CHAPTER II

METHODOLOGY

Introduction

The general methodology of Quaternary geology study is originated base on the geomorphological interpretation for planning the detail fieldwork exploration. The physical geography within the investigated vicinity such as topography, landforms were discussed. Literature surveying of previous works together with mineral exploration reports were also collected. Geomorphological analyses using aerial photographs is the first step for classifying landforms into suitable units for detailed study. Subsequently, Quaternary sediment occurring in the area will be collected for the physical description and qualitative analysis to be able to explain the major geological processes and their source. An attempt to find out the duration of major geological events also carried out. Finally, some suggestion about gemstone exploration and assessment of its potential will be proposed as well. In short, the research methodology can be illustrated in fig. 2.1.

Data Collection

The previous reports and geologic maps, topographic maps and aerial photographs were collected. The major information sources for the research work are from the Mineral Resources Department of Thailand, Department of Geology, Chulalongkorn University, Department of Meteorology of Thailand, Royal Thai Survey Department .

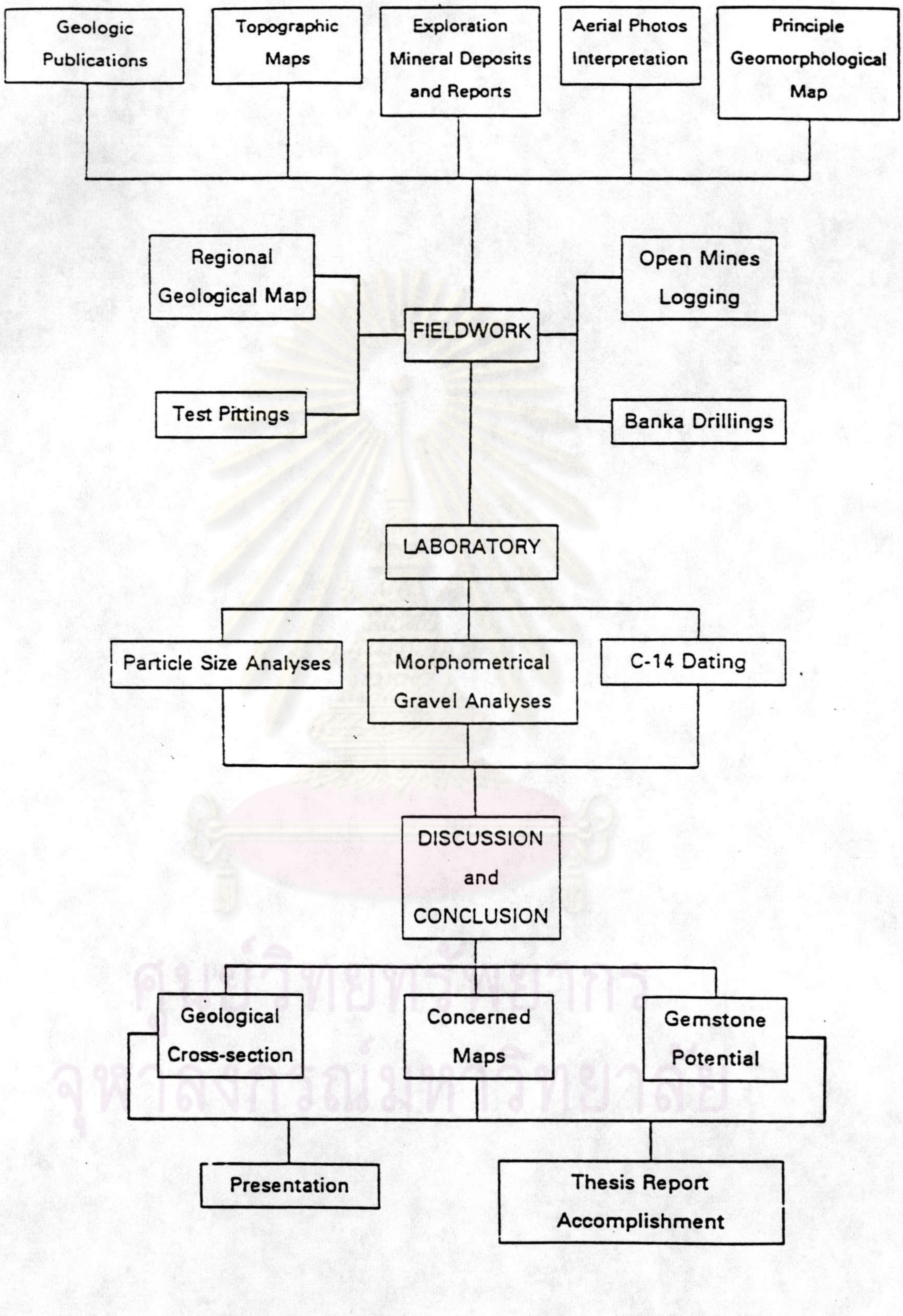


Figure 2.1 Flow chart illustrates the methodology using in this research.

