Chapter 2

GEOLOGY OF THE STUDY AREA

2.1 General Geology

According to previous investigation by Sattayarak *et al.*,(1998) proposed that northeastern Thailand comprises two main areas: the mountains of the Loei-Petchabun foldbelt to the west and the Khorat Plateau to the east. The study area is in the Loei-Petchabun foldbelt. The rocks are composed predominantly of Permian rock and Quaternary sediments (DMR, 2005) (Figure 2.1). Wielchowsky and Young (1985) conducted the field investigation of carbonate and siliciclastic lithofacies in Lower and Middle Permian rocks of the Petchabun fold and thrust belt of northeastern and central Thailand. They established three paleogeographic provinces of the Permian Nam Duk sea (Figure 1.3): Khao Khwang platform to the west, Nam Duk basin in the middle, and Pha Nok Khao platform to the east. Over half of the thickness of the total Permian section measured at Khao Somphot area was deposit during Middle Permian.

Khao Somphot area is a location of the dolomite contact with limestone found in the Permian shelf carbonate section. The dolomite is light brown to medium gray massive to thick bedded, with crinoid fragment and overly the light gray limestone. In the southeast of Khao Somphot, there is an abandoned quarry, consists of thin to thick bedded skeletal wackstone, packstones, grainstones and coral bafflestones. Fusulinids, dasycladaen algae, bivalves, crinoid, sponge, and gastropod. Dominates beds are preceded by an increasing concentration of *Alatoconcha* bivalves and coral rich beds reaching bafflestones proportions. Fossil assemblages suggest a deposition of upper Middle Permian carbonate in platform interior sand shoal environment (Wielchowsky and Young, 1985).

