# 1 Introduction

## 1.1 History of study

Mongolia faces a serious economic crisis owing to the halt in barter trade under COMECON, and the Mongolian government intends to overcome this crisis by developing and utilizing its abundant coal resources. Coal deposits in Mongolia are said to amount to as much as 150 billion tons; there are supposedly 24 billion tons for which surveys have been carried out in some manner and deposits confirmed. However, annual coal production in Mongolia peaked at 8.6 million tons in 1988, and has since declined yearly, falling to 6.2 million tons in 1992.

For this reason Mongolia is in recent years verging on an energy crisis, and finds itself in especially acute circumstances during its bitterly cold winters. This, it would seem, finds its cause in the deterioration of facilities, the shortage of spare parts, and limited economic vitality. The Mongolian government sees the development of its abundant coal resources as a top-priority task, and in view of this situation it urgently needs to formulate a comprehensive program for development and utilization that includes renovating its main coal mines and developing new coal fields.

## 1.2 Objectives and scope of study

The two main objectives of this study are:

- To formulate a program for the renovation of two existing coal mines that is technically, economically, and financially optimum, and to prepare a feasibility study report; and
- To forecast a long-term coal supply and demand, formulate a coal development and utilization program and a conceptual action plan, and prepare a master plan report.

Another important objective is to transfer technology to our Mongolian counterparts through the study.

This study consists of Part I (Renovation study of Baganuur coal mine and Shivee Ovoo coal mine) and Part II (Master plan study for coal development and utilization).

Scope and approach of Part I are:

(1) Collecting information for a study on the coal mine renovation program

(2) Selecting two coal mines to be studied

(3) Developing effective renovation programs including environmental study

(4) Study of investment and operating costs

(5) Financial and economic analyses

Scope and approach of Part II are:

(1) Collecting information for the coal development and utilization program's master plan

(2) Coal supply and demand projections

(3) Coal development program

(4) Coal utilization program

(5) Energy conservation program and environmental measures for coal-related facilities

(6) Preliminary studies for selected plans

(7) Conceptual action plan

The text consists of two volumes. Volume I includes the formulations of Part I (Chapter I: Baganuur coal mine, Chapter II: Shivee Ovoo coal mine), while volume II is separated and includes Part II.

This Chapter II reports the renovation plan of Shivee Ovoo coal mine.

The purpose of study on renovation of Shivee Ovoo coal mine, which was selected by Ministry of Energy, Geology and Mining (MEGM) and JICA Study Team agreed to carry out this study, includes mine planning, selection of mining equipment to be introduced, estimation of capital cost, calculation of operating cost, economic evaluation, countermeasures for environmental impacts in order to increase the production capacity to 2 million tons per year from the present capacity of 0.5 million tons per year.

Shivee Ovoo coal field, where geographical features are only hilly, is located in Prefecture of Dorunogobi, 250 km South East of Ulaanbaatar and 1,180 - 1,230 m above sea level. As a result of preliminary exploration works, the Sine-us area was selected as a mining area to be exploited. The Shine Us area is located at the North East area of the Shivee Ovoo Coal field. The coal seams to be exploited are Seams I, II and V in 8 coal seams which occur in the Shine Us area. The Seam I occurs at the bottom. Mongolian Mining Engineers carried out exploration works of the area, preliminary feasibility study and feasibility study. Therefore, Shivee Ovoo coal mine was developed by Mongolian mining engineering. Production of coal commenced in 1992 as a small scale open pit coal mine.

The background for development of Shivee Ovoo coal mine was that Sharyngol coal mine, which is one of the coal mines supplying coal to the power plants in Ulaanbaatar, has already exploited over half of the minable reserves. Although Baganuur coal mine also supplies coal to the power plants in Ulaanbaatar, MEGM recognizes that the increased production at Shivee Ovoo coal mine can solve problems if troubles in production capacity and coal quality occur at both Sharyngol and Baganuur coal mines. Also, MEGM has planned to increase production of coal at Shivee Ovoo coal mine because it is projected that demand for coal will increase and the shortage of coal will occur in Mongolia in the near future.

It has been said that coal quality of coal produced at Shivee Ovoo coal mine is similar to that of Baganuur coal mine while the carbonization is earlier stage in comparison with that of Sharyngol coal mine. As it is possible to increase production capacity at Shivee Ovoo coal mine because coal reserves, geological and mining conditions are favorable, MEGM is now carrying out combustion test of coal produced from Shivee Ovoo coal mine at the power station in Ulaanbaatar, aiming for introduction to the market.

In order to meet the demand of coal in Mongolia, it is planned to increase the capacity of production at Shivee Ovoo coal mine to 1 million tons per year in 1997, to 1.5 million tons per year in 1999 and to 2 million tons per year thereafter. Furthermore, MEGM pointed out the needs to increase the capacity of production at Shivee Ovoo coal mine to 4 million tons per year if the demand of coal increases in Mongolia and if the capacities of production at both Baganuur and Sharyngol coal mines decrease substantially in the near future. Issues of mining operation, which Shivee Ovoo coal mine have been experiencing at present, are quality control of coal. Calorific value of coal is low at 2,800 kcal/kg because the oxidized coal near the surface has been mined from the beginning of production in 1992. However, Calorific values of coal mined at present often reaches up to 3,000 kcal/kg because stripping of overburden has been advanced and coal is dried at the coal stockyard prior to loading in summer. Major issue on quality control is high total moisture contents of coal supplied to the power stations in Ulaanbaatar due to delays of dewatering underground water. Total moisture contents of coal exceeds 40 % when coal is supplied without sufficient natural drying at the coal stockyard. For example, combustion of coal in a boiler at the No 4 power station stopped in August, 1994 because coal has calorific value of 2,260 kcal/kg with total moisture of 47 %. Normally, coal produced from Shivee Ovoo coal mine is burned with diesel to sustain the required operating efficiency of boilers at the No 4 power station. Another issue is size of coal exceeding 300 mm being supplied to the power stations in Ulaanbaatar because a crushing and screening plant has not been installed.

There are also some problems associated with spontaneous combustion of coal exposed after removing overburden at Shivee Ovoo coal mine. Mine operations were adversely affected for three weeks in May, 1994 because spontaneous combustion on the exposed coal was occurred at the wall of coal bench over 100 m. Stripping of overburden and production of coal had to be stopped to cover the burning coal by dirts.

It was identified that poor availability of mining equipment is due to lack of spare parts and unavailability of skilled maintenance engineers as well as maintenance workers. Furthermore, production at Shivee Ovoo coal mine commenced without constructing the surface facilities such as workshop, warehouse and office required for maintenance of mining equipment. Delivery of spare parts to the mine site through Nuurs Co. Ltd., which is one of the state owned monopoly companies, takes three to nine months.

As to housing and facilities at Shivee Ovoo coal mine, apartments which were constructed by former Soviet Union military garrison are well utilized. Because of this, it can be said that communication and housing (apartments) are well established.

Reviewing the progress of mine development at Shivee Ovoo Coal, it has to be stressed that the initial capital investment for a new mine development should include not only the cost of mine development, but also the cost of supporting facilities such as crushing and sizing plant, workshop, warehouse, mine office and shower room. To offer better working conditions for mine workers at a new coal mine is an absolutely necessary to boost moral of mingle working and to achieve high productivity.

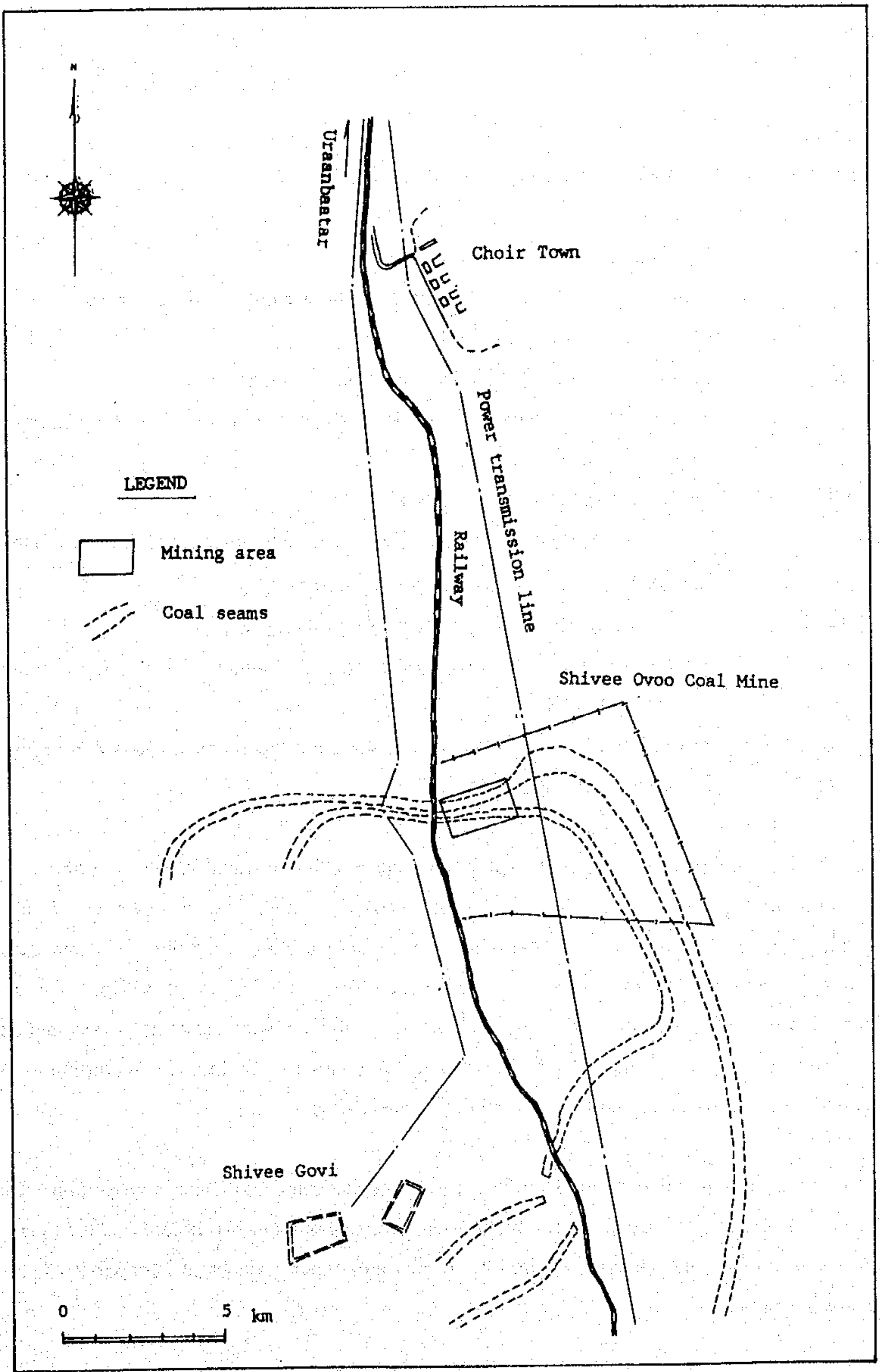



Figure 1.1 Location of Shivee Ovoo Coal Mine

## 2 Study on Coal Resources

### 2.1 History of exploration

Exploration and Development were carried out by Mongolia.

| | | |
|---|---|---|
| 1986 | : | Exploration (all area of Shivee Ovoo)<br>(Number of boreholes : 72, total length of boreholes : 16,221.56 m, borehole interval : 2-4 km) |
| 1986 | : | Detailed exploration (Shine Us area, first mining area)<br>(Number of boreholes : 65, total length of boreholes : 5,452.1 m, borehole interval : 250 m) |
| 1987 | : | Detailed exploration(Shine Us area)<br>(Number of boreholes : 80, total length of boreholes : 15,152.5 m, borehole interval 500 m, cross section interval : 200-500 m) |
| 1987 | : | Detailed exploration (Shine Us area, first mining area)<br>(Number of boreholes : 54, total length of boreholes : 9,472.0 m, borehole interval : 250 m) |
| 1987-1991 | : | Preparation of development, start of small production by small-size machine |
| 1992 | : | Start of production(146,000 t/y) |

Extensive Shivee Ovoo coal deposit is explored in sequence, and especially, detail exploration was carried out in the Shine Us area. Figure 2.1 shows geological map. Shine Us area was developed and it is now called as Shivee Ovoo coal mine. Geological structure of the Shine Us area is stable comparatively and exploration work is reasonable according to the interval of drilling. Therefore, exploration of this area considered to be accurate. As Shivee Ovoo coal mine is operated as an opencut mine, it is flexible to deal with the changes in geological conditions. According to these reasons, further exploration work is seemed to be unnecessary.

As Shivee Ovoo coal mine is comparatively a new opencut mine and has a large volume of coal reserves, it is possible to expand production capacity without much problems. However, the location of mining will rapidly move into the deeper area when production is expanded with the wider working area.

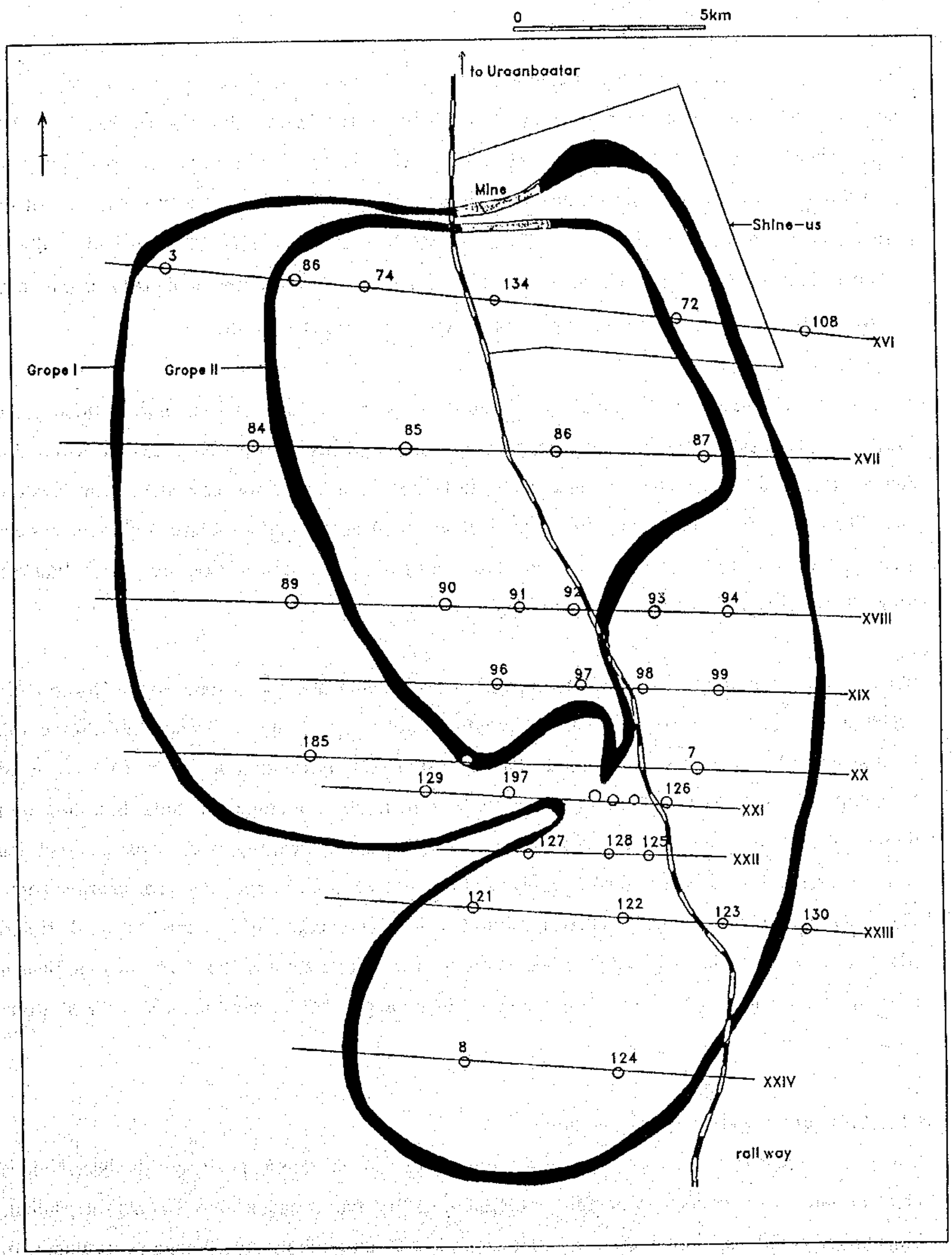



Figure 2.1 Geological Map of Shivee Ovoo

## 2.2 Geology and geological structure

### 2.2.1 Topography and geology

Choir Niarga basin has a number of coal deposits. Choir coal basin is located southern part of the Choir Niarga basin and is surrounded with low mountains where is the zone of desert in plate shape. There are few trees and the altitude is about 1200 m above sea level. Temperature is 32 degrees in summer and is under minus 30 degrees in winter. Shivee Ovoo is northern part of the folded zone of the Choir Coal basin. The area of Shivee Ovoo is about 371 $km^2$ and a railway from Russia to China is located in the center of the area. Shivee Ovoo coal mine is located eastern part of this Shine Us area and called as the Shine Us. This area is 24.4 $km^2$.

Coal seams of Mongolia are intercalated in upper Paleozoic (Carboniferous and Permian ) and Mesozoic (Triassic, Jurassic and Cretaceous), and are distributed in all areas in Mongolia. Anthracite and bituminous coal are intercalated in Paleozoic and are only distributed in the western area. Sub-bituminous coal and lignite are intercalated in Mesozoic and are distributed in the eastern area. Those two areas are called as "Western Mongolia Coal Distribution area" and "Eastern Mongolia Coal Distribution area" respectively.

Shivee Ovoo coal mine is located 260 km southeast to Ulaanbaatar and belongs to the Dorno Gobi Prefecture. It is 20 km from the Choir city which is the capital city of Dorno Gobi Prefecture. Coal seams of Shivee Ovoo belong to the Tebushin-gobi Formation in lower Cretaceous of Mesozoic. Tebushin Gobi Formation consists of sandstone, mudstone, siltstone, limestone and lignite. It is divided into 5 zones which are a lower non-coal-bearing zone, lower coal-bearing zone, central non-coal-bearing zone, upper coal-bearing zone and upper non-coal-bearing zone. The Lower coal-bearing zone is called as group I which is composed of 3 seams, Seams I, II and III. The Upper coal-bearing zone is called as group II which is composed of 5 coal seams, Seams IV-VIII. Coal is produced from Seams I and II. In some parts of the west area, Seam V of grope II is thickening.

### 2.2.2 Structure of Shivee Ovoo coal mine

Mongolia is located in extensively orogenic zone in the Asian continent where the basement is Precambrian or Paleozoic. Mongolia is influenced by the orogenic movements of Baikal, Caledonian and Hercynian. There are wide metamorphic belt and intrusive granite everywhere. In general the formation of Mongolia is showing a tendency to be young from the northern part to the southern part. The direction of geological structures is north-northwest in the western part, east to west in the central part, northeast in the eastern part, and convex to south in all over the area in general.

Shivee Ovoo coal deposit is located in southern part of Choir Niarga basin and shaped like an ellipse plate. Northern part of the coal deposit has advantage because the location is close to Ulaanbaatar and coal seams are thickening. This area is called as the Shine Us and is developed into Shivee Ovoo coal mine. The beds of strata strike north or northeast convex from north to east in the northern part and dip 6-10 degrees south in the eastern area. The deepest level of coal seams is about 300 m from the surface. As large faults are not found in this area, it seems that geological structure is stable comparatively. Thickness of interburden between Seam I and Seam II is 0.6-10.9 m with average of 3 m. Fig 2.2 and Fig 2.3 show geological cross section and geological columnar section respectively. The condition of coal distribution is shown by a structure contour map of Seam I(see Figure 2.4).

