CHAPTER 4

SEDIMENTARY ANALYSIS

Sedimentary samples were collected from 15 locations in both of the study areas, including the gap between them for better comparing results (Figure 4.1 – 4.2). Fourty eight samples came from the other depths (Table 4.1). The samples were done in terms of sedimentary analysis and the results lead to summarize the sedimentary distribution, characteristics of the deposition, facies analysis, provenance of the sediments, and depositional environments. The gravels and sands were emphasized more than the silt and clay because the study areas were in the zone of the talus deposit, as mentioned in Chapter 3. The gemstones in the study areas were mainly discovered in the gravel beds.

The sedimentary analysis for the study areas follows four steps leading to the statistic data and the results would be revealed in the following topics respectively:

- Textural analysis
- Graphic presentation of particle size distribution
- Graphic measures of the frequency distribution
- Provenance and facies analysis

4.1 TEXTURAL ANALYSIS

4.1.1 EQUIPMENTS

- Sample splitter
- Ro-tab testing sieve shaker

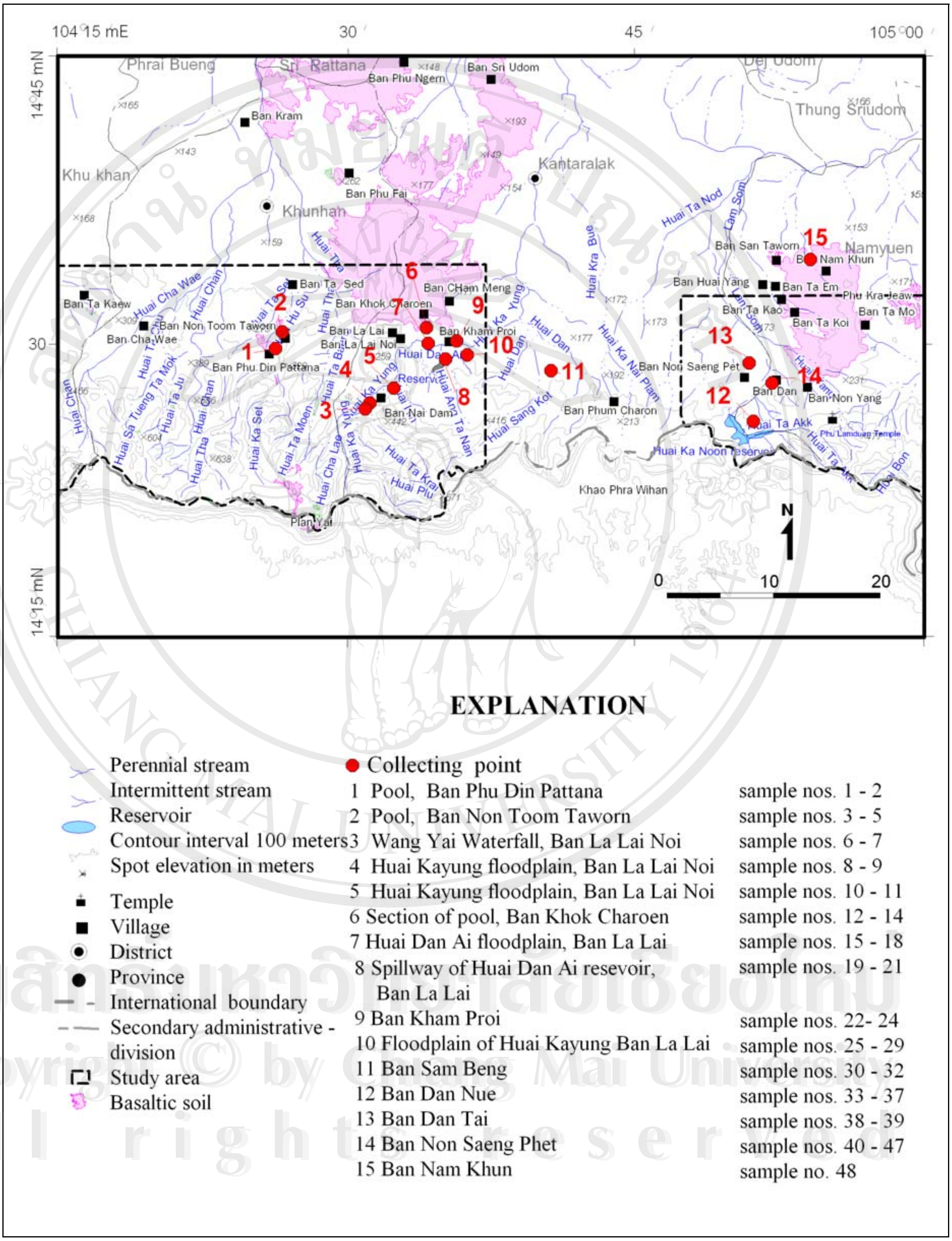

Figure 4.1 The locations of collecting samples.

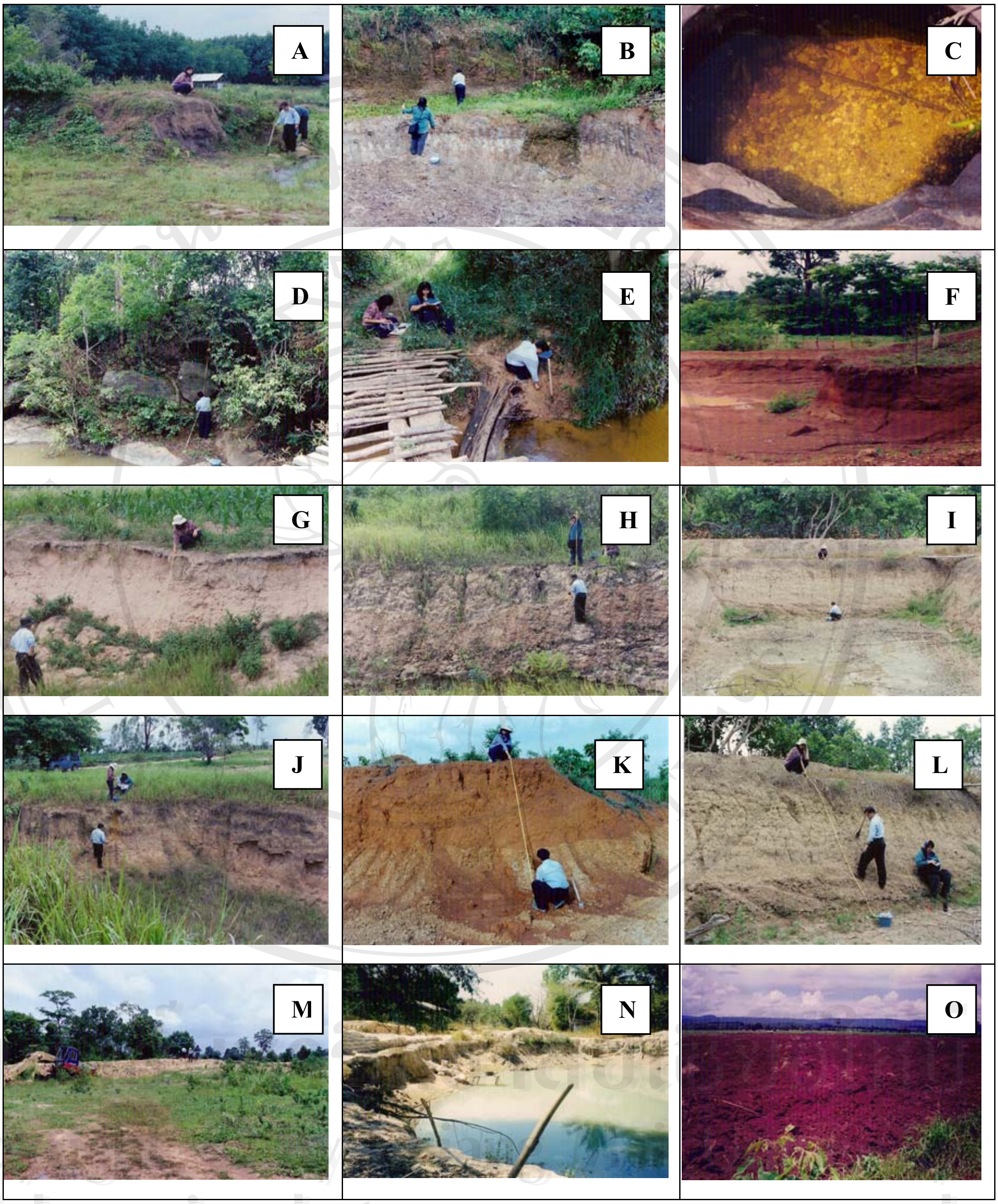

Figure 4.2 Locations of collecting samples: (A) Location 1, (B) Location 2, (C) Location 3, (D) Location 4, (E) Location 5, (F) Location 6, (G) Location 7, (H) Location 8, (I) Location 9, (J) Location 10, (K) Location 11, (L) Location 12, (M) Location 13, (N) Location 14 and (O) Location 15.

