CHAPTER II

METHODOLOGY

The methodology to study geomorphology is of interest at the moment. Many researchers have attempted to find the way to emphasize on particular geomorphological matter. In the present study, the author uses the basic concept to reach such a method. The detailed field investigation and laboratory analyses are two most important counterparts for this study. At first, literature survey of previous works was carried out. Geomorphological analysis using aerial photographs is the next step for classifying particular landforms into appropriate units used as a guide for further study in detail. Consequently, fieldwork was carried out to investigate the presentation of major geological evidences. Intensive sampling of surficial materials was also launched in the field to bring back any ample evidences for the laboratory analysis. The sediments were collected for the physical sorting. Quantitative analysis is introduced to be able to detrmine their characteristic, sources of materials, stratigraphic integrity, their processes, and their palaeoenvironment.

The method of study is summarized showing on flow chart in Figure 2.1 and can be grouped into 5 steps as follow:

Data collection

This step is to study principle geomorphology with special emphasis on fluvial processes, form, and their material properties. Then, collect and criticise previous works, prepare every basic base map as topographic map, geological maps and their reports, aerial photographs, and other concerned maps of the area. The major information comes from Department of Geology, Chulalongkorn University, Department of Mineral Resources of Thailand, Royal Thai Survey Department, Land Development Department, and Department of Meteorology of Thailand.

Interpretation of Aerial photographs

The map showing distribution of various different geomorphological units were interpreted from black and white aerial photographs of Worldwide Survey (1954) with scale

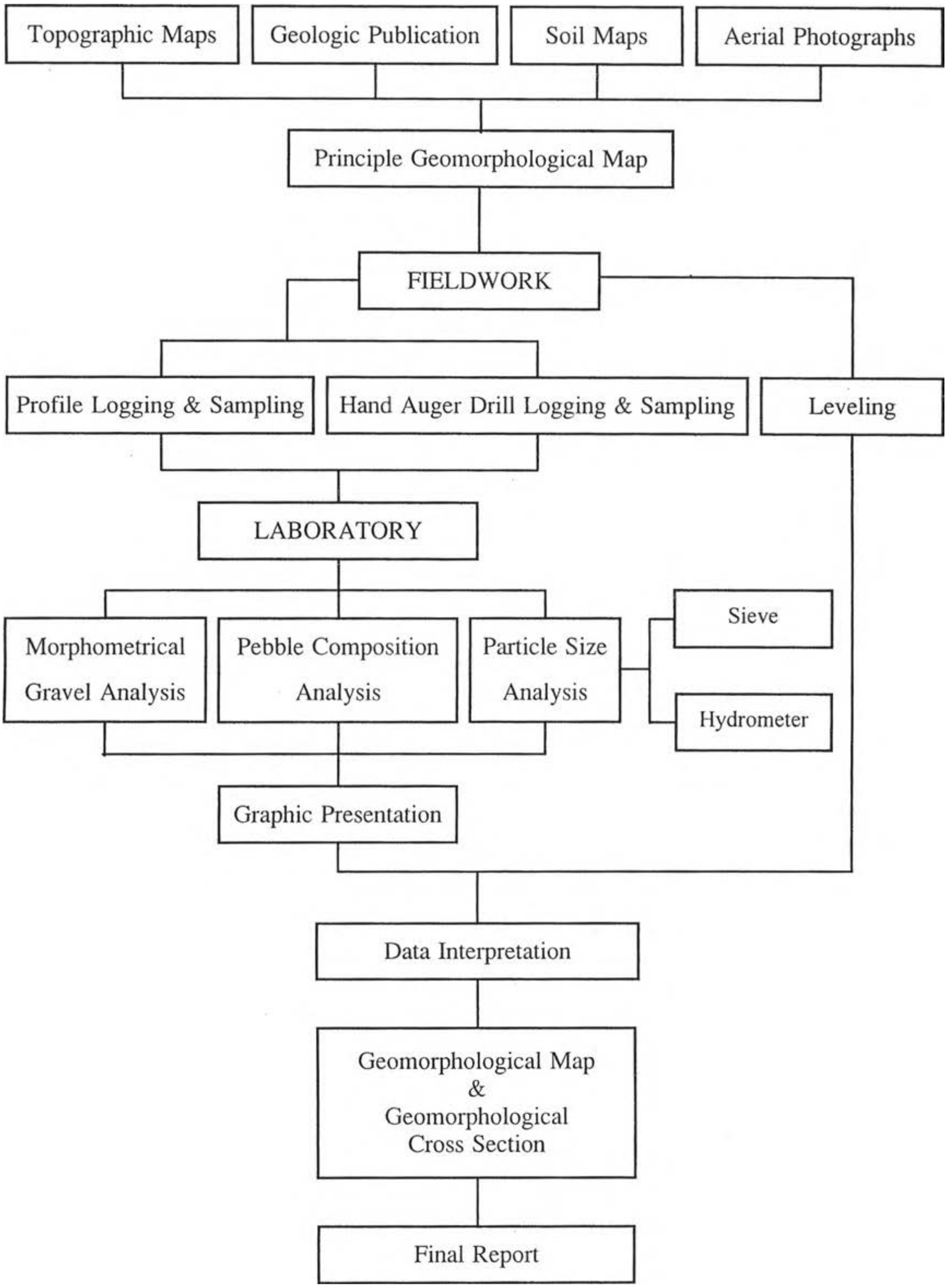


Figure 2.1 Flow chart illustrates the methodology using in this research.

approximately of 1:50,000. Moreover, aerial photographs are able to use to navigate the pre-selected sample sites and their accessibility.

