JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

DEPARTMENT OF MINERAL RESOURCES
MINISTRY OF INDUSTRY
THE KINGDOM OF THAILAND

THE STUDY ON COAL EXPLORATION AND ASSESSMENT IN THE KINGDOM OF THAILAND

FINAL REPORT SUMMARY

DECEMBER 1997

MITSUBISHI MATERIALS CORPORATION
MITSUI MINING ENGINEERING CO., LTD.

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PREFACE

In response to a request from the Government of the Kingdom of Thailand, the Government of Japan decided to conduct the Technical Cooperation for the Study on Coal Exploration and Assessment in the Kingdom of Thailand and entrusted the Study to the Japan International Cooperation Agency (JICA).

JICA sent a study team led by Mr. Jiro Muraoka of Mitsubishi Materials Corporation to the Kingdom of Thailand seven times from July 1995 to October 1997.

The Team held discussions with officials concerned of the Government of the Kingdom of Thailand, 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 Kingdom of Thailand for their close cooperation through the Study.

December 1997

Kimio FUJITA
President
Japan International Cooperation Agency

December 1997

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

Dear Mr. Fujita:

Letter of Transmittal

We are pleased to submit to you the report on the Study on Coal Exploration and Assessment in the Kingdom of Thailand. The report contains the advice and suggestions of the authorities concerned of the Government of Japan and your Agency as well as formulations of the above mentioned study. Also included are comments made by the Department of Mineral Resources (DMR), the Ministry of Industry, during technical discussions on the draft report which were held in Bangkok.

The report presents results of the exploration, assessment and conceptual mine development plan in the Phrae Basin, the Nong Plab Basin and the Mae Lamao Basin. Also included are the details and results of the technical transfer was carried out satisfactory on the study.

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 Department of Mineral Resources and other authorities concerned the Government of the Kingdom Thailand for the close cooperation and assistance extended to us during our study.

Very truly yours,

村岡 次郎

Jiro Muraoka
Team Leader
The Study on Coal Exploration and Assessment in the Kingdom of Thailand

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1 Introduction

1.1 Background of the Study

To boost a new method and model in coal exploration together with upgrading the exploration results and speed up the Coal Exploration and Assessment Project project's works, the Department of Mineral Resources of Ministry of Industry (hereinafter referred to as "DMR") requires more modern equipment and advanced technology as well as advanced knowledge in the fields of coal geology and geophysical exploration. In accordance with such requirements, the Government of Thailand requested the Government of Japan to provide a joint coal exploration program. The joint exploration program was expected that advanced technology with the modern equipment would be applied in it and it would create a new coal exploration scheme in Thailand, furthermore DMR personnel might absorb invaluable experience and know-how from Japanese experts.

In response to the request of the Government of Thailand, the Government of Japan decided to conduct the Study on Coal Exploration and Assessment (hereinafter referred to as "the Study"). Accordingly, the Japan International Cooperation Agency (hereinafter referred to as "JICA"), the official agency responsible for the implementation of the technical cooperation program of the Government of Japan, agreed to undertake the Study in close cooperation with DMR. JICA assigned a joint study team (hereinafter referred to as "the Study Team"), composed of Mitsubishi Materials Corporation and Mitsui Mining Engineering Co., Ltd. to carry out the Study . The Study in Thailand was executed by the Study Team and DMR in close cooperation from July, 1995 to July, 1997 and the whole study was completed successfully in October, 1997. This Report is the results of the Study.

1.2 Objectives of the Study

The main objectives of the Study are:

(1) Coal exploration and assessment for the selected basins (hereinafter referred to as "the Study Sites") by joint action of Japanese side and Thai side.

(2) Technology transfer to DMR personnel from the Study Team in the course of cooperative study in both Thailand and Japan.

1.3 Study Sites

The Study Sites are as follows:

(1) Phrae Basin, Phrae.

(2) Nong Plab Basin, Prachuabkirikan.

(3) Mae Lamao Basin, Tak.

2 Coal Resources Management of Thailand

2.1 Present state of the Coal Exploration and Development Section of DMR

2.1.1 Organization

The Coal Exploration and Development Section of DMR, the counterpart study team of the Study, consists of the following members at present.

Table 2.1-1 Main members of the Coal Exploration and Development Section

Position	Name	Duty
Chief	Songpope Polachan	Nominal
Acting chief	Nawee Pitchayakul	Management
Senior geologist	Somchai Poom-im	Ditto, Technical supervisor
	Surachai Krobbuaban	Ditto, Geophysical supervisor
Geologist	Phumee Srisuwon	Statistics and information
	Apichart Jeenagool	Chief of exploration team
	Wuttipong Khongphetesok	Ditto
	Kriangkrai Pomin	Ditto
	Tinnakorn Sunee	Ditto

Each exploration team consists of a chief and a few junior geologists with surveyors, technicians and drivers.

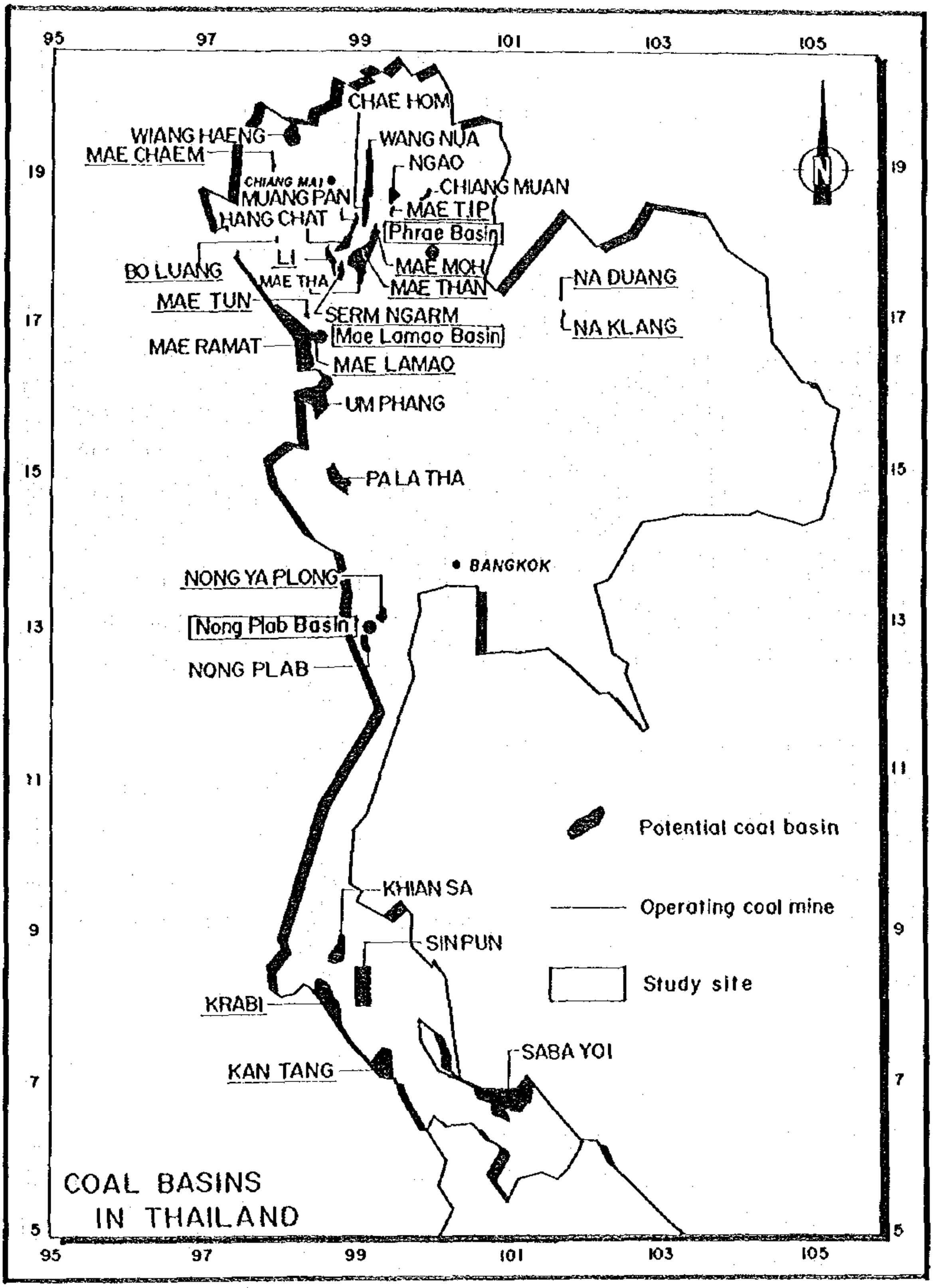


Fig. 2.2-1 Location of the Study Sites, Coal Production Area and Coal Potential Area in Thailand

2.1.2 Function

The present functions of the Section are as follows:

- Exploration of the coal basins out of the budget of coal exploration and assessment project (CEP),
- Publication of the exploration data for public and private sectors;
- Coal data statistics;
- Investigation of various coal utilization systems.

2.1.3 Exploration method

DMR is conducting exploration by means of outcrop survey, drilling borehole, geophysical logging of borehole and seismic survey. The coal samples are collected from the recovered borehole cores and analysed. These methods are not different from the ordinary exploration method conducted in the countries where coal mining has industrial importance. But DMR only arranges the obtained data for publication without further geological analysis. Here exists the significant difference in exploration between DMR's method and the ordinary method, which necessitates further geological analysis for the purpose of development.

2.1.4 Expansion plan of the Coal Exploration Section

Coal Exploration Section of DMR was changed its title to Coal Exploration and Development Section during the Study in March 1996. Furthermore DMR plans restructuring of its organization. The section will be a part of a prospective division which has responsibility for exploration, utilization and development of all kinds of solid energy resources.

2.2 Coal resources management of Thailand

DMR enacted The Master Plan for Coal Resources Management of Thailand (dated April, 1996) in September, 1996. **The Master Plan contains important information and policy concerning coal in Thailand. Therefore, some chapters of the Master Plan, important and related to the Study, are shown hereinafter.**

2.2.1 Background

The 8th National Economic and Social Development Plan of Thailand (1997-2001) has assigned the issue related to the coal management as follows :

(1) Accelerate the effort in exploration for coal reserve of the country.

(2) Accelerate the bidding process for those coal basins explored by DMR.

(3) Determine new clean coal technology to minimize the environmental impact.

A total coal reserves in Thailand are estimated at approximately 2,800 million tons. At present, about 1,000 million tons of coal have not been planned for development. The coal reserves of Thailand are mainly lignite. About 75% of the annual coal production are consumed for electric power generation, the remaining 25% are used by the cement industry and other industrial consumers such as paper industry, food industry, tobacco drying, sugar industry, lime works etc. The coal deposits in Thailand have been mined recently from 12 basins . Other discovered coal deposits are in 17 basins which have not been exploited .

2.2.2 Economic growth and energy consumption and demand

The growth of the Gross Domestic Product (GDP) is considered a significant measure of the trend of the economy. A secure energy basis is a precondition of growth as well. Based on the statistics relating to economic growth and energy consumption as well as energy intensity, sufficiently reliable prognostic estimates can be made with regard to primary and final energy requirements. To determine the future primary and final energy requirements, the following basic conditions :

(1) Inclusion of renewable sources of energy into primary energy consumption/demand figures at an annual growth rate of 1%.

(2) The economic growth, expressed by the increase of the GDP following the price adjustment.

1994 - 1996 Estimated of 7.6% GDP growth per annum

1997 - 2001 Estimated of 6.3% GDP growth per annum

2002 - 2006 Estimated of 6.0% GDP growth per annum

2007 - 2011 Estimated of 5.5% GDP growth per annum

2012 - 2016 Estimated of 5.0% GDP growth per annum

(3) Based on the statistics of Thailand, as the GDP growth rises by 1 %, primary energy consumption will rise by more than 1%. However, after two oil crises, there have been attempts towards an efficient use of energy. This results in a reduction in primary energy consumption from 0.9 % of every 1% GDP growth to 0.7%. Based on the above conditions, the primary energy demand for every 1% economic growth will be: 1996 - 2001 1.0% (max.) 0.9% (min.).

(4) The rate of inflation was set at 4% for the total period of time

For important industrial processes exist in the time, the specific energy supply is as follows :

production of electricity :	<2,150	kcal/kWatt Electric
production of cement :	700 - 800	kcal/1 kg clinker
lime-burning :	< 850	kcal/1 kg CaO
ceramic :	350 - 475	kcal/ kg
kitchenware, china :	<4,700	kcal/ kg
sanitary china :	900 - 1,000	kcal/ kg
fire resistant refractory :	1,100 - 2,200	kcal/ kg
base metallurgy :	<4,500	kcal/ kg raw steel
	< 450	kg coke/ kg raw steel
glass industry - lead-glass	1,300 - 1,500	kcal/kg
- flat glass	2,300 - 2,700	kcal/ kg
- resotherm	<3,500	kcal/ kg

(Notes)

The Thai economy took an unexpected downturn in 1996. The economic growth for 1996 was 6.4%, the first year of below 8% growth since 1993. In 1997, the GDP was expected 5.3% at the early of the year, is expected 2.5 to 3.0 % at middle of the year. However, the Thai economy still has potentialities, therefore it is not too much to say that the above estimate of GDP growth rate is still reasonable.

Table 2.2-1 Development of Economy and Energy at Prices 1984

Years	Real GDP %	Primary Energy %	Final Energy %	Real GDP mill US$	Primary Energy 1,000 toe	Final Energy 1,000 toe
1984	100.0	100.0	100.0	55,339	25,731	17,420
1985	104.6	104.5	106.5	57,904	26,899	18,554
1986	110.3	110.5	113.1	61,066	28,433	19,698
1987	121.0	123.2	123.8	66,043	31,706	21,560
1988	137.0	134.4	136.5	75,829	34,592	23,749
1989	153.8	155.5	159.6	85,086	40,010	27,799
1990	171.6	175.4	175.9	94,936	45,122	30,642
1991	185.4	187.9	186.0	102,620	48,361	32,407
1992	199.6	204.2	201.5	110,431	52,535	35,104
1993	215.1	220.0	225.8	119,060	56,616	39,328
1994	231.8	252.9	251.7	128,265	65,069	43,849

* Final Energy with Renewable Energy

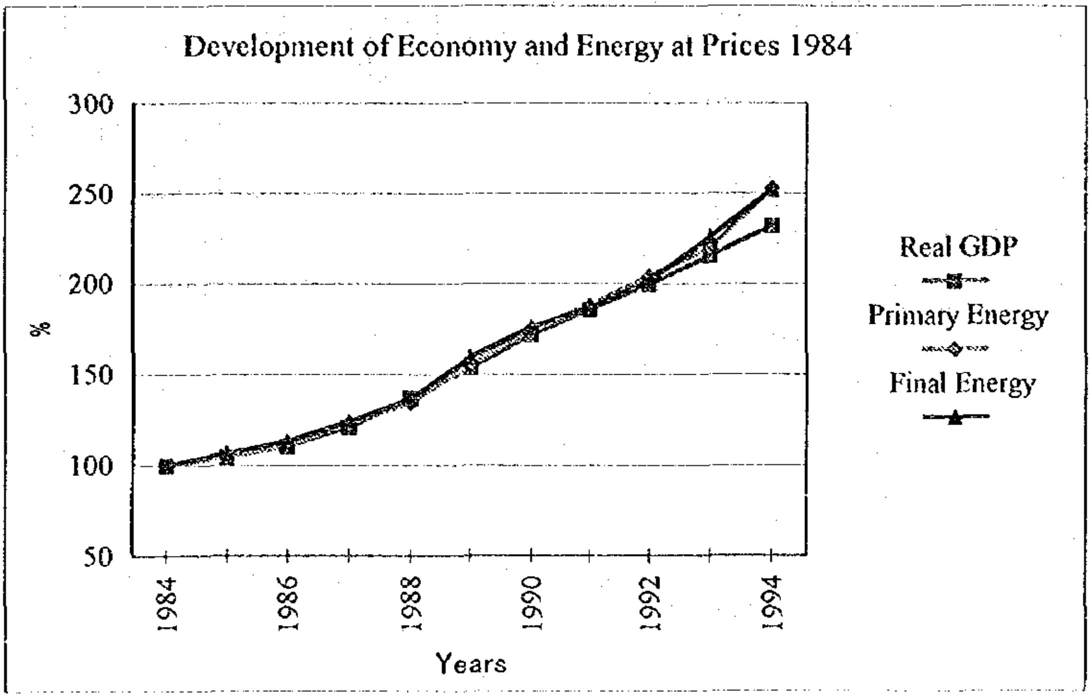


Table 2.2-2 Primary Energy Supply / Demand by Sources of Coal (ktoe)

Unit : ktoe
: %

Sources	1986	1991	1994	1996	2001	2006	2011	2016
Total Coal	1,627	4,466	6,122	6,931	14.455	24,080	34,563	47,221
	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Domestic Coal	1,486	4,135	5,158	5,579	7,120	9,087	11,598	14,802
	91.3	92.6	84.3	80.5	49.3	37.7	33.6	31.3
Imported Coal	141	331	960	1,352	7,335	14,993	22,965	32,419
	8.7	7.4	15.7	19.5	50.7	62.3	66.4	68.7

1994 -1996 growth rate Domestic Coal = 4.0 % / Year
1997 -2016 growth rate Domestic Coal = 5.0 % / Year
1994 -2016 Imported Coal = Coal Total - Domestic Coal

Table 2.2-3 Primary Energy Supply / Demand by Sources of Coal (kt)

Unit : kt
: %

Sources	1986	1991	1994	1996	2001	2006	2011	2016
Total Coal	5,145	14,217	18,611	20,632	35,318	54,097	75,180	100,930
	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Domestic Coal	4,919	13,687	17,073	18,466	23,568	30,079	38,390	48,996
	95.6	96.3	91.7	89.5	66.7	55.6	51.1	48.5
Imported Coal	226	530	1,538	2,166	11,750	24,018	36,790	51,934
	4.4	3.7	8.3	10.5	33.3	44.4	48.9	51.5

1994 -1996 growth rate Domestic Coal = 4.0 % / Year
1997 -2016 growth rate Domestic Coal = 5.0 % / Year
1994 -2016 Imported Coal = Coal Total - Domestic Coal

Table 2.2-4 Possibility of Final Energy Demand by Sources of Coal

Unit: 1,000 tons

Sources	1996	2001	2006	2011	2016
Domestic Coal	18,466.1	23,568.0	30,079.4	38,389.8	48,996.2
Power Plants*[1]	15,162.0	15,490.0	15,490.0	14,444.0	19,444.0
Others = (Final Energy)	3,304.1	8,078.0	14,589.0	23,945.8	29,552.2
Imported Coal	2,166.1	11,750.3	24,018.1	36,789.7	51,934.5
Power Plants	-	-	2,499.0	11,110.0	16,110.0
Others = (Final Energy)	-	-	21,519.1	25,679.7	35,824.5
Final Energy Coals	15,162.0	15,490.0	17,989.0	25,554.0	35,554.0
Coal Total	20,632.2	35,318.3	54,097.5	75,179.5	100,930.6

1994 - 1996 Growth Rate Domestic Coal = 4.0% / Year

1997 - 2016 Growth Rate Domestic Coal = 5.0% / Year

1994 - 1996 Growth Rate Imported Coal = Total Coal - Domestic Coal

*[1] not calculated as final energy

The demand of coal for power station is obtained the information from Electricity Generating Authority of Thailand (EGAT) up to year 2011. The electricity intensity and the consumption of electricity are shown in Table 2.2-5 and 2.2-6.