Table 4.1 Locations and samples

Number	Location	Sample number	Depth (m)
1	Ban Phu Din Pattana, Tambon Bak Dong, Amphoe Khun Han	1 2	4.7 – 5.5 5.5 – 5.7
2	Ban Non Toom Taworn, Tambon Bak Dong, Amphoe Khun Han	3 4 5	0.0 – 0.7 0.7 – 1.2 0.7 – 1.4
3	Wang Yai Waterfall, Ban La Lai Noi,Tambon La Lai Amphoe Kantaralak	6 7	Pothole (~ 1.0 – 1.2) Pothole (~ 1.0 – 1.2)
4	Huai Ka Yung floodplain, Ban La Lai Noi Tambon La Lai, Amphoe Kantaralak	8 9	Bank 0.0 – 2.0 In chanel (~2.5)
5	Huai Ka Yung floodplain, Ban La Lai Noi, Tambon La Lai , Amphoe Kantaralak	10 11	Bank 0.0 – 2.0 In chanel (~2.5)
6	Ban Khok Charoen, Tambon La Lai, Amphoe Kantaralak	12 13 14	0.0 – 1.0 1.0 – 2.0 2.0 – 3.0
7	Huai Dan Ai floodplain, Ban La Lai Tambon La Lai , Amphoe Kantaralak	15 16 17 18	0.0 – 1.0 1.0 – 2.8 2.0 – 2.8 2.8 – 3.5
8	Spillway of Huai Dan Ai reservoir, Ban La Lai, Tambon La Lai , Amphoe Kantaralak	19 20 21	0.0 – 0.5 0.5 – 1.4 1.4 – 2.5
9	Ban Kham Proi, Tambon La Lai , Amphoe Kantaralak	22 23 24	0.0 – 1.5 1.5 – 2.5 2.5 – 3.5
10	Floodplain of Huai Ka Yung, Ban La Lai, Tambon La Lai , Amphoe Kantaralak	25 26 27 28 29	Bank 4.0 – 5.0 Bank 5.0 – 6.0 Terrace 0.0 – 0.6 Terrace 0.6 – 1.0 Terrace 1.0 – 2.2
11	Residual basaltic soil, Ban Sam Beng, Tambon Kra Sang, Amphoe Kantaralak	30 31 32	0.0 – 2.0 2.0 – 3.0 2.0 – 3.0
12	Ban Dan Nue, Tambon Phu Pha Mok, Amphoe Kantaralak	33 34 35 36 37	2.3 – 2.5 0.0 – 0.9 0.9 – 2.3 2.3 – 2.6 2.3 – 2.6
13	Ban Dan Tai, Tambon Phu Pha Mok, Amphoe Kantaralak	38 39	0.0 – 1.8 1.8 – 2.5
14	Ban Non Saeng Phet, Tambon Khok Sa – ard, Amphoe Nam Khun	40 41 42 43 44 45 46 47	0.0 – 1.0 0.0 – 1.0 1.0 – 2.0 1.0 – 2.5 2.5 – 3.5 2.5 – 3.5 3.5 – 4.0 3.5 – 4.0
15	Basalt flow, Ban Nam Khun, Tambon Khi Lek, Amphoe Nam Khun	48	1.0 – 2.2

Note: Amphoe Khun Han and Amphoe Kantaralak are in Si Sa Ket Province. Amphoe Nam Khun is in Ubon Ratchathani Province. Ban = Village, Tambon = Sub – district, Amphoe = District.

- Wire-mesh sieves
- Knife or spatula with large blade
- Sheets if high-gloss paper (approximately 40 x 40 cm)
- Balance
- Brush for cleaning sieves
- Binocular microscope

4.1.2 METHODS

The samples were dried by sunlight and hit by the rubber hammer to make the grains loosed out. Then each of the samples were split to obtain material representative of the samples originally taken in the field, and to reduce the sample size to that required in sieving analysis. The mechanical sample splitter (Figure 4.3A) was used here.

1. Each of the samples was heaped into a cone on a sheet of paper.

2. The cone from (1) was cut into quarter with a knife or spatula the first and third quarters or second and forth quarters were rejected (Figure 4.3 B).

3. The remaining two quarters were heaped into a cone again, and divided the sample once more into quarters; reject quarters as before. Finally, each sample was weighted about 600 g (gravel) and 100 g (sand).

4. The 50 g. or 100 g. sample now was split with a mechanical splitter. A sample was divided into 2 halves equally, each collected in a separated container. A first half was split and the other for sieving in the next step.

5. The wire-mesh sieves size 256 mm, 128 mm, 64 mm, 32 mm, 16 mm, 8 mm, 4 mm, 2 mm, 1 mm, 0.5 mm, 0.25 mm, 0.0625 mm were overlapped. The 256 mm. sieves was on the top and the 0.0625 mm. was in the lowest position respectively. The scale of particle size follow Friedman and Sanders (1978) (Table 4.2).

6. The set of the sieves was supported at the bottom with a pan covered at the top with a metal lid. The sample was put into the 256 mm wire- sieve, and settle into the position. Then all sets of a sample were shaken about 20-30 minutes by the Ro-tab shaker (Figure 4.3C). The sample was separated from top to bottom into any sizes upon the wire-mesh sieve.

7. The wire-mesh sieves were removed from the shaker and carefully pour contents of each sieve onto a sheet of clean, high-gloss paper.

8. Each sieve screen was cleaned quickly inverting it and slamming it sharply and evenly on the paper. Screen could be cleaned further by brushing it gently with fine to medium- bristle point brush while it is inverted on paper.

9. The fractions retained on each sieve were weighted and recorded, and saved each fraction for later textural analysis.

10. The sieve loss (weight and weight percent of material lost in sieving procedure) was determined and recorded.

11. The fraction retains from (9) were calculated weight percent by the formular :

$$\textbf{Weight percent of any retain} = \frac{(A \times 100)}{T}$$

A = The weight of any retain

T = Total of the weight of the sample

12. The weights of the refraction retain were calculated the cumulative percent using the formular :

$$\textbf{Cumulative percent} = \frac{(\Sigma n0\text{-}n14) \times 100}{T}$$

$\Sigma n0\text{-}n14$ = the total of all refraction retains from the dust in the pan to the grains in the 256 wire-mesh sieve + the loss weight which was noted.

The weight percent from (11) was plotted to the histogram and the cumulative percent from (12) was plotted to cumulative curve in the arithmetic scale.

13. The cumulative curves were noticed the percentile at 5, 16, 25, 50, 75, 84 and 95 by drawing the straight lines paralleling the horizontal grain size bars (unit was phi (ϕ)). The points which the stated percentiles cut the graph will be begun line the vertical lines until attached to the grain size bar. At these attached points, the phi (ϕ) which matched to those percentiles would be used to calculate graphic mean, sorting, skewness and kurtosis using the following formulars.

Graphic mean (M_Z)= $$\frac{(\phi 16) + (\phi 50) + (\phi 84)}{3}$$

Inclusive graphic standard deviation (sorting)

$$(\sigma I) = \frac{(\phi 84) - (\phi 16)}{4} + \frac{(\phi 95) - (\phi 5)}{6.6}$$

Inclusive graphic skewness

$$\textbf{(SK1)} = \frac{(\phi 84 + \phi 16 - 2\phi 50)}{2(\phi 84 - \phi 16)} + \frac{(\phi 95 + \phi 5 - 2\phi 50)}{2(\phi 95 - \phi 5)}$$

Graphic kurtosis (KG) = $$\frac{(\phi 95 - \phi 5)}{2.44(\phi 75 - \phi 25)}$$

The results data were interpreted by using data from Table 4.3

Another reference (Dixon and Massey, 1957; Griffiths, 1967) stated the other statistic values called simple sorting and simple skewness. From the study, they cannot replace the calculated value from inclusive graphic standard deviation and inclusive graphic skewness, but they were useful plotting the graphs to imply some data. They could be calculated from the following formulars:

Simple sorting measure (Sos) = $\frac{1}{2}(\phi 95 - \phi 5)$

Simple skewness measure (αs) = $(\phi 95 + \phi 5) - 2(\phi 50)$

14. Study of particle shapes and kinds. The study of particle shapes reflected their origin, sources and processing done to the particles, sometimes the agents of transport, rigors of transport including distance and energy of the agents of transportation. Particle shapes were classified into 4 kinds : roller; sphere; blade; disc, and were also expressed in terms of varying sphericity and roundness (Figure 4.3 D – E).

A handful amount of each sample was contained into a plastic box having grid lines at the bottom The sediments lying on the grid lines 200 grains were random to analyze shape, roundness, sphericity and kinds. The results were represented into graphs. And the kind data of the each sample, which was separated to be quartz, feldspar and lithic were plotted to the FQL diagram to know source of sediments, the provenance.

