2. Geological Investigation

2.1 Previous Exploration Works

The previous exploration works in the present exploration area and its vicinity are shown in Table 2-1.

Table 2－1 Previous Exploration Works

Organization	NEA*	EGAT	EGAT	DMR	EGAT	DMR-EGAT	DMR
Year	1977	1978	1982	1988	1994	1997	1997/98
(Thai year)	(2520)	(2521)	(2525)	(2531)	(2537)	(2540)	(2540/41)
Boreholes	25	16	12	22	—	12	21
Depth (m)	1,924	2,103	2,017	6,212	—	1,086	6,005
Σ Borehole	25	41	53	75	—	87	108
Seismic Survey	—	—	—	—	18 lines 61.75km	—	—

*: Data not available

NEA: National Energy Administration DMR: Department of Mineral Resources

EGAT: Electricity Generating Authority of Thailand

Eighty-three (83) boreholes have been drilled in Ngao Coal basin and forty-one (41) boreholes have penetrated coal zones since 1978 in the exploration area. Those boreholes are concentrated at the northwest and the southeast areas, where the coal-bearing formation exists near the surface.

Proximate analysis results are available in the previous reports. The results from only eighteen boreholes have been used for estimating coal quality in Ngao coal basin.

Some amount of coal samples were taken from a trench made by hand near the borehole LN1/21 several times in the past. However those analysis results were not available.

2.2 Method of Geological Investigation

2.2.1 Field Geological Survey

The coal-bearing formation does not crop out in this field because of thick cover of soil (2 to 5 m thick). Drilling, trenching and geophysical exploration are useful for the Ngao coal basin.

A trench was excavated for taking a large amount of coal sample during this exploration period. The location was selected by three preparatory 10 m-boreholes. Five exploration boreholes were carried out. These borehole locations were designed based on the previous borehole data and were fixed by mean of geological mapping. Surveyors carried out the traverse survey for all these boreholes.

2.2.2 Bulk Sampling

A large trench of 6m wide, 10m long and 7.5 m deep was dug with a backhoe in order to collect a bulk sample for quality upgrade test. About 630 kg of coal was sampled from 1m of coal section in the upper part of Zone I. Beside the bulk sample, about 10kg of channel sample was taken manually as a standard sample.

Bulk sample was packed into plastic bags, about 20kg in each bag, in order to prevent drying and transported to the laboratory of Lanna Lignite Public Company at Li by pickup truck. (Ph-1, 2, 3)

Location of three preparatory boreholes and the trench are shown in Figure 2-1 and Figure 2-2 shows the columnar sections of those boreholes and the trench.

2.2.3 Exploration Drilling

Based on previous drilling and geophysical data, the geological structure was interpreted roughly. Five (5) drilling locations were selected through the geological study to get more detail information on coal beds in Ngao. Geophysical logging and Piezometric test were carried out in those boreholes.

- Name of Boreholes : NGJ1/43, NGJ2/43, NGJ3/43, NGJ4/43, NGJ5/43
- Total Depth : 1,052m in total
- Size of Drilling : HQ (about 95mm in diameter)
- Geophysical loggings : Self-electric potential log, electric resistance log, Density log, Natural gamma ray, caliper
- Piezometic test : Done in the holes of NGJ1/43 and NGJ4/43
- Drilling Work : Carried out with two drilling rigs by two shifts (3 to 4 members/shift, 24 hours operation) in order to complete about 1,000m of total depth within two months.

Those borehole locations are shown in Figure 2-1 . Columnar sections of boreholes are shown in Figure 2-3.