From the statistics of Thailand for the last 10 year, an electricity growth rate of 1.38% has been obtained for every 1% of economic growth. Here again, a high electricity intensity of the Thailand economy is obvious in comparison with other countries, where figures of only 1% for every 1% of economic growth are dominant. However, a reduction in electricity intensity in Thailand has been forecasted for the period from 2006 to 2016. The coverage of primary energy consumption according to energy sources has been taken from statistics of Thailand. In the future, Thailand intends to increase a higher share of domestic coals and imported coals for meeting the primary energy demand. This objective is based on the world reserves of coal as well as favorable and stable prices.

Table 2.2-5 Development of Economy and Electricity Consumption

Years	Real GDP (at Prices 1988)		Electricity Consumption		Electricity Intensity per GDP	Electricity Consumption per Capita
	Mill Baht	%	GWU	%	kWh/1.000 Baht	kWh / Pers.
1984	-	-	18.586	-	-	-
1985	1.119.125	100.00	20.041	100.00	17.91	386
1986	1.257.177	105.50	21.049	110.00	17.53	416
1987	1.376.847	115.60	24.902	124.30	18.09	462
1988	1.559.804	130.90	28.272	141.00	18.13	514
1989	1.749.952	146.90	32.381	161.60	18.50	579
1990	1.953.382	164.00	38.203	190.60	19.55	678
1991	2.117.582	177.80	44.239	220.70	20.89	776
1992	2.285.339	191.80	49.331	246.20	21.59	854
1993	2.477.278	208.00	55.231	275.60	22.30	947
1994	2.692.801	226.00	62.559	312.20	23.23	1.059

Table 2.2-6 Electricity Consumption for the Whole Country

Years	Residential	Business	Industrial	Agriculture	Others	EGAT(Direct -Customers)	Total
1990	8,063.19	9,406.81	16,717.23	96.23	2,470.43	1,449.07	38,202.96
1991	9,122.71	11,352.91	19,406.02	90.94	2,735.05	1,531.24	44,238.87
1992	10,199.84	12,515.27	21,641.01	117.69	3,132.51	1,724.85	49,331.17
1993	11,390.12	14,009.97	24,321.28	133.19	3,551.31	1,825.42	55,231.29
1994	12,866.83	15,808.35	27,758.43	95.75	4,057.54	1,974.09	62,558.02

According to the future demand of Thailand for primary and final energy, a first rough estimate of the shares of domestic and imported coals was made as shown in Table 2.2.4

For this purpose, the basic condition of the share of petroleum/petroleum products was increased from currently 60% to 67% in the year 2016 and for renewable energies an annual growth rate of 1% was assumed. Electric energy based on water power was regarded constant.

Table 2.2-7 Primary Energy Supply / Demand by Sources

Unit : 1,000 tons (toe)

Sources	1986	1991	1994	1996	2001	2006	2011	2016
Total Coal	1,627	4,466	6,122	6,931	14,455	24,080	34,563	47,221
(%)	5.7	9.2	9.4	9.2	14.1	17.6	19.3	20.7
Petroleum /NG/ Petroleum products	13,942	27,546	38,501	44,824	63,312	86,865	116,396	152,305
(%)	49.0	57.0	59.2	59.5	61.9	63.5	65.1	66.7
Electricity	1,293	1,063	1,070	1,070	1,070	1,070	1,070	1,070
(%)	4.5	2.2	1.6	1.4	1.0	0.8	0.6	0.5
Renewable Energy	11,571	15,286	19,376	22,475	23,413	24,819	26,808	27,650
(%)	40.7	31.6	29.8	29.8	22.9	18.1	15.0	12.1
Total	28,443	48,361	65,069	75,300	102,250	136,834	178,837	228,246
(%)	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

1994 - 2016 Hydro Electricity = Constant

1997 - 2016 Growth Rate Renewable Energy = 1.0 % / Year

1997 - 2001 Growth Rate Petroleum /NG/ Petroleum Products = 0.8 % / Year

2002 - 2016 Growth Rate Petroleum /NG/ Petroleum Products = 0.5 % / Year

Consequently, the coal quantities required in the year 2016 will amount to approximately 47,220 k tones. This mean that approximately 100 million tones of coal will have to be made available, a quantity which is about five times the amount consumed at the present.

The forecast trends in Table 2.2-7 and 2.2-8 show that in 2016, domestic coals mining/utilization of 47 million tones annually is regarded possible. Considering that

EGAT have planned to use about 14.4 million tones of domestic coal for electricity generation in 2011 (Table 2.2-8) and that further additional 5 million tones will be available for electricity generation to 2016, about 29 million tones per annum will remain for the use in industry and other areas.

Table 2.2-8 Supply / Demand of Electricity

Years	MW	Increase (%)	Unit GWh	Increase (%)	Utilization Factor (%)
1984	3,547.30	10.70	21,066.44	10.49	67.79
1985	3,878.40	9.33	23,356.57	10.87	68.75
1986	4,180.90	7.80	24,779.53	6.09	67.66
1987	4,733.90	13.23	28,193.16	13.78	67.99
1988	5,444.00	15.00	31,996.94	13.49	67.09
1989	6,232.70	14.49	36,457.09	13.94	66.77
1990	7,093.70	13.81	43,188.79	18.46	69.50
1991	8,045.00	13.41	49,225.03	13.98	69.85
1992	8,876.90	10.34	56,006.44	13.78	72.02
1993	9,730.00	9.61	62,179.73	11.02	72.95
1994	10,708.80	10.06	69,651.14	12.02	74.25
(1985 - 1994)		(11.68)		(12.70)	
1995	11,880.00	10.94	78,023.00	12.02	74.97
1996	13,009.00	9.50	85,571.00	9.67	75.09
1997	14,193.00	9.10	92,879.00	8.54	74.70
1998	15,315.00	7.91	100,383.00	8.08	74.82
1999	16,446.00	7.38	108,160.00	7.75	75.08
2000	17,685.00	7.53	116,795.00	7.98	75.39
2001	19,029.00	7.60	126,025.00	7.90	75.60
2002	20,237.00	6.35	134,041.00	6.36	75.61
2003	21,440.00	5.94	142,849.00	6.57	76.06
2004	22,690.00	5.83	152,529.00	6.78	76.74
2005	23,997.00	5.76	162,187.00	6.33	77.15
2006	25,371.00	5.73	171,745.00	5.89	77.28
2007	26,835.00	5.77	181,745.00	5.82	77.31
2008	28,409.00	5.87	193,505.00	6.47	77.76
2009	30,044.00	5.76	204,956.00	5.92	77.88
2010	31,749.00	5.68	216,428.00	5.60	77.82
2011	33,532.00	5.62	228,445.00	5.55	77.77

Table 2.2-9 Forecast Demand of Electricity (Information by EGAT)

Energy	Unit	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Hydro	GWh	4,299	4,555	4,555	4,711	4,711	5,040	5,205	5,205	5,452	6,064	6,428	6,428	6,428	7,338	7,779	7,779	7,779
	%	5.5	5.3	4.9	4.7	4.4	4.3	4.1	3.9	3.8	4.0	4.0	3.7	3.5	3.8	3.8	3.6	3.4
Natural Gas (indigenous)	GWh	26,390	18,818	19,438	20,005	36,706	38,521	39,571	39,809	38,240	41,106	40,952	41,006	39,706	39,706	33,243	28,774	23,813
	%	33.8	22.0	20.9	28.9	33.9	33.0	31.5	29.7	26.8	26.9	25.2	23.9	21.8	20.3	16.2	13.3	10.4
	million ft3/day	673	501	516	672	819	862	890	892	850	927	922	922	880	868	716	605	492
Natural Gas (Burma)	GWh	0	0	0	701	10,819	18,560	18,692	18,692	18,551	18,692	18,692	18,691	18,691	18,691	18,691	18,691	18,691
	%	0.0	0.0	0.0	0.7	10.0	15.9	14.8	13.9	13.0	12.3	11.5	10.9	10.3	9.7	9.1	8.6	8.2
	million ft3/day	0	0	0	29	408	525	525	525	521	525	525	525	525	525	525	525	525
Fuel Oil	GWh	22,630	26,418	27,917	27,170	14,133	6,603	6,747	4,028	4,769	4,260	4,163	2,995	3,585	3,785	3,750	8,476	18,597
	%	29.0	30.9	30.1	27.1	13.1	5.7	5.4	3.0	3.3	2.8	2.6	1.7	2.0	2.0	1.8	3.9	8.1
	million litters	5,609	6,512	6,865	6,628	3,402	1,610	1,586	959	1,175	981	961	704	837	883	847	1,934	4,184
Diesel	GWh	2,015	2,757	4,782	2,303	302	302	302	302	302	302	302	302	302	302	302	385	450
	%	2.6	3.2	5.1	2.3	0.3	0.3	0.3	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
	million litters	579.0	757.0	1,450.0	566.9	160.4	160.7	160.7	161.0	161.0	161.3	174.5	187.7	201.1	214.4	227.9	250.1	272.7
Domestic Coal	GWh	14,447	16,697	19,418	18,395	17,255	17,255	17,255	17,255	17,255	17,255	17,255	17,255	17,255	17,255	16,270	16,270	16,270
	%	18.5	19.5	20.9	18.3	16.0	14.8	13.7	12.9	12.1	11.3	10.6	10.0	9.5	8.9	7.9	7.5	7.1
	million tons	12,283	15,162	17,669	16,513	15,490	15,490	15,490	15,490	15,490	15,490	15,490	15,490	15,490	15,490	14,444	14,444	14,444
Imported Coal	GWh	0	0	0	0	0	0	0	0	0	0	3,285	7,388	11,528	15,938	27,531	32,628	32,850
	%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.0	4.3	6.3	8.2	13.4	15.1	14.4
	million tons	0	0	0	0	0	0	0	0	0	0	1,111	2,499	3,899	5,390	9,311	11,035	11,110
IPP and others	GWh	8,242	16,326	16,769	18,089	24,216	30,496	38,055	48,732	58,262	64,832	71,092	77,662	84,232	90,802	97,372	103,425	109,995
	%	10.6	19.1	18.1	18.0	22.4	26.1	30.2	36.4	40.8	42.5	43.8	45.2	46.3	46.9	47.5	47.8	48.1
Total	GWh	78,023	85,571	92,879	100,383	108,160	116,795	126,025	134,041	142,849	152,529	162,187	171,745	181,745	193,505	204,956	216,428	228,445
	%	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

2.2.3 Coal in Thailand

(1) Coal Deposits and Coal Production in Thailand

Thailand has coal reserves amounting to a total of approximately 2,800 million tones. Approximately 1,100 million tones of coal are regarded as measured reserve. Most of the coal deposits are located in the north region of Thailand (Fig.2.1-1). The Mae Moh deposit in Changwat Lampang being the largest deposit with 1,400 million tones reserve, is also situated in this region. There are only few deposits in the central and southern parts of Thailand. Coals are classified mostly to lignite and subbituminous.

Currently, there are 14 coal deposits that have been developed. In 1996, coal was mined from 9 deposits in which a total of about 21.5 million tons was produced and consumed. In addition, about 2.5 million tones of coal and coal products (coke and briquette) were imported and consumed. Table 2.2-10 illustrates details of reserves and qualities of productive coal deposits and discovered coal basins in Thailand.

For each coal deposit; figures on moisture, ash, sulfur contents and calorific value relating to volatile matter as well as fixed carbon are available. However, others details about ash composition, ash fusibility, ash distribution in the seam, forms of sulfur bonding and further qualitative characteristic are not available at present. Table 2.2-11 shows the cumulative coal production in Thailand subdivided according to deposits for the period from 1955 to 1996.

(Note)

JICA provided three coal quality analysis equipment for the Study and they were donated to DMR at the end of the Study. These three analysis equipment are, "Ash Fusibility Determinator", " Thermalgravimetric Determinator", "Sulfur Determinator". It is available to analyze the details about the most of matters which are mentioned above by DMR at present.

