PART II SPECIFIC INFORMATION

CHAPTER 1 ANALYSIS OF EXISTING DATA
(Karaotkel District)

1-1 Purpose of the Survey

Public and existing data on depths of the bedrocks of the Pre-tertiary Period and on reserves and grades of ore beds in the survey area was collected, sorted and analyzed to identify locations of ore bed groups in the Karaotkel district.

1-2 Analysis

1-2-1 Subsurface structure of bedrock of Tertiary Period

A total of 79 geological cross sections showing the area of the Karaotkel Placer and its vicinities compiled by the counterpart organizations of Kazakhstan and other organizations in 1982 as a result of an exploratory boring survey were obtained at the East Kazakhstan Geological Bureau and were analyzed to secure depth data of the bedrock of the Tertiary Period. Data concerning geochemical exploratory boring positions and depths of the foot lock of weathered crusts compiled in 1992 was obtained. Bedrock depths and bedrock geology of 2,617 exploratory boring pits (total 44,877.8m) were interpreted (See Appendix 2-9.). Depths to the foot rock of weathered crusts of the bedrock were interpreted from the data of geochemical exploratory boring positions and depths of foot rock of weathered crusts. Isopach maps showing total layer thicknesses of weathered crusts and layers of the Cainozoic Era compiled by the counterpart organization of Kazakhstan were obtained (Fig. I-4-1 and PL. II-2-2.).

The positions and depth data of the exploratory boring and geochemical exploratory boring were compiled and a subsurface contour map (subsurface structure diagram, PL.II-2-3) on a scale of 1:25000 of the bedrock of the Tertiary Period (unconformity surfaces of Aral Formation of the Tertiary Period and weathered crusts of bedrock and foot rock surfaces of weathered crusts of bedrock in some parts around Karaotkel Placer) and a geological map of the bedrock of the Pre-tertiary Period (PL. II-2-3) were prepared.

Compared with the Preobrazhenskiy complex, the subsurface contour of the bedrock of the Tertiary Period lacks relief and resembles a plain. The altitude of the bedrock is 493m maximum, 369m minimum and 435m average. It is estimated that the valleys developed from the hills around the rock mass in a dendritic form and merged in the middle of the rock mass, flowing toward southeast. The drainage systems of these palaeo-landform channels seem to represent weak lines such as cracks in the Karaotkelskiy complex (PL. II-2-3).

Hills in a semicircular shape can be spotted on the north side of the Karaotkelskiy complex. These hills can be considered convex lands that were formed around the rock mass when granitic rocks intruded into the sedimentary rock layer of the Carboniferous Period in the north to northeastern parts of the rock mass, forming hornfels that are relatively firm. These hills have had a resistance to denudation. Straight convex lands of a moderate height could also be spotted on the southwestern part of the rock mass and these lands are also assumed to show outer edges of the rock mass.

The Karaotkelskiy complex is composed of gabbro, diorite, syenite and granite and is rectangular, stretching in NW-SE. It measures 10km in width and 14km or longer in length. Due to lack of boring data, the southeastern border of it is not defined, whether it is still open or closed. By area, the complex is mostly syenite, in which gabbro and diorite are distributed like spots. Granite is intruded in the center, north and west parts of the complex like small rock stumps 2 to 4km in diameter. Only syenite and granite can be observed as outcrops.

1-2-2 Recalculations of ore reserves

The Karaotkel ilmenite and zircon ore beds were found in 1965 - 1967 by a nonferrous material geological group during boring for coal. In 1972, the group completed initial exploration of the Karaotkel Placer and calculated ore reserves of ilmenite and zircon (B + C_1). An ore-dressing test was conducted in that year. In 1973, the National Rare Metal Research Institute (GIREDMET) conducted a feasibility study (FS) of the Karaotkel Placer, but concluded that the ore bed would not be a suitable development project that assured profits because ore reserves were not large and grade was low. However, GIREDMET added that the profitability of the ore bed would improve if feldspar concentrates were developed as a by-product. As a result, in 1983 to 1989, GIREDMET reappraised ore reserves of the ore bed including those of feldspar and quartz and the following ore reserves were calculated setting a cut-off grade of 15kg/m^3 for ilmenite. The ore reserves were approved in 1990 by the National Ore Reserves Committee of the Soviet Union.

Table I-5-1 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+C_1	≧15	147,579	23.3	3,438

In addition to ilmenite, ore reserves and grades (Category $B+C_1$) for the following minerals were also approved:

①	Titanium white (leucoxene)	0.51 (kg/m^3)
②	Zircon	3.5 (kg/m^3)
③	Feldspar	290.7 (kg/m^3)
④	Mica	107.4 (kg/m^3)
⑤	Clay	1,079.6 (kg/m^3)

The ratio of ilmenite and zircon was 6.7:1.

However, it was concluded that there would be no possibilities at that time and in the near future to develop the Karaotkel Placer. The following reasons were cited for this conclusion: The ilmenite content was significantly low, sale of feldspar in ores would be difficult because the ceramic material market in Kazakhstan was small, possibilities of high ore-dressing cost to obtain ilmenite and zircon concentrates because ores contained a high clay content and ilmenite and titanic minerals were fine grains (86% between -0.315 and +0.04mm), and the characteristics of ilmenite concentrates from this ore bed could not be applied to production of titanium white, which promised a larger profit.

In Phase III, a total of 79 geological cross sections showing the area of the Karaotkel Placer and its vicinities compiled by the counterpart organizations of Kazakhstan and other organizations in 1982 as a result of an exploratory boring survey were obtained at the East Kazakhstan Geological Bureau and were analyzed. The boring was carried out at intervals of 25 to 400m along traverse lines arranged at intervals of 200 to 300m in azimuth of about 52° and direction of 142°. Drilling in thickened ilmenite seams was carried at intervals of 25 to 100m (See Fig. II-1-1.). Fig. II-1-2 shows the cross section of Traverse Line 42 with a drilling interval of 25m in more detail.

The geological cross sections show that two types of ore beds exist in the thickened ilmenite seams (15kg/m^3 or more) included by the counterpart organization of Kazakhstan as ore reserves. They are eluvial deposits that distribute in granitic rocks (Karaotkelskiy Complex: gabbro, diorite, syenite and granite) of the bedrock of the Tertiary Period and alluvial deposits of ilmenite that was separated from weathered granitic rocks, carried by flowing water and deposited in the Aral Formation of the Tertiary Period directly above the bedrock.

Appendix 2-9 shows sample depths and ilmenite grades in the ore reserves calculation range (15kg/m^3 or more) compiled from the data for the 2,617 drilling pits (total 44,877.8m) presented in Fig. II-1-1. Of the 2,110 pits in total within the ore reserves calculation range, 729 pits landed in alluvial deposits and showed an average grade of 28.0kg/m^3, while 730 pits landed in both alluvial and eluvial deposits and showed an average grade of 24.4kg/m^3 and 651 pits landed in eluvial deposits and showed an average grade of 18.4kg/m^3 (See Fig. II-1-3.). Among these pits, 443 pits showed an average grade of 50kg/m^3 or more of ilmenite. Furthermore, 393 pits landed in alluvial deposits with an average grade of 69.3kg/m^3 and 15 pits landed in both alluvial and eluvial deposits with an average grade of 67.3kg/m^3. Only 35 pits landed in eluvial deposits with an average grade of 61.6kg/m^3. Thus, high ilmenite contents are known to concentrate in alluvial deposits (See Fig. II-1-3.). Average ilmenite and zircon grades of granitic rocks in origin rocks were calculated back assuming TiO_2 in ilmenite to be 53%, Zr in zircon to be 49.5% and granite density to be 2.6t/m^3 based on analytical values of TiO_2 and Zr. The calculations showed 14kg/m^3 and 3.7kg/m^3 for ilmenite and zircon respectively. Fig. II-1-4 shows the relationship between the zircon and ilmenite grades. The relationship with eluvial deposits is 18kg/m^3 for ilmenite and about 2kg/m^3 for zircon and is almost constant. The relationship with alluvial deposits shows that both ilmenite and zircon grades increase hand in hand. This indicates that the proportion of ilmenite and zircon contained in origin rocks of eluvial deposits is almost constant, thus escaping enrichment by weathering, whereas both ilmenite and zircon are enriched in alluvial deposits by transportation and sedimentation.

An ore bed cross section was set by extracting thickened seams with an ilmenite content of 50kg/m^3 or more from the drilling data to calculate ranges and ore reserves of high-grade ore beds with a focus on alluvial deposits (Appendix 2-9). The ore bed sections were set by connecting adjoining thickened seams with an ilmenite content of 50kg/m^3 or more to make a trapezoid. A triangle of one half of the distance to the nearest adjoining drilling pit that was not included in the ore reserves was set at both ends of the trapezoid. A 50m triangle was set when there were no adjoining drilling pits. The average grade of ore-bed cross sections was weighting lengths of ore deposits hit by drilling. Cross sections of these ore beds were connected in three dimensions to set ore bed ranges and 68 ore blocks were set (See Fig. II-1-1.). These ore bed ranges almost coincided with furrows of the subsurface structure of the bedrock of the Tertiary Period, namely, palaeo-landform channels, as with the Bektimir placers in the Year-2 survey.

Ore reserves in the ore bed ranges were calculated by the following method (section integration method):

① Ore Reserves: Ore reserves V (m^3) of an ore block between two sections (A_1, A_2 (m^3) that are apart by dm were calculated by $V=d\times(A_1+A_2)/2$.

The ore block of the cross section (A_3 (m^3)) at the end was considered as a cone that was separated by distance dm and was calculated by V= 1/3×d×A3. The distance dm was calculated as 1/2 of the distance to the nearest traverse line not calculated in ore reserves and d = 50m was used when there was no adjoining traverse line.

② Grade: The grade (G kg/m^3) of an ore block between two cross sections was calculated as a weighted average of sectional areas (A_1, A_2 (m^3) of two sectional grades (G_1, G_2 kg/m^3) and was obtained by $G=(G_1 \times A_1+G_2 \times A_2)/(A_1+A_2)$. Grades (G kg/$m^3$) of continuous ore blocks V1, V2, V3, ... were calculated by weighting the averages of ore reserves (V1, V2, V3 (m^3) of each ore block and were calculated by $G=(G_1 \times V_1+G_2 \times V_2 +G_3 \times V_3+ \ldots)/(V_1+V_2+V_3+ \ldots)$. The grade of ore-block total sum was calculated by weighting the averages of ore reserves.

Appendix 2-9 shows ore reserves and grades of ore beds of each ore block with an ilmenite content of 50kg/m^3 or more. Total sums of ore reserves and grades are presented below. Compared with calculations for ore reserves made earlier, the ore reserves are 1/15 because high-grade parts were mainly extracted with a focus on alluvial deposits. However, the grades are 3 times or more and high-grade parts could be extracted.

TableⅡ-1-２ 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 is 13.0kg/m^3 and the ilmenite:zircon ratio, 5.7:1. The heavy-mineral content was 4.85% (ilmenite 85%, zircon 15%).

These ore reserves are deposited continuously in relatively shallow depths of 8m or shallower on average. Therefore, it will be desirable to restudy the economical efficiency of them based on results obtained in mining Bektimir Placer No. 3.

1-2-3 Quality of ilmenite grade

Compared with the grain size of ilmenite in Bektimir Placer No. 1 (92.0 to 98.8% in range of -0.40 + 0.05mm, average 96.3%, mode about 0.2mm), 86% of the grain size of ilmenite in the Karaotkel placer distributed between -0.315 and +0.04mm and is slightly fine grained.

The ratios of mineral quantity of ilmenite concentrate left in a former test plant in the Karaotkel ore-dressing plant (Karaotkel Pit 2) examined under a microscope were generally as follows: Pseudorutile 65 to 72% (0.005 to 0.5mm), ilmenite 1 to 5% (0.02 to 0.25mm), rutile <1% (0.01 to 0.3mm), magnetite <2% (0.1mm), hematite <1% (0.07 to 0.25mm), zircon 17 to 20% (0.03 to 1mm), allanite <1% (0.2mm), monazite <1% (0.05 to 0.2mm), quartz 5 to 7% (0.015 to 0.55mm), feldspar 1% (0.015 to 0.55mm), and rock chips 2 to 3% (0.015 to 0.4mm). The average diameter of ilmenite grains was 0.09mm, diameter mode was 0.02mm and roundness, 0.65.

The quality of ilmenite based on an average of analytical values of ten titanic minerals in the EDX semi-quantitative analysis shown in Appendix 2-20 is TiO_2 about 59% as shown below. 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 bed 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 weathering alteration. The degree of enrichment is high compared with Bektimir Placer No. 1. Karaotkel Placer offers a possibility of producing ilmenite concentrates of a higher grade. It will be desirable to conduct an ore-dressing test again and to study economy of ore bed 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

1-2-4 Geological history of Cainozoic Era

The order of stratification of the Tertiary System of Zaisanskaya Basin is described in literature compiled by V. S. Erofeev (1969), et al. According to the literature, the order of 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, all covering the layers of the early Cretaceous Period without conformity (See Figs. I-5-1 and II-1-5.).

The North Zaisanskaya Series is 20 to 200m in layer thickness and consists of clay and sandy clay with red spots. The series sandwiches thin layers of sandstone. It contains siliceous and ferrous cement, fossils of dinosaur egg fragments, fossils of Mammalia, evergreen trees of the subtropical zone and fossils of deciduous trees. The Turanginskaya Series is 25 to 100m in layer thickness and is made up of sandy clay and quartzose sand. It contains sand, gravel, green clay, black carbonaceous clay and brown coal. The surface color of it is greenish gray where it is not oxidized. It contains carbonized plant fossils of evergreen trees of the tropical and subtropical zones, Mammalia and reptiles. It accompanies pyrite. The Tuzkabakskaya Series measures 20 to 110m in layer thickness and is composed of brownish green sandy clay, brown clay, clayey sandstone, iron carbonate cement and dark gray carbonaceous clay. It contains a large amount of iron calcium and iron carbonate, rarely containing iron hydroxide. It accompanies fossils of vertebrate animals and evergreen trees of the subtropical zone. The Ashutasskaya Series is 20 to 110m in layer thickness and is made up of greenish gray clayey sand where it is not oxidized and quartz- feldspar sand. It sandwiches thin layers and lenses of sand layers, gravel, clay, black coal, brown coal and carbonaceous clay. It contains carbides of broad-leaf tree plants and disseminates pyrite. The Aral Series measures 50 to 350m in layer thickness and is made up of green and greenish brown clay and sandy clay. It sandwiches quartzose-feldspathic sand. It sometimes contains calcium carbonate and gypsum, rarely disseminating sulfates and chlorides. The central Zaisanskaya Basin sandwiches lenses of clayey limestone. It contains fossils of vertebras, shrubs and broad-leaf trees, indicating temperate climate. The Pavlodar Series is 100 to 500m in layer thickness and is made up of reddish brown or primrose yellow-brown clay. It sandwiches sand, gravel, rock fragments, thin layers of green clay and lenses. Te base of it sandwiches quartzose-feldspathic sand, gravel, greenish brown clay and sandy clay. It disseminates brown iron oxide and calcium carbonate and contains fossils of vertebrates and foreign flowers in steppes. The Vtorushinskaya Series measures 15 to 180m in layer thickness and consists of tan or yellowish brown loam, sandwiching thin layers and lenses of sand, gravel, rock fragments, etc.

According to the geological history of South Altai in the Cainozoic Era authored by V. S. Erofeyev (1969), the geological history of the survey area can be summarized as follows. Palaeogeographic maps of each period are shown in Figs. II-1-5 (1) to (8).

End of the early Cretaceous Period (Denmark Age to North Zaisanskaya Period about 140 million to 56.5 million years ago, Fig. II-1-5 (1)): The Zaisanskaya Basin, which forms a gentle inclination, started to sink. Chemical weathering of the bedrock started to deposit a formation of a clayey layer mainly consisting of montmorillonite and a red bed composed of clay layer and iron hydroxide. The basin was 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 Zaisanskaya Basin was a moist plain facing a coast and the southeastern and eastern flanks of it were dry areas. The climate of the sedimentary basin 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. Thickets of 水羊歯 and 三色藻 spread in lakes and marshes.

Mid- to early Eocene Epoch (Turangyn Age, about 56.5 to 38.6 million years ago, Fig. II-1-5 (2)): During this age, the middle Altai area started to uplift, thereby changing river flow. Sedimentation of clay and red beds stopped around the Zaisanskaya Basin and sedimentation of coal increased, starting deposition of pyrite and calcareous clay. Soluble salts such as sulfates and chlorides are contained in clay. Woods and forest plains of lowlands spread near the survey area, and denuded clastics were moved to the Zaisanskaya Basin.

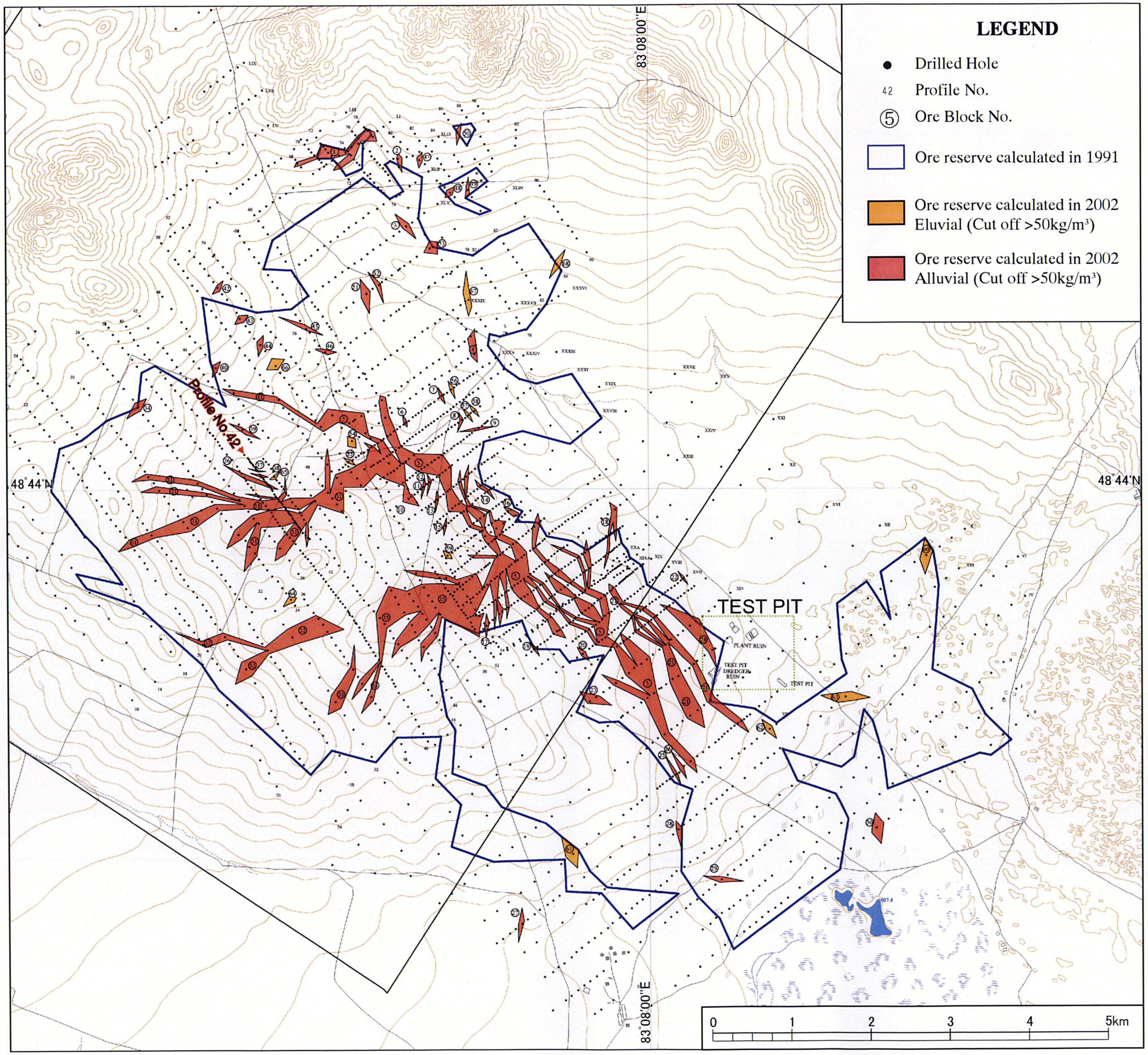
Early Eocene Period - Late Oligocene Epoch (Tuzkabak Age, about 38.6 to 29.3 million years ago, Fig. II-1-5 (3)): Exposed to land breezes and rainfalls during the monsoon and rainy season, moss, woods and forests spread in marshes and swamps along rivers in plains. As a result, silt-like clayey beds green or greenish brown in color deposited in drainage areas, while brown silt containing iron deposited in plains.

Mid- to early Pliocene Epoch (アシュタス Age, 29.3 to 23.3 million years ago, Fig.

II-1-5 (4)): 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 mid-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 Basin in southeast.

Late to Mid-Miocene Epoch (Aral Age: 23.3 to 10.4 million years ago, Fig. II-1-5 (5)): 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 steppes. 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 composed 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 10.4 to 1.6 million years ago, Figs. II-1-5 (6) and II-1-5 (7)): 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 the Zaisanskaya Basin and new sediments from nearby areas started to deposit.



BLOCK NUMBER	BLOCK VOLUME (m^3)	ILMENITE GRADE (kg/m^3)	ZIRCON GRADE (kg/m^3)
1	144,928	153.9	30.1
2	2,550	55.6	12.7
3	12,267	50.1	11.8
4	65,133	69.0	7.0
5	4,487,353	68.0	12.9
6	1,533	70.0	18.0
7	1,133	58.9	11.5
8	9,067	72.5	0.2
9	14,813	57.7	2.1
10	22,750	57.1	7.5
11	3,754	65.8	9.2
12	5,171	75.8	10.0
13	975	61.1	11.7
14	4,004	56.8	11.2
15	2,708	98.4	13.1
16	2,729	55.0	8.2
17	3,867	56.1	13.2
18	15,963	54.3	9.2
19	4,667	58.9	16.2
20	19,742	69.6	11.8
21	577,938	71.7	13.6
22	4,667	62.0	13.6
23	28,158	79.9	19.0
24	141,158	32.4	5.6
25	9,467	69.1	12.9
26	4,000	76.5	22.1
27	4,167	50.1	10.6
28	4,167	50.1	10.6
29	18,375	58.8	14.0
30	28,688	60.5	9.8
31	1,918,634	71.8	11.0
32	233,327	75.2	10.6
33	55,910	74.9	12.6
34	11,783	50.2	8.2
35	1,646,450	96.4	16.7
36	15,183	115.9	15.4
37	650	163.7	5.0
38	650	52.1	2.5
39	7,333	98.6	0.8
40	4,800	59.7	6.2
41	115,250	55.4	10.2
42	14,750	71.0	11.8
43	2,833	107.1	14.4
44	2,667	72.3	11.5
45	9,642	62.5	0.9
46	2,850	54.8	5.3
47	1,933	71.7	16.2
48	1,233	87.2	22.1
49	3,000	73.3	14.8
50	2,250	100.3	2.4
51	13,867	52.4	1.7
52	20,000	57.3	3.7
53	7,500	54.3	3.5
54	7,350	51.2	8.2
55	1,625	84.7	11.2
56	1,000	55.7	10.5
57	6,667	62.9	0.3
58	4,600	50.0	0.6
59	1,013	63.0	9.1
60	16,000	64.8	0.5
61	8,528	68.7	0.5
62	27,100	52.5	0.8
63	27,600	52.0	4.3
64	5,542	77.4	0.8
65	1,300	62.1	2.4
66	17,750	58.8	1.8
67	7,425	50.1	4.3
68	6,417	52.9	1.2
Grand Total	9,878,301	74.3	13.0

Fig.II-1-1 Ore Reserves Block of the Karaotokel Deposit

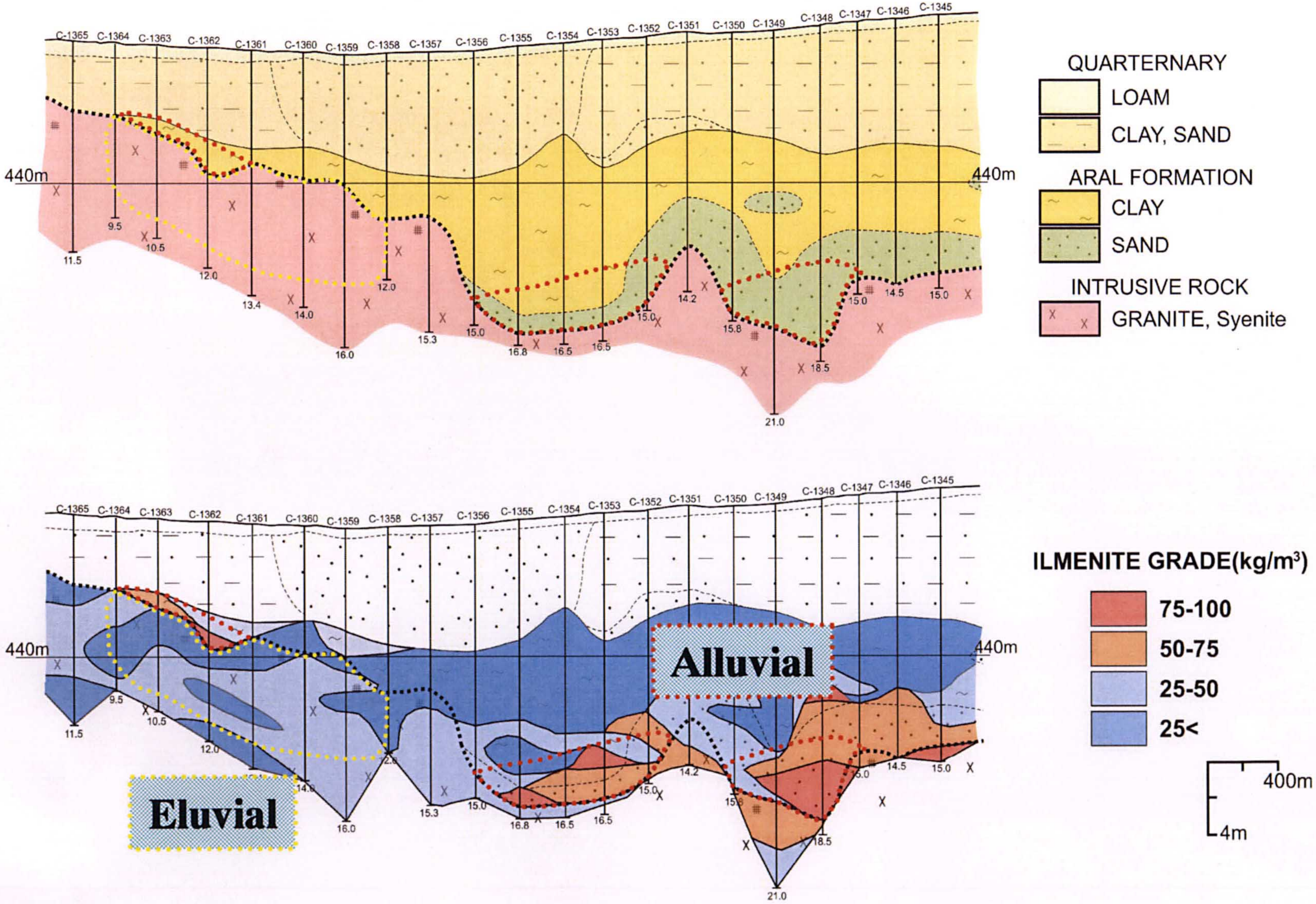


Fig.II-1-2 Geological Cross Section along profile No.42 of the Karaotkel deposit

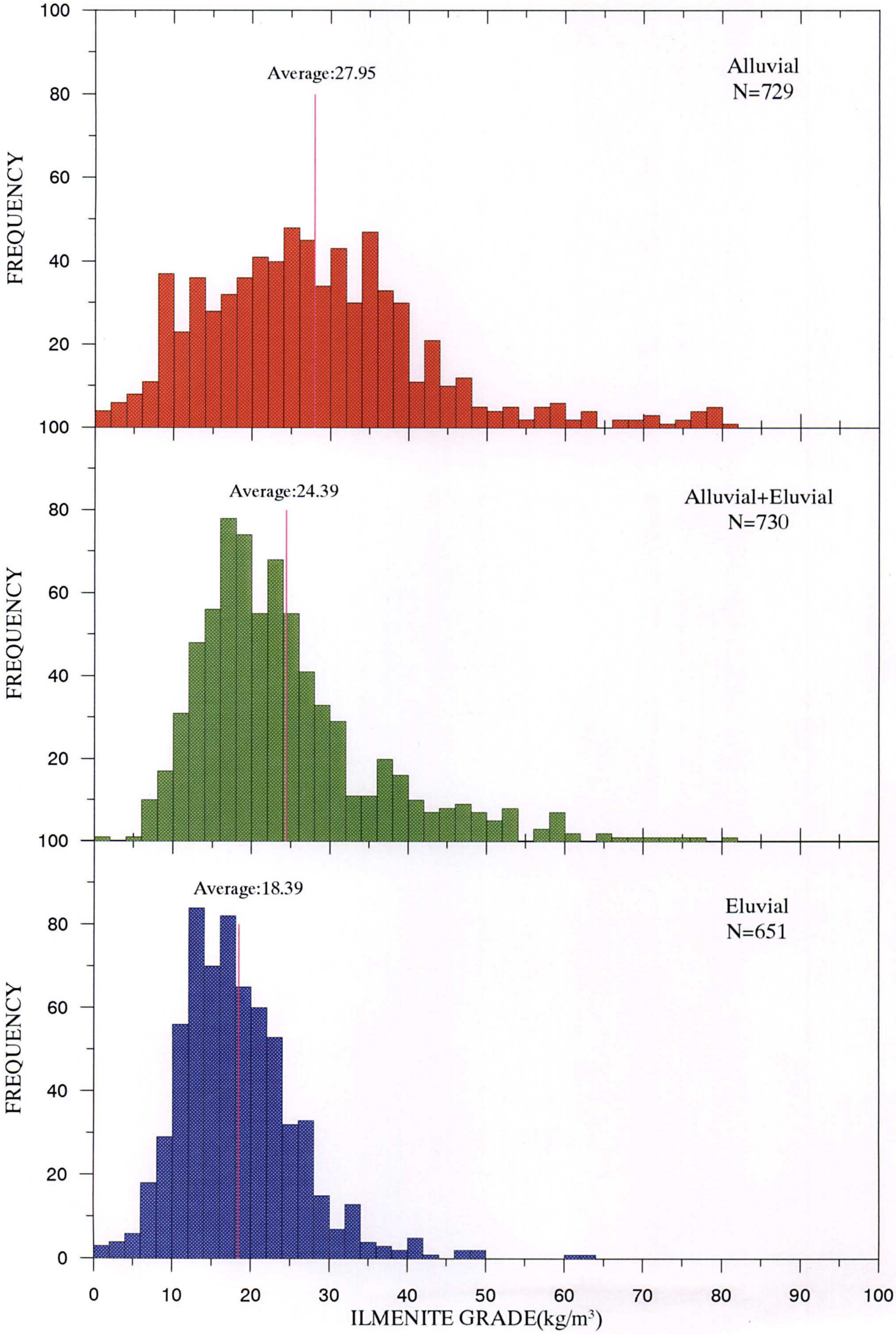


Fig. II-1-3 Frequency of Ilmenite Grade in Alluvial and Eluvial

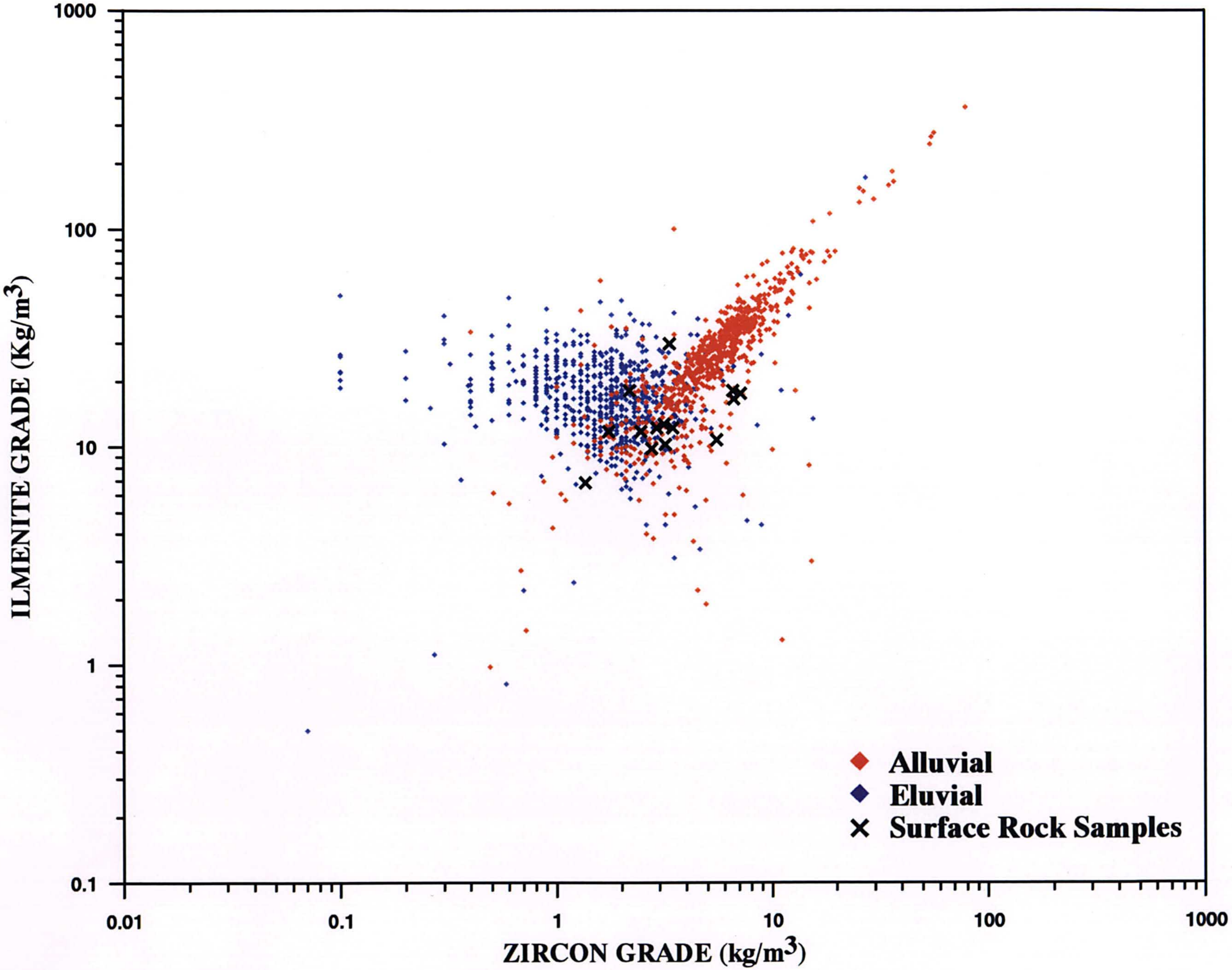
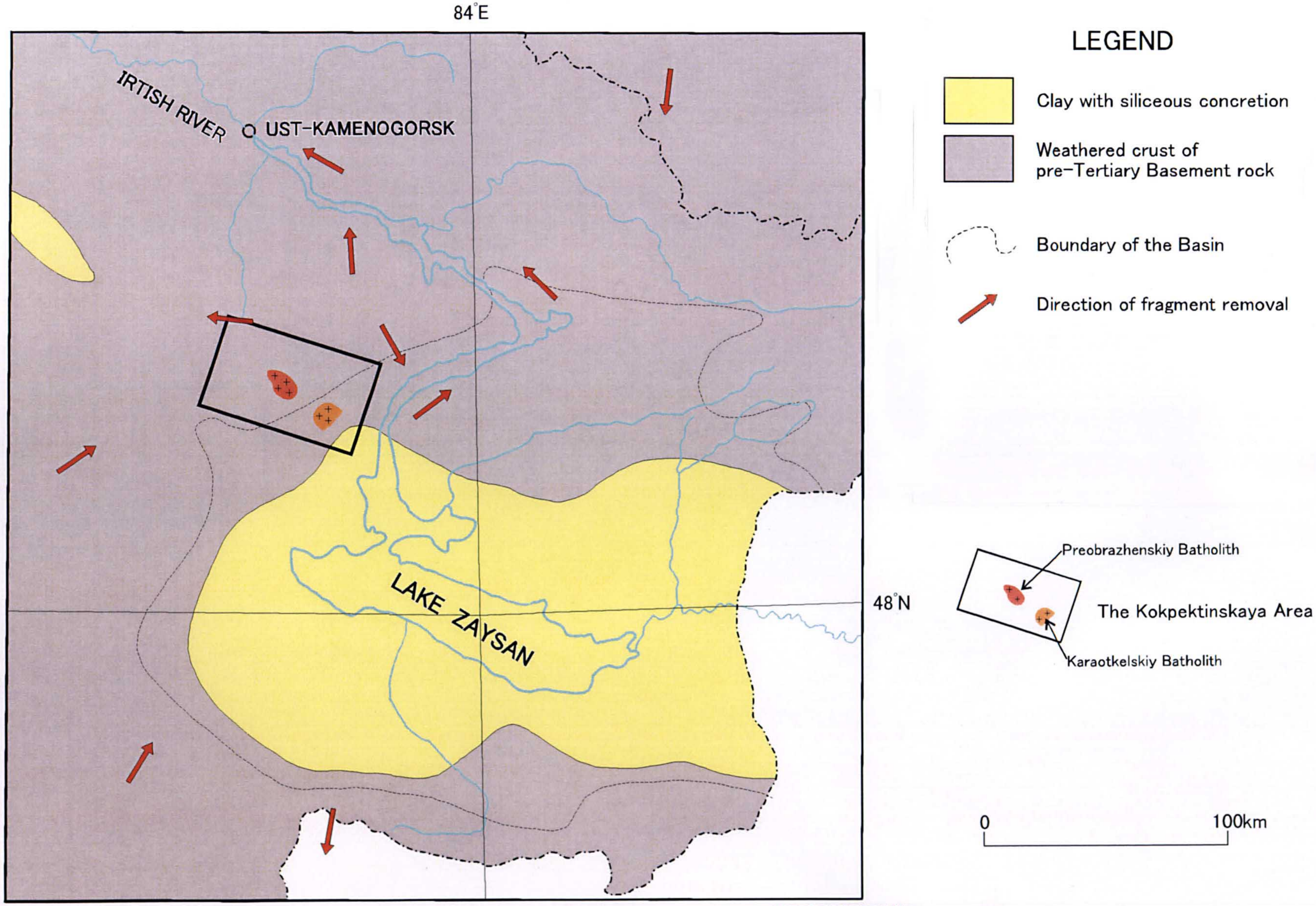


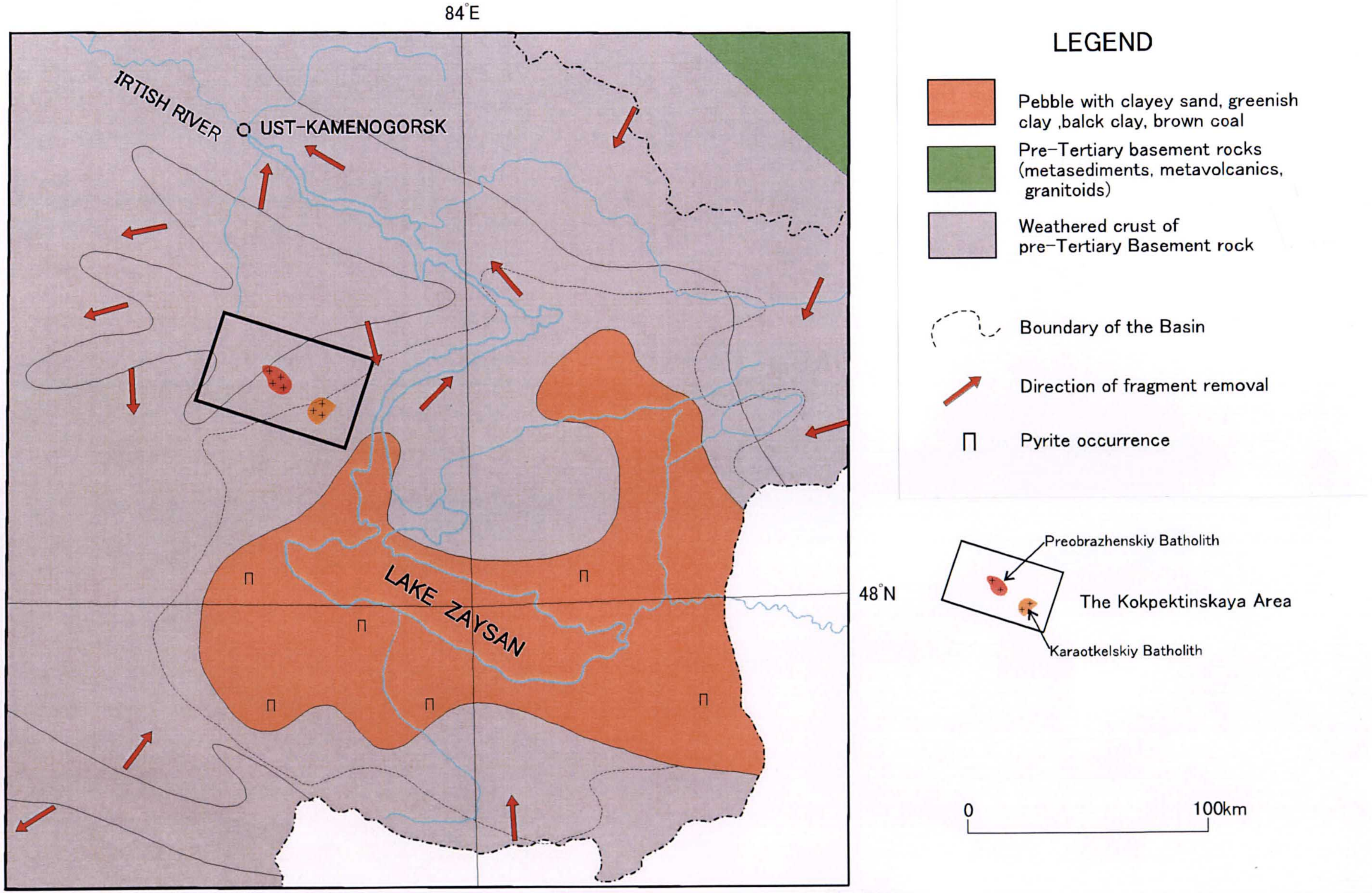
Fig.II-1-4 Ilmenite vs Zircon Grade of the Karaotkel Deposit



North Zaysanskaya Age
(Paleocene)
Before 56.5 Ma

AFTER:EROFEEV,V.S.
MATSUI, V.M.
TSEHOVSKI,YU.G.

