CHAPTER 2

GEOLOGICAL SETTING

The geological map scaled 1:250,000 of the Long District area was first compiled by Piyasin (1972). A further detailed geological map on 1:50,000 scale was published by Charoenpravat *et al.*, 1992). More detailed, 1:15,000 geological maps were made by the senior students of Department of Geological Sciences, Faculty of Science, Chiang Mai University (Chaiyasan *et al.*, 2003; Chumpukawin *et al.*, 2003; Nondedgoon *et al.*, 2003; Janejitpaiboon *et al.*, 2003; Yodthon *et al.*, 2003; Chantaragumthorn *et al.*, 2003; Mansawatapaiboon *et al.*, 2003; Wannagoon *et al.*, 2003; Chankaew *et al.*, 2003). Accordingly, the study area is largely underlain by sedimentary and volcanic rocks that can be separated into five major lithostratigraphic units from older to younger as follows: Permian sedimentary rocks, Triassic sedimentary rocks, Upper Triassic - Lower Jurassic volcanic rocks, Cenozoic volcanic rocks and Quaternary unconsolidated sediments (Fig. 1.2). In addition, the Permian to Triassic sedimentary strata were intruded by minor plutonic masses that are Upper Triassic in age. The details of all the lithostratigraphic units and the Upper Triassic plutonic rocks are separately summarized below.

2.1 PERMIAN SEDIMENTARY ROCKS

The Permian sedimentary rocks occur in the eastern part of the study area, and are generally known as Huai Thak formation (Bunopas, 1981). They unconformably underlie the Triassic sedimentary rocks and the Upper Triassic - Lower Jurassic volcanic rocks and are made up largely of gray to dark gray limestone, with minor dark gray shale, greenish gray sandstone, and red paraconglomerate interbeds. The

limestone is fine-grained and thinly bedded to massive, with black chert nodules and fossils (e.g. coral, crinoid, fusulinid, bryozoa and brachiopod). The shale beds show well-developed fissility, while the sandstone beds are fine- to coarse-grained, and moderately to well sorted. Either the shale beds or sandstone beds have partly undergone silicification. The age of these rocks is given as Permian due to the occurrence of fusulinid fossils.

2.2 TRIASSIC SEDIMENTARY ROCKS

The Triassic sedimentary rocks are the most widespread lithostratigraphic unit in the study area and unconformably underlie the Upper Triassic- Lower Jurassic volcanic rocks. Index fossils in these rocks constrain the age for this sedimentary unit. The Triassic sedimentary rocks can be separated into four subunits from older to younger as follows: (1) sandstone interbedded with shale; (2) limestone interbedded with shale (3) shale, siltstone, sandstone and conglomerate; and (4) shale interbedded with sandstone (Chaiyasan *et al.*, 2003; Chumpukawin *et al.*, 2003; Nondedgoon *et al.*, 2003; Janejitpaiboon *et al.*, 2003; Yodthon *et al.*, 2003; Chantaragumthorn *et al.*, 2003; Mansawatapaiboon *et al.*, 2003; Wannagoon *et al.*, 2003; Chankaew *et al.*, 2003).

The oldest unit (sandstone interbedded with shale) has a reddish purple color. The sandstone is very fine- to fine-grained and poorly sorted, whereas the shale is partly replaced by silica.

The limestone of the second subunit has a dark gray color and thin to thick beds, and is composed calcarenite, calcirudite, and calcilutite, which show graded bedding. It contains fossils of crinoid, coral and ammonite. The shale interbeds are dark gray to greenish gray, whereas the sandstone interbeds are light gray.

The third subunit (shale, siltstone, sandstone and conglomerate) can be subdivided into the upper, middle and lower parts. The upper part comprises dark

gray, micaceous shale, gray siltstone and greenish gray sandstone. The siltstone and sandstone interbeds are thinly to thickly bedded, and contains fossils of *costatoria* sp. The middle part consists of purplish, tuffaceous sandstone with shale intercalation in part. The tuffaceous sandstone is fine to medium-grained and massive. The lower part is composed of basal conglomerate of which clasts are shale, sandstone, tuff and limestone. The conglomerate locally has layers of dark gray, fissile shale intercalated with thinly to thickly bedded, gray sandstone that show coarsening upward.

The youngest subunit (shale interbedded with sandstone) is constituted almost totally by gray shale and calcareous shale, which have fossils of *claraia raliaris* and *daonella* sp., with thinly bedded sandstone interbeds. Conglomerate, consisting significantly of clasts of tuff and sandstone, is also present in this subunit in minor amount.

2.3 UPPER TRIASSIC – LOWER JURASSIC VOLCANIC ROCKS

The Upper Triassic – Lower Jurassic volcanic rocks largely occur in the eastern part of the study area and are unconformably underlain by the Triassic sedimentary rocks. These volcanic rocks are constituted largely by felsic to mafic volcaniclastic rocks with minor rhyolite, dacitie, andesite and basalt. The pyroclastic rocks are dominated by grading beds of agglomerate/volcanic breccia, lapilli tuff, coarse tuff and fine tuff. The volcanic rocks in the project area were previously inferred to have formed in the periods of Permo-Triassic and Late Triassic – Early Jurassic by many workers. The coherent geochemical patterns of the inferred Permo-Triassic and Upper Triassic – Lower Jurassic volcanic rocks presented in this study (see Chapter 3) however signify that they are essentially comagmatic. In addition, an inferred Permo-Triassic rock in the easternmost part of the project area cropped out at Highway Number 11 (Lampang – Denchai) yields a U-Pb zircon age of 229 ± 4 (Upper Triassic)(Khositanont, pers. comm., 2006). These lead to a deduction that all the studied volcanic rocks have formed in the Late Triassic – Early Jurassic.

2.4 CENOZOIC VOLCANIC ROCKS

The Cenozoic (?Tertiary) volcanic rocks occur as small masses in the southwestern part of the study area. These rocks are dark gray to black basalt and commonly show a porphyritic texture, with phenocrysts of olivine, plagioclase, clinopyroxene and/or magnetite. Vesicular textures, and/or columnar and platy joints have been observed from place to place. Chemically, they are trachybasalt of mildly alkalic magma series (Limtrakun *et al.*, 2005).

2.5 QUATERNARY UNCONSOLIDATED SEDIMENTS

The Quaternary unconsolidated sediments in this area are distributed along drainage patterns. These sediments form as terrace deposits and alluvial deposits. The terrace deposits include those as a high terrace and as a low terrace. The high terrace deposits are characterized by gravel, cobble and boulder that occur as a high-level terrace and along the drainage patterns. The epiclasts in high terrace deposits are quartz, shale, sandstone, limestone, pyroclastic rocks, rhyolite and andesite/basalt. The low terrace deposits are made up of clay, silt and sand that form a low-level terrace. The alluvial deposits comprise clay, silt, sand and gravel that form as fluvial deposits, recent flood plains and channel deposits.

2.6 UPPER TRIASSIC PLUTONIC ROCKS

The Upper Triassic plutonic rocks occur either as plutons or as dikes invaded the Permian and the Triassic sedimentary rocks. They consist of fine- to medium-grained, equigranular-textured granodiorite and seriate-textured diorite. The Upper Triassic age is confirmed by a U-Pb zircon age of 224 ± 4 that obtained from the granitic rock at Mae Khaem Village on Highway Number 11 (Lampang – Denchai) (Khositanont, pers. comm., 2006).