Table 2.2-10 Geological Reserves of Coal and Quality of Coal in Thailand

Deposit Locations	Country	Province	Measured Reserves (Million t)	Reserves (Million t)	Heating Value (raw) (kcal/kg)	Moisture (raw) (%)	Ash (raw) (%)	VM (raw) (%)	Fix Carbon (raw) (%)	S (dry) (%)	Density (g/cm3)	Average Heating Value (kcal/kg)	Vertical Stripping Ratio	Number of Nain Seams (m)	Accumulated Thickness of Seams (m)	Production 1995 (t)	Operator/Owner
Northern Area																	
Mae Moh	Mae Moh	Lampang	820.90	1,408.00	1,900- 4,600	30.2	25.4	28.5	16.5	3.0	1.5	2,700	1:5.1	3	20-30	13,191,850	EGAT/active
Li	Li	Lamphun	28.00	-	2,800-6,600	10.4	16.4	26.5	46.7	1.6	1.4	5,350		1-2	3-30	2,902,594	DEDP/active
Mae Chaem	Mae Chaem	Chiang Mai	1.20	N.A.	2,800-6,600									1	0.5	203,762	DEDP/active
Mae Teep	Ngao	Lampang	11.0	N.A.	2,400-?	12.3	14.0	31.0	42.8	2.2	1.5	3,800			10	0	Private/active
Mae Tum	Mae Ramat	Tak	1.23	N.A.	1,700-?											0	Private/active
Mae Lamao	Mae Sot	Tak	13.90	34.21	3,300-5,200	14.6	30.8	27.9	26.7	3.0	-	3,100		2		85,902	Private/active
Mae Than	Mae Tha	Lampang	-	35.00	3,600-5,800	20.0	30.4	26.5	23.1	4.0	1.5	3,068		2	15-20	2,583,110	Private/active
Wiang Haeng	Wiang Haeng	Chiang Mai	93.02	125.14	1,616-5,256	24.3	32.2	23.5	20.1	0.9	1.7	2,908		2	0.1-21.5		Feasibility Study Non Power use
Wang Nua	Wang Nua	Lampang	9.01	31.16	1,636-4,965	16.9	36.0	28.0	19.2	2.5	1.6	2,980		1-2	0.2-5.0		Preliminary
Ngao	Ngao	Lampang	48.38	99.10	1,041-3,972	16.0	45.0	27.4	11.7	5.0	1.7	2,100		2	0.1-42.4		Feasibility Study Power use
Chae Hom	Chae Hom Muang	Pan Lampang	16.20	57.23	1,130-4,427	14.3	48.9	25.0	11.9	3.7	1.7	2,044		1	0.3-6.9		Non active Preliminary
Serm Ngam	Serm Ngam	Lampang	6.19	19.40	1,800-4,910	22.3	13.9	32.7	31.1	2.4	1.4	4,127		1	0.3-5.5		
Mae Ramat	Mae Ramat	Tak	14.00	46.00	4,469	7.0	30.2	27.4	35.5	7.8	1.6	4,469		5-10	0.1-22.9		
Hua Sua Pha	Mae Tha	Lampang	1.85	N.A.	N.A.												
Chiang Muan	Chiang Muan	Phayao	25.30	43.30	1,300-4,457	23.0	26.6	30.4	20.0	3.1	1.5	3,213		1	3.5-16.9		Feasibility Study Non Power use
Mae Tha	Mae Tha	Lampang	15.30	60.70	1,282-5,542	16.02	33.1	28.5	22.4	5.4		3,600		2-3	0.12-11.9		
Bo Luang	Hod	Chiang Mai	0.63	N.A.	N.A.											185,151	Private/active
Hang Chat		Lampang	10.32	28.26		17.2	30.1	31.7	21.0	3.4	1.6	2,907		1.5	0.17-15.3		
Pa La Tha		Tak	4.60	14.80										3	0.5-11		
Um Phang		Tak	3.40	6.83		14.0	38.0	25.4	22.6	3.4	1.6	3,100		2	0.3-4.3		
Pobphra			-	-		11.1	43.2	30.4	15.3	3.9	1.7	2,627					
Central Area																	
Nong Ya Plong	Nong Ya Plong	Petchaburi	1.40	N.A.	2,400-7,800	12.3	14.0	31.0	42.8	0.8	1.4	5,444		1	0.3-0.9	0	Private/suspend.
Nong Plab		Prachuap Khiri Khan	11.20	14.90		16.8	25.6	30.3	27.3	3.6	1.4	3,834		1-2	0.1-8.6		
Southern Area																	
Krabi	Klong Thom	Krabi	83.60	120.80	1,600-4,700	23.7	19.8	32.7	23.9	1.9	1.4	3,545				144,233	EGAT/active
Sin Pun	Thung Yai	Krabi	91.06	91.06	1,210-4,763	24.4	18.5	32.8	24.3	6.2	1.4	3,534		2	8.4-11.7		Feasibility Study Power use
Khian Sa	Khian Sa	Surat Thani	15.41	55.42	1,743-5,869	13.8	23.0	31.8	31.4	7.0	1.3	3,936		1-4	0.5-4.2		
Saba Yoi	Saba Yoi	Songkhla	350.00	605.00	2,530	29.2	28.7	26.4	17.8	2.7	1.4	2,530					Feasibility Study Power use
Kantang		Trang				14.5	20.3	35.8	28.5	4.2	nd.	3,580				0	Private/active
North Eastern Area																	
Na Duang		Loei				3.0	27.0	5.3	64.7	0.8	1.4	6,000		1	2-3	5,000	Private/active
Na Klang		Udon Thani	N.A.	13.50	2,200-4,000							6,000					Non active

Table 2.2-11 Coal Production in Thailand during 1955-1996

Unit : tons

Years	Mae Moh	Krabi	Li	Mae Tuen	Mae Teep	Nong Ya Plong	Na Duang	Na Klang	Mae Lamao	Mae Than	Mae Chaem	Kang Tang	Bo Luang	Chieng Muan	Total
1955	22,118.0														22,118.0
1956	77,826.0														77,826.0
1957	99,782.8														99,782.8
1958	105,843.7														105,843.7
1959	114,781.9														114,781.9
1960	101,719.2														101,719.2
1961	118,583.7														118,583.7
1962	129,767.0														129,767.0
1963	139,113.0														139,113.0
1964	104,749.0	4,384.4													109,133.4
1965	49,313.5	62,648.5													111,962.0
1966	42,795.5	105,847.3													148,642.8
1967	124,913.0	177,162.9													302,075.9
1968	118,245.0	211,851.5													330,096.5
1969	102,129.5	208,553.1													310,682.6
1970	145,560.5	229,627.2	6,463.7												381,651.4
1971	154,148.5	292,978.1	4,678.2												451,804.8
1972	117,976.0	258,109.8	7,157.4		1,900.0										385,143.2
1973	111,864.9	249,569.8	7,449.3		3,100.0										371,984.0
1974	171,091.9	263,367.4	26,922.0		450.0										461,831.3
1975	195,754.4	332,082.2	57,434.5	600.0	295.0										586,166.1
1976	177,315.0	313,683.6	72,425.0	0.0	670.0										564,093.6
1977	162,717.0	294,600.9	101,722.0	0.0	3,970.0										563,009.9
1978	179,793.0	268,177.4	110,106.5	0.0	5,500.0										563,576.9
1979	875,143.6	283,125.3	108,439.5	0.0	10,900.0										1,277,608.4
1980	875,425.4	363,806.3	165,447.2	0.0	11,900.0										1,416,578.9
1981	1,184,936.6	362,433.4	181,874.7	2,592.0	37,605.8										1,769,442.5
1982	1,393,433.3	372,301.6	233,963.4	83,439.9	102,266.3		6,120.0								1,991,584.5
1983	1,278,460.6	351,749.9	229,421.0	66,689.0	68,781.0		11,100.0	2,050.0							2,008,251.5
1984	1,525,360.8	271,245.7	250,821.6	80,212.0	57,895.0	62,763.0	0.0	4,350.0							2,252,658.1
1985	4,217,537.1	395,000.0	350,243.2	41,090.0	23,413.0	118,992.0	3,000.0	75.0							5,149,350.3
1986	4,556,916.7	212,000.0	668,293.2	20,032.0	2,420.0	87,626.0	2,500.0	0.0							5,549,787.9
1987	5,564,536.7	191,000.0	945,720.2	28,764.0	48,882.0	85,662.0	8,350.0	0.0	18,747.0	3,500.0					6,895,161.9
1988	5,717,243.0	237,396.2	1,202,537.4	0.0	52,389.0	21,184.0	15,330.0	0.0	37,356.0	3,761.0	3,600.0				7,290,602.6
1989	6,541,191.3	318,584.8	1,558,426.8	0.0	86,848.0	89,050.0	15,340.0	0.0	82,029.0	88,341.0	114,524.0	400.0			8,914,734.9
1990	9,652,991.3	156,262.4	2,028,983.3	0.0	132,681.0	8,000.0	20,600.0	0.0	77,607.0	113,178.0	165,937.0	0.0			12,356,240.0
1991	11,513,774.8	242,699.4	2,392,436.6	0.0	168,477.0	0.0	14,300.0	0.0	93,303.0	90,200.0	188,049.0	0.0			14,703,239.8
1992	12,135,010.1	263,950.0	2,475,292.0	0.0	59,572.0	0.0	22,000.0	0.0	73,450.0	326,897.0	249,254.0	2,800.0	12,004.5		15,640,229.6
1993	11,221,088.0	216,800.0	2,923,548.0	0.0	0.0	0.0	15,500.0	0.0	85,717.0	689,044.1	392,208.0	6,390.0	57,891.5		15,608,186.6
1994	11,906,553.0	266,487.6	3,176,079.0	0.0	0.0	0.0	11,900.0	0.0	92,019.0	1,265,821.0	250,841.0	0.0	141,781.0		17,111,481.6
1995	13,191,850.0	144,232.6	2,902,594.0	0.0	0.0	0.0	5,000.0	0.0	85,802.0	2,583,110.0	203,762.0	0.0	185,151.0		19,303,501.6
1996	16,262,262.0	0.0	2,939,838.0	0.0	0.0	23,315.0	3,000.0	0.0	74,869.0	1,762,736.0	143,657.0	0.0	169,902.0	182,765.0	21,562,677.0
Total	122,304,622.3	7,921,719.3	25,328,310.7	323,482.9	879,915.1	496,592.0	154,040.0	6,475.0	720,699.0	6,926,588.1	1,731,232.0	9,590.0	566,730.0	182,765.0	167,349,797.4

(2) Possible Uses of Domestic Coals

The domestic coals have qualitative characteristics as shown in Table 2.2-12. Generally, the coal deposits of Thailand are characterized by high contents of ash ranging from 14 to 50%, contents of sulfur 1 to 7 %, moisture contents from 10 to 30%, and calorific value ranging from 2,500 to 5,000 kcal/kg (Dry Basis).

The requirements to be met in coal utilization according to available processes and technology are summarized in Table 2.2-13.

An important prerequisite for using domestic coals instead of other energy sources (imported coal, oil) in the industry is an improvement in transportation capability, economy and in handling properties. Measures to be taken to this effect are:

1) selective mining or preparation of coals, with included coal drying;
2) produced coal, should be prepared and controlled the chemical and physical properties, on the site of the mine which concern the preparation of :
   - lump coals for fixed-bed firing,
   - steaming coals for fluid-bed combustion,
   - powder coals for pulverized-fuel firing, possibly with addition of limestone.

The necessity to reduce the specific energy demand per unit of the real GDP at the present time forces the industry sector to use low-energy consumption technologies and economy saving measures. Table 2.2-14 illustrates grouping of coals in Thailand according to their production process and utilization on basis of the data in the Tables 2.2-12 and 2.2-13. From Table 2.2-15, it follows that cooking of these coals to produce fine cokes (as active cokes) for waste-gas and water purification or to produce lump cokes are not suitable.

Taking into consideration the utilization of coal at the present time as well as coal reserves and available producing (active) plants, grouping of deposits can be made according to their regional/local importance (to industries) (Table 2.2-15). Regional importance is considered from (minimum production rates of 0.1 million tons per annum for 15 years) sufficient for electricity generation or other uses within the distance of 250 km from the deposit. For coal industry need to be developed, about twenty items investigations should be carried out, followings are the first five.

- Investigation of selective mining of high-quality coals;
- Investigation of utilization of the remaining coal of high-ash content;
- Investigation of washability of coal particles of high ash contents such as, float-and-sink analyses;
- Feasibility studies relating to coal preparation plants;
- Construction of coal preparation plants; etc.

(3) Demand for Coals in Various Branches of Industry

The use of coals in the individual branches of industry is shown in Table 2.2-15. The domestic coals are utilized mainly for electricity generation and cement industry. A small share is used for heat generation process in other branches of industry. This utilization is expected to be similar trend in the future for both domestic and imported coals.

Table 2.2-12 Properties of Coal for Various Uses

Conditions and Analysis	Combustion					Briquetting		Gasification		Pyrolysis		Liquefaction of Coal	Coal Preparation	Coal Powder for Combustion and Cement	Fine Coal for Fluid-Bed Combustion
	Power Station	Boiler	Cement	Tobacco	Residential Combustion	without Binder	with Binder	Low-C Gas Production	High-C Gas Production	Coke for Water and Gas Cleaning	Coke for Metallurgy Process	Process for Bergius Piere			
Type of Coal	Lignite Hard Coal Anthracite	Lignite Hard Coal Anthracite	Lignite Hard Coal Anthracite	Lignite Hard Coal Anthracite	Lignite Hard Coal Anthracite	Lignite	Lignite Hard Coal Anthracite	Lignite Hard Coal	Lignite Hard Coal	Lignite	Lignite Hard Coal	Lignite	Lignite Hard Coal Anthracite	Lignite Brown Coal	Lignite Brown Coal
Moisture (%)	<60	<20	<15	<20	<20	>40 (insitu Seam) (dry up) <20	<15	<15	<20	>45 (insitu Seam)	<10	<55 (<2% after Drying)	<45	<15 >30 Drying	<15 >30 Drying
Ash (Ad) (%)	<50	<20	<15	<50	<15	<15	<15	<15	<20	<5	<10	<12	<15	<15	<15
Heating Value (kcal/kg)	>1,100	>4,000	>4,500	>4,000	>4,000		>4,000	>4,000	>3,500					>4,000	>4,000
VM (%)	X	X	X	X	<20 (mf)	X	<20 (mf)			>50					
Sulfur (%)	<5	<2	>1 - 3	<1	<1 >1 - 2 add Lime	<2 bei 1 - 2% add Lime	<2 bei 1 - 2% add Lime	<0.6% >0.6% with H2S Cleaning	>1 - 5	<1	<1	<3		<1 1 - 2 (Mixing with Limestone)	<1 1 - 2 (Mixing with Limestone)
Sulfur Binding (%)	X	X			X										
Coal Elemental Analysis (%) C/H/N/S/O	X														
Ash Oxide Analysis (%)	X		X				X	X	X	X		X		X	X
Ash Fusion TEMP. (C) tA/tB/tC	tB > 1,100	tB > 1,100		tB > 1,060				tB > 1,100	tB > 1,150					tB > 1,100	X
Grain Size (mm)	X	0.5/0 4/0 80/10		0.5/0 4/0 80/10	> 20/ < 100	< 5/0	< 5/0	50/10	70/10	70/6		< 0.5/0		0.5/0	6/0
Carbonization Analysis								X	X	X		X			
Ash Particle Analysis (%)						X							X		
Coal Preparation Analysis													X		
Strength of Coal Hardgrove Abrasive Strength	X		X					X X	X X				X		
Content of Bitumen												X			
Swelling Index											X				
Maceral Analysis										X	X	X			

Table 2.2-13 Recommendation for Utilization of Coal in Thailand According to the Coal Quality

Deposit Location	Moisture (raw)	Ash (raw)	VM (raw)	Fix Carbon (raw)	S (dry)	Density	Average Heating Value	Use: Coal Preparation	Powder Coal	Fluid-Bed Coal for Boiler	Briquettes: without Binder	Briquettes: with Binder	Gasification: Weak Gas	Gasification: Rich Gas	Coal Liquefaction	Combustion: Power Station	Combustion: Boiler	Combustion: Cement	Combustion: Tobacco	Combustion: Residential
	%	%	%	%	%	g/m3	kcal/kg													
Mae Moh	30.2	25.4	28.5	16.5	3.0	1.5	2,700	XP								X	X			
Krabi	23.7	19.8	32.7	23.9	1.9	1.4	3,545	XP		XP						X	X	X		
Li	10.4	16.4	26.5	46.7	1.6	1.4	5,350					XP					X	X		Briquettes X
Mae Teep	12.3	14.0	31.0	42.8	2.2	1.5		X	X								X		X	
Nong Ya Plong	12.3	14.0	31.0	42.8	0.8	1.4	5,444		X								X			Briquettes X
Mae Than	20.0	30.4	26.5	23.1	4.0	1.5	3,068	XP								X	X			
Wiang Haeng	24.3	32.2	23.5	20.1	0.9	1.7	2,908	XP								X	X		X	Briquettes X
Sin Pun	24.4	18.5	32.8	24.3	6.2	1.4	3,534	XP								X		XP		
Khian Sa	13.8	23.0	31.8	31.4	7.0	1.3	3,936	XP										XP		
Saba Yoi	29.2	28.7	26.4	17.8	2.7	nd.	2,530	XP								X	X	X		
Wang Nua	16.9	36.0	28.0	19.2	2.5	1.6	2,980	X									X	X		
Ngao	16.0	45.0	27.4	11.7	5.0	1.7	2,100	XP								X	X	X		
Chae Hom	14.3	48.9	25.0	11.9	3.7	1.7	2,044	X									X			
Serm Ngam	22.3	13.9	32.7	31.1	2.4	1.4	4,127										X			
Mae Ramat	7.	30.2	27.4	35.5	7.8	1.6	4,469	XP								X	X			
Chiang Muan	23.0	26.6	30.4	20.0	3.1	1.5	3,213	XP									X	X	X	
Mae Tha	16.0	33.1	28.5	22.4	5.4			XP												
Kantang	14.5	20.3	35.8	28.5	4.2	1.4	3,580													
Na Duang	3.	27.0	5.3	64.7	0.8		6,000					XP					X	X	X	Briquettes X
Na Klang							6,000					XP					X	X	X	Briquettes X
Um Phang	14.0	38.0	25.4	22.0	3.4	1.6	3,100										X			

P = partly / part of coal

Table 2.2-14 Grouping of Coal Deposits for Various Kinds of Utilization

Coal Deposits of Thailand

12 Deposits active		12 Deposits active	
Regional Importance 6 Deposits	Local Importance 6 Deposits	Regional Importance 8 Deposits	Local Importance 4 Deposits
Mae Moh, Li, Krabi Mae Lamao Mae Than Mae Chaem	Mae Teep Nong Ya Plong Mae Tuen, Kantang, Na Duang, Na Klang	Wiang Haeng Chiang Muan Ngao, Saba Yoi Sin Pun, Wang Nua, Mae Ramat, Chae Hom	Mae Tha Serm Ngam, Khian Sa, Nong Plab

Power Stations	Boiler (regional)	Cement	Drying Tobacco	Boiler (local)	Briquettes	Ceramics	Glass	Asphalt-Mix Plants
Mae Moh Krabi Saba Yoi Ngao Sin Pun	Li Krabi Mae Lamao Mae Than Wiang Haeng Chiang Muan Saba Yoi Hang Chat Wang Nua	Li Krabi Wiang Haeng Khian Sa 1) Sin Pun 1) Saba Yoi Chae Hom	Na Duang Na Klang Nong Ya Plong Li	Wang Nua Mae Tha Serm Ngam Mae Chaem Mae Tuen Wang Nua Chae Hom Na Duang Na Klang	Li Nong Ya Plong Wiang Haeng Na Duang 2) Na Klang 2)	Li Sin Pun } * Khian Sa Others	Li Sin Pun } * Khian Sa Others	Wiang Haeng Saba Yoi Wang Nua Krabi Mae Ramat Hang Chat Chae Hom Chiang Muan

1) Partially use (mix with imported coal)
2) only coal < 6 mm grain size
*) Gasification

Table 2.2-15 Coal Utilization in Various Industries

Unit : tons / year

Years / Industry	1992		1993		1994	
	Quantity	%	Quantity	%	Quantity	%
Electricity	12,370,639	78.80	11,490,327	73.00	12,164,222	71.50
Cement	2,166,726	13.80	2,918,098	18.50	3,438,147	20.20
Lime	63,194	0.40	51,569	0.30	77,262	0.45
Tobacco	154,186	0.98	227,257	1.40	63,009	0.37
Pulp	505,865	3.22	524,004	3.30	873,050	5.13
Food	58,791	0.37	54,313	0.30	74,900	0.44
Polymer	55,015	0.35	119,271	0.80	115,800	0.68
Metal	12,386	0.08	10,826	0.07	3,500	0.02
Battery	4,400	0.03	5,230	0.03	837	0.00
Others	307,652	1.96	338,911	2.20	205,808	1.21
Total	15,698,856	100.00	15,739,806	100.00	17,016,534	100.00

The utilization of imported coals is also determined by transport means and distances. The location of receiving terminals should be considered. Possible uses of domestic coals as well as imported coals, can be estimated for each individual industry.