### 2.2.3 Hydrogeology

Topography of this area is flat and there are no mountains and forests, therefore, underground water is accumulated in layers instead of the surface. Soft sandstone, conglomerate, siltstone and coal seams are permeable layers, and those layers are between 15.3 to 260 m from the surface. As sandstone of the lower Cretaceous is high density, groundwater level of Shivee Ovoo coal mine is about 20 m from the surface. It has to be pulled out prior to mining, pumping up 3000-4000 $m^3$ per day from 10 boreholes. Sometimes the accumulated water has to be pumped up from a pit. It is necessary, therefore, to pull out groundwater continuously.

## 2.3 Coal reserves

### 2.3.1 Proved reserves by each coal seam

Shivee Ovoo coal mine produces coal from seam I and Seam II of group I.

(1) Seam I

In Shivee Ovoo coal mine, Seam I is the lower seam and thickness is 6.6-23.2 m with average thickness of 15.5 m. At the center of the basin, Seam I is likely to annex with Seam II or become thickening. At the outline of the eastern part, however, thickness of Seam I is likely to become thinner. Seam I splits and increases ash contents. Moisture content of Seam I is lower

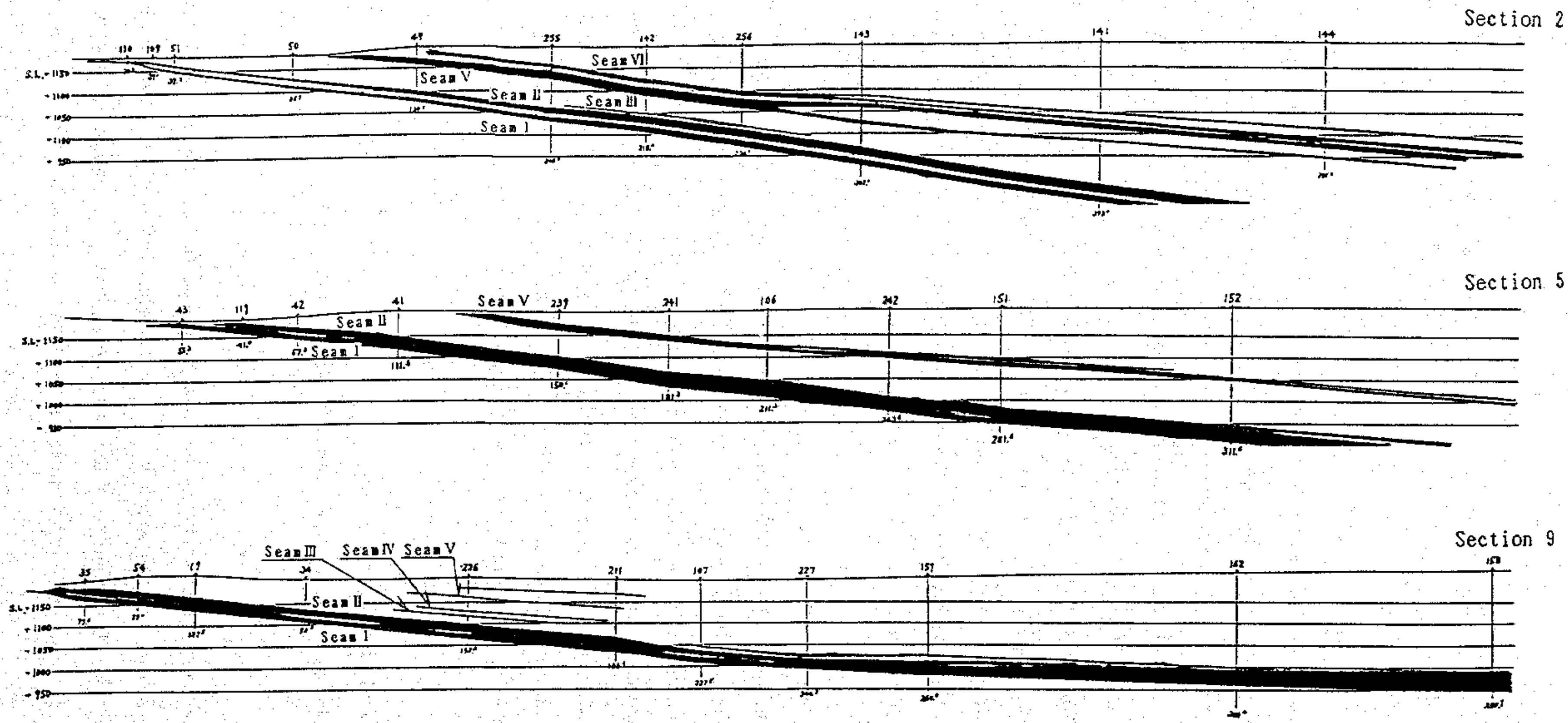



Figure 2.2 Geological Cross Section

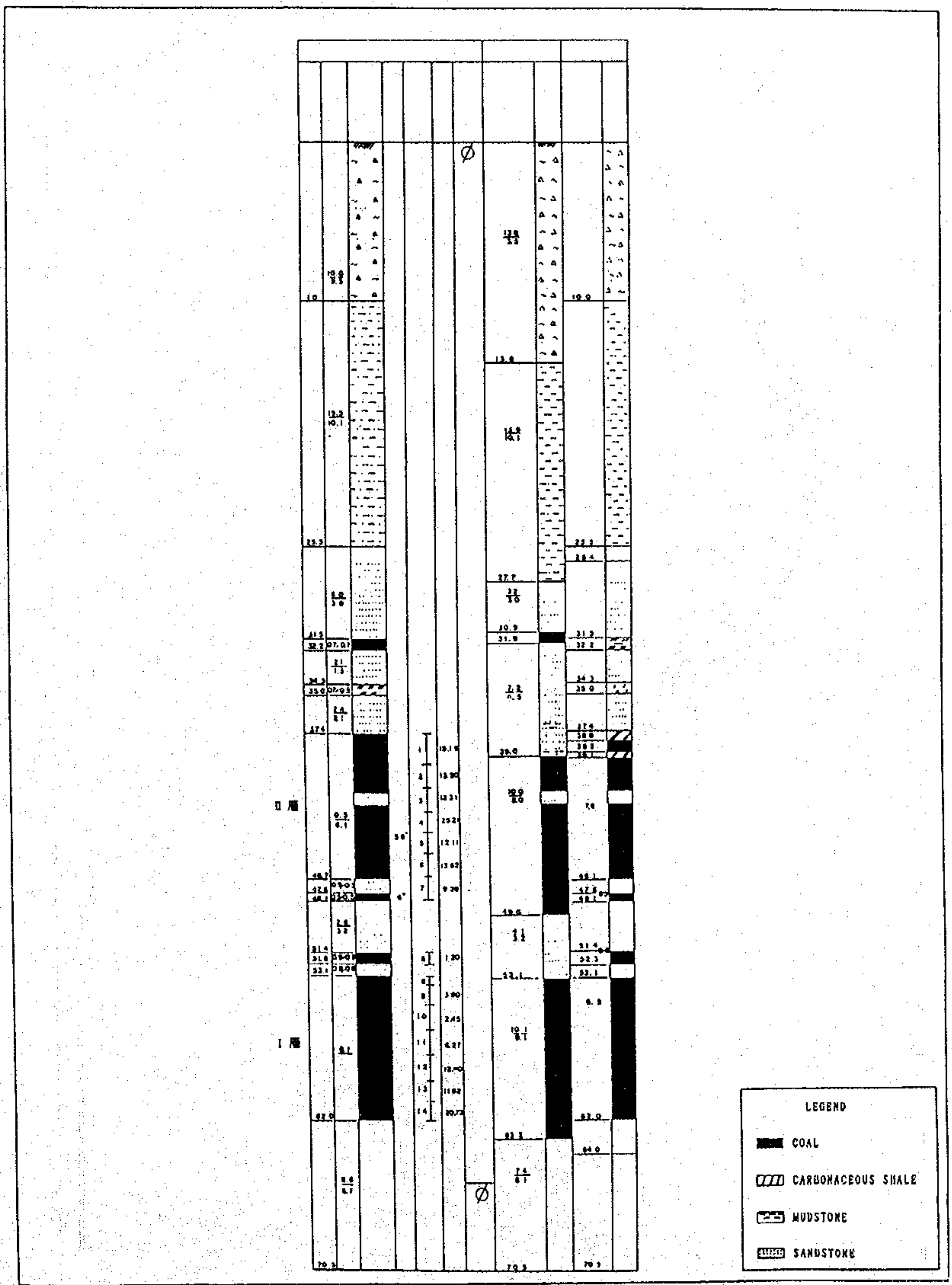



Figure 2.3 Geological Columnar Section

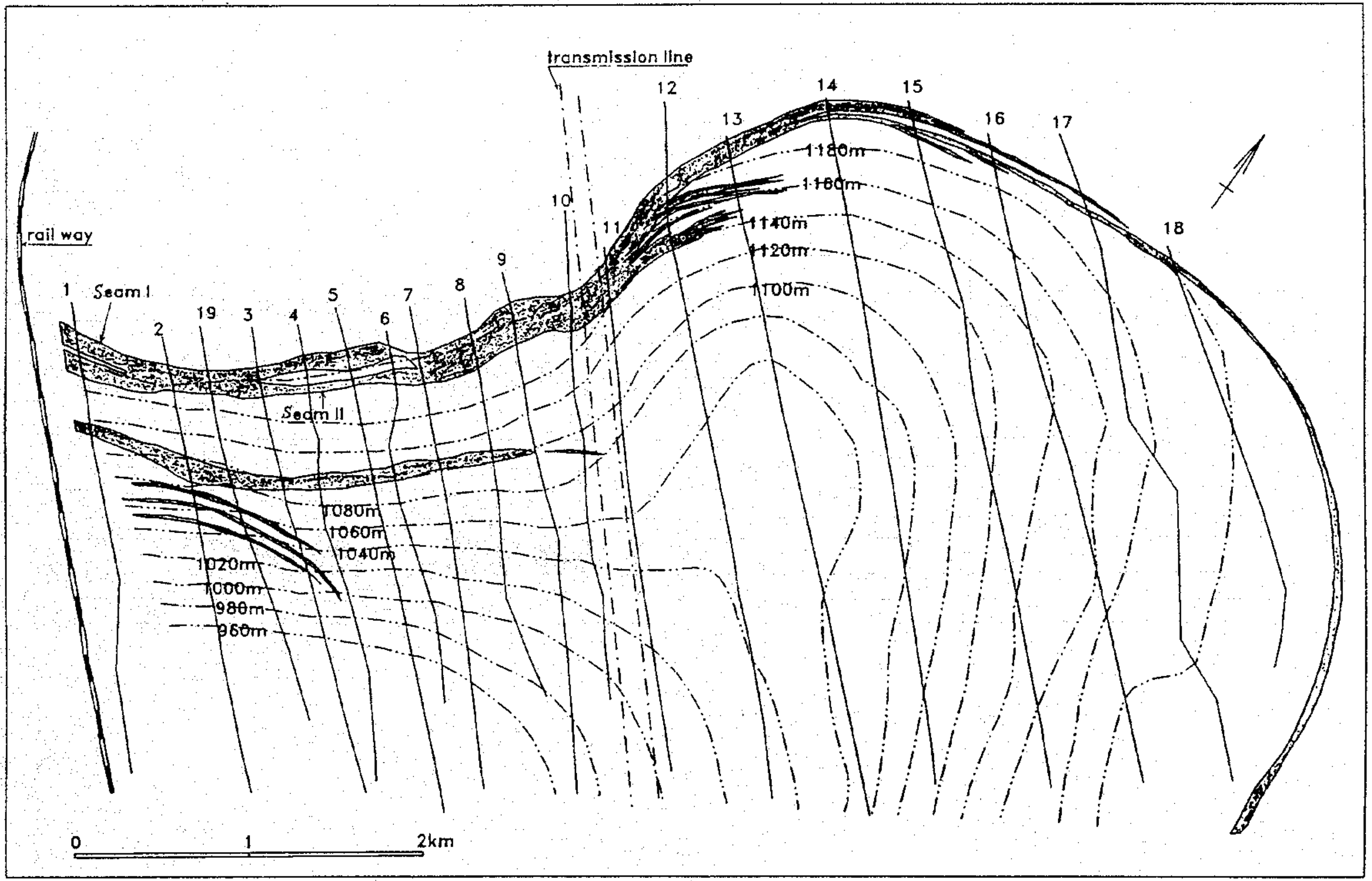



Figure 2.4 Seam Contour Map of Seam I

than Seam II, because interburden between Seam I and Seam II is a cap rock and prevents from water intrusion. Spontaneous combustion is found in the northern part.

(2) Seam II

Seam II is upper seam. Thickness of interburden between Seam I and Seam II is 0.6-10.9 m with average thickness of 3 m. Thickness of Seam II is 9.3-17.4 m with average thickness of 12.5 m. Seam II is likely to become thinner or split and increases ash contents like Seam I.

As Seam I and Seam II are likely to annex, coal reserves are calculated as total of Seam I and Seam II. Measured coal reserves are 550 million tons, including 66 million tons of coal reserves below 250 m from the surface.

(3) Seam V

Seam V is the main coal seam of group II and is showing a tendency to thicken in the southwestern part of this area. However, this seam becomes thin in the northeaster part. Therefore, production plan of coal includes only Seam I and Seam II without Seam V. It is recommended that Seam V should be mined because 45 million tons of coal reserves exist over Seam I and Seam II.

2.3.2 Minable coal reserves planned by Mongolia

The basis of minable coal reserves calculation of Shivee Ovoo coal mine is as follows:

- Shine-us area (See Fig 2.1)
- Seam I and Seam II(exclusive Seam V) (See Fig 2.3)
- Interbeds of coal seams are excluded from total coal seam thickness
- Oxidized coal reserves are excluded from coal reserves
- Calculate up to 250 m from the surface(S.L.960 m)
- Width of 150 m from a rail way is precluded from mining area.

| | |
|---|---|
| Measured coal reserves | : 484 million tons |
| Total overburdens volume | : 1,691 million BCM |
| Stripping | : 3.49 |

Coal is produced from Seam I and Seam II(Seam III in some part). Seam V distributes in the southwest part of the present mining area and quality of Seam V is similar of Seam I and Seam II.

As Seam V is unevenly and partially distributed, mining of Seam V has not been planned. However, it is recommended Seam V to be mined because the of coal reserves of seam V exists over Seam I and Seam II, if it is found. Reduction of stripping ratio can be expected if Seam V is mined. The measured coal reserves by block are shown in Table 2.1 and Fig 2.5 shows coal reserves calculation map.

Table 2.1 Calculation of Measured Coal Reserves

| Block No.* | Area flat ($m^2$) | Dip (° ) | Area slope ($m^2$) | Thickness (m) | specific gravity | reserves (t ) |
|---|---|---|---|---|---|---|
| 1 | 104,000 | 9 | 105,000 | 5 | 1.25 | 656,000 |
| 2 | 105,000 | 9 | 106,000 | 13 | 1.25 | 1,722,000 |
| 3 | 429,000 | 9 | 434,000 | 18 | 1.25 | 9,765,000 |
| 4 | 656,000 | 9 | 664,000 | 23 | 1.25 | 19,090,000 |
| 5 | 920,000 | 9 | 937,000 | 27 | 1.25 | 31,623,000 |
| 6 | 228,000 | 9 | 231,000 | 37 | 1.25 | 10,683,000 |
| 7 | 189,000 | 9 | 191,000 | 37 | 1.25 | 8,833,000 |
| 8 | 1,969,000 | 9 | 1,994,000 | 33 | 1.25 | 82,252,000 |
| 9 | 2,231,000 | 5 | 2,240,000 | 28 | 1.25 | 78,400,000 |
| 10 | 189,000 | 9 | 191,000 | 36 | 1.25 | 8,595,000 |
| 11 | 680,000 | 5 | 683,000 | 19 | 1.25 | 16,221,000 |
| 12 | 2,016,000 | 5 | 2,024,000 | 23 | 1.25 | 58,190,000 |
| 13 | 2,022,000 | 5 | 2,030,000 | 17 | 1.25 | 43,137,000 |
| 14 | 4,688,000 | 5 | 4,706,000 | 14 | 1.25 | 82,355,000 |
| 15 | 753,000 | 5 | 756,000 | 17 | 1.25 | 16,065,000 |
| 16 | 50,000 | 5 | 50,000 | 26 | 1.25 | 1,625,000 |
| 17 | 177,000 | 5 | 178,000 | 23 | 1.25 | 5,117,000 |
| 18 | 1,053,000 | 5 | 1,057,000 | 8 | 1.25 | 10,570,000 |
| Total | | | | | | 484,899,000 |

Note : See Fig 2.5

Coal reserves below 250m from the surface

| Block No.* | Area flat ($m^2$) | Dip (° ) | Area slope ($m^2$) | Thickness (m) | Specific gravity | Reserves (t) |
|---|---|---|---|---|---|---|
| 19 | 1,428,000 | 9 | 1,445,000 | 37 | 1.25 | 66,000,000 |

Note : See Fig 2.5

Coal reserves of Seam V

| Block No. | Area flat ($m^2$) | Dip (°) | Area slope ($m^2$) | Thickness (m) | Specific gravity | Reserves (t) |
|---|---|---|---|---|---|---|
| | 1,7898,000 | 9 | 1,820,000 | 20 | 1.25 | 45,000,000 |

2.4 Coal type and quality

Coal seams occur in the Cretaceous in this deposit. In general coal seams belonging to the Cretaceous is expected to be good quality like Bituminous coal. Shivee Ovoo coal is lignite because it seems to be low degree of coalification as the Cretaceous coal. The reason is that the layers of this area have not been buried deeply, and digenesis must have been made the in shallow depth. Therefore, coalification did not progress in the Cretaceous. Coal quality is shown in Table 2.2.

Table 2.2 Average Coal Quality of Main Seams in Shivee Ovoo Coal Mine

| Name of Coal Seam | Main Average Value | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Total Moisture | Inherent Moisture | Ash (dry basis) | Volatile Matter (dry ash free basis) | Total Sulfur (dry ash free basis) | Calorific Value *1 (dry ash free basis) | | Calorific Value *2 (with moisture, ash basis) | |
| | | | | | | Kcal/kg | MJ/kg | Kcal/kg | MJ/kg |
| I | 32.53 | 8.30 | 16.3 | 44.00 | 0.64 | 6,708 | 28.08 | 3,762 | 15.75 |
| II | 33.40 | 9.19 | 15.7 | 42.66 | 0.69 | 6,779 | 28.38 | 3,674 | 14.43 |
| V | 29.55 | 7.67 | 17.3 | 47.88 | 0.92 | 6,573 | 27.51 | 3,897 | 15.31 |
| Average | 31.83 | 8.39 | 16.4 | 44.66 | 0.75 | 6,687 | 27.99 | 3,776 | 15.81 |

Note *1; High Heating Value
*2; Low Heating Value

Quality of Shivee Ovoo coal is similar to quality of Baganuur coal excluding the oxidized coal near the surface. According to some examples taken from Shivee Ovoo coal mine, outcrop coal that passed long time on the open space shows very low moisture content and high calorific value. Therefore, if Shivee Ovoo coal is used after drying, calorific value should increase. Figure 2.6 shows the relationship of moisture and calorific value as ash free basis. Further study is necessary because of lack of sample. According to this graph it can be expected that calorific value should increase 1,400 kcal/kg, if moisture contents can be reduced from 38% to 22%.

Moisture contents of Shivee Ovoo coal are generally very high, especially Seam II shows over 40% of moisture that most of all is free moisture. Therefore, dewatering of ground water and drainage of suspended water in the mining area of the open pit must be completely implemented.