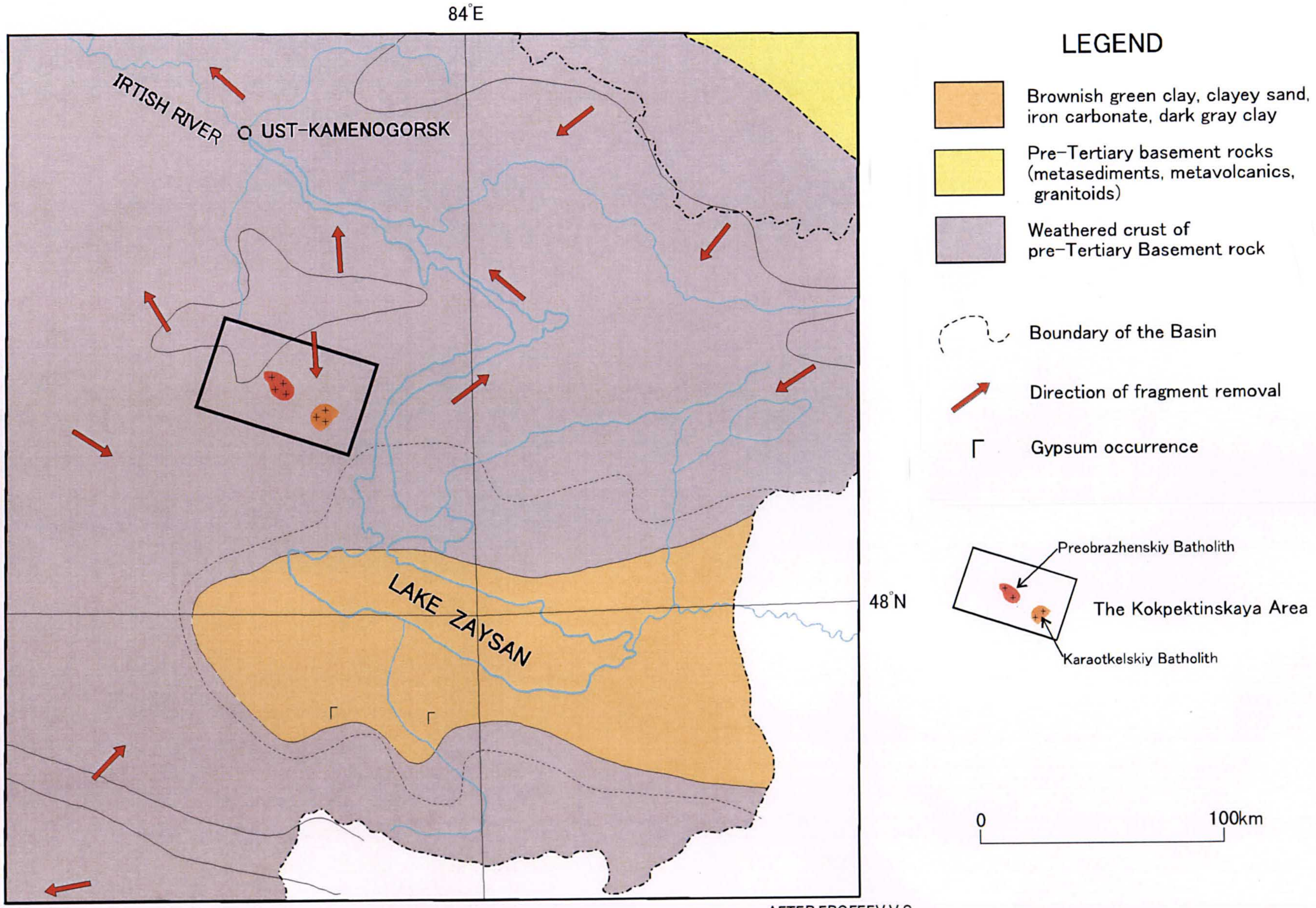
Fig II-1-5 Paleogeographic Map of the Zaysan Basin (1)



Turangynskaya Age
(Early to Middle Eocene)
Ca. 56.5 – 38.6 Ma

AFTER:EROFEEV,V.S.
MATSUI, V.M.
TSEHOVSKI,YU.G.

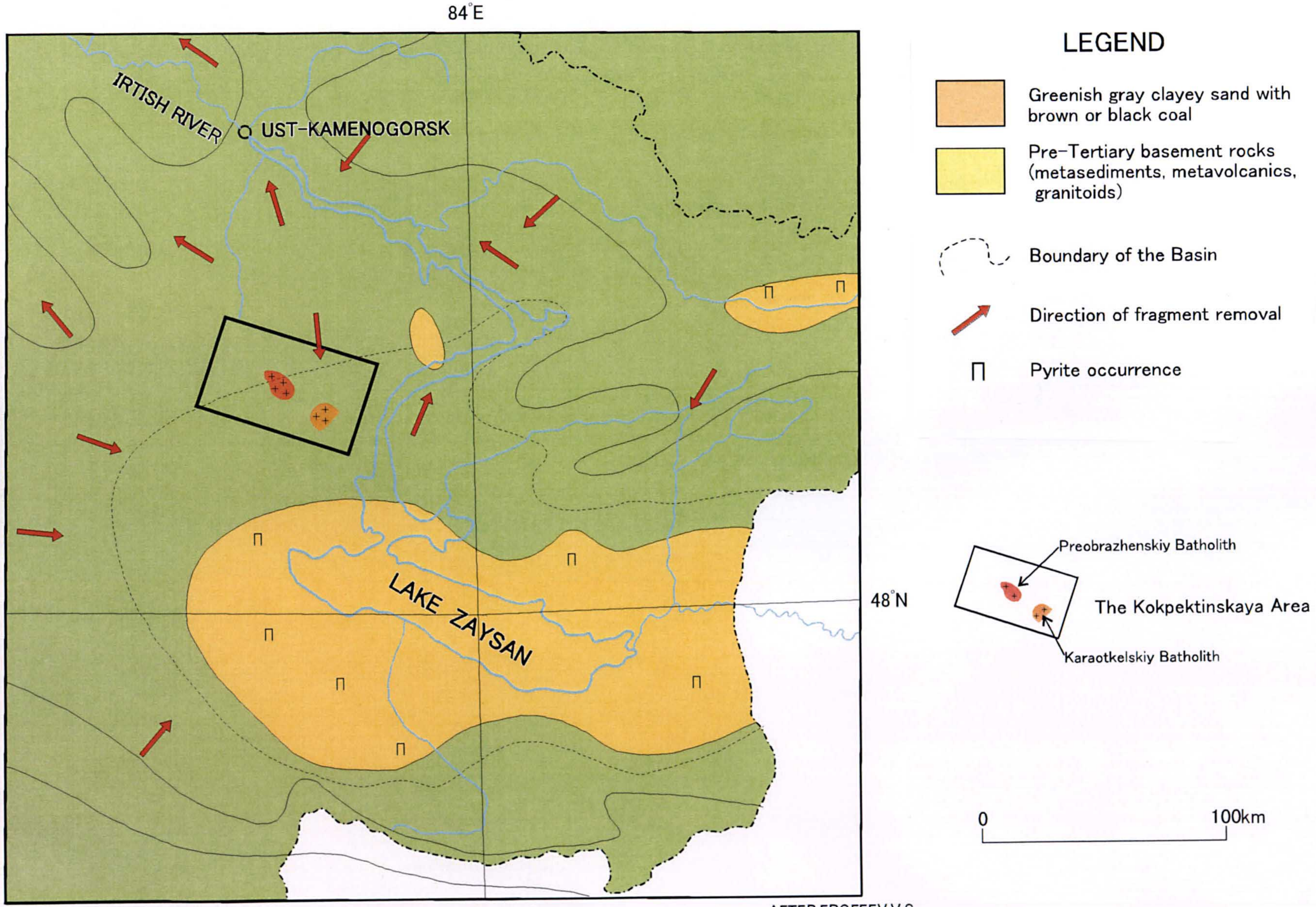
Fig II-1-5 Paleogeographic Map of the Zaysanskaya Basin (2)



AFTER:EROFEEV,V.S.
MATSUI, V.M.
TSEHOVSKI,YU.G.

Tuzkabakskaya Age
(Late Eocene toEarly Oligogene)
Ca. 38.6 - 29.3 Ma

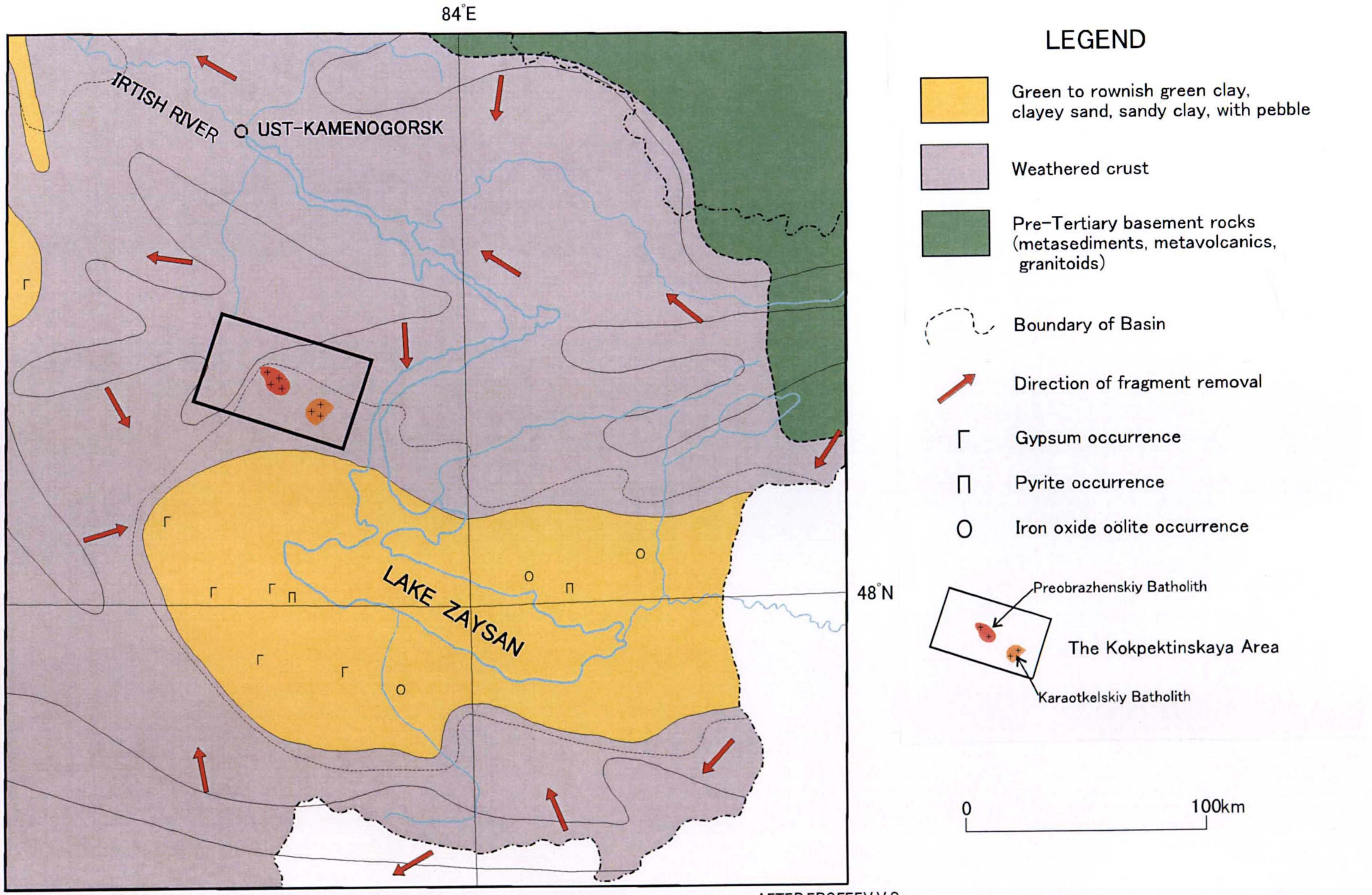
Fig II-1-5 Paleogeographic Map of the Zaysanskaya Basin (3)



Ashutasskaya Age
(Middle to Late Oligogene)
Ca. 29.3 − 23.3 Ma

AFTER:EROFEEV,V.S.
MATSUI, V.M.
TSEHOVSKI,YU.G.

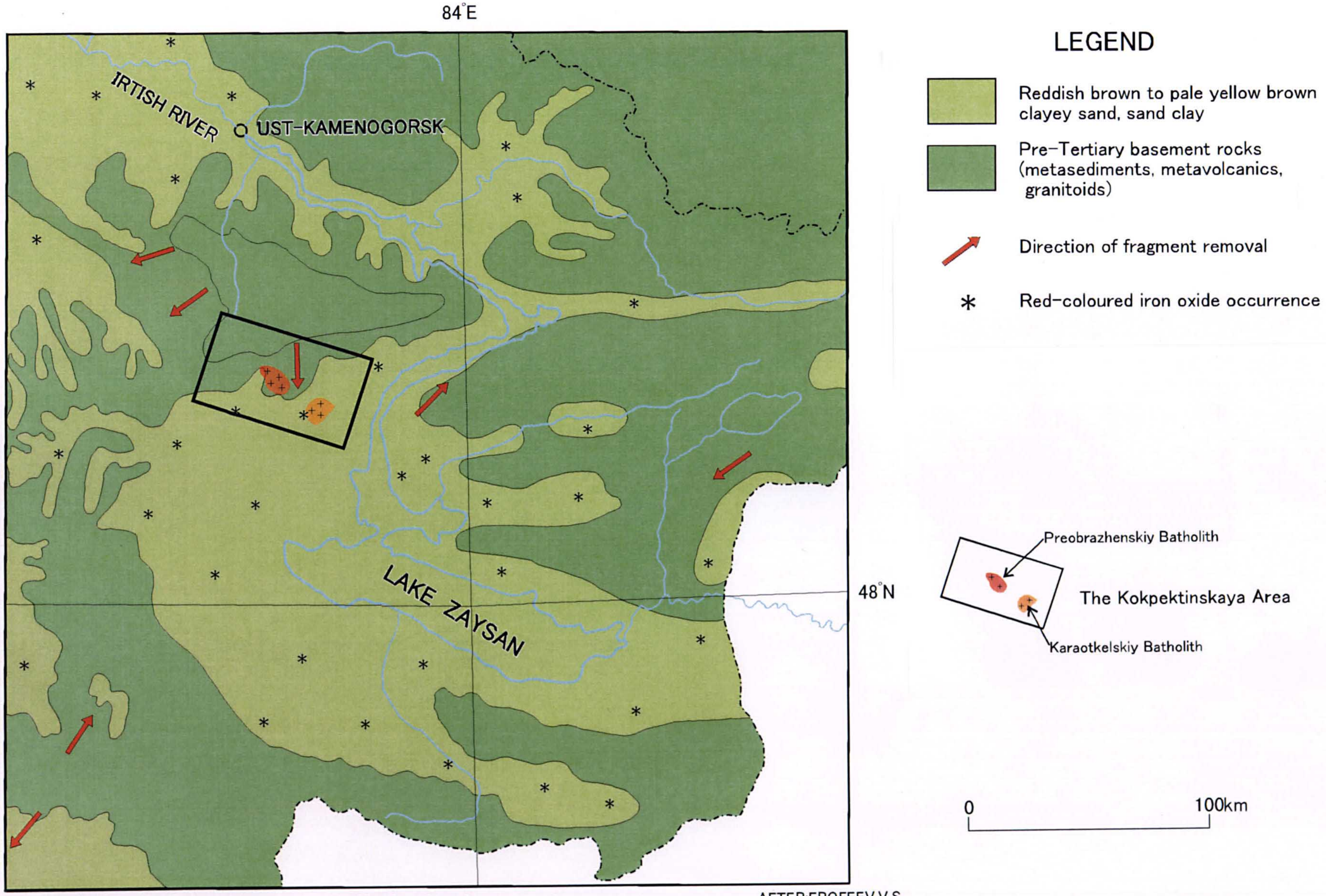
Fig II-1-5 Paleogeographic Map of the Zaysanskaya Basin (4)



Aral Age
(Early to Middle Miocene)
Ca. 23.3 – 10.4 Ma

AFTER:EROFEEV,V.S.
MATSUI, V.M.
TSEHOVSKI,YU.G.

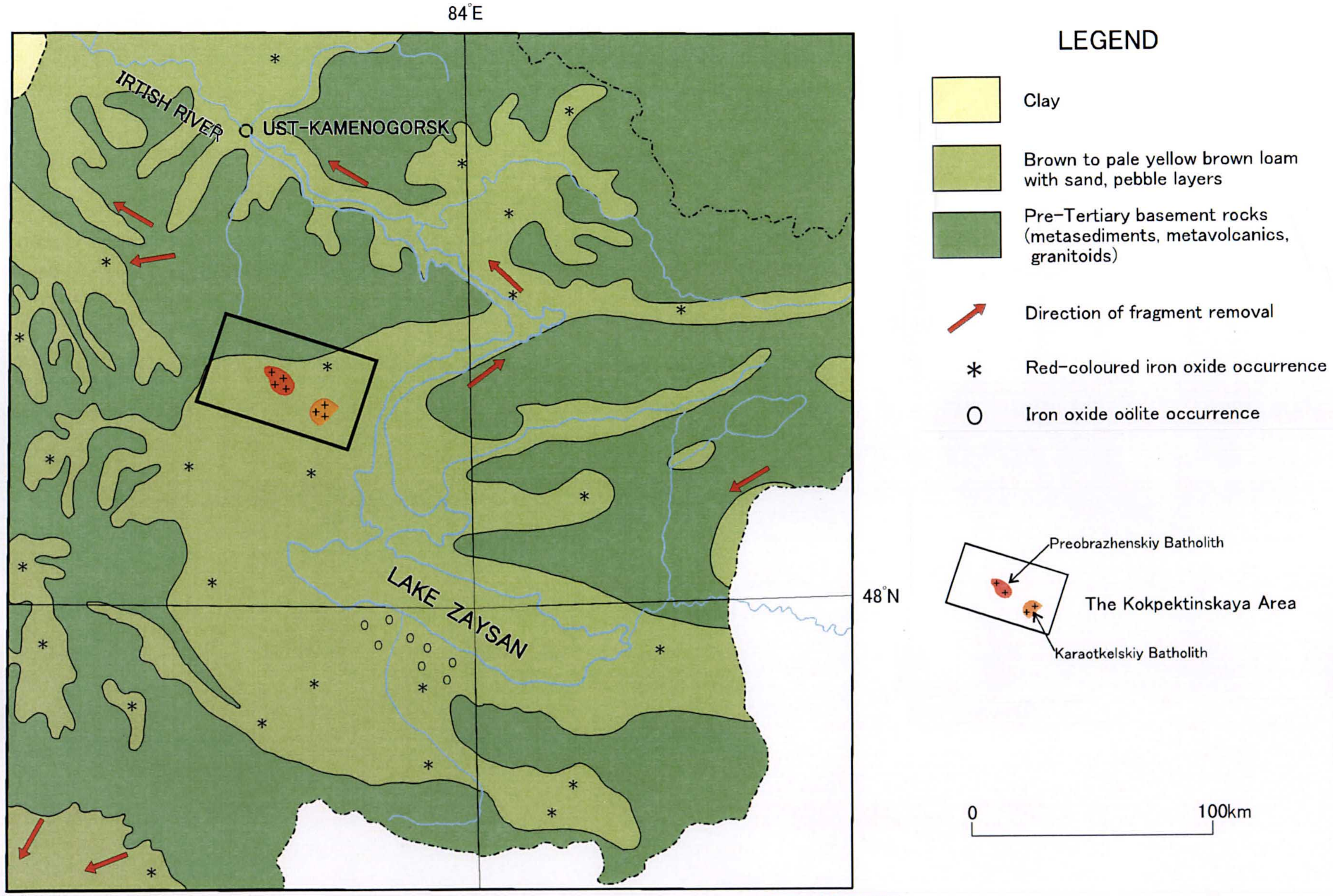
Fig II-1-5 Paleogeographic Map of the Zaysanskaya Basin (5)



Pavlodar Age
(Middle to Late Miocene)
Ca. 10.4 – 3.4 Ma

AFTER:EROFEEV,V.S.
MATSUI, V.M.
TSEHOVSKI,YU.G.

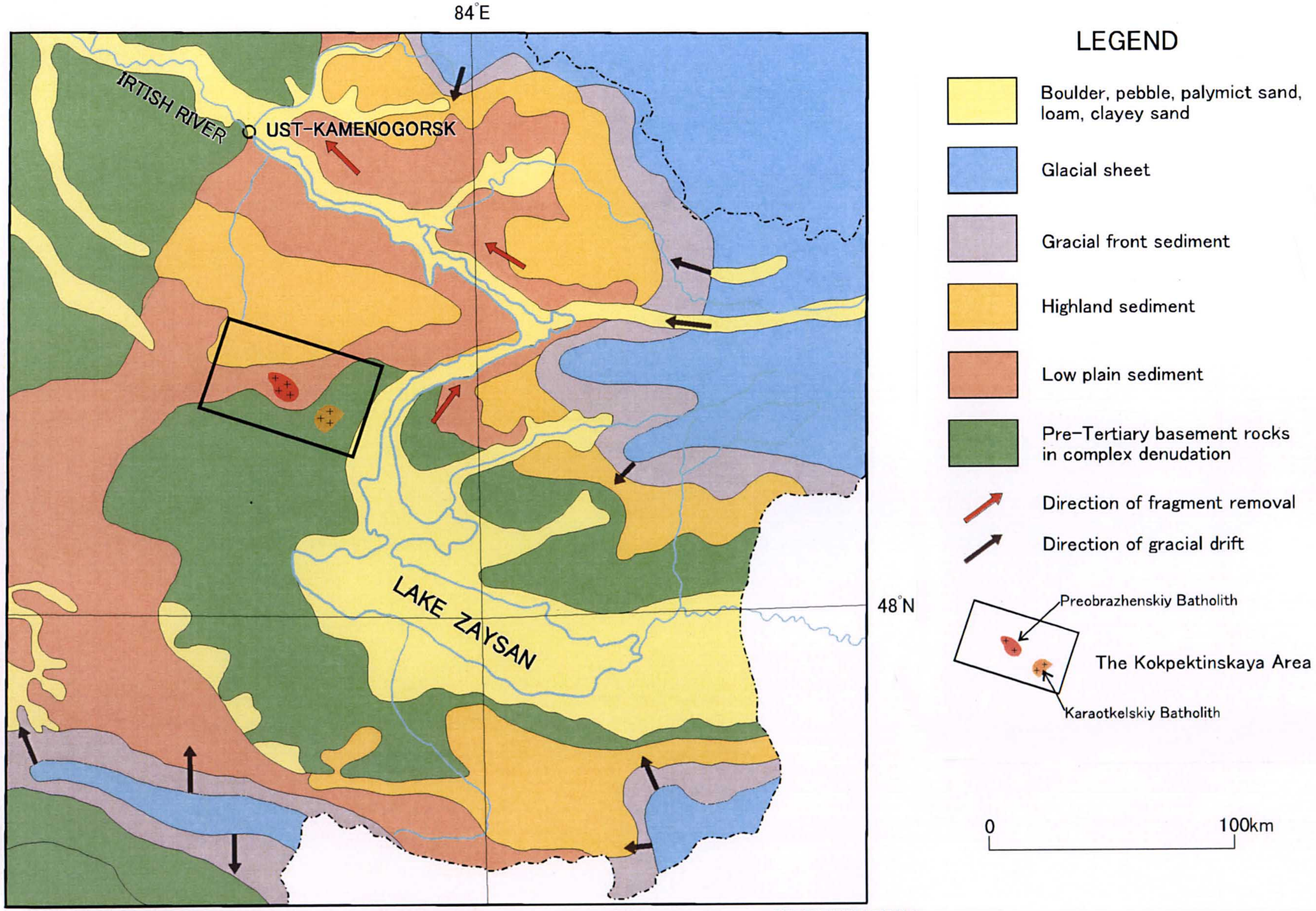
Fig II-1-5 Paleogeographic Map of the Zaysanskaya Basin (6)



Vtorushinskaya Age
(Middle to Late Pliocene)
Ca. 3.4 −1.6 Ma

AFTER:EROFEEV,V.S.
MATSUI, V.M.
TSEHOVSKI,YU.G.

Fig II-1-5 Paleogeographic Map of the Zaysanskaya Basin (7)



Quaternary

AFTER:EROFEEV,V.S.
MATSUI, V.M.
TSEHOVSKI,YU.G.

Ca. 1.6 Ma

Fig II-1-5 Paleogeographic Map of the Zaysanskaya Basin (8)

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 Karaotkelskiy complex by the same survey technique as that used with the Preobrazhenskiy complex in the Phase II survey to determine rock species 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 the Survey

In the survey of the survey area in Phase II, 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 as in the Phase II survey.

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

Concurrently with the geological survey, magnetic susceptibilities of the rocks at the outcrops were measured and recorded (Appendix 2-19). The magnetic susceptibilities were measured on fresh, flat and smooth rock outcrops at 168 geological outcrops using a portable magnetic susceptibility meter (Micro KAPPA, model KT-5c). Ten measurements were taken at each outcrop.

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 14 of these samples. To compare with the survey in Phase III, one sample (G423) was sampled from the Preobrazhenskiy complex in the survey area of Phase II and whole rock analysis and trace component analysis were carried out. Rocks found to contain SiO_2 and Na_2O+K_2O in the whole rock analysis were named in accordance with Cox et al. (1979). Furthermore, CIPW normative calculations were made and rocks named in accordance with Streckeisen (1967) were also referenced. 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 performed to quantitatively classify rocks of the Karaotkelskiy complex. Nineteen polished thin sections were prepared for use in laboratory tests from the 15 samples used in the whole rock and trace component analysis and from the four samples of sedimentary rocks of the Carboniferous Period. These sections were used in microscope observation. Six of these samples were used in 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 4,000 intersections on 1/5×1/6mm section paper. A total of 77 opaque mineral grains out of 81 grains found on 19 of polished thin sections were analyzed for semi-quantitative analysis using EDX (manufactured by JEOL, model JSM-5310). Two samples (G378 and I232) were subjected to area analysis using EPMA (manufactured by JEOL, model JXA-8800R) to determine the distribution of Ti, Fe, Mn and O and mineral species (Appendixes 2-8 and 2-20). To examine mineralogical composition of ilmenite, one ilmenite concentrate sample (Karaotkel Pit 2) sampled from the concentrate storage mine in the former pilot plant of the Karaotkel Plant (see Fig. II-1-1) was subjected to the following analyses: One powder X-ray diffraction analysis by a powder X-ray diffraction apparatus (manufactured by BRUKER axs, Model MXP18, X-ray generator 18kW, tube voltage 40kV, tube current 150mA), one polished thin section was prepared, 15 semi-quantitative analyses by EDX, and one area analysis by EPMA (manufactured by JEOL, model JXA-8800R). One powder X-ray diffraction test was performed with one clay sample (Karaotkel Pit 1) sampled from a Karaotkel test pit (see Fig. II-1-1) to determine clayey minerals. K-Ar age measurement was performed with two Karaotkelskiy complex samples and three Preobrazhenskiy complex samples sampled from these complexes in the positions illustrated in Fig. II-2-1.

Appendixes 2-5 and 2-6 show the results of the whole rock analysis and trace component analysis. Appendix 2-7 shows the results of the CIPW normative calculations and mode analysis of opaque minerals. Appendixes 2-2, 2-3 and 2-5 show microscopic observation results and microscope photos of rock thin sections. Appendix 2-20 shows results of EDX semi-quantitative analysis of opaque minerals. Distributions of TiO_2 in granitic rocks of the Karaotkelskiy complex is shown in Fig. II-2-2. Appendixes 2-3, 2-4, 2-20 and 2-8 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 ($C_1V_{2-3}ar$)

This bed distributes from the southern flank of the Baladzhalskiy Fault in the northern part of the study area to the center of the survey area. Intruded by the Karaotkelskiy complex, it has become extensively hornfelsic.

In the Kokpetinskaya survey area, this bed is composed of conglomerate, arkose sandstone, sandstone, siltstone and shale. Fine alternations are developed in it. Where it contacts the Preobrazhenskiy complex, the rocks have become hornfelsic and carboniferous shale has become graphite. This bed is made up of shale, siltstone, sandstone, gabbro, tuff and limestone and contains fossils of brachiopods, corals, etc. The total bed thickness is estimated to be 1,500 to 2,000m.

The sedimentary rocks comprising this bed sometimes contain small amounts of titanic minerals such as ilmenite and anatase, ilmenite content often reaching 2%. The northwestern part of the survey area is distributed with hornfels, whose origin rocks are siltstone that contains a large amount of magnetite. These facts show that some titanic minerals had already existed in the Carboniferous Period before the Karaotkelskiy complex intruded and that horizons with thickened magnetite existed in some parts. Sample G-365 is siliceous tuff covered with hornfelsic alteration. Phenocrysts of quartz and plagioclase mainly 0.05 to 2mm in grain size are contained in matrixes of quartz measuring 0.005 to 0.05mm in fine grain size. Matrixes of it contain ilmenite 0.002 to 0.225mm in grain size, columnar anatase 0.002 to 0.02mm in grain size, needle-like and columnar euhedral andalusite, and extremely small amounts of biotite and zircon. Anatase, biotite and andalusite are authigenic minerals formed during contact alteration. Sample G-387 is pyroxene-porphyrite and matrixes of it comprising fine-grained plagioclase, augite, biotite and a small amount of quartz 0.01 to 0.1mm in grain size contain hypohyaline plagioclase and augite 0.2 to 2.5mm in grain size. As accessory component minerals, about 3% of fine-grained ilmenite 0.005 to 0.125mm in grain size and very small amounts of sphene 0.01 to 0.1mm in grain size and zircon and hematite 0.075 to 0.1mm in grain size are found. Sample G-395 is hornfels, whose origin rock is considered to be siltstone, and is made up of quartz with a good balance in grain size between 0.01 to 0.03mm, biotite 0.01 to 0.06mm in grain size and cordierite 0.006 to 0.06 in grain size. As accessory component minerals, about 2% of fine-grained ilmenite 0.002 to 0.05mm in grain size and an extremely small amount of tourmaline are found. Because a small amount of ilmenite is contained, the magnetic susceptibility of this sample is slightly high, 0.41×10^{-3} S.I.U. Sample G-445 is hornfels whose origin rock is considered to be sandstone and is mainly composed of quartz 0.05 to 0.25mm in grain size and biotite 0.05 to 0.2mm in grain size, as well as a small amount of plagioclase 0.05 to 0.2mm in grain size. As accessory component minerals, about 4% of magnetite 0.001 to 0.08mm in grain size and 2 to 3% of ilmenite 0.005 to 0.03mm in grain size are found. This hornfels is distributed in a lens shape in low hills in the northwestern part of the survey area and shows a predominantly high magnetic susceptibility 30 to 50×10^{-3} S.I.U. because it contains a large amount of magnetite.

2) Bukon bed of upper coal-series（$C_2 bk_2$）

This bed occupies the bulk of the southwestern part of the Karaotkel district and is intruded into the Karaotkelskiy complex in some parts. The bed is covered thickly by the Aral Formation of the Tertiary Period and layers of the Quaternary Period.

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

This bed widely distributes in the western flank of the Karaotkelskiy complex and forms low hills. It continues from near Koitas to southeast and widely distributes toward southwest of the survey area forming low hills. It emerged as a weathered crust of basement rock in drilling near basement rock in the eastern area of Bektimir.

This bed is generally coarse and bulky and is dark green in color. It is composed of tuff, andesitic porphyrite sandwiching 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 looks like porous sponge rock on its weathered surfaces. Sample G031 sampled during the survey in Phase II has phenocrysts of altered euhedral plagioclase 0.2 to 0.5mm in size, subhedral 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 illite. This rock suffered strong contact metamorphism by the Karaotkelskiy and Preobrazhenskiy complexes that generated actinolite and became hornfelsic. It contains more than 1% of magnetite as an opaque mineral and a small amount of ilmenite is sometimes contained. 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 Karaotkelskiy and Preobrazhenskiy complexes intruded during the Palaeozoic are distributed.

1) Karaotkelskiy Complex

According to existing drilling data, this intrusive rock mass occupies the majority of the survey area and is a rectangle stretching NW-SE. It measures 10km in width and 14km or more in length. In the absence of drilling data, the southeastern border of it is not closed. The granitic rocks that make up the complex are gabbro, diorite, syenite and granite. Areawise, syenite accounts for most and gabbro and diorite distribute in it like spots. Granite is intruded in the central, northern and western parts as small rock stumps 2 to 4km in diameter (PL. II-2-1). According to a rock naming method of Cox et al. (1979), syenite corresponds to quartzose-monzonite (Fig. II-2-6). Granite corresponds to monzonitic granite according to the naming method by Streckeisen (1967). This report follows the method proposed by Cox et al. (1979) to have conformity with rock names appearing in the existing and public drilling data. The bulk of this complex is covered by layers of the Cainozoic Era. Except for syenite and granite, which contact sedimentary rocks of the Arkalyk layer of the late Carboniferous Period, expose in small areas in the hills located in the northern to western parts, syenite (Sample G-450) is exposed in the bottoms of the test pits in southeast of the survey area and a very small amount of granite (Sample I-232) is exposed in low hills in southwest of the survey area. Gabbro or diorite is not exposed.

Granite is coarse-grained or medium-grained holocrystalline and main rock-forming minerals are potassium feldspars accounting for 55 to 60% that has a perthite texture with a grain size of 3 to 6mm and often shows Carlsbad twins, quartz accounting for about 25% and 0.5 to 4mm in grain size, plagioclase (gray albite) accounting for about 20% and 1 to 1.5mm in grain size, clinopyroxene accounting for about 0.5% and 0.6mm in grain size, amphibole accounting for about 0.5% and 0.3 to 1.5mm in grain size, and small amounts of biotite, zircon, apatite and sillimanite. Clinopyroxene and amphibole are replaced by actinolite and biotite, forming needle-like radiated sillimanite. There are traces showing that some edges of almost all quartz and feldspar grains were recrystallized and were subjected to fine-graining and deformation.

Sample G-370 is amphibole augite granite and is mainly composed of potassium feldspars, quartz and plagioclase 0.05 to 5mm in grain size and small amounts of amphibole and clinopyroxene, showing a perthite texture in potassium feldspars in a microscope test. As accessory component minerals, 0.3% of ilmenite 0.01 to 0.3mm in grain size, extremely small amounts of zircon 0.01 to 0.17mm in grain size and of allanite 0.15 to 0.17mm in grain size, and 0.1% of magnetite 0.005 to 0.15mm in grain size are found. Opaque minerals account for 0.4% in total. Sample G-416 is porphyritic amphibole granite and is mainly composed of potassium feldspars, quartz and plagioclase 0.05 to 5mm in grain size and a very small amount of amphibole, showing a perthite texture in potassium feldspars in a microscope test. As accessory component minerals, very small amounts of ilmenite 0.04 to 0.45mm in grain size and of zircon 0.005 to 0.015mm in grain size are found. Sample G-433 is porphyritic amphibole granite and is mainly composed of potassium feldspars and quartz 0.3 to 6mm in grain size and a very small amount of amphibole. As accessory component minerals, 0.4% of ilmenite 0.02 to 0.3mm in grain size, 0.3% of magnetite 0.012 to 0.16mm in grain size, and hematite showing a lamina-like exsolution texture with ilmenite and magnetite are found. Opaque minerals account for 0.7% in total. Sample G-442 is amphibole augite granite with a clear porphyritic texture and is mainly composed of phenocrystalline potassium feldspars 1.5 to 4mm in grain size, while its matrix is composed of quartz of relatively fine grains 0.1 to 0.6mm in grain size, amphibole, clinopyroxene and plagioclase. As accessory component minerals, about 1% of ilmenite 0.01 to 0.15mm in grain size and an extremely small amount of zircon 0.1 to 0. 6mm in grain size are found in the matrix. Sample G-449 is biotite granite porphyry of a medium grain size and is mainly composed of potassium feldspars, quartz and plagioclase 0.05 to 5mm in grain size and biotite 0.05 to 0.8mm in grain size. A perthite texture and sericitization are found with potassium feldspars and pleochroic halo due to zircon is found in biotite in a microscope test. As accessory component minerals, extremely small amounts of zircon 0.02 to 0.04mm in grain size and of tourmaline 0.03 to 0.12mm in grain size and very small amounts of ilmenite 0.04 to 0.09mm in grain size and monazite 0.05 to 0.09mm in grain size are found. Sample I-162 is slightly porphyritic augite biotite granite and is mainly composed of potassium feldspars and quartz 0.2 to 5mm in grain size and small amounts of plagioclase, clinopyroxene and biotite. As accessory component minerals, 1% or less of ilmenite 0.02 to 0.2mm in grain size and very small amounts of monazite 0.03 to 0.06mm in grain size and of zircon 0.03 to 0. 2mm in grain size are found. As altered minerals, very small amounts of goethite, sericite and columnar or needle-shaped epidote and chlorite are found. Sample I-173 is biotite amphibole granite of a medium grain size and is mainly composed of potassium feldspars and quartz 0.05 to 5mm in grain size, small amounts of plagioclase and clinopyroxene, and very small amounts of biotite and amphibole. As accessory component minerals, 0.7% of ilmenite 0.04 to 0.4mm in grain size, 0.3% of magnetite 0.02 to 0.2mm in grain size and very small amounts of zircon 0.08 to 0. 4mm in grain size, of monazite 0.03 to 0.14mm in grain size and hematite about 0.2mm in grain size are found. Opaque minerals total 1%. As altered minerals, very small amounts of needle-shaped epidote and chlorite are found in potassium feldspars. Sample I-178 is biotite augite granite of a medium grain size and is mainly composed of potassium feldspars and quartz 0.02 to 5mm in grain size, small amounts of clinopyroxene and plagioclase, and very small amounts of amphibole and biotite. As accessory component minerals, about 0.5% of ilmenite 0.05 to 0.35mm in grain size, about 0.3% of magnetite 0.035 to 0.25mm in grain size and goethite 0.05 to 0.1mm in grain size are found. Hematite is found in magnetite in a lamina form. Sample I-232 is biotite granite of a medium grain size and is mainly composed of potassium feldspars and quartz 0.05 to 5mm in grain size and small amounts of plagioclase and biotite. Potassium feldspars show a perthite texture, forming sericite. As accessory component minerals, 0.2% of ilmenite 0.015 to 0.15mm in grain size, 0.1% of pseudorutile and leucoxene 0.015 to 0.15mm in grain size, and extremely small amounts of magnetite and zircon (0.06 to 0.13mm in grain size) are found.

Syenite is a holocrystalline mineral of coarse and medium grains. The main rock-forming minerals are potassium feldspars that are slightly sericitized, have a perthite texture, are 1.5 to 7mm in grain size and account for 55 to 60% of the total. They often show Carlsbad twins. Other main rock-forming minerals are about 25% in plagioclase (gray albite) 1 to 4mm in grain size, about 5% in amphibole 2.5mm in grain size, about 10% in quartz 0.5 to 3mm in grain size, and very small amounts of biotite, zircon, apatite, actinolite, goethite and other minerals. Potassium feldspars contain small plagioclase and parts of them are recrystallized in microplagioclase. Amphibole forms an intersertal texture with feldspars and is crushed. Quartz grains are recrystallized and form intergrowth with potassium feldspars.

Sample G-378 is augite amphibole quartzose-syenite of a medium grain size and is mainly composed of potassium feldspars, quartz, plagioclase, clinopyroxene and biotite 0.05 to 5mm in grain size. A perthite texture is found with potassium feldspars. As accessory component minerals, less than 1% of ilmenite and hematite 0.025 to 0.35mm in grain size and a very small amount of zircon 0.025 to 0.1mm in grain size are found. Sample G-396 is amphibole quartzose-syenite of a medium grain size and is mainly composed of potassium feldspars, quartz and plagioclase 0.4 to 5mm in grain size and a small amount of amphibole. Potassium feldspars show a perthite texture. As accessory component minerals, 0.3% of ilmenite 0.03 to 0.2mm in grain size and a very small amount of zircon 0.005 to 0.08mm in grain size are found. Sample G-450 is augite quartzose-syenite of a medium grain size and is mainly composed of plagioclase that is partially sericitized, potassium feldspars and clinopyroxene 0.15 to 4mm in grain size and small amounts of quartz and biotite. As accessory component minerals, 1.3% of ilmenite 0.02 to 0.25mm in grain size, 0.2% of magnetite and apatite (0.01 to 0.18mm in grain size) and very small amounts of zircon and goethite 0.05 to 0.18mm in grain size are found. Opaque minerals account for 1.5% of the total. Sample I-190 is amphibole biotite quartzose-syenite of a medium grain size and is mainly composed of potassium feldspars, plagioclase and quartz 0.05 to 5mm in grain size and small amounts of amphibole and biotite. Potassium feldspars show a perthite texture. As accessory component minerals, about 0.5% of ilmenite 0.05 to 0.4mm in grain size and very small amounts of magnetite 0.002 to 0.2mm in grain size, and zircon, hematite in magnetite showing a laminar exsolution texture and secondary-formation goethite 0.01 to 0.2mm in grain size are found. Sample I-212 is biotite quartzose-syenite of a medium grain size and is mainly composed of potassium feldspars and quartz 0.05 to 5mm in grain size, a small amount of plagioclase and biotite. Potassium feldspars show a perthite texture. As accessory component minerals, about 0.5% of ilmenite 0.02 to 0.25mm in grain size and very small amounts of rutile 0.04 to 0.15mm in grain size, zircon 0.02 to 0.12mm in grain size, and secondary-formation goethite are found.

