# 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, however the result of the works conducted by NEA (National Energy Administration) in 1977 is not available at present.

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 | — | — |

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. Borehole spacing is various and irregular. One of the reasons is that three organizations had carried out the drilling program independently for 23 years. The seismic survey was conducted in 1994. The reflectance from the unconformity between the Basement and the Tertiary units and the bottom and the top of the Tertiary coal-bearing formation were recorded and

interpreted. The seismic survey is a very useful exploration method for estimating the three-dimensional geological condition. Interpretation of the seismic data is required to be restudied along with the new drilling result.

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

| |
|---|
| NG3/40, NG5/40, NG10/40, NG12/40, NG16/40, NGG1/40, NGG2/40, NGG3/40, NGG4/40, LN1/21, LN3/21, LN11/21, LN26/21, LN27/21, LN28/21,NG3/31, NG7/31, NG9/31 |

The coal bed is generally dipping toward the southwest or the west, so that the coal-bearing formation comes near the surface at the east and the northeast areas. A coal bed was found 2m below the ground surface near the borehole LN1/21 and some amount of coal samples were taken from a trench made by hand 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) above the exposed coal bed in the past time. The surface of the study area shows gentle topographic features with some small shallow streams. That shows no deep erosive activities have been occurred. 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. Three (3) preparatory 10 m-boreholes and five (5) exploration boreholes were drilled. These borehole locations were designed based on the previous borehole data and were fixed by mean of geological mapping, which is a kind of simple survey method by using a tape, a compass and a hand level. In order to improve the accuracy of mapping result, surveyors of DMR carried out the traverse survey for seven control points and all these boreholes. Figure 2-1 shows an example of mapping sheet.

### 2.2.2 Bulk Sampling

A large amount of coal sample was collected near the surface for quality upgrade test. Based on the results of the three 10 m-preparatory boreholes, the sampling location was selected close to PH3. A trench of 6m wide, 10m long and 7.5 m deep was dug with a backhoe in order to collect a bulk sample. 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 2-2 and Figure 2-3 shows the columnar sections of those boreholes and the trench. Specification of those boreholes is as follows.

- Name of Borehole : PH1, PH2, PH3
- Depth of a Borehole : 10m
- Size of Borehole : HQ (about 95mm in diameter)

