THE INTERIM REPORT
FOR
THE FEASIBILITY STUDY
ON
EFFECTIVE UTILIZATION OF BANKO COAL
IN
THE REPUBLIC OF INDONESIA

— STAGE II —

March, 1988

JAPAN INTERNATIONAL COOPERATION AGENCY

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ATTACHMENT (Separate Volume)

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1. INTRODUCTION

In response to the request of the government of the Republic of Indonesia, the Government of Japan decided to conduct the Feasibility Study on Banko Coal Effective Utilization as one of the international cooperation programs for the social and economic development of developing countries.

Japan International Cooperation Agency (JICA), the official agency responsible for the implementation of the technical cooperation programs of the government of Japan, and Agency for the Assessment and Application of Technology (Badan Pengkajian dan Penerapan Teknologi: BPPT) as a counterpart agency concluded the Agreement (Scope of Work) on February 24, 1984.

The Institute of Energy Economics, Japan (IEE, Japan), as the consultant for the implementation of the Study, (Japanese Study Team), is undertaking the Study in close cooperation with the counterpart.

The Study will be carried out in the following three (3) stages:

First stage : Strategic Investigation Stage (1 year)

Second stage : Coal Gasification Test Stage (2.5 years)

Third stage : Feasibility Study Stage (1.5 years)

The strategic investigation stage is to establish a master plan of Banko coal effective utilization and to select optimum technology for the Banko coal gasification test stage.

The coal gasification test stage is to grasp characteristics of gasification of Banko coal and to select coal basin to be studied in the following stage.

The feasibility study stage encompasses analysis and synthesis of collected information and data at the previous stages, investigation of various project plans of Banko coal effective utilization, and preparation of the proposed Project.

2. BACKGROUND OF THE STUDY

During the past decade, the environment of energy problems has greatly changed with the two oil crises as turning points. That is, the oil crises triggered sharp oil price increases followed by worldwide recessions and developments of alternative energy resources, resulting to urge for oil producing countries to cut its crude oil prices as well as the amount of export. These structural changes in oil supply-demand and prices have naturally produced great impacts on national alternative energy development policies throughout the world.

In particular, development plans of synthetic fuel, from coal through gasification and liquefaction, which have brilliantly started after the first oil crisis under the initiative taken by Japan, the United States and West Europe, are recently exposed to a severe trial because of surplus and price down of crude oil.

However, during the past decade, conventional alternative energies, including coal, natural gas and nuclear power, have constantly expanded their shares in primary energy, thus greatly contributing to save the oil consumption.

On the other hand, alternative energy development in developing countries has various aspects different from development plans designed for advanced countries. In other words, alternative energy development is developing countries should not merely pursue introduction of energy sources to substitute for oil but be closely related to their industrialization plans.

This means needs to promote industries, expand employment and improve income levels through energy development. In this point Indonesia is not exceptional.

To maintain exports of oil and natural gas at the maximum possible level, the Indonesia Government has been taking the policies to save domestic consumption of those energy resources and to facilitate the development of alternative energies.

Fig. 2-1 shows crude oil production, domestic demand and export of oil and oil products in Indonesia.

Among national programs, given priorities by the Indonesian Government are to develop alternative energies, to promote the transmigration and to develop industries.

Banko coal available in South Sumatra is the most potential natural resources in view of above mentioned programs, because its estimated reserves are abundant (see Fig. 2-2 and 2-3) and South Sumatra is nominated as one of the most prospective sites for the transmigration from Jawa.

The other hand, Banko coal, classified into brown coal which has low calorific value as fuel and troublesome features so called as spontaneous combustion, denies long-distance transport from both technical and economic aspects.

Therefore the typical utilization as fuel for electric generation or industrial heat source is practically difficult in view of technical and economic aspects.

From technical stand point of view, gasification of Banko coal and production of the derivatives seem to be a potential plan. (see Fig. 2-4)

From these prospective, the Indonesian Government requests to the Japanese Government to conduct a development survey which will be essential for the preparation of the Banko coal development and its utilization plan.

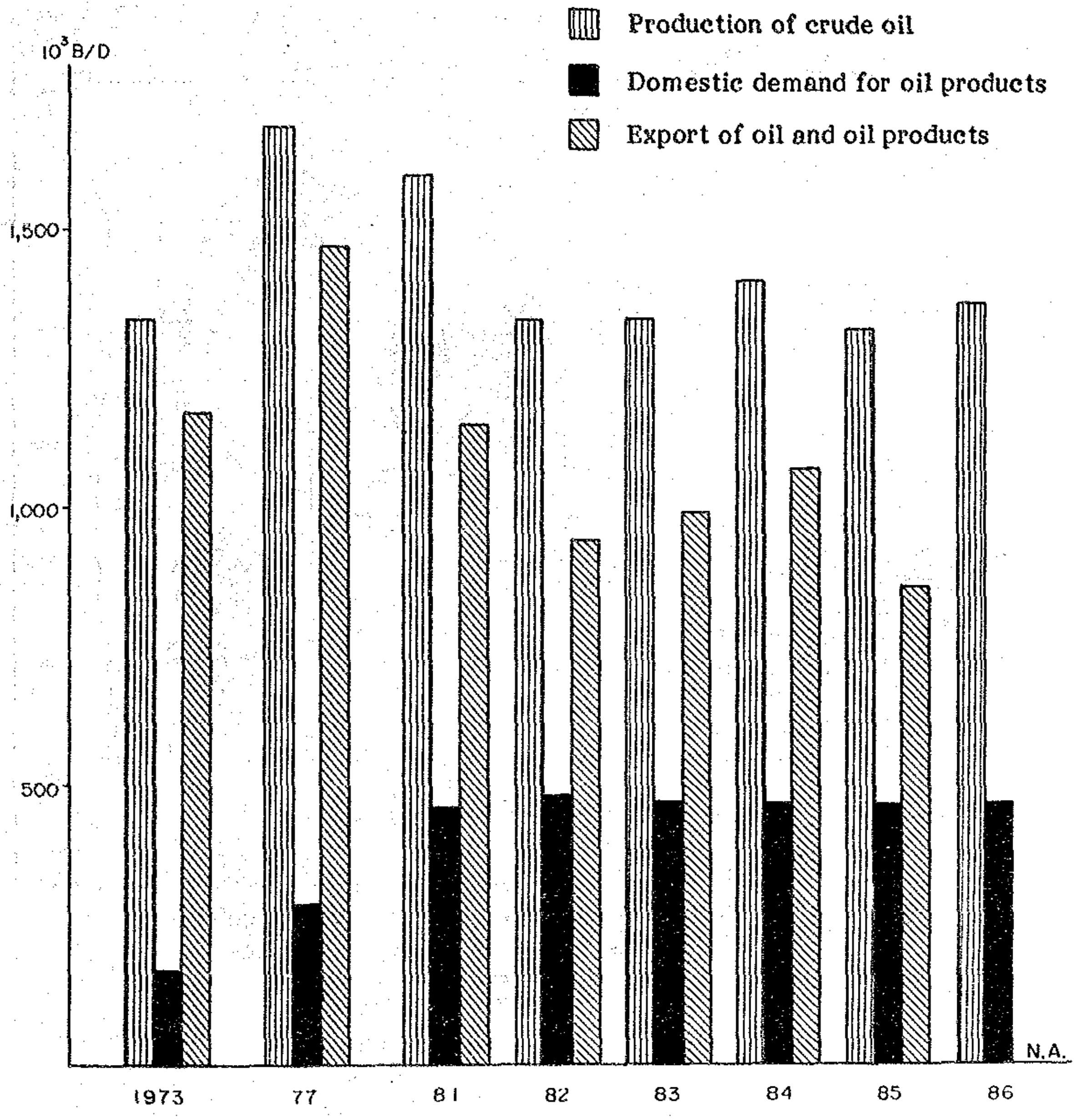
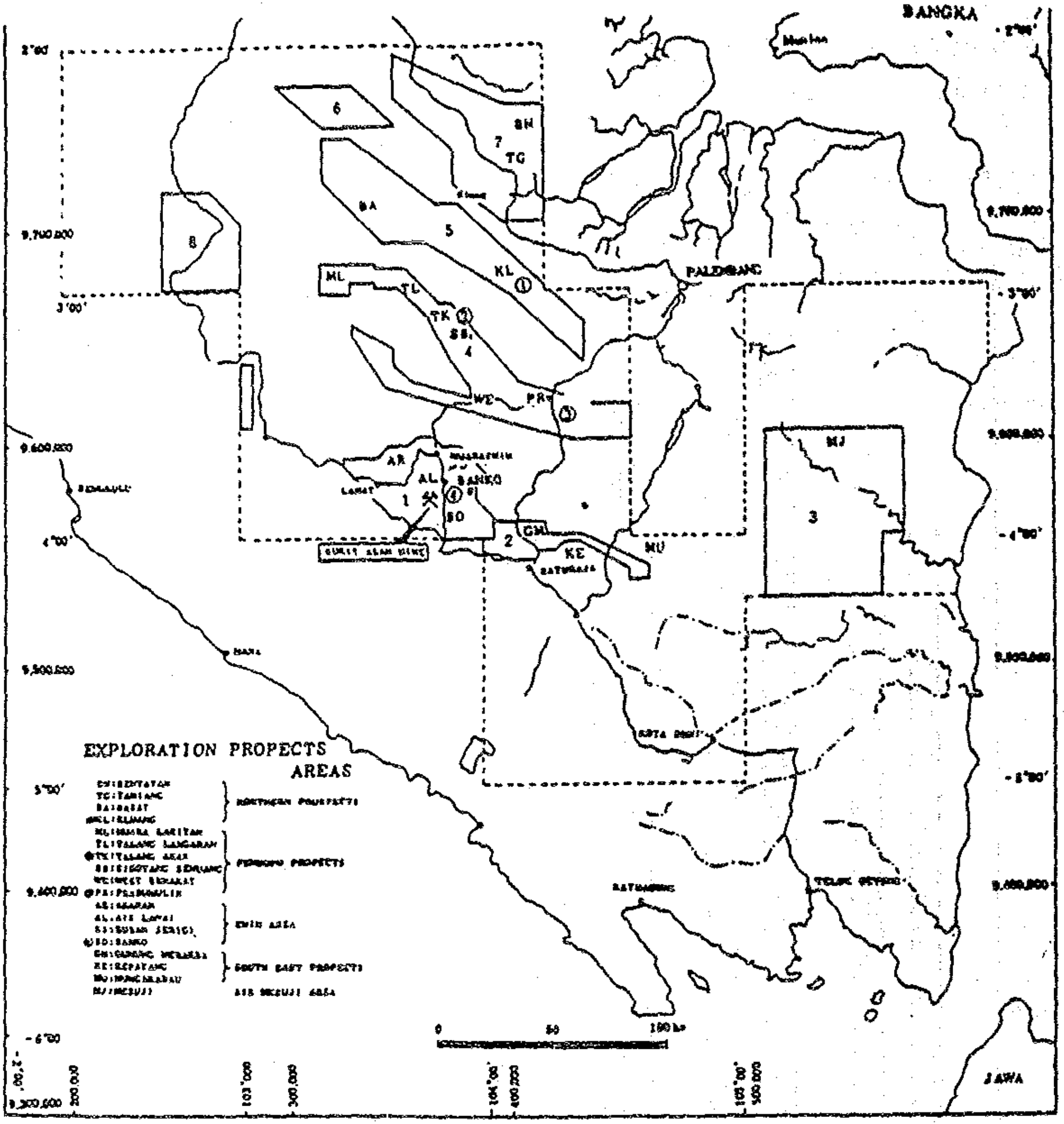


Fig. 2-1 Oil Production, Export and Demand in Indonesia

Fig. 2-2 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, Muncalabau)	150
Mesuji	250
Total :	5,135

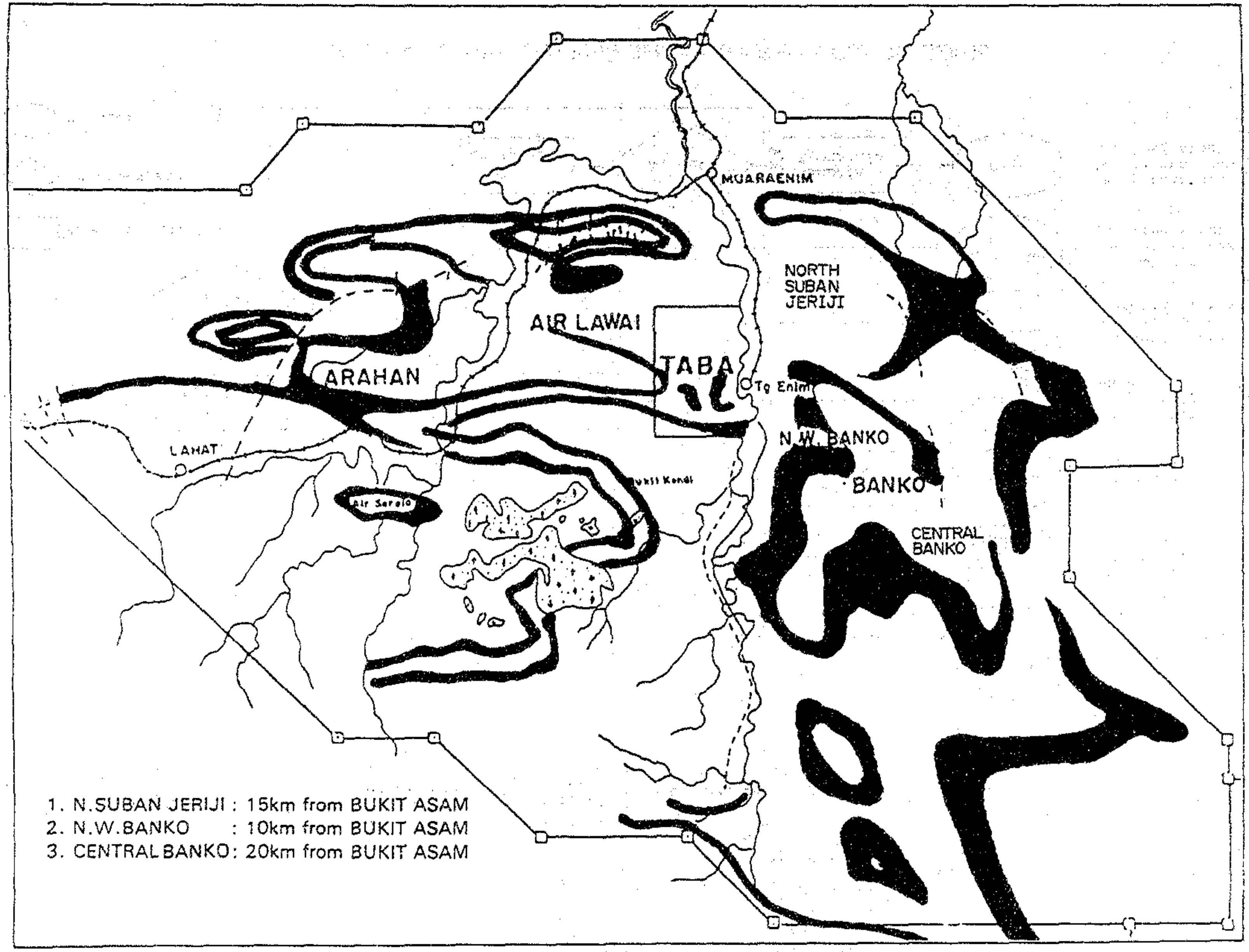


Fig. 2-3 Coal Resources in Western Part of South Sumatora Area

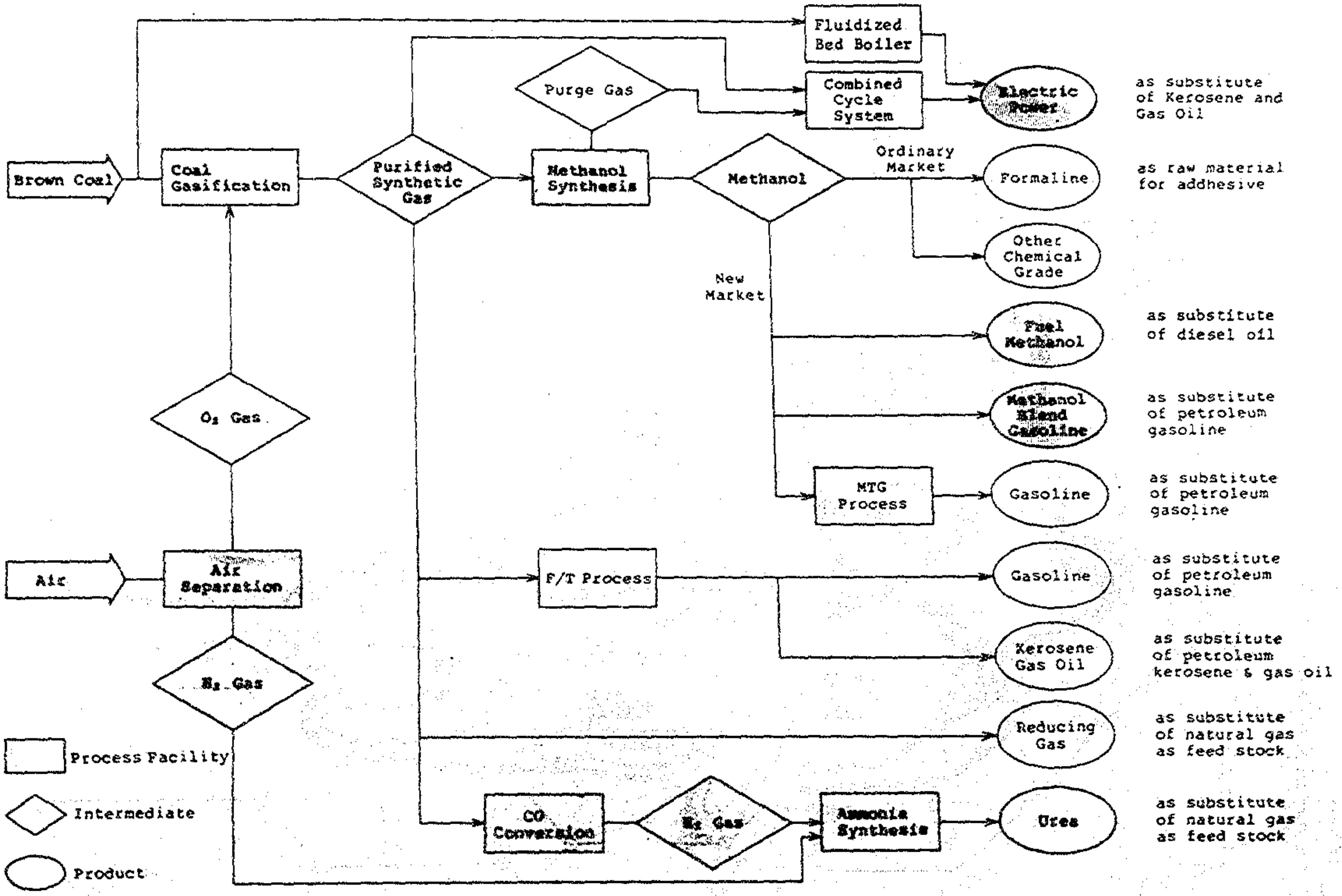


Fig. 2-4 Preliminary Flow Scheme for Brown Coal Utilization

3. HISTORY OF THE AGREEMENT

(1) In November 1981, the Ministry of International Trade and Industry (MITI) dispatched a mission to Indonesia to investigate preliminarily the feasibility of producing methanol from coal.
As a result of this investigation, Japanese Government found a possibility to produce methanol from Banko coal.

(2) In March 1982, Prof. Dr. Ing. B.J. Habibie, the Minister of Research and Technology, made a request to MITI and the Ministry of Foreign Affairs for the implementation of the feasibility study by Japanese experts when Prof. Dr. Habibie visited Japan.

(3) In the 6th Indonesia-Japan Technology Cooperation Conference held in June 1982, Japanese and Indonesian Governments agreed on the implementation of the study in their research and development program.

(4) Following this agreement, in November 1982, JICA dispatched a delegation in order to confirm the policy and implementation plan of the Indonesian Government.

(5) In February 24, 1984, JICA concluded the Agreement with BPPT for the implementation of this study and recorded the details in the Scope of Work.

4. OUTLINE OF THE STUDY

4-1 AGREEMENT

Based on the above mentioned background, BPPT and JICA agreed upon the development survey which is titled as "Effective Utilization of Banko Coal", on 24 February, 1984.

The Agreement sets forth the scope of work in details with regard to the Study.

The contents of the Agreement are as follows:

I. Introduction
II. Objective of the Study
III. Scope of the Study
IV. Schedule of the Study
V. Reports
VI. Undertaking of the Government of the Republic of Indonesia
VII. Undertaking of the Government of Japan
VIII. Technical Undertaking of Both Governments
IX. Consultation

APPENDIX

I. Flow Chart of the Implementation Plan
II. Schedule of the Study
III. Division of Technical Undertaking

4-2 OBJECTIVE OF THE STUDY

The objective of the Study is to establish an appropriate master plan of effective utilization of Banko coal and to examine its technical, economic and financial feasibility, including coal gasification study, and to prepare the reports synthesizing the result of overall investigations and studies.

4-3 SCOPE OF THE STUDY

The Study will be carried out in the following three (3) stages:

1. Strategic Investigation Stage
2. Coal Gasification Test Stage
3. Feasibility Study Stage

The strategic investigation stage is to establish a master plan of Banko coal effective utilization and to select optimum technology for the Banko coal gasification test stage.

The coal gasification test stage is to grasp characteristics of gasification of Banko coal and to select coal basin to be studied in the following stage.

The feasibility study stage encompasses analysis and synthesis of collected information and data at the previous stages, investigation of various project plans to Banko coal effective utilization, and preparation of the proposed Project.

The outline of the Scope of the Study and the consulting procedure for the Scope of Work of each stage are summarized on the flow chart of the implementation plan attached as Fig. 4-1.

4-4 SCHEDULE OF THE STUDY

Total period required for the Study will be about Five (5) years, and is divided into three (3) stages.

