CHAPTER VI

GENESIS OF GEMSTONES IN THE STUDY AREA

Genesis of Gemstones

1. Introduction

Basalt in Bo Phloi area appears to be genitically associated with gemstones, especially blue sapphire. At present, a group of seven low-hills called Khao Lan Tom of basaltic rock have been observed on the east side of the local road number 3086. Detailed researches on the basalt have been carried out by many workers. It can be concluded that basalt is nepheline-hawaiite in accordance with its chemical composition (Yaemniyom, 1982 ; Barr and Macdonald, 1978) and basanitoid (Vichit et al., 1978).

In the fieldwork, two localities of basaltic exposures, except Bo Phloi basalt have been discovered. Firstly, at Huai Num Pu, situated in the eastern part of Khao Skylap, about six kilometres from Bo Phloi basalt to the northeast, weathered looseblocks of basalt are prevalent around this creek. Megacrysts of pyroxenes, olivines, spinels are still clearly observed. Historically, this locality has been dug for gemstones. Basalt has been discovered under surface soil of the deserted pits around this area. In the field, lateritic gravels have been observed along Huai Pu creek. Gravels are abundant of angular fragments of quartzite and quartz. It has been suggested that this laterite was developed from weathering of basaltic rock (Aranyakanon, 1988). Basalt underlying gravel beds of ancient river

in the middle part of the Bo Phloi Basin, especially in Ban Chong Dan area is about seven meters thick. (Hansawek et al., 1996). The other at Khao Hin Lap, southern part of Bo Phloi district, gravels of basalt have been seen in some test pits (Aranyakanon, person. comm., 1996). In a fluorite mine at Khao Chong Insi, small diabase veins intruded into layers of schist and gneiss.

Due to the abundance of gemstone occurrence in the study area, a possible distribution of basaltic rock within the study area will be discussed based on compilation of various informations together with the result of airborne magnetic survey.

2. Occurrence of Basalt in the Study Area

2.1 Khao Lan Tom Basalt. (Bo Phloi Basalt) : Abundant researches on Bo Phloi basalt have been done by many researchers due to many favorable circumstances such as easy accessibility, its fame, and its freshness. On the basis of petrochemistry and petrography, this basalt has been classified as nepheline-hawaiite (Barr and Macdonald, 1981, and Yaemniyom, 1982) and basanitoid (Vichit et al., 1978). The basalt is dark gray and dense. Some megacrysts of black spinel, black pyroxene, sanidine and xenoliths of ultramafic rock as lherzolite have been recorded. Its ages determined by K-Ar dating method is 3.17 ± 0.14 Ma (Barr and Macdonald, 1981). However, Sutthirat et al (1994) reported its age as being 4.17 ± 0.11 Ma. Despite different figures, these ages are equivalent to late Tertiary or Pliocene epoch.

A large area of gemstone placer deposit has been discovered in the western part of Khao Lan Tom basalt. Basaltic gravels mixed with other gravels

have been observed in some gemstone mining faces, and they show texture similar to Khao Lan Tom basalt.

2.2 Huai Num Pu Basalt : Basalt has been formed along Huai Num Pu creek, located at the eastern part of Khao Skylap (Grid ref. 582879), and it underlies the colluvial deposits. Some megacrysts of black spinels and black pyroxenes extensively occur in the basalt. Furthermore, looseblocks of basalt with megacrysts of black pyroxene, olivine and lherzolite are generally prevalent. Previous pits prospecting for gemstones around Khao Skylap have also been noted. Aranyakanon (1988) suggested that basaltic eruption through Ma Kah creek (Huai Num Pu) might have created lava flows as high as 200 meters flowing to the west over the Skylap range and running down to the basin plain of Lam Ta Phoen. None of the flow went down to the eastern part as neither trace of gems nor other associated minerals have been found on the eastern part of the hill. This is due to the fact that why basalt has been found below the sapphire paysteak in the Chong Dan area, and gem deposits have been discovered and mined only on the east side of Lam Ta Phoen basin.

Furthermore, an occurrence of lateritic gravel of angular quartzitic rock at Huai Ma Kah may indicate that the basalt has thoroughly been weathered giving rise to high iron content in residual soil. An interesting idea regarding to weathering of the basalt was proposed by Aranyakanon (1988). He observed the residual soil on the Khao Skylap, Khao Wong and the hill area behind Amphoe Bo Phloi, and suggested that it has been derived from basalt. The early stage of its development would show greenish to yellowish-green appearence and gradually turns to yellowish, and finally becomes reddish-brown due to the richness of high iron and manganese content. High iron and maganese content dissolved in water

introduces suitable environment for laterite formation. Soils occurring around these basaltic terrane contain goethitic nodules and form hard-pan laterite. In some places, fragments of other parent rocks cemented by hydrated oxides of iron or manganese have also been observed.

As it has been mentioned above that the basalt might have flowed to the west overlying on the channel lag deposits. Due to it had flowed into the basin containing plently of water, therefore, it would have been rapidly weathered resulting to yellowish-brown weathered basalt layers and some gravels of weathered basalt within gravel bed.

Some possibilities regarding to the origin of corundum have been proposed by Vichit ,1975 (see Yaemniyom, 1982) as follows.

1. Corundum in xenoliths with or without reaction with wall rock
   (a) the shallow environment and (b) the deep environment.
2. Corundum-bearing ultramafics and /or mafic xenoliths
3. Corundum as megacrysts in basalts.

Vichit (1975) believed that the corundum originated as megacrysts in the basalts seems to be most likely case in Thailand including Bo Phloi basalt. Its low silica and high TiO2 content have characterize a deep seated source origin. The Bo Phloi corundum is usually found associated with isolated megacrysts of alluminous clinopyroxene and spinel in ground of basaltic terrane. Until now, no more corundum crystals are found within the basaltic rocks in this area, except for the only one rock sample collected by the Late Mr.Saman Buravas. Subsequencetly, two currently different ideas concerning with the origin of

gemstone in this area have been suggested. Firstly, it is believed that the gemstone especially corundum might have been crystallized within this basaltic magma and the other opinion is that gemstones might have been carried upward by basaltic magma from the depth. (Yaemniyom, 1982)

3. The Expected Area of Basalt

In order to explore the potential distribution of the basalt in Bo Phloi and its adjacent area, this has been done by studying Airborne Geophysical data including enhanced geophysical maps such as Reduced to the Pole; Total Field Magnetics; Radiometric Ternary Colour, which have been prepared by Airborne Geophysical Section of Department of Mineral Resource of Thailand. According to Sindhusen and others (1994), the primary purpose of the magnetic interpretation is to determine the magnetic signature of the exposed Bo Phloi basalt aiming to locate similar magnetic signature that may represent other concealed basalt.

