JAPAN INTERNATIONAL COOPERATION AGENCY(JICA)

THE ERDENET MINE
MONGOLIA

REPORT
ON
STUDY OF THE ERDENET MINE MODERNIZATION AND DEVELOPMENT PROGRAM

SUMMARY

December, 1993

MITSUI MINERAL DEVELOPMENT ENGINEERING CO., LTD.,
TOKYO

(MINDECO)

JAPAN INTERNATIONAL COOPERATION AGENCY(JICA)

THE ERDENET MINE
MONGOLIA

REPORT
ON
STUDY OF THE ERDENET MINE MODERNIZATION AND DEVELOPMENT PROGRAM

SUMMARY

December, 1993

MITSUI MINERAL DEVELOPMENT ENGINEERING CO., LTD.,
TOKYO

(MINDECO)

Summary

CONTENTS

Volume 1. Modernization Plan 1

1. Introduction 1
   1-1 Background to the Study 1
   1-2 Purpose and Scope of the Study 1

2. Current State of the Mongolian Economy and World Copper Supply and Demand 3
   2-1 General Situation of the Mongolian Economy 3
   2-2 Global Copper Supply and Demand Trends 4

3. Overview of the Erdenet Mine 5
   3-1 Overview 5
   3-2 Geology and Ore Reserves 5
   3-3 Production Results 5
   3-4 Organization and Personnel 6

4. Erdenet Mine Diagnostic Study Results 7
   4-1 Overview 7
   4-2 Exploration and Mining 7
   4-3 Mineral Processing 8
   4-4 Workshop 9
   4-5 Utilities 9
   4-6 Environmental Protection 10
   4-7 Business Management 10

5. Modernization Plan 13
   5-1 Basic Plan 13
   5-2 Exploration 14
   5-3 Mining 14
   5-4 Mineral Processing 15
   5-5 Workshop 15
   5-6 Utilities 16
   5-7 Business Management 17
   5-8 Modernization Implementation Plan 19
   5-9 Environmental Protection 20

6. Financial and Economic Analysis 21

7. Conclusion and Recommendation 28

Volume 2. Recommendation on Asset Valuation Method 32

1. Asset Valuation Methods 32

2. Valuation Method Suitable for Erdenet Mine 33

Volume 3. Recommendation on the Copper Smelter Construction 34

1. Domestic Viewpoint 34

2. Overseas Perspective 34

3. Overall Evaluation of the Plan 35

Table 1 List of Total Investment Cost 23

Table 2 Income Statement 25

Figure 1 Mine Production Cost 37

Volume 1 Modernization Plan

Chapter 1 Introduction

1-1 Background to the Study

Mongolia has begun to shift from a socialist economy to a market economy.

Until recently Mongolia has depended on Russia for its principal goods. However, the economic confusion which the former USSR faces does not allow Mongolia to import oil, machine parts and other products from Russia.

As a consequence, production at the Erdenet mine, which plays a key role in the Mongolian economy, has declined, resulting in a drop in foreign currency revenue.

The Mongolian economy could be stabilized in several ways, but modernizing and improving Erdenet Mine appears to be the quickest. It is on this basis, that this survey has been conducted.

1-2 Purpose and Scope of the Study

The purpose of this study was to prepare a modernization plan for the Erdenet mine. In order to make the plan it was necessary to implement a survey on the following items:

(1) Determine and analyze the macroeconomic environment, including Mongolia's economic policies.

(2) Diagnose and improve production conditions at the Erdenet mine.

(3) Draw up medium and long-term production plans, including investment and its economic evaluations.

(4) Diagnose business management and propose improvements.

(5) Assess the concept underlying privatization.

(6) Propose techniques for asset valuation.

(7) Current status of the copper smelter construction plan.

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

2-1 General Situation of the Mongolian Economy

(1) The Mongolian economy has shifted from a centrally-planned economy to a market economy.

The Mongolian economy was closely related to that of the former Soviet Union, and the collapse of the latter has disrupted the former. As a result, Mongolia faces an economic crisis.

Since January 1991, when prices were deregulated, inflation has increased dramatically, with prices ten times higher than their pre-deregulation levels.

Although excessive import levels have been declining, exports have been slow to grow. The government is running a deficit and unemployment is estimated at about 8%.

Mongolia has moved to a floating exchange rate and devaluation of the currency has been continuing on foreign exchange markets. With 400TG/US$, the dual structure has been removed, and foreign exchange has been stabilized for the time being.

(2) Although privatization is being implemented for companies over a diverse range of fields, privatization of major State-run companies such as Erdenet, is still at the exploration stage.

(3) In terms of support from the international community, Mongolia has moved closer to western countries and has joined the ADB, IMF and the World

Bank. Between 1991 and 1993, Japan's contributions reached $152 million on a commitment basis, representing an outstanding figure among donor countries.

2-2 Global Copper Supply and Demand Trends

(1) Copper supply and demand are influenced by the world economic trends. Given economic growth, we can expect that supply and demand of copper as well as its prices will move in line with other commodities prices. Growth in Asian countries deserves attention.

(2) The mine production of copper ore appears to be increasing for quite some time. Smelters are expected to be able to process the increased amount of ore with existing facilities. Production of copper ore in countries such as Chile is expanding rapidly. 30% of the electrolytic copper production increase is expected to be produced by the solvent extraction (SX-EW) method.

(3) Copper prices are expected to recover from 1994. With an average annual growth of about 1.7%, copper prices are expected to reach $2500/mt in 1998. However, forecasting prices for base metals such as copper is difficult as they are affected by the economic and political environment (labor disputes, war, etc.).

