(3) Main Assumptions and Preconditions

Table 6-3-1 shows exogenous variables used in this forecast. The followings are brief explanation about assumptions and preconditions to forecast energy demand and supply in the year 1995.

i) Crude oil production

We assumed crude oil production of Indonesia to be stagnant at 1,400 x 10^3 B/D of the year 1984 level because of relatively lower growth of oil consumption of free world, which was estimated to be 51,500 x 10^3 B/D, 1.2%/yr. growth rate from 1983 to 1995. Dependence of free world oil production 46,700 x 10^3 B/D upon that of OPEC countries of 24,000 x 10^3 B/D was estimated to be a little higher to 51.4% in 1995 from 46.0% of 1983. Economic growth rate and oil consumption in free world are assumed to be 2.5%/yr. and 1.2%/yr. respectively and therefore elasticity of oil consumption relative to GDP growth rate is to be 0.48.

ii) Crude oil price

We estimated crude oil price level to be stagnant through the year 1986 in nominal term, stagnant through the year around 1989 in real term and after that through the year 1995 to increase by 1%/yr. in real term. Taking the inflation rate into consideration, crude oil price is estimated to increase by 3.5%/yr. to the year 1995.

iii) Deflator for agricultural goods export price

Here we assumed the deflator for agricultural goods export price to increase by around 7%/yr. through the year 1995 based upon the past trend.

Table6-3-1 Exogenous Variables Used in Forecast

	%/Yr. 1995/82	Remarks
Growth rate of crude oil production	0.35	1982; 133.7 $\times 10^4$ B/D 1995; 140 $\times 10^4$ B/D
Growth rate of exported crude oil price	3.5	29.53 $/BBL ('83)
Deflator for agricultural goods export price	7.1	
Index for international export price	7.1	
Exchange rate of Rp. relative to U.S.$	-5	
Population	2.0	2.3 (80/71) 158 million ('83)
Government consumption expenditure	14.0	6831 x 10^9 Rp. ('82)

Note : Nominal price in Indonesian crude oil will be 46.2 $/BBL in 1995.

Table 6-3-2 Long term prospects of world economy

	95/83
Economic Growth Rate (%/yr.)	
World Wide	2.5
OECD Countries	2.3
LDC	3.2
Inflation rate in OECD Countries (%/yr.)	
85/83	3
90/85	4
95/90	5

iv) Index for international export price

Here we assumed the growth rate of international export price to increase by around 7%/yr. through the year 1995 based upon growth rates of GDP in both developed countries (ex. OECD countries) and less developed countries.

v) Exchange rate of Rupiah relative to U.S.$

Indonesia's Repiah has been devaluated twice between the year 1977 and the year 1983 and the exchange rate of Rupiah relative to U.S.$ has been weakened by around 14%/yr. during this period. Here we assumed value of Rupiah relative to U.S.$ to be remained relatively stable as weakening by 5%/yr. through the year 1995 compared with past six years.

vi) Population

As to the growth rate of population we estimated to increase by around 2.0%/yr. through the year 1995. This was based upon the figure in REPELITA-IV. This estimated growth rate is a little lower than the figure of 2.3%/yr. between 1971 and 1980.

vii) Government consumption expenditure

We assumed government consumption expenditure to increase by around 14%/yr. through the year 1995 based upon the past trend. The growth rate of this item has been decreased gradually from 25%/yr. between 1977 and 1983 to 18%/yr. in the period of 1980 and 1983.

(4) Results of the Forecast in 1995

We will briefly summarize those results from forecast using the computer model.

i) Macro economy (Table 6-3-3)

As to macro economy in Indonesia, growth rate of GDP will be decreased to 5.2%/yr. in the period of 1995/1980 from 7.5%/yr. in the period of 1980/1975. Judging from past trend in 1970's and GDP growth target in the program of REPELITA-IV, the growth rate of 5.2% in the period of 1995/1980 can be understood as relatively stable rather than high growth.

As to such factors which supports economic growth as private consumption expenditure and government consumption expenditure etc, about 5%/yr. to 9%/yr. growth is forecasted in each factor except for export. Lower growth of export is mainly because of the lower growth rate of crude oil price for export.

As to consumer price index and wholesale price index, growth rate of such indices will be decreased to about 7%/yr. in the period of 1995/1980 from around 20%/yr. in the period of 1980/1975.

ii) Domestic Energy Consumption (Commercial Energy) (Table 6-3-5)

The share of oil in domestic energy consumption is expected to be decreased to 60% in 1995 from 75% in 1982. The domestic energy consumption comprises final energy consumption, energy industry's own use and energy transformation sector use excluding non-domestic use such as natural gas for manufacturing LNG for export.

This reduction of oil share is prospected mainly because of higher growth rate in alternative energy sources like coal, hydropower and geothermal energies. Coal and hydropower are, for example, prospected to grow by 41%/yr., 19%/yr. respectively in this period. As a result, shares of coal and hydropower are to be expanded to 15% and 8% respectively in 1995. On the other hand, share of natural gas is to be decreased to

17% in 1995 from 23% in 1982. Slightly lower growth rate of natural gas consumption compared with oil is mainly because such a factor as natural gas pricing policy which closely relates to fuel switch is not included in this projection.

As a whole, total commercial energy is projected to grow by less than 7%/yr. up to 1995. This growth rate was 14%/yr. in 1980/1970 and 11%/yr. in 1982/1977. Compared with these historical trends, future growth rate in this projection is to be decreased furthermore.

Energy demand elasticity to GDP growth rate is to be dropped to 1.4 in 1995/1982 from 1.8 in 1978/1970. Furthermore, in terms of oil, elasticity ratio is to be dropped to 1.0 in this period from 1.8 in 1978/1970.

iii) Share of commercial energy and non-commercial energy (Table 6-3-7)

Non-commercial energy is more than 50% in final energy consumption basis in 1982. And therefore, it is also important to prospect the future trend of non-commercial energy in total energy consumption.

Though in REPELITA-IV, the Government aims to increase the proportion of commercial energy to around 60% at the end year of that program, that target is to be achieved in 1995 according to our estimation.

So long as we based upon 2.7%/yr. of lower growth rate in non-commercial energy, it will be necessary for commercial energy to grow by 7.6%/yr. in 1995/1982.

iv) Coal consumption in each sector (Table 6-3-9)

Coal consumption is projected to grow to 19,200 x 10^3 tce in 1995 from 260 x 10^3 tce in 1982, showing 40%/yr. growth in this period.

As to coal consumption in each sector, electricity generating sector occupies 87% in total coal consumption and industrial sector such as cement, aluminum and tin occupies 11%.

We estimated very small amount of coal consumption in residential and commercial sector of 100 x 10^3 tce in 1995. This is because we projected small amount of coal would be consumed mainly in household sector in rural areas as a form of briquettes.

v) Consumption of natural gas by sector (Table 6-3-10)

Though about 95% of domestic natural gas consumption is for industrial sector in 1982, this pattern will be retained even in 1995. The growth rate of natural gas consumption is expected to be around 10%/yr. in 1995/1982. The growth rate of natural gas in industrial sector is higher than that of oil. This is mainly because fuel switch to natural gas from oil is projected to expand in this sector.

vi) Demand for each petroleum product by sector (Table 6-3-11)

Total petroleum consumption will expand to 76,620 x 10^3 tce (1,050 x 10^3 BOE/D) in 1995, representing less than 5%/yr. growth rate in 1995/1982. It will grow by 90% in this period from 41,170 x 10^3 tce (563 x 10^3 BOE/D).

As to the petroleum product demand by each sector, the share of residential and commercial sector will expand to 36% in 1995 from 26% in 1982. And also, the share of transportation sector will expand to 38% in 1995. Therefore, about three quarter will be occupied with these two sectors.

The expansion in the share of petroleum product in residential and commercial sector is mainly because we did not expect much switch from kerosene to natural gas, LPG or electricity in this sector. Furthermore, this is because its potential demand is large and we did not expect the change in price competitiveness with other competing fuels.

Therefore, so long as existing pattern of using kerosene is retained, kerosene demand is to grow as high as by 7%/yr.

As to petroleum product demand by each sector, diesel oil and kerosene for industrial sector are to grow by 8%/yr. respectively, and jet fuel oil and gasoline is to grow by 7%/yr. respectively.

And also, the growth rate of diesel oil for automobile is to grow by relatively low rate of 4.1%/yr.. This is because this petroleum product is to be buffered in electricity generating sector. And, finally, the negative growth rate in heavy fuel oil is because fuel switch to natural gas and coal is projected.

Table 6-3-3 Main Indigenous Variables About

Macro-Economy in Indonesia

unit: 10^9 Rupiah

	1975	1980	1995
GDP(nominal) (GDP)	12642.5	43765.0 (28.2%)	261828.2 (12.7%)
GDP(real) (GDP73)	7630.8	10953.9 (7.5%)	23459.1 (5.2%)
Private Consumption Expenditure (CP73)	5678.9	8289.0 (7.9%)	21751.1 (6.6%)
Government Consumption Expenditure (CG73)	835.5	1669.2 (14.8%)	4036.8 (6.1%)
Gross Capital Formation (ITP73)	1650.2	2868.5 (11.7%)	8040.8 (7.1%)
Exports (EXP73)	1266.8	1684.9 (5.9%)	2096.0 (1.5%)
Imports (IMP73)	1800.6	3557.7 (14.6%)	12465.6 (8.7%)
Gross National Products (GNP73)	7270.5	10156.9 (6.9%)	21788.9 (5.2%)
Consumer Price Index (CPI73)	167.5	373.2 (17.4%)	1002.9 (6.8%)
Wholesale Price Index (XPI73)	157.3	449.7 (23.4%)	1278.5 (7.2%)

(Note) * Figures in parentheses are growth rates (%/yr.) in those periods.

* As to the year 1975 and the year 1980, figures are from energy balance tables in Indonesia.

Total 6-3-4 Energy Demand and GDP

Item \ Year	1975	1980	1995
GDP (10^9 RP.)	7630.8	10953.9 (7.5%)	23459.1 (5.2%)
Indigenous Primary Energy Demand (10^3TCE)	63605	99565 (9.4%)	209696 (5.1%)
Primary Energy Demand by unit of GDP	8.34	9.09 (1.7%)	8.94 (△0.1%)
Demand Elasticity by Growth of GDP		1.25	0.98
Final Consumption (10^3TCE)	54153	72262 (5.9%)	147796 (4.9%)
Final consumption by unit of GDP	7.10	6.60 (△1.4%)	6.30 (△0.3%)
Demand Elasticity by Growth of GDP		0.79	0.94
Industry Sector	16413	12718 (△5%)	27832 (5.4%)
Residential & Commercial Sector	30438	45970 (8.6%)	82415 (4.0%)
Transportation Sector	6097	11253 (13.0%)	29148 (6.6%)
Government Sector	705	943 (6.0%)	2395 (6.4%)
Non-Energy Use	500	1377 (22.5%)	6007 (10.3%)

(Note) * Figures in parentheses are growth rates in those periods.

* As to the year 1975 and the year 1980, figures are from energy balance table in Indonesia.

Table 6-3-5 Domestic Energy Consumption (Commercial)

	1982 10^3tce	1982 Physical Unit	%	1995 10^3tce	1995 Physical Unit	%	95/82 (%/yr.)
Natural Gas	12781		23.1	21968		16.8	4.3
Coal	217		0.4	19160		14.6	41.2
Hydro-Power	1060		1.9	10626		8.1	19.4
Geo-thermal	0		0	1029		0.8	-
Oil	41357	206371 $565x10^3$ B/D	74.6	78073	389584 $1067x10^3$ B/D	60.0	5.0
Grand Total	55415	276521 $758x10^3$ B/D	100	130856	652971 $1789x10^3$ B/D	100	6.8

Note:

* 1tce = $714m^3$ of NG = 4.99BOE

* NG = Final energy consumption + Energy sector's own use + Town gas production

* Oil = Final energy consumption + Energy sector's own use + Town gas production + Electricity Generation

* We assumed no statistical difference in the figures of the year 1995.

* Figures in the year 1982 are calculated from those figures in energy balance table available in Migas.

Table 6-3-6 Composition of Final Consumption

unit: 10^3TCE

	Total Commercial Energy Consumption			Total Non-Commercial Energy Consumption			Share of Commercial Energy		
	1975	1980	1995	1975	1980	1995	1975	1980	1995
Final Consumption	16137	30535 (13.6)	89135 (7.4)	38016	41726 (1.9)	58660 (2.3)	29.8%	42.3%	60.3%
Industry	2390	6415 (21.8)	18078 (7.2)	14023	6303 (14.5)	9754 (3.0)	14.6%	50.4%	65.0%
Residential & Commercial	6489	10583 (10.3)	33590 (8.0)	23949	35387 (8.1)	48825 (2.2)	21.3%	23.0%	40.8%
Transportation	6053	11217 (13.1)	29066 (6.6)	44	36 (△30.4)	82 (5.6)	99.3%	99.7%	99.7%
Government	705	943 (6.0)	2395 (6.4)	0	0	0	100%	100%	100%
Non-Energy use	500	1377 (22.5)	6007 (10.3)	0	0	0	100%	100%	100%

(Note) * Figures in parentheses are average growth rates(%/yr.) during these periods.

* As to the year 1975 and the year 1980, figures are from energy balance table in Indonesia

Table 6-3-7 Share of Commercial Energy and Non-commercial Energy (Final Energy Consumption)

	1982		1995		95/82
	10^3tce	%	10^3tce	%	
Commercial energy	32259	43.6	83129	58.6	7.6
Non-commercial energy	41726	56.4	58660	41.4	2.7
Grand total of energy consumption	73985	100	141789	100	5.1

Table 6-3-8 Fuel Composition in Power Generation Section

	1982		1995	
	10^3TCE	%	10^3TCE	%
Solid Fuel	20	0.4	16718	46.4
Petroleum Product	5210	82.8 [100]	7676	21.3 [100]
ADO	2341	[44.9]	999	[13.0]
IDO	485	[9.3]	4292	[55.9]
HFO	2385	[45.8]	2385	[31.1]
Hydro-Power	1060	19.0	10626	29.5
Geothermal	-	-	1029	2.9
Total	6290	100	36049	100
Electricity Generated	1399		10814	
$\times 10^6$ KWH	11.37		87.92	

10^6 KWH thermal = 123tce (← 860Kcal/KWH)

Note: The gap between demand and supply is to be buffered with Automotive Diesel Oil in our estimation.

Demand side

Sector	90/82 (%/yr.)	95/90 (%/yr.)
. Industry	20	15
. Residential & Commercial	20	20
. Government	20	15

Supply side	1982 (MW)	1995 (MW)	95/82 (%/yr.)
Hydro	437.1	4371	19.4
Geothermal	30	830	29.1
Coal		7745	(exogenous variable)

Table 6-3-9 Consumption of Coal by Sector

	1982		1995		95/83
	10^3tce	%	10^3tce	%	%/yr.
Electricity Generation	20	7.7	16718	87.3	67.8
Energy Industry's own-use	40	15.4	70	0.4	4.4
Final Energy Consumption	183	70.4	2266	11.8	21.4
Industry	163	[89.1]	2100	[92.7]	21.7
Residential & Commercial	-		100	[4.4]	-
Transportation	20	[10.9]	66	[2.9]	9.6
Government	-				
Non-Energy Use	17	6.5	106	0.6	15.1
Grand Total	260	100	19160	100	39.2

Note: We expect coal will be used in residential and commercial sector in the form of briquettes in the year 1995.

Table 6-3-10 Domestic Consumption of Natural Gas

	1982		1995		95/82
	10^3tce	Physical unit	10^3tce	Physical unit($10^6 m^3$)	Growth rate
Town-gas production	70	50.0	293	209.2	11.6
Final Energy Consumption	1365	974.6	4712	3364	10
Industry	1365	974.6	4712		10
Residential & Commercial					
Transportation					
Government					
Total	1435	1024	5005	3574	10.1

Note: "Total" does not include consumption of natural gas for manufacturing LNG.

Table 6-3-11 Demand for each Petroleum Product by Sector (BBM)

	1982		1995		95/82
	10^3tce	%	10^3tce	%	%/yr.
Residential & Commercial	10718	26.0	27605	36.0	7.5
Transportation	12787	31.1	29000	37.8	6.5
Industry	4938	12.0	7714	10.1	3.5
Government	779	1.9	967	1.3	1.7
Energy Transformation	5248	12.7	7707	10.1	3.0
Electricity Generation	5210	12.7	7676	10.0	3.0
Town-gan Production	38	0.1	31	0.04	-1.5
Energy Industry's own use	6696	16.3	3626	4.7	-4.6
Total	41166	100	76619	100	4.9
Total (10^3BOE/D)	563		1047		

Table 6-3-12 Demand for each Petroleum Product (BBM)

	1982			1995		
	10^3tce	10^3BOE	%	10^3tce	10^3BOE	%
Gasoline	6113	30504	14.8	12476	62255	16.7
Kerosene	10718	53483	26.0	27605	137749	36.9
JFO	1402	6996	3.4	3482	17375	4.7
ADO	11539	57580	28.0	19557	97689	25.5
IDO	2850	14222	6.9	8142	40629	10.9
HFO	8545	42640	20.8	5356	26726	7.2
Total	41167	205423	100	76618	382324	100

1 tce = 4.99BOE

Total 1982: (563×10^3 BOE/D)

Total 1995: (1047×10^3 BOE/D)

Growth rate of each product demand

	95/82
Gasoline	5.6
Kerosene	7.5
JFO	7.2
ADO	4.1
IDO	8.4
HFO	-3.5
Total	4.9

(5) Some Implications from the Long-term Forecast

Indonesian government has introduced the price policy to promote energy conservation in domestic market and to reduce subsidy for fuels, leading to lighten the national budgetary burden. As a matter of fact, weighted average price of petroleum products increased by 390% in the period of March 1979 and January 1984. (Rp 44/ℓ to Rp 217/ℓ)

As a result, growth rate of petroleum product consumption was only 4.1% in the period from 1980 to 1983. On the other hand, GDP growth rate (real term) in this period achieved 4.8% and, therefore, petroleum product demand elasticity against GDP growth rate was as low as 0.85 in this period.

Main reasons for significant drop in growth rate of petroleum products are a big price hike of petroleum products and economic recession influenced by world- wide economic recession post second oil crisis. The period of REPELITA-IV is, in this sense, characterized to be a transitional one which aims to reconstruct domestic economy and change present pattern of energy consumption toward decreasing oil dependence.

Oil consumption in the period of REPELITA-IV is projected to remain in as low growth rate as around 2%/yr.. As a result, oil demand elasticity against GDP growth rate is projected to be around 0.5. Therefore, switch to alternative energy sources such as natural gas, coal, hydropower and geothermal energy from oil should be promoted steadily in order to realize REPELITA-IV. And also, in order to promote energy conservation in REPELITA-IV, there are two conditions. One is to promote development of alternative energy sources smoothly and the other is to keep domestic petroleum price high.

On the other hand, according to energy projection by JICA team, domestic commercial energy consumption, and petroleum product consumption which include energy transformation sector (less natural gas consumption for manufacturing LNG) and own use in energy sector, grow by 6.8%, 4.9% respectively. These figures are the results which were calculated based upon 5%/yr. of economic growth in REPELITA-IV. Growth rates of energy consumption and petroleum products consumption in JICA team projection are higher compared with those figures in REPELITA-IV.

One reason for that is that the model structure of JICA team does not have a structure where price has impact to energy demand. The other reason is that projected energy demand was significantly influenced by past pattern of energy consumption in 1970's, because each equation was decided by last ten years recording high growth in energy demand. In short, the model JICA team used this time has not the structure where the relation between energy demand and energy price is taken into account.

Therefore, though we took some qualitative consideration into account, energy demand projection is still influenced by past pattern of high growth in energy demand. In other words, what we can get as an implication from this simulation work is that potential energy (esp. oil) demand would be much higher than that envisaged in REPELITA-IV if the government should loose present high price policy. This is because the reduction in energy demand in the period of 1983/1980, we understand, might be due to short term economic recession and high price policy for energy by the government to reduce fuel subsidy.

As a conclusion from our projection, growth in long term energy demand would probably be higher than that of GDP.

6-4 Preliminary Evaluation on Markets of Banko Coal and its Derivatives

(1) Fuel for Electricity Generation

Methanol produced from synthetic gas of coal is very hopeful alternative fuel to replace diesel oil. There are many small scale diesel generators in the rural areas in Indonesia. As demand for electricity in developing country like Indonesia is not so big and not so concentrated except large cities such as Jakarta, Bandong, it may be rather economical to generate electricity by small generator in rural areas compared with electricity supply by large scale power plant and transmission line.

Present electricity supply is divided by PLN (the state owned power generating company) and Non-PLN (most of them are captive power owned by private sector) sources.

According to the statistics provided by PLN, total installed generating capacity in Indonesia is 7,274 MW* in 1983, PLN takes 54% or 3,935 MW of total capacity. Moreover, the capacity of diesel and gas turbine generator owned by PLN accounts for 1,812 MW, the share of them in total installed capacity takes 45.8%. So that, diesel oil consumption by PLN reached to 1,100 x 10^3 kl in 1982.

It is estimated that most capacity of private power generation is taken by diesel and gas turbine generator, although there are many unknown factors in this fields, because much capacity is installed in remote area, particularly in outside Java island.