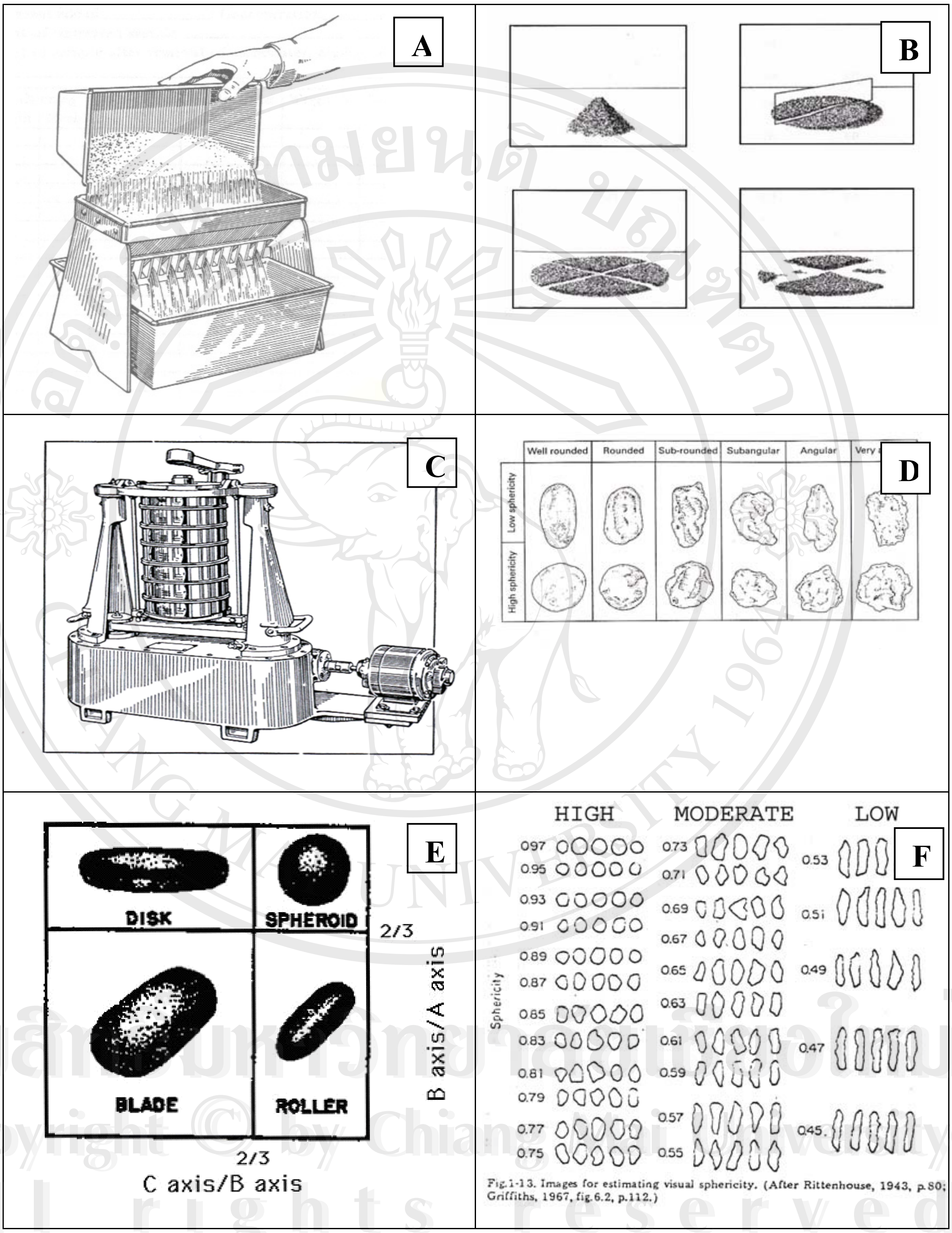

Figure 4.3 (A) The mechanical splitter, (B) Coning and quartering a sample, (C) The Ro-Tap mechanical shaker, (D) Roundness and sphericity estimate comparison chart (after Petijohn *et al.*, 1987), (E) Shape of particle (after Zingg, 1935) (F) Image for estimating visual sphericity (after Griffiths, 1967).

Table 4.2 Particle Grade – Size Scale (after Friedman and Sanders, 1978)

Limiting Particle Diameter (mm)	(ϕ units)	(Microns μ)	Size Class			Scale
2048	−11		V. Large	Boulders	GRAVEL	
1024	−10		Large	Boulders	GRAVEL	1m
512	−9		Medium	Boulders	GRAVEL	
256	−8		Small	Boulders	GRAVEL	
128	−7		Large	Cobbles	GRAVEL	
64	−6		Small	Cobbles	GRAVEL	10^{-1}
32	−5		V. Coarse	Pebbles	GRAVEL	
16	−4		Coarse	Pebbles	GRAVEL	
8	−3		Medium	Pebbles	GRAVEL	10^{-2}
4	−2		Fine	Pebbles	GRAVEL	
2	−1		V. Fine	Pebbles	GRAVEL	
1	0		V. Coarse	Sand		10^{-3}
1/2	+1	500	Coarse	Sand		
1/4	+2	250	Medium	Sand		
1/8	+3	125	Fine	Sand		
1/16	+4	62	V. Fine	Sand		10^{-4}
1/32	+5	31	V. Coarse	Silt	MUD	
1/64	+6	16	Coarse	Silt	MUD	
1/128	+7	8	Medium	Silt	MUD	10^{-5}
1/256	+8	4	Fine	Silt	MUD	
1/512	+9	2	V. Fine	Silt	MUD	
				Clay	MUD	

Table 4.3 Statistical parameters of grain size (Folk and Ward, 1957) *in* http://gpc.edu/~janderso/historic/labman/sievean.htm (2006).

Table 4.3 A Graphic mean: M Values:		
Values from	to	Equal
- ∝	- 1∅	gravel
>- 1	0∅	Very coarse sand
>+ 0	+ 1∅	Coarse sand
>+ 1	+ 2∅	Medium sand
>+ 2	+ 3∅	Fine sand
>+ 3	+ 4∅	Very fine sand
>+ 4	+ 8∅	Silt
>+ 8	∝ ∅	Clay

Table 4.3 B Inclusive Graphic Standard Deviation (D): D Values:		
Values from	to	Equal
0.00	0.35∅	Very well sorted
> 0.35	0.50∅	Well sorted
> 0.50	0.71∅	Moderately well sorted
> 0.71	1.00∅	Moderately sorted
> 1.00	2.00∅	Poorly sorted
> 2.00	4.00∅	Very poorly sorted
>4.00	∝ ∅	Extremely poorly sorted

Table 4.3 C Inclusive Graphic Skewness (S): S Values:			
Values from	to	Mathematically:	Graphically skewed to the:
+ 1.00	+ 0.30	Strongly positive skewed	Very Negative phi values, coarse
< + 0.30	+ 0.10	Positive skewed	Negative phi values
< + 0.10	- 0.10	Near symmetrical	Symmetrical
< - 0.10	- 0.30	Negative skewed	Positive phi values
< - 0.30	- 1.00	Strongly negative skewed	Very Positive phi values, fine

Remark : skewness is the forth property of a sieve analysis, or degree of lop-sidedness. Samples weighted towards the coarse end-member are said to be positively skewed (lop-sided toward the negative phi values), samples weighted towards the fine end are said to be negatively skewed (lop-sided toward the positive phi values)

Table 4.3 D Graphic Kurtosis (K):		
Values from	to	Equal
> 0.41	0.67	Very platykurtic
> 0.67	0.90	Platykurtic
> 0.90	1.10	Mesokurtic
> 1.10	1.50	Leptokurtic
> 1.50	3.00	Very Leptokurtic
> 3.00	∝	Extremely Leptokurtic

Remark : Kurtosis is the term of a third property of a grain size frequency curve or the degree of “peakedness”. Curves which are more peaked than the normal distribution curve are termed “leptokurtic”; those which are saggier than normal are said to be “platykurtic”

