Chapter 3

Data Analysis

In this chapter, although special emphasis is placed on the analysis of numerical (or analytical, "sensu stricto" data from the spatial database, previously described in the first chapter. It is also necessarily important herein to explain briefly how the analytical data are collected and transferred from the EGAT data files. Therefore in this chapter, the procedure from data collection, treatment, and preparation to program design are sequentially elucidated.

3.1   Data Collection

3.1.1   Sin Pun Area

Fig. 3.1 shows the bore-hole location map in the Sin Pun area. However, in EGAT's report (Pronrattanapitak and Jitapunkul, 1985), it is concluded that, the coal seams -P1, P2, P3, P4 and M are not encountered in each bore hole and that the designation of drill-holes is based basically upon the results of seismic interpretation (see also Yang & Just, 1988; Bowman, 1989). As shown in Fig. 3.2, there are 5 deposit areas observed in the Sin Pun basin. Due to the fact that only the bore-holes with analytical data are selected, the first step is, therefore, to sort all the 1,181 bore-hole data (see Fig. 3.1) using appropriate software programs. The results after sorting show good quality data from 56 bore-holes and they are displayed in Fig. 3.2. They include :

1.   Tha Khi Rad Deposit (with 26 bore-holes)   although   some   holes   were drilled, no sample analysis was taken from these holes. This is due to the small size of the sub-basin;

2.   Bang Sai Deposit (with 196 bore-holes) 11 bore-holes with analytical data are recognized ; i.e. 1, 4, 71,72, 73, 75, 76, 505, 512, 587, and 588;

3.   North Kuan Klang Deposit (with 306 bore-holes) 7 bore-holes with analytical data are encountered, namely nos. 5,15, 20, 21, 23, 24, and 625;

4.   South Kuan Klang Deposit (with 130 bore-holes) 7 bore-holes are selected including nos. 10, 11, 12, 29, 31, 572, 1037, 1044, and 1053; and

5.   Nong Wa Depoist (with 523 bore-holes) 26 bore-holes are found to contain analytical data. They are bore-hole nos. 801, 807, 808, 902, 903, 904, 905, 907, 908, 909, 922, 935, 945, 955, 958, 959, 966, 977, 91, 993, 997, 1005, 1008, 1015, 1038, and 1054.

After sorting, the good-quality data are stored in the database system. It is observed clearly from the above mentioned data (Fig. 3.2) that Nong Wa deposit contains more qualified drill-hole information than the other deposits. Therefore, in this study, the Nong Wa deposit is chosen as the representative for the Sin Pun area. Subsequently, the results from 26 bore-hole data are sorted using VULCAN software based upon the occurrence of the individual coal subsumes, as shown in Figs. 3.3 to 3.7. It is summarized after selection by seam that

1.   P1 SEAM (Fig. 3.3) with its distribution in bore-holes shown in Fig.3.3, is observed in 25 holes, including 801, 807, 808, 902, 903, 904, 905, 906, 907, 908, 909, 922, 955, 959, 965, 966, 992, 997, 991, 993, 997, 1005, 1008, 1038, and 1054;

2.   P2 SEAM with its distribution displayed in Fig. 3.4 is discovered form 18 holes. They include nos. 807, 902, 903, 904, 905, 908, 922, 935, 955, 959, 966, 991, 993, 997, 1005, 1008, 1038, and 1054;

3.   P3 SEAM (Fig. 3.5) is found from 23 holes, including nos. 801, 807, 808, 902, 903, 904, 905, 907, 908, 909, 922, 935, 955, 958, 959, 977, 991, 993, 1005, 1008, 1015, 1038, and 1054;

4.   P4 SEAM (Fig. 3.6) is detected from 23 holes, including nos. 801, 807, 808, 902, 903, 904, 905, 907, 908, 909, 922, 935, 955, 958, 959, 977, 991, 993, 1005, 1008, 1015, 1038, and 1054;

5.   M SEAM (Fig. 3.7) is observed from 26 holes, including nos. 801, 807, 808, 902, 903, 904, 905, 907, 908, 909, 922, 935, 945, 955, 958, 959, 966, 977, 991, 993, 997, 1005, 1008, 1015, 1038, and 1054;

3.1.2   Saba Yoi Area

With the same methodology as described in section 3.1.1, it was found using data concluded in Results of the Preliminary Geological Assessment of the Saba Yoi Coal Deposit (Vol.1) by Marston & Marston (1990) that there are 4 main seams namely S1, S2, S3, and S4

Fig. 3.8 shows a total of 581 bore-holes distributed in the Saba Yoi area, and Fig. 3.9, after data sorting, shows location of bore-holes suitable for database input. The results from each sub-basin includes :

1.   Ban Khok Tok Deposit (with 67 bore-holes) 10 bore-holes with analytical data includes nos. 481, 483, 489, 490, 503, 508, 538, 570, 598, and 600 ;

2.   Ban Khok Ok Deposit (with 82 bore-holes)12 bore-holes with good data includes nos.4, 6, 7, 307, 315, 331, 347, 595, 619, 621, 632, and 634 ;

3.   Ban Sao Deposit (with 192 bore-holes) all drill-holes containing quality data; and all holes containing qualified data ;

4.   Ban Bao Deposit (with 120 bore-holes) all drill-holes containing quality data; and all holes containing qualified data ; and

5.   Ban Kho Lo Mu Do Deposit (with 120 bore-holes) all drill-holes containing quality data; and all holes containing qualified data ; and

With the application of the VULCAN software program for data selection/sorting as that of the Sin Pun area, the Saba Yoi area shows different characteristic. No sub-basin (or deposit) is select to represent the whole area. Based upon the appearance of individual coal seams, it is discovered that :

1.   S1 SEAM with its distribution mostly in Ban Khok Tok (Fig. 3.8) is observed in 10 drill-holes including nos. 489, 490, 503, 508, 538,570, 598, and 600 ;

2.   S2 SEAM with its distribution mostly in Ban Khok Ok (Fig. 3.9) is observed in 12 drill-holes including nos. 4, 6, 7, 307, 315, 331, 347, 595, 612, 619, 632, 634 ;

3.   S3 SEAM with its distribution mostly in Ban Sao (Fig. 3.10) is observed in 26 drill-holes including nos. 99, 246, 273, 279, 283, 288, 290, 295, 338, 339, 386, 390, 420, 425, 470, 472, 477, 479, 516, 521, 563, 382, 589, and 593 ;

4.   S4 SEAM with its distribution mostly in Ban Sao (Fig. 3.11) is observed in 26 drill-holes including nos. 246, 273, 279, 283, 288, 290, 295, 338, 339, 386, 390, 420, 425, 470, 472, 477, 479, 516, 521, 563, 382, 589, and 593.

