CHAPTER 5

LITHOFACIES AND DEPOSITIONAL ENVIRONMENT OF THE STUDY AREAS

The 72 borehole – drilling which are in the boundary of the study areas, are selected from 125 bore – drilling. The 61 pits are also selected from the other sources to supply the data for creating the lithofacies and depositional environments of the sediments in the study areas. The subsurface data are from:

1. Borehole – drilling data from Banka – drilling (Saraphanchotwitthaya and Tangpong, 2001)

2. Pitting data from Tangpong (1990)

3. Pitting data from Tonthongchai and Monjai (1998)

4. Pitting data from Rattanaruangamphai and Trakoonthewin (2001)

5. Pitting and section studying from field trip during 2003s and during 2005s

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All of the data are compiled to dominate their lithofacies and studied for the depositional environments of the sediments in the study areas, especially the gemstone-bearing sediments. The investigations are emphasized in the interesting areas in the Huai Tha and its tributaries, Huai Ka Yung and its tributaries, Lam Som and its tributaries as shown in the Figure 5.1 (names of streams see Figure 1.1).

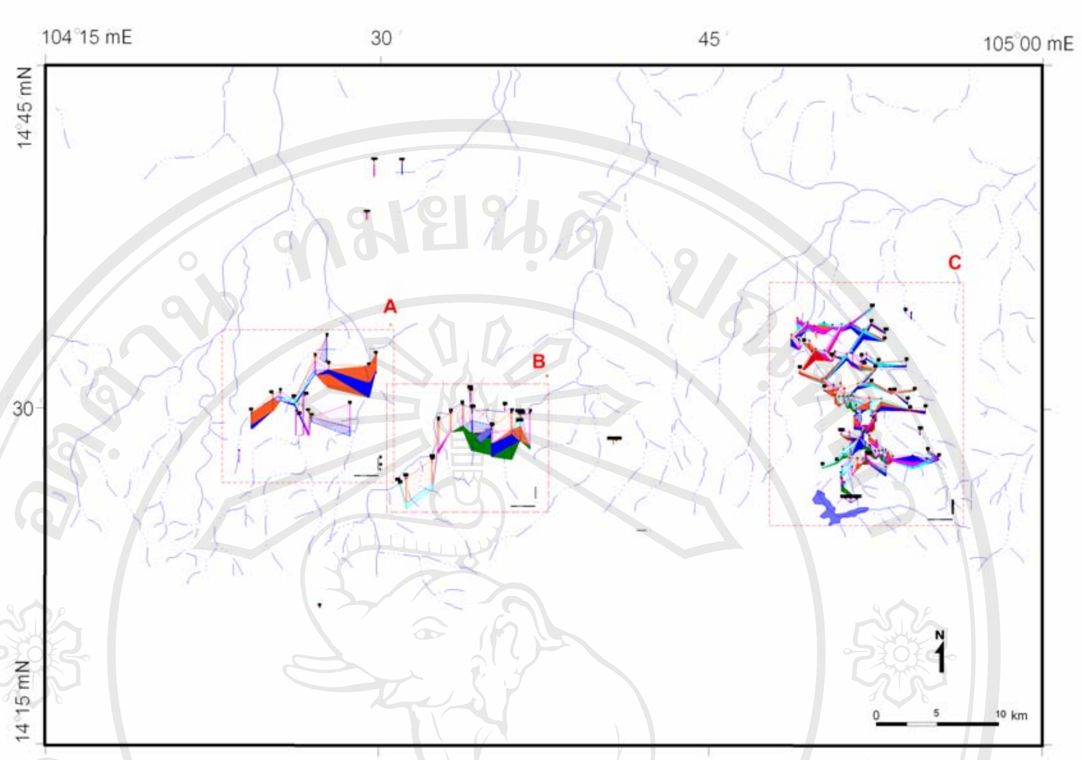

Figure 5.1 The subsurface investigating areas from 3 sources. (A) Huai Tha and its tributaries, (B) Huai Ka Yung and its tributaries, (C) Lam Som and its tributaries.

5.1 THE ELEMENTARY FACIES DESCRIPTION

The classification of lithofacies characteristics are based on Miall (1978, 1984); Rust (1983); Anderson *et al*. (2006), but it is different that the code names of the lithofacies are modified. Because most of data are generated from borehole – drillings and pits, the sedimentary structures are not clearly to identify. However, the results of this study show that the lithofacies of the study areas are the fluvial and the volcanic environments.

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THE FLUVIAL ENVIRONMENT

The fluvial environment is the mojor. The lithofacies are composed of 3 gravelly facies, 2 sandy facies, 1 fine – grained facies. These lithofacies are subdivided into 2 groups upon depositional period to be *the ancient sediments* and *the present – day sediments*. The former is underlain by the latter, and changing to be laterite. The gravelly facies has the members are : **G1, G1(a), G2, G2(a), G3, G3(a).** The sandy facies consists of **S1, S1(a), S2, S2(a).** The fine – grained facies is composed of **F, F(a).** Where (a) represents the abbreviate letter which means the same characteristics but older age (see appendix B).

THE VOLCANIC ENVIRONMENT

The volcanic environment is the minor. Some sediments concluding of the gemstones are generated from it to the fluvial process. The volcanic rocks in the study areas appear in a lithofacies but different ages: **the ancient basalt lithofacies (bs(a))** which are discovered from the results of banka – drilling in form of basaltic clay overlying on the country rock surface and underlying the fluvial sediments of the Fluvial environments. Most of them generate the gemstones; and **the present - day basalt lithofacies (bs)** which scatter along the rim of the Khorat Plateau, is overlying some parts of the unconsolidated sediments of the Fluvial environment. The description of each lithofacies is in Table 5.1, 5.2. The association of the lithofacies is illustrated in Figures 5.1 – 5.4.

