No. 2

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

MINERALS AND GEOSCIENCE DEPARTMENT(MGD)
MINISTRY OF PRIMARY INDUSTRY
MALAYSIA

THE STUDY
ON
COAL EXPLORATION AND ASSESSMENT
IN
SABAH, MALAYSIA

FINAL REPORT

September 1999

MITSUI MINING ENGINEERING CO., LTD.
NIKKO EXPLORATION AND DEVELOPMENT CO.,LTD.
JAPAN

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Preface

In response to the request from the Government of Malaysia, the Government of Japan decided to conduct a study on Coal Exploration and Assessment in Sabah, Malaysia and entrusted the study to the Japan International Cooperation Agency (JICA).

JICA sent a study team headed by Mr. Takehiko Shima of Mitsui Mining Engineering Company Ltd. to Malaysia eleven times during the period from March 1997 to July 1999. The team held discussions with the officials concerned of the Government of Malaysia, and conducted field surveys in the study area. After the study team returned to Japan, further studies were conducted and the present report was prepared.

I hope that this report will contribute to the exploration and the assessment of the coal resources in Sabah and to the enhancement of friendly relationship between our two countries.

I wish to express my sincere appreciation to the officials concerned of the Government of Malaysia for their close cooperation extended to the study team.

September 1999

Kimio Fujita

Kimio Fujita
President
Japan International Cooperation Agency

September 1999

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

Dear Mr. Fujita,

Letter of Transmittal

We are pleased to submit to you the report on the Study on Coal Exploration and Assessment in Sabah, Malaysia. The report contains the advice and suggestions of the authorities concerned of the Government of Japan and your Agency as well as the formulations of the above mentioned study. Also included are comments made by the Minerals and Geoscience Department, the Ministry of Primary Industry of the Government of Malaysia during technical discussions on the draft report which were held in Kuala Lumpur.

The study was divided into two Phases. Malibau, Southwest Malibau and Silimpopon areas were selected for detailed study in Phase 2 from the extensive study area in the south central Sabah based on the results of Phase 1.

The report comprises the studies in both Phases and presents the geological assessment of coal resources in the study area and a conceptual mine development plan as well as initial environmental examination in Southwest Malibau and Silimpopon areas. Finally, the economical potential of coal mine development was evaluated in the report. It was concluded that Silimpopon area had some potential for future development.

In view of the need for development of indigenous coal resources in Malaysia, we recommended further investigation in Silimpopon area and a comprehensive master plan on coal resources development including Maliau and surrounding area.

We wish to take this opportunity to express our sincere gratitude to your Agency, the Ministry of Foreign Affairs, and the Ministry of International Trade and Industry. We also wish to express our deep gratitude to the Minerals and Geoscience Department and other authorities concerned of the Government of Malaysia for the close cooperation and assistance extended to us during our study.

Very truly yours,

T. Shima

Takehiko Shima
Team Leader
The Study on Coal Exploration and
Assessment in Sabah, Malaysia

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1. Introduction

1. Introduction

1.1. Outline of the Study

1.1.1. History of the Study

In response to the request of the Government of Malaysia, the Government of Japan decided to conduct a Study on Coal Exploration and Assessment in Sabah, Malaysia (the Study). The Scope of Work for the Study was agreed upon between Geological Survey Department Malaysia (GSD) and Japan International Cooperation Agency (JICA) on 21 November 1996.

The study consists of two phases and Phase 1 study was carried out from March 1997 to March 1998. At the Evaluation Committee Meeting held in Kuala Lumpur on 11 march 1998, a decision was made to proceed to Phase 2 based on the result of Phase 1 study. Phase 2 study was commenced in July 1998 and all the field investigations and the studies in Malaysia were completed in March 1999. Further study was carried on in Japan to complete this final report, which incorporated all the results of Phase 1 and Phase 2 studies.

The study has been carried out by JICA study team, which is composed of Mitsui Mining Engineering Co., Ltd. and Nikko Exploration and Development Co., Ltd., in close cooperation with GSD personnel. The members directly involved in the study are as follows:

<u>JICA Study Team</u>	
Takehiko Shima	Team Leader
Norikatsu Kaneko	Geology
Yuzo Kawaguchi	Geology
Hideya Kikuchi	Geology
Yoshihiro Kikuchi	Geology
Masahiro Suzuki	Geology
Atsushi Kakizaki	Mine Development
Tokichiro Tani	Environment

GSD Sabah

Alexander S.W.Yan	Leader
Wong Vui Chung	Geology
Badrol Mohamad	Geology
Dee Dee L. Lakkui	Geology
Mohamad Faizul Hamdan	Geology
Richard Clemen	Geology

Since 1st July 1999, Geological Survey Department Malaysia (GSD) has been referred as Minerals and Geoscience Department Malaysia (MGD) following the merger of Geological Survey Department and Mines Department. In the present report, however, former name (GSD) is used as the counterpart agency of the Malaysian Government.

1.1.2. Objective and Scope of the Study

(1) Objective of the Study

The following is the overall objective of the Study as defined in the "Scope of Work":

(a) To conduct coal exploration and assessment in the Malibau and Silimpopon-Serudong Basins. The study area is shown in Figure 1-1.

(b) To transfer technology and know-how to GSD personnel in the course of the cooperative study both in Malaysia and Japan.

(2) Scope of the Study

The Study consists of two phases and the scope of the study in each phase are as follows:

(a) Phase 1 - Geological reconnaissance survey in the whole study area and preliminary evaluation of coal resources

(i) Collection and analysis of existing information, data and reports

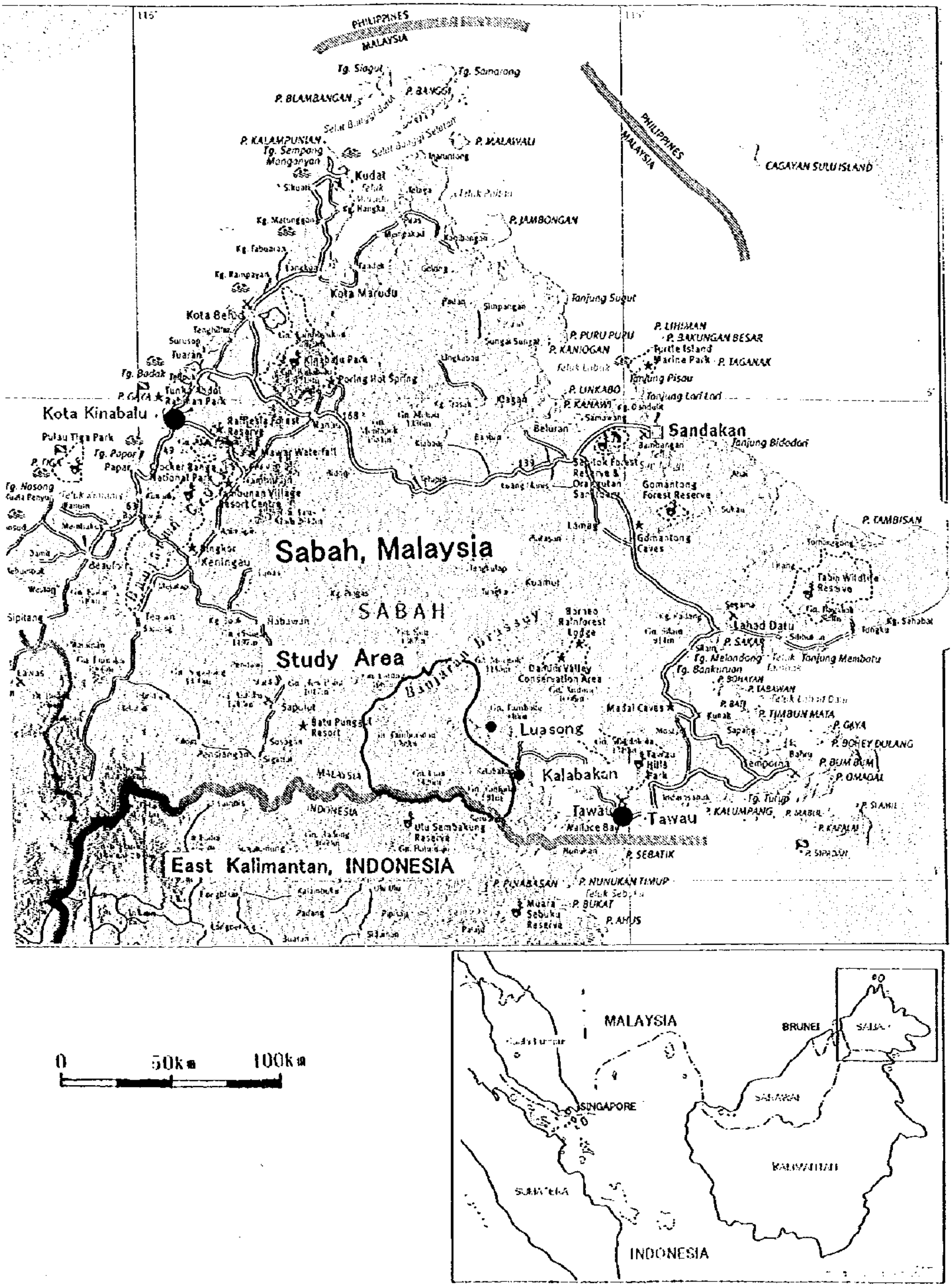


Figure 1-1 Location of Study Area

(ii) Geological reconnaissance survey
(iii) Coal sampling and analysis
(iv) Evaluation of coal resources - reserves and quality
(v) Preliminary appraisal of mining potential

Based on the results of the Phase 1 study, implementation of Phase 2 is decided at the final stage of Phase 1.

(b) Phase 2 - Detailed geological mapping, preliminary mining plan, initial environmental examination and recommendation on coal resource development

(i) Photogrammetric mapping at a scale of 1:10,000
(ii) Detailed geological mapping in the selected areas
(iii) Coal sampling and analysis
(iv) Evaluation of coal resources - reserves and quality
(v) Preliminary plan of coal mine development
(vi) Initial environmental examination
(vii) Evaluation of potential and recommendation for coal mine development

Overall schedule of the study is shown in Figure 1-2.

1.2. Background of the Study

1.2.1. Energy Policy in Malaysia - Role of Coal

Malaysia has various kinds of energy resources. Their in-situ reserves and potential capacity as of 1995 has been estimated as follows :

Crude oil	:	4.1 billion barrels (540 mtoe)
Natural gas	:	85 tcf (2,160 mtoe)
Hydro power	:	29,000 MW
Coal	:	982 million tonnes

(Source: Seventh Malaysia Plan)

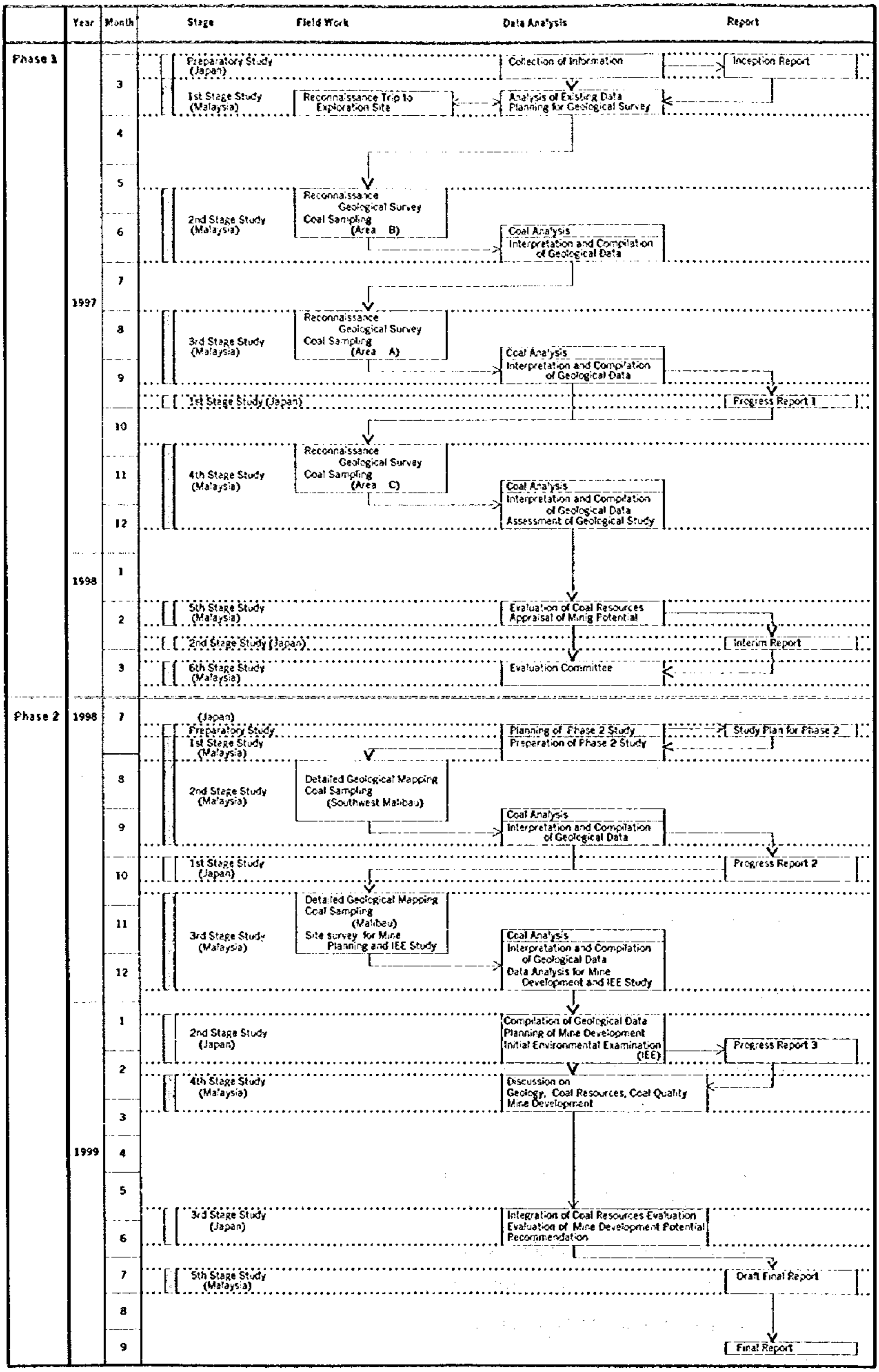


Figure 1-2 General Flow Chart of the Study

In the past, energy consumption in Malaysia was primarily dependent on imported oil. After the second oil crisis in 1988, however, nation's strategy was shifted to conserve existing oil reserves and to increase gas utilization for the purpose of decrease in oil dependence and diversification of energy sources.

This strategy was succeeded by "Four Fuel Energy Policy ", which is the principle of the present energy policy and pursues diversification and balanced utilization among the four energy options - oil, gas, hydro and coal. An important part of this policy is the priority given to indigenous energy utilization.

In the Seventh Malaysia Plan (1996 - 2000) established in 1996, stronger emphasis is given to coal utilization. One of the reason is the concern about long-term sustainability of gas utilization owing to diminishing natural gas reserves. It is suggested that the gas utilization for power generation may be declined after the year 2000, if further gas reserves are not discovered.

In the Seventh Malaysia Plan, the role of coal is stressed as quoted below :

" In line with efforts to pursue the fuel diversification policy within the least-cost planning, coal will play an increasingly important role during the Plan period. Exploration and assessment of coal resources will be stepped up by the Geological Survey Department and the private sector, particularly in Sabah and Sarawak. The development of known coal deposits is expected to be intensified in view of high demand for coal in electricity generation and cement manufacture. About 90% of the 5.5 million tonnes required annually by the country will be met by import. With improvements in the infrastructure leading to coal deposits, the production of local coal is expected to increase further. Local coal production is expected to increase from 200,000 tonnes in 1995 to 510,000 tonnes by the year 2000, most of which will be used locally."

It is also mentioned in the Plan that the private sector is expected to play a key role in the activities of exploration, development and production of coal. However, due to the long lead time, the benefit of this private sector-led initiative is expected to be realized after 2000. Further, the importance of the efforts is pointed out to increase the pool of expertise and improve the know-how, especially in underground mining.

Next table is the fuel mix in electricity generation shown in the Plan. It indicates that natural gas occupies 70% of total fuel and the share of coal will increase from 9.7% in 1995 to 16.5% in 2000.

Fuel Mix in Electricity Generation, 1990-2000

	1990		1995		2000	
	GWH	(%)	GWH	(%)	GWH	(%)
Oil	9,532	(41.9)	4,704	(11.2)	4,667	(6.7)
Coal	3,146	(13.8)	4,068	(9.7)	11,427	(16.5)
Gas	5,967	(26.2)	28,689	(68.4)	48,029	(69.2)
Hydro	4,061	(17.8)	4,424	(10.5)	5,204	(7.5)
Others	62	(0.3)	76	(0.2)	69	(0.1)
Total	22,768	(100.0)	41,961	(100.0)	69,416	(100.0)

(Source: Seventh Malaysia Plan)

1.2.2. Coal Demand and Supply

(1) Present Status

(a) Coal resources

Almost all the coal resources in Malaysia are present in Sarawak and Sabah of East Malaysia with a small amount in Peninsula Malaysia. Next table is a summary the known coal resources in Malaysia by State and by resource class.

Coal Resources in Malaysia (1,000 t)

	Measured	Indicated	Inferred	Total	
Sarawak	170,680	100,910	455,840	727,430	(74%)
Sabah	4,800	1,500	231,700	238,000	(24%)
Peninsula	-	-	17,000	17,000	(2%)
Total	175,480	102,410	704,540	982,430	(100%)

(Source: Geological Survey Department Malaysia)

(b) Coal supply

As shown in the following table, more than 90% of total coal supply is dependent on the imported coal.

Coal Supply in Malaysia (t)

	Domestic	Imported	Total
1994	173,749	1,380,833	1,554,582
1995	114,100	2,003,315	2,117,415
1996	73,747	3,003,294	3,077,041
1997	105,231	2,550,511	2,655,742

(Source: Malaysian Minerals Yearbook)

The main countries exporting coal to Malaysia are shown in next table. The maximum exporter is Indonesia followed by Australia. These two countries occupy more than 90% of total import.

Coal Import by Countries (t)

	1994	(%)	1995	(%)
Indonesia	935,099	(67.7)	1,303,833	(65.1)
Australia	330,247	(23.9)	509,198	(25.4)
India	65,623	(4.8)	62,675	(3.1)
China	8,734	(0.6)	25,587	(1.3)
Vietnam	6,945	(0.5)	9,814	(0.4)
South Africa	32,659	(2.4)	133	(<0.1)
Others	1,526	(0.1)	92,075	(4.6)
Total	1,380,833	(100.0)	2,003,315	(100.0)

(Source: Department of Statistics)

Beradai Mine, owned by Global Minerals, is an only coal producer in Malaysia. It is located in the central part of Sarawak and operating an open-cut mine with truck and shovel system. Coal production is at lower level than expected. One of the difficulties for the mine is coal transportation. Coal is transported with trucks and barges for more than 300 km to the shipping point. Product coal is used mainly in power stations in Port Kelang and Kuching, with small portion for export to Japan and Taiwan.