With this kind of specimen selection, all the specimens are sent for some selected analyses. There are about 166 bore-holes from both Sin Pun (56) and Saba Yoi (110) are determined, selected and sorted. All the data are then stored in the VULCAN database with ".dbl" files.
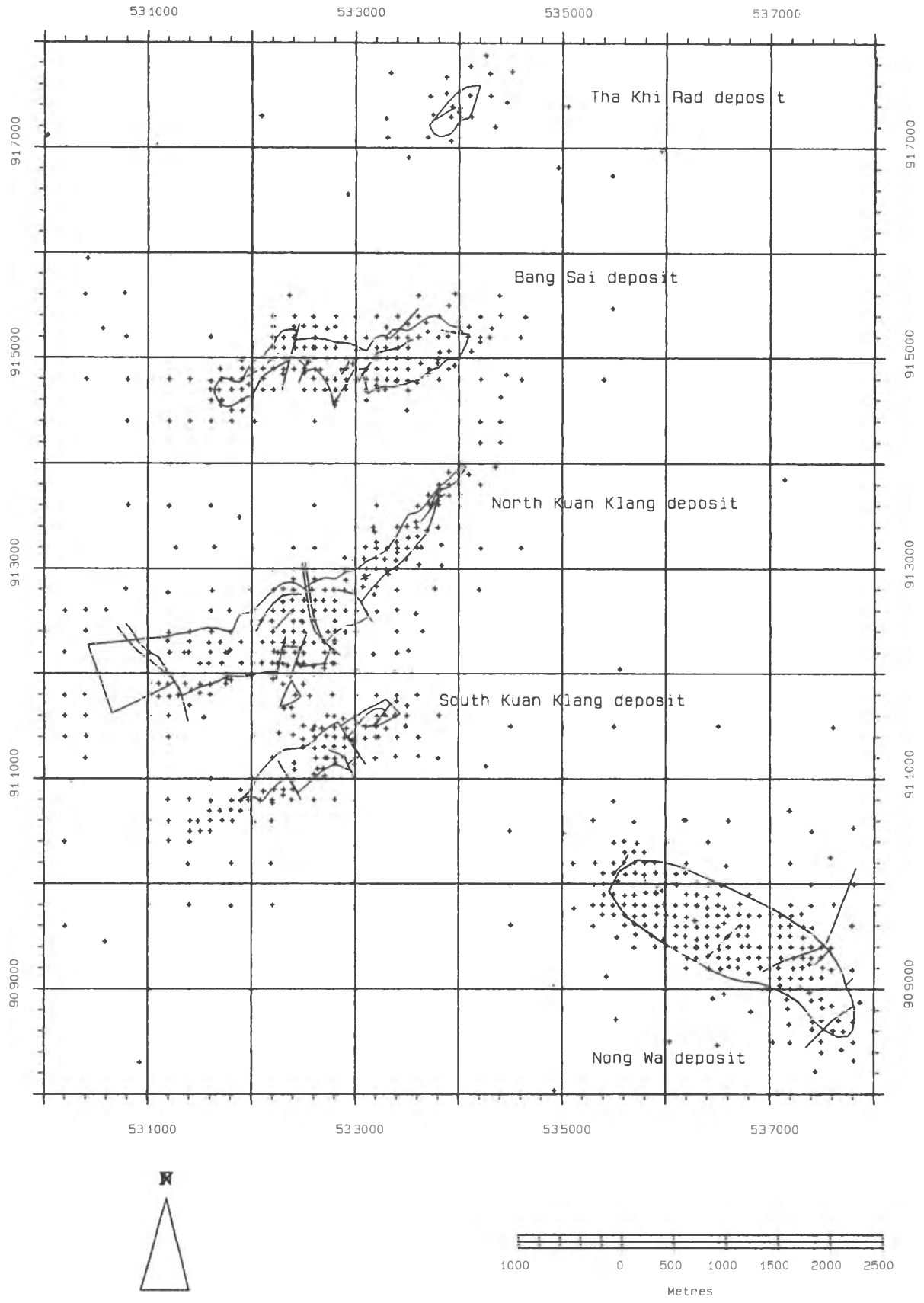
Fig.3.1.   Bore-hole location map of sub-basins deposits in the Sin Pun

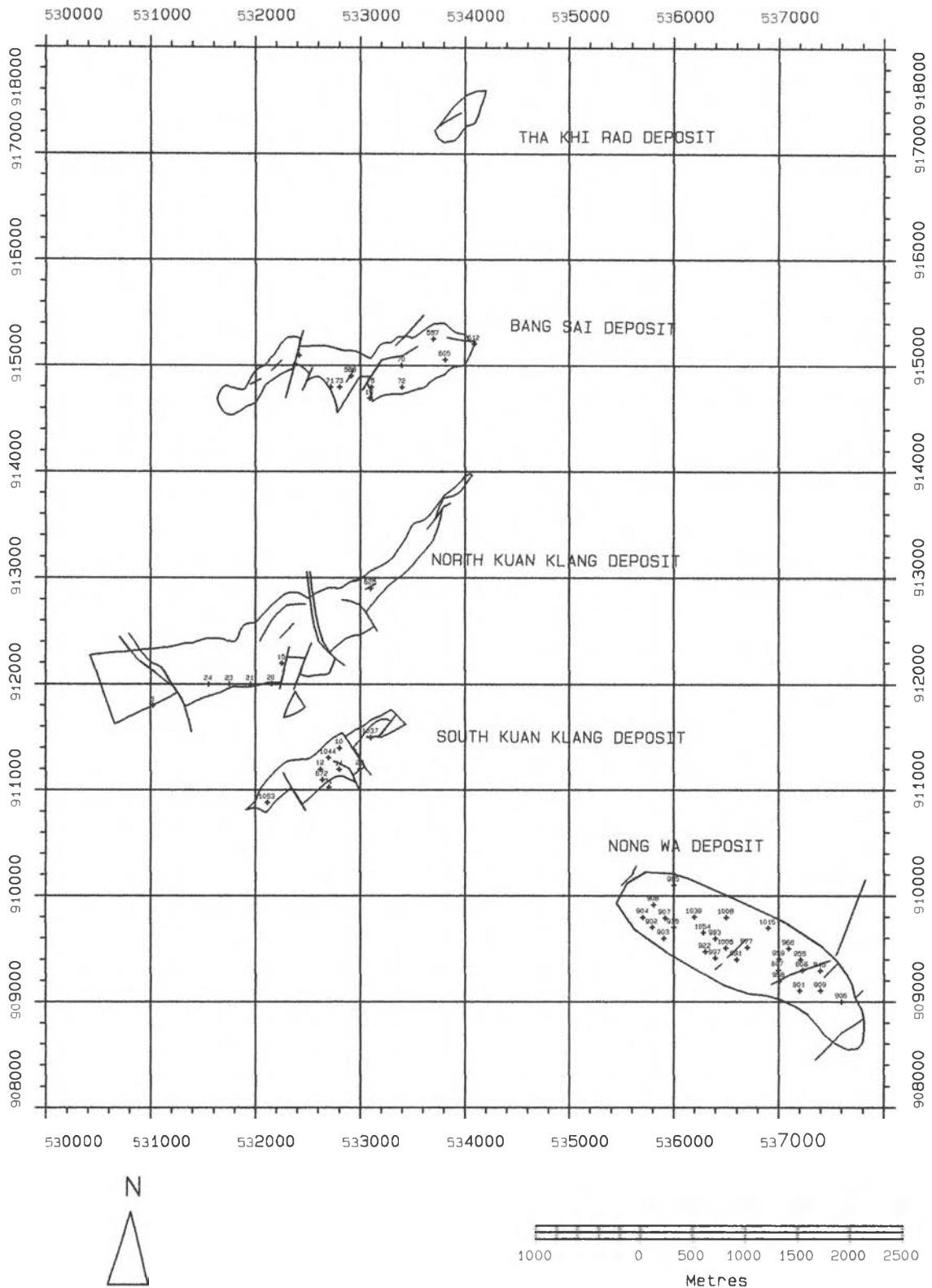area. Noted that the red line indicates fractures and faults.