The landform classification from aerial photograph interpretation was preceded and followed by primary geomorphological map construction. Airphotos coverage the large scale of the investigated area are as follows :

PRIORITY AREA 1 SHEET 3 OF 4

STRIP NUMBER	NEGATIVE NUMBER
18	1666-1664,1792-1791,1317-1315
17	1689-1694
16	1860-1865
15	1830-1836
14	1906-1913
13	2425-2431
12	2481-2488
11	2828-2837
10	2768-2774
9	3062-3065
8	3066-3068

PRIORITY AREA 6 SHEET 3 OF 23

STRIP NUMBER	NEGATIVE NUMBER
84	16670-16675
83	16652-16659
82	16608-16614
81	16594-16600
80	16550-16554

Index aerial photographic scale of the area priority 1 is approximately 1: 240,000 with approximate scale of photographs 1 : 40,000

Index aerial photographic scale of the area priority 6 is estimately 1: 300,000 with approximate scale of photographs 1: 50,000

Geological Study in the Field

Fieldwork in the area has been carried out after data collecting and interpretation of geomorphological features using aerial photographs. Geological survey as well as pitting and banka drilling has been done in order to obtain detail information of sedimentary characteristics.

1. Test Pitting

Based on the history of gemstone digging, the present mining activities together with the interpretation of Quaternary landforms, the locations for test pitting have been accordingly planned. Previously gem has been dug out from low-hills and shallow ground. It is observed that the locations of gem prospectings are commonly related to terrace landforms and residual deposits of the basaltic flow which are obscurely observed in aerial photographs. To delineate the boundaries of gemstone distribution is the main purpose of test pitting. A one by one squaremeter test pit is applicable to this study (Fig. 2.4). The depth of pitting generally depends on various factors such as the depth of bedrock, natural obstruction, e.g., the big-size looseblock, the hard-pan laterite, the occcurence of groundwater and capability of pitting equipments. The description using in test pitting study is following data formats :

a) Layer nomenclature : The different sedimentary layers were recorded in the terms of representative strata, for example, clay layer, sand layer, gravel bed, laterite layer etc.

b) Colour of strata : Muncell's rock color chart is carefully applied to classify all sedimentary layers which is adventageous to their stratigraphic correlation.

c) Sediment components : Both major and minor sediment composition will be noted together for identification of sedimentary types , for example, slightly sandy clay, silty sand, clayey silt ,etc.

d) Particle size : Sedimentary size measurement were adopted after the slightly modified Wentworth's such as illustrated in Table 2.1.

Table 2.1 Modification Wentworth's scale using in this field investigation.

NAME		SIZE
Clay		< 1/512 mm.
Silt		1/512-1/32 mm.
Sand	Fine	1/32-1/8 mm.
	Medium	1/8-1/4 mm.
	Coarse	1/4-1 mm.
Gravel	Granules	1-2 mm.
	Pebbles	2-32 mm.
	Cobbles	32-128 mm.
	Boulders	> 128 mm.

e) Particle shape : The sphericity and roundness of particles are also considered. The sphericity is divided into low and high while roundness is classified to very angular, angular, subangular, subrounded, rounded and well rounded. The determination of both properties has been done by visual mean modified after Pettijohn et al., 1962.

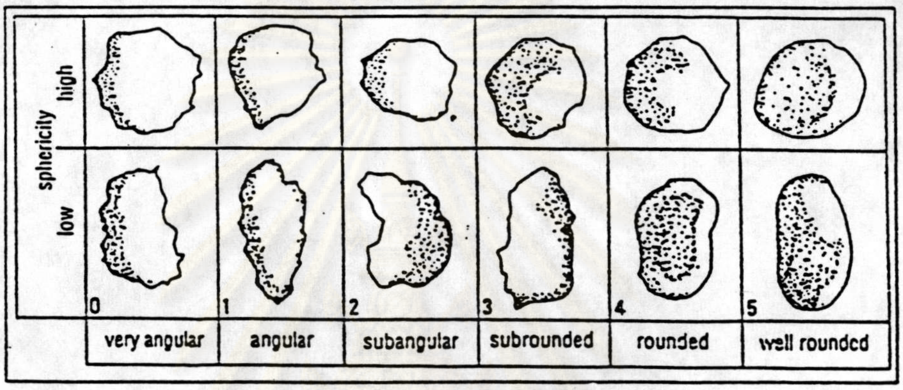


Figure 2.2 Visual determination of sphericity and roundness using in the field.

(Modified after Pettijohn et al., 1962)

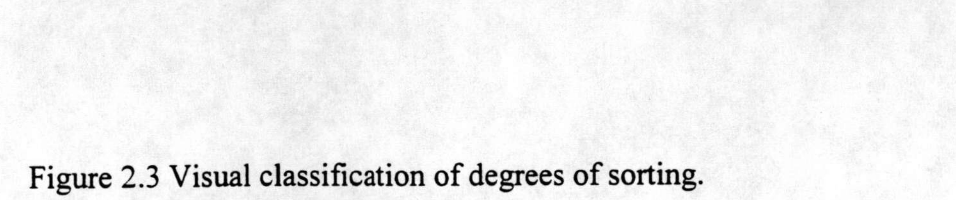


Figure 2.3 Visual classification of degrees of sorting.

(Modified after Pettijohn, 1962)

f) Grain sorting : In the field, the general description of grain sorting can be divided into five levels such as very well sorted, well sorted, moderately sorted, poorly sorted, very poorly sorted as illustrated in fig. 2.3.

g) Mottle or concretions : The pisolitic concretion was abundantly observed in the upper part of the general profile, especially the central region of the area. In this way, the mottle or concretion will be recorded too.

h) Associate minerals : Other minerals occurring especially in gravel strata will be recorded, for example, corundum, spinel, pyroxene, magnetite, olivine, etc.

i) Layer contact : Naturally, the deposition of the unconsolidated sediment will not be continuously accumulated. So, the recording of depositional layer contact can indicate the continuation of the deposition. The general recording in layer contact can be divided into sharp (changing between 1-3 cm.), gradual (changing between 3-10 cm.) and unclear contacts (changing more than 10 cm.).

