JAPAN INTERNATIONAL COOPERATION AGENCY(JICA)

THE ERDENET MINE
MONGOLIA

REPORT
ON
STUDY OF THE ERDENET MINE MODERNIZATION AND DEVELOPMENT PROGRAM

VOLUME I
MODERNIZATION PLAN

December, 1993

MITSUI MINERAL DEVELOPMENT ENGINEERING CO., LTD.,
TOKYO
(MINDECO)

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Preface

In response to a request from the Government of Mongolia, the Government of Japan decided to conduct a study on the Erdenet Mine Modernization and Development Program in Mongolia and entrusted the study to the Japan International Cooperation Agency (JICA).

JICA sent to Mongolia a study team headed by Mr. Shigeru Sakai of Mitsui Mineral Development Engineering Co., Ltd., four times between December, 1992 to December, 1993.

The team held discussions with the officials concerned of the Government of Mongolia, and conducted field surveys at the study area. After the team returned to Japan, further studies were made and the present report was prepared.

I do hope that this report will contribute to the promotion of the program and enhancement of friendly relations between our two countries.

I wish to express my sincere appreciation to the officials concerned of the Government of Mongolia for their close cooperation extended to the team.

December, 1993

Kensuke Yanagiya

Kensuke Yanagiya
President

Japan International Cooperation Agency

December 1993

Mr. Kensuke Yanagiya

President

Japan International Cooperation Agency

Tokyo, Japan

Dear Mr. Yanagiya,

Letter of Transmittal

We are pleased to submit to you the report on Study of the Erdenet Mine Modernization and Development Program in Mongolia. This report contains the modernization plan for the improvement of management and operations of the Erdenet copper mine as well as recommendations on asset valuation method and copper smelter construction, consisting of three volumes: "Modernization Plan" (volume 1), "Recommendations on Asset Valuation Method" (volume 2), and "Recommendations on the Copper Smelter Construction" (volume 3). Also included are results of discussions on the draft report which were held at the Erdenet mine in December 1993.

The basic aim of the modernization plan in this report is to stabilize operations and to prevent decreasing of foreign currency earnings due to a reduction in copper production caused by a decline in the grade of crude ore which is expected in the future. To achieve this purpose, it is proposed that the Mining and Mineral Processing Departments build a system to process the crude ore approximately 1.5 times of the present tonnage and that the Workshop Department introduce state-of-the-art facilities to improve the mine products' quality and quantity. In

addition, it is recommended that a power plant be constructed at an early stage, in compliance with Mongolia's electricity development plan, in order to achieve a stable power supply, which is a key factor in the stabilization and maintenance of operations. If this plan is implemented, copper production will be restored to 120 thousand tons/year and maintained at that level, and the mine's role as the largest source of foreign currency earnings in Mongolia will be achieved.

For Mongolia, whose economic reconstruction has become urgent, it can be said that the Erdenet mine's stable operation is the key to secure foreign currency earnings. We, therefore, recommend that His Majesty's government implement this Project as a top priority.

We wish to take this opportunity to express our sincere gratitude to your Agency, the Ministry of Foreign Affairs, and the Ministry of International Trade and Industry. We also wish to express our deep gratitude to all parties concerned of His Majesty's Government of Mongolia for the close cooperation and assistance extended to us during our investigations and study.

Very truly yours,

S. Sakai

Shigeru Sakai

Team Leader

Study of the Erdenet Mine Modernization and Development Program

Conclusions and Recommendations

1. Conclusions

The conclusions drawn from the results of the field study and discussions with those concerned with the Erdenet mine and the Mongolian authorities are as below:

— The income generated by the Erdenet mine greatly affects the Mongolian economy. Currently, production targets are not being reached and, in order to return to normal production conditions, it is essential that the electricity supply and parts supply shortage be settled. To this end, the construction of an electricity generating plant would be a recommendable measure.

— A plan to maintain future production at 120,000 tons/year of copper in concentrate and a necessary investment plan have been drafted.
According to these, investment of between $ 337 million and $ 342 million will be required in the 15 years from 1994 and the implementation of the investment is economically and effectively feasible.
For the country, the separation of copper and molybdenum concentrates has the advantage of earning greater foreign currency income but, for the Erdenet mine (the enterprise), the bulk concentrate method is more profitable.

— Efforts should be made to adopt business management methods suitable for a market economy, to improve technology and to reduce costs.
Around the world there are mines with a finished copper cost as low as 30

¢/lb but, in this draft modernization plan, a cost of 40-50 ¢/lb is forecast. This means that the mine's costs can stand comparison with those of other foremost copper mines around the world.

— As it is still too early to privatize the whole mine, some divisions should be spun off as a separate private company.

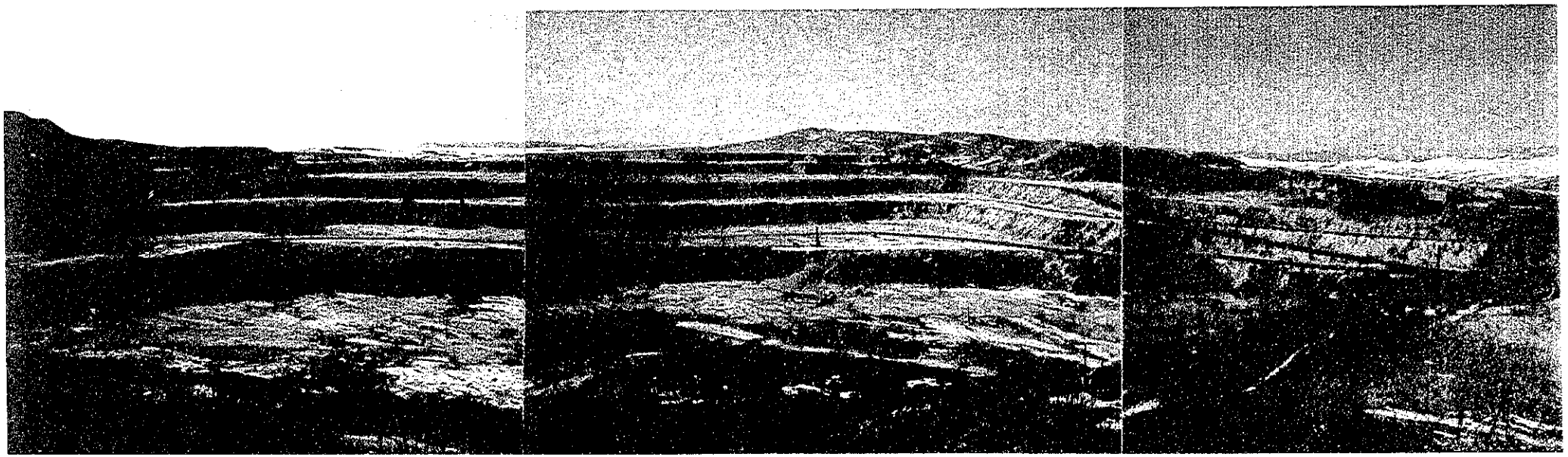
— The DCF method is recommended for asset valuation.

— There is no alternative but to freeze copper smelter construction for the present. The work should be resumed when the Mongolian Economy rallies. However, research and investigation relating to such fields as accumulation of technology, personnel training, by-products' markets, environmental impact assessment and fund raising, should be continued. For the drafting of a practical plan, a skilled and experienced planning company should be engaged.

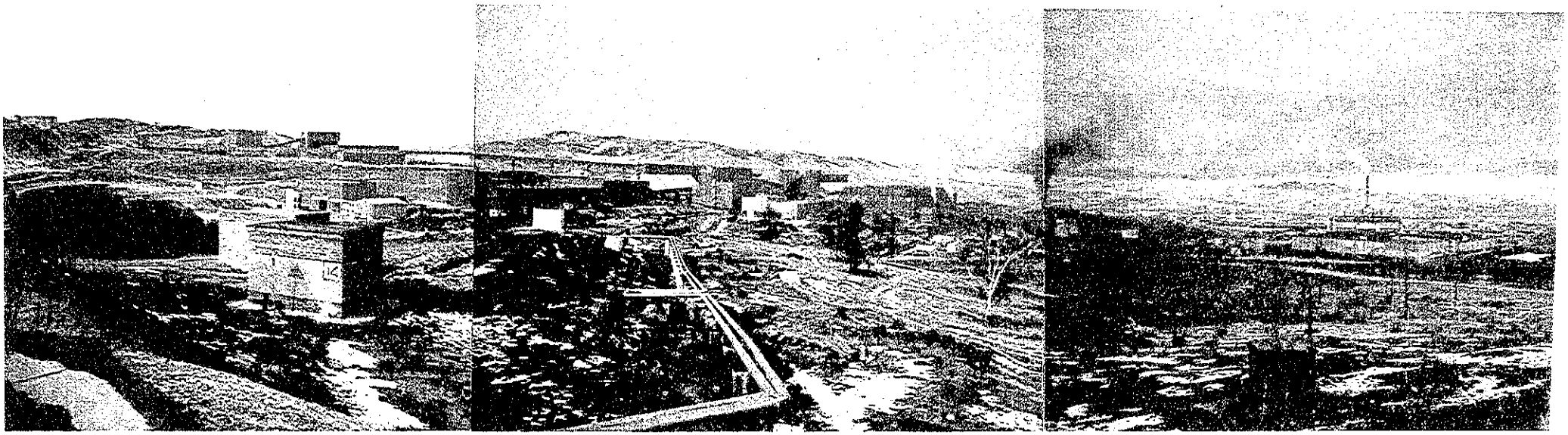
2. Recommendation

— All the modernization measures, which should be implemented as quickly as possible, should be adopted with care after appropriate study and investigation.

— As a result of the shift to a market economy the mine will be exposed to free-market competition. However, it is desired that, based on a principle of continually fair business practice, the Erdenet mine hold a place among the top mines in the world.



Panoramic View of the Erdenet Mine's Open Pit



Panoramic View of the Erdent Mine's Plant & Facilities

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1 Introduction

1. Introduction

1-1 Background to Investigation

In the early 1990s, world politics and economics have changed more than we had expected.

The pattern of world politics that has been characterized since the Second World War by the Cold War changed, and now new relations between nations are being established.

These changes in world politics and economics, which are complicated and interwoven with each other, are as stated below.

- Disruption of the state-planned economic bloc, and movement toward privatization.
- Economic stagnation in advanced countries.
- Aid to developing countries for economic re-building by advanced countries.

Until three years ago Mongolia was dependent upon Russia (the former Soviet Union) for a large part of its staple goods such as petroleum. Even now it is closely linked with Russia, but the turmoil in the Russian economy has prevented the Mongolian people from freely importing machines and spare parts from Russia, leading to a crisis to Mongolia in terms of industrial activity and civil life.

Meanwhile, the Mongolian Government has decided to adopt a market economy, and has already begun to privatize government-run enterprises. However, it is not easy to achieve this goal as Mongolia has been under a state-planned economic system for a long time, and therefore lacks know-how and experience of management under a market economy. Although the Mongolian

Government is now giving first priority to stabilization of the national livelihood, it will be forced to forge a path to a self-supporting economy by laying emphasis on encouragement of export-promoting and import-substituting industries. On that score, various economic aids from western countries will be necessary to achieve the objectives.

Japan has shown an interest in the policy of the Mongolian Government to shift the political and economic systems to a democratic system and market economic system, and announced that it would aid Mongolia actively as a fellow Asian country.

Under these circumstances, the JICA has dispatched a study team several times since November 1991 to draw up a project. As a result of the studies, it was found that it is necessary to draw up a plan for rationalizing and improving the Erdenet mine, which is Mongolia's greatest source of foreign exchange, as one of the supporting measures that would have an immediate effect on the restoration of the country's economy.

The suggestions of the study team, together with a request from the Mongolian Government, has led us to dispatch a team to perform a full-scale study.

1-2 Purpose and Scope of Study

This study aims to set up a plan for improving the management and productivity of the Erdenet mine.

Mongolia has been dependent upon the former Soviet Union for the supply of electric power and spare parts for machines, however an unstable supply from Russia is causing a serious decline in production.

Erdenet mine earnings, on which the Mongolian Government has relied for the acquisition of foreign exchange, have decreased and, as a consequence, there has been some confusion in the economic program of the country as a whole for acquiring foreign exchange and for paying for imported goods. Faced with the crisis of a foreign exchange shortage, the Mongolian Government, for the moment, is spending scanty foreign exchange mainly on importing foods and other necessities to maintain the living standard of the people, but the time will come when a certain amount of foreign exchange has to be allocated to investment in industries which will, in turn, become earners of foreign exchange.

Let us examine the problems regarding the operation of Erdenet Mine from a long-term point of view. Both the grade of crude ore and concentrate will deteriorate in the near future. Therefore, the production plan will have to be revised in order to maintain a given level of foreign exchange earnings.

In a market economy where market mechanism works, the Erdenet mine will be tried by strict requirements such as reduction of production costs as well as guarantee for a sales commitment, arrival date and product quality. It will not be until the Erdenet mine meets such production requirements that it can hope to be a competitor in western markets. On that point, competition under a market

economy is different from that under a COMECON bloc state-planned economy . That is the reason that drastic reform is required.

What should be done first in order to develop and support this project is to obtain some management consulting about the state of the mine and how it is managed, and on the basis of results of this consultation the reform plan should be drawn up.

This is the reason why several drastic reform measures, such as preparation of an appropriate production plan, administrative improvement and introduction of new technology, are required to stabilize and develop this business.

Therefore, the present condition of the mine is studied diagnostically and the modernization plan will be based on the results of this study.

As shown in this report, we have made studies and proposals as follows:

—Research and analysis of the Mongolian macro-environment such as economic policies, etc.

—Diagnosis and improvement of Erdenet Mine production.

—Preparation of medium and long-term production plans and investment and its evaluation.

—Diagnosis of the management and proposals for its improvement.

—Proposals for an asset valuation method.

—Evaluation of the privatization plan.

—Study on the present planning situation for the copper smelter construction.

In making the proposals, we have tried not only to develop the mine's merits under the past centrally-planned economy, but also to modify and strengthen what will be its weak points under a market economy.

1-3 Organization of the Study Team and Site Survey Schedule

1-3-1 Organization of the Study Team

The following table shows the organization of the Study Team.

Appointed as	Name	Firm	In charge of
Leader	Shigeru Sakai	MINDECO*	●General management
Subleader	Hiroshi Komatsu	MINDECO	●Business management
Group Members	Kazuki Shingu	MINDECO	●Prospecting and mining
	Hisamitu Ōki	MINDECO	●Mineral processing (Equipment)
	Mikio Takahashi	MINDECO	●Mineral processing (Test and analysis)
	Kōkichi Kitahara	MESCO**	●Workshop ●Casting
	Takeshi Kobayashi	MESCO	●Utilities
	Takashi Nakajima	MESCO	●Environmental problems ●Pollution control
	Kei Arai	B.O.T.***	●Financial and Economic Analysis
	Haruo Matsuura	MINDECO	●Integration of equipment
Interpreter	Ryōji Tsuyuzaki	M.K.S.S.****	●Interpretation (Russian/Japanese)
Coordinator	Kinzō Asari	MINDECO	●Coordination

* MINDECO: Mitsui Mineral Development Engineering Co., Ltd.

** MESCO: MESCO Inc, Engineering Division of Mitsui Mining & Smelting Co., Ltd.

*** B.O.T.: The Bank of Tokyo, Ltd.

**** M.K.S.S.: Mitsui Kinzoku Staff Service Co., Ltd.

1-3-2 Site Survey Schedule

The site survey was conducted according to the following schedule.

	Date	Outline	Site
1st Site Survey	From December 7, 1992 to December 23, 1992 (17 days)	● Arrangement on the study plan ● Preliminary study	Ulaanbaatar Erdenet Mine
2nd Site Survey	From February 24, 1993 to March 28, 1993 (33 days)	● Diagonostic study	Ulaanbaatar Erdenet Mine
3rd Site Survey	From June 15, 1993 to July 8, 1993 (24 days)	● Explanation of the intermediate report ●Supplementary study	Ulaanbaatar Erdenet Mine
4th Site Survey	From November 28, 1993 to December 10, 1993 (13 days)	● Explanation of the Final Report (draft)	Ulaanbaatar Erdenet Mine

2 Current State of the Mongolian Economy and World Copper Supply

2. Current State of the Mongolian Economy and World Copper Supply and Demand

2-1 Economic Situation

2-1-1 Historical Background

At the time of its founding, having no industry other than traditional nomadic ones, Mongolia could not help but be largely dependent economically on the former U.S.S.R. Of all the former Comecon countries, Mongolia was particularly dependent on the former Soviet Union, and remained so for 70 years following independence.

The wave of democratization that spread through the U.S.S.R. and eastern Europe in the second half of the 1980s extended as far as Mongolia, and there too economic reforms, characterized by the move to a market economy and the promotion of privatization, were implemented. At the outset, so great a change was bound to cause some temporary economic confusion, but the collapse of Russia's own economic transition and its descent into poverty drew Mongolia, with its heavy dependence on Russia, into economic crisis. At present, in these difficult conditions, Mongolia is continuing to grapple with the move to a market economy.

2-1-2 Recent Economic Conditions

(1) Economic Confusion

As described above, owing to Russia's economic crisis and the confusion resulting from the shift to a market economy, the Mongolian economy is experiencing shortages of goods and high inflation. Goods in short supply range from consumer items, including food, to machinery and spare parts required for industrial production, and all sectors of the economy are affected. Furthermore, the entire manufacturing sector suffers from the shortage of electricity; in the past some power came from Russia. Public transport and the national distribution system are badly impaired by the scarcity of petroleum products, and particularly gasoline.

Since January 1991, when the government carried out price liberalization measures, the Mongolian economy has been experiencing rapid inflation: as of the end of May 1993, the consumer price index for all goods and services is more than ten times as high as that before the price liberalization: e.g. prices for groceries has increased by fourteen times, daily necessities by eleven times, transportation and communication by seven times.

As for exchange rate, the official rate has been gradually reduced since the reform: it has decreased from US$ 1 = Tg 7.10 to US$ 1 = Tg 40 in June 1991 and to US$ 1 = Tg 150 in January 1991. The separate commercial rate (exchange rate primarily for tourists) moved between US$ 1 = Tg 380 and US$ 1 = Tg 360 in the first half of 1993. The dual exchange rate has subsisted for a long period. In May 1993, the government implemented exchange liberalization to shift the official rate to a fluctuating system. As of June 1993, the rate is

moving around US$ 1 = Tg 400.

As the authorities are planning to increase public utility charges such as housing rents and bus fares with the exchange liberalization, confusion is likely to continue to prevail over Mongolian economy.

