

CHAPTER I

INTRODUCTION

General Statement

The northeastern part of Thailand consists of two tectonic subbasins - Khorat and Sakon Nakhon basins (Fig. 1.1). The rocks of Khorat Group which can be recognized by several sequences of clastic rocks are revealed at the marginal area of the Khorat Plateau (or Basin). The rock unit interested, as shown in the surface geological map such as the scale 1:250,000 by Chonglakmani and others (1979) is only located in the upper part of the Sakon Nakhon subbasin, eastern part of Changwat Nong Khai. The rock formation was introduced the term "Phu Thok formation" which was an informal formation and first reported by Chonglakmani and others (1979) and as "Phu Tok formation" by Sattayarak (1983). However, in term "Phu Thok formation" or "Phu Thok type section" (herein referred by the author in the next chapter) should be limited as only the red sandstone or the other rocks at Khao Phu Thok and Khao Phu Wua in the study area. "The Phu Thok formation" (in this thesis) has not extended to cover the rock sequences of "Phu Thok formation or Phu Tok formation" which mentioned in the other works.

The Phu Thok formation (in term of the author's works) is only exposed quite well at three mountains, namely Phu Sink (or Phu Thok), Phu Wua, and Phu Langka. It consists of two sandstone types, one with very large-scale cross-beds and the other with small wavy structures. The sandstone was described as a red-coloured, fine-grained, well-sorted, and rather friable. The gross characteristics of this formation resembled an eolian-dune deposits (Sattayarak, 1983, Imsamut and others, 1994).

At the reference section in Phu Thok (in this study area), these terrestrial sandstone strata are often characterized by a sparse fossil record (Imsamut and others, 1994) and are not conformed with any known - age rock unit. The mountainous area of Phu Thok formation is first mapped by Ministry of Geology of the USSR at a scale of 1:2,000,000 in year 1969-1973. They recorded the Jurassic sandstone in mountainous areas and Lower Cretaceous soft rocks in the undulated areas near the