Maps used for this study include topographic map (1969) with a scale of 1:50,000 of Amphoe Ban Tak (Sheet 4843III) and soil map with a scale of 1:100,000 of Changwat Tak.

The landform classification from aerial photographs was preceded and followed by primary geomorphological map construction. Air-photos covering the study area are as following numbers:

Priority Area 6 Sheet Number 15

Strip Number	Negative Number
47	8593-8596
48	8598-8602
49	11179-11181

Field investigation

In this study, field investigation was focused on the study of landforms and their characteristics especially terrace profiles, which exposed by river cutting and quarrying. Then, sample collecting was carried out; gravels for morphometrical gravel analysis and pebble composition analysis; sand, silt, and clay for particle size analyses. This involved the collection of both quantitative and qualitative information so that not only could the physical character of the materials be analyzed, but also interpretations could be made regarding to source materials, stratigraphic relationships, relative ages, and the environmental conditions under which the materials might have evolved (Thiramongkol, 1975).

Where the unconsolidated material contained rock debris above sand particle size, lithology and percentage proportions of difference sizes of fragments were recorded, and morphometric analysis was carried out (Cailleux, 1956, quoted by Thiramongkol, 1975). Moreover, pebbles sampling for pebble composition analysis were also carried out in the field. In this study, fifty stones within one square-meter of the ground or layer were selected for morphometrical gravel analysis and pebble composition analysis (Figures 2.4 a, b).

Hand auger is the most applicable tool used in the field investigation for fine sediments (Figure 2.5). The sampling site was first marked on aerial photographs. The samples from boreholes will be recorded and described such as depth, color, and physical properties of sediments in different levels (Figure 2.6).

The description using in field survey is following data formats:

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

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

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

d) Particle size: The size measurement is slightly modified after Wenworth's as follow:

Name		**Size**
Clay		<1/256 mm
Silt		1/256-1/16 mm
Sand	Fine	1/16-1/4 mm
	Medium	1/4-1/2 mm
	Coarse	1/2-2 mm
Gravel	Granules	2-4 mm
	Pebbles	4-64 mm
	Cobbles	64-256 mm
	Boulders	>256 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 Compton, 1985.

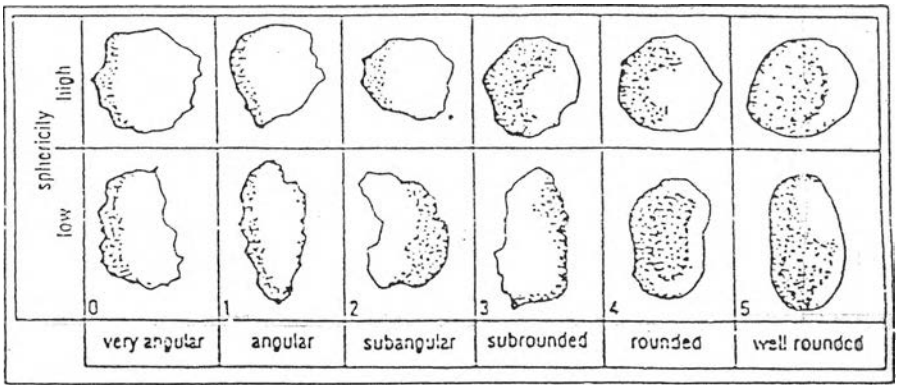


Figure 2.2 Visual determination of sphericity and roundness using in the field.

(Modified after Compton , 1985)

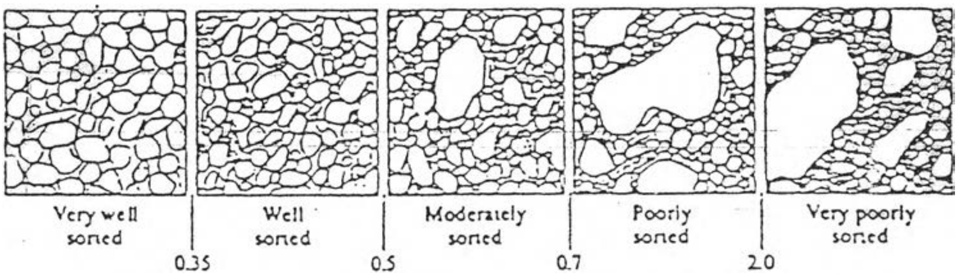


Figure 2.3 Visual classification of degree of sorting.