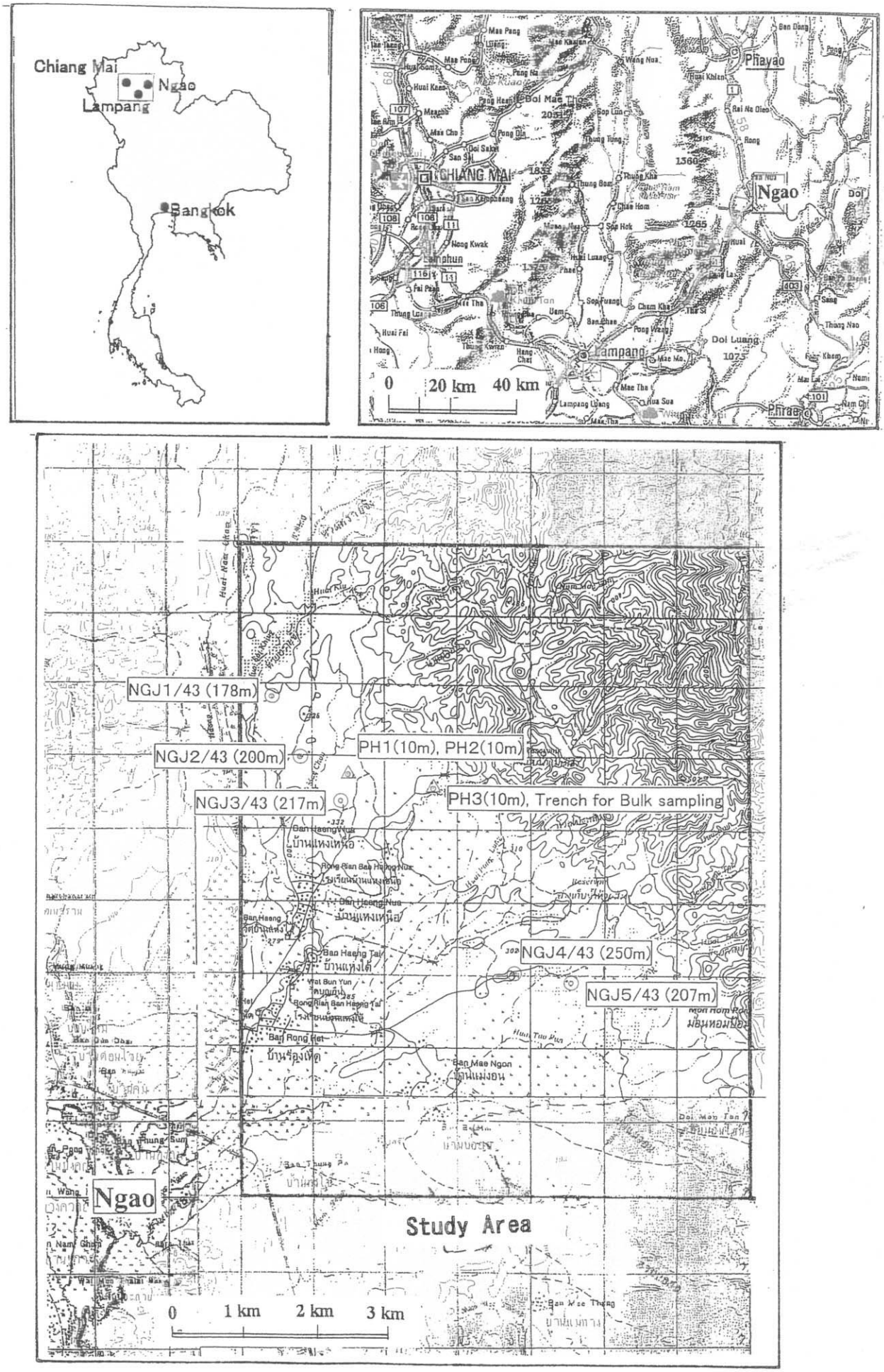


Figure 2-1 Location of Drilling and Trenching

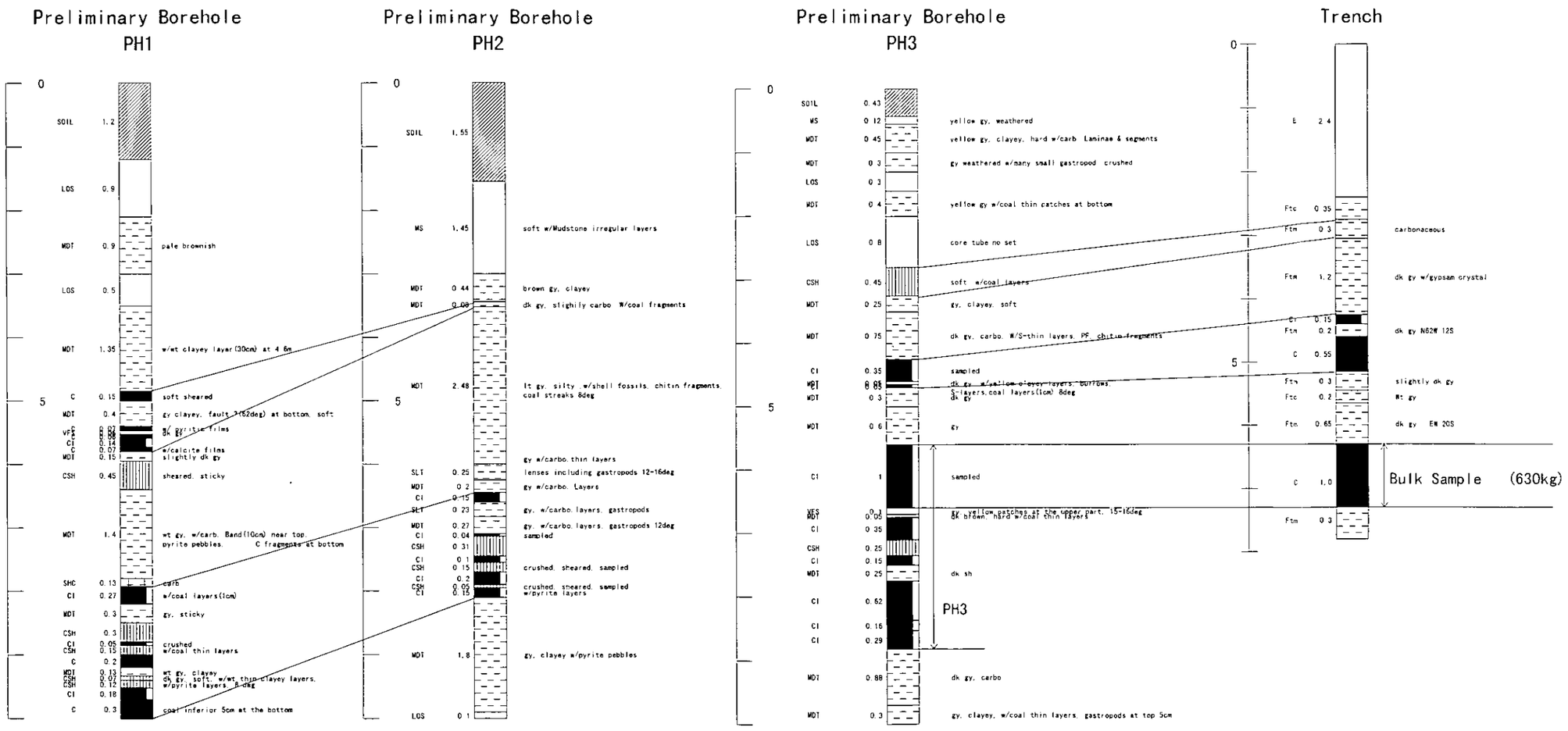


Figure2-2 Sections of Preliminary Borehole and Trench

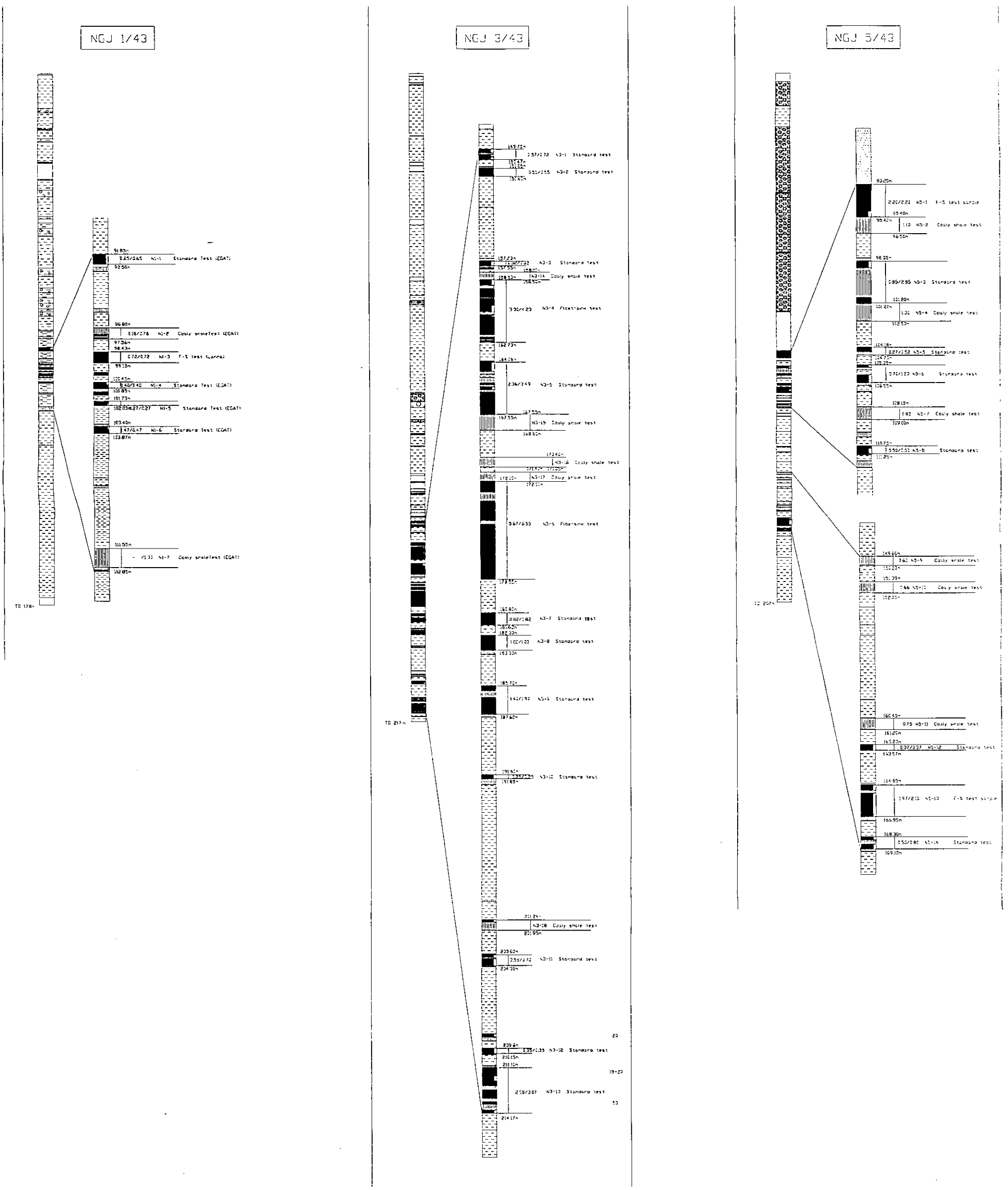


Figure 2-3　Sections of Exploration Boreholes

2.2.4 Coal Sampling

Coal samples are taken from cores of three exploration boreholes (NGJ1/43, NGJ1/43, NGJ5/43) and one preparatory hole (PH3) for float-sink test and coal analysis. Coal beds of more than 20cm thick were sampled. Some of carbonaceous mudstone beds were also sampled for reference. Sampled cores were sent to Lanna Lignite Company's laboratory or EGAT's laboratory as soon as possible. Sampled parts and these sample numbers are shown in Figure 2-2 and 2-3 respectively.

2.2.5 Rock Sampling

Rock samples were taken from drill core at depth of around 50m and 100m of each drill hole for measuring the rock properties through uniaxial and triaxial compression tests.

2.3 Regional Geology

2.3.1 Stratigraphy

Geologic map and stratigraphic section around the exploration area are shown in Figure 2-4 and Figure 2-5 respectively. The exploration area consists of basement unit, Tertiary unit and Quaternary unit. The basement unit is composed of sandstone, shale and limestone of Triassic (Mesozoic) in age. Miocene fluvial sediments (Unit A) unconformably overlie the basement rocks. Unit A, variegated brown and reddish brown in color, consists of mudstone and sandstone with pebbles.

Lacustrine sediment (Unit B) was deposited in a subsided basin of the basement during Miocene to Pliocene (Neogene) in age. Unit B contains many coal beds and is characterized by fresh limestone.