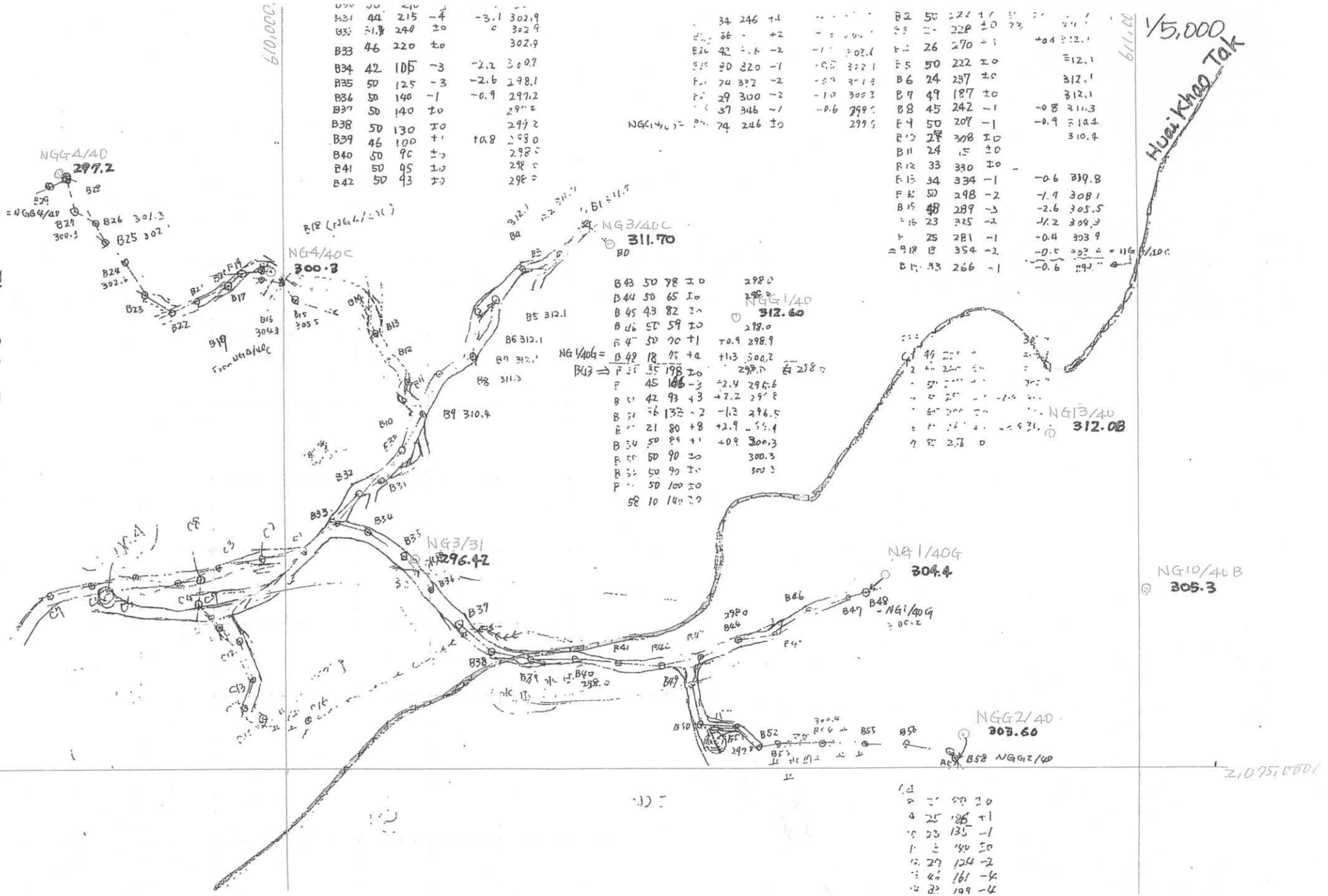



Figure 2-1 Example of Mapping Sheet

Visual core-loggings were done and interpreted by geologist for selecting a location of a 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. Specification of those works is as follows.

- 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.

Locations of the above boreholes are shown in Figure 2-2 and specification of drill work was summarized in Table 2-2. Core-logging sheets, records of geophysical loggings and results of Piezometer test are attached in the Appendix 1, 2 and 3 respectively. Columnar sections of boreholes are shown in Figure 2-4.