The magnetic response of this basaltic plug regarding to the total magnetic field plot is an isolated, positive anomaly of moderate amplitude with asymmetric low to the north and south. At Bo Phloi the fresh outcrop of basalt covers an area of approximately half square kilometer. The basalt shows plug-like body, and there is no field evidence indicates that the basalt may extend over the gravel deposits.

The Reduced to the Pole Total Magnetic Field Map (fig. 6.1) was prepared to facilitate the interpretation. On this map the Bo Phloi Basalt gives the

anomaly trending in north-south direction. Other four anomalies that could represent unexposed basalt plugs are located as follows:

Anomaly number 1 : It is situated approximately 10 km to the northeast of Bo Phloi outcrop at UTM grid of 562500 mE, 1591400 mN. General geology in this location consists predominantly of Silurian-Devonian quartzite. No field evidence confirmed the existance of basalt yet.

Anomaly number 2 : It is situated approximately 16 km to the north-northeast of Bo Phloi in Khao Chong Insi range or at UTM grid of 560100 mE, 1597700 mN. Near this area, some diabase veins have been recorded in the flourite mine.

Anomaly number 3 : It is situated approximately 10 km to the west of Bo Phloi. This anomaly shows a similar signature to Bo Phloi, and is located at Huai Sing To having UTM grid of 546200 mE, 1585500 mN. In the field, this area is covered by thick secondary calcareous deposits with some lateritic nodules. The secondary calcareous deposit is about 2 meters thick and occasionally contains angular quartzite rock fragments.

Anomaly number 4 : It is located approximately 15 km to the southeast of Bo Phloi at UTM grid of 549100 mE, 157400 mN. It is covered by Ordovician limestone and quartzite in contact with Devonian-Silurian quartzite, sandstone and limestone. However, the anomaly shows signature indicating remnant magnetism similar to the Bo Phloi basalt.

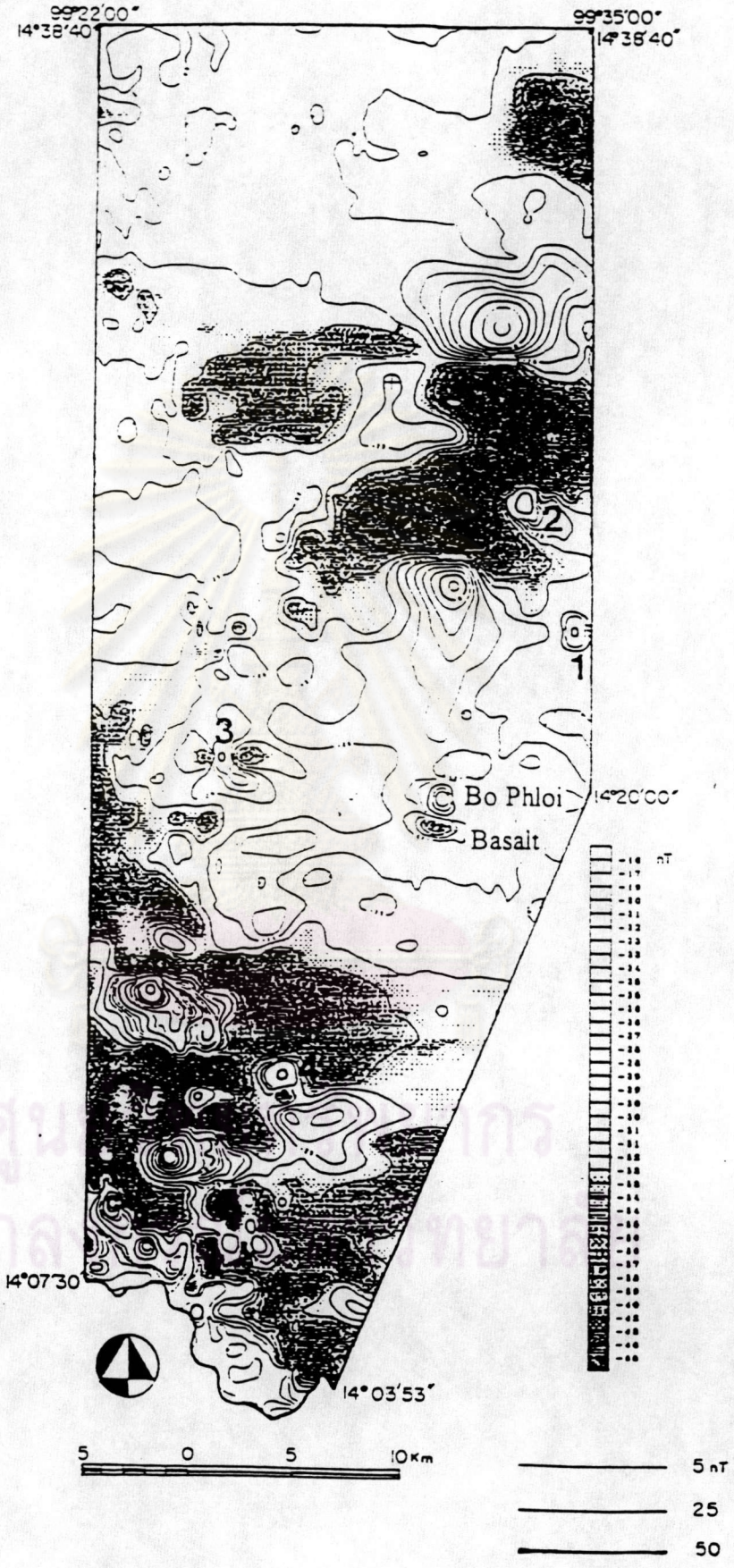

Figure 6.1 Map showing magnetic anomalies in the study area. (Choowong and others, 1995)

The differences of aerial photographic from these signatures four magnetic anomalies may have indicated the dominant residual soil that would have been derived from basaltic rocks. Geomorphologically, terrace landforms which are characterized by lateritic gravels trending in north-south direction along the west side of Khao Chong Insi and the east side of western mountain range, have been observed. The lateritic gravel is situated in the same position showing magnetic anomaly. According to these evidence, it may be suggested that the widespread iron oxide in the lateritic gravel might have been derived from basalt which had already been completely weathered.

Naturally, heavy minerals in placer deposit, such as tin, gold, etc, have short distance of transportation. The noteworthly occurrence of gemstones in the anomaly number 4, Khao Hin Lap, is approximately 15 km far from the Bo Phloi basalt. The appearence of basalt gravels together with increasing abundance of spinel and black pyroxene within gravel bed, which is located not exceeding 2 m from the surface, could support the assumption that once the basaltic rock might have existed in this area (Aranyakanon, 1988).