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 ilmenite than magnetite is called magnetite-series granitoid. According to this classification method, the Karaotkelskiy complex belongs to a classification of ilmenite-series granitoid.

2) Dikes

Dikes of aplite are intruded into the Karaotkelskiy complex in the hilly area in the north.

2-3-3 Post-granitic rocks

Outcrops of post-granitic rocks are found only in the Aral Formation of the Tertiary Period and in the layers of the Quaternary Period that expose in limited locations of the test pits in southeast of the survey area and details of post-granitic rocks could not be determined. Therefore, the descriptions were made using existing drilling data.

1) Bed-rock weathered crust (K_2)

Weathered crusts 10 to 40m in thickness are developed on sedimentary and volcanic rocks of the upper coal series and are covered by the Aral Formation of the Tertiary Period and Quaternary-period layers. Weathered crusts formed on the bedrock of granitic rocks were formed by chemical weathering under moist and warm climate at the end of the early Cretaceous Period (about 140 million years ago). Some ilmenite and zircon are thickened in autochthonous sediments remaining in the area after water-soluble materials are carried away.

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

The Aral Formation covers basement rocks of the Palaeozoic or their weathered crusts without conformity and is covered widely by the Quaternary-Period layers. According to existing drilling data, this formation is made up of sandy clay, coarse-grained clayey quartz - feldspathic sand, rarely containing gravel layers, indicating that the geology of this formation is almost identical to that of the Bektimir district. The formation is 1.5 to 37m in thickness, averaging 5.5m. The sandy clay is mainly made up of kaolin and potassium feldspars, containing a medium quantity of quartz and a small amount of plagioclase. The lower bed of this formation contains ilmenite alluvial deposits.

3) Quaternary-Period Layer (Q)

The Quaternary-period layers distribute widely in this area and are mainly loam and riverbed sediments of small rivers. The layers are mainly cobblestone, gravel, sand, silt, loam and clay. The layers are 0.2 to 31.7m in thickness, averaging 5.7m.

2-3-4 Quantitative petrology of granitic rocks

1) Principal chemical components of granitic rocks

Whole rock analysis of 15 granitic rock samples sampled from the survey area was undertaken (See Appendix 2-5.). The analysis was conducted by The Eastern Mining and Metallurgical Research Institute for Nonferrous Metals in Ust-Kamenogorsk. Many of the analysis values do not total 100% because moisture content ($H_2O\pm$) was not analyzed. 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 Phase II, 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. The TiO_2 contents of most of granitic rocks in the Karaotkel complex are less than 0.4%, while the differentiation indexes (D.I.) of them are above 85, mostly 90 or more. These rocks are most advanced in crystallization differentiation of magma. Fig. II-2-2 shows the distributions of TiO_2 in the granitic rocks of the Preobrazhenskiy and Karaotkelskiy complexes. Compared with the Preobrazhenskiy complex, crystallization differentiation of the Karaotkelskiy complex is generally advanced and the TiO_2 content of it is low. Therefore, it is safe to determine that the ilmenite content of it is also low and that it does not excel as origin rocks of an ilmenite alluvial deposit.

According to the $Na_2O+K_2O-SiO_2$ diagram (Cox, K. G., et al., 1979), the granitic rocks in the survey area fall into the region of granite to syenite and are clearly classified into the group that contains only less 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 (>5%). Those granitic rocks in the Preobrazhenskiy complex examined during the Phase II survey and 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 in the Preobrazhenskiy complex examined during the Phase II survey and that contained more than 1% of TiO_2 were lean in alkali, but were rich in MgO and ΣFeO.

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). Fig. II-2-9 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 (SI) 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 2-5 shows SIs of granitic rocks in the survey area. S.I.s of granitic rocks that contain less than 0.4% of TiO_2 as in the Karaotkel complex are below 6 and are mostly 3 or less. S.I.s of some granitic rocks containing more than 1% of TiO_2 as in the Preobrazhenskiy complex examined during the Phase II survey are higher than 10.

The De la Roche R1 - R2 diagram plots R1= 4Si-11(Na+K)-2(Fe+Ti) on the axis of abscissas and R2=6Ca+2Mg+Al on the axis of ordinates to classify granitic rocks by origin. It can classify granitic rocks into the mantle origin, plate hem origin, Caledonian Orogenic Belt origin, late orogenic belt origin, anorogenic belt origin and crustal fusion origin (Richard et al. (1985)). Fig. II-2-18 shows the De la Roche R1-R2 diagram of the granitic rocks of the Kokpentinskaya area. The monzonite and diorite of the Preobrazhenskiy complex can be classified into ranges that intruded during the plate collision period and granite, into the late orogenic period. The syenite and granite of the Karaotkelskiy complex can be classified into ranges that intruded from the late orogenic period to the anorogenic period. The Kokpentinskaya area is located in a collision area between the Kazakhstani continent and former Gorny Altai continent. The collision is estimated to have occurred in the final period of the Hercynian tectonic movement in the Carboniferous Period of the Palaeozoic Era along the Charsko-Zimunayskaya fracture zone stretching 800km (10-15 to 70km in width) in NW direction. The Baladzhalskiy fault running in WNW-ESE direction forms part of this fracture zone and is considered as the path of molten magma. When studied in conjunction with the results of the K-Ar age determination that is described later, it can be interpreted that monzonitic magma intruded into the collision area between the Kazakhstani continent and former Gorny Altai continent around the early Carboniferous Period (300Ma) first started differentiation.

Syenite intruded between the early Carboniferous Period and late orogenic period in the late Permian Period (295Ma). Granite differentiated during the anorogenic period of the late Permian Period (280Ma) and intruded along this fracture zone.

The CIPW normative values calculated based on the whole rock analysis are shown in Appendix 2-7.

The classification of granitic rocks by the normative albite - orthoclase - quartz ratio diagram (Streckeison, A. L., 1967) classifies syenite into the region of quartzose monzonite and granitic rocks into the region of monzonitic granite region, belonging to a group that contains only less than 1% of TiO_2. It clearly divides these regions from a group that contains more than 1% of TiO_2 as in part of the Preobrazhenskiy complex surveyed in Phase II (See Fig. II-2-10.).

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 2-6 shows the results of the analysis.

When data of the Preobrazhenskiy complex is integrated, the values of trace components relative to SiO_2 in parent ferrous elements such as Ni and Co tend to decrease as SiO_2 increases. Conversely, the values of trace components in parent copper elements such as Cu and Pb tend to level off or slightly decrease when SiO_2 increases, while Pb slightly increases. 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. Compared with the Preobrazhenskiy complex, the Karaotkelskiy complex slightly lacks Ba, but is slightly rich in Ni and Pb (See Fig. II-2-11.).

Granitic rocks of Type I (igneous rock origin) and Type S (sedimentary rock origin) were proposed as classification of calc-alkali granitic rocks. These types were later fragmented into Type Cs (crustal sedimentary rock origin), Type Ci (crustal igneous rock origin) and Type M (mantle origin) (Richard et al. (1985)). Further, Type-I granite was fragmented into Type A (alkali or anorogenic belt origin) granite brought from the continental crust and Type M granite brought from fusion or the sinking part of the oceanic crust or from the mantle (Whelen et al. (1987)). Type A granite can be characterized by high SiO_2, Na_2O+K_2O and Fe/Mg ratio, REE excluding F, Zr, Nb, Ga, Sn, Y and Eu, and low CaO, Ba and Sr. It can be discriminated from other granite types by comparing the Ga/Al ratio, main components and Y, Ce, Nb and Zr. As minerals, it contains annite, alkali-amphibole and soda-pyroxene. Feldspar is alkali-feldspar and is generally a eutectic texture of plagioclase and orthoclase (Whelen et al. (1987)). Fig. II-2-17 plots the Ga/Al ratios, main components and Y and Nb of the granitic rocks of the Kokpentinskaya area. All the items can be plotted within the range of Type-A granite.

By plotting SiO_2, trace components and groups of trace components such as Rb-Y-Nb, Rb-Yb-Ta, Y-Nb, Tb-Ta, Rb-(Y+Nb) Rb-(Yb+Ta), intrusion positions (ocean ridge granite: ORG, volcanic arc granite: VAG, within plate granite: WPG and collision granite: COLG) of granitic rocks in a tectonic zone can be classified (Pearce et al. (1984). Among the granitic rocks of the Kokpentinskaya area, the granitic rocks of the Preobrazhenskiy complex can be plotted entirely as VAG and those of the Karaotkelskiy complex, as VAG to WPG (See Fig. II-2-19.).

The rare earth pattern obtained by normalizing rare earths in granitic rocks of the survey area using leedey chondrite becomes a concave pattern showing a negative anomaly of Eu as in the granitic rocks containing only less than 1% of TiO_2 as in the granitic rocks obtained from the Preobrazhenskiy complex during the survey in Phase II, while almost all granitic rocks contain only 0.4% of TiO_2 (See Fig. II-2-12.). Tu, et al., (1980) stated that granitic gneiss in ancient time 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 together with K, whose ion radius is similar, and is believed to have thickened in potassium feldspars and mica during end of magmatic crystallization differentiation (Brockley, 1978). Tu, et al., (1980) stated that granitic rocks with 250 or less of the K/Rb ratio in southern China were caused by refusion of existing rocks while those with 250 or more in the K/Rb ratio were caused by magmatic crystallization differentiation. These views support that the K/Rb ratios of both granitic rocks (gabbro, diorite and monzonite) containing more than 1% of TiO_2 and of the Karaotkelskiy complex (syenite and granite) containing only less than 1% of TiO_2 are 250 or more and that both are granitic rocks produced by crystallization differentiation of magma. Nevertheless, Rb of granitic rocks containing more than 1% of TiO_2 proportionately increases as K_2O increases. Rb of granitic rocks containing only less than 1% of TiO_2 slightly decreases as K_2O increases (Fig. II-2-13). These two types of granitic rocks show different behaviors 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 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 by the Rb/Sr ratio also (See Fig. II-2-15.).

3) Magnetic Susceptibility of Granitic Rocks

The measured magnetic susceptibilities are presented in Appendix 2-19. The measured magnetic susceptibility of granitic rocks is generally below 0.3×10^{-3} S.I.U., averaging about 0.15×10^{-3} S.I.U., and is generally low. The measurement locations tended to concentrate on the northern to the western parts of the survey area where the outcrops were distributed. Therefore, a magnetic-susceptibility contour diagram could not be prepared.

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 $0.\ 5 \times 10^{-3}$ 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 (D.I.) increases (See Fig. II-2-9.). Therefore, the magnetic susceptibility of granitic rocks tends to increase, larger the content of ferromagnetic minerals is, such as magnetite and titanic magnetite (See Fig. II-2-9.).

4) Opaque Minerals in Granitic Ores

(1) Modal ratio of opaque mineral

Mode ratios of opaque minerals (ilmenite, magnetite and other minerals) in the granitic rocks measured by a microscope are presented in Appendix 2-5. The distribution of samples of granitic rocks that could be sampled was not uniform and concentrated on the northern to western parts of the survey area, where the outcrops were found. Therefore, the distribution trend of opaque minerals cannot be described unqualifiedly. However, mode ratios of syenite and granite in the northern seam of the Karaotkelskiy were below 1%, but granite in the western seam showed slightly high ratios, 1 to 2%. This suggests the trend that TiO_2 is high, higher the mode ratio of an opaque mineral is (See Fig. II-2-3.).

(2) Mineral composition of opaque mineral

Appendix 2-19 shows results of an EDX semi-quantitative analysis by a microscope of opaque minerals in granitic rocks randomly selected and the names of the minerals. Fig. II-2-4 shows the distribution of them.

The opaque minerals in granitic rocks of the Karaotkelskiy complex 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.

Most of the opaque minerals in granitic rocks are ilmenite or altered ilmenite. Some seams in the hills in the northern part of the survey area contain about 30% of magnetite. Granitic rocks containing more than 50% of titanic magnetite and magnetite are distributed in the western to southwestern parts of the survey area. The magnetic susceptibility in these parts is about 0.2 to 0.5×10^{-3} S.I.U. and is slightly higher than about 0.15×10^{-3} S.I.U. which is the average for other parts.

Ilmenite is euhedral or subhedral and often accompanies hematite, goethite and magnetite. Sample G-378 showed ilmenite which accompanied magnetite that became goethite. Sample I-232 showed parts that were discolored to bright colors in 5 to 30 μm in width along external edges of ilmenite grains and cracks inside grains and were altered to a coarse and bulky texture. Compared with parts that were not altered, these parts contained less Mn and Fe and much Ti was contained (Appendix 2-8). Sample I-232 contained grains whose cores were ilmenite (TiO_2 51%, Fe_2O_3 39.4%, MnO 4.2%) and parts around the cores were mixed with grains that were altered to pseudorutile or leucoxene (TiO_2 67.4%, Fe_2O_3 31.3%, MnO 1.3%). Ilmenite grains sometimes have a magnetite core in the center and ilmenite alters to altered ilmenite or pseudorutile by weathering alteration. Sample G-433 contained grains whose cores were altered to magnetite (average TiO_2 2%, Fe_2O_3 98.0%, MnO 4.1%) and whose parts around the cores were altered to altered ilmenite (average TiO_2 53.3%, Fe_2O_3 42.6%, MnO 4.1%). Sample G-445 contained grains whose cores were altered to magnetite (average TiO_2 0%, Fe_2O_3 100.0%, MnO 0%) and whose parts around the cores were altered to pseudorutile (average TiO_2 62.4%, Fe_2O_3 31.3%, MnO 6.5%).

Almost all ilmenite that was weathered and separated from granitic rocks was altered to pseudorutile. Concentrates produced by a test plant in the Karaotkel ore-dressing plant (Karaotkel Pit 2) showed TiO_2 47.7%, Fe_2O_3 46.5% and MnO 5.8% for unaltered parts compared with TiO_2 58.6%, Fe_2O_3 35.3% and MnO 2.1% for altered parts (Appendix 2-20). Powder X-ray diffraction tests of concentrates detected large amounts of pseudorutile, zircon and quarts, small amounts of hematite, ilmenite and rutile and a very small amount of plagioclase (Appendix 2-4). This suggests that ilmenite had already been weathered and altered while it was contained in granitic rocks and that Fe leached through edges and cracks of grains, to enrich Ti and to produce altered ilmenite and pseudorutile. Ilmenite then was separated from country rocks and was oxidized during sedimentation and thickening so that almost all ilmenite would become pseudorutile.

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 Preobrazhenskiy complex was generally low, below 0.3×10^{-3} S.I.U.

5) K-Ar Age Measurement of Granitic Rocks

A K-Ar age measurement was performed with the following five samples to calculate the intrusion age of granitic rocks and to estimate the process of magma differentiation and other processes: 3 samples from the Preobrazhenskiy complex surveyed in Phase II (D-2 gabbro, D-3 biotite granite, D-4 monzonite) and 2 samples from the Karaotkelskiy complex surveyed in Phase III (D-5 granite, D-6 syenite). The samples were sampled from as fresh outcrops as possible. The work to separate minerals containing potassium and to measure them was contracted to the Department of Geochronology and Isotopic Geochemistry, Activation Laboratories Ltd. of Ontario, Canada. The K content was analyzed by ICP and Ar by a rare-gas mass analyzer. Fig. II-2-1 shows the locations where the samples were sampled. Fig. II-2-16 and Table II-2-1 summarize sample minerals and measurement results.

Sample D-2 was gabbro and consisted of 35% (in volumetric ratio) of plagioclase (intermediate feldspar) 1 to 3mm in grain size that was partially or completely sericitized, 50% of amphibole 0.5 to 3.5mm in grain size partially replaced by biotite and actinolite, 3% of orthopyroxene 2mm or less in grain size, 4% of biotite 3mm or less in grain size partially replaced by chlorite and 8% of sericite in micro grain size. Amphibole that was least altered was measured. Sample D-3 was biotite granite coarse in grain size and consisted of 25% (in volumetric ratio) of plagioclase 2 to 3.5mm in grain size that was partially sericitized, 25% of orthoclase 2 to 4.5mm in grain size that was partially sericitized, 25% of quartz 0.5 to 3mm in grain size that was recrystallized, 20% of perthite, 4% of biotite 1 to 3mm in grain size, 1% of amphibole that is partially replaced by biotite, and other minerals. Plagioclase that was least altered was used for measurement. Sample D-4 was olivine augite monzonite coarse grained and consisted of 35% (in volumetric ratio) of plagioclase (albite - intermediate feldspar) 0.5 to 3.5mm in grain size, 30% of orthoclase 1 to 4mm in grain size, 22% of perthite 2 to 4mm in grain size containing laminas of alkali-feldspar, 5% of augite 0.5 to 1.5mm in grain size, 4% of peridotite 1mm or less in grain size, 1% of amphibole that replaces hems of peridotite and other minerals. Plagioclase that was least altered was used for measurement. Granite Sample D-5 was extremely coarse grained and was made up 55 to 60% (in volumetric ratio) of potassium feldspar 3 to 6 mm in grain size with a perthite texture, 25% of quartz 0.5 to 4mm in grain size, 20% of plagioclase (gray albite) 1 to 1.5mm in grain size, 0.5% of clinopyroxene 0.6mm in grain size, 0.5% of amphibole 0.3 to 1.5mm in grain size, and other minerals. Plagioclase that was least altered was used for measurement. Sample D-6 of quartzose-syenite was coarse grained and was made up 55 to 60% (in volumetric ratio) of slightly sericitized potassium feldspar with a perthite texture 1.5 to 7mm in grain size, 25% of plagioclase (gray albite) 1 to 4mm in grain size, 5% of amphibole 2.5mm in grain size, 10% of quartz 0.5 to 3mm in grain size, a small amount of biotite, and other minerals. Plagioclase that was least altered was used for measurement.

Table II-2-1 K-Ar dating result of granitoids.

No.	Sample No.	Mineral	$^{40}Ar_{rad}$, nl/g	%K	$^{40}Ar_{air}$	Age(Ma)
1	D-2	amphibole	2.76	0.29	16.1	237.1±9.8
2	D-3	K-feldspar	74.39	6.33	2.1	284.7±4.9
3	D-4	K-feldspar	54.58	4.35	13.1	302.6±9.1
4	D-5	K-feldspar	73.15	6.43	1.1	276.0±6.5
5	D-6	K-feldspar	85.23	6.99	0.8	294.4±8.9

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 (See Fig. II-2-16.). 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, only gabbro had amphibole as a survey mineral, and authigenic actinolite was formed in some parts, so that younger age than actual age is shown.

According to 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 (Japan International Cooperation Agency and Metal Mining Agency of Japan, 2000).

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 indicates that the Preobrazhenskiy and Karaotkelskiy complexes forming simple rock masses 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 is estimated to have intruded into these rock masses in the mid-Triassic Period (240Ma).

2-3-5 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 Karaotkelskiy complex intruded into the Bektimirskaya ridge anticline situated in the middle of them. A fault in N40°E direction cuts the Maityab and Arkalyk layers of the Carboniferous Period in the western flank of the survey area.

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. The layers in the survey area are the Arkalyk layer of late Carboniferous Period (shale, siltstone, sandstone, tuff 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- to early Carboniferous Period (tuff, andesitic porphyrite sandwiching 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 Karaotkelskiy complex that intruded in the early part of the Carboniferous Period (294.4 ±8Ma) to the mid-Triassic Period (276.0 ±6.5Ma). The complex is ilmenite-series granitic rocks of Type S. Chemical composition analysis classifies it into syenite and granite.

Syenite and granite are the bulk of the Karaotkelskiy complex. They are rich in SiO_2, Na_2O and K_2O, but are lean in FeO, MgO and CaO. The solidification index of the complex is below 3, while it contains less than 0.4% of TiO_2 and its differentiation index is 85 or higher, mostly 90 or higher. The complex is rocks that are most advanced in magma crystallization and differentiation. Therefore, compared with the Preobrazhenskiy complex, the Karaotkelskiy complex is generally advanced in crystallization and differentiation and is low in the TiO_2 content. The ilmenite content of it is low and is considered not superior as an origin rock of ilmenite alluvial deposits.

The rare-earth pattern of the Karaotkelskiy complex shows that the 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. This shows that crystallization differentiation by magma is very advanced.

Opaque-mineral mode ratios of the granitic rocks are 2% or less with granite and 1% or less with almost other minerals. Opaque minerals are pseudorutile (Ti 36%), ilmenite (Ti 32%), titanic magnetite (Ti 1.5 to 14%), and magnetite (Ti 0 to 1.5%). The average magnetic susceptibility is about 0.15×10^{-3} S.I.U. and is generally low. More pseudorutile and ilmenite are contained than magnetite and titanic magnetite. However, quantities of them are small. Compared with the Preobrazhenskiy complex, the Karaotkelskiy complex generally is advanced in crystallization differentiation and has a low TiO_2 content, thus a low ilmenite content also. Therefore, it can be judged that the complex is not superior as origin rock of ilmenite alluvial deposits.

Results of K-Ar age determination of Karaotkelskiy and Preobrazhenskiy 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	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

(3) Bed-rock weathered crust

Weathered crusts of bedrock are clayey weathered remnants that were developed on sedimentary rocks, volcanic rocks and intrusive rocks of the Carboniferous Period in thickness of 10 to 40m. They are covered by the Aral Formation of the Neogene Period and Quaternary-period layers. They are strongly influenced by illite and kaolinization. Weathered crusts of bedrock are believed to have been formed by chemical weathering under moist and warm climate at the end of the early Cretaceous Period (about 140 million years ago). Some ilmenite and zircon are thickened in autochthonous sediments remaining in the area after water-soluble materials are carried away.

(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 layers of the Quaternary Period. According to existing drilling data, the formation is 1.5 to 37m in thickness, averaging 5.5m. The layer consists of clay, sandy clay and clayey sand comprising quartz, kaolin, smectite and a small amount of illite. The formation rarely sandwiches gravel beds. Clay sampled from the bottom of a Karaotkel test pit (Karaotkel Pit 1) is considered part of top seam of this formation and is made up of large amounts of kaolin and potassium feldspar, a medium amount of quartz and a small amount of plagioclase.

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

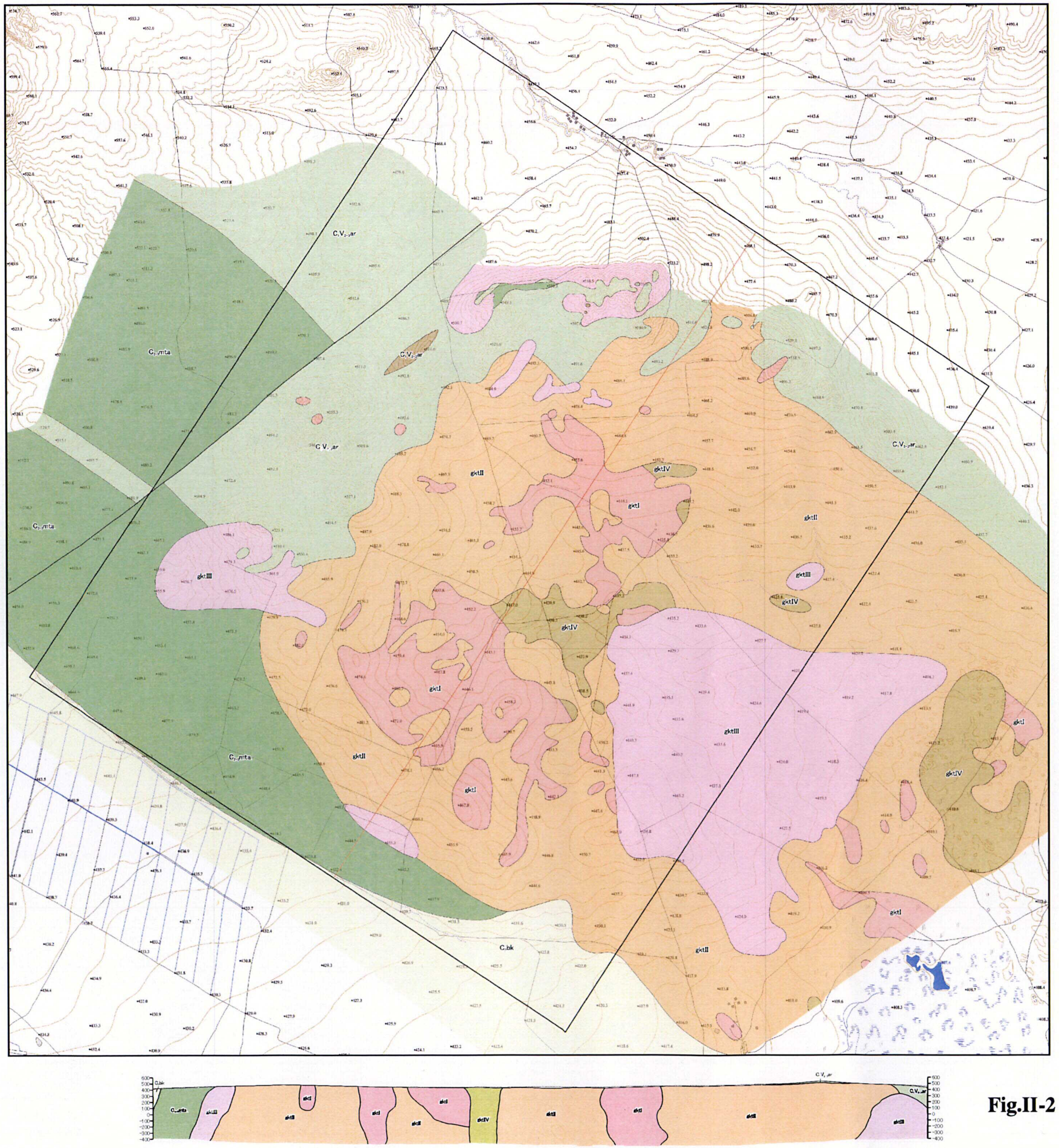
The Quaternary-period layers widely distribute in this area and cover the Aral layer of the Neogene Period and directly pregranitic rocks and intrusive rocks without conformity. The layers mainly consist of loam and riverbed sediments of small rivers that are cobblestone, gravel, sand, silt, loam and clay. The layers are 0.2 to 31.7m thick, averaging 5.7m.

2) Geological Structure

The extension of the Baladzhalskiy Fault in WNW-ESE direction from the survey area of Phase II passes the northeast side outside of the survey area while the extension of the South Terektinskiy Fault passes the southwestern side. The Karaotkelskiy complex intruded into the Bektimirskaya ridge anticline situated between them. A fault running in NEN-SWS direction cuts the Maityab and Arkalyk layers of pre-granitic rocks in the west of the Karaotkelskiy complex.

The Tertiary-period Aral Formation is a generally flat 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.



THE MINERAL EXPLORATION
IN
THE KOKPETINSKAYA AREA
THE THE REPUBLIC OF KAZFKHSTAN
(PHASE III)

Pl. II-2-1 Geological Map of Pre -Tertiary Basement

JAPAN INTERNATIONAL COOPERATION AGENCY
METAL MINING AGENCY OF JAPAN
JANUARY 2003

LEGEND

Carboniferous	Maityub formation	C_{2-3}mta	conglomerate, sandstone, siltstone, mudstone
	Bukon formation	C_1bk	conglomerate, sandstone, siltstone, mudstone
	Arkalyk formation	C_1V_{2-3}ar	shale, sandstone, conglomerate /magnetite rich sandstone
Permian to Jurassic	Karaotkel batholith	gktIV	gabbro
		gktIII	granite
		gktII	syenite
		gktI	diorite

Fig.II-2 Geological Map and Cross Section in the Surveyed Area

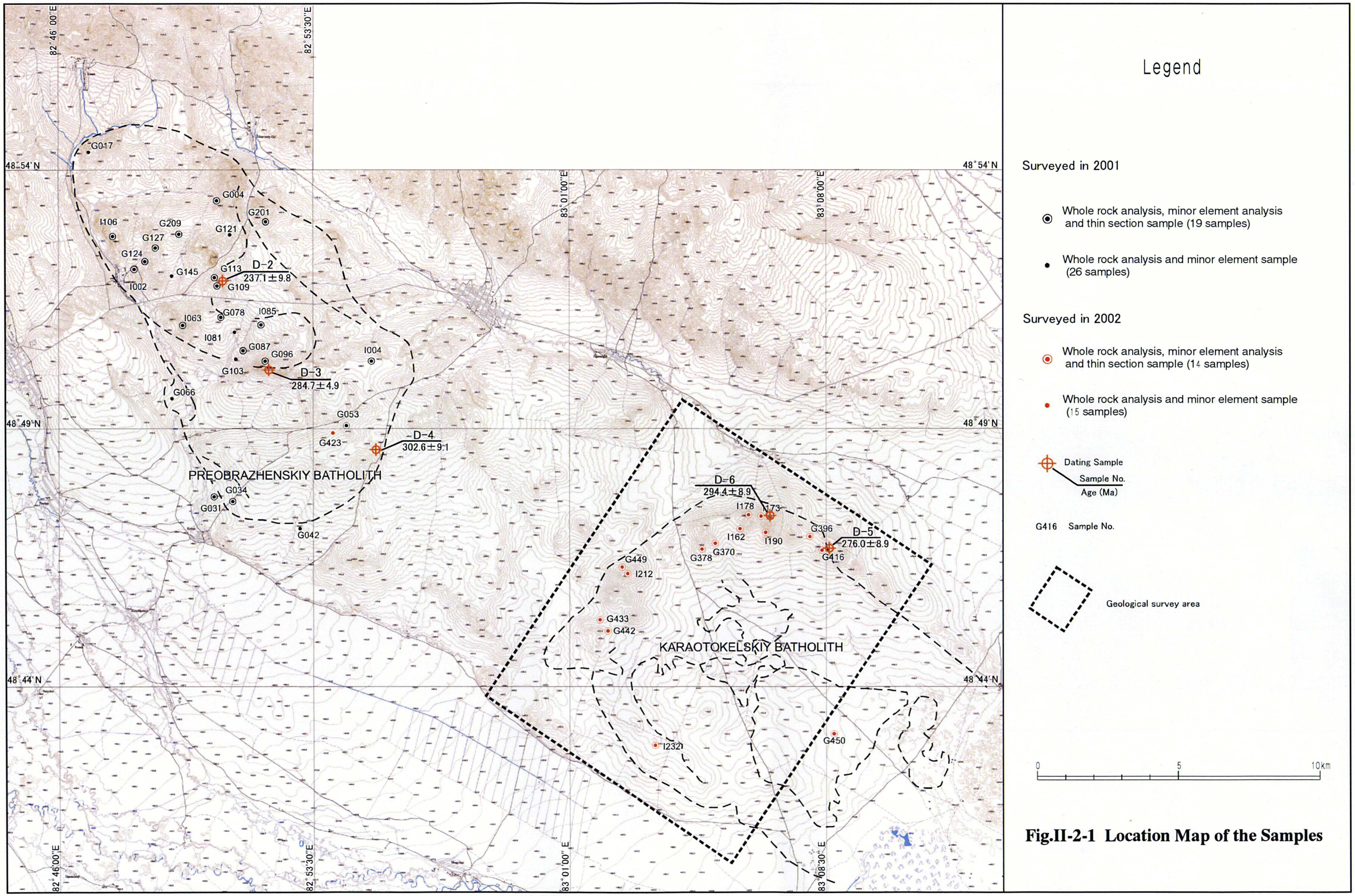


Fig.II-2-1 Location Map of the Samples

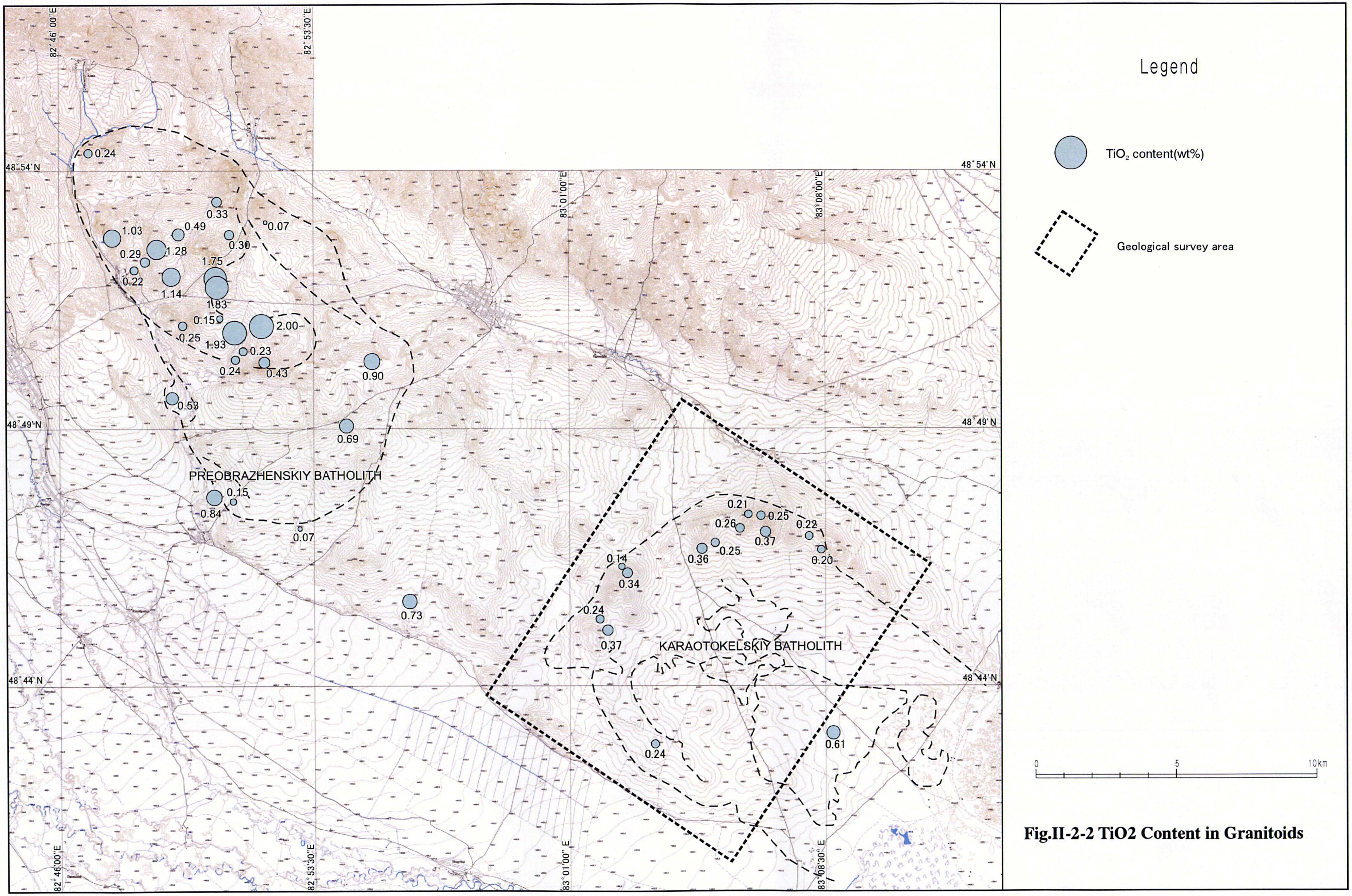


Fig.II-2-2 TiO2 Content in Granitoids

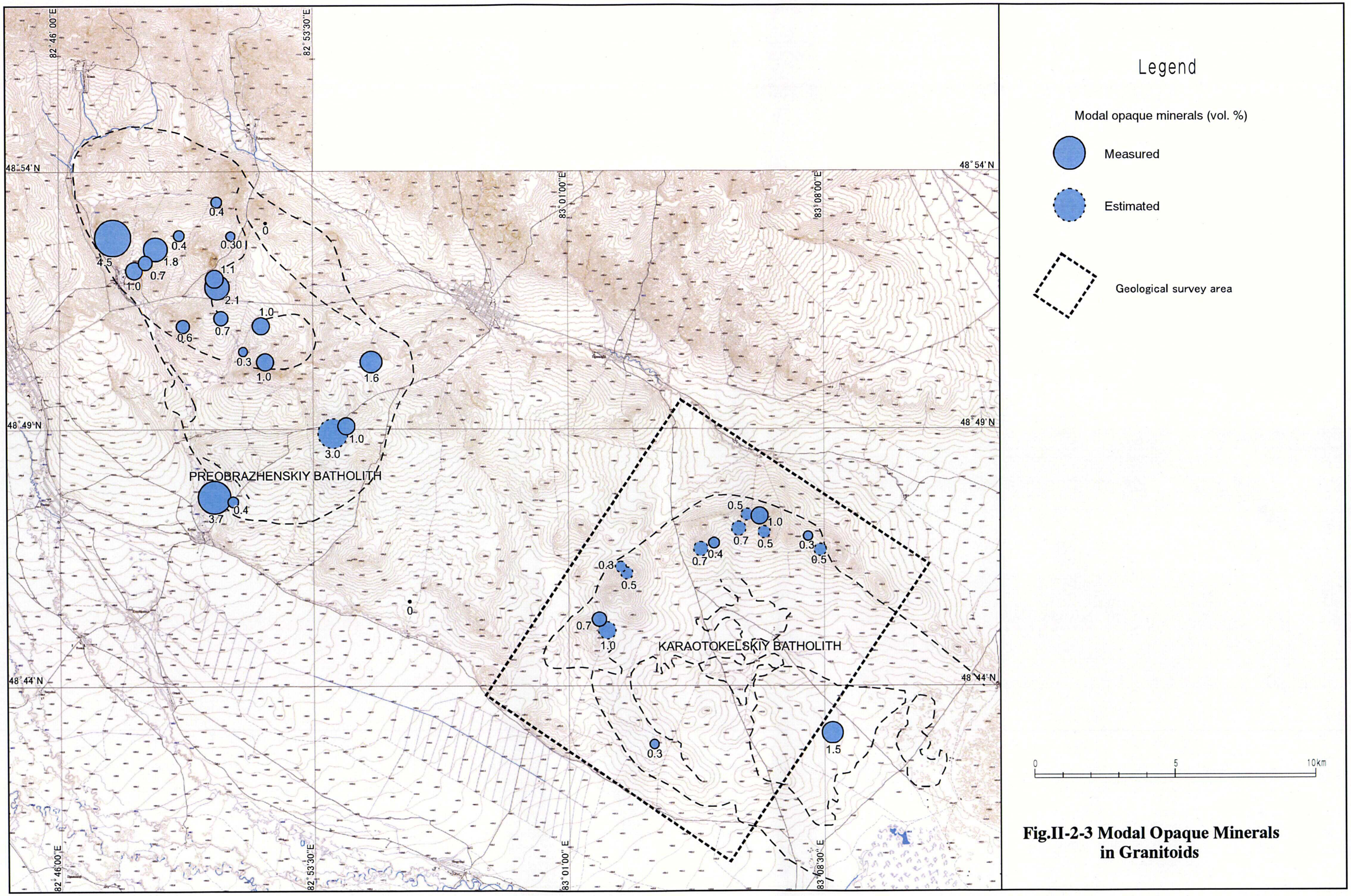


Fig.II-2-3 Modal Opaque Minerals in Granitoids

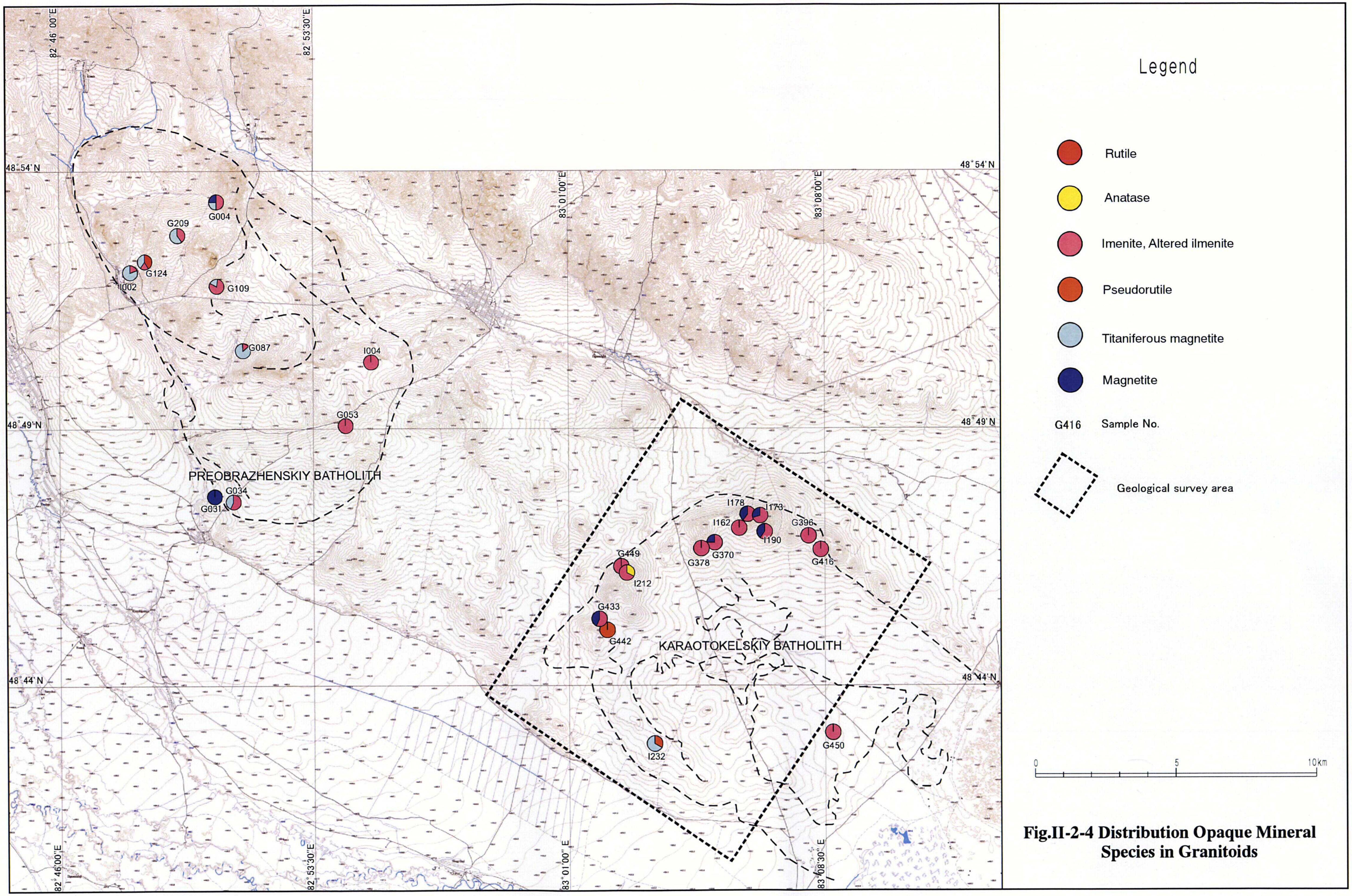


Fig.II-2-4 Distribution Opaque Mineral Species in Granitoids

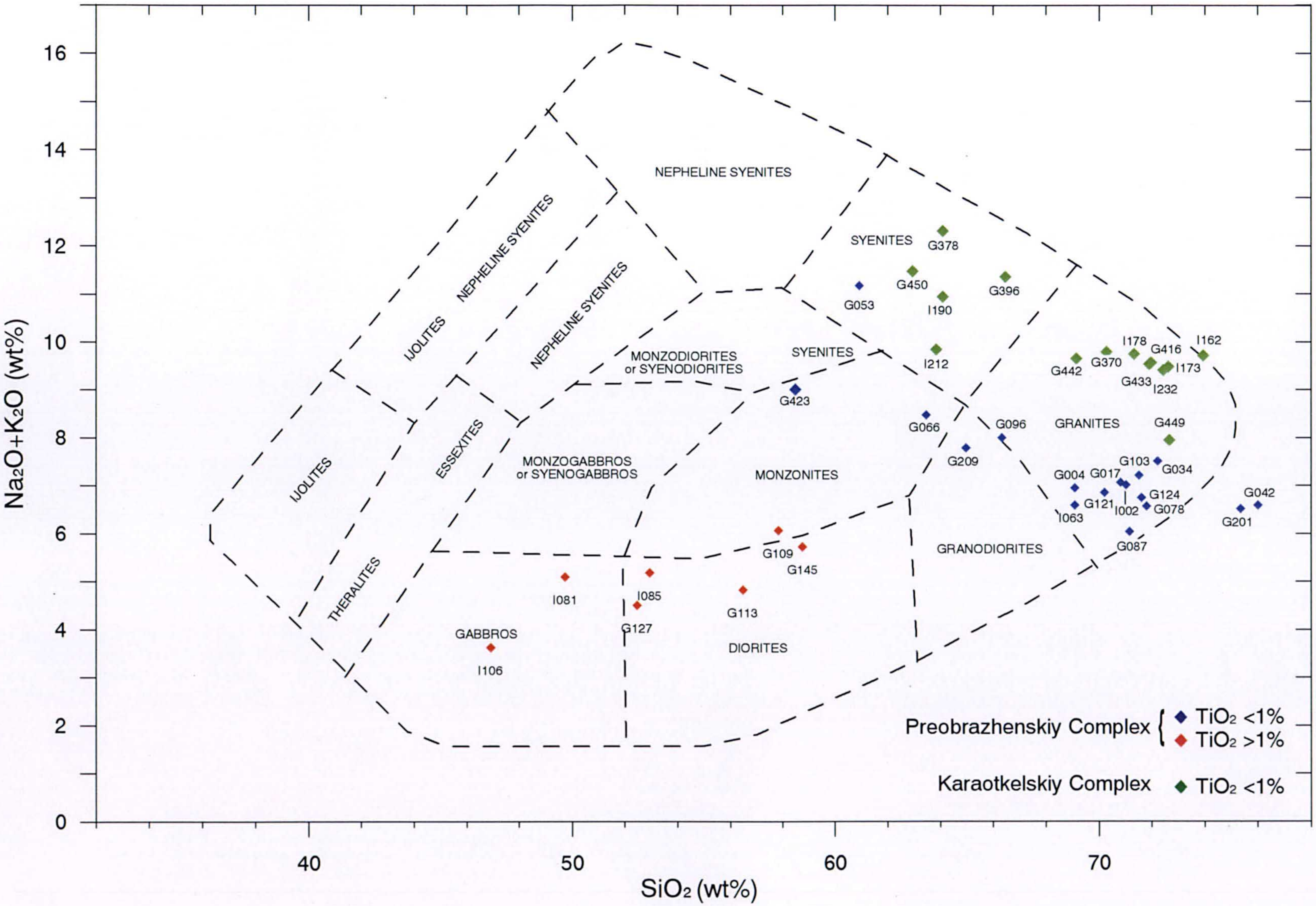


Fig.II-2-5 SiO_2-Na_2O+K_2O Diagram (after Cox et al., 1979)