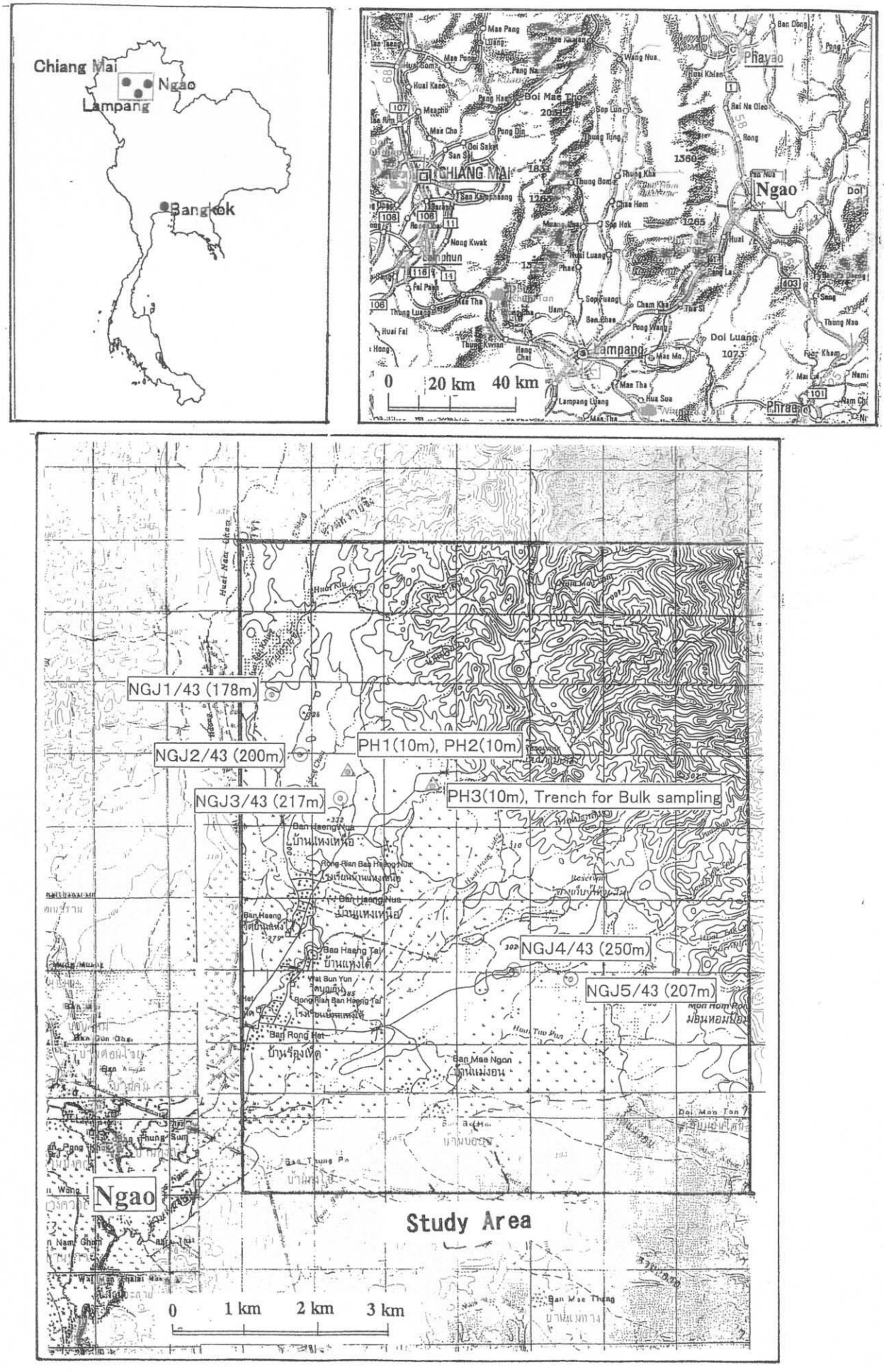



Figure 2-2 Location of Drilling and Trenching

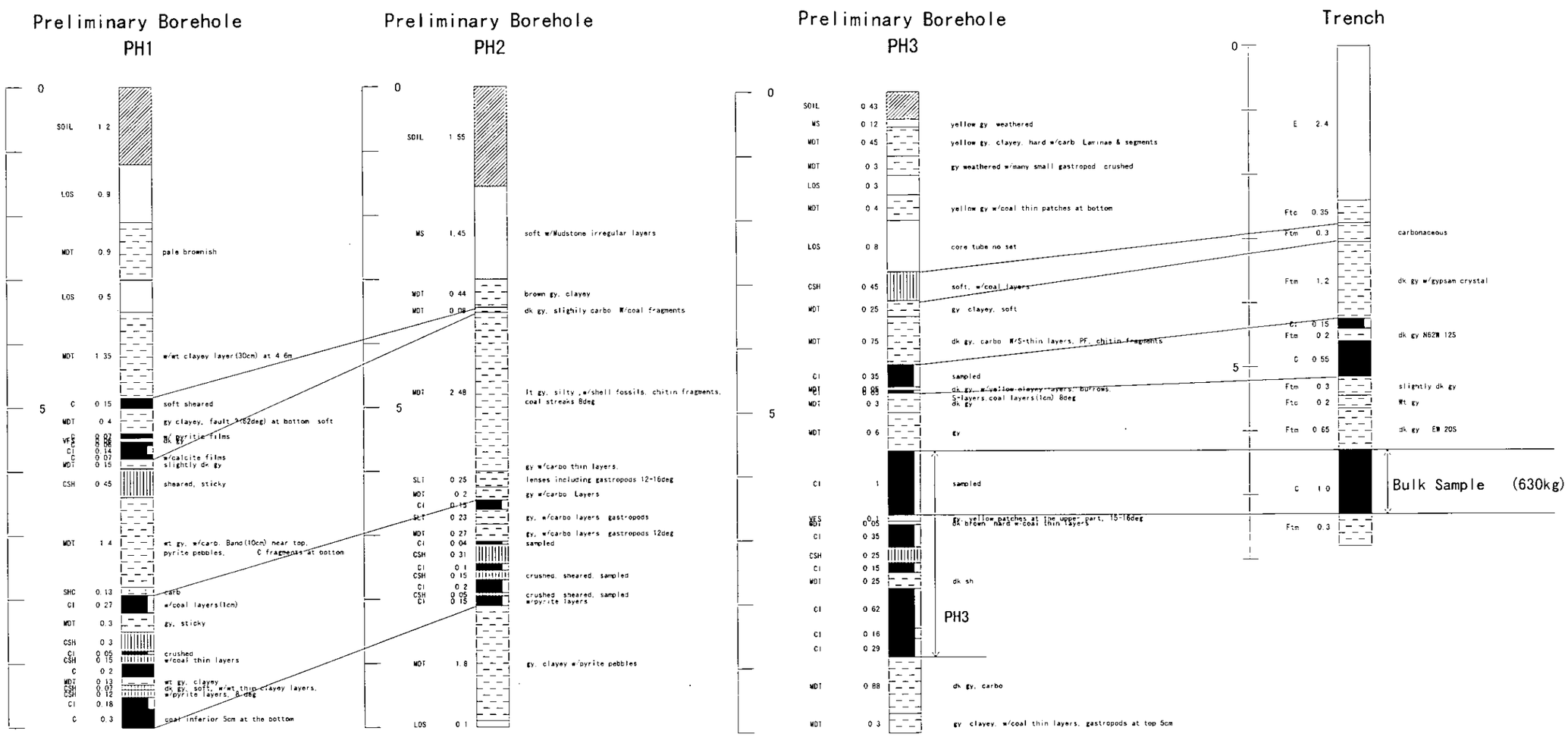



Fig2-3 Sections of Preliminary Boreholes and Trench

Tabele2-2 Specification of drilling

| | | Preparatory drill holes | | | Exploration drill holes | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | ＰＨ１ | ＰＨ２ | ＰＨ３ | ＮＧＪ１ | ＮＧＪ２ | ＮＧＪ３ | ＮＧＪ４ | ＮＧＪ５ |
| Location | Easting | 607,532 | 607,540 | 608,540 | 606,531 | 606,815 | 607,425 | 609,819 | 610,529 |
| | Northing | 2,077,896 | 2,077,904 | 2,077,688 | 2,078,915 | 2,078,123 | 2,077,475 | 2,075,209 | 2,075,068 |
| | Elevation | 304 | 304 | 303 | 316 | 302 | 306 | 304 | 299 |
| Start of drilling | | 2000.09.30 | 2000.10.01 | 2000.09.29 | 2001.01.17 | 2000.12.30 | 2000.12.05 | 2000.12.05 | 2001.01.01 |
| Finish of drilling | | 2000.10.01 | 2000.10.02 | 2000.09.30 | 2001.01.30 | 2001.01.16 | 2000.12.30 | 2000.12.31 | 2001.01.21 |
| Drill length | | １０ｍ | １０ｍ | １０ｍ | １７８ｍ | ２００ｍ | ２１７ｍ | ２５０ｍ | ２０７ｍ |
| Diameter | | ＨＱ(about 95mm) | | | ＨＱ(about 95mm) | | | | |
| Drill machine | | Ａｃｋｅｒ ＭａｒｋⅢ | | | Ａｃｋｅｒ ＭａｒｋⅢ | | | | |
| Piezometer test | | × | × | × | ○ | × | × | ○ | × |
| Geological logging | | × | × | × | ○ | ○ | ○ | ○ | ○ |