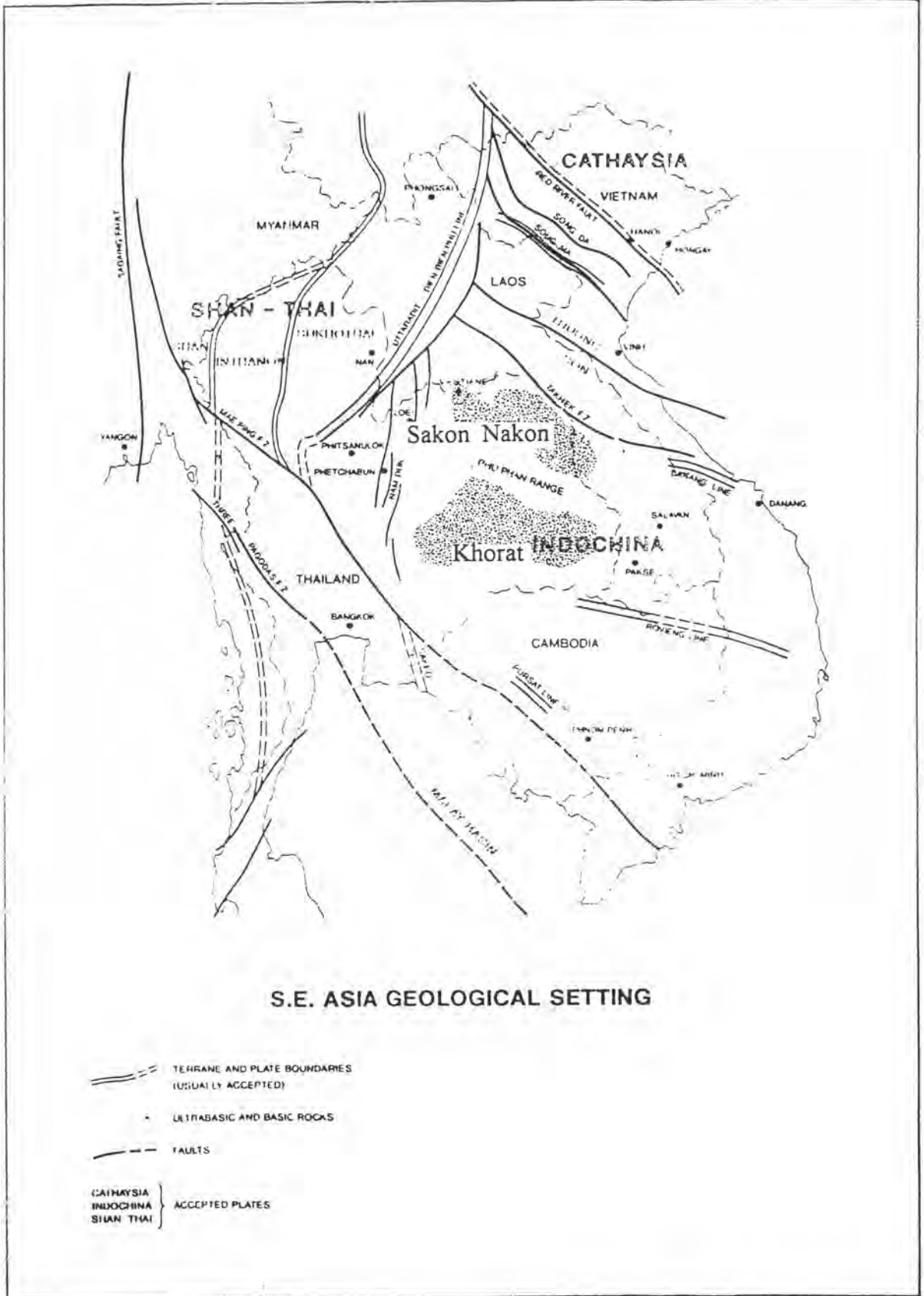


Figure 1.1 Index map of Thailand showing two tectonic subbasins, Khorat and Sakon Nakhon basins, at the northeastern part of Thailand (after Mouret, 1994).

mountains. Javanaphet (1969) compiled the geologic map of Thailand at a scale of 1:1,000,000. These sandstone rocks are believed to have similar age to that of the Phu Phan range. Jurassic which was assigned for the Phu Phan-Phra Wihan Formation is inferred for these three mountains of the Sakon Nakhon Basin. However, during communist invasion, semi-detailed geological studies of Chonglakmani and others (1979) and Sattayarak (1983) assigned the age of Phu Thok formation at the study area as Tertiary Period or possibly down to Late Cretaceous (Sattayarak and Polachan, 1990). However, with more detailed studies the Phu Thok formation at the area become older (Pattarametha and others, 1988, Imsamut and others, op. cit.). In the past decade, the Phu Thok formation (informal name- as suggested by Sattayarak, 1983) was suggested to be unconformably overlying the Maha Sarakam Formation. In 1990, Sattayarak and Polachan, however, reported the lithostratigraphic data based on potash and groundwater drilling holes, that the Maha Sarakam Formation in the central part of both subbasins is unconformably covered by the brick red-colored claystone, siltstone and sandstone sequences (or Upper Claystone-informal name) which are assumed equivalent to the red sandstone Phu Thok formation in the reference section (this study area).

However, the stratigraphic relationship between the Phu Thok formation in the study area (i.e., the well-exposed type section) and the central part of Sakon Nakhon subbasin (underground section) is currently unclear. Moreover, structural features and lithology of Phu Thok in the area suggest the similarity between the Phu Thok Formation and the rocks in the upper part of the Khorat Group, such as Khok Kruat Formation which is older than the Maha Sarakam Formation. Therefore, it is inferred that the Phu Thok sandstone may be older than the Maha Sarakam sequence. Because the evidences of geological mapping is very confusing, the reliable chronology of this rock unit, therefore, is needed to be answered by a special scientific dating method. The iron-oxide minerals are usually found as the accessory minerals of the red-colored Phu Thok clastic rocks and adequately effected the magnetic significant of the rocks (Pattarametha and others, 1988). Therefore, the presence of Fe-oxide minerals can be applied to determine the age of the red-colored clastic sedimentary rocks by the paleomagnetic method. The application is called magnetostratigraphy, a branch of stratigraphic study which is based upon the magnetic signatures, particularly the remanent magnetization. It depends on the irregular changing of normal and reverse polarities of the earth. Therefore, the alternation of normal and reverse magnetic polarities of Phu Thok rock sequences or the magnetostratigraphy in

