Chapter 8 Development Plan of the Zhaman-Aibat Mine

8-1 Geology and Ore Deposit

According to the previous survey results, geology and ore deposit of the Zhaman-Aibat Deposit are summarized as follows:

(1) Type of deposit: Stratiform Cu

(2) Country rock: Sandstone, siltstone and agglomerate in the Carboniferous and Permian Ages.

(3) Ore horizon: 10 (ten) ore horizons ore confirmed. Horizon 4-I is the only minable one and contains 80~90 % of the total ore reserves in the Zhaman-Aibat Deposit.

(4) Occurrence of ore deposit:
- Distribution of ore deposit: 12km (E-W)×3km (N-S)
- Orebodies: Three orebodies, namely; Eastern, Central and Northern orebodies are confirmed.
- Depth below the ground surface: -350m (eastern end of Eastern orebody) ~ -710m (western end of Northern orebody), minable depth is -480m (Eastern orebody) ~ -650m (Central orebody).
- Thickness of ore: 0.3 ~ 16 m, average 5.15m.
- Faults etc.: A deep-seated fault is located beneath the Northern orebody. Some small faults with E~W direction are confirmed both in the Eastern and Central orebodies.

(5) Ore type:
- Mineral composition
  - Cu minerals: chalcocite, digenite, djurleite, bornite, chalcopyrite
  - Pb mineral: galena
  - Zn mineral: sphalerite
  - Ag minerals: electrum, stromeyerite
  - others: pyrite
- Ore type
  - Cu ore: mainly Cu minerals
  - Complex Ore: Cu, Pb and Zn minerals

8-2 Minable Ore Reserve Calculation

8-2-1 Database

The data used for geological reserves estimation in chapter 3-1 are stored in the Zhaman-Aibat Database, and were also used in the minable ore reserve estimation.

They are;

(1) Drilling data

(1)-a Coordinates of drill collar (x, y, z)

(1)-b Drill inclination data (azimuth, degree)

(2) Chemical assay data of drill cores

(2)-a Sampling depth and interval

(2)-b Chemical assay data: Cu (%), Pb (%), Zn (%), Ag (g/t), Re (g/t), S (%)

(3) Ore horizon

By using the above mentioned data, the ore thickness (m) was finalized by hand method considering ore grades, such as Cu (%), Ag (g/t), and the mode of occurrence of country rock between mineralized layers and these data were stored in the data file as input data for minable ore reserve estimation.

8-2-2 Statistical Analysis of Input Data of Minable Ore Reserve Estimation

(1) Basic Statistical

The available drill holes for minable ore reserve estimation numbered 800. In detail, 798 drill holes were drills by the A.O. Zhezkazgangeologiya and 2 drill holes by the Metal Mining Agency of Japan (MMAJ) during this project. Among these 798 drill holes, 46% of the total drill holes, that is 371 contributed to the minable ore reserve estimation. The result of basic statistical analysis on input data of averages grade of Cu (%), Pb (%), Ag (g/t) and ore thickness (m) are shown in the Table 2-8-1.

The result are summarized as follows;

- The maximum thickness of ore was 17.75m in the drill 572. The highest Cu content was 7.68% in the drill 449 and the highest Ag content was 169.19 g/t in the drill 795.

- In general, the average Cu content (%) and standard deviation of each orebody were quite stable. Especially in the Eastern Orebody, the average Cu content was 1.47% with a standard deviation of 1.12% Cu. The average Pb (%) and Zn (%) content of the Central orebody was higher than other orebodies, but showed high standard deviations. The highest Ag (g/t) content were noticed in the Northern orebody but continuity of Ag content in each drill hole was so erratic that it was very difficult to evaluate Ag reserves.

(2) Geostatistical Analysis of Input Data

To assess the continuity of grade and thickness of ore, and determine the grade distance to be used for interpolating block grades, a geostatistical analysis was conducted. 2D variograms were developed for Cu (%), Pb (%), Zn (%), Ag (g/t) and thickness of Ore Horizon 4-I. Variograms of Pb (%) and Zn (%) in the Eastern orebody were not computed due to their low content and are not economic for commercial recovery. The representative examples of nugget effect/sill and range

(m) of each variogram are shown in Figure 2-8-1.

Most variograms curves fitted to the spherical model, except that of the ore thickness of the Eastern orebody. The following comments refer to variograms calculated in Horizon 4-I.

Nugget effect/sill ratios of Cu (%) of the Eastern and Central orebodies were 0.219 and 0.158, respectively. And the same ratios of Ag (g/t) of the Eastern, Central and Northern orebodies were 0.167, 0.306, 0.193, respectively. On the other hand, range (m) of Cu (%) in the Eastern and Central orebodies was 350m and 264m, respectively, and as short as 119m in the Northern orebody. The range of Ag (g/t) of the Eastern and Central orebodies computed as 306m and 221m, respectively. The higher nugget effect/sill ratio and shorter range indicate the more variable character and small area extent, respectively, of Ag (g/t) of the Central orebody. Large range values and lower nugget effect/sill ratio are evident for Cu (%) when compared which Ag (g/t) which tends to be more erratic.

The study of the variograms for each parameter in Horizon 3 concluded that most variograms showed the pure nugget effect and this meant that the drill hole spacing might be greater than the range or no continuity could be present in Ore Horizon 3.

8-2-3 Minable Ore Reserve Estimation

The minable ore reserve estimation was based on ore blocks 100m × 100m × thickness determined by the range of the variograms. For the interpolation of grade and thickness of ore, the geostatistical technique of kriging utilising the variogram models was used to estimate the block parameters. The procedure for the estimation is as follows;

(1) The search distance (m) for the kringing interpolation was determined by the variogram range.

(2) Cu (%), Pb (%), Zn (%), Ag (%) and thickness of ore (m) were interpolated for each ore block.

(3) The specific gravity of the deposit was adopted as 2,600 and total ore reserve metal amount and average grade were calculated.

(4) Two mining parameters, namely mining ore recovery (%) and dilution of ore (%) were determined by the following procedure. The panel and pillar mining method applied at the Zhezkazgan Mine was selected. The mining ore recovery and dilution of ore were determined as 75% and 5%, respectively. This is based on the field survey of the Zhezkazgan Mine in 1995. The result of the survey concluded the mining recovery of 6m ore thickness, and diameter of room pillar of 6.8m and the width of rib pillar of 16.3m, is estimated as low as 75.3% at the depth of 600m below the ground. Secondary mining adopting filling was not considered due to the relatively low grades of Cu of the Zhaman-Aibat Deposit.

(5) Finally, minable ore reserves, metal amount, average ore grade and average ore thickness with the cutoff grade of 0.4% Cu and with the minimum mining height of 3.0m were calculated and the results are shown in Table 2-8-3. The copper grade distribution in each block is shown in Figure 2-8-2. The minable reserves were calculated by the following formula, after the mining area (enclosed by the red line in Figure 2-8-2) was delineated.

Minable reserves(t) = Reserves(t) × Extraction rate (%) / 100 × (1+Dilution (%) / 100)

The minable reserves with the cutoff of 0.4% Cu and with the minimum mining height of 3.0m are shown in Table 2-8-3. Copper and silver are considered to be saleable in the following deposit evaluation. Since the amount of lead and zinc is extremely small compared with copper their profitability were assumed to be negative.

Table 2-8-1 Basic Statistics of Input (Drill Hole) Data for Minable Ore Reserve Estimation

Orebody	Statistics	Thickness (m)	Cu (%)	Pb (%)	Zn (%)	Ag (g/t)	Re (g/t)	S (%)
Eastern	Maximum	16.30	7.68	2.00	1.81	169.19	23.20	15.46
	Minimum	0.50	0.21	0.00	0.00	0.00	0.00	0.00
n=200	Average	5.50	1.47	0.08	0.03	11.79	1.34	0.77
	Median	5.20	1.14	0.00	0.00	5.56	0.66	0.54
	Standard deviation	3.25	1.12	0.23	0.16	20.06	2.40	1.24
Central	Maximum	15.80	6.03	4.91	2.20	67.49	11.74	2.84
	Minimum	0.60	0.00	0.00	0.00	0.00	0.00	0.00
n=112	Average	4.63	1.53	1.02	0.19	12.28	1.96	0.92
	Median	3.80	1.12	0.57	0.00	7.06	1.42	0.82
	Standard deviation	2.96	1.32	1.14	0.41	15.09	1.99	0.64
Northern	Maximum	17.75	4.30	1.95	1.42	124.43	11.00	2.91
	Minimum	0.60	0.00	0.00	0.00	0.00	0.00	0.00
n=57	Average	5.67	1.20	0.23	0.09	32.89	1.37	0.69
	Median	5.40	0.98	0.00	0.00	30.22	0.56	0.41
	Standard deviation	3.59	0.87	0.51	0.29	30.25	2.15	0.75
Whole Area	Maximum	17.75	7.68	4.91	2.20	169.19	23.20	15.46
	Minimum	0.50	0.00	0.00	0.00	0.00	0.00	0.00
n=369	Average	5.26	1.45	0.39	0.09	15.20	1.53	0.80
	Median	4.90	1.11	0.02	0.00	6.63	0.79	0.60
	Standard deviation	3.24	1.15	0.79	0.29	21.98	2.26	1.02

Table 2-8-2 Variograms on Each Parameter of Ore Horizon 4-I

Parameters	Orebody	Sill	Nugget	Nugget Effect /Sill	Range(m)
Copper	Northern	0.494	-	-	119
	Eastern	0.590	0.129	0.219	350
	Central	1.061	0.168	0.158	264
Lead	Northern	NC	NC	NC	NC
	Eastern	NC	NC	NC	NC
	Central	0.477	0.100	0.210	167
Zinc	Northern	NC	NC	NC	NC
	Eastern	NC	NC	NC	NC
	Central	0.086	0.01	0.116	343
Silver	Northern	519	100	0.193	230
	Eastern	79.6	13.3	0.167	306
	Central	71.5	21.9	0.306	221
Thickness	Northern	NC	NC	NC	NC
	Eastern	12.38	3.28	0.265	251
	Central	24.29	5.00	0.206	171

NC : Not calculated due to low grade and poor viability

Table 2-8-3 Summary of Minable Ore Reserve on Ore Horizon 4-I

Mnable reserves	Average thickness	Amount of metal				Average grade			
		Cu	Ag	Pb	Zn	Cu	Ag	Pb	Zn
		kt	t	kt	kt	%	g/t	%	%
118742 kt	5.47 m	1,375	1,019	195	35	1.16	8.59	0.16	0.03

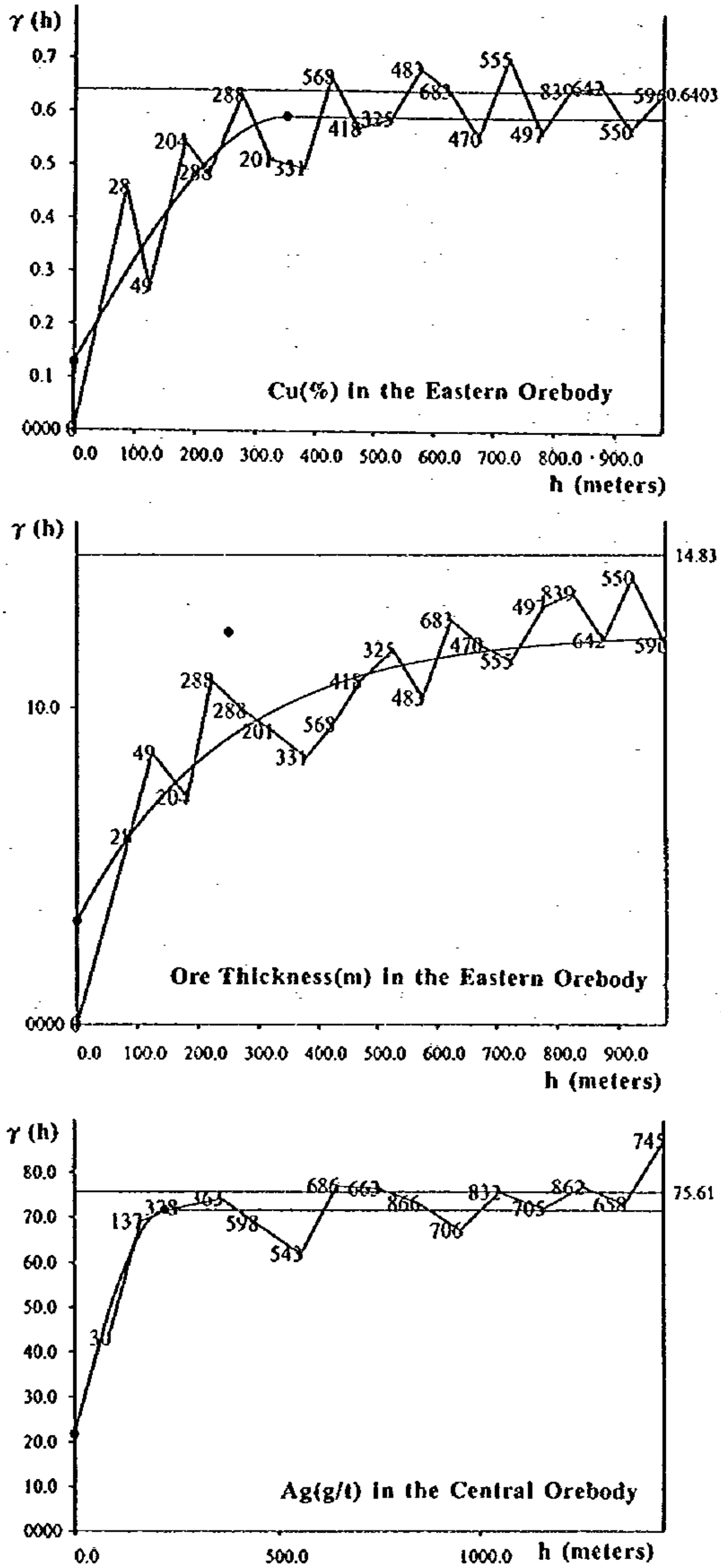


Fig.2-8-1 Representative examples of Variograms
for Cu(%), Ag(g/t) and Thickness(m) of Ore

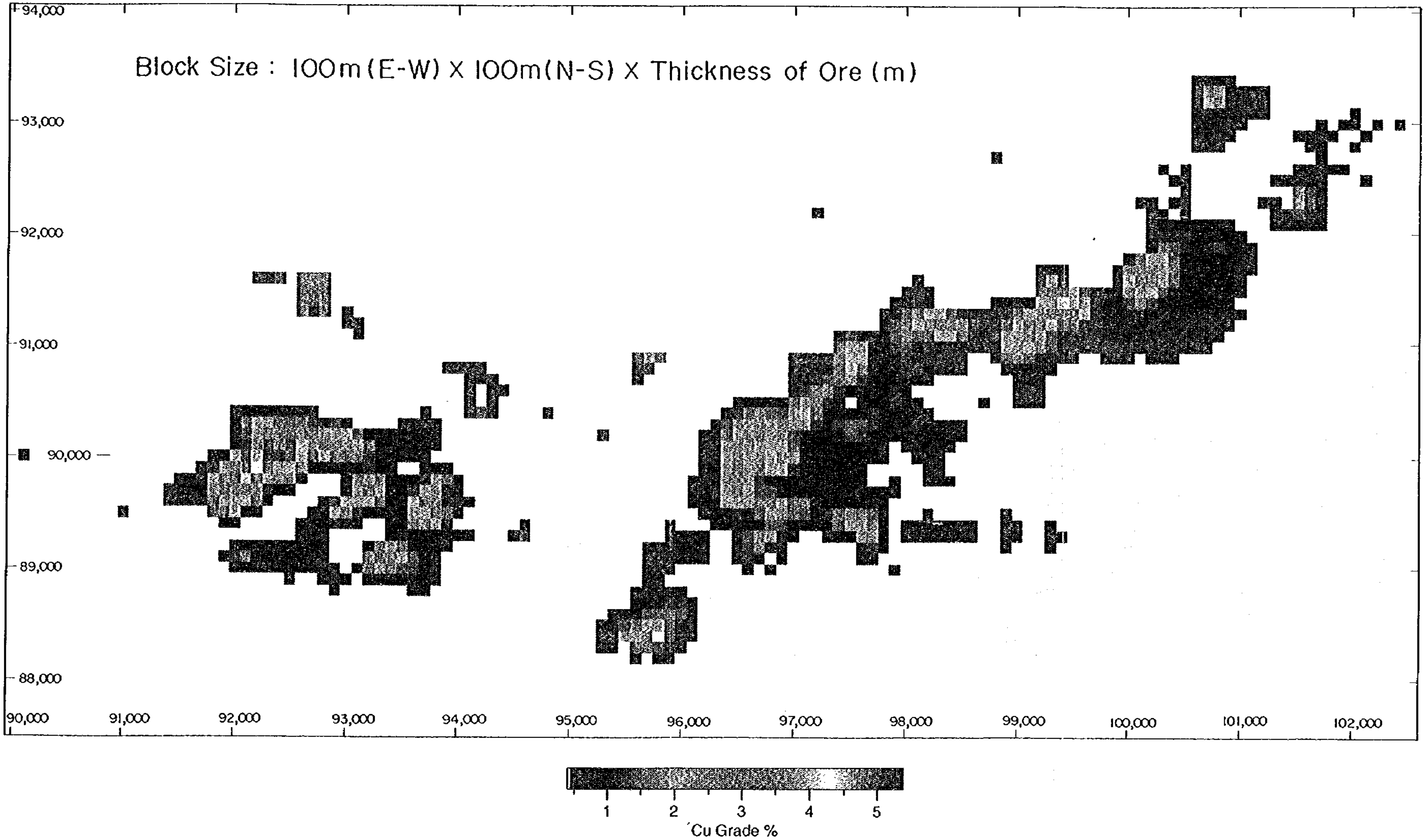


Fig. 2-8-2 Distribution of Cu(%) on Each Ore Blocks

8-3 Conceptual design of the Zhaman-Aibat Mine

8-3-1 Purpose of Conceptual Design and Estimation of Design Parameters

There are two purposes in the following conceptual design of this year's campaign.

One is ton know the feature, scale and potential value of resources of the Zhaman-Aibat Deposit. And the other is to clarify what will be important in the pre-Feasibility Study (hereinafter pre-F/S) and Feasibility Study (hereinafter F/S) in the future.

Because the accuracy of ore reserve estimation of the Zhaman-Aibat Deposit has already reached that required for the pre-F/S, the conceptual design was made based on this reserve estimation. Since the technical Feasibility Study is not sufficient enough to investigate, the mine development and mining method are adopted based on verbal reports on the Zhezkazgan Mine whose deposit has analogies to the Zhaman-Aibat Deposit.

For the calculation of the mine development cost, "the Bureau of Mines Cost Estimating System Handbook (1987)" published by US Bureau of Mines, Department of Interior was used in this conceptual design.

It is estimated that the error of estimation of design parameters is ±30~35%.

8-3-2 Outlines of the Zhaman-Aibat Mine

The configuration of the Zhaman-Aibat Mine by this conceptual design was drawn from the following;

(1) Zhaman-Aibat Mine is located 180km to the southeast of Zhezkazgan City. The mine is surrounded by the dry steppe field while topography is characterized by hummock relief with relative elevations up to bear comparison with 30m. The altitude of the deposit area is 320~380m above the sea level.

(2) The mine will be of medium size incorporating the underground mining method supported by several vertical shafts.

(3) A railroad and paved road will be constructed between Zhezkazgan City and the Mine site.

(4) A panel and pillar mining method will be incorporated. Ore transportation and service and ventilation shafts will be sunk and the required annual ore will be mined. However no secondary mining by filling would be performed.

(5) An ore dressing plant will be constructed at the mine site and the produced copper concentrates will be transported to the processing plant in Zhezkazgan City.

(6) The water necessary for the mine and ore dressing operation and for the daily life, will be provided by pipeline from a water well located 20~30km from the mine site and the used water and underground mine water will be recycled.

(7) Electricity will be supplied from a transformer station located between Zhezkazgan and Karaganda by a 220kV power line.

(8) Officers and staff will reside near the mine. For their daily life, houses, facilities of social affairs, central heating facilities etc. will be constructed.

(9) A suitable waste dump will be constructed in the steppe field.

(10) Copper and silver contained in the copper concentrates will be sold to the Zhezkazgan smelting plant.

The site plan of the Zhaman-Aibat Mine facilities are shown in Figure 2-8-3.

8-3-3 Exploration

By using previous drill data of 800 drill holes, the present drill interval and accuracy of ore reserve estimation were assessed by a geostastical approach. And referring to definition standards in several countries, such as Australia, USA, Canada, and Japan, the estimation accuracy and ore reserves category of the minable reserves of the Zhaman-Aibat Deposit were studied and are summarized as follows;

(1) Three types of drill spacing, namely 200～400m × 200～400m, 200m × 200m, 200m × 100m were practiced in the Zhaman-Aibat Deposit. The minable ore of the Zhaman-Aibat Deposit was able to be categorized as "probable ore reserve".

(2) The result of assessment of the error of estimation by grid spacing and ore reserve revealed that the error would be smaller than ±30～35%, which meant that the accuracy of the ore reserve estimation of the Zhaman-Aibat Deposit would be sufficient for this conceptual design.

For the exploration of the Zhaman-Aibat Deposit, the accuracy of ore reserve estimation should be increased from the present category of probable ore reserve to the level of proved ore reserve. But the cost of these exploration is not included. However, the exploration cost (mainly drilling cost) for mining plan of actual mine production was considered to be a part of mining activities and was included to the mining cost.