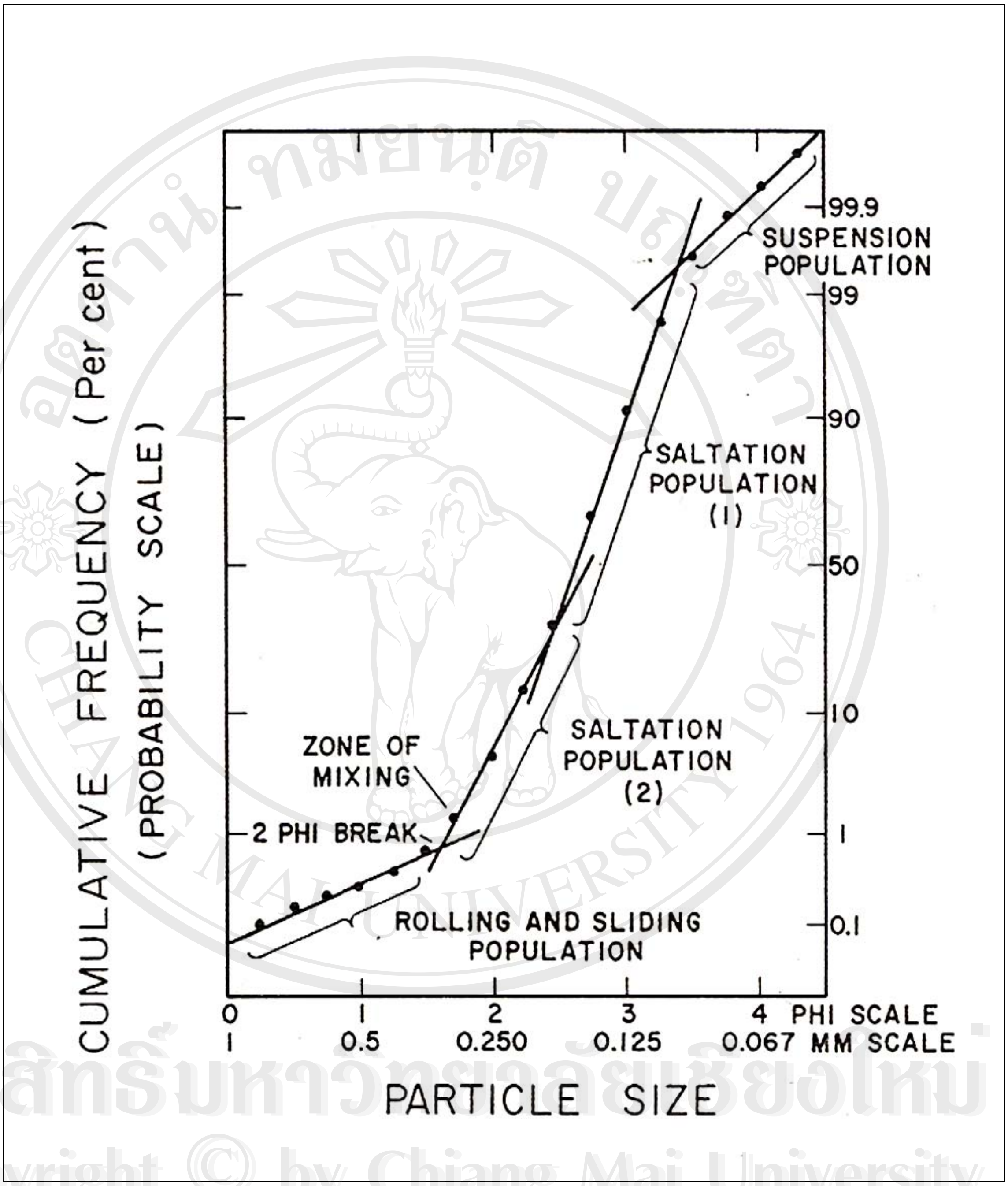

Figure 4.4 The slope and breaks on cumulative curves (Visher, 1969) which reflect sorting and depositional mechanism. This curve is used to compare the cumulative curves of samples from the study areas.

4.2 RESULT AND INTERPRETATION

The distribution of particle size in sediments was a function of (1) the availability of different sizes of particles in the parent material and (2) the processes operating where the particles were deposited. In order to interpret a given sedimentary accumulation, it was necessary to present size distribution data graphically. This can be done in the form of a (i) histogram (ii) frequency curve, or (iii) cumulative frequency curve. They are illustrated in the appendix A together with the interpretative tables.

In spite of the histogram cannot be used for determination of statistical parameters and its shape is greatly affected by the sieve interval which was chosen for the sieving analysis. The histogram was thus useless for detailed analysis. The frequency curve and the cumulative - frequency curve were used to interpret the distribution of the sediments (Figure 4.4).

The frequency curve was plotted for the proportion of the sediments in percent, against the phi unit. It was used to present the distribution of the sediments comparing to the normal frequency-distribution curve. The frequency curves of the samples are grouped together upon their locations and interpreted as shown in the Appendix A.

The cumulative curves which were plotted for the proportion of the sediments in percent against the phi unit have generated the needed percentiles and then were calculated as described in the method (14). Then the results of the calculations (Table 4.4) were compared to the Table 4.3 to show graphic mean, sorting, kurtosis and skewness. The interpretation of them were shown in Appendix A.

The graphic mean of samples no. 1 to samples no.48 were plotted for comparison as shown in Figure 4.5.

The simple skewness measure of all samples were plotted against the simple sorting mature. The distribution of the samples can be grouped upon their clusters (Figure 4.6 A). The skewness measure of all samples were plotted against the graphic mean values. Their clusters also exhibit the same characteristics of the sediments (Figure 4.6 B).

The shape, roundness, sphericity and kind of each sample were studied and presented in the bar graphs (Figure 4.7) from sample number 1 to number 48. By doing so, the shape, roundness , sphericity and kind of all samples will be compared.

Kind of the particles dividing in quartz, feldspar and lithic can be used for implying the sources of them, or provenance using plotting into FQL ternary diagram (Dickinson *et al.*, 1983) as shown in Figure 4.7.

Hence, the details of the interpretation for each location of the samples will be arranged as follows:

1 Histograms and Frequency curves

2 Cumulative curves

3 Graphic mean, Sorting, Kurtosis and Skewness

4. Graphic mean values of all samples

5 Scatter plots of simple skewness measure versus the simple sorting mature. and Scatter plot of skewness measure versus graphic mean values

6 Roundness, Shape, Sphericity and Kind analysis

7 Provenance of the sediments in the study areas

The topics 1 to 3 are the details which will be explained in each location. The description will be ordered upon surface to deeper sedimentary beds.

The topics 4 – 7 are the total interpretation which will be stated later after the description of the locations.

4.2.1 HISTOGRAMS, FREQUENCY AND CUMULATIVE CURVES

Location 1 Ban Phu Din Pattana (sample nos. 1-2) and
Location 2 Ban Nontoom -Taworn (sample nos. 3 - 5)

The samples 1 and 2 were collected from the unconsolidated beds interbedded with the lava flow and the basement rock located about 4.5-5.5 m from surface. The metamorphosed sediments which on the surfaces of them were not included. These unconsolidated sediments are the representative of the paleosediments deposited before the volcanic of the Ban Phu Din Pattana and the Ban Nontoon Taworn basalts flowing over them.

Whereas the samples nos.3-5 are the section of unconsolidated sedimentary beds which is along lava flow and basement rock. The sample no. 3 was from the basaltic soil mixing with sand from sheet washing. The sample nos. 4-5 are overlain by the sample no.3. They were collected from the same depth but different side of pits (sample no. 4 : 0.7-1.2 m, sample no. 5 : 0.7-1.4 m). These samples should be the presenters of the unconsolidated sediments.

Location 3 Wang Yai waterfall, Ban Lalai Noi (sample nos. 6 - 7)

These samples were collected from the potholes as a part of Huai Ka Yung stream at Wang Yai waterfall. The pothole is the good location which help to

Table 4.4 Statistical parameters of grain size of samples

SAMPLE NUMBER	GRAPHIC MEAN (Mz)	INCLUSIVE GRAPHIC STANDARD DEVIATION (D)	SIMPLE SORTING MEASURE (SOs)	GRAPHIC KURTOSIS (K)	INCLUSIVE GRAPHIC SKEWNESS (SK1)	SIMPLE SKEWNESS (Ks)
1	-0.35	2.50	3.45	0.86	0.45	3.00
2	-0.16	2.09	3.34	0.92	-0.09	-0.61
3	2.15	1.15	1.70	0.77	0.53	1.81
4	1.61	1.79	3.87	2.40	-0.24	-2.67
5	1.81	1.19	2.35	1.64	0.16	0.71
6	-2.98	1.26	1.98	0.90	0.11	0.76
7	-3.09	1.29	2.05	0.97	0.03	0.39
8	1.85	1.02	1.79	2.03	0.32	0.80
9	0.46	1.00	1.62	1.27	-0.09	-0.37
10	1.98	1.00	1.67	1.28	0.33	0.89
11	1.67	0.53	0.89	1.61	0.27	0.69
12	-1.19	1.99	3.39	1.10	0.48	3.73
13	-1.92	1.44	2.33	0.99	0.28	1.69
14	-1.88	1.88	3.13	1.00	0.09	0.85
15	1.71	1.33	2.45	1.39	0.06	0.72
16	-1.49	2.45	3.90	0.89	0.15	1.59
17	0.98	1.32	2.15	1.01	0.18	1.02
18	0.67	2.03	3.49	1.15	-0.11	-0.24
19	2.26	1.17	1.75	0.78	0.51	1.82
20	1.92	1.34	2.18	1.12	0.26	0.88
21	0.79	2.45	3.44	0.64	-0.22	-1.51
22	1.78	1.95	2.90	0.74	0.07	0.30
23	1.19	1.81	3.11	1.14	-0.09	0.12
24	-0.24	2.48	3.83	0.78	0.19	2.10
25	1.82	1.26	2.57	1.84	0.12	0.26
26	1.67	0.86	1.74	2.16	0.27	0.93
27	2.24	1.08	1.84	1.30	0.23	1.23
28	0.19	1.79	2.78	0.87	-0.23	-1.01
29	2.26	1.15	1.71	0.76	0.47	1.49
30	1.35	1.96	3.19	1.01	-0.13	-0.36
31	-4.67	2.61	4.42	1.49	0.10	1.94
32	-3.47	2.42	4.13	1.06	0.20	2.65
33	2.13	1.18	1.82	0.80	0.43	1.22
34	2.63	1.19	1.82	0.81	-0.07	-0.04
35	2.26	1.04	1.65	1.12	0.31	1.21
36	-0.17	2.28	3.48	0.81	0.25	1.96
37	-1.27	2.42	3.71	0.68	0.50	4.00
38	2.09	1.36	2.20	1.03	0.14	0.63
39	0.89	2.00	3.19	0.82	-0.09	0.14
40	2.95	1.30	1.95	0.75	-0.30	-0.93
41	2.25	1.12	1.60	0.69	0.34	0.88
42	2.13	1.19	1.86	0.81	0.43	1.28
43	1.94	1.06	1.99	1.39	0.24	1.13
44	1.79	0.72	1.23	1.87	0.41	1.22
45	1.99	1.08	2.12	1.61	0.19	1.04
46	2.85	0.66	0.97	1.16	0.29	0.58
47	2.09	1.07	1.65	1.01	0.47	1.43
48	-2.26	2.23	3.84	1.31	0.43	3.90

confine or preserve the interesting samples, for example, the paleo gravels, gemstones and others transported passing the potholes. On the other hand, the relict sediments discovered in the potholes can be the clues for the depositional sediments, which were derived from the mountainous area.

