



## CHAPTER 2

### GENERAL GEOLOGY

The geology of the study area reported here is the results of the present field observation and the previous works, especially that described by Bunopas (1980). Geological map of the study area is illustrated in Figure 2.1 for the scale 1:250,000 and in the enclosure for the scale 1:50,000.

Rocks distributed in the area are sequences of sedimentary and their low grade metamorphic equivalent and igneous rocks ranging in ages from Silurian-Devonian to Triassic. The Silurian-Devonian sedimentary and low grade metamorphic rocks which include metatuff, marble, quartzite, phyllite, schist, and chert are distributed in the central part of the area. These rocks are overlain unconformably by sandstone and shale of the Carboniferous age. The Permian rocks, characterized by predominantly massive to thin bedded limestone are exposed in the SW of the area. The Mesozoic sequence is composed of Triassic tuffaceous sandstone, shale, and limestone and Jurassic red beds. It lies unconformably on the Paleozoic sequences. The Quaternary terraces and alluviums are developed in the Chao Phraya plain which covers about 70% of the study area.

Igneous rocks, plutonic, volcanic, and volcanoclastic, are widespread in the eastern part of the western mountains, central plain, and area along the eastern part of Changwat Nakhon Sawan. They occur as stocks, dykes, and lava flows. The intrusive

