CHAPTER 2

GEMSTONES FROM THE STUDY AREAS

Corundum and associated gemstones occurring in the Khorat Plateau have been discussed about their hosts or their genesis since 1970 (Aranyakanont *et al.,* 1970) because of the most important evidence, the rock which the corundum megacryst embeds in, is still not discovered. Until recently, during gemstone exploration in 2001, there is a good evidence for supporting the association of gemstones in the study areas with the basaltic rocks (see topic 2.1.6).

The position of their occurrence, distribution, and characteristics of gemstones in the study areas has also been proposed in this Chapter. They are useful as the clues of their source rocks.

2.1 THE SOURCE ROCK OF GEMSTONES

The gemstones in the study areas, especially the corundum, are assumed to associate with the basaltic rocks. There are data supporting this assumption as follows:

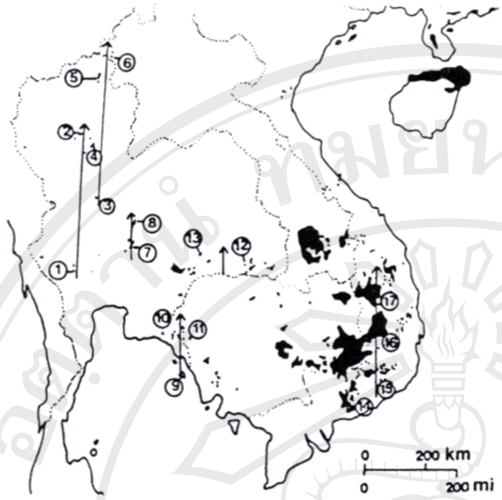
2.1.1 THE SIMILARITY OF LOCATIONS AND ROCKS ASSOCIATED WITH CORUNDUM IN THAILAND AND ADJACENT COUNTRIES

The gemstones in the study areas are discovered in the zone where the basaltic eruption occurred as those in the other sources of Thailand and adjacent countries (Figure 2.1 – 2.2). Although most recent basalts in the study areas have no potential of gemstones as proposed in Chapter 1, some of them has potential. As the results from borehole – drilling described in Chapter 5, the remnants of gem – bearing basalts are underneath the paleochannel sediments and lie on the Khorat Group surface whilst the recent phase basalts overly the sediments. It is presumed that the remnants are the previous phase of basalts. Figure 2.2 shows the Late Cenozoic basalts and the corundum deposits in Thailand and the Indochina region. It is seen that basaltic outcrops in Indochina can be simply divided into 2 groups: the small body and the large body outcrops. The corundum deposits are rather discovered in the small body group than in the large body, at least all corundum deposits in Thailand and adjacent areas such as Lao PDR and Cambodia are discovered in the small body group. Thus the source rock of gemstones in the study areas should be the small body basalts erupting before this appearing phase.

2.1.2 THE SIMILARITY OF GEMSTONE DEPOSITIONAL ENVIRONMENT AND MINERALS ASSOCIATED WITH CORUNDUM

There are 3 kinds of corundum hosted rock discovered in Southeast Asia : (1) *Corundum is in pegmatite interwoven with granite in Vietnam* (Figure 2.3 A). The gemstone discovered primarily within the pegmatite and secondary deposit in alluvial gravels in the bottom part of valley and along hillside of streams. Associated minerals discovered together are hercinite, pleonaste, magnetite, hematite/ilmenite, ilmenohematite, hyperstene, saphirine, sillimanite, cordierite, garnet, biotite, feldspar, staurolite, gahnite, and eutile (Hughes, 1997).

(2) *Corundum occurs in carbonate rocks in Myanmar* (Figure 2.3B). The gemstones are discovered primarily within marble and secondary deposits in elluvium and alluvial placers. Major associated minerals are spinel, zircon, iolite, moonstone, topaz, amethyst, aquamarine, tourmarine, lapis-lazuri, and chrysolite (Inthasopa, 2000, personal communication).



Localities	Age (Ma)	
(★ Gem Deposits)	K/Ar[1]	Ar/Ar[2]
1.Bo Ploi ★	3. 14 ± 0.17	3. 0 ± 0 . 08
2.Lampang	0. 6 ± 0.2[3]	0.76 ± 0 . 06
3.Phitsanulok	10 . 3 ± 0.2[4]	
4.Denchai ★	5. 64 ± 0 . 28	
5.Chiang Khian	1. 69 ± 1 .25	
6.Chiang Khong	1.74 ± 0.18	
7.Khok Samrong Lam Narai	11.29 ± 0. 64 18.1 ± 0. 7[6] 24.1± 1. 0[6]	9.7 ± (0.07?)
8.Wichianburi ★		7.75 ± 0. 13 9.72 ± 0. 13[7] 11.63 ± 0. 06[7]
9.Ko Mai Si Lek	8 . 5 ± 1[5]	
10.Khao Ploi wan★ Khao Wua ★ Nong Bon ★	0 . 44 ± 0.11 1.31 ± 0. 17[1]	2.7 ± 0. 21 3.62 ± 0. 28[7] 2.75 ± 0. 21[7]
11.Pailin ★	1 . 30 ± 0.17	
12.Khun Han ★	3 . 28 ± 0.48	
13.Phu Kradong	0 . 92 ± 0 .30	
14.Xuan Loc	2 . 62 ± 0. 2	
15.Dijring	12 . 3 ± 1. 1	
16.Darlac	3. 4 ± 0. 2	
17. Pleiku	2.1 ± 0. 1	

Ages after : 1 Barr and Macdonald (1981)
2. Charusiri (1985)
3. Sasada and Ratanasthein (1985 *in* Ratanasthein, 1986)
4. Knox and Wakefield (1983)
5. Bignell and Snelling (1977)
6. Sutthirat (1993)
7. Charusiri (1989)

Figure 2.1 Distribution of Late Cenozoic basalts and gemstone deposits of corundum and zircon in Thailand and the Indochina region (modified from Tritrangan, 1992).

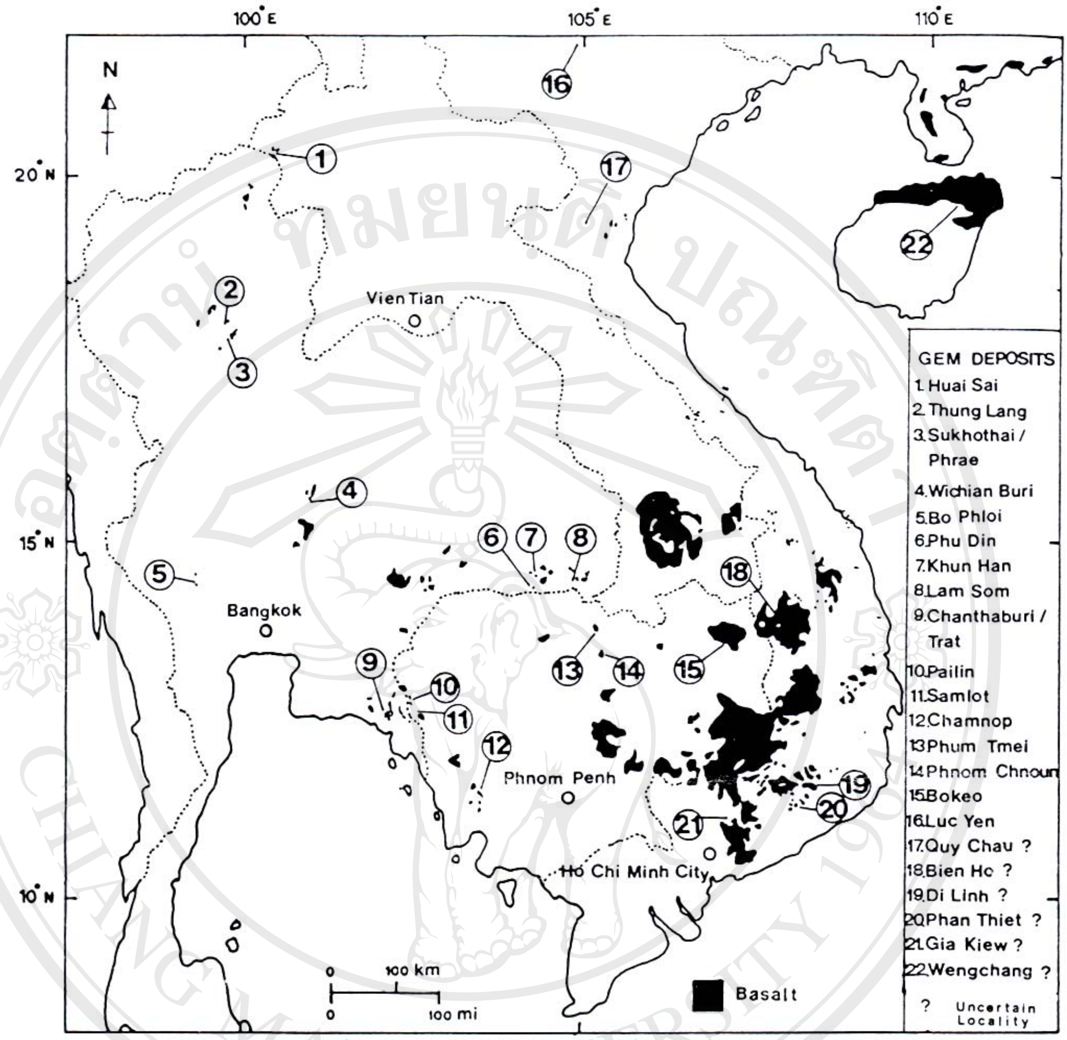


Figure 2.2 The Late Cenozoic basalts in Thailand and the Indochina region (modified from Tritrangan, 1992 and Sutthirat, 1993).

Both of them indicate that gemstones are embeded in hard rocks, whilst in secondary deposits most of gemstone grains are still embeded in rocks and gravels and can be index for their hosted rocks. The topography of them are generally light color as seen in Figures 2.3 A – D, resulting in the light colors of hosted rocks. This characteristic light color differs from basaltic rock gemfields.

(3) *Corundum associated with alkali basalt rocks is mostly discovered in Thailand, Lao PDR, Cambodia and Vietnam.* The gemstones are always discovered in

secondary deposits: in the residual basalt soil, elluvium, and alluvium. The major associated minerals are black spinel, clinopyroxene, garnet, zircon, and magnetite/ilmenite. The distinctive features of basaltic gemfields are red topography and iron – rich lateritic beds in basaltic soils which cover and cement sediments within the gemfield areas (Figure 2.3 E – F and Figure 2.4).