Table 2.2-19 and 2.2-20 display estimation of the future coals demand according to domestic and imported coals.

Table 2.2-16 Estimated Demand for Domestic Coals According to Sectors / Branches of Industry

Unit : million tons / year

Industry	Years				
	1996	2001	2006	2011	2016
Power Stations	15.2	15.5	15.5	14.5 - 15.5	18.0 - 20.0
Boilers/Industry	1.0	5.5	7.0 - 8.0	9.0 - 10.5	11.0 - 13.0
Cement	3.0	3.5	4.0	4.5	4.5
Coal Industry	0.1	0.4	1.0	1.5	2.0
Lime	0.1	0.4	0.6	0.8	1.0
Base Metallurgy	0.1	0.4	0.5	0.5	0.7
Glass			0.1	0.2	0.3
Ceramics			0.4	0.7	1.1
Agriculture/Tobacco	0.1	0.2	0.2	0.2	0.2
Asphalt-Mix Plants		0.1	0.2	0.3	0.4
Others	0.3	0.4	0.6	1.0	1.4
Total	19.9	25.4	30.1 - 31.1	33.2 -35.7	40.6 - 44.6

Table 2.2-17 Estimated Demand for Imported Coals According to Sectors / Branches of Industry

Unit : million tons / year

Industry	Years				
	1996	2001	2006	2011	2016
Power Stations			2.5	11.2	18.0 - 20.0
Boilers/Industry	0.5	5.0 - 6.0	7.0 - 8.0	9.0 - 10.5	12.0 - 15.0
Cement	1.0	1.1	1.2 - 1.4	1.5 - 2.0	2.5 - 4.0
Lime	0.1	0.1 - 0.2	0.3	0.4 - 0.5	0.6 - 1.0
Base Metallurgy	0.2	0.5	0.8	1.0 - 1.4	1.5 - 2.5
Glass		0.1	0.2	0.3	0.5
Ceramics		0.3	0.5	0.8	1.0 - 1.5
Agriculture/Tobacco	0.1	0.1	0.2	0.2	0.3 - 0.5
Asphalt-Mix Plants		0.2	0.3	0.4	0.5
Others	0.5 - 0.9	1.0 - 1.6	2.0 - 2.5	3.0	3.5 - 4.5
Total	2.4 - 2.8	8.3 - 10.0	15.0 - 16.7	28.0 -30.4	40.3 - 50.0

2.2.4 Development of coal deposits in Thailand

Almost all Coal deposits in Thailand occurred in the Tertiary basins. Tertiary basins are found;

(1) To the north in Changwat Lampang and in the vicinity,

(2) To the northwest in Changwat Tak,

(3) To the south in Changwat Krabi and in the vicinity.

According to the information above three main Tertiary basins, three main centers for exploration and utilization are as follows :

1) The northern region having Mae Moh deposits as center surrounded by Wiang Haeng, Chae Hom, Hang Chat, Mae Tha, Ngao, Serm Ngam, Wang Nua, Mae Chang.
2) The northwestern region having Mae Lamao and Mae Ramat deposits as center surrounded by Pala Tha, Um Phang.
3) The southern region having Krabi and Saba Yoi deposits as center.

For Serm Ngam coal deposit; although the deposit contains good quality coal, it has small reserves and the coal seams are relatively thin. For other remaining 4 coal deposits, the coals contain relatively high sulfur contents which required the following study prior to bidding;

- Total Sulfur content
- Total inorganic Sulfur content
- Forms of sulfur
- Ash composition

After the results of the above studies have been evaluated for those 5 coal deposits, the decision could be made regarding to their utilization and mine planning for each individual stage. Table 2.2-24 displays the forecast of possible production of coals which are upgraded by several processes for the period of 5 years.

It is forecasted that the domestic coals could be supplied to consumers for at least 20 years.

Table 2.2-18 Possibility of Production of Prepared Coal, Powder Coal, Fluid-Bed Coal and Briquettes

(calculated as run-of-mine coal) Unit : Million tons/Year

Produce	1996	2001	2006	2011	2016
Prepared Coal		1.0	3.0 - 4.0	5.0 - 6.0	7.0 - 7.5
Powder Coal				1.0 - 2.0	3.0 - 3.5
Fluid-Bed Coal			1.0	2.0 - 2.5	3.0 - 3.5
Briquettes		0.1	0.3	0.5	0.6 - 1.0

Table 2.2-19 Cost of Coal Processes

Processes	Unit of Price	Price
Preparation of Coal	US$ / t Prep. Coal	25.61
Produce of Powder Coal	US$ / t Prep. Coal	46.10
Produce of Fluid-Bed Coal	US$ / t F-B. Coal	42.08
Briquetting with Binder (without Drying of Coal)	US$ / t Briq.	45.98
Briquetting with Binder (with Drying of Coal)	US$ / t Briq.	68.77
Produce of Low Heating Gas	US$ / t Mwh	26.41

2.2.5 Managing conditions and regulations

(1) Managing conditions and regulations management

Previous government policies on coal resources management are determined through cabinet resolutions which can be concluded as follows :

- Cabinet Resolution on June 9, 1987.
  - National Energy Policy Office (NEPO) was authorized for policy formulation and coordination with those agencies concerning with coal resources development.
  - Department of Mineral Resources (DMR) was authorized for coal exploration and contract bidding.

- Electricity Generating Authority of Thailand (EGAT) was authorized for producing coal for power generating and has a special privilege in choosing coal basin prior to DMR bidding.
- Department of Energy Development and Promotion (DEDP) was authorized for research in coal utilization.

• Cabinet resolution on July 12, 1988.
  - Endorsing DMR to call for bidding for Khian Sa coal basin
  - Endorsing DMR to reserve Wiang Haeng and Sin Pun coal basins for EGAT's power generating scheme.

• Cabinet resolution in June 1990
  - Endorsing DMR to call for bidding for Chiang Muan, Chae Hom, and Wang Nua coal basins.
  - Endorsing DMR to reserve Ngao coal basin for EGAT.

• Cabinet resolution in May 1992
  - Endorsing the return of Wiang Haeng coal basin from EGAT to DMR for bidding.
  - Revoking EGAT's privilege made on June 9, 1987, making EGAT to compete with private sectors in bidding for coal basins in the areas announced under sub-clause 6 of the Mining Act.

(2) Arrangement by State Agencies

It is a known fact that there is an unbalanced statistics between the growth of worldwide consumption of gas and oil and that of solid energy sources which will cause critical problems to our succeeding generations in solving their energy issues. The worldwide recoverable reserve of oil and gas is estimated at 25% while that of coal is amounted to 75%, but their consumption figures are in the inverse proportion. Coal consumption has only 8% share of the total amount. If the current scenario is allowed to continue, the recoverable gas and oil reserves will be depleted within 50 years, whereas coal will still be available up-to the year 2200. It is, therefore, obviously crucial to examine the domestic sources of coal with regard to long-term energy use in all individual cases. The same applies to imported coal as well.

For the role of the government, should be established in order to facilitate a favorable climate for the following :

1) Long-term energy supply security

2) Provision of basic conditions

3) Governmental executive, advisory and control bodies should be established and/or those existing governmental bodies should be made fit for the forthcoming task as Energy Efficiency and Economical Use of Energy

(3) Economic Arrangements

In the energy market, domestic coal is facing a strong competition with imported coals, oil and gas and, increasingly, with various kinds of energy made from wasted materials (waste oil, petroleum coke, old tires) as regards,

- energy prices
- diversified forms of energy product and handling
- expenditure on processing technology
- environmental conditions in production and processing

For domestic coals, the imported coals should be regarded as competitors in addition to gas and oil. In future, stronger activities will therefore be needed for domestic coal to win new shares and maintain its current shares of the energy market.

(4) Regulations

In the early time of coal resources development, the role of the government has been emphasized only on some particular aspects which are controlling, exploration, and production under the rules and regulations provided in the Mining Law. However, at present, the situations on supply and demand as well as economical consideration of coal have been changed dramatically. It is necessary that the government should review its role as well as those rules and regulations concerning coal development in order to support private sector, who now possessing more capability in technology and investment.

3 Results of the Geological Study

3.1 Phrae Basin

3.1.1 Geography

The basin is elliptic with NNW-SSW long axis of 60 km and WNW-ESE short axis of 15 km with a subbasin stretching 20 km toward north. The basin is surrounded by relatively gentle mountain ranges ranging from 500 m to 1,000 m in altitude. A terrace occur in the western periphery of the sub basin. The Yom River, the main river system, flows in the western side of the basin meandering and gathering tributaries, which flow into the basin from east and west. The northeastern hilly area is mainly utilized for extensive farming of maize, sugar cane, tobacco and stock farming. The rest is intensively cultivated for rice farming except housing sites.

3.1.2 Exploration and geological investigation

(1) Exploration

Table 3.1-1 Exploration in the Phrae Basin

	1994	1995	1996	1997	Total
Geological mapping		all outcrops			
Drilling (holes) total depth (m)		5 3,551	3 1,779	5 2,954	13 8,284
Geophysical logging (hole) total depth (m)		5 2,994	2 972	3 1,874.5	10 5,840.5
Seismic survey (lines) total length (km)	9* 156			6 30	15 186
Coal analysis (samples)			10		10

* Previously conducted by Petroleum Authority of Thailand (PTT).

(2) Geological investigation

1) Geological mapping

Location of outcrops and measured strikes and dips were plotted on base map of scale 1 : 50,000.

2) Decision f the borehole exploration sites.

The borehole exploration sites were decided through discussion with DMR. The suitable sites were decided to the southern part of the basin as the results of geological mapping and observation of EGAT's borehole cores and interpretation of the seismic profiles.

3) Interpretation of seismic profiles

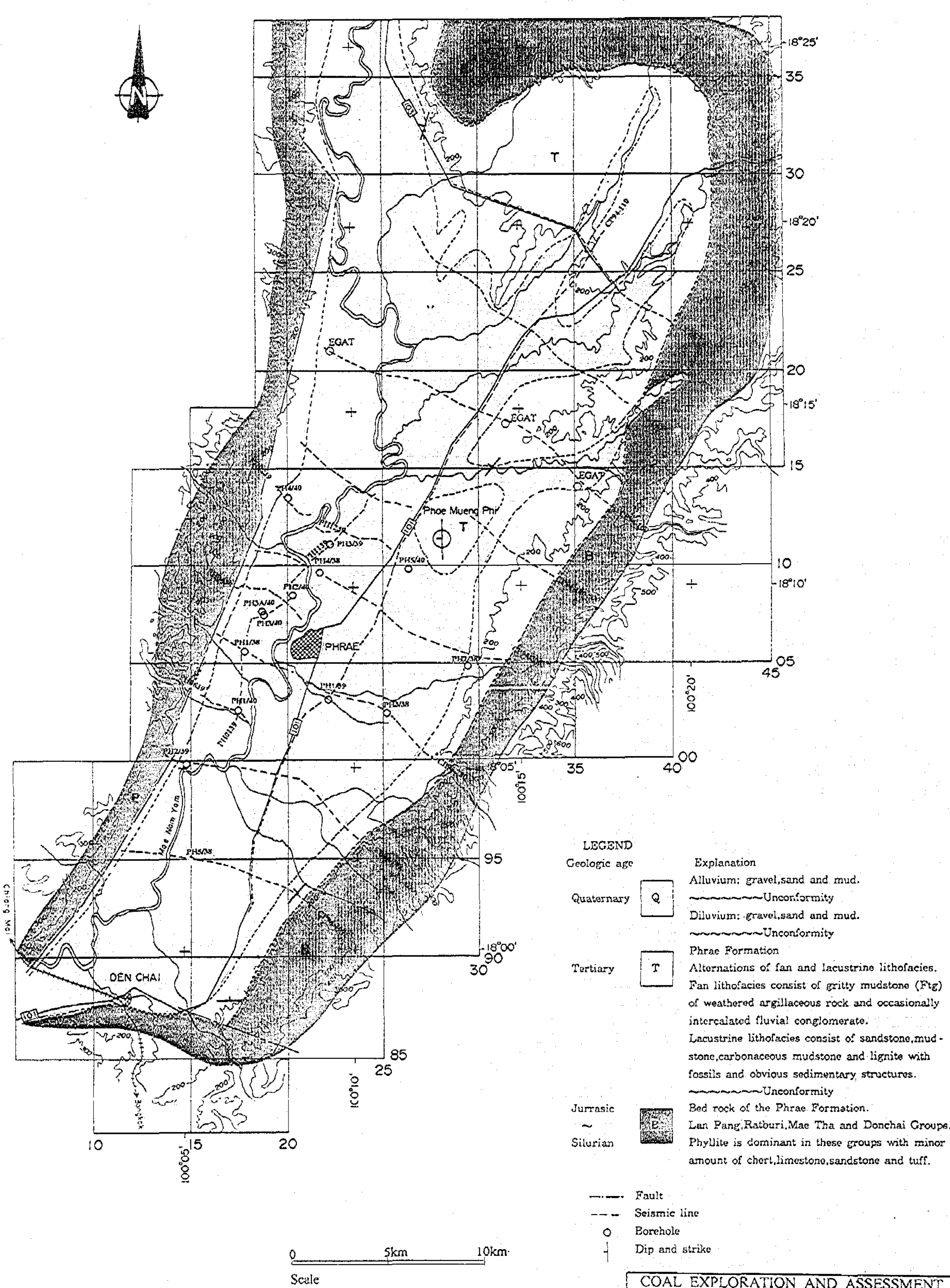
The remarkable reflectors on each seismic profile were colored and traced so far as recognizable on the profiles, and their travel time were converted into the depth.

4) Lithofacies logs

Most of the borehole cores were logged by the Study Team. The depth of each marker bed was adjusted to the geophysical logs, and the lithology of non-cored interval was presumed from the geophysical logs.

5) Correlation and sedimentary facies

The borehole logs on a scale of 1 : 2,000 were drafted and correlated each other referring to the depths of the remarkable reflectors. For the purpose of correlation, the main sedimentary facies were decided by lithofacies. The comprehensive stratigraphic column is shown in Fig. 3.1-3. Investigation of sedimentary environments has revealed that the coal deposits are understood to be accompanied to lacustrine facies.