8-3-4 Mining

(1) Mine Production

The annual production was estimated using the following empirical formula;

$$AAPR = (M)^{0.75} / 6.5$$

AAPR: Amount of Annual Production (Mt/year)
M: Minable ore reserve (Mt)

The annual production of the Zhaman-Aibat Deposit is estimated as 5.6Mt, that corresponds to a daily production of 16,000 tons from the above formula, if the annual operating days are assumed to be 350 days as in Zhezkazgan Mine. In this Study, the profitability in the case of production of ±20% of the annual production 5.6Mt is discussed. The assumed production rate is shown in Table 2-8-4.

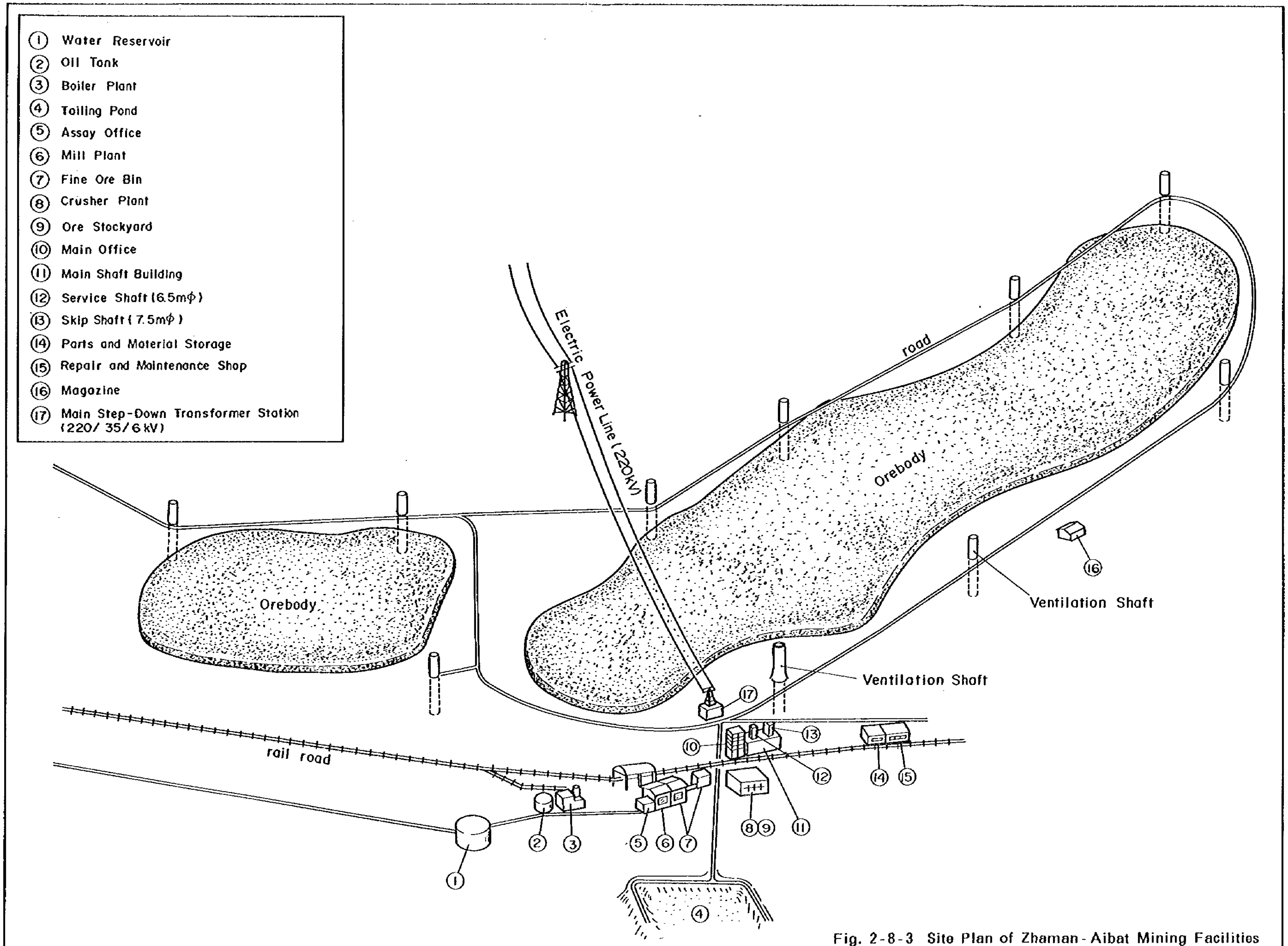


Fig. 2-8-3 Site Plan of Zhaman-Aibat Mining Facilities

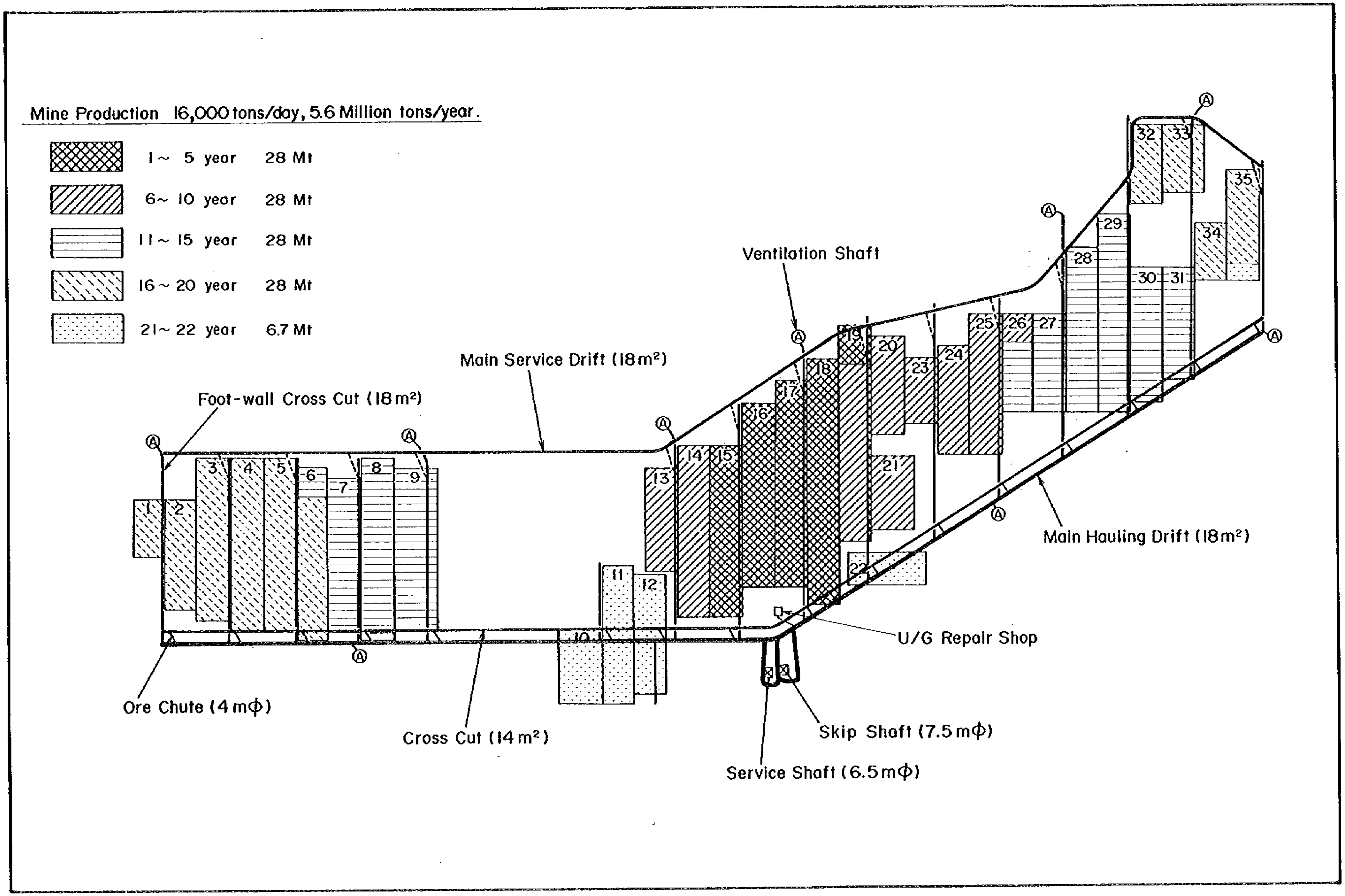


Fig. 2-8-4 Conceptual Design of Underground Development

Table 2-8-4 Assumed Production and Mine Life

Annual production (Mt/year)	Daily production* (t/day)	Mine life (year)
4.5	12,800	27
5.6	16,000	22
6.7	19,200	18

*)Operating days in a year: 350 days

Table 2-8-5 Specifications and Total Length of Each Shaft and Drift

Items	Specifications	Total length
Skip shaft	Diameter 7.5m Φ	700m
Service shaft	Diameter 6.5m Φ	700m
Ventilation shaft	Diameter 6.5m Φ	4.5Mt/year—4,200m 5.6Mt/year—6,300m 6.7Mt/year—8,400m
Main drift	Cross section area $18m^2$	11,000m
Main hauling drift	Cross section area $18m^2$	11,000m
Crosscut in footwall	Cross section area $18m^2$	31,800m
Ventilation drift	Cross section area $14.4m^2$	10,500m
Ore chute	Diameter 4.0m Φ	1,460m

Table 2-8-6 Main Ore Dressing Equipments and Specifications

Equipment	Specifications	Number
1.Gyratory crusher	1,520mm Φ, 300kw	1
2. SAG mill	10m Φ ×4m, 7,050kw	2
3. Vibrating screen	2m×5m	6
4. Ball mill	5m Φ ×7m	3
5. Ball mill (for regrinding)	4m Φ ×8m, 1,300kw	1
6. Flotation cell	$28.3m^3$, 45kw	33
7. Flotation cell (for cleaning)	$4.2m^3$, 11kw	20
8. Thickener	5m Φ	1
9. Disc filter	$74m^2$	1
10. Thickener	33m Φ	1

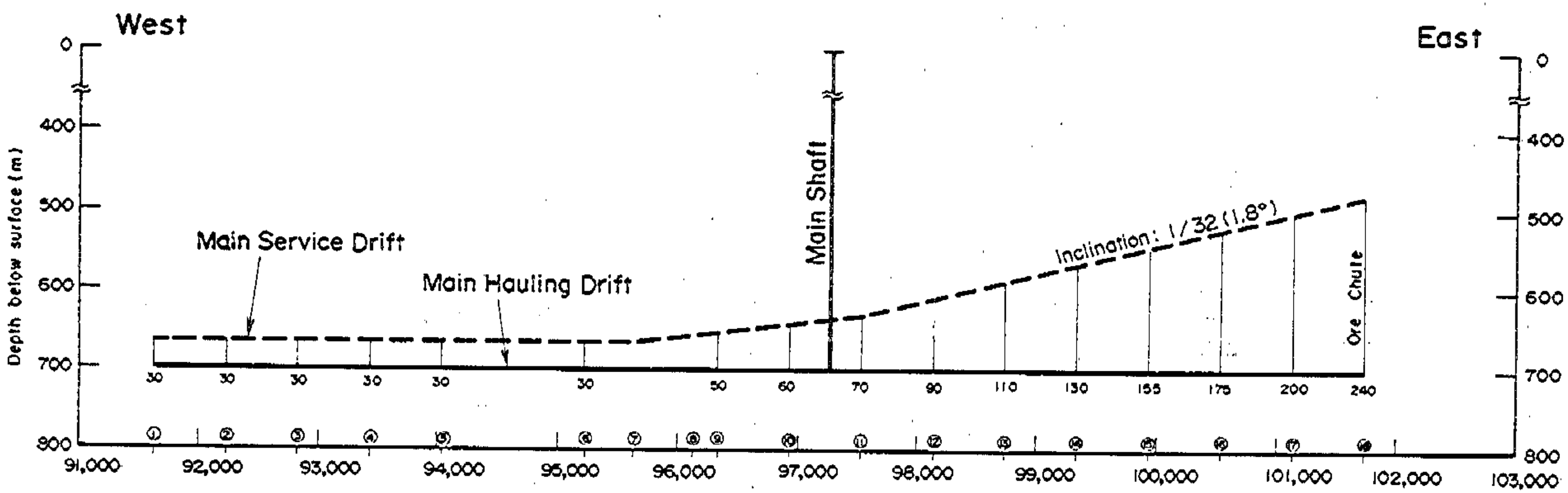


Fig. 2-8-5 Cross-section of Underground Mine Development of the Zhaman-Aibat Deposit

(2) Underground Development

A plan and cross section of the underground mine development of the Zhaman-Aibat Deposit are shown in Figure 2-8-4 and 2-8-5. The conceptual plans of the underground development are as follows;

a) A skip shaft for transportation of ore and waste rock as well as a service shaft for transportation of workers is constructed in the center of the deposit.

b) A main drift is constructed along the northern part of the deposit. A main transportation drift is constructed 700m under the surface to connect the service drift with ore chutes. A double track rail line is established in the main transportation drift.

c) Crosscuts in the footwall are constructed from the main drift into the deposit at intervals of 600m. In order to establish a ventilation network, each crosscut in footwall is connected to a ventilation drift and ventilation shafts are constructed at suitable positions.

d) The number of ventilation shafts is decided in order to supply an air flow volume of $5m^3$/min. per 1kw of rated output of internal combustion engines which are applied in the underground mine.

The specifications and total length of each shaft and drift are shown in Table 2-8-5.

8-3-5 Ore Dressing

(1) Outlines of Ore Dressing

The standard amount of milling ore per year is expected to be 5,600,000 tons with copper grade 1.16% and silver grade 8.59 g/t. Referring to the results of other mill plants in the Republic of Kazakhstan, the rate of plant utilization is expected to be approximately 80% (292 days per year). Therefore, the amount of milling ore per day is as follows;

$$5{,}600{,}000t / (365\ days \times 0.8) = 19{,}178\ ton/day$$

Then, the milling capacity is assumed to be 20,000 ton/day.

The crushing operation is assumed to be carried out seven days per week, with two 8 hour shifts per day (total 16 hours per day). Grinding and flotation operations are assumed to be seven days per week and 24 hours per day.

The valuable minerals are copper, lead, zinc and silver, however, lead and zinc are not considered because their extraction is probably not profitable. Only copper concentrate which contains copper and silver will be recovered by plain copper flotation.

From the results of the milling tests, the copper concentrate recovered is expected to be 35% Cu grade with a recovery of approximately 90%. The amount of copper concentrate is therefore as follows;

$$20{,}000t \times 0.0116 \times 0.9 / 0.35 = 596t/day$$

(2) Ore Dressing Process

The flow chart of the ore dressing process are shown in Figure 2-8-6.

The ore mined underground is transported by mine cars through a grizzly of 800mm opening and less than 150mm by a gyratory crusher (300kw). The crushed ore is stored in a crude ore bin. Crushed ore is ground by two SAG mills (10m $\phi \times$4m, 3,000kw) closed with vibrating screens, and then the second grinding is done by a three ball mill (5m $\phi \times$9m, 2,000kw) closed with cyclones. The grinding size will be 65% under 200 mesh. A plain flotation circuit is adopted with the flotation feed pulp fed to rougher flotation cells (28.3m^3, 17 cells) after conditioning. The tailing of the rougher flotation is fed to scavenging cells (28.3m^3, 16 cells) and the tailing is the final tailing. The rougher concentrate is reground by a ball mill (4m $\phi \times$8m) closed with cyclones and then cleaned by cleaner cells (4.2m^3, 20 cells). The cleaner tailing is recalculated.

The sand/slime flotation which is often applied in the Kazakhstan is considered not suitable for this type of ore, because of its complicated procedure.

The copper concentrate is thickened in a 5m diameter thickener and after filtering by a disc filter, the copper concentrate is stored in a concentrate storage bin.

The main ore dressing equipment are listed and specified in Table 2-8-6.

8-3-6 Tailing and Effluent Treatment

The flotation tailings are pumped to the tailing pond after being thickened in a thickener (33m ϕ). The supernatant is recalculated to the flotation circuit.

8-3-7 Infrastructure

All of the concentrate produced at Zahman-Aibat Mine will be transported to Zhezkazgan by rail which must be constructed. An access road must also be constructed and electric power must be secured by construction of a power line betweeen Zhezkazgan and Karaganda. Construction of the following infrastructure are required and have been included in the evaluation of the mine's profitability.

(1) Rail way : 155km
(2) Road (width 5m) : 85km
(3) Electric power line : 130km

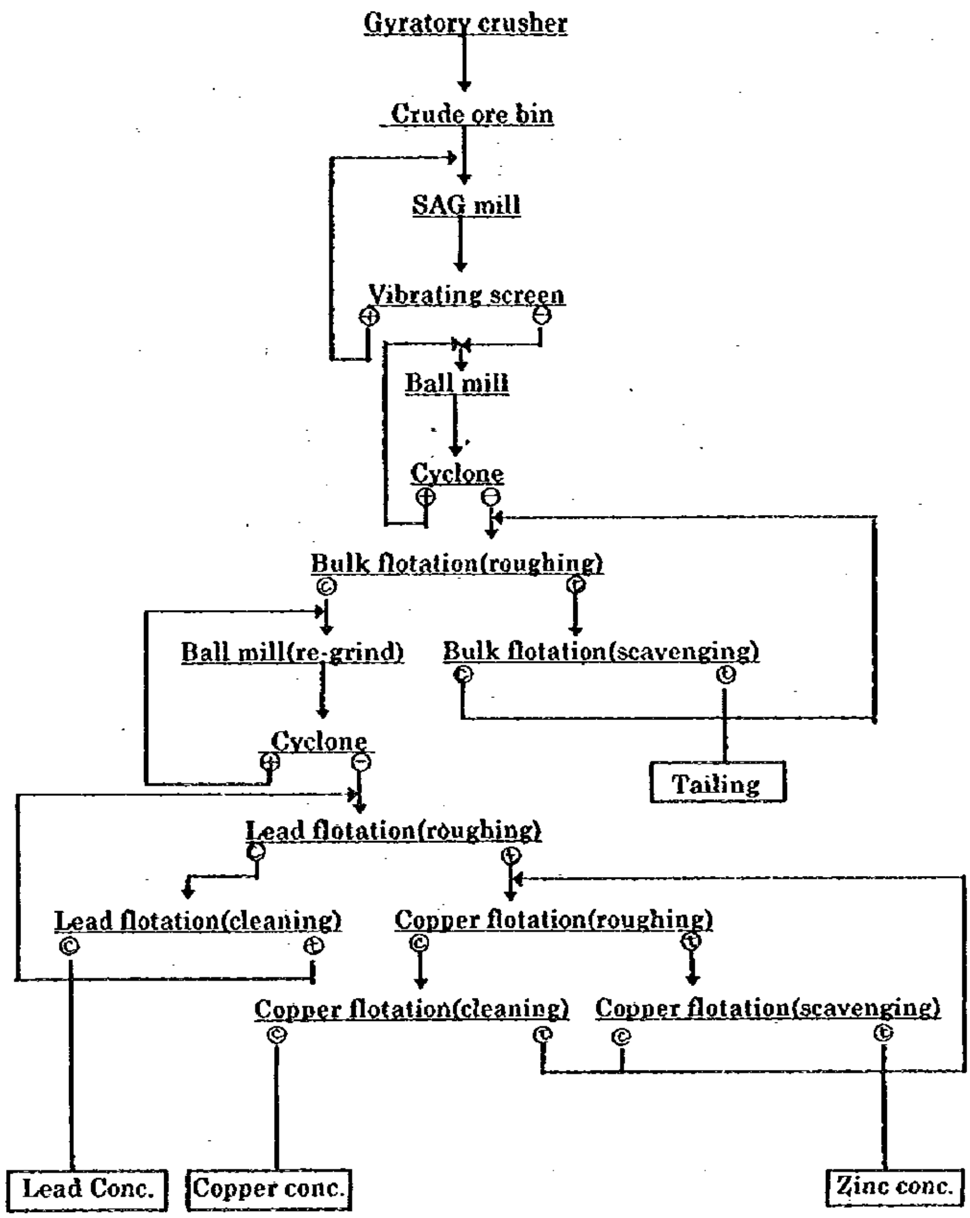


Fig.2-8-6 Flow Sheet of Ore Dressing Plant of the Zhaman-Aibat Mine

8-4 Production and Personnel Plan

(1) Production Plan

In order to increase productivity and to reduce costs, it is assumed that mining will be done intensively in distinct areas established every 5 years. Mining areas associated with the annual production of 5.6Mt are shown in Figure 2-8-7. The production, grade and metal contained in each area are shown in Table 2-8-7.