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* excluded: Asahan Hydro PP (603 MW), Jatiluhur Hydro PP (150MW), Larona Hydro PP (165 MW), Krakatau Steal Oil PP (400 MW), Aneka Tambang Diesel PP (32.3 MW)

Accordingly total diesel oil consumption for generating facilities (PLN + Non-PLN) may be estimated to reach 2,000 x 10^3 kl at least in 1982. As it is well known, PLN is now promoting to develop such power generations as hydro, coal combustion, geothermal other than oil firing power station. However, it is expected that the small scale diesel generator and gas turbine generator will continue to take the important position in electricity supply in Indonesia.

Actually, PLN estimates that total generating capacity to be installed in 1995 will reach to 19,500 MW, the capacity of diesel power and gas turbine power plant will take the share of around 20% in total capacity. Besides, diesel oil consumption for generator by only PLN is accounted for 2,600 x 10^3 kl in 1995, if consumption in private power generators owned by private sector will be added on this, total diesel oil consumption may reach to more than 4,000 x 10^3 kl. If accordingly, diesel oil as fuel for small scale generator could be replaced to methanol in the future, that gives a large impact to save oil in Indonesia.

However, there are some essential problems to be solved in usage of methanol, which is, for example, necessary to develop "new diesel generator" because methanol has much lower cetane number than that of diesel oil. That is to say, methanol as fuel is not applicable for compressed combustion like diesel engine, but for flashed firing engine.

Another problem in methanol use is the low calorific value of it. So that, if methanol will be used as fuel for generator, some additional storage and transport capacities of fuel are needed because of lower calorific value than diesel oil.

It is, anyhow, very significant matter in this survey project to make a study for methanol use in small scale generator.

Table 6-4-1 Actual Fuel Consumption in Transportation Sector

10^3B/D

	1980	1981	1982	1983
Aviation Gas.	0.35	0.28	0.27	0.23
Aviation Turbo	8.9	10.2	10.7	10.1
Motor Gas.	65.8	71.9	71.4	67.7
Kerosene	-	-	-	-
ADO	50.2	55.4	63.3	63.1
IDO	3.1	3.0	3.0	2.8
FO	6.1	2.9	3.7	3.2
Total	134.6	143.7	152.3	147.0

Source: MIGAS

(2) Fuel for Automotive Engine

Methanol is one of the most hopeful alternative fuel for automotive engine in the meaning of replacement gasoline and diesel oil. Methanol can be produced from synthetic gas obtained through gasification process of coal. It is needless to say whether methanol production from coal will have the economical and technical viabilities depend upon the future energy price, demand, and technology development.

On the other hand, utilization of methanol for gasoline engine (otto engine) has been researched in view of gasoline/methanol blended fuel and neat fuel methanol in U.S.A., W. Europe and Japan for several years. According to the study results, if content of methanol in gasoline is less than 5 vol %, there is basically no worse effect for engine by onl minor modifications of engine. Methanol as an octane booster has rather an advantage to improve engine power.

As shown Table 6-4-1, fuel consumption in transportation sector in 1983 concentrated to motor gasoline and ADO (Automotive Diesel Oil), and consumed volume for each fuel was 68 x 10^3 B/D (3,926 x 10^3 kl/yr.), 63 x 10^3 B/D (3,660 x 10^3 kl/yr.) respectively. The share of both fuels in total consumption volume in transportation sector reached 89%. Gasoline and ADO, in short, have majority position in fuel consumption of transportation sector.

According to the long term demand prospect which was done by JICA team, demand for motor gasoline is estimated to increase 6.7% per year between 1982 and 1995 and to amount to 170 x 10^3 B/D (9,900 x 10^3 kl/yr.). Besides, ADO demand is forecasted to grow 5.6% per year for the same period and to reach 178 x 10^3 B/D (10,360 x 10^3 kl/yr.). These forecasted demand volume may over-estimate in comparison with the actual trend of consumption in past four years.

However, it is surely said that the fuel demand for automobile which are not only gasoline car but diesel one will expand year by year for the time being. Accordingly, if any part of these fuels for automobile, buses and tracks can be replaced with methanol, that must contribute to oil saving policy in Indonesia.

In the mean time, it is necessary to develop a proper engine to be applicable for methanol use, if neat methanol is used as automotive fuel. Some automotive companies in Japan have been developing a prototype engine for neat methanol use. In general, it is said that neat methanol as automotive fuel can cover its disadvantage in terms of low calorific value of it through improvement of thermal efficiency in the methanol proper engine. The impact for environment by exhaust gas from methanol engine is prospected to be lower than that in case of regular engine by hydro-carbon fuel like

Table 6-4-2 Physical Properties of Alcohol and Gasoline

Fuel		Gasoline	Ethanol	Methanol
Chemical formula		~ C_7H_{16}	C_2H_5OH	CH_3OH
Molecular weight		~ 100	46	32
Specific gravity (20°C)		0.75	0.790	0.794
	C	~ 84	52.0	37.5
Weight %	H	~ 16	13.0	12.5
	O	0	35.0	50.0
Stoichiometric air fuel ratio		14.8	9.0	6.47
Lower calorific value (Kcal/kg)		10,500	6,400	4,800
Ratio of calorific value to gasoline		1.00	0.61	0.46
Calorific value based on Stoichiometric air fuel ratio				
wet charge (Kcal/ air)		0.910	0.921	0.959
dry charge (Kcal/ mix)		0.899	0.889	0.887
Latent heat (Kcal/kg)		80	206	263
Latent heat based on stoichiometric air fuel ratio				
wet charge (Kcal/ air)		0.0069	0.030	0.053
dry charge (Kcal/ mix)		0.0068	0.028	0.046
The drop in temperature caused by evaporation of fuel based on stoichiometric air fuel ratio (°C)		~ 18	74	122
Octane number	RON	91 (regular) 98 (premium)	110	109
	MON	82 (regular) 88 (premium)	89	92
Cetane number		~ 12	8	3
Self ignition temperature (°C)		257	420	500
Flash point (°C)		-43	13	11
Flammability limit (vol %)		1.4-7.6	4.3-19	6.7-36
Biling point (°C)		20-210	78.3	64.5

Note: wet charge - assumes fuel is in a completely liquid form, the volume of which may be disregarded.

dry charge - where fuel is vaporized completely and is induced as mixture.

gasoline. However, there are still some problems to use methanol as automotive fuel in the actual energy market.

They are establishment of distribution system and securing of methanol handling other than development of neat methanol engine.

Nevertheless, methanol and/or methanol blended fuel will be expected to take an important position in Indonesian fuel market in the future in accordance with expansion of gasoline and diesel oil demand.

(3) Preliminary Estimation on Market of Chemicals

1) Methanol

Methanol is the one of important chemicals to be directly synthesized from synthetic gas, and is used as raw materials for other chemicals and as solvent without further processing as shown in Table 6-4-3 "Break down of Demand for Methanol in 1982."

World methanol balance between production capacity and consumption is illustrated in Fig. 6-4-1. Also the world demand forecast made by Cellanese is listed in Table 6-4-4. As seen from these figure and table, methanol is suffered from over-production-capacity. And this trend will continue for the coming several years. However, various research efforts are exerted to use neat-or blend-methanol as fuel for automobiles and electric power generators. When such efforts are commercialized, this situation is to be drastically changed.

Due to such over-production-capacity, the price of methanol has been reducing as shown in Fig. 6-4-2 and Fig. 6-4-3, even if compared with crude oil and other feed stocks.

Methanol balance of each block is illustrated in Fig. 6-4-4. As seen from this figure, in Asia including Japan, consumption of methanol exceeds the production. This comes mainly from that some old methanol plant, especially of which raw material was naphtha, have been stopped the operation due to the incompetitiveness of production cost against new-natural gas-started-plants. Actually six plants, of which total capacity was over one million ton per year, have been stopped since 1981 to this data.

Consumption and production of methanol in Asian countries are listed in Table 6-4-5, which shows the above mentioned again.

In Indonesia methanol is mainly used for production of glue for plywood. Demand forecast of glue made by DGBCI is listed in Table 6-4-6. Methanol amount required to produce such amount of glue is also listed in the table based on our estimation.

On the other hand methanol is a raw material of acetic acid and Indonesia is importing all necessary acetic acid. According to PERTAMINA, the demand of acetic acid in 1990, even if TA/PTA plant in Plaju is to be put into operation, will be 15,000 ton per year. However this demand is far small to install a commercial scale acetic acid plant since the standard capacity of the plant is 150,000 to 200,000 ton per year.

As summary, although a demand of methanol as raw materials can be estimated as 177,000 ton per year in 1987 and 276,000 ton per year in 1990, these amounts are to be smaller than the production capacity of Bunyu Island Methanol Plant to be put into operation in 1985. Therefore, we cannot expect an additional methanol plant for chemicals.

As to fuel methanol, another careful study shall be continued, since a demand of methanol will be changed drastically when commercialization of fuel-use-methanol is to be taken place.

Also as seen from Table 6-4-5, the production of methanol in Asian countries will be lower than the consumption. So if the production cost of methanol in this project is well competitive to it in Middle East, Oceania, etc., there will be a chance to export.

2) Fertilizer

A demand of urea is estimated by DGBCI as follows;

1985	1986	1987
3,666,000 T/Y	4,002,000 T/Y	4,371,000 T/Y

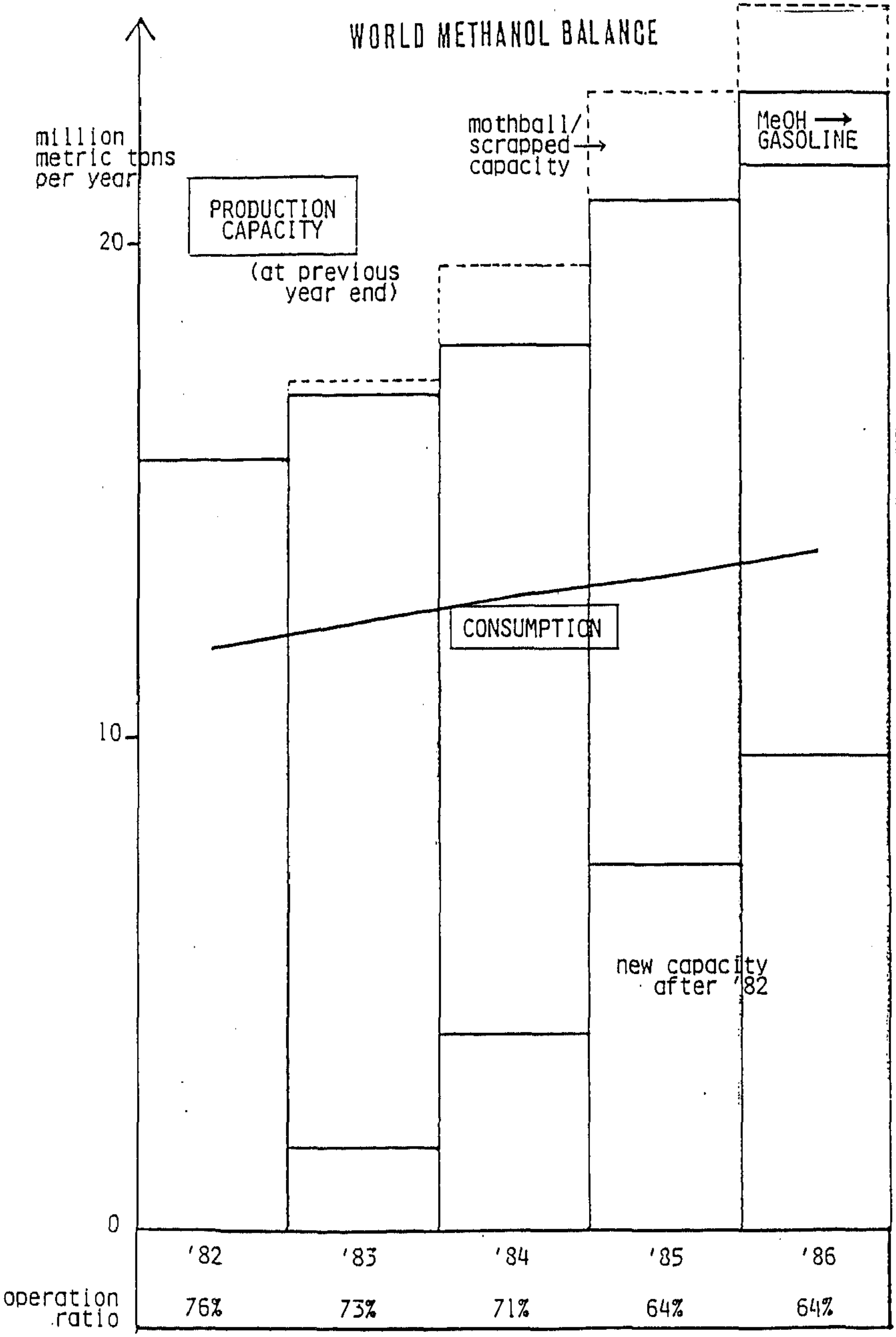
Another estimate for production of fertilizer is listed in Table 6-4-7. And the plant locations are shown in Fig. 6-4-5.

As seen from Table 6-4-7, a plan for new fertilizer plants, of which feedstock is natural gas, has been established until 1990. So the fertilizer production by this project should be discussed within a frame after 1990. As seen from Fig. 6-4-5, an adequate location of a new plant will be eastern part of Indonesia, such as Sulawesi, for domestic supply. Also the north Sumatra will be adequate for a new plant for export. The natural gas supply for PUSRI will be enough for twenty years, since a new gas reservoir was found recently in Musi area. So we cannot find out a reason why the production of fertilizer in Banko area is advantageous. And a viability of fertilizer production within this project depends only on the production cost.

Table 6-4-3 BREAKDOWN OF DEMAND FOR METHANOL in 1982

	U.S.A.	W. Europe	Japan
Formaline	30 %	50 %	47 %
Chloreomethane	9	6	3
DMT	4	4	1
Methylamine	4	4	2
MMA	4	3	6
Acetic acid	12	5	10
Solvent	10	6	6
MTBE	8	5	-
Gasoline blend	6	5	-
Others	13	12	25
Total	100	100	100
Demand (10^3Ton/y)	3,155	3,257	1,070

Fig 6-4-1



WORLD METHANOL BALANCE
million metric tons per year
20
10
0
PRODUCTION CAPACITY
(at previous year end)
mothball/ scrapped capacity
MeOH → GASOLINE
CONSUMPTION
new capacity after '82
'82
'83
'84
'85
'86
operation ratio
76%
73%
71%
64%
64%

Table 6-4-4 WORLD DEMAND FORECAST FOR METHANOL

(x 1,000 MT)

	1980		1982		1985		1987		1990	
	World	USA	World	USA	World	USA	World	USA	World	USA
Current Uses	11,724	3,315	13,051	3,704	15,323	4,524	17,056	4,889	20,028	5,772
New Uses										
MTBE	316	241	558	362	784	543	859	603	949	678
Single Cell Protein	90	0	90	0	180	0	270	0	270	0
Fuels										
MTBE/tertiary butyl alcohol blend	30	30	196	166	603	452	904	678	1,205	904
Gasoline Blending	60	30	60	30	362	30	3,647	3,014	5,154	4,521
Peak Power Shaving	9	9	9	9	75	75	150	150	1,500	1,500
Total	12,229	3,625	13,964	4,271	17,327	5,624	22,888	9,334	29,115	13,382
Name Plate Capacity	14,937	4,150	17,017	4,557	22,065	5,790	27,551	8,776	34,182	13,304
Capacity Use (%)	82	87	82	94	79	98	83	100	85	100
Net US Imports		99		398		726		1,875		2,080

(Chem. Eng. News July, '80)

