками золотой руды эпитермального типа (области

Nos 10' & 11', Nos 23 - 25, № 31, Nos 43 - 45), признаки руды, имеюшие некоторую вероятность признаков руды эпитермального месторождения золота (области Nos 34 & 35, № 37), признаки руды типа порфирной меди и признаки руды кварца пластового типа. В особенности несущая золото кварцевая жила, содержащая от 4,16 до 9,78 г/т золота, от 1,1 до 2,0 метров ширины и 350 метров длины, а также силисифицированная зона большого масштаба были найдены в признаках руды области Шутен.

Тем не менее, предполагается, что кварцевые жилы и/или сети, содержащие золото, могут присутствовать вокруг или ниже силисифицированной зоны в признаках руды в области Шутен.

В результате обследования в 1994 году рекомендуется провести следующие обследования для вышеуказанных признаков руды в 1995 году.

(1) В области Шутен

а) Создание простой топографической карты в масштабе около 1:10.000 на основании обследования местности.

б) Подробное гелогическое обследование и образцы для лабораторных работ.

в) Проведение геохимических поисков и разведки с целью обследования образцов почвы и скал

(2) Подробное геологическое обследование и отбор образцов для лабораторных работ в области соседней с северовосточной от области Шутен, NOS. 10' & 11', NOS. 23 - 25, № 31 и областях 43 - 45.

(3) Действительное обследование породы для зон изменения породы по сложению и составу, выбранных из анализированных сателлитных отображений и известные, как подающие надежды на наличие признаков руды в областях, которые были отобраны , как области, обещающие наличие месторождений золота исходя из анализа имеющихся данных в восточной половине обследованной области к западу от 103° восточной долготы.

SUMMARY

SUMMARY

The result of the the first year's survey, conducted from August, 1994 to February, 1995 in accordace with the Scope of Work on the survey for mineral resources in the Altan Tal Area, Mongolia for two years from 1994 to 1995 conclued on 29, July 1994, is described in this report.

The main objective of the survey is to find gold showing or deposit in the survey area described below, through analyzing synthetically the results obtained from collection, compilation, analysis, and evaluation of the existing data, interpretation of the satellite image, and ground truth survey accompanied by geological survey, and to pursue technology transfer to the Mongolian counterpart personnel in the course of the survey.

The region, called "Altantal area", to be surveyed covers an area of approximately 330,000 square kilometers, bounded by longitude 98° E, latitude 46° N, the line connecting intersections of latitude 46° N and longitude 106° E and of latitude 44° N and longitude 109° E, longitude 109° E, and the borderline between Mongolia and China. The ground truth survey in 1994 was conducted in the eastern half part, to the east of longitude 103° E, of the survey area.

Topographically, the survey area can be divided into three regions, that is, the Govi Altai Mountains occupying western and southern parts of the survey area, the Govi Lowland of the southeastern part adjacent to the east of the Govi Altai Mountains, and the Eastern Mongolian Highland of the central and northeastern parts.

The survey area is geologically situated in the fold felt between the Siberian platform black to the north and the Sino-Korean block to the south, formally called "Mongolian Geosyncline". Geology of the survey area consists of, from the oldest, the upper Proterozoic Group which is distributed sporadically in the direction of the east and west in the northern part of the area, the Paleozoic Group and the Mesozoic Group distributed widely in the whole area, and the Tertiary System of the Cenozoic Group distributed in the northern part of the area. These strata were subjected to the orogenic movements in the Baikalian (latest Proterozoic), the Caledonian (early Paleozoic), and the Hercynian (late Paleozoic) periods and were intruded by granitic rocks of various ages since latest Proterozoic.

In the survey area, the igneous activities most actively repeated in Paleozoic and Mesozoic, especially in Paleozoic, and ore deposits formed in relation to the igneous activity are distributed. Especially, many ore showings of porphyry copper deposits formed in close association with the igneous activity of late Carboniferous to early Permian are found in the area.

The results of the collection and analysis, interpretation of satellite image, and ground truth survey are summarized as follows.

(1) Collection and analysis of the existing data

As the result of the collection, compilation, and analysis of the existing data on geological survey, geochemical exploration, geophysical exploration, drilling, and so on for ore deposit and ore showing of gold, silver, copper, lead, and zinc in the survey area, 10 areas, namely Tsagaan Ovoo, Ulziit-Gulvansaihan, Olon Ovoot, Narangin Hudak-Tsagaansubraga, Ih Shanhai, Harmagtai, Bayanhongor, Bayan Govi, Bogd, Mt.Nemegt, where many ore showings which contain gold swarm, have been selected.

Out of these 10 areas, Tsagaan Ovoo, Ulziit-Gulvansaihan, Olon Ovoot, Narangin Hudak-Tsagaansubraga, Ih Shanhai, and Harmagtai areas are situated in the ground truth survey area to the east of longitude 103° E and other four areas are situated in the western half part of the west of longitude 103° E.

(2) Interpretation of satellite image

Thirty-three scenes of the Landsat TM images covering the whole survey area have been interpreted and the alteration zones and lineament in the satellite images have been selected. The selected alteration zones which show same color in the analyzed satellite images as that of the Shuten area or Ih Shanhai area have numbered 96 areas in the whole survey area and 47 areas in the eastern half area investigated by the ground truth survey.

In the eastern half part of the survey area to the east of longitude 103° E, two linear structures, namely northeast to east-northeast and west-northwest directions, are predominant and extend for a long distance.

The curved to circular structures in the satellite images are clearly observed in the Shuten area, an area to the southeast of Shuten, the Hanbogd area, and an area to the south-southeast of Luus.

The lineament of the east and west direction is dominant in the Nos.43 and 44 areas, the east-northeast direction in the Shuten and Ih Shanhai areas, and the east and west direction in the Nos.23, 24 and 25 areas.

As the result of the ground truth survey for the selected alteration zones, it is concluded to be possible to select the ore showings accompanied by the silicified and argillized zones covering an area of more than 300 meters in diameter. Therefore, it seems to be useful to survey the selected alteration zone as a clue to search for epithermal gold deposit.

(3) Ground truth survey

Forty-five areas out of 47 areas selected from the analyzed satellite images of the eastern half part of the survey area to the east of longitude 103 ° E were investigated in the field. In 24 areas out of these 45 areas, neither silicification nor argillization was observed.

Out of remaining 21 areas, Shuten mineralized zone of epithermal gold deposit type (No.5), silicified zones which may be epithermal type gold ore showings (Nos.10' & 11', Nos.23～25, No.31, Nos.43～45 areas), weak alteration zones (Nos.34 & 35, No.37 areas), porphyry copper type ore showings, and quartz veins were found in the ground truth survey area. In particular, gold-bearing quartz vein containing 4.16 to 9.78 g/t of gold, 1.1 to 2.0 meters wide and 350 meters long, and large-scale silicified zone were found in the Shuten mineralized zone. Therefore, it is expected that quartz veins and/or networks containing gold may be present around and below the silicified zone in the Shuten mineralized zone.

(4) General commentary

The ground truth survey for 45 hydroathermal alteration zones which are situated in the eastern half part of the survey area to the east of longitude 103° E, out of 96 alteration zone selected from the whole survey area by the satellite image analysis, and 2 known silicified zone which were not detected on the analyzed satellite image was carried out. As a result, hydrotheral alteration zones were observed at 21 localities. Fifteen localities out of these 21 localities are newly found alteration zones by the satellite image analysis. Out of 23 localities where hydrothermal alteration zones were found, Shuten mineralized zone which seems to be of epithermal type gold deposit, 10 silicified zones, namely No.10, No.11, No.23, No.24, No.25, No.31, No.43, No.44, No.45, and the area adjacent to the northeast of Shuten, which may be epithermal type gold ore showing, and 3 weak hydrothermal alteration zones (No.34, No.35, and No.37) is thought to be surveyed further in detail. In spite of the vast survey area covering 330,000 square kilometers, hydrothermal alteration zones were effectively found. This fact indicates that the satellite image analysis is useful for search of epithermal type gold deposit.

As the result of the survey in 1994, it is recommended that the following surveys for the above ore showings should be conducted in 1995.

(1) The ground truth survey to find hopeful area of gold for the alteration zones selected in the analyzed satellite images and known hopeful gold showings in the areas, where gold showings swarm, which have been selected from the analysis of the existing data, in the western half part of the survey area to the west of longitude 103° E.

(2) Detailed geological survey, sampling for laboratory works, and geochemical prospecting by means of soil and rock samples in the Shuten mineralized zone area.

(3) Semi-detailed geological survey and sampling for the laboratory works in the area adjacent to the northeast of Shuten, Nos.10' & 11', Nos.23~25, No.31, Nos.43~45, Nos.34 & 35, and No.37 areas.

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PART I THE GENERAL

PART I THE GENERAL

CHAPTER 1 INTRODUCTION

1-1 The background and objective of the survey

The Mongolia has recently opened the door of the economy to western countries and is now pursuing a policy which promotes the introduction of funds and technology from these countries. The Mongolia government has approached Japanese government positively and private companies are also taking a strong interest in development of the mineral resources in Mongolia. Technological cooperation with Japan, in the field of mining, was desired and a written request for survey to develop rare earth element deposit 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 survey for copper, lead, zinc and rare earth minerals was confirmed.

A second project finding mission was dispatched in March of 1991, following three additional requests for assistance from Mongolia in February of 1991. The purpose of this mission was to investigate the feasibility of the surveys which had previously been proposed and to discuss specific survey items with Mongolian counterparts. As a result, the survey mission and the State Geological Center of Mongolian People's Republic agreed upon the commencement of the survey in the Uudam-Tal area and a Scope of Work (S/W) dated March 16th, 1991 was signed. The survey in the Uudam-Tal area had been conducted from 1991 to 1993 according to this Scope of Work.