Table 2-8-7 Production Plan on Each Annual Production

(1) Annual production: 4.5Mt

Period (year)	Production (Mt)	Average Ore grade		Metal contained	
		Cu(%)	Ag(g/t)	Cu(kt)	Ag(t)
1~5	22.5	1.21	5.62	272	126
6~10	22.5	1.18	6.14	266	138
11~15	22.5	1.18	7.46	266	168
16~20	22.5	1.29	10.21	290	230
21~25	22.5	1.03	11.53	232	259
26~27	6.3	0.83	15.67	53	99

(2) Annual production: 5.6Mt

Period (year)	Production (Mt)	Average Ore grade		Metal contained	
		Cu(%)	Ag(g/t)	Cu(kt)	Ag(t)
1~5	28.0	1.16	5.31	326	149
6~10	28.0	1.23	6.93	344	194
11~15	28.0	1.04	9.19	291	257
16~20	28.0	1.28	11.19	358	313
21~22	6.8	0.84	15.71	57	107

(3) Annual production: 6.7Mt

Period (year)	Production (Mt)	Average Ore grade		Metal contained	
		Cu(%)	Ag(g/t)	Cu(kt)	Ag(t)
1~5	33.5	1.15	5.22	385	175
6~10	33.5	1.23	7.52	412	252
11~15	33.5	1.14	10.66	385	357
16~18	18.2	1.07	12.92	195	235

(2) Personnel Plan

In this conceptual design, the cost estimation manual compiled by the US Bureau of Mine is used for the estimation by coefficient of each cost parameter. Therefore in each coefficient, standard numbers of personnel and their labor cost necessary for mine operation are included. It is very difficult to determine standard numbers of personnel. However by the result of operating mines in the world and of cost estimation in this Study, it is estimated that the total number of mine workers including management staff, will be 930. In detail, there will be 450 underground workers, 350 surface workers, 130 engineers and general/administration staff.

8-5 Development Schedule

The underground development is assumed to progress according to the rate of extension of mining area. Specifically the development work required for the production from each planned 5 year area should be completed before beginning the production. Other surface facilities should also be completed by the beginning of the production. The development period before the beginning of production is assumed to be three years. The underground development plan of each five year period is shown in Table 2-8-8.

8-6 Cost Calculation

8-6-1 Operation Cost

(1) Method of Operation Cost Calculation

The operation cost of Zhaman-Aibat Deposit is calculated by the Bureau of Mines Cost Estimating System Handbook of 1987. The cost in 1996 is gained by revising 1984's costs with Cost Indexes shown in Mining Cost Service (Western Mine Service Co.).

The parameters used in calculation of the operating cost are shown in Table 2-8-9.

(2) Results of Operating Cost Calculation

The calculated operating costs of the Zhaman-Aibat Deposit are shown in Table 2-8-10. The details are shown in Appendix 41, 42 and 43.

The mining cost (including operating cost of mine facilities and administration cost) of the Zhezkazgan Mine at the mine site were 576 Tenge/ton of ore (US$9.6/ton of ore) and the milling cost was 258 Tenge/ton of ore. Because these costs are almost the same as the estimated operating costs shown in Table 2-8-10, it is considered that the operating costs estimated by the Cost Estimating System Handbook are reasonable. These costs are calculated under the assumptions of ore grade 1.16%, mill recovery 90% and smelting recovery 95.5%.

Table 2-8-8 Underground Development Plan on Each Annual Production

(1) Annual production: 4.5Mt (Unit: m)

Production year	-3~0	1~5	6~10	11~15	16~20	21~25	26~27	Total
Skip shaft	700							700
Service shaft	700							700
Ventilation shaft	1,400		1,400		1,400			4,200
Main service shaft	2,000	700	4,900	2,600	800			11,000
Main transportation shaft	2,000	700	4,900	2,600	800			11,000
Crosscut in footwall	8,900	2,100	9,000	6,700	3,200	1,900		31,800
Ventilation drift	2,100	600	2,400	1,800	1,300	2,300		10,500
Ore chute	270	110	375	405	270	30		1,460

(2) Annual production: 5.6Mt (Unit: m)

Production year	-3~0	1~5	6~10	11~15	16~20	21~22	Total
Skip shaft	700						700
Service shaft	700						700
Ventilation shaft	2,100	1,400	1,400	1,400			6,300
Main service shaft.	2,000	2,000	5,000	2,000			11,000
Main transportation shaft	2,000	2,000	5,000	2,000			11,000
Crosscut in footwall	8,900	6,000	10,100	4,900	1,900		31,800
Ventilation drift	2,100	1,800	2,400	1,900	2,300		10,500
Ore chute	270	395	465	300	30		1,460

(3) Annual production: 6.7Mt (Unit: m)

Production year	-3~0	1~5	6~10	11~15	16~18	Total
Skip shaft	700					700
Service shaft	700					700
Ventilation shaft	2,800	2,800	2,800			8,400
Main service shaft.	2,000	5,600	2,000	1,400		11,000
Main transportation shaft	2,000	5,600	2,000	1,400		11,000
Crosscut in footwall	8,900	13,000	6,700	3,200		31,800
Ventilation drift	2,100	3,700	1,200	3,500		10,500
Ore chute	270	535	405	250		1,460

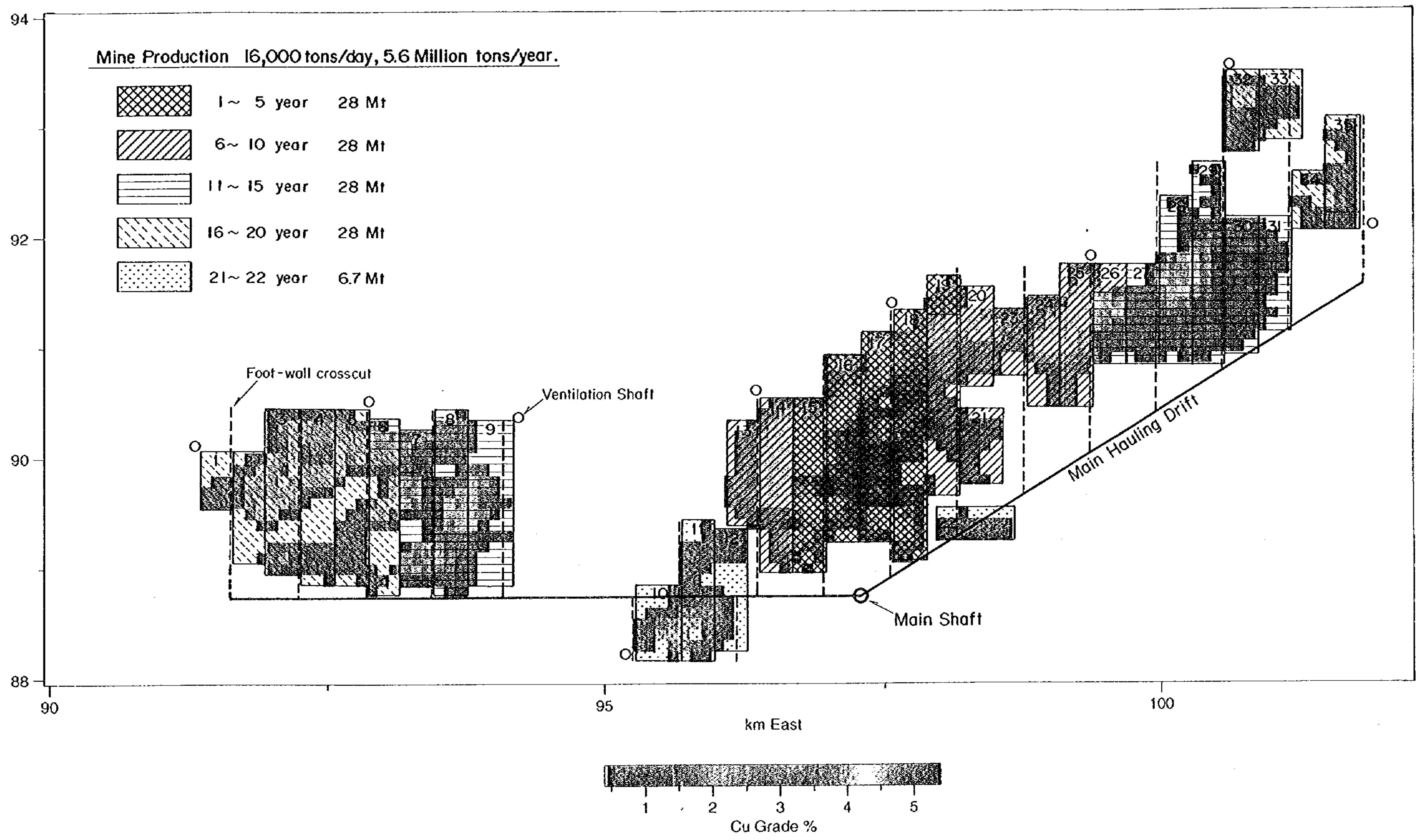


Fig. 2-8-7 Mining Area Map with Annual Production of 5.6 Million Tons

Table 2-8-9 Basic Parameters for Operating Cost Estimation

Annual production		4.5Mt	5.6Mt	6.7Mt
Production per day	(t/day)	12,800	16,000	19,200
Drill length	(m/year)	5,000	5,000	5,000
Winding capacity of skip	(t/hour)	1,100	1,300	1,600
One way distance of truck in u/g	(km)	1.0	1.0	1.0
One way distance of rail in u/g	(km)	5.5	5.5	5.5
Compressed air	(m^3/min.)	1,800	2,000	2,200
Total air flow	(m^3/min)	40,000	64,000	82,000
Underground waste water	(m^3/day)	20,000	20,000	20,000
Water supply	(m^3/day)	5,000	5,000	5,000
Mill plant capacity	(t/day)	16,000	20,000	24,000
Population of residence	(person)	2,000	2,000	2,000
Concentrate transported by rail	(t/day)	560	700	840
One way distance of trans. of conc.	(km)	155	155	155

Table 2-8-10 Summary of Estimated Operation Costs of the Zhaman-Aibat Mine

Unit (US$/t of ore)

Annual production	4.5Mt	5.6Mt	6.7Mt
1. Mining	5.560	5.306	5.152
2. Mine facilities	2.272	2.064	1.912
3. Ore dressing	4.330	4.080	4.000
4. Administration	1.028	0.934	0.863
5. Concentrate transport	0.311	0.311	0.311
6. Camp management	3.246	2.597	2.164
Total operating cost			
(US$/t of ore)	16.747	15.291	14.402
(US$/t of copper)	1,629	1,487	1,401
(cent/lb of copper)	73.9	67.4	63.5

8-6-2 Capital Cost

(1) Method of Capital Cost Calculation

The capital cost of the Zhaman-Aibat development is calculated using the Bureau of Mines Cost Estimating System Handbook like the operating cost.

The life of mining equipment is assumed to be approximately 10 years, and the renewal of equipment is assumed to be required twice in the case of the annual production of 4.5Mt (mine life 27 years) and once in the case of the annual production of 6.7Mt (mine life 18 years). The parameters used for calculation of capital cost are shown in Table 2-8-11.

(2) Results of Capital Cost Calculation

The total capital cost through the mine life (summary) is shown in Table 2-8-12. The details are shown in Appendix 44, 45 and 46.

Table 2-8-11 Basic Parameters for Capital Cost Estimation

Annual production		4.5Mt	5.6Mt	6.7Mt
Production per day	t/day	12,800	16,000	19,200
Room for underground crusher	m^3	24,000	24,000	24,000
plant	m^3	9,600	9,600	9,600
Room for underground work shop	t	8,000×2	10,000×2	12,000×2
Ore storage capacity in	m^3/day	20,000	20,000	20,000
underground	t/hour	1,100	1,300	1,600
Underground drainage	m^3/min.	1,800	2,000	2,200
Skip winding capacity	kW	80,000	100,000	120,000
Compressed air consumption	m^3/min.	40,000	64,000	82,000
Power consumption	m^3/day	5,000	5,000	5,000
Total air flow volume	t/day	16,000	20,000	24,000
Water supply	MVA	40	50	60
Mill plant capacity				
Power load				

Table 2-8-12 Summary of Estimated Capital Costs of the Zhaman-Aibat Mine

Unit (US$ × 1,000)

Annual production	4.5Mt	5.6Mt	6.7Mt
1. Underground development	131,331	153,335	175,337
2. Mining equipment	149,640	125,055	144,120
3 Mining facilities	16,706	21,744	28,931
4. Infrastructure	74,516	75,506	76,362
5. Mill plant	78,000	95,000	112,000
Sub total	450,193	470,640	536,750
Working capital	18,700	21,300	24,100
Total of capital cost	468,893	491,940	560,850
Primary investment	297,533	341,766	388,510
Additional investment	171,360	150,174	172,340

8-7 Evaluation of Profitability

The profitability of the Zhaman-Aibat Deposit is evaluated using the above operating and capital cost.

8-7-1 Assumptions

The assumptions used ton evaluate profitability are shown in Table 2-8-13.

The recoveries of ore dressing and smelting are taken from the results obtained from the Zhezkazgan complex. The metal price is assumed be $2,500/ton of copper and Treatment Charge / Refinery Charge (CT/RC) are assumed on the basis of the treatment charge at own smelter and refining. Taxation and depreciation are not considered because of their complexity and fluctuation. Financial costs such as interest on loans are also not considered.

Table 2-8-13 Basic Parameters for Profitability Evaluation

Items	Cu	Ag
Mill recovery	90.0%	90.0%
Smelter recovery	98.0%	94.5%
TC/RC	20 cent/lb	0.3 US$/TR.OZ
Metal price	2,500 US$/t (1.134 US$/lb)	4.0 US$/TR.OZ

8-7-2 Outline of Evaluation

The results of cash flow analysis are shown in Appendix 47, 48 and 49.

The economic evaluation is based on the conceptual design and includes the annual production of 5.6 million tons of ore, the TC/RC of 20 cents per pound and the copper price of US$2,500 per ton are assumed. Although the TC/RC of 20 cents per copper pound at domestic smelters and refineries is reasonable, the TC/RC cost in case of selling copper concentrate to custom smelters will increase ton 25 cents per pound of copper and more after transportation and insurance fees are added. The copper price of US$2,500 per ton is rather high. The following two cases are discussed.

- Annual production of 6.7 million tons and a mine life of 18 years
- Annual production of 4.5 million tons and a mine life of 22 years

The results are as follows;

	Internal Rate of Return (IRR)
The standard case (5.6 million tons per year)	5.40%
The alternative case 1 (6.7 million tons per year)	6.80%
The alternative case 2 (4.5 million tons per year)	3.04%

These values are obtained by eliminating the capital cost and tax. For consideration of the capital cost and tax, the following formula is approximately applicable.

$$R = (r - i) \times (1 - t)$$

Here,

r = Internal rate of return without tax and interest
R = Internal rate of return including tax and interest
i = Interest rate (financial charge)
t = tax rate

Even if the capital is assumed ton be supplied from an international funding agency, generally rate of return of 8% is expected. Considering a tax rate of 30%, and assuming an internal rate of return of 3%;

$$0.03 = (r - 0.08) \times (1 - 0.3)$$

At least r =12.3% will be necessary.

8-7-3 Sensitivity Analysis

The internal rate of return was studied by varying the parameters of copper price, TC/RC, capital costs and operating costs from the standard model (annual production 5.6 million tons, copper price US$2,500/lb., TC/RC 20 cent/lb.). The results are shown in Table 2-8-14 and illustrated Fig.2-8-8.

8-7-4 Summary of Economic Model and Future Problems

The summary of economic model is as follows;

(1) Under the standard parameters of this economic model, the possibility of profitable development of this deposit is small according to recent copper price.

(2) The copper price has the biggest impact on the internal rate of return (IRR), but is unfortunately beyond our control.

(3) The operating cost has the second biggest impact on IRR. For example, in the case of 30% reduction of the operating cost, the IRR will increase to 7.77%, on the other hand a saving in capital cost of 30% will improve the IRR to 4.99%. Even if the TC/RC increases 30% (to 24 cent/lb.), the IRR will decrease only 2.62%. The round figure of the IRR can be known by the combination of these parameters, when the IRR corresponding with the variation of parameter is required.

Future problems;

(1) Methods of decreasing the operating cost should be studied in details in the Feasibility Study including a study of mining methods.

(2) After studying the optimum development plan including the mining sequence, the progressive pre-Feasibility Study should be carried out with more accurate capital cost.

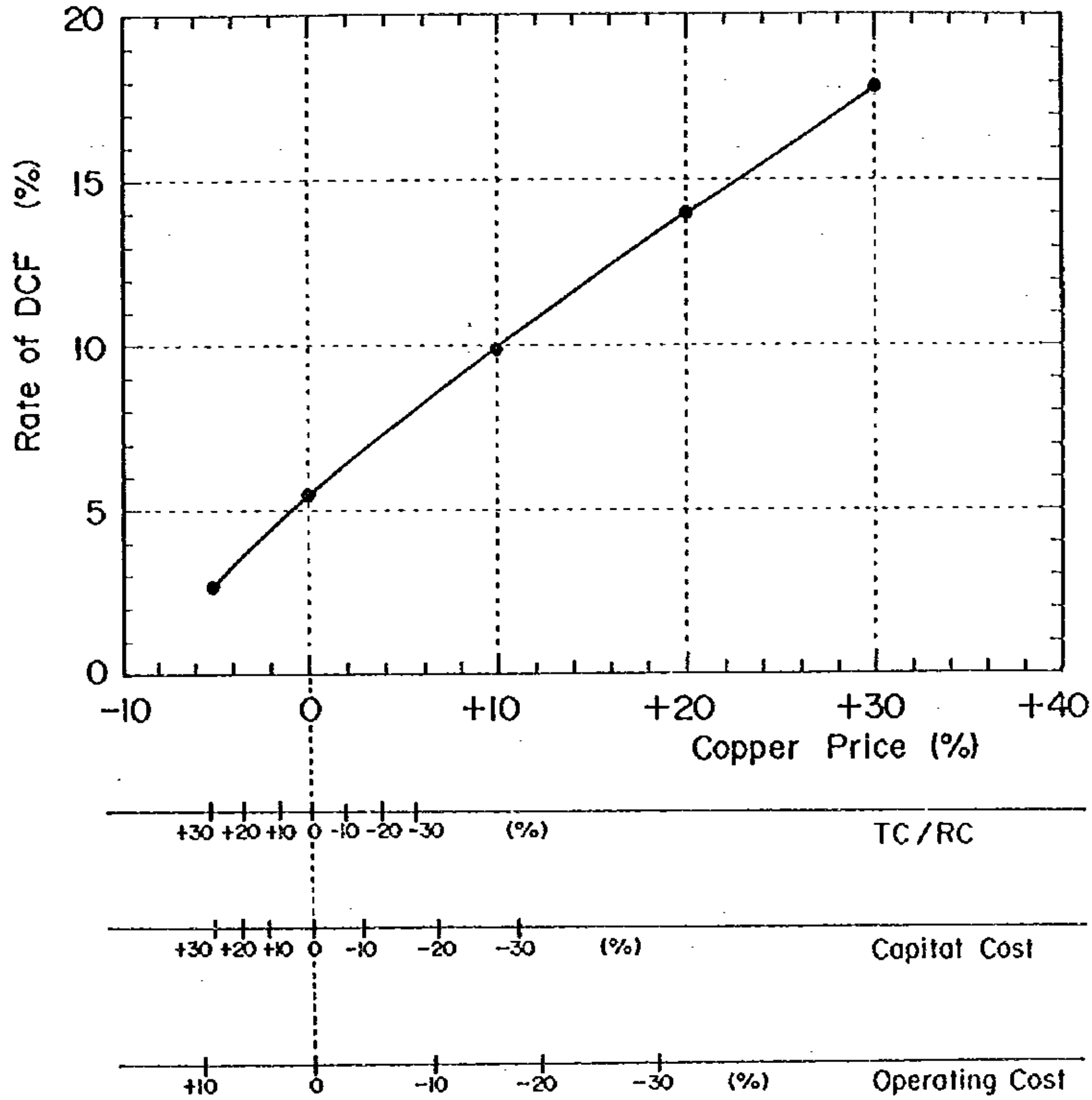


Fig.2-8-8 Sensitivity Scales for Main Parameters
(Rate of DCF(%))

(3) The economy of this project should be discussed from not only a viewpoint of the financial analysis of the market economy but also from the viewpoint of the nation at interest in terms of Cost-Benefit Analysis.

8-7-5 Discussion of Cutoff Grade

The optimum cutoff grade of the Zhaman-Aibat Deposit is discussed here again. The cutoff grade is defined by the following formula;

Salable metal (Cu) value contained in ore of one ton = Operating cost + TC/RC

Therefore the cutoff grade is calculated as follows;

$$X = \frac{C}{R_{mill} \times R_{smelter} \times (P_{Cu} - 2,204 \times T_{Cu})/100}$$

- X : Cutoff grade (% Cu)
- C : Operating cost (US$/t Ore)
- R_{mill} : Milling recovery (%)
- $R_{smelter}$: Smelting recovery (%)
- P_{Cu} : Copper price (US$/t Cu)
- T_{Cu} : TC/RC of copper (US$/lb. Cu)

The milling recovery, smelting recovery and TC/RC are shown in Table 2-8-13. The relation between the copper price and cutoff grade is shown in Table 2-8-15. From the Table 2-8-15, it is concluded that a significantly higher cutoff grade should be applied ton the Zhaman-Aibat Deposit than that used for Zhezkazgan Mine.

As shown in Table 2-5-15, cutoff grade which is analogous ton Economic Break Even Point will fluctuate with copper price. As well as copper price IRR is quite sensitive to the ore grade. An increase in ore grade of mine production corresponds to an increase in cutoff grade and decrease in minable ore reserve. In the previous soviet economic system, the concept of profit was lucking and cutoff grade was considered ton be invariable. However, in the market economy system optimum cutoff grades show sharp fluctuation with varying copper price and other parameters. In future cutoff grade of the Zhaman-Aibat Mine should be flexible and should be much higher than the copper grade than 0.4% Cu in the Zhezkazgan mine.

