JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

MINISTRY OF ENERGY, GEOLOGY AND MINING (MEGM)
MONGOLIA

STUDY
ON
COMPREHENSIVE COAL DEVELOPMENT
AND UTILIZATION
IN
MONGOLIA

FINAL REPORT

(PART I : RENOVATION STUDY)

MAIN REPORT

NOVEMBER 1995

THE INSTITUTE OF ENERGY ECONOMICS, JAPAN (IEEJ)

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PREFACE

In response to a request from the Government of the Mongolia, the Government of Japan decided to conduct the Study on Comprehensive Coal Development and Utilization in Mongolia and entrusted the study to the Japan International Cooperation Agency (JICA).

JICA sent a study team led by Mr. Takehiko Sato of the Institute of Energy Economics, Japan (IEEJ) and organized by IEEJ to Mongolia seven times from November 1993 to September 1995.

The team held discussions with the officials concerned of the Government of Mongolia, and conducted related field surveys. After returning to Japan, the team conducted further studies and compiled the final results in this report.

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

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

November 1995

Kimio Fujita
President
Japan International Cooperation Agency

November 1995

Mr. Kimio Fujita
President
Japan International Cooperation Agency
Tokyo, Japan

Dear Mr. Fujita,

Letter of Transmittal

We are pleased to submit to you the study report on Comprehensive Coal Development and Utilization in Mongolia. The report contains the advice and suggestions of authorities concerned of the Government of Japan and your Agency as well as the formulation of the above mentioned project. Also included are comments made by the Ministry of Energy, Geology, and Mining of Mongolia during technical discussions on the draft report which were held in Ulaanbaatar. The study is divided into two Parts:

Part I : Feasibility study for the renovation of two coal mines

Part II: Master plan study for the coal development and utilization and preliminary action plan

Baganuur coal mine and Shivee Ovoo coal mine were selected as "two coal mines" to be studied in Part I by both study teams in accordance with the procedure of Scope of Work.

This report presents the results of the Study, which has been implemented since November 1993 in cooperation with the Ministry of Energy, Geology and Mining as the Counterpart, and consists of three separate volumes, the summary (110 pages), Part I (the renovation plans:650 pages) and Part II(the master plan:430 pages) of the main texts.

Part I reports the renovation plan of Baganuur coal mine (Chapter I) and Shivee Ovoo coal mine (Chapter II). Each Chapter includes;coal resources; present mining status; renovation plan; capital and operating costs;financial and economic analysis; and conclusion.
Part II reports the master plan and the preliminary action plans, and includes: coal demand and supply forecast; coal development and utilization plan; conceptual study of the selected plans; and conceptual "Action Plan"

In view of the urgency of renovation of coal mines in Mongolia, we recommend that Mongolian government implements the renovation plans of Baganuur coal mine and Shivee ovoo coal mine in accordance with the coal development master plan.

We wish to take this opportunity to express our sincere gratitude to your Agency, the Ministry of Foreign Affairs, and the Ministry of International Trade and Industry. We also wish to express our deep gratitude to the Ministry of Energy, Geology, and Mining of Mongolia, the JOCV Ulaanbaatar office, and the Embassy of Japan in Ulaanbaatar for the close cooperation and assistance extended to us during our investigation and study.

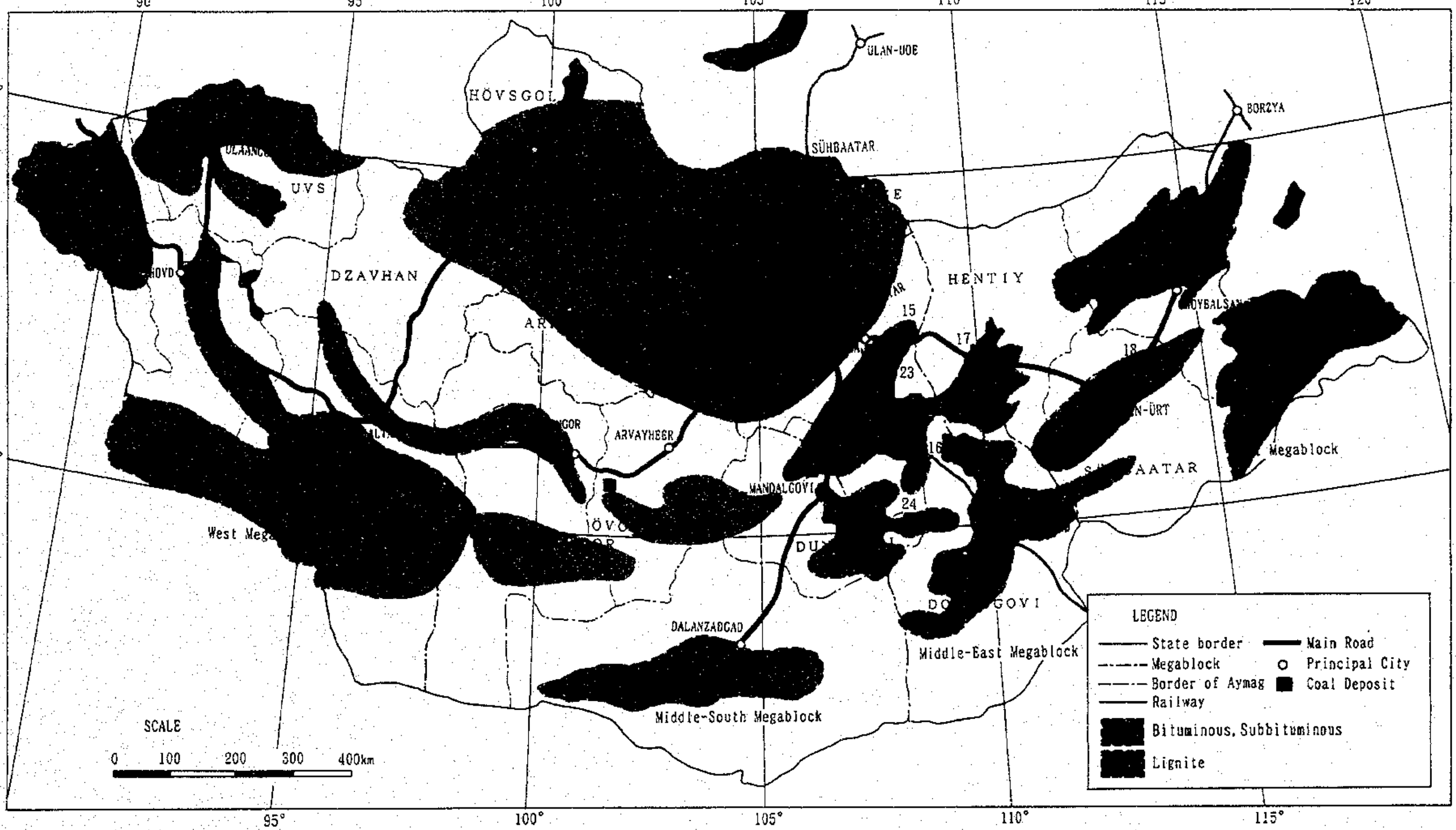
Very truly yours,

T. Sato

Takehiko Sato

Team Leader
The Study on Comprehensive Coal
Development and Utilization in Mongolia

Coal Resouces in Mongolia



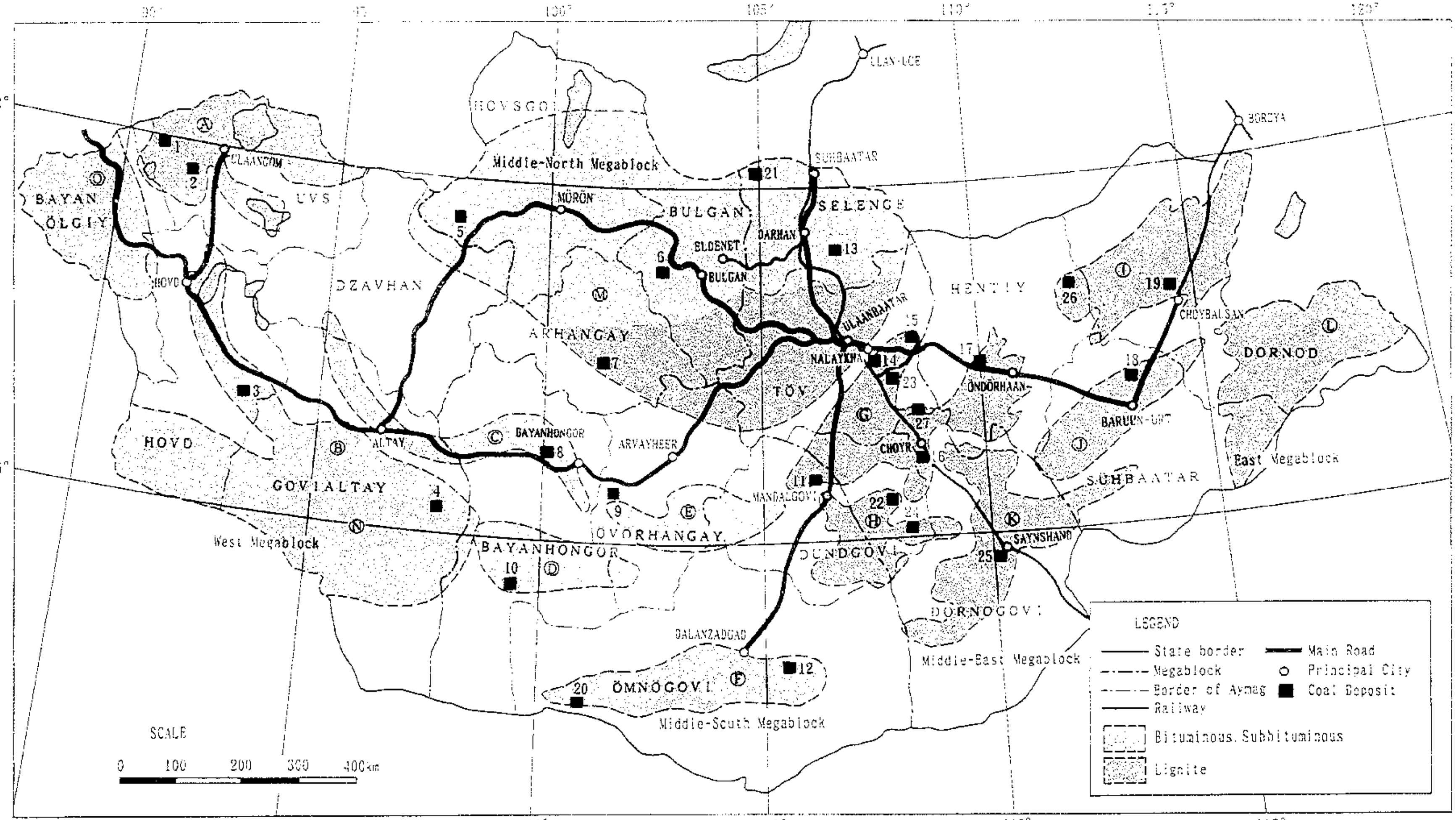
Names of basins
- Ⓐ:Kharkhiraa (C)
- Ⓑ:Mongol Altay (C)
- Ⓒ:South Khangay (P)
- Ⓓ:Big Bogdyn (J)
- Ⓔ:Ongiyngol (J)
- Ⓕ:South Govi (P)
- Ⓖ:Choir-Niarga (K)
- Ⓗ:Middle Govi (K)
- Ⓘ:Choybalsan (K)
- Ⓙ:Sukhe Bator (K)
- Ⓚ:East Govi (K)
- Ⓛ:Tamtsak (K)
- Ⓜ:Orkhon-Selenge (J)
- Ⓝ:Altay-Chandmani (C)
- Ⓞ:Bayan-Ulegei (C)

* C-Carboniferous, P-Permian, J-Jurassic, K-Cretaceous

Names of deposits
1 Nuursthotgor Deposit
2 Khartarvagatai Deposit
3 Khusheet Deposit
4 Zeegt Deposit
5 Mogoingol Deposit
6 Saihan-Ovoo Deposit
7 Bayantsagaan Deposit
8 Uburchuluut Deposit
9 Bayanteeg Deposit
10 Shinjinst Deposit
11 Tevshiingovi Deposit
12 Tavantologoi Deposit
13 Sharyngol Deposit
14 Nalaykha Deposit
15 Baganuur Deposit
16 Shivee-Ovoo Deposit
17 Chandagantal Deposit
18 Talbulag Deposit
19 Aduunchuluun Deposit
20 Narynsohait Deposit
21 Ulaan-Ovoo Deposit
22 Khoot Deposit
23 Tsaidamnuur Deposit
24 Ovdok-Huduk Deposit
25 Sainshand Deposit
26 Hulstnuur Deposit
27 Tugrugnuur Deposit

c

Coal Resouces in Mongolia



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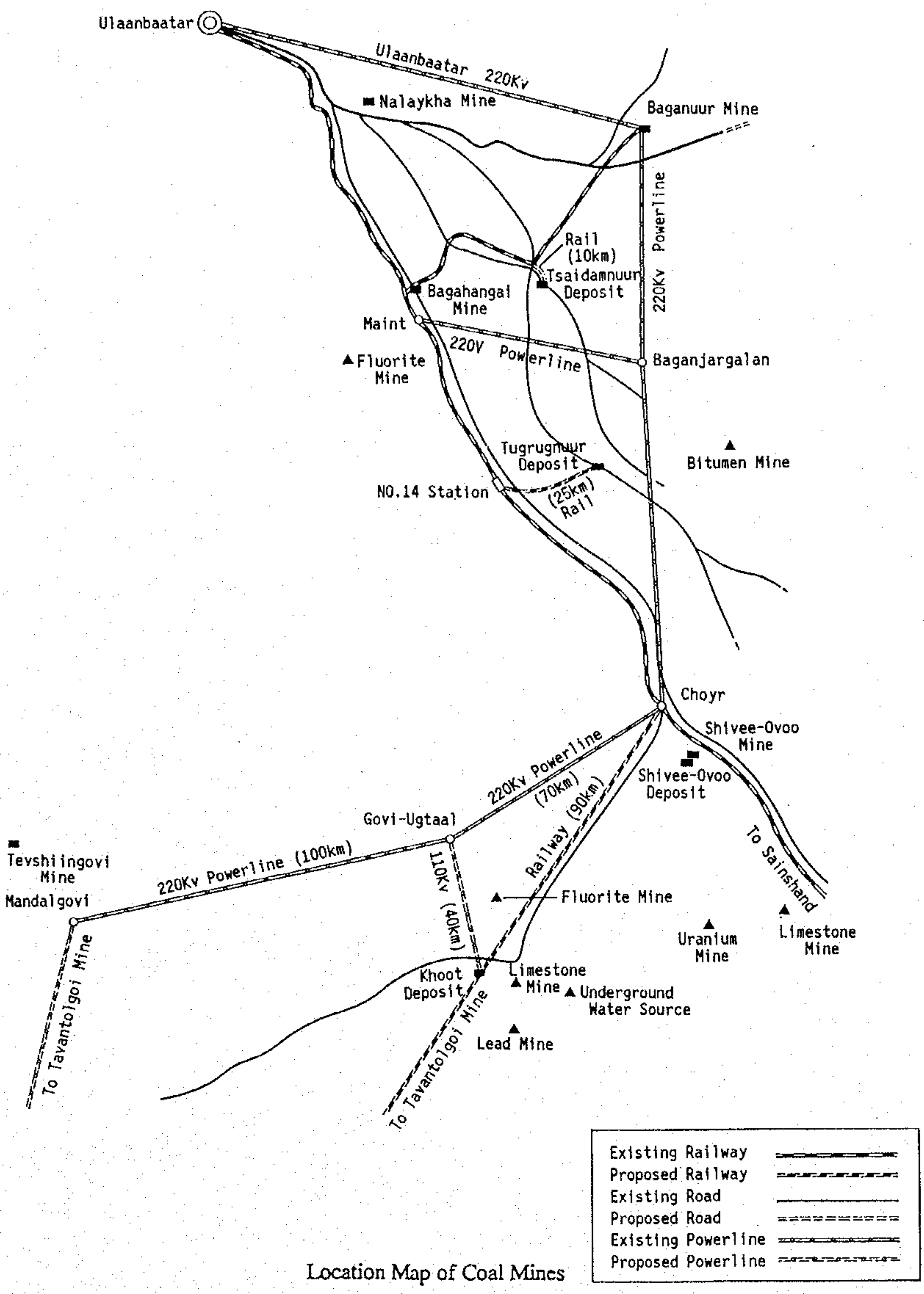
25 Sainshand Deposit
26 Hulstnuur Deposit
27 Tugrugnuur Deposit



