and therefore, the SOx in the exhaust gas at the outlet is deemed to be 300 to 400 ppm which is comparatively low. (Concentration subject to desulfurization is generally > 500 ppm).

However, although there is no measured data but by visual observation, the fly ash seems to be more than 500 mg/m^3 and we observed during our stay that the white smoke is suspended at the low level due to phenomenon of inverted layer. This is due to the fact that there is only venturi scrubber for dust collection and that there may be some problem in its control.

In Western World, there is a dry type electrostatic precipitator and the boiler dust emission of this scale is limited to less than 250 mg/m^3.

2) Black smoke from copper concentrate dryer (oil combustion)

In order to prevent dust generation and freezing during the transportation, the copper concentrate is dried using limited oil as heat source in a rotary dryer to decrease the moisture content to less than 10%.

However, the operation of the preceding stage disc filter is unstable due to power failure, and the moisture content in the concentrate at the inlet of the dryer fluctuates widely. When the operation is done to obtain moisture content of less than 10% in the final stage, over drying happens from time to time and the black dust (color of copper concentrate) in the gas cannot be removed and fell into the plant area. (Please refer to the attached photographs.)

The cyclones type dust collector is not functioning well.

This black dust in the smoke is also a final product of the mine meaning that there is a double damage of loss of production and pollution.

3) Dust generation from tailing pond (Please refer to Figure 50)

In a year, from November to May, the atmospheric temperature drops below 0°C and during this period, the surface of the pond and solution inside the pipe are frozen. To cope with this, the slurry from mineral processing tailing is discharged through route B during this period, not through normal route A.

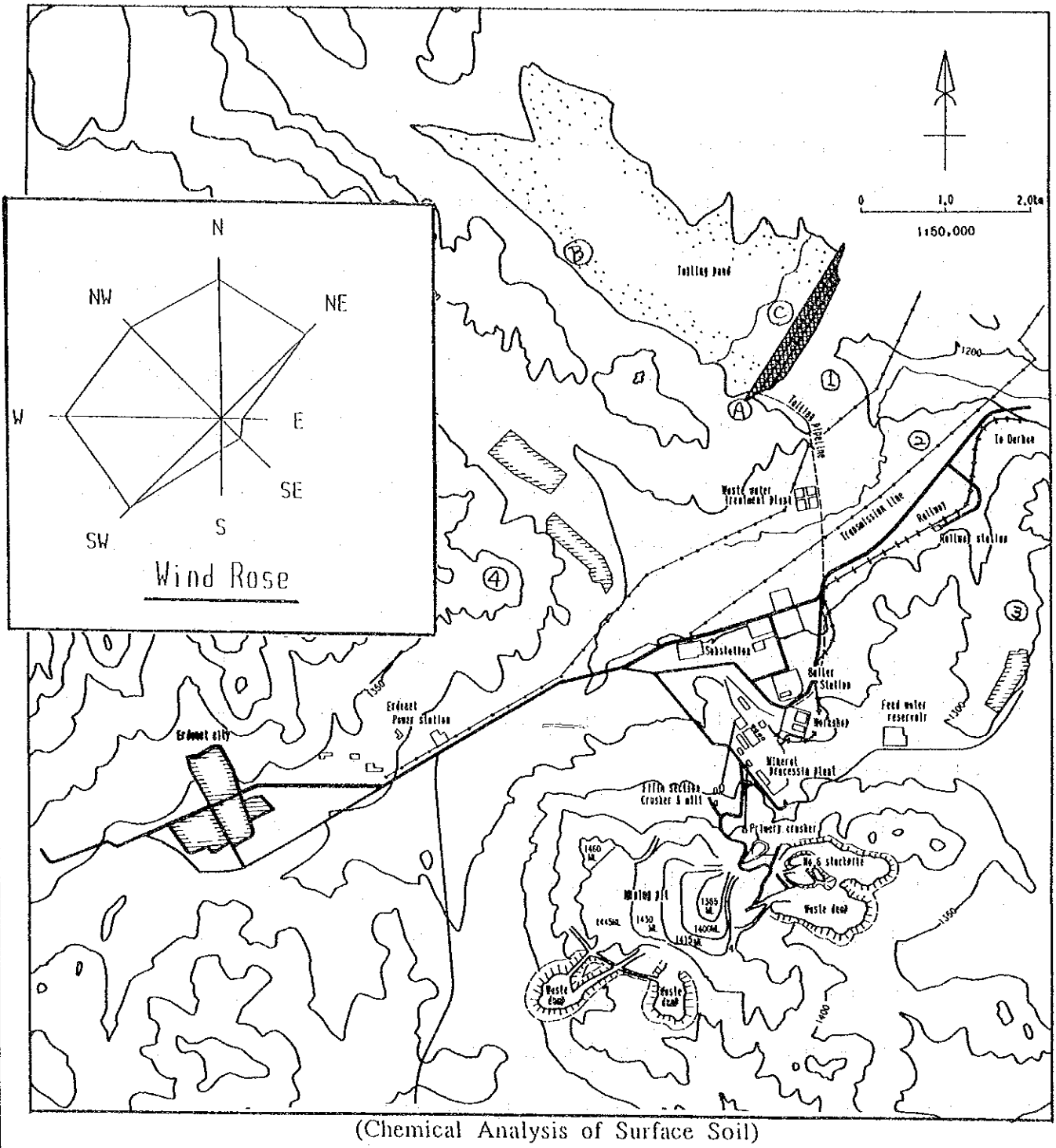
As a result, when the atmospheric temperature during day time starts to rise above 0°C, which starts in March, the surface of Area C (2,300 mW x 200 to 300 mL) is dried and when the wind from north or west is strong, powder dust is blown to Erdenet Station located at downstream where "you cannot see the face of others."

This phenomenon is taking place after the construction of the tailing pond and there is a strong apprehension on the hygiene of the inhabitants as well as to animal and plant growth.

Figure 50 shows the wind rose in April with the analysis results of the soil from the points where the dust lands and also of the soil from the back ground areas where there is no pollution as well as the analysis results of tailing.

According to these analytical results, with only few samples, only the copper content draws minor interest but the dust from the tailing pond shows the value too small to say that it is influencing the soil contamination.

According to an interview at the Weather Bureau of Erdenet city which is the local branch of Ministry of Nature and Environment (the executive officer was also the executive officer of the Erdenet branch of Green Party), they have a strong administrative power over the industries and may execute it (for example, the boiler of the city was stopped several times due to excess NOx emission).



(Chemical Analysis of Surface Soil)

(unit: %)

No.	Cu	SiO_2	Fe_2O_3	Al_2O_3	Cl	Reference
1	0.01>	55.6	6.0	11.5	0.004	(300 m)
2	0.01>	56.5	4.5	10.7	0.001	(1000 m)
3	0.01>	51.3	4.2	10.1	0.004	(2000 m)
4	0.01>	57.1	5.0	11.7	0.002	Background
5	0.15	67.2	2.7	11.0	0.001>	Tailing

Fig. 50 Tailing Dum, Wind Rose (April), Soil Analysis

From their stand point, their opinion is to raise objection against construction of facilities which may generating environmental pollutants.

An influence to the inhabitants could not be ignored when implementing the modernization. It is necessary always to take a measure to harmonize the development with the nature.

The following is a referential sample of the calculation of atmospheric dispersion by boiler waste gas.

(1) Gas conditions

The gas conditions for the calculation of dispersion are as follows.

Actual height of stack:	100 m
Boiler fuel:	coal, sulfur content 0.7% (Max.)
Boiler gas volume:	300,000 m^3/hr (90°C)/2 boilers
	→ 225,620 Nm^3/hr

The average exhaust gas factor of the boiler burning only coal is 9.1 Nm^3/kg and therefore, assuming that sulphur in fed coal is burned by 100 %, the SO_2 concentration is estimated to be as follows.

$$\frac{0.007 \times 22.4[Nm^3/kg] \times 10^6}{9.1[Nm^3/kg] \times 32} = 538 \text{ ppm (Max.)}$$

(2) Weather conditions

The calculation of dispersion was done under the following two conditions.

[Condition 1] South east wind 5.0 m/s → Data name [erdd]

Stability D (neutral). No reverse flow at upper layer

[Condition 2] South east wind 1.0 m/s → Data name [erda]

Stability A (Strongly unstable), height of reverse flow 300m

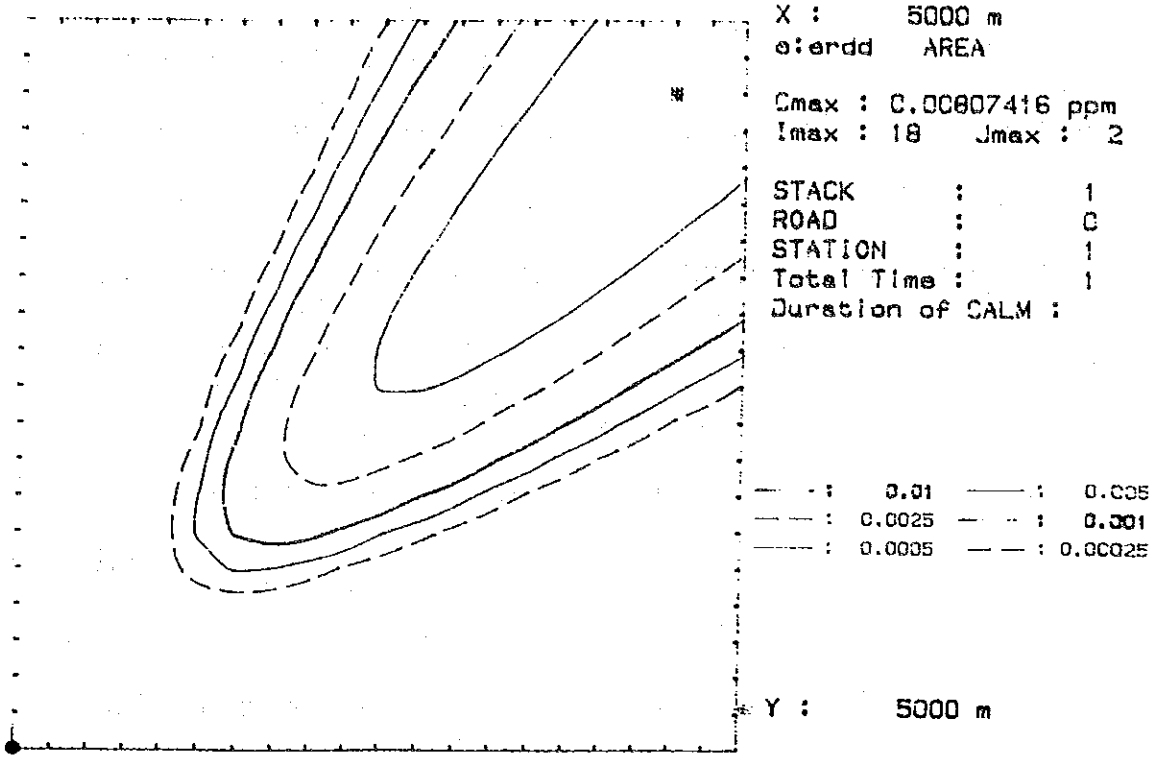
Condition 1 is a weather condition when it is cloudy or with a strong wind and Condition 2 is when the sun light is strong during day time and when the height of the reverse flow layer at the top of growing mixed layer is almost the same as the effective height of the stack. Trial calculations were done under several other conditions but this Condition 2 was the worst weather condition.

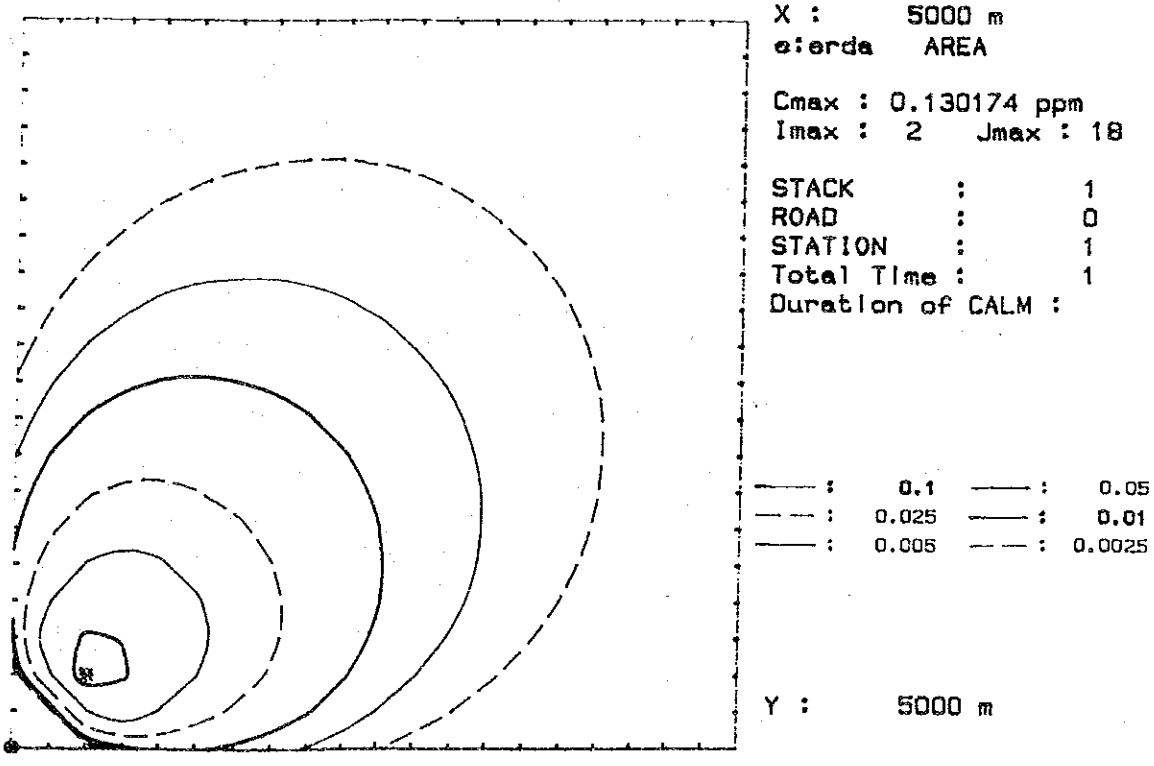
(3) Result of calculation (Fig. 51 Simulation of Atmospheric Dispersion)

Under Condition 1, the maximum ground concentration was 0.0081 ppm and it decreases as the wind velocity increases. Under this condition, there seems to be no particular problem even when compared with the Japanese environmental standards.

The maximum ground concentration was 0.1302 ppm under Condition 2 which is more than ten times that of Condition 1 which exceeds greatly the environmental standards. This indicates possibility of high concentration contamination but how frequent and when this Condition 2 appears are not known yet and further detailed study is required.

Fig.51 Simulation of Atmospheric Dispersion





4-6-2 Waste Water Treatment

There is a sewage treatment system at Erdenet Mine which is also under the control of Energy Department which includes an organic bio-treatment and the operation is well done.

The capacity of this system is 28,000 m_3/day and it is treating together the city sewer from Erdenet city (70%) and effluent from the mine (30%). (Figure 52: Waste Water Treatment Flow Sheet)

The final discharge from this system is once settled in a sedimentation pond and then discharged in Orhon River and analysis and monitoring at downstream of the river is done with proper control.

The mine is well equipped with a water circulation system and it is the plant with comparatively small quantity of effluent compared with its size.

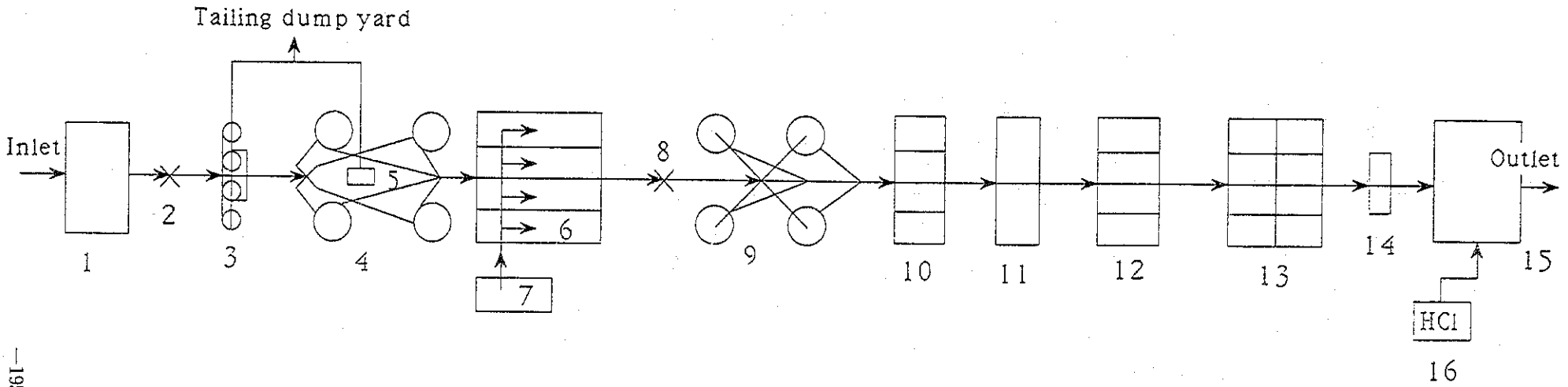
Being a dry area with average annual rain fall of 350 mm, it is well recognized that water is quite important and should be effectively utilized.

Because of the above, a sewer treatment facility with sufficient capacity for city sewer and waste water is operated and the operating conditions and waste water data (Table 49) indicate no basic problem and it is, in general, a very good facility.

In the future, it is necessary to study the possibility of problems and countermeasures during water flow from other area or abnormal rain fall as well as effective utilization of treated waste water.

The only problem noted is the existing analyzers and measuring systems for sufficient control.

Fig. 52 Waste Water Treatment Flowsheet

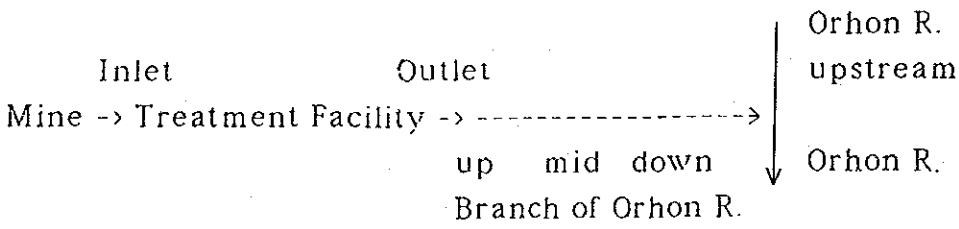


1	Intake	9	No. 2 Settling
2	Intake valve	10	Tank
3	Sand settling	11	Pump station
4	No. 1 Settling	12	Rotary filter
5	Crude sediment pump	13	Sand filter
6	Air babbling	14	Water recycling
7	Air blower	15	Mixing tank
8	Distribution pipe	16	HCl adding PH control

Capacity	28000 m3/day
Operator	80 men
Analysis Center	5 men
Treatment Rate	94 %

Table 49 Waste Water Treatment Data (Average for 1992)

Description	Unit	Waste Water Treatment		Branch of Orhon River			Main Stream Orhon (Up)
		Inlet	Outlet	Up	Middle	Down	
PH	-	8.3	7.4	8.3	7.6	7.6	7.6
Transparency	cm	5.8	29.5	13.9	9.3	15.0	30.0
SS	mg/l	128.3	11.9	306.8	98.6	85.6	3.5
COD	mg(o)/l	96.0	20.0	38.1	24.4	31.4	16.8
BOD	mg(o)/l	34.3	1.4	7.0	6.1	1.5	1.4
Cu ion	mg/l	4.0	3.6	0.08	0.07	2.8	3.4
Fe ion	mg/l	0.15	0.13	0.09	0.07	0.2	0.09
Mo ion	mg/l	-	-	0.18	0.06	-	0.03



4-6-3 Improvement of working environment

As a result of 15 years operation, labor diseases listed in Figure 53 were found to be apparent in each section by medical checkup (1989 to 1993).

Actually, in each section of the Erdenet mine, the measuring results above the working environmental standard are found and despite of the efforts of related personnel, the adverse effect of "Production First" is appearing gradually.

A comparison was made between the actual measurements taken by the dust meter and gas analyzer brought by the Japanese experts and the data such as measurements of the working environment, occurrence of labor disease and related regulations. In the process of measuring, a technical transfer was conducted.

The mine has already established an overall improvement plan for working environment and has started to implement it.

It seems that there is an influence of budget distribution and lack of materials in this section and the measures are not enough. Particularly, labor disease related to pneumoconiosis caused by dust (free silica) is becoming apparent as shown in Figure 53 and requires immediate improvement.