In Figure 2.4, it is seen distinguishingly that the depositional environment of the study areas is same kind of gemfields which have basaltic hosted rocks.

2.1.3 THE DATING FROM THE MAJOR ASSOCIATED MINERALS

Zircon is important mineral for corundum – bearing basalts because they are in the same group of xenoliths which are migrated to surface by magma. Zircon can also be used for age determination of associated sapphire formation because this mineral contains trace uranium, at least the age of host basaltic eruption can be known from zircon dating (Coenraads *et al*., 1995). Recently, the experiment of Xie *et al*., (2002) reported that corundum can be crystallized from magma, which produced from partial melting. Hence it is possible that corundum and zircon can be derived from same magma. However this is very special conditions in the natural (Boonsoong, 2006, personal communication).

The zircon grains from Ta Koi Village, Nam Yuen District of Ubon Ratchathani Province (a part of study areas) were taken for dating by fission track method (Hansawek, 1996). In the study areas, zircon grains are the most important associated mineral which always discovered together with corundum. The dating indicates that the age of hosted basalts are 12.1 $\pm$ 1.1 million years approximately (middle Miocene). This age is accordant to that of basaltic rocks in the Khorat Plateau. Accordingly, the corundum in study areas was derived from the previous phase of the Cenozoic basalts in the study areas and vicinities.

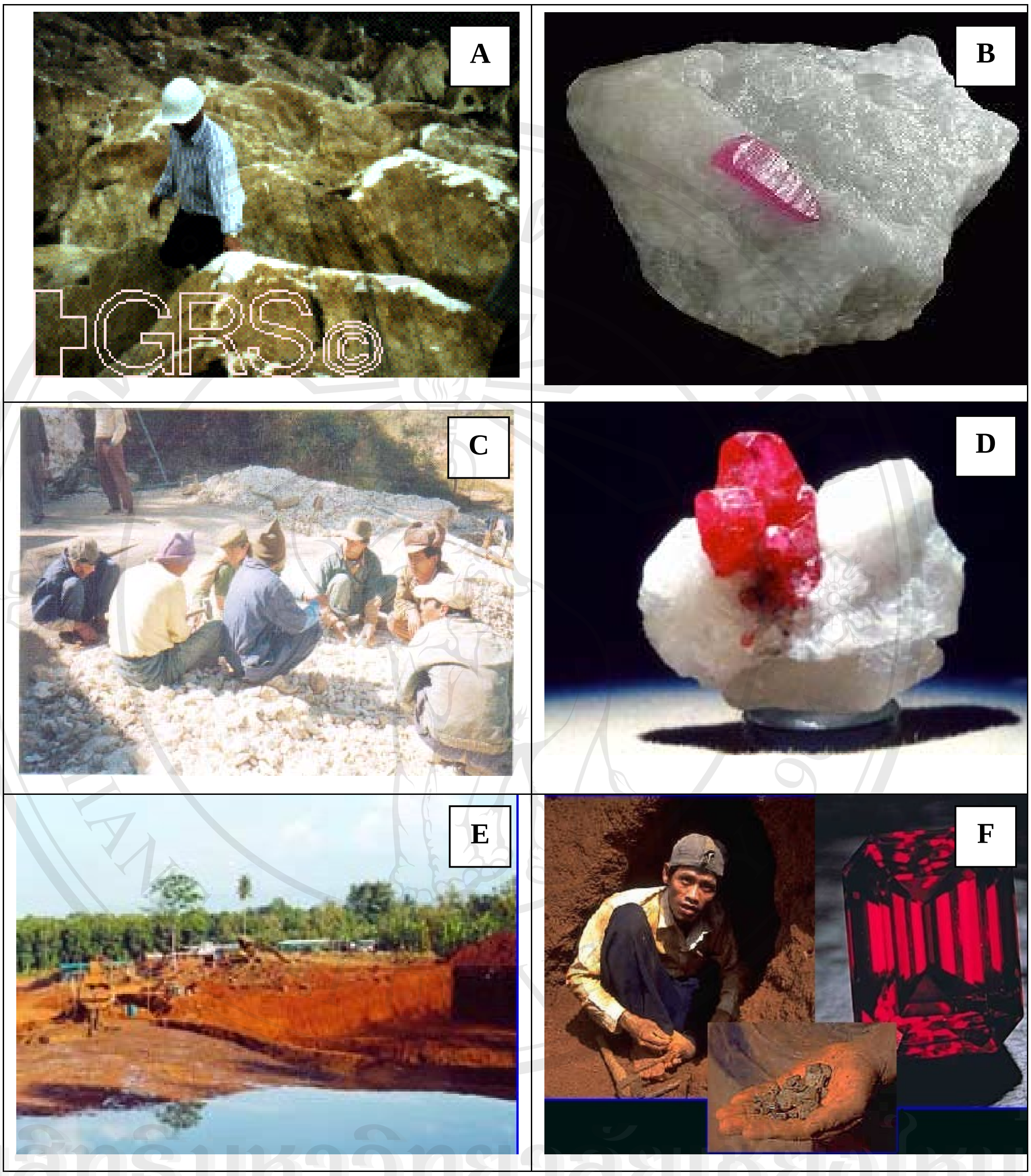


Figure 2.3 (A) Marble rock at the ruby mines in Luc Yen, north Vietnam; the veins in the rock contain rubies and gold (www.gemresearch.htm , 2004), (B) ruby from Luc Yen, Yen Bai (Betts, 2001), (C) Prospecting for gemstone in Mogok, Myanmarr, (D) ruby embeds in carbonate rock from Mogok mine (hometown.aol.com, 2004), (E) Corundum mining from weathered alkali basalt at Tha Mai District of Chanthaburi Province (www.Thaitambon.com, 2003), (F) A miner works with old methods at Khao Ploi Waen of Chanthaburi. (modified from Hughes, 2002) and the exotic facet ruby from the mines along the Thai/Cambodian border in the area of Chanthaburi (modified from www.palagems.com, 2004).

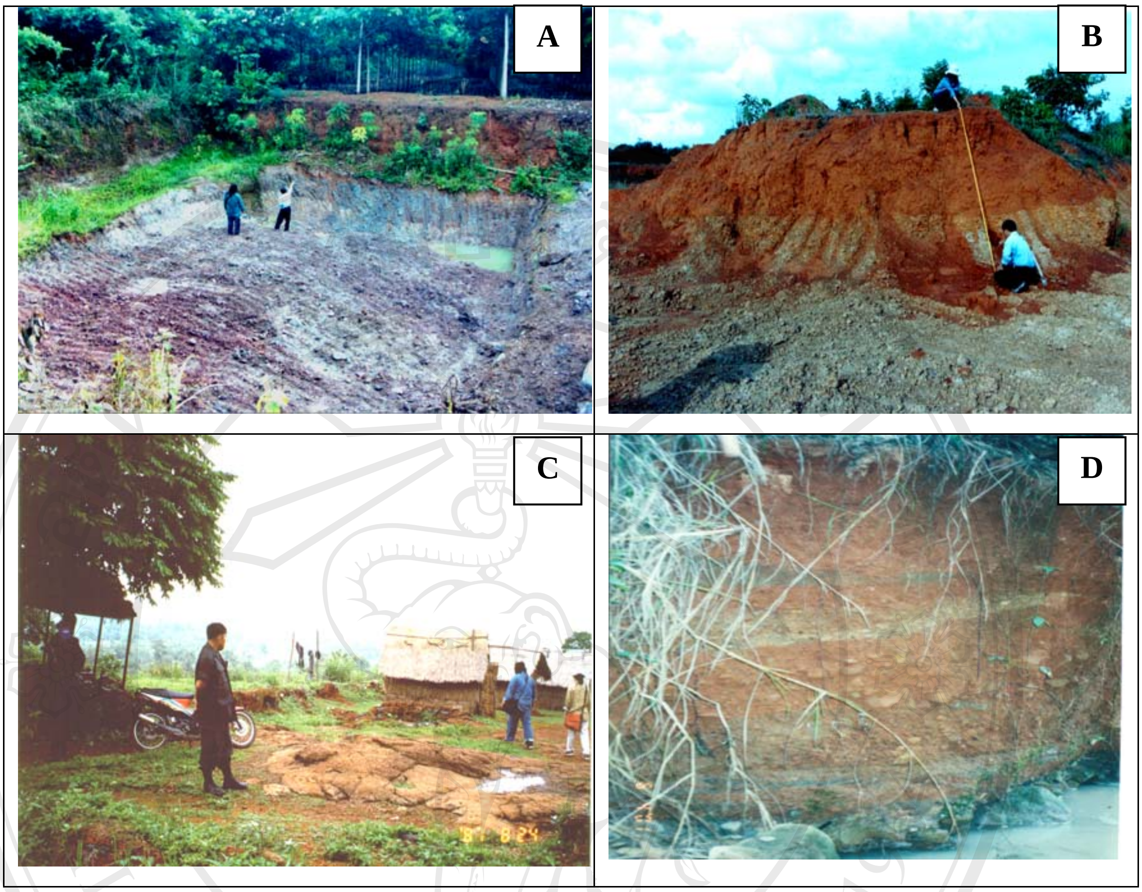


Figure 2.4 (A – B) The red color topography of the study areas where alkali basalts flow covering unconsolidated sediments and country rocks, no great tectonic setting since post Tertiary makes it is clear that these scattering basalt outcrops around the Khorat Plateau are occurred at the same or adjacent vents of older basalt outcrops which give gemstones but weathered already now. (C) A part of basaltic outcrop which provides corundum. It is only place where the rock is still not weathered absolutely. (D) The lateritic bed in the study areas, consisting of sediments and Fe oxide cement.

2.1.4 RESULTS FROM STUDYING SURFACE FEATURES OF RUBY AND SAPPHIRE

Coenraads (1992) had studied the surfaces of ruby and sapphires associated with volcanic provinces in both eastern Australia and Thailand (Figure 2.5 - 2.6). This study indicates the features which remark the association to alkali basalts. Those features are :

1. Negative crystal impressions suggest that the corundum grew as part of coarsely crystallized aggregates together with minerals such as anorthoclase, zircon and spinel. 2. Surface resorption of etching and layer dissolution features clearly (Figure 2.6) results from reaction with the magmas responsible for carrying the corundum to the surface, consisting of 2.1) triangular and hexagonal hillocks and depressions on faces perpendicular to the *c* axis, 2.2) stacks of triangular prisms on surfaces parallel to the *c* axis of the corundum crystal. These chatter marks imply that the corundum has been subject to stress prior to, or possibly during transport to the surface. Coenradds (1992) also revealed that natural corundum associated with alkali basalts can be discovered the chatter marks as described above, on the surface of crystal. On the other hand, the natural crystals of corundum having these chatter marks are decided to associate with alkali basalts.