Location Map of Coal Mines

STUDY ON COMPREHENSIVE COAL DEVELOPMENT AND UTILIZATION IN MONGOLIA

FINAL REPORT

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PART II Master Plan Study

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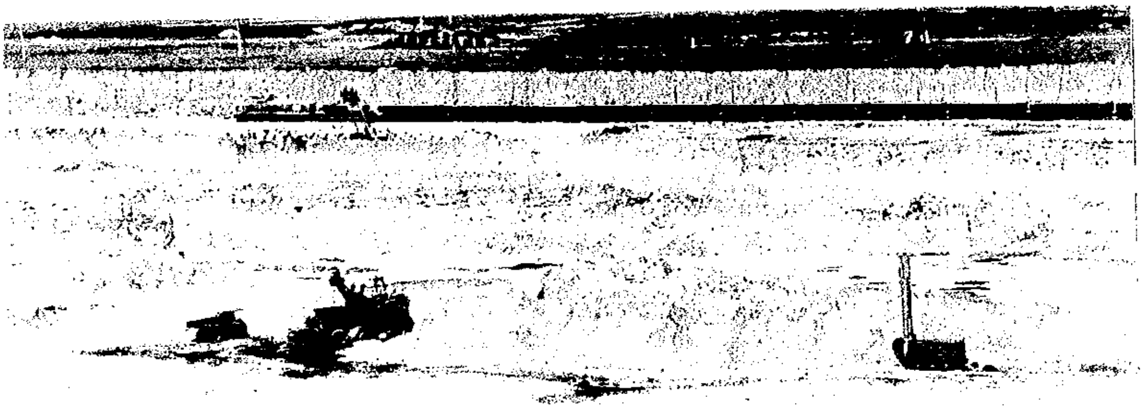
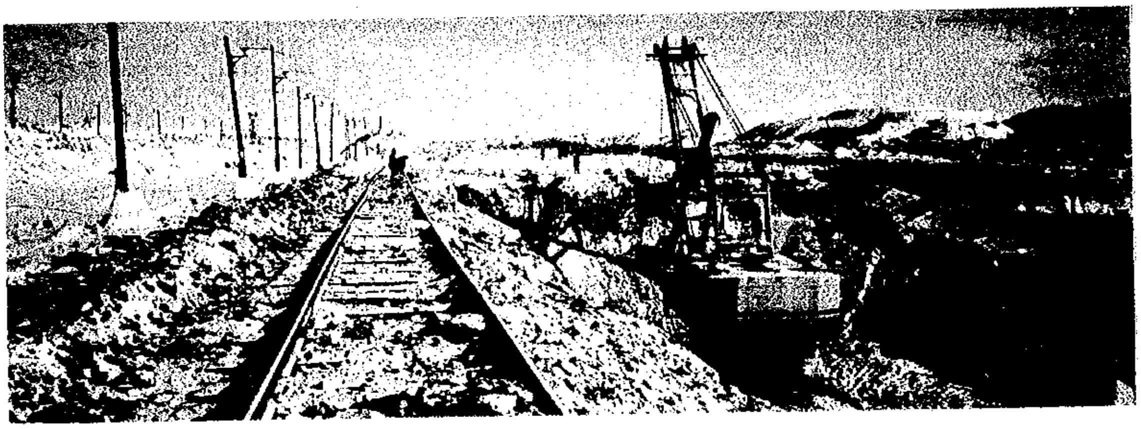
Abbreviations

AD,ad	: Air Dried Basis
ADB	: Asian Development Bank
AR,ar	: As Received Basis
ASTM	: American Society for Testing and Materials
atm.	: Atmosphere(s)
bbl	: Barrel
BCM	: Bank Cubic Meter
BWE	: Bucket Wheel Excavator
CES	: Central Energy System
CIF	: Cost, Insurance and Freight
COMECON	: Communist Economic Conference
D/L	: Dragline
D/T	: Dump Truck
DB,db	: Dry Basis
DAF,daf	: Dry Ash Free
dB(A)	: Decibel in Scale A
DCF	: Discounted Cash Flow
E.C.	: Electric Conductivity
EIRR	: Economic Internal Rate of Return
F/S	: Feasibility Study
FBC	: Fluidized Bed Combustion
FEL	: Front End Loader
FIRR	: Financial Internal Rate of Return
FLIR	: Foreign Loan Interested Rate
FOB	: Free on Board
Gcal	: Giga-calorie
GDP	: Gross Domestic Product
GHV	: Gross Heating Value
GWh	: Giga-watt-hour(s)
ha	: Hectare(s)
HCV	: Higher Calorific Value
HHV	: Higher Heating Value
HP	: Horsepower
HV	: Heating Value
HVDC	: High Voltage Direct Current

Hz.	: Hertz
IEEJ	: The Institute of Energy Economics, Japan
INPS	: Institute of National Project for the former Soviet Union
IRR	: Internal Rate of Return
JCI	: Japan Consultant Institute
JICA	: Japan International Cooperation Agency
JIS	: Japanese Industrial Standards
KV,kV	: Kilo-volt
KVA,kVA	: Kilo-volt-ampere
kW	: Kilo-watt(s)
kWh	: Kilo-watt-hour(s)
LCV	: Lower Calorific Value
LHV	: Lower Heating Value
m.,mil.	: Million
MCR	: Maximum Continuous Rating
MEGM	: Ministry of Energy, Geology and Mining of Mongolia
MJ	: Mega-joule
MTI	: Ministry of Trade and Industry of Mongolia
MW	: Mega-watt(s)
NDB	: The National Development Board
NEDO	: New Energy and Industrial Technology Development Organization
NMP	: Net Material Product
NPV	: Net Present Value
ODA	: Official Development Assistance
OECD	: Organization for Economic Co-operation and Development
PCF	: Pulverized Coal Fired
ppb.	: Parts per Billion
rpm	: Revolutions per Minute
S.L.	: Sea Level
SNG	: Substitute Natural Gas
SPM	: Suspended Particulate Matter
SS	: Suspended Solid
TBCM	: Total Bank Cubic Meter
TCE,tce	: Ton Coal Equivalent
Tg, tg	: Tugrug(s)
TSP	: Total Suspended Particulates
UNCED	: U. N. Conference on Environment and Development



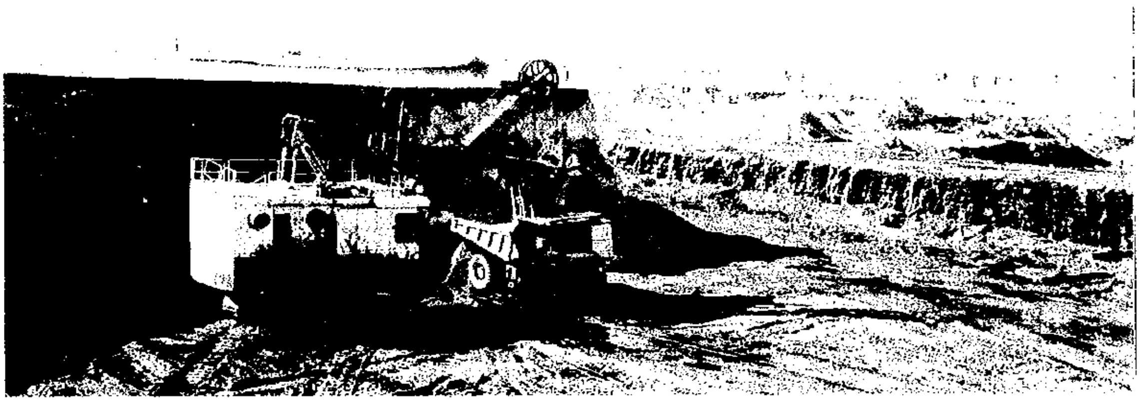
Removal of Overburden by Shovel/Railway and Shovel/Truck System



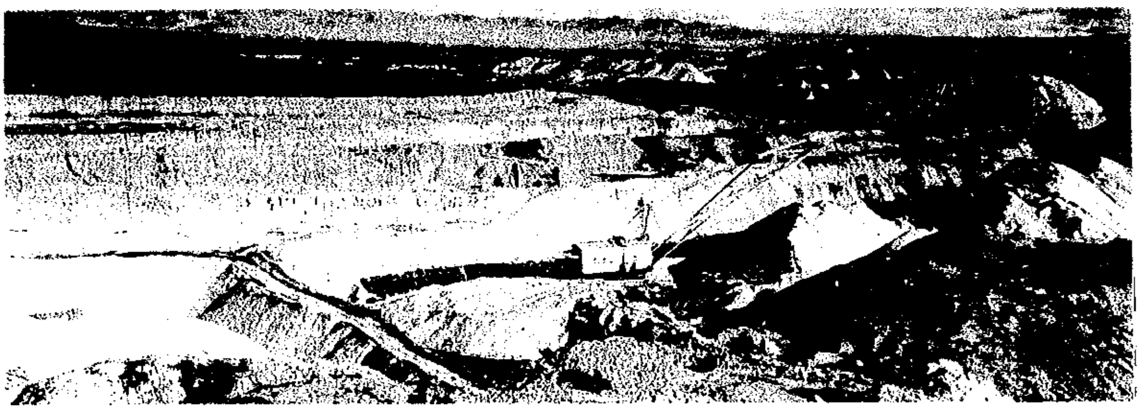
Removal of Overburden by Shovel/Railway System

Transportation of Overburden by Railway System

Dumping Overburden from Wagons at Overburden Dump



Removal of Overburden by Shovel/Truck System



Removal of Overburden by Dragline

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 I reports the renovation plan of Baganuur coal mine.

Baganuur coal mine is located in 110 km east of Ulaanbaatar and 1,350 m above sea level. Proved coal reserves are 560 million tones and lignite with about 3,600 kcal/kg received, (LHV) is mined by large scale open cut mining method. The majority of coal produced at Baganuur coal mine is consumed at the power stations in Ulaanbaatar. Baganuur coal mine was designed to produce 6 million tons per year of coal, however, the recent production records show only 3-4 million tons per year of coal due to delays of overburden removal. The reasons for delays of overburden removal are the shortage of spare parts, low operation efficiency of the shovel and railway system, etc. Target of the renovation study is set to achieve coal production of 6 million tons per year.

