Chapter 6

Discussion

It is clear, from Chapters 4 and 5, that there are appropriate information to provide discussion on the computer programs, the geological and exploration contexts, and the geostatistical application.

6.1 Computer Software Programs

As specified in Chapter 4, one of the versatile , nonfrustrating, and easy- using database software's FoxPro program, which has been applied to this current study. The program can successfully run on a PC system with the assistance of the Microsoft office. Since the original data are stored in the database of Vulcan software, which are considered quite more complicated, only the well trained persons can access in this work. One of the major tasks is to create the new database system using FoxPro program by transferring some data from UNIX software with the rearranged format through excel program. So it is quite easy for one who needs to look through the available data. This database system was designed have to propose any EGAT and any program users who involve in the coal industry. This new database system has been assigned in this study, suitable for the development of economically-promising coal deposits, which in this case are Sin Pun and Saba Yoi. In the future, for the exploitation and development stages, more parameters and other numerical and attribute data can be added to this database system. It is quite notably appropriate to discuss herein also that not only the FoxPro program can run on the Microsoft office which allows ones to look-up into the system, but also it has the wizard that helps to explain procedure of the system. This enables ones who are not familiar with the system being access rapidly before investigating and manipulating the available data.

The other program regarded necessarily important for this study is the Geo-EAS software program. this software is a free ware program so it can download from the internet [http: //www// curie.ei.jrc.it/software/geoeas.htm]. Furthermore, the program is a small memory [=4 Mb]- ideal size for a swift geostatistic determination. However, through the author' s experience, due to its small memory, some problems may arise, particularly the technique of displaying multi-colored figures and graphic print-outs with high resolution. This program is, therefore, likely inappropriate for geographic presentation, but timelessly suitable for statistic approach; e. g. mean, variance, variogram, kriging, and error estimation. It is noteworthy that in the future, if this program can develop the better- quality presentation, it is regarded as one of the best programs ever-used for geostatical determination and evaluation.

The last computer software worth to be mentioned is the SURFER program with its memory of about 16 Mb. This program is applied in the last step due to its applicability displaying the beautifully muti-coloured graphic chromes. Apart from kringing estimation, the SURFER program can determine the statistical values using the conventional methods including triangulation, inverse distance, and polygons. Although the program successfully and swiftly determine the geostatistic estimates by kriging method, it cannot be applied for variogram analysis.

6.2 Geostatistical Application to Exploration and Production Planning

The application of kriging methods and computer technology to deposit valuation and quality modeling is gaining momentum because of the increased accuracy and speed of valuation that these techniques can afford. While the previous chapters dealt with estimation by kriging, this chapter (or section) points to the application of such a method to problems related to exploration and mine planning. Quite practically, the study or analysis of directional anisotropy in the variogram can help to optimally locate the new or additional drilling holes (see also Baaff et al., 1986).

As in the case of Nong Wa P1 coal seams (Sin Pun area), it is observed that there are 5 spaces to put the additional holes, but with the use of ***directional variogram***, only 3 holes are required for the further bore-hole data (Figs. 3.3-3.6). Another word, the possibility of choosing anisotropic patterns of spatial continuity of our random function model can give a powerful ability to customize the estimation procedure.

The important parameter that points to the new drill-hole locations is *directional distance* including R-major, R-minor, and anisotropy ratio (R-major / R-minor). For example, as shown in Fig. 6.1 and Table 6.1, variogram model of ash content of Nong Wa P3 coal seam indicates the direction of maximum continuity in the WSW-ENE direction with R-major of 650 m and R-minor at 250 m (based upon cross validation). It is therefore visualized that the information needs to be more studied should be limited within this area (more than the red-point zone).

In this study, the ***tolerance angle*** ($\pm$ 45°) applied herein appears to be large enough to allow well-defined directional variograms while still preserving the evident anisotropy. Unfortunately, small directional or angular tolerance gives so few pairs that the directional variogram is too erratic to serve as a useful and practical description.