Other informations such as the total depth of pit, some fossil evidences, the appearance of sedimentary structures are necessarily recorded too. The sample collected from gravel beds will be carefully looked for gemstones using wood-panning. (Fig. 2.5)

Figure 2.4 One square-meter pit using in this fieldwork.

2. Banka Drilling

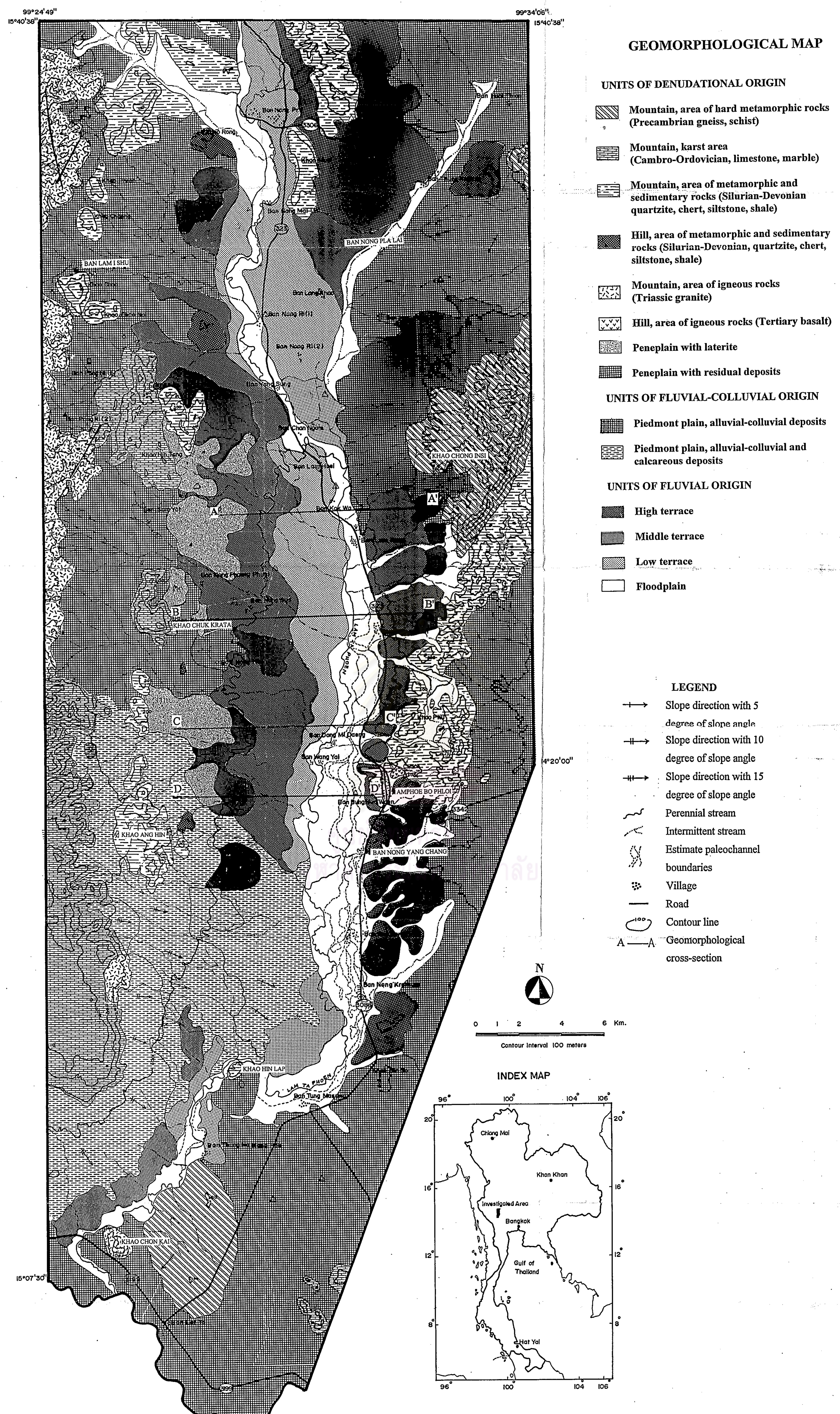
In place, especially within the flat area in the central part of the Bo Phloi Basin where the gemstone placer occurs at depth too deep for pitting. Instead, Banka drilling, modified from tin-placer exploration, is most applicable sampling method (fig. 2.6).

On the basis of colour changing, particle size distribution and various kind of particles were considered to collect every representative sample layers. The simple method for gemstone distribution testing as similar to pitting procedure which using wood-panning was also provided.

Figure 2.5 Wood-panning for gemstones.

Figure 2.6 Banka drilling is applied to collect samples in the middle part of the area.