Strategic Investigation Stage	:	One (1) year
Coal Gasification Test Stage	:	Two and half (2.5) years
Feasibility Study Stage	:	One and half (1.5) years

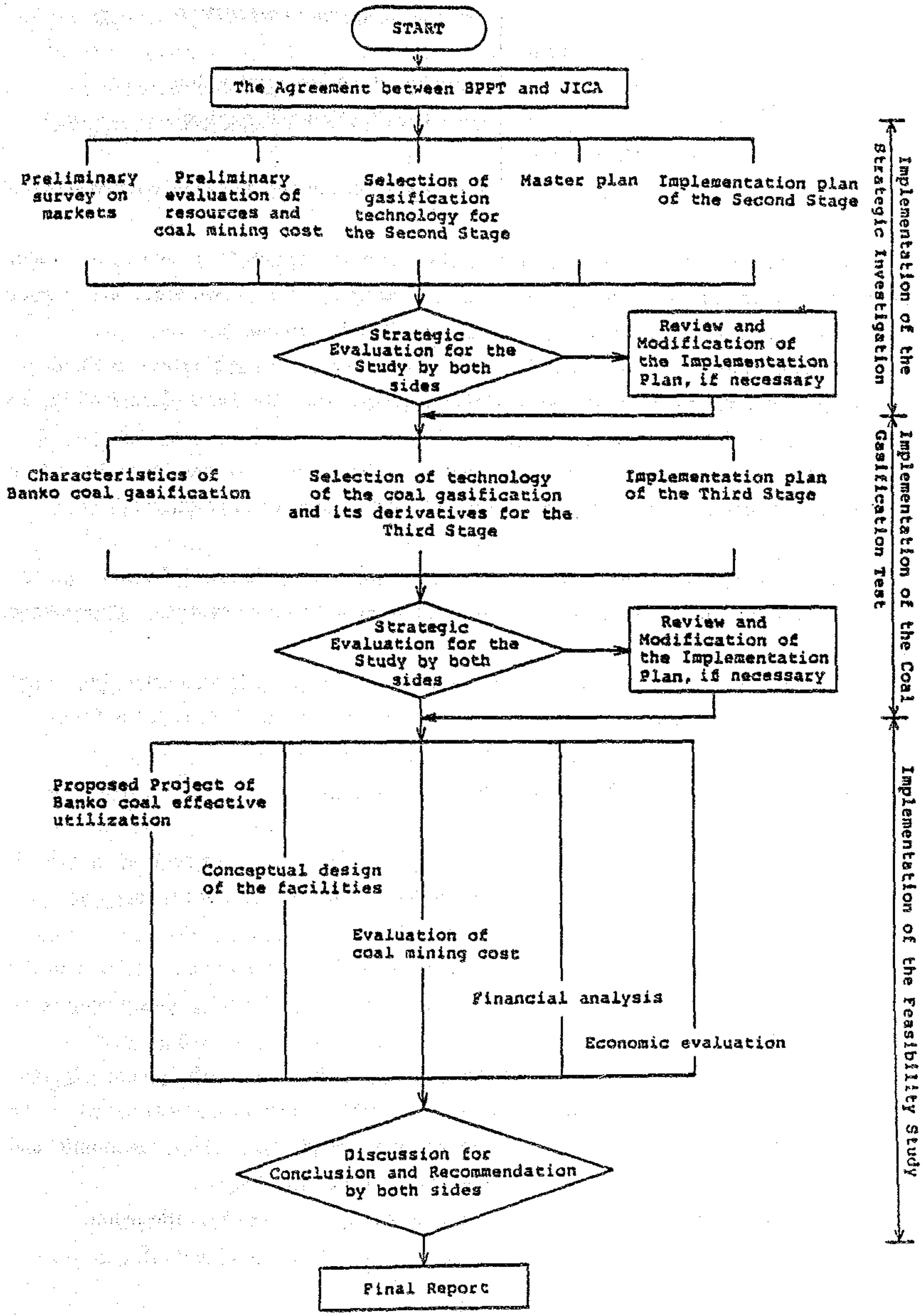
The overall schedule of the Study is detailed in Fig. 4-2.

4-5 STRATEGIC POINTS OF THE STUDY

4-5-1 Coal Gasification Technology

For the Study on Banko coal effective utilization, coal gasification and synthesis process were selected as principle technology as well as direct use as energy.

Fig. 4-1 Flow Chart of Implementation Plan



- Banko coal
  - Direct use
    - Conventional combustion
    - Fluidized bed combustion
  - Conversion
    - Gasification and synthesis
    - Gasification and electricity generation

Coke production and direct liquefaction were excluded from scope of study, because there is no technology for coke production from brown coal and direct liquefaction is still at the beginning stage of technical development.

In particular, the study shall put emphasis on coal gasification technology, including coal gasification test, because it is reported that the type of coal of Banko area has wide variety by area and seam.

Therefore, the coal gasification technology to be selected for the Project must be able to gasify such a wide variety of brown coal without any technical difficulty.

The selection of the coal gasification technology shall also be influenced on the field of utilization of produced gas, either electric generation or synthesis of produced gas.

The reliability of the technology in commercial operation is also other important factor. Such a study mentioned above shall be deeply investigated through the Study.

4-5-2 Market of Derivatives/Energy Policy

As described in the Fig. 2-4 synthetic fuel and basic chemicals such as methanol, gasoline, kerosene, gas oil and urea can be produced by coal gasification and synthesis of produced gas in technical stand point of view.

It is needless to say that the kinds and amount of derivatives to be produced in the Project shall be selected in accordance with the demand in Indonesia, considering some amount of export.

The production costs and prices of the derivatives shall be carefully studied, since the prices of energy and chemicals for the domestic market are estimated to be supported and controlled by the government in a view of the national economic and energy policy and will influence the financial feasibility of the Project.

It is obvious that the demand of products is greatly influenced on the price.

Therefore, the demand and price of the derivatives must be carefully investigated with the highest priority in relation with economic and energy policy of Indonesia.

Required endeavor for the market development of the derivatives shall be also studied in the course of the Study.

4-5-3 Mining Cost and Quality of Coal

Roughly speaking, the production cost of synthetic gas in Japan is shared in 30% for coal, 20% for oxygen, 20% for facilities and 30% for utilities and others.

Therefore the mining cost is one of important factors for economic and financial feasibility of the Project. It is important to investigate the mining cost of coal as feed stock for gasification, considering geological features, coal seam structure, coal quality, infrastructure required and mining system to be employed.

In particular, mining system to be employed shall be studied in relation with transmigration policy and labor cost in Banko area.

Coal quality is another important subject to be investigated because coal quality is one of the key factors for selection of coal gasification technology to be employed in the Project.

4-5-4 Labor Cost/Transmigration Policy

It is estimated that labor cost of the Project has deep relation with trasmigration policy and industrialization plan of Banko area.

In particular, the development of Banko coal resources and the effective utilization are expected to contribute for not only production of a alternative energy and basic chemicals but also promotion of transmigration policy with reasonable working gain for transmigrator.

In view of national economy, working gain at transmigration area are to be evaluated as benefit for the country.

From above mentioned prospects, the estimated labor cost for the Project should be discussed and decided in the course of the Study.

4-5-5 Infrastructure Development Plan of the South Sumatra

The infrastructure and the investment required for the Project shall be studied in relation with development plans of the South Sumatra.

In particular, the development plans related to the expansion project of the BUKIT ASAM shall be studied in details.

Plant site shall be decided considering the development plans, distance from transmigration area and the coal mining field as well as other industrial projects in future.

Required infrastructure shall be designed to contribute to and harmonize with the overall development plan of the South Sumatra.

The undertaking of the Indonesian Government and the Project for the construction of the infrastructure shall be discussed and clarified in the course of the Study.

5. OUTCOME OF THE 1ST STAGE

5-1 OBJECTIVE AND SCOPE OF STUDY

The strategic investigation in FY1984 puts emphasis on establishment of an appropriate master plan of Banko coal effective utilization.

The investigation study includes the following fields.

a) Preliminary market survey of Banko coal and its derivatives
b) Survey on Banko coal resources and preliminary estimation of coal mining cost
c) Survey on coal utilization technology
d) Strategic study for Banko coal effective utilization
e) Basic plan for coal gasification test

5-2 PRELIMINARY SURVEY ON MARKET

The most possible utilization of Banko coal is production of fuel methanol, urea and electricity generation by coal gasification in view of market, technology, economics and Indonesian Government policy.

5-2-1 Fuel Methanol

(1) Methanol as Fuel for Specific Usage

Methanol production from synthesis gas is promising as an alternative fuel to oil and especially there would be very big economic impact by substituting methanol for diesel oil, which has big domestic demand for car and diesel engine power generator.

(2) Methanol for Blended Gasoline

R & D activities in some western countries are active for methanol blended gasoline these days. As a matter of fact, blending methanol with gasoline (about 3% of blending ratio) is being considered also in Indonesia.

5-2-2 Fertilizer

Domestic demand for fertilizer has been growing by as high as 10%/Yr. Though natural gas has been used as its feedstock, the feedstock price for fertilizer company has been kept in low level from political consideration. So, fertilizer production from synthesis gas via coal depends largely on the policy in Indonesia.

5-2-3 Fuel for Power Plant

Banko coal utilization as a fuel for coal fired power plant is very promising. However, the feasibility study on power generation through direct combustion or combined cycle with gasification at mine mouth should be necessary because of difficulty in long distance transportation of Banko coal.

5-3 PRELIMINARY SURVEY ON BANKO COAL RESOURCES

The major objectives of the survey are as follows:

a) To clarify Banko coal resources and its quality

b) To grasp preliminarily coal mining cost

(1) Coal Reserves and Quality in Banko Area

The results of survey carried out by Shell are summerized in Table 5-3-1.

(2) Preliminary Estimation of Coal Mining Cost

The preliminary mining cost of Banko coal is estimated to be 20$/t (wet base) and 14$/t (wet base) by continuous and non-continuous mining method respectively, assuming that coal production rate is 3 million tons/year and mine life is 33 years.

Table 5-3-1 Coal Reserves and Quality in Banko Area by Shell Report

(up to 100 m in depth)

Area	Measured Reserves 10^6 tons	Strip Ratio m^3/t coal	Coal Quality
Block A (North West Banko)	129.5	2.0	Total Moisture 28 - 35%
Block B (West & Central Banko)	178.5	1.5	Ash 4 - 16% (dry base)
Block C (Central Banko)	127.5	2.5	Volatile Matter 40.5 - 48.5% (dry base)
Total	435.5	-	Total Sulfur 0.15 - 2.4% (dry base)
			Calorific value 6100 - 7100 (dry base)

5-4 PRELIMINARY SURVEY ON COAL UTILIZATION TECHNOLOGY

The following fields of brown coal utilization technology were studied and it was clarified that commercial technology in each field is well developed and ready for commercialization.

a) Brown coal gasification technology
b) Technology for derivative production
c) Technology for electricity generation
d) Neat methanol engine

5-4-1 Survey on Coal Gasification Technology

(1) Classification of Coal Gasification

More than ten of advanced coal gasification technology has been developed since the first oil crisis. The reaction mechanism and structure of these advanced gasifiers are different, but can be classified into the four types.

a) Fixed bed gasifier ⎤
b) Fluidized bed gasifier ⎦ — suitable for electricity generation

c) Entrained flow gasifier ⎤
d) Molten iron bath gasifier ⎦ — available for synthesis and electricity generation

(2) Technology for Synthesis Gas Production

Overall evaluation has given that oxygen blown-molten iron bath gasifier is superior for production of synthesis gas from brown coal. Pressurized molten iron bath gasifier will be more better, if such a technology will be developed.
The ranking of overall evaluation for gasification technology is as follows;

1st : Molten iron bath (oxygen blow)
2nd : Fluidized bed (oxygen blow)
2nd : Entrained flow (oxygen blow)
4th : Fixed bed (oxygen blow, dry ash)

(3) Technology for Coal Gasification Combined Cycle Power Generation

Overall evaluation has given that air blow-pressurized type of fluidized bed gasifier is superior for CGCC power generation, providing that the technical development of hot gas clean-up system will be completed.
The ranking of overall evaluation for gasification technology is as follows;

1st : Fluidized bed (pressurized, air blow)
2nd : Entrained flow (pressurized, oxygen blow)
3rd : Fixed bed (dry ash, air blow)
3rd : Molten iron bath (atmospheric pressure, oxygen blow)

5-4-2 Survey on Technology for Derivative Production

The following technology was investigated, considering possibility of production in Indonesia.

a) Methanol as fuel and chemicals
b) Synthetic fuel oil (F/T process)
c) Ammonia and urea
d) Single cell protein
e) Gasoline from methanol (MTG process)

It was clarified that commercial technology for above products is well developed and ready for commercialization.

5-4-3 Survey on Technology for Electricity Generation

(1) Conventional Coal Firing Power Plant

Banko coal is difficult to utilize in a conventional coal firing power plant, because high sodium-in-ash will cause severe fouling and slagging on heat transfer surfaces within the boiler.

(2) Fluidized Bed Combustion Power Plant

Fluidized bed combustion boiler seems to be suitable for Banko coal, because low combustion temperature eliminates the potential for fouling and slagging. The details will be studied in futher study.

(3) Coal Gasification Combined Cycle Power Plant

CGCC power plant seems to be more suitable for Banko coal, if high temperature gas turbine and hot gas clean-up system will be developed. However more concrete evaluation will be done in further study, watching the technical development.

5-4-4 Survey on Neat Methanol Engine

(1) Gas Turbine

Gas turbine is highly suitable engine for neat methanol. In case of the existing gas turbine, neat methanol can be easily applied by minor changes of fuel supply system and combustion chamber.

(2) Gasoline Engine (Otto cycle)

Gasoline engine is also suitable engine for fuel methanol. However, commercial application of neat methanol car for multi-purpose utilization will not be easy because of "chicken and egg" dilemma between car manufacturers, methanol producers and methanol distributors.

(3) Diesel Engine (Sabathe cycle)

Ordinary diesel engine is unsuitable engine for neat methanol because methanol is low in its cetane value.
However spark assist diesel engine developed by Komatsu in Japan can be applied for neat methanol as well as diesel oil.
It is notable that spark assist diesel engine designed for neat methanol has flexibility for fuel selection, neat methanol or diesel oil.

5-5 MASTER PLAN FOR BANKO COAL EFFECTIVE UTILIZATION

1) The following two cases were selected as principal utilization of Banko coal, reflecting the study results for market, coal resources and utilization technology.

   a) Fuel methanol and mine mouth power generation

   b) Fuel methanol, urea and mine mouth power generation

   Furthermore, according to the different capacities of mine mouth power generation, six cases of heat and material balances (required coal demand, production capacity and utilities consumptions) were studied to select the master plan.

2) According to the heat and material balance, all of six cases were evaluated to be available for commercialization in Banko area.

3) As conclusion, the following two cases were selected as the master plan of Banko coal effective utilization.
   The suitable power generation capacity will be studied in further study, including the economics of high voltage transmission line.

Table 5-5-1 Master Plan for Banko Coal Effective Utilization

Power generation capacity	MW	300	1,000
Required coal (wet)	million ton/year	3.9	6.0
" (dry)	"	2.8	4.8
Methanol production	"	1.6	1.6
Quality of methanol	-	Chemical grade	Chemical grade
Electricity to JAWA	MW	85	800
Required cooling water	ton/hr	2,400	5,100

6. PROGRESS MADE IN THE 2ND STAGE

6-1 SCOPE OF WORK FOR THE 2ND STAGE

6-1-1 Objective

The objective of the 2nd stage (the coal gasification test stage) is to grasp characteristics of gasification of Banko coal and select coal basin to be studied in the 3rd stage.

The another objective is to carry out the secondary strategic evaluation on Banko coal effective utilization.

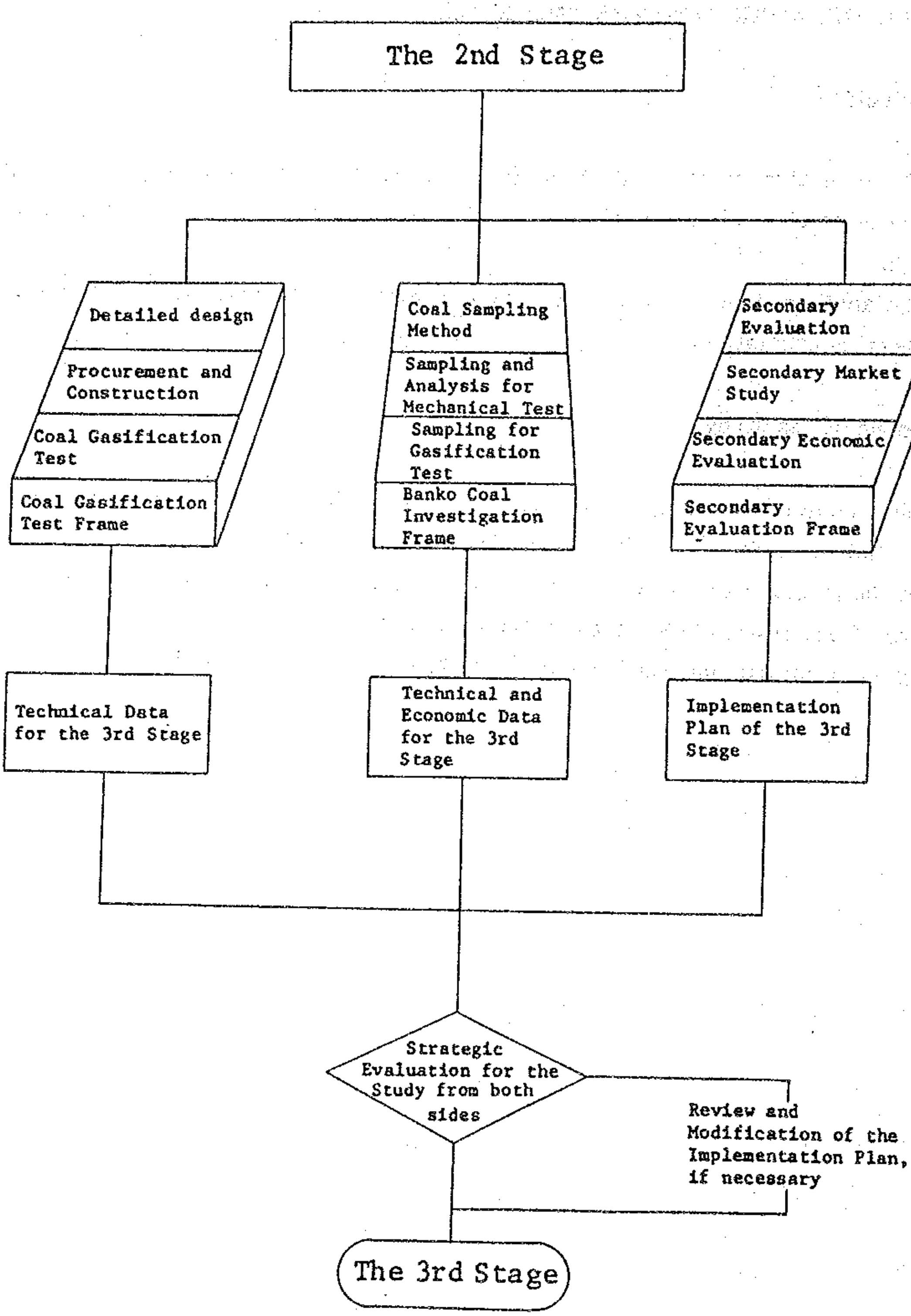
6-1-2 Scope of the Study

The scope of the study for the 2nd stage was basically same with Scope of Work for the Study on Effective Utilization of Banko Coal, on Feb. 24, 1984.

In the response to the request of Indonesian side, the market study for fuel alcohol was carried out as one of the study items in the 2nd stage.

The overall implementation plan of the 2nd stage is shown in Fig. 6-1-1.

Fig. 6-1-1 Flow Chart of Implementation Plan of the 2nd Stage



6-2 PROGRESS MADE IN THE 2ND STAGE

6-2-1 Scope of Work and Time Schedule of the Study

The scope of the study in each year is as follows;

(1) FY 1985

1) Detailed design on coal gasification test facilities
2) Survey on coal quality
3) Preliminary evaluation of economic feasibility
4) Investigation of the market for final product

(2) FY 1986

1) Fabrication, construction and mechanical test operation of coal gasification test facilities including pilot plant building and utilities supply system
2) Coal sampling work (1st phase)
3) Preliminary evaluation of economic feasibility of coal mining, urea production and electricity generation
4) Study of market for fuel alcohol and its supply system in Indonesia

(3) FY 1987

1) Coal gasification test
2) Coal sampling work (2nd phase)
3) Analysis and evaluation of coal gasification test
4) Overall evaluation for the study of the 2nd stage

The detailed time schedule of the study is given in the Inception Report for the Feasibility Study on Effective Utilization of Banko Coal - Stage II (May 1985, Revised in May 1986 and in July 1987). All of the studies were carried out in accordance with the above mentioned schedule.

6-2-2 Organization of the Study Team

Fig. 6-2-1 shows the organization of the study team. The counterpart also organizes the Indonesian team corresponding to the Japanese team.

6-2-3 Field Work

Fourteen (14) of the study team were dispatched to Indonesia during the 2nd Stage as shown on Table 6-2-1.