(c) Coal consumption

Most of the coal in Malaysia are used for power generation and cement manufacture. Broadly speaking, 60% is for power generation and 40% is for cement manufacture as shown in the next table :

Domestic Coal Consumption (Unit : 1,000 t)

	Electricity	(%)	Cement	(%)	Others	Total
1990	1,161	(61.3)	692	(36.6)	40	1,893
1991	1,375	(61.7)	815	(36.5)	40	2,230
1992	1,382	(59.0)	914	(39.0)	45	2,341
1993	1,262	(54.7)	1,002	(43.4)	45	2,309
1994	1,350	(55.3)	1,040	(42.6)	50	2,440
1995	1,570	(56.3)	1,170	(41.9)	50	2,790

(Source: Barlow Jonker Pty. Ltd. Malaysian coal profile 1996)

(2) Future Prospect

Based on the figures in the Seventh Malaysia Plan, the future trend of coal demand in Malaysia was estimated.

(a) Power Generation

Based on the table of "fuel mix in electricity generation", coal demand in 2000 is estimated in comparison with the results in 1995.

	1995		2000
Installed capacity (GWH)	4,068		11,427
Coal demand (1,000 t)	1,570	→	4,410

The following are the power plants, existing and under construction.

Power Plant	Capacity (MW)	Operation	Coal Demand (1000 t)
TNB Port Kelang - Phase 2	2 x 300	1998	1,500
TNB Port Kelang - Phase 3	2 x 500	1999	2,500
SESCo Kuching	2 x 50	1999	400

(b) Cement manufacture

Estimate from the table "final commercial energy demand by source". In this table, the amount of coal is regarded as for cement manufacture.

		1995		2000
Energy (coal)	(PJ)	40.1		92.0
Coal demand	(1,000 t)	1,170	→	2,680

(c) Total demand (a + b)

	1995	2000
Power	1,570	4,410
Cement	1,170	2,680
Total	2,740	7,090

The above-mentioned figures of 4.4 million tonnes for power generation is the assured coal demand after the operation start in the power plants under construction. Afterward, there are plans to construct large scale power plants including IPP (Independent Power Producer) between 2001 and 2005. Coal requirement for these new plants exceeds 10 million tonnes. Although the time for completion of these plant is uncertain, the possibility of significant increase in coal demand for power generation must be high in near future.

The second oil crisis in late 1970s prompted cement companies to convert fuel used in their plants from oil to coal. By 1988, all plants were using only imported coal or mixing with oil. Demand for cement product is largely affected by the tendency of construction industry, particularly of public undertaking. It is expected that the demand for cement will grow in near future as the recession in Asian countries is being recovered.

With respect to the coal supply, production of Beradai Mine, which is the sole coal producer in Malaysia, stays in a low level and development of new coal mine will not be realized easily and quickly. Therefore, to meet the increasing demand for coal, dependency to imported coal will continue for the moment. As stated in the Seventh Malaysia Plan, it is expected to facilitate the exploration and develop a new coal mine in the near future.

2. Summary of Phase 1 Study

2. Summary of Phase I Study

2.1. Study Area

2.1.1. Location and Access

The Study Area is situated in the south-central part of State of Sabah as shown in Figure 1-1. It is bounded by the Indonesian border on the south and lies in an area of latitude 4° 51′ N on the north and longitude 117° 30′ E and 116° 50′ E on the east and west respectively. The area is approximately 2,000 km² in size and covered by the following existing topographic sheets on a scale of 1 to 50,000:

4/116/8 (Tambulanan), 4/116/12 (Gunung Maliat), 4/117/1 (Gunong Kuli),
4/117/2 (Gunong Moritok), 4/117/5 (Sungai Kalabakan), 4/117/6 (Sungai Tiagau)
4/117/9 (Gunong Luis), 4/117/10 (Serudong)

The area is accessible by road from Tawau via Luasong or Kalabakan at a distance of about 90 km to the eastern border of the area. Within the area, several routes are passable by vehicle and some of them are being used for log transportation at present. However, most of the previous logging roads branching off from the main roads have been deteriorated and abandoned as soon as logging operations finished.

There is neither village nor inhabitant within the area except a few camps owned by timber companies. Nearest villages to the study area are Kalabakan and Luasong; both are located close to the eastern border of the area. Kalabakan is a base of timber related activities where saw mills and loading facilities to barge are in operation. In Luasong, there is the forestry center operated by Yayasan Sabah (Sabah Foundation).

2.1.2. Topography and Climate

Figure 2-1 shows the topography and drainage system in the area.

The major part of the area, particularly the western part, is hilly and mountainous and mostly covered by the secondary jungle. Several mountain tops exceed 1,000 m with the highest peak of 5,500 ft (1,676 m) in the southwest. The relief becomes gentle and lower toward the southeast and comes to low-lying land in the lower reaches of several rivers. Extensive plantation of oil palm is found in this part.

The drainage system in the area is complex but divided into two main systems as a whole. The one extends in the major part of the area and comprises several rivers, including Kalabakan, Serudong and Silimpopon Rivers. They flow principally toward the southeast and finally into Cowie Harbour. The other is Kuamut River and its tributaries in the northwestern part of the area. It flows toward the northeast as far as Sulu Sea near Sandakan. A winding range of mountains forms the watershed of the area as shown in Figure 2-1.

The meteorological data in Table 2-1 are extracted from the statistics for the past seven years observed at Forestry Center in Luasong.

Table 2-1 Meteorological Data at Luasong (1990 ~ 1996)

	RAINFALL (mm)			TEMPERATURE (℃)	
	Average	Maximum	Minimum	High	Low
Jan	190.9	296.7	50.6	31.7	21.5
Feb	202.0	333.0	108.6	32.1	21.9
Mar	210.1	494.3	60.2	32.6	22.2
Apr	170.5	320.4	44.5	32.8	22.7
May	259.1	359.0	156.7	32.9	23.1
Jun	208.8	268.0	144.2	32.2	22.9
Jul	232.4	428.7	142.5	32.0	22.8
Aug	233.1	395.8	111.5	32.1	22.9
Sep	230.4	413.0	88.2	32.2	22.7
Oct	297.8	489.1	136.4	32.4	22.5
Nov	260.1	367.1	180.5	32.7	22.5
Dec	271.5	391.6	186.1	31.6	22.2
Total	2766.8	3919.6	2072.1		

As seen in the above table, the temperature is invariable throughout the year. A difference of 10℃ between the highest and the lowest temperatures represents the change in a day.

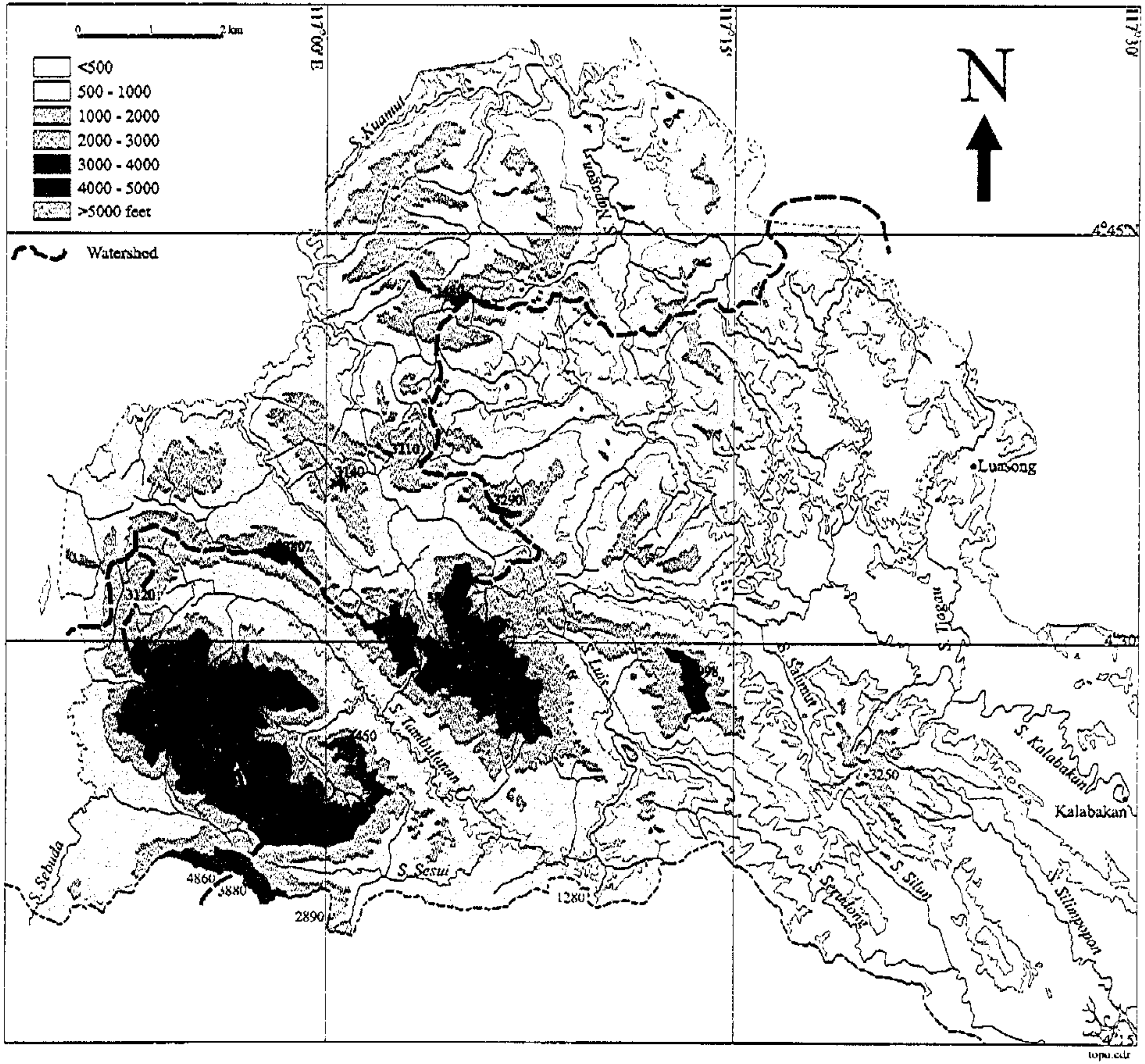


Figure 2-1 Topography and Drainage

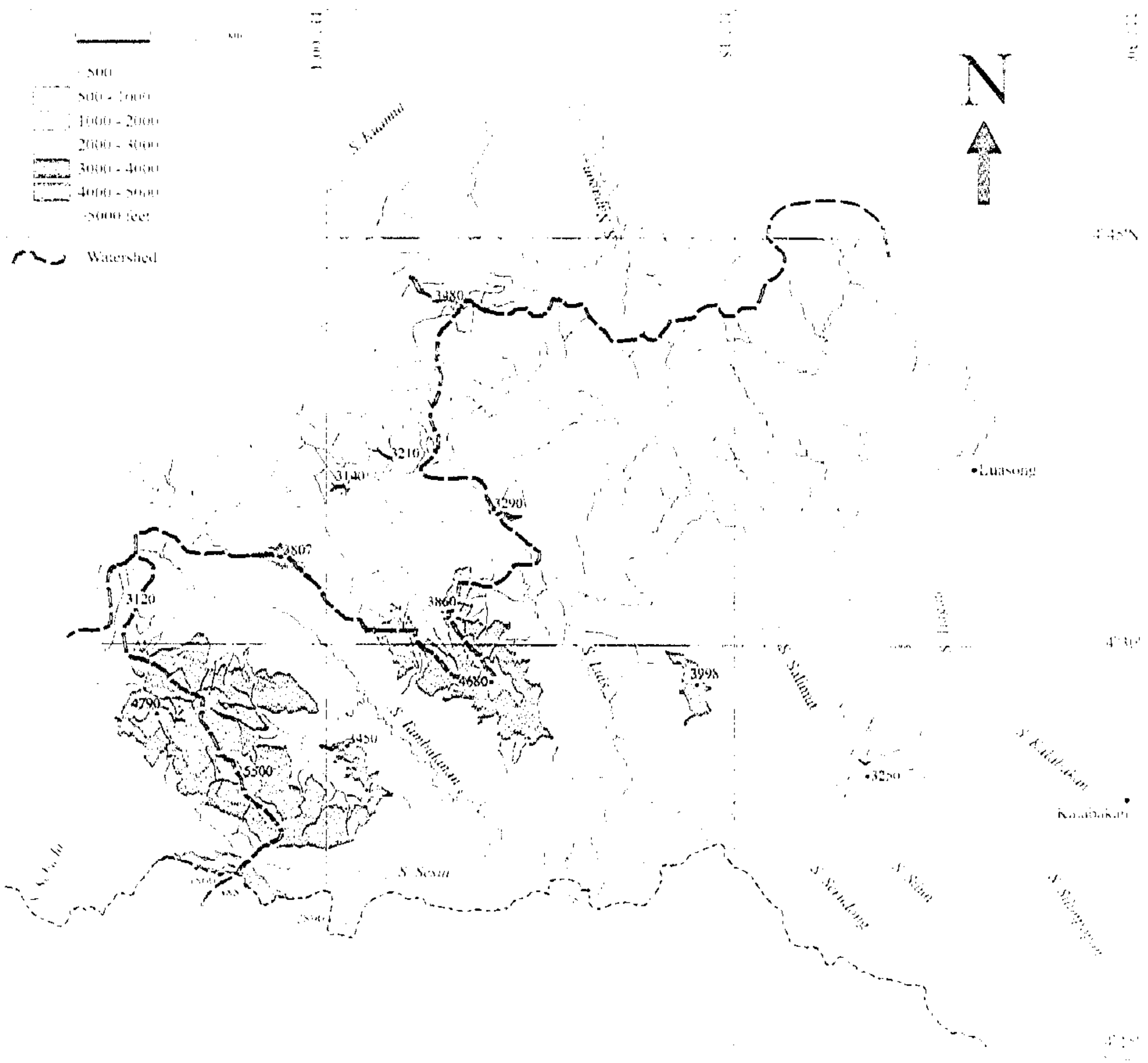


Figure 2-1 Topography and Drainage

The annual rainfall shows a great variation from 2,072 mm in 1991 to 3,920 mm in 1995. Monthly rainfall figures do not indicate any clear distinction between dry and wet seasons. It seems that, however, rainfall in January to April is less and that in October to December is more compared with other months, although it also varies widely in every year.

2.2. Geological Investigation

2.2.1. Previous Work

In early 1900's, geological traverses or reconnaissance trips have been made by several foreign geologists in and around the study area, but their reports are unavailable. Between 1950 and 1952, P. Collenette made a geological investigation on the coal deposits in Silimpopon area. He also carried out a reconnaissance geological survey between 1958 and 1960 in a wide area of south-central part of Sabah, including the present study area. The results of these investigations are given in the following reports:

Collenette, P. (1954). The coal deposits and a summary of the geology of the Silimpopon area, Tawau District, Colony of North Borneo.

Collenette, P. (1965). The geology and mineral resources of the Pensiangan and Upper Kinabatangan area, Sabah, Malaysia.

BHP Minerals has carried out reconnaissance coal exploration in the major part of south central Sabah, which includes Maliau, Malibau, Luis-Sesui, Serudong and Silimpopon ares, for several years since 1986 under a prospecting licence. Their results indicate a good potential of coal resources in Maliau Basin.

GSD Sabah has started exploration for coal in the study area in 1994 under the Mineral Exploration Programme and the results are given in the following reports:

Reconnaissance prospecting for coal in Malibau Basin. Report No. SB/CL/94/1

Reconnaissance survey for coal in Gunong Luis Area. Report No. SB/CL/95/1

Follow-up prospecting for coal in Malibau Basin. Report No. SB/CL/95/2

Reconnaissance survey for coal in Southwest Malibau Area. Report No. SB/CL/96/1

Reconnaissance prospecting for coal inTambulanan Barat. Report No. SB/CL/96/2

Reconnaissance prospecting for coal inTambulanan Timur. Report No. SB/CL/96/3

All the relevant information in the above reports were examined and used for the present study.

2.2.2. Method of Geological Investigation

In order to investigate whole of the extensive study area within a limited period, surface geological survey was carried out laying emphasis on the areas or zones where the occurrence of coal seam had been expected based on the previous reports.

The study area was divided into following three sub-areas: (approximate size)

Sub-area A : Northeastern part including Malibau area, (800 km^2)
Sub-area B : Southwestern part including Southwest Malibau area, (700 km^2)
Sub-area C : Southeastern part including Silimpopon area, (500 km^2)

Each sub-area was investigated at three separate stages. A base camp was set up in each sub-area and temporary camps were required where investigating sites were unaccessible by vehicle and too far to travel on foot. Representative mapping routes were selected mostly along old logging tracks or streams. Every outcrop along the routes was geologically investigated and at the same time, its location and elevation was surveyed with a compass, tape and hand level. Outcrop positions and survey points were plotted instantly in field mapping sheets together with the observed geological data.

All the coal outcrops were logged lithologically and numbered except thin seams or of poor quality like coaly shale. Forty five (45) coal samples were collected from outcrops and analyzed at the coal laboratory in GSD Sarawak. During the field work in sub-area C, an outcrop of Queen Seam near the old mine site was investigated and sampled.

The advantage of the above-mentioned mapping method is that a geological route map is prepared and available in the field and the stratigraphic position of each outcrop can be understood by drawing a cross section along the route. This method is effective particularly for the coal field like the study area where a large number of coal seams are present with steep dips.

The location and the number of the mapping routes are shown in Figure 2-2 and all the field activities carried out in Phase 1 are summarized in Table 2-2.

Table 2-2 Summary of Geological Field Work (Phase 1)

Sub-area	A (Malibau)	B (SW Malibau)	C (Silimpopon)	Total
Size (approximate km²)	800	700	500	2,000
Period of Field Work	6-30 Aug	16 May-15Jun	28Oct-21Nov	81days
Distance of Mapping Route	40km (13rt)	71km (15rt)	78km (15rt)	189km (43rt)
Coal Outcrops Investigated	141	112	37	290
Coal Samples (analyzed)	12	14	19	45

2.2.3. Regional Geology

According to the Geological Map of Sabah (Third Edition, 1985), most of the study area is underlain by the Tanjong and the Kapilit Formation of Early to Middle Miocene age, as shown in Figure 2-3. Other Tertiary Formations named Labang, Kuamut, Kalabakan and Simengaris distribute in the periphery of the area.

Collenette (1965) has indicated that the Tanjong Formation passes into the Kapilit and the Kalabakan Formations to the southeast. The relationship among these formations is uncertain but it is possible that the Kapilit and the Kalabakan Formations are lateral equivalents of upper and lower units of the Tanjong Formation respectively.

The Tanjong Formation lies unconformably on the Labang Formation of Oligocene age in the western side of the study area, while in the eastern side, the Kapilit Formation lies conformably on the Kalabakan Formation and is overlain by the Simengaris Formation of Late Miocene to Pliocene age probably with slight unconformity.

The Tanjong Formation consists of mudstone, siltstone, sandstone and coal with rare beds of conglomerate and limestone. The dominant lithology varies by areas. In general, argillaceous rock appears to be dominant in northwestern area including Maliau Basin and it becomes more arenaceous in southwestern part, where the formation is mapped as the Kapilit Formation. The maximum thickness of the Tanjong Formation has been estimated by Collenette to reach 40,000 feet in Maliau Basin and 7,000 feet for the Kapilit Formation in Silimpopon area.