Additionally theoretical reasoning and practical experience have shown that a minimum of 30 evenly distributed sample points are required to obtain a reliable variogram or semivariogram (Whitchurch et al., 1987). However, for the Sin Pun and Saba Yoi areas, the maximum numbers of qualified drilled-holes are 17 , which are less than the suggested minimum points.

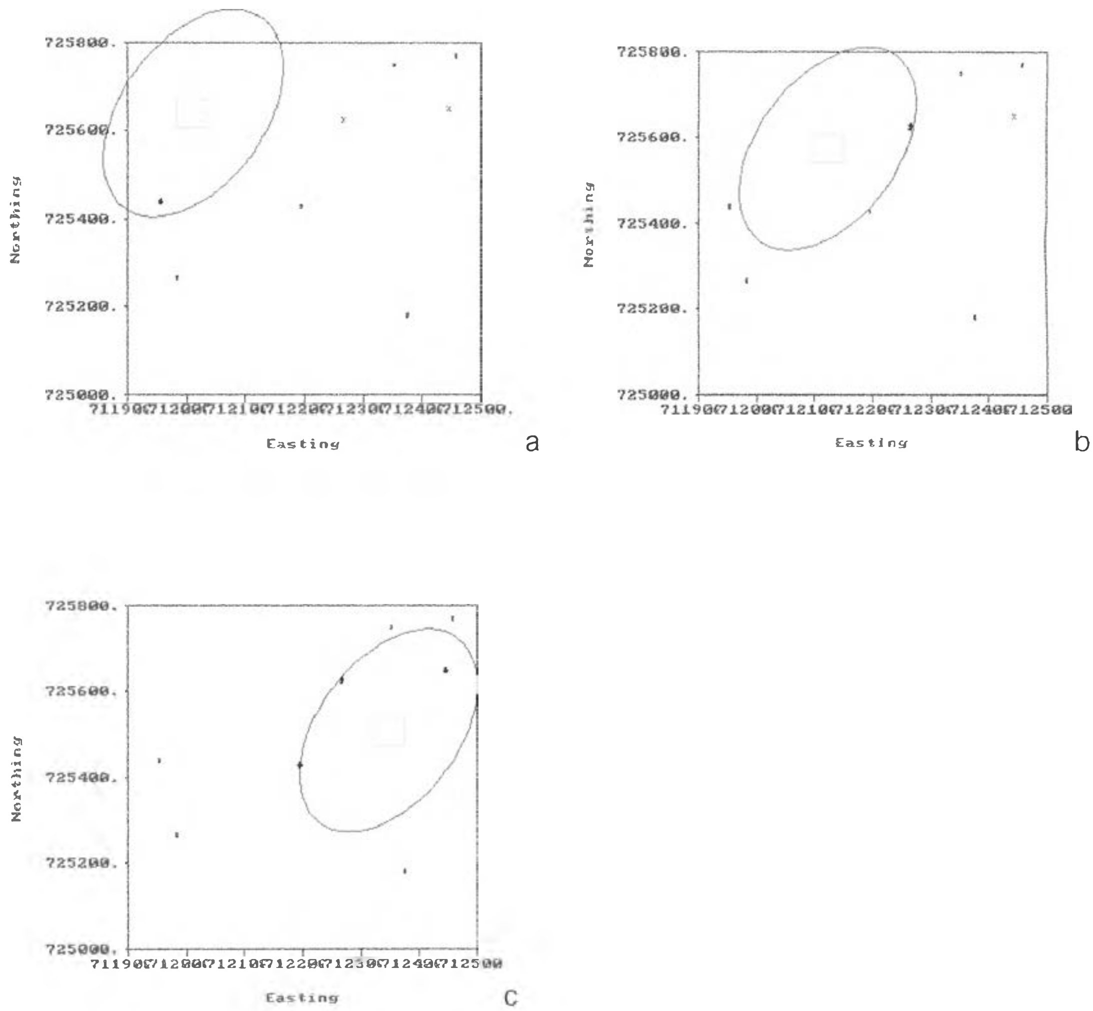


Fig. 6.1. Example for new drill-holes planning of ash content (%), Saba Yoi S2 seam.

Table 6.1. Estimation error of ash content in new drill-holes.