Fig 6-4-2 METHANOL MARKET PRICE TREND

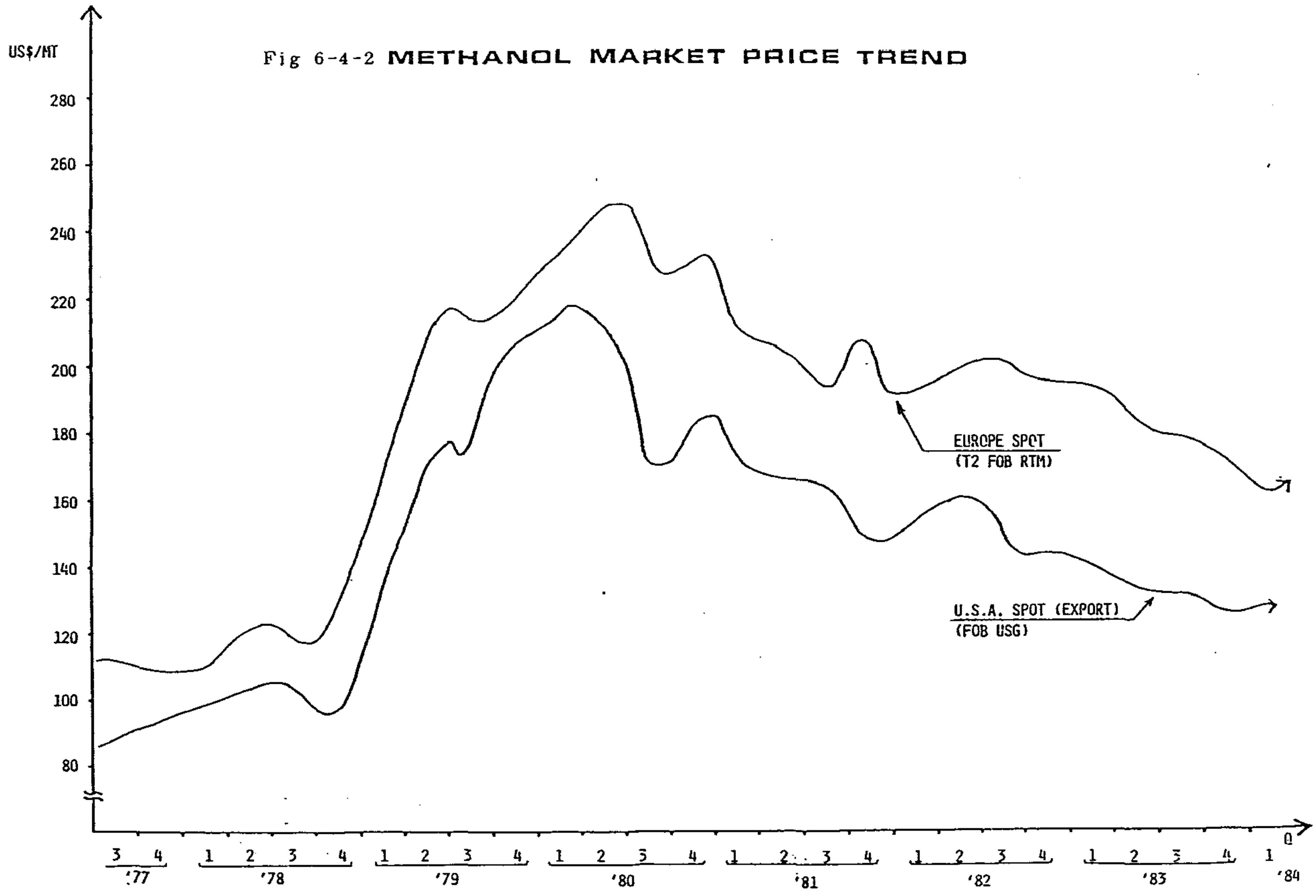


Fig 6-4-3 FEEDSTOCK PRICE TREND

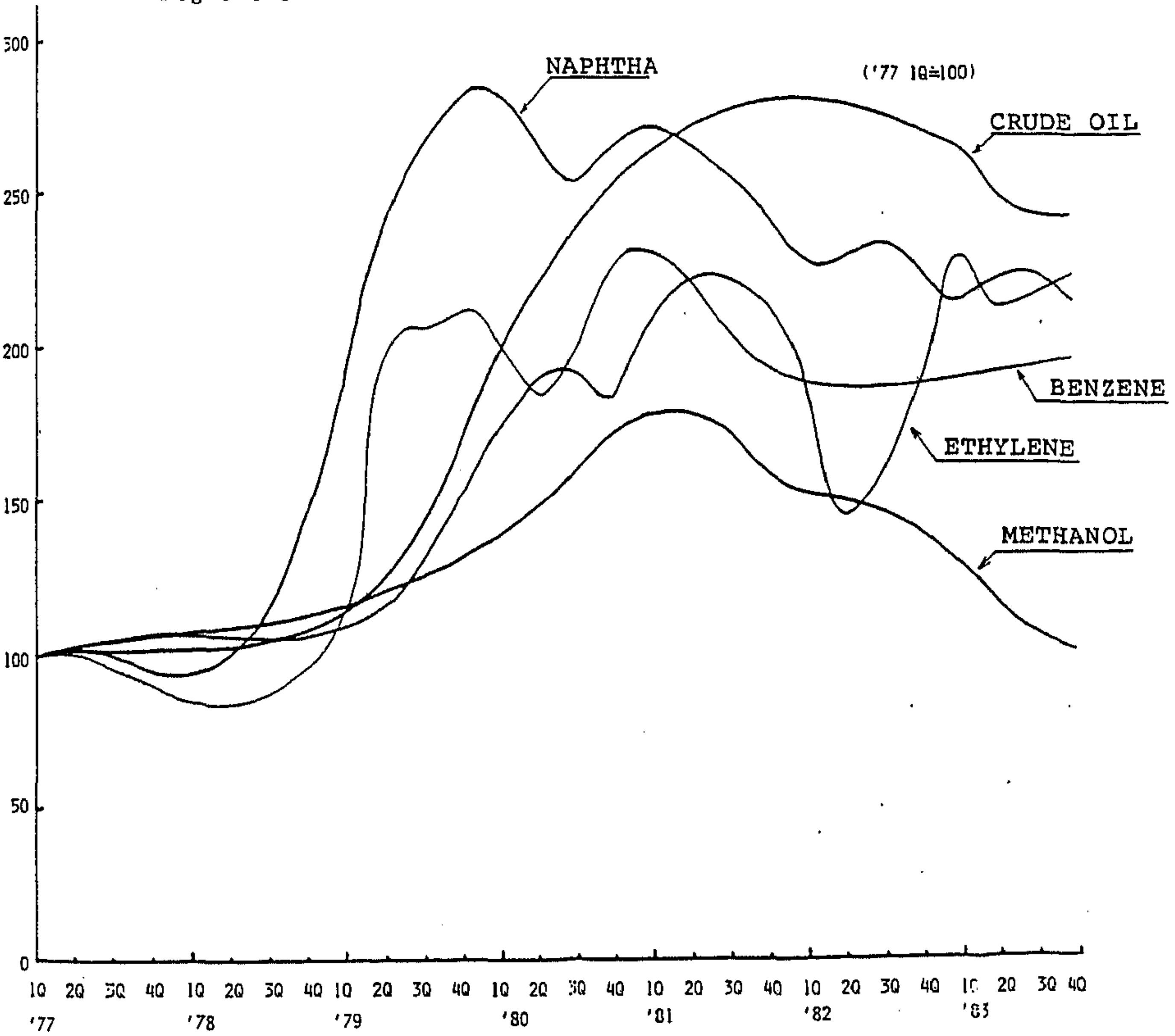


Fig 6-4-4 '84 METHANOL BALANCE OF EACH BLOCK

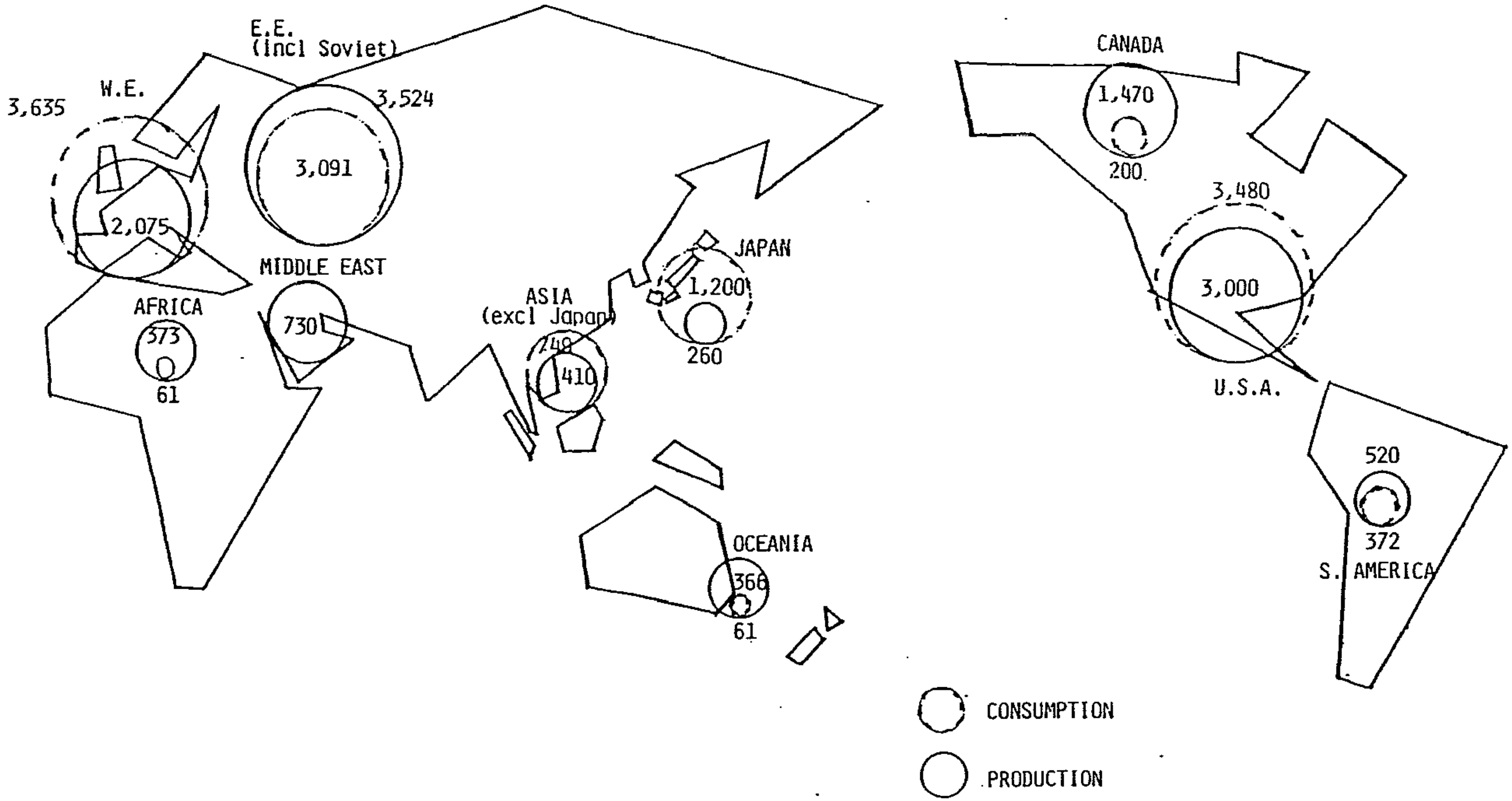


Table 6-4-5 DEMAND AND SUPPLY FORECAST FOR METHANOL IN ASIAN COUNTRIES

(UNIT: 1,000 TON/YEAR)

		JAPAN	KOREA	TAIWAN	PHILIPPINES	THAILAND	MALAYSIA	SINGAPORE	INDONESIA	INDIA	CHINA	TOTAL
1982	Production	639	111	26	3	8	0	0	0	40	245	1,072
	Import	474	0	89	16	8	50	40	35 *	50	0	
	Export	16	13	0	0	0	15	15	0	0	30	
	Consumption	1,097	98	115	19	16	35	25	35	90	215	1,800
1983	Production	340	64	8	0	8	0	0	0	40	235	695
	Import	845	49	121	20	10	41	60	46	40	0	
	Export	12	0	0	0	0	11	40	0	0	20	
	Consumption	1,173	113	129	20	18	30	20	46	80	215	1,899
1984	Production	260	8	30	0	8	100	0	0	40	230	1,042
	Import	950	110	120	20	12	40	80	65	45	0	
	Export	10	0	0	0	0	105	60	0	0	10	
	Consumption	1,200	118	150	20	20	35	20	65	85	220	1,994
1985	Production	240	0	50	0	8	400	0	0	40	228	1,332
	Import	1,030	125	120	21	12	0	40	80	50	0	
	Export	10	0	0	0	0	365	20	0	0	3	
	Consumption	1,260	125	170	21	20	35	20	80	90	225	2,112
1986	Production	150	0	50	0	8	500	0	0	40	230	1,345
	Import	1,130	130	130	22	13	0	20	90	55	0	
	Export	5	0	0	0	0	465	0	0	0	0	
	Consumption	1,275	130	100	22	21	35	20	90	95	230	2,165

*: According to Import Statistics, Indonesia imported 56,100 ton per year of methanol.

Table 6-4-6

DEMAND FORECAST FOR METHANOL AND GLUE IN INDONESIA

	GLUE	METHANOL
1982	120,500 T/Y	42,200 T/Y
1983	192,800	67,500
1984	321,000	112,400
1985	385,600	135,000
1986	421,300	147,500
1987	505,000	176,800
1988		(205,000)
1989		(238,000)
1990		(276,000)

Note:

1) Figures in parenthesis is extrapolated one using a trend in the former three years.
2) Methanol consumptions are estimated by an assumption that 0.35 tons of methanol are required to produce 1.00 ton of glue.

Table 6-4-7 INDONESIAN FERTILIZER PLANT CAPACITIES AND PRODUCTION POTENTIAL, 1981-90

(Product Tons)

Plant	Design Capacity (tpy)	Status	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
			Projected Output ('000 tpy at 90% of design)									
Urea												
P.T. PUSRI I	100,000	Operating	38	90	90	90	90	90	90	90	90	90
P.T. PUSRI II	380,000	Operating	334	350	350	350	350	350	350	350	350	350
P.T. PUSRI III	570,000	Operating	527	513	513	513	513	513	513	513	513	513
P.T. PUSRI IV	570,000	Operating	579	513	513	513	513	513	513	513	513	513
Subtotal			1,478	1,466	1,466	1,466	1,466	1,466	1,466	1,466	1,466	1,466
P.T. Kujang I	570,000	Operating	528	513	513	513	513	513	513	513	513	513
P.T. Kujang II	570,000	Approved						57	456	513	513	513
P.T. Kujang III	570,000	Possible								57	456	513
P.T. Kaltim I	570,000	Commissioning			57	456	513	513	513	513	513	513
P.T. Kaltim II	570,000	Approved						57	456	513	513	513
P.T. Kaltim III	570,000	Approved							57	456	513	513
P.T. Asean Aceh 60% to Indonesia	570,000	Construction			36	273	308	308	308	308	308	308
P.T. Iskanda Muda	570,000	Construction					399	456	513	513	513	513
Total Urea			2,006	1,979	2,072	2,708	3,199	3,370	4,282	4,852	5,308	5,365
Ammonium Sulfate												
P.T. Petrakimia I	150,000	Operating	135	135	135	135	135	135	135	135	135	135
P.T. Petrakimia II	250,000	Approved				90	180	200	225	225	225	225
Total AS			135	135	135	225	315	335	360	360	360	360
Ammonia												
P.T. Kaltim I	165,000	Construction			16	132	148	148	148	148	148	148
P.T. Kaltim II	165,000	Approved						16	132	148	148	148
Total Ammonia					16	132	148	164	280	296	296	296
TSP/DAP												
P.T. Petrokimia I	450,000	Operating	559	540	405	405	405	405	405	405	405	405
P.T. Petrokimia II	450,000	Construction			315	405	405	405	405	405	405	405
P.T. Petrokimia III	450,000	Approved				45	315	405	405	405	405	405
Total TSP/DAP			559	540	720	855	1,125	1,215	1,215	1,215	1,215	1,215

a. Actual data for 1981. Not including 15,000 tons of urea by P.T. Petrokimia I.
b. Kaltim I delayed into 1983. Kaltim II also assumed 1 year delay
Source: PUSRI data from Department of Industry, with later information.

Fig 6-4-5 Location of Fertilizer Production Units
and
Bagging Station

6-5. Conclusion and Recommendation

(1) Conclusion

1) on Long Term Energy Projection

(i) The potential energy demand in Indonesia will remain to be bull according to the energy projection to 1995 by JICA team. Especially, potential demand for petroleum products will grow by around 5%/yr. even though significant introduction of such alternative energy sources to oil as hydro and coal.

(ii) As to sectoral demand for petroleum products, its demand in industrial sector will be decreased in its growth rate because of projected rapid introduction of coal and natural gas in this sector.
As a result, such percentages as of gasoline, ADO and diesel oil for power generation will increase respectively. Therefore, it will be much more important to introduce alternative fuels in these products.

(iii) The energy demand level in longer term will mainly depend upon government pricing policy. So long as present high price policy of fuel, which is named as "a proper price policy" by Indonesian government, is maintained, the growth rate of energy consumption will be kept in relatively low level. However, this policy might create some distortions domestically unless it is accompanied by the increase of income level. Therefore, it might be more important for government to coordinate the relationship between energy demand and its price level.

2) on Market of Energy and Chemical Products

(i) Application of neat methanol as an alternative fuel for gas turbine generator (diesel oil is used as fuel) and diesel engine generator seems to be the most prospective market in future, though more detailed study including an application technology is necessary for materialization.

(ii) Application of methanol for automotive use (GASOHOL) seems also to be expectable market, though its demand for methanol is comparatively less than replacement for diesel oil . The influence of toxic nature of methanol blended gasoline must be studied, considering local conditions in Indonesia.

(iii) Demand for urea is highly prospective in Indonesia. But economic feasibility of coal gasification system seems to be rather political matters because the price of natural gas which is ordinary feedstock for urea for the time being is settled politically in lower level. The selection of utilization of natural gas reserved in South Sumatra, as feedstock of urea in PUSRI or fuel in Java by installation of pipeline, shall also give great influence on demand of synthetic gas produced from Banko coal. Therefore, demand for urea must be studied, considering future prospect of above mentioned political matters.

(iv) Electricity generation at mine mouth and supply of the electricity to Java by high voltage - direct current transmission line seems to be a very interesting idea for effective utilization of coal in Bukit Asam and Banko, because it is expected that such system provides higher overall efficiency and less investment compared with ordinary system.
Therefore, it is proposed that a preliminary feasibility study shall be carried out as subsidiary subject of the Study.
In above proposed preliminary study, the comparison between HVDC system and ordinary system as well as the comparison between direct combustion system in steam power plant and gasification and combustion system in combined cycle generation plant shall be the main theme.

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(v) Demand of methanol for chemical use is rather lower level for the time being.

(2) Recommendation

As the result of the preliminary survey on markets, some of subsidiary subjects to be studied were proposed to the Indonesian Government.

The major subjects are as follows:

i) Market development study on methanol as fuel for gas turbine generator and diesel engine generator

ii) Preliminary feasibility study on mine mouth generation and high voltage - direct current transmission line

iii) Safety assessment for GASOHOL

Above mentioned subsidiary subjects seem to play an important role for evaluation of market and demand of brown coal and its derivatives. Therefore it is recommended to take into the revised Scope of the Study which will be discussed at the end of the Stratetic Investigation Stage.

7. Results of Survey on Banko and Resources

7-1 Existing Data and Information on Banko Coal Resources

(1) Survey by Shell

1) As shown in Fig. 7-1-1, a number of coal seams develops through the Tertiary formation in South Sumatra. Particularly the Muara Erim coal formation belonging to the Middle Palembang formation contains a number of well developing coal seams ranging from brown coal to bituminous coal.

2) Shell Mijonbow N.V., a Indonesian unit of Royal Dutch Shell group to engage in the development and exports of Indonesian coal, concluded in October 1973 a two-year agreement on coal exploration in South Sumatra with the Indonesian Coal Corporation (PNTB) and acquired the right of coal exploration over an area of 71,450 km^2 as shown in Fig. 7-1-2.

3) In 1974 and 1975 Shell had invested more than $20 million and drilled 588 boreholes, 150m-in depth on the average, with nine boring machines, as the preliminary survey, and revealed that South Sumatra was blessed with a huge amount of coal reserves.
Drilling length amounted to some 9,000m, of which 30% was cored (2"1/2) and 70% open holes. Geophysical investigation was simultaneously conducted.
A total of 16,000 samples were taken to analyze fixed carbon, VM, ash, S, Cl and calorific value.
As shown in Fig. 7-1-3, the survey revealed that brown coal reserves (up to 50m in depth) in 15 blocks amounted to 6,500 million tons.

4) In May 1976, when the two-years agreement was terminated, Shell returned the right of coal exploration over 75 percent of the original area to the Indonesian Coal Corporation (PNTB).