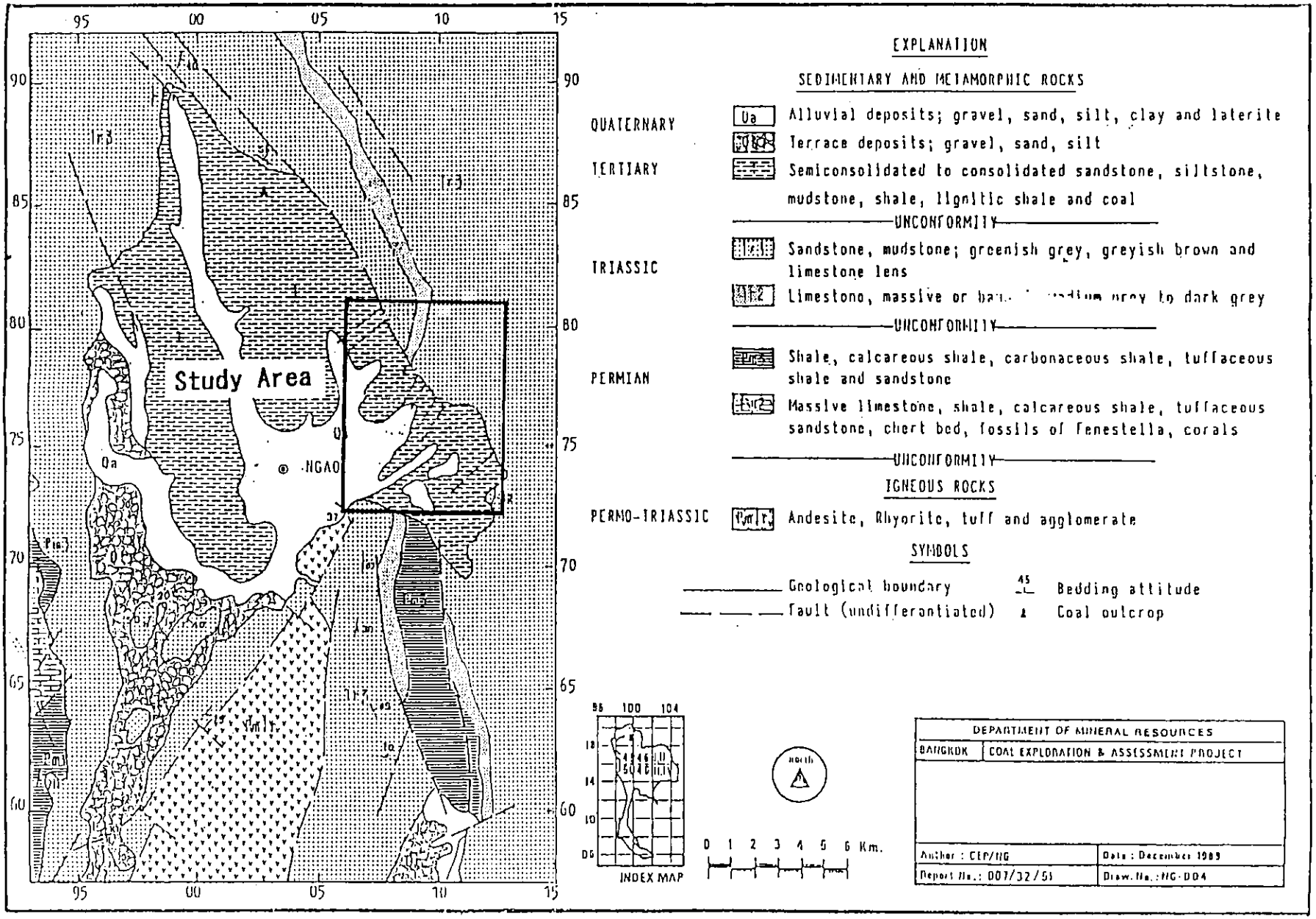


Figure 2-4 Geological Map

Figure 2-5 Stratigraphic Section

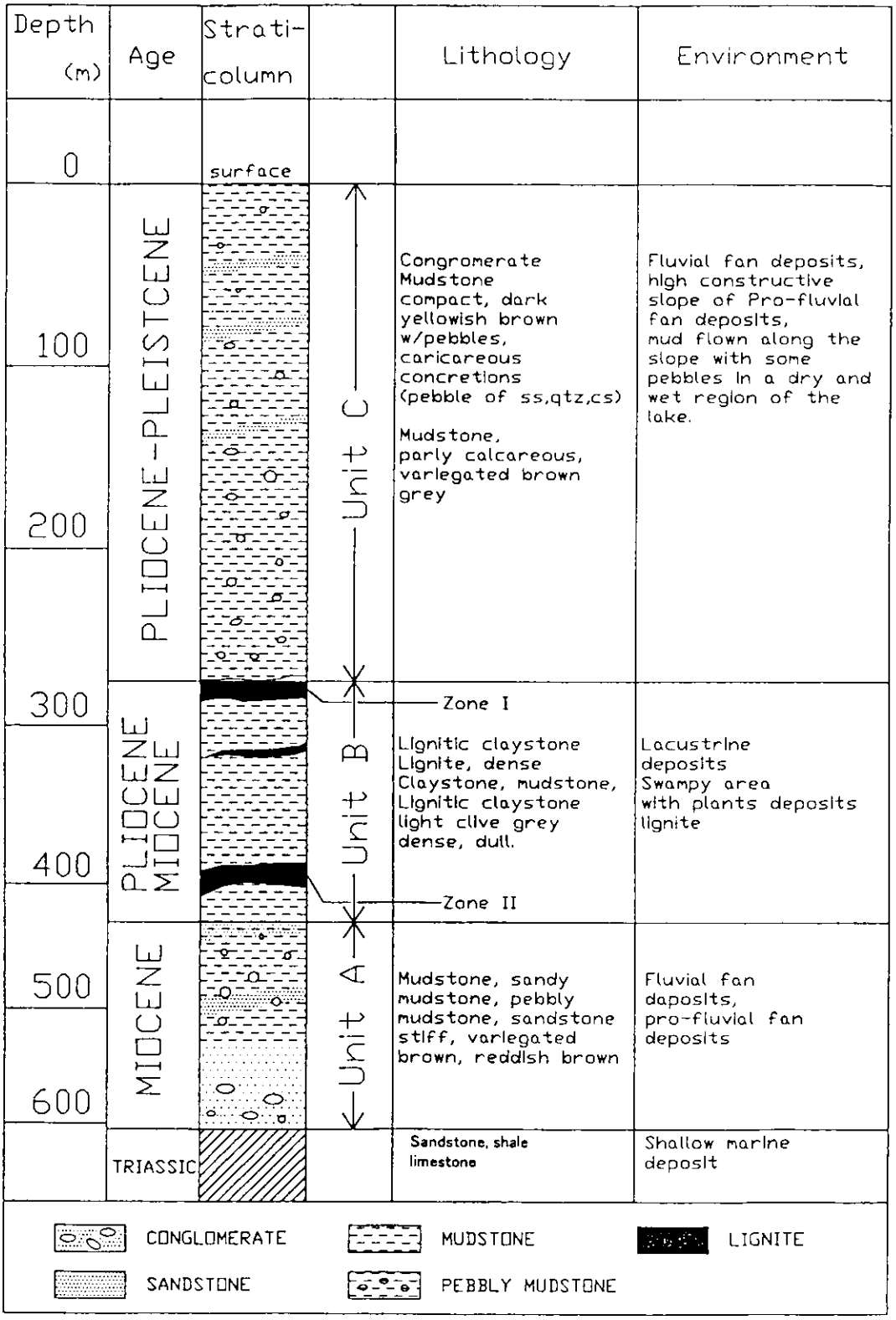


Figure 2-6

Stratigraphy and Environment of Tertiory Sediments in Ngao Basin by Water Resource Engineering CO. 1998 May

Fluvial fan deposits (Unit C) from Pliocene to Pleistocene in age overlies the coal-bearing unit (Unit B). Unit C consists of mudstone and conglomerate with variegated brownish grey in color. The mudstone bed is characterized by containing pebble to cobble of weathered limestone.

Soil, 2 to 5 m thick, covers the whole exploration area. The coal-bearing formation does not crop out due to the thick soil and gentle topography.

2.3.2 Geological Structure

Geological structure in Ngao basin is mostly in homocline. The old rocks expose in the eastern part and younger to the west. The structure lies approximately in the N-S strike with dipping west or southwest. The major faults running northwest to southeast are normal faults with the west block moving downward relative to the east block. Other related faults are estimated as normal fault to run northeast to southwest dipping east. The exploration area is divided into ten blocks by those faults. Drill and seismic data shows that the coal beds are dipping toward the central part of the block F. There are only a few drill holes because the area was out of mining planning area due to the deep depth.

Six drill holes reached the basement limestone bed at the shallower depth between Block H and Block I. It is interpreted that there was a high mountains of limestone when peat swamps were formed around the area.

The geological structure map around the exploration area are shown in Figure 2-6.

