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

ATTACHMENT

March 1989

JAPAN INTERNATIONAL COOPERATION AGENCY

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PREFACE

In response to a request from the Government of the Republic of Indonesia, the Japanese Government decided to conduct a feasibility study on Effective Utilization of Banko Coal and entrusted the study to the Japan International Cooperation Agency (JICA).

JICA has sent to Indonesia a study team headed by Mr. Takehiko Sato, the Institute of Energy Economics, Japan, as many as eighteen times during the period of five years from May 9, 1984 to December 20, 1988.

The team has had a series of discussions with concerned officials of the Government of the Republic of Indonesia, and conducted field surveys, gasification tests, and so on. After the team returned to Japan, further studies were made and the present report was prepared.

I hope that this report will contribute to the development of the project and to the promotion of friendly relations between our two countries.

I wish to express my sincerest appreciation to the concerned officials of the Government of the Republic of Indonesia for their close cooperation extended to the team.

March, 1989

Kensuke Yanagiya

Kensuke Yanagiya
President
Japan International Cooperation Agency

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1. A Study on Introduceable Quantity of Fuel Methanol in Indonesia
   (Evaluation and Analysis by Using LP model)

1. A Study on Introduceable Quantity of Fuel Methanol in Indonesia (Evaluation and Analysis by Using LP model)

1. OUTLINE OF STUDY

This survey is aimed at quantitativly evaluating and analysing, in the "Effective Utilization of Banko Coal," the impacts of introducing fuel methanol into Indonesia as a substitute fuel for various oil products.

In the study, an LP model (linear programming model), which represents the crude oil and oil-product flows in Indonesia, has been prepared and used.

The presence or absence of economic benefits obtained by introducing fuel methanol into Indonesia may be determined by the difference in magnitude between the cost for introduction (namely, methanol price) and the increase in profits obtainable from the increase in the export of crude oil and oil products, etc.

In this study, the methanol introduction is evaluated by profit difference between base case (without methanol introduction) and methanol introduction cases.

2. CONSTRUCTION OF LP MODEL

2-1 Outline

The LP model used in the present survey consists of matrices comprising about 2,000 equations and about 3,500 variables. Table 1 shows the main matrices; Fig. 1 and 2 show the entire flow charts.

Matrices are composed of such parts as crude oil production, oil refining, demand location and methanol production.

Object functions are defined as profit functions, and optimization has been performed to maximize the profits.

2-2 Crude Oil

For the crude oil produced, the following six kinds of oil have been set up; and other crude oils have been included into the six crude oils according to their respective production areas:

Sumatra Light	(SL)
Arjuna	(AJ)
Attaka	(AT)
Bekapai	(BP)
Handil	(HD)
Arun Condensate	(AC)

The contents of inputs for the respective crude oil are as follows:

Upper limit of production

Production cost per kℓ ($/kℓ)

Transportation cost to one of four refineries ($/kℓ)

Export price (FOB: $/kℓ)

Since the object functions are profit functions, the sign for the object function is minus in respect to the cost. Namely, production and transportation (domestic use) of crude oil decrease profits. Conversely, the sign of the export price for the object function is plus, and the export of crude oil and oil products will earn profit.

A quantitative balance shall be obtained by the following:

Crude oil production - Crude oil export - Domestic transportation of crude oil (Domestic consumption) = 0

Part of the crude oil production is transported to a domestic refinery, and the remainder is exported. Provided that it has been assumed that the total production of the Arun Condensate will be exported, and the upper limit of this export has been set up. Natural gas also has a set-up upper limit for export, and is used at the Balikpapan refinery for manufacturing hydrogen. For producing lubricants, it has been assumed that Arabian Light (AL) will be imported and processed at Cilacap.

2-3 Refineries

At present, there are nine refineries in Indonesia, but in the model, refineries which are in adjacent areas are grouped, and all Indonesian refineries are represented by the following four refineries:

P. Brandan Dumai S.Pakning	---------------	Dumai
Plaju S. Gerong	---------------	Plaju
Cilacap Wonokromo Cepu	---------------	Cilacap
Balikpapan	---------------	Balikpapan

"Refining capacity" is the total capacity of the respective grouped refineries.

The topper yield of crude oil and yields of respective refinery facilities, unit consumptions, etc., have been set up on the basis of data obtained by the site survey, and the validity of these data has been confirmed by comparing them with the actual data of oil refining in 1985.

For each refinery facility, the following data have been inputted.

Processing capacity (1,000 kℓ/y)
Material balance
Home-use fuel consumption
Hydrogen balance
Steam consumption
Electric power consumption
Catalysts and chemical costs

Of the above items, home-use fuel, hydrogen, steam and electric power are all provided by the refinery, and catalysts and chemicals will be purchased.

For product blending, the following restrictions have been posed.

Gasoline

Research octane number (RON) 84 (clear) or above

50% dist. temp.	88°C or above
Reid vapor pressure (R.V.P.)	9 psi or above
Gas oil	
Kinetic viscosity (100°F)	1.6 cSt or above
10% carbon residue	0.1% or above
Cetane index	48 or above
Heavy oil	
Kinetic viscosity (100°F)	1.250 sec or below (Redwood)
Carbon residue	10% or below

Quantity balances at the refinery are as follows:

Domestic crude oil transported - Topper crude-runs = 0

Finished-product production - Domestic product transportation - Product export = 0

Blending stock and unfinished product balance in the refinery

It has been assumed that the finished products are transported to domestic demand regions and the remainder is exported.

The domestic transportation cost of products has been set up on the basis of the marine transportation distance from the refinery to the demand region concerned. Land transportation costs have been omitted, because they do not affect variation in profits among the various cases.

2-4 Domestic Demand

Domestic demand has been divided into eight regions according to the sales units of PERTAMINA.

Demand Region 1	Acheh, Riau, North Sumatra, West Sumatra and their surrounding areas
Demand Region 2	Jambi, South Sumatra, West Sumatra and their surrounding areas
Demand Region 3	Jakarta, West Java and their surrounding area

Demand Region 4	Central Java, Jogyakarta and their surrounding areas
Demand Region 5	East Java, Bali, Madura and their surrounding area
Demand Region 6	South Sulawesi, Central Sulawesi and their surrounding area
Demand Region 7	North Sulawesi, South East Sulawesi, Maluku and their surrounding area
Demand Region 8	Irian Jaya and its surrounding areas

For each product at each demand region, the following data are inputted:

Demand quantity

Sales price

The quantitative balance is as follows:

Domestic transportation of products from 4 refineries - Demand at demand area concerned = 0

Thus, products transported from the refinery are sold at the demand region and earn profits.

Table 1 Main Matrix of LP Model

Equation \ Structural Variables	Crude Oil: Production	Crude Oil: Export	Crude Oil: Domestic Trans-portation	Refineries: Crude Oil Input	Refineries: Refining Unit	Refineries: Refining Unit	Refineries: Blending	Refineries: Oil Products	Refineries: Oil Products Export	Products trans-portation	Domestic Demand	Methanol Trans-portation	Methanol Production	(Type)
Objective Function (Profit)	- Production Cost	+ Export Price	- Trans-portation Cost		- Refining Cost	- Refining Cost			+ Export Price	- Trans-portation Cost	+ Sales Price	- Trans-portation Cost	- Production Cost	= Max.
Crude Oil Volume Balance														
Crude Oil Volume	+	-	-											= 0
Material Balance in Refineries														
Material Balance 1				+	-									= 0
Material Balance 2					+	-								= 0
Unfinished Products						+	-							= 0
Oil Product Production							+	-						= 0
Oil Product Delivered								+	-	-				= 0
Refining Unit														
Processed Volume					+	+								< Capa.
Own use					-	-								= 0
Product Specification														
Max.							+	-						< 0
Min.							+	-						> 0
Balance of Transported Volume														
Crude Oil			+	-										= 0
Oil Products										+	-			= 0
Methanol											-	+		= 0
Methanol														
Methanol Production												-	+	= 0
Constraint Conditions	Production Level	Exports Level			Processing Capacity	Processing Capacity		Product Specifi-cation			Demand Level		Production Level	

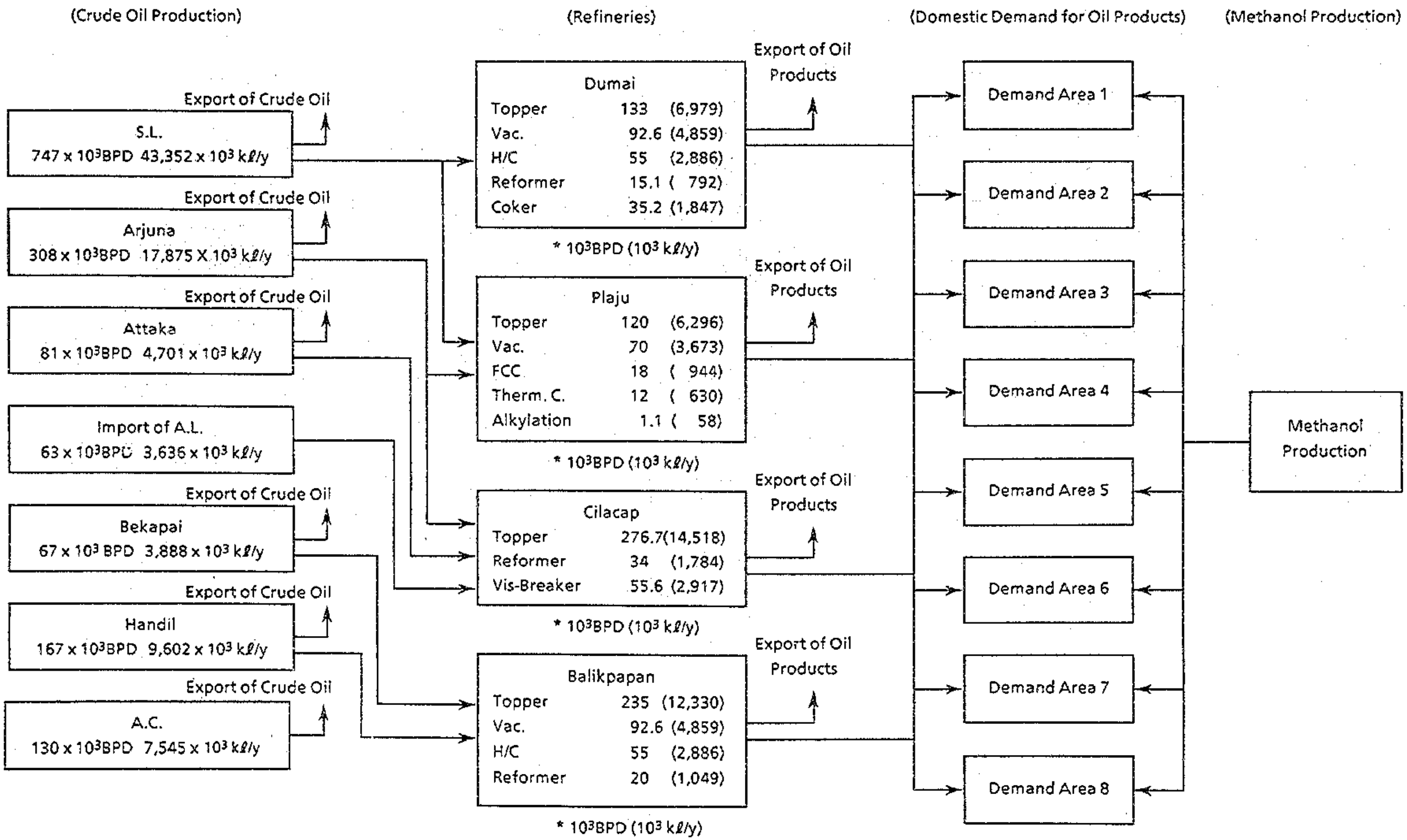


Fig. 1 Flow of LP Model in Indonesia (Existing Capacity Case)

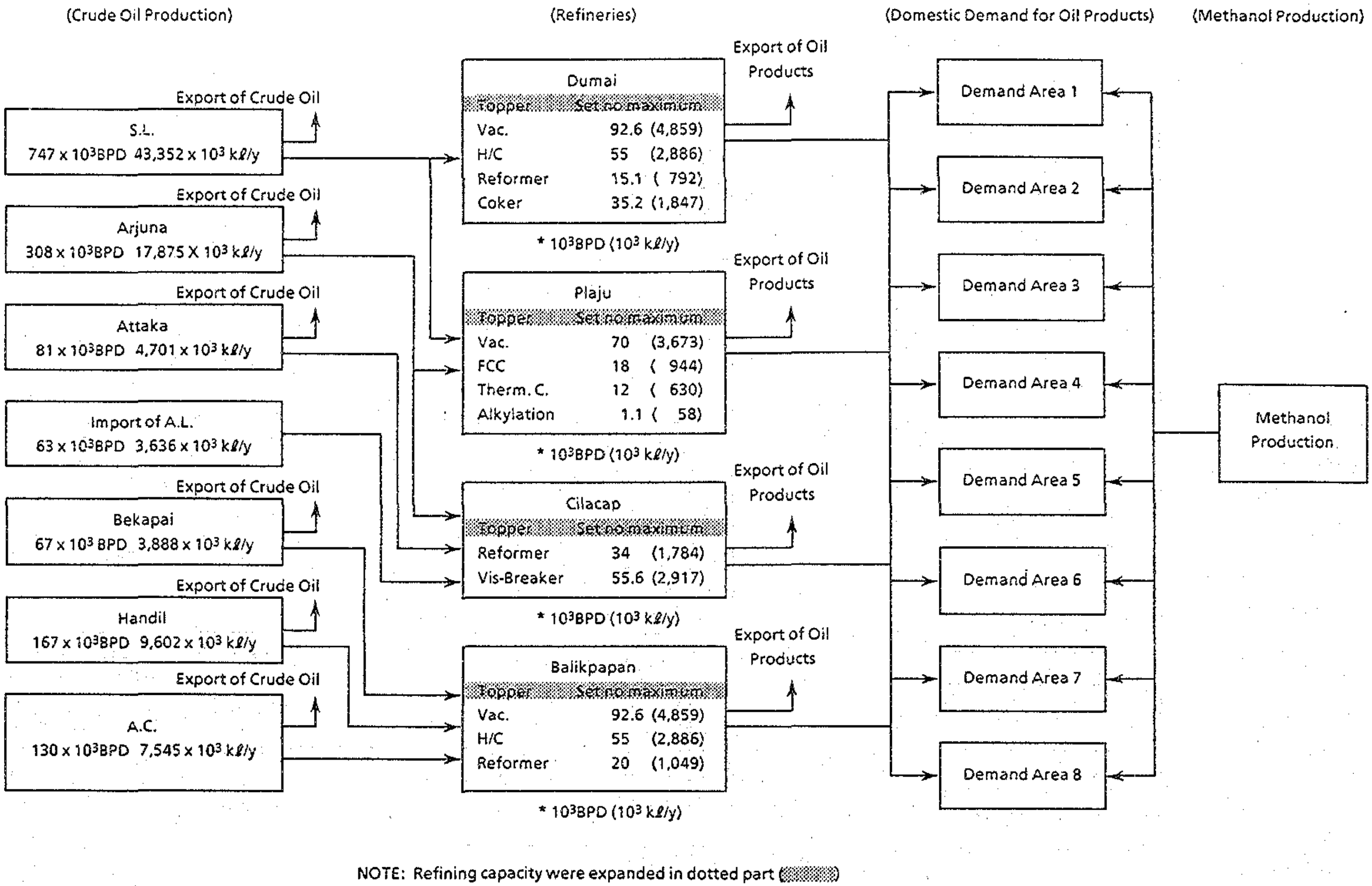


Fig. 2 Flow of LP Model in Indonesia (Expanded Capacity Case)

3. MAJOR CONDITIONS FOR CALCULATION

3-1 Scenario

The demand forecast of petroleum products in Indonesia is defined based on the BPPT study. It is shown in the Table 3.

The price of crude oil and petroleum products are forecast by each scenario as OPEC average crude oil price. 155$/t, 165$/t and 175$/t are used as methanol price. The basic case for calculation is the case when fuel methanol are not introduced. In this case, petroleum products import are needed, for they can not supply in the existing refining capacity. Then as methanol introduction case, three different oil price are defined. As a reference, the expansion of topper unit in four refineries are calculated.

3-2 Crude Oil

3-2-1 Production Ceiling

SL	747 × 10^3 BPD	43,352 × 10^3 kℓ
AJ	308 × 10^3 BPD	17,875 × 10^3 kℓ
AT	81 × 10^3 BPD	4,701 × 10^3 kℓ
BP	67 × 10^3 BPD	3,888 × 10^3 kℓ
HD	167 × 10^3 BPD	9,692 × 10^3 kℓ
AC	130 × 10^3 BPD	7,545 × 10^3 kℓ
Total	1,500 × 10^3 BPD	87,053 × 10^3 kℓ

3-2-2 Production Cost

SL	\$1.86/bbl	\$11.7/kℓ
AJ	\$9.01/bbl	\$56.7/kℓ
AT	\$10.49/bbl	\$66.0/kℓ
BP	\$4.73/bbl	\$29.7/kℓ
HD	\$4.50/bbl	\$28.3/kℓ
AC	\$1.86/bbl	\$11.7/kℓ

3-2-3 Transportation Cost

Wt. Av. in total Indonesia:\$3.05/kℓ (\$0.006/km·kℓ)

	Dumai	Plaju	Cilacap	Balikpapan
SL	0.0	4.32	—	—
AJ	—	4.50	4.50	—
AT	—	—	9.72	—
BP	—	—	—	0.0
HD	—	—	—	0.0
AC	—	—	—	—
AL	—	—	8.00	—

The number of \$0.006/km·kℓ was calculated based upon wt.av. transportation cost of \$3.05/kℓ.

3-2-4 Export Volume

Production volume - processing volume.

3-2-5 Export Price

SL Ave. Crude Oil Price in OPEC + 0.5$/bbl
AJ Ave. Crude Oil Price in OPEC + 1.0$/bbl
AT Ave. Crude Oil Price in OPEC + 1.3$/bbl
BP Ave. Crude Oil Price in OPEC + 1.3$/bbl
HD Ave. Crude Oil Price in OPEC + 1.0$/bbl
AC Ave. Crude Oil Price In OPEC + 1.1$/bbl

3-2-6 Import Volume of AL

3,636 × 10^3 kℓ (400 × 10^3 of Lub demand and 11% of its yield were assumed.)

3-2-7 Import Price of AL

The price was assumed to be the same of Ave. Price of OPEC crude oil.

3-3 Oil Refining

3-3-1 Processing Capacity by Refineries

10^3 kℓ/y

	Dumai	Plaju	Cilacap	Balikpapan
Topper	6,979	6,000	14,518	12,330
Vacuum	4,859	3,673	0	4,859
Reformer	792	0	1,784	1,049
FCC	0	944	0	0
Alkylation	0	58	0	0
H/C	2,886	0	0	2,886
Coker	1,847	0	0	0
Visbreaker	0	0	2,917	0

The following capacities were assumed as added refining capacities.

10^3 kℓ/y

	Dumai	Plaju	Cilacap	Balikpapan
Topper	No upper limit	No upper limit	No upper limit	No upper limit
Vacuum	4,859	3,673	0	4,859
Reformer	792	0	1,784	1,049
FCC	0	944	0	0
Alkylation	0	58	0	0
H/C	2,886	0	0	2,886
Coker	1,847	0	0	0
Visbreaker	0	0	2,917	0

3-3-2 Crude Oil Processed in Each Refinery

	Dumai	Plaju	Cilacap	Balikpapan
SL	○	○	—	—
AJ	—	○	○	—
AT	—	—	○	—
BP	—	—	—	○
HD	—	—	—	○
AC	—	—	—	—
AL	—	—	○	—

3-4 Demand for Petroleum Product

3-4-1 Petroleum Products Demand by Regions

The two demand scenarios of high and low are set for 2000, 2005 and 2010.

3-4-2 Domestic Sales Price of the Petroleum Products

(Av. Price of OPEC crude oil × 1.05 + 6.95) $/kℓ

(5% is refining cost + 6.95 of ave. transportation cost)

3-4-3 Transportation Cost of Petroleum Products of Crude Oil Price

$6.95/kℓ ($0.014/km·kℓ)

	Dumai	Plaju	Cilacap	Balikpapan
Demand Region 1	5.60	15.40	32.20	
Demand Region 2	10.50	0.00	17.50	25.90
Demand Region 3	18.90	7.70	0.00	21.00
Demand Region 4	21.00	11.62	0.00	16.10
Demand Region 5	25.20	15.40	0.00	12.60
Demand Region 6	30.10	32.90	21.00	7.84
Demand Region 7	—	—	37.10	13.58
Demand Region 8	—	—	—	35.00

The number of $0.014/km·kℓ was calculated based on wt.av. transportation cost of $6.95/kℓ.

3-4-4 Export Price of Products

Export prices are assumed from market prices of 1985 in Singapore.

Naphtha : Ave. Crude Oil Price of OPEC × 1.0
Kerosene : Ave. Crude Oil Price of OPEC × 1.2
Gas Oil : Ave. Crude Oil Price of OPEC × 1.2
Reformate: Ave. Crude Oil Price of OPEC × 1.3
Fuel Oil : Ave. Crude Oil Price of OPEC × 0.9

3-4-5 Import Price of Products

Gasoline	:	Ave. Crude Oil Price of OPEC × 1.2 + 40
Kerosene	:	Ave. Crude Oil Price of OPEC × 1.2 + 40
Gas Oil	:	Ave. Crude Oil Price of OPEC × 1.2 + 40

3-5 Cases for Introducing Methanol

3-5-1 Production Area

South Sumatra

3-5-2 Production Volume

No upper limit (Gr. 0.796)

3-5-3 Methanol Sales Price at Palembang

175$/t, 165$/t, 155$/t

3-5-4 Introducing Area

One half of kerosene demand of each region was assumed to be max. for methanol demand.

As to introduction of methanol for gasoline, market and diesel oil, demand region 3 and 5 are selected because of their bigger shares in total. (without ceiling of introducing volume)

3-5-5 Substituting Volume of Petroleum Products by Methanol

Gasoline : 0.52 kℓ/1 kℓ of methanol
Kerosene : 0.49
ADO : 0.47
(calorific equivalent base)

3-5-6 Transportation Cost

The same cost in the case of petroleum product (cost per/unit volume) was assumed for this.

Table 2 The Investigation Case

Case	Scenario	Year	Domestic demand	OPEC average crude oil price	Methanol price	
H2000-0	High scenario	2000	Ref. Table-3	28$/bbl	No introduction	Base case (no introduction of fuel methanol)
H2000-1	↓	↓	↓	↓	175$/t	Introduction case in 175$/t (no import of petroleum products)
H2000-2	↓	↓	↓	↓	165$/t	Introduction case in 165$/t (no import of petroleum products)
H2000-3	↓	↓	↓	↓	155$/t	Introduction case in 155$/t (no import of petroleum products)
H2000-4	↓	↓	↓	↓	No introduction	Refinery expansion cae (Topper) (no introduction of fuel methanol)
H2005-0	↓	2005	↓	36$/bbl	No introduction	Base case (no introduction of fuel methanol)
H2005-1	↓	↓	↓	↓	175$/t	Introduction case in 175$/t (no import of petroleum products)
H2005-2	↓	↓	↓	↓	165$/t	Introduction case in 165$/t (no import of petroleum products)
H2005-3	↓	↓	↓	↓	155$/t	Introduction case in 155$/t (no import of petroleum products)
H2005-4	↓	↓	↓	↓	No introduction	Refinery expansion cae (Topper) (introduction of fuel methanol)
H2010-0	↓	2010	↓	45$/bbl	No introduction	Base case (no introduction of fuel methanol)
H2010-1	↓	↓	↓	↓	175$/t	Introduction case in 175$/t (no import of petroleum products)
H2010-2	↓	↓	↓	↓	165$/t	Introduction case in 165$/t (no import of petroleum products)
H2010-3	↓	↓	↓	↓	155$/t	Introduction case in 155$/t (no import of petroleum products)
H2010-4	↓	↓	↓	↓	No introduction	Refinery expansion cae (Topper) (introduction of fuel methanol)
L2000-0	Low scenario	2000	↓	21$/bbl	No introduction	Base case (no introduction of fuel methanol)
L2000-1	↓	↓	↓	↓	175$/t	Introduction case in 175$/t (no import of petroleum products)
L2000-2	↓	↓	↓	↓	165$/t	Introduction case in 165$/t (no import of petroleum products)
L2000-3	↓	↓	↓	↓	155$/t	Introduction case in 155$/t (no import of petroleum products)
L2005-0	↓	2005	↓	25$/bbl	No introduction	Base case (no introduction of fuel methanol)
L2005-1	↓	↓	↓	↓	175$/t	Introduction case in 175$/t (no import of petroleum products)
L2005-2	↓	↓	↓	↓	165$/t	Introduction case in 165$/t (no import of petroleum products)
L2005-3	↓	↓	↓	↓	155$/t	Introduction case in 155$/t (no import of petroleum products)
L2010-0	↓	2010	↓	29$/bbl	No introduction	Base case (no introduction of fuel methanol)
L2010-1	↓	↓	↓	↓	175$/t	Introduction case in 175$/t (no import of petroleum products)
L2010-2	↓	↓	↓	↓	165$/t	Introduction case in 175$/t (no import of petroleum products)
L2010-3	↓	↓	↓	↓	155$/t	Introduction case in 175$/t (no import of petroleum products)
H175-32~37	High scenario	2000	↓	32~37 $/bbl	175$/t	Analysis of the amount of methanol introduced when the oil price is changed from 32$/bbl to 37$/bbl in case 175$/t of methanol price.
H165-29~35	↓	↓	↓	29~35 $/bbl	165$/t	Analysis of the amount of methanol introduced when the oil price is changed from 29$/bbl to 35$/bbl in case 165$/t of methanol price.
H175-28~33	↓	↓	↓	28~33 $/bbl	155$/t	Analysis of the amount of methanol introduced when the oil price is changed from 28$/bbl to 33$/bbl in case 155$/t of methanol price.

