NO.

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

(PHASE Ⅲ)

MARCH 2003

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 third year (Phase III) of the survey commenced in the fiscal year 2002, the MMAJ organized and sent to the Republic of Kazakhstan a three-man survey team for the period from June 29 to September 7, 2002. 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 III 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.

January, 2003

Takao Kawakami
President
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Fig. I -1 Location Map of the Kokpetinskaya Area

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

РЕЗЮМЕ

Данное Изучение было предпринято в третьем (заключительном) году проведения «Базового Изучение в ходе сотрудничества в разработке минеральных ресурсов: Республика Казахстан, Кокпетинский район», начатого в качестве 3-летней программы на основании соглашения об «Объеме работ», заключенного между Японским Агентством Международного Сотрудничества (JICA) и Агентством по разработке руд металлов Японии (MMAJ), с одной стороны, и Комитетом геологии, охраны и использования недр Министерства энергетики и природных ресурсов (ранее – Министерство природных ресурсов и охраны окружающей среды) Республики Казахстан, с другой стороны.

Целью данного Изучения является выяснение геологии месторождений, содержащих ильменит аллювиального происхождения, а также выяснение положения с запасами указанных месторождений, для поддержки разработки природных ресурсов в Республике Казахстан. Изучение ставит также целью трансферт технологий организациям Республики Казахстан в течение периода проведения изучения.

В этом (3-ем) году проведения Изучения был выполнен сбор и анализ уже имеющихся материалов по Караоткерскому участку (110 кв. км) Кокпетинского района. Здесь также была проведена геологическая разведка (полудетализированная разведка). Было также выполнено разведочное бурение на южных участках Бектемирского рудного тела №1 (18 скважин, совокупная глубина бурения 940,5 м), на южных участках Бектемирского рудного тела №3 (8 скважин, совокупная глубина бурения 290,5 м), а также на участках восточной части Бектемирского района (41 скважина, совокупная глубина бурения 1036,50 м)

Геология Караоткерского района представлена пластами каменноугольного периода с интрузиями гранитоидных скальных пород, проникшими сквозь них за время с верхнекаменноугольного по середину триасового периода (Караоткерский комплекс). Указанные пласты неоднородно покрыты аральской формацией третичного периода кайнозойской эры и пластами четвертичного периода. По своему химическому составу гранитоидные скальные породы можно классифицировать на гранит и сиенит. Разведка показала, что из непроницаемых минералов они содержат псевдорутил (Ti 36%), ильменит (Ti 32%), магнетит (Ti 0%), гематит (Ti 0%) и др. Во всех случаях гранитоидные скальные породы здесь содержат не более 0,4% TiO_2, и их магнитная восприимчивость ниже, чем у пород Преображенского комплекс, расположенного северо-западнее. Низко здесь также и содержание ильменита. Таким образом, в качестве базовой породы залегания ильменитов аллювиального происхождения следует дать более высокую оценку Преображенскому комплексу.

В ходе анализа имеющихся данных была также проведена переоценка уже известных рудных месторождений ильменита на Караоткерском участке. Было выяснено, что с геологической точки зрения уже подсчитанные запасы руды включают элювиальные отложения с низким содержание полезного вещества. Был произведен перерасчет количества руды, целью которого было выявить рудные месторождения аллювиального происхождения со сравнительно высоким содержанием полезного вещества. Для этого был применен принцип отсечения породы, содержащей менее 50 кг полезного вещества на 1 $м^3$. В результате расчетов был получен объем руды 9,9 млн. $м^3$, содержащей 734 тыс. т ильменита, при среднем содержании ильменита 74 кг/$м^3$. Указанные месторождения руды залегают на сравнительно небольших глубинах – примерно 20 м. В отношении этих руд следует повторно произвести технико-экономическое обоснование.

В результате разведочного бурения на Бектемирском участке было выявлено, что рудное тело

имеет значительные масштабы: его средняя толщина на южном продолжении рудного тела №1 составила 4,8 , при максимальной ширине в более чем 2000 м. Если брать в расчет только руды, в которых содержание ильменита составляет от 100 кг/м^3 и более, то прирост рудных ресурсов составляет 1,8 млн. м^3, с содержанием ильменита 1686 тыс. т, при среднем содержании ильменита 113,5 кг/м3. Здесь может быть получен коэффициент вскрыши 12,8. В результате рассчитанные в ходе 3-летнего Изучения запасы руды составили 13, 3 млн. м^3, при содержании ильменита 1686 тыс. т, со средним содержанием ильменита 126,7 кг/м^3 и при коэффициенте вскрыши 7,83. Вместе с ресурсами, подтвержденными ранее, это означает увеличение размера подтвержденных запасов руды почти в 2 раза.

С помощью осуществления дополнительного разведочного бурения на южном участке Бектемирского рудного тела №3 был вычислен потенциал месторождения. При ширине месторождения до 400 м и средней глубине 3,7 м, месторождение содержит (исходя из условия рассмотрения руды с содержанием ильменита от 100 кг/м^3 и выше) 0,8 млн. м^3 руды, при содержании ильменита 109 тыс. т, со средним содержанием ильменита 133, 5 кг/м^3, при коэффициенте вскрыши 8,49. В южных участках Бектемирского рудного тела №1 и рудного тела №3 была выяснена тенденция к увеличению до 40 м и более толщины слоя земли, покрывающего рудное тело, по мере передвижения к участкам, лежащим ниже по течению древних рек. Для разработки указанных ресурсов в будущем потребуется создание новой технологии добычи.

На участке восточной части Бектемирского района в месте, разведка на котором еще не проводилась, была обнаружена зона с повышенным содержанием ильменита (14,3 ~ 61,5 кг/м^3). Зона имеет ширину 200 ~ 600 м, залегая пластом толщиной 0,7 ~ 4,5 м на сравнительно небольшой глубине – около 10 м. Потенциал месторождения (исходя из условия рассмотрения руды с содержанием ильменита от 20 кг/м^3 и выше) составляет 1,05 млн. м^3, при содержании ильменита 32,5 тыс. т, со средним содержанием ильменита 30,9 кг/м^3. При продвижении ниже по течению просматривается тенденция к постепенному увеличению масштабов месторождения и содержания ильменита в породе, так что можно рассчитывать на то, что месторождение протянулось дальше.

SUMMARY

This survey was undertaken as a third-year (final year) survey in "The Mineral Exploration: Kokpetinskaya Area of Republic of Kazakhstan" that was started as a three-year program in 2000 based on the Scope of Works concluded between the Ministry of Energy and Natural Resources (formerly Ministry of Natural Resources and Environment Protection) of the Republic of Kazakhstan, Committee for Geology and Mineral Protection and the East-Kazakhstan Territorial Department, and Japan International Cooperation Agency/Metal Mining Agency of Japan.

The survey aims at analyzing geology in the survey area that contains ilmenite ore deposits of the drift sand type and ore bearing condition of the ore deposits, 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 Year 3, public data of the Karaotkel district of the Kokpetinskaya area (110km^2) was collected and analyzed. A geological survey (reconnaissance survey) was conducted in the district. Boring surveys were conducted in the southern flank of Bektimir Placer No. 1 (18 drill pits, 940.5m in drilling length), southern flank of Bektimir Placer No. 3 (8 drill pits, 290.5m) and eastern flank in the Bektimir district (41 drill pits, 1,036.50m).

The Karaotkel district geologically consists of Carboniferous Period layers and granitic rocks that intruded into them in the early Carboniferous Period to mid Triassic Period (Karaotkelskiy Complex), as well as Aral Formation of the Tertiary Period in the Cainozoic Era and Quaternary-Period layers that cover them without conformity. Based on chemical compositions, the granitic rocks can be classified into granite and syenite. The surveys show that the area contains pseudorutile (Ti 36%), ilmenite (Ti 32%), magnetite (Ti 0%), hematite (Ti 0%) and other minerals as opaque minerals. All these granitic rocks contain 0.4% or less of TiO_2 and their magnetic susceptibilities are lower than those of the Preobrazhenskiy complex which is located next to them in northwest. Their ilmenite contents are also low. Therefore, the Preobrazhenskiy complex can be appraised to be more superior as origin rocks of ilmenite alluvial deposits.

Analyzing existing survey data, known ilmenite ore deposits in he Karaotkel district were reappraised. It could be determined that geologically eluvial deposits of a low grade were contained in the ore deposits, whose ore reserves were included in the ore reserves calculations. A recalculation of ore reserves covering alluvial deposits of relatively high grades was made using a cut-off range of 50kg/m^3. The calculation showed 9.9 million m^3

in ore reserves potential, 734,000t in ilmenite ore reserves and 74kg/m^3 in average ilmenite content. These ore reserves are deposited in relatively shallow depths, less than 20m from the surfaces of the ore deposits, and an economical feasibility of them should be restudied.

A boring survey of the Bektimir district has shown that the thickness of the southern flank of Bektimir Placer No. 1 is 4.8m on average and the breadth, more than 2,000m maximum, which can be considered as a large-scale ore deposit. Using a cut-off range of 100kg/m^3 in average ilmenite content, an increase in ore reserves potential of 1.8 million m^3 could be calculated, while ilmenite ore reserves of 204,000t, average ilmenite content of 113.5kg/m^3 and stripping ratio of 12.8 could be obtained. As a result, ore reserves potentials calculated during the survey in the past three years are 13.3 million m^3, with ilmenite ore reserves of 1,686,000t, average ilmenite content of 126.7kg/m^3 and stripping ratio of 7.83. When combined with ore reserves potentials confirmed so far, proved ore reserves potentials almost double.

An ore reserves potential estimated based on additional boring could be calculated for Southern Flank of Bektimir Placer No. 3. Based on an ore deposit breadth of 400m or less, average thickness of 3.7m and a cut-off range of 100kg/m^3 in ilmenite content, the ore reserves potential was 0.8 million m^3, while ilmenite ore reserves were 109,000t, average ilmenite content, 133.5kg/m^3 and stripping ratio, 8.49. The strata that covered the ore deposits in Southern Flanks of Bektimir Placers Nos. 1 and 3 tended to become more thick, 40m or more, in the downstream. The development of a new exploratory mining technique is desired for future development.