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5.1.1 Facies G1 and G1 (a)

This lithofacies comprises gravels supported by a poorly sorted matrix of sand, silt and mud. They are poorly – very poorly sorted. The bed may be massive or may show grading of clasts and/or matrix. In places, it shows coarsening upward or fining upward sequences whilst imbrication is absent. The bed usually lies on the country rocks but some places are on the ancient basalt lithofacies and overlain by the younger beds. This lithofacies appears near the foot hill.

The beds has very pale orange – yellowish brown – grayish brown. Their thickness varies from 1.0 – 4.7 m but generally about 4 m. Their compositions are generally silt to clay 10 – 25%, sand 20 – 60 %, gravel 50 – 90 %. Gravels consist of very angular – subangular sandstone, siltstone pebbles, cobbles and boulders, which were up to 70 cm in diameter. Around the ancient - basaltic mounds, the remnant of basaltic gravels is also found. The subrounded – well rounded gravels of quartz, chert and quartzite are mixed in the bed, and are derived from eroded country rocks. The G1 and G1(a) lithofacies contain the pieces of tektite, petrified wood, and gemstone grains, especially ones overlying the ancient – basalt mounds.

5.1.2 Facies G2 and G2 (a)

This lithofacies consists of pebble to cobble clasts with crude horizontal stratification. Clasts are imbricated. The bed is underlain by the country rocks or the lithofacies G1, and overlain by the younger beds. Generally, this lithofacies is discovered more widespread than the G1. However, it is associated with G1.

The beds has pale to dark yellowish gray – yellowish brown and their thickness varies from 1.0 – 8.0 m but generally about 2 - 5 m. Their compositions are generally sand mixing clay and silt 40 – 60%, gravel 40 – 60 %. Gravels consist of angular – subangular sandstone, siltstone pebbles and cobbles, generally 10 - 25 cm in diameter. The subrounded – well rounded gravels of quartz, chert and quartzite are mixed in the bed. They are eroded from country rocks and from reworking of former bed. The G2(a) lithofacies contains the gemstone grains if its position is near the ancient – basalt mounds.

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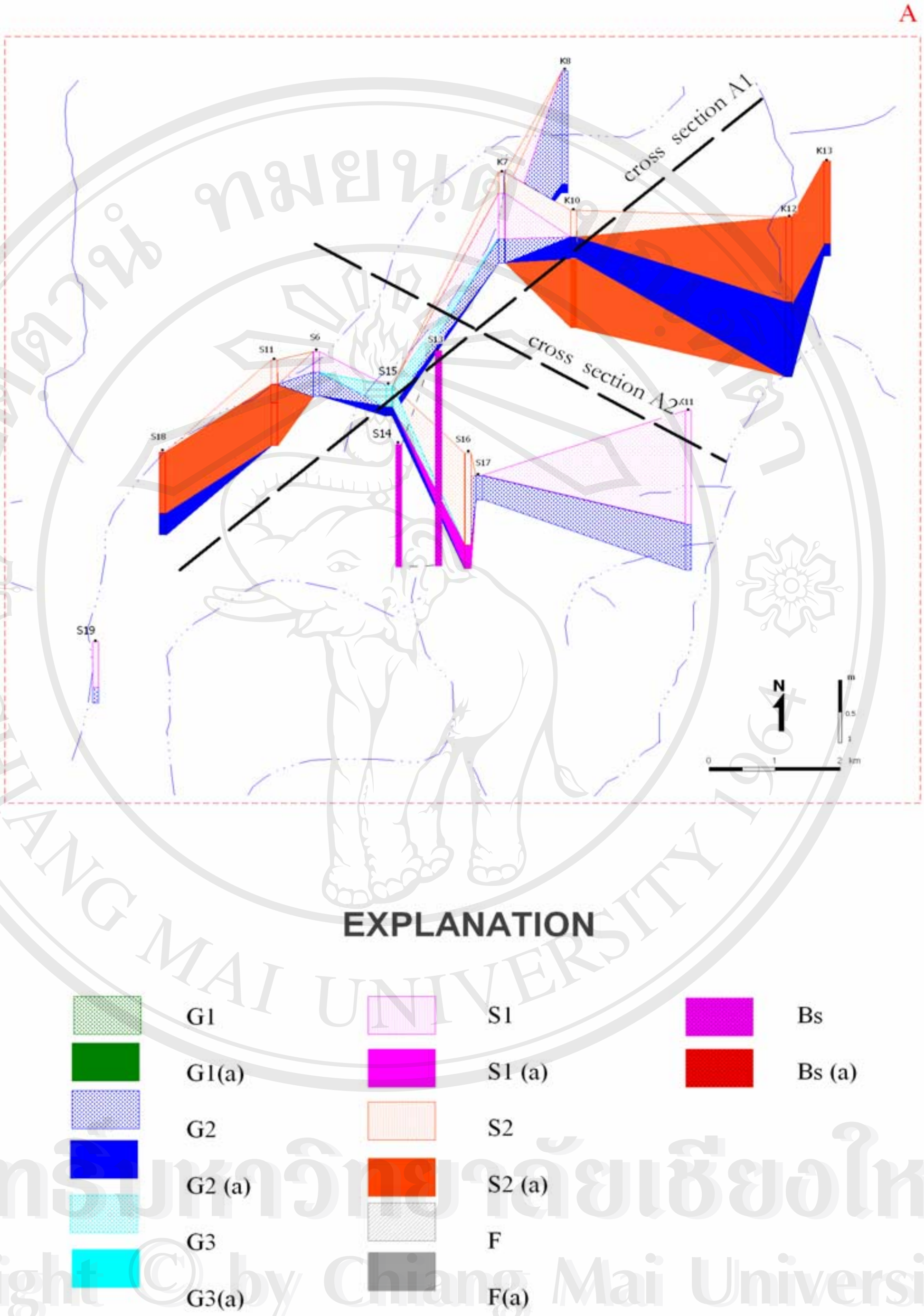

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Figure 5.2 A Fence diagram of area A showing the correlation of the lithofacies. The cross section A1 and A2 are illustrated in Figure 5.2B.