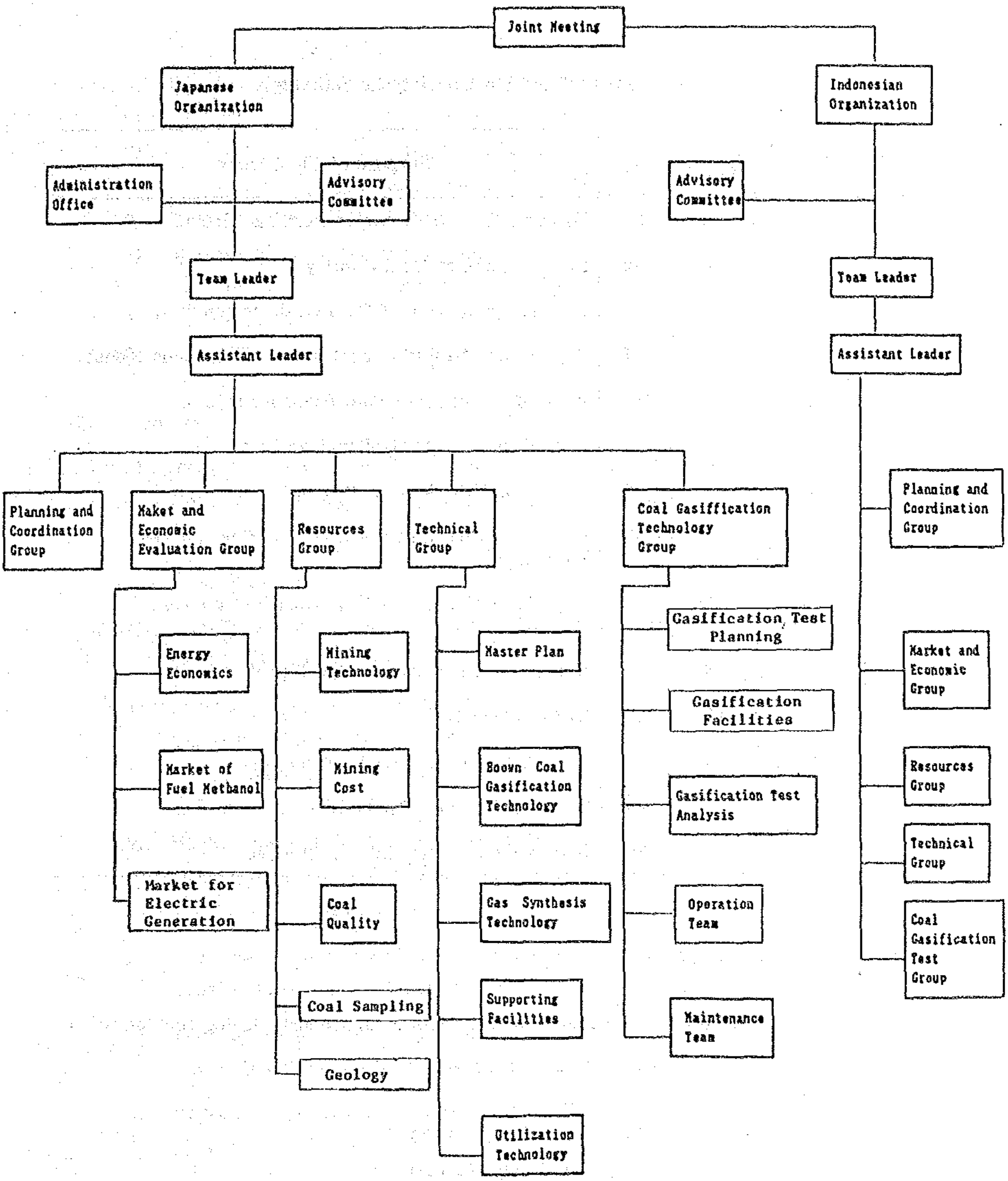


Fig. 6-2-1 Organization of the Study Team

Table 6-2-1 Field Work during the 2nd Stage

FY	Name of Team	No. of Staff	Days	Purpose of Field Work
1985	A	5	30	Discussion of Gasification Test Facilities
	B	6	99	Investigation of Coal Quality
	C	3	27	Overall Evaluation of Coal Gasification Test
	D	7	17	Discussion of Field Report and Draft Interim Report
1986	A	4	12	Kick-off Meeting of Fuel Alcohol Project
	B	5	109	Coal Sampling for Gasification Test
	C	7	30	Survey on Fuel Alcohol Project
	D	3	37	Installation Work of the Coal Gasification Test Facilities
	E	10	83	Test Operation of the Coal Gasification Test Facilities
	F	3	17	Discussion on Draft Interim Report
1987	A	16	146	Gasification Test
	B	2	69	Coal Sampling for Gasification Test
	C	2	20	Gasification Data Analysis
	D	6	10	Discussion on Draft Interim Report

6-2-4 Records and Reports

Following list shows the subjects of the records and reports during the 2nd Stage.

(1) Records

1) Minutes of Meeting, dated June 1, 1985
2) ditto , dated July 12, 1985
3) ditto , dated Aug. 29, 1985
4) ditto , dated Sept. 30, 1985

5) Minutes of Meeting, dated March 20, 1986
6) ditto , dated June 26, 1986
7) ditto , dated Sept. 10, 1986
8) ditto , dated March 16, 1987
9) Memorandum , dated July 28, 1987
10) Minutes of Meeting, dated Sept. 25, 1987
11) ditto , dated Oct. 16, 1987
12) ditto , dated Dec. 9, 1987
13) ditto , dated Feb. 16, 1988

(2) Reports

1) Inception Report for the Feasibility Study on Effective Utilization of Banko Coal, Stage II, May 1985 (Revised in May 1986 and in July 1987).

2) Interim Report II for the Feasibility Study on Effective Utilization of Banko Coal (FY1985), May 1986

3) Interim Report III for the Feasibility Study on Effective Utilization of Banko Coal (FY1986), July 1987

4) Interim Report for the Feasibility Study on Effective Utilization of Banko Coal (2nd Stage), March 1988

5) Inspection Report of Mechanical and Electrical Work for Banko Coal Test Facilities, January 1987

6) Banko Coal Gasification Test Plant Final Drawings, March 1987
Vol. 1. Mechanical Drawings, Electrical Drawings
Vol. 2. Instrument Drawings

7) The Maintenance Manual of Coal Gasification Test Facilities on the Feasibility Study on Effective Utilization of Banko Coal, March 1987

8) The Operation Procedure of Coal Gasification Test Facilities on the Feasibility Study on Effective Utilization of Banko Coal, March 1987

9) Report of the Acceptance Test Run of Banko Coal Gasification Plant, March 1987

10) Field Report of Gasification Test for the Feasibility Study on Effective Utilization of Banko Coal, December 1987.

7. RESULTS OF SURVEY ON BANKO COAL RESOURCES

7-1 DATA AND INFORMATION ON BANCO COAL RESOURCES

7-1-1 Exploration by Shell

The first systematic investigation on Banko coal field was carried out by the hands of Shell Mijonbow N.V., one of Indonesian Corporation of Royal Dutch Shell group which engaged in exploitation and export of Indonesian coal (hereinafter, referred to as Shell), under two years agreement on coal exploration work in South Sumatra concluded with Perum Tambang Batubara, the state-owned Coal Corporation (hereinafter, referred to as PTB) in October 1973.

Shell carried out geological and geophysical survey, and drove 588 of boreholes (about 9,000 meters in total length) on huge area of 71,450 km^2 at an enormous cost of about U.S.$ 20 million in 1974 and 1975.

Thereafter, Shell released the exploration right on 75% of the above mentioned licensed area and concentrated their exploration activities into the following most promising area in May 1976 on the expiry of the contract.

Northern Prospect
Pendopo Prospect
Southern Prospect
Enim Prospect

490 of boreholes (about 12,000 meters in total length) were driven, 50 of pits and trenches were dug and mining tests also were done in several places at a cost of U.S.$ 48 million through June 1976 into May 1978.

The exploration activities were concentrated upon Banko area especially North-West Banko area, and preliminary survey was carried out on Suban Jeriji area.

7-1-2 Summary of Survey Results Performed by Shell

(1) Outline of the South Sumatra Coal Field

The Central and South Sumatra Neocene Coalfield Basins are considered to be parts of one very large depositional environment.

These basins are interpreted as "foreland basins" or "backdeeps" of the Alpidic fold chain ("island arc") and are parallel to the subduction zone on the plate boundary from south-west of Sumatra to south of Java.

The development of these foreland basins started locally at the Oligocene/Miocene boundary. During the lower Miocene, the basins developed as a whole, with continental fluvial, limnic lagoonal and open marine phases. Much of the sedimentary material filling the basins is derived from the contemporaneous volcanicity of the "volcanic arc" south-west of the basins.

The very extensive and economically interesting coal deposits in this region were deposited during the Tertiary epoch of geological history by a rising and subsiding landmass controlled and influenced by comparatively young events related to plate tectonics, young volcanicity within the region of present Sumatra island, worldwide sea level fluctuations and climatic changes. There are two center coal mining area in Sumatra, now, one of them is Ombilin Coal Mine and the other one is Bukit Asam Coal Mine.

South Sumatra coalfield is one of the most important coalfield in Indonesia together with Central Sumatra. It exists in the south of Tigapuluh and extends to the eastern coast of Sumatra Island through an openfield sharing the borders with the Barisan Mountains Range by fault, which uplifted in the Tertiary epoch.

The coalfield is drawn the line of demarkation with Lampung High in south-east part and Sunda mass is close to the coalfield at east-northeast part. The basin is found within the above area and divided into two parts, that is, Central Palembang sub-basin and South Palembang sub-basin of Lematang depressed ground, based on basement structure.

Almost all of coal deposits are formed within the above mentioned sub-basins.

Tartiary sedimentary formation are lifted up by fault, the formation is thickest at the fringe of the Barisan Mountains Range, and there is general tendency to be getting thiner and thiner toward north-east direction.

Coal seams exisist among any formation, however, the most minable coal seams belong to the Muara Enim formation.

The Muara Enim formation is sub-divided into four units, i.e. M_1 - M_4 of which the M_2 and M_4 sub-divisions of Upper Miocene age are most important economically. The M_1 sub-division of which thickness is 100 - 300 meters is the oldest unit of the said formation geologically two coal seams, Merapi (D) and Kladi coal seam exist among the M_1 sub-division, both of them have no economic value.

The rocks of M_1 sub-division are brown and gray sand, silt and, clay with minor glaucanitic sand.

The M_2 sub-division is the most important one, from the economical point of view. It contains the Mangus (A), the Suban (B) and the Petai (C) coal seam complex (from the top to the bottom) which varys in thickness from 30 meters to 50 meters.

Several good marker features in the form of characteristically positioned clay bands in the Suban (B) coal seam and pelletoidal clay horizon (volcanic tuff) between A_1 and A_2 coal seam are found in the coal seams of M_2 sub-division. The accompanying rocks are limnic water sediments with brown to brown-gray clay and sandy clay, brown-grey fine to medium sand and some green-grey fine-grained sand in lower parts, and only minor participational volcanic components.

The M_3 sub-division (40 - 120 meters thickness) is basically a sand and silt complex, more fluvial than limic or lagoonal/brockish in the upper part, underlain by blue-green clay, containing a characteristic siderite module horizon just above the A_1 coal seam. There are a few thin coal seam (Burung, Benuang) and thin coal layers, but those coal seams and layers have no economic value.

The M_4 sub-division (120 - 200 meters thickness) is the uppermost and stratigraphically youngest sequence of the Muara Enim Foundation. It contains the so-called "hanging layers" including the Lematang coal seems (the Jelawatan coal seam in the eastern part) and 10 - 30 meters thickness of the Enim coal seam complex. Both coal seams have an interesting resource potential within reacheable range by surface mining.

The predominant rocks are blue-green tuffaceous (volcanics) clay and sandy clay, some dark-brown coaly clay, some white and grey fine to coarse sand with occasional glauconite, indicating marine deltaic-fluvial conditions. A characteristic marker is a sand body, just below the Enim coal seam.

The M_4 coal contains about two third of the total coal resource of the South Sumatra Basin, however, those coal have higher moisture contents (up to 60% of the total volume) and are of a lower rank in terms of heating value, generally. On the contrary, the M_2 coal is lower in moisture contant and has a higher heating value i.e. it has of a higher rank in coal maturity.

The geological and physical characteristics of the coal deposits in the South Sumatra basin are determined by the following tectonical structures.

a) The Lematang Valley between Gedong Agung and Gunung Agung follows a major tectonical zone probably a NE-SW striking transfer fault.

b) The Enim Valley is also the place of some tectonic lineament; as is the Air Niru Valley.

c) These linearment dissect the area across the "general strike of folding into four segments."

d) The following tectonic structures exist in the "West of Lematang segment (from south to north).
Air Serelo Syncline (outside the project area)

Lahat anticline
South Arahan Syncline
North-Arahan Synclinorium
North-Arahan Syclinal Area
Rather unknown structures north and west of Arahan Village

The Lematang-Enim Segment has moved relatively on the Lematang transfer fault about 3.3 KM toward NE. There are the following tectonic structures. (from south to north).

a) The volcanic area of Bukit Serelo-Bukit Kendi, which appears to occupy anticlinal positions.

b) The large South Air Lawai Syncline, a direct easterly extension of the South Arahan Syncline

c) The anticlinal central structure of Muara Tiga Besar and Kecil, extending into the Bukit Asam dome structure in the east. This anticline bifurcates towards the west (about halfway south of Muara Tiga Besar), into southern, west to east striking, and northern north-west to south-east striking, branches. The synclinal structure of North Arahan exists in between. The south branch of the Muara Tiga anticline extends into the Arahan anticline from 2 km offset at the Lematang transfer fault.

d) The North Air Lawai synclinorium is complex and is influenced by the western downward plunging extension of the Klawas anticline, and by the Air Lawai dome.

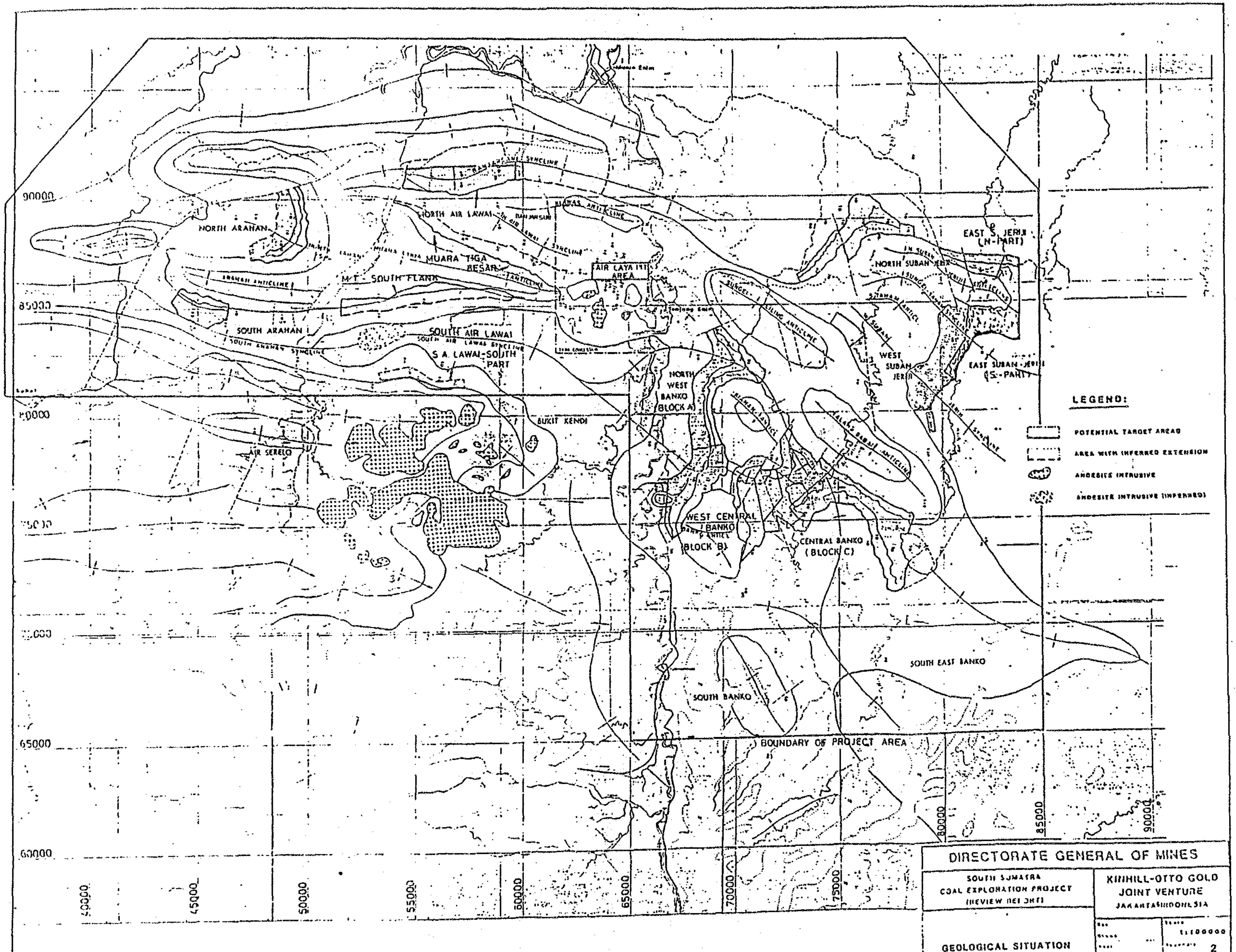


Fig. 7-1-1 Tectonical Structures in the South Sumatra Basin

e) The Klawas anticline has a short (3.5 km) east north-east to west south-west strike, with steep flanks, and is developed only in the eastern portion of the Lematang-Enim segment; it sharply plunges down in the middle of the segment, causing some suspected anticlinal and dome structures within the North Air Lawai synclinorium.

f) The Air Laya domelike structure with north to south extension is connecting the Muara Tiga Anticline in the south with the Klawas anticline in the north. It is caused by an andesitic intrusion into the M_1 formation below the M_2 coal.

g) The Muara Lawai anticlinorium is poorly defined and appears to plunge and disappear towards the east, prior to reaching the Enim River.

h) The Muara Enim synclinorium is the most northern feature.

i) Fault zone is not so clear in the "Air Enim Lime" same as that in the Lematang lineament, but it seems as if the changing place of tectonic chracter and the anticlines and synclines hold more south-easterly directions.

j) The south-west part of the segment forms a synclinorium which strikes north-west - south, south-east largely, following the Upper Enim River, and, connecting the North to the South Air Lawai syncline and to the synclinal structures of West, Central and North West Banko.

h) The short NNW-SSE striking anticline of South Banko

l) There is a wide synclinorium at South East Banko - South Banko and Central Banko.

m) The domelike roundish anticlines of South West Banko and Kiahan - Banko lie on the north side.

n) A more distinct linear set of NE-SW striking anticlines streches from Talang-Babat to Sungai Lilling, continuing to Klawas.

o) The Talang-Babat Anticline follows the Sungai-Tahan Syncline and the Sungai-Tahan domelike anticline (suspected of magmatic intrusion).

p) The Sungai Jeriji syncline and northly adjacent anticline have NW-SE strike, but change strike to west and south-west, and then disappear in the west of the Suban Jeriji coal area.

q) The large but shallow northern synclinorium is a continution of the North Air Lawai and the Muara Enim synclinoriums to the west side.

r) There are several NNW-SSW and NNW-SSE striking faults, presumably transform faults.

The survey results carried out by Shell are summarized in the following paragraphs.

(2) Banko Coal Area

The coal area is situated between 3 - 9 km south-east of Tanjung Enim and has an advantage in existing in the closest area to the railway at Tanjung Enim over other area explored by Shell. Banko coal area is subdivided into three blocks. (see Fig. 7-1-2), i.e.

block A	:	North West Banko
block B	:	West Banko, the southern (south-westerly) extension of NW Banko
block C	:	Central Banko, east of the western part of West Banko and south of NW Banko

South and South East Banko coal area is 8 km further south and clearly separated from the above mentioned three blocks, therefore, discribed separately.

1) North West Banko, West Banko and Central Banko

The area is characterized by smooth hills in the northwest and low-lying swampy regions in the south-east. Small creeks drain to the Air Selingking or the Air Niru (river). Most of the area are covered by secondary forest but grasslands are dominant in the western and eastern regions. Only quite limited parts in some places within the said area are cultivated.

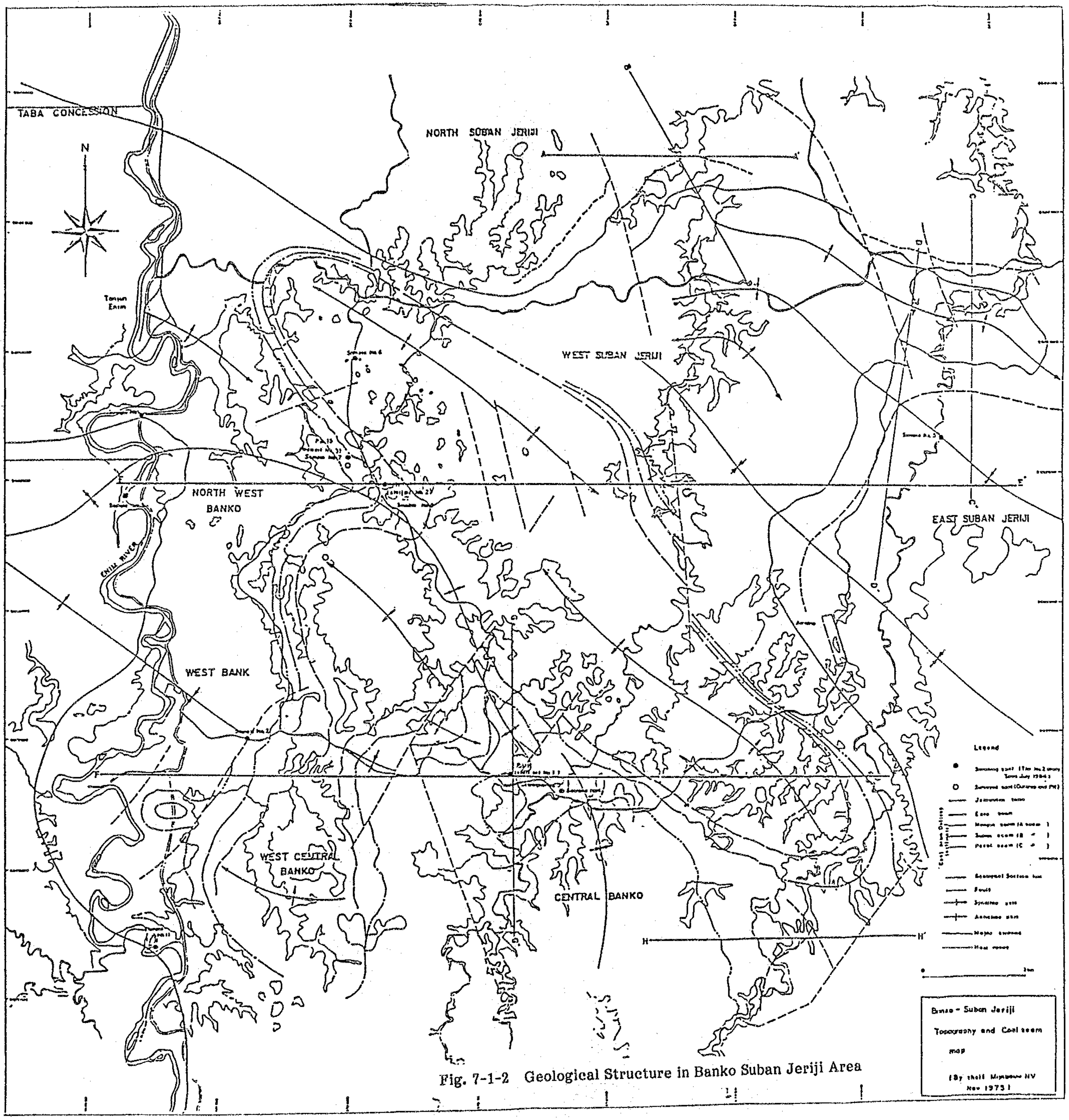


Fig. 7-1-2 Geological Structure in Banko Suban Jeriji Area

i) Exploration activity performed by Shell

The following number of holes, pits, trenches and test mining pits were driven or dug by Shell

		NW Banko	W Banko	C Banko
	cored	88		
	non-cored	49		
Boreholes	partially cored	6		
	re-drilled	18		
	Total	143	34	68
pit, trenches and test ming pits		37		1

ii) Tectonic structure

Major structural features, striking NW-SE and plunging to the NW influence the configuration of the deposit and the quality of the coal seams, i.e.

a) The Sungai Lilling (Killing) anticline adjoining the NW Banko Syncline
b) The North West Banko syncline
c) The Kiahan (or Banko) anticline with NW-SE-strike and with a steep NE-flank, showing dips up to 55^{o} - the anticline is overthrusted to the north-east with an approximate maximum horizontal displacement of 150 meters.
d) The SW-Banko anticline, a circular domelike structure with pronounced plunge to the west and east
e) The synclinal, westerly dipping area of block B which is actually the eastern margin of the large South Air Lawai - Air Enim synclinorium.
f) The Talang-Babat anticline as a south-western extension of the Sungai Lilling anticlinal structure is asymmetric with a steep NE-flank showing dips up to 78^{o} and a moderately inclined SW flank,

north-west and south-east plunging. Transverse major faults severly affect the SW flank.

g) The Central Banko syncline is surrounded by the Talang-Babat anticline in the north-east and the SW Banko anticline in south-west, whereas the south-east plunging Kiahan anticline causes unduations at the bottom of the syncline. The north-east part is also affected by a group of wrench faults which display a right-hand horizontal displacement of several hundred meters.

