

CHAPTER I

INTRODUCTION



The carbonate rocks are fundamental to economic growth and environmental aspect. They are extremely valuable raw materials for wide ranges of industries, significant host of base-metal deposits, and petroleum reservoirs. From the scientific view point, unlike siliciclastic, the carbonate rocks are more specific and restricted under accumulating conditions. Therefore, they can be generally used as indicator for climate and environment determination. With such economic importance and their share of geological complexity, the carbonate rocks themselves are fascinated to study and classify in order to understand the complexity and their facies relationship.

Geologically, the greatest distribution of carbonate rocks throughout Thailand have been dated in Upper Paleozoic of which the Permian has been mainly recognized. In the former time, the succession had been monotonously considered as the Ratburi Limestone (Brown *et al.*, 1951) or later on as the Ratburi Group (Javanaphet, 1969). The group has been diversely designated under several names (Fig. 1.1) according to their geographic distribution and plate tectonic regimes. The two predominant groups namely, the Ratburi Group, and the Saraburi Group, have been established (Bunopas, 1981; Department of Mineral Resources, 1987; 1989; 1992). The Saraburi Group, widely exposed along the western rim of the Khorat Plateau from Saraburi to Loei regions, is the most significant terrane of the country. Almost all of the limestone raw material for the cement industry and the crushed rock for construction are mainly exploited for this area.

Despite of the economic importance of carbonate rocks from this area, the geological knowledge of the Saraburi Group particularly regarding the stratigraphy of this rock unit, remains controversial. Additional, the determination and correlation of relative age of different successions in different areas have been poorly established in details.

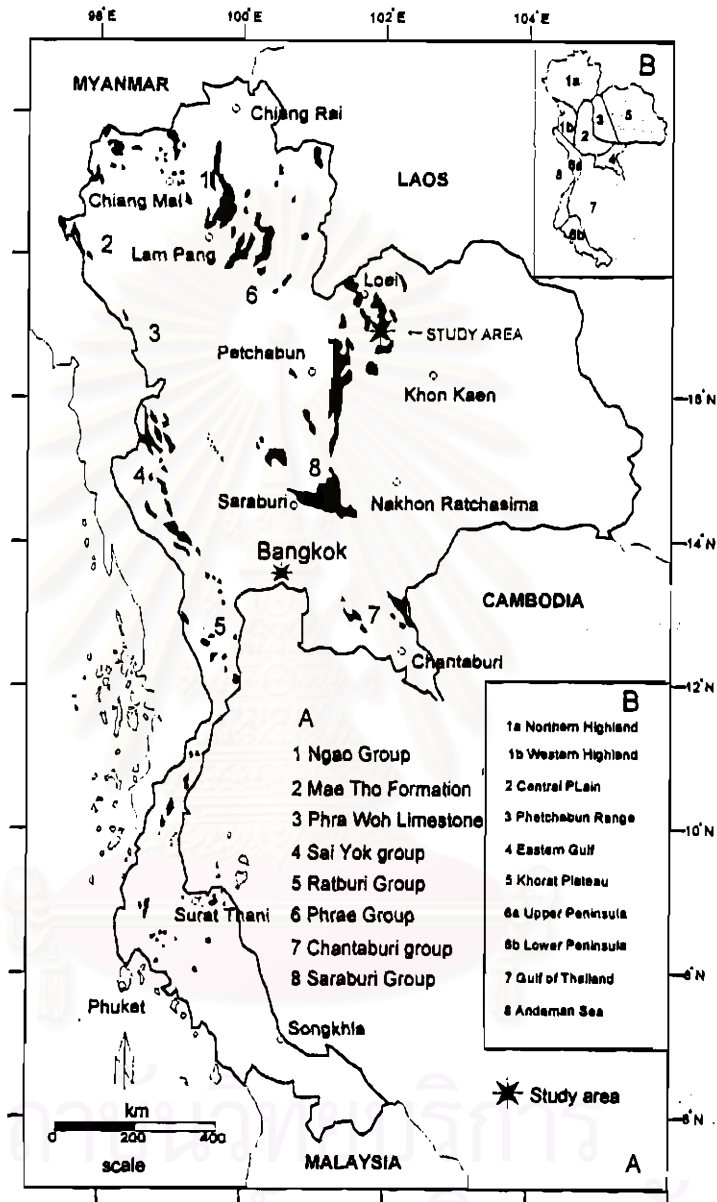


Fig. 1.1 Index map of Thailand showing distribution of Permian rocks (A) and the physiographic regions (B) (modified after Geological Map of Thailand on 1:2,500,000 scale, Department of Mineral Resources, 1987; 1992)