Chapter 3 Overview of the Erdenet Mine

3-1 Overview

Erdenet Mine is located in the city of Erdenet, some 250 km northwest of Ulaanbaatar, the capital of Mongolia.

The city of Erdenet is the third largest city in Mongolia, and developed around the mining industry. Apart from the mine, the city has carpet, cement, and other factories. The city's population of about 60,000 is growing rapidly.

3-2 Geology and Ore Reserves

The ore deposit is a large mass of porphyry copper type containing molybdenum. Although there are five deposits in the area, the Erdenetiin Oboo ore body, located in the north western section, is the only one that has been developed.

Of the 2,000 million tons of ore, 1,500 million tons is minable by open pit, with a copper content of 0.52% and molybdenum content of 0.014%.

3-3 Production Results

The mine commenced production in 1978, and in 14 years produced about 210 million tons of crude ore, with copper content reaching 1.45 million tons.

Concentrates are sold mainly to the former Soviet bloc. However, sales of concentrate to the western countries and Japan are increasing. The copper concentrates are also sent to Kazakhstan smelter under toll basis.

3-4 Organization and Personnel

In 1992 there were about 6500 employees in the mine. Of these, 66% were engaged to the production sector, 31% to non-production, and 3% to production control and management. As the mine is a joint venture with Russia, about 1,200 of the employees are Russian.

Chapter 4 Erdenet Mine Diagnostic Study Results

4-1 Overview

(1) The Erdenet mine has a disadvantage in its location of being inland. However, the mine has large ore reserves and excellent mining conditions. The mine can compete with the other outstanding mines in the world. Furthermore, technical levels are high and organizational and management systems are firmly established.

(2) Production, which had been steadily increasing since the mine opened, has been rapidly decreasing since 1991. Major causes for the rapid decrease are the unstable electricity supply and shortage of spare parts. With obsolete machines and facilities and a declining operating rate, productivity has also begun to decrease.

(3) The mining portion will be moving gradually from the high grade secondary enriched zone to the low grade primary ore zone.

4-2 Exploration and Mining

(1) In addition to the deep section of the deposit in the north western area, the ore deposits in the central and south eastern areas have been discovered. Although exploration of these areas will not be necessary for some time because there are sufficient ore reserves in the north-west orebody, they will need to be prospected in the future.

(2) In the area surrounding the mine there are ore deposits of gold, skarn, coal, limestone and so forth. More detailed investigation will be required in the future.

(3) The production of Erdenet Mine was steadily increased up to 1990, then

began to rapidly decrease from 1991.

The reason for this was the drop in the operation rate of mining machines resulting from frequent power failures and increasing repair time due to the shortage of spare parts.

The open pit is gentle spoon-shaped as a result of advanced waste stripping. Mining operation is being carried out 365 days a year with a four duty three shift system.

4-3 Mineral Processing

(1) As a consequence of the decrease in mining output, the amount of processed ore has become significantly lower than the budget level since 1991.

(2) The high arsenic content of the copper concentrate (because of the presence of tennantite) has become disadvantage in the sales of concentrate to the western countries. This tennantite is difficult to be eliminated during mineral processing.

Preliminary sampling and assaying of ore from the pit have been conducted, which revealed the deposit is uneven.

It is possible for this to be dealt with in the process of mining if further surveys are conducted to map the three dimensional distribution of arsenic in the orebody.

(3) At present, the mine is excavating the secondary enrichment ore zone. However, in the near future, mining face will move to the primary ore zone. Mineral processing methods will need to be improved to accord with the changes of ore character and to improve recovery rates. It will therefore be necessary to

improve the mineralogical facilities which to be used to obtain the basic data for this purpose.

4-4 Workshop

The production of both casting plant and machinery plant has been rapidly decreasing since 1991, reaching only 40% to 50% of the projected level.

Major causes of such a poor performance are frequent power blackouts, shortages of raw materials, decline in operating rate and a poor yield rate caused by the obsolete machinery and equipment.

4-5 Utilities

(1) Electricity

Erdenet Mine receives a supply of electricity from the central energy grid.

Centered around Ulaanbaatar there are five thermal power plants with a installed capacity of 800 MW. However, power generation has declined to 500 MW.

The electricity supplied from Russia has also declined from 70 MW to 40 MW.

As a result, the amount of electricity supplied to the mine has declined to 75% of the projected level in 1991, and 80% in 1992 . A more significant factor in the mine's operations are the frequent power blackouts. In 1990 there were 94 power blackouts. This increased to 975 in 1991, and 481 in 1992. This situation has still not yet improved.

(2) Water

The Selenge River is the only source of water. Water is pumped from the

river and pipelined for a distance of 60 km and elevation of 600 m. Half of the water supply is used for civic purposes, with the remainder used for industrial purposes such as mineral processing and the boilers.

Water from the tailing pond is pumped up in the downstream of the tailing dam. 90% of the water used for mineral processing is recycled.

Electricity used to pump the water accounts for 18% of the total power consumption of the mine.

4-6 Environmental Protection

(1) Dust is generated from three sources: boilers, copper concentrate driers and tailing dam. It is necessary to take measures to curb this air pollution. When low wind speeds and inversion conditions occur, the air pollution levels exceed acceptable limits.

(2) Industrial diseases caused by dust are found among the workers in some places of the plant. Necessary measures are therefore urgently required.

(3) Treatment of discharge water is carried out correctly.

4-7 Business Management

(1) The mine is managed by Mongol-Soviet Joint Mining and Refining Corporation. This company is a joint venture established under the agreement (revised in 1991, effective for 12 years) made between the former Mongolian People's Republic and the former USSR.