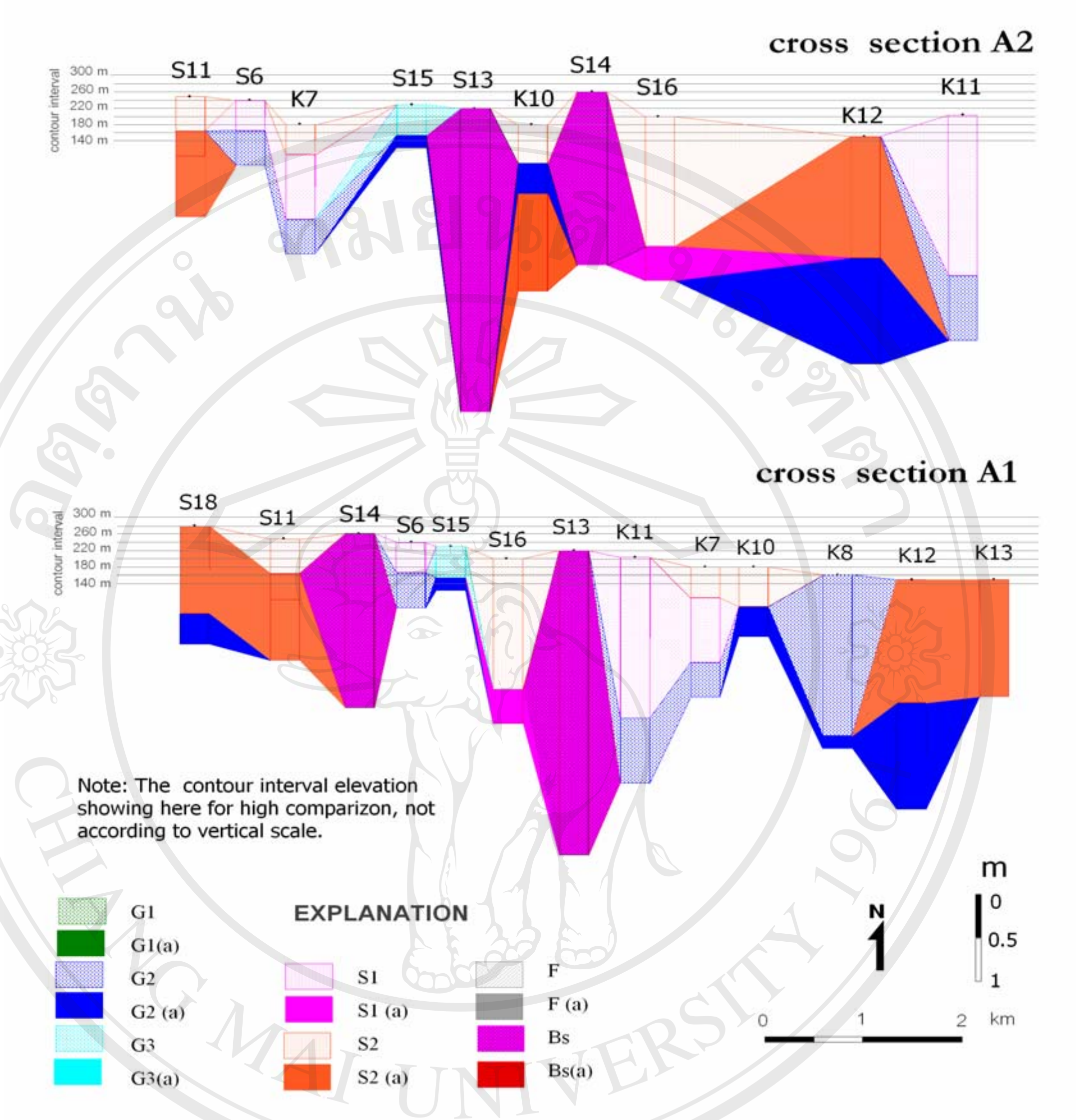

Figure 5.2 B The cross section A1 and A2 of area A..

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Table 5.1 The lithofacies scheme for fluvial enviroment in the study areas.

Facies code	Lithofacies	Sedimentary structures	Process Interpretation
G1 G1(a)	- Massive, matrix supported gravel - Coarse massive gravel with cobbles and boulders: sandy matrix, trace silt; weaky imbricated	None	- Deposited during period of Very high discharge
G2 G2(a)	- Massive to poorly stratified medium to coarse gravel - Massive or crudely bedded gravel	Horizontal bedding, imbrication	- Deposited as flow decreased from higher discharge associated with G1 - longitudinal bars, Lag deposits, Sieve deposits
G3 G3(a)	- Stratified fine to medium sandy gravel - gravel stratified	Trough crossbeds	- Deposited during sustained, relatively low flow condition on the flanks of bars or in chutes cut between bars - Fills concave – up scours cut into coarser gravel lithofacies - Minor channel fills
S1 S1(a)	- Horizontal to low angle bedded fine to medium sand	Horizontal lamination, parting or streaming lineation	- Formed as high velocity flow diverged over bar tops or in the low flow regime as aggradation on plane or low angle bed in channels or bar flanks - Scour fills
S2 S2(a)	- Ripple – laminated, very fine to fine sand - Sand, fine	Low angle ($<10^{\circ}$) crossbeds	- Formed as flow wanned near the limit of sand bedload transport, either on the top of bars or in emerging chutes along bar flanks - Scour fills, - Crevasse splays, antitude
F F(a)	- Laminated very fine to fine grained sand and silt - sand, silt, mud	Fine lamination, very small ripples	- Deposited in stagnant flow conditions where suspended material settled out rapidly in cut - off channels or bar top pools; occurs as a thick drape along filling channel scours, except that periodic fluxes of sediment were followed by stagnant periods. - Overbank or wanning flood deposit

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Table 5.2 The lithofacies scheme for volcanic environment in the study areas.