The study area

The 120-square kilometre study area is located in the northwestern part of northeastern Thailand between latitudes $17^{\circ} 02' N.$ to $17^{\circ} 08' N.$, and between longitudes $101^{\circ} 52' E.$ to $101^{\circ} 59' E.$ The area embraces part of Amphoe Wang Saphung, Amphoe Phu Kradung, and Amphoe Pha Khao, Changwat Loei. The reference topographic map on the 1: 250, 000 scale of series 150 S is the sheet NE 47-12 (Changwat Loei), Edition 2-RTSD (Fig. 1.2), and the topographic map 1: 50, 000 scale of series L 7017 is the sheet 5343 II (Ban Nong Hin), Edition 1-RTSD (Fig.1.3).

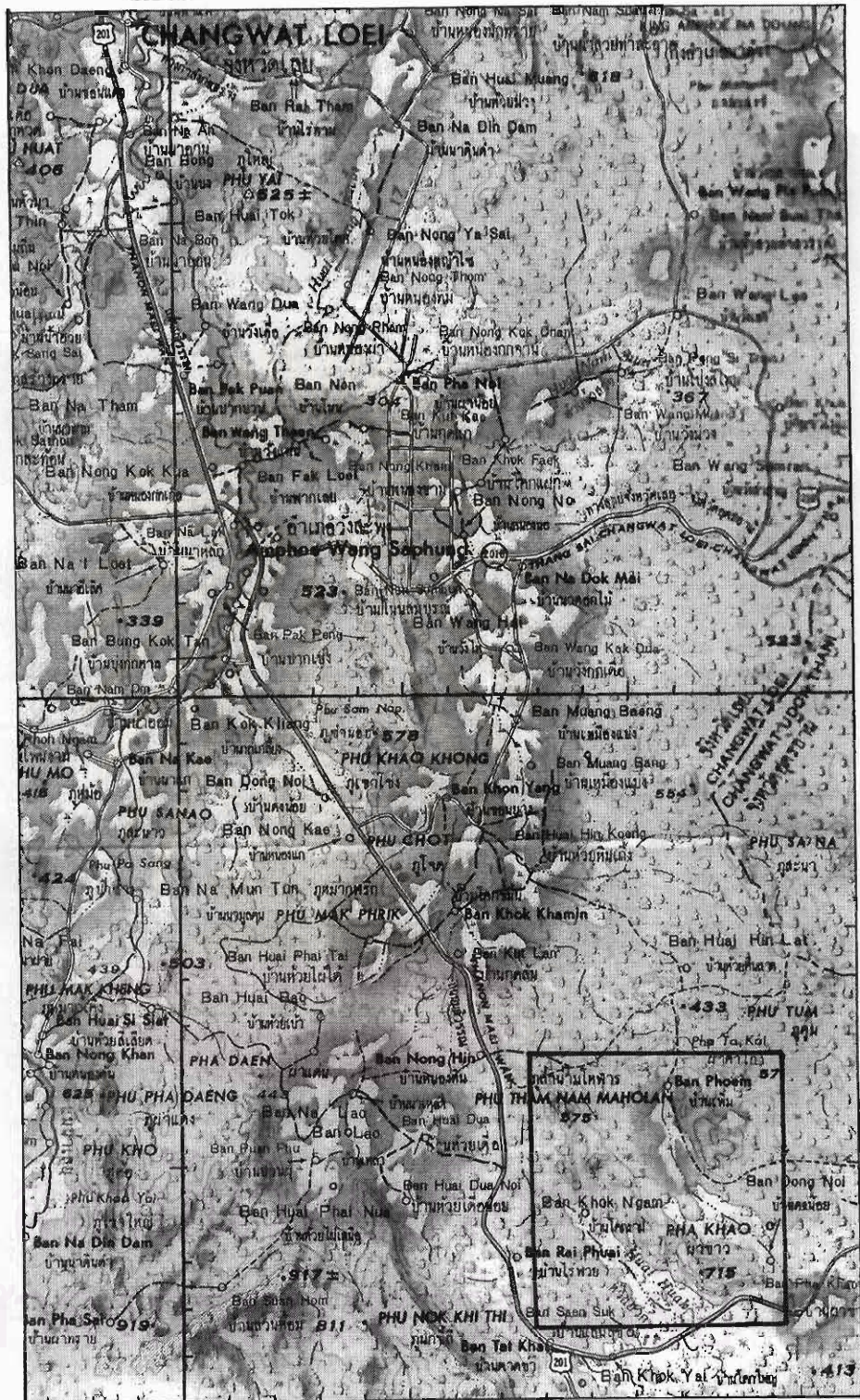
Accessibility to the study area can be undertaken via many convenient routes (Fig. 1.4). The national highway no. 201 (Wang Saphung-Phu Kradung) lies approximately in the north-south direction approximately 2 kilometres to the west of the study area. The paved provincial highways, Ban Nong Hin-Ban Poem, and Ban Tat Kha-Ban Pha Khao lie approximately in the east-west direction to the north and south of the area respectively. Besides, there are network of several local dirt tracks in the area.