—There were areas with abnormally high dust concentration in the actual data and actual measuring was done at site revealing the same values.

—The place with highest dust concentration was the workshop. There were two units of bag filters operating for dust collection of exhaust gas from the electric furnace but due to poor maintenance, the dust concentration in the room where they were installed was as high as 2.4 mg/m^3.

—The analysis of free silica in the dust emitted in each section is as shown

below and the regulation for dust concentration in Japan is shown in Tables 50 and 51.

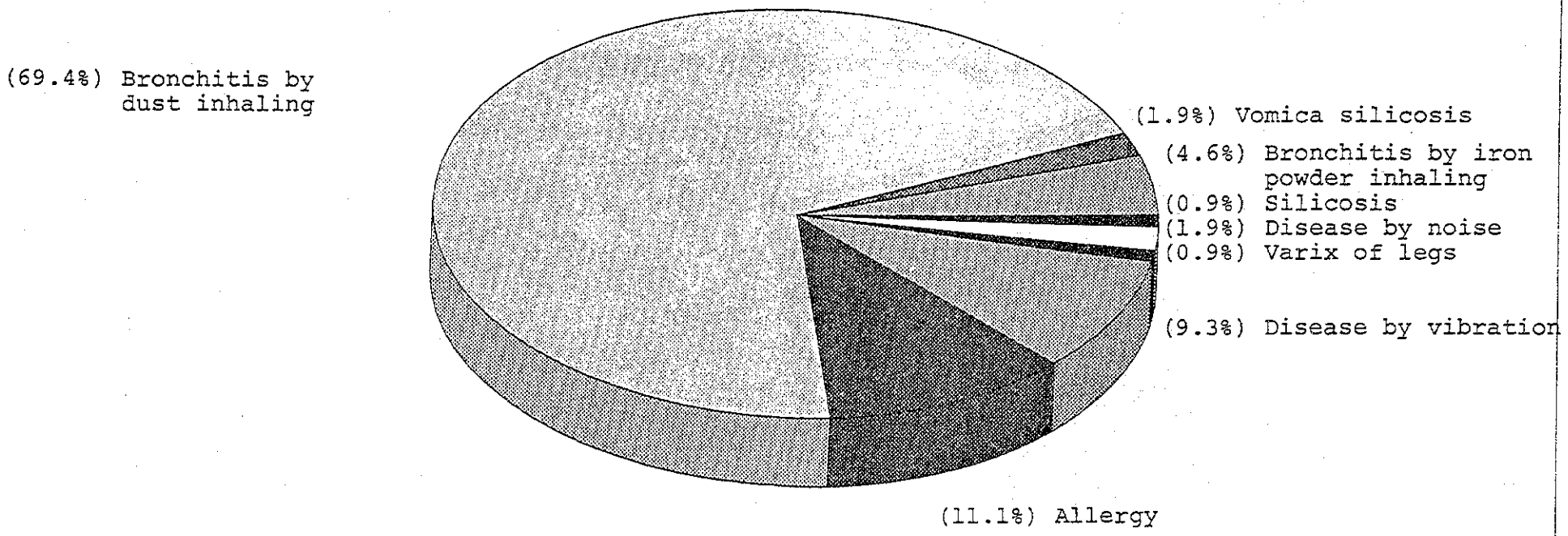
Mining and mineral processing	> 50%
Workshop (casting sand)	> 70%
Tailing damp yard (tailing)	> 60%

—Despite of labor disease becoming significant, the quantity and performance of the equipment to measure and analyze the working environment is unsatisfactory. This will be referred to in section 5-9-5.

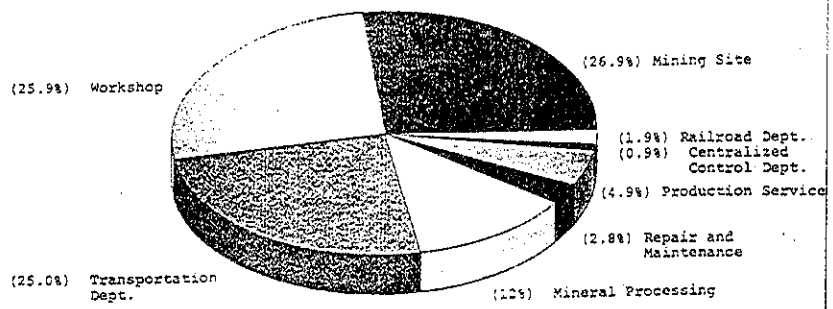
—A simple type dust mask is, in general, distributed to the operators but they are not used as expected at site and the work is conducted in a dusty environment. Diseases like pneumoconiosis group, once affected, are difficult to cure and an immediate countermeasure is required.

Fig.53

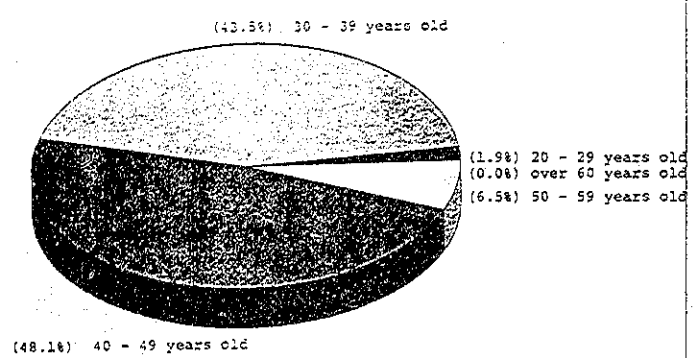
1. Distribution of Labor Diseases



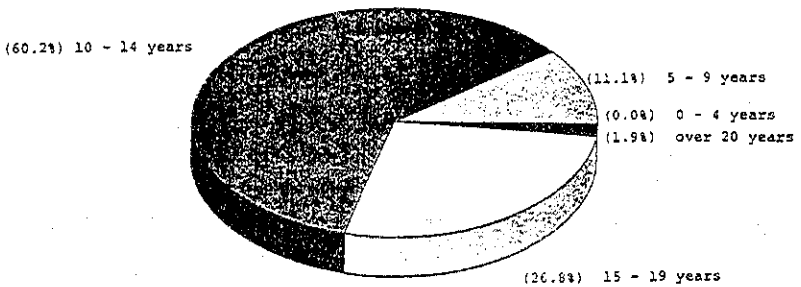
2. Classification by Job Site



3. Classification by Age



4. Classification by Yeras at Work



5. Classification by Craft

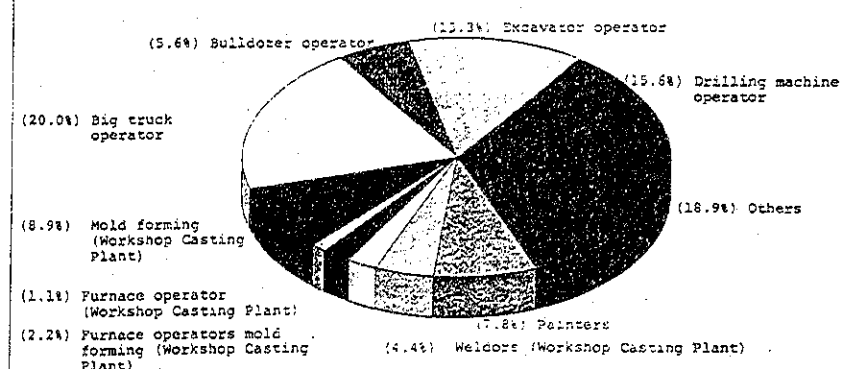


Table 50 Tolerable Limit of Dust (Japan Industrial Hygiene Society)

1. The tolerable limit of powder dust containing more than 10% free silica is calculated from the following formula.

$$\text{Tolerable limit of inhale powder dust} = \frac{2.9}{0.22 \times \text{free silica content (\%)} + 1} \quad \text{mg/m}^3$$

$$\text{Tolerable limit of total powder dust} = \frac{12}{0.23 \times \text{free silica content (\%)} + 1} \quad \text{mg/m}^3$$

2. Types of Powder Dust

Class 1 powder dust :

Talc, pagodite, aluminum, alumina, tripolite, sulfide mineral, sulfide calcine, bentonite, kaolinite, activated carbon, graphite

Tolerable limits : Inhale powder dust 0.5 (mg/m^3)
Total powder dust 2 (mg/m^3)

Class 2 powder dust

Mineral dust with less than 10% free silica, iron oxide, carbon black, coal, zinc oxide, titanium dioxide, Portland cement, lime stone, marble, powder material for incense, powdered crops, cotton dust, wood powder, leather powder, calk powder, bakelite

Tolerable limits : Inhale powder dust 1 (mg/m^3)
Total powder dust 4 (mg/m^3)

Class 3 powder dust

Other inorganic and organic powder dust

Tolerable limits : Inhale powder dust 2 (mg/m^3)
: Total powder dust 8 (mg/m^3)

Asbestos powder dust

Chrysotile, amosite, tremolite, anthoinite, actinolite

Tolerable limit : 2 fibre/cm^3

Crocidelite

Tolerable limit : 0.2 fibre/cm^3

3. Free Silica Content in Dust Generated at Each Work Place in Erdenet Mine and Its Tolerable Limit

Name of Dust	Work Place	Free Silica (%)	Tolerance mg/m^3
Crude ore	Mining, mineral processing	> 50%	0.24 (0.96)
Casting sand	Casting, workshop	> 70%	0.18 (0.70)
Tailing	Tailing pond	> 60%	0.20 (0.81)

Figures in ( ) : Total dust

Table 51 PERFORMANCE OF EACH TYPE OF MASK

The material, structure, performance and other characteristics of dust masks are tested according to the National Test Code of Ministry of Labor and only those masks that have satisfied this qualification of this Test are named "Dust Mask" and permitted to wear the seal (metal) indicating that it has been approved by the national approval test. Therefore, gauze masks or sponge masks are only sanitary masks and they are not preferable to be used under the environment specified by the Safety and Hygiene Regulation.

S-Type dust masks of the world's highest standard will assure safe work under dusty environment.

The performance of each type of mask is described below.

Type	Collecting efficiency (Average)	Respiratory resistance (Average)
Replaceable dust mask (S-Type, Model 6005 RR)	99.9%	4.0 mmH_2O
Replaceable dust mask (S-Type, Model 1010 A)	99.9%	5.6 mmH_2O
Disposable dust mask (S-Type, Model Hirack 310)	99.6%	$3.6 \pm 1.0 mmH_2O$
Sponge mask (20 mm thick)	30 to 40%	3 to 5 mmH_2O
Gauze mask (with dust filter and odor filter sandwiched)	20 to 50%	2 to 8 mmH_2O
Gauze mask (with only gauze)	7 to 15%	2 to 5 mmH_2O

4-7 Summary

(1) Operation of Erdenet Mine will greatly affect the Mongolian economy. It is not, therefore, possible to change the operation drastically or to introduce bold measures, even in order to ensure the mining venture's stability. Currently, the performance is not favorable because assistance from the former Soviet Union has decreased. Although the mine is seeking Western assistance to fill the gap, this change is in its infancy. The results of these efforts are therefore difficult to evaluate.

The mine is attempting to seek assistance from governments in accordance with Western procedures. The International Monetary Fund and the World Bank have already begun survey work. The indications are that the mine will receive assistance. However, there are difficult hurdles the mine must clear before it can participate in a competitive market economy.

The former Soviet Union assisted by supplying materials, human resources and technology and as the two countries have been closely linked, it will be impossible to change this arrangement rapidly. However, the level of assistance from this source has recently been decreasing, and as soon as this support became less reliable, the mine's operations became confused, resulting in reduced productivity. The mine must recover its earlier production levels quickly, or it will lose its economic viability.

There were many excellent aspects to the old system, and virtually no discrimination in the treatment of employees. Workers of state-owned companies enjoyed preferential treatment, particularly in salaries, housing and welfare.

(2) Erdenet Mine has great potential as a company including the potential to be sufficiently profitable. However, when it comes to raising and using funds, problems arise in relation to Mongolia's foreign currency policies.

The ore's deposits are excellent in the world standard. However, its inland location is a handicap, resulting in high transport costs for raw materials and products. The supply of energy is unstable, and the communication and information systems are poor. A positive factor is high employee morale, resulting in a good capacity to assimilate technological innovation.

Maintaining and increasing production in the future will require a certain amount of investment. Furthermore, the mine must be prepared to carry out fund-raising on its own. Financial assistance from foreign countries is possible for environmental conservation, human resource training and surveying and study. However, fair competition in the international market precludes the provision of foreign financial assistance for production. Strategies for investment and procurement of funds must be set up in accordance with the principles of a liberalistic economy.

(3) Erdenet Mine initially adopted Russian standards for its organization, technology, facilities, equipment, buildings and so forth. Soviet concepts and standards for systems are different from those in western countries, and thus may not comply with international standards. However, the ideas behind the Russian facilities and systems designs are fundamentally well-conceived.

The mine has entered a period during which productivity will decline unless facilities are modified. The mine has not accumulated the expertise to modify or adapt its systems. During its 15 years of operations, hardly any

facilities have been modified. It may be difficult to modify all the facilities and systems at once.

In addition to cost factors, proposals to introduce Western facilities or systems will require examination of more comprehensive aspects such as facility lifespan and lead times to procurement or installation.

As the frequency of exchanging parts increases, the number of machines affected also increases. With reduced operation rates per unit, the number of units must be increased. This makes control unwieldy and more complex. During this process, the number of dead stock parts accumulates and results in deterioration in the flow of funds. It appears that the mine is approaching this undesirable situation.

(4) Mongolia has only recently established a free-market economy framework. Confusion can arise in relation to unfamiliar matters such as obligations, claims and settlement in foreign currencies. However, these concepts are quickly being adopted.

The former COMECON comprised one closed economic zone and differed from western economies. Commodity prices were kept low in relation to the economy of each country, and thus a balance was maintained. When COMECON disbanded, Mongolia came into contact with commodity price levels of the free economic zone for the first time. It is not difficult to imagine that the differences and structure of a free-market economy seemed foreign and unfamiliar.

Settlement in dollars rather than roubles is necessary for sales made to Russia. However, the shortage of dollars in Russia is not easily solved. If there is any delay in the collection of payment for the sale of ore, management of the mine

will be jeopardized.

Customers to whom concentrates are sold include many countries that belonged to the Soviet Union. Since 1989, the Mine has been expanding its sales network in western nations. In drawing up sales strategies targeting western nations, such matters as a reduction in the arsenic level will be important.

In the sales of copper concentrate, copper quality, sales conditions treatment charges, refining charges, settlement conditions and other issues are determined in accordance with international conditions. Furthermore, negotiations for the procurement of parts are determined by the skills of the sellers and buyers. Mine management has no other choice but to understand international practices and accumulate experience.

(5) As the highest priority is given to achieving sales targets, environmental conservation considerations and safety tend to be neglected. Western industries have had the bitter experience of giving priority to development at the cost of the environment. Mongolia should not follow the same path that western industries have.

(6) Diagnostic Results in each Field

① Exploration

Erdenet Mine has sufficient ore reserves. Therefore, since it started operations, few exploration activities in neighboring areas have been carried out. It would be desirable to utilize wider survey technologies such as geophysical and chemical exploration, to explore underground water and other resource development opportunities.

Furthermore, in calculating the ore reserves, a method which can be

directly used in production is desirable, such as dividing the deposit into blocks corresponding to bench heights.

② Mining

The Mine has entered a period in which it is necessary to modify machinery. Improvements must be made in the truck transport system, which comes under the control of the transport division.

Mine management should also examine the transport system used in deep levels of the pit, and examine selective mining as a strategy to reduce arsenic recovery and prolong machinery life.

③ Mineral processing

There are many changes that should be implemented in order to increase responsiveness to ore quality changes, including production plans, planning procedure, surveys and research.

It is necessary to attempt to increase productivity by modifying machines and improving quality (reduction in arsenic grade and increase in concentrate grades), and to change ideas, such as considering the elimination of the production by separation-flotation in view of cost performance.

④ Workshop

—Some deficiencies have been identified in the area of quality control. By modifying machinery and revising systems, productivity and product quality will be improved.

—With plants left in a polluted condition, the mine is finding it hard to respond to shortages in materials and analytical facilities, and a decrease in skilled workers. In order for Erdenet Mine to transform itself into a company

without limitations, it will be necessary to upgrade technology in this area.

It will be a misfortune if this division is maintained unmodified as a part of Erdenet Mine, when the mine intends to make it into a leading facility in the future.

⑤ Utilities

—The shortage of electricity must be solved urgently. Establishing an energy supply system compatible with the country's energy policies is desirable. As an economic measure, it may be possible to secure a second water source or improve the thermal efficiency of plants. It is advisable for mine management to learn from the use of new energy-efficient materials, and from the advanced energy-saving measures adopted in western countries.

—Early acquisition of information is important in commercial activities. The world has already entered the age of satellite transmission for international communications. Erdenet Mine needs to gather information on an international scale. To do so would require enhanced communications facilities. Therefore, an increase in the domestic telephone communications facilities is required.

⑥ Management Control

—The allocation and organization of personnel

The number of workers at Erdenet Mine is fairly large in comparison with mines of a similar size in Western countries. The number of workers is still rather large in comparison with copper mines in developing countries. In Mongolia, as the number of people engaged in the mining and manufacturing industries is small, human resources are scarce. The Erdenet mine should ensure that it makes best use of its present workers and, where appropriate, relocates

them to improve efficiency. The excess workforce should be transferred to new industries. To do this, it may be necessary to set up separate companies and revise the mining company's organization.

It is recommended that the mine's managers examine appropriate relocation options for personnel, ensuring adequate consideration is given to all relevant factors, such as workers who are experienced having undergone education and training, workers who received their training in Russia and workers who have come into contact with Western information and are therefore able to build new ideas.

—Although the mine has depended on Russia for the cultivation of human resources, it will be necessary for mine management to pursue its own personnel development plans. Many other countries have come to focus on workforce development and education covering a wide spectrum, often utilizing foreign assistance. The development of human resources for the entire region of Erdenet is considered the responsibility of Erdenet Mine.

—Management Systems

The management system is strictly implemented in accordance with job descriptions and obligations implicit in job titles. As a consequence there is insufficient flexibility to carry out job functions in response to circumstances. Although this may help maintain order, including establishing responsibility, it may be detracting from operational efficiency.

Continued education and training for managers is particularly desirable.

—Wage System

As wage levels are determined by the economic power of a nation,

evaluating salaries for a company is difficult. The time has come for the mine management to examine how they will be able to motivate employees within the established wage framework, how to evaluate potential abilities, how to evaluate performance and so forth. Furthermore, the poor relationship between the salary and personnel systems raises concern.

—Welfare System

The current welfare system is well maintained. Although the welfare system at this mine is considered far better than at others in Mongolia, future welfare policies remain unclear. With a widening gap in the sense of values, a new vision for welfare policies to further benefit employees will be necessary.

—Production Plans

Long-term management plans are established, and budgets are prepared for each fiscal year based on these plans. After receiving input from each division, the 14 members of the management committee (comprising representatives from both partners) determine the production plan. Under a free-market economy it will be necessary for the mine to pay greater attention to the prevailing economic environment and to gather relevant information before making such decisions.

⑦ Financial Accounting

Apart from the categories depreciation and of funds for welfare and awards for performance, accounting at Erdenet is not significantly different from that found in the west.

If the mine cannot conform to governmental policies such as tax system, foreign currency control, or barter system, financial situation of the mine would

be seriously affected.

In order to compete in a free-market economy, clear accounting rules and a free-standing, continuous, and stable system are required.

⑧ Environmental Conservation and the Workplace Environment

Environmental conservation measures should be taken before pollution occurs. It will be necessary to improve survey equipment and analytical systems to achieve this.

The issue of vocational diseases is significant, and early intervention measures should be set up to address it.

5 Modernization Plan

5. Modernization Plan

5-1 Basic Plan

5-1-1 Basic Modernization Policy

The major problems currently facing Erdenet Mine are summarized below.

—Production output has not reached planned levels for three consecutive years (1990-93).

Copper and molybdenum concentrates produced at the mine account for 60% of Mongolia's foreign currency revenues. The production shortfall immediately causes a reduction in foreign currency inflow, which affects the purchase of necessities such as oil and food, as well as of production materials, fundamentally destabilizing the Mongolian economy.

—The grade of crude ore will become lower in the future, with a consequent degradation in the grade of concentrates.

The decrease in crude ore grade is the result of the shift in mining from secondary enriched ore zone to primary ore zone. If the mine intends to produce the same amount of copper metal content, they will need to increase production of crude ore as well as introducing measures to deal with associated mine products and utilities.

—With the shift to a market economy, the mine will face a new environment. How will it respond to this?

