NO.

REPORT
ON
THE MINERAL EXPLORATION
IN
THE KOKPETINSKAYA AREA
THE REPUBLIC OF KAZAKHSTAN

(PHASE II)

March 2002

JAPAN INTERNATIONAL COOPERATION AGENCY
METAL MINING AGENCY OF JAPAN

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PREFACE

In response to the request of the Government of the Republic of Kazakhstan, the Japanese Government determined to conduct a series of survey involving geological survey, drilling survey and other surveys related to exploration of ore deposits, for the purpose of examining the potentials of mineral resources in the Kokpetinskaya Area, situated some 750 km northeast of Almaty, the Kazakhstan's ex-capital city, and entrusted the survey to the Japan International Cooperation agency (JICA).

In view of the geological and mineralogical nature of the intended survey, the JICA commissioned the Metal Mining Agency of Japan (MMAJ) to execute the survey.

During the second year (Phase II) of the survey commenced in the fiscal year 2001, the MMAJ organized and sent to the Republic of Kazakhstan a three-man survey team for the period from June 30 to September 9, 2001. The field survey was completed as scheduled, in close collaboration with the Kazakh government agencies concerned and the Committee of Geology and Underground Resources Protection, the Ministry of Energy and Mineral Resources of the Republic of Kazakhstan.

This Report summarizes the results of the Phase II survey and will form an integral part of the final survey report to be elaborated.

We should like to take this opportunity to express our sincere gratefulness to the Kazakh government agencies concerned for their valuable cooperation. We are also thankful to the Japanese Ministry of Foreign Affairs, the Ministry of Economy and Industry, the Embassy of Japan in Kazakhstan and persons concerned who have rendered assistance and support for the survey.

March, 2002

Takao Kawakami
President
Japan International Cooperation Agency

Naohiro Tashiro
President
Metal Mining Agency of Japan

Fig. I -1 Location Map of the Kokpetinskaya Area

Fig. I -2 Detailed Location Map of the Kokpetinskaya Area

Р Е З Ю М Е

В настоящем Резюме вкратце описываются результаты исследования на второй год, проведенного в рамках 3-летней программы “Основное геологоразведочное исследование по линии оказания сотрудничества в области разработки природных ресурсов на Кокпетинском участке Республики Казахстан”, которая осуществляется на основании “Соглашения по объему геологоразведочных работ”, заключенного между Японским агентством по международному сотрудничеству (JICA), Японским агентством металлодобывающей промышленности (MMAJ), Комитетом геологии и охраны недр Министерства энергетики и минеральных (бывшего Министерства природных ресурсов и охраны окружающей среды) Республики Казахстан.

Основные цели оговоренного исследования заключаются в определении геологии и процесса образования россыпей ильменитовых месторождений и их распределения на названном участке, и, тем самым, оказать Республике Казахстан содействие в разработке и освоении природных ресурсов. Ещё одна же цель исследования заключается в передаче различных технологий соответствующим организациям РК в ходе совместной работы в течение периода осуществления данной программы.

В рамках исследования на текущий финансовый год относительно всего Кокпетинского участка (общей площадью 256 кв. м) были осуществлены сбор существующих технических данных и информации, их анализ и геологическая разведка (предварительно-прецизионная). Помимо этого, было осуществлено разбуривание 20 скважин с общей глубиной бурения 1033,0 м в южной части Бектемирской россыпи №1, 25 скважин с общей глубиной бурения 903,5 м в южной части Бектемирской россыпи №3 и 5 скважин с общей глубиной бурения 335,0 м в северной части Бектемирского района.

Общая геология на данном участке, в основном, состоит из пластов, относящихся к каменноугольному периоду и вторгнувшихся в эти пласты интрузивных различных гранитных пород, а также покрывающихся первые Аральских слоев третичного и четвертичного периодов кайнозойской эры. В ходе исследования было выяснено, что гранитные породы, по их химическому составу, разделяются на гранит и монцонит – диорит, а также что эти породы содержат непрозрачные минералы, такие как ильменит (Ti 35%), титаносодержащий магнетит (Ti 1,5 – 14%) и магнетит (Ti 0%), и что среди монцонито – диоритных пород те породные тела с низкой намагниченностью содержат больше ильменит, чем остальные. Предполагаем, что такие непрозрачные минералы отделились под воздействием химического выветривания в влажных и теплых климатических условиях в конце верхнемелового периода (140 млн. лет назад) и сконцентрировались в профильных впадинах в породном основании (палеогеологических каналах) при осаждении Аральских слоев в неогеновом период (40 млн. лет назад).

Разведка с разбуриванием скважин показала, что месторождение в южной части Бектемирской россыпи №1 имеет толщину 1,8 – 10,0 м, ширину не менее 1000 м, количество увеличения рудных запасов 6,5 млн. куб. м, запасы ильменитовой руды 857 тыс. тонн со средним содержанием чистого ильменита 132 кг / куб. м, коэффициент вскрытия 8,3. На Бектемирской россыпи №3 расположенные параллельно друг другу два месторождения имеют ширину примерно 200 м, соответственно, и являются меньшими по масштабу, чем то на россыпь №1. Толщина данного месторождения составляет 1,5 – 4,4 м, объем потенциальных запасов – 3,8 млн. куб. м, объем запасов ильменитовой руды – 493 тыс. тонны со средним содержанием 130 кг / куб. м, а коэффициент вскрытия – 9,7. Подробное определение объема запасов руды в северной части Бектемирской россыпи не проводилось с учетом низкого среднего содержания ильменита.

В основном, ильменитовые россыпные месторождения образуется в палеогеологических каналах в породном основании Аральского слоя. Следовательно, можно сказать, что выделение палеогеологических каналов обеспечит возможность определения новых (других) мест, где с высокой вероятностью зарождаются рудные месторождения. По более верхнему потоку находятся диоритно – монцонитные породы, которые характеризуются высоким содержанием ильменита, и ожидается нахождение пород с намагниченностью не более 1 x 10^3 S.I.U. и низким содержанием магнетита или титаносодержащего магнетита.

Говоря об общем направлениях исследования на третий год, мы считаем целесообразным провести дополнительную разведку с бурением скважин (подробную разведку) в южной части Бектемирского россыпного месторождения №1, которое, должно быть, продолжаться ещё южнее, и в южной части Бектемирского россыпного месторождения №3, от которого можно ожидать довольно большие потенциальные рудные запасы. Помимо этих месторождений, необходимым считаем проведение дополнительной разведки с бурением скважин в восточной части Бектемирского россыпного месторождения №1 и северной части Бектемирского россыпного месторождения №2 (район Белое), где предполагается нахождение палеогеологических каналов.

В Караоткельском районе необходимо в дальнейшем выделить пойменные болота и палеогеологические каналы, имеющие соответствующие характеристики и, тем самым, обеспечить возможность провести переоценку уже разведанных ильменитовых россыпных месторождений. Кроме того, рекомендуется провести поиски и предварительную оценку различных районов по всей территории Республики Казахстан, которые имеют историю, подобную исследуемым в рамках нашей текущей работы, с целью, чтобы найти другие ильменитовые россыпные месторождения.

SUMMARY

This survey was undertaken as a second-year survey in “Basic Resource Development Cooperation Survey: Kokpetinskaya Area of Republic of Kazakhstan” that was started as a three-year project in 2000 based on the Scope of Works concluded between the the Committee of Geology and Underground Resources Protection of the Ministry of Energy and Mineral Resources, Government of the Republic of Kazakhstan, and Japan International Cooperation Agency/Metal Mining Agency of Japan.

The survey aims at analyzing geology in the survey area that contains ilmenite ore beds of the drift sand type and ore bearing condition of the ore beds, to support resource development by the Republic of Kazakhstan. The survey also aims at transferring technology to the counterparts of Kazakhstan during the survey period.

In Phase II, public data of the entire area of the Kokpetinskaya Area (256km^2) was collected and analyzed. A geological survey (semi-detailed survey) was conducted in the area. Boring surveys were conducted in the southern flank of Bektimir Placer No. 1 (20 drill pits, 1033.0m in drilling length), southern flank of Bektimir Placer No. 3 (25 drill pits, 903.5m) and northern flank of Bektimir (5 drill pits, 335.0m).

This area consists of Carboniferous Period layers and granitic rocks that intrude into them, as well as Aral Formation of the Tertiary Period in the Cainozoic Era and Quaternary-Period layers that cover them. Based on chemical compositions, granitic rocks could be classified into granite and monzonite - diorite. The surveys showed that the area contained ilmenite (Ti 35%), titanic magnetite (Ti 1.5 to 14%), and magnetite (Ti 0%) as opaque minerals and that more ilmenite was contained in rock bodies of monzonite - diorite that showed a low magnetic susceptibility. It is estimated that opaque minerals were separated by chemical weathering under wet and warm climate at the end of early Cretaceous Period (about 140 million years ago) and were thickened in furrows (palaeo-landform channels) of the bedrock when the Aral Formation was deposited in the Neogene Period (about 40 million years ago).

The drilling surveys showed that the southern flank of Bektimir Placer No. 1 was 1.8 to 10.0m thick, more than 1000m in width, 6.5 million m^3 in ore reserves potential, 857,000t in ilmenite ore reserves, 132kg/m^3 in ilmenite content and 8.3 in stripping ratio. In the southern flank of Bektimir Placer No. 3, the widths of two parallel ore deposits were about 200m and were narrow compared with that of Placer No. 1. Placer 2 was 1.5 to 4.4m thick, 3.8 million m^3 in ore reserves potential, 493,000t in ilmenite ore reserves, 130kg/m^3 in ilmenite content and 9.7 in stripping ratio. The grade of ilmenite-thickened seams in the

northern flank of Bektimir was low and ore reserves calculations of it were not made.

Ilmenite placer deposits are contained in palaeo-landform channels of the bedrock of the Aral Formation. Seams with high possibilities for deposition of new ore deposits can therefore be extracted by extracting palaeo-landform channels. When exploring such seams, upstream areas of them should preferably be rock bodies of diorite - monzonite, containing a high proportion of ilmenite but less magnetite and titanic magnetite. The magnetic susceptibility of them should preferably be less than 1×10^{-3} S.I.U..

As a survey policy for Phase III surveys, additional drilling (detailed survey) of the southern flank of Bektimir Placer No. 1, for which a further extension of ore deposits is expected, and the southern flank of Bektimir Placer No. 3, where sufficient potentials are expected, is desired. Palaeo-landform channels are anticipated in the eastern flank of Bektimir Placer No. 1 and the northern flank of Bektimir Placer No. 2 (Beloe District) as other potential districts. A drilling survey of these districts is deemed preferable.

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PART I

GENERALITIES

Chapter 1 Introduction

1-1 Antecedents of the Survey

This survey was undertaken as a second-year survey in continuation of a mineral resource survey conducted in the Kokpetinskaya area in 2000 based on the Scope of Works concluded between the Governments of the Republic of Kazakhstan and Japan on June 6, 2000, at a request of the Government of the Republic of Kazakhstan.

The survey aims at analyzing geology that contains ilmenite drift-sand ore beds in the survey area shown in Fig. I-1 and reserves of drift-sand ore beds, to support resource development by the Republic of Kazakhstan. The survey also aims at transferring technology to the Committee of Geology and Underground Resources Protection, the Ministry of Energy and Mineral Resources and the East Kazakhstan Geology Bureau, which are counterpart organizations in the Republic of Kazakhstan, during the survey period.

The Republic of Kazakhstan is known for her rich subsurface resources and many of her metallic resource reserves are very large by a world standard. Ten years after the independence of the republic, the nonferrous metal industry of the country is registering a prominent growth, mainly in gold, titanium (sponge titanium), zinc and copper ores through technology transfer and introduction of new management techniques in conjunction with investments by overseas corporations. A new chromium mine has started its operation. In 2001, the nonferrous metal industry registered a growth of 14% over the preceding year. The republic has many other ore beds with a high future potentiality and the industry is expected to register a further growth. Among these metals, the production of sponge titanium increased 75% over the preceding year and ranked fourth in the world. The Republic of Kazakhstan ranks sixth in the production of magnesium ore, which is a by-product of sponge titanium, in the world.

Reserves potentials of titanium resources in the survey area have been regarded promising from early on. A large-scale titanium refining kombinat with new electric furnaces has been put into operation by Ust-Kamenogorsk Titanium Manganese Kombinat (UKTMK) in Ust-Kamenogorsk, about 150km north of the survey area. In case reserves that are high in commercial value are found in this area, ilmenite as a titanium raw material can be supplied to the area and these reserves can be developed relatively easily. At present, the kombinat imports ilmenite and other titanium raw materials from Russia and other countries and is spending an effort in developing titanium resources in the republic, which are more attractive in acquiring foreign currencies. This survey was requested under these backdrops.

1-2 Outline of the Phase II Survey

1-2-1 Survey area

The Kokpetinskaya area is located in the Kokpetinskiy district, about 750km northeast of the former capital Almaty and about 150km south of Ust-Kamenogorsk, which is the provincial capital of East Kazakhstan Province. The Year-2 survey district is located in the Bektimir district within the area. The area contains communities such as Beloe, Koitas and Prebrazensky Villages (See Fig. I-1).

The landform of the survey area is hilly land about 500m in altitude and most of it is almost flat, with gentle inclination only in some parts of it. The area is covered by cultivated fields for wheat, sunflowers and other crops and meadows. Paved and partially unpaved roads are developed, crossing flat hilly land.

1-2-2 Contents of the survey

In Year 2, public geological information was collected and analyzed and a geological survey was conducted in the survey area and an area 350km^2 north of the survey area. A driling survey was also made in three districts in the survey area (Southern Flank of Bektimir Placer No. 1, Southern Flank of Bektimir Placer No. 3 and Bektimir Northern Flank). A total of 50 pits were drilled, totaling 2,271.0m in length.

1) Analysis of Public Geological Information

(1) Purpose of the analysis

The Year-1 survey showed that ilmenite drift-sand ore beds deposited under riverbeds of old gorges and in flat land under lakes. The survey in Year 2 was undertaken to understand the palaeo-landform when the deposition was formed.

(2) Analysis method

A detailed subsurface contour map of the bedrock surface of the pre-Tertiary-Period layer, which is the foot rock of ilmenite drift-sand ore beds, was prepared. A subsurface contour map of the bedrock surface of a pre-Quaternary-Period layer was also prepared. To prepare these maps, depth data of the bed rock of the Pre-Tertiary Period and depth data of the Quaternary Period at about 1,600 points was collected from a collection of driling geological cross sections prepared by the counterparts in Kazakhstan for geochemical exploration of bed-rock weathered crusts near Bektimir ore beds in the

Kokpetinskaya area. Geological history bibliographies of paleoclimate, sedimentary environment and other subjects of wide areas including the survey area were collected. (Erofeyev, 1969, and others)

(3) Execution locations

The analysis was conducted in Kazakhstan and Japan.

2) Geological Survey

(1) Purpose of the survey

The survey was conducted to understand the geology and geological structure of ilmenite-origin rock areas and ilmenite drift-sand ore beds and to analyze, based on results of this survey, the outline and economical feasibility of the ore beds in the survey area.

(2) Survey method

As pointed out in Year 1, ilmenite in the Bektimir ore bed was estimated to have originated from granitic rocks of the Preobrazhenskiy intrusive rock body. Zonation of granitic rocks with a high content of ilmenite became necessary. For this purpose, magnetic susceptibility was measured at 512 points and a whole rock analysis and trace component analysis of 25 rock were made. In a driling survey, the development status of ilmenite ore bodies was surveyed in the Bektimir District 3.

The following geological reconnaissance survey was conducted in the entire Kokpetinskaya area (256km^2).

Table Ⅰ-1-1 Outline of the Survey (1)

Survey Nature	Survey Type and Survey Quantity
Geological Survey	Geological survey (Semi-reconnaissance survey) Survey Quantity Area: 256 km^2 Reconnaissance length: 100 km Driling Survey (See Appendix 3.) Total length: 2,271 m (50 pits)

The reconnaissance survey was conducted using a topographic map on a scale of 1/25,000 and the survey results were plotted on a geological map on a scale of 1/25,000. The driling result was plotted in a driling-core columnar section on a scale of 1/200. The driling survey result was plotted on a geological section for each exploratory traverse line.

Concurrently with the geological reconnaissance survey and driling survey, laboratory tests were performed to the extent shown in Appendix 2-1, for reflection on the analysis.

3) Driling Survey

(1) Purpose

The driling survey was conducted to capture and determine the development status of ore bodies in the extended areas south of the Bektimir Placers No. 1 and 3, which are known ore beds, and in north Bektimir.

(2) Driling Locations and Survey Quantities

The driling survey was conducted in the locations shown in Fig. II-3-1. The survey quantities are shown on the following pages.

(3) Field survey

The drilling was performed by employing GEOINCENTRE, a local driling company. After appraisal and photographing, cores were sampled in the quantities shown in Appendix 2-1, followed by laboratory tests. The core appraisal results were plotted on columnar sections in the scale of 1/200.

Table Ⅰ-1-1 Outline of the Survey (2)

District	Test Drill No.	Azimuth	Inclination	Drilling Length
Bektimir (Southern Flank of Placer No. 1) 500m x 200m Grid	MJBK-18	—	-90°	30.0m
	MJBK-19	—	-90°	44.0m
	MJBK-20	—	-90°	37.0m
	MJBK-21	—	-90°	43.0m
	MJBK-22	—	-90°	65.0m
	MJBK-23	—	-90°	60.0m
	MJBK-24	—	-90°	58.0m
	MJBK-25	—	-90°	43.0m
	MJBK-26	—	-90°	50.0m
	MJBK-27	—	-90°	50.0m
	MJBK-28	—	-90°	54.0m
	MJBK-29	—	-90°	58.0m
	MJBK-30	—	-90°	60.0m
	MJBK-31	—	-90°	51.0m
	MJBK-32	—	-90°	58.0m
	MJBK-33	—	-90°	53.0m
	MJBK-34	—	-90°	60.0m
	MJBK-35	—	-90°	60.0m
	MJBK-36	—	-90°	51.0m
	MJBK-37	—	-90°	48.0m
Total	20 Pits			1,033.0m
Bektimir (Southern Flank of Placer No. 3) 400m Spacing	MJBKS-1	—	-90°	40.0m
	MJBKS-2	—	-90°	40.5m
	MJBKS-3	—	-90°	35.0m
	MJBKS-4	—	-90°	31.0m
	MJBKS-5	—	-90°	32.0m
	MJBKS-6	—	-90°	42.0m
	MJBKS-7	—	-90°	33.0m
	MJBKS-8	—	-90°	30.5m
	MJBKS-9	—	-90°	29.0m
	MJBKS-10	—	-90°	25.0m
	MJBKS-11	—	-90°	35.0m
	MJBKS-12	—	-90°	39.0m
	MJBKS-13	—	-90°	34.0m
	MJBKS-14	—	-90°	37.0m
	MJBKS-15	—	-90°	33.0m
	MJBKS-16	—	-90°	45.0m
	MJBKS-17	—	-90°	40.0m
	MJBKS-18	—	-90°	40.5m
	MJBKS-19	—	-90°	35.0m
	MJBKS-20	—	-90°	43.0m
	MJBKS-21	—	-90°	37.0m
	MJBKS-22	—	-90°	32.0m
	MJBKS-23	—	-90°	40.0m
	MJBKS-24	—	-90°	41.0m
	MJBKS-25	—	-90°	34.0m
Total	25 Pits			903.5m
Bektimir (Northern Flank)	MJBKN-1	—	-90°	67.0m
	MJBKN-2	—	-90°	70.0m

1000m Spacing	MJBKN-3 MJBKN-4 MJBKN-5	— — —	-90° -90° -90°	68.0m 60.0m 70.0m
Total	5 pits			335.0m
Total	50 pits			2,271.5m

1-2-3 Organization of the survey team

Those who participated in planning, negotiations and field survey of this survey are as follows:

1) Survey Planning and Negotiations

Japanese Members		Kazakhstani Members	
Name	Organization	Name	Organization
Toshio Sakarasegawa (Team Leader, Coordination)	Metal Mining Agency of Japan	M. Saiduakasv	C.G.U.R.P
Masayuki Chiba (Work Supervision)	Japan International Cooperation Agency	A. M. Zhylkaidarov	C.G.U.R.P
Keita Kanda (Geology)	Metal Mining Agency of Japan	S. B. Berikbolov	C.G.U.R.P
Hiroyoshi Okishima (Mining Situation)	Same as above		

2) Field Survey Team

Japanese Members		Kazakhstani Members	
Name	Organization	Name	Organization
Atsushi Gomi (Team Leader)	Mitsui Mineral Development Engineering Co., Ltd	M. Saiduakasv (General)	C.G.U.R.P
Yoshiaki Ishizuka (Driling)	Same as above	A. M. Zhylkaidarov (General)	C.G.U.R.P
Toshio Inoue (Driling)	Same as above	Dmitrij Titov (General)	East Kazakhstan Geology Bureau
	Same as above	Ivan Vorontsov (General)	Same as above
		E. M. Selifonov (General)	GEOINCENTRE
		I. E. Selifonov (General)	Same as above
		E. G. Maksimov (Geology)	Same as above
		V. Y. Pashov (Geology)	Same as above

C.G.U.R.P. Tthe Ministry of Energy and Mineral Resources and the East Kazakh,
The Committee of Geology and Underground Resources Protection

3) Field Work Supervision

Hiroyoshi Okishima Metal Mining Agency of Japan July 25 and 26, August 27 to 29, 2001

Tadashi Ito Metal Mining Agency of Japan July 25 and 26, 2001

1-2-4 Period of the survey

Task	2001							2002		
	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Period
Planning and Preparations	29									June 29 - June 29
Field Survey	30			9						June 30 - Sept. 9
Test and Analysis			5					15		Aug. 5 - Jan. 15
Report Compilation					10			30		Aug. 15 - Jan. 31

Chapter2　Geography of the Survey Area

2-1 Location and Access

The survey area is located in the Kokpektinskaya area, which was surveyed in Year 1, and administratively belongs to the Kokpektinskiy district of East Kazakhstan Province (See Fig. I-1-2). Table I-2-1 presents coordinates of each angular point of the survey area.

Table Ⅰ-2-1　Geographic Coordinates of the Survey Area

Angular points of Area's contour	Coordinates(WGS-84)	
	Northern latitude	Eastern longitude
1	48°44'01.70"	82°58'58.29"
2	48°47'57.98"	82°49'13.42"
3	48°48'37.59"	83°03'14.25"
4	48°40'48.47"	82°55'59.58"
5	48°50'52.91"	82°57'39.92"
6	48°46'16.81"	82°53'24.27"
7	48°44'44.49"	82°46'15.09"
9	48°46'02.53"	82°47'30.24"
10	48°53'56.77"	82°42'15.15"
11	48°47'15.17"	82°51'41.49"
12	48°55'09.59"	82°46'26.94"

The population density is high in Preobrazhenka Village in the west of the survey area and Beloe Village in the northeast. Trekti and Koitas Communities are located near Bektimir Placer No. 1, which is the major ore bed.

The survey team members stayed in Beloe Village during the survey. The village is located northeast of the survey area and is connected to Ust-Kamenogorsk, the provincial capital, through the Kokpekti/Samarskaya/Ust-Kamenogorsk Road (224km), which is the major road on the eastern flank, and through the Kokpekti/Georgievka/Ust-Kamenogorsk Road (200km) on the west. These roads can be used throughout the year, except for sections of the roads in the mountainous areas that are closed due to snowstorms and avalanches.

A network of unpaved roadways is built connecting many communities in the survey area.

2-2　Topography and Drainage Systems

1) Landform

The landform of this area belongs to the northwestern edge of Basin Zaysanskaya.

The northwestern edge of Basin Zaysanskaya is flat land south of Podgornoye, Beloe and Marinogorska Villages. The land is exposed with weathered residual hills of the sedimentary rocks and pyroclastic rock of Carboniferous Period that were subjected to contact metamorphism when they contacted Preobrazhenskiy and Karaotkelskiy intrusive rock bodies in the Quaternary Period. The altitude of the area is 650m in hilly land in the north and northwest parts and 450 to 480m in flat land in the south of the driling survey area (Southern Flanks of Bektimir Placers No. 1 and No. 3 and Northern Flank of Bektimir).

2) Drainage System

The survey area is situated on the left bank of the Irtysh River (currently Zaysan Reservoir). The Tentek river flows the survey area from northwest to southeast through Preobrajenka Village. The Espe river in the northeast of the Preobrazhenskiy rock body flows from northwest to southeast through Beloe Village. The Bektimir river in the southwest of the rock body flows from northwest to southeast through Koitas Village.

The river-flooding season in the piedmont areas is April to June, while April and May are the flooding season in the downstream. Beginning June, surface water no longer flows. The rivers are frozen beginning end November - end December and ice melts in April.

2-3 Climate, Fauna and Flora

1) Climate

The climate in the survey area is a mixture of Mongolian-type continental, Central Asian step/semi-desert and west Siberian-type continental climates. Daily, seasonal and annual variations of air temperature are prominent and the humidity is low.

Principal meteorological data is shown in Table I-2-2.

The weather in winter is generally fair. The coldest month is January, with minimum air temperature reaching -36 to -45°C. Snowfall starts around October 20 and heavy snow falls beginning November. The surface soil freezes down to 1.5m in depth and the ground is covered with snow to depths of 0.9 to 1.1m. Days with continuous snow cover total 150 to 160 days per year. During winter, north winds and east winds 4 to 7m/s in wind velocity blow many days. Snowstorms are frequent, reaching 3 to 15 days per month (10 days on average). Snow begins to melt end

March to early April.

The weather in summer is generally fair. Air temperature during the day fluctuates prominently. In July, when it is most warm, air temperature rises to 35 to 42°C. The amount of rainfall during summer accounts for 30 to 40% of the annual amount of rainfall. Rainfalls are mainly heavy rains that accompany thunders, but flood damage is rare. The dry season from spring through summer runs one or two months.

April to mid-October is suitable for outdoor work.

2) Animals and Plant

(1) Plants

Vegetation is varied. In addition to natural vegetation, the ground is cultivated land, forestation land, grassland and pastures.

Many thickets grown with sedges and rushes, marshes and cultivated land are found along the rivers in the northwestern edge of Zaysanskaya Basin.

(2) Animals

Black grouses, hazel grouses, wild quails, wild pigeons, foxes, wolves and snake inhabit in mountainous and low mountainous areas.

Table I -2-2 Climatic Features of the Kokpetinskaya Area

Month	1	2	3	4	5	6	7	8	9	10	11	12	Total	Average
Temperature (℃)	-17,9	-15,4	+9,9	+4,9	+13,4	+19	+21,4	+19,8	+19,1	+4,9	-7,2	-15,6		+3,04
Precipitation (mm)	27	20	30	33	45	47	42	46	19	12	15	23	359	-
Evaporation from the surface (mm)	-	-	-	60	98	99	96	90	70	51	-	-	564	-
Average number of days with unfavorable conditions; Strong wind (≧15 m/sec)	-	-	-	0,8	1,5	1,3	1,0	1,4	1,0	-	-	-	7.0	-
Ditto; Dust storms	-	-	-	0,5	2,1	2,7	3,3	3,2	2,3	-	-	-	14.1	-

Chapter 3 Existing Geological Data on the Survey Area

3-1 Outline of Previous Surveys

1) Geological Surveys

G. I. Sokratov prepared a geological map for the M-44-XXIX sheet format in 1:200,000 in 1964 and sheet format descriptions in 1965 (Refer to Year-1 Report.). In 1963, B. F. Baranov, et al., prepared a geological map for the M-44-XXX sheet format. In 1961, N. N. Popova, et al., prepared a geological map (M-44-XXIX) sheet format and sheet format descriptions.

In 1964 to 1968, an Altai geological and physical exploration unit conducted magnetic exploration and electrical exploration in 1:50,000. Promising ore beds could not be detected in these explorations. In 1969, V.S.Erofeyev compiled a geological history of the Tertiary Period of South Altai including the survey area.

2) Ore Bed Surveys

In 1965 to 1967, a nonmetallic material geological unit drilled for coal beds and found Karaotkel ilmenite and zircon ore beds. In 1972, initial exploration was conducted. In 1983 to 1989, GIREDMET reassessed ore reserves. In 1990, the National Ore Reserves Commission approved recalculated ore reserves. However, development was not undertaken.

In 1988 to 1992, an Altai geological exploration unit conducted geochemical exploration in the Karaotkel ore bed area and found Bektimir ilmenite placers in 1989. In 1990 to 1995, ilmenite ore beds (Bektimir Placers No. 1, 2 and 3) were found near the Preobrazhenskiy composite rock mass during driling.

In 1997 to 1998, the Bektimir Placer No. 1 was assayed, confirming 9,269,000m^3 in ore reserves, 1,634,000t in ilmenite and 176.3kg/m^3 in average ilmenite content. In 1998 and 1999, 11,958,000m^3 in ore reserves, 1,815,000t in ilmenite and 151.78kg/m^3 in average ilmenite content were confirmed.

In 1999, a feasibility study for an ilmenite concentration plant project of the Bektimir placers was conducted by UNIDO. In August 2001, the Titanium Magnesium Kombinat built a pilot concentration plant in Kaznakovka, supplying ilmenite ore from a test pit drilled 4km east of Koitas.

3-2 General Geology and Geologic Structure

1) General Geology

The order of stratification in the survey area consists of pre-granitic rocks (Carboniferous Period stratum), granitic rocks intruded into them, Aral Formation of the Tertiary Period in the Cainozoic Era covering them without conformity and Quaternary-Period layer that covers all of them without conformity. Weathered crusts are widely developed in the bed rock of Aral Formation of the Tertiary Period.

(1) Pre-granitic rocks

The geology in the area consists of sedimentary rocks (shale, sandstone and conglomerate), pyroclastic rocks and lava (andesite and 玢岩). From the bottom, the layers are the lower Carboniferous Period Arkalyk layer (sedimentary rocks, pyroclastic rocks and limestone), lower Carboniferous-Period Kokpekti layer (sedimentary rocks, pyroclastic rocks and limestone), middle Carboniferous Period Bukon layer (conglomerate, sandstone and shale - the upper seam is shale, coaly shale, sandstone and tuffaceous sandstone), and middle-upper Maityab layer (andesitic 玢岩 sandwiching tuff and tuffaceous sandstone, andesite and, rarely, basaltic and diabasic 玢岩). The survey area is distributed with Kokpekti, Bukon and Maityab layers.

(2) Granitic rocks

The area is distributed with Preobrazhenskiy composite rock mass, Karaotkelskiy composite rock mass and dikes that intruded into a Palaeozoic layer. These composite rock masses are considered classifiable into Maksutskiy composite rock mass (early Permian Period, late Triassic Period - gabbro, diorite and monzonite), Saikanskiy composite rock mass (mid- to upper early Triassic Period - syenite, diorite and monzonite) and Delbegeteyskiy composite rock mass (late to mid Jurassic Period, granite and granitic syenite). Furthermore, granite porphyry, syenite porphyry, granodiorite and aplite dike are intruded into the Palaeozoic layer and granitic rocks.

The survey area is distributed with Preobrazhenskiy composite rock mass. According to geologic surveys and physical explorations, Preobrazhenskiy composite rock mass is in the lopolith form. The exposed area on the ground surface of it is $164km^2$ and it expands to $340km^2$ 3km underground. It is assumed to merge with the Karaotkel composite rock mass, which is located next to it, into one rock mass.

Among granitic rocks, much TiO_2 is said contained in gabbro and monzonite, while granite and syenite are said to contain much zircon.

(3) Bed-rock weathered crust

Bed-rock weathered crusts are kaolin, sericite and smectite clayey weathered remnants developed on sedimentary rocks, volcanic rock and intrusive rock of the Carboniferous

Period. Bedrock weathered crusts were formed by chemical weathering of moist and warm climate at the end of early Cretaceous Period (about 140 million years ago). (Erofeyev, 1969)

(4) Tertiary-Period Aral Formation

The Tertiary-Period Aral Formation covers pre-granitic rocks and intrusive rocks, as well as their weathered crusts, without conformity. The layer consists of clay, sandy clay and clayey sand comprising quartz, plagioclase, kaolin, smectite and sericite. Ilmenite drift-sand ore beds are deposited in sandy clay to clayey sand that is located as narrow seams in the bottom or seams near the bottom of this layer.

(5) Quaternary-Period layer

The Quaternary-Period layer consists of gravel, loam, clay and Recent riverbed sediments that cover without conformity the Neogene-Period Aral Formation and directly pre-granitic rocks and intrusive rock.

2) Geological Structure

The Kokpetinskaya area is located in an area where the Kazakhstani continent and the old Gorny Altai continent collided. The collision took place during the latter part of the Hercynian structure motion. The Baladzhalskiy Fault running in the WNW-ESE direction passing Beloe Village in northeast of the survey area is part of this fracture zone (See Fig. I-3-1.). The Lskiy Fault is considered a path of magma and the intrusion of the Preobrazhenskiy and Karaotkelskiy composite rock masses is considered related to this fracture zone.

The survey area is bordered by the Baladzhalskiy Fault on its northeastern flank and by the South Terektinskiy Fault on the southwest flank. The Preobrazhenskiy composite rock mass intruded into the Bektimirskaya ridge anticline situated in the middle of them.

The Bektemirskiy Fault and Espinskiy Fault, which are cracks running in the NEN-SWS direction, are considered lateral faults or faults with less dislocation. These faults cut the Carboniferous Period layer made up of the Preobrazhenskiy composite rock mass and pre-granitic rocks. Palaeo-landform channels deposited with some ilmenite sand ore bodies were believed formed along these weak lines. These palaeo-landform channels change to the NW-SE direction near the Baladzhalskiy Fault running in the WNW-ESE direction and the South Terektinskiy Fault because of dominant cracks in the NW-SE direction.

The Tertiary-Period Aral Formation is a generally flat stratum and covers

Preobrazhenskiy composite rock mass and pre-granitic rocks.

The Quaternary-Period layers are also generally flat strata and cover the Tertiary-Period Aral Formation. Recent rivers are located in locations that relatively well overlap with palaeo-landform channels of the Tertiary-Period Aral Formation bed rock.

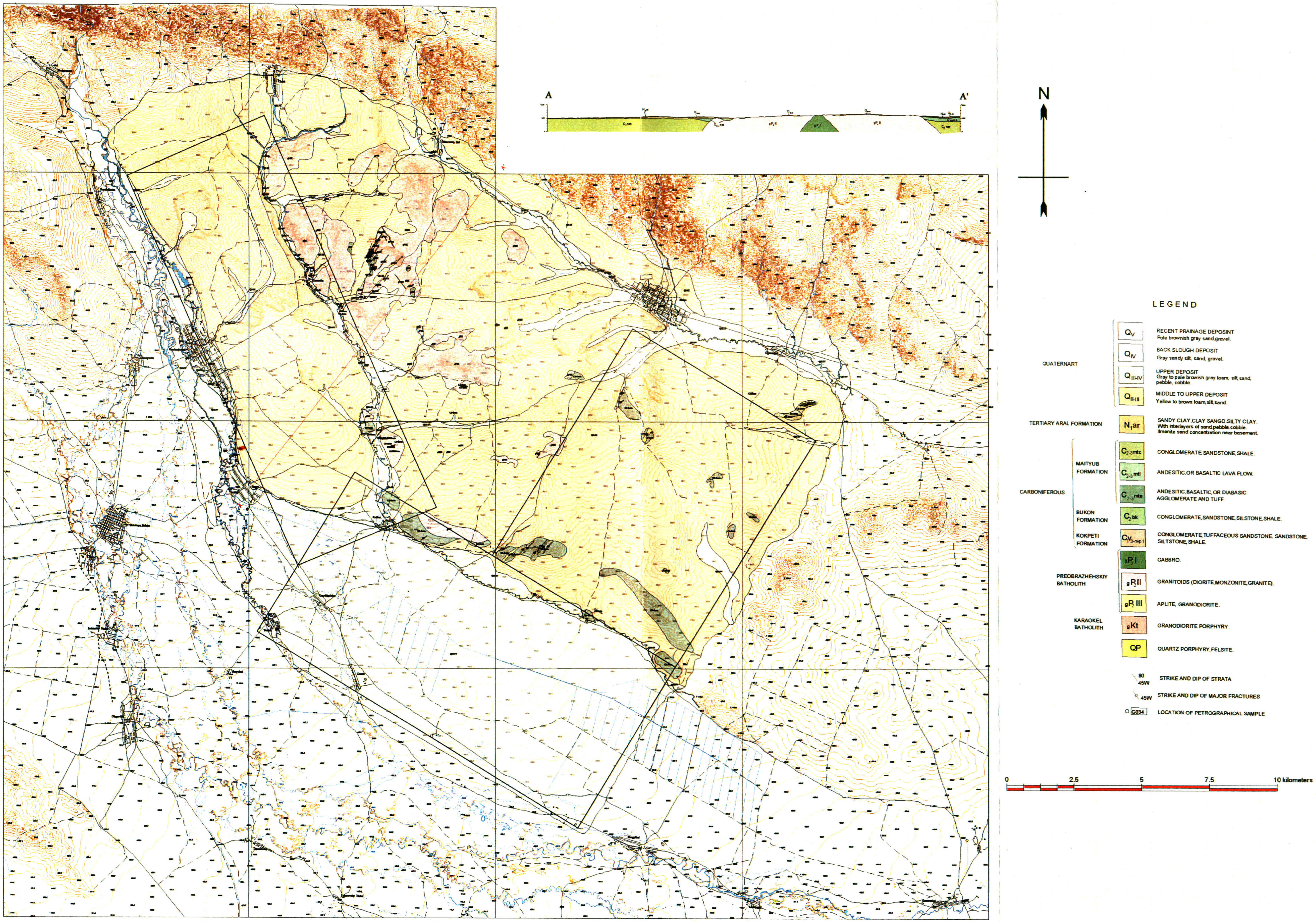
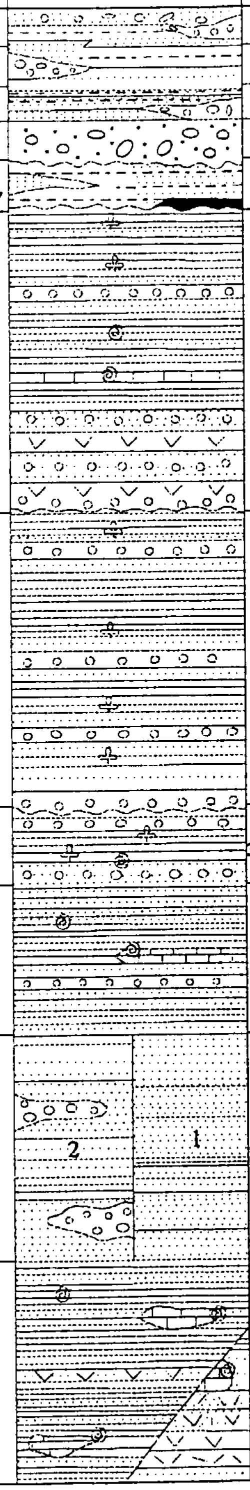


Fig. I-3-1 Geological Map of the Kokpetinskaya Area



System	Series	Stage	Mark	Geologic column	Thickness	Characteristics of rock
Quaternary	Recent		Q_4		0-5	Pebble, sand, sandy loam, loam and clay with rock fragments
	Upper		Q_{3-4}		0-15	Pebble, sand, sandy loam, loam and clay with rock fragments
	Middle		Q_2		0-10	Pebble, sand, clay, loam and sandy loam
	Lower		Q_1		0-10	Sand, pebble and gravel
Neogene	Miocene		$N_1^{2-3}pv$		0-20	Aral formation; clay, sandy clay and sand with ilmenite placer
Carboniferous	Middle and Upper		$C_{2-3}mt$		1500-2000	Maityab formation; Conglomerate, sandstone, siltstone, shale, limestone, andesite, porphyrite and tuff, with flora and fauna
	Middle		C_2bk		1500-2000	Bukon formation; Conglomerate, arkose sandstone, sandstone, siltstone, shale, coaly shale and coal with flora
	Lower	Visean and Namur	$C_1v_3\text{-}nkp_3$		300-500	Upper Kokpekti formation; Conglomerate, greywacke sandstone, siltstone, shale and coal with flora and fauna
			$C_1v_3\text{-}nkp_2$		1000	Middle Kokpekti formation; Tuffaceous conglomerate, sandstone, siltstone, shale and limestone with fauna
			$C_1v_3\text{-}nkp_1$	2 / 1	1500	Lower Kokpekti formation; 1. North east zone-Tuffaceous sandstone, siltstone and shale 2. South west zone- Conglomerate, tuffaceous sandstone, siltstone, and shale with flora and fauna
		Visean	$C_1v_{2-3}ar$		1500 1000	Arkalyk formation; 1. North east zone- Sandstone, siltstone, shale, limestone, tuff, diabase, porphyrite, felsite 2. South west zone- Shale, siltstone, sandstone, tuff, limestone with fauna

Fig. I-3-2 Schematic Geologic Column of the Kokpetinskaya Area

Chapter 4 Overall Review of the Survey Findings

4-1 Geology and Geologic Structure

The survey in Year 1 led to the assumption that ilmenite was probably originated from gabbro and monzonite among granitic rocks that comprise the Preobrazhenskiy composite rock mass, which is exposed in the upstream.

The TiO_2 content of rocks is decided by amounts of titanium ores such as ilmenite that are contained in rocks. It could be ascertained that monzonite - diorite containing more than 1% of TiO_2 and granite containing less than 1% of TiO_2 can be clearly segregated by rock compositions (main components, norm minerals and trace components). Generally, TiO_2 of rocks in magmatic differentiation is smaller more advanced magmatic differentiation of rocks is.

It could be ascertained that opaque minerals contained in granitic rocks contained ilmenite (Ti 35%), magnetite (Ti 0%) and titanic magnetite (Ti 1.5 - 14%). Origin rocks of titanium drift-sand ore beds should preferably contain only ilmenite. Mixture of magnetite or titanic magnetite may lower the Ti content of ore beds. Much ilmenite is contained in the southeastern flank of the Preobrazhenskiy composite rock mass, while the proportions of magnetite and titanic magnetite are high in the northwestern flank. The southeastern flank is considered more promising as an ore bed of origin rock.

Granitic rocks with high proportions of magnetite and titanic magnetite are believed to show high magnetic susceptibilities on the ground surface. Therefore, granitic rocks higher than 1×10^{-3} (S.I.U.) in magnetic susceptibility distributed in the northwestern flank of the Preobrazhenskiy composite rock mass are believed to overlap with rock mass that contains much magnetite or titanic magnetite. Speaking of components of iron sand produced in Japan, acidic iron sand derived from granite contain less titanic minerals, while basic iron sand contain much titanic components. Residual iron sand remaining at sites especially contained titanic minerals in high proportions (Miyamoto, 1960).

A subsurface tectonic line map of the palaeo-landform of the foot rock under the ore beds was prepared. Through this map, many channels of palaeo-landform that originate in areas distributed with granitic rocks could be extracted. Gorges of them were formed about 40 to 50 million years ago when old climate repeated high-temperature moist and dry climate. At that time, rocks became clayey due to weathering along structurally weak lines. During floods, water carried ilmenite sand and eroded land to form the gorges. All known ilmenite drift-sand ore beds are deposited in these palaeo-landform channels. An analysis of distribution of ilmenite grain size shows that coarse ilmenite is concentrated in the centers of the gorges of the palaeo-landform channels, whereas ilmenite is distributed mainly around the gorges, supporting the existence of palaeo-landform channels.

As main weak lines in the survey area, the Baladzhalskiy Fault runs in the northeastern flank of the area in the WNW-ESE direction and the South Terektinskiy Fault, on the southwestern flank. Between these two faults, a crack in the NEN-SWS direction cuts the Carboniferous Period layer made up of the Preobrazhenskiy composite rock mass and pre-granitic rocks. The palaeo-landform channels that were assumed formed along these weak lines are believed dominant in hills in the NEN-SWS direction. However, they are estimated to change in the NW-SE direction in plains as they approach the Baladzhalskiy Fault and South Terektinskiy Fault. This indicates that a rapid change of palaeo-landform channels in the NW-SE direction should be taken into consideration when surveying ilmenite drift-sand ore beds in plains.

The foregoing survey results would infer the following conditions for existence of promising ilmenite drift-sand ore beds:

(1) Origin rocks such as monzonite, diorite and gabbro, which are not advanced in crystallization differentiation, are distributed in the upstream.

(2) In some areas the magnetic susceptibility is below 1×10^{-3} S.I.U.

(3) Palaeo-landform channels.

Several areas meeting these conditions can be extracted from an area northeast to east of the Preobrazhenskiy composite rock mass.

The survey of the Bektimir area has resulted in acquiring a technique that would enable extracting promising ilmenite sand-drift ore beds by extracting hinterland with appropriate properties and palaeo-landform channels. Therefore, this technique can be applied to the Karaotkel district to reassess ilmenite sand-drift ore beds.

The other areas of the Republic of Kazakhstan have possibilities for deposition of intrusive rocks with chemical compositions similar to those of the Preobrazhenskiy composite rock mass. Preliminary assessment should preferably be undertaken in areas that have a similar geological history as that of the survey area to explore possibilities for deposition of new ilmenite sand-drift ore beds.

4-2 Ore Deposits and Heavy Minerals

1) Economical Efficiency of Ore Deposits

The Republic of Kazakhstan has an index (a former Soviet Union standard) to gauge whether or not an ore body can be economically mined by open-cut mining. This index shows that mining of only the ore bed found in Year 2 in the Southern Flank of Bektimir Placer No. 1 will not be economical.

Table I-4-1 Ilmenite Content and Maximum Economical Stripping Ratio

Average content of ilmenite kg/m^3	Maximum economical stripping ratio m^3/m^3
100	2.58
110	3.90
120	5.21
130	6.56
131.93	**8.25**
140	7.87
150	9.21

Ilmenite grains produced in Bektimir Placer No. 1 showed alteration along external edges and cracks inside grains. Compared with unaltered seams, altered seams contained less Fe, but more Ti. In powder X-ray diffraction analysis of ilmenite, diffraction lines that were considered to be rutiles with a low crystallinity could be found in ilmenite. Judging from these, it was estimated that ilmenite was oxidized while it was separated from granitic rocks by weathering and was deposited and thickened. During this process, Fe would have been leached and Ti would have been enriched. Based on this assumption, it would indicate that ilmenite was separated from granitic rocks by weathering of the Bektimir Placer No. 1 and that ilmenite was oxidized while it was deposited and thickened. Fe would have been leached and Ti would have been enriched so that the TiO_2 content would be higher in this ore bed, toward the downstream. Based on this, it will be necessary to calculate ore reserves again after conducting a driling survey of the extensions of the parts where the content would be high.

2) Quality of Ilmenite Concentrates

The quantity of ilmenite in the survey area is shown below. While the quality does not meet the International Trading Standard, it meets the manufacturing requirements for sponge titanium and titanium oxides in the Republic of Kazakhstan. (Japan International Cooperation Agency and Metal Mining Agency of Japan, 2001) Compared with ilmenite produced in Russia, ilmenite concentrates produced from Bektimir Placer No. 1 contain more FeO, but less TiO_2. However, they are almost equal in quality compared with ilmenite produced in Capel, West Australia.

Element	TiO_2 (%)	FeO (%)	SiO_2 (%)	P_2O_5 (%)	Cr_2O_3 (%)	V_2O_5 (%)
Assay result	48.48～51.25	7.98～26.52	1.41～2.24	0.01～0.025	0.02～0.038	0.185～0.242
Average	50.31	18.01	1.80	0.02	0.03	0.21
International Trading Standard	≧54	28～32	≦1.5	≦0.05	≦0.05	≦0.1

4-3 Potentials as Ore Deposits

The foregoing survey results obtained in Years 1 and 2 would imply the following conditions for existence of promising ilmenite drift-sand ore beds:

(1) Origin rocks such as monzonite, diorite and gabbro, which are not advanced in crystallization differentiation, are distributed in the upstream.

(2) In some areas the magnetic susceptibility is below 1×10^{-3} S.I.U.