Table 2-8-14 Sensitivity Analysis between Various Parameters and Internal Rate of Return (%)

Item		Parameter		Internal rate of return
Copper price	-20(%)	$2,000/t	0.97 cent/lb	minus
	-10	$2,250/t	1.02 cent/lb	minus
	-5	$2,375/t	1.04 cent/lb	2.78
	0	$2,500/t	1.13 cent/lb	5.40
	+10	$2,750/t	1.25 cent/lb	9.97
	+20	$3,000/t	1.36 cent/lb	14.40
	+30	$3,250/t	1.47 cent/lb	17.70
TC/RC	-30	14 (cent/lb)		7.91
	-20	16		7.10
	-10	18		6.26
	0	20		5.40
	+10	22		4.51
	+20	24		3.59
	+30	26		2.62
Capital cost	-30	344,360 (th$)		10.37
	-20	393,554		8.40
	-10	442,749		6.77
	0	491,943		5.40
	+10	541,137		4.22
	+20	590,332		3.19
	+30	639,526		2.28
Operating cost	-30			13.17
	-20			10.78
	-10			8.21
	0			5.40
	+10			2.20
	+20			minus
	+30			minus

Table 2-8-15 Relationship between Copper Price and Cut-off Grade

Copper price (US$/t of Cu)	Cutoff grade (%)
2,000	1.19
2,100	1.11
2,200	1.05
2,300	0.99
2,400	0.93
2,500	0.89
2,600	0.84
2,700	0.80

8-8 Environment

The mining industry has a big impact upon the environment. Therefore, environmental impact including rehabilitation after mine closure must be considered before mine development.

The surface topography of Zhaman-Aibat area is almost flat and the population in this area is small. Agriculture and fishing are not carried out. The total annual precipitation is very small and there are no major rivers. The proposed mining method is underground mining.

Considering the above situation, it is concluded that there are very few problems of impact to inhabitants and to the environment caused by mine development. However, it is our responsibility to reduce the impact to the environment from the view of the global environmental safeguard.

Therefore, the following plans are proposed;
(1) To construct some wells surrounding the tailing pond to monitor the underground water.
(2) To reclaim the waste dump and tailing pond after mine closure.

PART III DETAILED REPORT ON THE SAMARSKY AREA

Part III Detailed Report on the Samarsky Area

Chapter 1 Previous Survey Data

1-1 Geological Surveys

Geological studies of this territory at the scale of 1:200,000 were completed by 1959. At the same time a large-scale geological survey began and a geological map at the scale 1:50,000 was prepared during the period from 1956 to 1958.

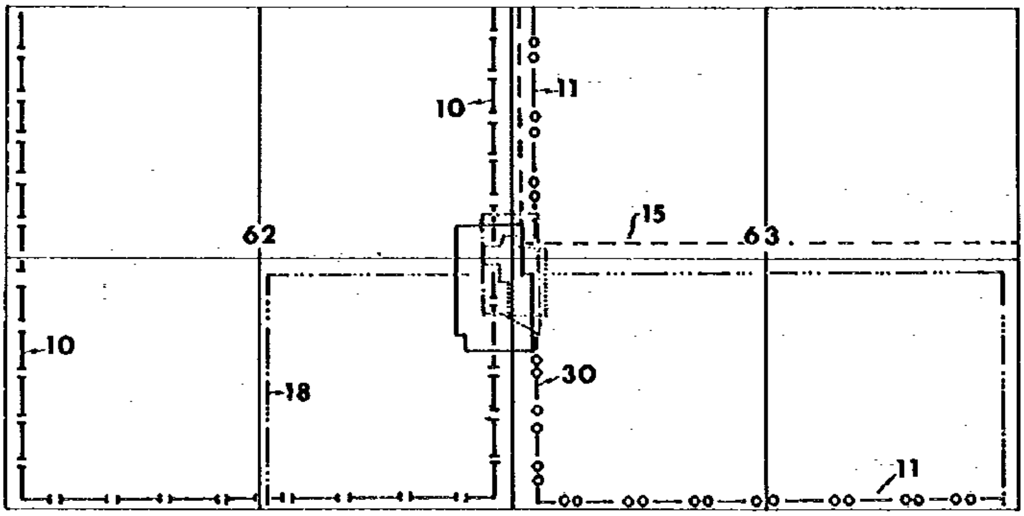
The first recorded prospecting in the "Sarymsak" area dates to 1935, when the prospecting for tourmalized secondary quartzite of Sarymsak mountain was carried out. The main target of this work was raw boron minerals. In 1954 the Sarymsak area was studied again as a possible deposit of raw boron materials. A number of trenches and exploring shafts were driven and a geological map at the scale 1:2,000 was compiled with general characteristics of secondary quartzites.

Gold mineralization was first detected in 1953 and was named "Nurin deposit". At the same time some small elongated zones with malachite and azurite were revealed among light colored (secondary quartzite) rocks. From 1956 to 1959 the area became the object of systematic investigations under the name "Nurin deposit" as a representative of tourmaline formation. Attention was drawn to the possible connection between tourmalinized rocks and gold and copper mineralization and a drilling survey for gold and copper was carried out (4 boreholes). Copper dispersion haloes (0.1-0.4% in epicentres) and molybdenum haloes (0.02%) associated with secondary quartzite were found in the vicinity of the Sarymsak hill but could not confirm any ore deposit.

These works resulted in an understanding of the stratigraphy, tectonic and metallogenic zoning with the recommendation to conduct detailed prospecting for copper-porphyric deposits in secondary quartzites.

As the Sarymsak secondary quartzite massive was considered to be very prospective from the standpoint of copper-porphyric type deposits, a geological survey has carried out in 1962 together with geophysical surveys at the scale of 1:10,000, covering the area of 15.75km^2. To explore the revealed anomalous zones and geochemical haloes, shallow drilling and exploratory workings were carried out (shafts 8.5m, trenches 35m^3, boreholes 770m). During 1966-1972 the Samarsky ore field including areas (ore occurrences) Samarsky Severny, Zapadny, Tsentralny and Yuzhny was studied and the following surveys were carried out: gravity (22.1km^2), sampling and analysis for gold (6km), trenches (5,204.3m^1), shafts (163.8 m.) and boreholes (2,398.5m). The results have confirmed, that the area is prospective for gold and copper-porphyric mineralization. Certain recommendations on conducting further exploratory work were made.

After summarizing all past data by the Karagandageologiya (Karaganda Expedition), in 1989, the area was again targetted for intensive exploration drilling. To complete the geologic map of the central Samarsky copper deposit and surrounding area, mapping drillings (shallow drillings penetrating sediment cover to the bed rock) were carried out. Since 1990 exploration drilling has



Legend

10 MSU (Moscow State University) Konfel O.M. 1:200,000. 1959

11 MSU Mozarovich O.A. 1:200,000 1959

15 CKGA, CKPhE Bydrin V.P. 1:200,000 1967

18 CKGA, Aksamentova N.V. 1: 50,000 1956-1957

30 Contour of work by P.I. Khomchenko 1: 10,000 1960

Contour of work by Opravhat V.A. 1: 10,000 1965

Area covered by works of X.K. Ismailova 1: 10,000

Contour coveredby work of Samarsky Party 1: 10,000 1994

scale 1:500,000

0 10 20 30 40 50km

Fig.3-1-1 Index Map of Previous Geological Surveys in the Samarsky Area

Table 3-1-1 Drilling Statistics in the Samarsky Area

Area, Type / Year	Samarsky Ore Field			Samarsky Copper Area			Samarsky Gold Area			Annual Total	
	Kind of Drill	No. of Holes	Total Length	Kind of Drill	No. of Holes	Total Length	Kind of Drill	No. of Holes	Total Length	No. of Holes	Total Length
1989	Mapping Drill	548	17,913 m	-	-	- m	-	-	- m		17,913.0 m
1990	-	-	m	Core Drill	21	8,006 m	Core * Drill	19	2,829.2 m		10,835.2 m
1991	-	-	m	-	-	- m	-	-	- m		0.0 m
1992	-	-	m	-	-	- m	Core Drill	11	2,251 m		- m
1993	Mapping Drill	47	795 m	Core Drill	25	19,970 m				('92-93)	2,251.0 m
1994							-	-	- m	('93-94)	20,765.0 m
Mapping		595	18,708 m			m			m	595	18,708.0 m
Exploration					46	27,976		30	5,080.2	76	33,056.2
Total										671	51,764.2

* Core Drill : for Exploration

delineated the ore body of the "Central" Samarsky copper deposit and the "Western" Samarsky gold-polymetallic deposit. A total of 76 exploration holes have been drilled (Fig.3-1-1, Table 3-1-1).

1-2 Geochemical Surveys

From the beginning of the systematic prospecting of ores in the Samarsky area in the 1950's, geochemical survey methods were adopted and played an important role in outlining the target area. Since 1957, lithological and geochemical prospecting of secondary haloes have been carried out in the area. Over 30,000 samples have been taken. Sampling has been carried in a network of 100m x 20m or 100m x 25m.

Spectral analysis makes it possible to determine the following contents of 23 elements: Mo, Ag, Pb, Cu, Co, Bi, Sn, Cd, Ge, V, Be, Sr, Ni, Sb, W, Li, Ti, Mn, As, B, Zn, Ba and Au. This work has resulted in compiling maps of secondary haloes of 13 elements which express the influence of mineralization in the area : Cu, Mo, Sn, W, Ag, Bi, Au, Ba, B, Ge, Pb, Zn and As. They characterize geochemical properties of geological structure of the area and make it possible to evaluate its prospects.

At the Central and Northern parts of the area copper haloes outline an intrusive massive, hosting copper molybdenum deposit. Series of small linear haloes are associated with zones of gold and polymetallic mineralization. A halo with an intensity of 0.01-0.1% outlines the Central ore field of impregnated copper ore. It has ring shape. Richer and closer to surface zones of copper mineralization are outlined within it by the most intensive anomalies from 0.03 to 0.1%.

Haloes of W(0.003-0.03%), Sn(0.0002-0.0005%) and Mo(0.0003-0.01%) are morphologically close to each other, have ring shape, apparently determined by morphology of a younger intrusion, breaking through monzodiorite.

Summarized halo of Cu, Mo, W and Sn is outlines the area of copper mineralization. Tourmalinization zones mapped by B(boron) haloes are also interesting from the standpoint of gold. Au(gold) halo is morphologically close to the projection of ore zone to the surface and is well correlated with copper.

Haloes of Ag, Pb, Zn, As and Bi are located at the flanks of the Cu halo and characterize zones of hydrothermally altered volcanicas, with zones of polymetallic mineralization.

Vertical geochemical zonation of the primary haloes has been analyzed on the Line 34 at the cross-section of 11 exploration drillings. Haloes of Cu, Mo, Sn, W, B, Ge, Sr, Ni, Bi, Co, Pb and Zn have been studied there. Cross-sections clearly define morphology of mineralization zones, which has inherited the anticline structure of the ore field. The ore zone is arc-shaped with its Western limb dipping steeply more than the Eastern one. Axial zonation of the ore body has been studied at the Western limb. The following above-ore elements are clearly defined here: Ge, Bo and Sn. The ore body is characterized by haloes of Mo, Au and Pb. Lower parts of ore body are characterized by Zn and Mo; below-ore, low-productive levels are characteristic for Bi and Cr.

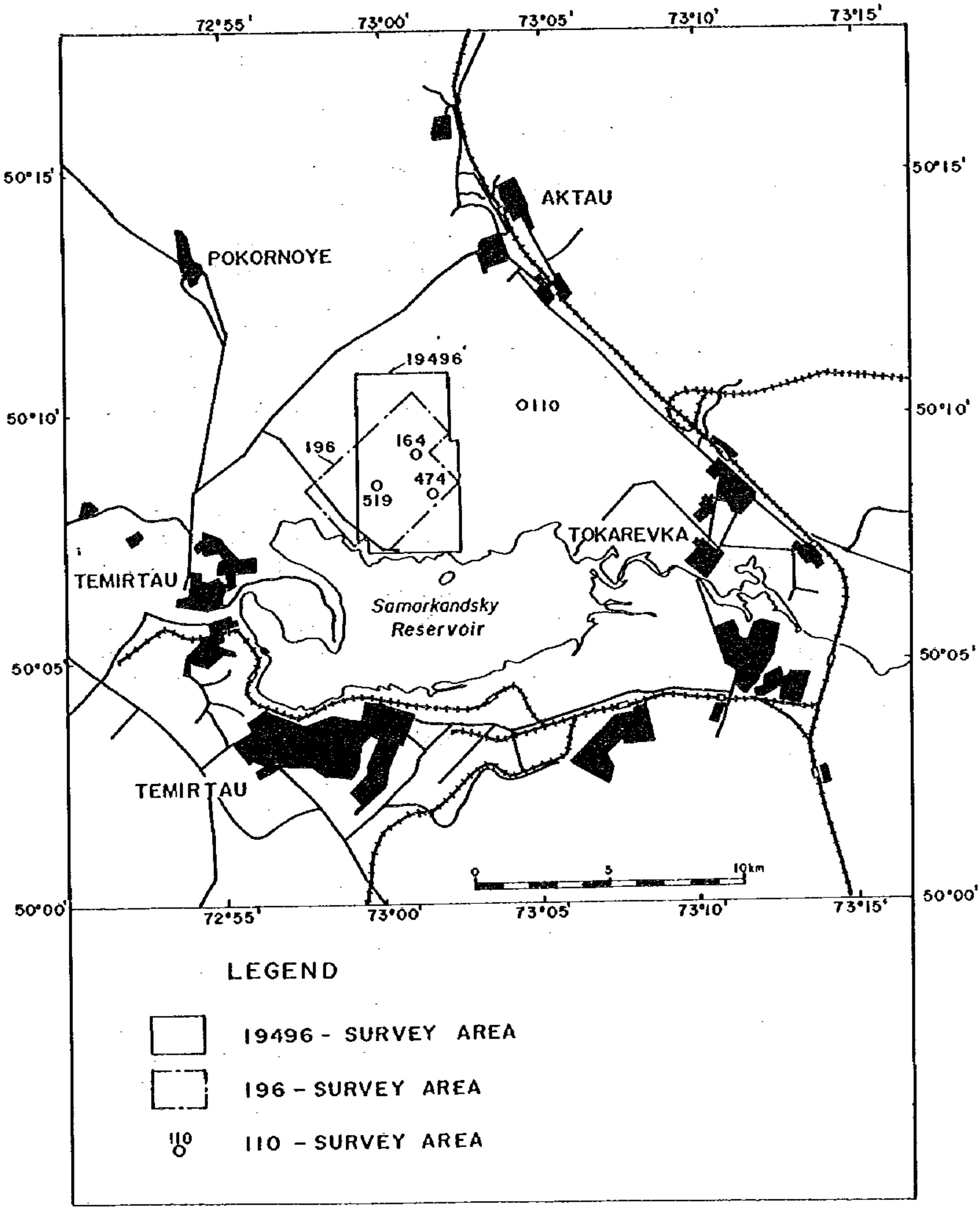


Fig.3-1-2 Index Map of Previous Geochemical Surveys in the Samarsky Area

1-3 Geophysical Surveys

The information on previous geophysical studies of the Samarsky area are given in the list of previous geophysical surveys (Table 3-1-2) and in the schematic map (Fig.3-1-3).

Systematic study of the Samarsky ore field started in 1960 with a combination of geological and geophysical surveys at a scale of 1:50,000. In 1961 while checking a geochemical anomaly an area, 0.5km x 1.6km in size, was selected for detailed geophysical survey. An electrical potential anomaly with 50mV was obtained by the electrical method of SP.

Based on the positive results of that work, an area of 15.75km^2 was covered by a 1:10,000 scale survey in 1962. The following geological-geophysical methods have been applied: magnetic survey and metallometric surveys in a network of 100m x 20m (15.75km^2), IP, SP electric surveys (7km^2). The area has been regarded as prospective for gold and silver as well as for copper-porphyritic and polymetallic ores and it was recommended for detailed study. The "Samarsky Zapadny" section was surveyed within its limits and was subsequently defined as prospective for polymetals. Anomalies of Induced Polarization with intensity 6 to 8% were detected in the course of an electric survey by IP method at the background value of 2%. A band of mineralized rocks with width of 100m, stretching for 400m in the north-west direction was delineated.

The quality of geophysical and geochemical surveys carried out in 1961-1962 does not correspond to current requirements. Besides that, anomalies at Lines 16 to 20 cast doubt on the accuracy of the surveys. According to V.P. VYDRIN the total prospective area is 40km^2. Since 1966 the Samarsky ore field has been studied by the Alexandrovskaya group of CGPE (Central Geophysical Expedition). A gravity survey in a network 200m x 100m (22.1km^2), magnetic survey in a network 100m x 20m (7km^2) and geochemical surveys in a networks of 100m x 20m and 100m x 100m (6km^2) were applied. Based on the prospecting results obtained from 1965 to 1972 (Grankin and others), Thematic party (1989) recommended further prospecting work in this area. The Samarsky area was considered to be prospective for gold and polymetals. which justified further prospecting at the scale 1:10,000 in this area.

Geophysical analysis utilized data obtained by the Batembai party and the gravity map at the scale of 1:10,000 from the report of the Rybinskaia geophysical party.

Data from the gravity survey of 1972 carried out on the Samarsky deposit area show the complicated gravity field. Most probably it is connected with the wide development, in the area, of various genesis of magmatic rocks and their intensive hydrothermal alteration down to more than 500m. The southern part of the anticlinal Tulkulin volcano plutonic circular structure on the gravity map is clearly marked by a considerable increase of the gravity field and in the northern part, by lower values. The border between them coincides with a zone of steep gradient on which the Sarymsak-Tulkulin fault is mapped. According to the data of the magnetic survey at the scale of 1:10,000 the studied area is clearly divided into two different parts according to the nature of the structure of the magnetic field. The region of positive magnetic field is formed with metasomatically changed granitoids and volcanic rocks of the Zharsor Formation. In plan it coincides with the central part of the Tulkulin structure and has mainly longitudinal orientation of changes of the magnetic field. The region of negative magnetic field encircles the outcrops of conglomerate-sandstone mass of the Kagyr Formation on the sides of this structure. The region of positive magnetic field has a complicated structure expressed with a large number of anomalies of various amplitude, strikes and dimensions. The magnetic anomalies can be conventionally divided into 4 parts:

- the zone of small intrusives and dikes of the basic rocks
- the outcrops of monzodiorite containing copper porphyric bodies
- the area of development of gold polymetal mineralization in the western area
- the outcrops of volcanic rocks of Zharsor Formation (south-eastern part).

(1) The Anomalies of Intrusives and Dikes

The anomaly zone located within Line 28 (stations 200 to 350) is a series of small anomalies. Spatially the described zone coincides with the area of development of andesite-basalt and monzodiorite containing a large number of small intrusives and dikes of subalkaline gabbro-diorite and dolerite of the Late Permian Manybay complex. It ought to be noted that singling out volcanogenic and intrusive formations according to magnetic survey data is quite complicated here because of widely expressed processes of metasomatism.

(2) The Anomalies of Monzodiorite

An anomalous zone of magnetic field forms to the of north the first zone and occupies the central part of Lines 28 to 50 (stations 200 to 380). It is characterized by a pair of high (500 to 1,000 nT) and low anomalies (200 to 300 nT). Spatially the zone coincides with outcrops of the Tulkulin small intrusive of altered monzodiorite of the first and second phases of Kukkudukutubin complex containing bodies of copper porphyric ores. According to the drilling data, the intrusive on the depth increases significantly. Dipping of its roof in the south-eastern direction at the angle of 30 deg is observed.

It should be noted that within ore bodies granitoid and volcanic rocks of Devonian are everywhere changed metasomatically to facies of beresite and propylite and in less changed shape are preserved only in small areas. Within this zone outcrops of beresite and beresitized quartz monzodiorite of the second phase of intrusion form a broken half-ring, which in the western part coincides in plan with the most intensive half-ring magnetic anomaly. According to results of determination of physical properties of less changed samples of quartz monzodiorite they have average magnetic susceptibilities as high as 1,631x10e-^{5} SI.

However, the drilling determined that sometimes ore and ore containing beresite developed in monzodiorite of the first stage of intrusion have high magnetic susceptibility. In borehole No58 in samples taken from subore-and supraore-beresite, high magnetic susceptibility of these rocks (3,000 to 5,500 x 10e-^{5}SI) was measured. Similar high magnetic ore beresite were intersected in boreholes No 48 and 49 at the depth of 100m to 312m, where the average magnetic susceptibility varies from 308 to 3,182 x 10e-^{5}SI reaching maximum values of 6,000 to 9,000 x 10e-5 SI. Taking into account all this data and the complex geological structure it can be concluded that the described half-ring magnetic anomaly is most probably conditioned with not only quartz monzodiorite of the second phase but also with ore containing and hematite and magnetite containing beresite developed mainly in monzodiorite of the first phase of Kukkudukutubin complex. This zone of the magnetic field is characterized by the presence of secondary areas of dispersion of molybdenum, copper, gold, silver. Calculated anomaly grades appear to be equal and the strike of secondary areas agrees with the strike of primary structures.

According to data from the report of the Dalnenskaia geophysical party (1962), which carried out the electric survey works in this area, the Samarsky copper porphyry mineralization is marked with IP anomalies with intensity 6 to 10% on a background of 3%.

In the south-western part of the area a positive magnetic anomaly is defined in Lines 12 to 26 (stations 16 to 220). This large anomaly is isometric in plan and is stretched in longitudinal direction with intensities up to 900-1,000nT. It corresponds to the zone where the Tulkulin fault adjoins small intrusions of quartz monzodiorite of Early Permian Vishnev complex and hornfels.