(2) The Progress of Privatization

Together with the above price and exchange liberalization, privatization is one of the most important aspects of the economic reforms. So far, it has progressed as follows.

Privatization in Mongolia is being carried out by way of a coupon (also known as voucher) system under the supervision of a privatization committee. Under this system, coupons enabling all Mongolian citizens to purchase state-owned enterprises are distributed free of charge, and citizens can either purchase shares directly (for small to medium-sized enterprises) or (for large enterprises) bid for shares at auction.

As part of the first stage of the privatization process, the committee has selected for privatization about 2000 state-owned enterprises, with a total value of Tg 2000 million. Of these, three-quarters (by value), worth a total of Tg 1500 million, had already been privatized by February 1993. Additionally, the shares of 238 large privatized enterprises have been sold through securities exchanges. According to the committee, this first stage, using the coupon system, is expected to be complete by the end of this year.

In the second stage, it is expected that other important state-owned enterprises such as communications, railways and other infrastructural industries, as well as mining, will be targeted for privatization. However, a

concrete program to realize privatization, including companies to be targeted, has not been worked out yet, as further examination is required.

(3) Economic Performance

As mentioned above and reflected in various economic indicators, the Mongolian economy is in great confusion as a result of the dissolution of the Soviet Union and the shift to a market economy. (See Table 1 "Statistical Data of Mongolian Economy.")

The Mongolian real GDP has recently shown an accelerating decline: the annual growth rate of real GDP was −9% in 1991, and −19% in 1992.

The 1992 Net Material Products (at 1986 prices) of every sector, used as an indicator of output, dropped from the previous year. Compared with that of 1991, the 1992 indicator showed 6.2 % decline in agriculture, 11.4 % in mining and manufacturing, 11.3 % in construction and 14.5 % in distribution. According to the resources, such negative growth mainly results from the shortage of necessities including parts & spares, fuel and electric power.

As for international trade, most of the distortion in prices has been removed since payment on a doliar basis was adopted in 1990, because since then, exports and imports have been traded at market prices. Consequently, the considerable Mongolian trade deficit has been partially reduced. However, the country is having difficulties in increasing trading volume. In 1991, exports declined by 22 % and imports by 44% over the previous year. Nor did the following year see any improvement in volume.

Mongolia also suffers from budget deficit. The deficit reached 7 billion tugrik in 1992. This amounts to 16 % of GDP. In January 1993 tax reform was

implemented and the government hopes that tax revenue will increase under the new system.

The number of unemployed is 54,000, equivalent to 8 % of the Mongolian labor force, as of the end of 1992. Most of them can be grouped into the following categories:

- Those who had been civil service workers but were discharged with the rationalization of the government sector.
- College and technical school students, forced to return to Mongolia from East European countries or the ex-Soviet Union and residing in large cities.

This leads us to consider countermeasures in anticipation of a situation where the shift to a market economy brings about an increase in the number of unemployed, as it is expected to be accompanied by problems such as corporate bankruptcy.

Table 1 Statistical Data of Mongolian Economy (1)

(in millions of Tugrik, unless otherwise specified)

	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
(1) GDP at currnet prices	6,754.9	7,426.3	8,205.3	8,768.4	8,995.7	9,371.9	9,310.0	9,709.8	10,301.0	10,730.9	10,465.1	18,909.6	42,869.5
(2) GDP at constant 1986 prices	5,718	6,352	7,106	7,631	7,827	8,155	8,052	9,631.6	10,183.6	10,546.8	10,281.4	9,330.7	7,522.0
(3) Net Material Products and composition by sector (constant 1986 prices)	4,939.8	5,353.3	5,802.1	6,157.7	6,434.0	6,776.7	7,153.5	7,400.7	7,712.6	8,461.9	8,143.9	6,988.9	6,033.3
Agriculture	1,004.9	1,111.9	1,268.9	1,280.7	1,232.4	1,348.1	1,426.6	1,335.7	1,367.1	1,556.3	1,525.6	1,448.4	1,358.3
Industry	1,575.2	1,714.3	1,897.9	2,085.8	2,267.7	2,390.0	2,442.8	2,511.3	2,604.6	2,902.3	2,892.8	2,412.7	2,137.0
Construction	342.1	342.3	346.1	352.6	367.5	382.0	423.1	503.8	563.1	617.2	462.3	383.4	340.0
Distribution & Warehousing	1,365.0	1,493.3	1,545.8	1,649.5	1,737.6	1,770.8	1,865.2	2,036.2	2,129.9	2,327.4	2,280.5	1,987.6	1,700.0
Other Sectors	652.6	691.5	743.4	789.1	828.8	885.8	995.8	1,013.7	1,047.9	1,058.7	982.7	756.8	498.3
(4) Price Indices (1978=100)													
Consumer prices	100.1	100.0	102.5	102.5	102.5	103.1	102.1	102.1	102.1	102.1			
Wholesale prices	108.8	113.9	120.5	126.8	132.6	138.0	144.9	150.1	157.4	165.4			

	('91/1/16)	('92/1/1)	('93/1/1)	('93/6/1)
Consumer prices	100.00	154.30	649.80	1,382.6
Wholesale prices	n.a.	n.a.	n.a.	n.a.
Food Stuffs	100.0	134.4	755.4	1,382.6
Clothes and Shoes	100.0	192.4	679.1	813.2
Rent and Price of energy	100.0	115.5	245.8	286.0
Housing Goods	100.0	209.6	795.8	1,152.4
Medicine	100.0	100.0	196.7	487.6
Transport and Communication Costs	100.0	137.3	535.3	738.3
Articles for Cultural Needs	100.0	277.3	581.0	1,271.4
Other Goods and Services	100.0	152.3	430.2	791.1

Statistical Data of Mongolian Economy (2)

(in millions of Tugrik, unless otherwise specified)

(5) State Budget
and composition by categories

	1987	1988	1989	1990	1991	1992
Total Revenue	-	-	-	6,092.9	10,639.9	38,407.2
(a) Tax Revenue	-	-	-	5,053.1	9,767.5	30,023.8
1. Corporate taxes	-	-	-	2,485.9	5,097.7	11,142.4
2. Taxes on individuals	-	-	-	100.0	115.2	324.5
3. Revenue from bus service	-	-	-	8.2	8.1	536.0
4. Special revenue	-	-	-	1,592.1	1,691.8	5,944.0
5. Turnover taxes	-	-	-	572.2	1,064.7	5,551.9
6. Customs duties	-	-	-	294.7	1,790.0	6,525.0
(b) Other	-	-	-	1,007.3	352.4	3,493.4
(c) ODA	-	-	-	32.5	520.0	4,890.0
Total Expenditure	-	-	-	8,929.3	12,929.4	45,439.8
(a) Material sector expenditure	-	-	-	1,426.1	725.8	2,215.2
(b) Nonmaterial sector expenditure	-	-	-	5,687.3	9,518.9	27,082.5
on research	-	-	-	192.1	212.3	532.2
on education	-	-	-	1,827.2	2,635.6	6,917.5
on culture	-	-	-	271.4	472.6	1,166.9
on health	-	-	-	950.8	1,625.2	4,478.7
on sports	-	-	-	32.1	74.4	183.6
on administration	-	-	-	546.0	916.9	3,112.9
on defence	-	-	-	692.3	1,102.8	3,638.3
on environmental protection	-	-	-	48.5	146.8	347.5
on maintenance	-	-	-	78.6	109.5	299.0
on pension	-	-	-	1,048.3	1,148.7	3,699.4
on children's wear	-	-	-	0.0	125.5	0.0
on social security	-	-	-	0.0	30.0	120.0
other	-	-	-	0.0	918.6	2,586.5
(c) covering budget deficit of local government	-	-	-	0.0	0.0	1,464.1
(d) sharing expenditure of local government	-	-	-	378.5	424.3	1,543.0
(e) other	-	-	-	418.8	1,260.4	9,602.0
(f) investment	-	-	-	1,018.6	1,000.0	3,533.0

Statistical Data of Mongolian Economy (3)

	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
(6) Trade Balance													
with tht CMEA countries only (in millions of transferable rubles)													
Export (FOB)	253.5	306.2	365.1	403.6	451.2	448.6	504.7	503.1	503.9	484.5			
Import (CIF)	430.2	540.1	633.7	732.3	731.5	819.5	926.7	854.2	918.2	770.8			
with the whole world (in millions of US$)													
Export (FOB)											444.8	346.5	355.8
Import (CIF)											759.3	426.5	400.0
(7) Population and Employment (in thousands)													
Total Population	1,639.7	1,682.0	1,724.7	1,767.5	1,808.9	1,854.3	1,900.6	1,949.7	1,997.0	2,044.0	2,095.6	2,149.3	2,187.2
Under age 16	724.7	743.4	762.3	781.2	799.5	819.6	840.0	861.8	882.7	904.3	920.6	936.9	953.6
Active Age	798.5	819.1	839.9	860.8	880.9	903.0	925.6	949.5	972.5	995.1	1,028.2	1,061.9	1,080.5
Over Active Age	116.5	119.5	122.5	125.5	128.5	131.7	135.0	138.4	141.8	144.6	146.8	150.5	153.1
Total Employed	511.2	518.0	532.2	543.0	550.3	561.6	580.0	598.4	616.2	633.2	651.4	665.8	n.a.
Unemployment(Registered unemployed)	-	-	-	-	-	-	-	21.4	28.9	30.0	45.1	55.4	(*) 54.0

(*) According to the government official, the total number of unemployed (including non-registered unemployed) should be around 108 thousand in 1992.

(All data above were obtained from the Government of Mongolia.)

2-1-3 Support from the International Community

(1) Japanese Economic Cooperation

Since it provided a grant for the construction of a cashmere factory in 1977, Japan has participated in various forms of economic cooperation to Mongolia. In recent times, relations between the two countries have rapidly strengthened, and Japan is actively assisting Mongolia in its efforts to implement economic reforms in harsh conditions. In addition, Japan has taken the initiative and held a Conference of Nations Supporting Mongolia three times in Tokyo as joint chairman with the World Bank. Table 2 shows the loans and grants Japan has offered to Mongolia thus far.

Table 2 Loans and Grants from Japan to Mongolia (unit: ¥ 100 million)

	Loans		Grants	
Cumulative total as of fiscal 1990		None		56.04
Fiscal 1991		48.36		33.08
	Goods on loan	48.36	Social welfare plan	1.00
			Communications facilities provision plan	9.48
			Non-project assistance	20.00
			Food assistance	2.00
			Musical instruments	0.50
			3 additional items	0.10
Fiscal 1992		24.58		18.98
	Goods on loan	24.58	Ulaanbaatar No. 4 power station repairs	9.36
			Food assistance	2.00
			Assistance to increase food production	1.50
			Communications facilities provision	5.62
			Mongolian language printing machinery	0.50
Fiscal 1993				28.21
			Ulaanbaatar No. 4 power station repairs	6.62
			Transshipment facilities	11.21
			Basic medical equipment and materials provision	5.38
			Food assistance (wheat from China)	3.00
			Assistance to increase food production	2.00

Note)

- As of September 1993.
- Amounts are based on the official documents.
- Japan has declared a 7.4 billion - yen loan for the railroad industry at the third Conference of Nations Supporting Mongolia held in September 1993.

(Sources: Association for Promotion of International Cooperation, Japanese government development assistance results by country for fiscal 1992 and Bank of Tokyo data.)

(2) Other countries

Mongolia was seriously affected by the deterioration in economic conditions that took place from 1990 onwards in its traditional main sources of aid, the former U.S.S.R. and eastern Europe. It therefore strengthened its relations with all western countries, and in 1991 joined the Asia Development Bank (ADB), the International Monetary Fund (IMF) and the World Bank.

The commitments of support for Mongolia from each nation and international institution from 1991 to 1993, are detailed below. (Table 3, Fig. 1)

Table 3 Details of support commitments for Mongolia from 1991 to 1993 (as of June 1993)

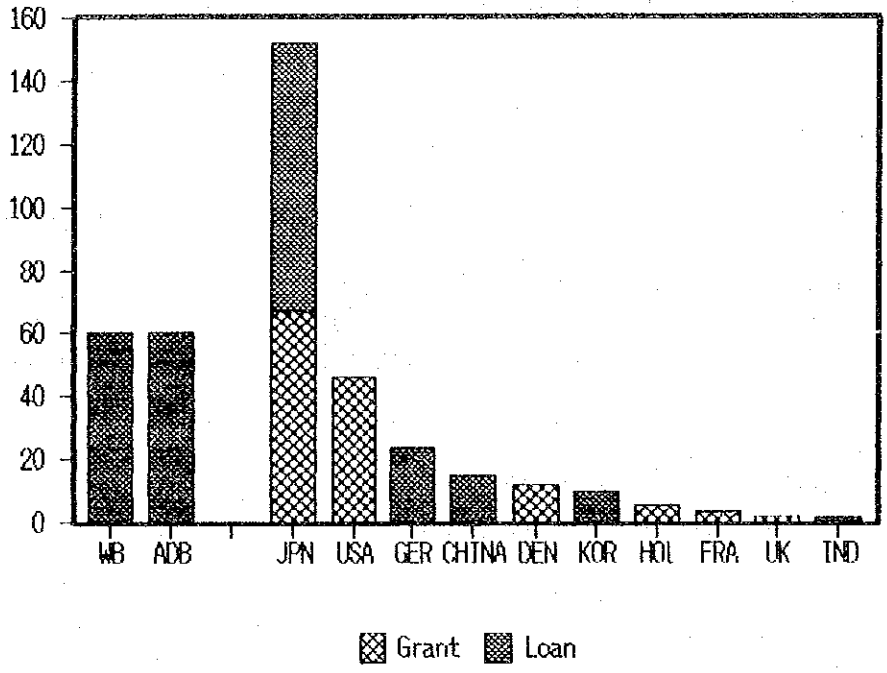
(unit: US$ 1 million)

	Loans	Grants	Total
World Bank	60.0		60.0
ADB	60.0		60.0
Japan	85.0	67.0	152.0
USA		46.0	46.0
Germany	23.7		23.7
China	14.9		14.9
Denmark		11.6	11.6
Korea	10.0		10.0
Holland		5.2	5.2
France		3.5	3.5
UK		2.0	2.0
India	1.7		1.7
Total	255.3	135.3	390.8

(Sources: Mongolian Govenment internal data)

Fig. 1 ODA to Mongolia

1991-1993 commitment base (mil.US$)



2-2 Development Plans

2-2-1 National Development Plan

Since 1948, Mongolia has tried to promote the development of industry in accordance with the Five-Year Plan prepared under the planned-economy. This plan was, however, discontinued after the national economy began to shift to a market system. After having decided on the shift, the government has drawn up a Four-Year Plan to start the new system. The 1st New Economy Four-Year Plan, applied to the period from 1993 to 1996, was prepared mainly by National Development Board which was also charged with planning economic policies before the reform.

The basic policies of the new plan are to control inflation and stabilize the economy in the initial 2 years, and to lay the foundation for economic development and get all the necessities for raising national living standards. To put it concretely, the aim of this plan is to attain the following the objectives:

(1) Increasing production in all sectors. (19.5%)

(2) Overcoming the food shortage

(3) Improving the balance of trade: increasing exports and controlling imports

(4) By controlling inflation, completing the necessary conditions for economic development.

To achieve the above purposes, the below macro economic policies and concrete measures will be implemented.

[Macro-economic policies]

① Development of privatization

② The creation of structures appropriate for a market economy

③ Exchange rate liberalization

④ Reduction of the budget deficit

⑤ Tax reform

⑥ Control of foreign debts

[Concrete measures]

① Realization of food self-sufficiency

② Increasing production of exportable goods, particularly:

—Technological improvement for fluorite production in Bor-Undur and copper production in the Erdenet Mine.

—Productivity and quality improvement of leather and cashmere goods.

—Development of gold mines.

③ Petroleum production and processing to partially cover domestic demand.

④ Reinforcement of energy supply base by improving the 3rd & 4th Ulaanbaatar Power Station and Darhan Power Station, and constructing new power stations.

⑤ Actively promoting the R & D in major fields.

2-2-2 Mining Development Plan

The Ministry of Geology and Mineral Resources of Mongolia takes a leading role in preparing the Mining Development Plan. The Ministry announced measures in four fields that should be taken in the period 1993 – 1996, in accordance with the Four-Year Plan.

(1) Support of domestic and foreign companies, including private enterprises, in the mining of lead, zinc, silver etc. in order to increase exports.

—Boring survey and feasibility study of the Tsav deposit with Japanese aid.

—Preliminary Study for the mining of the Ulaanordo deposit.

—Negotiation between Japan, Russia and Mongolia on the establishment of a joint venture to develop mixed ore in Tomurtiin Ovoo, Tsav and Ulaan.

—Establishment of a foreign-capital joint venture to develop silver ore in Asgatto.

(2) Modernization of the Erdenet Mine (producing copper ore) and the Bor-Undur Mine (fluorite).

—Modernization of the Erdenet Mine after a study in cooperation with Japan.

—Selling of copper cathode produced on commission in the Balkhash smelter.

—Construction of a fluorite plant with 15,000 MT/y in Bor-Undur.

—Modernization, together with Russian partners, of the Bor-Undur plant

or similar plants, in Russia, to produce fluorite blocks.

(3) Quadrupling gold production by private and state enterprises.

—Establishment of laws concerning gold development.

—Development of gold deposits in various districts by private and state enterprises, and semi-governmental corporations.

—Development of the gold deposit in the Boroo district by a U.S. - Mongolian joint corporation.

—Environmental study prior to alluvial gold mining (placer mining) in the Zamuur region.

(4) Construction of a plant to produce and the export of gold bullion.

—Construction of a gold production plant with capacity of 5 MT/y.

2-3 Outlook for Global Copper Supply and Demand

Although it is difficult to forecast the movements of copper prices, and supply & demand in the long term, it can be linked to economic growth.

The medium-term trend is relatively clear and the results of our analysis of this are as follows (Table 4):

(1) Outlook for the world economy

The economic trend is an essential factor in analyzing the copper supply and demand, because the latter is always influenced by the former.

In particular, demand correlates closely with industrial output.

—In 1993 the world economy has shown slight signs of recovery, but business activities will not recover on a large scale before 1995.

—In medium term, the growth rate of the world economy is estimated to be around 4%. It is expected that mineral supply and demand will firm in line with this growth and market prices will increase correspondingly.

—The economic growth rate of developing countries is not expected to be lower than that of industrialized countries, which is expected to increase gradually. The growth of Asian countries should be especially noteworthy.