The Labang, Kalabakan and Simengaris Formations, which lie below or above the Tanjong Formation, are understood to have been deposited in marine environment. During the deposition of the Tanjong Formation, peat swamps were formed in some places not far from seashore. It appears that the most of these swamps were unstable and their positions migrated from time to time.

Major faults in the area show northeast trend as represented by Lonod Fault which separates Malibau Basin from Maliau Basin. The Kapilit Formation in the southeastern part is characterized by several broad synclinal structures, such as Sesui, Luis and Silimpopon Synclines.

2.3. Coal Seam Occurrence

2.3.1. General

In the present study, the term of "coal zone" has been used for such a stratigraphic unit as coal seams occur in some degree of frequency, although not a clear definition. Because the field investigation gave priority on coal zone, the whole sequence of the Tanjong Formation was not observed. Therefore, only the coal zone in each sub-area is the subject of the study in terms of stratigraphy and correlation.

As shown in Figure 2-4-1 to 2-4-5, the geological data obtained along mapping routes are compiled in the topographic map on a scale of 1 to 50,000 together with the previous data in surrounding area. As indicated in these figures, the coal zones which extend longer in strike direction with considerable thickness are recognized in four areas, namely, Malibau, Southwest Malibau, Sesui West and Silimpopon areas. The main geological features including distribution of coal zone are summarized in Figure 2-5.

Figure 2-6-1 to 2-6-3 are the lithologic logs along the mapping routes. These graphic logs

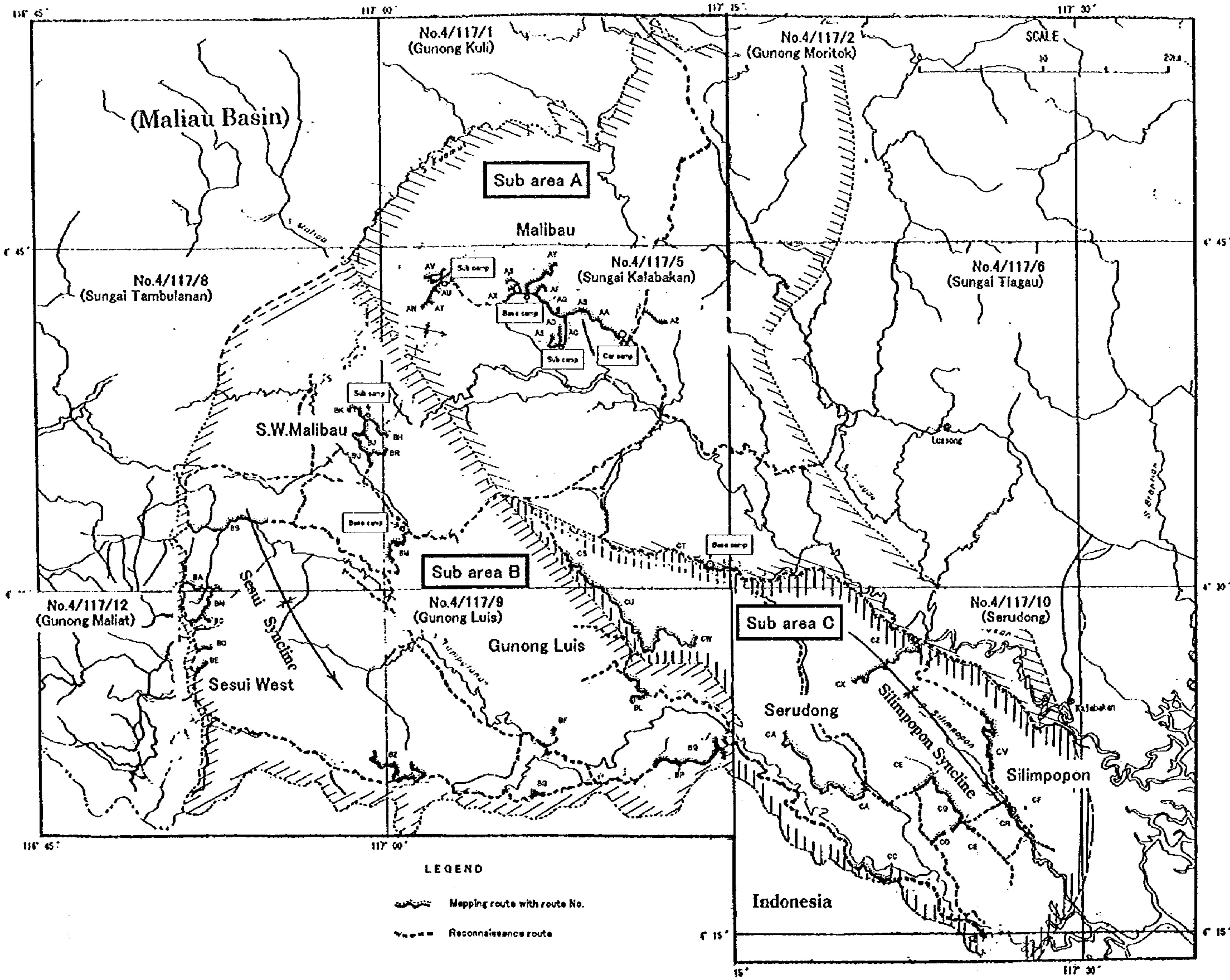
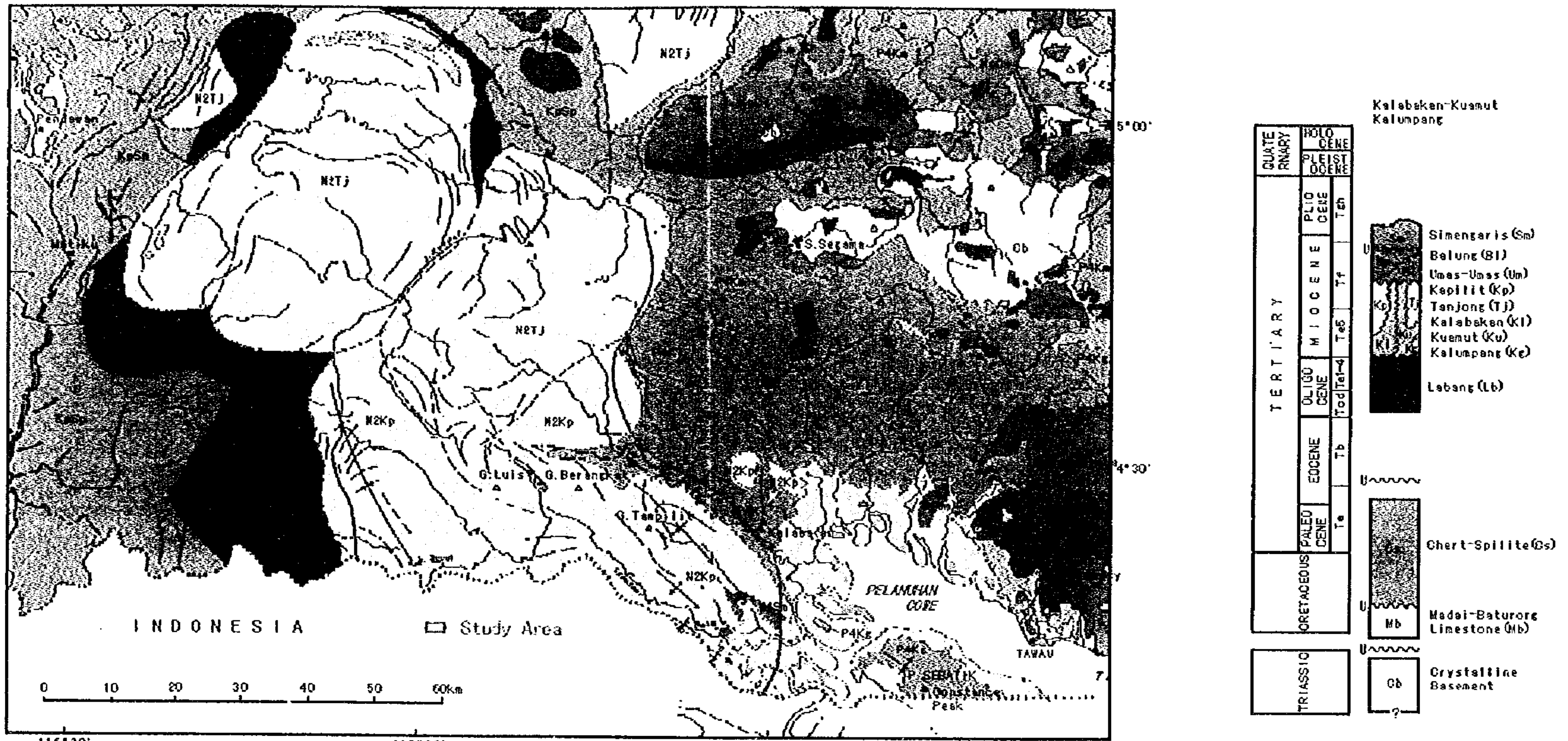


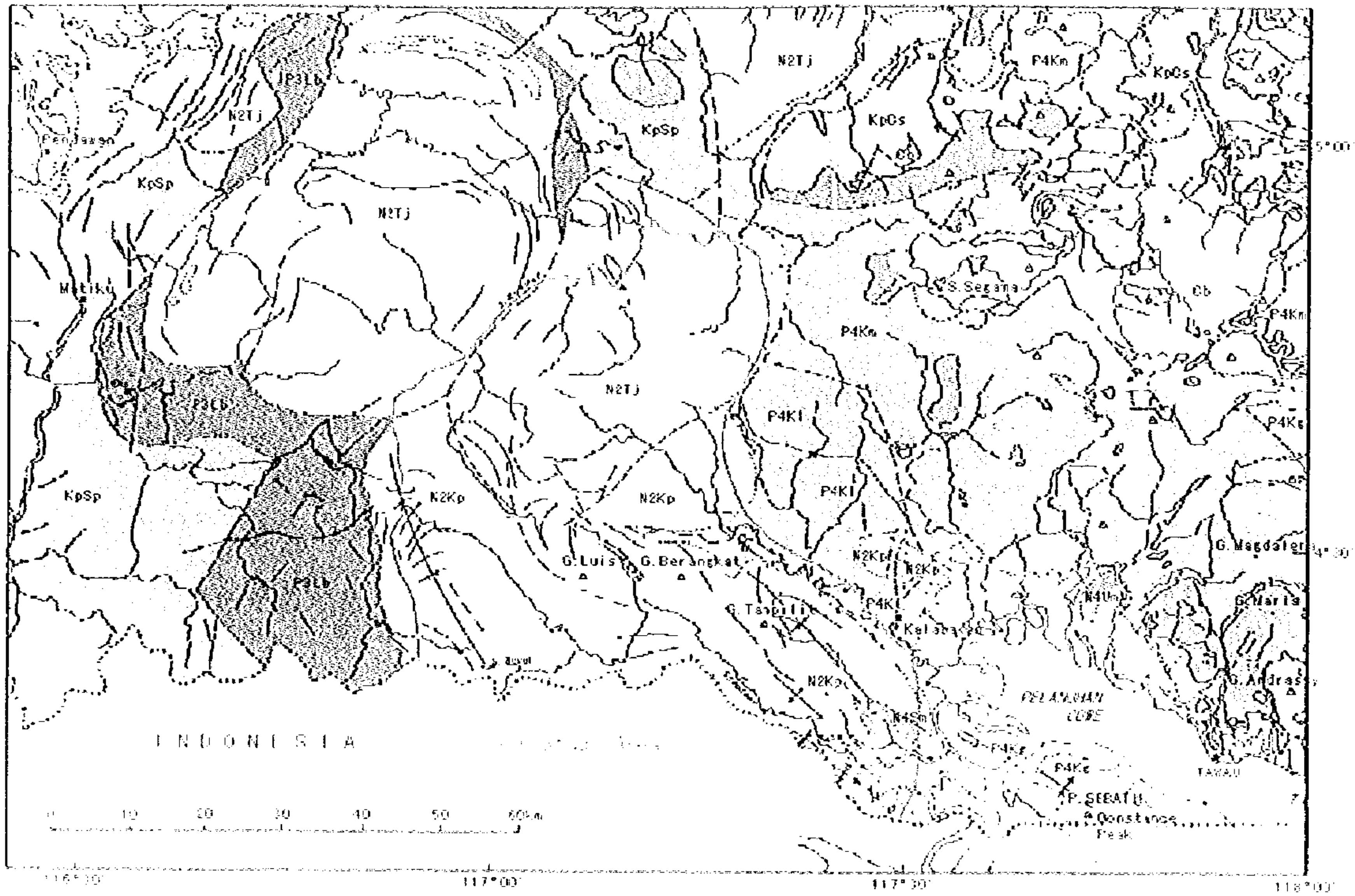
Figure 2-2 **Location of Mapping Routes (Phase 1)**

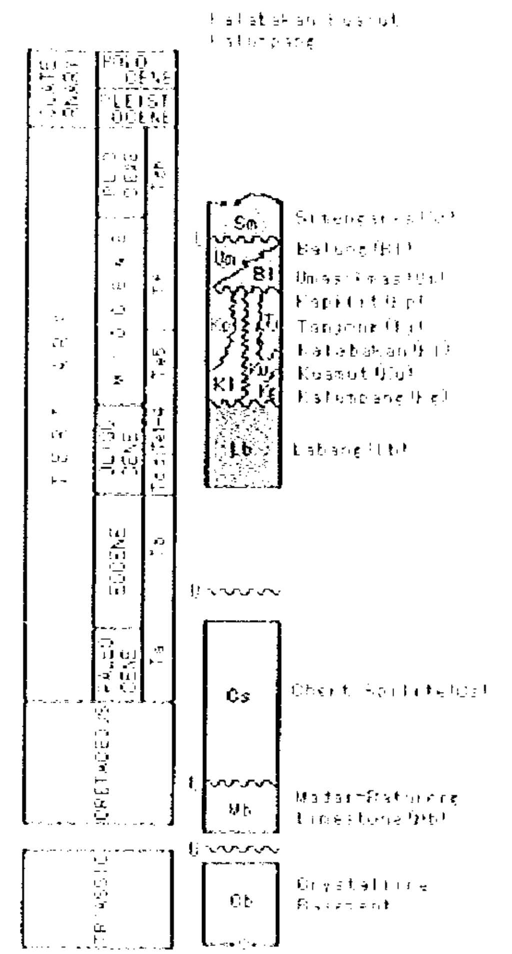


Source: Geological Survey Department, Malaysia

RECENT		Coastal and river alluvium
PLEISTOCENE		Terrace sand and gravel
MIDDLE MIOCENE-PLIOCENE		Sandstone, mudstone, siltstone, shale, conglomerate and lignite with minor limestone and tuff Umas Umas (N4Um), Simengaris (N4Sm)
EARLY MIOCENE-MIDDLE MIOCENE	N2	Mudstone, sandstone, siltstone, conglomerate, minor limestone and lignite Tanjong (N2Tj) and Kapilit (N2Kp)
OLIGOCENE-MIDDLE MIOCENE	P4	Slump breccia and sequences of interbedded mudstone tuff, tuffaceous sandstone, shale, conglomerate with minor chert and limestone Kusmut (P4Ku), Kalabakan (P4Kl) and Kalumpang (P4Kg)
OLIGOCENE		Sandstone, shale, mudstone, siltstone, conglomerate and limestone Rhythmic alternations of siltstone and shale with rare limestone Labang (P3Lb)
LATE CRETACEOUS-LATE EOCENE	KP	Mudstone with some sandstone, conglomerate and limestone Sapulut (KpSp)
CRETACEOUS-EOCENE	KP	Sandstone, chert, conglomerate, volcanic breccia, agglomerate, basalt, spilite Chert-Spilite (KpCs)
TRIASSIC	Cb	Gneiss, schist, amphibolite and associated granite, granodiorite and tonalite, mainly in the Upper Segama-Darvel Bay area
PLEISTOCENE-HOLOCENE		Basalt and Dacite
PLIOCENE		Dacitic pyroclastic rocks and lava at G.Magdalena, andesitic pyroclastic rocks and lava at G.Andrassy
CRETACEOUS-EARLY TERTIARY		Gabbro, dolerite, serpentinite, peridotite, dunite, pyroxenite

Figure 2-3 Regional Geology





Source: Geological Survey Department Malaysia

RECENT		Coastal and river alluvium
PLEISTOCENE		Terrace sand and gravel
MIDDLE MIOCENE-PLIOCENE	N4	Sandstone, mudstone, siltstone, shale, conglomerate and lignite with minor limestone and tuff Umas Umas (N4Um), Simengaris (N4Sm)
EARLY MIOCENE-MIDDLE MIOCENE	N2	Mudstone, sandstone, siltstone, conglomerate, minor limestone and lignite Tanjong (N2Tj) and Kapilit (N2Kp)
OLIGOCENE-MIDDLE MIOCENE	P4	Chump breccia and sequences of interbedded mudstone tuff, tuffaceous sandstone, shale, conglomerate with minor chert and limestone Kuamut (P4Km), Kalabakan (P4Kl) and Kalumpang (P4Kc)
OLIGOCENE	P3	Sandstone, shale, mudstone, siltstone, conglomerate and limestone Rhythmic alternations of siltstone and shale with rare limestone Labang (P3Lb)
LATE CRETACEOUS-LATE EOCENE	KP	Mudstone with some sandstone, conglomerate and limestone Sapulut (KpSp)
CRETACEOUS-EOCENE	KP	Sandstone, chert, conglomerate, volcanic breccia, agglomerate, basalt, spilite Chert-Spilite (KpCs)
TRIASSIC	Cb	Gneiss, schist, amphibolite and associated granite, granodiorite and tonalite mainly in the Upper Segama-Darvel Bay area
PLEISTOCENE-HOLOCENE		Basalt and Dacite
PLIOCENE		Dacitic pyroclastic rocks and lava at G. Magdalena, andesitic pyroclastic rocks and lava at G. Andrassy
CRETACEOUS-EARLY TERTIARY		Gabbro, dolerite, serpentinite, peridotite, dunite, pyroxenite