Major faulting is aligned on a north-east, south-west pattern. Intensive normal foulting with varying amounts of horizontal displacement is evident in the south-eastern part of the North-West Banko syncline and along the western flank of the Banko anticline.

Although the prevailing pattern of faulting shows a radial configuration NW-SE and NE-SW striking fault patterns predominate. Intense jointing and fracturing is also known to be present and will have consequence on mine slope stability.

NW Banko is probably one of the most severely structurally disturbed block in the South Sumatra coal field.

Dips of strata and coal seams within mining area will change between 6^o and 15^o and average will be about 8^o. The expected mining area in NW Banko is bounded by steep dip of coal seam (more than 15^o) in the north, and by faulting in the south, coal seam outcrops and faulting is exposed on the ground in the east, and minable area is limited by the thickness of overburden in the west.

Central Banko is structually very complicated. The average dip of the coal bearing sequence of the M_2 division of the Muara Tiga Formation are recorded by Shell to be within the range of 0^o to 15^o. Horizontal dislocation and vertical displacement of faulted blocks can be expected. West Banko however, is structually less complex than Central and NW Banko.

iii) Coal and interburden thickness

Shell estimated coal and interburden thickness based on their survey results as follows:

<table>
<tr><th rowspan="2"></th><th colspan="6">NW Banko (block A)</th><th colspan="2">W Banko (block B)</th><th colspan="4">C Banko (block C)</th></tr>
<tr><th colspan="2">Max. (m)</th><th colspan="2">Min. (m)</th><th colspan="2">Average (m)</th><th colspan="2">Western Part (m)</th><th colspan="2">Northern Part (m)</th><th colspan="2">Shouthern Part (m)</th></tr>
<tr><th>Coal seam</th><th>Coal</th><th>Inter-burden</th><th>Coal</th><th>Inter-burden</th><th>Coal</th><th>Inter-burden</th><th>Coal</th><th>Inter-burden</th><th>Coal</th><th>Inter-burden</th><th>Coal</th><th>Inter-burden</th></tr>
<tr><td>Mangus 1 A_1</td><td>12.1</td><td></td><td>4.6</td><td></td><td>9.2</td><td></td><td>9.2</td><td></td><td>-</td><td></td><td>-</td><td></td></tr>
<tr><td></td><td></td><td>22.8</td><td></td><td>10.3</td><td></td><td>16.7</td><td></td><td>-</td><td></td><td>-</td><td></td><td>-</td></tr>
<tr><td>Mangus 2 A_2</td><td>11.8</td><td></td><td>8.4</td><td></td><td>10.4</td><td></td><td>6.3</td><td></td><td>-</td><td></td><td>-</td><td></td></tr>
<tr><td></td><td></td><td>15.3</td><td></td><td>11.4</td><td></td><td>13.3</td><td></td><td>-</td><td></td><td>-</td><td></td><td>-</td></tr>
<tr><td>Suban 1 B_1</td><td>13.7</td><td></td><td>9.5</td><td></td><td>12.5</td><td></td><td>10.3</td><td></td><td rowspan="3">18.7</td><td></td><td rowspan="3">13.4</td><td></td></tr>
<tr><td></td><td></td><td>12.3</td><td></td><td>1.3</td><td></td><td>6.9</td><td></td><td>-</td><td>-</td><td>-</td></tr>
<tr><td>Suban 2 B_2</td><td>5.5</td><td></td><td>4.2</td><td></td><td>-</td><td></td><td>13.7</td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td>43.5</td><td></td><td>28.1</td><td></td><td>36.3</td><td></td><td>-</td><td></td><td>-</td><td></td><td>-</td></tr>
<tr><td>Petai C</td><td>12.4</td><td></td><td>10.4</td><td></td><td>11.5</td><td></td><td>C_1 5.2
C_2 6.9</td><td></td><td>13.5</td><td></td><td>11.9</td><td></td></tr>
<tr><td>Total (Coal)</td><td>55.1</td><td></td><td>37.1</td><td></td><td>43.6</td><td></td><td>51.6</td><td></td><td>32.2</td><td></td><td>25.3</td><td></td></tr>
</table>

(preconditions) Shell set the following conditions forth as a premise in calculating the above mentioned thickness of coal and interburden.

a) final pit slope : less than 15^{o}

b) coal seam exisists among main faults continuously.

c) maximum sunk depth below the footwall of Petai coal seam is 100 meters.

d) extremely complicated structures are not in existence.

iv) Coal Quality

Average coal quality data of the said area and ash component analysis results presented by Shell are shown in Table 7-1-1 and Table 7-3-2, respectively, Shell pointed out that the coal quality deteriorates regionally from the north-west to the south and south-east.

v) Coal Reserve

Coal reserves are as follows:

a) NW Banko

	Coal reserves				Minable coal reserves				Average thickness	
	Final pit slope: 15°		Final pit slope: 20°		Final pit slope: 15°		Final pit slope: 20°			
	Coal million t	Waste million M^3	Coal million t	Waste million M^3	Coal million t	Waste million M^3	Coal million t	Waste million M^3	Coal (m)	Waste (m)
Mangus 1 (A_1)	23.66	147.37	23.17	126.78	23.66	147.37	23.17	126.78	8.1	41.7
Mangus 2 (A_2)	28.50	34.55	28.02	33.22	28.50	34.35	28.02	33.32	8.6	13.6
Suban 1 (B_1)	39.48	27.91	38.58	27.19	39.48	27.91	38.52	27.19	10.2	10.6
Suban 2 (B_2)	14.95	20.18	14.90	19.98	14.95	20.18	14.90	19.98	3.8	6.7
Petai (C)	41.45	107.53	40.81	105.77	18.43	51.57	18.38	51.40	9.8	26.3
Total	148.04	337.54	145.48	313.04	125.02	281.38	122.99	258.67		
Considering safety factor of 85%	128.5	354.7	123.7	330.1	106.3	296.0	104.6	273.1		
Stripping ratio	2.82 : 1		2.67 : 1		2.78 : 1		2.61 : 1			

b) W Banko (block B) and C Banko (block C)

	W Banko Million t	C Banko Million t
Mangus (A)	3.0	-
Suban (B)	77.0	51.0
Petai (C)	98.5	76.5
Total	178.5	127.5
Stripping ratio	Optimistic 1.5 : 1 Probable 2.5 : 1	2.5 : 1

Table 7-1-1 Summary of Proximate Analysis Results (Banko Area)

Coal seam \ Area			NW Banko (1983 Shell)	NW Banko (1978 Shell) (1980 Geoservices)	W Banko	C Banko
Manguas 1 (A_1) (or) combined A	total moisture	(calculated) %	29.00			
		(analysed) %	30.00(?)	28.50		
	sulphur (d) %		0.57	0.54		
	ash (d) %		8.20	8.45		
	Volatile matter (d.a.f.) %		49.70	50.50		
	calorific value	(d.a.f.) Kcal/kg	7,240	7,329		
		net Kcal/kg	4,310	4,460		
Manguas 2 (A_2)	total moisture	(calculated) %	29.40	-	30.80	
		(analysed) %	30.00	29.00	-	
	sulphur (d) %		0.23	0.25	0.23	
	ash (d) %		5.00	6.90	9.40	
	volatile matter (d.a.f.) %		48.60	49.40	49.20	
	calorific value	(d.a.f.) Kcal/kg	7,275	7,304	72.5	
		net Kcal/kg	4,490	4,485	4,180	
Suban 1 (B_1)	total moisture	(calculated) %	29.00	-	32.50	(test pit)
		(analysed) %	30.00(?)	28.50	-	38.30
	sulphur (d) %		0.27	0.27	0.23	0.24
	ash (d) %		5.90	5.85	6.25	4.98
	volatile matter (d.a.f.) %		48.80	48.60	49.10	49.80
	calorific value	(d.a.f.) Kcal/kg	7,295	7,323	7,145	7,105
		net Kcal/kg	4,460	4,590	4,170	3,790
Suban 2 (B_2)	total moisture	(calculated) %	28.50	-	31.80	33.20
		(analysed) %	30.00(?)	28.00	-	-
	sulphur (d) %		1.09	1.18	0.78	0.88
	ash (d) %		6.50	7.60	9.50	10.50
	volatile matter (d.a.f.) %		47.90	49.30	48.50	47.60
	calorific value	(d.a.f.) Kcal/kg	7,310	7,319	7,175	7,115
		net Kcal/kg	4,440	4,530	4,085	3,900
Petai C	total moisture	(calculated) %	26.20	-	28.70	30.90
		(analysed) %	30.00(?)	27.50	-	-
	sulphur (d) %		0.97	1.13	0.90	0.87
	ash (d) %		8.00	8.85	11.25	11.74
	volatile matter (d.a.f.) %		48.40	49.50	49.60	49.00
	calorific value	(d.a.f.) Kcal/kg	7,410	7,457	7,305	7,210
		net Kcal/kg	4,430	4,595	4,290	4,060

Table 7-1-2 Summary of Ash Component Analysis Results

	Average	Range	Standard diviation
SiO_2	44.4	20.0 - 61.0	6.4
Fe_2O_3	4.7	0.8 - 17.0	3.7
Al_2O_3	28.5	19.0 - 41.0	5.7
CaO	7.0	0.6 - 13.0	4.1
MgO	3.7	0.2 - 6.6	2.3
Na_2O	6.2	0.2 - 20.0	6.4
K_2O	0.5	0.2 - 0.6	0.2
SO_3	4.4	0.6 - 13.0	3.5
TiO_2	1.0		0.3
P_2O_5	0.4	0.04 - 0.8	0.2

2) South and South East Banko

i) Location

The NNW-SSE striking anticlinal structure of South Banko is situated about 6 to 11 km south of West Banko.

ii) Exploration Activity Performed by Shell

The area was investigated by geological survey and 5 boreholes which penetrated A, B and C coal seam have been drilled.
A_1 coal seam is considered uneconomical one thickness of A_2, B and C coal seam are 6 - 8 m, 15 m and 6 - 8 m respectively, and total coal thickness reaches 30 meters. The Kladi coal seam (thickness is unknown) outcrops in the center of the anticline.
The Enim coal seam at the north-east flank of the South Banko anticline has been mapped and was caught by 2 of 4 boreholes. The Enim seam (3.6 meters thickness) is apparently deteriorated, (moisture 46%, low C.V) but an improvement towards the east may be expected.

iii) Coal Quality

Analysis result of only one borehole shows that coal quality is rather low, i.e. CV (d.a.f.) : 6,700 - 7,000 Kcal/kg, total moisture: 41 -43%, net CV : 3,400 - 3,500 Kcal/kg, average ash (d) : 3 - 3.5 %.

iv) Coal Reserve

The coal reserves 100 meters below the surface is estimated at 170 million tons, adding up A_2, B and C coal seam. Enim coal seam may be uneconomical because of the thickness.
The said area has only secondary importance because of steep dip large number of faults and suspected faults, and comparative inaccessible area.

(3) Suban Jeriji

1) Location

The large coal area of Suban Jeriji extends to maximum 4 km of Tanjung Enim. The Air Niru flows through the area from south to north dividing the area into two parts i.e. eastern part and western part.
The area is covered by dense secondary forest in the north and the west. The south-western section which forms highly elevated area, drains to the north-west. The north-eastern part is located smooth ground high land with small creeks draining to the south-east and north-east.
The northern part of Suban Jeriji East is mostly covered by grass and bush land with minor patches of forest and over most of the southern part, glasslands with minor dense vegetation along the bank of Air Niru predominant.

2) Exploration Activity Performed by Shell

5 boreholes were drilled in the Suban Jeriji West, however, only 2 boreholes of them intersected coal seams. 13 boreholes in total were drilled in the north, however, only 7 of them are relevant for defining the interest area.
Although 18 boreholes were drilled by Shell at Suban Jeriji East, effective holes are only 4.

3) Tectonic Structure

i) The Suban Jeriji North area is located on the north-west flank of the North Suban Jeriji anticline. The area is divided by a major NNW-SSE striking fault which laterally displaces both parts of the deposit by 300 to 400 meters. The southern boundary of the area is defined by the outcrop/sub-outcrop lines of the Jelawatan and Enim coal seam.

ii) The down-dip boundary in the north-west and north-east of the semi-circular prospect area was defined on the basis of 100 meters overburden cutoff to the top of the Enim coal seam. Side boundaries were defined arbittarily and significant lateral extension is possible.

iii) Coal seam dips are reported to range from horizontal to 8^{o} to the north-west and north respectively.

iv) The northern part of Suban Jeriji East lies along the northern flank of the North Suban Jeriji anticline. The Jelawatan coal seam and the Enim coal seam complex are present in the area and show low dip angle of 4^o to 5^o to the north.

v) A major NNW-SSE fault with a lateral displacement of about 50 to 100 meters divides the area. Another major transverse fault with an even greater lateral displacement and similar strike direction, bounds the area to the west. The eastern boundary is defined by the Air Niru, which probably also follows a fault zone.

vi) From the structural point of view and based on the average geological waste to coal ratio the northern part appears more favourable than the southern part in Suban Jeriji East.

vii) The center of Suban Jeriji East demonstrates a minor doming effect caused by the Sungai-Taham anticlinal structure, the center of which is situated about 3 km of the north-west.
In the southern part, a synclinal development is indicated, which is related to the major Sungai-Taham syncline. This syncline strikes NW-SE with a south-easterly plunge.

viii) The overall fracture of fault patterns in Suban Jeriji East is not known well because of the limited number of borehole and lack of detailed structural analysis.

ix) The coal seam dips at very low angles (3^o To 7^o) to the south-East.

x) Suban Jeriji West is a small area with M_2 coal (A, B and C coal seams) close to the surface. It is located on the north-eastern flank of the south-west plunging Sungai-Liling anticline between Suban Jeriji and North-West Banko, immediately west of a major fault line and south-west of the Sungai-Taham syncline and the Sungai-Taham anticline structure.

xi) Moderately steep dip angles (10^o or more) are dominant. Major and minor faulting have not been recorded, but probably exist, judging from the proximity of the major structural features surrounding the area.

xii) The area is not considered attractive from the structural point of view and due to the limited size of the area.

4) Coal and Interburden Thickness

i) M_2 coal Seam (Suban Jeriji West only)

The coal and interburden thickness in the said area are estimated based on the drilling results of only 2 boreholes, as follows:

Coal seam	Average (m)		Range (m)	
	Coal	Waste	Coal	Waste
		50.00		0-10.0
Mangus 1 A_1	9.50		9.0-10.0	
		3.75		3.5-4.0
Mangus 2 A_2	12.25		12.0-12.5	
		13.50		13.0-14.0
Suban 1 B_1	12.75		12.5-13.0	
		26.00		26.0
Suban 2 B_2	4.00		4.0	
		33.00		33.0
Petai C	13.50		13.5	
Total	52.0		51.0-53.0	

(Note) Shell suggested to adopt 75% of safety factor because the above estimation based on only 2 boreholes.

ii) M_4 coal (Suban Jeriji North and East)

	Suban Jeriji North				Suban Jeriji East			
					Northern part		Southern part	
	Average (m)		Range (m)		Average (m)		Average (m)	
Coal seam	Coal	Waste	Coal	Waste	Coal	Waste	Coal	Waste
		75.0		0-124.0		-		0-60.0
Upper coal seam*1	9.0		-		-		-	
		-		-		-		-
Jelawatan	13.5		10.0-17.7		5.0*2		3.0*2	
		43.4		29.0-60.0		40.0		32.0
Enim (upper split)	13.1		9.5-17.7		11.0		13.0	
		4.7		1.0-9.6		8.0		6.0
Enim (middle split)	4.4		2.8-5.2		-		-	
		5.3		4.4-6.0		-		-
Enim (lower split)	7.4		5.9-8.3		6.0		6.0	
Total (Jelawatan Enim)	38.4		28.2-48.9		22.0		22.0	
Jelawatan	13.5		10.0-17.7		5.0		3.0	
Enim	24.9		18.2-31.2		17.0		19.0	

(Note 1) North-Central part only

(Note 2) High ash

(Note 3) Shell suggested that the Jelawatan coal seam will not be economical because of high ash content.

5) Coal Reserves

Shell classifys all coal reserves in Suban Jeriji area as inferred category.

i) M_2 coal (Suban Jeriji West only)

Shell had not computed coal reserve in the said area however, assigned coal thickness of 33 meters and 13 meters to Mangus-Suban coal complete and Petai respectively and 20 million tons of coal reserves are estimated in 0.5 km^2 of the said area. Cutoff depth of 100 m overburden to the top of the A_1 coal seam and specific gravity of 1.3 were applied. Average and maximum geological stripping rato was estimated at 3 : 1 and 5 : 1 respectively.

ii) M_4 coal (Suban Jeriji North and East)

Overburden cutoff parameter of 100 meters to the top of the Enim coal seam was applied. Coal reserve in the area (including the area of east of Air Niru river) is as follows:

		Suban Jeriji North		Suban Jeriji East	
		SW block	NE block	N part	S part
				2.3	5.4
Area (Km^2)		6.5		7.7	
	Jelawatan	13	39	-	-
Coal reserve	Enim	61	129	65.5	154.5
		74	168	65.5	154.5
	Total	242		219.9	
Geological stripping ratio		2.9 : 1			
Specific gravity		1.3		1.3	

6) Coal Quality

Coal quality data (air-dry basis) are shown in Table 7-1-2. Thermal upgrading of the coal was considered possible and account for the comparatively high calorific values determined in place in Suban Jeriji North. Such upgrading could possibly originate from a hidden intrusive body beneath one of anticline features in the vicinity of the area (e.g. in the dome-like feature of the Sungai Takam Anticline).

Table 7-1-3 (1) Summary of Proximate Analysis Results (Suban Jeriji Area)

			North	West	East N part	East S part	East S part BH SU 51
Jelawatan	total moisture	(calculated) (%)	41.50				
		(analysed) (%)	-				44.40
	sulphur (d)	(%)	0.18		0.54	0.48	0.23
	ash (d)	(%)	11.08		30.98	28.45	2.54
	volatile matter (d.a.f.)	(%)	55.40				52.10
	calorific value	(d.a.f.) Kcal/kg	6,780				6,663
		net Kcal/kg	3,140				3,215
Enim	total moisture	(calculated) (%)	40.60		42.90		-
		(analysed) (%)	-		-		42.00
	sulphur (d)	(%)	0.22		0.23		0.89
	ash (d)	(%)	5.39		7.24		6.60
	volatile matter (d.a.f.)	(%)	51.40		56.80		51.90
	calorific value	(d.a.f.) Kcal/kg	6,810		6,710		6,778
		net Kcal/kg	3,450		3,170		3,290
Mangus 1 A_1	total moisture	(calculated) (%)		31.40			
		(analysed) (%)		-			
	sulphur (d)	(%)		0.60			
	ash (d)	(%)		4.58			
	volatile matter (d.a.f.)	(%)		49.70			
	calorific value	(d.a.f.) Kcal/kg		7,040			
		net Kcal/kg		4,255			
Mangus 2 A_2	total moisture	(calculated) (%)		30.90			
		(analysed) (%)		-			
	sulphur (d)	(%)		0.23			
	ash (d)	(%)		2.64			
	volatile matter (d.a.f.)	(%)		49.80			
	calorific value	(d.a.f.) Kcal/kg		7,100			
		net Kcal/kg		4,400			

Table 7-1-3 (2) Summary of Proximate Analysis Results (Suban Jeriji Area)

			North	West	East		
					N part	S part	S part BH SU 51
Suban 1 B_1	total moisture	(calculated) (%)		33.10			
		(analysed) (%)		-			
	sulphur (d) (%)			1.13			
	ash (d) (%)			5.80			
	volatile matter (d.a.f.) (%)			47.80			
	calorific value	(d.a.f.) Kcal/kg		7,185			
		net Kcal/kg		4,400			
Suban 2 B_2	total moisture	(calculated) (%)		33.10			
		(analysed) (%)		-			
	sulphur (d) (%)			1.13			
	ash (d) (%)			5.80			
	volatile matter (d.a.f.) (%)			47.80			
	calorific value	(d.a.f.) Kcal/kg		7,120			
		net Kcal/kg		4,130			
Petai C	total moisture	(calculated) (%)		26.70			
		(analysed) (%)		-			
	sulphur (d) (%)			0.43			
	ash (d) (%)			5.49			
	volatile matter (d.a.f.) (%)			48.60			
	calorific value	(d.a.f.) Kcal/kg		7,265			
		net Kcal/kg		4,700			

Shell also shows the following only one ash component analysis data on Enim coal seam.

SiO_2	Fe_2O_3	Al_2O_3	CaO	MgO	Na_2O	K_2O	SO_3	TiO_2	P_2O_5
22.1	9.4	25.3	19.5	3.0	2.7	0.4	11.4	1.3	0.3

The report prepared by Kinhill-Otto GOld Joint Venture, "South Sumatra Coal Exploration Project - Review Report, May 1984, was consulted and quoted mostly to compose this section.

7-2 ADDITIONAL INFORMATION PROVIDED BY THE INDONESIA SDIE

The world Bank has granted a loan to the Government of Indonesia to undertake a programme to assess the coal resources in South Sumatra coalfield and to carry out feasibility study on each area which might be considered as the coal supply sources for the expansion of Suralaya Power Stations.

The above mentioned programme was composed of mapping, surveying, core-drilling, geophysical wireline logging, coal analysis, geotechnical testing, flowing water volume measurements in rivers and well drilling programme including pumping tests.

Whole the field works had been completed, then the feasibility study reports on the North West Banko area and the Muara Tiga Besar, and, the pre-feasibility study report on the Banjarsari have been submitted to the Government of Indonesia.

Besides the study report on the Arahan area is preparing by the hands of the foreign consultants company, Kinhill-Otto gold Joint Venture which was entrusted the work by the Government of Indonesia.

The above additional work was carried out to take over the exploration work done by Shell.

Some information on the investigated results on the Banko-Suban Jeriji area were utilized to prepare the report through the courtesy of D.O.C.

A brief outline of the above mentioned work is given as under.

7-2-1 North West Banko

27 boreholes were driven extending the boundary of drilled area by Shell, Kinhill-Otto Gold Joint Venture draws the following conclusion, after considering their own and Shell's survey results.