New thickened parts of ilmenite measuring 200 to 600m in breadth, 0.7 to 4.5m in thickness and 14.3 to 61.5kg/m^3 in ilmenite content could be found in relatively shallow depths, less than 10m from the surfaces of ore deposits in the eastern part of the Bektimir district where exploratory mining was undertaken. Using a cut-off range of 20kg/m^3 in ilmenite content, an ore reserves potential is 1.0.5 million m^3, while ilmenite ore reserves are 32,500t and average ilmenite content, 30.9kg/m^3. The sizes and ilmenite contents of these thickened parts of ilmenite tend to increase toward downstream and a further continuity of these parts can be expected.

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PART I GENERAL

CHAPTER 1 INTRODUCTION

1-1 Background of the Survey

This survey was undertaken as a third-year (final year) survey in continuation of a mineral resource survey that was executed in 2000 in the Kokpektinskaya area based on the Scope of Work concluded on June 6, 2000 between the Governments of the Republic of Kazakhstan and Japan at the request of the former government.

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 Ministry of Energy and Natural Resources of the Republic of Kazakhstan, Committee for Geology and Mineral Protection and the East-Kazakhstan Territorial Department, 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. The nonferrous metal industry registered a growth of 14% in 2001 over the previous 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 estimated production of sponge titanium reached 12,000 tons in 2001, up 50% over the previous year, ranking 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 Magnesium Kombinat (UK-TMK) in Ust-Kamenogorsk, about 150km north of the survey area. Bektimir Placer No. 1 in the area is test-mined by open-cut mining, to supply ore to an ore-dressing pilot plant in Kaznakovka as ilmenite concentrate for use as a titanium raw material. At present, the kombinat imports ilmenite, titanium slag and other titanium raw materials from Canada, 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 III 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 Phase III survey area is located in the Bektimir and Karaotkel districts within this area. The area contains communities such as Koitas and Karaotkel (See Fig.-2).

The landform of the survey area is hilly land about 400 to 500m in altitude and most of it is almost flat, with gentle inclination only. The area is covered by cultivated fields for wheat, sunflowers and other crops and meadows. Paved national roads and unpaved roads for agriculture uses cross the flat hilly land.

1-2-2 Content of the Survey

In Phase III, existing and public geological information for the Karaotkel district measuring 110km^2 in area was collected and analyzed and a geological survey was conducted. A drilling survey (67 pits total 2,267.5m) was conducted in three flanks in the Bektimir district (Southern Flank of Placer No. 1, Southern Flank of Placer No. 3 and Eastern Flank of Bektimir).

1) Analysis of Public Geological Information

(1) Purpose of the analysis

The Year-2 survey showed that ilmenite alluvial deposits found in the Bektimir district were deposited along former rivers (palaeo-landform channels) of the layer bedrock of the Pre-tertiary Period. The survey in Phase III was therefore undertaken to understand the relationship between palaeo-landform channels and known ilmenite alluvial deposits in the Karaotkel district, which adjourns the southeastern part of the Bektimir district, using existing geological information.

(2) Analysis method

A detailed subsurface contour map of the surface of the layer bedrock of the Pre-tertiary Period, which is the foot rock of ilmenite alluvial deposits, and a geological map of the bedrock of the Pre-tertiary Period were prepared. Ore reserves of ilmenite and zircon were reappraised. As basic data for this reappraisal, data for 2,617 pits (total

44,877.8m) from 79 Drilling geological profiles prepared by the counterpart organizations and other parties in 1982 for exploration of Karaotkel Placer were interpreted. Through this interpretation, data on the depths of the Pre-tertiary Period bedrock and Quaternary Period bedrock, bedrock geology, analytical grades of ilmenite and zircon, and calculations of ore reserves could be collected. Additionally, geological history literatures on paleometeorology, sedimentary environment and other subjects of wide areas including the survey area was collected.

(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

The Year-2 survey showed that ilmenite of the Bektimir ore beds originated from granitic rocks of the Preobrazhenskiy complex. It was known that granitic rocks could be classified in accordance with magnetic susceptibility and chemical composition allowing determination of granitic rocks that contained a large amount of ilmenite. In Phase III, a similar survey method was used with the Karaotkelskiy complex also, namely, whole rock analysis in accordance with magnetic susceptibility measurement and rock samples and trace component analysis, to determine granitic rocks that would contain a large amount of ilmenite. The development condition of ilmenite ore beds was surveyed in three flanks of the Bektimir district by a Drilling survey (67 pits, total 2,267.5m).

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: 110 km^2 Reconnaissance length: 20 km Drilling Survey (See Appendix 3.) Total length: 2,267.5 m (67 pits)

The survey (reconnaissance survey) was conducted using a topographic map on a scale of 1/25,000 and the results of the survey were plotted on a geological map on a scale of 1/25,000. During the survey, magnetic susceptibility was measured on outcrops. The results of the Drilling survey were plotted on a Drilling core columnar section on a scale of 1/200. The results of Drilling were plotted on a geological section for each survey traverse line.

During the survey, samples of rocks and ores were collected from fresh outcrops. These samples in the quantities shown in Appendix 2-1 were tested, analyzed and assayed in a laboratory and were used in analysis.

3) Drilling Survey

(1) Purpose

The Drilling survey was conducted to determine and understand the development condition of ore bodies in the extended areas south of the Bektimir Placers No. 1 and 3, which are known ore beds, and in east Bektimir.

(2) Drilling Locations and Survey Quantities

The Drilling survey was conducted in the locations shown in Fig. II-3-1. Drilling was carried out for a total of 67 pits and 2,267.5m in length at the following locations: Southern Flank of Placer No. 1 (detailed survey area) 18 pits and 940.5m, Southern Flank of Placer No. 3 (detailed survey area) 8 pits and 290.5m, and Eastern Flank of Placer No. 3 (reconnaissance survey area) 41 pits and 1,036.5m.

The quantities of survey are shown In Table I-1-1.

(3) Field survey

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

Table I -1-1 Outline of the Survey (2)

District	Drill hole No.	Azimuth	Inclination	Drilling Length

Bektimir (Southern Flank of Placer No. 1) 500m x 200m Grid	MJBK-38	—	-90°	64.0m
	MJBK-39	—	-90°	36.0m
	MJBK-40	—	-90°	64.5m
	MJBK-41	—	-90°	40.0m
	MJBK-42	—	-90°	44.0m
	MJBK-43	—	-90°	50.0m
	MJBK-44	—	-90°	60.0m
	MJBK-45	—	-90°	61.0m
	MJBK-46	—	-90°	28.0m
	MJBK-47	—	-90°	36.0m
	MJBK-48	—	-90°	51.0m
	MJBK-49	—	-90°	54.0m
	MJBK-50	—	-90°	59.0m
	MJBK-51	—	-90°	55.0m
	MJBK-52	—	-90°	55.0m
	MJBK-53	—	-90°	65.0m
	MJBK-54	—	-90°	60.0m
	MJBK-55	—	-90°	58.0m
Total	18 holes			940.5m
Bektimir (Southern Flank of Placer No. 3) 200m Spacing	MJBKS-26	—	-90°	31.0m
	MJBKS-27	—	-90°	30.0m
	MJBKS-28	—	-90°	33.5m
	MJBKS-29	—	-90°	40.0m
	MJBKS-30	—	-90°	40.0m
	MJBKS-31	—	-90°	41.0m
	MJBKS-32	—	-90°	40.0m
	MJBKS-33	—	-90°	35.0m
Total	8 holes			290.5m
Bektimir (Eastern Area)	MJBKE-1	—	-90°	45.0m
	MJBKE-2	—	-90°	50.0m
	MJBKE-3	—	-90°	41.0m
	MJBKE-4	—	-90°	17.0m
	MJBKE-5	—	-90°	18.0m
	MJBKE-6	—	-90°	22.0m
	MJBKE-7	—	-90°	44.0m
	MJBKE-8	—	-90°	59.5m
	MJBKE-9	—	-90°	55.5m
	MJBKE-10	—	-90°	22.0m
	MJBKE-11	—	-90°	12.0m
	MJBKE-12	—	-90°	29.0m
	MJBKE-13	—	-90°	42.0m
	MJBKE-14	—	-90°	48.0m
	MJBKE-15	—	-90°	45.0m
	MJBKE-16	—	-90°	29.0m
	MJBKE-17	—	-90°	25.0m
	MJBKE-18	—	-90°	17.0m

	MJBKE-19	—	-90°	19.0m
	MJBKE-20	—	-90°	12.0m
	MJBKE-21	—	-90°	18.0m
	MJBKE-22	—	-90°	8.0m
	MJBKE-23	—	-90°	15.0m
	MJBKE-24	—	-90°	12.0m
	MJBKE-25	—	-90°	29.0m
	MJBKE-26	—	-90°	17.0m
	MJBKE-27	—	-90°	6.0m
	MJBKE-28	—	-90°	15.0m
	MJBKE-29	—	-90°	20.0m
	MJBKE-30	—	-90°	19.0m
	MJBKE-31	—	-90°	19.0m
	MJBKE-32	—	-90°	15.0m
	MJBKE-33	—	-90°	22.0m
	MJBKE-34	—	-90°	34.0m
	MJBKE-35	—	-90°	16.0m
	MJBKE-36	—	-90°	20.0m
	MJBKE-37	—	-90°	21.0m
	MJBKE-38	—	-90°	21.0m
	MJBKE-39	—	-90°	15.0m
	MJBKE-40	—	-90°	14.5m
	MJBKE-41	—	-90°	18.0m
Total	41 holes			1,036.5m
Total	67 holes			2,267.5m

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	The Ministry of Energy and Natural Resources of the Republic of Kazakhstan, Committee for Geology and Mineral Protection
Masayuki Chiba	Japan International	A. M. Zhylkaidarov	Same as above