(3) Palaeo-landform channels.

It is also important that prominent weathering took place in the geological history and that denudation did not occur after ilmenite drift-sand ore beds sedimented.

The survey policies for each district in Year 3 are as follows:

1) Bektimir District

(1) Southern Flank of Bektimir Placer No. 1

The southern extension of Bektimir Placer No. 1 expands more than 1000m in ore bed width and the extension direction of palaeo-landform channels changes from NEN-SWS to NW-SE with the result that the ore bed boundaries in the eastern direction of the portion with a high content cannot be confirmed yet. It is possible that the TiO_2 content may enhance toward the downstream from the upstream because Fe would leach and Ti would enrich because ilmenite oxidizes as it separates from granitic rocks by weathering and deposits and thickens. For this reason, additional driling should be conducted (a detailed survey) and ore reserves must be reassessed. Adjacent to the eastern flank of palaeo-landform channels where a driling survey was undertaken, other channels may exist and an additional driling survey including this area is considered necessary.

(2) Southern Flank of Bektimir Placer No. 3

The driling survey in this year found ore beds in six of 25 pits and these ore beds were found narrow seams. However, two pits were channeled in palaeo-landform and sufficiently high potentials can be anticipated. Interpolation of the inferred two palaeo-landform channels and survey of the upstream have not been undertaken yet. An additional driling survey for them is therefore deemed necessary.

2) North Bektimir District

According to the driling survey undertaken this year, the potential ore bearing depth of this district is deep, more than 60m underground. Prominent thickening of ilmenite could not be found. The granitic rocks in the hinterland showed a high magnetic susceptibility. It appears that supply of quality ilmenite cannot be expected from this district.

3) Other Districts

(1) Eastern Flank of Bektimir Placer No. 1

An analysis of public data in Year 2 shows that about two palaeo-landform channels are expected to exist in the area. A driling survey (reconnaissance survey) of these channels will be necessary.

(2) Northern Flank of Bektimir Placer No. 2 (Beloe District)

An analysis of public data in Year 2 shows that two palaeo-landform channels can be expected to exist in the area. The downstream part of one of these two channels was drilled as part of Bektimir Placer No. 2. Diorite - monzonite distribute in the hinterland of the ore bed and there are some areas where the magnetic susceptibility is low. For these reasons, existence of two palaeo-landform channels originating in this ore bed is forecasted. A driling survey of these channels is considered promising.

(3) Karaotkel District

Ilmenite was found in the Karaotkel district in an early stage and ore reserves of it were calculated in 1972 after driling exploration. However, the grade was low (ore reserves 147,579,000m^3, ilmenite content 23.3kg/m^3) and development was not undertaken.

However, a technique was shown with possibilities to find promising ilmenite drift-sand ore beds in the survey of the Bektimir district by extracting a hinterland and palaeo-landform channels that show suitable properties. It is desired that this technique should be applied additionally to the Karaotkel district to reassess ilmenite drift-sand ore beds, to extract deposits with a high content.

(4) Granitic rock in wide areas

There are possibilities that intrusive rock masses having chemical components similar to those of Preobrazhenskiy composite rock mass exist in the Republic of Kazakhstan. This means that there re possibilities for finding new ilmenite drift-sand ore beds in areas that have had a similar geological history as that of the survey area.

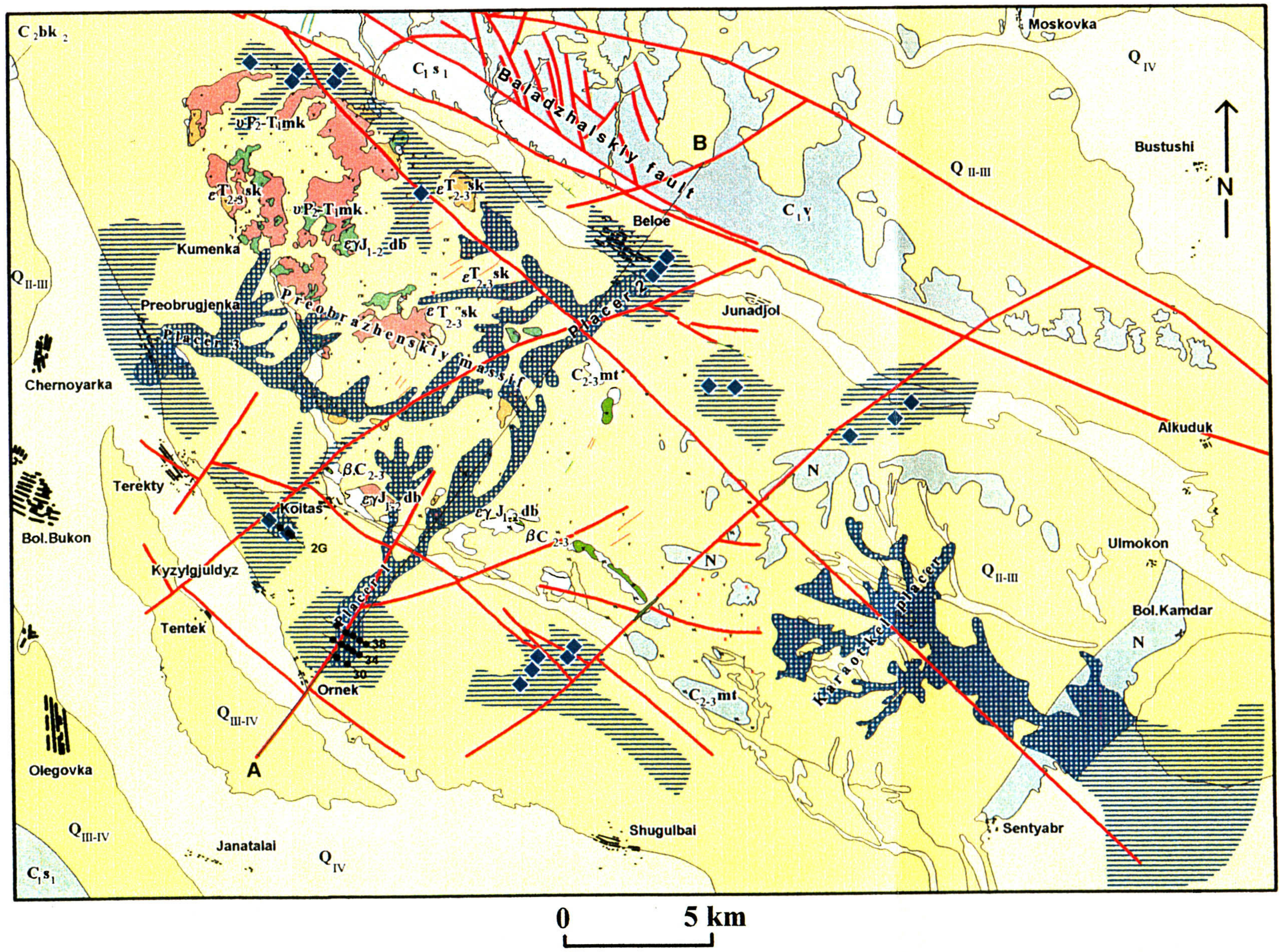
It will be possible to expand application of the technique to other ore kinds that accompany granitic rocks, such as tin, tantalum, tungsten and rare earths. A assessment can be undertaken through an analysis of literature and regional prediction surveys (sampling, age measurement, analysis of trace components, laboratory tests of rocks and minerals and other analyses and tests).

Table I -4-1 List of the Placer Ore Bodies in the Kokpetinskaya Area

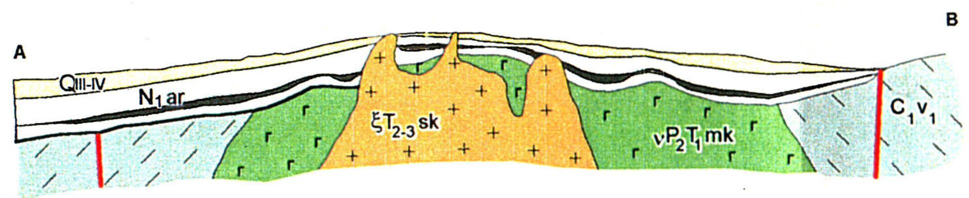
Name of the Ore Bodies	Size of Ore Body		Ore Reserves		Ilmenite Grade (kg/m^3)	Zircon Grade (kg/m^3)	Thickness of the Ore Body (m)	Thickness of the Overburden (m)	Source Rock of Ilmenite
	Length (m)	Width (m)	Category	Ore Reserves (th.m^3)					
Bektemir No.1 Ore Body	5,250	150-250 ～650	$B+C_1+C_2$	11,958	151.78	—	5.4	18.7	Preobrazhenskiy intrusive body
South of Bektemir No.1 Ore Body (MMAJ, 2000)	1,000	650	C_2	5,009	123.95	0.5-3.4	5.5	29.6	Preobrazhenskiy intrusive body
Bektemir No.2 Ore Body	4,000	200 ～400	C_2+P_1	36,048	80.24	0.5-1.5	7.7	—	Preobrazhenskiy intrusive body
Bektemir No.3 Ore Body	12,500	100-200 ～800	C_2+P_1	59,447	64.81	—	7.6-14.5	—	Preobrazhenskiy intrusive body
Karaotkel Ore Body	12,000	300-600 ～1,600	$B+C_1$	147,579	23.3	1.7-5.9	7.3	7.6	Karaotkelskiy intrusive body

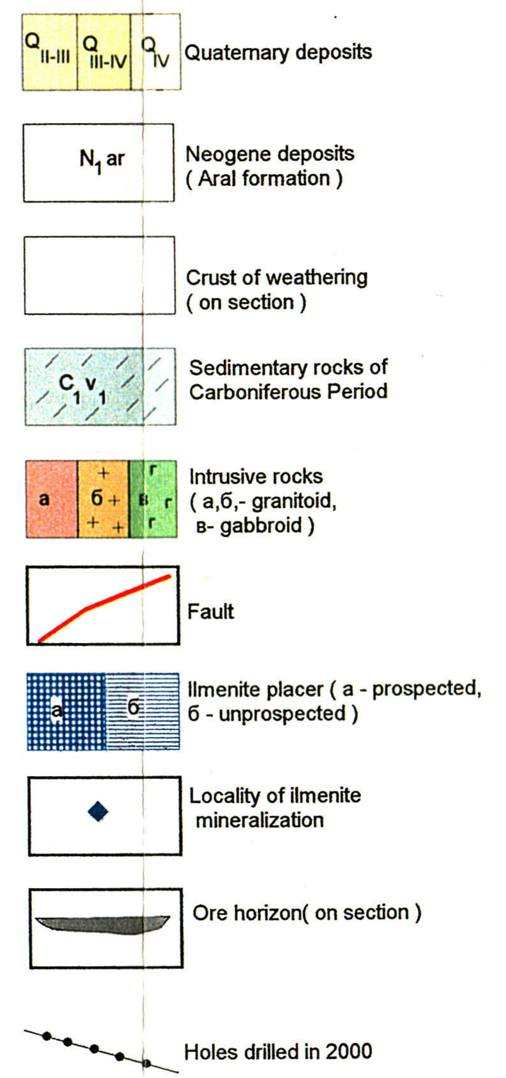
— : No data

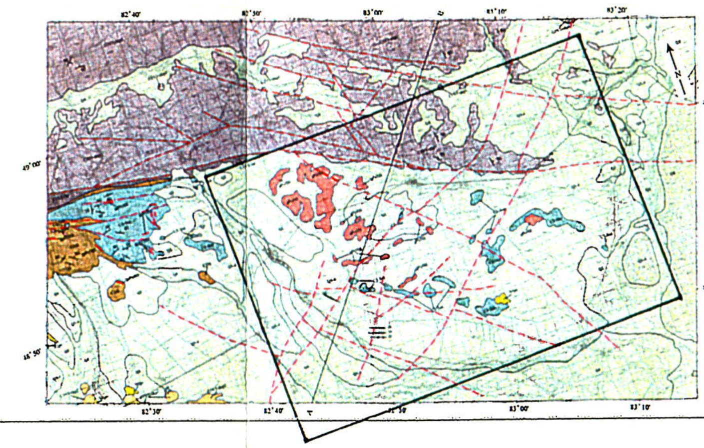
Fig. I-4-1 Schematic Geological Map of the Kokpetinskaya Area



Cross section A-B







Chapter 5 Conclusion and Recommendations for the Future

5-1 Conclusions

5-1-1 Geological survey

1) Geology

The order of stratification of this area consists of pre-granitic rocks (Carboniferous Period layers), granitic rocks intruded into pre-granitic rocks, Aral Formation of the Tertiary Period in the Cainozoic Era covering them without conformity and Quaternary-Period layers that cover all of them without conformity. Weathered crusts are widely developed in the bed rock of Aral Formation of the Tertiary Period.

(1) Pre-granitic rocks

The geology in the area consists of sedimentary rocks (shale, sandstone and conglomerate), pyroclastic rocks and lava (andesite and porphyrite) of the Carboniferous Period. The solidification indexes of pyroclastic rocks and lava are 18 or higher, while differentiation indexes of them are 50 or lower. Magnetite is contained more than 1% as an opaque mineral.

(2) Granitic rocks

The area is distributed with Preobrazhenskiy composite rock mass, believed to have intruded from the early Permian Period to the mid-Jurassic Period. The composite rock mass is ilmenite-series granitoids. Granitic rocks that contain only less than 1% of TiO_2 are close to Type S. Granitic rocks containing more than 1% of TiO_2 fall into Type I.

Granite is the bulk of the Preobrazhenskiy composite rock mass. It has a high alkali content, but is lean in mafic. The solidification index is below 3, while the differentiation index is 80 or higher. It contains less than 1% of TiO_2. Monzonite - diorite partially distribute near the center of the Preobrazhenskiy rock mass. They conversely are lean in alkali, but are rich in mafic elements. The solidification indexes of them are higher than 10, while the differentiation indexes are 60 or less. They contain more than 1% of TiO_2. It can be said that TiO_2 becomes lean higher the magma crystallization differentiation is. Granite - diorite are clearly classified as trace components also.

Opaque-mineral modal ratios of granitic rocks are 0.7% or less with granite and 1% or more with monzonite - diorite. Opaque minerals are ilmenite (Ti 35%), titanic magnetite (Ti 1.5 to 14%), and magnetite (Ti 0%). More magnetite and titanic magnetite than ilmenite are contained in granitic rocks that show a magnetic susceptibility of 1×10^{-3} S.I.U. or higher. Rock masses showing a magnetic susceptibility of 1×10^{-3} S.I.U. or higher are distributed in the northwestern flank of the Preobrazhenskiy composite rock mass.

(3) Bed-rock weathered crust

Bed-rock weathered crusts are clayey weathered remnants developed 10 to 20m in thickness on sedimentary rocks, volcanic rock and intrusive rock of the Carboniferous Period. They are covered by the Aral Formation of the Neogene Period and on the Quaternary-Period layers. They are prominently influenced by kaolin, sericite and smectite. Bed-rock weathered crusts were formed by chemical weathering of moist and warm climate at the end of early Cretaceous Period (about 140 million years ago).

(4) Tertiary-Period Aral Formation

The Tertiary-Period Aral Formation covers pre-granitic rocks and intrusive rocks, as well as their weathered crusts, without conformity. The layer is covered by the Quaternary-Period layer without conformity and is 20 to 50m in thickness. The layer consists of clay, sandy clay and clayey sand comprising quartz, kaolin, smectite and a small amount of sericite. It rarely contains a gravel layer of a thin thickness. Ilmenite drift-sand ore beds are deposited in sandy clay to clayey sand that is located as narrow seams in the bottom or parts near the bottom of this layer.

(5) Quaternary-Period layer

The Quaternary-Period layer consists of gravel, loam and clay of the Diluvium 5 to 10m in thickness and Recent riverbed sediments that cover without conformity the Neogene-Period Aral Formation and directly pre-granitic rocks and intrusive rock.

2) Geological Structure

The survey area is bordered by the Baladzhalskiy Fault running in the WNW-ESE direction on its northeastern flank and by the South Terektinskiy Fault on the southwestern flank. The Preobrazhenskiy composite rock mass intruded into the Bektimirskaya ridge anticline situated in the middle of them.

Cracks in the NEN-SWS direction cut the Carboniferous Period layers made up of the

Preobrazhenskiy composite rock mass and pre-granitic rocks. Palaeo-landform channels deposited with some ilmenite sand ore bodies were believed formed along these weak lines. These palaeo-landform channels change to the NW-SE direction near the Baladzhalskiy Fault running in the WNW-ESE direction and the South Terektinskiy Fault because of dominant cracks in the NW-SE direction. Known ilmenite drift-sand ore beds are contained inside palaeo-landform channels.

The Tertiary-Period Aral Formation is a generally horizontal stratum and covers Preobrazhenskiy composite rock mass and pre-granitic rocks.

The Quaternary-Period layers are generally horizontal strata and cover the Tertiary-Period Aral Formation. Recent rivers are located in locations that relatively well overlap with palaeo-landform channels of the Tertiary-Period Aral Formation bed rock.

3) Ore Beds

Ore deposits are ilmenite drift-sand ore beds that contain a very small amount of zircon about 1/60 that of ilmenite in weight ratio.

Ilmenite drift-sand ore beds are contained in sandy clay and clayey sand in palaeo-landform channels in the lower layer of the Aral Formation of the Tertiary Period. Ilmenite in the Bektimir ore beds (Bektimir Placers No. 1, 2 and 3) is assumed derived from monzonite - diorite, which are not advanced in magma crystallization differentiation, and from rock mass low in magnetic susceptibility, among granitic rocks of the Preobrazhenskiy composite rock mass. Ilmenite grains showed leaching of FeO and enrichment of TiO_2 along external edges and cracks of the grains in the weathering, leaching and thickening process.

5-1-2 Driling survey

1) Southern Flank of Bektimir Placer No. 1 (Detailed Survey District)

Driling was conducted in 20 pits along six traverse lines in a grid of 500×200m over 2.5km on the southern flank of the confirmed III-C_2 Ore Reserves Block of Bektimir Placer No. 1. The driling lengths totaled 1,033.0m.

The ore bed is contained in a wide palaeo-landform channel in the Aral Formation bed rock in the NEN-SWS direction. The eastern flank of the ore bed is deposited directly on the bedrock. Part of the western seam of the ore bed is contained in the bottom of the

Aral Formation as narrow seams. The ore bed captured in driling measured 1.8 to 10.0m in thickness. The ilmenite content was 94 to 216kg/m^3. The overburden on the ore bed was 25 to 53m in thickness.

The thickness of the ore bed tended to slightly decrease toward the south. The thickness of overburden increased, but the width of the ore bed increased to 1,000m, to increase the volume. The lateral boundaries remain unconfirmed. The extension direction especially changed from NEN-SWS to NW-SE and the ore bed boundaries toward the eastern flank are unconfirmed.

When cut-off conditions were set 70kg/m^3 or more for the upper seam of an ore bed, 100kg/m^3 or more for the lower seam, or 2.0m × 100kg/m^3 or more, ore reserves calculations showed the following ore reserves increases corresponding to Category C_2 (Ore reserves 6.5 million m^3, ilmenite reserves 857,000 tons, average ilmenite content 132kg/m^3, and stripping ratio 8.3).

The III-C_2 ore reserves confirmed in Year 1 and the total increase in Year 2 (Ore Reserves Block No.. III+IV-C_2) are shown below (Ore reserves 11.3 million m^3, ilmenite reserves 1,472,000 tons, average ilmenite content 131kg/m^3, and stripping ratio 7.26) .

Table I-5-1 Ore Reserves Calculation of Category C_2 for the Southern Flank of Placer No.1

Block No	Block area 10^3m^2	Ore bed thickness m.	Ore sands reserves 10^3m^3	Ilmenite content, kg/m^3	Ilmenite reserves 10^3t	Overburden thickness m	Overburden volume 10^3m^3	Stripping ratio, m^3/m^3
III-C_2	909.0	5.51	5,008.59	123.95	620.81	29.64	26,942.8	5.4
IV-C_2	**1364.0**	**4.76**	**6,492.6**	**131.93**	**856.57**	**39.3**	**53,605.2**	**8.3**
III+IV-C_2	**2,273.0**	**4.95**	**11,251.35**	**130.84**	**1,472.13**	**35.94**	**81,691.6**	**7.3**

2) Southern Flank of Bektimir Placer No. 3 (Reconnaissance Survey District)

Driling was conducted in 25 pits at 400m spacing totaling 903.5m in length. In six of the 25 pits, thickened ilmenite seams higher than the cut-off grade of 100kg/m^3 could be confirmed.

The ore bed is deposited directly above two parallel palaeo-landform channels in the Aral Formation bed rock running in the N30°E direction. The width of the ore bed was about 200m and was small compared with that of Bektimir Placer No. 1. The ore bed thickness captured by driling was 1.5 - 4.4m and the ilmenite content was 111 to 181kg/m^3. Overburden on the ore bed was 23 to 30m in thickness and tended to increase toward south.

Only six pits showed contents higher than 100kg/m^3 and were not sufficient for ore reserves calculations. However, the following calculation data can be obtained by designating an area 100m in radius centering on a driling pit as a block.

Table I-5-2 Ore Reserves Calculation of Category P_1 for the Southern Flank of Placer No.3

Block No	Block area 10^3m^2	Ore bed thickness m.	Ore sands reserves 10^3m^3	Ilmenite content, kg/m^3	Ilmenite reserves 10^3t	Overburden thickness, M	Overburden volume 10^3m^3	Stripping ratio, m^3/m^3
P_1	188.4	2.76	512.0	130.05	67.6	26.7	5,011.4	9.7

Potential calculations in a very bold fashion assuming that the driling pits in the palaeo-landform channels that hit an ore bed were continuous produce the following results: Ore reserves 3.8 million m^3, ilmenite reserves 493,000 tons, average ilmenite content 130kg/m^3, and stripping ratio 9.7.

Table I-5-2 Ore Reserves Calculation of Category P_1 for the Southern Flank of Placer No.3

Block No	Block area 10^3m^2	Ore bed thickness m.	Ore sands reserves 10^3m^3	Ilmenite content, kg/m^3	Ilmenite reserves 10^3t	Overburden thickness, m	Overburden volume 10^3m^3	Stripping ratio, m^3/m^3
I-P_1	680.5	3.03	2,061.9	117.76	242.8	26.6	18,101.3	8.8
II-P_1	690.1	2.50	1,725.2	144.76	249.7	26.8	18,494.7	10.7
Total	1,370.6	2.76	3,787.1	130.05	492.5	26.7	36,596.0	9.7

3) Bektimir Northern Placer (Reconnaissance Survey District)

Driling was conducted in five pits along one traverse line at a spacing of 800m. The driling lengths totaled 335.0m.

Thickened ilmenite seam was deposited in the Aral Formation directly above the bedrock and in cracks of weathered crusts of the bedrock. The driling survey showed that the content of thickened ilmenite seam was low and the expanse of the ore bed could not be captured. Ore reserves were, therefore, not calculated.

5-1-3 Geophysical Properties

The resistivity and magnetic susceptibility of each geological unit in the survey area were measured for use as basic data for airborne electromagnetic survey and analysis. The magnetic susceptibilities of the bed rocks were measured. Granitic rocks of the Preobrazhenskiy composite rock mass were classified quantitatively.

The resistivity, magnetic susceptibility and radioactive intensity of each geological unit in the survey area were measured (See Table I-5-3.).

Table I-5-3 Geophysical Properties of geological units

GEOLOGICAL UNIT	LOCATION	RESISTVILITY (Ωm)			MAGNETIC SUSCEPTIBILITY ($\times10^{-3}$S.I.U.)			RADIOACTIVITY (×μSV/h)		
		HIGH	LOW	AVERAGE	HIGH	LOW	AVERAGE	HIGH	LOW	AVERAGE
PRE-GRANITOIDS VOLCANICS (CARBONIFEROUS)	OUTCROP	NOT MEASURED			59.3	0.26	8.3	0.04	0.01	0.02
PRE-GRANITOIDS SANDSTONE (CARBONIFEROUS)	OUTCROP	NOT MEASURED			0.40	0.21	0.33	NOT MEASURED		
WEATHERED CRUST	BORING CORE	101.3	9.7	38.7	0.27	0.06	0.18	0.07	0.01	0.03
GRANITOIDS	OUTCROP	12400	596	6498	31.5	0.02	2.44	0.09	0.01	0.04
ARAL FORMATION	TMK TEST PIT	3	2	2.5	0.25	0.2	0.22	0.02	0.02	0.02
	BORING CORE	599	4.3	50.5	0.33	0.05	0.15	0.04	0	0.02
ARAL FORMATION WITH ILMENITE LAYERS	TMK TEST PIT	NOT MEASURED			0.61	0.21	0.40	NOT MEASURED		
	BORING CORE	27	5.3	9.3	0.90	0.26	0.48	0.04	0	0.02
QUARTERNARY	TMK TESTPIT	286	17	80	1.04	0.17	0.71	0.02	0.02	0.02
	BORING CORE	NOT MEASURED			NOT MEASURED			NOT MEASURED		

1) The resistivities of the driling cores 39 and 51 Ω m for weathered crusts and Tertiary-Period Aral Formation were and did not vary greatly. This may be explained by the groundwater surface, which was located almost directly above the unconformity plane between the Tertiary-Period Aral Formation and Quaternary-Period layers, and by the moist state of the formation and layer by groundwater which contained electrolytes. The minerals comprising the formation and layer were the same and a clear lithofacies boundary could not be found between the two. The resistivity of the thickened ilmenite seams in the Tertiary-Period Aral Formation slightly increased.

The resistivities of the Tertiary-Period Aral Formation and Quaternary-Period layer of 51 and 80 Ω m showed a difference. The Tertiary-Period Aral Formation was moist and the Quaternary-Period layer, semi-dry. This difference seems to have produced a difference in the resistivity.

2) The magnetic susceptibility of thickened ilmenite seams was 0.4 x 10^{-3} S.I.U. and was high compared with that of a stratum that did not contain a thickened ilmenite seam of 0.2 $\times 10^{-3}$ S.I.U.

5-2 Recommendations for Phase III Survey

5-2-1 Recommendations for survey area

The survey in Year 2 provided the following guidelines for ore bed exploration:

1) The known ilmenite drift-sand ore beds are deposited in palaeo-landform furrows (palaeo-landform channels) of the Tertiary-Period Aral Formation. Locations with high potentials for deposition of new ore beds can be identified by extracting palaeo-landform channels.

2) Diorite - monzonite, rather than granite, and rock mass with a magnetic susceptibility of less than 1×10^{-3} S.I.U., which is believed to contain a large proportion of ilmenite as an opaque mineral contained, are preferred as granitic rocks in the hinterland.

The survey policies for each district in Year 3 are as follows:

1) Bektimir District

(1) Eastern Flank of Bektimir Placer No. 1

The southern extension of Bektimir Placer No. 1 expands more than 1000m in ore bed width and the extension direction changes from NEN-SWS to NW-SE with the result that the ore bed boundaries in the eastern direction of the area with a high content cannot be confirmed yet. Additional driling should be conducted (a detailed survey) and ore reserves must be reassessed. Adjacent to the eastern flank of palaeo-landform channels where a driling survey was undertaken, other channels may exist and an additional driling survey including this area is considered desirable. However, the depth of the ore bed becomes deeper toward south and overburden becomes thicker. A survey must therefore be undertaken by discerning the relationship between an economically feasible depth and ore grade.

(2) Southern Flank of Bektimir Placer No. 3

The driling survey in this year found ore beds to be narrow seams. However, sufficiently high potentials can be anticipated. Interpolation of the inferred palaeo-landform channels and a survey of the upstream have not been undertaken yet. An additional driling survey (detailed survey) for them is deemed preferable.

2) North Bektimir District

According to the driling survey undertaken this year, the potential ore bearing depth of this district is deep, more than 60m underground. Prominent thickening of ilmenite could not be found. The granitic rocks in the hinterland showed a high magnetic susceptibility. It appears that supply of quality ilmenite cannot be expected from this district. Surveys of this district should be terminated after this year.

3) Other Districts

(1) Eastern Flank of Bektimir Placer No. 1

An analysis of public data in Year 2 shows that about two palaeo-landform channels are expected to exist in the area. A driling survey (reconnaissance survey) of these channels is deemed preferable.

(2) Northern Flank of Bektimir Placer No. 2 (Beloe District)

An analysis of public data in Year 2 shows that diorite - monzonite distribute in the hinterland and that there are areas where the magnetic susceptibility is low. Two palaeo-landform channels originating from these areas are expected to exist. A driling survey of these channels is deemed preferable.

PART II

SPECIFIC INFORMATION

Chapter 1　Analysis of Existing Data

1-1 Purpose of the Survey

The survey in Year 2 was conducted to collect, resort and analyze existing public geological data on bearing of ores in known ore beds in the survey area and on depths of the bedrocks of the Tertiary and Quaternary Periods to understand geology and geological structure of an ilmenite-origin rock area and following the survey undertaken in Year 1.

1-2 Analysis

A large volume of driling data for the survey area exists. The driling projects undertaken in the past in the survey area include geochemical exploration driling by an Altai geological exploration unit between 1988 and 1992 and ilmenite drift-sand ore beds from 1990 to the present. The geochemical exploration driling project undertaken from 1988 to 1992 especially reached bedrock weathered crusts at spacing of 200m along a traverse line and recovered samples of bedrock weathered crusts. The rock samples of the weathered crusts were used in rock geochemical exploration. Through these efforts, depth data to the bedrocks of the Tertiary-Period Aral Formation and Quaternary-Period layer is now available. Nevertheless, under the regime of the former Soviet Union, this data was used only for preparing cross sections for each traverse line and was not compiled.

In Year 2, this depth data was compiled to prepare subsurface contour maps (subsurface structure diagrams) of the bedrock surface of the Tertiary-Period layer (unconformity plane between Tertiary-Period Aral Formation and bed-rock weathered crusts) and Quaternary-Period bedrock (unconformity plane between Quaternary-Period layer and Tertiary-Period Aral Formation). The subsurface structure of the bed rock of the Tertiary Period showed palaeo-landform when the Aral Formation of the Tertiary Period was started to deposit (about 40 million years ago), defining palaeo-landform channels, in which ilmenite drift-sand ore beds are deposited (PL. II-2-3 - 4).

1-2-1 Subsurface structure of Tertiary-Period bed rock

Subsurface contours of the Tertiary-Period bed rock are rich in relief. The gorges seem to represent weak lines of edges, faults and cracks in the Preobrazhenskiy composite rock mass (PL. II-2-3).

An oval furrow, which is considered to show the contour of the Preobrazhenskiy composite rock mass, measures 17km in major axis and 5km in minor axis. The contour of the southwestern flank is not clear, but the contour from the north to the northeastern flank is clear. This furrow is estimated formed along the periphery of the rock mass due to a difference in erosion between the Carboniferous Period layer, which had a weak resistance, compared with rocks in the northern to northeastern flank of the rock mass that were relatively hard and resistant to weathering and erosion. An arc-shaped furrow could be found in the southeastern flank of the rock mass. This land too was estimated to show the outer edge of the rock mass. The upstream part of Bektimir Placer No. 1 is contained in this land.

Another arc-shaped furrow in the farther inner side of the arc-shaped furrow in the southeastern flank, which is supposed to form the outer edge of the Preobrazhenskiy rock mass, contains Bektimir Placer No. 3. This furrow is estimated to be a NE-SW fault and is called the Bektimirskiy Fault. (Japan International Cooperation Agency, Metal Mining Agency of Japan 2001) It is possible that this land shows the southeastern edge of granitic rock mass high in magnetic susceptibility.

The NE-SW furrow is estimated to have been formed by erosion after the Palaeocene Epoch along a weak line of a NE-SW crack formed after the intrusion of the Preobrazhenskiy intrusive rock mass.

The NW-SE furrow coincides with the strike direction of the Carboniferous Period layer and is estimated to be a structural strike gorge.

1-2-2 Subsurface structure of Quaternary-Period bed rock

The groundwater surface was located directly above the unconformity plane between the Tertiary-Period Aral Formation and Quaternary-Period layer. This suggests a possibility of the subsurface contour of the Quaternary-Period bedrock generally showing the groundwater surface (PL. II-2.4).

Compared with the subsurface contour of the Tertiary-Period bedrock, the subsurface contour of the Quaternary-Period bedrock lacks relief and is generally flat. Fairly substantial portions of the landform furrows overlap with palaeo-landform furrows of the bedrock in the Aral Formation of the Tertiary Period. Many of them also overlap with Recent rivers and gorges. This suggests that, generally speaking, gorges have always been gorges through the geological generations with less landform changes.

1-2-3 Geological history of Cenozoic Era

According to the geological history of South Altai in the Cenozoic Era authored by V. S. Erofeyev (1969), the geological history of the survey area can be summarized as follows.

End of the early Cretaceous Period (Denmark Age, about 140 million years ago): The Zaysan Furrow, which forms a gentle inclination, started to sink. Chemical weathering of the bed rock started to deposit a formation of a clayey layer mainly consisting of montmorillonite and a red bed composed of iron hydroxide. Sedimentary basins were lakes, marshes and lowlands along rivers with a slow flow speed. These basins were clayey layers forming diagonal bedding sandwiching sand layers. The southwestern part of Zaysan Furrow was a moist plain facing a coast and the southeastern and eastern flanks of it were dry areas. The climate of the sedimentary basins was a repetition of high-temperature, high-humidity climate and dry climate. The amount of rainfall was high during the wet season and rivers were flooded. Lowlands became lakes and marshes. During the dry season, leaves of deciduous trees fell and sediments were cracked. Surface water and humus soil permeated and reacted with basement rock. Iron was eluded and red beds composed of iron hydroxide were formed. In some places, ceramic materials, bauxite, titanium sand ore beds were formed. As animals, dinosaurs and water turtles inhabited, while woods and forests of hemp palms, seqouias, araucarias, magnolias, chestnuts, gingkoes, coniferous trees, metasequoias, sycamores, maples and other species spread in the south.

Mid- to early Eocene Epoch (Turangin Age, about 45 to 40 million years ago): During this age, middle Altai started to uplift, thereby changing river flow. Sedimentation of clay and red beds stopped around the Zaysan Furrow and sedimentation of coal increased, starting deposition of pyrite and calcareous clay. Soluble salts such as sulfates and chlorides were contained in clay. Woods and forest plains of lowland spread near the survey area, and denuded clastics were moved to the Zaysan Furrow.

Early Eocene Period - Late Oligocene Epoch (Tyzkabak Age, about 40 to 30 million years ago) Exposed to land breezes and rainfalls during the monsoon and rainy season, moss, woods and forests spread in marshes and swamps along rivers in plains. As a result, silt-like clayey beds green or greenish brown in color deposited in drainage areas, while brown silt containing iron deposited in plains.

Mid- to early Pliocene Epoch (Ashtas Age, 30 to 26 million years ago): The Narym structural motion started in the mid-Pliocene Epoch, causing uplift motion and starting deposition of carbonates, coal and pyrite in some areas. Thick calcareous clay beds were characteristically formed. In the middle of the Pliocene Epoch, the climate changed to dry, cold climate and subtropical plants disappeared. The drainage systems denuded weathered rocks and continued sedimentation. The survey area continued to be low woods and forest plains and denuded clastics were moved to the Zayzan Furrow in southeast.

Late to Mid-Miocene Epoch (Aral Age: 26 to 15 million years ago): The cold and dry climate that started in the early Palaeocene Epoch further intensified and the land profile greatly changed in the late to mid-Miocene, changing to steps. Woods and forests were limited to areas near rivers, lakes and marshes and soil changed to brown or light brown soil of fine grains, mainly composted of montmorillonite. Gypsum and carbonates were formed by occasional rainfalls in a semi-dry climate. Sulfates were formed only in small amounts. Salts were developed only when evaporation was intense during dry climate. Weathered clastics were eroded in new drainage systems and were deposited again in them, forming light green sediments containing carbonates and sulfates.

Early Miocene Epoch - Pliocene Epoch (Pavlodar and Vtorushinsk Ages, about 25 to 5 million years ago): Structural motion called Tarbagatayskaya Tectonics took place in this age and sedimentation of sediments stopped. The climate returned to tropical climate and new sediments started to cover again. The lowland in the survey area was engulfed in the rims of sedimentary basins and new sediments from nearby areas started to deposit.

Chapter 2 Geological Survey

2-1 Purpose of the Survey

To determine the relationship between geology and drift-sand ore beds in the survey area.

1) To quantitatively classify granitic rocks of the Preobrazhenskiy rock mass, which was designated in the survey in Year 1 as a hinterland of drift-sand ore beds, and to determine rocks promising as origin rocks of ilmenite and their distributions.
2) To measure magnetic susceptibilities of basement rocks and to determine their values and distributions for use in Task 1) above.

2-2 Method of Survey

In the survey of the survey area in Year 2, a semi-detailed survey was conducted to the extent shown in Table I-1-1. A former kindergarten building in Beloe Village was used as the base camp after repairing the inside of it.

In the geological survey, locations of outcrops were confirmed using a topographical map 1:25,000 in scale and GPS (manufactured by Magellan model GPS320). At each outcrop, the field name, grain size, texture, stratification, fissure system and other items of the rock were observed and were entered in a field note, to prepare a field route map. Results of these surveys were summarized in surface geological maps and cross sections 1:25,000 in scale (PL. II-2-1) and in basement-rock geological maps of the pre-Tertiary Period in a scale of 1:25,000 (PL. II-2-2).

Concurrently with the geological survey, magnetic susceptibilities of the rocks at the outcrops were measured and recorded (See Appendix 2-21.). The magnetic susceptibilities were measured on fresh, flat and smooth rock outcrops at 509 geological outcrops using a portable magnetic susceptibility meter (Micro KAPPA, model KT-5c). Ten measurements were taken at each outcrop and mathematical averages of them were plotted on a magnetic-susceptibility distribution diagram 1:50,000 in scale (PL. II-2-2). At some outcrops, the dose-equivalent rates were measured using a radioactivity meter equipped with a GM tube (manufactured by Calcite, model CS-201), to examine the feasibility of differentiating rock masses based on a difference in content of radioactive zircon in rocks.

At the same time when the geological survey was conducted, rocks were sampled in positions shown in Fig. II-2-1. Whole rock analysis and trace component analysis was performed with 26 of these samples. Based on the results of the whole rock analysis, CIPW norm calculations were made and rocks were named in accordance with Streckeisen (1967).

AFM and other diagrams were prepared using the results of the whole rock analysis. REE pattern and other diagrams were prepared based on the results of the trace component analysis. The analysis was made to quantitatively classify rocks of the Preobrazhenskiy rock mass. Seven rock thin sections and 12 polished sections were prepared for use in laboratory tests from the 26 samples used in the whole rock and trace component analysis. These sections were used in microscope observation and mode measurement of opaque minerals. The modes of the opaque minerals were measured using a point counter manufactured by James Swift & Son, model F, by measuring 2,000 intersections on 1/5× 1/6mm section paper. A total of 53 opaque mineral grains found on nine of polished sections were analyzed for semi-quantitative analysis using EDX (manufactured by JEOL, model JSM-5310), to determine mineral species and Ti contents. To examine mineralogical composition of ilmenite, one ilmenite concentrate sampled from the TMK test pit in Bektimir No. 1 Placer was subjected to the following analyses: One powder X-ray diffraction analysis, one polished section was prepared, eight semi-quantitative analyses by EDX, linear analysis by EPMA (manufactured by JEOL, model JXA-8800R), area analysis, and two qualitative analyses.

Appendixes 2-6 and 2-7 show the results of the whole rock analysis and trace component analysis. Appendix 2-8 shows the results of the CIPW norm calculations. Appendixes 2-2, 2-6 and 2-3 show microscopic observation results, results of opaque mineral mode measurement and microscope photos. Appendix 2-23 shows results of EDX semi-quantitative analysis of opaque minerals. Distributions of TiO_2 in granitic rocks of the Preobrazhenskiy rock mass, of opaque mineral modes and of opaque mineral kinds are shown in Figs. II-2-2, II-2-3 and II-2-4, respectively. Appendixes 2-24, 2-5, 2-9 and 2-23 respectively show results of microscope observation of ilmenite concentrate, EDX semi-quantitative analysis and EPMA quantitative analysis.

2-3 Survey Findings

The geological order of stratification of the survey area is made up of pre-granitic rocks (Carboniferous Period layer), granitic rocks intruded into them, Aral Formation of the Tertiary Epoch layer in the Cainozoic Era that covers them without conformity, and the Quaternary Epoch that covers all of them without conformity. Weathered crusts widely develop on pre-granitic rocks (Carboniferous Period layer) and granitic rocks, which are the bed rock of the Aral Formation of Neogene Period.

2-3-1 Pre-granitic rocks (Carboniferous Period layer)

Pre-granitic rocks are sedimentary rocks (shale, sandstone and conglomerate), pyroclastic rocks, and lava (andsite and porphyrite).

1) Arkalyk bed of lower coal series ($C_1V_{2-3}ar$)

Outside of the study area, this bed distributes in the form of a narrow strip 1.5km in width in northwest of the survey area along the southern flank of the Baladzhalskiy Fault. Inside the study area, the bed is extensively covered by the Aral Formation of the Tertiary Period and Quaternary-Period layer and is hardly exposed. However, a small outcrop of siltstone of this bed, which has become hornfelsic, could be located north of Kamenka in northwest, adjoining the Preobrazhenskiy rock mass.

This bed consists of shale, siltstone, sandstone, tuff and limestone and is said to contain fossils of Brachiopodas and corals. The total bed thickness is about 1,500m.

2) Kokpeti lower bed of middle coal series (C_1V_3-nkp_1)

This bed widely distributes in the northern flank of the Baladzhalskiy Fault.

This bed consists of conglomerate, tuffaceous sandstone, sandstone, siltstone and shale. The total bed thickness is about 1,500m.

3) Bukon bed of upper coal-series (C_2bk)

This bed distributes on the southern flank of the Preobrazhenskiy composite rock mass. The bed is covered thickly by the Aral Formation of the Tertiary Period and Quaternary-Period bed and is exposed only along the Bektimir river 5km east of Koitas. In driling in the southern flank of Bektimir Placer No. 1 and in the southern district of Bektimir Placer No. 3, the bed is exposed as a bedrock weathered crust.

In the survey area, this bed consists of conglomerate, arcose sandstone, sandstone, siltstone and shale. A thin alteration of strata is developed. Rocks in the part of the bed that contact the Preobrazhenskiy intrusive rock mass have become hornfellsic and carboniferous shale has become graphite. The total bed thickness is 1,500 to 2,000m.

4) Middle to upper coal-series Maityab bed ($C_{2-3}mt$)

This bed widely distributes in the southern to the eastern flanks of the Preobrazhenskiy composite rock mass. It distributes widely as small hills from near Koitas to the east. It emerged as a boulder in driling near a basement rock in the northern area of Bektimir.

This bed is generally coarse and bulky and is dark green in color. It is composted of tuff, andesitic porphyrites wiching tuffaceous sandstone, andesite, rarely basaltic porphyrite, and volcanic breccia of diabasic porphyrite. Andesitic porphyrite and andesite often show brecciated or subbrecciated texture that contains rock fragments of different crystallinities. For this reason, this rock appears like porous sponge rock on its weathered surfaces. In microchemical analysis, this bed appears as phenocrysts of altered euhedral plagioclase 0.2 to 0.5mm in size, semi-euhedral amphibole about 0.2mm in size, and euhedral pyroxene about 0.1mm in diameter. Its groundmass is found altered into an aggregate of chlorite and sericite (G031). This rock underwent strong contact metamorphism by the Preobrazhenskiy intrusive rock mass that generated actinolite and became hornfelsic (I023). It contains more than 1% of magnetite as an opaque mineral, but ilmenite could not be detected. The part of this rock exposed near Beloe sometimes contains ilmenite that shows a holocrystalline texture of fine grains consisting of a large amount of pyroxene about 0.05mm in diameter, a small amount of biotite, semi-euhedral quartz and plagioclase (I004).

The solidification indexes of pyroclastic rocks and lava are higher than 18 and differentiation indexes, less than 50.

2-3-2 Granitic rocks and dikes

Granitic rocks and dikes of the Preobrazhenskiy composite rock mass intruded during the Palaeozoic are distributed.

(1) Preobrazhenskiy Composite Rock Mass

This intrusive rock mass occupies the majority of the survey area and is exposed in an area 8km×17km. According to the analysis of literature, the following three rock masses have been identified. However, these rock masses cannot be discriminated clearly outdoors. The three rock masses are: The Maksutskiy composite rock mass made up of gabbro, monzonite and diorite that intruded in the early Permian Period to the late Triassic Period, the Saykanskiy composite rock mass made up of syenite, syenite-diorite and granitic syenite intruded between the middle and early Triassic Period, and the Delbegeteyskiy composite rock mass made up of granitic rocks intruded during the late to the middle parts of Jurassic Period.

Noritic gabbro (I106) is exposed in a small area near Kamenka located northwest of the Preobrazhenskiy composite rock mass. In microchemical analysis, euhedral plagioclase 0.03 to 1mm in size is dominant. Other minerals include hypidiomorphic olivine about 0.1mm in diameter, which is surrounded by pyroxene, biotite, intergranular spinel and other anhedral minerals. Plagioclase is prominent in twin and a zonal structure could not be found.

Monzonite diorite - diorite are fine or medium grained and expose near the center of the Preobrazhenskiy composite rock mass. By naked eyes, color index is about 40. In microchemical analysis, they consist of anhedral and altered potassium feldspars, anhedral quartz, semi-euhedral amphibole 0.1 to 0.5mm in size, and semi-euhedral biotite 0.2 to 1mm in size that is partially turned chlorite. Amphibole and biotite accompany euhedral and semi-euhedral ilmenite about 0.03 to 0.3mm in diameter and titanic magnetite as opaque minerals (G109, G113 and I085).

Monzonite granite and monzonite of medium to coarse grains have the largest exposure area in the Preobrazhenskiy composite rock mass and are distributed around the rock mass. When observed by naked eyes, pink potassium feldspars, grayish white quartz, dark biotite and amphibole in medium to coarse grain sizes could be found. Color indexes of them are about 5 to 10. Microchemical analysis found anhedral potassium feldspars showing a perthite texture, anhedral quartz, semi-euhedral brown amphibole 0.1 to 1.5mm in size, and dark brown or greenish brown semi-euhedral biotite that has partially become chlorite 0.2 to 2mm in size. Zircon is contained as an accessory mineral. As opaque minerals, euhedral and semi-euhedral ilmenite about 0.03 to 0.5mm in diameter, titanic magnetite and magnetite are accompanied. In the southeastern flank of the rock mass, almost 100% of opaque minerals are ilmenite, while ilmenite accounts for 20 to 50% and the balance, titanic magnetite and magnetite, in the northwestern flank of the rock mass (Fig. II-2-3).

Ishihara, et al., classified granitoids into magnetite-series granitoid and ilmenite-series granitoid depending on whether or not magnetite is contained (1977). A rock mass that has a larger number of observations of magnetite than ilmenite is called magnetite-series granitoid. According to this classification method, the northwestern flank of the Preobrazhenskiy composite rock mass belongs to a classification near magnetite-series granitoid.

(2) Dikes

Dikes of quartz porphyry and aplite are intruded into the Palaeozoic layer and Preobrazhenskiy composite rock mass. Quartz porphyry is dominant in white color and dense lumps and is intruded in NE and NW directions as dikes. Aplite is dominant in the northwestern flank of the rock mass and is intruded in EW and NE directions.

2-3-4 Post-granitic rocks

1) Bed-rock weathered crust (K_2)

Weathered crusts developed on sedimentary rocks and volcanic rocks of the upper coal series and are covered by the Aral Formation of the Tertiary Period and Quaternary-Period layers. Bedrock weathered crusts were formed by chemical weathering under moist and warm climate at the end of the early Cretaceous Period (about 140 million years ago).