Facies code	Lithofacies	Sedimentary structures	Process Interpretation
Bs	Hard rock, no gemstones potential	Thick bed, single – small/ large shield shape	Thick bed of basaltic flow
Bs(a)	Clay, very sticky, most of them generate gemstones	Single - small mound	In – situ weathering of basaltic flow

5.1.3 Facies G3 and G3 (a)

This lithofacies is discovered on the flanks of bars or in chutes cut between bars of the lithofacies G1 or G2. In places, the facies is found lying on the coarser gravel lithofacies or the present – day minor channel fills. Hence, it has broad, shallow scoop shape and has broader distribution comparing to the lithofacies G1 and G2. However, it is distinguished at the proximal braided plains of the study areas. The G3 and G3(a) lithofacies lies on the surfaces of the country rocks or the lithofacies Bs(a), G1(a), G1, G2(a) or G2 in the alluvial plains. But it can be discovered as incision into the fine – grained lithofacies in the proximal to distal braided plains.

The beds has pale to dark -light brown – light to dark brownish gray. They are 1.0 – 7.0 m thick but generally 2 m. Their compositions are generally silt to sand 10 – 55%, gravel 45 – 90 %. Gravels consist of very subangular – subrounded sandstone, siltstone pebbles and cobbles, boulders are very rare (< 5%). The subrounded – well rounded gravels of quartz, chert and quartzite are mixed in the bed. They are reworked from the lower beds. The G3 and G3(a) lithofacies contain some gemstone grains, if ones are underlain by the ancient – basalt mounds or the gemstones are reworked from the gem – bearing beds.

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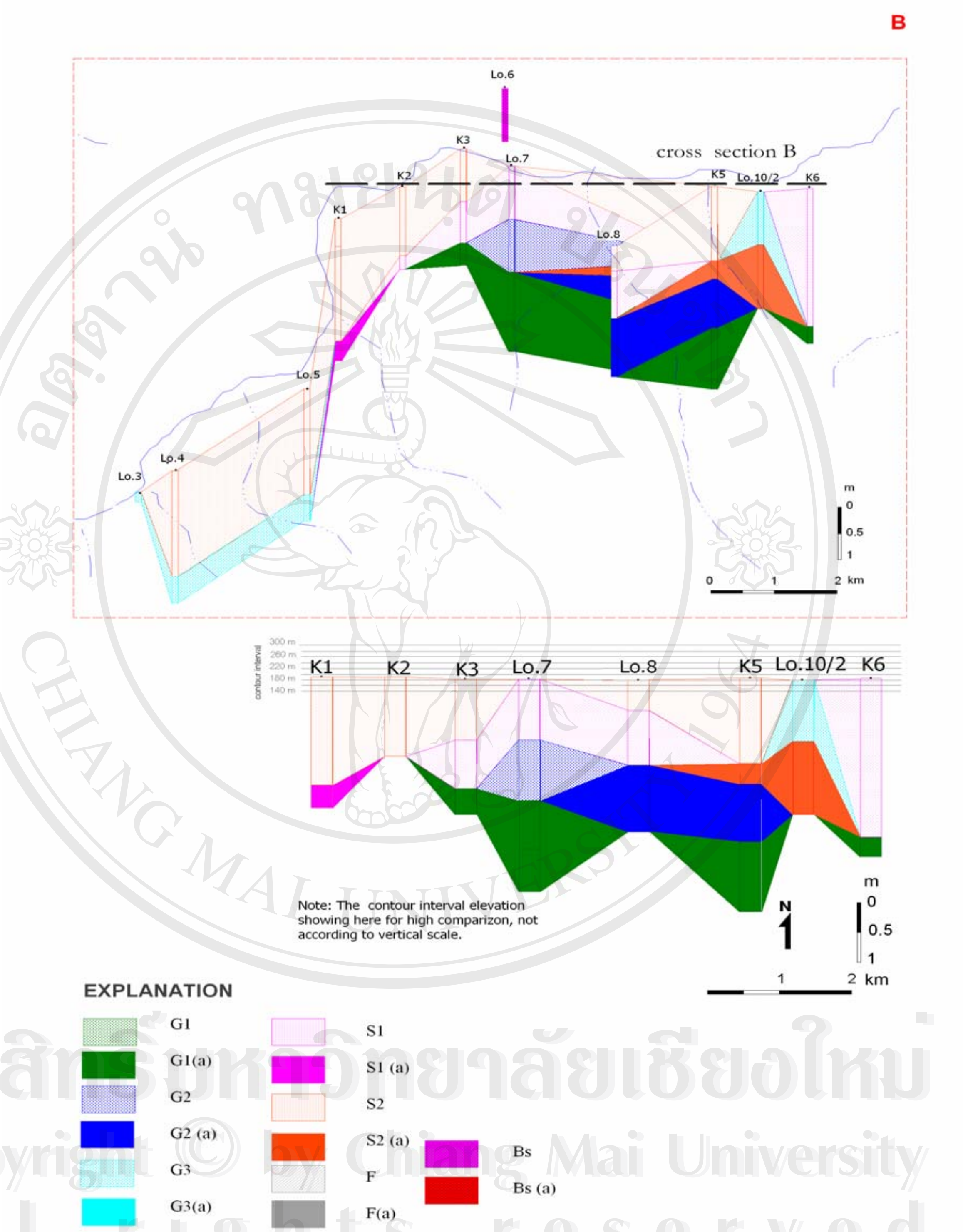

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Figure 5.3 Fence diagram and cross section of area B showing the correlation of the lithofacies.

5.1.4 Facies S1 and S1 (a)

This lithofacies is discovered either in the channels or overbank deposits. In channel deposits, the lithofacies S2 and S2 (a) are rather thicker and contain more amount of pebbles than overbank deposits. It always overlies on the gravelly facies. The lithofacies S2 and S2(a) has wide and flat shapes. It seems this lithofacies is fullfilled the top of the coarser lithofacies.

The beds has pale to dark yellowish brown – light to yellowish orange – light gray. They are 1.0 – 6.0 m thick but generally 2 - 3 m. Their compositions are generally silt to sand 70 – 90 %, very fine to medium pebbles 10 – 30 %. Gravels consist of very subangular – subrounded sandstone, siltstone pebbles. The subrounded – well rounded pebbles of quartz, chert and quartzite are mixed in the bed. They are reworked from the lower beds. This lithofacies contain some gemstone grains, if ones are underlain by the ancient – basalt mounds or the gemstones are reworked from the gem – bearing beds.