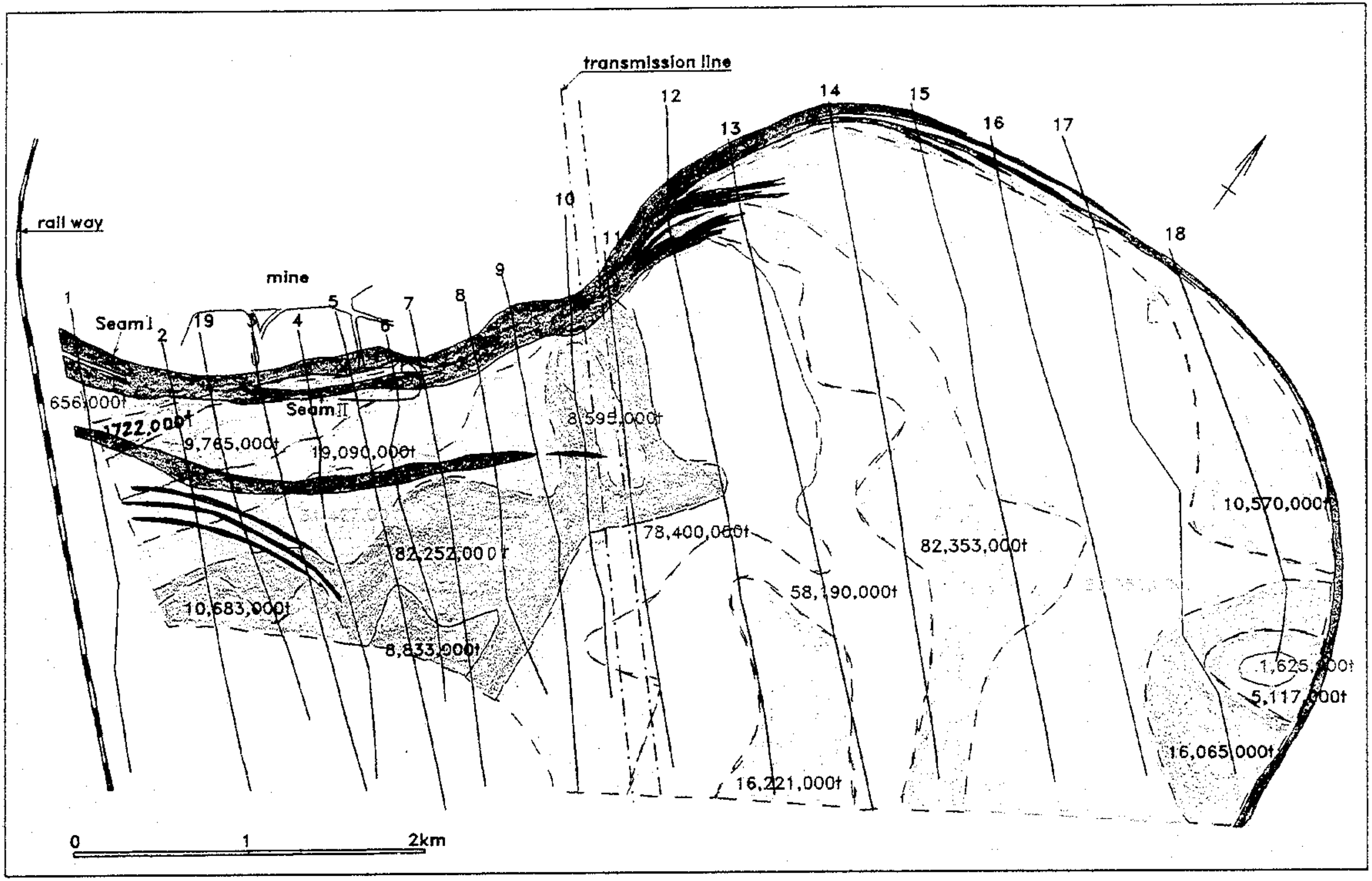



Figure 2.5 Coal Reserve Calculation Map of Shivee Ovoo coal mine

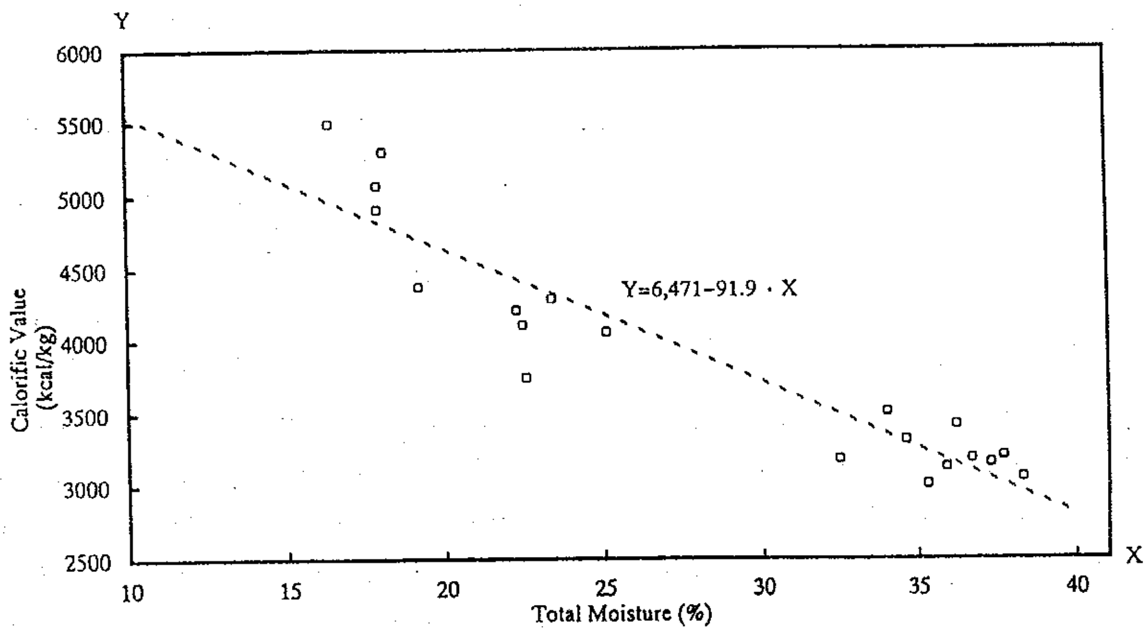



Figure 2.6 Relationship between Moisture and Calorific Value

The samples taken from Seams I and II one by one were analyzed by both methods, Mongolian method and Japanese Industrial Standard (JIS), as shown in Table 2.3. Table shows that the analysis result which was obtained by both methods is almost the same.

Table 2.3 Result of Coal Analysis by Mongolian Method and by JIS Respectively

| | | by Mongolia | | by JIS | |
|---|---|---|---|---|---|
| | | Seam I | SeamII | Seam I | Seam II |
| Total moisture | (as received) | 30.4 | 41.8 | 30.2 | 41.2 |
| | | | | 14.6 | 15.7 |
| Inherent moisture | | n,a | n,a | n,a | n,a |
| | | | | 17.5 | 20.8 |
| Ash | (as received) | 15.2 | 14.0 | 14.3 | 14.5 |
| | | | | 34.8 | 31.0 |
| Volatile matter | (dry ash free) | 46.0 | 47.9 | 51.3 | 48.8 |
| | | | | 33.1 | 32.5 |
| Fixed carbon | | n,a | n,a | n,a | n,a |
| | | | | 0.72 | 2.18 |
| Total sulfur*1 | (dry basis) | 0.87 | 2.27 | 0.84 | 2.59 |
| | | | | 4,610 | 4,260 |
| Calorific value*2 | (as received,LHV) | 3,377 | 2,596 | 3,451 | 2,627 |

Note : - The analysis result on upper lines of JIS part was analyzed under equilibrium moisture basis.
- The analysis result on lower lines of JIS part was calculated from the upper result.
*1 : Total sulfur content of Seam II is very high, because this sample was taken from high sulfur area.
*2 : Calorific value of Seam II is not so high, because this sample was taken from low calorific value area near surface.

Although net calorific value is adopted as the standard of coal quality in Mongolia, gross calorific value is adopted in Japan. In general gross calorific value shows 300-500 kcal/kg higher values compare with net value. Ash content does not show high value remarkably although interburden between Seam I and Seam II is mudstone or siltstone. The thickness of this interburden is 0.6-10.9 m with average thickness of 3.0 m. Due to the mining method with large-size mining machine, it is difficult to mine separately interburden less than 1 m. So if small-size mining machines are introduced additionally, selective mining method can be utilized to reduce ash content.

As Shivee Ovoo coal produced from near the surface where the coal is oxidized with calorific value of only 2,800 kcal/kg, claims for coal quality are often made by the power stations in Ulaanbaatar. Coal with 3,000 kcal/kg is expected at present mining area and when mining of coal progresses toward the deep area, coal over 3,700 kcal/kg could be expected without oxidized coal and interburden. However, first of all, management of Shivee Ovoo coal has to deal with the oxidized coal problems. The reasons why the oxidized coal should not be mined are obvious from the following coal quality required by power station:

Table 2.4 Typical Coal Quality Required by Power Station

| | | | |
|---|---|---|---|
| Moisture(as received basis) | under | 36 | % |
| Total sulfur(dry basis) | under | 1.5 | % |
| Calorific value(as received basis) | over | 3,000 | kcal/kg |
| Size | | 0-300 | mm |

Because a crushing and screening plant has not been installed at Shivee Ovoo coal mine, push dozing at the coal stockyard is carried out for crushing. But it is not sufficient for the users. Since size of coal affects power plants efficiency, it is recommended to install a crasher at the loading site. Although coal samples are only analyzed at Ulaanbaatar, it is necessary to carry out at mine site because management of Shivee Ovoo coal mine needs data of coal analysis for discussion of specifications with the users.

## 2.5 Study of mining area

### 2.5.1 Mining area designed by Mongolia

Shivee Ovoo coal basin shapes like an ellipse tray. Northern part of the coal basin has advantage because the location is close to Ulaanbaatar and coal seams become thickening. This area called Shine Us is developed into Shivee Ovoo Coal mine. There is a high power transmission line in the center of this area that becomes the eastern outline of the present mining area.

### 2.5.2 Recommended mining area for 2 million tons per year and design parameters

It seems that mining plan prepared by Mongolian is reasonable in view of the feature of Shivee Ovoo coal basin and expansion of coal production can be easily implemented. 480 million ton of coal reserves are confirmed in the Shine Us area and there are 150 million tons in the western side area of the transmission line. Shivee Ovoo coal mine produced 500,000 tons of coal from the present pit in 1993. It is possible to increase production capacity to 2 million tons of coal if another three pits similar to the present pit are developed or the pit is expanded four times the present size. The high power transmission lines prevent from expansion of pit to the eastern area. So if it is planned to increase production, it is necessary to remove this high power transmission line or open another pit on the other side of the transmission line. If expansion of coal production is required immediately, it is recommended that coal to be produced from the present pit instead of removing transmission line. It is possible to increase production immediately because the wide area and sufficient coal reserves are available. For a long term mine plan it is recommended that the transmission line to be relocated. If the transmission line remains as it is, a large amount of coal reserves can not be mined. Therefore, it is advantageous to relocate the transmission line because expansion to the eastern area must be considered.

# 3 Present Status of Shivee Ovoo Coal Mine

## 3.1 History of exploitation

### 3.1.1 History

Mining Institute of Ministry of Energy, Geology and Mining carried out a preliminary feasibility study on development of Shivee Ovoo coal mine in 1986. According to this preliminary feasibility study, a preliminary plan of mine development was to have a production capacity of 300,000 tons per year for the first three years and 500,000 tons per year thereafter. Since then, Mining Institute completed feasibility study in 1990. Production plan in this feasibility study is specified to be shown in Table 3.1.

Table 3.1 Production Plan

| | Coal | Overburden | S/R |
|---|---|---|---|
| 1992 | 300,000 t/y | 1,283,000 BCM | 4.27 |
| 1993 | 350,000 t/y | 1,096,500 BCM | 3.13 |
| 1994 | 400,000 t/y | 1,200,000 BCM | 3.00 |
| 1995 | 450,000 t/y | 1,260,000 BCM | 2.80 |
| 1996 | 500,000 t/y | 1,309,500 BCM | 2.62 |
| 1997 - 2000 | 2,000,000 t/y | 5,240,500 BCM | 2.62 |
| 2001 - 2003 | 1,500,000 t/y | 4,203,800 BCM | 2.80 |
| | | | Average 2.90 |

Development of Shivee Ovoo coal mine was commenced in 1991 in accordance with the feasibility study done by Mining Institute in 1991 and started production of coal in 1992. The actual production records were shown in Table 3.2.

Table 3.2 Actual Production

| | Coal | Overburden | S/R |
|---|---|---|---|
| 1992 | 140,000 t/y | 727,000 BCM | 5.2 |
| 1993 | 590,000 t/y | 1,100,000 BCM | 1.9 |

As the demand for Shivee Ovoo coal increased in 1993, Shivee Ovoo coal mine produced 590,000 tons per year utilizing available full production capacity of mining equipment. Mining

Institute completed the draft feasibility study for expansion of the production capacity to 1.5 million tons per year at Shivee Ovoo coal mine in November, 1993. The purpose of this draft feasibility study was to fulfill the expected increase in demand on coal in Mongolia to the year 2000. Plan of production expansion specified in this draft feasibility study is shown in Table 3.3

Table 3.3 Plan of Production Expansion

| | Coal | Overburden | S/R |
|---|---|---|---|
| 1994 - 95 | 800,000 t/y | 2,400,000 | 3.00 |
| 1996 - 97 | 1,000,000 t/y | 2,950,000 | 2.95 |
| 1998 - 99 | 1,500,000 t/y | 3,615,000 | 2.41 |
| 2000 | 1,500,000 t/y | 3,615,000 | 2.41 |
| | | Average | 2.70 |

3.1.2 Supply of coal

Coal produced at Shivee Ovoo coal mine was supplied to the power plant (No. 3 and No. 4) in Ulaanbaatar. Eighty percent of coal supplied to the power plant was in sizes of 0 and 300 mm , while 20 percent of coal was off-specification size, larger than 300 mm. Delivery of coal of 800,000 tons per year is to the power plant (No. 3 and No. 4) , town and village of the neighboring prefectures to Shivee Ovoo coal mine, the boiler at Choir City and Erdenet Copper mine. In case of production capacity of 1.5 million tons per year, the increased production will be mainly supplied to the No. 4 power plant because the transportation capacity of the railway to Ulaanbaatar has sufficient capacity. However, the coal stockyard and the train loading facility at the mine need to be expanded because the present capacity is considered to be designed for the capacity of 600,000 tons per year approximately.

Responsible officers at Ministry of Energy, Geology and Mining (MEGM) decides the demand of coal in Mongolia after consultation with the users of coal. Then, production volume of coal at each coal mine is decided on the basis of annual coal supply plan. In 1994, the demand and supply plan of coal in Mongolia is budgeted to be 7,185,000 tons per year and production of coal at Shivee Ovoo coal mine is decided to be 650,000 tons per year. Hereafter 1997 - 98, coal demand and supply plan has not been formulated by MEGM.

## 3.2 Present mining status

### 3.2.1 Present mining system and equipment

(1) Mining system

1) Geological and mining conditions

The Shine Us area, which was selected as a mining area, is located at North West of Shivee Ovoo coal deposit. As a result of detailed exploration program, it was found that 8 coal seams occur and the coal seams to be mined are Seams I,II and V seam. The dip of coal seam between cross section No. 2 and No. 9 varies from 4 to 10 degrees with average at 6 degrees. Interburden between I and II seam varies from 5 to 10 m. The present area for mining is width of 180 m, length of 1,400 m, pit depth of 48 m and overburden depth of 25 m. Present average seam thickness of I and II seam including parting is 11 and 12 m respectively. Thickness of interburden between I and II seam is about 5 m on average. Overburden consists of soft sandstone, hard sandstone, siltstone and argillite. Frozen depth of overburden reaches up to 3 m from the surface in the winter season. Frozen overburden and hard sand stone require blasting.

2) Outline of present mining operations

Shivee Ovoo coal mine, which was developed on the basis of feasibility study carried out by Mining Institute of Mongolia, is the small scale opencut coal mine. Mining method is a bench mining utilizing small Russian made rear dump trucks and electric rope shovels which carry out stripping of overburden, extraction of coal and transportation. The construction of Shivee Ovoo coal mine was commenced with the designed production capacity of 300,000 tons per year in 1991 and production commenced in 1992. Cycle of mining operations consists of dewatering of underground water, drilling and blasting (required only during winter), stripping of overburden, extraction of coal from II seam, removal of interburden, extraction of coal from Seam I and train loading without the process of crushing and screening of coal produced. Lumpy run of mine coals are crushed by a bucket of electric rope shovel EKG 5A before loading onto rear dump truck Belaz 548. Bulldozers also crush lumpy run of mine coal at the coal stockyard by push dozing. Electric rope shovel EKG 5A loads coal directly into wagons on the spur line of the railway for delivery to the power stations in Ulaanbaatar. In 1992, 140,000 tons of coal was produced with stripping of overburden of 727,000 BCM. In 1993, the actual production was 590,000 tons of coal and 1,100,000 BCM of overburden with stripping ratio of 1.9 although production budget was

500,000 tons of coal and 1,500,000 BCM of overburden with stripping ratio of 3.0. The present operating benches are three benches for stripping of overburden and two benches for extraction of the coal. Bench height for stripping of overburden is 10 m and bench height for extraction of coal is the same height as the coal seam. Bench height for removing interburden is the same height as interburden. Electric rope shovel EKG 5A with 5 $m^3$ bucket capacity loads overburden onto rear dump trucks Belaz 548 with 40 tons capacities which haul approximately 1.3 km to the waste stockpile. Also electric rope shovel EKG 5A with 5 $m^3$ bucket capacity loads coal onto rear dump trucks Belaz 548 with 40 tons capacity which haul 2.3 km to the coal stockyard. Prior to mining operations, underground water is dewatered from 10 dewatering wells with a submersible pump in the mining area of open pit. Main mining equipment consists of 2 electric drill rigs CbR 160 (one kept in the warehouse at present), 4 electric rope shovels EKG 5A with 5 $m^3$ bucket capacity and 15 rear dump trucks Belaz 548 with 40 tons capacity. The allocation of 4 electric rope shovels EKG 5A with 5 $m^3$ bucket capacity is 2 for stripping of overburden, 1 for extraction of coal and 1 for coal loading into the wagons of a unit train at the coal stockyard. Rear dump trucks Belaz 548 with 40 tons capacity hauls both overburden and coal. The majority of main mining equipment utilized at Shivee Ovoo coal mine are imported from Russia. Outline of the present mining operations is shown in Figure 3.1 and a cross section of the present open pit is shown in Figure 3.2

3) Basic parameters for mine design

Basic parameter for mine design is shown in Table 3.4.