Table 3 Domestic Demand for Petroleum Products

H Scenario

(Unit: 1,000 kℓ/y)

(H2000)

	LPG	Gasoline	Kerosene	ADO	IDO	Fuel Oil	Total
Demand Area 1	151.3	773.7	1,089.1	1,350.9	286.5	238.8	3,890.3
Demand Area 2	53.9	465.6	612.6	948.3	201.1	39.8	2,321.3
Demand Area 3	1,146.5	2,636.1	3,403.3	2,782.2	590.2	573.1	11,131.4
Demand Area 4	209.4	807.9	1,351.6	957.2	203.0	115.4	3,644.5
Demand Area 5	433.3	1,287.2	2,187.8	1,476.1	313.1	801.9	6,499.4
Demand Area 6	0	335.5	427.8	751.5	159.4	0	1,674.2
Demand Area 7	80.9	438.2	515.4	465.2	98.7	220.9	1,819.3
Demand Area 8	0	95.9	136.1	214.7	45.5	0	492.2
Total	2,075.3	6,840.1	9,723.7	8,946.1	1,897.5	1,989.9	31,472.6

(H2005)

	LPG	Gasoline	Kerosene	ADO	IDO	Fuel Oil	Total
Demand Area 1	238.7	861.3	1,055.8	1,548.7	328.5	269.0	4,302.0
Demand Area 2	85.0	518.3	593.9	1,087.2	230.6	44.8	2,559.8
Demand Area 3	1,808.4	2,934.6	3,299.2	3,189.8	676.6	645.6	12,554.2
Demand Area 4	330.3	899.4	1,310.3	1,097.5	232.8	130.0	4,000.3
Demand Area 5	683.4	1,433.0	2,120.9	1,692.3	359.0	903.4	7,192.0
Demand Area 6	0	373.5	414.8	861.6	182.8	0	1,832.7
Demand Area 7	127.5	487.8	499.6	533.3	113.1	248.8	2,010.1
Demand Area 8	0	106.7	132.0	246.2	52.2	0	537.1
Total	3,273.3	7,614.6	9,426.5	10,256.6	2,175.6	2,241.6	34,988.2

(H2010)

	LPG	Gasoline	Kerosene	ADO	IDO	Fuel Oil	Total
Demand Area 1	214.3	1,007.2	1,150.6	1,793.4	380.4	316.9	4,862.8
Demand Area 2	76.3	606.1	647.2	1,258.9	267.0	52.8	2,908.3
Demand Area 3	1,623.6	3,431.8	3,595.6	3,693.6	783.5	760.5	13,888.5
Demand Area 4	296.5	1,051.8	1,427.9	1,270.8	254.4	153.2	4,454.6
Demand Area 5	613.6	1,675.8	2,311.4	1,959.6	415.7	1,064.2	8,040.3
Demand Area 6	0	436.8	452.0	997.6	211.6	9	2,098.0
Demand Area 7	114.5	570.5	544.5	617.6	131.0	293.1	2,271.2
Demand Area 8	0	124.8	143.8	285.0	60.5	0	614.1
Total	2,938.8	8,904.7	10,273.0	11,876.5	2,504.1	2,640.7	39,137.8

L Scenario

(Unit: 1,000 kℓ/y)

(L2000)

	LPG	Gasoline	Kerosene	ADO	IDO	Fuel Oil	Total
Demand Area 1	152.5	680.4	1,062.8	1,127.4	239.1	220.7	3,482.9
Demand Area 2	54.3	409.4	597.8	791.4	167.8	36.8	2,057.5
Demand Area 3	1,155.3	2,318.1	3,321.0	2,321.8	492.5	529.7	10,138.4
Demand Area 4	211.0	710.4	1,318.9	798.8	169.4	106.7	3,315.2
Demand Area 5	436.6	1,131.9	2,134.9	1,231.9	261.3	741.2	5,937.8
Demand Area 6	0	295.0	417.5	627.2	133.0	0	1,472.7
Demand Area 7	81.5	385.3	502.9	388.2	82.4	204.2	1,644.5
Demand Area 8	0	84.3	132.8	179.2	38.0	0	434.3
Total	2,091.2	6,014.8	9,488.6	7,465.9	1,583.5	1,839.3	28,483.3

(L2005)

	LPG	Gasoline	Kerosene	ADO	IDO	Fuel Oil	Total
Demand Area 1	267.6	697.0	967.0	1,191.7	252.7	232.5	3,608.5
Demand Area 2	95.3	419.4	543.9	836.5	177.4	38.7	2,111.2
Demand Area 3	2,027.7	2,374.8	3,021.7	2,454.3	520.7	557.9	10,957.1
Demand Area 4	370.3	727.8	1,200.1	844.4	179.1	112.3	3,434.0
Demand Area 5	766.3	1,159.6	1,942.5	1,302.1	276.2	780.7	6,227.4
Demand Area 6	0	302.2	379.8	662.9	140.6	0	1,485.5
Demand Area 7	143.1	394.8	457.6	410.4	87.1	215.0	1,708.0
Demand Area 8	0	86.4	120.8	189.4	40.1	0	436.7
Total	3,670.3	6,162.0	8,633.4	7,891.7	1,673.9	1,937.1	29,968.4

(L2010)

	LPG	Gasoline	Kerosene	ADO	IDO	Fuel Oil	Total
Demand Area 1	248.8	753.0	1,002.3	1,244.6	264.0	235.2	3,747.9
Demand Area 2	88.6	453.1	563.6	873.7	185.3	39.2	2,203.7
Demand Area 3	1,885.3	2,565.6	3,132.0	2,563.3	543.8	564.6	11,254.6
Demand Area 4	344.3	786.3	1,243.8	881.9	187.0	113.7	3,557.0
Demand Area 5	712.5	1,252.8	2,013.4	1,359.9	288.5	790.0	6,417.1
Demand Area 6	0	326.5	393.7	692.4	146.9	0	1,559.5
Demand Area 7	133.0	426.5	474.3	428.6	90.9	217.6	1,770.9
Demand Area 8	0	93.3	125.2	197.8	41.9	0	458.2
Total	3,412.5	6,657.1	8,948.5	8,242.2	1,748.3	1,960.3	30,968.9

4. RESULT OF LP MODEL STUDY

4-1 Introduceable Amount of Methanol

4-1-1 High Scenario in 2000 (H2000)

In base case (H2000), the refining capacity reaches the maximum in all refineries, and 881 thousand kℓ/y of gasoline and 199 thousand kℓ/y of ADO is imported. On the other hand, naphtha and fuel oil are exported. The amount of methanol introduction is 0.88 million kℓ/y as a substitution of kerosene and 1.7 million kℓ/y as a substitution of gasoline in these three methanol introduction case (H2000-1 ~ 3). These amounts are equal to the import of petroleum products in base case (H2000-0).

4-1-2 High Scenario in 2005

The amounts of importation are 1,663 thousand kℓ/y in gasoline, 397 thousand kℓ/y in kerosene and 867 thousand kℓ in ADO in base case (H2005-0).

The amount of methanol introduction is 7,282 thousand kℓ/y in introduction case 1 (175$/t of methanol). 1,721 thousand kℓ/y of gasoline and 1,947 kℓ/y of kerosene are substituted. These amounts are more than import production in base case. The profit is also more than base case. Methanol is introduced in region 2 for kerosene (606 thousand kℓ/y) and in region 3 for gasoline (3,309 thousand kℓ/y) and kerosene (3,367 kℓ/y).

The amount of methanol introduction is 11,744 thousand kℓ/y in introduction case 2 (165$/t of methanol). 2,672 thousand kℓ/y of gasoline, 2,602 thousand kℓ/y of kerosene and 609 thousand kℓ/y of diesel oil are substituted. Methanol is introduced in region 3 for gasoline (1,829 thousand kℓ/y) and ADO (1,296 thousand kℓ/y) and in region 4 for kerosene (1,337 thousand kℓ/y) in addition to the amount in above case.

The amount of methanol introduction is 20,849 thousand kℓ/y in introduction case 3 (155$/t of methanol). The methanol is introduced 505 thousand kℓ/y for gasoline and 5,491 thousand kℓ/y for ADO in region 3 and 945 thousand kℓ/y of gasoline and 2,164 thousand kℓ/y of kerosene in region 5 in addition to the amount in introduction case 2.

4-1-3 High Scenario in 2010 (H2010)

In base case, 2,954 thousand kℓ/y of gasoline, 2,019 thousand kℓ/y of kerosene and 1,763 thousand kℓ/y of ADO are imported.

In 175$/t case, methanol is introduced to reach the maximum level in region 1-5. In 165 and 155$/t case, methanol is also introduced in region 6 to the maximum level. Methanol introduction shows the high advantage in this scenario.

4-1-4 Low Scenario in 2000 (L2000)

In base case, 62 thousand kℓ/y of gasoline is imported. The gasoline production is 5,953 thousand kℓ/y. This is because expansion of gasoline production costs higher than gasoline import.

The methanol is introduced as the substitution of 48 thousand kℓ/y of gasoline in all three introduction cases. Gasoline production is 5,990 thousand kℓ/y and seems to be the maximum level.

4-1-5 Low Scenario in 2005 (L2005)

In base case, 223 thousand kℓ/y of gasoline is imported. The gasoline production is 5,939 thousand kℓ/y. This is also because expansion of gasoline production costs higher than gasoline import.

The methanol is introduced as the substitution of 330 thousand kℓ/y of gasoline in all three introduction cases. Gasoline production reached the same level as L2000 case of 5,990 thousand kℓ/y.

4-1-6 Low Scenario in 2010 (L2010)

In base case, 712 thousand kℓ/y of gasoline is imported. The gasoline production is 5,945 thousand kℓ/y. This is also because expansion of gasoline production costs higher than gasoline import.

The methanol is introduced as the substitution of 1,281 thousand kℓ/y in 175$/t case, 11,348 thousand kℓ/y in 165$/t case and 1,370 thousand kℓ/y in 155$/t case. In 155$/t case, the same amount methanol as gasoline import in base case is introduced.

4-2 Relation between Introduceable Quantity of Methanol and Crude Oil Price

Introduceable quantity of methanol is calculated when crude oil price moves by 1$/bbl in high scenario in 2000. The result is shown in Fig. 3.

4-2-1 175$/t Case (H175-32 ~ 37)

In 175$/t case, methanol is not introduced when crude oil price is less than 32$/bbl.

1,695 thousand kℓ/y of methanol is introduced in region 3 as the substitution of gasoline when oil price becomes 33$/bbl. This is the same amount as gasoline import in H175-32 case. Product flow does not change but gasoline is not imported and methanol is introduced. Methanol cost is supposed to be almost equal to gasoline import cost.

When oil price becomes 34$/bbl, additional 220 thousand kℓ/y of methanol is introduced in region 3 as gasoline substitution, and 422 thousand kℓ/y is introduced in region 2 as kerosene substitution. As the result, there is no need to import the petroleum products and 103 thousand kℓ/y of reformate is exported. Methanol introduction cost has advantage to import cost of products, but does not have advantage to their production cost. This is because crude oil refining pattern is not changed.

When oil price becomes 35$/t, additional methanol is introduced in regions 3 as gasoline substitution and in region 2 as kerosene substitution. As the result, crude oil refining pattern is changed and crude oil export is increased. Methanol has cost advantage compared to petroleum products in the above two regions.

When oil price becomes 36 and 37$/bbl, methanol is introduced also in region 3 as kerosene substitution and this causes the expansion of crude oil export.

4-2-2 165$/t Case (H165-32 ~ 37)

Methanol is not introduced when oil price is less than 29$/bbl, and products flow shows almost the same as H2000-0 case.

Methanol introduction cost becomes equal to the gasoline import cost when oil price becomes 30 and 31$/bbl. When oil price becomes more than 32$/bbl, methanol introduction keeps advantage than petroleum products in region 3 as gasoline substitution and in region 2 as substitution of kerosene.

4-2-3 155$/t Case (H155-32 ~ 37)

Methanol introduction cost becomes equal to the gasoline import cost when oil price becomes 29$/bbl. Methanol introduction keeps its advantage compared to petroleum products in the above mentioned two region when oil price becomes higher than 30$/bbl.

4-3 Changes of Profit Composition

The changes of profit composition are examined here. The results are shown in Table 9 and 10.

"Crude oil production cost" is not changed because crude oil production is at a maximum level in each case. When domestic refining is increased, "crude oil export amount is minus (profit decrease), "crude oil transportation cost" is plus (cost increase) and "catalyst/chemicals cost" is minus (cost increase).

As methanol has lower heat value than petroleum products, the amount of transportation is increased when methanol is introduced, and "product transportation cost" becomes less (Cost increase).

4-3-1 High Scenario in 2000 (H2000)

The amount of methanol introduced in this scenario is equal to product import in base case (H2000-0). Product import cost (271 million $) in base case is smaller than methanol introduction cost (methanol production cost and products transportation cost).

4-3-2 High Scenario in 2005 (H2005)

Cost increase caused by methanol introduction is covered by plus factor as "product import cost" and "the amount of crude oil export". In H2005-1, 2, "the amount of product export" is minus due to export decrease of unprofitable naphtha and fuel oil. In H2005-3, "the amount of product export" also becomes plus factor due to export increase of reformate, kerosene and diesel oil in addition to the above export decrease.

4-3-3 High Scenario in 2010 (H2010)

The profit structure is the same as H2005-3, and the profit of methanol introduction is larger than base case.

4-3-4 Low Scenario in 2000 (L2000)

Gasoline import in base case is covered by increase of crude oil refining and methanol introduction. Because petroleum products are not imported in methanol introduction case. But their costs are larger then that of gasoline imports.

4-3-5 Low Scenario in 2005 (L2005)

The change of profit composition is the same as L2000.

4-3-6 Low Scenario in 2010 (L2010)

The profit composition of L2010-1 & 2 is the same as L2000. But "products export cost" is almost equal to "methanol introduction cost" in 2010-3.

4-4 Change of Products Transportation

The change of products transportation caused by methanol introduction is studied according to cases in 4-2.

4-4-1 Change of Gasoline Flow

Methanol is introduced as gasoline substitution in region 3. The change of product flow caused by methanol introduction is as follows.

I) Gasoline is transported from Plaju and Cilacap to region 3. At first, transportation from Cilacap to region 3 is decreased. This decreased amount is transported to region 4. And gasoline transportation from Dumai to region 4 is decreased.

II) Then the transportation of gasoline from Plaju to region 3 is decreased, and this decrease amount is sent to region 1. As the result, gasoline production in Dumai is decreased and reformate is exported.

4-4-2 Change of Kerosene Flow

As kerosene substitution, methanol is introduced firstly as kerosene substitution in region 2 and then in region 3. The change of product flow caused by methanol introduction is as follows.

I) At present time, kerosene is transported from Dumai and Plaju in region 2. However, first of all, transportation from Dumai is decreased.

II) Then kerosene from Plaju to region 3 is changed to supply from Cilacap, and kerosene from Plaju supply to region 2. Supply from Dumai decreased furthermore.

III) When methanol is introduced in region 3, kerosene from Cilacap to region 3 is decreased and is supplied to region 4. As a result, kerosene from Dumai to region 4 is decreased.

Table 4 Summary of the Study (High Scenario)

Case				H2000-0	H2000-1	H2000-2	H2000-3	H2000-4	H2005-0	H2005-1	H2005-2	H2005-3	H2005-4	H2010-0	H2010-1	H2010-2	H2010-3	H2010-4
				Base case				Expanding refinery	Base case				Expanding refinery	Base case				Expanding refinery
Crude Oil Price			$/bbl	28	28	28	28	28	36	36	36	36	36	45	45	45	45	45
Methanol Price			$/t	---	175	165	155	---	---	175	165	155	---	---	175	165	155	---
Methanol Introduced	Demand Area 1	Kerosene	1000 kℓ/y	---	0	0	0	---	---	0	0	0	---	---	1,174	1,174	1,174	---
	Demand Area 2	Kerosene	1000 kℓ/y	---	398	401	401	---	---	606	606	606	---	---	660	660	660	---
	Demand Area 3	Gasoline	1000 kℓ/y	---	1,693	1,695	1,695	---	---	3,309	5,138	5,643	---	---	6,599	6,599	6,599	---
		Kerosene	1000 kℓ/y	---	0	0	0	---	---	3,367	3,367	3,367	---	---	3,669	3,669	3,669	---
		ADO	1000 kℓ/y	---	0	0	0	---	---	0	1,296	6,787	---	---	7,859	7,859	7,859	---
	Demand Area 4	Kerosene	1000 kℓ/y	---	0	0	0	---	---	0	1,337	1,337	---	---	1,457	1,457	1,457	---
	Demand Area 5	Gasoline	1000 kℓ/y	---	0	0	0	---	---	0	0	945	---	---	3,223	3,223	3,223	---
		Kerosene	1000 kℓ/y	---	0	0	0	---	---	0	0	2,164	---	---	2,359	2,359	2,359	---
		ADO	1000 kℓ/y	---	0	0	0	---	---	0	0	0	---	---	4,169	4,169	4,169	---
	Demand Area 6	Kerosene	1000 kℓ/y	---	0	0	0	---	---	0	0	0	---	---	0	461	461	---
	Total		1000 kℓ/y	---	2,091	2,096	2,096	---	---	7,282	11,744	20,849	---	---	31,169	31,630	31,630	---
			1000 t/y	---	1,664	1,668	1,668	---	---	5,796	9,348	16,596	---	---	24,811	25,177	25,177	---
Petroleum products substitution		Gasoline	1000 kℓ/y	---	880	881	881	---	---	1,721	2,672	3,426	---	---	5,107	5,107	5,107	---
		Kerosene	1000 kℓ/y	---	195	196	196	---	---	1,947	2,602	3,662	---	---	4,566	4,792	4,792	---
		ADO	1000 kℓ/y	---	0	0	0	---	---	0	609	3,190	---	---	5,653	5,653	5,653	---
Petroleum Products import		Gasoline	1000 kℓ/y	881	---	---	---	842	1,663	---	---	---	1,662	2,954	---	---	---	2,909
		Kerosene	1000 kℓ/y	0	---	---	---	0	397	---	---	---	0	2,019	---	---	---	0
		ADO	1000 kℓ/y	199	---	---	---	0	867	---	---	---	0	1,763	---	---	---	943

Table 5 Summary of the Study (Low Scenario)

Case				L2000-0	L2000-1	L2000-2	L2000-3	L2005-0	L2005-1	L2005-2	L2005-3	L2010-0	L2010-1	L2010-2	L2010-3
				Base case				Base case				Base case			
Crude Oil Price			$/bbl	21	21	21	21	25	25	25	25	29	29	29	29
Methanol Price			$/t	---	175	165	155	---	175	165	155	---	175	165	155
Methanol Introduced	Demand Area 1	Kerosene	1000 kℓ/y	---	0	0	0	---	0	0	0	---	0	0	0
	Demand Area 2	Kerosene	1000 kℓ/y	---	0	0	0	---	0	0	0	---	0	0	0
	Demand Area 3	Gasoline	1000 kℓ/y	---	48	48	48	---	330	330	330	---	1,281	1,348	1,370
		Kerosene	1000 kℓ/y	---	0	0	0	---	0	0	0	---	0	0	0
		ADO	1000 kℓ/y	---	0	0	0	---	0	0	0	---	0	0	0
	Demand Area 4	Kerosene	1000 kℓ/y	---	0	0	0	---	0	0	0	---	0	0	0
	Demand Area 5	Gasoline	1000 kℓ/y	---	0	0	0	---	0	0	0	---	0	0	0
		Kerosene	1000 kℓ/y	---	0	0	0	---	0	0	0	---	0	0	0
		ADO	1000 kℓ/y	---	0	0	0	---	0	0	0	---	0	0	0
	Demand Area 6	Kerosene	1000 kℓ/y	---	0	0	0	---	0	0	0	---	0	0	0
	Total		1000 kℓ/y	---	48	48	48	---	330	330	330	---	1,281	1,348	1,370
			1000 t/y	---	38	38	38	---	263	263	263	---	1,020	1,073	1,091
Petroleum products substitution		Gasoline	1000 kℓ/y	---	25	25	25	---	172	172	172	---	666	701	712
		Kerosene	1000 kℓ/y	---	0	0	0	---	0	0	0	---	0	0	0
		ADO	1000 kℓ/y	---	0	0	0	---	0	0	0	---	0	0	0
Petroleum Products import		Gasoline	1000 kℓ/y	62	---	---	---	223	---	---	---	712	---	---	---
		Kerosene	1000 kℓ/y	0	---	---	---	0	---	---	---	0	---	---	---
		ADO	1000 kℓ/y	0	---	---	---	0	---	---	---	0	---	---	---

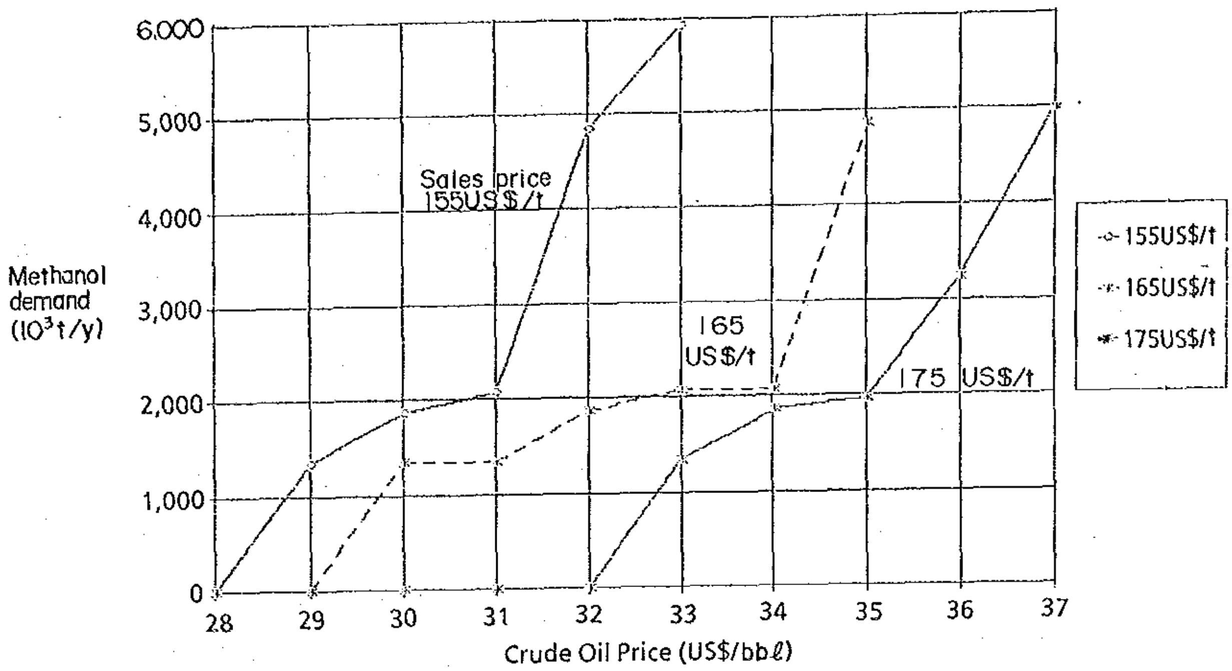


Fig. 3 Fuel Methanol Demand vs Oil Price

Table 6 Summary of the Study (Methanol Introduction v.s. Crude Oil Price ①)

Case				H175-32	H175-33	H175-34	H175-35	H175-36	H175-37
Crude Oil Price			$/bbl	32	33	34	35	36	37
Methanol Price			$/t	175	175	175	175	175	175
Methanol Introduced	Demand Area 1	Kerosene	1000 kℓ/y	0	0	0	0	0	0
	Demand Area 2	Kerosene	1000 kℓ/y	0	0	422	487	625	625
	Demand Area 3	Gasoline	1000 kℓ/y	0	1,695	1,915	1,988	1,988	2,173
		Kerosene	1000 kℓ/y	0	0	0	0	1,453	3,473
		ADO	1000 kℓ/y	0	0	0	0	0	0
	Demand Area 4	Kerosene	1000 kℓ/y	0	0	0	0	0	0
	Demand Area 5	Gasoline	1000 kℓ/y	0	0	0	0	0	0
		Kerosene	1000 kℓ/y	0	0	0	0	0	0
		ADO	1000 kℓ/y	0	0	0	0	0	0
	Demand Area 6	Kerosene	1000 kℓ/y	0	0	0	0	0	0
	Total		1000 kℓ/y	0	1,695	2,337	2,475	4,066	6,271
			1000 t/y	0	1,349	1,860	1,970	3,237	4,992
Petroleum products substitution		Gasoline	1000 kℓ/y	0	881	996	1,034	1,034	1,130
		Kerosene	1000 kℓ/y	0	0	207	239	1,018	2,008
		ADO	1000 kℓ/y	0	0	0	0	0	0
Petroleum Products import		Gasoline	1000 kℓ/y	881	0	0	0	0	0
		Kerosene	1000 kℓ/y	0	0	0	0	0	0
		ADO	1000 kℓ/y	197	197	0	0	0	0

Table 7 Summary of the Study (Methanol Introduction v.s. Crude Oil Price ②)

Case			Unit	H165-29	H165-30	H165-31	H165-32	H165-33	H165-34	H165-35
Crude Oil Price			\$/bbl	29	30	31	32	33	34	35
Methanol Price			\$/t	165	165	165	165	165	165	165
Methanol Introduced	Demand Area 1	Kerosene	1000 kℓ/y	0	0	0	0	0	0	0
	Demand Area 2	Kerosene	1000 kℓ/y	0	0	0	427	625	625	625
	Demand Area 3	Gasoline	1000 kℓ/y	0	1,695	1,695	1,915	1,988	1,988	2,007
		Kerosene	1000 kℓ/y	0	0	0	0	0	0	3,473
		ADO	1000 kℓ/y	0	0	0	0	0	0	0
	Demand Area 4	Kerosene	1000 kℓ/y	0	0	0	0	0	0	0
	Demand Area 5	Gasoline	1000 kℓ/y	0	0	0	0	0	0	0
		Kerosene	1000 kℓ/y	0	0	0	0	0	0	0
		ADO	1000 kℓ/y	0	0	0	0	0	0	0
	Demand Area 6	Kerosene	1000 kℓ/y	0	0	0	0	0	0	0
	Total		1000 kℓ/y	0	1,695	1,695	2,342	2,613	2,613	6,105
			1000 t/y	0	1,349	1,349	1,864	2,080	2,080	4,860
Petroleum products substitution		Gasoline	1000 kℓ/y	0	881	881	996	1034	1,034	1,044
		Kerosene	1000 kℓ/y	0	0	0	209	306	306	2,008
		ADO	1000 kℓ/y	0	0	0	0	0	0	0
Petroleum Products import		Gasoline	1000 kℓ/y	881	0	0	0	0	0	0
		Kerosene	1000 kℓ/y	0	0	0	0	0	0	0
		ADO	1000 kℓ/y	199	199	199	0	0	0	0

Table 8 Summary of the Study.
(Methanol Introduction v.s. Crude Oil Price ③)

Case				H155-28	H155-29	H155-30	H155-31	H155-32	H155-33
Crude Oil Price			$/bbl	28	29	30	31	32	33
Methanol Price			$/t	155	155	155	155	155	155
Methanol Introduced	Demand Area 1	Kerosene	1000 kℓ/y	0	0	0	0	0	0
	Demand Area 2	Kerosene	1000 kℓ/y	0	0	427	625	625	625
	Demand Area 3	Gasoline	1000 kℓ/y	0	1,695	1,915	1,988	1,988	3,348
		Kerosene	1000 kℓ/y	0	0	0	0	3,473	3,473
		ADO	1000 kℓ/y	0	0	0	0	0	0
	Demand Area 4	Kerosene	1000 kℓ/y	0	0	0	0	0	0
	Demand Area 5	Gasoline	1000 kℓ/y	0	0	0	0	0	0
		Kerosene	1000 kℓ/y	0	0	0	0	0	0
		ADO	1000 kℓ/y	0	0	0	0	0	0
	Demand Area 6	Kerosene	1000 kℓ/y	0	0	0	0	0	0
	Total		1000 kℓ/y	0	1,695	2,342	2,613	6,086	7,446
			1000 t/y	0	1,349	1,864	2,080	4,844	5,927
Petroleum products substitution		Gasoline	1000 kℓ/y	0	881	996	1,034	1,034	1,741
		Kerosene	1000 kℓ/y	0	0	209	306	2,008	2,008
		ADO	1000 kℓ/y	0	0	0	0	0	0
Petroleum Products import		Gasoline	1000 kℓ/y	881	0	0	0	0	0
		Kerosene	1000 kℓ/y	0	0	0	0	0	0
		ADO	1000 kℓ/y	199	199	0	0	0	0

Table 9 The Change of Profit Framework (High Scenario)

(million US$)

Item \ Case	H2000-0	H2000-1	H2000-2	H2000-3	H2000-4	H2005-0	H2005-1	H2005-2	H2005-3	H2005-4	H2010-0	H2010-1	H2010-2	H2010-3	H2010-4
	Base case				Expanding refinery	Base case				Expanding refinery	Base case				Expanding refinery
		(Comparison to H-2000-0 case)					(Comparison to H-2005-0 case)					(Comparison to H-2010-0 case)			
Crude Oil Production Cost	---	0	0	0	−1	---	0	0	0	−1	---	0	0	0	−1
Amount of Money of Crude Oil Export	---	0	0	0	+15	---	+499	+1,415	+1,883	−727	---	+1,521	+1,521	+1,521	−2,323
Crude Oil Transportation Cost	---	0	0	0	+8	---	+10	+26	+36	−8	---	+24	+24	+24	−28
Amount of Money of AL Import	---	0	0	0	0	---	0	0	0	0	---	0	0	0	0
Catalyst, Chemical Cost	---	0	0	0	−2	---	+1	+2	+3	−3	---	+1	+1	+1	−4
Amount of Money of Products Export	---	−1	−1	−1	−30	---	−254	−506	+243	+374	---	+1,487	+1,563	+1,594	+1,248
Products Transportation Cost	---	−15	−14	−14	−12	---	−54	−79	−114	−21	---	−264	−278	−278	−32
Amount of Domestic Profit	---	0	0	0	−15	---	−34	−94	−136	+38	---	−107	−105	−137	+143
Methanol Production Cost	---	−291	−275	−258	0	---	−1,012	−1,538	−2,564	0	---	−4,332	−4,144	−3,890	0
Products Import Cost		+271	+271	+271	+59	---	+910	+910	+910	+393	---	+2,560	+2,560	+2,560	+1,096
Total	---	−36	−19	−2	+22	---	+66	+136	+261	+45	---	+890	+1,142	+1,395	+99

Note) +: Profit increase or cost decrease −: Profit decrease or cost increase
Crude oil production cost includes natural gas production cost (Natural gas is used in Balikpapan)
Products transportation cost includes methanol.
Amount of petroleum products include LPG.