Location 4 and Location 5 Huai Ka Yung floodplain, Ban Lalai Noi (sample nos. 8-9 and sample nos. 10 – 11)

The two sets of these samples were collected from the banks and in channel deposits of the Huai Ka Yung stream. The high level flooding during collecting the samples may cause confusion of the sediments, especially the samples from bank deposits. The sample no.8 was from the banks whereas the sample no.9 was from the bedload beneath water level. This is the same for the sample nos.10 and 11 respectively.

The sample nos.8 - 11 should be the presenters of the recent floodplain where the gemstones (fine particles) are reworked and deposited together with their sediments. Their graphic values and curves (Figure 4.4) are interpreted as same as in the Figure 4.6.

Location 6 Ban Khok Charoen (sample nos. 12 – 14)

This set was collected from the residual basaltic soil. The aim of this chosen location is for having data of sediments from the basaltic soil to compare with the other facies. The samples were picked from top soil though the loosed soil to the weathered basalt. The sample nos.12, 13, and 14 were picked from 0.0 – 1.0 m, 1.0 - 2.0 m, and 2.0 – 3.0 m respectively. Their curves and Graphic Values were interpreted as shown in Figures 4.5 and 4.7.

Location 7 Huai Dan Ai floodplain, Ban Lalai (sample nos. 15 – 18) and Location 8 Spillway of Huai Dan Ai Reservoir, Ban Lalai (sample nos. 19 - 21)

This set of samples were collected from the section beside the Huai Dan AI spillway (sample nos. 19 - 21) and the location is far northeast from the former (samples nos. 15-18).

The location where the sample nos.15-18 were picked (no.15 from 0.0-1.0 m, no.16 from 1.0-2.0 m, no.17 from 2.0-2.8 m, no.18 from 2.8-3.5 m) are the zone of more deposition than in the mountainous area of the sediments and the small size (less than 2 mm) of gemstones were discovered along the channel of Huai Ka Yung stream supporting sediments to the spillway and adjacent areas.

The location where the sample nos.19-21 were collected (no.19 from 0.0-0.5 m, no.20 from 0.5-1.4 m, no.21 from 1.4-2.5 m) is a point in floodplain of Huai Ka Yung stream. Both of them have similar characteristics, consisting of sandstone – basement rocks and overlying unconsolidated sediments.

Location 9 Ban Kham Proi (sample nos. 22 - 24)

The samples were collected from a location in Huai Ka Yung floodplain. The sample no. 22 was picked from the top bed, 0.0 – 1.5 m. The sample no. 23 was picked from the loosed sand bed, 1.5 – 2.5 m. The sample no. 24 was picked from the unconsolidated bed changing to lateritic soil, 2.5 – 3.5 m. However, the 3.5 m is not the end of this section, but the pitting cannot be performed until basement rocks.

Location 10 Floodplain of Huai Ka Yung, Ban La Lai (sample nos. 25 - 29)

These samples are separated into 2 sub - groups. Sample nos. 25 – 26 were collected from 4.0 – 5.0 m and 5.0 – 6.0 m of banks at Huai Ka Yung (the 0.0 – 5.0 m could not collect because they were bare rocks with intrusions of big rootlets).

Another samples were collected from a pit on the terrace of Huai Ka Yung, 20 m southwest from the stream line. This pit was dug to the basement - sandstone rock. The sediments were studied and separated into 3 beds: 0.0 – 0.6 m (sample no. 27); 0.6 – 1.0 m (sample no. 28); 1.0 – 2.2 m (sample no. 29).

Location 11 Basaltic flow at Ban Sam Beng (sample nos. 30 - 32)

These samples were collected from a section of quarry locating at Ban Sam Beng. The section reveals the residual basalts overlying on the lateritic gravel bed. The sample no. 30 was taken from 0.0 – 2.0 m of the residual – basaltic soil. The sample nos. 31 – 32 were taken from 2.0 – 3.0 m of very hard pan – lateritic gravel bed. It is possible that the lateritic - gravel bed is either the older phase basalt or the ancient bed before lava flow. However, the frequency curve shows only one mode, meaning the unity of sedimentary source. Accordingly, both of them should be changed from basaltic rocks.

Location 12 Ban Dan Nue (sample nos. 33 - 37) and Location 13 Ban Dan Tai (sample nos. 38 - 39)

The sample no. 33 was taken from 2.3 – 2.5 m of a section (the beds over 2.3 m were left because of man – made contamination), 10 m eastward the sample nos. 34 – 37 which were collected from a section of the unconsolidated sediments. The sample no. 34 was from 0.0 – 0.9 m in a bed of fine sand mixing with the rootlets of grass. The sample no. 35 was from 0.9 – 2.3 m in a bed of sand with the appearance of the lateritic spots having more quantity upon the depths. The sample nos. 36 – 37 were taken from 2.3 – 2.6 m in a grave - sand bed containing many laterites.

The samples nos. 38 – 39 were collected from a section in the Huai Dan floodplain. The sample no.38 was sampling from 0.0 – 1.8 m and the sample no. 39 was sampling from 1.8 – 2.5 m where it was occupied by the lateritization.

Location 14 Ban Non Saeng Phet (sample nos. 40 - 47)

The samples nos. 40 – 41, the sample no. 42, the sample no. 43, the samples no. 44 – 45 and the samples no. 46 – 47 were picked from 0.0 – 0.1 m, 1.0 – 2.0 m, 1.0 – 2.5 m, 2.5 – 3.5 m and 3.5 – 4.0 m, respectively.

It is very hard to collect samples from gravel beds deposited on basement rocks. This is due to sizes and cementation by lateritization (Figure 4.6) of cobbles and boulders. Gemstones were sometimes cemented together.

Location 15 Basaltic soil, Ban Nam Khun (sample no. 48)

This sample was collected from the basaltic soil area. It is the presenter of the eastest basalts of the study areas. The sample was taken from 0.0 – 0.7 m of the basaltic soil covering on the sandstone as basement rocks.

4.2.2 GRAPHIC MEAN VALUES OF ALL SAMPLES

The graphic means of the sample nos. 1 – 48 were illustrated in the Figure 4.5. Generally, the sediments from the same location have coarser grain depending on the depths, and the graph of samples would slope up. But some locations are different, e.g. samples number 15 – 18. It is noticed that the point break of sample nos. 16 – 17 is reversed, stating the change of depositional particles, i.e. changing of lithofacies.

It can be seen from the plot (Figure 4.5) that the particles of samples have the grain size varying from fine sand to coarse pebble (horizontal bar). By the fact that the sediments which deposit in the same time and environment should have the similar graphic means. On the other hand, if there is the change of depositional status or environment they should affect the depositional sediments. Hence, the change of the graphic means of the samples may imply the change of depositional status. This is applied to separate the lithofacies of the samples, and is also used to correlate the samples having the same graphic means. The output is in according with the fact in the field. The result will be exhibited in the discussion later.

4.2.3 SCATTER PLOTS OF SIMPLE SKEWNESS MEASURE VERSUS THE SIMPLE SORTING MEASURES

The simple sorting measures of the samples were plotted against the simple skewness. Friedman and Sanders (1978) used this kind of the scatter plot for separating the beach sands and river sands because they cluster apart from the other dominantly. This plot was applied to the sediments from the study areas. It illustrates the result as shown in Figure 4.6 A. It is noticed that the particles cluster within 2 zones. Zone A is composed of the sediments from the in - situ basalts and lateritic sediments which are overlain by the younger sediments. Whilst zone B is composed of the sediments from recent floodplain.

4.2.4 SCATTER PLOT OF SIMPLE SORTING MEASURE VERSUS GRAPHIC MEAN VALUES

The scatter plot of the graphic mean versus the sorting was used to illustrate the tendency of distribution of the particles in Choowong (1996). The plot was applied for the samples from the study areas. Figure 4.6 B illustrates 4 clusters. Cluster A has the members from In situ basalts and lateritic sediments. Cluster B has the members from coarse sediments as coarse sands and gravels. Cluster C has the members from finer sediments as medium sand to silt. Cluster D has members being pebbles from potholes. The graphic means of the samples (Figure 4.5) support clustering of the particles.