(Modified after Pettijohn et al., 1957)

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 Figure 2.3.

g) Mottle or concretions: The pisolitic concretion was abundantly observed in the profile. In this way, the mottle or concretion was recorded too.

h) Layer contact: Naturally, the deposition of the unconsolidated sediment will not be continuously accumulated. Thus, the recording of the 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).

a

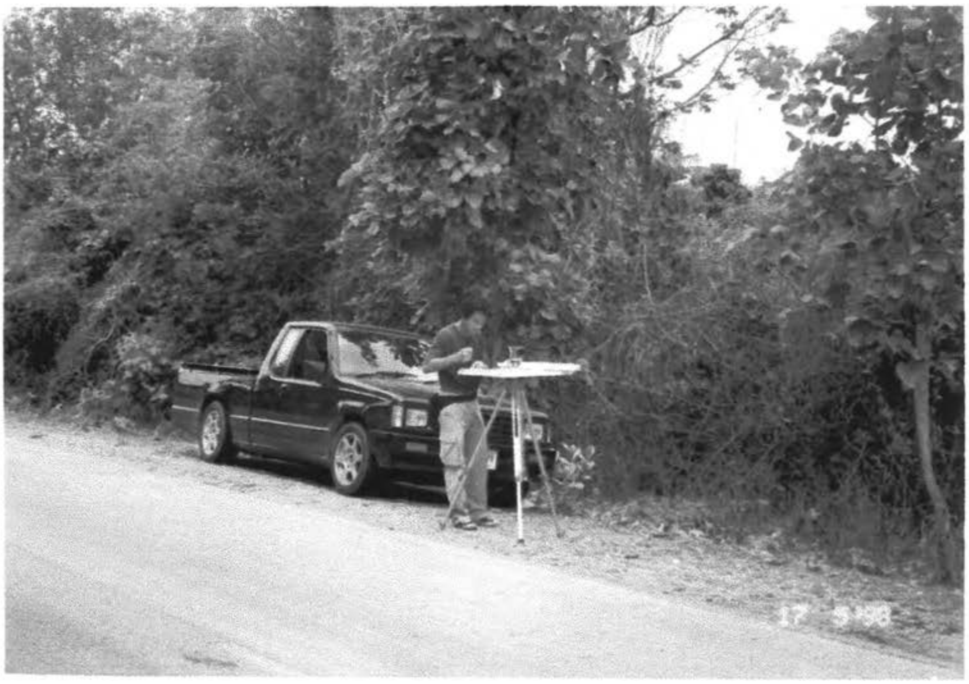
b

Figure 2.4 a, b Fifty stones within one square-meter of the ground or layer were selected for morphometrical gravel analysis and pebble composition analysis

Figure 2.5 Hand auger is the most application tool used in the field.

Figure 2.6 Samples from borehole were recorded and described.

a



b

Figure 2.7 a, b Survey work to see cross section of the area, slope, width, altitude and distance from main river were measured.

Other informations such as the total depth of pit or profile, the appearance of sedimentary structures are necessarily recorded too.

Furthermore, survey work to see cross section of river, slope, width, altitude and distance from the main river of some geomorphological unit was measured by survey camera equipment (Figures 2.7 a, b).

Laboratory investigation

Morphometrical gravel analyses

This method is proposed by Cailleux (1956) (Quoted by Thiramongkol, 1975) to classify gravel shapes. The shape and roundness of rock fragments are of special interest because they reflect the environment of their formation and distance traveled from source as well as their lithological characteristics (Thiramongkol, 1975).

The stones within one square meter of the ground, 50 stones were simply selected and measured. The stones from different rock types tend to have different characteristic shapes that will be segregated lithologically for further shape measurement. The size of stones will be limited less than 6 cm. in diameters (Thiramongkol, 1975).

The stone is classified in terms of length, breadth, height and radius of curvature that 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 of height, r the least radius of curvature in the principal plane as shown in Figure 2.8.

Figure 2.8 Parameters used for morphometric analysis in the method of Cailleux.

Scale for morphometric analysis of stone is shown in Figure 2.9 (After Cailleux, 1956, quoted by Thiramongkol, 1975).

Pebble composition analysis

Pebble composition analysis of the terrace sediments were carried out in this study by using pebbles with a diameter > 2 cm. The type and color of the pebbles were determined on fresh rupture surfaces. The pebbles were gathered from as a small surface as possible, mostly of 1 square meters. Great many components were distinguished in the counting but many of them have been united into groups in the diagrams, for the sake of clearness.

Particle size analysis

Particle size analysis is one of the most widely use methods of investigation of unconsolidated geological materials (Gale and Hoare, 1991). Fluvial geomorphologists are interest in the particle sizes transported by floods of different sizes. Particle size plays an important part in so many geomorphic processes that the analysis of particle size takes place in most geomorphology laboratories (Mayer, 1990)

This method was carried out in order to describe particle size distribution. Samples from the field were prepared by cone and quartering sampling method, which can be selected the representative samples before test. In this study, the method for determining the distribution of particle size was subdivided into two categories that relate to size of materials. Sand, material finer than 2.00 mm and coarser than 0.0625 mm, was analyzed by mechanical sieving. Particle finer than 0.0625-mm, silt and clay or finer fraction was analyzed by hydrometer method.