In the process of shifting from a socialist centrally planned economy to a market economy, the mine will encounter many new challenges. It will be necessary to implement some reforms and improvements, while retaining the strong points of the existing system.

Bearing in mind the above-mentioned current situation, the development of a modernization plan is outlined below.

① Conditions that will enable the mine to achieve its targeted production must be quickly established, and promptly and smoothly implemented.

—To solve the electricity shortage, it will be necessary to build a reliable power system (60,000 kW power station) to make the mine not entirely dependent of the existing unstable energy system. The mine need not be solely responsible for this initiative, but could develop it in conjunction with an upgrading of the nation's energy system. This would guarantee the mine a steady supply of electricity.

—To solve the parts' shortage problem, and to improve the capacity to produce adequate volumes of quality products, the workshop should be improved.

② To maintain income over the long term, the production system must enable output of pre-1990 copper metal in copper concentrates. This will require careful attention to economic factors, and aggressive, strategic investment incorporating adequate contingency plans and addressing the medium and long terms.

— World demand for copper is increasing with growth in industrial production. Copper prices are expected to rise along with rises in other commodity prices. Between 1965 and 1989, copper prices increased at a mean annual rate of 5.7%, based on the sterling-denominated London Metal Exchange prices. However, in real terms, after allowing for inflation and other factors, copper prices have actually fallen over the long-term, although there have been no major price fluctuations. It can be assumed that income maintenance can be

achieved by setting the management goal to be the preservation of copper volume.

— Sustaining the mine's income can be achieved by maintaining copper production levels, which in turn can be maintained at the 1990 level by increasing production of crude ore and improving the mineral processing recovery to compensate for decrease in the ore grade.

— Preventing a decline in production and productivity requires new investment, which in turn requires profitability under a market economy. Internationally recognized financial evaluation should be implemented.

③ It will be necessary to establish a structure to deal with competition in a market economy.

— A market economy is based on the principle of competition, and prices vary in response to market mechanisms. The mine must therefore produce a profit in the international market and improve productivity.

— The mine should use accumulated technology and expertise to improve the efficiency of the operation, and to move into businesses other than mining. While the mine already incorporates divisions that would be useful in diversification, the principal body of Erdenet Mine should be organized in such a manner as to focus on its core business.

— The management system for divisions supporting production should be improved. In addition, personnel, labor-management, organizational and financial management as well as procurement and control of materials should be reviewed in accordance with the medium-to-long term planning.

— It would be desirable to conduct business in a fair manner and to build a structure that would stand up to international appraisal. Attention needs to be

paid to such matters as environmental conservation, security of employment and employee health. The mine should, as a matter of urgency, establish administrative machinery for environmental conservation and introduce measures to prevent occupational illness.

④ It will be necessary to examine the effects of investment on the Mongolian economy.

Although the company should benefit from the effects of investment, its impacts on the Mongolian economy should also be examined.

5-1-2 Production Plans

The production capacity of the existing facilities is principally limited by the crude ore processing capacity of the plant.

In the long-term, as the mining pit becomes deeper, the minerals being excavated will change from chalcocite and bornite to pyrite. A decline in concentrate grade is unavoidable. This degradation will be offset by increasing the overall mineral processing recovery rate and increasing the tonnage of crude ore processed. To enable this, with investment as a precondition, an annual production target of 120,000 tons/year of copper in concentrate should be set as the index for modernization plans.

(1) Long-term mining plan (Tables 52, 53)

The mining plan is designed to cover 15 years, from 1994 to 2008. It provides for increases in mining and processing to compensate for the decline in grade, so that the 1990 income level will be maintained, under the sales conditions prevailing in November 1992.

By 2008, production will have increased by about 50% over 1992 production, with the amount of crude ore mined increasing to about 30,000,000 tons a year.

In the mining division, annual quantities mined, including strip and ore, will remain almost constant, at about 40,000,000 tons. Facilities will not, therefore, need significantly augmenting. If the capacity of the facilities is maintained, no serious problems will arise. Management of the number of heavy machines and personnel allocation will also be simplified.

(2) Mineral processing plan

— Although annual increases in production are proposed, piecemeal mineral processing capacity increases are not realistic. With a 50% increase in production targeted for 2008, an increase in the mineral processing capacity in Units Nos. 1 to 5 and the establishment of a sixth unit should be combined.

Expansion plans for processing facilities should be implemented in the following stages:

Year	1st	2nd	3rd	4th	5th	6th
Throughput	21,000	22,000	23,000	24,000	25,000	30,000

The processing facilities of Units Nos. 1-4 should be improved through the introduction of larger flotation machines to increase capacity from 4 to 5 million tons/year. Processing facilities with an additional capacity of 1 million tons/year will be added to Unit No. 5. Designs will be revised to give the proposed Unit No. 6 processing facility a capacity of 5 million tons/year. The mill has adequate space to accommodate the proposed upgrading and expansion.

— Tables 52 and 53 show the results of an examination and analysis of mineral processing recovery rates and grades of concentrates.

(3) Factors in calculating income from product sales

Transactions for mineral products use conditions common throughout the world. The price of copper concentrates is determined by evaluating and adding the silver price to the copper price and subtracting recovery percentages of smelting, and refining expenses. The price is quoted per ton of dry ore, with an

Table 52 Long-Term Production Plan(Mo/Cu Separation)

Item				Annual Plan														Note
Kind	Classific.	Distinct.	Unit	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	
Feed Ore	Exploit.W	Estimat.M	mil.t/a	# 20,500	20,500	21,000	22,000	23,000	24,000	25,000	24,839	25,213	25,212	25,444	27,811	27,804	27,803	27,804	28,242	
		Plan M.		21,000	22,000	24,000	25,000	25,000	25,000	25,000	25,000	25,000	25,000	25,000	25,000	25,000	25,000	25,000	25,000	
	Throughput	Estimat.P	mil.t/a	# 20,500	20,510	20,993	22,006	23,000	24,000	25,009	24,835	25,213	25,213	25,440	26,937	27,804	27,804	27,804	28,238	
		Plan B.		20,500	20,500	21,000	22,000	22,500	22,500	22,500	25,000	25,000	25,000	25,000	25,000	25,000	25,000	25,000	26,000	
	Exploit.	Estimat.M	%	# 0.720	0.640	0.670	0.620	0.600	0.600	0.600	0.579	0.570	0.570	0.565	0.535	0.520	0.520	0.520	0.500	+ (Cu Metal'93 in Cu Conc.)/(Cu Rec.'9X)/ (Estimated Exploit. Weight '9X)
	Cu Grade	Plan M.		0.72	0.69	0.63	0.60	0.60	0.60	0.58	0.57	0.57	0.57	0.54	0.52	0.52	0.52	0.52	0.49	
		Contrast		0.965	1.063	0.940	0.968	1.000	1.000	0.967	0.985	1.000	1.000	1.009	0.971	1.000	1.000	1.000	0.979	
	Feed Ore	Estimat.P	%	# 0.70	0.68	0.63	0.60	0.60	0.60	0.58	0.57	0.57	0.57	0.57	0.52	0.52	0.52	0.52	0.49	
	Cu Grade	Plan B.		0.73	0.72	0.70	0.67	0.66	0.66	0.64	0.57	0.57	0.57	0.57	0.52	0.52	0.52	0.52	0.49	
	Mo Grade	Plan M.	%	0.0176	0.0169	0.0155	0.0148	0.0148	0.0148	0.0142	0.0142	0.0142	0.0142	0.0141	0.0141	0.0141	0.0141	0.0141	0.0128	
		Plan B.		0.0204	0.0169	0.0155	0.0149	0.1490	0.0149	0.0142	0.0142	0.0142	0.0142	0.0141	0.0141	0.0141	0.0141	0.0141	0.0128	
Cu Conc.	Weight	Estimat.P	t/a	#400,103	370,666	383,902	389,064	412,549	436,911	446,841	450,926	465,022	472,404	484,070	473,431	495,697	495,697	495,697	493,850	+ (Cu Metal'93 in Cu Conc.)/(Cu Grad.'9X)
		Plan B.		403,711	400,000	404,722	441,176	441,176	441,176	430,147	482,118	492,118	492,118	492,118	486,697	486,697	486,697	486,697	500,481	
	Cu Grade	Estimat.P	%	# 28.24	30.29	28.25	27.83	27.43	27.03	26.62	26.21	25.81	25.40	25.01	24.61	24.21	24.21	24.21	23.79	
		Estm Bulk		0	0.00	28.00	27.60	27.20	26.80	26.40	26.00	25.60	25.20	24.80	24.40	24.00	24.00	24.00	23.60	
		Plan B.		29.00	30.00	29.65	27.20	27.20	27.20	27.20	23.47	23.47	23.47	23.47	21.80	21.80	21.80	21.80	20.80	
	Cu Rec.	Estimat.P	%	# 79.32	80.50	82.00	82.00	82.00	82.00	82.00	83.50	83.50	83.50	83.50	83.00	83.00	83.00	83.00	82.00	
		Estm Bulk				84.56	84.56	84.56	84.56	84.56	86.11	86.11	86.11	86.11	85.59	85.59	85.59	85.59	84.56	
		Plan B.		80.50	80.50	80.50	80.50	80.50	80.50	80.90	81.30	81.30	81.30	81.30	81.65	81.65	81.65	81.65	82.00	
	Mo Grade	Plan B.	%	# 0.15	0.12	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	
		Result																		
	Ag Grade	Plan B.	g/t	# 65.0	65.0	65.0	65.0	65.0	65.0	65.0	65.0	64.6	64.2	63.8	63.4	63.0	63.0	63.0	62.0	
		Result																		
	As Grade	Plan B.	%	# 0.30	0.29	0.29	0.29	0.29	0.28	0.28	0.28	0.28	0.27	0.27	0.26	0.26	0.26	0.26	0.25	
		Estm Bulk				0.29	0.29	0.28	0.28	0.28	0.28	0.27	0.27	0.27	0.26	0.26	0.26	0.25	0.25	
Mo Conc.	Weight	Plan B.	t/a	3,464	3,849	3,611	3,645	3,722	3,722	3,555	3,945	3,945	3,945	4,225	4,225	4,225	4,225	4,225	4,000	
		Result																		
	Mo Grade	Plan B.	%	50.00	45.00	45.00	45.00	45.00	45.00	45.00	45.00	45.00	45.00	40.00	40.00	40.00	40.00	40.00	40.00	
		Result																		
	Cu Grade	Plan B.	%																	* Estimated from WB.Data
		Result																		# Estimated by MINDECO
	Mo Rec.	Plan B.	%	48.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	48.00	48.00	48.00	48.00	48.00	-Estimat.M:Estimation of Mining Exp.
		Result																		
Tailing	Weight	Estimat.P	t/a	# 20,096	20,135	20,606	21,613	22,584	23,559	24,558	24,380	24,744	24,736	24,951	26,520	27,304	27,304	27,304	28,741	-Estimat.P:Estimation of Process. Exp.
		Result																		
	Cu Grade	Estimat.P	%	# 0.147	0.135	0.116	0.110	0.110	0.110	0.106	0.096	0.096	0.096	0.096	0.090	0.090	0.090	0.090	0.090	- Plan M.:Plan of Mining Dpt.
		Result																		
	Mo Grade	Estimat.P	%	# 0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.005	0.005	0.005	0.006	0.006	0.006	0.006	0.006	0.006	- Plan P.:Plan of Beneficiation Dpt.
		Result																		

Table 53 Long-Term Production Plan(Bulk)

Item				Annual Plan														Note
Kind	Classific.	Distinct.	Unit	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	
Feed Ore	Exploit.W	Estimat.M	mil.t/a	# 20,500	20,500	21,000	22,000	23,000	24,000	25,000	24,839	25,213	25,212	25,444	27,011	27,804	27,803	27,804	28,242	
		Plan M.		21,000	22,000	24,000	25,000	25,000	25,000	25,000	25,000	25,000	25,000	25,000	25,000	25,000	25,000	25,000	25,000	
	Throughput	Estimat.P	mil.t/a	# 20,500	20,501	21,000	22,050	23,000	24,000	25,000	25,482	25,879	25,911	26,335	27,736	28,515	28,515	28,515	29,388	
		Plan B.		20,500	20,500	21,000	22,000	22,500	22,500	22,500	25,000	25,000	25,000	25,000	25,000	25,000	25,000	25,000	26,000	
		Result		20,500	20,500	21,000	22,000	23,000	24,000	25,000	30,000	30,000	30,000	30,000	30,000	30,000	30,000	30,000	30,000	+ Capacity Increase
	Exploit.	Estimat.M	%	# 0.720	0.640	0.670	0.620	0.600	0.600	0.600	0.579	0.570	0.570	0.565	0.535	0.520	0.520	0.520	0.500	+ (Cu Metal'93 in Cu
	Cu Grade	Plan M.		0.72	0.69	0.63	0.60	0.60	0.60	0.58	0.57	0.57	0.57	0.54	0.52	0.52	0.52	0.52	0.49	Conc.)/(Cu Rec.'9X)/
		Contrast		0.965	1.063	0.940	0.968	1.000	1.000	0.967	0.985	1.000	1.000	1.009	0.971	1.000	1.000	1.000	0.979	(Estimated Exploit.
	Feed Ore	Estimat.P	%	# 0.695	0.680	0.630	0.600	0.600	0.600	0.580	0.570	0.570	0.570	0.570	0.520	0.520	0.520	0.520	0.490	Weight '9X)
	Cu Grade	Plan B.		0.73	0.72	0.70	0.67	0.66	0.66	0.64	0.57	0.57	0.57	0.57	0.52	0.52	0.52	0.52	0.49	
		Result		0.695																
	Mo Grade	Plan M.	%	0.0177	0.0169	0.0155	0.0148	0.0148	0.0148	0.0142	0.0142	0.0142	0.0142	0.0141	0.0141	0.0141	0.0141	0.0141	0.0128	
		Plan B.		0.0204	0.0169	0.0155	0.0149	0.0149	0.0149	0.0142	0.0142	0.0142	0.0142	0.0141	0.0141	0.0141	0.0141	0.0141	0.0128	
		Result		0.0179																
Cu Conc.	Weight	Estimat.P	t/a	#400,103	370,514	386,986	395,223	422,405	450,851	464,613	468,822	483,398	491,071	503,483	492,464	515,625	515,625	515,625	513,353	+ (Cu Metal'93 in Cu
		Plan B.		403,711	400,000	404,722	441,176	441,176	441,176	430,147	482,118	492,118	492,118	492,118	486,697	486,697	486,697	486,697	500,481	Conc.)/(Cu Grad.'9X)
		Result		400,103																
	Cu Grade	Estm Bulk		28.24	30.29	28.20	27.74	27.29	26.85	26.40	26.00	25.60	25.20	24.80	24.40	24.00	24.00	24.00	23.60	
		Plan B.		29.00	30.00	29.65	27.20	27.20	27.20	27.20	23.47	23.47	23.47	23.47	21.80	21.80	21.80	21.80	20.80	
	Cu Rec.	Estm Bulk		79.32	80.50	82.51	83.03	83.54	84.05	84.56	86.11	86.11	86.11	86.11	85.59	85.59	85.59	85.59	84.56	
		Plan B.		80.50	80.50	80.50	80.50	80.50	80.50	80.50	81.30	81.30	81.30	81.30	81.65	81.65	81.65	81.65	82.00	
	Mo Grade	Plan B.	%	* 0.15	0.12	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	
		Estm Bulk		0.58	0.58	0.52	0.51	0.49	0.47	0.44	0.48	0.47	0.46	0.44	0.44	0.43	0.43	0.43	0.41	
	Ag Grade	Plan B.	g/t	* 65.0	65.0	65.0	65.0	65.0	65.0	65.0	65.0	64.6	64.2	63.8	63.4	63.0	63.0	63.0	62.0	
		Estm Bulk		64.4	64.3	64.4	64.4	64.4	64.5	64.5	64.5	64.1	63.7	63.3	62.9	62.5	62.5	62.5	61.5	
	As Grade	Plan B.	%	* 0.30	0.29	0.29	0.29	0.29	0.28	0.28	0.28	0.28	0.27	0.27	0.26	0.26	0.26	0.26	0.25	
		Estm Bulk		0.28	0.28	0.27	0.27	0.27	0.27	0.27	0.27	0.26	0.26	0.25	0.25	0.25	0.25	0.24	0.24	
Mo Conc.	Weight	Plan B.	t/a	3,464	3,849	3,611	2,187	1,489	744	0	0	0	0	0	0	0	0	0	0	
		Result		3,464	3,849	3,611	3,645	3,722	3,722	3,555	3,945	3,945	3,945	4,225	4,225	4,225	4,225	4,225	4,000	
	Mo Grade	Plan B.	%	50.00	45.00	45.00	45.00	45.00	45.00	0	0	0	0	0	0	0	0	0	0	
		Result		50.00	45.00	45.00	45.00	45.00	45.00	45.00	45.00	45.00	45.00	40.00	40.00	40.00	40.00	40.00	40.00	
	Cu Grade	Plan B.	%																	* Estimated from WB.Data
		Result																		# Estimated by MINDECO
	Mo Rec.	Plan B.	%	55.00	50.00	50	50	50	50	0	0	0	0	0	0	0	0	0	0	·Estimat.M;Estimation of
		Result		48.00																Mining Exp.
Tailing	Weight	Estimat.P	t/a	# 20,096	20,127	20,609	21,653	22,576	#23,548	24,535	25,014	25,396	25,420	25,832	27,303	27,999	27,999	27,999	29,475	·Estimat.P;Estimation of
		Result		20,096	20,496	20,996	21,996	22,996	23,996	24,996	28,996	28,996	28,996	28,996	28,996	28,996	28,996	28,996	28,996	Process. Exp.
	Cu Grade	Estimat.P	%	# 0.147	0.135	0.112	0.105	0.101	0.098	0.091	0.093	0.094	0.094	0.098	0.088	0.088	0.088	0.088	0.087	· Plan M.;Plan of Mining
		Result																		Dpt.
	Mo Grade	Estimat.P	%	# 0.006	0.006	0.006	0.009	0.010	0.012	0.013	0.013	0.013	0.013	0.012	0.013	0.013	0.013	0.013	0.011	· Plan P.;Plan of
		Result																		Beneficiation Dpt.

arsenic penalty subtracted. Wet ore weight transportation expenses are subtracted during the calculation of sales. The sales conditions in the modernization plan use the prices and other conditions current at the commencement of this survey (November 1992).

Copper prices tend to fluctuate frequently, but basically in line with other commodity prices. Because of the difficulty in forecasting prices, calculations have been made on the basis of a fixed price from 1994 to 2008.

① Metal prices

•Copper	London settlement	£1400/MT
•Silver	London spot	$3.76/TOZ
•Molybdenum	--	$2.5/MO Pure pound

② Refining expenses and other conditions

•T/C	--	$100/T
•R/C	--	10¢/ lb
•P.P	at 90¢/ lb	±10%
•Cross rate	as of November, 1992	1.55

•Conditional recovery rate

Copper	unit extraction	1%
Silver	>35 g	90%

•Penalty conditions

Arsenic (As)	0.2% and above	$2.5/0.1%
	substracted from unit price of one ton of concentrate	

③ Other conditions

— Conditions for collecting accounts receivable

Normally, invoices are settled within three MAMA. This factor is not included in calculations because it does not affect sales conditions and prices.

— Analysis etc.

Analysis uses average values from sellers' and buyers' analyses but trial calculations were made using unrevised analysis data from Erdenet Mine.

It is necessary for sellers and buyers to set the splitting limit of analytical values. As the splitting limit is considered to be around 0.5% for copper, sellers and buyers consult together to decide on the splitting limit using this as a reference.

— Transport expenses

Sales figures are determined by subtracting transport expenses of concentrate including water from the price of concentrates.

- Sale prices to inland countries such as Russia, Kazakhstan and some parts of China include freight to the national frontier; domestic transport expenses are borne by the seller.
- Transport costs to overseas countries such as Japan are based on C.I.F. conditions (landing charges borne by the purchaser).

5-2 Geology and Exploration

(1) Further exploration

Downward extension of the Erdenetiin Oboo orebody has been systematically drilled to the level of 920m, and the block of ore was calculated in ore reserve estimate of 1988. Further extension of ore body has been proved down to the level of 560m by a few drill hole and this section of ore was calculated as a possible ore reserves. Further drilling to the downward extension below the 920m level will be needed in the future when a mining of the deeper portion of Erdenetiin Oboo ore body is considered.

Aside from the Erdenetiin Oboo, existence of two ore bodies one in the Central area and the other is the Southeast area are known. As the grades of ore of these deposits except for the secondary enrichment zone of the Central orebody are rather low, it seems not to be workable at present. Further exploration will be needed in the future.