Furthermore, the Scope of Work on the survey in the Altan-Tal area adjacent to the west of the Uudam-Tal area was signed on the 29th of July, 1994, and the survey scheduled to conduct in 1994 and 1995 was commenced in September of 1994.

The main objective of the survey is to find gold occurrence or deposit in the survey area described below, through analyzing synthetically the results obtained from collection, compilation, analysis, and evaluation of the existing data, interpretation of the satellite image, and ground truth survey accompanied by geological survey, and to pursue technology transfer to the Mongolian counterpart personnel in the course of the survey.

1-2 Outline of the survey

1-2-1 Survey area (Fig.I-1-1)

The region, called "Altantal area", to be surveyed covers an area of approximately 330,000 square kilometers, bounded by longitude 98° E, latitude 46° N, the line connecting intersections of latitude 46° N and longitude 106° E and of latitude 44° N and longitude 109° E, longitude 109° E, and the borderline between Mongolia and China, as shown in the location map attatched. The ground truth survey in 1994 has been conducted in the eastern half part, to the east of longitude 103° E, of the survey area.

1-2-2 Contents of the survey

(1) Collection, compilation, analysis and evaluation of existing data

The existing data, that the Mongolian autholities concerned have, on geological survey, geochemical prospecting, geophysical prospecting, and drilling for mineral deposit, prospect, and occurrence, which contain gold or seem to contain gold, in the survey area have been collected, compiled, analyzed, and evaluted to serve for analizing, interpreting, and drawing conclusions the result of the ground truth survey in 1994 and to select the promising gold-bearing mineral deposit or occurrence, accompanied by hydrothermal alteration zone, which seems to be of epithermal origin related to the volcanic activity and will be the target of the ground truth survey in 1995.

(2) Interpretation of satellite image

The hydrothermal alteration zones and lineaments have been extracted from the Landsat TM (Thematic Mapper) images, in the scale of 1 to 200,000, within the survey area to find epithermal gold deposit, accompanied by the hydrothermal alteration zone and related to the volcanic activity, through investigating the extracted hydrothermal alteration zones in the field.

(3) Ground truth survey (field survey)

The hydrothermal alteration zones selected by the interpretation of the Landsat TM images, as well as known hydrothermal alteration zone and mineral occurrences which seem to contain gold, were investigated in the field to find epithermal gold deposit which is accompanied by the dydrothermal alteration zone and is related to the volcanic activity.

Furthermore, samples of rock, ore, quartz, hydrothermally altered rock were taken at the time of the field survey to conduct the following laboratory works for the purpose of clarifying the conditions of geology, geological structure, mineralization, and hydrothermal alteration at and around the hydrothermal alteration zones and mineral occurrences.

a) Chemical analysis of host rock taken at and around the hydrothermal alteration zone

b) Microscopic observation of the thin section made from host rock taken at and around the hydrothermal alteration zone.

c) Chemical analysis of the ore sample taken at the mineralized zone.

d) Microscopic observation of the polished section made from the ore sample taken at the mineralized zone.

e) Age determination by K-Ar method of hydrothermally altered and nonaltered host rocks taken at and around the hydrothermal alteration zone.

f) X-ray diffraction examination of hydrothermally altered rock taken at the hydrothermal alteration zone.

g) Measurement of the homogenization temperature of the fluid inclusion in quartz taken from the quartz vein or silicified zone at the mineralized zone.

(4) Synthetic analysis

The promising area where gold-bearing mineral deposit or occurrence seems to be present have been selected through studying and analyzing synthetically the results of analysis of the existing data, interpretation of the Landsat TM image, and ground truth survey in the field, and the most appropriate and effective plan of the survey for 1995 has been made.

1-2-3 Members participating in the survey

(1) Members participating in planning and negotiation

a) Japanese member

Shingoro TSUCHIYA	Metal Mining Agency of Japan, Tokyo
Jiro OHSAKO	Metal Mining Agency of Japan, Tokyo

Katsumi YOKOKAWA	Metal Mining Agency of Japan, Beijing
Yoshihiro KUBOTA	Metal Mining Agency of Japan, Tokyo
Naoki SATO	Metal Mining Agency of Japan, Tokyo
Koichi NAKAMURA	Ministry of Trade and Industry, Tokyo
Kazuko MATSUMOTO	Japan International Cooperation Agency, Tokyo

b) Mongolian members

Dambin SANJAADORJ	General Director of Department of Geology, Ministry of Energy, Geology and Mining
Tsegmidyn SUKHBAATAR	Director of Department of Cooperation, Ministry of Energy, Geology and Mining
Khalzkhugiin NARANKHUU	Director of Department of Industry and Foreign Investment, Ministry of Trade and Industry
Jamiyangiin TSEND AYUSH	Senior Geologist of Department of Geology, Ministry of Energy, Geology and Mining
Tsendiin ENKHBOLD	Coordinator for International Projects, Ministry of Energy, Geology and Mining
Lodoidambyn NASANBUYAN	Officer of Department of International Trade and Cooperation, Ministry of Trade and Industry
Lkhamjavyn TSERENJAV	Deputy Director of Department of Industry and Foreign Investment, Ministry of Trade and Industry
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1-2-4 Period of the survey

(1) Interpretation of satellite image
August 18, 1994～February 24, 1995

(2) Ground truth survey
September 19, 1994～November 2, 1994

(3) Collection and analysis of existing data
September 19, 1994～November 17, 1994

(4) Synthetic analysis
November 3, 1994～February 24, 1995

CHAPTER 2 GEOGRAPHY OF THE SURVEY AREA

2-1 Location and access (Fig. I-2-1)

The survey area is situated in the southern part of Mongolia, covering an area of about 330,000 km², and extends over five administrative districts, namely, Dundgovi, Dornogovi, Ömnögovi, Övörhangai, and Bayanhongor. The ground truth survey (field survey) in 1994 was conducted in the eastern half part of the survey area to the east of longitude of 103E, extending over Dundgovi, Dornogovi, and Ömnögovi districts.

Ulaanbaatar, the capital of Mongolia, can be reached, in general, by air from Tokyo via Beijing. There is a couple of air services a day between Tokyo (Narita) and Beijing and the flight time is about four hours. An air service of Air China and Mongolian Airlines between Beijing and Ulaanbaatar with a flight time of two hours is available for six flights a week except Sunday. The domestic air service of Mongolian Airlines between Ulaanbaatar and Dalandzadgad, which is a main city in the survey area and is the capital city of Ömnögovi Prefecture, is available for two flights a week and the flight time of the propeller airplane is one hour and forty minutes. Dalandzadgad, 553 km distant from Ulaanbaatar by land, is accessible by mortor vehicle through the vast desert steppe at an elevation of 1,000 to 1,500 m. Most of the localities of mineral occurrences and hydrothermal alteration zones in the survey area are also easily accessible by motor vehicle. However, most of the roads are not hard surfaced and can only be traveled at a speed of about 40 km an hour.

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

2-2-1 Topography

Mongolia is situated in the northern part of the Central Asia plateau between Russia and China. The plateau at an elevation of 1,000 to 3,000 m occupies about 80 % of the country. Average elevation of Mongolia is 1,580 m and the elevation at Ulaanbaatar is 1,351 m. On the whole, the northern and western parts of Mongolia are occupied by mountains and the other part is generally steppe with small hills, although the southern part is occupied by desert.