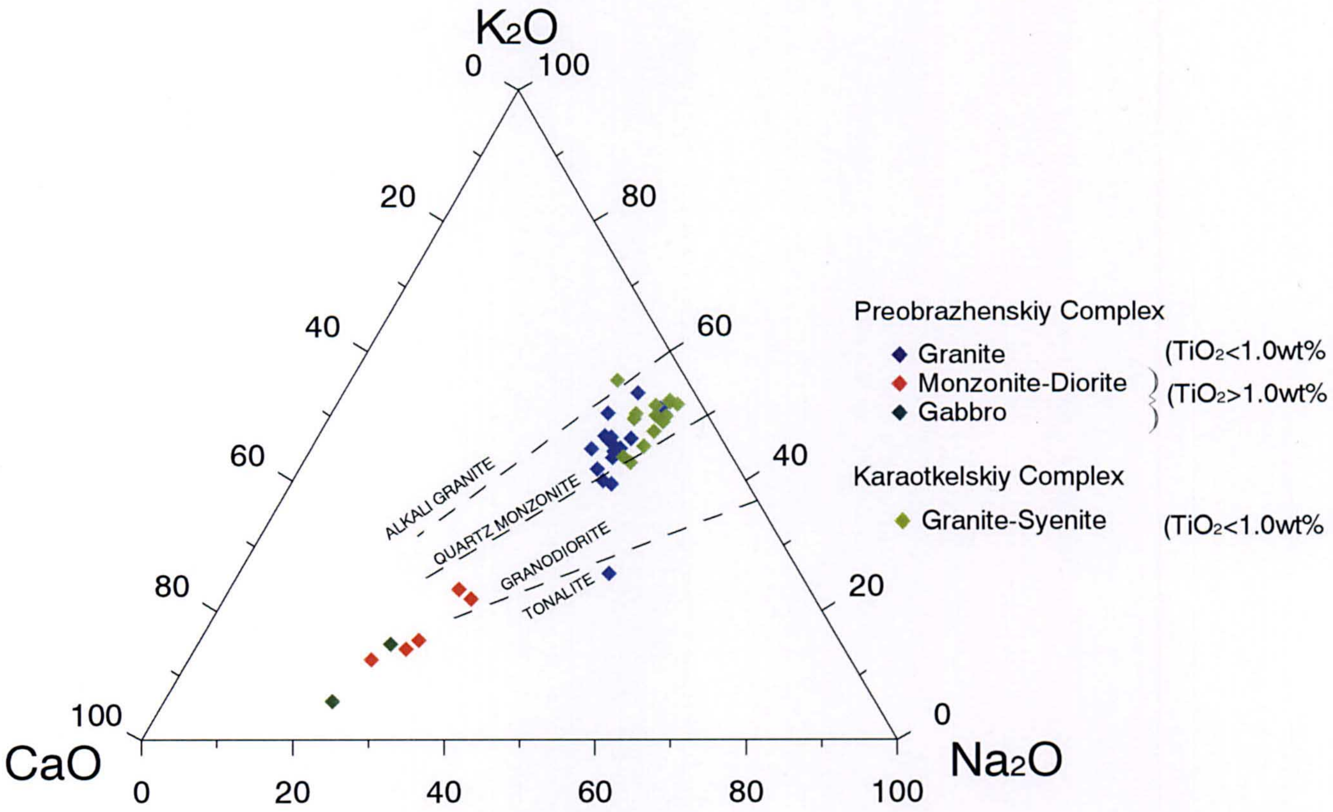


Fig.II-2-6 K_2O-CaO-Na_2O Diagram

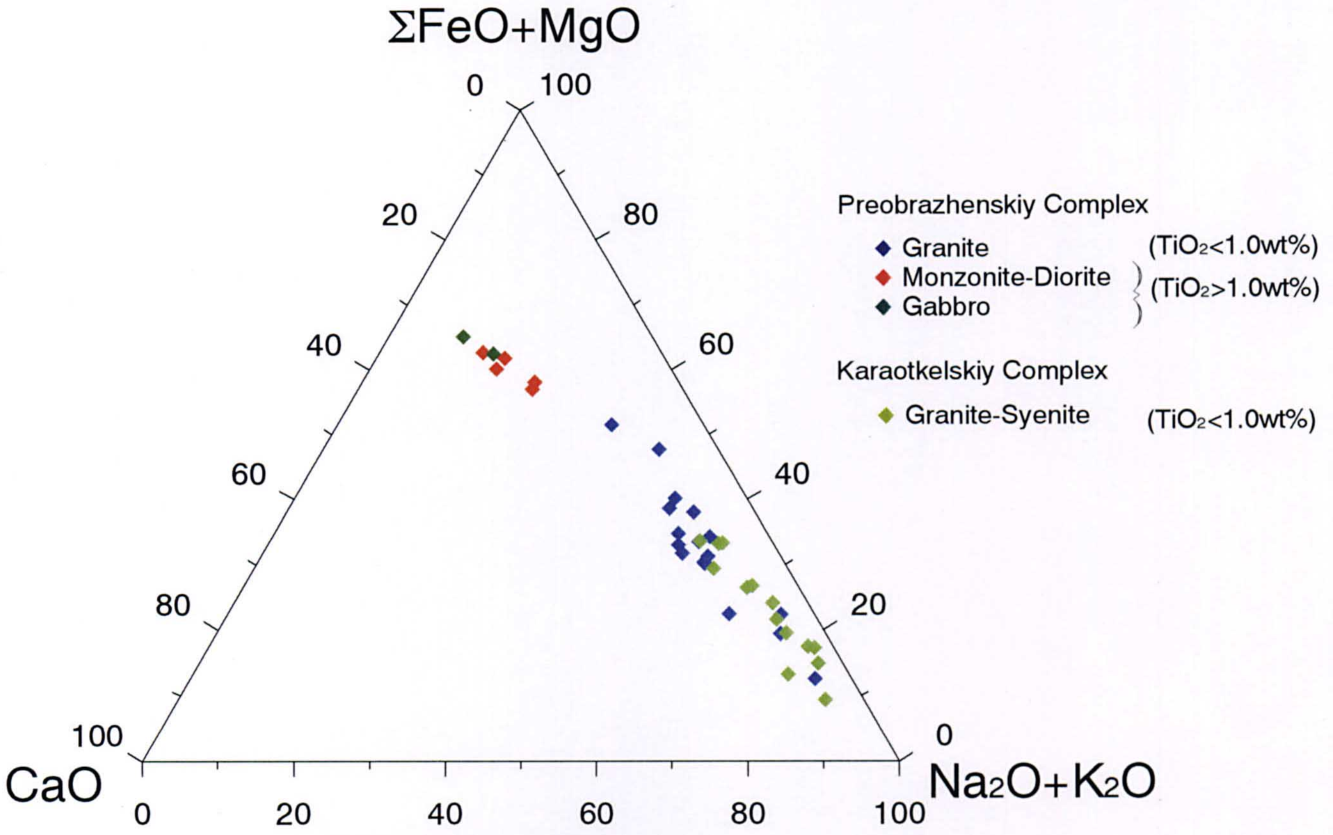


Fig.II-2-7 AFM(ΣFeO+MgO-CaO-Na_2O+K_2O) Diagram

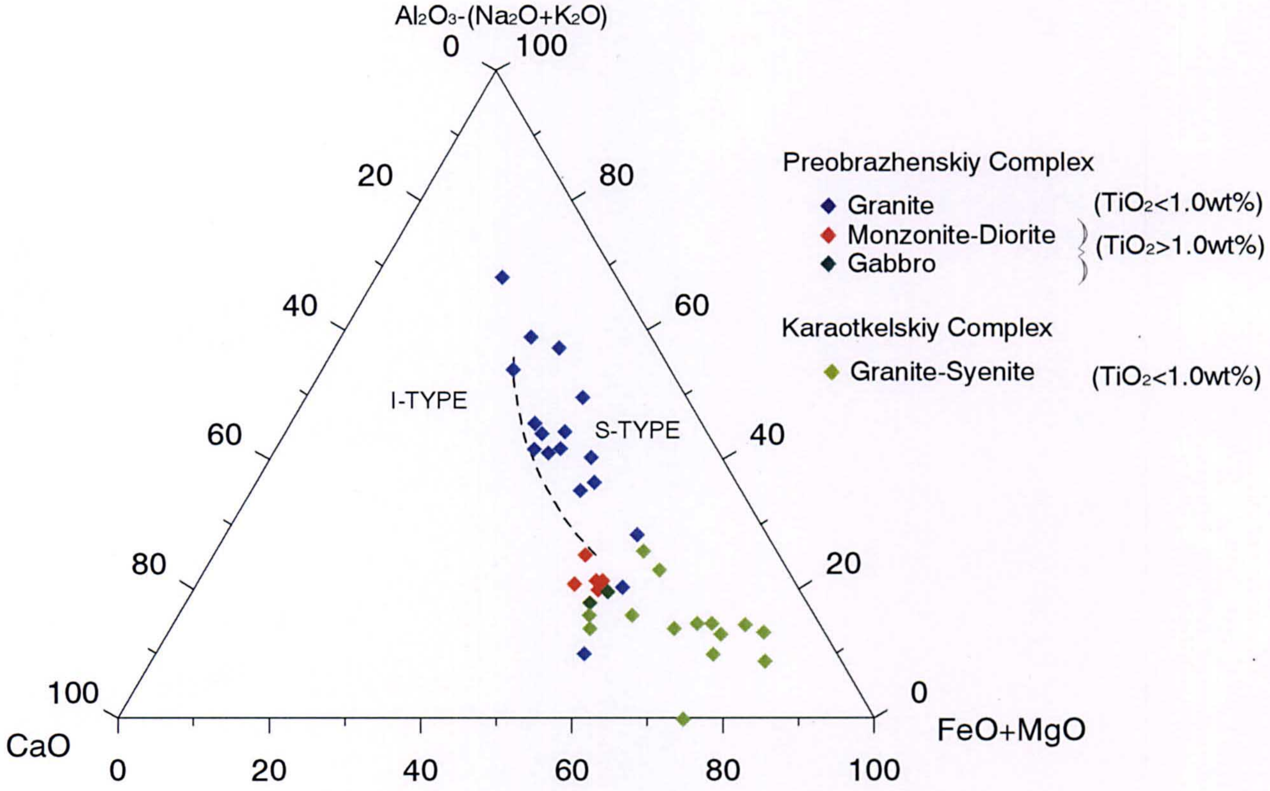


Fig.II-2-8 ACF Diagram

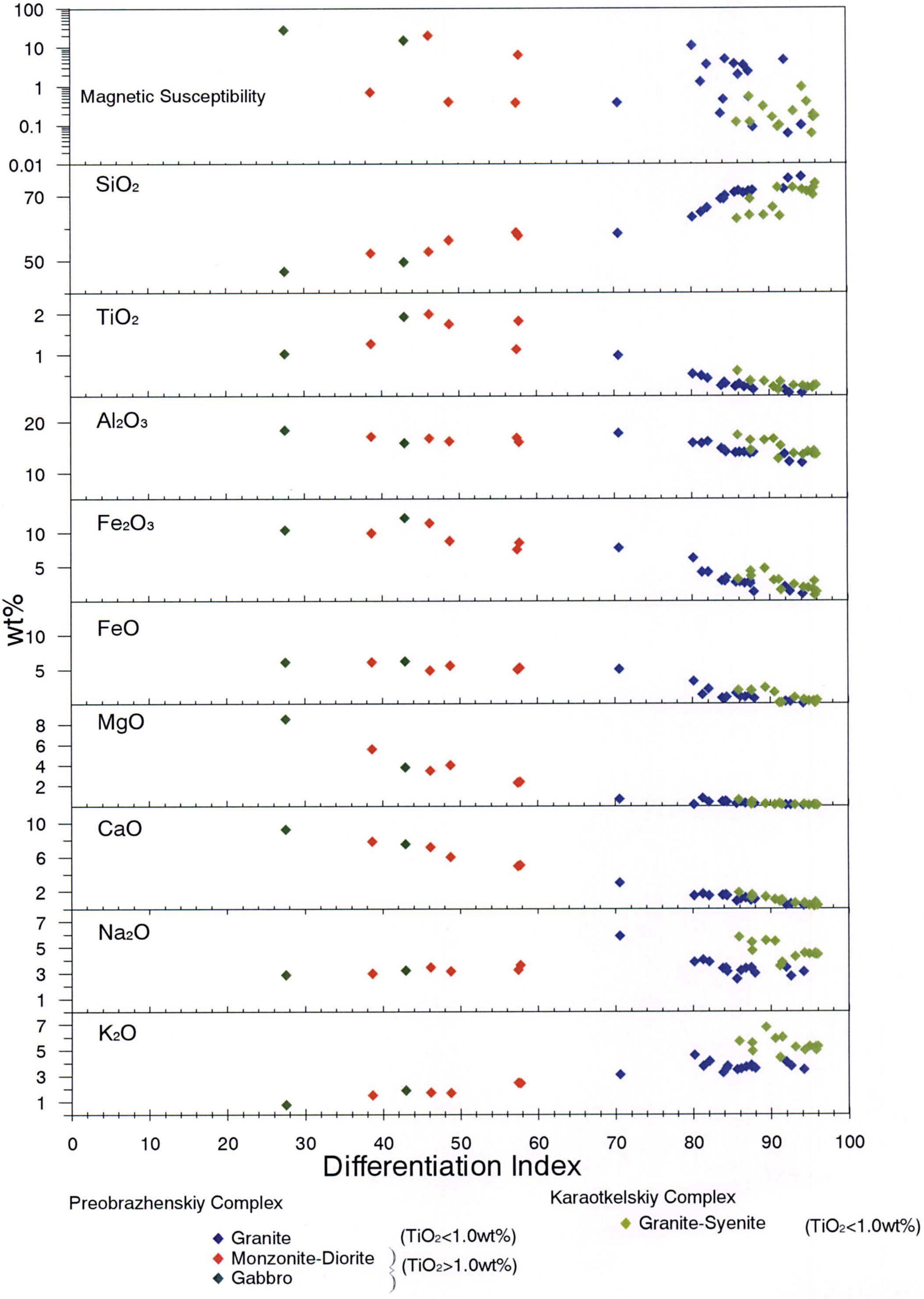


Fig.II-2-9 Differentiation Index (D.I.)-Oxide Variation Diagram

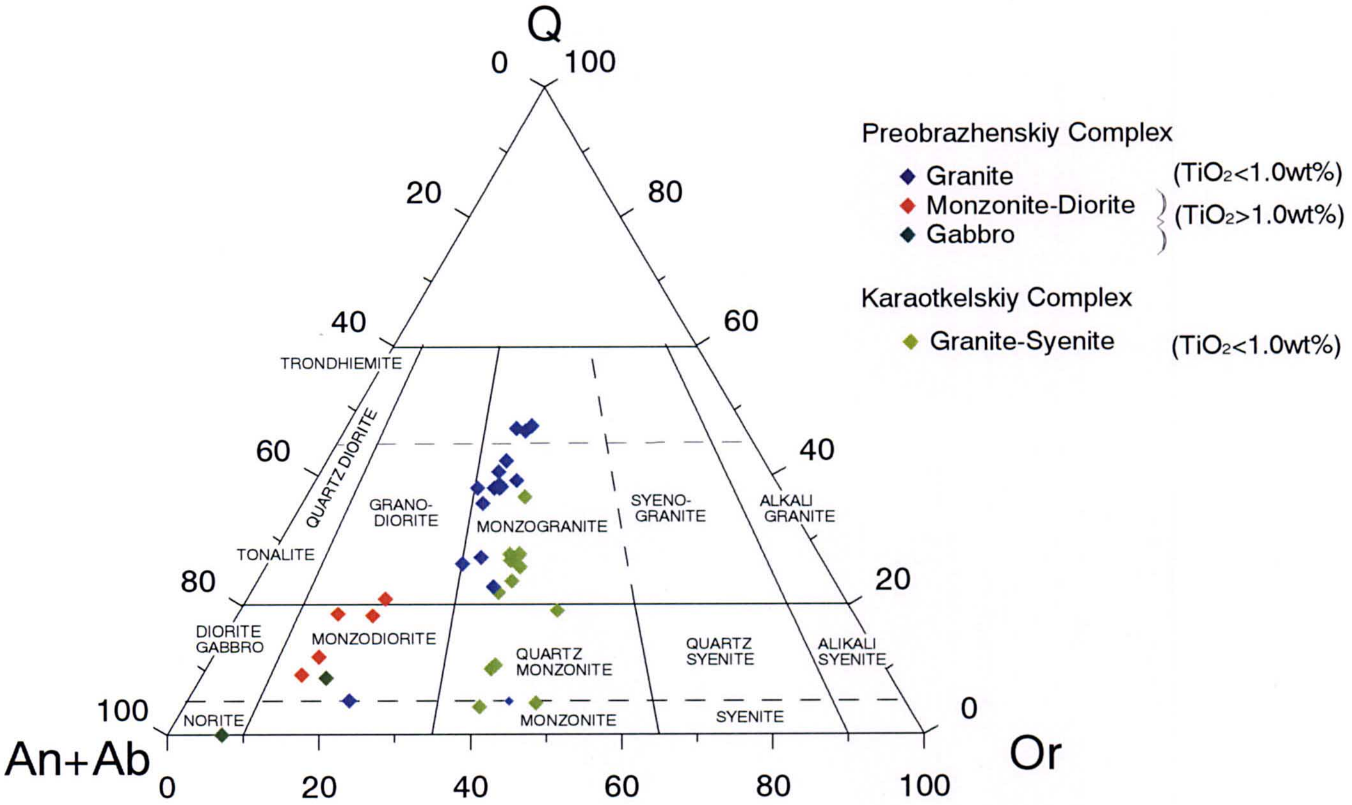


Fig.II-2-10 An+Ab-Or-Q Diagram

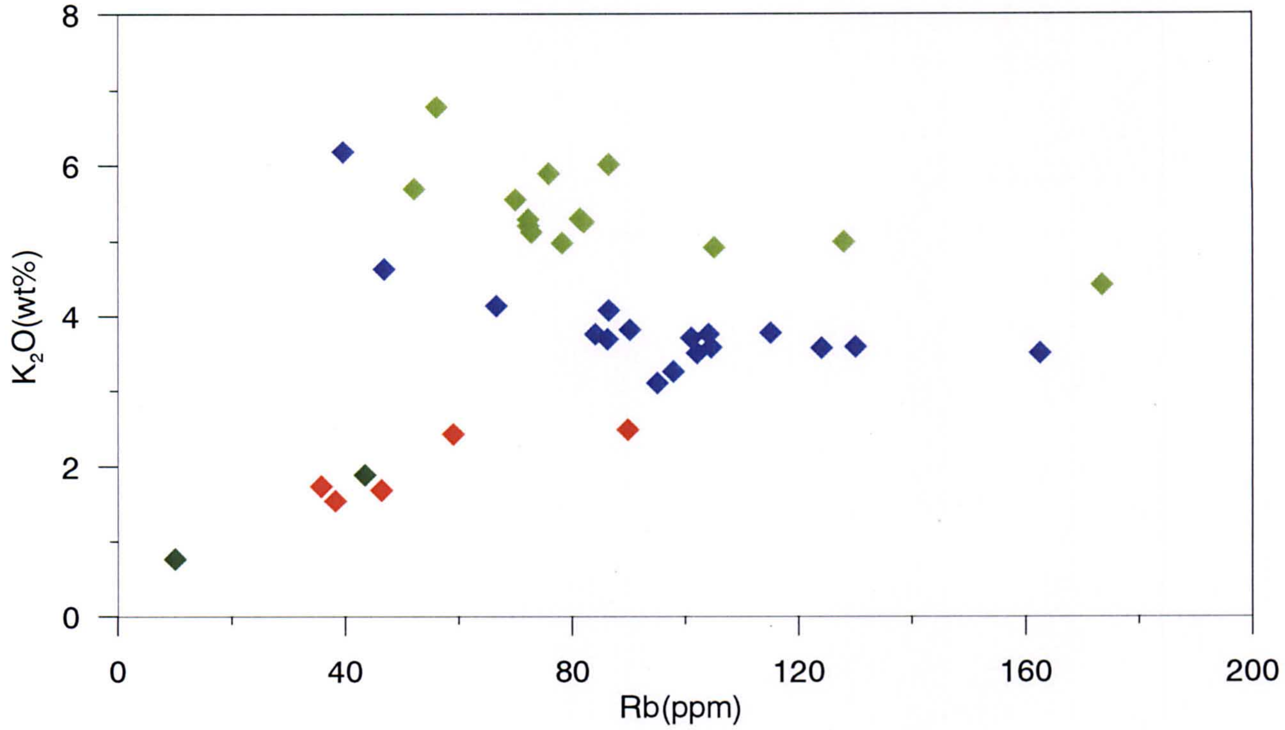


Fig.II-1-11 K_2O-Rb diagram

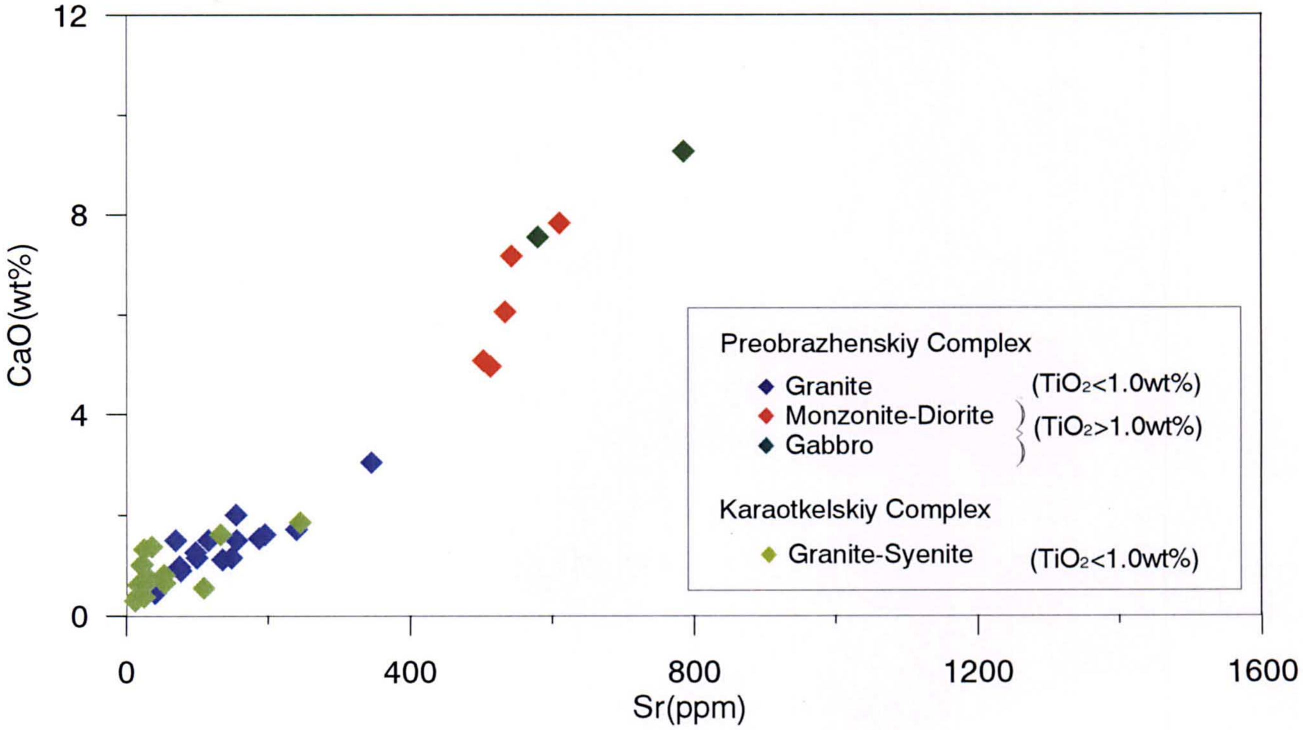


Fig.II-1-12 CaO-Sr diagram

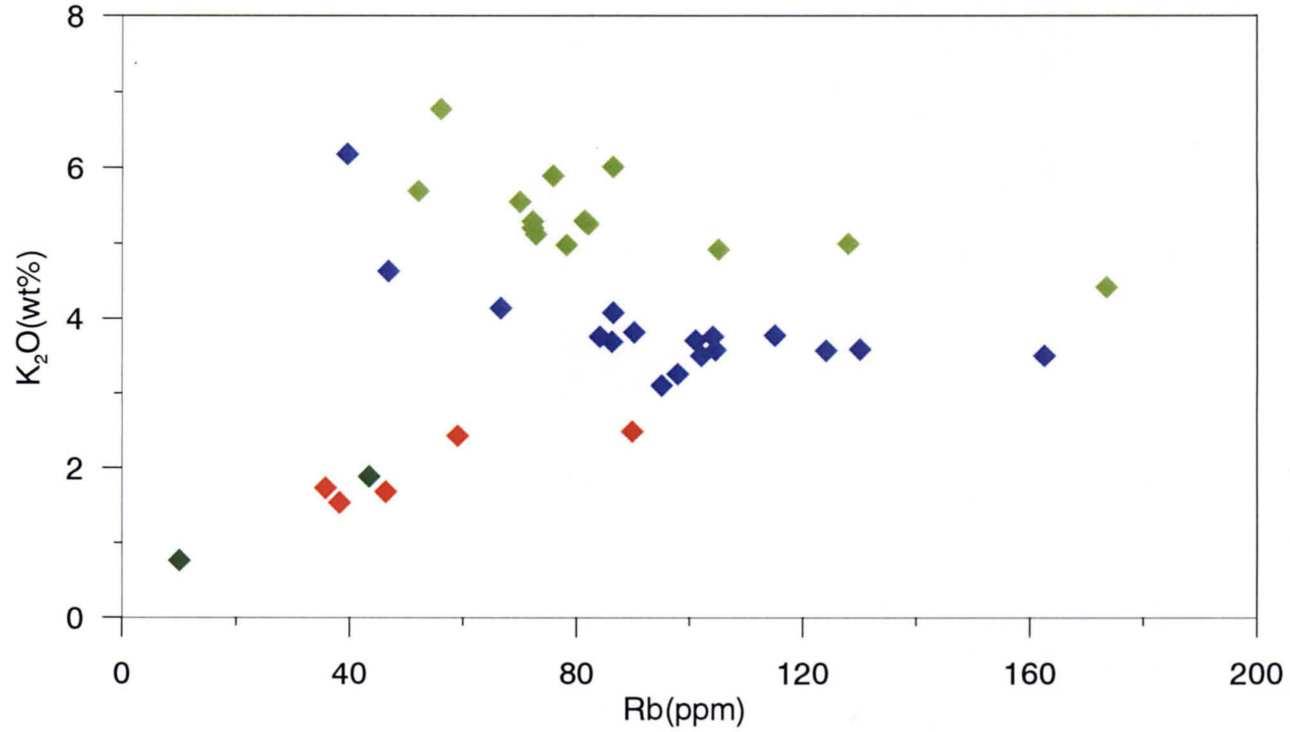


Fig.II-2-13 K$_2$O-Rb diagram

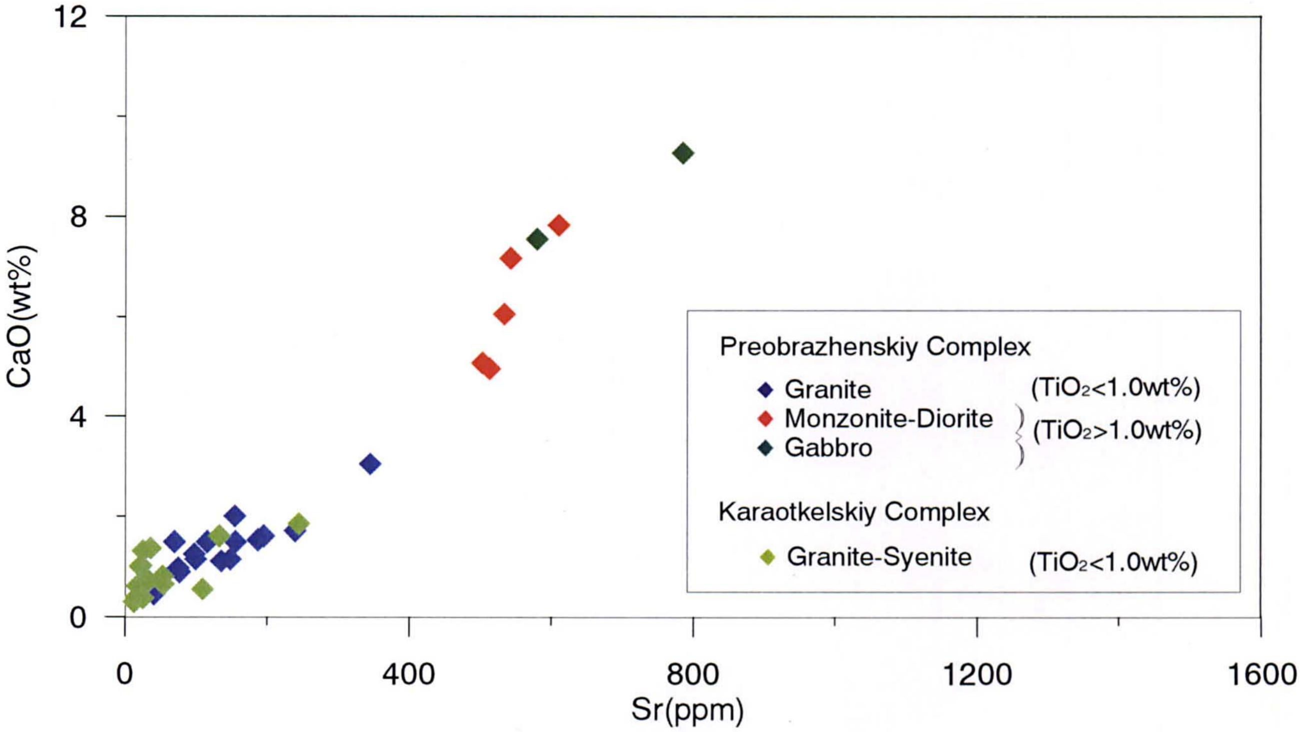


Fig.II-2-14 CaO-Sr diagram

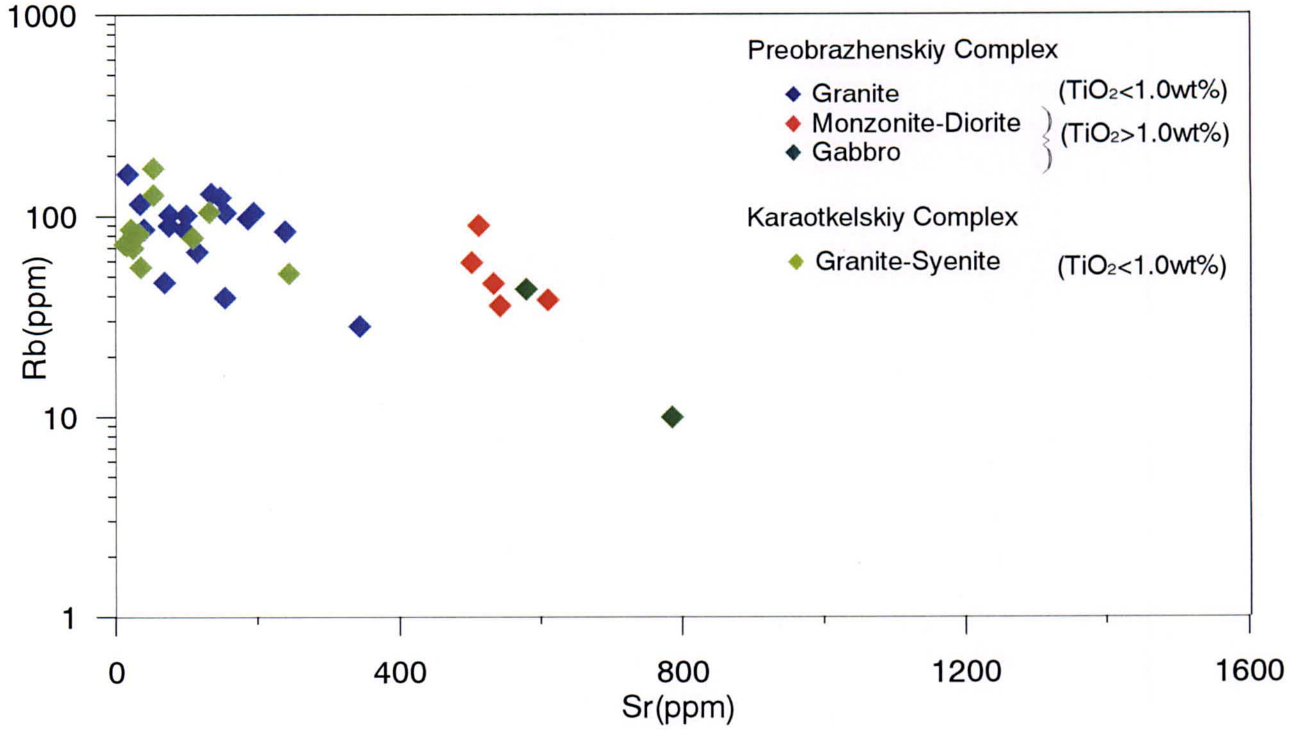


Fig.II-2-15 Rb-Sr diagram

No.	Sample No.	Mineral	$^{40}Ar_{rad}$, nl/g	%K	$^{40}Ar_{air}$	Age(Ma)
1	D-2	amphibole	2.76	0.29	16.1	237.1±9.8
2	D-3	K-feldspar	74.39	6.33	2.1	284.7±4.9
3	D-4	K-feldspar	54.58	4.35	13.1	302.6±9.1
4	D-5	K-feldspar	73.15	6.43	1.1	276.0±6.5
5	D-6	K-feldspar	85.23	6.99	0.8	294.4±8.9