2) Aral Formation of Tertiary Period ($N_1^{1-2}ar$)

The Aral Formation covers basement rocks of the Palaeozoic or their weathered crusts without conformity and is covered widely by the Quaternary-Period layers. This formation is made up of sandy clay, coarse-grained clayey quartz - feldspathic sand, rarely containing a gravel layer. The lower bed of this formation contains ilmenite drift-sand ore beds.

This formation is divided into lower and upper layers as follows:

(1) Lower layer

This layer is dark gray and bluish sandy clay and contains coarse-grained clayey sand, gravels and wooden fragments. In ore bed areas, this layer contains a large amount of ilmenite and deposits drift-sand ore beds in it.

(2) Upper layer

The color of it changes from brownish gray to light gray. It often consists of clay of miscellaneous colors or brown - brownish gray. The sandy content is low, 3 - 5% or less. It contains a large amount of oolith of iron hydroxide and manganese hydroxide. It rarely contains gypsum crystals and their aggregates.

3) Quaternary-Period Layer (Q)

The Quaternary-Period layers distribute widely in this area. The layer is divided into the lower bed, middle-upper bed, upper-Recent bed and Recent bed.

(1) Lower bed (Q_1)

The lower Pleistocene Epoch layer is characterized by a cobblestone bed and distributes in the southern and western parts of this area, covering the basement rocks of the Aral Formation of the Tertiary Period and Palaeozoic. The upper part this bed consists of reddish brown and brown loam and clay, accompanying a lenticular sand bed. The lower part of the bed is a cobblestone bed. The roundness of gravel is medium or good and the gravel consists of tuffaceous sandstone, mudstone, porphyrite, andesite and hornfels. The thickness of this bed is 5 to 13-14 m.

(2) Middle - upper bed (Q_{2-3})

This bed is composed of loess-like brownish gray loam and is distributed by covering basement rock of the Aral Formation of the Tertiary Period and Palaeozoic. It is developed especially in the hilly land in the eastern flank of Preobrazenska Village. Normally, this bed has dark brown sandy clay beds and accompanies coarse-grained sand beds mixed with granules. Ilmenite (maximum 5 - 12 kg/m^3) is often found in these beds. The thickness of this bed varies between 2 and 20 m.

(3) Upper - Recent bed ($Q_{3\text{-}4}$)

This bed is composed of loam that contains a large volume of rock fragments of basement rock of the Palaeozoic. The amount and size of gravel increase toward the upstream. This bed does not exceed 1 or 2 m in thickness.

(4) Recent bed (Q_4)

This bed consists of riverbed sediments and contains cobblestone, gravel, sand, sandy loam, silt, loam and clay. The thickness of this bed is 0.5 to 2.5 m.

2-3-5 Quantitative petrology of granitic rocks

1) Principal chemical components of granitic rocks

Whole rock analysis of 22 granitic rock samples sampled from the survey area was undertaken (See Appendix 2-6.). Except for Sample No. G053, the analysis was conducted by the Nonferrous Metal Mining and Metallurgy Research Institute in Ust-Kamenogorsk. Sample No. G053 was analyzed by the ALS Chemex Assay Laboratory in Vancouver, Canada. Many of the analysis values do not reach from 100% in total. However, the analysis values were believed sufficient to observe trends of the chemical analysis and were used as they were.

As pointed out in the survey during Year 1, the TiO_2 content in granitic rocks was low with rocks that were advanced in crystallization differentiation of magma as in granite and syenite and was high with rocks that were not advanced in crystallization differentiation as in gabbro and diorite - monzonite.

In Japan also, autochthonous ilmenite drift-sand ore beds accompanying gabbro rock mass are known and were explored (Suzuki et al. 1954, Haraguchi et al. 1956, Kusama et al. 1958, Miyamoto 1959, Soma 1963, and Tsusue et al. 1969). As far as working in Japan of iron sand components is concerned (Miyamoto, 1960), acidic iron sand accompanying granite contained less titanic minerals. Basic iron sand contained much titanic components. Autochthonous residual iron sand especially contained a very high proportion of titanic minerals.

The $Na_2O + K_2O - SiO_2$ diagram (Cox, K. G., et al., 1979) is used to roughly classify plutonic rock and extrusive rock in terms of chemical components. The granitic rocks in the survey area could be classified clearly into two groups. The one group covers a region from granite to syenite, containing less than 1% of TiO_2. The other group covers a region from monzonite to diorite and gabbro, containing more than 1% of TiO_2 (Fig. II-2-5).

In the K_2O - CaO - Na_2O diagram (see Fig. II-2-6), granitic rocks that contained less than 1% of TiO_2 were lean in CaO (<2%), but were slightly rich in K_2O (>3%). Those granitic rocks that contained more than 1% of TiO_2 were rich in CaO, but were slightly lean in K_2O.

In the AFM diagram (see Fig. II-2-7), the granitic rocks in the survey area fall into the calc-alkali rock region. Those granitic rocks that contained only less than 1% of TiO_2 were rich in alkali ($Na_2O + K_2O$), but were lean in MgO and ΣFeO. Those granitic rocks that contained more than 1% of TiO_2 were lean in alkali, but were rich in MgO and ΣFeO.

The ACF diagram (see Fig. II-2-8) is used in classifying granitic rocks of the Types I and S using granitic rocks of Australia as sampling land (White and Chappel, 1977). In the continental crust, granitic rocks of the Type I are classified as igneous rock origin, and granitic rocks of the Type S, as sedimentary rock origin. Takahashi et al. (1980) compared between magnetite-series and ilmenite-series granitoids and between granitic rocks of the Types I and S. In general, granitic rocks of the Type I contain a high level of Na_2O, higher than 3.2%, while the $Al_2O_3/Na_2O + K_2O + CaO$ molar ratio is low, below 1.1. The Type-I granitic rocks contain a small amount of diopside or a very small amount of corandum as normative minerals. The granitic rocks of the Type S generally have a low content of Na_2O, less than 3.2%. The $Al_2O_3/Na_2O + K_2O + CaO$ molar ratio is high, more than 1.1. The comparison between magnetite-series and ilmenite-series granitic rocks and between granitic rocks of the Types I and S shows that magnetite-series granitic rocks are the same as the Type I granitic rocks, but that ilmenite-series granitic rocks contain granitic rocks of both Types I and S. Those granitic rocks of the Preobrazhenskiy composite rock mass that contained only less than 1% of TiO_2 fall into the Type-S region with the exception of G053, while monzonite - diorite rocks containing more than 1% of TiO_2 fall into the Type-I region.

The FeO/Fe_2O_3 ratio is low with granite (below 1) and is high with monzonite - diorite and noritic gabbro (about 1 or higher), suggesting that monzonite - diorite and gabbro were formed at low oxygen partial pressure (Tsusue, et al., 1974, Ishihara, et al., 1977).

The differentiation index (DI) is calculated by a total of weight percentages of quartz, orthoclase, plagioclase, nepheline and kalsilite, which are normative minerals. Because the chemical composition of magma residual liquids approaches SiO_2 - $NaAlSiO_4$ - $KAlSiO_4$ as crystallization differentiation advances, the DI increases as magma crystallization differentiation advances and is used to show the degree of magma differentiation (C.P.Thornton et al., 1960). The figure shows the relationship between the differentiation index (DI) and oxide components. The DIs of granitic rocks containing only less than 1% of TiO2 are higher than 80. As DIs increase, TiO_2, Al_2O_3, Fe_2O_3, FeO, MgO, CaO, Na_2O and K_2O tend to decrease. DIs of granitic rocks containing more than 1% of TiO_2 are below 60 and alkali (NaO_2 and K_2O) increases as DI increases, while Al_2O_3, Fe_2O_3 and FeO rather decrease slightly and MgO and CaO prominently decrease. The trends of TiO_2 are not steady (See Fig. II-2-9.).

The solidification index (S.I.) is calculated by $100 \times MgO/(MgO + FeO + Na_2O + K_2O)$ and decreases as magma crystallization differentiation advances. It is used to indicate the degree of magma crystallization differentiation (Kuno et al., 1957). Appendix 2-6 shows S.I. of granitic rocks in the survey area. S.I. of granitic rocks that contain less than 1% of TiO_2 are below 6 and are mostly 3 or less. S.I. of granitic rocks containing more than 1% of TiO_2 are higher than 10.

The TiO_2 content distribution of the Preobrazhenskiy composite rock mass is shown in Fig. II-2-4. The distribution is high in the center of the rock mass and almost equals the distribution regions of diorite and gabbro.

The CIPW normative values calculated based on the whole rock analysis are shown in Appendix 2-8.

The classification of granitic rocks by the plagioclase - potassium feldspars - quartz ratio diagram (Streckeison, A. L., 1967) clearly classifies granitic rocks into a group that falls into a monzonitic granite region containing only less than 1% of TiO_2 and into a group that falls into a monzonitic diorite and norite region containing more than 1% of TiO_2 (See Fig. II-2-10.).

The Maksutskiy composite rock mass composed of gabbro, monzonite and diorite described by Sokratov (1964) may correspond to monzonite - diorite and gabbro, while the Saykanskiy composite rock mass composed of syenite, diorite and granitic syenite and Delbegeteyskiy composite rock mass composed of granitic rocks may correspond to granitic rocks.

2) Trace Components of Granitic Rocks

Trace components of granitic rocks were analyzed by the ALS Chemex Assay Laboratory in Vancouver, Canada by ICP. Appendix 2-7 shows the results of the analysis.

Values of trace components to SiO_2 in parent ferrous elements such as Ni and Co tend to decrease as SiO_2 increases independent of the TiO_2 content. Conversely, the values of trace components in parent copper elements such as Cu and Pb tend to level off even though SiO_2 increases independent of the TiO_2 content. Ba in granitic rocks that contain only less than 1% of TiO_2 decreases as SiO_2 increases. Ba in granitic rocks containing more than 1% of TiO_2 almost levels off (See Fig. II-2-11.).

The rare earth pattern obtained by normalizing rare earths in granitic rocks of the survey area using leedey condrite becomes a concave when granitic rocks containing only less than 1% of TiO_2 are Eu, while it becomes almost linear with granitic rocks containing more than 1% of TiO_2 (See Fig. II-2-12.).

Rb is estimated to behave together with K, whose ion radius is almost identical and is believed to thicken in potassium feldspars and mica at the end of magma crystallization differentiation (Blockley, 1978). When the K_2O/Rb ratio is examined, Rb in granitic rocks that contain more than 1% of TiO_2 also increases proportionately as K_2O increases. Rb in granitic rocks that contain only less than 1% of TiO_2 tends to slightly decrease as K_2O increases (See Fig. II-2-13.). This shows that both behave differently and can be discriminated clearly.

Sr is fetched in an initial stage of magma crystallization differentiation by substituting part of K in potassium feldspars and part of Ca in plagioclase and is believed to be contained less in residual liquids of magma (Blockley, 1978). Therefore, the relationship between CaO and Sr is proportional as Sr also will decrease when CaO decreases after magma crystallization differentiation progresses (See Fig. II-2-14.). Because Sr decreases while Rb increases in case magma crystallization differentiation advances, rock masses with advanced crystallization differentiation will have higher values when the Rb/Sr ratio is examined. The ratio with granitic rocks that contain more than 1% of TiO_2 is about 0.01, while that of granitic rocks containing only less than 1% of TiO_2 is about 1. These can be distinguished clearly in the Rb/Sr ratio also (Fig. II-2-15).

3) Magnetic Susceptibility of Granitic Rocks

The measured magnetic susceptibilities and magnetic susceptibility contour are presented in Appendix 2-22 and Fig. II-4-4.

The magnetic susceptibilities of the granitic rocks in the survey area varied greatly, between 0.06 and 27.7×10^{-3} (S.I.U.). However, as shown in Fig. II-2-9, the magnetic susceptibilities of granitic rocks that contained only less than 1% of TiO_2 tended to lower as the DI increased. Those granitic rocks that contained more than 1% of TiO_2 did not show any trend.

The part of the Preobrazhenskiy composite rock mass that showed more than 1×10^{-3} (S.I.U.) in magnetic susceptibility was an area of the rock mass from the center to the northwestern part of it, which coincided with the area which contained less ilmenite, but contained titanic magnetite and magnetite among opaque minerals contained in granitic rocks.

The magnetic susceptibilities of dikes composed of quartz porphyry and aplite were about 0.1×10^{-3} (S.I.U.) and were very low.

4) Opaque Minerals in Granitic Ores

(1) Modal ratio of opaque mineral

Modal ratios of opaque minerals in granitic rocks measured by a microscope are presented in Appendix 2-23. Their distribution is plotted in Fig. II-2-3. The distribution of samples of granitic rocks that could be sampled was not uniform and a distribution trend of opaque minerals cannot be described unqualifiedly. However, modal ratios of opaque minerals were slightly high, 1 to 2%, in the center of the Preobrazhenskiy composite rock mass, while those of opaque minerals in the northeastern and southwestern seams of the rock mass were low, 0 to 0.4%. This suggests the trend that TiO_2 was high, higher the modal ratio of an opaque mineral was (See Fig. II-2-3.).

(2) Mineral composition of opaque mineral

Appendix 2-23 shows results of an EDX semi-quantitative analysis by a microscope of opaque minerals randomly selected and the names of the minerals. Fig. II-2-4 plots ratios and distribution of the minerals.

The selected opaque minerals were ilmenite (Ti 35%), titanic magnetite (Ti 1.5 to 14%) and magnetite (Ti 0%). Ilmenite accounted for all or the majority of opaque minerals in the center to northeast part of the Preobrazhenskiy composite rock mass, whereas the part of the rock mass from its center to the northwestern flank was distributed with rock bodies which showed higher contents of titanic magnetite and magnetite than ilmenite. The magnetic susceptibility of this part was 1×10^{-3} (S.I.U.) or higher (See Fig. II-2-4.). In case rock mass that contains more titanic magnetite and magnetite is placed in the hinterland of a drift-sand ore bed, the proportion of ilmenite among heavy minerals in a formed drift-sand ore bed is believed small, while possibilities for formation of an ore bed with a low Ti content would be high.

Tsusue et al. surveyed opaque minerals in granitic rocks of Japan (1974). Tsusue et al. found that Fe-Ti oxide minerals in granitic rocks in the outer belt, Ryoke belt and Sanyo - Naegi belt were mainly ilmenite, that these Fe-Ti oxide minerals solution dissolved hematite end members up to 4 mol%, and that Fe-Ti oxide minerals in homogeneous rocks in the San-in - Shirakawa belt were mainly magnetite, accompanying magnetite that formed intergrowth with ilmenite, ilmenite that formed intergrowth with hematite and other minerals. These differences well harmonize with the regional distribution of magnetic susceptibilities (Ishihara, 1973). This survey area has a similarity in that differences of opaque minerals in granitic rocks can be discriminated by magnetic susceptibility.

2-3-6 Geological structure

The survey area is bordered by the Baladzhalskiy Fault running in the WNW-ESE direction on its northeastern flank and by the South Terektinskiy Fault on the southwestern flank. The Preobrazhenskiy composite rock mass intruded into the Bektimirskaya ridge anticline situated in the middle of them.

Cracks running in the NEN-SWS direction cut the Carboniferous Period layer made up of the Preobrazhenskiy composite rock mass and pre-granitic rocks. Palaeo-landform channels deposited with some ilmenite sand ore bodies were believed formed along these weak lines. These palaeo-landform channels change to the NW-SE direction near the Baladzhalskiy Fault running in the WNW-ESE direction and the South Terektinskiy Fault because of dominant cracks in the NW-SE direction.

The Tertiary-Period Aral Formation is a generally flat stratum and covers Preobrazhenskiy composite rock mass and pre-granitic rocks.

The Quaternary-Period layers are also generally flat strata and cover the Tertiary-Period Aral Formation. Recent rivers are located in locations that relatively well overlap with palaeo-landform channels of the Tertiary-Period Aral Formation bed rock.

2-4 Conclusions and Considerations

1) Geology

The order of stratification in the survey area consists of pre-granitic rocks (Carboniferous Period stratum), granitic rocks intruded into it, Aral Formation of the

Tertiary Period in the Cainozoic Era covering them without conformity and Quaternary-Period layer that covers all of them without conformity. Weathered crusts are widely developed in the bedrock of Aral Formation of the Neogene Period.

(1) Pre-granitic rocks

The geology in the area consists of sedimentary rocks (shale, sandstone and conglomerate), pyroclastic rocks and lava (andesite and porphyrite) of the Carboniferous Period. From the bottom, the layers are the Kokpekti layer of late Carboniferous Period (sedimentary rocks, pyroclastic rocks and limestone), Bukon layer of the mid-Carboniferous Period (conglomerate, sandstone and shale - the upper layer is shale, coaly shale, sandstone and tuffaceous sandstone), and Maityab layer of the mid-early Carboniferous Period (andesitic porphyritesand wiching tuff and tuffaceous sandstone, andesite and, rarely, basaltic and diabasic porphyrite). The solidification indexes of pyroclastic rocks and lava were 18 or higher and differentiation indexes of them, below 50. As an opaque mineral, magnetite was contained more than 1%.

(2) Granitic rocks

The area is distributed with Preobrazhenskiy composite rock mass that is considered to have intruded in the early part of the Permian Period to the mid-Jurassic Period. The rock mass is ilmenite-series granitic rocks of Type S. Chemical composition analysis classifies it into granite and monzonite - diorite.

Granite is the bulk of the Preobrazhenskiy rock mass. It is rich in SiO_2, Na_2O and K_2O, but is lean in FeO, MgO and CaO. The solidification index of it is below 3, while the differentiation index is 80 or higher. It contains only less than 1% of TiO_2. Monzonite - diorite partially distribute near the center of the Preobrazhenskiy rock mass. They conversely are lean in SiO_2, Na_2O and K_2O, but is rich in FeO, MgO and CaO. The solidification indexes of them are higher than 10, while the differentiation indexes are 60 or less. They contain more than 1% of TiO_2. It can be said that TiO_2 becomes lean higher the magma crystallization differentiation is.

The rare earth pattern of granitic rocks containing less than 1% of TiO_2 is almost linear, while that of monzonite - diorite containing more than 1% of TiO_2 becomes a polygon with a concave with Eu. This shows that granite and monzonite - diorite can be discriminated clearly in trace components also.

Opaque-mineral modal ratios of granitic rocks are 0.7% or less with granite and 1% or more with monzonite - diorite. Opaque minerals are ilmenite (Ti 35%), titanic magnetite (Ti 1.5 to 14%), and magnetite (Ti 0%). More magnetite and titanic magnetite than ilmenite are contained in granitic rocks that show a magnetic susceptibility of 1×10^{-3} S.I.U. or higher, showing the characteristics of magnetite-series granitoid. Rock masses showing a magnetic susceptibility of 1×10^{-3} S.I.U. or higher are distributed in the northwestern flank of the Preobrazhenskiy composite rock mass.

Regarding opaque minerals in granitic rocks of Japan, Fe-Ti oxide minerals in granitic rocks in the outer belt, Ryoke belt and Sanyo - Naegi belt are mainly ilmenite, solution-dissolving hematite end members. On the other hand, Fe-Ti oxide minerals in homogeneous rocks in the San-in - Shirakawa belt were mainly magnetite, accompanying magnetite that formed intergrowth with ilmenite, and ilmenite that formed intergrowth with hematite. These differences well harmonize with the regional distribution of magnetic susceptibilities. This survey area has a similarity in that differences of opaque minerals in granitic rocks can be discriminated by magnetic susceptibility. Fe-Ti oxide minerals crystallize from granitic magma most early and magma in a more oxidized state is said to crystallize magnetite. (Tsusue et al. 1974 and 1976, Ishihara et al. 1977) The Preobrazhenskiy intrusive rock mass intruded into a stratum of the Carboniferous Period that was relatively rich in carbon. It is estimated that magma started to solidify in the early phase of intrusion under a condition of relatively low oxygen partial pressure.

(3) Bed-rock weathered crust

Bedrock weathered crusts are clayey weathered remnants that were developed on sedimentary rocks, volcanic rock and intrusive rock of the Carboniferous Period in thickness of 10 to 20m. They are covered by the Aral Formation of the Neogene Period and Quaternary-Period layer. They are strongly influenced by kaolin, sericite and smectite. Bed-rock weathered crusts are believed formed by chemical weathering of moist and warm climate at the end of early Cretaceous Period (about 140 million years ago)

(4) Tertiary-Period Aral Formation

The Tertiary-Period Aral Formation covers pre-granitic rocks and intrusive rocks, as well as their weathered crusts, without conformity. The formation is covered without conformity by the layer of the Quaternary Period. The formation is 20 to 50m in thickness. The layer consists of clay, sandy clay and clayey sand comprising quartz, kaolin, smectite and a small amount of sericite. The rarely contains gravel beds.

Ilmenite drift-sand ore beds are deposited in sandy clay to clayey sand that is located as narrow seams in the bottom or parts near the bottom of this layer.

(5) Quaternary-Period layer

The Quaternary-Period layer consists of gravel, loam, clay and Recent riverbed sediments of the Diluvium 5 to 10m in thickness that cover without conformity the Neogene-Period Aral Formation and directly pre-granitic rocks and intrusive rock.

2) Geological Structure

The survey area is bordered by the Baladzhalskiy Fault on its northeastern flank and by the South Terektinskiy Fault on the southwestern flank. The Preobrazhenskiy composite rock mass intruded into the Bektimirskaya ridge anticline situated in the middle of them.

The cracks running in the NEN-SWS direction cut the Carboniferous Period layers made up of the Preobrazhenskiy composite rock mass and pre-granitic rocks. Palaeo-landform channels deposited with some ilmenite sand ore bodies were believed formed along these weak lines. These palaeo-landform channels change to the NW-SE direction near the Baladzhalskiy Fault running in the WNW-ESE direction and the South Terektinskiy Fault because of dominant cracks in the NW-SE direction.

The Tertiary-Period Aral Formation is a generally flat stratum and covers Preobrazhenskiy composite rock mass and pre-granitic rocks.

The Quaternary-Period layers are generally flat strata and cover the Tertiary-Period Aral Formation. Recent rivers are located in locations that relatively well overlap with palaeo-landform channels of the Tertiary-Period Aral Formation bed rock.

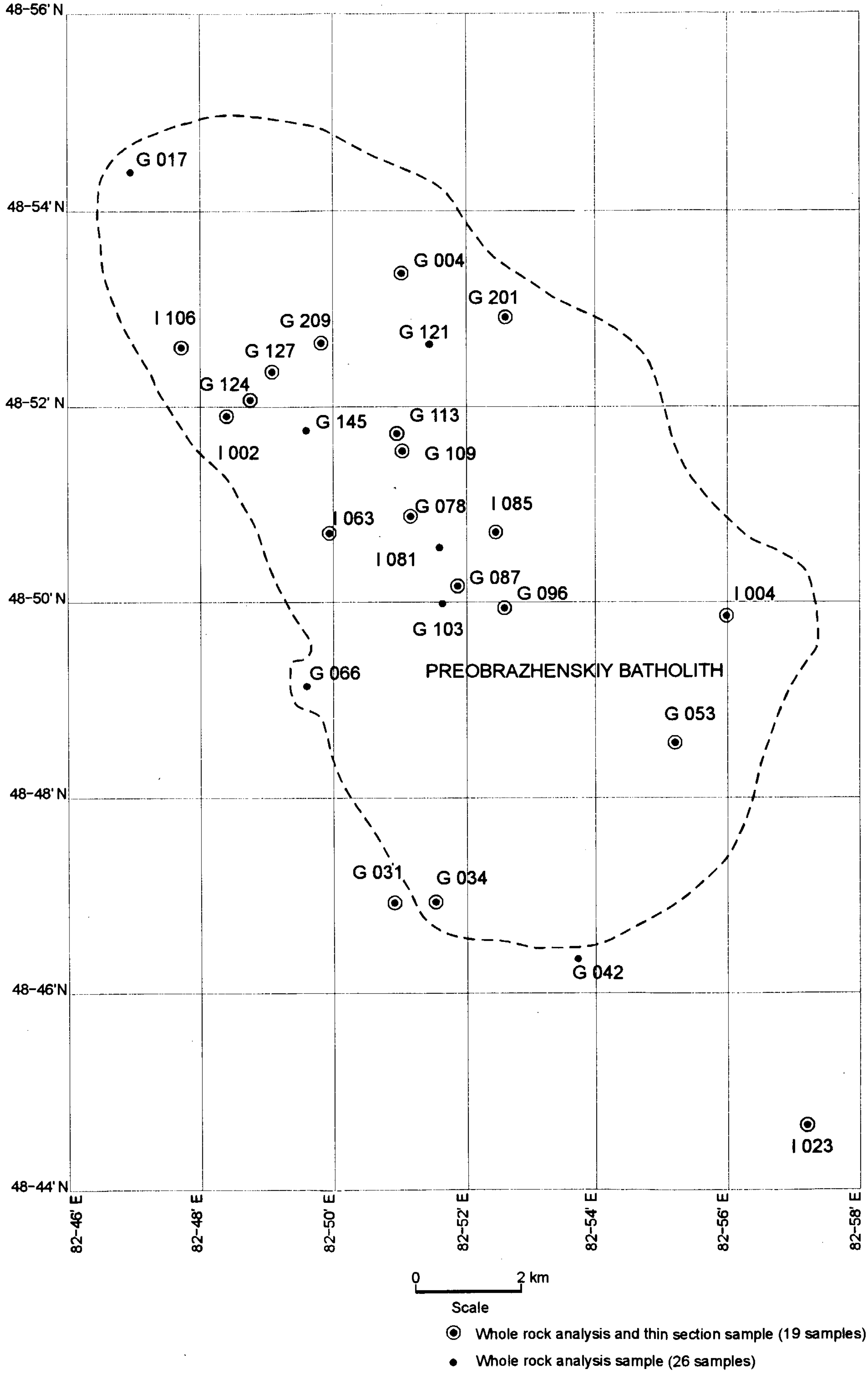


Fig.II-2-1 Location Map of the Samples

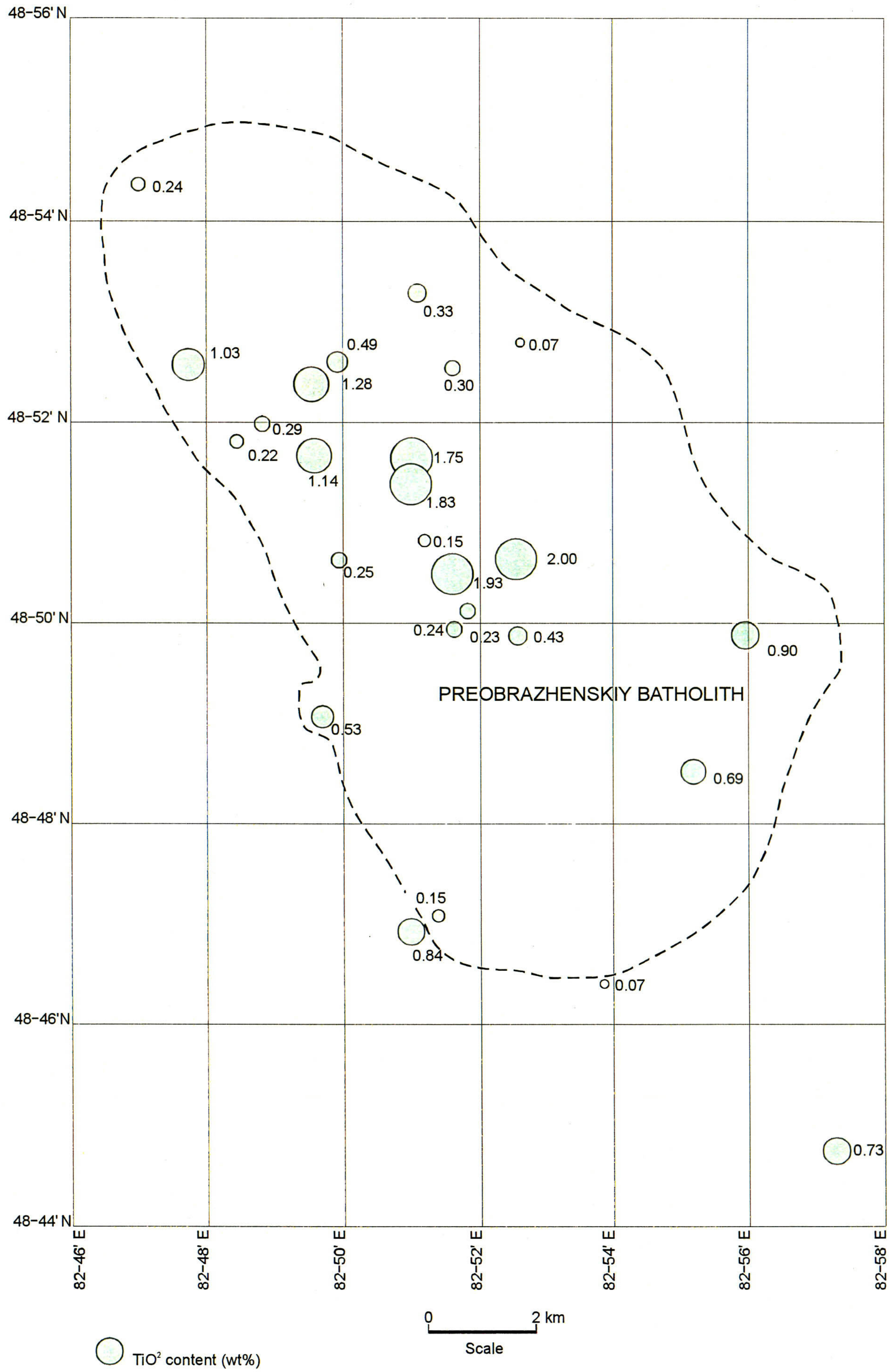


Fig.II-2-2 TiO_2 Content in Granitoids

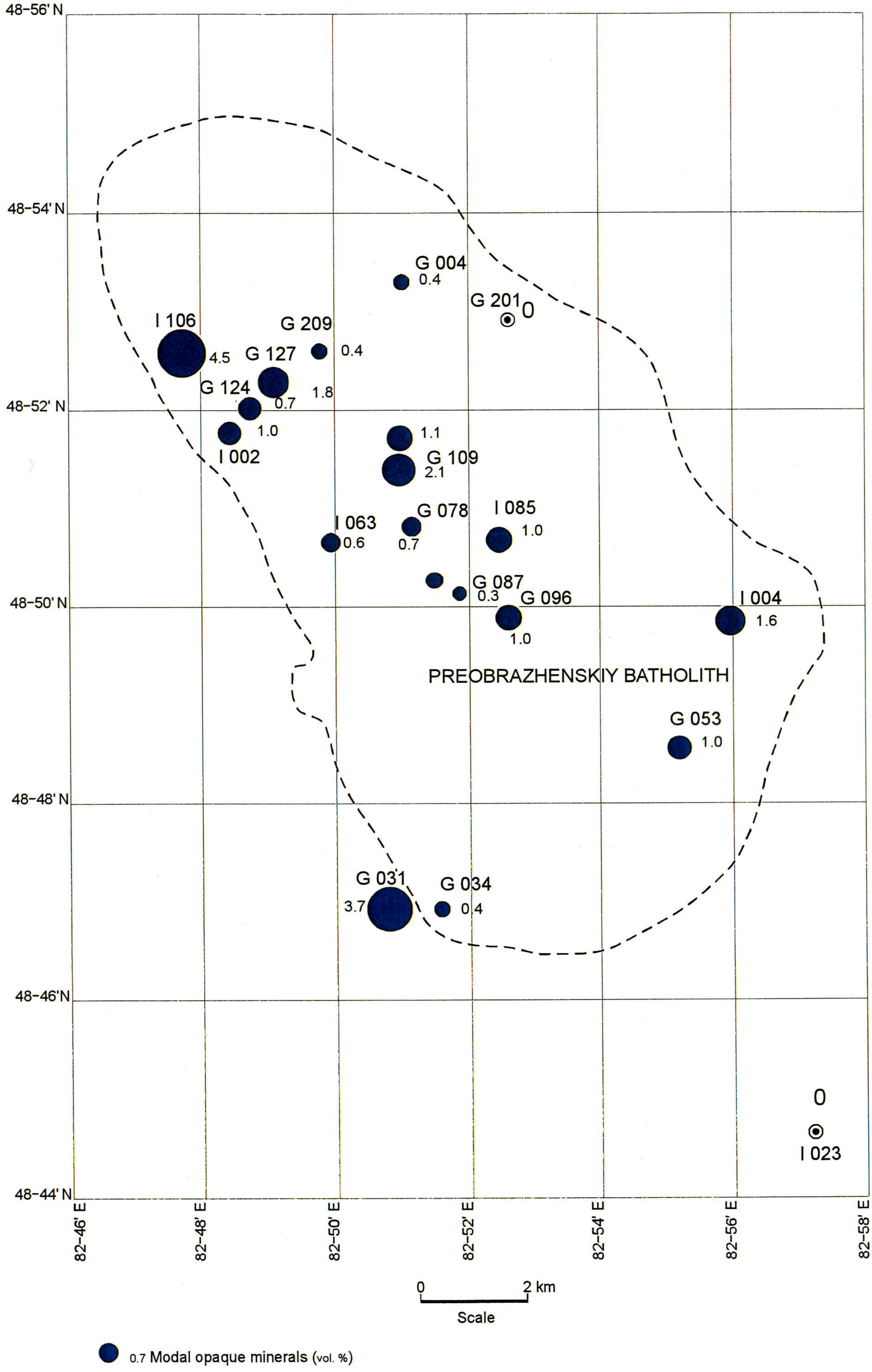


Fig.II-2-3 Modal Opaque Minerals in Granitoids

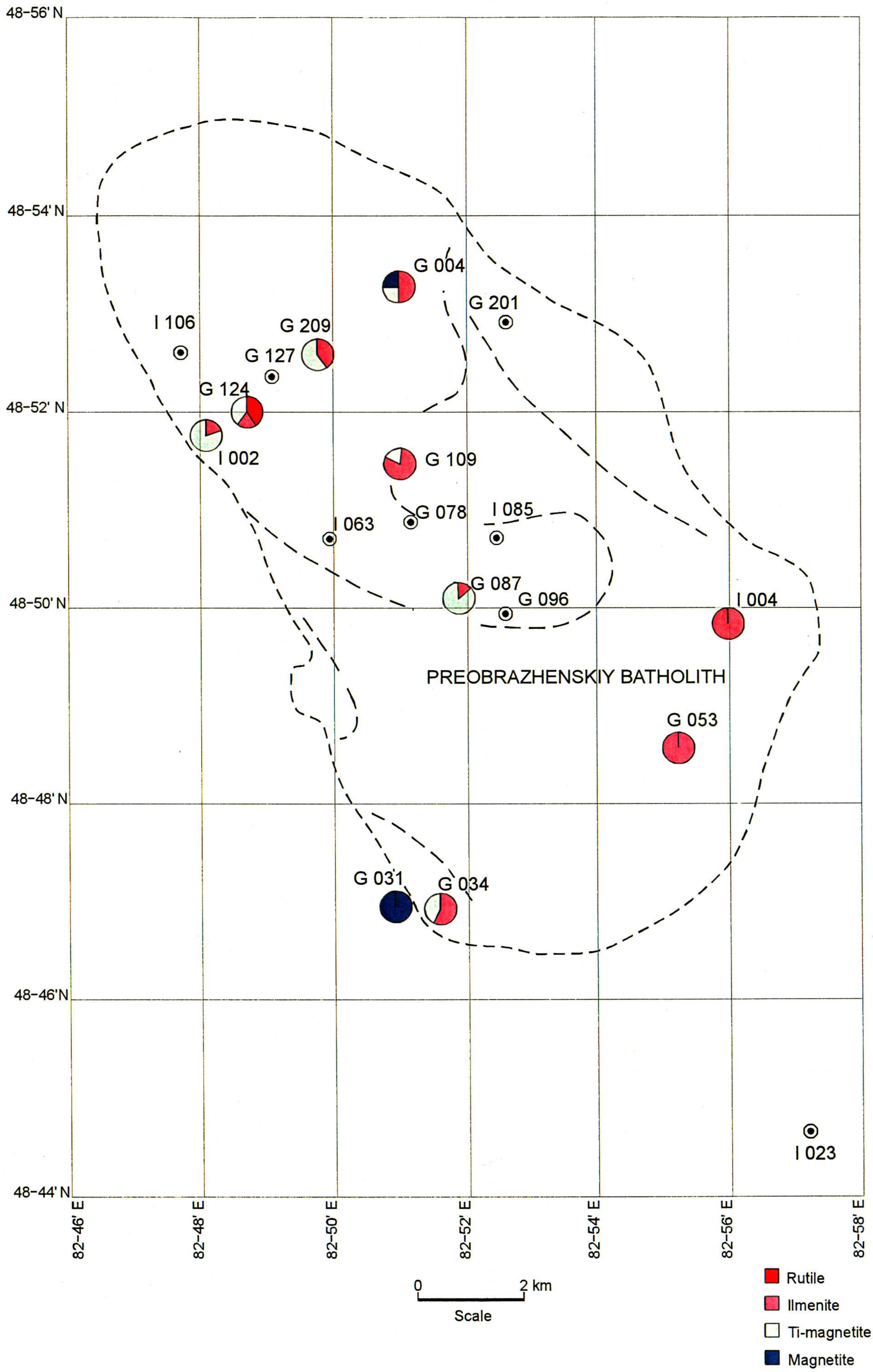


Fig.II-2-4 Distribution of Opaque Mineral Species in Granitoids

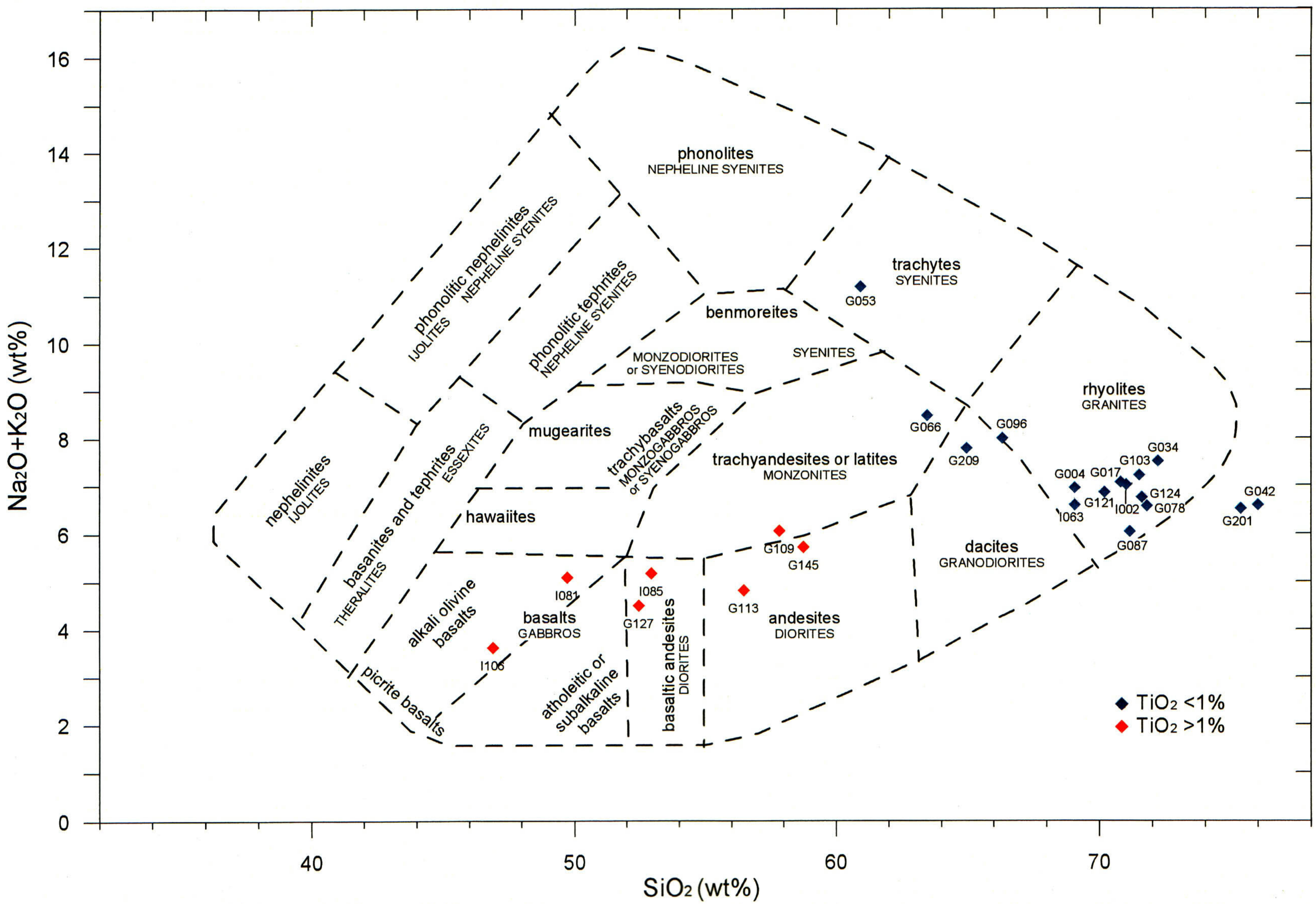


Fig.II-2-5 SiO_2-Na_2O+K_2O Diagram (after Cox et al., 1979)