the area can be visualized and compared them with the similar alternation of normal and reverse polarities of the magnetostratigraphy of the standard lithostratigraphy of the known (or inferred) ages.

The successful results of dating by this special method are the paleomagnetic dating of the Quaternary sequence in central part of China (Xinghua, 1985) and the Axhandle lacustrine basin in USA (Talling and others, 1994). In Thailand, Maranate (1982) and Pattarametha and others (1988) suggested the age of the rock formations in the Khorat group based upon the preliminary magnetostratigraphy. In addition, the results of preliminary paleomagnetic works in this study area which were purposed by Pattarametha and others (1988), and Bunopas and others (1989) suggested the good effected the magnetic significant of the rocks and less presence the secondary magnetization in the red-bed in the area. Therefore, if the very detailed magnetostratigraphy in this study can be made, it may give the way of interpretation of Phu Thok formation age in the study area.

Location and Accessibility

The investigated area is located in Khao Phu Thok Noi, King Amphoe Sri Wilai, and Khao Phu Wua, King Amphoe Bung Kha, Changwat Nong Khai (Fig. 1.2). It is bounded by longitude 103°45' to 104°00'E and latitude 18° 05' to 18° 20'N. The area is in the 1:250,000 topographic map sheet NE 48-6, series L 7017, Muang Pak Sun and topographic map, scale of 1:50,000, sheets Ban Khok Kong (5745 I) and Ban Nam Chan (5745 II). The area is approximately 24 km east- west by about 22 km north-south, covering an areal approximately 528 km². The two measuring sections were made for stratigraphic correlation - one located in the western side of Khao Phu Thok, at longitude 103°53'E and latitude 18°07'N and the other section, located in the eastern part of Khao Phu Wua Lang Tham Pai, at longitude 103°58'E and latitude 18°14'N .

Geographically, the area consists mainly of low - relief undulated terrain (approximately 190 m above m.s.l.) in the central part of the area and two high relief mountainous areas (200-452 m above m.s.l.) in western and eastern sides of the concerned area. Khao Phu Sink range, the western side, forms the narrow, mesa with steep escarpment trending NW-SE. The other, Khao Phu Wua range on the