Table 3.4 Basic Parameters

| | |
|---|---|
| Repose angle of overburden stockpile | 24 degrees |
| Slope angle of highwall | 70 degrees |
| Pit width | 195 m |
| Pit length | 1,400 m |
| Present bench level | 28 m from surface |
| Final bench level | 300 m from surface |
| Blasting block | 250 m/month |
| Gradient of access road | 6 degrees |
| Swell factor | 1.25 |
| Powder factor: Coal | 0.13 kg/t |
| Overburden | 0. 313 kg/BCM |
| Stripping ratio at final bench height of 250 m | 3.0 |
| Actual stripping ratio in 1993 | 1.65 |
| Density of coal | 1.25 |

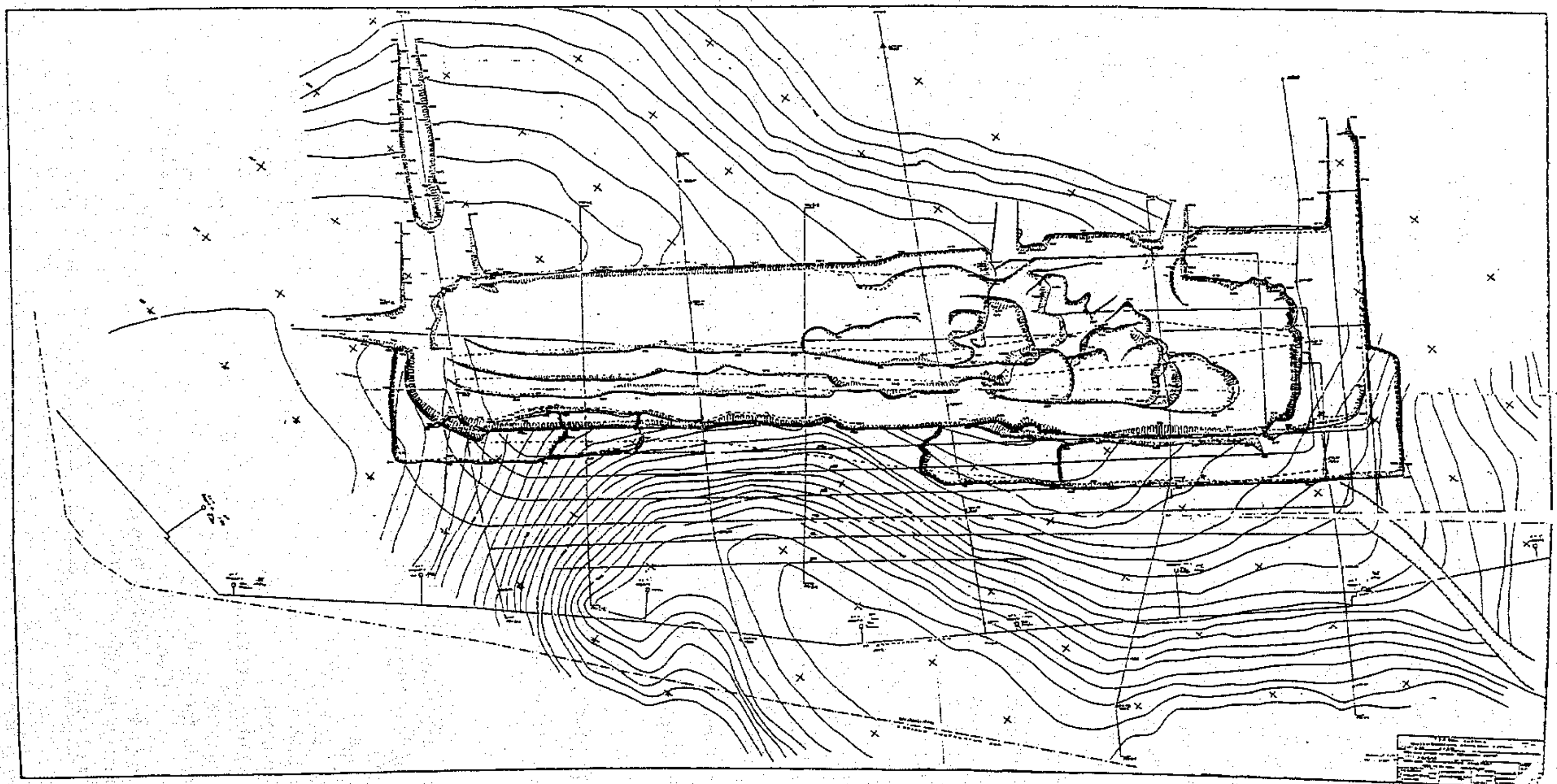


Figure 3.1 Outline of the Present Mining Operation

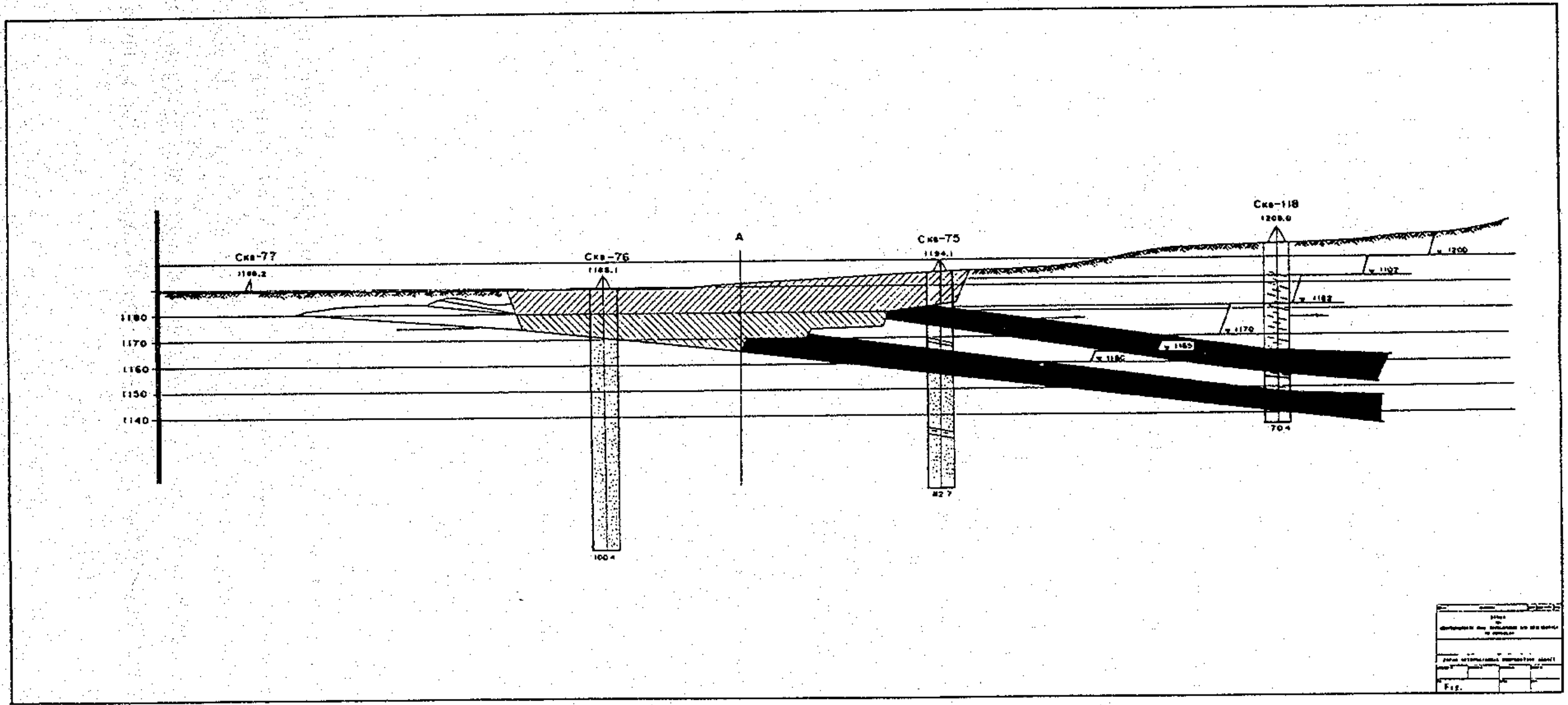



Figure 3.2 Cross Section of Open Pit

4) Annual working days

Plan in 1993

| | |
|---|---|
| Public holiday | 8 days |
| Stoppages due to bad weather | 20 days |
| Annual working days : 365 days - 28 days = | 337 days/year |

Actual in 1993

| | |
|---|---|
| Actual annual working days | 292 days |

5) Shift operating hours

Stripping of overburden and coal extraction are carried out by two shifts per day and shift operating time is as follows;

08:00 - 20:00
20:00 - 08:00

Effective shift operating hours are as follows;

| | |
|---|---|
| Scheduled hours = 12 hours | = 720 minutes |
| less preshift meeting | = 25 minutes |
| meal time | = 35 minutes |
| end shift meeting | = 15 minutes |
| Effective shift operating time | = 645 minutes |

6) Annual scheduled maintenance days

| | |
|---|---|
| Drill rigs | 50 days |
| Shovels | 51 days |
| Trucks | 58 days |

7) Annual scheduled working hours

| | |
|---|---|
| Drill rigs | n.a |
| Shovels | 5,400 hours |
| Trucks | 5,616 hours |

8) Dewatering

As the ground water level is high in the mining area of openpit, stripping of overburden and extraction of coal are carried out while ground water is dewatered from the dewatering wells with submersible pump. There are 12 dewatering wells; 10 wells for dewatering and 2 wells for monitoring the ground water level. Total dewatering capacity is 8,748 $m^3$/day which are pumped by pipe to the pond located at 5 km from the openpit. The location of dewatering pumps is shown in Figure 3.3.

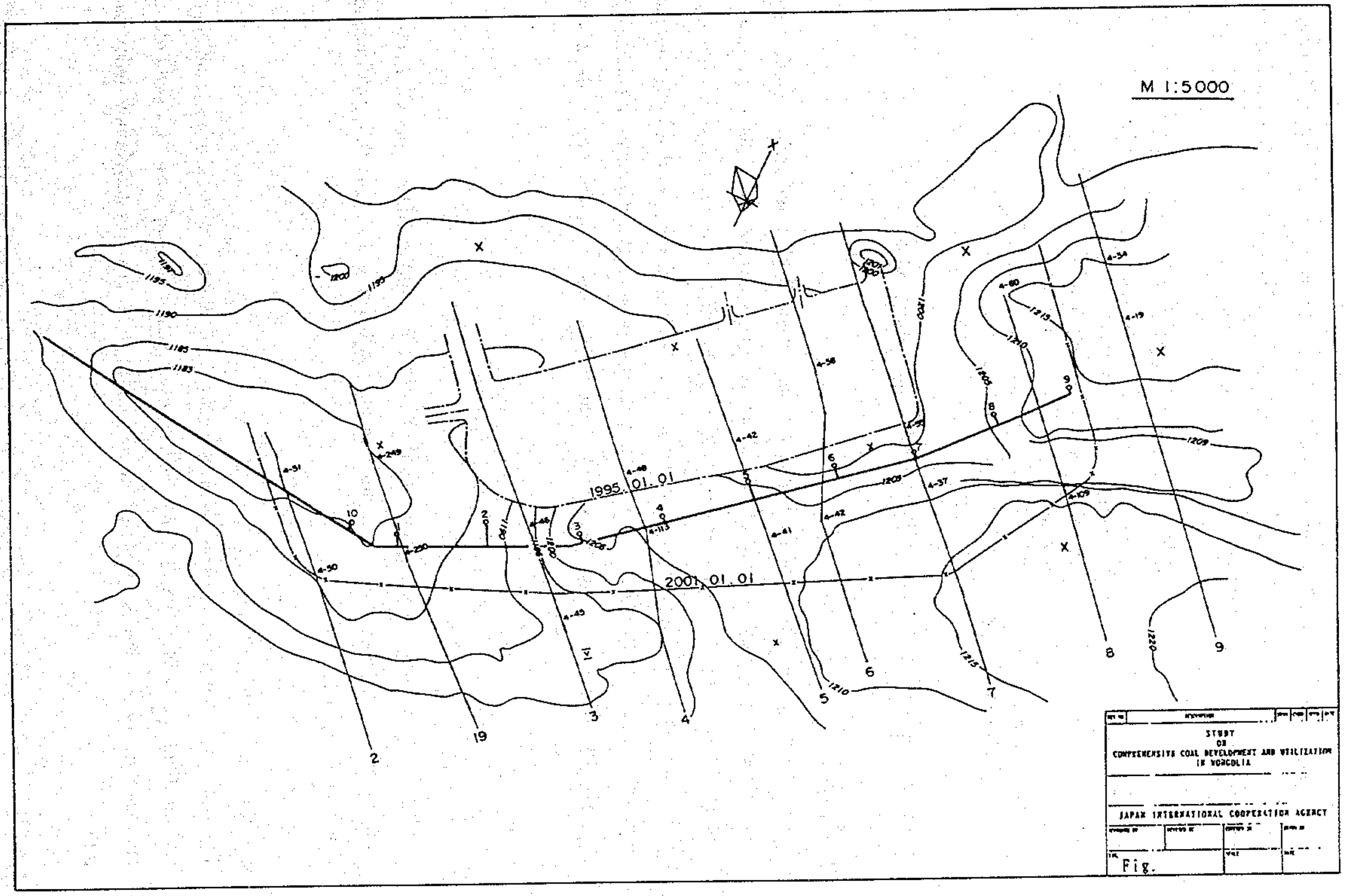



Figure 3.3 Location of Dewatering Wells

9) Drilling

Although there 2 Russian made electric drilling rigs, CbR 160, one drill rig is kept in the warehouse. The specifications of drill rigs are diameter of hole with 160 mm and penetration rate of 0.05 m/sec. Drilling is required only in the winter.

| | | | | | |
|---|---|---|---|---|---|
| Coal | : | drilling depth | : | 10.5 m |
| | | spacing | : | 6 m |
| Overburden | : | bench height | : | 10.5 m |
| | | drilling depth | : | 11.0 m |
| | | Spacing | : | 4 m |
| Overburden | : | 150 m/shift | | |
| Total Drilling length | : | 210 m/shift | | |
| | : | 100 m/shift | | |

Note: Drilling depth and spacing differ according the mining block.

10) Blasting

Explosives for openpit blasting are imported from Russia for blasting of overburden and coal. Explosives imported are three kinds of Ammoniate, Gramonit and Igdanit. Normally, ANFO 6Gb are directly loaded into dry holes but plastic tubes are used for the wet holes. ANFO is made by mixing Nitrogen fertilizer and oil. Mixing ratio is 5 - 10 % oil for normal usage and 20 -21 % oil for wet area to be blasted. It is planned to mechanize manufacturing of ANFO by the construction of an explosive factory. Blasting is required only in the winter

| | | | |
|---|---|---|---|
| Powder factor : | coal | : 0.13 | kg/ton |
| | overburden | : 0.313 | kg/BCM |

Explosive loaded for one blasting block varies from 1 ton (min) to 50 tons (max). In order to reduce shock waves, flying rocks and coal dusts in blasting, 0.02 and 0.04 millisecond delays are idealized.

11) Stripping of overburden

Bench height for stripping of overburden by electric rope shovel was decided by examining specifications of electric rope shovel and geotechnical characteristics of overburden. Hardness of overburden is classified in accordance with Prof. Protadykonov index as follows;

| | |
|---|---|
| Soft sandstone | 0.54 = 54 kg/cm$^2$ |
| Argillite | 0.59 |
| Siltstone | 0.63 |
| Hard sandstone | 0.6 - 1.27 |

For stripping of overburden, two Russian made electric rope shovels, EKG 5A with 5 m$^3$ bucket capacity are utilized for loading overburden onto rear dump truck Belaz 548 with 40 tons of capacity which hauls overburden to the waste stockpile located outside openpit. Hauling distance to the waste stockpile is 1.4 km approximately. Measured cycle time was 10 minutes approximately. 14 rear dump trucks, Belaz 548 with 40-ton-capacity are utilized for hauling both overburden and coal.

12) Extraction of coal

Similar to stripping of overburden, one Russian made electric rope shovel EKG 5A with 5 m$^3$ bucket capacity is utilized for loading coal onto a fleet of rear dump truck Belaz 548 with 40 tons of capacity which hauls coal to the coal stockyard. Hauling distance to the coal stockyard is 2.4 km approximately. Measured cycle time was 14 minutes approximately.

13) Coal stockyard

The coal stockyard is located at the area 2.4 km from the mining area of openpit. As there is no crushing and screening plant, run of mine coal is directly hauled to the coal stockyard by a fleet of rear dump truck Belaz 548 with 40 tons of capacity. Lumpy run of mine coal is crushed by a Bulldozer. Annual throughput of the coal stock yard is 600,000 tons per year approximately.

14) Crushing and screening plant

Crushing and Screening plants have not been installed.

15) Train loading

An Electric Rope Shovel EKG 5A with 5 m$^3$ bucket capacity loads coal directly into the wagons of a unit train which transports coal to the power plants in Ulaanbaatar. The location of surface facilities is shown in Figure 3.4.

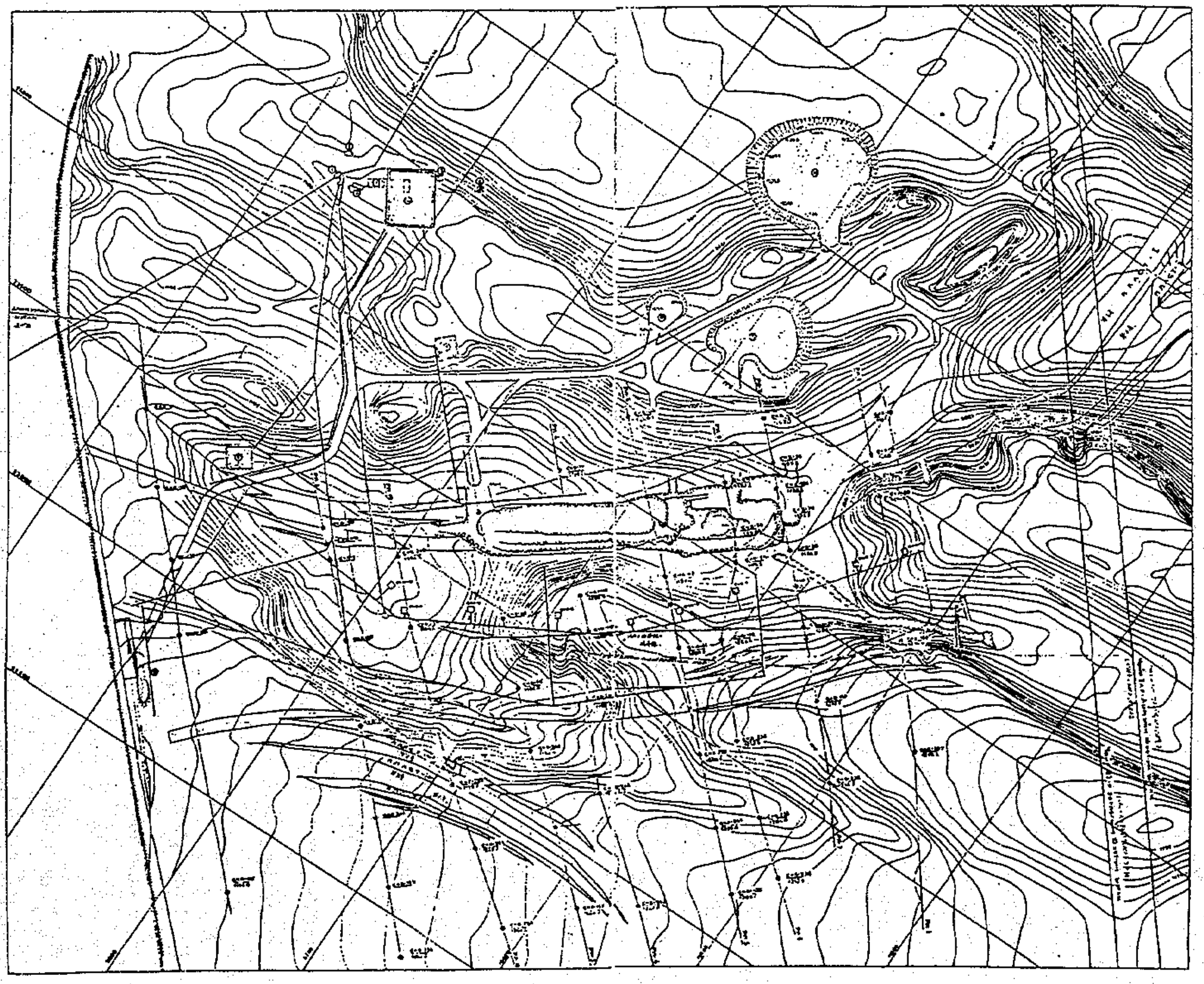


Figure 3.4 Location of Surface Facilities

(2) Mining equipment

Main mining equipment such as electric rope shovels and drills are electric equipment which uses the electrical energy produced from the domestic coal. The energy source of mobile equipment such as dump trucks, bulldozers, motor graders and other light vehicles are the imported fuel which requires foreign currency. Conventional truck & shovel operation is applied at the Shivee Ovoo coal mine. Main mining equipment and its purchased year are shown in Table 3.5.