Work of Coenradds (1992) is a part of inspiration for Srichan (2002) who studied the relationship between crystal morphology, chemical composition and occurrence of corundum in mainland Southeast Asia and Sri Lanka. The corundum is separated into 2 groups according to hosted rocks: basaltic hosted and metamorphic hosted rocks. This study discovered that **basaltic ruby crystals** tend to grow as tabular hexagonal prism truncated by rhombohedron faces, and **basaltic sapphire crystals** are generally found as barrel shaped hexagonal pyramid, **metamorphic ruby** crystal form is dominated by dipyramidal faces with subordinate basal pinacoid and rhombohedron, and **metamorphic sapphire** shows spindle shaped hexagonal dipyramid. The very interesting point is that this study show basaltic corundum, including which from the study areas, can be observed the etching surface features whereas the metamorphic corundum can not be observed. So the etching surface features are, therefore, another support for alkali basalt hosted rock of corundum in the study areas (Figure 2.7).

2.1.5 RESULTS FROM CHEMICAL ANALYSES

Srichan (2002) used trace elements in corundum from mainland Southeast Asia and Sri Lanka to distinguish corundum of basaltic affiliation from those of metamorphic affiliation by using electron microprobe analysis (EMPA). The results are plotted in diagram Fe_2O_3 / TiO_2 versus Cr_2O_3 / Ga_2O_3 (Figure 2.8) and Fe_2O_3

versus Cr_2O_3 (Figure 2.9). Both of those diagrams arrange the corundum from the study areas to be in Group II, that means sapphire of basaltic affiliation (or magmatic suites) (Sutherland *et al*., 1998a, b and Sutherland and Schwarz, 2001 *in* Srichan, 2002) which shows high Fe, Ti, and Ga but low Cr contents, with Cr_2O_3 / Ga_2O_3 ratio generally < 1 and and Fe_2O_3 / TiO_2 ratio between 1 and 90. This result is another support for alkali basalt hosted rock of corundum in the study areas.

2.1.6 THE SAPPHIRE CRYSTAL IN BASALTIC HOSTED ROCK

Corundum cryatals in basaltic hosted rock are only discovered especially in the study areas. A corundum crystal is discovered among 1500 kilogram basaltic soil and basalt rock fragments approximately during author's investigation in 2001, that is very dilute (Figure 2.10). Another interesting thing is a basaltic outcrop discovered is in a restricted military area. This outcrop has properties for being corundum - bearing basaltic rock, that is different from scattering basalts in the Khorat Plateau. This basaltic outcrop is named in map as Phanom Kantung, called by the field army as 610 hill. It locates at the fault scarp longitude 441300 meter east and latitude 1586950 meter north in an area of Khun Han District. This area is very difficult to investigate because of many land mines. According to this study, the basaltic area should be calculated as 3 square kilometers but the position for accessibility is just a field army camp covering about 0.5 square kilometer. The basaltic outcrop here overlies on the Phra Wihan or Phu Phan Formations. The outcrop shows columnar joint structure (Figure 2.12). It is quite thick at the camp, and rather thinner (changing to be laterite) in the distance. The gemstones are discovered from basaltic soil, and in adjacent areas. Those gemstones are garnet, zircon, black pyroxene, including corundum which is very very rare (Figure 2.11).

The characteristics of basalt are dark gray color, very fine - grained texture and have megacrysts of pyroxene, garnet, zircon, etc., and xenoliths, embeded in rock. Lherzolites of olivine and pyroxene are also discovered in rock. The biggest lherzolite xenolith discovered is 5-12 millimeters in diameter (Figure 2.13). These are the important characteristics of corundum bearing basalts as discovered in Chanthaburi, Trat and Kanchanaburi Provinces (Vichit *et al.*, 1978).

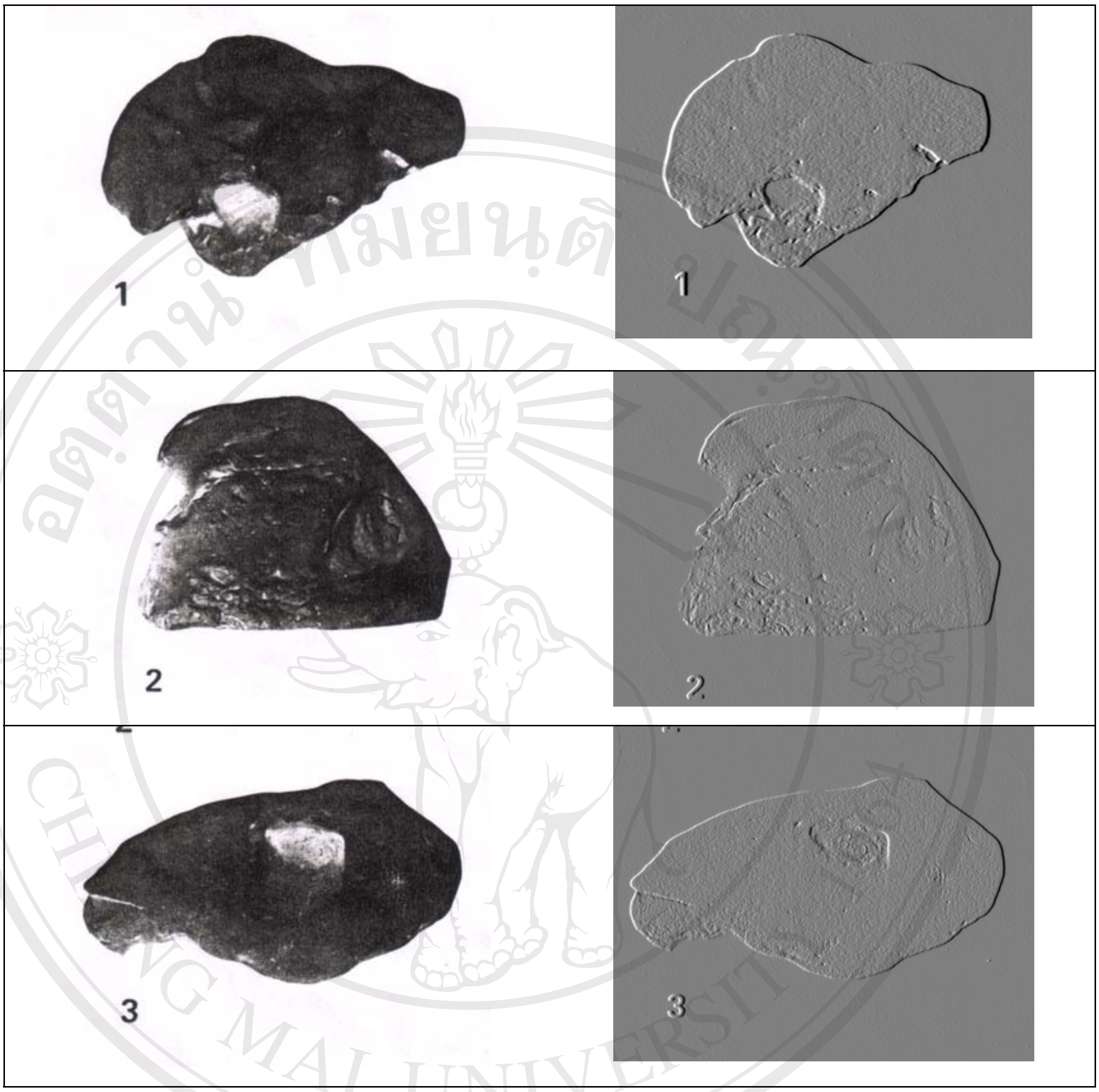


Figure 2.5 The negative crystal impressions, the pictures are embossed as seen in right column for more clearing. All pictures show sharp edged, deep, geometric shaped holes, or crystal impressions of the order of 0.5-1.0 mm across on sapphire and ruby crystal faces. The angles between the impression faces in picture 1 and 2 are 120. The negative crystal shape in picture 3 is particularly interesting that it appears to show tetragonal symmetry, thus precluding the possibility of it having been a fluid filled negative crystal cavity. These impressions developed as the corundum grew as part of a coarsely crystallized aggregate with minerals such as anorthoclase and zircon (picture 1 blue sapphire from Chanthaburi-Trat x 18, picture 2 blue–purple sapphire from Chanthaburi-Trat x 14, picture 3 purple ruby from Chanthaburi-Trat x 14) (modified from Coenraads, 1992).

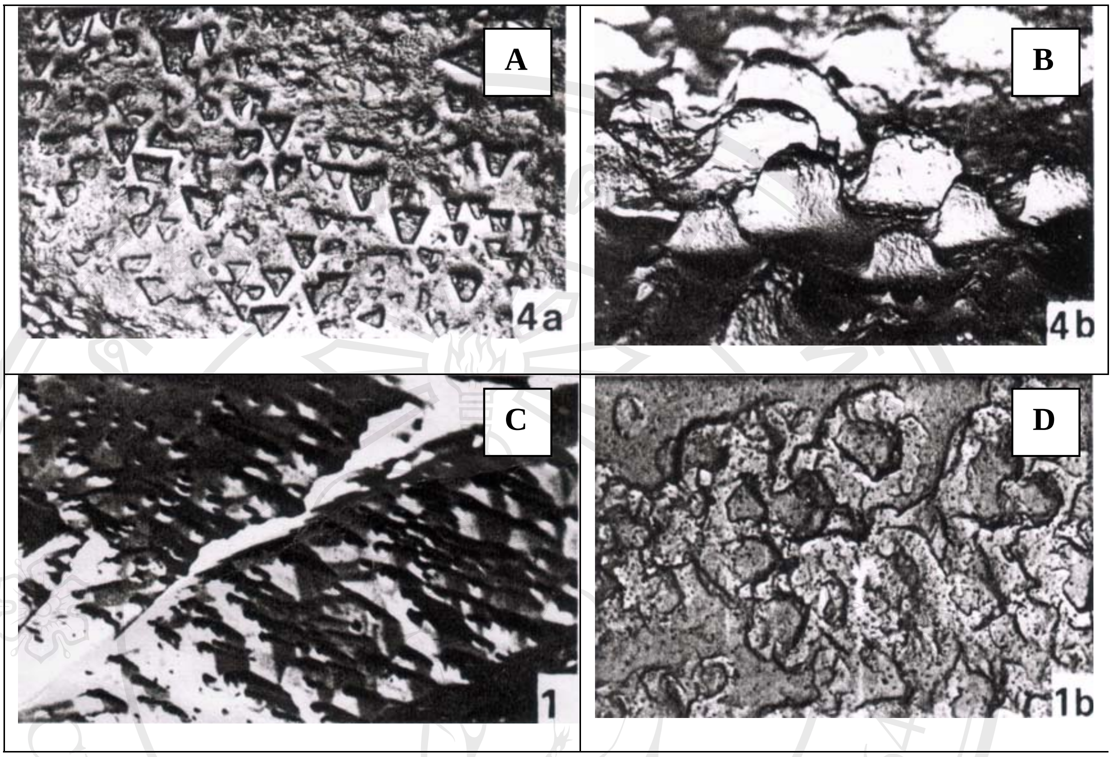


Figure 2.6 (A)sapphire from Reddestone Creek, New England (x 66) showing details of flat topped triangular hillocks (B) sapphire from Reddestone Creek, New England (x 330), detail showing relief of hillocks and their irregular, eroded appearance (C) blue sapphire from Braemar, New England (x 3300) showing details of etch surface at a low angle to the *c* axis resembling trigonal prismatic “bricks” (D) blue sapphire from Reddestone Creek, New England, surface perpendicular to the c axis (x 2200) showing details of several hexagonal depressions (modified from Coenraads, 1992).