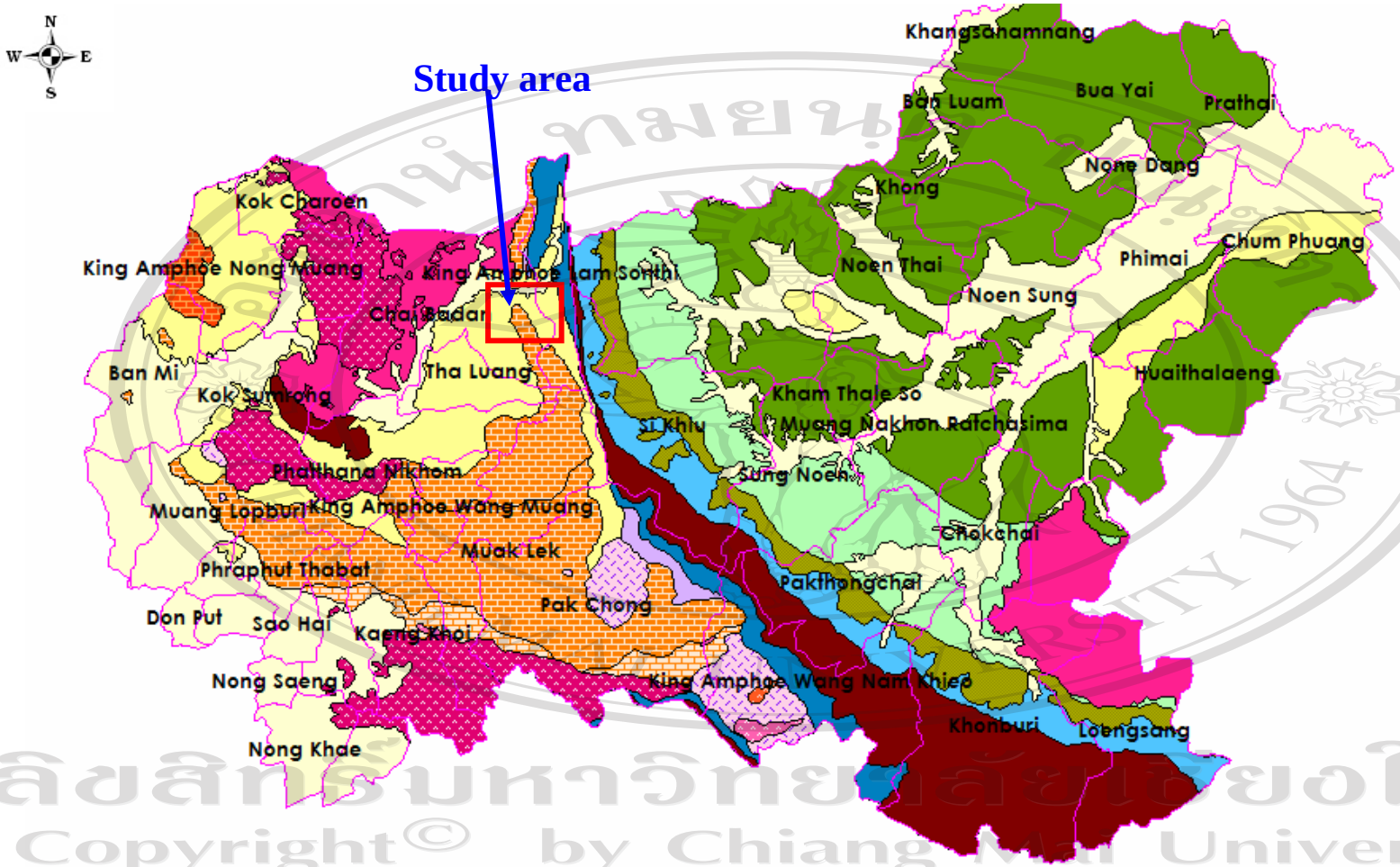


Figure 2.1 Geologic Map of : Lopburi , Saraburi, Nakhonratchasima Province (modified after DMR, 2005)

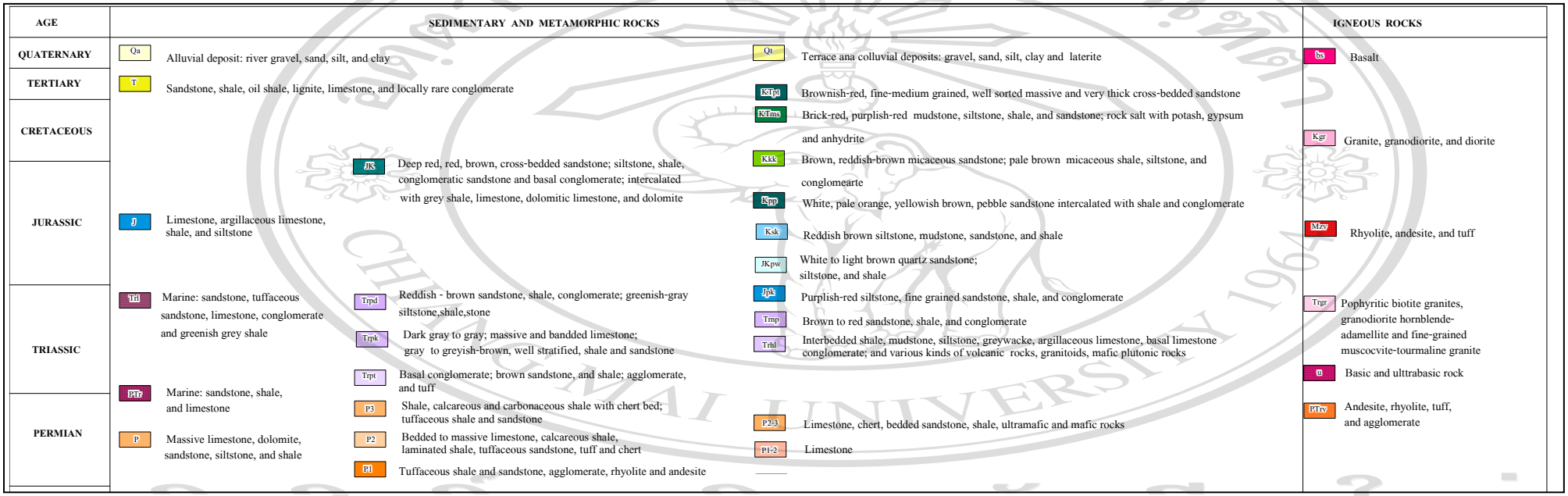


Figure 2.1 (continue) Legend of Geologic Map (modified after DMR, 2005)