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Fig.3.2.   Distribution of after-sorting bore-holes with good-quality data in
sub-basins (or deposit) of the Sin Pun area. Noted that most bore-holes
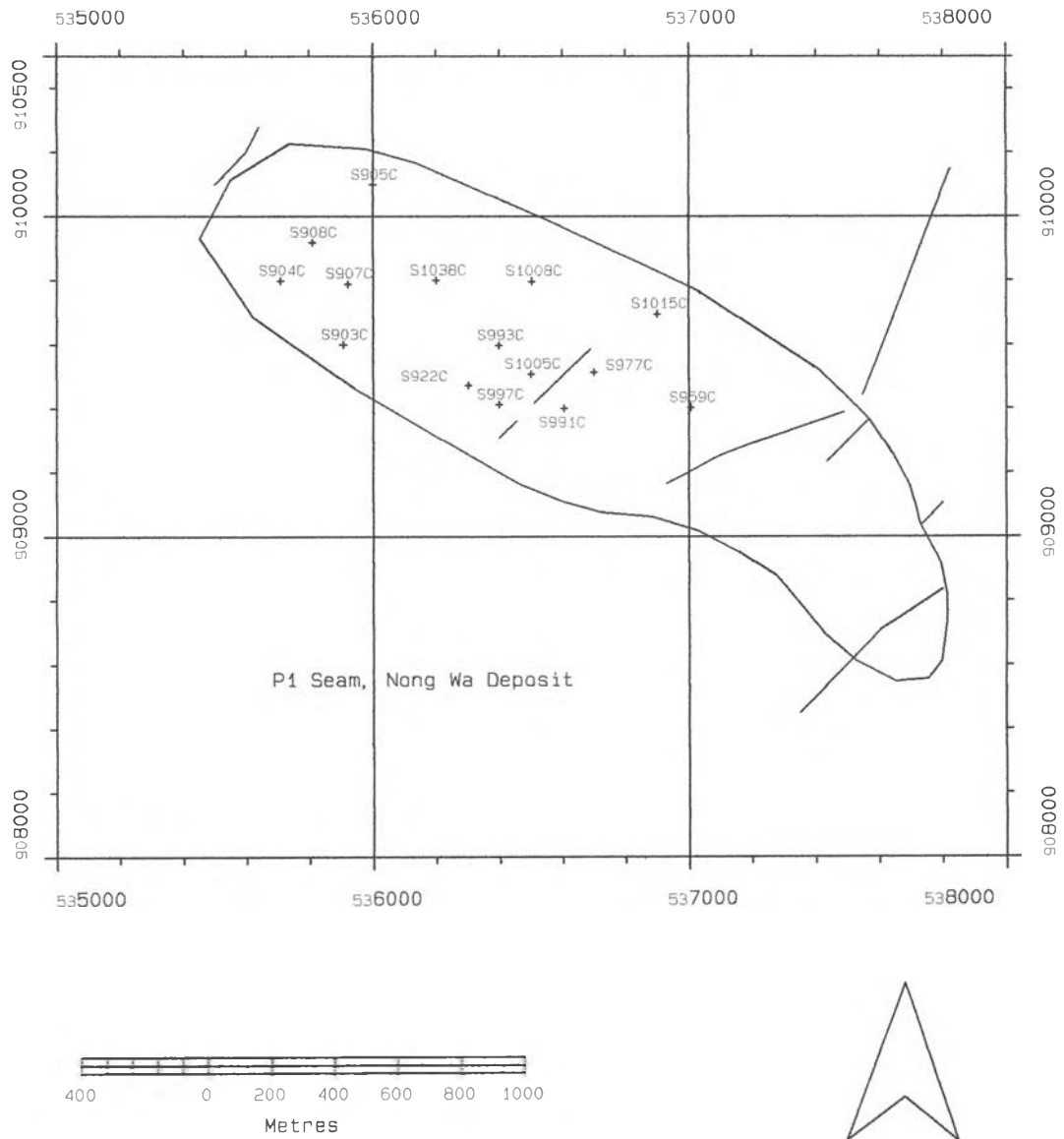are located in the southern part, in Nong Wa deposit area.

Fig.3.3.   Bore-hole location map showing distribution of the drill-holes with the P1 SEAM, Nong Wa deposit, Sin Pun area. Noted that most bore-holes are located in the northern and central parts of the Nong Wa deposit, and red lines indicate fractures and faults.
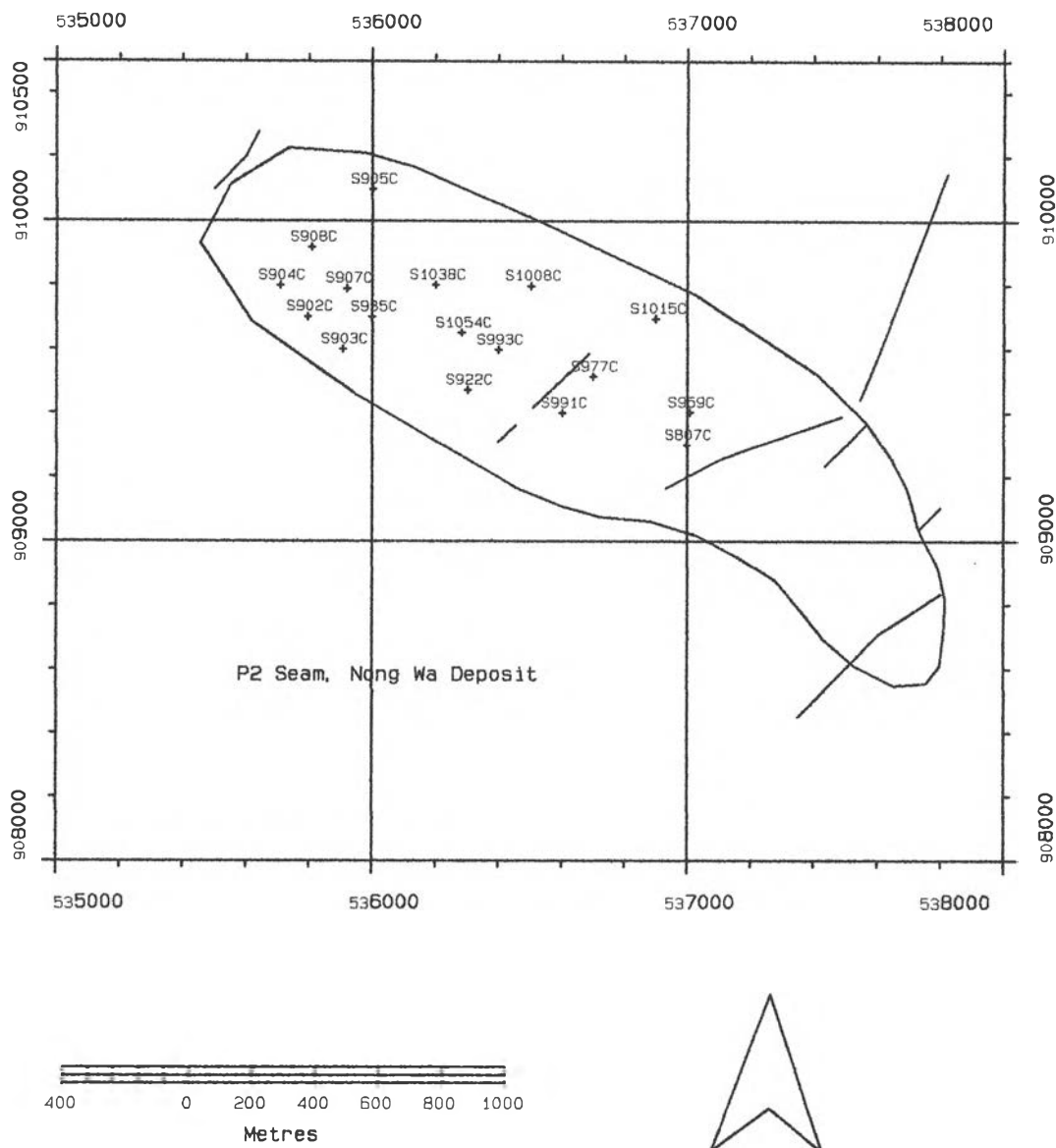
Fig. 3.4.   Bore-hole location map showing distribution of drill-holes with P2