PLATE I



GEOMORPHOLOGICAL MAP
UNITS OF DENUDATIONAL ORIGIN
Mountain, area of hard metamorphic rocks (Precambrian gneiss, schist)
Mountain, karst area (Cambro-Ordovician, limestone, marble)
Mountain, area of metamorphic and sedimentary rocks (Silurian-Devonian quartzite, chert, siltstone, shale)
Hill, area of metamorphic and sedimentary rocks (Silurian-Devonian, quartzite, chert, siltstone, shale)
Mountain, area of igneous rocks (Triassic granite)
Hill, area of igneous rocks (Tertiary basalt)
Peneplain with laterite
Peneplain with residual deposits
UNITS OF FLUVIAL-COLLUVIAL ORIGIN
Piedmont plain, alluvial-colluvial deposits
Piedmont plain, alluvial-colluvial and calcareous deposits
UNITS OF FLUVIAL ORIGIN
High terrace
Middle terrace
Low terrace
Floodplain
LEGEND
Slope direction with 5 degree of slope angle
Slope direction with 10 degree of slope angle
Slope direction with 15 degree of slope angle
Perennial stream
Intermittent stream
Estimate paleochannel boundaries
Village
Road
Contour line
Geomorphological cross-section
N
0 1 2 4 6 Km.
Contour Interval 100 meters
INDEX MAP
Chiang Mai
Khon Khan
Investigated Area
Bangkok
Gulf of Thailand
Hat Yai
99°24'49"
99°34'08"
15°40'38"
15°07'30"
BAN LAM I SHU
BAN NONG PLA LAI
KHAO CHONG INSI
KHAO CHUK KRATA
AMPHOE BO PHLOI
BAN NONG YANG CHANG
KHAO ANG HIN
KHAO HIN LAP
KHAO CHON KAI
LAM TA PHOEN

Laboratory Analyses

Morphometrical gravel analyses and particle size analyses are applied to describe shape of gravel and size distribution of unconsolidated sediment respectively. Furthermore, the existence of wood fragments collected from a sedimentary layers overlying on the gemstone-bearing gravel beds may indicate that this area had been immediately flooded in the past. The flood event will be verified by dating the age of wood fragments using radiocarbon method. A total of twelve samples of gravel are for morphometrical gravel analyses, nineteen samples of sand are for particle size analyses, and seven samples of wood fragments are for C-14 age determination.

1. Morphometrical Gravel Analyses

The shape of rock fragments and gravels, especially roundness are significant evidence because they illustrates their lithological characteristics, the environment of their deposition and distance traversing from source. The simple method as widespread application is proposed by Cailleux (1956, in Thiramongkol, 1975) due to these method is less time-consuming than others, and applied to studied gravel shape in this study.

Fifty stones within one square-meter of the ground or layer was selected and measured. The stones were segregated lithologically for measurement.The general size of stones for this study was limited less than six centrimetres in diameters (Thiramongkol, 1975).

The stone is classified in terms of length, breadth, height and radius of curvature which can be described in term of two indices as follows :

1. Index of flatness $\frac{L+l}{2E} \times 100$

2. Index of roundness $\frac{2r}{L} \times 1000$

where L is length, l the width, E thickness or height, r the least radius of curvature in the principal plane.

Figure 2.7 Parameters used for morphometric analysis in the method of Cailleux. (1956, in Thiramongkol, 1975)

The relationship of morphometric parameters will be illustrated in a form of graphic presentation in regard to roundness and flatness of stones. Cailleux (1956) (in Thiramongkol,1975), suggested the index of roundness of stones within the most environments and processes with a range of a minimum 0 to 1000, and 100 for minimum flatness to a theoretical maximum of infinity. Thiramongkol (1975) proposed a comparision of roundness and degree of roundness from the result of his laboratory testing and his experience from the field that provided as below figure .

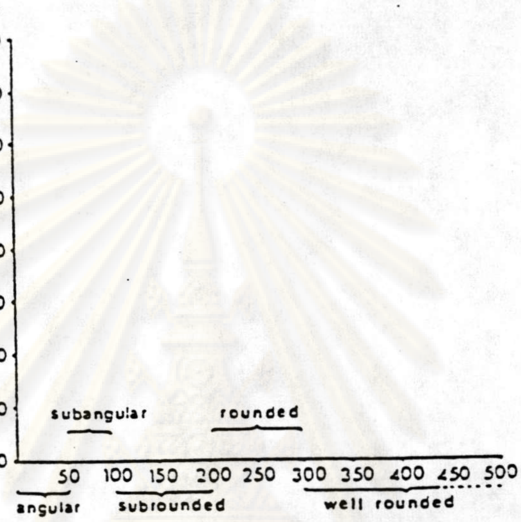


Figure 2.8 A comparision of degree and index of roundness of stones after measured by Cailleux method (After Thiramongkol, 1975).