Figure 2-3 Regional Geology

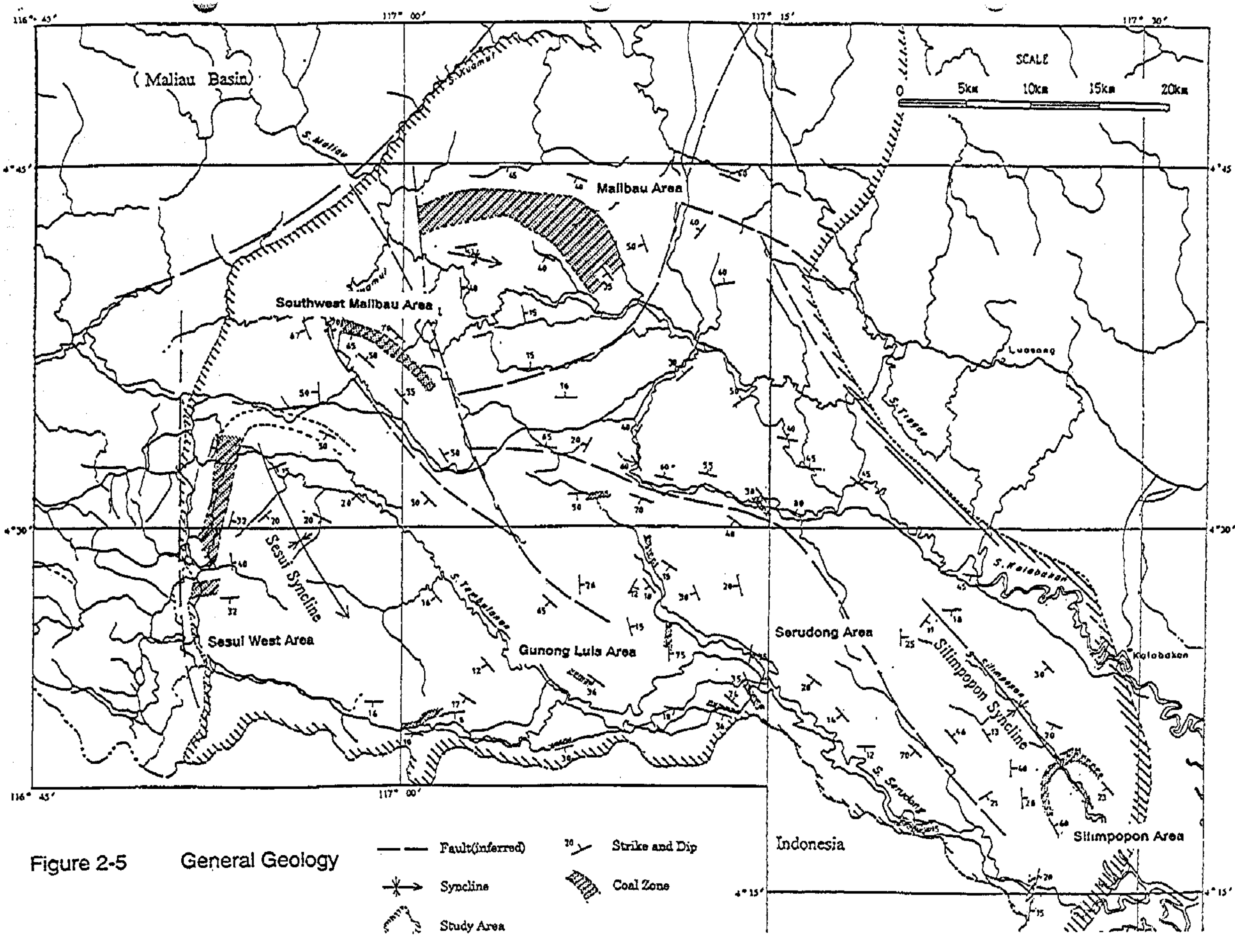


Figure 2-5 General Geology

were produced from geological cross sections in which observed outcrop data were projected. Although these logs contain many blank portions corresponding to no exposure along the route, the thickness of the coal zone and an approximate number and stratigraphic position of coal seams are generally understandable by correlating these logs. Figure 2-7 shows the representative stratigraphic section of coal zone of each area produced by integrating the above logs in each route.

A large number of coal outcrops were observed within these coal zones. They are listed in Table 2-3 and coal seam profiles measured at these outcrops are shown in Figures 2-8-1 to 2-8-3. A list of coal outcrops and their profiles of Malibau and Southwest Malibau areas are shown separately in Tables 3-1-1 to 3-1-2 and Figures 4-3-1 to 4-3-3 respectively together with those observed in Phase 2.

The following is a summary of the modes of occurrence of coal seams in each area based on the findings in the field work of Phase 1.

2.3.2. Malibau Area

The coal zone extends over 12 km along the strike direction with the thickness ranging from 800 m in the western part and 1,150 m in the central to eastern part.

Number and stratigraphic level of coal seams also varies in each part of the area. In the western part, only four coal seams exist in the lower section of the coal zone. However, ten coal seams were observed in the central and the eastern parts at different levels of coal zone, namely, in the middle to lower sections in the central part and in the middle to upper sections in the eastern part.

The thickness of coal seams are generally thin. Coal outcrops of more than 1 m thick were observed only at several locations. The outcrop at the southeastern end of the area (HK012) has the maximum thickness of 1.50 m, but it contains many partings.

The geological structure of the area is relatively simple. The coal seams have E-W trending strike in general, turning gradually to NW-SE at the eastern part and to ENE-WSW at the western part. The dip of coal seams ranges from 25 to 50 degrees toward the south, 35

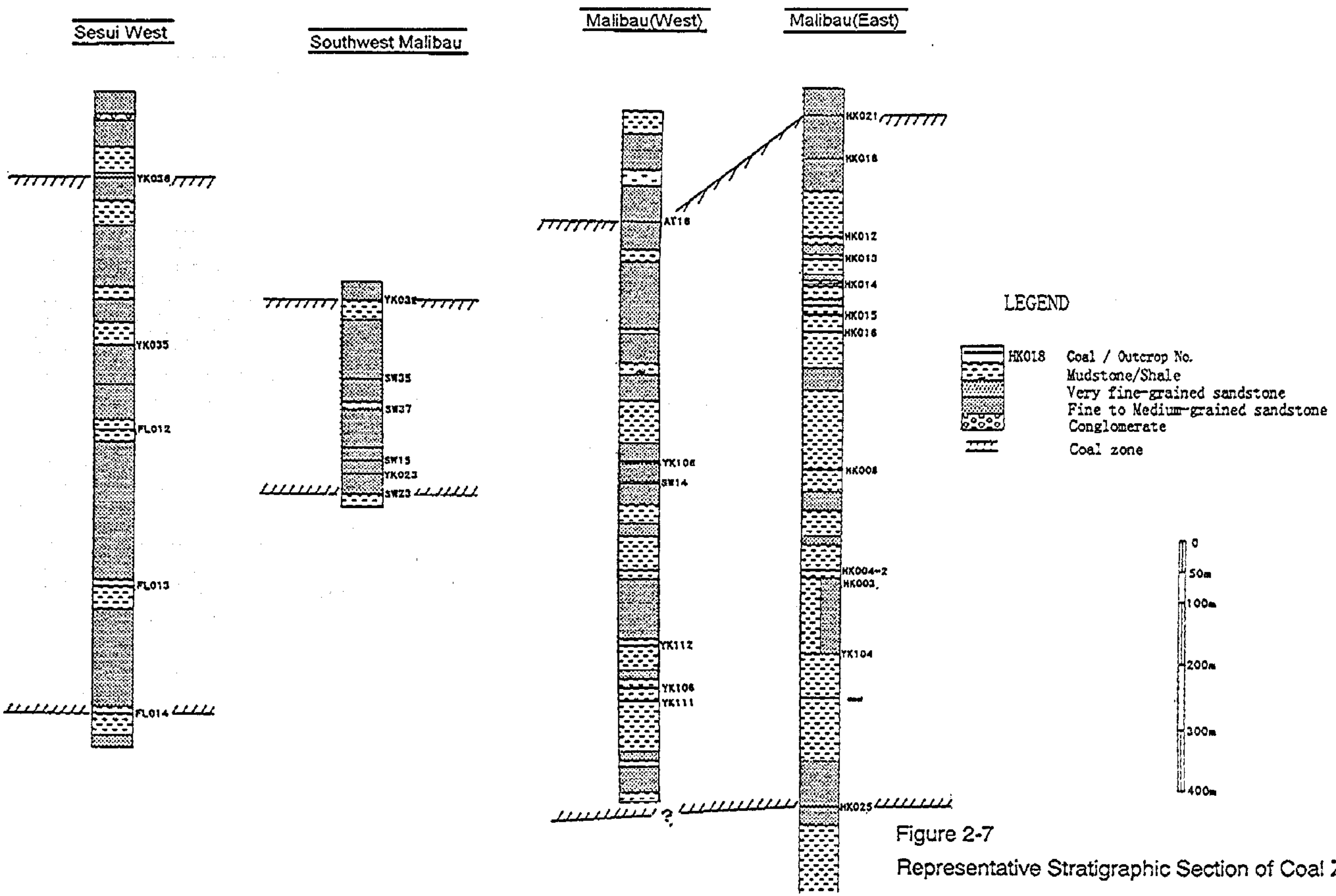


Figure 2-7
Representative Stratigraphic Section of Coal Zone

Table 2-3 List of Coal Outcrops

Mapping Route	O/C No.	Mapping No.	Seam Thick.(m)	Coal Thick.(m)	Strike	Dip	
AZ route	---	AZ21-22	0.10	0.10	N60E	60N	
	---	AZ24-25	0.10	0.10			
	---	AZ28-29	0.10	0.10	N30E	40N	
	---	AZ40	0.10	0.10	N35E	32N	
	---	AZ56-57	0.10	0.10			
	YK101	AZ57	0.20-0.50	0.20-0.50	N30E	40N	
	---	AZ68	0.10-0.20	0.10-0.20			
BA route	FL014	BA31	1.05	1.05	N50E	7S	
	FL013	BA23	1.50	1.20	N30E	28E	
	FL012	BA31	0.25	0.25	N10E	46E	
BB route	NK001	BB49	---	---	N5W	26E	CSH
	NK002	BB52	0.35	0.30	NS	27E	FL03(?)
	NK003	BB60	0.30	0.15	N10E	31E	
	NK004	BB73-1	0.75	0.15	N20E	35E	
	NK005	BB96	0.20	0.00	N40E	32E	CSH
BM route	---	BM4	0.30	0.30	N10E	42E	
	---	BM12	0.15	0.15	N10W	42E	
	YK036	BM57	0.51	0.40	N10E	33E	
	---	BM59	0.40	---	NS	35E	CSH
	YK035	BM44	0.50	0.50	N10E	35E	
	---	BM45	0.15	---	N10E	35E	CSH
BC route	FL015	BC22-BC23					traced over 50m,
	FL016	BC30	0.20	0.20			roof/flower SS
	---	BC31	0.5-0.3	---	NS		CSH
BD route	YK001*	BD0	1.16	1.13	N85E	32S	
	YK002	BD7	---	---	N75W	30S	
	YK003	BD11	0.55	0.55	N60W	25SW	
	YK004	BD13	0.50	0.50	N85W	40S	
	---	BD15	0.50	0.50	N84W	31S	
	---	BD16	0.50	0.50			
	YK005	BD22	1.22	1.22	N88E	32S	
	YK006	BD23	0.65	0.40	EW	32S	
	YK007	BD27	1.90	1.45	N88E	22S	
BE route	YK008	BE41	0.78	0.78	N80E	30S	
BF route	YK010*	BF0	0.63	0.63	N45W	38S	
	---	BF2	thin out				
	YK011	BF4	0.60	0.60	N60W	28S	thin out at BF6-BF7
BG route	YK013*	BG5	1.20	0.95	N50E	37S	
	---	BG1	0.20		N50E	30S	
	YK014*	BG24	0.60	0.60	N45E	30S	
BL route	YK034	BL90	0.50	0.50	N35W	60W	
	---	BL78	0.25	0.25	NS	75W	
	---	BL69	0.30	0.30	N15E	85E	
	---	BL69	0.50	0.50	N15E	85E	
	---	BL51-BL52	0.40	0.40	NS	90	
	---	BL50	0.15	0.15			
	---	BL47	0.60	0.60	N10E	75E	
	YK033	BL7	0.53	0.38	N55W	42S	
BQ route	NK021	BQ80	0.47	0.22	N36W	34SW	
	NK020	BQ73-1	0.20	0.10	N30W	28SW	thin out at around BQ78
	NK017	BQ63	0.47	0.42	N20W	35SW	0.13/0.63, 0.15/0.55
		BQ62-BQ63	0.63	0.13	N20W	35SW	
		BQ62	0.55	0.15	N30W	32W	
	NK018*	BQ57	0.42	0.37	N34W	37SW	
	NK016	BQ54-BQ55	0.55	0.30	N30W	40SW	
	ditto	BQ54-BQ55	0.45	0.20	N30W	30W	
	NK019	BQ63-13-14	0.55	0.40	N16W	20SW	
	NK015	BQ13	0.45	0.35	EW	27S	
	---	BQ9	0.10	0.10	N80W	28S	
	---	BQ3	0.60	0.40	N80W	36S	
	---	BQ2-BQ3	0.30	0.30	N80W	36S	
	NK014	BQ1	0.50	0.45	EW	50S	
	---	BQ38-4	0.35	0.35	N60W	30N	
	---	BQ38-4-5	0.25	0.25	N60W	24N	

Mapping Route	O/C No.	Mapping No.	Seam Thick.(m)	Coal Thick.(m)	Strike	Dip	
BZ route	NK010*	BZ183	2.58	1.49	N85E	8S	
	NK009*	BZ168	0.48	0.48	N85E	6S	
	---	BZ166-2	0.50	0.50	N75E	14S	
	---	BZ166-3	0.40	0.40	N56E	5S	
	---	BZ136-2	1.00	1.00			Faulted
	NK008*	BZ94-3	1.15	1.00			
	NK007*	BZ94-2	0.70	0.60			
CA route	---	CA53-54	0.15	---	N70W	20SW	CSH
CB route	---	CB2	0.35	0.15	N18E	16SE	
	---	CB15	0.70	---	N33W	21NE	CSH - SHC
CC route	KK003	CC30	0.90	0.40	N85E	10S	
	KK005	CC33	0.50	0.37	N58W	15SW	
	---	CC43	0.30	---	N33W	24SW	SHC
	KK006	CC52-1	0.32	0.17	N78W	20SW	
	KK007	CC61	0.86	0.34	N42E	16SE	
	KK008	CC64	1.26	0.44	N26E	19SE	
	---	CC65	0.78	---	N56E	25SE	
	KK009	CC74	1.35	0.82	N18E	15SE	
CR route	KK011	CR15	1.64+	1.58+	N61E	11SE	Queen Seam
CW route	YK201	CW108	0.25	0.25	N15W	10W	
	---	CW138	0.50	---			CSH
CU-CS route	---	CU71	0.14	---			COAL-CSH
	YK202	CU73	0.19	0.15	N70W	12S	
	YK203	CU77	0.30	0.10	N20W	20W	
	---	CU79	0.12	0.07	N30W	12W	
	---	CU81	0.17	0.10	N55W	12W	
	YK204	CU82	0.41	0.23	N50W	10S	
	---	CU83	0.07	0.07	N35W	8W	
	---	CU86	0.05	0.05	N50W	15W	
	---	CU88	0.10	0.10	N40W	10W	
	---	CU90	0.07	0.07	N50W	15W	
	---	CU95	0.06	---	N55W	12S	CSH
	---	CU96	0.05	0.05			
	---	CU98	0.05	0.05	N65W	8S	
	---	CU103	0.05	0.05	N35W	15W	
	YK207	CU105	0.07	0.19	NS	8W	
	---	CU107	0.13	0.13	NS	8W	
	YK208	CS06	0.27	0.27	EW	20S	
	YK209	CS54-55	0.52	0.17	N40E	50S	
	YK210	CS55	0.65	0.20	N65E	50S	
	YK211	CS55-56	0.53	0.36	N80E	55S	
CT route	YK205	CT27	1.38	1.03	N40W	30SW	
	YK206	CT28-1	0.68	0.45	N40W	30SW	
	---	CT29	0.30	---	N50W	50SW	CSH

degrees on an average. No significant disturbance in geological structure was found in the field.

2.3.3. Southwest Malibau Area

The coal zone of the area has the thickness of 330 m and extends over 4.5 km in the strike direction with possible extension of 1 km each to both NW and SE sides. The coal seams are observed at six stratigraphic levels in the western part of the area, while they increase to nine in the eastern part.

The coal seams in the area are much thicker than those of Malibau area. More than half of the investigated outcrops exceed 1 m in thickness. The maximum thickness is 4.86 m at the western end of the observed coal zone which, however, appears to be thinning toward the east.

The coal seams extend with a general strike of NW-SE direction, slightly turning to the west at the western end of the coal zone. They incline very steeply to the southwest in general, but nearly vertical or northerly dipping at some places in the eastern part. At the immediate south of the coal zone in the central part, there appears to be a synclinal structure parallel to the coal zone. Because of a poor coal seam occurrence on the southern side of the apparent synclinal axis, a question was left in Phase 1 whether this is a synclinal structure or a overturned structure of steeply dipping coal seams on the northen side

2.3.4. Silimpopon Area

Out of several coal seams in the area, only the Queen Seam has a mineable thickness. There was a coal mine which produced about 1.5 million tons of coal from the Queen Seam and it was closed in 1932 after 27 years operation. Nine boreholes were sunk in early 1900's to explore the Queen Seam and geological investigation in the area was carried out by P. Collenette around 1950. The following explanation is based on the report of the above investigation as well as the field mapping in the present study.

The outcrop of the Queen Seam has been traced for the distance of about 7 km from the north to the southeast. The Seam has a thickness of more than 1.6 m at the northern part but it thins and deteriorates toward the southeast. In the western part, no outcrop was observed due to a lack of exposure. However, three thin coal outcrops at the southwestern part may be correlated to the Queen Seam, suggesting a same thinning trend as in the eastern part.

The geological structure in the area is dominated by a broad syncline, with an axis plunging to the southeast. The coal seam inclines toward the axis at 10 to 25 degrees. A fault is inferred from the displacement of the sandstone bed overlying the Queen Seam. The Queen Seam was not encountered in two boreholes at western part, although they were drilled deep enough for expected coal seam position. It is uncertain that the missing of the Queen Seam is due to faulting or seam deterioration.

2.3.5. Other Areas

Besides the above mentioned areas, about 20 routes were traversed and a large number of coal outcrops were observed. Most of them, however, are thin and exist in a limited extent. The following is a brief explanation of the coal seam occurrence in these routes.

(1) Sesui West Area

The area is situated in the western flank of the Sesui Syncline and close to the western border of the study area. Several routes were surveyed and a coal zone of 600 to 800 m thick appears to extend for the distance of about 8 km in N-S direction. Most of the coal seams in this coal zone are very thin or deteriorated to carbonaceous shale. Although two outcrops near the bottom of the coal zone are more than 1 m in thickness, they are found only in one route and seem to be thinning to the north.

Relatively thick coal seams are exposed in two routes at southernmost part. However, they are very variable in thickness and thought to discontinue to the coal zone in the north, judging from the difference of strike direction.

The coal zone in this area was expected to extend at the eastern flank of the Sesui Syncline. According to the previous report, however, only a few thin coal or carbonaceous shale were found in the expected zone on this side. It is concluded, therefore, that the possibility of the presence of thick coal is low in the eastern flank of the syncline.

The location of coal outcrops and their profiles in this area are shown in Figure 2-4-2, 2-4-3 and Figure 2-8-1 respectively.

(2) Gunong Luis Area

A large number of coal outcrops were observed along the several routes in and adjacent to the Gunong Luis map sheet. Their location and profiles are shown in Figure 2-4-1, 2-4-4 and Figure 2-8-2 respectively.