Table 10 The Change of Profit Framework (High Scenario)

(million US$)

Item \ Case	H2000-0	H2000-1	H2000-2	H2000-3	H2005-0	H2005-1	H2005-2	H2005-3	H2010-0	H2010-1	H2010-2	H2010-3
	Base case				Base case				Base case			
		(Comparison to L-2000-0 case)				(Comparison to L-2005-0 case)				(Comparison to L-2010-0 case)		
Crude Oil Production Cost	---	0	0	0	---	0	0	0	---	0	0	0
Amount of Money of Crude Oil Export	---	−18	−18	−19	---	−25	−25	−25	---	−28	−4	0
Crude Oil Transportation Cost	---	0	0	−1	---	0	0	0	---	0	+1	0
Amount of Money of AL Import	---	0	0	0	---	0	0	0	---	0	0	0
Catalyst. Chemical Cost	---	0	0	0	---	0	0	0	---	0	0	0
Amount of Money of Products Export	---	+9	+9	+10	---	+12	+12	+12	---	+14	+1	0
Products Transportation Cost	---	−1	−1	0	---	−2	−2	−2	---	−10	−10	−10
Amount of Domestic Profit	---	+2	+2	+2	---	0	0	+1	---	+1	−1	0
Methanol Production Cost	---	−7	−6	−6	---	−46	−43	−41	---	−178	−177	−169
Products Import Cost	---	+12	+12	+12	---	+51	+51	+51	---	+184	+184	+184
Total	---	−3	−2	−2	---	−10	−7	−4	---	−17	−6	+5

Note) +: Profit increase or cost decrease −: Profit decrease or cost increase
Crude oil production cost includes natural gas production cost (Natural gas is used in Balikpapan)
Products transportation cost includes methanol.
Amount of petroleum products include LPG.

Table 11 Change of Products Transportation (Gasoline Flow)

Demand Area / Refinery	Demand Area 1	Demand Area 2	Demand Area 3	Demand Area 4	Demand Area 5	Demand Area 6	Demand Area 7	Demand Area 8
Dumai	↓ ③			↓ ③				
Plaju	↑ ②		↓ ①					
Cilacap			↓ ①	↑ ②				
Balikpapan								
Methanol Introduced			○					

Table 12 Change of Products Transportation (Kerosene Flow)

Demand Area / Refinery	Demand Area 1	Demand Area 2	Demand Area 3	Demand Area 4	Demand Area 5	Demand Area 6	Demand Area 7	Demand Area 8
Dumai		↓ ③		↓ ③				
Plaju		↑ ②	↓ ①					
Cilacap			↓ ①	↑ ②				
Balikpapan								
Methanol Introduced		○	○					

ATTACHMENT 6-1

1. Reference Drawings of Banko Coal Resources

1. Reference Drawings of Banko Coal Resources

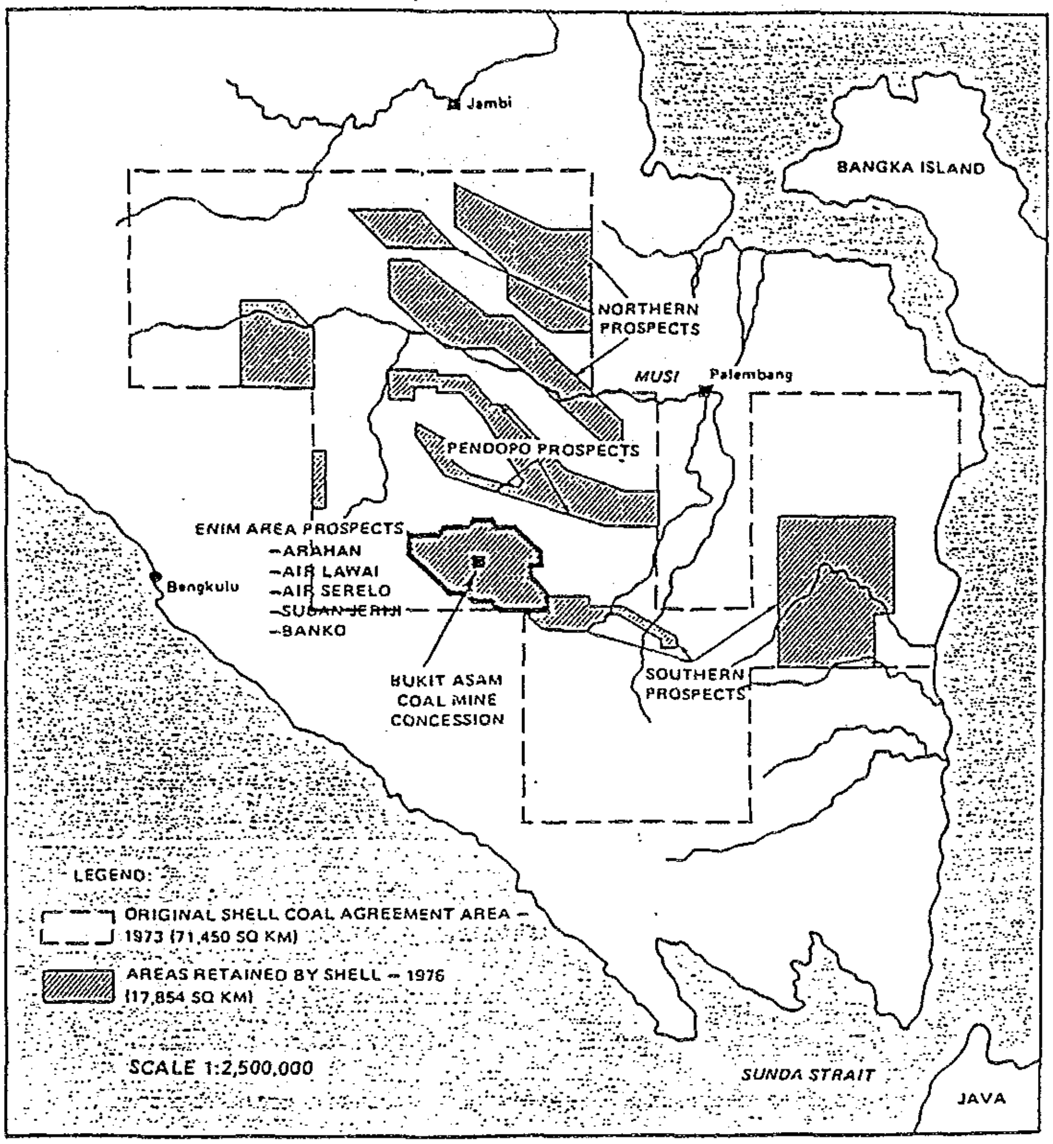


Fig. 1 Surveyed Area by Shell Mijonbow N.V. In South Sumatra

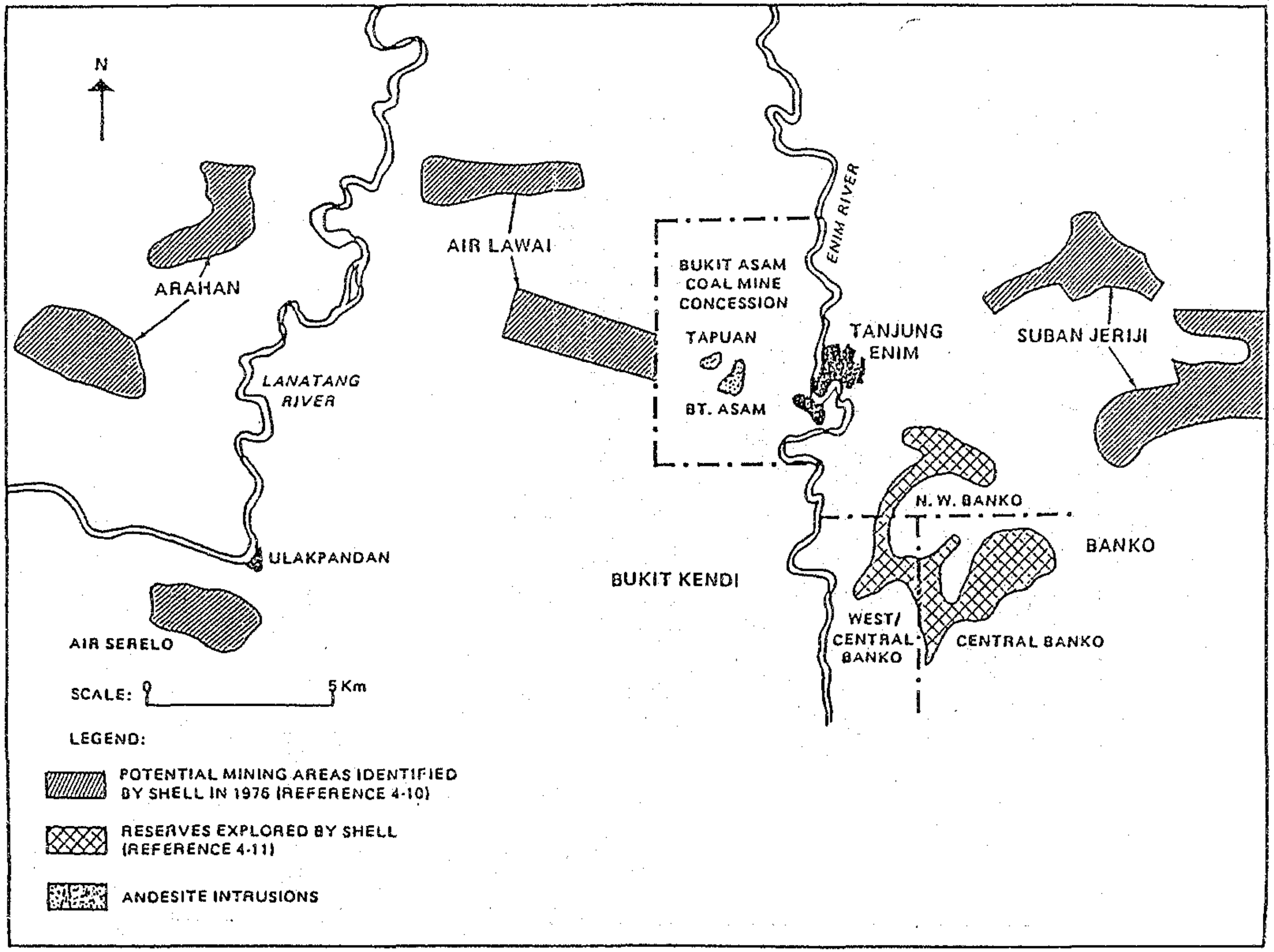


Fig. 2 Most Promising Area around Bukit Asam Coal Mine

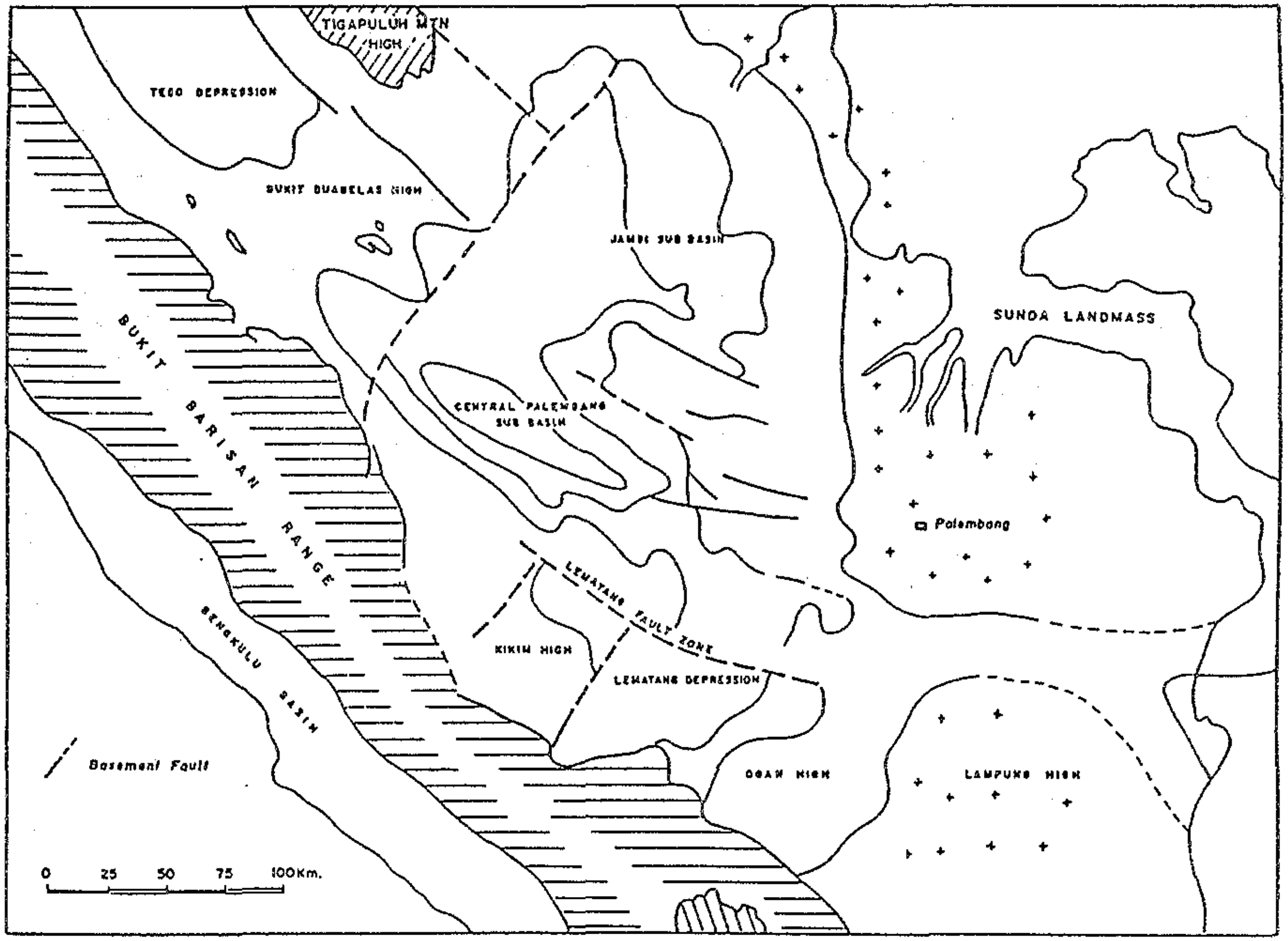


Fig. 3 Basin formed in Tertiary Epoch in South Sumatra

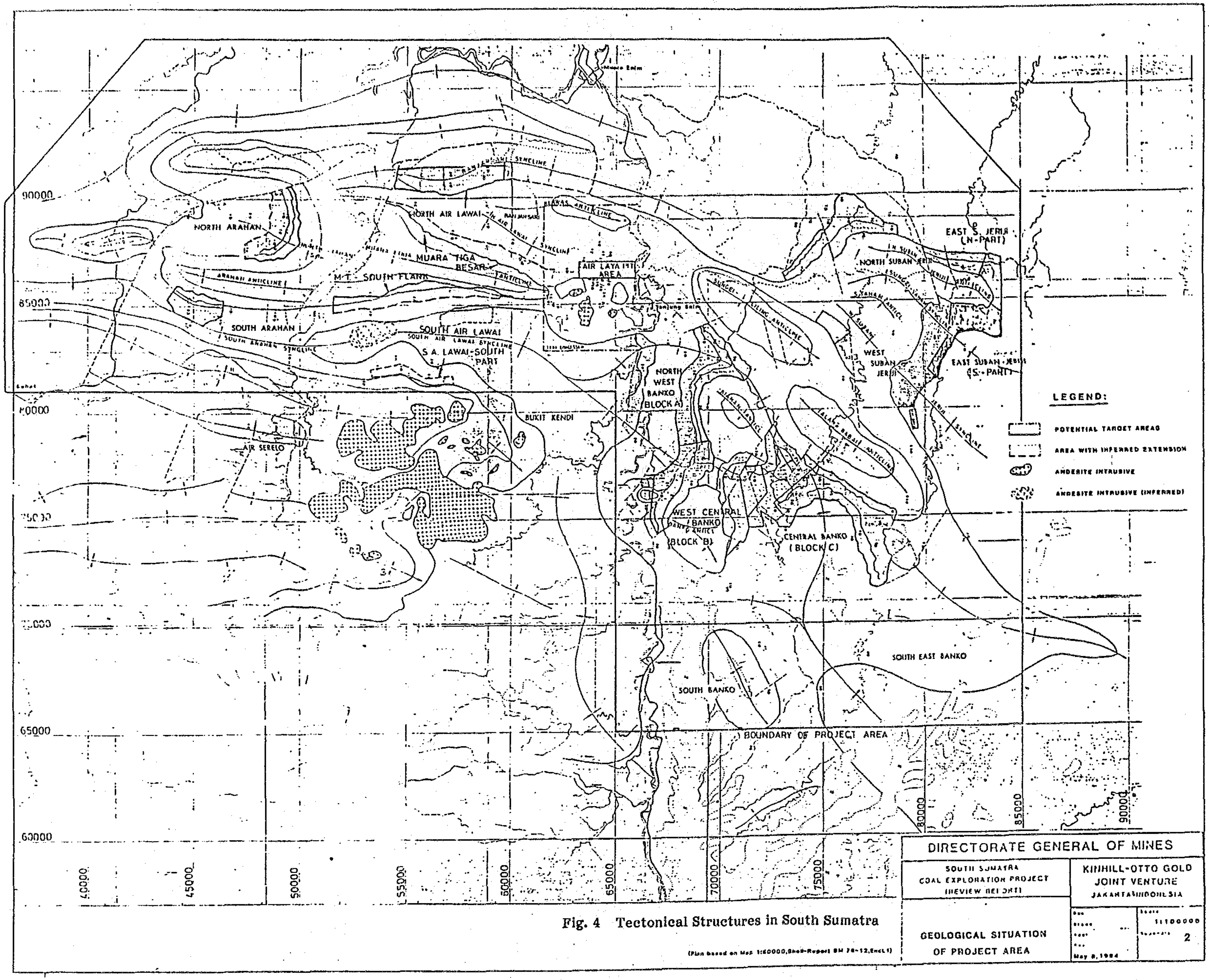


Fig. 4 Tectonical Structures in South Sumatra

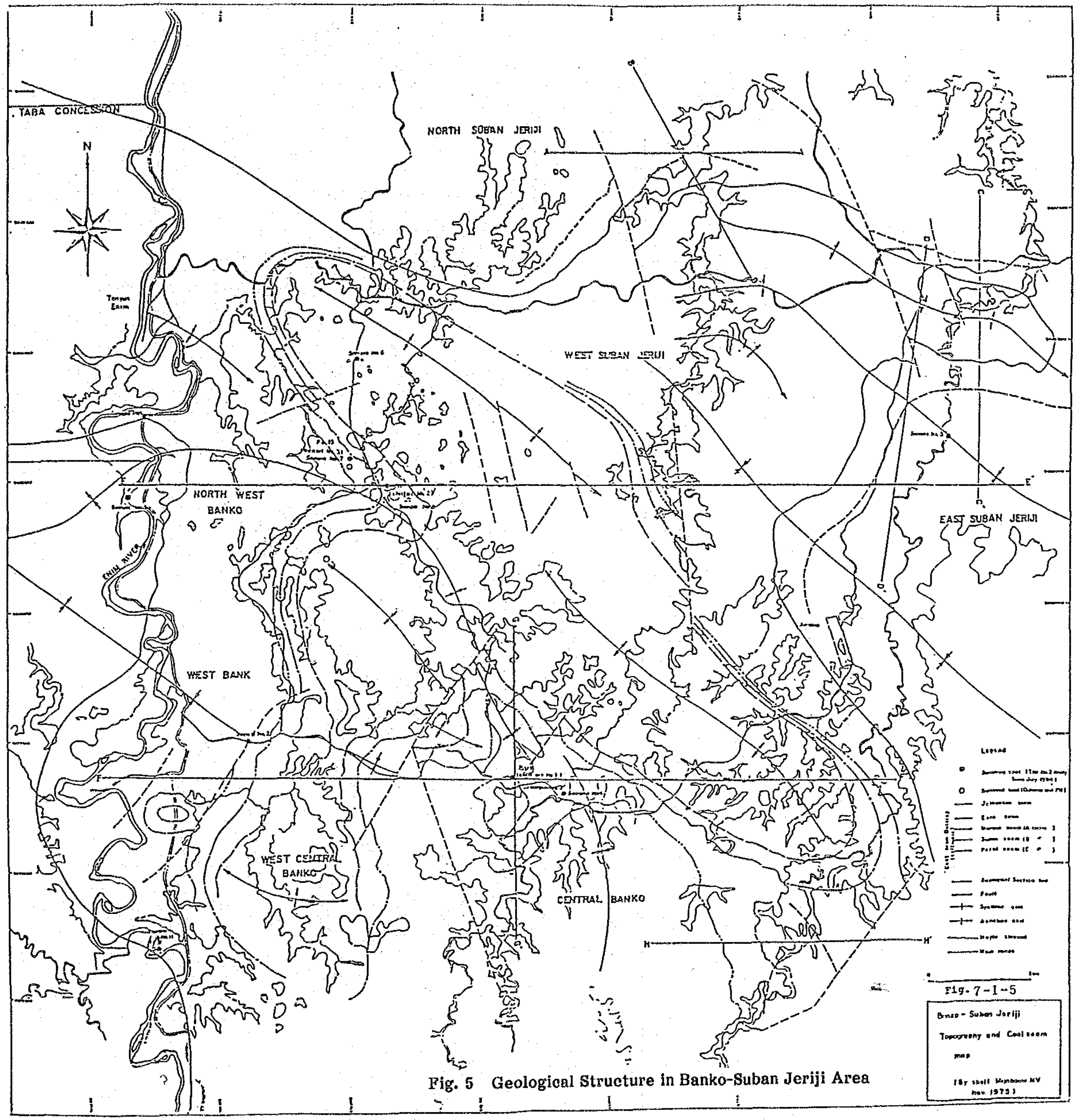


Fig. 5 Geological Structure in Banko-Suban Jeriji Area

Fig. 6 Columner Sections of Boreholes driven by Shell (1)