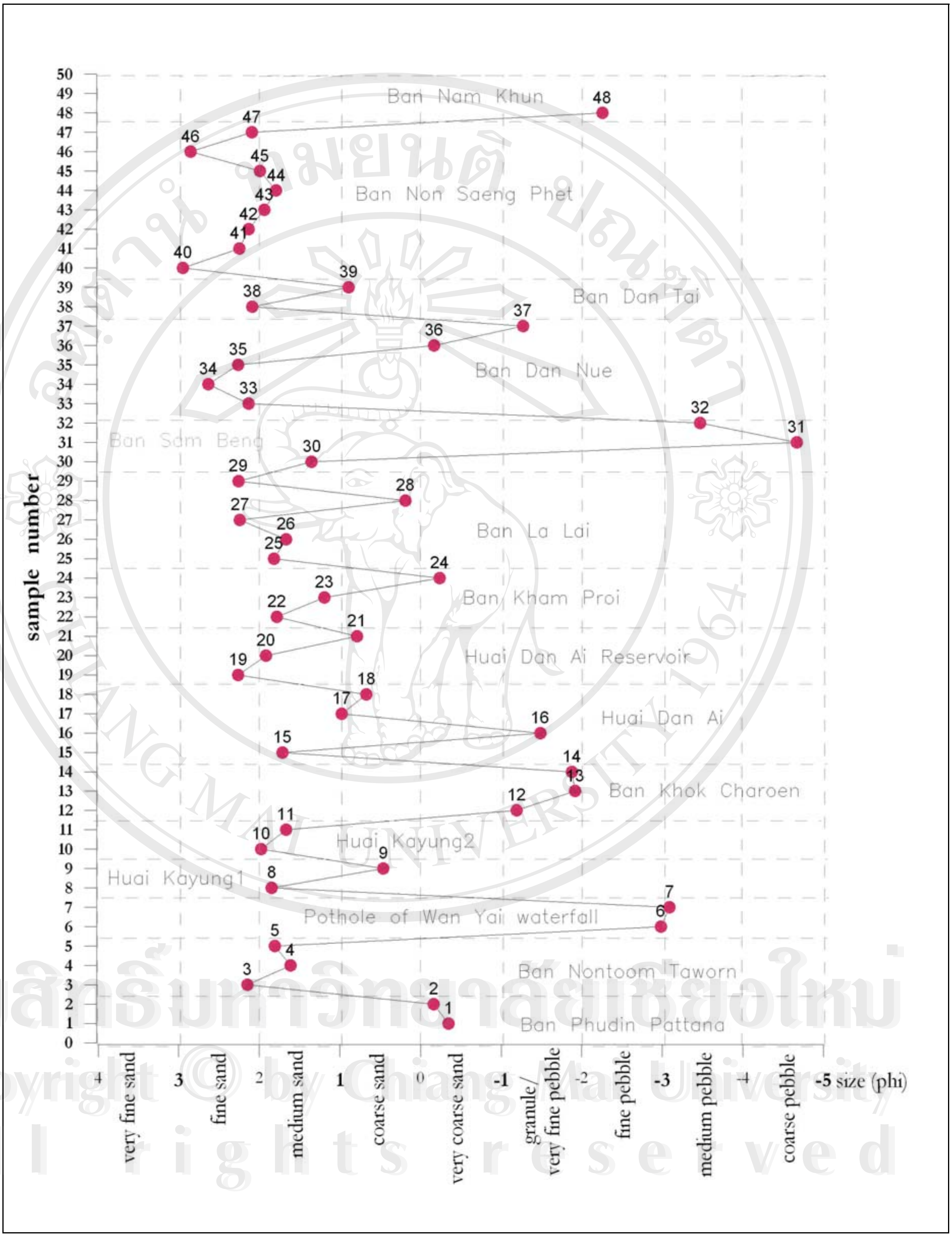

Figure 4.5 The graphic mean of sample nos. 1 – 48.

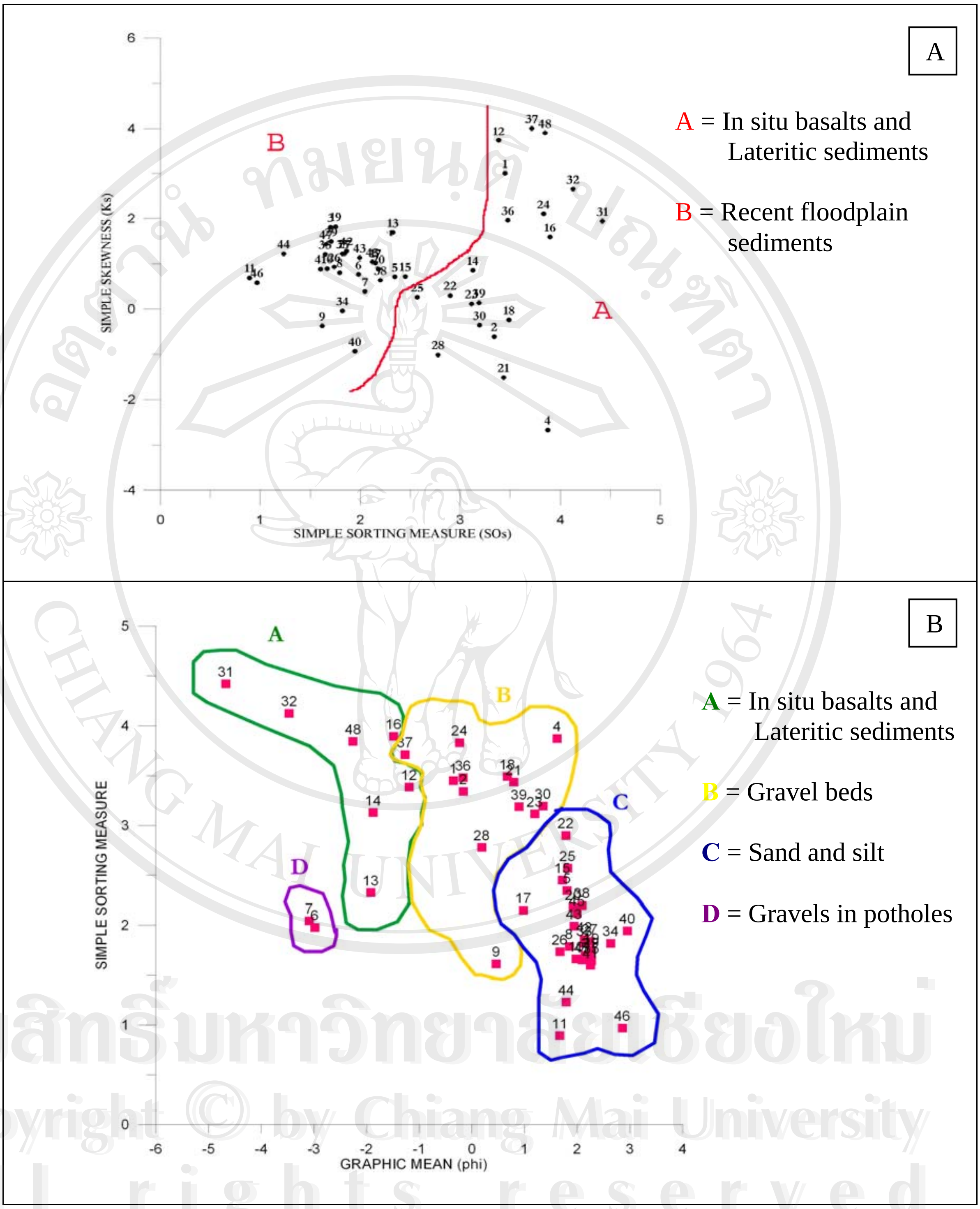

Figure 4.6 (A) The scatter plot of simple sorting mature versus simple skewness measure of all samples for in - situ basalt and ancient sediments. (B) The scatter plot of graphic mean versus the simple sorting measure, for the In situ basalts and lateritic sediments, gravel beds, sand and silt and gravels in potholes.

4.2.5 ROUNDNESS, SHAPE, SPHERICITY AND KIND ANALYSIS

The roundness is divided into 5 classes (Pettijohn *et al.*, 1987) comprising very angular, angular, subangular, sub - rounded, rounded, well rounded. Figure 4.7A reveals that most of particles prefers very angular, subangular and angular shapes than sub – rounded, rounded and well rounded, respectively. It implies that the sediments in the study and adjacent areas have no longer transporting but deposited near the source rocks.

The shape has divided into 4 classes: roller; blade; sphere; disc (Zingg, 1935). Figure 4.7 B shows that the sphere shape has much more than the disc, blade, and roller shapes.

The sphericity has divided into 3 classes, high, medium and low. Figure 4.7 C illustrates the medium sphericity is the most dominant, followed by the low sphericity and the high sphericity.

The grains of each sample were grouped into 3 kinds, quartz, feldspar and lithics. Figure 4.7D dominantly shows that quartz has most amount, lithic and feldspar are respectively less amount.

4.2.6 PROVENANCE OF THE SEDIMENTS IN THE STUDY AREAS

The 48 samples from the study areas were picked to interpret in terms of provenance. Most of samples were collected from the fluvial channels and floodplains, but some samples were collected from the volcanic outcrops as representatives of all kinds of sediments in the study areas. After being cleaned, sieved and calculated statically in the grain size analysis step, the number from studied kinds of sedimentary grains for each modal sample, provided a basis for interpretation source terrain of them. The QFL ternary diagram (Dickinson *et al.*, 1983) was used for this. The 200 grains of each modal sample were distinguished into 3 groups of quartz, feldspar and lithic. Then the data were calculated to percent and plotted into the diagram as shown in Figure 4.8.