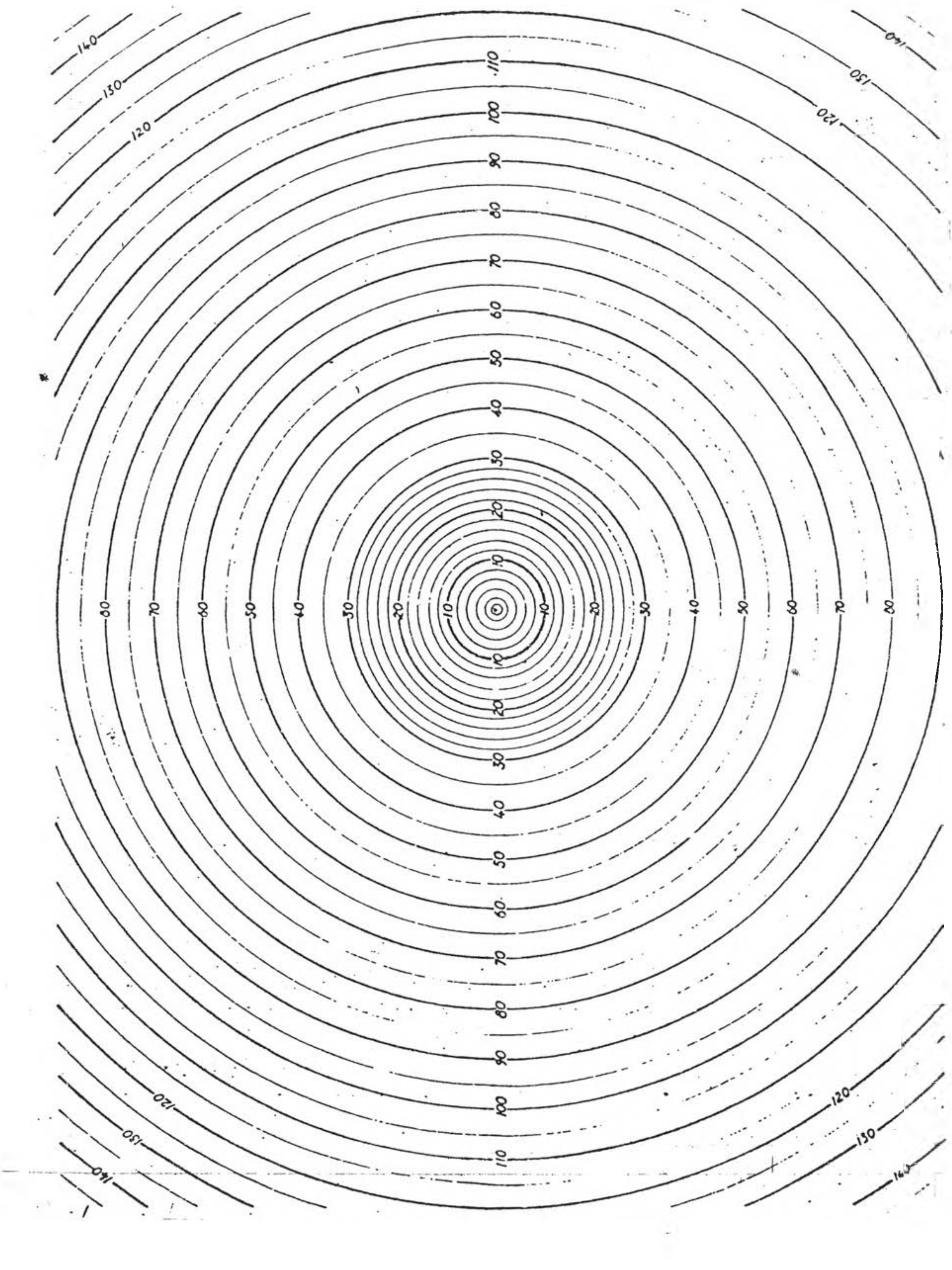


Figure 2.9 Scale for morphometric analysis of stone (After Cailleux, 1956, quoted by Thiramongkol, 1975)

Sieve analysis

The size fractionation was done on 400 grams sample by splitter. Large lumps was broken down by gloved hand; relatively dry clods may be reduced in size by careful use of a pestle and mortar, but fragile clasts must not be damaged (Gale and Hoare, 1991). Dried samples were weighed and filtered by using electrical shacking sieve. The automatic shacking apparatus using in this study contains normally seven sieves. The coarse fractions will be separated into granule (>10 mesh), very coarse sand (18-10 mesh), coarse sand (35-18 mesh), medium sand (60-35 mesh), fine sand (120-60 mesh), and very fine sand (230-120 mesh) size fraction by using sieve apparatus. 78 samples were analyzed using the above equipment and method.

The weight of each sample from sieve apparatus in term of weight retained was recorded. Normally, sieve loss after sieving test is not more than one per cent. The percent of weight retained was calculated and presented.