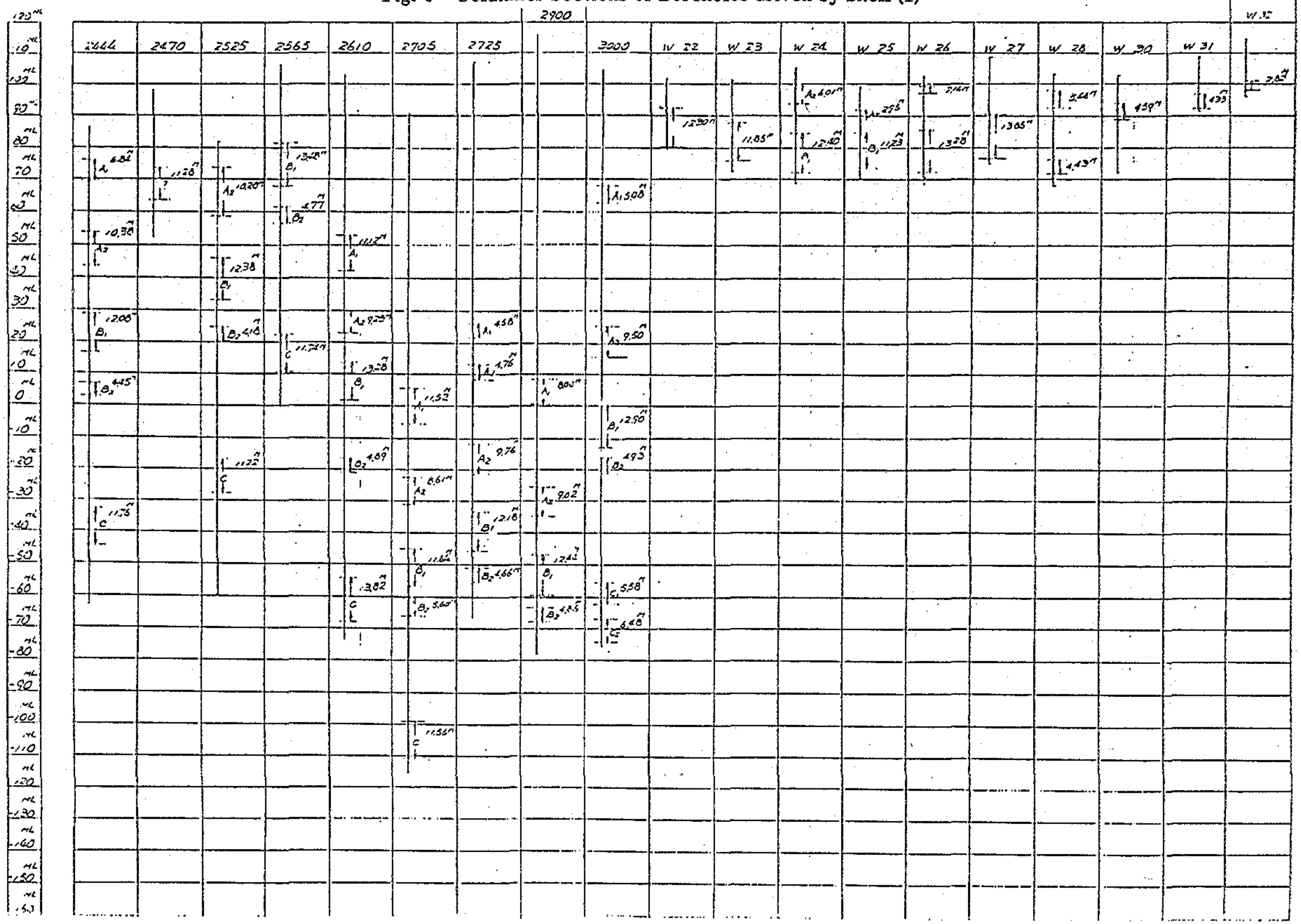


Fig. 7 Columner Sections of Boreholes driven by Shell (2)

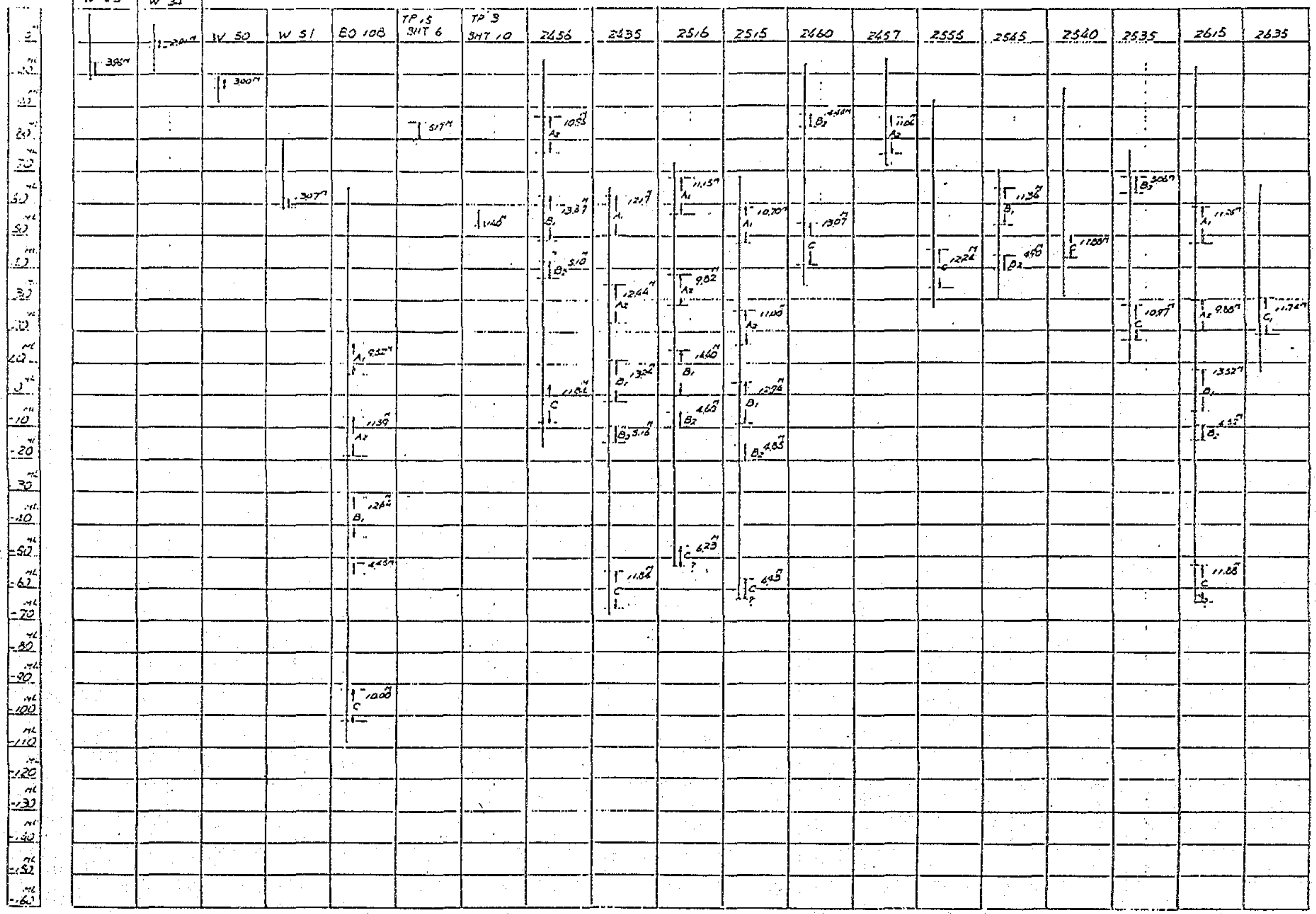


Fig. 8 Columner Sections of Boreholes driven by Shell (3)

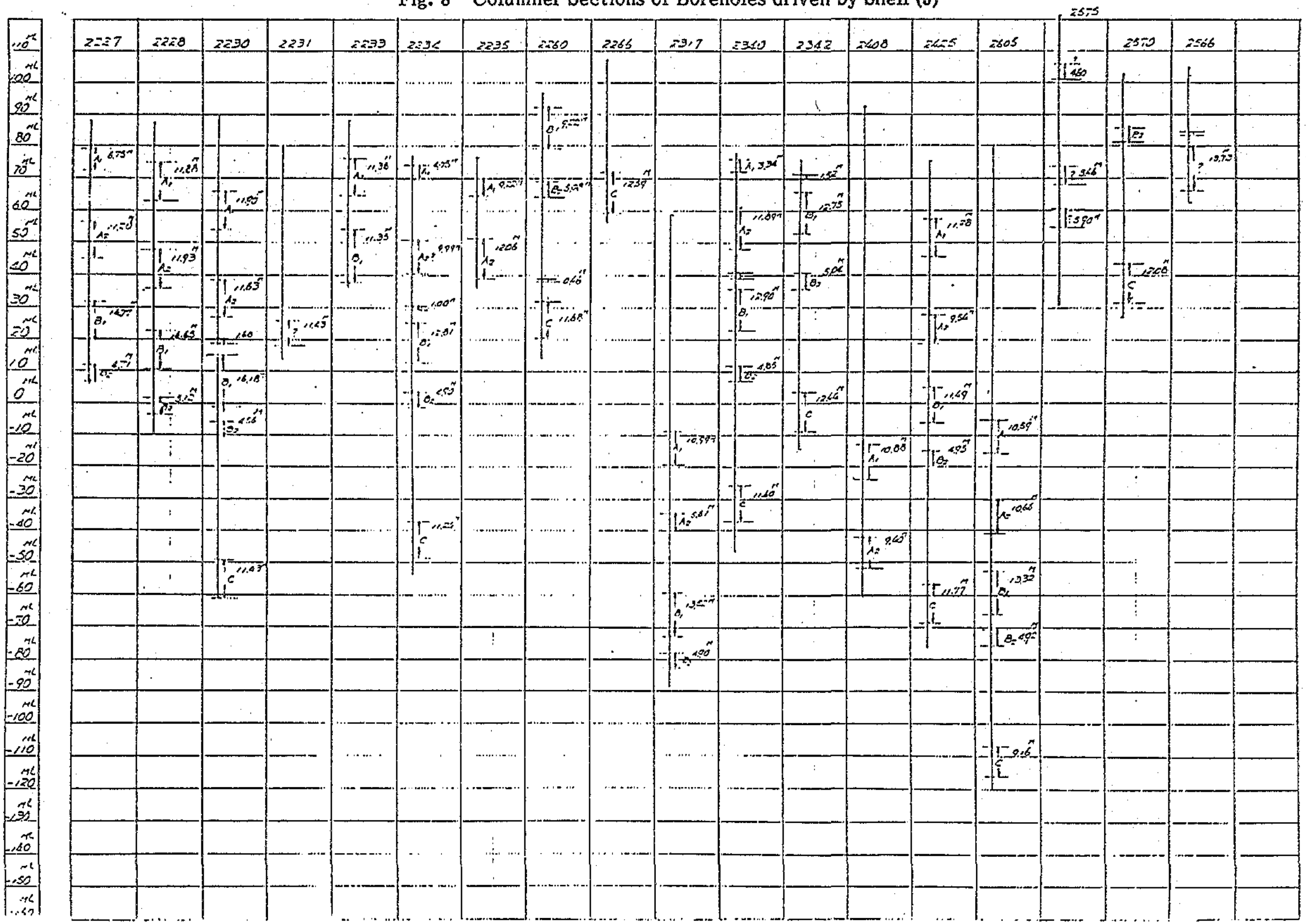


Fig. 9 Columner Sections of Boreholes driven by Shell (4)

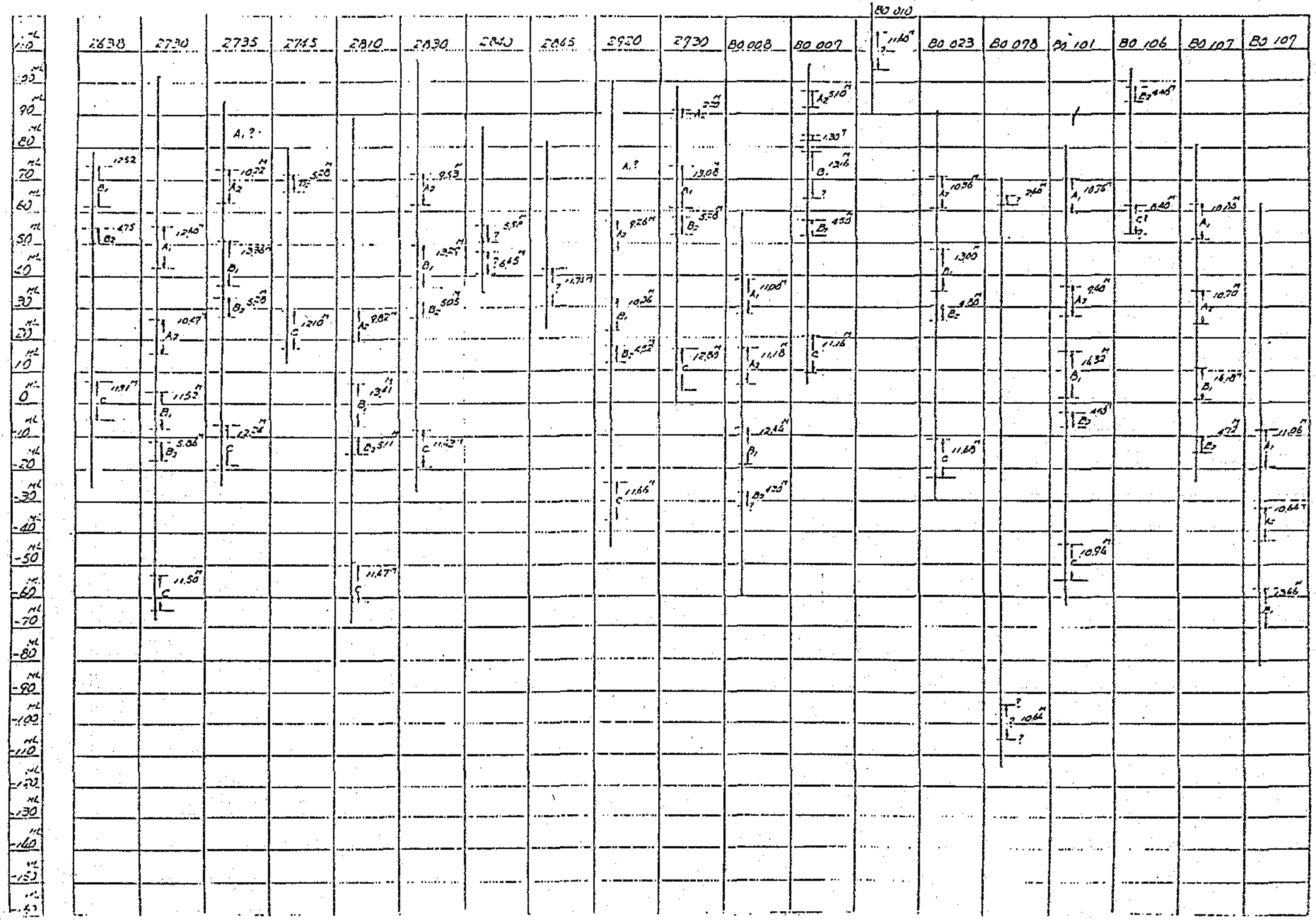


Fig. 10 Columner Sections of Boreholes driven by Shell (5)

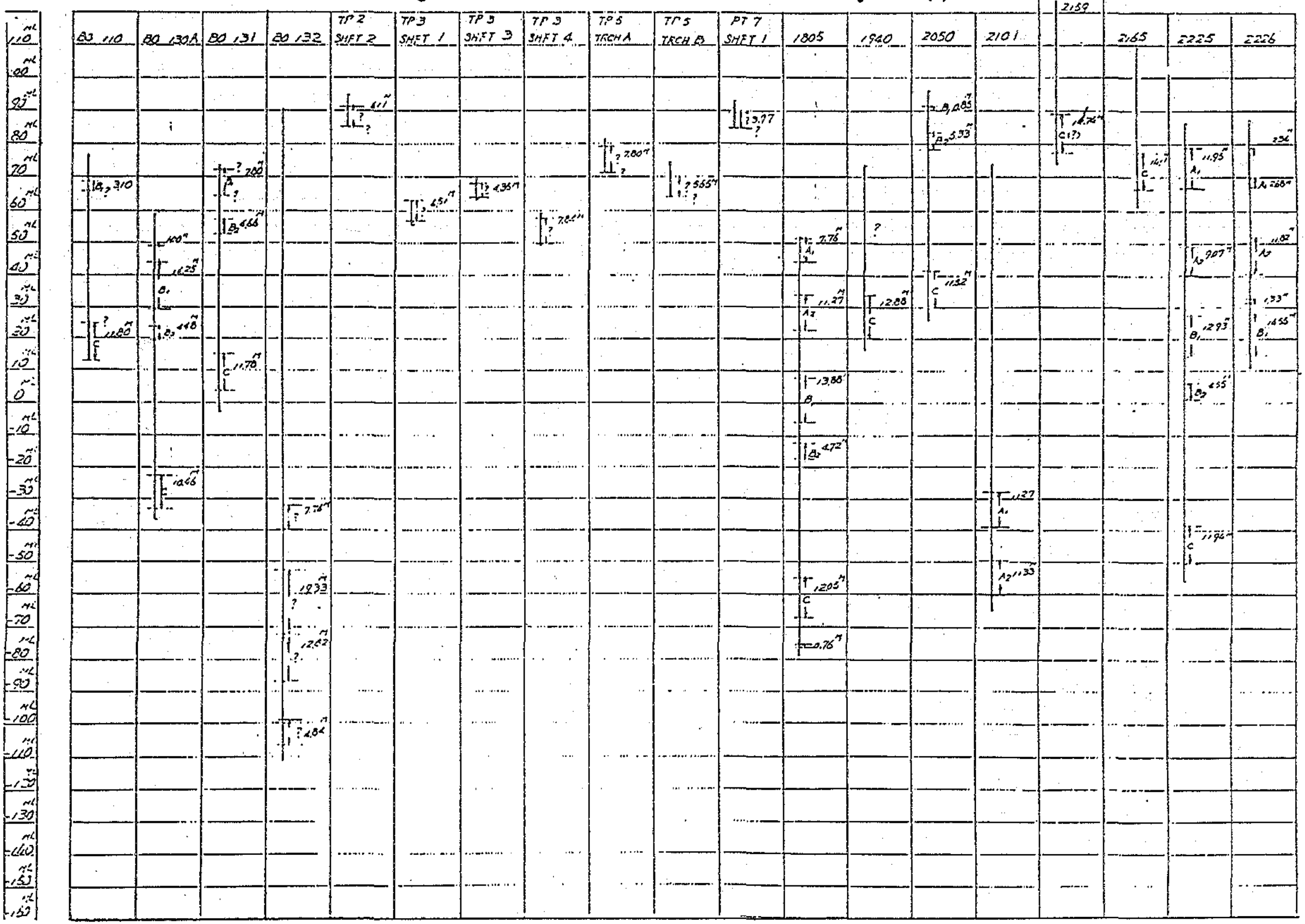


Fig. 11 Columner Sections of Boreholes driven by DOC (1)

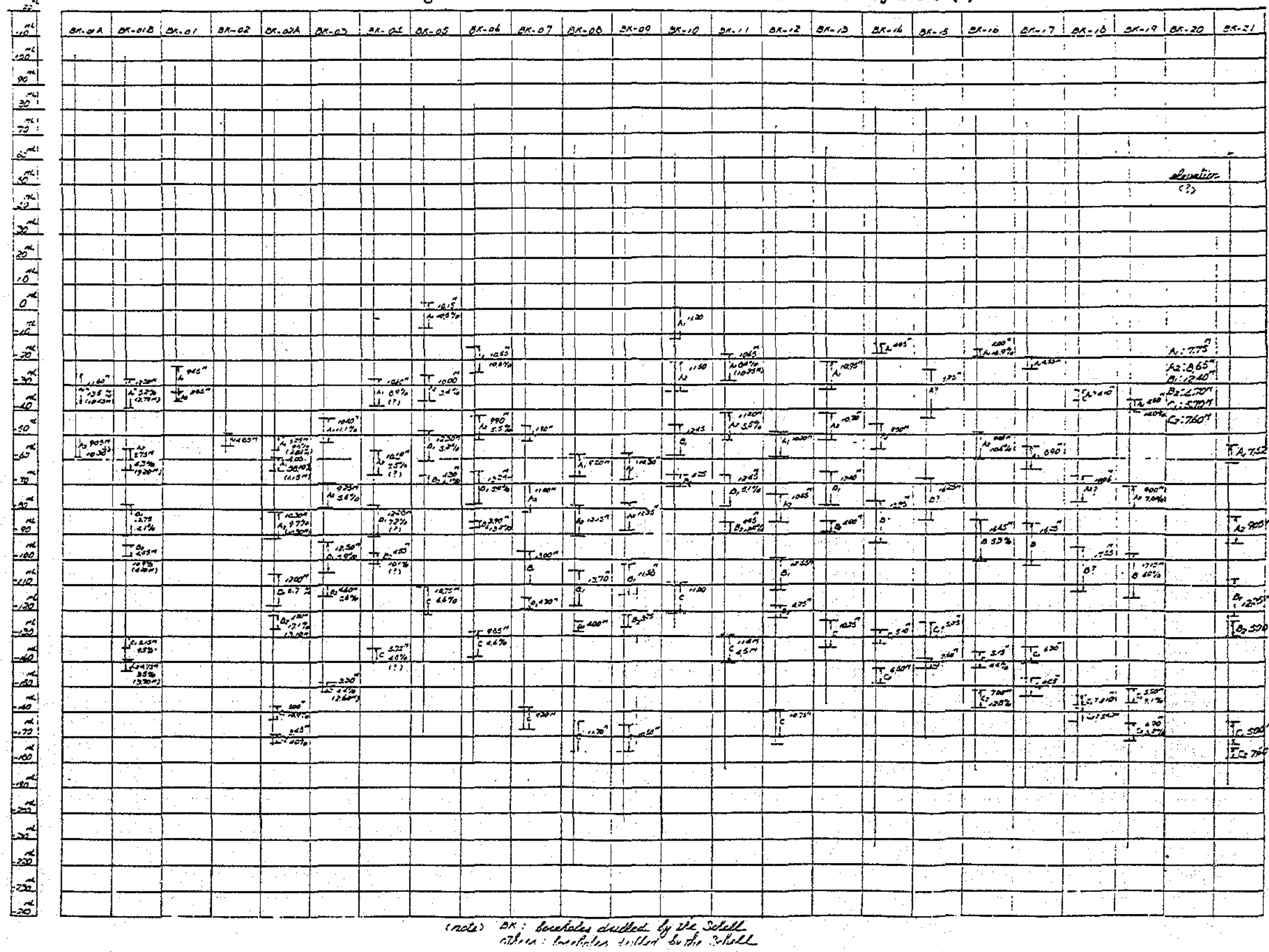
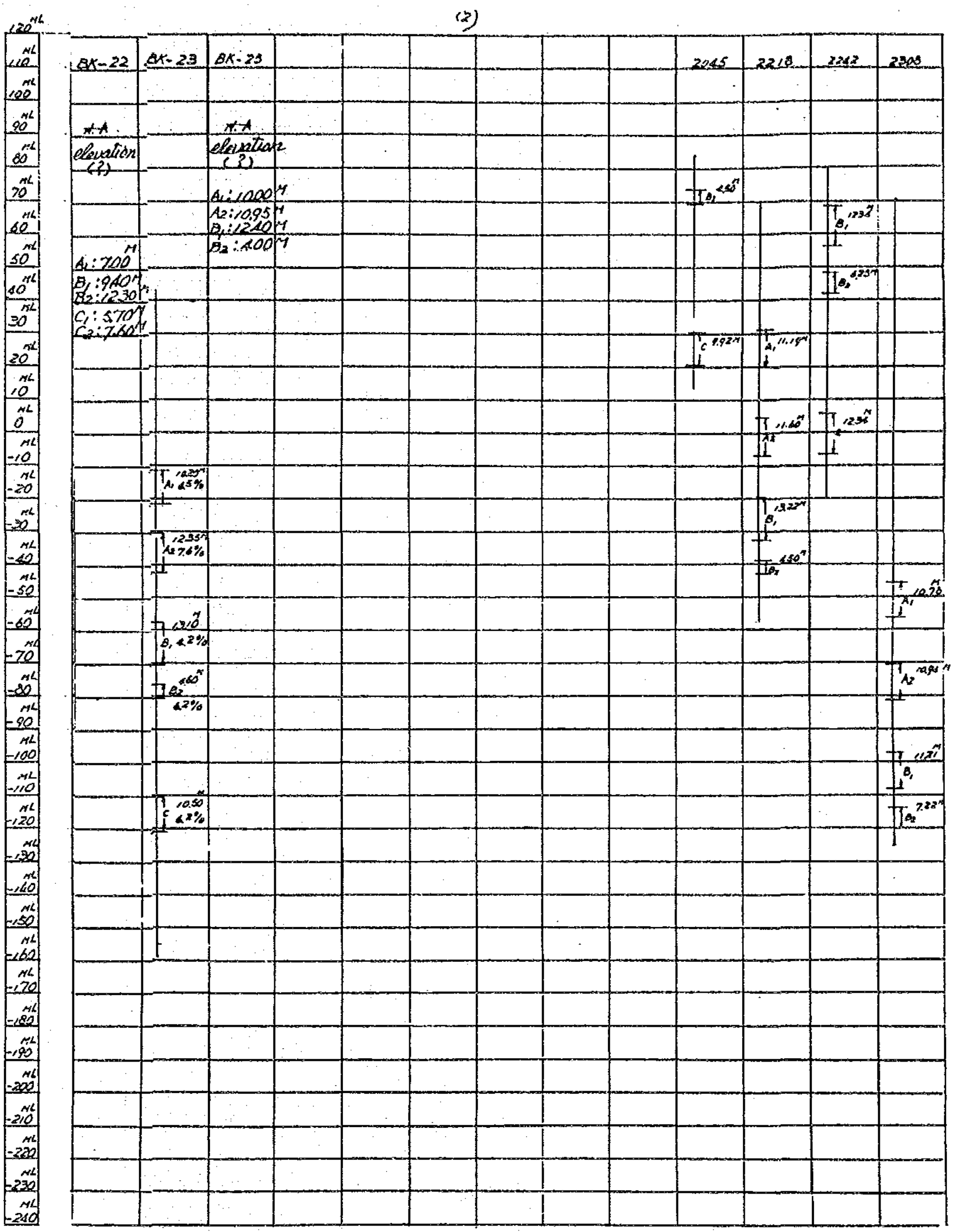


Fig. 12 Columner Sections of Boreholes driven by DOC (2)