(2) Outlook for copper supply and demand

—Copper demand slightly increased in 1992, although the world economy did not seem to be very active. The dullness in German, Japanese and other markets were complemented by demand increases in the U.S., Asian countries (Taiwan and Korea) and Europe (Italy and UK).

—Demand for copper is expected to start recovering in 1994 and grow by

2.6 % annually until 1998. Demand in Asia will be particularly brisk. Mongolia, as an Asian country, should carefully follow such movement.

(3) Outlook for copper production

—In the medium term, it is estimated that world ore production will increase considerably, compared with the 1993 level, as many mines will be expanded or newly developed. In Chile alone, the production increase will reach 500 thousands of tons.

(unit: thousands of tons)

e.g.:	El Abra:	155
	La Canderalia	100
	Chuqui Norle	75
	Quebrada Blanca	75

– Smelting capacity will be sufficient to handle the increase in ore production owing to the expansion of newly established facilities, including the following:

	Capacity (unit: thousands of tons)
Gresik (Indonesia)	150
Garfield (U.S.A.)	110
Refinera Pacifico (Chile)	200

Of the increase in electrolytic copper, one-third results from the application of the SX-EW method.

(4) Outlook for the copper price

The copper price is expected pick up due to reduction in stock and adjustment of supply and demand.

—In 1992, the copper price dropped to US$ 2,285 per metric ton. However, it is thought to be firmly back on an upward course, and some

analysts predict that it will reach US$ 2,550/ton in 1998, a price rise of 1.7 % annually.

—The delay in economic recovery (the recession) has affected the balance of power between labor and management, as the former has been forced to refrain from making firm demands. At smelters in the USA and Poland, negotiations between workers and employers turned out to be smooth and there was no decline in production resulting from strikes, and this resulted in a copper price reduction.

The increase in production of recycled copper is another factor which has pulled down the price. However, instability of supply from the CIS and Eastern Europe and uneasiness about the brisk expansion of the smelting capacity are positive factors. In light of all these factors, the price is estimated to rise gradually.

Table 4 Forecast of world copper supply, demand and price*

	1991	1992	1993	1994	1995	1996	1997	1998
Copper consumption (in thousands of tons)	8,968	9,050	9,350	9,700	10,050	10,300	10,550	10,750
Mine production (copper contents) (in thousands of tons)	7,411	7,550	7,800	8,050	8,350	8,600	8,850	9,075
Metal production (in thousands of tons)	8,539	8,800	9,050	9,400	9,700	10,000	10,350	10,550
Stock (in thousands of tons)	862	912	890	860	810	760	790	820
Quatation price (US$/t)	2,352	2,285	2,315	2,460	2,675	2,790	2,965	3,070
Spot price (US$/t)	2,465	2,356	2,315	2,375	2,500	2,505	2,560	2,550

Source: Foreign Mining Information Vol. 265 P. 24

[Note]

* Based on Western statistics.

3 Overview of the Erdenet Mine

3. Overview of Erdenet Mine

3-1 Historical Background

A brief history of the surveying and development of the Erdenet mine follows:

1941:	Soviet geologist discovered the showing of copper deposits in Erdenetiin Oboo.
1964-1968:	Joint Czech-Mongolian survey: geological, geophysical and geochemical surveys and exploratory drilling
1968:	Czechoslovakia withdrew from the survey due to the Czech disturbances.
1968-1969:	Supplementary survey by Mongolia alone
1970-1972:	Joint Soviet-Mongolian development survey started.
1973:	Soviet and Mongolian governments signed the Joint-development agreement.
1974-1977:	Construction and infrastructure preparation
1978:	Production commenced.
1981:	Processing plant, with capacity of 16 million tons of crude ore per annum, completed.
1989:	Processing plant, with capacity of 20 million tons of crude ore per annum, completed.
1991:	Amendment of the Agreement concluded with the Soviet Union in 1973.

3-2 Location, Transport and Layout of Facilities

Erdenet mine is at longitude 104 ° 8′ E, latitude 48 ° 59′ N, 250 km north-west of Ulaanbaatar, the capital of Mongolia.

It is in a mountainous region, 1300 to 1600 m above sea level, between two major Mongolian rivers, the Selenge and the Orhon. The area is in a transitional zone between woodland and grassland. The climate is typically continental, with summer maxima of 40° C and winter minima of −30° to −40° C.

There is a daily train service between Erdenet and Ulaanbaatar via Darhan (a 410 km journey, taking about 12 hours). (Fig. 2)

Erdenet is the third largest city in Mongolia, with a population of about 60,000. The city developed around the mines, but also has a power station, a carpet-weaving factory, a meat processing works and other industrial plants. The population is rapidly growing. Facilities are arranged as shown in Figure 3.

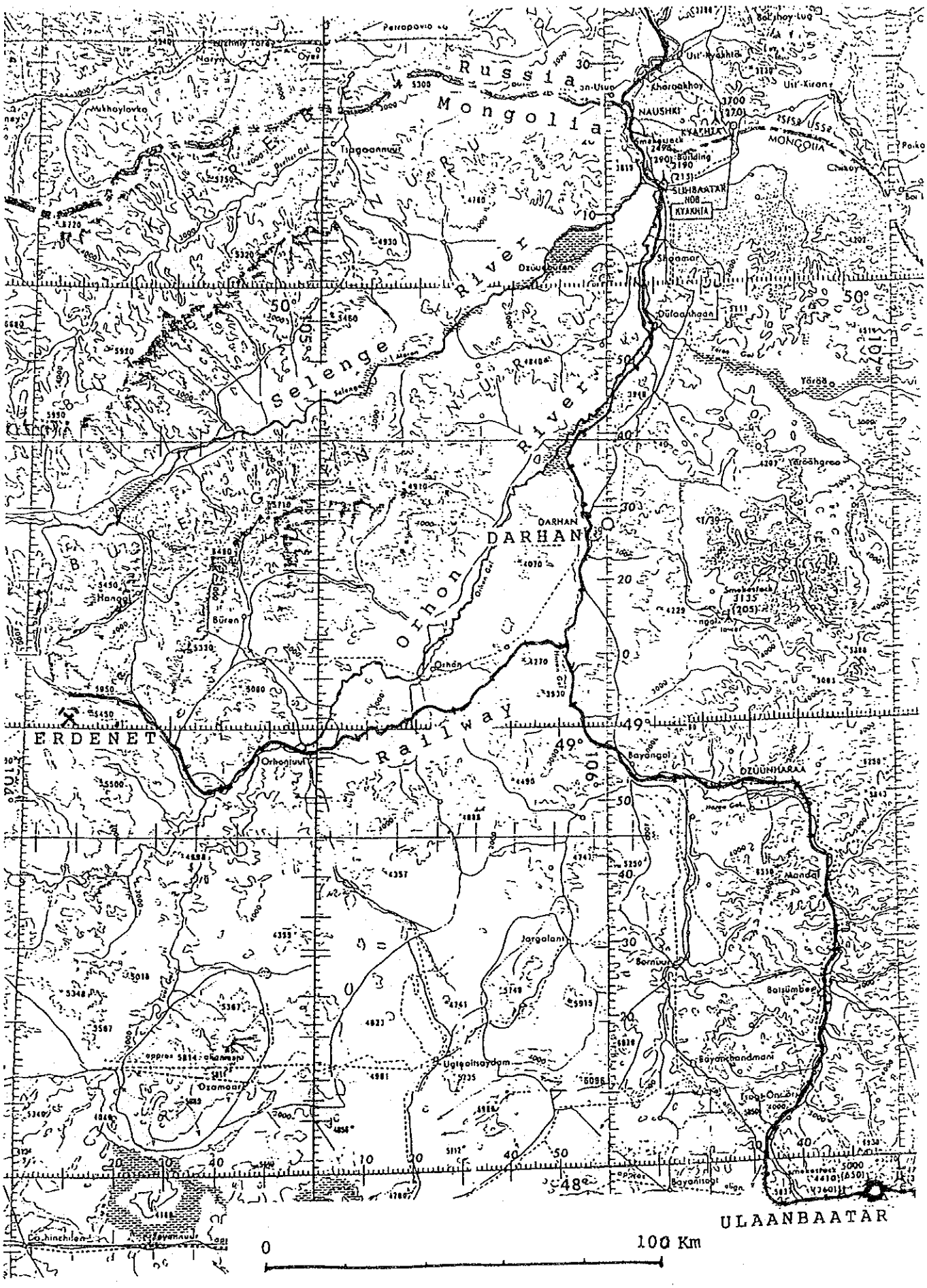


Fig. 2 Location Map

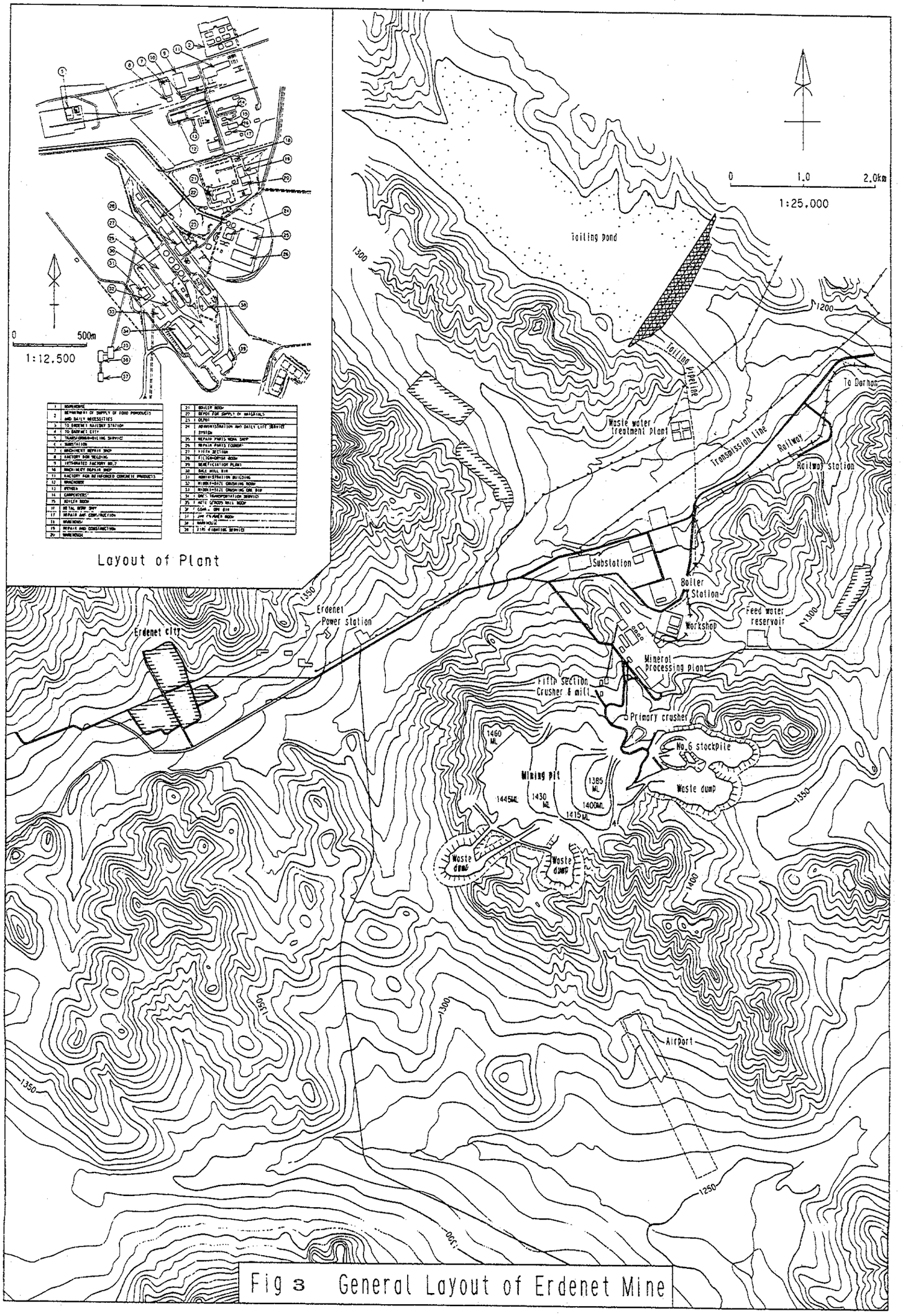


Fig 3 General Layout of Erdenet Mine

3-3 Geology and Ore Reserves

Ore deposits of the Erdenet mine area are porphyry type copper-molybdenum deposits. Mineralization in this area extends over 20km in NW-SE direction, where five ore deposits, namely North, North-West, Central, Central-Southeast and Southeast are located. Among them, North-West (Erdenetiin Oboo) deposit is currently being mined.

The Erdenetiin Oboo deposit is located on top of the hill of 1600m above sea level. Orebody has an oval shape elongated NW-SE direction with 3km in long axis and 1.5km in short axis. Downward extension has been determined at least 1000m from the surface. A thick secondary enrichment zone was developed near the surface.

Principal ore minerals are chalcocite and chalcopyrite associated with abundant pyrite and minor amount of bornite, covellite, molybdenite and tennantite.

The ore reserves has been computed on the two deposits of Northwest and Central. Potential ore has been estimated in the Southeast deposit.

Summary of ore reserves computed in 1988 shows 1544 mil. tons Cu : 0.52%, Mo : 0.0014% of minable ore in the Erdentiin Oboo.

(Table 8).

3-4 Production and Sales Results

Table 5 and Figure 4 show the production results of the Erdenet mine since it started. The copper concentrate production increased continuously until 1990, but has declined since the following year.

Table 6 details the sales of concentrates classified by country. Until 1990, most were sold to the ex-Soviet Union. Since 1991, when the USSR governmental system collapsed, the share of exports to Russia in the sales has fallen, while dealings with various other countries have started. The concentrates exported to Kazakhstan are smelted on a toll basis. The sales to Japan, which started in 1989, are gradually increasing.

Table 5 Production Results

Year	Crude ore			Cu Concentrate			Mo Concentrate	
	Quantity	Grade		Quantity	Quantit	Metal Con-	Quantity	Grade
	1,000t	Cu%	Mo%	t/year	Cu%	tent (t)	t/year	Cu%
1978	464.3	0.680	0.0160	NA	NA			
1979	3,657.2	0.804	0.0790	NA	33.64		NA	
1980	7,132.0	0.851	0.0180	NA	33.49		NA	
1981	13,069.0	0.792	0.0165	NA	33.48		NA	
1982	15,940.0	0.862	0.0157	(推)315,000	33.80	106,470	NA	
1983	16,500.0	0.893	0.0154	" 320,000	33.10	105,920	NA	
1984	17,173.0	0.889	0.0154	" 320,000	33.70	107,840	NA	
1985	16,950.0	0.877	0.0163	" 340,000	33.41	113,594	NA	
1986	17,042.0	0.869	0.0162	" 360,000	33.05	118,980	NA	
1987	17,124.0	0.865	0.0162	343,580	35.19	120,901	2,790	54.59
1988	17,179.0	0.866	0.0162	355,539	34.22	121,665	2,843	54.03
1989	17,805.0	0.863	0.0171	372,839	32.38	123,521	2,894	54.65
1990	18,657.0	0.826	0.0218	407,543	30.41	123,933	3,697	53.50
1991	14,168.0	0.834	0.0219	329,123	29.98	98,671	3,623	51.84
1992	16,866.0	0.791	0.0199	340,033	30.05	102,180	2,929	52.57

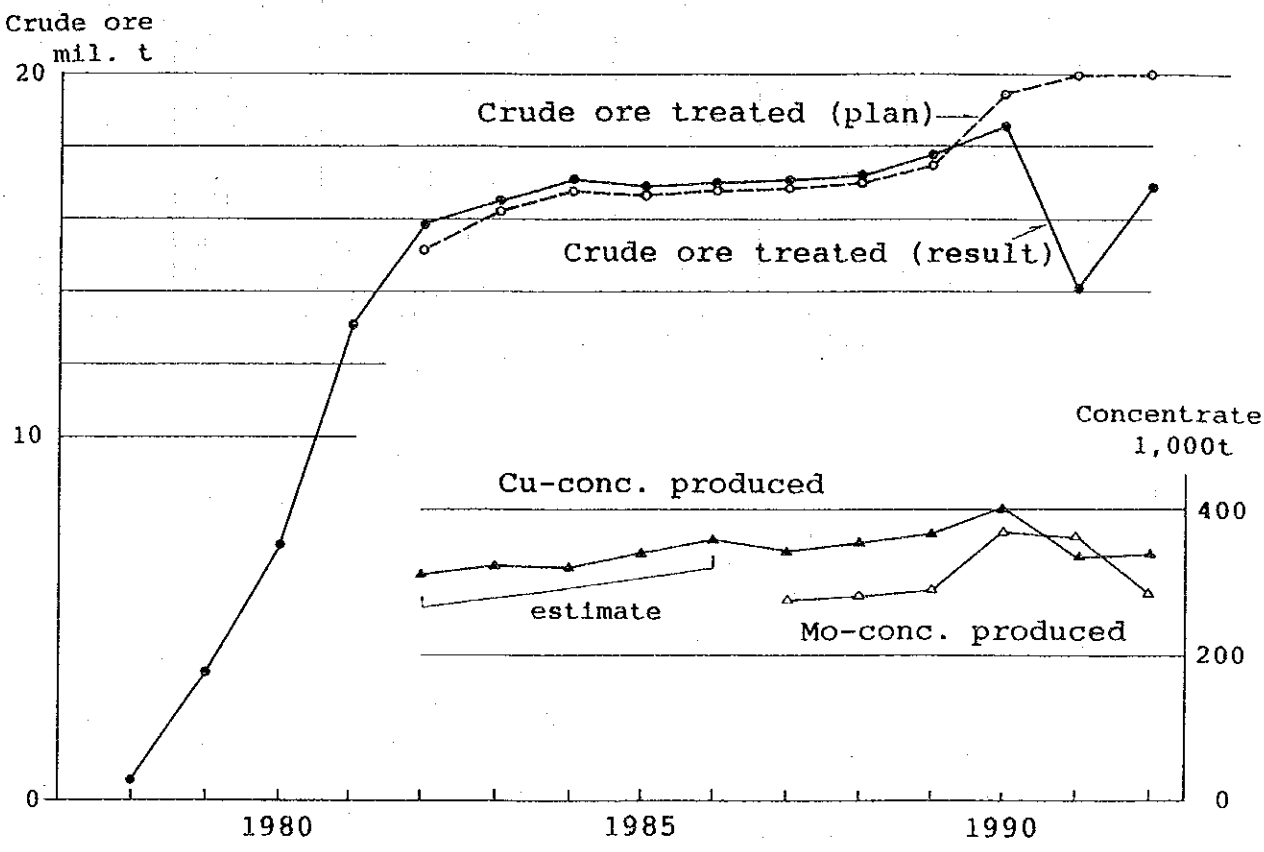


Fig. 4 Production Record

Table 6 Shipping Results by Country (unit: dry metric ton)

	1988	1989	1990	1991	1992	planned for 1993
(Copper Concentrate)						
Russia	303,153	294,416	305,250	194,755		138,000
Kazakhstan	38,559	63,572	79,070	51,786	133,382	138,000
Hungary	2,051	2,145	2,748			
Czechoslovakia	5,149	5,279	5,769		5,511	
Germany	5,114	4,910	5,701			
China			1,174	11,413	27,395	20,000
Japan		3,442	2,298	29,903	31,162	27,300
Finland		1,445				
Swiss Maastricht				4,698	34,679	
Yugoslavia				10,696		
Swiss Ulcop					124,826	40,000
Other					3,288	
Total	354,027	375,208	402,010	303,252	360,244	363,300
(Molybdenum Ore)						
Russia	2,847	2,849	3,468	2,799	1,758	
Bulgaria	80		39			
Finland					500	
Other				42	520	
Total	2,927	2,849	3,508	2,841	2,779	

(source: Erdenet mine company data)

3-5 Organization and Personnel

●The organizational chart is shown in the Figure 5.