Hydrometer analysis

The hydrometer analysis is base on strokes' law which gives the relationship among the velocity of fall of spheres in a fluid, the diameter of the sphere, the specific weight of the sphere and of the fluid, and the fluid viscosity, In the equation form this relationship is

$$v = \frac{2}{9}\,\frac{Gs - Gf}{\eta}\,(D/2)^2 \qquad (2.1)$$

where v = velocity of fall of the spheres, cm/s

Gs = specific gravity of the sphere

Gf = specific gravity of Fluid - varies with temparature

η = absolute, or dynamic, viscosity of the fluid, dyn s/cm^2 [or g/(cm s)]

D = diameter of sphere, cm

G = 980.7 cm/s^2 (acceleration of gravity)

1 g =980.7 dynes (grams force)

Solving equation 2.1 for D and using the specific gravity of water Gw. We obtain

$$D = \sqrt{\frac{18\eta v}{Gs-Gw}} \tag{2.2}$$

For computation purposes, Eq. (2.2) is usually rewritten using L in cm and t in min to obtain D in mm as follows:

$$D = K\sqrt{\frac{L}{t}}\ \text{mm} \tag{2.3}$$

where $$K = \sqrt{\frac{30\eta}{(Gs-1)}} \tag{2.4}$$

Note that the value of K is a function of Gs and η, which are dependent on the temperature of the test. Table 2.1 gives the variation of K with the test temperature and the specific gravity of soil solids.

Table 2.1 Values of K from Eq. (2.3) (after ASTM (1991) quoted by Das, 1994)

t (°C)	Gs							
	2.45	2.50	2.55	2.60	265	2.70	2.75	2.80
24	0.01388	0.01365	0.01342	0.01321	0.01301	0.01282	0.01264	0.01246
25	0.01372	0.01349	0.01327	0.01306	0.01286	0.01267	0.01249	0.01232
26	0.01357	0.01334	0.01312	0.01291	0.01272	0.01253	0.01235	0.01218
27	0.01342	0.01319	0.01297	0.01277	0.01258	0.01239	0.01221	0.01204
28	0.01327	0.01304	0.01283	0.01264	0.01244	0.01225	0.01208	0.01191
29	0.01312	0.01290	0.01269	0.01249	0.01230	0.01212	0.01195	0.01178
30	0.01298	0.01276	0.01256	0.01236	0.01217	0.01199	0.01182	0.01169

Hydrometer is available based on the principle of sedimentation of particles grain in water. When sediment is dispersed in water, the particles settle at different velocities depending on their shape, size, weight, and the viscosity of the water. It is first assumed that all particles are spheres and Strokes's law can express the velocity of particles.

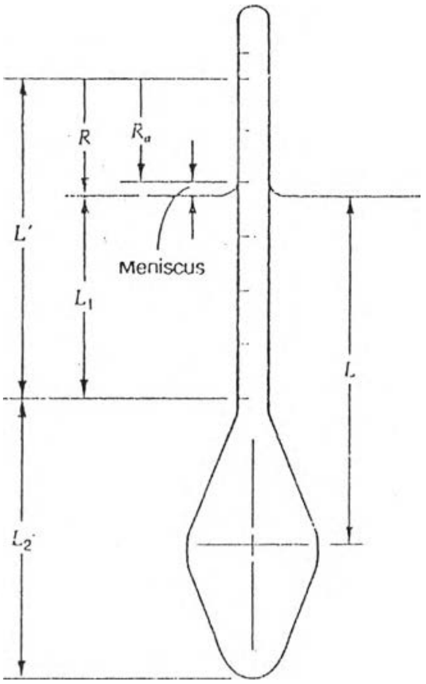
Hydrometer analysis is a widely method for obtaining an estimate of the distribution of particle sizes from the No. 200 (0.075 mm) sieve to around 0.001 mm. The data are plotted on a semi-log scatter plot of percent finer versus particle diameters and may be combined with the data from a mechanical analysis of the material retain (+) on the No. 200 sieve.

In preparation for hydrometer analysis, wash 200 to 500 g of air-dry sample through the No. 200 sieve. Save the material passing on dish and the material retained in another. Oven-dry both dishes of sample and sum the two masses of sample for the total mass of dry sample. Next do a mechanical sieves with the No. 200 on the bottom. Compute the % Finer for the composite grain size curve using the total dry mass. Save the oven-dry material passing the No. 200 sieve for the hydrometer test following.

The hydrometer test was conducted in a sedimentation cylinder with 50 g of oven-dried sample. The sedimentation cylinder is 18 in. (457.2 mm) high and 2.5 in. (63.5 mm) in diameter. It is mark for a volume of 1000 ml. Sodium hexametaphosphate is generally used as the dispersing agent. The volume of dispersed sediment suspension is brought up to 1000 ml by adding distilled water. A small sample of 50 or 100 g passing the sieve can have such a small fraction of particles smaller than 0.075 mm that the hydrometer test may be effectively using only 10 to 15 g, the remainder having settled below the bulb. This cannot possibly be as representative as using 50 g (Bowles, 1992).