Fig 7-1-1

中・南部スマトラ地質図

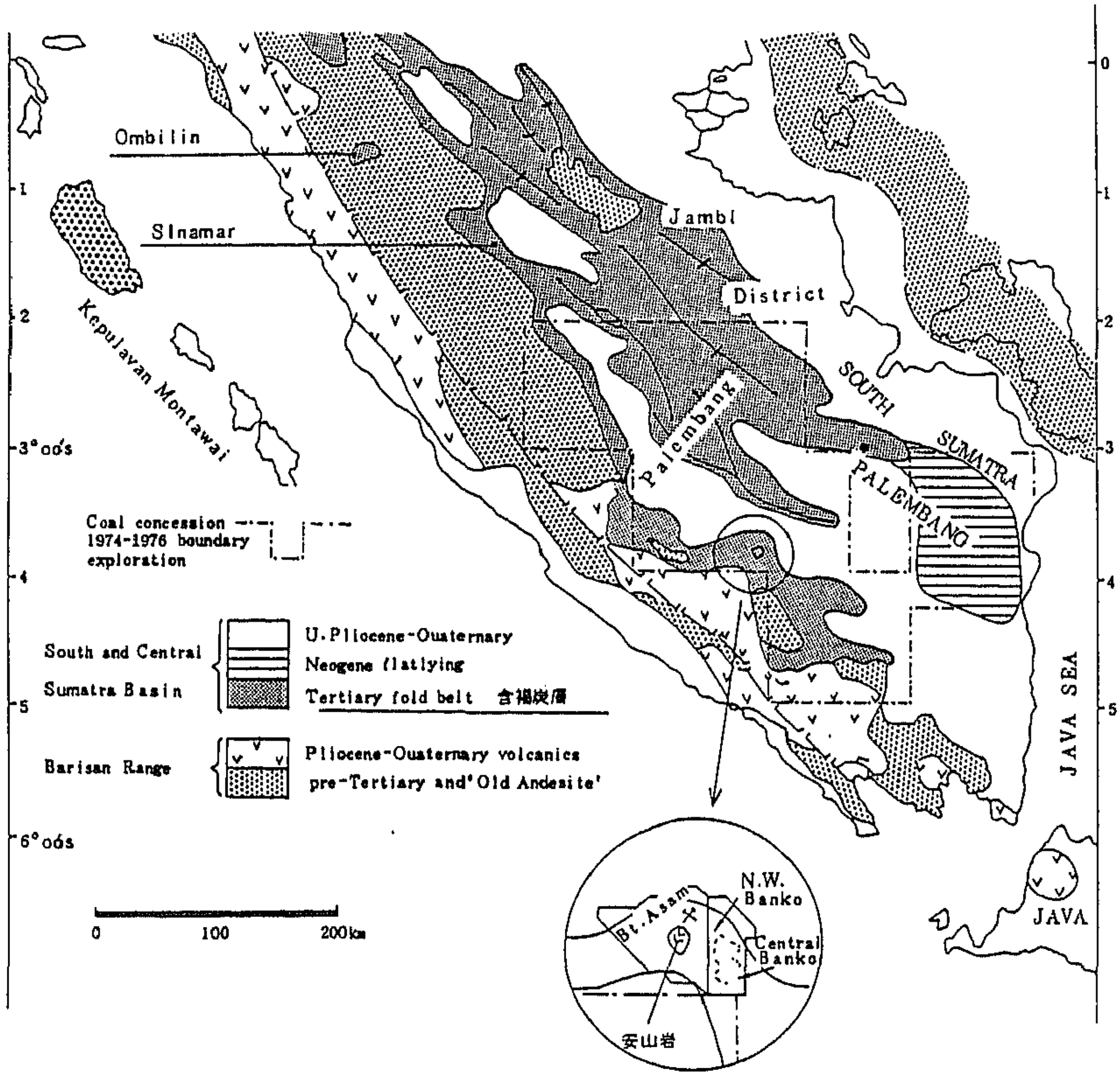


Fig 7-1-2 Blocks Covered by Shell's Exploration

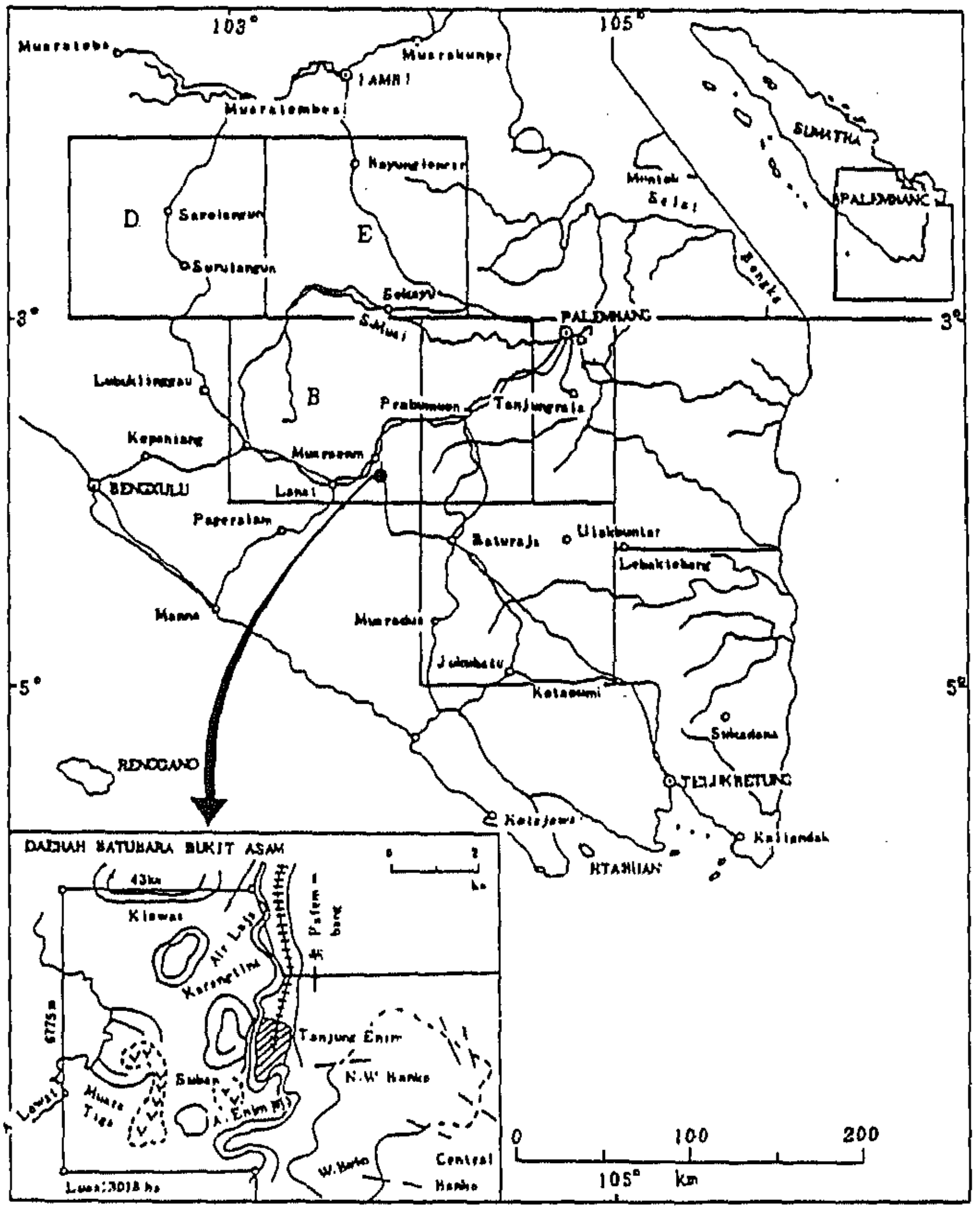
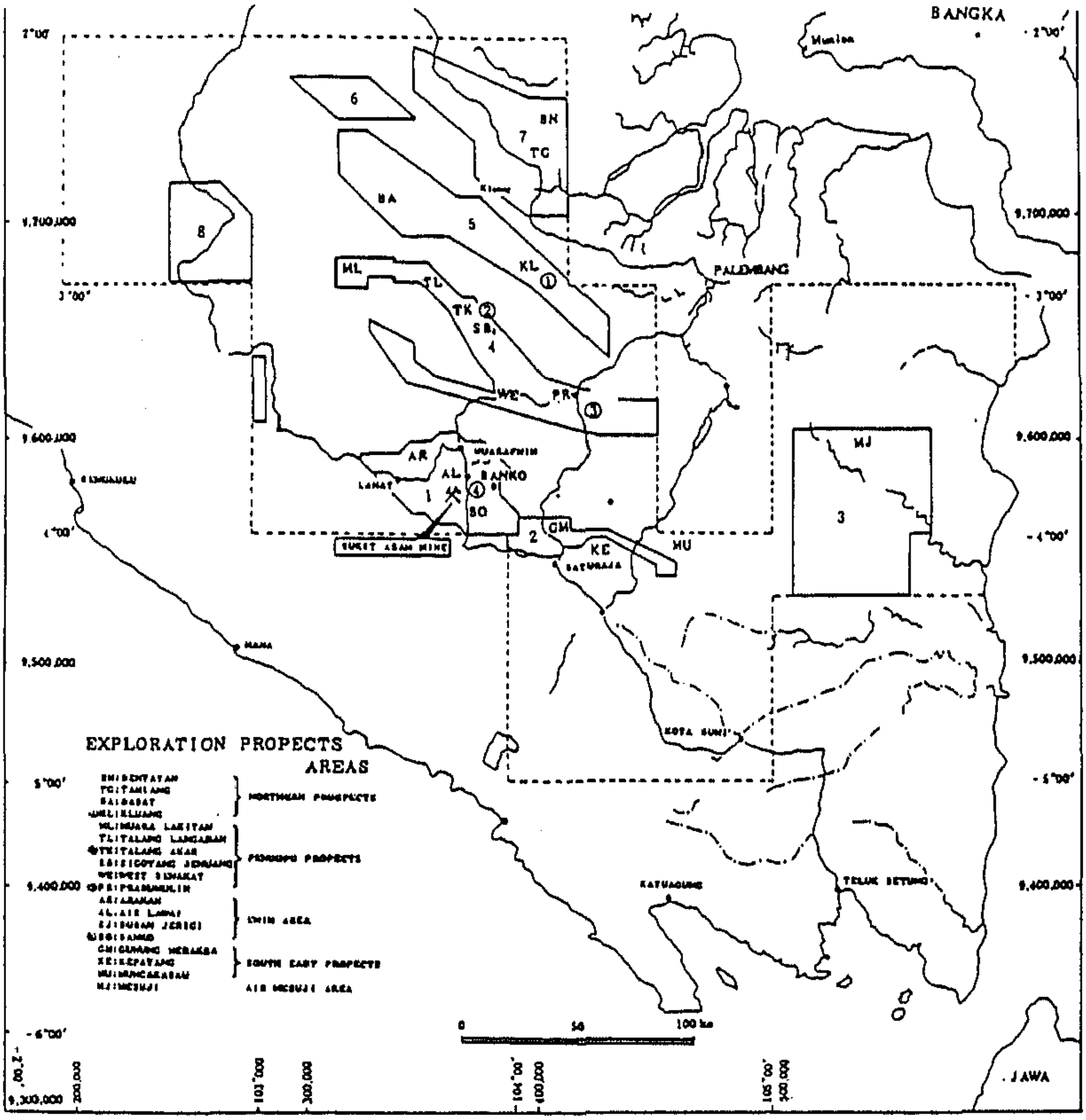


Fig 7-1-3 Map of Blocks for Coal Exploration in South Sumatra



Estimated Reserves in Major Blocks of South Sumatra Coal Field (up to 50 m in depth)

Area	Approximate volumes of coal resources to 50 m. depth. million cubic metres
Bentayan	75
N. Tamiang	100
S.E. Tamiang	40
① N. Kluang	200
S. Kluang(Musi)	1,300
N. Babat	220
S. Babat	90
N. Pendopo(Muara Lakitan, Talang Langaran)	300
② Pendopo North Flank(Talang Akar, Sigoyang Benuang)	1,330
③ Prabumulih	400
West Enim(Arahan, Air Lawai)	120
④ East Enim(Banko, Suban Jerigi)	450
Meraksa	110
Baturaja(Kepayung, Muncakabau)	150
Mesuji	250
Total :	5,135

The criteria to select the area to be retained were that coal seams with a net thickness of 10 meters or more, and existed down to 200 meters from the surface. Also coal quality and mining cost were taken into consideration.

5) From June 1976 through March 1978, Shell had conducted additional and detailed exploration focusing on the most potential area (Banko area), covering an area of some 150km^2 located in southeast of Tanjun Enim, during this period 490 boreholes at intervals of 200-800m, and 50 shafts, trenches and test pits were carried out. Of the 490 boreholes, 435 were NX core drilling (2"5/8), which included 380 wire line lagged, and 55 were shallow holes drilled with portable winkil drills. The boreholes measured 15-215m in depth, many of which reached at the Petai coal seams.
Total boring length was 12,000m and total exploration cost during this period is reported to have amounted up to $48 million.
This detailed exploration was conducted in the Banko area, consisting of Northwest Banko, West Banko, West Central Banko and Central Banko. Particularly this exploration was focused in Northwest Banko.

6) The preliminary survey of the Suban Jeriji area adjoining the Banko area on the east was conducted during the 1975 wide-range survey. However, the detailed exploration in 1976 through 1978 did not cover this area. As a result, less data are available on coal in the Suban Jeriji area.

7) Data obtained by Shell's survey are stored in a computer employing the COGEO-B system, which are now under analysis work by an Indonesian team led by the MTDC.

(2) Study on Coal Distribution, Reserves, and Quality by Shell

1) Geological conditions of the Banko and Suban Jeriji areas

i) All the coal seams in the Banko and Suban Jeriji areas belong to the Muara Enim coal formation (Middle Palembang formation) having been formed in the Upper Miocene to Pliocene periods.
The Muara Enim coal formation can roughly be divided into the Upper and Lower Middle Palembang formations. Jelawatan and Enim coal seams are developing in the former, while Mangus (M_1, M_2), Suban (S_1, S_2) and Petai (P_1, P_2) coal seams are located in the latter as shown in Fig. 7-1-4.

ii) The Banko and Suban Jeriji areas are affected by four major anticline and synchline axes (strike NW-SE) and form a dome structure as a whole.
In its western wing fronting the River Enim located are North West Banko and West Banko, while Central Banko is situated in its southern wing. (see Fig. 7-1-5)

iii) Major faults include east-westward one with a 20-meter displacement marking off the northern part of North West Banko, south-northward one bordering the southern part of West Banko and Central Banko, and south-northward one bordering North Suban Jeriji and East Suban Jeriji. (see Fig. 7-1-5)
Among faults, some mark drastic displacement or dip of coal seam. For instance, one of the east of West Suban Jeriji shows a displacement exceeding 300m and one on the north of North West Banko shows steeper dip reaching as much as 70°.
However almost all of coal seams in these areas show moderate dip of less than 15°.

iv) Strike of coal seams in this area run from south to north on the east and west while from east to west on the north. On the south, however, they show remarkable foldings and run toward various directions, including south-north, east-west and north-south.

v) Major types of rocks forming the areas are claystone, sandstone, siltstone, and tuff, which are not firmly consolidated.

2) Coal distribution

i) Outline

Fig. 7-1-5 and 7-1-6 show distribution of coal seams in the Banko and Suban Jeriji area.

Because of geological features such as a wide dome structure, repeated foldings and several faults, Jelawatan and Enim coal seams (upper coal seams) are distributed in the outside zone of the areas, while Mangus, Suban and Petai coal seams (lower coal seams) in the inside zone.

Especially lower coal seams are developing well with a relatively stable distribution in the area ranging from the North West Banko to West Banko. Fig. 7-1-4 explains major coal seams in the Muara Enim Formation, while Fig. 7-1-7 shows geologic colummar section of North West Banko.

ii) The major coal seams

a) Jelawatan coal seam

This seam is developed from North Suban Jeriji to East Suban Jeriji.

Although, this coal seam is only of economic interest in the northern part of Suban Jeriji where it attains a maximum net thickness of 12 meters, elsewhere it is either highly split (East Suban Jeriji) or completely absent.

Ash content of Jelawatan coal (excluding bands) ranges from 6 to 8% (m.f.) and the sulphur content is less than 0.25% (m.f.). Calorific value of Jelawatan coal in the area where it is economically attractive is 6,800 kcal/kg (d.a.f.).

b) Enim coal seam

The Enim coal seam is distributed along with the flanks of the areas from Enim riverside of Western Banko to East Suban Jeriji and North Suban Jeriji. The Enim seam reaches its maximum development in North Suban Jeriji where it attains a net coal thickness of more than 25 meters. However, for the remainder of the area the seam is usually about 15m in thickness on the average.

Where the seam is well developed it is characterized by six prominent tonstein horizons, a mean ash content (excluding dirt bands) of 4-5% (m.f.), and a mean sulphur content of less than 0.25% (m.f.).

Total moisture content exceeds 40%, much higher compared with lower coal seams.

c) Mangus coal seam

The Mangus coal seam develops uppermost in the lower Middle Palembang formation and located in the lower part of the Enim coal seam at some 350 to 380 meters in depth.

The Mangus coal seam is divided into 2-3 splits or more, thereby the upper part is called M_1 seam and the lower part M_2 seam.

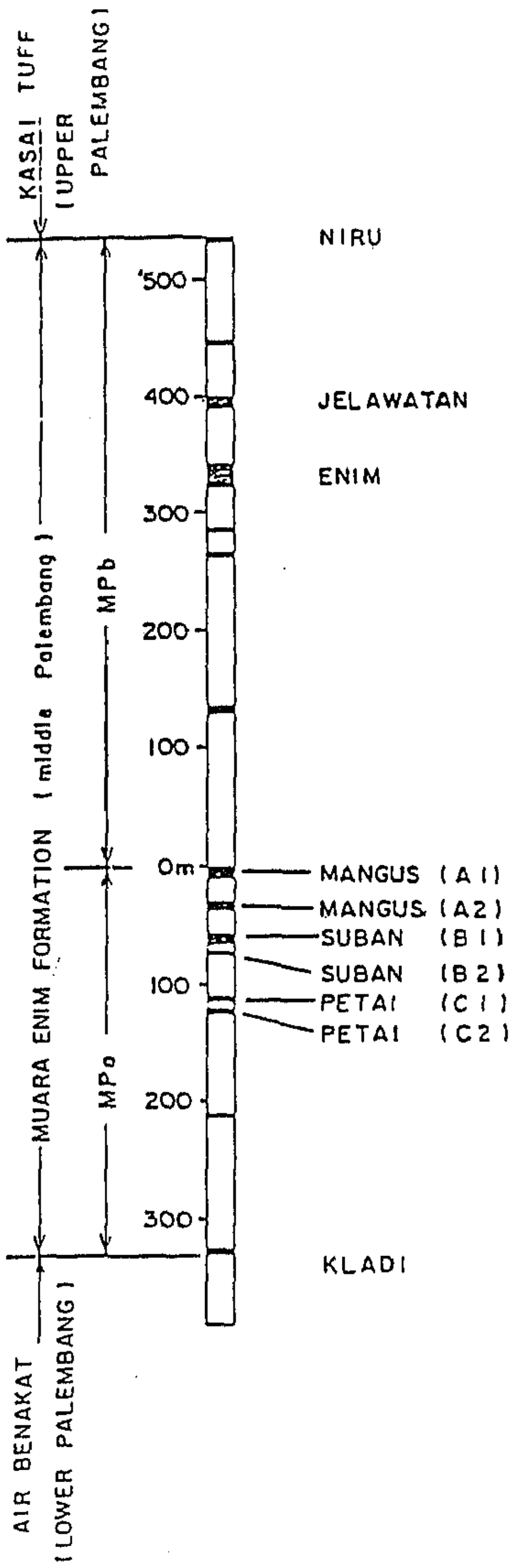
Both the M_1 and M_2 seams measure some 9-10 meters in thickness on the average.

Though developing well in North West Banko, the Mangus coal seam deteriorates in the West Central Banko area, where it is divided into thinner seams. The Mangus coal seam is absent in Central Banko (see Fig. 7-1-9).

d) Suban coal seam

The Suban coal seam is developing 10-20m away from the Mangus coal seams (see Fig. 7-1-7). The Suban coal seam is often divided into 2-3 splits or more, thereby called S_1 and S_2 seams. The seams are widely and dominantly developing in the Banko

Fig. 7-1-4 Major Coal Seams in the Muara Enim Formation



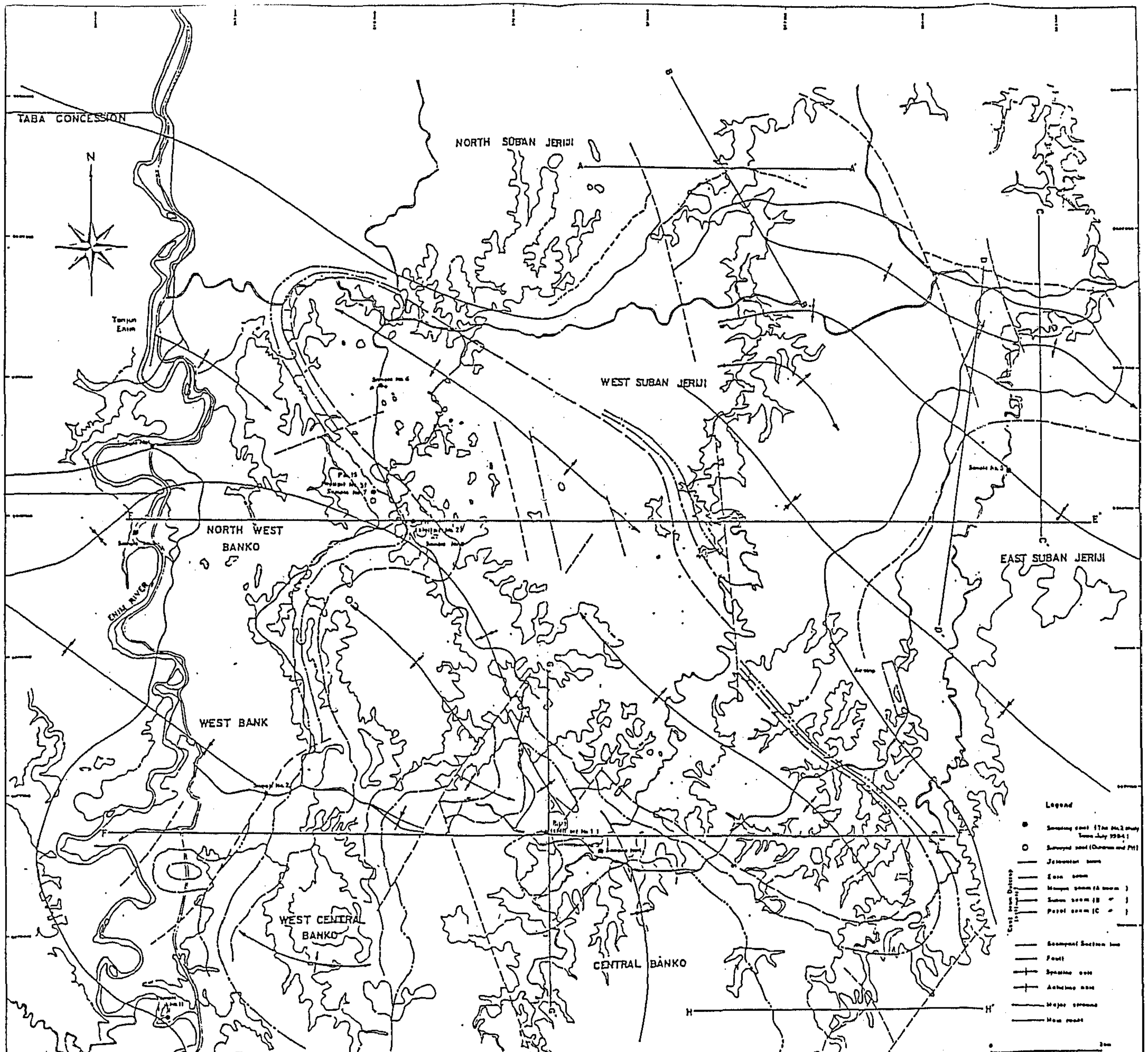


Fig. 7-1-5

Banko - Suban Jerlji
Topography and Coal seam map
(By shell Mijnbouw NV Nov 1973)

Fig. 7-1-6 Geological Section Map

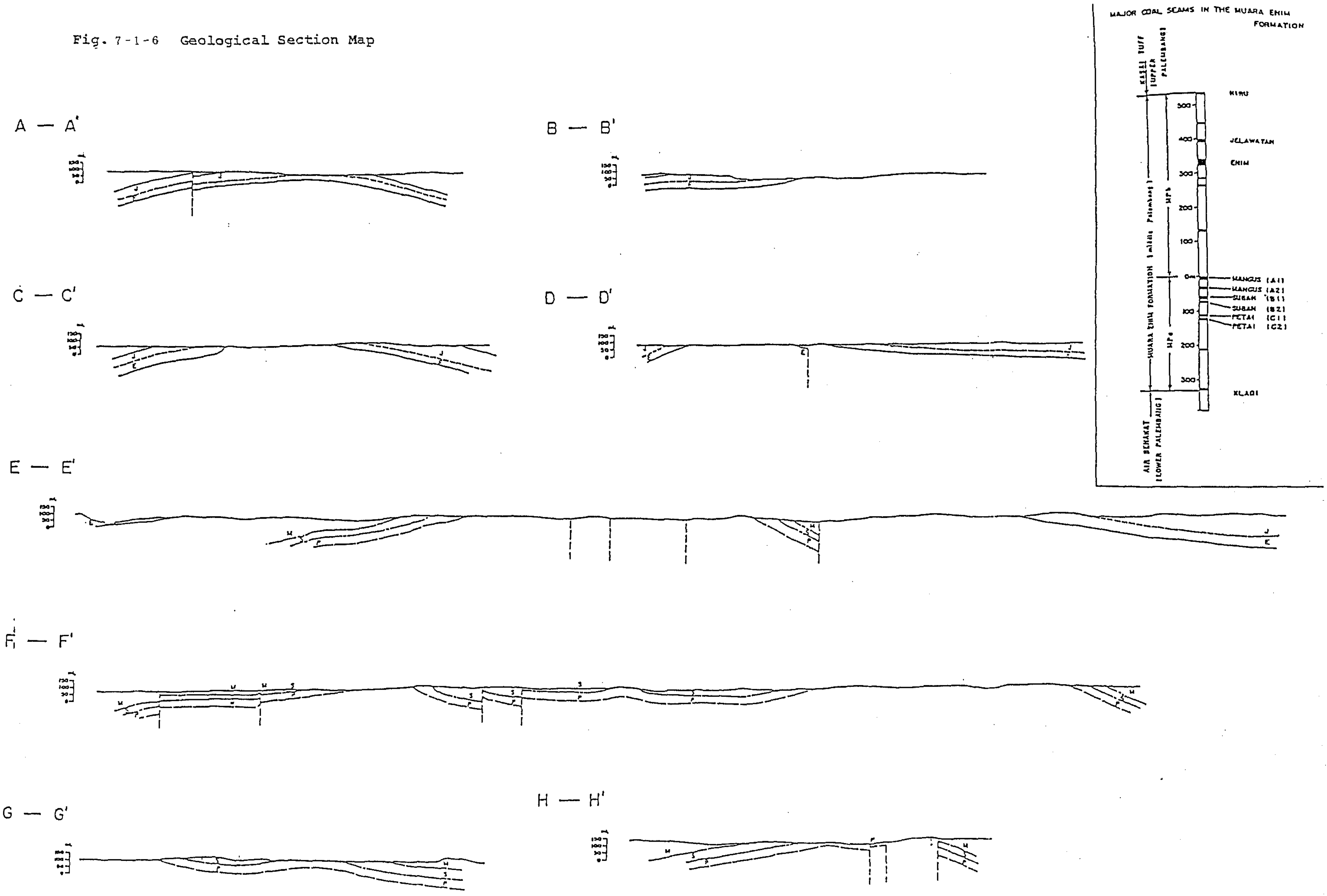
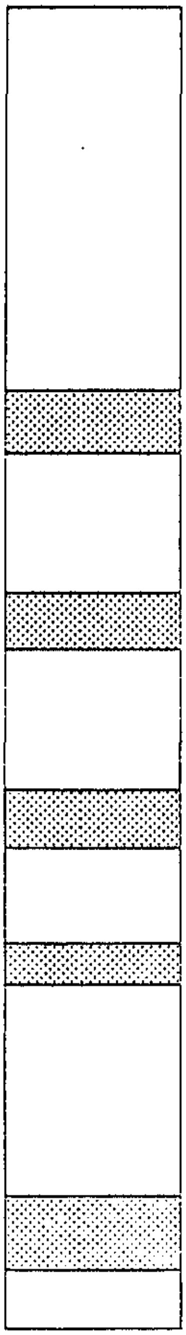