5.1.5 Facies S2 and S2(a)

This lithofacies are similar to the lithofacies S2 and S2(a) which they are commonly associated with. This lithofacies shows low angle cross – bedding. The lithfacies comprises very fine to fine sand, moderately- well sorted. It is possible to have medium to coarse sand or some very fine to fine pebbles in the lower part of the beds. The lithofacies S1/ S1 (a) was formed as flow wanned near the limit of sand bedload transport, either on the top of bars or in emerging chutes along bar flanks, or be the scour fills. It can also be discovered being the creavasse splays.

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The beds has light brown to medium yellowish brown – grayish orange. They are 1.0 – 5.0 m thick but generally about 3 m for S1(a) and 1 m for S1. Their compositions are generally very fine to fine sand 70 – 90%, very fine to medium pebbles 10 – 30 %. They are moderately – well sorted and rather slightly sticky.

Gravels consist of very subangular to subrounded sandstone, siltstone and the subrounded – well rounded of quartz, chert and quartzite. The gemstones are rare. Some which are discovered are small grains about medium sand size. Their surface features are implied the reworked transportation.

5.1.6 Facies F and F(a)

These lithofacies occupy the overbank areas, comprising very fine sand, silt, mud and fine – grained organic matters. In the study areas, they appear in the pairs of overbanks.

The beds has dark yellowish orange – medium – dark yellowish brown. They are 0.8 – 2.0 m thick but generally 1 m. Their compositions are generally very fine sand, silt and clay 100%, may be coarse sand or very fine pebble < 5 %. The bed is slightly sticky to loosed. The rootlet is common.

5.1.7 Facies Bs and Bs (a)

These lithofacies are in the volcanic environment. The lithofacies Bs is seen clearly on the ground, showing hard rocks with weathering surfaces. They overly the unconsolidated sediments. Whereas the lithofacies Bs (a) is beneath the unconsolidated sediments and on the surface of the Khorat group. The results from bangka – drilling (Saraphanchotwitthaya and Tangpong, 2002) show the residual – basalt mounds which the gravels eroded from them are not transported far from the sources. No dominant evidences of tuff or pyroclastic sediments are found. Orton (1996) calls the basaltic magma erupts to the surface that *Effusive eruption* which the magma has low viscosity and it can easily degas and more commonly reach the surface as lavas. Hence the volcanic fragments are hardly appeared.

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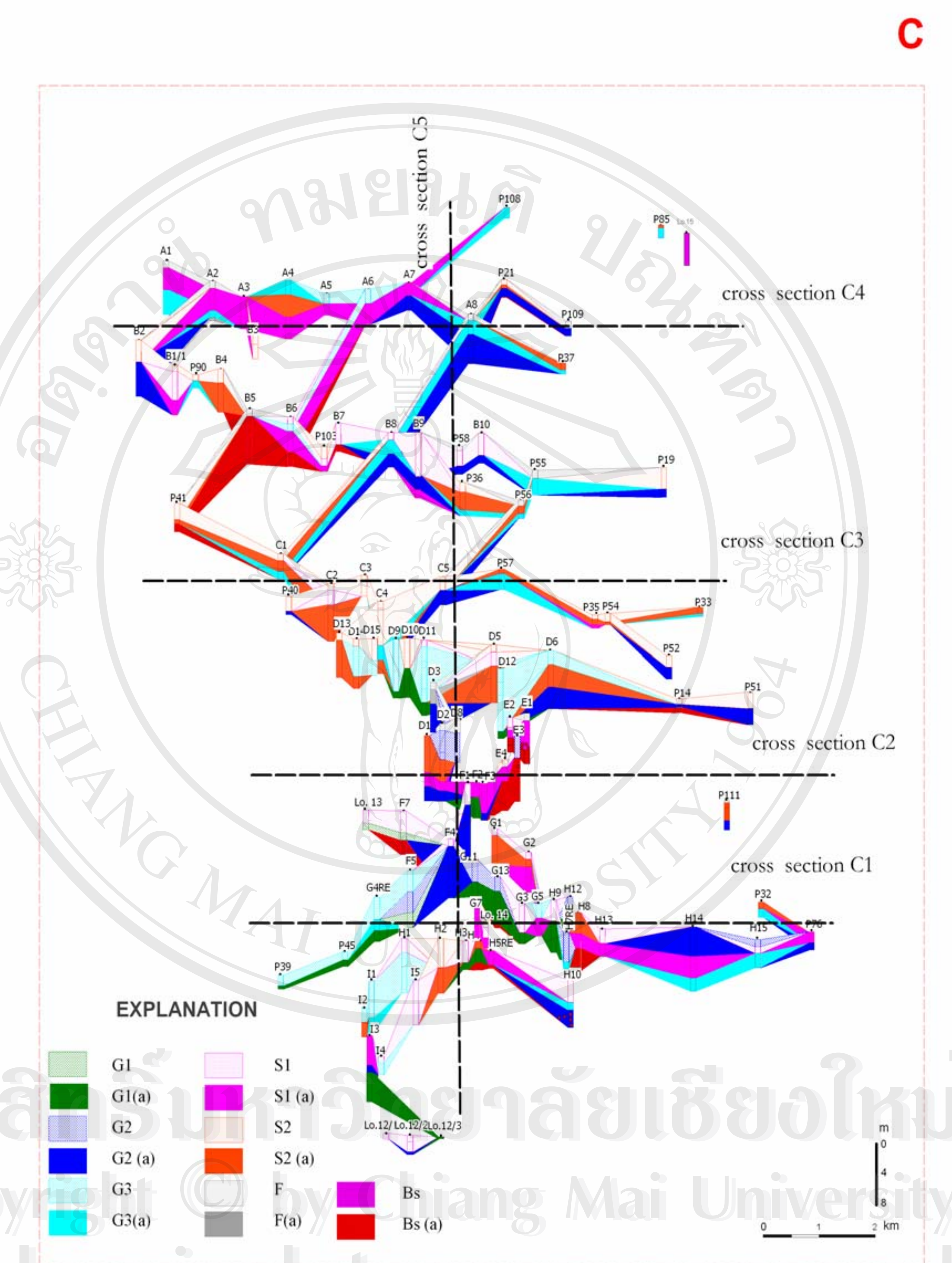

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Figure 5.4 A Fence diagram of area C showing the correlation of the lithofacies. The cross section C1 - C5 are illustrated in Figure 5.4 B.