●The president is Mongolian and the first vice-president is Russian.

The organization is firmly systematized.

—Personnel

● The number of employees is 6,574 as of November, 1992.

● Table 7 details the personnel by division and section.

As shown in Table 7, 4,339 employees (66%) are engaged in production, 2,063 (31%) personnel work in non-production sections, and there are 172 (3%) executives, including directors, charged with production control.

● Table 7 also indicates that many Russians, including engineers, have been employed in this Joint Venture: 1,805 in 1990 and 1,196 at the end of 1992. 500, and frequently as many as 1,000, Russians are newly hired annually and the number of Russian personnel fluctuates.

Erdenet City has a population of about 60,000. Supposing that the average family in the city has 5 members, 50 % of the work force is connected with the mine.

Fig. 5 Organization Chart (1)

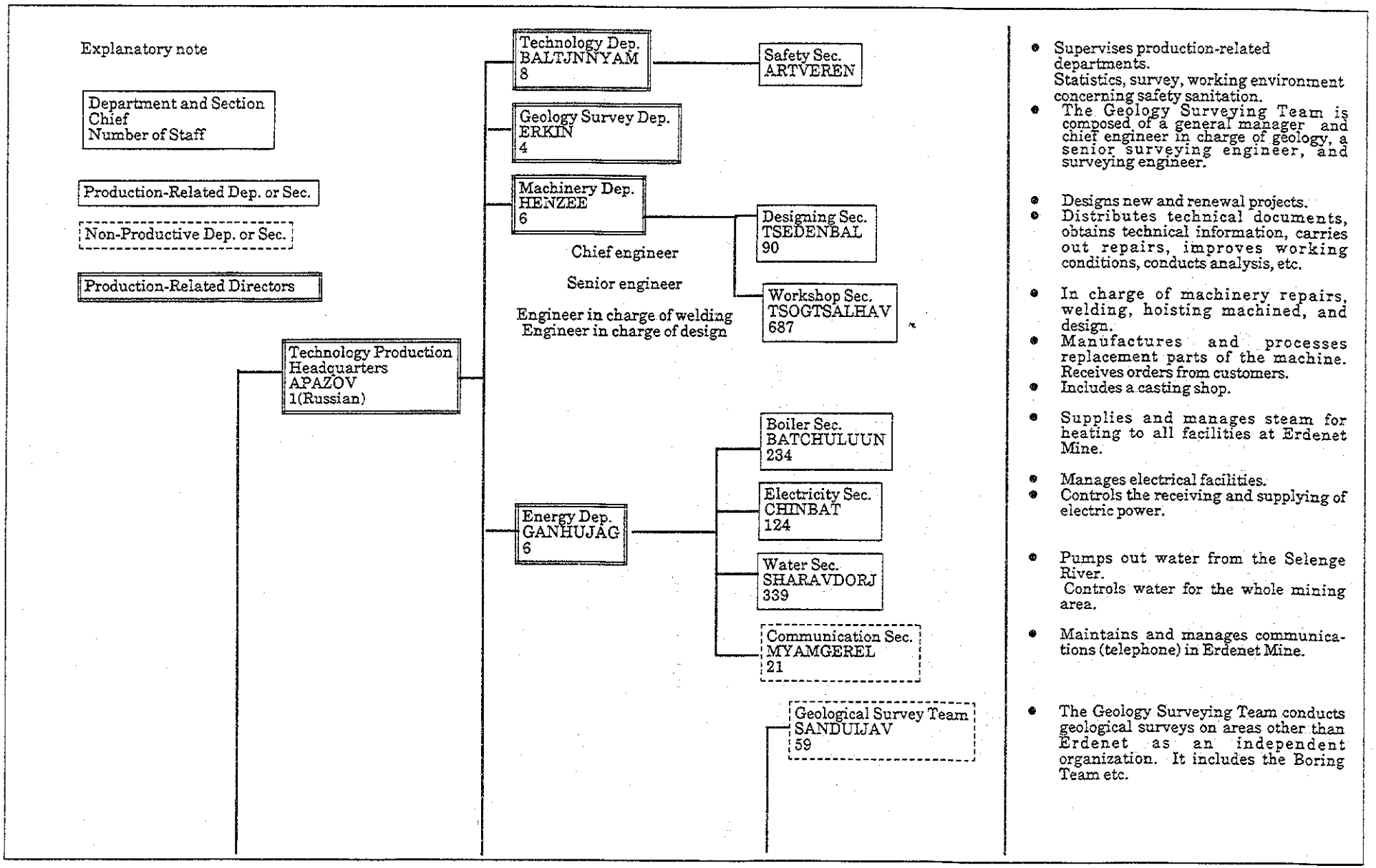


Fig. 5 Organization Chart (2)

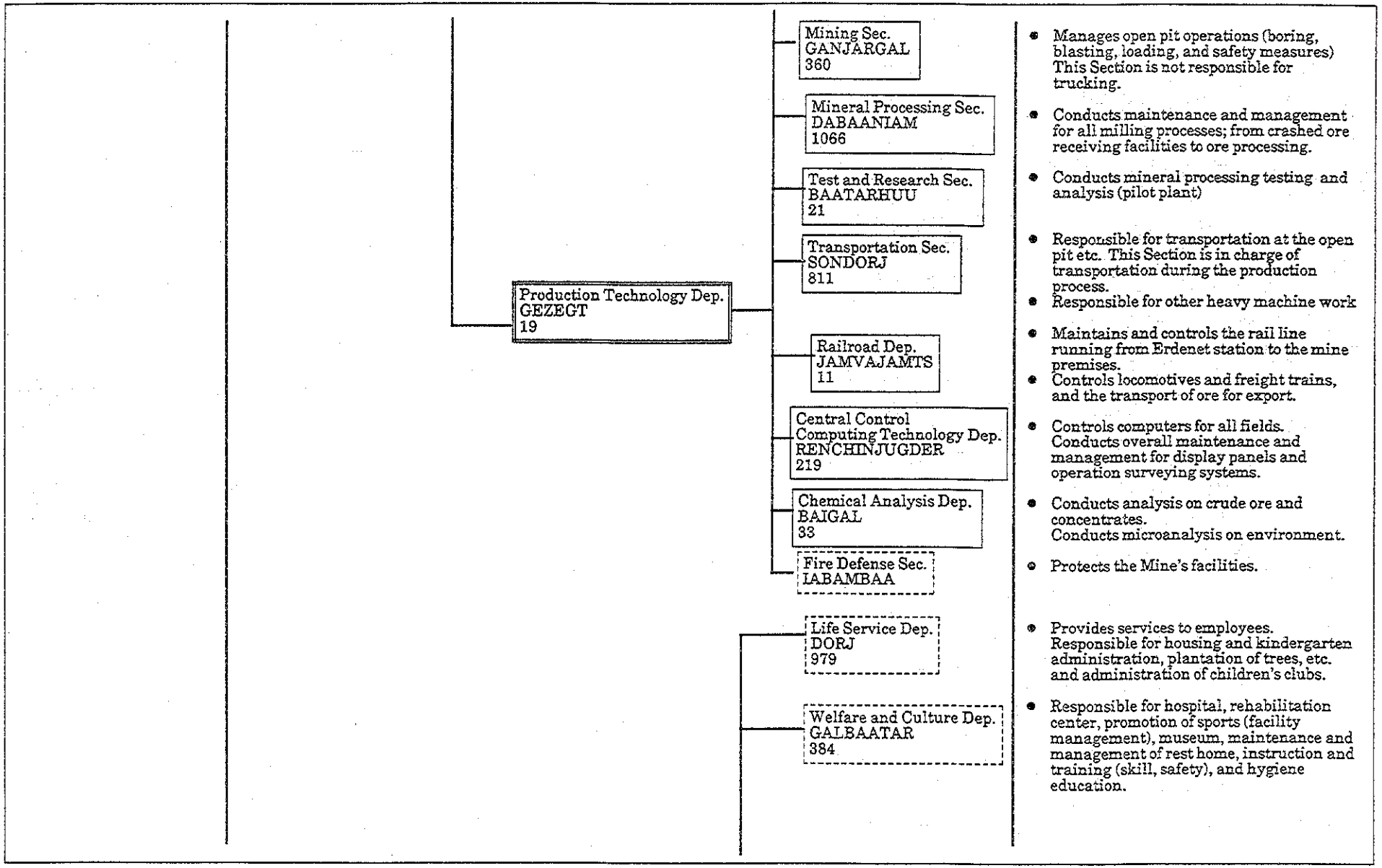


Fig. 5 Organization Chart (3)

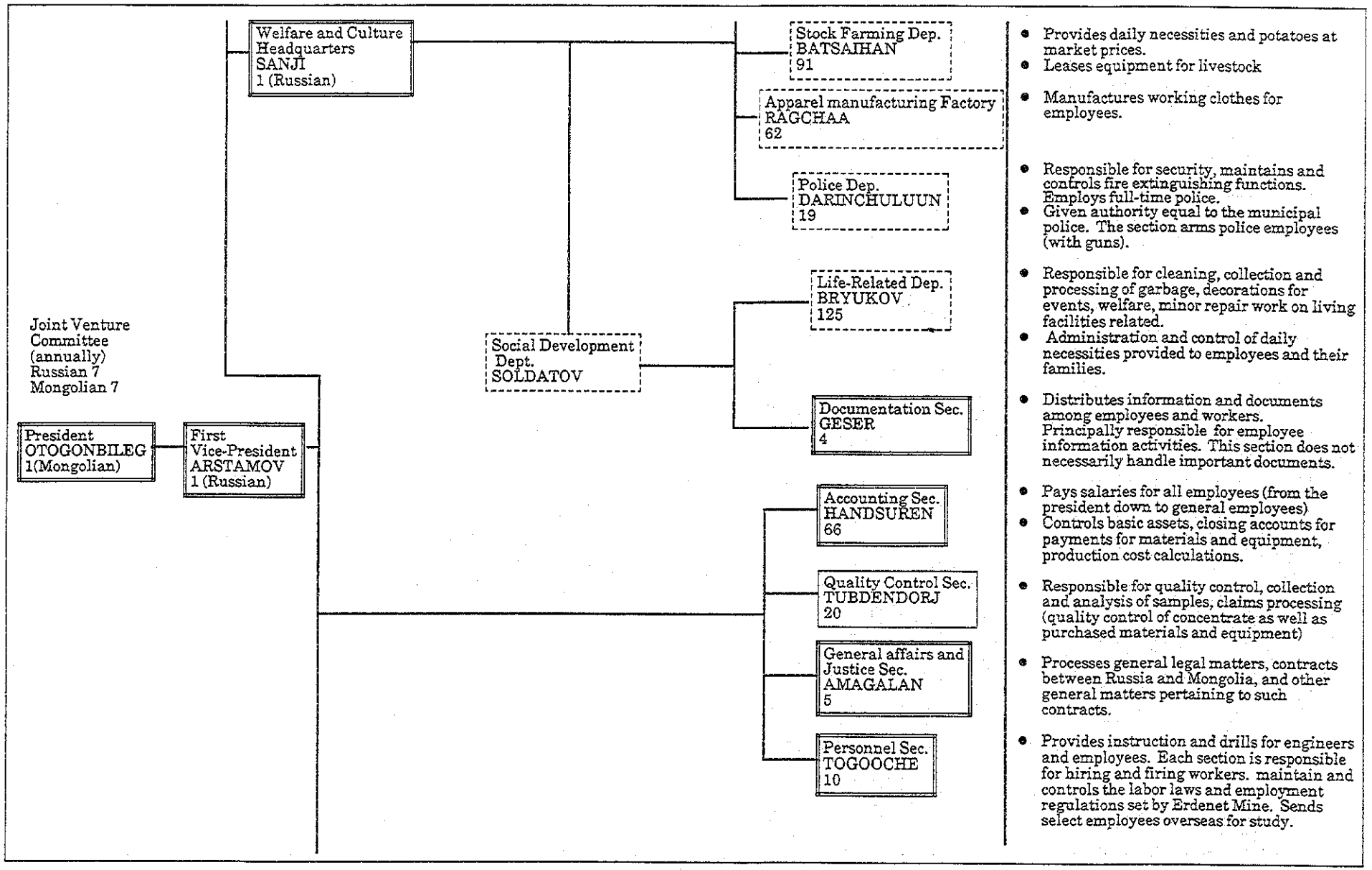
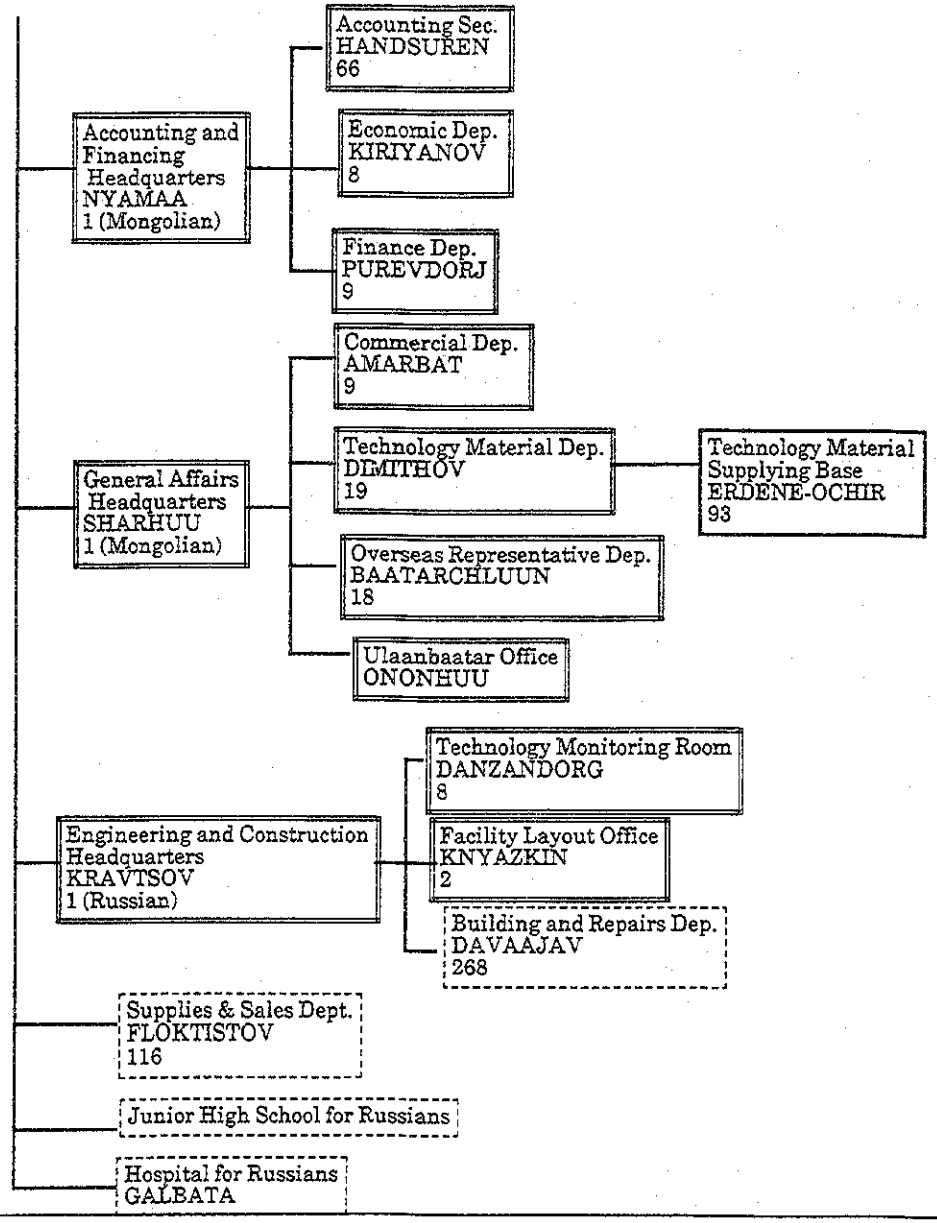


Fig. 5 Organization Chart (4)



- Directly controlled by first vice-president.
- Prepares production standards (determines targets). Prepares standard operations criteria. Sorts out and settles income earned from experts. This section incorporates the salary control and labor sections.
- Administers finance, borrowing, foreign exchange settlements, etc.
- Negotiates import and export transactions, negotiates all sales conditions, sells ordered products, such as cast products.
- Administers contracts for purchase of machinery and parts and other procurement.
- Conducts joint operations at the materials center (storage and allocation of materials)
- Controls offices located in Ulaanbaatar as well as Moscow and other foreign countries.
- Collects information and administers procurement and liaison operations for import and export procedures.
- Collects information and negotiates with the authorities concerned.
- Supervise construction standards for mining facilities, kindergartens and other structures.
- Accept and inspect imports and other goods and deploy machines.
- Construct and administer mining facilities (regardless of their size), construction machinery, electric tools.
- Employ carpenters and plasters. This section is classified into 5 departments.
- Administers hotels, Russian shop and apartment, and sells essential goods.