In the route BZ, three coal seams were observed at four outcrops. The thickest one is 2.58 m but contains many partings of carbonaceous shale. In the routes BG and BF, one coal seam is found in each route. They are not persistent in thickness and show lenticular occurrence as shown in the profiles of the route BF.

Many coal outcrops are present in the route CS but all of them are very thin or deteriorated to carbonaceous shale. The coal outcrops observed in the routes BL and BQ are also thin and dirty but show a constant thickness of about 0.5 m. The geologic structure is complicated in both routes.

(3) Serudong Area

Several routes were investigated in and adjacent to the Serudong map sheet. Location of coal outcrops and their profiles are shown in Figures 2-4-1, 2-4-5 and Figure 2-8-3 respectively. All of the coal outcrops observed in this area are thin and dirty with many partings except for the Queen Seam, of which condition has been already described in the previous section.

2.4. Estimate of Coal Resources

2.4.1. Malibau and Southwest Malibau Areas

An attempt was made to estimate the geological coal resources of Malibau and Southwest

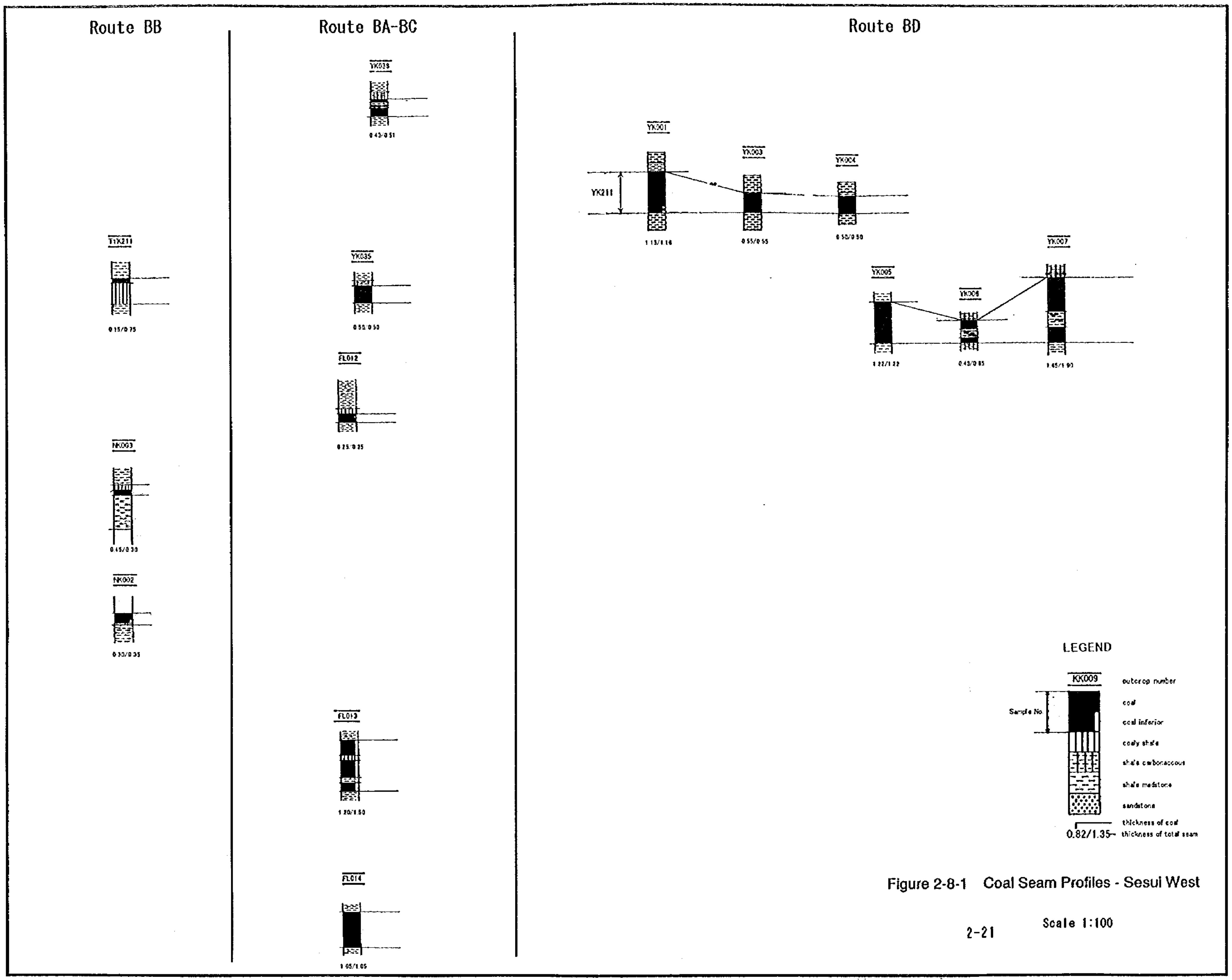


Figure 2-8-1 Coal Seam Profiles - Sesui West

Scale 1:100

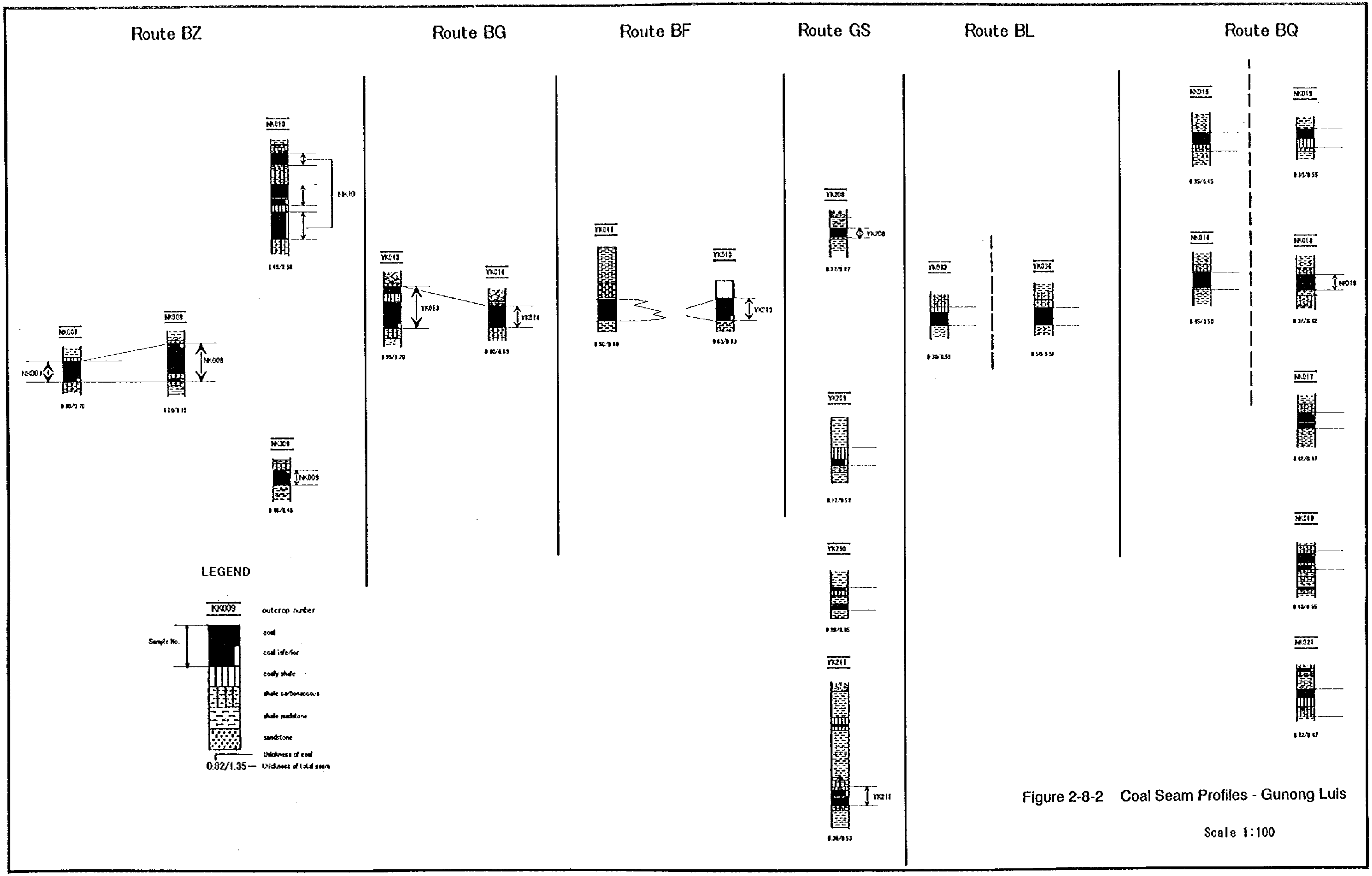


Figure 2-8-2 Coal Seam Profiles - Gunong Luis

Scale 1:100

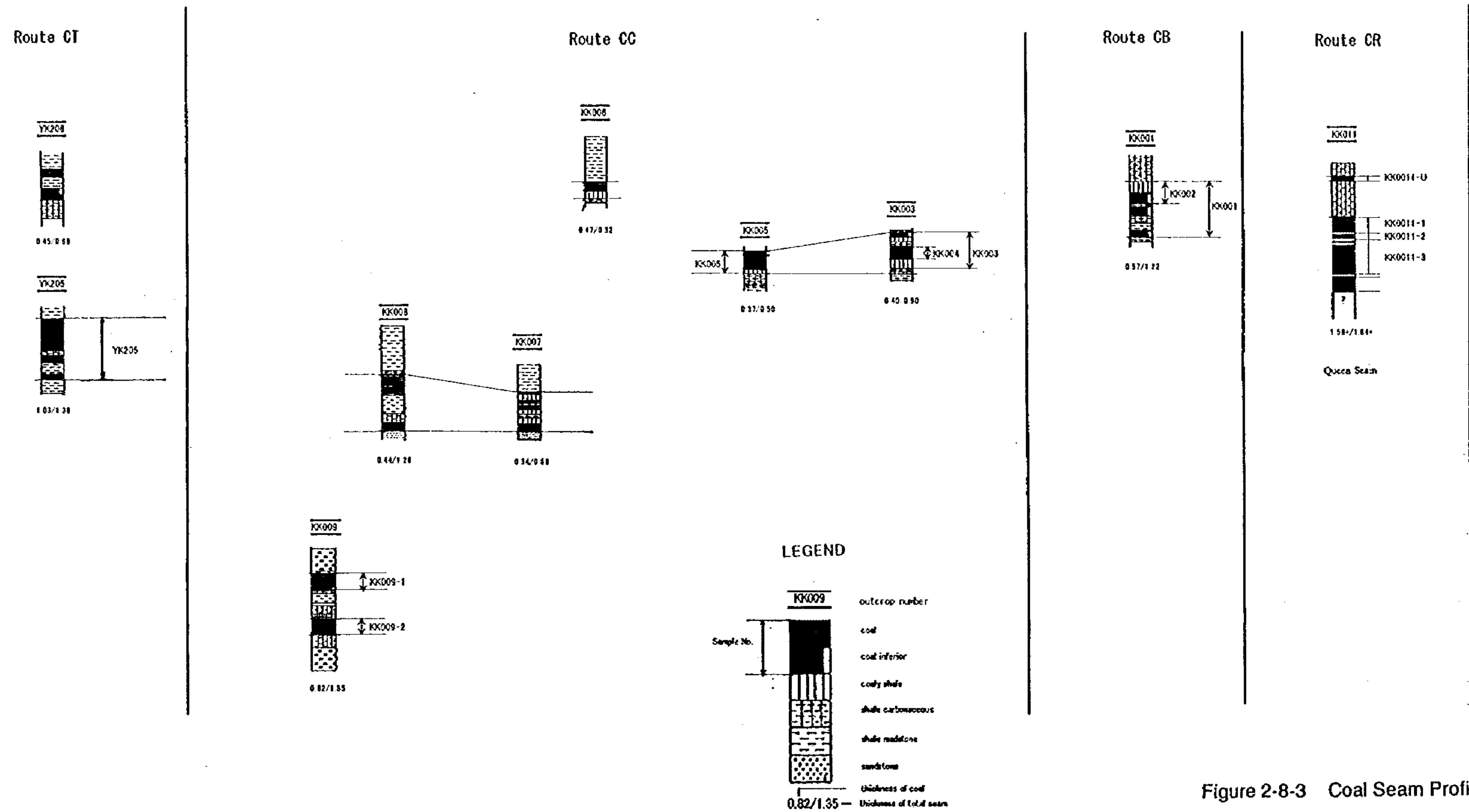


Figure 2-8-3 Coal Seam Profiles - Serudong

Scale 1:100

Malibau Areas, based on the result of investigation in Phase 1. The estimate was made basically in accordance with the GSD's "Reserve/Resource Classification System" which was established by a slight modification of the "United Nations International Framework Classification for Reserves/Resources". The extract of GSD's classification system is given in Appendix 1.

The following are the criteria adopted for coal resource estimate in the present study :

(a) Resource class

The present exploration is regarded as "prospecting stage" of geological study according to the definitions of the GSD system. Consequently, estimated quantity is classified as "Inferred Resources (333)".

(b) Limiting factors

The following factors were adopted for resource estimate in this study :

Minimum coal thickness : 0.6 m

Maximum distance in dip direction from the surface along the seam : 500 m

Specific Gravity of coal : 1.3

(c) Method of estimate

Area of estimate is divided into four blocks in Malibau and three blocks in Southwest Malibau areas. In each block, the average coal thickness of individual coal seams are calculated by averaging measured thickness at outcrops within the block and an accumulated coal thickness of individual coal seams is used for tonnage calculation.

Resource of each block is obtained with the following formula :

Resource (t) = length of block (m) x 500 (m) x accumulated thickness (m) x 1.3

Figures 2-9-1 and 2-9-2 show the details of resource estimate of individual blocks in Malibau and Southwest Malibau areas respectively and the estimated resources are summarized in Table 2-4. In Malibau area, the total resources are 25 million tonnes, most of which are of coal seams less than 1 m thick. In Southwest Malibau area, the coal resources amount to 26 million tonnes and major part of them are of coal seams more than 1 m thick.

Table 2-4 COAL RESOURCES

(MALIBAU AREA)

BLOCK	A		B		C		D		TOTAL
Total coal thickness		2.60 m	*	2.35 m		2.10 m		4.70 m	
Coal seams (>0.6m)	4 seams		uncertain		3 seams		6 seams		
							MC-1	0.60 m	
	MW-1	0.60 m					MC-2	0.90 m	
	MW-2	0.70 m					MC-3	1.20 m	
	MW-3	0.70 m			MC-4	0.60 m	MC-4	0.60 m	
	MW-4	0.60 m					MC-5	0.60 m	
					MC-6	0.60 m			
					MC-7	0.90 m	MC-7	0.80 m	
Strike length		5.0 km		2.5 km		4.0 km		2.5 km	
Dip length		500 m		500 m		500 m		500 m	
Specific gravity		1.3		1.3		1.3		1.3	
Resources (mil.tonnes)		8.450		3.819		5.460		7.638	25.367

* : Mean thickness of A and C

(SOUTHWEST MALIBAU AREA)

BLOCK	A		B		C		TOTAL
Total coal thickness		6.00 m		6.50 m		6.10 m	
Coal seams (>0.6m)	5 seams		7 seams		6 seams		
			SW-1	1.00 m	SW-1	1.60 m	
	SW-2	1.40 m	SW-2	1.00 m	SW-2	0.80 m	
	SW-3	2.30 m	SW-3	1.00 m			
			SW-4	1.10 m	SW-4	1.10 m	
	SW-5	0.60 m	SW-5	0.70 m	SW-5	1.10 m	
	SW-6	0.60 m	SW-6	0.60 m	SW-6	0.60 m	
	SW-7	1.10 m	SW-7	1.10 m	SW-7	0.90 m	
Strike length		2.25 km		2.0 km		2.25 km	
Dip length		500 m		500 m		500 m	
Specific gravity		1.3		1.3		1.3	
Resources (mil.tonnes)		8.775		8.450		8.921	26.146