In the outside of Erdenet area, a gold deposit in Tesiig area 150km northwest of Erdenet and a lead and zinc skarn deposit in Zaamar-Buregkhangai area are known. Exploration of these deposits will be needed in the future.

(2) Application of new geochemical survey and geophysical survey methods

In order to make an effective exploration on the above described deposits, it is advisable to apply the latest geochemical method and geophysical method. The conventional geochemical survey and geophysical survey such as gravity survey and magnetic survey have been previously conducted in the Erdenet area. Multi-

elements geochemical survey and resistivity survey by electromagnetic method (TEM) are to be adopted to the above exploration.

(3) Purchasing small size diamond drill machine

Capacity of the diamond drill machines held by the Mine is large and inconvenient for grass-root exploration as shown in the following table. It is recommended to purchase a small diamond drill machine for outside exploration.

Table 54 Drilling machines held by the Mine

model	capacity (m)	No. of drill
ZIF-650M	650 - 800	1
SKB-5	800 - 1200	1
UGB-50	50 - 80	1
URB-3AM	- 800	2

(4) Introducing a latest ore reserve computation method by computer

Procedure of ore reserve computation currently adopted by the Mine is manual but it seems to be reasonable and there is no significant defect. The size of ore block, however, is larger than 125m X 200 - 300m X 60m (equivalent to 5 - 6 mil. tons) which correspond to the 100 days mine output.

In order to control the grade of ore of mine output, a detail map showing the grade of ore in the pit is indispensable. The present ore reserves map can not be utilized for this purpose.

Ore reserve computation for porphyry copper deposit is commonly done in the following manner.

* Grid interval of drill hole is 60 - 100m.

* Dimension of unit ore block is 10 - 20m and the thickness is equal to the mining bench (15m).

* Ore grade of every blocks of ore is computed by computer from the assay of surrounding drill holes.

The planes and sections of ore reserves prepared by the above procedure show the detail distribution of ore grade which may be utilized for mining operation.

The estimated costs of ore reserve computation system are as follows:

Hardware	US$	30,000
Software		70,000
Training		30,000
Total	US$	130,000

5-3 Mining

5-3-1 Production control

(1) Study for renovation of principal machines

It is necessary to dispose principal effective machines in order to carry out the production plan followed by the Erdenet Mine Modernization. Most of the heavy machineries and equipment presently used in the mine are Russian made, and basically there is no variety. Important factors to be considered in selecting such machineries are: *a. Price, b. Capacity, c. Life, d. Easiness of operation, e. After-service, f. Spare parts supply, g. Training of operator, etc.* In case of the Erdenet mine, items *e.*, *f.* and *g.* seem to be most important.

The mine has now the serious problem that there are too many machineries in reserve to compensate deficit of their parts. If we set the machineries in the same way as present, number of machines increases remarkably in accordance with ore production. For instance, rotary drill must be reinforced 5 to 8, power shovel 7 to 11, dump truck 47 to 69, bulldozer 10 to 15. This increment would be directly connected with cost-up of repair and parts of machineries. Thus it is disadvantage for management of the mine.

Under these circumstances, we try to study adopting western machineries replaced by Russian ones at their renovations. We, therefore, estimate number of machineries as minimum, assuming that every parts will be supplied instantly and sufficiently.

①Combination of power shovel and dump truck in 1994

Cycle time was calculated, assuming that dipper capacity of power shovel

would be 13 m3 and vessel capacity of dump truck 120t. Cycle time for ore transportation is indicated in Table 55, waste transportation in Table 56. The combination of machines and handling-quantity calculated from the cycle time are shown in Table 57. Formula for *loading time* (min.) in Table 57 is given as follows:

$$\text{loading time} = \frac{C_1}{q_1 \times \text{K}} \times \text{cms}$$

Where c_1 is vessel capacity of 120t dump truck (80m^3 for ore, 83.3m^3 for waste), q_1 is dipper capacity of power shovel (13m^3), K is dipper factor (0.85), cms is cycle time in minutes.

Loss time is the sum of dumping time and standby time for truck. *Cycle time* is the sum of loading time, *time taken* (transportation time) and loss time. *Truck number* is the figure of cycle time divided by loading time, and is also adjusted somehow to get the minimum production. Here, *productivity* is given as follows:

$$\text{Productivity} = \frac{\text{C} \times 60 \times Et \times \text{M}}{\text{cycle time}}$$

Where, C is vessel capacity of truck (120t), Et is job efficiency of truck (0.85), M is number of dump truck.

Production is calculated by trial and error to get necessary quantity of ore and waste assuming that ore handling time is x hours, and waste is (24-x) hours. *Surplus/shortage* is the difference between productivity and necessary production of each level.

Table 55 Cycle time for transportation of ore

1994 120t truck ore			Distance	Grade Resistance	Rolling Resistance	Total Resistance	Max Travel Speed	Speed Factor	Ave. Speed	Time Taken
level 1370	loaded	Flat	450	0	5	5	400	0.5	200	2.3
		Uphill	1150	10	5	15	117	0.8	94	12.3
	Unloaded	Flat	450	0	5	5	733	0.5	367	1.2
		Uphill	1150	-10	5	-5	983	0.8	786	1.5
									Total	17.2
level 1385	loaded	Flat	450	0	5	5	400	0.5	200	2.3
		Uphill	1150	10	5	15	117	0.8	94	12.3
	Unloaded	Flat	450	0	5	5	733	0.5	367	1.2
		Uphill	1150	-10	5	-5	983	0.8	786	1.5
									Total	17.2
1400	loaded	Flat	850	0	5	5	400	0.65	260	3.3
		Uphill	850	10	5	15	117	0.8	94	9.1
	Unloaded	Flat	850	0	5	5	733	0.65	476	1.8
		Uphill	850	-10	5	-5	983	0.8	786	1.1
									Total	15.2
1415	loaded	Flat	700	0	5	5	400	0.6	240	2.9
		Uphill	850	10	5	15	117	0.8	94	9.1
		Downhill	550	-10	5	-5	717	0.75	538	1.0
	Unloaded	Flat	700	0	5	5	733	0.6	440	1.6
		Downhill	850	-10	5	-5	983	0.8	786	1.1
		Uphill	550	10	5	15	333	0.75	250	2.2
									Total	17.9
1430	loaded	Flat	500	0	5	5	400	0.6	240	2.1
		Uphill	850	10	5	15	117	0.8	94	9.1
	Unloaded	Flat	500	0	5	5	733	0.6	440	1.1
		Uphill	850	-10	5	-5	983	0.8	786	1.1
									Total	13.4
1445	loaded	Flat	500	0	5	5	400	0.6	240	2.1
		Uphill	850	10	5	15	117	0.8	94	9.1
	Unloaded	Flat	500	0	5	5	733	0.6	440	1.1
		Uphill	850	-10	5	-5	983	0.8	786	1.1
									Total	13.4

Table 56 Cycle time for transportation of waste

1994 120t truck waste			Distance	Grade Resistance	Rolling Resistance	Total Resistance	Max Travel Speed	Speed Factor	Ave. Speed	Time Taken
level 1370	loaded	Flat	1150	0	5	5	400	0.7	280	4.1
		Uphill	1100	10	5	15	133	0.8	106	10.3
	Unloaded	Flat	1150	0	5	5	733	0.7	513	2.2
		Uphill	1100	-10	5	-5	983	0.8	786	1.4
									Total	18.1
level 1385	loaded	Flat	1150	0	5	5	400	0.7	280	4.1
		Uphill	1100	10	5	15	133	0.8	106	10.3
	Unloaded	Flat	1150	0	5	5	733	0.7	513	2.2
		Uphill	1100	-10	5	-5	983	0.8	786	1.4
									Total	18.1
1400	loaded	Flat	1550	0	5	5	400	0.7	280	5.5
		Uphill	850	10	5	15	133	0.8	106	8.0
	Unloaded	Flat	1550	0	5	5	733	0.7	513	3.0
		Uphill	850	-10	5	-5	983	0.8	786	1.1
									Total	17.6
1415	loaded	Flat	1350	0	5	5	400	0.7	280	4.8
		Uphill	850	10	5	15	117	0.8	94	9.1
		Downhill	550	-10	5	-5	717	0.75	538	1.0
	Unloaded	Flat	1350	0	5	5	733	0.7	513	2.6
		Downhill	850	-10	5	-5	983	0.8	786	1.1
		Uphill	550	10	5	15	333	0.75	250	2.2
									Total	20.8
1430	loaded	Flat	1250	0	5	5	400	0.7	280	4.5
		Uphill	850	10	5	15	117	0.8	94	9.1
		Downhill	850	-10	5	-5	717	0.8	574	1.5
	Unloaded	Flat	1250	0	5	5	733	0.7	513	2.4
		Downhill	850	-10	5	-5	983	0.8	786	1.1
		Uphill	850	10	5	15	333	0.8	266	3.2
									Total	21.7
1445	loaded	Flat	1200	0	5	5	400	0.7	280	4.3
		Uphill	850	10	5	15	117	0.8	94	9.1
		Downhill	1650	-10	5	-5	717	0.8	574	2.9
	Unloaded	Flat	1200	0	5	5	733	0.7	513	2.3
		Downhill	850	-10	5	-5	983	0.8	786	1.1
		Uphill	1650	10	5	15	333	0.8	266	6.2
									Total	25.9

Table 57 Machines at each level & their productivity('94)

level	power shovel	dump truck	material	loading time	time taken	loss time	cycle time	truck number	productivity	production	surplus/ shortage
1370	13 m3	120 t	ore	5.6	17.2	1.9	24.7	5	1210	13307	3946
	13 m3	120 t	waste	5.6	18.1	1.9	25.6	5	1167	15173	6041
1385	13 m3	120 t	ore	5.6	17.2	1.9	24.7	4	968	10646	1285
	13 m3	120 t	waste	5.6	18.1	1.9	25.6	4	934	12139	3007
1400	13 m3	120 t	ore	5.6	15.2	1.9	22.7	4	1053	11583	2222
	13 m3	120 t	waste	5.6	17.6	1.9	25.1	4	952	12381	3249
1415	13 m3	120 t	ore	5.6	17.9	1.9	25.4	4	941	10352	991
	13 m3	120 t	waste	5.6	20.8	1.9	28.3	4	845	10981	1849
1430	13 m3	120 t	ore	5.6	13.4	1.9	20.9	4	1144	12581	3220
	13 m3	120 t	waste	5.6	21.7	1.9	29.2	4	819	10642	1510
1445	13 m3	120 t	ore	5.6	13.4	1.9	20.9	4	1144	12581	3220
	13 m3	120 t	waste	5.6	25.9	1.9	33.4	4	716	9304	172
								Total	ore	71050	14884
									waste	70620	15828

②Combination of power shovel and dump truck in 2000

Calculated cycle time for ore transportation is indicated in Table 58 and waste transportation, in Table 59. The combination of machines and handling-quantity calculated from the cycle time are shown in Table 60.

According to Table 60, 5 levels are sufficient to get necessary output of ore and waste. Therefore, minimum numbers of shovel and truck are 5 and 22 respectively. If spare would be taken account as 10%, total numbers of power shovel and truck are 6 and 24 respectively.

Table 58 Cycle time for transportation of ore

2000 120t truck ore			Distance	Grade Resistance	Rolling Resistance	Total Resistance	Max Travel Speed	Speed Factor	Ave. Speed	Time Taken
level 1340	loaded	Flat	750	0	5	5	400	0.65	260	2.9
		Uphill	900	10	5	15	117	0.8	94	9.6
	Unloaded	Flat	750	0	5	5	733	0.65	476	1.6
		Downhill	900	-10	5	-5	983	0.8	786	1.1
									Total	15.2
1355	loaded	Flat	900	0	5	5	400	0.65	260	3.5
		Uphill	950	10	5	15	117	0.8	94	10.1
	Unloaded	Flat	900	0	5	5	733	0.65	476	1.9
		Downhill	950	-10	5	-5	983	0.8	786	1.2
									Total	16.7
1370	loaded	Flat	1275	0	5	5	400	0.7	280	4.6
		Uphill	500	10	5	15	117	0.75	88	5.7
	Unloaded	Flat	1275	0	5	5	733	0.7	513	2.5
		Downhill	500	-10	5	-5	983	0.75	737	0.7
									Total	13.4
1385	loaded	Flat	1225	0	5	5	400	0.7	280	4.4
		Uphill	200	10	5	15	117	0.6	70	2.8
	Unloaded	Flat	1225	0	5	5	733	0.7	513	2.4
		Downhill	200	-10	5	-5	983	0.6	590	0.3
									Total	10.0
1400	loaded	Flat	1850	0	5	5	400	0.7	280	6.6
		Uphill	0	10	5	15	117	0	0	0
	Unloaded	Flat	1850	0	5	5	733	0.7	513	3.6
		Downhill	0	-10	5	-5	983	0	0	0
									Total	10.2
1415	loaded	Flat	1775	0	5	5	400	0.7	280	6.3
		Downhill	225	-10	5	-5	983	0.6	590	0.4
	Unloaded	Flat	1775	0	5	5	733	0.7	513	3.5
		Uphill	225	10	5	15	117	0.6	70	3.2
									Total	13.4

Table 59 Cycle time for transportation of waste

2000 120t truck waste			Distance	Grade Resistance	Rolling Resistance	Total Resistance	Max Travel Speed	Speed Factor	Ave. Speed	Time Taken
level 1340	loaded	Flat	3150	0	5	5	400	0.85	340	9.3
		Uphill	2100	10	5	15	117	0.9	105	19.9
	Unloaded	Flat	3150	0	5	5	733	0.85	623	5.1
		Downhill	2100	-10	5	-5	983	0.9	885	2.4
									Total	36.6
1355	loaded	Flat	3275	0	5	5	400	0.85	340	9.6
		Uphill	2150	10	5	15	117	0.9	105	20.4
	Unloaded	Flat	3275	0	5	5	733	0.85	623	5.3
		Downhill	2150	-10	5	-5	983	0.9	885	2.4
									Total	37.7
1370	loaded	Flat	3650	0	5	5	400	0.85	340	10.7
		Uphill	1700	10	5	15	117	0.8	94	18.2
	Unloaded	Flat	3650	0	5	5	733	0.85	623	5.9
		Downhill	1700	-10	5	-5	983	0.8	786	2.2
									Total	36.9
1385	loaded	Flat	2450	0	5	5	400	0.85	340	7.2
		Uphill	1400	10	5	15	117	0.8	94	15.0
	Unloaded	Flat	2450	0	5	5	733	0.85	623	3.9
		Downhill	1400	-10	5	-5	983	0.8	786	1.8
									Total	27.9
1400	loaded	Flat	2000	0	5	5	400	0.85	340	5.9
		Uphill	1200	10	5	15	117	0.8	94	12.8
	Unloaded	Flat	2000	0	5	5	733	0.85	623	3.2
		Downhill	1200	-10	5	-5	983	0.8	786	1.5
									Total	23.4
1415	loaded	Flat	850	0	5	5	400	0.65	260	3.3
		Uphill	1000	10	5	15	117	0.8	94	10.7
	Unloaded	Flat	850	0	5	5	733	0.65	476	1.8
		Downhill	1000	-10	5	-5	983	0.8	786	1.3
									Total	17.0

Table 60 Machines at each level & their productivity(2000)

level	power shovel	dump truck	material	loading time	time taken	loss time	cycle time	truck number	produc-tivety	produc-tion	surplus/ shortage
1340	13 m3	120 t	ore	5.6	15.2	1.9	22.7	5	1316	14479	3137
	13 m3	120 t	waste	5.6	36.6	1.9	44.1	5	678	8808	1730
1355	13 m3	120 t	ore	5.6	16.7	1.9	24.2	5	1235	13582	2240
	13 m3	120 t	waste	5.6	37.7	1.9	45.2	5	661	8594	1516
1370	13 m3	120 t	ore	5.6	13.4	1.9	20.9	4	1144	12581	1239
	13 m3	120 t	waste	5.6	36.9	1.9	44.4	4	538	6999	-79
1385	13 m3	120 t	ore	5.6	10.0	1.9	17.5	4	1366	15025	3683
	13 m3	120 t	waste	5.6	27.9	1.9	35.4	4	675	8778	1700
1400	13 m3	120 t	ore	5.6	10.2	1.9	17.7	4	1351	14856	3514
	13 m3	120 t	waste	5.6	23.4	1.9	30.9	4	774	10057	2979
1415	13 m3	120 t	ore	5.6	13.4	1.9	20.9	4	1144	12581	1239
	13 m3	120 t	waste	5.6	17.0	1.9	24.5	4	976	12684	5606
								Total	ore	83104	15052
									waste	55920	13452

③Combination of power shovel and dump truck in 2008

Calculated cycle time for ore transportation is indicated in Table 61, waste transportation in Table 62. The combination of machines and handling-quantity calculated from the cycle time are shown in Table 63.

According to Table 63, 5 levels are sufficient to get necessary output of ore and waste. Therefore, minimum numbers of shovel and truck are 5 and 30 respectively. If spare would be taken account as 10%, total numbers of power shovel and truck are 6 and 3 respectively.

Table 61 Cycle time for transportation of ore

2008 120t truck ore			Distance	Grade Resistance	Rolling Resistance	Total Resistance	Max Travel Speed	Speed Factor	Ave. Speed	Time Taken
level 1280	loaded	Flat	550	0	5	5	400	0.6	240	2.3
		Uphill	2500	10	5	15	117	0.9	105	23.7
	Unloaded	Flat	550	0	5	5	733	0.6	440	1.3
		Downhill	2500	-10	5	-5	983	0.9	885	2.8
									Total	30.1
1295	loaded	Flat	600	0	5	5	400	0.6	240	2.5
		Uphill	2250	10	5	15	117	0.9	105	21.4
	Unloaded	Flat	600	0	5	5	733	0.6	440	1.4
		Downhill	2250	-10	5	-5	983	0.9	885	2.5
									Total	27.8
1310	loaded	Flat	600	0	5	5	400	0.6	240	2.5
		Uphill	1950	10	5	15	117	0.8	94	20.8
	Unloaded	Flat	600	0	5	5	733	0.6	440	1.4
		Downhill	1950	-10	5	-5	983	0.8	786	2.5
									Total	27.2
1325	loaded	Flat	750	0	5	5	400	0.65	260	2.9
		Uphill	1950	10	5	15	117	0.8	94	20.8
	Unloaded	Flat	750	0	5	5	733	0.65	476	1.6
		Downhill	1950	-10	5	-5	983	0.8	786	2.5
									Total	27.8
1340	loaded	Flat	600	0	5	5	400	0.6	240	2.5
		Uphill	1700	10	5	15	117	0.8	94	18.2
	Unloaded	Flat	600	0	5	5	733	0.6	440	1.4
		Downhill	1700	-10	5	-5	983	0.8	786	2.2
									Total	24.2
1355	loaded	Flat	600	0	5	5	400	0.6	240	2.5
		Uphill	1450	10	5	15	117	0.8	94	15.5
	Unloaded	Flat	600	0	5	5	733	0.6	440	1.4
		Downhill	1450	-10	5	-5	983	0.8	786	1.8
									Total	21.2
1370	loaded	Flat	1500	0	5	5	400	0.7	280	5.4
		Uphill	1450	10	5	15	117	0.8	94	15.5
		Downhill	350	-10	5	-5	717	0.7	502	0.7
	loaded	Flat	1500	0	5	5	733	0.7	513	2.9
		Downhill	1450	-10	5	-5	983	0.8	786	1.8
		Uphill	350	10	5	15	333	0.7	233	1.5
									Total	27.8