Table 7 Personnel by Department and Section

Dept./Section	Production-Related Dept./Sec.					Non-Productive Dept./Sec.					Gran Total	Note
	Engineers	Workers	Clerks	Scrubmen	Total	Engineers	Workers	Clerks	Scrubmen	Total		
1. Chemical Analysis Dep.	5	28			33						33	
2. Technology Material Supplying Base	6	50	24	13	93						93	
3. Mining Sec.	56	294	4	5	359	1				1	360	
4. Mineral Processing Sec.	108	918	7	27	1,060						1,060	
5. Transportation Sec.	67	678	8		753		39		19	58	811	
6. Workshop Sec.	81	556	8	42	687						687	
7. Railroad Dep.	6	62	7	2	77						77	
8. Boiler Sec.	28	194	3	9	234						234	
9. Water Sec.	51	186	5	16	258	1	80			81	339	
10. C'ral C'rol Computing Technology Dept.	78	137	1	3	219						219	
11. Electricity Sec.	49	68	2	5	124							
12. Quality Control Sec.	3	22			25						25	
13. Life Related Dep.	5	28	21	71	125						125	
14. Building & Repairs Dep.	33	195	4	10	242		24			24	266	
15. Test & Research Sec.	7	14			21						21	
16. Designing Sec.	28		1		29						29	
17. Machinery Repairs Sec.						7	83			90	90	
18. Apparel Manufacturing Factory						6	49	3	4	62	62	
19. Supplies & Sales Dep.						4	70	24	18	116	116	
20. Life Service Dep.						35	254	476	214	979	979	Recreational facilities & kindegarten workers
21. Stock Farming Dep.						6	82	1	2	91	91	including stock farm workers
22. Welfare & Culture Dep.						13	100	155	116	384	384	
23. Overseas Representative Dep.						5	5	3	5	18	18	Ulaanbaatar, Moscow, Beijing, etc.
24. Geological Survey Team						19	39	1		59	59	
25. Communication Sec.						5	16			21	21	
26. Police Dep.						7	36	35	1	79	79	
Total	611	3,430	95	203	4,339	109	877	698	379	2,063	6,402	
Staffs related to production	96	8	68		172							
(1)Directors					(7)							President, Vice-president, 5 Directors
(2)Geology Survey Dep.					(4)							
(3)Machinery Dep.					(6)							
(4)Energy Dep.					(6)							
(5)Production Technology Dep.					(19)							
(6)Accounting Sec.					(48)							
(7)Economic Dep.					(8)							Employees 6,402
(8)Technology Dep.					(8)							Staffs 172
(9)Technology Monitoring Room					(8)							Total 6,574
(10)Personnel Sec.					(10)							
(11)Technology Material Dep.					(19)							
(12)General affairs & Justice Sec.					(5)							
(13)Documentation Sec.					(4)							
(14)Facility Layout Office					(2)							
(15)Finance Dep.					(9)							
(16)Commercial Dep.					(9)							

4 Erdenet Mine Diagnostic Study Results

4. Erdenet Mine Diagonostic Study Results

4-1 Geology and Mining

4-1-1 Geology

(1) Geology and mineralization (Fig. 6)

Geology of the Erdenet mine area is composed of 1) gneiss and volcanics of Permian age, 2)intrusives of late Permian age (Selenge complex), 3)acidic porphyritic intrusives of late Permian to early Triassic age (Erdenet complex), 4) volcanics and intrusives of Triassic and Jurassic age.

Prominent geological structure, such as folding and faulting has a general trend of NW-SE.

Ore deposits of this area are porphyry type copper-molybdenum deposits, hosted principally in the Erdenet complex and partly in the Selenge complex. Mineralized zone are known in the five areas, namely North (Tsagan), North-West (Erdenetiin Oboo) Central, Central-Southeast, Southeast (Ouyut). Occurrence of the similar type mineralization is known in a few area outside of the mine area.

A thick secondary enrichment zone was developed in Erdenetiin Oboo ore body. Main constituents of ore minerals are chalcocite and chalcopyrite associated with minor amount of bornite, covellite, molybdenite and tennantite. (Fig. 7)

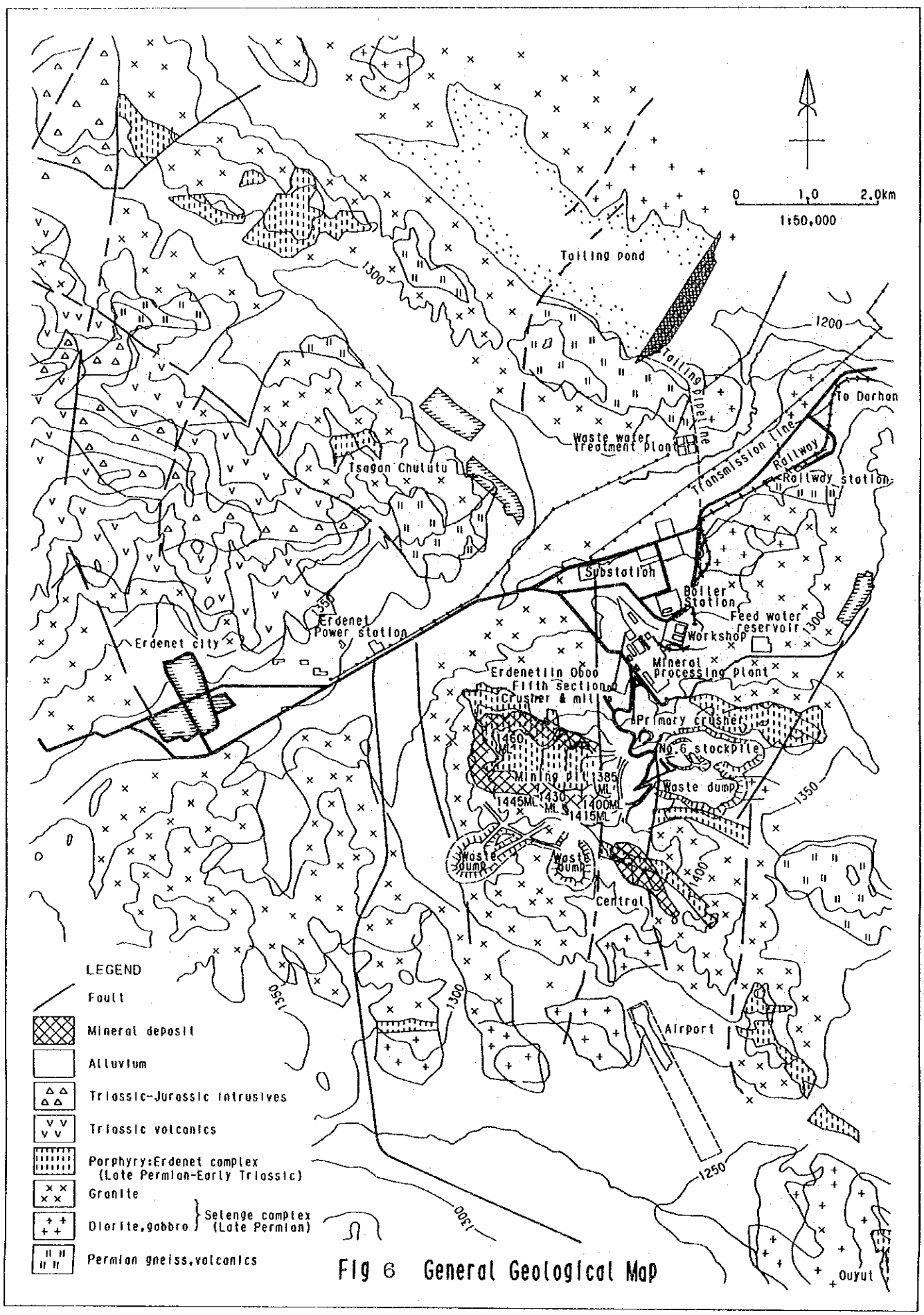


Fig 6 General Geological Map

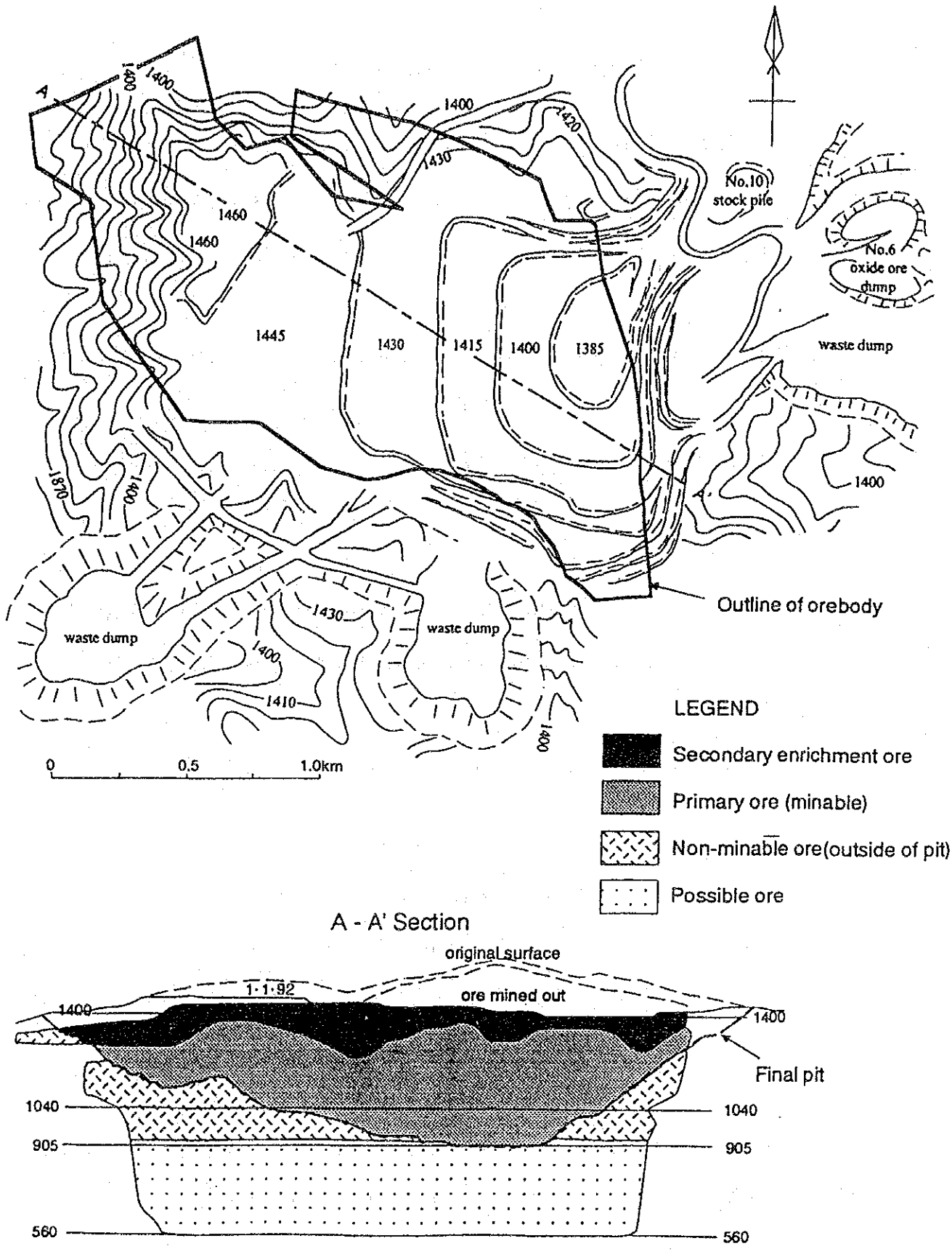


Fig 7 Plan and Section of Erdenetiin Oboo Orebody

(2) Diamond drilling in Erdenetiin Oboo (Fig. 8)

A series of diamond drill holes has been drilled along the lines of cross section (N30 E), which were preliminary designed to be perpendicular to the elongation of orebody with 125m intervals. Spacing of drill holes on the line is from 125m to 60m.

Drill cores (average core recovery is about 80%) were splitted and assayed for Cu and Mo in every one meter. Then the average grade for every 15 meters are calculated, which were used as a base data for ore reserve computation.

(3) Ore reserve estimate

The latest ore reserve estimate has been computed in 1988 for Erdenetiin Oboo orebody and Central orebody. The coming ore reserve estimate is scheduled to be done in 1995.

The basic procedure of ore reserve computation is as follows:

* Classification of ore

B ore ; Grid interval of drill holes is less than 125m

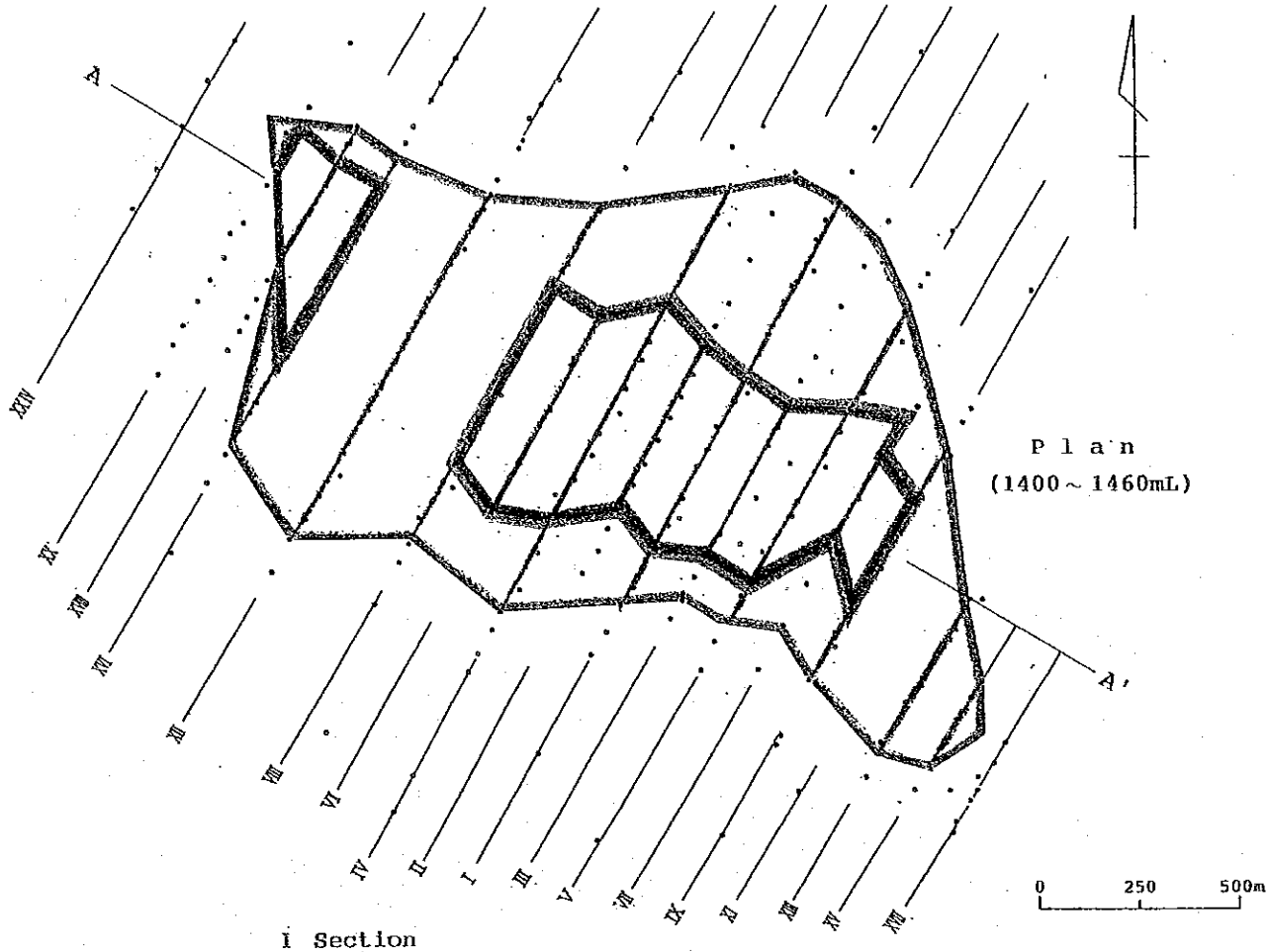
C1 ore ; Grid interval of drill holes is 125m X 250m

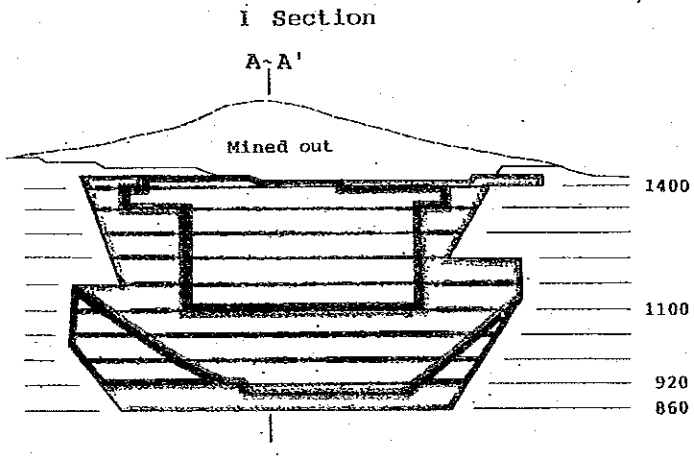
C2 ore ; Grid interval of drill holes is 250m X 250m

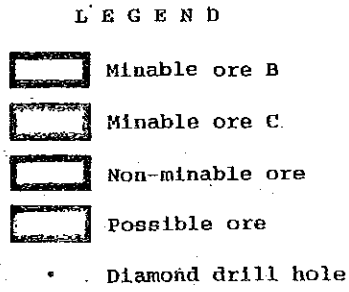
* Cut off grade

Ore reserves were computed with three kinds of out off grade (Cu 0.20%, 0.25%, 0.30%), then the cut off grade of Cu 0.25% was finally selected after comparison of the results.