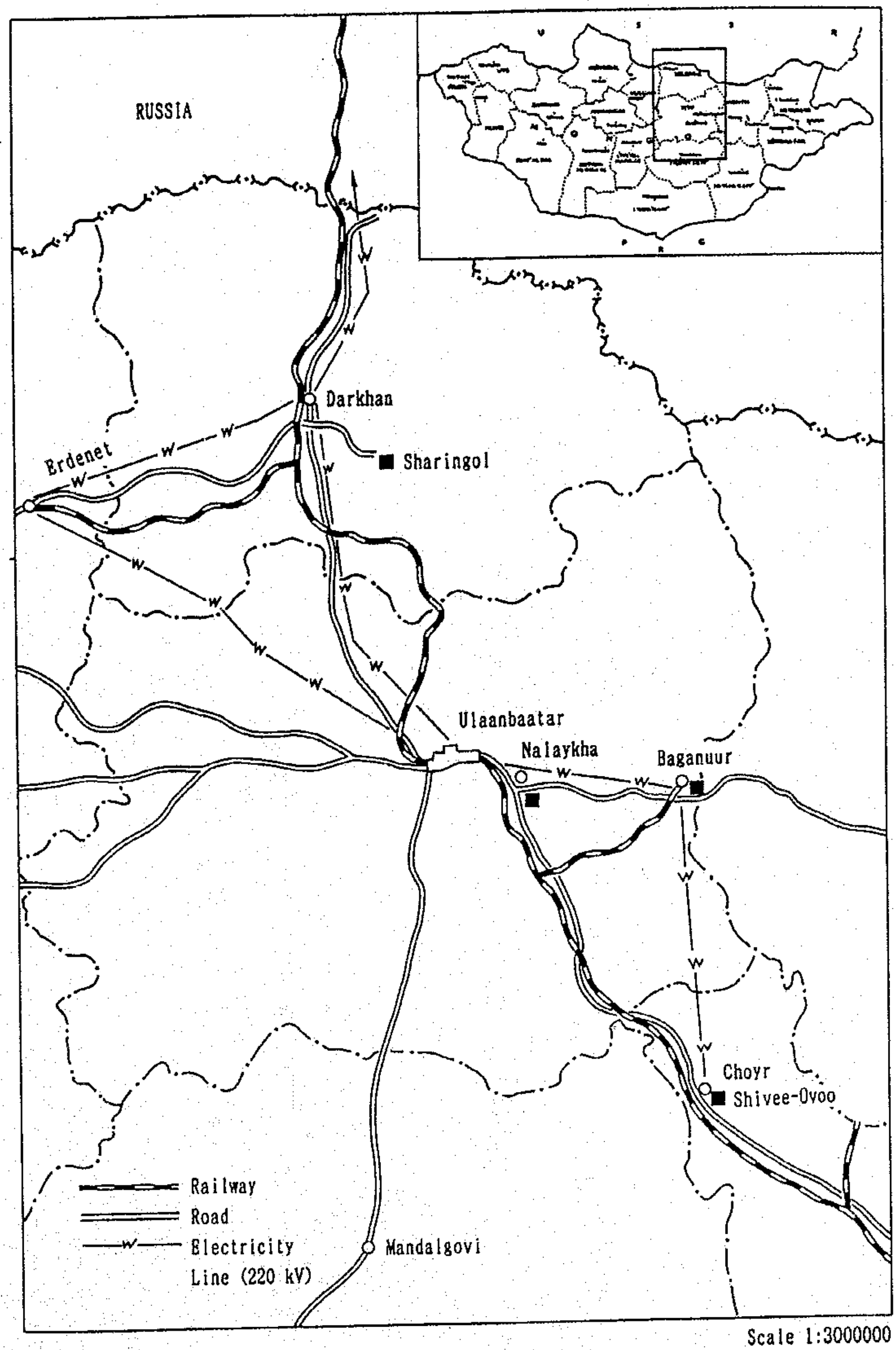


Figure 1.1 Location of Coal Mines and Infrastructures

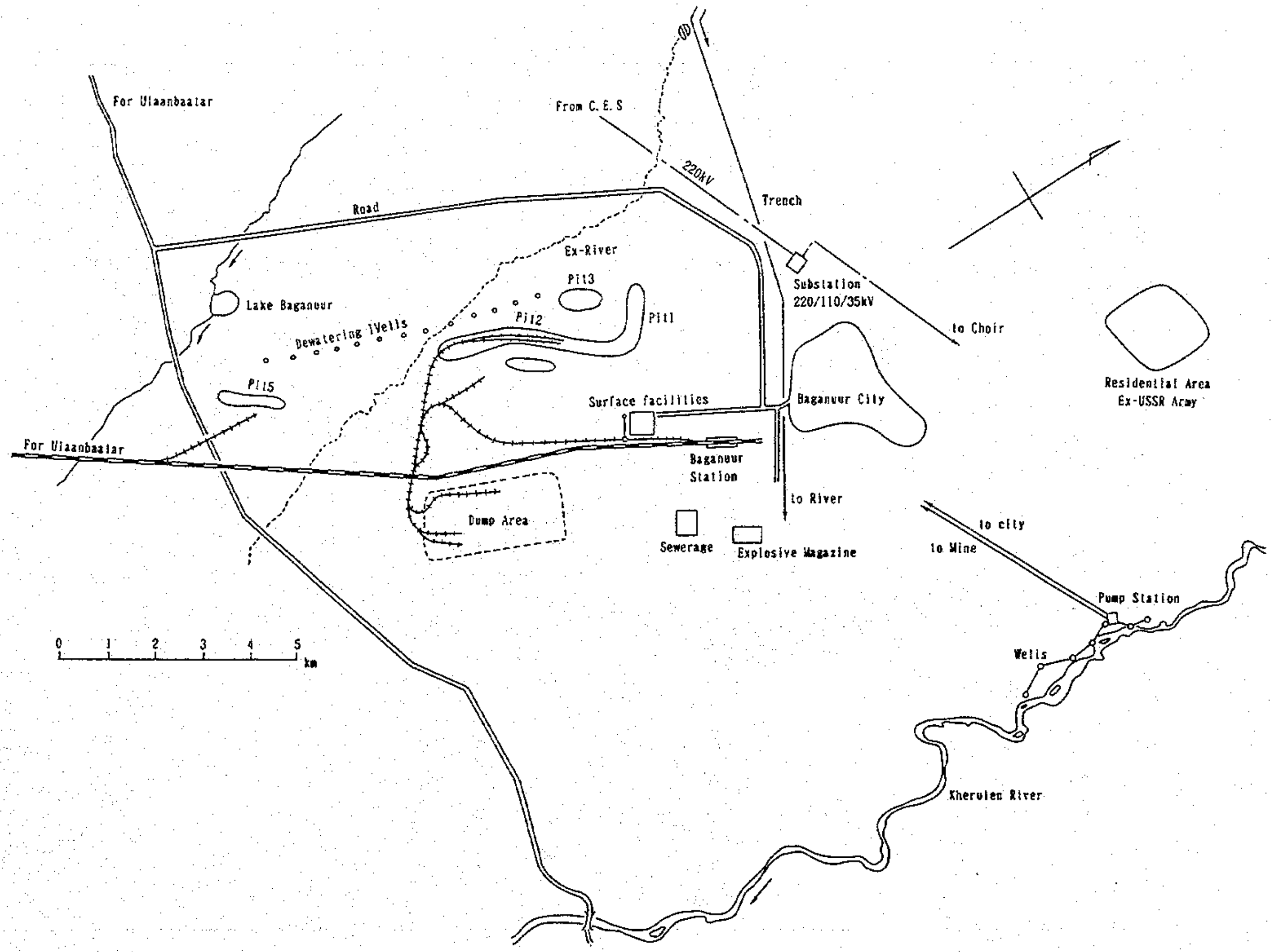


Figure 1.2 Layout of Baganuur Coal Mine

2 Study on Coal Resources

2.1 History of exploration

Exploration and development were carried out under technical and economic cooperation of the former Soviet Union.

1925-1926 :	Firstly recorded by the former Soviet Union		
1931 :	Exploration		
	- evaluated as a hopeless deposit		
1964 :	Exploration		
	drilling	:	7 holes
	trenching	:	7 sites, 26 holes
	- evaluated as a promising large deposit		
1974-1975 :	Exploration		
	prospecting line	:	20 lines, interval of 500m
1976-1977 :	Detailed exploration		
	Number of boreholes	:	502
	Depth of boreholes	:	15~280m
	Total length of boreholes	:	49,881m
	Borehole interval	:	150m
	Interval of cross section	:	250m
1978-1979 :	Preparation of development		
	Start of production by using small-size mining equipment		
1979-1980 :	Start of production (1 million tons per year) by using large-size mining equipment		

Exploration of Baganuur coal mine was carried out according to the detail exploration plan prepared under the Russian exploration standard for study of geological structure. According to the Russian exploration standard, a detail exploration program is defined to drill borehole every 150m. As Baganuur coal mine is an opencut mine, it is flexible to deal with the changeable geological conditions. Therefore, further additional exploration works are seemed to be unnecessary.

2.2 Geology and structure

2.2.1 Topography and geology

National land of Mongolia is 1.57 million km^2. There are 3,500 lakes and 7,000 rivers approximately in Mongolia. Northwestern part of Mongolia is surrounded by high mountains. Most of the southeastern part is a desert area while the center part is a flat area. The highest point is the Taban-Bogda mountain (S.L.4,374m) in Aerhtai and the lowest point is Huhunuur (S.L.560m). Average height of Mongolia is at S.L.1,580m and Ulaanbaatar is located at S.L.1,350m. Baganuur coal mine is located at 110km east to Ulaanbaatar and 200km by a railway. The altitude of Baganuur coal mine is 1,350m above sea level, where the geographical features are flat. Baganuur coal deposit is located in the area of 55km^2 with 4.5km of width and 12.0km of length.

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.

Baganuur coal deposit belongs to the Cretaceous system. The thickness of coal bearing formation is 500m approximately. This formation is composed of sandstone, mudstone, siltstone, limestone and lignite and 24 coal seams occur in upper and lower coal bearing zone.

2.2.2 Structure of Baganuur 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 movement of Baikal, Caledonian and Hercynian. There are wide metamorphic belt and intrusive granite here and there. In general the formation of Mongolian 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.

Baganuur coal mine is located in the northern peak of the Choyr-niarga basin which belongs to the Cretaceous system. Figure 2.1 shows the geological map of Baganuur coal deposit. This coal

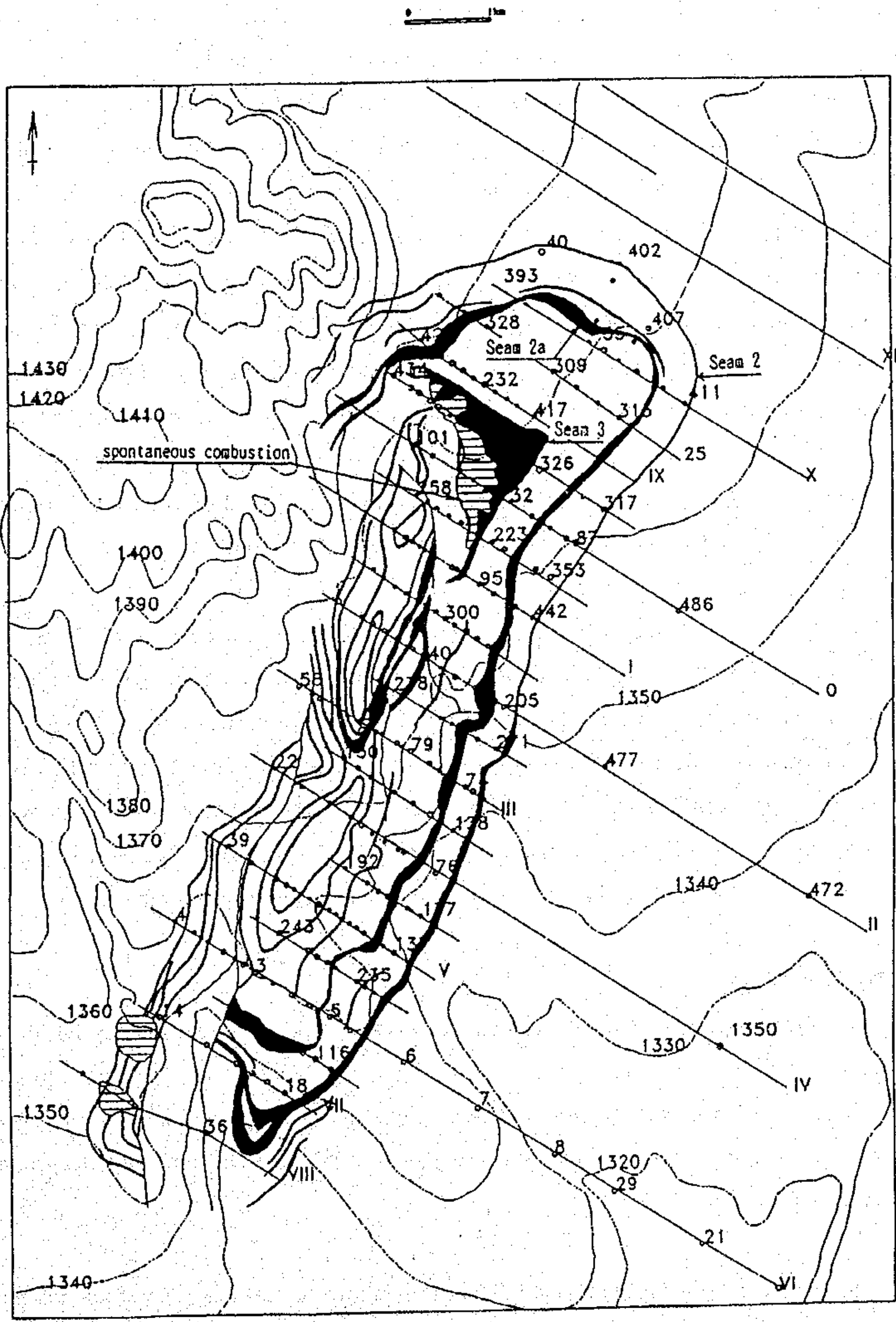


Figure 2.1 Geological Map of Baganuur Coal Mine

deposit is an oval shape with a syncline. The geological structure of this coal deposit is syncline, and the eastern and western part of the axes of this syncline are symmetrical. The direction of oval shaped coal basin is from north-northeast to south-southwest which is shown in Figure 2.1. The deepest level of coal seams is about 400m from the surface which is also the axis of this syncline (see Figure 2.2). According to the degree of coalification of coal seams, the diagenesis depth of coal seams are shallow. It is remarked that this coal basin is formed by a simple burial process of strata instead of the complicated ground stress. From the northeastern part to the east side of southern part of this coal deposit, coal seams are showing a tendency to be thickened comparatively according to the results of the past exploration works. So this area is an advantageous condition for opencut coal mining. The beds of strata and coal seams strike east-west and dip 5-20 degrees south in the northern part. It strikes north-south with dip of 5-18 degrees west and 45 degrees west near the large fault in the central part. There are 3 main faults, A-fault, B-fault, C-fault in this coal basin. B-fault is the largest fault in all and displacement is about 140m with dip of 60-65 degrees. The direction of these faults is from north-northeast to south-southwest.

Baganuur coal mine produces coal from 3 coal seams which are called as Seam 2, Seam 2a, Seam 3 from the bottom in the upper coal bearing zone. There are many lateral changes in these seams such as split and annex, thickening and thinning, etc. Some parts of coal seams have partings and lenses of coarse sandstone. The occurrence condition of coal seams is better in the eastern side than the western side in this coal deposit. Seam 2a is the best coal seam in this coal deposit and the main coal seam of Baganuur coal mine. Thickness of Seam 2a is 2.4-52m including seam splits with average thickness of 17.2m. Fig 2.3 shows the geological columbar section.

2.2.3 Hydrogeology

This area is surrounded by the mountains which consist of volcanic rocks and metamorphic rocks, and belongs to the Taban sobai drainage texture. There are 3 permeable zones called as Quaternary, Cretaceous coal bearing formation and lower Cretaceous. The small lake called Baga Gun is located in the central part of this area. The water level of this lake is related with the groundwater level of it's surrounded area.

The groundwater level at Baganuur coal mine is 15m below the surface. Therefore, it is necessary to pump out the groundwater before mining. The permeable layers were confirmed by the past exploration drillings. Baganuur coal mine has 40 boreholes for dewatering of the groundwater.