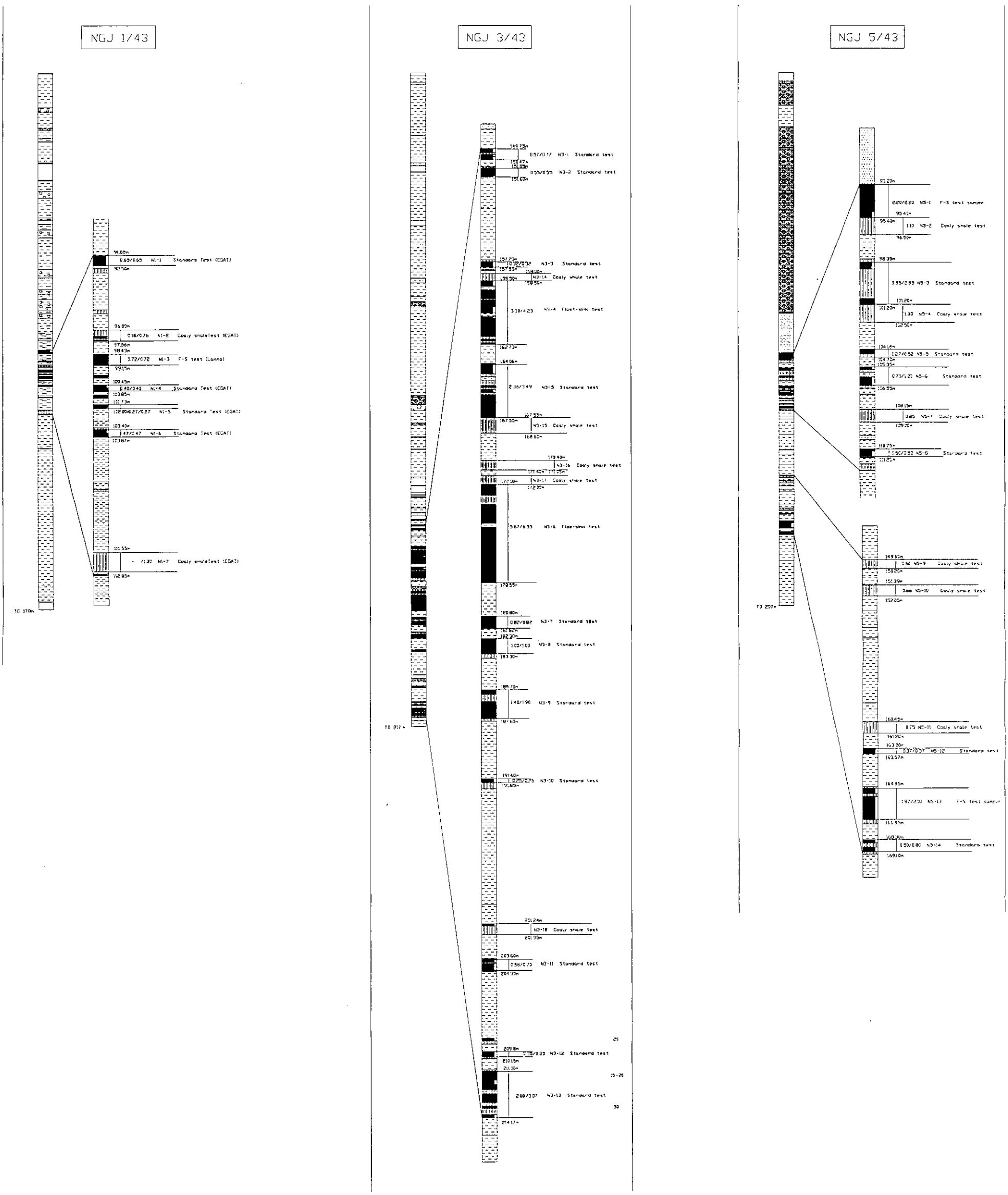



Figure 2-4 Section of Exploration Boreholes

### 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 2-3 and 2-4 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 uni–axial and tri-axial compression tests. Sampled were wrapped with cooking film to keep the moisture condition and packed in PBC tube to protect from break during transportation. Rock samples are listed in Table 2-3.

## 2.3 Regional Geology

### 2.3.1 Stratigraphy

Geologic map and stratigraphic section around the exploration area are shown in Figure 2-5 and Figure 2-6 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 with brown and reddish brown in color, consists of mudstone and sandstone with pebbles.

Table 2-3 NGAO ROCK TEST SAMPLES LIS

| Hole No. | | DATE | Sampling Depth | | | | Description |
|---|---|---|---|---|---|---|---|
| | | | Uniaxial Test | | Triaxial Test | | |
| NGJ1/43 | 50m | 22,Jan,2001 | J1/43-RU1 | 26.10 ----- 26.40 | J1/43-RT1 | 28.80 ----- 29.00 | mod red br mst |
| | | | J1/43-RU2 | 27.30 ----- 27.60 | J1/43-RT2 | 29.00 ----- 29.30 | |
| | | | J1/43-RU3 | 28.23 ----- 28.50 | J1/43-RT3 | 29.30 ----- 29.60 | |
| | 100m | 23,Jan,2001 | J1/43-RU4 | 81.34 ----- 81.54 | J1/43-RT4 | 83.00 ----- 83.23 | |
| | | | J1/43-RU5 | 81.54 ----- 81.75 | J1/43-RT5 | 83.23 ----- 83.45 | |
| | | | J1/43-RU6 | 81.75 ----- 82.00 | J1/43-RT6 | 83.65 ----- 83.90 | |
| NGJ2/43 | 50m | 07,Jan,2001 | J2/43-RU1 | 49.50 ----- 49.67 | J2/43-RT1 | 55.00 ----- 55.24 | bl gy mst, w/granule |
| | | | J2/43-RU2 | 49.69 ----- 49.98 | J2/43-RT2 | 55.28 ----- 55.50 | |
| | | | J2/43-RU3 | 51.46 ----- 51.71 | J2/43-RT3 | 55.50 ----- 55.75 | |
| | 100m | 07,Jan,2001 | J2/43-RU4 | 99.34 ----- 99.57 | J2/43-RT4 | 104.18 ----- 104.41 | bl gy mst, w/granule |