Fig 7-1-7 Geologic Colummar Section of North West Banko Area



SHELL NOTATION	ROCK UNIT NAME	REAL THICKNESS(m.)		
		Max.	Min.	Average
MO	MANGUS OVERBURDEN	-	-	
MA1	MANGUS 1 SEAM	12.1	4.6	9.2
MP	MANGUS PARTING	22.8	10.3	16.7
MA2	MANGUS 2 SEAM	11.8	8.4	10.4
SO	SUBAN OVERBURDEN	15.3	11.4	13.3
SU1	SUBAN 1 SEAM	13.7	9.5	12.5
SP	SUBAN PARTING	12.3	1.3	6.9
SU2	SUBAN 2 SEAM	5.5	4.2	-
PO	PETAI OVERBURDEN	43.5	28.1	36.3
PE	PETAI SEAM	12.4	10.4	11.5

Vertical scale approx. 1:1000

Fig 7-1-8 Range of Mangus Seam Covered by Reserve Calculations

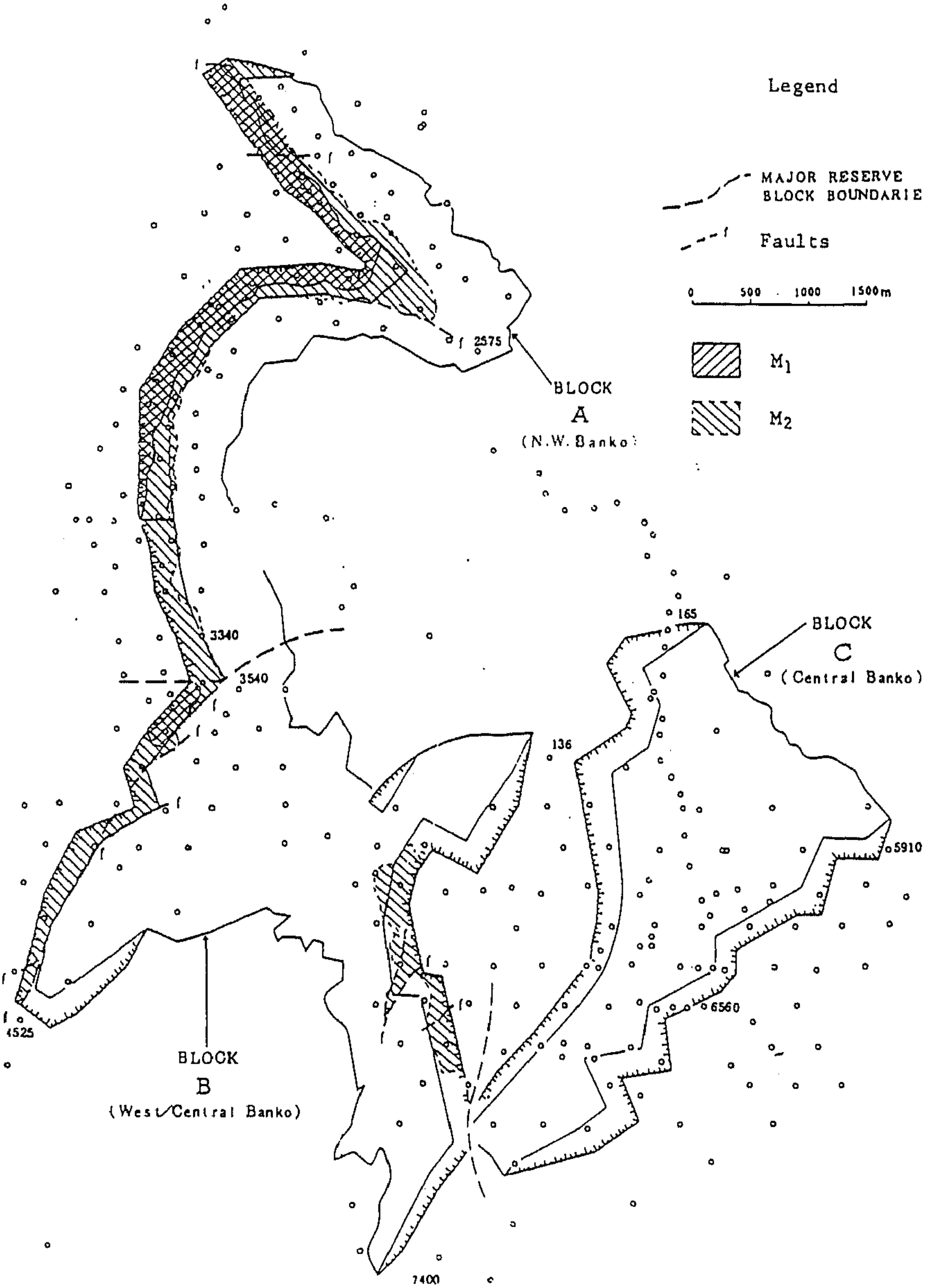
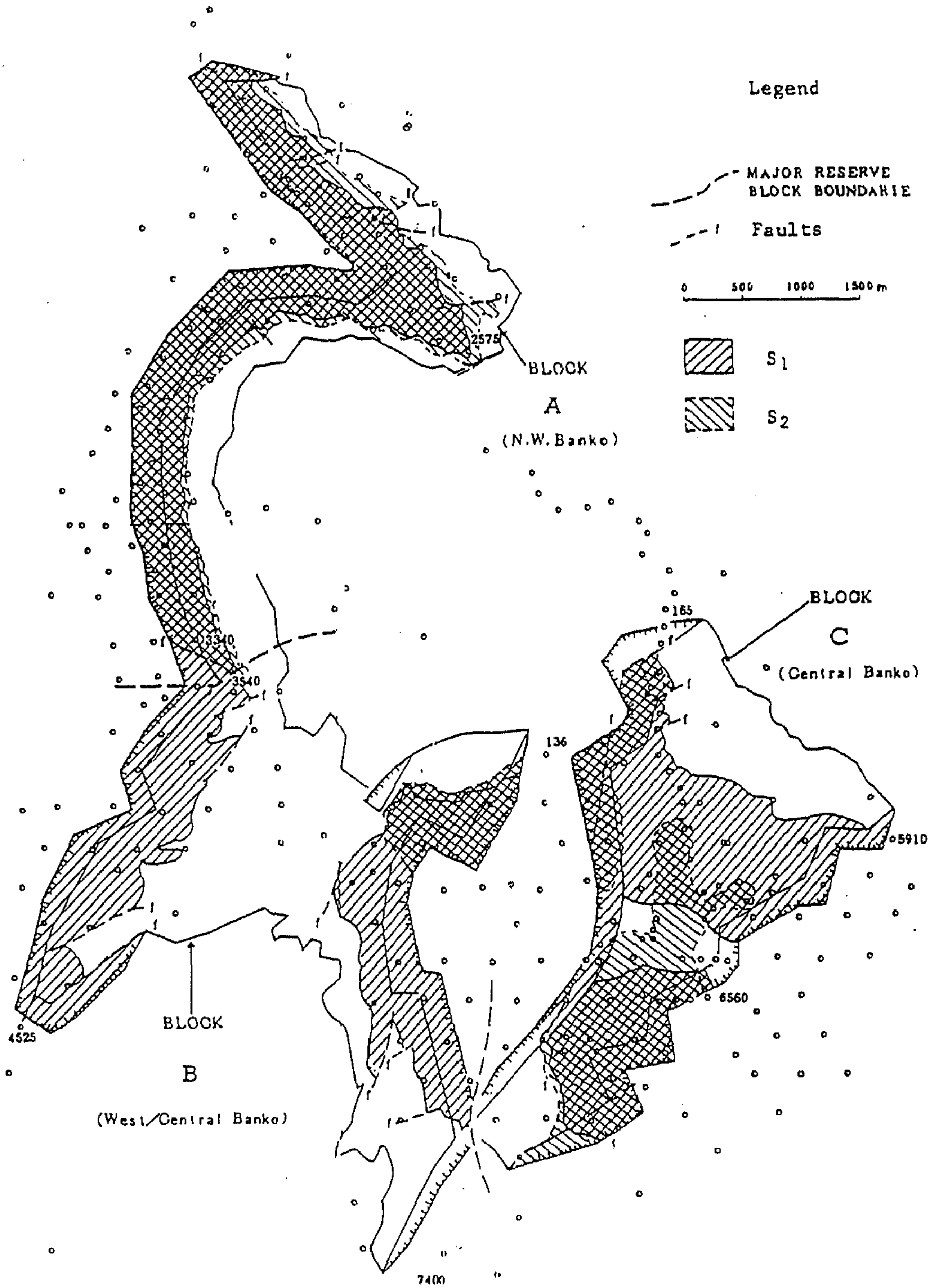


Fig 7-1-9 Range of Suban Seam Covered by Reserve Calculations



area (see Fig. 7-1-10).
The thickest part of the Suban coal seams reaches nearly 20 meters.
In North West Banko, the S_1 seam is constantly thick (12-18m) and features stable distribution.

e) Petai coal seam
The Petai coal seam develops in the lower 40-30m part of the Suban coal seam (see Fig. 7-1-4 and 7-1-7). The coal seam as a whole measures 10-15m in thickness.
Like other coal seams, the Petai coal seam is also divided into 2-3 splits (called P_1, P_2). In the area from North West Banko to Central Banko Petai seam is constantly distributed, though interburden layer of carbonous and silty rocks between P_1 and P_2 develop thicker from north to southward (see Fig. 7-1-11).

3) Coal reserves

i) Summary

a) Results of the preliminary and detailed surveys conducted by Shell since 1974 report a total of 897 million tons reserves in the Banko and Suban Jeriji areas.

b) Because detailed exploration on the Suban Jeriji area is not yet carried out only inferred reserves are available for the Suban Jeriji area.
Also strip ratio of the Suban Jeriji area is not clarified. Therefore, collection of detailed data on the raio and others will critically be needed in order to assess the value of the Suban Jeriji area.

Fig. 7-1-10 Range of Petai Seam Covered by Reserve Calculations

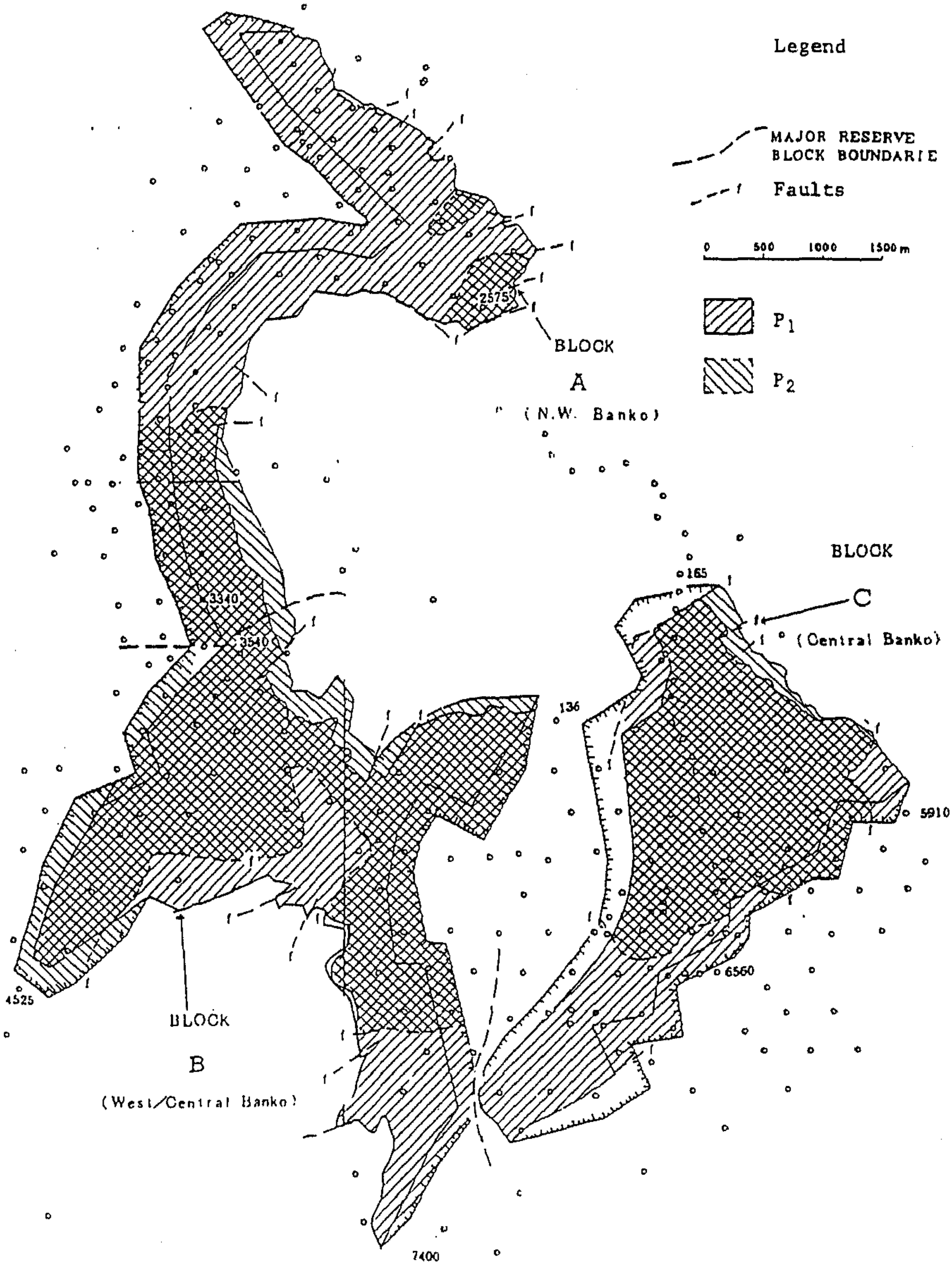


Fig. 7-1-11 Range Covered by Boring

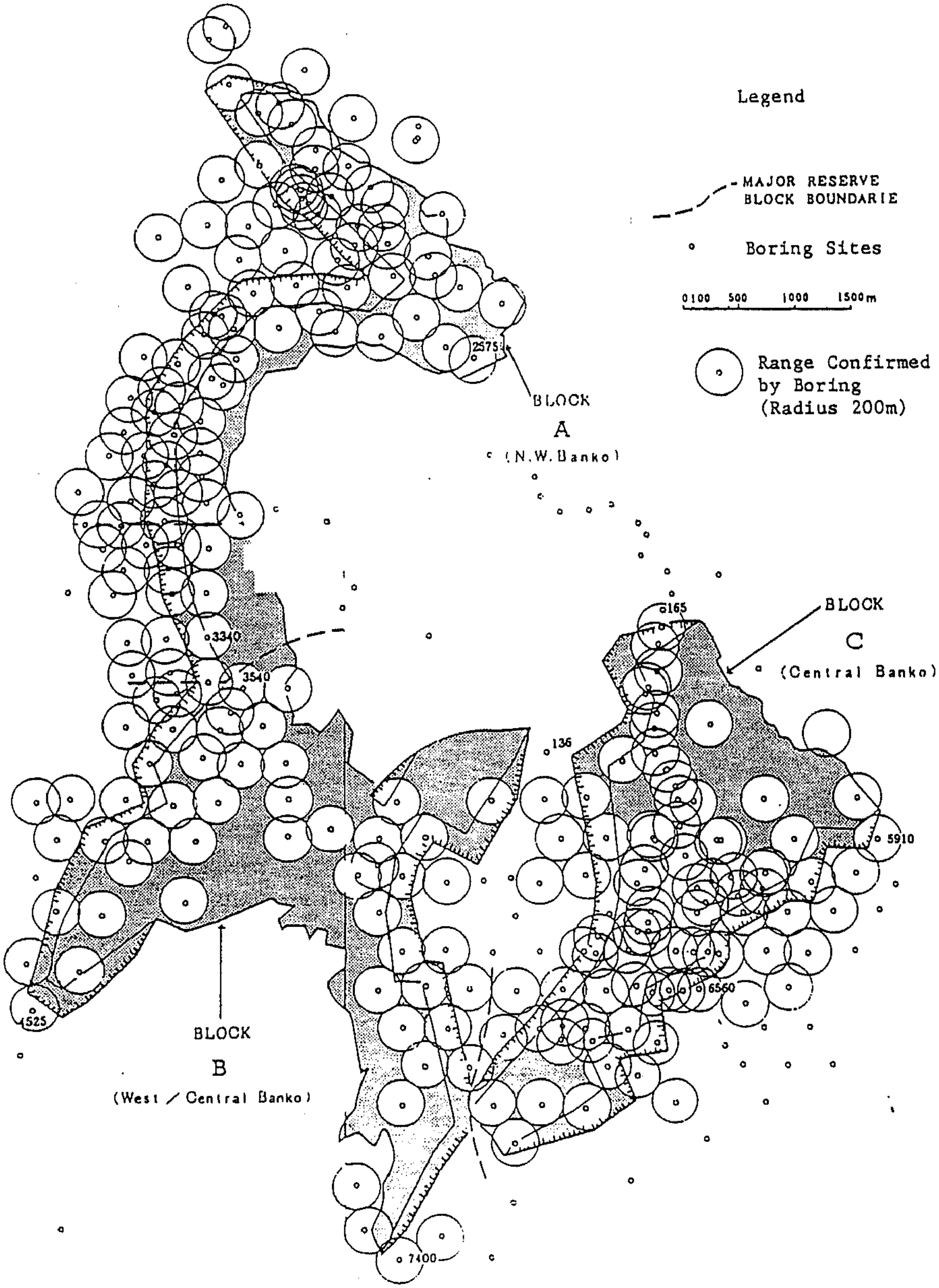


Table 7-1-1 Summary of Coal Reserves

Area		Coal Reserve (1,000 ton)			
		Measured	Indicated	Inferred	Total
Banko		435.5	-	-	435.5
Suban Jeriji	North S.J.	-	-	242	242
	East S.J.	-	-	219.9	219.9
Total		435.5		461.9	897.4

ii) Calculation of coal reserves in the Banko area

a) Based on its survey results conducted by 1978, Shell employed the preconditions shown in Table 7-1-2 and 7-1-3 and calculated coal reserves in the Banko area. As shown in Table 7-1-4, Shell's calculation results indicated that coal reserves in the three blocks, including A, B and C, totalled 435.5 million tons. Ranges of individual coal seams subject to the calculations are shown in Fig. 7-1-9, 7-1-10 and 7-1-11.
The area covered by 400m-interval boring was so broad (see Fig. 7-1-8) that the calculation results should be regarded as highly accurate.

b) In 1983, upon a request made by the Indonesian government, Shell reviewed mineable reserves in the A-block (N.W. Banko and part of West Banko) as a preliminary step toward a development plan of the block.
As a result, Shell estimated mineable reserves in the block at slightly more than 100 million tons (see Table 7-1-5).

4) Coal quality by Shell

i) General properties

Brown coal in the Banko area is black or dark brown in color without showing much luster. Speciifc gravity ranges from 1.26 to 1.28 and bulk density stays at 0.73 in case of T.M. 30.4%.

ii) Chemical properties (see Table 7-1-6, 7-1-7 and Fig. 7-1-12).

a) Total Moisture

Banko coal contains T.M. of 28-38%.

T.M. content becomes higher from north to the southward in the Banko area.

It becomes even higher in the upper coal seam groups, such as the Jelawatan and Enim coal seams.

b) Volatile Matter (dry base)

Banko coal contains V.M. of 42-48%, which varies little within the Banko area.

However, it slightly declines in the lower coal seams.

c) Ash (dry base)

Ash content ranges from 4 to 16%, with 6-8% most popularly found.

However, in the West Central and Central Banko areas, where carbonous and silty interburden layer develop well, ash content is expected to be higher than that in North West Banko due to mixture of the interburden layer.

d) Total Sulfur (dry base)

T.S. ranges from 0.2 to 1.8% and stands as low as less than 0.5% in the majority cases.

e) Na_2O (see Table 7-1-8)

Brown coal throughout the Banko area features its high Na content and contains Na_2O of more than 0.6% within coal.