Table 3.5 List of Major Machine

| | Type | unit | purchased year |
|---|---|---|---|
| Shovel | EKG 5A 5 $m^3$ | 4 | 1991 x 2, 1993, 1994 |
| Dump truck | Belaz 548 40 ton | 15 | 1990-1994 |
| | Kraz 250 | 2 | 1990 |
| Bulldozer | CAT D8N 289 HP | 2 | 1993 |
| | DET 250 250 HP | 2 | 1990, 1993 |
| | T171 160 HP | 1 | 1990 |
| Drill | CbR 160 | 2 | 1993 |
| Hydraulic shovel | EO 5111 | 1 | 1991 |
| Hydraulic backhoe | EO 4124 | 1 | 1991 |
| EFL | Case USA | 1 | 1992 |
| Grader | DE 122A | 1 | 1991 |
| Water truck | Belaz 540 | 1 | 1990 |
| | Kraz 256 | 2 | 1991 |

1) Drilling and blasting equipment for overburden

In winter season, overburden is frozen, so drilling and blasting are required. Interburden and coal are hard and blasting is necessary all the year round. There are two units of Russian drilling machine in Shivee Ovoo coal mine. Currently only one unit of the drilling machines is in operation. Two units have enough capacity for the production level of 1.5 million tons. The equipment was purchased in 1993.

Specifications of the drilling machine are shown in Table 3.6.

Table 3.6 Specification of Drill Machine

| Type | CbR 160 |
|---|---|
| Make | Russia |
| Hole diam | 160 mm |
| Drill inclination | 90, 75 degrees |
| Power source | Electric, 184 kW |
| penetration rate | 0.05 m/sec. |
| Rod | 4.2 m, spiral type |
| Dimension | L x W x H =7,080 x 3,420 x 12,925 |
| Weight | 24.9 ton |
| Dust collector | not equipped |
| Unit | 2 (1 is in operation) |
| Designed capacity | 150 m/shift |
| | 20,000 m/year approx. |
| Availability | 60% (Mongolian standard) |

ANFO truck has not been used for ANFO transportation and charging.

2) Excavator for overburden removal

Four units of 5 $m^3$ shovel are operated in Shivee Ovoo coal mine. Eight $m^3$ electric rope shovel and five $m^3$ electric rope shovel were compared in a feasibility study carried out by Mining Institute of Mongolia. From the economical and technical reasons, five $m^3$ electric rope shovel was selected. Specifications and allocation of the equipment are shown in Table 3.7.

Table 3.7 Specification of Electric Rope Shovel

| Type | | EKG 5A |
|---|---|---|
| Make | | Russia |
| Bucket capacity ($m^3$) | | 5 |
| Boom length (m) | | 11.4 |
| Boom angle (degree) | | 45 |
| Max.dumping height(m) | | 7.5 |
| Rated power(kW) | | 250 |
| cycle time(sec.) | | 25 |
| production capacity | | 1,440,000 $m^3$/year for rock |
| (with 40 ton rear dump trucks) | | 1,690,000 $m^3$/year for coal |
| unit | | 4 |
| Overburden | D/T loading | 2 |
| Coal | D/T loading | 1 |
| | Train loading | 1 |
| Purchased year | | 1991, 1991, 1993, 1994 |
| Availability | | 90%, 85%, 50% |

There are two small hydraulic shovels at Shivee Ovoo coal mine. EO-5111 is a power shovel and EO-4124 is a backhoe. These equipments are used for removal of interburden and partings.

3) Dump truck for overburden transportation

Fifteen units of rear dump trucks are in operation. Another 4 units were purchased in 1994. These rear dump trucks are used for transportation of overburden as well as coal. These trucks are still new, but the maintenance is still poor and availability is low. Specifications of rear dump truck are shown in Table 3.8.

Table 3.8 Specification of Rear Dump Truck

| Type | Belaz-548 |
|---|---|
| Make | Russia |
| Payload | 40 ton |
| Vessel capacity | 18 $m^3$ |
| Loading volume | 20.5 $m^3$ |
| Power | 500 HP |
| unit | 15 |
| cycle time | 24.3 min. |
| transport capacity | 303 $m^3$/shift/unit |

Another two units of Kraz-250 are used for the supplement works.

4) Drilling and blasting equipment for coal seam

One drill machine is drilling the blast holes for overburden and coal. Specifications drilling machine used for coal are the same as the drilling machine used for overburden. All coals are blasted. ANFO truck has not been introduced yet.

5) Excavator for coal winning

One unit of 5 $m^3$ electric shovel is operated for coal winning. Specifications of the shovel are the same as shovel for overburden removal. Scheduled figure of availability is 85% and operation days are 280 days per year.

6) Dump truck for coal transportation

Belaz 548 rear dump trucks are operated for coal transportation as well as overburden. Due to the limited size of the vessel, this rear dump trucks can transport only 25 tons of coal while the chassis is strong enough to transport 40 tons of materials.

7) Supporting equipment

Bulldozers, motor graders, water trucks and other service equipment are operating at Shivee Ovoo coal mine. Five units of bulldozer are operated. Main specifications of bulldozer are as follows:

| Type | D8N | DET 250 | T 171 |
|---|---|---|---|
| Make | Caterpillar | Russia | Russia |
| Power | 289 HP | 250 HP | 160 HP |
| Weight | 35 ton | 32 ton | |
| Unit | 2 | 2 | 1 |
| Purchased | 1993 | 1990, 1993 | 1990 |
| Availability | 90 % | 80 % | |

Equipment from the western countries require a winter grade oil, while Russian equipment do not require it. Generally speaking, Russian equipment shows a good performance under the cold weather conditions. One unit of motor grader is operated for the road maintenance. Specifications of motor grader are as follows:

| Type | DE-122A |
|---|---|
| Make | Russia |
| Power | 60 HP |
| Unit | 1 |
| Purchased | 1991.10 |
| Availability | 70 % |

(3) Design Capacity

Shivee Ovoo coal mine was developed from 1991 on the basis of feasibility study done by Mining Institute of Mongolia and commenced production in 1992. In this feasibility study, the capacity of production was to be 300,000 tons per year in 1992 and to be increased to 500,000 tons per year in 1996 with incremental annual expansion of 50,000 t/y. However, actual production was 140,000 tons per year in 1992 and 590,000 tons per year in 1993. Production budget in 1994 is 650,000 t/y. The capacity of production at Shivee Ovoo coal mine has been increased because the shortage of coal supply has been occurring due to the decreased coal production by other coal mines. Thus, one additional electric rope shovel EKG 5A with 5 $m^3$ bucket capacity was introduced in the first quarter in 1994 and four additional rear dump trucks Belaz 548 with 40-ton-capacity were introduced in August, 1994. Therefore, production capacity of Shivee Ovoo coal mine has exceeded design capacity specified in the feasibility study at present. The capacity of production utilizing the present mining equipment is evaluated in the Section 3.4 .

3.2.2 Surface Facilities

1) Workshop

Currently a workshop has been under construction and maintenance of equipment is carried out under the sky. The workshop under construction is designed for the production capacity of 0.5 million tons per year. Therefore, expansion of the workshop will be required for the production capacity of 2 million tons per annum. Lack of the skilled workers is one of the problems in the area of maintenance. It is necessary to bring up many skilled workers in order to carry out a proper maintenance for mining equipment. Establishment of the Training Center is one of the solutions to this problem.

2) Warehouse

A warehouse will be constructed soon. Currently mining equipment are still new, but availability is not high enough due to the poor maintenance conditions and operating life of mining equipment is considerably short. In order to support mining activities, the stock of proper level for spare parts is required.

3) Coal stock yard

Coal produced from the pit is transported to the train loading site. In order to reduce free moisture contents of coal, natural drying process has been utilized. Coal is turned over by bulldozers as well as electric rope shovels. Present stock capacity is 100 thousand tons. About two months are required for natural drying process. There is no permanent coal handling facilities at the mine site. Maximum stock pile height is restricted to 9 m.

4) Sizing and loading facilities

Coal mined from the pit is transported to the stockyard near the loading site. Lumpy coals are crushed and pushed by bulldozers. 5 $m^3$ electric rope shovel loads coal into the freight cars. One fleet of the freight cars to Ulaanbaatar is formed by 29 freight cars. Triple track-lines are installed at the siding and the length is long enough. But there is no permanent loading facilities and 23 freight cars are maximum loading capacity at one time. A small electric winch and diesel locomotive are used for the freight car operation. As a diesel locomotive does not belong to the mine, it has to be hired from the railway company and the rental fees are required. In case of the production capacity is more than 800,000 tons per year, it is better to purchase mine's own diesel locomotive. Actually there is a plan to purchase one unit of diesel locomotive in 1994. At the Choir station, the fleet is formed by 29 freight cars. In winter season, the freight cars are hauled to Ulaanbaatar 3 or 4 days after loading. Coal in freight cars is frozen due to low temperature and high moisture contents of coal. In order to satisfy requirements of the user, a crushing facility is required.

5) Electric supply

The electricity which is used at the mine site and Shivee Gobi city is supplied from the Central Energy System. The city of Choir is located at the north of the Shivee Ovoo coal mine, and there is a substation which is covering the district. The transformer of the Choir substation is 220/110/35 KV and distributes the electricity to Shivee Ovoo coal mine at the voltage of 35 KV. There is a transformer of 35/6 KV with 1,600 KVA at the mine site. In the original mining plan, required capacity of the mine transformer was 3,500 KVA, but it could not be introduced unfortunately. For 0.5 million tons of coal production per year, the capacity of 1,600 KVA is still enough. But it is necessary to install much bigger transformer for expansion of production. Electric rope shovels are operated at 6 KV. There are some units of 6/0.4 KV transformer and distribute the electricity to drilling machines, pumps and lighting plant at 400 V. The transmission line of 110 KV is crossing the mining concession, and the mining area is limited by this transmission line. There is a plan to relocate the transmission line to the outside of the mining area.

6) Communication

Total lines of telephone communication system are still limited. Only 12 lines are connected to the mine site. Internal telephone system has not introduced yet. Internal telephone with 200 lines is scheduled to be introduced in 1994. International telecommunication is available through Ulaanbaatar operator. Wireless communication system is also planned to be introduced in 1994 for mining operations.

7) Water supply

Shivee Ovoo City is located about 17 km from the mine site and there is a well near the Shivee Ovoo City. Potable water is transported from this well by 5.5-ton water truck. It ia also possible to transport potable from Choir City if required. Industrial water is transported by the water trucks. Industrial water is used for watering as well as fire fighting. There is a fire engine and used for fire fighting. Water trucks are also used for this purpose. There are some water plugs near the dewatering wells in the mining area. Supply system of hot water is operating at the city of Shivee Gobi. Water is sourced from the industrial water. Supply system of hot water for the mining complex is under construction. When the survey by JICA team were conducted, the supply system of hot water was out of order due to troubles of the control system.

8) Dewatering

The original underground water level is high and it is necessary to down the level for mining activities and quality control of coal produced. There are 12 wells in the vicinity to the mining area. 10 of them are used for dewatering and other two wells are used for monitoring the water level. The water from the dewatering wells are discharged at the outside of the mining area about 5 km from the pit. There is a lake made by this discharged water. Drainage capacity of the wells is about 8,700 $m^3$ per day. Submersible pumps started its operation from 1992. From May 1992 to November 1993, more than 3 million $m^3$ of the underground water were drained. There are some rainfalls from June until October. In order to prevent from the surface water flowing into the pit, the trenches were dug around the pit. In-pit waters are drained by the centrifugal pump type D-318. In the cold season, pipe line of the drainage system is faced to the freezing problem. The hot water can be sent into the pipe line and prevent the pipe line from freezing. Diesel generator DT-60 (75 KVA) can be operated in the event of the electricity failure, so that some pumps can be continued to be operated.

3.2.3 Current production data

(1) Current production data

The fiscal year in Mongolia is from the 1st January to 31st December. Responsible offices of each department prepare production budget of the next year at the beginning of December for discussion at the mine site and then the budget will be explained to Ministry of Energy, Geology and Mining for seeking approval.

1) Production in 1993

Production plan in 1993 was as follows;

| | | |
|---|---|---|
| Overburden | | 1,500,000 BCM |
| Coal | | 500,000 t |
| Stripping Ratio | | 3.0 |
| Hauling distance of overburden | | 1.8 km |
| Hauling distance of coal | | 2.4 km |
| Trucks | : Belaz 548 40 t | 13 |
| | Belaz 12 t | 2 |
| Shovel | : EKG 5A | 3 |

Actual results in 1993 were as follows;

| | |
|---|---|
| Overburden | 1,100,000 BCM |
| Coal | 590,000 t |
| Stripping ratio | 1.9 |
| Sold coal | 465,000 t |
| Hauling distance of overburden | 1.4 km |
| Hauling distance of coal | 2.3 km |

The prime reason for the reduced volume of overburden stripping was that four to five of thirteen trucks could not be utilized due to lack of spare parts. Three rear dump trucks Belaz 548 with 40-ton-capacity were delivered to the mine site in August although it was planned to be delivered to the mine site in the beginning of 1993. The cause for delayed stripping of overburden was due to this late delivery of rear dump trucks. Three new rear dump trucks were utilized for catching up stripping of overburden.

2) Production plan in 1994

Shivee Ovoo coal mine was requested to increase coal production to 1 million tons per year in August, 1993. However, coal production was decided to be 650,000 tons per year due to high total moisture contents and low calorific values of coal in the plan of demand and supply of coal in 1994. It was decided to introduce 10 additional rear dump trucks in August, 1993. The reason for increased coal production is that coal production at both Sharyngol and Baganuur coal mines have been decreasing, and Shivee Ovoo coal mine is planned to cover the reduced production of coal at both Sharyngol and Baganuur coal mines. Production parameters are as follows;

| | |
|---|---|
| Overburden | 2,360,000 BCM |
| Coal | 650,000 t |
| Stripping ratio | 3.6 |
| Sales of coal | 650,000 t |
| Hauling distance of overburden | 1.4 km |
| Hauling distance of coal | 2.3 km |
| Exposed coal in 1993 | 40,000 t |

Mining method are as follows;

| | |
|---|---|
| Overburden | 3 benches |
| Coal | 2 benches |
| Width of pit for overburden | 24 ms<br>advance to the south area by 32 ms |
| Pit for coal | advance along dip of coal seam and working bench will be 12 m lower than the present benches |
| Production capacity of shovel : | Coal 650,000 t<br>Overburden 2,250,000 BCM |

3) Comments on production

In 1992 and 1993, the oxidized coal near the surface was mined at very low stripping ratio of 1.9. In 1993, the actual total excavated volume of coal and overburden of 1.6 million BCM per year was less than the planned volume (1.9 m.BCM per year) due to delay of arrival of some additional equipment.

Table 3.9 Comparison of Coal and Overburden Excavation

| Year | Coal production (m.t) | | Overburden removal (m. BCM/y) | | Total excavation (m. BCM/y) | |
|---|---|---|---|---|---|---|
| | Planned | Actual | Planned | Actual | Planned | Actual |
| 1992 | 0.30 | 0.14 | n,a | 0.7 | n,a | 0.8 |
| 1993 | 0.50 | 0.59 | 1.5 | 1.1 | 1.9 | 1.6 |

4) Production cost

Summary of actual operating cost in percentage in 1993 was as follows;

Table 3.10 Summary of Production Cost in 1993

| | Percentage |
|---|---|
| Coal production (t) | 603,100 |
| Material's | 6.85 |
| Fuel, diesel, lubricants | 24.45 |
| Spare parts | 1.95 |
| Electricity | 4.37 |
| Boiler (heat) | 0.32 |
| Water | 0.03 |
| Funds for repair materials | 0.24 |
| Low cost and quick wearing stocks | 0.18 |
| Depreciation of LCQWS | 0.01 |
| Fire and security | 0.01 |
| Allowance for business trip | 0.03 |
| Drilling, newspaper, document and communication | 0.06 |
| Tax of land and resources usages | 6.43 |
| including health and transport tax | |
| Safety (work clothes and safety boots) | |
| Interest for short term loan | 1.34 |
| Other expenses | 0.22 |
| Depreciation of capital assets | 26.34 |
| Wages with production bonus | 26.65 |
| Social insurance | 0.54 |
| Price of sold coal (Tg/t) | 1,305.7 |
| Difference (Tg) | |
| Incomes (Tg) | 656,757,000 |
| Profit (loss) (Tg) | 178,845 |

### 3.2.4 Organization and manpower

(1) Organization

Organization, management, staff and workers of Shivee Ovoo coal mine at the time of May, 1994 are as follows;

- Director
  - Chief Engineer
    - General Mechanics — Maintenance manager
    - Operation Manager
    - General Electrician — Adjuster Engineer
    - Chief of mining section — Production Foremen
    - Mine's Surveyor
  - Chief Accountant
    - Deputy Accountant
    - Accountant
    - Economist
    - Accounting Officer
    - Store keeper
  - Personnel Officer
    - Training Officer
    - Chancellery
  - Deputy Director
    - Supply Engineer
    - Housing Section
    - Managerial Section

Fig 3.5 Organization Chart

(2) Manpower

| | |
|---|---|
| Director | 1 |
| Chief Engineer | 1 |
| General Mechanics | 1 |
| Maintenance Manager | 1 |
| Operation Manager | 1 |
| General Electrician | 1 |
| Adjuster Engineer | 1 |
| Chief of Mining Section | 1 |
| Production Foreman | 3 |
| Mine Surveyor | 1 |
| Assistant Mine Surveyor | 1 |
| Chief Accountant | 1 |
| Deputy accountant | 1 |
| Accountant | 2 |
| Economist | 2 |
| Accounting Officer and Store Keeper | 4 |
| Personnel Officer | 1 |
| Training officer | 1 |
| Chancellery | 1 |
| Deputy Director | 1 |
| Supply Engineer | 2 |
| Mechanical Section | 76 |
| Electrician | 10 |
| Mining Section | 81 |
| Supply | 25 |
| Housing Section | 9 |
| Managerial Section | 38 |

Problem areas identified in respect of organization and function at Shivee Ovoo coal mines are management of coal quality control, procurement of spare parts and maintenance of mining equipment.

Although problem areas on management of coal quality control are studied in the master plan, it is recommended that a new independent department should be created to co-ordinage production activities; dewatering schedule of underground water and pumping out surface water in the mining areas determination of mining area based upon exploration drill (zone of oxidize and fresh coal), selection of mining sequence, blending of raw coal the stockyard, natural drying of raw coal and delivery schedule.

Regular weekly meeting in necessary to advice production department coal quality supplied to the power plants in Ulanbaartar and corrective actions to be taken for satisfying specifications of coal quality stated in the contract.

The most important function of this department is to ensure that supply of coal is timely with constant coal quality specified in the contract. This objective can be eventuated by containment of total moistures in coal produced.Department head of coal quality control should directly report to the director of Shivee Ovoo coal mine.

For the problem areas on procurement of spare parts and maintenance management of mining equipment, a training center should be established to educate and train employees. A compute soft, which is capable of issuing of purchasing order automatically when stock of spare parts reduced to the pre-determined level, must be introduced. Preventative maintenance system, which is based upon conditions of mining equipment, is needed, replacing present method of operating hour based maintenance. The details will be described in a section of training center in the master plan.

### 3.3 Issues of present Shivee Ovoo coal mine

Surface moistures of coal mined since the commencement of production have been too high. In spite of this major problem it has been delivered to the users without control of total moistures due to;

- Delays of dewatering work, resulting in high groundwater level at the mining site
- Lack of the drying facility
- Lack of system on moisture management of coal and on-line monitoring equipment

Calorific value of coal has been too low against the specifications of sales contract due to;

- Mining of the oxidized coal near the surface because production of coal is easy (stripping ratio : 1.9).
- High inherent moistures in coal
- High surface moisture in coal

Equipment cannot be operated at high availability and maintenance works are difficult due to;

- lack of spare parts, workshop and maintenance specialists

Violent economic inflation decreased the present value of funds prepared for procurement of spare parts, resulting lack of spare parts.