| | | | J2/43-RU5 | 99.58 ----- 99.80 | J2/43-RT5 | 104.41 ----- 104.72 | |
| | | | J2/43-RU6 | 101.72 ----- 102.00 | J2/43-RT6 | 105.00 ----- 105.30 | |
| NGJ3/43 | 50m | 16,Dec,2000 | J3/43-RU1 | 46.00 ----- 46.30 | J3/43-RT1 | 42.00 ----- 42.30 | br gy mst, w/Lst grains |
| | | | J3/43-RU2 | 46.56 ----- 46.80 | J3/43-RT2 | 42.30 ----- 42.60 | |
| | | | J3/43-RU3 | 47.20 ----- 47.40 | J3/43-RT3 | 43.05 ----- 43.25 | |
| | 100m | 19,Dec,2000 | J3/43-RU4 | 92.18 ----- 92.43 | J3/43-RT4 | 93.75 ----- 93.95 | red br gy - br gy sandy mst |
| | | | J3/43-RU5 | 92.43 ----- 92.68 | J3/43-RT5 | 94.10 ----- 94.30 | |
| | | | J3/43-RU6 | 92.68 ----- 92.93 | J3/43-RT6 | 94.45 ----- 94.65 | |
| NGJ4/43 | 50m | 8.9.10,Dec, 2000 | J4/43-RU1 | 39.27 ----- 39.43 | J4/43-RT1 | 34.10 ----- 34.35 | br gy mst, w/Lst grains |
| | | | J4/43-RU2 | 39.46 ----- 39.70 | J4/43-RT2 | 34.40 ----- 34.70 | |
| | | | J4/43-RU3 | 39.70 ----- 40.00 | J4/43-RT3 | 35.31 ----- 35.61 | |
| | 100m | 19,Dec,2000 | J4/43-RU4 | 87.25 ----- 87.48 | J4/43-RT4 | 97.52 ----- 97.74 | RU4 - 6 br gy mst, w/Lst grains RT4 - 6 mod br St |
| | | | J4/43-RU5 | 91.72 ----- 92.00 | J4/43-RT5 | 97.74 ----- 98.00 | |
| | | | J4/43-RU6 | 93.07 ----- 93.35 | J4/43-RT6 | 99.00 ----- 99.29 | |
| NGJ5/43 | 50m | 09,Jan,2001 | J5/43-RU1 | 48.30 ----- 48.50 | J5/43-RT1 | 55.30 ----- 55.55 | RU1 - 3 bl gy mst RT1 - 3 red br mst |
| | | | J5/43-RU2 | 49.03 ----- 49.26 | J5/43-RT2 | 55.70 ----- 55.90 | |
| | | | J5/43-RU3 | 49.55 ----- 49.78 | J5/43-RT3 | 55.90 ----- 56.10 | |
| | 100m | 11,Jan,2001 | J5/43-RU4 | 90.19 ----- 90.37 | J5/43-RT4 | 91.00 ----- 91.18 | gy St |
| | | | J5/43-RU5 | 90.37 ----- 90.56 | J5/43-RT5 | 91.18 ----- 91.35 | |
| | | | J5/43-RU6 | 90.73 ----- 90.88 | J5/43-RT6 | 91.35 ----- 91.54 | |