The capital of the company is 500 million rubles, with total assets of about Tg 10.3 thousand million (excluding mining rights). The net worth ratio is about 65%, and the profit to sales ratio is about 40%. With this performance the mine

can be described as an excellent company.

(2) The cash flow of the mine is problematic. The mine has an obligation to sell 55% of the earned foreign currency to the government. Although the mine allocated 45% of its foreign currency to purchase spare parts, this was not sufficient. Therefore, in 1993, the foreign currency allocation rate was revised to 48% to the government and 52% to the Erdenet mine.

The monetary value of inventory is about six months worth of sales, and this has become a burden on cash flow.

(3) Sales of concentrates are based on long-term contracts and short-term spot contracts with Russia, China, Japan and so forth. A part of the copper concentrate is sent to smelters under toll bases.

(4) There are about 6,500 employees, a fairly large number in comparison with the mines of similar scale in western countries.

The company employs a personnel management system similar to the line staff system in western countries. Level of business management system is high. Wage difference between managers and workers are small. As the company places emphasis on education and training, the general educational level of employees is high.

(5) Production declined mainly because of shortage in supply of materials from the former Soviet Union. Unless this problem is quickly solved, the company's capacity to earn the foreign currency will decline significantly and affect the entire Mongolian economy. Recovery of production is urgently needed.

(6) The mine has a potential to produce a large amount of profits. It is one of the outstanding mines in the world. Future operations require further

investment. An important matter is how the mine will raise the funds for such investment.

(7) In terms of interchange with western countries, it should be noticed that there is a difference in standards applied to machines, and in the systems of financial accounting and purchasing.

It will be necessary for the mine to aim at communicating with western countries and make an effort to minimize these differences.

Chapter 5 Modernization Plan

5-1 Basic Plan

(1) Basic Policies for the Modernization Plan

① The mine should eliminate the factors that impede production (shortage of electricity and spare parts), and thereby recover normal operations.

② The mine should prepare a long-term investment plan that aims at copper production of 120,000 tons/year over 15 years, beginning from 1994. The mine should examine the feasibility of the plan from both the company's financial perspective and in relation to its impact on the nation's economy.

③ In order to set up a production system to withstand competition in a market economy, the mine should replace, enforce and improve machineries in each section.

(2) Production

120,000 tons of copper, contained in copper concentrate per year, the production level already achieved before 1990, should be maintained for the 15 years from 1994 to 2008.

As mining portion will shift from the secondary enrichment ore zone to the primary ore zone, the grade of the crude ore will decline (0.72% - 0.50%). In order to maintain the above production level, the amount of crude ore for processing will be increased to 30 million tons/year in 2008.

This tonnage is equivalent to the full capacity in case that the existing units Nos. 1 to 5 were enforced and the new Unit No. 6 was installed.

5-2 Exploration

(1) Gold deposits and skarn type copper deposits distributing in the surrounding area require further exploration. Exploration for groundwater in the neighboring area of Erdenet city is considered necessary. In order to promote these exploration effectively, the mine should adopt exploration techniques such as multicomponent geochemical exploration and electromagnetic survey.

(2) It is also advisable to introduce the latest computerized ore reserves calculation methods in order to clarify detailed distribution of ore grades in the deposit, and use such data to control the grade of ore mined.

5-3 Mining

(1) In selecting replacement mining machines, consideration should be given to all factors; price, capacity, expected life, and reliability of spare parts supply. Through this selection an attempt to reduce costs as well as to increase operating efficiency should be considered. Since waste excavation is well advanced, even if ore output is increased, the waste excavation may be reduced to adjust total tonnage of excavation equal.

(2) Systems to control the grade of ore mined should be improved.

(3) Transfer of dump trucks for hauling ore to Mining Department should be considered. Installation of an in-pit crusher and belt conveyor should be considered in the future.

5-4 Mineral Processing

(1) The capacity of Units Nos. 1 to 5 should be increased and a new Unit No. 6 is to be installed in order to meet the crude ore processing capacity to 30 million tons/year by 2008.

(2) An appropriate mineral processing reagent should be selected to match the changes of ore character from secondary enrichment zone to primary zone.

(3) Comparison of copper-molybdenum separating flotation and bulk flotation should be conducted.

Bulk flotation will reduce the sales of molybdenum concentrate, as disadvantage, but will save the separating flotation cost of copper and molybdenum, and improve the copper recovery. It is necessary for the mine to carry out careful comparison of the two cases to ensure an appropriate selection.

5-5 Workshop

(1) Capacity of the casting plant should be increased from 6,500 tons/year to 10,000 tons/year to meet the increase in processing of crude ore and increase in outside sales.

(2) Yield of defects and cost of production should be reduced by introducing new VRH techniques. In addition, die cast machines should be introduced, and quality control enforced.

(3) The equipment in the machining plant is noticeably outdated in comparison with that of advanced countries. NC machines for the lathes, milling machines and boring machines should be introduced.

Other existing equipment should be upgraded by adding sensors and

control devices so that one operator can operate more than two machines simultaneously.

5-6 Utilities

(1) Electricity

Urgent measures are required to avoid frequent power blackouts and to stabilize the mine operations. When crude ore processing reaches 30 million tons/year the amount of electricity required at the mine will increase from 100 MW to 150 MW.

The installation of 60 MW generators utilizing the existing boiler is being studied as a solution to this problem. We believe this to be a very effective and appropriate plan.