SEAM, Nong Wa deposit, Sin Pun area. Note that bore-holes are

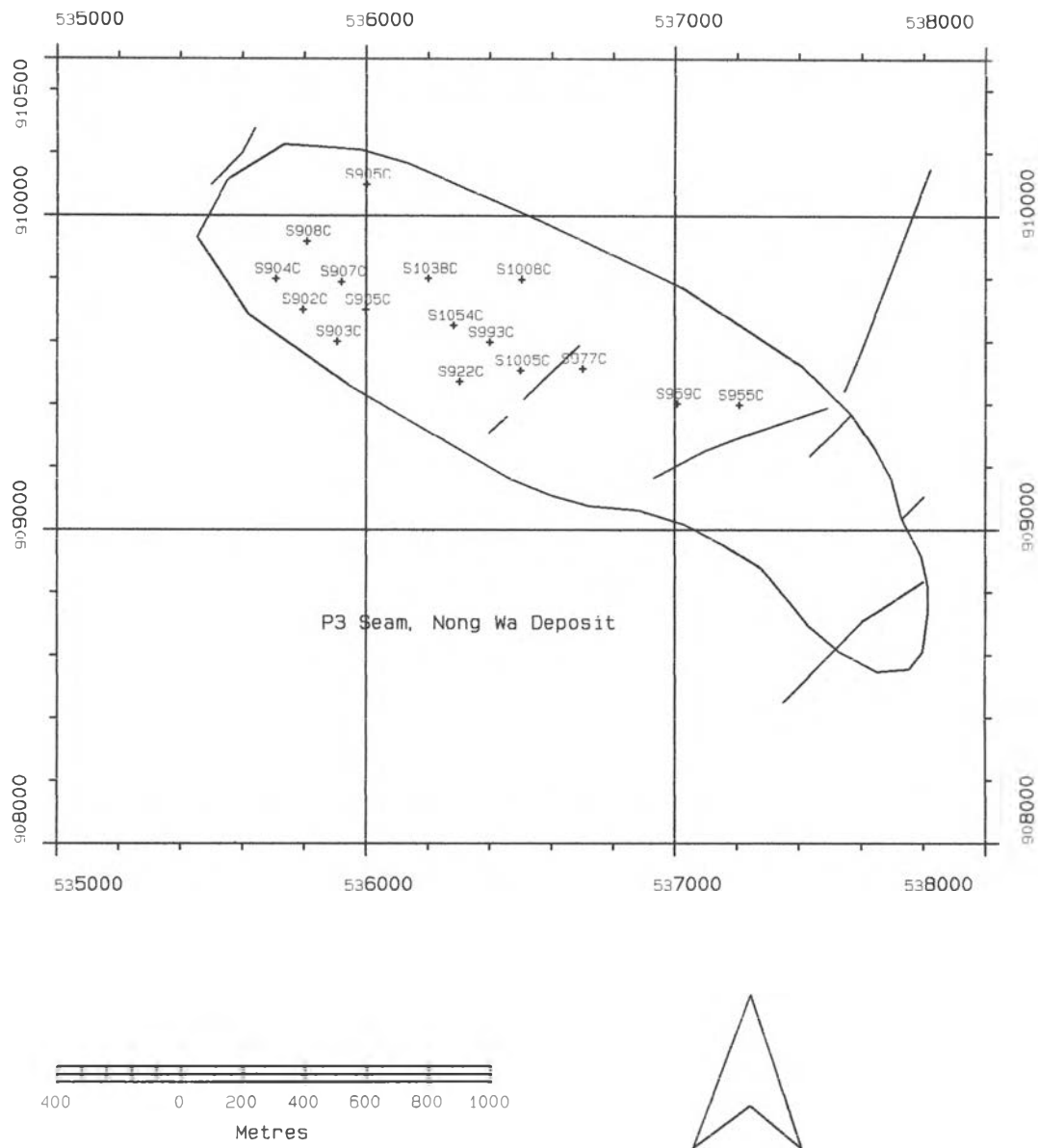distributed throughout the resource area.