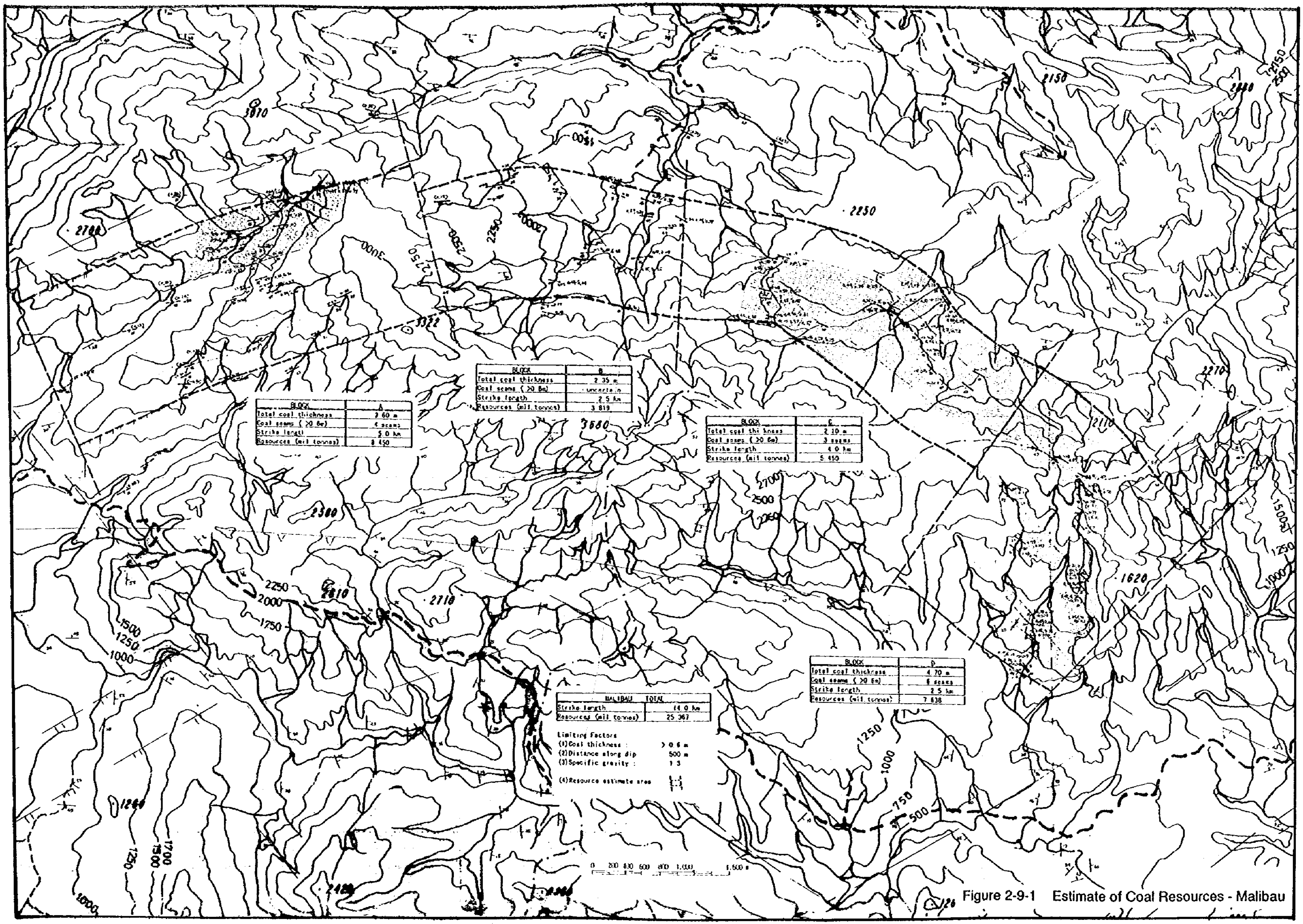
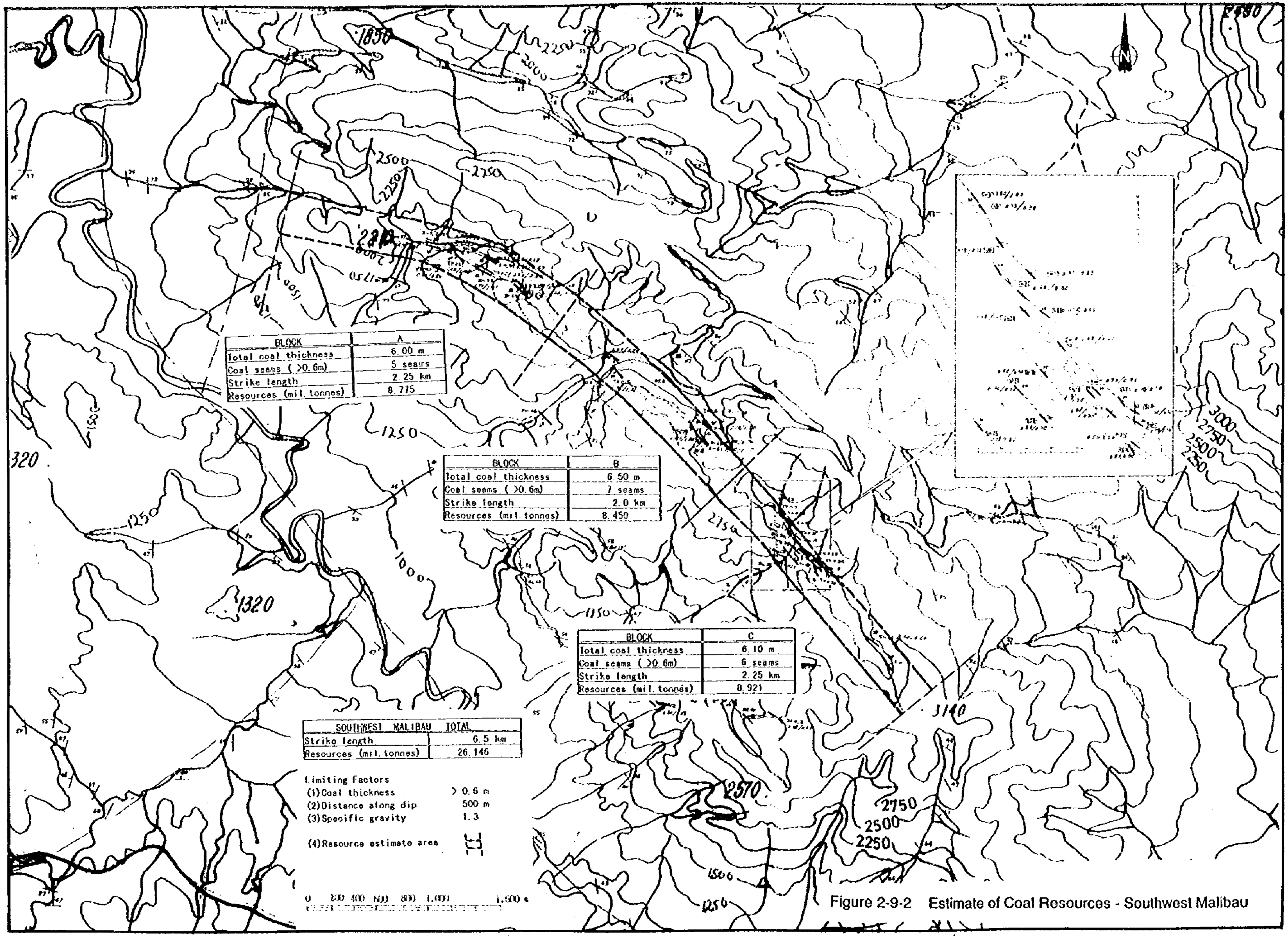


Figure 2-9-1 Estimate of Coal Resources - Malibau



BLOCK	A
Total coal thickness	6.00 m
Coal seams (>0.6m)	5 seams
Strike length	2.25 km
Resources (mil. tonnes)	8.775

BLOCK	B
Total coal thickness	6.50 m
Coal seams (>0.6m)	7 seams
Strike length	2.0 km
Resources (mil. tonnes)	8.450

BLOCK	C
Total coal thickness	6.10 m
Coal seams (>0.6m)	6 seams
Strike length	2.25 km
Resources (mil. tonnes)	8.921

SOUTHWEST MALIBAU TOTAL	
Strike length	6.5 km
Resources (mil. tonnes)	26.146

Figure 2-9-2 Estimate of Coal Resources - Southwest Malibau

2.4.2. Silimpopon Area

The coal resources of the Queen Seam in Silimpopon area have not been estimated in the present study, because the estimated reserves have been given in the previous report (P.Collenette, 1954) and no additional exploration has been done since then.
The coal reserves given in the above report are shown in Table 2-5.

Table 2-5 Coal Reserves of Queen Seam (P.Collenette, 1954)

	Remaining Reserves	Coal Available for Mining
Measured	4,851,000	2,739,000
Indicated	1,496,000	1,472,000
Inferred	7,745,000	6,403,000
Total	14,092,000	10,614,000

Notes : (i) Reserves are shown in long tons.
(ii) Minimum coal thickness is 3 feet.
(iii) Remaining reserves are the original reserves less coal already mined and coal lost in mining.
(iv) Coal available for mining is the remaining reserves less coal to be left in barriers to the mined out area and near the surface.

2.5. Evaluation of Coal Quality

Forty five (45) coal samples were collected from outcrops and analyzed at the coal laboratory of GSD Sarawak. Analytical items are Proximate Analysis, Gross Calorific Value, Total Sulphur, Ultimate Analysis (C,H,N,) and Free Swelling Index (FSI). Analytical results are shown in Table 2-6. General comments on each analytical item are as follows :

(a) Moisture content on air dried basis ranges from 0.6 to 6.3%. Samples with more than 2.5% moisture may have been affected by weathering.

(b) Raw ash content ranges widely from 2.9 to 48.2%. The sample with higher ash than 50% is not regarded as coal. High ash values of some samples from Malibau are due

Table 2-6

COAL ANALYSIS (Phase 1)

Analysis by GSD, SARAWAK

Area	Sample No.	Seam No. *	Total Moisture % a.r	Proximate Analysis (a.d.) Moisture %	Ash %	V.M. %	F.C. %	G.C.V. (a.d.) kcal/kg	T.Sulfur (a.d.) %	Ultimate Analysis (d.a.f.) C %	H %	N %	FSI	Fuel Ratio	Coal Rank (ASTM)
Malibau	HK012		14.0	3.9	44.5	24.0	27.6	3,633	0.85	73.6	5.39	0.85	0	1.15	hvCb
	HK013		9.4	2.0	32.0	30.4	35.6	5,198	3.79	77.9	5.67	1.08	1	1.17	hvAb
	HK014	ME	6.4	0.6	31.3	34.9	33.2	5,442	3.12	79.3	6.15	1.26	1.5	0.95	hvAb
	HK015		11.9	2.5	48.2	24.3	25.0	3,759	0.70	79.1	6.25	1.95	0	1.03	hvAb
	HK017		5.8	1.3	41.0	28.4	29.3	4,543	0.19	78.9	6.26	1.02	1	1.03	hvAb
	HK018		6.6	1.7	17.8	38.2	42.3	6,546	2.53	82.5	5.99	1.17	2	1.11	hvAb
	HK021		7.8	1.8	15.5	39.3	43.4	6,699	2.56	81.4	5.78	1.27	1.5	1.10	hvAb
	HK022		10.4	2.2	27.6	33.6	36.6	5,542	1.46	78.8	5.63	1.33	1	1.09	hvAb
	HK025	MA	5.1	1.6	10.6	40.5	47.3	7,151	0.40	82.9	5.38	1.90	2	1.17	hvAb
	HK026	MA	5.2	2.0	10.9	39.8	47.3	7,041	0.33	82.9	5.97	1.70	1.5	1.19	hvAb
	YK115	MD	8.0	2.6	12.9	39.6	44.9	6,668	0.90	79.6	5.81	1.40	1	1.13	hvBb
	YK120	MB	5.4	1.8	19.3	38.6	40.3	6,388	1.66	81.7	6.11	1.34	2	1.04	hvAb
SW Malibau	YK027	SE2	6.7	3.2	4.8	44.4	47.6	7,246	0.45	81.1	5.79	1.48	1	1.07	hvBb
	YK031	SE2	12.7	4.8	9.4	38.4	47.4	6,302	1.27	77.5	5.35	1.24	0	1.23	hvCb
	SW036	SE1	8.5	2.9	2.9	45.1	49.1	7,397	0.65	81.2	5.90	1.44	1	1.09	hvBb
Rt. BR	NK013		12.4	4.9	24.6	31.7	38.8	4,928	1.11	75.5	5.11	1.93	0	1.22	hvCb
Route BZ	NK007		30.5	6.3	9.1	37.3	47.3	5,961	3.53	74.8	5.01	1.56	0	1.27	hvCb
	NK008		12.6	3.2	5.7	42.7	48.4	7,120	3.83	79.1	5.65	1.66	1	1.13	hvBb
	NK009		15.6	3.4	14.4	37.9	44.3	6,145	4.35	76.8	5.28	1.34	0.5	1.17	hvBb
	NK010		7.2	2.1	19.7	38.9	39.3	6,159	5.14	78.8	5.55	1.25	1	1.01	hvAb
Route BQ	NK018		4.7	1.3	14.2	35.3	49.2	6,694	1.39	80.2	5.61	1.50	8	1.39	hvAb
Route BD	YK001		4.0	2.3	5.1	45.3	47.3	7,366	0.49	81.3	6.04	1.24	1	1.04	hvAb
Route BF	YK010		2.9	1.5	3.3	42.8	52.4	7,889	1.78	84.6	6.27	1.52	7.5	1.22	hvAb
Route BG	YK013		4.4	1.8	12.1	42.7	43.4	6,780	5.79	78.6	5.75	1.37	1	1.02	hvAb
	YK014		4.2	1.8	5.4	48.8	44.0	7,497	3.51	81.0	6.25	1.39	1	0.90	hvAb
	TN001		3.7	1.5	9.6	47.5	41.4	7,282	4.65	81.5	6.51	1.55	2	0.90	hvAb
Route CB	KK001		15.3	1.7	37.6	30.6	30.1	4,500	4.52	78.6	5.85	0.78	0.5	0.98	hvAb
	KK002		9.6	1.5	36.5	30.0	32.0	4,648	5.16	77.7	5.68	0.78	1	1.07	hvAb
Route CC	KK003		15.6	1.8	38.3	29.9	30.0	4,551	2.46	77.0	5.61	1.13	1	1.00	hvAb
	KK004		9.6	1.4	7.7	42.9	48.0	7,423	3.31	81.8	5.94	1.59	2	1.12	hvAb
	KK005		8.4	1.4	30.8	33.3	34.5	5,338	2.14	80.1	6.15	1.19	1	1.04	hvAb
	KK009-1		11.9	1.8	18.3	38.9	41.0	6,508	2.09	81.7	6.02	1.73	1.5	1.05	hvAb
	KK009-2		20.7	2.8	14.2	37.1	45.9	6,334	3.72	78.5	5.29	1.74	1	1.24	hvBb
Silimpopon	KK011-U		8.8	1.6	6.5	43.0	48.9	7,310	3.40	80.3	5.52	0.91	1	1.14	hvAb
	KK011-1	Queen	7.9	0.9	20.6	40.3	38.2	6,239	2.29	79.4	6.10	0.74	1.5	0.95	hvAb
	KK011-2	Queen	8.8	1.1	28.3	35.7	34.9	5,398	1.72	78.6	6.06	0.78	1	0.98	hvAb
	KK011-3	Queen	6.5	1.1	9.0	46.2	43.7	7,555	2.18	83.2	6.18	1.05	6	0.95	hvAb
(No. Sincline)	KK010		5.4	0.6	8.7	48.0	42.7	7,642	4.72	82.7	6.11	0.96	6	0.89	hvAb
Route CW	YK201		3.6	0.9	66.5	16.6	16.0	2,434	2.64	79.0	5.90	0.15	1	0.96	hvAb
Route CU	YK202		7.4	0.7	15.4	32.3	51.6	7,081	3.67	86.2	5.35	0.96	9	1.60	hvAb
	YK203		9.3	1.6	53.2	19.7	25.5	3,375	3.52	79.7	5.27	0.13	1	1.29	hvAb
	YK204		9.8	1.1	46.6	21.3	31.0	4,071	3.90	80.5	5.24	0.28	1	1.46	hvAb
Route CS	YK208		3.8	1.0	16.5	42.8	39.7	6,521	9.14	77.2	5.16	0.95	4	0.93	hvAb
	YK211		16.5	2.8	21.5	35.1	40.6	5,804	2.53	78.6	5.21	1.64	1	1.16	hvBb
Route CT	YK205		13.6	5.0	18.2	24.9	51.9	5,592	1.35	80.7	3.94	1.23	0	2.08	hvCb

Analysis according to ASTM Standard

* : designated for resource estimate

a.r. : as recieved basis, a.d. : airdried basis, d.a.f. :dry ash-free basis,

V.M. : volatile matter, F.C. : fixed carbon, G.C.V. : gross calorific value, FSI: free swelling index

hvAb : High volatile A bituminous coal

hvBb : High volatile B bituminous coal

hvCb : High volatile C bituminous coal

to the presence of many non-coal partings. Ash content of normal coal seam with few parting is assumed to be in a range of 5 to 15%.

(c) Volatile matter content ranges from 21.3 to 48.8% on air dried basis (40.7 to 52.6% on dry ash-free basis). Fuel ratio, which is equivalent to fixed carbon divided by volatile matter, is mostly in a range of 0.9 to 1.3. This is a suitable value for combustion purpose.

(d) Calorific value is inversely proportional to ash content. Though it is in a wide range as ash content varies, an approximate calorific value is estimated at 7,100 kcal/kg for coal of 10% ash and 6,650 kcal/kg for 15% ash of unweathered samples.

(e) Sulphur content in coal is generally high. However, there is regional variation. High sulphur coals of more than 2% are found in the southeastern part of the area, including Gunong Luis, Serudong, Silimpopon, and eastern part of Malibau area. In the northwestern part, including Southwest Malibau and the main part of Malibau area, it decreases down to 1.5% or less.

(f) Nitrogen content of all samples is less than 2%, normally less than 1.5% on dry ash-free basis. This is suitable value for steaming coal.

(g) Free swelling index (FSI) is mostly ranging from 0 to 2. Although FSI is very sensitive to weathering, the coal in the area seems to be of low coking property. The cause of exceptionally high FSI (6 to 9) in some samples is unknown at present.

(h) Most of the coal samples are classified as high volatile A bituminous (hvAb) in coal rank according to ASTM standard. The coal samples ranked as hvBb and hvCb contain more moisture than 2.5% and 4% respectively, which indicates the decrease of calorific value by weathering.

To sum up, the coal in the area has characteristics in quality of low to medium ash, high calorific value, high volatile, low nitrogen and widely ranging sulphur. These are suitable quality as steaming coal in general. Although undesirable quality values such as high sulphur and high ash are found in some samples, they seem to be improved in some degree by selecting coal seams in the main coal deposits.

2.6. Conclusion of Phase 1 Study

2.6.1. Geological Assessment

During the field work programme of Phase 1 study, a large number of coal outcrops were observed in the study area. All of the collected data as well as existing information were examined and evaluated from the viewpoints of geological condition, coal reserves, coal quality and mineability.

As a result, the following three areas, namely, Malibau, Southwest Malibau, and Silimpopon areas, have been identified as the areas with some potential for coal resource development. In other area, almost all the coal seams observed at outcrops are thin and exist in a limited extent, therefore, have no mining possibility.

The conditions of coal seams in the above three areas are summarized as follows :

(1) Malibau Area

A large number of coal seams exist in a coal zone extending more widely compared with other areas. However, the coal seams are generally thin. Only a few coal seams exceed 1 m which is thought to be the lower limit of efficiently mineable thickness. Geological structure seems to be stable with an average dip of 35 degrees. Inferred coal resources have been estimated at about 25 million tonnes at this stage. Coal quality is generally suitable for steaming coal, although high ash and high sulphur coal is found in eastern part.

(2) Southwest Malibau Area

Although the extent of the coal zone is smaller, the coal seam thickness is greater compared with Malibu area. Out of nine coal seams, six seams are more than 1 m thick with the maximum thickness of 4.86 m. The coal seams occur with very steep dip, nearly vertical at some places. Inferred resources have been estimated at about 26 million tonnes. With regard to the coal quality, high grade of steaming coal of low ash, high calorific value, and low to medium sulfur can be expected.

(3) Silimpopon Area

Mostly based on the previous information, the coal seam condition in the area is summarized as follows : The Queen Seam, the only one coal seam with mining interest, has a thickness of about 1.8 m at the northern part showing thinning trend to the south. It lies in a broad synclinal structure with a gentle dip, which gives better mining condition than other areas. A total reserves of 14 million tons have been estimated previously. Analytical result indicates suitability for steaming coal in general, except for relatively high sulfur content.

2.6.2. Mining Potential

The following is a very preliminary consideration on mining potential of the coal seams in the above three areas from the technical point of view :

(1) Each area has different characteristics in mining condition, namely, thin coal seams with moderate to steep dip in Malibau, thicker coal seams with very steep dip in Southwest Malibau, and a moderately thick coal seam with gentle dip in Silimpopon. Suitable mining methods should be selected for different mining condition in each area.

(2) Open cut mining method is probably not applicable to the coal seams in such topographic and geological conditions as in these areas. With regard to the underground mining, conventional mining methods such as longwall mining or room and pillar mining, can be applied to the coal seam with gentle dip. To the steeply dipping coal seam, a step-cut mining is to be studied for example, which has been experienced in some coal mines in Japan with similar conditions. These are not fully mechanized system and an advanced technical expertise is not required.

(3) In consideration of the magnitude of coal reserves and geological conditions, an appropriate production scale of the mine will be small, for example, 100 to 200 thousand tonnes per year, which makes the capital investments minimized.

(4) Judging from the result of coal analysis, the coal in the area can be used as steaming coal for various purposes, including power generation, cement manufacture, and any

other industries.

(5) The possible route and means of transportation of product coal is as follows, in the case of exporting to outside of Sabah :

Mine site -- (truck) -- Kalabakan -- (barge)--Tawau -- (barge or vessel)-- Consumers

(6) The possible impacts on surrounding environment will be minimal by operation of small scale underground mines.