Gemstone Placer Deposit

The gemstone production from Bo Phloi has been known for the last three decades, especially in the area around the low hills. Local people previously looked for gemstones by pittings and found them in a gravel layer about 1-2 meters deep. At present, extensive gemstone mining has been operated by many companies in deeper part of the deposition westward to the middle part of the basin. Gemstones have still been found in gravels transported by river processes. So, a broad area of gemstone placer deposit has been realized since then.

The present field investigation has been carried out with a cooperation from Gemstone Exploration Section, DMR during 1993 and 1994. It is composed of detailed field observation at various gemstone mining faces, test pitting and banka drilling. Due to a compilation of data from 58 test pits with a total depth of 219.3 meters and 19 banka boreholes with a total depth of 406.4 meters, the depositional area of gemstones can be divided into three locations as follows.

1. Ban Chong Dan Area

Huai Num Pu (Huai Ma Kah) is situated in the eastern part of Khao Skylap and covered by basalt which appears to be the source of gemstone. According to field evidence, the upper boundary potential of gemstone field is situated between Ban Lum Rang and Ban Chong Dan. From previous records, the gemstones observed in this area were abundantly composed of large corundum (especially blue sapphire), black spinel and black pyroxene. Gemstones were found within gravel bed overlying the weathered basaltic layers. Gemstone paystreak is ranging from 1-4 meters thick. Average deep of the gemstone paystreak is 14 meter from the surface with average 2.6 meter thick. The content of spinel and pyroxene, with their diameter sometimes greater than 2 mm, in the paystreak ranges from 140 to 1,270 grams per cubic-meter with an average of 690 grams per cubic-meter. The distribution of gemstones has been illustrated in fig.6.2. An idealized Quaternary cross-section of the Ban Chong Dan deposit is shown in fig. 6.3., and its idealized stratigraphic sequence showing detailed lithofacies is shown in figure 6.4 (A).

2. Ban Bung Hua Waen Area

In this area a gravel bed of about 5 meters thick has been found. It contains some gravels of weathered basalt mixing with quartzite and chert. The depth of gemstones paystreak is generally ranging from 8 to 17 meters. Spinel and pyroxene quantity with their diameter greater than 2 mm in it is between 290 to 1,600 grams per cubic-meter with are average of 1,030 grams per cubic-meter. Gemstones paystreak, especially in western part of Lam Ta Phoen are between 1.6 to 7 meters thick, and averaging 3.7 meter. The depth of gemstone bearing-layer ranges from 12 to 20 meters. Spinel and pyroxene quantity with their diameters greater than 2 mm it is ranging from 90 to 1,240 grams per cubic-meter with averaging 780 grams per cubic-meter. In this area, gemstones are smaller sizes and less quantity than at Ban Chong Dan area. The distribution of gemstones has been drawn out in accordance with data obtained from banka drilling and it has also been shown in figure 6.2, and its idealized stratigraphic sequence showing detailed lithofacies is shown in figure 6.4 (B). Based on field evidence the important source of gemstone around Ban Bung Hua Waen area appears to be one of basaltic flow of Khao Lan Tom basalt and some gemstones have been transported from Ban Chong Dan along the paleochannel. .

3. Khao Hin Lap-Khao Chon Kai Area

Based on the following evidences that : (1) a long distance of transportation of high specific gravity minerals from Bo Phloi is generally uncommon, (2) numerous existence of euhedral and subhedral crystals of black spinel and still preserved, (3) gemstone depositional layer here is shallower than Bo Phloi area ; and (4) some basaltic looseblocks found in test pits have been

reported by Aranyakanon (1988), it reasonable to make an assumption that basalt may has existed in this area. In addition, an airborne magnetic anomaly exists at Khao Hin Lap indicating a possibility for existence of the basalt. According to Hansawek et al (1996), this area can be subdivided into three parts as follows.

3.1 Ban Bung Lom - Ban Wang Dong : Based on banka drill information, a gemstone paystreak has been observed between 6 to 12 meters from surface with an average of 10 meter deep. The paystreak thickness is ranging from 1 to 8 meters with an average of 3.6 meters. Its spinel and pyroxene content with their diameters greater than 2 mm is 100 to 1,780 grams per cubic-meter with an average of 970 grams per cubic-meter.

3.2 Ban Wang Dong - Ban Thung Masang : Based on banka drill data, a gemstone paystreak has been found between 6 to 9 meter with average 7.5 meter deep from surface. Its thickness is ranging from 1 to 3.8 meters with an average of 2.5 meters. Its spinel and pyroxene content with their diameters greater than 2 mm ranging from 10 to 570 grams per cubic-meter with an average of 330 grams per cubic-meter.

3.3 Khao Hin Lap - Khao Chon Kai : Based on test pitting in the middle terrace along both sides of Lam Ta Phoen, a gemstones paystreak has been observed between 0-2 meters deep from surface. Its spinel and pyroxene quantity with their diameters greater than 2 mm is ranging from 0.5 to 1,630 grams per cubic-meter with an average of 160 grams per cubic-meter.

Results from Banka drilling in the vicinity of Khao Hin Lap indicate that gemstone depositional layer is deeper than 6 meters. It can be correlated with