When a hydrometer is placed in the soil suspension at time t, measured from the start of sedimentation, it measures the specific gravity in the vicinity of its bulb at a depth L. The specific gravity is a function of the amount of particles presents per unit volume of suspension at the depth. Also, at time t, the particles in suspension at a depth L will have a diameter smaller than D as calculates in equation (2.3). The larger particles would have settled beyond the zone of measurement. Hydrometers are designed to give the amount of sample, in grams that are still in suspension. Hydrometer are calibrated for soils that have a specific gravity, gs, of 2.65; for soils of other specific gravity, it is necessary to make a correction (Das, 1994).

By knowing the amount of particles in suspension, L, and t, we can calculate the percentage of particle by weight finer than a given diameter. Note that L is the depth measured from the surface of the water to the center of gravity of the hydrometer bulb at which the density of the suspension is measured. The value of L will change with time t; its variation with the hydrometer readings is given in the Annual Book of ASTM Standards, 1991 (Das, 1994)-see appendix.



$v = L/t$ cm/s

$L = L_1 + 1/2(L_2 - V_b/A\text{grad})$

$L_1 = 10.5$ cm for $R=0$

$L_1 = 2.30$ cm for $R=50$

$L_2 = 14$ cm (ASTM)

$V_b = 67$ cm^3

Agrad = 27.8 cm^2 for 1000 mL Graduated cylinder (not a hydrometer jar)

R_a = actual reading

$R = R_a$ corrected for meniscus

Figure 2.10 Hydrometer dimensions and terms (after Das, 1994).

Graphical presentation

The relationship among morphometric parameters was illustrated in forms of various graphic presentation, in particular roundness and flatness of stones. The index of roundness of stones within the most environments and processes with a range of minimum 0 to 1000, and 100 for minimum flatness to a theoretical maximum of infinity (Cailleux, 1956 in Thiramongkol, 1975). 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.

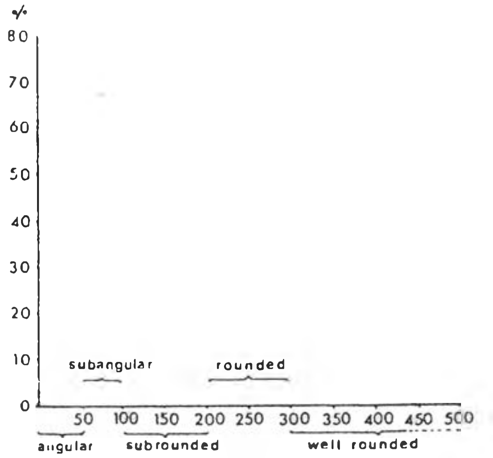


Figure 2.11 A comparison of degree and index of roundness of stones after measured by Cailleux method (After Thiramonkol, 1975)

Pebble composition analysis is present by 100% Stack Column (Figure 2.12). Compare the percentage each of value contributes to total across categories. The percentages of quartzite are plotted from the bottommost, and then up to quartz and those of sandstones and finally, if present, those of meta-sandstones in the upper. The rest group remains at the uppermost.

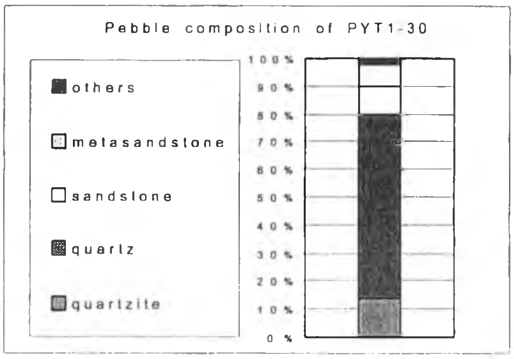


Figure 2.12 100% stack column shows result of pebble composition analysis.

In this study, results of particle size analysis, the percent of weight retained and a cumulative weight retained were calculated and presented. Various graphic presentation of size relationship, for instance, a cumulative weight frequency and diameter in millimeters were provided and plotted in both semi-log and phi scale. Relations between logarithmic grade scale and diameters in millimeters, the phi scale to Wenworth grades is shown in Figure 2.13 (Krumbein and Pettijohn, 1938).

Histogram (Figure 2.14a) and semi-logarithmic plot (Figure 2.14b) known as particle size distribution curves generally presents the results of sieve and hydrometer analysis. The particle diameters are plotted in log scale; whereas, the corresponding percent finer is plotted in arithmetic scale.