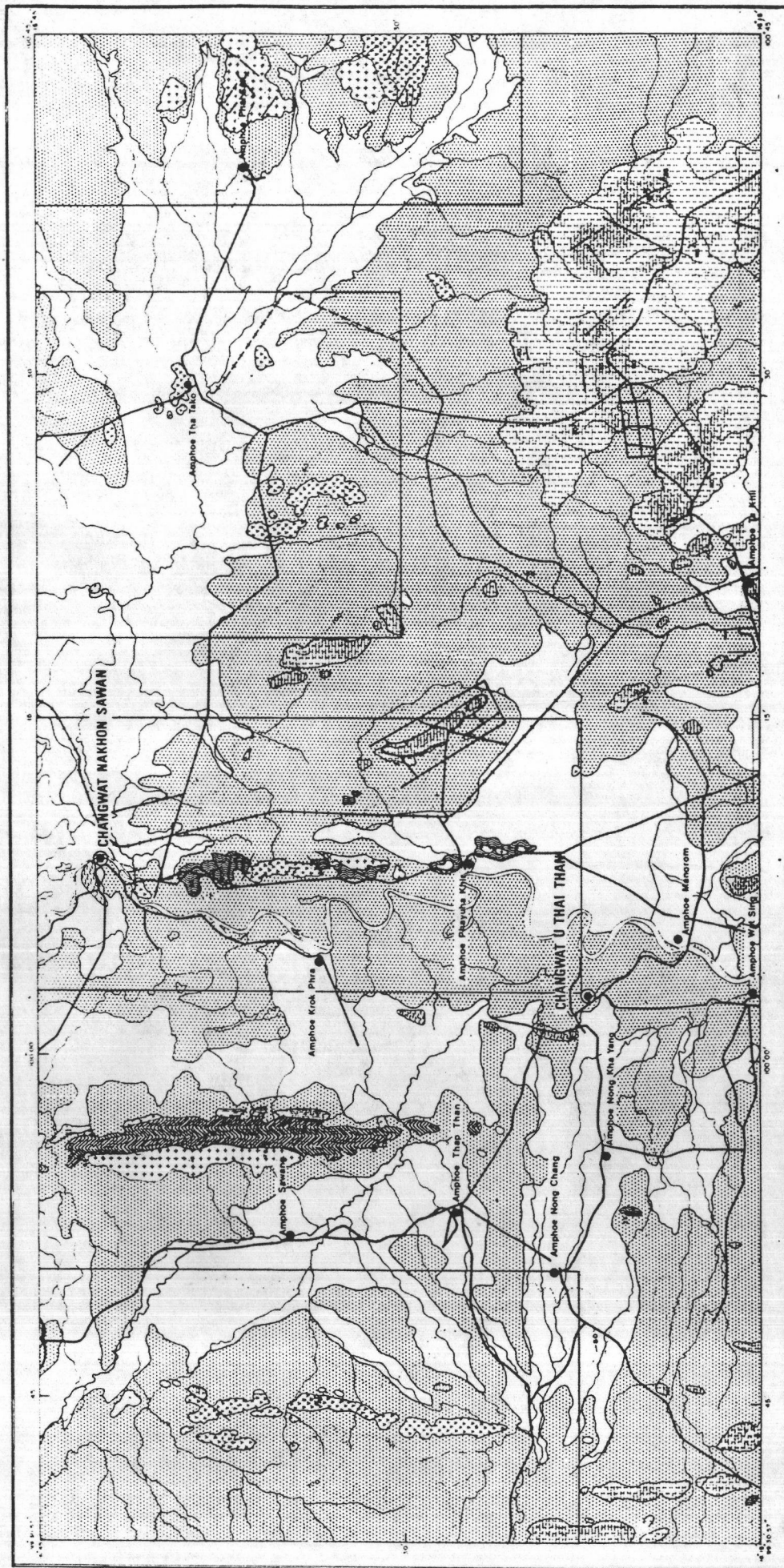




























Figure 2.1 Geological map of the study area covering Changwat Nakhon Sawan and Uthai Thani. This map is the results of this study as well as from the geological map of Changwat Nakhon Sawan compiled by Sangad Bunopas (1976) and geological map of Amphoe Ban Mi compiled by Nikhon Nakornsri (1976).

EXPLANATION

	Recent flood plain alluvials, sands, silts and back swamps		RECENT	} CENOZOIC
	Old alluvial fan, colluvial and old flood in deposits of high and low terraces consisting of gravels, sands, silts and laterite		PLEISTOCENE	
UNCONFORMITY				
	Mainly red sandstones, shales and minor conglomerates, volcanic conglomerate	KHAO CHONKAN FORMATION	? JURASSIC	} MESOZOIC
UNCONFORMITY				
	Beaded to massive, grey limestones with fusulinids, minor shale, chert and conglomerate	RATBURI GROUP	PERMIAN	} PALAEOZOIC
	Intercalations of red shale sandstone, quartz sandstone, intrastified conglomerates, and also reddish grey shale and sandstone	TAKLI SANDSTONE	? CARBONIFEROUS	
UNCONFORMITY				
	Mainly chert beds and thinly interbedded tuff and shale	KHAO GOB CHERTS	} DEVONIAN SILURIAN	
	Mainly grey to white, massive to poorly bedded marble	KHAO MANO MARBLES		
	Mainly quartz feldspathic tuff, green schist and graywacke	KHAO LUANG TUFF		
	Undifferentiated sequences of quartzite, phyllite, graywacke, chert beds and local conglomerate	BAN RAI FORMATION		
UNCONFORMITY				
	Quartzite, phyllite and quartz - biotite schist	HUAI WAI QUARTZITE	CAMBRIAN	
UNCONFORMITY				
	Metamorphic complexes of amphibolite facies, augen gneiss, granite gneiss, biotite - microcline gneiss, quartz feldspathic gneiss, biotite schist, banded quartzite, calc - silicate rocks and marbles	UTHAI THANI COMPLEXES	PRECAMBRIAN	} PROTEROZOIC
IGNEOUS ROCKS				
	Granite, granodiorite		} MESOZOIC	
	Rhyolite, andesite			

GEOLOGICAL SYMBOLS

	Contact		(Overturned)
	Strike and dip		(Inferred)
	Anticline		(Inferred)
	Syncline		(Inferred)
	Fault		(Inferred)
	Thrust Fault		
	Fossil Locality		
	Mine, Quarry or Alluvial Working		

rocks are granite, granodiorite, and diorite. The volcanic and volcanoclastic rocks are ranging in composition from andesite to dacite and rhyolite. Igneous rocks in this area are believed to have been occurred during the period in between post Permian and pre-Jurassic ages (Bunopas, 1980).

### 2.1 Silurian-Devonian Rocks

In the area studied rocks of the Silurian-Devonian ages, Tanao Sri Group, are further subdivided by Bunopas (1976,1980) into four rock formations. Order of the rock sequence from older to younger is as follows :

1. Ban Rai Formation
2. Khao Luang Tuff
3. Khao Mano Mables
4. Khao Gob Cherts

Generally, the rocks of the Silurian-Devonian ages are distributed only along the western and central parts of the area studied. Mountain ranges or isolated hills formed by these rocks are always aligned in the north-south direction. They were moderately to strongly folded. Subsequently they were partly emplaced and covered by post-Permian diorite-granite plutons and andesite-rhyolite lavas and tuffs, respectively.

The Ban Rai Formation is composed of quartzite, phyllite, graywacke, chert, and conglomerate. Its north-south distribution extends from Khao Khieo, Khao Phra, and Khao Mu Si, south of Changwat Nakhon Sawan to Khao Khok Mai Den south of Amphoe Phayuha Khiri. Few

small additional isolated hills of the Ban Rai Formation are found scatterly in this area.