(3) The Anomaly of Au-Polymetal Mineralization

The anomalous zone covers the north-western part of the study area. In a gravity map the area of the relative gravity represents a decrease of values of gravity force, associated with the massive of granitoids located at depth. The character of the magnetic field within this zone is marked by relatively decreased values (from -50 to +100nT). Spatially it coincides with the area of development of sandstone of the Konyrskaia Formation and metasomatically changed tuffites, tuffoconglomerate breccia and large-fragmental tuff andesite of the Upper Zharsor Subformation. Magnetic anomalies of small dimension are conditioned with small unexposed dike-like bodies of quartz monzodiorite of Early Permian. Small exposures of these rocks are marked in many places within this zone and they were identified in many exploration wells. Within Lines 52 to 57 (stations 150 to 120) weakly positive or negative anomalies correlate with anomalous zones of supposed polarization associated with hydrothermal activity. Three maximums of intensity of 7 to 8% confined to tourmaline-serisite-quartz sulphide zones are defined within this anomalous zone. Secondary areas of dispersion of lead, zinc, gold and, more seldom copper, are confined to tourmaline-sericite-quartz metasomatically altered rock. According to drilling data all large bodies of gold-polymetal ores and zones of mineralization are localized within this zone.

(4) The Anomalies of the South-Eastern Part

The south-eastern part of the area, (Lines 0 to 30), is characterized by a magnetic field of small intensity 100 to 300nT. In plan this zone coincides with outcrops of volcanic rocks of the Zharsor Formation. Spatially it coincides with the area of development of Middle Devonian terrigenous rocks of the Konyr Formation.

Table 3-1-2 Previous Geophysical Surveys in the Samarsky Area

(after BOOK1, 1992)

Report	Year	Author	Method , scale	Network, spacing
148	1960	Khomchenko P. I. Zinchenko O. V. CKSD, CGPE	Ms - 1:100,000 1:10,000 Gch- 1:50,000 1:25,000 Es - 1:25,000	500x100 m 1,000x100 m 1,000x50, 500x50m 100x20 m 500x50m 250x50m
161	1961	Pak V.P. Kaz	Ms - 1:100,000	height 40m
164	1961	Khomchenko P. I. Vydrin V.P. CKSD, CGPE	Ms - 1:10,000 Gch- 1:10,000 Es(VES)- Es(IP) -	100x20 100x20 distance 2,000m pitch 500m 200x200m 400x200m 100x20m
196	1962	Khomchenko P. I. Belousov A. I. CKSD, CGPE	Ms - 1:10,000(15.75) Gch- 1:10,000 Es - 1:10,000 (7) (SP, IP)	100x20m 100x20m 200x40m
494	1965 - 1972	Opravhat V.A. Pacholyuk V.P. CKTSD, CGPE	Gr - 1:25,000 (22.1) Ms - 1:10,000 (4) Gch- 1:10,000 (6)	200x100 m 100x20 m 100x20 m, 100x100m
950	1983	Mageramova E.A. CKTSD, KSPE Geophysical party	Ms - 1:10,000 Es - 1:10,000 (SP)- --	100x25 m 200x50 m pitch 25 m

Gr:Gravity, Es:Electric, Ms:Metallometric, Gch:Geochemical

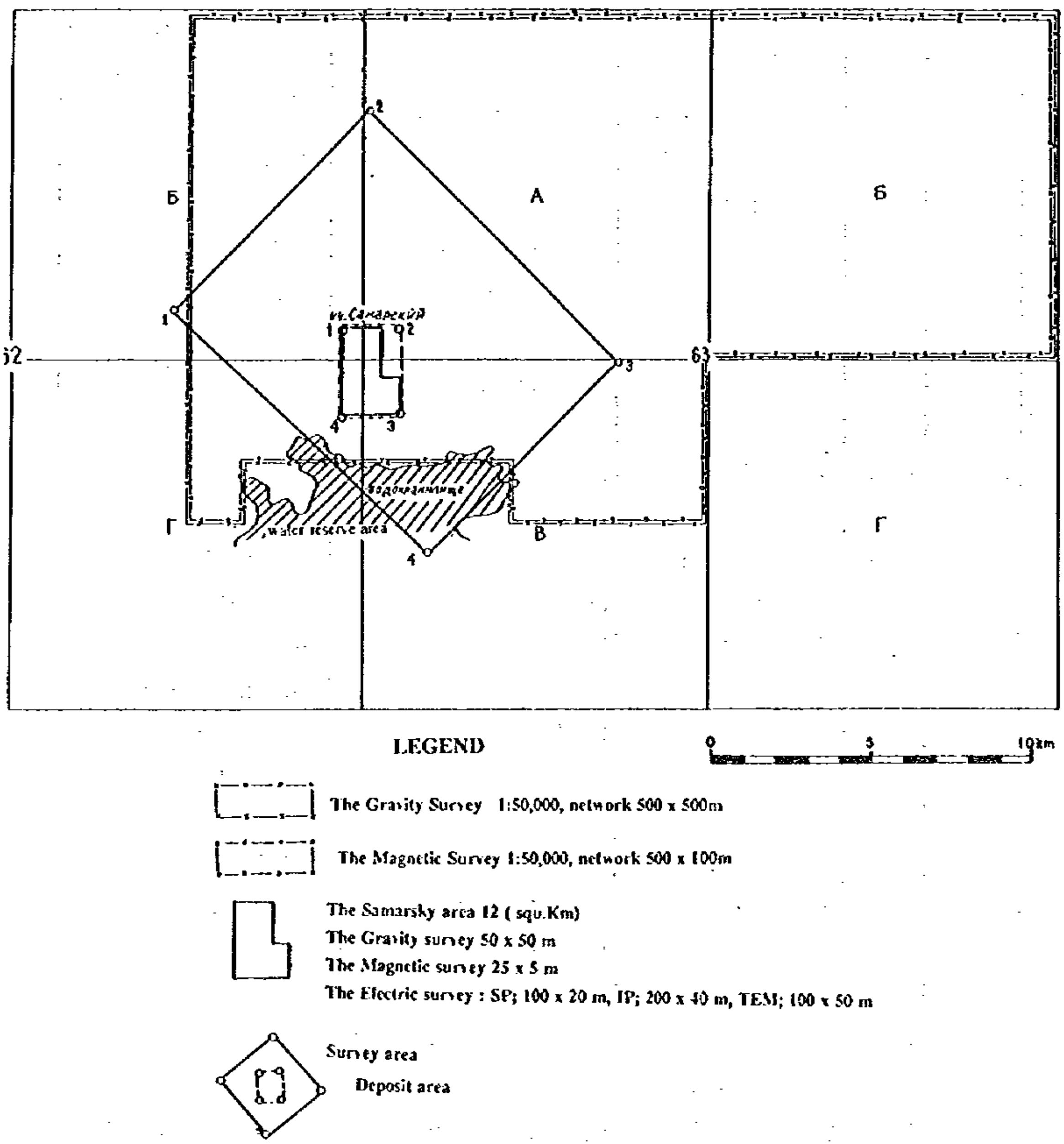


Fig.3-1-3 Index Map of Previous Geophysical Surveys in the Samarsky Area

Chapter 2 Geology and mineralization

2-1 Geology

The Samarsky area is located at the marginal Devonian volcanic belt at the junction of large caledonide structures, Erementay-Nyazsky anticlinorium, Semizbugin and Shokshan synclinoria. The structural position of the area results in wide development of volcanic, intrusive and volcanogenic-sedimentary formations of Devonian age. The stratified divisions of sedimentary formations and intrusive formations have been defined as described below:

2-1-1 Sedimentary formation

(1) Devonian System

Devonian system deposits are widely spread through the territory of the area. They compose basically the wings of a Tulkulin ring volcanic-plutonic structure and are divided into Early-Devonian Zharsor tuffogeneous volcanogenic and Middle-Devonian Konyr volcanogenic sedimentary Formations. The former is subdivided in turn into Lower and Upper Subformations.

Early-Devonian Zharsor Formation

According to petrochemical and lithologic data the Formation is divided into Lower and Upper Subformations mainly composed of volcanics of basalt, andesite and dacite compositions respectively.

Lower Subformation : The Lower Subformation of Zharsor Formation is most widely spread in the South-Western and North-Eastern parts of the Samarsky ore field. The Subformation discordantly overlaps the Silurian and Ordovician deposits and it is concordantly overlapped by the rocks of the Upper Subformation within the area. The thickness of the Lower Subformation is not less than 545m. The formation is mainly composed of agglomerate tuff. Lower Subformation volcanics in the Zapadny area are metasomatically altered to fully-manifested beresite with abundant pyrite.

Upper Subformation : The Upper Subformation of Zharsor Formation is concordantly overlapped by volcanogenic-sedimentary deposits of the Middle Devonian Konyr Formation. The described deposits are most widely developed in the South-Eastern and North-Western parts of the site dipping at angles of 20-30°. It constitutes limbs of the Tulkulin volcano-plutonic structure. It is composed of coarse-fragmental pyroclastic tuff and sometimes lava of andesitic dacite and andesite. The thickness of the Upper Subformation is more than 510m.

Subvolcanic formations : Subvolcanic formations of the Early Devonian related to the volcanism of Zharsor time are widely spread at the Lower Subformation. It is mainly composed of leucocratic basaltic, andesitic basaltic rocks.

Middle Devonian Konyr Formation

Deposits of this Formation in the Zhivet stage widely occur in Northern and Western parts of the Samarsky area. Konyr Formation with washout and angular unconformity overlaps the volcanic rocks of lower and upper members of the Zharsor Formation and it is in turn overlapped by Neogene clay. The formation is composed mainly of red-colored tuffaceous inequigranular sandstone, conglomerate. The incomplete thickness of the formation is less than 250m.

(2) Neogene System

The deposits of Neogene age are represented by Kalbaman, middle to late Miocene and Pavloda late Miocene-early Pliocene formations composed mainly of clay and formations of redeposited disintegrated weathering crust with lenses of sand and pebble.

Middle-late Miocene. Kalkaman Formation : The deposits occurring widely in the area overlap the rocks of Paleozoic and they are overlapped by the formations of Pavlodar series. The Kalkaman Formation is composed mainly of lacustrine, alluvial-lacustrine and diluvial-proluvial grey-green fat clay and redeposited weathering crust. The thickness of the Formation varies from a few meters up to 50m.

Late Miocene-Early Paleocene. Pavlodar Formation : The deposits of this formation have wider areal occurrence in comparison with those of the Kalkaman Formation. The largest areas in which their bedrocks are found are in the northern and north-eastern parts of the site. They overlap the Kalkaman Formation and Paleozoic rocks and they are covered by Quaternary formations. The formation is composed mainly by red-brown, more rarely by speckled, washed lacustrine, lacustrine-alluvial sandy clays. The formation thickness varies from a few meters up to 22 and 35m.

(3) Quaternary System

The lower layer in the Quaternary system is Lacustrine-alluvial deposits that occur most often in the western part of the area. They are represented by lacustrine-alluvial and alluvial brownish-beige loam, clay and polymictic fine-middle grained sand. The thickness of the rock mass is less than 5m.

Middle-Upper layers are Proluvial-diluvial deposits (pd QII-III). They are represented by carbonaceous sandy loam with the debris. The thickness of these deposits does not usually exceed 1-2m. Recent layer is Proluvial and lacustrine deposits composed of proluvial loams, sandy loams and sands occur most widely in this layer. The thickness of such deposits is not more than 1m.

2-1-2 Intrusive formations

Intrusive formations in the Samarsky area are strongly variable depending on the time of their intrusion, petrochemical properties and structural position. All of them are closely connected with Devonian volcanism, which resulted in the formation of ore containing Tulkulin volcanic-plutonic structure and with Permian stage of Epicaledonian tectonic-magmatic activation. The following complexes have been conventionally defined.

(1) Lower Devonian Karamendin Complex

Early Devonian Karamendin complex of quartz-diorite, associated with the first phase of intrusion and granodiorite porphyry of the second phase of intrusion constitute the Tulkulin intrusion, which is outcropping in the central part of the volcanic-plutonic structure in the Samarsky area. Both major phases are accompanied by sub-phase intrusive activities.

The former sub-phase is composed of the associated metasomatic formations of medium-fine grained, microdiorite and quartz-diorite-porphyry of exocontact facies, beresite, potassium feldspar facies, propylite and secondary quartzite.

The latter sub-phase, continuing to the second phase formed associated intrusives and dikes that coincide in places. They are composed by quartz-diorite-porphyry biotite-plagioclase-like, eruptive breccia of granodiorite-porphyry, beresite and potassium feldspar facies. This complex is most widely spread within the Devonian volcanic belt and is closely connected with Devonian volcanics. During all of these activities some parts of the intrusive bodies were brecciated and formed so-called breccia pipes in the central part of the massive. The breccia pipes include many kinds of clastic fragments of early stages and hosting rocks of Early Devonian Formations. These breccia pipes played an important role in the hydrothermal alteration and copper-porphyritic and gold polymetallic mineralization in the second phase intrusion of the complex.

Plan view of Tulkulin massive shows that it has an oval shape, and is apparently represented by a stock-shaped body, 6 x 3km in size. At the Western part of the area the intrusion is cut off by the Western-Tulkulin upthrust-overlap. Almost everywhere rocks of this complex are almost completely altered by metasomatism to beresite.

(2) Lower Permian Vishnev Complex of Quartz Monzodiorite

Lower Permian Vishnev complex of quartz monzodiorite, less frequently monzodiorite and granodiorite has been conventionally defined within the Samarsky complex. This complex consists of minor intrusions and dikes, mostly located in peripheral parts of Tulkulin volcanic-plutonic structure and zones of faults. Most of them are partly or completely overlaid by Neogene clays or are not uncovered by erosion at the sandstone of the Konyr Formation. The most widely spread rocks are represented in the complex by quartz monzodiorite, constituting the majority of dikes and intrusive bodies.

(3) Upper Permian Manybay Complex

The complex of sub-alkaline dolerite, gabbro and gabbro-diorite has been conventionally defined in the surveyed territory. This complex includes groups of dikes and minor intrusions, located mostly at axial parts of the Tulkulin volcanic-plutonic structure. Most often granitoids of this complex occur in the Southern part of the territory.

(4) Upper Permian Koitas Complex

The Koitas complex of rhyodacite-porphyry, rhyolite-porphyry and granite-porphyry is defined conventionally. This complex includes group of dikes and less frequently, minor intrusions, mainly located at the peripheral part of Tulkulin volcanic-plutonic ring structure.

2-1-3 Tectonic Structure

The territory of the Samarsky area is located within marginal Devonian volcanic belt, at the junction of large Caledonian structures-Erementay-Nyaz anticlinorium, Semizbugin and Shokshan synclinorium, adjacent to the junction zone of Caledonian and Early Hercynian structures of Central Kazakhstan, thus determining its complicated tectonic structure. There are two structural stages and five structural and intrusive complexes defined based on the type of prevailing folding and fault tectonics are on the magmatic and sedimentary formations within the area. The main structural element of the Samarsky area is the Tulkulin volcanic-plutonic ring structure. The first and the second structural stages are defined within the orogenic stage of development.

First structural stage : The first structural stage is composed of continental andesitic basalt-dacite Lower Devonian formation of Zharsor Formation and Early Devonian orogenic intrusive Karamendin complex of diorites. By the beginning of Lower Devonian age the area had undergone significant tectonic restructuring by Caledonian tectonic movement and the Tulkulin ore-containing volcanic-plutonic ring structure with minor intrusions was formed. Above-intrusion roof of Tulkulin minor intrusions is composed of volcanics of andesitic basalt-dacite formation in the Western and Eastern part. The central part of the volcanic-plutonic structure is complicated by numerous faults and minor intrusive and dike bodies of the Permian age. These are mostly granodiorite of Early Devonian Karamendin complex. They form the Tulkulin intrusion, containing gold-polymetallic and copper-porphyritic mineralization. It has a dome structure with its nucleus composed of hydrothermally altered granodiorite of Early Devonian Karamendin complex.

Second structural stage : The second structural stage is composed of continental-marine Middle Devonian molasse rock associated with the Konyr Formation, constituting overlaying Samarkand syncline. The syncline forms the structure of the Northern, Western and Eastern limbs of the Tulkulin volcanic-plutonic structure.

Stage of developing Epicaledonian activity : Epicaledonian activity is represented by minor bodies and dikes of alkaline and acidic composition of Early and Late Permian Vishnev, Manybay and Koitas complexes. The described folding and intrusive complexes are complicated by numerous faults, that are characterized as having important tectonic and ore-determining roles.

Faults are widely spread and play an important role in the geology of the area, determining prevalence of small blocks in its structure. The major faults are the Tulkulin, West-and East-Tulkulin, Sarymsak-Tulkulin and Sarymsak faults. The largest fault is the Tulkulin deep seated fault which is assumed to have a steep Western dip (60-85°), meridional strike and is stretching from the South to the North through all the Western part of the territory of the area. In the Western part of the area it limits placement of mostly copper-porphyritic mineralization of the Samarsky deposit, and its outlining tectonic cracks are responsible for placement of gold-polymetallic mineralization. The East-Tulkulin fault, which has a North-Eastern direction, is located in the South-Eastern part of the area, upthrusting with dislocation, directed to the East at the angle of 70°. The fault outlines outcrops of the Tulkulin intrusion and the Eastern flank of a copper-porphyritic body to the West of the Samarsky area. The Sarymsak-Tulkulin fault is located in the Central part of the area. It has a steep, almost vertical dip and is outlined by dike-like bodies of granodiorite of Early Permian age and coincides with outcrops of granodiorite of the second intrusion phase of the Karamendin complex. Other numerous smaller faults can be divided into two groups of tectonic cracks with North-Eastern (younger age) and North-Western strike.

2-2 Mineralization and Alteration

2-2-1 Mineralization

Ore deposits and occurrences, located within the Samarsky survey area are included in copper-molybdenum-gold formation and are closely associated with Devonian volcanism, that has resulted in formation of ore-containing Tulkulin volcanic-plutonic structure. The structural position of the Samarsky survey area resulted in development of two types of mineralization: copper-porphyritic and gold polymetallic.

(1) Porphyry copper type mineralization

Two comparatively large bodies of copper-porphyritic ore occur in the Samarsky survey area. They are located in the Northern part (No.1 body) and in the central part (No.2 body) of the area. Both ore bodies are composed of metasomatic altered rocks of quartz diorite, granodiorite of the Early Devonian.

Ore body No.2 is the object of geological ore reserve estimates in this year. It is located at the above-intrusion zone of Tulkulin massive. The massive is composed of hydrothermally altered rocks of beresite-sericite composition. The ore body was delineated based on the cut-off grade of copper of 0.2%; it has an isometric shape with irregular borders and a size of 500mx400m. It is cut by faults, having North-Eastern (Sarymsak-Tulkulin, Sarymsak) and meridional directions (Tulkulin). Ore body No.2 is shaped like a cone and is located in the upper parts of the intrusive massive. The bottom of this cone is close to oval shaped, with the size 2,000m x 1500m. The vertical range of mineralization is over 500m.

Ore body No.1 has a similar character to No.2. The shape is like a cylinder with a slightly stretched oval cross section approximately 400m x 250m in plan view. Their major sulphide ores are veinlet-impregnated and impregnated-veinlet types.

(2) Gold-polymetallic type mineralization

This type of ore has been found in the "Western" section and its Southern extension. Ore mineralized zones are associated with the Zharsor Formation of Lower Devonian. Gold ore mineralization is developed at the zone of crushing and hydrothermal alteration (sericite-beresite metasomatic alteration).

Ore and ore mineralized zones do not have clear geological borders. They have been delineated by sampling and are represented by accumulations of gold-polymetallic quartz, quartz-carbonate, quartz-sulphide, sulphide veinlets. The mineralized zones have conformable orientations with surrounding crushed zone of North-Eastern strike with the inclination of 35-55°. Analysis of spatial distribution and structure of ore bodies shows, that all of them have zonal structures. The outer zone contains poor polymetallic and gold mineralization, inner parts contain commercial mineralization (over 3 g/t Au).

Four gold ore bodies have been discovered in a north to south line in the North-Western Dumkorin section. In the two northern bodies gold prevails over lead and zinc and in the southern bodies lead and zinc prevail over gold.

(3) Gold-bearing crusts of weathering.