Table 62 Cycle time for transportation of waste

2008 120t truck waste			Distance	Grade Resistance	Rolling Resistance	Total Resistance	Max Travel Speed	Speed Factor	Ave. Speed	Time Taken
level 1280	loaded	Flat	1250	0	5	5	400	0.7	280	4.5
		Uphill	3200	10	5	15	117	0.9	105	30.4
	Unloaded	Flat	1250	0	5	5	733	0.7	513	2.4
		Downhill	3200	-10	5	-5	983	0.9	885	3.6
									Total	40.9
1295	loaded	Flat	1300	0	5	5	400	0.7	280	4.6
		Uphill	2900	10	5	15	117	0.9	105	27.5
	Unloaded	Flat	1300	0	5	5	733	0.7	513	2.5
		Downhill	2900	-10	5	-5	983	0.9	885	3.3
									Total	38.0
1310	loaded	Flat	1300	0	5	5	400	0.7	280	4.6
		Uphill	2650	10	5	15	117	0.9	105	25.2
	Unloaded	Flat	1300	0	5	5	733	0.7	513	2.5
		Downhill	2650	-10	5	-5	983	0.9	885	3.0
									Total	35.3
1325	loaded	Flat	1300	0	5	5	400	0.7	280	4.6
		Uphill	2250	10	5	15	117	0.9	105	21.4
	Unloaded	Flat	1300	0	5	5	733	0.7	513	2.5
		Downhill	2250	-10	5	-5	983	0.9	885	2.5
									Total	31.1
1340	loaded	Flat	1300	0	5	5	400	0.7	280	4.6
		Uphill	1900	10	5	15	117	0.8	94	20.3
	Unloaded	Flat	1300	0	5	5	733	0.7	513	2.5
		Downhill	1900	-10	5	-5	983	0.8	786	2.4
									Total	29.3
1355	loaded	Flat	1250	0	5	5	400	0.7	280	4.5
		Uphill	1400	10	5	15	117	0.8	94	15.0
	Unloaded	Flat	1250	0	5	5	733	0.7	513	2.4
		Downhill	1400	-10	5	-5	983	0.8	786	1.8
									Total	23.6
1370	loaded	Flat	1200	0	5	5	400	0.7	280	4.3
		Uphill	1050	10	5	15	117	0.8	94	11.2
	Unloaded	Flat	1200	0	5	5	733	0.7	513	2.3
		Downhill	1050	-10	5	-5	983	0.8	786	1.3
									Total	19.2

Table 63 Machines at each level & their productivity(2008)

level	power shovel	dump truck	material	loading time	time taken	loss time	cycle time	truck number	productivety	production	surplus/ shortage
1280	13 m3	120 t	ore	5.6	30.1	1.9	37.6	6	954	15735	4290
	13 m3	120 t	waste	5.6	40.9	1.9	48.4	6	741	5556	1256
1295	13 m3	120 t	ore	5.6	27.8	1.9	35.3	6	1016	16760	5315
	13 m3	120 t	waste	5.6	38.0	1.9	45.5	6	788	5910	1610
1310	13 m3	120 t	ore	5.6	27.2	1.9	34.7	6	1033	17050	5605
	13 m3	120 t	waste	5.6	35.6	1.9	43.1	6	832	6239	1939
1325	13 m3	120 t	ore	5.6	27.8	1.9	35.3	6	1016	16760	5315
	13 m3	120 t	waste	5.6	29.8	1.9	37.3	6	961	7210	2910
1340	13 m3	120 t	ore	5.6	24.2	1.9	31.7	6	1131	18663	7218
	13 m3	120 t	waste	5.6	29.9	1.9	37.4	6	959	7190	2890
1355	13 m3	120 t	ore	5.6	21.2	1.9	28.7	5	1041	17178	5733
	13 m3	120 t	waste	5.6	23.6	1.9	31.1	5	961	7206	2906
1370	13 m3	120 t	ore	5.6	27.8	1.9	35.3	5	846	13967	2522
	13 m3	120 t	waste	5.6	19.2	1.9	26.7	5	1119	8393	4093
								Total	ore	116112	35997
									waste	47705	17605

④Renovation plan for power shovel and dump truck

Present Russian machines will be gradually renovated by the western machines from 1994, supposing that a 120t western truck is equivalent to 3 Russian 42t trucks. Renovation plan for power shovel is listed in Table 64 and dump truck, in Table 65.

Table 64 Renovation schedule for Power Shovel (WITH)

Machine	Puchased	Type	93	94	95	96	97	98	99	00	01	02	03	04	05	06	07	08
1	1978	8m3		×														
2	1978	8m3		×														
3	1981	8m3		×														
4	1982	8m3		×														
5	1984	8m3				×												
6	1989	8m3					×											
7	1990	10m3	※					×										
New1		13m3		◎				※				※				※		
2		13m3		◎				※				※				※		
3		13m3		◎				※				※				※		
4		13m3		◎				※				※				※		
5		13m3				◎				※				※				※
6		13m3					◎				※				※			

NOTE: ○=renovation of same typed machine, ×=disuse of same typed one
◎=replcement with western machine, ※=overhaul

Table 65 Renovation schedule for Dump Truck (WITH)

Machine	Puchased	Type	93	94	95	96	97	98	99	00	01	02	03	04	05	06	07	08
1	1989	110t	○		※		×											
2	1989	110t	○		※		×											
3	1990	110t		×														
4	1991	110t	※		×													
5	1991	110t	※		×													
6	1989	42t	○		※		×											
7	1989	42t	○		※		×											
8	1989	42t	○		※		×											
9	1989	42t	○		※		×											
10	1989	42t	○		※		×											
11	1989	42t	○		※		×											
12	1989	42t	○		※		×											
13	1989	42t	○		※		×											
14	1989	42t	○		※		×											
15	1989	42t	○		※		×											
16	1989	42t	○		※		×											
17	1989	42t	○		※		×											
18	1989	42t	○		※		×											
19	1990	42t		×														
20	1990	42t		×														
21	1990	42t		×														
22	1990	42t		×														
23	1990	42t		×														
24	1990	42t		×														
25	1990	42t		×														
26	1990	42t		×														
27	1990	42t		×														
28	1990	42t		×														
29	1990	42t		×														
30	1990	42t		×														
31	1990	42t		×														
32	1990	42t		×														
33	1990	42t		×														
34	1990	42t		×														
35	1990	42t		×														
36	1991	42t	※		×													
37	1991	42t	※		×													
38	1991	42t	※		×													
39	1991	42t	※		×													
40	1992	42t		※		×												
41	1992	42t		※		×												
42	1992	42t		※		×												
43	1992	42t		※		×												
44	1992	42t		※		×												
45	1992	42t		※		×												
46	1992	42t		※		×												
47	1992	42t		※		×												

Machine	Puchased	Type	93	94	95	96	97	98	99	00	01	02	03	04	05	06	07	08
New1		120t		◎			※		○			※		○			※	
2		120t		◎			※		○			※		○			※	
3		120t		◎			※		○			※		○			※	
4		120t		◎			※		○			※		○			※	
5		120t		◎			※		○			※		○			※	
6		120t		◎			※		○			※		○			※	
7		120t		◎			※		○			※		○			※	
8		120t		◎			※		○			※		○			※	
9		120t		◎			※		○			※		○			※	
10		120t		◎			※		○			※		○			※	
11		120t			◎			※		○			※		○			※
12		120t			◎			※		○			※		○			※
13		120t			◎			※		○			※		○			※
14		120t				◎			※		○			※		○		
15		120t				◎			※		○			※		○		
16		120t				◎			※		○			※		○		
17		120t					◎			※		○			※		○	
18		120t					◎			※		○			※		○	
19		120t					◎			※		○			※		○	
20		120t					◎			※		○			※		○	
21		120t					◎			※		○			※		○	
22		120t					◎			※		○			※		○	
23		120t					◎			※		○			※		○	
24		120t						◎			※		○			※		○
25		120t									◎			※		○		
26		120t									◎			※		○		
27		120t										◎			※		○	
28		120t										◎			※		○	
29		120t											◎			※		○
30		120t											◎			※		○
31		120t												◎			※	
32		120t												◎			※	
33		120t													◎			※

NOTE: ○=renovation of same typed machine, ×=disuse of same typed one
◎=replcement with western machine, ※=overhaul

⑤Renovation plan for the other machines

We prepared renovation plan for the other principal machines except power shovel and dump truck. Renovation plan for rotary drill is shown in Table 66, motor grader in Table 67 and bulldozer in Table 68.

Table 66 Renovation schedule for Rotary Drill (WITH)

Machine	Puchased	Type	93	94	95	96	97	98	99	00	01	02	03	04	05	06	07	08
1	1986	250mm	○				×											
2	1987	250mm		×														
3	1988	250mm		×														
4	1988	250mm		×														
5	1989	250mm		×														
New1		250mm		◎				※			○				※			○
2		250mm		◎				※			○				※			○
3		250mm		◎				※			○				※			○
4		250mm		◎				※			○				※			○
5		250mm					◎				※			○				※

NOTE: ○=renovation of same typed machine, ×=disuse of same typed one
◎=replcement with western machine, ※=overhaul

Table 67 Renovation schedule for Motor Grader (WITH)

Machine	Puchased	Type	93	94	95	96	97	98	99	00	01	02	03	04	05	06	07	08
New1		110t		◎		※		○		※		○		※		○		※
2		110t		◎		※		○		※		○		※		○		※
3		110t		◎		※		○		※		○		※		○		※
4		110t						◎		※		○		※		○		※

NOTE: ○=renovation of same typed machine,
◎=replcement with western machine, ※=overhaul

Table 68 Renovation schedule for Bulldozer (WITH)

Machine	Puchased	Type	93	94	95	96	97	98	99	00	01	02	03	04	05	06	07	08
1	1987	330PS		×														
2	1988	330PS			×													
3	1988	330PS			×													
4	1989	330PS			×													
5	1989	330PS			×													
6	1989	330PS			×													
7	1989	330PS			×													
8	1989	330PS			×													
9	1990	330PS	※		×													
10	1990	330PS	※		×													
11	1991	330PS		※		×												
12	1991	330PS		※		×												
13	1992	330PS			※		×											
14	1992	330PS			※		×											
15	1992	330PS			※		×											
New1		320PS		◎			※		○			※		○			※	
2		320PS			◎			※		○			※		○			※
3		320PS			◎			※		○			※		○			※
4		320PS			◎			※		○			※		○			※
5		320PS			◎			※		○			※		○			※
6		320PS			◎			※		○			※		○			※
7		320PS			◎			※		○			※		○			※
8		320PS			◎			※		○			※		○			※
9		320PS			◎			※		○			※		○			※
10		320PS				◎			※		○			※		○		
11		320PS				◎			※		○			※		○		
12		320PS					◎			※		○			※		○	
13		320PS					◎			※		○			※		○	
14		320PS					◎			※		○			※		○	
15		320PS						◎			※		○			※		○
16		320PS									◎			※		○		
17		320PS										◎			※		○	
18		320PS											◎			※		○
19		320PS												◎			※	
20		320PS													◎			※
21		320PS														◎		

NOTE: ○=renovation of same typed machine, ×=disuse of same typed one
◎=replcement with western machine, ※=overhaul

(2) Study on mining cost

Mining cost is estimated on basis of modernization of Erdenet mine. Unit consumable material like explosives, bits, power shovel teeth and electricity is fixed and used for following years. Labor cost, additional labor cost and insurance are in proportion to the number of workers which is proportional to number of machineries except trucks. Cost for Transportation Department is calculated by unit price of 1992, that is, t·km for ore and m^3·km for waste respectively.

Cost related to heavy machines is estimated proportional to number of machines including dump trucks. Amortization is neglected, because the detail of present amortization is unknown. Only purchase cost is included in each renovational year. Under this condition, mining cost is calculated and indicated in Table 69. Lower table shows stripping cost. According to this table, mining cost increases only 59% in spite of 73% increase of production. This is due to efficiency-up caused by large-sizing of machineries and decreasing of stripping volume.

Table 69 Mining cost (WITH)

year		1992				1994		1995		1996		1997		1998		1999		2000		2001		
output (t)		16,875,000				20,500,000		21,000,000		22,000,000		23,000,000		24,000,000		25,000,000		24,839,000		25,213,000		25
cost item	unit	uint consumable	unit price	consumable amount	sum (1,000Tg)	consumable amount	sum (1,000Tg)	consumable amount	sum (1,000Tg)	consumable amount	sum (1,000Tg)	consumable amount	sum (1,000Tg)	consumable amount	sum (1,000Tg)	consumable amount	sum (1,000Tg)	consumable amount	sum (1,000Tg)	consumable amount	sum (1,000Tg)	co
1.material					129,088		156,524		160,042		167,977		175,612		183,248		190,883		189,654		192,509	
explosive	Kg	0.201	32.91	3,398,445	111,843	4,120,500	135,606	4,221,000	138,913	4,422,000	145,528	4,623,000	152,143	4,824,000	158,758	5,025,000	165,373	4,992,639	164,308	5,067,813	166,782	5
fuse	m	0.025	4.889	425,865	1,997	512,500	2,403	525,000	2,462	550,000	2,579	575,000	2,696	600,000	2,813	625,000	2,931	620,975	2,912	630,325	2,956	
detonator	pcs.	0.223	0.823	3,766	3	4,572	4	4,572	4	4,906	4	5,129	4	5,352	4	5,575	5	5,539	5	5,622	5	
bit	pcs.	0.0177	20,456	298	6,096	363	7,422	363	7,422	389	7,966	407	8,328	425	8,690	443	9,052	440	8,993	446	9,129	
rod	pcs.	0.002	89,794	34	3,053	41	3,682	41	3,682	44	3,951	46	4,131	48	4,310	50	4,490	50	4,461	50	4,528	
dipper-teeth	pcs.	0.0143	4018	241	968	293	1,178	293	1,178	315	1,264	329	1,322	343	1,379	358	1,436	355	1,427	361	1,449	
etc					5,128	0	6,230	0	6,382	0	6,685	0	6,989	0	7,293	0	7,597	0	7,548	0	7,662	
2.electricity	KWH	0.44	1.79	7,431,421	13,302	9,020,000	16,146	9,240,000	16,540	9,680,000	17,327	10,120,000	18,115	10,560,000	18,902	11,000,000	19,690	10,929,160	19,563	11,093,720	19,858	11
3.labor					7,682		8,231		8,231		8,231		8,231		8,231		8,231		8,231			
4.add. labor					688		737		737		737		737		737		737		737			
5.insurance					1,133		1,214		1,214		1,214		1,214		1,214		1,214		1,214			
6.amortization					0																	
7.transp.	t・Km		3.319	29,130,000	96,682	32,816,000	108,916	34,195,000	113,493	36,447,000	120,968	38,755,000	128,628	41,120,000	136,477	43,542,000	144,516	43,966,000	145,923	47,075,000	156,242	4
8.stripping					134,286		270,366		266,432		255,603		243,727		233,801		223,321		225,651		221,164	
9.geology					11,280		11,280		11,280		11,280		11,280		11,280		11,280		11,280		11,280	
10.heavy mach.					47,980		44,142		42,222		39,024		33,906		34,546		34,546		34,546		36,465	
11.staff-salary					12,434		12,434		12,434		12,434		12,434		12,434		12,434		12,434		12,434	
total					454,556		629,990		632,625		634,795		633,884		640,870		646,852		649,233		649,952	
(% to previous year)					—		1.39		1.00		1.00		1.00		1.01		1.01		1.00		1.00	

year		1992				1994		1995		1996		1997		1998		1999		2000		2001		
stripped volume (m3)		2,672,000				8,163,000		7,959,000		7,551,000		7,143,000		6,735,000		6,327,000		6,327,000		6,204,000		
cost item	unit	uint consumable	unit price	consumable amount	sum (1,000Tg)	consumable amount	sum (1,000Tg)	consumable amount	sum (1,000Tg)	consumable amount	sum (1,000Tg)	consumable amount	sum (1,000Tg)	consumable amount	sum (1,000Tg)	consumable amount	sum (1,000Tg)	consumable amount	sum (1,000Tg)	consumable amount	sum (1,000Tg)	co
1.material					52,053		157,609		153,671		145,793		137,916		130,038		122,160		122,160		119,786	
explosive	Kg	0.501	34.08	1,352,289	46,081	4,089,663	139,376	3,987,459	135,893	3,783,051	128,926	3,578,643	121,960	3,374,235	114,994	3,169,827	108,028	3,169,827	108,028	3,108,204	105,928	
fuse	m	0.064	5.316	170,216	905	522,432	2,777	509,376	2,708	483,264	2,569	457,152	2,430	431,040	2,291	404,928	2,153	404,928	2,153	397,056	2,111	
detonator	pcs.	0.568	0.725	1,517	1	4,637	3	4,521	3	4,289	3	4,057	3	3,825	3	3,594	3	3,594	3	3,524	3	
bit	pcs.	0.0498	20,255	133	2694	407	8,234	396	8,028	376	7,617	356	7,205	335	6,794	315	6,382	315	6,382	309	6,258	
rod	pcs.	0.0037	88,170	10	882	30	2,663	29	2,596	28	2,463	26	2,330	25	2,197	23	2,064	23	2,064	23	2,024	
dipper-teeth	pcs.	0.0382	4520	102	461	312	1,409	304	1,374	288	1,304	273	1,233	257	1,163	242	1,092	242	1,092	237	1,071	
etc					1,030		3,147		3,068		2,911		2,753		2,596		2,439		2,439		2,392	
2.electricity	KWH	1.09	2.019	2,913,707	5,882	8,897,670	17,964	8,675,310	17,515	8,230,590	16,618	7,785,870	15,720	7,341,150	14,822	6,896,430	13,924	6,896,430	13,924	6,762,360	13,653	
3.labor					3,002		3,216		3,216		3,216		3,216		3,216		3,216		3,216		3,324	
4.add. labor					267		286		286		286		286		286		286		286		296	
5.insurance					429		460		460		460		460		460		460		460		475	
6.amortization																						
7.transp.	t・Km		3.037	16,105,000	48,905	22,582,000	68,582	22,978,000	69,784	22,713,000	68,979	22,350,000	67,877	21,889,000	66,477	21,328,000	64,773	22,095,000	67,103	21,198,000	64,378	2
8.stripping																						
9.geology																						
10.heavy mach.					18,734		17,235		16,486		15,237		13,239		13,488		13,488		13,488		14,238	
11.staff-salary					5,014		5,014		5,014		5,014		5,014		5,014		5,014		5,014		5,014	
total					134,286		270,366		266,432		255,603		243,727		233,801		223,321		225,651		221,164	
(% to previous year)					—		2.01		0.99		0.96		0.95		0.96		0.96		1.01		0.98	

1998		1999		2000		2001		2002		2003		2004		2005		2006		2007		2008	
,000,000		25,000,000		24,839,000		25,213,000		25,212,000		25,444,000		27,011,000		27,804,000		27,803,000		27,804,000		29,242,000	
nsumable amount	sum (1,000Tg)	consumable amount	sum (1,000Tg)	consumable amount	sum (1,000Tg)	consumable amount	sum (1,000Tg)	consumable amount	sum (1,000Tg)	consumable amount	sum (1,000Tg)	consumable amount	sum (1,000Tg)	consumable amount	sum (1,000Tg)	consumable amount	sum (1,000Tg)	consumable amount	sum (1,000Tg)	consumable amount	sum (1,000Tg)
	183,248		190,883		189,654		192,509		192,502		194,273		206,238		212,292		212,285		212,292		223,272
,824,000	158,758	5,025,000	165,373	4,932,639	164,308	5,067,813	166,782	5,067,612	166,775	5,114,244	168,310	5,429,211	178,675	5,588,604	183,921	5,588,403	183,914	5,588,604	183,921	5,877,642	193,433
800,000	2,813	625,000	2,931	620,975	2,912	630,325	2,956	630,300	2,955	636,100	2,983	675,275	3,166	695,100	3,259	695,075	3,259	695,100	3,259	731,050	3,428
5,352	4	5,575	5	5,539	5	5,622	5	5,622	5	5,674	5	6,023	5	6,200	5	6,200	5	6,200	5	6,521	5
425	8,630	443	9,052	440	8,993	446	9,129	446	9,129	450	9,213	478	9,780	492	10,067	492	10,067	492	10,067	518	10,588
48	4,310	50	4,490	50	4,461	50	4,528	50	4,528	51	4,563	54	4,851	56	4,993	56	4,993	56	4,993	58	5,252
343	1,379	358	1,436	355	1,427	361	1,449	361	1,449	364	1,462	386	1,552	398	1,598	398	1,597	398	1,598	418	1,680
0	7,293	0	7,597	0	7,548	0	7,662	0	7,661	0	7,732	0	8,208	0	8,449	0	8,449	0	8,449	0	8,886
,560,000	18,902	11,000,000	19,690	10,929,160	19,563	11,093,720	19,858	11,093,280	19,857	11,195,360	20,040	11,884,840	21,274	12,233,760	21,898	12,233,320	21,898	12,233,760	21,898	12,866,480	23,031
	8,231		8,231		8,231																
	737		737		737																
	1,214		1,214		1,214																
,120,000	136,477	43,542,000	144,518	43,966,000	145,923	47,075,000	156,242	49,521,000	164,360	52,447,000	174,072	58,299,000	193,494	62,710,000	208,134	65,407,000	217,086	68,109,000	226,054	74,470,000	247,166
	233,801		223,321		225,651		221,164		218,033		212,397		194,099		190,466		183,862		182,699		162,997
	11,280		11,280		11,280		11,280		11,280		11,280		11,280		11,280		11,280		11,280		11,280
	34,546		34,546		34,546		36,465		38,384		40,303		42,222		43,502		44,142		44,142		44,142
	12,434		12,434		12,434		12,434		12,434		12,434		12,434		12,434		12,434		12,434		12,434
	640,870		646,852		649,233		649,952		656,850		664,799		681,041		700,007		702,987		710,800		724,322
	1.01		1.01		1.00		1.00		1.01		1.01		1.02		1.03		1.00		1.01		1.02