Fig. 3.5.   Bore-hole location map showing distribution of the drill-holes with the P3 SEAM, Nong Wa deposit, Sin Pun area. Noted that bore-holes containing P3 SEAM are also distributed throughout Nong Wa with similar pattern to those of P2 SEAM.
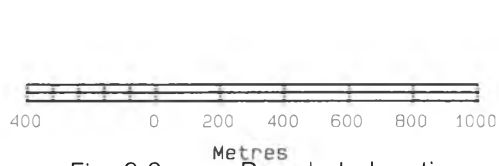
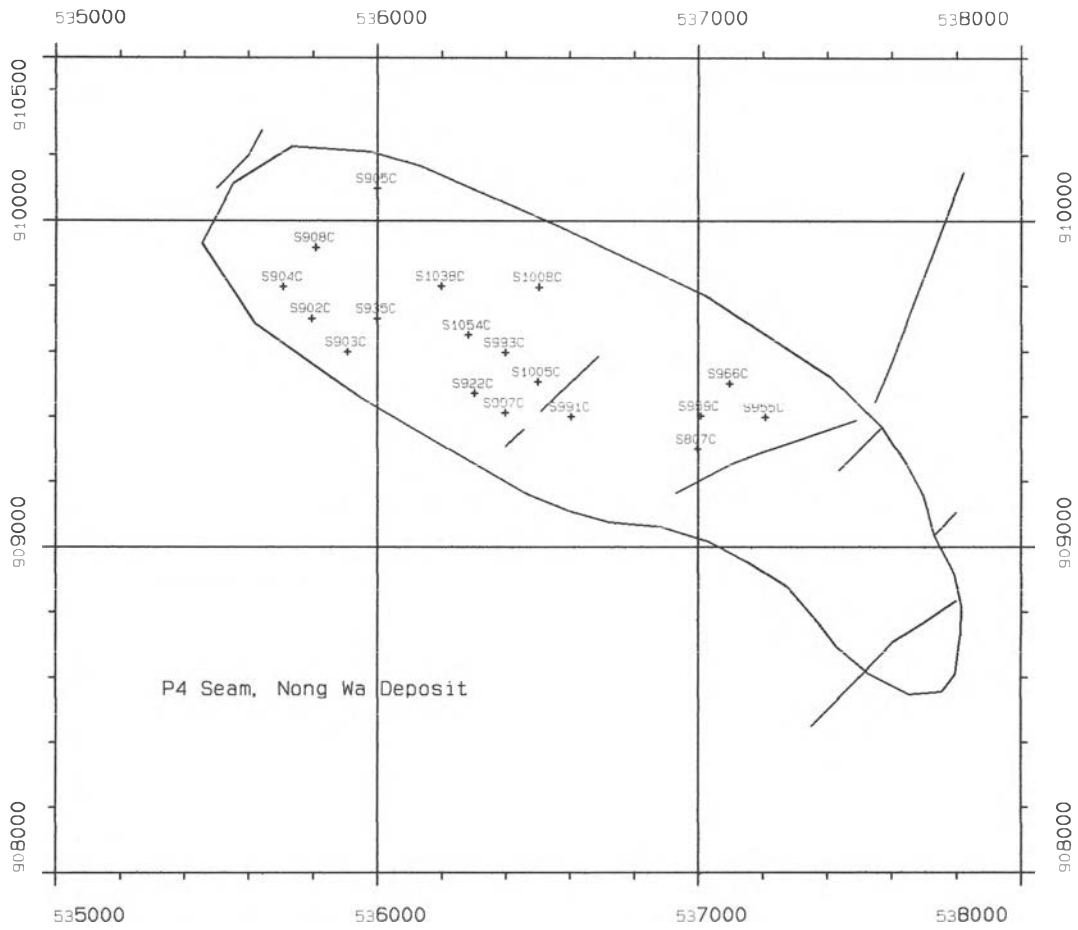Fig. 3.6. Bore-hole location map showing distribution of the bore-holes with P4 SEAM, Nong Wa deposit, Sin Pun area. Noted that the bore holes also concentrate in the southern part of the Nong Wa.
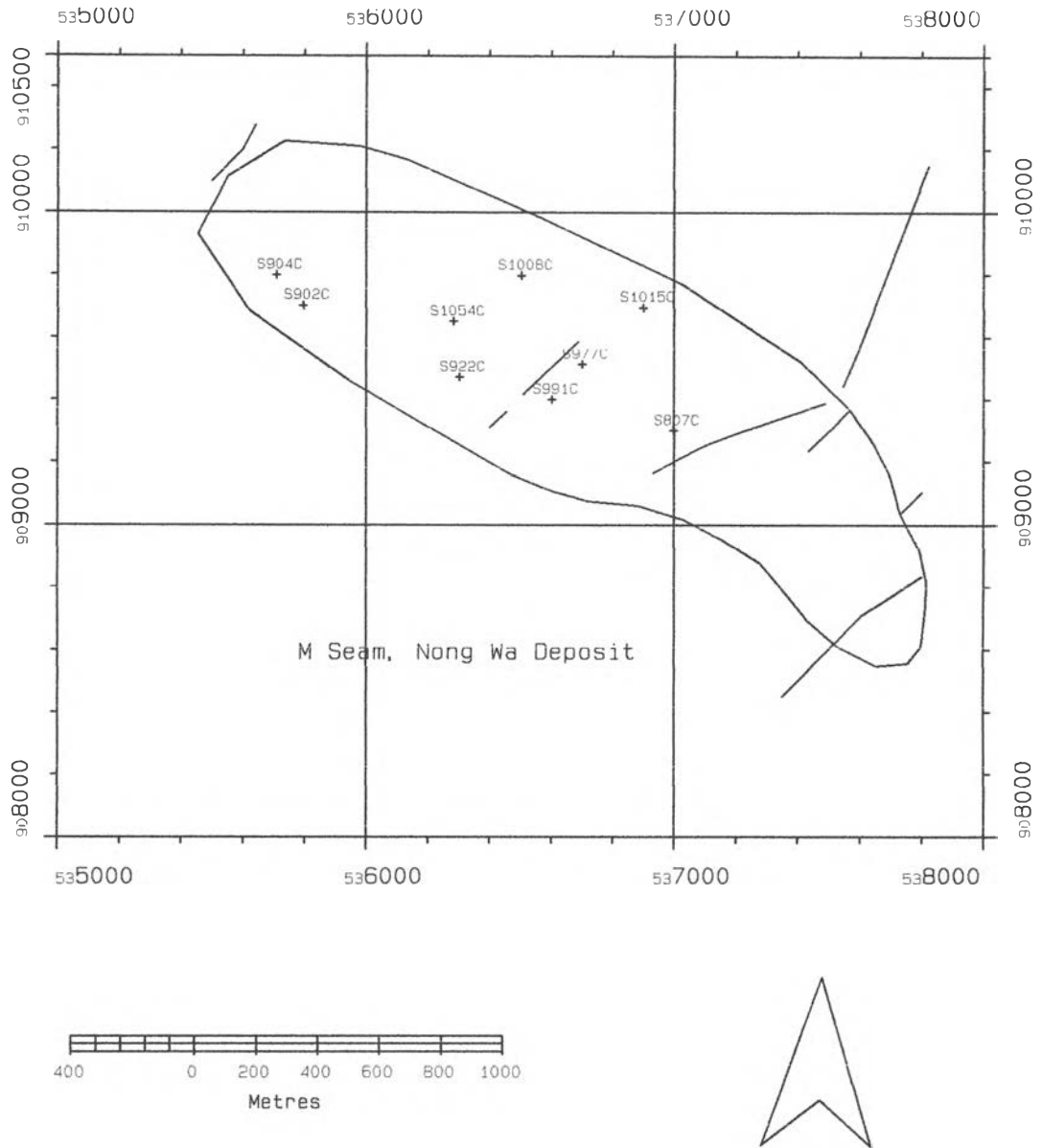
Fig. 3.7.   Bore-hole location map showing the scattering of drill-holes with the occurrence of the M SEAM, Nong Wa Deposit, Sin Pun area.
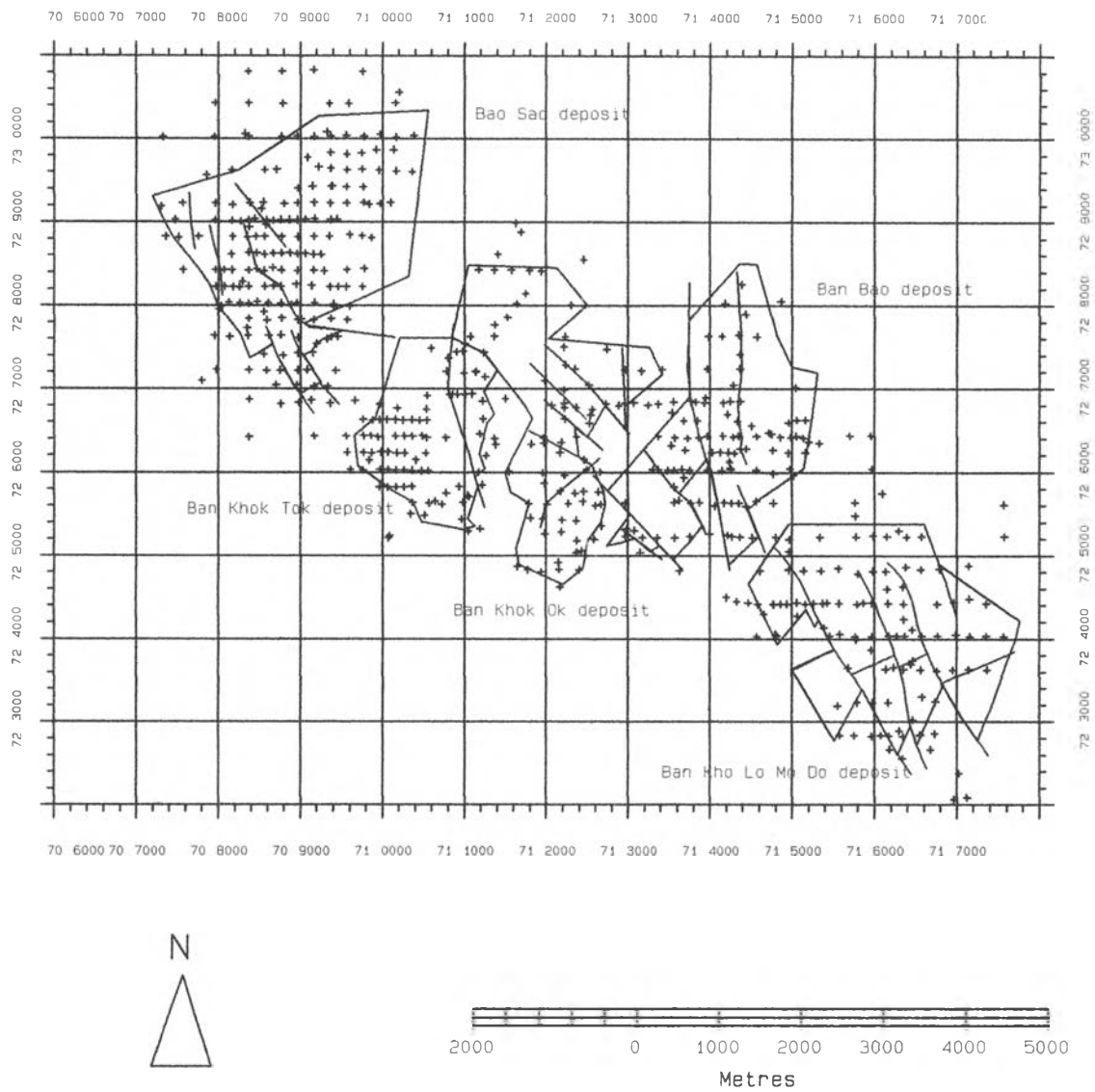
Fig. 3.8.   Bore-hole location map of sub-basins (or deposits) in the Saba Yoi area.
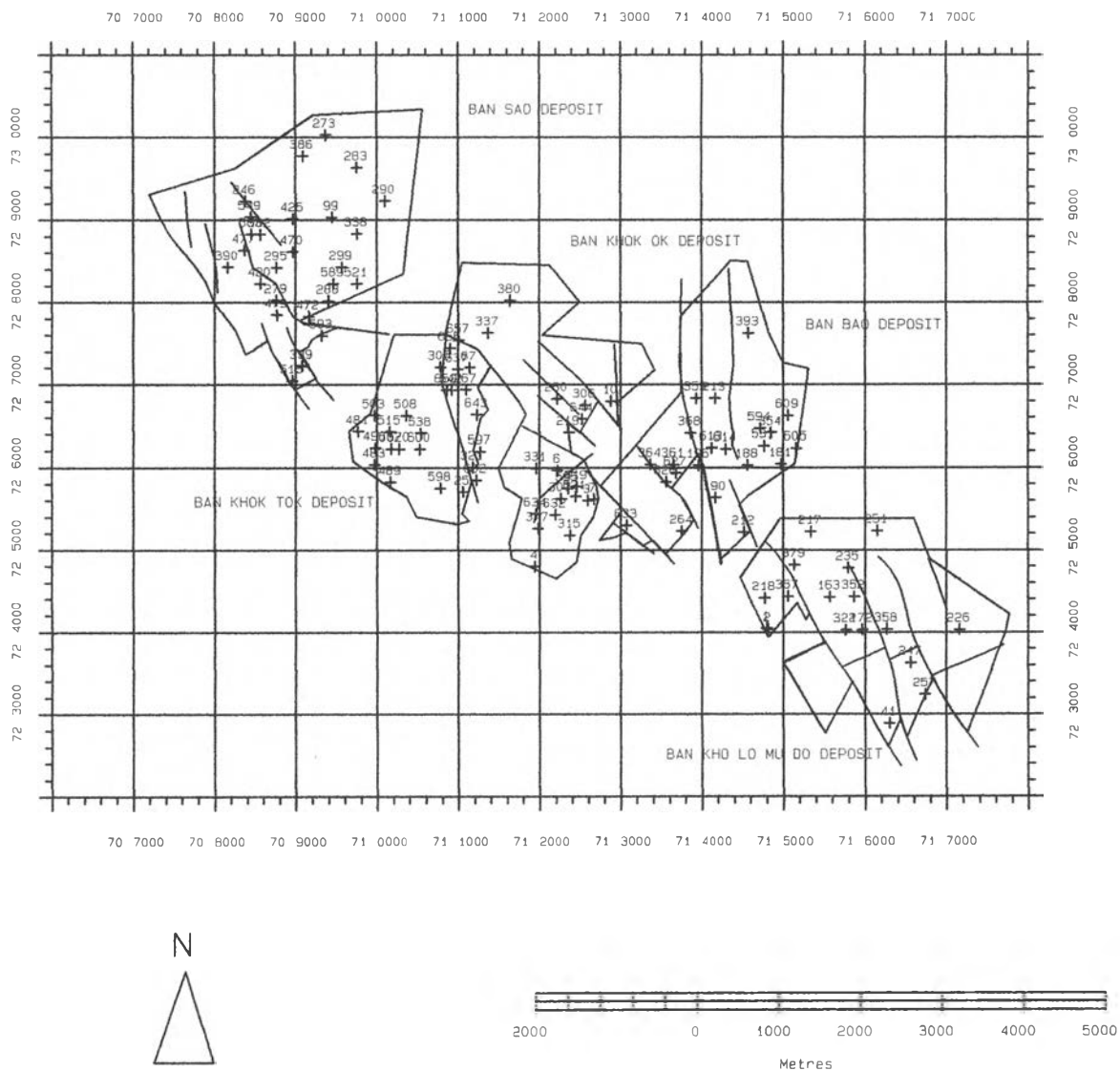
Fig. 3.9.   Distribution of after-sorting bore-holes with good-quality data in sub-basins (or deposits), of the Sin Pun area. Noted that bore-holes are distributed throughout the Saba Yoi area.