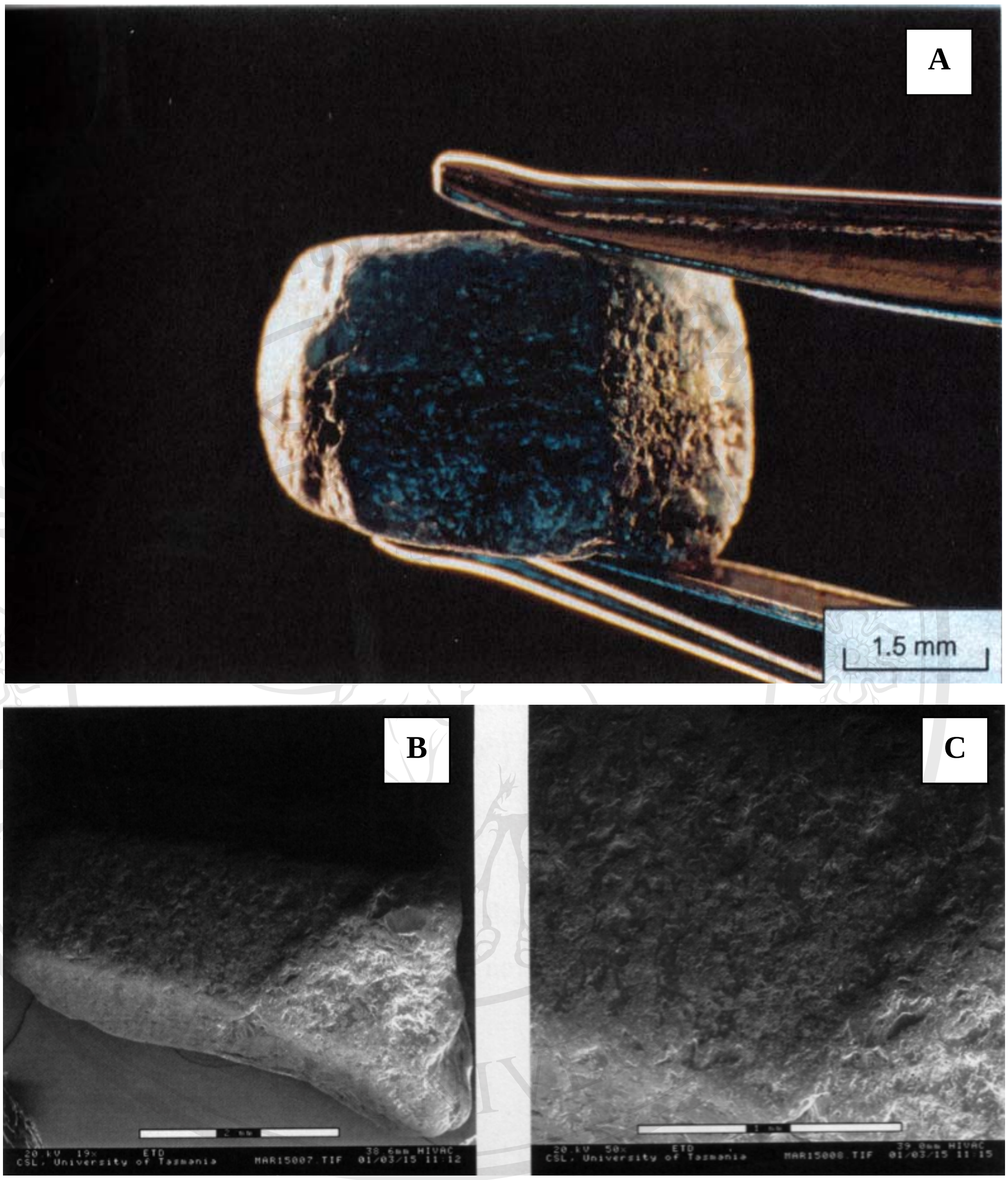


Figure 2.7 (A) blocky shape of Ubon Ratchathani sapphire showing hexagonal pyramid and basal pinacoid form with the corroded surface feature of etching by basaltic magma during transportation to earth surface. (B) - (C) SEM images of Ubon Ratchathani sapphire showing triangular hillock resulted from etching by basaltic magma (Srichan, 2002).

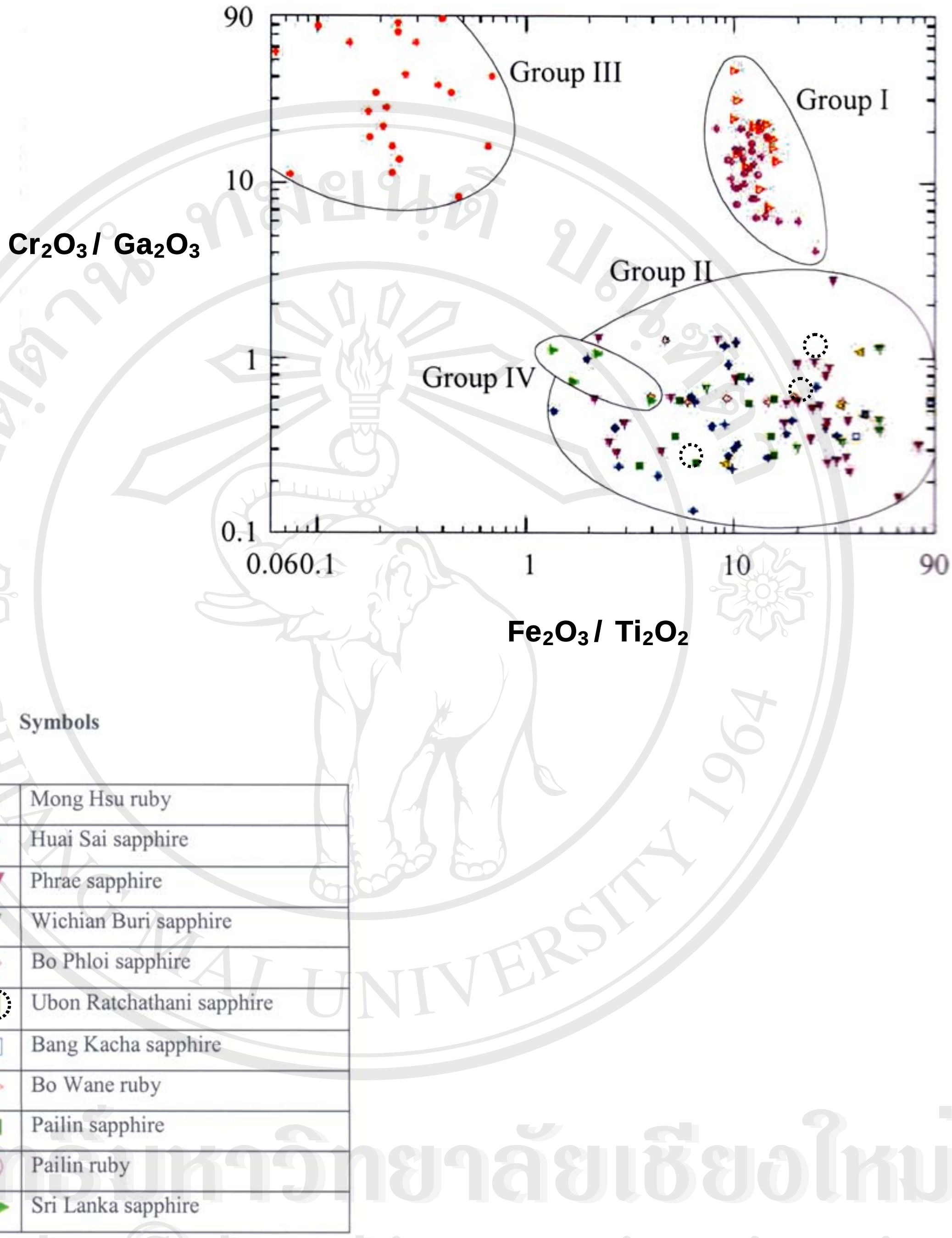


Figure 2.8 Chemical variation diagrams (wt% plot) of trace element contents of corundums from mainland Southeast Asia and Sri Lanka; *show four groups including, group I, high Cr and low Ga content (ruby of basaltic affiliation); group II high Fe, Ti, Ga and low Cr contents (sapphire of basaltic affiliation), group III high Cr and low Fe, Ti contents (ruby of metamorphic affiliation) and group IV low Fe, Ti and Cr contents (sapphire of metamorphic affiliation)* (a symbol is modified for distinction) (Srichan, 2002). It is noticed that sapphire from Ubon Ratchathani is in the same group of sapphire from all gemfields of Thailand, Pailin of Cambodia and Huai Sai of Lao PDR.