1998		1999		2000		2001		2002		2003		2004		2005		2006		2007		2008	
,735,000		6,327,000		6,327,000		6,204,000		6,122,000		5,959,000		5,388,000		5,102,000		5,102,000		5,102,000		4,490,000	
nsumable amount	sum (1,000Tg)	consumable amount	sum (1,000Tg)	consumable amount	sum (1,000Tg)	consumable amount	sum (1,000Tg)	consumable amount	sum (1,000Tg)	consumable amount	sum (1,000Tg)	consumable amount	sum (1,000Tg)	consumable amount	sum (1,000Tg)	consumable amount	sum (1,000Tg)	consumable amount	sum (1,000Tg)	consumable amount	sum (1,000Tg)
	130,038		122,160		122,160		119,786		118,202		115,055		104,030		98,508		98,508		98,508		86,692
,374,235	114,934	3,169,827	108,028	3,169,827	108,028	3,108,204	105,928	3,067,122	104,528	2,985,459	101,744	2,699,388	91,995	2,556,102	87,112	2,556,102	87,112	2,556,102	87,112	2,249,490	76,663
431,040	2,291	404,928	2,153	404,928	2,153	397,056	2,111	391,808	2,083	381,376	2,027	344,832	1,833	326,528	1,736	326,528	1,736	326,528	1,736	287,360	1,528
3,825	3	3,594	3	3,594	3	3,524	3	3,477	3	3,385	2	3,060	2	2,898	2	2,898	2	2,898	2	2,550	2
335	6,734	315	6,382	315	6,382	309	6,258	305	6,175	297	6,011	268	5,435	254	5,146	254	5,146	254	5,146	224	4,529
25	2,197	23	2,064	23	2,064	23	2,024	23	1,997	22	1,944	20	1,758	19	1,664	19	1,664	19	1,664	17	1,465
257	1,163	242	1,092	242	1,092	237	1,071	234	1,057	228	1,029	206	930	195	881	195	881	195	881	172	775
	2,596		2,439		2,439		2,392		2,360		2,297		2,077		1,967		1,967		1,967		1,731
,341,150	14,822	6,896,430	13,924	6,896,430	13,924	6,762,360	13,653	6,672,980	13,473	6,495,310	13,114	5,872,920	11,857	5,561,180	11,228	5,561,180	11,228	5,561,180	11,228	4,894,100	9,881
	3,216		3,216		3,216		3,324		3,431		3,538		3,645		3,753		3,860		3,860		3,860
	286		286		286		296		305		315		324		334		343		343		343
	460		460		460		475		490		506		521		536		552		552		552
,889,000	66,477	21,328,000	64,773	22,095,000	67,103	21,198,000	64,378	20,458,000	62,131	19,466,000	59,118	17,195,000	52,221	17,816,000	54,107	15,516,000	47,122	15,133,000	45,959	12,980,000	39,420
	13,488		13,488		13,488		14,238		14,987		15,737		16,486		16,985		17,235		17,235		17,235
	5,014		5,014		5,014		5,014		5,014		5,014		5,014		5,014		5,014		5,014		5,014
	233,801		223,321		225,651		221,164		218,033		212,397		194,099		190,466		183,862		182,699		162,997
	0.96		0.96		1.01		0.98		0.99		0.97		0.91		0.98		0.97		0.99		0.89

(3) Utilizing computer for mining design

Computers are frequently used to compile the operational data to improve the mining operation at present. It is desirable, however, to utilize computers for making a design such as dimensional display and simulation of mining benches and waste excavation, based on the data of diamond drill holes and rock mechanics. In order to maintain the heavy machineries in good condition, it is also recommendable to make a data file on the operation of those machineries so that the necessary spare parts are properly stored.

(4) Control system for grade of ore output

The control system for grade of ore output at Erdenet mine is basically the same to that of western countries. What is important is to follow the regulated procedure in the actual operation. Especially in sludge sampling of rotary drill holes, the depth of drill hole must be coincident with the depth of blast hole.

The grade of mill feed in the processing plant is considerably fluctuating. In order to maintain the mill feed at a certain level, it is advisable to make a blending of different grade ore from different ore pile at the mine site.

(5) Assignment of dump truck to Mining Department

Operation of dump truck for hauling ore from the mine to the processing plant is managed by Transportation Department, and other mining equipment, including power shovels and rotary drills, belong to Mining Department. Since the operation of dump truck is much dependent on the operation of power shovel and other mining equipment, it is advisable that the management of dump truck,

including maintenance of the road from mine to processing plant are to be assigned to Mining Department.

(6) Future ore hauling system

Distance of ore hauling will increase as the mining pit become deeper. Increasing hauling distance by every one bench is estimated 167m. In final pit, the hauling distance will become 2500m longer than the present hauling distance as the number of benches in the final pit is presumed to be 15. Long distance ore hauling by truck will require a number of trucks and cause a break down of truck. Therefore, other hauling system for instance, crush the ore at the bottom of pit then haul the crushed ore to the processing plant by belt conveyers is to be considered.

5-3-2 Investment Necessary for Modernization

(1) Investment for modernization (WITH)

Investment for mining is calculated in case of increased production according to modernization of the mine. Yearly investment is shown in Table 70. The investment for mining amounts to US$277 million at financial cost and US$264 million at economic cost.

(2) Estimation of mining cost WITHOUT modernization

Mining cost for coming years is estimated on the same calculation base of modernization, assuming that operation scale of 1992 would be maintained in future. Yearly estimation of mining cost is listed in Table 71. This table describes that cost-up during 1994 to 2008 is 17%, which owes to increasing machineries and labors caused by increasing transportation distance although amount of output would be unchanged.

Table 70 INVESTMENT IN MINING

(US$1000)

ITEMS	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	Total
Rotary Drill	5,276			1,319	1,583			5,672			1,319	1,583			5,672	22,423
Purchase	5,276			1,319				5,276			1,319				5,276	18,466
Overhaul					1,583			396				1,583			396	3,957
Power Shovel	21,844		5,461	5,461	6,553		1,638	1,638	6,553		1,638	1,638	6,553		1,638	60,617
Purchase	21,844		5,461	5,461												32,766
Overhaul					6,553		1,638	1,638	6,553		1,638	1,638	6,553		1,638	27,851
Bulldozer	529	3,439	814	1,343	1,384	651	3,622	1,343	1,750	1,791	1,180	4,151	1,465	1,872	1,913	27,248
Purchase	407	3,256	814	1,221	407	407	3,256	1,221	1,628	814	814	3,663	1,221	1,628	814	21,571
Overhaul	122	183		122	977	244	366	122	122	977	366	488	244	244	1,099	5,677
Motor Grader	966		290		1,288		386		1,288		386		1,288		386	6,279
Purchase	966				1,288				1,288				1,288			4,830
Overhaul			290				386				386				386	1,449
Dump Truck	14,258	5,746	4,032	13,440	2,554	14,650	6,954	7,123	16,128	5,272	18,144	9,005	7,930	16,934	5,645	147,814
Purchase	13,440	4,032	4,032	9,408	1,344	13,440	4,132	6,720	12,096	4,032	16,128	5,376	6,720	12,096	4,032	117,028
Overhaul	818	1,714		4,032	1,210	1,210	2,822	403	4,032	1,240	2,016	3,629	1,210	4,838	1,613	30,786
Economic Cost Total	42,873	9,185	10,597	21,563	13,361	15,301	12,601	15,776	25,719	7,062	22,668	16,377	17,236	18,807	15,254	264,382
Foreign currency	42,184	9,037	10,426	21,217	13,147	15,055	12,399	15,523	25,306	6,949	22,304	16,114	16,959	18,504	15,009	260,133
Local currency	689	148	170	347	215	246	203	254	413	114	364	263	277	302	245	4,249
Import & Sales Tax	10,546	2,259														12,805
Financial Cost Total	53,419	11,444	10,597	21,563	13,361	15,301	12,601	15,776	25,719	7,062	22,668	16,377	17,236	18,807	15,254	277,187
Foreign currency	42,184	9,037	10,426	21,217	13,147	15,055	12,399	15,523	25,306	6,949	22,304	16,114	16,959	18,504	15,009	260,133
Local currency	11,235	2,407	170	347	215	246	203	254	413	114	364	263	277	302	245	17,054

Table 71 Mining cost (WITHOUT)

year		1992				1994		1995		1996		1997		1998		1999		2000		2001	
output (t)		16,875,000				17,000,000		17,000,000		17,000,000		17,000,000		17,000,000		17,000,000		17,000,000		17,000,000	
cost item	unit	unit consumable	unit price	consumable amount	sum (1,000Tg)	consumable amount	sum (1,000Tg)	consumable amount	sum (1,000Tg)	consumable amount	sum (1,000Tg)	consumable amount	sum (1,000Tg)	consumable amount	sum (1,000Tg)	consumable amount	sum (1,000Tg)	consumable amount	sum (1,000Tg)	consumable amount	sum (1,000Tg)
1.material					129,088		129,800		129,800		129,800		129,800		129,800		129,800		129,800		129,800
explosives	Kg	0.201	32.91	3,338,445	111,843	3,417,000	112,453	3,417,000	112,453	3,417,000	112,453	3,417,000	112,453	3,417,000	112,453	3,417,000	112,453	3,417,000	112,453	3,417,000	112,453
fuse	m	0.025	4.689	425,865	1,997	425,000	1,993	425,000	1,993	425,000	1,993	425,000	1,993	425,000	1,993	425,000	1,993	425,000	1,993	425,000	1,993
detonator	psc.	0.223	0.823	3,766	3	3,791	3	3,791	3	3,791	3	3,791	3	3,791	3	3,791	3	3,791	3	3,791	3
bit	psc.	0.0177	20,456	298	6,096	301	6,155	301	6,155	301	6,155	301	6,155	301	6,155	301	6,155	301	6,155	301	6,155
rod	psc.	0.002	89,794	34	3,053	34	3,053	34	3,053	34	3,053	34	3,053	34	3,053	34	3,053	34	3,053	34	3,053
dipper-teeth	psc.	0.0143	4018	241	968	243	977	243	977	243	977	243	977	243	977	243	977	243	977	243	977
etc					5,128	0	5,166	0	5,166	0	5,166	0	5,166	0	5,166	0	5,166	0	5,166	0	5,166
2.electricity	KWH	0.44	1.79	7,431,421	13,302	7,480,000	13,389	7,480,000	13,389	7,480,000	13,389	7,480,000	13,389	7,480,000	13,389	7,480,000	13,389	7,480,000	13,389	7,480,000	13,389
3.labor					7,682		8,231		8,231		8,231		8,231		8,505		8,505		8,505		8,779
4.add. labor					688		737		737		737		737		762		762		762		786
5.insurance					1,133		1,214		1,214		1,214		1,214		1,254		1,254		1,254		1,295
6.amotization					0																
7.transp.	t·Km		3.319	29,130,000	96,682	27,213,000	90,320	27,682,000	91,877	28,164,000	93,476	28,645,000	95,073	29,127,000	96,673	29,609,000	98,272	30,091,000	99,872	31,741,000	105,348
8.stripping					134,286		162,506		164,152		165,801		167,450		169,984		171,633		173,285		173,389
9.geology					11,280		11,280		11,280		11,280		11,280		11,280		11,280		11,280		11,280
10.heavy mach.					47,980		49,259		49,259		49,259		49,259		51,179		51,179		51,179		53,738
11.suaff-salary					12,434		12,434		12,434		12,434		12,434		12,434		12,434		12,434		12,434
total					454,556		479,170		482,373		485,622		488,867		495,260		498,503		501,761		510,239
(% to previous	year)				—		1.05		1.01		1.01		1.01		1.01		1.01		1.01		1.02

year		1992				1994		1995		1996		1997		1998		1999		2000		2001	
stripping volume(m3)		2,672,000				4,490,000		4,490,000		4,490,000		4,490,000		4,490,000		4,490,000		4,490,000		4,490,000	
cost item	unit	unit consumable	unit price	consumable amount	sum (1,000Tg)	consumable amount	sum (1,000Tg)	consumable amount	sum (1,000Tg)	consumable amount	sum (1,000Tg)	consumable amount	sum (1,000Tg)	consumable amount	sum (1,000Tg)	consumable amount	sum (1,000Tg)	consumable amount	sum (1,000Tg)	consumable amount	sum (1,000Tg)
1.material					52,053		86,692		86,692		86,692		86,692		86,692		86,692		86,692		86,692
explosives	Kg	0.501	34.08	1,352,289	46,081	2,249,490	76,663	2,249,490	76,663	2,249,490	76,663	2,249,490	76,663	2,249,490	76,663	2,249,490	76,663	2,249,490	76,663	2,249,490	76,663
fuse	m	0.064	5.316	170,216	905	287,360	1,528	287,360	1,528	287,360	1,528	287,360	1,528	287,360	1,528	287,360	1,528	287,360	1,528	287,360	1,528
detonator	psc.	0.568	0.725	1,517	1	2,550	2	2,550	2	2,550	2	2,550	2	2,550	2	2,550	2	2,550	2	2,550	2
bit	psc.	0.0498	20,255	133	2694	224	4,529	224	4,529	224	4,529	224	4,529	224	4,529	224	4,529	224	4,529	224	4,529
rod	psc.	0.0037	88,170	10	882	17	1,465	17	1,465	17	1,465	17	1,465	17	1,465	17	1,465	17	1,465	17	1,465
dipper-teeth	psc.	0.0382	4520	102	461	172	775	172	775	172	775	172	775	172	775	172	775	172	775	172	775
etc					1,030	0	1,731	0	1,731	0	1,731	0	1,731	0	1,731	0	1,731	0	1,731	0	1,731
2.electricity	KWH	1.09	2.019	2,913,707	5,882	4,894,100	9,881	4,894,100	9,881	4,894,100	9,881	4,894,100	9,881	4,894,100	9,881	4,894,100	9,881	4,894,100	9,881	4,894,100	9,881
3.labor					3,002		3,216		3,216		3,216		3,216		3,324		3,324		3,324		3,431
4.add. labor					267		286		286		286		286		296		296		296		305
5.insurance					429		460		460		460		460		475		475		475		490
6.amotization																					
7.transp.	t·Km		3.037	16,105,000	48,905	12,421,000	37,723	12,963,000	39,369	13,506,000	41,018	14,049,000	42,667	14,593,000	44,319	15,136,000	45,968	15,680,000	47,620	15,342,000	46,594
8.stripping																					
9.geology																					
10.heavy mach.					18,734		19,234		19,234		19,234		19,234		19,983		19,983		19,983		20,982
11.suaff-salary					5,014		5,014		5,014		5,014		5,014		5,014		5,014		5,014		5,014
total					134,286		162,506		164,152		165,801		167,450		169,984		171,633		173,285		173,389
(% to previous	year)				—		1.21		1.01		1.01		1.01		1.02		1.01		1.01		1.00

1998		1999		2000		2001		2002		2003		2004		2005		2006		2007		2008	
000,000		17,000,000		17,000,000		17,000,000		17,000,000		17,000,000		17,000,000		17,000,000		17,000,000		17,000,000		17,000,000	
sumable amount	sum (1,000Tg)	consumable amount	sum (1,000Tg)	consumable amount	sum (1,000Tg)	consumable amount	sum (1,000Tg)	consumable amount	sum (1,000Tg)	consumable amount	sum (1,000Tg)	consumable amount	sum (1,000Tg)	consumable amount	sum (1,000Tg)	consumable amount	sum (1,000Tg)	consumable amount	sum (1,000Tg)	consumable amount	sum (1,000Tg)
	129,800		129,800		129,800		129,800		129,800		129,800		129,800		129,800		129,800		129,800		129,800
417,000	112,453	3,417,000	112,453	3,417,000	112,453	3,417,000	112,453	3,417,000	112,453	3,417,000	112,453	3,417,000	112,453	3,417,000	112,453	3,417,000	112,453	3,417,000	112,453	3,417,000	112,453
425,000	1,993	425,000	1,993	425,000	1,993	425,000	1,993	425,000	1,993	425,000	1,993	425,000	1,993	425,000	1,993	425,000	1,993	425,000	1,993	425,000	1,993
3,791	3	3,791	3	3,791	3	3,791	3	3,791	3	3,791	3	3,791	3	3,791	3	3,791	3	3,791	3	3,791	3
301	6,155	301	6,155	301	6,155	301	6,155	301	6,155	301	6,155	301	6,155	301	6,155	301	6,155	301	6,155	301	6,155
34	3,053	34	3,053	34	3,053	34	3,053	34	3,053	34	3,053	34	3,053	34	3,053	34	3,053	34	3,053	34	3,053
243	977	243	977	243	977	243	977	243	977	243	977	243	977	243	977	243	977	243	977	243	977
0	5,166	0	5,166	0	5,166	0	5,166	0	5,166	0	5,166	0	5,166	0	5,166	0	5,166	0	5,166	0	5,166
480,000	13,389	7,480,000	13,389	7,480,000	13,389	7,480,000	13,389	7,480,000	13,389	7,480,000	13,389	7,480,000	13,389	7,480,000	13,389	7,480,000	13,389	7,480,000	13,389	7,480,000	13,389
	8,505		8,505		8,505		8,779		9,054		9,328		9,603		9,877		10,151		10,151		10,151
	762		762		762		786		811		835		860		885		909		909		909
	1,254		1,254		1,254		1,295		1,335		1,376		1,416		1,457		1,497		1,497		1,497
127,000	96,673	29,609,000	98,272	30,091,000	99,872	31,741,000	105,348	33,391,000	110,825	35,042,000	116,304	36,692,000	121,781	38,342,000	127,257	39,993,000	132,737	41,643,000	138,213	43,294,000	143,693
	169,984		171,633		173,285		173,389		173,744		174,101		174,206		179,437		173,922		172,899		171,872
	11,280		11,280		11,280		11,280		11,280		11,280		11,280		11,280		11,280		11,280		11,280
	51,179		51,179		51,179		53,738		56,936		60,135		62,694		65,253		66,532		66,532		66,532
	12,434		12,434		12,434		12,434		12,434		12,434		12,434		12,434		12,434		12,434		12,434
	495,260		498,509		501,761		510,239		519,609		528,983		537,464		551,070		552,652		557,105		561,558
	1.01		1.01		1.01		1.02		1.02		1.02		1.02		1.03		1.00		1.01		1.01

1998		1999		2000		2001		2002		2003		2004		2005		2006		2007		2008	
,490,000		4,490,000		4,490,000		4,490,000		4,490,000		4,490,000		4,490,000		4,490,000		4,490,000		4,490,000		4,490,000	
nsumable amount	sum (1,000Tg)	consumable amount	sum (1,000Tg)	consumable amount	sum (1,000Tg)	consumable amount	sum (1,000Tg)	consumable amount	sum (1,000Tg)	consumable amount	sum (1,000Tg)	consumable amount	sum (1,000Tg)	consumable amount	sum (1,000Tg)	consumable amount	sum (1,000Tg)	consumable amount	sum (1,000Tg)	consumable amount	sum (1,000Tg)
	86,692		86,692		86,692		86,692		86,692		86,692		86,692		86,692		86,692		86,692		86,692
,249,490	76,663	2,249,490	76,663	2,249,490	76,663	2,249,490	76,663	2,249,490	76,663	2,249,490	76,663	2,249,490	76,663	2,249,490	76,663	2,249,490	76,663	2,249,490	76,663	2,249,490	76,663
287,360	1,528	287,360	1,528	287,360	1,528	287,360	1,528	287,360	1,528	287,360	1,528	287,360	1,528	287,360	1,528	287,360	1,528	287,360	1,528	287,360	1,528
2,550	2	2,550	2	2,550	2	2,550	2	2,550	2	2,550	2	2,550	2	2,550	2	2,550	2	2,550	2	2,550	2
224	4,529	224	4,529	224	4,529	224	4,529	224	4,529	224	4,529	224	4,529	224	4,529	224	4,529	224	4,529	224	4,529
17	1,465	17	1,465	17	1,465	17	1,465	17	1,465	17	1,465	17	1,465	17	1,465	17	1,465	17	1,465	17	1,465
172	775	172	775	172	775	172	775	172	775	172	775	172	775	172	775	172	775	172	775	172	775
0	1,731	0	1,731	0	1,731	0	1,731	0	1,731	0	1,731	0	1,731	0	1,731	0	1,731	0	1,731		1,731
,894,100	9,881	4,894,100	9,881	4,894,100	9,881	4,894,100	9,881	4,894,100	9,881	4,894,100	9,881	4,894,100	9,881	4,894,100	9,881	4,894,100	9,881	4,894,100	9,881	4,894,100	9,881
	3,324		3,324		3,324		3,431		3,538		3,645		3,753		3,860		3,967		3,967		3,967
	296		296		296		305		315		324		334		343		353		353		353
	475		475		475		490		506		521		536		552		567		567		567
,593,000	44,319	15,136,000	45,968	15,680,000	47,620	15,342,000	46,594	15,004,000	45,567	14,667,000	44,544	14,329,000	43,517	15,679,000	47,617	13,655,000	41,470	13,318,000	40,447	12,980,000	39,420
	19,983		19,983		19,983		20,982		22,231		23,480		24,479		25,478		25,978		25,978		25,978
	5,014		5,014		5,014		5,014		5,014		5,014		5,014		5,014		5,014		5,014		5,014
	169,984		171,633		173,285		173,389		173,744		174,101		174,206		179,437		173,922		172,899		171,872
	1.02		1.01		1.01		1.00		1.00		1.00		1.00		1.03		0.97		0.99		0.99

(3) Investment for WITHOUT

In the same manner as WITH, renovation and increment of machineries in 1992 is studied. In case of WITHOUT, present same type machineries made in Russia are assumed to be used. Renovation of rotary drill is indicated in Table 72, power shovel in Table 73, motor grader in Table 74, dump truck and bulldozer in Tables 75 and 76.