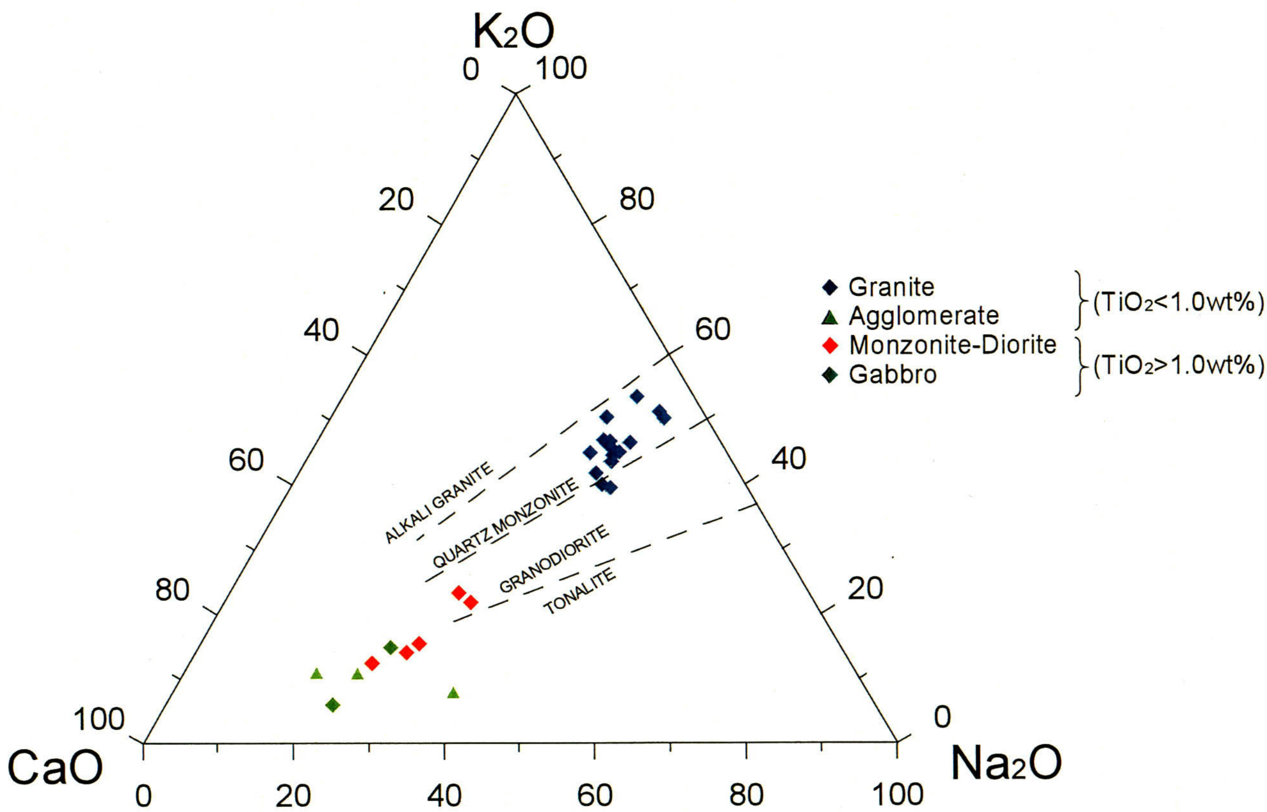


Fig.II-2-6 K_2O-CaO-Na_2O Diagram

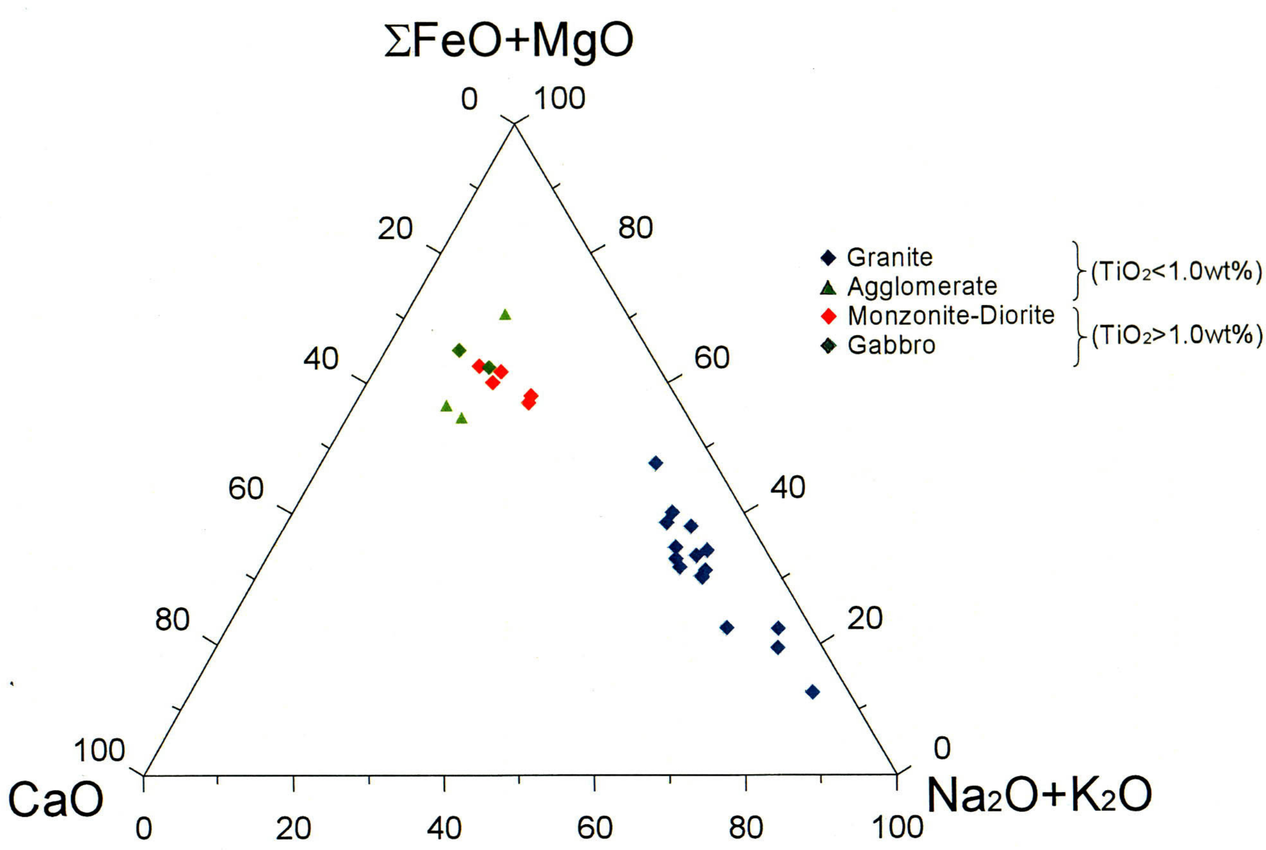


Fig.II-2-7 AFM($\Sigma FeO+MgO$-CaO-Na_2O+K_2O) Diagram

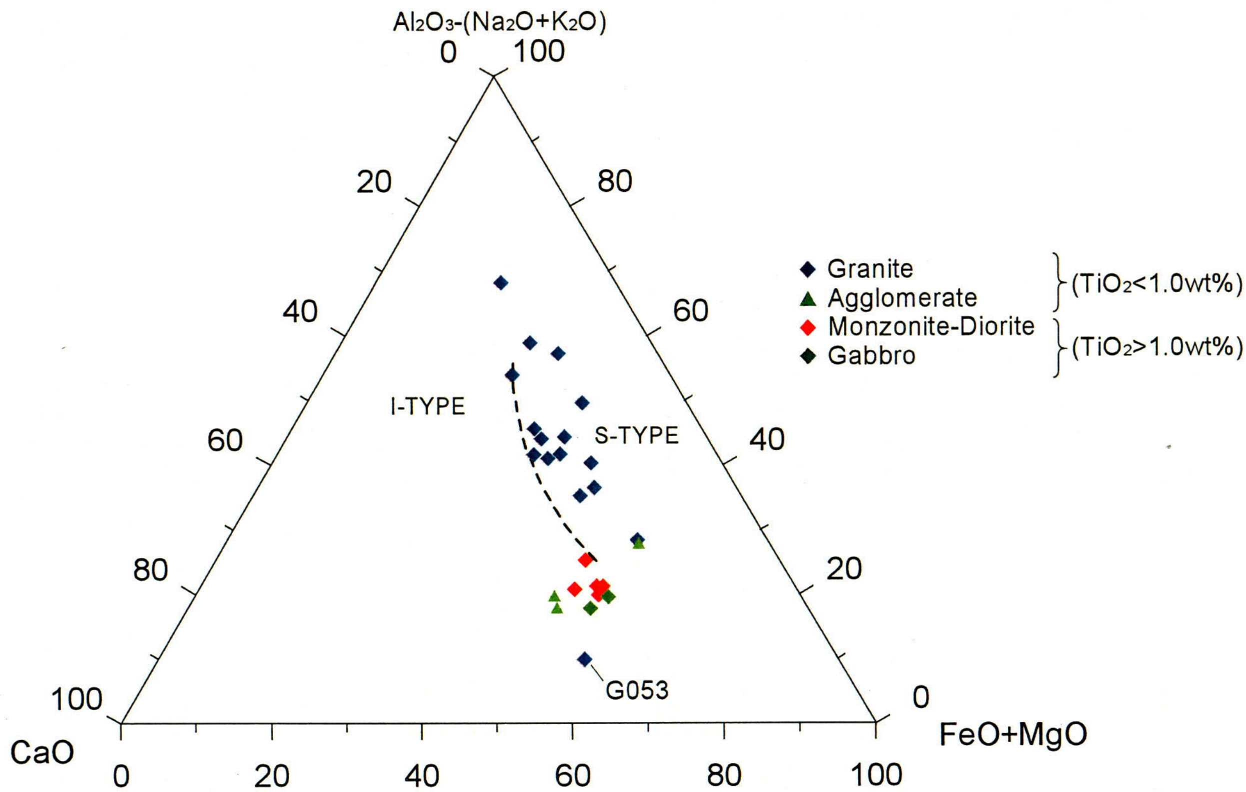


Fig.II-2-8 ACF Diagram

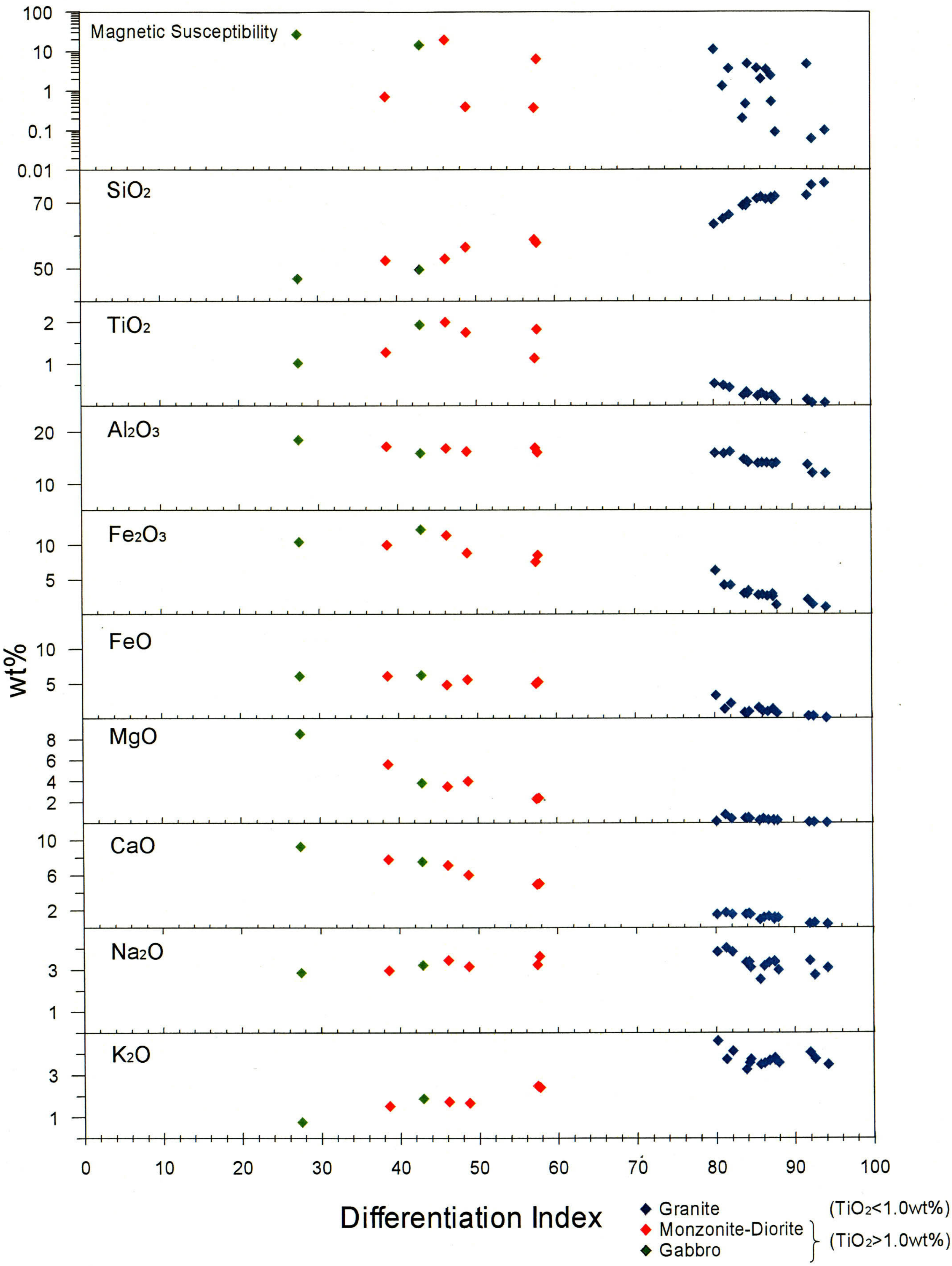


Fig.II-2-9 Differentiation Index (D.I.)-Oxide Variation Diagram

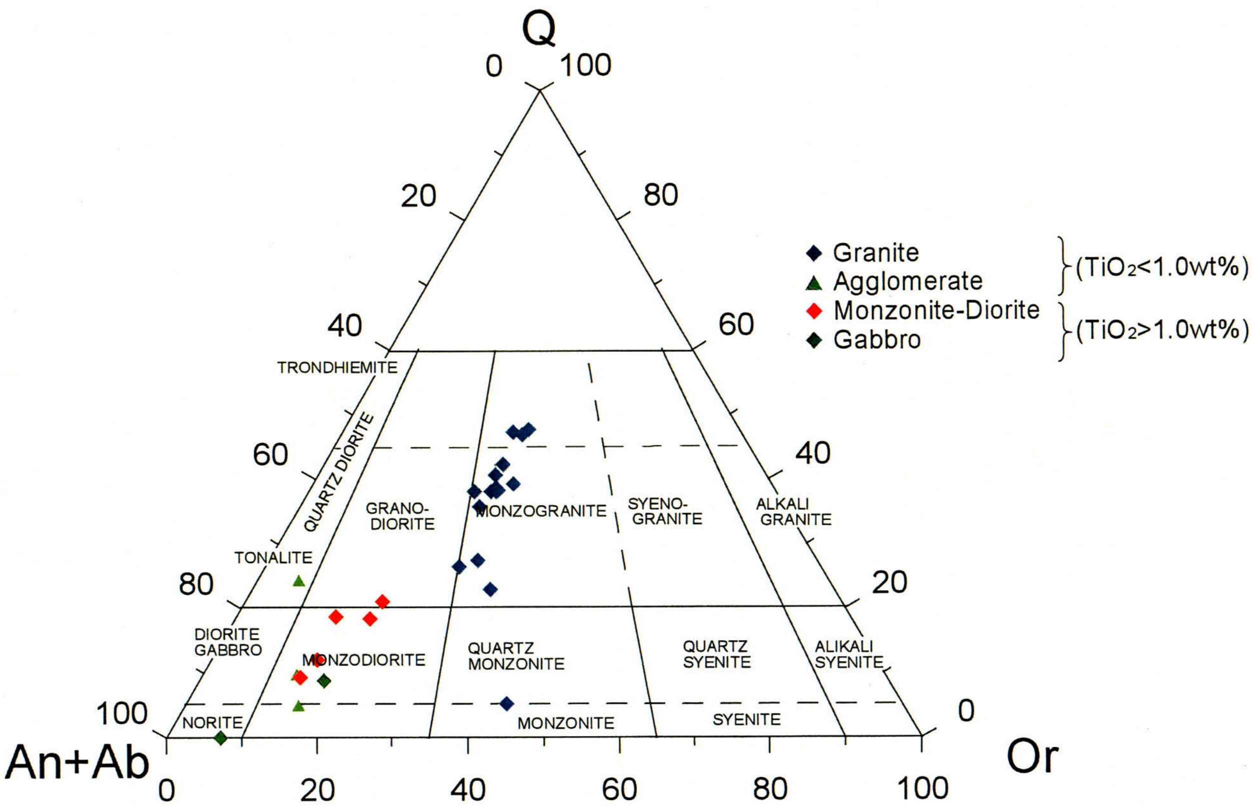


Fig.II-2-10 An+Ab-Or-Q Diagram

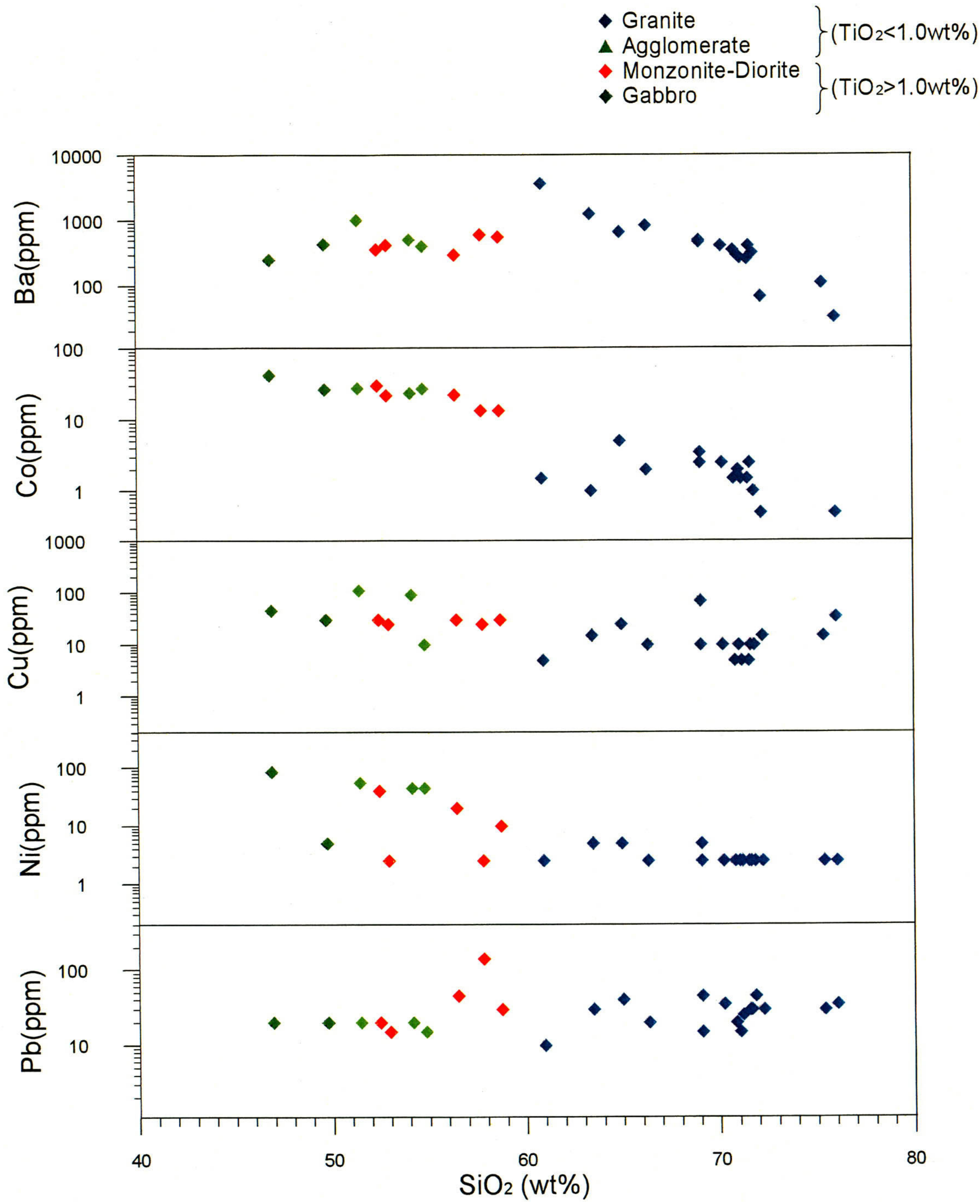
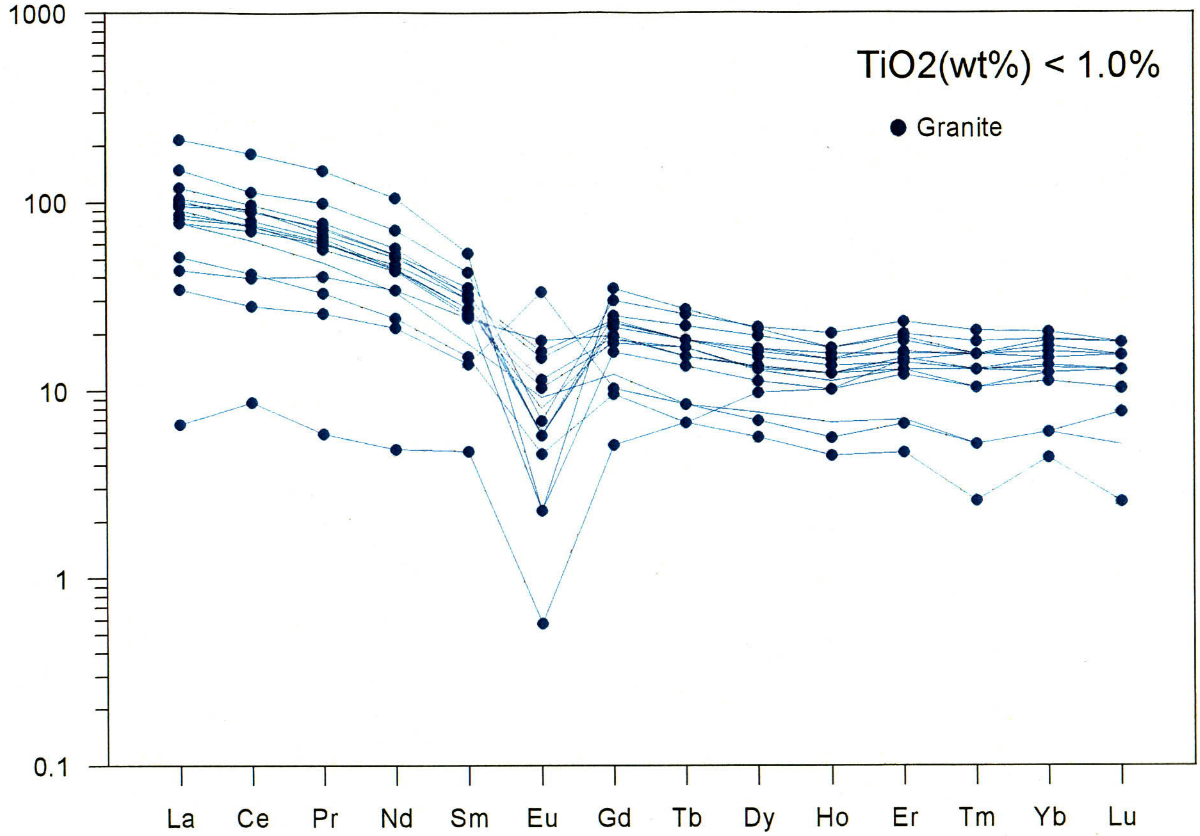


Fig.II-2-11 Minor Element-SiO_2 Variation Diagram



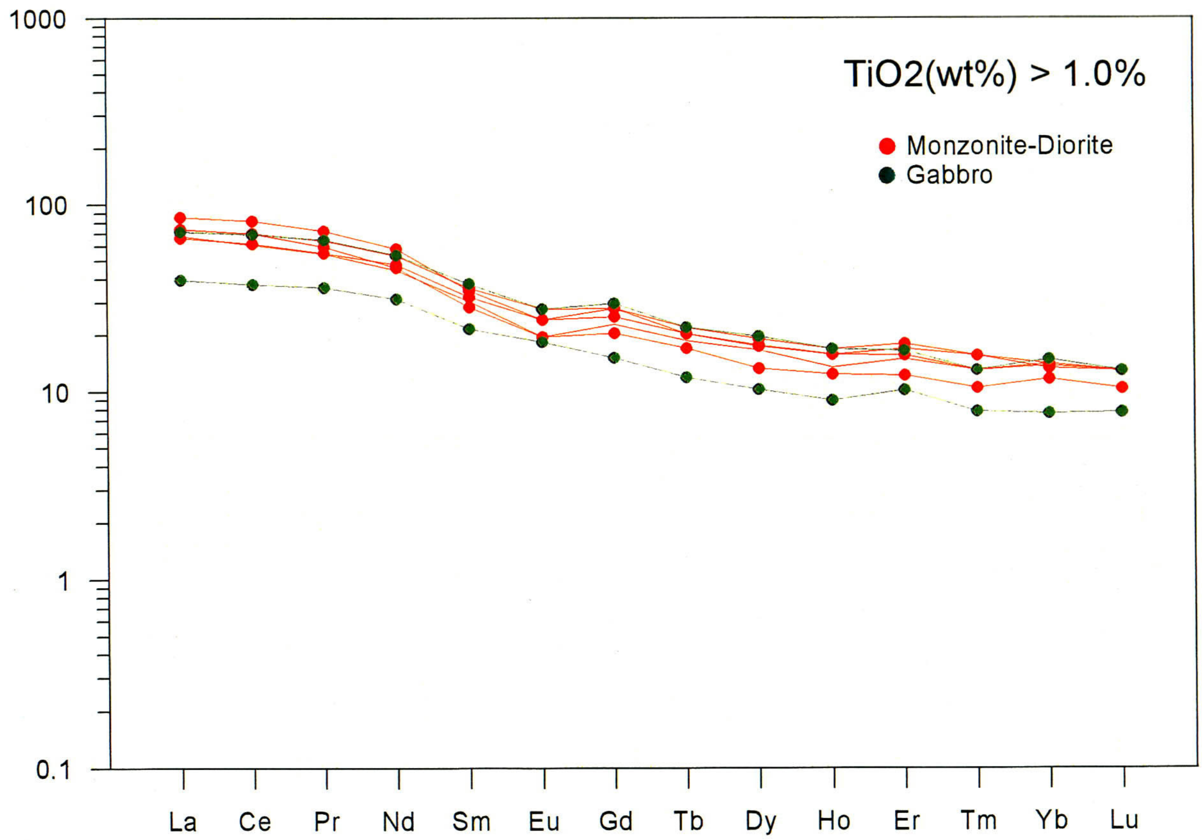


Fig.II-2-12 Chondrite-Normalized REE Pattern

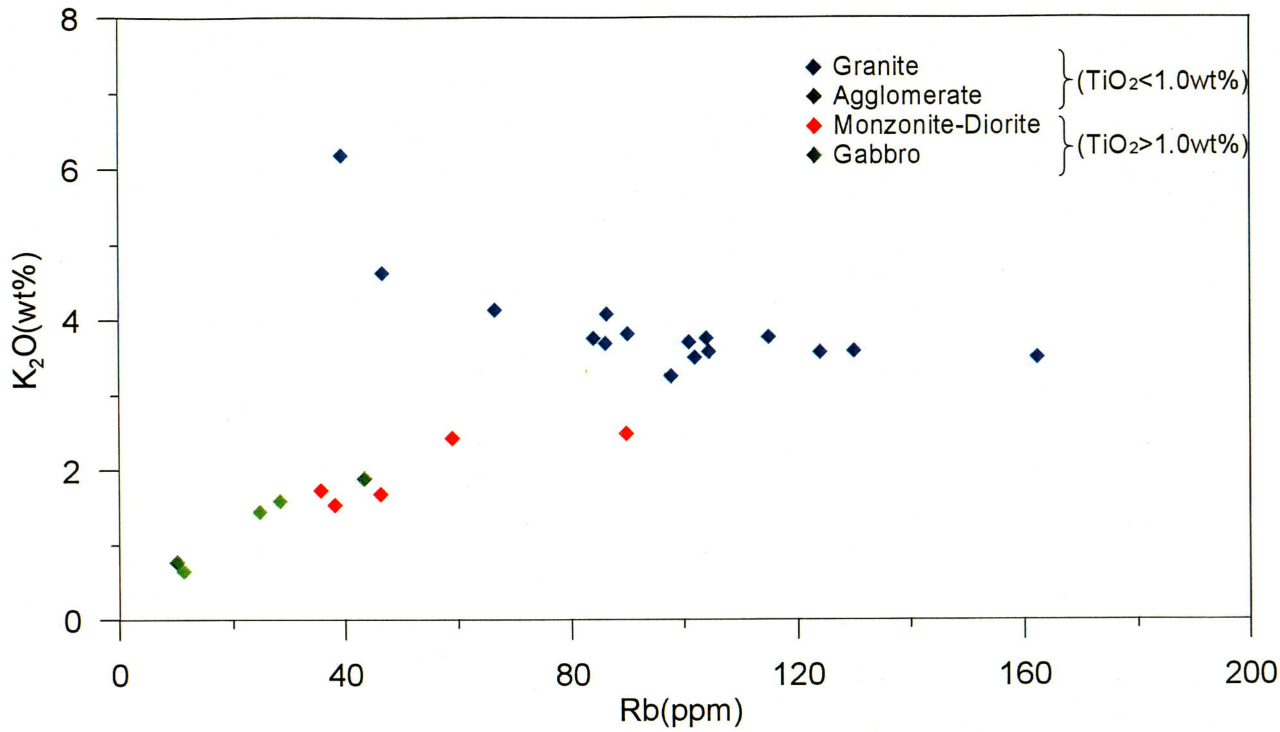


Fig.II-2-13 K_2O-Rb diagram

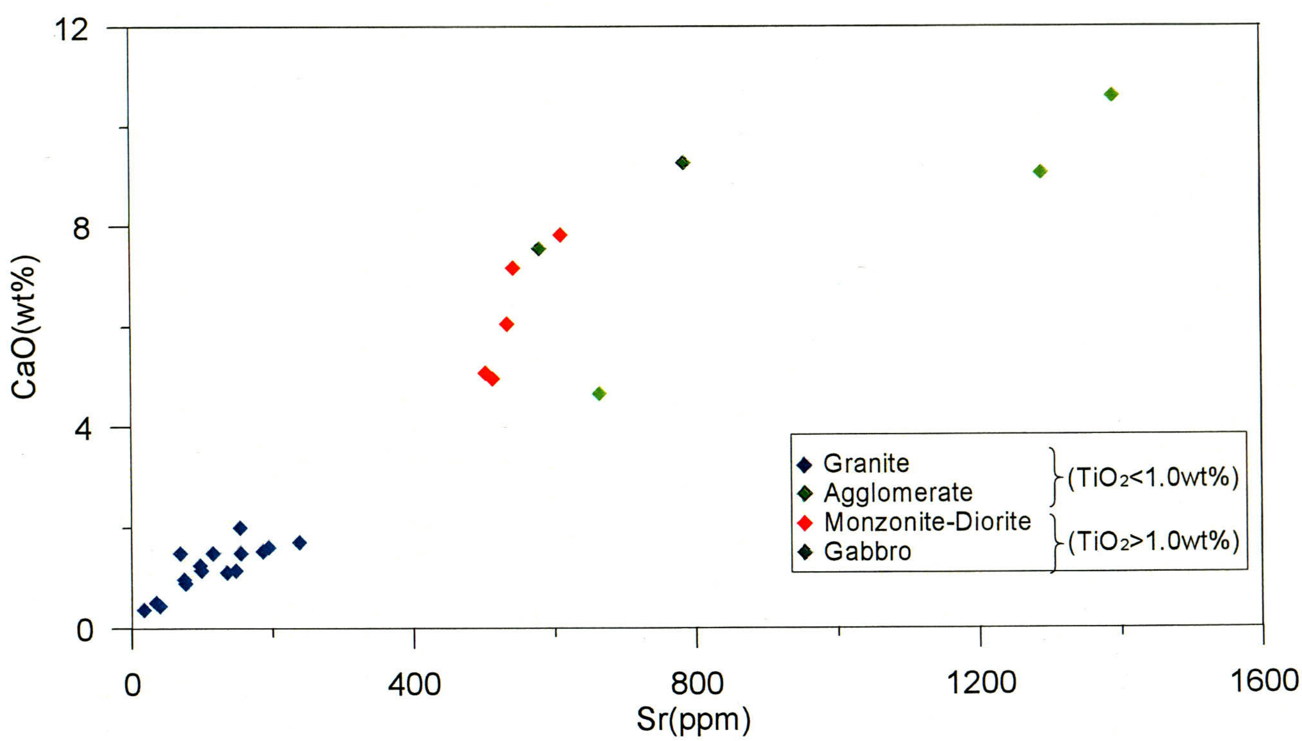


Fig.II-2-14 CaO-Sr diagram

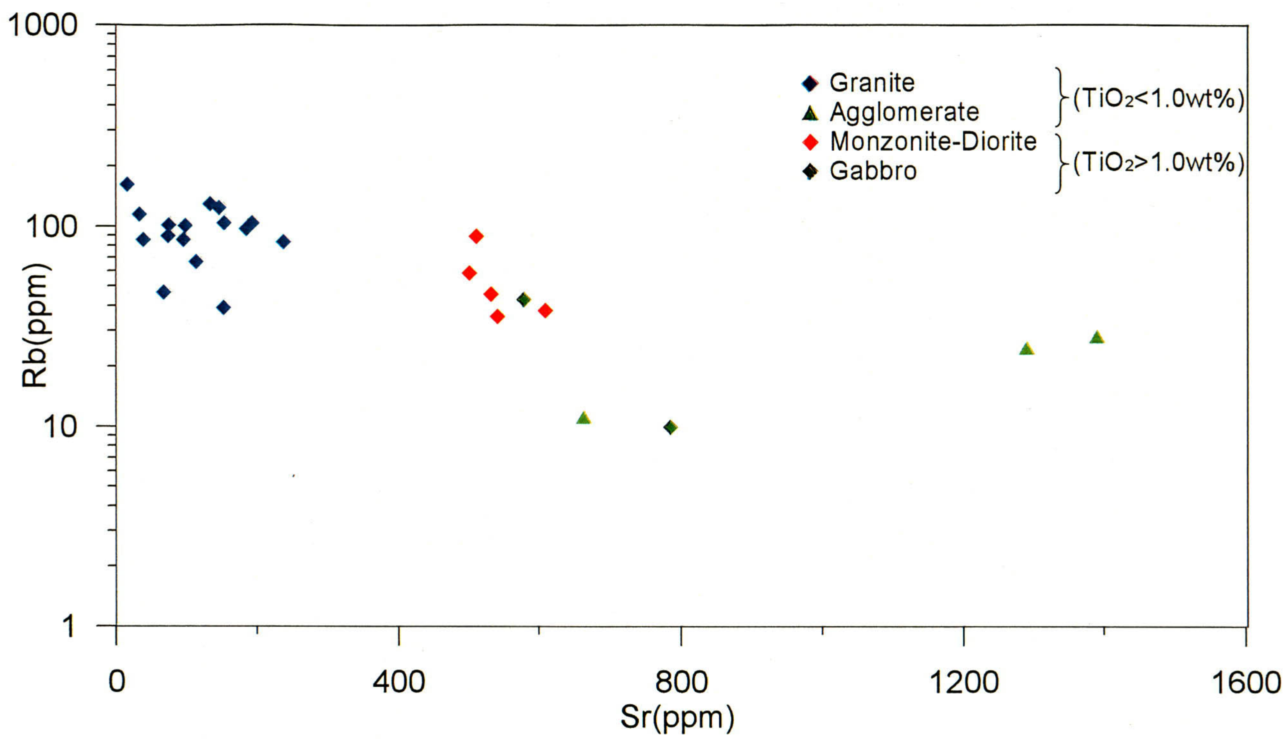


Fig.II-2-15 Rb-Sr diagram

Chapter 3 Drilling Survey

3-1 Purposes of the Survey

The boring survey was conducted to capture ore beds in an area on the southern extensions of Bektimir Placers No. 1 and 3, which are known ore beds. The survey was undertaken to grasp the development status of ore beds and to confirm ore reserves, as well as to capture orders of stratification and ore beds near the northwestern flank of the Preobrazhenskiy composite rock mass in the northern flank of Bektimir. Another purpose of the survey was to determine the development status of these ore beds.

3-2 Method of the Survey

1) Outline of Work

Using the personnel and equipment procured by a local boring company, GEOINCENTER, boring work was undertaken in 20 pits in the southern flank of Bektimir Placer No. 1 (detailed survey area) totaling 1,033.0m in drilling length, in 25 pits in the southern flank of Bektimir Placer No. 3 (reconnaissance survey area) totaling 903.5m in drilling length and in 5 pits in the southern flank (reconnaissance survey area) totaling 335.0m in drilling length.

The locations of the boring pits are shown in Figs. II-3-1 and 2.

Table II-3-1 summarizes the drilling length, core recovery rate and efficiency for each pit. Drilling work hours, consumables spent and other information related to the boring work are summarized in Tables II-3-2 to 5. Main machines and equipment, work results of each pit and process flow are summarized in Appendixes 3-1 to 3-3.

(1) Southern Flank of Bektimir Placer No. 1 (Detailed Survey District)

Drilling was conducted in 20 pits along six traverse lines (Traverse Lines 34, 30, 26, 22, 18 and 14) in a grid of 500×200m over 2.5km on the southern flank of the confirmed III-C_2 Ore Reserves Block of Bektimir Placer No. 1. The boring lengths totaled 1,033.0m.

Two percussion-type drilling rigs manufactured in Russia (model UGB-3UK) were used.

As a rule, drilling was performed two shifts per day, working eight hours per shift. When the drilling were installed and removed, work was performed only one shift per day.

The personnel per team were one engineer, two machine leaders, three assistants, one foreman and two workers for water carrying, totaling nine persons.

The boring rig and equipment were moved and installed using a truck and tractor.

The surface soil and gravel layer mixed with cobblestone was drilled by a bailer 240mm in diameter, and 10” casing pipes were driven and inserted. The drilling work in Year 2 was difficult as many calcretes, which had gravel hardened with lime carbonate, emerged. Clay, clayey sand and weathered crusts of the Aral Formation were drilled by the percussion method driving a sampler 190mm in diameter.

The boring work was performed from July 2 to August 31, 2001, or 61 days in total.

(2) Southern Flank of Bektimir Placer No. 3 (Reconnaissance Survey District)

Drilling was conducted in 25 pits along Traverse Lines 1G, 2G and 3G and with Traverse Lines 114G and 116G, which crossed them orthogonally, at spacings of 400 or 600m totaling 903.5m.

One rotary-type drilling rig manufactured in Russia (model UGB-2A-2) was used.

As a rule, drilling was performed two shifts per day, working eight hours per shift. When the drilling were installed and removed, work was performed only one shift per day.

The personnel per team were one engineer, two machine leaders, three assistants, one foreman, one mechanic and two workers for water carrying, totaling ten persons.

The boring rig and equipment were moved and installed using a truck and tractor.

Drilling mud was carried to the site by a 2m^3 tank lorry.

The surface soil and gravel layer mixed with cobblestone was drilled by the ordinary rotary drilling method using a 4” Tricone bits. Drilling was performed by circulating bentonite and 127mm casing pipes were driven and inserted. Clay, clayey sand and weathered crusts of the Aral Formation were drilled by the ordinary rotary drilling method using a 92mm-diameter metal bit while circulating bentonite drilling mud.

The boring work was performed from July 2 to August 11, 2001, or 41 days in total.

(3) Bektimir Northern Placer (Reconnaissance Survey District)

Drilling was conducted in 5 pits along one traverse line at spacing of 1,000 totaling 335.0m.

One rotary-type drilling rig manufactured in Russia (model UGB-2A-2) was used.

As a rule, drilling was performed two shifts per day, working eight hours per shift.

When the drilling were installed and removed, work was performed only one shift per day.

The personnel per team were one engineer, two machine leaders, three assistants, one foreman, one mechanic and two workers for water carrying, totaling ten persons.

The boring rig and equipment were moved and installed using a truck and tractor.

Drilling mud was carried to the site by a $2m^3$ tank lorry.

The surface soil and gravel layer mixed with cobblestone was drilled by the ordinary rotary drilling method using a 4" Tricone bit. Drilling was performed by circulating bentonite and 127mm casing pipes were driven and inserted. Clay, clayey sand and weathered crusts of the Aral Formation were drilled by the ordinary rotary drilling method using a 92mm-diameter metal bit while circulating bentonite drilling mud.

The boring work was performed from August 12 to 25, 2001, or 14 days in total.

3-3 Survey Findings

3-3-1 Geology

1) Bed-Rock Weathered Crust ($C_{2\text{-}3}$mt)

Bed-rock weathered crusts are weathered crusts developed on sedimentary rocks, volcanic rocks and intrusive rocks of the Carboniferous Period by chemical weathering in tropical moist climate in the latter part of the Cretaceous Period (Denmark Epoch, about 140 million years ago). (Erofeyev, 1969)

Weathered crusts that made sandstone and shale of the Bukon layer (C_2bk) of the mid-Carboniferous Period distributed in southwest of the Preobrazhenskiy composite rock mass as source rocks could be found in the boring survey area. Weathered crusts are fragile and are bleached and discolored to grayish white with a brownish tint. When wet, weathered crusts can be crushed easily by hand. Only stratification structures are sometimes left, but their complete structures are generally unclear. Boundaries with the Aral Formation of the Tertiary Period, which covers weathered crusts without conformity, often move slowly.

According to powder X-ray diffraction analysis, these weathered crusts are mainly composed of kaolin, sometimes mixing smectite and sericite. Small amounts of plagioclase and potassium feldspars sometimes accompany them (See Appendix 2-4.). Shallow weathering is caused by physical and biological weathering action on the upper part of the surface based on changes of climatic conditions on the ground surface so that an interstitial surface, through which interstitial water can easily move is formed. Chemical reaction between surface water and rock causes oxidation, reduction and carbonization and soluble substances precipitate, erode and reprecicipate (Shoji, 1971). Through this process, potassium feldspars in granitic rocks change to kaolin and chemical weathering would be performed imperfectly, generating illite when some portion of K is still left.

2) Aral Formation of Tertiary Period ($N_1^{1-2}ar$)

The Aral Formation of the Tertiary Period covers weathered crusts without conformity and is covered widely by Quaternary-Period layers. Sedimentation is believed started beginning around the Oligocene Epoch of the Tertiary Period (about 40 million years ago). (Erofeyev, 1969)

This layer is 20 to 50m in thickness and consists of clay, sandy clay and clayey sand layer, rarely containing gravel layers of narrow seams. In a wet condition, this layer is slightly soft and is fluid. When it is dry, it checks and cracks, becoming fragile. Based on rock facies, the formation is divided into lower and upper beds.

Lower bed: The lower bed is made up of dense and light gray clayey fine sand and dark gray sandy clay, sometimes sandwiching light gray sand layers of fine grains to coarse grains. Dark gray sandy clay is dense and is similar to paddy soil. It contains organic substances and wooden fragments. Sand layers are 1 to 10m in thickness and are located thinly directly above unconformity planes or 4 to 15m above unconformity planes. Some parts are contaminated brown by limonite dissemination or nodules of small lumps. Quartz subrounded gravel is often contained in the base. Light gray sand layers accompany thickened ilmenite seams and contain ilmenite drift-sand ore beds. According to powder X-ray diffraction analysis, sandy clay layers contain large amounts of quartz and plagioclase, medium amounts of kaolin and smectite, and small amount of sericite. Light gray sand layers are made up of a large amount of quartz, a medium amount of kaolin, and sometimes plagioclase. Smectite is contained only occasionally.

Upper bed: This layer consists of dense clay in various colors, brownish gray, light reddish brown and yellowish gray. It is characterized by limonite contamination, limonite in a vein form, and oolith of manganese hydroxide 3 to 5mm in diameter. In powder X-ray diffraction analysis, a medium amount of kaolin is accompanied in a large amount of quartz, frequently containing smectite and a small amount of plagioclase.

3) Quaternary-Period Layer (Q)

This layer is 5 to 10m in thickness and is composed of unsolidified cobblestone, gravel and silt and widely covers the Aral Formation of the Tertiary Period without conformity. Gravel kinds are mostly shale and sandstone of the Carboniferous Period. The southern flank of Bektimir Placer No. 1 contains calcretes, which are less than 2m in thickness and have gravel hardened with lime carbonate, in depths of about 10m. This layer does not contain prominent thickened ilmenite seams. However, some parts of the Bektimir Placer No. 2 accompany thickened ilmenite seams in the base of this layer (Geoincentre, 1999).

3-3-2 Southern Flank of Bektimir Placer No. 1

Drilling was conducted in 20 pits along six traverse lines (Traverse Lines 34, 30, 26, 22, 18 and 14) in a grid of 500×200m over 2.5km on the southern flank of the confirmed III-C_2 Ore Reserves Block of Placer No. 1. The boring lengths totaled 1,033.0m.

The results of the boring survey are shown in geological cross sections of the boring area (Figs. II-3-3 to 6).

The ore bed is contained in a wide palaeo-landform channel in the Aral Formation bed rock in the NEN-SWS direction. Two more channels exist inside the palaeo-landform channel. Thickened ilmenite seams deposit directly on the bedrock in the eastern flank. Part of the western flank of the ore bed is contained in the bottom of the Aral Formation. The ore bed captured in boring measured 1.8 to 10.0m in thickness. The ilmenite content was 94 to 216kg/m^3. The overburden on the ore bed was 25 to 53m in thickness.

Regarding Traverse Lines 34 and 30, the results of MJBK-19 and MJBK-24 confirmed deterioration in ore bed thickness and grade on the western flank of the ore body (1.6m× 23.44kg/m^3, 1.3m × 119.46kg/m^3). Closure of the ore bed could be determined. Regarding Traverse Lines 30 and 26, the results of MJBK-20 and MJBK-25 confirmed deterioration in ore bed thickness and grade on the eastern flank of the ore body (3.2m× 55.82kg/m^3, 1.5m×50.04kg/m^3). MJBK-37 (no signs of ore bearing) confirmed the southern limit of thickened ilmenite seams and a change in the ore bed extension direction from NEN-SWS to NW-SE could be estimated.

1) MJBK-18 (Direction -, inclination -90°, drilling length 33.0m) (Line 34)

(1) Geology

The geology consisted of a gravel layer mixed with surface soil and cobblestone from the well-head to the depth of 6.50m, clay of the Aral Formation between the depths of 6.50 and 28.50m, and weathered crusts between the depth of 28.50m and pit bottom.

(2) Thickened ilmenite seam

As shown in Fig. II-3-2, a thickened ilmenite seam (thickness 3.50m, ilmenite content 215.79kg/m^3) could be captured between the depths of 25.00 and 28.50m.

2) MJBK-19 (Direction -, inclination -90°, drilling length 44.0m) (Line 34)

(1) Geology

The geology consisted of a gravel layer mixed with surface soil and cobblestone from the well-head to the depth of 7.50m, clay, sandy clay and clayey sand of the Aral Formation between the depths of 7.50 and 42.00m, and weathered crusts between the depth of 42.00m and pit bottom.

(2) Thickened ilmenite seam

The main thickened ilmenite seam is shown in Table II-3-6.

As shown in Fig. II-3-2, a weak thickened ilmenite seam (thickness 1.60m, ilmenite content 23.445kg/m^3) could be captured between the depths of 28.00 and 29.60m.

3) MJBK-20 (Direction -, inclination -90°, drilling length 37.0m) (Line 30)

(1) Geology

The geology consisted of a gravel layer mixed with surface soil and cobblestone from the well-head to the depth of 7.40m, clay and sandy clay of the Aral Formation between the depths of 7.40 and 34.20m, and weathered crusts between the depth of 34.20m and pit bottom.

(2) Thickened ilmenite seam

The main thickened ilmenite seam is shown in Table II-3-6.

As shown in Fig. II-3-2, a weak thickened ilmenite seam (thickness 3.20m, ilmenite content 55.82kg/m^3) could be captured between the depths of 31.00 and 34.20m.

4) MJBK-21 (Direction -, inclination -90°, drilling length 43.0m) (Line 30)

(1) Geology

The geology consisted of a gravel layer mixed with surface soil and cobblestone from the well-head to the depth of 10.00m, clay and sandy clay of the Aral Formation between the depths of 10.00 and 41.20m, and weathered crusts between the depth of 41.20m and pit bottom.

(2) Thickened ilmenite seam

The main thickened ilmenite seam is shown in Table II-3-6.

As shown in Fig. II-3-3, a thickened ilmenite seam (thickness 3.70m, ilmenite content 128.45kg/m^3) could be captured between the depths of 37.50 and 41.20m.

5) MJBK-22 (Direction -, inclination -90°, drilling length 65.0m) (Line 30)

(1) Geology

The geology consisted of a gravel layer mixed with surface soil and cobblestone from the well-head to the depth of 9.00m, clay and sandy clay of the Aral Formation between the depths of 9.00 and 58.00m, redeposited weathered crusts between the depths of 29.90 and 34.00m, and weathered crusts between the depth of 58.00 and pit bottom.

(2) Thickened ilmenite seam

The main thickened ilmenite seam is shown in Table II-3-6.

As shown in Fig. II-3-3, a thickened ilmenite seam (thickness 5.00m, ilmenite content 190.68kg/m^3) could be captured between the depths of 37.80 and 42.80m.

6) MJBK-23 (Direction -, inclination -90°, drilling length 60.0m) (Line 30)

(1) Geology

The geology consisted of a gravel layer mixed with surface soil and cobblestone from the wellhead to the depth of 10.00m and clay, sandy clay and clayey sand of the Aral Formation between the depths of 10.00m and pit bottom.

(2) Thickened ilmenite seam

The main thickened ilmenite seam is shown in Table II-3-6.

As shown in Fig. II-3-3, a thickened ilmenite seam (thickness 1.90m, ilmenite content 167.40kg/m^3) could be captured between the depths of 38.10 and 40.00m.

7) MJBK-24 (Direction -, inclination -90°, drilling length 58.0m) (Line 30)

(1) Geology

The geology consisted of a gravel layer mixed with surface soil and cobblestone from the well-head to the depth of 8.00m, clay, sandy clay and clayey sand of the Aral Formation between the depths of 8.00 and 56.20m, and weathered crusts between the depth of 56.20m and pit bottom.

(2) Thickened ilmenite seam

The main thickened ilmenite seam is shown in Table II-3-6.

As shown in Fig. II-3-3, a thickened ilmenite seam (thickness 1.30m, ilmenite content 119.46kg/m^3) could be captured between the depths of 40.80 and 42.10m.

8) MJBK-25 (Direction -, inclination -90°, drilling length 43.0m) (Line 26)

(1) Geology

The geology consisted of a gravel layer mixed with surface soil and cobblestone from the well-head to the depth of 10.00m, clay, sandy clay and clayey sand of the Aral Formation between the depths of 10.00 and 39.50m, and weathered crusts between the depth of 39.50m and pit bottom.

(2) Thickened ilmenite seam

The main thickened ilmenite seam is shown in Table II-3-6.

As shown in Fig. II-3-4, a weak thickened ilmenite seam (thickness 1.50m, ilmenite content 50.04kg/m^3) could be captured between the depths of 37.00 and 38.50m.

9) MJBK-26 (Direction -, inclination -90°, drilling length 50.0m) (Line 26)

(1) Geology

The geology consisted of a gravel layer mixed with surface soil and cobblestone from the well-head to the depth of 10.00m, clay, sandy clay and clayey sand of the Aral Formation between the depths of 9.00 and 48.70m, and weathered crusts between the depth of 48.70m and pit bottom.

(2) Thickened ilmenite seam

The main thickened ilmenite seam is shown in Table II-3-6.

As shown in Fig. II-3-4, a thickened ilmenite seam (thickness 2.50m, ilmenite content 110.48kg/m^3) could be captured between the depths of 38.00 and 40.50m.

10) MJBK-27 (Direction -, inclination -90°, drilling length 50.0m) (Line 26)

(1) Geology

The geology consisted of a gravel layer mixed with surface soil and cobblestone from the well-head to the depth of 9.00m, clay, sandy clay and clayey sand of the Aral Formation between the depths of 9.00 and 48.00m, and weathered crusts between the depth of 48.00m and pit bottom.

(2) Thickened ilmenite seam

The main thickened ilmenite seam is shown in Table II-3-6.

As shown in Fig. II-3-4, a thickened ilmenite seam (thickness 5.50m, ilmenite content 94.37kg/m^3) could be captured between the depths of 39.00 and 44.50m.

11) MJBK-28 (Direction -, inclination -90°, drilling length 54.0m) (Line 26)

(1) Geology

The geology consisted of a gravel layer mixed with surface soil and cobblestone from the well-head to the depth of 8.00m, clay, sandy clay and clayey sand of the Aral Formation between the depths of 8.00 and 51.50m, and weathered crusts between the depth of 51.50m and pit bottom.

(2) Thickened ilmenite seam

The main thickened ilmenite seam is shown in Table II-3-6.

As shown in Fig. II-3-4, a thickened ilmenite seam (thickness 5.00m, ilmenite content 121.01kg/m^3) could be captured between the depths of 43.50 and 48.50m.

12) MJBK-29 (Direction -, inclination -90°, drilling length 58.0m) (Line 26)

(1) Geology

The geology consisted of a gravel layer mixed with surface soil and cobblestone from the well-head to the depth of 9.00m, clay, sandy clay and clayey sand of the Aral Formation between the depths of 9.00 and 55.80m, and weathered crusts between the depth of 55.80m and pit bottom.

(2) Thickened ilmenite seam

The main thickened ilmenite seam is shown in Table II-3-6.

As shown in Fig. II-3-4, a thickened ilmenite seam (thickness 5.00m, ilmenite content 117.70kg/m^3) could be captured between the depths of 43.00 and 48.00m.

13) MJBK-30 (Direction -, inclination -90°, drilling length 60.0m) (Line 26)

(1) Geology

The geology consisted of a gravel layer mixed with surface soil and cobblestone from the well-head to the depth of 8.00m, clay, sandy clay and clayey sand of the Aral Formation between the depths of 8.00 and 56.30m, and weathered crusts between the depth of 56.30m and pit bottom.

(2) Thickened ilmenite seam

The main thickened ilmenite seam is shown in Table II-3-6.