2.2 Regional Permian Stratigraphy

In 1992, the Geological Survey Division, Department of Mineral Resources established the lexicon of the stratigraphic names of Thailand. The Permian rock in Thailand have been proposed into two groups as illustrated in the geological map of Thailand at the scale 1: 2,500,000 (DMR, 2005) (Figure 2.2). These are the Ratburi Group and the Saraburi Group. The name of Saraburi Group was originally proposed by Bunopas (1981) for a mixed carbonate and clastic sequence outcropping in the eastern side of the Central Plain from Nakhon Sawan southwardly to Saraburi, and also at the western edge of the Khorat Plateau from Loei southwardly to Saraburi or the Phetchabun Ranges (DMR, 1992; Bunopas, 1992). The group has been considered to be developed along the western edge of the Indochina terrane. Stratigraphically, the strata conformably overlie the Upper Carboniferous carbonate-clastic/volaniclastic sequences and underlie the Permo-Triassic volcanic/volcaniclastic sequence and/or the Upper Triassic conglomerate. Fusulinaceans, smaller foraminifers and brachiopods indicate Asselien to Midian age (e.g. Dawson, 1978; Chonglakmani and Fontaine, 1990; Fontaine and Suteethorn, 1992; Charoentitirat, 1995, 2002).

2.3 Stratigraphy Nomenclature

The Saraburi Group contains clastic and non-clastic rocks ranging in age from Late Carboniferous to Late Permian that formed on the Indochina terreane. The name Saraburi Group was proposed by Bunopas (1981) for mixed carbonate and clastic sequence outcropping in the eastern side of the Central Plain from Nakhon Sawan southwardly to Saraburi Province, and also at the western edge of the Khorat Plateau from Loei southwardly to the Phetchabun Ranges (DMR, 1992; Bunopas, 1992). The group has been considered to be developed along the western edge of the Indochina terrane, the difference name of formation in this group can be correlated in Table 1.1. The Saraburi Group in area around Saraburi province consists of six formations (Hinthong *et al.*, 1985) in ascending order (Figure 2.3) as Phu Phe Formation, Khao Khwang Formation, Nong Phong Formation, Pang Asok Formation, Khao Khad Formation, and Sab Bon Formation. Brief descriptions of the formations are as follows:

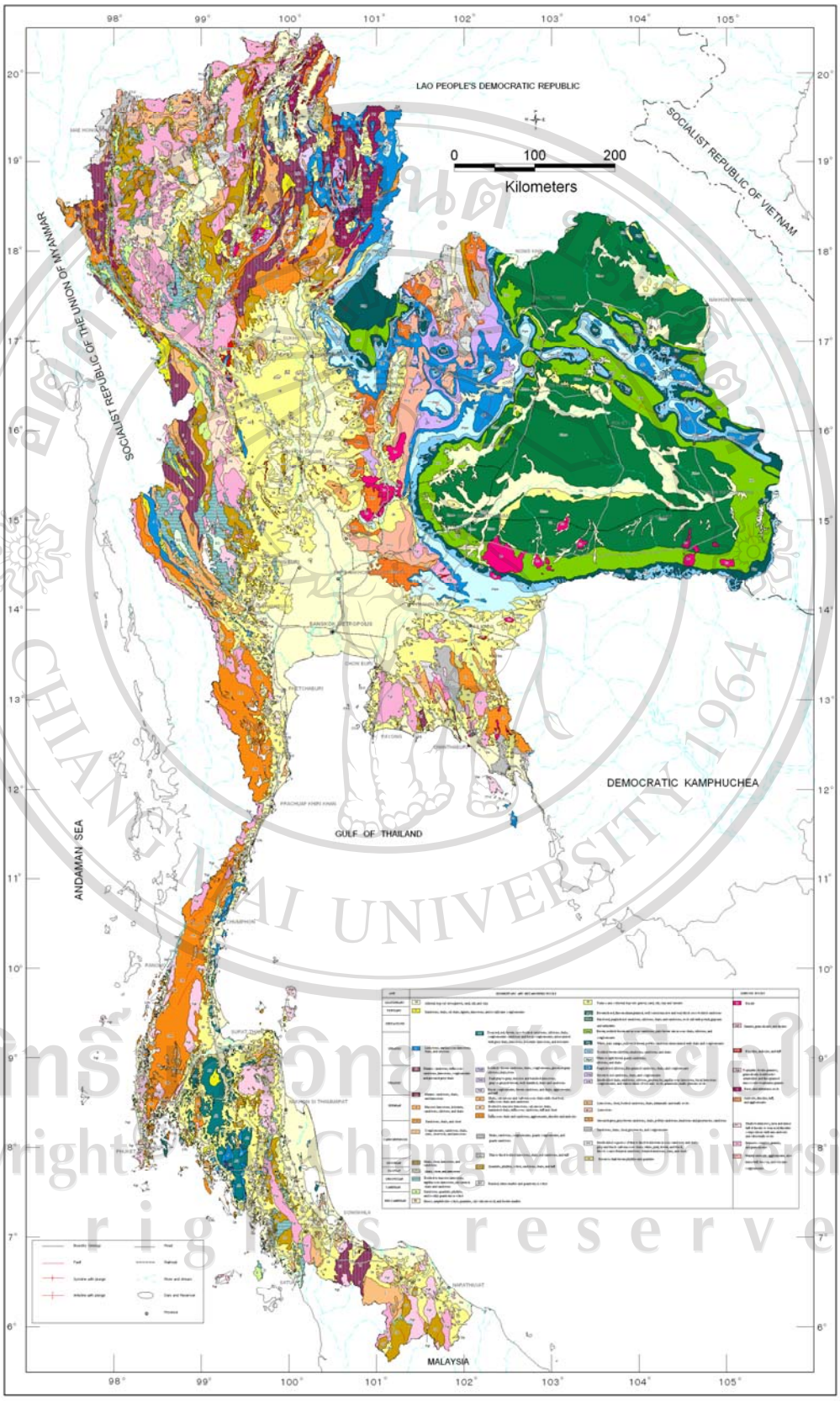
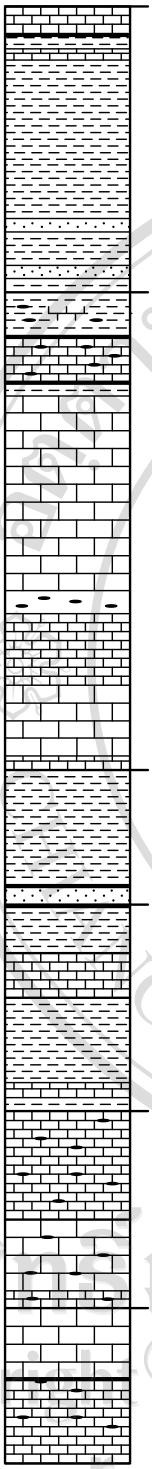


Figure 2.2 Geological map of Thailand at the scale 1: 2,500,000 (DMR, 2005)



Sap Bon Formation: about 1,000 meters thick, gray shale and siltstone, with minor sandstone and limestone. Chert nodules are common in limestone and in shale, particular in the upper part of the unit.

Khao Khad Formation: about 2,000 meters thick, is typically thin to thick bedded and massive, light- to dark-gray, limestone. Shale, silstone and sandstone appear as a part of the unit. Chert nodules and beds are common. Parts of limestone were locally metamorphosed to be marble and calc-silicate hornfels due to igneous intrusions. Fusulinids including brachiopods, gastropods, ammonites, cephalopods, corals, bryozoas, crinoid stems and algaes are common.

Pang Asok Formation: 400-500 meters thick, gray, greenish-gray shale and slaty shale with intercalated arkosic sandstone. Part of the unit was subject to metamorphism and turned rocks to be slate, phyllitic shale.

Nong Pong Formation: about 700 meters thick, mainly of shale and minor interbedded, gray to dark gray limestone. Limestone with chert beds is partly thick-bedded or laminated or argillaceous. Fossils of early Early Permian (Artinskian to Kungurian) fusulinids and *Agathiceras* sp. are found within the unit.

Khao Khwang Formation: about 500 meters thick or more, mainly thick-bedded limestone. The unit is partly interbedded by dolomitic limestone, shale, sandstone and tuffaceous sandstone including rhyolite dike and chert nodule. Fusulinids are found in the lower part but brachiopods and bivalves are in the upper part, and indicate Early Permain.