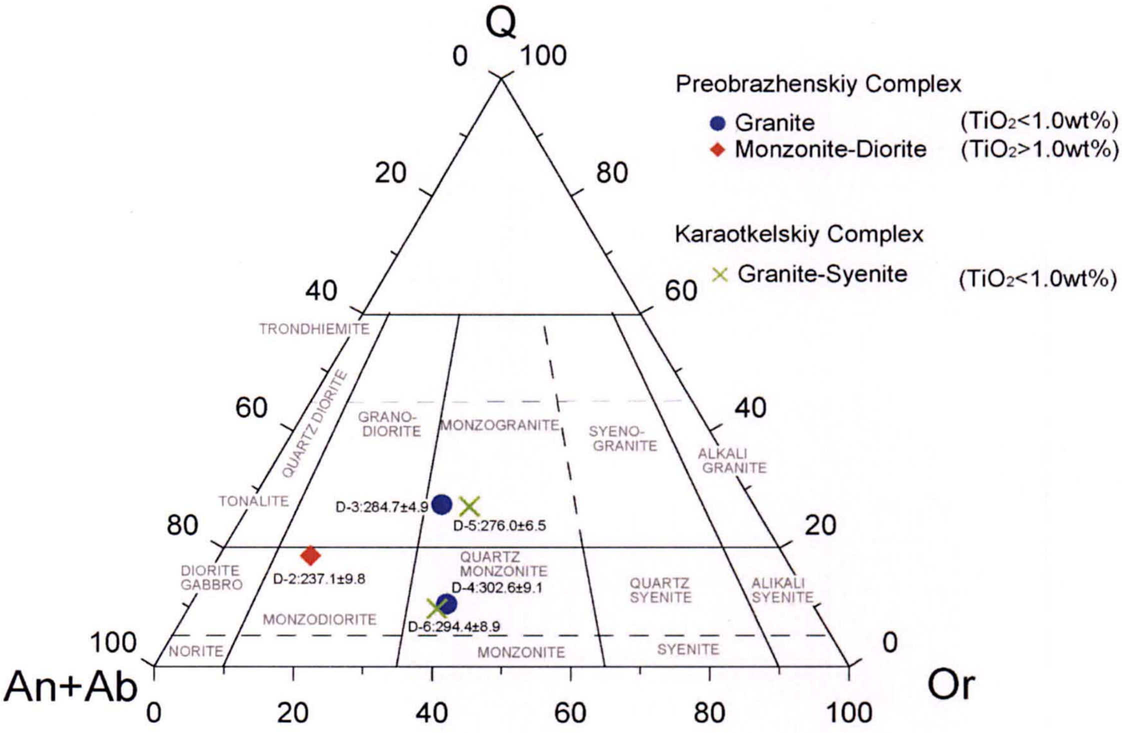


Fig.II-2-16 The Results of K-Ar Dating

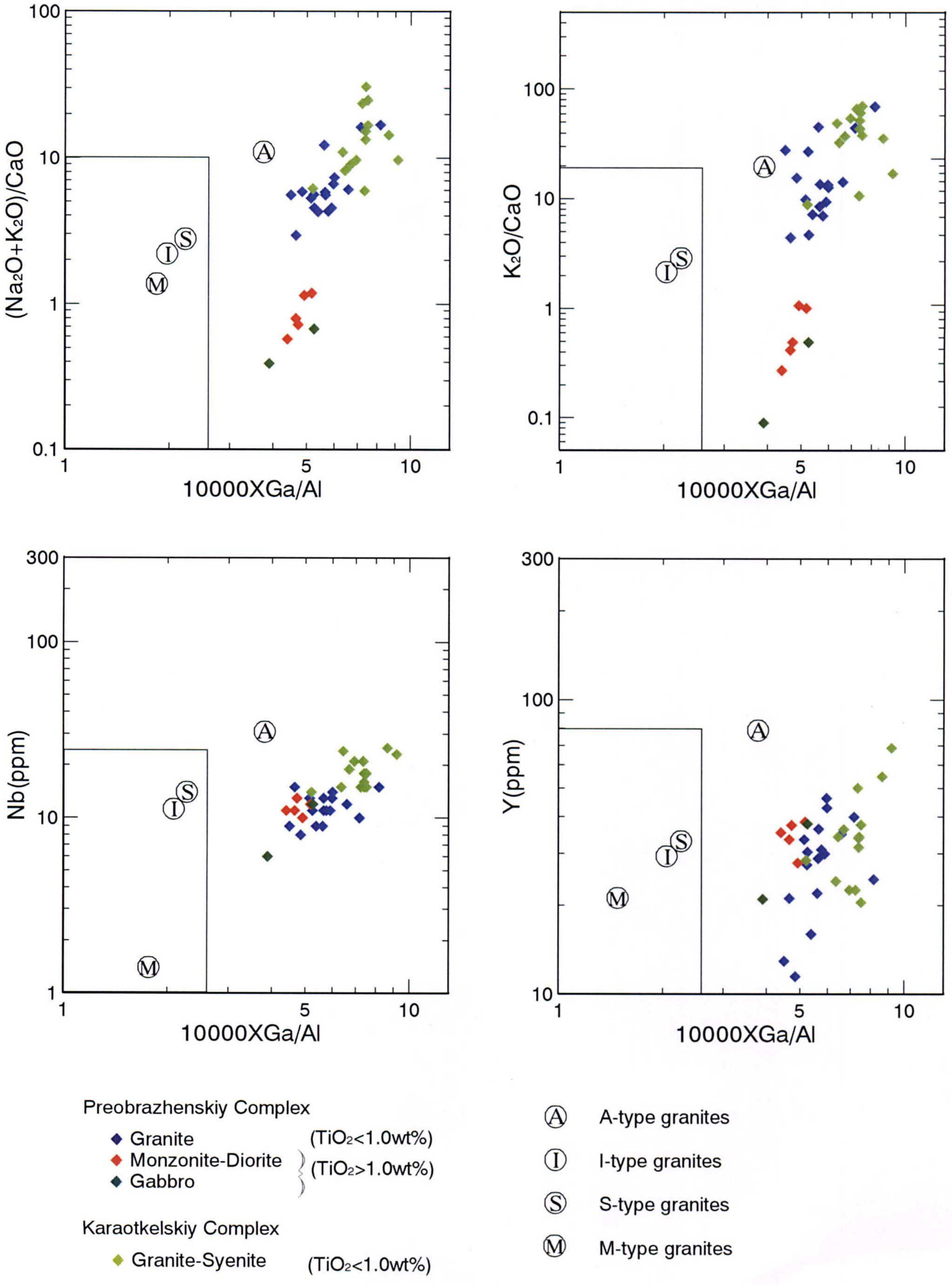
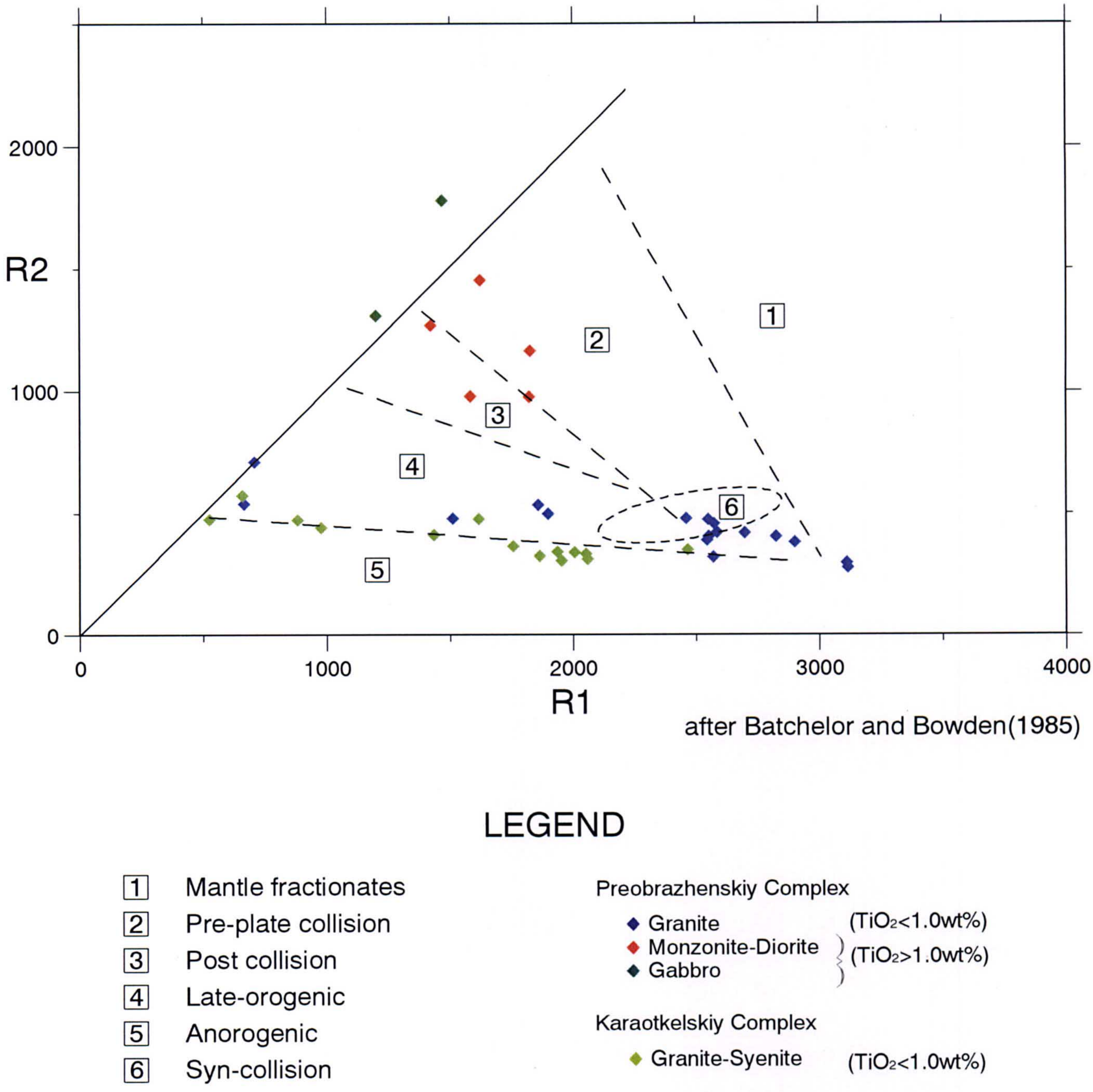


Fig.II-2-17 A-type granite discrimination diagram



R1 = 4Si-11(Na+K)-2(Fe+Ti)

R2 = 6Ca+2Mg+Al

Fig.II-2-18 R1-R2 diagram

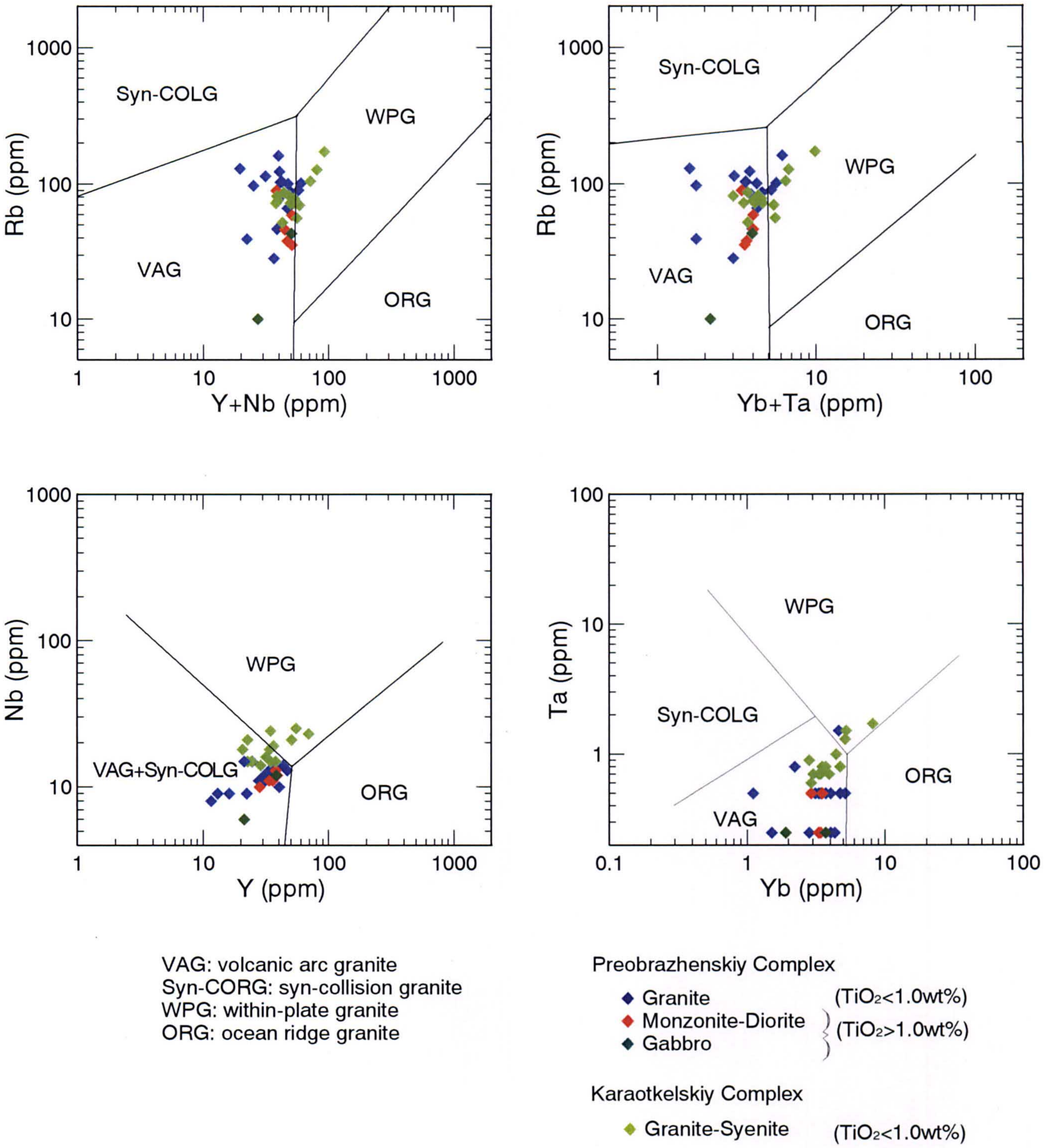


Fig.II-2-19 Trace element discrimination diagram (after Pearce, 1984)

CHAPTER 3　DRILLING SURVEY

3-1 Purposes of the Survey

The drilling survey was conducted to determine ore deposits in an area on the southern extension of Bektimir Placers No. 1 and 3, which are known ore deposits. The survey was undertaken to grasp the development condition of ore deposits and to confirm ore reserves, as well as to determine orders of stratification, and ore deposits near the southeastern flank of the Preobrazhenskiy complex in the eastern flank of Bektimir. Another purpose of the survey was to determine the development condition of these ore deposits.

3-2 Method of the Survey

1) Outline of Work

Using the personnel and equipment procured by a local drilling company, GEOINCENTER, drilling work was undertaken in 18 drill pits totaling 940.5m in drilling length in the southern flank of Bektimir Placer No. 1 (detailed survey area), in 8 drill pits totaling 290.5m in the southern flank of Bektimir Placer No. 3 (detailed survey area) and in 41 drill pits totaling 1,036.5m in the eastern flank (reconnaissance survey area). Drilling was conducted in 67 pits in total and 2,267.5m in total drilling length. The local drilling company installed a camp near Koitas Village.

The locations of the drilling pits are shown in Figs. II-3-1.

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 drilling 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)

Sequel to Phase II, drilling was conducted in 18 drill pits totaling 940.5m 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 Block of Bektimir Placer No. 1.

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 drilling 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 Phase III was very difficult as many hard gravel layers (calcretes), which had gravel about 1.5m in thickness hardened with lime carbonate, also emerged. Clay, clayey sand and weathered crusts of the Aral Formation were drilled by the percussion method driving a sampler 190mm in diameter.

The drilling work was performed from July 6 to August 23, 2002, or 49 days in total.

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

Drilling was conducted in 8 drill pits totaling 290.5m along Traverse Lines 2A, 3G and 3A at an interval of 200

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 drilling rig and equipment were moved and installed using a truck and tractor. The drilling mud pits were excavated using a tractor and were filled back after the completion of drilling and waste drilling mud was dried out.

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” triconebit. 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 drilling work was performed from July 11to July 26, 2002, or 16 days in total.

(3) Bektimir Eastern Placer (Reconnaissance Survey District)

Drilling was conducted in this placer in 41 drill pits along 11 traverse totaling 1,036.5m. Of these drill pits, drilling was performed in 12 pits along four traverse lines totaling 498m in the northern flank and in 29 pits along seven traverse lines totaling 538.5m in the southern flank.

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 drilling 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” triconebit. 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 drilling work was performed from July 6 to 10, 2002, and from July 27 to August 27, 2002, or 37 days in total.

2) Laboratory Tests

Thickened ilmenite seams caught in cores during the drilling were 1m maximum hit length and 0.3m minimum hit length. Ilmenite was sampled in 1/4 of cores in percussion drilling and in 1/2 of cores in rotary drilling. Totals of 191, 78 and 185 samples were sampled in the southern flank of Bektimir Placer No. 1, southern flank of Bektimir Placer No. 3 and in the eastern flank of the Bektimir district. Wet and dry weights of the samples were weighed and the whole samples were fully disintegrated in water, to separate quartz, feldspar, heavy mineral and clay grains. Almost 100% of heavy minerals were less than 1.0mm in grain size. The samples were dried and were sieved through a sieve mesh of 1.0mm, to sieve out grains less than 1.0mm in grain size. The grains were separated by heavy medium (ブロロホルム) separation to separate heavy minerals, which were then segregated into ilmenite, zircon, rutile, leucoxene, magnetite and other minerals by magnetic separation, electrostatic separation and other methods. Weights of these heavy minerals were weighed (See Appendix 2-10.).

Seven samples of thickened ilmenite seams, two ilmenite concentrate samples, one bedrock sample and one Quaternary Period calcrete gravel sample were sampled from drilling cores. Using these samples, seven polished thin sections (3 sections from Southern Flank of Bektimir Placer No. 1, 4 from Eastern Flank) and two thin polished ilmenite concentrate sections (2 sections from Southern Flank of Bektimir Placer No. 1) were prepared for laboratory tests and were examined using a microscope. Two powder X-ray diffraction tests were conducted with two samples of ilmenite sampled from the Eastern Flank to determine component minerals using a powder X-ray diffraction apparatus (manufactured by BRUKER axs, Model MXP18, X-ray generator 18kW, tube voltage 40kV, tube current 150mA). Polished thin sections and a total of 61 test pieces from 60 opaque mineral grains found on 9 polished thin sections were analyzed for semi-quantitative analysis using EDX (manufactured by JEOL, model JSM-5310) to determine mineral species and to measure titanium contents (See Appendix 2-20.). Three samples (MJBK-54 57.5m, MJBKE-29 14.1m, MJBKE-33 13.3m) were analyzed for area analysis using EPMA (manufactured by JEOL, model JXA-8800R) to determine mineral species and the distribution of Ti, Fe, Mn and O. One sample (MJBKE-29 14.1m) was analyzed for surface analysis. Radii, diameters corresponding to circle, roundness and other parameters of ilmenite and other titanic minerals were measured by processing microscope images to obtain data on transportation and sedimentation conditions when alluvial deposits were formed (Appendix 2-18).

Nine powder X-ray diffraction tests were conducted with nine samples of clay taken from the drilling cores sampled from the Aral Formation to determine clayey minerals using a powder X-ray diffraction apparatus (manufactured by BRUKER axs, Model MXP18, X-ray generator 18kW, tube voltage 40kV, tube current 150mA). Clayey mineral species of eight of these nine samples were determined by additionally preparing constant-azimuth samples and by EG and HCI processing (Appendix 2-4).

3-3 Survey Findings

3-3-1 Geology

1) Bed-Rock Weathered Crust (C_{2-3}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 drilling 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 illite. Small amounts of plagioclase and potassium feldspars sometimes accompany them.

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. It is estimated that sedimentation started beginning around the early Miocene Epoch of the Tertiary Period (23 million years ago) (Erofeyev, 1969).

This layer is 10 to 45m 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. Iron oxide contamination, manganese oxide oolite and gypsum crystals are sometime contained. 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 deposits. 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 illite. 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 oolite 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 9m 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 (Detailed Survey District)

Sequel to Phase II, drilling was conducted in 18 drill pits totaling 940.5m along three traverse lines (Traverse Lines 26, 22 and 18) in a grid of 500×200m on the east and west flanks of the confirmed IV-C_2 Ore Reserves Block of Placer No. 1. Thickened ilmenite seams could be caught in 11 of the 18 pits. Of these pits, five pits showed 100kg/m^3 in ilmenite content and were registered in a mining block.

The results of the drilling survey are shown in geological cross sections of the drilling area (Figs. II-3-2 to 4).

The ore deposit is contained in a wide palaeo-landform channel in the Aral Formation bed rock in the NEN-SWS direction. Two more small channels (along MJBK-26-32-50 and MJBK-42-48) exist inside the palaeo-landform channel. Thickened ilmenite seams deposit directly on the bedrock unconformity plane in the part east of the line that links MJBK-18-12-29-33. The seams in the western flank of them are sandwiched in the Aral Formation. The ore deposits determined in drilling measured 0.9 to 9.0m in thickness. The ilmenite content was 7 to 134kg/m^3. The overburden on the ore deposit was 41 to 54.3m in thickness. The seams were deeper toward west.

The examination of MJBK-19 and MJBK-24 on Traverse Lines 34 and 30 in Phase II confirmed deterioration in ore deposit 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 deposit could be determined. Regarding Traverse Lines 26 and 22 in the south, the examinations of MJBK-44, 45 and 53 confirmed deterioration in ore deposit thickness to be below 2m and a continuation of thickened ilmenite seams. The ore deposit was found not closed. MJBK-54 showed a thickened ilmenite seam 4.2m in width and an ilmenite content of

115kg/m^3, which met conditions for registration in a mining area. It is possible that the seam with a high ilmenite content is expanding westward even though the size of it is reduced.

On the eastern part of the bedrock, MJBK-41, 42, 46, 47 and 48 on Traverse Lines 22 and 18 showed grade deterioration of the thickened ilmenite seams and radical rises of the ore deposit where the ore deposit closes. MJBK-37 (no ore bearing potential) confirmed the southern limit of thickened ilmenite seams, indicating that directions of ore deposit extensions are changing in west or southeastern directions while the ore deposit width is narrowing.

1) MJBK-38 (Direction -, inclination -90°, drilling length 64.0m) (Line 26)

(1) Geology

The geology consisted of surface soil and a gravel layer mixed with cobblestone from the wellhead to the depth of 8.00m and clay of the Aral Formation between the depth of 8.00 and pit bottom. The calcrete sample (MJBK-38) at 6m depth is rounded gravel 2.7cm in gravel size and conglomerate of rounded gravel 2 to 6mm in gravel size. Rounded gravel 2.7cm in gravel size is composed of calcite containing fine quartzose fragments (0.01 to 0.025mm in fragment size). Round granules in the vicinities are sandstone and shale rock fragments. Recrystallized calcite (0.01 to 0.1mm in grain size) and very small amounts of ilmenite and hematite 0.01 to 0.03mm in grain size were found in cement parts.

(2) Thickened ilmenite seam

As shown in Fig. II-3-2, a thickened ilmenite seam (thickness 3.00m, ilmenite content 126.83kg/m^3) could be captured between the depths of 59.00 and 62.00m.

2) MJBK-39 (Direction -, inclination -90°, drilling length 39.0m) (Line 26)

(1) Geology

The geology consisted of surface soil and a gravel layer mixed with cobblestone from the wellhead to the depth of 9.00m, clay, sandy clay and clayey sand of the Aral Formation between the depths of 9.00 and 31.80 and weathered crusts from the depth of 31.80 to the pit bottom.

(2) Thickened ilmenite seam

As shown in Fig. II-3-2, a thickened ilmenite seam could not be determined.

3) MJBK-40 (Direction -, inclination -90°, drilling length 64.5m) (Line 26)

(1) Geology

The geology consisted of surface soil and a gravel layer mixed with cobblestone from the wellhead to the depth of 7.00m and clay of the Aral Formation between the depth of 7.00 and pit bottom.

(2) Thickened ilmenite seam

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

As shown in Fig. II-3-2, a weak thickened ilmenite seam (thickness 2.00m, ilmenite content 104.88kg/m^3) could be captured between the depths of 46.00 and 48.00m.

4) MJBK-41 (Direction -, inclination -90°, drilling length 40.0m) (Line 22)

(1) Geology

The geology consisted of surface soil and a gravel layer mixed with cobblestone from the wellhead to the depth of 10.00m, clay and sandy clay of the Aral Formation between the depths of 10.00 and 35.50 and weathered crusts from the depth of 35.50 to the pit bottom.

(2) Thickened ilmenite seam

As shown in Fig. II-3-3, a thickened ilmenite seam could not be determined.

5) MJBK-42 (Direction -, inclination -90°, drilling length 44.0m) (Line 22)

(1) Geology

The geology consisted of surface soil and a gravel layer mixed with cobblestone from the wellhead to the depth of 10.00m, clay and sandy clay of the Aral Formation between the depths of 10.00 and 41.90 and weathered crusts from the depth of 41.90 to the pit bottom.

(2) Thickened ilmenite seam

As shown in Fig. II-3-32, a thickened ilmenite seam could not be determined.

6) MJBK-43 (Direction -, inclination -90°, drilling length 50.0m) (Line 22)

(1) Geology

The geology consisted of surface soil and a gravel layer mixed with cobblestone from the wellhead to the depth of 10.50m, clay and sandy clay of the Aral Formation between the depths of 10.50 and 45.50 and weathered crusts from the depth of 45.50 to the 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 weak thickened ilmenite seam (thickness 2.70m, ilmenite content 109.78kg/m^3) could be captured between the depths of 41.50 and 43.70m.

7) MJBK-44 (Direction -, inclination -90°, drilling length 60.0m) (Line 22)

(1) Geology

The geology consisted of surface soil and a gravel layer mixed with cobblestone from the wellhead to the depth of 7.00m and clay of the Aral Formation between the depth of 7.00 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 weak thickened ilmenite seam (thickness 1.20m, ilmenite content 119.57kg/m^3) could be captured between the depths of 50.40 and 51.60m.

8) MJBK-45 (Direction -, inclination -90°, drilling length 61.0m) (Line 22)

(1) Geology

The geology consisted of surface soil and a gravel layer mixed with cobblestone from the wellhead to the depth of 9.00m and clay of the Aral Formation between the depth of 9.00 to 39.50 and the 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 weak thickened ilmenite seam (thickness 1.90m, ilmenite content 63.59kg/m^3) could be determined between the depths of 53.00 and 54.90m.

9) MJBK-46 (Direction -, inclination -90°, drilling length 28.0m) (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 8.00m, clay, sandy clay and clayey sand of the Aral Formation between the depths of 8.00 and 19.80m, and weathered crusts between the depth of 19.80m and pit bottom.

(2) Thickened ilmenite seam

As shown in Fig. II-3-4, a thickened ilmenite seam could not be determined.

10) MJBK-47 (Direction -, inclination -90°, drilling length 36.0m) (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 8.00m, clay, sandy clay and clayey sand of the Aral Formation between the depths of 8.00 and 34.00m, and weathered crusts between the depth of 34.00m and pit bottom.

(2) Thickened ilmenite seam

As shown in Fig. II-3-4, a thickened ilmenite seam could not be determined.

11) MJBK-48 (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 8.00m, clay, sandy clay and clayey sand of the Aral Formation between the depths of 8.00 and 49.50m, and weathered crusts between the depth of 49.50m 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 0.90m, ilmenite content 61.60kg/m^3) could be determined between the depths of 48.60 and 49.50m.

12) MJBK-49 (Direction -, inclination -90°, drilling length 54.0m) (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 9.00m, clay, sandy clay and clayey sand of the Aral Formation between the depths of 7.50 and 52.40m, and weathered crusts between the depth of 52.40m 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 2.60m, ilmenite content 133.96kg/m^3) could be captured between the depths of 39.00 and 41.60m.

13) MJBK-50 (Direction -, inclination -90°, drilling length 59.0m) (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 7.00m, clay, sandy clay and clayey sand of the Aral Formation between the depths of 7.00 and 57.00m, and weathered crusts between the depth of 57.00m 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 7.10m, ilmenite content 103.21kg/m^3) could be captured between the depths of 38.00 and 45.10m.

14) MJBK-51 (Direction -, inclination -90°, drilling length 55.0m) (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 7.00m, clay, sandy clay and clayey sand of the Aral Formation between the depths of 7.00 and 51.70m, and weathered crusts between the depth of 51.70m and pit bottom.

(2) Thickened ilmenite seam

As shown in Fig. II-3-4, a thickened ilmenite seam could not be determined.

15) MJBK-52 (Direction -, inclination -90°, drilling length 55.0m) (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 8.00m, clay, sandy clay and clayey sand of the Aral Formation between the depths of 8.00 and 50.60m, and weathered crusts between the depth of 50.60m 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 1.60m, ilmenite content 133.49kg/m^3) could be captured between the depths of 44.80 and 46.40m.

16) MJBK-53 (Direction -, inclination -90°, drilling length 65.0m) (Line 26)

(1) Geology

The geology consisted of surface soil and a gravel layer mixed with cobblestone from the wellhead to the depth of 8.00m and clay, sandy clay and clayey sand of the Aral Formation between the depth of 8.00 and the pit bottom.

(2) Thickened ilmenite seam

Main thickened ilmenite seams are the thickened ilmenite seams shown in Table II-3-6.

As shown in Fig. II-3-2, a thickened ilmenite seam (thickness 1.10m, ilmenite content 158.32kg/m^3) could be determined between the depths of 56.50 and 57.10m.

17) MJBK-54(Direction -, inclination -90°, drilling length 60.0m) (Line 22)

(1) Geology

The geology consisted of surface soil and a gravel layer mixed with cobblestone from the wellhead to the depth of 9.00m and clay, sandy clay and clayey sand of the Aral Formation between the depth of 9.00 and the pit bottom. The sandy clay (Sample MJBK-54 54.7m) mainly consisted of rock fragments 0.1 to 1.8mm in grain size, quartz and cement materials. As accessory components, about 10% of ilmenite 0.02 to 0.5mm in grain size and extremely small amounts of zircon 0.1 to 0.2mm in grain size and copper metals (0.03mm in grain size) could be found. Ilmenite was turning into pseudorutile and the proportion is estimated to be 70% for ilmenite and 30% for pseudorutile. Sericite could be found in the cement materials. The sandy clay

(Sample MJBK-54 57.5m) mainly consisted of rock fragments 0.05 to 2.3mm in grain size, quartz, cement materials and potassium feldspar. As accessory components, about 15 to 20% of ilmenite and pseudorutile 0.05 to 0.8mm in grain size, a very small amount of zircon 0.12 to 0.3mm in grain size and extremely small amounts of rutile (0.2mm in grain size) and monazite (0.2mm to 0.3mm in grain size) could be found. Ilmenite was prominently turning into pseudorutile and the proportion is estimated to be 35% for ilmenite and 65% for pseudorutile. Sericite could be found in the cement materials. The sandy clay (Sample MJBK-54 56.5m) mainly consisted of quartz and pseudorutile 0.05 to 0.7mm in grain size, ilmenite (0.005 to 0.375mm in grain size) and cement materials. Small amounts of potassium feldspar, plagioclase and rock fragments could be found. As accessory components, about 2% of zircon (0.1 to 0.3mm in grain size) and very small amounts of rutile (0.1 to 0.26mm in grain size) and copper metals (0.002 to 0.05mm in grain size) could be found. Ilmenite was turning into pseudorutile and the proportion is estimated to be 5% for ilmenite and 95% for pseudorutile. Sericite could be found in the cement materials. Copper metals may be admixtures of fragments of broken drilling bits.

(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 4.20m, ilmenite content 115.04g/m^3) could be captured between the depths of 54.30 and 58.50m. Ilmenite has turned into pseudorutile by weathering alteration. The proportion of pseudorutile increases deeper the depth is.

18) MJBK-55(Direction -, inclination -90°, drilling length 58.0m) (Line 18)

(1) Geology

The geology consisted of surface soil and a gravel layer mixed with cobblestone from the wellhead to the depth of 7.00m, clay, sandy clay and clayey sand of the Aral Formation between the depths of 7.00 and 57.00m and weathered crusts between the depth of 57.00 and pit bottom.

(2) Thickened ilmenite seam

As shown in Fig. II-3-4, a thickened ilmenite seam could not be determined.

3-3-3 Southern Flank of Bektimir Placer No. 3 (Detailed Survey Area)

Drilling was conducted in 8 pits totaling 290.5m at an interval of 200m along Traverse Lines 2A, 3G and 3A. Thickened ilmenite seams with a cut-off grade of 100kg/m^3 or higher could be confirmed in four of the eight pits.

The survey results are shown in geological cross sections along the drilling pits (Figs. II-3-5 - 7).

The ore deposit is deposited directly above a palaeo-landform channel branched in the form of letter “Y” in the bedrock of the Aral Formation in the direction of N30° E. The width of the placer is estimated to be about 600m and is narrow and is small in scale compared with Placer No. 1. The thicknesses and ilmenite contents of the thickened ilmenite seams determined in Phase III are 0.5 to 6m and 13 to 134.5kg/m^3 respectively. The overburden above the placer was 25 to 34m in thickness. As in Bektimir Placer No. 1, the seam thickness tended to increase toward the south, or the downstream.

1) MJBK-26(Direction -, inclination -90°, drilling length 31.0m) (Line 2G)

(1) Geology

The geology consisted of surface soil and a gravel layer mixed with cobblestone from the wellhead to the depth of 15.00m, clay and sandy clay of the Aral Formation between the depths of 15.00 and 21.40m and weathered crusts between the depth of 21.40 and pit bottom.

(2) Thickened ilmenite seam

As shown in Fig. II-3-5, a thickened ilmenite seam could not be determined.

2) MJBK-27(Direction -, inclination -90°, drilling length 40.50m) (Line 2G)

(1) Geology

The geology consisted of surface soil and a gravel layer mixed with cobblestone from the wellhead to the depth of 10.00m, clay, sandy clay and clayey sand of the Aral Formation between the depths of 10.00 and 23.00m and weathered crusts between the depth of 23.00 and pit bottom.

(2) Thickened ilmenite seam

As shown in Fig. II-3-5, a thickened ilmenite seam could not be determined.

3) MJBK-28(Direction -, inclination -90°, drilling length 33.50m) (Line 3G)

(1) Geology

The geology consisted of surface soil and a gravel layer mixed with cobblestone from the wellhead to the depth of 10.00m, clay and sandy clay of the Aral Formation between the depths of 9.50 and 31.60m and weathered crusts between the depth of 31.60 and pit bottom.

(2) Thickened ilmenite seam

As shown in Fig. II-3-6, a thickened ilmenite seam could not be determined.

4) MJBK-29(Direction -, inclination -90°, drilling length 40.00m) (Line 3G)

(1) Geology

The geology consisted of surface soil and a gravel layer mixed with cobblestone from the wellhead to the depth of 8.00m, clay and sandy clay of the Aral Formation between the depths of 8.00 and 36.00m and weathered crusts between the depth of 36.00 and pit bottom.

(2) Thickened ilmenite seam

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

As shown in Fig. II-3-6, a thickened ilmenite seam (thickness 4.00m, ilmenite content 110.57kg/m^3) could be captured between the depths of 32.00 and 36.00m.

5) MJBK-30(Direction -, inclination -90°, drilling length 40.00m) (Line 3A)

(1) Geology

The geology consisted of surface soil and a gravel layer mixed with cobblestone from the wellhead to the depth of 8.70m, clay, sandy clay and clayey sand of the Aral Formation between the depths of 8.70 and 35.20m and weathered crusts between the depth of 35.20 and pit bottom.

(2) Thickened ilmenite seam

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

As shown in Fig. II-3-7, a thickened ilmenite seam (thickness0.50m, ilmenite content 134.53kg/m^3) could be captured between the depths of 34.00 and 34.50m.

6) MJBK-31(Direction -, inclination -90°, drilling length 41.0m) (Line 3A)

(1) Geology

The geology consisted of surface soil and a gravel layer mixed with cobblestone from the wellhead to the depth of 9.00m, clay, sandy clay and clayey sand of the Aral Formation between the depths of 9.00 and 35.50m and weathered crusts between the depth of 35.50 and pit bottom.

(2) Thickened ilmenite seam

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

As shown in Fig. II-3-7, a thickened ilmenite seam (thickness3.50m, ilmenite content 128.63kg/m^3) could be captured between the depths of 32.00 and 35.50m.

7) MJBK-32(Direction -, inclination -90°, drilling length 40.00m) (Line 3A)

(1) Geology

The geology consisted of surface soil and a gravel layer mixed with cobblestone from the wellhead to the depth of 9.00m, clay and sandy clay of the Aral Formation between

the depths of 9.00 and 35.00m and weathered crusts between the depth of 35.50 and pit bottom. Powder X-ray diffraction tests show that the sandy clay (Samples MJBK-52 10.0m, 20.0m and 32.5m) and weathered basement rock of the Aral Formation are mainly composed of quartz, containing a medium amount of smectite and a small amount of kaolin. A medium amount of illite is mixed at 38.0m of the weathered basement rock (See Appendix 2-4.).

(2) Thickened ilmenite seam

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

As shown in Fig. II-3-7, a thickened ilmenite seam (thickness3.80m, ilmenite content 117.35kg/m^3) could be captured between the depths of 32.20 and 36.00m.

8) MJBK-33(Direction -, inclination -90°, drilling length 35.00m) (Line 3A)

(1) Geology

The geology consisted of surface soil and a gravel layer mixed with cobblestone from the wellhead to the depth of 9.00m, clay and sandy clay of the Aral Formation between the depths of 9.00 and 29.80m and weathered crusts between the depth of 29.80 and pit bottom.

(2) Thickened ilmenite seam

As shown in Fig. II-3-7, a thickened ilmenite seam could not be determined.

3-3-4 Eastern Flank of Bektimir (Reconnaissance Survey Area)

During the Year-2 survey, this district was identified as a district with new possibilities for deposit of seams. In this district, granitic rocks with a magnetic susceptibility of 1×10^{-3} S.I.U. or lower, which is an index for a high possibility of ilmenite reserves, are distributed in the upstream region. Two systems (in north and south) of palaeo-landform furrows (palaeo-landform channels) were forecasted in the bedrock of the Aral Formation of the Tertiary Period in this district. Drilling was conducted in this district in 41 pits totaling 1,036.5m on 11 traverse lines. In the northern part of this district, drilling was carried out in 12 pits and 498m in total on four traverse lines, while drilling was carried out in 29 pits and 538.5m in total on seven traverse lines in the southern part. Thickened ilmenite seams were found in ten of the 29 pits in the south (tentatively called Japan MMAJ Potential Ore Deposit).

Originally, one major palaeo-landform channel was forecasted in the northern part of the eastern flank in about the same position as that of a valley of a Recent river and another channel of a small size on the western side of the major channel. Loam layers of the

Quaternary Period thickly deposit in the whole of the district 15 to 25m in thickness. The major palaeo-landform channel could be confirmed in MJBKE-1 to 3, 7 to 9, 13 to 15 and 34. Only thickened ilmenite seams of very small sizes could be found in MJBKE-13 (7.78kg/m^3 in 1.0m between depths 38.2 and 39.2m and zircon 1.15kg/m^3) and in MJBKE-34 (7.94kg/m^3 in 0.5m between depths 30.0 and 30.5m and zircon 0.56kg/m^3). Drilling was carried out in MJBKE-10 and 11 to explore the small-size palaeo-landform channel, which was initially forecasted to bear an ilmenite seam, but the bedrock was hit at a depth of 20m or less and a palaeo-landform channel could not be located.

The results of the drilling survey are shown in geological cross sections of the drilling area (Fig. II-3-8).

1) MJBKE-1 (Direction -, inclination -90°, drilling length 45.0m) (Line-I)

(1) Geology

The geology consisted of surface soil and a gravel layer mixed with cobblestone from the wellhead to the depth of 7.00m, clay of the Aral Formation between the depths of 7.00 and 43.50m and weathered crusts between the depth of 43.50 and pit bottom.

(2) Thickened ilmenite seam

A thickened ilmenite seam could not be found in this pit.

2) MJBKE-2 (Direction -, inclination -90°, drilling length 50.0m) (Line-I)

(1) Geology

The geology consisted of surface soil and a gravel layer mixed with cobblestone from the wellhead to the depth of 12.00m, clay, sandy clay and clayey sand of the Aral Formation between the depths of 12.00 and 43.30m and weathered crusts between the depth of 43.30 and pit bottom.

(2) Thickened ilmenite seam

A thickened ilmenite seam could not be found in this pit.

3) MJBKE-3 (Direction -, inclination -90°, drilling length 41.00m) (Line-I)

(1) Geology

The geology consisted of surface soil and a gravel layer mixed with cobblestone from the wellhead to the depth of 7.00m, clay and sandy clay of the Aral Formation between the depths of 7.00 and 35.20m and weathered crusts between the depth of 35.20 and pit bottom.

(2) Thickened ilmenite seam

A thickened ilmenite seam could not be found in this pit.

4) MJBKE-4 (Direction -, inclination -90°, drilling length 17.00m) (Line-IV)

(1) Geology

The geology consisted of surface soil and a gravel layer mixed with cobblestone from the wellhead to the depth of 3.00m, clay and sandy clay of the Aral Formation between the depths of 3.00 and 13.50m and weathered crusts between the depth of 13.50 and pit bottom.

(2) Thickened ilmenite seam

A thickened ilmenite seam could not be found in this pit.

5) MJBKE-5 (Direction -, inclination -90°, drilling length 18.00m) (Line-IV)

(1) Geology

The geology consisted of surface soil and a gravel layer mixed with cobblestone from the wellhead to the depth of 5.00m, clay and sandy clay of the Aral Formation between the depths of 5.00 and 14.70m and weathered crusts between the depth of 14.70 and pit bottom.

(2) Thickened ilmenite seam

A thickened ilmenite seam could not be found in this pit.

6) MJBKE-6 (Direction -, inclination -90°, drilling length 22.00m) (Line-IV)

(1) Geology

The geology consisted of surface soil and a gravel layer mixed with cobblestone from the wellhead to the depth of 3.00m, clay and sandy clay of the Aral Formation between the depths of 3.00 and 19.80m and weathered crusts between the depth of 19.80 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 thickened ilmenite seam (thickness0.80m, ilmenite content 19.60kg/m^3) could be captured between the depths of 19.00 and 19.80m.

7) MJBKE-7 (Direction -, inclination -90°, drilling length 44.00m) (Line-II)

(1) Geology

The geology consisted of surface soil and a gravel layer mixed with cobblestone from the wellhead to the depth of 8.00m, clay, sandy clay and clayey sand of the Aral Formation between the depths of 8.00 and 34.20m and weathered crusts between the depth of 34.20 and pit bottom.

(2) Thickened ilmenite seam

A thickened ilmenite seam could not be found in this pit.

8) MJBKE-8 (Direction -, inclination -90°, drilling length 59.50m) (Line-II)

(1) Geology

The geology consisted of surface soil and a gravel layer mixed with cobblestone from the wellhead to the depth of 4.00m, clay and sandy clay of the Aral Formation between the depths of 4.00 and 51.80m and weathered crusts between the depth of 51.80 and pit bottom. Powder X-ray diffraction tests show that the sandy clay (Samples MJBKE-8 41.4m, 50.4m, and 57.8m) of the Aral Formation was mainly composed of quartz and kaolin. Medium amounts of smectite and illite were contained. A medium amount of plagioclase was mixed at 57.8m in the bottom.

(2) Thickened ilmenite seam

A thickened ilmenite seam could not be found in this pit.