After Briggs (1977), for a number of reasons, it has become conventional to plot particle size distribution not as a simple frequency curve, but as a cumulative frequency curve. This is plotted on arithmetic probability paper. It has already been noted that particle size follows a log-normal distribution. However, by using the phi scale of measurement, the data are transformed to an arithmetic normal distribution - they are normalized. Thus when plotting the cumulative percentage frequency distribution of sediment size, the phi classes are

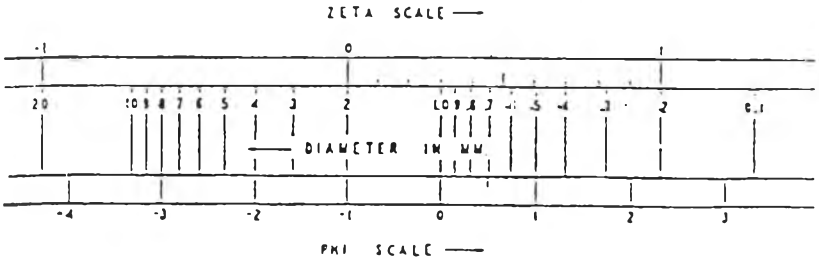


Figure 2.13 Relations between logarithmic grade scale and diameters in millimeters, the phi scale to Wenworth grades. (Krumbein and Pettijohn, 1938)

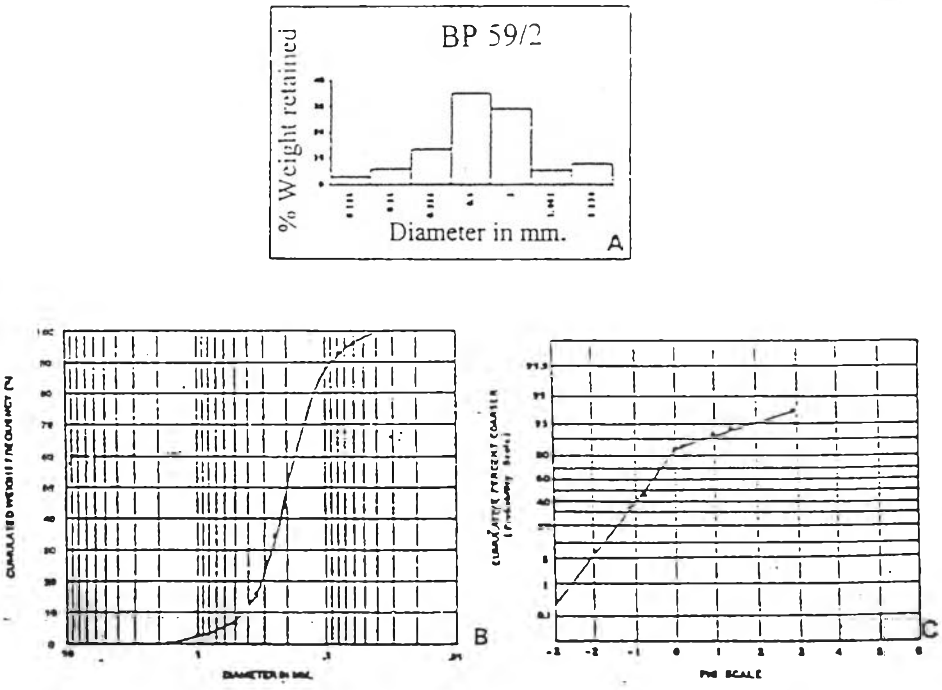


Figure 2.14 Three type of size distribution plots. a) histogram of normal size distribution, b) S-curve when using log-scale plots and c) phi scale plot for degree of sorting calculation (Choowong, 1996)

plotted on the x (arithmetic) axis. The transformed log-normal distribution is then represented by a straight line (Figures 2.14c and 2.15).

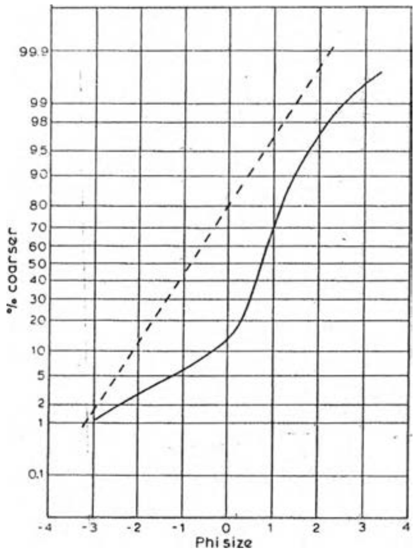


Figure 2.15 Cumulative percentage frequency curves of normal and non-normal size distributions. (Briggs, 1977)

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). The size parameters can be calculated directly from the graph of particle size distribution on phi against probability scales. A summary of the major size parameters, and methods of graphically extracting them, are summarized in Table 2.2.