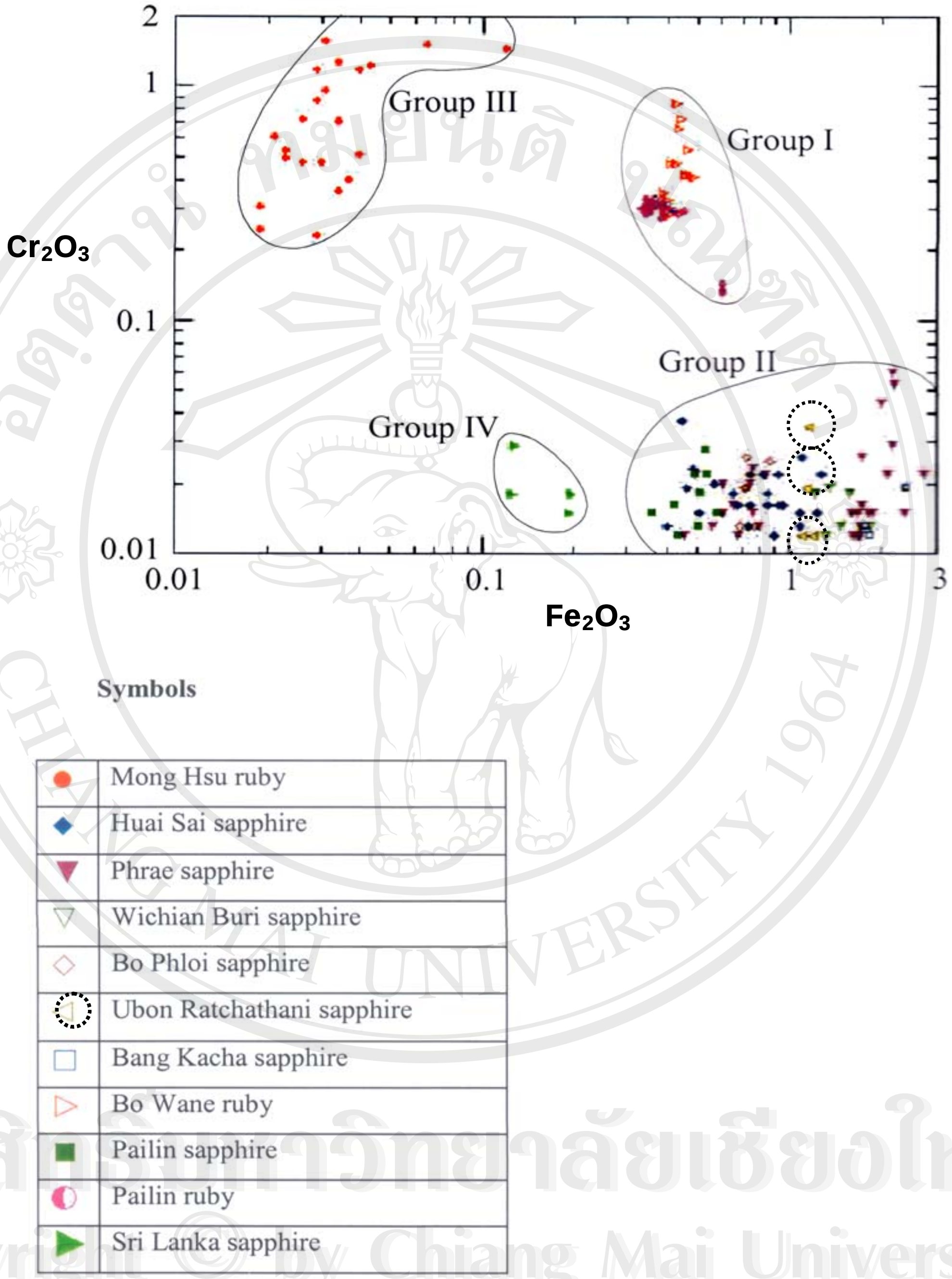


Figure 2.9 Chemical variation diagrams (wt% plot) between Fe2O3 and Cr2O3 of corundums from mainland Southeast Asia and Sri Lanka ; (a symbol is modified for distinction) (Srichan, 2002). It is noticed that sapphire from Ubon Ratchathani is in the same group of that from all gemfields of Thailand, Pailin of Cambodia and Huai Sai of LaoPDR.

Figure 2.10 Photographs of discovered green dull corundum which embed in basaltic rock showing hexagonal shape. A part of this crystal is flaked out to be run by Fourier Transform Infrared : FTIR to prove certain corundum being. This corundum crystal is taken from area of a basaltic outcrop called Phanom Kantung (610 hill following field army) near fault scarp in Khun Han District, Si Sa Ket Province.

Figure 2.11 Other gemstones discovered in Phanom Kantung, (A) garnet (B) magnetite (C) zircon.

Figure 2.12 The corundum bearing basalt outcrop called Phanom Kantung in Khun Han District showing hard rock with columnar joint structure and gemstones as pyroxene, garnet, zircon can be discovered from basaltic soils here.

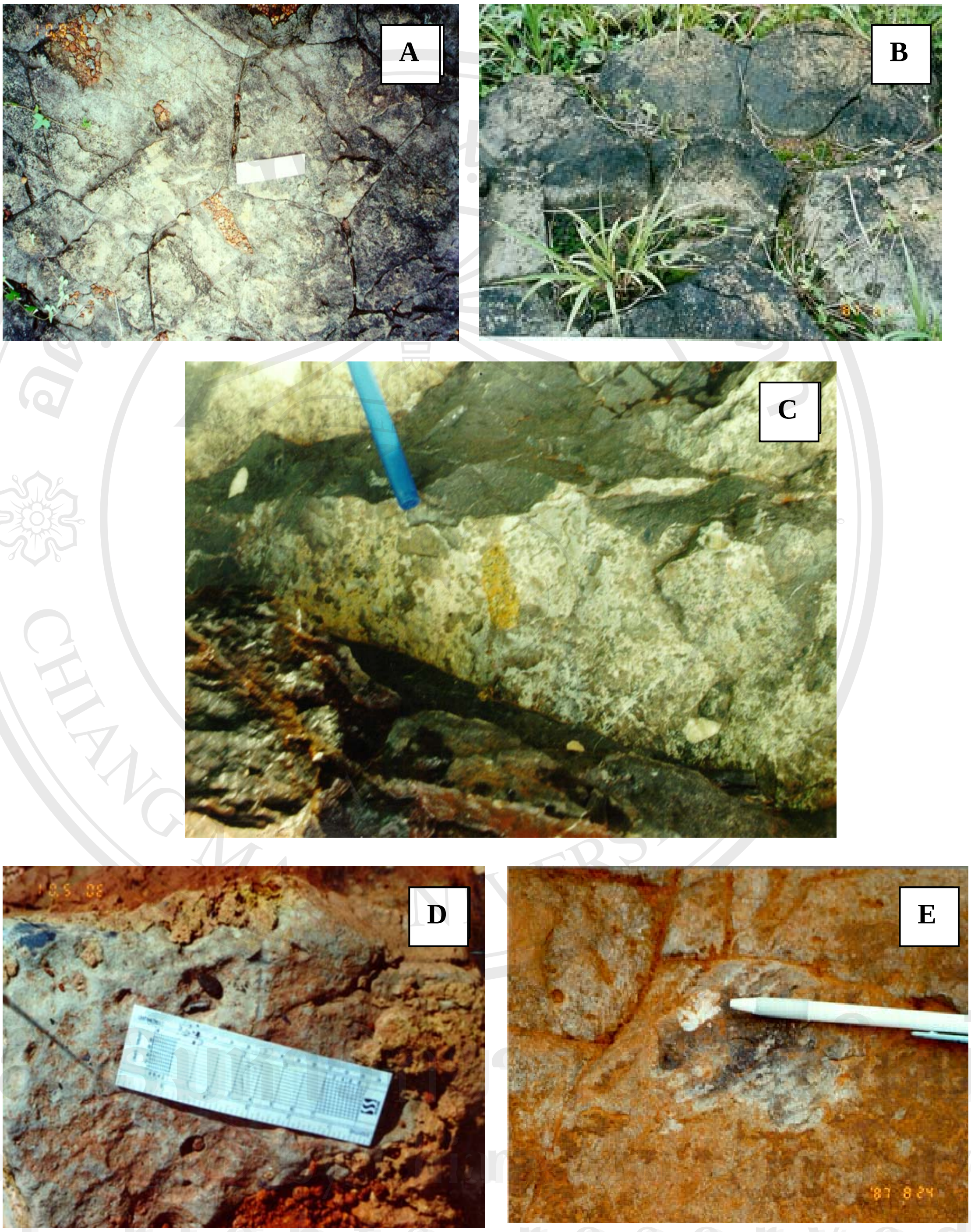


Figure 2.13 The characteristics of corundum bearing basalt discovered in Khun Han District, Si Sa Ket Province: (A) – (B) columnar joint structures, (C) lherzolite in rock, (D) – (E) black pyroxene megacrysts.

2.2 SHAPE ANALYSIS OF THE GEMSTONE GRAINS

The gemstones grains of the study areas which most of them are zircon, corundum, some are garnet, magnetite, ilmenite, are collected from 15 locations. They are not enough quantity to do sedimentary analysis, but their properties of the sedimentary particles can be studied to make the data which supply about souce rocks and depositional process. The criteria used to study the gemstone grains are:

Roundness : reverses to the route from the source, so applied for comparing of the gemstone roundness; more round grain is more distance further from the source.

Sphericity : is the same concept as the roundness that higher sphericity grain means more distance further from the source.

However, it is realized that the hardness of each mineral effecting roundness and sphericity. Based on Moh's scale, the hardness values of zircon, corundum, sanidine, magnetite, and ilmenite are7.5, 9, 6, 5.5 – 6, and 5 -6 respectively. Hence, zircon and corundum are the dominant relicts of their hosted rocks.

Grain size : each kind of gemstones has different grain size, but generally the bigger grains always deposit near source than the smaller grain.

The perfect of the crystal : it is possible to discover the euhedral crystal of the gemstones deposits near the source than the subhedral crystal. On the other hand, the transported process makes the euhedral is broken and got the abrassion until being subhedral upon the further route from the source.

Kind of gemstone : It is possible to use the kinds of discovered gemstones being the index of source, for example, the medium hardness as moonstone is not discovered more over further from the source rock. So it can cite its near source. Moreover, kind of gemstone can be stated kind of source rock.

Figure 2.14 exhibits the locations where the gemstones were discovered, together the enlarged Figures in the following sereies. The selected gemstone figures can be the representatives of their groups. From Figure 2.14, the locations of discovered gemstones were divided to 5 zones as shown in Figures 2.15 – 2.19. Most of the gemstones were discovered in the mountainous area, talus deposit and in the channel deposit.