(1) Tectonic structure

The explorated area lies at the flanks of the North-West Banko syncline, Lilling anticline and Banko anticline. The fold axes stike and plunge to the north-west. Dips are generally to the west and range from about 6^{o} to 16^{o} (average 8^{o})

The Banko Barat coalfield is terminated in the south by the Noman-Kiahan fault zone. This fault zone has north-easterly-south-westerly strike. The fault has a vertical displacement of about 120 m, with the southern side uplifted. The northern and central zone of the coalfield were selected for mine planning due to more favourable structural conditions (gentle dips) and absence of large faults.

(2) Coal reserve

The Tertiary Muara Enim Formation has its origin from the Upper Miocene and is primarily encountered in limnic-telmatic facies. The thickness of the formation reaches about 650 meters, which is divided into four divisions M_1 -M_4.
Sub-Divisions M_2 contains A_1, A_2, B_1, B_2 and C coal seam which are minable economically. Thickness of Sub-Division M_2 is about 110 meters and accumulated thickness of coal seams is estimated at about 46 meters.
The individual thickness (average) of coal seams are as follows.

Thickness (m)	A_1	A_2	B_1	B_2	C_1	C_2
Coal seam	7.3	9.8	12.7	4.5	5.1	6.2

The drilling data on 142 boreholes in total were used to estimate the geological coal reserves. The statistical spacing of boreholes is 252 meters and standard deviation was 76.8 meters. The top of the uppermost coal seam (A_1) is generally within 150 meters from the ground surface, for the most part.
The total geological measured reserves in Banko Barat amount to 560 million tons at 250 meters depth (maximum 150 meters overburden above uppermost coal seam) the geological W:C ratio (m^3/t vertical in situ) is 2.31:1. In the geological model, no deduction of coal loss caused by weathering was not considered.

million tons

Coal seam	A_1	A_2	B_1	B_2	C_1	C_2	Total
Coal reserve	63.8	104.0	152.3	60.3	79.8	99.8	560.0

(3) Coal Quality

The Banko Barat coal is sub-bituminous B and C (corresponding to hard brown coal) with mainly low ash percentages (average in situ 6.3%, including C coal seam) low sulphur content (0.4%) relatively low volatiles (33%) low bed moisture (total moisture 25-26%), medium hardness (37-54 Hardgrove Units) and relatively high calorific values (4,300-4,778 Kcal/kg).
The sodium content average 4.5-6% throughout the whole deposit, but Na_2O contents may be over 6% locally.

(4) Hydrology and Hydrogeology

The average yearly rainfall is about 3,200 mm, actual evaporation is approximately 1,400 mm, mean temperature is 28°C.

The outer catchment area (10.4 km^2) of the Air Kiahan Besar/Air Bintan system will yield approximately Qmax = 140 m^3/sec after 100-year, 3-hours downpour at the point where the creeks enter the mining area.

Six stream guages were set and the maximum runoff rate observed in the Air Kiahan Besar was about 70 m^3/sec. Channels, dams and pumping stations are to be planned for mine protection.

All strata are water-saturated. The overburden/coal seam sequence forms a multi-aquifer system of low to very low permeability the coal seams likely having the highest. Pressure heads of about 1.4 MPa are expected to prevail in the B/C interburden at the deepest point of the mine, and pressure relief will be required. Inflow of large groundwater quantities is not likely, but installation of dewatering measures will be required to maintain the stability of the pit slopes.

(5) Geotechnics

The wastes have a specific character between hard soil and soft rock. Long-term slope angles in all sterile wastes section will be 21-22° at 20 meters height, when drainage is enough and 14° at 100 meters hight in the overburden above A_1 coal seam.

Coal slope will be kept standing at 60-70°. Overall slope angles of 25-30° between the A_1 and B_2 coal seam are probably stable with effective drainage.

Heaping of waste is possible at an overall slope inclination of 5:1 (H:V), if supported by an external layer and base drainage.

(6) Further Investigation

For detailed mine planning, the following further investigation are necessary:

Subcrop drilling (1,200 meters); exploration drilling (1,000 meters) geomechanical testing; runoff and water level measurements with permeability test; sieve analysis on samples of additional exploration drilling.

(7) Outline of the Production Plan

Coal production in the initial year will be 2.5 million tons increasing 4 million tons in year 2 and 5.4 million tons thereafter.
The production level will be maintained until year 30, then annual production will be decreased to 4.6 million tons in year 31 and 4.7 million tons in year 32.
Needed coal tonnage for Suralaya Power Plant No. 3 and No. 4 unit, which will start operation in February and Novemer 1989 respectively, (generating capacity of each unit is 400 MW) is 2.7 million tons per year.
The planned date of commencement of operation of No. 5 and No. 6 unit, is not decided yet, however the planned capacity of each unit is also 400 MW.
Therefore, NW Banko supplys the coal demand for Suralaya Power Plant from No. 3 to No. 6 unit, if the production at N.W Banko progresses satisfactorily, as scheduled.

164 million tons of coal and 386 million M^3 of waste will be excavated over the mine life.
Coal will only be recovered from the A_1, A_2, B_1 and B_2 coal seam, because incremental W:C ratio to remove inturburden between B_2 and C coal seam will exceed the economical limit at the present. The average W:C ratio over the mine life will be 2.34 M^3 : 1 ton.
The average property of the mined coal will be 4,563 Kcal/kg of calorific value, 25.9% of moisture content, 6.7% of ash content, 0.3% of sulphur content and 3.8% of sodium-in-ash. Sodium-in-ash values will increase during mining and reach the peak of 7.2% in the last year.
The report prepared by Kinhill Otto-Gold Joint Venture, "Banko Barat Feasibility Study Volume VIII" was consulted and quoted mostly to compose this section.

7-2-2 Central Banko

DOC and Kinhill Otto-GOld Joint Venture drilled 4 boreholes in the said area, however, further attractive progress has not been made in the investigation on the Central Banko since then.

Some persons in the administrative post of D.O.C vent opinions that the said area has no appear for exploitation because of quite complicated structural conditions.

7-2-3 Suban Jeriji

DOC and Kinhill Otto-Gold Joint Venture drilled 5 boreholes newly in Suban Jeriji North and some boreholes in Suban Jeriji East and West.

However, high priority on the ranking of exploration was not assign to the said area and then remarkable progress has not been seen in the investigation work on the said area.

7-3 SURVEY WORK CARRIED OUT IN THE SECOND STAGE

7-3-1 The Purpose of the Work

The survey work in the field (Banko area of South Sumatra coalfield) in the second stage had been carried out by the hands of the work team dispatched by Pusat Pengembangan Teknologi Mineral which is one of Indonesian governmental organization under the control of Ministry of Mines and Energy (hereinafter, referred to as PPTM), spending the funds provided by Badan Pengkajian dan Penerapan Teknologi (hereinafter, referred to as BPPT), according to the plan which was prepared by the survey team dispatched by Japan International Cooperation Agency and obtained consent of the parties concerned, and by united efforts of the JICA survey team, extending over three years from FY1985/86 to FY1987/88.

The main purpose of the above mentioned field work was to obtain needed numbers and volume of coal sample through the whole area of Banko for the coal gasification test at Serpong

7-3-2 Work Allotment

The following works related to the coal sampling were performed by the Indonesian counterparts including funding, however coal spontaneous combustion test in FY1987/88 was carried out under initiative of the JICA survey team, by use of apparatuses prepared by JICA, because such a test was the first attempt in Indonesia.

1) large diameter drilling work to obtain coal samples from each coal seam for the regular coal gasification test.
2) pitting work to take bulk coal sample for the test run of the coal gasification facilities (coal sampling at remote places from existing road was done by means of pitting).
3) shallow hole drilling to check the thickness of overburden at planned places.
4) surveying to locate the position of drilled holes and excavated pits.
5) proximate, ultimate and ash component analyses of the coal samples.

Geological survey also were carried out by the hands of the jointed survey team, organized by work teams dispatched by PPTM and JICA to select proper coal sampling places, one year earlier than coal sampling work in each area.

JICA dispatched several engineers and prepared some apparatuses and tools which are needed aroung half a year to be imported in Indonesia, to cooperate with the Indonesian counterparts and to fulfil the scheduled works within the specified time limit overcoming heavy rainy season.

7-3-3 Progress of Work

All planned works were performed though the commencement of the field work was forced to be delayed considerably, in the first year (FY1985/86) and second year (FY1986/87), especially in the first year, for the reason of delay on administration works in Indonesian side.

The field work in the third year (FY1987/88) was progress quite well, favored by good weather in spite of the rainy season.

The breaf outline of the field works during the recent three years (from FY1985/86 to FY1987/88) is as follows:

(1) Geological Survey

Geological survey was carried out in the North West Banko area in FY1985/86, and in the Central Banko and in the North Suban Jeriji area in FY1986/87 to select proper coal sampling places and to confirm outcrops/sub-outcrops lines estimated by Shell, respectively.

In FY1987/88, Arahan and Banjarsari area also were reconnoitered partially to obtain coal samples for coal gasification test at Serpong, according to the advice of Drs Johannas, the director of Directorate of Coal Directorate, General of Mines Ministry of Mines and Energy.

1) North West Banko

The JICA survey team integrated topographic, geological and outcrop/sub-outcrop maps prepared by Shell into one combined map after temparing with their own survey (see Fig. 7-3-1' of ATTACHMENT 7-3).

Twenty of estimated coal seam sections were also drown up, based on the above mentioned map and core drilling results, driven by Directorate of Coal (hereinafter, referred to as DOC) and Shell. (see from Fig. 7-3-2' to Fig. 7-3-11' of ATTACHMENT 7-3)

Geological survey also was carried out in FY1976/77 and then coal sampling places and method was selected taking the following circumstance and factors into consideration.

i) relative difficultly of drilling machine from the existing road to coal sampling sites and obtainability of water near the drilling site.

ii) the total amount of budget prepared by BPPT for the field work.

iii) period alloted for the field work.

iv) weather conditions.

v) execution of effective and practical sampling work.

vi) needed numbers and volume of coal samples

2) Central Banko

Geological survey on the Central Banko area also carried out in FY1986/87 for coal sampling works on the said area, which was planned in FY1987/88 based on the same key idea of FY1985/86.

Although an effort to draw up a map combined topographic maps with geological maps prepared by Shell separately and proffered by DOC through their courtesy, the combined map was not completed in FY1986/87 and the work team could not catch C Coal Seam at the planned place near the existing road until the end of working period in FY1986/87, regrettably because of lack of outcrop/sub-outcrop map, covered eastern part of the Central Banko drawn up by Shell.

The attached combined map of the Central Banko (see Fig. 7-3-1) was brought to perfection in FY1987/88, after the work team was transfered the above mentioned map by the courtesy of Perum Tambang Batubara and reconnoitered the eastern part of Central Banko. (see Fig. 7-3-2 (1) and (2))

Five coal sampling places (for Mangus 1 (A_1), Mangus 2 (A_2), Suban (B_1), Suban (B_2) and Petai (C)) were selected as shown on Fig. 7-3-1, based on the above mentioned survey.

Fig. 7-3-1 Combined Map (Geological and Topographic Maps), Shown Proposed Drilling Places Central Banko

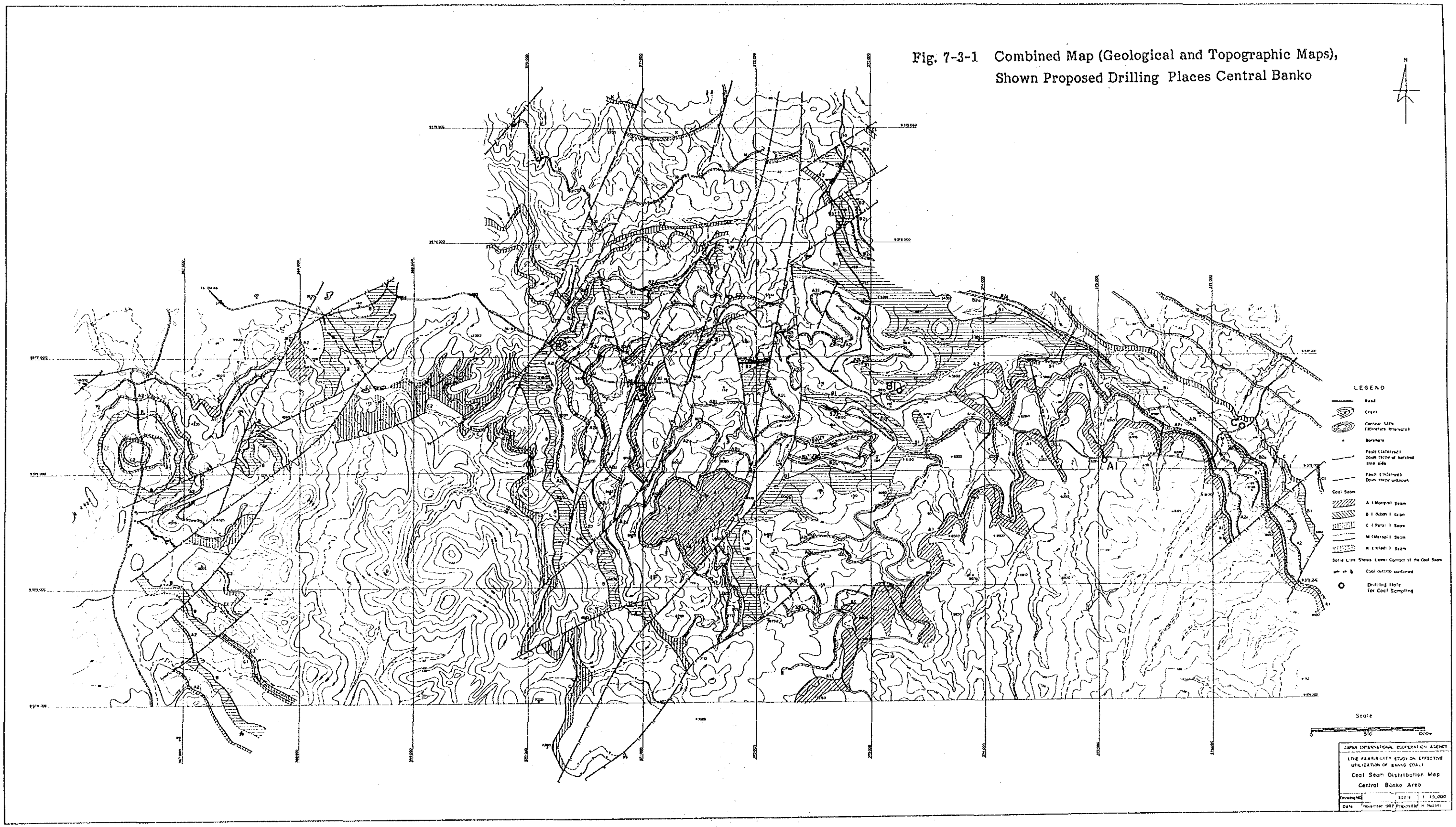
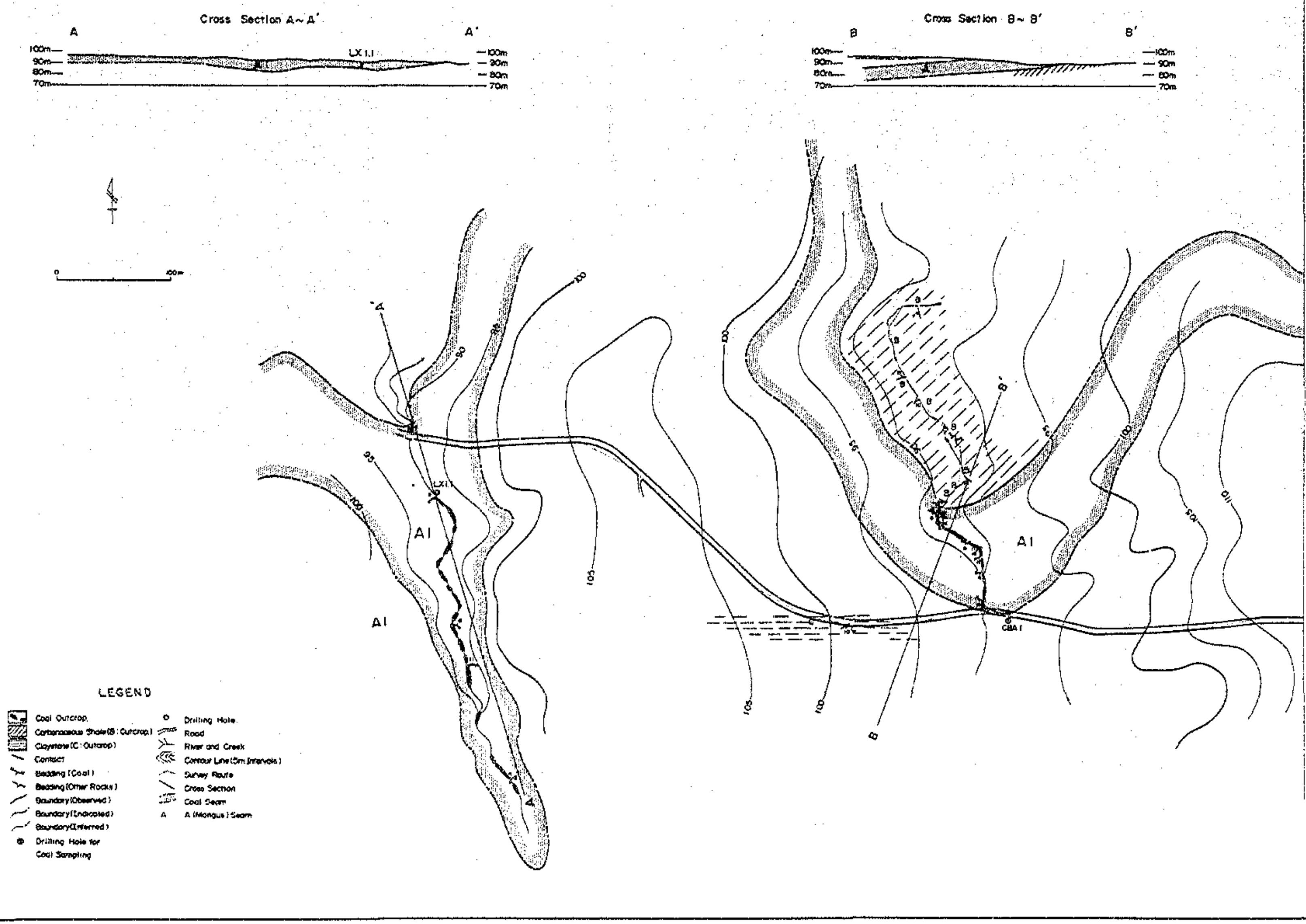


Fig. 7-3-2 (1)
Geological Survey Map
Eastern Part of Central Banko Area (1)



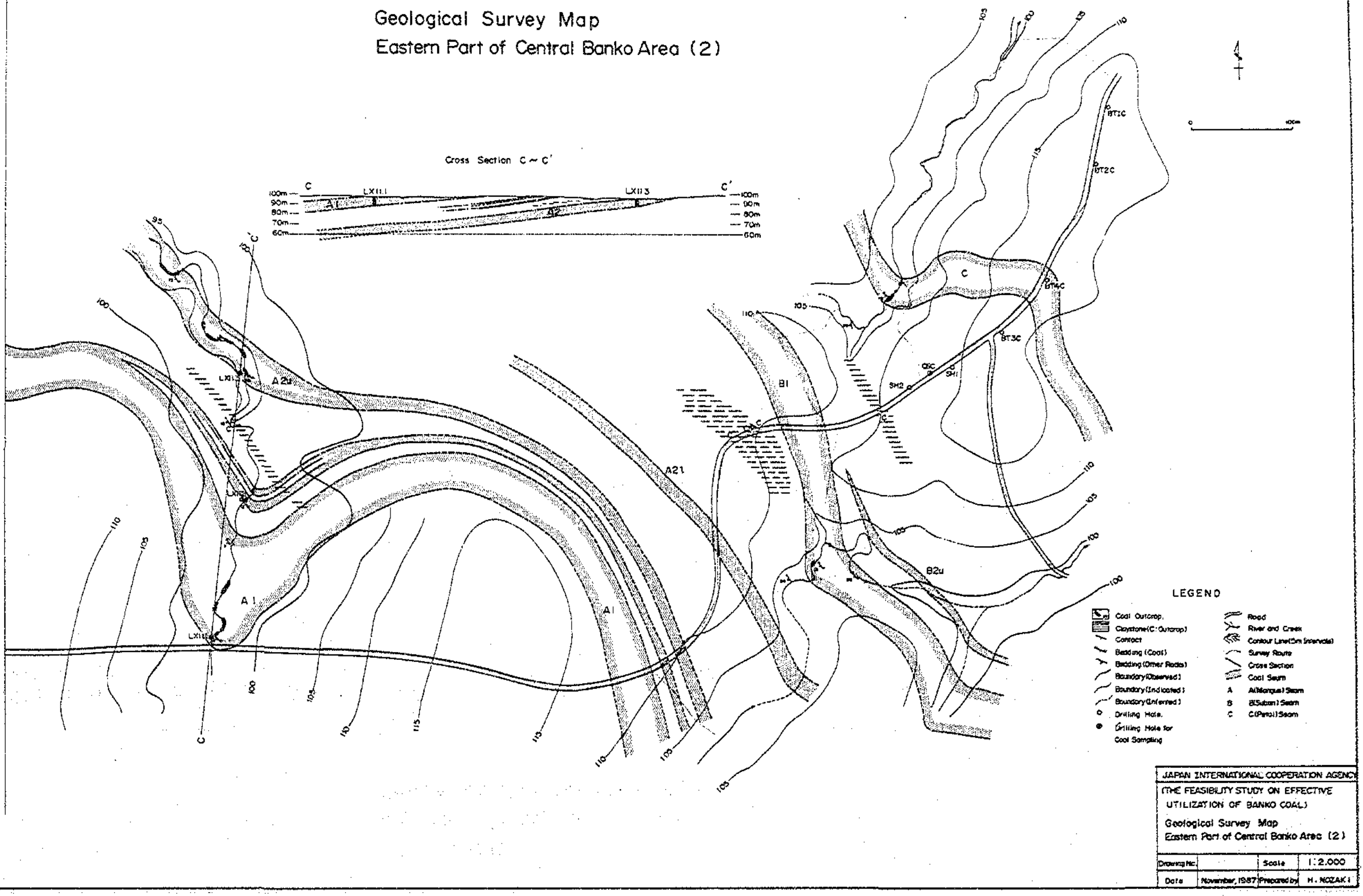
JAPAN INTERNATIONAL COOPERATION AGENCY
(THE FEASIBILITY STUDY ON EFFECTIVE UTILIZATION OF BANKO COAL)
Geological Survey Map
Eastern Part of Central Banko Area (1)

Drawing No.		Scale	1:2,000
Date	November, 1987	Prepared by	H. NOZAKI

Fig. 7-3-2 (2)

Geological Survey Map

Eastern Part of Central Banko Area (2)



3) North Suban Jeriji

DOC kindly provided columnar sections of the boreholes driven by them in the area and geological map of the area in a scale of 1 : 10,000. (Fig. 7-3-26' of ATTACHMENT 7-3)
The geological survey was achieved by the hands of the jointed survey team in a short period of time in FY1986/87 through kind arrangement of DOC. Sincere gratitude is expressed to DOC.
Seven cross sections of coal seams on the North Suban Jeriji were drawn up (see from Fig. 7-3-19' to Fig. 7-3-25') and three coal sampling places (for Jelawatan, Enim 1 and Enim 2 coal seam) were selected in FY1986/87 (Fig. 7-3-3).