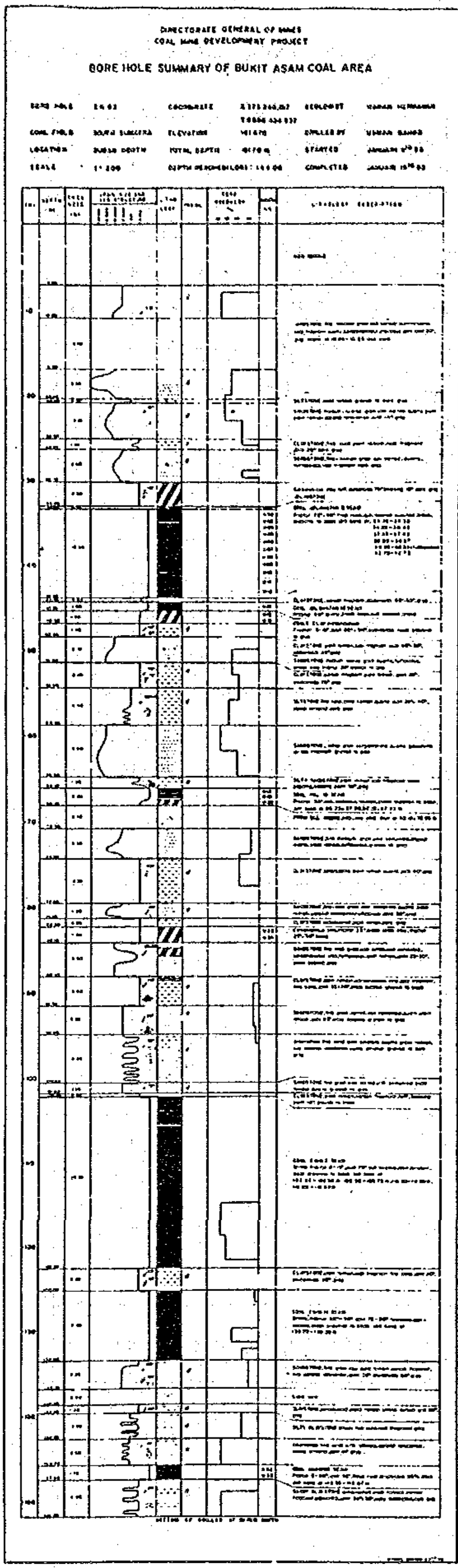


Fig. 13

An Example of Columner Sections Prepared by DOC

Fig. 14 Combined Map (Topographical, Geological and Outcrop/Sub-Outcrop Map) Showing Location of Coal Sampling, North West Banko

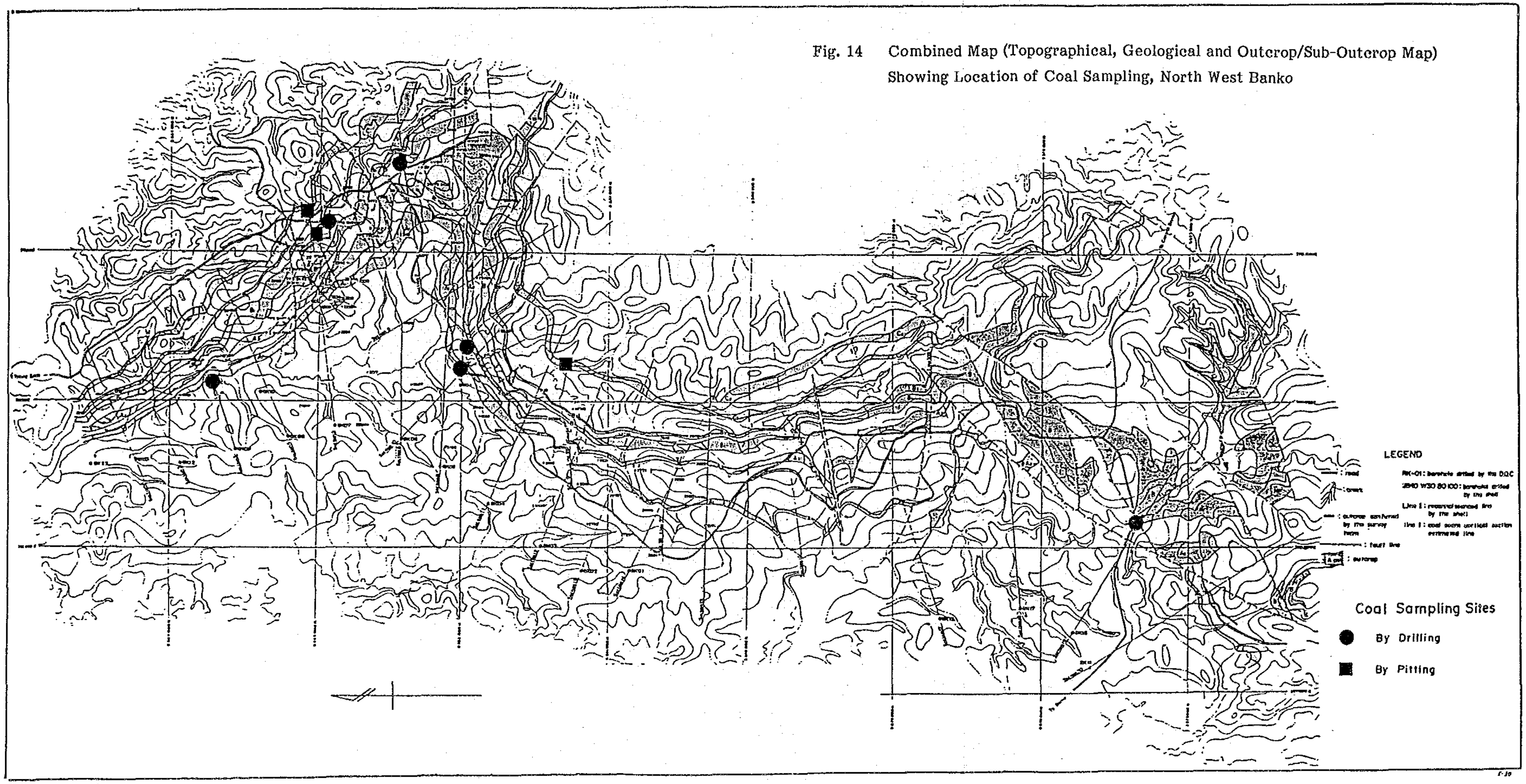


Fig. 15 Reconnaissance Route Map and Estimated Vertical Section on the Line 1, North West Banko

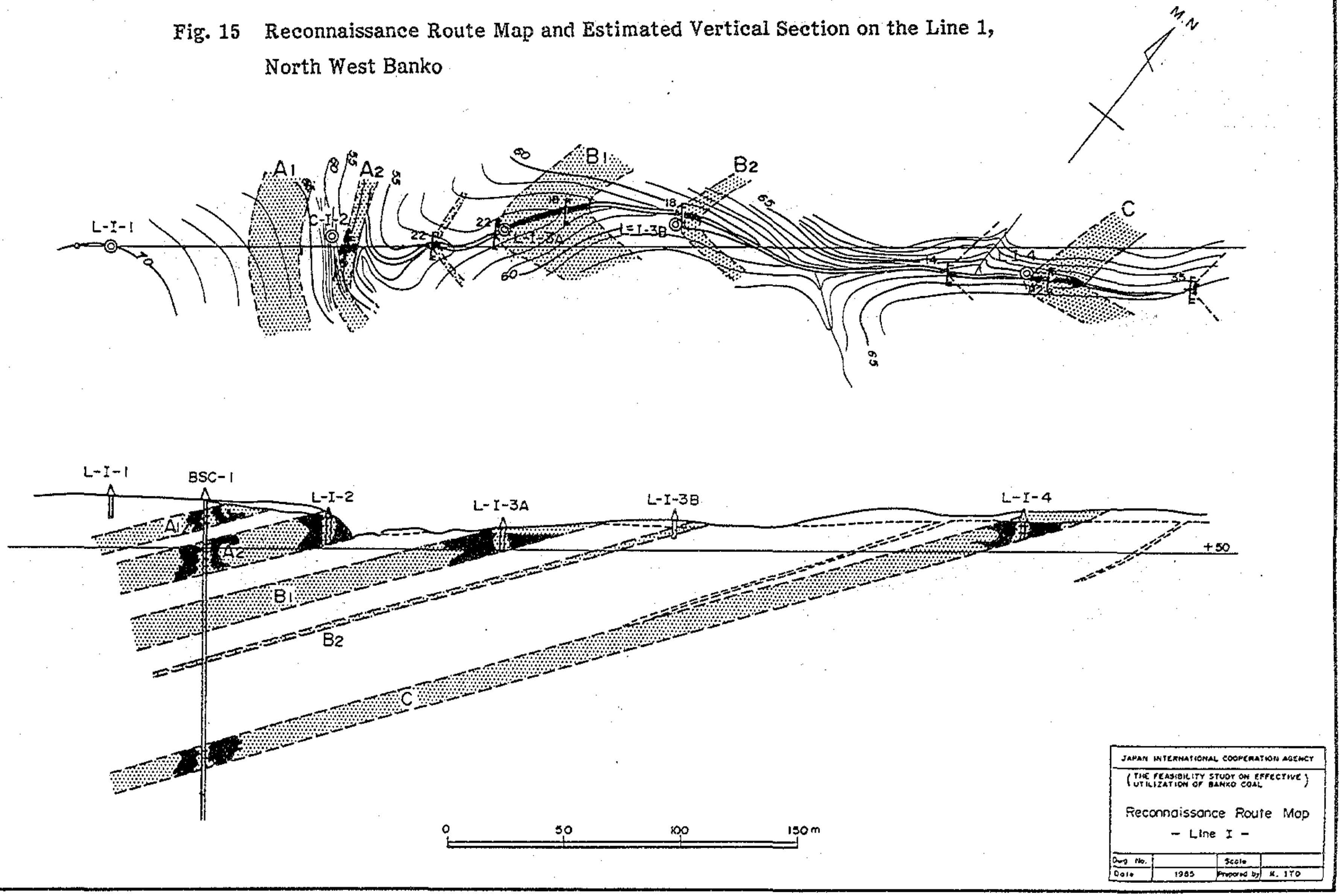


Fig. 16 Reconnaissance Route Map and Estimated Vertical Section on the Line 2, North West Banko

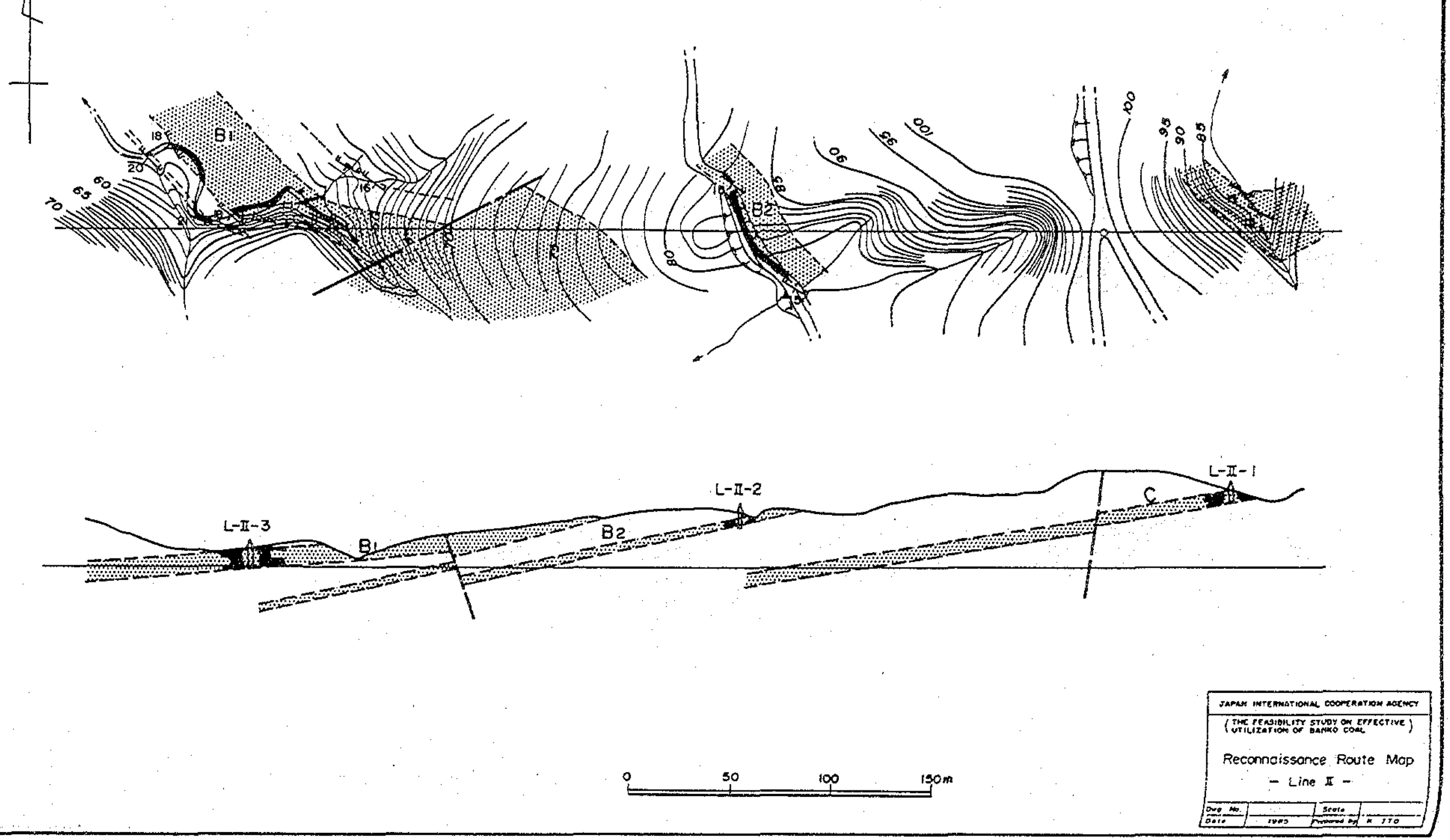


Fig. 17 Reconnaissance Route Map and Estimated Vertical Section on the Line 3, North West Banko

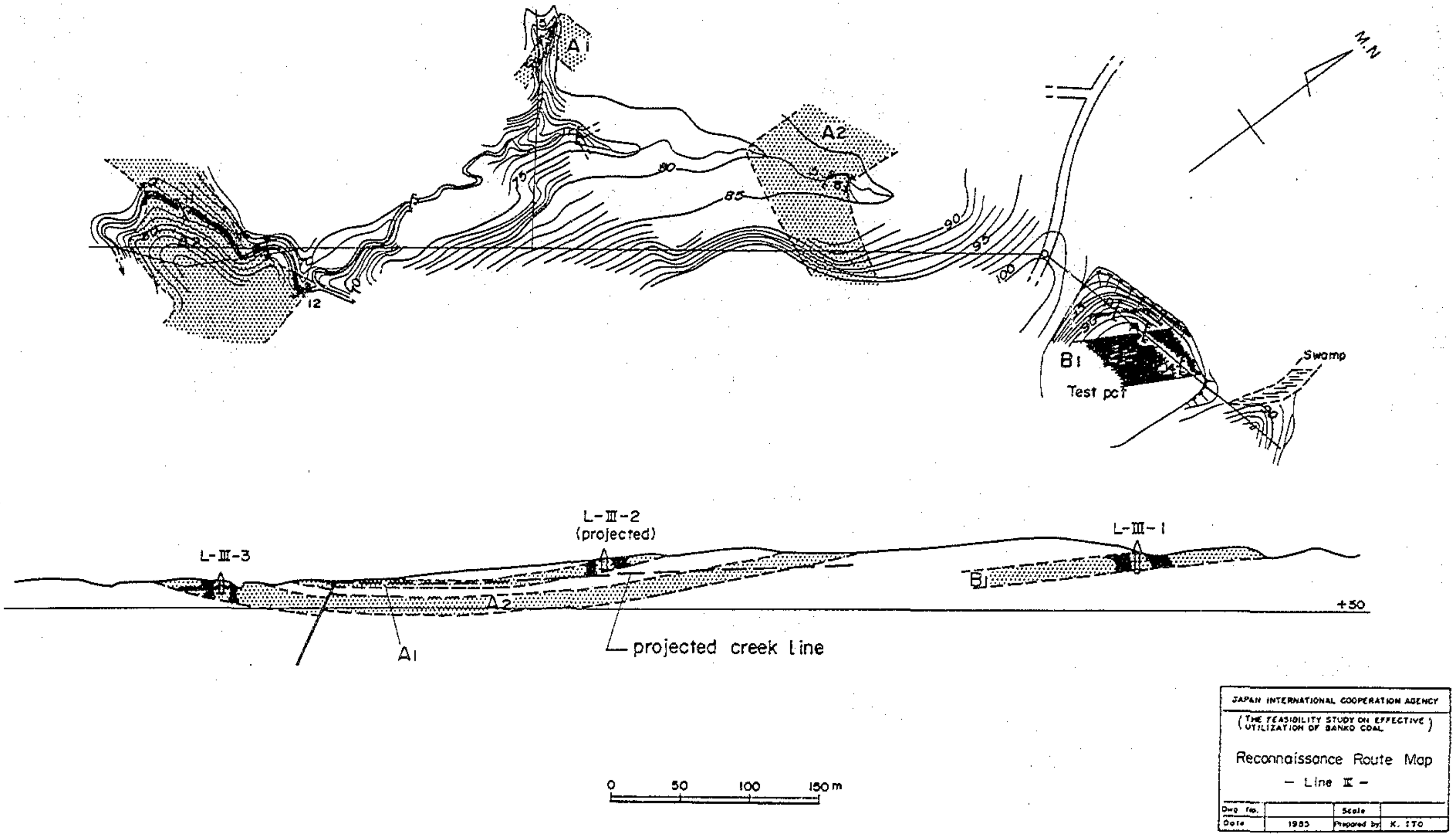


Fig. 18 Reconnaissance Route Map and Estimated Vertical Section on the Line 4, North West Banko

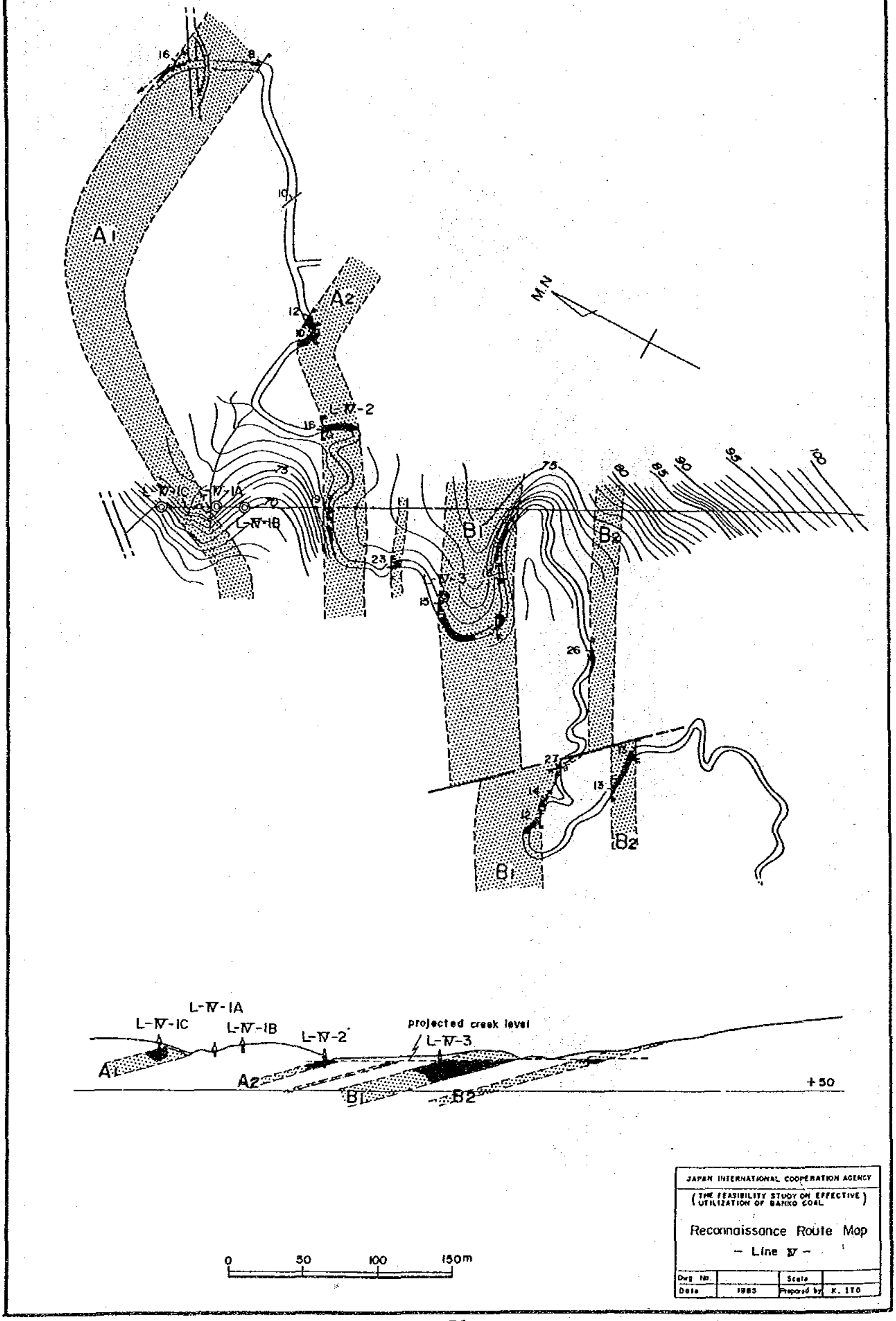


Fig. 19 Reconnaissance Route Map and Estimated Vertical Section on the Line 5, North West Banko

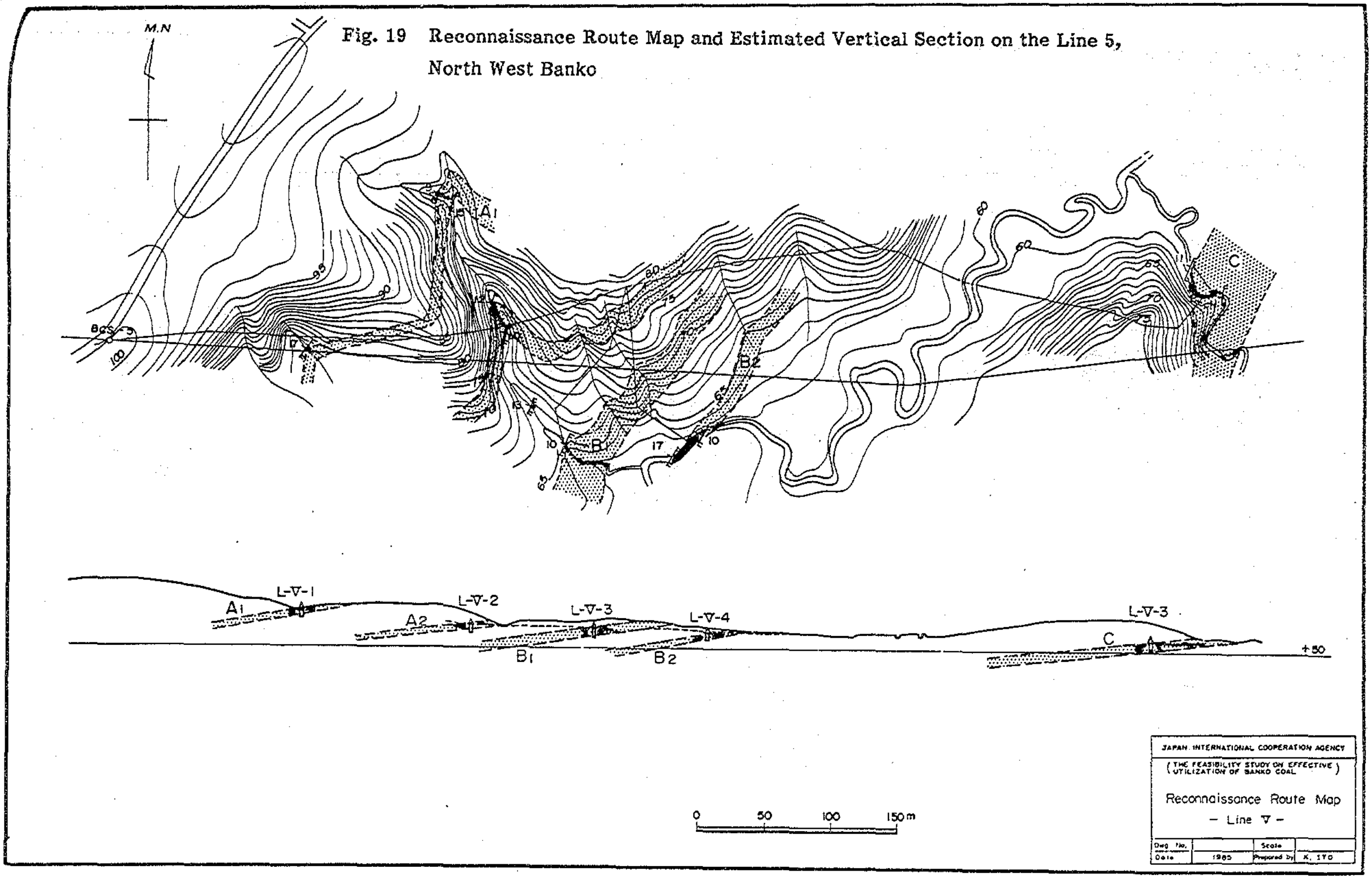


Fig. 20 Reconnaissance Route Map and Estimated Vertical Section on the Line 6, North West Banko