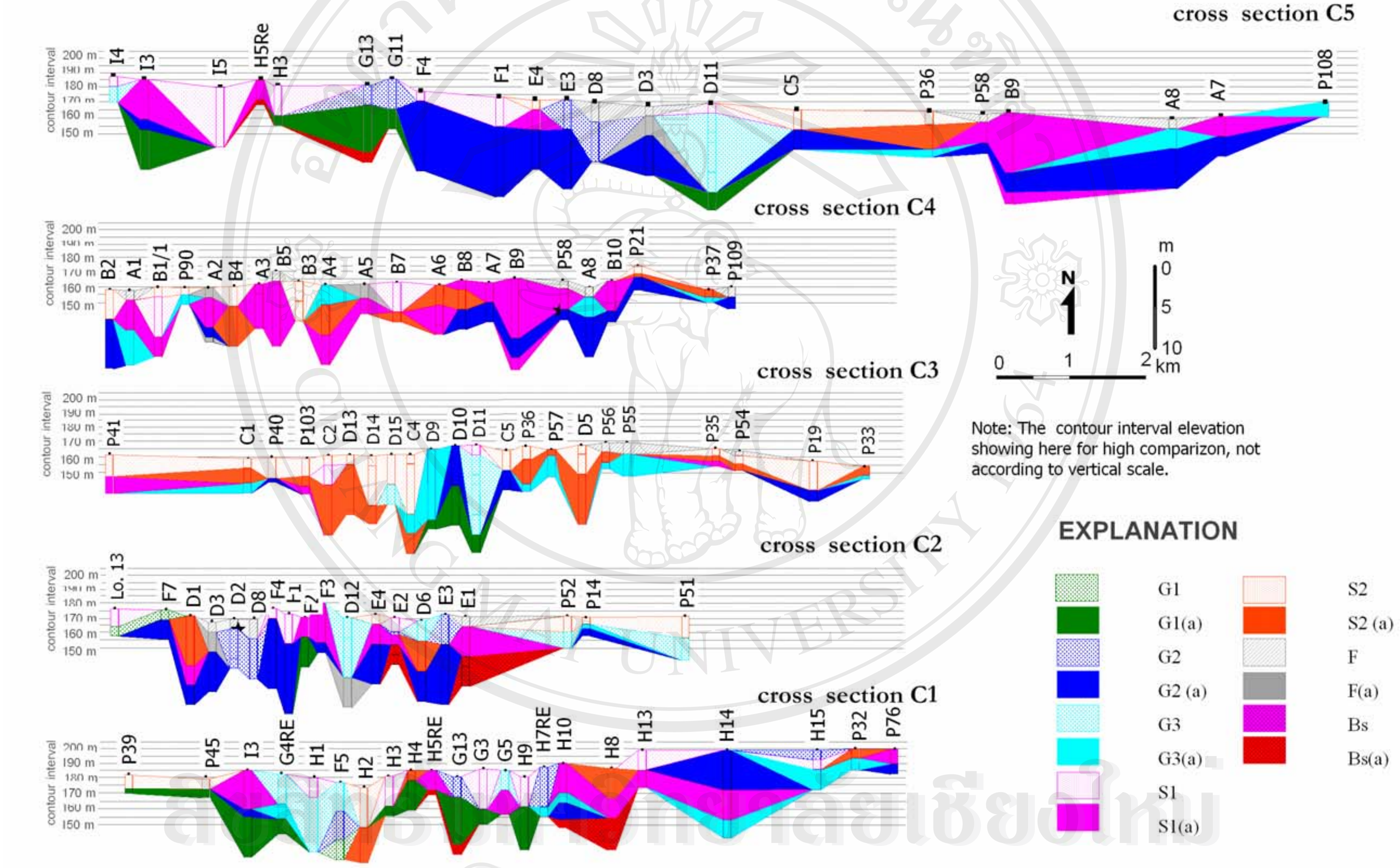

Figure 5.4 B The cross section C1 – C5 of area C.

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In comparison, the lithofacies Bs(a) generates the gemstones mostly than the lithofacies Bs. Most of the gemstones is zircon, the minor is sapphire, ruby and garnet.

The elementary facies description above can be used to make the decision of the gemstone bearing lithofacies. The own Bs(a) is the first important gemstone bearing. The ancient - gravelly facies and sandy facies comprise G1(a), G2(a), G3(a) and S2 (a) are also the important gemstone bearing when they lie on the gemstone bearing Bs(a). The present – day gravelly and sandy facies are not important though some gemstones are discovered in the beds. Because the gemstones are the reworked result from the older facies. Hence the gemstones are so small as silt or sand sizes. However, if the areas are confined characteristics, for examples the potholes or the reservoirs, there are opportunity to discover more gemstones in the present – day facies.

5.2 DEPOSITIONAL ENVIRONMENTS

The environments are in the continental nonmarine group. The lithofacies of the study areas and their correlations (Figures 5.2 to 5.4) reflect 2 depositional environments: The Fluvial and Volcanic environments. The former has distinct characteristics of coarse alluvial deposits and can be subdivided into the Alluvial fan and the braided streams. The latter is individual environments comprising pre – paleofluvium basalts and post – paleofluvium basalts.

The simplifies cartoon of Crick (2005) and the gray tone 3D illustrator of the study areas are useful to understand the depositional environments of the sedimentary in the study areas and vicinities (Figure 5.5).