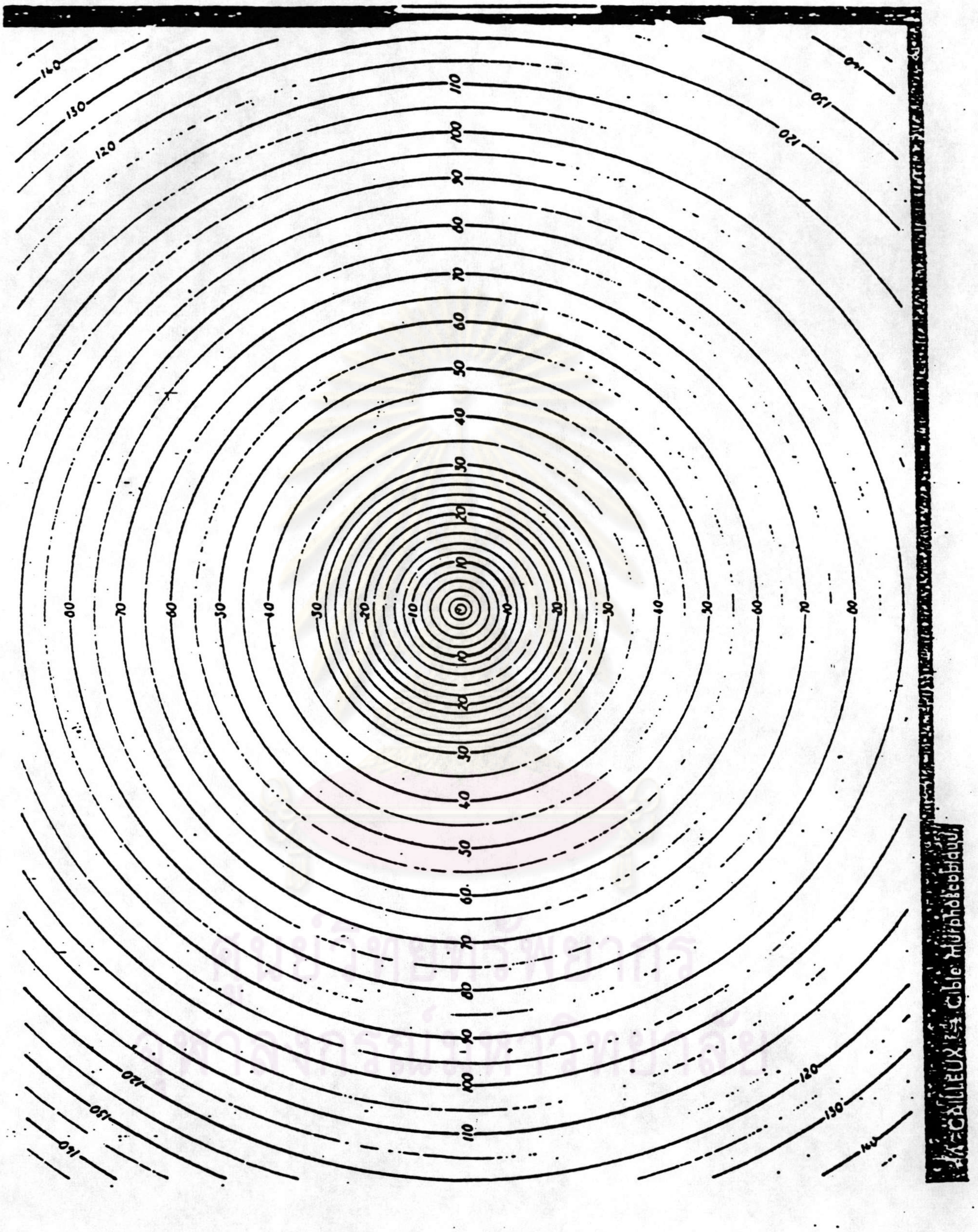


Figure 2.9 Scale for morphometric analysis of stone (After Cailleux, 1956, in Thiramongkol, 1975)

2. Particle Size Analyses

Sieve analysis was used in this research in order to describe particle size distribution. All sample that combined from this area was dried and not nescessary to pretreatment. Sand samples from the field will be prepared by cone and quartering sampling method which can be selected the representative samples before sieving test .

About 100-500 grams of dried samples were firstly weighed and filtered by using electrical shaking sieve. The automatic shaking apparatus contains normally nine sieves. The number of meshs are vary which depending on size of samples. A several meshs are 9, 10, 20, 35, 40, 45, 60, 120 and 230 with diameter 2.000, 1.651, 1.000, 0.841, 0.500, 0.420, 0.355, 0.250, 0.125 and 0.063 millimeters, respectively. Nineteen samples of sand from each layer in the profile of open mines were also analysed using the above epuipment and method.

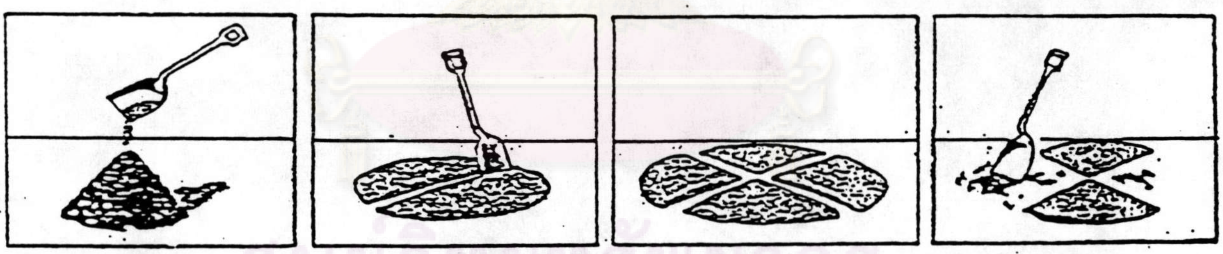


Figure 2.10 Cone and quatering sampling method as applied to divide sand sample before sieving test.(Meechumna, 1994)

The weight of each sample from sieve apparatus in a term of weight retained will be recorded. Normally, sieve loss after sieving test is not more than one per cent. The percent of weight retained and cumulative weight retained will be calculated and presented. Various graphic representative of size relationship, for instance, cumulative weight frequence and diameter in millimetres will be provided and ploted in both semi-log and phi scale which have a relation as below equation and figure.

$$\phi = -\log d$$

where ϕ as phi scale and d as the particle diameter in millimeters.