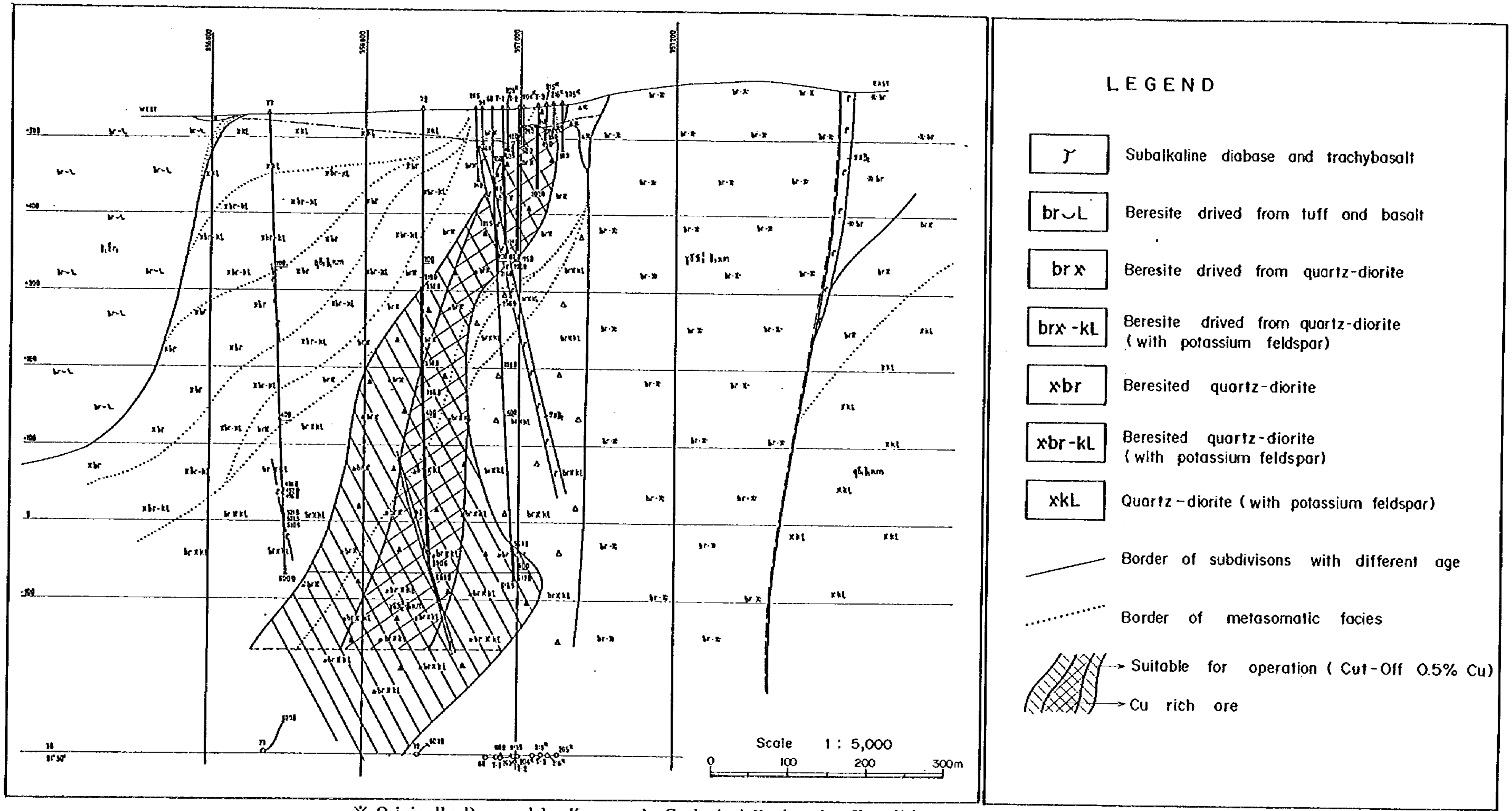
Gold-bearing crusts of weathering are widely developed within the Dumkorin tectonic block (Zapadny-"Western" section) and are localized in Neogene sediments. They have an average thickness of 20m and average content of gold of 0.2 g/t Au.

2-2-2 Mineral Composition

Based on the results of microscopic observation and others, general characteristics of selected ores has been studied for mineral composition in the Samarsky ore deposits area. Two main types of ore have been defined here: copper ore and lead-zinc ore with gold. Their characteristics are as follows:

Copper ore : According to the assemblage of copper minerals, copper ores are classified into chalcopyrite ore and chalcopyrite-molybdenite ore. Chalcopyrite mineralization is being regularly replaced at depth by chalcopyrite-molybdenite mineralization. Chalcopyrite ores are basically composed of chalcopyrite, pyrite and accessory sphalerite, rutile and magnetite. Molybdenite-chalcopyrite ores are mostly composed of accessory molybdenite, pyrite and rutile. Hosting rocks of these ores have spotted textures.

Polymetallic ore : Polymetallic ore is composed of lead, zinc and in some cases gold is also present. Their mineral composition is basically sphalerite, galena, pyrite, chalcopyrite and, as a minor minerals, chalcocite, tetrahedrite, native gold, magnetite and rutile are also present in some cases. The dominant texture is "impregnated" with some veinlet-like and veinlet/jointing textures also apparent. Gold is found in the veinlet type texture ore.



※ Originally Prepared by Karaganda Geological Exploration Expedition.

Fig. 3-2-1 Section of the Central Cu-Mo Deposit along the E-W line in the Samarsky Area

2-2-3 Alteration

Intrusives and hosting volcanogenic rocks are affected by intensive hydrothermal alteration. Distribution of hydrothermally-altered rocks is in the form of concentric zones (Fig.3-2-2). Silicified rocks are located in the center. Moving outward, they are replaced by vast zones of quartz-sericite composition, transforming into sericite, which is then replaced by quartz-tourmaline and tourmaline. Flanks of the area are mostly occupied by propylite. Hosting rocks of copper-porphyritic deposits are generally altered with various intensity to beresite. In general, mineralized zones of gold are also associated with sericite-beresite metasomatic rocks. Gold ore mineralization is developed at the zone of crushing and hydrothermal alteration containing fine impregnation of pyrite. The secondary alterations in the rocks of the Konyr Formation were expressed by recrystallization of cement and they are presented mainly by the processes of chloritization, carbonization and silicification.

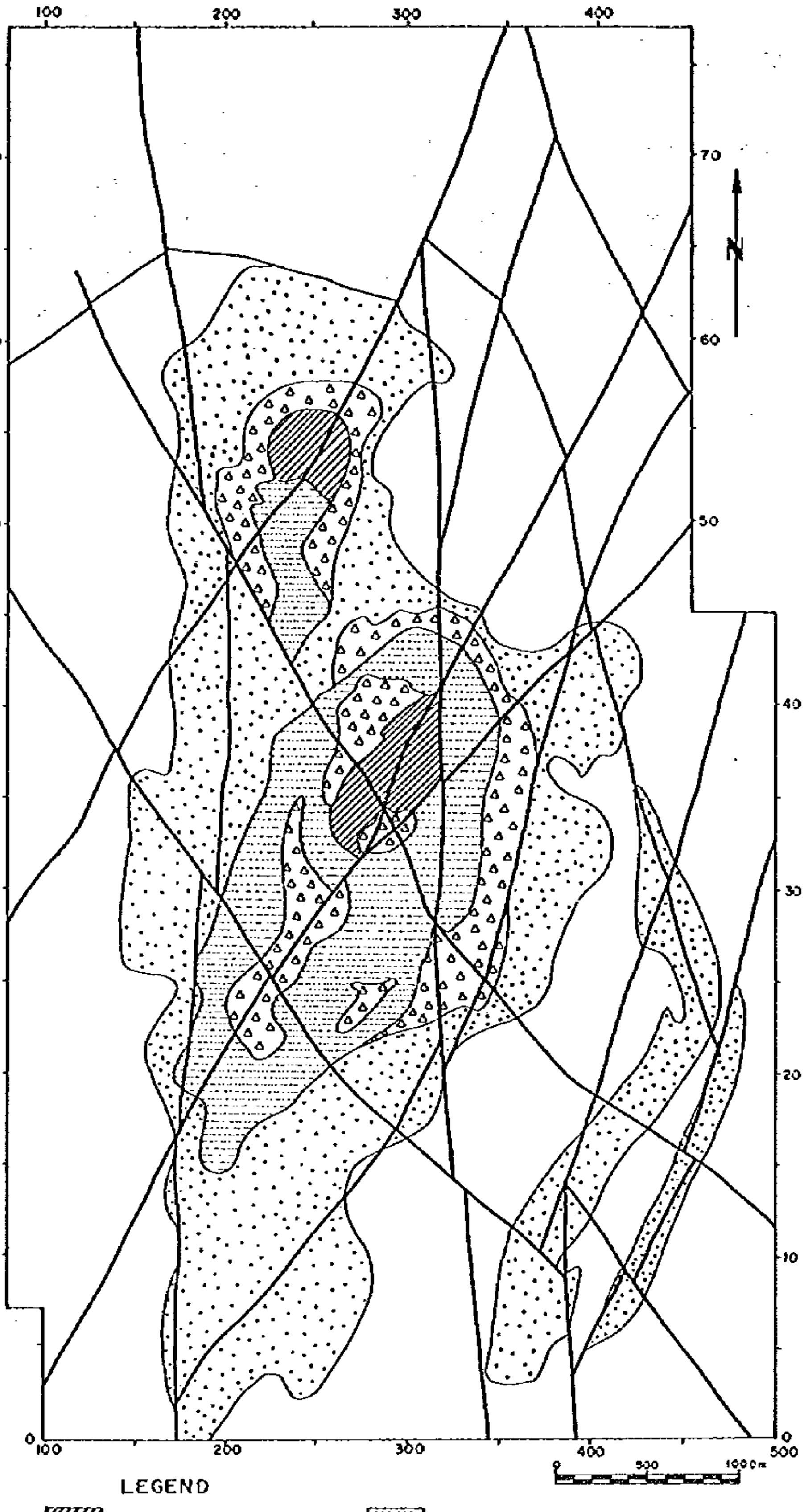


Fig.3-2-2 Alteration Map of the Central Cu-Mo Deposit in the Samarsky Area

Chapter 3 Geological Resources Estimation

In the Samarsky survey area, two types of ore deposit have been discovered as mentioned below. The Japanese survey team checked the geological ore reserve estimation for the Samarsky porphyry copper deposit.

3-1 Data Base

The copper-bearing part of the core sample was determined by semi-qualitative analysis of all cores. Only samples with high copper contents were separated and analyzed in the Karagandageologiya laboratory for copper, molybdenum, silver, gold and zinc. The analyzed sample units are basically 2m long core section. These analyzed data are put in the hand-written chemical master file with their drill numbers and sampling depths.

For the preparation of the data base of ore reserves in Samarsky deposit, analytical results were entered by the Japanese survey team using personal computers with spread-sheet-type software. Because of time limitation, data only inside the Samarsky porphyry copper ore body were considered. The total number of drillholes entered is 30 holes and the total number of analyzed data is 2,197 sets.

3-2 Calculation Method

3-2-1 Calculation Method of the Karagandageologya

The copper deposit block is delineated by the conditions listed below:

(1) The cut-off grade of copper deposit is 0.5%Cu on the basis of studies by the Karagandageologiya on the engineering and economical conditions for the Samarsky deposit. The rich ore is defined by the value of Cu equal to or higher than 1.0% .

(2) In the case where the ore is intersected in two distinct layers separated by a length of country rock, the country rock and both intersection are considered to be one ore intersection provided: a) the length of included country rock does not exceed 15m and b) the length weighted mean of grades exceeds 0.5%Cu. If either of these conditions is not met then the intersections are considered separately (i.e. two different ore bodies).

(3) If the ore intersection continues to the bottom of a drillhole then the length of intersection was assumed to extend for an additional 100m. As all the exploration drill holes are 600m deep, the maximum depth of the calculated geological ore block is 700m (about 200m above sea level).

(4) The panel/section method was used by Karagandageologiya to delineate the block ore body in plan. Parallel panel sections were arranged at 100m intervals along an east-west axis. The section view of the ore body on each panel was determined by the distribution of ore intersections in

drillholes located in the plane of the section. The shape of the ore body in plan was determined by interpolating between neighbouring section.

(5) In cases where the extent of the ore body was not defined in any panel to the north or south an additional intersection of 0m was assumed at a distance of 100m. In this manner the ore body was closed in the north and south directions by wedges.

An ore body defined in this manner was used by Karagandageologiya to evaluate the geological reserves by the following method.

(1) **Area of ore in panels** : A planimeter was used to determine the area of intersection of the ore body in the panels described above. The planimeter calculation was checked by summing the area of triangles fitted to the area of intersection.

(2) **Average grade of panels** : Average ore grade of a drillholes is calculated by the length-weighted average of each analyzed sample. The panel average grade is calculated by the length weighted average of the average grade of drillholes in each panel. The block average grade is calculated by the area-weighted mean of the average grades of all panels in a block.

(3) **Volume calculation of a block** : For volume estimation of ore, each block was calculated by either prism-equation, truncated-pyramid-equation or wedge-equation. In cases where the difference of ore area in the neighbouring panels was less than 40%, the prism-volume calculation equation was adopted. If the difference was more than or equal to 40%, the truncated pyramid-volume calculation equation was adopted. And in the case that ore extends beyond the last panel section, the wedge-volume calculation equation was adopted.

(4) **Weight of ore** : In order to calculate the weight of ore reserves, Karagandageologiya utilized the average measured copper ore density of 2.76 t/m^3.

3-2-2 Calculation Method of the Japanese Survey Team

The Japanese survey team checked the accuracy of the Karagandageologiya estimate by repeating the calculation using the same procedure.

In this operation the Japanese team adopted the same value of each analyzed sample, ore block delineation, cut-off grade and delineation condition used by Karagandageologiya. The panel area, block volume, density and average ore grade were calculated, and using these values, the weight and amount of metal in each block were determined. The subsequent summation of blocks gave the final geological ore reserve estimation. Except for the measurement and the calculation of ore block areas in panel sections, all other calculations were by personal computer using spread-sheet type software.

3-3 Result of the Calculation

Comparing the geological ore reserves of Samarsky calculated by Karagandageologiya and the Japanese survey team, similar values are observed, and are shown in Table 3-3-1.

The total area of Samarsky ore block panels calculated by the Japanese survey team is 378,838m^2 (99.0% of 382,663m^2 of Karagandageologiya). Then the volume of ore body is 41,447,469m^3 (101.8% of 40,729,933m^3). Multiplying the conventional value of density, 2.76 (same value) the total ore reserve is calculated as 114,395,015t (101.8% of 112,414,616t). The average copper content is 1.28%Cu (102.8% of 1.24%Cu) and the copper metal amount is 1,458,777t (104.4% of 1,397,806t) as calculated by the Japanese survey team.

In these calculations of geological ore reserves some problems were identified. The most important problem is that only 12 drillholes intersect the ore body. From such a small number of intersections it is impossible to precisely delineate the ore body. The continuity of the ore block is therefore very uncertain at present.

Table 3-3-1 Summary of Geological Resources Estimation of the Central Cu-Mo Deposit in the Samarsky Area

ITEM	TEAM/Calc.	Japanese Survey Team (1995)	Karagandageologiya (1994)	Note
Category of Estimation		Geological Ore Reserve (not Mining Reserve)	Geological Ore Reserve (not Mining Reserve)	
Calculation Method		Panel/section Method	Panel/section Method	
No. of Used Drills		14	14	
No. penetrate Ore		12	12	
Outline of Estimation		(A)	(B)	Ratio(A)/(B) (%)
Dimension of Dep.	Leng. (ENE) (m)	800	800	
	Width(WNW) (m)	400(max)- 300	400(max)- 300	
Depth of Dep.	Min. (m)	89	89	
	Max. (m)	612	612	
Average Thickness (m)		—	—	
Volume (m)		41,447,469	40,729,933	101.8
Ore Density		2.76	2.76	100.0
Ore Weight (t)		114,395,015	112,414,616	101.8
Ore Grade	Cu (%)	1.28	1.24	102.8
	Mo (%)	0.01	not calculated	-
	Ag (g/t)	2.46	not calculated	-
	Au (g/t)	0.48	not calculated	-
Metal Amount	Cu (t)	1,458,777	1,397,806	104.4
	Mo (t)	10,576	not calculated	-
	Ag (kg)	281,709	not calculated	-
	Au (kg)	54,716	not calculated	-
Condition of Calculation	1) Ore body boundary delineated by the Karagandageologiya is adoped. It is the bisector of drills penetrated ore and not penetrated. 2) Block volume is calculated by either prism or truncated pyramid depending on the defference of section area on end panel. In the case of ore-pinch out, wedge volume calculation is adopted. 3) The cut-off grade is 0.5%Cu. Interlayer is less than 15 m.			
Results	1) There is no significant difference in the results. 2) The difference of values depends on area and grade differences.			

PART IV CONCLUSION AND RECOMMENDATION

Part IV Conclusion and Recommendation

Chapter 1 Zhaman-Aibat Area

1-1 Conclusion

Geology and Mineralization

(1) The stratiform copper mineralization occurs exclusively in the grey-colored alluvial-deltaic sandstone faces within " Red Sandstone Formation" of the Carboniferous.

(2) More than 900 drill holes on a 200m × 200m grid spacing confirm that there are three main orebodies, namely, the Central, Northern and Eastern Orebodies. These orebodies are distributed in an area with dimensions : 12.5km in the east-west direction and approximately 5 km in the north-south direction. The depth of the ore horizon is approximately 460m～480m in the eastern area and the depth increases towards the west. At the western edge of the Central Orebody it reaches 650m in depth.

(3) The mineral assemblage of the ore is comparatively simple. The main minerals are chalcocite, digenite and bornite. Galena, sphalerite, chalcopyrite and pyrite are in small amounts. Major ore types are confined to the Copper Ore (Cu), Complex Ore (Cu+Pb+Zn) and Lead-Zinc Ore (Pb+Zn).

(4) The geological resources were calculated as ;

Eastern Orebody:	116million tons	(mainly Cu Ore: 1.3%Cu, 11g/tAg, 5.5m thick),
Central Orebody:	38million tons	(Cu Ore: 1.9%Cu, 11g/tAg, 3.9m thick,
		Complex Ore: 1.5%Cu, 1.8%Pb,0.3%Zn, 11g/tAg, 5.6m thick),
Northern Orebody:	39million tons	(mainly Cu Ore: 1.3%, 37g/t Ag, 6.6m thick),
Total:	193million tons	(1.4%Cu, 0.3%Pb, 16g/tAg, 5.4m thick)

Drilling Survey

(1) For the purpose of confirming ore stratigraphy and occurrence, and of providing samples for the ore dressing tests, two holes, MJK-1 and MJK-2 were drilled.

(2) MJK-1 (final depth: 650.5m, vertical) was drilled in the Eastern Orebody in 1995 and the copper mineralization (Ore Horizon 4-Ⅰ) could be observed between the depths of 598.0m and 605.8m.

(3) MJK-2 (final depth: 700.0m, vertical) was drilled in the Central Orebody in 1996. In this drill hole, the copper and lead mineralization (Ore Horizon 4-Ⅰ) could be observed between the depths of 605.4m and 619.7m, and weak copper mineralization (Ore Horizons 3-Ⅵ and 3-Ⅱ) between the depths of 630.0m and 635.7m and between 688.9m and 692.5m respectively.

Ore Dressing Test

(1) The ore dressing tests of the Copper Ore and of the Complex Ore were carried out.

(2) From the series of test results, it is considered that bulk differential flotation is adaptable to both the Copper Ore and to the Complex Ore.

(3) Test samples consisted of MJK-1 core mixed with some rock from the hanging wall and foot wall. The grade of the composite samples after preparation was 1.69%Cu, 0.51%Pb, 0.03%Zn, 1.80%Fe, 1.01%S, <0.1g/tAu, 12g/tAg. By the bulk differential flotation process, a copper concentrate of 39%Cu with copper recovery of 86% and a lead concentrate of 48%Pb with lead recovery of 67% were obtained.

(4) Test samples of the Coomplex Ore were composed of MJK-2 core and ore samples which had been obtained by the Kazakhstan team. The grade of composite samples after preparation was 1.70%Cu, 1.11%Pb, 0.03%Zn, 2.21%Fe, 1.00%S, <0.1g/tAu, and 5g/tAg. By the bulk differential flotation process, a copper concentrate of 32%Cu with copper recovery of 92% and a lead concentrate of 66%Pb with lead recovery of 78% were obtained.

Mining Technology in the Zhezkazgan Mine

(1) The Zhezkazgan Mine is clearly morphologically and genetically analogous to the Zhaman-Aibat Deposit. The investigation of the Zhezkazgan Mine confirmed that mining technology being used in the mine is applicable to the exploitation of the Zhaman-Aibat copper deposit.

(2) The orebody of the Zhezkazgan copper deposit is being mined by three kinds of the underground mining method, namely panel and pillar, room and pillar, and slicing methods. These mining methods were chosen according to the morphology and properties of the ore deposits, such as thickness(m), ore grade(%Cu), inclination (degree) and the character of the country rock and ore. The mining recovery is quite sensitive to parameters, such as diameter of room pillars, width of rib pillars and depth from the surface.

(3) By using formulae developed by the Giprotsvetmet Institute in Moscow, if the thickness of ore is 6m, the mining recovery is calculated as 87.3%, 86.3%, 84.4%, 83.3% with increasing depth of 200m, 300m, 400m and 500m respectively. The Zhaman-Aibat Deposit is located at greater depth than the Zhezkazgan Mine, and mining recovery of 6m of ore thickness is estimated to be as low as 75.3% and 73.7% at the depths of 600m and 700m respectively.

Conceptual Design of the Zhaman-Aibat Mine

(1) For the conceptual design and the cost calculation of the Zhaman-Aibat Mine development, definition standards in several countries, such as Australia and USA were used. And the mine development and mining method were adopted based on verbal reports on the Zhezkazgan Mine whose deposit has analogies to the Zhaman-Aibat Deposit.

(2) The panel and pillar mining method applied at the Zhezkazgan Mine was selected. The mining ore recovery and dilution of ore were determined as 75% and 5%, respectively. The minable ore reserves, metal amount, average ore grade and average ore thickness with the cutoff grade of 0.4% Cu and with the minimum mining height of 3.0m were calculated. The results indicates that the minable ore reserves were 118,742 kilo tons and total metal amounts were estimated to be as 1,375 kilo tons Cu, 195 kilo tons Pb, 35 kilo tons Zn, 1,019 tons Ag, respectively. Thus, the average metal contents are 1.16%Cu, 0.16%Pb, 0.03%Zn, 8.59g/tAg, respectively.