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

Descriptive Terms	Brigg(1977)
Median	∅50
Mean	(∅75+∅50+∅25)/3
Sorting	(∅90+∅80+∅70-∅30-∅20-∅10)/5.3
Skewness	{(∅84-∅50)/(∅84-∅16)}-{(∅50-∅10)/(∅90-∅10)}
Kurtosis	(∅90-∅10)/1.9(∅75-∅25)

a) Phi Median

Median is the value, which divided a distribution into two equal halves. The median is calculated from the size measurements in millimeters. For this research, the phi scale is used in size analysis, and the median should be computed from the phi values, which took from the graph of particle size distribution.

b) Mean

An alternative measure of the average grain size is the arithmetic mean, commonly referred to simply as the mean. This is more sophisticate than the median, for locates a weighted central point to the distribution. The median is based on the ranked values of the distribution, taking no account of the true values; the mean, conversely, uses the true values.

c) Phi Skewness

Skewness is the deviation or asymmetry and gives an assessment of the non-normality of a distribution. A distribution can be positively or 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 (from Table 3.1), 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.

d) 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 well sorted). It can be noted that a high degree of sorting is represented by a low sorting value (Briggs, 1977).

e) 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 a more peaked distribution than a normal curve while the poor sorted sediment has lower. Generally, the range of kurtosis values varies from about 0.5 to 3.5. A 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--0.3
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	1.11-1.5	Positively skewed	0.1-0.3
Poorly sorted	1.00-2.00	Very leptokurtic	1.50-3.00	Very positively skewed	0.3-1
Very poorly sorted	2.00-4.00	Extremely leptokurtic	>3.00		
Extremely poorly sorted	>4.00				

Bivariate scattergrams is often with plotting the size parameters, which can be used as a basis for further study. There are graphs of any two size parameters. They are of particular value in paleoenvironment 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 (Brigg, 1977).

Data analysis, interpretation, and reporting

All of data from both field and laboratory investigation will finally be analysed, interpreted and displayed as detail geomorphological map, stratigraphical profile. Laboratory results will be presented in form of scatter graph, diagram and table. Then, discussion and conclusion of this study about geomorphological units and their process, material characteristics or properties, structure, evaluation, and land use in different geomorphological units were carried out for the final reporting.

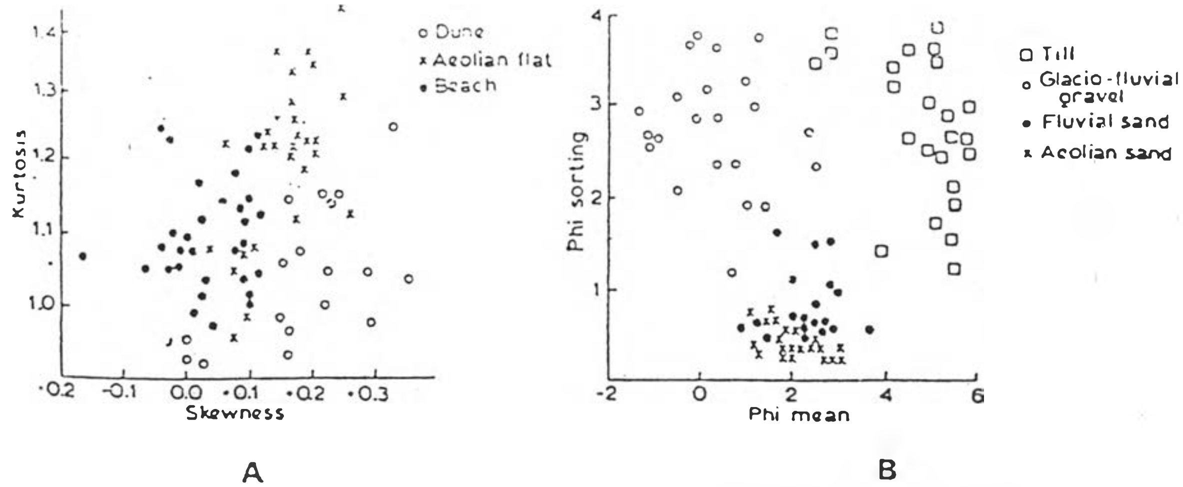


Figure 2.16 Bivariate scattergrams for selected sediments from various environments. a) kurtosis and skewness, and b) mean size and sorting. (Briggs, 1977)

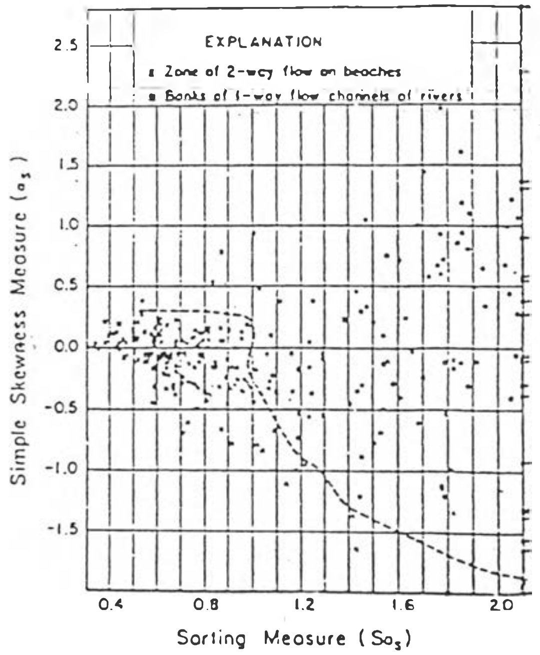


Figure 2.17 Scatter plot, simple skewness measure versus simple sorting measure for beach and river sands. (After Friedman and Sanders, 1978)