As shown in Fig. II-3-4, a thickened ilmenite seam (thickness 3.00m, ilmenite content 200.25kg/m^3) could be captured between the depths of 40.50 and 43.50m.

14) MJBK-31 (Direction -, inclination -90°, drilling length 51.0m) (Line 22)

(1) Geology

The geology consisted of a gravel layer mixed with surface soil and cobblestone from the well-head to the depth of 10.00m, clay, sandy clay and clayey sand of the Aral Formation between the depths of 10.00 and 49.70m, and weathered crusts between the depth of 49.70m and pit bottom.

(2) Thickened ilmenite seam

The main thickened ilmenite seam is shown in Table II-3-6.

As shown in Fig. II-3-5, a thickened ilmenite seam (thickness 3.50m, ilmenite content 131.62kg/m^3) could be captured between the depths of 46.00 and 49.50m.

15) MJBK-32 (Direction -, inclination -90°, drilling length 58.0m) (Line 22)

(1) Geology

The geology consisted of a gravel layer mixed with surface soil and cobblestone from the well-head to the depth of 8.00m, clay, sandy clay and clayey sand of the Aral

Formation between the depths of 8.00 and 57.90m, and weathered crusts between the depth of 57.90m and pit bottom.

(2) Thickened ilmenite seam

The main thickened ilmenite seam is shown in Table II-3-6.

As shown in Fig. II-3-5, a thickened ilmenite seam (thickness 5.00m, ilmenite content 98.13kg/m^3) could be captured between the depths of 53.00 and 58.00m.

16) MJBK-33 (Direction -, inclination -90°, drilling length 53.0m)　(Line 22)

(1) Geology

The geology consisted of a gravel layer mixed with surface soil and cobblestone from the well-head to the depth of 9.00m, clay, sandy clay and clayey sand of the Aral Formation between the depths of 9.00 and 51.00m, and weathered crusts between the depth of 51.00m and pit bottom.

(2) Thickened ilmenite seam

The main thickened ilmenite seam is shown in Table II-3-6.

As shown in Fig. II-3-5, a thickened ilmenite seam (thickness 10.00m, ilmenite content 132.95kg/m^3) could be captured between the depths of 41.00 and 51.00m.

17) MJBK-34 (Direction -, inclination -90°, drilling length 60.0m)　(Line 22)

(1) Geology

The geology consisted of a gravel layer mixed with surface soil and cobblestone from the well-head to the depth of 9.00m, clay, sandy clay and clayey sand of the Aral Formation between the depths of 9.00 and 44.00m, and weathered crusts between the depth of 44.00m and pit bottom.

(2) Thickened ilmenite seam

The main thickened ilmenite seam is shown in Table II-3-6.

As shown in Fig. II-3-5, a thickened ilmenite seam (thickness 3.40m, ilmenite content 162.39kg/m^3) could be captured between the depths of 42.00 and 45.40m.

18) MJBK-35 (Direction -, inclination -90°, drilling length 60.0m)　(Line 22)

(1) Geology

The geology consisted of a gravel layer mixed with surface soil and cobblestone from the well-head to the depth of 8.00m, clay, sandy clay and clayey sand of the Aral Formation between the depths of 8.00 and 57.80m, and weathered crusts between the depth of 57.80m and pit bottom.

(2) Thickened ilmenite seam

The main thickened ilmenite seam is shown in Table II-3-6.

As shown in Fig. II-3-5, a thickened ilmenite seam (thickness 1.80m, ilmenite content 201.71kg/m^3) could be captured between the depths of 43.00 and 44.80m.

19) MJBK-36 (Direction -, inclination -90°, drilling length 51.0m) (Line 18)

(1) Geology

The geology consisted of a gravel layer mixed with surface soil and cobblestone from the well-head to the depth of 5.00m, clay, sandy clay and clayey sand of the Aral Formation between the depths of 5.00 and 50.20m, and weathered crusts between the depth of 50.20m and pit bottom.

(2) Thickened ilmenite seam

The main thickened ilmenite seam is shown in Table II-3-6.

As shown in Fig. II-3-6, a thickened ilmenite seam (thickness 9.30m, ilmenite content 111.84kg/m^3) could be captured between the depths of 41.00 and 50.30m.

20) MJBK-37 (Direction -, inclination -90°, drilling length 37.0m) (Line 14)

(1) Geology

The geology consisted of a gravel layer mixed with surface soil and cobblestone from the well-head to the depth of 7.50m, clay, sandy clay and clayey sand of the Aral Formation between the depths of 7.50 and 44.00m, and weathered crusts between the depth of 44.00m and pit bottom.

(2) Thickened ilmenite seam

As shown in Table II-3-6, thickened ilmenite seams could not be captured.

3-3-3 Southern Flank of Bektimir Placer No. 3

The results of the boring survey are shown in geological cross sections of the boring area (Figs. II-3-7 to 11).

Drilling was conducted in 25 pits along Traverse Lines 1G, 2G and 3G and along Traverse Lines 114G and 116G orthogonally crossing the foregoing traverse lines, at spacings between 400 and 600m. The boring lengths totaled 903.5m. Thickened ilmenite seams with a cut-off content of 100kg/m^3 or higher could be confirmed with six of the 25 pits.

The ore bed is contained directly above two parallel palaeo-landform channels in the Aral Formation bedrock in the N30° E direction. The width of the ore bed is estimated to be about 200m and is narrow compared with that of Placer No. 2. The thicknesses of the ore body captured by the boring were 1.5 to 4.4m and ilmenite content was 111 to 181kg/m^3. The overburden on the ore bed was 23 to 30m in thickness and the thickness of overburden increased toward the southern flank, namely, toward the downstream.

1) MJBKS-1 (Direction -, inclination -90°, drilling length 40.0m) (Line 2G)

(1) Geology

The geology consisted of a gravel layer mixed with surface soil and cobblestone from the well-head to the depth of 11.00m, clay and sandy clay of the Aral Formation between the depths of 11.00 and 28.00m, redeposited weathered crusts between the depths of 24.00 and 27.20m and weathered crusts between the depth of 28.00m and pit bottom.

(2) Thickened ilmenite seam

The main thickened ilmenite seam is shown in Table II-3-7.

As shown in Fig. II-3-8, a weak thickened ilmenite seam (thickness 5.00m, ilmenite content 4.04kg/m^3) could be captured between the depths of 20.00 and 25.00m.

2) MJBKS-2 (Direction -, inclination -90°, drilling length 40.5m) (Line 2G)

(1) Geology

The geology consisted of a gravel layer mixed with surface soil and cobblestone from the well-head to the depth of 10.00m, clay, sandy clay and clayey sand of the Aral Formation between the depths of 10.00 and 28.00m, and weathered crusts between the depth of 28.00m and pit bottom.

(2) Thickened ilmenite seam

As shown in Fig. II-3-8, thickened ilmenite seams could not be captured.

3) MJBKS-3 (Direction -, inclination -90°, drilling length 35.00m) (Line 2G)

(1) Geology

The geology consisted of a gravel layer mixed with surface soil and cobblestone from the well-head to the depth of 12.00m, clay and sandy clay of the Aral Formation between the depths of 12.00 and 26.00m, and weathered crusts between the depth of 26.00m and pit bottom.

(2) Thickened ilmenite seam

As shown in Fig. II-3-8, thickened ilmenite seams could not be captured.

4) MJBKS-4 (Direction -, inclination -90°, drilling length 31.00m) (Line 1G)

(1) Geology

The geology consisted of a gravel layer mixed with surface soil and cobblestone from the well-head to the depth of 16.00m and weathered crusts between the depth of 16.00 and pit bottom.

(2) Thickened ilmenite seam

As shown in Fig. II-3-7, thickened ilmenite seams could not be captured.

5) MJBKS-5 (Direction -, inclination -90°, drilling length 32.0m) (Line 1G)

(1) Geology

The geology consisted of a gravel layer mixed with surface soil and cobblestone from the well-head to the depth of 12.00m, clay, sandy clay and clayey sand of the Aral Formation between the depths of 12.00 and 18.00m, and weathered crusts between the depth of 18.00m and pit bottom.

(2) Thickened ilmenite seam

As shown in Fig. II-3-7, thickened ilmenite seams could not be captured.

6) MJBKS-6 (Direction -, inclination -90°, drilling length 42.0m) (Line 1G)

(1) Geology

The geology consisted of a gravel layer mixed with surface soil and cobblestone from the well-head to the depth of 14.00m and weathered crusts between the depth of 14.00 and pit bottom.

(2) Thickened ilmenite seam

As shown in Fig. II-3-7, thickened ilmenite seams could not be captured.

7) MJBKS-7 (Direction -, inclination -90°, drilling length 33.00m) (Line 1G)

(1) Geology

The geology consisted of a gravel layer mixed with surface soil and cobblestone from the well-head to the depth of 12.00m, clay and sandy clay of the Aral Formation between the depths of 12.00 and 28.30m, and weathered crusts between the depth of 28.30m and pit bottom.

(2) Thickened ilmenite seam

Main thickened ilmenite seams are shown in Table II-3-7.

As shown in Fig. II-3-7, a thickened ilmenite seam (thickness 3.20m, ilmenite content 113.33kg/m^3) could be captured between the depths of 24.80 and 27.00m.

8) MJBKS-8 (Direction -, inclination -90°, drilling length 30.50m) (Line 1G)

(1) Geology

The geology consisted of a gravel layer mixed with surface soil and cobblestone from the well-head to the depth of 12.00m and weathered crusts between the depth of 12.00m and pit bottom.

(2) Thickened ilmenite seam

As shown in Fig. II-3-7, thickened ilmenite seams could not be captured.

9) MJBKS-9 (Direction -, inclination -90°, drilling length 29.0m) (Line 1G)

(1) Geology

The geology consisted of a gravel layer mixed with surface soil and cobblestone from the well-head to the depth of 11.00m, clay, sandy clay and clayey sand of the Aral Formation between the depths of 11.00 and 21.00m and weathered crusts between the depth of 21.00m and pit bottom.

(2) Thickened ilmenite seam

As shown in Fig. II-3-7, thickened ilmenite seams could not be captured.

10) MJBKS-10 (Direction -, inclination -90°, drilling length 25.0m) (Line 1G)

(1) Geology

The geology consisted of a gravel layer mixed with surface soil and cobblestone from the well-head to the depth of 11.00m and weathered crusts between the depth of 11.00m and pit bottom.

(2) Thickened ilmenite seam

As shown in Fig. II-3-7, thickened ilmenite seams could not be captured.

11) MJBKS-11 (Direction -, inclination -90°, drilling length 35.0m) (Line 114G)

(1) Geology

The geology consisted of a gravel layer mixed with surface soil and cobblestone from the well-head to the depth of 10.00m, clay and sandy clay of the Aral Formation between the depths of 10.00 and 25.10m, and weathered crusts between the depth of 25.10m and pit bottom.

(2) Thickened ilmenite seam

Main thickened ilmenite seams are shown in Table II-3-7.

As shown in Fig. II-3-10, a thickened ilmenite seam (thickness 2.00m, ilmenite content 112.42kg/m^3) could be captured between the depths of 23.00 and 25.00m.

12) MJBKS-12 (Direction -, inclination -90°, drilling length 39.0m) (Line 116G)

(1) Geology

The geology consisted of a gravel layer mixed with surface soil and cobblestone from the well-head to the depth of 9.00m and weathered crusts between the depth of 9.00 and pit bottom.

(2) Thickened ilmenite seam

As shown in Fig. II-3-11, thickened ilmenite seams could not be captured.

13) MJBKS-13 (Direction -, inclination -90°, drilling length 34.0m) (Line

116G)

(1) Geology

The geology consisted of a gravel layer mixed with surface soil and cobblestone from the well-head to the depth of 8.50m, clay, sandy clay and clayey sand of the Aral Formation between the depths of 8.50 and 32.00m, and weathered crusts between the depth of 32.00m and pit bottom.

(2) Thickened ilmenite seam

Main thickened ilmenite seams are shown in Table II-3-7.

As shown in Fig. II-3-11, a thickened ilmenite seam (thickness 1.50m, ilmenite content 117.36kg/m^3) could be captured between the depths of 30.50 and 32.00m.

14) MJBKS-14 (Direction -, inclination -90°, drilling length 37.0m) (Line 114G)

(1) Geology

The geology consisted of a gravel layer mixed with surface soil and cobblestone from the well-head to the depth of 9.00m, clay, sandy clay and clayey sand of the Aral Formation between the depths of 9.00 and 28.00m, and weathered crusts between the depth of 28.00m and pit bottom.

(2) Thickened ilmenite seam

Main thickened ilmenite seams are shown in Table II-3-7.

As shown in Fig. II-3-10, a weak thickened ilmenite seam (thickness 1.00m, ilmenite content 4.02kg/m^3) could be captured between the depths of 24.00 and 25.00m.

15) MJBKS-15 (Direction -, inclination -90°, drilling length 33.0m) (Line 3G)

(1) Geology

The geology consisted of a gravel layer mixed with surface soil and cobblestone from the well-head to the depth of 7.00m, clay and sandy clay of the Aral Formation between the depths of 7.00 and 28.50m, redeposited weathered crusts between the depths of 23.00 and 32.80, and weathered crusts between the depth of 28.50m and pit bottom.

(2) Thickened ilmenite seam

As shown in Fig. II-3-19, thickened ilmenite seams could not be captured.

16) MJBKS-16 (Direction -, inclination -90°, drilling length 45.0m) (Line 3G)

(1) Geology

The geology consisted of a gravel layer mixed with surface soil and cobblestone from the well-head to the depth of 9.00m, clay, sandy clay and clayey sand of the Aral Formation between the depths of 9.00 and 41.60m, and weathered crusts between the depth of 41.60m and pit bottom.

(2) Thickened ilmenite seam

Main thickened ilmenite seams are shown in Table II-3-7.

As shown in Fig. II-3-9, a thickened ilmenite seam (thickness 3.60m, ilmenite content 180.7kg/m^3) could be captured between the depths of 29.50 and 33.10m.

17) MJBKS-17 (Direction -, inclination -90°, drilling length 40.0m) (Line 3G)

(1) Geology

The geology consisted of a gravel layer mixed with surface soil and cobblestone from the well-head to the depth of 9.00m, clay, sandy clay and clayey sand of the Aral Formation between the depths of 9.00 and 33.30m, and weathered crusts between the depth of 33.30m and pit bottom.

(2) Thickened ilmenite seam

Main thickened ilmenite seams are shown in Table II-3-7.

As shown in Fig. II-3-9, a thickened ilmenite seam (thickness 0.20m, ilmenite content 180.00kg/m^3) could be captured between the depths of 33.10 and 33.30m.

18) MJBKS-18 (Direction -, inclination -90°, drilling length 35.00m) (Line 3G)

(1) Geology

The geology consisted of a gravel layer mixed with surface soil and cobblestone from the well-head to the depth of 8.00m, clay and sandy clay of the Aral Formation between the depths of 8.00 and 32.50m, and weathered crusts between the depth of 31.50m and pit bottom.

(2) Thickened ilmenite seam

Main thickened ilmenite seams are shown in Table II-3-7.

As shown in Fig. II-3-9, a weak thickened ilmenite seam (thickness 0.80m, ilmenite content 15.95kg/m^3) could be captured between the depths of 22.00 and 22.80m.

19) MJBKS-19 (Direction -, inclination -90°, drilling length 35.0m) (Line 3G)

(1) Geology

The geology consisted of a gravel layer mixed with surface soil and cobblestone from the well-head to the depth of 8.00m, clay and sandy clay of the Aral Formation between the depths of 8.00 and 31.50m, and weathered crusts between the depth of 31.50m and pit bottom.

(2) Thickened ilmenite seam

As shown in Fig. II-3-9, thickened ilmenite seams could not be captured.

20) MJBKS-20 (Direction -, inclination -90°, drilling length 43.0m) (Line 3G)

(1) Geology

The geology consisted of a gravel layer mixed with surface soil and cobblestone from the well-head to the depth of 7.00m, clay, sandy clay and clayey sand of the Aral Formation between the depths of 7.00 and 39.10m, and weathered crusts between the depth of 39.10m and pit bottom.

(2) Thickened ilmenite seam

Main thickened ilmenite seams are shown in Table II-3-7.

As shown in Fig. II-3-9, thickened ilmenite seams could not be captured.

21) MJBKS-21 (Direction -, inclination -90°, drilling length 37.0m) (Line 3G)

(1) Geology

The geology consisted of a gravel layer mixed with surface soil and cobblestone from the well-head to the depth of 6.00m, clay, sandy clay and clayey sand of the Aral Formation between the depths of 6.00 and 32.00m, and weathered crusts between the depth of 32.00 and pit bottom.

(2) Thickened ilmenite seam

As shown in Fig. II-3-9, thickened ilmenite seams could not be captured.

22) MJBKS-22 (Direction -, inclination -90°, drilling length 32.0m) (Line 3G)

(1) Geology

The geology consisted of a gravel layer mixed with surface soil and cobblestone from the well-head to the depth of 7.00m, clay and sandy clay of the Aral Formation between the depths of 7.00 and 27.00m, and weathered crusts between the depth of 27.00m and pit bottom.

(2) Thickened ilmenite seam

As shown in Fig. II-3-9, thickened ilmenite seams could not be captured.

23) MJBKS-23 (Direction -, inclination -90°, drilling length 40.00m) (Line 3G)

(1) Geology

The geology consisted of a gravel layer mixed with surface soil and cobblestone from the well-head to the depth of 7.00m, clay and sandy clay of the Aral Formation between the depths of 7.00 and 37.00m, and weathered crusts between the depth of 37.00m and pit bottom.

(2) Thickened ilmenite seam

As shown in Fig. II-3-9, thickened ilmenite seams could not be captured.

24) MJBKS-24 (Direction -, inclination -90°, drilling length 41.0m) (Line 114G)

(1) Geology

The geology consisted of a gravel layer mixed with surface soil and cobblestone from the well-head to the depth of 7.00m, clay, sandy clay and clayey sand of the Aral Formation between the depths of 7.00 and 40.00m, and weathered crusts between the depth of 40.00m and pit bottom.

(2) Thickened ilmenite seam

As shown in Fig. II-3-10, thickened ilmenite seams could not be captured.

25) MJBKS-25 (Direction -, inclination -90°, drilling length 34.00m) (Line 116G)

(1) Geology

The geology consisted of a gravel layer mixed with surface soil and cobblestone from the well-head to the depth of 7.60m, clay and sandy clay of the Aral Formation between the depths of 7.60 and 30.90m, and weathered crusts between the depth of 30.90m and pit bottom.

(2) Thickened ilmenite seam

As shown in Fig. II-3-11, thickened ilmenite seams could not be captured.

3-3-4 North of Bektimir

The results of the boring survey are shown in geological cross sections of the boring area (Fig. II-3-12).

1) MJBKN-1 (Direction -, inclination -90°, drilling length 67.00m) (Line 1C)

(1) Geology

The geology consisted of a gravel layer mixed with surface soil and cobblestone from the well-head to the depth of 7.00m, clay and sandy clay of the Aral Formation between the depths of 7.00 and 64.90m, and weathered crusts between the depth of 64.90m and pit bottom.

(2) Thickened ilmenite seam

Thickened ilmenite seams could not be captured in this pit.

2) MJBKN-2 (Direction -, inclination -90°, drilling length 70.00m) (Line 1C)

(1) Geology

The geology consisted of a gravel layer mixed with surface soil and cobblestone from the well-head to the depth of 2.50m, clay, sandy clay and clayey sand of the Aral

Formation between the depths of 2.50 and 66.40m, and weathered crusts between the depth of 66.40m and pit bottom.

(2) Thickened ilmenite seam

Thickened ilmenite seams could not be captured in this pit.

3) MJBKN-3 (Direction -, inclination -90°, drilling length 68.00m) (Line 1C)

(1) Geology

The geology consisted of a gravel layer mixed with surface soil and cobblestone from the well-head to the depth of 4.00m, clay and sandy clay of the Aral Formation between the depths of 4.00 and 69.30m, and weathered crusts between the depth of 69.30m and pit bottom.

(2) Thickened ilmenite seam

Thickened ilmenite seams could not be captured in this pit.

4) MJBKN-4 (Direction -, inclination -90°, drilling length 60.00m) (Line 1C)

(1) Geology

The geology consisted of a gravel layer mixed with surface soil and cobblestone from the well-head to the depth of 9.50m, clay and sandy clay of the Aral Formation between the depths of 9.50 and 59.50m, and weathered crusts between the depth of 59.50m and pit bottom.

(2) Thickened ilmenite seam

Thickened ilmenite seams could not be captured in this pit.

5) MJBKN-5 (Direction -, inclination -90°, drilling length 70.00m) (Line 1C)

(1) Geology

The geology consisted of a gravel layer mixed with surface soil and cobblestone from the well-head to the depth of 24.50m and clay, sandy clay and clayey sand of the Aral Formation between the depths of 24.50m and pit bottom.

(2) Thickened ilmenite seam

Thickened ilmenite seams could not be captured in this pit.

3-3-5 Ore reserves estimation

Approximate ore reserves and potentials were estimateed for the southern flanks of Bektimir Placers No. 1 and 3, respectively. Only slight signs of ilmenite thickening could be captured for the northern district of Bektimir and ore reserves calculations for this district were not made.

1) Ore Reserves Calculations for Southern District of Bektimir Placer No. 1

Drilling was conducted in Year 2 along three traverse lines in a grid of 500×200m over 1km on the southern flank of the confirmed III-C_2 Ore Reserves Block of Bektimir Placer No.1. Based on the results of the boring survey, approximate ore reserves for assay of captured ore reserves were calculated on a trial basis.

1) Calculation Method

(1) Grade analysis and calculation

Those thickened ilmenite seams that were captured in the boring were sampled by cutting cores 1m in maximum length and 0.3m in minimum length to 1/4. Wet and dry weights of the samples were weighed and whole samples were perfectly disintegrated in water, to separate quartz, feldspars, heavy minerals and clay grains. Almost 100% of heavy minerals were less than 1.0mm in grain size. After drying the samples, grains less than 1.0mm in grain size were sieved on a sieve of 1.0mm mesh. The grains that passed the sieve were separated by a heavy liquid (プロロホルム) to sort out heavy minerals, which were separated into ilmenite, zircon, rutile, leucoxene and other heavy minerals by magnetic, electrostatic and other separation methods. Their weights were weighed. Weighted weights were divided by dry weights of the samples and contents per ton of samples were calculated. Assuming the density per cubic meter of mineral to be 1.8, grades per cubic meter of ore beds were calculated by multiplying grade per ton by 1.8.

$G = M/O \times 1000 \times 1.8$

G: Ilmenite grade (content) per kg/m^3

M: Dry weight of separated ilmenite (g)

O: Dry weight of sample (kg)

(2) Ore beds for ore reserves calculation

The average grades of thickened ilmenite seams confirmed in the boring were calculated as weighted averages of cores. Of them, grades higher than $100kg/m^3$ were taken as ore beds. If thickened ilmenite seams were located in upper layers, grades higher than $70kg/m^3$ were included in ore beds. Deposits more than 2.0m in thickness $\times 100\ kg/m^3$ in grade were defined as ore beds.

(3) Range of block

In case an ore bed could not be confirmed by boring of an extended part of an ore bed captured in the boring survey, up to the middle point was defined the range of a block. If the extended part of an ore bed captured in boring is not explored and is not closed, as a rule, up to 50m from ore-bed capturing boring was defined the range of a block (IV-C2) (See Fig. II-3-13.).

(4) Grade for each block

The grade of an ore bed confirmed in boring was weighted averaged by the thickness of the ore bed and was defined as the block grade for each traverse line. The average grade of all blocks was then calculated (Table II-3-8).

(5) Ore reserves

Ilmenite ore reserves of each block were calculated by the following expression (Table I-5-1).:

$V = S \times W \times C \times 1/1{,}000$

V: Ilmenite ore reserves (t)

S: Plane area of an ore bed = 1,364,000m^2

W: Average thickness of ore bed = 4.76m

C: Average ilmenite grade of ore beds = 131.93kg/m^3

$V = 1{,}364{,}000 \times 4.76 \times 131.93 \times 1/1{,}000 = 856{,}574$

2) Calculation Results

Trial calculations of ore reserves of the southern extension part of Bektimir Placer No. 1 in Year 2 produced 6.5 million m^3 as captured ore sand reserves of C_2 Category, ilmenite grade of 131.93kg/m^3, ilmenite ore reserves of 857,000 tons, and stripping ratio of 8.3 (Table I-5-1).

2) Ore Potentials of Southern Flank of Bektimir Placer No. 3

Reconnaissance boring was conducted in the southern flank of Bektimir Placer No. 3 in Year 2 in grids of 400×400 to 400×600m to confirm thickened ilmenite seams estimated to deposit in two parallel palaeo-landform channels.

(1) Ore Reserves

Only six boring pits could be confirmed with a grade higher than 100kg/m^3. This number was not sufficient for ore reserves calculations. However, ore reserves were calculated on a trial basis, defining an area 100m in radius of the boring pits that hit ores.

i) Calculation method

(1) Grade analysis and calculation

The same analysis and calculation methods as those for Bektimir Placer No. 1 were used.

(2) Target ore bed for ore reserves calculations

The same ore beds as those for Bektimir Placer No. 1 were used.

(3) Range of block

An area 100m in radius from the centers of ore beds captured in the boring was defined the range of a block.

(4) Grade per block

Grades of ore beds confirmed in the boring were weighted averaged by the thicknesses of the ore beds to obtain a block grade for each traverse line. The average grade of all blocks was then calculated (Table II-3-9).

(5) Ore reserves

Ilmenite ore reserves of each block were calculated by the following expression (Table I-5-2):

$V = S \times W \times C \times 1/1,000$

V: Ilmenite ore reserves (t)

S: Plane area of an ore bed = 188,400m^2

W: Average thickness of ore bed = 2.76m

C: Average ilmenite grade of ore beds = 130.05kg/m^3

$V = 188,400 \times 2.76 \times 130.05 \times 1/1,000 = 67,600$

ii) Calculation Results

Trial calculations of ore reserves of the southern flank of Bektimir Placer No. 3 in Year 2 produced 0.52 million m^3 as ore reserved, ilmenite grade of 130.05kg/m^3, ilmenite ore reserves of 68,000 tons, and stripping ratio of 9.7 (Table II-3-9).

(2) Potential Calculation

Potential calculations in a very bold fashion assuming that the boring pits in the palaeo-landform channels that hit an ore bed were continuous produced the following results. These results can be used as a criterion in setting exploration guidelines.

i) Calculation method

(1) Grade analysis and calculation

The same analysis and calculation methods as those for Bektimir Placer No. 1 were used.

(2) Target ore bed for ore reserves calculations

The same ore beds as those for Bektimir Placer No. 1 were used.

(3) Range of block

In case an ore bed could not be confirmed by boring of an extended part of an ore bed captured in the boring survey, up to the middle point was defined the range of a block. If the extended part of an ore bed captured in boring is not explored and is not closed, as a rule, up to 100m from ore-bed capturing boring was defined as the range of a block (See Fig. II-3-14.). The anticipated palaeo-landform channels were used as a base for defining block extensions.

(4) Grade per block

Grades of ore beds confirmed in the boring were weighted averaged by the thicknesses of the ore beds to obtain a block grade for each traverse line. The average grade of all blocks was then calculated (Table II-3-9).

(5) Ore reserves

Ilmenite ore reserves of each block were calculated by the following expression (Table I-5-2):

$V = S \times W \times C \times 1/1,000$

V: Ilmenite ore reserves (t)

S: Plane area of an ore bed = 1,370,600 m^2

W: Average thickness of ore bed = 2.76m

C: Average ilmenite grade of ore beds = 130.05kg/m^3

$V = 1,370,600 \times 2.76 \times 130.05 \times 1/1,000 = 492,200$

ii) Calculation Results

Trial calculations of ore reserves of the southern flank of Bektimir Placer No. 3 in Year 2 produced 3.8 million m^3 as ore reserves, ilmenite grade of 130.05kg/m^3, ilmenite ore reserves of 492,000 tons, and stripping ratio of 9.7 (Table II-3-11). These results are very approximate calculations of six boring pits with wide spacings.

3-3-6Mineralogical descriptions of heavy minerals

Polished sections were prepared from samples of light-gray sand bed samples containing ilmenite and recovered from Drilling Pit MJBK-21 at the depth of 41.0m and Drilling Pit MJBK-29 at the depth of 48.0m in the southern flank of Bektimir Placer No. 1 after the samples were hardened using a resin. These polished sections were observed under a microscope. An ilmenite concentrate produced in the TMK test pit was placed at a bench angle of 15° on an iso-dynamic magnetic separator and was magnetically separated at current intensities of 0.1A or lower, 0.10 to 0.21A and 0.21A or higher for microscopic observation.

Light-gray sand bed samples containing ilmenite and recovered from Drilling Pit MJBK-21 at the depth of 41.0m and Drilling Pit MJBK-29 at the depth of 48.0m consisted of a large amount of quartz and ilmenite and a very small amount of zircon and feldspars angular or subangular in shape and 0.05 to 0.3mm in grain size under a microscope. Intergranular spaces were filled by polysynthetic clayey minerals. Ilmenite was euhedral or semi-euhedral. Some parts of it were discolored to bright colors in 5 to 15 μ m in width along external edges of grains and cracks inside grains and were altered to a coarse and bulky texture (Appendix 2-9). These parts contained less Fe compared with parts that were not altered and much Ti was contained. The unaltered parts of the concentrates produced from the TMK Test Pit contained 53.0% of TiO_2, 45.8% of FeO and 2.4% of MnO on average. The altered parts of the concentrates produced contained 58.6% of TiO_2, 35.3% of FeO and 2.1% of MnO on average (Appendix 2-5). In powder X-ray diffraction analysis of ilmenite, diffraction lines that were considered to be rutiles (leucoxene) with a low crystallinity could be found on the high angle side of clear diffraction lines of ilmenite (Appendix 2-5). Judging from these, it was estimated that ilmenite was oxidized while it was separated from granitic rocks by weathering and was deposited and thickened. During this process, Fe would have been leached and Ti would have been enriched.

Ferromagnetic ilmenite in ilmenite that was magnetically separated was mostly unaltered ilmenite, while weakly magnetic ilmenite was altered and contained much Ti.

According to semi-quantitative analysis of ilmenite using EDX, ilmenite from the TMK Test Pit in the Bektimir Placer No. 1 located in the upstream contained 49.5% of TiO_2 on average, which was low. In MJBK-21 in the downstream, ilmenite contained 52.7% of TiO_2 on average. The average content of TiO_2 of ilmenite in MJBK-29, which was located farther downstream, was 57.0%, increasing in grade (Appendix 2-23).

Ferrous minerals and titanic minerals form mineral compositions that belong to the FeO - Fe203 - TiO2 series and are mutually solubles and exsolubles. Compared with ilmenite produced in Russia, ilmenite concentrates produced from Bektimir Placer No. 1 contain more FeO, but less TiO_2. However, they are almost equal in quality compared with ilmenite produced in Capel, West Australia (Fig. II-3-15). Speaking of components of iron sand produced in Japan, acidic iron sand derived from granite contained less titanic minerals, while basic iron sand contained much titanic components. Residual iron sand remaining at sites especially contained titanic minerals in high proportions.

In Year 2, 92.0 to 98.8% of the ilmenite grain size was within the range of -0.40 +0.05mm, averaging 96.3%, and the mode was about 0.2mm. The grain size distribution was about the same as that in Year 1. Area by area, the proportion of coarse ilmenite with a grain size of 0.1mm or more concentrated in centers of the gorges in the palaeo-landform channels, while llmenite with a grain size of 0.1mm or less concentrated in areas around the gorges (See Fig. II-3-16.). This may be explained by coarse-grained ilmenite moving and depositing more in the centers of palaeo-landform channels, where the flow speed was fast, whereas fine-grained ilmenite deposited on banks where the flow speed was slow. Shoji (1971) stated that the inherent critical flow speed varied in proportion to the 1.5 power of the grain size between inherent grain sizes of 0.1 to 0.75mm and in proportion to the 1.0 power in grain sizes of 0.75 to 3.5mm. Smirnoff (1979) showed an expression for inherent critical flow speeds to clastics and stated that the flow speed by carrying was faster 1.35 to 1.5 times compared with the inherent critical flow speed. Smirnoff showed criteria that the critical stagnant flow speed on river bottoms are 0.27m/sec with grains 0.1mm in grain size and 0.31m/sec with the grain size of 0.25mm. Because grain sizes of ilmenite in the TMK test pit of Bektimir Placer No. 1 was about 0.3mm and the mode of grain size of ilmenite in the southern part was about 0.2mm, it can be estimated that the flow speed of the river beds in palaeo-landform channels was about 0.5m/sec or more in the upstream area such as near the TMK test pit and was about 0.45m/sec or more in the downstream.

3-4 Summary and Considerations

3-4-1 Ore deposits and signs for ore bearing

1) Southern Flank of Bektimir Placer No. 1 (Detailed Survey District)

Drilling was conducted in 20 pits along six traverse lines (Traverse Lines 34, 30, 26, 22, 18 and 14) in a grid of 500×200m over 2.5km on the southern flank of the confirmed III-C_2 Ore Reserves Block of Bektimir Placer No. 1. The boring lengths totaled 1,033.0m.

Regarding Traverse Lines 34 and 30, the results of MJBK-19 and MJBK-24 confirmed deterioration in ore bed thickness and grade on the western flank of the ore body. Closure of the ore bed could be determined. Regarding Traverse Lines 30 and 26, the results of MJBK-20 and MJBK-25 confirmed deterioration in ore bed thickness and grade on the eastern flank of the ore body. MJBK-37 (no signs of ore bearing) confirmed the southern limit of thickened ilmenite seams and a change in the ore bed extension direction from NEN-SWS to NW-SE could be estimated.

The thickness of the ore bed tended to slightly decrease toward the south. The thickness of overburden increased, but the width of the ore bed increased to 1,000m, to increase the volume. The southeastern lateral boundaries remain unconfirmed.

When cut-off conditions were set 100kg/m^3 or more, or 2.0m×100kg/m^3 or more, ore reserves calculations showed the following ore reserves increases corresponding to Category C_2 (Block IV-C_2). Ore reserves were 6.5 million m^3, ilmenite reserves, 857,000 tons, average ilmenite content 132kg/m^3, and stripping ratio, 8.3.

The III-C_2 ore reserves confirmed in Year 1 and the total increase in Year 2 (Ore Reserves Block No.. III+IV-C_2) are shown below. Ore reserves were 11.3 million m^3, ilmenite reserves, 1,472,000 tons, average ilmenite content, 131kg/m^3, and stripping ratio, 7.26)

Table I-5-1 Ore Reserves Calculation of Category C_2 for the Southern Flank of Placer No.1

Block No	Block area 10^3m^2	Ore bed thickness m.	Ore sands reserves 10^3m^3	Ilmenite content, kg/m ^{3}	Ilmenite reserves 10^3t	Overburden thickness m	Overburden volume 10^3m^3	Stripping ratio, m^3/m^3
III-C_2	909.0	5.51	5,008.59	123.95	620.81	29.64	26,942.8	5.4
IV-C_2	**1364.0**	**4.76**	**6,492.6**	**131.93**	**856.57**	**39.3**	**53,605.2**	**8.3**
III+IV-C_2	**2,273.0**	**4.95**	**11,251.35**	**130.84**	**1,472.13**	**35.94**	**81,691.6**	**7.3**

2) Southern Flank of Bektimir Placer No. 3 (Reconnaissance Survey District)

Drilling was conducted in 25 pits at 400 to 600m spacing on Traverse Lines 1G, 2G and 3G and Traverse Lines 114G and 116G orthogonally crossing the foregoing three traverse lines, totaling 903.5m in length. In six of the 25 pits, thickened ilmenite seams more than the cut-off grade of 100kg/m^3 could be confirmed.

The ore bed is deposited directly above two parallel palaeo-landform channels in the Aral Formation bed rock running in the N30°E direction. The width of the ore bed was estimated at about 200m and was small compared with that of Bektimir Placer No. 1. The ore bed thickness captured by boring was 1.5 to 4.4m and the ilmenite content was 111 to 181kg/m^3. Overburden on the ore bed was 23 to 30m in thickness and tended to increase toward south, that is, toward the downstream.

Only six pits showed contents higher than 100kg/m^3 and were not sufficient for ore reserves calculations. However, the following calculation data can be obtained by designating an area 100m in radius centering on a boring pit as a block.

Block No	Block area 10^3m^2	Ore bed thickness m.	Ore sands reserves 10^3m^3	Ilmenite content, kg/m^3	Ilmenite reserves 10^3t	Overburden thickness, M	Overburden volume 10^3m^3	Stripping ratio, m^3/m^3
P_1	188.4	2.76	512.0	130.05	67.6	26.7	5,011.4	9.7

Potential calculations in a very bold fashion assuming that the boring pits in the palaeo-landform channels that hit an ore bed were continuous produce the following results: Ore reserves 3.8 million m^3, ilmenite reserves 493,000 tons, average ilmenite content 130kg/m^3, and stripping ratio 9.7.

Table I-5-2 Ore Reserves Calculation of Category P_1 for the Southern Flank of Placer No.3

Block No	Block area 10^3m^2	Ore bed thickness m.	Ore sands reserves 10^3m^3	Ilmenite content, kg/m^3	Ilmenite reserves 10^3t	Overburden thickness, M	Overburden volume 10^3m^3	Stripping ratio, m^3/m^3
I-P_1	680.5	3.03	2,061.9	117.76	242.8	26.6	18,101.3	8.8
II-P_1	690.1	2.50	1,725.2	144.76	249.7	26.8	18,494.7	10.7
Total	1,370.6	2.76	3,787.1	130.05	492.5	26.7	36,596.0	9.7

3) Bektimir Northern Placer (Reconnaissance Survey District)

Drilling was conducted in 5 pits along one traverse line at a spacing of 1,000m. The boring lengths totaled 335.0m.

Thickened ilmenite seam was deposited in the Aral Formation directly above the bed rock and in cracks of weathered crusts of the bed rock. The boring survey showed that thickened ilmenite seams were 1 to 7m in thickness and that ilmenite contents were 14 to 21kg/m^3. Traces of ilmenite could be detected as mentioned above, but the grade was low and expanse of the ore bed could not be captured. Ore reserves were, therefore, not calculated.

3-4-2 Heavy minerals

Samples of light-gray sand beds containing ilmenite consisted of a large amount of quartz and ilmenite and a very small amount of zircon and feldspars that were angular or subangular in shape. Intergranular spaces were filled by polysynthetic clayey minerals. Some parts of it were altered to a coarse and bulky texture believed to contain leucoxene along outer edges of ilmenite grains and cracks inside grains. Compared with unaltered parts, altered parts contained less Fe, but more Ti. Ferromagnetic ilmenite in ilmenite that was magnetically separated was mostly unaltered ilmenite, while weakly magnetic ilmenite was altered and contained much Ti. The TiO_2 grade increased in the Bektimir Placer No. 1 more toward the downstream, rather than in the upstream. It is estimated that ilmenite was oxidized while it was separated from granitic rocks by weathering and was deposited and thickened. During this process, Fe would have been leached and Ti would have been enriched.

Data shows that 92.0 to 98.8% of the ilmenite grain size was within the range of -0.40 +0.05mm, averaging 96.3%, and that the mode was about 0.2mm. Area by area, the proportion of coarse ilmenite with a grain size of 0.1mm or more concentrated in centers of the gorges in the palaeo-landform channels, while llmenite with a grain size of 0.1mm or less concentrated in areas around the gorges. This may be explained by coarse-grained ilmenite moving and depositing more in the centers of palaeo-landform channels, where the flow speed was fast, whereas fine-grained ilmenite deposited on banks where the flow speed was slow. The flow speed of the riverbeds in palaeo-landform channels was about 0.5m/sec or more in the upstream area such as near the TMK test pit and was about 0.45m/sec or more in the downstream.

3-4-3 Consideration

1) Ore-Bed Bearing Channel

As main weak lines in the survey area, the Baladzhalskiy Fault runs in the northeast flank of the area in the WNW-ESE direction and the South Terektinskiy Fault, on the southwestern flank. Between these two faults, a crack in the NEN-SWS direction cuts the Preobrazhenskiy composite rock mass and a Carboniferous Period layer made up of pre-granitic rocks. Weathering and denudation progressed in tropical humid climate in the latter part of the Cretaceous Period, thus forming the palaeo-landform channels along these weak lines. Palaeo-landform channels are dominant in hills in the NEN-SWS direction. However, they are estimated to change in the NW-SE direction because cracks in the NW-SE direction are dominant in plains as they approach the Baladzhalskiy Fault and South Terektinskiy Fault.

This indicates that a rapid change of palaeo-landform channels in the NW-SE direction should be taken into consideration when surveying ilmenite drift-sand ore beds in plains including a survey of an extension of Bektimir Placer No. 1.

2) Economical Efficiency of Ore Beds

(1) Ilmenite grade and stripping ratio

The Republic of Kazakhstan has an index (a former Soviet Union standard) to gauge whether or not an ore body can be economically mined by open-cut mining. This index shows that mining in only the ore bed found in Year 2 in the Southern Flank of Bektimir Placer No. 1 is not sufficient for economical mining.

Table I-4-1 Ilmenite Content and Maximum Economical Stripping Ratio

Average content of ilmenite kg/m^3	Maximum economical stripping ratio m^3/m^3
100	2.58
110	3.90

120	5.21
130	6.56
131.93	**8.25**
140	7.87
150	9.21

However, when ore reserves are calculated by adding the ore beds captured in the Year-1 survey, ore reserves can be mined generally economically compared with the index as shown below.

Average content of ilmenite kg/m^3	Maximum economical stripping ratio m^3/m^3
100	2.58
110	3.90
120	5.21
130	6.56
130.84	**7.26**
140	7.87
150	9.21

It is estimated that ilmenite was oxidized while it was separated from granitic rocks by weathering and was deposited and thickened. During this process, Fe would have been leached and Ti would have been enriched so that the TiO_2 content would be higher in this ore bed, toward the downstream. The ore-bed extension direction is estimated to bend toward southeast along palaeo-landform channels. Based on this, it will be necessary to calculate ore reserves again by setting blocks that are more economical, after conducting a boring survey of the extensions of the parts where the content would be high.

(2) Quality of Ilmenite Concentrates

In Year 2, 92.0 to 98.8% of the ilmenite grain size was within the range of -0.40 +0.05mm, averaging 96.3%, and the mode was about 0.2mm. The grain size distribution was about the same as that in Year 1. The quantity of ilmenite in the survey area is shown below. While the quality does not meet the International Trading Standard (Yoshida, 1992), it meets the manufacturing requirements for sponge titanium and titanium oxides in the Republic of Kazakhstan. Compared with ilmenite produced in Russia, ilmenite concentrates produced from Bektimir Placer No. 1 contain more FeO, but less TiO_2. However, they are almost equal in quality compared with ilmenite produced in Capel, West Australia.

Element	TiO_2 (%)	FeO (%)	SiO_2 (%)	P_2O_5 (%)	Cr_2O_3 (%)	V_2O_5 (%)
Assay result	48.48～51.25	7.98～26.52	1.41～2.24	0.01～0.025	0.02～0.038	0.185～0.242
Average	50.31	18.01	1.80	0.02	0.03	0.21
International Trading Standard	≧54	≧28	≦1.5	≦0.05	≦0.05	≦0.1

Guaranteed Grade by Sri Lanka Mineral Sands Corp.

Element	TiO_2 (%)	FeO (%)	SiO_2 (%)	P_2O_5 (%)	Cr_2O_3 (%)	V_2O_5 (%)
Grade	≧53	Fe2O3≦ 1	≦1	≦0.05		

Standard Grade of Ilmenite Concentrate (Low Grade) Produced by Malaysia

Element	TiO_2 (%)	FeO＊ (%)
Grade	≧50	≧30

*A suitable amount (28 to 32%) of FeO should preferably be contained in the manufacture of titanium oxide by the sulfuric acid method. A penalty would result if the FeO content is low.