(3) The configuration of the Zhaman-Aibat Mine by this conceptual design was drawn from the following; The mine will be of medium size incorporating the underground mining method supported by several vertical shafts. A railroad and paved road will be constructed between Zhezkazgan City and the Mine site. Electricity will be supplied from a transformer station by a 220kV power line. An ore dressing plant will be constructed at the mine site and the produced copper concentrates will be transported to the processing plant in Zhezkazgan City. Copper and silver contained in the copper concentrates will be sold to the Zhezkazgan smelting plant.

(4) The annual production of the Zhaman-Aibat Deposit is estimated as 5.6 million tons (mine life : 22 years), that is set for the base case. From the results of the milling tests, the copper concentrate recovered is expected to be 35% Cu grade with a recovery of approximately 90%. The amount of copper concentrate is 596 tons / day.

(5) It is estimated that the total number of mine workers including management staff, will be 930. In detail, there will be 450 underground workers, 350 surface workers, 130 engineers and general / administration staff.

(6) It is estimated that the operation cost will be 15.92 $US / ton ore, 67 cent/ lb of Cu in the base case. In detail, mining will be 35%, mine facilities 13%, ore dressing 27%, administration 6%, concentrate transport 2% and camp management 17%.

(7) The capital cost was estimated as 492 million $US in the base cae within which 471 million $US are for construction cost and 21 million $US are for working capital. Of the estimated 492 million $US, 347 million $US will be needed for primary investment and 150 million $US for additional investment.

(8) The discount cash flow / internal rate of return (hereinafter DCF / IRR) was estimated as 5.40% in the base case, under the conditions of ore dressing recovery of 90% and 98%, respectively, treatment charge /refining charge (hereinafter TC /RC) is 20 cent/ lb Cu, and metal prices 2,500$US / ton for Cu and 4.0 $US / TR OZ for Ag. It should be noted that capital costs and taxes are not taken into account in this DCR /IRR. Considering a tax rate of 30%, and assuming an IRR of 3%, an IRR (before paying tax and interest) of at least 12% will be necessary.

(9) A sensitivity analysi for the rate of return was performed by varying the parameters of copper price, TC / RC, capital costs and investiment costs from the standard model (annual production :5.6 million tons, copper price :2,500$US / ton Cu, TC /RC :20 cent/ lb Cu). In the case of 30% reduction of the operating cost, the IRR will increase to 7.77%, on the other hand a saving in capital cost of 30% will improve the IRR to 4.99%.

1-2 Recommendation

(1) Although present development of the Zhaman-Aibat Deposit is considered economically marginal, the deposit satisfies essential criteria for successful future mining and it has a clear potential for exploitation. It is expected that an increase of sales revenue resulting from rising copper prices in the international market and decreasing mining costs associated with the introduction of more efficient mining technologies will impact beneficially on the economics of the project. Continuous review and re-assessment of the economics of the Zhaman-Aibat Deposit is therefore strongly recommended.

(2) In order to realize the profitable development of the Zhaman-Aibat Mine, the government sholud actively support infrastructure construction such as railroads, roads, electricity and water supplies. Further support from the government should include exemptions from taxes, sales duties and import duties.

(3) By the results of this year's geostatistical assessment, the accuracy of the ore reserve estimation is adequate for pre-F/S stage. Additional drilling to confirm the grade distribution of high Cu and Ag in each orebody and the detailed distribution of Pb and Zn grades in the Central Orebody should be undertaken.

(4) The construction of a highly reliable data base and management of the data base are essential for the ore reserve evaluation and economic study. The introduction of a computer system, computer data base and an appropriate ore reserve evaluation methods which meet the requirement of a market economy system are urgently required.

Chapter 2 Samarsky Area

2-1 Conclusion

(1) It is confirmed that there are two types of ore deposit, porphyry type copper-molybdenum deposit and gold-bearing polymetallic deposit. These deposits show zonal distributions centered on copper-molybdenum zones.

(2) The porphyry type copper-molybdenum mineralization occurs in breccia pipes which were formed within the intrusive bodies of quartzdiorite at an early stage and in the granodiorite porphyry at a later stage. The oxidized zone is confirmed to the depth of 30m - 50m and the primary sulfide zone starts from this depth and continues to greater depths. Secondary enrichment zones have not been reported.

(3) The high grade zone of greater than 1.0%Cu is exclusively found within the breccia pipes mentioned above. Thus, the shape of the high grade copper orebody is represented by that of the breccia pipes. The actual shape of the orebody shows an increasing diameter towards greater depth.

(4) Gold-bearing polymetallic deposits are distributed in the sheared zone of the hanging wall side of thrusts running in the north-south direction in the north-western to western part of the survey area. The previous survey confirmed that there is one main vein and three branch veins. These veins strike in the north-south direction and dip 35° - 50° to the west. The average thickness and ore grade is estimated to be respectively 5.6m and 3.82 g/t Au and 20g/tAg. It is confirmed that the ore zone continues approximately 800m along the strike direction and 1,000m along the dip direction, which means that mineralization is confirmed to a depth of 350m below the surface.

(5) The veins consist of mainly quartz accompanied by galena, sphalerite, chalcopyrite. Gold occurs as native gold in quartz veins and some in galena, chalcopyrite and pyrite.

(6) The geological resources inside the Central Samarsky Copper Deposit were calculated by the japanese survey team. The results indicates that the ore reserves were 114,395 kilo tons, total metal amounts 1,459 kilo tons Cu, the average metal contents 1.28%Cu, rerespectively.

2-2 Recommendation

(1) In the Samarsky copper-molybdenum deposit, it is confirmed that the high grade copper mineralized zone is located deep beneath the surface. Considering the reality of the actual mining operation, some difficulties associated with the depth of mining are expected. Thus, the future exploration should focus on surveys for finding new copper-molybdenum mineralization at shallower depths. It is recommended that the following works be carried out in future campaigns:

- the eastern marginal area of the quartz diorite intrusive body
- in the areas surrounding the breccia pipe located, about 1km southeast of the known orebody
- in the area between the known orebody and the Tulkulin Fault.

(2) The exploration works for the southern extension and the deeper mineralization of the known gold-bearing polymetallic deposit are requied

(3) Following explorations are recommended for the future campaigns.

- Remote-sensing data analysis and ground truth checking of the Samarsky Area
- Electric survey (charged potential method) in the Cu-Mo deposit, in order to detect subsurface conductive bodies of copper-molybdenum deposits
- drilling surveys of the intrusives and the breccia pipes related to the copper-molybdenum deposits at shallower depth
- Seismic exploration (reflection wave method) to study geological structures at the vicinity of gold-bearing polymetallic deposit
- drilling surveys of the southern extension and the deeper mineralization of the gold-bearing polymetallic deposit.

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Appendices

Appendix 1 Summary of previous studies of ore-dressing tests of ores from Zhaman-Aibat and Taskura deposits (1)

##	Author of a Report	Name of Report, year of issue	Stage, sub-stage of a project, scale of survey (type of samples)	Description of survey, weight of samples, description of ore-dressing technological process	Results and effectiveness of ore-dressing technologies. Reason of low effectiveness of ore-dressing
1.	Parkhomenko L.P.	Report on assignments ## 495, 496: Studying of dressing of sulphide copper and copper-lead-zinc ores from Zhaman-Aibat deposit (samples 3, 4), Karaganda, LOPI TsLTsKNGO, 1986	Prospecting	1. Studying of ore material composition; 2. Grinding of ore before flotation; 3. Sorting of grind ore up to ± 0.074 mm; 4. Flotation of ore: - copper ore, 52 kg (sample 3), - copper-lead-zinc, 53 kg (sample 4), based on flow charts of ore-dressing facilities # 1 and # 3 of Zhezkazgan-tsvetmet Combine 5. Additional grinding of concentrate and intermediate products.	Copper concentrate (KM-2 brand) with copper grade 34.2% was obtained from copper ore (copper grade 2.12%) (recovery value equal to 90.1%). It was concluded, that improving quality of concentrate requires reducing consumption of foaming agents down to 60 g/t against 17-210 g/t as applied at ore-dressing facility. Three concentrates were obtained as result of dressing of copper-lead-zinc ore (grade of copper - 2.21%, lead - 1.44% and zinc - 1.83%): - copper (KM-7 brand) with copper grade 39.92% (recovery 79.1%); - lead (KS-7 brand) with lead grade 40.0% (recovery 71.0%); - zinc (KTs-6 brand) with zinc grade 48.5% (recovery 53.2%). Close intergrowth of copper, lead and zinc minerals was detected, it brings down selection in collective concentrate and results in big losses of metals in intermediate products.
2.	Malinova T.V.	Report on assignments ## 554, 556. Studying of ore-dressing of balance oxidized and sulphide copper ores from Taskura deposit (samples ## 10, 11), Karaganda, LOPI TsL TsKPGO, 1991	Prospecting-estimation	1. Studying of ore material composition; 2. Grinding of ore before flotation; 3. Screening and precipitation analysis of ore for sorting into particle size classes; 4. Flotation of ore, including oxidized ore (sample # 10) with sulphidization; 4.1. Preliminary testing of sulphurous sodium consumption and separate flotation of sand and sludge; 4.2. Testing within closed cycle as per flow chart of Zhezkazgan ore-dressing facility # 1 of Zhezkazgantsvetmet JSK	Dressing of oxidized ore (sample # 10 with weight 179.8 kg with copper grade 3.04%) resulted in obtaining copper concentrate (KM-7 brand) with copper grade 16.73% (recovery 77.70%). Sludge formation process, resulting in losses of copper in tailings of sand flotation and intermediate products. Dressing of sulphide ore (sample # 11 with weight 207.6 kg and copper grade 1.55%) resulted in obtaining copper concentrate (KM-2 brand) with copper grade 32.49% (recovery 91.88%)
3.	Malinova T.V.	Report on assignment # 590. Studying of dressing of sulphide zinc ore from Zhaman-Aibat deposit (sample # 60), Karaganda, LOPI TsL TsKPGO, 1991	Preliminary	1. Studying of ore material composition; 2. Grinding of ore before flotation; 3. Screening and precipitation analysis of ore for sorting into particle size classes; 4. Ore flotation; 4.1. Preliminary testing; 4.2. Testing within closed cycle as per flow chart and reagents regime of Zhezkazgan ore-dressing facility # 3 of Zhezkazgantsvetmet JSK	Dressing of zinc ore with sample weight 250 kg and zinc grade 1.16%, lead grade 0.33% and copper grade 0.29% resulted in obtaining 3 concentrates: - zinc concentrate (KTs-4 brand) with zinc grade 50.51% (recovery 76.36%); -lead concentrate (KS-6 brand) with lead grade 48.11% (recovery 69.01%); -copper concentrate (KM-4 brand) with copper grade 32.63% (recovery 45.52%).

Appendix 1 Summary of previous studies of ore-dressing tests of ores from Zhaman-Aibat and Taskura deposits (2)

##	Author of a Report	Name of Report, year of issue	Stage, sub-stage of a project, scale of survey (type of samples)	Description of survey, weight of samples, description of ore-dressing technological process	Results and effectiveness of ore-dressing technologies, Reason of low effectiveness of ore-dressing
4.	Raykh M.A.	Report of assignment # 593. Studying of dressing of suplhide lead ore from Zhaman-Aibat deposit (sample # 70). Karaganda, LOPI TsL TsKPGO, 1991	Preliminary exploration	1. Studying of ore material composition; 2. Grinding of ore before flotation; 3. Screening and precipitation analysis of ore for sorting into particle size classes; 4. Ore flotation; 4.1. Preliminary testing to determine consumption of xanthate; 4.2. Testing within closed cycle as per flow chart and reagents regime of Zhezkazgan ore-dressing facility # 3 of Zhezkazgantsvetmet JSK	Dressing of lead ore with sample weight 270 kg and lead grade 1.78%, copper grade 0.25% and zinc grade 0.17% resulted in obtaining lead concentrate (KS-6 brand) with lead grade 52.93% (recovery 85.84%). Tailings of lead flotation contain 18.5 g/t of silver, 18 g/t of rhenium, 0.18% of cadmium, 2.26 g/t of indium, 0.10 g/t of osmium, therefore they don't have to be wasted. They have to be directed into cycle of complex ores dressing of ore-dressing facility # 3.
5.	Ivanova N.P.	Report on assignment # 598. Studying of dressing of suplhide copper-silver ores from Zhaman-Aibat deposit (samples ## 91 and 100). Karaganda, LOPI TsL TsKPGO, 1991	Preliminary exploration	1. Studying of ore material composition; 2. Grinding of ore before flotation; 3. Screening and precipitation analysis of ore for sorting into particle size classes; 4. Pilot testing for selecting optimal degree of ore grinding, consumption f sulphurous sodium, butyne xanthate, foaming agent, re-concentration of concentrates.	Dressing of copper-silver ore - sample 91 with weight 349 kg, copper grade 1.05%, silver grade 42 g/t - resulted in obtaining copper concentrate (brand KM-1) with copper grade 48.66% (recovery 87.31%), with silver grade 2092 g/t (recovery 91.93%); - sample # 100 with weight 120 kg, copper grade 0.75% and silver grade 52 g/t - resulted in obtaining copper concentrate (brand KM-1) with copper grade 55.4% (recovery 90.74%), with silver grade 4004 g/t (recovery 90.15%).
6.	Malinova T.V.	Report on assignment # 550 Studying of dressing of 50 small-scale technological samples of copper ores from the deposit, for mapping aims (## 5-9, 13-15, 18, 19, 21-30, 32, 42-47, 50-53, 55-57, 61-64, 69, 77, 78, 80-88), Karaganda, LOPI TsL TsKPGO, 1991	Preliminary exploration	1. Studying of ore material composition; 2. Grinding of ore before flotation; 3. Screening analysis of ore of original particles size 1.0-0.0 mm; 4. Screening and precipitation analysis of ore for sorting into particle size classes; 5. Testing of flotation within closed cycle as per flow chart of Zhezkazgan ore-dressing facility # 1 Sample weight from 5 to 28 kg.	The ores can be processed at ore-dressing facility # 1. Dressing of those ores requires finer degree of grinding; chalcopyrite ores with increased content of pyrite require different reagent regime (providing depressing pyrite). There is an opportunity to dress off-balance copper sulphide ores, obtaining concentrates KM-6 and KM-3. Highest content of silver (1094.5 g/t - average for 5 samples) is contained in KM-3 concentrate from off-balance copper ore from the Northern deposit, which is typical only for rich copper ores of the same deposit.
7.	Shamaeva T.S.	Report on assignment # 550[a]. Studying of ore-dressing of 30 small-scale technological samples of zinc, lead-zinc, copper-lead, copper-lead-zinc and copper-zinc ores from Zhaman-Aibat deposit, Karaganda, LOPI TsL TsKPGO, 1991	Preliminary exploration	1. Studying of ore material composition; 2. Grinding of ore before flotation; 3. Screening and precipitation analysis of ore for sorting into particle size classes; 4. Ore flotation; 4.1. Carrying out of preliminary testing; 4.2. Carrying out of flotation testing as per established flow chart and reagent regime; 5. Chemical assaying of original ore,	All ores can be dressed at ore-dressing facility # 3, except zinc ores, that require separate technology and reagent regime. Ores of the Central and Northern deposit are favorable for dressing. Deep grinding of ore or intermediate product is required; pyrite has to be extracted into pyrite concentrate.

Appendix 1 Summary of previous studies of ore-dressing tests of ores from Zhaman-Aibat and Taskura deposits (3)

##	Author of a Report	Name of Report, year of issue	Stage, sub-stage of a project, scale of survey (type of samples)	Description of survey, weight of samples, description of ore-dressing technological process	Results and effectiveness of ore-dressing technologies. Reason of low effectiveness of ore-dressing
				intermediate products due to small weight of samples (5-16 kg) 6. Description of metrological (instrumentation) support for research	
8.	Ivanova N.P.	Report on assignment # 603. Studying of dressing of lead ore from Zhaman-Aibat deposit (sample # 105). Karaganda, LOPI TsL TsKPGO, 1991	Preliminary exploration	1. Studying of ore material composition; 2. Grinding of ore before flotation; 3. Ore flotation tests with screening and precipitation analysis of ore with particles size as required for flotation; 4. Ore flotation tests within closed cycle 5. Description of required instrumentation	Dressing of lead ore (sample # 105, weight 126 kg with lead grade 1.13%) as per established flow chart resulted in producing standard lead concentrate (KS-3a brand, as per OST 48-92-75 or KS-2 as per OST 48-92-75), option #1-5 with lead grade 62.37% (recovery 90.08%). Galena is highly active for flotation. Ore is classified as easily dressible.
9.	Shamaeva T.S.	Addition to the Report on assignment # 550[a]. Results of testing dressing of sulphide lead ore in small-scale technological sample # 121. LOPI TsL TsKPGO, 1992	Preliminary exploration	1. Studying of ore material composition; 2. Grinding of ore before flotation; 3. Screening and precipitation analysis of ore with particles size as required for flotation; 4. Ore flotation as per flow chart and reagents consumption regime established at Zhezkazgan ore-dressing facility # 3; 5. Phase semi-quantitative spectral analysis of original ore from the deposits: Central one - 12 samples (## 59, 65-68, 73, 74, 89, 90, 94, 99, 103); Northern one - 10 samples (16, 17, 33-36, 49, 54, 75, 76); Eastern one - 7 samples (12, 20, 39-41, 58, 72)	Dressing of lead ore in sample 121 with weight 8 kg and lead grade 1.18% and copper grade 0.28% resulted in producing two concentrates: - lead concentrate - (KS-4 brand) with lead grade 70.79% (recovery 85.44%) and copper grade 3.57; - copper concentrate - (KM-7 brand) with copper grade 16.76% (recovery 54.51%) and lead grade 4.86%. The ore can be dressed at Zhezkazgan ore-dressing facility # 3.
10.	Malinova T.V.	Addition to the Report on assignment # 550. Studying dressing of 12 small-scale technological samples of copper ores from Zhaman-Aibat deposit for mapping purposes (samples ## 92, 93, 95-98, 101, 102, 104, 106, 111, 112). LOPI TsL TsKPGO, 1992	Preliminary exploration	1. Studying of ore material composition; 2. Grinding of ore before flotation; 3. Screening analysis of ore with initial particles size 1.0-0.0 mm 4. Screening and precipitation analysis of ore with particles size as required for flotation; 5. Flotation tests within closed cycle as per flow chart, established at Zhezkazgan ore-dressing facility # 1. Samples weight from 5 to 22 kg. 6. Technological parameters related to distribution of accessory valuable and hollow components (silicates) in ore-	Ores can be dressed at Zhezkazgan ore-dressing facility # 1. Finer degree of grinding is required for ore-dressing. There is an opportunity to dress off-balance copper sulphide ores obtaining concentrates of KM-5 and KM-2 brand. Concentrate produced of 2 off-balance samples of ore from the Northern deposit contain the highest content of silver 1101 and 1816 g/t (silver grade in original ore is equal to, accordingly, to 19.8 and 25.3 g/t, which is typical only for rich ores.