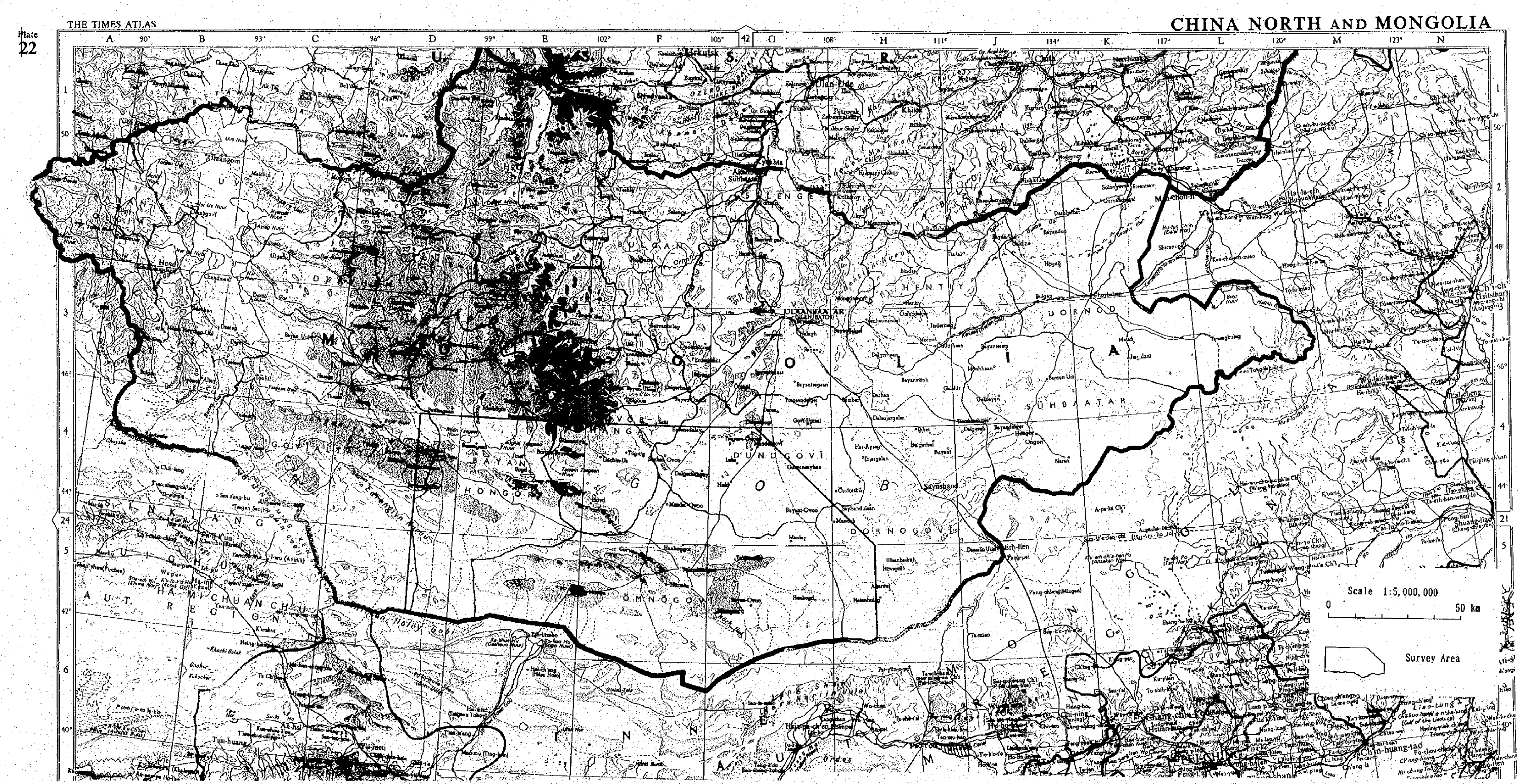


Fig. I-2-1 Geophysical Map of Mongolia

Main mountain ranges in Mongolia are the Mongolian Altai Range and the Hangai Range in the western part of the country and the Hentei Range in the northern part of central Mongolia. The Mongolian Altai Range extends for a distance of about 1,500 km from the northwest to the southeast, decreasing gradually its altitude southeastward and shifts into the Govi Altai Mountains, and its southeasternmost end dies finally out in the Govi Desert. Mt. Hueiten, the highest mountain in Mongolia at an elevation of 4,374 m, which is situated at the westernmost end of Mongolia and at the border of Mongolia, China and Russia, and other many high peaks at an elevation of around 4,000 m stand in the Mongolian Altai Range. Mt. Otgon Tenger at an elevation of 4,021 m and other high peaks with an altitude of 3,000 m level range in the Hangai Mountains. The Hentei Range is lower than the above two ranges in altitude and consists of Mt. Hairhan, which is situated to the northeast of Ulaanbaatar and has an elevation of 2,800 m, and other mountains with an elevation of 2,000 m level.

The plateau, which is arranged in a zone extending from the west of the Hangai Range to the space between the Mongolian Altai Range and the Hangai Range, joins to the vast plain, which extends from the central to eastern parts and includes the Govi Desert of the southeastern part, in the central part of the country.

Topographically, the survey area can be divided into three regions, that is, the Govi Altai Mountains of the western and southern parts of the country, occupying the east-southeast part of the Mongolian Altai Range, the Govi Lowland of the southeastern part adjacent to the east of the Govi Altai Mountains, and the Eastern Mongolian Highland of the central and northeastern parts.

The Govi Altai Mountains are composed of several mountain ranges, that is, the main range of the Govi Altai Mountains at an elevation of 1,500 to 3,500 m, the Gurvan Saihan Mountains ranging in altitude from 1,500 to 2,800 m, the Ih Shanhai Mountains which have an elevation of 1,500 to 1,800 m, the Ih Nomgon Mountains with an elevation of 1,500 to 2,100 m, and so on.

The Govi Altai Mountains turn their direction from west-northwest to east and west in the survey area and then end in the Govi Lowland extending from the southwest to the northeast.

High mountains with an elevation of 3,000 m level, such as Mt. Ih Bogd at an elevation of 3,957 m which is the highest mountain in the survey area, Mt. Baga

Bogd with an altitude of 3,590 m, and Mt. Bayan Tsagaan which has an elevation of 3,452 m, range in the Govi Altai Mountains within the survey area.

The Govi Lowland is a low land in geological structure and a desert zone with a width of 30 to 150 km and an elevation of 900 to 1,000 m. The erosional remnant hills of the uplifted blocks with an altitude of 1,000 to 1,200 m are found in a scattered pattern in the Govi Lowland.

The Eastern Mongolian Highland adjacent to the north of the Govi Lowland is a gently andulating plain at an elevation of 1,000 to 1,500 m, with scattered erosional remnant hills at an elevation of 1,500 to 1,700 m. The Eastern Mongolian Highland adjoins to the Hentei Mountains on the north and to the Govi Altai Mountains on the west respectively, and, on the whole, is higher in the northwest and lower in the southeast in altitude.

2-2-2 Drainage

The rivers in Mongolia are estimated at about 1,200 in total numbers and at about 70,000 km in total length, and are divided into three groups, that is, the Arctic Ocean, The Pacific Ocean, and the inland river systems. The majority of big rivers in Mongolia, such as the Selenge River, which has many riverheads in the Hangai Mountains and the Darhadin Mountains adjacent to the north of the Hangai Mountains and flows into Lake Baykal in Russia via Sühbaatar on the borders of Russia, the Orhon River which flows from the eastern part of the Hangai Mountains and joins the Selenge River at Sühbaatar, and the Tuul River which has headwaters in the Hentei Mountains, crosses Ulaanbaatar, and joins the Orhon River nearby the Erdenet mine, belongs to the Arctic Ocean system. The Onon River which has the head in the eastern part of the Hentei Mountains and flows northward to Russia, the Helen River which has the headwaters in the southeastern end of the Hentei Mountains and flows eastward to China through Choybalsan, and the Uuldza River which flows northeastward between the Onon River and the Helen River, belong to the Pacific Ocean system and flow into the Amur River. Main rivers flowing into the inland lakes are the Hovd River, which has the headwaters in the Mongolian Altai Mountains in the western part of Mongolia and flows into Lake Har Us between the Mongolian Altai and the Hangai Mountains, the Tesin River, which has the head in the northwestern part of the Hangai Mountains and flows westward to Lake Uvs, the Dzavhan River which flows from the southwestern part of the Hangai Mountains northwestward to Lake Hyargas, the Baydrag River flowing from the southern part of the Hangai Mountains southward to

Lake Böön Tsagaan, and the Ongiin River, which has the headwaters in the eastern part of the Hangai Mountains and flows southward to an unnamed lake in the Mongolian plain. Running water of the above rivers comes mainly from rainfall and molten snow in the mountainous districts. Therefore, the flow of the river increases in the summer season due to rainfall and molten snow and decreases considerably in the winter season because of no rainfall and freezing of running water.

There are more than 4,000 lakes in Mongolia. The big lakes are Lake Hovsgol which is the biggest lake in Mongolia with an area of 3,350 km², Lake Haar, Lake Buir, and so on in addition to the above Lake Uvs, Lake Hyargas, and Lake Har Us. These lakes are fresh-water lakes and are mostly situated in the lowland between the Mongolian Altai Mountains and the Hangai Mountains except for Lake Hovsgol which is to the north of the Hangai Mountains and Lake Buir situated in the northernmost end of the Eastern Mongolian Highland.

The main rivers in the survey area are the Ongiin River and Baydrag River mentioned above, the Ar Aguim River and the Taatz River between the Ongiin and Baydrag rivers, and flow into the inland lakes in the lowland between the Govi Altai and Hangai ranges. In the areas to the east of the Ongiin River and to the south of the Govi Altai Mountains, there are no rivers with constant running water and all the rivers flow into the Govi Lowland and die out in the dry lakes.

2-3 Climate and Vegetation

2-3-1 Climate (Table I-2-1, Table I-2-2)

The climate of Mongolia is continental and is characterized by the great difference in temperature, low humidity, and low precipitation. Average annual temperature of Mongolia is -2.9℃. An isothermal line of the average annual temperature of 0℃ lies in the middle part of Mongolia in terms of latitude. The average annual temperature is -5℃ in the northern area on the north of the isothermal line of 0℃ and is 5℃ in the southern area. For example, in Dalandzadgad situated in the southern area, in latitude 43° North, in the southern area, the average annual temperature is 3.9℃, the highest average monthly temperature is 21.2℃ in July and the lowest is -15.4℃ in January. In Ulaanbaatar situated in latitude 48° North in the northern area, the average annual temperature is -2.9℃, with the highest average monthly temperature of 17.0℃ in July and the lowest of -26.1℃ in January. The highest temperature recorded is 42℃ in Sainshand in the southern area with the lowest of -56℃ in the Lake Uvs basin.

Precipitation in Mongolia varies with season, elevation, and district. The annual precipitation ranges from a high of 400 mm in the Hangai Mountains and the Hangai Plain on the north of the Hangai Mountains to a low of 100 mm level in the Govi Lowland and the western part of the country.

The survey area extends over the steppe of the Eastern Mongolian Highlands and the desert of the Govi Lowland. The average annual temperature is -0.7℃ in Bayanhongor situated near the northernmost end of the survey area and is 3.9℃ in Dalandzadgad in the southern part of the survey area. In general, the temperature difference through a year in the survey area shows about 80℃ ranging from the highest of 47℃ in the Govi desert area to the lowest of -35℃ in Bayanhongor.

The annual precipitation in the survey area ranges generally from 100 to 250 mm with the highest of 216.3 mm in Bayanhongor to the lowest of less than 100 mm in the Govi desert area, and, on the whole, is higher in the north than in the south. The precipitation in the survey area varies greatly with season, that is, the rainy season lasts from May to September with the peak rainfall in July and the winter is a dry season with only a few millimeters of precipitation per month.

The wind is generally strong throughout the year in the survey area. The strongest winds are observed in the Govi desert area during the months of March, April, May, and November. There are 40 to 50 days of sand storms each year during these months. Furthermore, the winds with a temperature of above 40℃ blow during the summer in the Govi desert area.