In the weathering zone up to 20-40m in depth from the ground surface, Na is washed out by surface water and turns to be lower.

However, it is reported that Na tends to resume condensing in the lower part of the weathering zone.

Table 7-1-9 shows average quality of raw coal available in the North West Banko area on a dry base.

The data represent numeric values presented as preconditions by Shell in April 1983, when Shell reviewed a plan for the development of the North West Banko area and utilization of coal in the area.

As shown in Table 7-1-9, North West Banko coal contains 6.7% ash, where Na_2O in ash is range of 4-40% in the weathering zone and 12% on the average below 40m in depth.

Table 7-1-2 Classification of Reserve Blocks by Shell (1979)

Block	Descriptions	
A (N.W. Banko)	Northern limit:	The east-west fault (with displacement of 20 m). In the north of the fault, dip of coal seams exceeds 15°.
	Southern limit:	The NE-SW fault (estimated), located immediately next to the northern side of Borehole 3540.
	West side:	Up to the depth of 100 m within the P_2 seam.
	East side:	The outcrop of the P_2 seam (partly including a fault).
B (West Central Banko)	Northern limit:	The boundary with the A-block and the NE-SW fault. The outcrop of the P_2 seam.
	Southern limit:	West Banko - up to the depth of 100 m from the P_2 seam. Central Banko - the outcrop of the P_2 seam.
	East side:	Up to the depth of 100 m from the P_2 seam.
	West side:	The major fault.
C (Central Banko)	North side:	The outcrop of the P_2 seam.
	South side:	The outcrop of the P_2 seam.
	East side:	River Air Lingi - a distance of 100 m is taken into account between the top of highwall and the river.
	West side:	The major fault.

Table 7-1-3 Criteria Taken by Shell for Calculation of Coal Reserves

Item	Criteria	Remarks
Dip of coal seams	Less than 15°	Steeper dip than 15° is only in the northernmost part of N.W. Banko.
Outcrop	Strike of outcrop was estimated by outcrops and analyses on geologic structure.	As far as N.W. Banko is concerned, most part of the strike of outcrop was determined based on such factors as pits and shallow boring.
Major faults	In general, displacement exceeding 40 m is regarded as faults.	
Depth	Up to 100 m	
Major topographic features	Only River Air Lingi is taken into consideration	Because it is difficult to change the route of the river, coal reserves available in the area were excluded from the calculation.
Slope stability angle of high-walls of pits at the final stage	20°	In the geotechnical report a 16° slope was recommended.
Thickness of coal seams	More than 2 m at minimum.	Coal reserves measuring less than 2 m in thickness is negligible amount.
Chemical quality of brown coal	Ash content of less than 15% (dry base)	
Strip ratio	Less than 3 m^3/total	In bank
Weathering	Weathering loss of 5%	Estimated
Specific gravity	Block A 1.28 Block B 1.27 Block C 1.26	In bank

Table 7-1-4 Coal Reserves in Banko Area

Block	Coal Seam	Reserves (10^6 tons)	Strip Ratio m^3/t	Chemical Compsition (dry base %)			Carolific value (dry base) kcal/kg
				Ash	VM	T.S	
A	M	21.5	2	4-15	41.5-48	0.15-0.8	6.250 7.000
	S	52		4-13	51.5-47.5	0.2 -1.7	6.350 7.000
	P	56		5-14	41.5-48	0.3 -1.6	6.400 7.100
	Sub total	129.5					
B	M	3	1.5	5-13	43 -48	0.2 -0.8	6.200 6.850
	S	77		4-10	43 -47.5	0.2 -0.85	6.450 6.950
	P			6-16	40.5-47.5	0.3 -24	6.200 6.500
	Sub total	178.5					
C	M	-	2.5	-	-	-	-
	S	51		5-11	42 -48.5	0.2 -1.3	6.300 6.800
	P	76.5		6-16	40.5-46	0.3 -1.6	6.100 6.800
	Sub total	127.5					
	Total	435.5					

Table 7-1-5 Mineable Resources in the N.W. Bankoo (By Shell, April, 1983)

Mining Conditions / Cool Reserves and Strip Ratio	highwall/end wall slopes	
	15°	20°
Total coal available for mining (X10^6 tonnes) Strip Ratio (m^3/t)	126 2.82:1	124 2.67:1
Mineable Coal (X10^6 tonnes) Strip Ratio (m^3/t)	106 2.78:1	105 2.61:1

Table 7-1-6 Coal Quality of Each Coal Seam (Dry Basis)

SEAM COMPLEX	ASH (%)			VOL. MATTER (%)			GCV. (kcal/kg)			TOTAL SULPHUR (%)		
	Max.	Min.	Av.	Max.	Min.	Av.	Max.	Min.	Av.	Max.	Min.	Av.
Mangus 1	12.4	6.4	8.2	48.4	42.0	45.6	6785	6287	6647	0.79	0.34	0.57
Mangus 2	8.3	3.6	5.0	48.2	44.3	46.2	7056	6639	6910	0.33	0.15	0.23
Suban 1	9.0	3.9	5.9	47.4	43.8	45.9	6989	6853	6863	0.47	0.20	0.27
Suban 2	8.4	4.5	6.5	47.4	41.9	44.6	7009	6561	6836	1.72	0.62	1.09
Petai	15.7	5.6	8.0	45.8	41.9	44.5	6994	6247	6816	1.79	0.40	0.97

Table 7-1-7 Analytic Values of Coal Samples from Banko by Shell

Sampling Site (sampling time)	Coal Seam (m)	MOISTURE (I.M.) A・D	MOISTURE (T.M.) A・R	Proximate Analytic Values (dry %) ASH	V.M.	F.C.	Sulphur	CV Kcal/kg	H.G.I	Ash Fusion Temps (Reducing) I・D	H・T	P・T	Ash Analysis (%) SiO_2	Al_2O_3	Fe_2O_3	MgO	CaO	Na_2O	K_2O	SO_3	P_2O_5	Remarks
Shell Pit -BO 002 (1976)	Enim Seam Thickness* (11.4)	624 / 1804	322 / 3500	31 / 62	4810 / 51.23	4462 / 4816	0.12 / 0.21	6760 / 6950	61.2 / 72.6	1,130 / 1,240	1,180 / 1,305	1,230 / 1,330	18.4 / 25.0	24.1 / 26.9	8.4 / 10.2	2.8 / 3.2	11.6 / 20.7	2.6 / 2.8	0.4	7.6 / 15.5	0.03 / 0.6	Shell Report (Nov 1976)
Shell Pit -028 (1976)	Suban-1 Seam Thickness* (5.15)	14.98 / 2.61	33.7 / 35.8	5.13 / 5.6	45.70 / 47.8	46.6 / 49.17	0.12 / 0.26	6790	62.0 / 81.4	1,210 / 1,380	1,360 / 1,450	1,390 / 1,510	29.3 / 38.0	30.4 / 31.7	3.74 / 4.7	4.38 / 4.5	14.7 / 15.1	0.24 / 0.3	0.12	4.95 / 10.5	1.14	〃
Shell Pit -BO 090 (1976)	Mangus-2 Seam Thickness* (5.0)	9.94 / 15.78	37.5 / 39.4	4.8 / 5.17	44.4 / 48.6	46.6 / 48.64	0.22 / 0.25	6820	55.87 / 83.7	1,130 / 1,220	1,160 / 1,240	1,240 / 1,265	27.6 / 29.8	17.28 / 24.0	1.83 / 5.47	4.83 / 5.66	16.7 / 20.2	2.43 / 2.59	0.40 / 0.52	8.65 / 9.18	0.92 / 1.27	〃
	Claystone Band	14.3	–	24.9	45.5	29.6	–	–	–	+1400	+1400	+1400	51.8	38.0	0.81	.096	3.16	1.00	0.44	1.00	0.12	
N. W. Banko No.2,3 Pit Central Banko No.1 Pit (1977)	N. W. Banko No.2 Suban-2 No.3 Suban-1 No.1 Mangus-2	13.0	31.1	4.6	40.4		0.25	5985 (gross)	59	+1400	+1400	+1400	51.9	35.6	3.55	0.33	1.68	0.38	0.30	0.26	0.79	Short Report on APMC Trial
N. W. Banko (1980 7)	NA			4.95	34.34	38.48	0.22	5156		1295 ~ 1315												Directorate General of Mines Analysis

*Thickness of the coal seam subject to sampling

Sample Pit No.	Total H_2O	C	H*	N	O*	Cl	S	Al	Ba	Ca	Fe	Mg	Na	Si	Σ	Remarks
002	35.43	(68.49) 44.81	((5.05)) 3.33	(0.73) 0.48	(23.44) 15.33	0.02	(0.21) 0.14	0.31	0.01	0.42	0.22	0.05	0.05	0.23	100.83	Figures in parentheses are dry base excluding H and O, which are non-water base.
028	34.5	(66.23) 42.12	((6.17)) 3.51	(0.95) 0.62	(23.75) 15.88	0.01	(0.23) 0.13	0.63	0.01	0.45	0.13	0.11	0.01	0.53	100.01	
090	29.23	(65.69) 40.63	((5.18)) 3.21	(1.11) 0.68	(25.55) 15.80	0.01	(0.19) 0.12	0.36	0.01	0.11	0.11	0.33	0.05	0.39	101.08	
Shipped to Rawang	31.1	62.7 (ad)	4.6 (ad)	1.2 (ad)												Data provided by the Indonesian Government

Table 7-1-8 Relation between Ash Content and Na_2O

%

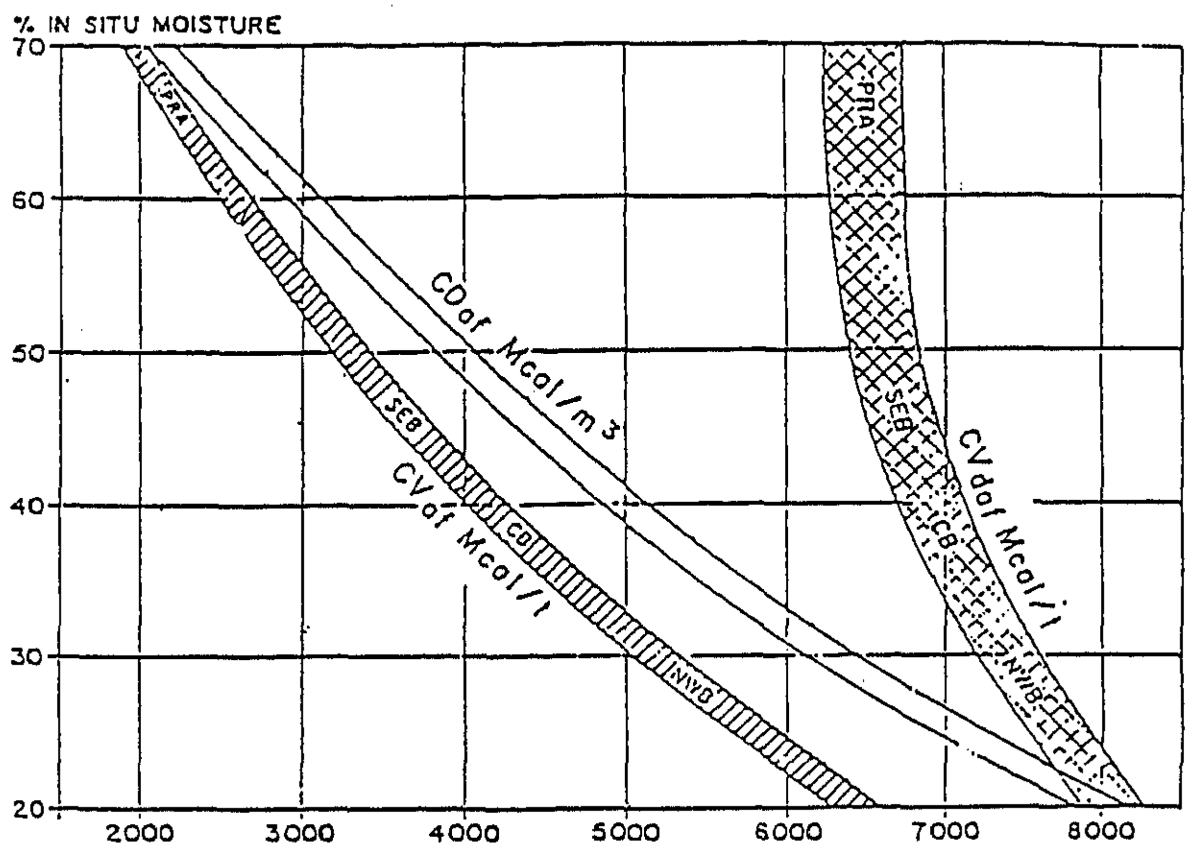
Ash content of Brown Coal	Sodium oxide units	Sodium oxide in ash
2.0	0.81	39.6
5.0	0.77	15.4
8.0	0.74	9.3
12.0	0.71	5.9
20.0	0.65	3.3
50.0	0.40	0.8

Table 7-1-9 Proximate Percentage Analysis of NW. Banko Coal

(Average coal, dry base)

Ash (%)	6.7	
Volatile Matter (%)	45.4	
Gross C.V. (Kcal/kg)	6820	
Total Sulphur (%)	0.59	
In-situ Moisture (%)	25-35	(Range)
Sodium Oxide in Ash (%)	4-40	(Range)
" " below 40 m (%)	12	(Average)

Fig 7-1-9. Relations between in Situ Moisture and Specific Energy



(3) Mining Condition and Method by Shell

1) Mining conditions of North West Banko area

i) Mining depth

Minable coal reserves were calculated based on pit base down to 100m below surface, but limited for pit base around 40m above mean sealevel.

ii) Highwall angle

20°

iii) Mineable Coal and Overburden

Seam	Average thickness (m)	Coal "In-situ" ($x10^6$t)
M1	8.1	23.17
M2	8.6	28.02
S1	10.2	38.52
S2	3.8	14.90
P(1+2)	9.8	18.38
Sub-total		123.04
Grand total		104.6

(discounted by 15%, assuming weathering loss 5% and geological loss 10%)

Overburden in bank (m^3)	273.1
Strip ratio (m^3/t)	2.61:1

2) Selection of the mining method

The following four mining method were studied

- Draglines
- Stripping shovels
- Bucket wheel excavators
- Shovels and trucks

The shovels and trucks combination, a well proven method of surface mining, is proposed as the best mining method for the use in the North West Banko area on account of the following advantages:-

Flexibility - With a number of units employed, equipment applications will be diverse and ensure continuity of production.

Selectivity - Proper selections of equipment, enables that the coal seams and interburden layers are mined selectively, thus reducing mining losses and dilution.

Financial Considerations - It is characteristically a low capital/high operating cost operation.

3) Selection of the mining system

i) Excavator options

- Front-end loaders
- Hydraulic shovels
- Rope shovels

Rope shovels have been selected on account of their reliability, proven productivity and the availability of spares worldwide. However, the machines have two basic disadvantages:-

a) The crowd/hoist action of shovel dipper makes it difficult to follow the contours of steeply dipping beds, thereby,
   - Increasing the extraneous dirt in coal.
   - Possibly undercutting dipping beds and inducing slope failure.

b) Dippers are not designed to handle clay-rich materials.

However these difficulties, overcome at Bukit Asam, can also be eliminated in North West Banko.

ii) Transportation

- Belt conveyors
- Trucks

Belt conveyors probably offer the lowest system available in the long term to move large quantities of materials, regardless coal or wastes.

iii) Proposed combination of equipment

Various types of equipment with the most outstanding features could be combined to establish an optional mining system for use in North West Banko. A good example of such a system would be a combination of shovels and trucks with belt conveyors for long-distance transportation of materials.

7-2 Site Reconnaissance and Chip Sampling

(1) Topographic and Geographic Conditions

1) Topographic conditions

i) The Banko and Suban Jeriji areas, as a whole, are hilly and covered with assorted trees and grass.

ii) These areas stand at around 40-100m above sea level.

iii) The area, aparsely populated, contains a limited number of houses, around which small farmlands are cultivated. Small-size rubber plantations are also in operation.

iv) Though available, roads leading to small villages are generally narrow. After heavy raining, they turn to be muddy, disabling jeeps to pass through here and there.

v) Major rivers include the Lengi virtually in the central part of the area and the Niru at the eastern limit, both running from south to north from the southern to northern sides and pouring into the River Enim.

vi) These rivers are spanned with iron-framed or concrete-made bridges, while their tributaries and other smaller rivers are generally spanned with wooden ones, many of which are aged, with some too obsolete to permit jeeps to pass through.

vii) The East Suban Jeriji area contains an air strip for Cessna planes used by Shell in its survey on the area in 1977-78.

2) Geographical conditions

i) Climatic conditions

With a typical tropic climate, the area is hot and features high humidity when raining.

The rainy season starts from October or November, shifted to the dry season in May or June.

According to measurements covering the 1955-75 period, annual rainfall in Tanjung Enim amounted to 3,109mm.

Raining pattern in the rainy season generally shows heavy rain late afternoon, which turns to be dew early morning. With the sky thickly covered with clouds in general, raining can last as long as more than 14 days, followed by 1-3 days without raining. In the dry season clear days continue, though seldom involving evening showers or thunderstorms. Unlike other areas, typhoon is absent in the area. In general, southeastern winds blow in the dry season and northwestern ones in the rainy season. The details of the climate conditions at Tanjung Enim is shown in Table 7-2-1.

ii) Surface condition

Sedmentary rocks of the Mio-pliocene age forming the areas are less solidified, being in the state of sub-soil.

The part near the ground surface, where these rocks are weathered, is covered with resultant weathering zone.

The zone measures some 10-15m in thickness in hill areas and around 5m on the average vicinity of streams.

(2) Outcrops and Chip Sampling

1) Outcrops and chip sampling

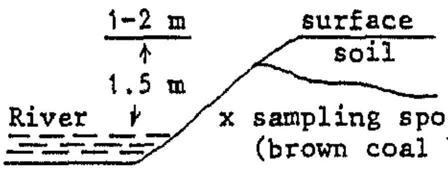
i) Slight amounts of coal samples were taken from some spot near 12 outcrops in the Banko, Suban Jeriji and Baturaja area for the analysis purpose.

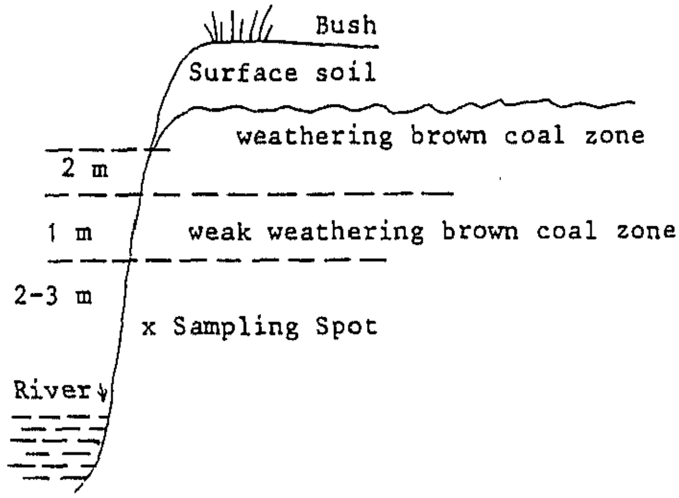
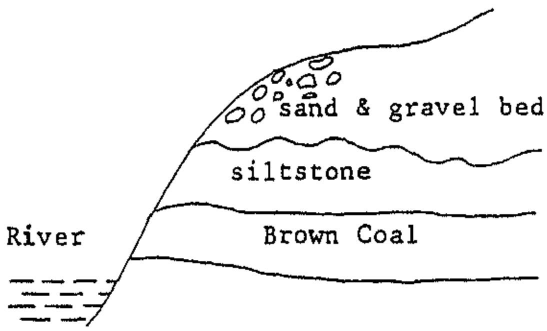
The locations of sampling spots are shown in Fig. 7-1-5, while conditions of sampling spots are illustrated in Table 7-2-2.

Table 7-2-1 Climate Data for Tanjung Enim

		March, '83	August, '84
Monthly average temperature	°c	27.7	27.4
Monthly max. temperature	°c	34.0	33.5
Monthly min. temperature	°c	21.5	20.0
Monthly average relative humidity	%	78.2	72.8
Monthly max. relative humidity	%	99.0	99.0
Monthly min. relative humidity	%	48.0	41.0
Rainfall in one month	mm	432.7	140.7
Max. rainfall in 10 minutes	mm	19.0	10.7
Max. rainfall in 1 hour	mm	56.2	32.2
Max. rainfall in 1 day	mm	78.2	67.4
Average wind velocity	m/s	2.5	2.8
Max. wind velocity	m/s	8.0	8.0

Table 7-2-2 Brown Coal Sampling

Sampling date	Sample No.	Location	Conditions of Sampling Spot
July 19th	1	Enim River Riverside	<u>Enim Seam</u> <u>Brown Coal</u> Coal bed outcrop development of Riverside its extension about 100 m coal bed thickness 3 m dip 5-10°
	2	West Central Banko	<u>Suban Seam</u> <u>Brown Coal</u> Coal bed outcrop 2 x 5 m
	3	Central Banko (shell pit No. 1)	<u>Suban Seam</u> <u>Brown Coal</u> Outcrops spread over an area of about 500 m x 50 m and brown coal seams thickness about 15 m
	4	Central Banko Lengi River Riverside	Suban Seam Brown Coal 
	5	East Suban Jeriji Niru River Riverside	Jelawatan or Enim Seam? Brown Coal outcrop extension 10-20 m coal bed thickness 1-2 m dip 10°S strike N60°W
July 20th	6	Northern part of NW Banko	<u>Suban Seam</u> <u>Brown Coal</u> Coal bed is folding dip 70°W, strike N20°W Coal Seam width 2-3 m
	7	NW Banko Pit No. 15 (Shell pit No. 3)	<u>Suban Seam</u> <u>Brown Coal</u> Subject to test mining are coal seams located about 10-20 m from outcrop. Four clay bands, each measuring a few centimeters in thickness, are developing. Thickness of the Coal Seam is around 8 m from top of outcrop.