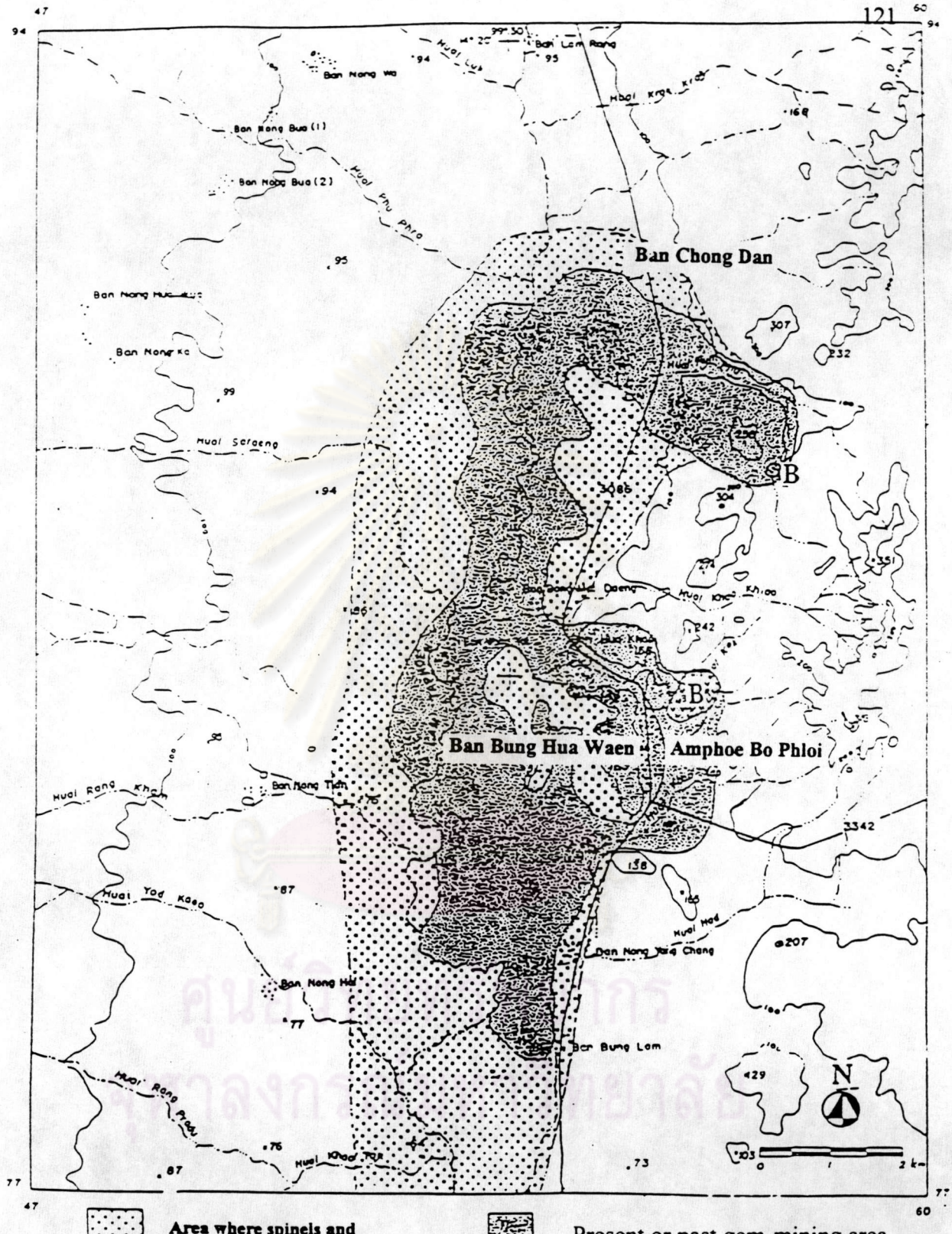

Figure 6.2 Map showing distribution of sapphires and spinels in Ban Chong Dan and Ban Bung Hua Waen.

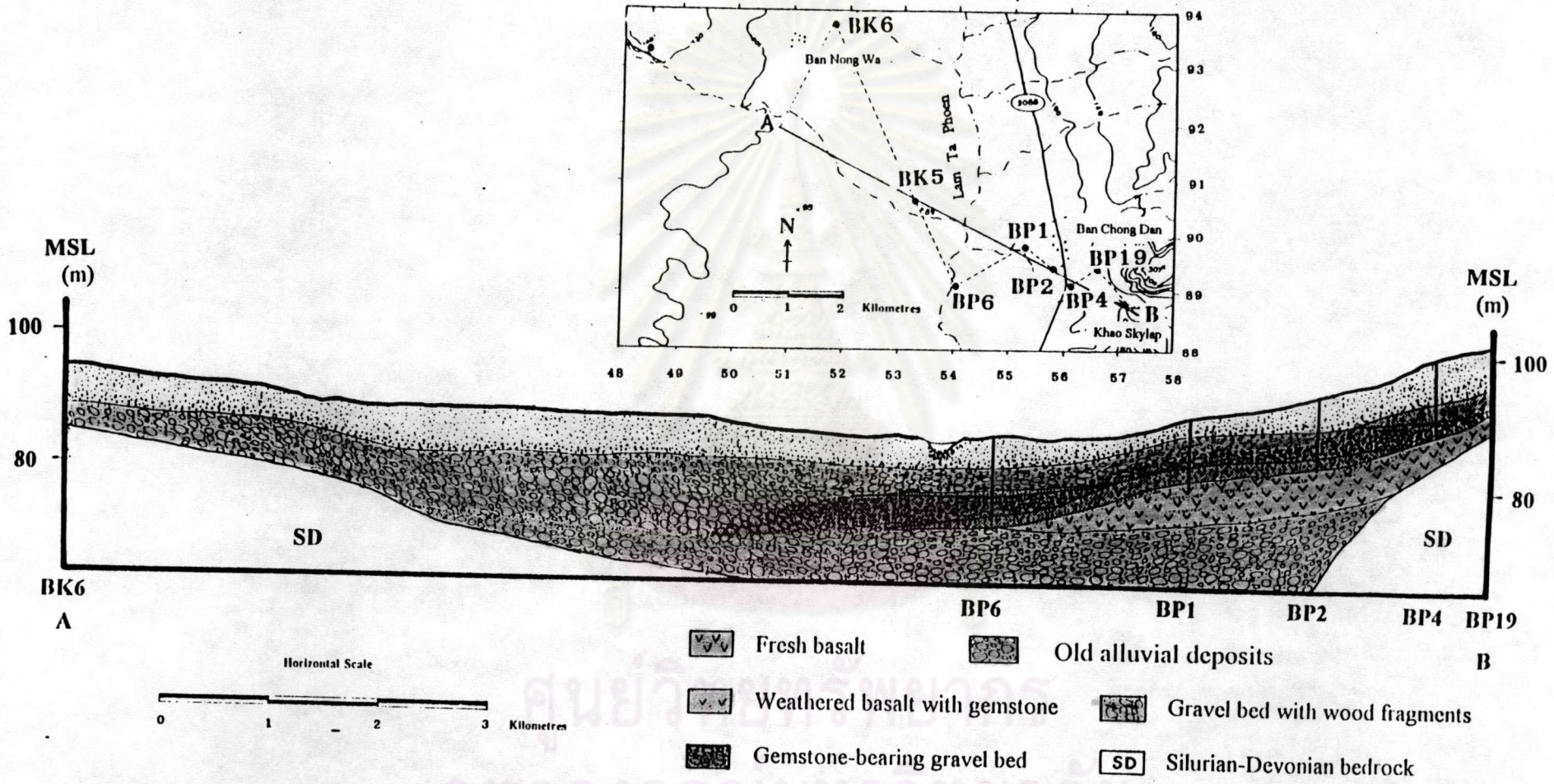

Figure 6.3 Idealized Quaternary stratigraphic cross-section showing gemstone placer deposit overlying on basaltic flows at Ban Chong Dan area, Amphoe Bo Phloi, Changwat Kanchanaburi.