The existing Erdenet Power Plant has excess capacity in its steam production. If this excess capacity is utilized, the advantage will be even greater.

(2) Water

The Selenge River is the only water source. If the water supply system meets with troubles, the operations of the mine and the lives of the citizens will be severely affected. To avoid having such a situation occur unexpectedly, as well as to save electric power, it is necessary to secure a second water source in the area neighboring the city of Erdenet.

A branch of the Orhon River runs to the north and south of the city. Based on the annual rainfall and catchment area, groundwater resources are estimated to be equivalent to the water supply of the Selenge River.

A survey of groundwater should proceed in the following order:

① Hydrology and hydrogeological survey; ② Resistivity survey; ③ Drill bore holes. New technologies will be required to conduct the resistivity survey. From the geological structure of this area it may be possible to construct an underground water reservoir.

(3) The telephone exchange system requires upgrading. The use of satellite communications is conceivable.

5-7 Business Management

(1) Western accounting methods should be introduced if the mine intends to participate in the western market and introduce foreign capital. The government should undertake a study, take a leading role, and attempt to introduce such an accounting system at a national level.

(2) The allocation of foreign currency earned by Erdenet Mine is determined through consultation between the government and Erdenet Mine. However, priority should be given to ensuring Erdenet Mine has sufficient foreign currency to procure materials and parts to maintain the production level of the mine.

(3) It is necessary to have stable clients (custom smelters) for the sale of concentrate. To achieve this, attention should be paid to such matters as consistent quality, steady supply, and payment in accordance with international business practice.

(4) Inventory management should be computerized in order to keep inventory at an appropriate level.

(5) Improving organization:

The mine has a number of divisions that support mining activities. In response to Mongolia's shift to a market economy and to changes in the

management environment, some parts of the organization should be separated from the mine and privatized.

Specifically, the following divisions should be spun off and made into independent entities:

a. Livestock Division

b. Sewing Factory

c. Construction Group

d. Daily Necessities Supply System

(6) The organization of personnel and labor management should be centralized, as to control the matters such as employment, dismissal and promotion.

(7) Careful study on the wage system should be undertaken, based on the results of job analysis and with consideration paid to the influence that changes may have on other industries.

(8) A technical training center should be established to promote education and training.

(9) Privatization

Privatization of government enterprises is being promoted in the national policies of Mongolia. However, Mongolian economic environment (accumulation of domestic capital, improvements in domestic stock market and banking system, etc.) in which large companies like the Erdenet mine would privatize has not been laid out. Privatizing the Erdenet mine is therefore considered premature at this stage.

Separating to establish independent enterprise and their privatization

should be promoted on the areas of livestock, sewing, construction and supply of daily necessities. However, it is necessary to watch the environment for some time before contemplating privatization of the Erdenet mine itself.

5-8 Modernization Implementation Plan

This draft plan for modernization includes urgent implementation measures, and strategy that can be implemented over long term. These are as follows:

(1) Measures that should be implemented urgently.

① Construct power plant utilizing existing boilers.

② Upgrade workshop to improve its operating efficiency, and increase quantity of imported parts to eliminate shortages.

③ Prevent skilled workers from resignation.

(2) Measures that should be implemented over long term

① Replace existing mining machines with larger ones.

② Expand mineral processing capacity to 30 million tons/year.

③ Modernize the workshop and improve other areas (introduce VRH technique and NC machines).

(3) Investment required to implement modernization plan

The investment required to implement separate copper and molybdenum production is estimated to be $342 million and that for bulk production, $337 million. (See Table 1: Investment).

Investment of about $200 million will be required even if the Modernization Plan is not implemented and the present level of production maintained.

④ Explore a second water source.

⑤ Modernize management and organization.

5-9 Environmental Protection

(1) As the dust discharged from the boiler may have negative effects, depending on the season and wind speed, an electrostatic precipitator should be installed when the new power plant is constructed.

(2) Measures to reduce dust discharged from the copper concentrate driers, such as high-pressure filtration machines, should be introduced when mineral processing is improved.

(3) Dust suppression measures such as sprinkling water and spraying cement mortar should be introduced to reduce dust generated at the tailing dam.

(4) Workers should wear dust masks as a preventive measure against occupational diseases.

Chapter 6 Financial and Economic Analysis

(1) Economic Effects Based on the Implementation of the Modernization Plan

We conducted a comparative examination of the investment costs and economic effects of the two scenarios: if the plan is implemented (With), and if the plan is not implemented and the current situation is maintained (Without).

The sales amounts of concentrate produced by two alternative methods, copper and molybdenum separation-flotation and bulk concentrate were also calculated (Table 2).

The calculation of revenues uses data for November 1992, and does not take into consideration copper price increase, inflation and other factors.

The conditions for selling copper concentrates are:

£1400/MT, T/C: $100/t, P.P. at 90 ¢/lb ± 10%, cross rate: $1.55/£, revenues from molybdenum and silver, arsenic penalties, transport expenses and so forth are unrevised.

(2) Results of Financial and Economic Analysis

The financial and economic analysis calculations for each product are:

Copper Price	Financial internal rate of return (%)		Economic internal rate of return (%)	
	Separate Production	Bulk Production	Separate Production	Bulk Production
1400£/MT	14.04	20.12	26.75	40.17

The financial internal rate of return for separate production of copper and molybdenum is 14%, while that for bulk production is 20%. Both cases exceed the

5% interest rate on borrowings. The modernization plan is therefore a sufficiently profitable investment plan for Erdenet Mine.