(Work Supervision)	Cooperation Agency		
Keita Kanda (Geology)	Metal Mining Agency of Japan	S. B. Berikbolov	Same as above
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)	The Ministry of Energy and Natural Resources of the Republic of Kazakhstan, Committee for Geology and Mineral Protection
Yoshiaki Ishizuka (Drilling)	Same as above	A. M. Zhylkaidarov (General)	Same as above
Toshio Inoue (Drilling)	Same as above	Dmitrij Titov (General)	East-Kazakhstan Territorial Department
		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

3) Field Work Supervision

Hiroyoshi Okishima   Metal Mining Agency of Japan

From July 27 to 30, From August 29 to September 5, 2002

Tetsuya Honjyo   Metal Mining Agency of Japan

From August 27 to September 6, 2002

1-2-4 Perod of the survey

Task	2002							2003		
	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Period
Planning and Preparations	28 –									Jun. 28
Field Survey	29			6						Jun. 29 - Sept. 6
Test and Analysis			5					15		Aug. 5 - Jan. 15
Report Compilation				7				31		Sep. 7 - Jan. 31

CHAPTER 2　GEOGRAPHY OF SURVEY AREA

2-1 Location and Access

The Year-3 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. Southern Flank of Placer No. 1 and Southern and Eastern Flanks of Placer No. 3 covered by the boring survey, as well as the Karaotkel district covered by the geological survey, are included in the Kokpektinskaya area (See Figs. I-1 and 2.). Appendix I-2 and Table I-2-1 present coordinates survey locations in the boring survey and of each angular point of the geological survey area of the Karaotkel district.

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°49'30.54"	83°04'16.96"
2	48°43'44.80"	82°58'30.29"
3	48°40'33.67"	83°05'46.07"
4	48°46'20.85"	83°11'32.74"

The population density is high in Preobrazhenka Village in the west of the survey area and Beloe Village in the northeast. Koitas and Ornok Communities are located near Bektimir Placer No. 1, which is the major ore bed, while Terekti and other communities are located near Placer No. 3. Zhanozhol and Karaotkel Communities are located in the northern and southeastern parts of the Karaotkel district.

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 System

1) Topgraphy

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 flatland in the south of the boring survey area (Southern Flanks of Bektimir Placers No. 1 and No. 3) The altitudes in the upstream and downstream parts of Eastern Flank of Bektimir are 510 - 540m and 490 - 460m, respectively. In the Karaotkel district, the altitudes in the hilly part in north around the Karaotkelskiy intrusive rock mass and in the southern flatlands made up of intrusive rock mass are 450 - 500m and 404 - 458m, respectively. The southern plains are extremely flat.

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. In the survey area, most of the Karaotkel district is flat plains and main drainage systems are not found there.

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) Fauna and Flora

(1) Flora

Vegetation is varied. In addition to natural vegetation, the ground is cultivated land, forestation land, grassland and pastures. Main farm crops are wheat and sunflowers. Potatoes, tomatoes and other vegetables are grown near farmhouses.

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

(2) Fauna

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 EXISITING GEOLOGICAL DATA OF 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 including feldspar and quartz. Based on a 15kg/m^3 cut-off grade of ilmenite, ore reserves of 147,579,000mm^3, ilmenite reserves of 3,438,000 tons and ilmenite content of 23.3kg/m^3 were calculated. 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 drilling.

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 Geological Structure

1) General Geology

The order of stratification in the survey area consists of pre-granitic rocks (Carboniferous Period layers), granitic rocks intruded into them, Aral Formation of the Miocene Epoch in the Neogene Period of 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 the Aral Formation

(1) Pre-granitic rocks

The geology in the area consists of sedimentary rocks (shale, sandstone and conglomerate), pyroclastic rocks and lava (andesite and porphyrite). From the bottom, the layers are Arkalyk layer (sedimentary rocks, pyroclastic rocks and limestone) of the lower Carboniferous Period, Kokpekti layer (sedimentary rocks, pyroclastic rocks and limestone) of the late Carboniferous Period, Bukon layer (conglomerate, sandstone and shale - the upper seam is shale, coaly shale, sandstone and tuffaceous sandstone) of the mid-Carboniferous Period, and Maityab layer (andesitic porphyrite sandwiching tuff and tuffaceous sandstone, andesite and, rarely, basaltic and diabasic porphyrite) of the mid- to early Carboniferous Period. 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. Preobrazhenskiy complex is considered classifiable into Maksutskiy complex (early Permian Period, late Triassic Period - gabbro, diorite and monzonite), Saikanskiy complex (mid- to early Triassic Period - syenite, diorite and monzonite) and Delbegeteyskiy complex (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 and Karaotkelskiy complexes. 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

Weathered crusts of bedrock are kaolin, illite and smectite clayey weathered remnants developed on sedimentary rocks, volcanic rock and intrusive rock of the Carboniferous Period. Weathered crusts of bedrock were formed by chemical weathering under moist and warm climate at the end of early Cretaceous Period (about 140 million years ago) (Erofeyev, 1969).

(4) Tertiary-Period Aral Formation

The order of stratification of the Tertiary Series in the Zaisanskaya Basin is described in Erofeyev (1969) and other literature (See Fig. I-3-2.). According to this information, the North Zaisanskaya Series of the Palaeocene Epoch, Turanginskaya Series of the mid- to early Eocene Epoch, Tuzkabakskaya Series of the early Eocene Period to late Oligocene Epoch, Ashutasskaya Series of the early to mid-Oligocene Period, Aral Series of the late to mid-Miocene Epoch, Pavlodar Series of the early Miocene Epoch to early Pliocene Epoch and Vtorushinskaya Series of the mid- to early Pliocene Epoch stack by covering the upper Cretaceous Period without conformity.

Among these series, the Aral Series is well developed in the survey area and covers pre-granitic rocks, intrusive rocks and weathered crusts of them without conformity. The layers consist of clay, sandy clay and clayey sand comprising quartz, plagioclase, kaolin, smectite and illite. Ilmenite alluvial deposits 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.

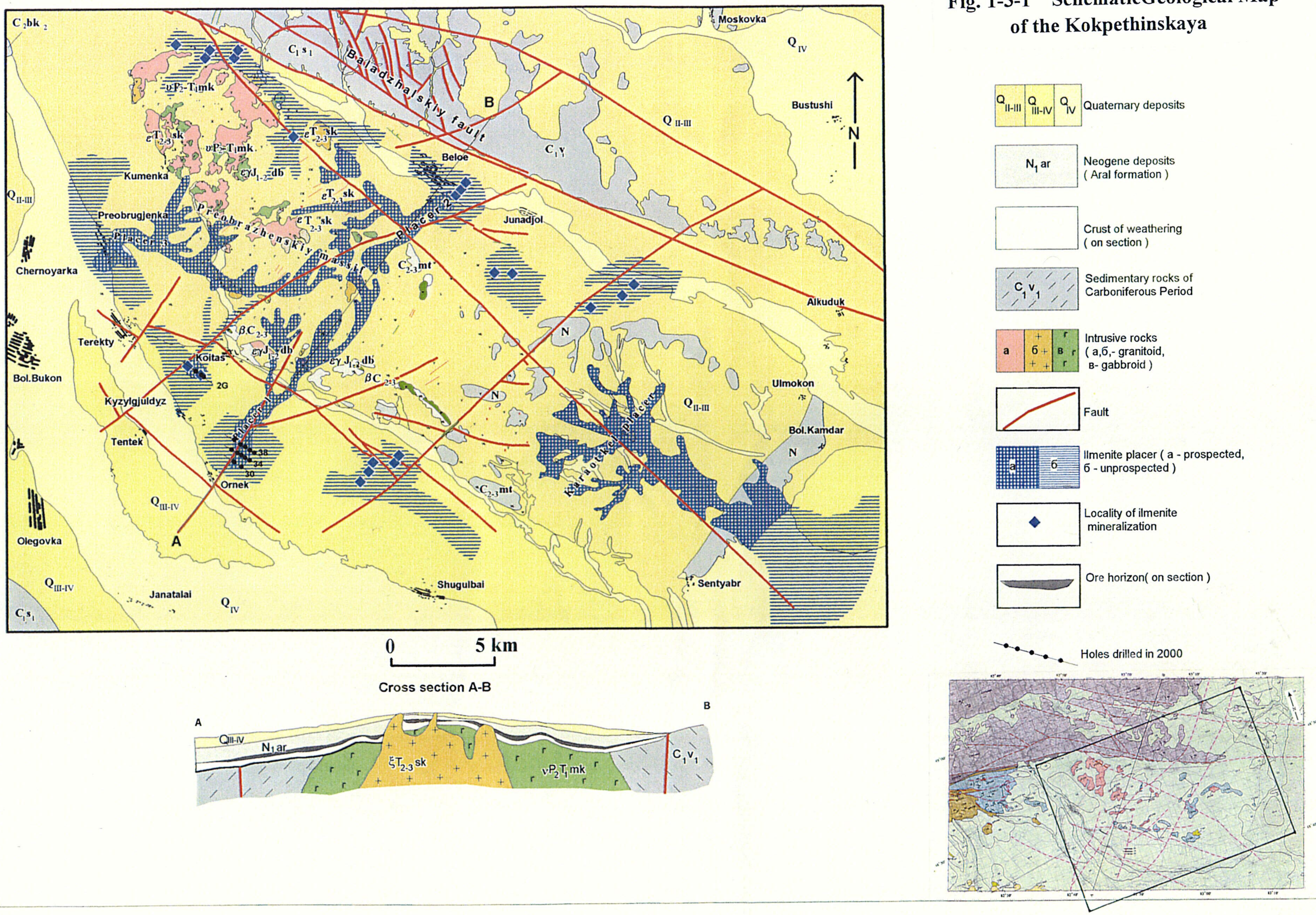
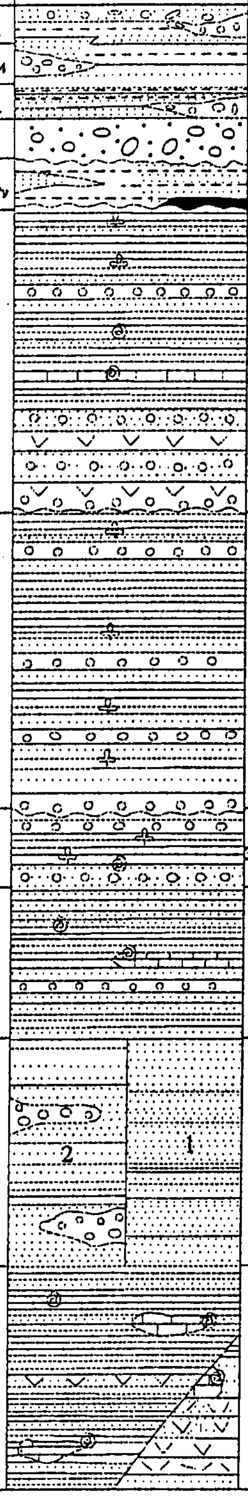


Fig. 1-3-1 SchematicGeological Map of the Kokpethinskaya



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
			$C_1V_3\text{-}nkp_1$		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 Geological Structure

The survey in Phase I led to the assumption that ilmenite in ilmenite alluvial deposits was probably originated from granitic rocks that comprised the Preobrazhenskiy complex, which was exposed in the upstream. It was also assumed that gabbro and monzonite contained ilmenite in large amounts among these rocks.