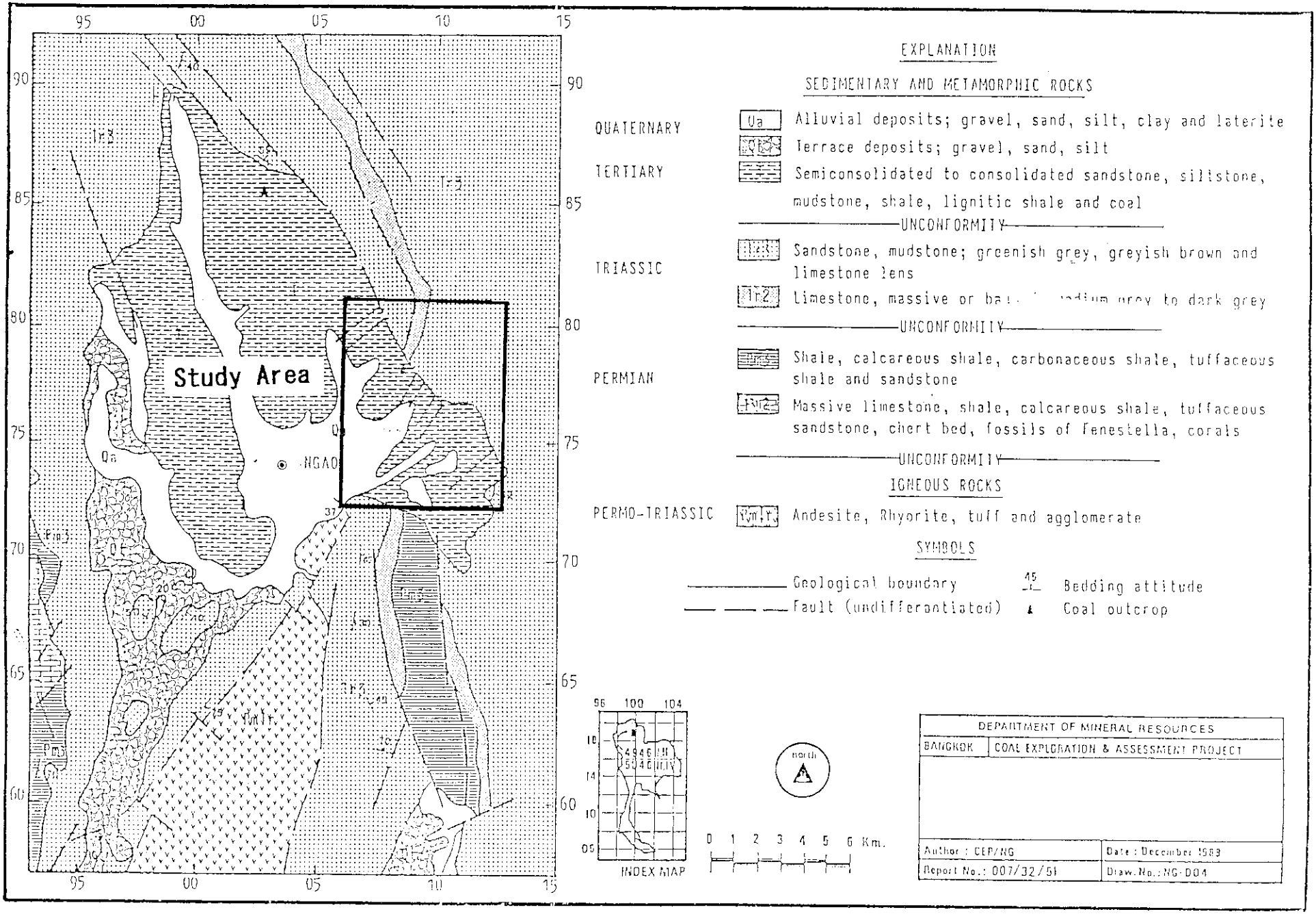
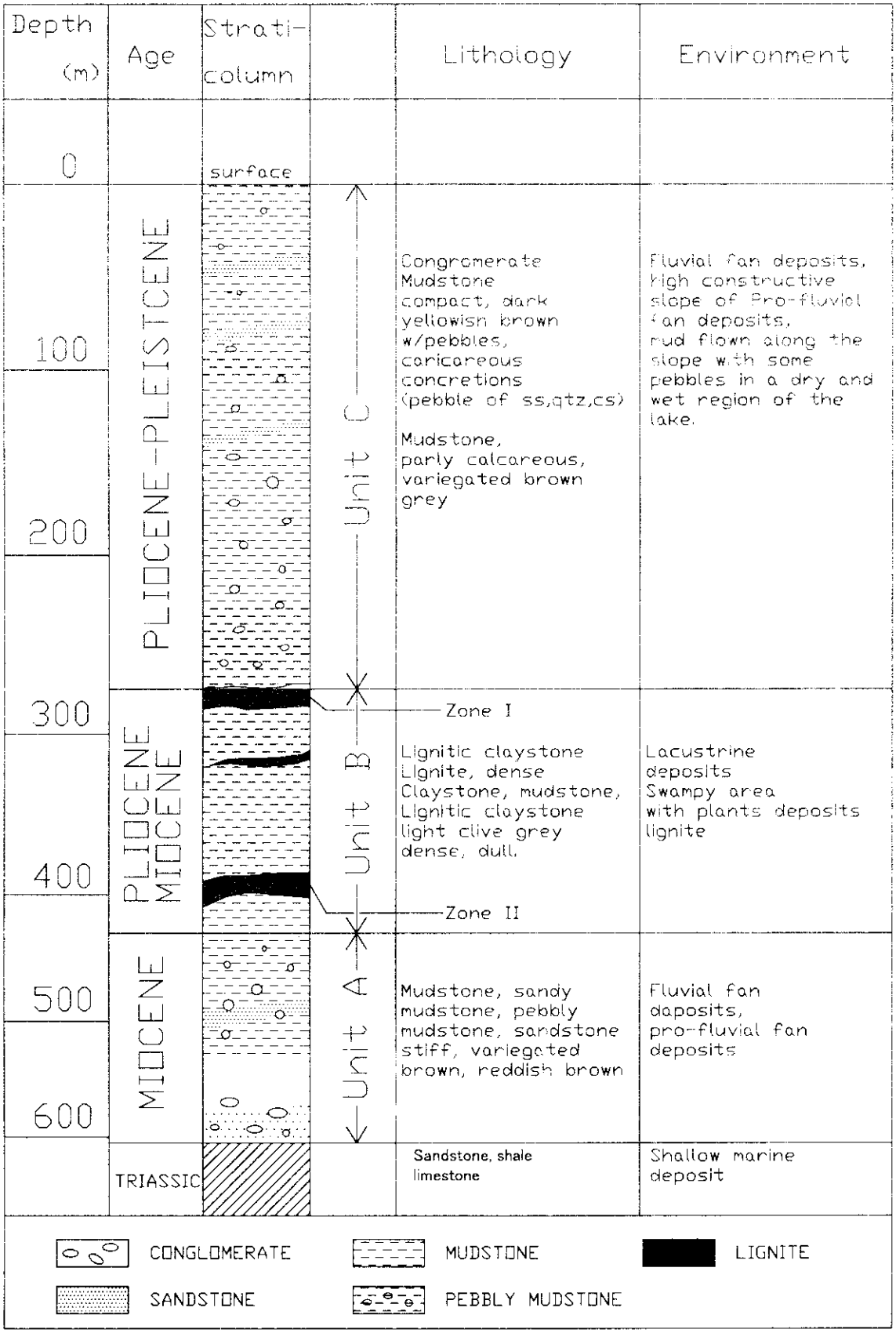