2-3-2 Vegetation

The vegetation in the survey area is largely controlled by the balance between the amounts of rainfall and evaporation. The northern part of the Eastern Mongolian Highlands, where the precipitation is relatively high but the temperature is low, resulting in a little evaporation in the summer, is covered with relatively tall and dense grass and few trees due to the low evaporation, forming the steppe. On the other hand, the Govi Lowland, where the precipitation is generally low and the temperature is very high in the summer, is mainly occupied by the desert due to strong aridity. The intermediate zone between the northern part of the Eastern Mongolian Highlands and the Govi Lowland is a semi-desert steppe covered with short and little vegetation. In this area, on the whole, trees are very scarse and are only found at the oases and on the lowlands of the desert which occasionally become swamps during rainy season.

Table I-2-1 Mean Monthly and Annual Temperature (℃) in Mongolia

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 climatc 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℃ lasts about 170-190 days, increasing to the south and south-east up to 200-215 days.

Table I-2-2 Mean Monthly Precipitation (mm) in Mongolia

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 (Octover-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.

CHAPTER 3 EXISTING INFORMATION ON GEOLOGY OF THE SURVEY AREA

3-1 Outline of Past Surveys

The modern geological survey on the mineral resources in the survey area began with a survey over a wide area around the Tsagaansubraga copper deposit, which was discovered by local people in 1964, conducted by the Soviet Union in 1965. Since then geological surveys by COMECON countries led by the Soviet Union had been carried out very intensively in Mongolia including survey area. From 1971 to 1972, the Soviet Union conducted a detailed geological survey around Tsagaansubraga deposit and discovered many porphyry copper type mineralized zones, such as Mandah, Narim Huduk, Ulgen, Alagbayan, Shuten, Narangin Huduk, Dachin Hural, Uhaa Huduk, Harmagtai, Ih Shanhai, Dzaragin Hural, Uhaa Huduk, Harmagtai, Ih Shanhai, Dzaragin, and Ovoot Hira besides Tsagaansubraga within an area of about 300 kilometers from east to west by approximately 200 kilometers from north to south. In paticular, more detaild geological survey, geochemical prospecting, trenching, drilling, and underground prospecting for the Serven Suhait deposit, one of the Tsagaansubraga deposit group, were carried out during 1979 to 1982. As a result, ore body, 500 meters wide and 2,000 meters long, with 240 million tons of ore reserves grading 0.53 % Cu and 0.019 % Mo were confirmed. Furthermore, Lugiin Gol rare earth element deposit in 1972, Bayan Hoshoo strontium deposit in 1976, and Mushgia Huduk rare earth element deposit were discovered respectively. In 1979 to 1982, gold showings in the Ulziit area, namely, Olon Ovoot, Onh, and Dugshin were discovered.

Thus mineral resources surveys in the survey area increased rapidly from 1964 on, and most of the presently known deposits were discovered during the ten years until mid-1970's. Since then a follow-up survey was conducted on each deposit. However, due to rapidly worsened economics of the COMECON countries, many mineral showings were investigated only intermittently up to now.

Surveys conducted by international geological survey groups organized by COMECON countries were generally large-scale and systematic. Usually at the beginning of surveys, airborne magnetic survey was conducted, and at the same time a geological mapping over a wide area in a scale of 1:500,000 was carried out. They were followed by a geological survey over a wide area in a scale of 1:200,000 accompanied mainly by systematic geochemical exploration and aerial photo analysis. In case some mineral showing was found, further detailed geological survey was conducted, and at the same time, various kinds of explorations, such as γ-ray spectrum method, IP method, pitting, trenching, drilling, and tunneling were 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.

The geological survey and mineral exploration in the Uudum Tal area were carried out by Japan from 1991 to 1993 and drillig for Olon Ovoot gold deposit revealed that gold deposit extends to depths.

3-2 Geological Situation of the Survey Area (Fig. I-3-1, Fig. I-3-2, Fig. I-3-3)

Mongolia is situated in the vast fold belt, which continues from the Ural Mountains to the west to the Da Xing An Ling to the east, formerly called Mongolian geosyncline between Siberian platform block and Sino-Korean block. The sedimentation of the "geosyncline" took place from Precambrian to Paleozic and these sedimentary rocks were subjected to the orogenic movements in the Baikalian (latest Proterozoic), the Caledonian (early Paleozoic) and the Hercynian (late Paleozoic) periods. The rocks of the fold belt, which consist of gneiss, schist, phyllite, crystalline limestone, sandstone, shale, siltstone, limestone, rhyolitic to basaltic volcanic rocks, and so on, are distributed outside the Siberian block, folding intensively and bending in an arc southward. These sediments were intruded by granitic rocks of various ages since latest Proterozoic. In general, granitic rocks become in age younger from north to south. In the area from eastern Mongolia to Da Xing An Ling, the igneous activity lasted to Mesozoic Era, and volcanic and granitic rocks of Jurassic to Cretaceous ages (Yenshan period) are widely distributed. In the Govi district, serpentinized ultrabasic rocks supposed to be ophiolite are distributed sporadically along a major tectonic line parallel to the fold axis.

On the east side of the fold belt, there is a block called Dong Bei para-platform (Breya block), and on 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, several to ten kilometers thick, but the basement of the crystalline metamorphic rocks exist at depth. Between these basins, the mountains of Altai, Tenshan, and Kunlun composed of metamorphic rocks of the Hercynian Period range from east to west (Fig. I-3-1).

In the Govi district, there are some inland sedimentary basins, accompanied by many coal field, of Mesozoic (mainly Cretaceous), in addition to the above.

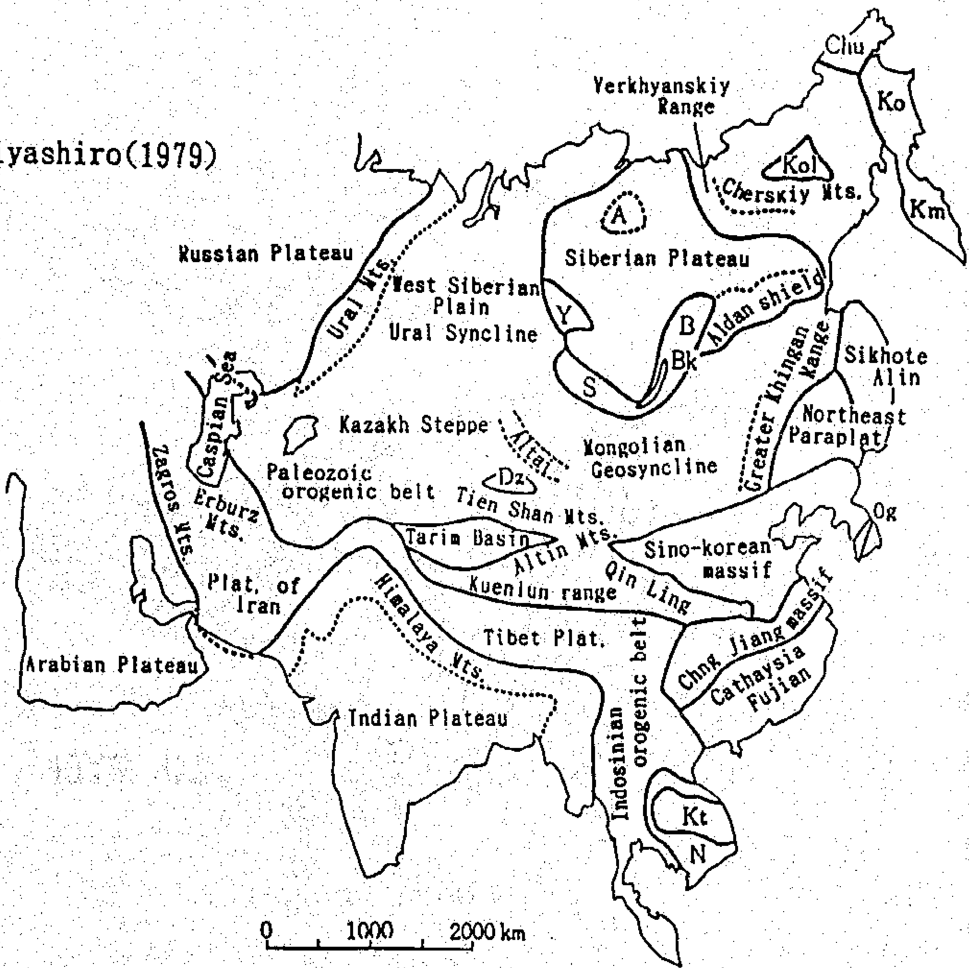
The above geological structure has been interpreted as follows by the theory of plate tectonics (after Parker and Gealey, 1985).

The vast ocean which was a part of the Tethys Sea existed in the present place of the Mongolian fold belt during Paleozoic. On the north of the Tethys Sea, there was a continental plate, called the Siberia plate or the Angara plate, consisting mainly of the Siberia block, and a oceanic plate subducted northward beneath the continental plate. On the south, there was another continental plate which was formed by the incorporation of the microcontinents such as Breya, Sino-Korea, Tarim, and so on, and the above oceanic plate also subducted southward beneath this continental plate (Fig. I-3-2). Junggar and Tsaidam were microcontinents too.

The Mongolian fold belt is considered to be an accretionary zone to the Siberia plate by the subduction of the oceanic plate in Paleozoic Era. The island arc as well as occeanic crust and overlying sediment is assumed to have been accreted and incorporated to the continental plate, because the Mongolian fold belt is accompanied by ophiolite, high pressure type metamorphic rock, and volcanic rock of island arc. The fact that sediments and metamorphic rocks of the Mongolian fold belt become in age younger from north to south suggests that the accretion had taken place continuously during Paleozoic, and, consequently, the subduction zone had receded southward.