### 3.3.1 Issues of mining system and equipment

(1) Issues of mining system

Production of coal was commenced without construction of workshop, warehouse, boiler, office and other facilities because demand of coal in Mongolia was projected to be increased in the early 1990s and those surface facilities are remained to be constructed although workshop and boiler are under construction at present. Therefore, effective maintenance of mining equipment is not possible and availability of rear dump truck Belaz 548 is poor at 58 % in 1993. Also, spare parts required for maintenance of mining equipment are always not available when it is required due to lack of fund.

The other major issue of Shivee Ovoo coal mine is a lack of technical knowledge on management of coal quality control system. The issue is explained as follows.

The oxidized zone of Seams I and II seam, which has been known to be poor coal quality, has been mined from the beginning of mine operation. Coal has been supplied to the power stations in Ulaanbaatar without proper drying process at the stockyard when demand of coal by the power plants exceeds the capacity of natural drying at the stockyard. The crushing and screening plant have not been installed. As the level of ground water is high in the mining area, the floor of coal mining bench becomes soft and it affects adversely loading coal by electric rope shovel EKG 5A with 5 $m^3$ bucket capacities and hauling of coal by rear dump truck Belaz 548 with 42-ton-capacity when dewatering ground water from dewatering wells was delayed. It was observed during our inspection of mining operation that shovel which was utilized to load coal was bogged down due to soft floor of the interburden because dewatering work was delayed. As the surface of haul road froze in the winter season, operator of rear dump trucks cannot operate safely due to slippery conditions. There are no major troubles on design of openpit mine, mining sequence, the location of haul road, selection of mining equipment, volume of overburden stripping, coal production, the location of internal and external waste stockpile in mining system. Although the power line in the Eastern edge and the railway in the Western edge exist in the mining area, mining operations will not be restricted in the near future. However, the relocation of both the power line and the railway is recommended in the early stage because it is possible to increase production capacity up to 4 million tons per year in the near future if it is required. The majority of mining equipment utilized now at Shivee Ovoo coal mine consists of a fleet of small Russian made equipment. Also, it is identified that Russian mining equipment requires longer annual scheduled maintenance than mining equipment designed and manufactured in the western countries.

The following problems of Shivee Ovoo coal mine have to be resolved for establishing production capacity of 2 million tons per year at Shivee Ovoo coal mine;

1) Dewatering

Production is adversely affected due to lack of the dewatering capacity. Although two wells are available for monitoring of the ground water, it requires to investigate the quality of water and volume of water to be dewatered.

2) Mine infrastructures

It is required to build a repair workshop and an office building in case of expansion of production to 2 million tons per year.

3) Working environment

Working environment for workforce has to be improved because proper workshop, warehouse, mine office, shower room, etc.are not been constructed yet.

4) Electricity

Three electric rope shovels EKG 5A operate at present. Once one electric rope shovel EKG 5A, which is now assembled at the mine site, commences operation, the shortage of power supply will occur due to limit of power supply to the mine site.

5) Train loading

Although the spur line of the railway is designed for loading coal into 29 wagons, it is possible to load only 23 wagons at present. Therefore, it is required to rearrange a unit train to have 29 wagons at the Choir railway station.

6) Road

It is required to seal the road between the City of Shivee Ovoo and Shivee Ovoo coal mine, and the roads in the mine site.

7) Professional engineer

It is required to educate, train, recruit professional engineers.

8) Communication

It is required to improve communication within the mine site, and between the mine site and Ulaanbaatar.

9) Data processing

Computer is required to carry out planning in the Control Section, processing data by the Accounting Department and sharing data at the mine site.

10) Repair workshop

The repair workshop which is under construction at present was designed for production capacity of 500,000 tons per year.

11) Power line and communication line

It is required to relocate the power line and communication line which are located in the mine site.

12) Dewatering equipment

As dewatering works are behind the schedule, it is difficult to establish production capacity of 2 million tons per year unless dewatering facilities are upgraded.

(2) Issues of mining equipment

Mining equipment is almost new, but the availability are not high enough due to the poor maintenance condition. Some equipment from the western countries are not so strong for cold weather, and it is necessary to pay attention for oil quality. Surface facilities such as workshop and warehouse are under construction. They must be completed as early as possible. Capacity of the electric supply system is not enough for mine expansion.

3.3.2 Issues of surface facilities

1) Workshop

New workshop for the production capacity of 500,000 tons is under construction. It is necessary to expand the workshop to meet with the mine expansion, and manpower training is also necessary.

2) Warehouse

Currently, equipment is still new and down time is not so long. So spare parts supply is not a serious problem so far. But it is clear that the equipment will getting older and maintenance will be required. Supply of spare parts must be smooth and warehouse with enough holding capacity is required. Bigger warehouse and computer system are necessary for mine expansion.

3) Coal stock yard

Coal handling facilities such as reclaimer or conveyer system have not yet introduced. So push dozing operation is applied for coal handling. Spontaneous combustion characteristics of coal must be seriously studied when construction of a coal stock yard is planned.

4) Sizing and loading

In order to satisfy requirement of the users, simple crushing facility is required. There is a plan to introduce a diesel locomotive in 1994 for the purpose of shifting the freight cars at the siding of the track. Integrated coal loading facility will be required.

5) Electric supply

The capacity of the mine site transformer is 35/6 KV, 1600 KVA while the designed capacity was 3500 KVA. The capacity is still enough for production of 0.5 million tons. Current electric consumption is about 1100-1200 KVA. Transmission line is crossing the mining concession area and it is necessary to relocate.

6) Communication

Number of the telephone lines are limited. Facsimile service has not been available at the mine site while it is available at the telephone office of Choir City. International telecommunication cable which connects Beijing and Moscow via Ulaanbaatar lays under the ground of mining concession.

7) Water supply

Water supply system is not facing a serious problem. But pipe lines are not installed and the waters are transported by water trucks.

8) Dewatering

Water drainage is very important for mining activities and control of coal quality. It is necessary to keep dewatering without any delay. The mining area will move into the deeper area and high head pumps will be required in the future.

### 3.3.3 Fund

With respect to the present mining equipment and facilities utilized at Shivee Ovoo coal mine, annual funds have been accumulated for replacement and major overhaul. Ratio of replacement and overhaul in annual funds is 60:40. However, those accumulated funds are not only sufficient to replace equipment because of the recent high inflation but also are withdrawn for purchase of spare parts. As matter of fact, those accumulated funds in the past were all expended at present. Therefore, additional capital are required for replacement and overhaul of mining equipment.

### 3.4 Evaluation of production capacity of existing coal mine

#### 3.4.1 Time study

Time study was carried out on 29th November, 1993 to find cycle time of loading and hauling of overburden and coal. Purpose of time study was to get real operating data which are required to project real production capacity of Shivee Ovoo coal mine. Collected data are summarized as follow;

(1) Overburden - shovel (loading)

| | | |
|---|---|---|
| Shovel | : | EKG 5A |
| Rear dump truck | : | Belaz 548 (40 t) |
| Cycle time | : | 2 minutes 13 seconds |

(2) Overburden - truck (hauling)

| | | |
|---|---|---|
| Hauling distance | : | 1.2 - 1.4 km |
| Rear dump truck | : | Belaz 548 (40 t) |
| Cycle time | : | 9 minutes 48 seconds |

(3) Coal - shovel (loading)

| | | |
|---|---|---|
| Shovel | : | EKG 5A |
| Rear dump truck | : | Belaz 548 (40 t) |
| Cycle time | : | 2 minutes 49 seconds |

(4) Coal - truck (hauling)

| | | |
|---|---|---|
| Hauling distance | : | 2 - 2.4 km |
| Rear dump truck | : | Belaz 548 (40 t) |
| Cycle time | : | 14 minutes 19 seconds |

#### 3.4.2 Evaluation of production capacity

Real production capacity of Shivee Ovoo coal mine on stripping of overburden and extraction of coal was estimated utilizing report of Utilization on mining equipment in 1993.

| | |
|---|---|
| Rear dump truck (Belaz 548) | 58% |
| Electric rope shovel (EKG 5A) | 85% |

As time study for truck and shovel operation was carried out during the inspection of mine site in 1993, the results of time study were reflected in calculation of real production capacity. The calculation of the true production capacity is based on volume of overburden stripping, coal production, hauling distance of overburden and coal which are shown in production budget for 1994 as well as a draft feasibility study done by Mining Institute. The results of the calculation are shown on Table 3.11.

From the results above, true production capacity with existing mining equipment at Shivee Ovoo coal mine is coal production of 822,000 tons and overburden stripping of 2,551,000 BCM with stripping ratio at 3.10. It has been claimed that production capacity is 800,000 tons of coal and 2,500,000 BCM of overburden with stripping ratio at 3.13. Therefore, this true production capacity is utilized as a base for production expansion to 2 million tons per year at Shivee Ovoo coal mine.

Table 3.11 Real Production Capacity of Shivee Ovoo Coal Mine

| | Fleet 1 | | Fleet 2 | Fleet 3 | |
|---|---|---|---|---|---|
| | Coal | O/B | O/B | O/B | Total |
| Haul distance(km) | 2.3 | 1.4 | 1.4 | 1.4 | |
| | | | | | |
| Assigned ave. speed | | | | | |
| Loaded (km/hour) | 18 | 18 | 18 | 18 | |
| Empty (km/hour) | 18 | 18 | 18 | 18 | |
| | | | | | |
| Total travel | | | | | |
| - time round trip (min) | 15.3 | 9.3 | 9.3 | 9.3 | |
| Fixed time/truck trip | | | | | |
| Spot at loader (min) | 1.0 | 1.0 | 1.0 | 1.0 | |
| Loading (min) | 2.6 | 2.6 | 2.6 | 2.6 | |
| Turn and dump (min) | 1.0 | 1.0 | 1.0 | 1.0 | |
| Subtotal fixed time (min) | 4.6 | 4.6 | 4.6 | 4.6 | |
| Total cycle time (min) | 19.9 | 13.9 | 13.9 | 13.9 | |
| Max truck/loader | 4 | 3 | 3 | 3 | |
| Fleet size per loader | 7 | 5 | 5 | 5 | |
| 58% fleet availability | | | | | |
| | | | | | |
| BCM/trip (BCM) | 20.6 | 20.6 | 20.6 | 20.6 | |
| Operating hour/shift (min) | 645 | 645 | 645 | 645 | |
| No. of trip/shift | 31 | 45 | 45 | 45 | |
| BCM/shift/truck | 639 | 927 | 927 | 927 | |
| BCM/shift/fleet | 2,554 | 2,781 | 2,781 | 2,781 | |
| | | | | | |
| EKG 5A | | | | | |
| Availability | 85 | 85 | 85 | 85 | |
| Utilization | 83 | 83 | 83 | 83 | |
| Assigned BCM/shift/day | 1,802 | 1,962 | 1,962 | 1,962 | |
| | | | | | |
| Scheduled shifts/day | 2 | 2 | 2 | 2 | |
| Scheduled days/year | 190 | 90 | 280 | 280 | |
| BCM/year/fleet (x 1,000) | 685 | 353 | 1,099 | 1,099 | 3,235 |
| Ton/Year (x 1,000) | | | | | 822 |
| BCM/year(x 1,000) | | | | | 2,551 |
| | | | | | |
| Stripping Ratio | | | | | 3.10 |

Analyses of operation data show that the operating efficiency of electric rope shovel is higher than that of the modern type, while that of rear dump truck is a little low due to frequent mechanical troubles.

Table 3.12 Efficiency of Mining Equipment

%, as of 1992

| Equipment | Existing equipment | | | Desired Efficiency |
|---|---|---|---|---|
| | Availability | Utilization | Efficiency | |
| Electric shovel | n,a | n,a | 85 | 72 |
| Dump truck | n,a | n,a | 58 | 68 |

Note : Efficiency of the existing equipment is very high due to new equipment and the flexible mining system.

Analysis results show that the production capacity of existing mining equipment is about 3.2 m.BCM/y as of the end of 1993, providing to resolve the above mentioned maintenance issues.

Table 3.13 Capacity of Existing Coal Mine

million BCM per year, as of 1993

| | Planned value | Current/actual | Improved/estimated |
|---|---|---|---|
| Shovel/truck | 1.9 | 1.6* | 3.2 |
| (Coal) | (0.41) | (0.49) | (0.9-0.6) |
| (Overburden) | (1.5) | (1.1) | (2.3-2.6) |

Note : Some new additional equipment were not delivered in time.

Improved coal production capacity is varied by the required stripping ratio.
In case of the present miming location near coal outcrop, it is about 1.2 million tons per year with the stripping ratio at 1.9, while it is 0.8 million tons per year with the average stripping ratio of Shivee Ovoo coal mine at 3.5. To improve the low calorific value as soon as possible, a new pit toward fresh coal zone must be developed, and therefore, the estimated capacity of existing equipment is assumed to be about 0.8 million tons per year.

To achieve above-mentioned improvement, 1.5 million US$ per year of the foreign currency is required for procurement of spare parts and maintenance machines.

# 4 Renovation Study of Shivee Ovoo Coal Mine

## 4.1 Study of effective mining system

### 4.1.1 Targets of renovation

As other coal mines in the CES region have been decreasing the production capabilities year by year, there is a possibility of the shortage on supply of coal to the power plants in Ulaanbaatar unless production capacity of Shivee Ovoo coal mine increases to 2 million tons per year within the next 3 years.

On the basis of this circumstance in Mongolia, the target of renovation on Shivee Ovoo coal mine is to expand the production capacity to 2 million tons per year from the present production capacity of 500,000 tons per year. Three options for new mining system were investigated to increase production capacity of Shivee Ovoo coal mine to 2 million tons per year based on the present mine system. Options are additional introduction of the same type of the existing mining equipment, introduction of new medium size trucks and Front End Loader, and introduction of a two small size or a medium size dragline. Best option will be selected for recommendation after processing data of mine planning on overburden stripping and coal production, selection of mining equipment, allocation of mining equipment, replacement plan, manpower, estimation of capital and operating cost, etc. by economic evaluation model.

### 4.1.2 Study of effective mining system

(1) Options for additional mining system

Prior to JICA study, Mining Institute of Mongolia has provided the draft feasibility study report to increase the capacity to 1.5 million tons per year. After review and examination of the design philosophy and data used in the report, it was recognized that all technical data such as the basic plan of open pit, design parameters, stripping volume of overburden, minable coal reserves, stripping ratio, mining sequence, the location of haul road, internal and external waste stockpile are properly studied. Therefore, data and information described in this draft feasibility study were fully utilized in feasibility study of JICA Study Team.

For conducting the feasibility study by JICA Study Team, a preliminary production plan was established to increase production capacity of Shivee Ovoo coal mine to 2 million tons per year from 1995. Summary of yearly volume of overburden stripping and coal production from

Seam I and Seam II together with stripping ratio are shown in Table 4.1.

Table 4.1 Summary of Production Plan

| | Coal | Overburden | Stripping Ratio |
|---|---|---|---|
| 1994 | 650 | 1,932 | 3.0 |
| 1995 | 2,000 | 5,739 | 2.9 |
| 1996 | 2,000 | 5,338 | 2.7 |
| 1997 | 2,000 | 4,990 | 2.5 |

The following four options based on the production plan above are investigated for expansion of production capacity to 2 million tons per year.

Case 1 Additional introduction of the present mining equipment

Case 2 Introduction of new medium size trucks and front end loaders

Case 3 Introduction of a new medium size dragline

Case 4 Introduction of two new small size draglines

1) Case 1

In addition to the present mining equipment utilized at Shivee Ovoo coal mine, required additional number of Electric Rope Shovel EKG 5A, Rear Dump Truck Belaz 548 with 40-ton-capacity and auxiliary equipment are to be calculated for expansion of production capacity to 2 million tons per year. Conceptual mining method is shown in Figure 4.1.

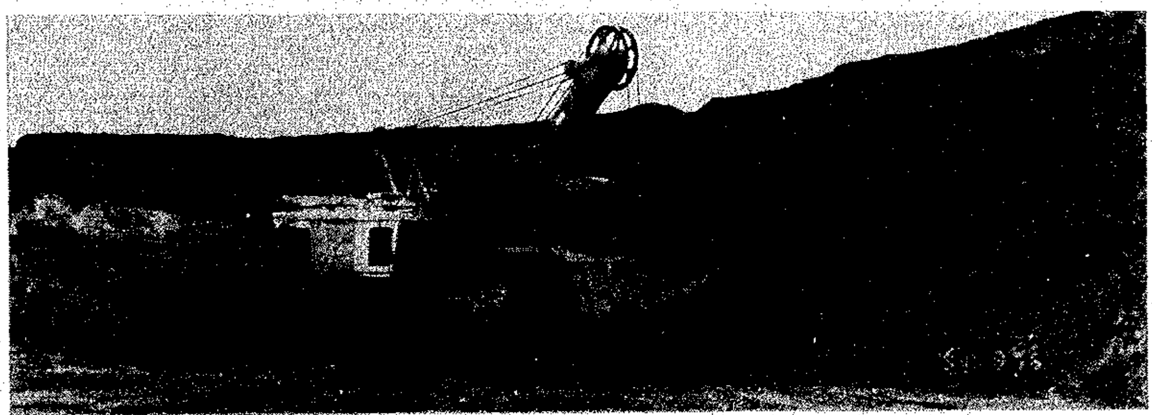


Figure 4.1 Case 1 - Conceptual Mining Method

2) Case 2

Mining method is the same as Case 1 of additional introduction of the present mining equipment. However, required number of new medium size Front End Loader with bucket size of 10 $m^3$, new medium size rear dump truck with hauling capacity of 50 $m^3$ and auxiliary equipment are to be calculated for expansion of production capacity to 2 million tons per year. Conceptual mining method is shown in Figure 4.2.

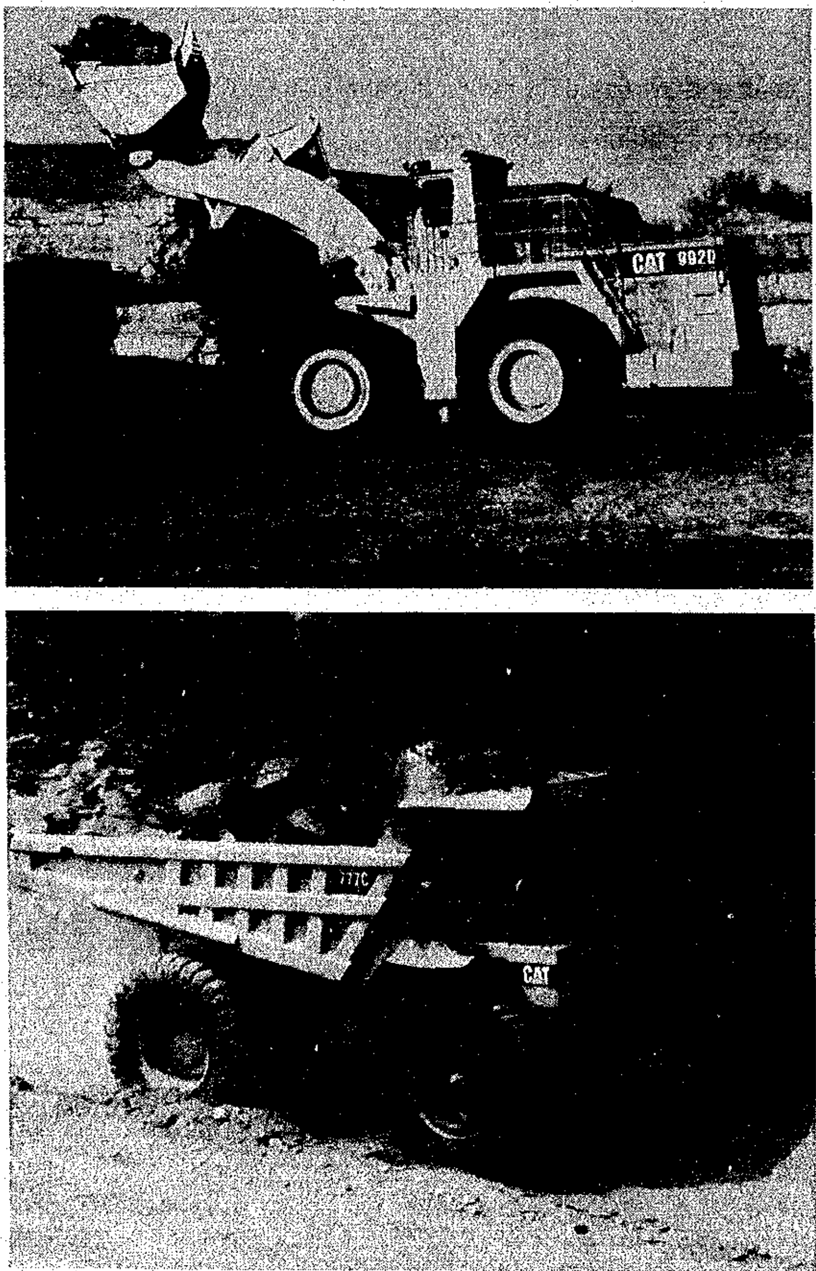



Figure 4.2 Case 2 - Conceptual Mining Method

3) Case 3

Although the existing electric rope shovel EKG 5A and rear dump truck Belaz 548 with 40-ton capacities will be utilized for removal of interburden and coal, investigation is carried out for introduction of a medium size dragline with bucket capacity of 29 $m^3$ for stripping of overburden. Conceptual mining method is shown in Figure 4.3.