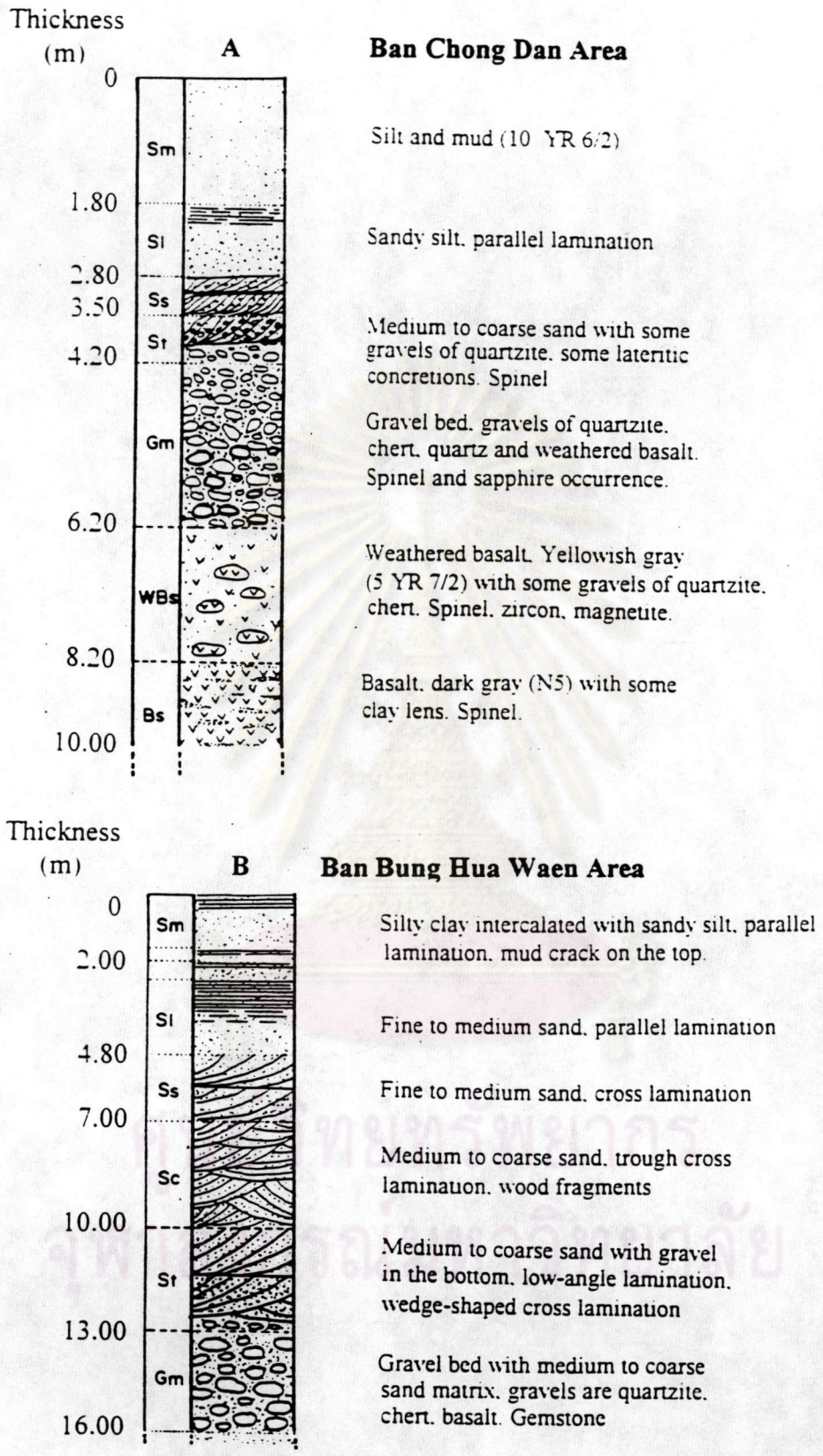

Figure 6.4 Idealized Quaternary stratigraphic sequence showing detailed lithofacies and gem-paystreak. A) Ban Chong Dan Area. B) Ban Bung Hua Waen Area.

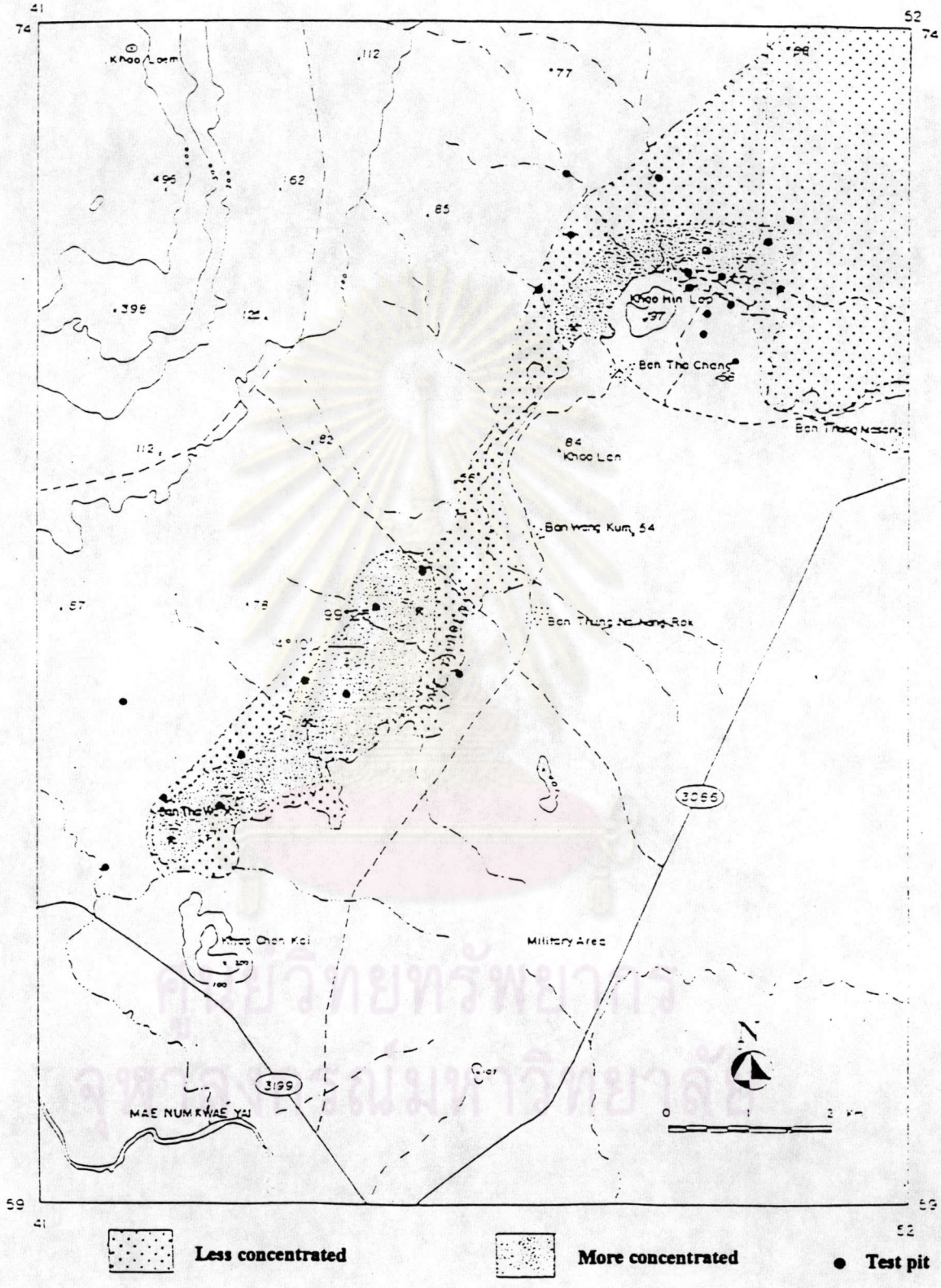

Figure 6.5 Map showing the distribution of sapphires and spinels extending from Khao Hin Lap to Khao Chon Kai.