The ocean continued to become small as the result of the successive subduction and, finally, two continental plates collided. The suture line is assumed to be the Yinshan-Tumen ophiolite zone extending from Inner Mongolia to the Pacific Ocean for a distance of 1,800 km. It is inferred that the collision began at first in the west in the uncertain age and took place in the central part in Permian and in the eastern part (from eastern Mongolia to northeastern China) in middle Jurassic (Fig. I-3-3). In late Triassic to early Jurassic (Indosinia Period), the South China plate consisting mainly of the Yangtzu block and the Indosinia plate collided against the southern part of the Breya-Sino Korea-Tarim plate. Its suture line is said to be the fold belt extending from the Kun Lun Mountains to the Chin Ling Mountains. Thus, the frame of geology of East Asia had been made until Jurassic.

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

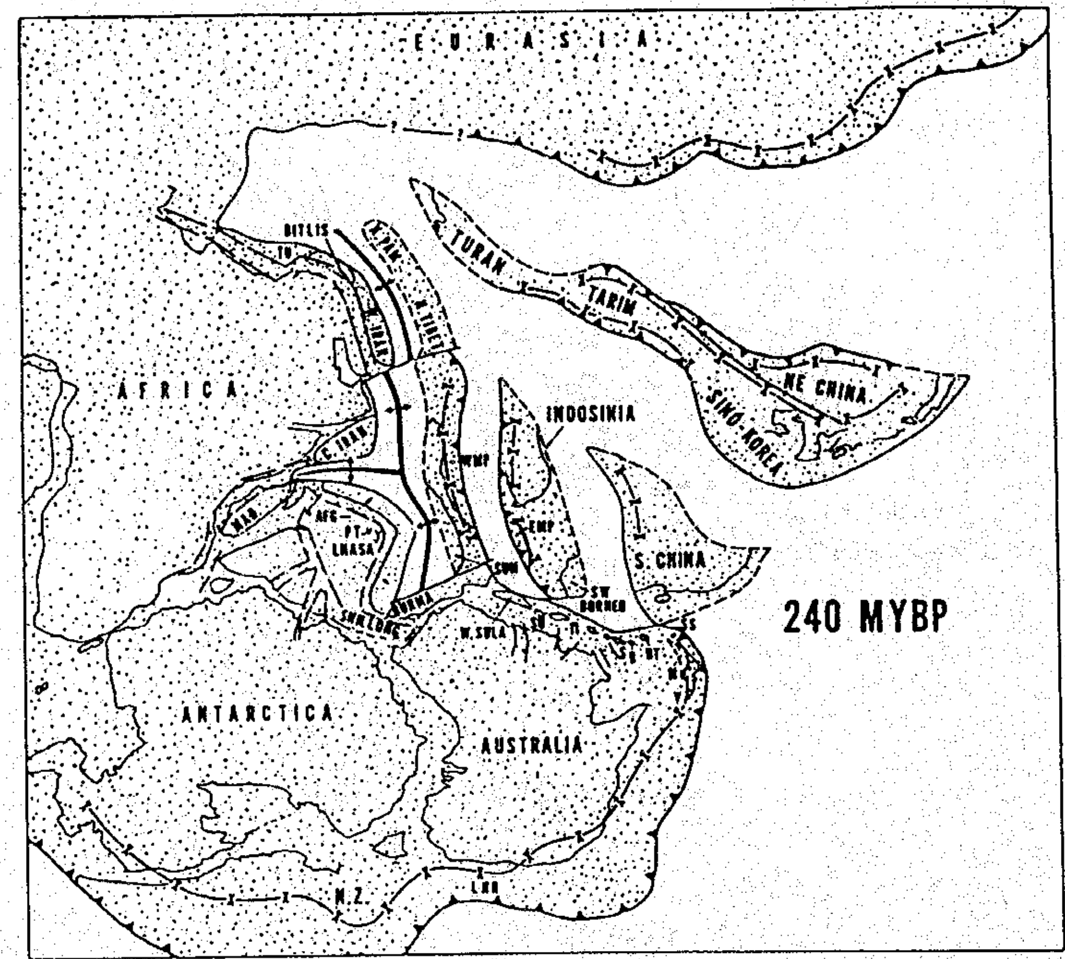
N: Hersinian ologenic belt

Og: Ogcheon Geosyncline

S: Sayan Mts.

Y: Yenisei Mts.

Fig. I-3-1 Geological setting of Area



continental crust
oceanic crust
active ridge
inactive ridge
active subduction zone
inactive subduction zone
suture
magmatic activity zone
transform fault
normal fault

Fig. I-3-2 Plate tectonics in the East Asia area in early Permian

(Parker and Gealey , 1985)

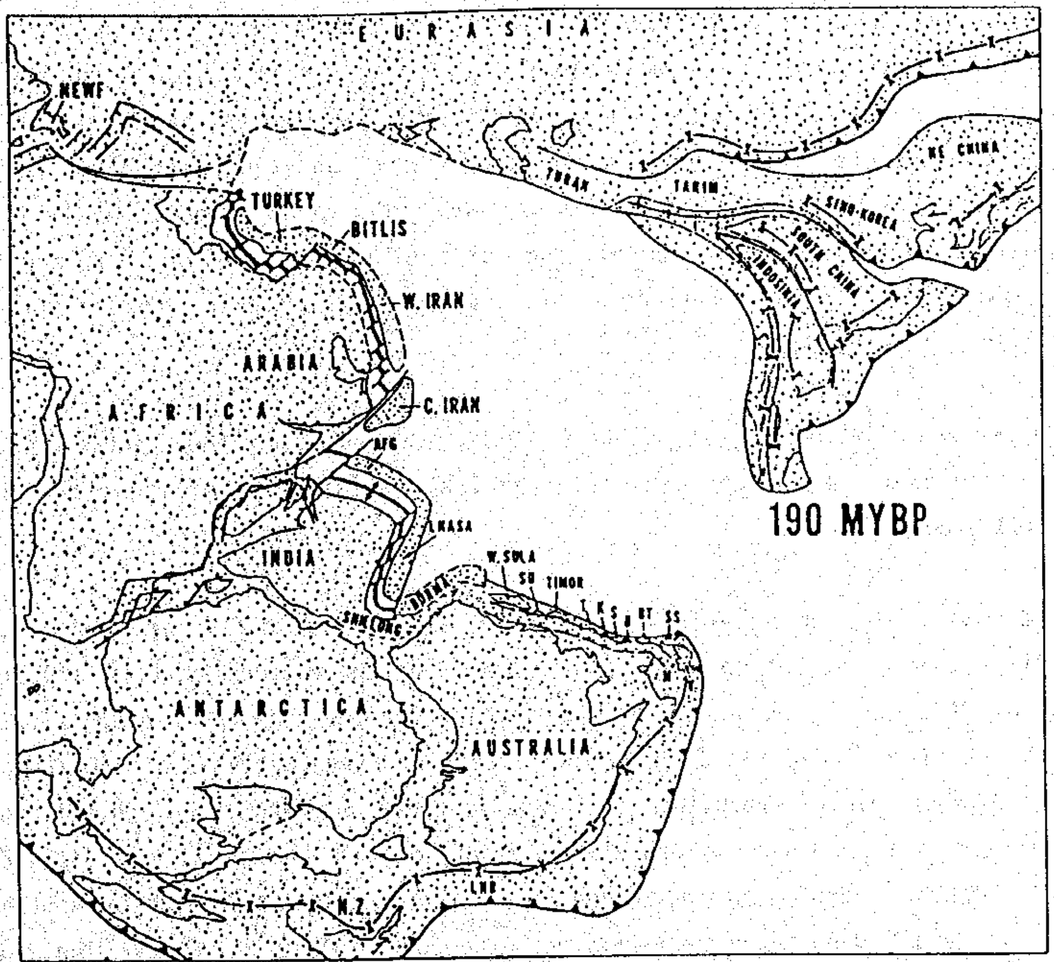


Fig. I-3-3 Plate tectonics in the East Asia area in early Jurassic legend is same as in Fig. I-3-2 (Parker and Gealey, 1985)

3-3 General Geology around the Survey Area

The survey area is situated in the fold belt, formerly called "Mongolian geosyncline", on the south of the Siberian platform. Geology of the area consists of, from the oldest, the upper Proterozoic Group which is distributed sporadically in the direction of the east and west from the south of Mandalgovi in the northern part of the survey area to the south of Lake Bon Tsagan, the Paleozoic Group and the Mesozoic Group distributed widely in the whole area, and the Tertiary System of the Cenozoic Group distributed between the Ongiin River and the Tuwin River in the northern part of the area. These strata were subjected to the orogenic movements in the Baikalian (latest Proterozoic), the Caledonian (early Paleozoic), and the Hercynian (late Paleozoic) periods and were intruded by granitic rocks of various ages since latest Proterozoic.

The upper Proterozoic Group is exposed in inlier surrounded by the Paleozoic Group and the Mesozoic Group and consists of gneiss, schist, crystalline limestone, quartzite, and so on.

The Paleozoic Group, found widely in the whole area, consists of schist, phyllite, sandstone, shale, siltstone, limestone, chert, and the various kinds of volcanic rocks of Silurian, Devonian, Carboniferous, and Permian ages, and is distributed outside the Siberian block, folding intensively and bending in an arc southward. In the Govi district, serpentinized ultrabasic rocks supposed to be ophyolite are distributed in a scattered pattern along a major tectonic line parallel to the fold axis. These sediments were intruded by granitic rocks of various ages since Paleozoic, and Tsagaansubraga porphyry copper deposit (315 ±16 Ma) and Olon Ovoot gold deposit (283 ± 14 Ma) related to the igneous activity of Paleozoic were formed.

The Mesozoic Group, also distributed widely in the survey area, consists of volcanic and granitic rocks of Jurassic to Cretaceous ages (Yenshan Period), and sediments, more than 3,000 m thick, of the inland sedimentary basins of Cretaceous accompanied by coal seam.