Figure 4.3 Case 3 - Conceptual Mining Method

4) Case 4

This is a similar to Case 3, but introduction of two small size dragline with bucket capacity of 20 $m^3$.

(2) Operating parameters

The following operating parameters are applied for projection of production capacity on three options mentioned above.

1) Annual possible working days

| | |
|---|---|
| Annual calendar days | 365 days |
| Public holiday | 8 days |
| Bad weather | 20 days |
| Annual working days | 337 days |

2) Shift hours

| | |
|---|---|
| Overburden | 12 hours/shift x 2 shifts/day |
| Coal | 12 hours/shift x 2 shifts/day |

| | |
|---|---|
| Drill rigs | 7 days/week |
| Shovels | |
| - Overburden | 7 days/week |
| - Coal | 7 days/week |
| Front End Loader | 7 days/week |
| Trucks | |
| - Overburden | 7 days/week |
| - Coal | 7 days/week |
| Dragline | 6 days/week |

3) Annual scheduled maintenance days

| | |
|---|---|
| Drill Rigs | 50 days |
| Shovels | 51 days |
| Front End Loader | 51 days |
| Trucks | 58 days |
| Dragline (Modern) | 50 days |

Please note that annual scheduled maintenance days are required for mining equipment made in Russia.

4) Annual possible working hours

Scheduled working minutes/shift = 720 min - 75 min/shift
= 645 min

Drill Rigs (337 days - 50 days) x 645 min/shift x 2 shifts/day
= 370,230 min
= 6,170.5 hours

Shovels /Front End Loader (337 days - 51 days) x 645 min/shift x 2 shifts/day
= 368,940 min
= 6,149 hours

Trucks (337 days - 58 days) x 645 min/shift x 2 shifts/day
= 359,910 min
= 5,998.5 hours

Dragline (337 days - 50 days) x 645 min/shift x 2 shifts/day
=370,230 min
=6,170.5 hour

5) Utilization of mining equipment

Utilization of mining equipment is assumed to be as follows;

| | |
|---|---|
| Drill rigs | 85% |
| Shovels | 85% |
| Front End Loader | 85% |
| Trucks (Russian) | 58% |

| | |
|---|---|
| (Modern) | 75% |
| Dragline | 85% |

6) Annual operating hours

| | |
|---|---|
| Drill Rigs | 6,170.50 hours x 0.85 = 5,244.93 hours |
| Shovels | 6,149,00 hours x 0.85 = 5,226.65 hours |
| Front End Loader | 5,998.50 hours x 0.85 = 5,098.73 hours |
| Trucks (Russian) | 5,998.50 hours x 0.58 = 3,479.13 hours |
| (Modern) | 5,998.50 hours x 0.75 = 4,498.88 hours |
| Dragline (Modern) | 6,170.50 hours x 0.85 = 5,244.93 hours |

7) Mining parameters

Mining parameters described in Sections 3.2.1 and 3.2.3 are utilized for mine planning.

(3) Calculation of required number of mining equipment

True production capacity of the present mining equipment was calculated in evaluation of production capacity in the Section 3.4.2. Required number of additional equipment and new equipment for expansion of production capacity to 2 million tons per year on each option are calculated based on the results of above parameters and are shown in Table 4.2 for Case 1, Table 4.3 for Case 2, and Tables 4.4 and 4.5 for Case 3.

## Table 4.2 Case 1 - Production Capacity by Additional Russian Equipment

Production Capacity (2 million tones)
EKG-5A & Belaz 548

| | | [Fleet A] Coal | [Fleet B] Coal | Overburden | [Fleet C] Overburden | [Fleet D] Overburden | [Fleet E] Overburden | [Fleet F] Overburden | [Fleet G] Overburden | Total |
|---|---|---|---|---|---|---|---|---|---|---|
| Haul Distance | km | 2.3 | 2.3 | 1.4 | 1.4 | 1.4 | 1.4 | 1.4 | 1.4 | |
| Assigned Ave. Speed | | | | | | | | | | |
| Loaded | km/hour | 18 | 18 | 18 | 18 | 18 | 18 | 18 | 18 | |
| Empty | km/hour | 18 | 18 | 18 | 18 | 18 | 18 | 18 | 18 | |
| Total travel time round trip | | 15.3 | 15.3 | 9.3 | 9.3 | 9.3 | 9.3 | 9.3 | 9.3 | |
| Fixed time/truck trip | | | | | | | | | | |
| Spot at Loader | min | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | |
| Load | min | 2.6 | 2.6 | 2.6 | 2.6 | 2.6 | 2.6 | 2.6 | 2.6 | |
| Turn and Dump | min | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | |
| Subtotal Fixed Time | min | 4.6 | 4.6 | 4.6 | 4.6 | 4.6 | 4.6 | 4.6 | 4.6 | |
| Total Cycle Time | min | 19.9 | 19.9 | 13.9 | 13.9 | 13.9 | 13.9 | 13.9 | 13.9 | |
| Max tuck/loader | | 4 | 4 | 3 | 3 | 3 | 3 | 3 | 3 | |
| Fleet size per loader | | 7 | 7 | 5 | 5 | 5 | 5 | 5 | 5 | |
| 58% fleet availability | | | | | | | | | | |
| BCM/trip | BCM | 20.6 | 20.6 | 20.6 | 20.6 | 20.6 | 20.6 | 20.6 | 20.6 | |
| Operating hour/shift | Min | 645 | 645 | 645 | 645 | 645 | 645 | 645 | 645 | |
| No. of trip/shift | Trips | 31 | 31 | 45 | 45 | 45 | 45 | 45 | 45 | |
| BCM/shift/truck | BCM | 639 | 639 | 927 | 927 | 927 | 927 | 927 | 927 | |
| BCM/shift/fleet | BCM | 2,554 | 2,554 | 2,781 | 2,781 | 2,781 | 2,781 | 2,781 | 2,781.0 | |
| Operating time factor | | | | | | | | | | |
| EKG 5A Availability | | 85 | 85 | 85 | 85 | 85 | 85 | 85 | 85 | |
| Utilisation | | 83 | 83 | 83 | 83 | 83 | 83 | 83 | 83 | |
| Net operating time | | 71 | 71 | 71 | 71 | 71 | 71 | 71 | 71 | |
| Assigned BCM/shift/day | | 1,802 | 1,802 | 1,962 | 1,962 | 1,962 | 1,962 | 1,962 | 1,962 | |
| Scheduled shifts/day | | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | |
| Scheduled days/year | Days | 280 | 183 | 97 | 280 | 280 | 280 | 280 | 280 | |
| BCM/Year/Fleet(x 1,000) | BCM | 1,009 | 660 | 381 | 1,099 | 1,099 | 1,099 | 1,099 | 1,099 | |
| Tonnes/year (x 1,000) | | | | | | | | | | 2,002 |
| BCM/Year (x 1,000) | | | | | | | | | | 5,874 |
| Stripping Ratio | | | | | | | | | | 2.93 |

| | |
|---|---|
| Existing Equipment | |
| EKG-5A | 3 |
| Belaz 548 | 17 |
| Additional Equirement Required | |
| EKG-5A | 4 |
| Belaz 548 | 22 |
| Total | |
| EKG-5A | 7 |
| Belaz 548 | 39 |

## Table 4.3 Case 2 - Production Capacity by Introducing New FEL and Truck

Transportation Capacity (2 million tones)
EKG-5A & Belaz 548
FED(10m3) &Dump Truck(50m3)

| | | [Fleet A] | [Fleet B] | | [Fleet C] | [Fleet D] | [Fleet E] | |
|---|---|---|---|---|---|---|---|---|
| | | Coal | Coal | Overburden | Overburden | Overburden | Overburden | Total |
| Haul Distance | km | 2.3 | 2.3 | 1.4 | 1.4 | 1.4 | 1.4 | |
| Assigned Ave. Speed | | | | | | | | |
| Loaded | km/hour | 18 | 18 | 18 | 18 | 18 | 18 | |
| Empty | km/hour | 18 | 18 | 18 | 18 | 18 | 18 | |
| Total travel time round trip | | 15.3 | 15.3 | 9.3 | 9.3 | 9.3 | 9.3 | |
| Fixed time/truck trip | | | | | | | | |
| Spot at Loader | min | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | |
| Load | min | 2.6 | 2.6 | 2.6 | 2.6 | 2.6 | 2.6 | |
| Turn and Dump | min | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | |
| Subtotal Fixed Time | min | 4.6 | 4.6 | 4.6 | 4.6 | 4.6 | 4.6 | |
| Total Cycle Time | min | 19.9 | 19.9 | 13.9 | 13.9 | 13.9 | 13.9 | |
| Max tuck/loader | | 4 | 4 | 3 | 3 | 3 | 3 | |
| Fleet size per loader | | 7 | 7 | 5 | 5 | 4 | 4 | |
| 58% fleet availability [Belaz] | | | | | | | | |
| 75% fleet availability [NEW] | | | | | | | | |
| BCM/trip | BCM | 20.6 | 20.6 | 20.6 | 20.6 | 42.8 | 42.8 | |
| Operating hour/shift | Min | 645 | 645 | 645 | 645 | 645 | 645 | |
| No. of trip/shift | Trips | 31 | 31 | 45 | 45 | 45 | 45 | |
| BCM/shift/truck | BCM | 639 | 639 | 927 | 927 | 1,926 | 1,926 | |
| BCM/shift/fleet | BCM | 2,554 | 2,554 | 2,781 | 2,781 | 5,778 | 5,778 | |
| Operating time factor | | | | | | | | |
| Mech. Elec. Delays | | 85 | 85 | 85 | 85 | 85 | 85 | |
| Other delays | | 83 | 83 | 83 | 83 | 83 | 83 | |
| Net operating time | | 71 | 71 | 71 | 71 | 71 | 71 | |
| Assigned BCM/shift/day | | 1,802 | 1,802 | 1,962 | 1,962 | 4,076 | 4,076 | |
| Scheduled shifts/day | | 2 | 2 | 2 | 2 | 2 | 2 | |
| Scheduled days/year | Days | 280 | 183 | 97 | 280 | 280 | 280 | |
| BCM/Year/Fleet(x 1,000) | BCM | 1,009 | 660 | 381 | 1,099 | 2,283 | 2,283 | |
| Tonnes/year (x 1,000) | | | | | | | | 2,002 |
| BCM/Year (x 1,000) | | | | | | | | 6,044 |
| Stripping Ratio | | | | | | | | 3.02 |

| | |
|---|---|
| Existing Equipment | |
| EKG-5A | 3 |
| Belaz 548 | 17 |
| Additional Equirement Required | |
| Front End Loader (10 m3) | 2 |
| Rear Dump Truck (50 m3) | 8 |

## Table 4.4 Case 3 - Overburden Production Capacity by Introducing a New Medium Size Dragline

Production Capacity (2 million tons)
Dragline - Bucket size of 29 cubic meters

Reference : Hoist motor : 2 x 1300 HP
: Drag motor : 2 x 1300 HP
: Swing motor : 4 x 500 HP

| | | |
|---|---|---|
| Hoist speed (mpm) | 178 (Reave) | 283 (Pay) |
| Avg Swing (sec) | 16.7 (90 deg) | 19.7(120 deg) |

| | | Highwall Side Key | Plug | Total |
|---|---|---|---|---|
| **Cycle Parameters** | | | | |
| Hoist travel dist. (m) | | 10 | 27 | 23 |
| Swing angle (deg) | | 98 | 90 | 92 |
| Operator Adjust. factor | | 1.20 | 1.20 | 1.20 |
| **Cycle Components (seconds)** | | | | |
| Hoist time loaded | | 4.4 | 10.1 | |
| Swing time loaded (includes any hoist sement) | | 20.5 < | 16.7 < | 17.7 |
| Dump time | | 3.0 < | 3.0 < | 3.0 |
| Hoist pay time | | 2.1 | 5.7 | |
| Swing time empty | | 17.5 < | 16.7 < | 16.9 |
| Drag spot time | | 3.0 < | 3.0 < | 3.0 |
| Drag to fill time | | 12.6 < | 12.6 < | 12.6 |
| Theoretical cycle time | | 56.6 | 52.0 | 53.2 |
| Adjust cycle time | | 67.9 | 62.4 | 63.8 |
| **Hourly Production** | | | | |
| Cycle / hour | | 53.0 | 67.7 | 58.5 |
| Bucket capacity (c.m. / cycle) | | 29.0 | 29.0 | 29.0 |
| Material swell factor | | 1.25 | 1.25 | 1.25 |
| Bucket fill factor | | 1.03 | 1.03 | 1.03 |
| BCM / Cycle | | 23.9 | 23.9 | 23.9 |
| Application factor | | 1.0 | 1.0 | 1.0 |
| BCM / operating hour | | 1,267 | 1,379 | 1,351 |
| **Overburden Placement Information** | | | | |
| Dragline OB placed in final configuration(s.q.meters) | | 471 | 1,205 | |
| Dragline OB to be rehandled again | | 144 | 790 | |
| Dragline rehandle as % of final configuration volume | | 30.5% | 83.5% | 56.0% |
| Blasted OB placed in final location by other equipmer | | 0 | 0 | 0 |
| **Final Placement % cast : Based on area = 0** | | | | |
| Effective OB depth permanently mined (m) | | 8 | 20 | 28 |
| Bench width (m) | | 60 | 60 | 60 |
| **Annual Dragline Operation Production** | | | | |
| Scheduled hours | 6,720 | | | 6,720 |
| Mech & Elec delays (hrs) | 85% | | | 1,008 |
| Operational delays (hrs) | 85% | | | 857 |
| Total operating hours | | 1,492 | 4,444 | 4,855 |
| Prime Bank Cubic Meters (M) | | 1.45 | 3.7 | 5.15 |
| Total Bank Cubic Meters (M) | | 1.89 | 6.13 | 6.56 |
| Linear Pit Advance (m) | | | | 3,073 |
| Total production Factor (TBCM / Yr) / (LCM / cycle | | 2,120,000 | 2,310,000 | 2,260,000 |
| Total Annual Prime Overburden Production by Mining Operation | | | | 5.15 M |

Note: The Scheduled Oper. Hrs are based on 280 days & 24 hrs / day

Table 4.5 Case 3 - Coal Production Capacity by Existing Shovel and Truck

Production Capacity (2 million tons)
EKG-5A & Belaz 548

| | | [Fleet A] Coal | [Fleet B] Coal | Total |
|---|---|---|---|---|
| Haul Distance | km | 2.3 | 2.3 | |
| Assigned Ave. Speed | | | | |
| Loaded | km/hour | 18 | 18 | |
| Empty | km/hour | 18 | 18 | |
| Total travel time round trip | | 15.3 | 15.3 | |
| Fixed time/truck trip | | | | |
| Spot at Shovel | min | 1.0 | 1.0 | |
| Load | min | 2.6 | 2.6 | |
| Turn and Dump | min | 1.0 | 1.0 | |
| Subtotal Fixed Time | min | 4.6 | 4.6 | |
| Total Cycle Time | min | 19.9 | 19.9 | |
| Max truck/shovel | | 4 | 4 | |
| Fleet size per EKG 5A | | 7 | 7 | |
| 58% fleet availability | | | | |
| BCM/trip | BCM | 20.6 | 20.6 | |
| Operating hour/shift | Min | 645 | 645 | |
| No. of trip/shift | Trips | 31 | 31 | |
| BCM/shift/truck | BCM | 639 | 639 | |
| BCM/shift/fleet | BCM | 2,554 | 2,554 | |
| EKG 5A Availability | | 85 | 85 | |
| Utilisation | | 83 | 83 | |
| Assigned BCM/shift/day | | 1,802 | 1,802 | |
| Scheduled shifts/day | | 2 | 2 | |
| Scheduled days/year | Days | 280 | 185 | |
| BCM/Year/Fleet(x 1,000) | BCM | 1,009 | 667 | 1,676 |
| Tonnes/year (x 1000) | | | | 2,011 |

| Required existing Equipment | |
|---|---|
| EKG-5A | 2 |
| Belaz | 14 |

(4) Required numbers of mining equipment

In addition to the present mining equipment utilized at Shivee Ovoo coal mine, the following numbers of additional and new equipment by each option are required to increase production capacity to 2 million tons per year.

Table 4.6 Required Number of Mining Equipment

| Case 1 | Unit | Case 2 | Unit | Case 3 | Unit | Case 4 | Unit |
|---|---|---|---|---|---|---|---|
| EKG - 5A | 4 | FEL (10 $m^3$) | 2 | D/L (29 $m^3$) | 1 | D/L (20 m3) | 2 |
| Belaz 548 | 22 | D/T (80 t) | 8 | Dozer | 1 | Dozer | 2 |
| Wheel Dozer | 2 | Wheel Dozer | 1 | Grader | 1 | Grader | 1 |
| Grader | 2 | Grader | 1 | | | | |

where, the capacity of mining equipment mentioned above are as follows;

| | |
|---|---|
| EKG 5A | - Electric rope shovel (5 $m^3$) |
| Belaz 548 | - Rear dump truck (40 t) |
| FEL (10 $m^3$) | - Front End Loader (10 $m^3$) |
| D/T (80 t) | - Rear dump truck (80 t) |
| Wheel Dozer | - Wheel dozer (230 kW) |
| D/L (29 $m^3$) | - Walking dragline (29 $m^3$) |
| D/L (20 $m^3$) | - Walking dragline (20 $m^3$) |
| Dozer | - Bulldozer (388 kW) |
| Grader | - Motor grader (205 kW) |

(5) Capital cost

Price of mining equipment on CIF Ulaanbaatar, which was provided by suppliers of mining equipment, is utilized for estimation of capital cost for each option.