9) MJBKE-9 (Direction -, inclination -90°, drilling length 60.00m) (Line-II)

(1) Geology

The geology consisted of surface soil and a gravel layer mixed with cobblestone from the wellhead to the depth of 8.00m, clay and sandy clay of the Aral Formation between the depths of 8.00 and 48.50m and weathered crusts between the depth of 48.50 and pit bottom.

(2) Thickened ilmenite seam

A thickened ilmenite seam could not be found in this pit.

10) MJBKE-10 (Direction -, inclination -90°, drilling length 22.00m) (Line-II)

(1) Geology

The geology consisted of surface soil and a gravel layer mixed with cobblestone from the wellhead to the depth of 18.00m, clay and sandy clay of the Aral Formation between the depths of 18.00 and 18.80m and weathered crusts between the depth of 18.80 and pit bottom.

(2) Thickened ilmenite seam

A thickened ilmenite seam could not be found in this pit.

11) MJBKE-11 (Direction -, inclination -90°, drilling length 12.00m) (Line-II)

(1) Geology

The geology from the wellhead to the depth of 6.00m consisted of loam, clay and sandy clay of the Aral Formation between depths 6.00 and 10.00 and weathered crusts between the depth of 10.00 and the pit bottom.

(2) Thickened ilmenite seam

A thickened ilmenite seam could not be found in this pit.

12) MJBKE-12 (Direction -, inclination -90°, drilling length 29.00m) (Line-IX)

(1) Geology

The geology from the wellhead to the depth of 9.00m consisted of loam, clay, sandy clay and clayey sand of the Aral Formation between depths 9.00 and 28.00 and weathered crusts between the depth of 28.00 and the pit bottom. Weathered basement rock (Sample MJBKE-12 29.0m) sampled at 29.0m in the pit bottom is porphyritic diorite and is mainly made up of a clayey mineral assumed to be montmorilonite and a small amount of quartz (grain size 0.02 to 0.5mm). A phenocrystic texture of plagioclase remains in it. It is possible that this rock is a small rock stump that intruded into the Maityab layer of the upper Carboniferous Series (C_{2-3} mt).

(2) Thickened ilmenite seam

A thickened ilmenite seam could not be found in this pit.

13) MJBKE-13 (Direction -, inclination -90°, drilling length 42.00m) (Line-III)

(1) Geology

The geology from the wellhead to the depth of 21.00m consisted of loam, clay and sandy clay of the Aral Formation between depths 21.00 and 39.20 and weathered crusts between the depth of 39.20 and the pit bottom.

(2) Thickened ilmenite seam

A very small thickened ilmenite seam with an ilmenite content of 7.78kg/m^3 and zircon content of 1.15kg/m^3 could be found in 1.0m between 38.2 and 39.2m in this pit.

14) MJBKE-14 (Direction -, inclination -90°, drilling length 48.00m) (Line-III)

(1) Geology

The geology from the wellhead to the depth of 22.00m consisted of loam, clay and sandy clay of the Aral Formation between depths 22.00 and 46.50 and weathered crusts between the depth of 46.50 and the pit bottom.

(2) Thickened ilmenite seam

A thickened ilmenite seam could not be found in this pit.

15) MJBKE-15 (Direction -, inclination -90°, drilling length 45.00m) (Line-III)

(1) Geology

The geology from the wellhead to the depth of 23.00m consisted of loam, clay and sandy clay of the Aral Formation between depths 23.00 and 41.40 and weathered crusts between the depth of 41.40 and the pit bottom.

(2) Thickened ilmenite seam

A thickened ilmenite seam could not be found in this pit.

16) MJBKE-16 (Direction -, inclination -90°, drilling length 29.00m) (Line- IX)

(1) Geology

The geology consisted of surface soil and a gravel layer mixed with cobblestone from the wellhead to the depth of 6.40m, clay and sandy clay of the Aral Formation between the depths of 6.40 and 27.80m and weathered crusts between the depth of 27.80 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 thickened ilmenite seam (thickness3.80m, ilmenite content 25.50kg/m^3) could be captured between the depths of 24.00 and 27.80m.

17) MJBKE-17 (Direction -, inclination -90°, drilling length 25.0m) (Line- IX)

(1) Geology

The geology consisted of surface soil and a gravel layer mixed with cobblestone from the wellhead to the depth of 6.00m, clay, sandy clay and clayey sand of the Aral Formation between the depths of 6.00 and 20.10m and weathered crusts between the depth of 20.10 and pit bottom.

(2) Thickened ilmenite seam

A thickened ilmenite seam could not be found in this pit.

18) MJBKE-18 (Direction -, inclination -90°, drilling length 17.00m) (Line- IX)

(1) Geology

The geology consisted of surface soil and a gravel layer mixed with cobblestone from the wellhead to the depth of 7.60m, clay and sandy clay of the Aral Formation between the depths of 7.60 and 16.00m and weathered crusts between the depth of 16.00 and pit bottom.

(2) Thickened ilmenite seam

A thickened ilmenite seam could not be found in this pit.

19) MJBKE-19 (Direction -, inclination -90°, drilling length 19.00m) (Line- IV)

(1) Geology

The geology consisted of surface soil and a gravel layer mixed with cobblestone from the wellhead to the depth of 2.00m, clay and sandy clay of the Aral Formation between

the depths of 2.00 and 14.90m and weathered crusts between the depth of 14.90 and pit bottom.

(2) Thickened ilmenite seam

A thickened ilmenite seam could not be found in this pit.

20) MJBKE-20 (Direction -, inclination -90°, drilling length 12.00m) (Line-IV)

(1) Geology

The geology from the wellhead to the depth of 8.00m consisted of surface soil and a gravel layer mixed with cobblestone and weathered crusts between the depth of 8.00 and the pit bottom.

(2) Thickened ilmenite seam

A thickened ilmenite seam could not be found in this pit.

21) MJBKE-21 (Direction -, inclination -90°, drilling length 18.00m) (Line-IV)

(1) Geology

The geology consisted of surface soil and a gravel layer mixed with cobblestone from the wellhead to the depth of 9.00m, clay and sandy clay of the Aral Formation between the depths of 9.00 and 17.20m and weathered crusts between the depth of 17.20 and pit bottom.

(2) Thickened ilmenite seam

A thickened ilmenite seam could not be found in this pit.

22) MJBKE-22 (Direction -, inclination -90°, drilling length 8.00m) (Line-V)

(1) Geology

The geology from the wellhead to the depth of 7.50m consisted of surface soil and a gravel layer mixed with cobblestone and weathered crusts between the depth of 7.50 and the pit bottom.

(2) Thickened ilmenite seam

A thickened ilmenite seam could not be found in this pit.

23) MJBKE-23 (Direction -, inclination -90°, drilling length 15.00m) (Line-V)

(1) Geology

The geology from the wellhead to the depth of 8.30m consisted of surface soil and basement rock between the depth of 8.30 and the pit bottom.

(2) Thickened ilmenite seam

A thickened ilmenite seam could not be found in this pit.

24) MJBKE-24 (Direction -, inclination -90°, drilling length 12.00m) (Line-V)

(1) Geology

The geology from the wellhead to the depth of 6.00m consisted of surface soil and basement rock between the depth of 6.00 and the pit bottom.

(2) Thickened ilmenite seam

A thickened ilmenite seam could not be found in this pit.

25) MJBKE-25 (Direction -, inclination -90°, drilling length 29.00m) (Line-IV)

(1) Geology

The geology consisted of surface soil and a gravel layer mixed with cobblestone from the wellhead to the depth of 4.00m, clay and sandy clay of the Aral Formation between the depths of 4.00 and 26.50m and weathered crusts between the depth of 26.50 and pit bottom. The sandy clay (Sample MJBKE-25 24.5m) mainly consisted of quartz and potassium feldspar 0. 5 to 1.5mm in grain size and small amounts of cement materials and biotite. About 2% of ilmenite (0.04 to 0.325mm in grain size), very small amounts of magnetite (0.2mm to 0.4mm in grain size) and hematite (0.25mm in grain size) and extremely small amounts of rutile (0.04mm in grain size) and zircon (0.1mm in grain size) could be found. Ilmenite was turning into grayish white pseudorutile on grain surfaces and along cracks. The proportion is estimated to be 80% for ilmenite and 20% for pseudorutile.

(2) Thickened ilmenite seam

Table II-3-7 lists the main thickened ilmenite seams.

As shown in Fig. II-3-8, weak thickened ilmenite seams (4.50m thick, 27.80kg/m^3 ilmenite content) could be found between depths 22.00 and 26.50m. Powder X-ray diffraction analysis of a concentrate sample (Sample MJBKE-25 23.7m) at depth of 23.7m shows that the seams are mainly made up of ilmenite, zircon and quartz and a very small amount of hematite.

26) MJBKE-26 (Direction -, inclination -90°, drilling length 27.00m) (Line-IV)

(1) Geology

The geology from the wellhead to the depth of 6.00m consisted of surface soil and a gravel layer mixed with cobblestone, clay and sandy clay of the Aral Formation between depths 6.00 and 20.70 and weathered crusts between the depth of 20.70 and the pit bottom. Powder X-ray diffraction analysis of sandy clay (Sample MJBKE-26

21.2m) at depth of 21.2m shows that the seams are mainly made up of quartz, kaolin and smectite and a medium amount of plagioclase.

(2) Thickened ilmenite seam

A thickened ilmenite seam could not be found in this pit.

27) MJBKE-27 (Direction -, inclination -90°, drilling length 6.00m) (Line- X)

(1) Geology

The geology from the wellhead to the depth of 5.00m consisted of surface soil and basement rock between the depth of 5.00 and the pit bottom.

(2) Thickened ilmenite seam

A thickened ilmenite seam could not be found in this pit.

28) MJBKE-28 (Direction -, inclination -90°, drilling length 15.00m) (Line- XI)

(1) Geology

The geology consisted of surface soil and a gravel layer mixed with cobblestone from the wellhead to the depth of 10.00m, clay and sandy clay of the Aral Formation between the depths of 10.00 and 13.00m and weathered crusts between the depth of 13.00 and pit bottom.

(2) Thickened ilmenite seam

A thickened ilmenite seam could not be found in this pit.

29) MJBKE-29 (Direction -, inclination -90°, drilling length 20.00m) (Line- XI)

(1) Geology

The geology consisted of surface soil and a gravel layer mixed with cobblestone from the wellhead to the depth of 10.70m, clay and sandy clay of the Aral Formation between the depths of 10.70 and 14.10m and weathered crusts between the depth of 14.10 and pit bottom. The sandy clay (Sample MJBKE-29) mainly consisted of quartz 0.03 to 2mm in grain size, rock fragments 0.1 to 5mm in grain size and cement materials. As accessory components, about 2 to 3% of ilmenite 0.03 to 0.25mm in grain size and a very small amount of rutile (0.03mm to 0.14mm in grain size) could be found. Ilmenite was significantly turning into pseudorutile. Sericite and goethite were found in cement materials.

(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 (thickness2.00m, ilmenite content 21.90kg/m^3) could be captured between the depths of 12.00 and 14.00m.

30) MJBKE-30 (Direction -, inclination -90°, drilling length 19.00m) (Line-XI)

(1) Geology

The geology consisted of surface soil and a gravel layer mixed with cobblestone from the wellhead to the depth of 9.50m, clay and sandy clay of the Aral Formation between the depths of 9.50 and 11.30m and weathered crusts between the depth of 11.30 and pit bottom.

(2) Thickened ilmenite seam

As shown in Fig. II-3-7, a weak thickened ilmenite seam (thickness 1.30m, ilmenite content 10.96kg/m^3) could be captured between the depths of 9.50 and 10.80m.

31) MJBKE-31 (Direction -, inclination -90°, drilling length 19.00m) (Line-XI)

(1) Geology

The geology consisted of surface soil and a gravel layer mixed with cobblestone from the wellhead to the depth of 9.60m, clay and sandy clay of the Aral Formation between the depths of 9.60 and 12.00m and weathered crusts between the depth of 12.00 and pit bottom.

(2) Thickened ilmenite seam

A thickened ilmenite seam could not be found in this pit.

32) MJBKE-32 (Direction -, inclination -90°, drilling length 15.00m) (Line-XI)

(1) Geology

The geology consisted of surface soil and a gravel layer mixed with cobblestone from the wellhead to the depth of 8.00m, clay, sandy clay and clayey sand of the Aral Formation between the depths of 8.00 and 8.50m and weathered crusts between the depth of 8.50 and pit bottom.

(2) Thickened ilmenite seam

A thickened ilmenite seam could not be found in this pit.

33) MJBKE-33 (Direction -, inclination -90°, drilling length 22.00m) (Line-XI)

(1) Geology

The geology consisted of surface soil and a gravel layer mixed with cobblestone from the wellhead to the depth of 8.50m, clay and sandy clay of the Aral Formation between

the depths of 8.50 and 13.80m and weathered crusts between the depth of 13.80 and pit bottom. The sandy clay (Sample MJBKE-33 13.3m) mainly consisted of rock fragments 0. 5 to 1.5mm in grain size, quartz and cement materials and a small amounts of potassium feldspar and plagioclase. As accessory components, about 7% of ilmenite 0.03 to 0.8mm in grain size, about 0.5% of hematite 0.04 to 0.33mm in grain size and extremely small amounts of zircon (0.03mm in grain size) and brown iron hydroxide dissemination could be found. Ilmenite was extensively turning into pseudorutile and the proportion is estimated to be 20% for ilmenite and 80% for pseudorutile.

(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 (thickness4.40m, ilmenite content 31.86kg/m^3) could be captured between the depths of 9.30 and 13.70m.

34) MJBKE-34(Direction -, inclination -90°, drilling length 34.00m)(Line- VII)

(1) Geology

The geology consisted of surface soil and a gravel layer mixed with cobblestone from the wellhead to the depth of 13.00m, clay and sandy clay of the Aral Formation between the depths of 13.00 and 30.70m and weathered crusts between the depth of 30.70 and pit bottom.

(2) Thickened ilmenite seam

The result from this pit was finding of only a very small thickened ilmenite seam in 0.5m between depths 30.0 and 30.5 containing 7.94kg/m^3 ilmenite and 0.56kg/m^3 zircon.

35) MJBKE-35 (Direction -, inclination -90°, drilling length 16.00m) (Line- XI)

(1) Geology

The geology consisted of surface soil and a gravel layer mixed with cobblestone from the wellhead to the depth of 10.10m, clay and sandy clay of the Aral Formation between the depths of 10.10 and 11.60m and weathered crusts between the depth of 11.60 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 0.70m, ilmenite content 22.20kg/m^3) could be captured between the depths of 10.80 and 11.500m.

36) MJBKE-36 (Direction -, inclination -90°, drilling length 20.0m) (Line- X)

(1) Geology

The geology consisted of surface soil and a gravel layer mixed with cobblestone from the wellhead to the depth of 4.00m, clay and sandy clay of the Aral Formation between the depths of 4.00 and 17.80m and weathered crusts between the depth of 17.80 and pit bottom. The sandy clay (Sample MJBKE-36 17.8m) at the depth of 17.8 mainly consisted of quartz and cement materials 0.03 to 1.0mm in grain size and a small amount of sericite. About 1.5% of ilmenite 0.04 to 1.5mm in grain size, a very small amount of hematite (0.4mm in grain size), and extremely small amounts of rutile (0.1 to 0.275mm in grain size) and zircon (0.1 to 0.25mm in grain size) could be found. Ilmenite was showing grayish white altered parts on the exteriors of grains and along cracks, producing pseudorutile. The proportion is estimated to be 50% for ilmenite and 50% for pseudorutile. Sericite and extremely small amounts of biotite and amphibole could be found in the cement materials.

(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 0.80m, ilmenite content 31.97kg/m^3) could be captured between the depths of 17.00 and 17.80m.

37) MJBKE-37 (Direction -, inclination -90°, drilling length 21.0m) (Line- X)

(1) Geology

The geology consisted of surface soil and a gravel layer mixed with cobblestone from the wellhead to the depth of 2.00m, clay, sandy clay and clayey sand of the Aral Formation between the depths of 2.00 and 17.00m and weathered crusts between the depth of 17.00 and pit bottom.

(2) Thickened ilmenite seam

A thickened ilmenite seam could not be found in this pit.

38) MJBKE-38 (Direction -, inclination -90°, drilling length 21.0m) (Line- XII)

(1) Geology

The geology consisted of surface soil and a gravel layer mixed with cobblestone from the wellhead to the depth of 12.00m, clay and sandy clay of the Aral Formation between the depths of 12.00 and 13.00m and weathered crusts between the depth of 13.00 and pit bottom.

(2) Thickened ilmenite seam

A thickened ilmenite seam could not be found in this pit.

39) MJBKE-39(Direction -, inclination -90°, drilling length 15.00m) (Line- XII)

(1) Geology

The geology consisted of surface soil and a gravel layer mixed with cobblestone from the wellhead to the depth of 13.00m, clay and sandy clay of the Aral Formation between the depths of 13.00 and 14.60m and weathered crusts between the depth of 14.60 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 1.60m, ilmenite content 32.19kg/m^3) could be captured between the depths of 13.20 and 14.80m.

40) MJBKE-40(Direction -, inclination -90°, drilling length 14.50m) (Line- XII)

(1) Geology

The geology consisted of surface soil and a gravel layer mixed with cobblestone from the wellhead to the depth of 11.00m, clay and sandy clay of the Aral Formation between the depths of 11.00 and 13.80m and weathered crusts between the depth of 13.80 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 1.00m, ilmenite content 33.52kg/m^3) could be captured between the depths of 12.80 and 13.80m.

41) MJBKE-41(Direction -, inclination -90°, drilling length 18.00m) (Line- XII)

(1) Geology

The geology consisted of surface soil and a gravel layer mixed with cobblestone from the wellhead to the depth of 9.90m, clay and sandy clay of the Aral Formation between the depths of 9.90 and 15.00m and weathered crusts between the depth of 15.00 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 2.00m, ilmenite content 61.50kg/m^3) could be captured between the depths of 13.00 and 15.00m.

3-3-5 Ore reserves estimation

Only approximate ore reserves were calculated for Southern Flank of Bektimir Placers No. 1 and Placer No. 3. The southern part of Eastern Flank of Bektimir was still an area with probable thickened ilmenite seams and only potentials were calculated for it. Only slight signs of ilmenite seams could be obtained for the northern part of Eastern Flank of Bektimir and ore reserves calculations were not made for it.

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

Drilling was conducted in Phase III on three traverse lines (Traverse Lines 26, 22 and 18) in a grid of 500 x 200m along the east and west extensions of confirmed IV-C2 Ore-reserve Mining Block of Placer 1. Based on results of this drilling, approximate ore reserves were calculated on a trial basis to appraise ore reserves found this year.

(1) Calculation Method

① Grade analysis and calculation

Thickened ilmenite seams caught in cores during percussion drilling were 1m maximum hit length and 0.3m minimum hit length. Ilmenite was sampled in 1/4 of cores. Wet and dry weights of the sample were weighed and the whole samples were fully disintegrated in water, to separate quartz, feldspar, heavy mineral and clay grains. Almost 100% of heavy minerals were less than 1.0mm in grain size. The samples were dried and were sieved through a sieve mesh of 1.0mm, to sieve out grains less than 1.0mm in grain size. The grains were separated by heavy medium separation to separate heavy minerals, which were then segregated into ilmenite, zircon, rutile, leucoxene, magnetite and other minerals by magnetic separation, electrostatic separation and other methods. Weights of these heavy minerals 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 deposits 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 deposits for ore reserves calculation

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

③ Range of block

In case an ore deposit could not be confirmed by drilling of an extended part of an ore deposit captured in the drilling survey, up to the middle point was defined the range of a block. If the extended part of an ore deposit captured in drilling is not explored and is not closed, as a rule, up to 50m from ore-bed capturing drilling was defined the range of a block (IV-C2) (See Fig. II-3-9.).

④ Grade for each block

The grade of an ore deposit confirmed in drilling was weighted averaged by the thickness of the ore deposit and was defined as the 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 deposit = 500,000m^2

W: Average thickness of ore deposit = 3.60m

C: Average ilmenite grade of ore deposits = 113.47kg/m^3

$V = 500{,}000 \times 3.60 \times 113.47 \times 1/1{,}000 = 204{,}246$

(2) Calculation Results

Trial calculations of ore reserves of the southern extension part of Bektimir Placer No. 1 in Phase II produced 0.5 million m^3 as captured ore sand reserves of C_2 Category, ilmenite grade of 113.47kg/m^3, ilmenite ore reserves of 204,000 tons, and stripping ratio of 12.83 (Table I-5-2).

2) Ore Reserves Calculations for Southern District of Bektimir Placer No. 3

Reconnaissance-survey drilling was conducted in Phase III in the Southern Flank of Bektimir Placer No. 3 in grids of 400×400m to 400×600m. A thickened ilmenite seam estimated to be contained in one palaeo-landform channel could be confirmed.

(1) Ore Reserves

Only six drilling 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 drilling pits that hit ores.

i) Calculation method

① Grade analysis and calculation

A thickened ilmenite seam caught in cores during rotary drilling was sampled in 1/2 of cores with a maximum hit length of 1m and minimum hit length of 0.3m. Grade analysis and calculations were made by the same methods as those used for Bektimir Placer No. 1.

② Target ore deposit for ore reserves calculations

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

③ Range of block

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

④ Grade per block

Grades of ore deposits confirmed in the drilling were weighted averaged by the thicknesses of the ore deposits to obtain a block grade for each traverse line. The average grade of all blocks was then calculated (Table II-3-10).

⑤ Ore reserves

Ilmenite ore reserves of each block were calculated by the following expression (Table I-5-3):

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

V: Ilmenite ore reserves (t)

S: Plane area of an ore deposit = $220,000\text{m}^2$

W: Average thickness of ore deposit = 3.70m

C: Average ilmenite grade of ore deposits = 113.49kg/m^3

$V = 220,000 \times 3.70 \times 113.49 \times 1/1,000 = 108.66$

ii) Calculation Results

Trial calculations of ore reserves of the southern flank of Bektimir Placer No. 3 in Phase III produced 0.814 million m^3 as ore reserved, ilmenite grade of 113.49kg/m^3, ilmenite ore reserves of 108,660 tons, and stripping ratio of 8.49 (Table I-5-3).

3) Potential Calculations for Southern Part in Eastern Flank of Bektimir

Only part of thickened ilmenite seams in the southern part of this district could be determined and data is not sufficient to make ore reserves calculations. However, rough potentials of it are calculated on a trial basis.

i) Calculation method

① Grade analysis and calculation

A thickened ilmenite seam caught in cores during rotary drilling was sampled in 1/2 of cores with a maximum hit length of 1m and minimum hit length of 0.3m. Grade analysis and calculations were made by the same methods as those used for Bektimir Placer No. 1.

② Range of block

The ore deposit sections were set by connecting adjoining drilled thickened seams with an ilmenite content of 20kg/m^3 or more to make a trapezoid. A triangle of one half of the distance to the nearest adjoining drilling pit that was not included in the ore reserves was set at both ends of the trapezoid. A 50m triangle was set when there were no adjoining drilling pits. The average grade of ore-bed cross sections was weighted lengths of ore deposits hit by drilling (Fig. II-3-8).

③ Grade per block

The grade (G kg/m^3) of an ore block between two cross sections was calculated as a weighted average of sectional areas (A_1, A_2 (m^3) of two sectional grades (G_1, G_2 kg/m^3) and was obtained by $G= (G_1 \times A_1+G_2 \times A_2)/(A_1+A_2)$. Grades (G kg/$m^3$) of continuous ore blocks V1, V2, V3 ... were calculated by weighting averages of ore reserves (V1, V2, V3 (m^3) of each ore block and were calculated by $G= (G_1 \times V_1+G_2 \times V_2+G_3 \times V_3+ \ldots)/(V_1+V_2+V_3+ \ldots)$. The grade of ore-block total sum was calculated by weighting averages of ore reserves. Grades of ore deposits confirmed by drilling were weighting-averaged by thicknesses of ore deposits to obtain an ore block grade for each traverse line and average grades for entire ore blocks were calculated (Table II-3-11).

④ Ore reserves

Ore reserves V (m^3) of an ore block between two sections (A_1, A_2 (m^3) that are apart by dm was calculated by $V =d \times (A_1+A_2)/2$. The ore block of the cross section (A_3 (m^3)) at the northern and southern ends was considered as a cone that was separated by distance 50m and was calculated by $V =1/3 \times d \times 50 \times A3$ (Table II-3-11).

ii) Calculation Results

Trial potential calculations of the southern part in Eastern Flank of Bektimir showed the Category of P_2, potential ore reserves of 1.05 million m^3, ilmenite content of 30.92kg/m^3, ilmenite reserves of 32,500 tons, and a stripping ratio of 15.97. The potential calculations for two traverse lines in the southern part with a relatively low stripping ratio showed potential ore reserves of 0.34 million m^3, ilmenite content of 38.36kg/m^3, ilmenite reserves of 13,100 tons, and a stripping ratio of 11.48 (Table I-5-4).

3-3-6 Mineralogical descriptions of heavy minerals

Polished thin sections were prepared from samples of light-gray sand bed samples containing ilmenite and recovered from Drilling Pit MJBK-54 at the depths of 54.7 and 57.5m and Drilling Pit MJBK-54 at the depth of 56.5m in the southern flank of Bektimir Placer No. 1 after the samples were hardened by a resin. A polished thin section of ilmenite sampled at the MJBK-44 depth was observed under a microscope after thickening and separating ilmenite and hardening it by a resin. Polished thin sections were prepared from samples of brownish light-gray clayey sand bed samples containing ilmenite and recovered from Drilling Pits MJBKE-25 at the depth of 24.5m, MJBKE-36 at 17.8m, MJBKE-33 at 13.3m and MJBKE-29 at 14.1m in the southern flank of Bektimir Placer No. 1 after the samples were hardened by a resin. These polished thin sections were observed under a microscope.

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 2-8). 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). Judging from this, 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.

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.

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. Speaking of components of iron sand produced in Japan(Miyamoto, 1960) , 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.

The zircon grade was ZrO_2 average 60.6%, Hf 0.51%, and Th <0.01%.

The data shows that 95.8 to 99.5% averaging 98.5% of ilmenite grain sizes were within the range of -0.40 + 0.05mm and 76.7 to 90.3% averaging 86.3 were within the range of -0.40 + 0.10mm. The mode was about 0.2mm. The grain size distribution was almost identical to those in Years 1 and 2. Specifically, ilmenite with a coarse grain size of 0.1mm or more concentrated in the centers of valleys of palaeo-landform channels, while ilmenite of a fine grain size of 0.1mm or less concentrated around valleys. This may be explained by coarse-grained ilmenite that was transported and deposited in the centers of valleys of palaeo-landform channels where flow velocity was fast, while ilmenite of a fine grain size was deposited in banks where flow velocity was slow. The flow velocity was influenced by maximum inclinations of palaeo-landform channels and the relationship between inclinations near the drilling pits and seam grade was calculated based on existing cross sections of Bektimir Placer No. 1 (Fig. II-3-12). The relationship shows that the flow velocity increased excessively when inclinations of palaeo-landform channels exceeded about 2°, making it difficult for ilmenite to deposit and that thickened ilmenite seams with a high ilmenite content of $100kg/m^3$ or more concentrated where the inclination was 2° or less.

Variations of grain size, roundness and other parameters of ilmenite grains from the upstream to the downstream were analyzed to study the thickened ilmenite seams in the southern part in Eastern Flank of Bektimir. Ilmenite that was collected in the drilling pits in the drilling conducted from the upstream to the downstream (MJBKE-16 depth 26.4m, MJBKE-6 depth 19.7m, MJBKE-25 depth 23.7m, MJBKE-29 depth 14.1m, MJBKE-33 depth 12.7m, MJBKE-39 depth 13.5m) was thickened and hardened by a resin to produce polished thin sections. These thin sections were analyzed by preparing reflection microscope images. Each section was calculated for area, diameter corresponding to circle, radius, roundness, size, fluid diameter, surface unevenness, linearity, maximum, minimum and average center of gravity distances, absolute maximum length, absolute maximum starting point XY, absolute maximum ending point XY, elliptic major axis, elliptic minor axis and ratio between elliptic major and minor axes. Radius (r) was calculated by: Equivalent circle radius of the same area (s) as the area of an ilmenite grain $r = \sqrt{s/\pi}$. Roundness (R) was calculated: Roundness (R) = $4\pi s/l^2$ based on circumferential length (l) of an ilmenite grain (Appendix 2-18). The diameter corresponding to a circle was calculated based on the diameter of an equivalent circuit that has the same area as that of the area of a grain, size by 2 × area (s)/circumferential length (l), fluid diameter by 4 × area (s)/circumferential length (l), surface unevenness by square of circumferential length (l^2)/area (s)$\times 1/4\pi$, and linearity by square of absolute maximum length (L^2)/area (s)$\times \pi/4$. Grain radii average 0.03mm in the upstream, averaging 0.024 to 0.026mm toward the downstream. Farther down toward downstream, the grain size again becomes coarse, 0.029 to 0.03mm (See Fig. II-3-13.). In terms of roundness, grains are relatively square in the upstream, averaging 0.57. Grains are rounded toward the downstream, reaching 0.61 to 0.60, but again become square and reach 0.57 (See Fig. II-3-14.).

3-4 Conclusions and Considerations

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

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

Drilling was conducted in 18 drill pits totaling 940.5m along three traverse lines (Traverse Lines 26, 22 and 18) in a grid of 500×200m in the east and west extensions of the confirmed IV-C_2 Ore Reserves Block of Bektimir Placer No. 1.

Regarding Traverse Lines 34 and 30, the results of MJBK-19 and MJBK-24 confirmed deterioration in ore deposit thickness and grade on the western flank of the ore body. Closure of the ore deposit could be determined. Regarding Traverse Lines 30 and 26, the results of MJBK-20 and MJBK-25 confirmed deterioration in ore deposit 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 deposit extension direction to west or southeast could be estimated.

The thickness of the ore deposit tended to slightly decrease toward the south. The thickness of overburden increased, but the width of the ore deposit increased to 2,000m, 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 0.5 million m^3, ilmenite reserves, 204,000 tons, average ilmenite content 113kg/m^3, and stripping ratio, 12.8.

The III-VI-C_2 ore reserves confirmed in Phase I and II and the total increase in Phase

III (Ore Reserves Block No.. III+IV+V-C_2) are summarized below, showing ore reserves 13.3 million m^3, ilmenite reserves 1,686,000 tons, average ilmenite content 126.7kg/m^3, and stripping ratio 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 deposits 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	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	1,800.00	113.47	204.25	46.20	23,100	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 deposit is deposited directly above a palaeo-landform channel branched in the form of letter “Y” in the bedrock of the Aral Formation in the direction of N30°E. The width of the ore deposit was estimated at about 600m and was small compared with that of Bektimir Placer No. 1. The ore deposit thickness captured by drilling was 0.5 to 6m and the ilmenite content was 13 to 135kg/m^3. Overburden on the ore deposit was 20 to 31m in thickness and tended to increase toward south, that is, toward the downstream.

Only six drilling pits qualify the grade requirement of 100kg/m^3 or more and they are not adequate for use in ore reserves calculations. However, if the cut-off condition is set at 100kg/m^3 or more for ore deposits, or 2.0m × 100kg/m^3 or more, ore reserves calculations show the following ore reserves corresponding to Category C_2. Ore reserves are 0.8 million m^3, ilmenite reserves 109,000 tons, average ilmenite content 133.5kg/m^3, and stripping ratio 8.5.

Block No	Block area 10^3m^2	Ore deposits 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) Easter Flank of Bektimir District (Reconnaissance Survey Area)

The survey undertaken in Phase II identified this district as a new high potential area for ore bearing for the following reasons: (1) Granitic rocks in hinterland are diorite-monzonite and rock masses with a magnetic susceptibility of 1×10^{-3} S.I.U. or less that are considered to contain a high content of ilmenite in the upstream regions. (2) Two systems of palaeo-landform furrows (palaeo-landform channels) of the bedrock of the Aral Formation of the Tertiary Period are forecasted.

Drilling was carried out in this district in 41 pits totaling 1,036.5m on 11 traverse lines. New thickened ilmenite seams could be found in ten pits of the 29 pits along seven traverse lines drilled in the southern flank. The found thickened ilmenite seams were deposited directly above a palaeo-landform channel in the Aral Formation bedrock running in the N10 - 45°E direction. The seams were 200 to 600m in width, 0.7 to 4.5m in thickness, 14.3 to 61.5 kg/m^3 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 and are gravel in layers of the Quaternary Period. Clay of Aral Formation is scant. The grades and widths of ore deposits improve toward the south in the downstream

.

Table I-5-1 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

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. Some parts are altering to grayish white coarse textures that are estimated to contain pseudorutile and leucoxene on ilmenite grain surfaces and along cracks. Compared with unaltered parts, altered parts contain less Fe and 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.

The data shows that 95.8 to 99.5% averaging 98.5% of ilmenite grain sizes were within the range of -0.40 + 0.05mm and 76.7 to 90.3% averaging 86.3 were within the range of

-0.40 + 0.10mm. The mode was about 0.2mm. The grain size distribution was almost identical to those of Years 1 and 2. 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 deposits 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 deposit found in Phase III 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	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

Even when ore reserves are calculated by adding the ore deposits determined in the Year-1 and -2 surveys, ore reserves compare with the indexes as follows and economical mining would 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 economy of the mining method. It is estimated that ilmenite is oxidized while it is separated from granitic rocks by weathering and is deposited and is thickened. During this process, Fe is leached and Ti is enriched. The TiO_2 grade tends to rise from the upstream to the downstream. Seams with a high content should be identified and more economical ore blocks should be set in calculating high-grade ore reserves.

(2) Quality of Ilmenite Concentrates

The data shows that 95.8 to 99.5% averaging 98.5% of ilmenite grain sizes are within the range of -0.40 + 0.05mm. The mode is about 0.2mm. The grain size distribution is almost identical to those in Years 1 and 2. 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	48.25～50.84	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

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(1)

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−38	64.00	5.60 10.00	100.0	5.33	0.67	53.0	18.2	-	12.1	3.0	13.6	—
MJBK−39	36.00	7.00 9.00	100.0	3.27	0.41	35.6	29.7	-	15.8	5.9	12.9	—
MJBK−40	64.50	6.00 7.00	100.0	8.06	1.01	43.1	29.2	-	11.1	5.6	11.1	—
MJBK−41	40.00	7.00 10.00	100.0	4.00	0.50	34.0	29.8	-	17.0	4.3	14.9	—
MJBK−42	44.00	7.00 10.00	100.0	3.67	0.46	52.8	25.0	-	7.4	3.7	11.1	—
MJBK−43	50.00	8.00 11.60	100.0	6.25	0.78	44.4	30.6	-	11.1	2.8	11.1	—
MJBK−44	60.00	8.00 10.00	100.0	6.00	0.75	36.5	30.2	-	8.3	8.3	16.7	—
MJBK−45	61.00	5.60 10.00	100.0	5.55	0.69	50.0	18.0	-	16.0	4.0	12.0	—
MJBK−46	28.00	8.00 10.00	100.0	3.11	0.39	32.5	42.5	-	5.0	10.0	10.0	—
MJBK−47	36.00	5.00 10.00	100.0	2.57	0.32	16.4	39.3	26.2	3.3	6.6	8.2	—
MJBK−48	51.00	6.00 10.00	100.0	6.38	0.80	43.4	26.3	-	5.3	9.2	15.8	—
MJBK−49	54.00	7.00 10.00	100.0	3.18	0.40	36.4	21.6	12.5	4.5	6.8	18.2	—
MJBK−50	59.00	7.00 10.00	100.0	2.81	0.35	13.0	29.2	27.1	16.7	1.6	12.5	—
MJBK−51	55.00	5.00 8.00	100.0	6.11	0.76	26.2	26.2	19.0	9.5	4.8	14.3	—
MJBK−52	55.00	7.00 9.00	100.0	6.11	0.76	47.7	22.7	-	9.1	2.3	18.2	—
MJBK−53	65.00	7.00 10.00	100.0	5.42	0.68	49.1	18.8	-	14.3	3.6	14.3	—
MJBK−54	60.00	6.00 9.00	100.0	7.50	0.94	48.3	17.2	-	13.8	6.9	13.8	—
MJBK−55	58.00	5.00 7.00	100.0	9.67	1.21	42.6	24.1	-	14.8	7.4	11.1	—
MJBKS−26	31.00	11.00	100.0	7.75	0.97	20.0	37.5	-	12.5	10.0	20.0	—
MJBKS−27	30.00	11.00	100.0	15.00	1.88	45.0	15.0	-	10.0	10.0	20.0	—
MJBKS−28	33.50	9.00	100.0	5.58	0.70	37.9	31.0	-	6.9	6.9	17.2	—
MJBKS−29	40.00	13.00	100.0	3.64	0.45	13.8	11.7	51.1	11.7	5.3	6.4	—
MJBKS−30	40.00	11.00	100.0	20.00	2.50	50.0	15.0	-	5.0	10.0	20.0	—
MJBKS−31	41.00	11.00	100.0	20.50	2.56	47.6	14.3	-	4.8	14.3	19.0	—
MJBKS−32	40.00	11.00	100.0	20.00	2.50	45.0	15.0	-	10.0	10.0	20.0	—
MJBKS−33	35.00	11.00	100.0	17.50	2.19	45.0	15.0	-	10.0	10.0	20.0	—

Table II-3-1 Quantity of Drilling Works, Core Recovery and Efficiency of Drilling in the Kokpetinskaya Area(2)

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
MJBKE−1	45.00		100.0	22.50	2.81	25.0	10.0	−	40.0	5.0	20.0	−
MJBKE−2	50.00		100.0	25.00	3.13	22.7	9.1	−	36.4	4.5	27.3	−
MJBKE−3	41.00		100.0	41.00	5.13	41.7	16.7	−	4.2	4.2	33.3	−
MJBKE−4	17.00		100.0	17.00	2.13	50.0	20.0	−	5.0	5.0	20.0	−
MJBKE−5	18.00		100.0	18.00	2.25	50.0	20.0	−	5.0	5.0	20.0	−
MJBKE−6	22.00		100.0	22.00	2.75	50.0	20.0	−	5.0	5.0	20.0	−
MJBKE−7	44.00		100.0	44.00	5.50	40.0	30.0	−	5.0	5.0	20.0	−
MJBKE−8	59.50		100.0	29.75	3.72	40.0	20.0	−	10.0	10.0	20.0	−
MJBKE−9	55.50		100.0	18.50	2.31	40.0	20.0	−	10.0	10.0	20.0	−
MJBKE−10	22.00	13.00	100.0	1.83	0.23	8.0	11.0	44.0	32.0	1.0	4.0	−
MJBKE−11	12.00	3.00	100.0	3.00	0.38	25.0	15.0	−	20.0	20.0	20.0	−
MJBKE−12	29.00		100.0	29.00	3.63	41.7	16.7	−	4.2	4.2	33.3	−
MJBKE−13	42.00	9.00	100.0	10.50	1.31	26.3	36.8	−	10.5	10.5	15.8	−
MJBKE−14	48.00		100.0	48.00	6.00	33.3	16.7	−	8.3	8.3	33.3	−
MJBKE−15	45.00		100.0	45.00	5.63	33.3	16.7	−	8.3	8.3	33.3	−
MJBKE−16	29.00		100.0	58.00	7.25	33.3	16.7	−	8.3	8.3	33.3	−
MJBKE−17	25.00		100.0	50.00	6.25	33.3	16.7	−	8.3	8.3	33.3	−
MJBKE−18	17.00		100.0	34.00	4.25	33.3	16.7	−	8.3	8.3	33.3	−
MJBKE−19	19.00		100.0	38.00	4.75	33.3	16.7	−	8.3	8.3	33.3	−
MJBKE−20	12.00		100.0	12.00	1.50	50.0	20.0	−	5.0	5.0	20.0	−
MJBKE−21	18.00		100.0	18.00	2.25	50.0	20.0	−	5.0	5.0	20.0	−
MJBKE−22	8.00		100.0	12.80	1.60	42.9	14.3	−	7.1	7.1	28.6	−
MJBKE−23	15.00		100.0	20.00	2.50	50.0	12.5	−	6.3	6.3	25.0	−
MJBKE−24	12.00		100.0	24.00	3.00	42.9	14.3	−	7.1	7.1	28.6	−
MJBKE−25	29.00		100.0	29.00	3.63	41.7	16.7	−	4.2	4.2	33.3	−
MJBKE−26	27.00		100.0	27.00	3.38	50.0	20.0	−	5.0	5.0	20.0	−
MJBKE−27	6.00		100.0	6.00	0.75	50.0	20.0	−	5.0	5.0	20.0	−
MJBKE−28	15.00		100.0	15.00	1.88	50.0	20.0	−	5.0	5.0	20.0	−
MJBKE−29	20.00		100.0	20.00	2.50	50.0	20.0	−	5.0	5.0	20.0	−
MJBKE−30	19.00		100.0	19.00	2.38	50.0	20.0	−	5.0	5.0	20.0	−
MJBKE−31	19.00		100.0	9.50	1.19	36.4	18.2	−	9.1	9.1	27.3	−
MJBKE−32	15.00		100.0	7.50	0.94	40.0	20.0	−	10.0	10.0	20.0	−
MJBKE−33	22.00		100.0	22.00	2.75	41.7	16.7	−	4.2	4.2	33.3	−
MJBKE−34	34.00		100.0	34.00	4.25	35.7	14.3	−	3.6	3.6	42.9	−
MJBKE−35	16.00		100.0	16.00	2.00	41.7	16.7	−	4.2	4.2	33.3	−
MJBKE−36	20.00		100.0	20.00	2.50	50.0	20.0	−	5.0	5.0	20.0	−
MJBKE−37	21.00		100.0	21.00	2.63	41.7	16.7	−	4.2	4.2	33.3	−
MJBKE−38	21.00	11.00	100.0	14.00	1.75	33.3	27.8	−	2.8	2.8	33.3	−
MJBKE−39	15.00	12.00	100.0	6.00	0.75	42.9	19.6	−	7.1	1.8	28.6	−
MJBKE−40	14.50	11.00	100.0	9.67	1.21	42.9	19.6	−	7.1	1.8	28.6	−
MJBKE−41	18.00	10.00	100.0	12.00	1.50	33.3	27.8	−	2.8	2.8	33.3	−
Total	2267.50	157.00	5,000	1134.50	141.81	2636.6	1393.3	179.9	623.0	421.6	1445.5	−
Average by each hole	33.84	2.34	74.6	16.93	2.12	39.4	20.8	2.7	9.3	6.3	21.6	−