The survey in Phase II showed that the TiO_2 content in rocks in the Preobrazhenskiy complex could be decided by the amount of titanic minerals such as ilmenite contained in granitic rocks. It was shown that monzonite-diorite containing more than 1% of TiO_2 and granite containing less than 1% of TiO_2 could be clearly distinguished by the characteristics of chemical components (main components, normative minerals, trace components) and that the TiO_2 content would be less, higher the magmatic crystallization differentiation was. Opaque minerals contained in granitic rocks are pseudorutile, ilmenite, magnetite and titanic magnetite. Granitic rocks containing a high proportion of pseudorutile and ilmenite were known to show a low magnetic susceptibility of 1×10^{-3} S.I.U. or less on the surface. Conversely, granitic rocks showing a high magnetic susceptibility of 1×10^{-3} S.I.U. or higher contain a large amount of magnetite and titanic magnetite and are, therefore, not superior as origin rocks of titanic ore deposits. A palaeogeomorphological subsurface structure diagram of the bedrock under the ore deposits was prepared. Many palaeo-landform channels originating in areas that were distributed with granitic rocks could be extracted in the diagram. Based on the foregoing survey results, it can be inferred that the following is the conditions that would allow promising ilmenite alluvial deposits to exist:

①Palaeo-landform channels that have

②Origin rocks that are not much advanced in crystallization differentiation, such as monzonite, diorite and gabbro, are distributed in upstream areas and that have

③Areas with a magnetic susceptibility of less than 1×10^{-3} S.I.U.

In the Phase III survey, a survey technique similar to one that was acquired during the survey of the Bektimir district was used with the Karaotkelskiy complex that was adjoining in southeast. As pointed out in the Phase II survey, a study of the main chemical components showed that the Karaotkelskiy complex was rocks with advanced magmatic crystallization differentiation such as granite and syenite and that the TiO_2 content in granitic rocks was low. This indicates that most of granitic rocks in the Karaotkelskiy complex are rocks with a TiO_2 content of less than 0.4%, 85 or higher and mostly 90 or higher in differentiation index (DI) and most advanced in magmatic crystallization differentiation. Compared with the Preobrazhenskiy complex, the crystallization differentiation of the Karaotkelskiy complex is generally advanced so that its TiO_2 content and, therefore, ilmenite content are low, indicating that the rock mass is not superior as an origin rock for ilmenite alluvial deposits.

In the Na_2O+K_2O-SiO_2 diagram, the granitic rocks of Karaotkelskiy complex fall into the region of granite to syenite and are clearly grouped into a group that contains only 1% or less of TiO_2. In the K_2O+CaO-Na_2O diagram, the granitic rocks containing more than 1% of TiO_2 are rich in CaO, but are slightly scant in K_2O as in the granitic rocks of the Preobrazhenskiy complex surveyed in the Phase II survey. However, granitic rocks as those in the Karaotkelskiy complex that contain only less than 1% of TiO_2 are scant in CaO (<2%), but are slightly rich in K_2O (>5%). Granitic rocks as those in the Karaotkelskiy complex that contain only less than 1% of TiO_2 are rich in alkali (Na_2O+K_2O), but are scant in MgO and Σ FeO. Compared with them, the granitic rocks as those in the Preobrazhenskiy complex surveyed in Phase II that contain more than 1% of TiO_2 are scant in alkali, but are rich in MgO and Σ FeO, making a clear distinction possible. The differentiation index (D.I.) increases as crystallization differentiation of chemical components of residual magma advances. However, granitic rocks as those in the Karaotkelskiy complex that contain only less than 1% of TiO_2 are rich in alkali (Na_2O and K_2O), but are scant in MgO and Σ FeO. Their DI is 90 or more, sometimes reaching 95, and TiO_2, Al_2O_3, Fe_2O_3, FeO, MgO, CaO, Na_2O and K_2O tend to decrease as DI increases. On the other hand, DI of granitic rocks that contain more than 1% of TiO_2 is 60 or less, and alkali (Na_2O and K_2O) increases, while Al_2O_3, Fe_2O_3 and FeO rather decrease slightly and MgO and CaO decrease prominently as D.I. increases. The solidification index (SI) decreases, more advanced magmatic crystallization differentiation is, thus showing the degree of magmatic crystallization differentiation. The SI of granitic rocks containing only less than 1% of TiO_2 as in the Karaotkelskiy complex is 6 or less, most being 3 or less. The SI of some of the granitic rocks of the Preobrazhenskiy complex analyzed in the Phase II survey that contain more than 1% of TiO_2 is more than 10. In the classification of granitic rocks by the normative albite-orthoclase-quartz ratio diagram, syenite and granitic rocks of the Karaotkelskiy complex fall into the regions of quartz monzonite and monzonitic granite. They belong to a group that contains only less than 1% of TiO_2 and are clearly separated from a group that contains more than 1% of TiO_2 as in some of the granitic rocks of the Preobrazhenskiy complex analyzed in the Phase II survey.

When trace components of granitic rocks are combined with the Preobrazhenskiy complex, it is clear that the Karaotkelskiy complex belongs to granitic rocks with most advanced magma differentiation. The values of trace components to SiO_2 tend to decrease with siderophile elements such as Ni and Co as SiO_2 increases. Conversely, Cu levels off or slightly decreases while Pb slightly increases with chalcophile elements such as Cu and Pb as SiO_2 increases. Ba in granitic rocks containing only 0.4% or less of TiO_2 as in the Karaotkelskiy complex decreases as SiO_2 increases. Ba in granitic rocks containing more than 1% of TiO_2 almost levels off. Compared with the Preobrazhenskiy complex, Ba in the Karaotkelskiy complex is slightly less, but the complex is slightly rich in Ni and Pb. The rare-earth pattern, which was obtained by normalizing rare earths in granitic rocks of the Karaotkelskiy complex by Leedey Chondrite, shows that almost all granitic rocks contain only 0.4% of TiO_2 and illustrates a dent, indicating a negative anomaly of Eu, as is the case with the granitic rocks of the Preobrazhenskiy complex analyzed in the Phase II survey that contained only less than 1% of TiO_2. Tu, et al., (1980) stated that granitic gneiss in ancient times showed a small negative anomaly of Eu in rare-earth patterns of granitic rocks of southern China so that the granitization of it did not progress to a fusion stage, thus failing to cause crystallization differentiation. Tu, et al., analyzed that granitic rocks of the Yanshan Age (end of Mesozoic Era) showed a strong negative anomaly of Eu and were formed by resurgent magma by crystallization differentiation. Qu, et al., (2002) showed a chemical analysis of rare earths in the southwestern part of China in the Post-Orogenic Age and stated that a rare-earth pattern of the strong negative anomaly of Eu was caused by magma differentiation due to crystallization separation of anorthosite. Qu, et al., stated that this was a pattern unique to granite in the earth's crust. Ogata, et al., (2002) calculated variations of rare-earth patterns normalized by Leedey Chondrite when a granitic melt of granite in Miyako, Iwate Prefecture, Japan was treated for fractional crystallization. Ogata, et al., showed that the rare-earth content in residual liquid increased as fractional crystallization progressed, that the melt was rich in light rare-earth elements and that the pattern changed to a rare-earth pattern with a strong negative Eu anomaly. These views support that the Karaotkelskiy complex that shows a strong negative Eu anomaly is granitic rocks with most advanced magma differentiation in the Kokpentinskaya survey area and that these granitic rocks are most scant in TiO_2. Rb is assumed to behave with K, whose ion radius is similar, and is believed to have thickened in potassium feldspars and mica during end of magmatic crystallization differentiation. Tu, et al., (1980) stated that granitic rocks with 250 or less in the K/Rb ratio in southern China were caused by refusion of existing rocks while those in 250 or more in the K/Rb ratio were caused by magmatic crystallization differentiation. These views support that the K/Rb ratio of both granitic rocks (gabbro, diorite and monzonite) containing more than 1% of TiO_2 and the Karaotkelskiy complex (syenite and granite) containing only less than 1% of TiO_2 is 250 or more in the K/Rb ratio and that both are granitic rocks produced by cyrstallization differentiation of magma. Nevertheless, Rb of granitic rocks containing more than 1% of TiO_2 proportionately increase as K_2O increases. Rb of granitic rocks containing less than 1% of TiO_2 slightly decreases as K_2O increases. These two types of granitic rocks show different behaviors and can be discriminated clearly. Sr is fetched in the initial stage of crystallization differentiation by substituting part of K of potassium feldspars or of Ca of plagioclase and is believed to gradually decrease in residual magma. Therefore, the relationship between CaO and Sr is in a proportional relationship of Sr also decreasing when CaO decreases as crystallization differentiation of magma advances. The amount of Rb increases and that of Sr decreases as crystallization differentiation of magma advances. Therefore, the Rb/Sr ratio of rocks with an advanced level of crystallization differentiation increases. The Rb/Sr ratio is about 0.01 with granitic rocks of the Preobrazhenskiy complex containing more than 1% of TiO_2. This ratio is about 1 with granitic rocks in the northern part of the Preobrazhenskiy complex and with granitic rocks of the Karaotkelskiy complex that contain only less than 1% of TiO_2 after crystallization differentiation advances. These differences can be distinguished clearly in the Rb/Sr ratio.