Table 4.7 Price of Mining Equipment and Capital Cost

Case 1 (Unit US$)

| Item | Unit price | Units | Total costs |
|---|---|---|---|
| EKG - 5A | 876,000 | 4 | 3,504,000 |
| Belaz 548 | 80,000 | 22 | 1,760,000 |
| W Dozer | 357,000 | 2 | 714,000 |
| Grader | 426,000 | 2 | 852,000 |
| Total | | | 6,830,000 |

Case 2

| Item | Unit price | Units | Total costs |
|---|---|---|---|
| FEL | 1,200,000 | 2 | 2,400,000 |
| D/T | 633,000 | 8 | 5,064,000 |
| W Dozer | 357,000 | 1 | 357,000 |
| Grader | 426,000 | 1 | 426,000 |
| Total | | | 8,247,000 |

Case 3

| Item | Unit price | Units | Total costs |
|---|---|---|---|
| D/L (29 m3) | 16,615,000 | 1 | 16,615,000 |
| Dozer | 616,000 | 1 | 616,000 |
| Grader | 426,000 | 1 | 426,000 |
| Total | | | 17,652,000 |

Case 4

| Item | Unit price | Units | Total costs |
|---|---|---|---|
| D/L ($20m^3$) | 12,171,000 | 2 | 24,342,000 |
| Dozer | 616,000 | 2 | 1,232,000 |
| Grader | 426,000 | 1 | 426,000 |
| Total | | | 26,100,000 |

(6) Operating cost

For each option,operating cost is estimated. Details of estimation method for operating cost are described in Appendix 2 Estimation of production cost.

Tax, interest and royalty are not included in cost comparison studies.

Following energy prices are used in cost comparison studies;

| | | | |
|---|---|---|---|
| Diesel oil | : | International price | (169 US$/t) x 1.1 |
| Gasoline | : | " | (186 US$/t) x 1.1 |
| Coal | : | " | (15.7 US$/t) x 0.7 |
| Electricity | : | " | (0.062 US$/kWh) x 0.9 |

Note : ( ) shows prices (FOB) as of the end of 1993

Table 4.8 Operating Cost Per Ton

Unit : US$/ton

| Option | Case 1 | Case 2 | Case 3 | Case 4 |
|---|---|---|---|---|
| Labor | 0.23 | 0.08 | 0.03 | 0.06 |
| Materials | 1.62 | 1.34 | 2.27 | 3.33 |
| Energy, etc | 2.49 | 2.42 | 0.65 | 1.16 |
| Total | 4.34 | 3.84 | 2.95 | 4.55 |

(7) Economic comparison of new minig systems

Table 4.9 shows the production cost of each option. Production cost of the present mining equipment utilized at Shivee Ovoo coal mine and replacement costs are common cost in all options. Similarly, capital cost required for construction of crushing and screening plant, stockyard, train loading facilities, etc. in establishing the capacity of production to 2 million tons per year and operating costs of these mine infrastructures are common cost in all options. Selection of the source of energy for mining equipment, the electrical energy generated in Mongolia, or diesel oil which was imported by the hard currency gives an important impact on Mongolian economy. For example, Case 2 (introduction of new medium truck and front end loader) requires diesel oil as a source of energy while Case 3 (introduction of a new medium dragline) requires the electricity which is generated in Mongolia. Electricity driven equipment is the most advantageous for the national interest of Mongolia.

As shown on Table 4.9, Case 3 has the lowest production cost per tone. Diesel and tire cost in cases 1 and 2 are substantially higher than Cases 3 and 4. Diesel and tire have to be imported by spending hard currency. Additional mining equipment to be introduced in Case 1 is made in Russia. It is the fact that availability of these Russian equipment is lower than these made in the western countries. Electricity required in Cases 3 and 4 is domestically produced in Mongolia. Considering these factors, it is recommended that Case 3 should be selected as the best option for Mongolia. Case 3 is an option of introduction of a new medium dragline.

Table 4.9 Comparison Study of New Systems

| | Unit | Existing Improved | Additional system Case 1 | Case 2 | Case 3 | Case 4 |
|---|---|---|---|---|---|---|
| Existing excavating capacity | m.BCM/y | 3.2 | - | - | - | - |
| Additional capacity required | m.BCM/y | - | 5.5 | 5.5 | 5.5 | 5.5 |
| Required number of fleets *1 | | - | 4 | 2 | 1 | 2 |
| Additional initial capital *2 | m.US$ | - | 6.8 | 8.2 | 17.7 | 26.1 |
| Operating cost *1 | m.US$/y | 2.6 | 4.9 | 4.6 | 3.5 | 5.4 |
| Spare parts | | (1.5) | (1.9) | (1.6) | (2.7) | (4.0) |
| Consumable | | (1.1) | (3.0) | (3.0) | (0.8) | (1.4) |
| Capital cost *2 | m.US$/y | 1.8 | 1.9 | 1.7 | 0.9 | 1.4 |
| Equipment | | (1.4) | (1.7) | (1.6) | (0.9) | (1.3) |
| Labor etc. | | (0.4) | (0.2) | (0.1) | (0.04) | (0.1) |
| Total cost *2 | m.US$/y | 4.4 | 6.8 | 6.3 | 4.4 | 6.8 |
| Mining cost index | $/BCM | 1.4 | 1.2 | 1.1 | 0.8 | 1.2 |

Note *1 : Fleets were planned based on the most modern equipment.
*2 : Tax, interest, royalty and surface facilities are not included.

4.2 Recommended mining equipment and facilities

4.2.1 Recommended mining equipment

(1) Proposed Mining System

1) Removable of overburden

A new medium size dragline with bucket capacity of 29m$^3$ carries out stripping of overburden. Pit width of overburden removable is designed at 60m and removal method recommended to be adopted is "extended bench method" which is shown in Figure 4.5.

2) Coal mining of Seam II

The existing electric rope should EKG 5A and a fleet of rear dump truck Belaz 548 carry out coal mining of Seam II, which is exposed by removal of a new medium size dragline. Mining height of bench is the same as the thickness of Seam II.

3) Removable of interburden

After coal mining of Seam II, the existing electric rope EKG 5A and a fleet of rear dump truck Belaz 548 should carry out removable of interburden, which exist between Seam I and II.

4) Coal mining of Seam I

After removal of interburden, the existing electric rope EKG 5A and a fleet of rear dump truck Belaz 548 carry out coal mining of Seam I. Mining height of bench is the same as the thickness of Seam I.

5) Restoration of the mined out area

Interburden must be dumped over the spoil pile stacked by a new medium size dragline and a dozer pushes dumped interburden to flat the surface of spoil pile. Thus, the mined out area is restored with seeding trees and plants.

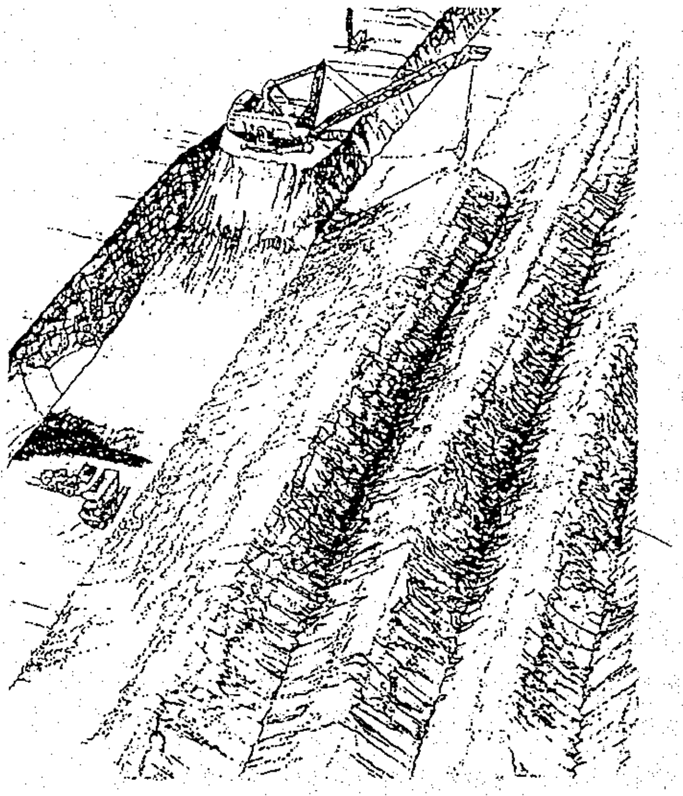
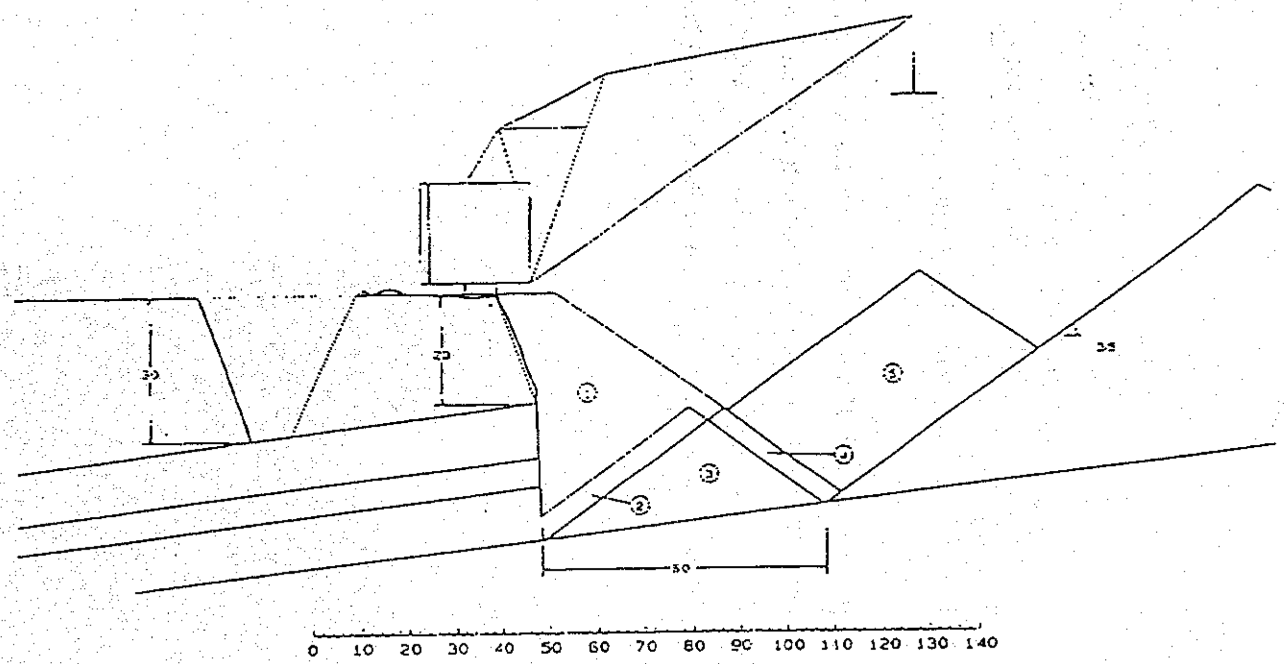


Figure 4.4 Proposed Mining System




| DESIGNATOR | BANKED AREA | CURRENTLY SWELLED BY | MAXIMUM SWELL | REPOSE ANGLE | AREA TYPE |
|---|---|---|---|---|---|
| 1 | 789.5 | 25.0 % | 25.0 % | 35.0 deg | DL REHANDLE |
| 2 | 143.8 | 25.0 % | 25.0 % | 35.0 deg | DL REHANDLE |
| 3 | 471.1 | 25.0 % | 25.0 % | 35.0 deg | DL SPOIL |
| 4 | 96.1 | 25.0 % | 25.0 % | 35.0 deg | DL SPOIL |
| 5 | 1108.6 | 25.0 % | 25.0 % | 35.0 deg | DL SPOIL |

DRAGLINE: 7820X51 OP RAD: 88.1 DUMP HT: 40 SWING ANGLE SHOWN: 90

MONGOLIA PROJECT

MARION 7820: 315 FT. BOOM LENGTH

EXTENDED BENCH: AVE. THICKNESS OF

TOP OB @ 28m. REHANDLE @ 56%

DESIGNED BY: J.O. WIENTJES

DATE: MAY 27, 1994

SCALE: 1 - 32

(OC P11005 FILE NAME: MONGOL1) PIT 2 OF 3 STEP 2 OF 5

Figure 4.5 Range Diagram of Dragline

(2) Recommended Mining Equipment

The following additional mining equipment, or equivalent is recommended.

Table 4.10 Additional Equipment List

| Equipment | Required number | Life (years) S*1 | Life (years) L*1 | Unit price*2 (m.us$) | Major use |
|---|---|---|---|---|---|
| 29 $m^3$ Dragline | 1 | 30 | 30 | 16.6 | Overburden removal |
| Bulldozer 388 kW | 1 | 6 | 8 | 0.6 | Support |
| Grader 205 kW | 1 | 6 | 8 | 0.4 | Road maintenance |

Note *1: "S" is short-life case and "L" is long-life case.
*2: All costs and fees for manufacturing, packing, transportation, field assembly and training are included in unit price.

Design philosophy of Shivee Ovoo coal mine was reviewed, however, any necessity of change of the design basis is not found. Note that recovery ratio in the original mining design was 100%. Stripping ratio to be used in the study of renovation is 3.5 (average). Additional equipment is one dragline with the excavating capacity of 5.5 million BCM per year. New additional equipment is as follows;

1) Dragline

General specifications of proposed dragline are shown in Figure 4.6.

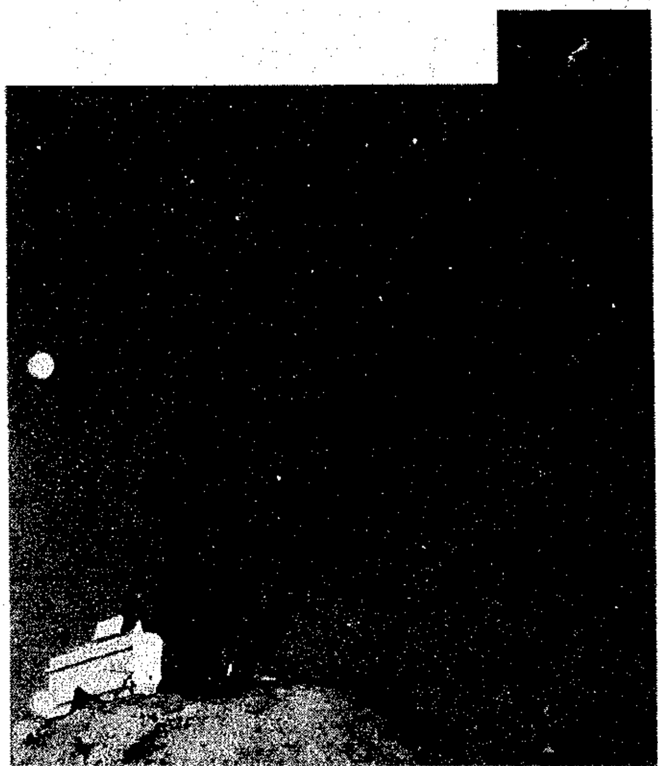


Figure 4.6 Dragline

Specifications

| Working range | Meter |
|---|---|
| Boom length | 96.0 |
| Boom point sheeve, pitch diameter | 2.3 |
| Boom angle, approx. | 32.7 |
| Dumping radius | 88.0 |
| Dumping height | 39.9 |
| Depth | 53.6 |
| Maximum allowable load, kg | 79,400 |
| Hoist drum, pitch diameter (mm) | 2.2 |
| Hoist rope, twin/single hitch, diameter (mm) | 60 |
| Drag drum, pitch diameter | 2.2 |
| Drag rope,twin/single hitch, diameter (mm) | 70 |
| **Base** | |
| Outside Diameter,nominal | 15.5 |
| Bearing area, effective ($m^2$) | 189.8 |
| Rail circle, mean diameter | 15.2 |
| Main swing gear, pitch diameter, approx | 13.0 |
| **Walking traction** | |
| Width of shoe | 2.7 |
| Length of shoe | 16.8 |
| Width over both shoe | 21.6 |
| Bearing area of both shoes ($m^2$) | 92.0 |
| Bearing pressure 80% of working weigh ($kg/cm^2$) | 1.72 |
| Length of step, approx. | 2.1 |
| **Rotating frame** | |
| Width rear end | 13.1 |
| Length | 23.4 |
| Depth sill members | 2.0 |
| Clearance radius, rear end | 16.8 |
| Clearance under frame | 2.2 |
| Center rotation to boom foot | 6.2 |
| Ground to boom foot | 4.1 |
| **Electrical equipment** | |
| Hoist motors, two, 970 kw each, total (kW) | 1,940 |
| Drag motors, two, 970 kw each, total (kW) | 1,940 |
| Swing motors, four, 373 kw each, total (kW) | 1,492 |
| Propel motor, one, total (kW) | 970 |
| AC driving motors, total (kW) | 2,611 |
| **Weights** | |
| Domestic shipping weight(inc. bucket) (kg) | 1,588,000 |
| Working weight, (lbs) | 1,974,000 |
| Ballast(furnished by purchaser) (lbs) | 386,000 |

2) Bulldozer

General specifications of proposed bulldozer are shown in Figure 4.7.

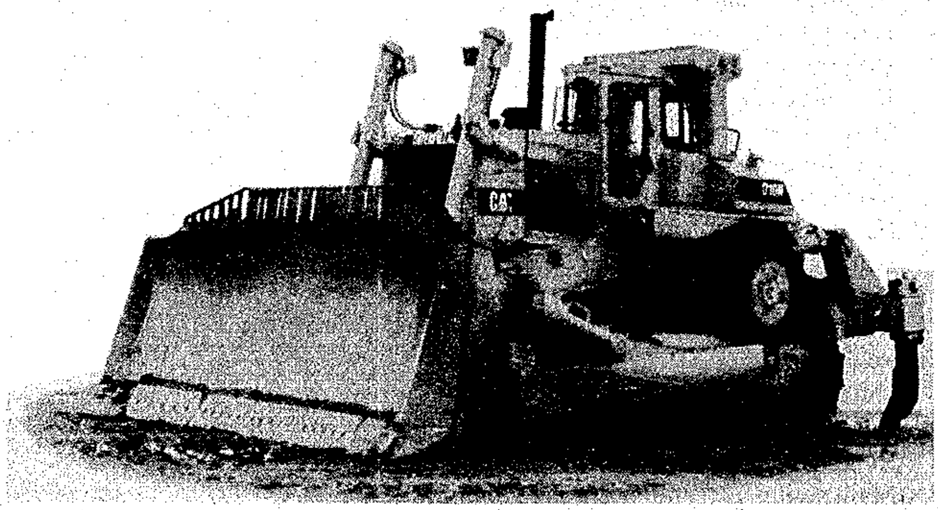



Figure 4.7 Bulldozer

Specifications

| | |
|---|---|
| Flywheel power | 276 kW |
| Operating weight | 42,816 kg |
| Rated engine | 1,900 r.p.m. |
| No. of cylinder | 8 |
| Bore | 137 mm |
| Stroke | 152 mm |
| Displacement | 18 l |
| Track rollers (each side) | 8 |
| Width of standard track shoe | 610 mm |
| Length of track on ground | 3.47 m |
| Ground contact area | 4.24 $m^2$ |
| Track gauge | 2.25 m |
| General dimension | |
| Height (stripped top) | 2.93 m |
| Height (to top of ROPS canopy) | 3.91 m |
| Overall length (with SU blade) | 6.87 m |
| (without blade) | 5.17 m |
| Width (over trunnion) | 3.25 m |
| Width (without trunnion) | 2.89 m |
| Ground clearance | 505 mm |
| Fuel tank refill capacity | 731 l |

3) Motor grader

General specifications of proposed motor grader are shown in Figure 4.8.

Figure 4.8 Motor Grader

Specifications

| | |
|---|---|
| Net flywheel power | 205 kW |
| Equipped operating weight | 27,284 kg |
| Rated engine | 2,000 r.p.m. |
| No. of cylinder | 6 |
| Displacement | 16 l |
| Max torque rise | 30 % |
| No. of speed forward/reverse | 8/8 |
| Top speed forward | 43.6 km/h |
| Reverse | 42.6 km/h |
| Std. tire - front & rear | 18.0-25 |
| Minimum turning radius | 8.2 m |
| Fuel tank capacity | 489 l |