The topography of the area is characterized by both mountainous, and undulating as well as flat plain. The mountainous area consists of the high and rugged limestone mountain chain, Phu Tham Maholan, Phu Tham Nam, and Phu Pha Khao, of approximately 13-kilometre long, 2-kilometre wide, elongated in the northwest-southeast direction with the peak of 715 metres MSL; and oval-shaped limestone mountains, Phu Pha Ya, Pha Ta Kai, to the northeast of the mountain chain with peak of 571 metres MSL. The mountainous area is surrounded by slightly undulating and flat plain with the elevation ranging from 290 to 320 metres MSL. The undulating and flat plain is gently sloping toward the southeast direction.

101°45'

102°00'

17°30'



17°15'

17°00'

Fig. 1.2 Topographic map of the study area and its vicinity.

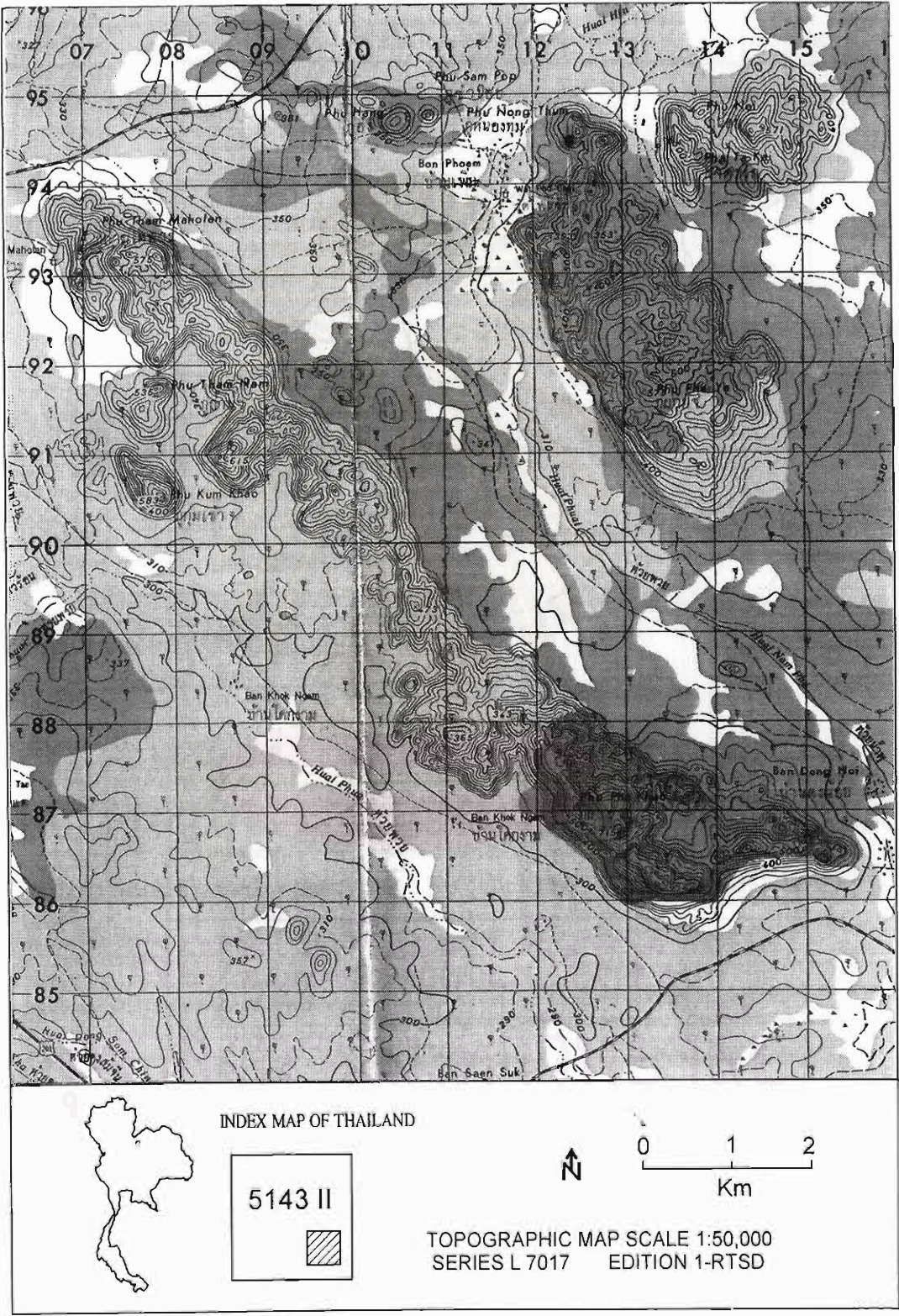


Fig. 1.3 Topographic map of the study area.