* Density







A - A' Projection

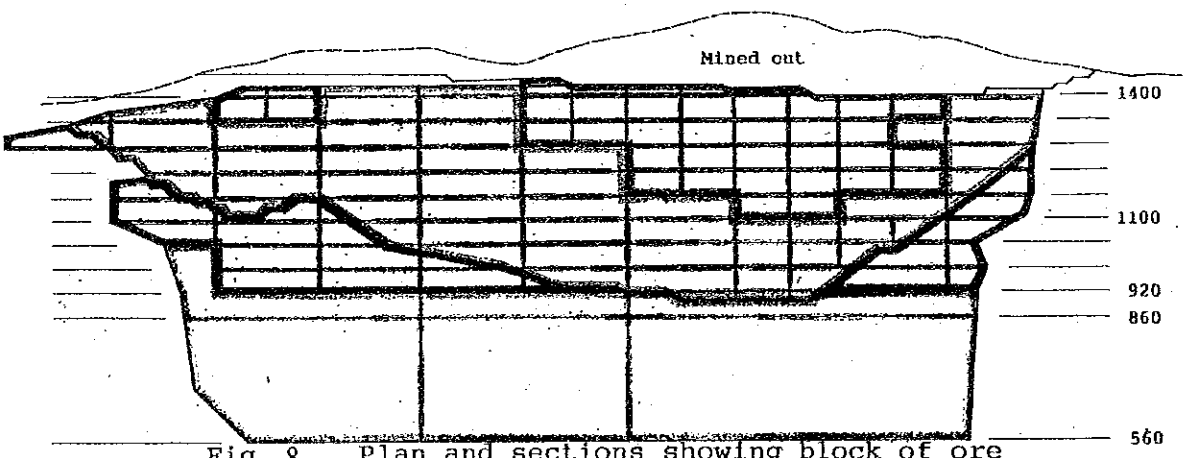


Fig. 8 Plan and sections showing block of ore for ore reserve computation

Ore ; 2.55

Waste ; 2.45

* Delineation of ore body

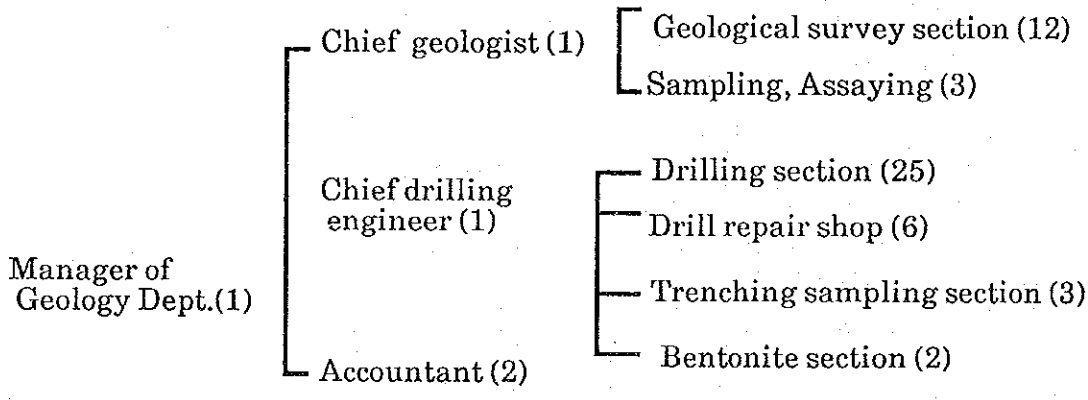
Outline of orebody was firstly delineated on the every cross sections, then it was projected to the planes of every 60 meters intervals. Every blocks of ore were classified into three (B, C1, C2) categories according to the grid interval of drill holes (Fig. 8).

* Minable ore ; Waste or low grade portions (less than Cu 0.25%) of more than 15 meters thick within orebody are deducted to calculate minable ore.

* Oxide ore ; Excluded from ore reserve computation.

Summary of ore reserves calculated by the above described procedure is shown in Table 8 and 9.

(4) Organization of Geology Department



(5) Work program of Geology Department

Past record and middle term work program of Geology Department is shown in Table 10.

Detail diamond drilling for Erdenetiin Oboo has almost completed and an emphasis of the future exploration will be laid on Zelter coal mine and Khu limestone mine.

* Zelter coal mine

The mine, located near the border of Russia north of Erdenet, is supplying 300,000 t/y of coal to Erdenet mine. Expansion of the mine aiming to produce 1,200,000 t/y of coal is being planned.

*Khu Tul limestone mine

The mine, located in the west of Darhan, is producing 60,000 t/y of limestone. A plan to produce cement (300,000 t/y) is being prepared.

Table 8 Summary of Ore Reserves

Area	Cut off grade	Tonnage (1,000t)		% Cu	% Mo
North (Tsagan Chulutu)		not estimated			
North-West (Erdentiin Oboo)	0.25	Minable B	414,432	0.63	0.017
		Minable C1	1,125,819	0.48	0.014
		Minable C2	3,646	0.43	0.010
		Minable Total	1,543,897	0.52	0.014
		Non-Minable ore	531,456	0.32	0.011
		Sub-total	2,075,353	0.47	0.013
	0.20	Possible ore	478,367	0.39	0.011
		Total	2,553,720	0.52	0.015
Central	0.25		154,000	0.44	0.019
Central-Southeast		not estimated			
Southeast(Ouyut)		Potential	98,000	0.32	0.007

Table 9 Ore Reserves of Erdenetiin Oboo 1988.1.7

				Ore Reserve I					Ore Reserve II				
				B	C1	B+C1	C2	Total	B	C1	B+C1	C2	Total
Minable ore	Minable ore A		1000t	54,865	0	54,865	0	54,865	50,305	0	50,305	0	50,305
		Cu	%	0.816	0.000	0.816	0.000	0.816	0.881	0.000	0.881	0.000	0.881
		Mo	%	0.014	0.000	0.014	0.000	0.014	0.014	0.000	0.014	0.000	0.014
		Cu	1000t	448	0	448	0	448	443	0	443	0	443
		Mo	t	7,681	0	7,681	0	7,681	7,270	0	7,270	0	7,270
	Minable ore B		1000t	43,296	89,400	132,696	0	132,696	38,219	66,540	104,759	0	104,759
		Cu	%	0.760	0.656	0.690	0.000	0.690	0.821	0.786	0.799	0.000	0.799
		Mo	%	0.015	0.012	0.013	0.000	0.014	0.016	0.014	0.015	0.000	0.015
		Cu	1000t	329	587	916	0	916	314	523	837	0	837
		Mo	t	6,682	10,929	17,611	468	18,079	6,214	9,119	15,333	0	15,333
	Minable ore C		1000t	349,564	1,255,038	1,604,602	4,634	1,609,236	325,908	1,059,279	1,385,187	3,646	1,388,833
		Cu	%	0.546	0.419	0.447	0.371	0.447	0.572	0.462	0.488	0.425	0.488
		Mo	%	0.016	0.013	0.014	0.010	0.014	0.017	0.014	0.015	0.010	0.014
		Cu	1000t	1,908	5,262	7,170	17	7,187	1,866	4,895	6,760	16	6,776
		Mo	t	57,158	160,987	218,145	468	218,613	55,242	145,622	200,864	372	201,236
	Total		1000t	447,725	1,344,438	1,792,163	4,634	1,796,797	414,432	1,125,819	1,540,251	3,646	1,543,897
		Cu	%	0.600	0.435	0.476	0.371	0.476	0.633	0.481	0.522	0.425	0.522
		Mo	%	0.016	0.013	0.014	0.020	0.014	0.017	0.014	0.015	0.010	0.014
		Cu	1000t	2,685	5,848	8,533	17	8,550	2,623	5,418	8,041	16	8,056
		Mo	t	71,521	171,916	243,437	936	244,373	68,726	154,741	223,467	372	223,839
Non-minable ore	Non-minable ore A		1000t	0	700	700	0	700	0	265	265	0	265
		Cu	%	0.000	0.400	0.400	0.000	0.400	0.000	0.642	0.642	0.000	0.642
		Mo	%	0.000	0.009	0.009	0.000	0.009	0.000	0.013	0.013	0.000	0.013
		Cu	1000t	0	3	3	0	3	0	2	2	0	2
		Mo	t	0	61	61	0	61	0	35	35	0	35
	Non-minable ore B		1000t	0	556,831	556,831	52,140	608,971	0	485,438	485,438	45,753	531,191
		Cu	%	0.000	0.299	0.299	0.326	0.301	0.000	0.320	0.320	0.349	0.322
		Mo	%	0.000	0.010	0.010	0.012	0.010	0.000	0.011	0.011	0.012	0.011
		Cu	1000t	0	1,664	1,664	170	1,834	0	1,551	1,551	160	1,711
		Mo	t	0	57,513	57,513	6,178	63,691	0	51,735	51,735	5,492	57,227
	Total		1000t	0	557,531	557,531	52,140	609,671	0	485,703	485,703	45,753	531,456
		Cu	%	0.000	0.299	0.299	0.326	0.301	0.000	0.320	0.320	0.349	0.322
		Mo	%	0.000	0.010	0.010	0.012	0.010	0.000	0.011	0.011	0.012	0.011
		Cu	1000t	0	1,666	1,666	170	1,837	0	1,553	1,553	160	1,713
		Mo	t	0	57,574	57,574	6,178	63,752	0	51,770	51,770	5,492	57,262
Possible ore	Possible ore A		1000t	0	0	0	155,824	155,824	0	0	0	111,910	111,910
		Cu	%	0.000	0.000	0.000	0.307	0.307	0.000	0.000	0.000	0.366	0.366
		Mo	%	0.000	0.000	0.000	0.012	0.012	0.000	0.000	0.000	0.014	0.014
		Cu	1000t	0	0	0	478	478	0	0	0	410	410
		Mo	t	0	0	0	17,927	17,927	0	0	0	15,158	15,158
	Possible ore B		1000t	0	0	0	563,893	563,893	0	0	0	366,457	366,457
		Cu	%	0.000	0.000	0.000	0.302	0.302	0.000	0.000	0.000	0.391	0.391
		Mo	%	0.000	0.000	0.000	0.009	0.009	0.000	0.000	0.000	0.010	0.010
		Cu	1000t	0	0	0	1,702	1,702	0	0	0	1,432	1,432
		Mo	t	0	0	0	53,491	53,491	0	0	0	36,870	36,870
	Total		1000t	0	0	0	719,717	719,717	0	0	0	478,367	478,367
		Cu	%	0.000	0.000	0.000	0.303	0.303	0.000	0.000	0.000	0.385	0.385
		Mo	%	0.000	0.000	0.000	0.010	0.010	0.000	0.000	0.000	0.011	0.011
		Cu	1000t	0	0	0	2,181	2,181	0	0	0	1,842	1,842
		Mo	t	0	0	0	71,418	71,418	0	0	0	52,028	52,028
Gland total			1000t	447,725	1,901,969	2,349,694	776,491	3,126,185	414,432	1,611,522	2,025,954	527,766	2,553,720
		Cu	%	0.600	0.395	0.434	0.562	0.466	0.633	0.433	0.474	0.698	0.520
		Mo	%	0.016	0.012	0.013	0.018	0.014	0.017	0.013	0.014	0.020	0.015
		Cu	1000t	2,685	7,515	10,200	4,361	14,561	2,623	6,971	9,593	3,684	13,278
		Mo	t	71,521	229,490	301,011	142,836	443,847	68,726	206,511	275,237	104,056	379,293

Minable ore A: Surface～1430mL
Minable ore B: 1430mL～1400mL
Minable ore C: 1400mL～905mL
Non-minable ore A: Low grade (0.2～0.4%)
Surface～1400mL
Non-minable ore B: Outside of rit (over0.2%)
Possible ore A: 905mL～860mL (over0.2%)
Possible ore B: 860mL～560m+ (over0.2%)

Ore Reserve I : Ore reserve including inside waste
Ore Reserve II : Ore reserve excluding inside waste above 5m thick
B ore : Grid interral of drill hole is 125mx625～125m
C1 ore : Grid interral of drill hole is 125mx250m
C2 ore : Grid interral of drill hole is 250mx250m

Table 10 Work Program of Geology Department

Item	Unit	1991			1992			1993	1994	1995
		Plan	Result	Ratio	Plan	Result	Ratio	Plan	Plan	Plan
Detail drilling	m	4,700	5,151	109.6	5,100	5,116	100.3	0	0	5,000
	Tg	4,000	4,295	107.4	5,500	4,000	72.7	0	0	10,000
Drilling new	m	7,000	7,086	101.2	360	365	101.4	0	2,500	1,500
deposits	Tg	3,000	3,090	103.0	500	300	60.0	0	5,000	3,000
Coal mine	m	0	0		1,740	1,440	82.8	6,000	6,000	6,000
drilling	Tg	0	0		5,500	4,805	87.4	12,000	12,000	12,000
Coal mine	m	0	0		0	0		1,500	1,500	1,500
Stripping	Tg	0	0		0	0		3,000	3,000	3,000
Limestone	m	0	0		0	0		2,500	2,000	1,000
drilling	Tg	0	0		0	0		5,000	4,000	2,000
Soil exploration	m	0	0		0	0		500	0	0
	Tg	0	0		0	0		1,000	0	0
Total	m	11,700	12,237	104.6	7,200	6,921	96.1	10,500	12,000	15,000
	Tg	7,000	7,385	105.5	11,500	9,105	79.2	21,000	24,000	30,000

m: drill length in meter
Tg: 1000Tug

4-1-2 Mining

(1) Present situation

1.93 mil. tones (Cu 0.82%) of crude ore have been mined since the commencement of mining operation in 1975. High grade secondary enrichment ore has been mined to date. In the future, however, as the ratio of primary ore to the secondary enrichment ore will increase, the grade of crude ore will be presumed to decrease considerably.

Elevation of the present mining bench is 1460mL at the top and 1370m at the bottom. Seven benches of 15m height with 50° to 60° working bench slope have been set out for mining operation. The size of the present pit is about 2.5km in the long axis (east to west) and 1.5km in the short axis (north to south) which correspond to 90% of the final pit. Therefore, the present pit has an enough lateral extent against the depth (Fig. 7). Present operating pit has a very gentle slope with approximately 17°.

(2) Final pit

According to the long range mining program prepared by Erdenet mine in 1990, the final pit will be 2.8km × 1.6km in a lateral extent with 1040mL at the bottom. 15 benches will be set out for the pit depth of 225m at 15m bench interval. The final pit slope is 30° (Fig. 9).

(3) Stability of final pit

An analysis to predict the stability of the final pit has been conducted along the long axis of ore body (AA' section of Fig. 9).

Rocks properties for stability analysis are shown in Table 11.

Table 11 Rocks properties

	Density (ton/m^3)	Viscosity (kg/cm^2)	Angle of Internal Friction (°)
Weathered rock	2.50	0.000	46.00
Secondary enrichment ore	3.24	1.890	48.25
Primary ore	2.82	0.469	43.25

The result of the analysis is shown in Fig. 10 and 11, in which a possible land slide may occur in the section where safety factor is less than 1.2. In the south-east side of the pit a small and local land slide may occur in weathered zone but it is not fatal. In the north-west side of the pit, the pit as a whole is also stable and no land slide is expected.

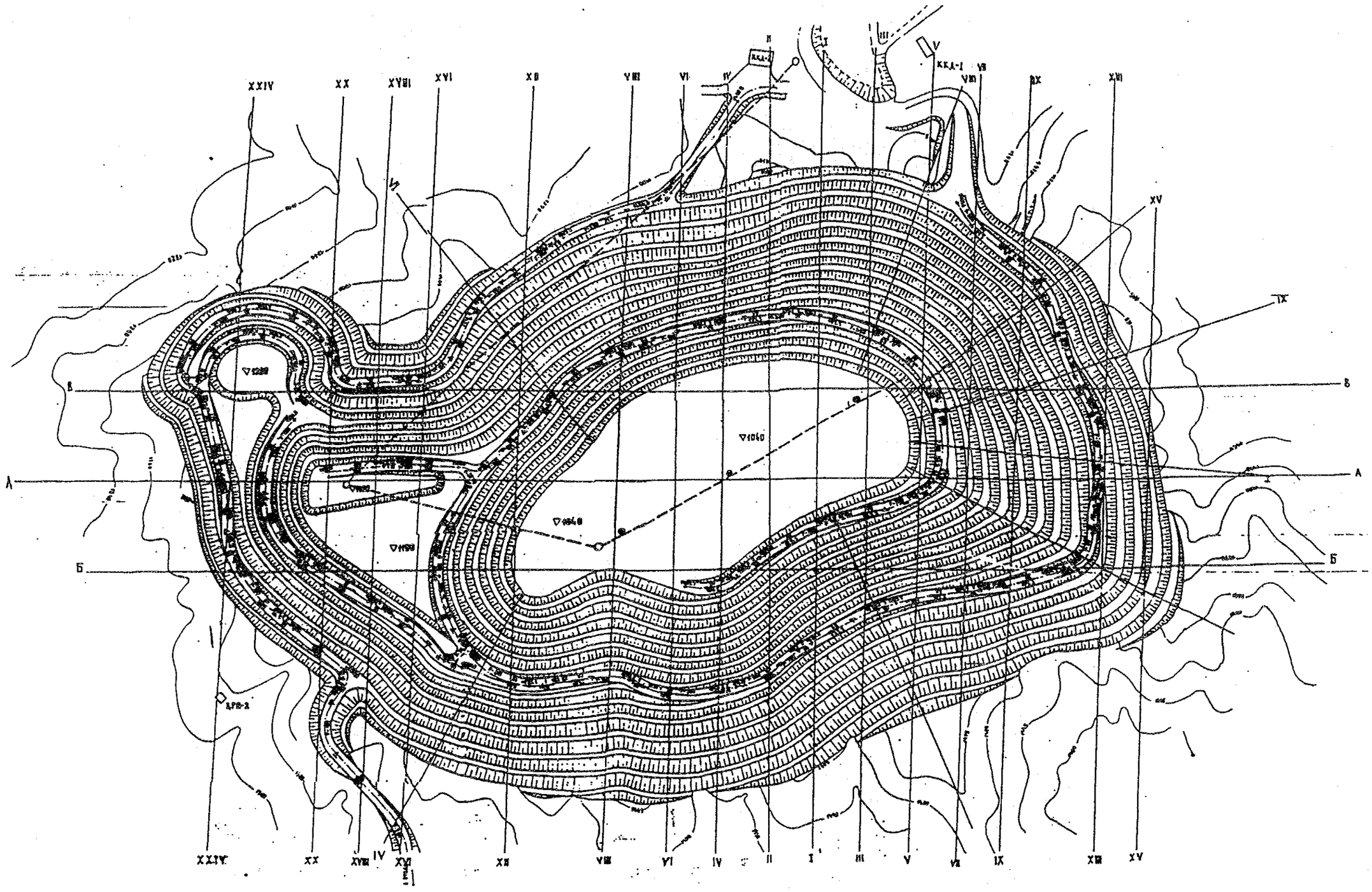


Fig 9 Final Pit Design

Note:weathered rock secondary enrichment ore primary ore

parts of possible land-slide to be occured underground water level

LAYER	DENSITY (g/cm3)	COHESION (MPa)	FRICTION ANGLE(DEG.)
WEATHERED	2.50	0.00	46.00
PRIMARY	2.82	4.78	43.25

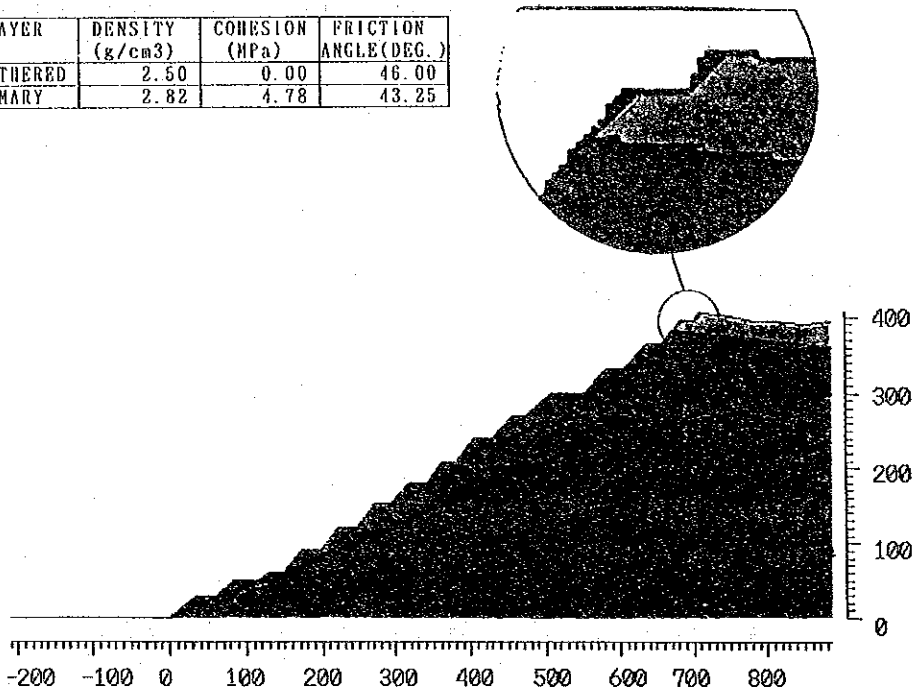


Fig 10 sectional southeast side of the pit

LAYER	DENSITY (g/cm3)	COHESION (MPa)	FRICTION ANGLE(DEG.)
WEATHERED	2.50	0.00	46.00
SECONDARY	3.24	19.29	48.25
PRIMARY	2.82	4.78	43.25