Phu Phe Formation: 600 meters thick, mainly of massive limestone in the upper part while shale and slaty shale are intercalated in the lower. Chert beds and nodules are commonly found in the limestone.

Limestone | Limestone with chert nodules | Shale | Siltstone and sandstone | Chert bed | Marble and calc-silicate

Figure 2.3 Stratigraphy of the Saraburi Group (Hinthong *et al*., 1985)

Phu Phe Formation

The formation, 600 meters thick, is chiefly composed of massive limestone in the upper part while shale and slaty shale are intercalated in the lower. Chert beds and nodules are commonly found in limestone. The type section at Khao Phu Phe, east of km 131-132 of the Friendship Highway, consists of purplish gray to very dark gray, thick-to very thick- bedded fine grained carbonate rocks with nodular chert and intercalated slaty shale in some parts. The boundary of the formation is upthrusted (Borax and Stewart, 1966) onto Sap Bon Formation. Fusulinaceans yield *Pseudoschwagerina* cf. *toriyamai*, *Pseudoschwagerina* sp. (Aceroschwagerina), *Pseudoschwagerina* (Robustoschwagerina) cf. *toriyamai*, *Paraschwagerina*, *Pseudoschwagerina* (Zellia) *turbida* Kahler, smaller foraminifers *Triticites* sp. cf. *ellipsoidalis* indicate a Sakmarian age (Early Permian) (Hinthong *et al*., 1985).

Khao Khwang Formation

The rock unit, about 500 meters or more in thickness, is characterized by thick-bedded limestone. Chert nodules are common but more frequently in the upper part of the unit. The unit is partly interbedded by dolomitic limestone, shale, sandstone and tuffaceous sandstone including rhyolite dike. The type location at Khao Khwang, Saraburi Province consists of black, dark to light gray, thick-bedded limestone with thin-bedded and nodular cherts. Locally, the formation has been dolomitized in various degrees and/or partly associate with purplish brown and greenish gray shale, sandstone, tuffaceous sandstone, and volcanic/volcaniclastic rocks. The thickness of the formation is about 490 meters. Fusulinids are found in the lower part but brachiopods and bivalves are in the upper part, and indicate a Sakmarian age (Early Permian) (Hinthong *et al*., 1985).

Nong Phong Formation

The rock unit, about 700 meters thick, consists mainly of shale and subordinately interbedded, gray to dark gray limestone. Limestone with chert beds is partly thick-bedded or laminated or argillaceous. Some chert lenses are in the upper siliceous shale. The 673 meters thick of the type locality at Ban Nong Pong, east of Khao Khwang, Saraburi Province. The formation consists laminated to thin bedded shale and limestone with locally argillite and chert intercalation. *Agathiceras* sp. and

several unidentified fusulinaceans indicate Artinskian to Kungurian (early Early Permian). This formation was interpreted as being deposited in rather deep carbonate shelf environment (Pendexter, 1980).

Pang Asok Formation

The rock unit, about 400-500 meters thick, generally contains pale-brown, gray, and greenish-gray shale and slaty shale with intercalated arkosic sandstone. Part of the unit was subject to metamorphism and turned rocks to be slate, phyllitic shale. These rocks are also used for building stone. Thin limestone lenses are irregularly interbedded in the unit. The formation takes its name from Ban Pang Asok near Pang Asok railway station, Saraburi Province. The 366 meters thick of sequence consists of the interbedded brownish gray to greenish gray shale and slaty shale with locally limestone lens. Scarce fossils such as small bivalves and leafs are found but cannot identify the age of rock forming. However, the unit is gradually conformable to the underlying Nong Pong Formation and the overlying Khao Khad Fomation. Thus, the unit age is considered to be Artinskian to Kungurian age (Late Early Permian). The formation is correlated with Khao Luak Formation in the area of Nakorn Sawan and Lopburi Province (Nakornsri, 1977; Bunopas, 1981).