From a national perspective the economic internal rate of return for separate copper and molybdenum production is 27% while that for bulk production is 40%, showing very high levels. These levels far exceed the 10-12% generally considered by international organizations as a standard for assessing the appropriateness of a project. From the perspective of economic development for Mongolia, these figures show that this modernization plan is a very promising project.

Table 1 LIST OF TOTAL INVESTMENT COST (1)---MINING AND MINERAL PROCESSING

(US$1000)

ITEM	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	Total
1. Mining																
Rotary Drill	5,276			1,319	1,583			5,672			1,319	1,583			5,672	22,424
Power Shovel	21,844		5,461	5,461	6,553		1,638	1,638	6,553		1,638	1,638	6,553		1,638	60,615
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	27,247
Motor Grader	966		290		1,288		386		1,288		386		1,288		386	6,278
Dump Truck	14,258	5,746	4,082	13,440	2,554	14,650	6,954	7,123	16,128	5,272	18,144	9,005	7,930	16,934	5,645	147,815
Total(economic cost)	42,873	9,185	10,597	21,563	13,362	15,301	12,600	15,776	25,719	7,063	22,667	16,377	17,236	18,806	15,254	264,379
Import & Sales Tax	10,546	2,259														12,805
Total(financial cost)	53,419	11,444	10,597	21,563	13,362	15,301	12,600	15,776	25,719	7,063	22,667	16,377	17,236	18,806	15,254	277,184
2. Mineral Processing																
Crushing																
Cone Crusher Renewal			3,000	1,200												4,200
Grinding																
AG, Ball Mill for No.6 Sec.					500	1,600										2,100
Process Water					500	370										870
No. 1-4 Ball Mill renweal							2,100	2,100								4,200
Flotation																
A. Mo/Cu Separation																
No.6 section	6,100	4,200														10,300
No.1-4 Renewal		1,100	1,100	1,100	1,100											4,400
No.5 expansion						220										220
B. Bulk																
No.6 section	4,154	2,859														7,013
No.1-4 Renewal		837	837	837	837											3,348
No.5 expansion						150										150
Filtering																
Ceramic Filter	2,000	750														2,750
Compressor Reinforcement		1,200	1,000	631												2,831
Crane for Concentrate	500	331														831
Waste Treatment																
Slurry Pump Reinforcement			1,330	340												1,670
Waste Dam Step Banking			600	600												1,200
Water Reclaiming																
Reclaim Water System	1,630	500														2,130
Reclaim Water No.3 Pipe			1,000	671												1,671
Miscellaneous																
Reagent Storehouse	100	740														840
Lime Handling Equipment	330															330
Lime Storehouse	25	75														100
Research Apparatus	300	200	100													600
Total(economic cost)																
A. Mo/Cu Separation	10,985	9,096	8,130	4,542	2,100	2,190	2,100	2,100								41,243
B. Bulk	9,039	7,492	7,867	4,279	1,837	2,120	2,100	2,100								36,834
Import & Sales Tax																
A. Mo/Cu Separation	2,135	1,690														3,825
B. Bulk	1,751	1,377														3,128
Total(financial cost)																
A. Mo/Cu Separation	13,120	10,786	8,130	4,542	2,100	2,190	2,100	2,100								45,068
B. Bulk	10,790	8,869	7,867	4,279	1,837	2,120	2,100	2,100								39,962

Table 1 LIST OF TOTAL INVESTMENT COST (2)---UTILITIES, WORKSHOP AND OTHERS

(US$1000)

ITEM	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	Total
1. Utilities																
Hot water Supply Facilities	1,080	2,140														3,220
Telephone Exchanger	600															600
INMMALSAT Ground Station	220															220
communication Facilities	66															66
Total(economic cost)	1,966	2,140														4,106
Import & Sales Tax	421	380														801
Total(financial cost)	2,387	2,520														4,907
2. Workshop																
VRH Facilities		3,285														3,285
Mold Forming	233															233
Shake out Machine	272															272
Shot Blast	480															480
Dust Collecting Facility	1,004															1,004
Sand Analyzer/Silica Program	66															66
Metal Analyzer, etc.	440															440
Alumi Die Casting Machine		1,372														1,372
NCLathe, etc.	1,639															1,639
Semi-Auto. of Turning Table		743														743
semi-auto.of B.Machine, etc.			800													800
Spline Fabricating Machine	400															400
Training on Heat Treatment		54														54
Cutting Machine	160															160
Precision Boring Machine		937														937
Bolt/Nut Auto- Fab. Machine		457														457
Total(economic cost)	4,694	6,848	800													12,342
Import & Sales Tax	1,038	1,388														2,426
Total(financial cost)	5,732	8,236	800													14,768
3. Others																
CAD System	60															60
Total(economic cost)	60															60
Import & Sales Tax	15															15
Total(financial cost)	75															75
Gran Total																
Economic Cost																
A. Mo/Cu Separation	60,578	27,269	19,527	26,105	15,462	17,491	14,700	17,876	25,719	7,063	22,667	16,377	17,236	18,806	15,254	322,130
B. Bulk	58,632	25,665	19,264	25,842	15,199	17,421	14,700	17,876	25,719	7,063	22,667	16,377	17,236	18,806	15,254	317,721
Financial Cost																
A. Mo/Cu Separation	74,733	32,986	19,527	26,105	15,462	17,491	14,700	17,876	25,719	7,063	22,667	16,377	17,236	18,806	15,254	342,002
B. Bulk	72,403	31,069	19,264	25,842	15,199	17,421	14,700	17,876	25,719	7,063	22,667	16,377	17,236	18,806	15,254	336,896