3. Procedure of Phase 2 Study.

3. Procedure of Phase 2 Study

3.1. General

Based on the result of Phase 1 study, implementation of Phase 2 study was decided at the Evaluation Committee Meeting held at the end of Phase 1. The Study Plan for Phase 2 was designed in line with the original Scope of Work and discussed at the above meeting. The main points of the study plan were as follows :

(1) Study areas and their approximate size (see Figure 3-1)

(a) Malibau area - 78 km²
(b) Southwest Malibau area - 26 km²
(c) Silimpopon area - 30 km²

(2) Purpose and Scope of the study

The purpose of Phase 2 study is to make geological assessment and evaluate the mine development potential of the coal resources in the selected areas. The scope of Phase 2 study included detailed geological mapping, preliminary mine planning and initial environmental examination to obtain the basic data for the above purpose. Detailed items of the study have been stated previously in 1.1.2. Schedule of the study is shown in Figure 1-2 together with that of Phase 1.

3.2. Field Work Programme

3.2.1. Photogrammetric Mapping

In Phase 1 study, existing topographic maps on a scale of 1:50,000 with 250 feet (76 m) contour intervals were used as the base map for geological mapping and data compilation. Since Phase 2 study requires higher accuracy than Phase 1, new topographic maps of 1:10,000 with 10 meter contour intervals were prepared for Malibau and Southwest Malibau areas as shown in Figure 3-2.

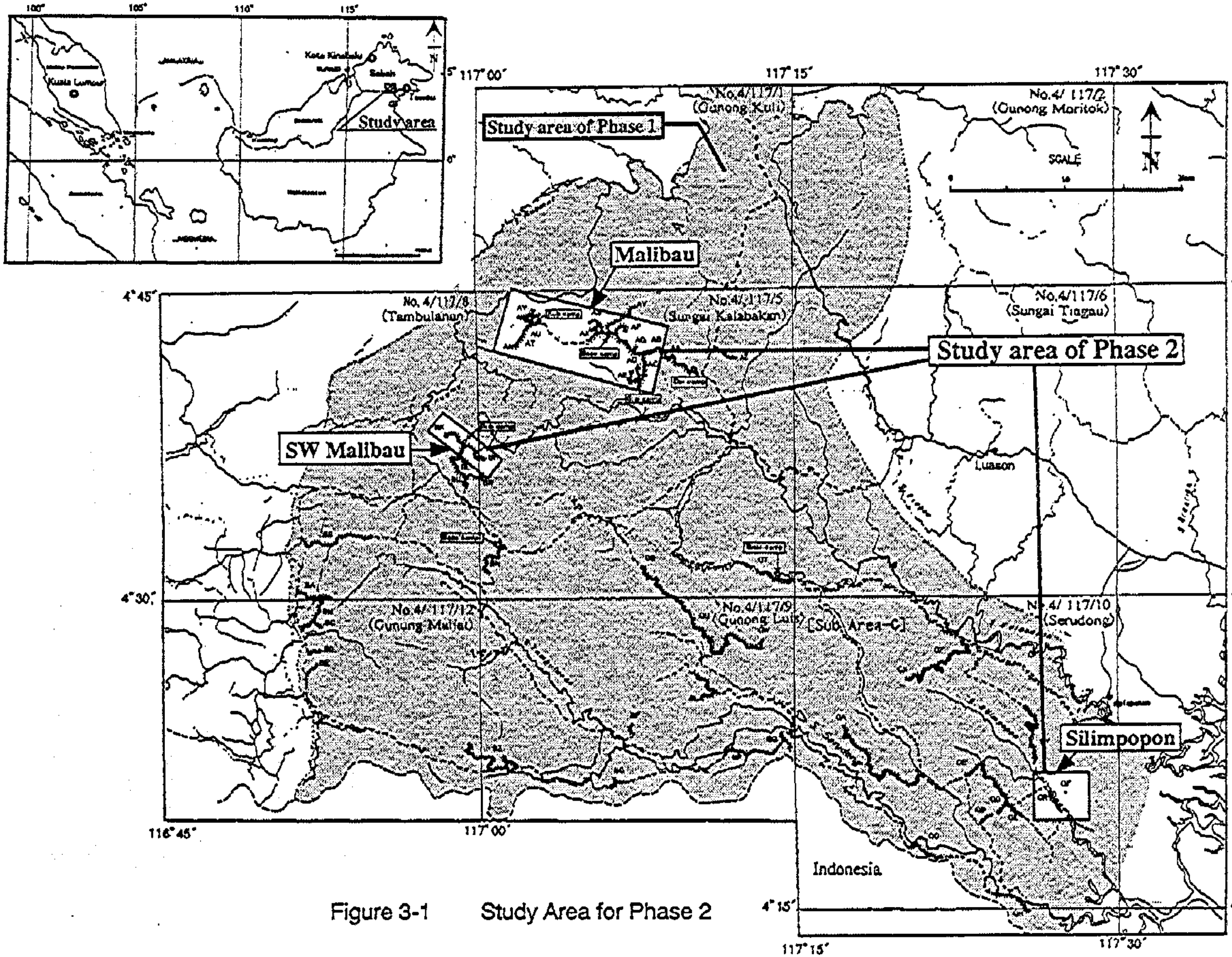


Figure 3-1 Study Area for Phase 2

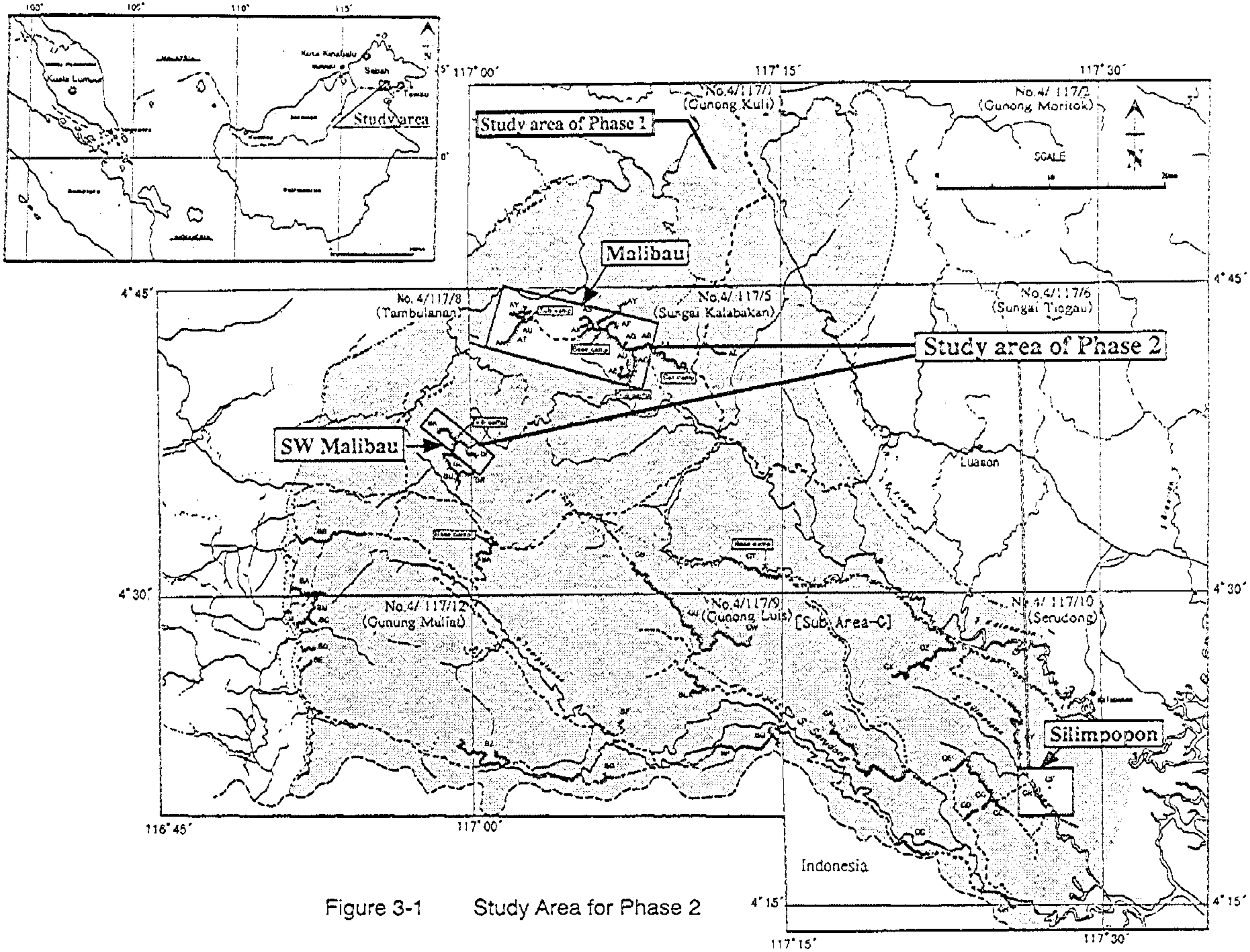
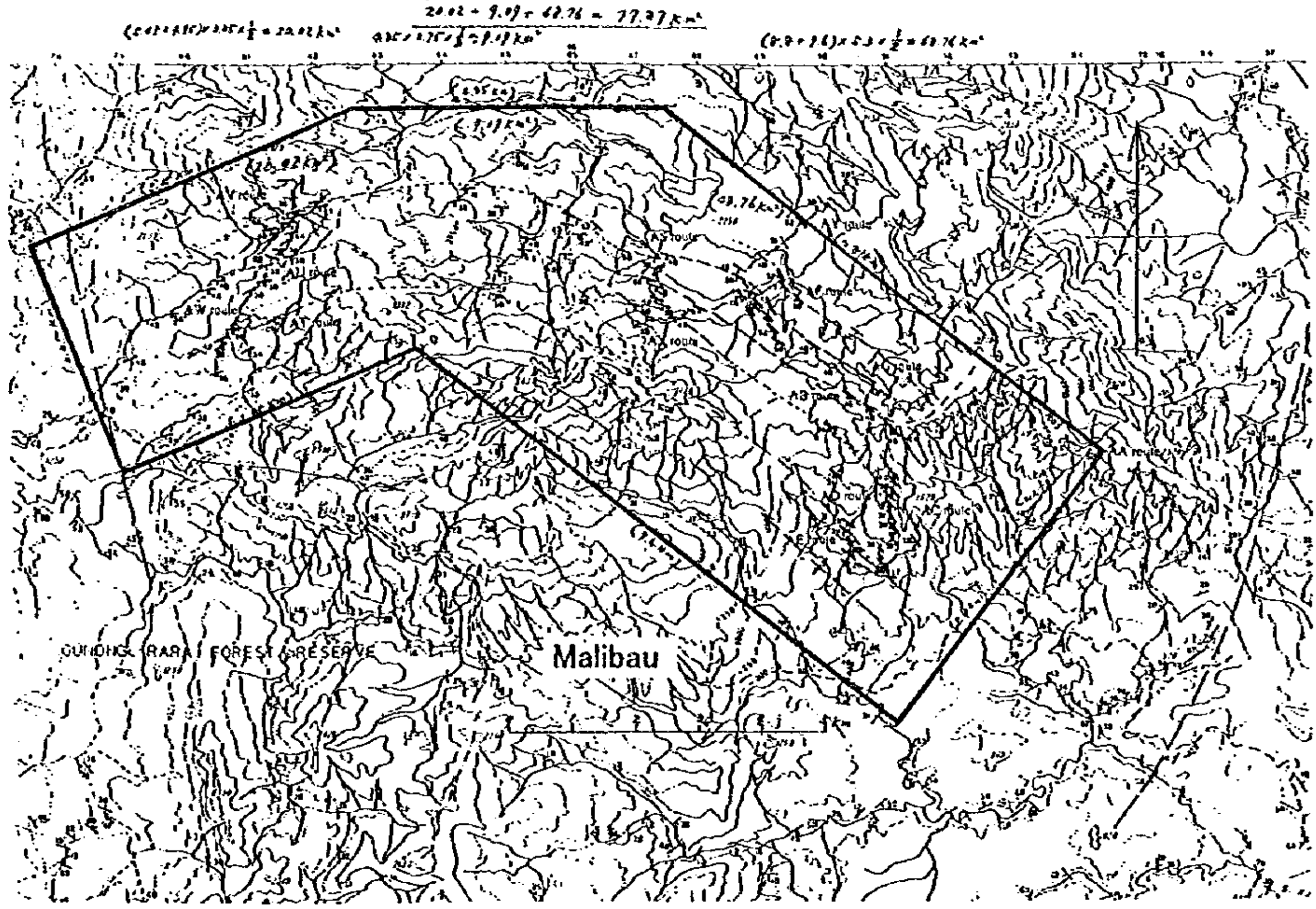


Figure 3-1 Study Area for Phase 2



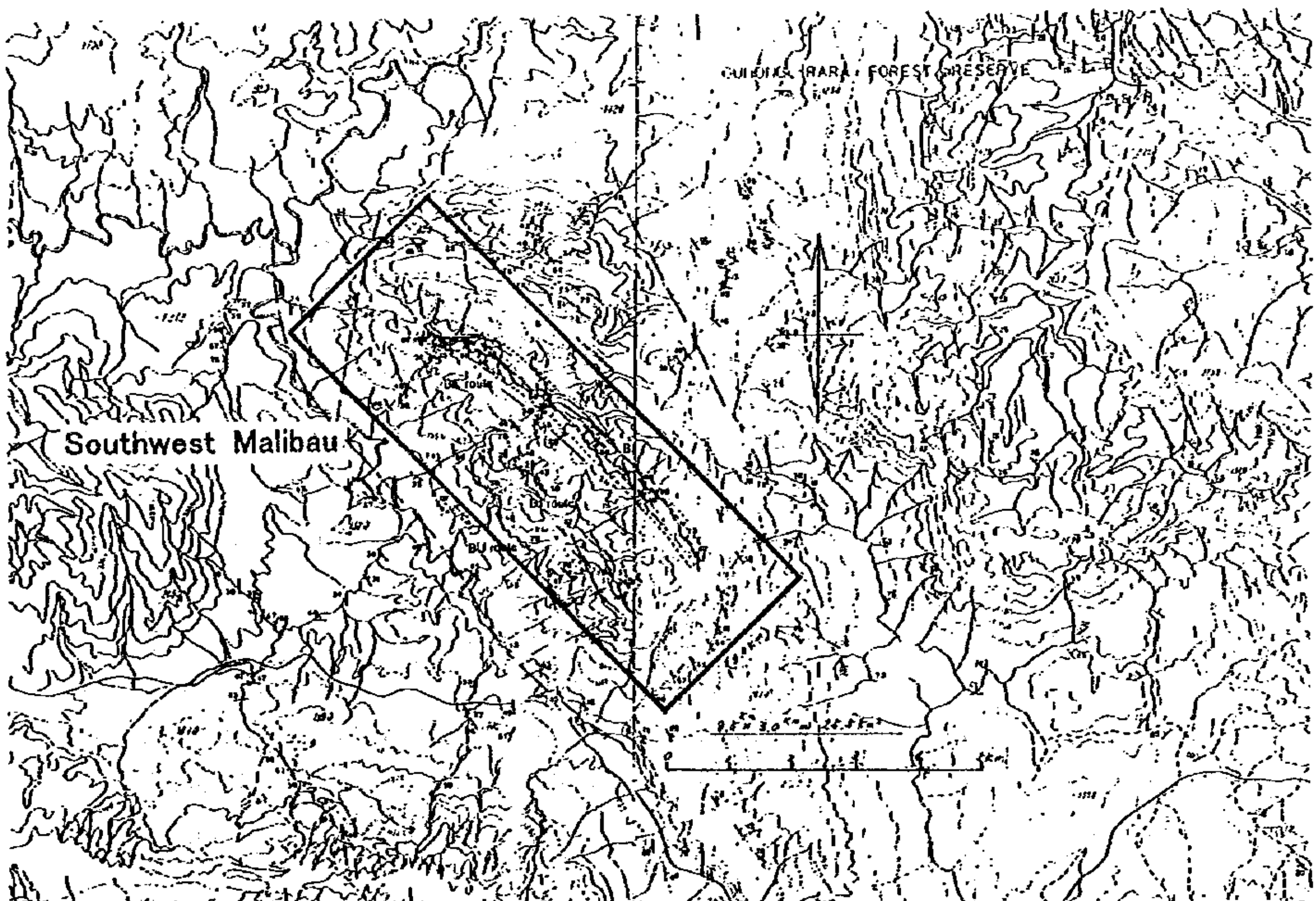
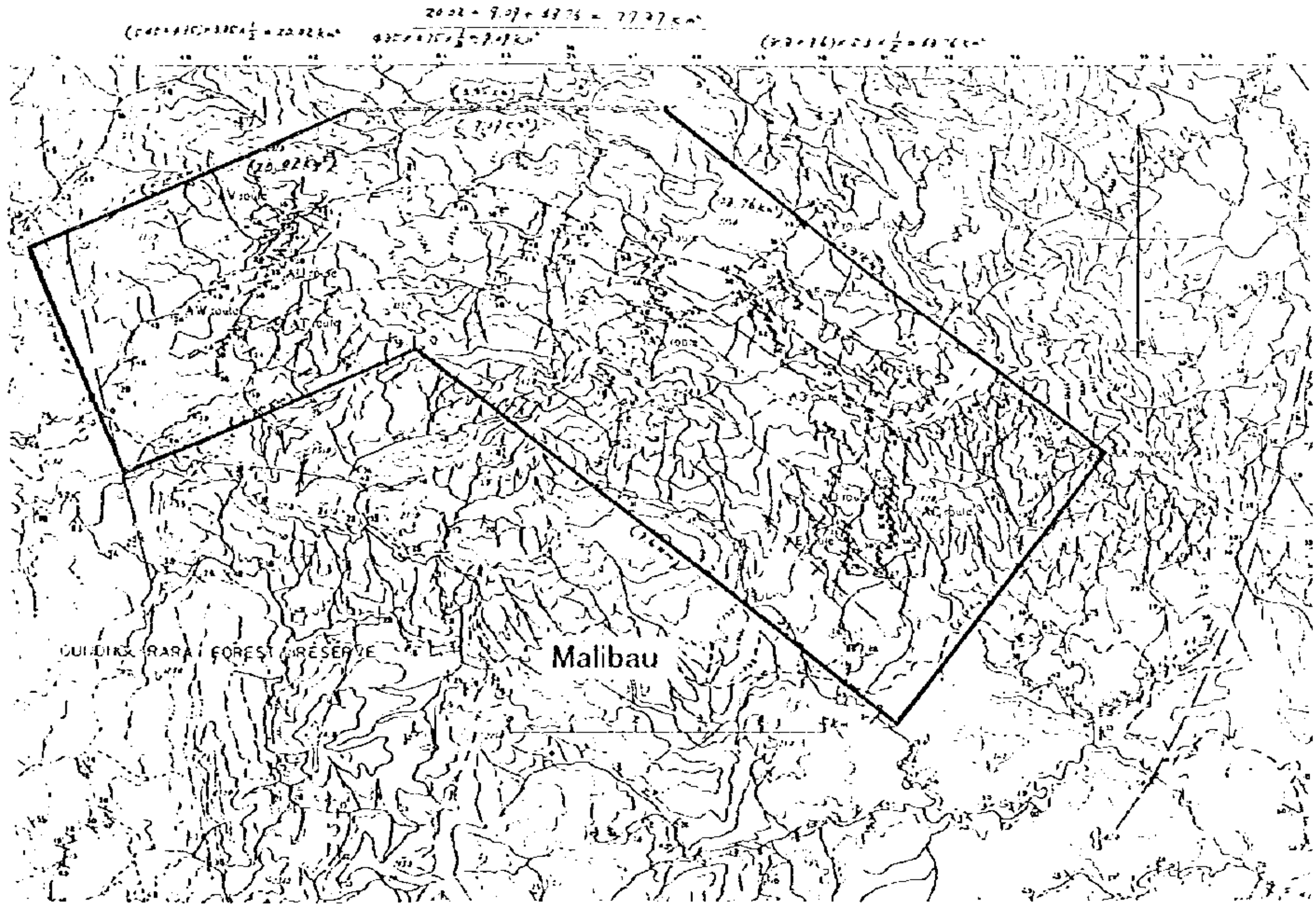