COAL EXPLORATION AND ASSESSMENT IN THAILAND

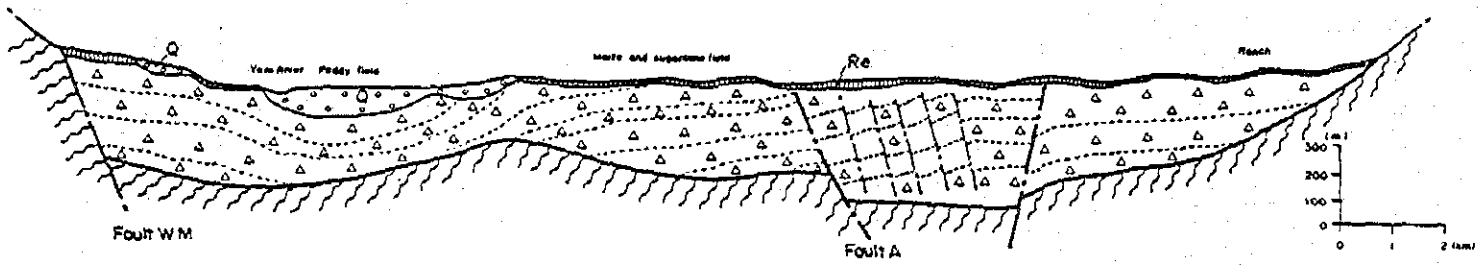
PHRAE BASIN

Geological Map

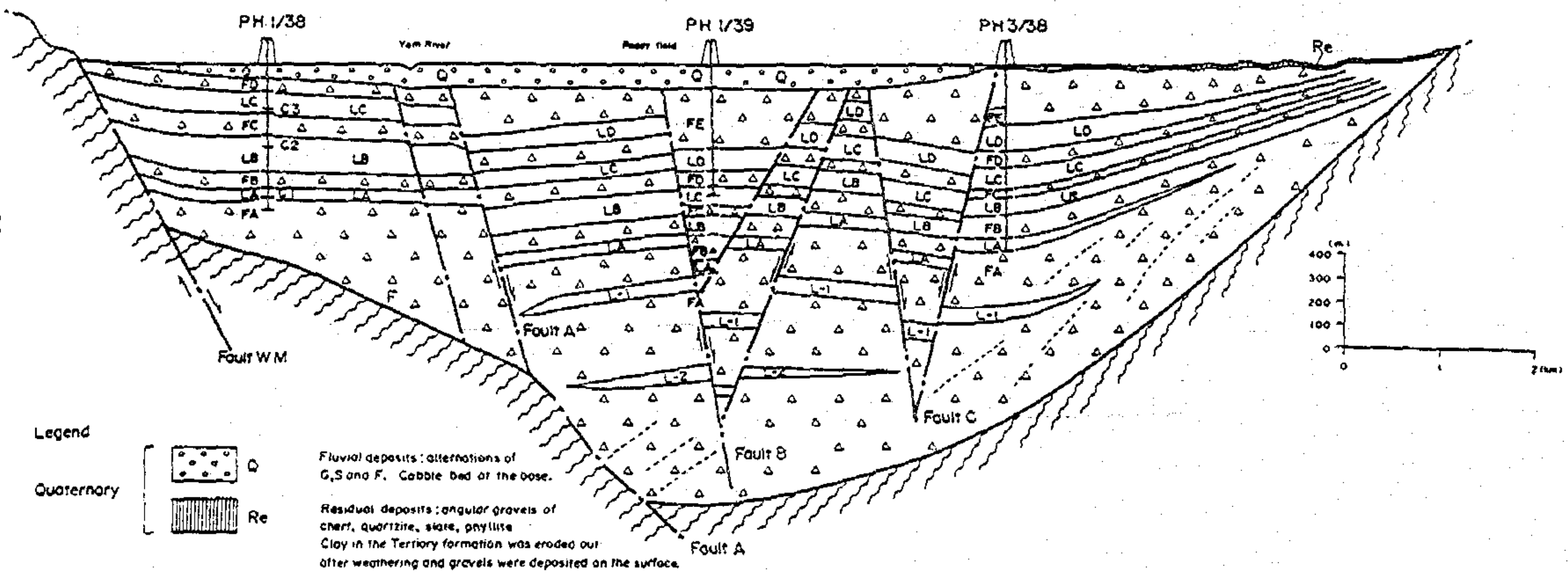
Fig. 3.1-1

GEOLOGY OF THE PHRAE BASIN (Conceptual profile)

W ~ E Profile , Northern area CP94-120



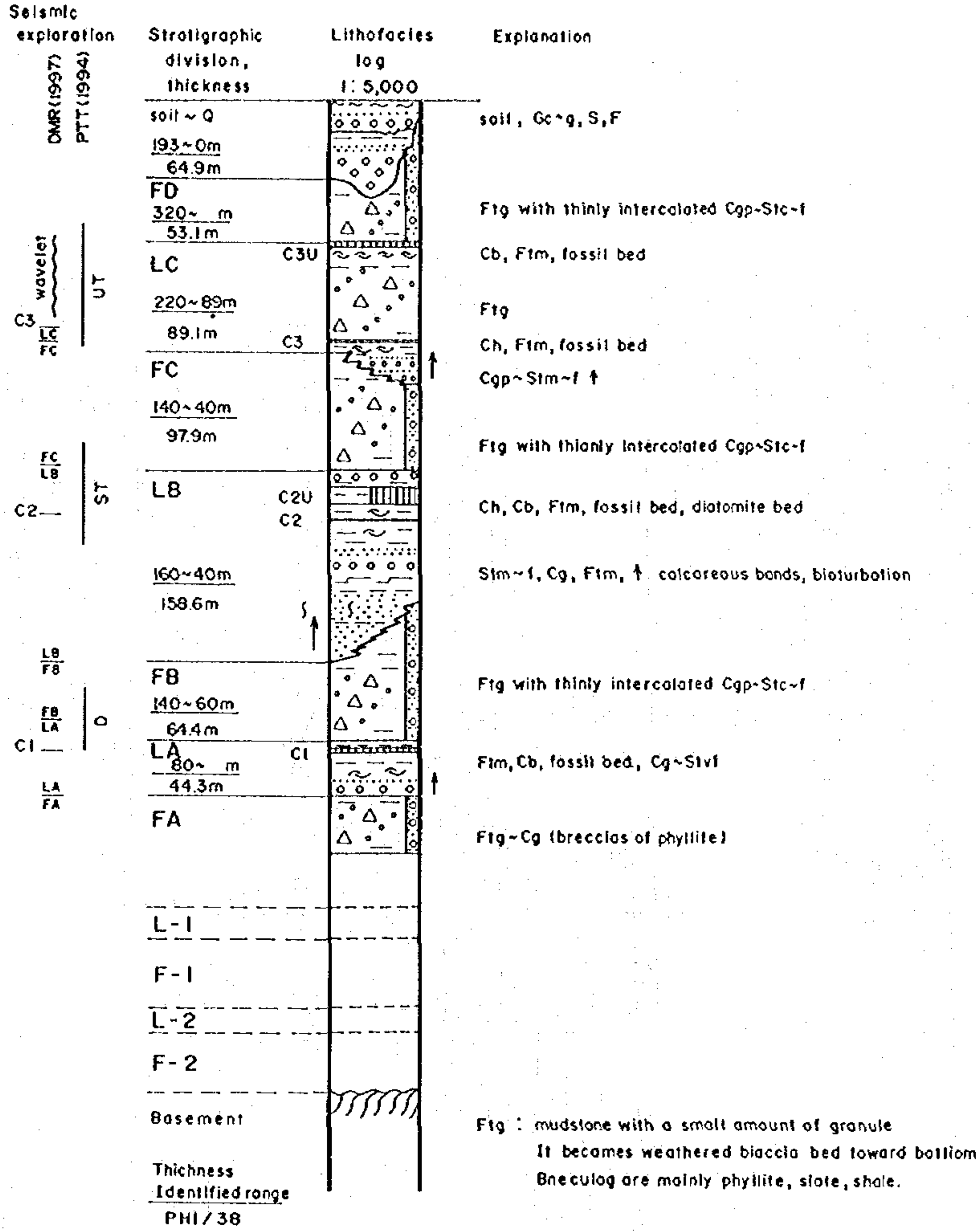
W ~ E Profile , Southern area CP94-220



Legend

Quaternary	Q		Fluvial deposits : alternations of G, S and F. Cobble bed at the base.
	Re		Residual deposits : angular gravels of chert, quartzite, slate, phyllite. Clay in the Tertiary formation was eroded out after weathering and gravels were deposited on the surface.
Tertiary (Phrae Formation)		LA ~ LD L-1, L-2	Lacustrine, fluvial, small delta deposits : characterized by massive on laminated Fm, St, Cg, and various lacustrine deposits such as fossil bed, carbonaceous or calcareous beds. Thin fan deposits are included.
	Δ Δ Δ Δ	FA ~ FE	Fan deposits : Mainly consists of Ftg (gritty mudstone) with thin bands of Cg in the upper horizon. This mudstone contains weathered or fresh phyllite breccia in the lower horizon. Therefore this mudstone is understood to be weathered conglomerate.
Triassic Carboniferous			Mainly consists of phyllite and slate. A lesser amount of chert, quartzite and limestone are included.

COAL EXPLORATION AND ASSESSMENT IN THAILAND
PHRAE BASIN
Conceptual Profile
Fig. 3.1-2



Phrae Basin, Stratigraphy

Type : PH1/38

COAL EXPLORATION AND ASSESSMENT IN THAILAND
PHRAE BASIN
Stratigraphic Column
Fig.3.1-3

3.1.3 Geology

(1) Stratigraphy

Table 3.1- 2 Stratigraphy of the Phrae Basin

Geologic age	Deposits	Exploration
Quaternary	Alluvium	Thin fluvial deposits along the Recent rivers.
	Residual deposits	Unconsolidated gravel, thin residue of the weathered Phrae Formation.
	Diluvium	Unconsolidated gravel, NW area : terrace deposits, central and southern areas: thick gravel bed
	~~Unconformity~~~~~~~~~~~~~~~~~~~~	
Tertiary (Miocene or younger)	Phrae Formation	Alternations of fan and lacustrine lithofacies. Fan lithofacies consist of weathered breccia of argillaceous rock and thin conglomerate. Lacustrine lithofacies consist of sandstone, mudstone, carbonaceous mudstone, and lignite with fossil beds
	~~Unconformity~~~~~~~~~~~~~~~~~~~~	
Triassic ~ Silurian	Lan Pang, Ratburi, Mae Tha and Donchai Group	Mainly consist of argillaceou rock, chert, quartzite, limestone and tuff. Basement for the Phrae Formation.

Table 3.1-3 Summary of Coal Beds in Boreholes

		1/38	2/38	3/38	4/38	5/38	1/39	2/39	3/39	1/40	2/40	3A/40	4/40	5/40
Elevation(m)		158.807	195.787	167.651	152.203	149.503	155.700	148.563	157.157	151.683	154.718	158.817	164.541	169.646
Total depth(m)		622.0	691.0	738.0	650.0	850.0	575.0	554.0	650.0	650.0	445.5	650.0	597.5	611.0
C3U	Thickness	0.00/1.75	0.00/0.90	0.00/1.20	0.40/2.10	?	thinning out	eroded	*0.80/1.70	eroded	*0.30/1.60	0.00/0.70	0.00/0.80	0.33/3.00
	Roof	118.75	204.10	361.20	295.20				297.80		301.60	225.50	173.45	238.60
	Floor	120.50	205.00	362.40	297.30				299.50		303.20	226.20	174.25	241.60
C3	Thickness	1.10/1.65	0.00/1.30	0.00/0.30	*1.30/1.50	1.30/1.90	thinning out	0.00/0.10	0.00/1.40	*0.25/1.10	*0.68/2.30	0.00/1.30	thinning out	thinning out
	Roof	197.85	294.00	433.80	407.20	458.40		109.70	393.40	130.90	402.70	310.60		
	Floor	199.50	295.30	434.10	408.70	460.30		109.80	394.80	132.00	405.00	311.90		
C2U	Thickness	0.47/0.61	thinning out	thinning out	?	?		0.00/1.85	0.80/1.00	0.00/1.10		0.00/0.70	0.00/1.95	0.00/0.25
	Roof	333.09						245.15	566.00	262.95		465.20	406.00	576.00
	Floor	333.70						247.00	567.00	264.05		465.90	407.95	576.25
C2	Thickness	1.54/1.95	0.40/1.40	0.00/0.30	?	?		*0.80/1.20	*0.81/1.20	*1.52/2.15		1.50/1.70	0.00/1.20	0.00/1.00
	Roof	346.65	496.00	593.80				257.60	590.80	274.10		484.00	416.30	591.75
	Floor	348.60	497.40	594.10				258.80	592.00	276.25		485.70	417.50	592.75
C1	Thickness	0.00/0.30	thinning out	thinning out				0.00/0.10		0.00/0.10			thinning out	
	Roof	533.25						443.40		476.60				
	Floor	533.55						443.50		476.70				

*:These coal beds were analyzed in Japan.

(2) Coal bed

1) Coal occurrence

The coal bed in the Phrae Basin are relatively thin and their thickness are variable. Four coal beds including carbonaceous mudstone have been found by borehole exploration. They have been denominated C-1, C-2, C-3, and C-4 in ascending order which were deposited in each lacustrine unit of LA, LB, LC, and LD respectively.

Lithofacies investigation of each borehole reveals the deposition of coal beds as follows:

- Coal beds were deposited in lacustrine lithofacies, which is occasionally intercalated in fan lithofacies.
- In the northern and eastern parts of the basin, fan lithofacies dominates the Phrae Formation, and lacustrine lithofacies is concluded thin and not stable to intercalate any coal bed except for thin carbonaceous bands.
- In the southern part of the basin, the western side (between W.M. Fault and A Fault) is concluded to intercalate the relatively thick coal beds owing to stable depositional condition of lacustrine lithofacies. On the contrary, the eastern side of A Fault is concluded that the coal beds were deposited not thick enough or too deep to estimate the resources.

2) Coal quality

The half of cores which were collected from the relatively thick coal bed were analyzed in Japan. Based on the analytical results, the general coal quality of the Phrae Basin seems to be high ash, high sulfur and low heating value. The sampling intervals are indicated in Fig. 3.1-4. The remaining half of the cores were analyzed in DMR laboratory.

Ash analysis indicates that the Fe_2O_3 and CaO contents are relatively high, probably due to the sedimentary environments of high temperature and precipitation of Fe^{3+} and Ca^{2+}. Also high ash and sulfur contents in coal mean their concentration from the result of strong decomposition of original peat under the environments of high temperature and dry climate.

(3) Geologic structure

The western margin is delineated by W.M Fault (Western Margin Fault), and at the eastern margin Tertiary deposits are gradually thinning, steeply dipping and abutting against the basement. Three main faults are present in the basin. All of these faults are NNE-trending normal faults dipping east. Maximum displacement is approximately 200m. In the southwestern part of the basin, a gentle syncline of NNE-SSW axis occurs. It extends toward north to NE-SW direction. The general structure indicates relatively gentle with dipping angle of between 5 to 8 degrees.

(4) Sedimentary environment of lignite

1) Lignite-bearing lacustrine lithofacies

Stratigraphy of the Phrae Basin is characterized of its alternations of fan and lacustrine lithofacies compared to the standard stratigraphy of the Tertiary intermontane coal basins in northern Thailand. Peat, the precursor of lignite or coal, is believed to be deposited as peat swamp in shallow lacustrine or deltatic environment which lasts for long period under calm condition with least inflow of clastics in general. Fan lithofacies, consisting of coares clastics transported under the high energy regime, might not provide the suitable environment for peat swamp.

2) Sedimentary environment of the lignite beds

・ Incessant inflow of coarse clastics from the uplifting mountain range around the Phrae Basin formed fan deposits all over the basin.

・ While the supply of coarse clastics was lessened, lacustrine environment was maintained where fan did not progradate.

・ Lacustrine environment enabled growth of peat swamp. But its short period and topogenous water prevented peat swamp to change to domed peat from planar peat.

・ The reactivated inflow of coarse clastics formed fan deposits overlying the lacustrine deposits.