Table 2 (1) Income Statement : WITH (Mo/Cu Separation)

(US$ 1,000)

Year		(a) Sales	(b) Ope.costs	(c) Depreci'n	(d) Interest 5.0%	(e) Prft bf tx	(f) Tax 40%	(g) Net Income
1	1994	173,570	92,589	10,299	1,957	68,725	27,490	41,235
2	1995	163,703	93,789	13,711	4,828	51,375	20,550	30,825
3	1996	162,600	96,277	15,813	5,741	44,769	17,907	26,861
4	1997	168,838	99,001	19,912	5,741	44,184	17,673	26,510
5	1998	174,893	101,944	22,876	5,741	44,332	17,733	26,599
6	1999	174,636	104,622	23,547	5,741	40,726	16,290	24,435
7	2000	173,840	104,657	23,693	5,582	39,908	15,963	23,945
8	2001	175,249	105,950	24,261	4,944	40,094	16,038	24,056
9	2002	174,277	106,242	25,505	4,306	38,224	15,290	22,934
19	2003	175,448	107,276	26,028	3,668	38,476	15,390	23,086
11	2004	168,294	111,835	27,360	3,030	26,069	10,428	15,641
12	2005	170,413	114,867	27,847	2,392	25,307	10,123	15,184
13	2006	170,413	114,942	28,125	1,754	25,592	10,237	15,355
14	2007	170,413	115,135	29,746	1,116	24,416	9,766	14,649
15	2008	165,199	115,444	31,112	478	18,165	7,266	10,899
Total		2,561,786	1,584,570	349,835	57,023	570,358	228,143	342,215

Table 2 (2) Income Statement : WITH (Production of Bulk Concentrates)

(US$ 1,000)

Year		(a) Sales	(b) Ope.costs	(c) Depreci'n	(d) Interest 5.0%	(e) Prft bf tx	(f) Tax 40%	(g) Net Income
1	1994	173,466	92,586	10,170	1,897	68,813	27,525	41,288
2	1995	164,493	89,937	13,467	4,660	56,429	22,572	33,858
3	1996	160,232	90,258	15,549	5,525	48,900	19,560	29,340
4	1997	165,254	90,924	19,627	5,525	49,178	19,671	29,507
5	1998	170,140	91,902	22,567	5,525	50,146	20,058	30,087
6	1999	169,207	92,612	23,231	5,525	47,839	19,135	28,703
7	2000	167,144	92,572	23,377	5,372	45,823	18,329	27,494
8	2001	168,638	93,762	23,945	4,758	46,173	18,469	27,704
9	2002	167,554	94,059	25,189	4,144	44,162	17,665	26,497
19	2003	167,930	95,039	25,712	3,530	43,649	17,460	26,189
11	2004	160,482	99,157	27,044	2,916	31,365	12,546	18,819
12	2005	164,081	101,985	27,531	2,302	32,263	12,905	19,358
13	2006	164,093	102,057	27,809	1,688	32,539	13,015	19,523
14	2007	164,142	102,255	29,430	1,074	31,383	12,553	18,830
15	2008	159,467	106,129	30,778	460	22,100	8,840	13,260
Total		2,486,323	1,435,234	345,426	54,904	650,759	260,304	390,456

Table 2 (3) Income Statement : WITHOUT

(US$ 1,000)

Year		(a) Sales	(b) Ope.costs	(c) Depreci'n	(d) Interest 5.0%	(e) Prft bf tx	(f) Tax 40%	(g) Net Income
1	1994	143,537	77,565	8,248	0	57,724	23,090	34,634
2	1995	146,153	77,376	10,415	0	58,362	23,345	35,017
3	1996	136,060	76,592	13,277	0	46,191	18,476	27,715
4	1997	128,299	76,468	14,847	0	36,984	14,794	22,190
5	1998	125,175	76,035	15,655	0	33,485	13,394	20,091
6	1999	124,714	75,660	16,384	0	32,670	13,068	19,602
7	2000	125,841	75,742	16,919	0	33,180	13,272	19,908
8	2001	126,273	76,440	17,006	0	32,827	13,131	19,696
9	2002	116,378	77,313	15,900	0	23,165	9,266	13,899
19	2003	116,163	77,494	17,237	0	21,432	8,573	12,859
11	2004	115,401	77,664	18,638	0	19,099	7,640	11,459
12	2005	114,069	78,004	18,261	0	17,804	7,122	10,682
13	2006	114,102	78,043	17,975	0	18,084	7,234	10,850
14	2007	113,210	78,109	18,471	0	16,630	6,652	9,978
15	2008	104,907	78,400	22,949	0	3,558	1,423	2,135
Total		1,850,282	1,156,905	242,182	0	451,195	180,478	270,717

Chapter 7 Conclusion and Recommendation

The primary aim of the proposed modernization plan is to stabilize mining operations over the 15 years beginning 1994 and to achieve forecast sales (foreign currency revenue) and profit.

To do so, we set the target amount of copper in the concentrate at 120,000 tons/year. Given the mining conditions, a fall in the grade of crude ore and investment in the addition and modification of facilities, we plan for a 50% increase in the amount of crude ore mined, from 20 million to 30 million tons per annum.

The amount of investment required over 15 years to implement this plan is $342 million under the method of separating copper and molybdenum (the separation method) and $337 million for the mixed concentrate method (the bulk method). Financial and economic analysis on the investment amount and anticipated income show outstanding results, indicating that the plan is feasible.

The internal financial rate of return of this plan is 14% for the separation method and 20% for the bulk method. Both cases exceed the assumed interest rate (5%) on invested borrowings, showing that these projects are profitable.