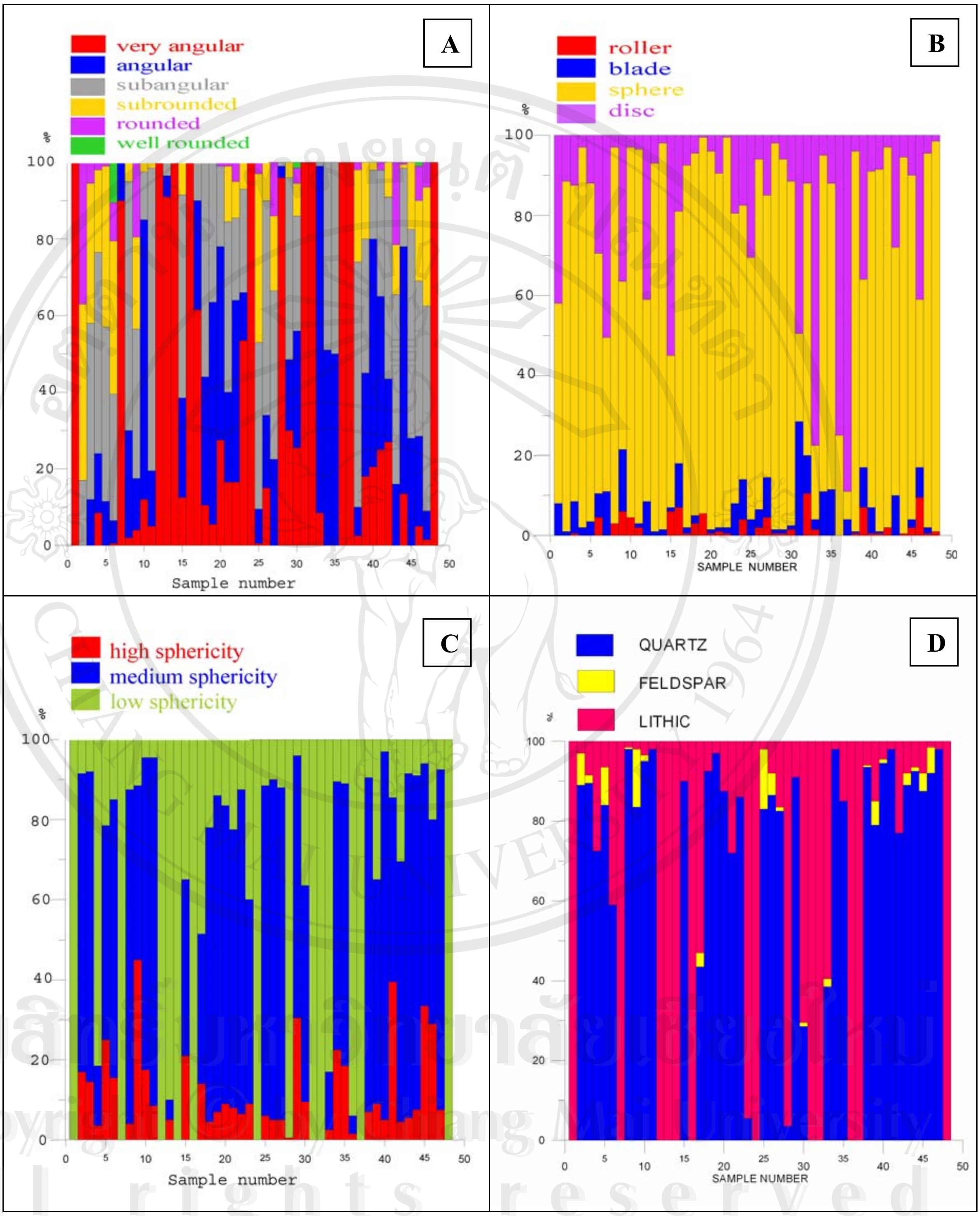

Figure 4.7 Graph of grain analysis showing in vertical bar, the sample number (horizontal bar) orders from sample number 1 to number 48 but cannot reveal all the inspected Figures. (A) Roundness, (B) Shape, (C) Sphericity, and (D) Kind.

PETROGRAPHIC RESULT

The data from the study reveal that most of each sample comprise quartz grain more than feldspar grain and lithic fragments; some samples reveal 100 percent quartz grains. The samples from volcanic outcrop revealed 100 percent lithic fragments. The feldspar grains are not only rarely solely discovered but are always together with quartz grains.

Quartz : is the most quantity of sediments from fluvial deposits. They are mostly very angular – subangular, moderate – low sphericity, and sphere and blade shapes.

Feldspar : comprise slightly in the fluvial sediments; feldspar grains are always discovered together with quartz grains. Most of them display very angular – subangular, moderate – low sphericity, and sphere and blade shapes.

Lithic fragment : They are derived from the country rocks and volcanic rocks. They were discovered partly in fluvial sediments by rock and lateritic fragments but they are absolutely lithic fragments if they are derived from volcanic outcrops. They were always stained by brownish red color of iron oxides, which became within the body of sediments. The lithic fragments, after distinguishing, show very angular, low sphericity, and sphere and blade shapes.

SOURCE ROCK AND TECTONIC SETTING

The proportion of sediments of each sample was plotted into QFL ternary diagram (Dickinson *et al.*, 1983). It is illustrated that most of data were fitted into the Recycle orogenic area and the remnants were fitted to the Craton interior and in the Undissected arc areas (Figure 4.7). The recycled orogenic provenances imply that the sediments were derived from the uplifted sedimentary and metasedimentary terrains (www. eos. ubc.ca, 1997). The craton interior implies the sediments within the continental block provenances where hardly changed during past long time (www. eos. ubc.ca, 1997). And the Undissected arcs imply the volcanoclastic debris consists largely of volcanic lithic fragments (www. eos. ubc.ca, 1997). According to the facts of the Khorat Plateau is a part of the non – active continental terrain after uplifting. The sediments consisting of sand, gravels and clay, are mainly derived from the basement rocks, the Phanom Dong Rak mountain ranges, and also from the volcanic outcrops located in the southern rim of the Plateau. (Sattayarak *et al,* 1998).

Conversely, the data plotted into the QFL ternary diagram (Figure 4.8) can illustrate the tectonic setting of their source rocks. It is interpreted that the study areas are a part of the continental terrain where were uplifted and occurred as an orogenic area not changed during past long time. And there were also the volcanic rocks erupted within the terrain.

4.3 SUMMARY

According to recognition and interpretation in Chapter 1, the sediments of the study areas, accumulating within the Khorat Plateau, were derived from non – active continental block provenances. The sediments are the result from fluvial and gravity actions.

Generally, the discovered sedimentary beddings can be divided into 2 groups based on their different characteristics. The first group is always buried under the second group. In some locations (i. e. Locations 1 and 2), the unconsolidated sediments are discovered underlying the volcanic outcrops. This reveals that there are still sedimentary relicts which older than 0.92 – 3.28 Ma (Tritrangan, 1992). Their sediments illustrate the red bed having oxidized dots, and in some places the particles cluster together changing to be hard pans. In any case they show the characteristic of top soil mixing rootlet, but they are underlain by the sediments of the second group. It implies the occupation of younger sediments on the older sediments.