The magnetic susceptibility of granitic rocks of the Karaotkelskiy complex is below 0.3×10^{-3} S.I.U., averaging about 0.15×10^{-3} S.I.U., and is generally low. The magnetic susceptibility of granitic rocks in the survey area is 0.09 to 0.95×10^{-3} S.I.U., varying greatly, but averaging about 0.15×10^{-3} S.I.U. Granitic rocks showing a slightly high magnetic susceptibility of about 0.2 to 0. 5×10^{-3} S.I.U. are distributed in parts of the northern and western sections. As in granitic rocks of the Preobrazhenskiy complex containing less than 1% of TiO_2, granitic rocks of the Karaotkelskiy complex contain less than 0.4% of TiO_2 and the magnetic susceptibility of them lowers as their differentiation index (DI) increase. Therefore, the magnetic susceptibility of granitic rocks tends to increase larger the amount of content of ferromagnetic minerals is, such as magnetite and titanic magnetite.

Distribution trends of the mode ratios of opaque minerals cannot be stated unqualifiedly because the distribution of samples is not uniform and is not balanced, concentrating from the northern part to the western part of the survey area where outcrops distribute. The mode ratio is below 1% with syenite and granite in the northern part of the Karaotkelskiy complex, compared with 1 to 2%, which is slightly high, with granite in the western part. TiO_2 tends to be high, higher the mode ratio of opaque minerals is.

The mode ratios of opaque minerals in granitic rocks of the Karaotkelskiy complex are less than 2% with granite, mostly below 1%. Opaque mineral species are anatase (Ti 60%), pseudorutile (Ti > 36%), ilmenite or altered ilmenite (Ti 32 - 36%), titanic magnetite (Ti 1.5 - 14%), magnetite (Ti 0 - 1.5%), hematite (Ti 0%) and goethite (Ti 0%). Pseudorutile and altered ilmenite are produced by weathering alteration of ilmenite and goethite, by weathering alteration of magnetite. The magnetic susceptibility of granitic rocks of the Preobrazhenskiy complex surveyed during the Phase II survey was high, over 1×10^{-3} S.I.U., higher the content of titanic magnetite or magnetite in granitic rocks was. The magnetic susceptibility of the Karaotkelskiy complex was generally low, below 0.3×10^{-3} S.I.U., averaging about 0.15×10^{-3} S.I.U. This is probably because the Karaotkelskiy complex contained pseudorutile and ilmenite more than magnetite and titanic magnetite. However, contents of these minerals are small. Compared with the Preobrazhenskiy complex, crystallization differentiation of the Karaotkelskiy complex is advanced and has a low TiO_2 content so that it has low ilmenite content and low magnetic susceptibility, indicating that it is not superior as rocks of ilmenite alluvial deposits.

The intrusion ages of the Preobrazhenskiy and Karaotkelskiy complexes were as follows:

Sample No.	Rock name	Measured mineral	Age(Ma)	Complex
D-2	Gabbro	Amphibole	273.1±9.8	Preobrazhenskiy
D-3	Granite	K-feldspar	284.7±4.9	Preobrazhenskiy
D-4	Monzonite	K-feldspar	302.6±9.1	Preobrazhenskiy
D-5	Granite	K-feldspar	276.0±6.5	Karaotkelskiy
D-6	Syenite	K-feldspar	294.4±8.9	Karaotkelskiy

Plotting these granitic rocks in the normative albite - orthoclase - quartz ratio diagram, monzonite, syenite and granite are young in this order. Only gabbro is youngest and can be plotted in the basic region. This suggests a possibility that raw magma was monzonite, with syenite and granite gradually differentiating and with only gabbro lastly intruding from other magma. However, the survey mineral of gabbro only was amphibole and authigenic actinolite was formed in some parts, so that younger age than actual age may be shown.

According to a geological survey and physical exploration conducted by a survey organization of the republic, the Preobrazhenskiy and Karaotkelskiy complexes show a lopolith state and occupy the following areas by depth, believed to be forming simple rock masses in deep subsurface layers.

Depth (km)	Area of Preobrazhenskiy Complex (km^2)	Area of Karaotkelskiy Complex (km^2)
Surface	164	126
-1.8	—	800
-3	340	450
-5	—	90

This suggests that the Preobrazhenskiy and Karaotkelskiy complexes forming simple complexes in deep subsurface layers started differentiation from monzonitic magma almost in the same age, in early Carboniferous Period (300Ma) and differentiation-intruded into granite in the late Permian Period (280Ma) through syenite in the early Carboniferous Period to the late Permian Period (295Ma). Gabbro was estimated intruded into these complexes in the mid-Triassic Period (240Ma).

As shown in the subsurface contour map, many drainage systems of palaeo-landform channels flowing from complexes could be analyzed. A substantial number of these palaeo-landform channels generally have already been surveyed in the former Soviet Union period. Palaeo-landform channels in the southeastern part of the Preobrazhenskiy complex and in the western part of Beloe Community have not been surveyed yet. The economical efficiency of palaeo-landform channels that have already been surveyed and new ones is low in case overburdens of the Cainozoic Era on them are thick. Therefore, palaeo-landform channels that have thin overburdens of the Cainozoic Era should be identified using compile diagrams (Figs. I-4-1 and PL.II-2-2) with an isopach map of the Cainozoic Era.

4-2 Ore Deposits and Heavy Minerals

1) Economical Efficiency of Ore Deposits

(1) Karaotkel Placer

A study of existing and public data of the Karaotkel district has shown that thickened seams of ilmenite can be classified into two ore deposit types; eluvial deposits and alluvial deposits, and that alluvial deposits generally have a higher grade. The following ilmenite reserves of a high grade could be identified when reserves and grades of mainly alluvial deposits with grades of more than 50kg/m^3 among reserves calculated in 1982 (cut-off: ilmenite content 15kg/m^3, ore reserves 147,579,000mm^3, ilmenite reserves 3,438,000 tons and ilmenite grade 23.3kg/m^3):

Name of Ore Body	Category	Cut-Off Range (kg/m^3)	Ore Reserves (th. m^3)	Ilmenite Grade (kg/m^3)	Ilmenite Reserves (th. t)
Karaotkel	B	≧50	9,878.3	74.3	734.0

Because these ore reserves are deposited in relatively shallow depths, less than 15m from the surface, and because the price per ton of ore of the Karaotkel Placer is about $6 according to a recalculation, which is close to about $10, which is the price for ore deposits being developed in Australia at present, the development of this ore deposit may become economically feasible.

DEPOSIT	RESERVES(Mt)	HEAVY MINERAL (%)	ILMENITE (%)	ZIRCON (%)	RUTILE (%)	ORE VALUE ($/t)
KARAOTKEL	9.88	4.85	85	15	0	5.84
WEMEN, AUSTRALIA	9.16	5.00	44	12	28	10.16
MID WEST, AUSTRALIA		5.20	64	24	12	9.66
SOUTH WEST, AUSTRALIA		10.70	81	7	10	14.37

* Ore price based on ilmenite $80/t, zircon $350/t and rutile $450/t.

The Wemen Ore Deposit now in operation in Murray Basin of Victoria State in Australia is an inland mineral-sand ore deposit with reserves of 21.3 million tons and mineral-sand grade of 3.3% (ilmenite 51%, rutile 28% and zircon 11%). In this ore deposit, heavy mining equipment is now removing the overburden and dredgers are digging ores with an ore deposit that measures about 200m in width, 4 to 15m in thickness and 11km in total length, including proved reserves of 9.16 million tons and heavy-mineral grade of 5.0% (ilmenite 44%, rutile 28% and zircon 12%). (Mason, 1999) The overburden measures 8 to 20m in thickness and consists of fine-grained sand, silt, sandy clay, clay and gravel. After removing them by open-cut mining, the plan calls for mining 2.5 million tons of ore per year with a 3.7% heavy-mineral grade by dredgers by increasing the water level in the drill pits. The surface altitude is about 60m and underground water level, 42m.

It will be desirable to study the economical efficiency of the Karaotkel Placer again after development-mining of Bektimir Placer No. 3 is started.

(2) Bektimir Placers

An index to gauge whether or not ore bodies can be mined economically by open-cut mining is instituted in the Republic of Kazakhstan (a former Soviet Union standard). This index shows that mining of only the ore deposit found in Phase III in the Southern Flank of Bektimir Placer No. 1 will not be economical because the stripping ratio is extremely high.

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

Average content of ilmenite	Maximum economical stripping ratio
kg/m^3	m^3/m^3
100	2.58
110	3.9
113.5	**12.8**
120	5.21
130	6.56
140	7.87

Reserves calculations made by combining data of ore deposits acquired in Years 1 and 2 show the following figures compared with the index. The following data indicates that economical mining will not be feasible.