Table II-3-1 Quantity of Drilling Works, Core Recovery and Efficiency of Drilling in the Kokpetinskaya Area

Hole No.	Drilling length (m)	Legth of casing pipes (m)	Core recovery (%)	Efficiency		Ratio of drilling work (%)						
				m/shift	m/hr	Drilling	Outdrilling	Recovery from accident	Preparation	Dismount/ Mobilization	Transportation of water	Others
MJBK−18	30.00	7.00	100.0	4.62	1.25	31.5	39.5	−	7.9	5.3	15.8	−
MJBK−19	44.00	8.00	100.0	44.00	4.89	45.0	15.0	−	10.0	10.0	20.0	−
MJBK−20	37.00	9.00	100.0	12.33	2.64	35.0	30.0	−	5.0	10.0	20.0	−
MJBK−21	43.00	11.00	100.0	4.53	1.08	38.5	25.0	9.6	3.8	7.7	15.4	−
MJBK−22	65.00	9.00 16.00	100.0	5.20	1.33	34.5	37.4	3.5	2.1	7.0	15.5	−
MJBK−23	60.00	6.00 10.00	100.0	2.45	1.30	20.3	28.8	31.4	1.8	3.5	14.2	−
MJBK−24	58.00	9.00	100.0	6.11	1.61	34.6	29.8	9.6	3.9	6.7	15.4	−
MJBK−25	43.00	8.00 10.00	100.0	6.62	1.26	44.7	26.3	−	7.9	5.3	15.8	−
MJBK−26	50.00	8.00 9.00	100.0	6.66	1.47	39.5	30.2	−	4.7	9.3	16.3	−
MJBK−27	50.00	7.00 9.00	100.0	5.26	1.09	43.4	23.6	1.9	7.5	6.6	17.0	−
MJBK−28	54.00	6.00 8.00	100.0	6.00	1.64	36.2	16.5	26.4	4.4	4.4	12.1	−
MJBK−29	58.00	8.00 8.00	100.0	7.25	1.81	36.4	21.6	12.5	4.5	6.8	18.2	−
MJBK−30	60.00	8.00 8.00	100.0	5.22	1.20	41.0	19.7	16.3	3.3	4.9	14.8	−
MJBK−31	51.00	7.00 10.00	100.0	4.86	1.00	44.0	28.4	−	3.5	6.9	17.2	−
MJBK−32	58.00	8.00 8.00	100.0	7.53	1.87	36.0	24.4	11.6	4.7	7.0	16.3	−
MJBK−33	53.00	9.00 9.00	100.0	5.89	1.26	43.7	27.1	−	4.2	8.3	16.7	−
MJBK−34	60.00	7.00 9.00	100.0	3.24	1.20	25.8	19.6	30.9	3.1	3.1	17.5	−
MJBK−35	60.00	10.00	100.0	6.32	2.00	30.0	47.0	−	4.0	7.0	12.0	−
MJBK−36	51.00	7.00	100.0	7.29	2.43	14.6	25.7	−	45.1	3.5	11.1	−
MJBK−37	48.00	10.00	100.0	9.60	2.00	40.0	26.7	−	8.3	5.0	20.0	−
MJBKS−1	40.00	7.00	100.0	32.00	4.44	45.0	15.0	−	10.0	10.0	20.0	−
MJBKS−2	40.50	10.00	100.0	32.40	4.50	45.0	15.0	−	10.0	10.0	20.0	−
MJBKS−3	35.00	12.00	100.0	28.00	3.89	45.0	15.0	−	10.0	10.0	20.0	−
MJBKS−4	31.00	16.00	100.0	24.80	3.10	50.0	15.0	−	5.0	10.0	20.0	−
MJBKS−5	32.00	12.00	100.0	25.60	4.71	35.0	15.0	−	15.0	15.0	20.0	−
MJBKS−6	42.00	0.00	100.0	24.00	5.25	33.4	20.8	−	8.3	20.8	16.7	−
MJBKS−7	33.00	12.00	100.0	26.40	3.67	45.0	15.0	−	10.0	10.0	20.0	−
MJBKS−8	30.50	12.00	100.0	24.40	3.81	40.0	15.0	−	10.0	15.0	20.0	−
MJBKS−9	29.00	11.00	100.0	14.50	2.90	15.6	60.9	−	4.7	12.5	6.3	−
MJBKS−10	25.00	11.00	100.0	7.69	2.50	25.0	40.0	−	5.0	10.0	20.0	−
MJBKS−11	35.00	10.00	100.0	28.00	3.89	45.0	15.0	−	10.0	10.0	20.0	−
MJBKS−12	39.00	9.00	100.0	14.18	3.25	37.5	31.3	−	6.3	12.5	12.5	−
MJBKS−13	34.00	10.00	100.0	2.62	1.79	17.0	17.0	−	57.1	1.8	7.1	−
MJBKS−14	37.00	9.00	100.0	29.60	4.63	40.0	15.0	−	10.0	15.0	20.0	−
MJBKS−15	33.00	7.00	100.0	10.50	3.30	25.0	40.0	−	5.0	10.0	20.0	−
MJBKS−16	45.00	9.00	100.0	20.00	3.75	40.0	20.0	−	6.7	13.3	20.0	−
MJBKS−17	40.00	9.00	100.0	17.78	3.33	40.0	20.0	−	6.7	13.3	20.0	−
MJBKS−18	40.50	9.00	100.0	16.20	2.53	16.3	4.1	−	69.4	4.1	6.1	−
MJBKS−19	35.00	9.00	100.0	8.50	5.00	43.8	18.7	−	12.5	25.0	0.0	−
MJBKS−20	43.00	7.00	100.0	24.57	5.38	33.3	25.0	−	8.3	16.7	16.7	−
MJBKS−21	37.00	7.00	100.0	24.67	4.63	33.3	25.0	−	8.3	16.7	16.7	−
MJBKS−22	32.00	8.00	100.0	32.00	4.57	35.0	15.0	−	10.0	20.0	20.0	−
MJBKS−23	40.00	8.00	100.0	22.86	4.44	37.5	20.8	−	8.3	16.7	16.7	−
MJBKS−24	41.00	9.00	100.0	23.43	4.56	37.5	20.8	−	8.3	16.7	16.7	−
MJBKS−25	34.00	7.40	100.0	22.67	4.25	33.3	25.0	−	8.3	16.7	16.7	−
MJBKN−1	67.00	7.00	100.0	15.76	3.72	36.0	28.0	−	8.0	8.0	20.0	−
MJBKN−2	70.00	0.00	100.0	16.47	3.50	40.0	32.0	−	4.0	4.0	20.0	−
MJBKN−3	68.00	5.00	100.0	10.07	1.89	47.4	21.0	−	5.3	10.5	15.8	−
MJBKN−4	60.00	4.00	100.0	18.46	3.75	42.1	28.9	−	5.3	7.9	15.8	−
MJBKN−5	70.00	10.50	100.0	17.50	2.80	44.6	26.8	−	3.6	10.7	14.3	−
Total	2271.50	283.90	5,000	776.61	148.06	1818.3	1218.4	153.7	489.1	501.2	819.4	−
Average by each hole	45.43	5.68	100.0	15.53	2.96	36.4	24.4	3.1	9.8	10.0	16.4	−

Table Ⅱ-3-2 Results of Drilling Survey by Each Hole in the Kokpetinskaya Area

Hole No.	Period of Drilling	Drilling length	Quantity of working shift	Total workers				Contents of work								Consumable materials													Non-core	Core	Casing
				Engineer			Worker	Drilling	Preparation	Dismount	Out-drilling	Recovery from accident	Transportation of water	Other	Total	Bit			Shoe				Deisel oil	Gasoline	Lubricating oil	Grease	Bentonite	Total amount of water			
				Japanese	Operator	Geologist	Assistant/driver									4"T.B.	mm 190	mm 92	mm 400	mm 270	mm 200	mm 133									
		m						hr	hr	hr	hr	hr	hr	hr	hr	pc	pc	pc	pc	pc	pc	pc	l	l	l	kg	bag	m³	m	m	m
MJBK 18	2001. 7. 9 2001. 7.13	30.00	8	3	17	1.0	40	24.0	6.0	4.0	30.0		12.0		76.0		2			1			1,230	50	8	8		36	6.0	24.0	7.0
MJBK 19	2001. 7.13 2001. 7.14	44.00	2	1	4	1.0	10	9.0	2.0	2.0	3.0		4.0		20.0		1			1			400	40	2	3		12	7.5	36.5	8.0
MJBK 20	2001. 7.11 2001. 7.12	37.00	4	2	8	2.0	10	14.0	2.0	4.0	12.0		8.0		40.0		1			1			1,120	70	10	5		24	8.0	29.0	9.0
MJBK 21	2001. 7.13 2001. 7.18	43.00	11	4	21	6.0	55	40.0	4.0	8.0	26.0	10.0	16.0		104.0		4			3			1,990	115	17	13		48	11.0	32.0	11.0
MJBK 22	2001. 8.24 2001. 8.31	65.00	15	4	31	7.0	70	49.0	3.0	10.0	53.0	5.0	22.0		142.0		6			5	7		2,430	180	30	25		66	9.0	56.0	9.0 16.0
MJBK 23	2001. 7.14 2001. 7.27	60.00	26	12	53	2.0	130	46.0	4.0	8.0	65.0	71.0	32.0		226.0		7			4			3,120	350	28	20		96	10.0	50.0	6.0 10.0
MJBK 24	2001. 7.18 2001. 7.23	58.00	11	5	21	5.0	55	36.0	4.0	7.0	31.0	10.0	16.0		104.0		6			2			1,810	120	120	12		48	8.0	50.0	9.0
MJBK 25	2001. 8.22 2001. 8.25	43.00	8	7	13	4.0	40	34.0	6.0	4.0	20.0		12.0		76.0		3			2	3		1,200	100	10	10		36	10.0	33.0	8.0 10.0
MJBK 26	2001. 8.20 2001. 8.24	50.00	9	4	20	5.0	45	34.0	4.0	8.0	26.0		14.0		86.0		6			4	3		1,430	180	10	10		42	9.0	41.0	8.0 9.0
MJBK 27	2001. 8.14 2001. 8.19	50.00	11	5	21	5.0	55	46.0	8.0	7.0	25.0	2.0	18.0		106.0		5			4	2		1,650	220	20	12		54	9.0	41.0	7.0 9.0
MJBK 28	2001. 8. 9 2001. 8.14	54.00	10	4	20	5.0	50	33.0	4.0	4.0	15.0	24.0	11.0		91.0		5			3			2,100	160	20	13		33	8.0	46.0	6.0 8.0
MJBK 29	2001. 8. 5 2001. 8. 9	58.00	9	4	20	5.0	45	32.0	4.0	6.0	19.0	11.0	16.0		88.0		4			3	2		1,600	210	13	10		48	8.0	50.0	8.0 8.0
MJBK 30	2001. 7.29 2001. 8. 4	60.00	13	5	25	6.0	65	50.0	4.0	6.0	24.0	20.0	18.0		122.0		3			3	2		1,720	200	15	10		54	8.0	52.0	8.0 8.0
MJBK 31	2001. 8.16 2001. 8.21	51.00	12	5	10	6.0	60	51.0	4.0	8.0	33.0		20.0		116.0		5			3	2		2,200	300	20	10		60	10.0	41.0	7.0 10.0
MJBK 32	2001. 8.11 2001. 8.15	58.00	9	3	18	4.0	40	31.0	4.0	6.0	21.0	10.0	14.0		86.0		2			3			1,320	70	10	10		42	8.0	50.0	8.0 8.0
MJBK 33	2001. 8. 6 2001. 8.11	53.00	10	5	20	5.0	50	42.0	4.0	8.0	26.0		16.0		96.0		6			4	4		1,610	210	10	10		48	9.0	44.0	9.0 9.0
MJBK 34	2001. 7.27 2001. 8. 6	60.00	20	5	45	10.0	100	50.0	6.0	6.0	38.0	60.0	34.0		194.0		8			3	3		2,930	260	23	17		102	6.0	54.0	7.0 9.0
MJBK 35	2001. 7.24 2001. 7.29	60.00	11	6	23	6.0	55	30.0	4.0	7.0	47.0		12.0		100.0		3			2			1,620	80	10	7		36	8.0	52.0	10.0
MJBK 36	2001. 7. 2 2001. 7.16	51.00	16	4	45	20.0	85	21.0	65.0	5.0	37.0		16.0		144.0		3	2		1			2,300	200	15	13	62	48	6.0	45.0	7.0
MJBK 37	2001. 7. 9 2001. 7.15	48.00	6	3	13	4.0	30	24.0	5.0	3.0	16.0		12.0		60.0		2	1		1			1,450	110	7	10	45	36	6.0	42.0	10.0
MJBKS 1	2001. 8.10 2001. 8.10	40.00	2	1	3	1.0	10	9.0	2.0	2.0	3.0		4.0		20.0	1		2				1	420	60	4	5	45	12	11.0	29.0	7.0
MJBKS 2	2001. 8. 8 2001. 8. 8	40.50	2	1	3	1.0	10	9.0	2.0	2.0	3.0		4.0		20.0	1		2				1	400	50	3	3	45	12	10.0	30.5	10.0
MJBKS 3	2001. 8. 9 2001. 8. 9	35.00	2	1	3	1.0	10	9.0	2.0	2.0	3.0		4.0		20.0	1		2				1	410	50	3	5	45	12	12.0	23.0	12.0
MJBKS 4	2001. 8.11 2001. 8.11	31.00	2	1	3	1.0	10	10.0	1.0	2.0	3.0		4.0		20.0	2		2				1	400	40	5	3	50	12	16.0	15.0	16.0
MJBKS 5	2001. 7.29 2001. 7.30	32.00	2	1	3	1.0	10	7.0	3.0	3.0	3.0		4.0		20.0			1				1	580	45	3	3	35	12	12.0	21.0	12.0
MJBKS 6	2001. 7.28 2001. 7.29	42.00	2.5	1	5	1.5	12.5	8.0	2.0	5.0	5.0		4.0		24.0	1		2				1	460	70	3	3	40	12	14.0	28.0	0.0
MJBKS 7	2001. 7.27 2001. 7.27	33.00	2	1	3	1.0	10	9.0	2.0	2.0	3.0		4.0		20.0	1		2				1	410	50	3	3	45	12	12.0	21.0	12.0
MJBKS 8	2001. 7.26 2001. 7.26	30.50	2	1	3	1.0	10	8.0	2.0	3.0	3.0		4.0		20.0			2				1	390	50	4	3	42	12	12.0	18.5	12.0
MJBKS 9	2001. 7.30 2001. 8. 4	29.00	7.5	1	23	5.5	37.5	10.0	3.0	8.0	39.0		4.0		64.0	1		1				1	410	90	15	10	40	12	11.0	18.0	11.0
MJBKS 10	2001. 8. 5 2001. 8. 6	25.00	4	2	6	2.0	20	10.0	2.0	4.0	16.0		8.0		40.0	1		2				1	400	60	5	5	43	24	11.0	14.0	11.0
MJBKS 11	2001. 8. 7 2001. 8. 7	35.00	2	1	3	1.0	10	9.0	2.0	2.0	3.0		4.0		20.0	1		2				1	380	50	3	3	45	12	10.0	25.0	10.0
MJBKS 12	2001. 7.24 2001. 7.25	39.00	3.5	1	5	1.5	16	12.0	2.0	4.0	10.0		4.0		32.0	1		2				1	400	50	5	3	40	12	9.0	30.0	9.0
MJBKS 13	2001. 7. 2 2001. 7. 8	34.00	13	2	37	10.0	70	19.0	64.0	2.0	19.0		8.0		112.0		2			1			1,270	80	6	6		24	8.0	26.0	10.0
MJBKS 14	2001. 7.22 2001. 7.22	37.00	2	1	3	1.0	10	8.0	2.0	3.0	3.0		4.0		20.0			1				1	430	50	3	3	45	12	9.0	28.0	9.0
MJBKS 15	2001. 7.22 2001. 7.22	33.00	4	2	6	2.0	20	10.0	2.0	4.0	16.0		8.0		40.0	1		2				1	810	60	5	5	45	24	7.0	26.0	7.0
MJBKS 16	2001. 7.18 2001. 7.19	45.00	3	1	4	1.0	15	12.0	2.0	4.0	6.0		6.0		30.0	1		2				2	690	70	5	5	40	18	9.0	36.0	9.0
MJBKS 17	2001. 7.17 2001. 7.18	40.00	3	1	6	1.0	15	12.0	2.0	4.0	6.0		6.0		30.0	1		2				2	680	75	3	5	42	18	9.0	31.0	9.0
MJBKS 18	2001. 7. 2 2001. 7. 7	40.50	11	2	34	9.0	60	16.0	68.0	4.0	4.0		6.0		98.0	1		2				3	700	90	10	5	45	18	9.0	31.5	9.0
MJBKS 19	2001. 7. 9 2001. 7.10	35.00	2	1	3	1.0	10	7.0	2.0	4.0	3.0		0.0		16.0	1		2				1	420	80	5	5	40	0	8.5	26.5	9.0
MJBKS 20	2001. 7.10 2001. 7.11	43.00	2.5	1	4.5	1.5	12.5	8.0	2.0	4.0	6.0		4.0		24.0	1		2				2	400	80	8	5	48	12	7.0	36.0	7.0
MJBKS 21	2001. 7.10 2001. 7.11	37.00	2.5	1	3.5	1.0	12.5	8.0	2.0	4.0	6.0		4.0		24.0			2				1	400	75	5	5	40	12	6.0	31.0	7.0
MJBKS 22	2001. 7.12 2001. 7.13	32.00	2	1	3	1.0	10	7.0	2.0	4.0	3.0		4.0		20.0			2				1	390	70	5	5	50	12	7.5	24.5	8.0
MJBKS 23	2001. 7.13 2001. 7.14	40.00	2.5	1	3.5	1.0	12.5	9.0	2.0	4.0	5.0		4.0		24.0	1		2				1	410	80	7	5	50	12	7.0	33.0	8.0
MJBKS 24	2001. 7.23 2001. 7.24	41.00	2.5	1	4.5	1.5	10.25	9.0	2.0	4.0	5.0		4.0		24.0	1		2				1	415	70	5	5	48	12	7.0	34.0	9.0
MJBKS 25	2001. 7. 8 2001. 7. 9	34.00	2.5	1	4.5	1.5	12.5	8.0	2.0	4.0	6.0		4.0		24.0	1		2				2	430	90	10	5	45	12	8.0	26.0	7.4
MJBKN 1	2001. 8.21 2001. 8.23	67.00	5	3	12	3.0	30	18.0	4.0	4.0	14.0		10.0		50.0	1		2				1	430	70	10	5	45	30	7.0	60.0	7.0
MJBKN 2	2001. 8.23 2001. 8.25	70.00	5	3	19	2.0	50	20.0	2.0	2.0	16.0		10.0		50.0			6					500	100	10	5	50	30	2.5	67.5	0.0
MJBKN 3	2001. 8.17 2001. 8.20	68.00	8	2	7	4.0	25	36.0	4.0	8.0	16.0		12.0		76.0			3				1	800	120	10	10	72	36	4.0	64.0	5.0
MJBKN 4	2001. 8.15 2001. 8.16	60.00	4	4	12	2.0	40	16.0	2.0	3.0	11.0		6.0		38.0			2				1	400	50	5	5	41	18	3.0	57.0	4.0
MJBKN 5	2001. 8.12 2001. 8.14	70.00	6	3	9	3.0	30	25.0	2.0	6.0	15.0		8.0		56.0			3				1	600	80	10	6	60	24	10.0	60.0	10.5
Total	2001. 7. 2 2001. 8.31	2271.50	335	135	887	174.0	1701	1054.0	340.0	232.0	821.0	223.0	483.0		3153.0	21	84	64	0	54	28	34	50,465	5280	576	372	1428	1449	433.0	1839.5	532.9

Table II-3-3 Results of Drilling Survey by Each Machine in the Kokpetinskaya Area

Content of work		Quantity of working shift	Total workers				Contents of work								Consumable materials			
			Engineer			worker	Transport	Carrying	Prepa-ration	Waiting for material	Recovery from accident	Dism-ount	Other	Total	Gasoline	Diesel oil	Lubricanting oil	Grease
			Japnaese	Operator	Geologist	Locals												
Detailed survey (No.1 machine)							hr	hr	hr	hr	hr	hr	hr	hr	l	l	l	kg
Travel	Tokyo-Almaty-Samarskaya		5											0.0				
Preparation	2001. 7. 2～2001. 7. 6	15	2	4	2	10	8.0	6.0	108.0					122.0	20	250	20	5
Holiday														0.0				
Dismount	2001. 8. 31～2001. 8. 31	4.05	2	1		8						70.0		70.0	10	300	15	10
Travel	2001. 9. 1～2000. 9. 9		10											0.0				
Total	2001. 7. 2～2001. 8. 31	19.05	19.0	5.0	2.0	18.0	8.0	6.0	108.0	0.0	82.0	70.0		192.0	30	550	35	15
Detailed survey (No.2 machine)																		
Travel	Tokyo-Almaty-Samarskaya													0.0				
Preparation	2001. 7. 2～2001. 7. 6	8.75	5	2	1	12	10.0	2.0	100.0					112.0	10	130	10	5
Holyday														0.0				
Dismount	2001. 8. 25～2001. 8. 25	6	1	1		7						50.0		50.0	9	250	15	8
Travel	2001. 8. 26～2000. 9. 4		10											0.0				
Total	2001. 7. 2～2001. 8. 25	14.75	16.0	3.0	1.0	19.0	10.0	2.0	100.0	0.0	141.0	50.0		162.0	19	380	25	13
General survey (No. 3 machine)																		
Travel	Tokyo-Almaty-Samarskaya		5											0.0				
Preparation	2001. 7. 2～2001. 7. 6	35.75	5	3	1	8	9.0	1.0	132.0					142.0	15	280	20	10
Holyday														0.0				
Dismount	2001. 8. 25～2001. 8. 25	11	1	3	1	10						112.0		112.0	10	300	25	15
Travel	2001. 8. 26～2000. 9. 4		10											0.0				
Total	2001. 7. 2～2001. 8. 25	46.75	21.0	6.0	2.0	18.0	9.0	1.0	132.0	0.0	0.0	112.0		254.0	25	580	45	25
Total		80.55	56.0	14.0	5.0	55.0	27.0	9.0	340.0	0.0	223.0	232.0		608.0	74	1,510	105	53

Table Ⅱ-3-4 General Results of the Drilling Works in the Kokpetinskaya Area

Drilling machine			NO.1 machine		NO.2 machine	NO.3 machine			Total	Description
District			South of Placer No.1	South of Placer No.3	South of Placer No.1	South of Placer No.1	South of Placer No.3	North of Bektemir		
Number of holes			10.6	1	8.4	1	24	5	50	
Length of drilling (m)			564.50	34.00	419.00	49.50	869.50	335.00	2271.50	
Ave. length of drillholes (m)			53.25	34.00	49.88	49.50	36.23	67.00	45.43	
Survey days	Period		2001. 7. 9	2001. 7. 2	2001. 7. 2	2001. 7.15	2001. 7. 2	2001. 8.12	2001. 7. 2	
			2001. 8.31	2001. 7. 8	2001. 8.25	2001. 7.16	2001. 8.11	2001. 8.25	2001. 8.31	
	Drilling days		46.625	2.25	44.975	1.25	21.75	11.125	127.975	
	Other days		7	4.25	9.525	0.625	16.0	2.875	40.275	Travel, transport, preparation and dismount
	Holidays		—		—	—	—	—	—	
	Total days		53.625	6.5	54.5	1.875	37.750	14	168.25	
Workers	Local staff	Engineer	263	39	279	12	169.5	60	822.5	
		Worker	535	70	545	20	366.25	145	1681.25	
		Geologist	51	1	54	4	41	12	163	
		Total	849	110	878	36	576.75	217	2666.75	
	Japanese staff		41	4	45	3	25	15	88	
Efficiency of drilling days (m/day·machine)			12.11	15.11	9.32	39.60	39.98	30.11	17.75	
Efficiency of survey days (m/day·machine)			10.53	5.23	7.69	26.40	23.03	23.93	13.50	

Table Ⅱ-3-5 Consumable Drilling Articles in the Kokpetinskaya Area

Item	Unit	Quantity	Average		Note
Tricone bit (4″)	pcs	21	9.21 m/pc	1.05 pcs/hole	
Metal bit (φ92mm)	pcs	64	12.52 m/pc	2.06 pcs/hole	
Metal bit (φ190mm)	pcs	84	11.41 m/pc	4.00 pcs/hole	
Shoe(φ270mm)	pcs	54	3.30 m/pc	2.57 pcs/hole	
Shoe(φ200mm)	pcs	28	3.14 m/pc	3.11 pcs/hole	
Shoe(φ133mm)	pcs	34	7.79 m/pc	1.21 pcs/hole	
Deisel oil	liters	50,465	22.22 l/m	1009.30 l/hole	
Gasoline	liters	5,280	2.32 l/m	105.60 l/hole	
Lubricating oil	liters	576	0.25 l/m	11.52 l/hole	
Grease	kg	372	0.16 l/m	7.44 l/hole	
Bentonite	bags*	1,428	0.63 bags/m	28.56 bags/hole	
Total amount of water	m^3	1,449	0.64 m^3/m	28.98 m^3/hole	

*1bag=25kg

Table Ⅱ-3-6 Major Mineralization Zones Revealed by Drillings on the Southern flank of Placer No.1

Hole No.	Depth (m)	Width (m)	Ilmenite content (kg/m³)	Zircon content (kg/m³)	Remarks
MJBK-18	25.00～28.50	3.50	215.79	3.46	
MJBK-19	28.00～29.60	1.60	23.44	0.50	
	35.80～36.90	1.10	20.52	0.58	
MJBK-20	31.00～34.20	3.20	55.82	0.89	
MJBK-21	37.50～41.20	3.70	105.41	1.76	
MJBK-22	37.80～42.80	5.00	190.68	3.15	
MJBK-23	38.10～40.00	1.90	167.40	2.73	
MJBK-24	40.80～42.10	1.30	119.46	2.10	
MJBK-25	37.00～38.50	1.50	50.04	1.86	
MJBK-26	38.00～40.50	2.50	110.48	2.17	
MJBK-27	39.00～44.50	5.50	94.37	1.71	
MJBK-28	43.50～48.50	5.00	121.01	2.22	
MJBK-29	43.00～48.00	5.00	117.70	2.05	
MJBK-30	40.50～43.50	3.00	200.25	2.84	
MJBK-31	46.00～49.50	3.50	131.62	2.10	
MJBK-32	53.00～58.00	5.00	98.13	1.55	
MJBK-33	41.00～51.00	10.00	132.95	1.52	
MJBK-34	42.00～45.40	3.40	162.39	2.26	
MJBK-35	43.00～44.80	1.80	201.71	3.40	
MJBK-36	41.00～50.30	9.30	111.84	1.58	

Table II-3-7 Major Mineralization Zones Revealed by Drillings on the Southern flank of Placer No.3

Hole No.	Depth (m)	Width (m)	Ilmenite content (kg/m^3)	Zircon content (kg/m^3)	Remarks
MJBKS-1	20.00～25.00	5.00	4.04	0.13	
MJBKS-7	24.80～28.00	3.20	113.33	3.26	
MJBKS-11	23.00～25.00	2.00	112.42	2.60	
MJBKS-13	30.50～32.00	1.50	117.36	2.35	
MJBKS-14	24.00～25.00	1.00	4.02	0.06	
MJBKS-16	29.50～33.10	3.60	180.70	3.87	
MJBKS-17	33.10～33.30	0.30	180.00	4.11	
MJBKS-18	22.00～22.80	0.80	15.95	0.61	
MJBKS-24	24.00～25.00	1.00	2.88	0.11	
MJBKS-25	27.50～29.50	2.00	3.20	0.04	

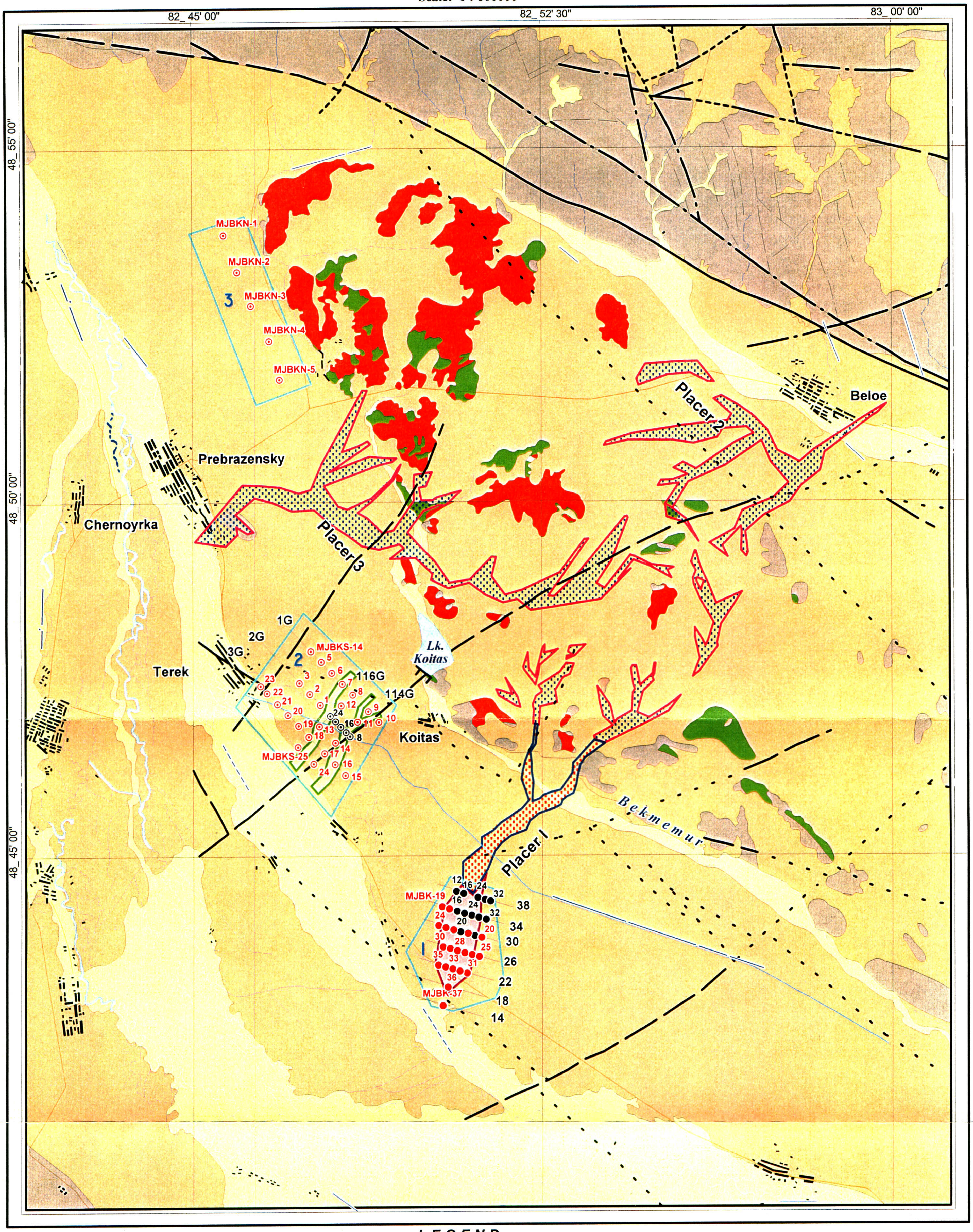
Table II-3-8 Ilmenite content, Ore Sands and Overburden Thickness at the Southern Flank of Placer No1 in block IV –C_2

No.	Profiles No.	Hole No.	Thickness m.		Average ilmenite content, kg/м^3	Thickness x ilmenite, 4x6
			Ore sands	Overburden		
1	*2*	*3*	*4*	*5*	*6*	*7*
1	34	MJBK-18	3.5	25.0	215.79	755.26
2	34	MJBK-19	5.6	29.0	119.36	668.42
3	30	MJBK-23	1.9	38.1	167.40	318.06
4	30	MJBK-22	5.0	37.8	190.68	953.40
5	30	MJBK-17	7.0	36.0	105.41	737.87
6	30	MJBK-21	3.7	37.5	128.45	475.26
7	30	MJBK-16	5.0	34.0	114.46	572.30
8	26	MJBK-30	3.0	40.5	200.25	600.75
9	26	MJBK-29	5.0	43.0	117.70	588.50
10	26	MJBK-28	5.0	43.5	121.01	605.05
11	26	MJBK-27	5.5	39.0	94.37	519.04
12	26	MJBK-26	2.5	38.0	110.48	276.20
13	22	MJBK-35	1.8	43.0	201.71	363.08
14	22	MJBK-34	3.4	42.0	162.39	552.13
15	22	MJBK-33	10.0	41.0	132.95	1329.50
16	22	MJBK-32	5.0	53.0	98.13	490.65
17	22	MJBK-31	3.5	46.0	131.62	460.67
18	18	MJBK-36	9.3	41.0	111.84	1040.11
Total:			**85.7**	**707.4**		**11306.25**
Average:			**4.76**	**39.3**	**131.93**	

Table II-3-9 Ilmenite content. Ore Sands and Overburden Thickness on blocks of estimated reserves on Southern flank of Placer No3.

No	Profiles No	Holes No	Thickness. m		Average ilmenite content kg/m^3	Thickness x ilmenite. 4x6
			Ore sands	Overburden		
1	*2*	*3*	*4*	*5*	*6*	*7*
			Block I – P$_1$			
1	1г	MJBKS-7	3.2	24.8	113.33	362.66
2	2г	MJBK-15	4.4	24.5	121.11	532.88
3	116г	MJBKS-13	1.5	30.5	117.36	176.04
Total:			**9.1**	**79.8**		**1071.58**
Average:			**3.03**	**26.6**	**117.76**	
			Block II – P$_1$			
1	114г	MJBKS-11	2.0	23.0	112.42	224.84
2	2г	MJBK-12	1.9	28.0	110.72	210.37
3	3г	MJBKS-16	3.6	29.5	180.70	650.52
Total:			**7.5**	**80.5**		**1085.73**
Average:			**2.50**	**26.8**	**144.76**	

Scale: 1 : 100000



LEGEND

Fig.II-3-1 Location Map of the Drillholes in the Bektimir No.1 South , No.3 South, and Bektimir North Areas

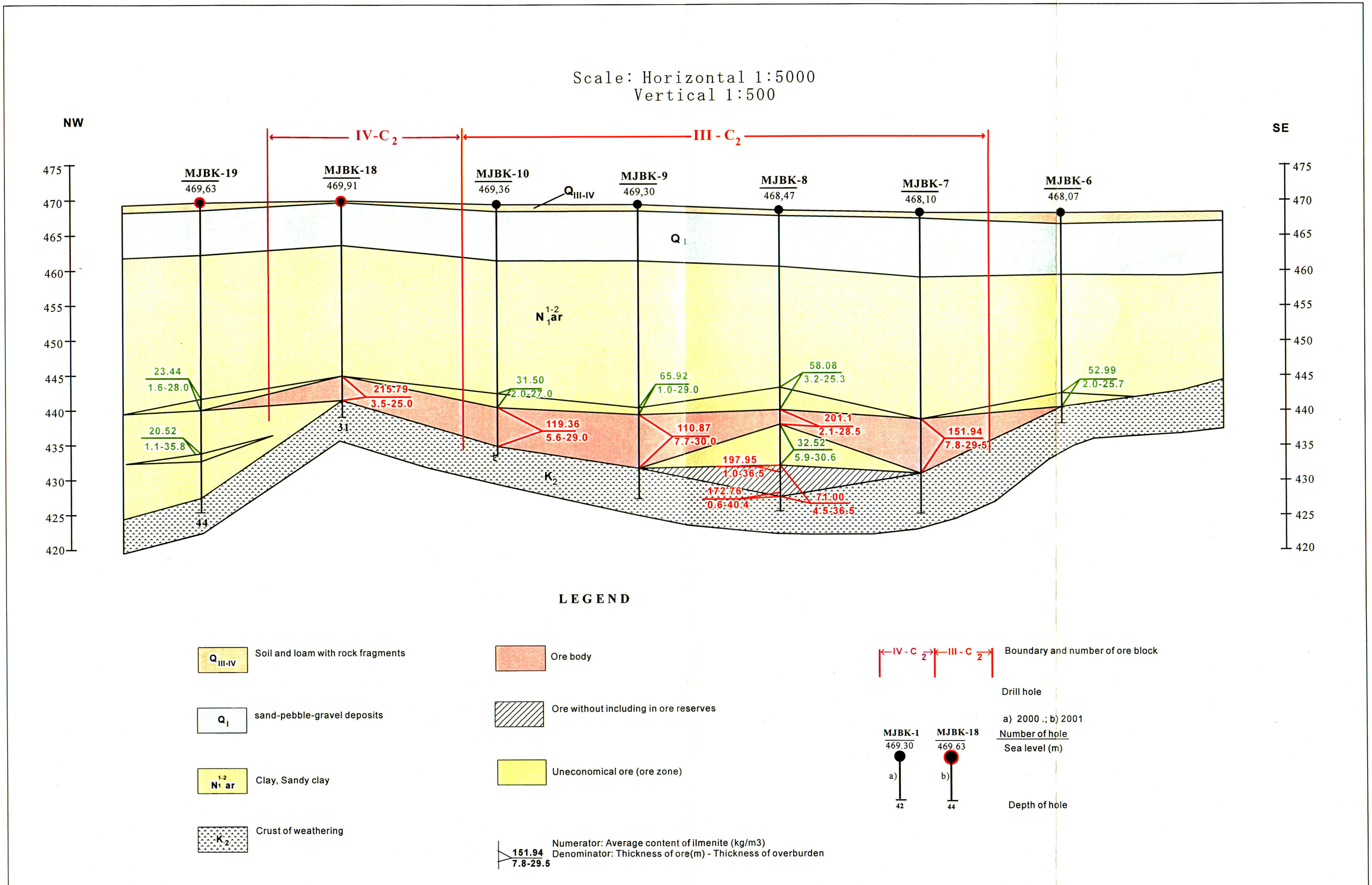


Fig. II-3-2 Geological Section along MJBK-6,7,8,9,10,18,19(Line-34)

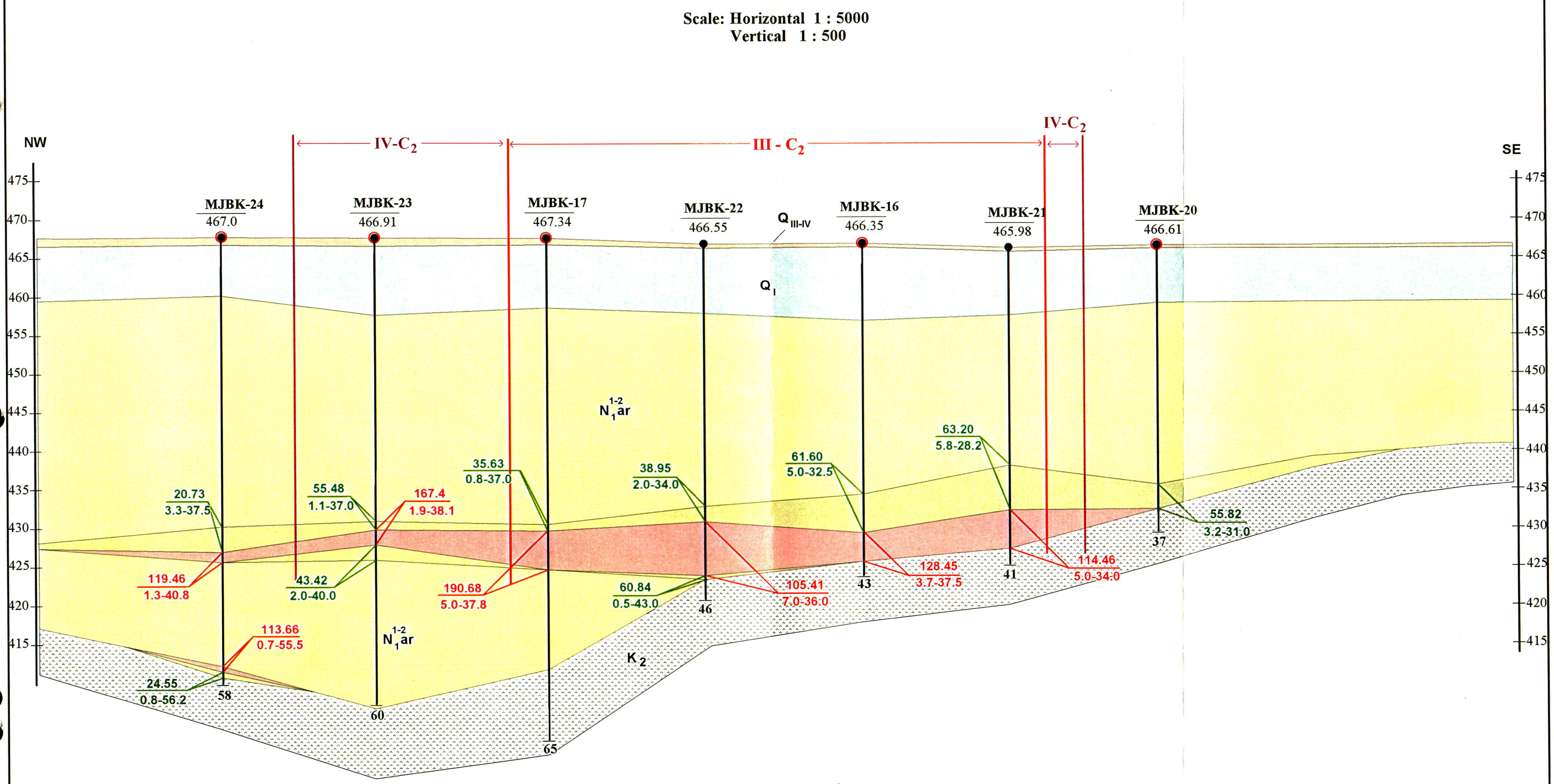


Fig.II-3-3 Geological Section along MJBK-20, 16, 21, 17, 22, 23 and 24 (Line-30)

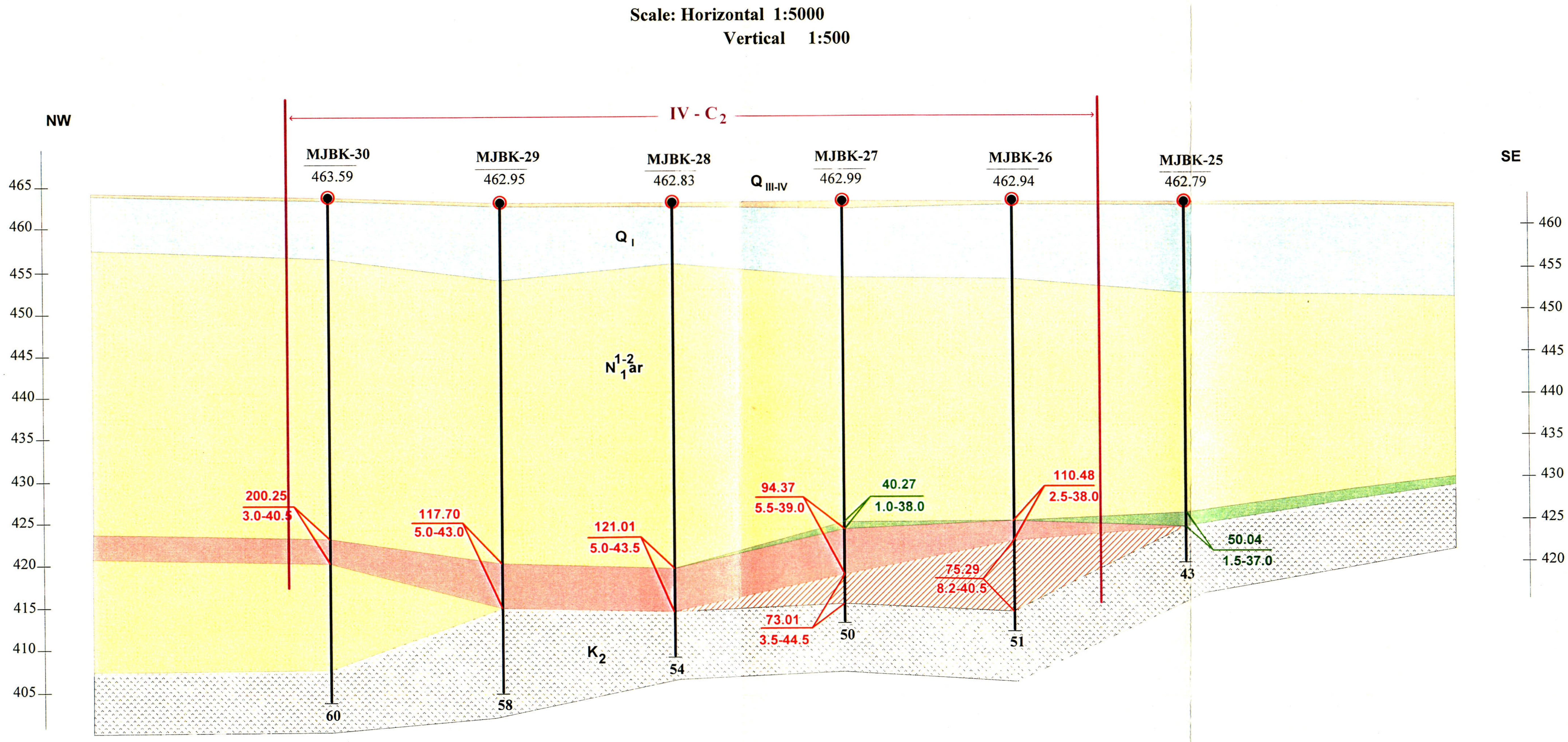


Fig.II-3-4 Geological Section along MJBK-25, 26, 27, 28, 29 and 30(Line-26)

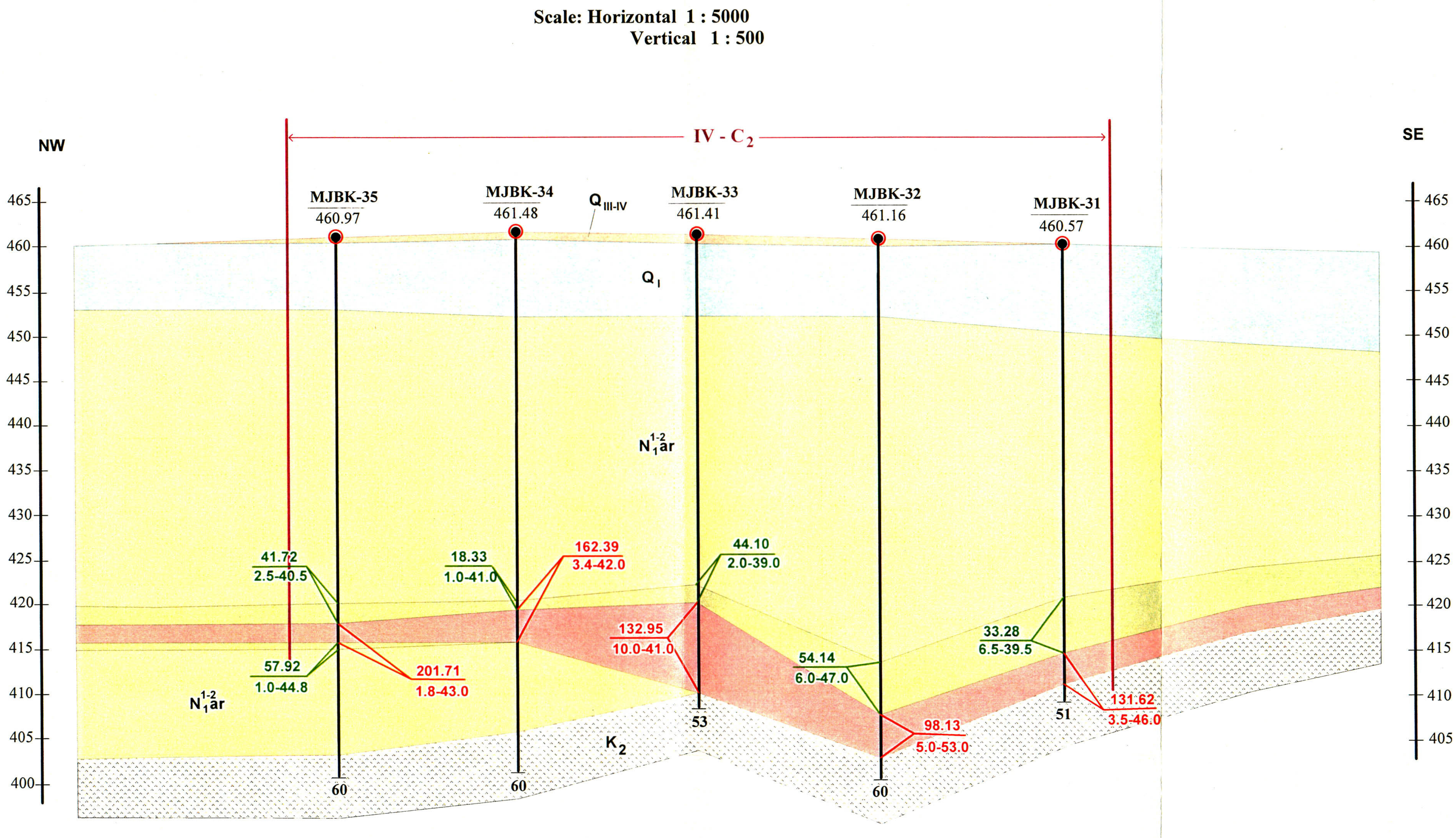


Fig.II-3-5 Geologic Section along MJBK-31, 32, 33, 34 and 35 (Line-22)