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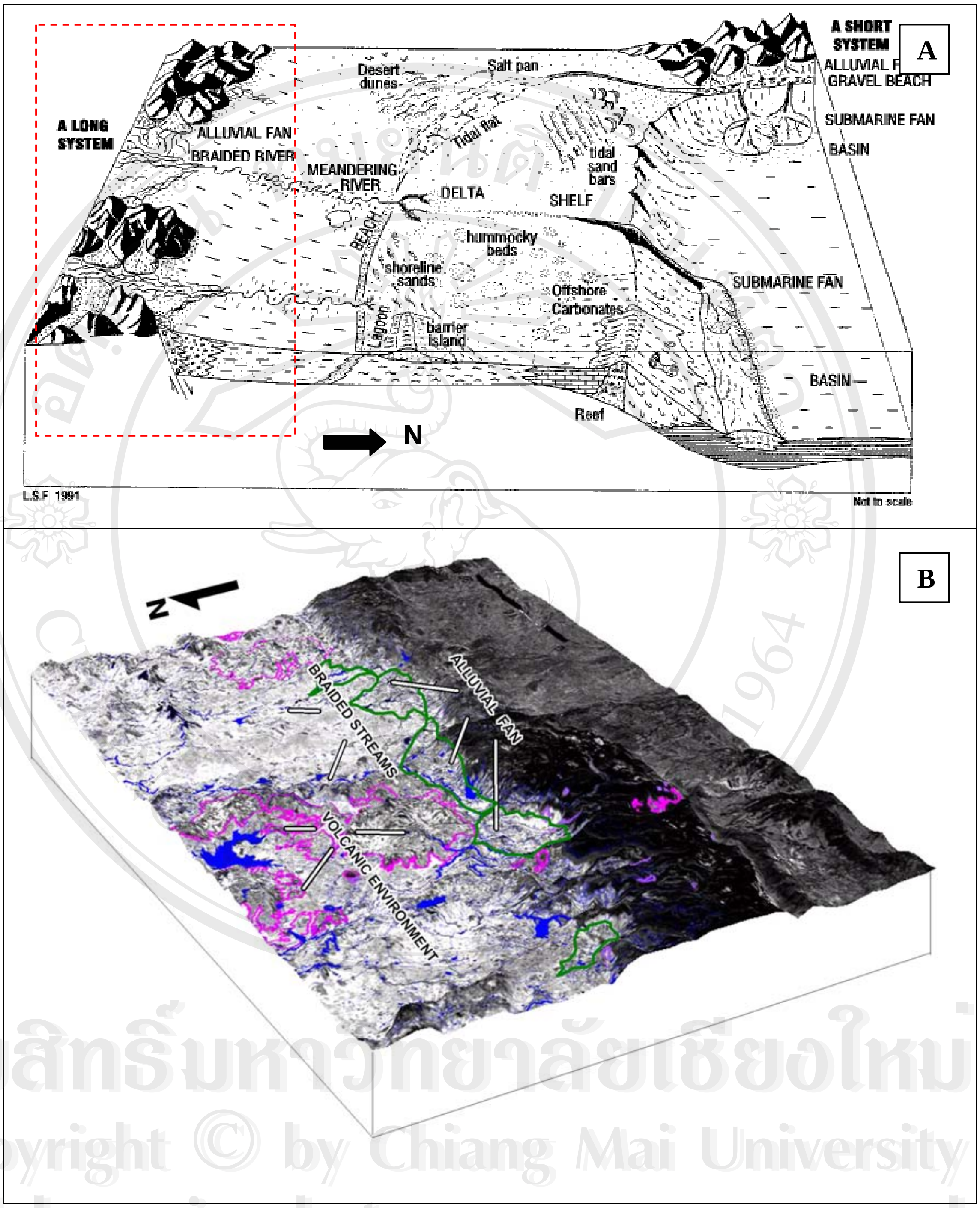

Figure 5.5 (A) The cartoons illustrate the depositional environments of the sediments in the study areas (in the red – dashed boxes), modified from Crick (2005). (B) The illustrator of the study areas showing depositional environments, the alluvial fans are bounded by the green lines, the volcanic environments are bounded by the pink lines.

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5.3 THE EPISODIC EVOLUTION OF THE FACIES

The lithofacies in the study areas is associated with the Himalayan Orogeny and weathering of the Khorat Group. The Khun Han and Kantaralak Basins are developed from the incision of the channels which follow the lineament structures. During the Upper Tertiary, the sedimentary rocks of the Khorat basin have been affected from the Himalayan Orogeny. Hence the uplifting of the Khorat Plateau was occurred with the fractures, which are the vents for the lithofacies Bs (a) erupted to surface. The remnants of them have the characteristics of very sticky greenish gray or bluish gray clay mounds which are subsurface and lack the dating evidence. However, the zircon grains in the lithofacies Bs(a) have been dated giving the age of 12.1 ± 11 Ma (see Chapter 2, Topic 2.1.3).

After the uplifting of the Khorat Group, the fluvial system and gravity have affected to the rock continuously. In the foothill area, the talus and the fluvial deposits of lithofacies G1(a) and G2(a) are occurred in the initial planes, together the streams incised the rock surface. Hence the initial fluvial systems begin even though the water still run along the braided depositional sediments. The G3 (a) appears after the fluvial system incises the older sediments, whilst the sandy facies as S1(a), S2(a) and the fine – grained facies F(a) are deposited overlying the coarser facies. The tektites and silicified wood are discovered in the lithofacies G1(a), G2(a), G3(a). The tektites in the gravels provide the age at 0.68 to 0.73 Ma B.P.(Wongsomsak, 1983; 1985). Salayapong *et al.* (1994) studied the tektites discovered in the Northeast Thailand and date the sediments they embed in. The dating shows the age 0.76 Ma. B.P. Whilst Charusiri *et al* (2002) studied the tektite samples and their sediment hosts at Ban Tachang sand pit, Chaloem Prakiat District, Nakhon Ratchasima Province, and the dates of tektites were estimated at about 0.69 to 0.80 B.P. The silicified woods provide the age Late Pliocene or Pleistocene age (Kobayashi, 1960; 1964). Hence, the paleochannel sediments range in age from 0.68 to 0.80 Ma B.P. or in the Pleistocene.