Khao Khad Formation

The rock unit, about 2,000 meters in thickness, is typically thin to thick bedded with occasionally massive, light- to dark-gray limestone. Chert nodules and lenses are common in limestone. Some limestones show dolomitic composition and intraformational breccia. Shale, siltstone and sandstone appear as a part of the unit. Parts of limestone were locally metamorphosed to be marble and calc-silicate hornfels due to igneous intrusions. The type location is designated at Khao Khad, Phra Phuttabat District, Saraburi Province with a total thickness of 1,812 meters. The formation exposes in many areas of Lopburi, Saraburi Provinces, the Phetchabun ranges, and northwest of the Khorat plateau with east-west trending. This formation in Lopburi area, Nakornsri (1977, 1981) proposed Tak Fa Formation. Fusulinids including bachiopods, gastropods, ammonite, cephalopods, corals, bryozoas, crinoid stems and algae are common. Fossil identifications particularly fusulinids, indicate the

rock age to be Artinskian to Kungurian age (late Early to early Middle Permian) (Pitakpaivan, 1965; Toriyama *et al*., 1974; 1975; Tittirananda, 1976).

Sab Bon Formation

The rock unit, about 1,000 meters thick, comprises gray shale and siltstone, with minor sandstone and gray to dark gray limestones. Chert nodules are common in limestones and in shale, particular in the upper part of the unit. In parts, shale has siliceous composition and is interbedded with chert. The formation was considered to be uppermost formation of the Saraburi Group in the Saraburi area. The type section is located at Ban Sap Bon near Tab Kwang District, Saraburi Province. Fusulinacean yields *Pseudofusulina* sp., *Colania* cf. *douvillei* Ozawa and *Neoschwagerina* cf. *magaritae* and ammonoid *Agathiceras* sp. found in shale and siltstone indicate the Kungurian to Kazanian age (late Middle to early Late Permian) (Hinthong, 1981; 1985).

2.4 Geology of the study area

The geology of the study area was mapped on the Ban Mi sheet of the Geological map of Thailand 1:250,000 published by Nakornsri (1977), and later modified in detail by Department of Mineral Resource (2005) (Figure 2.4). Generally, rocks distributed in this area comprise the sequences of sedimentary rocks in ages from Permian and Quaternary. The Quaternary sediments are developed in Pa Sak flood plain in the western part of Khao Somphot. The detail of all lithologic unit present in the study area and vicinity are separately summarized below.

Permain Rocks

The Khao Somphot mount exhibits the northernmost Permain outcrop in the area under investigation. The extensive outcrops were easy to reach. Borax and Stewart (1966) examined between 15° 12' N and 15° 06' N (Figure 1.1). They were able to measure a 525.2 meters long section of “fine-grained, gray limestones with fusulines” underlain by dolomites of 19.5 meters thickness. The strata become younger towards the east.