2.4. Coal Beds in Ngao Basin

The coal seam in the Ngao coal basin contains many shale partings and varies its

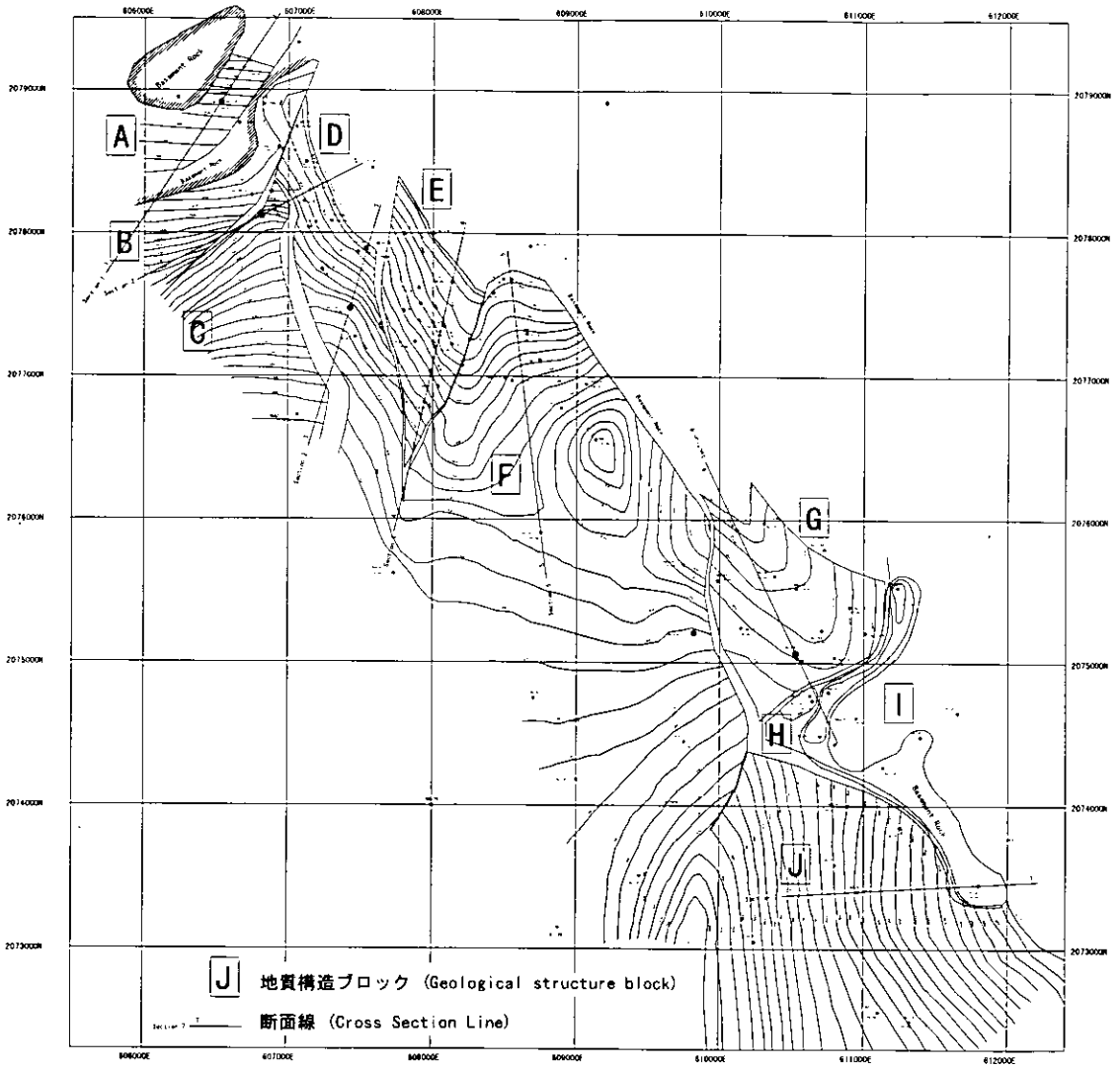


Figure2-6 Structure Contour Map(Roof of Zone I)

thickness quickly. Coal is classified as “lignite” and consists mainly of dull coal. There are rarely massive dull beds without any shale partings in the coal bed, however coal beds usually include thin layers of coaly-shale or shale. The Ngao coal was formed at peat swamps in an intermontane basin as other coal basins in Thailand. Type of peat swamp in Ngao is interpreted as “planar peat” mentioned by Cecil et al in 1985. Characteristics of peat types are shown in Table 2-2. It is presumed that frequent rising of water level had caused inflow of mud into a swamp and interruption of peat deposition.

The following two reasons make correlation of coal seam difficult throughout the area. However, it becomes clear that boreholes in a same block divided by faults have a similar pattern of coal and partings.

Top part of the coal seams, which is relatively correlatable, is designated as “ Zone I “ according to the DMR’s report. Lower part of the coal seams, designated ”Zone II”, has not been interpreted enough, because only a small number of boreholes penetrated the lower part. Judging from the available borehole data, coal seams in Zone II are present more sparsely than those in Zone I so that the potential for open cut mining seems to be low.

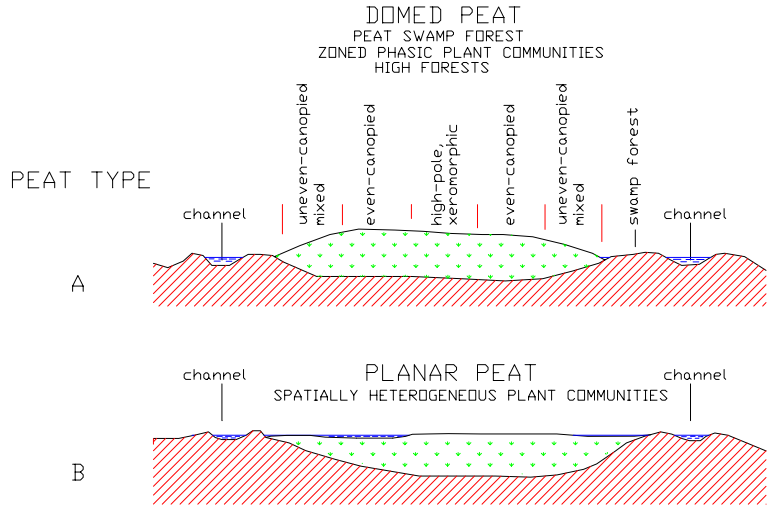
The exploration area is divided into ten (10) blocks by faults based on the interpretation of the data of previous boreholes, seismic survey and new boreholes.

Correlation chart, Structure contour map of the bottom of Zone I and geological cross section are respectively shown in Figure 2-7, Figure 2-8 and Figure 2-9.

Table 2-2 Characteristics of Generalized Types of Peat-forming Environments

Characteristic(ピートスワンプの型)	**Type A （ドーム型）**	**Type B （プラナー型）**
climate	ever-wet tropical	seasonal tropical
water source	ombrogenous	topogenous
nutrient content	oligotrophic	mesotrophic to eutropical
surface morphology	**domed**	**planar**
pH	< 4	4 to 7
Eh	?	?
floral communities	low diversity zoned;xeromorphic	high diversity random;luxuriant
microbial activity	low (cellulose preserved)	low (cellulose degraded)
mechanism of degradation	primarily chemical	primarily microbial
ash content	low, uniform	high, variable
sulfur content	low, uniform	low, variable
nitrogen content	low, uniform	low, variable
cation exchange capacity	high	low
specific conductivity	low	high
base saturation	low	high
[Ca^{2+}]	low	high
fiber content	fibric	hemic to sapric
biogenic sulfide	low	high
biogenic methane	low	high

Cecil,C.B., Santon,R.W., Neuzil,S.G., Dulong,F.T., Ruppert,L.F. and Pierce,B.C., 1985. Paleoclimate controls on the Paleozoic sedimentation and peat formation in the central Appalachian basin(USA). Inter. J. of Coal Geology, 5: 195-230.