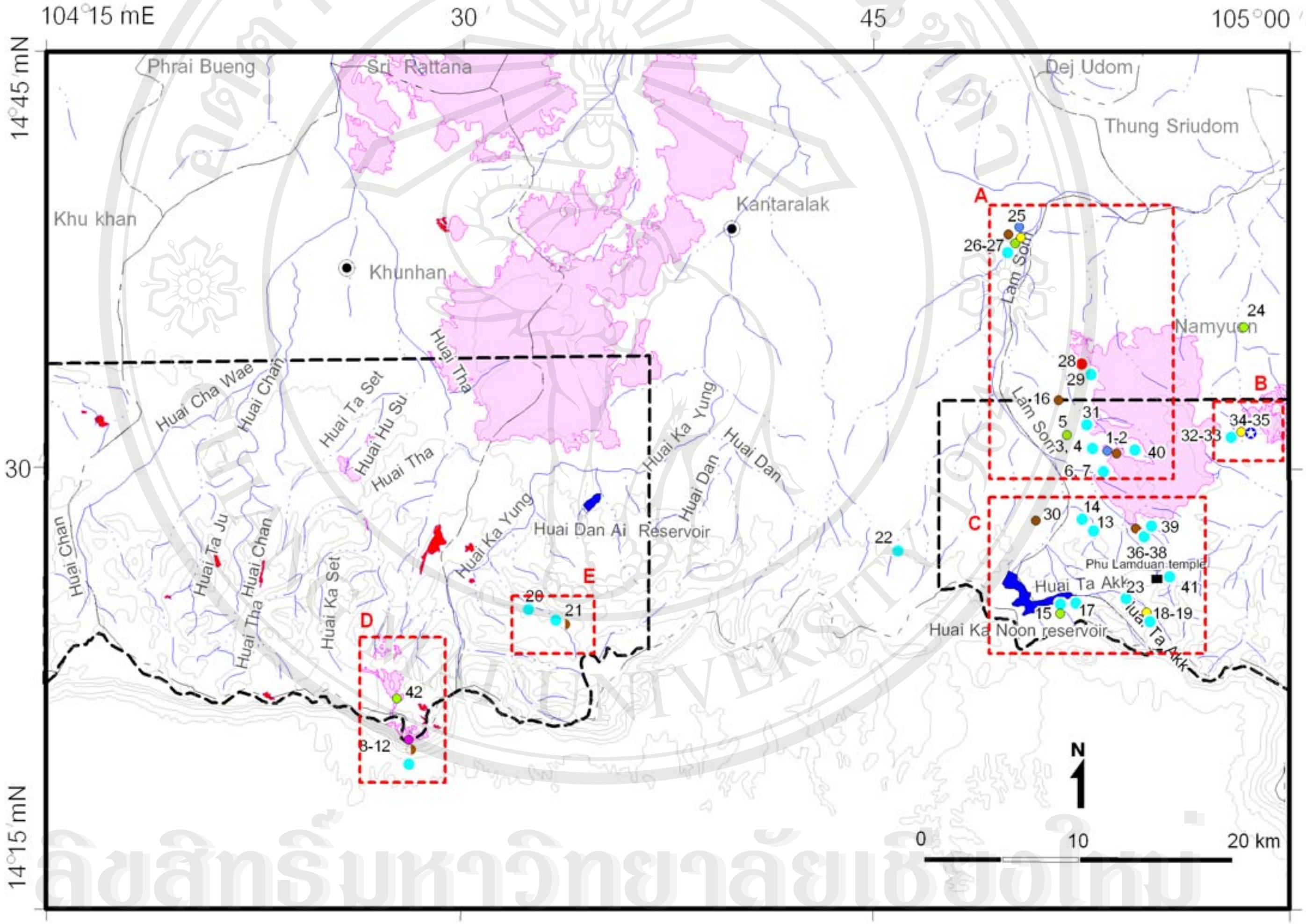


Figure 2.14A The discovered gemstones were grouped together. The explanation is in the figure 2.14 B.

EXPLANATION

Perennial stream
Intermittent stream
Reservoir
Contour interval 100 meters
basaltic rock
basaltic rock (boundary from satellite images)

Temple
Village
District
Secondary administrative division
International border line
study area
zone of discovered gemstones

ruby
yellow sapphire
blue, greenish blue sapphire
green, bluish green sapphire
brown, blackish brown, black sapphire
garnet
zircon
magnetite/ ilmenite

1 - 7 , 31 -33 , 40	Ban :Ta Koi Tambon: Khok Saad Amphoe: Nam Yuen Changwat: Ubon Ratchathani
8 - 12, 41	Phannom Kantung Amphoe: Khunhan Changwat: Si Sa Ket
3, 13, 36 - 39	Ban: Non Yang Tambon: Song Amphoe: Nam Yuen Changwat: Ubon Ratchathani
14, 30	Ban: Non Saeng Phet Tambon: Khok Saad Amphoe: Nam Khun Changwat: Ubon Ratchathani
15 - 19, 23	Huai Ta Akk Ban: Non Yang Tambon: Song Amphoe: Nam Yuen Changwat: Ubon Ratchathani
20 - 21	Huai Ta Krai Amphoe: Kantaralak Changwat: Si Sa Ket
22	Huai Ta Ngerd Ban: Phum Charon Tambon: Sao Thongchai Amphoe: Kantaralak Changwat: Si Sa Ket
24	Huai Ma Nao Ban: Nong Tao Tambon: Song Amphoe: Nam Yuen Changwat: Ubon Ratchanthani
25 - 27	Ban: Non Kamkaew Tambon: Phai Boon Amphoe: Nam Yuen Changwat: Ubon Ratchanthani
28 - 29	Ban: Saen Thaworn Tambon: Phai Boon Amphoe: Nam Yuen Changwat: Ubon Ratchanthani
34 - 35	Ban: Ta Mo Tambon: Phai Boon Amphoe: Nam Yuen Changwat: Ubon Ratchanthani

Remarks:
Ban : Village Tambon : Sub- district Amphoe : District Changwat : Province

Figure 2.14 B The explanation of Figure 2.14 A.

The investigation reveals that the gemstones of zone A (Figure 2.15) are coarser and generally bigger than of the zone C (Figure 2.17). Additional gemstones of zone A were always discovered in the shallow deposits about 1 –3 m on the terrace (Tangpong, 1990) (Figure 2.21 A - B) whereas the gemstones of zone C are discovered in more depth or in channel deposit (Saraphanchotwitthaya and Tangpong, 2001). Accordingly, it is concluded primarily that the gemstones of zone A and of zone C are not from the same sources even though they are closed. should be they are located in the same vicinity.

In zone A (Figure 2.15), there is not gemstone potential in the surface basalts (Chapter 1) but in the gravel bed and in the remnants of older phase basalt underlying them. The gemstone grains show angular to subrounded and low to medium sphericity. This reveals they are not far from source rock. And the location of gemstones in zones A show the older phase basalts are located little to the west of the recent basalt.

The gemstones from the zone B (Figure 2.16) were discovered around the western part underlying the basaltic soil. The investigation show that they were deposited in the paleofloodplain and some of them was reworked scatteringly around the basaltic outcrops. They are sub rounded – rounded, low sphericity, and generally small size (1 – 2 mm). The subhedral crystals were discovered but less than anhedral kind.

Most of the gemstones in the zone C (Figure 2.17) were discovered along the recent channels and their terrace. The shapes of them which are subrounded – rounded, low to high sphericity and being anhedral generally (except some which was confined to the pothole along the channel bed), convince that they were derived and reworkedly transported along these channels.

The discovered gemstones in zone D (Figure 2.18) do not exhibit the transportated characteristics distinguishly. They are angular – subangular, low – medium sphericity, rather big size, rather euhedral crystals. The interesting thing is the magnetite crystals, which are usually decayed easily, were discovered. These characteristics show the residual deposit type in - situ of the basaltic soil which according to the data from field check and satellite imagery study. The transported characteristics should be seen in the gemstones embedding the sediments around these basaltic outcrops if they could be picked up because the zone D area still suffers from the landmine problem.

The gemstones discovered in zone E are small grains. Most of them are zircon and Fe – oxide minerals. They are subrounded – rounded, low – medium sphericity, anhedral crystal generally. The surface characteristics which were showing transported situation, contrasted to the easily decayed Fe – oxide mineral, signified the gemstones are very near their source and reworkedly transported in the same channels .

2.3 THE GEMSTONE DISTRIBUTION

The gemstone occurrence (Tangpong, 1990; Tonthongchai and Monjai, 1998; Saraphanchotwitthaya and Tangpong, 2002) were plotted in Figure 2.20A for studying the distribution. It is realized that zircon is widespread and discovered in everywhere whether or not corundum deposits. The zircon was both derived from the same source rock of the corundum and derived directly from the large body basalts which were not hosted rocks of corundum (Hughes, 1991). This is the reason why the zircon is discovered in a huge amount in this region.

The ruby is occasionally discovered in both west and east of the study areas. The blue, green, yellow, brown sapphires were discovered in both study areas. The west had more frequency of the blue and yellow sapphires than the east of the study areas. On the other hand, the east area had more green sapphire than the west. The brown sapphire seems to be equal amount.

The garnet appears in less amount except for the soil decayed from the diabasic outcrop called "Khao Phu Fai" (see Chapter 1) where subhedral crystals are found in some parts of the outcrop.

The magnetite and ilmenite cannot be clearly defined their occurrence because of their easily weathering. However, they were discovered and affirmed not far from source rocks of the gemstones. The black spinel was occasionally discovered embedding in basaltic rocks in zone D (see Chapter 2 about the Phanom Kantung hill).

Comparing between the west and the east of the study areas, it is realized that the latter is more abundance of gemstone quantity than the former. It might be from the east area having both of shallow and deep deposits, even though the distributional areas were are equal.