Average content of ilmenite	Maximum economical stripping ratio
kg/m^3	m^3/m^3
100	2.58
110	3.9
120	5.21
130	6.56
133.5	**8.5**
140	7.87

These indexes were set by calculating, assuming open-cut mining as a precondition. It will be necessary to recalculate ore reserves after studying an economical efficiency of a mining method for ore deposits with a thick overburden that are deposited in deep parts. Altaev, et al., (2001) proposed a hydraulic mining method by triple-structure pipe installed in place, for Bektimir (referred to as Satpayesk in the literature) Placer 1. Thickened ilmenite layers 8 to 10m in thickness deposited in a depth of 50m were included as an object of mining. Water that was pressurized at 4.3 to 4.5MPa was injected at 140 to 150m^3/h through four mining pits installed at an interval of 40 to 50m to pull down sand layers that contained ilmenite and 10 to 30% of clay. Slimed ores were flowed onto the ground by airlift and 1000m^3 of ores were experimentally mined at 20m^3/h. Each mining pit has triple-structure pipe, whose inside diameters were 168, 108 and 50mm. The outermost pipe supplied pressurized water to pull down the sand layer and the innermost pipe supplied compressed air. Ore slime was lifted by air through the middle pipe. Separation losses inside pits caused by a difference in specific gravity of ilmenite were almost none. This would eliminate stripping and refilling of clay layers to sand layers that contained ilmenite, allowing a drastic reduction in the mining cost. However, control of mining grade would be difficult and only ilmenite that is contained in sandy layers is mined, to lower the mining recovery. Places are not refilled after mining and depressions of the surface cannot be avoided over the time.

In Bektimir Placer No. 1, ilmenite is oxidized as it weathers and separates from granitic rocks and as it deposits and thickens so that Fe leaches and Ti enriches. The TiO_2 grade tends to rise from the upstream to the downstream. It will be necessary to recalculate ore reserves of a high grade by extracting high-grade seams and setting more economical mining blocks.

2) Quality of Ilmenite Concentrates

(1) Karaotkel Placer

As shown below, the grade of ilmenite grains is about 59% in TiO_2. Assuming that this value approximates an average concentrate grade, the value fully meets the international trading standard (Yoshida, 1992). The grade of ilmenite of this ore deposit is higher than that of concentrates of other ilmenite producing areas. This is because almost all of ilmenite in Karaotkel Placer alters to pseudorutile or altered ilmenite due to severe weathering alteration. The degree of titanium enrichment is high compared with Bektimir Placer No. 1. Thus, Karaotkel Placer promises a possibility of producing ilmenite concentrates 50% or more in TiO_2, which is an excellent grade. It will be desirable to conduct an ore-dressing test again and to study economy of ore deposit mining and ore dressing.

Element	TiO_2(%)	FeO(%)	SiO_2(%)	P_2O_5(%)	Cr_2O_3(%)	V_2O_5(%)
Assay result (EDX)	59	33.5*				
International Trading Standard	≧54	≧28	≦1.5	≦0.05	≦0.05	≦0.1
Sri Lanka Mineral Sand Corp.	≧53	Fe2O3≦ 1	≦1	≦0.05		
Malaysia Ilmenite	≧50	≧30				
Mindarie, Australia	55.2	22.8	0.78	0.1	0.1	

*Calculated value

(2) Bektimir Placers

The quality of ilmenite in this district is shown below. While the quality does not meet the International Trading Standard, it meets the manufacturing requirements for sponge titanium and titanium oxides of 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.

Element	TiO_2 (%)	FeO (%)	SiO_2 (%)	P_2O_5 (%)	Cr_2O_3 (%)	V_2O_5 (%)
Assay result	48.25～50.84	12.93～26.76	1.16～2.59	0.01～0.30	0.015～0.026	0.157～0.260
Average	49.31	19.82	2.04	0.04	0.02	0.18
International Trading Standard	≧54	≧28	≦1.5	≦0.05	≦0.05	≦0.1

4-3 Potentials as Parent Ore Deposit

The foregoing survey results obtained in Years 1 to 3 would imply the following conditions for existence of promising ilmenite alluvial deposits:

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 channel parts where alluvial deposits are formed.

It is also important that prominent weathering took place in the geological history and that denudation did not occur after ilmenite alluvial deposits sedimented.

The survey policies for the districts for the future are as follows:

1) Karaotkel District

A surface survey has shown that the granitic rocks of the Karaotkelskiy complex consisted of granite and syenite, which are most advanced in differentiation, and that the ilmenite contents of them are smaller than the ilmenite content of the Preobrazhenskiy complex surveyed in Phase II. Therefore, the grade of the ilmenite ore deposits in the Karaotkel district would be low. However, the grade of ilmenite in alluvial deposits, where ilmenite was separated from country rock and redeposited in palaeo-landform channels, is high. When an ore reserve potential was recalculated based on a 50kg/m^3 cut-off grade of ilmenite, ore reserves of 9.9 million m^3, ilmenite reserves of 734,000 tons, average ilmenite content of 74kg/m^3 and average zircon content of 13 kg/m^3 could be obtained. The overburden on this ore bed is thin, about 10m, and this district may prove to be economical. A restudy of this district is necessary.

2) Bektimir District

(1) Southern Flank of Bektimir Placer No. 1

The southern flank of Bektimir Placer No. 1 has been expanded to be a large ore bed with a width of about 2000m. Based on a 100kg/m^3 cut-off grade of ilmenite, ore reserves of 13.3 million m^3, ilmenite reserves of 1,686,000 tons and average ilmenite content of 126.7kg/m^3 could be calculated during the surveys in the past three years. When ore reserves of 11.9 million m^3, ilmenite reserves of 1,815,000 tons and average ilmenite content of 151.8kg/m^3 calculated by the counterpart organization of Kazakhstan in 1998 and 1999 are added, ore reserves of 25.2 million m^3, ilmenite reserves of 3,501,000 tons and average ilmenite content of 139kg/m^3 can be calculated for this district. West and south directions have not been confirmed yet as boundaries for thickened ilmenite seams, however, the size of ore deposits could generally be determined. The ore deposits are buried deeper toward west and south and the overburden is substantially thick, 40 to 50m. Therefore, it will be desirable to restudy the mining method and to determine the relationship between an economically feasible depth and grade.

(2) Southern Flank of Bektimir Placer No. 3

The survey in Phase III found that alluvial deposits in this placer are narrow in width compared with those in Placer No. 1. However, sufficiently large potentials can be anticipated in the south. Nevertheless, as in Placer No. 1, the overburden on this placer is significantly thick and it will be desirable to continue the survey after studying the relationship between an economically feasible depth and grade.

3) Eastern Flank of Bektimir District

During the boring survey conducted in Phase III, thickened ilmenite seams could be detected as anticipated in palaeo-landform channels that originate from granitic rocks of the Preobrazhenskiy complex. These thickened ilmenite seams are located shallow, about 10m in depth, and the widths and grades of them increase in the downstream areas. There are possibilities that ore deposits in this district will become economically feasible depending on future surveys in the downstream areas. Therefore, it will be desirable to conduct rotary boring first in the downstream areas at an interval of 500m between traverse lines to determine sizes, grades and stripping ratios of ore deposits. After obtaining an assurance that the ore deposits will be economically feasible, precision interpolation boring should be conducted by percussion boring to calculate an ore reserve potential.

4) Technology Transfer to Other Districts

Considering that the accumulation of existing and public geological data and information in the Republic of Kazakhstan is very large, it will be desirable to conduct a preliminary appraisal by making literature studies and widearea prediction studies (sampling, age determination and laboratory research) for areas, in which intrusion rock masses with chemical components similar to those of Preobrazhenskiy and Karaotkelskiy Complexes exist and which have similar geological history as that of the study area, to pursue possibilities of finding new ilmenite alluvial deposits. It will constitute an important technology transfer to apply knowledge on classification of granitic rocks by chemical component (magnetite, ilmenite and other series) and on ore bed formation zones obtained especially in East Asia, to granitic rocks of the Republic of Kazakhstan.