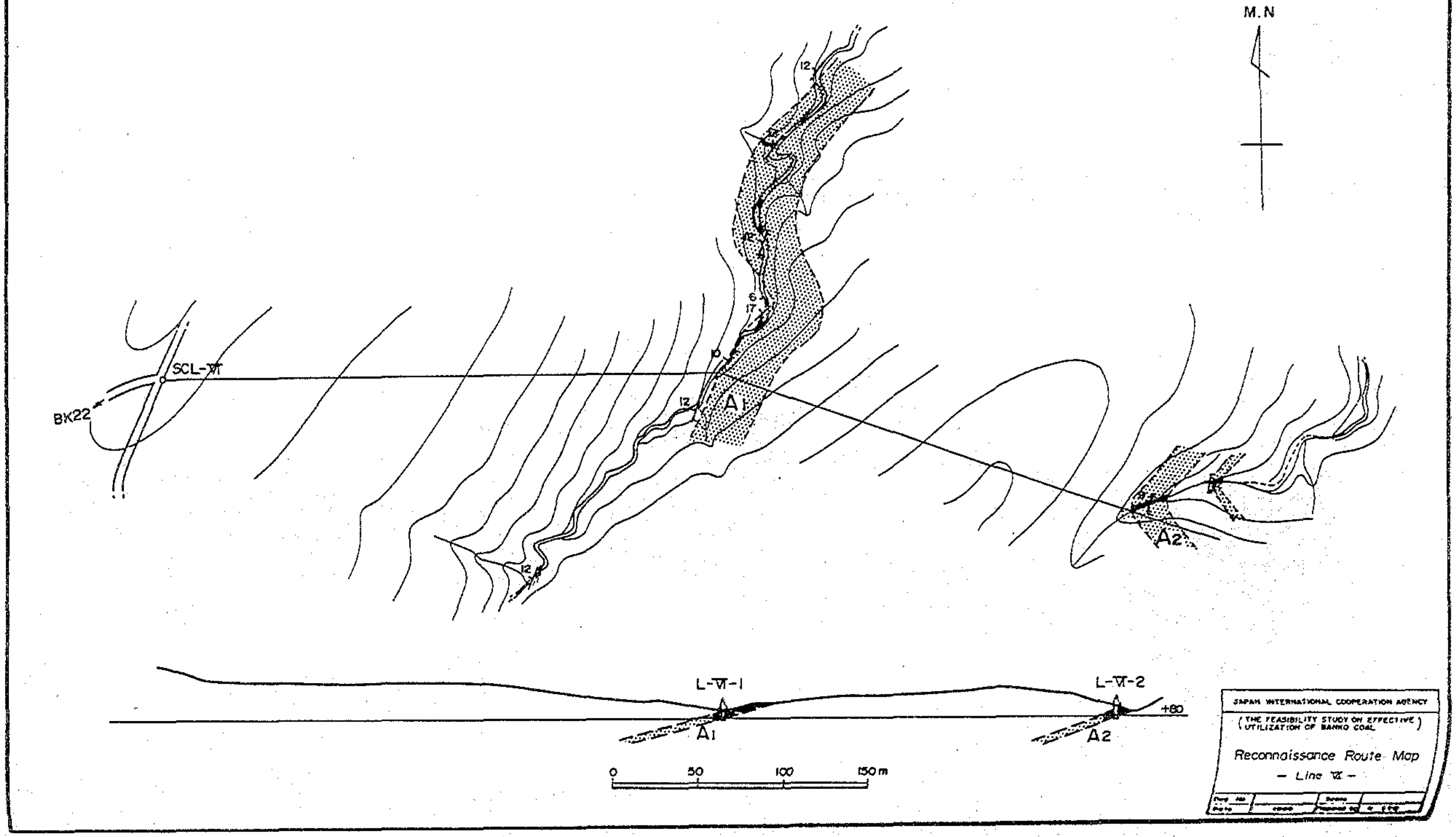


Fig. 21 Reconnaissance Route Map and Estimated Vertical Section on the Line 7, North West Banko

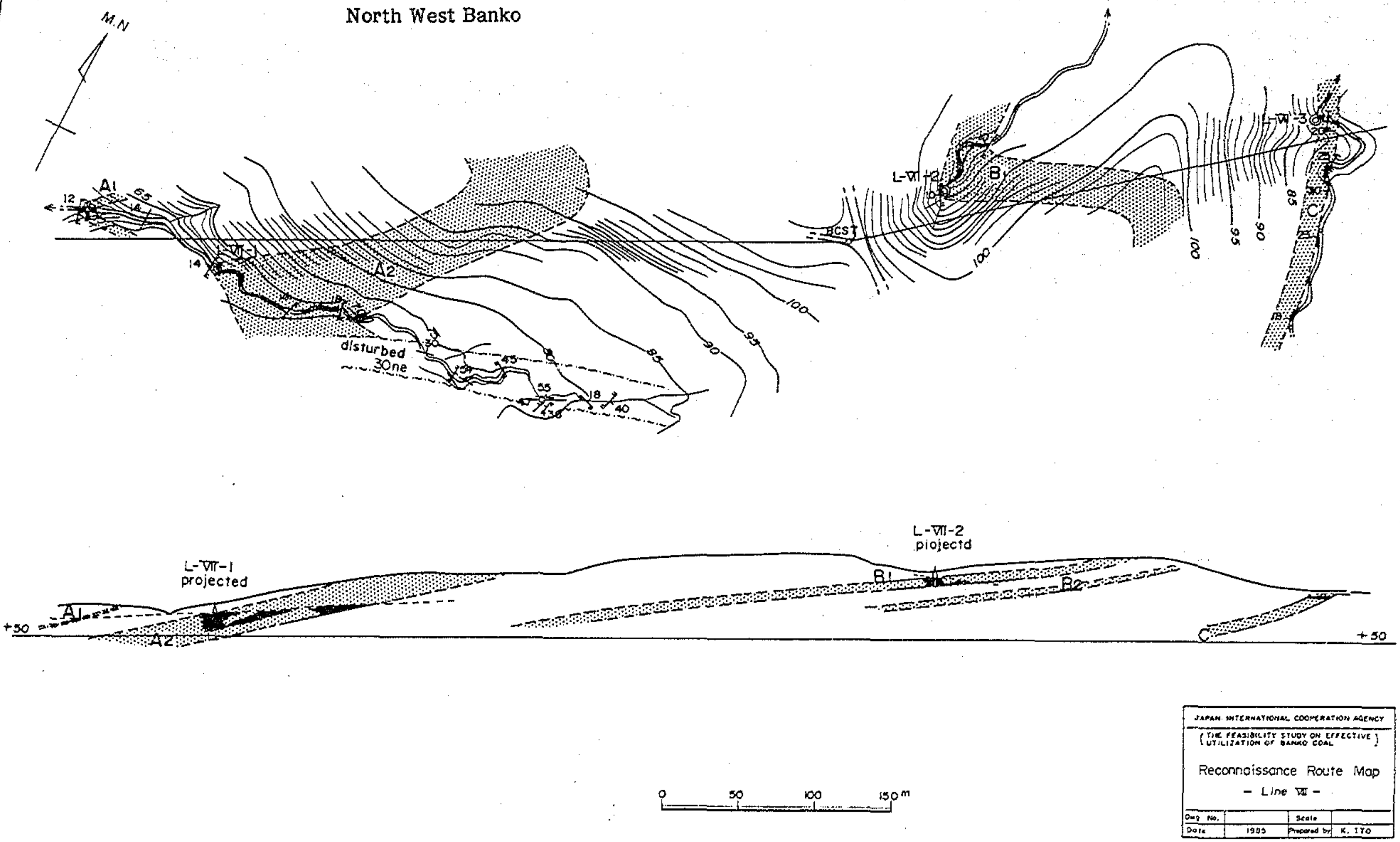


Fig. 22 Reconnaissance Route Map and Estimated Vertical Section on the Line 8, North West Banko

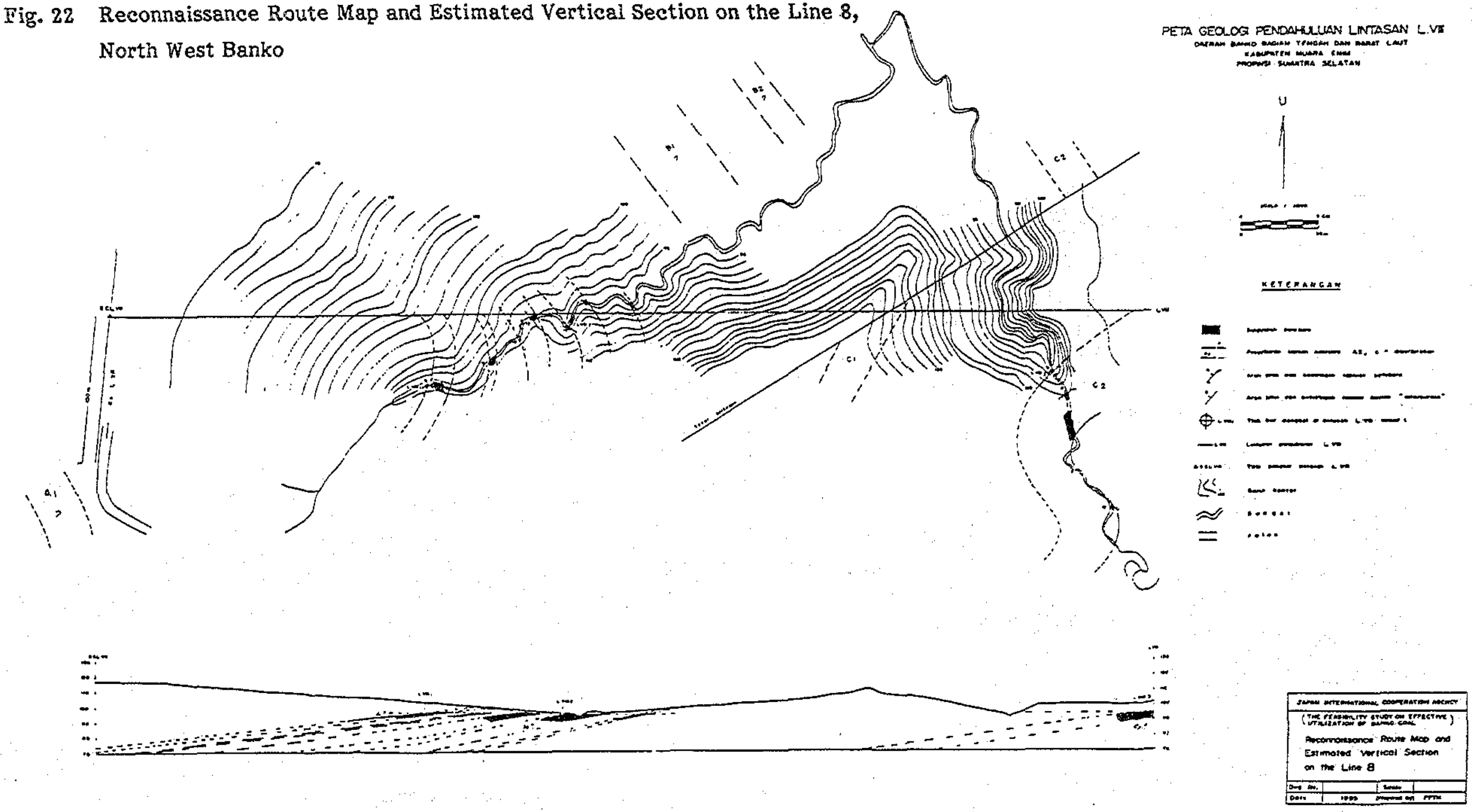


Fig. 23 Reconnaissance Route Map and Estimated Vertical Section on the Line 9, North West Banko

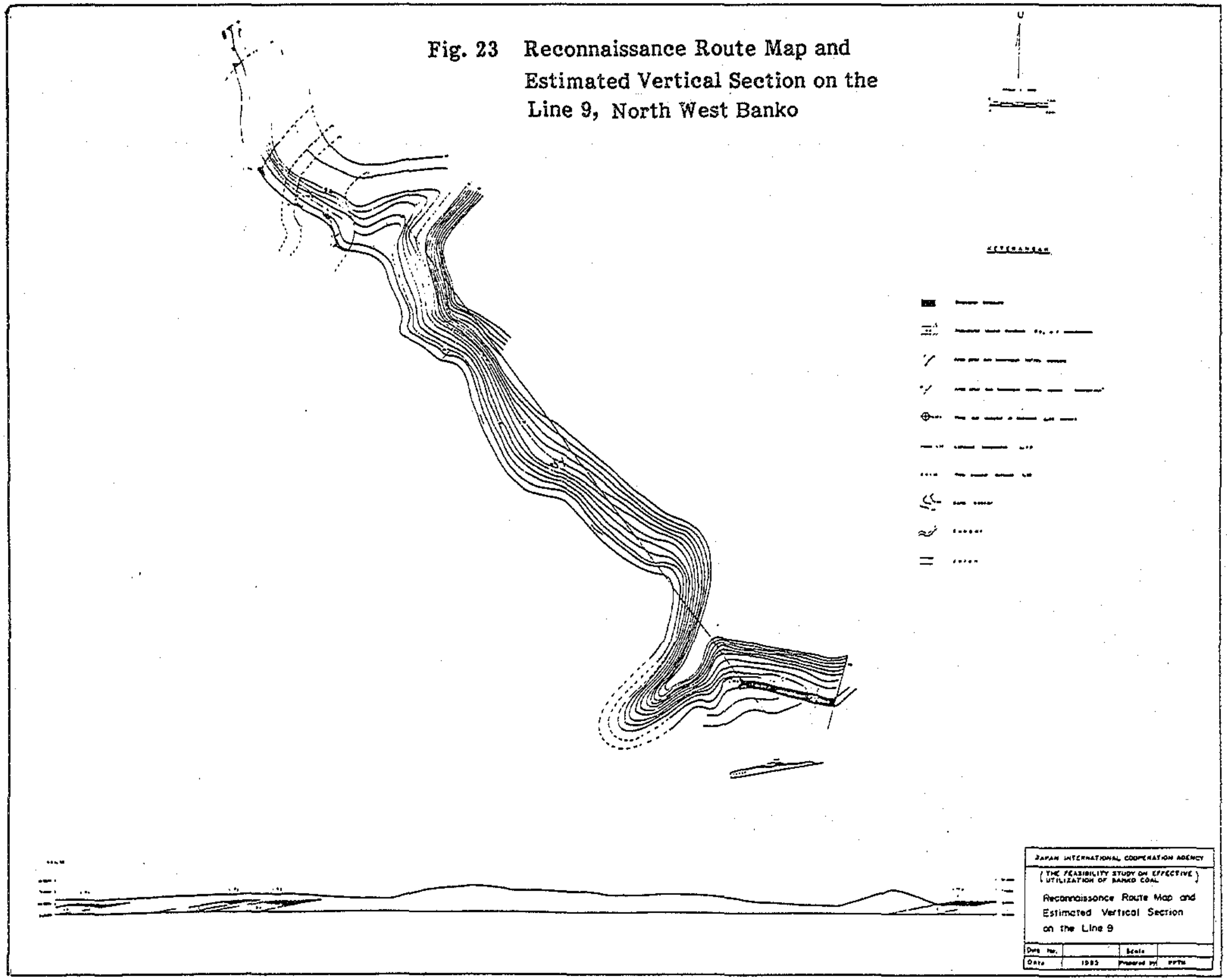
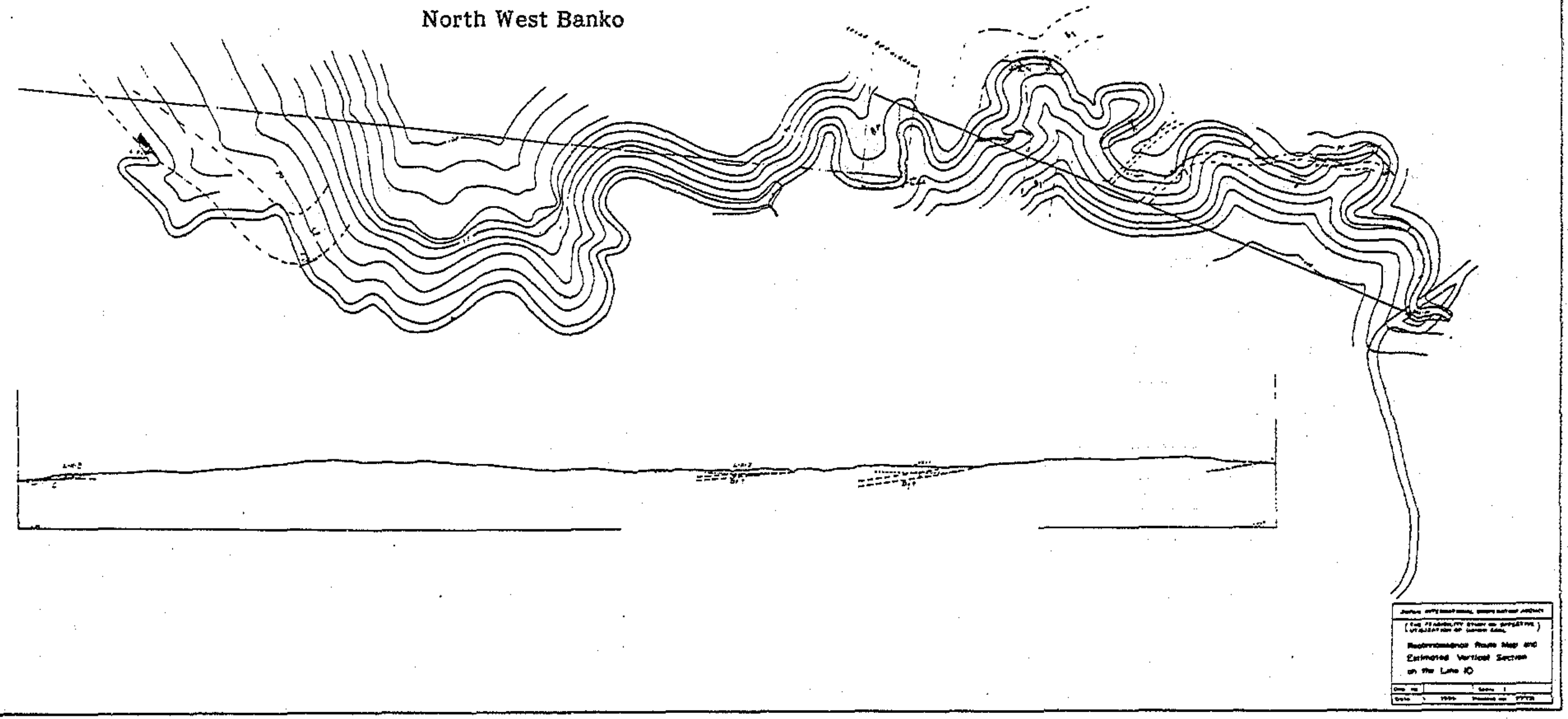


Fig. 24 Reconnaissance Route Map and Estimated Vertical Section on the Line 10, North West Banko



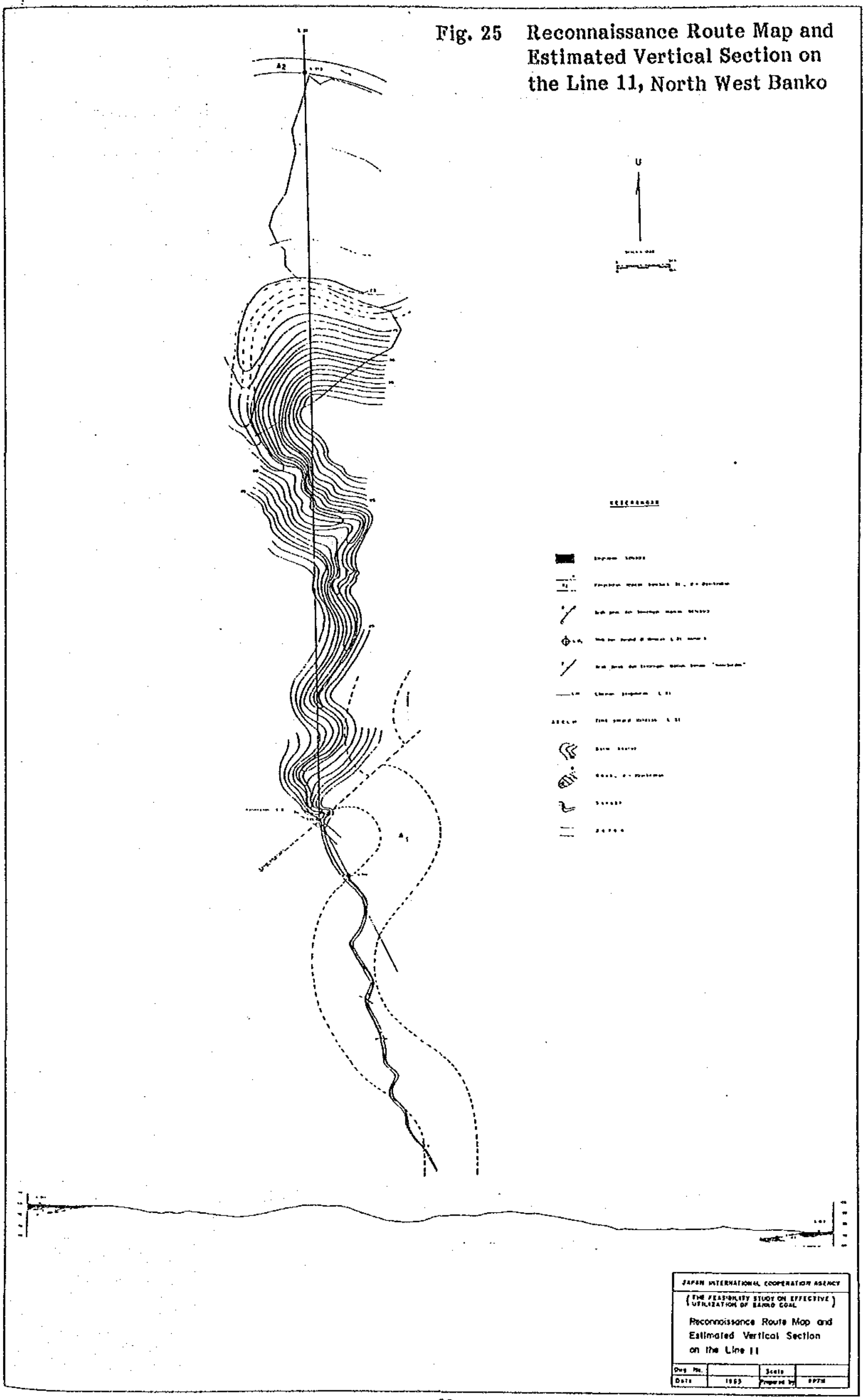


Fig. 25 Reconnaissance Route Map and Estimated Vertical Section on the Line 11, North West Banko

Fig. 26 **Reconnaissance Route Map and Estimated Vertical Section on the Line 12, North West Banko**

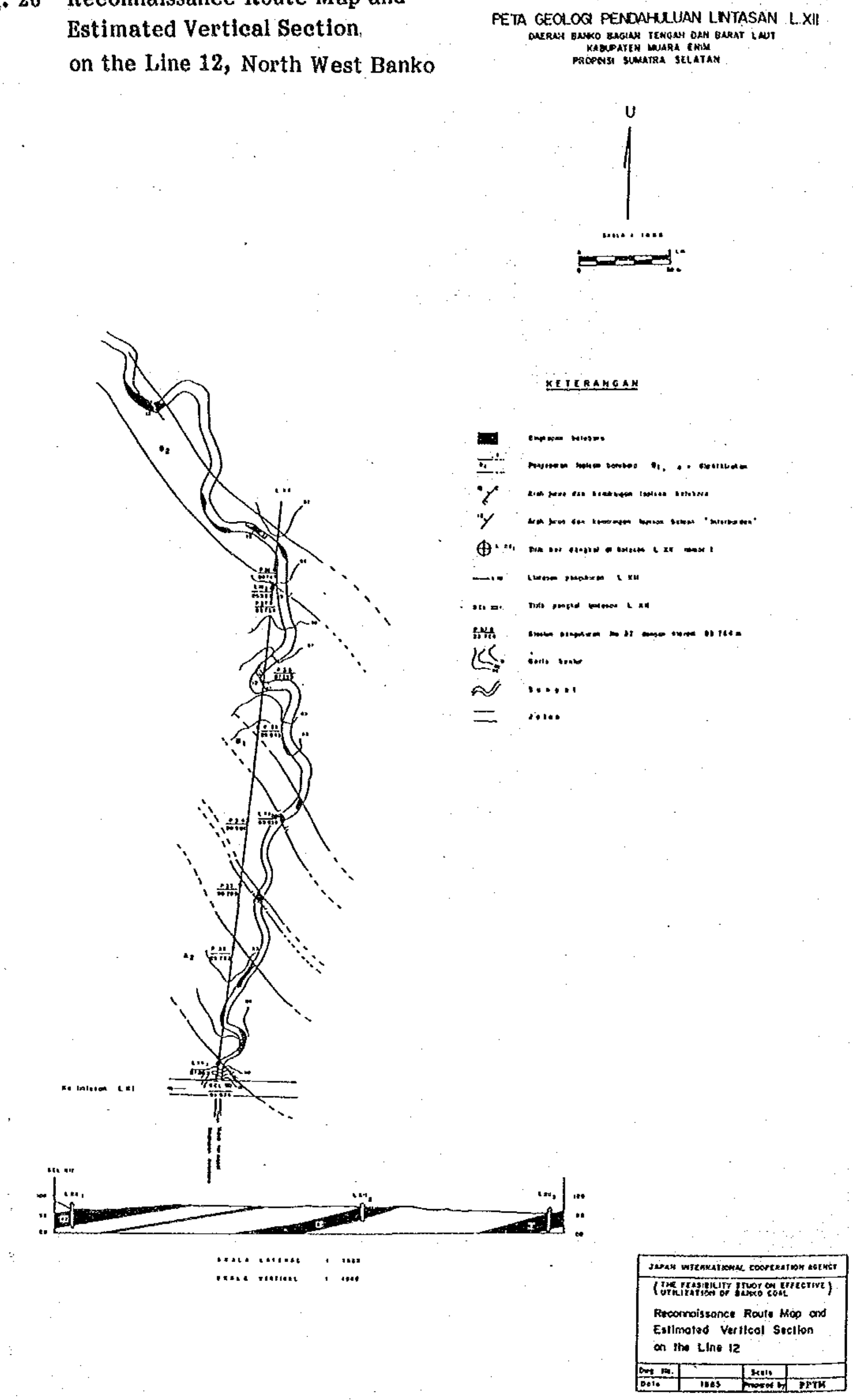


Fig. 27 Estimated Vertical Section, North West Banko (1)