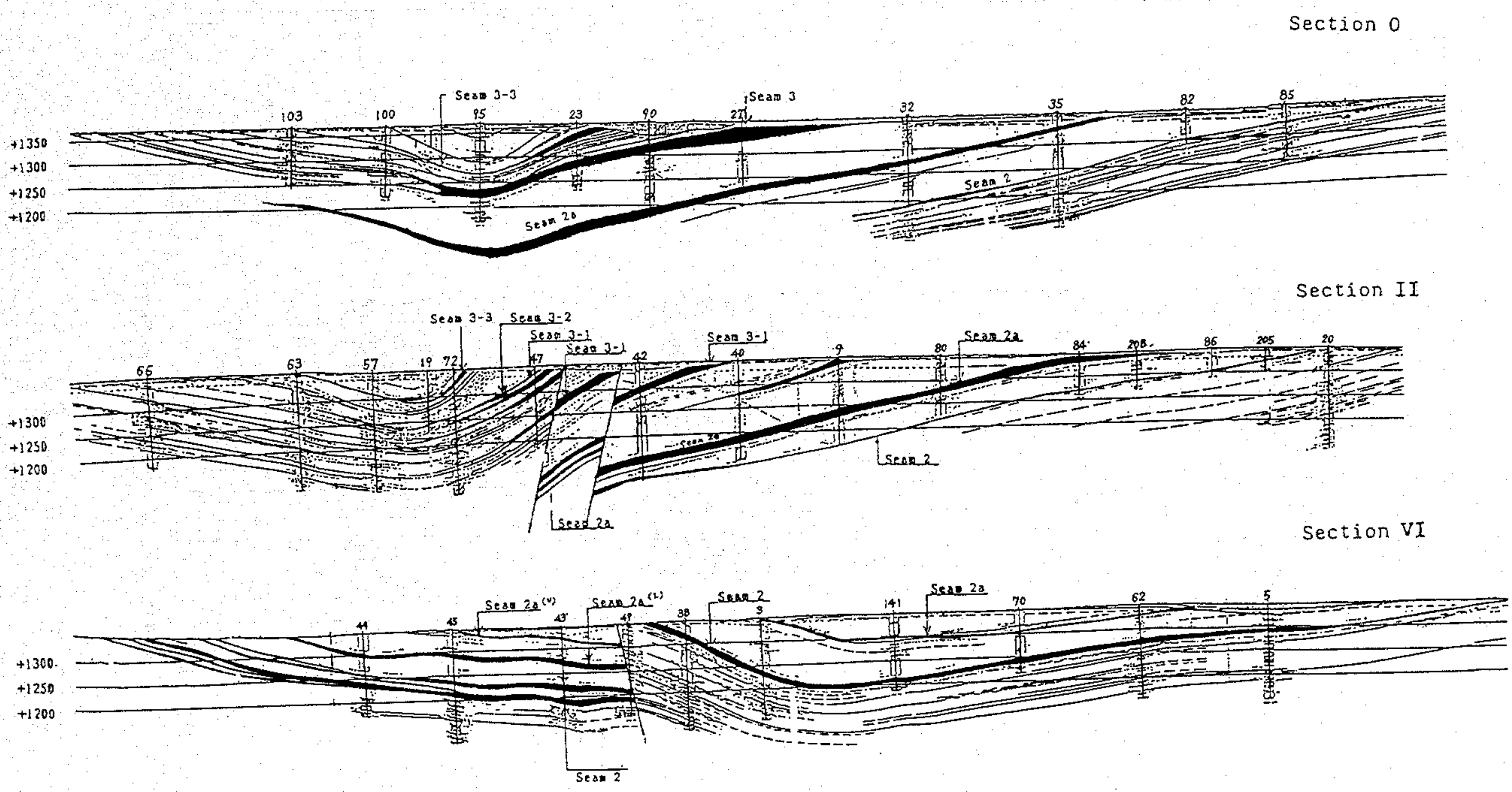


Figure 2.2 Geological Cross Section

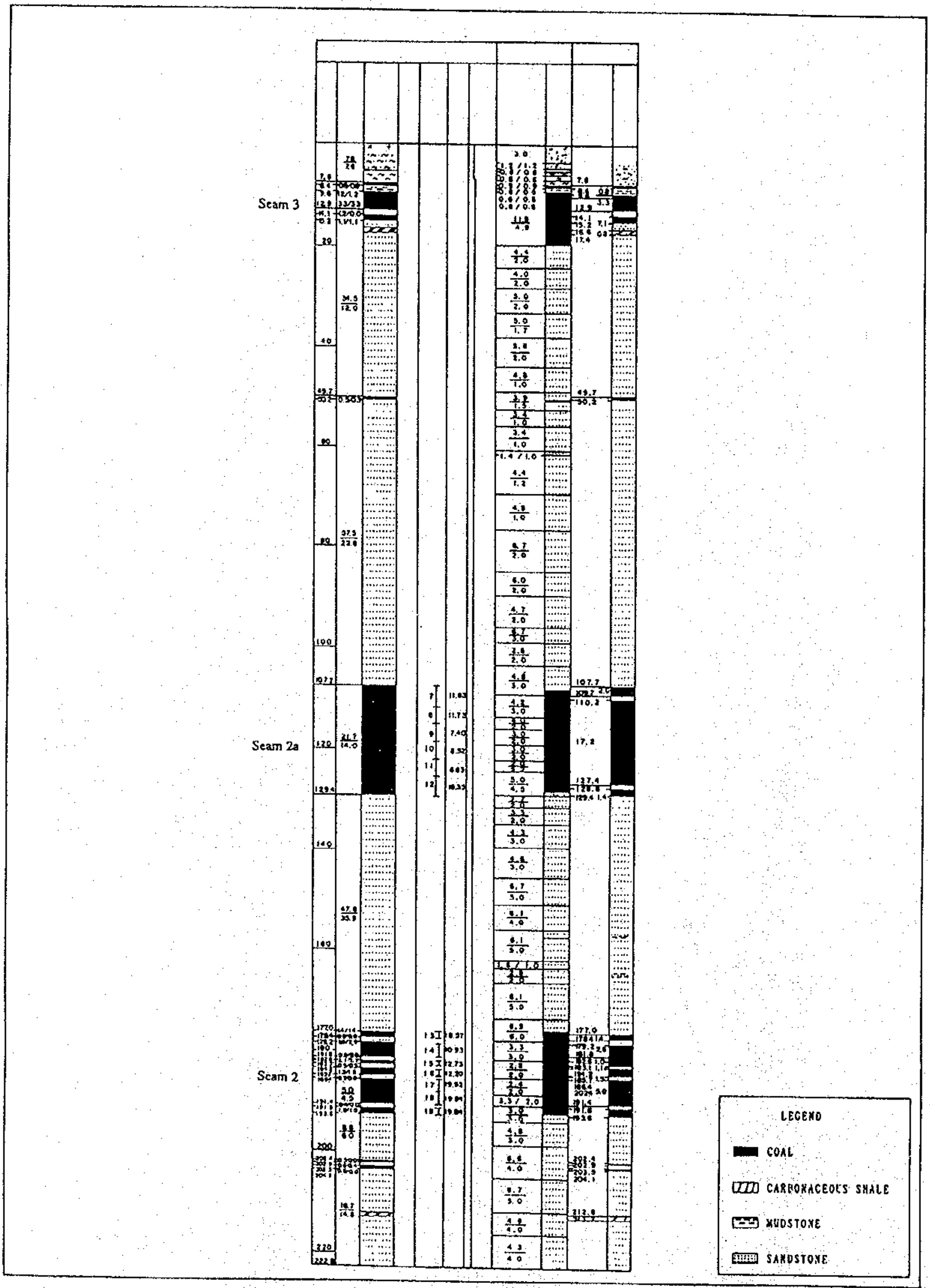


Figure 2.3 Geological Columnar Section

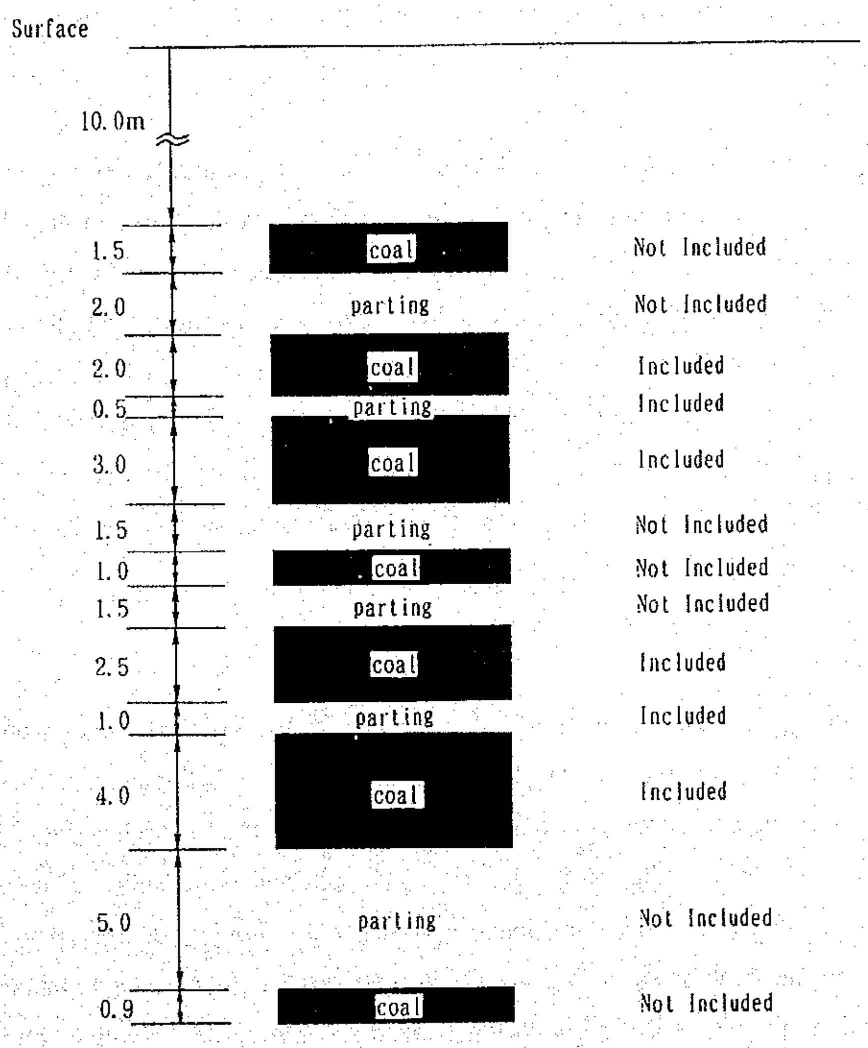
About 20,000-36,000 m^3 of the groundwater are pumped out in a day. New wells for dewatering have to be timely drilled. Also the water in mining pits has to be pumped up prior to mining of coal. Pumping up of water in Baganuur coal mine lowers the water level of the Baga Gun lake in the dry season. That is one of issues concerns for operation of Baganuur coal mine because the natural environment has to be protected.

2.3 Coal reserves

2.3.1 Proved reserves by each coal seam

Former Soviet Union calculated the proved minable coal reserves according to the Russian standard of reserves' calculation.

Proved Reserves Criteria (Baganuur)



- Coal seams less than 2.0m in thickness are not counted.

  Note: Selective mining of thinner coal seams less than 2.0m is disadvantageous to operate large-size mining equipment because it causes a reduction of mining efficiency.
- Parting material less than 1.0m in thickness is included in coal reserves.

  Note: Selective mining of thinner parting material less than 1.0m is disadvantageous.
- Oxidized coal with Overburden depth less than 10m is not included.

(1) Seam 2

Seam 2 is the lowest seam in 3 seams. It makes the outline of coal deposit. Seam 2 occurs in the area with length of 12km and width of 2.8-3.5km. In the northern part of this coal deposit, Seam 2 is showing a tendency to split and the thickness changes from 3.4m to 29m with average thickness of 10.3m. In general it is also showing a tendency to thin near the surface compare with the deep area. Proved reserves of Seam 2 are 268 million tons.

(2) Seam 2a

Seam 2a, which is upper coal seam of Seam 2, has partings and lenses of coarse sandstone. Seam 2a is the best coal seam of 3 coal seams and occurs in the area with length of 10km and width of 2.5km. The thickness of interburden between Seam 2 and Seam 2a is 7-90m with average thickness of 45m approximately and is showing a tendency to thin in the southern part including split seams. Total thickness of this seam is 2.4-52m with average thickness of 17.2m. There is the area where the coal was deteriorated by spontaneous combustion, but total volume of coal of spontaneous combustion is considered to be small. Proved reserves of Seam 2a are 246 million tons. Fig 2.4 shows the seam structure contour map of 2a seam for showing the dip direction of the oval shap deposit.

(3) Seam 3

Seam 3 is the uppermost coal seam of 3 coal seams. Seam 3 occurs in the area with length of 6.5km and width of 0.4-1.8km. The thickness of interburden between Seam 2a and Seam 3 is 20-140m with average thickness of 84m approximately. Seam 3 is divided into 3 split seams in northern part which are called as No.1 split, No.2 split and No.3 split. Seam 3 is folded by fault and is thickened by the lateral change in some areas. Average thickness of this coal seam is 11.8m and the thickest part is 120m. Seam 3 is partially affected by spontaneous combustion, of which the volume is 3 million tons. Proved reserves of Seam 3 are 53 million tons.

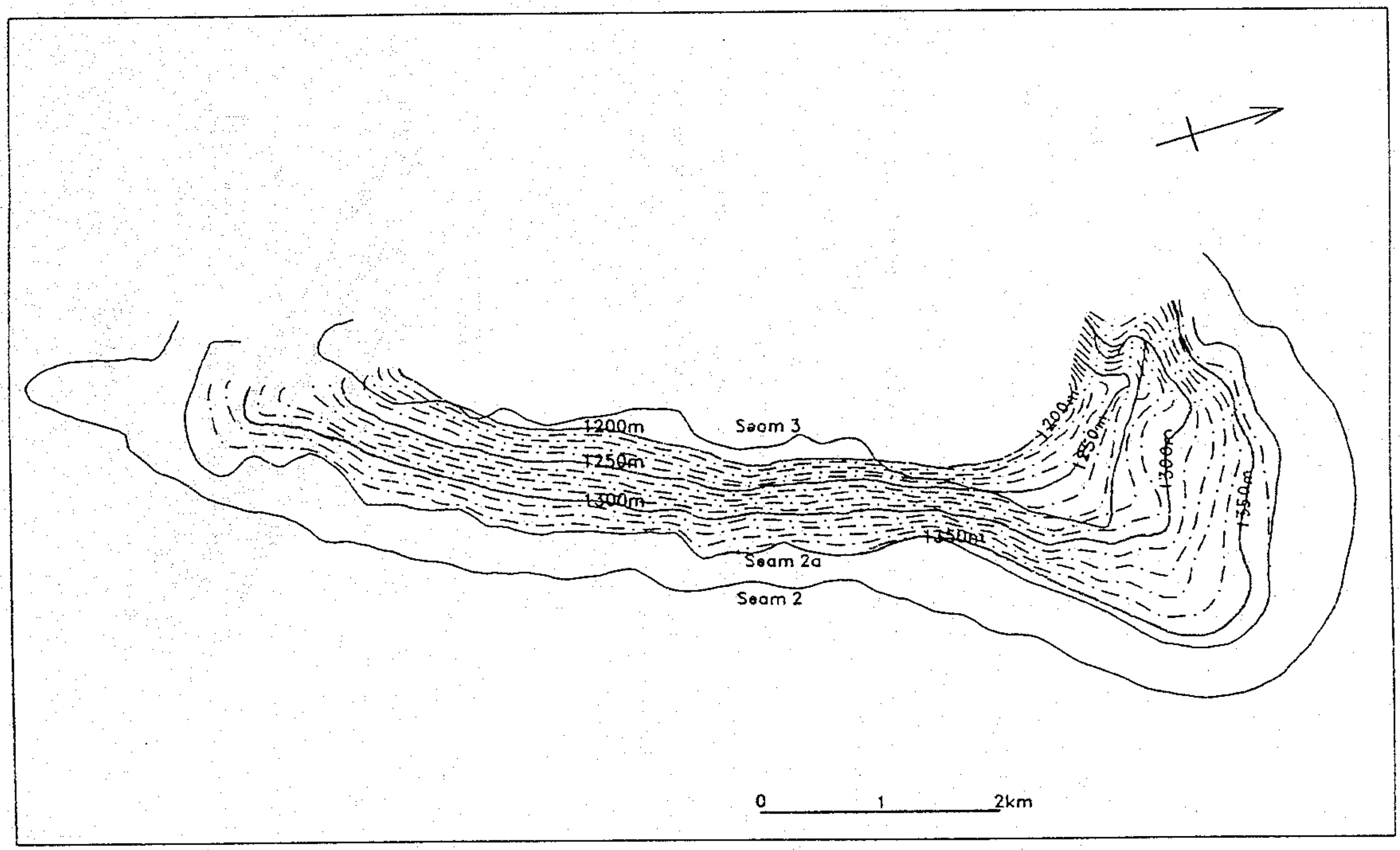


Figure 2.4 Seam Contour Map of Seam 2a

Total proved reserves of 3 coal seams are shown in Table 2.1.