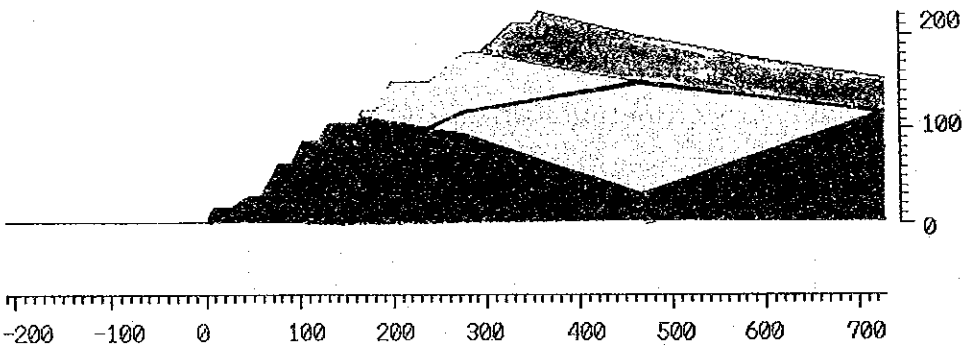


Fig 11 sectional northwest side of the pit

4-1-3 Production control

(1) Mining operation

Working time is three shifts a day, seven days a week and 365 days a year. The working hour is 8:00 to 16:00 in the first shift, 16:00 to 24:00 in the second shift and 0 to 8:00 in the third shift.

(2) Mine production

Mine production since the commencement of the mine operation is shown in Table 12. Tonnage of ore output and waste excavation has gradually increased until 1990. In 1991, however, mine production has rapidly decreased to 66.8% in ore output and 56.5% in waste excavation compared to the original plan. In 1992, the actual ore output was 84.4% and waste excavation was 43.4% to the original plan, that means the waste excavation was sacrificed to recover shortage of ore output.

Table 13 shows the detail of ore output. The grade of mill feed was the highest (Cu 0.896%) in 1983, then decreased gradually. This is due to that the ratio of primary ore to the secondary enrichment ore was increasing. The ratio of the primary ore is presumed to exceed 50% in 2004 or 2005. Table 14 shows the tonnage and grade of ore output in plan and result. In this table, by 1989 the actual tonnage of ore output has exceeded the level of plan and the actual grade of ore was about the same to the planned level. On the contrary, in the three years from 1990 the actual tonnage did not reach the planned level and the grade of ore was well above the planned grade which might means the high grade ore was intentionally mined to recover shortage of ore output.

Table 12 Result of Mining Production

year	waste stripped		ore mined		total		comparison(R/P)			strip ratio	
	plan(P)	result(R)	P	R	P	R	waste	ore	total	P	R
'75～'77	0	25,063	0	519	0	25,573					
1978	950	1,095	459	474	1,400	1,559	115.2	103.2	111.3	2.1	2.3
1979	5,070	6,938	3,193	3,730	8,200	10,595	136.8	116.8	129.2	1.6	1.9
1980	9,920	12,183	6,202	7,275	16,000	19,315	122.8	117.3	120.7	1.6	1.7
1981	13,300	14,284	11,098	13,331	24,180	27,353	107.4	120.1	113.1	1.2	1.1
1982	12,775	13,060	15,274	16,259	27,750	29,000	102.2	106.4	104.5	0.8	0.8
1983	12,500	13,500	16,320	16,830	28,500	30,000	108.0	103.1	105.3	0.8	0.8
1984	13,500	15,022	16,830	17,516	30,000	32,195	111.3	104.1	107.3	0.8	0.9
1985	14,300	14,638	17,034	17,289	31,000	31,588	102.4	101.5	101.9	0.8	0.8
1986	14,500	15,161	17,340	17,383	31,500	32,203	104.6	100.2	102.2	0.8	0.9
1987	15,150	15,583	16,932	16,958	31,750	32,208	102.9	100.2	101.4	0.9	0.9
1988	15,200	15,451	17,442	17,623	32,300	32,728	101.6	101.0	101.3	0.9	0.9
1989	16,020	16,172	18,085	18,143	33,750	33,959	100.9	100.3	100.6	0.9	0.9
1990	15,883	16,170	19,500	19,263	35,000	35,055	101.8	98.8	100.2	0.8	0.8
1991	17,393	9,832	20,000	13,308	37,000	22,879	56.5	66.5	61.8	0.9	0.7
1992	15,393	6,680	20,000	16,876	35,000	23,225	43.4	84.4	66.4	0.8	0.4

Table 13 Prodution Detail

year	Total Production			Feed ore to Plant			Stocked ore (No.10)			Stocked ore (No.6)		
	amount (1,000t)	grade (Cu%)	grade (Mo%)	amount (1,000t)	grade (Cu%)	grade (Mo%)	amount (1,000t)	grade (Cu%)	grade (Mo%)	amount (1,000t)	grade (Cu%)	grade (Mo%)
'75～'77	519			58								
1978	474	0.680	0.0160	386	0.710	0.0160				78	0.570	0.0160
1979	3,730	0.800	0.0179	3,225	0.840	0.0183				432	0.536	0.0154
1980	7,275	0.850	0.0180	6,656	0.850	0.0180	320	0.927	0.0180	156	0.776	0.0150
1981	13,331	0.790	0.0165	11,965	0.800	0.0164	396	0.798	0.0170	708	0.980	0.0191
1982	16,259	0.862	0.0176	13,300	0.857	0.0178	1560	0.860	0.0175	1080	0.939	0.0160
1983	16,830	0.893	0.0157	14,600	0.896	0.0156	1900	0.863	0.0166			
1984	17,516	0.889	0.0154	15,083	0.890	0.0154	2090	0.882	0.0154			
1985	17,289	0.877	0.0154	15,435	0.870	0.0154	1515	0.940	0.0151			
1986	17,383	0.869	0.0163	15,999	0.869	0.0169	1043	0.950	0.0166			
1987	16,958	0.865	0.0162	16,328	0.865	0.0162	298	0.885	0.0205			
1988	17,623	0.872	0.0168	17,176	0.866	0.0162	101	0.191	0.1190			
1989	18,143	0.863	0.0171	17,788	0.863	0.0171						
1990	19,263	0.809	0.0213	18,670	0.820	0.0214	591	0.477	0.0177			
1991	13,308	0.834	0.0219	12,754	0.844	0.0219	556	0.601	0.0227			
1992	16,876	0.791	0.0198	16,609	0.791	0.0198	267	0.748	0.021			

Table 14 Comparison of Plan with Result for Output

year	plan			result			comparison		
	output (1,000t)	Cu grade	Mo grade	output (1,000t)	Cu grade	Mo grade	output (1,000t)	Cu grade	Mo grade
'75～'77	0	(%)	(%)	519	(%)	(%)		(%)	(%)
1978	459	0.670	0.0130	474	0.680	0.0160	103.17	101.49	123.08
1979	3,193	0.830	0.0110	3,730	0.800	0.0179	116.85	96.39	162.73
1980	6,202	0.825	0.0130	7,275	0.850	0.0180	117.30	103.03	138.46
1981	11,098	0.785	0.0139	13,331	0.790	0.0165	120.12	100.64	118.71
1982	15,274	0.846	0.0151	16,259	0.862	0.0176	106.44	101.89	116.56
1983	16,320	0.894	0.0155	16,830	0.893	0.0157	103.13	99.89	101.29
1984	16,830	0.894	0.0154	17,516	0.889	0.0154	104.08	99.44	100.00
1985	17,034	0.881	0.0152	17,289	0.877	0.0154	101.50	99.55	101.32
1986	17,340	0.869	0.0160	17,383	0.869	0.0163	100.25	100.00	101.87
1987	16,932	0.865	0.0162	16,958	0.865	0.0162	100.15	100.00	100.00
1988	17,442	0.866	0.0162	17,623	0.872	0.0168	101.04	100.69	103.70
1989	18,085	0.860	0.0156	18,143	0.863	0.0171	100.32	100.35	109.62
1990	19,500	0.778	0.0169	19,263	0.809	0.0213	98.78	103.98	126.04
1991	20,000	0.768	0.0152	13,308	0.834	0.0219	66.54	108.59	144.08
1992	20,000	0.767	0.0205	16,876	0.791	0.0198	84.38	103.13	96.59

Table 15 shows the detail of waste excavation. From 1980 to 1990 waste excavation has been intensively performed in advance of mining. Amount of waste excavation, however, has been sharply decreased from 1991 as mentioned above. Present situation of the mining pit is still good condition owing to the extensive excavation which had been done previously. To maintain waste excavation in advance of mining is very important in long range mining operation. The ratio of waste contamination and the ratio of ore rejection are stable, which are about 5.90% and 3.20% respectively (Table 16).

(3) Control of ore output grade

The following procedure is being carried out to control the grade of ore output.

①Every two sludge samples, one from the collar to 7.5m and another from 7m to the bottom of blast hole are taken. Then the sludge sample is reduced to 250g by quartering.

②Total Cu, Mo and oxide Cu are analyzed.

③Blasted ore are classified into three groups, low grade ore (Cu $<$ 0.25%), medium grade ore (Cu 0.25 to 0.5%) and high grade ore (Cu $>$ 0.5%).

④Put up a flag on the blasted ore pile to show the grade of ore.

⑤Number of hauling trucks to each pile is properly assigned, so that the average grade of ore output is maintained at the planned level.

The aforementioned procedure to control the grade of output ore is usually adopted in a large scale open pit mine. Fig. 12 shows the comparison between mine site sample assay and mill feed sample assay. Correlation coefficient

Table 15 Waste Detail

year	Total Amount (1,000t)	Low grde Stock-ore (1,000t)	Waste (1,000t)	Remark
'75～'77	25,063			no stock-ore
1978	1,095			no stock-ore
1979	6,938	605	6,333	
1980	12,183	1,648	10,535	
1981	14,284	986	13,298	
1982	13,060	1,186	11,874	
1983	13,500	1,865	11,635	
1984	15,022	2,111	12,911	
1985	14,638	2,608	12,030	
1986	15,161	2,608	12,553	
1987	15,583	3,149	12,434	
1988	15,451	3,604	11,847	
1989	16,172	1,937	14,235	
1990	16,170	3,798	12,373	
1991	9,832	2,343	7,489	
1992	6,680	2,947	3,733	

Table 16 Result of Dilution

Item	unit	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
① ore mined	×1000t	98	537	3,889	7,132	13,069	15,819	16,361	16,885	16,632	16,687	16,245	16,863	17,332	18,729	12,939	16,391
②ore in pro.	×1000t	91	495	3,631	6,677	12,311	14,987	15,547	16,153	15,950	16,037	15,644	16,275	16,747	18,130	12,525	15,875
③ore in waste	×1000t	8	41	258	455	758	832	814	732	682	650	601	588	585	599	414	516
④waste in pro.	×1000t	31	125	257	455	758	953	953	1,020	1,000	1,005	981	1,002	1,041	1,132	785	1,000
⑤total pro.	×1000t	122	621	3,888	7,132	13,069	15,940	16,500	17,173	16,950	17,042	16,625	17,277	17,788	19,261	13,310	16,875
⑥ feed ore	×1000t	122	444	3,225	6,656	11,965	13,300	14,600	15,083	15,435	15,999	16,328	17,176	17,788	18,670	12,754	16,609
⑦stocked ore	×1000t	0	177	663	476	1,104	2,640	1,900	2,090	1,515	1,043	298	101	0	591	556	267
⑧ dilution	%	25.26	20.19	6.62	6.38	5.80	5.98	5.78	5.94	5.90	5.90	5.90	5.80	5.85	5.87	5.90	5.93
⑨deseted ratio	%	7.64	7.69	6.64	6.38	5.80	5.26	4.98	4.34	4.10	3.90	3.70	3.49	3.37	3.20	3.20	3.15

注) ①=②+③ ⑤=⑥+⑦ ②=⑤-④ ⑧=④/⑤ ⑨=③/①

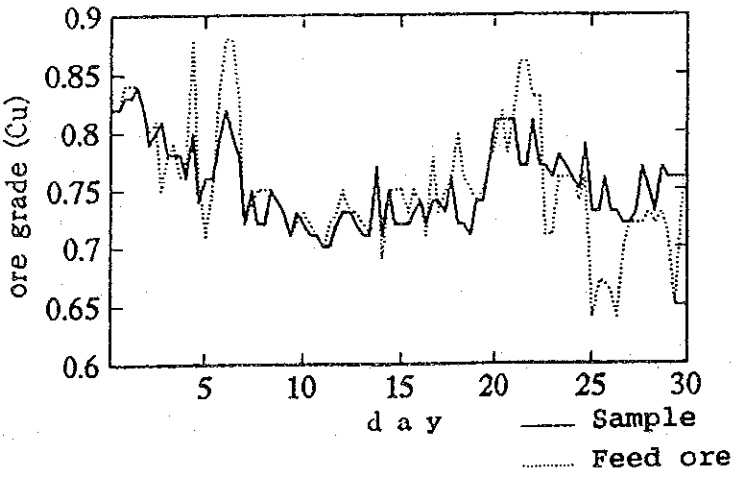


Fig 12 Grade of Sample & Grade of Feed ore

between two assays is 0.70. Considerable fluctuation of the ore grade by shift can be seen.

(4) Heavy machineries

①Rotary drill

Five rotary drills are working in the mine. Specification of the drill is shown in Table 17. Service life of the rotary drill was 7 years which has been altered to 4.16 years. Periodical check up or overhaul become difficult to be done and costly due to shortage of spare parts. This is a probable reason of shortening the service life. Electric power of 400V is used for drill. Specification and service life of bits is shown in Table 18.

Table 19 shows the summary of drill operation for the past five years. Total drilling length, which was constantly increased up to 1990 has dropped 37% in 1991. Working efficiency has dropped from 74.7% to 59.9% in 1991 and to 49.6% in 1992. The drop of efficiency in 1991 was mainly caused by power stoppage. In 1992, the repair time has remarkably increased, that is probably due to shortage of spare parts.

②Power shovel

Seven power shovels of which capacity is 4.6m^3, 8.0m^3 and 10.0m^3 are working in the mine. Table 20 shows the specification of power shovels.

Service life of power shovel was previously 16.6 years which was recently altered to 8.3 years. The reason of this alteration is probably the same to the case of rotary drill. Capacity of the shovel is adequate with 110t truck which will be replacing 40t truck in the future.

Table 17 Specification for Rotary Drill

No.	maker	type	year purchased	drill hole diameter	power	drilling depth	drilling speed	rotation	drilling angle	moving speed	climbing angle
				mm	kw	m	cm/min.	rpm		km/h	
1	VORONEJSKI	SBSH-250	1986	250	400	32	16	0～152	60° 75° 90	0.77	12°
2	〃	〃	1987	〃	〃	〃	〃	〃	〃	〃	〃
3	〃	〃	1988	〃	〃	〃	〃	〃	〃	〃	〃
4	〃	〃	1988	〃	〃	〃	〃	〃	〃	〃	〃
5	〃	〃	1989	〃	〃	〃	〃	〃	〃	〃	〃

Table 18 Specification for Drillbit

Item	maker	type	duration
bit	SERGINSKI	2445	650m
rod	VORONEJSKI		15000～17000m
connection	mine workshop		5000～6000m

Table 19 Working result of Rotary Drill

year	drilling length (unit :1000m)						working hour (hours) workability (%)						periodical repair time (hour)					
	No. 7	No. 8	No. 9	No. 10	No. 11	total	No. 7	No. 8	No. 9	No. 10	No. 11	total	No. 7	No. 8	No. 9	No. 10	No. 11	total
1988	60	60	40	29		189	6,354 72.3	6,578 74.9	4,485 76.3	3,146 71.2		20,563 73.8	1,142	1,060	656	472		3,330
1989	10	61	61	61		193	1,061 74.9	6,701 76.5	6,858 78.3	6,776 77.4		21,396 77.3	166	1,012	1,068	1,034		3,280
1990	53	57	61	61		232	5,926 73.9	6,480 74.0	6,620 75.6	6,597 75.3		25,623 74.7	1,038	1,098	1,136	1,140		4,412
1991	24	36	47	40		147	3,030 69.8	3,700 56.5	5,253 60.0	5,041 57.5		17,024 59.9	540	876	966	1,100		3,482
1992	34	36	47	36	23	176	4,340 49.4	4,602 52.4	4,705 53.6	3,898 44.4	2,080 47.1	19,625 49.6	1,050	1,030	1,045	810	428	4,363
total	181	250	256	227	23	937	21,002 67.0	28,343 68.1	28,211 68.9	25,739 65.2	2,080 47.1	104,517 66.2	3,936	5,076	4,871	4,556	428	18,867

year	stoppage hour repair time by breakdown						stoppage hour except repair						total (hour)					
	No. 7	No. 8	No. 9	No. 10	No. 11	total	No. 7	No. 8	No. 9	No. 10	No. 11	total	No. 7	No. 8	No. 9	No. 10	No. 11	total
1988	369	375	121	123		988	919	771	618	675		2,983 *186	8,784	8,784	5,880	4,416	0	27,864
1989	23	287	230	243		783	166	760	604	707		2,237 *149	1,416	8,760	8,760	8,760	0	27,696
1990	163	201	186	192		742	889	981	818	831		3,519 *362	8,016	8,760	8,760	8,760	0	34,296
1991	160	253	262	293		968	614	1,723	2,279	2,326		6,942 *1066	4,344	6,552	8,760	8,760	0	28,416
1992	1,020	910	939	723	116	3,708	2,374	2,241	2,095	3,353	1,792	11,855 *777	8,784	8,784	8,784	8,784	4,416	39,552
total	1,735	2,026	1,738	1,574	116	7,189	4,962	6,476	6,414	7,892	1,792	27,536 *2540	31,344	41,640	40,944	39,480	4,416	157,824

N.B. * is stoppage hours by shortage of electric power.