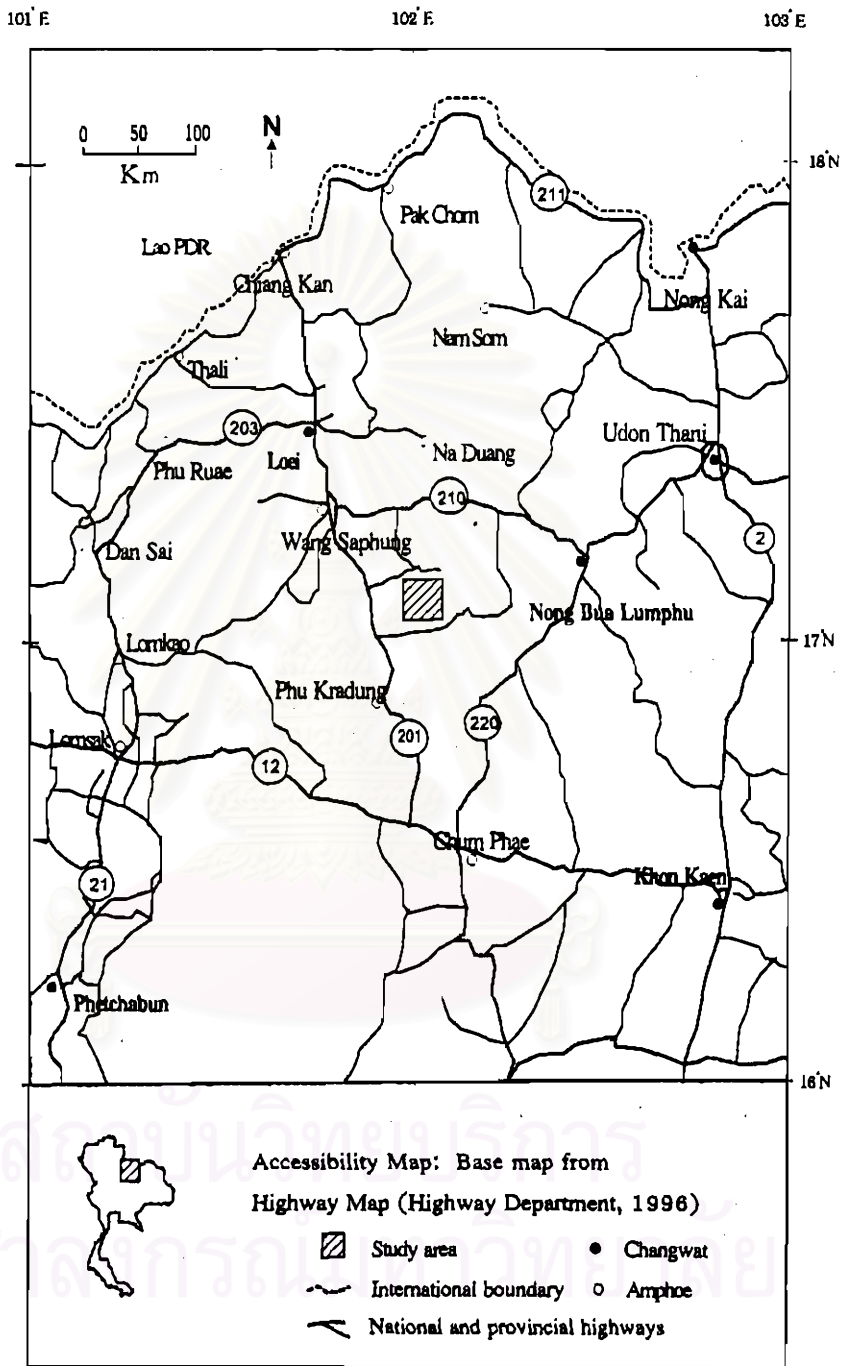


Fig. 1.4 Location of the study area and its vicinity illustrating the network of the national and provincial highways.

The climatic regime of the area is tropical savanna and notorious for cold spell during the cold season. The average annual rainfall is approximately 1, 200 mm. occurring almost exclusively during the rainy season from June to October under the influence of the southwest monsoon and depressions. Dry period extends from November to May with the cold dry during November to February under the influence of northeast monsoon. The temperature may occasionally dips down to 0 °C especially in the mountainous area during cold season. The hot season extends from March to May of which the temperature may exceed 40 °C with thunder storm. The mean annual temperature is about 26 °C.

Plants and vegetation of the mountainous area is characterized by deciduous forests and bamboo. The deforestation by slash-and-burn practice is most extensive in the undulating area. Most of low lands and flat plains have been intensively cultivated for the plantation of sugar cane, sweet tamarind, and corn. In addition, logan has been recently introduced into the area.

Objective

The primary objective of the present investigation is to establish the stratotype of carbonate succession representing the Nam Maholan Formation in the southeastern part of Changwat Loei. Additional attempts have been made to conduct the lithofacies analysis and the reconstruction of depositional environment of this carbonate succession.

Methodology and scope of work

Generally, the study methodology under the present investigation can be categorized into three main aspects, namely, the office work, the field work, and the laboratory work.

The office work includes the literature review on previous investigations of the area, and those regarding the theoretical framework and methodology. Additional photogeological work of the area has been carried out to serve as a basis for further field investigation programs. The study area covers approximately 120 square kilometre. Among these, the geological mapping has been undertaken covering approximately 100 square kilometre, and measuring of rock sections in the mountainous area of Phu Tham Maholan, Phu Tham Nam, and Phu Pha Khao covering approximately 20 square kilometre.