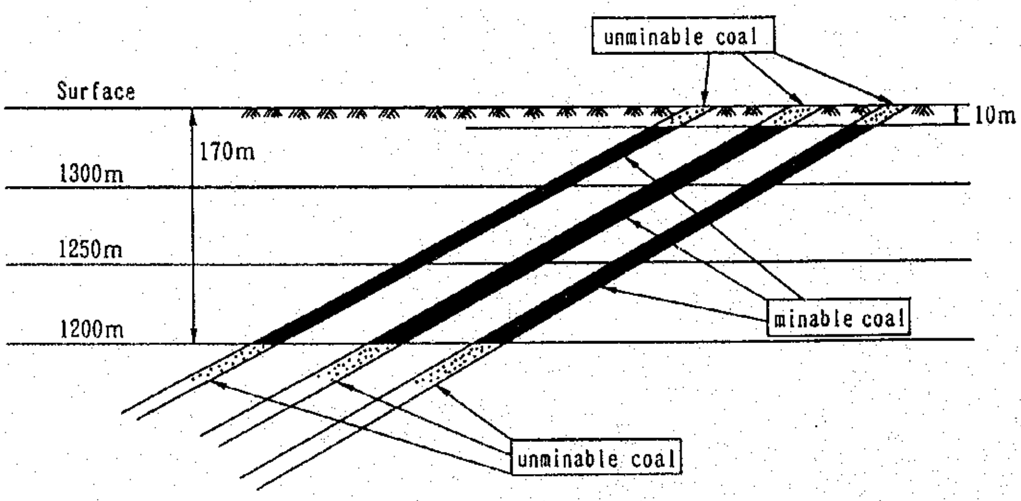
Table 2.1 Proved Reserves

Coal Seam	Proved Reserves (million tons)	Overburden/Interburden (million BCM)	S/R
3	53	113	2.13
2a	246	1,033	4.20
2	268	1,286	4.80
Total	567	2,432	4.30

2.3.2 Minable coal reserves calculated by the former Soviet Union

The basis of minable reserves calculation of Baganuur coal mine defined by the former Soviet Union is as follows.

- Coal seams less than 2.0m in thickness are not counted.
- Oxidized coal with overburden depth less than 10 m is not counted.
- Interburden less than 1.0m in thickness is counted in minable coal reserves.
- Coal seams more than 170m in depth from the surface (under 1,200 m sea level) are not counted.



There are many lateral changes in 3 coal seams such as splits and annexes, thickening and thinning, etc. Regarding to mining level, 170m from the surface is maximum mining depth. Minable reserves calculated by the former Soviet Union is 296 million tons, and total volume of overburden is 933 million BCM. Then average stripping ratio is 3.15.

Table 2.2 Minable Reserves

Coal Seam	Reserves (million tons)	Overburden/Interburden (million BCM)	S/R
3-3	6		
3-2	10	113	2.17
3-1	36		
2a	165	555	3.36
2	79	265	3.35
Total	296	933	3.15

2.4 Coal type and quality

Coal seams occur in the Cretaceous at this deposit. In general coal which belongs to the Cretaceous is expected to be good quality like bituminous coal. Baganuur coal is a lignite according to ASTM Standard and the coalification is low degree in spite of the Cretaceous coal. The reason is that layers of this area have not buried deeply, or diagenesis must have been made in the shallow depth. Accordingly, coalification did not progress in the Cretaceous. Typical coal qualities of each coal seam is shown on Table 2.3.

The samples taken respectively from Seam 2, 2a and 3 were analyzed by both methods, Mongolian method and Japanese Industrial standard (JIS), as shown in Table 2.4. Table shows that the results gained from the two methods are indistinguishable.

Table 2.3 Average Coal Quality of Main Coal Seams in Baganuur 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 basis)	Calorific Value *1 (dry ash free basis)		Calorific Value *2 (with moisture, ash basis)		Carbon (dry ash free basis)	Hydrocarbon (dry ash free basis)	Nitrogen (dry ash free basis)
						Kcal/kg	MJ/kg	Kcal/kg	MJ/kg			
2	28.9	11.0	14.8	42.7	0.73	6,854	23.7	3,829	16.0	73.14	4.60	1.0
	(55)	(569)		(382)	(492)	(266)				(154)	(154)	(75)
2a	29.8	11.4	14.2	44.1	0.67	6,828	28.6	3,761	15.7	72.82	4.68	0.99
	(61)	(738)		(446)	(173)	(426)				(190)	(190)	(105)
Seam 3-1	31.2	11.2	18.7	44.2	0.85	6,670	27.9	3,548	14.8	71.66	4.66	0.91
	(39)	(402)		(191)	(377)	(167)				(99)	(99)	(78)
Seam 3-2	32.8	11.3	16.9	45.0	0.81	6,671	27.9	3,379	14.1	71.11	4.79	0.87
	(10)	(155)		(87)	(136)	(59)				(40)	(40)	(29)
Seam 3-3	33.3	11.5	14.7	44.0	0.76	6,633	27.7	3,412	14.3	70.77	4.64	0.87
	(15)	(131)		(73)	(115)	(53)				(33)	(33)	(27)
Average of	32.4	11.4	15.8	44.4	0.80	6,660	27.9	n. a.	n. a.	71.18	4.69	0.86
Seam 3	(64)	(638)		(347)	(628)	(279)				(172)	(172)	(134)
Average of	33.3	11.2	14.9	43.8	0.73	6,780	28.4	3,616	15.11	72.38	4.65	0.96
All Seams	(180)	(1,995)		(1,175)	(1,793)	(971)				(516)	(516)	(314)

Note; ( ), Number of Samples
*1, High Heating Value
*2, Low Heating Value

Table 2.4 Result of Coal Analysis by Mongolian Method and by JIS Respectively

		by Mongolia			by JIS		
		Seam 2	Seam 2a	seam 3	Seam 2	Seam 2a	Seam 3
Total moisture	(as received)	32.9	37.8	29.5	35.3	37.2	31.6
Inherent moisture		n.a.	n.a.	n.a.	15.7 n.a.	14.5 n.a.	15.7 n.a.
Ash	(as received)	9.5	7.9	7.6	12.3 9.4	11.4 8.4	8.8 7.1
Volatile matter	(dry ash free)	43.6	45.1	46.4	32.0 44.4	33.6 45.3	44.0 58.3
Fixed carbon		n.a.	n.a.	n.a.	40.0 n.a.	40.5 n.a.	31.5 n.a.
Total sulfur	(dry basis)	0.92	0.63	0.45	0.83 0.98	0.66 0.77	0.45 0.53
Calorific value	(as received,LHV)	3,763	3,468	3,964	5,120 3,574	5,210 3,463	5,150 3,833

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.

Table 2.5 Typical Coal Qualities Required by Users

	Unit	Power Station	Industry	Other User
Moisture(as received basis)	(%)	35	36	35
Ash(dry basis)	(%)	18	15	12
Volatile matter(dry ash free)	(%)	45	45	45
Total sulfur(dry basis)	(%)	0.5	0.5	0.5
Calorific value(as received basis)	(kcal)	3,250	3,360	3,500
Size	(mm)	0-300	0-300	50-500

Baganuur coal is characterized with high moisture contents of over 30%, especially with high free moisture, and it is regarded as a low calorific coal with 3,500-3,700kcal/kg. According to some test data obtained in Shivee Ovoo Coal Mine, the calorific value can be increased if Baganuur coal is dried. Though it is necessary to study the features for drying method, it can be expected that the calorific value can be increased by 1,000kcal/kg to 1,400kcal/kg according to Figure 2.5 if it is possible to reduce total moisture from 38% to 22%.

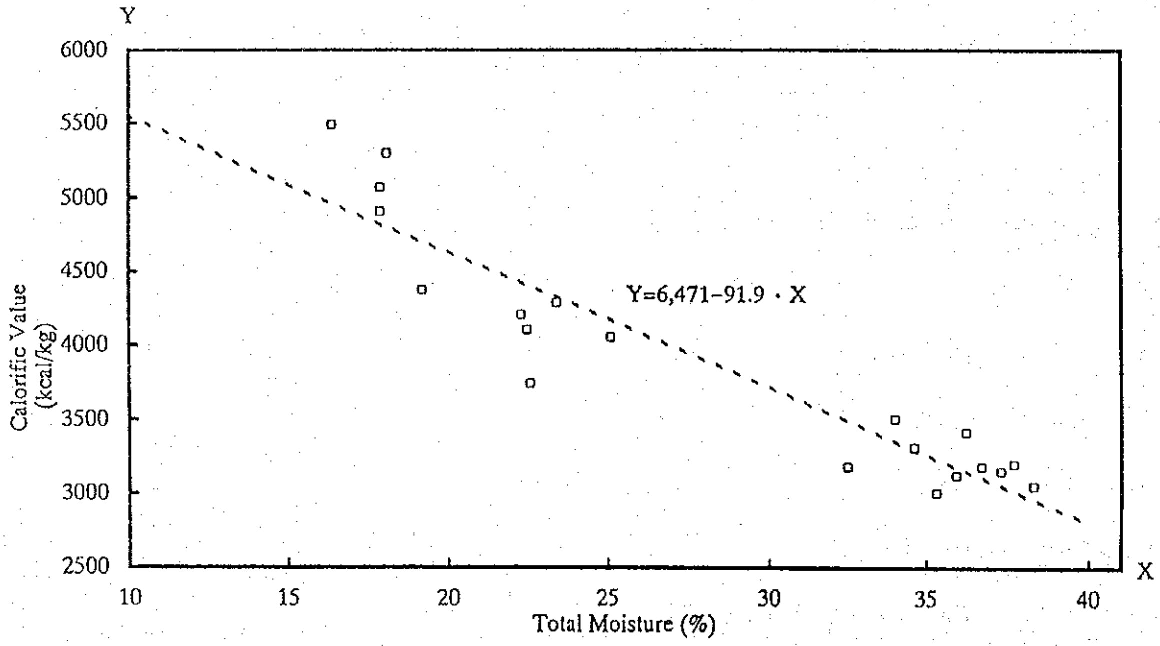


Figure 2.5 Relationship between Moisture and Calorific Value
(Shivee Ovoo Coal Mine)

Ash content does not show high value remarkably. When large-size mining equipment is used, interburdens less than 1m are sometimes mined out. When small-size mining equipment is used additionally, ash content can be reduced by applying selective mining.

Although coals produced at Pit 1, Pit 2 and Pit 3 are hauled by dump trucks and carried to the crushing and screening plant, there is no crusher at Pit 5. Therefore, it is difficult to control the size of coal produced at Pit 5. It is recommended to install a crasher at Pit 5, because it is required to control the size of coal in accordance with the contract of coal sales.

2.5 Study of mining area

2.5.1 Mining area designed by the former Soviet Union

The geological structure of this deposit is syncline. The eastern part and western part of the axes of the syncline are symmetrical. The distribution condition of coal seams is better in the east side than those in the west side. Therefore, it is evaluated that the Russian mining plan, which excavates coal from Seam 2a at Pit 1 and Pit 2, is a reasonable plan in view of the distribution of coal seams. Total minable coal reserves by coal seams and pits are shown in Table 2.6.

Table 2.6 Calculation of Measured Coal Reserves of Baganuur Coal Mine

Seam No.	Block No.*	Pit No.	Area flat (m^2)	Dip (°)	Area slope (m^2)	Thickness (m)	Specific Gravity	Reserves (million ton)
3	3-3	3	595,000	10	604,000	7.70	1.29	6
	3-2	3	774,000	13	794,000	9.76	1.29	10
	3-1	3	1,955,000	13	2,006,000	13.91	1.29	36
2a	2a-1	4	1,384,000	7	1,394,000	12.23	1.29	22
	2a-2	1	1,966,000	5	1,973,000	10.22	1.29	26
	2a-3	2	2,630,000	12	2,688,000	17.30	1.29	60
	2a-4	5	4,029,000	9	4,079,000	10.83	1.29	57
2	2-1	4	794,000	5	797,000	6.81	1.29	7
	2-2	5	5,458,000	8	5,511,000	10.13	1.29	72
						Total		296

Note : *See Fig 2.6

Figure 2.6 shows Coal Calculation Map of Baganuur coal mine. If 296 million tons of coal, which is total minable coal reserves, is produced, 933 million BCM of overburden have to be removed with stripping ratio of 3.15.

2.5.2 Recommended mining areas for 6 million tons per year

Considering the occurrence of coal seams and the amount of minable coal reserves at Baganuur coal mine, it is judged that production expansion to 6 million tons per year should be taken place by modifying a mining plan prepared by the former Soviet Union. Although the mining plan prepared by the former Soviet Union is a reasonable and practical, it is recommended to review mining depth, mining areas and coal recovery ratio for effective extraction and utilization of coal reserves at Baganuur coal mine. According to the mining plan prepared by the forme Soviet union, maximum mining depth is 170m from the surface. However, it was identified that the coal seams continue to extend below 170 m from the surface and substantial amount of coal reserves exist though these below 200 m from the surface are excluded. The occurrence and continuation of the coal seams are shown in Fig 2.2. There exist coal reserves 170 m underneath. They are minable economically and it would be advantageous for Baganuur coal mine to extend operating life. For example, the section 0 shows that thick coal Seam 2a is occurring in the deep area below 1,200 m sea level which is 170 m below the surface, also, mining Seam 2 at the Pit 2 is economical because the

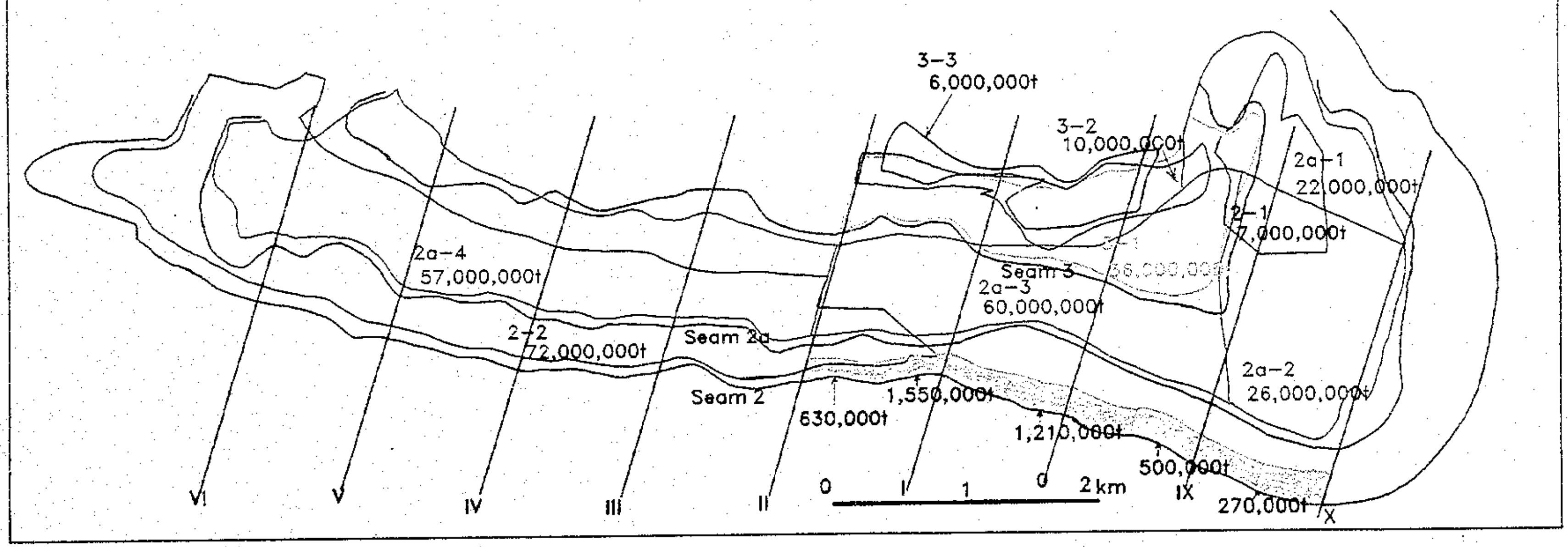


Figure 2.6 Coal Calculated Map of Baganuur Coal Mine

outcrop of seam 2 is occurring. Fig 2.7 shows mining plan and minable coal reserves. Stripping ratio of interburden between Seam 2a and Seam 2 against the coal reserves of Seam 2 is 5.0 approximately. Thus, overall stripping ratio of overburden and interburden against total coal reserves of whole coal seams is estimated to be about 4.2.