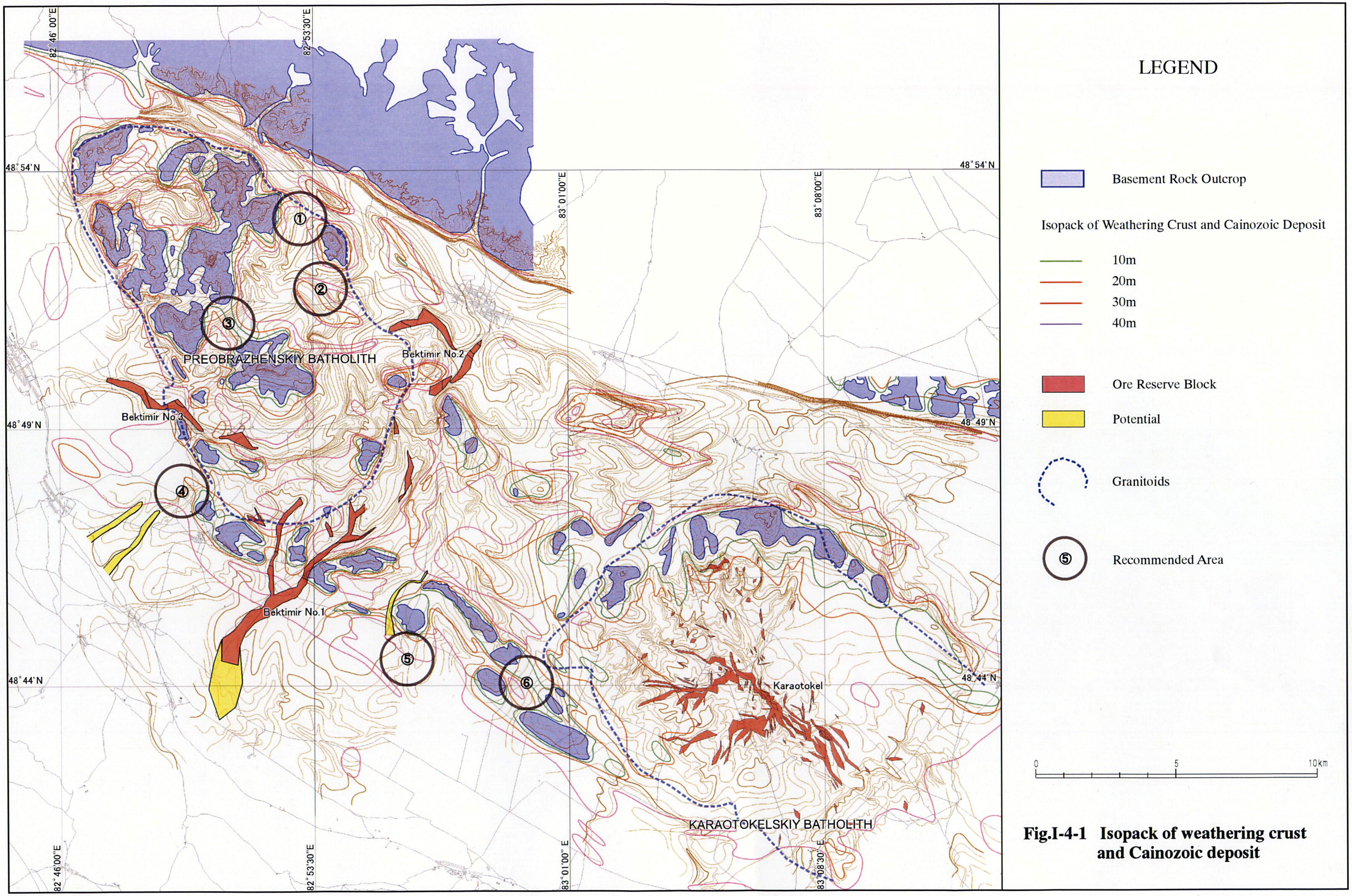


Fig.I-4-1 Isopack of weathering crust and Cainozoic deposit

CHAPTER 5 CONCLUSIONS AND RECOMMENDATIONS FOR THE FUTURE

5-1 Conclusions

5-1-1 Analysis of existing data

1) Restudy of Karaotkel Placer Deposits

A study of existing and public data of the Karaotkel district has shown that thickened seams of ilmenite can be classified into two ore bed types, eluvial deposits and alluvial deposits, and that alluvial deposits generally have a high grade. The following ilmenite reserves of a high grade could be identified when reserves and grades of alluvial deposits mainly with grades of more than 50kg/m^3 among reserves calculated in 1982 are recalculated (cut-off: ilmenite content 15kg/m^3, ore reserves 147,579,000mm^3, ilmenite reserves 3,438,000 tons and ilmenite grade 23.3kg/m^3).

TableI-5-1 Revised Ore Reserves and Grade of the Karaotkel Placer Deposit

Name of Ore Body	Category	Cut-Off Range (kg/m^3)	Ore Reserves (th. m^3)	Ilmenite Grade (kg/m^3)	Ilmenite Reserves (th. t)
Karaotkel	B	≧50	9,878.3	74.3	734.0

The zircon grade of the foregoing ore reserves was 13.0kg/m^3. Ilmenite was altered by weathering and generated pseudorutile. For these reasons, the ilmenite concentrate grade is expected to be high, higher than 50% in TiO_2. Because these ore reserves are deposited in relatively shallow depths, less than 15m from the surface, it will be desirable to restudy its economical efficiency based on mining results of Bektimir Placer No. 3.

2) Geological History of Cainozoic Era

The order of stratification of the Tertiary System for Zaisanskaya Basin covers the upper Cretaceous Period without conformity. The stratification is a stack of the North Zaisanskaya Series of the Palaeocene Epoch, Turanginskaya Series of the mid- to the early Eocene Epoch, Tuzkabakskaya Series of the early Eocene Epoch to the late Oligocene Epoch, Ashutasskaya Series of the early to mid-Oligocene Epoch, Aral Series of the late to mid-Miocene Epoch, Pavlodar Series of the early Miocene Epoch to the late Pliocene Epoch, and Vtorushinskaya Series of the mid- to early Pliocene Epoch (Fig.I-5-1). The climate was humid and warm in the Palaeogene Period, but changed to a dry steppe climate in the Neogene Period.

5-1-2 Geological survey

1) Geology

The order of stratification of the survey area consists of pre-granitic rocks (Carboniferous Period layers), granitic rocks intruded into pre-granitic rocks in the early Carboniferous Period to the late Permian Period, 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 bedrock 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 gabbro) of the Carboniferous Period. Arkalyk, Bukon and Maityab layers distribute in the survey area. 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. Hornfels is widely visible near contact parts with granitic rocks.

(2) Granitic rocks

The area is distributed with the Karaotkelskiy complex, believed to have intruded from the early Carboniferous Period (299.4 ±8.9Ma) to the late Permian Period (d f 276.0 ±6.5Ma). Complexes are classified into syenite and granite in accordance with their chemical composition.

Syenite and granite form the bulk of Karaotkelskiy complexes and are rich in SiO_2, Na_2O and K_2O, while scant in Σ FeO, MgO and CaO. Their solidification indexes are 3 or lower and their differentiation indexes are 90 or higher, sometimes showing 95 or higher. Generally, TiO_2 becomes lean higher the magma crystallization differentiation is. The Karaotkelskiy complex is rock masses that is most advanced in differentiation and contain only 0.4% or less of TiO_2 and 1% or less of ilmenite. Therefore, the grade of ilmenite alluvial deposits in the Karaotkel district that contains them as origin rocks can be appraised lower than that of Preobrazhenskiy Complex.

In the rare earth pattern, the Karaotkelskiy complex shows a negative anomaly of Eu and shows characteristics of granitic rocks with an advance in crystallization and differentiation containing less than 1% of TiO_2.

All granitic rocks show a susceptibility of 1 x 10^{-3} S.I.U. or less. Opaque minerals are anatase (Ti 60%), pseudorutile (Ti > 36%), ilmenite or altered ilmenite (Ti 32 to 36%), titanic magnetite (Ti 1.5 to 14%), magnetite (Ti 0 to 1.5%), hematite (Ti 0%) goethite (Ti 0%). Pseudorutile and altered ilmenite were generated by weathering and alteration of ilmenite, while goethite was generated by weathering and alteration of magnetite.

Results of K-Ar age determination of Preobrazhenskiy and the Karaotkelskiy Complexes are shown below. This suggests that these complexes form simple complexes in deep subsurface layers and that their differentiation was started from monzonitic magma almost in the same age, namely, in the early Carboniferous Period (300Ma). They differentiation-intruded into granite in the late Permian Period (280Ma) through syenite in the early Carboniferous Period to the late Permian Period (295Ma). Gabbro was estimated to have intruded into these complexes in the mid-Triassic Period (240Ma).

Sample No.	Rock name	Measured mineral	Age(Ma)	Complex
D-2	Gabbro	Amphibole	237.1±9.8	Preobrazhenskiy
D-3	Granite	K-feldspar	284.7±4.9	Preobrazhenskiy
D-4	Monzonite	K-feldspar	302.6±9.1	Preobrazhenskiy
D-5	Granite	K-feldspar	276.0±6.5	Karaotkelskiy
D-6	Syenite	K-feldspar	294.4±8.9	Karaotkelskiy

(3) Bed-rock weathered crust

Bed-rock weathered crusts are clayey weathered remnants developed 10 to 40m 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. Generally, thick weathered crusts are formed on granitic rocks, forming ilmenite eluvial deposits. They are prominently influenced by kaolin, illite 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 1.5 to 37m in thickness, averaging 5.5m. The layer consists of quartz, kaolin, smectite, clay made up of a small amount of illite, sandy clay and clayey sand. 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 0.2 to 31.7m in thickness, averaging 5.7m, 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.

A fault in NE-SW direction cuts the Maityab layers of the Carboniferous-period made up of pregranitic rocks on the west side of the Karaotkelskiy complex.

Palaeo-landform channels develop in the central part of the Karaotkelskiy complex in a dendritic form. These channels exist in a form which is close to drainage systems at present. All known ilmenite alluvial deposits are contained inside palaeo-landform channels.

The Tertiary-period Aral Formation is a generally horizontal layer and covers the Karaotkelskiy complex and pre-granitic rocks.

The Quaternary-Period layers are generally horizontal strata and cover the

Tertiary-Period Aral Formation.

3) Karaotkel Placer

The Karaotkel Placer is ilmenite eluvial deposits and alluvial deposits and accompanies zircon in a proportion 1/6 that of ilmenite in weight ratio. Ilmenite eluvial deposits are deposited in weathered and leached parts of granitic rocks. In palaeo-landform channels, ilmenite alluvial deposits are deposited in sandy clay and clayey sand in the bottom layers of the Aral Formation of the Tertiary Period. Ilmenite was originated from granitic rocks of the Karaotkelskiy complex. In the process of weathering, separation and thickening, FeO on outer edges and cracks of grains is leached and TiO_2 is enriched to produce altered ilmenite and pseudorutile.

5-1-3 Drilling survey

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

Following the drilling conducted in Year II, drilling was conducted in 18 drill pits along three traverse lines (Traverse Lines 26, 22 and 18) in a grid of 500×200m on the east-west flank of the confirmed IV-C_2 Ore Reserves Mining Block of Bektimir Placer No. 1. The drilling lengths totaled 940.5m.

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 drilling measured 0.9 to 9.0m in thickness. The ilmenite content was 7 to 134kg/m^3. The thickness of overburden on ore beds is 41 to 54.3m and the depth increases toward west and south. The width of the ore bed increases to 2,000m and the ore reserves tend to increase.

The bedrock radically rises on the eastern side of the ore bed where the ore bed closes. Thickened ilmenite seams continue on the western side of the ore bed. However, the depth becomes deep, while thickness and grade deteriorate. On Traverse Line 18, the southern limit of thickened ilmenite seams is confirmed by MJBK-37 (no ore bearing potential), indicating that directions of ore bed extensions are changing to west or southeastern directions. However, the sizes and grades of most parts of this ore bed have been known through the surveys in the past three years.

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 1.8 million m^3, ilmenite reserves 204,000 tons, average ilmenite content 113.47kg/m^3, and stripping ratio 12.83).

Total increases in proved ore reserves confirmed in Years 1 to 3 (Ore Reserves Block Nos. III + IV - C_2) are shown below, resulting in ore reserves of 13.3 million m^3, ilmenite reserves of 1,686,000 tons, average ilmenite content of 126.67kg/m^3 and stripping ratio of 7.83).