Appendix 1 Summary of previous studies of ore-dressing tests of ores from Zhaman-Aibat and Taskura deposits (4)

##	Author of a Report	Name of Report, year of issue	Stage, sub-stage of a project, scale of survey (type of samples)	Description of survey, weight of samples, description of ore-dressing technological process	Results and effectiveness of ore-dressing technologies. Reason of low effectiveness of ore-dressing
				dressing products of both those 12 samples and additionally 50 more previously studied samples.	
11.	Malinova T.V.	Report on assignment # 610. Studying of dressing of balance sulphide copper ore of Taskuduk Formation from Zhaman-Aibat deposit (sample # 119), LOPI TsL TsKPGO, 1992	Preliminary exploration	1. Studying of ore material composition; 2. Grinding of ore before flotation; 3. Screening analysis of initial ore with particles size 1.0-0.0 mm; 4. Screening and precipitation analysis of ore with particles size as required for flotation; 5. Preliminary testing of 5 weighted portions within closed cycle as per flow chart and reagents regime of Zhezkazgan ore-dressing facility # 1; 6. Testing within closed cycle of 10 weighted portions as per established flow charts and regime 7. Description of metrological (instrumentation) support	Dressing copper ore in sample 119 with weight 145 kg and copper grade 1.90%, lead grade 0.12% from lower ore horizons, resulted in obtaining copper concentrate (KM-2 brand) with copper grade 32.07% (recovery 91.28%) and lead grade 1.68%. Ore is suitable for dressing at Zhezkazgan ore-dressing facility # 1.
12.	Malinova T.V.	Report on assignment # 550[b]. Studying of dressing of small-scale samples of sulphide ore with native copper from Zhaman-Aibat deposit (samples ## 113, 114, 115, 116-mixed). LOPI TsL TsKPGO, 1992	Preliminary exploration	1. Studying of ore material composition; 2. Grinding of ore before flotation; 3. Screening analysis of initial ore with particles size 1.0-0.0 mm; 4. Screening and precipitation analysis of ore with particles size as required for flotation; 5. Preliminary tests; 5.1. Ore dressing within open cycle as per flotation-gravity and gravity-flotation pattern; 5.2. Tests within closed cycle as per flotation flow-chart; 5.3. Tests as per gravity technology of dressing native copper by hydrocyclon.	Ores are suitable for dressing at Zhezkazgan ore-dressing facility # not only by gravity method, but also by flotation method. Flotation resulted in obtaining copper concentrates: - in sample # 113 with weight 22.3 kg with copper grade 1.33% - KM-2 brand concentrate with copper grade 31.67% (recovery 91.90%); - in sample # 114 with weight 15.4 kg and copper grade 1.96% - KM-0 concentrate wit copper grade 44.04% (recovery 93.93%); - in sample # 115 with weight 17.6 kg and copper grade 3.61% - KM-0 brand concentrate with copper grade 50.83% (recovery 94.07%); - in sample 116-mixed - KM-0 copper concentrate with copper grade 44.46% (recovery 93.82). Gravity method for sample 116-mixed resulted in obtaining KM-0 copper concentrate with copper grade 81.47% (recovery 61.11%). Gravity products are suggested to be additionally extracted by flotation method.
13.	Pack V.P., Chalova R.T., Krukova E.I., et. al.	Report on testing in large-scale laboratory conditions of dressing two ore samples from Zhaman-Aibat	Preliminary exploration	1. Studying of ore material composition in small-scale laboratory sample # 5[a] with weight 268 kg and # 6[a] with weight 184 kg;	Applying flotation for ore dressing shows acceptable technological parameters: obtaining copper concentrate from copper ore, with copper grade 32-35% (recovery 91-92%); from complex (copper-lead) ore - copper concentrate with copper grade

Appendix 1 Summary of previous studies of ore-dressing tests of ores from Zhaman-Aibat and Taskura deposits (5)

##	Author of a Report	Name of Report, year of issue	Stage, sub-stage of a project, scale of survey (type of samples)	Description of survey, weight of samples, description of ore-dressing technological process	Results and effectiveness of ore-dressing technologies. Reason of low effectiveness of ore-dressing
		deposit as per flow charts of Zhezkazgan Mining and Smelting Combine providing complex utilization of raw materials. Almaty, KazNIIMS, 1991.		2. Laboratory testing of dressing of ore samples ## 5[a] and 6[a]; 3. Large-scale laboratory testing of dressing ore in sample of copper ore # 31 with weight 4640 kg and copper-lead ore # 71 with weight 6192 kg; 4. Designing of recycled water supply system for dressing ore from Zhaman-Aibat deposit; 5. Estimation of dressing properties in big chunks of copper ore by technique of r X-ray separation; 6. Assessment of waste-less technology of ore-dressing providing utilization of tailings of ore-dressing for production of construction materials	39-41% (recovery from ore 82-83%) and lead concentrate with lead grade 42-43% (recovery from ore 72-73%). Recycled and underground water from Zhezkazgan can be used as sources of water supply for flotation. It is expedient to include a step of preliminary ore concentration (by medium-heavy and X-ray separation) into ore-dressing flow-chart, having made prior assessment in the course of further exploration. Tailings, remaining from ore-dressing can be utilized for production of porous concrete (50 and 75 brand) (50% of tailings with addition of lime (15%) and powdered aluminum (0.03%) and water.
14.	Ospanova G.	Report on laboratory studies of geo-technological technologies of extraction of copper an accessory components from ores of Zhaman-Aibat deposit; flow charts for processing of productive solutions; feasibility estimation and selecting of the appropriate option for leaching out of copper, copper-lead, copper-silver ores in three samples with weight 50 kg each. Almaty, MTsNK-Interntional Laboratory, Kazakhstan branch, 1992.	Preliminary exploration	1. Analyzing the status of a problem and possibilities of leaching-out of copper from poor ores; 2. Studying material composition of ores in three samples (107, 108, 109); 3. Studying of leaching-out of copper and accessory components: - in agitation regime, - in percolation regime; 4. Working out of technologies for processing of productive solutions based on copper: - by cementation method, - by extraction method, - by sorption method; 5. Description of metrological (instrumentation) support.	In agitation regime the biggest influence onto extraction of copper, lead, zinc and silver into productive solution is produced by hypochlorite-ions (recovery of copper 90.0-95.1%, lead 85.7-97.3% and silver 81.4-95.3%). Regime of percolation in HCl media with hypochlorite-ion additives leads to full transformation of ore with recovery of copper, lead and silver 98-100% into productive solution. Highest extraction of copper from productive solution was reached using cementation sedimentation - 97%, extraction and sorption methods are similar - complete copper extraction 83.0-83.4%.
	Pack V.P., Chalova R.T.	Reference report on laboratory testing of ore-dressing of strontium-containing rocks from Zhaman-Aibat field. Almaty, KazNIIMS, 1992	Preliminary exploration	1. Studying of material composition of the sample 110 with the weight 240 kg; 2. Grinding of the sample; 3. Screening analysis of the sample 4. Studying of ore dressing as per flow chart for dressing celestine ore of Aurtash, Aryk deposits by gravity method.	Applying gravity technology for dressing sample of strontium-containing rocks with strontium grade 0.26% resulted in obtaining concentrate with strontium grade 2.14% (recovery from ore 25.15%). Mineralogical analysis detected no celestine. Strontium was presumably correlated to rock-forming minerals - quartz, feldspar, calcite. Further studying of technology of strontium extraction are inexpedient due to its low grade in original ore.

Appendix 1 Summary of previous studies of ore-dressing tests of ores from Zhaman-Aibat and Taskura deposits (6)

##	Author of a Report	Name of Report, year of issue	Stage, sub-stage of a project, scale of survey (type of samples)	Description of survey, weight of samples, description of ore-dressing technological process	Results and effectiveness of ore-dressing technologies. Reason of low effectiveness of ore-dressing
	Ginatullin A.M.	Report on geological and technological modeling based on data from Zhaman-Aibat deposit. Almaty, KOME, 1992	Preliminary exploration	1. Collecting and summarizing, statistical and correlation analysis of initial data (geological, chemical assay, mineralogical, ore-dressing), assessment of their variation; 2. Setting criteria (mathematical models) for estimating values of ore-dressing parameters, contents of minerals-concentrators, as based on ore composition; 3. Modeling of expected values of copper recovery into copper concentrate and bornite content in copper ore; 4. Compiling balance for breakdown of main and accessory components per minerals and ore-dressing products in 22 small-scale and laboratory samples (## 5, 6a, 19, 27-29, 31, 44, 57, 60, 63, 66, 69-71, 77, 82, 83, 85, 87, 99, 100)	1. Intervals of values of expected copper recovery into concentrate and content of bornite in ore were determined from chemical assay data based on worked out logic systems; correlation with experimental data was high. 2. Behavior of main and accessory components in the process of processing raw materials from ore to concentrate (including losses in wasted tailings separately for each type of ore) was analyzed based on compiled balances of breakdown of 22 samples. 3. The conclusion was made on expediency of further ore-dressing test and related testing. 4. It is recommended to continue geological and technological modeling at PC, including compiling maps of contours of expected ore-dressing parameters and preparation of balances of elements breakdown into ore minerals and ore-dressing products.
	Baybatchayev A.B.	Concluding Report on mining-geological conditions and mining-technological properties of development of Zhaman-Aibat deposit. Karaganda, KarPTI, 1990	Preliminary exploration	1. Field engineering-geological description of core in 25 exploration wells, including two benchmark-parametric wells (## 441 and 457) throughout total depth of drilling. 2. Analyzing and summarizing data of laboratory and geophysical studies of physical and mechanical rock properties. 3. Metrological (instrumentation) description. 4. The following issues have been defined and studied: 4.1. lithological types of rocks (at thin sections - 121 pieces); 4.2. Hydrophysical properties of rocks (at 146 samples); 4.3. strength properties of rocks (528 samples); 4.4. elastic-deformation properties of rocks (at 306 samples); 4.5. technical properties of rocks (284 samples);	Engineering-geological zonation of Zhaman-Aibat deposit (at the stage of preliminary exploration) was worked out based on complexity of mining-geological conditions and shock hazard for stripping and development. As per classification of engineering-geological conditions (VSEGINGEO), the deposit falls within V type. Based on difficulty of studying, the deposit is referred to deposits of medium difficulty. Based on complexity of engineering-geological conditions for stripping and development the deposit is characterized as having medium complexity (type 3b). Simple and medium complex areas with ore reserves (over 90%) are located at depths with potential shock hazard of rocks and ores. The deposit can be developed by underground mining applying breast-pillar system.

Appendix 1 Summary of previous studies of ore-dressing tests of ores from Zhaman-Aibat and Taskura deposits (7)

##	Author of a Report	Name of Report, year of issue	Stage, sub-stage of a project, scale of survey (type of samples)	Description of survey, weight of samples, description of ore-dressing technological process	Results and effectiveness of ore-dressing technologies. Reason of low effectiveness of ore-dressing
				4.6. drillability of rocks (102 samples from 12 wells); 4.7. physical and mechanical properties as determined by acoustic logging in 27 wells; 4.8. shock hazard of rocks (at 12 samples from 4 wells); 4.9. classifying areas as per stripping conditions and conditions for the deposit development.	

Appendix 2 Assay Results of Samples from the Zhaman-Aibat Ore Deposit.

Serial No.	Sample No.	Au (g/t)	Ag (g/t)	Cu (%)	Pd (%)	Zn (%)
1	2		6	2.09	0.01	0.01
2	3		13	4.82	<0.01	<0.01
3	4		8	3.2	0.01	<0.01
4	5		7	2.62	<0.01	<0.01
5	6	<0.1	19	5.16	0.01	<0.01
6	10		5	1.56	<0.01	0.01
7	13		22	4.28	0.02	0.01
8	14		60	8.99	0.03	<0.01
9	17		24	6.24	<0.01	<0.01
10	19		11	2.43	0.05	<0.01
11	21	<0.1	26	5.49	0.1	<0.01
12	22		25	5.28	<0.01	<0.01
13	23		15	3.72	0.16	<0.01
14	24		8	1.62	1.4	<0.01
15	28		14	7.04	0.01	<0.01
16	30		4	1.56	<0.01	<0.01
17	33		47	0.96	<0.01	<0.01
18	34		44	0.92	<0.01	0.01
19	35		8	4.42	<0.01	<0.01
20	36	<0.1	<1	0.78	<0.01	<0.01
21	41	<0.1	<1	2.88	0.01	<0.01
22	42		3	1.43	<0.01	<0.01
23	43		10	2.49	0.26	<0.01
24	44		10	2.24	0.81	<0.01
25	45		67	12.1	0.03	<0.01
26	46	<0.1	26	6.24	<0.01	<0.01
27	47		24	6.32	<0.01	0.01
28	48		5	1.43	0.13	<0.01
29	49		13	3.81	0.04	<0.01
30	50		17	4.02	<0.01	0.01

Appendix 2 Assay Results of Samples from the Zhanan-Aibat Ore Deposit. (continued)

Serial No.	Sample No.	Au (g/t)	Ag (g/t)	Cu (%)	Pd (%)	Zn (%)
1	1	<0.1	2	0.25	0.38	0.01
2	7		<1	0.23	<0.01	0.01
3	8		2	0.5	<0.01	0.01
4	9		2	0.63	0.06	0.02
5	11	<0.1	1	<0.01	<0.01	0.01
6	12		4	0.56	<0.01	0.01
7	15		1	0.35	<0.01	<0.01
8	16	<0.1	2	0.37	0.5	0.07
9	18		2	0.43	<0.01	<0.01
10	20		<1	0.39	0.09	0.01
11	25		<1	0.19	0.02	<0.01
12	26	<0.1	<1	0.34	0.8	<0.01
13	27		<1	0.24	0.04	<0.01
14	29		<1	0.46	<0.01	<0.01
15	31	<0.1	2	0.59	<0.01	<0.01
16	32		298	0.09	<0.01	<0.01
17	37			0.07	0.01	0.16
18	38			0.64	0.01	0.3
19	39			0.07	0.06	0.39
20	40			0.15	0.17	0.07

Appendix 3 Whole Rock Analysis of Samples from the Zhaman-Aibat Ore Deposit

Sample No.	DDM No.	Depth m	Formation	SiO_2 (%)	Al_2O_3 (%)	TiO_2 (%)	Fe_2O_3 (%)	FeO (%)	CaO (%)	MnO (%)	Na_2O (%)	Mgo (%)	K_2O (%)	P_2O_5 (%)	LOI (%)	Total (%)
WRA- 1	664	74.5	P_1kn	21.2	4.01	0.2	0.76	1.53	32.5	0.11	1.45	6.98	0.97	0.1	29.7	99.51
WRA- 2	577	130	P_1zd	66.1	12	0.6	4.07	0.61	3.92	0.09	4.79	1.23	2.1	0.14	3.92	99.57
WRA- 3	577	378	C_3dz	68.8	12.7	0.57	2.68	1.1	2.8	0.08	4.83	1.07	1.33	0.12	3.46	99.54
WRA- 4	584	404.6	C_3dz	66.5	12.1	0.42	0.71	1.52	4.96	0.12	4.53	1.08	1.72	0.11	5.01	98.78
WRA- 5	389	601.8	C_3dz	65.4	12.6	0.55	0.95	2.88	4.27	0.12	4	1.78	1.61	0.15	4.72	99.03
WRA- 6	593	601.9	C_3dz	60.2	16.7	0.64	1.88	4.43	1.63	0.13	1.63	2.65	3.95	0.16	4.79	98.79
WRA- 7	577	972	C_2ts	49.2	11.4	0.39	2.14	0.87	12	0.08	5.05	1.73	0.5	0.11	3.58	87.05
WRA- 8	753	830	C_2ts	62.8	16.2	0.73	4.75	0.85	1.41	0.03	3.94	2.14	3.28	0.15	3.06	99.34
WRA- 9	584	827.8	C_2ts	63.8	15.5	0.61	1.33	3.48	1.15	0.09	3.97	3.37	2.29	0.15	3.13	98.87
WRA-10	373	1045	C_1v_{3-5}	27.9	5.39	0.22	0.65	1.47	34	0.16	0.76	1.07	1	0.16	26.9	99.68

Appendix 4 Microscopic Observation of Polished Sections from the Zhaman-Aibat Ore Deposit (1)

Sample No.	DDH No.	Depth from (m)	Depth to (m)	Orebody /Horizon	Ore Type	Observation	Mineral composition (%) nCu	nAg	Cp	Bn	Cc	Dg	Cu	Py	Gt	Sp	Gn	Cr	UNK
P-1	179	643.5	644.05	Central/4-I	Cu ore	Main constituent minerals are bornite, chalcopyrite, sphalerite and galena, and small amounts of digenite, covellite and native silver are also identified under the microscope. These minerals, as an aggregate, fill parts of interstices of clastic particles.	<1			60	30	<1	<1			5	5		
P-2	719	629.45	630	Central/4-I	Cu ore	Chalcopyrite, pyrite and a small amount of goethite occur as interstices-filling minerals among clastic grains. Anhedral grains of pyrite are included in intersitial chalropyrite.			95					5	<1				
P-3	500	635.3	635.8	Eastern/3-V	Cu ore	Native copper and a small amount of digenite fill the interstices of clastic particles.	95					5							
P-4	296	575.5	576	Eastern/4-I	Cu ore	Aggregates of chalcocite and digenite fill the interstices of clastic particles. Digenite occasionally occurs as lamella in chalcocite.					60	40							
P-5	500	635.8	636.6	Eastern/3 V	Cu ore	Round aggregates of chalcocite and a small amount of digenite occur interstitially. Digenite is sometimes observed as lamella digenite in chalcoite aggregates.					95	5							
P-6	500	624.9	625.7	Eastern/3-VI	Cu ore	Pyrite and small amounts of chalropyrite, covellite and goethite fill the interspaces of clastic particles. Chalcopyrite and covellite occur toghter as veinlets within interstitial pyrite.			10				<1	80	5				
P-7	593(II)	587.7	588.2	Eastern/4-I	Cu ore	Chalropyrite and small amounts of bornite and covellite fill parts of the intersaces of clastic particles. Bornite is often included in intperstitial chalcopyrite, and covellite occurs along fissures of some of rims of chalcopyrite.			95	5			<1						
P-8	380(II)	620.9	621.4	Central/4-I	Cu-Ag ore	Chalcocite, bornite, digenite and small amounts of native silver, covellite and an unkwoun mineral are constituent minerals. Chalcocite and bornite occur together, and are often found as graphic texture up to 12mm in max. size. Small grains of native silver (10-40 μm in size) are contained in digenite. An unknown mineral occurs as lamella in chalcocite. It's optical properties are: slightly darker than chalcocite, distinctly birefectant (creamy olive to bluish grey), and weakly anisotropic.		<1		40	50	10	<1						<1
P-9	373	631.5	682.5	Central/4-I	Cu-Ag ore	Bornite, chalcopyrite, chalcocite, pyrite, native silver, digenite and covellite fill the interspaces of clastic particles. Small grains of native silver (40-50 μm in size) are found in the assemblage of bornite, chalcocite and digenite.		5	25	40									
P-10	179(XXXVI)	636.5	637.4	Central/4-I	Cu-Pb ore	Galera and small amounts of pyrite, bornite, chalcocite, digenite, germanite series mineral (probably colusite?) occur interstitially among clastic particles. Small grains of native silver (20-40xm in size) are contained in galena grains. Germanite series minerals is brownish grey in color, slightly lighter than bornite, and isotropic. It is associated with bornite and galema.		<1		10	5	5		15			60	5	

Appendix 4 Microscopic Observation of Polished Sections from the Zhaman-Aibat Ore Deposit (2)

Sample No.	DDH No.	Depth from (m)	Depth to (m)	Orebody /Horizon	Ore Type	Observation	Mineral composition (%) nCu	nAg	Cp	Bn	Cc	Dg	Cu	Py	Gt	Sp	Gn	Gr	NK
P-11	500	628.2	628.7	Eastern/3-VI	Cu-Pb ore	Constituent minerals are bornite, chalcocite and small amounts of digenite and galena. Bornite and chalcocite occasionally occur as graphic texture.				50	30	10					10		
P-12	552(IV)	662.5	663.4	Northern/4-I	Cu-Pb ore	Galena, pyrite and a small amount of goethite fill the interspaces of clastic particles. Large grains or aggregates of galena(about 8mm × 5mm in size) include prismatic crystals (0.2-1.2mm in length) of gangue minerals.								40	<1		60		
P-13	T-5	17.5	18.5	Taskura	Cu ore	Chalcocite, digenite and small amounts of chalcopyrite, covellite, pyrite, sphalerite and bornite are constituent minerals. Chalcopyrite and bornite occur as relicts in the assemblage of chalcocite, digenite and covelbite.			10	5	35	20	10	10		10			

nCu	native copper
nAg	native silver
Cp	chalcopyrite
Bn	bornite
Cc	chalcocite
Dg	digenite
Cv	covellite
Gr(?)	germanite series mineral(?)(probably colusite)
Py	pyrite
Gt	goethite
Sp	sphalerite
Gn	galena
UNK	unknown mineral

Appendix 5 Microscopic Observation of Thin Sections from the Zhaman-Aibat Ore Deposit

Sample No.	DDH No.	Depth(m)	Formation	Rock Name	Macroscopic Feature	Microscopic Feature	Identified Minerals
TS-1	838	314.0	C_1dz	Very fine-grained sandstone (Red sandstone)	Poor sorting, Average diameter:0.08mm φ	Matrix:carbonitization	Quartz:angular, 40%, Feldspar:plagioclase, K-felkspar, 40%, Muscovite, Opeque minerals, Goethite(?)
TS-2	710	673.2	C_1dz	Carbonatized conglomerate ("Raimundo" conglomerate)	Pebble size congls.:Max.dia..95mm φ, volcanic rocks, Limestone (micrites), Chert	Matrix:carbonatization	
TS-3	584	381.2	C_1dz	Laminated very fine-grained sandstone (Grey sandstone)	Average diameter:0.06mmx	Matrix:carbonitization	Quartz:angular, 30%, Feldspar:plagioclase, Opeque minerals, Calcite (20%)
TS-4	776	523.8	C_1dz	Very fine-grained sandstone (Grey sandstone)	Average diameter:0.1mm φ	Matrix:carbonitization	Quartz:angular, 40%, Feldspar:plagioclase, K-feldspar, 40%, Others:chlorite, Goethite(?)
TS-5	508	732.0	C_2ts	Carbonatized conglomerate ("Interformational conglomerate")	Pebble size congls.:Max.dia.10mm×6mm Limestone (micritic), Chert, Sandstone	Matrix:carbonitjaztion, quatz, plagioclase, K-feldspar, chlorite, etc.	
TS-6	577	912.0	C_2ts	Fine grained sandstone (Red sandstone)	Average diameter:0.18mm φ	Matrix:carbonitization	Quartz:angular, 30%, Feldspar:plagioclase, K-feldspar, 40%, Chlorite, Goethire, Biotie
TS-7	584	740.5	C_2ts	Coarse-grained siltstone (Green aleurolite)	Average diameter:0.05mm φ	Matrix:carbonitization	Quartz:angular, 20%, Feldspar:plagioclase, K-feldspar, 20%, Muscovite, Chlorite, Opeque minerals
TS-8	584	811.8	C_1s	Fossiliferous limestone (Biomicrite)	Fossils:brachiopods, mollusca, etc.	Micritic	Calcite, Opeque minerals, etc.
TS-9	664	74.5	P_1kn	Coarse-grained siltstone ("Marl")	Average diameter:0.05mm φ Rocks fragment:limestone, chert, volcanic rocks	Matrix:carbonitization	Quartz:angular, 20% Feldspar:plagioclase, K-feldspar, Perthire(?) .10%, Chlorite, Opeque minerals
TS-10	577	130.7	P_1zd	Coarse-grained sandstone (Red-sandstone)	Average diameter:0.5mm φ Rock fragment:limestone, chert, volcanic rocks	Matrix:carbonitizaton	Quartz:angular, 40%, Feldspar:plagioclase, K-feldspar, Perthire(?) .40%, Rock fragment:10%, Others:10%, (calcite:'10%)