The following threes cases were studied to make a comparison in selection of the optimum coal recovery ratio.

Case 1 : Present mining plan (up to 170m from the surface)
Case 2 : Medium depth of case 1 and case 3
Case 3 : Maximum mining depth (up to 200m from the surface)

Table 2.7 Comparison Study of Coal Recovery Ratio

	unit	Case 1	Case 2	Case 3
Depth of mining	m	170	190	200
Minable coal	m.t	260	400	480
Coal recovery ratio	%	54	83	base*1
Total coal production	m.t/y	6	6	6
Life of mine	years	43	67	80
Required total capacity	m.BCM/y	24	27	30
existing system		(17.3)	(17.3)	(17.3)
by additional system		(6.7)	(9.7)	(12.6)
Stripping ratio (average)	BCM/t	3.2	3.7	4.2

Note *1 This base of coal recovery ratio is assumed to be 100% which is about 85% of measured reserves, because the reserves below 200m is excluded due to insufficient geological data.

It is recommended to review coal recovery ratio in accordance with the results shown in Table 2.7. Comparative study were carried for these 3 cases in terms of coal cost index and results are shown in Table 4.4 in the section of economics 4.1.3.

The reasons are as follows;

- Coal recovery ratio is only 54% in accordance with the pit design carried out the former Soviet Union and the remaining in reserves will be wasted.
- Life of Baganuur coal mine can be extended to 80 year in case 3, if coal recovery ratio is increased to 85%.
- Stripping ratio of 4.2 in case 3 is considered to be liable economically because it is low

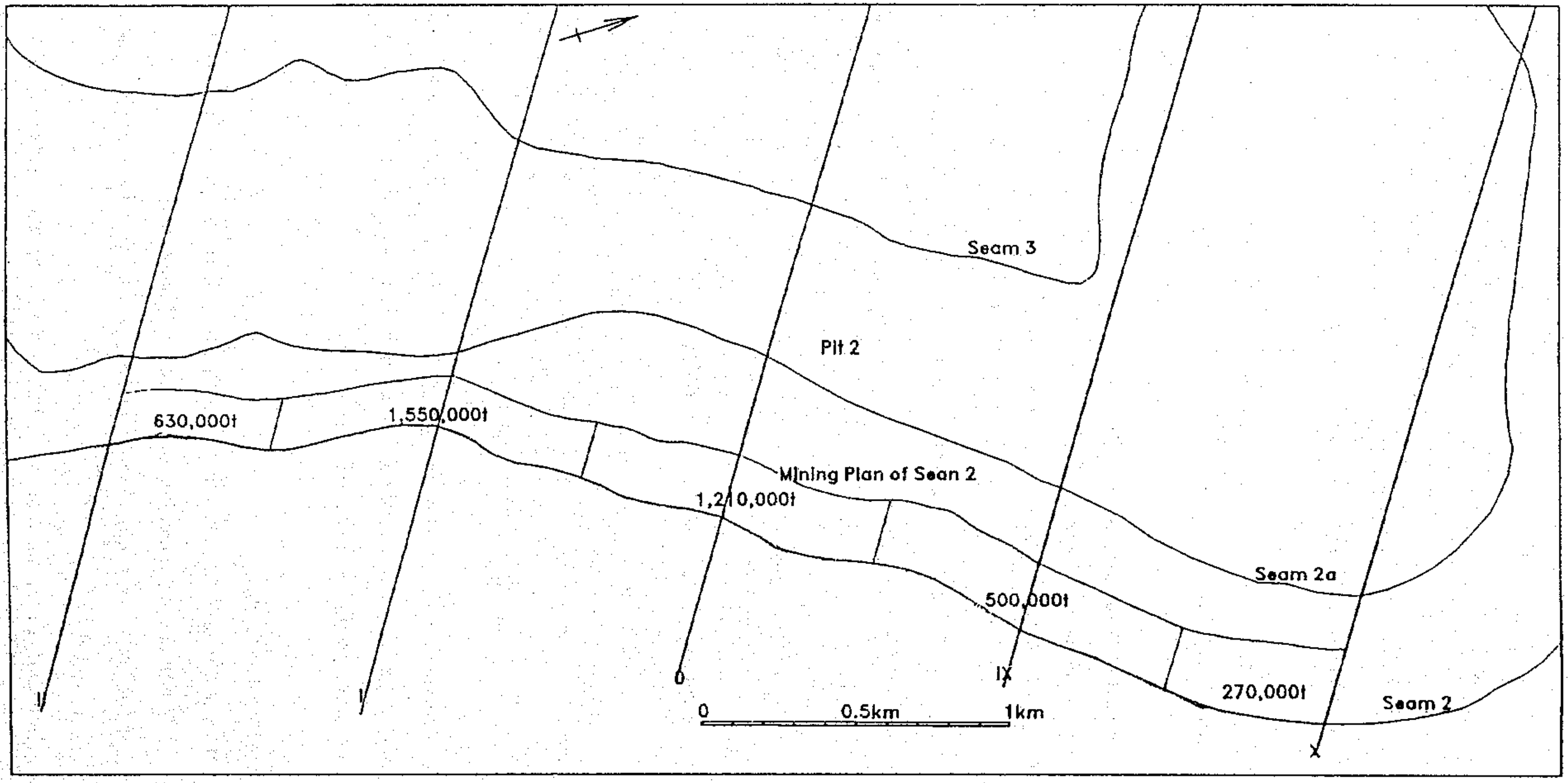


Figure 2.7 Mining Plan of Seam 2 in Pit No.2

enough in comparison with stripping ratio of 7 at Sharingol coal mine where coal with calorific values of 4,000 kcal/kg is mined.

Three million ton of Seam 3 near the surface is deteriorated by partial spontaneous combustion. Utilization of oxidized coal needs blending with high calorific coal.

Table 2.8 Volume of Oxidized Coal due to Spontaneous Combustion

Seam No.	Pit No.	Area flat (m^2)	Dip (°)	Area slope (m^2)	Thickness (m)	Specific gravity	Reserves (million ton)
3-1	3	177,000	13	181,000	13.91	1.29	3

3 Present Status of Baganuur Coal Mine

3.1 History of exploitation

Baganuur coal mine had been developed by the Mongolian government under the support of the former Soviet Union. Feasibility studies for mine development were carried out by the Institute of National Project of the former Soviet Union (INPS) which was located in Leningrad, and the report for the first stage (4 million tons of coal per year of design capacity) was submitted to the Mongolian government in 1979 and that for the second stage (6 million tons of coal per year) in 1985. Actual production of coal commenced by a small scale opencut in 1978, producing 155,000 tons of coal. Development of Baganuur coal mine with a large scale opencut commenced in 1979. Design capacity of Baganuur coal mine reached to 2 million tons of coal per year in 1986, to 4 million tons of coal per year in 1990 and to 6 million tons of coal per year in 1992. Details of design capacity of coal production are shown in Tables 3.1 and 3.2.

Coal production was peaked out at 4 million tons in 1988. However, production decreased year by year (see Tables 3.3 and 3.4) since then. Table 3.1 shows the actual trend of coal and overburden excavation in comparison with the designed volume. Total of coal production and corresponding overburden removal is increasing, although it was only 55 % of designed capacity in 1993.

Table 3.1 Comparison of Design Capacity and Actual Production

Year	Coal production (m.t/y)		Overburden removal (m. BCM/y)		Total (m. BCM/y)	
	Design	Actual	Design	Actual	Design	Actual
1983	1.0	0.7	2.2	3.2	3.0	3.7
1986	2.0	3.2	4.4	6.0	6.0	8.5
1989	3.0	3.8	10.2	8.1	12.5	11.1
1992	6.0	3.4	15.0	9.7	19.7	12.4
1993	6.0	2.9	17.0	9.7	21.7	11.9

Table 3.2 Design Capacity of Baganuur Coal Mine

Year	Seam 2	Seam 2a	Seam 3	Coal Total		Overburden Total	Grand Total	S/R
	×1000t	×1000t	×1000t	×1000t	×1000bcm	×1000bcm	×1000bcm	bcm/t
1981		200		200	155	1,415	1,570	7.1
1982		500		500	388	1,130	1,518	2.3
1983		1,000		1,000	775	2,230	3,005	2.2
1984		1,100		1,100	853	2,640	3,493	2.4
1985		1,500		1,500	1,163	3,775	4,938	2.5
1986		2,000		2,000	1,550	4,435	5,985	2.2
1987		2,000		2,000	1,550	5,430	6,980	2.7
1988		2,000		2,000	1,550	6,630	8,180	3.3
1989		3,000		3,000	2,325	10,160	12,485	3.4
1990		4,000		4,000	3,100	10,800	13,900	2.7
1991		5,000		5,000	3,875	12,550	16,425	2.5
1992		6,000		6,000	4,650	15,000	19,650	2.5
1993		6,000		6,000	4,650	17,020	21,670	2.8
1994		6,000	1,000	7,000	5,425	20,320	25,745	2.9
1995		6,860	1,140	8,000	6,200	22,970	29,170	2.9
1996		6,560	1,440	8,000	6,200	25,170	31,370	3.2
1997		6,150	1,850	8,000	6,200	26,840	33,040	3.4
1998		6,350	1,650	8,000	6,200	26,440	32,640	3.3
1999-2003		22,500	17,500	40,000	31,000	105,900	136,900	2.9
2004-2008		7,980	32,020	40,000	31,000	74,240	105,240	1.9
2009-2018	8,100	71,646	254	80,000	62,000	225,420	287,420	2.8
2019-2030	69,660	12,184		81,844	63,445	301,650	365,095	3.7
Total	77,760	180,530	56,854	315,144	244,254	922,165	1,166,419	2.9

Source; GIPRO F/S, USSR

Table 3.3 Production Record of Baganuur Coal Mine

Year	Pit 1			Pit 2			Pit 5			TOTAL			Grand	S/R
	Coal		Overburden removal	Coal		Overburden removal	Coal		Overburden removal	Coal (A)		Overburden removal(B)	Total of Excavation	
	x1000t	x1000bcm	x1000bcm	x1000t	x1000bcm	x1000bcm	x1000t	x1000bcm	x1000bcm	x1000t	x1000 bcm	x1000 bcm	x1000 bcm	B/A
1978							155.0	120.2	432.0	155.0	120.0	432.0	552.0	2.8
1979							430.0	333.3	446.0	430.0	333.0	446.0	779.0	1.0
1980							538.0	417.1	740.0	538.0	417.0	740.0	1,157.0	1.8
1981							171.0	132.6	711.9	171.0	133.0	711.9	844.9	4.2
1982	541.0	419.4	2,159.0				159.0	123.3	19.0	700.0	543.0	2,178.0	2,721.0	3.1
1983	620.0	480.6	3,140.0				97.0	75.2	16.0	717.0	556.0	3,156.0	3,712.0	4.4
1984	1,327.0	1,028.7	2,886.0				132.0	102.3		1,459.0	1,131.0	2,886.0	4,017.0	2.0
1985	2,363.0	1,831.8	3,258.0			1,741.0	204.0	158.1	655.0	2,567.0	1,990.0	5,654.0	7,644.0	2.2
1986	1,249.0	968.2	2,273.6	1,485.0	1,151.2	2,477.4	448.0	347.3	1,275.0	3,182.0	2,467.0	6,026.0	8,493.0	1.9
1987	830.0	643.4	2,426.0	2,032.0	1,575.2	3,081.0	477.0	369.8	752.0	3,339.0	2,588.0	6,259.0	8,847.0	1.9
1988	823.0	638.0	2,910.4	2,696.0	2,089.9	2,943.2	535.0	414.7	1,209.4	4,054.0	3,143.0	7,063.0	10,206.0	1.7
1989	891.0	690.7	2,000.0	2,551.0	1,977.5	4,816.0	344.0	266.7	1,297.0	3,786.0	2,935.0	8,113.0	11,048.0	2.1
1990	700.0	542.6	1,500.0	2,745.0	2,127.9	3,847.0	286.0	221.7	809.6	3,731.0	2,892.0	6,156.6	9,048.6	1.7
1991	571.0	442.6	2,072.0	2,371.0	1,838.0	4,401.0	890.0	689.9	756.0	3,832.0	2,971.0	7,229.0	10,200.0	1.9
1992	449.0	348.1	3,587.7	2,464.9	1,910.8	4,800.0	485.0	376.0	1,347.0	3,398.9	2,635.0	9,734.7	12,370.0	2.9
1993	449.4	348.4	2,837.1	1,974.3	1,530.5	5,507.0	424.0	328.7	1,335.9	2,847.7	2,208.0	9,680.0	11,888.0	3.4

Source; Ministry of Energy, Geology and Mining
Note; Specific gravity of coal, 1.29

Table 3.4 Overburden Removal of Baganuur Coal Mine

(Unit; 1000bcm)