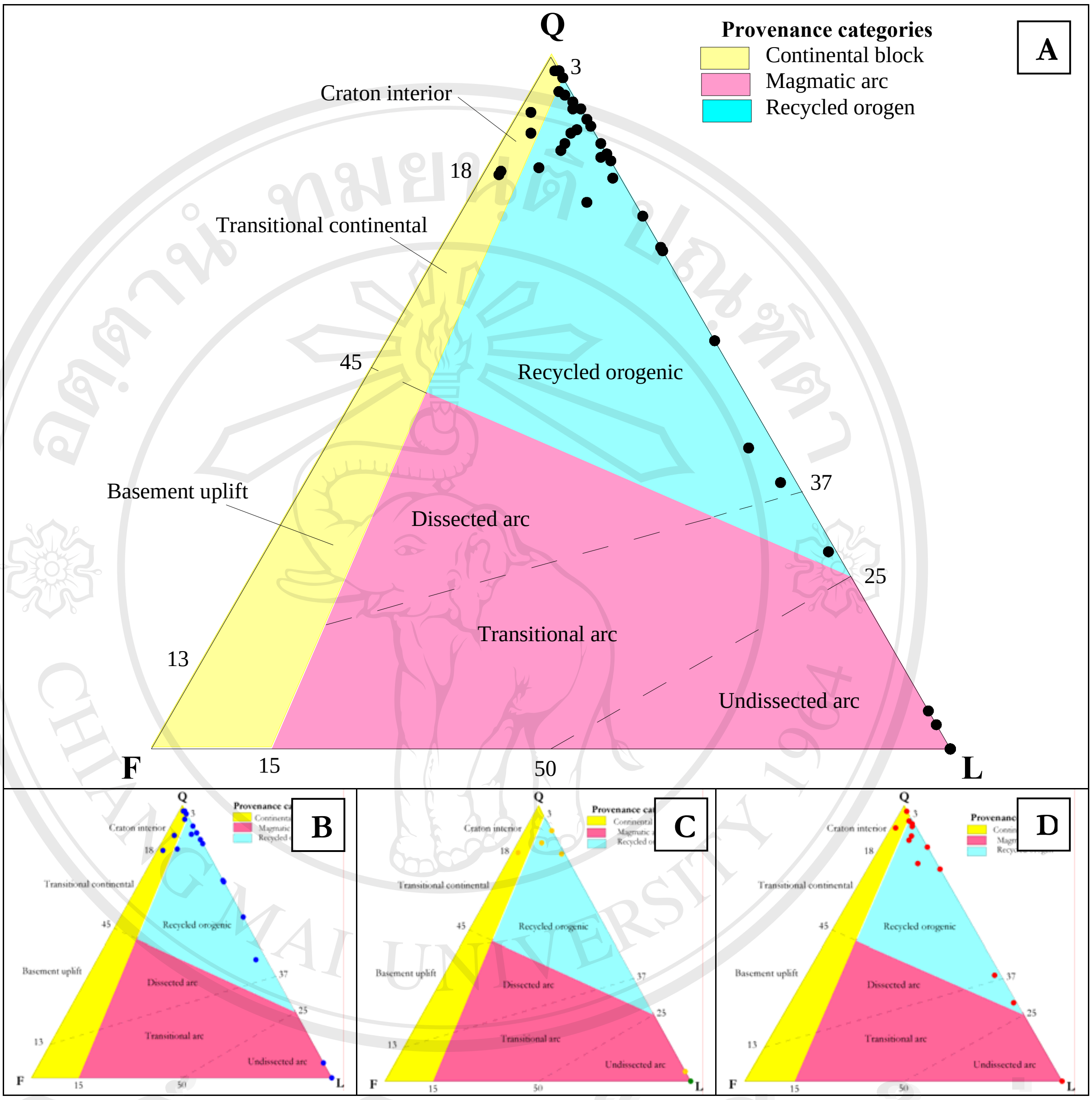

Figure 4.8 (A) Kinds of the particle dividing into Quartz, Feldspar and Lithic are plotted into the FQL diagram. It can be seen most of the grains are in the recycled orogenic, that means they are derived from the weathered rocks. The minors are in the Craton interior and in Undissected arc. Those imply there are the sediments are derived from the mountainous area in the continental plate, and from the volcanoclastic on land. The samples are separated according to the areas. (B) The samples are from the west area, (D) from the east area, and (C)from the area between them.

In addition, the sediments of the first group in some locations contain the petrified wood and tektites, together with gemstones. The results from borehole – drilling (Saraphanchotwitthaya and Tangpong, 2001) are shown (see appendix B).

Sattayarak *et al*. (1998) presented the general stratigraphic of Northeast Thailand (see Figure 1.2). The top of the column reveals the sediments are in Tertiary to Recent. The unconsolidated sediments are divided to be the Younger Redbed and the Gravel Bed. The Gravel bed is composed of pebbles mixing with silicified wood and petrified wood. This Gravel bed is primarily proven as originated in the Tertiary age and was reworked from Young Redbed below it.

Hence, the unconsolidated sediments in the study areas should be correlated to the Gravel Bed. Based on their difference and keys as described above, the sediments are divided to be the *ancient* and *present – day* sediments. The dominant samples of the former are sample nos. 2, 4, 5, 18, 24, 36, 39. The dominant samples of the latter are sample nos. 8 – 11, 34 –35. The characteristics of the ancient and the present – day sediments are revealed in Table 4.5, the section of sediments and their correlation is shown in Figure 4.9.

The idea of dividing sediments in the study areas to be the ancient sediment and present – day sediments, including their characteristics is corresponding to the summary of Alverinho and Neal (1990) and Román and Achab (1999) as quoted that " The coarsest modes show the preseat of relict deposit (paleolittoral environments), whereas the finest modes reflect accumulation zones or areas where the sediments are adjusting to new process ".

According to the results of sedimentary analysis from 15 Locations will then be performed together with the other data from borehole - drilling and pitting to analyze the lithofacies and build the depositional environment in next Chapter.

Table 4.5 The characteristics of ancient and present – day sediments from the study areas.

	Ancient sediments	present - day sediments
GRAPHIC MEAN (Mz)	Medium sand - gravel (most are very coarse sand to gravel)	Gravel - fine sand, Most of them are fine to medium sand.
INCLUSIVE GRAPHIC STANDARD DEVIATION (D)	Poorly - Very poorly sorted	Very poorly sorted - moderately well sorted, Most of them are poorly sorted.
GRAPHIC KURTOSIS (K)	Platykurtic - Very Leptokurtic, Most of them are Platykurtic.	Very Platykurtic - Very Leptokurtic, Most of them are Platykurtic.
INCLUSIVE GRAPHIC SKEWNESS (SK1)	It varies from Very negative phi values (coarse) - Positive phi values. Most of them are negative phi values and symmetrical.	It varies from Very negative phi values (coarse) - Positive phi values. Most of them are Very negative phi values (coarse) and negative phi values.
SHAPE	Most of them has sphere shape.	Most of them has sphere shape.
SPHERICITY	Most of them has low sphericity.	Most of them has moderate sphericity.

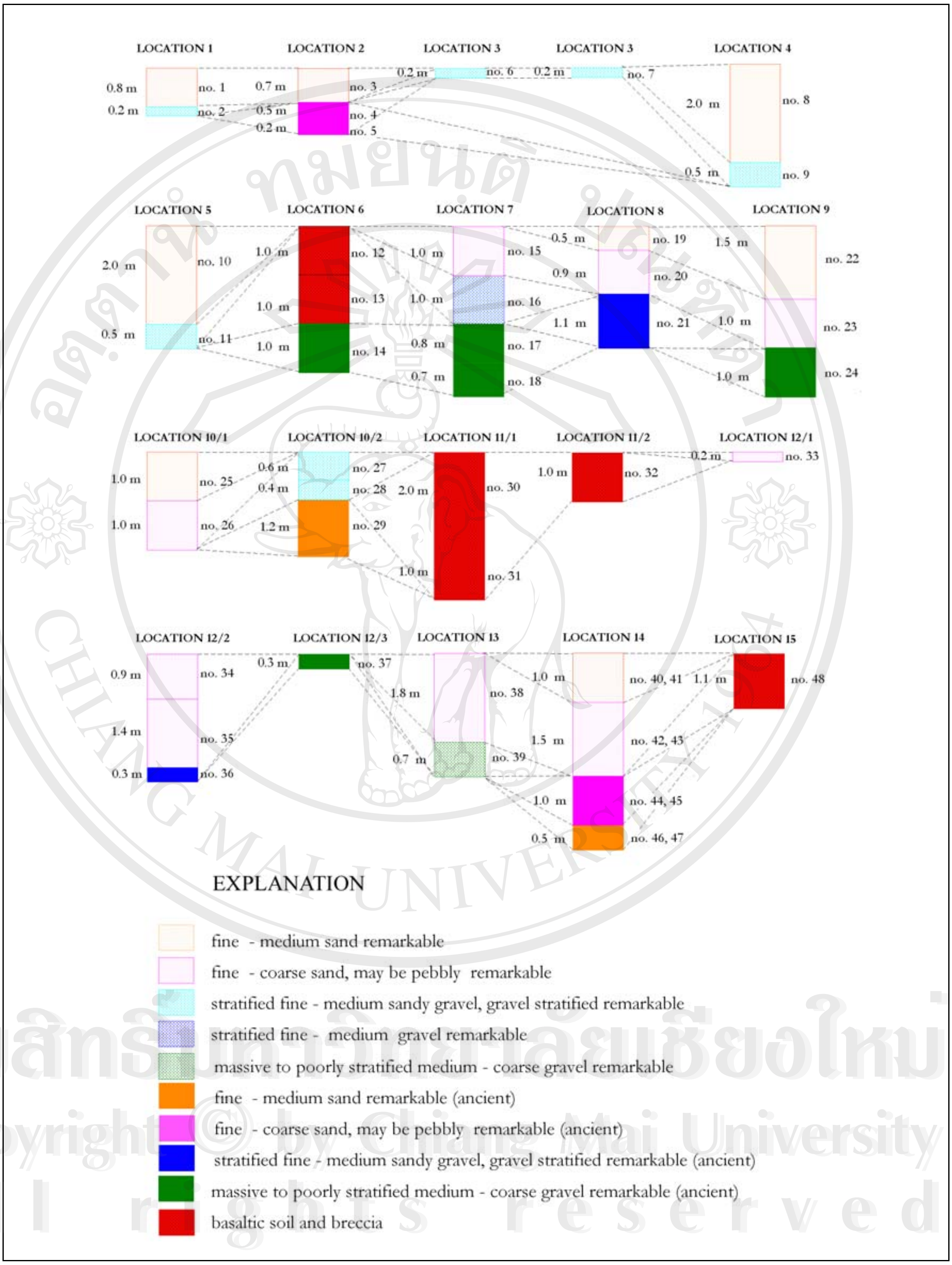

Figure 4.9 The section created from the change of the graphic mean values, reflecting the lithofacies simply. The Locations 1 – 9 are from the west of the study areas. The Locations 10 and 18 are from gap areas. The locations 11 – 17 are from the east of the study areas.