Figure 2-5 Geological Map




by Water Resource Engineering CO. 1998 May

Figure 2-6 Stratigraphic Section

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.

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. Clayey mudstone colored with pale blue comes at the lower part of Unit C. That mudstone is a kind of good indicator showing the horizon near coal zone when drilling.

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 monocline. The old rocks expose in the eastern part and younger to the west. The structure lies approximately in the N-S strike and west or southwest dipping. 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 bed is 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 2-7

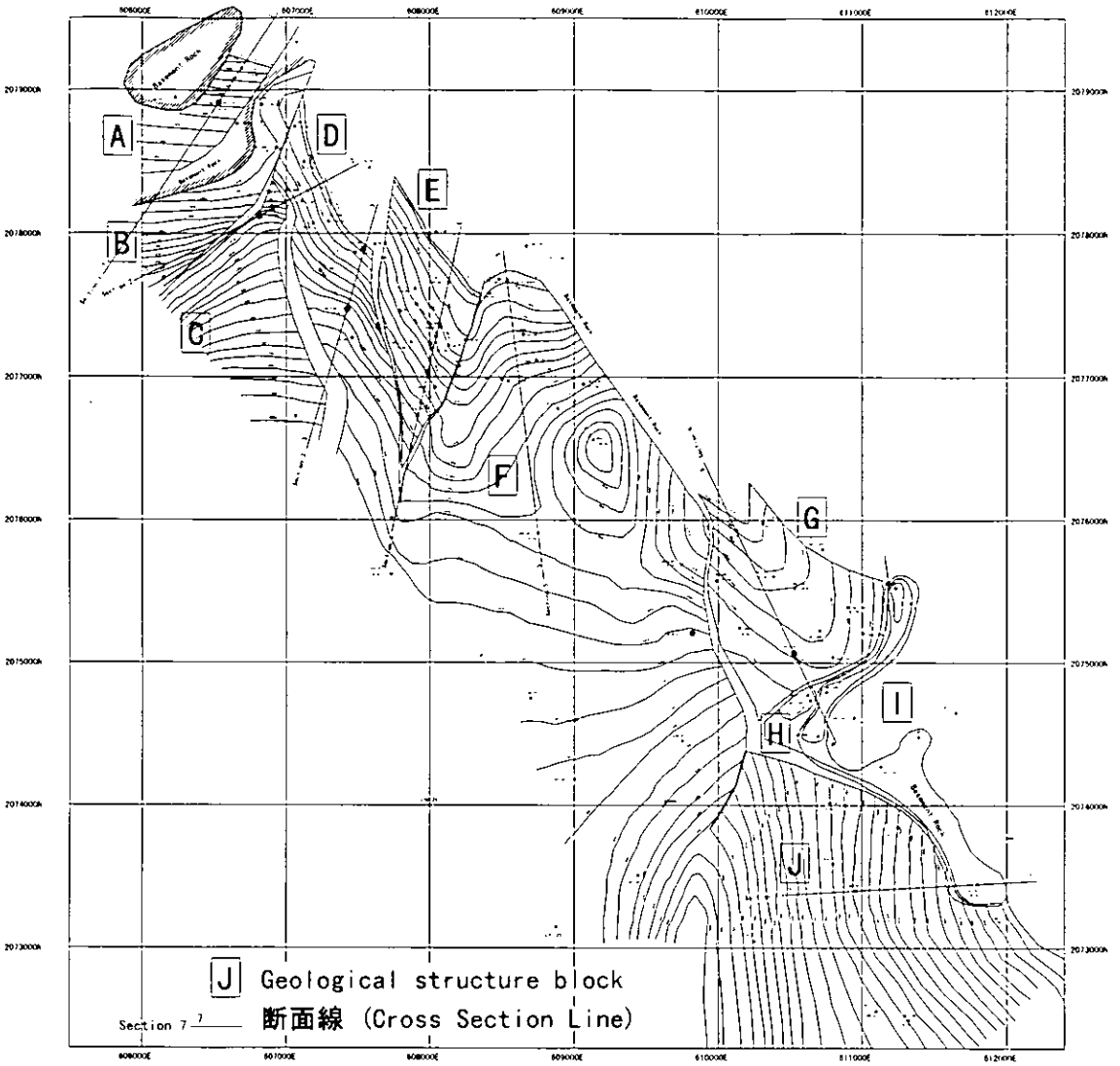



Figure2－7 Structure Contour Map(Roof of Zone Ⅰ)