Investment for WITHOUT is calculated, supposing that Russian machines would be bought at half value of western ones. Yearly investment is shown in Table 77.

Table 72 Renovation for Rotary Drill(WITHOUT)

Machine	Puchased	Type	93	94	95	96	97	98	99	00	01	02	03	04	05	06	07	08
1	1986	250mm	○		※		○		※		○		※		○		※	
2	1987	250mm		○		※		○		※		○		※		○		※
3	1988	250mm		○		※		○		※		○		※		○		※
4	1988	250mm		○		※		○		※		○		※		○		※
5	1989	250mm		○		※		○		※		○		※		○		※

NOTE: ○=renovation of same typed machine、※=overhaul

Table 73 Renovation for Power Shovel(WITHOUT)

Machine	Puchased	Type	93	94	95	96	97	98	99	00	01	02	03	04	05	06	07	08
1	1978	8m3		○				※				○				※		
2	1978	8m3		○				※				○				※		
3	1981	8m3		○				※				○				※		
4	1982	8m3		○				※				○				※		
5	1984	8m3				○				※				○				※
6	1989	8m3					○				※				○			
7	1990	8m3	※					○				※				○		

NOTE: ○=renovation of same typed machine、※=overhaul

Table 74 Renovation for Motor Grader(WITHOUT)

Machine	Puchased	Type	93	94	95	96	97	98	99	00	01	02	03	04	05	06	07	08
1		200PS	※	○		※	○		※	○		※	○		※	○		※
2		200PS		◎		※	○		※	○		※	○		※	○		※
3		200PS		◎		※	○		※	○		※	○		※	○		※
4		200PS						◎		※	○		※	○		※	○	

NOTE: ○=renovation of same typed machine、※=overhaul
◎=increment of same typed machine

Table 75 Renovation for Dump Truck(WITHOUT)

Machine	Puchased	Type	93	94	95	96	97	98	99	00	01	02	03	04	05	06	07	08
1	1989	110t	○		※		○		※		○		※		○		※	
2	1989	110t	○		※		○		※		○		※		○		※	
3	1990	110t		○		※		○		※		○		※		○		※
4	1991	110t	※		○		※		○		※		○		※		○	
5	1991	110t	※		○		※		○		※		○		※		○	
6		110t										◎		※		○		※
7		110t											◎		※		○	
8	1989	42t	○		※		○		※		○		※		○		※	
9	1989	42t	○		※		○		※		○		※		○		※	
10	1989	42t	○		※		○		※		○		※		○		※	
11	1989	42t	○		※		○		※		○		※		○		※	
12	1989	42t	○		※		○		※		○		※		○		※	
13	1989	42t	○		※		○		※		○		※		○		※	
14	1989	42t	○		※		○		※		○		※		○		※	
15	1989	42t	○		※		○		※		○		※		○		※	
16	1989	42t	○		※		○		※		○		※		○		※	
17	1989	42t	○		※		○		※		○		※		○		※	
18	1989	42t	○		※		○		※		○		※		○		※	
19	1989	42t	○		※		○		※		○		※		○		※	
20	1989	42t	○		※		○		※		○		※		○		※	
21	1990	42t		○		※		○		※		○		※		○		※
22	1990	42t		○		※		○		※		○		※		○		※
23	1990	42t		○		※		○		※		○		※		○		※
24	1990	42t		○		※		○		※		○		※		○		※
25	1990	42t		○		※		○		※		○		※		○		※
26	1990	42t		○		※		○		※		○		※		○		※
27	1990	42t		○		※		○		※		○		※		○		※
28	1990	42t		○		※		○		※		○		※		○		※
29	1990	42t		○		※		○		※		○		※		○		※
30	1990	42t		○		※		○		※		○		※		○		※
31	1990	42t		○		※		○		※		○		※		○		※
32	1990	42t		○		※		○		※		○		※		○		※
33	1990	42t		○		※		○		※		○		※		○		※
34	1990	42t		○		※		○		※		○		※		○		※
35	1990	42t		○		※		○		※		○		※		○		※
36	1990	42t		○		※		○		※		○		※		○		※
37	1990	42t		○		※		○		※		○		※		○		※
38	1991	42t	※		○		※		○		※		○		※		○	
39	1991	42t	※		○		※		○		※		○		※		○	
40	1991	42t	※		○		※		○		※		○		※		○	
41	1991	42t	※		○		※		○		※		○		※		○	
42	1992	42t		※		○		※		○		※		○		※		○
43	1992	42t		※		○		※		○		※		○		※		○
44	1992	42t		※		○		※		○		※		○		※		○
45	1992	42t		※		○		※		○		※		○		※		○
46	1992	42t		※		○		※		○		※		○		※		○
47	1992	42t		※		○		※		○		※		○		※		○
48	1992	42t		※		○		※		○		※		○		※		○
49	1992	42t		※		○		※		○		※		○		※		○

Machine	Puchased	Type	93	94	95	96	97	98	99	00	01	02	03	04	05	06	07	08
50		42t						◎		※		○		※		○		※
51		42t						◎		※		○		※		○		※
52		42t									◎		※		○		※	
53		42t									◎		※		○		※	
54		42t									◎		※		○		※	
55		42t										◎		※		○		※
56		42t										◎		※		○		※
57		42t										◎		※		○		※
58		42t											◎		※		○	
59		42t											◎		※		○	
60		42t											◎		※		○	
61		42t												◎		※		○
62		42t												◎		※		○
63		42t												◎		※		○
64		42t													◎		※	
65		42t													◎		※	
66		42t													◎		※	
67		42t														◎		※

NOTE: ○=renovation of same typed machine、※=overhaul
◎=increment of same typed machine

Table 76 Renovation for Buildozer(WITHOUT)

Machine	Puchased	Type	93	94	95	96	97	98	99	00	01	02	03	04	05	06	07	08
1	1987	330PS		○			※		○			※		○			※	
2	1988	330PS			○			※		○			※		○			※
3	1988	330PS			○			※		○			※		○			※
4	1989	330PS			○			※		○			※		○			※
5	1989	330PS			○			※		○			※		○			※
6	1989	330PS			○			※		○			※		○			※
7	1989	330PS			○			※		○			※		○			※
8	1989	330PS			○			※		○			※		○			※
9	1990	330PS	※		○			※		○			※		○			※
10	1990	330PS	※		○			※		○			※		○			※
11	1991	330PS		※		○			※		○			※		○		
12	1991	330PS		※		○			※		○			※		○		
13	1992	330PS			※		○			※		○			※		○	
14	1992	330PS			※		○			※		○			※		○	
15	1992	330PS			※		○			※		○			※		○	
16		330PS									◎			※		○		
17		330PS										◎			※		○	
18		330PS											◎			※		○
19		330PS												◎			※	
20		330PS													◎			※
21		330PS														◎		

NOTE: ○=renovation of same typed machine、※=overhaul
◎=increment of same typed machine

Table 77 INVESTMENT IN MINING (WITHOUT P/J)

(US$1000)

ITEMS	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	Total
Rotary Drill	2,638	201	791	670	2,638	201	791	670	2,638	201	791	670	2,638	201	791	16,532
Purchase	2,638			670	2,638			670	2,638			670	2,638			12,562
Overhaul		201	791			201	791			201	791			201	791	3,970
Power Shovel	10,922		2,731	2,731	6,008		819	819	11,741		2,731	2,731	6,008		819	48,060
Purchase	10,922		2,731	2,731	2,731				10,922		2,731	2,731	2,731			38,230
Overhaul					3,277		819	819	819		0	0	3,277		819	9,830
Bulldozer	326	2,015	407	672	550	326	2,015	611	875	754	590	2,279	875	936	815	14,046
Purchase	204	1,832	407	611		204	1,832	611	814	204	407	2,035	814	814	204	10,993
Overhaul	122	183		61	550	122	183		61	550	183	244	61	122	611	3,053
Motor Grader	483		145	483	161	145	531	161	145	531	161	145	531	161	145	3,928
Purchase	483			483	161		483	161		483	161		483	161		3,059
Overhaul			145			145	48		145	48		145	48		145	869
Dump Truck	7,997	4,402	7,292	6,519	7,862	4,402	4,805	7,527	9,542	6,385	6,317	9,039	10,181	6,687	6,418	105,375
Purchase	6,384	2,688	5,376	5,712	7,056	2,688	2,688	6,720	8,736	4,368	3,696	7,728	9,072	4,368	3,696	80,976
Overhaul	1,613	1,714	1,916	807	806	1,714	2,117	807	806	2,017	2,621	1,311	1,109	2,319	2,722	24,399
Economic Cost Total	22,366	6,618	11,366	11,075	17,218	5,074	8,962	9,788	24,941	7,871	10,591	14,864	20,233	7,985	8,988	187,942
Foreign currency	22,007	6,512	11,184	10,897	16,941	4,992	8,818	9,631	24,541	7,744	10,420	14,625	19,908	7,857	8,844	184,922
Local currency	359	106	182	178	277	82	144	157	401	126	170	239	325	128	144	3,020
Import & Sales Tax																0
Financial Cost Total	22,366	6,618	11,366	11,075	17,218	5,074	8,962	9,788	24,941	7,871	10,591	14,864	20,233	7,985	8,988	187,942
Foreign currency	22,007	6,512	11,184	10,897	16,941	4,992	8,818	9,631	24,541	7,744	10,420	14,625	19,908	7,857	8,844	184,922
Local currency	359	106	182	178	277	82	144	157	401	126	170	239	325	128	144	3,020

5-4 Mineral Processing

5-4-1 Production Process and Control

(1) Mineral Processing (quantity of concentrate)

① Operations plan

Tables 52 and 53 show draft production plans to the year 2008. Table 52 shows the case of separation-flotation and Table 53 shows the case of bulk flotation. This draft plan incorporated the following assumptions.

—Based on the 1993 budget prepared by Erdenet Mine, the amount of copper metal to be produced in 1994 was estimated at 120,000 tons a year. From 1994 onwards, this amount becomes the standard for production, to be maintained to the year 2008.

—Mineral processing recovery rate and copper concentrate grade were forecast based on the long-term plans prepared by the mineral processing section of Erdenet Mine and world processing results of porphyry copper ore and other factors and the laboratory investigation results of mineralogical studies and the results of mineral processing tests conducted by the Japanese group.

—Generally, when concentrates from bulk flotation are final products, the recovery rate for copper increases in comparison to the production of copper and molybdenum concentrates from separation-flotation. Table 53 shows the calculation on the assumption that the recovery rate of copper will increase by 2.5%.

(2) Production procedures

In order to maintain production of 120,000 tons of copper a year, it will be necessary to process 30 million tons of crude ore a year in 2008.

The current increased production plan should therefore be revised upwards from 26 million tons/year to 30 million tons/year.

— The processing capacity of Unit No. 6, where foundation work is in progress, needs to be urgently revised from the originally planned 4 millions tons/year to 5 million tons/year.

— Units Nos. 1-4 should also have their capacity increased to 5 million tons/year one by one on a yearly basis.

The processing capacity of Unit No. 5 should be increased by 1 million tons/year to 5 million tons/year.

On this basis, once Unit No. 6 is completed the proposed production increases, as shown in the Table 78 below, will become possible.

Table 78 Plans for Improvement and Expansion

Year	1995	1996	1997	1998	1999	2000
Capacity	21,000	22,000	23,000	24,000	25,000	30,000

This shows planning and procurement of some equipment in 1993 and 1994, equipment procurement and construction in 1994, and each year from 1995, for the addition of 1 million tons/year processing capacity.

Figure 54 is a concept illustration of the space required when the capacity of the mill has been expanded to 30 million tons/year.

This expansion is possible within the current processing facilities building.

(3) Proposals based on a diagnostic survey

① Results of mineralogical study

The arsenic minerals found in ore principally comprise tennantite.

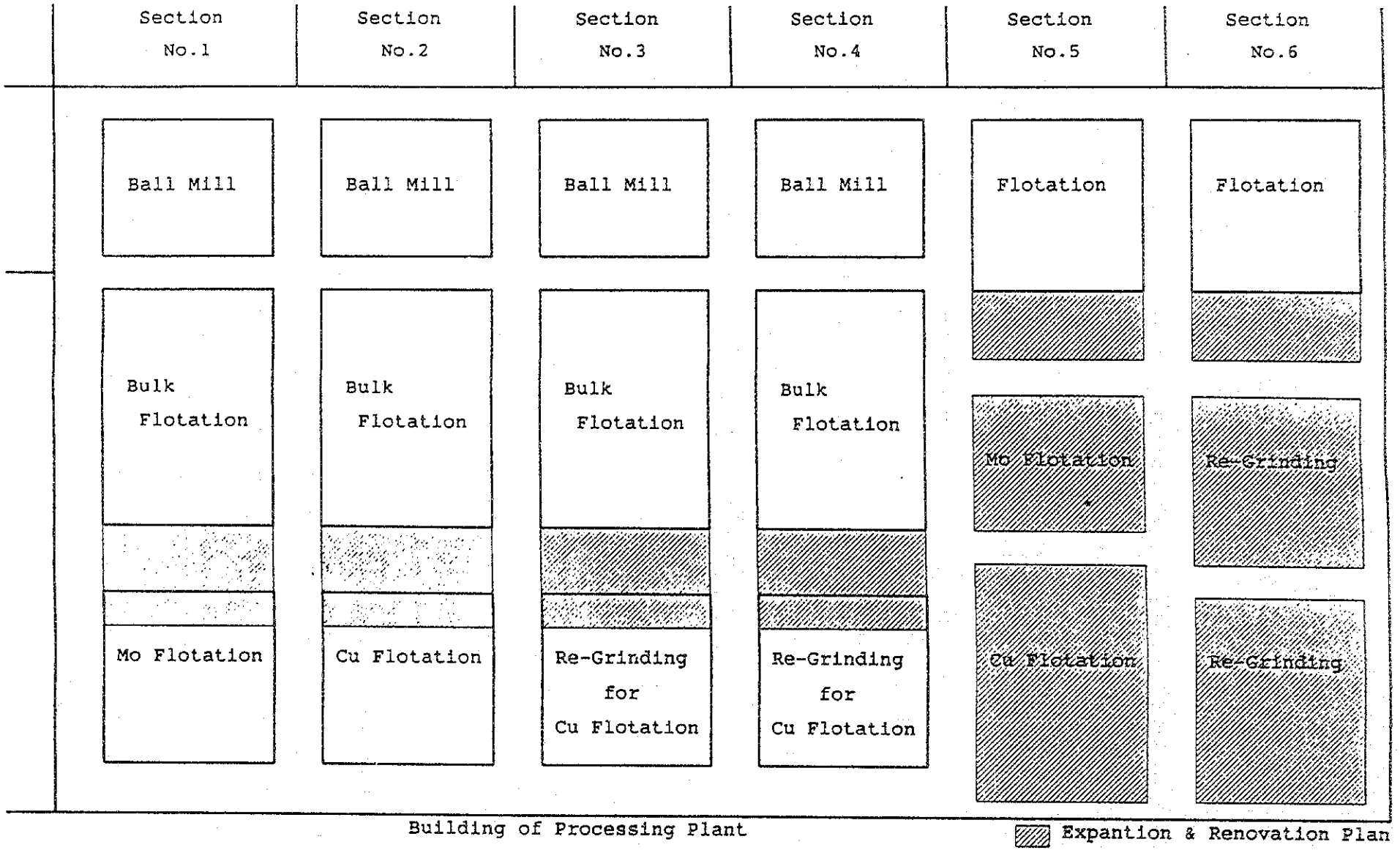


Fig. 54 Space required for expansion Plan

Separating copper and arsenic through mineral processing is difficult. However, arsenic minerals found in the pit are irregularly distributed, indicating the possibility for sorting mining in the pit.

② Results of the mineral processing test

The results of the mineral processing test indicate that the grade of copper concentrate and recovery rate will decline, when processing primary ore zone, from the grades and rates achieved with the current processing of secondary enriched ore zone. This tendency could be improved by modifying the collectors and frothers used during bulk flotation rougher, and by using an appropriate quantity of dispersing agent at the cleaning stage.

In parallel with this, in the separation-flotation stage of molybdenum and copper ores, a fall in the recovery rate can be prevented by employing hot water flotation using a weakly acidic circuit with sodium bisulfite following thermo-treatment process. However, it is expected that the results will not come up to the standard obtained when processing secondary enriched ore zone.

This means that, after peaking in around 1995, when the Cp/Cc ratio will exceed 50%, the copper recovery rate will gradually decline until 2005, when the primary ore zone will become dominant and the rate will stabilize. Tables 52 and 53 are based on the estimates in case that those improvement measures are taken.

We hope that the research results from the Japanese side will be revised and confirmed at Erdenet Mine.

③ Measures to be implemented over the long term

— Ore sorting in pit

Research should be conducted into arsenic distribution in the pit, in view of the need to separate out arsenic, which is biasedly existing in the form of tennantite. Survey results would provide an index to be used in sorting in mining pit.

— Cease flotation processing of oxidized ore, which is usually conducted for about a month in the end of a year. Stockpiles of this oxidized ore could be used as raw material for SX-EW, which has been under investigation.

— At the tailing pond, commence examination of the design for No. 8 bank, currently at the planning stage, and the site for construction of a second tailing pond.

— Review the number of employees engaged in operations, relocate them and review the relocation of employees directly involved in operations.

④ Matters to be implemented urgently

— Commence mineral processing tests in order to select an appropriate mineral processing reagent.

— Examine the trial use of the mineral processing reagents and procedures proposed by this survey group.

Using MIBC-4401A, AF77A-3418A, dispersing reagent (CMC), NaHS weak acid hot water flotation and bulk flotation, the recovery rate of copper from of copper concentrates should improve by at least 2-3%. It is very likely that copper grade of the copper concentrate will not decline to 21% in 2008, as forecast by Erdenet Mine.

Producing bulk concentrate as a final product is considered to have the following advantages and disadvantages:

•Copper recovery rate is improved by approx. 3% (calculated).

•Since a molybdenum/copper separation circuit is not required, the following expenses are greatly reduced (Refer to Figs. 55, 56):

—equipment(for thermo-treatment, and separation-flotation)

—reduction of operating cost (thermo-treatment, electricity for separation-flotation, reagents for separation-flotation, and repair of the above equipment)

•The flotation circuit is simplified and operating safety maintenance and automatization of control are facilitated.

•Although bulk concentrate is treated as copper concentrate, molybdenum grade in copper concentrate is higher than when the former is separated (a calculated increase of approx. 0.2%). This may be disadvantageous when delivering for smelting.

•Although the amount of copper concentrate increases, sales will be reduced because there are no molybdenum concentrate sales. Before adopting the bulk concentrate method, it is necessary to calculate sales and costs.

— Review the plan after 30 million tons/year has been set up.

Examine the feasibility of Tables 52 and 53 and Figure 54, and start at an early stage.

— Plan the introduction of state-of-the-art facilities and the upgrading of old facilities

Figs. 57 and 58 show the facilities in need of upgrading for a production level of 30 million tons/year and the investment plan.