Easting	Northing	Estimation	Standard Error	Kriging Variance
712009.80	725639.20	32.20	3.44	11.8
712122.10	725573.80	38.00	3.26	10.60
712346.00	725508.30	36.40	2.53	6.41

Therefore, in terms of variogram analysis, both areas are still in the early stage of exploration program, and variogram models can be used as a guide to sample spacing in a more detailed program, until sufficient samples have been collected from the deposit. According to Scott & Whateley (1955), this is analogous to using genetic model to guide mineral exploration. In some cases, the variogram model is of ***nugget-effect-type***, entailing a complete lack of spatial correlation and unrelated omnidirectional paired sample data, although careful consideration is made for sampling methodology of these two areas (see also Appendix A). Information from Fox Pro database critically reveals that coal seams with parting less than 30 cm is collected for proximate analysis. So it is inferred herein that nugget effect (or nugget variance) may have occurred as a result of mingle of clayey materials to coal seam upon sampling (see also Solid Fuel Database Center, 1994). It is recommended that for further exploration, these and similar samplings for unbiased quality analysis from individual seams have performed in detail together with careful lighological description from the exploratory drill-holes representing the whole basin. Then directional sample data for the next drill holes can be delineated in appropriate spacing and orientation (see also Fig. 6.1). This can be estimated through variogram analysis. In addition, direction of related drilled-holes can give rise to optimize number of holes for minimizing cost. This can be done using kriging result by using estimated variance plotted against added numbers of drilled-holes.

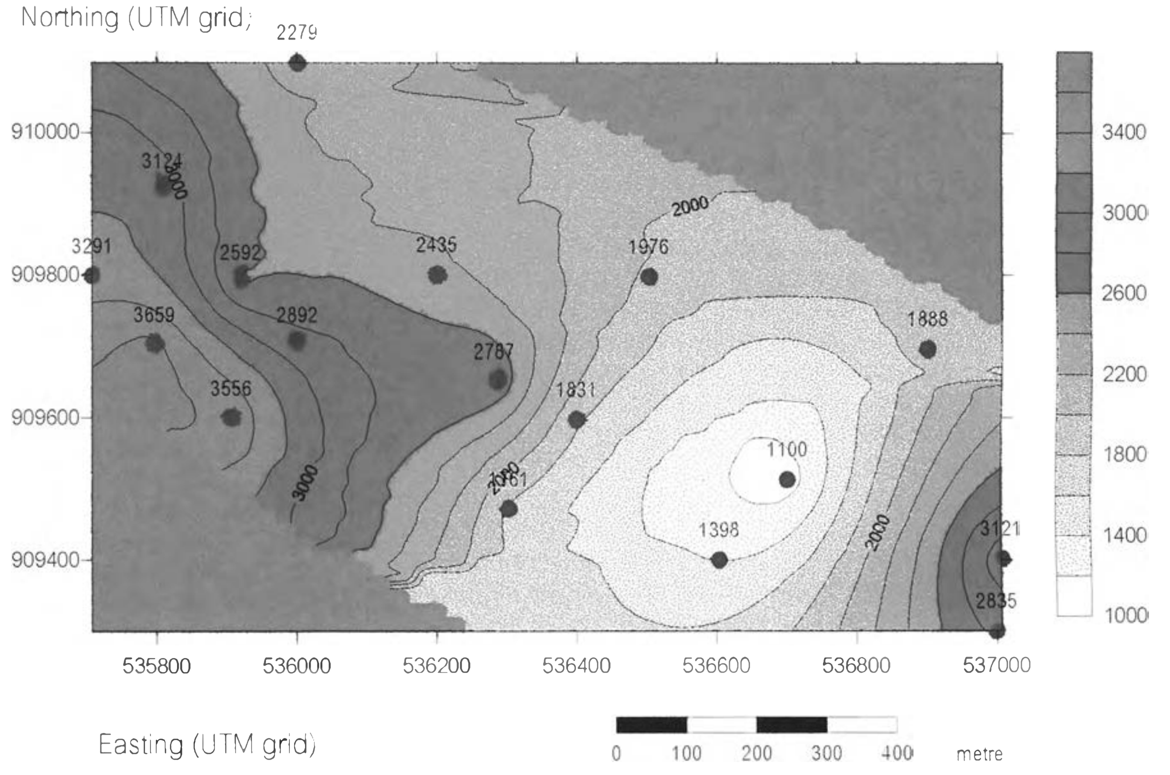
In the mine planning and decision, kriging estimate for coal quality modeling can delineate area, or zone of specific qualities. So direction of open-cast operation may be justified. As shown in Fig. 6.2, the higher quality values determined by heating values of Saba Yoi S3 seam is situated in the south of the Ban Sao sub-basin. If the coals with the heat content of 2,600-3,200 kcal/kg are required, mining front in the south should be done prior to the others. In some cases, blending the coals is more suitable, if the areas of interest contains variably higher and lower coal qualities (as shown from Foxpro database).