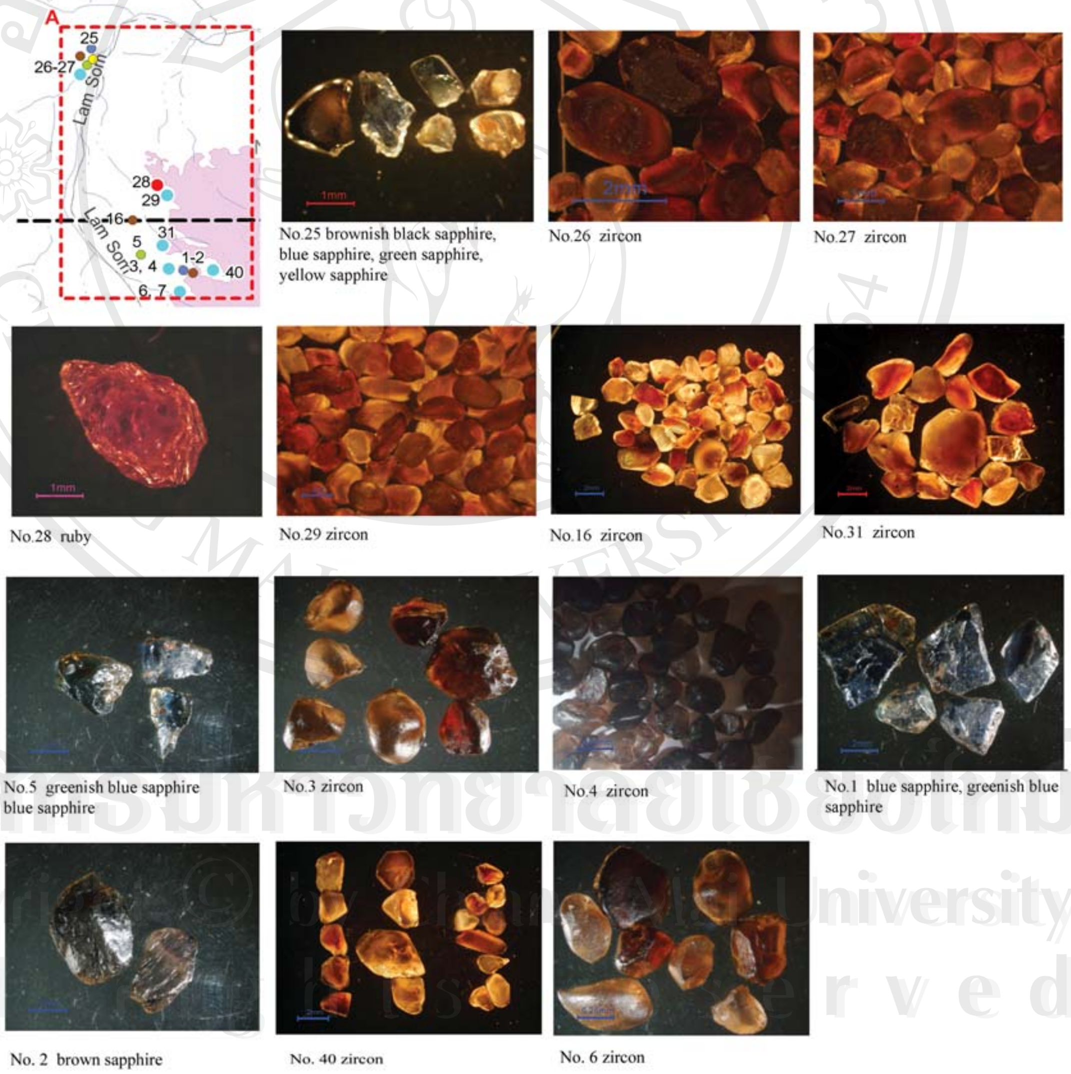


Figure 2.15 The gemstones from zone A show subangular -subrounded, low sphericity. Most of them are zircon having > 2 mm. Some subhedral crystals were discovered.

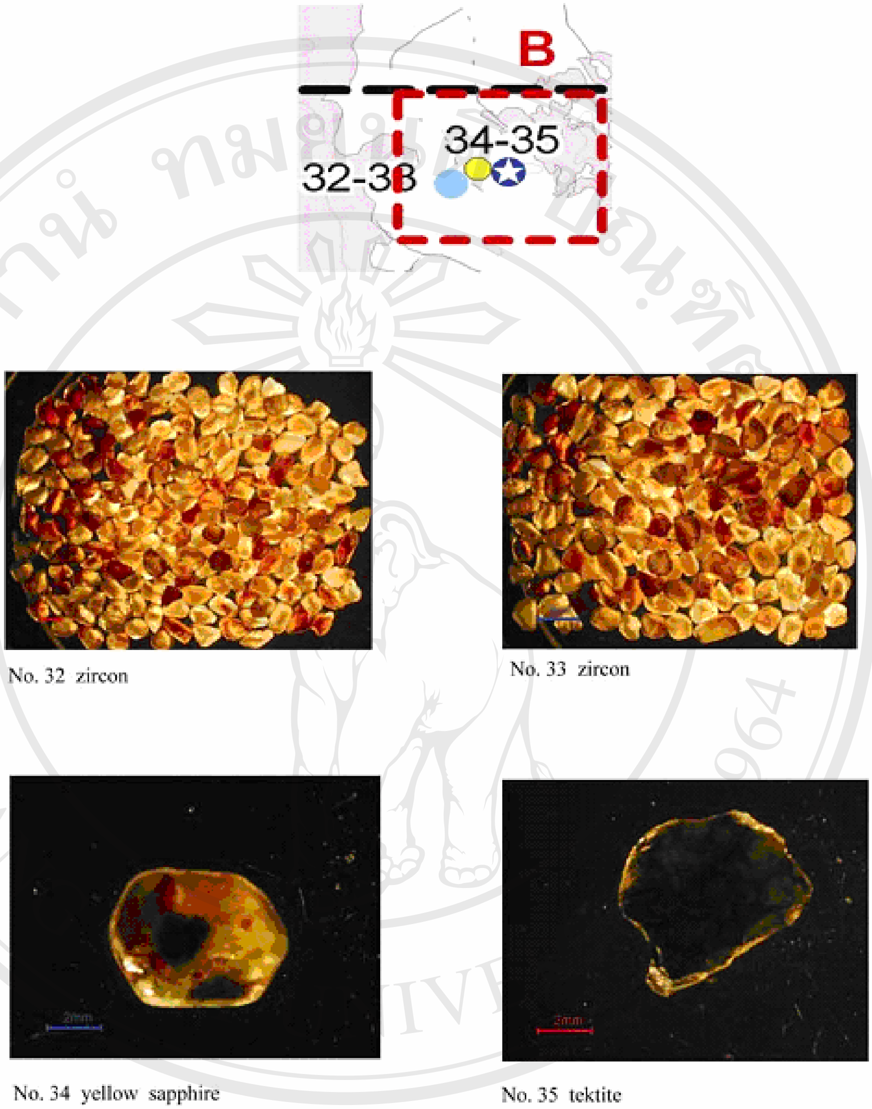


Figure 2.16 The gemstones from zone B show subrounded – rounded, low sphericity. Most of them are zircon having rather small grain size. The subhedral crystal was seen from a grain of yellow sapphire (No. 34).

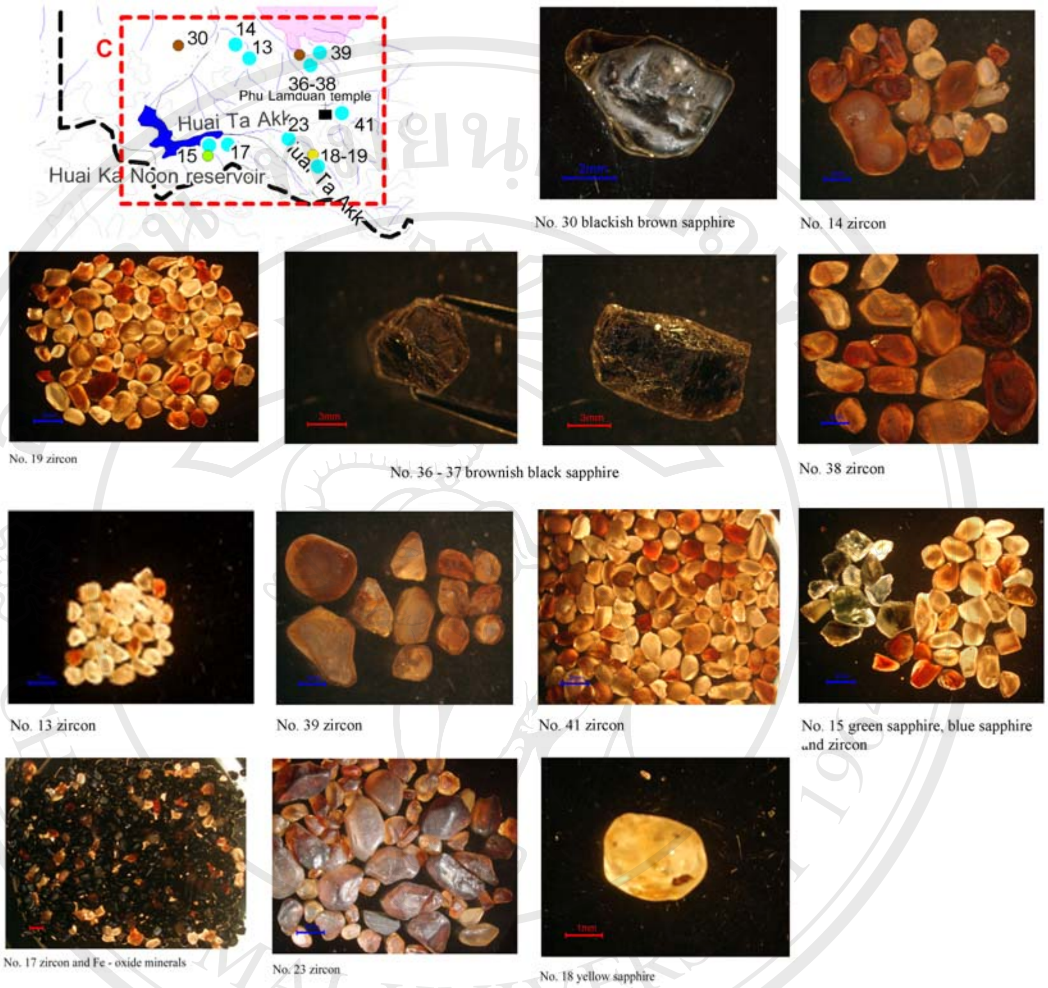


Figure 2.17 The gemstones from zone C show subangular – rounded low sphericity, 2 mm up grain size. Some of them still have euhedral – subhedral crystals, The small grain size such as no. 13 and no. 14 should be the reworked products of transportation.