Generalized cross-sections of domed and planar peat deposits

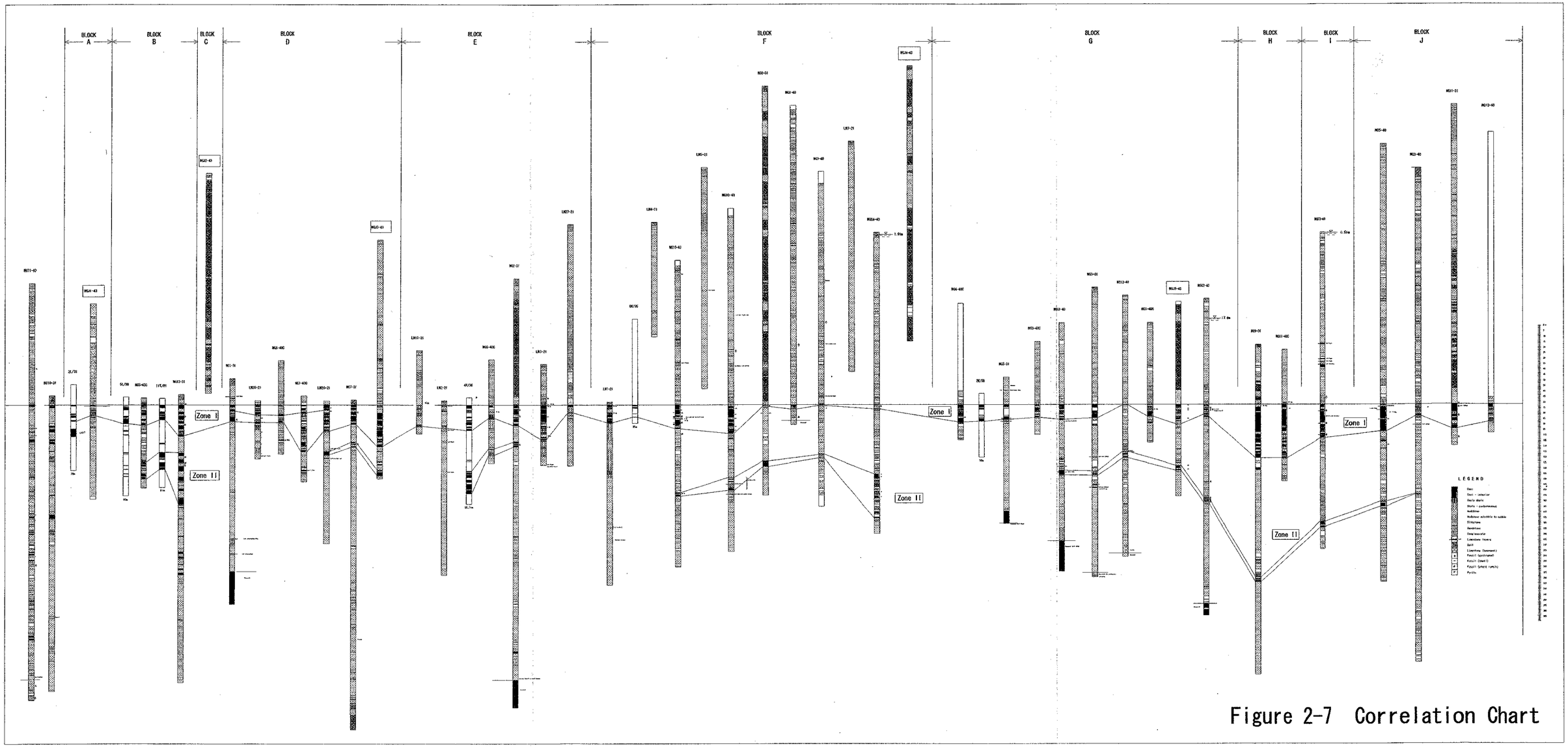


Figure 2-7 Correlation Chart