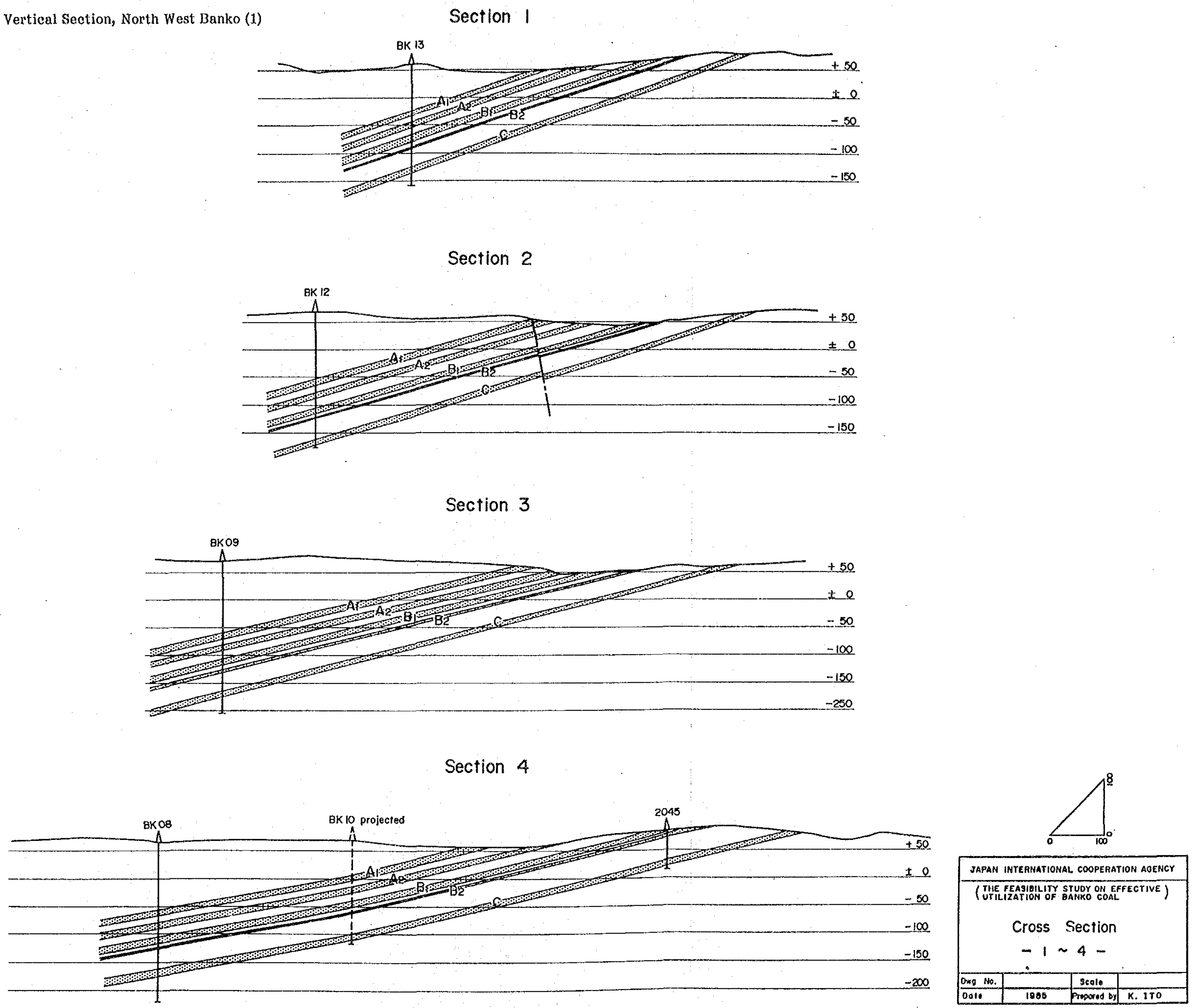
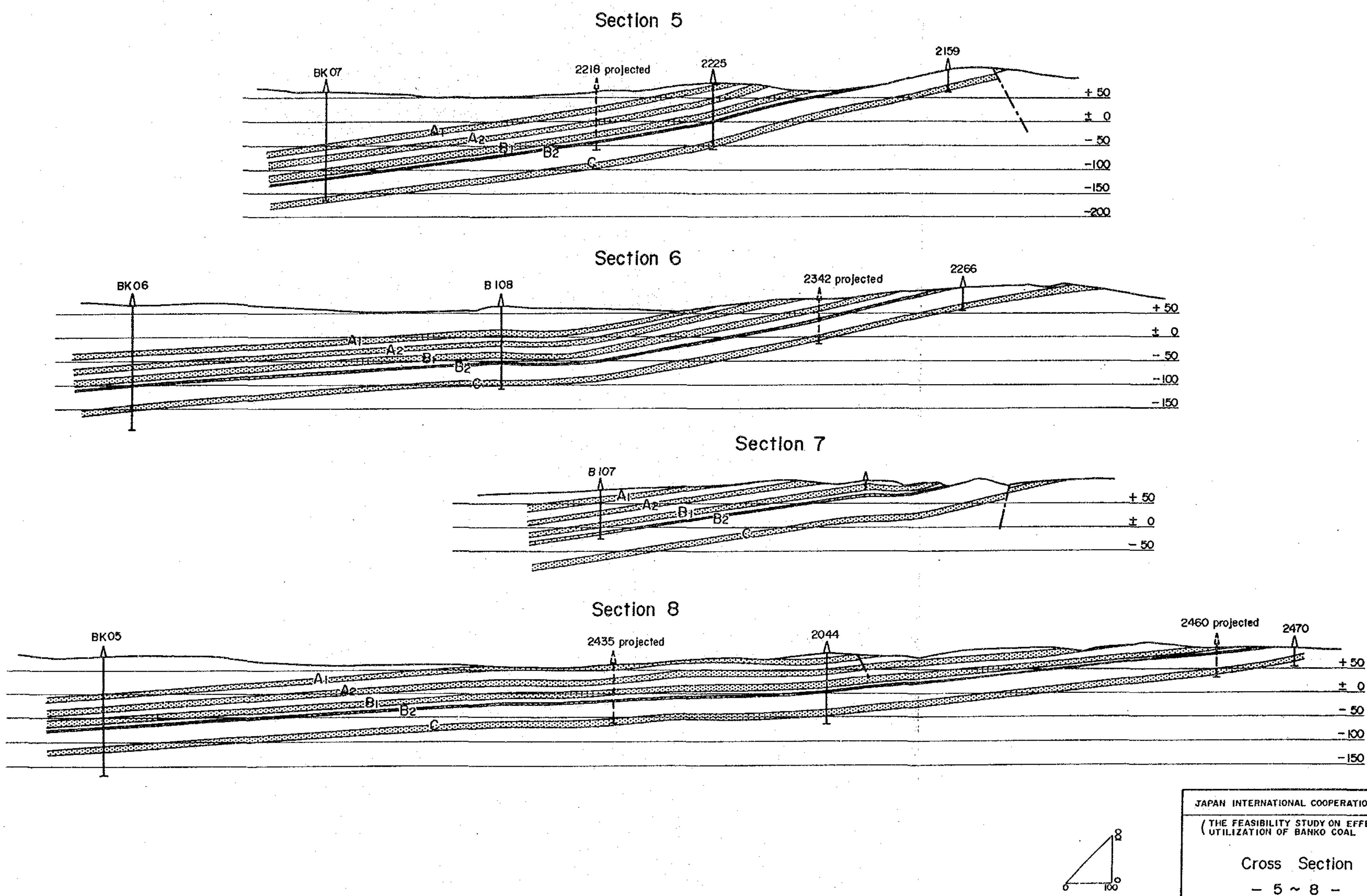


Fig. 28 Estimated Vertical Section, North West Banko (2)



JAPAN INTERNATIONAL COOPERATION AGENCY

(THE FEASIBILITY STUDY ON EFFECTIVE UTILIZATION OF BANKO COAL)

Cross Section

− 5 ~ 8 −

Dwg No.		Scale	
Date	1985	Prepared by	K. ITO

Fig. 29 Estimated Vertical Section, North West Banko (3)

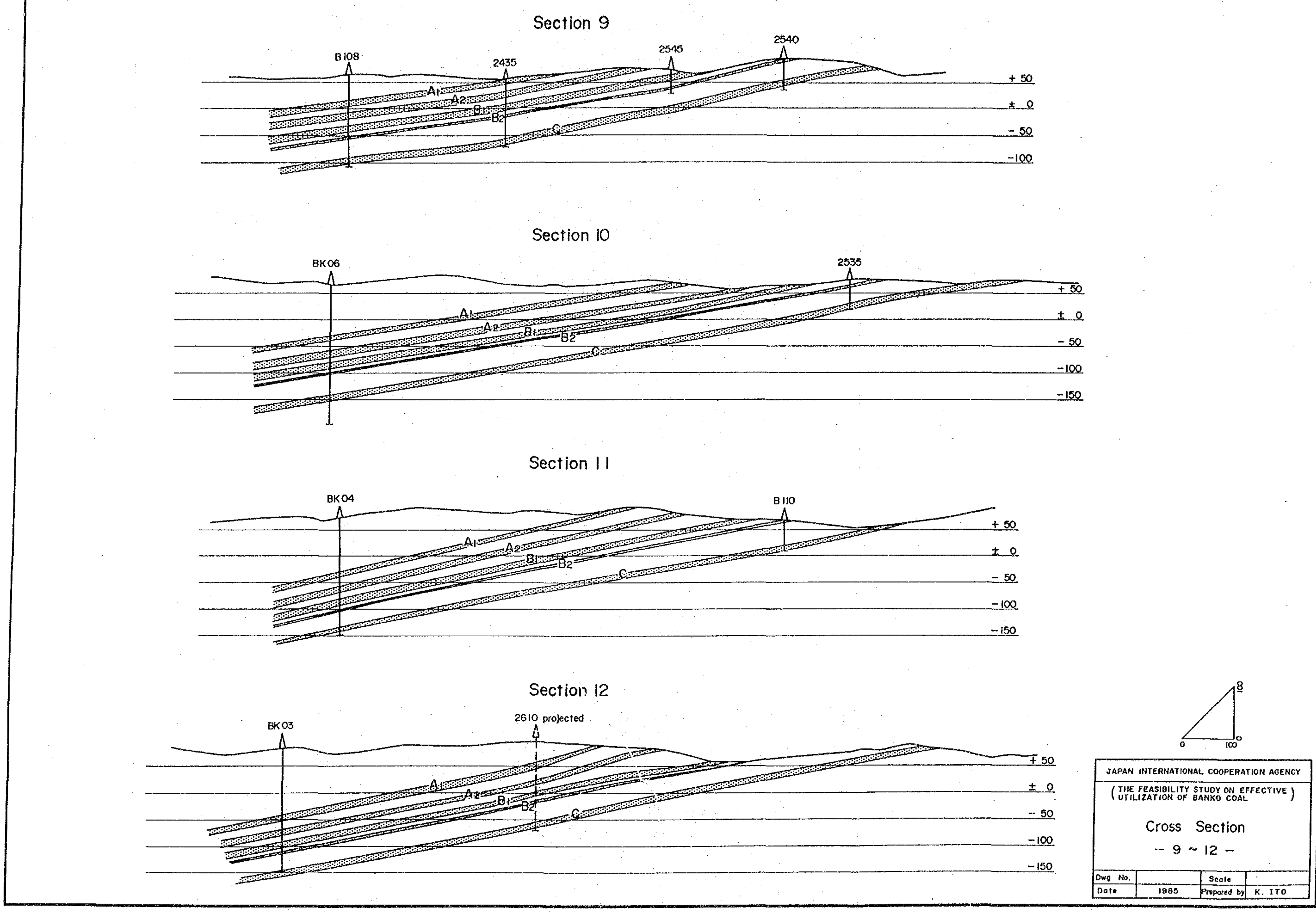


Fig. 30 Estimated Vertical Section, North West Banko (4)

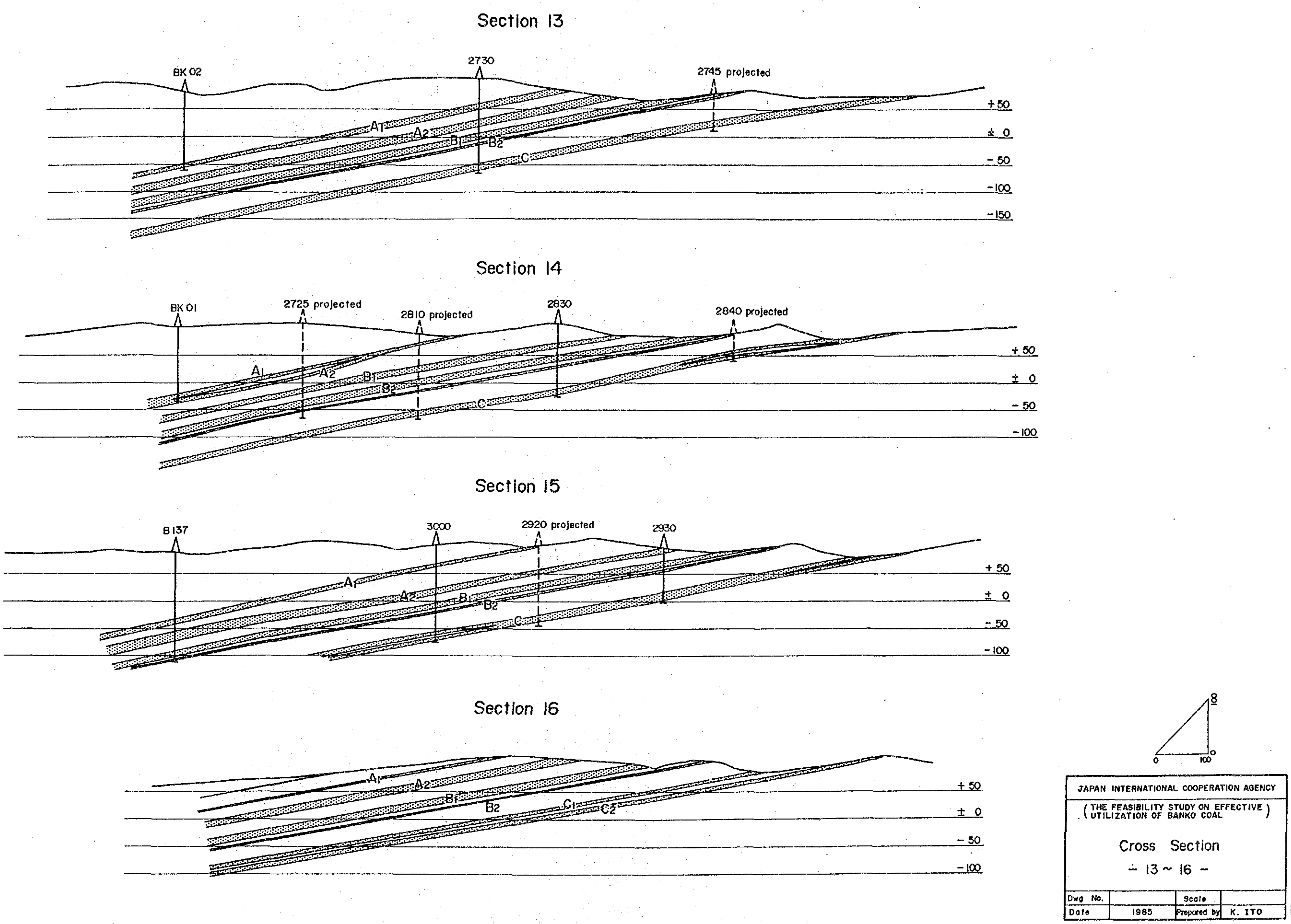


Fig. 31 Estimated Vertical Section, North West Banko (5)

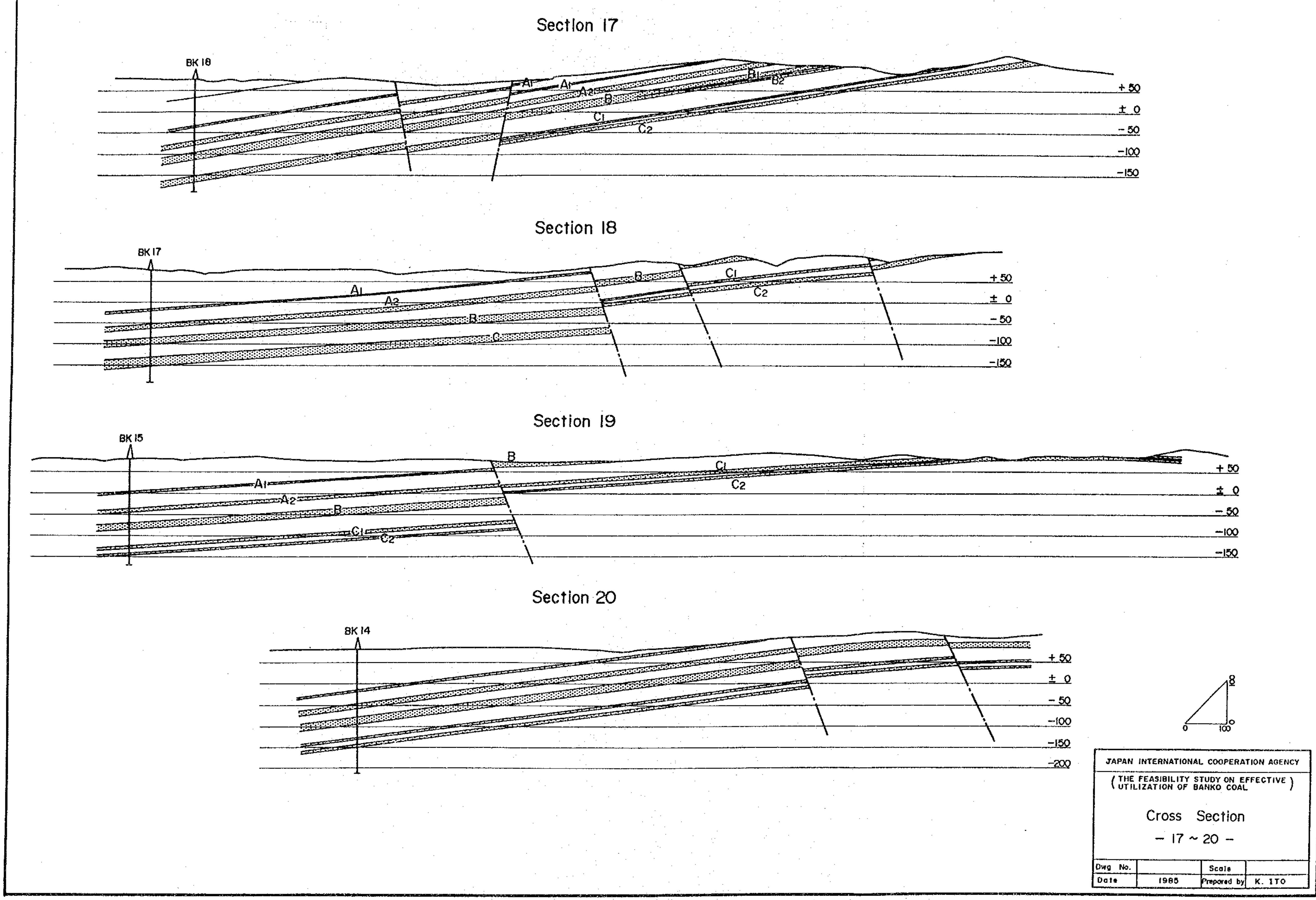


Fig. 32 Combined Map (Geological and Topographic Map) Showing Core-Drilling Places, Central Banko

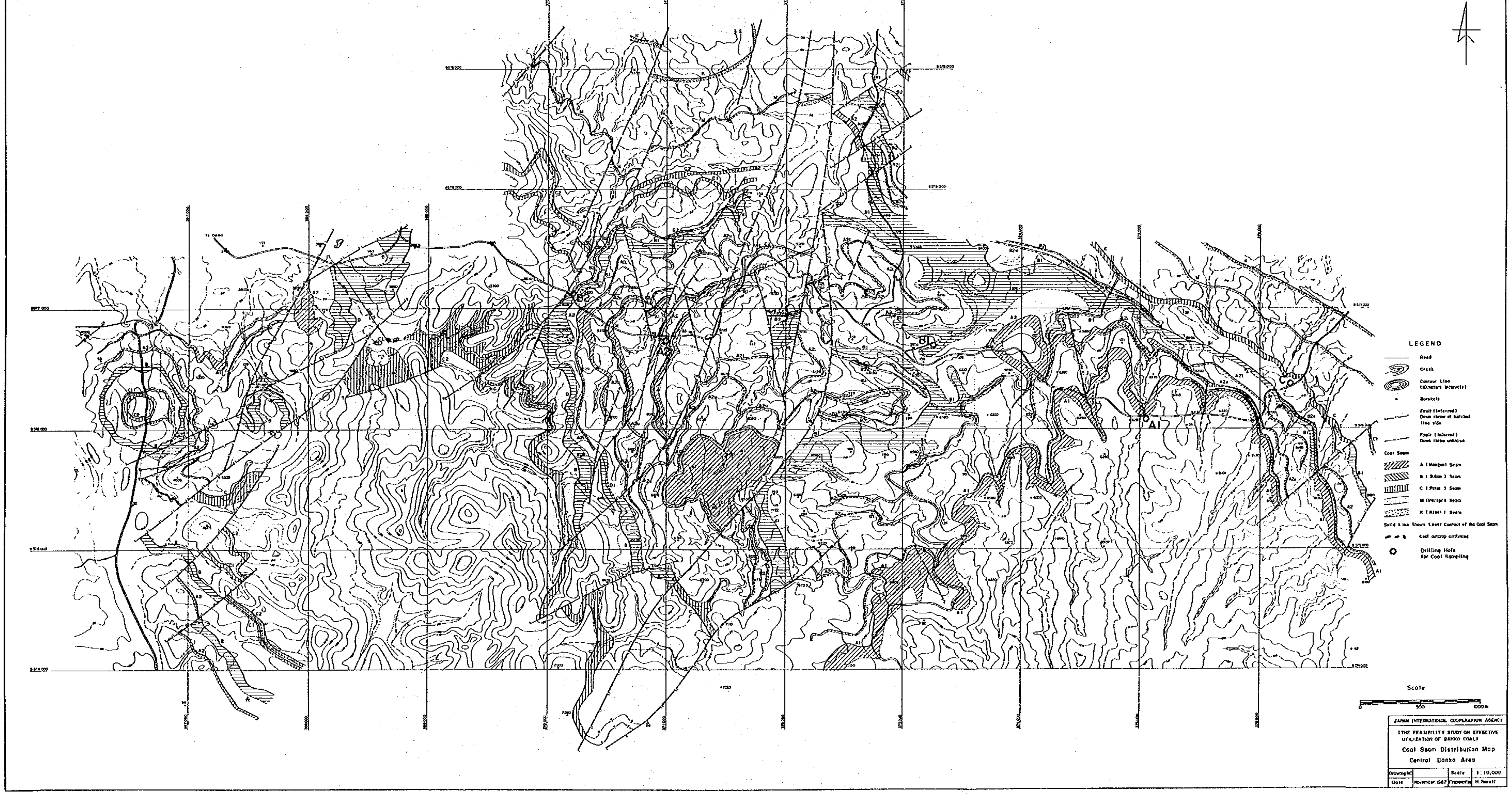


Fig. 33

Geological Survey Map, Western Part of Central Banko Area (1)

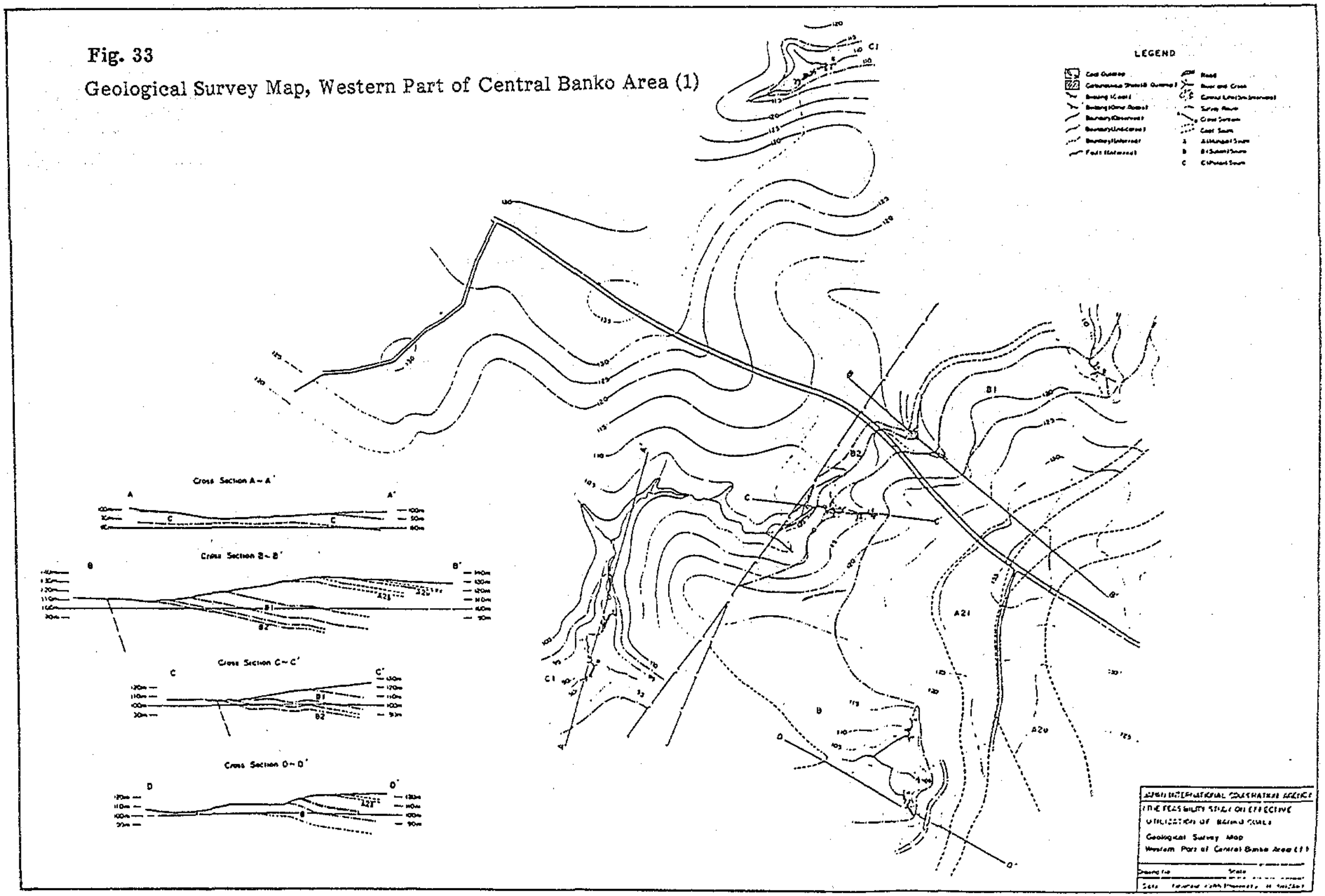


Fig. 34 Geological Survey Map, Western Part of Central Banko Area (2)