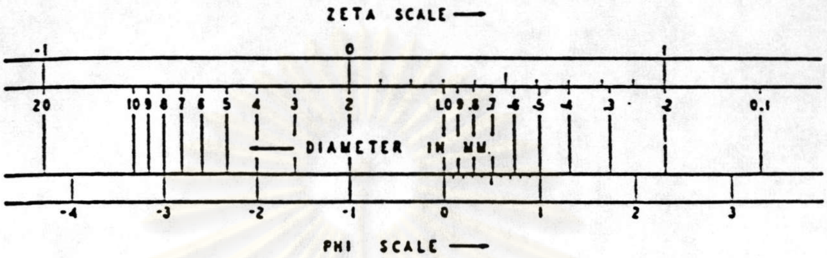


Figure 2.11 Relations between logarithmic grade scale and diameters in millimeters, the phi scale to Wentworth grades. (Krumbein and Pettijohn, 1938)

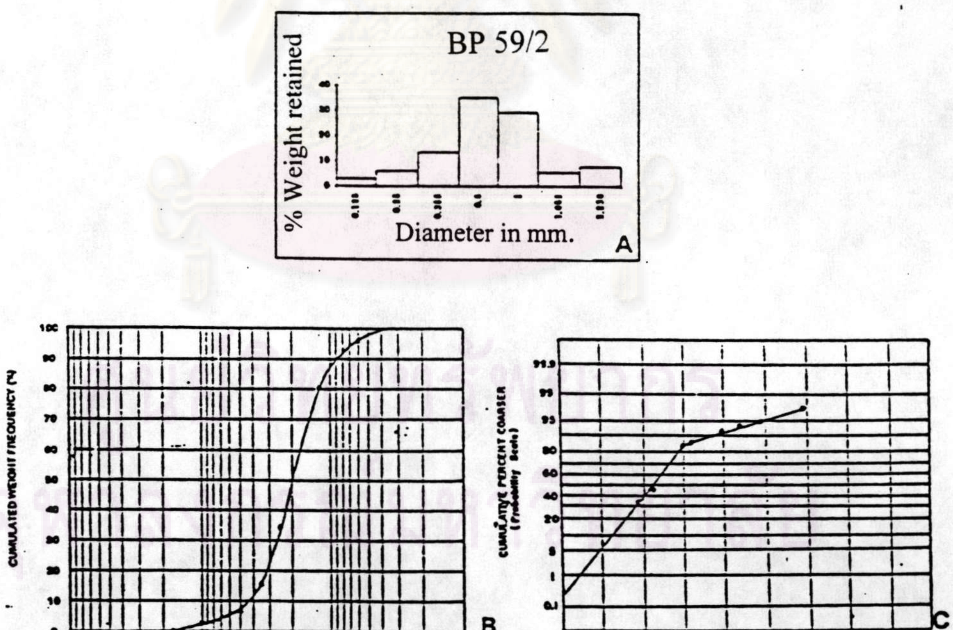
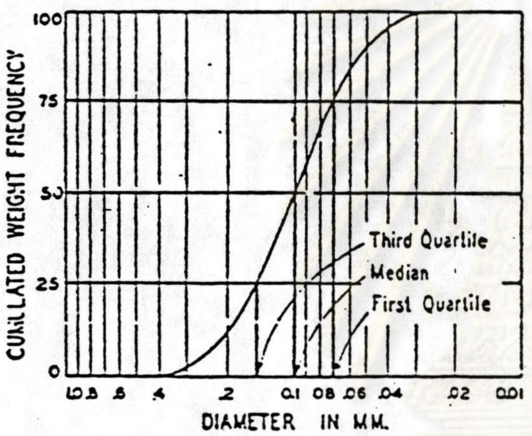


Figure 2.12 Three types of size distribution plots. A) histogram of normal size distribution, B) S-curve when using log-scale plots and C) phi scale plot for degree of sorting calculation.

Following Trask (1932, in Thiramongkol, 1975), the methodology of degree of sorting calculation by using stratigraphical values from cumulative weight frequency and diameter plots with logarithmic scale was mentioned as below equation.

$$\text{Coefficient of Sorting (So)} = \sqrt{Q3/Q1}$$

when Q1 is first quartile and Q3 is third quartile.



So-values	Sorting class
<2.5	well sorted
2.5 to 4.5	normally sorted
>4.5	poorly sorted

Figure 2.13 Method of reading median and quartiles from cumulative curve (Krumbein and Pettijohn, 1938) and a sorting value after calculated by quartile measure by Trask ,1932. (In Thiramongkol, 1975).

The descriptive statistics are used to describe, in quantitative terms, the shape of the particle size distribution. They involve the calculation of diagnostic values, known as size parameters (Briggs, 1977). In this study, the size parameters can be calculated directly from the graph of particle size distribution on phi against probability scales. The summary of the major size parameters, and methods of graphically extracting them, are summarized as follow table.