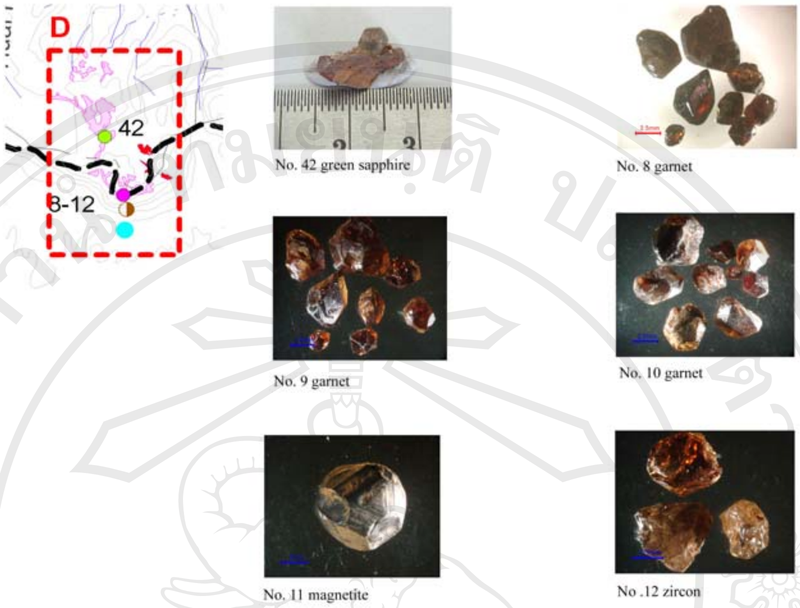


Figure 2.18 The gemstones from zone D illustrate the angular roundness, medium – high sphericity. Generally, they are biggest size comparing to the gemstones from the other units. Most of them have euhedral – subhedral crystals, especially a perfect - octahedral crystal of magnetite (no. 11) is very rare in natural because of its easily weathered situation. It reflects in – situ gemfields.

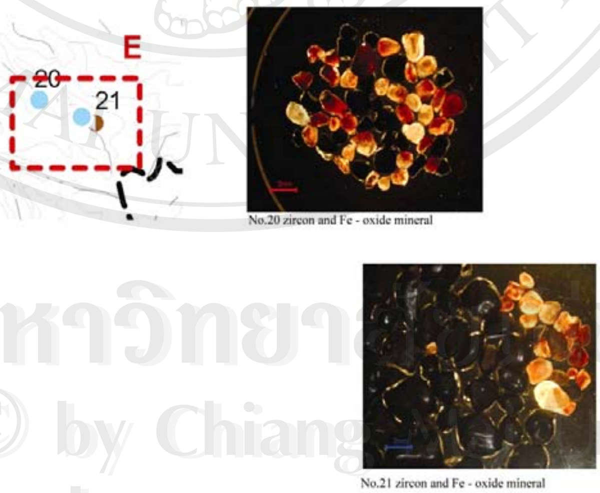


Figure 2.19 The gemstones from zone E. They show subrounded – rounded, medium – high sphericity, grain size about 2 mm and anhedral crystals. Most of them are zircon. The Fe – oxide minerals (probably ilmenite) were discovered together. Naturally, the Fe – oxide minerals are easy to be weathered, especially in high humid condition in the area they discovered. It is presumed that the gemstones of the unit E are reworked transportation not far from their hosted rock.

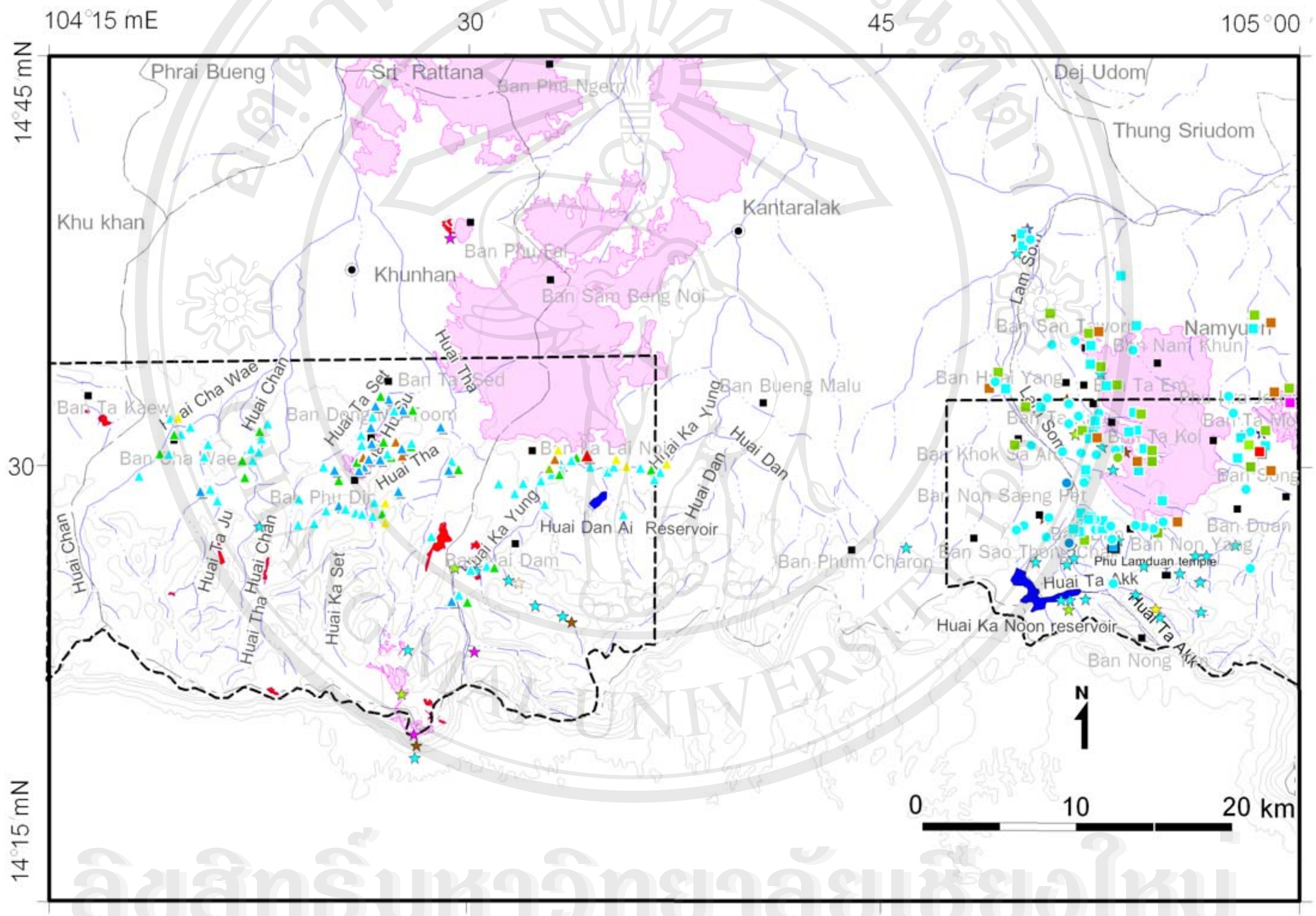


Figure 2.20A The gemstone distribution in the study areas (the explanation is in Figure 2.20 B).

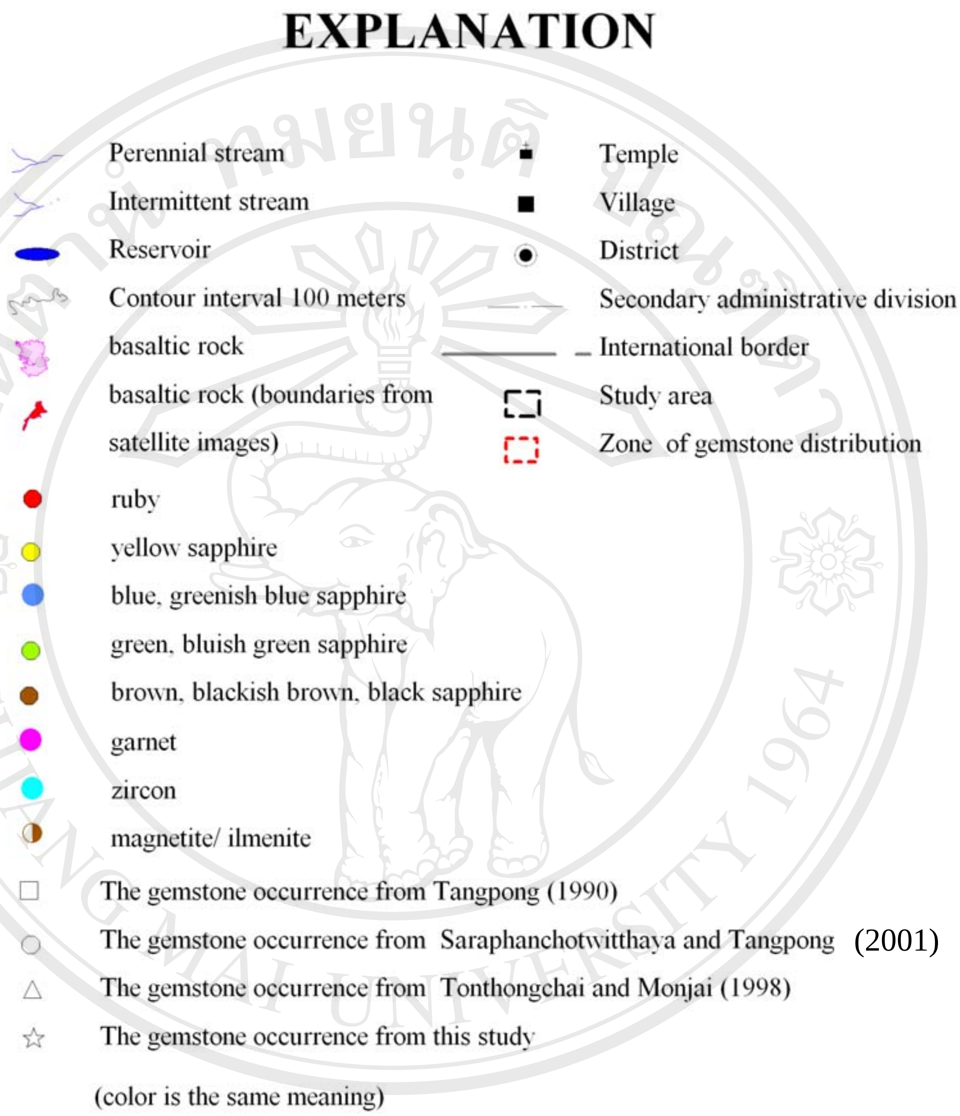


Figure 2.20 B The explanation of Figure 2.20 A.

Figure 2.21 A – B The local people were digging for the gemstones in the area of a village called Ban San Thaworn, Ta Kao District, Ubon Ratchthani Province, during 1990. The gemstone was in the gravel bed (1 m approximately) as they were flaking off, (photographs taken by Sirisak Thayaping).