Fig 55 Operation Cost Comparison
Separation, Bulk & Without

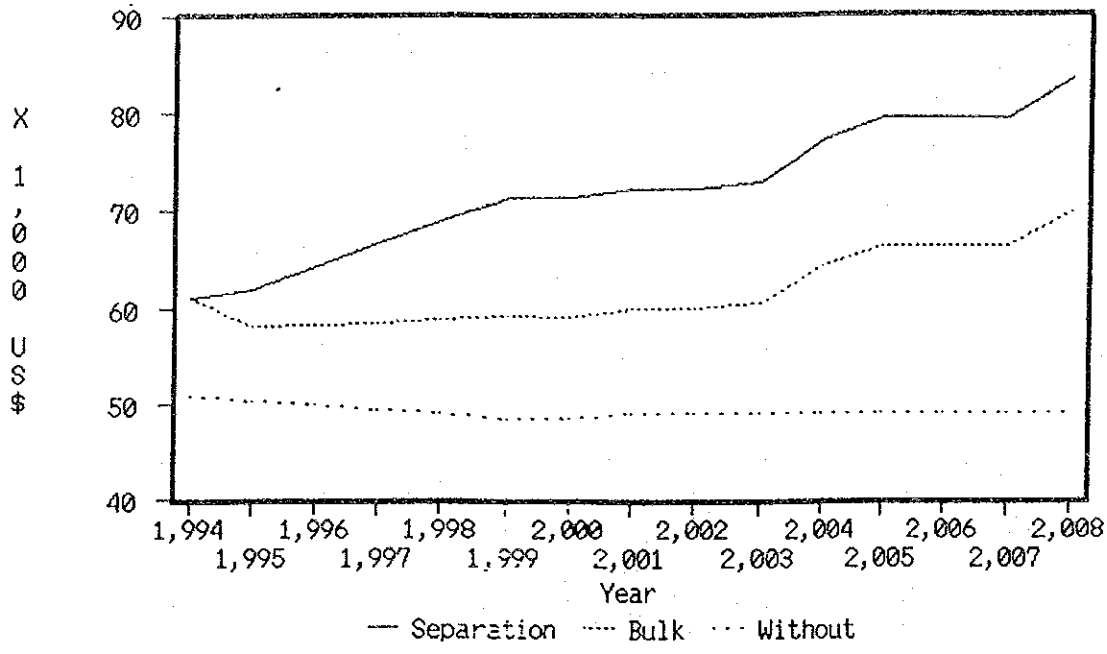
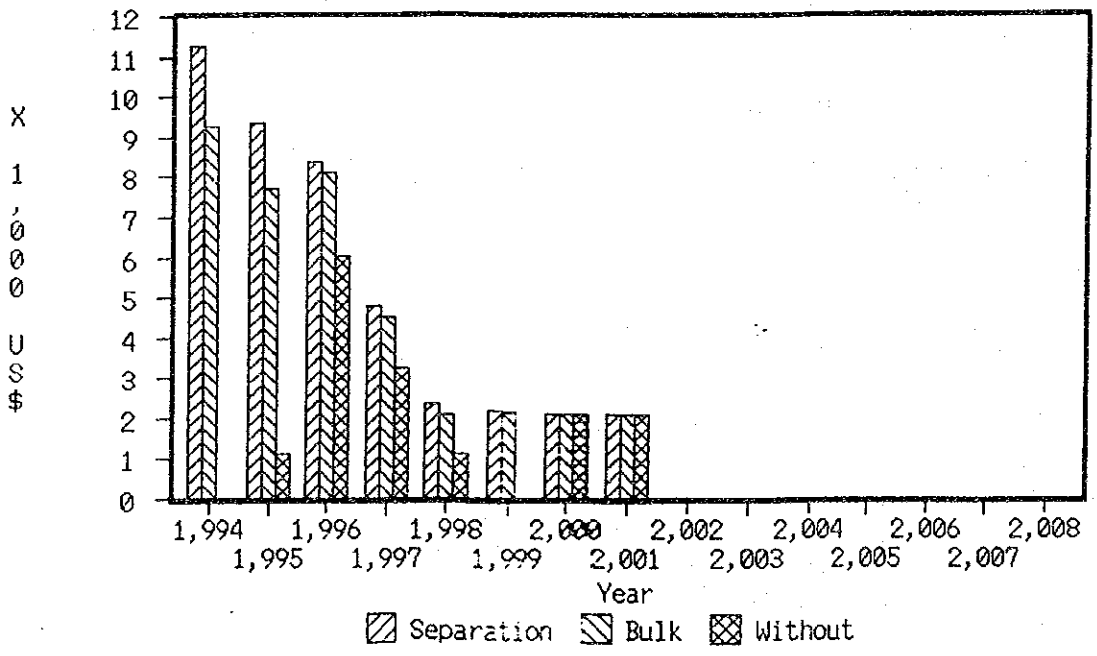


Fig 56 Investment Cost Comparison
Separation, Bulk & Without



To renovate and upgrade the facilities, the introduction of the following state-of-the-art, large-scale equipment must be examined:

- SAG (semi-autogeneous) mill
- large-scale flotation machine (50-80m^3/cell)
- pressure type ceramic filter
- automatization of grinding and flotation system (to enable "feed back" and "feed forward")

Currently AG (autogeneous) mills are used, but unfortunately the set values (target values) (4,500,000 tons/year, 5,000,000 tons/year) cannot be achieved.

We have heard that it is planned to change to a SAG mill, and we strongly recommend that such a change be investigated.

For the filters for concentrate dehydration, a ceramic suction filter is now being tested, and it will soon be able to achieve the target concentrate content of less than 10%. The target content will be surely achieved, at a stroke, by adopting pressure filters, enabling the omission of kilns for drying.

— Improve testing and research apparatus

An essential plank of this modernization plan is an increase in mining and an increase in processing by the mining and mineral processing divisions, in order to maintain the 1990 copper production level over the next 15 years or so.

Over the next 15 years, the ore to be mined will mainly comprise primary ore zone with low grades, not secondary enriched ore zone as has been excavated to date. Before the ore quality changes, the research division must establish the

new mineral processing procedures required. Moreover, with the increase in mining, the number of mineral tests preceding mining is expected to increase by up to 50%. This means that, if modernization plans are to go ahead smoothly, Erdenet Mine must put in place a new testing system. This will require installation of the latest facilities for mineral analysis, which, of all mineral testing, is the procedure currently consuming the most time and labor. Naturally, it is also desirable, at an early stage, to upgrade and add to ore preprocessing equipment before testing.

It is difficult to quantify the effects on production of investment in testing and research facilities. However, using a range of testing and research data, it is possible to minimize the risks associated with this modernization plan. Even if 1% or thereabouts of the total investment in modernization is spent on testing and research, that would not be an inappropriate figure.

At present, ore research apparatus at the mine are rather poor compared with those of western research institutes. It is necessary to introduce such facilities as image processing equipment and EPMA (SEM+EDX).

In addition to adequate conventional mineral processing research facilities, we recommend the mine to consider introducing advanced technology such as SX-EW equipment, which will be needed in the future.

— Establish a mechanism for obtaining information from western countries

Increase the number of telephone and facsimile lines for direct links with the global information network. It will be essential to set up a computerized system for scanning the technical literature from Japan, Europe and the United States, if technical innovations and improvements are to be made.

Fig -57 Expantion & Renovation Equipment & Schedule (Mo/Cu Separation)
(The Erdenet Mine Mongolia)

No.	Item Classification	Specification	Qnt's	Annual Plan 1,993	1,994	1,995	1,996	1,997	1,998	1,999	2,000	2,001	2,002	2,003	2,004	2,005	2,006	2,007	2,008
1	Crushing Stage																		
(1)	(1)Cone Crusher Renewal	φ3,600/380	2																
2	Grinding Stage																		
(1)	AG Mill for No.6 Section	φ8,000X3,000	2																
	Ball Mill for No.6 Section	φ5,500X6,500	2																
(2)	Process Water for AG Mill																		
(3)	No.1~4 Ball Mill Renewal	φ5,500X6,500	8																
3	Flotation Stage																		
(1)	No.6 Section Flotation Bulk	50 m3	7																
	Scav.	38 m3	15																
	Clean	16 m3	8																
	Sepa.	10 m3	40																
(2)	No.1~4 Section Renewal Bulk	50 m3 7X4	28																
	Scav.	50 m3 12X4	48																
	Clean	16 m3 8X4	32																
	Sepa.	10 m3 40X4	160																
(3)	No.5 Section Expantion Bulk	50 m3	2																
	Scav.	50 m3	4																
	Clean	16 m3	2																
	Sepa.	10 m3	12																
4	Filtering & Drying Stage																		
(1)	Ceraminc Filter	45 m2 Press Type	5																
(2)	Compressor Reinforcement																		
(3)	Crane for Concentrate	10 t C/W Balance	2																
5	Waste Treatment																		
(1)	Slurry Pump Reinforcement	110 m3/min,3,000 kW	3																
(2)	Waste Dam No.8 Step Banking	9 m	1																
6	Water Reclaiming																		
(1)	Reclaim Water system	70 m3/min, 900 kW	1																
(2)	Reclaim Water No.3 Pipe	φ1,000X6,400m	1																
7	Miscellaneous																		
(1)	Reagent Storehouse																		
(2)	Lime Handring Equipment																		
(3)	Lime Storehouse																		
(4)	Research Apparatus	EPMA,XRD,FIS etc.	1																
(5)	Automatic Control System	On-Line X-Ray Anal																	

Fig -58 Expantion & Renovation Equipment & Schedule (Bulk)
(The Erdenet Mine Mongolia)

No.	Classification	Specification	Qnt's	Annual Plan 1,993	1,994	1,995	1,996	1,997	1,998	1,999	2,000	2,001	2,002	2,003	2,004	2,005	2,006	2,007	2,008
1	Crushing Stage																		
(1)	(1)Cone Crusher Renewal	φ3,600/380	2																
2	Grinding Stage																		
(1)	AG Mill for No.6 Section	φ9,000X3,000	2																
	Ball Mill for No.6 Section	φ5,500X6,500	2																
(2)	Process Water for AG Mill																		
(3)	No.1~4 Ball Mill Renewal	φ5,500X6,500	8																
3	Flotation Stage																		
(1)	No.6 Section Flotation Bulk	50 m3	7																
	Scav.	38 m3	15																
	Clean	16 m3	8																
(2)	No.1~4 Section Renewal Bulk	50 m3 7X4	28																
	Scav.	50 m3 12X4	48																
	Clean	16 m3 12X4	32																
(3)	No.5 Section Expantion Bulk	50 m3	2																
	Scav.	50 m3	4																
	Clean	16 m3	2																
4	Filtering & Drying Stage																		
(1)	Ceraminc Filter	45 m2 Press Type	5																
(2)	Compressor Reinforcement																		
(3)	Crane for Concentrate	10 t C/W Balance	2																
5	Waste Treatment																		
(1)	Slurry Pump Reinforcement	110 m3/min,3,000 kW	3																
(2)	Waste Dam No.8 Step Banking	9 m	1																
6	Water Reclaiming																		
(1)	Reclaim Water system	70 m3/min, 900 kW	1																
(2)	Reclaim Water No.3 Pipe	φ1,000X6,400m	1																
7	Miscellaneous																		
(1)	Reagent Storehouse																		
(2)	Lime Handring Equipment																		
(3)	Lime Storehouse																		
(4)	Research Apparatus	EPMA,XRD,FIS etc.	1																
(5)	Automatic Control System	On-Line X-Ray Anal																	

5-4-2 Investment Necessary for Modernization

(1) Investment in facilities for modernization

Tables 79 and 80 show the investment required in cases of separation-flotation and bulk flotation, respectively. Also, Tables 81 and 82 show the operation costs for both cases. The investment in facilities is:

—separation-flotation

$45 million (financial cost)

$41 million (economic cost)

—bulk flotation

$40 million (financial cost)

$37 million (economic cost)

For a study of the upgrading and purchase of machinery and equipment for testing and research, we examined the mineral research division, whose facilities are conspicuously out of date.

We assessed the facilities needed for Erdenet Mine to conduct the mineral and any other researches necessary to achieve the scheduled increases in production and processing of the mining and milling divisions, and the investment amount will be $600,000 (economic cost). The details are as follows.

[Breakdown]

A. Mineral composition-related facilities — subtotal $545,000

Name	Quantity	Price (US$)
• Point counter	1 unit	10
• Ore microscope (reflected light)	1 unit	10
• Image analysis device + color CCD camera	1 set	75

• Analytical electron microscope (SEM + EDX)	1 unit	420
• Frantz magnetic separator	1 unit	30

B. Facilities for pretest processing —subtotal $55,000

Name	Quantity	Price (US$)
• Rock cutter	1 unit	10
• Polisher/polishing machine (automatic)	2 units	16
• Polishing agents, resin etc.	1 set	4
• Thin section preparation machine (Discoplan)	1 unit	25

(2) In the case when the modernization plan is not implemented

Tables 83 and 84 show the estimated investment in facilities and operating costs if the modernization plan is not implemented.

Table 79 INVESTMENT IN MINERAL PROCESSING (Mo/Cu Separation)

(US$1000)

ITEMS		1,994	1,995	1,996	1,997	1,998	1,999	2,000	2,001	2,002	2,003	2,004	2,005	2,006	2,007	2,008	Total
Crushing	Fo.			2,515	1,006												3,521
	Do.			485	194												679
Grinding	Fo.					740	1,534	1,761	1,761								5,795
	Do.					260	436	339	339								1,374
Flotation	Fo.	4,813	4,128	814	814	814	174										11,556
	Do.	1,287	1,172	286	286	286	46										3,363
Filtering	Fo.	1,948	1,843	838	529												5,158
	Do.	552	438	162	102												1,253
Waste Treatment	Fo.			1,316	535												1,850
	Do.			614	405												1,019
Reclaim Water	Fo.	1,286	395	641	430												2,752
System	Do.	344	105	359	241												1,049
Others	Fo.	491	397	89													977
	Do.	263	618	11													892
Economic Cost Total		10,985	9,095	8,130	4,540	2,100	2,190	2,100	2,100								41,240
	Fo.	8,539	6,761	6,213	3,312	1,554	1,707	1,761	1,761								31,608
	Do.	2,446	2,334	1,917	1,228	546	483	339	339								9,632
Import & Sales Tax		2,135	1,690														3,825
Financial Cost Total		13,120	10,785	8,130	4,540	2,100	2,190	2,100	2,100								45,065
	Fo.	8,539	6,761	6,213	3,312	1,554	1,707	1,761	1,761								31,608
	Do.	4,581	4,024	1,917	1,228	546	483	339	339								13,457

Note:Fo.=Foreign Currency, Do.=Domestic currency

Table 80 INVESTMENT IN MINERAL PROCESSING (BULK)

(US$1000)

ITEM		1,994	1,995	1,996	1,997	1,998	1,999	2,000	2,001	2,002	2,003	2,004	2,005	2,006	2,007	2,008	Total
Crushing	Fo.			2,515	1,006												3,521
	Do.			485	194												679
Grinding	Fo.					740	1,534	1,761	1,761								5,795
	Do.					260	436	339	339								1,374
Flotation	Fo.	3,278	2,875	619	619	619	118										8,130
	Do.	876	821	218	218	218	32										2,383
Filtering	Fo.	1,948	1,843	838	529												5,158
	Do.	552	438	162	102												1,253
Waste Treatment	Fo.			1,316	535												1,850
	Do.			614	405												1,019
Reclaim Water	Fo.	1,286	395	641	430												2,752
System	Do.	344	105	359	241												1,049
Others	Fo.	491	397	89													977
	Do.	263	618	11													892
Economic Cost Total		9,038	7,492	7,867	4,277	1,837	2,120	2,100	2,100								36,831
	Fo.	7,003	5,509	6,018	3,117	1,359	1,652	1,761	1,761								28,180
	Do.	2,035	1,983	1,849	1,160	478	468	339	339								8,651
Import & Sales Tax		1,751	1,377														3,128
Financial Cost Total		10,789	8,869	7,867	4,277	1,837	2,120	2,100	2,100								39,959
	Fo.	7,003	5,509	6,018	3,117	1,359	1,652	1,761	1,761								28,180
	Do.	3,786	3,360	1,849	1,160	478	468	339	339								11,779

Table 81 Operation Cost Estimation Process Plant (Separation)
(Erdenet Mine Mongolia)

X1,000 US$

No.	Item	Portion	1,994	1,995	1,996	1,997	1,998	1,999	Annual Plan 2,000	2,001	2,002	2,003	2,004	2,005	2,006	2,007	2,008	Total
	Plant Throughput	X1,000t/A	20,500	21,000	22,000	23,000	24,000	25,000	24,839	25,213	25,212	25,444	27,011	27,804	27,803	27,804	29,242	
2	Operation Cost																	
(1)	Electric Power Consumption		24,005	24,412	25,404	26,404	27,412	28,419	28,231	28,669	28,668	28,933	30,774	31,703	31,702	31,703	33,387	423,833
	·Crushing Stage		1,027	1,052	1,102	1,152	1,202	1,252	1,244	1,263	1,263	1,275	1,353	1,393	1,393	1,393	1,465	18,829
	·Grinding stage		12,445	12,749	13,356	13,963	14,570	15,177	15,079	15,306	15,306	15,446	16,398	16,879	16,878	16,879	17,752	228,182
	·Flotation Stage		6,701	6,701	6,865	7,028	7,191	7,355	7,302	7,425	7,424	7,500	8,012	8,272	8,271	8,272	8,742	113,061
	·Filtering & Drying Stage		311	304	304	311	327	342	339	345	345	348	372	384	384	384	406	5,207
	·Reagent Preparation Stage		36	37	39	41	42	44	44	45	45	45	48	49	49	49	52	664
	·Section No. 5 Stage		3,485	3,570	3,740	3,909	4,079	4,249	4,222	4,286	4,285	4,325	4,591	4,726	4,726	4,726	4,970	63,890
(2)	Steaming		3,448	3,532	3,700	3,868	4,036	4,204	4,177	4,240	4,240	4,278	4,543	4,676	4,676	4,676	4,918	63,211
(3)	Liner (Crusher,Mill etc.)		1,312	1,344	1,408	1,472	1,536	1,600	1,590	1,614	1,614	1,628	1,729	1,780	1,780	1,780	1,872	24,058
(4)	Ball (for Mill)		7,035	7,206	7,550	7,893	8,236	8,579	8,524	8,652	8,652	8,731	9,269	9,541	9,541	9,541	10,035	128,385
(5)	Reagent Oil		94	96	100	105	110	114	113	115	115	116	123	127	127	127	133	1,715
(6)	Reagent		6,773	6,939	7,269	7,599	7,930	8,260	8,207	8,331	8,330	8,407	8,925	9,187	9,186	9,187	9,662	124,193
(7)	Water Supply		4,496	4,605	4,825	5,044	5,263	5,482	5,447	5,529	5,529	5,580	5,923	6,097	6,097	6,097	6,413	82,428
	·Fresh Water		2,142	2,194	2,299	2,403	2,508	2,612	2,596	2,635	2,635	2,658	2,823	2,905	2,905	2,905	3,056	39,278
	·Reclaim Water		2,353	2,411	2,526	2,640	2,755	2,870	2,851	2,894	2,894	2,921	3,101	3,192	3,192	3,192	3,357	43,150
(8)	Light Oil		444	412	390	368	347	325	321	328	328	331	351	361	361	361	380	5,408
(9)	Spare Parts		615	615	630	645	660	675	670	681	681	687	729	751	751	751	790	10,332
(10)	Amortization		1,391	1,391	1,391	1,391	1,391	1,391	1,391	1,391	1,391	1,391	1,391	1,391	1,391	1,391	1,391	20,868
(11)	Salary & Wage		1,824	1,801	1,801	1,801	1,801	1,801	2,161	2,161	2,161	2,161	2,161	2,161	2,161	2,161	2,161	30,281
	·Engineer & Technician		234	231	231	231	231	231	277	277	277	277	277	277	277	277	277	3,880
	·Worker		1,570	1,550	1,550	1,550	1,550	1,550	1,861	1,861	1,861	1,861	1,861	1,861	1,861	1,861	1,861	26,068
	·Employee		7	6	6	6	6	6	8	8	8	8	8	8	8	8	8	108
	·Service Worker		14	13	13	13	13	13	16	16	16	16	16	16	16	16	16	225
(12)	Others		9,604	9,604	9,838	10,072	10,307	10,541	10,465	10,631	10,630	10,728	11,389	11,723	11,723	11,723	12,329	161,306
	Operation Cost Total		61,041	61,957	64,306	66,663	69,028	71,393	71,239	72,341	72,339	72,978	77,308	79,498	79,496	79,498	83,470	1,082,616
	(Unit Cost)	(US$/ton)	2.98	2.95	2.92	2.90	2.88	2.86	2.87	2.87	2.87	2.87	2.86	2.86	2.86	2.86	2.85	2.88