Table Ⅱ-3-2 Results of Drilling Survey by Each Hole in the Kokpetinskaya Area(1)

Hole No.	Period of Drilling	Drilling length	Quantity of working shift	Total workers				Contents of work								Consumable materials													Non-core	Core	Casing
				Engineer			Worker									Bit			Shoe												
		m		Japanese	Operator	Geologist	Assistant /driver	Drilling hr	Preparation hr	Dismount hr	Out-drilling hr	Recovery from accident hr	Transportation of water hr	Other hr	Total hr	4"T.B. pc	mm 190 pc	mm 92 pc	mm 400 pc	mm 270 pc	mm 200 pc	mm 133 pc	Deisel oil l	Gasoline l	Lubricating oil l	Grease kg	Bentonite bag	Total amount of water m³	m	m	m
MJBK 38	2002.8.7 2002.8.12	64.00	12	6	12	6.0	60	70.0	16.0	4.0	24.0		18.0		132.0		3			1			400	250	25	20		27	8.5	55.5	5.6 10.0
MJBK 39	2002.8.1 2002.8.6	36.00	11	5	10	5.0	55	36.0	16.0	6.0	30.0		13.0		101.0		3			2			480	120	15	17		19.5	7.0	29.0	7.0 9.0
MJBK 40	2002.7.28 2002.8.1	64.50	8	4	8	4.0	40	31.0	8.0	4.0	21.0		8.0		72.0		1			1			300	30	10	8		12	7.0	57.5	6.0 7.0
MJBK 41	2002.8.19 2002.8.23	40.00	10	5	10	5.0	50	32.0	16.0	4.0	28.0		14.0		94.0		1			1			350	150	15	10		21	10.0	30.0	7.0 10.0
MJBK 42	2002.8.1 2002.8.6	44.00	12	6	12	6.0	60	57.0	8.0	4.0	27.0		12.0		108.0		3			1			400	25	25	20		18	10.0	34.0	7.0 10.0
MJBK 43	2002.7.28 2002.7.31	50.00	8	3	6	3.0	40	32.0	8.0	2.0	22.0		8.0		72.0		1			1			350	150	15	10		12	10.5	39.5	8.0 11.6
MJBK 44	2002.7.23 2002.7.28	60.00	10	4.5	9	4.5	50	35.0	8.0	8.0	29.0		16.0		96.0		2			2			620	120	30	15		24	7.0	53.0	8.0 10.0
MJBK 45	2002.8.7 2002.8.12	61.00	11	3.5	7	3.5	55	50.0	16.0	4.0	18.0		12.0		100.0		1			1			200	20	5	5		18	9.0	52.0	5.6 10.0
MJBK 46	2002.7.23 2002.7.27	28.00	9	3.75	7.5	3.8	45	26.0	4.0	8.0	34.0		8.0		80.0		4			3			500	80	10	15		12	8.0	20.0	8.0 10.0
MJBK 47	2002.7.16 2002.7.23	36.00	14	6.125	12.25	6.1	70	20.0	4.0	8.0	48.0	32.0	10.0		122.0		2			1			460	160	20	20		15	8.0	28.0	5.0 10.0
MJBK 48	2002.7.12 2002.7.16	51.00	8	3.75	7.5	3.8	40	33.0	4.0	7.0	20.0		12.0		76.0		4			3			850	280	15	15		18	8.0	43.0	6.0 10.0
MJBK 49	2002.7.4 2002.7.12	54.00	17	7.625	15.25	7.6	85	32.0	4.0	6.0	19.0	11.0	16.0		88.0		4			3			890	250	20	15		24	8.0	44.1	7.0 10.0
MJBK 50	2002.7.4 2002.7.14	59.00	21	9.375	18.75	9.4	105	25.0	32.0	3.0	56.0	52.0	24.0		192.0		3			3			860	170	20	19		36	7.0	46.6	7.0 10.0
MJBK 51	2002.7.14 2002.7.18	55.00	9	3.75	7.5	3.8	45	22.0	8.0	4.0	22.0	16.0	12.0		84.0		1			1			430	80	15	12		18	7.0	48.0	5.0 8.0
MJBK 52	2002.7.19 2002.7.23	55.00	9	4.125	8.25	4.1	45	42.0	8.0	2.0	20.0		16.0		88.0		2			2			530	200	20	15		24	8.0	47.0	7.0 9.0
MJBK 53	2002.8.13 2002.8.18	65.00	12	6.25	12.5	6.3	60	55.0	16.0	4.0	21.0		16.0		112.0		3			1			330	200	30	20		24	8.5	56.5	7.0 10.0
MJBK 54	2002.8.12 2002.8.16	60.00	8	4	8	4.0	40	28.0	8.0	4.0	10.0		8.0		58.0		2			1			350	120	10	8		12	8.0	52.0	6.0 9.0
MJBK 55	2002.8.16 2002.8.19	58.00	6	3	6	3.0	30	23.0	8.0	4.0	13.0		6.0		54.0		2			1			380	160	15	13		9	7.0	51.0	5.0 7.0
MJBKS 26	2002.7.20 2002.7.21	31.00	4	2	4	2.0	20	8.0	5.0	4.0	15.0		8.0		40.0	1		2				1	220	45	10	6	30	12	11.0	20.0	11.0
MJBKS 27	2002.7.22 2002.7.22	30.00	2	1	2	1.0	10	9.0	2.0	2.0	3.0		4.0		20.0	1		1					120	30	5	3	30	6	10.0	20.0	11.0
MJBKS 28	2002.7.17 2002.7.19	33.50	6	3	6	3.0	30	22.0	4.0	4.0	18.0		10.0		58.0	1		3				1 1	340	100	15	5	20	15	9.5	24.0	9.0
MJBKS 29	2002.7.16 2002.7.16	40.00	11	5.25	10.5	5.3	48	13.0	11.0	5.0	11.0	48.0	6.0		94.0	3		1				1	250	80	15	5	30	9	9.0	31.0	13.0
MJBKS 30	2002.7.26 2002.7.26	40.00	2	1	2	1.0	10	10.0	1.0	2.0	3.0		4.0		20.0	1		1				1	125	40	10	8		6	8.7	31.3	11.0
MJBKS 31	2002.7.25 2002.7.25	41.00	2	1	2	1.0	10	10.0	1.0	3.0	3.0		4.0		21.0	1		1				1	130	40	10	10		6	9.0	32.0	11.0
MJBKS 32	2002.7.24 2002.7.24	40.00	2	1	2	1.0	10	9.0	2.0	2.0	3.0		4.0		20.0	1		1				1	130	35	5	6		6	9.0	31.0	11.0
MJBKS 33	2002.7.23 2002.7.23	35.00	2	1	2	1.0	10	9.0	2.0	2.0	3.0		4.0		20.0	1		1				1	120	30	5	3		6	9.0	26.0	11.0

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

Hole No.	Period of Drilling	Drilling length	Quantity of working shift	Total workers				Contents of work								Consumable materials													Non-core	Core	Casing
				Engineer			Worker									Bit			Shoe												
				Japanese	Operator	Geologist	Assistant /driver	Drilling	Preparation	Dismount	Out-drilling	Recovery from accident	Transportation of water	Other	Total	4"T.B.	mm 190	mm 92	mm 400	mm 270	mm 200	mm 133	Deisel oil	Gasoline	Lubricating oil	Grease	Bentonite	Total amount of water			
		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
MJBKE 1	2002.8.2 2002.8.2	45.00	2	1.25	2.5	1.3	10	5.0	8.0	1.0	2.0		4.0		20.0			1					120	80	20	5		6	8.0	37.0	
MJBKE 2	2002.8.3 2002.8.4	50.00	2	1	2	1.0	10	5.0	8.0	1.0	2.0		6.0		22.0			1					180	80	35	10	30	9	12.0	38.0	
MJBKE 3	2002.8.4 2002.8.4	41.00	1	0.5	1	0.5	5	5.0	0.5	0.5	2.0		4.0		12.0			1					120	80	20	5		6	7.0	34.0	
MJBKE 4	2002.8.9 2002.8.9	17.00	1	0.5	1	0.5	5	5.0	0.5	0.5	2.0		2.0		10.0			1					100	80	20	5		3	2.0	14.0	
MJBKE 5	2002.8.9 2002.8.9	18.00	1	0.5	1	0.5	5	5.0	0.5	0.5	2.0		2.0		10.0			1					140	70	20	5		3	5.0	13.0	
MJBKE 6	2002.8.10 2002.8.10	22.00	1	0.5	1	0.5	5	5.0	0.5	0.5	2.0		2.0		10.0			1					140	70	15	5		3	3.0	19.0	
MJBKE 7	2002.7.29 2002.7.29	44.00	1	0.75	1.5	0.8	5	4.0	0.5	0.5	3.0		2.0		10.0	1		1				1	120	50	10	5		3	7.0	37.0	
MJBKE 8	2002.7.29 2002.7.30	59.50	2	1	2	1.0	10	8.0	2.0	2.0	4.0		4.0		20.0			1				1	120	50	10	5		6	7.0	52.5	
MJBKE 9	2002.7.30 2002.7.31	55.50	3	1.5	3	1.5	15	8.0	2.0	2.0	4.0		4.0		20.0			1				1	140	60	20	5		6	8.0	47.5	
MJBKE 10	2002.7.4 2002.7.9	22.00	12	6	12	6.0	60	8.0	32.0	1.0	11.0	44.0	4.0		100.0	2		1				1	370	140	25	8	30	6	8.0	14.0	13.0
MJBKE 11	2002.7.10 2002.7.10	12.00	4	1	2	1.0	10	5.0	4.0	4.0	3.0		4.0		20.0			1					120	60	10	2		6	8.8	8.0	3.0
MJBKE 12	2002.8.12 2002.8.15	29.00	1	0.5	1	0.5	5	5.0	0.5	0.5	2.0		4.0		12.0			1					120	70	20	5		6	6.0	23.0	
MJBKE 13	2002.7.27 2002.7.28	42.00	4	2	4	2.0	20	10.0	4.0	4.0	14.0		6.0		38.0	1		1					320	130	25	25	30	9	8.0	34.0	9.0
MJBKE 14	2002.7.31 2002.7.31	48.00	1	0.5	1	0.5	5	4.0	1.0	1.0	2.0		4.0		12.0			1					100	40	20	5		6	8.0	40.0	
MJBKE 15	2002.8.1 2002.8.1	45.00	1	0.5	1	0.5	5	4.0	1.0	1.0	2.0		4.0		12.0			1					120	40	20	5		6	8.0	37.0	
MJBKE 16	2002.8.14 2002.8.14	29.00	0.5	0.25	0.5	0.3	2.5	2.0	0.5	0.5	1.0		2.0		6.0			1					100	70	20	5		3	5.0	24.0	
MJBKE 17	2002.8.14 2002.8.14	25.00	0.5	0.25	0.5	0.3	2.5	2.0	0.5	0.5	1.0		2.0		6.0			1					100	70	20	5		3	3.0	22.0	
MJBKE 18	2002.8.14 2002.8.14	17.00	0.5	0.25	0.5	0.3	2.5	2.0	0.5	0.5	1.0		2.0		6.0			1					100	70	20	5		3	4.0	13.0	
MJBKE 19	2002.8.14 2002.8.14	19.00	0.5	0.25	0.5	0.3	2.5	2.0	0.5	0.5	1.0		2.0		6.0			1					100	60	20	5		3	1.0	18.0	
MJBKE 20	2002.8.7 2002.8.7	12.00	1	0.5	1	0.5	5	5.0	0.5	0.5	2.0		2.0		10.0			1					100	80	20	5		3	8.0	4.0	
MJBKE 21	2002.8.7 2002.8.7	18.00	1	0.5	1	0.5	5	5.0	0.5	0.5	2.0		2.0		10.0			1					140	70	20	5		3	5.0	13.0	
MJBKE 22	2002.8.6 2002.8.6	8.00	0.625	0.3125	0.625	0.3	3.125	3.0	0.5	0.5	1.0		2.0		7.0			1					120	80	20	5		3	7.5	3.0	
MJBKE 23	2002.8.6 2002.8.6	15.00	0.75	0.375	0.75	0.4	3.75	4.0	0.5	0.5	1.0		2.0		8.0			1					150	80	10	5		3	5.0	8.0	
MJBKE 24	2002.8.6 2002.8.6	12.00	0.5	0.25	0.5	0.3	2.5	3.0	0.5	0.5	1.0		2.0		7.0			1					100	80	20	5		3	10.0	2.0	
MJBKE 25	2002.8.13 2002.8.13	29.00	1	0.5	1	0.5	5	5.0	0.5	0.5	2.0		4.0		12.0			1					140	70	20	5		6	2.0	27.0	
MJBKE 26	2002.8.13 2002.8.13	27.00	1	0.5	1	0.5	5	5.0	0.5	0.5	2.0		2.0		10.0			1					140	70	20	5		3	4.0	23.0	
MJBKE 27	2002.8.22 2002.8.22	6.00	1	0.5	1	0.5	5	5.0	0.5	0.5	2.0		2.0		10.0			1					40	20	10	5		3	5.0	1.0	
MJBKE 28	2002.8.16 2002.8.16	15.00	1	0.5	1	0.5	5	5.0	0.5	0.5	2.0		2.0		10.0			1					120	70	20	5		3	10.0	5.0	
MJBKE 29	2002.8.17 2002.8.17	20.00	1	0.5	1	0.5	5	5.0	0.5	0.5	2.0		2.0		10.0			2					200	80	15	5	30	3	10.0	11.0	
MJBKE 30	2002.8.18 2002.8.18	19.00	1	0.5	1	0.5	5	5.0	0.5	0.5	2.0		2.0		10.0			1					100	60	20	5		3	9.0	19.0	
MJBKE 31	2002.8.18 2002.8.19	19.00	2	1	2	1.0	10	8.0	2.0	2.0	4.0		6.0		22.0			1					100	60	20	5		9	9.5	9.5	
MJBKE 32	2002.8.19 2002.8.20	15.00	2	1	2	1.0	10	8.0	2.0	2.0	4.0		4.0		20.0			1					120	50	10	5		6	8.0	7.0	
MJBKE 33	2002.8.21 2002.8.21	22.00	1	0.5	1	0.5	5	5.0	0.5	0.5	2.0		4.0		12.0			1					100	45	10	5		6	8.4	13.6	
MJBKE 34	2002.8.15 2002.8.15	34.00	1	0.5	1	0.5	5	5.0	0.5	0.5	2.0		6.0		14.0			1					120	70	20	5		9	10.0	24.0	
MJBKE 35	2002.8.20 2002.8.20	16.00	1	0.5	1	0.5	5	5.0	0.5	0.5	2.0		4.0		12.0			1					80	30	10	5		6	9.0	7.0	
MJBKE 36	2002.8.22 2002.8.22	20.00	1	0.5	1	0.5	5	5.0	0.5	0.5	2.0		2.0		10.0			1					100	40	10	5		3	4.0	16.0	
MJBKE 37	2002.8.21 2002.8.21	21.00	1	0.5	1	0.5	5	5.0	0.5	0.5	2.0		4.0		12.0			1					80	50	10	5		6	2.0	19.0	
MJBKE 38	2002.8.26 2002.8.26	21.00	1.5	0.75	1.5	0.8	7.5	6.0	0.5	0.5	5.0		6.0		18.0	1		1				1	120	60	20	10	20	9	11.0	10.0	11.0
MJBKE 39	2002.8.24 2002.8.25	15.00	2.5	1.25	2.5	1.3	12.5	12.0	2.0	0.5	5.5		8.0		28.0	1		1				1	160	80	15	15	20	12	12.0	3.0	12.0
MJBKE 40	2002.8.25 2002.8.25	14.50	1.5	0.75	1.5	0.8	7.5	12.0	2.0	0.5	5.5		8.0		28.0	1		1				1	100	50	10	10	20	12	11.0	3.5	11.0
MJBKE 41	2002.8.26 2002.8.27	18.00	1.5	0.75	1.5	0.8	7.5	6.0	0.5	0.5	5.0		6.0		18.0	1		1				1	140	80	20	10	20	9	12.0	9.0	10.0
Total	2002.7.4 2002.8.27	2267.50	291	136	272	135.9	1322	960.0	304.0	148.0	640.0	203.0	419.0		2672.0	18	42	53	0	29	0	18	15.415	5710	1110	558	310	629	512.9	1764.6	444.8

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		3											0.0				
Preparation	2002. 7. 1～2002. 7. 4	7	2	7	2	21	8.0	6.0	42.0					56.0	40	200	20	10
Holiday														0.0				
Dismount	2002. 8. 20～2002. 8. 21	4	2	4		16						32.0		32.0	10	300	15	10
Travel	(2002. 7. 30～2000. 8. 3)		4											0.0				
Total	2002. 7. 1～2002. 8. 21	11.00	11.0	11.0	2.0	37.0	8.0	6.0	42.0	0.0	82.0	32.0		88.0	50	500	35	20
Detailed survey (No.2 machine)																		
Travel	Tokyo-Almaty-Samarskaya													0.0				
Preparation	2002. 7. 1～2002. 7. 4	6	2	7	2	21	8.0	8.0	32.0					48.0	30	180	10	15
Holyday														0.0				
Dismount	2002. 8. 23～2002. 8. 27	8	1	4		24						64.0		64.0	20	250	15	8
Travel														0.0				
Total	2002. 7. 1～2002. 8. 27	14.00	3.0	11.0	2.0	45.0	8.0	8.0	32.0	0.0	141.0	64.0		112.0	50	430	25	23
General survey (No. 3 machine)																		
Travel	Tokyo-Almaty-Samarskaya		3											0.0				
Preparation	2002. 7. 1～2002. 7. 4	8	2	7	2	21	6.0	6.0	52.0					64.0	15	250	20	10
Holyday														0.0				
Dismount	2002. 8. 28～2002. 8. 30	7	1	3	1	20						60.0		60.0	40	320	25	20
Travel	2002. 8. 31～2000. 9. 6		7											0.0				
Total	2002. 7. 1～2002. 9. 6	15.00	13.0	10.0	3.0	41.0	6.0	6.0	52.0	0.0	0.0	60.0		124.0	55	570	45	30
Total		40.00	27.0	32.0	7.0	123.0	22.0	20.0	126.0	0.0	223.0	156.0		324.0	155	1,500	105	73

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.1	East of Bektemir	South of Placer No.3	East of Bektemir		
Number of holes			9	9	2	8	39	67	
Length of drilling (m)			508.50	432.00	34.00	290.50	1002.50	2267.50	
Ave. length of drillholes (m)			56.50	48.00	17.00	36.31	25.71	33.84	
Survey days	Period		2002.7.4	2002.7.4	2002.7.4	2002.7.16	2002.7.27	2002.7.4	
			2002.8.19	2002.8.23	2002.7.10	2002.7.26	2002.8.27	2002.8.27	
	Drilling days		36.2	40.188	4.44	12.31	19.563	112.688	
	Other days		9	7.938	2.563	3.3	4.938	28.125	Travel, transport, preparation and dismount
	Holidays		—	—	—	—	—	—	
	Total days		45.6	48.1	7.000	15.563	25	140.81	
Workers	Local staff	Engineer	83	95	14	30.5	50	271.875	
		Worker	350	510	70	148.0	244	1322.375	
		Geologist	41	48	7	15.3	25	135.9375	
		Total	474	653	91	193.75	319	1730.19	
	Japanese staff		41	48	7	15.3	25	136	
Efficiency of drilling days (m/day·machine)			14.05	10.75	7.66	23.59	51.25	20.12	
Efficiency of survey days (m/day·machine)			11.15	8.98	4.86	18.67	40.92	16.10	

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

Item	Unit	Quantity	Average		Note
Tricone bit (4″)	pcs	18	7.75 m/pc	1.40 pcs/hole	
Metal bit (ϕ92mm)	pcs	53	18.45 m/pc	1.08 pcs/hole	
Metal bit (ϕ190mm)	pcs	42	22.39 m/pc	2.33 pcs/hole	
Shoe(ϕ270mm)	pcs	29	12.34 m/pc	1.04 pcs/hole	
Shoe(ϕ133mm)	pcs	16	4.31 m/pc	1.07 pcs/hole	
Deisel oil	liters	15,415	6.80 l/m	230.07 l/hole	
Gasoline	liters	5,710	2.52 l/m	85.22 l/hole	
Lubricating oil	liters	1,110	0.49 l/m	16.57 l/hole	
Grease	kg	558	0.25 l/m	8.33 l/hole	
Bentonite	bags*	310	0.14 bags/m	4.63 bags/hole	
Total amount of water	m^3	629	0.28 m^3/m	9.4 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/m^3)	Zircon content (kg/m^3)	Remarks
MJBK-38	59.00～62.00	3.00	126.83	2.43	
MJBK-39	-	-	-	-	
MJBK-40	46.00～48.00	2.00	104.88	1.91	
MJBK-41	-	-	-	-	
MJBK-42	-	-	-	-	
MJBK-43	41.00～43.70	2.70	109.78	1.31	
MJBK-44	48.30～50.40 50.40～51.60	2.10 1.20	78.30 119.57	1.46 2.89	
MJBK-45	53.00～54.90	1.90	63.59	1.14	
MJBK-46	-	-	-	-	
MJBK-47	-	-	-	-	
MJBK-48	48.60～49.50	0.90	61.60	1.03	
MJBK-49	39.00～41.60 41.60～51.00 51.00～52.40	2.60 9.40 1.40	133.96 61.17 101.93	2.52 1.30 1.58	
MJBK-50	38.00～45.10 45.10～53.00 53.00～57.20	7.10 7.90 4.20	103.21 62.47 117.90	1.75 1.25 1.57	
MJBK-51	50.00～51.40	1.40	36.50	0.72	
MJBK-52	39.30～44.80 44.80～46.40	5.50 1.60	34.42 133.49	0.67 2.12	
MJBK-53	56.00～57.10	1.10	158.32	3.28	
MJBK-54	54.30～58.50	4.20	115.04	2.33	
MJBK-55	48.00～57.00	9.00	7.16	0.26	

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-26	-	-	-	-	
MJBKS-27	20.00～23.00	3.00	16.67	0.61	
MJBKS-28	25.00～31.00	6.00	13.03	0.42	
MJBKS-29	27.80～32.00 32.00～36.00	4.20 4.00	53.01 110.57	1.75 2.81	
MJBKS-30	30.30～34.00 34.00～34.50 34.50～35.50	3.70 0.50 1.00	35.31 134.53 49.95	1.05 2.75 0.85	
MJBKS-31	31.00～32.00 32.00～35.50	1.00 3.50	25.53 128.63	0.67 3.05	
MJBKS-32	29.50～32.20 32.20～36.00	2.70 3.80	17.69 117.35	0.66 2.46	
MJBKS-33	27.00～29.00	2.00	44.54	1.24	

Table II -3-8 Major Mineralization Zones Revealed by Drillings on the East Bektimir

Hole No.	Depth (m)	Width (m)	Ilmenite content (kg/m^3)	Zircon content (kg/m^3)	Remarks
MJBKE-16	24.00～27.80	3.80	25.50	0.41	
MJBKE-25	22.00～26.50	4.50	27.80	1.36	
MJBKE-29	12.00～14.00	2.00	21.90	0.42	
MJBKE-33	9.30～13.70	4.40	31.86	1.73	
MJBKE-35	10.80～11.50	0.70	21.20	1.33	
MJBKE-36	17.00～17.80	0.80	31.97	1.13	
MJBKE-39	13.20～14.80	1.60	32.19	1.43	
MJBKS-40	12.80～13.80	1.00	33.52	1.53	
MJBKS-41	13.00～15.00	2.00	61.50	1.72	

Table II-3-9 Ilmenite content, Ore Sands and Overburden Thickness at the Southern Flank of Placer No1 in block V –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	26	MJBK-38	3.0	59.0	126.83	380.49
2	26	MJBK-40	2.0	46.0	104.88	209.76
3	22	MJBK-43	2.7	41.0	109.78	296.41
4	18	MJBK-49	2.6	39.0	133.96	348.30
5	18	MJBK-50	7.1	38.0	103.21	732.79
6	22	MJBK-54	4.2	54.3	115.04	483.17
Total:			21.6	277.3		2450.91
Average:			3.6	46.2	113.47	

Table II-3-10 Ilmenite content, Ore Sands and Overburden Thickness at the Southern Flank of Placer No3 in block II –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	3G	MJBKS-16	3.6	29.5	180.70	650.52
2	3G	MJBKS-29	4.0	32.0	110.57	442.28
3	3A	MJBKS-31	3.5	32.0	128.63	450.21
4	3A	MJBKS-32	3.8	32.2	117.35	445.93
Total:			14.9	125.7		1988.94
Average:			3.7	31.4	133.49	

Table II-3-11 Ilmenite content, Ore Sands on the blocks of Estimated reseves of the East Bektimir

No.	Profiles No.	Section Area (m^2)	Average ilmenite content, kg/м^3	Average Zircon content, kg/м^3	Block Volume (10^3 X m^3)
1	*2*	*3*	*4*	*5*	*7*
1	IX	380	25.5	0.4	
2	IV	450	27.8	1.4	
3	X	80	32.0	1.1	
4	XI	583	27.6	1.6	
5	XII	740	44.4	1.6	
Total:					1,050.08
Average:			30.92	1.31	

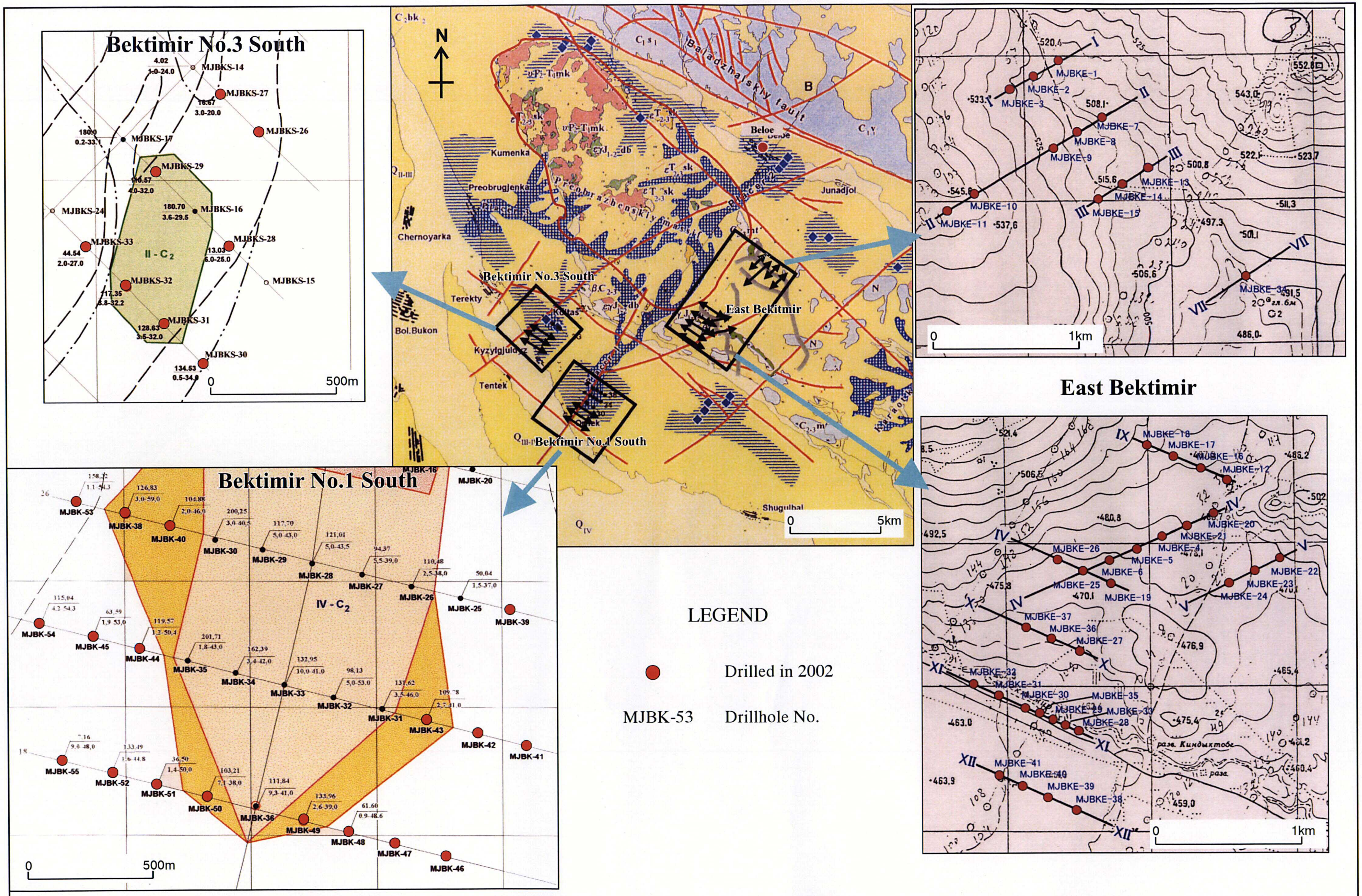


Fig.II-3-1 Location Map of the Drillholes in the Bektimir No.1 South. No.3 South and East Bektimir