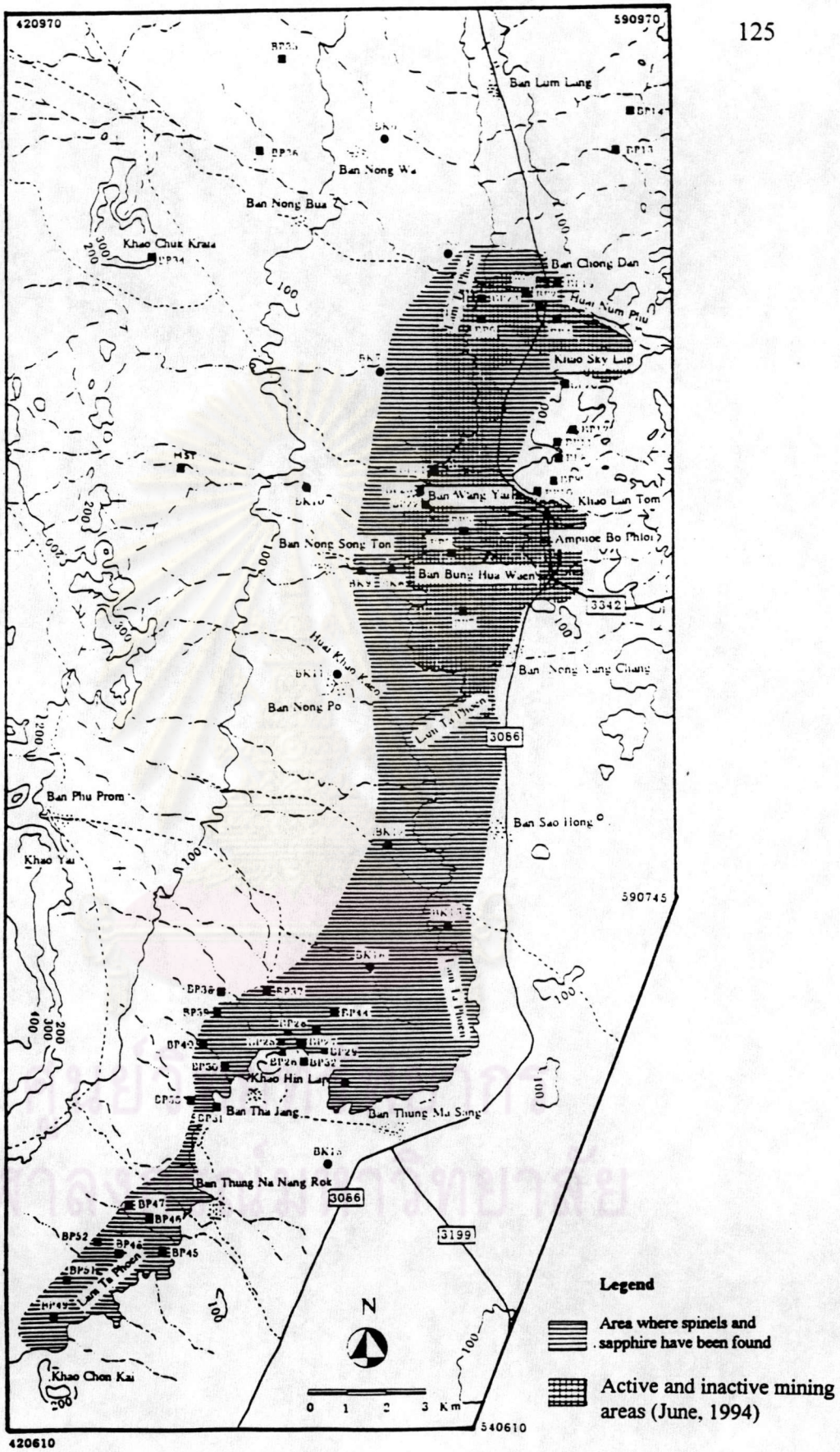

Figure 6.6 Map showing regional distribution of gemstones in the study area, Amphoe Bo Phloi, Changwat Kanchanaburi.