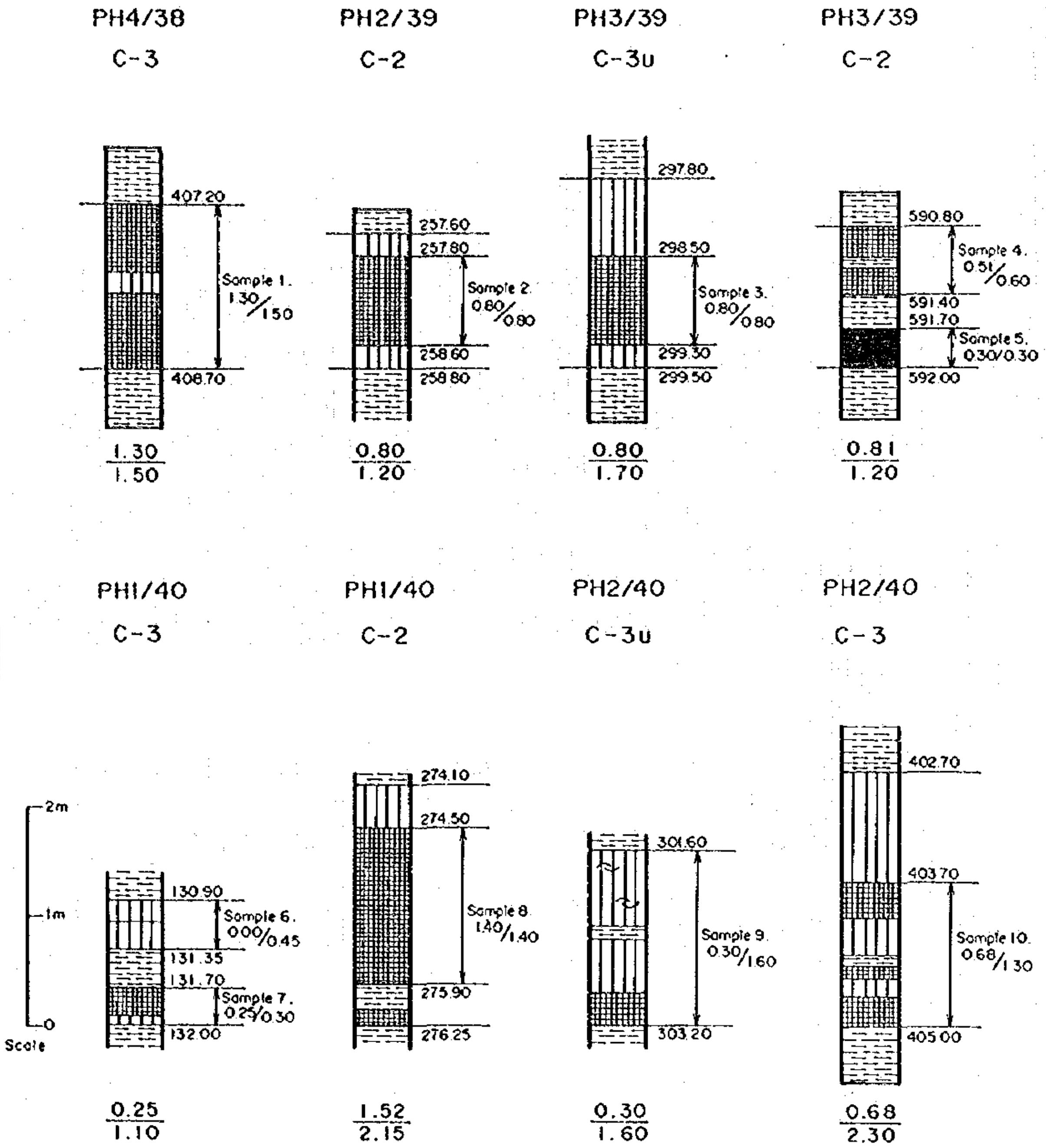
Table 3.1-4 Analytical Results of Sampled Coal Beds

DH No.	sample No.	analytical sample from	to	thick	as received TM	SM	as analysed basis M	ASH	VM	FC	(FR)	HV	TS	S ash	S comb
4 /38	1	407.20	408.70	1.50	16.5	6.8	10.4	56.1	23.3	10.2	0.44	1640	4.94	0.77	4.17
2 /39	2	257.80	258.60	0.80	27.5	14.4	15.3	25.6	38.2	20.9	0.55	3360	6.62		
3 /39	3	298.50	299.30	0.80	33.4	23.9	12.5	45.4	29.5	12.6	0.43	2370	7.82		
3 /39	4	590.80	591.40	0.60	23.4	13.6	11.3	43.9	27.8	17.0	0.61	2800	6.81	0.67	6.14
3 /39	5	591.70	592.00	0.30	27.7	16.1	13.8	26.8	33.7	25.7	0.76	4090	5.52	1.18	4.34
1 /40	6	130.90	131.35	0.45	35.3	28.3	9.8	61.1	19.5	9.6	0.49	1460	3.67		
1 /40	7	131.70	132.00	0.30	32.1	25.1	9.3	49.7	25.4	15.6	0.61	2210	8.94		
1 /40	8	274.50	275.90	1.40	15.2	4.0	11.7	32.5	33.2	22.6	0.68	3540	5.80		
2 /40	9	301.60	303.20	1.60	27.7	18.6	11.2	59.0	20.4	9.4	0.46	1570	4.47		
2 /40	10	403.70	405.00	1.30	18.7	8.5	11.1	51.2	25.6	12.1	0.47	2310	6.08		

DH No.	sample No.	dry basis ASH	VM	HV	TS	Ssulf	Spy	Sorg	C	H	O	N	S
4 /38	1	62.6	26.0	1830	5.51	1.69	2.54	1.28	19.0	2.02	11.17	0.54	4.65
2 /39	2	30.2	45.1	3967	7.82								
3 /39	3	51.9	33.7	2709	8.94								
3 /39	4	49.5	31.3	3157	7.68	0.89	4.73	2.06	30.3	2.45	9.84	1.00	6.92
3 /39	5	31.1	39.1	4745	6.40	0.80	3.94	1.66	47.0	3.55	11.78	1.54	5.03
1 /40	6	67.7	21.6	1619	4.07								
1 /40	7	54.8	28.0	2437	9.86								
1 /40	8	36.8	37.6	4009	6.57								
2 /40	9	66.4	23.0	1768	5.03								
2 /40	10	57.6	28.8	2598	6.84								

DH No.	sample No.	dry ash free basis CV	C	H	O	N	S	atomic ratio H/C	O/C	N/C	S/C	HGI	ash fusion temp C DT	ST	FT
4 /38	1	4896	50.8	5.40	29.89	1.44	12.45	128	44	2	9	100	1085	1230	1255
2 /39	2	5685													
3 /39	3	5629													
3 /39	4	6250	60.0	4.85	19.47	1.98	13.71	97	24	3	9	81	1070	1130	1155
3 /39	5	6886	68.2	5.15	17.10	2.23	7.31	91	19	3	4	58	1060	1080	1090
1 /40	6	5017													
1 /40	7	5390													
1 /40	8	6344													
2 /40	9	5268													
2 /40	10	6127													

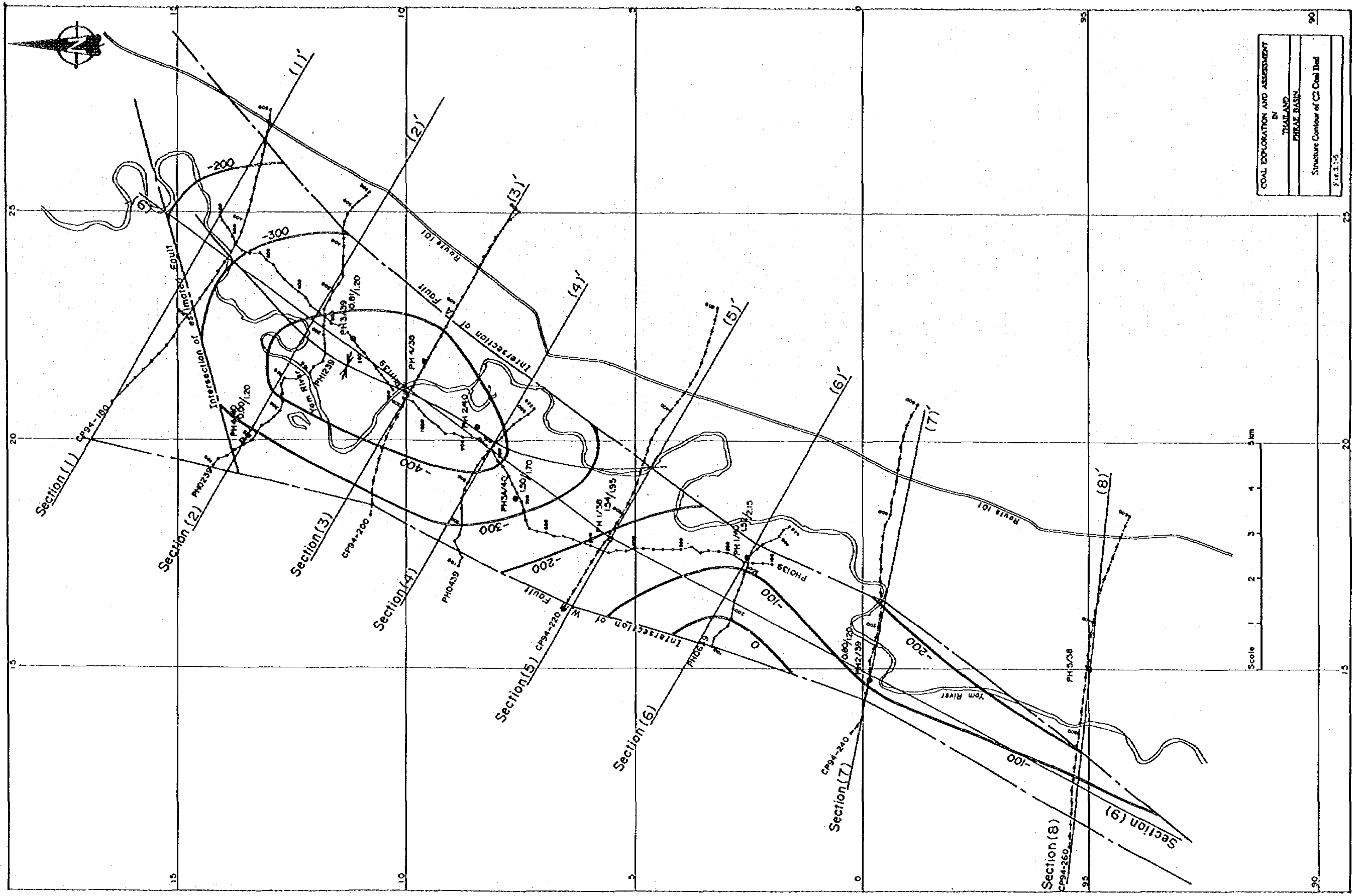
DH No.	sample No.	ash analysis as oxide Si	Al	Fe	Ca	Mg	Na	K	S	P	Ti	Mn	Ig loss	ASTM class Btu/lb	Class
4 /38	1	46.7	26.60	13.02	2.84	1.52	0.75	3.10	3.05	0.08	0.48	0.04	1.82	6148	ligB
2 /39	2													6684	ligA
3 /39	3													4965	ligB
3 /39	4	43.6	22.98	19.73	3.49	1.52	0.95	2.66	3.41	0.20	0.40	0.02	1.04	7270	ligA
3 /39	5	34.4	14.18	27.03	8.36	1.66	1.55	1.64	9.61	0.81	0.41	0.03	0.32	8122	ligA
1 /40	6													3423	ligB
1 /40	7													4709	ligB
1 /40	8													9238	subC
2 /40	9													4595	ligB
2 /40	10													7600	ligA

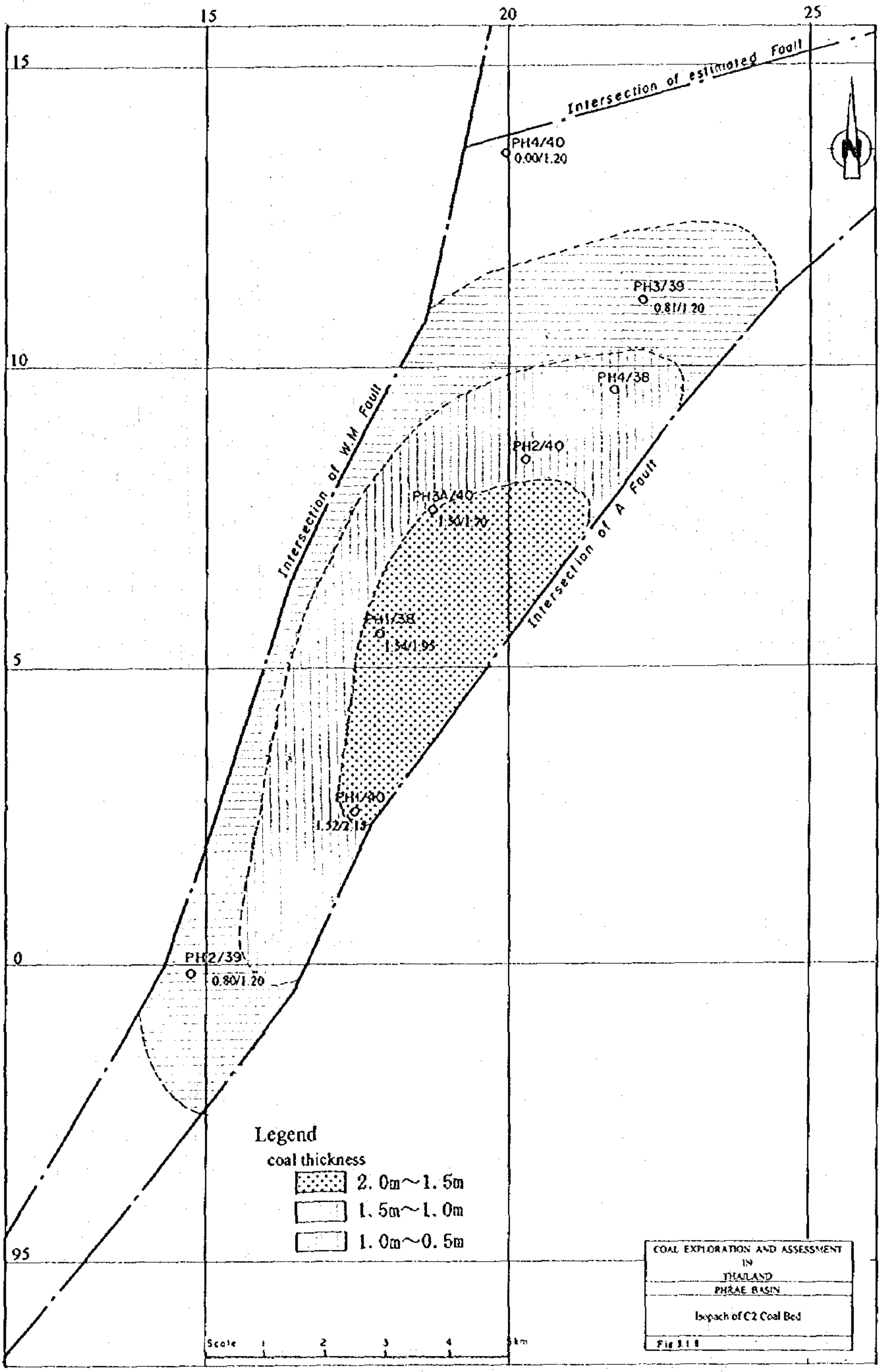


COAL EXPLORATION AND ASSESSMENT
IN
THAILAND
PHRAE BASIN

Section of Sampled Coal Beds

Fig.3.1-4


COAL EXPLORATION AND ASSESSMENT
IN
THAILAND
PHRAE BASIN
Structure Contour of C2 Coal Bed
Fig.3.1-5
Section (1)
Section (2)
Section (3)
Section (4)
Section (5)
Section (6)
Section (7)
Section (8)
Section (9)
(1)'
(2)'
(3)'
(4)'
(5)'
(6)'
(7)'
(8)'
Route 101
Yom River
Intersection of estimated Fault
Intersection of W Fault
Intersection of Fault
-100
-200
-300
-400
0
CP94-180
CP94-200
CP94-220
CP94-240
CP94-260
PH0239
PH0439
PH0139
PH0639
PH1239
PH 4/38
PH 2/40
PH3A/40
PH 1/38
PH 5/38
Scale
5km



15
20
25
15
10
5
0
95
Intersection of estimated Fault
PH4/40
0.00/1.20
PH3/39
0.81/1.20
PH4/38
PH2/40
PH3A/40
1.50/1.70
Intersection of W.M Fault
Intersection of A Fault
PH1/38
1.54/1.95
PH1/40
1.52/2.15
PH2/39
0.80/1.20
N
Legend
coal thickness
2. 0m～1. 5m
1. 5m～1. 0m
1. 0m～0. 5m
Scale 1 2 3 4 5km
COAL EXPLORATION AND ASSESSMENT
IN
THAILAND
PHRAE BASIN
Isopach of C2 Coal Bed

(5) Coal resources

1) Criteria of estimation

Table 3.1-5 Resources and Reserves Estimation Standards

		DMR	This Study	U.S. (U.S.Geol.Survey)
Geologic Assurance	Measured area	Radius≦ 200m	Radius≦200m	Radius≦400m
	Indicated area	Between the radius of 400 and 200m	Between the radius of 400 and 200m	Between the radius of 1200 to 400m
	Inferred area	None	Between the radius of	Between the radius of
Resources	Thickness (m)	≧0.2	≧0.5	≧0.75 (lignite and sub-bituminous)
	Ash Content (%)	≦40	≦45	≦33
	Depth (m)	0-50, 50-100,100-150,	≦1000	≦1800
	Estimation Method	ΣTotal coal thickness within the depth criteria ×area ×specific gravity	Each coal bed and block. *1) Σarea*2)×average coal thickness*3)×1.3	Each coal bed and block Σarea ×average coal thickness ×SG*4)
Reserves	Thickness (m)	None	Open pit≧ 0.5	[Reserve Base] ≧1.5
	Depth (m)	None	Open pit≦100*6) Underground≦500	Sub-bituminous ≦ 300 Lignite≦150
	Estimation	None	Same as the resources	Same as the resources
Mineable Reserves	Estimation	None	Each coal bed and block ΣPlanned mining area× mineable thickness×S.G. *5) ×recovery	[Reserves] Each coal bed and block Reserve base ×recovery×yield
Salable Reserves		None	Run of mine coal × beneficiation yield	

*1) Block means the area delineated by the major geologic structures.

*2) Area is subdivided on the coal bed map by geologic assurance, isopach lines of an appropriate interval of coal thickness and contour lines of elevation.

*3) Coal thickness is the average thickness between the two neighboring isopach lines.

*4) Average value is estimated.

*5) S.G. is estimated including partings.

*6) If the coal bed is thick enough, 150m or 200m can be used in relation to stripping ratio.