Table 2.2 Graphical measures for descriptive statistic terms. (modified from Briggs, 1977 and Friedman and Sanders, 1978).

Descriptive Terms	Friedman and Sanders (1978)	Brigg (1977)
MEAN	$\frac{\phi16+\phi50+\phi84}{3}$	$\frac{\phi75+\phi50+\phi25}{3}$
STANDARD DEVIATION	$\frac{\phi84-\phi16}{4}-\frac{\phi95-\phi5}{6.6}$	—
SORTING	$1/2(\phi95-\phi5)$	$\frac{(\phi90+\phi80+\phi70-\phi30-\phi20-\phi10)}{5.3}$
SKEWNESS	$(\phi95-\phi5)-2\phi50$	$\frac{(\phi84-\phi50)}{(\phi84-\phi16)}-\frac{(\phi50-\phi10)}{(\phi90-\phi10)}$
KURTOSIS	$\frac{(\phi95-\phi5)}{2.44(\phi75-\phi25)}$	$\frac{\phi90-\phi10}{1.9(\phi75-\phi25)}$

From a table above, it can be divided the parameters into two main groups. The central tendency of the distribution is median and mean values. Sorting, kurtosis and skewness are defined as scatter and non-normallity of the distribution.

The Phi Median, median is the value which divides the distribution into two equal halves. The median is calculated from the particle size distribution by location of the 50th percentile, and calculated from the size measurements in millimeters. For this research, the phi scale be used in size analysis, and the median should be computed from the phi values which taken from the graph of the particle size distribution.

The Phi Skewness, skewness is the deviation or asymmetry and gives an assessment of the non-normality of a distribution. The distribution can be positively of negatively skewed. Positive skewness represents a fine tail to the distribution, negative skewness a coarse tail. Normally, a results of skewness varies within the range -1.0 to

+1.0 in the equation, but most sediments do not exceed -0.8 to +0.8 . A normal distribution would have a skewness, measured by the equation, of 0.0.

Phi Sorting, sorting is a measure of dispersion of scatter, and is simple an expression of the standard deviation of the size distribution. Commonly, in case of sediments, it seems frequently to be correlated with the mean ; very coarse or very fine deposit tend to have a high standard deviation (are poorly sorted), whereas sands have a relatively low standard deviation (are well sorted). It can be noted that a high degree of sorting is represented by a low sorting value.

Phi Kurtosis, kurtosis is a more abstract parameter than sorting. It measures the peakedness of the size distribution and is therefore related both to sorting and the degree of non-normality of the distribution (Briggs, 1977). It can be observed that a well sorted sediment may have more peaked distribution than normal curve. Generally, the range of kurtosis values varies from about 0.5 to 3.5. The normal distribution has a value of 1.0.

Table 2.3 Descriptive terms for sorting, kurtosis and skewness, measured on phi scale of diameters and probability scale of cumulative weight percent. (Modified from Briggs, 1977)

Sorting		Kurtosis		Skewness	
Very well sorted	< 0.35	Very platykurtic	< 0.67	Very negatively skewed	-1.0—-0.3
Well sorted	0.35-0.50	Platykurtic	0.67-0.90	Negatively skewed	-0.3—-0.1
Moderately well sorted	0.50-0.70	Mesokurtic	0.90-1.11	Symmetrical	-0.1 -0.1
Moderately sorted	0.70-1.00	Leptokurtic	1.11-1.50	Positively skewed	0.1-0.3
Poorly sorted	1.00-2.00	Very leptokurtic	1.50-3.00	Very positively skewed	0.3-1.0
Very poorly sorted	2.00-4.00	Extremely leptokurtic	> 3.00		
Extremely poorly sorted	>4.00				

Table 2.4 Classification of sands into sorting classes based on standard deviation. (Friedman and Sanders, 1978).

Ranges of Values of Standard Deviation (φ units)	Sorting Class	Environments of Sands
< 0.35	Very well sorted	Coastal- and lake dunes; many beaches (foreshore); common on shallow marine shelf.
0.35–0.50	Well sorted	Most beaches (foreshore); shallow marine shelf; many inland dunes.
0.50–0.80	Moderately well sorted	Most inland dunes; most rivers; most lagoons; distal marine shelf.
0.80–1.40	Moderately sorted	Many glacio-fluvial settings; many rivers; some lagoons; some distal marine shelf.
1.40–2.00	Poorly sorted	Many glacio-fluvial settings.
2.00–2.60	Very poorly sorted	Many glacio-fluvial settings.
> 2.60	Extremely poorly sorted	Some glacio-fluvial settings.

Bivariate scattergrams is often ploting the size parameters which can be used as a basis for further study. There are graphs of any two size parameters (e.g. skewness and kurtosis, phi sorting and phi mean). They are of particular value in paleo-environment studies, where the aim is to identify the depositional environment of sedimentary deposits, and are also used as an aid to classification and correlation of sediments. (Briggs, 1977). It was concluded that bivariate plots of skewness against kurtosis, or mean size against sorting can utilize to distinguish sediments from different environments.