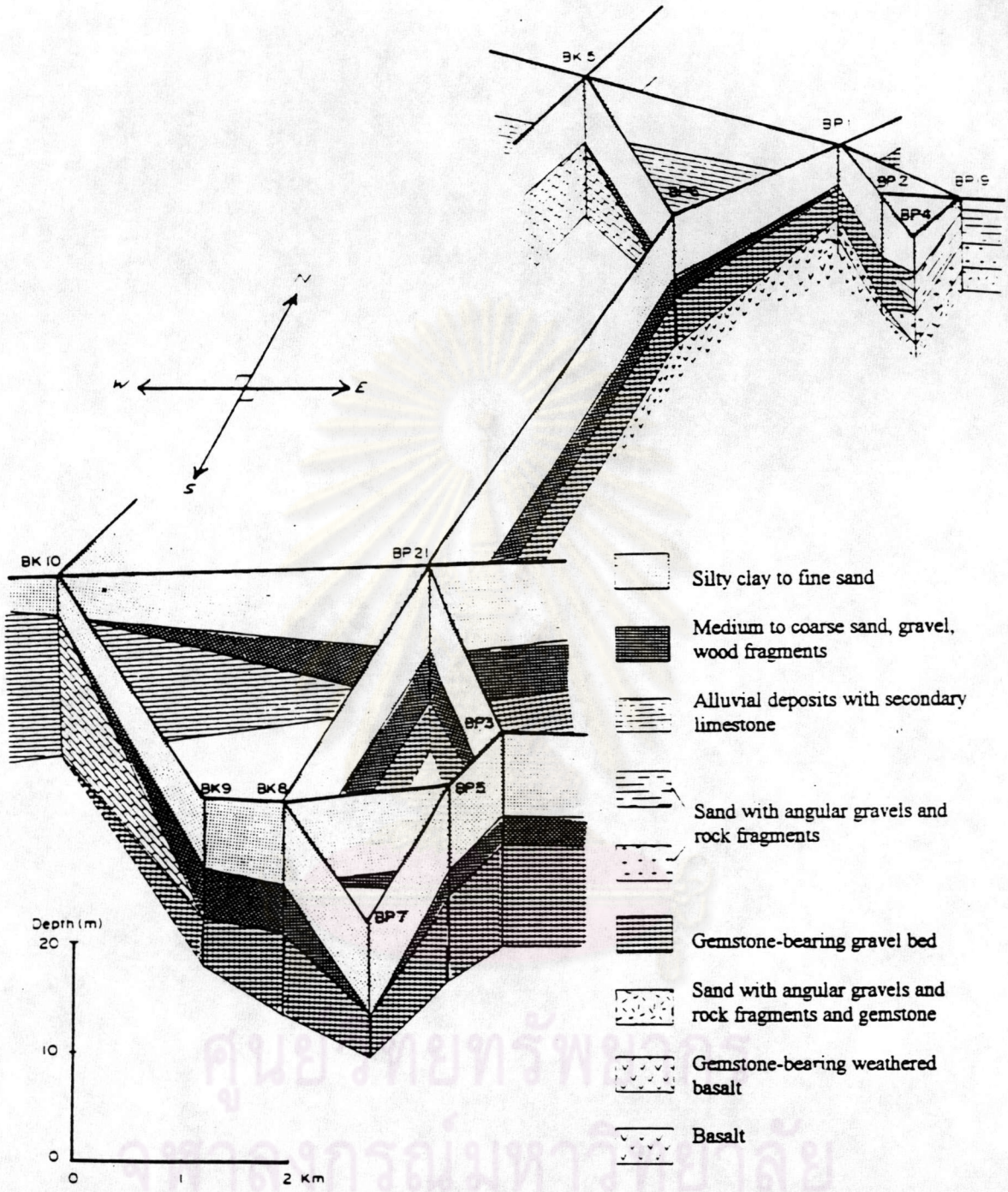

Figure 6.7 Fence diagram showing sedimentary correlation of depositional strata in the middle part of the Bo Phloi basin. Amphoe Bo Phloi, Changwat Kanchanaburi.

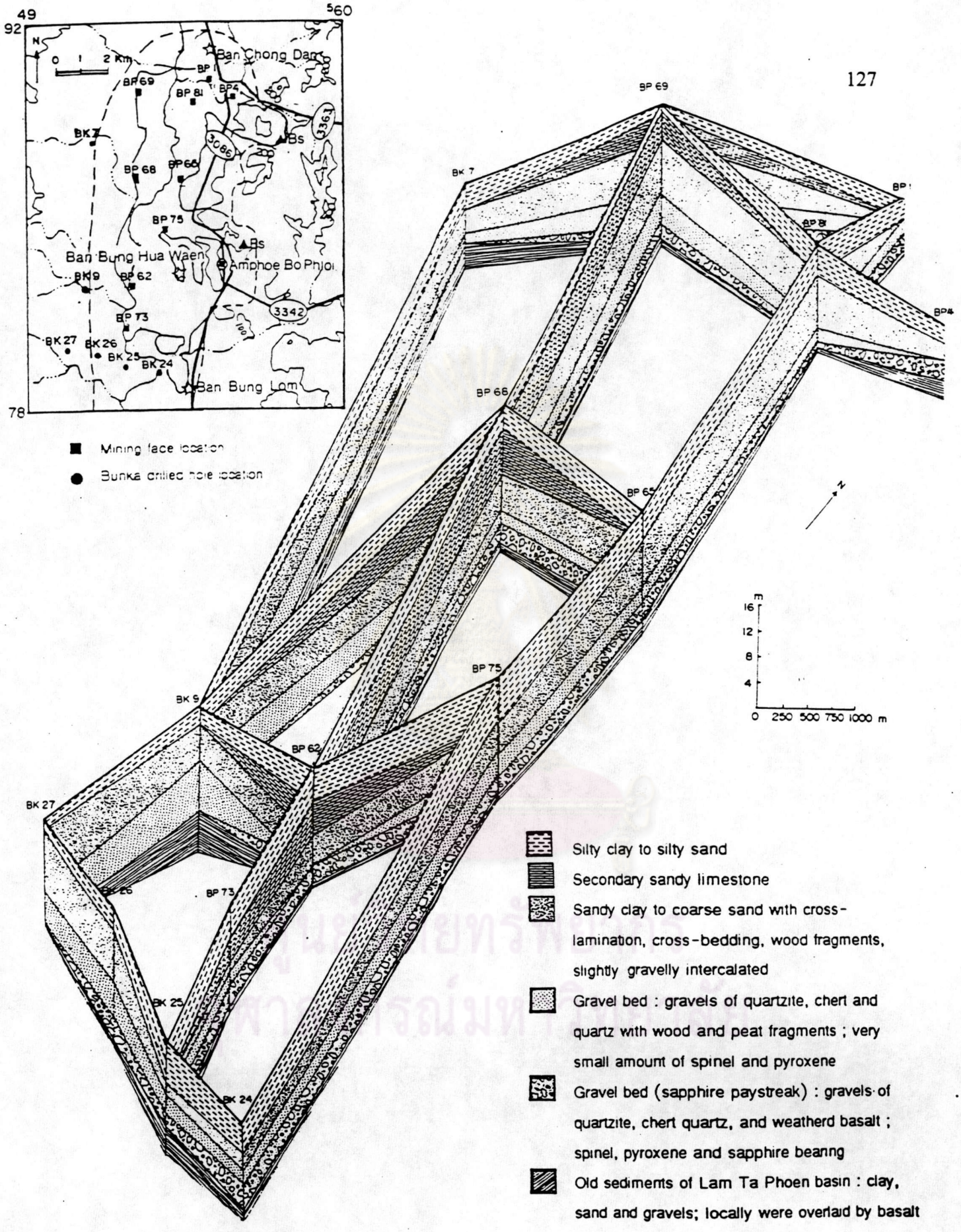

Figure 6.8 Fence diagram showing a generalized stratigraphic sections of sapphire producing area, Bo Phloi, Kanchanaburi. (Hunsawek et al., 1996)