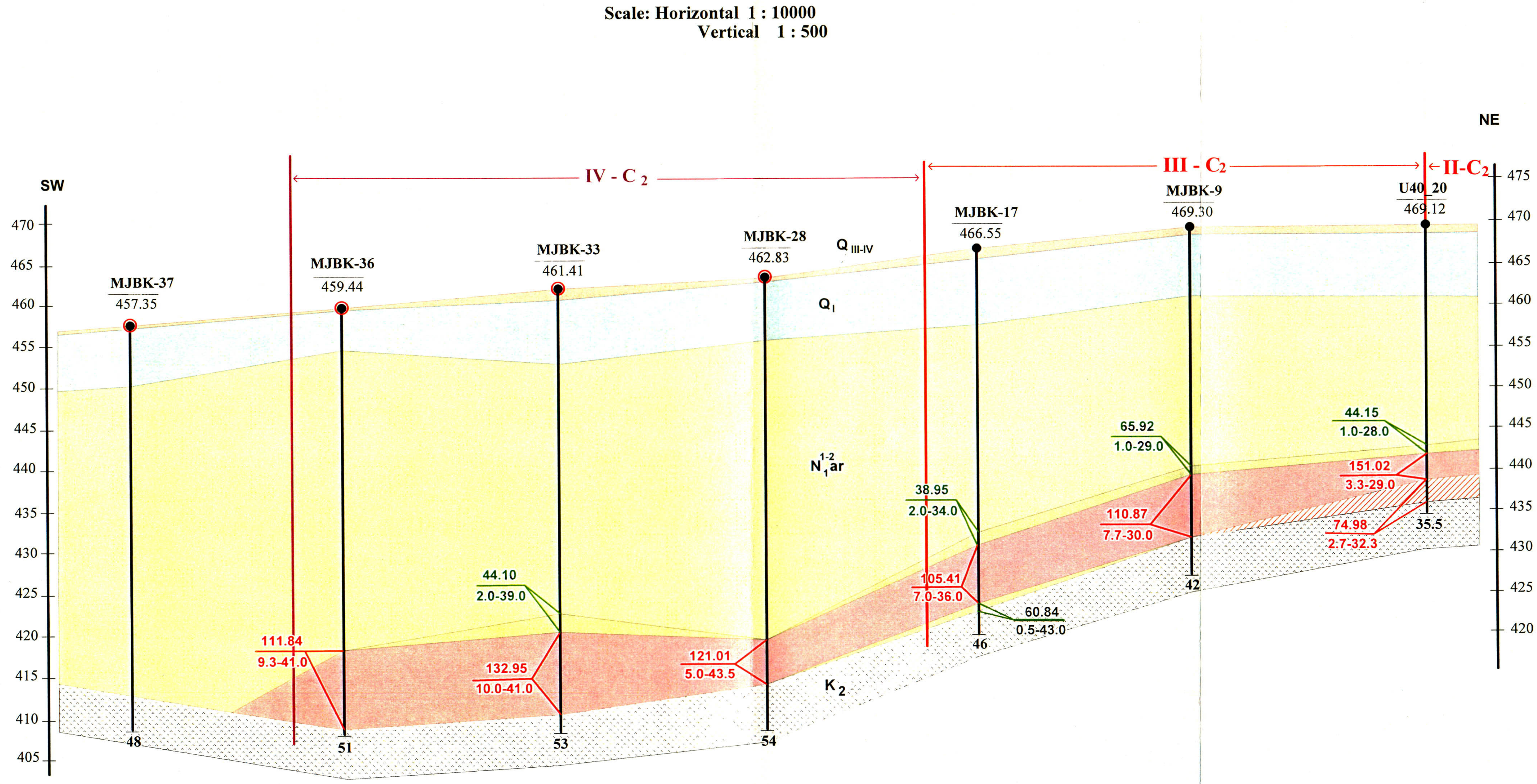


Fig.II-3-6 Geological Section along U40-20, MJBK-9, 17, 28, 33, 36 and 37

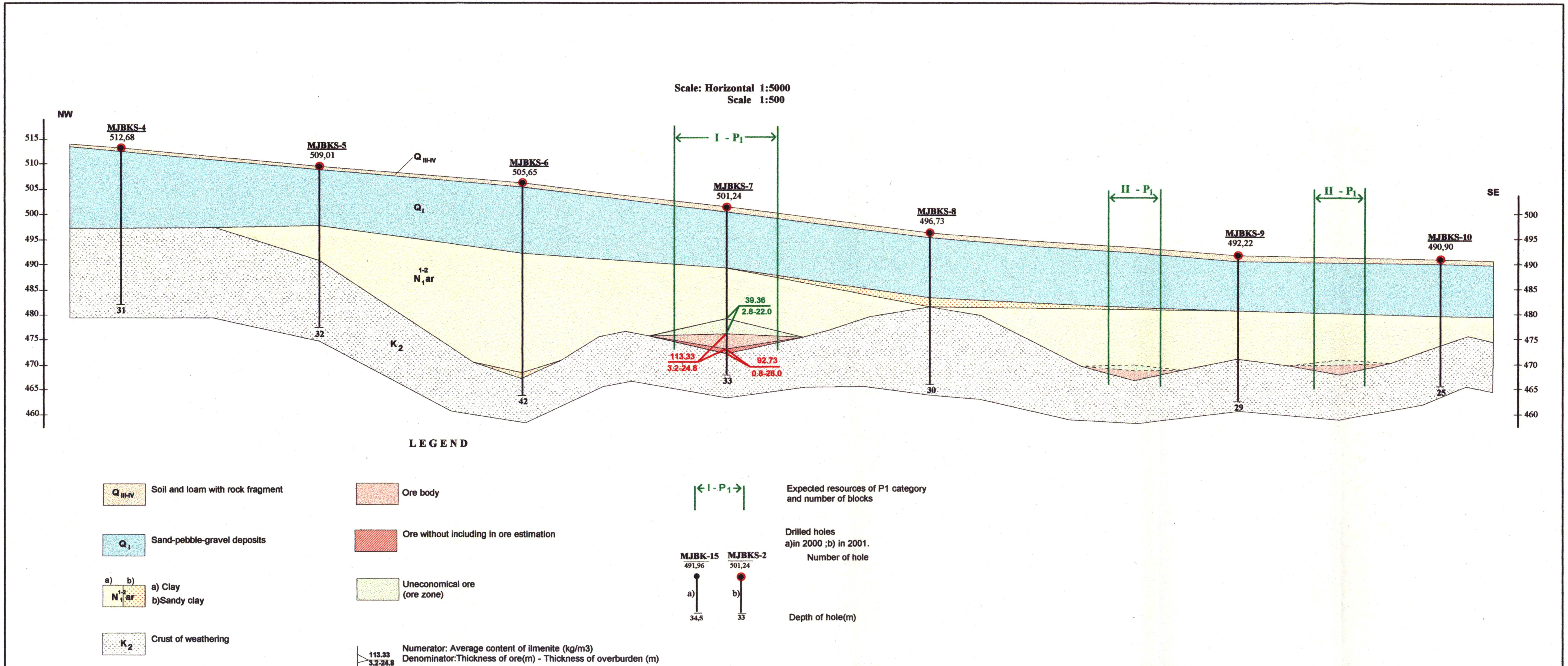


Fig.II-3-7 Geological Cross Section along Line-1G

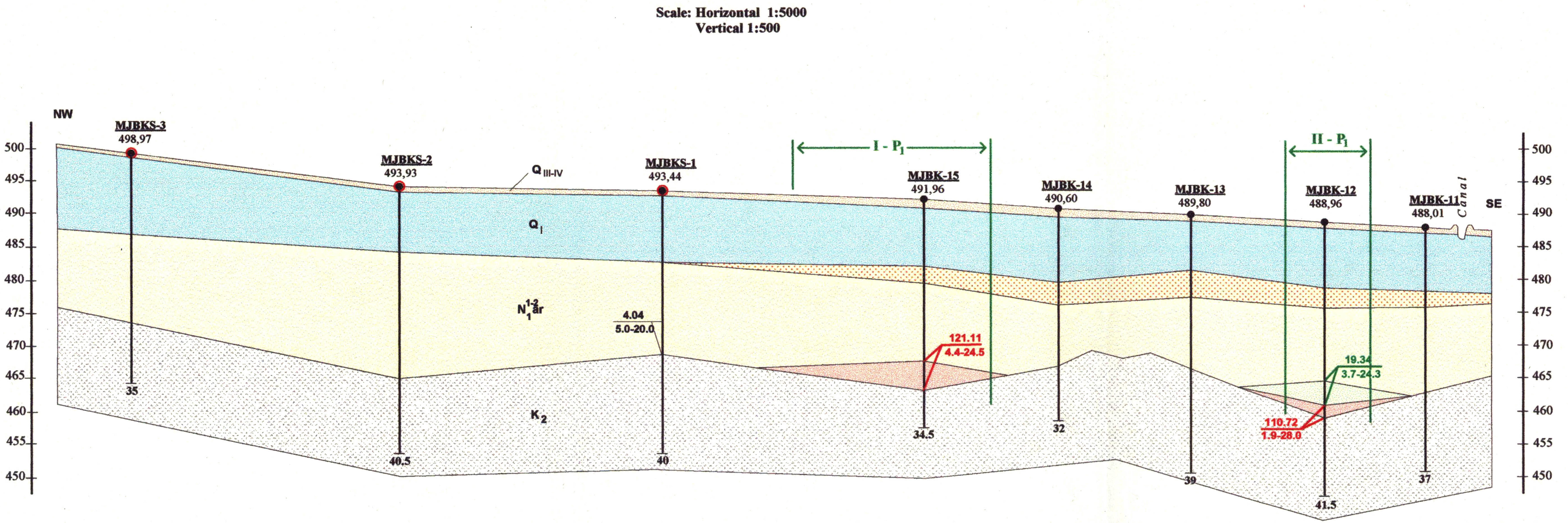


Fig.II-3-8 Geological Cross Section along Line-2G

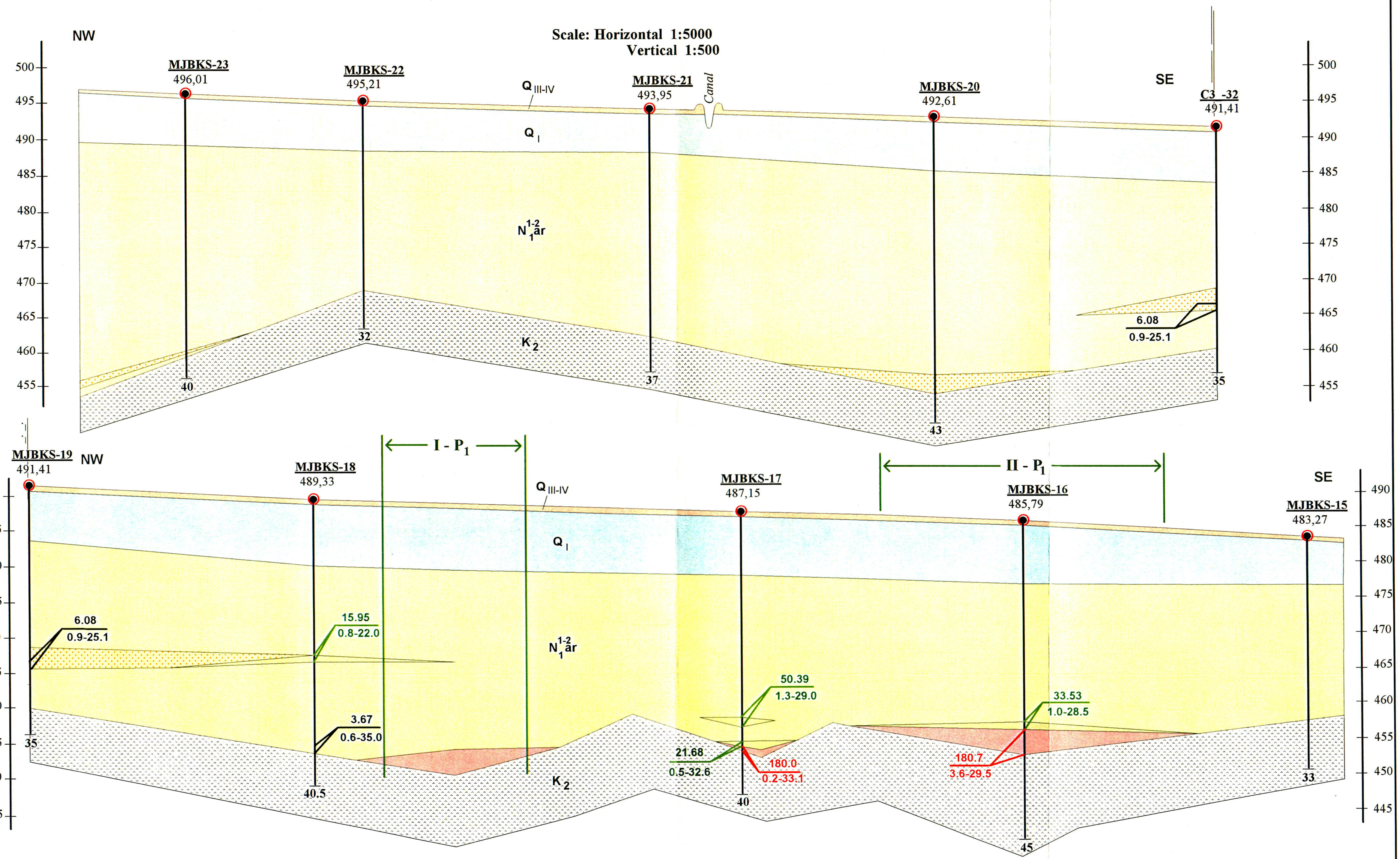


Fig.II-3-9 Geological Cross Section along Line-3G

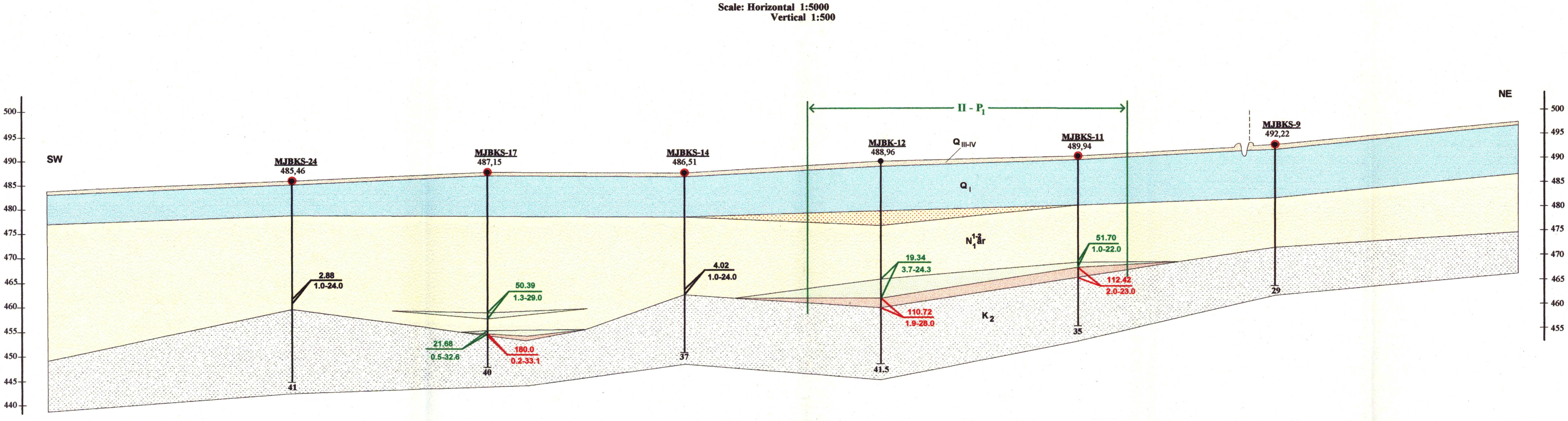


Fig.II-3-10 Geologic Cross Section alongLine-114G

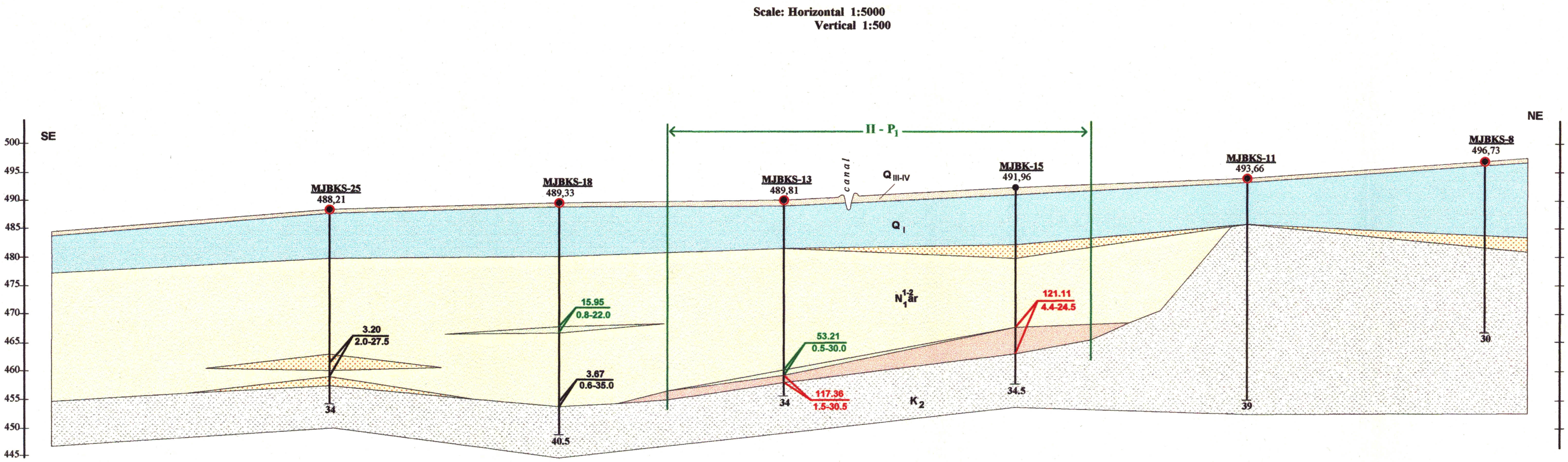


Fig.II-3-11 Geological Section along Line-116G

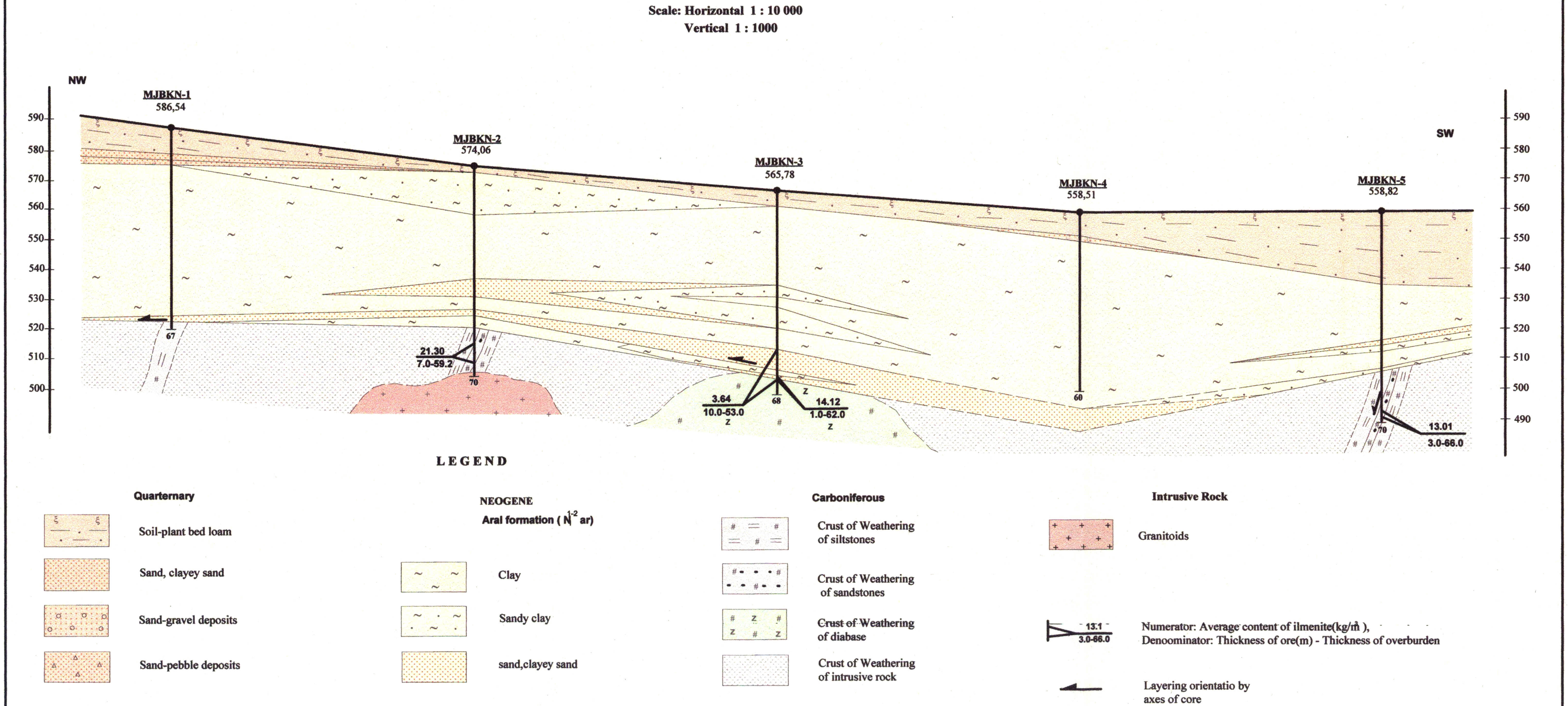


Fig.II-3-12 Geological Section along MJBKN-1, 2, 3,4 and5

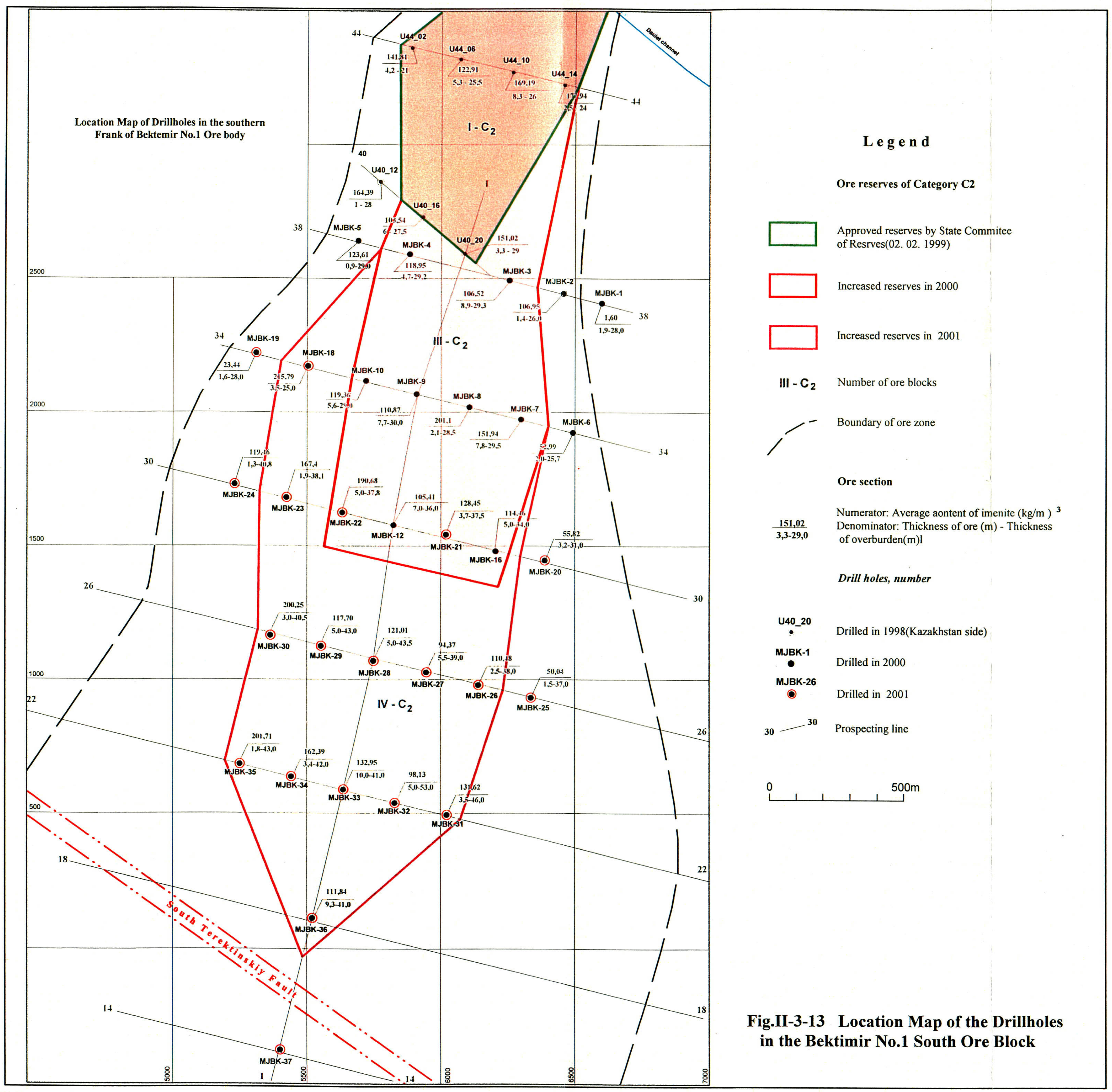


Fig.II-3-13 Location Map of the Drillholes in the Bektimir No.1 South Ore Block

Fig.II-3-14 Location Map of the Drill holes in the Bektimir No.3 South Ore Block

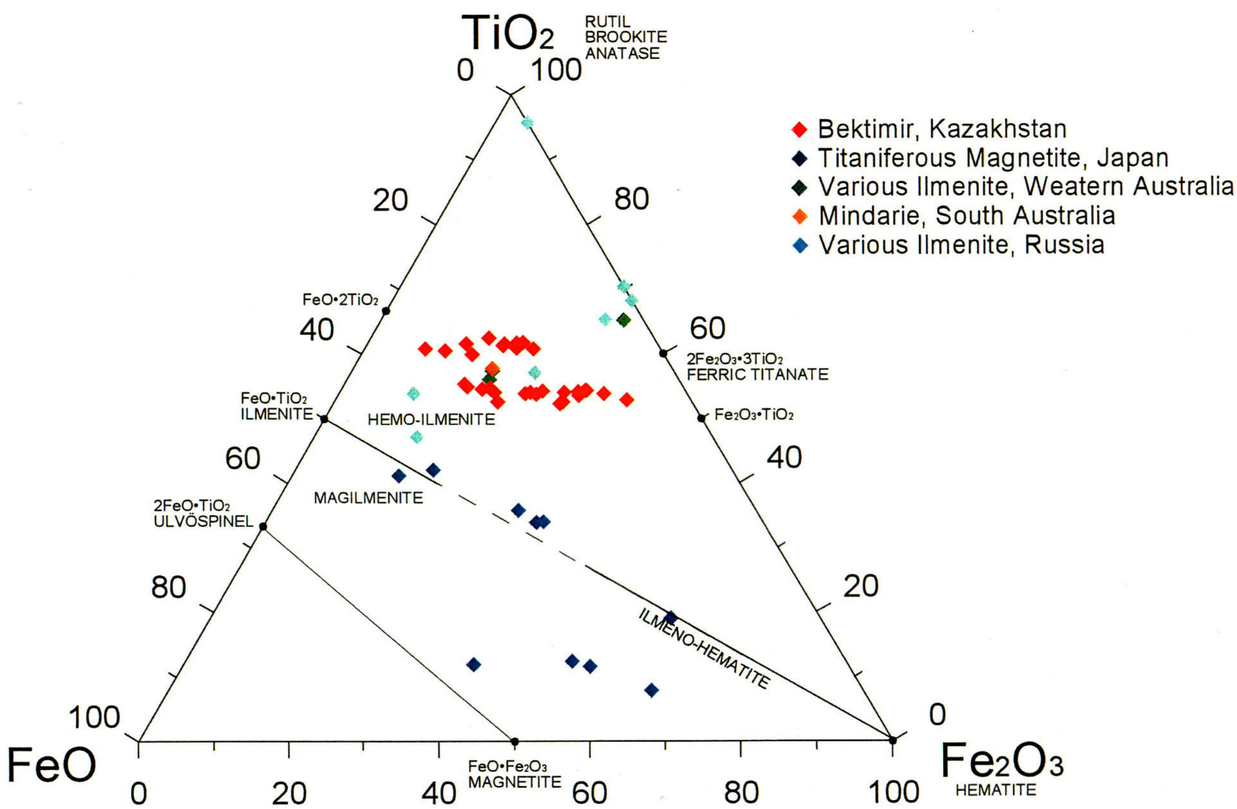


Fig.II-3-15 TiO_2-FeO-Fe_2O_3 Diagram of Ilmenite

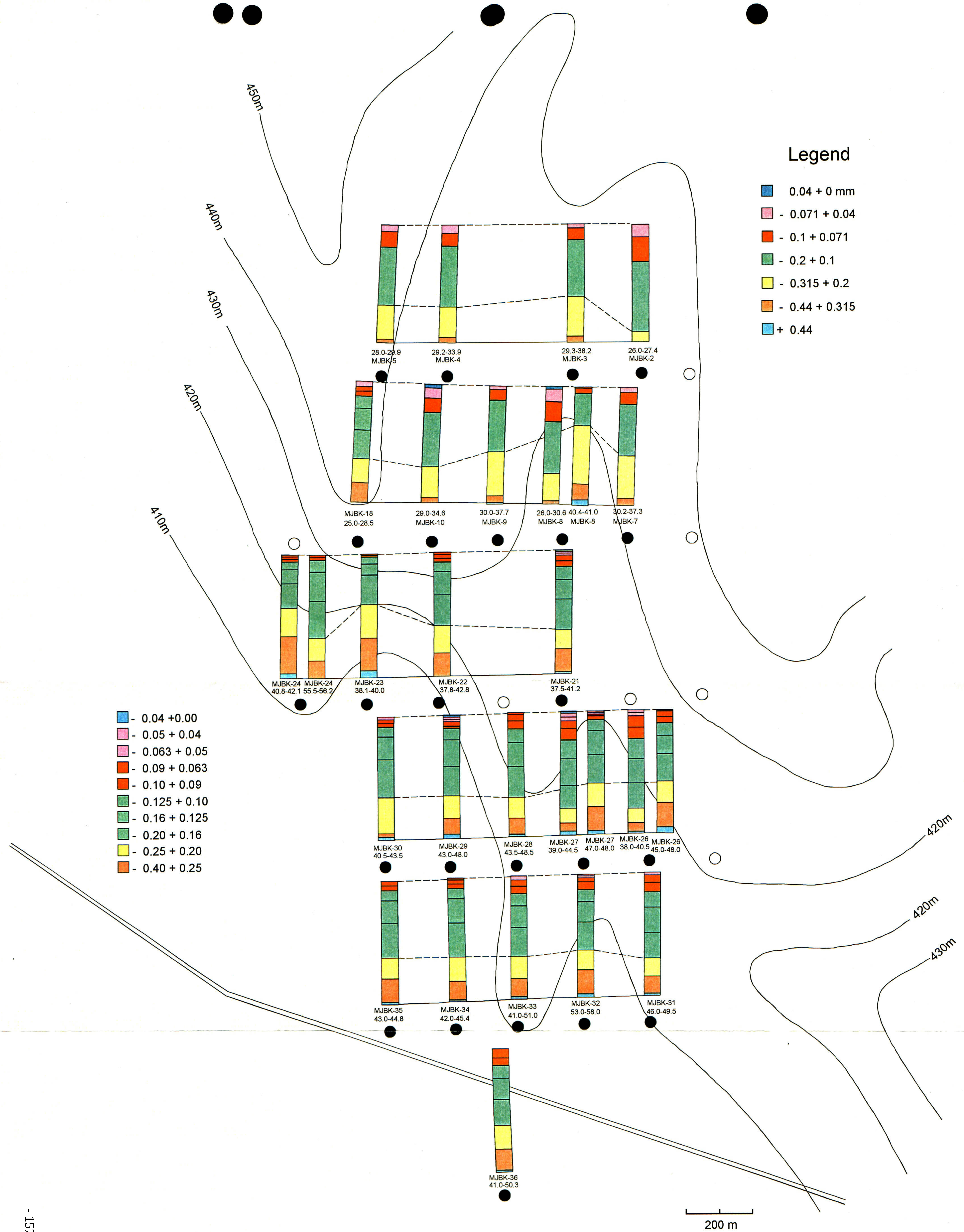


Fig. II-3-16 Grainmetric Distribution of Ilmenite of Bektimir No.1 Deposit

Chapter 4　Geophysical Properties

4-1 Purpose of the Survey

To measure resistivity and magnetic susceptibility of each geological unit in the survey area for use as basic data for airborne electromagnetic survey and analysis.

To measure magnetic susceptibilities of the bed rocks and to determine values and distribution of them to quantitatively classify granitic rocks of the Preobrazhenskiy composite rock mass to determine promising rock kinds as origin rocks of ilmenite and their distribution.

4-2 Method of the Survey

1) Resistivity

Concurrently with the geological survey, resistivity of the rocks at the outcrops was measured and recorded. However, smooth outcrops could not be found and measurement was performed only at one point (G-034). The resistivity was measured on a fresh and as smooth rock outcrop as possible by measuring ten times using a resistivity meter (manufactured by OYO Corporation, model mini OHM 2121) and recording mathematical averages of them.

The resistivities of bed-rock weathered crusts and Aral Formation of the Tertiary Period were measured in three representative pits (MJBK-30, MJBKS-1 and MJBKN-2) selected from each district concurrently with driling core assay and magnetic susceptibility measurement before the cores had dried up. The resistivity was measured by splitting driling cores into halves. Using a resistivity meter (manufactured by OYO Corporation, model mini OHM 2121), magnetic susceptibility for each 1m depth was measured five times on core surfaces that were smoother. Arithmetic average values of these measurements were plotted on columnar sections (See Figs. II-4-1 - 3.). A resistivity meter (manufactured by OYO Corporation, model mini OHM 2121) was directly grounded on a wall of the TMK test pit (4km east of Koitas, 48° 46' 18" N, 82° 53' 20"E) for measurement.

The resistivity of the Quaternary-Period layer was measured by directly grounding a resistivity meter (manufactured by OYO Corporation, model mini OHM 2121) on a wet outcrop of the wall of the TMK test pit.

2) Magnetic susceptibility

Concurrently with the geological survey, magnetic susceptibility of the rocks at the outcrops was measured. The magnetic susceptibility was measured on fresh and as smooth rock outcrops as possible at 509 geological outcrop points by measuring ten times using a portable magnetic susceptibility meter (Micro KAPPA, model KT-5c) and recording mathematical averages of them as shown in Appendixes 2-21 and 22. Fig. II-4-4 plots a distribution of magnetic susceptibilities which are shown in the S.I. unit.

The magnetic susceptibilities of bed-rock weathered crusts and Aral Formation of the Tertiary Period were measured in three selected representative pits (MJBK-30, MJBKS-1 and MJBKN-2) concurrently with driling core assay and resistivity measurement before the cores had dried up. The magnetic susceptibility was measured by splitting driling cores into halves. Using a portable magnetic susceptibility meter (Micro KAPPA, model KT-5c), magnetic susceptibility for each 1m depth was measured ten times on core surfaces that were smoother. Arithmetic average values of these measurements were plotted on columnar sections (See Figs. II-4-1 - 3 and Fig. II-4-5.).

A portable magnetic susceptibility meter (Micro KAPPA, model KT-5c) was directly grounded on a wall of the TMK test pit for measurement of the Quaternary-Period layer.

3) Radioactivity measurement

At some outcrops and in two driling pits (MJBK-19 and MJBKS-6), the dose-equivalent rates in 60sec were measured once using a radioactivity meter equipped with a GM tube (manufactured by Calcite, model CS-201), to examine the feasibility of differentiating rock masses based on a difference in content of radioactive zircon in rocks. The radioactivity of the driling cores was measured concurrently with driling core assay and measurement of resistivity and magnetic susceptibility. The measurement was made by splitting driling cores into halves. Using a radioactivity meter, dose-equivalent rate for each 1m depth was measured 60sec on core surfaces that were smoother. Measurement values were plotted on columnar sections (See Figs. II-4-1 and 2.).

4-3 Survey Findings

4-3-1 Resistivity

1) Pre-granitic rocks

Resistivity could not be measured because fresh and smooth surfaces suitable for measurement could not be obtained.

2) Granitic rocks

Resistivity varied between 600 and 12,400 Ω m, which were very high compared with those of the Aral Formation of the Tertiary Period and Quaternary-Period layers, showing a clear difference.

3) Weathered crust of bed rock

Resistivity of driling cores in a wet condition varied between 10 and 100 Ω m, averaging 39 Ω m.

4) Aral Formation of Tertiary Period

Resistivities of clay beds on walls of the TMK test pit in a wet condition were 2 to 3 Ω m and those of clayey sand beds, 2 Ω m. Those of clayey sand beds were 2 Ω m. Resistivities of driling cores in a wet condition varied between 4.3 and 599Ωm, averaging 50Ωm. The reason for the difference in resistivities of test pit walls and driling cores could not be ascertained.

Differences in exterior facies of driling cores between the Aral Formation of the Tertiary Period and weathered crusts of bedrock could not be found. Average resistivities did not show a prominent difference between them, even though weathered crusts of bed rock showed slightly higher values. Resistivities of thickened ilmenite seams tended high when resistivity was measured continuously from the Aral Formation of the Tertiary Period to weathered crusts in driling Pits MJBK-19 and MJBKN-2. This trend was especially prominent in MJBKN-2 (See Figs. II-4-1 - 3.).

5) Quaternary-Period layer

Affected by the moist condition of layers, resistivity of the TMK test pit varied between 17 and 286Ωm, averaging 80Ωm. The driling cores were disintegrated and resistivity of them could not be measured.

4-3-2 Magnetic Susceptibility

1) Pre-granitic rocks

Magnetic susceptibilities of sedimentary rocks of the Carboniferous Period (shale, sandstone and conglomerate) varied between 0.21 to 0.40×10^{-3}, while those of pyroclastic rocks and lava (andesite and 玢岩) varied 0.26 to 59.3×10^{-3}, varying in accordance with magnetite content. Averages for sedimentary rocks and pyroclastic rocks were 0.33×10^{-3} and 8.3×10^{-3}. The magnetic susceptibilities distributed in a bedded form and harmonized with geological strikes.

2) Granitic rocks

Magnetic susceptibilities measured on outcrops and a distribution of measured magnetic susceptibilities are shown in Appendix 2-22 and Fig. II-4-4, respectively. Magnetic susceptibilities varied 0.02 to 31.5×10^{-3}, apparently influenced by kinds of opaque minerals (ilmenite, titanic magnetite or magnetite) and amounts of them. Rock masses that showed magnetic susceptibilities above 1.0×10^{-3} were distributed in the northwestern flank of the Prebrazensky composite rock mass. High contents of titanic magnetite and magnetite in granitic rocks are the reason for this.

3) Weathered crust of bed rock

Magnetic susceptibilities of driling cores varied 0.06 to 0.27×10^{-3}, averaging 0.18×10^{-3}. Compared with bed rocks, magnetic susceptibilities of weathered crusts of bed rocks are low, about 1/10 those of bed rocks, because iron is diluted from bed rocks due to weathering.

4) Aral Formation of Tertiary Period

Magnetic susceptibilities in the TMK test pit varied 0.20 to 0.25×10^{-3}, averaging 0.22×10^{-3}.

Magnetic susceptibilities of driling cores (MJBK-30, MJBKS-1 and MJBKN-2) varied 0.05 to 0.33×10^{-3}, averaging 0.15×10^{-3}, which were almost identical to those of weathered crusts of bed rocks.

Magnetic susceptibilities of sandy clay to clayey sand containing thin thickened ilmenite seams in the bottom or parts near the bottom of this formation were 0.21 to 0.61×10^{-3} in the TMK test pit, averaging 0.40×10^{-3}. Magnetic susceptibilities of driling cores (MJBK-24) varied 0.26 to 0.90×10^{-3}, averaging 0.48×10^{-3}, which were higher than those of layers which did not contain ilmenite (See Fig. II-4-5.). Magnetic susceptibilities of thickened ilmenite seams in driling cores (MJBKN-2) also showed high values.

5) Quaternary-Period layer

Magnetic susceptibilities in the TMK test pit varied 0.21 to 1.05 x 10^{-3}, averaging 0.71 x 10^{-3}. The driling cores were disintegrated and magnetic susceptibilities of them could not be measured.

4-3-3 Radioactivity

1) Pre-granitic rocks (Carboniferous Period layer)

Radioactivities of pyroclastic rocks varied 0.01 to 0.04 μ Sv/h, averaging 0.02 μ Sv/h.

2) Granitic rocks

Radioactivities of granitic rocks varied 0.01 to 0.09 μ Sv/h, averaging 0.04 μ Sv/h, showing values slightly higher than those of pyroclastic rocks of layers of the Carboniferous Period. Differences due to rock facies of granitic rocks could not be detected.

3) Weathered crust of bed rock

Radioactivities of weathered crusts of bed rocks varied 0.01 to 0.07 μ Sv/h, averaging 0.03 μ Sv/h, hardly showing any difference with those of unweathered bed rocks.

4) Aral Formation of Tertiary Period

Radioactivities of the Aral Formation of the Tertiary Period varied 0 to 0.04 μ Sv/h, averaging 0.02 μ Sv/h, showing values that are slightly lower compared with those of weathered crusts of bed rocks.

5) Quaternary-Period layer

Radioactivity on the wall of the TMK test pit was 0.02 μ Sv/h, showing no difference with that of the Aral Formation of the Tertiary Period.

4-4 Summary and Considerations

Resistivities, magnetic susceptibilities and radioactivities of various geological units obtained in measurements are summarized in Table 5-3.

Table I-5-3　　Geophysical Properties of geological units

GEOLOGICAL UNIT	LOCATION	RESISTVILITY (Ωm)			MAGNETIC SUSCEPTIBILITY ($\times 10^{-3}$S.I.U.)			RADIOACTIVITY (×μSV/h)		
		HIGH	LOW	AVE.RAGE	HIGH	LOW	AVE.RAGE	HIGH	LOW	AVE.RAGE
PRE-GRANITOIDS VOLCANICS (CARBONIFEROUS)	OUTCROP	NOT MEASURED			59.3	0.26	8.3	0.04	0.01	0.02
PRE-GRANITOIDS SANDSTONE (CARBONIFEROUS)	OUTCROP	NOT MEASURED			0.40	0.21	0.33	NOT MEASURED		
WEATHERED CRUST	BORING CORE	101.3	9.7	38.7	0.27	0.06	0.18	0.07	0.01	0.03
GRANITOIDS	OUTCROP	12400	596	6498	31.5	0.02	2.44	0.09	0.01	0.04
ARAL FORMATION	TMK TEST PIT	3	2	2.5	0.25	0.2	0.22	0.02	0.02	0.02
	BORING CORE	599	4.3	50.5	0.33	0.05	0.15	0.04	0	0.02
ARAL FORMATION WITH ILMENITE LAYERS	TMK TEST PIT	NOT MEASURED			0.61	0.21	0.40	NOT MEASURED		
	BORING CORE	27	5.3	9.3	0.90	0.26	0.48	0.04	0	0.02
QUARTERNARY	TMK TESTPIT	286	17	80	1.04	0.17	0.71	0.02	0.02	0.02
	BORING CORE	NOT MEASURED			NOT MEASURED			NOT MEASURED		

1) As far as resistivity measurements of driling cores are concerned, a prominent difference could not be detected between 39Ωm with weathered crusts of bedrock and 51Ωm with the Aral Formation of Quaternary Period. This may be explained by the groundwater surface, which was located almost directly above the unconformity plane between the Tertiary-Period Aral Formation and Quaternary-Period layer, and the moist state of the formation and layer by groundwater (Ca^{+2} 170mg/l, Na^{+} 160mg/l) which contained electrolytes. The minerals composing the formation and layer were the same, both containing a large amount of quartz and medium or small amounts of clayey minerals of kaolin, smectite and sericite, as well as feldspars. A clear lithofacies boundary could not be found between the two. The resistivity of the thickened ilmenite seams in the Tertiary-Period Aral Formation slightly increased as in MJBKN-2 (See Fig. II-4-3.).

The resistivities of the Tertiary-Period Aral Formation and Quaternary-Period layer of 51 and 80 Ω m showed a difference. The Tertiary-Period Aral Formation was moist and the Quaternary-Period layer, semi-dry. This difference seems to have produced a difference in the resistivity.

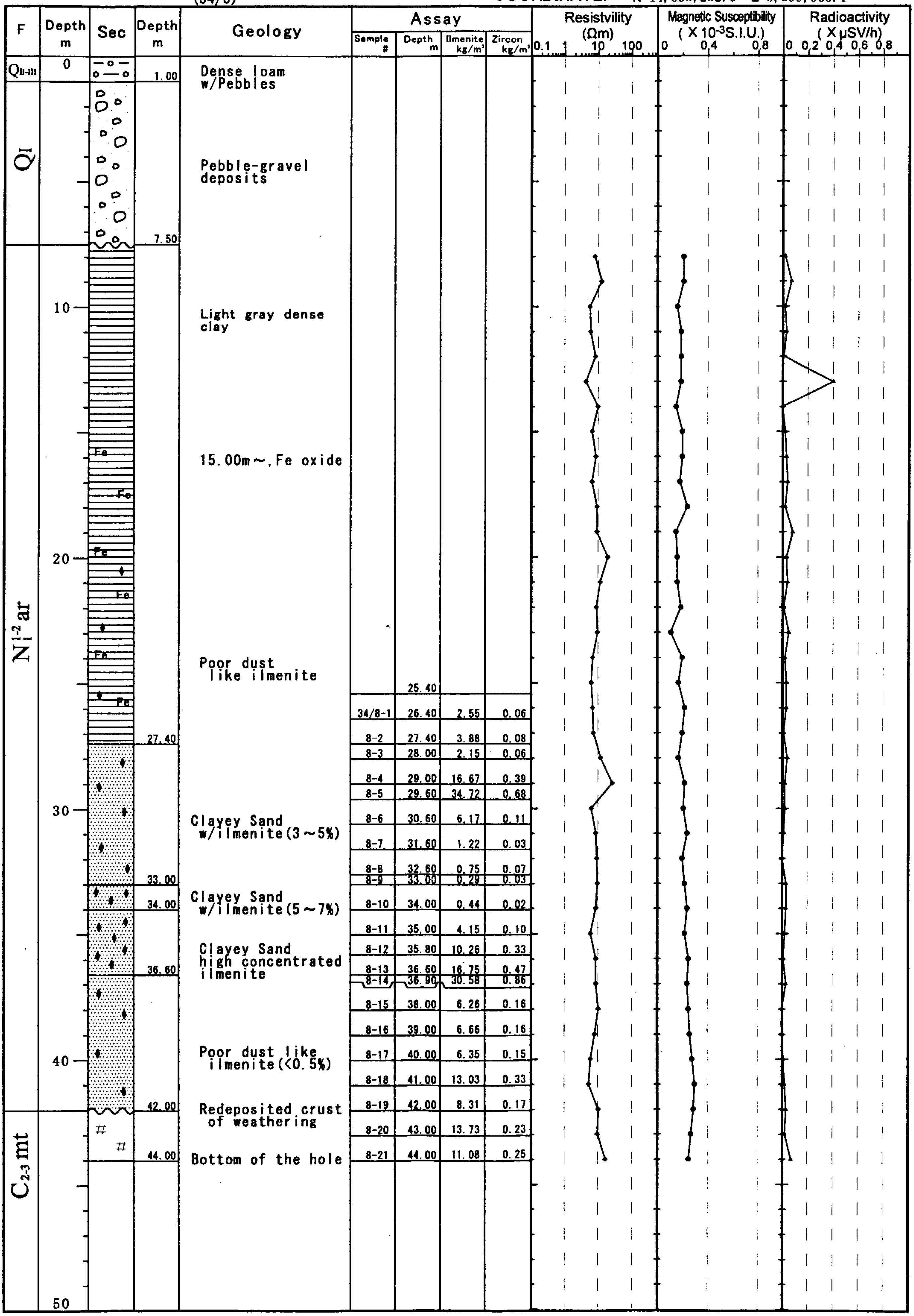
2) The magnetic susceptibilities of thickened ilmenite seams in clay layers of Tertiary-Period Aral Formation and sandy clay layers was about 0.2×10^{-3} S.I.U. Magnetic susceptibilities of sandy clay and clayey sand containing thickened ilmenite seams in the bottom or parts near the bottom varied between 0.40 and 0.48×10^{-3} S.I.U., clearly showing high values compared with those of strata that did not contain thickened ilmenite seams. Higher magnetic susceptibility would be shown for thickened ilmenite seams in which ilmenite is mixed with magnetite and titanic magnetite.

3) Radioactivities of granitic rocks and weathered crusts of bed rocks were 0.04 and 0.03 μSv/h, respectively. The average radioactivity for geological units was about 0.02 μSv/h and a great

difference could not be detected.