For the Mongolian nation, the internal economic rate of return is 27% for the separation method and 40% for the bulk method, showing very high levels.

These levels far exceed the 10% to 12% that international institutions use as criteria to determine the appropriateness of projects. Thus, the project can be considered to hold great benefits for Mongolia's economic development.

As for the selection of the concentrate production method: if more importance is placed on Mongolia's foreign currency income, the separation

method should be adopted. Alternatively, if the company wishes to seek greater profits, it should choose the bulk method. This choice must be up to the Mongolians.

Some of the forecast values in this plan are uncertain. In actually making the investment, we hope that a more detailed examination will be made to ensure that prudent measures are adopted.

In implementing the modernization plan we should like to raise the following as matters requiring attention.

(1) The first priority in investment should be to secure a steady supply of electricity. Because this is extremely important, it is necessary to quickly build a power generation plant in Erdenet in line with national energy policies. Under this plan, our conclusion is that the Central Energy System will build up a power generation plant and Erdenet Mine buys electricity from the System.

Investment in modernization should be directed at the addition and modification of machinery and equipment needed for production activities, the introduction of new processes and other areas. We have calculated the costs of mining equipment, mineral processing facilities and machine tools using western prices. However, as Mongolia lacks information on the specifications and prices of western equipment, we would like the mine to obtain more detailed information in the future.

(2) With regard to the amount of investment required in the first two years: we based our economic and financial analysis on the precondition that investment would be wholly financed by borrowings. About 30% of the investment needed to execute this modernization plan comes in the first two years. Further, because

economic conditions in the Mongolian economy are expected to remain severe, we believe that it would be most realistic for the mine to appropriate the amount of investment required to modernize in the first two years from overseas loans.

In this case, investment from the third year will be appropriated from the Mine's funds on hand (namely, funds generated by the Mine's profits). However, as such funds are an important source of foreign currency for Mongolia, and given the nation's financial conditions, investment should be made while conducting careful investigation at a national level.

(3) In terms of overall management, as Mongolia is currently shifting from a socialist to a market economy, the country must correct the weaknesses inherent in the previous system. The underlying principle of a market economy is free competition. To withstand free competition, productivity must be constantly improved and efforts must be made to reduce costs and improve quality.

Here, we propose that improvements in the following aspects of production and management be taken as key examples: the accounting system, personnel and wage policies, simplification of the organization, appropriate allocation of personnel, sales conditions, automation of operational control, concentrate quality control and the quality of the mine's products. In particular, to increase the feeling of employee unity with the company, and to access qualified workers, the mine must continue to provide training on skills, control, safety and other aspects. The mine must never cease to train its human resources.

(4) At present, we consider it premature to privatize the entire mine. However, the issue should be kept in mind for the future.

The mine should aim to separate businesses which have little connection to

mining operations and make them independent new companies. These companies should then be privatized and allowed to grow in an environment of free competition. In doing so, the mine should aim at strengthening companies which come under its aegis.

We would also like to propose that the mine establish a system under which other divisions accept relocated personnel. This system should be put in place in future, when the organization is simplified.

(5) The mine should adopt a corporate philosophy of carrying out fair business activities. So that the Mine can gain credit and a positive evaluation on an international level, it should continue to carry out sound management in the future. At the same time, we consider that the mine should ensure that it takes into sufficient consideration such matters as environmental conservation, employees' health and continued employment.

Volume 2 Recommendation on Asset Valuation Method

1. Asset Valuation Methods

There are several methods used to value assets, as value is the price buyers and sellers agree on at the time of company disposal. Naturally, the calculated results vary, but any method can be used as long as the value of the company is determined by a method acceptable to both seller and buyer. From the perspective of the seller, he must use a method which is normally used by investors, and must set a price acceptable to the purchaser.

(1) Net Asset Approach

This method uses the net assets of the company as a measure of the company's value.

Value of the company = Total assets - Total liabilities

(2) Price-Earnings Multiple Approach (PE Approach)

The value of the company is estimated using past examples of company disposals, based on disposal price as a multiple of net profit.

(3) Discounted Cash Flow Approach (DCF Approach)

The company's total future cash-based net profits are calculated and discounted at a specified rate to give their present value (DCF). The total value of these DCFs gives the asset value.

Value of company = Total of future DCFs

2. Valuation Method Suitable for Erdenet Mine

(1) The DCF method is the most appropriate asset valuation method for a mine. Furthermore, as DCF is commonly used in many countries, we propose that the mine use this method.

The value of Erdenet Mine is found in the profit generated by mining minerals, the quantity of which is reduced by mining. No matter how many expensive machines and facilities the mine has, it has no value if it cannot produce any profit.

(2) In the valuation of a mine it is important to consider production scale, number of years of operation, investment amount, operating expenses, sales revenues, profit, discount rate and so forth.

However, valuation of a mine requires many estimates. If the estimates are not accurate, the value will change. Asset valuation for a mine is, therefore, relative.

(3) Case Study

Figures used for the example calculation of the mine's value are fictitious. When appropriate operations plans are drawn up and figures in the table are replaced, a more realistic valuation will be possible.

Volume 3 Recommendation on the Copper Smelter Construction

Recommendation concerning the construction of a copper smelter in Mongolia are summarized as follows:

1. Domestic Viewpoint

(1) Given the present status of the Mongolian economy, the suspension of the plan was inevitable.

The plan contains difficult issues such as fund raising and the taking of environmental protection measures.

(2) At a level of 100,000 tons/year, production is rather low.