The field investigation program has been carried out into two steps, notably, the reconnaissance field investigation and detailed field investigation. The detailed field investigation have been carried out totally 45 days for the geological mapping, the measuring of 17 sections of totally 1000 metres including the sampling of 120 representative rock samples from the measured rock sections.

For laboratory works, emphases have been given to petrography and geochemistry. Totally, 120 thin-sections have been prepared and examined microscopically. Besides, 41 samples have been analyzed by the X-ray diffractometry technique for mineral identification and the determination of calcite/dolomite ratio. The quantitative analyses of standard majors oxides of 41 samples have been undertaken using the Atomic Absorbtion Spectrophotometry. Additional attempt has been made to determine the stable isotope of oxygen and carbon of totally 59 samples in order to assist in the reconstruction of depositional environment.

The study methodology employed in the present study can be summarized in Fig. 1.5

Previous investigations

Prior to the present study, numerous investigations have been carried out in the area and its vicinities regarding regional geology, carbonate facies and paleontology.

Regional and local geological surveys have been undertaken by Brown *et al.* (1955), Bleakly *et al.* (1965), Jacobson *et al.* (1969), Workman (1975), and Bunopas (1981). Besides, a number of geological reports and geological maps in the 1:50,000 scale have been published by many investigators from the Geological Survey Division, Department of Mineral Resources (Chairangsee *et al.*, 1978; 1990; Chairangsee and Macharoensap, 1985; Sillapalit *et al.*, 1984; and the Mineral Resources Development Project, 1988).