Fig. 3.10.   Bore-hole location map showing distribution of qualified bore-
holes with S1SEAM in Ban Khok Tok, S of Ban Khok Ok and Ban
Kho Lo Mu Do deposits.

Fig. 3.11.   Bore-hole location map showing distribution of qualified bore-holes
with S2 SEAM in Ban Khok Ok, S of Ban Sao deposits.

Fig. 3.12.   Bore-hole location map showing distribution of qualified bore-holes with S3 SEAM in Ban Sao deposits. Noted that bore-holes are distributed throughout..

Fig. 3.13.   Bore-hole location map showing distribution of qualified

bore-holes with S4 SEAM in Ban Sao deposits. Noted that

bore-holes are distributed throughout.

3.2   Data Preparation and Data Treatment

All the attribute and numerical data stored in the VULCAN software installed in the UNIX system are arranged in the following forms :

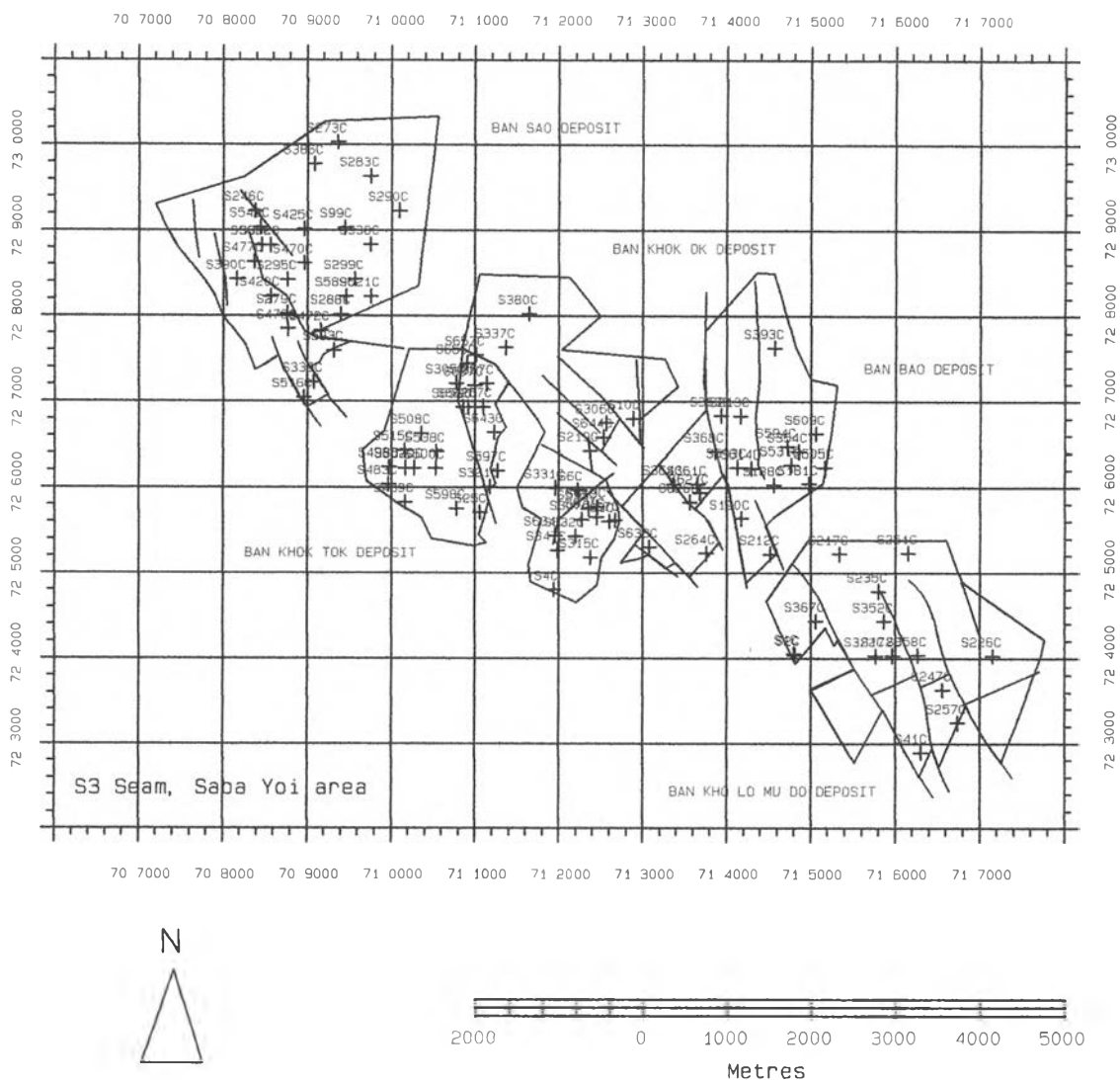1.   Header consisting of hole identity (or hole id), hole type, year of exploration, coordinate, elevation (in m), and total depth (in m);

2.   Drilling comprising exploration data, namely drill type, logging track, logging type, date of drilling start, date of drilling finish; and

3.   Lithological data composed of detailed description of the drilling such as depth, rock type, color, grain size, bulk, sediment, engineering properties, accessory mineral, fossils, seam name etc. In the last 5 columns, 5 more parameters are added, including ash content (%), calorific value (kcal/kg), moisture content(%), sulphur content(%), and density (g/cc).

After examining database information in VULCAN system and comparing them with those of the EGAT hard copy, it was found that the analytical data from 56 bore-holes of Sin Pun area and 40 of Saba Yoi have not yet been stored in the VULCAN system (see format of VULCAN in Fig. 3.14). Therefore, all these missing data had to be added to the database.