 Figure 3-2 Area of Photogramatic Mapping



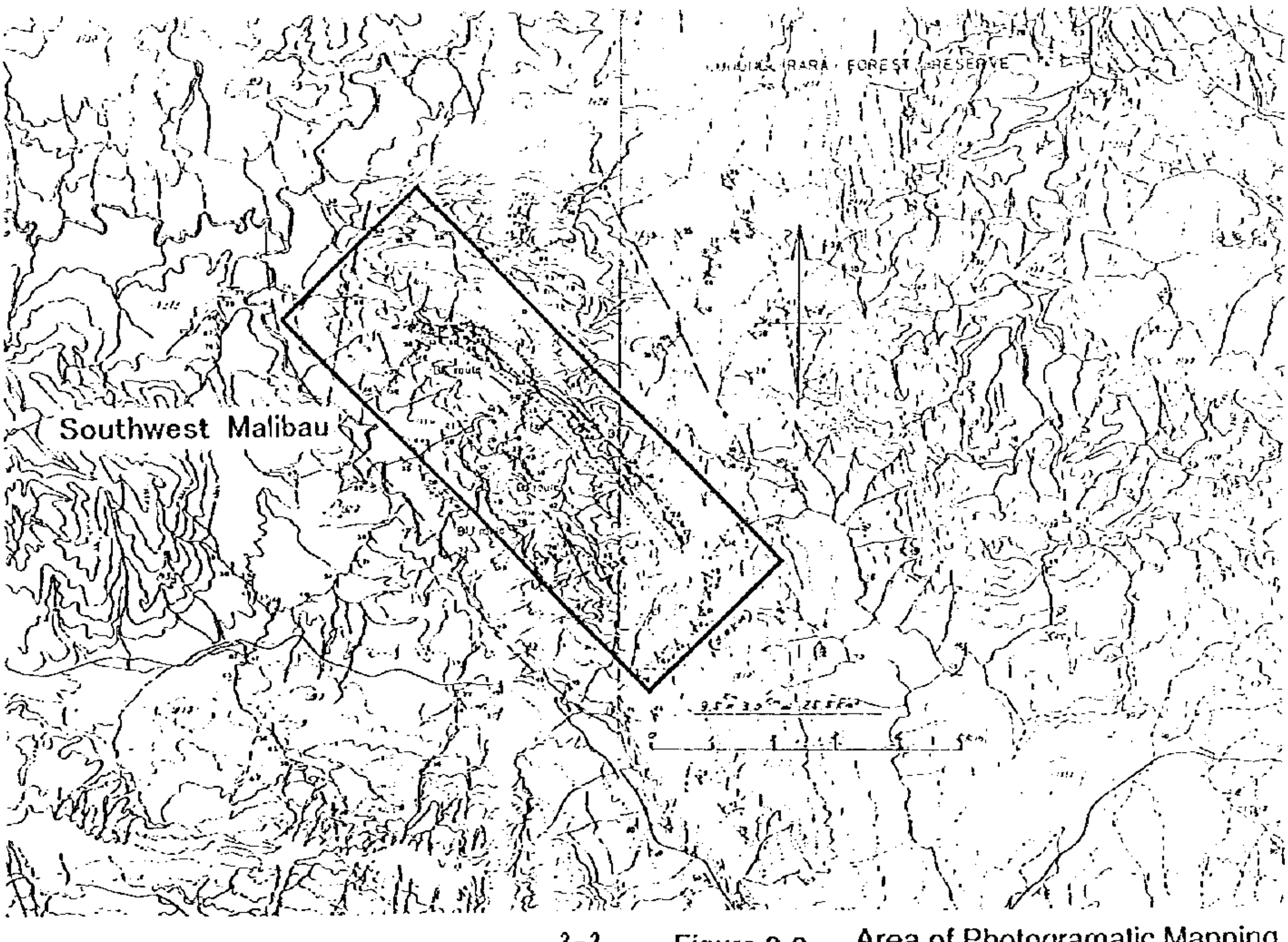


Figure 3-2 Area of Photogramatic Mapping

The new maps were produced from the latest aerial photographs on a scale of 1:25,000 provided by GSD covering areas of about 100 km². Mapping work including establishment of the ground control points was conducted by a contractor and the following final products were submitted by the end of October 1998 :

(a) Report for ground control point survey
(b) Full listing of inputs and results for aero triangulation
(c) Stereoplotter calibration and orientation record
(d) Maps : Colour prints - 3 sets, Ammonia prints - 3 sets, Film - 1 set
(e) Diskettes with drawing file in AutoCAD R14 format

3.2.2. Detailed Geological Mapping

Malibau and Southwest Malibau areas were selected as the areas for detailed geological mapping in Phase 2. As a result of Phase 1 study, the extent of coal zone was delineated and the number and the thickness of coal seams were roughly indicated in each area. However, due to the reconnaissance level of exploration in Phase 1, correlation of individual coal seams are at low level in accuracy.

Geological mapping in Phase 2 aimed at improving geological assurance of coal seam data to a level which upgrades the resource class to "Indicated" category and is sufficient for making a preliminary mine plan.

During the field work in Phase 2, emphasis was laid on to investigate the coal outcrops as many as possible in unexplored part in Phase 1 and to trace the relatively thick coal seams as long as possible along their expected outcrop lines, so that the correlation and continuity of individual coal seams could be confirmed at the required level of assurance.

In order to improve the accuracy of outcrop location, main points in the mapping routes were surveyed with GPS (Global Positioning System) by using ground control points established in photogrammetric mapping as reference points. Every mapping routes were connected to one of these GPS points to control the relative positions of coal outcrops. GPS data were processed and converted into BRSO (Borneo Rectified Skewed Orthomorphic) coordinate system.

The following is the actual performance of the mapping work in each area :

(1) Malibau area

Geological mapping was carried out from October 29 to December 5, 1998. A base camp was set up at the central part of the area and three additional camps were also set up at the southeastern, western and westernmost part to cover the wide area of 16 km long and 3 km wide.

Eighty six coal outcrops were investigated along the mapping routes of 59 km in total distance. Six main points were surveyed with GPS by using YY01 near the base camp as a control point. The mapping routes and the investigated outcrops are shown in Figure 3-3-1 and Table 3-1-1 respectively together with those of Phase 1.

(2) Southwest Malibau area

Geological mapping was carried out from August 7 to September 12, 1998. A base camp was set up at the central part of the area and two additional camps were also set up at eastern and western part to facilitate the mapping work.

Ninety three coal outcrops were investigated along the mapping routes of 30 km in total distance. In addition, seventeen previously found coal outcrops were relogged by digging trenches. Thirteen points were surveyed with GPS by using TK1, one of the ground control points established in photogrammetric mapping, as a reference point. The mapping routes and investigated coal outcrops are shown in Figure 3-3-2 and Table 3-1-2 respectively, together with those of Phase 1.

3.2.3. Coal Sampling and Analysis

Forty one coal samples were collected from representative outcrops of reasonably thick coal seams. After determining roof and floor of the coal seam, a channel sample was taken from the coal face exposed in a trench which was dug in order to minimize the influence of weathering.

Table 3-1-1 List of Coal Outcrops - Malibau Area

Outcrop No.	Location	Seam	Strike	Dip	Thickness Coal / Seam	Remarks
Phase 2						
NK201	GA13	MF	N 40 W	30 SW	0.75 / 0.75	Sampled
NK202	GA25	ME	N 40 W	30 SW	0.40 / 0.40	Sampled
NK203	GA27-GA28		N 40 W	30 SW	0.00 / 0.30	csh
NK204	GB25-1		N 30 E	26 SE	0.18 / 0.18	moved block
NK205	GB35-GB36	MF	N 50 W	30 SW	0.70 / 0.70	in the stream
NK206	GB37		N 45 W	37 SW	0.15 / 0.15	
NK207	GB52	ME	N 40 W	40 SW	0.40 / 0.40	Sampled
NK208	GB61		N 45 W	30 SW	0.00 / 1.60	csh, shc
NK209	GC14-GC15	MC	N 60 W	32 SW	0.00 / 1.05	csh, shc
NK210	GC25		N 40 W	35 SW	0.00 / 1.55	csh, shc
NK211	GC29-GC30		N 30 W	34 SW	0.00 / 0.80	csh, shc
NK212	GC41-GC42		N 40 W	30 SW	0.00 / 0.30	csh, shc
NK213	GD44		N 50 W	40 SW		csh, shc
NK214	GE65		N 54 W	45 SW	0.15 / 0.50	
NK215	GF35-GF36		N 40 W	45 SW	0.10 / 0.10	ci, csh, shc
NK216	GF41	MA	N 45 W	45 SW	0.70 / 0.70	Sampled
NK217	GG30		N 60 W	45 SW	0.80 / 0.83	Sampled
NK218	GH51~YK119		N 75 E	32 S	0.15 / 0.20	moved block, not mapped
NK219	GJ15-1		N 40 W	40 SW	0.30 / 0.32	Sampled
NK220	GJ21		N 50 W	60 SW	0.15 / 0.15	
NK221	GK38-GK39		N 80 W	50 S	0.10 / 0.10	
NK222	GK42		N 80 W	60 S	0.45 / 0.45	Sampled
NK223	GK43-1		N 70 W	58 S	0.35 / 0.50	
NK224	GK43		N 75 W	42 S	0.28 / 0.30	Sampled
NK225	GK47-GK48		N 85 W	45 S	0.54 / 0.92	Sampled 0.20m in lowest portion
NK226	GK59		N 80 W	40 S	0.45 / 0.45	Sampled
NK227	GK64-1		N 60 W	45 S	0.40 / 0.40	Sampled
NK228	GL1-GL2		N 70 W	50 S	0.20 / 0.23	
NK229	GL17		N 80 W	50 S	0.34 / 0.35	Sampled
NK230	GL20		N 40 W	40 SW	0.11 / 0.35	
NK231	GL31	MD	N 80 W	38 S	0.12 / 0.30	
NK232	GL37		N 75 W	45 S	0.35 / 0.35	Sampled
NK233	GM30-1		N 80 W	30 S	0.15 / 0.15	
NK233-1	GM42		N 70 W	36 S		0.20,0.05,0.10
NK234	GP0	MD	N 80 W	40 S	0.67 / 0.72	Sampled 0.55m in lowest portion
SK201	MA21		N 45 W	32 S	0.15 / 0.15	
SK202	MA32		N 35 W	35 W	0.10 / 0.10	Sampled
SK203	MA49	MC	N 13 W	37 W	0.37 / 0.37	
SK204	MA50-MA51		N 31 W	49 W	0.35 / 0.41	
SK205	MA85		N 56 E	60 W	0.41 / 0.41	
SK206	MA90		N 40 E	30 W	0.22 / 0.22	
SK207	MA93		N 10 W	20 W	0.20 / 0.20	
SK208	GB37-1	MF	N 55 W	25 W	0.73 / 0.75	
SK209	MC01		N 90 W	29 N	0.40 / 0.40	Sampled
SK210	MD76		N 30 W	51 S	0.40 / 0.43	Sampled
SK211	MD81		N 36 W	45 S	0.61 / 0.73	Sampled the bottom (0.51/0.51)
SK212	MD83		N 35 W	52 W	0.50 / 0.53	
SK213	MD87	MD	N 30 W	30 W	0.60 / 0.63	Sampled
SK214	MD90-2		N 40 W	55 W	0.25 / 0.25	
SK215	MD96		N 50 W	48 S	0.30 / 0.30	
SK216	MD111		N 45 W	50 S	0.13 / 0.13	
SK217	MD114-1	MC	N 50 W	38 S	1.03 / 1.03	Sampled
SK218	MD118-1	MC	N 54 W	37 S	0.72 / 1.37	
SK219	MD116-1	MC	N 45 W	25 S	1.25 / 1.51	Sampled the top (0.95/0.95)

Table 3-1-1 List of Coal Outcrops - Malibau Area

Outcrop No.	Location	Seam	Strike	Dip	Thickness Coal / Seam	Remarks
SK220	ME10	MC	N 70 W	25 S	0.83 / 0.93	
SK221	ME14	MC	N 45 W	30 S	0.67 / 0.67	
SK222	MF31		N 45 W	50 S	0.23 / 0.23	
SK223	MF32	MD	N 45 W	55 S	0.60 / 0.60	
SK224	MF52	MD	N 30 W	55 S	0.77 / 0.77	Sampled
SK225	MF55		N 40 W	62 S	0.40 / 0.40	
SK226	MF62		N 40 W	55 S	0.40 / 0.40	
SK227	MG53	MD	N 60 W	45 S	0.70 / 0.70	Sampled
SK228	MH48	MB	N 75 W	55 S	0.95 / 1.05	
SK229	MH49	MB	N 55 W	40 S	0.91 / 1.23	
SK230	MH47	MB	N 70 W	55 S	1.12 / 1.58	SK230A(the top coal part) SK230B(total seam)
SK231	MH52		N 75 E	27 S	0.80 / 0.87	
SK232	MH54		N 60 W	22 S	0.47 / 0.50	Sampled
SK233	MJ18		N 60 W	40 S	0.15 / 0.15	
SK234	MJ21		N 70 W	45 S	0.18 / 0.18	Upper 15cm Lower 18cm
SK235	MJ39				0.43 / 0.43	moved block
SK236	MJ63	MB	N 70 W	40 W	0.29 / 0.29	
SK237	MK13		N 70 W	45 S	0.56 / 0.57	Sampled
SK238	MK59	MD	N 50 W	42 S	0.85 / 0.85	Sampled
SK239	ML11	MD	N 70 E	40 S	0.13 / 0.13	
SK240	ML20				0.50 / 0.50	moved block
SK241	ML49		N 80 E	45 S	0.15 / 0.15	
SK242	ML51		N 85 W	40 S	0.20 / 0.20	
SK243	MM32		N 80 W	52 S	0.90 / 1.15	sample not including shale layer
SK244	MM53		N 70 W	45 S	0.43 / 0.49	Sampled
SK245	AX106	MD	N 80 W	30 S	0.58 / 0.58	
SK246	MN00		N 65 W	42 S	1.05 / 1.14	Sampled
WW01	WA19		N 70 W	53 S	0.40 / 0.40	
WW02	WB32		N 80 W	40 S	0.88 / 1.31	
WW03	WB40		N 83 W	50 S	0.30 / 0.30	
WW04	WB41		N 83 E	50 S	0.55 / 0.55	
WW05	WC03		N 78 E	35 S	0.32 / 0.32	
WW06	WC03-WC04		N 80 E	35 S	0.60 / 0.60	
Phase 1						
YK102	AY02		N 60 W	25 S	0.33 / 0.57	
YK103	AY03	MB	N 60 W	40 S	0.35 / 0.35	
YK104	AY11		N 65 W	50 S	0.44 / 0.74	
YK105	AX26	MD	N 90 E	45 S	0.75 / 0.75	
YK106	AW17-AW18		N 75 E	35 S	0.65 / 0.65	
YK107	AV07		N 80 E	40 S	0.60 / 0.60	
YK108	AV07-2		N 35 E	15 S	0.70 / 0.70	moved by landslide
YK109	AV40		N 80 E	50 S	0.67 / 0.67	
YK110	AV41		N 80 E	45 S	0.20 / 0.20	
YK111	AV43		N 80 E	45 S	0.65 / 0.65	
YK112	AV43		N 80 E	44 S	0.65 / 0.65	
YK115	AS16	MD	N 65 W	50 S	0.57 / 0.57	Sampled
YK116	AS19-20		N 65 W	40 S	0.46 / 0.46	
YK117	AS29		N 75 W	40 S	0.45 / 0.45	
YK118	AS36		N 70 W	56 S	0.50 / 0.50	
YK119	AS51	MB	N 70 W	45 S	0.80 / 1.00	
YK120	AS57	MB	N 80 W	50 S	0.67 / 0.80	Sampled
HK002	AA113-114		N 20 W	35 W	0.15 / 0.15	
HK003	AB6		N 30 W	38 W	0.42 / 0.59	
HK004-1	AB9		N 35 W	46 S	0.15 / 0.95	

Table 3-1-1 List of Coal Outcrops - Malibau Area

Outcrop No.	Location	Seam	Strike	Dip	Thickness Coal / Seam	Remarks
HK004-2			N 35 W	46 S	0.55 / 0.75	
HK005	AB15-1	MC	N 40 W	52 S	0.25 / 0.47	
HK006	AB18-19	MC	N 28 W	67 S	0.06 / 0.06	
HK007	AB29-1		N 60 W	40 S	0.45 / 0.45	
HK008	AB58-59	MC	N 45 W	40 S	0.85 / 0.93	
HK009	AB71-72	MC	N 45 W	40 S	0.37 / 0.40	
HK010	AB74-75	MC	N 50 W	45 S	0.40 / 0.50	
HK011	AD28		N 35 W	35 S	0.00 / 0.70	csh
HK012	AD35-36		N 33 W	30 S	1.24 / 1.50	Sampled
HK013	AD46-47		N 35 W	30 S	0.47 / 0.51	Sampled
HK014	AD51	ME	N 35 W	38 S	0.37 / 0.38	Sampled
HK015	AD55-56		N 40 W	34 S	0.57 / 0.81	Sampled
HK016	AD58		N 40 W	36 S	0.22 / 0.67	
HK017	AE41		N 40 W	20 NE	0.45 / 0.45	Sampled
HK018	AE41		N 40 W	18 NE	0.94 / 1.00	Sampled
HK019	AE47-48		N 50 W	25 NE	0.21 / 0.21	
HK020	AE61		N 90 E	15 N	0.45 / 0.45	
HK021	AE66-67		N 50 W	26 S	0.63 / 0.63	Sampled
HK022	AE71-72		N 40 W	25 S	0.38 / 0.45	Sampled
HK023	AF5-6		N 30 W	45 S	0.12 / 0.12	
HK024	AF23		N 30 W	45 S	0.15 / 0.15	
HK025	AF62-1	MA	N 40 W	50 S	0.83 / 0.85	Sampled
HK026	AF64-1	MA	N 30 W	55 S	1.09 / 1.09	Re-sampled at Phase 2