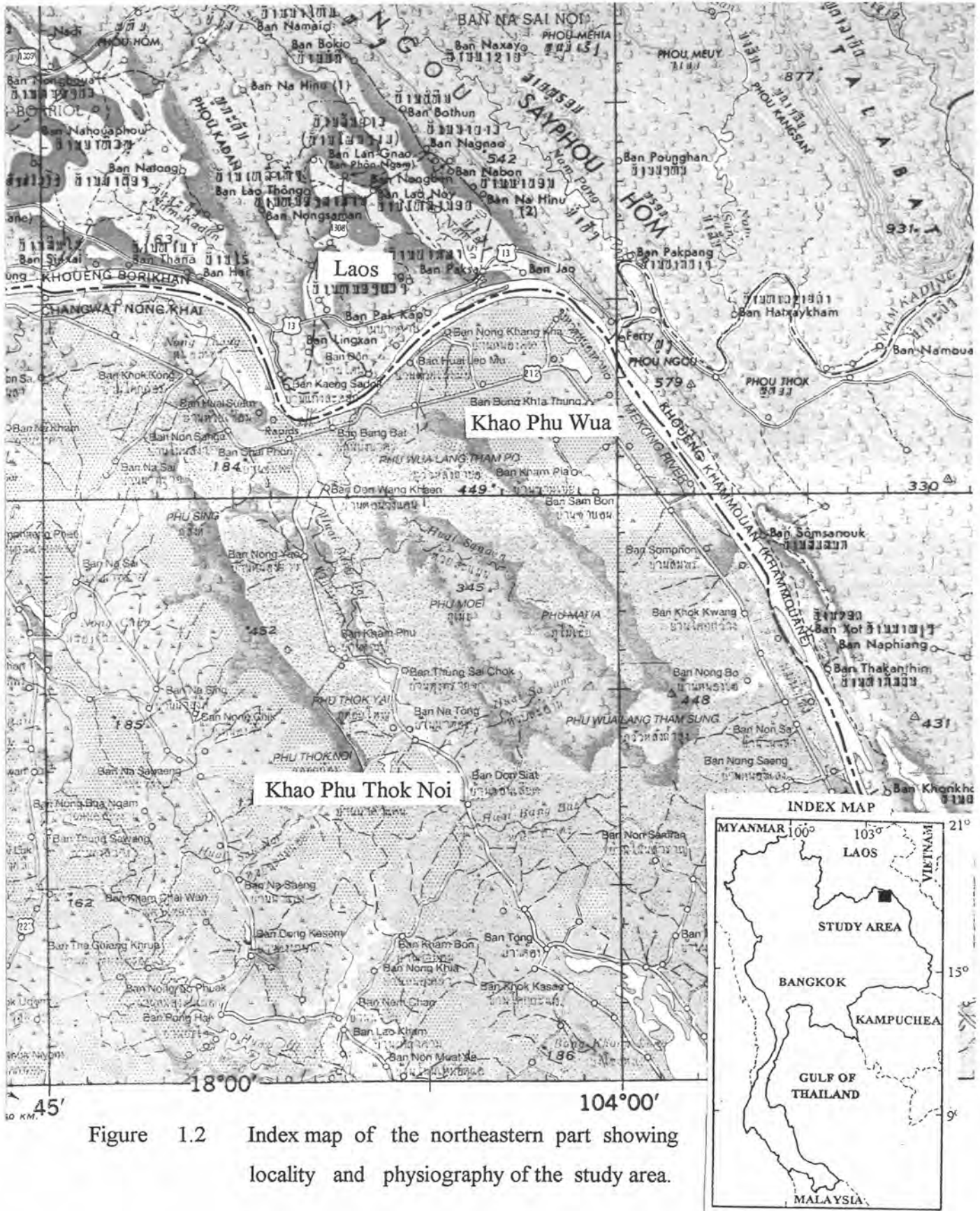


Figure 1.2 Index map of the northeastern part showing locality and physiography of the study area.

eastern side is similar in both form and trending direction. It shows a steep escarpment on northern and eastern sides of this cuesta (see Fig. 1.2). Mae Nam Khong is the main river in the north of map area. Huai Bang Bad, southeastward-flowing, is the main drainage system in the central part of the area. The consequent tributaries flow more perpendicular to the general strike of the rocks and join the Huai Bang Bad or discharge directly into Mae Nam Khong.

The study area is only accessible by the roads. It can be reached by Highway 2, from Bangkok to Changwat Nong Khai (approx. 615 km), and from Changwat Nong Khai to Amphoe Bung Kan by the asphaltic Highway 212 (135 km). From Amphoe Bung Kan intersection, Highway 222 (Amphoe Bung Kan to King Amphoe Sri Wilai ; about 22 km) and Highway 212 (Amphoe Bung Kan to King Amphoe Bung Kha ;45 km) lead to the study area. These highways are either asphaltic or loose-surface road.