The data were then transferred once again, using the FORTRAN program, into the UNIX format, so as to combine both analytical and lithological data into the same system using the FORTRAN program created by SAENGSUPHAN & later slightly modified by the author, as shown in Figs. 3.15 and 3.16. After that, only the data being used were sorted using EXCEL program to PC system, and they were transferred to FoxPro program with the ready made formats as shown in Fig. 3.17.

Fig.3.14 .   The somewhat detailed bore-hole datasheet format used by EGAT created by

the VULCAN software and run on the UNIX system.

```
PROGRAM FOR INSERT RECORD NUMBER IN GEO DATA FROM PC
BY ..... KAMPANAT  SANGSUPHAN.....
MODIFIED BY BUSSAKORN  PONGORAPIN

       CHARACTER ALPHA *80, LINE *80, FILNAM *13, OUTFIL *13, INTEGERIREC
       CHARACTER AA*6, ab*1
       ADD RECORD TYP3
       WRITE (*,*) 'PROGRAM INSERT RECORD NUMBER IN RAW-DATABASE
       WRITE (6,FMT = '(A,$)' 'Input  File  Name : :'
       READ (5,FMT = '(A)') FILNAM
       WRITE (6,FMT='(A)') Output File Name : '
       READ (5,FMT=' (A)') OUTFIL
       WRITE (*,*)' : PLEASE WAIT FOR RUNNING PROGRAM :'
       OPEN (2, FILE = FILNAM, READONLY, STATUS = 'OLD')
       OPEN (3,FILE = OUTFIL, : FORM = 'FORMATTED')
       1000 CONTINUE
       READ (2,10,END = 1001) LINE
       10 FORMAT (A)
       READ (LINE (2:7), 18) AA
       READ (LINE (8:8), 19) AB
       READ (LINE (9:9), 20) IREC
       READ (LINE (10:80),21) ALPHA
       8  FORMAT (A6)
       10 FORMAT (I1)
       11 FORMAT (A71)
       15 FORMAT (I1,2X,A6,A1,I1,A71)
       IF (IREC.EQ.0) THEN
       IREC = 3
       GO TO 101
       ENDIF
       IF (IREC.EQ.1) GO TO 101
       IF (IREC.EQ.2) GO TO 101
       IF (IREC.EQ.3) GO TO 101
       100 WRITE (3,10) LINE
       GO TO 1000
       101 WRITE (3,55) IREC, AA,AB,IREC,ALPHA
       GO TO 1000
       1001 CONTINUE
       CLOSE (2)
       CLOSE (3)
       STOP
       END
```

Fig. 3.15.   The created FORTRAN program for adding data to be recorded
                in PC file applied to this study.

```
PROGRAM FOR INSERT RECORD NUMBER IN GEO DATA FROM PC
BY ..... KAMPANAT SANGSUPHAN.....
MODIFIED BY BUSSAKORN PONGORAPIN

CHARACTER HE*1, AL*1, ALP*1, APHA*13, AH*58, LINE*84
CHARACTER FILNAM *13, OUTFIL*13
WRITE (*,*) 'PROGRAM CHANGE "chem.dat" to appropriate format'
WRITE (6, FMT= '(A,$)') 'Input File Name'
READ (5,FMT= '(A)') FILNAM
WRITE (*,*)' : 'Output File Name :'
READ (5,FMT= '(A)')OUTFIL
WRITE (*,*)' : PLEASE WAIT FOR RUNNING PROGRAM :'
OPEN (2,FILE=FILNAM, READONLY, STATUS='OLD'
OPEN(3,FILE=OUTFIL, : FORM ='FORMATTED'
1000 CONTINUE
READ (2,10,END=1001) LINE
10 FORMAT (A)
READ (LINE (1:1), 19) HE
READ (LINE(4:4), 19 AL
READ (LINE (5:5),19 ALP
READ (LINE(9:21), 19) AH
19 FORMAT (A)
IF (AL.EQ.' ' ) THEN
GO TO 25
ELSE
GOTO 27
ENDIF
25 WRITE (3,26) HE, ALP, APHA, AH
26 FORMAT (A1, A1, 5X, A13,6X,A58)
GO TO 1000
27 WRITE (3,26) HE, AL, ALP, APHA, AH
28 FORMAT (A1, A1, A1, 4X, A13, 6X, A58)
GO TO 1000
1001 CONTINUE
CLOSE (2)
CLOSE (3)
STOP
END
```

Fig. 3.16.   The created FORTRAN program for combining lithological data and analytical data used in this study.

Hole id	East	North	Collar	type	depth	rock	percent	int1	col1	int2	col2	zone	ash	cv	dense	moisture	sulphur

Fig. 3.17.   FoxPro format data sheet. Explanation int1 = major intensity, col1 = major color, int2 = minor intensity, col2 = minor intensity, zone - zone name, ash = ash content (%), cv = calorific value (kcal/kg), dense = density (g/cc), moisture = moisture content (%), sulphur = sulphur content (%), Vulcan format for data input in the new database system.

The combined lithological data and analytical data using the same database format are displayed in detail in Appendix A. All the data being synthesized were sorted including and analytical values (ash content, CV, moisture content, sulphur content, and density).

They were transferred to the EXCEL program for determining the representative values for each seam. This was performed due to the nature of sample spacing (see detail in Appendix A). The new values were then used for variogram analysis using Geo_EAS software (Englund, 1991). Sequence of determining representative values (arithmetic mean in this study) with the application of EXCEL software program is illustrated on the next page/ (Table 3.1).

It is clear from Table 3.1 that the hole no.S10 containing 2 data set of S3 SEAM. The mean value was calculated using the following formula

$$\text{Mean} \quad = \quad \sum_{i=1}^{n} Tk_i V_i \, / \sum Tk_i$$

When Tk = thickness (m), Vi = analytical value, and n = ply number. Therefore, the quality values were then calculated and transferred to Geo_EAS program . Followings are the values calculated from data displayed as below :

Mean (Ash Content)   =   (2.2x9.71) + (2.1x13.27) / (2.2+2.1)   = 11.14 %

Mean (Calorific Value)   =   (2.2x3904)+(2.1x3711) / (2.2+2.1)   = 3810 Kcal/Kg

Mean (Moisture Content) =   (2.2x25.72) +(2.1x24.70) / (2.2+2.1)   = 25.22 %

Mean (Sulphur Content)   =   (2.2x0.73) + (2.1x0.78) / (2.2+2.1)   = 0.75 %

Mean (Density)   =   (2.2x1.45) + (2.1x1.49) / (2.2+2.1)   = 1.47 g/cc

Table 3.1.   A example of showing selected P SEAM from Sin Pun area showing 5 important parameters being determed.

Hole id	East	North	Collar	type	depth	rock	percent	int1	col1	int2	col2	zone	ash	cv	dense	moisture	sulphur
S10	712883	726800	26.56	C1	4.00	CL	60	L	GR	D	YW	Q					
					4.00	SA	40	L	GR	D	YW	Q					
					19.00	CL	0	L	GR			T2L					
					79.35	LI	0		BK			S3B1					
					80.30	LI	0		BK			S3B1					
					80.40	LI	0		BK			S3B1	9.06	3993	1.44	25.48	0.58
					81.00	LI	0		BK			S3B1					
					83.20	LI	0		BK			S3B1	9.71	3904	1.45	25.72	0.73
					85.30	LI	0		BK			S3B1	13.27	3711	1.49	24.7	0.78

Explanation

ash = ash content (%), cv = calorific value (kcal/kg), dense = density (g/cc), moisture = moisture content (%), sulphur = sulphur content (%),

CL = clay, SA = sand, LI = lignite, L = light, D = dark, GR = gray, YW = yellow, BK = black, Q = Quaternary, T2L Tertiary (lacustrine).

The result, the hole no S10 posses representative values of S3 Seam , shown as following:

Ash Content	=	11.14	% ;
Calorific Value	=	3810	Kcal/Kg ;
Moisture Content	=	25.22	% ;
Sulphur Content)	=	0.75	%; and
Density)	=	1.47	g/cc.

For each coal seam, the representative parameters were eventually calculated, they were traced and transferred to the Geo_EAS program (see next chapter).