For economical operation of the copper smelter, production should be around 200,000 tons/year. Mongolia should consider the development of mines other than Erdenet.

(3) The training of smelting engineers is necessary.

Nothing can be done if there are no appropriate human resources.

These engineers will become a bargaining power at the time of the mine's negotiations for sales of concentrate and smelting of toll basis.

(4) It is important to gather information on smelting technology from western countries.

2. Overseas Perspective

(1) Throughout the world, the construction of new smelters is being postponed or suspended, and expansion of existing smelters is prevailing.

(2) The use of the hydrometallurgy method (SX-EW method) for copper

smelting is increasing. It is said that one third of increased copper production in the future will be by this method.

(3) Mongolia is geographically close to the potential market of copper metal and their byproducts.

If revenues from sulfuric acid offset the cost, this will improve the profitability of the smelter.

3. Overall Evaluation of the Plan

(1) The plan to construct a copper smelter will become effective when mining (upstream), infrastructure, facility repair systems and the processing division (downstream) are effectively linked to each other. IRR and EIRR must be calculated from an overall perspective. Based on these results, the feasibility of the plan must be proven.

(2) The report set the investment required for the construction at US$450 mil. Allowing for the necessary improvements in infrastructure, interest payments during construction and so forth, the amount of investment required will be US$600 mil. - $700 mil.

(3) Construction Period

Construction will take at least five years from the finalization of the plan.

The period required to obtain a government permit will also need to be added to this time frame.

(4) Necessary funds will be raised from overseas.

The amount raised from overseas is expected to be about $1,000 million.

Raising this amount will not be easy, and is likely to be the first obstacle in the implementation of this plan.

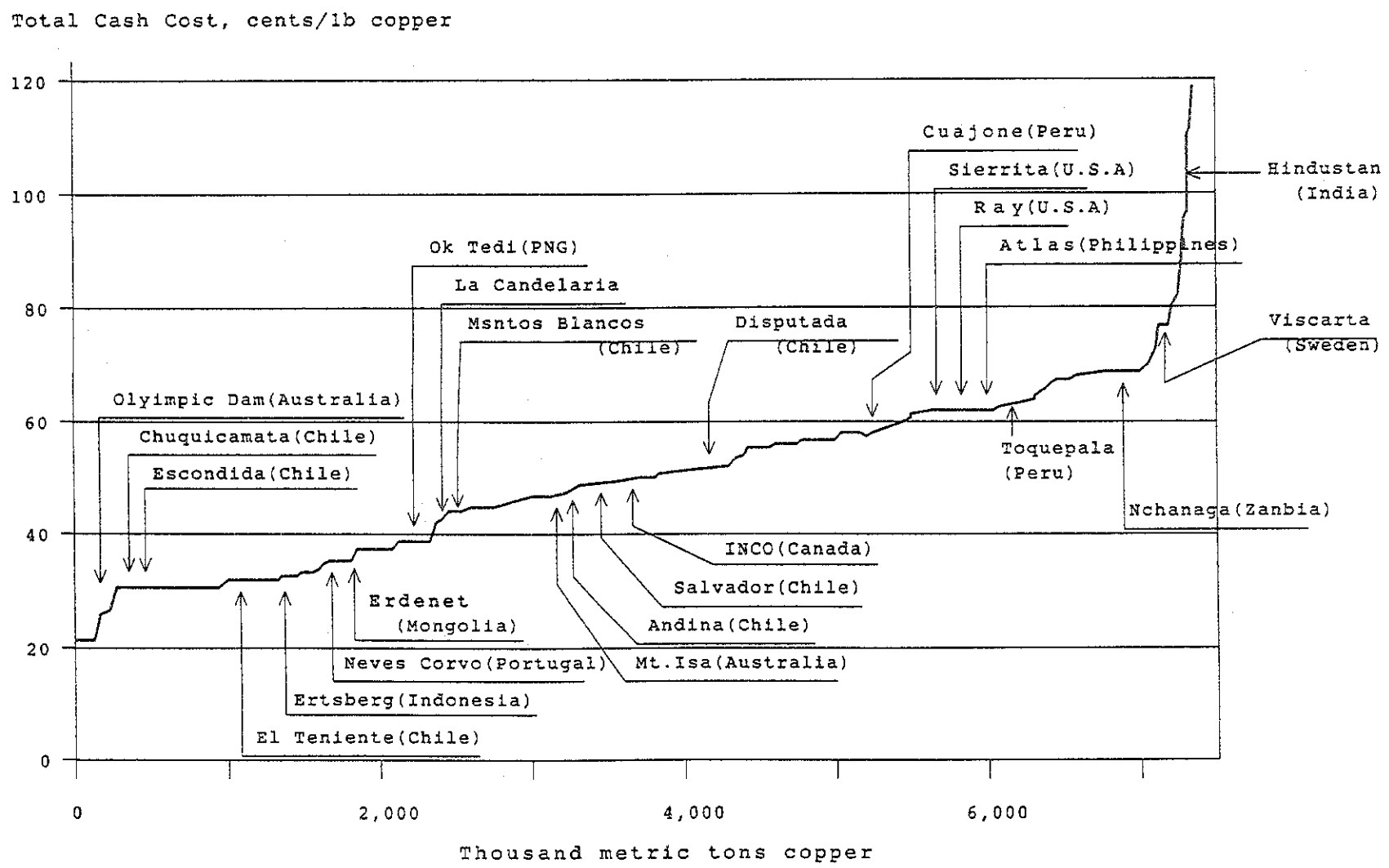

Fig 1 MINE PRODUCTION COST IN 1990