Furthermore, shallow holes were driven in the North West Banko in FY1985/86, in the Central Banko in FY1986/87 and FY1987/88, and in the North SUban Jeriji in FY1987/88, at proposed coal sampling places respectively, to check the thickness of overburden, one year before coal sampling work or prior to it in the same year, as a part of geological survey.

(2) Coal Sampling

Coal gasification facilities prepared by JICA had been installed at Serpong in FY1986/87. Mechanical and process test run using bulk coal samples were planned in the last quarter of FY1986/87.
Then regular coal gasification tests were expected to carry out in FY1987/88 dividing into two phases (the first phase would be carried out at the beginning of the fiscal year). (see Fig. 7-3-4)
Therefore coal sampling schedule during the second stage of the project was decided as follows:

i) Bulk coal samples for mechanical and process test run, and coal samples for the first phase coal gasification test should be obtained in FY1986/87 immediately after the governmental budget excution which was expected at the end of May, before the rainy season in Sumatra Island which would be at the peak in the second half of the fiscal year.

ii) Coal samples for the second phase should be obtained in FY1987/88 in the same season of the year as the first phase coal sampling by the same reason.

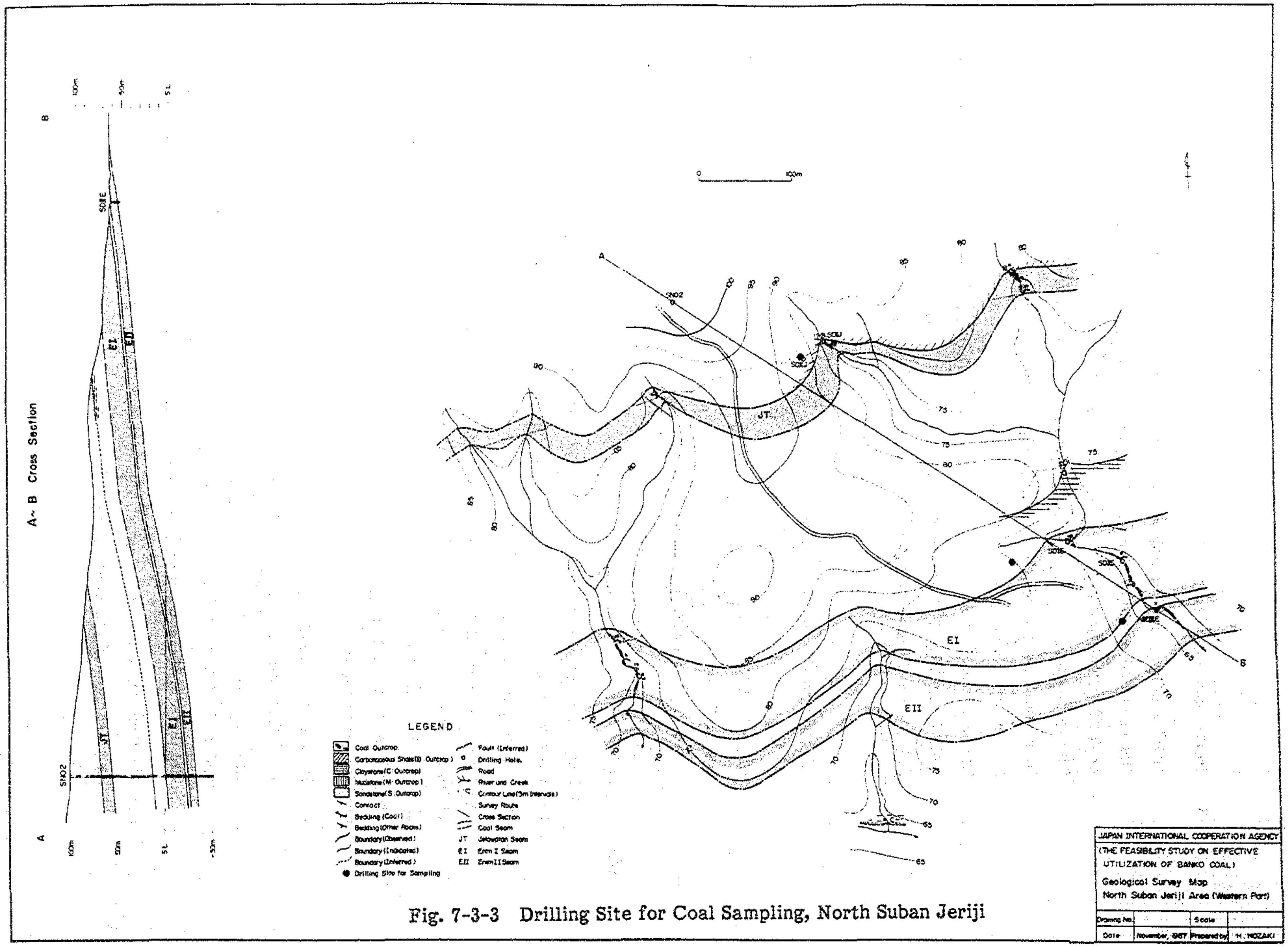


Fig. 7-3-3 Drilling Site for Coal Sampling, North Suban Jeriji

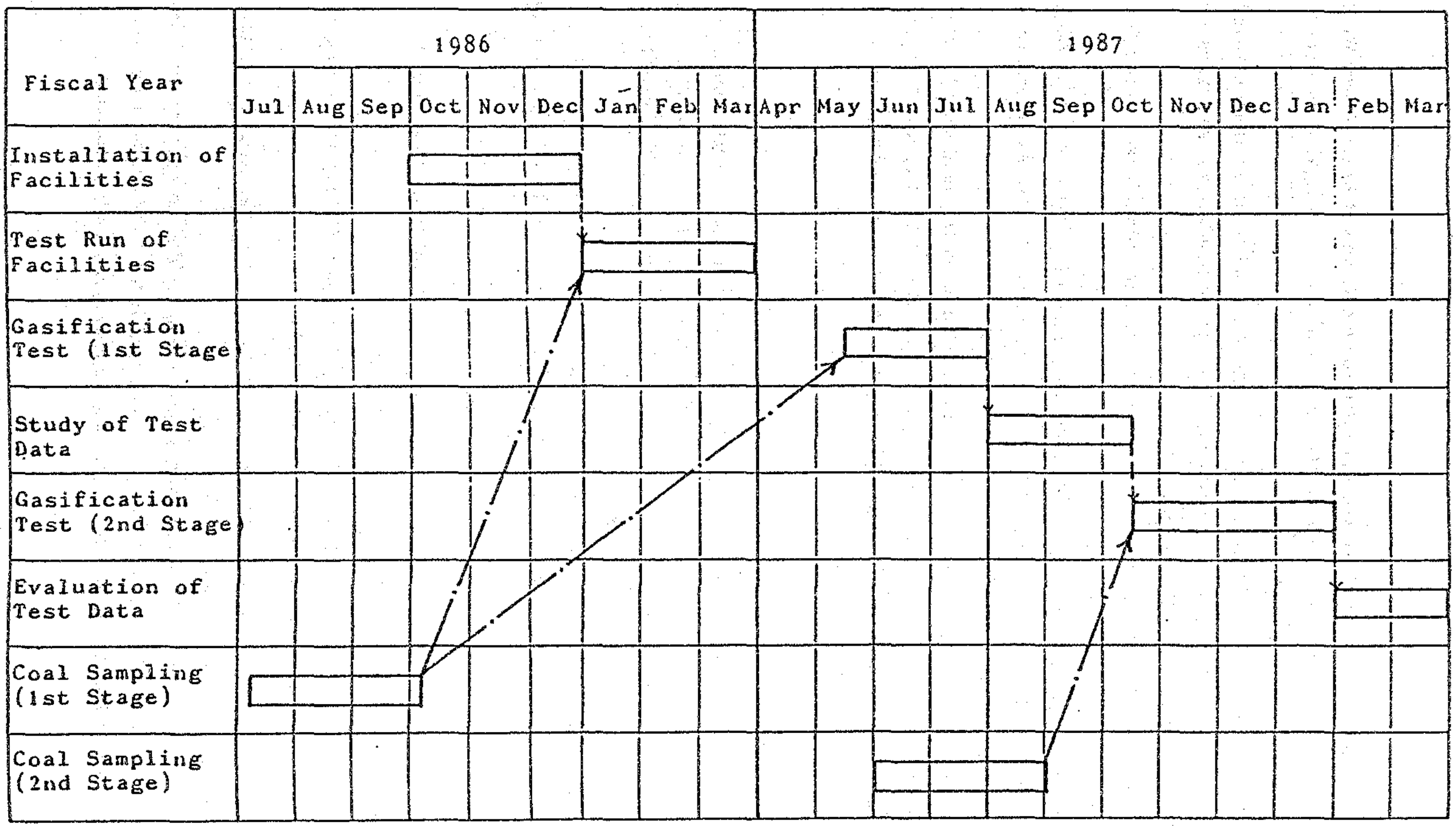


Fig. 7-3-4 Timeschedule of Coal Gasification Test and Sampling

Coal sampling in the first phase were decided to be carried out in the North West Banko area in FY1986/87, because the area had been investigated in detaild among the area to be studied.

The West Banko, the East Suban Jeriji and the West Suban Jeriji were omitted from coal sampling area, considering geological survey results and reconnaisance results carried out until the present.

The West Central Banko area also was given up trying to obtain bulk coal samples because of lack of access road.

Coal samples obtained from the North West Banko area in FY1986/87, then, from the Central Banko area and the North Suban Jeriji area in FY1987/88 are shown in Table 7-3-1 and Table 7-3-2).

Moreover, coal samples were obtained in the Arahan area (A_1 coal seam) and in the Banjarsari area (Enim 2 coal seam) by pitting, and collected in the stockyard of Bukit Asam Coal Mine (Air Laya Pit, A_2 coal seam) to compare gasifiability with those of coal in Banko area.

(3) Coal Analysis

All the works related with coal analysis (proximate, ultimate and ash component analysis) were the Indonesian portion and carried out by the hands of staffs of PPTM at the laboratory of PPTM or LSDE at Serpong using LECO apparatuses prepared by JICA (see Table 7-3-3)

There was differences in opinion about drying procedure of coal sample in the air between the Japanese survey team and the chemists of PPTM, which has an influence on ultimate analysis results.

The both parties discussed the matter mutually, based on

i) Standard Method of Laboratory Sampling and Analysis of Coal and Coke (American National Standard K18.1)

ii) Method for Proximate Analysis of Coal and Coke (JIS, M8812) and Method of Ultimate Analysis of Coal and Coke (JIS M8813)

iii) Method for the Analysis and Testing of Coal and Coke, part 6-Ultimate Analysis of Coal, (Australian Standard)

Prepared by the JICA survey team, and then, decided to do coal analyses again in FY1987/88 on coal samples to be gasified, by the hands of chemists sent by PPTM in Bandung, or at Serpong, following Australian Standard.

Table 7-3-1 Summary of Coal Sampling Data

Year	Area		Coal seam	Hole No.	Drilled or dug length (M): Overburden rock	Drilled or dug length (M): Coal	Drilled or dug length (M): Total	Coal recovered (M)	Core recovery (%)	Weight of coal sample (kg)	Sampling method
FY 1976/77	North West Banko	Northern part	A_1	1	4.14	6.26	10.40	4.79	76.5	40.20	Coring
				2	4.35	6.00	10.35	6.00	100.0	47.20	
				3	4.65	6.00	10.65	6.00	100.0	52.00	
				4	4.60	6.10	10.70	6.10	100.0	54.00	
				5	4.70	6.00	10.70	6.00	100.0	48.30	
				Sub-total	22.44	30.36	52.80	28.89	95.2	241.70	
			A_2*1	1	10.40	11.55	21.95	11.55	100.0	95.00	Coring
				2	9.75	11.60	21.35	9.90	85.3	94.70	
				Sub-total	20.15	23.15	43.30	21.45	92.7	189.70	
			B_1	1	5.50	4.80	10.30	4.80	100.0	25.00	Coring
				2	5.00	4.80	9.80	4.80	100.0	29.90	
				3	4.70	5.00	9.70	5.00	100.0	27.00	
				4	4.80	4.90	9.70	4.60	93.9	24.00	
				5	4.77	5.08	9.85	4.60	90.6	27.00	
				6	5.65	4.80	10.45	3.70	77.1	24.50	
				7	5.40	4.80	10.20	3.70	77.1	24.90	
				8	5.20	4.80	10.00	3.60	75.0	22.50	
				Sub-total	41.02	38.98	80.00	34.80	89.3	204.80	
			B_2	1	6.00	-	6.00	-	-	-	Coring
				2	2.85	3.35	6.25	1.80	53.8	14.00	
				1'	-	2.00	2.00	2.00	-	120.00	Pitting
				2'	-	2.00	2.00	2.00	-	120.00	
				Sub-total	8.85	7.35	16.20	5.80	-	254.00	
			C	1	-	2.00	2.00	2.00	-	130.00	Pitting
				2	-	2.00	2.00	2.00	-	106.00	
				Sub-total	-	4.00	4.00	4.00	-	236.00	
		Total			92.40	103.84	196.30	94.94	90.7	1,126.20	
		Southern part	A_1	1	4.26	12.44	16.70	12.44	100.0	104.45	Coring
				2	4.56	12.22	16.78	12.22	100.0	103.15	
				Sub-total	8.82	24.66	33.48	24.66	100.0	207.60	
			A_2	1	4.79	9.87	14.66	7.70	78.0	52.30	Coring
				2	4.45	10.60	15.05	8.25	77.8	53.30	
				3	3.99	10.41	14.40	8.80	84.5	51.50	
				4	5.05	10.50	15.55	8.70	82.9	49.40	
				1'	14.00	-	14.00	-	-	-	
				2'	13.00	-	13.00	-	-	-	
				Sub-total	45.28	41.38	86.66	33.45	80.8	206.50	
			B_1 + B_2	1	6.15	13.35	19.50	11.88	89.0	113.00	Coring
				2	4.15	13.35	17.50	13.35	100.0	127.00	
				3	3.95	13.35	17.30	12.75	95.5	123.00	
				4	3.80	12.95	16.75	12.95	100.0	118.50	
				Sub-total	18.05	53.00	71.05	50.93	96.1	481.50	
			C	1	-	2.00	2.00	2.00	-	79.00	Pitting
				2	-	2.00	2.00	2.00	-	78.00	
				3	-	2.00	2.00	2.00	-	57.00	
				Sub-total		6.00	6.00	6.00	-	214.00	
	Total				72.15	125.04	197.19	115.04	91.6	1,109.60	
	Ground total				164.61	228.88	393.49	209.98	91.2	2,235.80	

(Note 1) Samples of A_2 coal seam were obtained by boreholes for A_1 coal seam after extending and penetrating into A_2 coal seam.

Table 7-3-2 Summary of Coal Sampling Data

Year	Area	Coal seam	Hole No.	Drilled length (m) Overburden rock	Coal	Total	Coal recovered (m)	Core recovery (%)	Weight of coal weight (kg)	Sampling method
FY 1987/88	North Suban Jeriji	Jelawatan	1	4.65	8.40	13.05	8.40	100.0	61.50	Coring
			2	4.65	8.10	12.75	8.10	100.0	62.50	
			Sub-total	9.30	16.50	25.80	16.50	100.0	124.00	
		Enim 1	1	6.25	20.00	26.25	19.90	100.0	137.30	Coring
			Sub-total	6.25	20.00	26.25	19.90	100.0	137.30	
		Enim 2	1	4.10	8.05	12.15	7.10	88.2	60.00	Coring
			2	4.10	8.05	12.15	6.35	78.9	60.00	
			Sub-total	8.20	16.10	24.30	13.45	83.5	120.00	
			Total	23.75	52.60	76.35	49.85	94.8	381.30	
	Central Banko	A_1	1	3.45	12.85	16.30	11.35	88.3	112.50	Coring
			Sub-total	3.45	12.85	16.30	11.35	88.3	112.50	
		A_2	1	0.75	5.40	6.15	3.80	70.4	31.50	Coring
			2	1.80	6.30	8.10	5.00	79.4	42.00	
			3	1.66	5.74	7.40	4.40	76.3	33.50	
			Sub-total	4.21	17.44	21.65	13.20	75.7	107.00	
		B_1	1	3.40	13.70	17.10	14.70	100.0	124.50	Coring
			Sub-total	3.40	13.70	17.10	14.70	100.0	124.50	
		B_2	1	4.30	5.30	9.60	5.30	100.0	40.00	Coring
			2	4.30	5.40	9.70	5.30	98.1	43.00	
			3	4.80	4.90	9.70	4.80	98.1	41.00	
			Sub-total	13.40	15.60	29.00	15.40	98.8	124.00	
		C	1	17.10	8.60	25.70	8.60	100.0	68.50	Coring
			2	17.10	8.60	25.70	6.90	80.4	59.00	
			Sub-total	34.20	17.20	51.40	15.50	90.1	127.50	
			Total	58.66	76.79	135.45	70.15	91.4	595.50	
	Arahan (A_2 coal seam)								130.00	Pitting
	Banjarsari (Enim 2 coal seam)								130.00	Pitting
	Air Laya (A_2 coal seam)								130.00	Stockyard
	Grand total			82.41	129.39	211.80	-	-	1,366.80	

Table 7-3-3 Summary of Coal Analysis Performance

Grouping	Year	Analyzed at	Coal samples obtained by
Proximate analysis	FY1985/86	laboratory of PPTM	coring (shallow hole) (1)
	FY1986/87	LSDF at Serpong and laboratory of PPTM	coring (large diameter) (2) and pitting (3)
	FY1987/88	LSDF at Serpong	(2) and (3)
Ultimate analysis	FY1985/86	laboratory of PPTM	(1)
	FY1986/87	LSDE at Serpong and laboratory of PPTM	(2) and (3)
	FY1987/88	LSDE at Serpong	- do -
Ash component analysis	FY1985/86	laboratory of PPTM	(1)
	FY1987/88	- do -	(2) and (3)
	FY1987/88	- do -	- do -

Coal analyses results carried out in FY1987/88 are shown in Table 7-3-4, Table 7-3-5, and Table 7-3-6.

Pulvisized and dried coal sample were analysed again three days before blowing into the furnace.

(4) Spontaneous Combustion Test

The tests were carried out in the old test mining pit (B_1 coal seam) excavated by Shell in Central Banko, building two coal heaps (the height : 2 meters, the base area : 6.70 m^2) (see Fig. 7-3-5 and Fig. 7-3-8)

Dug fresh coal, after taking away 1.5 meters thickness of coal from the surface was used to make two coal heaps.

The change of temperature within the coal heaps was observed, covering about one month.

The observation results were shown in Fig. 7-3-6, Fig. 7-3-7 (No. 1 coal heap) and Fig. 7-3-8 (No. 2 coal heap). Fig. 7-3-9 and Fig. 7-3-10 show isothermal line of the inside of the coal heap every 5 meters at the beginning and in the middle of temperature observatjon.

Table 7-3-4 Coal Re-analysis Results of Coal Samples Obtained in FY1986/87

Sample No.	Remarks	Proximate Analysis (%)					Calorific Value (Cal./gr)	Total S (%)	Ultimate Analysis (%)				Sampling place
		Total moisture	Moisture	Ash	V.M.	F.C.			C	H	N	O	
BU1 A_1 and BU2 A_1	a.m.	23.18	21.85	5.52	35.10	37.53	(4670) average	0.43	55.73	6.77	0.93	30.62	North West Banko
	d.b.			7.06	44.92	48.02	of BU A_1	0.55	71.31	5.55	1.19	14.34	Northern Part
	d.a.f.				48.33	51.67		0.59	76.73	5.97	1.28	15.43	A_1 seam
BU1 A_2 and BU2 A_2	a.m.	28.05	23.85	2.51	35.09	38.55	(4906)	0.18	55.90	7.09	0.79	33.53	
	d.b.			3.29	46.08	50.63	average of	0.24	73.41	5.83	1.04	16.19	- do -
	d.a.f.				47.64	52.36	BU A_2	0.25	75.91	6.03	1.08	16.73	A_2 seam
BU2 B_1 BU4 B_1 and BU5 B_1	a.m.	31.60	23.32	31.3	35.21	38.34	(4445) average	0.70	53.84	6.78	0.88	34.67	
	d.b.			4.08	45.92	50.00	of BU B_1	0.91	70.21	5.46	1.15	18.19	- do -
	d.a.f.				47.87	52.13		0.95	73.19	5.69	1.20	18.97	B_1 seam
BU3 B_2	a.m.	26.64	25.45	1.71	35.47	37.37	(4407) BU2 B_2	1.24	53.25	7.06	0.91	35.83	
	d.b.			2.29	47.58	50.13		1.66	71.43	5.67	1.22	17.73	- do -
	d.a.f.				48.70	51.30		1.70	73.10	5.80	1.25	18.15	B_2 seam
BU2 C	a.m.	25.84	20.85	1.50	36.44	41.24	(5019)	0.35	57.84	6.54	10.5	32.72	
	d.b.			1.90	46.04	52.06	average	0.44	73.08	5.33	1.33	17.92	- do -
	d.a.f.				45.93	53.07	of BU C	0.45	74.50	5.43	1.36	18.26	C seam
BS1 A_1 and BS2 A_1	a.m.	28.25	22.00	3.35	36.37	38.28	(4729) average	0.53	54.60	6.71	0.85	33.96	North West Banko
	d.b.			4.29	46.63	49.08	of BS1 and BS2	0.68	69.99	5.47	1.09	18.48	Southern Part
	d.a.f.				48.72	51.28		0.71	73.13	5.72	1.14	19.30	A_1 seam
BS2 A_2	a.m.	29.73	24.18	3.41	34.59	37.82	(4909)	0.15	54.83	6.94	0.84	33.83	
	d.b.			4.50	45.62	49.88	average	0.20	72.32	5.61	1.11	16.26	- do -
	d.a.f.				47.77	52.23	of B5 A_2	0.21	75.73	5.87	1.16	17.03	A_2 seam
BS4 B	a.m.	28.11	22.32	3.49	36.70	37.49	(4168)	0.20	54.25	6.74	0.84	34.48	- do -
	a.b.			4.49	47.25	48.26	average	0.26	69.84	5.48	1.08	18.85	combined
	d.a.f.				49.47	50.53	of B5 B	0.27	73.12	5.74	1.13	19.74	B seam
BS1 C	a.m.	23.30	22.25	2.07	36.50	39.18	(5082)	0.45	57.84	6.89	1.06	33.53	
	d.b.			2.65	46.95	50.40	average	0.58	74.39	5.68	1.36	16.19	- do -
	d.a.f.				48.23	51.77	of BS C	0.60	76.41	5.83	1.40	16.73	C seam

(Note 1) Moisture shows moisture as received.