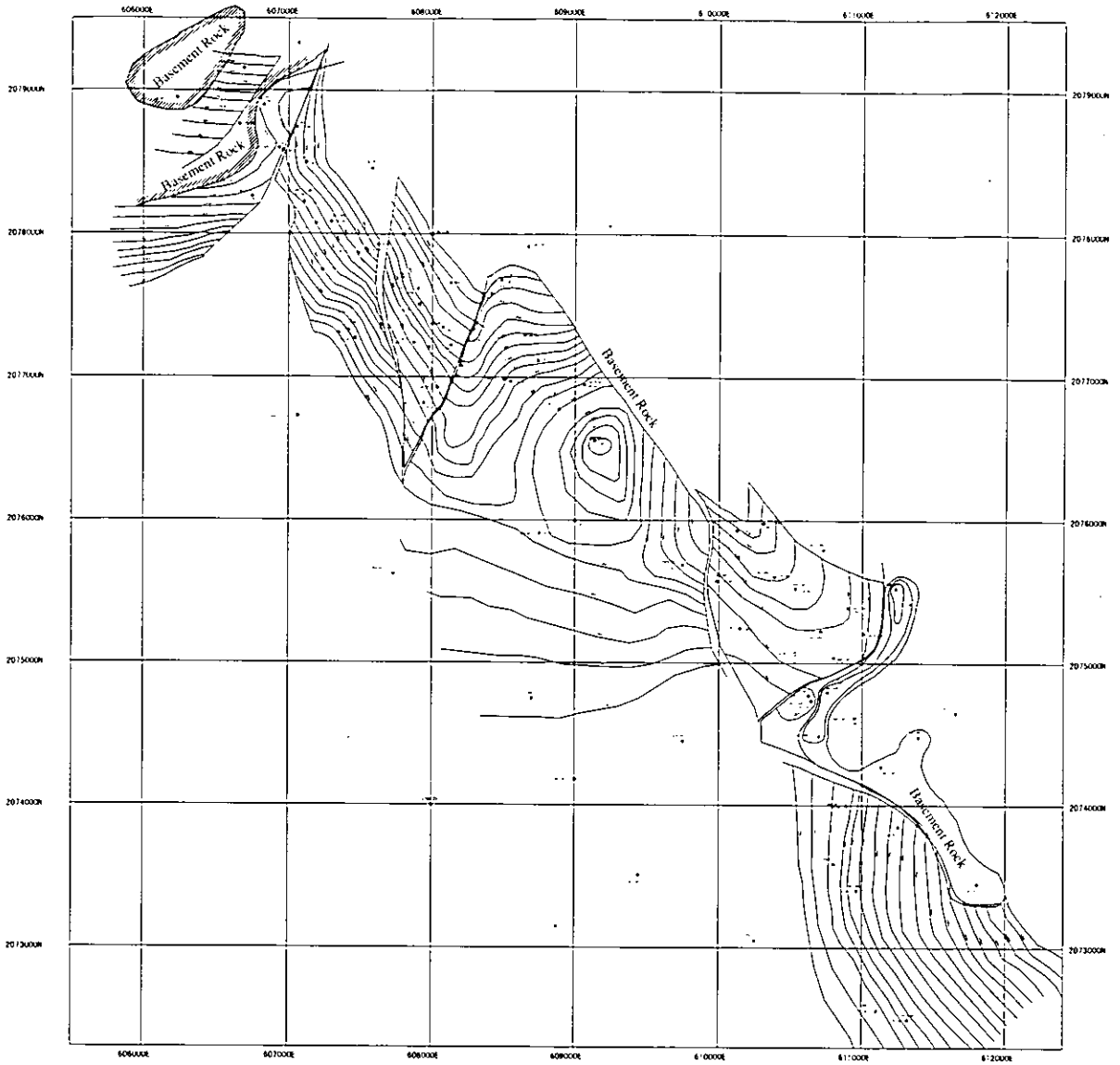


Figure2-8 Structure Contour Map(Bottom of Zone I)

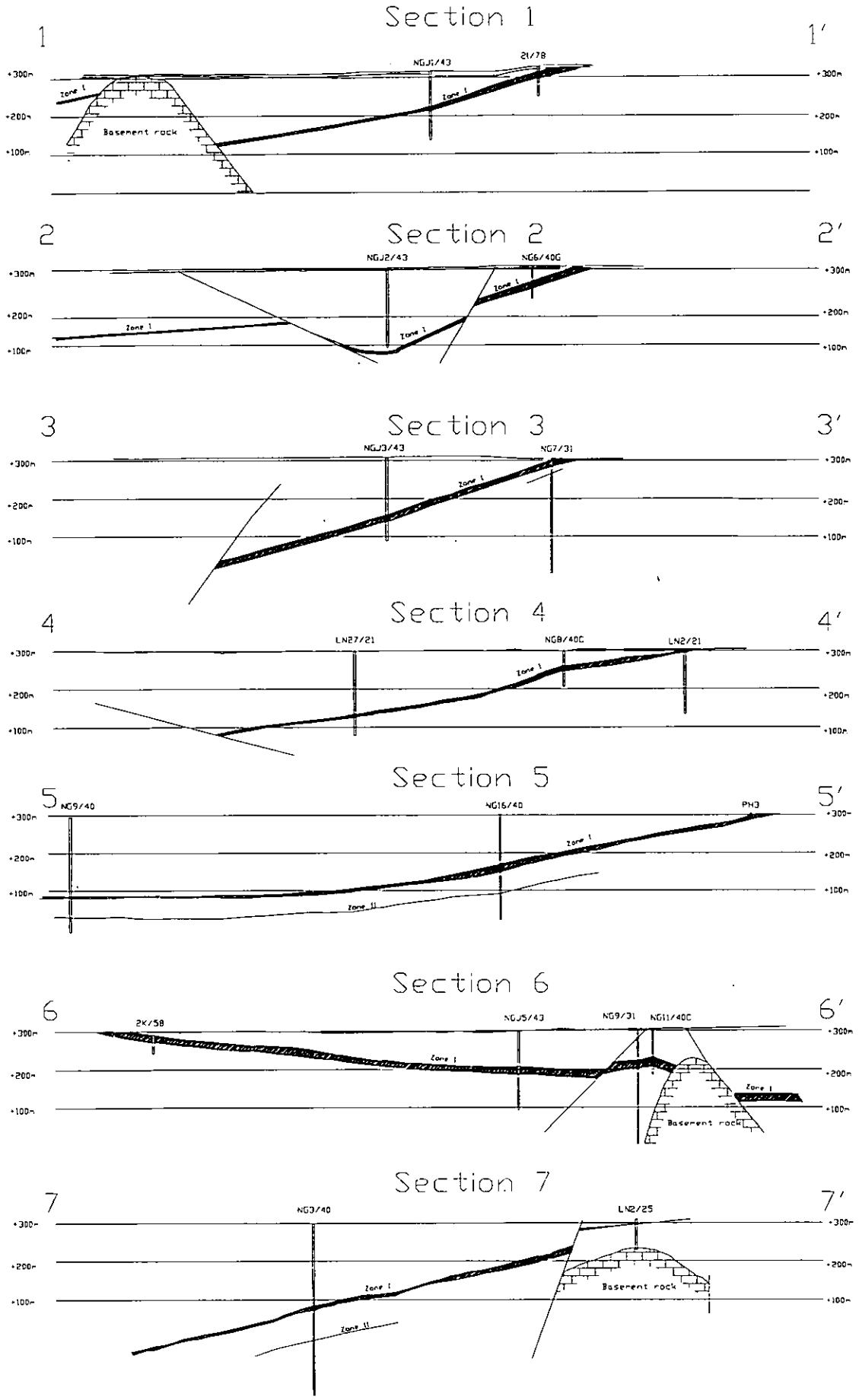


Figure 2-9 Geological Cross Sections