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The lithofacies Bs overlies the unconsolidated - paleochannel sediments.(see Chapter 1, topic 1.4.2.1, Igneous rock), that implies later occurrences. The locations of the basaltic outcrops are not the same positions of the lithofacies Bs(a) but it cannot deny the the existence of the lithofacies Bs(a) beneath the lithofacies Bs because it lacks the subsurface data.

The basalts from lithofacies Bs are dated and then provide the age 0.92 $\pm$ 0 .30 to 3. 28 $\pm$ 0.48 Ma B.P. (Barr and Macdonald, 1981). The age of the lithofacies Bs exhibits the older age than the lithofacies beneath them. Hence it needs more dating data of basalts in the study areas to decide exactly about the age of lithofacies Bs.

Parry (1996) proposes the changes in the geomorphic system affects the Khorat Plateau. It points out that during the middle to late Pleistocene the Khorat Plateau is in semi – arid phase which is increasing the aridity. It is hypothesized that the aridity effects those fluviual systems of the study areas. Most of them are drier.

In late Pleistocene to Holocene/ Recent, the Khorat Plateau is in more humid conditions (Parry, 1996). The fluvial systems have rejuvenated and the appearance of the present – day lithofacies composing is consisting of G1, G2, G3, S1, S2, F

5.4 SUBSURFACE GEMSTONE DEPOSITS

Lithofracies study provides the subsurface data of gemstone bearing sediments beyond the known gemstone deposits (see Chapter 1). The subsurface gemstone deposits are 22 square kilometers approximately. They are bounded as shown in Figure 5.6.

Beyond those are illustrated, the other subsurface gemstone deposits have opportunity to be discovered. Because most areas beneath the lithofacies Bs is not investigated. Nowadays the basaltic quarries in the study areas and adjacent areas disclose the subsurface data. Further days the sediments or the rocks beneath the quarries, including another subsurface gemstone deposits, should be known.

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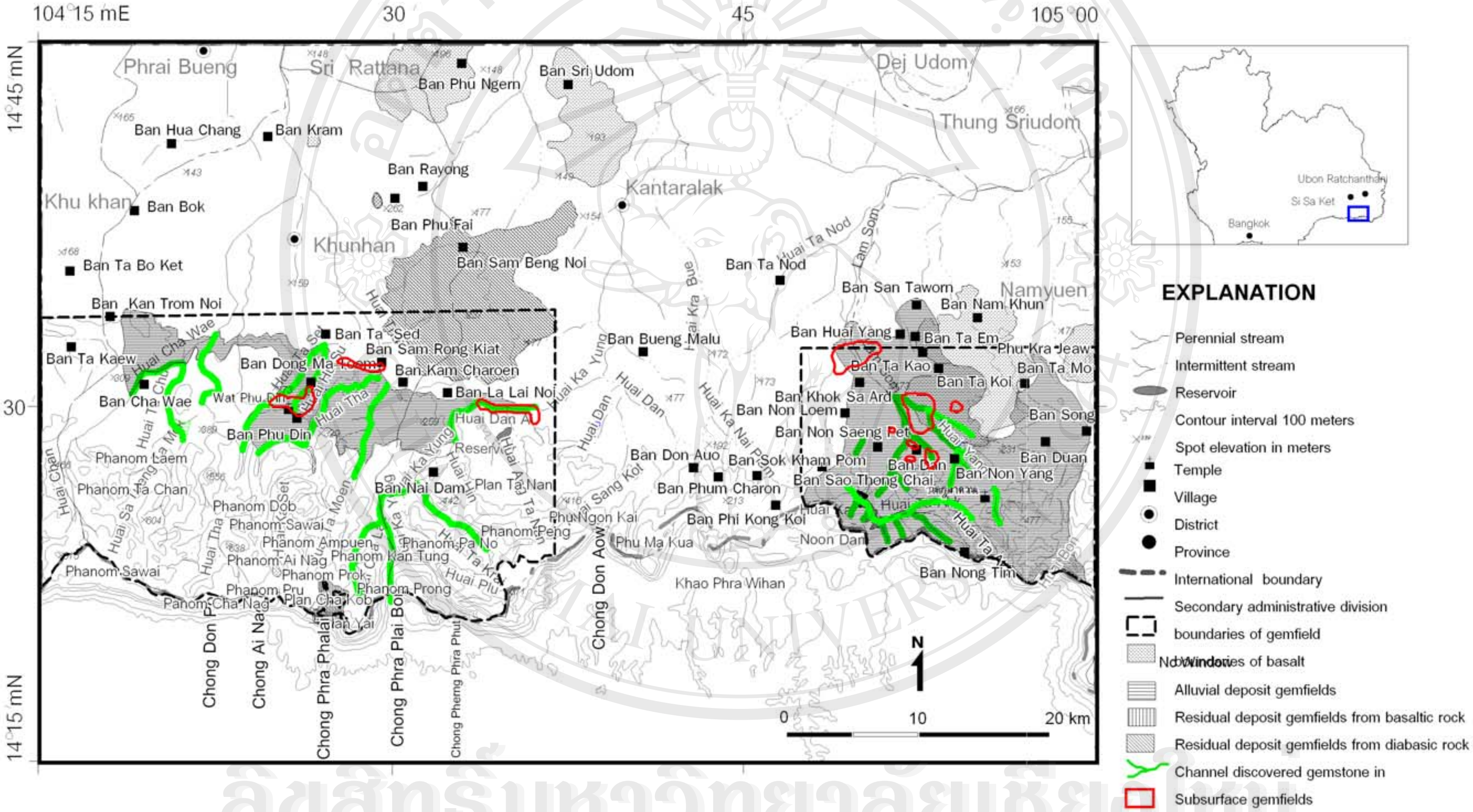

Figure 5.6 Surface and Subsurface gemfields of the study areas

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