Previous Paleomagnetic Studies

A Paleomagnetic study of the Indochina Mesozoic rocks was first done in 1975 by Tarling who reported results from 9 samples of Khorat red-beds of Jurassic Period. The data indicated a Jurassic relative paleopole position close to the present day geographic pole and a clockwise rotation of the declination of magnetization of 33° . Later paleomagnetic study of Barr and others (1978) was concentrated on Jurassic red beds and some Triassic rocks of this region. The study received the similar results for paleopoles of the Khorat Plateau localities. Bunopas and others (1978), using an independently collected sample and measured in a different laboratory, concluded that the Mesozoic continental red-beds of the Khorat Group could be the most reliable rocks. Later on, Bunopas (1981) reported the paleomagnetic measurements of 104 samples all over Thailand including 33 Khorat Group rocks from within and nearby Khorat Plateau. The Khorat samples are recognized from Nam Phong to Phu Phan Formations as a long space collection. He suggested international and regional correlations based on geomagnetic reversal stratigraphy, and concluded that a clockwise rotation of declination originally inferred by Tarling (1975) was mostly completed by Early Cretaceous.

Achache and Courtillot (1985) reported a preliminary paleomagnetic study of the Upper Triassic sedimentary rocks from northeast Thailand using 39 orientated

samples from five sites in Huai Hin Lat Formation. The paleontological data also provided a reliable age. They suggested that the clockwise rotation of magnetic declination of Huai Hin Lat Formation is 44° . Maranate and Vella (1986) reported the results from Maranate (1982) which based on 179 samples from six widely separated sections in Khorat Plateau, representing all formations of the Khorat Group. All samples were drilled from the oriented block samples and were demagnetized by thermal demagnetizer at about 100° - 600°C . They also suggested, based on the magnetostratigraphy, that the age of the Khorat Group ranges from Late Triassic to Middle Cretaceous Period. They reported the clockwise rotation of the paleomagnetic direction is about $37^\circ \pm 7^\circ$, and occurred at some time in the last 100 Ma. They also noted an unconformity suggested by the magnetostratigraphy between Sao Khua and Phu Phan Formations.

Pattarametha and others (1988) first studied a preliminary magnetostratigraphy of Phu Thok formation at Khao Phu Thok Noi and Khao Phu Wua, Changwat Nong Khai. They believed that their magnetostratigraphy from 80 samples may be comparable to the Late Jurassic to Early Cretaceous sequence in the Standard Geomagnetic Polarity Time Scale of Cox and others (1982). Chen Yen and Courtillot (1989) studied the remagnetization of Paleozoic and Mesozoic rocks of Indochina block in Thailand. They gave similar paleomagnetic data of the Khorat Group and suggested that the most of the Indochina block may have suffered a complete remagnetization after Triassic and possibly after Cretaceous or the early Cenozoic. Yang and Besse (1993) referred to Yang (1992) studied the paleomagnetism of Permian and Mesozoic rocks of northeastern Thailand from the former works and the new data of 49 sites near the Phu Pha Chik, Changwat Chaiyaphum. They concluded that the magnetic minerals in the variable rocks are hematite and sometimes both of magnetite and hematite, and suggested the sufficient cleaned demagnetization temperature is more than 300°C . The result indicated the clockwise rotation of about 15° for the Indochina block relative with South China block at a constant tropical latitude during the middle upper Mesozoic. They believed that the convergence between India and Eurasia effected to the separate of Khorat and Sichuan basins by the strike-slip Red River fault. Van der Voo (1993) summarized the paleomagnetic study of Indochina blocks and concluded that the remagnetization of the rocks took place during pre-Tertiary and the rotation of the block is older than late Neogene. His study was latest reviewed and discussed by Imsamut and others (1994). The result is, however, similar to that of Pattarametha and others (1988).

Purpose and Scope of the Study

The main purpose of this study is to create the magnetostratigraphy of the Phu Thok formation from the rock sequences in the area. The two magnetostratigraphic columns are created from two sites; Khao Phu Thok Noi and Khao Phu Wua. The composite magnetostratigraphy from both sections is recognized. The investigation of the chronology of rocks of the Phu Thok area, NE Thailand using paleomagnetic data of this study, along with the basic data for tectonic movement of the area, are also performed. The other objectives include to determine the paleogeography of the depositional area of the rocks in the area and to improve the geological information especially on the Phu Thok formation such as lithostratigraphy. The age of rocks in the area may be changed in order to conform with this paleomagnetic result. Paleoenvironment and sedimentary facies of the Phu Thok formation are beyond the scope of this research.