Since kriging estimation can be also applied to reserve estimation (Clark, 1976, Isaaks & Srivastava, 1989, Evan, 1951) of a specific area, the ratio of blending can be justified.

In addition, the drill-hole samplings can be determined using the variogram and kriging analyses (see also John et al., 1991, Davis, 1986). If the kriging variances of previous holes are relatively high in the designated areas, the shorter-spacing sampling pattern for next drill holes will then take into account. More importantly, variogram analysis can also be applied to the vertical sampling (e.g. designated sampling pattern in a descending order within the drill-hole). If the nearest previous hole data indicate high values of estimation variance, the new area with more-detailed spacing pattern is virtually required for a new drilling hole or in specific columns where high variance is anticipated.

For the optimum sample spacing, if the drilled core column contains a series of homogeneous, very massive coal seam with the thickness of more than 10 m and without clear partings, the original sample spacing pattern, e.g. 3 m apart, may have to be modified to a new one with the longer width, e.g., 5 m or more, for that homogeneous column.

From the result of variogram analysis in the study area, such as Nong Wa, Sin Pun area with another area ,e.g., North Kuan Klang, whose data are not adequate. The distance between new drilling holes in North Kuan Klang can be set by adopting ranges (or R-minor) from Nong Wa area. After the new area is drilled and additional data are available, the variogram of North Kuan Klang can be figured out again in order that the direction of coal deposit and ranges (or R-minor) are delineated.



Explanation

	=	degree of calorific value (CV), very high in dark red and decrease to white
	=	location of true value for CV
X-coordinate	=	easting (UTM grid)
Y-coordinate	=	northing (UTM grid)
contour interval	=	500 kcal/kg, contour line beginning at 1000-3500 kcal/kg

Fig. 6.2. Calorific value cut of 2600-3000, show in red shade, for Nong Wa P2 seam, Sin Pun area.

6.3 Application to Geologic Setting

At the beginning of the variogram analysis for coal quality (- such as ash content) of Sin Pun P1 seam, it is visualized that the variance is relatively high, and when variogram parameters (orientation, angular tolerance, and lag spacing) are applied for variogram analysis, the nugget-effect models are always encountered, implying no relationships among all the pair samples. Furthermore, it is assured that there are two fields when the input data are mostly clustered. After reassessing the data in the database system, it is observed that more data are concentrated in the northern and central parts of Nong Wa deposit, compared with those of the southern part (see Fig.3.3). For subsequent variogram analysis with the previously applied parameters, the new variances obtained became perceptibly lower, suggesting most relevant data sets for these two areas.

There exists controlling factors for the observable change in variances after applying new data sets. This can be explained geologically into two categories. One is the structural control, shown in Fig. 3.3, that the appearance of the fractures / faults may play an important role in variation in variogram results. However, since the faults are inferred as post-deposition, the structural feature appears not involved in the change in input variance, in turn indicating that faulting cannot disturb variance values, except those immediately at the fault plane. The other factor is the change in geological setting, or another word, the lateral-facies change. In this case, the continuity in sediment deposition may not be constant laterally from place to place. This perhaps may have caused the involvement of unrelated variance values of the same coal seam in the same basin which may have been triggered contained by changes in source supply, vegetation type, and clastic influxes. As a result, the coal quality may be dissimilar within the basin.