Rocks of the Khao Luang tuff are almost entirely cropped out along the north-south Khao Luang range, west of the Khao Khieo-Khao Khok Mai Den. They are mainly thick monotonous sequence of massive and poorly bedded quartzofeldspathic tuff, green schist, and graywacke. They are flanked along the west by intrusive rocks and along the east by rocks of the Khao Mano Marbles and rhyolite.

The rock sequence of the Khao Luang Tuff is overlain conformably by rocks of the Khao Mano Marbles along the eastern flank of the Khao Luang range. Rocks of the Khao Mano Marbles are alternating thick fine-grained beds of white and light gray to gray marbles. Fossils found in these rocks are fragments of unidentified shells and corals.

Khao Gob Cherts are the least common rocks of the Silurian-Devonian ages distributed in the area studied. They consist mainly of thin bedded white, gray, black, and brown cherts. Occasionally, cherts are interbedded with quartzofeldspathic tuff, quartzite, slate, and phyllite. The Khao Gob Cherts extend from Amphoe Muang, Changwat Nakhon Sawan through Khao Phawaeng to Khao Sakae Krang of Changwat U-Thai Thani.

## 2.2 Carboniferous Rocks

The Carboniferous rocks, the Takli Sandstones, are composed almost totally of clastic sediments. There are sparsely distributed in the area studied and the vicinity. Few small exposures are located

in Amphoe Takli, Changwat Nakhon Sawan; eastern part of Changwat Chainat; and Amphoe Ban Rai, Changwat Uthai Thani. The Takli Sandstones consist of red and gray sandstone, shale, and conglomerate. The Carboniferous clastic rocks overly unconformably on the Silurian-Devonian rocks but underly conformably on the Permian limestone in the west of Huai Khakhang, Amphoe Ban Rai, Changwat Uthai Thani.

### 2.3 Permian Rocks

Permian rocks are dominantly well bedded limestones that contain fossils of fusulinids, brachiopods and corals. These rocks in the area have been grouped into the Ratburi Group (Bunopas, 1980). They are exposed in two areas at Amphoe Takli and Phrayuhakiri, Changwat Nakhon Sawan and at Amphoe Thap Than and Nong Chang, Changwat Uthai Thani.

The limestone of the Takli-Phrayuhakiri area occurs as isolated mountains trending NW-SE. This rock is well bedded and containing fossils of fusulinids, brachiopods, and corals. Andesite dykes cross-cutting through this limestone can be observed at Khao Bo Kaew, Amphoe Phrayuhakiri.

The limestone of Thap Than-Nong Chang area is poorly bedded and gray to dark gray in colour. Fossils are uncommon in the rocks of this area.

It is noted that limestones from both areas are not found to be in contact with either older or younger sedimentary rocks. However, they are found to be intruded by a small stock of granite and covers by few patches of rhyolitic rocks.



#### 2.4 Triassic Rocks

The Triassic rocks of the classical Huai Hin Lat Formation are not found to be present in the study area. However sedimentary and volcanic rocks distributed at Khao Kwang Thong, Khao Pha Lat, Khao Hin Thoen, and Khao Khot Yang on western part of Changwat Uthai Thani are believed to have been developed during the Triassic age. The sedimentary rocks consist of limestone, sandstone, shale, and tuffaceous sandstone. Limestone in this area contains fossils of algae, coral, and foraminifera. The algae has been identified to be solenopora of Triassic age (Ingavat, personal communication). The volcanic rocks are andesite and rhyolitic tuff. Andesite is overlain by rhyolitic tuff at Khao Khot Yang. Rhyolitic tuff is interlayered within the sedimentary sequence. The Triassic rocks overly unconformably on the Paleozoic rocks.

#### 2.5 Quaternary Sediments

The Quaternary sediments consist of poorly consolidated silts, sands, and gravels of Pleistocene terrace and Recent alluvium. The Pleistocene terrace is featured by high and low terrace. The high terrace is about 40-150 meters above mean sea level and the low terrace is about 15-40 meters above the mean sea level. The low terrace has been found to contains Hippopotamus skull, Bulabus horn, and Stegodon molor (Brown et al., 1951; Von Koenigswald, 1959). Recent alluvium deposits consist of loose soil, sand, silt, and clay. It is about 14-15 meters above the mean sea level. The Recent alluvium contains wild dog's bone or Cuon alpinus (Takai, 1961).