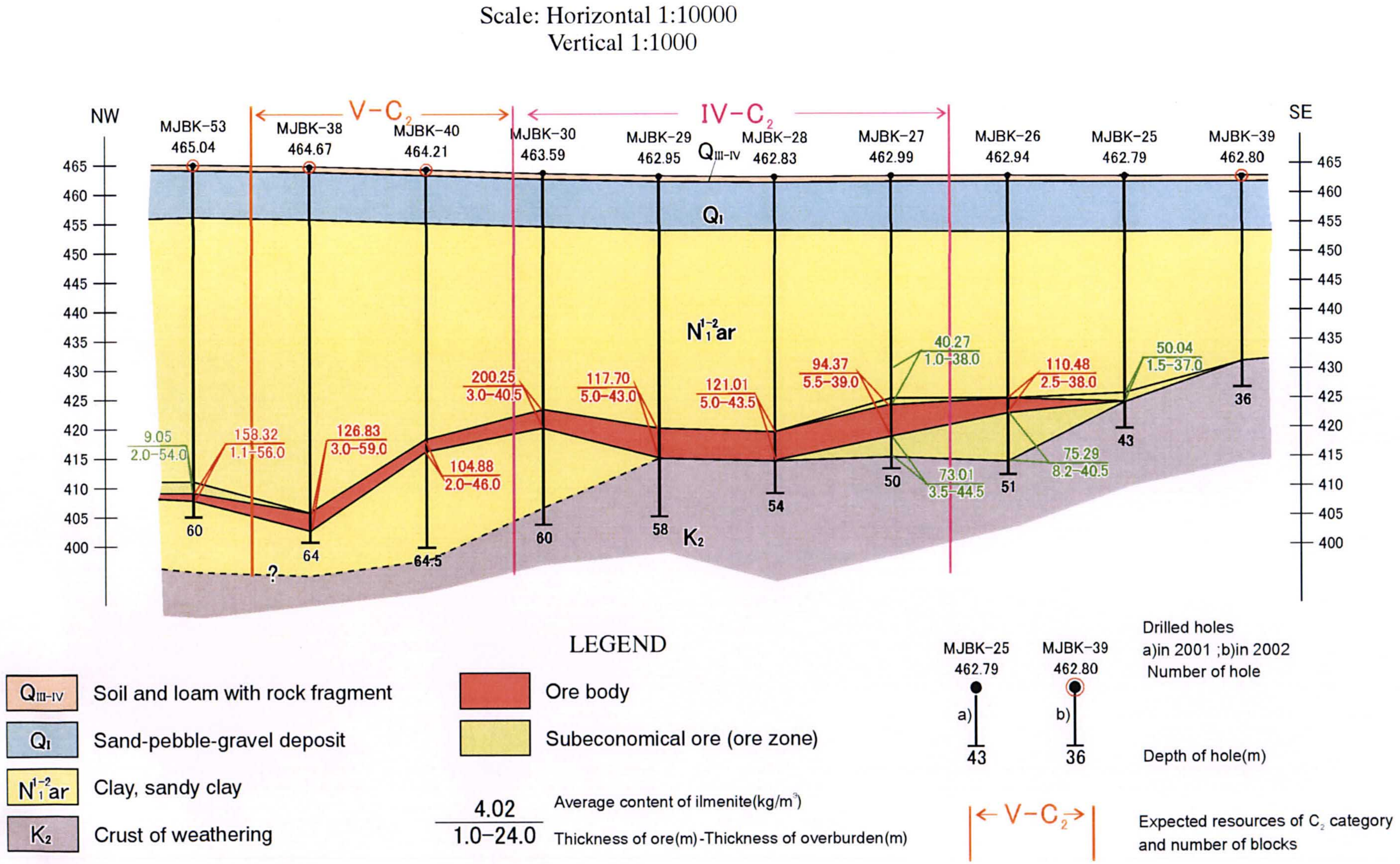


Fig.II-3-2 Geological Cross Section along Line-26

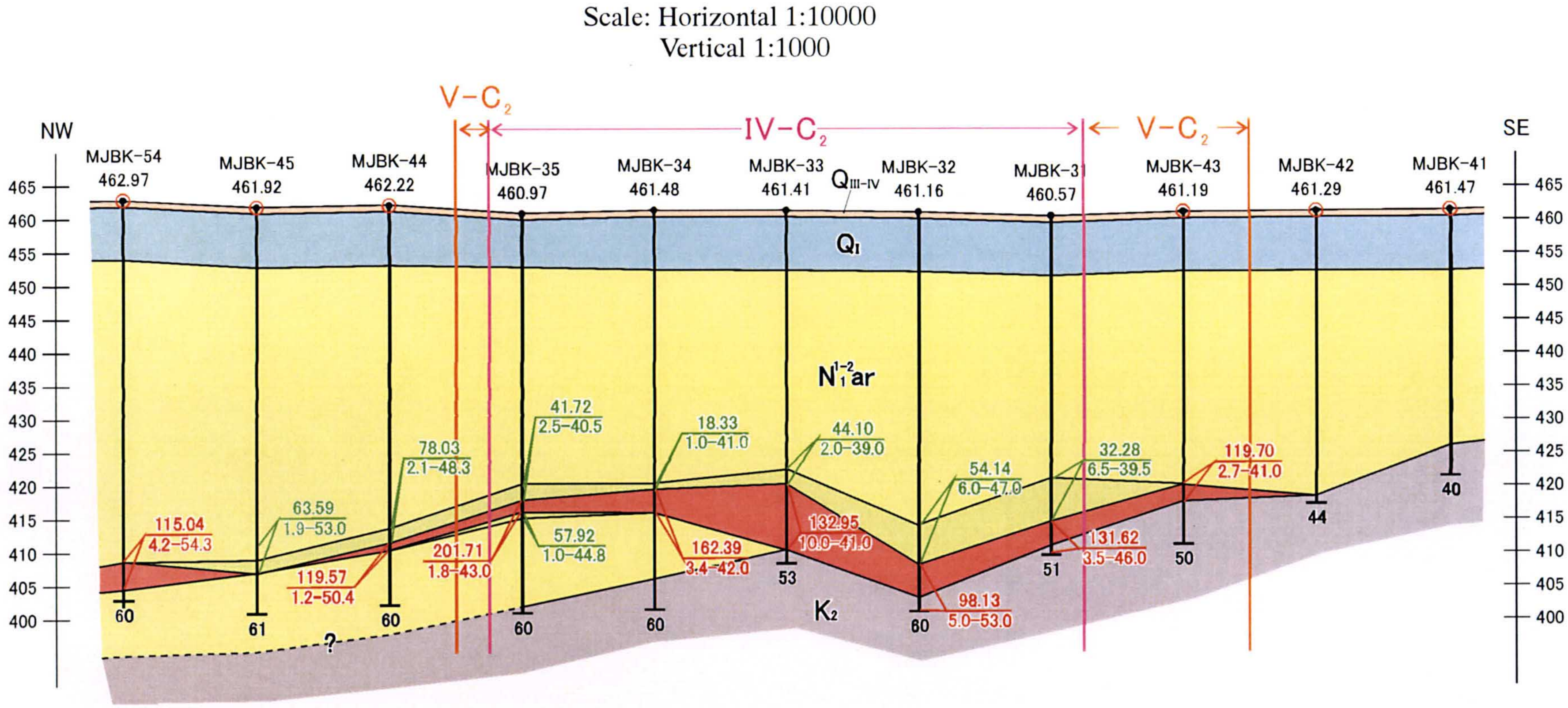


Fig.II-3-3 Geological Cross Section along Line-22

Scale: Horizontal 1:10000
Vertical 1:1000

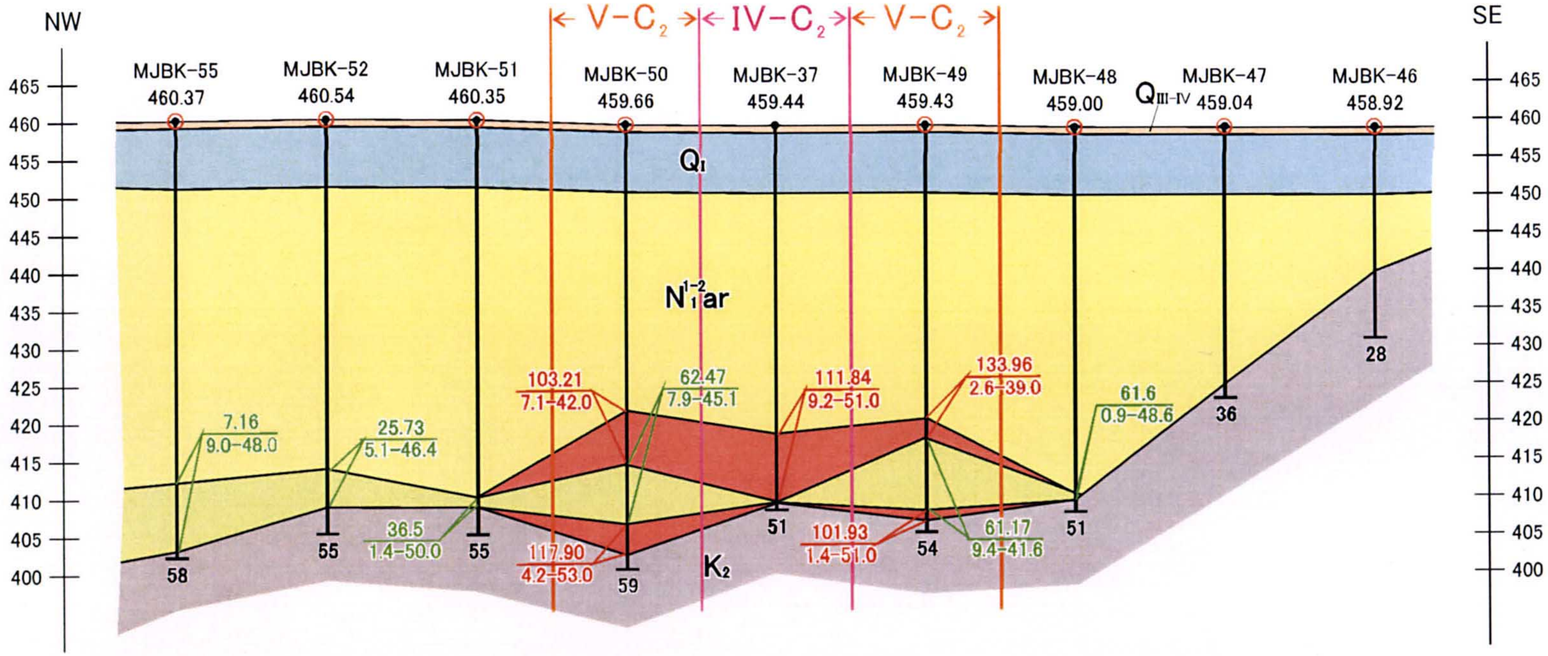


Fig.II-3-4 Geological Cross Section along Line-18

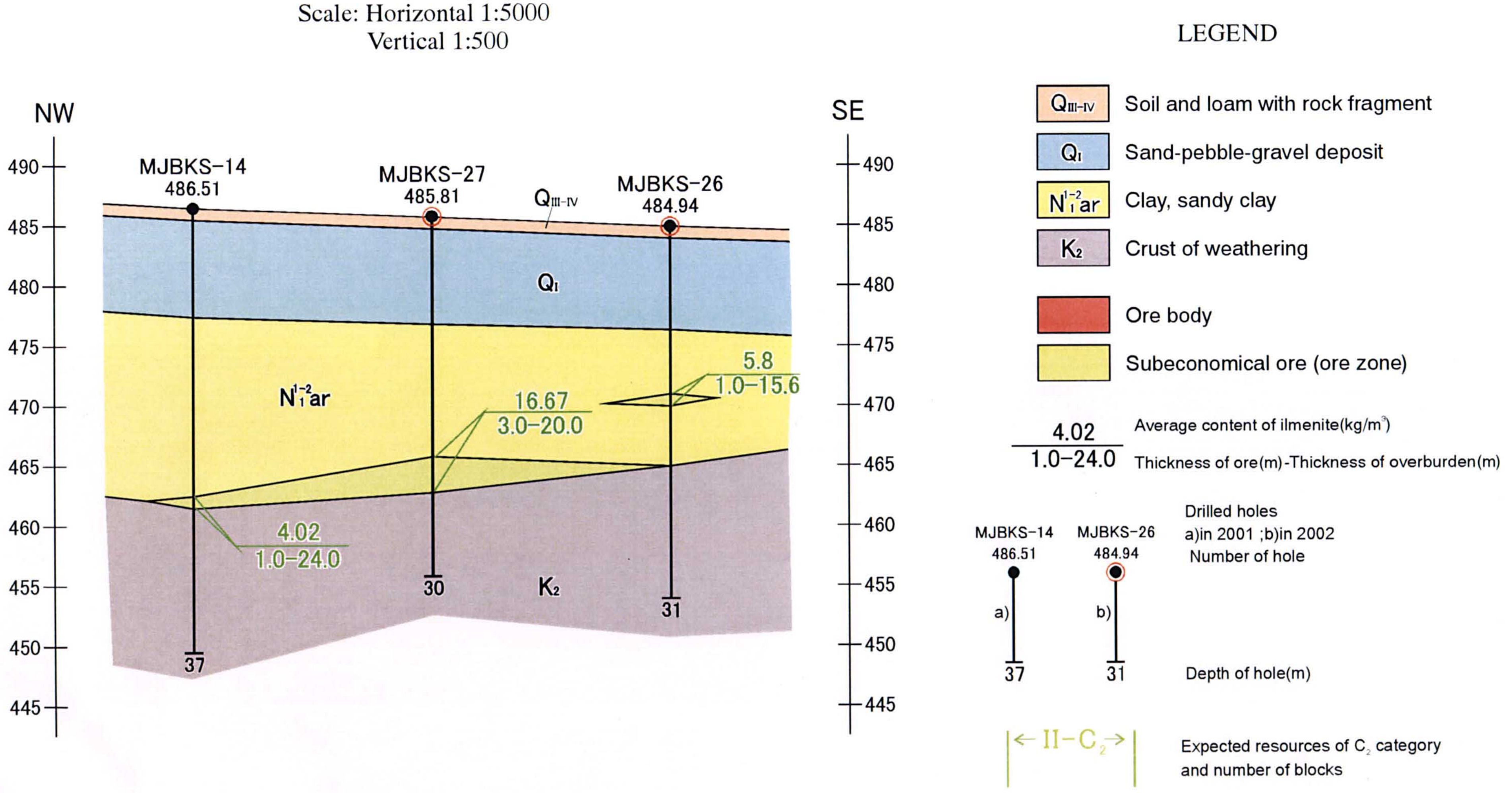


Fig.II-3-5 Geological Cross Section along Line-2A

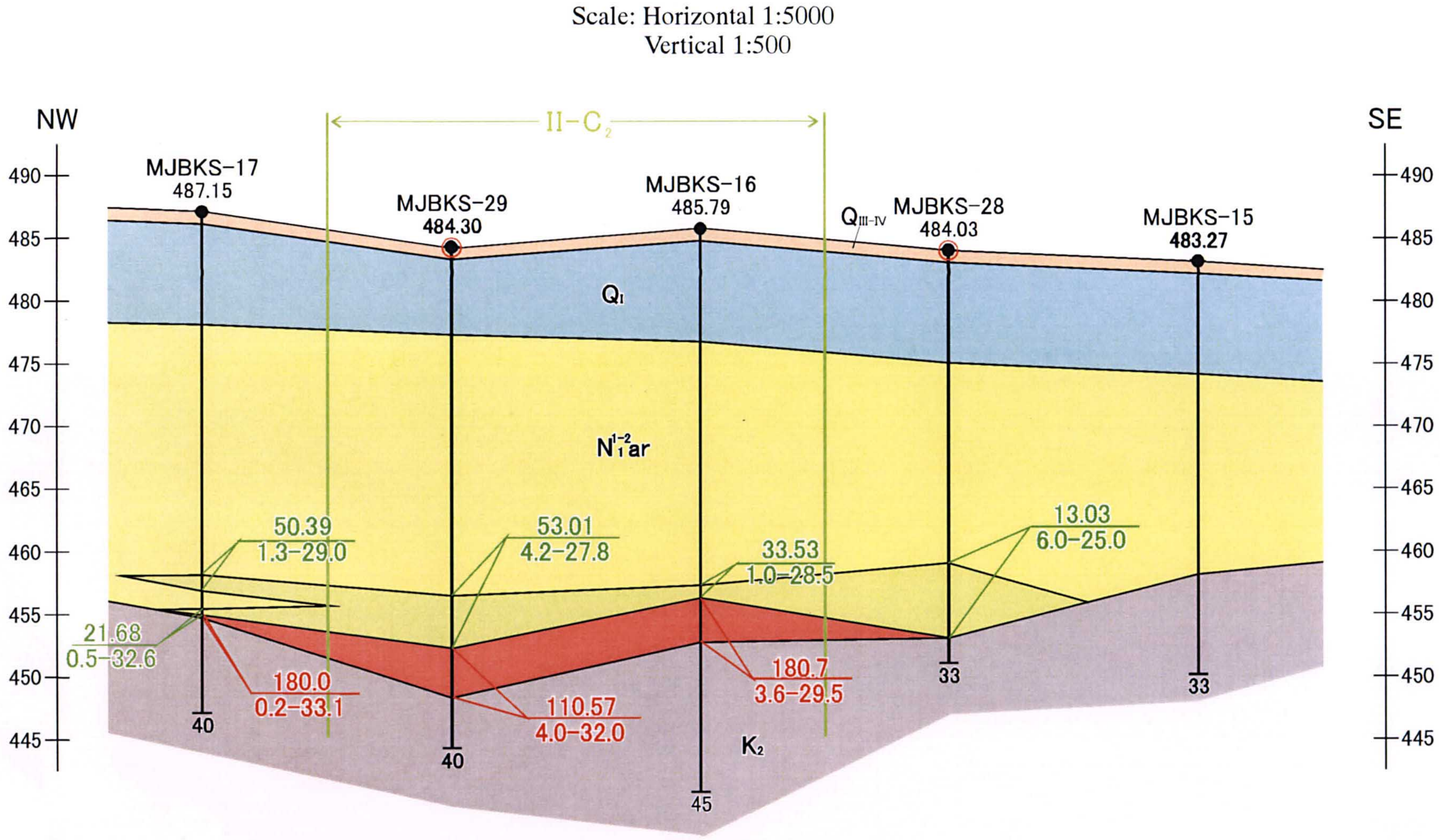


Fig.II-3-6 Geological Cross Section along Line-3G

Scale: Horizontal 1:5000
Vertical 1:500

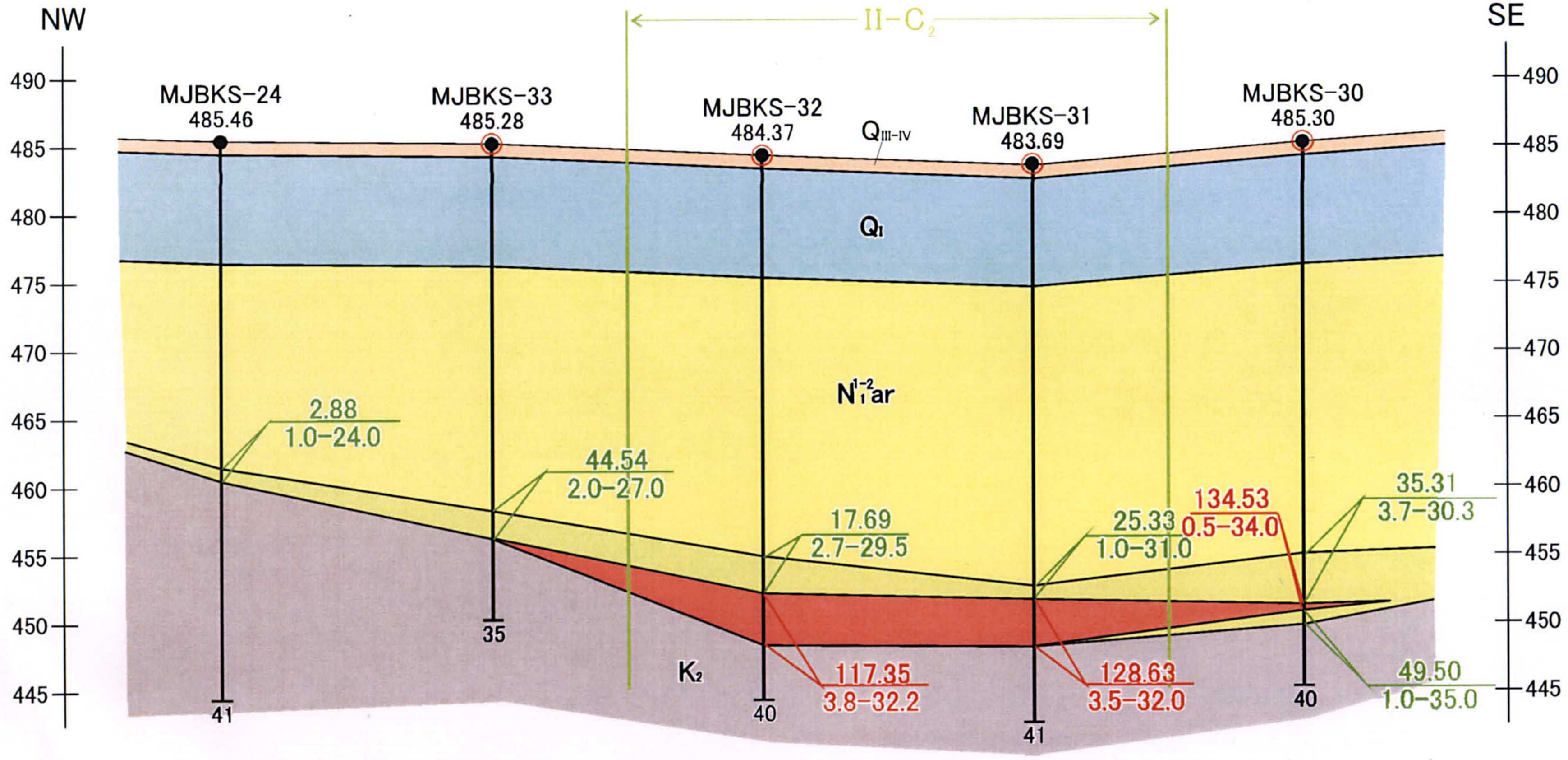


Fig.II-3-7 Geological Cross Section along Line-3A

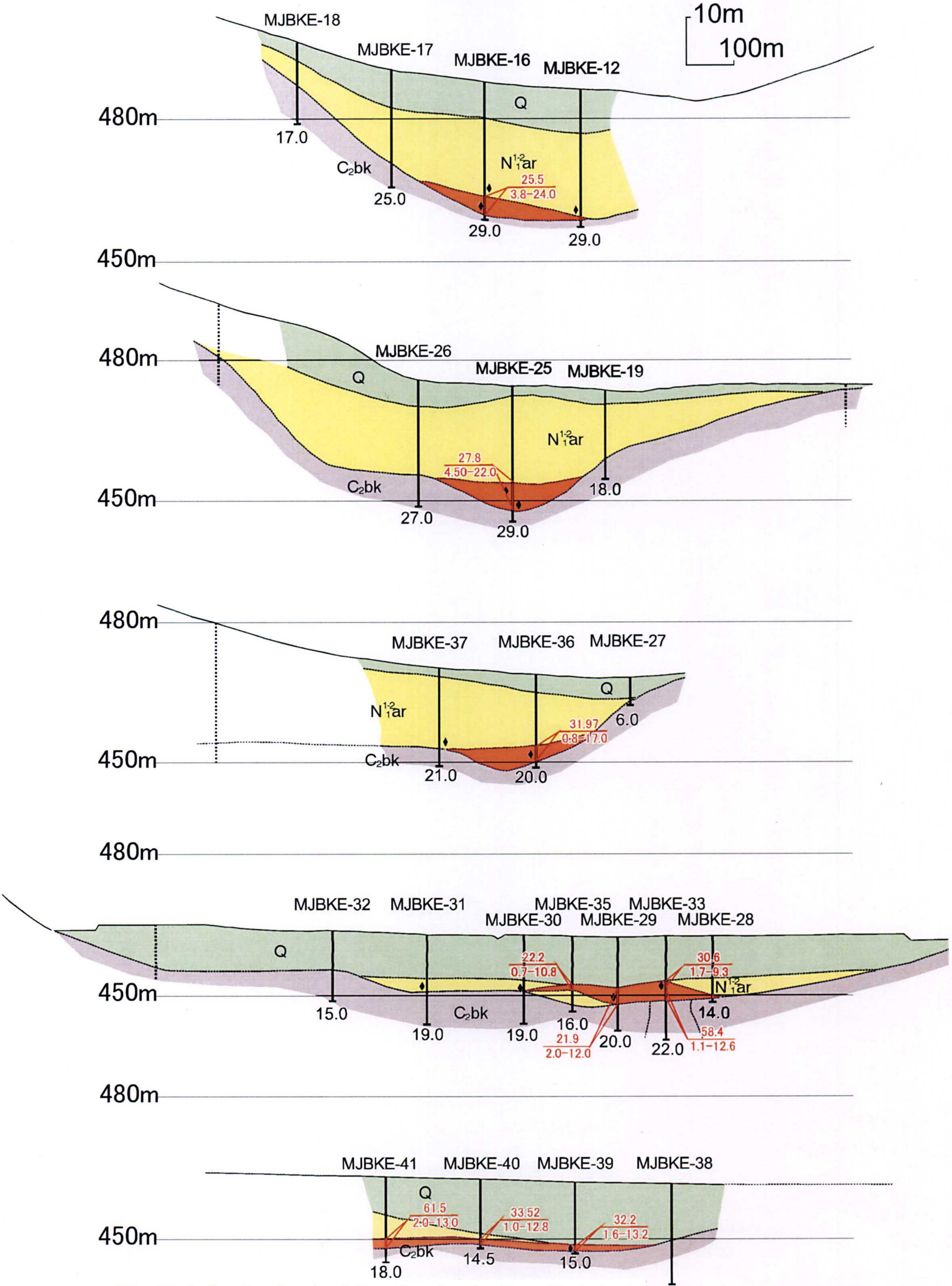


Fig.II-3-8 Geological Section in the East Bektimir

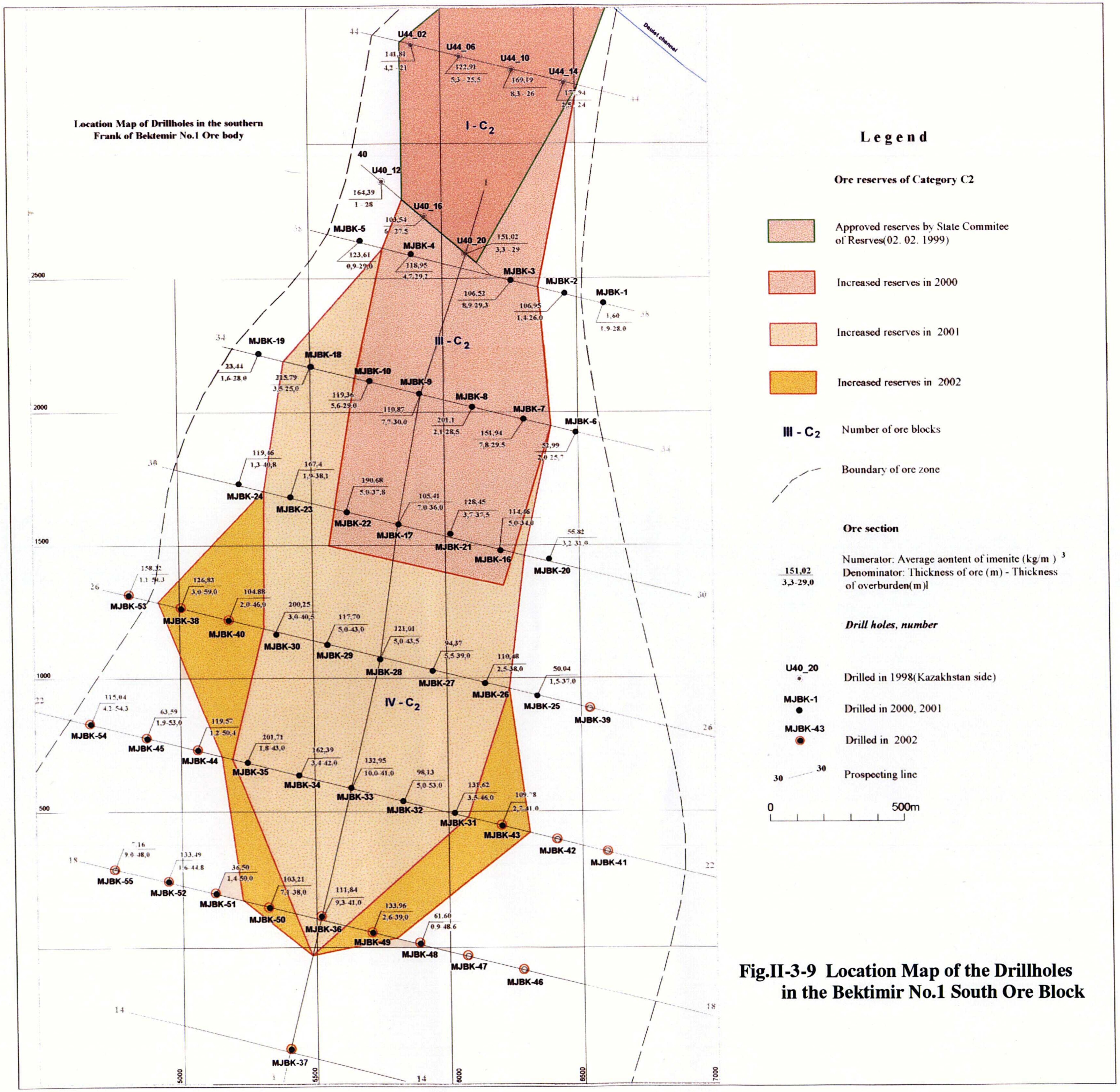


Fig.II-3-9 Location Map of the Drillholes in the Bektimir No.1 South Ore Block

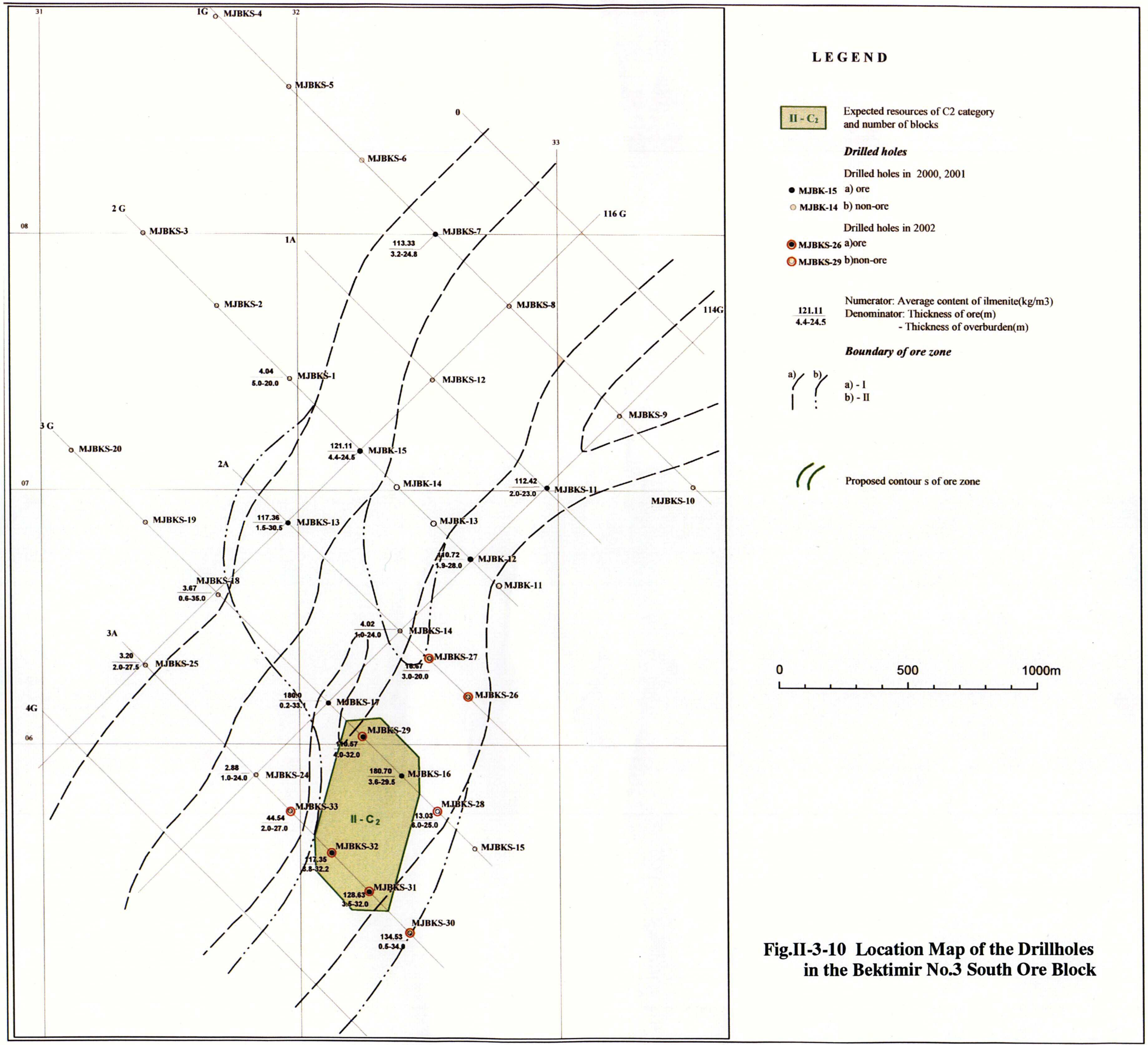


Fig.II-3-10 Location Map of the Drillholes in the Bektimir No.3 South Ore Block

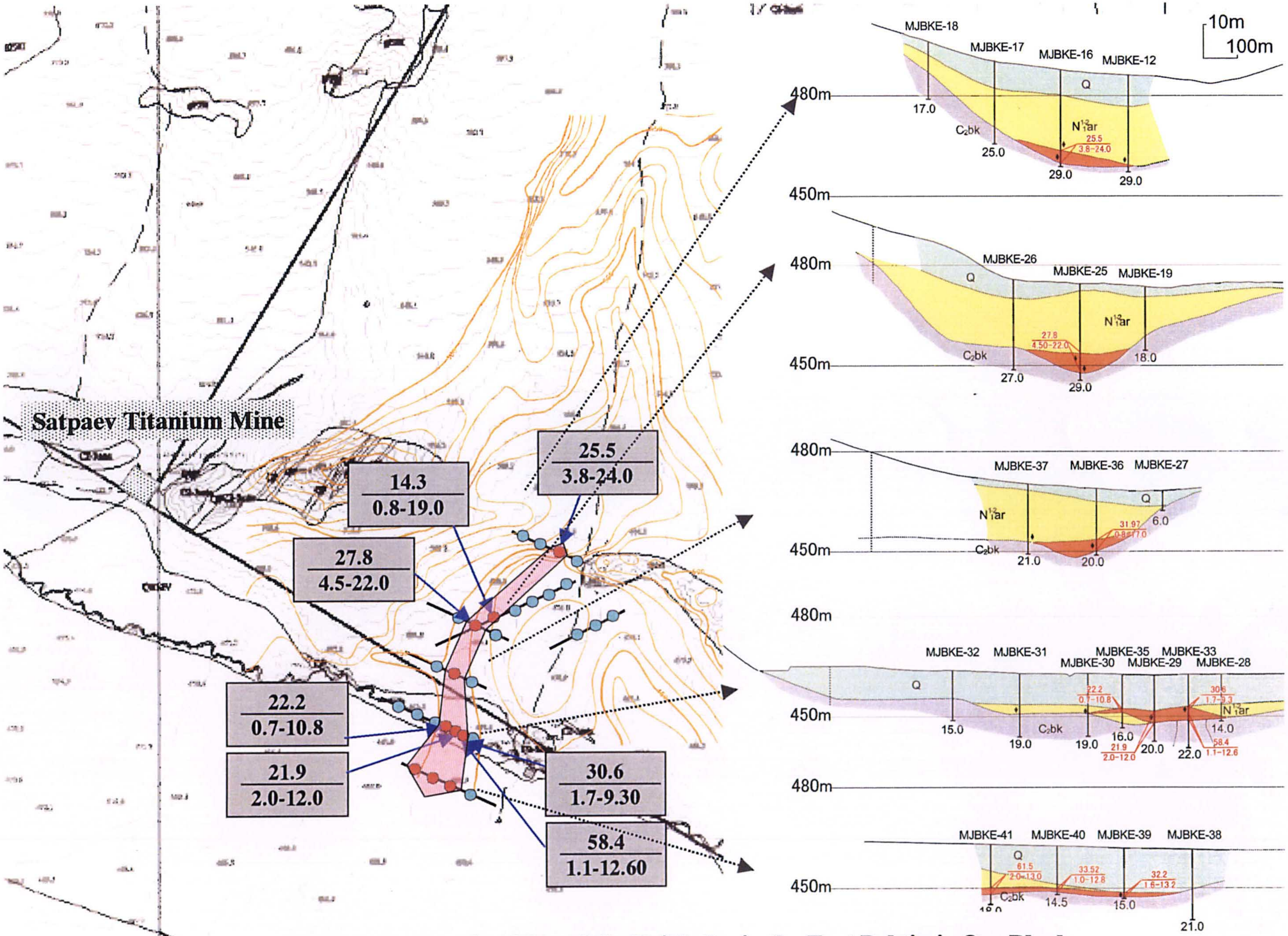


Fig.II-1-18 Location Map of the Drillholes in the East Bektimir Ore Block

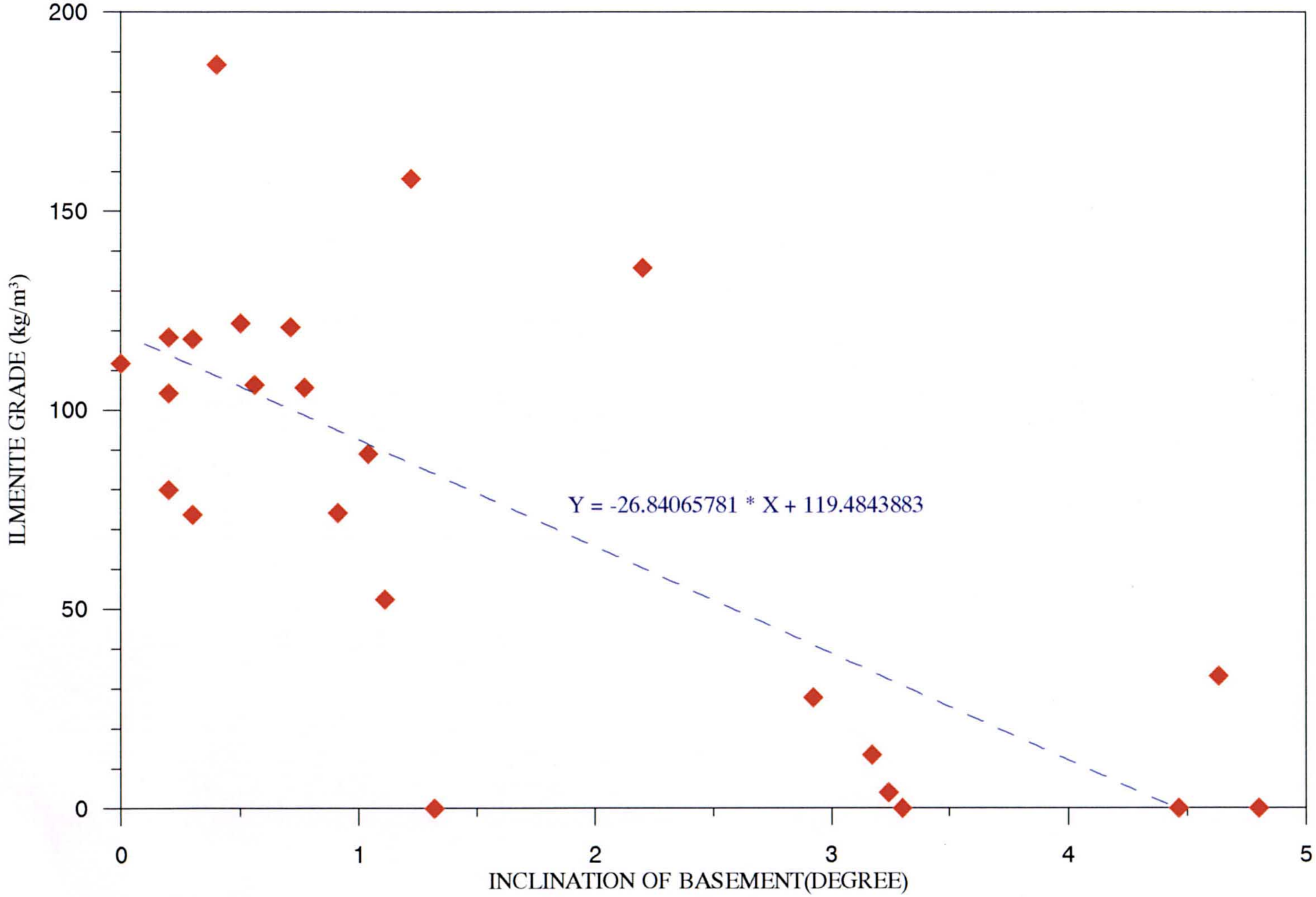


Fig.II-3-12 Ilmenite Grade vs Slope Angle of Basement in the Bektmir No.1 Deposit

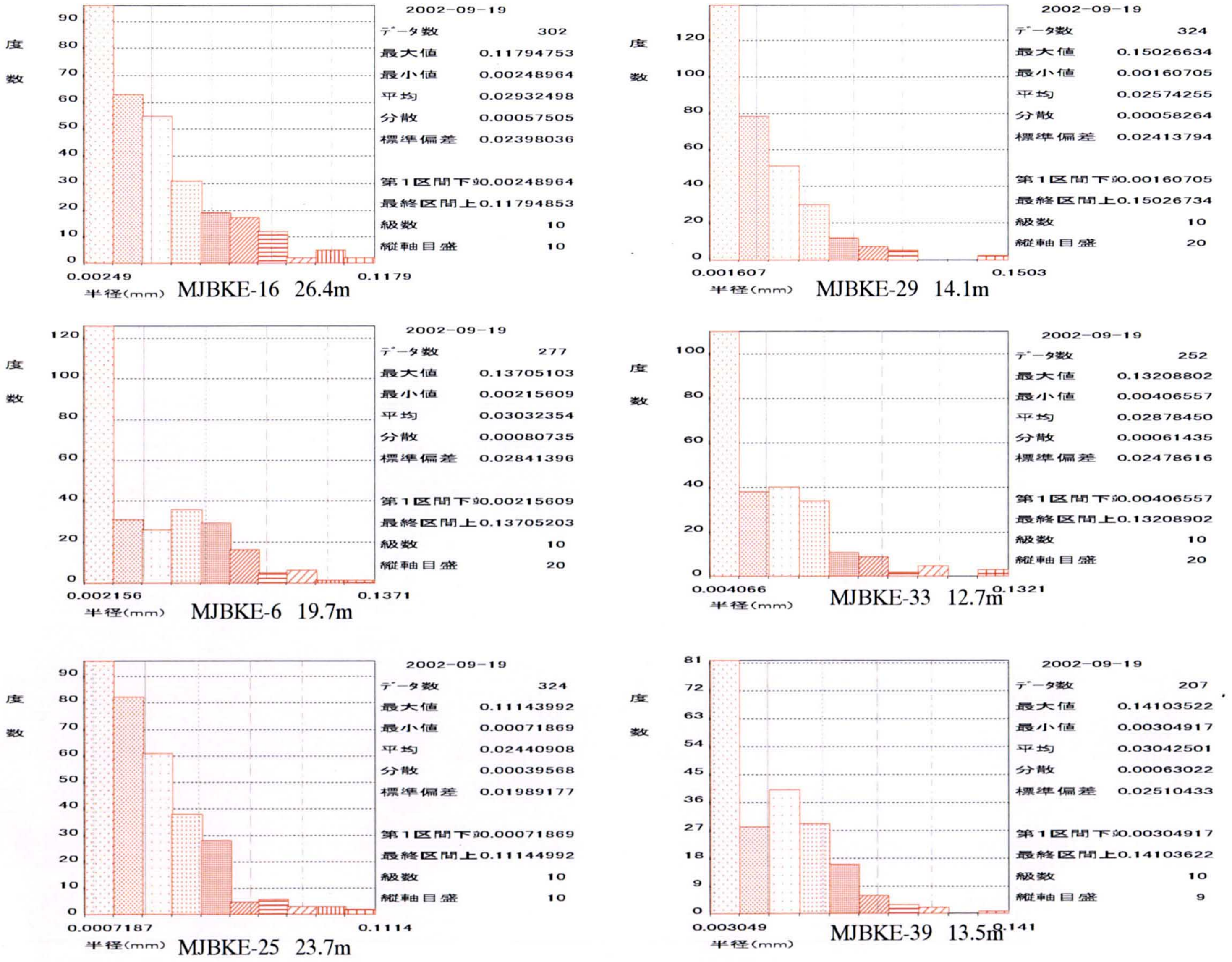
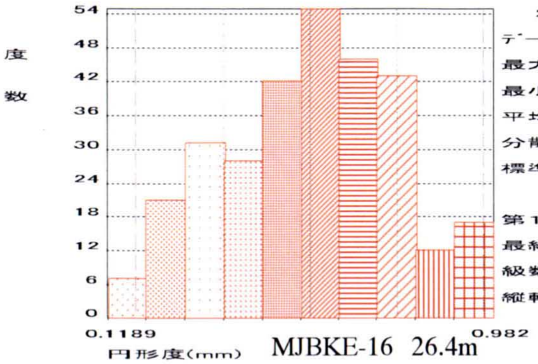
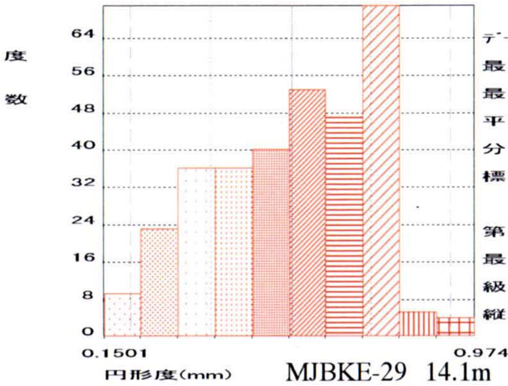


Fig.II-3-13 Histgram of Ilmenite Grain Radius (East Bektimir)



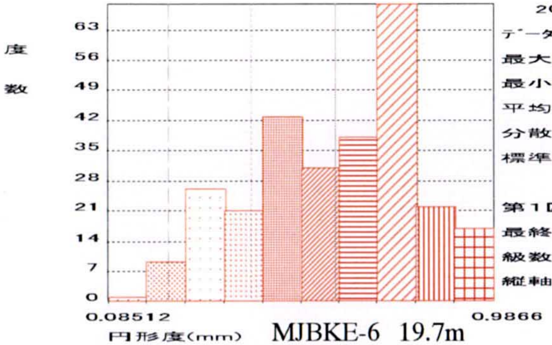
MJBKE-16 26.4m

2002-09-19	
ﾃﾞｰﾀ数	302
最大値	0.98198860
最小値	0.11887891
平均	0.57374883
分散	0.03755169
標準偏差	0.19378260
第1区間下限	0.11887891
最終区間上	0.98198960
級数	10
縦軸目盛	6



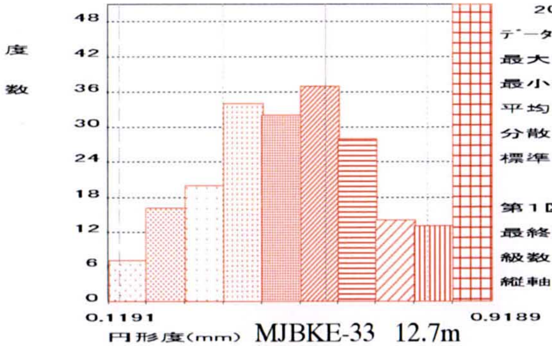
MJBKE-29 14.1m

2002-09-19	
ﾃﾞｰﾀ数	324
最大値	0.97435848
最小値	0.15007725
平均	0.56856211
分散	0.03160520
標準偏差	0.17777853
第1区間下限	0.15007725
最終区間上	0.97435948
級数	10
縦軸目盛	8



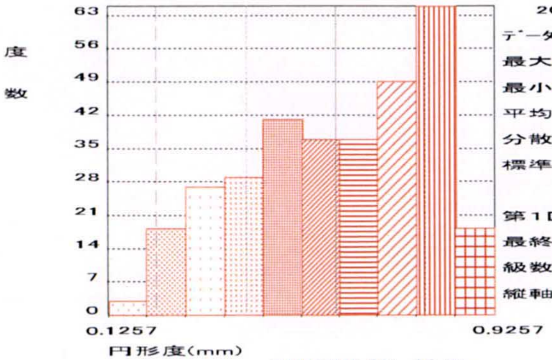
MJBKE-6 19.7m

2002-09-19	
ﾃﾞｰﾀ数	277
最大値	0.98663666
最小値	0.08512368
平均	0.61648089
分散	0.03793311
標準偏差	0.19476425
第1区間下限	0.08512368
最終区間上	0.98663766
級数	10
縦軸目盛	7



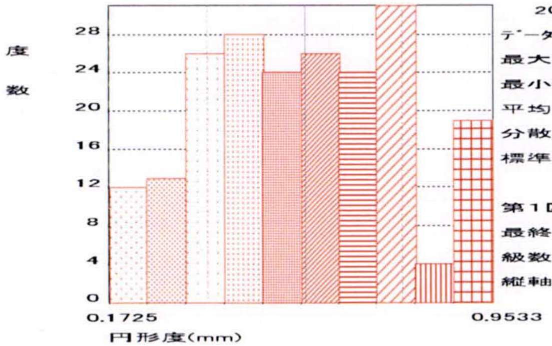
MJBKE-33 12.7m

2002-09-19	
ﾃﾞｰﾀ数	252
最大値	0.91889168
最小値	0.11907390
平均	0.57366172
分散	0.04559076
標準偏差	0.21351994
第1区間下限	0.11907390
最終区間上	0.91889268
級数	10
縦軸目盛	6



MJBKE-25 23.7m

2002-09-19	
ﾃﾞｰﾀ数	324
最大値	0.92567123
最小値	0.12566893
平均	0.59839249
分散	0.03464925
標準偏差	0.18614309
第1区間下限	0.12566893
最終区間上	0.92567223
級数	10
縦軸目盛	7



MJBKE-39 13.5m

2002-09-19	
ﾃﾞｰﾀ数	207
最大値	0.95328109
最小値	0.17249443
平均	0.57225646
分散	0.03913264
標準偏差	0.19781973
第1区間下限	0.17249443
最終区間上	0.95328209
級数	10
縦軸目盛	4

Fig.II-3-14 Histgram of Ilmenite Grain Rondness (East Bektimir)

PART III CONCLUSIONS AND RECOMMENDATIONS FOR THE FUTURE SURVEY

CHAPTER 1　CONCLUSIONS

1-1 Analysis of Existing Data

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, namely, 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 were recalculated among reserves calculated in 1982 (cut-off: ilmenite 15kg/m^3, ore reserves 147,579,000mm^3, ilmenite reserves 3,438,000 tons and ilmenite grade 23.3kg/m^3).

Table I-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. 1.

1-1 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 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 porphyrite) of the Carboniferous Period. Arkalyk, Maityab and Bukon 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. More than 1% of magnetite is contained as an opaque mineral. Hornfels is widely visible near contact parts with granitic rocks.

(2) Granitic rocks

The area is distributed with Karaotkelskiy complexes, believed to have intruded from the early Carboniferous Period (294.4 ±8.9Ma) to the late Permian Period (276.0 ±6.5Ma). Complexes are classified into syenite and granite in accordance with their chemical compositions.

Syenite and granite form the bulk of Karaotkelskiy complexes which 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. Generally, TiO_2 becomes lean higher the magma crystallization differentiation is. Karaotkelskiy complexes are rock masses that are 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 contain them as origin rocks can be appraised lower than that of Preobrazhenskiy Complex.

In the rare earth pattern, Karaotkelskiy complexes show a negative anomaly of Eu and 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 1×10^{-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%) and goethite (Ti 0%). Pseudorutile and altered ilmenite were generated by weathering alteration of ilmenite, while goethite, by weathering alteration of magnetite.

Results of K-Ar age determination of Preobrazhenskiy and 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 on the Aral Formation of the Neogene Period and on the Quaternary-Period layer. 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 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 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 rocks.

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 Karaotkelskiy complex intruded into the Bektimirskaya ridge anticline situated in the middle of them.

A fault in NE-SW direction cuts the Carboniferous-period Maityab layers 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. All known ilmenite alluvial deposits are contained inside palaeo-landform channels.

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

The Quaternary-Period layers are generally horizontal strata and cover the Tertiary-Period Aral Formation.

3) Ore Beds

The Karaotkel Placer is ilmenite eluvial deposits and alluvial deposits and accompany 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.

1-2 Drilling survey

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

Following the drilling conducted in Year 2, 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 beds captured in drilling measured 0.9 to 9.0m in thickness. The ilmenite content was 7 to 134kg/m^3. The thickness of overburdens on ore beds is 41 to 54.3m and the depths of them increase 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 is known to close. 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.

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 No. III+IV+V-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 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 believed still continuing 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 No. 1 the following increases in ore reserves corresponding to Category C_2 can be calculated. 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 the 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 was 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 and are gravel in layers of the Quaternary Period. Clay of Aral Formation is scant. The grades and widths of ore beds improve 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 potential 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

CHAPTER 2 Recommendations for Future

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 2. 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) Southern 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 3 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 3, 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).

2-2 Technical Deployment 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.