July 20th	8	NW Banko Pit No. 14 (Shell pit No. 2)	<u>Suban Seam</u> <u>Brown Coal</u> Coal Seams measuring about 2-3 m in thickness outcrop. The spread is about 50-60 m and the depth is around 5-15 m. Clay band of about 10 cm in developing in the Coal Seam.
	9	Enim River riverside	<u>Enim Seam</u> <u>Brown Coal</u> outcrop extension : about 50 m Coal bed thickness 2-4 m
	10	Southwestern side of South Banko	<u>Hangendes or Enim Seam</u> Brown Coal outcrop extension over 100 m 
	11	West Banko Enim River riverside (near shell No. 0.28 pit)	<u>Suban Seam</u> ? <u>Brown Coal</u> Thin brown coal bed Thickness 1 m or more less 
July 21st	12	Gunung Meraksa village North of Baturaja (about 30 km)	<u>Upper Palembang Coal Seam</u> <u>lignite</u> lignite bed outcrop in the stream. lignite bed thickness 10-30 cm Many lignite bolder in the stream.

* seam name by Mr. Fatah (P.T.B.A.)

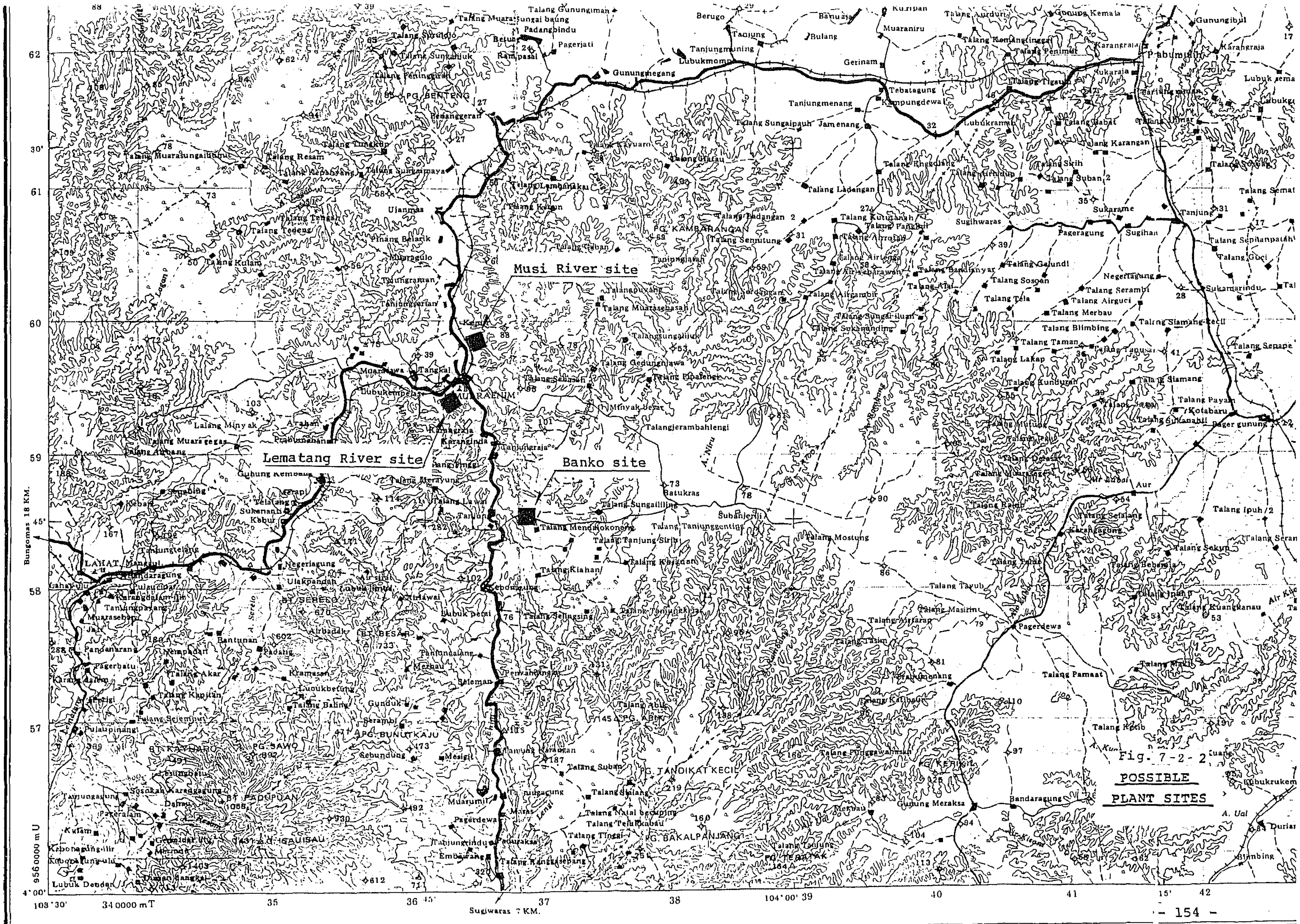


Fig. 7-2-2
POSSIBLE PLANT SITES

Sekala 1 : 250,000

Dicetak oleh Reptak Jantop T.N.I. A.D. th. 1974.

(3) Results of Chip Sample Analysis

1) Coal analysis method

i) General

There are two kinds of coal analysis. One is proximate analysis (Moisture (Mo), Volaite Matter (V.M.), Ash, Fixed Carbon (F.C.)*) and the other is ultimate analysis (Carbon, Hydrogen, Nitrogen, Sulfur and Oxygen*)

The determination of ash components and ash flusion temperature is very important for the coal gasification.

Note * These values are obtained by the calculation.

There are some International Standards (ISO Standards) established for the determination of the coal though some Standards of the chemical analysis are now undergoing to be established.

There are also JIS methods (Japan Industrial Standard). However, these Standard methods are very complicated because they must be stoichiometrical exact. These methods also need very expert chemical analysts and long time for the determination.

Therefore, usual and routine chemical analyses are done by Instrumental methods which are very easy and don't need expert chemical analysts.

Values of chemical components by the Instrumental methods are usually not absolute but relative. The values of the Instrumental methods must be identified by the values of the Standard methods or by using Certified Reference Materials (CRM).

ii) Proximate analysis of coal

The value of Mo is obtained from the decrease of the weight of the coal sample at 107°C in the nitrogen atmosphere, V.M. is also the weight loss at 900°C in the same atmosphere. Ash is the residue after burning the test portion at 815°C in the oxygen stream which reacts with carbon and hydrogen in the test portion.

The conditions of the determination by the Instrumental method are the same as the Standard ones. There is no need to be identified between two methods. The values of three elements are got automatically by the Instrumental method.

iii) Ultimate analysis of coal

a) Chemical analysis of carbon, hydrogen and nitrogen. Standard methods specify the determination of carbon and hydrogen as the weight increase of the soda-asbesto by carbon dioxide and of anhydron by water after burning the test portion in the oxygen stream.
Nitrogen can be obtained by the neutralization precipitation of ammonium derived from nitrogen in the acid solution which the test portion is dissolved in.
Instrumental methods adopt the infrared absorption measurement of carbon dioxide and water after burning the test portion in the oxygen stream. Nitrogen is analyzed in the helium stream after the removal of carbon dioxide, water and oxygen by the thermal conductivity.
These values must be identified by using the values of CRMS.

b) Chemical analysis of sulfur
One of the Standard methods specifies the determination of sulfur as the neutralization precipitation of sulfur dioxide in the peroxide water after burning the test portion in the oxygen stream.
An Instrumental method uses the infrared analysis of sulfur dioxide.

c) Oxygen
Oxygen can be calculated by the following equation:

$$O_2(\%) = 100 - c(\%) + H_2(\%) + S(\%) + N_2(\%)$$

$$+ Ash(\%) \times \frac{100}{100-Mo(\%)}$$

d) Slag analysis

Elements of the slag analyzed are CaO, SiO_2 Al_2O_3, MgO, Na_2O, Fe_2O_3 and S.
The former six elements are analyzed by the Xray fluorescence method. Sulfur is analyzed by the sulfur determinator of the coal previous mentioned. There is no standard method for the determination of the slag. There will be many problems of using the Xray fluorescence method for the determination of the slag elements, if the exact and precise data of the slag are needed. To make the calibration curve for the precise quantitative analysis of the slag is very difficult.
Exact and precise analyzed values are not needed for the slag analysis, because the values of the slag are used for the estimation of the desulfurization ability from the gas. Approximate values are adequate for this purpose.
The Xray fluorescence analyzer is also used for the analysis of the stone and the mineral which exist between coal layers.

2) Results of coal chip sample analysis

i) Analysis results

Coal chip samples taken up from shallow underground of 12 outcrops were 5 kg, respectively.
Such samples were sealed immediately after sampling work and analyzed within about 3 weeks at Coal Mining Research Centre, Japan in accordance with JIS M8811, 8812 and 8813. The results are shown in Table 7-2-3 and. Results of ultimate coal analysis as dry ash free base calculated from Table 7-2-4 are also shown in Table 7-2-5.

Needless to say, it was previously understood that the sampling spots and method were not adaptable for the rigid evaluation of coal quality of the areas.
However, the results of chemical analysis of coal chip samples show obviously the following general tendency.

a) Free moisture is very high, ranging from around 20 to 30%.
b) Among 12 samples, those of North West Banko (No. 7, 8) have the least amount of the free moisture.
c) Samples of river side (No. 4, 5, 10, 11, 12) have relatively high free moisture content.
d) Ash content of Banko coal is generally low, while sample No. 11 and 12 show extremely high ash content.
e) Ash flusion temperature Jelawatan and Enim seams (No. 1, 5, 9, 10) is low, while that of Suban seam (No. 2, 3, 4, 6, 7, 8, 11) shows more than 1500°C.
f) Ashes of Suban seam coals (No. 2, 3, 4, 6, 7, 8, 11) have rather high aluminium oxide and low calcium oxide contents which cause high ash fusion temperature.
g) Sodium oxide content of coal ashes is as same level as of Shell pit 028 shown in Table 7-1-7.
h) Sample No. 11 and 12 taken up from river floor seem to include extraneous dirt, judging from extremely high content of ash in coal and Si_2O in ash.

ii) Comparison with the existing data

a) Comparison with Shell data

Coal quality investigated by Shell is described in Table 7-1-6, especially in details in Table 7-1-7. Table 7-1-7 show the results of analysis carried out at Technish Laboratorium Laura and KSLA in Holland, and contains coal samples from Enim seam and Suban seam, which are same seam with samples of the Team.

Total moisture contents are same level, but volatile matter, carbon and oxygen contents are largely different from each other.

Shell's results show from 46% to 51% of V.M., from 66% to 68% of carbon and from 23% to 26% of oxygen, however results of the Team show from 41% to 44% of V.M., from 71% to 77% of carbon and from 18% to 23% of oxygen except for sample No. 11 & 12.

These data suggest that the weathering of all samples obtained by chip sampling has advanced because of the samples taken from near surface of the outcrops.

b) Evaluation by H/C and O/C

In order to compare the quality of coals in Banko area with others, the relationship between H/C and O/C of each sample is shown in Fig. 7-2-1.

Even though all samples have been weathered as previously pointed, Fig. 7-2-1 shows clearly the relationship of coal quality of each sample.

Samples of Suban coal seam (No. 2, 3, 4, 6, 7 and 8) look to take near positions to sub-bittuminous and samples of Enim seam (No. 1, 5, 9 and 10) near to brown coal while 11 and 12 show to be the typical brown coal even though weathered.

In the meantime, it is unreasonable to evaluate rigid quality of in-situ coals in Banko area as well as to estimate the rigid gas composition of the coal gasification, using the results of chip samples because the samples are weathered.

Therefore, the coal gasification test stage, it is desirable to take up the deep seam coals in order to avoid the effect of weathering and to estimate rigidly the relationship between the in-situ coal quality and the gas composition.

Table 7-2-3 Results of Banko Coal Analysis by the Team

(%)

Item \ Sample		No.1	No.2	No.3	No.4	No.5	No.6	No.7	No.8	No.9	No.10	No.11	No.12
Free Moisture		22.1	24.7	29.2	29.0	38.4	27.9	18.2	21.4	22.7	30.4	27.9	34.3
Total Moisture		32.1	34.7	38.2	38.1	46.4	35.5	28.1	31.8	32.6	40.8	37.1	41.0
Proximate	Moisture	11.4	11.1	11.5	8.5	11.1	8.4	8.9	10.2	9.9	11.9	9.9	7.8
	Ash	3.8	0.7	2.2	1.8	1.3	1.5	0.6	0.6	3.6	5.9	26.2	44.5
	V.M	40.9	41.0	41.8	43.5	43.0	43.7	43.3	42.1	43.2	43.1	33.3	26.9
	F.C	43.9	47.2	44.5	45.2	44.6	46.4	47.2	47.1	43.3	39.1	30.6	20.8
Ultimate	Ash	4.27	0.79	2.43	1.97	1.47	1.60	0.67	0.67	3.99	6.74	29.11	48.21
	C	69.30	74.15	71.03	71.89	70.06	75.64	74.55	74.02	70.09	66.93	47.83	32.73
	H	4.92	5.08	4.96	5.21	4.95	5.37	5.39	5.27	5.25	5.04	3.91	2.62
	N	0.79	1.08	1.15	1.00	1.01	1.19	0.96	1.13	1.18	1.14	0.77	0.53
	O	20.49	18.69	20.23	19.55	22.31	14.91	18.23	17.86	18.94	18.19	17.95	15.46
		0.23	0.24	0.20	0.38	0.20	1.29	0.20	1.05	0.55	1.96	0.43	0.45
GCV (Kcal/Kg)		5,880	6,320	5,950	6,170	5,810	6,010	6,510	6,470	6,190	5,750	4,060	2,850

Table 7-2-4. Composition of Ash by the Team

(%)

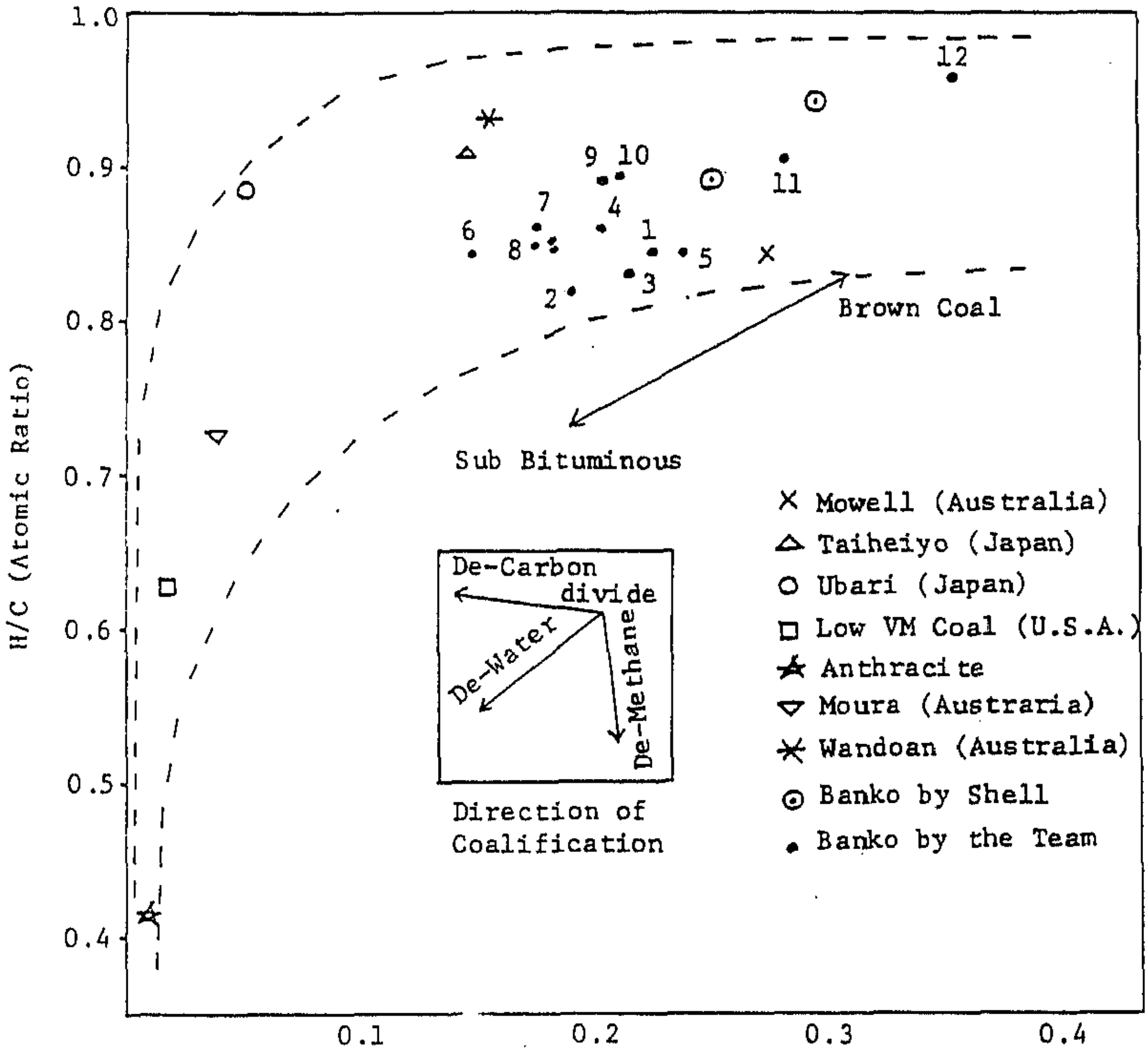
ITEM \ SAMPLE		NO-1	NO-2	NO-3	NO-4	NO-5	NO-6	NO-7	NO-8	NO-9	NO-10	NO-11	NO-12
SiO		32.92	17.06	31.92	11.78	34.66	39.68	12.38	27.5	46.60	3.58	56.27	83.78
Al_2O_3		35.03	56.76	51.07	48.27	6.01	47.96	66.05	40.37	35.18	9.37	32.12	4.93
Fe_2O_3		7.23	8.76	3.11	3.39	15.44	2.87	10.36	11.55	6.19	18.36	5.25	1.92
CaO		13.17	8.14	5.79	16.23	21.17	2.45	5.59	8.88	5.39	28.14	2.27	2.32
MgO		0.95	0.66	0.77	2.09	3.85	0.86	0.57	0.50	1.24	8.14	0.90	0.63
Na_2O		0.24	0.32	0.24	0.32	0.43	0.13	0.25	0.17	0.19	0.22	0.15	0.15
K_2O		0.03	0.27	0.02	0.19	0.33	0.10	0.03	0.16	0.38	0.11	0.32	0.21
SO_3		8.32	3.72	3.32	5.32	16.61	3.07	1.51	8.04	3.92	29.47	1.09	1.45
P_2O_5		0.26	0.08	1.12	11.88	0.11	1.12	0.17	0.35	0.04	0.16	0.05	0.01
TiO_2		0.96	0.73	2.23	0.44	0.30	1.52	1.35	0.30	0.67	0.99	1.05	0.17
V_2O_5													
Total		99.11	96.50	99.59	99.91	98.91	99.76	98.26	97.82	99.80	98.54	99.47	95.57
Ash Fusion	I.D.T	1,305	>1,500	>1,500	1,370	1,150	>1,500	1,300	1,310	1,320	1,320	>1,500	>1,500
	H.T	1,340	>1,500	>1,500	>1,500	1,200	>1,500	>1,500	>1,500	>1,500	1,400	>1,500	>1,500
	F.T	1,355	>1,500	>1,500	>1,500	1,220	>1,500	>1,500	>1,500	>1,500	1,440	>1,500	>1,500

Table 7-2-5 Ultimate Analysis of Banko Coal by the Team

(d.a.f) (%)

	No.1	No.2	No.3	No.4	No.5	No.6	No.7	No.8	No.9	No.10	No.11	No.12
C	72.39	74.74	72.80	73.33	71.11	76.87	75.05	74.52	73.00	71.77	67.47	63.20
H	5.14	5.12	5.08	5.31	5.02	5.46	5.43	5.31	5.47	5.40	5.12	5.06
N	0.83	1.09	1.18	1.02	1.03	1.21	0.97	1.14	1.23	1.22	1.09	1.02
S	0.24	0.21	0.20	0.39	0.20	1.31	0.20	1.06	0.57	2.10	0.61	0.87
O	21.40	18.84	20.73	19.94	22.64	15.15	18.35	17.98	19.73	19.50	25.32	29.85
H/C	0.852	0.822	0.837	0.869	0.847	0.852	0.868	0.855	0.900	0.903	0.911	0.961
O/C	0.222	0.189	0.214	0.204	0.239	0.148	0.183	0.181	0.203	0.240	0.281	0.354

Fig. 7-2-3 Relationship Between Hydrogen-Carbon-Oxygen



(4) Study on Sampling Spots and Method for Coal Gasification Test

1) Desired samples for coal gasification test

i) Desired sampling spots

Considering the purpose of coal gasification test, it is desired to take up samples from around 41 spots throughout the Banko area and Suban Jeriji by block and each coal seam (see Table 7-2-6), though practical sampling spots may be less than those because of difficulty of sampling in view of technical and economic aspects.

ii) Amount of each sample

An amount of each sample for coal gasification test, i.e., from one point and one coal seam, will be at least 200 kilograms.

iii) Quality of samples

Since coal lying in zone not so deep from a surface will be weathered as described in 7-2-2, it is desirable to take up samples in enough depth in order to avoid effect on coal gasification test.