The Tertiary System of the Cenozoic Group composed of mudstone, siltstone, sandstone, conglomerate, and so on is distributed in a limited area between the Ongiin River and the Tuwin Rivers in the northern part of the survey area.

In the survey area, the igneous activities most actively repeated in Paleozoic and Mesozoic, especially in Paleozoic, and ore deposits formed in relation to the igneous activity are distributed. Especially, many ore showings of porphyry copper deposits formed in close association with the igneous activity of late Carboniferous to early Permian are found in the area.

3-4 Brief History of Mining Industry (Fig. I-3-4, Table I-3-1)

The investigation, exploration, and development in Mongolia began with gold mining in the 11 to 12 centuries. Early in the 1800's, gold mining was started by gold traders in the Altai and south Hangai area, and early in the 1900's, "Mongolor", a Russian-Mongolian company, was founded and mining of placer gold began in the northern part of the Hentii hills. Though there have been many changes in the history of minig industry since then, alluvial gold mining had become the core of mining industry in the country until the middle of the 1970's. The mining industry is now one of the main industries in Mongolia and holds about 18 % of the total output of industry and over 60 % of the total export earnings in 1992. Mongolia exports now copper, molybdenum, tin, fluorite, and coal. Coal, copper, molybdenum, and fluorite have been mined on a large scale, but the minings of gold, tin, and tungsten are still small-scale.

The exploitations of copper and fluorite out of these minings are important for the Mongolian economy. Copper and molybdenum have been produced in the Erdenet mine and the output in 1992 was 105,100 tons of copper and 1,522 tons of molybdenum. Fluorite has been mined in seven mines. The output of fluorite of 871,000 tons in 1988 holded 15 % of all the world production and was ranked second in the world after China with the output of 1.5 million tons, and ore reserves of 22 million tons was ranked second in the world next to the former Soviet Union.

Although there is no mine in operation in the survey area except for coal mine, the main mining centers in Mongolia are as follows.

(1) Copper·Molybdenum : Erdenet
(2) Fluorite : Bor Undor, Urgen, Har Airag, Berkh
(3) Placer Gold : Tolgoit, Zaamar, Bayanhongor
(4) Coal : Baga Nuur, Shareen Gol, Anduunchuluu

The major minining districts, such as Erdenet-Zaamar, Bor Undor, Darhan, Ulaan-Tsav, mentioned below, have been well developed.

① Erdenet-Zaamar mining district

In the Erdenet-Zaamar mining district, there are the Erdenetin Ovoo (Erdenet) copper•molybdenum deposit and the Zaamar gold field in which placer gold and primary gold showings are found. Erdenet, a joint venture of Mongolia and Russia, is the largest mine in operation in Mongolia and had produced copper concentrates, grading 35 % Cu, of 3.7 million tons and molybdenum concentrates of 23,000 tons (Ministry and Industry, 1992). The ore reserves as of 1969 when exploration was completed was estimated at 512 million tons grading 0.84 % of Cu and 0.016 % of Mo with cut off grade of 0.4 % Cu, and about 170 million tons of ore are assumed to have already been mined mainly from the upper high grade part of the ore body until 1991.

There is the Zaamar gold district, where over 15 gold placer deposits and more than 150 gold-bearing quartz veins in shale of Cambrian are found, about 130 kilometers to the southeast of the Erdenet mine. Ore reserves of gold placer deposits are estimated at 85 tons of gold with a grade of 0.7 to 1.5 g/m^3. Gold placer deposit varies in scale and origin. The largest gold placer deposit contains about 52 tons of gold while the smallest one contains approximately 100 kilograms.

A large gold-bearing quartz vein, which is 800 meters long, 1 to 6 meters wide and 250 meters deep and contains about 10 tons of gold with average grade of 10 g/t, has been discovered by the exploration for primary gold deposite which was commenced in 1989.

② Bor Undor mining district

The center of this district is the Bor Undor fluorite mine which is operated by "Mongolsovtsvetmet" company, a joint venture of Mongolia and Russia. In the Bor Undor district, there are over 14 fluorite deposits and 7 deposits are now exploited. The largest deposit in the district is the Bor Undor deposit with ore reserves of 12 million tons grading 46.5 % CaF_2. One hundred and thirty thousand tons of fluorite concentrates a year are produced at the Bor Undor mine and all the products, namely ores and concentrates of fluorite, are exported to Russia.

③ Darhan mining district

In this district, various kinds of mining products, including coal from the Shareen Gol open pit mine and placer gold from the Tolgoit and Ikh Alt mines, all three mines being operated by the joint venture "Mongolsovtsvetmet", are produced. Several ore showings of skarn-type iron and rare earth element have been also discovered in the district. Furthermore, in the district, there are at least 10 gold placer deposits ready for exploitation and the total gold reserves of the district are estimated at 20 tons.

④ Ulaan-Tsav mining district

There are two ore deposits, namely Ulaan and Tsav, in this area. The Ulaan deposit has ore reserves of 68.1 million tons in total, out of which 38.8 million tons grading 1.2 % Pb, 2.0 % Zn, 53 g/t Ag, and 0.21 g/t Au are considered to be minable by open pit mining. The Tsav deposit situated near the railroad has 7 million tons of ore seserves with the average grade of 6 % Pb, 3 to 4 % Zn, 232 g/t Ag, and 0.8 g/t Au.

In addition to the above mining district, there are several potential areas for the future development of mineral resources in the country. Out of these areas, the most important area are as follows.

(1) Boro Area (gold)

There is the Boro gold deposit, which was formerly investigated by a joint venture of Mongolia and Germany, about 150 kilometers north of Ulaanbaatar. The proven ore reserves of this deposit are estimated at about 30 tons of gold with a grade of 4 to 5 g/t. Gold placer deposit in the valley close to the Boro deposit is estimated to contain approximately two tons of gold. Several gold-bearing quartz veins at the Sujegtei and Narantolgoi showings in the area surroung the Boro deposit have been discovered.

(2) Ondor Tsagaan Area (tungsten, molybdenum, lead, zinc)

There is the Ondor Tsagaan tungsten·molybdenum deposit approximately 270 kilometers east of Ulanbaatar. The deposit is about 1,800 meters long, 600 to 800 meters wide, and 10 to 800 meters deep and ore reserves are estimated at 186 million tons with the average grade of 0.17 % W_2O_3, 0.78 % Mo, 0.08 % Bi, and 0.031 % BeO.

There is also the Mungum Undur lead·zinc deposit with ore reserves of 13 million tons grading 1.26 % Pb, 0.97 % Zn, and 95 g/t Ag near the Ondor Tsagaan.

(3) Ygodzer Area

There are several ore showings of tungsten and molybdenum, which are of primary vein-type and greisen-type, in the Ygodzer Area, situated in the southeastern part of Mongolia, close to the Mongolia-Chinese border. The biggest ore deposit in the Ygodzer area is the Ygodzer deposit which consists of more than 12 ore veins and 1 elongated ore body. The Ygodzer deposit is distributed in an area of 1,700 meters by 100 to 120 meters and ore reserves are estimated at 21.6 million tons with the average grade of 0.2 % W_2O_3 and 0.56 % Mo.

(4) Tsagaan Suvraga Area (copper, molybdenum)

The Tsagaan Suvraga Area in the survey area is situated in the Govi Desert in the southeastern part of Mongolia. About 10 porphyry copper type mineralized zones in addion to the Serven Suhait porphyry copper deposit with ore reserves of 240 million tons grading 0.54 % Cu, 0.019 % Mo, 2.64 g/t Ag, and 0.39 % RE have been discovered to date.

(5) Tsahir Area

Several high grade ore showings of rare earth element, zirconium, tantalum, and niobium were discovered in 1989 to 1990 in the Tsahir Area, about 1,000 kilometers west of Ulaanbartar, situated between Lake Hyargas and Lake Harus in the west part of Mongolia. These ore showings are found in the alteration zone embedded in alkali rocks such as arfvedsonite granite, nordmarkite (quartz syenite), and syenite. The typical alteration zone is 300 to 1,200 meters long, 50 to 400 meters wide, and 100 to 200 meters deep. Ore reserves are estimated at 50 to 110 million tons grading 1.27 % Zr, 0.2 to 0.5 % Nb, 0.01 to 0.1 % Ta, and 0.08 to 0.5 % Y. The bigger ore deposits in the Tsahir Area are Halzan Burgeti, Tsahir, and Ulaan Tolgoi deposits.