Charoenprawat and Wongwanich (1976) and Charoenprawat *et al.* (1976) designated the Nam Maholan Formation for the Lower Permian carbonate succession of predominantly thick to massive limestone with minor shale and sandstone intercalation exposed in the vicinity of east and south of Changwat Loei. However, this formation was called the Pha Nok Khao Formation (Chonlakmani *et al.*, 1979) for its extension into Changwat Nong Bua Lumphu which have been illustrated in the geological map of Thailand on the 1: 250,000 scale of sheet NE 48-9 (Changwat Udon Thani and Vang-Vieng). The sequence probably extends beneath the present Khorat plateau as advocated by integrated geophysics and well interpretation as reported by Kozar *et al.* (1992), and Mouret (1994). Altermann *et al.* (1983), and Altermann (1987) described the lithology and tectonic implications covering part of the Permian rocks in Changwat Loei. Detailed lithostratigraphy of 1,100 metres thick of the sequence north of Phu Tham Maholan, at the Pha Doen area was further subdivided into 3 members (Homrareun, 1995). The lower unit, the Pha Doen Member, is 580 metre-thick and consists of light gray massive limestone and dolomite overlain by thickly bedded light to dark gray limestone of the 500 metre-thick the Pha Dam Member. The upper unit, 20 metre-thick the Huai Pha Khao

Member comprises of red to purplish red, fine- to coarse-grained clastic rocks and limestone conglomerates.

Regarding the regional facies variation based on physical and faunal characteristics, Wielchosky and Young (1985) recognized the Pha Nok Khao unit as a distinctive platform of mixed carbonate-silicilastic succession with the lithofacies were most likely controlled by both eustatic sea level variations and regional tectonic events. The seventeen carbonate facies and five carbonate depositional environments were characterized on the basis of basin versus platform where reef carbonates generally occurred. Chinoroje and Bhasavanija (1988) studied the Permian carbonate at Pha Ngam area, Amphoe Wang Saphung, and revealed that the Pha Ngam Reef was formed along the edge of Pha Nok Khao platform representing the transition zone between deep environment to the west and shallow sea to the east. Several carbonate facies and the depositional environments were presented outer platform and platform interior. Kozar *et al.* (1992) described the tectonic evolution of the Permian carbonate of the Khorat basin by integrating the geophysics with the biostratigraphic data and concluded that the carbonate depositional sequences ranging from Late Carboniferous to Middle Permian (Wolfamian to Early Guadalupian). The Late Carboniferous rifting were believed to be responsible for generating a north-south trending sea-way. During the Permian, stable platform provided favorable location for accumulated shallow water carbonate. Mouret (1994) reported that this carbonate platform facies is present between the lower and the upper clastic formations of Late Carboniferous to Permian sequence.

With respect to the fauna fossils, many authors have been identified the taxonomy and geological ages of mainly brachiopods, and foraminifers (Pitakpaiwan, 1965; Pitakpaiwan *et al.*, 1969; Igo, 1972; Sakagami and Iwai, 1974; Yanagida, 1964, 1970, 1988; Toriyama, 1982; Ingavat, 1984; Fontaine and Sutheethorn, 1992, etc.). Although some fusulinacean, coral, brachiopod indicated the stratigraphic range from Asselian to Midian age (Ingavat and Helmcke, 1993; Dawson *et al.*, 1993), but the more recent palaeontological works indicated the range from Late

Carboniferous to late Middle Permian (Fontaine *et al.*, 1994; Charoentitirat, 1995). It is noted that the fossil record of Upper Permian to Lower Triassic is completely absent from the stratigraphic sequence.

The Nam Maholan Formation in the study area revealed the age range from Asselian to Artinskian age as indicated by fossil brachiopods (Yanagida, 1967). Besides, Igo (1972, 1974) pointed that the fusulinaceans were belong to the *Triticites ozawai*-*Paraschwagerina Yanagidai* zone of Lower Permian. In addition, the Lower Permian limestone sequence was confirmed by the presence of fusulinaceans and conodonts (Ingavat, 1994). However, the Upper Carboniferous foraminifer *Schagonella* sp. was identified by Ueno *et al.* (1995).

The studies on taxonomy and age determination of fauna fossils in the carbonate rocks of the Nam Maholan Formation in the vicinity of Changwat Loei excluding the study area are numerous. Ingavat (1964) identified foraminifers from Ban Poem and concluded that they are of Sakmariian-Artinskian age (Lower Permian). Ueno and Igo (1993) reported the two fusulinacean species from Ban Na Din Dum indicating a Gzhelian (latest Carboniferous). Fontaine *et al.* (1981) described Moscovian fauna in limestone-shale sequence at Ban Na Duang. Fontaine *et al.* (1994) identified corals in Loei-Wang Saphung area indicating mainly Early Permian. Charoentitirat (1995) described morphology and evolution of fusulinacean assemblages in limestones exposed in eastern part of Changwat Loei indicating Late Carboniferous to Middle Permian under six depositional of shallow marine.