2) Site conditions for coal sampling

i) Surface soil and outcrops

Because the areas are generally covered with lateritic surface soil of at least more than two meters in thickness, it is very difficult to find outcrops of individual coal seam through ground surface surveyes. Therefore, to find reasonable sampling spots so many as shown in Table 7-2-6, introduction of more efficient methods supported by small diameter boring machines will be needed.

ii) Access road

As described in Fig. 7-2-2 roads leading to desired sampling block are not enough developed. Therefore it must be considered that utilizing of a large size of machines is economically difficult in almost of the area.

Table 7-2-6

Desired Sampling Locations for Coal Gasification

Block or Site	Jelawatan	Enim	Mangus		Suban		Petai		Total
			M1	M2	S1	S2	P1	P2	
NW Banko	0	0	T2	T2	T2	T2	T2	T2	T12
W Banko	0	0	T1	T1	T1	T1	T1	T1	T6
W/CL Banko	0	0	T1	0	T1	0	T1	T1	T4
Central Banko	0	0	T1	-	T2	T2	T2	T2	T9
East SJ	T2	T2		0	0	0	0	0	T4
North SJ	T2	T2		0	0	0	0	0	T4
Tanjum Enim	0	T1	0	0	0	0	0	0	T1
	0	T1	0	0	0	0	0	0	T1
	0	T1	0	0	0	0	0	0	T1
Total	T4	T7	T5	T3	T6	T5	T6	T6	T42

iii) Trench sampling

Trench sampling using some small machines is preferable to take up sample of more than 200 kg. However, with trench sampling, samples are taken from coal lying at around 5m in depth from the ground surface at maximum.

3) Further study

i) All things taken into consideration, the following work shall be carried out for selection of sampling spots and method.

a) Coal will be firstly analyzed for an affect of weathering. For this, samples will be taken out by utilizing small diameter core borings down to Petai seam and at least 50m down from a surface for several points.

b) Then other samll diameter auger drillings down to 10 meters from a surface will be carried out for an entire coal prospects at an adequate interval to find out outcrops of each coal seam.

c) Taking the results of 1) and 2) above into consideration, a number of samples and sampling method for each sampling point, i.e., trench or large diameter core boring, as well as locations of sampling points will be selected.

ii) Schedule of the work

The work above shall be carried out well before the coal gasification test.

4) Study on small boring machine

i) Performance of small boring machine

Small boring machine, model number TS-50 available from Tone Boring is discussed here as an example. The TS-50 model, with 55-66mm of boring diameter, is capable of offering drilling up to around 50m in depth and sampling of core of 35-45mm in bore diameter. The boring machine weighs 420 kg including its engine. Even with accessories required for up to around 10m-deep drilling included, its weight totals 600-700 kg. Because the body can be disassembled, it can be moved without requiring special carriers but by a jeep or a truck of the 1 to 2 ton class.

Disassembly and assembly of the boring machine require about an hour, each.

With its designed working speed, the machine is expected to offer two borings a day in the Banko area featuring soft rocks when drilling depth is around 10m.

The machine consumes 2-3ℓ of light oil when operated for 6-7 hours.

ii) Operation

Operation of the boring machine requires only one operator and about three assistants. As for water required for drilling, three to four drums of water is sufficient when drilling length is up to around 10m. This means that the machine does not restrict selection of drilling spots.

(5) Preliminary Study on Plant Site

1) Conditions for the plant site selection

During the selection of the plant site the followings must be taken into a consideration;

i) The site shall be close to the market of products or convenient for transportation of products.

ii) The site shall be close to the raw material sources or convenient for receiving of raw materials.

iii) The site shall be spacious and adequately topographical for plants and equipment layout.

iv) The site shall have good soil conditions and less chance for floodings.

v) The site shall be cheap and easy for land acquisition.

vi) The site shall be easy for obtaining of enough amount and good quality of water.

vii) The site shall be easy for pollution control, especially for wastes disposal.

viii) The site shall have well arranged infrastructures, such as airport, harbour, rail road, road, housing, medical treatment facilities, communication.

ix) The site shall be convenient for heavy equipment transportation.

x) The site shall be easy for obtaining skillfull construction and operation manpower and construction equipment.

2) Possible plant sites

During this study, the following three places have been selected as the possible plant site and visited;

i) Banko site

ii) Lematang River site

iii) Musi River site

Although these places are far from the possible product market, and inconvenient for construction of the plant in view of transportation of equipment and obtaining manpower and construction equipment, they have an advantage that they are close to the brown coal mine, since the transportation of brown coal is very difficult and costly.

These places are indicated on Fig. 7-2-2 and the pictures are shown in Fig. 7-2-3.

For this study the required plant area is assumed as follows;

- Coal crushing and drying plant including coal stock yard (one week)	150,000 m^2
- Coal gasification plant	100,000 m^2
- Derivatives plant (three plants)	200,000 m^2
- Power plant (300 MW)	100,000 m^2
- Offsites, offices, workshop, etc.	300,000 m^2
Total	850,000 m^2

Housing complex and solid wastes dumping area are not included in.

The brief discussion of these places are as follows;

i) Banko site

The possible plant site is located at the north of North West Banko. Coal will be transported by belt conveyors, of which length will be 5km to 15km, from N.W. Banko and Central Banko, respectively. The place is rather flat and high from Enim River (the altitide is 8 to 110 meters from the sea level), and spacious. A number of inhabitants is rather limited. The soil bearing force in this place seems to be rather high. The wastes will be disposed to the east of the site.

ii) Lematang River site

The Place is located at the north of PTBA concession. A distance from N.W. Banko and C. Banko is 15 to 20 kilometers, respectively. The place is flat but not so high from Lematang River. Although a number of inhabitants is limited, there are rice fields and farms. The soil bearing force seems to be low.

iii) Musi River site

The place is located at 2 kilometers east of the junction of Enim River and Lematang River. However, since it is 40 to 50 kilometer far from the coal mine, coal will be required to transport by a rail road. This is subject to further study. Also the space in this place is limited and there are farms and other facilities, such as schools. So the opposite site of Lematang River or the opposite side of the rail road would be required to study. An advantage of this place is a higher discharge rate of Lematang River than of Enim River.

The summary is shown on Table 7-2-7.

As one of common concerns for these three places, availability of water can be pointed out.

Discharge rate of Enim River during a dry season is 22.5 ton per second at Dusun Lingga, as shown in Fig. 7-2-4. There is no datum for Lematang River, although the discharge rate of

it is higher than of Enim River.
Although a required amount of cooling water and plant water has not established, one-through cooling water system cannot be apparently used and cooling tower must be installed.
Moreover, depending on a capacity of power plant to be selected, Banko site should be abandoned, or a capacity of power plant should be limited due to a shortage of make-up water, even if cooling tower is to be installed.
A road from Palembang to these places is not so good for transportation of heavy equipment. In case of the expansion project of PTBA, 30 tons is a maximum weight for inland transportation.
Considering of a nature of gasification, methanol and power plant equipment, an extent of knock-down and field assembly of equipment is rather limited and a drastic improvement of the road would be required.
The selection of the plant site shall be performed at the final stage of the study, since the plant configuration and capacities have not yet established. However, at this moment, Banko site seems to be superior to others.

3) Further study

i) Water resources

For a construction of the plant in Banko area or Lematang, an availability of cooling water will be critical. Therefore water resource study shall be additionally carried out during the study, such as measurement of discharge for Enim River and Lematang River, availability of ground water, possibility of a water reservoir.

ii) Maps and soil data

There is only 1:100,000 map for Lematang River site and Musi River site. For Banko site 1:25,000 map is in the hand. However, this is illegible. So, for further study a preparation of maps, of which scale is 1:10,000, will be necessary for these three places. Also some test borings will be required to obtain soil data.

Table 7-2-7 Comparison of Possible Plant Sites

PLANT SITE / CONDITION	Banko site	Lematang River Site	Masi River Site
Product delivery	Poor	Poor	Poor
Raw material receiving	Excellent	Good	Average
Space and topography	Good	Average	Average
Soil condition	Unknown	Unknown	Unknown
Water availability	Poor	Poor	Average
Infrastructure availability	Poor	Poor	Poor
Construction easiness	Poor	Poor	Poor
Total rank	A	C	B

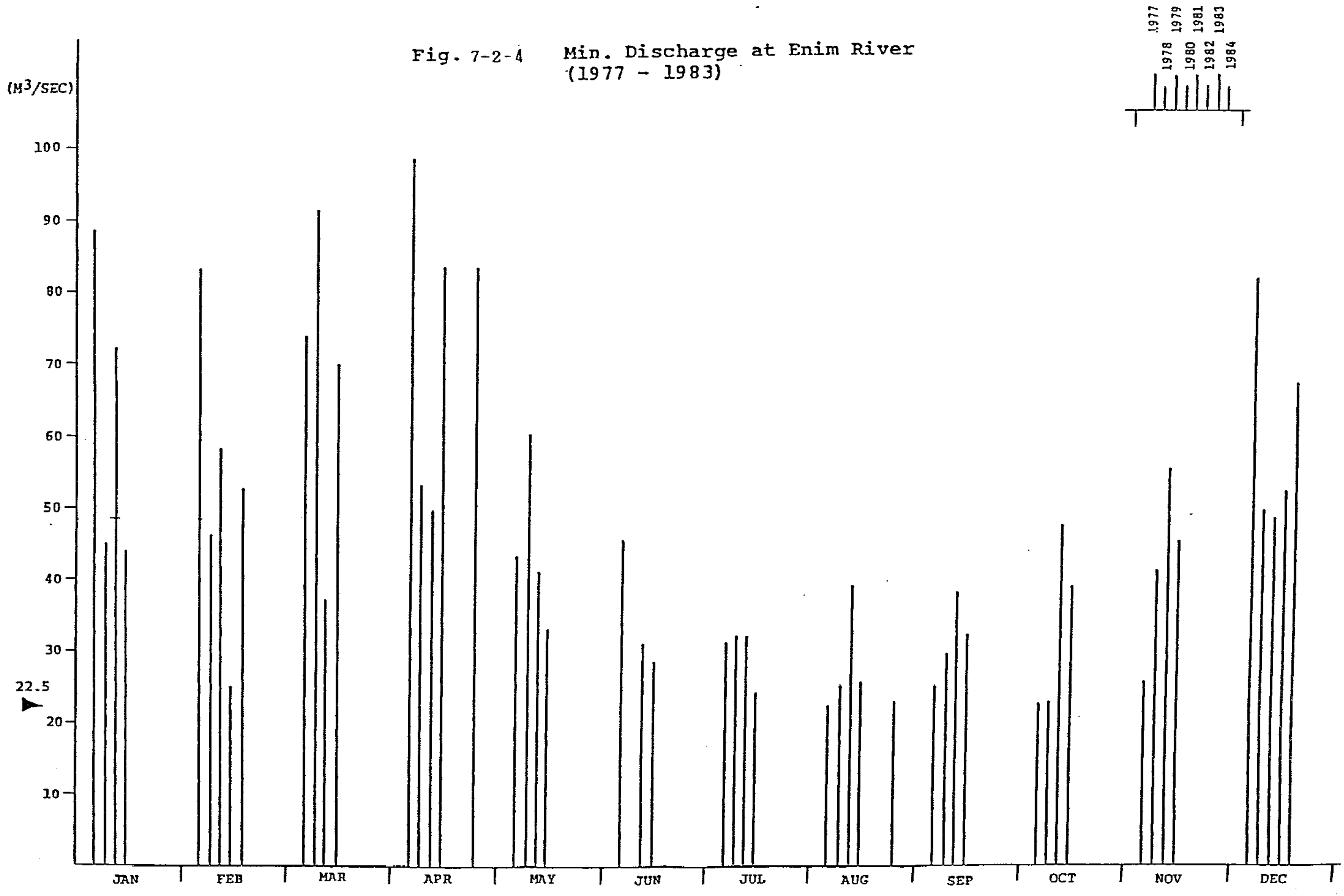
Fig. 7-2-3 Pictures for Possibile Plant Sites

Banko site

Lematang River site

Musi River site

Fig. 7-2-4 Min. Discharge at Enim River (1977 - 1983)



7-3 Preliminary Estimation of Coal Mining Cost

(1) Mining condition

i) Selection of coal prospect for preliminary cost estimation

North West Banko (Block A) is selected for preliminary cost estimation by the following reasons.

- i) Among coal prospects in South Sumatra, the Banko area is one of the most potential, because of its coal reserves, location next to the Bukit Asam mine already in operation and favourable topographic conditions permitting easier development.
- ii) The North West (Block A) Banko is superior to other blocks as follows:
  - a) Minable researves in the area is evaluated enough to open up a mine.
  - b) Coal seams developing in N.W. Banko show more moderate dipping and are accompanied by fewer faults, thus demonstrating the most stable geological conditions.
  - c) N.W. Banko shows lower total moisture.
- iii) Detailed exploration data are available for the study.

2) Geological conditions of N.W. Banko, Block-A

The proposed layout of mining area and spoil drump area is shown on Fig. 7-3-1.

Fig. 7-3-2 illustrates the cross section of mining area, including coal seam, overburden materials, highwall and pit base.

- i) Strike N - S
- ii) Dip 10 - 15°
- iii) Mining Area

  Northern Boundary: 20m fault and north of this line dips steepen to > 15°C

  Southern Boundary: artificial along a fault trending NE-8W just north of borehole 3540.

Fig 7-3-1 Location of Mining Area

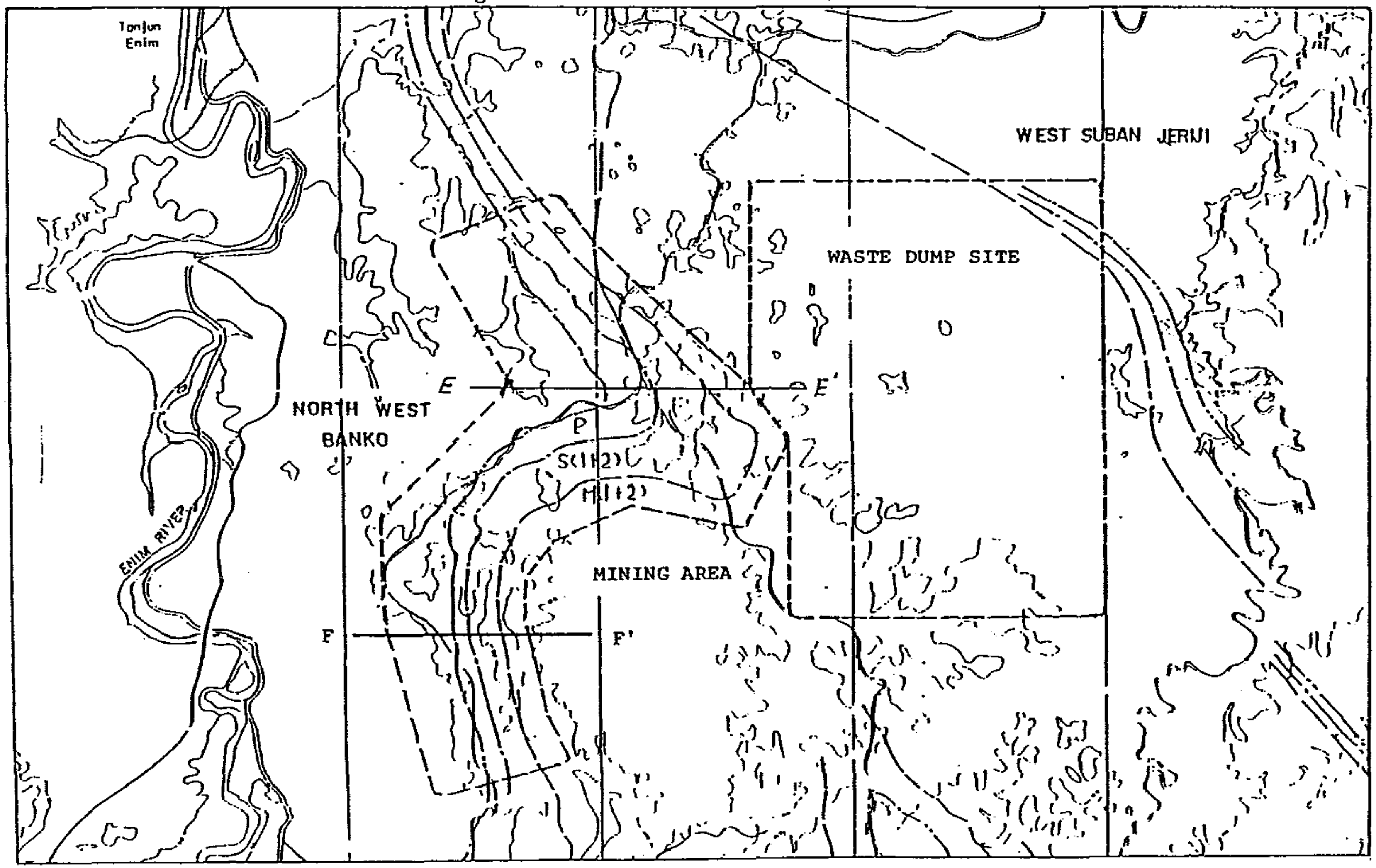
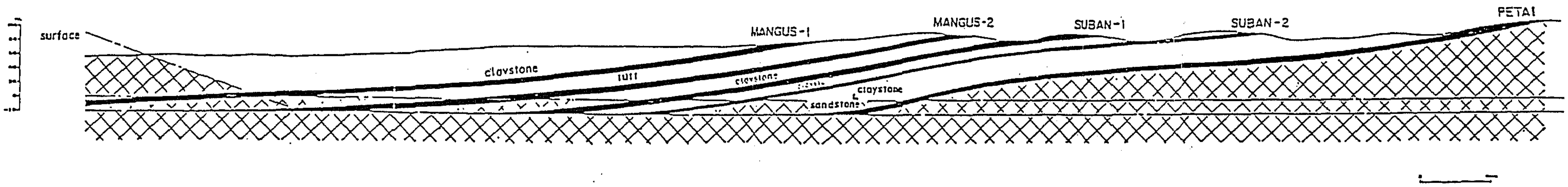
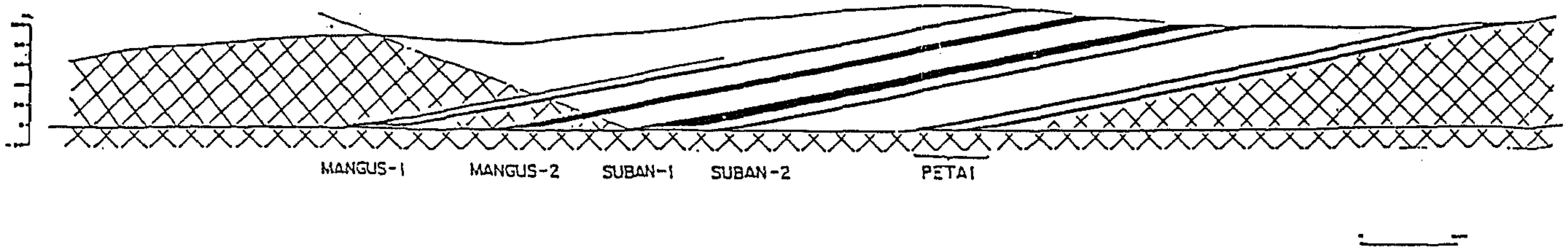


Fig 7-3-2 SECTION MAP OF MINING AREA

E-E'



F-F'



Eastern Boundary: outcrop of base of Petai (P_2) except in the nose of the Banko Syncline where it is fault bounded.

Western Boundary: 100m depth to base P_2.

a) Strikeside length about 8 km

b) Width on the average 520 m

iv) Thickness of coal seams and overburden materials.

	Interburden	Thickness (average) (m)	Seam	Quality	Thickness (average) (m)
MO	major Siltstone	41.7			
			M1	brown coal	8.1
MP	major Claystone	13.6			
			M2	"	8.6
SO	"	10.6			
			S1	"	10.2
SP	"	6.7			
			S2	"	3.8
PO	" somethimes Sandstone	26.3			
			P(1+2)	"	9.8
PU	Claystone				

v) Mining depth

Maximum depth of mining : 100m

Minable coal reserves was calculated based on pit base from 100m below surface, but limited for pit base around 40m above mean sealevel because floor level of Enim River is around 40m above sealevel.

vi) Properties of overburden materials

In regard to overburden materials, samples taken from a production pit of Bt. Asam Mine near the Banko area show following;

a) Overburden rock samples

Sample No.	Pit	Type of rock	Interburden
1	Muara Tiga	Upper rock of A1-seam	Claystone (blue clay)
2	〃	Base rock of A1-seam	Tuff
3	〃	Base rock of A1-seam	Claystone (blue clay)
4	〃	Base rock of A1-seam	Claystone (blue clay)
5	Air Laya	Base rock of A1-seam	Tuff