Table I-3-1 Productions of Non-ferrous Metallic Minerals and Fluorite of Mongolia (1986 ~1992)

Name of the Mines	Mineral	Products	Unit	1986	1987	1988	1989	1990	1991	1992	Note
1. Erdenet	Cu, Mo	Crude ore	M. t	17.0	16.6	17.3	17.9	17.9			Porphyry type
		Cu-conc. (35% Cu)	T. t	344.4	345.4	347.7	419.7	425.9	260.0	296.0	All exported to USSR and
		Mo-conc. (47% Mo)	t	3,232	3,240	3,268	3,072	3,156	3,373	3,075	Japan
1. Modot	Sn, W	Sn-conc. (50% Sn)	t	175.4	178.1	181.7	273.1	317.4	140.9	62.9	Placer type
		W- conc. (20% WO_3)	t	81.4	50.4	103.9	0	0	0	0	exported to CSR
1. Ulaan-uul (USSR) 2. Tsagaandavaa (HPR)	W	W- conc. (60% WO_3)	t	15.0	20.0	30.3	50.0	45.0	35	25	Quartz vein All exported
1. Bor-undur 2. Har-airag 3. Berh 4. Chuluut-tsagaandel	CaF_2	Crude ore	T. t	730.2	754.2	890.9	613.2	587.2	333.4	209.3	Vein type All exported, 1. ~3. to USSR, 4. to CSR
		CaF_2 conc. (95~96% CaF_2)	T. t	41.0	72.7	115.1	91.8	91.8	91.8	100.0	

Abbreviations ; USSR; Union of Soviet Socialist Republics, JPN; Japan, HPR; Hungarian People's Republic,
CSR; Czechoslovac Socialist Republic, conc. ; concentrate, M. t; million tons,
T. t; thousand tons, t; ton

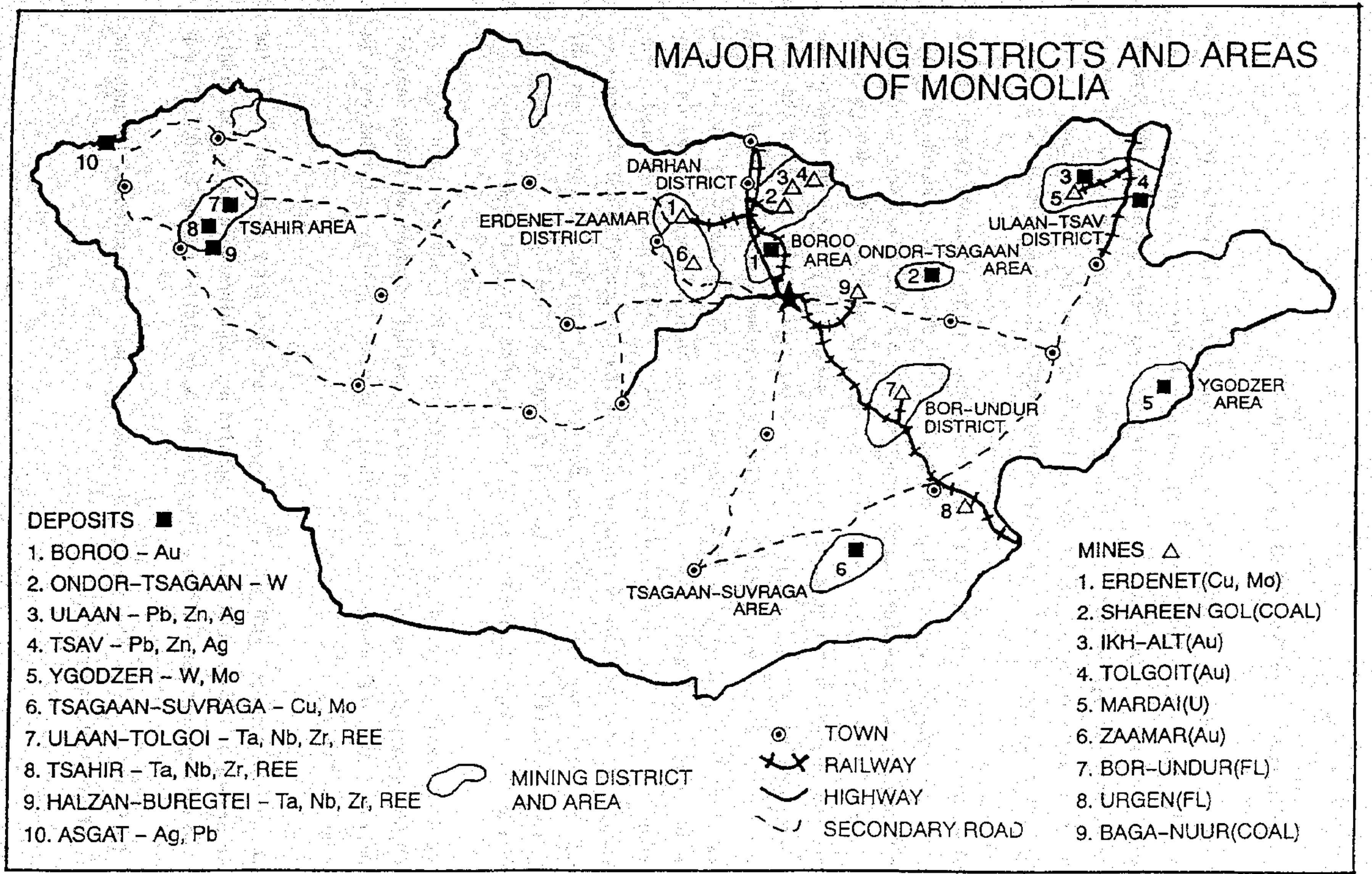


Fig. I-3-4 Major mining districts and areas of Mongolia

CHAPTER 4 GENERAL COMMENT ON THE SURVEY RESULT

4-1 Collection and Analysis of the Existing Data

The investigation of the existing data was mainly done on reports stored at the Geological Information Center (GIC) of Geological Survey of Mongolia. The work whose results are contained in these reports was entrusted to the Soviet international geology research institute by the Mongolian Government and the field work was carried out by teams comprising both Mongolian and Soviet members. The said reports were prepared by the above Soviet institute and is written in Russian.

Geoscientific survey of the area concerned began in the 1930s and there are 62 reports on geological investigations ranging from 1:1,000,000 to 1:50,000 in scale, also 9 reports on geophysical works including airborne geophysics were studied in the course of this project. Only airborne magnetic survey, 1:200,000 in scale covers the entire Altantal area. The geological works mostly covers the area to the north of latitude 43° N., and to the south of latitude 42° 20' and thus the Gobi Desert and the vicinity of Altai Mountains have not been surveyed. Particularly areas studied by geological survey, in a scale of 1:50,000 or larger scale, ore deposit assessment, and surface geophysics are concentrated in the zones of latitude 43° -45° N to the east of longitude 105° E. It is not clear whether the zones not investigated were considered to be of low prospectivity and abandoned or promising zones have not been found because of insufficient investigation. Therefore, satellite image analysis of the western half part to the west of longitude 103° E may indicate the necessity of further survey of these areas.

There is mineral distribution map covering the entire country in a scale of 1:500,000 showing the known ore deposits and showings together with geochemical anomalies. The explanatory test describing the grade, geology and occurrence is attached to this map.

In the present project, gold and silver deposits and showings were extracted for the whole area and copper, lead and zinc deposits and showings were extracted mainly for the western half part of the survey area and were plotted on the 1:1,000,000 map.

The following 10 areas where many gold showings swarm were selected through the study of available documents.

(1) Tsagaan Ovoo Area (Au)
(2) Ulziit-Gulvansaihan Area (polymetal)
(3) Narangin Hudak-Tsagaansubraga Area (Cu, Au)
(4) Ih Shanhai Area (Cu, Au)
(5) Harmagtai Area (Cu, Au)
(6) Olon Ovoot Area (Au)
(7) Bayan Hongor Area (Au)
(8) Bogd Area (Cu, Au)
(9) Bayan Govi Area (Cu, Au)
(10) Mt.Nemegt Area (placer gold)

Of the above areas, six areas from (1) to (6) are lecated in the ground truth survey area which was surveyed in 1994, and other four areas from (7) to (10) are situated in the western half part of the survey area to the west of longitude 103° E where ground truth survey will be conducted in 1995.

4-2 Interpretation of the Satellite Image

Thirty-three scenes of satellite images in Altantal area of Mongolia were analyzed and consequently 47 areas in the eastern half part of the Altantal area were selected as alteration zone areas, because these areas show same color in the analyzed satellite images as that of Shuten area or Ih-shanhai area. Forty-five areas out of 47 areas were investigated in the field as the subject of 1994's ground truth survey. It is concluded to be possible that silicified zone and argillized zone around ore showing covering an area of more than 300 meters in diameter can be selected in the analyzed satellite image. On the other hand, rock bodies which show characteristic structure (for example, ring structure etc) and have brown surface stained by oxidized iron minerals were selected in the analyzed satellite images. After try and error, it will be possible to select only argillized zones and silicified zones more precisely.

Geological relation between linear structure and ore showing is not clear, but main ore showings such as Shuten and Ih-shanhai seem to be arranged in a east-northeast or east and west direction.

4-3 Ground Truth Survey

From the analized satellite images of eastern half of the Altantal area, 47 areas were selected as alteration zones. Actually 64 areas subdivided from 45 areas out of 47 areas were investigated in the field in 1994. The areas which were reported as siliceous sediments from hot spring in Uudamtal area's MMAJ report (presented in March, 1994) were included in these 64 areas and were checked this time. Futhermore some areas which seemed to be attractive on the way of survey were also included in 64 areas and investigated. In 24 areas out of these 64 areas, neither silicification nor argillization was observed. In these areas accompanied by no mineralization and silicification, although a little amount of clay minerals were sometimes found, some rock bodies which have special structure or brown surface stained by oxidized iron minerals might be selected in the analyzed satellite images.

The areas which are necessary to be surveyed in detail have been selected based on four criteria, that is, broad silicified zone, strongly argillized zone, rather high contents of As, Sb and Hg, even though low content of Au, and volcanic or pyroclastic rocks as host rock. On selecting the areas to be surveyed further, showings of small barren quartz vein and porphyry copper type containing no gold have been excluded. Consequently No.5 (Shuten), Nos.10' & 11', Nos.23～25, No.31, and Nos.43～45 have been selected as areas to be surveyed in more detail. As Nos.34 & 35, No.37 areas are lacking in some of four criteria, these areas seem to rank next to the above areas as the subject of further survey. Regarding other areas, it is too early to conclude, but no data to promote further survey or exploration works have been obtained.