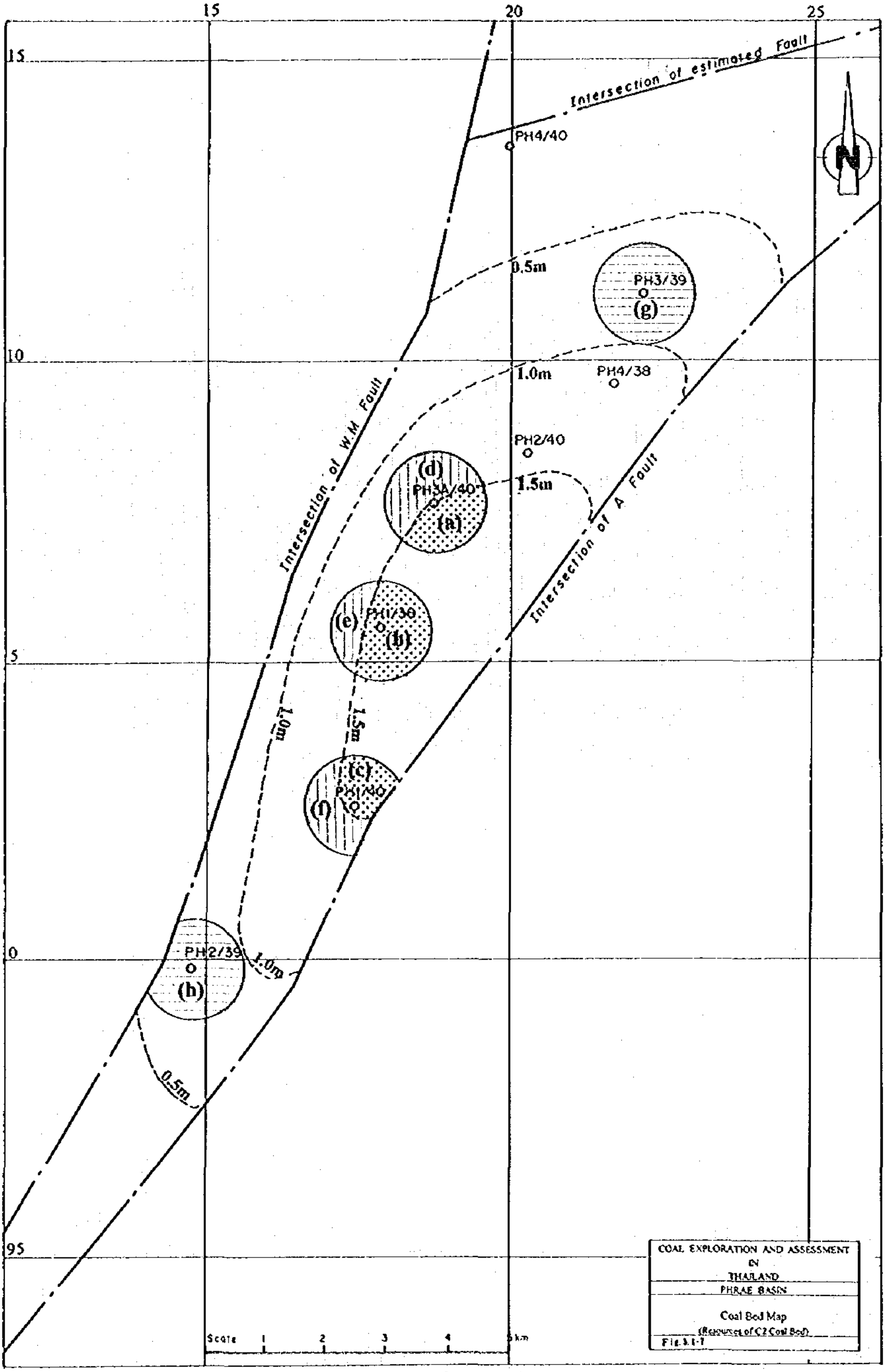
2) Coal resources

In situ coal resources of the Phrae Basin are estimated for the limited area between W.M Fault and A Fault on the basis of coal occurrence. The resources of C2 and C3 coal beds are estimated, because they are relatively stable in thickness and other coal beds are mostly composed of carbonaceous mudstone in quality. The total coal resources have been estimated at 20,909,000 t.

Table 3.1-6 Coal Resources of C2 and C3 Coal beds

Block	Thickness	Plan	Resources
	(m)	(1,000m2)	(1,000t)
C2 Coal Bed			
Measured+indicated+inferred			
(a)+(b)+(c)	1.50	3,070	5,987
(d)+(e)+(f)	1.25	2,660	4,323
(g)+(h)	0.75	3,810	3,715
Total	1.13	9,540	14,024
C3 Coal Bed			
Measured+indicated+inferred			
(a)+(b)+(c)	1.25	2,430	3,949
(d)+(e)+(f)	0.75	3,010	2,935
Total	0.97	5,440	6,884
Grand total	1.07	14,980	20,907

Specific gravity: 1.30



15
20
25
Intersection of estimated Fault
PH4/40
N
0.5m
PH3/39
(g)
1.0m
PH4/38
Intersection of W.M Fault
PH2/40
(d)
PH3A/40
1.5m
(a)
Intersection of A Fault
(e)
PH1/39
(b)
1.0m
1.5m
(c)
PH1/40
(f)
PH2/39
1.0m
(h)
0.5m
10
5
0
95
Scale 1 2 3 4 5 km
COAL EXPLORATION AND ASSESSMENT
IN
THAILAND
PHRAE BASIN
Coal Bed Map
(Resources of C2 Coal Bed)
Fig.3.1-7

3.1.4 Mining plan

The existing geological information is insufficient for preparation of a mining plan. It should be noted, therefore, that the following plan explains only a basic idea of underground mine development from the technical point of view.

(1) Mining area

Only the C2 Coal Bed is determined to have mineable thickness for underground mining to some extent. The possible mining area is between WM and A faults and an area with coal thickness of over 1 m in the isopach map.

(2) Mine access

The location of pit mouth is to be selected at relatively higher place near the shallowest part of the C2 Coal Bed to prevent the damage by flooding and to minimize the length of rock slopes. The slopes are 15 degrees in inclination and about 580 m each in length.

(3) Mine development

From the bottom of the slopes, main entries are developed in the coal bed toward northeast. Then, to the both sides of the main entries, inseam roads are driven to prepare mining panels. Owing to the very gentle dip of coal bed, a combination of a continuous miner and a shuttle car can be applied for road development. A set of four parallel roadways are planned both in main entries and in-seam road in order to reduce ventilation resistance.

(4) Room and Pillar mining

The surface of the mining plan area is intensively cultivated and irrigated for paddy field. In order to minimize the impact on the surface, room and pillar mining is suitable as the mining method in this area. However the mining recovery will be reduced to much less than longwall mining.

(5) Transportation and coal handling

Mined coal is loaded in a shuttle car, then unloaded on and transported by belt conveyor to the surface.

3.2 Nong Plab Basin

3.2.1 Geography

The Nong Plab Basin is elongated in shape with 12 km long in N-S and 5 km wide in E-W, covering an area of approximately 47 km^2 as shown in Fig. 3.2-1. The surface of the basin is mostly flat land with gentle hills ranging from 100 m to 190 m in altitude. The Pranburi River flows from north to south in the center of the basin. The land is utilized mainly for corn and pineapple field and stock farming.

3.2.2 Exploration and geological investigation

(1) Exploration

Table 3.2-1 Exploration in the Nong Plab Basin

		1993	1994	1995	Total
Drilling	(holes)	18	42	5	65
total depth	(m)	2,803.5	5,015	745.5	8,564
Geophysical Logging	(holes)	4	28	5	37
Seismic Survey	(lines)	15	-	19	34
total length	(km)	23	-	33	56
Coal Analysis	(samples)	13	41	-	54

(2) Geological investigation

- Cores of five boreholes drilled in 1995 were logged by the Study Team.
- All lithologic logs of a scale of 1:400 were correlated each other by taking the Upper Coal Bed as a stratigraphic marker.
- Coal bed sections on a scale of 1:100 were produced from core logs and adjusted to geophysical logs, when available. Each coal bed section was correlated on a ply by ply basis.

- Geologic structure were interpreted from seismic and borehole data, but the use of seismic profiles were only utilized to determine the general trend of dipping direction because of their poor quality.
- Based on the above investigation, various kinds of coal bed maps, such as an isopach map, a structure contour map, were produced.
- Coal resources and reserves of the Upper Coal Bed were estimated in accordance with the standard introduced in the Study.

3.2.3 Geology

(1) Stratigraphy

Tertiary formation in the Nong Plab Basin is divided into two units. The upper unit mainly consists of lacustrine mudstone and claystone with minor sandstone bands. Gastropod fossils are common and a few thin carbonaceous mudstone beds are present in this unit. The lower unit is characterized in lithology by increase of coarse clastics, such as sandstone and conglomerate, which indicates deltaic lithofacies. No molluscan fossil is observed in this unit. The unit is unconformably underlain by Paleozoic basement rocks.

(2) Coal bed

There are two coal beds in the lower unit of the Tertiary formation, namely the Upper and the Lower Coal Beds.

(3) Geologic structure

Geologic structure of the Nong Plab Basin is fairly complex. In the eastern part of the basin, the area is divided into several blocks by faults, which are assumed to be normal faults and denominated as from C to K faults. A synclinal structure exists in the middle of the area and the coal bed dips at 2 to 5 degrees eastward on the northwestern side and westward on the southeastern side of the syncline axis.

(4) Sedimentary environment

Stratigraphy of this basin is also similar to the typical coal basins in Thailand with slight difference in A : coarse clastics member and B : coal-bearing member. The Lower Coal Bed was deposited in a confined area overlying subsided basement.

(5) Coal resources and reserves

Coal resources of the Upper Coal Bed, as well as coal reserves, were estimated. Those of the Lower Coal Bed were excluded due to its restricted area of deposition.

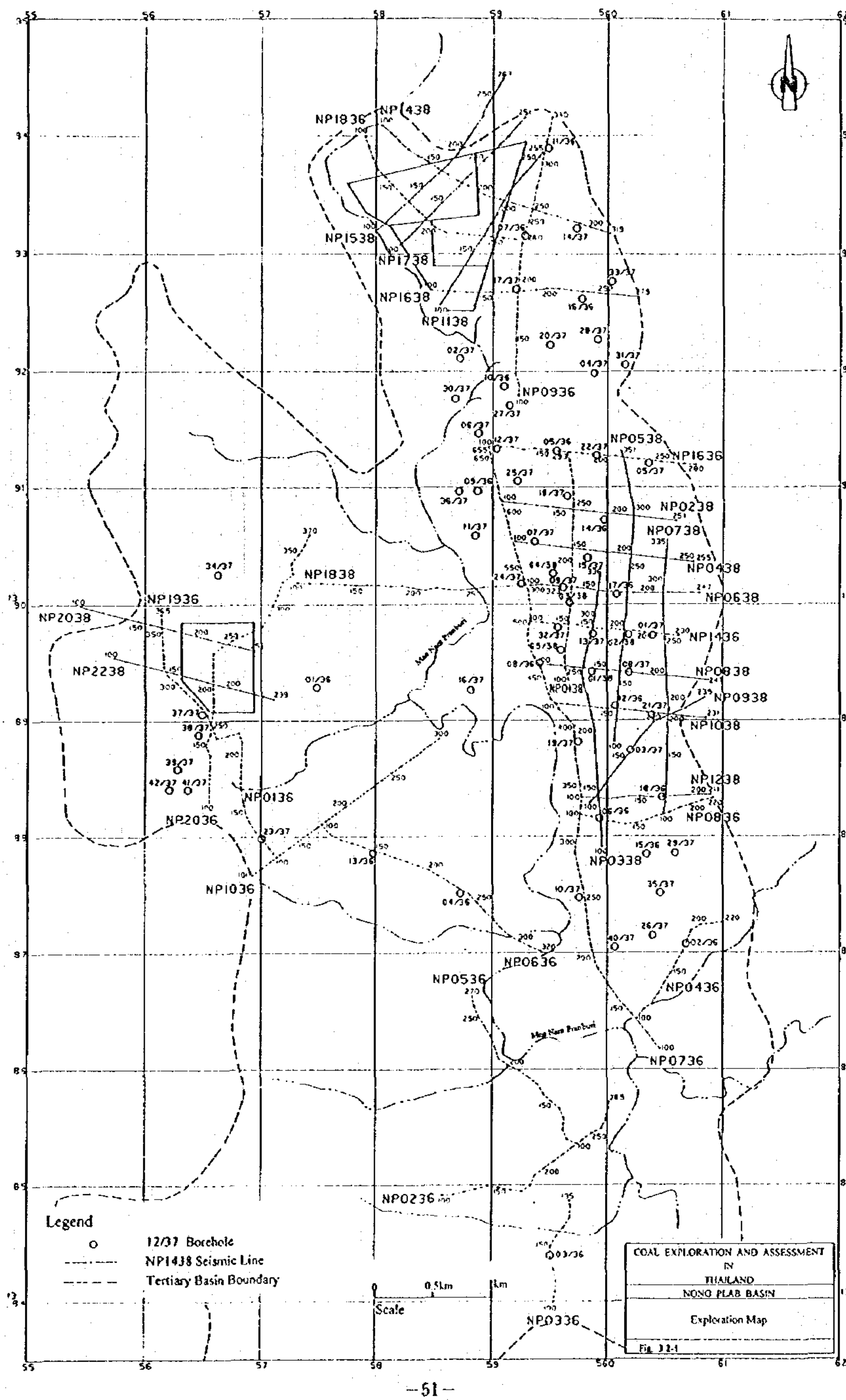
1) Resources

In situ coal resources of the Upper Coal Bed were calculated for each block divided by major faults and on the basis of coal thickness excluding partings. The total coal resources of the Upper Coal Bed have been estimated at 27,257,000 t, of which measured and indicated resources are 8,356,000 t.

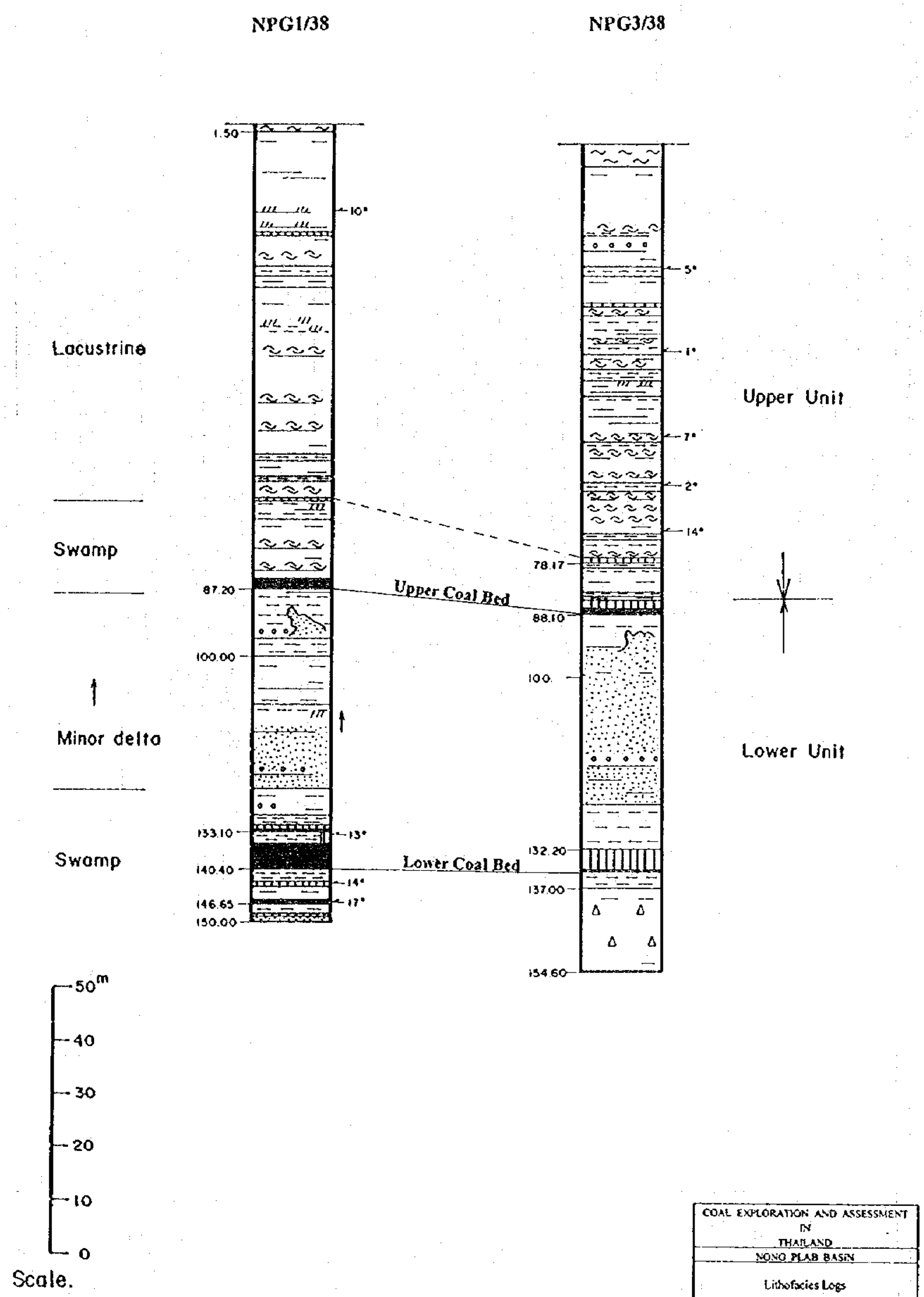
2) Reserves

Coal reserves are defined to be such a part of coal resources as esteemed to be possibly mineable by present technology. In the Nong Plab Basin, only the resources in a block bounded by E and F faults in the northern part is considered to be applicable to the above definition.