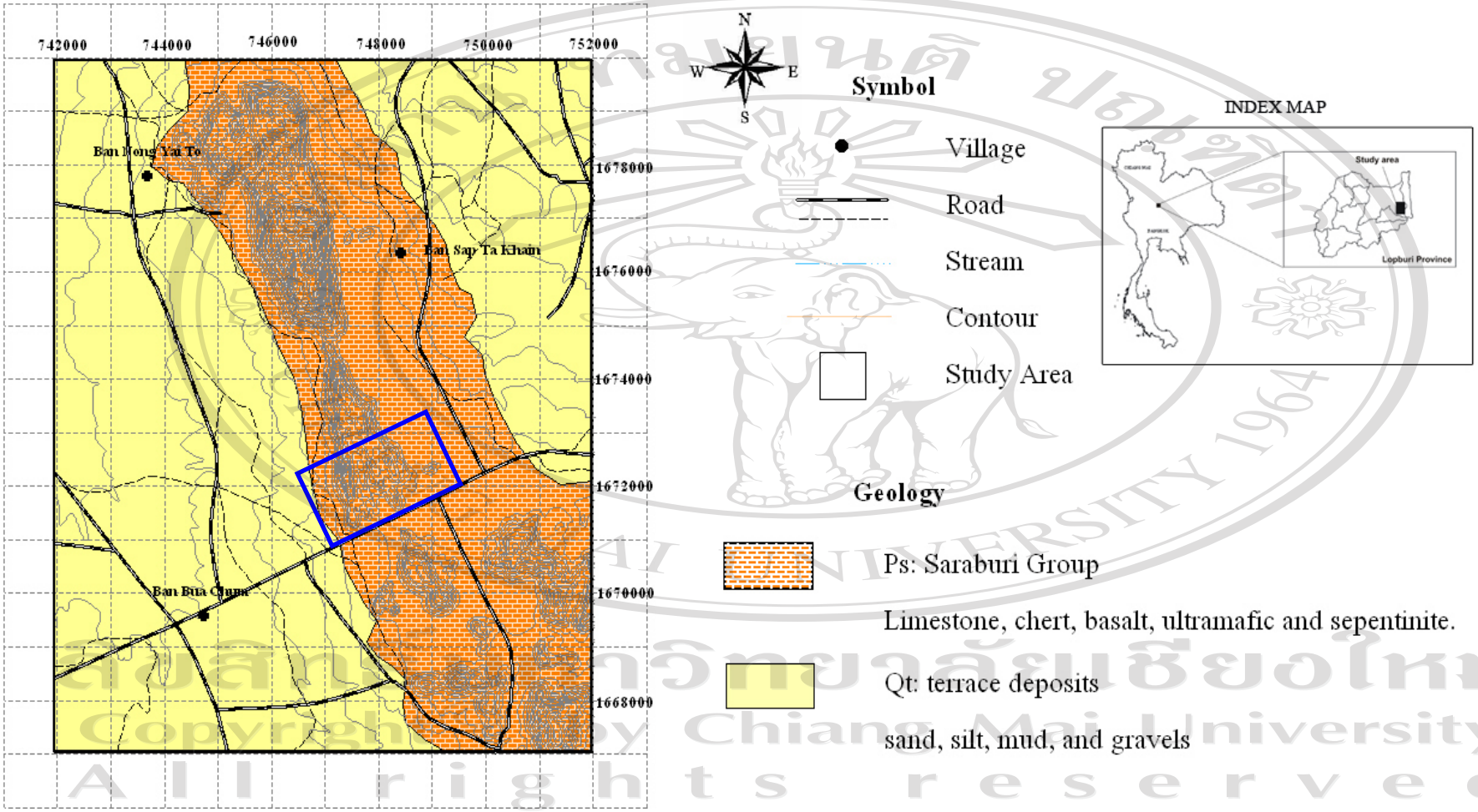


Figure 2.4 geologic map of study area.

Nakornsri (1977, 1981) proposed that the light gray dolomite interbedded with limestones found at Khao Somphot be part of the Tak Fa Formation. The fusulinaceans, corals, brachiopods, and bryozoans they contain indicate an Artinskian to Kungurian age. Further it was proposed that this formation could be correlated with the Saraburi Limestone and the Khao Khad Formation in the Saraburi area. Wielchowsky and Young (1985) measured a 1,260 meters thick sequence between 15° 06'N - 07.5' N; 101° 18'E - 19'E (Figure 1.1), ranging from Asselian through late Guadalupian, and devided into 2 sequences namely,

- Lower Carbonates sequence

Alternation of thin-thick to massive bedded limestone and dolomite which were laid down during Lower to Middle Permian Carbonate Platform.

- Upper Carbonates sequence

Thin-thick to massive bedded of fossiliferous limestone with light brown chert nodules are typical. Lithologies are ranging from mudstone to boundstone. Coral-Sponge Reefs are found along the sounthern margin of Khao Khwang Platform.

In Khao Somphot section, they recognized three sub environments of platform interior depositional area, observed medium-bedded carbonate mudstones overlain by skeletal packstones and grainstones. These facies were probably deposited in platform interior lagoon, platform interior mixed mud and sand complex, and platform interior sand shoal depositional environments. On the western part of the area, more severely formed strata are common. Folding and faulting are due to an orogeny during Permo-Triassic time and reactivation of Mae Ping Fault in Late Cretaceous (Wielchowsky and Young, 1985; Sattayarak *et al.*, 1997)

Quaternary

The unconsolidated surficial deposits occupy mainly the flat area, corresponding the weathering of parent rocks under the influence of fluvial processes. The deposits are generally only a few-meter thick and consists of a mixture clay, silt, sand and gravel in various proportions.