4-4 Geological Structure, Characteristic of Mineralization, and Structural Control of Mineralization

The surveyed area in 1994 lies in southern part of Mongolia which is now called Gobi plain. On the north and the south of the surveyed area, sedimentary rocks, volcanic rocks, plutonic rocks and metamorphic rocks of pre Cambrian period are widely distributed. In the surveyed area, that is, in Gobi plain, volcanic rocks, plutonic rocks and sedimentary rocks of Mesozoic are widely distributed, and Palaeozoic volcanic and plutonic rocks forming low mountains are exposed among Mesozoic rocks. These geologic features were bult up by collision of two tectonic plates, namely northern Siberia plate and southern Sinokorean plate, both of which are composed of pre Cambrian group, during Palaeozoic and first half of Mesozoic periods. Consequently in Mesozoic era, continental sedimentary basin was formed at the place of present Gobi plain (Parker and Gealey; 1985). Therefore, igneous activities were most active in late Palaeozoic to early Mesozoic.

Most of mineralization, silicification and argillization seem to have had genetical relation with volcanic activities (andesite and dacite) or plutonic activities (granite and granodiorite) of late Palaeozoic (Carboniferous to Permian).

At the central part of Shuten mineralized zone (No.5 area), there is silicified zone including alunite and kaolinite, and the original rock of silicified zone is andesite and its pyroclastics of late Carboniferous to early Permian. In this silicified zone, brecciated structure which seemed to be generated by hydrothermal explosion was seen everywhere. Around silicified zone, slightly propylitized andesite is distributed and a quartz vein containing gold of 4.16 to 9.78 g/t was found. There are many genetical models about hydrothermal gold ore deposit, the genetical model of Round Mountain gold deposit in Nevada (USA) which is considered as one of typical epithermal gold ore deposits is applicable to the Shuten mineralized zone as mentioned in the section II-4-4 except that host rock of Shuten is different from that of Round Mountain and adularia is not found at Shuten. The reason why adularia is not seen in Shuten seems to have resulted from acidic hydrothermal solution of Shuten compared with that of Round Mountain judging from the existence of alunite and kaolinite at Shuten. It can be concluded that Shuten mineralized zone is epithermal gold ore deposit, and it is expected that quartz veins and/or networks containing gold may be present around and below silicified zone in Shuten ore showing area.

Ore showings of Nos.10' & 11', Nos.23～25, No.31 and Nos.43～45 areas seem to be very resemble to that of Shuten area, therefore more detailed survey in these areas is thought to be also necessary. Furthermore, weak hydrothermal alteration zones (Nos.34 & 35 and No.37 areas) is considered to be surveyed in more detail.

Five areas such as No.2, No.6-A, No.16-B (Narinhudag), No.16-C, and No.20(Ih-shanhai) are thought to be porphyry copper type ore showings. Some samples from these areas contain a little amount of copper, but maximum content of copper is around 0.4 %. Although quartz veins were observed everywhere, possibility to be economically good ore deposits could not be realized. Regarding most of silicified zones or rocks in other areas, ore deposit type of the showing could not be deduced.

All the ore showings of epithermal gold deposit and porphyry copper deposit types are considered to have genetical relation with igneous activities in Carboniferous to Permian, and time of silicification and alteration seem to be almost same as or slightly later than these igneous activities.

4-5 Possibility of Emplacement of Ore Deposit

As mentioned in previous section (4-3), Shuten mineralized zone of epithermal gold ore deposit type, silicified zones such as Nos.10' & 11', Nos.23～25, No.31 and Nos. 43～45 areas which may be epithermal type gold ore showings, and weak hydrothermal alteration zones such as Nos.34 & 35 and No.37 areas, porphyry copper type ore showings and quartz veins were also found in the ground truth survey area. The target of this year's survey is to find out gold ore showings, therefore it is concluded to carry out the follow-up survey further in the areas where epithermal gold ore deposit type showing and possible epithermal type gold ore showings have been found. Especially in Shuten area, the more detaild follow-up survey for around and below silicified zone is thought to be necessary, and the area adjacent to the northeast of Shuten is also necessary to be surveyed judging from the existing data.

CHAPTER 5 CONCLUSION AND RECOMMENDATION

5-1 Conclusion

(1) Collection and analysis of the existing data

As the result of the collection, compilation, and analysis of the existing data on geological survey, geochemical exploration, geophysical exploration, drilling, and so on for ore deposit and ore showing of gold, silver, copper, lead, and zinc in the survey area, 10 areas, namely Tsagaan Ovoo, Ulziit-Gulvansaihan, Olon Ovoot, Narangin Hudak-Tsagaansubraga, Ih Shanhai, Harmagtai, Bayanhongor, Bayan Govi, Bogd, Mt.Nemegt, where many gold showings which contain gold swarm, have been selected.

Out of these 10 areas, Tsagaan Ovoo, Ulziit-Gulvansaihan, Olon Ovoot, Narangin Hudak-Tsagaansubraga, Ih Shanhai, and Harmagtai areas are situated in the ground truth survey area to the east of longitude 103° E and other four areas are situated in the western half part to the west of longitude 103° E.

(2) Interpretation of satellite image

Thirty-three scenes of the Landsat TM images covering the whole survey area have been interpreted and the alteration zones and lineament in the satellite images have been selected.

The selected alteration zones which show same color in the analyzed satellite images as that of the Shuten area or Ih Shanhai area have numbered 96 areas in the whole survey area and 47 areas in the eastern half area investigated by the ground truth survey.

The alteration zones selected seem to have a tendency to swarm in some areas such as the Mandalgovi-Saihan Ovoo area in the northern part of the ground truth survey area, Shuten-Ih Shanhai area in the east, and Hanbogd-Nomgon area in the south and are arraged in a east-northeast to east and west direction.

It was difficult to detect the known porphyry copper type ore showings such as Serven-Suhait, Harmagtai, and Narim Hudak in the satellite images, because they are not accompanied by strongly argillized and highly silicified zones. It was also difficult to detect vein type gold ore deposits such as Olon Ovoot deposit because of narrow alteration zone.

In the eastern half part of the survey area to the east of longitude 103° E, two linear structures, namely northeast to east-northeast and west-northwest directions, are predominant and extend for a long distance.

The curved to circular structures in the satellite images are clearly observed in the Shuten area, an area to the southeast of Shuten, the Hanbogd area, and an area to the south-southeast of Luus.

The lineament of the east and west direction is dominant in the Nos.43 and 44 areas, the east-northeast direction in the Shuten and Ih Shanhai areas, and the east and west direction in the Nos.23, 24, and 25 areas.

As the result of the ground truth survey for the selected alteration zones, it is concluded to be possible to select the ore showings accompanied by the silicified and argillized zones covering an area of more than 300 meters in diameter. Therefore, it seems to be useful to survey the selected alteration zone as a clue to search for epithermal gold deposit.

(3) Ground truth survey

Forty-five areas out of 47 areas selected from the analyzed satellite images of the eastern half part of the survey area to the east of longitude 103 ° E were investigated in the field. In 24 areas out of these 45 areas, neither silicification nor argillization was observed. In these areas accompanied by no argillization and silicification, although a little amount of clay minerals were sometimes found, some rock bodies which have special structure or brown surface stained by oxidized iron minerals might be selected by analyzed satellite images. No.5 (Shuten), Nos.10' and 11', Nos.23～25, No.31, and Nos.43～45 areas out of the remaining 21 areas are considered to be ore showings of epithermal type gold deposits related to the volcanic activity in late Carboniferous to early Permian, judging from the fact that host rocks of these areas have been subjected to intensive silicification and argillization, mineral assemblages of hydrothermal alteration zones consist mainly of quartz, alunite, and kaolinite, host rocks are andesitic volconic and pyroclastic rocks of late Carboniferous to early Permian, silicified breccias which seem to be hydrothermal explosion breccias are found everywhere in the silicified zones, and the silicified zones are rich in arsenic, antimony, and mercury. In particular, gold-bearing quartz vein containing 4.16 to 9.78 g/t of gold, 1.1 to 2.0 meters wide and 350 meters long, and large-scale silicified zone, 1.0 to 3.5 kilometers wide and about 7.0 kilometers long, are found in the Shuten mineralized zone. Therefore, It is expected that quartz veins and/or networks containing gold may be present around and below the silicified zone in the Shuten mineralized zone.

(4) General commentary

The ground truth survey for 45 hydrothermal alteration zones which are situated in the eastern half part of the survey area to the east of longitude 103° E, out of 96 alteration zone selected from the whole survey area by the satellite image analysis, and 2 known silicified zone which were not detected on the analyzed satellite image was carried out. As a result, hydrotheral alteration zones were observed at 21 localities. Fifteen localities out of these 21 localities are newly found alteration zones by the satellite image analysis. Out of 23 localities where hydrothermal alteration zones were found, Shuten mineralized zone which seems to be of epithermal type gold deposit, 10 silicified zones, namely No.10, No.11, No.23, No.24, No.25, No.31, No.43, No.44, No.45, and the area adjacent to the northeast of Shuten, which may be epithermal type gold ore showing, and 3 weak hydrothermal alteration zones (No.34, No.35, and No.37) is thought to be surveyed further in detail. In spite of the vast survey area covering 330,000 aquare kilometers, hydrothermal alteration zones were effectively found. This fact indicates that the satellite image analysis is useful for search of epithermal type gold deposit.

5-2 Recommendation for the second year's survey

1. In the western half part of the survey area to the west of longitude 103° E, the ground truth survey for the alteration zones selected in the analyzed satellite images and known hopeful gold showings in the areas, where gold showings swarm, which have been selected from the analysis of the existing data is recommended to be conducted to find hopeful area of gold, because no ground truth survey was carried out in 1994.

2. In the eastern half part of the survey area to the east of longitude 103° E, the following surveys is recommended to be conducted.

(1) Shuten mineralized zone area

a) Detailed geological survey and sampling for laboratory works
b) Geochemical prospecting by means of soil and rock samples

(2) Area adjacent to the northeast of Shuten, Nos.10' & 11', Nos.23~25, No.31, Nos.43~45, Nos.34 & 35, No.37 area

Semi-detailed geological survey and sampling for laboratory works