Prior to the advent of selected data to the variogram analysis using Geo_EAS computer software, it is quite necessary to create a data file format. As shown in Fig.3.18 as an example columns 1 and 2 shown coordinate (easting and northing) for each coal seam in the selected drill-holes, and columns 3 to 7 represent the added parameters including ash content(%), calorific value (Kcal/Kg), moisture content(%), sulphur content(%), and density (g/cc), respectively. Upon this stage, the variogram analysis and cross validation testing were applied using Geo_EAS software before the kriging was estimated for modeling by SURFER computer software(see also Fig. 3.19).   Fig.3.19 shows an example of creating data file format and inputting of the data.

3.3   Designation of Programs

In this study, available programs were selected sequentially depending on their applications and IBM-compatible formats. The Pentium (or model 486 model) computer with 8 Mb. was used in this investigation, and the programs used includes :

1.   VULCAN program (version 3.2) used for data collection and selection (see VULCAN format in Fig. 3.14) ;

2.   EXCEL program (versions 4 & 5) used for data conversion to FoxPro program and calculation ;

3.   FoxPro program (version 2.6) used for new database creation (see FoxPro format in Fig. 3.17 ;

4.   Geo_EAS program with the memory of 4 megabytes used for variogram analysis and cross validation (see Geo_EAS format in Fig. 3.18) ; and

5.   SURFER (version 32) with the 16-megabyte memory used for kriging and show the result of error estimation. (see SURFER format in Fig. 3.19).

The essential programs in this study are the FoxPro 26 software for creating new database, Geo_EAS for variogram analysis and SURFER for kriging estimation.

The detail of program design in this investigation is shown in Fig. 3.20.

p1.dat						
7	Variable no.					
Easting	UTM Grid					
Northing	UTM Grid					
Ash	(%)					
CV	(Kcal/Kg)					
Moisture	(%)					
Sulphur	(%)					
Density	(%)					
536499.58	909507.84	29.96	1737	25.71	4.20	1.64
536502.98	909797.44	37.78	823	21.95	2.11	1.52
536900.36	909695.79	25.34	2720	28.86	5.26	1.46
536199.74	909799.72	32.34	1726	22.63	4.00	1.42
535905.69	909598.97	6.80	3105	42.23	6.46	1.26
535707.80	909798.38	10.95	2976	40.10	6.46	1.37
536000.49	910098.54	35.81	1512	20.00	3.47	1.44
535920.31	909789.14	16.25	3347	26.23	6.86	1.30
535808.44	909918.02	19.07	3136	39.48	6.08	1.41
536302.03	909471.77	27.90	2108	23.80	4.27	1.40
537006.85	909401.80	39.66	1661	23.89	4.47	1.50
536700.07	909513.21	36.60	1022	25.25	1.52	1.46
536603.38	909400.02	28.07	1721	25.17	3.56	1.45
536399.09	909597.19	35.23	1073	23.18	2.31	1.50
536398.16	909412.16	26.33	1601	32.00	1.66	1.40

Fig. 3.18. An example of Geo_EAS format showing numerical data for variogram analysis, 15 bore-holes (see detailed explanation in text).

"X"	"Y""	"Z1"	"Z2"	"Z3"	"Z4"	"Z5"
536499.58	909507.84	29.96	1737	25.71	4.2	1.64
536502.98	909797.44	37.78	823	21.95	2.11	1.52
536900.36	909695.79	25.34	2720	28.86	5.26	1.46
536199.74	909799.72	32.34	1726	22.63	4	1.42
535905.69	909598.97	6.8	3105	42.23	6.46	1.26
535707.8	909798.38	10.95	2976	40.1	6.46	1.37
536000.49	910098.54	35.81	1512	20	3.47	1.44
535920.31	909789.14	16.25	3347	26.23	6.86	1.3
535808.44	909918.02	19.07	3136	39.48	6.08	1.41
536302.03	909471.77	27.9	2108	23.8	4.27	1.4
537006.85	909401.8	39.66	1661	23.89	4.47	1.5
536700.07	909513.21	36.6	1022	25.25	1.52	1.46
536603.38	909400.02	28.07	1721	25.17	3.56	1.45
536399.09	909597.19	35.23	1073	23.18	2.31	1.5
536398.16	909412.16	26.33	1601	32	1.66	1.4

Fig.3.19.   An example of SURFER format showing numerical data from Nong Wa
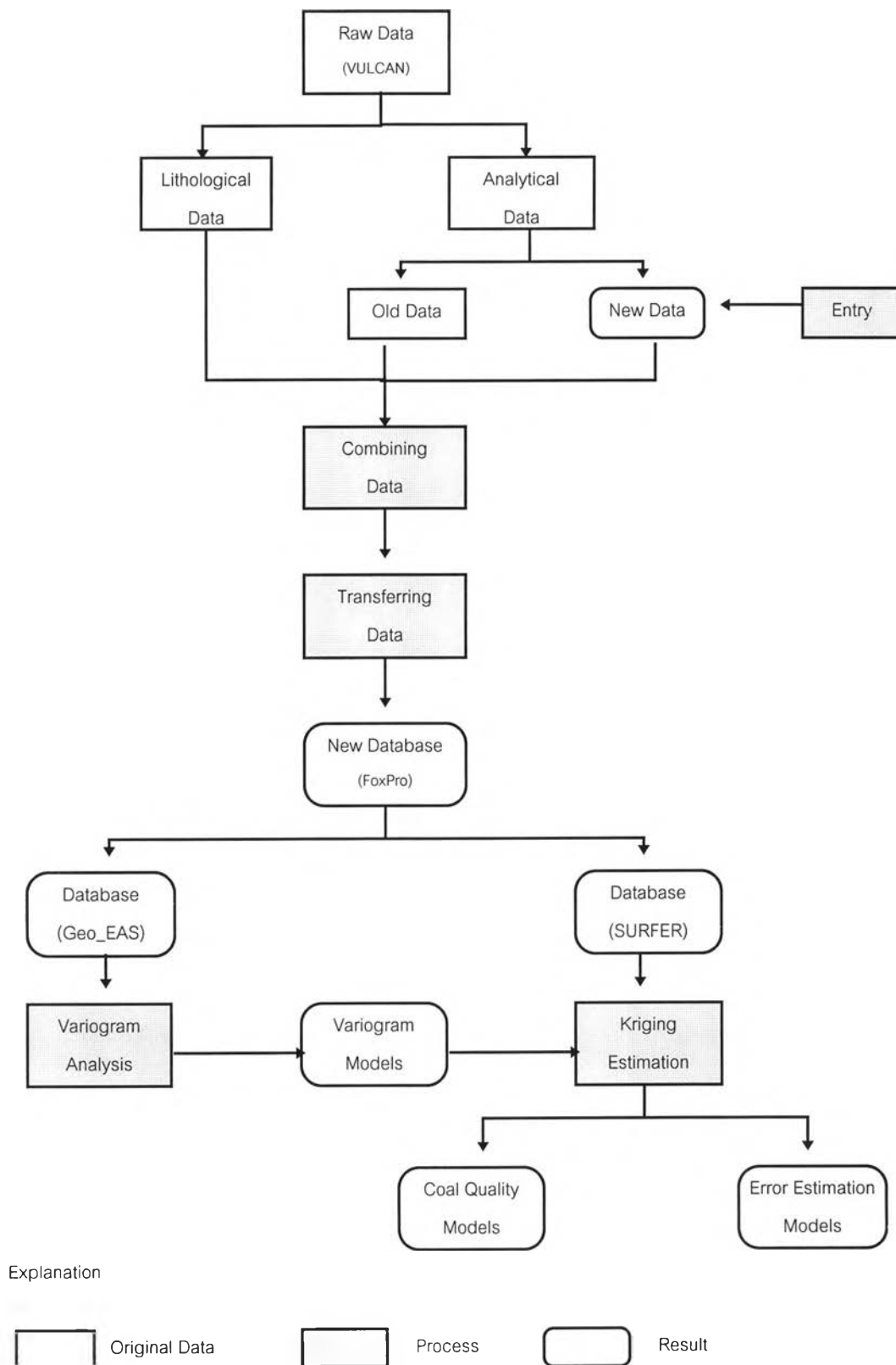P1 SEAM, Sin Pun area, for Kriging Estimation.

Fig. 3.20   Flowchart illustrating program design in this investigation.