Working efficiency of power shovel is shown in Table 21. Both of loading tonnage and working hour were sharply dropped from 1991. The reason for this is thought to be similar to the case of rotary drill.

③Dump truck

42 dump trucks with the capacities of 42t and 5 trucks with the capacity of 110t are working in the mine. Specifications of the trucks are shown in Table 22. It is desirable to replace 42t truck with 110t truck to increase the efficiency of ore hauling since the hauling distance will be increasing as the pit becomes deeper and also to meet the capacity of power shovels.

Table 23 shows the working efficiency of dump truck for past five years. Working efficiency of truck is sharply dropped from 1991 due to the same reason with rotary drill and power shovel.

④Bulldozer

15 bulldozers in which ten bulldozers are actually working in the mine. Specification of bulldozer is shown in Table 24. Service life was previously 7 years and presently 5.3 years.

Table 25 shows the working efficiency of bulldozers for past five years. Working efficiency used to be over 50% before 1990, then dropped from 1991 due to the shortage of spare parts and skilled workers.

⑤Maintenance of heavy equipment

Periodical inspection for rotary drill, power shovels and bulldozers is being conducted in every 56 hours and monthly check up is being conducted in every 690 hours. Check up for truck is scheduled to be done in the mileage of every

Table 20 Spccification for Power Shovel

No.	maker	type	year purchased	bucket capacity	weight	rotation		moving speed	climbing angle	loading capacity
						radius	speed			
1	IJORSKI	EKG-4.6	1975	4.6m3	20t	10.6m	25.5m/min	0.55km/h	12°	205m3/h
2	〃	〃	1976	〃	〃	〃	〃	〃	〃	〃
3	〃	EKG-8I	1976	8.0m3	36t	15.5m	28.8m/min	0.80km/h	〃	280m3/h
4	〃	〃	1978	〃	〃	〃	〃	〃	〃	〃
5	〃	〃	1978	〃	〃	〃	〃	〃	〃	〃
6	〃	〃	1978	〃	〃	〃	〃	〃	〃	〃
7	〃	〃	1980	〃	〃	〃	〃	〃	〃	〃
8	〃	〃	1981	〃	〃	〃	〃	〃	〃	〃
9	〃	〃	1982	〃	〃	〃	〃	〃	〃	〃
10	〃	〃	1984	〃	〃	〃	〃	〃	〃	〃
11	〃	〃	1989	〃	〃	〃	〃	〃	〃	〃
12	〃	EKG-10	1990	10m3	38t	15.8m	46.3m/min	0.42km/h	〃	370m3/h

Table 21 Working result of Poewr Shovel

year	loading amount (unit: 1000m3)											upper line: working hour (hour) lower line: workability (%)											periodical repair time (hour)										
	No.3	No.4	No.5	No.6	No.7	No.8	No.9	No.10	No.11	No.12	total	No.3	No.4	No.5	No.6	No.7	No.8	No.9	No.10	No.11	No.12	total	No.3	No.4	No.5	No.6	No.7	No.8	No.9	No.10	No.11	No.12	total
1988	2,173	2,084	1,832	812	1,189	722	2,110	2,155			13,077	6,901	7,035	6,322	4,553	4,410	2,854	6,376	6,834			45,885	782	792	806	496	418	216	841	787			5,138
												78.6	80.1	72.0	51.8	75.3	77.7	79.4	77.8			73.7											
1989	2,103	2,121	2,147	1,005		1,316	736	2,026	1,447		13,495	6,948	6,957	6,901	5,005		6,438	2,293	7,067	4,595		46,204	760	802	790	722		779	282	742	493		5,370
												79.3	79.4	78.8	57.1		73.5	79.6	80.7	78.1		75.3											
1990	1,806	765	1,671	1,910		1,894	1,761	2,192	1,993		13,992	6,765	2,124	5,805	6,800		6,490	6,500	6,932	6,905		48,321	783	252	542	764		778	716	772	760		5,367
												77.2	73.8	80.2	77.6		74.1	74.2	79.1	78.8		77.1											
1991	1,026		1,282	1,220		1,449	1,456	1,187	1,412		9,031	3,901		4,398	4,450		4,865	5,150	4,460	4,300		32,664	656		678	682		676	690	682	670		4,734
												44.5		50.2	50.8		55.5	58.8	50.2	55.8		52.3											
1992			1,103	1,237		1,454	1,254	1,411	1,406	1238	9,103			4,208	4,702		4,840	4,905	4,830	4,826	4,750	33,161			56	56		62	62	62	68	48	414
														47.8	53.5		55.1	55.8	55.0	56.1	54.1	53.9											
total	7,108	4,970	8,035	6,184	1,189	7,428	7,317	8,971	6,258	1,238	58,698	24,515	16,116	27,634	25,510	4,410	25,487	25,824	30,063	21,326	4,750	205,635	2,981	1,846	2,872	2,720	418	2,511	2,581	3,045	1,991	48	21,023
												69.9	78.8	65.3	58.2	75.3	65.8	68.0	68.6	66.3	54.1	66.5											

year	stoppage hour repair time by breakdown											stoppage hour excpt repair											total (hour)										
	No.3	No.4	No.5	No.6	No.7	No.8	No.9	No.10	No.11	No.12	total	No.3	No.4	No.5	No.6	No.7	No.8	No.9	No.10	No.11	No.12	total	No.3	No.4	No.5	No.6	No.7	No.8	No.9	No.10	No.11	No.12	total
1988	88	140	152	162	79	8	117	129			875	1,013	817	1,504	3,573	949	594	850	1,034			10,334	8,784	8,784	8,784	8,784	5,856	3,672	8,784	8,784			62,232
																						※307											
1989	168	97	178	145		175	95	150	111		1,119	884	904	891	2,888		1,368	210	801	681		8,627	8,760	8,760	8,760	8,760		8,760	2,880	8,760	5,880		61,320
																						※378											
1990	164	74	89	159		163	180	140			969	1,048	430	860	1,037		1,329	1,384	916	915		7,899	8,760	2,880	7,236	8,760		8,760	8,760	8,760	8,760		62,676
																						※934											
1991	158		121	169		140	151	146	135		1,020	4,045		3,583	3,455		3,079	2,769	3,532	3,055		23,502	8,760		8,760	8,760		8,760	8,760	8,760	8,760		61,320
																						※4,981											
1992			258	356		910	939	723	116	286	3,588			4,262	3,670		3,432	3,426	3,608	3,482	3,760	25,581			8,787	8,784		8,784	8,784	8,784	8,784	8,784	61,481
																						※2,143											
total	578	311	798	991	79	1,396	1,482	1,298	362	286	7,571	6,990	2,151	11,080	14,627	949	9,802	6,414	7,892	8,133	3,760	71,738	35,064	20,424	42,327	43,848	5,856	38,736	37,968	43,848	32,184	8,784	309,039
																						※7,848											

Table 22 Specification & Work-efficiency for Dump Truck

Item	110t truck	40t truck
maker	BELAZ	BELAZ
type	7519	7523
loading capa.	110t	42t
length	11250	8120
width	6100	3787
height	5130	3830
weight	84.5t	29.5t
min. curve(R)	12m	10.2m
seat no.	2	2
max. speed	50Km/h	40Km/h
exhaust	45200cm3	22300cm3
E/G power	1300 PS	500 PS
year	'89 '90 '91	'89 '90 '91 '92
purchased	2 1 2	13 17 4 8
truck no.	5	42
working hour	57220	433616
workability(%)	48.73	51.16
repair time	18403	124790
other stoppage	41809	289182
total(hour)	117432	847588

Table 23 Result of Efficiency for Dump Truck(t×km/truck)

type	1979	1980	1981	1982	1983	1984	1985
40t	22613	24436	26709	27673	28274	29076	29693
110t							
type	1986	1987	1988	1989	1990	1991	1992
40t	32869	34480	35715	35025	38595	21772	22961
110t				26790	33476	20445	18645

Table 24 Specification for Bulldozer

No.	maker	type	year purchased	power PS	weight t	width mm	speed Km/h	climb angle
1			1988	330	37.2	4540	20	50°
2	C		1989	〃	〃	〃	〃	〃
3	H		1990	〃	〃	〃	〃	〃
4	E	D	1992	〃	〃	〃	〃	〃
5	L	E	1990	〃	〃	〃	〃	〃
6	J	T	1989	〃	〃	〃	〃	〃
7	A		1987	〃	〃	〃	〃	〃
8	B	2	1988	〃	〃	〃	〃	〃
9	I	5	1992	〃	〃	〃	〃	〃
10	N	0	1989	〃	〃	〃	〃	〃
11	S		1991	〃	〃	〃	〃	〃
12	K		1991	〃	〃	〃	〃	〃
13	I		1989	〃	〃	〃	〃	〃
14			1989	〃	〃	〃	〃	〃
15			1992	〃	〃	〃	〃	〃

Table 25 Working Result of Bulldozer

Item	unit	1978	1979	1980	1981	1982	1983	1984	1985
workable machine No.		0.5	3.3	5.17	7.7	9.23	9	10	10
machine No.		8	8	10	13	14	15	15	15
working hour	hour	1,771	14,748	20,166	37,126	48,438	49,630	40,696	45,123
periodical repair time	hour	224	3,164	4,491	5,584	6,485	10,018	11,058	10,002
repair hour by breakdown	hour	72	505	3,965	3,673	5,316	5,184	5,760	6,048
stoppage time except repair	hour	2,349	10,491	16,667	21,069	20,616	14,008	35,510	26,427
total hour	hour	4,416	28,908	45,289	67,452	80,855	78,840	87,840	87,600
workability	%	40.1	51.0	44.5	55.0	59.9	63.0	46.3	51.5

Item	unit	1986	1987	1988	1989	1990	1991	1992
workable machine No.		10	10.6	10.8	12.1	11	9.4	6.8
machine No.		15	15	15	15	15	15	15
working hour	hour	50,905	48,908	50,730	54,501	48,638	38,364	25,051
periodical repair time	hour	9,090	12,142	10,154	10,636	8,546	10,190	8,060
repair hour by breakdown	hour	6,120	6,178	6,300	7,042	6,408	5,486	3,246
stoppage time except repair	hour	21,485	20,372	20,656	33,817	32,768	28,204	23,374
total hour	hour	87,600	87,600	87,840	105,996	96,360	82,344	59,731
workability	%	58.1	55.8	57.8	51.4	50.5	46.6	41.9

1500km. However, the periodical inspection is not done regularly due to the shortage of spare parts. Beside the price of spare parts has remarkably increased, so that the cost for overhaul become extremely increased. Shortage of the skilled workers is another problem.

(5) Blasting

According to a blasting manual of the mine, drilling pattern for blasting is minutely prescribed due to rock quality, as follows in Table 26:

Standard specification for explosive-charging is indicated Table 27. Blasting is carried out once a week (Friday) by means of detonating fuses against static electricity with use of 150 to 200t/once. Fragmentation of broken ore comparatively good under favor of rock quality. Almost all blast-hales contain water in lower levels, as well as more than half in upper levels.

(6) Organization, man power

Organization of Mining Department is shown in Fig. 13. Total man power is 362. Basic difference between the Erdenet mine and the mine of Western countries is control of dump truck. This organization chart doesn't include truck-drivers who belong to Department of Transportation. If number of drivers is counted for Mining Department, total workers number is no less than 456. This figure is 20~70% more than that of the same scale mine of the Western countries.

Table 26 Drilling Specification

rock quality	drilling pattern	bit-life m	drilling speed(m/m)	loading pattern	least burden(m)	D.spacing (W)m×(M)m
A	X	650>	1.82-2.26	Ⅲ	11.7	9.0×9.0
B	XⅠ	550-650	2.26-2.68	Ⅲ	11.7	9.0×9.0
C	XⅡ	450-550	2.68-3.30	Ⅲa	11.0	8.5×8.5
D	XⅢ	350-450	3.30-3.94	Ⅳ	10.4	8.5×8.5
E	XⅣ	250-350	3.94-4.82	Ⅳa	10.4	8.0×8.0
F	XⅤ	150-250	4.82-5.60	Ⅴ	9.8	7.5×7.5
G	XⅥ	50-150	5.60-6.78	Ⅵ	9.1	7.0×7.0
H	XⅦ	N.D.	6.78-7.86	Ⅵ		6.5×6.5
I	XⅧ	N.D.	7.86-9.40	Ⅶ		6.0×6.0

Table 27 Loading Specification

loading pattern	diameter φmm	least burden(m)	hole length(m)	loading weight(kg)	loading length(m)	blasting factor	tamping length(m)	detonator miliseco.	blasting amount(m3/m)	explosives used(kg/m3)
Ⅲ	255	11.7	17.5	395	8.6	0.491	8.9	50	69.4	0.325
Ⅲa	255	11.0	17.5	414	9.0	0.514	8.5	40	61.9	0.382
Ⅳ	255	10.4	17.5	432	9.4	0.537	8.1	35	54.9	0.450
Ⅴ	255	9.8	17.5	506	11.0	0.629	6.5	30	48.2	0.600
Ⅵ	255	9.1	17.5	573	12.4	0.709	5.1	20	42.0	0.780

N.B. Clearance of driling length must be less than 0.4 m.
Blasting amount is indicated by loose volume.

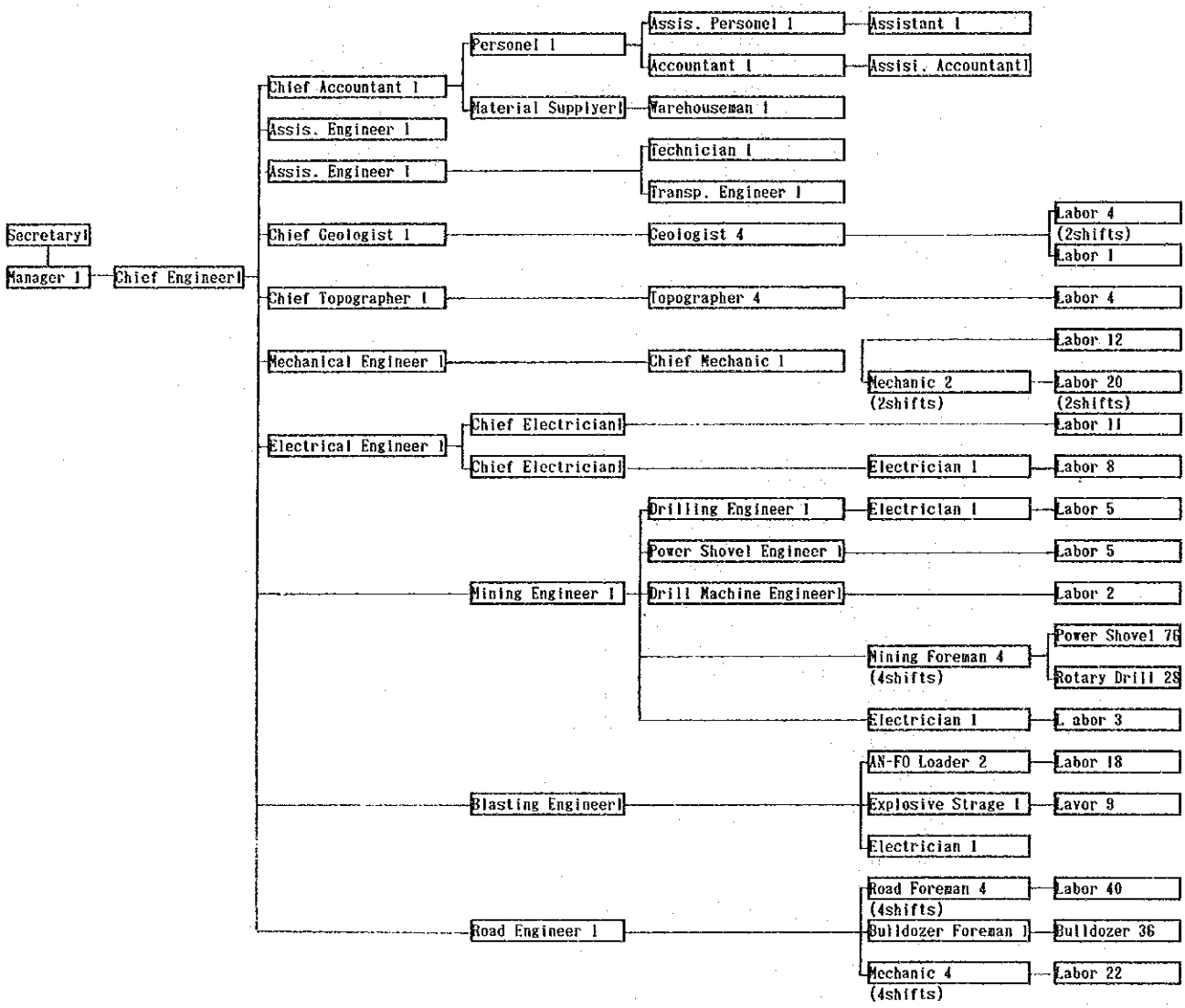


Fig. 13 Organization Chart of Mining Department