(Note 2) a.m., d.b. and d.a.f. are abbreviation for as mined, dry-basis and dry-ash-free, respectively.

(Note 3) Calorific values are analyses results in FY1986/87.

(Note 4) BU (or S) 1, A_1 of BU1 A_1 means Banko, Northern (or Southern) Part, Hole No. and name of coal seam.

Table 7-3-5 Coal Analysis Results of Coal Samples Obtained in FY1987/88

Sample No.	Remarks	Proximate Analysis (%)					Calorific Value (Cal./gr)	Total S (%)	Ultimate Analysis (%)				Sampling place
		Total moisture	Moisture	Ash	V.M.	F.C.			C	H	N	O	
CB A_1	a.m.	33.44	24.71	12.82	32.17	30.30	3754	1.07	43.48	6.35	0.70	35.58	Central
	d.b.			17.03	42.73	40.24		1.42	57.75	4.78	0.93	18.09	Banko
	d.a.f.				51.50	48.50		1.71	69.60	5.76	1.12	21.81	
CB A_2	a.m.	34.39	22.69	8.46	34.80	34.05	4273	0.24	49.27	6.46	0.80	34.77	- do -
	d.b.			10.91	45.01	44.05		0.31	63.73	5.10	1.03	18.89	
	d.a.f.				50.54	49.46		0.35	71.56	5.73	1.16	21.20	
CB B_1	a.m.	35.78	28.19	4.16	33.84	33.81	4219	0.24	48.59	7.07	0.86	39.08	
	d.b.			5.79	47.12	47.09		0.33	67.66	5.49	1.20	19.53	- do -
	d.a.f.				54.02	49.98		0.35	71.82	5.83	1.27	20.73	
CB B_2	a.m.	35.52	27.34	4.33	33.53	34.80	4307	0.25	49.93	6.96	0.85	37.68	
	d.b.			5.96	46.15	47.89		0.34	68.72	5.39	1.17	18.42	- do -
	d.a.f.				49.07	50.93		0.36	73.08	5.73	1.24	19.59	
CB C	a.m.	37.52	31.10	4.24	32.44	32.22	4018	0.24	46.70	726	0.96	40.60	
	d.b.			6.15	47.08	46.77		0.35	67.78	5.52	1.39	18.81	- do -
	d.a.f.				50.17	49.83		0.37	72.22	5.88	1.48	20.05	
SJ J	a.m.	42.33	29.80	8.39	33.19	28.62	3553	0.16	41.92	6.81	0.65	42.07	North Suban Jeriji
	d.b.			11.95	47.28	40.77		0.23	59.72	4.99	0.93	22.18	Jelawatan
	d.a.f.				53.70	46.30		0.26	67.83	5.67	1.06	25.18	coal seam
SJ E_1	d.a.b.	41.88	24.00	5.69	38.76	31.55	4289	0.17	49.44	6.82	0.72	37.16	North Suban Jeriji
	d.b.			7.49	51.00	41.51		0.22	65.05	5.46	0.95	20.83	Enim 1
	d.a.f.				55.13	44.87		0.24	70.32	5.90	1.03	22.51	coal seam
SJ E_2	d.a.b.	43.12	28.30	1.92	35.96	33.82	4187	0.12	49.13	6.96	0.77	41.10	North Suban Jeriji
	d.b.			2.68	50.15	47.17		0.17	68.52	5.33	1.07	22.23	Enim 2
	d.a.f.				51.53	48.47		0.17	70.41	5.48	1.10	22.84	coal seam
BJS E_2	d.a.b.	43.96	36.28	2.70	31.84	29.18	3502	0.32	41.81	7.50	0.70	46.97	Banjarsari
	d.b.			4.24	49.97	45.79		0.50	65.62	5.44	1.10	23.10	E_2 coal seam
	d.a.f.				52.18	47.82		0.52	68.52	5.68	1.15	24.13	
AR A_2	d.a.b.	36.13	29.76	1.58	33.71	34.95	4211	1.54	48.84	7.14	0.70	40.20	Arahan
	d.b.			2.25	47.99	49.76		2.19	69.53	5.45	0.99	19.59	A_2 coal seam
	d.a.f.				49.09	50.91		2.24	71.13	5.58	1.01	20.04	
AL A_2	d.a.b.	21.47	18.20	12.37	34.28	35.15	4697	1.58	50.80	6.27	0.84	28.14	Bkit Asam Coal Mine
	d.b.			15.12	41.91	42.97		1.93	62.10	5.19	1.03	14.63	Air Laya Pit
	d.a.f.				49.38	50.62		2.27	73.16	6.11	1.21	17.25	A_2 coal seam

Table 7-3-6 Ash Component Analysis Results of Coal Samples

Sample No.	5%										Ash (%) a.d.b.
	SiO_2	Al_2O_3	Fe_2O_3	TiO_2	CaO	MgO	K_2O	Na_2O	SO_3	P_2O_5	
BU1 A_1 and BU2 A_2	67.00	18.45	7.40	0.56	1.08	0.15	0.39	0.10	1.52	0.02	
BU1 A_2 and BU2 A_2	48.40	20.27	6.47	1.16	7.04	2.71	0.34	0.78	7.44	0.71	
BU2 B_1 BU4 B_1 and BU5 B_1	59.90	18.90	4.42	0.56	5.30	1.75	0.20	0.30	4.86	0.16	
BU3 B_2	41.50	36.99	7.07	3.06	1.76	0.58	0.47	0.23	0.44	0.03	
BU2 C	49.70	36.24	7.21	1.65	1.14	0.30	0.11	0.19	0.92	0.16	
BS1 A_1 and BS2 A_1	57.30	23.89	8.64	0.74	2.44	1.02	0.64	0.13	2.42	0.06	
BS2 A_2	64.60	8.58	5.92	0.48	6.64	1.93	0.18	1.78	5.98	0.44	
BS4 B	38.60	28.54	3.94	1.06	12.73	4.28	0.26	1.84	5.96	0.04	
BS1 C	61.10	7.41	6.41	0.36	7.33	2.95	0.07	0.24	8.33	0.09	
CB A_1	52.00	24.21	6.12	0.95	3.61	1.63	2.37	0.74	4.31	0.03	
CB A_2	73.70	13.65	2.89	0.55	2.79	0.66	0.64	0.43	2.99	0.02	
CB B_1	53.52	24.21	4.22	0.97	5.19	1.76	0.25	0.30	5.99	0.39	
CB B_2	69.60	13.47	4.41	0.54	3.02	1.22	0.14	0.06	3.88	0.13	
CB C	41.80	24.80	6.53	0.95	9.84	4.19	0.23	0.17	6.75	0.44	
SJ J	56.70	23.62	5.27	1.38	3.57	0.92	0.37	0.08	3.38	0.05	
SJ E_1	59.20	28.64	2.86	1.31	2.11	0.50	0.19	0.07	0.05	1.31	
SJ E_2	62.60	22.24	5.22	1.07	1.49	0.42	0.25	0.04	1.66	0.03	
BJS E_2	17.10	11.90	28.67	0.94	14.89	2.51	0.35	0.41	17.59	0.02	
AR A_2	9.90	13.82	14.02	0.72	35.64	13.51	0.08	0.10	10.31	0.01	
AL A_2	55.20	27.56	6.82	0.90	1.64	1.39	1.28	1.81	1.52	0.02	

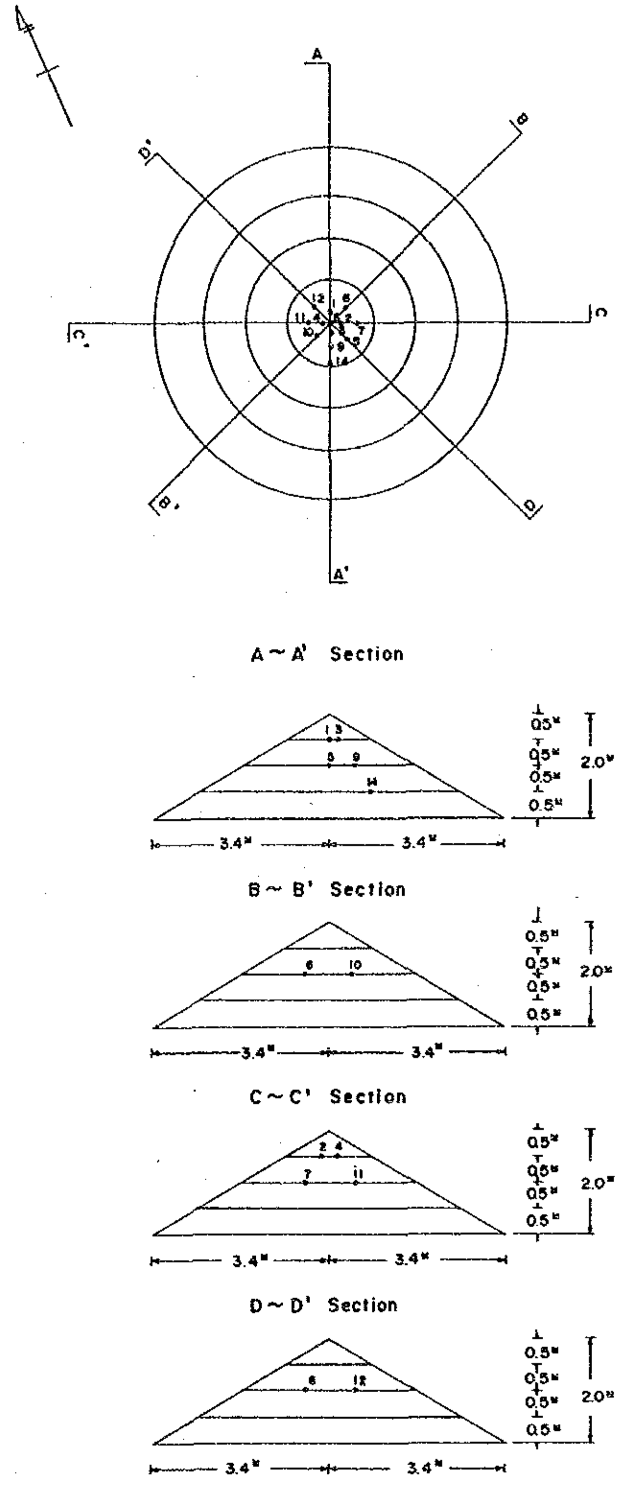


Fig. 7-3-5 Horizontal and Vertical Section of No. 1 Coal Heap for Spontaneous Combustion Test showing Thermometers Installed Position.

Fig. 7-3-6 Change of Measured Temperature at each Point (No. 1 Coal Heap)

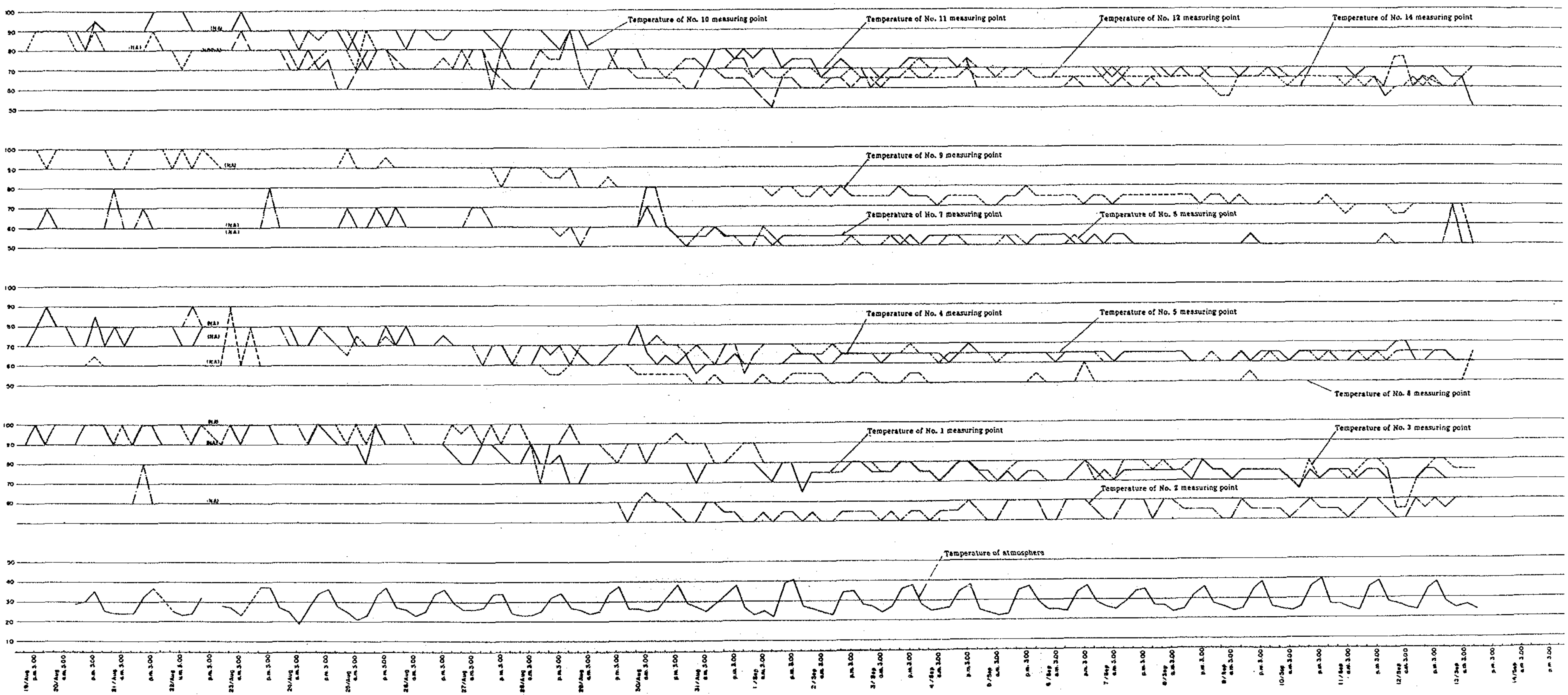
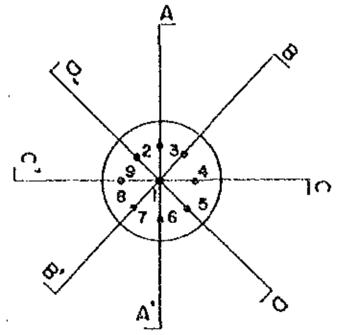
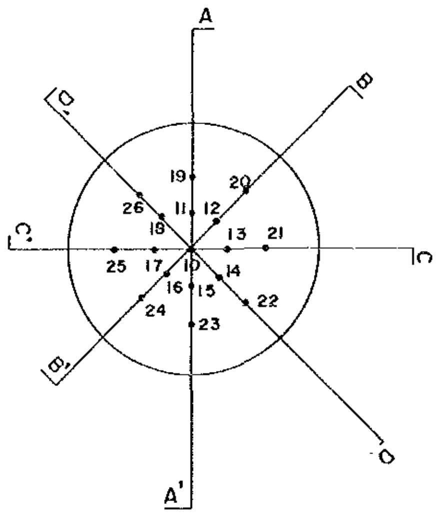


Fig. 7-3-7 Final Measured Temperature (No. 1 Coal Heap)

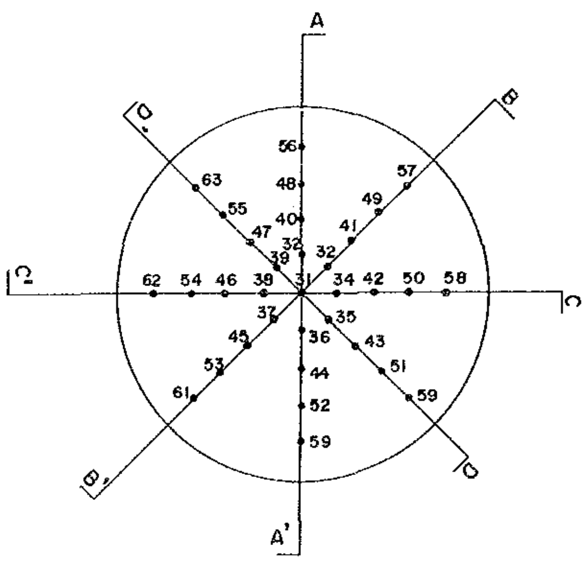
Below 0.5 meters from the top



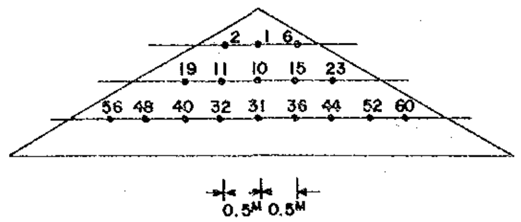
Below 10 meters from the top



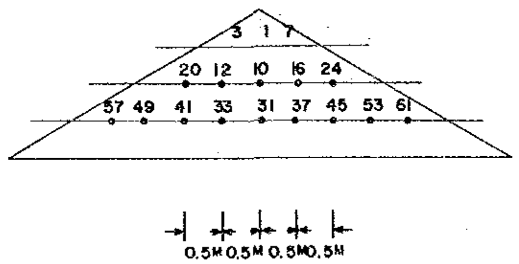
Below 15 meters from the top



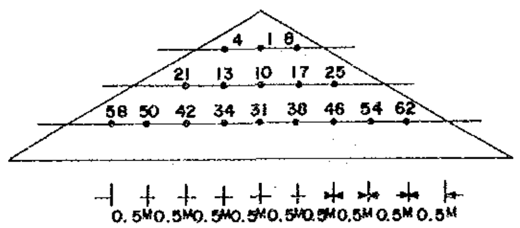
A ~ A' Section



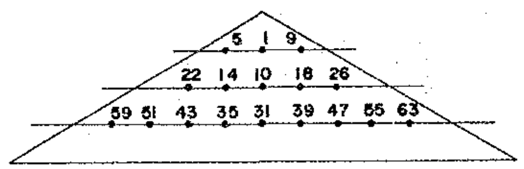
B ~ B' Section



C ~ C' Section



D ~ D' Section



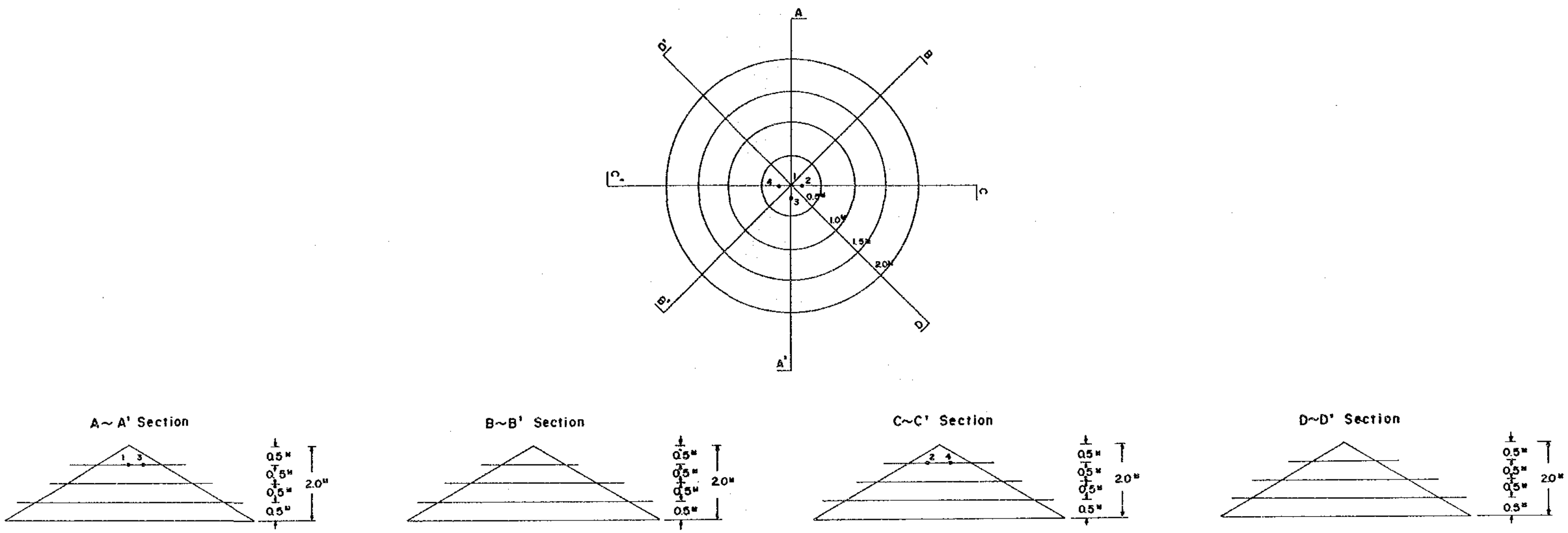
Level	Measuring point	Temperature °C -10cm*	-40cm*
0.5 m level	1	65	75
	2	50	55
	3	55	60
	4	50	50
	5	50	55
	6	60	65
	7	60	65
	8	50	60
	9	55	55

Level	Measuring point	Temperature -10cm* °C
10 m level	10	80
	11	55
	12	55
	13	50
	14	50
	15	60
	16	65
	17	60
	18	50
	19	50
	20	50
	21	45
	22	50
	23	55
	24	50
	26	50
	23	40

Level	Measuring point	Temperature °C -10cm*	-40cm*
1.5 m level	31	70	65
	32	60	60
	33	65	60
	34	60	60
	35	60	60
	36	70	75
	37	70	65
	38	70	50
	39	60	65
	40	60	60
	41	60	60
	42	60	55
	43	60	60
	44	60	60
	45	60	60
	46	65	50
	47	50	55
	48	55	50
	49	50	55
	50	50	50
	51	50	55
	52	60	55
	53	60	60
	54	50	
	55	50	55
	56	50	
	57	60	?
	58	45	
	59	45	
	60	55	
	61	60	?
	62	45	
	63	50	

(Note) * shows measured depth

Fig. 7-3-8 Horizontal and Vertical Section of No. 2 Coal Heap for Spontaneous Combustion Test showing Thermometers Installed Position and Observation Results



Change of measured temperature at each point (No. 2 coal heap)