Table I-5-2 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+IV-C	2,273.0	4.95	11,251.35	130.84	1,472.13	35.94	81,691.6	7.3
V-C_2	500.0	3.60	1,800.0	113.47	204.25	46.20	23,100.0	12.83
III+IV+ V-C_2	2,773.0	4.80	13,310.40	126.67	1,686.03	37.45	103,848.9	7.83

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

Drilling was conducted in 8 drill pits along Traverse Lines 2A, 3G and 3A at 200m interval totaling 290.5m in length. In four of the 8 drill pits, thickened ilmenite seams higher than the cut-off grade of 100kg/m^3 could be confirmed.

The ore bed is deposited directly above a parallel palaeo-landform channel in the shape of Y in the Aral Formation bedrock running in the N30°E direction. The width of the ore bed was below 400m and was small compared with that of Bektimir Placer No. 1. The ore bed is still believed to continue toward south. The ore bed thickness determined by drilling was 0.5 - 4.0m and the ilmenite content was 111 to 145kg/m^3. Overburden on the ore bed was 32 to 34m in thickness and tended to increase toward south as in Bektimir Placer No. 1. Ore reserves calculations under the same cut-off conditions as those of the ore beds of Bektimir Placer 1 show the following increases in ore reserves corresponding to Category C_2. Ore reserves 0.81 million m^3, ilmenite reserves 109,000 tons, average ilmenite content 133.49kg/m^3 and stripping ratio 8.49.

Table I-5-3 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
II-C_2	220.0	3.7	814.0	133.49	108.66	31.40	6,908.0	8.49

3) Bektimir Eastern Placer (Reconnaissance Survey District)

This district was identified in Year-2 survey as a district with high possibilities of ore beds deposited in it. Granitic rocks with a magnetic susceptibility of 1×10^{-3} S.I.U. or less, which is an index for a high proportion of ilmenite being contained, are distributed in the upstream area. This district is estimated to contain palaeo-landform furrows (palaeo-landform channels) in the Aral Formation of the Tertiary Period.

Drilling was conducted in 41 drill pits along 11 traverse lines. The drilling lengths totaled 1,036.5m. Of these drill pits, 12 drill pits along four traverse lines and 29 pits along 7 traverse lines were drilled in the northern and southern flanks respectively.

New thickened ilmenite seams could be found in ten of the 29 pits along the seven traverse lines drilled in the southern flank. The detected thickened ilmenite seams are deposited directly above palaeo-landform channels running in N10 to 45°E, with 200 to 600m in width, 0.7 to 4.5m in thickness and 14.3 to 61.5 in ilmenite content. The potentials when the cut-off ilmenite content is set at $20kgm/^3$ are listed below. The overburden layers along the traverse lines in the southern flank are thin, 9.3 to 13.2m, compared with Bektimir Placers No. 1 and 3. The ore beds are made up of gravel of layers of the Quaternary Period. Clay of the Aral Formation is scant. The grades and widths of ore beds are improved toward the south in the downstream.

Table I-5-4 Ore Reserves Calculation of Category P_1 for the East Placer

Block No	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	1,050.1	30.9	32.5	16.0	11,502.5	10.95

5-2 Recommendations for Future

5-2-1 Recommendations for survey area

The future survey policies for each district are as follows:

1) Karaotkel District

A surface survey has shown that the granitic rocks of the Karaotkelskiy complex consisted of granite and syenite, which are most advanced in differentiation, and that the ilmenite contents of them are smaller than the ilmenite content of the Preobrazhenskiy complex surveyed in Year II. Therefore, the grade of the ilmenite ore beds in the Karaotkel district would be low. However, the grade of ilmenite in alluvial deposits, where ilmenite was separated from country rock and redeposited in palaeo-landform channels, showing an improvement. When an ore reserve potential was recalculated based on a 50kg/m^3 cut-off grade of ilmenite, ore reserves of 9.9 million m^3, ilmenite reserves of 734,000 tons and average ilmenite content of 74kg/m^3 could be obtained. The overburden on this ore bed is thin, about 10m, and this district may prove to be economical. A restudy of this district is necessary.

2) Bektimir District

(1) Eastern Flank of Bektimir Placer No. 1

The southern flank of Bektimir Placer No. 1 has been expanded to a large ore bed with a width of about 2000m. Based on a 100kg/m^3 cut-off grade of ilmenite, ore reserves of 13.3 million m^3, ilmenite reserves of 1,686,000 tons and average ilmenite content of 126.7kg/m^3 could be calculated during the surveys in the past three years. However, boundaries of thickened ilmenite seams in west and south directions have not been confirmed yet. The ore beds are buried deeper toward west and south and the overburden is substantially thick, 40 to 50m. Therefore, it will be desirable to restudy the mining method and to determine the relationship between an economically feasible depth and grade.

(2) Southern Flank of Bektimir Placer No. 3

The survey in Year III found that alluvial deposits in this placer are narrow compared with those in Placer No. 1. However, sufficiently high potentials can be anticipated in the south. Nevertheless, as in Placer No. 1, the overburden in this placer is significantly thick and it will be desirable to continue the survey after studying the relationship between economically feasible depth and grade. The overburdens in the upstream parts are expected to be thin and a survey of areas around this district should desirably be undertaken (See Fig. I-4-1④.) .

3) Eastern Flank of Bektimir

During the drilling survey conducted in Year III, thickened ilmenite seams could be detected as anticipated in palaeo-landform channels that originate from granitic rocks of the Preobrazhenskiy complex. These thickened ilmenite seams are shallow, about 10m in depth, and the widths and grades increase in the downstream areas. There are possibilities that ore beds in this district will become economically feasible depending on future surveys in the downstream areas. Therefore, it will be desirable to conduct drilling first in the downstream areas（Fig.I-4-1⑤） at an interval of 500m between traverse lines to determine sizes, grades and stripping ratios of ore beds. After obtaining a prospect that the ore beds will be economically feasible, precision interpolation drilling should be conducted to calculate an ore reserve potential.

4) Other Bektimir Placers

(1) Other Bektimir placers

Parts of those palaeo-landform channels that have granitic rocks, which are rich in ilmenite, in upstream areas and have thin overburdens (Aral Formation of the Tertiary Period and Quaternary Period layers) offer possibilities of finding ilmenite ore beds of the drift sand type in relatively shallow places (Fig. I-4-1①②③⑥).

5-2-2 Technology deployments to other areas

The accumulation of existing geological data and information regarding granitic rocks in the Republic of Kazakhstan is very large. It will be desirable to conduct a preliminary appraisal by studying existing data and literature and by widearea prediction studies (sampling, age determination and laboratory research) for the areas, which have intrusion rock masses with chemical components similar to those of Preobrazhenskiy and Karaotkelskiy Complexes and have similar geological history as that of the study area, to pursue possibilities of finding new ilmenite alluvial deposits. It will constitute an important technology transfer to apply knowledge on classification of granitic rocks by chemical component (magnetite series, ilmenite series, Type I, Type S, Type M, Type A and other series) and on ore bed formation zones obtained especially in East Asia, to granitic rocks of the Republic of Kazakhstan.

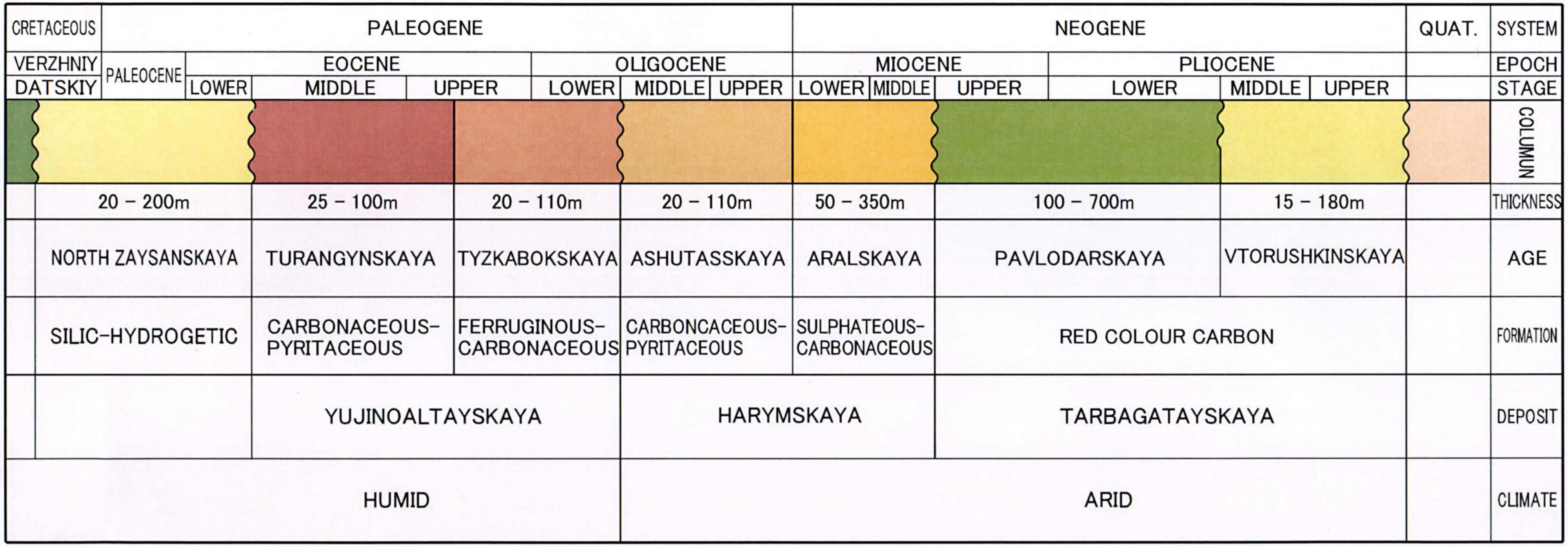


Fig. I-5-1 Schematic Stratigraphic Columun of the Zaysanskaya Basin