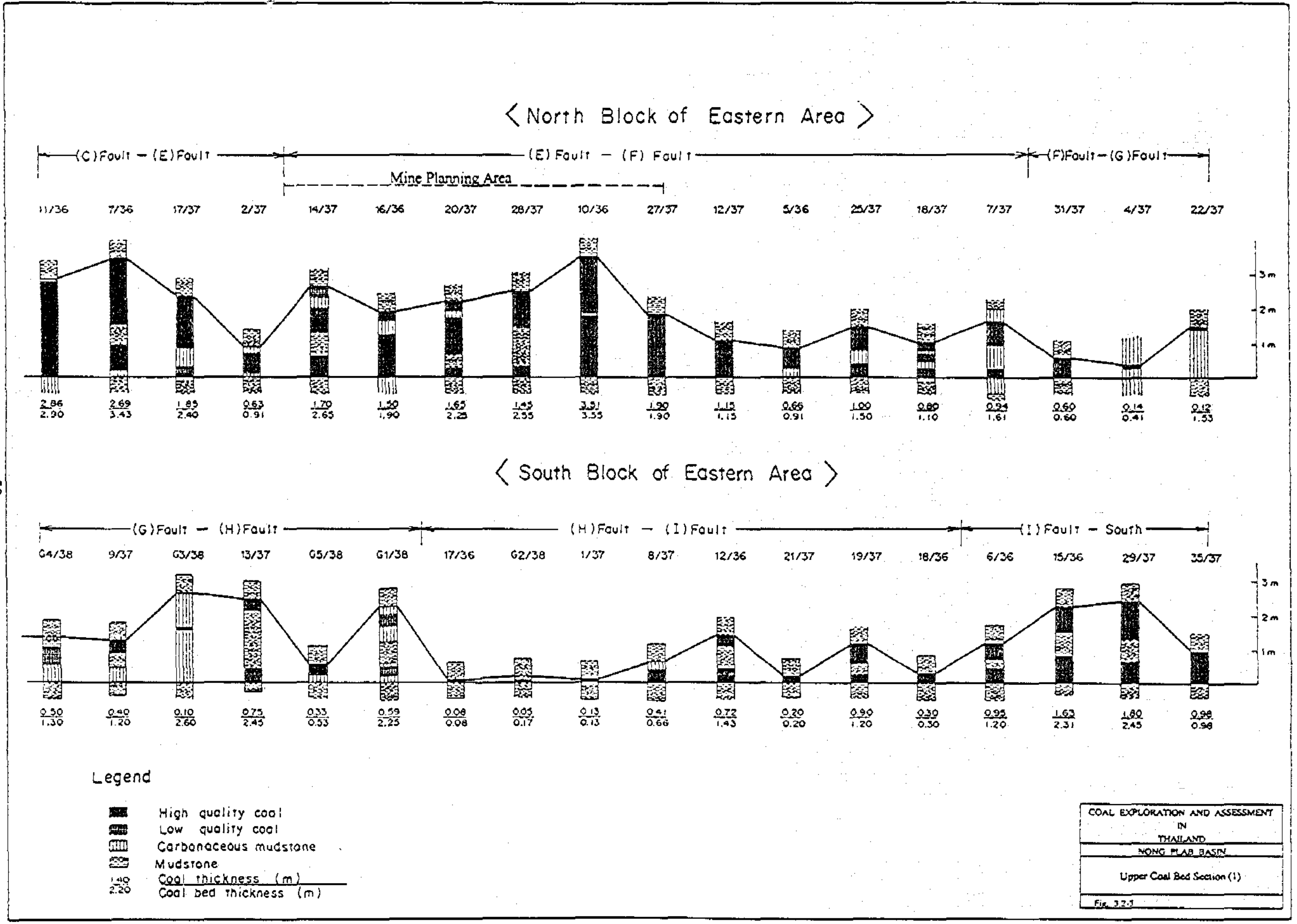
Consequently, the coal reserves in the Nong Plab Basin is estimated at 4,353,000 t.

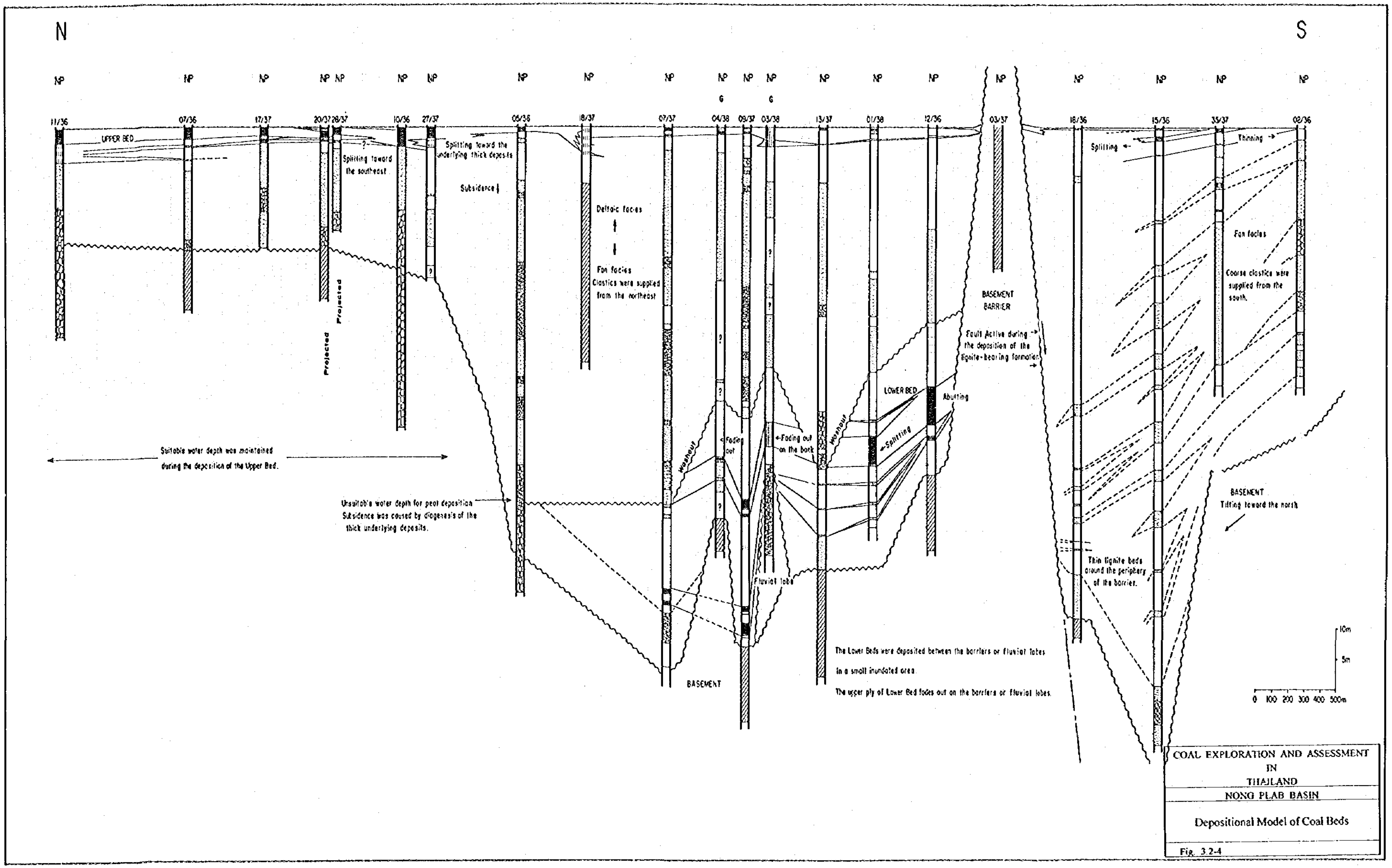


Legend
12/37 Borehole
NP1438 Seismic Line
Tertiary Basin Boundary
0.5km
1km
Scale
COAL EXPLORATION AND ASSESSMENT
IN
THAILAND
NONG PLAB BASIN
Exploration Map
Fig. 3.2-1
NP1836
NP1438
NP1538
NP1738
NP1638
NP1138
NP0936
NP0538
NP1636
NP0238
NP0738
NP0438
NP0638
NP1436
NP0838
NP0938
NP1038
NP1238
NP0836
NP0338
NP0636
NP0536
NP0436
NP0736
NP0236
NP0336
NP1838
NP1936
NP2038
NP2238
NP0136
NP2036
NP1036
NP0138



COAL EXPLORATION AND ASSESSMENT IN THAILAND
NONO PLAB BASIN
Lithofacies Logs
Fig.2.2-2


〈 North Block of Eastern Area 〉
(C) Fault – (E) Fault
(E) Fault – (F) Fault
(F) Fault – (G) Fault
Mine Planning Area
11/36 7/36 17/37 2/37 14/37 16/36 20/37 28/37 10/36 27/37 12/37 5/36 25/37 18/37 7/37 31/37 4/37 22/37
2.86/2.90 2.69/3.43 1.85/2.40 0.63/0.91 1.70/2.65 1.50/1.90 1.65/2.25 1.45/2.55 3.31/3.55 1.90/1.90 1.15/1.15 0.66/0.91 1.00/1.50 0.80/1.10 0.94/1.61 0.60/0.60 0.14/0.41 0.12/1.53
3 m
2 m
1 m
〈 South Block of Eastern Area 〉
(G) Fault – (H) Fault
(H) Fault – (I) Fault
(I) Fault – South
G4/38 9/37 G3/38 13/37 G5/38 G1/38 17/36 G2/38 1/37 8/37 12/36 21/37 19/37 18/36 6/36 15/36 29/37 35/37
0.50/1.30 0.40/1.20 0.10/2.60 0.75/2.45 0.33/0.53 0.59/2.25 0.08/0.08 0.05/0.17 0.13/0.13 0.41/0.66 0.72/1.43 0.20/0.20 0.90/1.20 0.30/0.30 0.95/1.20 1.63/2.31 1.80/2.45 0.98/0.98
3 m
2 m
1 m
Legend
High quality coal
Low quality coal
Carbonaceous mudstone
Mudstone
1.40 Coal thickness (m)
2.20 Coal bed thickness (m)
COAL EXPLORATION AND ASSESSMENT IN THAILAND
NONG PLAB BASIN
Upper Coal Bed Section (1)
Fig. 3.2-1



COAL EXPLORATION AND ASSESSMENT IN THAILAND

NONG PLAB BASIN

Depositional Model of Coal Beds

Fig. 3.2-4

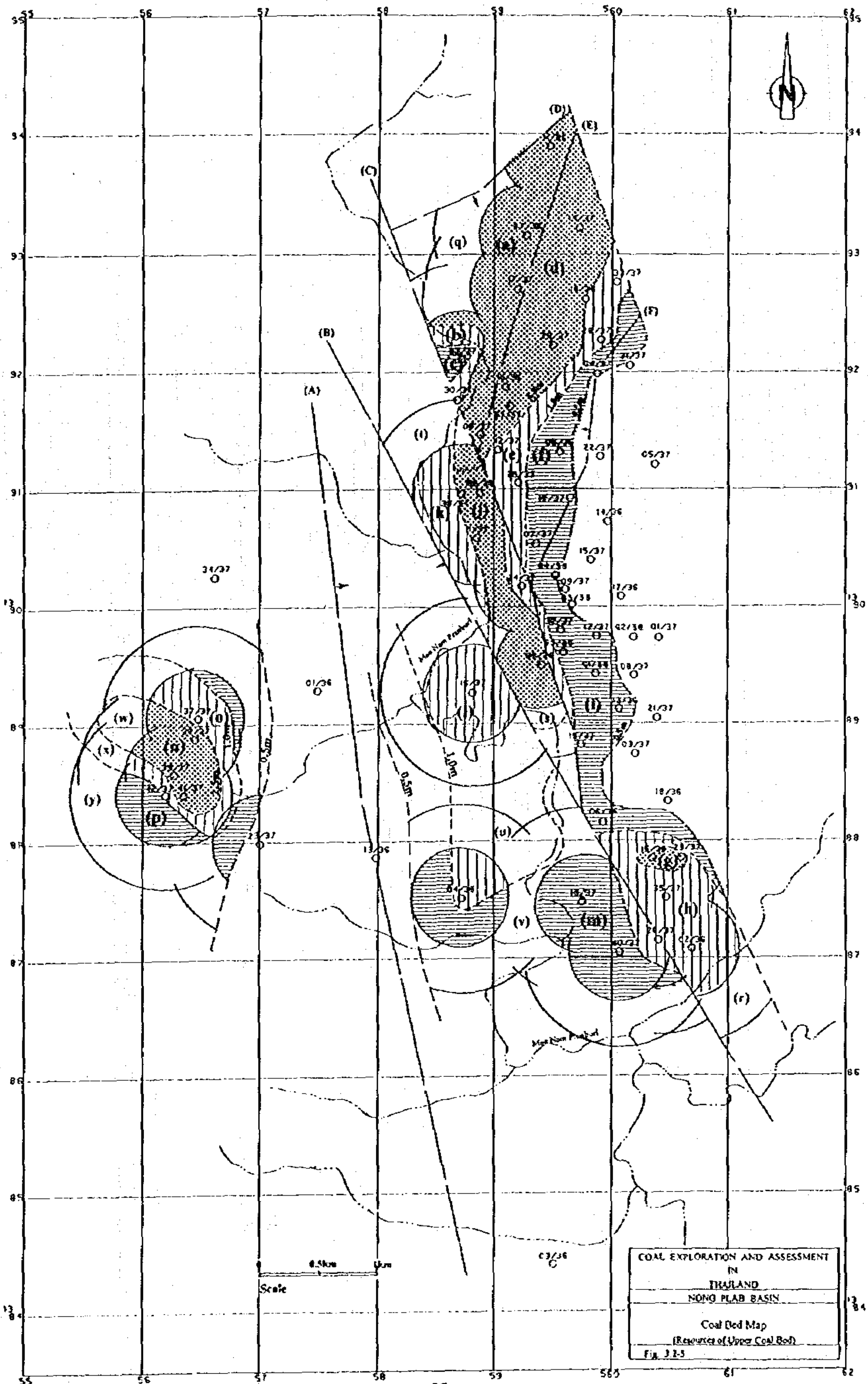

COAL EXPLORATION AND ASSESSMENT
IN
THAILAND
NONG PLAB BASIN
Coal Bed Map
(Resources of Upper Coal Bed)
Fig. 3.2-5
Scale
0.5km
1km
Mae Nam Prasbol

Table 3.2-2 Coal Resources of Upper Coal Bed

Area	Block	Thickness (m)	Plan area (1,000m2)	Resources (1,000t)
Measured+Indicated				
(C)-(E)Fault	(a)	2.47	1,002	3,217
	(b)	1.25	153	249
	(c)	0.75	54	53
	Subtotal		1,209	3,519
(E)-(F)Fault	(d)	2.05	1,220	3,251
	(e)	1.25	678	1,102
	(f)	0.75	464	452
	Subtotal		2,362	4,805
South of (F)Fault	(g)	1.72	70	157
	(h)	1.25	805	1,308
	(i)	0.75	998	973
	Subtotal		1,873	2,438
(B)-(C)Fault	(j)	2.05	767	2,044
	(k)	1.25	488	793
	Subtotal		1,255	2,837
(A)-(B)Fault	(l)	1.25	794	1,290
	(m)	0.75	1,180	1,151
	Subtotal		1,974	2,441
West of (A)Fault	(n)	1.97	425	1,088
	(o)	1.25	454	738
	(p)	0.75	503	490
	Subtotal		1,382	2,316
Total		1.40	10,055	18,356
Inferred				
East of (C)Fault	(q)	2.47	478	1,535
	(r)	1.25	300	488
	Subtotal		778	2,023
(B)-(C)Fault	(s)	2.05	84	224
	(t)	1.75	353	803
	Subtotal		437	1,027
(A)-(B)Fault	(u)	1.25	1,100	1,788
	(v)	0.75	1,973	1,924
	Subtotal		3,073	3,712
West of (A)Fault	(w)	1.97	146	374
	(x)	1.25	252	410
	(y)	0.75	1,390	1,355
	Subtotal		1,788	2,139
Total		1.13	6,076	8,901
Grand total		1.30	16,131	27,257