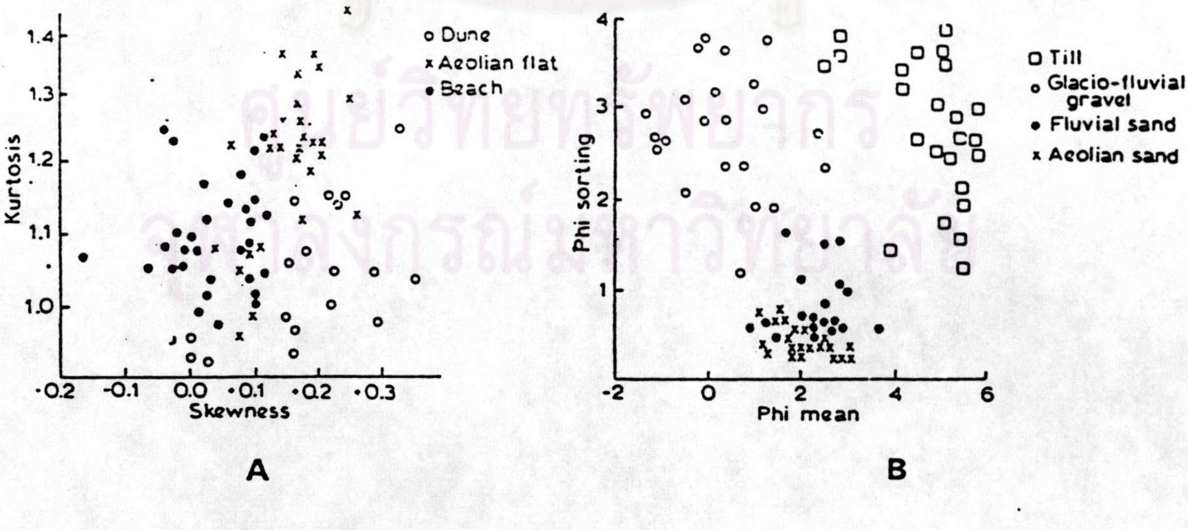


Figure 2.14 Bivariate scattergrams for selected sediments from various environments. A) kurtosis and skewness, and B) mean size and sorting. (Briggs,1977).

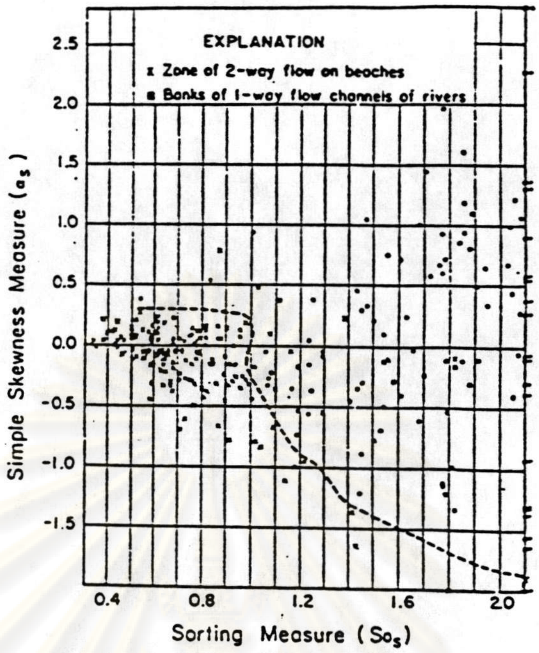


Figure 2.15 Scatter plot, simple skewness measure versus simple sorting measure for beach and river sands. (After Friedman and Sanders, 1978)

3. <u>Radiocarbon Dating</u>

The general methodology to analysed the relative age of Quaternary deposit by using C-14 dating was commonly mentioned. In the field, big tree remained and abundant wood fragments were observed especially over the gemstone-bearing gravel bed. Seven representative wood samples were selected to indicate the age of deposition. The author presumed that the flooding processes have been occurred widespreadly in the area, emphatically the central part of this basin, so that the result of these wood age dating will be suggested the time of these flooding event.

Carbon-14 is produced in the earth's upper atmosphere by the bombardment of atmospheric nitrogen by cosmic-ray produced neutron. It is taken up directly by green plant photosynthesis, or less directly by other organisms through food chains.

The amount taken up in this way is in much the same proportion to stable carbon as exists in the atmosphere. This exchange ceases on death, where upon the unstable carbon-14 is subject to radioactive decay. By measuring the amount of radioactivity in a fossil sample, comparing it with a modern standard, and armed with a knowledge of its rate of decay (half-life), it will be possible to calculate the time that has elapsed since death. This allows the dating of geological events with which the sample was contemporaneous. It is assumed that the rate of carbon-14 production over time was constant. (Bowen, 1978).

Production : $^{14}_{7}N$ + n ————> $^{14}_{6}C$ + P

atmospheric nitrogen, free neutron, carbon-14, proton

Decay : $^{14}_{6}C$ ————> $^{14}_{7}N$ + β

carbon-14, nitrogen, beta particle

The amount of carbon-14 in a sample is determined by measuring its beta particle activity. This is achieved by various counter systems operated over long periods so as to accumulate a statistical reliability for the number of counts per sample. It is necessary for a long count because radioactive decay is a spontaneous process. At least 10,000 counts will be required if an accuracy to ± 1 percent is desired, which takes about 24 hours. Radiocarbon dates are , therefore, always reported in the form of a ± error in years. (Bowen, 1978)

The sources of error of radiocarbon dating are uncertainties in the initial carbon-14 per carbon-12 ratio, contamination of modern material with a samples, a long term changes in atmospheric carbon-14 content, and fractionation in young samples.