## 2.6 Igneous Rocks

Igneous rocks have been found to be present throughout the study area. They are plutonic (diorite, granodiorite, and granite), volcanic (andesite, dacite, and rhyolite), and volcanoclastic rocks. The plutonic rocks occur as stocks of various sizes. Some may intrude the older sedimentary rocks of Permian and Silurian-Devonian ages. The volcanic and volcanoclastic rocks occur as lava flows and ejectas. They overlie on Permian and pre-Permian rocks.

In general trending of the igneous rocks characterized by chains of small hills or mountains or outline of stocks in sedimentary rocks usually follows the general north-south direction of the area.

### 2.6.1 Diorite-granodiorite-granite

The plutonic rocks are distributed mainly along the central and eastern portions of the study area. Diorite is present only in small amount as compared with granodiorite and granite. It is mainly exposed in the central part, for instance at Khao Chedi, Khao Luk Chang, south of Changwat Nakhon Sawan and at Khao Phanom Rok, north of Amphoe Tha Tako. Granodiorite crops out as faulted contact with Silurian-Devonian rocks at the west flank of Khao Luang. It is also present at Khao Yong-Khao Rusi, Khao Kaew, and Khao Khok Mai Den of Amphoe Phrayuha Khiri. In the study area granite is almost entirely present at the east of Amphoe Phai Sali for instance at Khao Samo Bot, Khao Khwang-Khao Khok-Khao Krok Pradu, and Phu Khao Phra - Phuthabat.



It is apparent from the field evidences that the plutonic rocks become more silicic in composition toward the east and the volume of the plutonic rocks exposed increases rapidly from diorite, granodiorite to granite.

Diorite and granodiorite are frequently found to be penetrated by andesite dykes, e.g., at Khao Rusi, Khao Kaeo, Khao Yong, and Khao Khok Mai Den. These andesitic dyke rocks are similar mineralogically to the diorite and granodiorite. Furthermore, they are in close relation to the andesitic lava outpoured in that location. Therefore, it is believed that diorite and granodiorite were emplaced into this area at shallow depth.

#### 2.6.2 Andesite dacite-rhyolite

Andesite, like diorite in the plutonic suite, is present only small amount in the area studied. It is frequently found as dykes penetrated through plutonic and sedimentary rocks. Small volume of andesitic lava is found at Khao Khot Yang, a small hill at the south of western volcanic chain. Here, the andesitic lava is subsequently covered by rhyolitic tuff and tuffaceous sediments. At Khao Luk Chang and Khao Yong, about 10 kilometers south of Changwat Nakhon Sawan, andesite occurs as lava flow overlying the Silurian-Devonian metavolcanic rocks.

Dacite and rhyolite at Khao Khang Khao, Khao Wong, Khao Sa Wang Kaeo, Khao Laem, Khao Tabaeng, Khao Khwang, Khao Don Kha, and Khao Khok Phen, hills and mountains around Amphoe Tha Tako, are closely related genetically. They are transitionally changed from one rock

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type to another. Small amounts of these lava rocks presumably more rhyolitic in composition, are also found to be associated with the rhyolitic tuffs and tuffaceous sediments in the western volcanic chain. East of Amphoe Phai Sali, these granitic lava outpoured at Phu Khao Phra Phutthabat.

Volcanic ejectas are tuffs, lapillae, and agglomerates of rhyolitic composition. They are mainly cropped out at the western volcanic chain such as Khao Burapha Banphot, Khao Kwang Thong, Khao Pha Lat, Khao Hin Thoen, and Khao Khot Yang. The rocks here, are rhyolitic tuff and agglomerate interbedded with volcanic conglomerate, tuffaceous sandstone, graywacke, shale, and limestone. The limestone in this area contains fossils of algae, coral and foraminifera. The algae has been identified and dated to be Solenopora of Middle Triassic (Ingavat, personal communication). At Khao Pun, Khao Kwang, and Khao Don Kha, east of Amphoe Tha Tako, the rhyolitic tuff and agglomerate are also present and they are in close association with the lava of dacitic-rhyolitic and calc-silicate rock and chert of Permian age

It can be tentatively concluded, here, that as the composition of the volcanic rocks is getting more silicic, the volume increases and the volume ratio of ejecta to lava also increases. It is also pointed out from the field evidence that dacitic-rhyolitic lava, at least at Phu Khao Phra Phutthabat, are related to the granitic pluton. Therefore it is very possible that the granite, similar to diorite and granodiorite is also emplaced into this area at shallow depth.

The activities of emplacement and effusion of these igneous rocks were inevitably taken place at post-Permian. It is even possible from the present study to indicate that the activities took place between post-Permian and Middle Triassic based on the stratigraphic succession and the palaeontological evidence.