Year	No.1 Pit						No.2 Pit						No.5 Pit				Total		From total							
																			D/L		Rail		Truck		Rehandle	
	*Proj.	D/L	Rail	Truck	Actual	D/L rehandle	Proj.	D/L	Rail	Truck	Actual	D/L rehandle	D/L	Truck	Actual	D/L rehandle	Proj.	Actual	Proj.	Actual	Proj.	Actual	Proj.	Actual	Proj.	Actual
1978														432.0	432.0			432.0								
1979														446.0	446.0			446.0								
1980														739.6	740.0			740.0								
1981	1,415.0	885.1			885.1									711.9	711.9		1,415.0	1,597.0	1,415.0	835.0						
1982	1,130.0	2,159.0			2,159.0	906.7								19.0	19.0		1,130.0	2,178.0	1,130.0	2,178.0				19.0	300.0	906.7
1983	2,230.0	3,140.0			3,140.0	768.0								16.0	16.0		2,230.0	3,156.0	2,230.0	3,140.0				16.0	500.0	768.0
1984	2,640.0	2,884.0		2.0	2,886.0	900.0											2,640.0	2,886.0	2,640.0	2,884.0				2.0	700.0	900.0
1985	3,775.0	3,258.0			3,258.0	579.2		1,741.0			1,741.0		623.0	32.0	655.0	201.8	3,775.0	5,654.0	3,775.0	5,622.0					1,000.0	579.2
1986	4,435.0	2,202.0		71.6	2,273.6	513.1		2,477.4			2,477.4		1,222.0	52.7	1,275.0		4,435.0	6,026.0	4,435.0	5,901.4				124.3	2,400.0	513.1
1987	5,430.0	2,398.9		27.1	2,426.0	618.3		2,450.0	631.0		3,081.0		752.4		752.0	434.0	5,430.0	6,259.0	5,430.0	5,601.0	1,000.0	631.0		27.1	2,400.0	7,339.5
1988	6,630.0	1,134.1	1,713.9	62.4	2,910.4	1,710.7		2,771.6	171.5		2,943.2		1,209.4		1,209.4	422.1	6,630.0	7,063.0	6,630.0	5,286.8	2,200.0	1,885.4		62.5	2,400.0	2,804.0
1989	6,930.0	2,000.0			2,000.0	2,472.1	3,230.0	1,202.2	3,614.0		4,816.0		1,274.7	22.3	1,297.0	331.8	10,160.0	8,113.0	6,930.0	4,476.7	5,600.0	3,614.0		22.3	2,400.0	2,803.9
1990	6,630.0	1,500.0			1,500.0	3,000.0	4,170.0	1,457.0	2,390.0		3,847.0	305.3	809.1	0.5	809.6	689.2	10,800.0	6,156.6	4,800.0	3,766.1	6,000.0	2,390.0		0.5	2,400.0	3,995.4
1991	6,730.0	2,072.0			2,072.0	2,160.0	5,820.0	1,424.2	2,148.5	628.3	4,401.0	1,381.8	722.5	33.5	756.0	641.0	12,550.0	7,229.0	4,650.0	4,218.6	7,900.0	2,148.5		861.8	2,450.0	4,163.3
1992	6,630.0	2,231.5	94.5	1,261.7	3,587.7	1,451.9	8,370.0	2,000.0	1,000.0	1,800.0	4,800.0	2,000.0	1,124.2	223.2	1,347.0	507.6	15,000.0	9,734.7	4,770.0	5,355.3	10,230.0	1,094.5		3,284.9	2,450.0	4,093.4
1993	6,530.0	2,055.6	81.5	700.0	2,837.1	1,000.0	10,490.0	2,416.9	1,900.0	1,190.3	5,507.0	1,949.0	982.5	353.4	1,335.9	469.1	17,020.0	9,680.0	4,470.0	5,455.0	12,250.0	1,981.3		2,243.7	2,500.0	3,418.1

Source; Ministry of Eenrgy, Geology and Mining

Note; *Proj. : GIPRO F/S(1985), USSR

3.2 Present mining status

3.2.1 Present mining system and equipment

(1) Present mining system

Present mining system of Baganuur coal mine was designed by INPS of the former Soviet Union, which is made of the following 3 sub-systems(Figures 3.1 and 3.2);

- shovel and railway
- shovel and truck
- dragline (no transportation)

The features of mining system of Baganuur coal mine are that stripping and transportation of overburden are carried out by the various type of electric mining equipment such as draglines, electric rope shovels and electric locomotives with railway wagons. Only rear dump trucks, which hauls coal, are operated by the imported diesel oil as an energy source, while all other electric mining equipment are operated by the electricity which is domestically generated from domestic coal.

Shovel and railway subsystem has been utilized to carry out forward stripping of overburden. Although shovel and truck subsystem was adopted to haul coal to the crushing and sizing plant from the coal pits, it is now utilized for hauling both coal and overburden because stripping of overburden by shovel and railway subsystem has been delayed due to low utilization. Dragline subsystem has been utilized to expose coal by sidecasting overburden after forward stripping of overburden which was taken place in advance by shovel and railway subsystem. Before excavation of overburden, drilling and blasting are carried out especially in winter season due to freezing of coal and overburden in the cold weather. Dewatering work is carried out by pumping the underground water from wells in advance of excavation work in order to prevent from water troubles at the working face of pits. Much in decrease of moisture content in coal through more thorough dewatering work are desired. Design basis for mine design is shown in Table 3.5.

Table 3.5 Basic Parameter for Mine Design

Rest angle of spoil	35 - 36 degrees
High wall	60 - 80 degrees
Pit length	800 m, 1,000 m, 1,200 m
Interval of ramp	400 m
Width of ramp	15 m
Inclination of ramp	70/1,000
Depth of pit	50 m
Specific weight	1.3 tons/m^3 (In-situ coal) 2.2 tons/m^3 (Solid rocks) 0.9 - 1.0 tons/m^3 (loose coal)
Swell factor	25 %
Rehandling	62 %
Rail transporting distance	8 km
Rail gradient	25/1,000
Coal transporting distance	4 km
Waste transporting distance by truck	3.5 km
Drilling pattern	3 x 3 - 6 m 10 - 25 m of depth
Powder factor	coal 0.15 - 0.2 kg/BCM waste 0.25 - 0.6 kg/BCM
Underground water level	1 - 24m from surface
Dewatering well	1st row 38 2nd row 21
Rain fall	300 mm/year
Operating days	Public holidays 8 Cold weather 20 Total 337
Operating hour	3 shifts, 8 hours/shift
Annual scheduled working hours	D/L and shovel 6,363 hrs Truck 6,208 hrs Drill rig 6,386 hrs

(2) Mining equipment

As Baganuur coal mine was designed by INPS of the former Soviet Union, almost all of the equipment were imported from the former Soviet Union. Most of technical documents are written in Russian language. However, maintenance manuals or books of spare parts are not available for some of the equipment. Spare parts are imported from Russia. Currently, price of the Russian made equipment is around one third or fourth of the international standard price. However, the Russian economic condition is in the process of changing to market economy from planned economy. It is necessary to pay attention to the price of Russian equipment if use of Russian equipment is considered, because the price structure in Russia has not yet achieved to the stable condition so far and will increase to price of international level in the future.

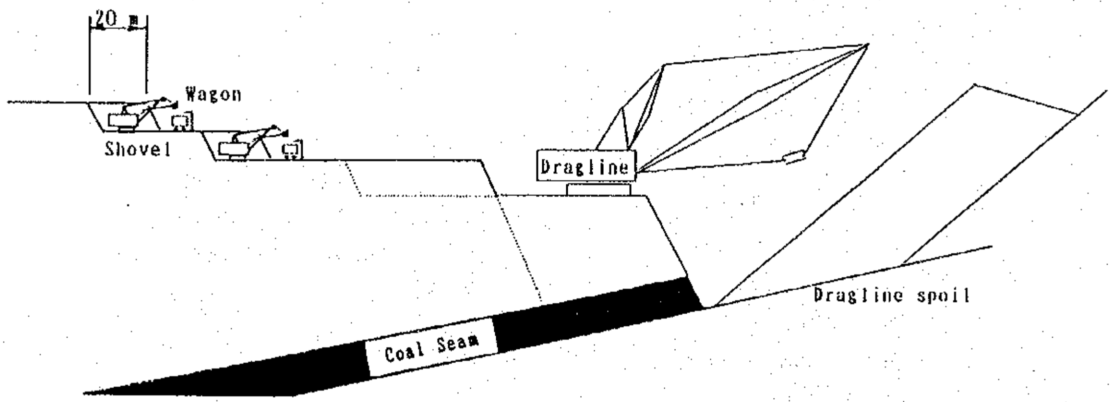


Figure 3.1 Present Mining System

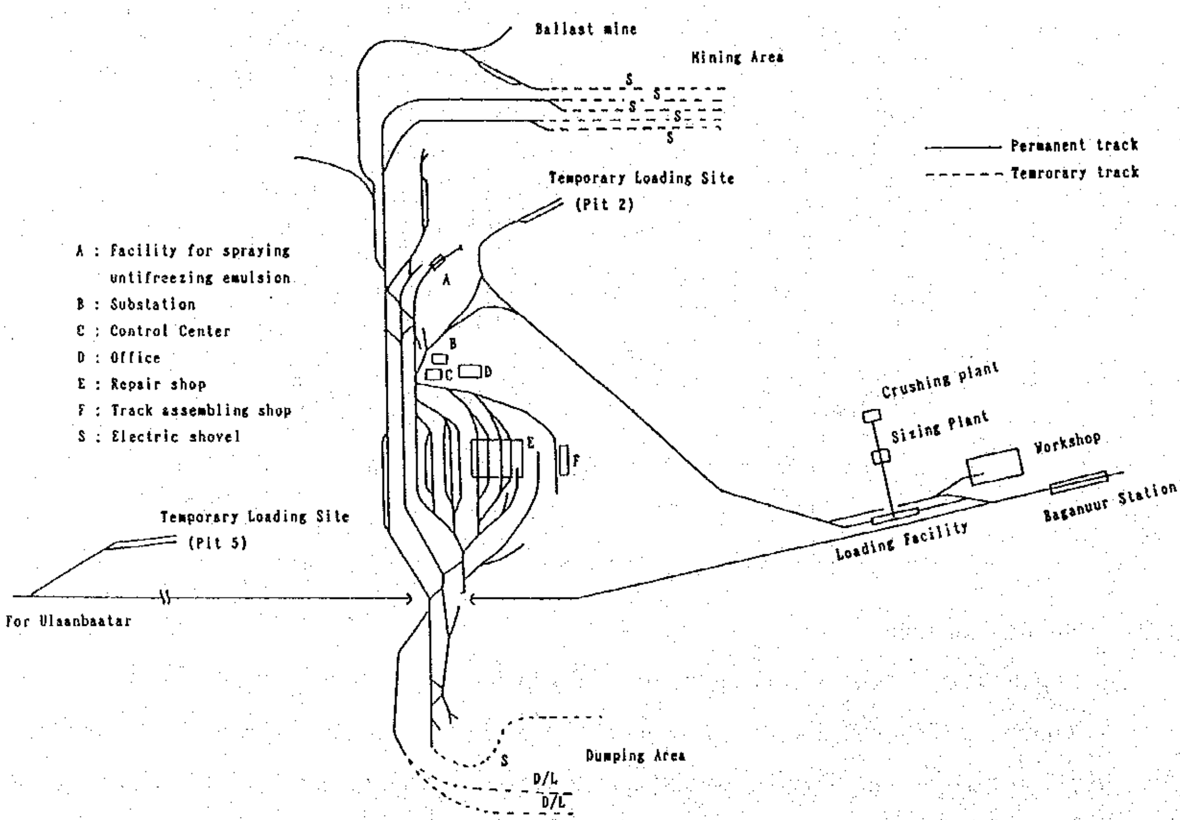


Figure 3.2 Schematic Layout of Railway System

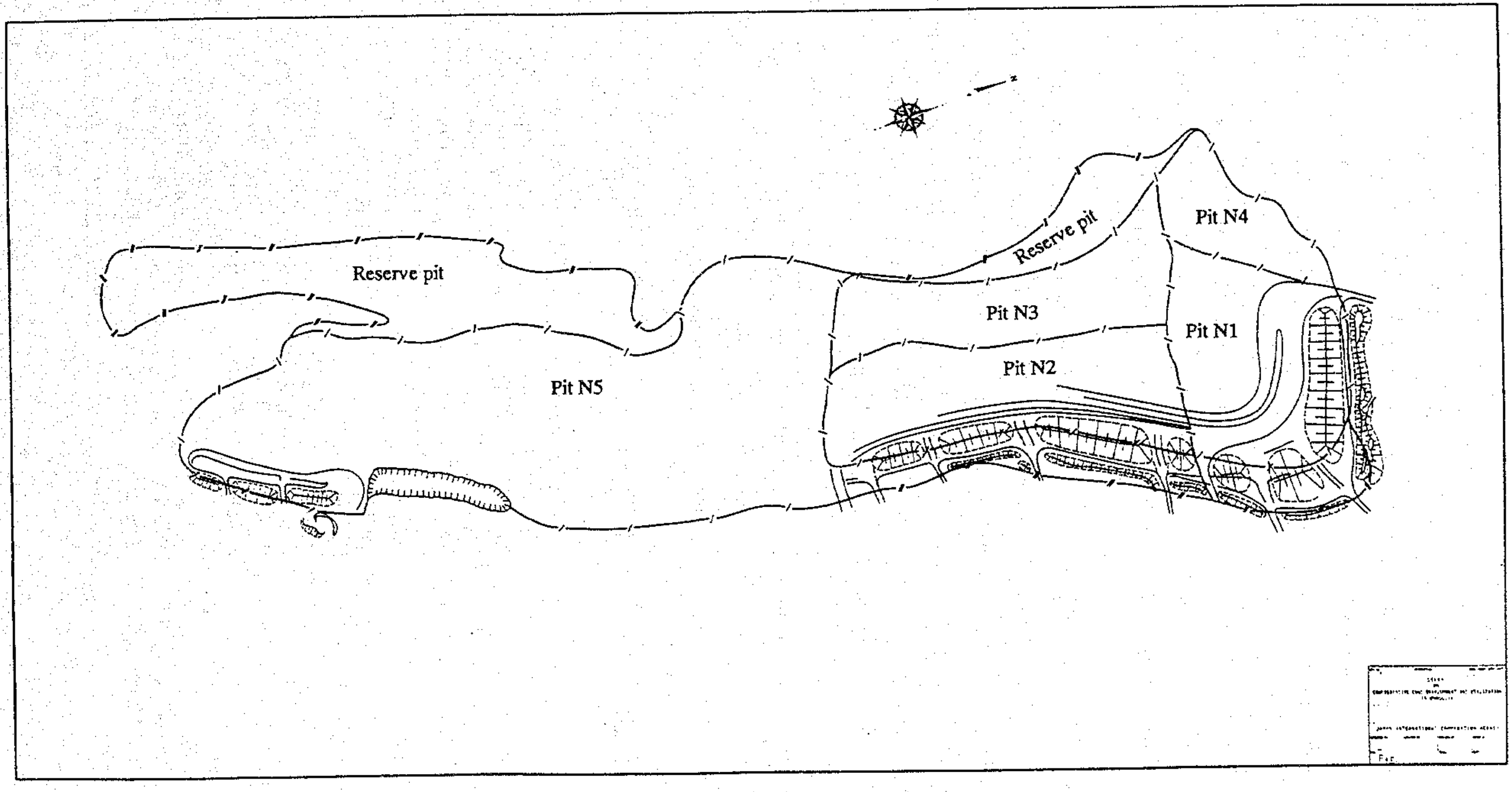


Figure 3.3 Current Layout of Baganuur Mine

The Russian equipment are well suited for cold weather and it is not so difficult to purchase the spare parts if foreign currency is available. Main mining equipment such as dragline, shovel and drill are operated by the electricity which is generated by domestic coal. Energy source of mobile equipment such as dump truck, bulldozer, grader and other vehicles are imported fuel which requires foreign currency to purchase. Analysis by the Mining Institute of Mongolia shows that utilization of main equipment have been getting lower year by year. Main reason of low utilization is due to the shortage in supply of spare parts. The shortage of fuel and explosives is also another reason for low utilization of mining equipment.

In Mongolia, performance of mining activity or equipment are evaluated by the efficiency, while mechanical availability is not calculated for analysis. In this study, therefore, mechanical availability as well as utilization were also analyzed by JICA study team. As a result, it was found that mechanical availability is reasonably high, but efficiency is low due to the low utilization because of delays associated with lack of operators, railway wagons, etc. Definition of availability and utilization is shown in Appendix 1.