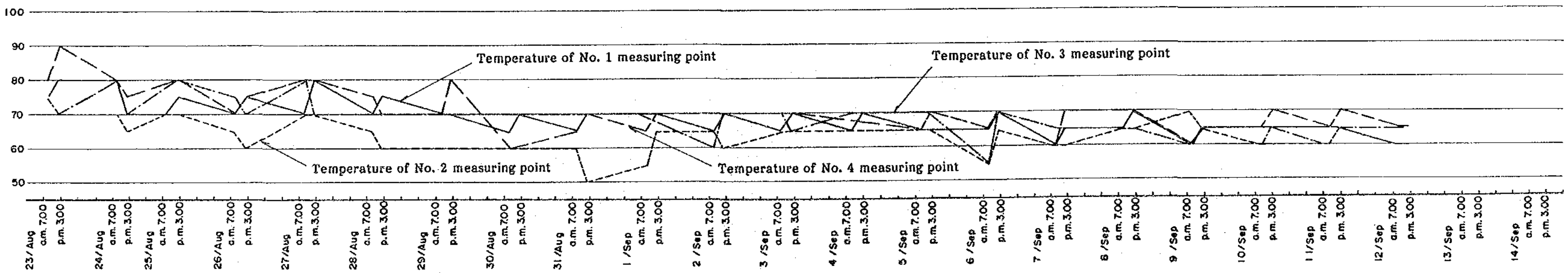
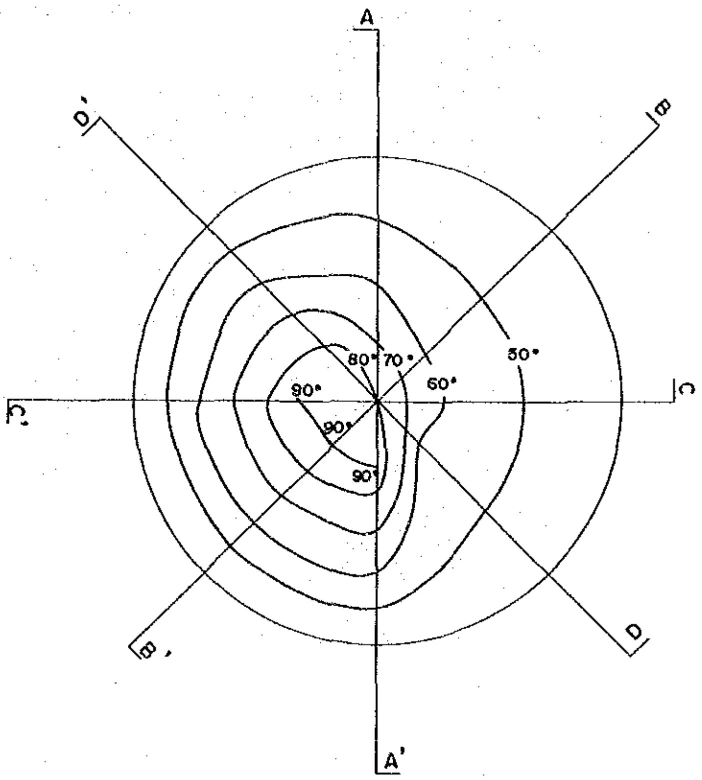
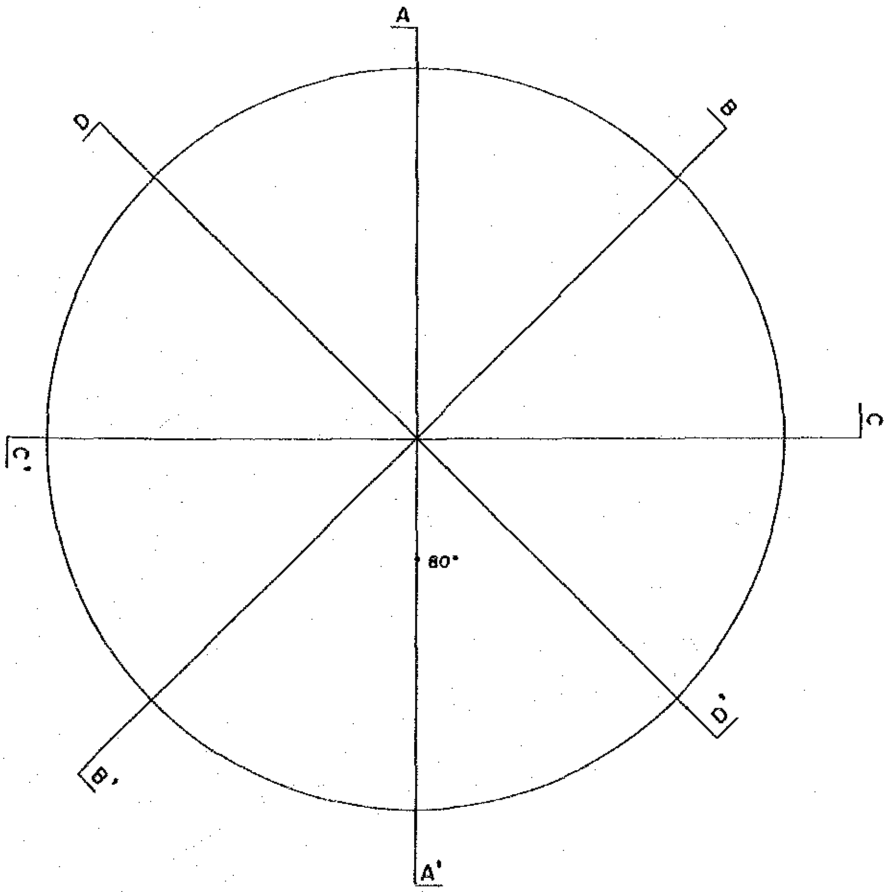


Fig. 7-3-9 Isothermal Line of the Inside of No. 1 Coal Heap at PM 7:00 on 22 August 1987 (1) Horizontal Section

Below 10 meters from the top



Below 15 metes from the top Below



Below 5 meters from the top

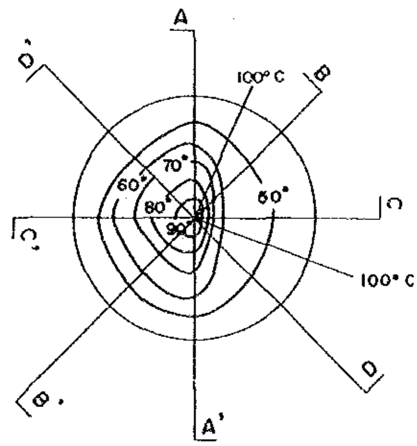
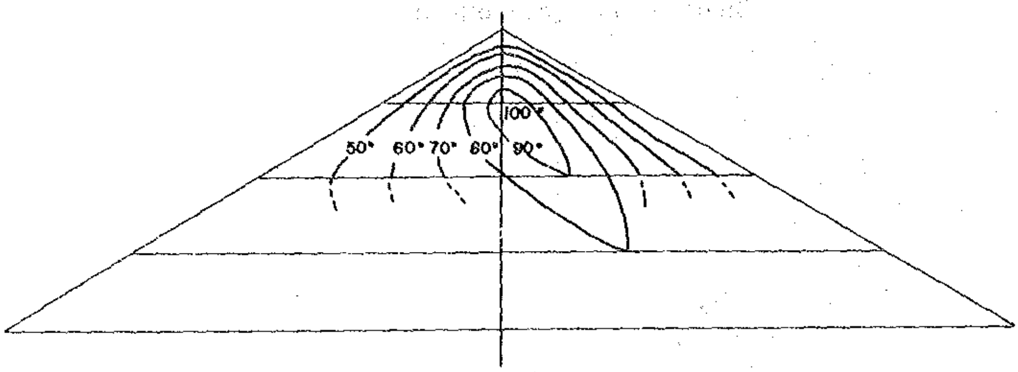
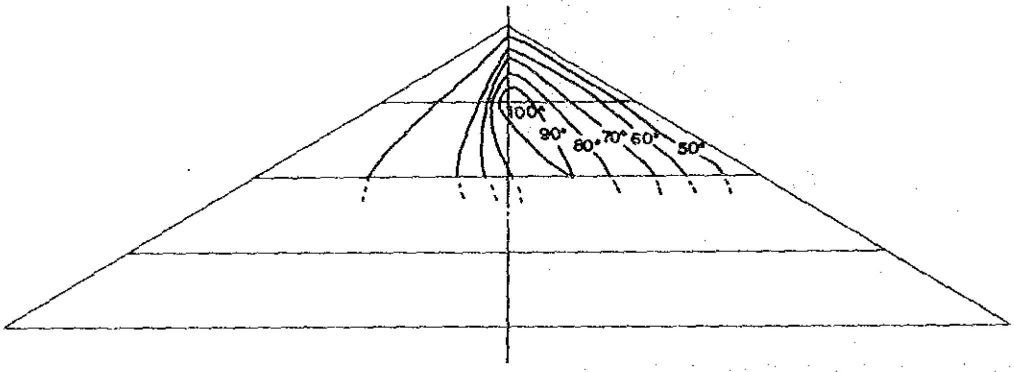


Fig. 7-3-9 Isothermal Line of the Inside of No. 1 Coal Heap at PM 7:00 on 22 August 1987 (2)
Vertical Section

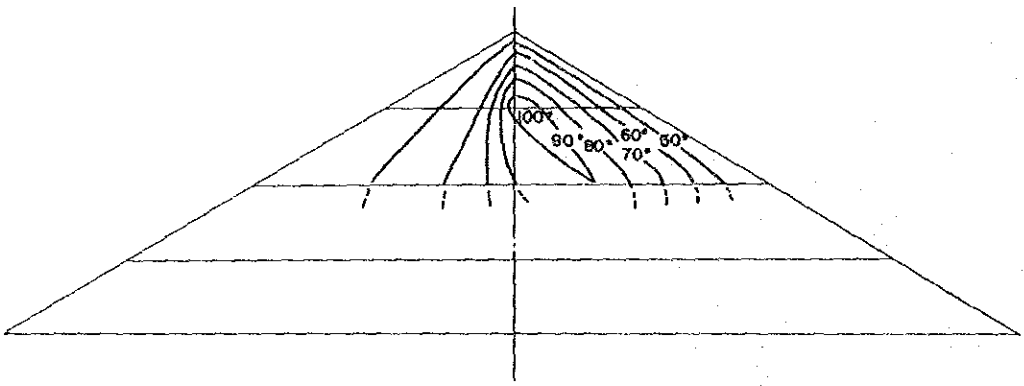
A ~ A' Section



B ~ B' Section



C ~ C' Section



D ~ D' Section

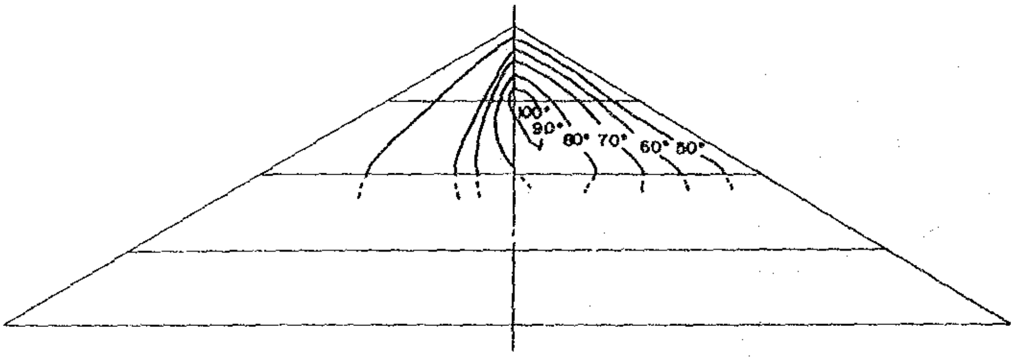
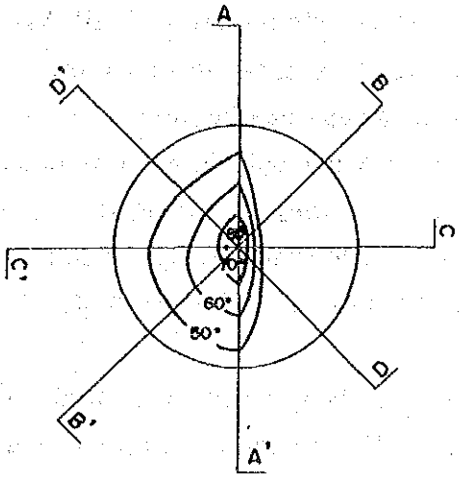
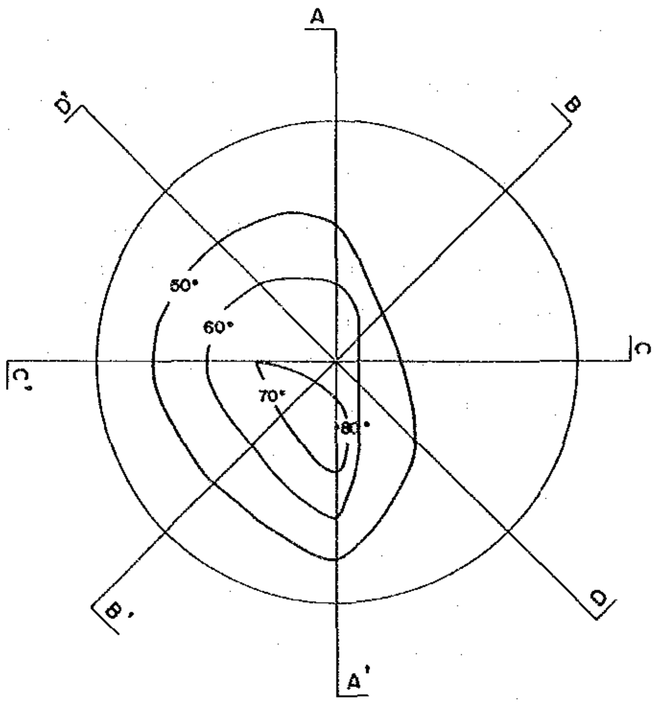


Fig. 7-3-10 Isothermal Line of the inside of No. 1 Coal Heap at AM 11:00 on 2 September 1987
Horizontal Section

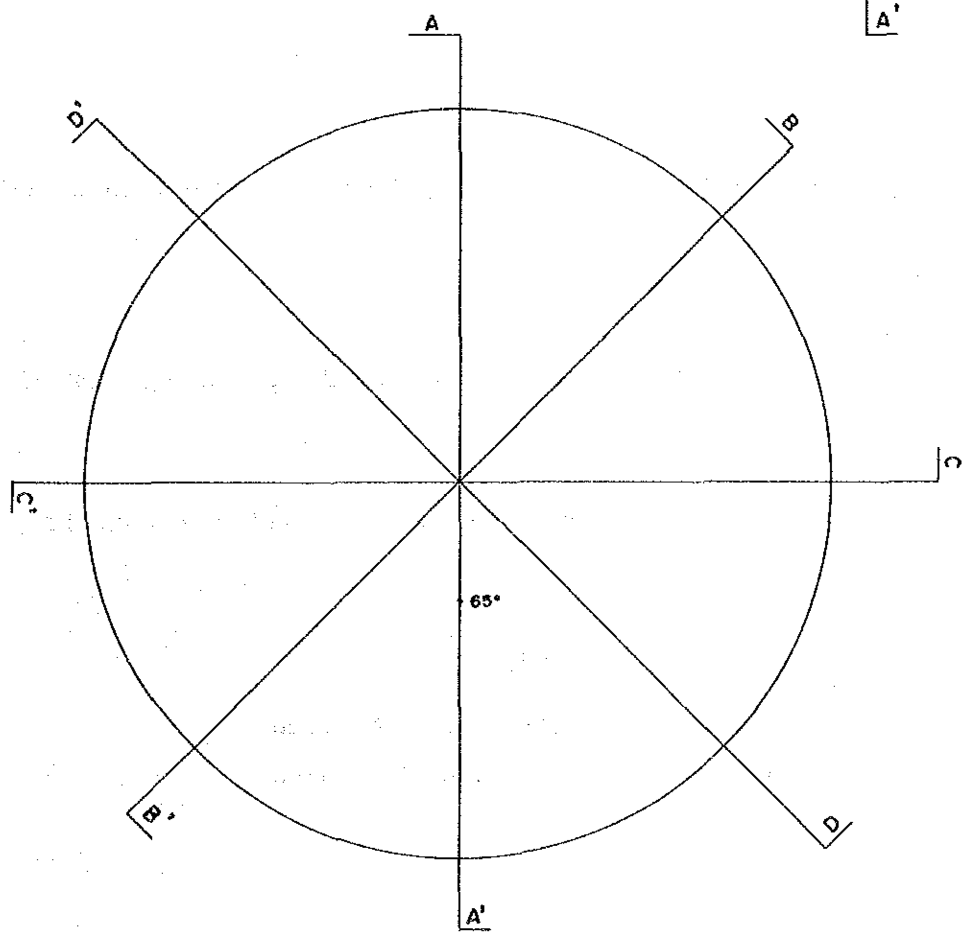
Below 5 meters from the top



Below 10 meters from the top



Below 15 metes from the top



Spontaneous combustion in strict sense was not brought about, unfortunately, however, phenomena of sudden temperature rising (the highest temperature was 100°C), fuming and stinking were observed.

115°C of the maximum temperature was observed at the stockyard of Bukit Asam Coal Mine on the test which was entrusted to the safety department of PTBA.

The Indonesian counterparts understand that spontaneous combustion is a quite important matter that they can not afford to overlook not only in case of Banko coal but all coal within South Sumatra region, therefore they appraised the above mentioned test results which was the first time to be held such a test in Indonesia, and desired earnestly to continue the test in the next fiscal year under the cooperation of JICA.

It seems that heating, fuming and stinking at the coal heap within the stockyard come to happen frequently in the rainy season according to the resident manager of Bukit Asam Coal Mine.

Water contents in coal heap may perform an important role on spontaneous combustion and it may be affected by the direction and velocity of the wind.

When spontaneous combustion will be carried out in the next fiscal year, the following apparatuses shall be procured and the following respects shall be taken into consideration.

i) List of apparatuses to be procured

- a) Thermometers which length (including lead) are more than 6 meters (max. 500°C)
- b) A wind direction indicator
- c) An anemometer
- d) A hygrometer and a thermometer (or a wet and dry bulb hygrometer)
- f) A rain guage
- g) An instrument shelter
- h) A water content measuring apparatus inside of the coal heap (if available)

ii) Respects to be taken into consideration

- a) The test shall be carried out during the rainy season.
- b) The height of coal heaps shall be around 6 meters.

c) The coal heap shall be built, mixing fine coal and coal boulder (maximum size : 30 cm x 30 cm x 30 cm)

d) Steel pipes or plastic pipes shall be installed in the coal heaps, in advance to insert thermometers into the coal heaps.

f) The observation shall be continued for three months at least (if possible for 6 months).

8. RESULTS OF BANKO COAL GASIFICATION TEST

8-1 COAL GASIFICATION TEST FACILITIES

8-1-1 Introduction

Molten iron bath process was selected for coal gasification test facilities on the base of the conclusion obtained by the study of the 1st stage.

The basic design was carried out on the basis of the concept of the test facilities designed on the Scorp of Work.

The concept is as follows:

i) Capacity: Approximately 20 kg/hr as coal sufficient capacity necessary to grasp characteristics of gasification of brown coal

ii) Test facilities:
- Pretreatment unit of coal
- Gasification unit
- Post-treatment unit of produced gas
- Analysis equipment
- Utilities supply facilities
- Civil and architecture related above facilities
- Disposed treatment system, if necessary

8-1-2 Design on Coal Gasification Test Facilities

(1) Design Condition

1) Location

The facilities are constructed in the Pilot-Plant Building in PUSPIPTEK, Serpong, Jakarta, the Republic of Indonesia in accordance to the agreement on Scope of Work.

2) Capacity

The facilities have a capacity to generate minimum 40 Nm^3/h of produced gas, corresponding to minimum 20 kg/h feeding rate of pulverized coal, in order to make an accurate analysis of product gas component by minimizing the external disturbance.

Therefore the capacity of the test facilities is designed as follows:

1) maximum feeding rate of coal is 40 kg/h
2) normal feeding rate of coal is 30 kg/h
3) minimum feeding rate of coal is 20 kg/h

3) Other Design Conditions

The other design conditions such as climate data, materials, wastes and utilities are shown in Table 8-1-1.

(2) Process Flow Diagram of Coal Gasification Test Facilities

Process flow diagram and engineering flow diagram of test facilities are shown in Fig. 8-1-1 and Fig. 8-1-2.

(3) General Layout

The major test facilities are installed inside of the Pilot-Plant building in PUSPIPTEK as shown in Fig. 8-1-3 and Fig. 8-1-4.
On the other hand, the some utility equipments such as water cooling tower and a flare stack are constructed outside of the building.

(4) Description and Specification of Coal Gasification Test Facilities

1) Coal Drying System

100 kg of raw coal having 35% moisture is dried in a chassis-typed dryer until its moisture content is reduced down to 5% in approximately one hour.
After that, the dried coal is charged to a hopper of the coal pulverizer.

2) Coal Pulverize and Coal Injection System

A coal pulverize and coal injection system is composed of a coal pulverizer and a coal injector.
After charging to the hopper, the dried coal is pulverized into 0.074 mm particle in a hammer-typed pulverizer and the pulverized coal is gathered in a blow tank.

And then it is fed out in a predetermined amount, approximately 30 kg/h of coal, by a rotary feeder and transported pneumatically to a coal blowing lance by mean of a carrier gas and nitrogen gas.

3) Melting Furnace

The molten iron required for coal gasification test is produced in a medium-frequency induction furnace from scrapped iron in approximately two hours.

The molten iron produced is transported to a gasifier through a runner after being adjusted for its chemical composition, mainly carbon conent, and for temperature.

4) Gasifier

The gasifier is lined with magnesia refractory bricks on internal wall and equipped with a lance, through which both coal and oxygen are blown and a induction coil to maintain temperature of molten iron constant.

30 kg/h of pulverized coal, blown at a high speed with oxygen onto the surface of molten iron bath in the gasifier, is instantaneously gasified and 64.5 Nm^3/h of gas is produced.

The assemble drawings of the gasifier and the main lance are shown in Fig. 8-1-5 and Fig. 8-1-6.

During gasification, temperature and carbon content of molten iron in the gasifier are measured by a sub-lance.

Further main chemical compositions of molten iron and slag are measured by a iron analyzer and a slag analyzer.

5) Produced Gas Filtration System

A produced gas filtration system is composed of a water-cooled duct, a cyclone and a bug filter.

The produced gas in the gasifier is recovered through a hood directly connected to the gasifier.

The recovered gas is cooled and dedusted by the water-cooled duct, the cyclone and the bug filter.

Finally, it is burned at a flare stack and released to atmosphere.

Moreover the recovered gas is sampled by a gas sampling equipment and chemical compositions of it are measured by some types of gas analyzers.

6) Slag Treatment System

A slag treatment system is composed of a slag pot and a slag pot car.

After coal gasification test, the molten iron is discharged to the slag pot and then the molten iron is cooled naturally.