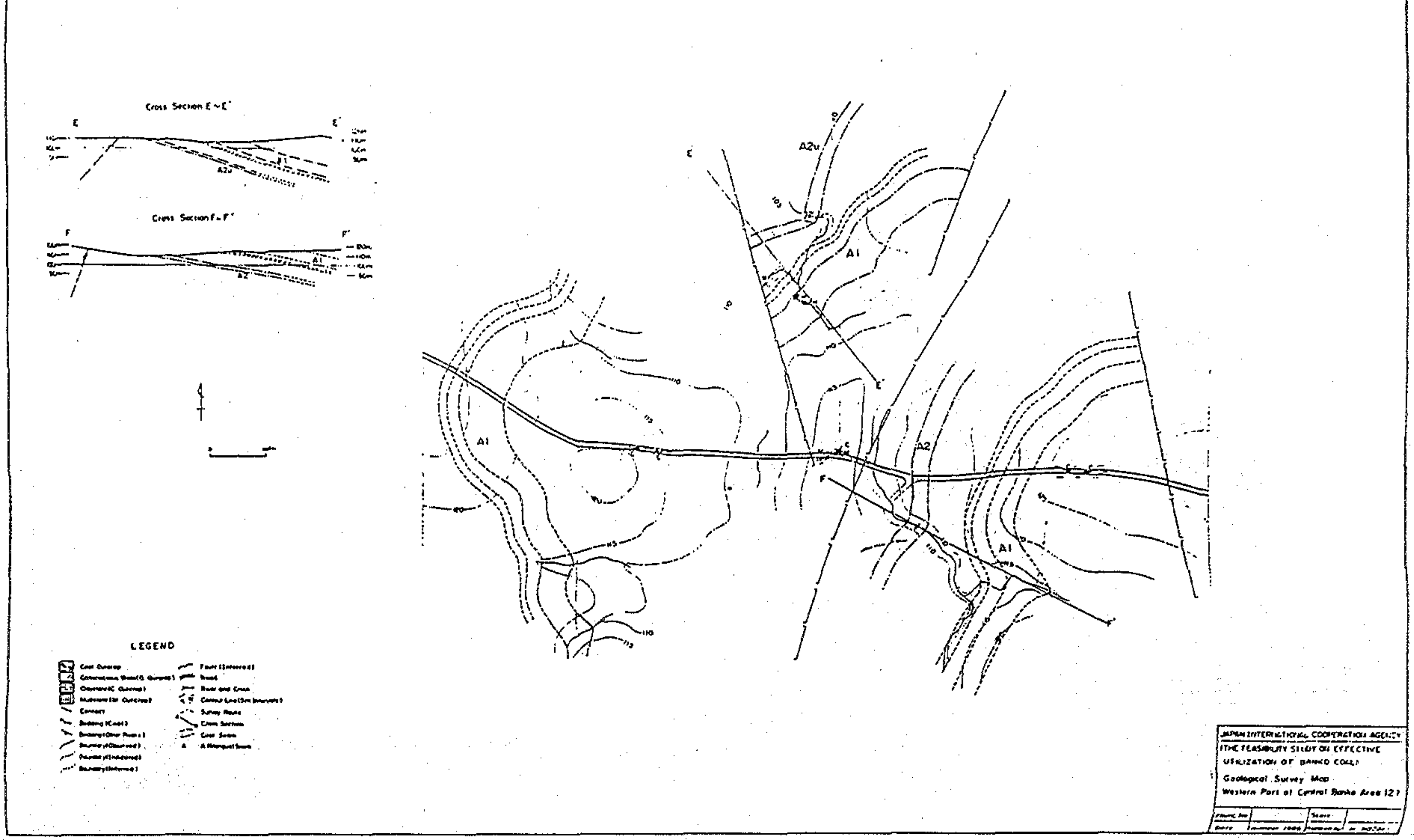


Fig. 35

Geological Survey Map, Western Part of Central Banko Area (3)

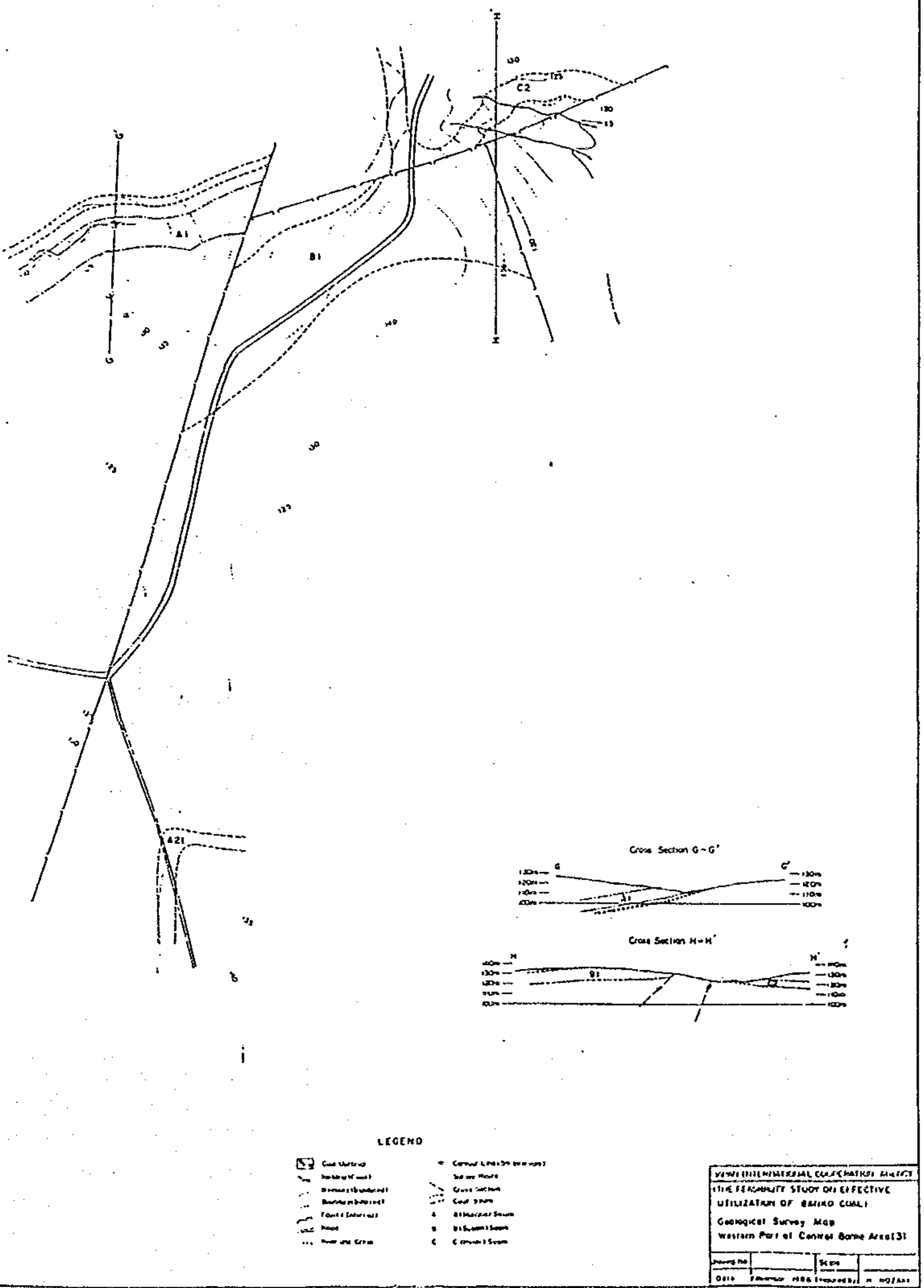
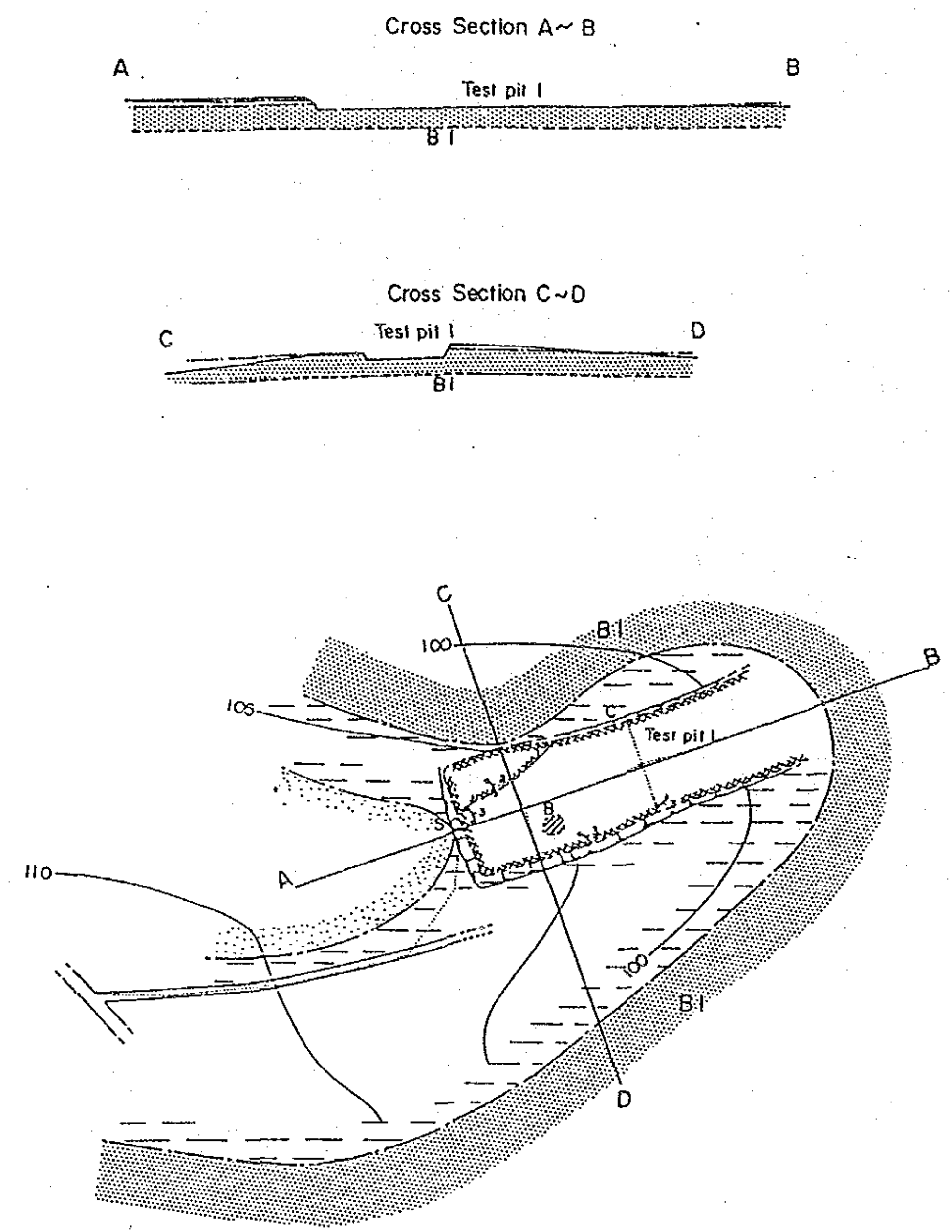


Fig. 36

Geological Survey Map, Central Part of Central Banko Area



LEGEND

- Coal in Test Pit
- Carbonoceous Shale (B: Outcrop.)
- Claystone (C: Outcrop)
- Sandstone (S: Outcrop)
- Bedding (Coal)
- Bedding (Other Rocks)
- Boundary (Indicated)
- Boundary (Inferred)
- Road
- Contour Line (5m Intervals)
- Survey Route
- Cross Section
- Coal Seam
- B — B (Subon) Seam

JAPAN INTERNATIONAL COOPERATION AGENCY

(THE FEASIBILITY STUDY ON EFFECTIVE UTILIZATION OF BANKO COAL)

Geological Survey Map
Central Part of Central Banko Area

Drawing No.		Scale	
Date	November, 1986	Prepared by	H. NOZAKI

Fig. 37

Geological Survey Map, Northern Part of Central Banko Area

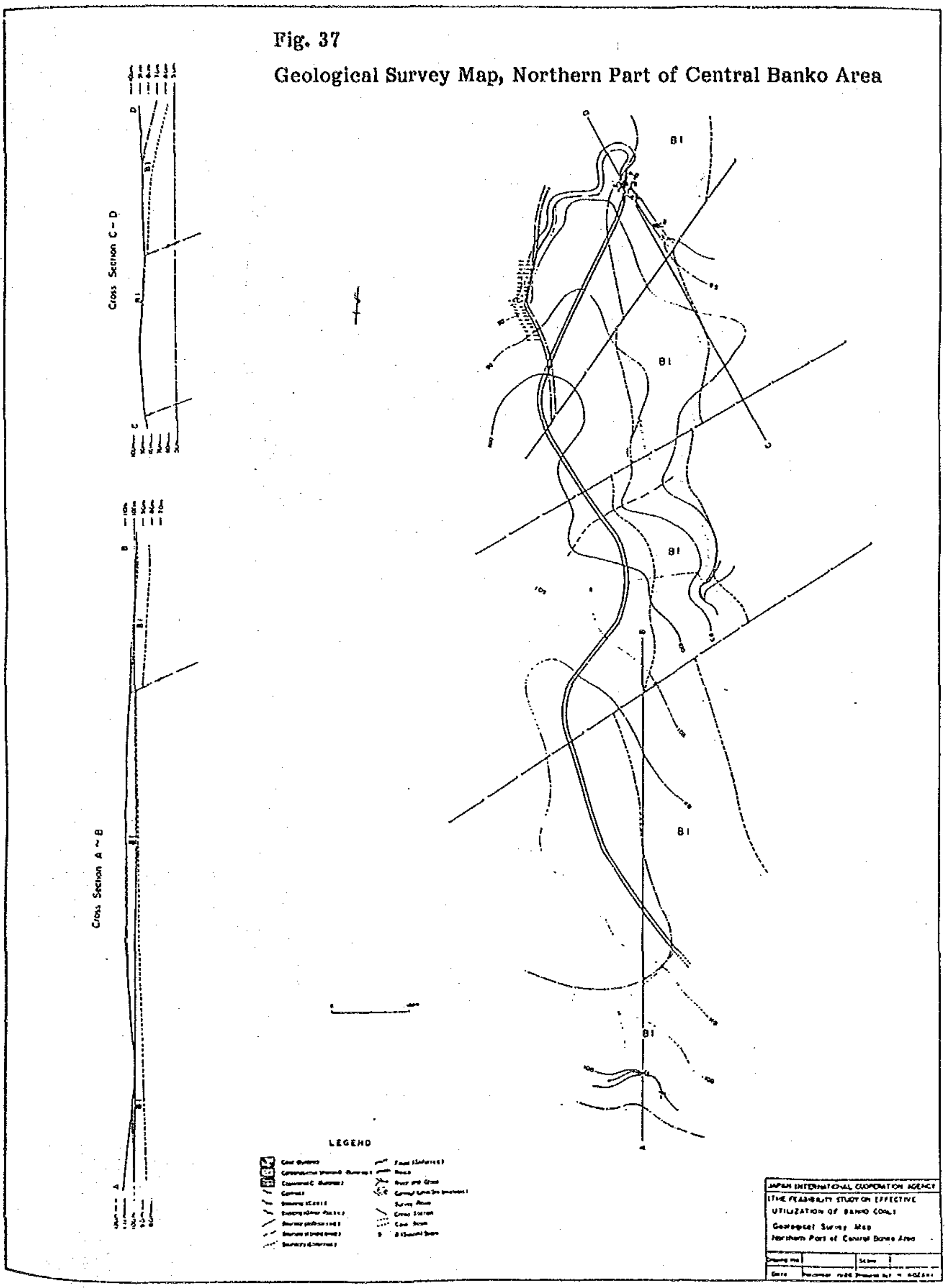


Fig. 38
Geological Survey Map,
Eastern Part of Central Banko Area (1)

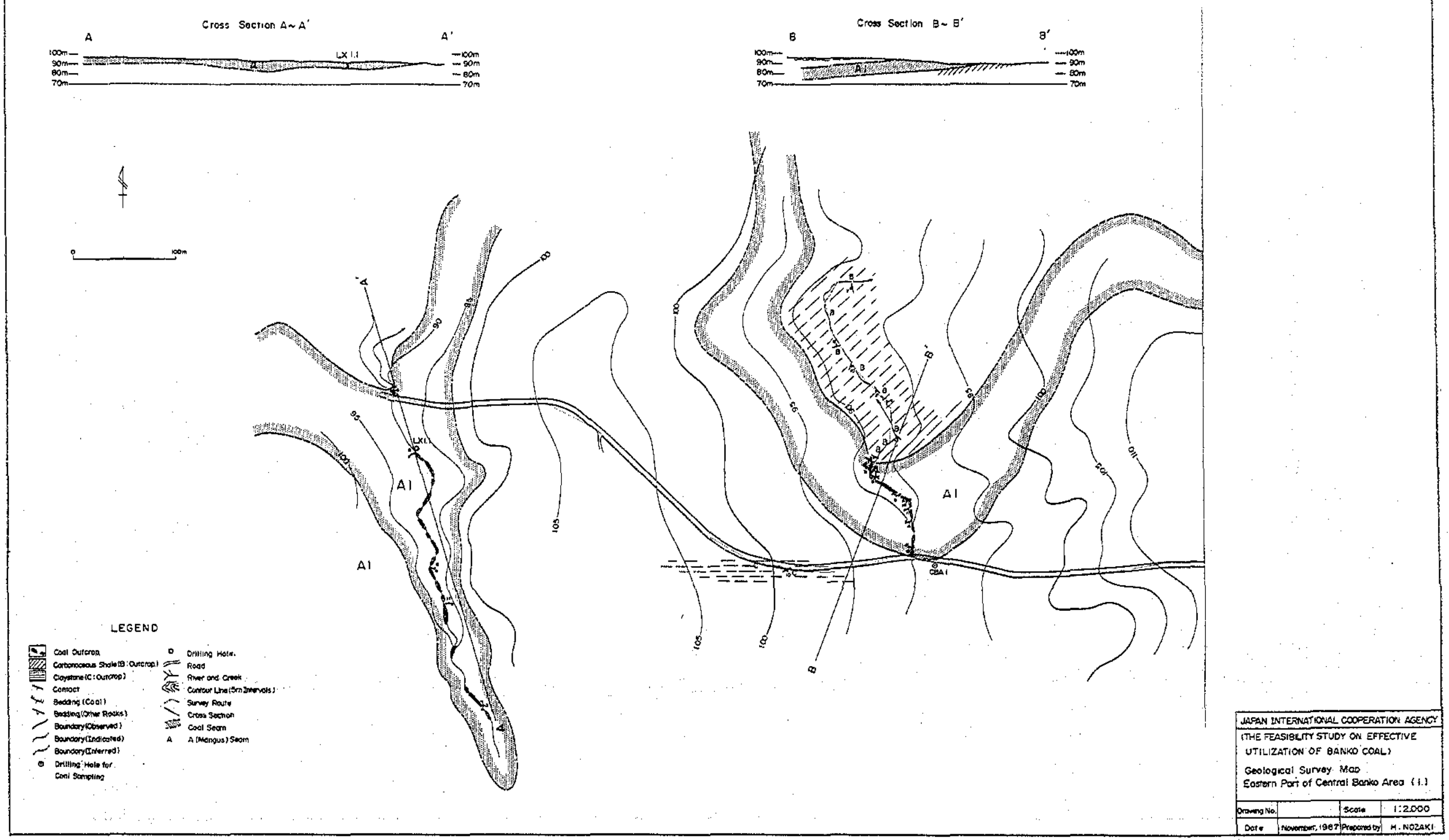
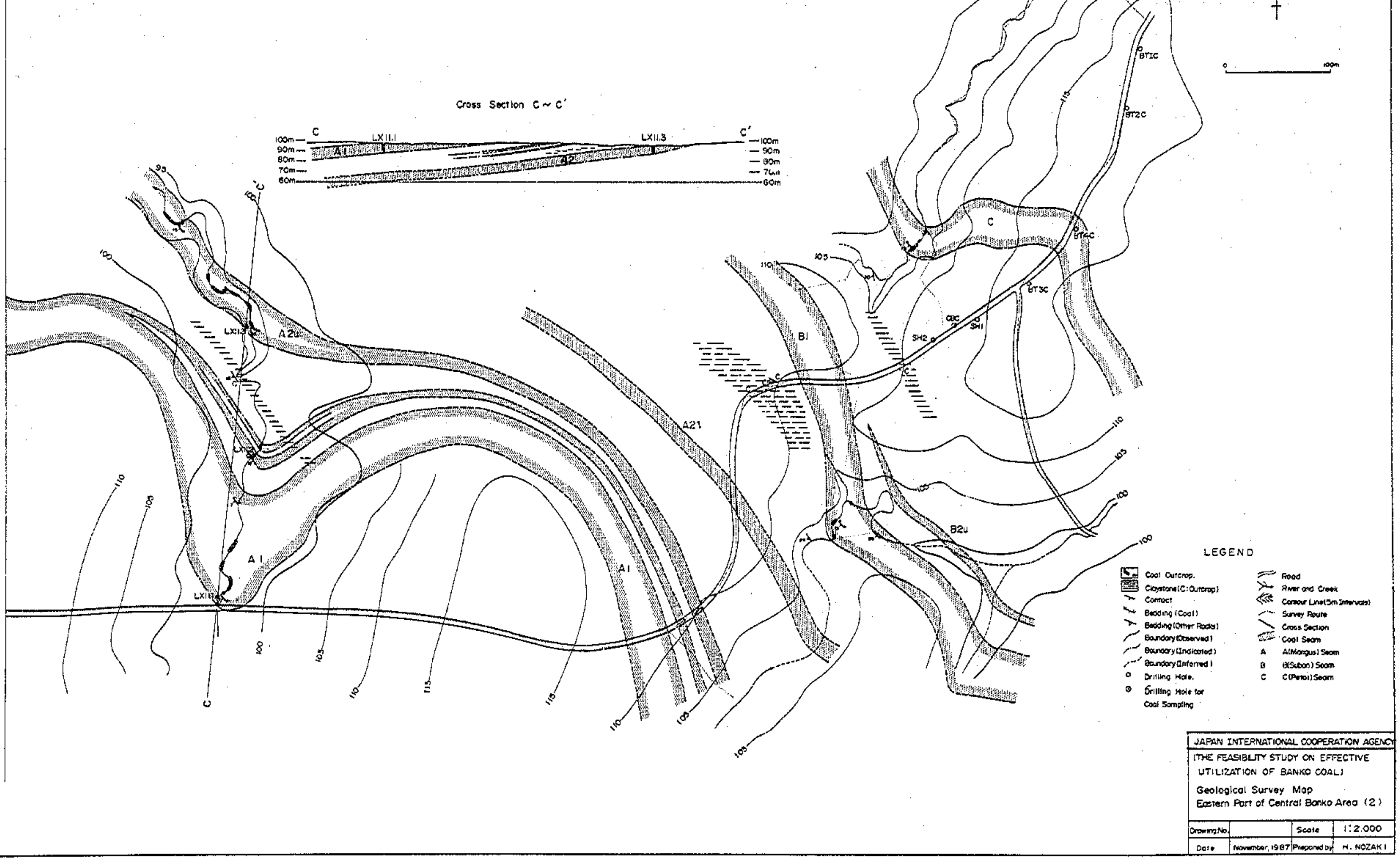


Fig. 39
Geological Survey Map,
Eastern Part of Central Banko Area (2)



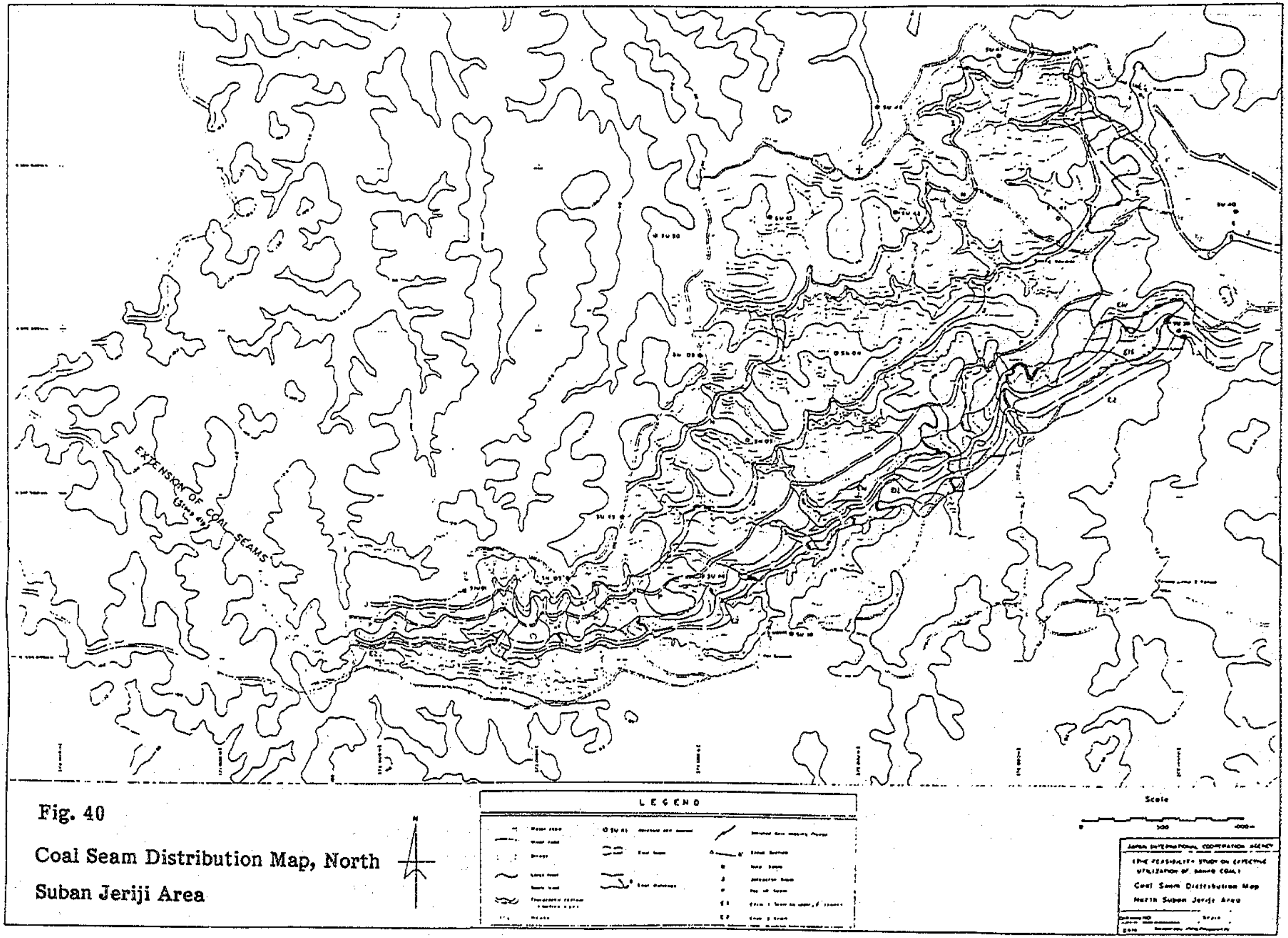


Fig. 40

Coal Seam Distribution Map, North Suban Jeriji Area