Installed main equipment at the end of 1993 are shown in Table 3.6

Table 3.6 List of Major Equipment

	Type		unit	purchased
Dragline	ESH 20/90	20m^3	1	1985
	ESH 15/90	15m^3	1	1981
	ESH 10/70	10m^3	2	1980, 1989
	ESH 13/50	13m^3	3	1987, 1988, 1991
Shovel	EKG 8u	8m^3	4	1987, 1988, 1989, 1989
	EKG 5A	5m^3	5	1984, 1986, 1988,1991,1993
	EKG 4.6b	4.6m^3	4	1979, 1982, 1982, 1985
	EKG 4y	4m^3	2	1987, 1988
Drill	CbR 160		8	1983 -- 1992
	SVB 2M		2	1987
Bulldozer	DE-110		4	1990
	DET-250	250 HP	6	1988 -- 1992
	D-155	289 HP	6	1992 x 3, 1993 x 3
Dump truck	Belaz	40 ton	19	1987 -- 1993
	Komatsu	32 ton	20	1992
Scraper			2	1989, 1992
Grader			3	1989, 1992 x 2
Electric locomotive	ONE 1A	4,000 HP	10	1987 -- 1990
Diesel locomotive	TEM 2	1,200 HP	5	1987 -- 1994
Wagon	2BC-105	50m^3	106	1987 -- 1992

Operation hour analysis is shown in Appendix 2. According to our operating hour analysis, the current real production capacity of overall mining system is estimated to be about 4.0 million tons of coal and 14.2 million BCM of overburden. Regarding to the stripping capacity of draglines, 5.7 million BCM of overburden will be only possible for the shallow area. The capacity of shovel and railway system is estimated to be about 3.6 million BCM per year.

1) Drilling and blasting equipment

From November to May, overburden is frozen and blasting is required. Eight units of Russian drilling machines are operated for drilling the blast holes. Specifications of drilling machines are shown in Table 3.7.

Table 3.7 Specification of Drilling Machine

Type		CbR 160	SVB 2M
Make		Russia	Russia
Rod length		4.2 meter spiral	1.8 meter
Hole diameter		160 mm	150 mm
Power		Electric 184 kW	Electric
Drill angle		90, 75 degrees	90, 70 degrees
Dimension	Length	7,080 mm	4,300 mm
	Width	3,420 mm	2,826 mm
	Height	12,925 mm	6,030 mm
Weight		24.9 tons	9.8 tons
penetration rate		0.05 m/sec.	0.16 m/sec
		35 m/hour	136 m/hour
Designed capacity		20,000 m/year approx.	50,000 m/year approx.
Age		10, 6, 6, 5, 5, 4, 3, 2	6, 6
Operation record (1992)			
Availability		50%	n.a
Utilization		56%	n.a
Efficiency		28%	n.a

All drilling machines are a crawler mounted type and dust collector is not equipped. Results of the operating hour analysis show that mechanical availability is around 50%, because the time required for planned maintenance is so long. Utilization is lower than 60%, because the equipment are not required to operate in summer season. Total efficiency is lower than 30%. ANFO trucks are operated for ANFO transportation and charging.

2) Dragline

In total, 7 draglines are operated at Baganuur coal mine. 5 draglines are operated for overburden removal and 2 small draglines are operated for material handling at waste dump spoil. All draglines are Russian made. Specification of the draglines are shown in Table 3.8.

Table 3.8 Specification of Dragline

Type	ESH 20/90	ESH 15/90	ESH 10/70	ESH 13/50
Make	Russia	Russia	Russia	Russia
Boom length	90	90	70	50
Boom angle (degree)	32	32	32	35
Operating radius(m)	83	83	66.5	46.5
Max.dumping height(m)	38.5	39.5	27.5	20.5
Max.Digging depth(m)	42.5	42.5	35.0	21.0
Bucket capacity	20	15	10	13
Rated power(kW)	2,500	2,100	1,380	1,380
cycle time(sec.)	63	63	55	39
Capacity (1000 BCM/y)	3,800	3,200	2,300	3,000
unit	1	1	2	3
age	8	12	13, 4	6, 4, 2
Allocation				
Overburden removal	1	1	2	1
Waste dump				2
Operation record (1992, %)				
Availability	78	81	84, 74	90, 90, 85
Utilization	79	89	94, 93	68, 57, 63
Efficiency	62	72	78, 68	61, 51, 53
Operation record (1993, %)				
Availability	29	87	68, 76	81, 71, 83
Utilization	93	94	93, 94	72, 69, 97
Efficiency	27	82	63, 71	58, 49, 80
Reasons of low efficiency (1992-1993)				
Mechanical break down	40%	25%	20%	
Due to blasting delay			27%	
Delay of overburden removal (1,000BCM)	800	300	800	

The structures of 20/90 and 15/90 are basically the same excepting bucket capacity and power rate. DC motors are operated by the Ward Leonard system. Walking shoes are operated by hydraulic cylinder system. 13/50 dragline has a short boom with a small bucket, but its swing speed is much faster than the larger draglines. Its handling capacity is not so small compared with the larger draglines. 13/50 dragline is not so effective for overburden removal but good for waste handling of the railway system. Generally speaking, bucket fill factor is not so high due to the stuck materials in the bucket.

In 1993, 20/90 dragline had a long break down. Due to the lack of maintenance manual and spare parts, it could not be operated for 6 months. Big equipment like a dragline is usually elected at mine site. In case of Baganuur coal mine, the equipment was transported by a railway, and elected at mine site. Transportation size and weight are limited due to the capacity of the railway from the former Soviet Union. In case of a big dragline, it is divided into more than 100 cartons.

3) Excavator for overburden removal

Electric rope shovels are mainly operated for removal of overburden. The shovel loads the materials into either the wagons or rear dump trucks. In total, 15 units of electric rope shovel are operated in Baganuur coal mine. Specifications and allocation of the electric rope shovels are shown in Table 3.9. Production capacity shown in the table is for shovel alone and the figures are much less under the combination of rear dump trucks or wagons.

EKG 8u is the biggest loading shovel currently used at Baganuur coal mine and mainly used with the railway system. It is also used for loading of overburden for rear dump trucks.

EKG 4y is also used with the railway system. The feature of this loading shovel is its long boom. This shovel is similar to a stripping shovel but used as a loading shovel. This shovel can load the materials from low position to the wagons located on the upper bench. The loading capacity is not so large because the size of bucket is only 4 cubic meters and its swing speed is not so fast. Power rate is almost the same as that of 8 cubic meter shovel. There is no plan to purchase this shovel again for the moment.

Table 3.9 Specification of Electric Shovel

Type	EKG 8u	EKG 5A	EKG 4.6b	EKG 4y
Make	Russia	Russia	Russia	Russia
Boom length (m)	13.3	11.4	10.5	20.6
Max.dumping height (m)	8.6	7.5	6.4	17.5
Bucket capacity (m^3)	8.0	5.0	4.6	4.0
Operating radius (m)	15.6	11.8	10.0	22.0
Rated power (kW)	630	250	250	520
cycle time (sec.)	26	25	23	30
Capacity (1000BCM/y)	2,900	2,000	2,000	1,300
unit	4	5	4	2
age	3,4,5,6	0,2,5, 7,9	8,11,11 14	5,6
Allocation				
Overburden				
Wagon loading	3			2
D/T loading		1		
Waste dump	1			
Coal				
D/T loading		4	1	
Wagon loading			3	
Total	4	5	4	2

Operation record and reasons of stoppage

	1992		1993	
	All shovels	Rail system	All shovels	Rail system
Operation record(%)				
Availability	81	79	77	71
Utilization	71	66	78	79
Efficiency	58	52	60	56
Reasons of stoppage(%)				
Spare parts	6	13	27	49
Break down	28	21	23	14

EKG 5A is the most popular shovel used in Mongolia. At Baganuur coal mine, it is mainly used for coal winning. Its use in combination with 40 ton rear dump truck is very good. Although another shovel with bucket size of 10 cubic meters was introduced in 1990, it has not been utilized so far. But management of the mine site has an intention to utilize this shovel from 1994. Operating hour analysis shows that availability is low due to the break down and the shortage of spare parts. Removal of the parting is much difficult to conduct by the existing shovels.

4) Locomotive and wagon

Electric locomotive and wagon system has been utilized for overburden transportation in forward stripping. The system was introduced in 1987. Original design was to use a hybrid type locomotive which was designed to run by diesel engine on the temporary railway track and to run by electric motor on the permanent railway track. But this kind of a hybrid locomotive had not yet been authorized for export by the authorities in the former Soviet Union at that time. And thus electric locomotives were introduced. This is the reason why additional work of installation and removal of trolley lines are required.

Specification of the locomotive and wagon are shown in Table 3.10.

Table 3.10 Specification of Locomotive and Wagon

	Locomotive		Wagon
Type	ONE1A	TEM2	2CB-105
Make	Dnepretrovsk Russia	Briansk Russia	Zelengur Poland
Weight (ton)	372	125	105
Power (HP)	4,000	1,200	-
Power source	Electric	Diesel	-
Capacity	-	-	50 m^3 (40 BCM)
Unit	10	5	106
Utilized	6	5	72

One locomotive and 12 wagons form one fleet. One fleet is capable of transporting 480 BCM/cycle. In summer season cycle time is shorter while it is longer in winter season, because additional works are required for cleaning up and spraying anti-freezing emulsion for wagons after dumping overburden. Diesel locomotives are used for supporting works. Motor wagons are the side dump type equipped with electric motor. Motor wagons are connected to the electric locomotive in order to get high power, and used on the steep railway tracks. Total registered length of the railway truck is about 32 km, and 27.5 km is utilized as of May 1, 1994. Total length of the temporary railway track is 14.5 km and total length of the permanent railway track is 13 km. In 1993, 10,480 meters were removed and installed, and 8,500 meters are planned in 1994. Rail gage is 1,524 mm and the size is 65 kg/m or 50 kg/m, length of the rail module is 12.5 meters. Two fleets of wagons are normally allocated for one electric rope shovel. Planned operation of overburden removal consists of 4 electric rope shovels and 8 fleets of wagons, but due to low availability of the electric rope shovels, only two or three are in operation. Wireless communication system is applied for communication between locomotives and the control station. Points operation of the junction is carried out from the control station. Although availability of the locomotives has not been so low, its utilization is not high enough. Main reason for low utilization is due to low availability of loading electric rope shovels. Regarding to the maintenance of the locomotives, the shortage of repairing materials is a serious problem. Planned maximum inclination of the railway track is 25/1,000. This means that railway transportation system is difficult to apply for the deeper areas of overburden removal. The truck and shovel method is one of the methods available for transportation of overburden from the deeper areas. Adoption of the belt conveyer system is an alternative method as a solution to this problem. Concept of the belt conveyer system is to lift up the materials from the deeper level to the higher level by means of belt conveyer in order to load into the wagons. The loaded wagons are then hauled to the dump area of overburden. Each wagon has a side dump system with 3 air cylinders at both side. Compressed air is supplied from the locomotive. Two units of 13/50 dragline and one unit of EKG 8u are allocated for double handling of the dumped overburden from the wagons. According to the F/S, double handling of the dumped overburden was assigned for draglines, but it was not for an rope electric shovel. Cycle time of the railway transportation is about 171 minutes in summer time and 230 minutes in winter season. There is a marshaling yard and maintenance pit near the operation center. Daily inspection and maintenance are carried out at this maintenance pit. Cross ties of the rails are made at the sawmill.

5) Dump truck for overburden transportation

Formally, main usage of rear dump trucks has been transportation of coal. But for the purpose of recovering the delayed overburden removal, rear dump trucks are now used for overburden transportation, in addition to transportation of coal. The truck and shovel operation is also conducted at Pit 1, Pit 2 and Pit 3 for the removal of overburden. Two types of rear dump trucks are operated for transportation of overburden and coal. One is Belaz-548 and the other is Komatsu HD-325-5. Specification of the trucks are shown in Table 3.11.

Table 3.11 Specification of Rear Dump Truck

Type	Belaz-548	HD-325-5
Make	Russia	Komatsu
Capacity	40 ton	32 ton
	18 m^3	18 m^3
Weight	29 ton	27.2 ton
Power	500 HP	463 HP
No.of unit	19	20
Operation record (1992)		
Availability (%)	74	81
Utilization (%)	88	85
Efficiency (%)	66	69
Operation record (1993)		
Availability (%)	57	81
Utilization (%)	64	69
Efficiency (%)	36	56

Mechanical availability is low because of the break down and the shortage of repairing materials. Utilization of rear dump trucks is reasonably high. Due to the hard natural conditions and inefficient maintenance works, average operating life of Russian made rear dump trucks is about 2.5 years. Russian rear dump trucks are essentially robust for cold weathers, but Komatsu rear dump trucks are modified to bear cold weather. Oil pan heater and cylinder block heater are attached and some electric devices are replaced by the modified type.

Large equipment is divided into some components for the transportation when it is imported. Transportation of equipment from the former Soviet Union is not so complicated in comparison with transportation through China. In case of transportation through China, the size of a cargo is limited because there are a number of tunnels on the way to Mongolia. Different sizes of the railway gage are also another problem for transportation of equipment through China, while Russian gage is the same as that of Mongolia. In case of transporting Belaz rear dump trucks, only vessel and tires are removed from the body. On the other hand, vessel is divided into 3 parts and welded at mine site in case of Komatsu. Komatsu rear dump trucks are transported by 6 blocks per unit and assembling works at mine site are difficult works to carry out.

Price of Komatsu rear dump truck is about four times of Belaz as of 1994, while total operation costs including depreciation have not been yet calculated. Operating life of Belaz rear dump trucks is only about 2.5 years due to the hard operating conditions and bad maintenance works. Data on operating life for Komatsu equipment under Mongolian conditions are not yet available, because only two years have passed since Komatsu equipment is introduced. Some Komatsu rear dump trucks are not in operation, because their tires have not arrived yet. Result of operating hour analysis shows that mechanical availability is 77% in 1992 and 70% in 1993. Utilization is 87% in 1992, and 67% in 1993. It is surprising to know that more than 23,000 hours are not operated due to "not enough labor" in 1993 although it was 7,000 hours in 1992.

6) Drilling equipment for coal seam

In winter season, blasting of coal seam is required. Specifications of the equipment are the same as the equipment used for overburden drills. Penetration rate is a little faster than that of overburden drilling.

7) Excavator for coal mining

Electric rope shovel EKG 5A and EKG 4.6B are operated for coal mining. Five passes are required for loading coal to Belaz 40 ton rear dump trucks. Annual loading capacity of these shovels is about 1.5 million tons per unit. Utilization is not so high because removal of overburden has been delayed, and exposed coal seams are limited.

8) Rear dump truck for coal transportation

The same Belaz 40 tons rear dump trucks are used for transportation of overburden and coal. Although the capacity of transportation is about 40 tons but only 20 tons of coal are transported due to the limited size of vessel. Thus, fuel is not used efficiently. Ideally it is better to have a fleet of coal hauler and rear dump trucks for transportation of overburden.

9) Supporting equipment

Bulldozer:

Push dozing is one of effective overburden removal methods for the shorter distance of transportation. Usually large equipment such as draglines is supported by bulldozers. Bulldozer will be able to clean up the working floor for mining equipment, and will be able