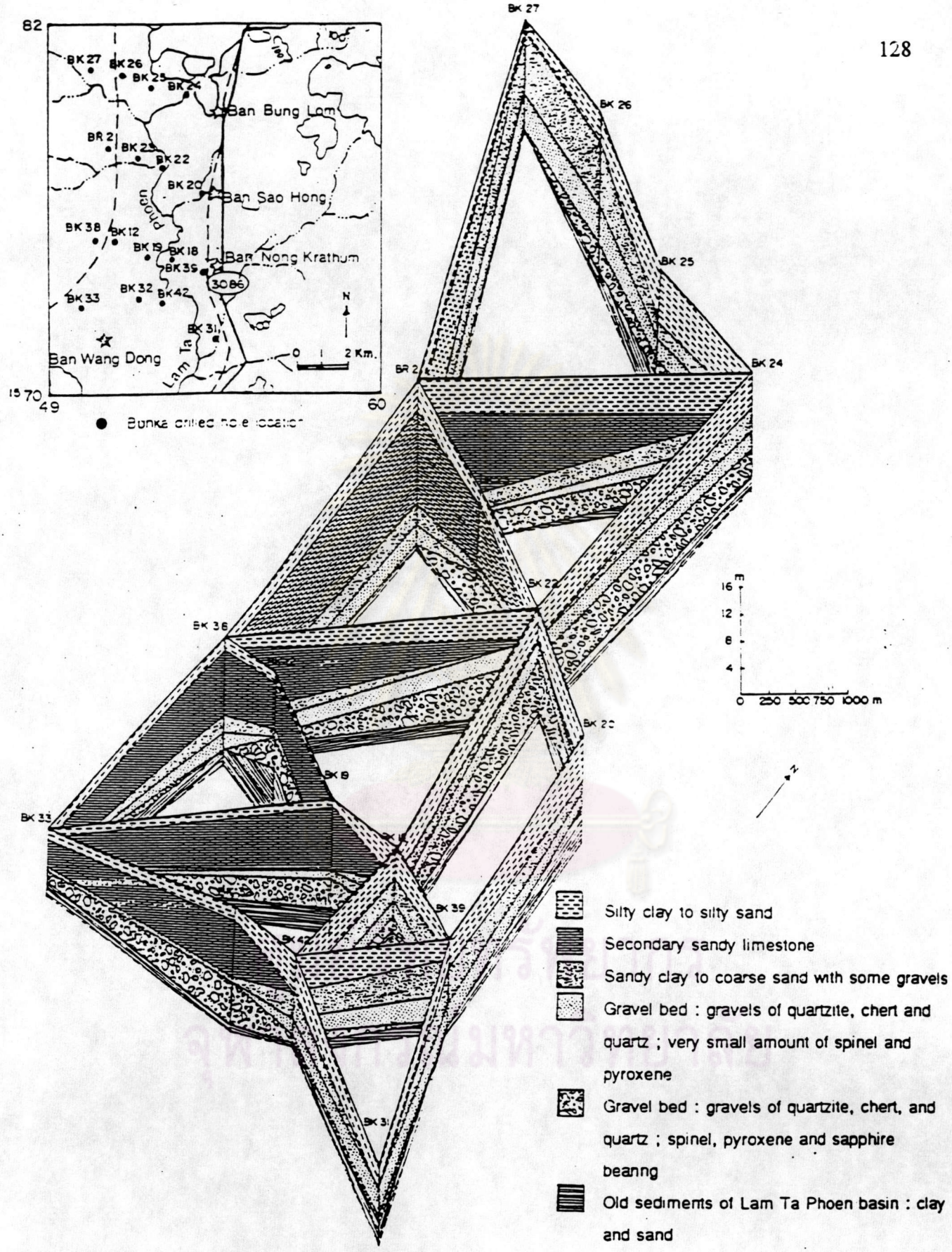

Figure 6.9 Fence diagram illustrating generalized stratigraphic sections of potential sapphire producing area, Ban Bung Lom to Ban Wang Dong, Bo Phloi, Kanchanaburi. (Hansawek et at., 1996)

the Ban Bung Hua Waen deposit. This means that there seems to be two gemstone depositional layers. The first one is located not deeper than 2 meters from surface, and the other is situated at similar depth with that of the Ban Bung Hua Waen deposit which is between 6 up to 12 meters deep. The distribution of gemstones have been shown in fig. 6.5.

The regional distribution of gemstones in the study area is shown in fig. 6.6. It illustrates the areas where spinels and sapphire have been found and indicates the area were active until June 1994. Fence diagrams illustrating the correlation of sedimentary layers in the area are contructed based on information from pittings and banka drilling which are shown in fig. 6.7, 6.8 and 6.9.

4. Preliminary Gemstone Reserve Estimation

The preliminary sapphire reserve estimation has been carried out by many gemstone-producers. The evaluation at Ban Bung Lom and Ban Chong Dan areas were done by BHOL & SONS Co.,Ltd during the year 1991 to 1992 (Rouay Limsuwan, person. comm., 1994). These two project areas are located at the UTM grid of 542000E, 792500N (Area I : Ban Bung Lom) and the UTM grid of 541500E, 902000N (Area II : Ban Chong Dan). The reserve estimation is commonly defined as the weight of spinel (in kilogram) found in one cubic meter of paystreak, or the weight of sapphire (in carat) found in one cubic meter of paystreak.

The total reserve of paystreak in area I comprises 3,408,066 cu.m. of clay, 1,937,102 cu.m.of sand and 1,465,785 cu.m. of gravels. The total reserve of

aggregate of area II consists of 907,092 cu.m.of clay, 706,166 cu.m. of sand, and 708,478 cu.m. of gravels.

The reserves of black spinel and sapphire in area I are 177,418 kg. and 538,635 carats, respectively. The ratio of spinel to sapphire is averaged at 1,600 : 1 The reserves of black spinel and sapphire in area II are 159,100 kg. and 1,118,834 carats respectively. The ratio of spinel to sapphire is averaged at 700 : 1. These results are shown in table 6.1 and 6.2.

Table 6.1 Summary of alluvium and its contents.(modified from Limsuwan, 1992)

Area no.	Surface Area (m^2)	Alluvium		Clay		Sand/Gravels	
		Thickness (m)	Volume (m^3)	Thickness (m)	Volume (m^3)	Thickness (m)	Volume (m^3)
I Average		14.77		4.56		10.21	
Total	360,000		5,317,200		1,641,600		3,675 600
II Average		19.90		6.30		13.60	
Total	115,296		2,294,390		726,364		1,568,818

Table 6.2 Summary of gemstone grades and indicated reserves. (modified from Limsuwan, 1992)

Area no.	Surface area (m^2)	Alluvium thickness (m)	Volume of alluvium (m^3)	Spinel		Sapphire		Indicated reserves ratio of spinel/sapphire
				average grade (kg/m^3)	indicated reserves (kg)	average grade ($carat/m^3$)	indicated reserves (carat)	
I Average		14.77		0.02		0.12		1,600:1
Total	360,000		5,317,520		117,418		538,635	
II Average		19.90		0.10		0.92		700:1
Total	115,296		2,298,390		159,110		1,118,434	