MJBK－19 (34/8) (1:200)

ELEVATION : 469.63m
COORDINATE: N 14,635,252.6 E 5,399,965.1



Sample #	Depth m	Ilmenite kg/m³	Zircon kg/m³
	25.40		
34/8-1	26.40	2.55	0.06
8-2	27.40	3.88	0.08
8-3	28.00	2.15	0.06
8-4	29.00	16.67	0.39
8-5	29.60	34.72	0.68
8-6	30.60	6.17	0.11
8-7	31.60	1.22	0.03
8-8	32.60	0.75	0.07
8-9	33.00	0.29	0.03
8-10	34.00	0.44	0.02
8-11	35.00	4.15	0.10
8-12	35.80	10.26	0.33
8-13	36.60	16.75	0.47
8-14	36.90	30.58	0.86
8-15	38.00	6.26	0.16
8-16	39.00	6.66	0.16
8-17	40.00	6.35	0.15
8-18	41.00	13.03	0.33
8-19	42.00	8.31	0.17
8-20	43.00	13.73	0.23
8-21	44.00	11.08	0.25

Fig.II-4-1 Magnetic Susceotibility and Resistibility Logging of MJBK-19

M J B K S − 6 (1Γ/40) (1:200)

ELEVATION : 505.65m
COORDINATE: N 14,632,195.9 E 5,406,026.6

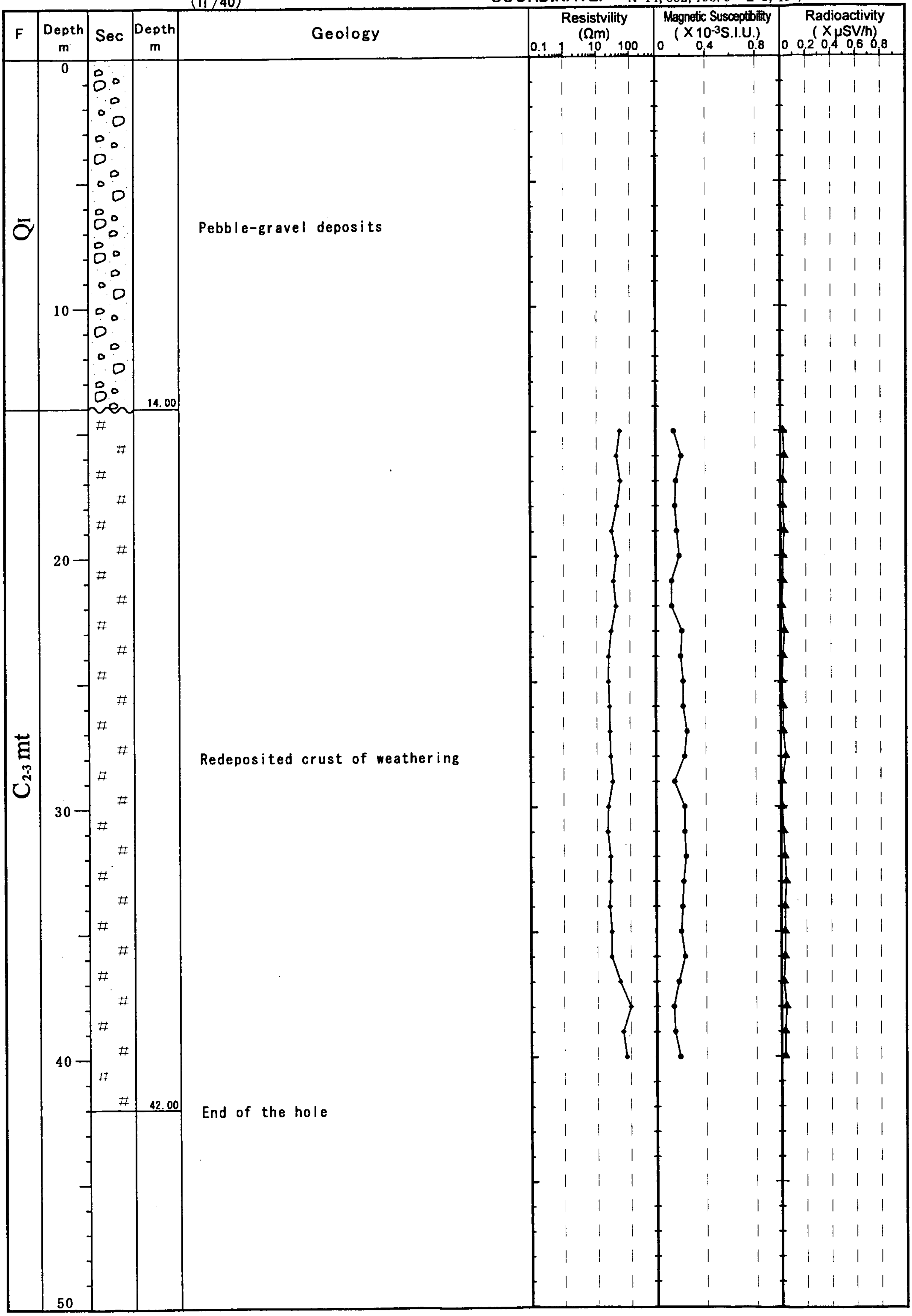


Fig.II-4-2 Magnetic Susceotibility and Resistibility Logging of MJBKS-6

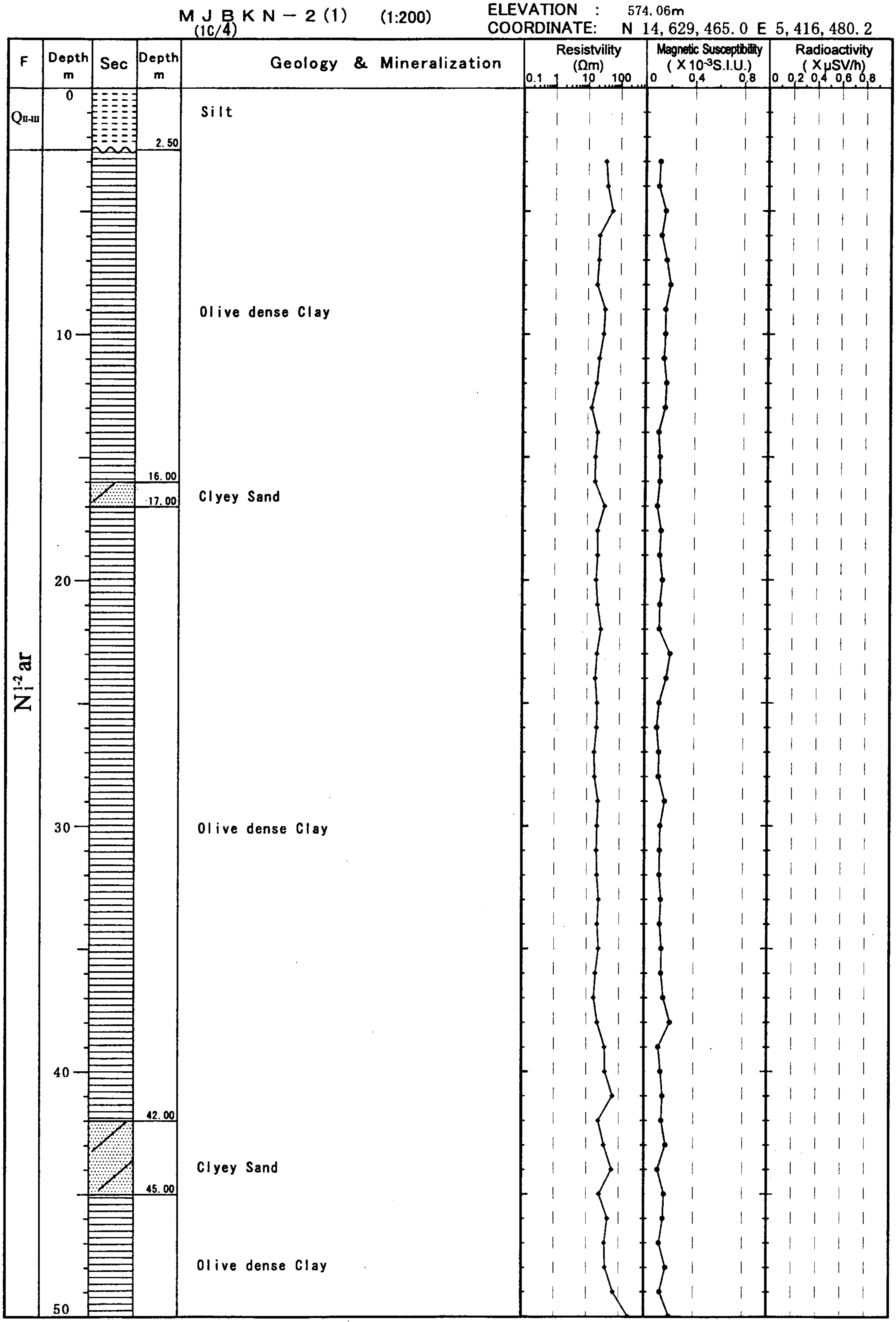


Fig.II-4-3 Magnetic Susceotibility and Resistibility Logging of MJBKN-2

M J B K N − 2 (2) (1:200)
(1C/4)

ELEVATION : 574.06m
COORDINATE: N 14, 629, 465. 0 E 5, 416, 480. 2

F	Depth m	Depth m	Geology
N_1^{1-2} ar	50	51.10	Sand with Clay
		58.00	Pale gray dense clay
		59.00	Fng Sand
	60	60.30	Pale gray dense clay
		65.00	Fng Silty Sand
		66.40	Dark gray fng Sand w/silt
$C_{2\text{-}3}$ mt	70	70.00	Redeposited crust of weathering
	80		
	90		
	100		

Assay			
Sample #	Depth m	Ilmenite kg/m³	Zircon kg/m³
	57.00		
1C/4-1	58.00	0.35	0.04
1C/4-2	59.20	3.84	0.16
1C/4-3	60.30	26.04	0.98
1C/4-4	61.00	14.40	0.93
1C/4-5	62.00	17.63	0.93
1C/4-6	63.00	28.54	1.19
1C/4-7	64.00	25.54	0.89
1C/4-8	64.40	8.51	0.49
1C/4-9	65.00	16.11	1.23
1C/4-10	66.20	21.36	0.96
1C/4-11	67.00	8.03	0.76

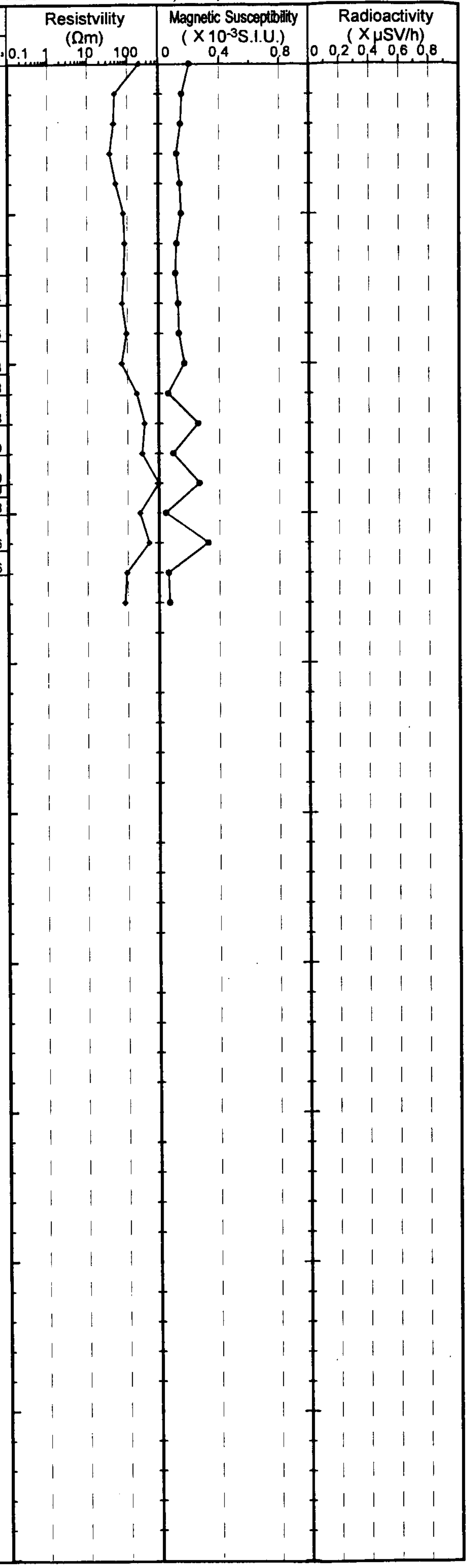


Fig.II-4-3 Magnetic Susceotibility and Resistibility Logging of MJBKN-2

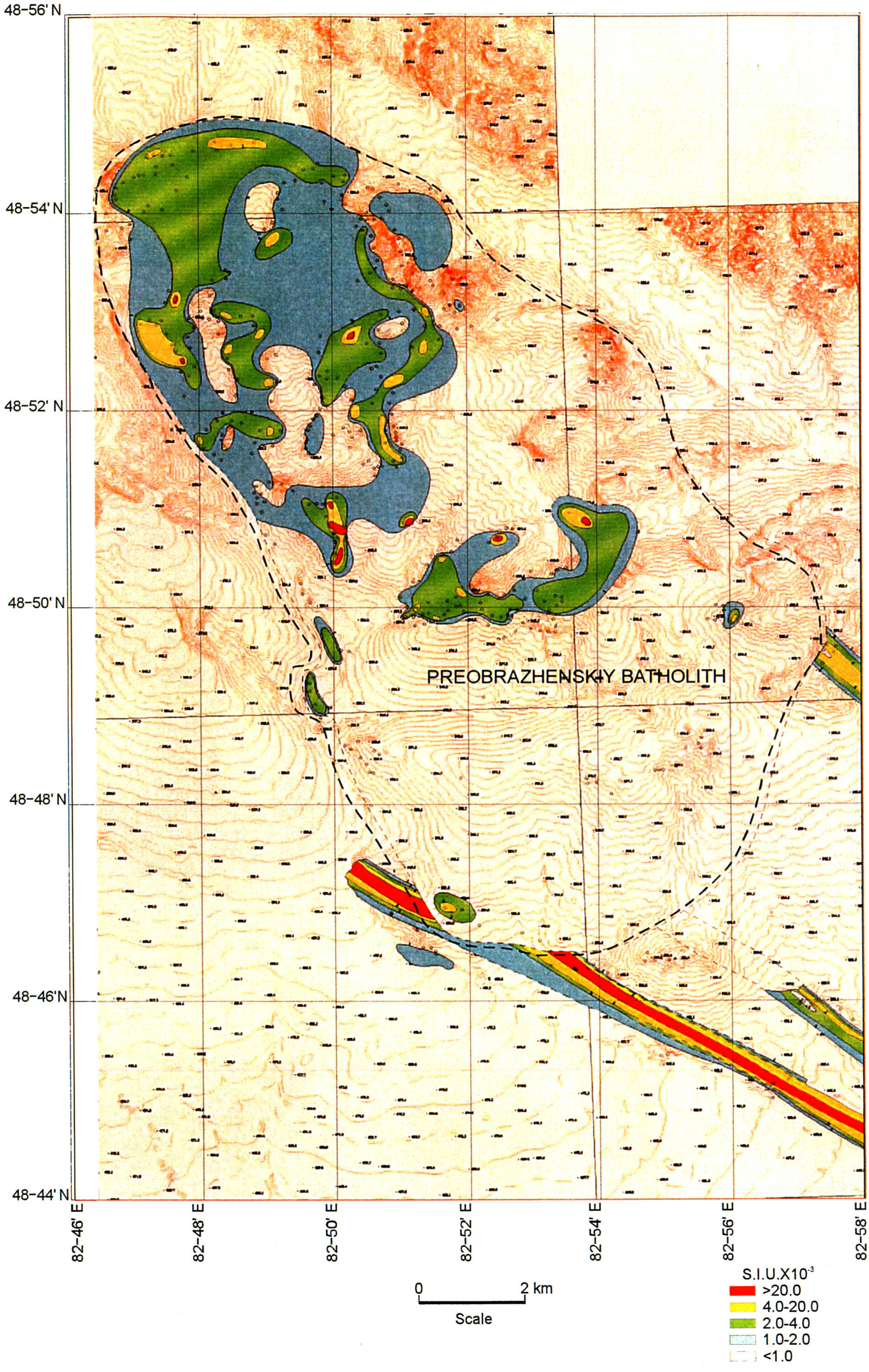


Fig.II-4-4 Contour Map of Magnetic Susceptibility of Prebrazenski Batholith

MJBK－24(1) (30/8) (1:200)

ELEVATION : 467.01m
COORDINATE: N 14,635,172.6 E 5,399,475.3

F	Depth m (from)	Depth m (to)	Geology
QI	0	8.00	Pebble-gravel deposits
$N_1^{1-2}ar$	8.00	25.00	Greenish gray dense clay w/Mn oxide
$N_1^{1-2}ar$	25.00	36.50	Dark gray dense clay
$N_1^{1-2}ar$	36.50	38.50	Sandy clay w/ilmenite(～1%)
$N_1^{1-2}ar$	38.50	39.50	Brownish gray clay w/Fn ochre
$N_1^{1-2}ar$	39.50	42.10	Sandy clay w/ilmenite(5～7%)
$N_1^{1-2}ar$	42.10	50	Brownish gray dense clay

Assay

Sample #	Depth m	Ilmenite kg/m³	Zircon kg/m³
	34.50		
30/8-1	35.50	1.41	0.04
8-2	36.50	1.45	0.03
8-3	37.50	5.92	0.22
8-4	38.50	30.54	1.05
8-5	39.50	15.68	0.30
8-6	40.80	17.08	0.45
8-7	42.10	119.46	2.10
8-8	43.00	0.71	0.01
8-9	44.00	0.75	0.01

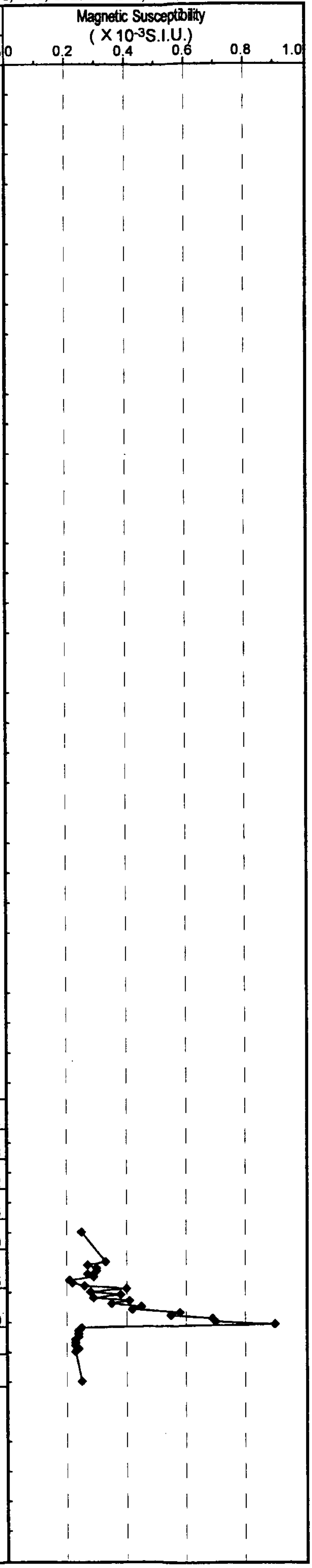


Fig.II-4-5 Magnetic Susceotibility Logging of MJBK-24

PART III

CONCLUSIONS AND RECOMMENDATIONS

FOR THE FUTURE Survey

Chapter 1 Conclusions

1-1 Geological Survey

1) Geology

The order of stratification of this area consists of pre-granitic rocks (Carboniferous Period), granitic rocks intruded into pre-granitic rocks, Aral Formation of the Tertiary Period in the Cainozoic Era covering them without conformity and Quaternary-Period layer that covers all of them without conformity. Weathered crusts are widely developed in the bed rock of Aral Formation of the Tertiary Period.

(1) Pre-granitic rocks

The geology in the area consists of sedimentary rocks (shale, sandstone and conglomerate), pyroclastic rocks and lava (andesite and 玢岩) of the Carboniferous Period. The survey area is distributed with Kokpekti, Bukon and Maityab layers. The solidification indexes of pyroclastic rocks and lava are 18 or higher, while differentiation indexes of them are 50 or lower. Magnetite is contained more than 1% as an opaque mineral.

(2) Granitic rocks

The area is distributed with Preobrazhenskiy composite rock mass, believed to have intruded from the early Permian Period to the mid-Jurassic Period. The composite rock mass is ilmenite-series granitoids. Granitic rocks that contain only less than 1% of TiO_2 fall into the region of Type I/S. Granitic rocks containing more than 1% of TiO_2 fall into Type I.

Granitic rocks are classified into granite and monzonite - diorite, in accordance with chemical composition.

Granite is the bulk of the Preobrazhenskiy composite rock mass. It is rich in SiO_2, Na_2O and K_2O, but is lean in ΣFeO, MgO and CaO. The solidification index of granite is below 3, while the differentiation index is 80 or higher. It contains less than 1% of TiO_2. Monzonite - diorite partially distribute near the center of the Preobrazhenskiy composite rock mass. They conversely are lean in SiO_2, Na_2O and K_2O, but are rich in ΣFeO, MgO and CaO. The solidification indexes of them are higher than 10, while the differentiation indexes are 60 or less. They contain more than 1% of TiO_2. TiO_2 becomes leaner the more magma crystallization differentiation advances.

The rare earth pattern of granitic rocks containing less than 1% of TiO_2 is almost linear, while that of monzonite - diorite containing more than 1% of TiO_2 becomes a polygon with a concave with Eu. This shows that granite and monzonite can be discriminated clearly in trace components also.

Opaque-mineral modal ratios of granitic rocks are 0.7% or less with granite and 1% or more with monzonite - diorite. Opaque minerals are ilmenite (Ti 35%), titanic magnetite (Ti 1.5 to 14%), and magnetite (Ti 0%). More magnetite and titanic magnetite than ilmenite are contained in granitic rocks that show a magnetic susceptibility of 1×10^{-3} S.I.U. or higher. Rock masses showing a magnetic susceptibility of 1×10^{-3} S.I.U. or higher are distributed in the northwestern flank of the Preobrazhenskiy composite rock mass.

(3) Bed-rock weathered crust

Bed-rock weathered crusts are clayey weathered remnants developed 10 to 20m in thickness on sedimentary rocks, volcanic rock and intrusive rock of the Carboniferous Period. They are covered on the Aral Formation of the Neogene Period and on the Quaternary-Period layer. They are prominently influenced by kaolin, sericite and smectite. Bed-rock weathered crusts were formed by chemical weathering of moist and warm climate at the end of early Cretaceous Period (about 140 million years ago).

(4) Tertiary-Period Aral Formation

The Tertiary-Period Aral Formation covers pre-granitic rocks and intrusive rocks, as well as their weathered crusts, without conformity. The layer covers the Quaternary-Period layer without conformity and is 20 to 50m in thickness. The layer consists of sandy clay and clayey sand comprising quartz, kaolin, smectite and a small amount of sericite. It rarely contains a gravel layer. Ilmenite drift-sand ore beds are deposited in sandy clay to clayey sand that is contained in the bottom or parts near the bottom of this layer.

(5) Quaternary-Period layer

The Quaternary-Period layer consists of gravel, loam and clay of the Diluvium 5 to 10m in thickness and Recent riverbed sediments that cover without conformity the Neogene-Period Aral Formation and directly pre-granitic rocks and intrusive rock

2) Geological Structure

The survey area is bordered by the Baladzhalskiy Fault running in the WNW-ESE direction on its northeastern flank and by the South Terektinskiy Fault on the southwestern flank. The Preobrazhenskiy composite rock mass intruded into the Bektimirskaya ridge anticline situated in the middle of them.

Cracks in the NEN-SWS direction cut the Carboniferous Period layer made up of the Preobrazhenskiy composite rock mass and pre-granitic rocks. Palaeo-landform channels deposited with some ilmenite sand ore bodies were believed formed along these weak lines. These palaeo-landform channels change to the NW-SE direction near the Baladzhalskiy Fault running in the WNW-ESE direction and the South Terektinskiy Fault because of dominant cracks in the NW-SE direction. All known ilmenite drift-sand ore beds are contained in palaeo-landform channels.

The Tertiary-Period Aral Formation is a generally horizontal stratum and covers Preobrazhenskiy composite rock mass and pre-granitic rocks.

The Quaternary-Period layers are generally horizontal strata and cover the Tertiary-Period Aral Formation. Recent rivers are located in locations that relatively well overlap with palaeo-landform channels of the Tertiary-Period Aral Formation bed rock.

3) Ore Beds

Ore deposits are ilmenite drift-sand ore beds that contain a very small amount of zircon about 1/60 that of ilmenite in weight ratio. In the Bektimir district, Bektimir Placers No. 1, 2 and 3 are well known.

Ilmenite drift-sand ore beds are contained in sandy clay and clayey sand in palaeo-landform channels in the lower layer of the Aral Formation of the Tertiary Period. Ilmenite in the Bektimir ore beds is assumed derived from monzonite - diorite, which are not advanced in magma crystallization differentiation, and from rock mass low in magnetic susceptibility, among granitic rocks of the Preobrazhenskiy composite rock mass. Ilmenite grains showed leaching of FeO and enrichment of TiO_2 along external edges and cracks of the grains in the weathering, leaching and thickening process.

1-2 Driling survey

1) Southern Flank of Bektimir Placer No. 1 (Detailed Survey District)

Driling was conducted in 20 pits along six traverse lines (Traverse Lines 34, 30, 26, 22, 18 and 14) in a grid of 500×200m over 2.5km on the southern flank of the confirmed III-C_2 Ore Reserves Block of Bektimir Placer No. 1. The driling lengths totaled 1,033.0m.

The ore bed is contained in a wide palaeo-landform channel in the Aral Formation bed rock in the NEN-SWS direction. The eastern flank of the ore bed is deposited directly on the bedrock. Part of the western seam of the ore bed is contained in the bottom of the

Aral Formation as narrow seams. The ore beds captured in driling measured 1.8 to 10.0m in thickness. The ilmenite content was 94 to 216kg/m^3. The overburden on the ore beds was 25 to 53m in thickness.

Closure of the western flank of the ore bed on Traverse Lines 34 and 30 and of the eastern flank of the ore bed on Traverse Lines 30 and 26 could be confirmed due to deterioration in ore bed thickness and grade of thickened ilmenite seams. On Traverse Line 14, MJBK-37 (no signs of ore bearing) confirmed the southern limit of thickened ilmenite seams and a change in the ore bed extension direction from NEN-SWS to NW-SE could be estimated.

The thickness of the ore bed tended to slightly decrease toward the south. The thickness of overburden increased, but the width of the ore bed increased to 1,000m, to increase the volume. The southeastern lateral boundaries remain unconfirmed. When cut-off conditions were set 70kg/m^3 or more for the upper seam of an ore bed, 100kg/m^3 or more for the lower seam, or 2.0m x 100kg/m^3 or more, ore reserves calculations showed the following ore reserves increases corresponding to Category C_2 (Ore reserves 6.5 million m^3, ilmenite reserves 857,000 tons, average ilmenite content 132kg/m^3, and stripping ratio 8.3).

The III-C_2 ore reserves confirmed in Year 1 and the total increase in Year 2 (Ore Reserves Block No.. III+IV-C_2) are shown below (Ore reserves 11.3 million m^3, ilmenite reserves 1,472,000 tons, average ilmenite content 131kg/m^3, and stripping ratio 7.26).

Table I-5-1 Ore Reserves Calculation of Category C_2 for the Southern Flank of Placer No.1

Block No	Block area 10^3m^2	Ore bed thickness m.	Ore sands reserves 10^3m^3	Ilmenite content, kg/m^3	Ilmenite reserves 10^3t	Overburden thickness m	Overburden volume 10^3m^3	Stripping ratio, m^3/m^3
III-C_2	909.0	5.51	5,008.59	123.95	620.81	29.64	26,942.8	5.4
IV-C_2	**1364.0**	**4.76**	**6,492.6**	**131.93**	**856.57**	**39.3**	**53,605.2**	**8.3**
III+IV-C_2	**2,273.0**	**4.95**	**11,251.35**	**130.84**	**1,472.13**	**35.94**	**81,691.6**	**7.3**

2) Southern Flank of Bektimir Placer No. 3 (Reconnaissance Survey District)

Driling was conducted in 25 pits on Traverse Lines 1G, 2G and 3G and on Traverse Lines 114G and 116G, which orthogonally crossed the foregoing traverse lines, at 400m spacing totaling 903.5m in length. In six of the 25 pits, thickened ilmenite seams more than the cut-off grade of 100kg/m^3 could be confirmed.

The ore bed is deposited directly above two parallel palaeo-landform channels in the Aral Formation bed rock running in the N30°E direction. The width of the ore bed was about 200m and was small compared with that of Bektimir Placer No. 1. The ore bed thickness captured by driling was 1.5 - 4.4m and the ilmenite content was 111 to 181kg/m^3. Overburden on the ore bed was 23 to 30m in thickness and tended to increase toward south.

Only six pits showed contents higher than 100kg/m^3 and were not sufficient for ore reserves calculations. However, the following calculation data can be obtained by designating an area 100m in radius centering on a driling pit as a block.

Table I-5-2 Ore Reserves Calculation of Category P_1 for the Southern Flank of Placer No.3

Block No	Block area 10^3m^2	Ore bed thicknes m.	Ore sands reserves 10^3m^3	Ilmenite content, kg/m^3	Ilmenite reserves 10^3t	Overburden thickness, M	Overburden volume 10^3m^3	Stripping ratio, m^3/m^3
P_1	188.4	2.76	512.0	130.05	67.6	26.7	5,011.4	9.7

Potential calculations in a very bold fashion assuming that the driling pits in the palaeo-landform channels that hit an ore bed were continuous produce the following results as a potential: Ore reserves 3.8 million m^3, ilmenite reserves 493,000 tons, average ilmenite content 130kg/m^3, and stripping ratio 9.7.

Table I-5-2 Ore Reserves Calculation of Category P_1 for the Southern Flank of Placer No.3

Block No	Block area 10^3m^2	Ore bed thickness m.	Ore sands reserves 10^3m^3	Ilmenite content, kg/m^3	Ilmenite reserves 10^3t	Overburden thickness, m	Overburden volume 10^3m^3	Stripping ratio, m^3/m^3
I-P_1	680.5	3.03	2,061.9	117.76	242.8	26.6	18,101.3	8.8
II-P_1	690.1	2.50	1,725.2	144.76	249.7	26.8	18,494.7	10.7
Total	1,370.6	2.76	3,787.1	130.05	492.5	26.7	36,596.0	9.7

3) Bektimir Northern Placer (Reconnaissance Survey District)

Driling was conducted in 5 pits along one traverse line at a spacing of 1,000m. The driling lengths totaled 335.0m.

The driling survey showed that thickened ilmenite seams were 1 to 7m in thickness and that ilmenite contents were 14 to 21kg/m^3. Traces of ilmenite could be detected as mentioned above, but the grade was low and expanse of the ore bed could not be captured.

Ore reserves were, therefore, not calculated.

1-3 Geophysical Properties

The resistivity, magnetic susceptibility and radioactive intensity of each geological unit in the survey area were measured to gauge the resistivity and magnetic susceptibility of each geological unit in the survey area for use as basic data for airborne electromagnetic survey and to measure the magnetic susceptibilities of the bed rocks to quantitatively classify granitic rocks of the Preobrazhenskiy composite rock mass.

1) Pre-granitic rocks

Magnetic susceptibilities of sedimentary rocks (shale, sandstone and conglomerate) averaged 0.33 x 10^{-3} S.I.U., while those of pyroclastic rocks and lava (andesite and 玢岩) averaged 8.3 x 10^{-3}, varying in accordance with magnetite content.

2) Granitic rocks

The resistivity averaged 6500 Ω m and was very high. Magnetic susceptibilities averaged 2.4×10^{-3} S.I.U, varying influenced by rock facies and kinds of opaque minerals (ilmenite, titanic magnetite or magnetite) and amounts of them. Rock masses that showed magnetic susceptibilities above 1.0×10^{-3} were distributed in the northwestern flank of the Prebrazensky composite rock mass. The radioactivity averaged 0.04 μ Sv/h.

3) Weathered crust of bed rock

The resistivity in a wet condition averaged 39 Ω m and magnetic susceptibility, 0.18×10^{-3} S.I.U. The radioactivity averaged 0.03 μ Sv/h.

4) Aral Formation of Tertiary Period

The resistivity in a wet condition averaged 51 Ω m and magnetic susceptibility, 0.2×10^{-3} S.I.U.

Magnetic susceptibilities of sandy clay to clayey sand containing thin thickened ilmenite seams in the bottom or parts near the bottom of this formation averaged 0.4×10^{-3} S.I.U., showing higher values than layers that did not contain thickened ilmenite seams. Magnetic susceptibilities also showed slightly high values.

5) Quaternary-Period layer

The resistivity is affected by wet condition of layers and averaged 80 Ω m, while the magnetic susceptibility averaged 0.7×10^{-3} S.I.U.

Table I-5-3 Geophysical Properties of geological units

GEOLOGICAL UNIT	LOCATION	RESISTVILITY (Ωm)			MAGNETIC SUSCEPTIBILITY ($\times 10^{-3}$S.I.U.)			RADIOACTIVITY (×μSV/h)		
		HIGH	LOW	AVE.RAGE	HIGH	LOW	AVE.RAGE	HIGH	LOW	AVE.RAGE
PRE-GRANITOIDS VOLCANICS (CARBONIFEROUS)	OUTCROP	NOT MEASURED			59.3	0.26	8.3	0.04	0.01	0.02
PRE-GRANITOIDS SANDSTONE (CARBONIFEROUS)	OUTCROP	NOT MEASURED			0.40	0.21	0.33	NOT MEASURED		
WEATHERED CRUST	BORING CORE	101.3	9.7	38.7	0.27	0.06	0.18	0.07	0.01	0.03
GRANITOIDS	OUTCROP	12400	596	6498	31.5	0.02	2.44	0.09	0.01	0.04
ARAL FORMATION	TMK TEST PIT	3	2	2.5	0.25	0.2	0.22	0.02	0.02	0.02
	BORING CORE	599	4.3	50.5	0.33	0.05	0.15	0.04	0	0.02
ARAL FORMATION WITH ILMENITE LAYERS	TMK TEST PIT	NOT MEASURED			0.61	0.21	0.40	NOT MEASURED		
	BORING CORE	27	5.3	9.3	0.90	0.26	0.48	0.04	0	0.02
QUARTERNARY	TMK TESTPIT	286	17	80	1.04	0.17	0.71	0.02	0.02	0.02
	BORING CORE	NOT MEASURED			NOT MEASURED			NOT MEASURED		

1) The resistivities of the driling cores of weathered crusts and Tertiary-Period Aral Formation varied between 39 and 51 Ω m which did not represent a great variance. This may be explained by the groundwater surface, which was located almost directly above the unconformity plane between the Tertiary-Period Aral Formation and Quaternary-Period layer, and the moist state of the formation and layer by groundwater, which contained electrolytes. The minerals comprising the formation and layer were the same and a clear lithofacies boundary could not be found between the two. The resistivity of the thickened ilmenite seams in the Tertiary-Period Aral Formation slightly increased.

The resistivities of the Tertiary-Period Aral Formation and Quaternary-Period layer of 51 and 80 Ω m showed a difference. The Tertiary-Period Aral Formation was moist and the Quaternary-Period layer, semi-dry. This difference seems to have produced a difference in the resistivity.

2) The magnetic susceptibility of thickened ilmenite seams was 0.4×10^{-3} S.I.U. and was high compared with that of a stratum that did not contain a thickened ilmenite seam of 0.2×10^{-3} S.I.U.

Chapter 2 Recommendations for the Phase III Survey

2-1 Recommendations for Survey Area

The survey in Year 2 provided the following guidelines for ore bed exploration:

1) The known ilmenite drift-sand ore beds are deposited in palaeo-landform furrows (palaeo-landform channels) of the Tertiary-Period Aral Formation. Locations with high potentials for deposition of new ore beds can be identified by extracting palaeo-landform channels.

2) Diorite - monzonite, rather than granite, and rock mass with a magnetic susceptibility of less than 1×10^{-3} S.I.U., which is believed to contain a large proportion of ilmenite as an opaque mineral contained, are preferred as granitic rocks in the hinterland.

The survey policies for each district in Year 3 are as follows:

1) Bektimir District

(1) Eastern Flank of Bektimir Placer No. 1

The southern extension of Bektimir Placer No. 1 expands more than 1000m in ore bed width and the extension direction changes from NEN-SWS to NW-SE with the result that the ore bed boundaries in the eastern direction of the portion with a high content cannot be confirmed yet. Additional driling should be conducted (a detailed survey) and ore reserves must be reassessed, such as by extracting high-grade seams. Adjacent to the eastern flank of palaeo-landform channels where a driling survey was undertaken, other channels may exist and an additional driling survey including this area is considered necessary. However, the depth of the ore bed becomes deeper toward south and overburden becomes thicker. A survey must therefore be undertaken by discerning the relationship between an economically feasible depth and ore grade.

(2) Southern Flank of Bektimir Placer No. 3

The driling survey in this year found ore beds to be narrow seams. However, sufficiently high potentials can be anticipated. Interpolation of the inferred palaeo-landform channels and survey of the upstream have not been undertaken yet. An additional driling survey (detailed survey) for them is deemed necessary.

2) Northern Bektimir District

According to the driling survey undertaken this year, the potential ore bearing depth of this district is deep, more than 60m underground. Prominent thickening of ilmenite could not be found. The granitic rocks in the hinterland showed a high magnetic susceptibility. It appears that supply of quality ilmenite cannot be expected from this district. Surveys of this district should be terminated after this year.

3) Other Districts

(1) Eastern Flank of Bektimir Placer No. 1

An analysis of public data in Year 2 shows that about two palaeo-landform channels are expected to exist in the area. A driling survey (reconnaissance survey) of these channels will be necessary.

(2) North seam of Bektimir Placer No. 2 (Beloe District)

An analysis of public data in Year 2 shows that diorite - monzonite distribute in the hinterland and that there are areas where the magnetic susceptibility is low. Two palaeo-landform channels originating from these areas are expected to exist. A driling survey of these channels is considered necessary.

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Collected Data

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NO.

REPORT
ON
THE MINERAL EXPLORATION
IN
THE KOKPETINSKAYA AREA
THE REPUBLIC OF KAZAKHSTAN

(PHASE II)

March 2002

JAPAN INTERNATIONAL COOPERATION AGENCY

METAL MINING AGENCY OF JAPAN

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PREFACE

In response to the request of the Government of the Republic of Kazakhstan, the Japanese Government determined to conduct a series of survey involving geological survey, drilling survey and other surveys related to exploration of ore deposits, for the purpose of examining the potentials of mineral resources in the Kokpetinskaya Area, situated some 750 km northeast of Almaty, the Kazakhstan's ex-capital city, and entrusted the survey to the Japan International Cooperation agency (JICA).

In view of the geological and mineralogical nature of the intended survey, the JICA commissioned the Metal Mining Agency of Japan (MMAJ) to execute the survey.

During the second year (Phase II) of the survey commenced in the fiscal year 2001, the MMAJ organized and sent to the Republic of Kazakhstan a three-man survey team for the period from June 30 to September 9, 2001. The field survey was completed as scheduled, in close collaboration with the Kazakh government agencies concerned and the Committee of Geology and Underground Resources Protection, the Ministry of Energy and Mineral Resources of the Republic of Kazakhstan.

This Report summarizes the results of the Phase II survey and will form an integral part of the final survey report to be elaborated.

We should like to take this opportunity to express our sincere gratefulness to the Kazakh government agencies concerned for their valuable cooperation. We are also thankful to the Japanese Ministry of Foreign Affairs, the Ministry of Economy and Industry, the Embassy of Japan in Kazakhstan and persons concerned who have rendered assistance and support for the survey.

March, 2002

川上隆朗

Takao Kawakami
President
Japan International Cooperation Agency

Naohiro Tashiro

Naohiro Tashiro
President
Metal Mining Agency of Japan

Fig. I -1 Location Map of the Kokpetinskaya Area

Fig. I -2 Detailed Location Map of the Kokpetinskaya Area

Р Е З Ю М Е

В настоящем Резюме вкратце описываются результаты исследования на второй год, проведенного в рамках 3-летней программы “Основное геологоразведочное исследование по линии оказания сотрудничества в области разработки природных ресурсов на Кокпетинском участке Республики Казахстан”, которая осуществляется на основании “Соглашения по объему геологоразведочных работ”, заключенного между Японским агентством по международному сотрудничеству (JICA), Японским агентством металлодобывающей промышленности (MMAJ), Комитетом геологии и охраны недр Министерства энергетики и минеральных (бывшего Министерства природных ресурсов и охраны окружающей среды) Республики Казахстан.

Основные цели оговоренного исследования заключаются в определении геологии и процесса образования россыпей ильменитовых месторождений и их распределения на названном участке, и, тем самым, оказать Республике Казахстан содействие в разработке и освоении природных ресурсов. Ещё одна же цель исследования заключается в передаче различных технологий соответствующим организациям РК в ходе совместной работы в течение периода осуществления данной программы.

В рамках исследования на текущий финансовый год относительно всего Кокпетинского участка (общей площадью 256 кв. м) были осуществлены сбор существующих технических данных и информации, их анализ и геологическая разведка (предварительно-прецизионная). Помимо этого, было осуществлено разбуривание 20 скважин с общей глубиной бурения 1033,0 м в южной части Бектемирской россыпи №1, 25 скважин с общей глубиной бурения 903,5 м в южной части Бектемирской россыпи №3 и 5 скважин с общей глубиной бурения 335,0 м в северной части Бектемирского района.

Общая геология на данном участке, в основном, состоит из пластов, относящихся к каменноугольному периоду и вторгнувшихся в эти пласты интрузивных различных гранитных пород, а также покрывающихся первые Аральских слоев третичного и четвертичного периодов кайнозойской эры. В ходе исследования было выяснено, что гранитные породы, по их химическому составу, разделяются на гранит и монцонит – диорит, а также что эти породы содержат непрозрачные минералы, такие как ильменит (Ti 35%), титаносодержащий магнетит (Ti 1,5 – 14%) и магнетит (Ti 0%), и что среди монцонито – диоритных пород те породные тела с низкой намагниченностью содержат больше ильменит, чем остальные. Предполагаем, что такие непрозрачные минералы отделились под воздействием химического выветривания в влажных и теплых климатических условиях в конце верхнемелового периода (140 млн. лет назад) и сконцентрировались в профильных впадинах в породном основании (палеогеологических каналах) при осаждении Аральских слоев в неогеновом период (40 млн. лет назад).

Разведка с разбуриванием скважин показала, что месторождение в южной части Бектемирской россыпи №1 имеет толщину 1,8 – 10,0 м, ширину не менее 1000 м, количество увеличения рудных запасов 6,5 млн. куб. м, запасы ильменитовой руды 857 тыс. тонн со средним содержанием чистого ильменита 132 кг / куб. м, коэффициент вскрытия 8,3. На Бектемирской россыпи №3 расположенные параллельно друг другу два месторождения имеют ширину примерно 200 м, соответственно, и являются меньшими по масштабу, чем то на россыпь №1. Толщина данного месторождения составляет 1,5 – 4,4 м, объем потенциальных запасов – 3,8 млн. куб. м, объем запасов ильменитовой руды – 493 тыс. тонны со средним содержанием 130 кг / куб. м, а коэффициент вскрытия – 9,7. Подробное определение объема запасов руды в северной части Бектемирской россыпи не проводилось с учетом низкого среднего содержания ильменита.

В основном, ильменитовые россыпные месторождения образуется в палеогеологических каналах в породном основании Аральского слоя. Следовательно, можно сказать, что выделение палеогеологических каналов обеспечит возможность определения новых (других) мест, где с высокой вероятностью зарождаются рудные месторождения. По более верхнему потоку находятся диоритно – монцонитные породы, которые характеризуются высоким содержанием ильменита, и ожидается нахождение пород с намагниченностью не более 1 x 10^3 S.I.U. и низким содержанием магнетита или титаносодержащего магнетита.

Говоря об общем направлениях исследования на третий год, мы считаем целесообразным провести дополнительную разведку с бурением скважин (подробную разведку) в южной части Бектемирского россыпного месторождения №1, которое, должно быть, продолжаться ещё южнее, и в южной части Бектемирского россыпного месторождения №3, от которого можно ожидать довольно большие потенциальные рудные запасы. Помимо этих месторождений, необходимым считаем проведение дополнительной разведки с бурением скважин в восточной части Бектемирского россыпного месторождения №1 и северной части Бектемирского россыпного месторождения №2 (район Белое), где предполагается нахождение палеогеологических каналов.

В Караоткельском районе необходимо в дальнейшем выделить пойменные болота и палеогеологические каналы, имеющие соответствующие характеристики и, тем самым, обеспечить возможность провести переоценку уже разведанных ильменитовых россыпных месторождений. Кроме того, рекомендуется провести поиски и предварительную оценку различных районов по всей территории Республики Казахстан, которые имеют историю, подобную исследуемым в рамках нашей текущей работы, с целью, чтобы найти другие ильменитовые россыпные месторождения.

SUMMARY

This survey was undertaken as a second-year survey in "Basic Resource Development Cooperation Survey: Kokpetinskaya Area of Republic of Kazakhstan" that was started as a three-year project in 2000 based on the Scope of Works concluded between the the Committee of Geology and Underground Resources Protection of the Ministry of Energy and Mineral Resources, Government of the Republic of Kazakhstan, and Japan International Cooperation Agency/Metal Mining Agency of Japan.

The survey aims at analyzing geology in the survey area that contains ilmenite ore beds of the drift sand type and ore bearing condition of the ore beds, to support resource development by the Republic of Kazakhstan. The survey also aims at transferring technology to the counterparts of Kazakhstan during the survey period.

In Phase II, public data of the entire area of the Kokpetinskaya Area (256km^2) was collected and analyzed. A geological survey (semi-detailed survey) was conducted in the area. Boring surveys were conducted in the southern flank of Bektimir Placer No. 1 (20 drill pits, 1033.0m in drilling length), southern flank of Bektimir Placer No. 3 (25 drill pits, 903.5m) and northern flank of Bektimir (5 drill pits, 335.0m).

This area consists of Carboniferous Period layers and granitic rocks that intrude into them, as well as Aral Formation of the Tertiary Period in the Cainozoic Era and Quaternary-Period layers that cover them. Based on chemical compositions, granitic rocks could be classified into granite and monzonite - diorite. The surveys showed that the area contained ilmenite (Ti 35%), titanic magnetite (Ti 1.5 to 14%), and magnetite (Ti 0%) as opaque minerals and that more ilmenite was contained in rock bodies of monzonite - diorite that showed a low magnetic susceptibility. It is estimated that opaque minerals were separated by chemical weathering under wet and warm climate at the end of early Cretaceous Period (about 140 million years ago) and were thickened in furrows (palaeo-landform channels) of the bedrock when the Aral Formation was deposited in the Neogene Period (about 40 million years ago).

The drilling surveys showed that the southern flank of Bektimir Placer No. 1 was 1.8 to 10.0m thick, more than 1000m in width, 6.5 million m^3 in ore reserves potential, 857,000t in ilmenite ore reserves, 132kg/m^3 in ilmenite content and 8.3 in stripping ratio. In the southern flank of Bektimir Placer No. 3, the widths of two parallel ore deposits were about 200m and were narrow compared with that of Placer No. 1. Placer 2 was 1.5 to 4.4m thick, 3.8 million m^3 in ore reserves potential, 493,000t in ilmenite ore reserves, 130kg/m^3 in ilmenite content and 9.7 in stripping ratio. The grade of ilmenite-thickened seams in the

northern flank of Bektimir was low and ore reserves calculations of it were not made.

Ilmenite placer deposits are contained in palaeo-landform channels of the bedrock of the Aral Formation. Seams with high possibilities for deposition of new ore deposits can therefore be extracted by extracting palaeo-landform channels. When exploring such seams, upstream areas of them should preferably be rock bodies of diorite - monzonite, containing a high proportion of ilmenite but less magnetite and titanic magnetite. The magnetic susceptibility of them should preferably be less than 1×10^{-3} S.I.U..

As a survey policy for Phase III surveys, additional drilling (detailed survey) of the southern flank of Bektimir Placer No. 1, for which a further extension of ore deposits is expected, and the southern flank of Bektimir Placer No. 3, where sufficient potentials are expected, is desired. Palaeo-landform channels are anticipated in the eastern flank of Bektimir Placer No. 1 and the northern flank of Bektimir Placer No. 2 (Beloe District) as other potential districts. A drilling survey of these districts is deemed preferable.

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