CHAPTER IX

CONCLUSION

The Phu Thok formation at Khao Phu Thok and Phu Wua, Changwat Nong Khai has thickness of sandstone sequence at about 205 m. The altitude of both sections ranges from 220 (bottom) to 452 m (top). The formation consists of interbedded reddish brown clastic sequences of thickly - bedded (commonly 5m or up to 20 m), fine- to medium- grained arkosic sandstone and purplish brownish red, calcareous, very fine-grained sandstone to siltstone in the upper sequence and dominantly very fined-grained sandstone in the lower sequence. The fine- to medium-grained arkosic sandstone invariably depicts large-scale, multi-directional cross-bedding and the very fine - grained sandstone posses wavy structures. Interbeds of red clastics are separated, based on lithostratigraphic features, into three members as B, C and D at the Phu Thok section and four members as A, B, C and D at the Phu Wua section. The correlation of both sections using marker beds as shale and medium- to coarse - grained sandstone give rise to the composite Phu Thok section (illustrated in chapter IV). Major structural trend in the area lies approximately in the NW-SE direction. Dipping of both sides of Phu Thok syncline range (Phu Thok section) is about 5° to 10° whereas that of Phu Wua syncline range (Phu Wua section), is about 11° to 15°. These synclinal structures of both mountainous areas plunge SE with low angles. The major set of NW-SE faulting is normally conformable with orientation of the mountainous range.

Core samples of observable continuous Phu Thok (72 samples) and Phu Wua (68 samples) sections were systematically collected from undisturbed or non-metamorphosed oriented red bed strata. Approximately spacing interval of core sampling is about 2 m. The core sample is generally 2.5 cm in diameter and 8-15 cm in length. The error of core sample direction is not more than 2-3 degree. For the laboratory investigation, 3 individual specimens (2.5 cm in diameter and 2.2 cm in

length) from 4-7 total specimens are performed from each sample site. Natural remanent magnetization (NRM) was measured with a Schonstedt DSM-2 spinner magnetometer and all specimens are demagnetized using stepwise incremental heating technique in TSD-1 temperature-controlled oven at temperature ranging from 100° or 250° to 680° or 730°C with an increase of 50°C for the next step (see Appendix D). The paleomagnetic work was performed at the paleomagnetic laboratory of Chengdu Institute, Sichuan, China.

From the petrographic evidences and the demagnetization behaviour, Detrital Remanent Magnetization (DRM) is regarded as primary magnetism in Phu Thok rocks at the study area whereas Partial Thermal Remanent Magnetization (PTRM) is of the secondary type. Features of magnetic components in the rocks are characterized by thermally distributed components. Detrital magnetite and hematite are the primary magnetic carriers whereas the secondary magnetism is carried by goethite and protohematite. The steep drop in intensity near zero for demagnetized temperature at about 680° to 730°C is regarded as the mainly primary magnetism is carried by hematite.

The Phu Thok rocks at Khao Phu Thok and Phu Wua, both have low magnetic susceptibility, generally lower than 120 x 10^{-6}. The very fine-grained sandstone has susceptibility ranging from 38 to 141 x 10^{-6} whereas those the fine-to medium-grained arkosic rocks range from 18 to 106 x 10^{-6} (see Appendix G). The intensity of all rocks are normally lower than 2 mA/m. The very fine-grained sandstone certainly gives lower intensity (0.32 to 27.00 and average 1.00 mA/m) than the coarser-grained arkosic rocks (0.49 to 55.00 and average 1.50 mA/m). Average Q-value of rocks is 0.6 for the very fine-grained sandstone and 0.85 for fine-to medium-grained sandstone. It is assumed that the stable or good recorder of the ancient geomagnetic field is recognized in the arkosic rocks.

Demagnetization behaviour of 140 progressive demagnetized specimens based on Kirsch software of Enkin (1990), indicates that the primary magnetization or

component C is generally composed of 40 to 95% NRM. Intensity plot shows that the primary magnetism is characterized by the constant intensity of remanence magnetism at demagnetized temperature below 450° to 680° C and steeply drop in intensity near zero at curie point. Magnetic direction of the primary magnetism is generally NW. The secondary magnetization, usually overprinting the primary magnetism, is composed of 5 to 60% NRM. It is separated into 3 components, the first is the very low temperature component or component A, the second is the low temperature component or component B_1 , and the third is the medium temperature or component B_2. Magnetic direction of the secondary magnetism is E-W or N-S. These components are completely demagnetized at temperature from 100° to 450° or up to 600° C, as indicated by zijderveld plot . Appropriated selected temperature of almost samples is between 350° and 500° C and sometimes, up to 650° C. The 50 to 70% (0.6 to 1.0 mA/m) NRM are only believed to require the ancient geologic magnetism.

192 specimens of Phu Thok section show the dominantly NW-trending magnetic direction with positive inclination. Results of declination and inclination of the 132 specimen of Phu Wua section are similar to the Phu Thok results. The magnetostratigraphy of the Phu Thok section composed largely of three long and one stripe normal zones with three short reverse zones in the middle part. The magnetostratigraphy of the Phu Wua section consists of six normal and six reverse zones. The upper-middle part of the magnetostratigraphic section can be well correlated with the Phu Thok magnetostratigraphy. The correlation of both sections (see Fig. 7.1) which results in the composite magnetostratigraphy of Phu Thok Formation, mainly comprises of normal (70%), with seven normal and seven reverse polarities bands. The key polarity bands for correlation of both magnetostratigraphy include the long normal and some reverse bands in the middle part with the support of lithologic marker beds.

The magnetostratigraphy is subdivided on the basis of polarity into four polarity zones as PT-A Reverse (R1, N1 and R2), PT-B Normal (N2, N3 and R3), PT-C Normal (N4, N5, R4 and R5) and PT-D mixed Polarity Zones (R6, N6, R7 and N7).

The characteristics of the composite magnetostratigraphy shows the long reverse (at least 40 m thick) at the lower part which is alternated by normal band. The upper part of the magnetostratigraphic sequence reveals the long normal (30-50 m thick) intercalated with the short brief reversal band (2-3 m thick). The higher frequency of normal/reverse alternation is found in middle and upper part.

Magnetostratigraphy of the Phu Thok formation is possibly correlated with Standard Geomagnetic Polarity Time Scale of IUGS (1987) and Geological Society of America (1988) at time of late Early Cretaceous (108-118 Ma by IUGS and 117-126 Ma by Geol. Soc. of America) and Early Cretaceous (117-123 Ma by IUGS and 125-133 Ma by Geol. Soc. of America) (see chapter 7). However, from the basis of magnetostratigraphic character such as frequency of alternation of polarity and tectonic history of the Khorat Group, the Early Cretaceous (117-123 Ma by IUGS, 1987) is better fit to the age of the Phu Thok sequence at the study area. It is determined that the sedimentation rate of Phu Thok is about 33 m/Ma. It is recognized based on the magnetostratigraphic correlation that the very fine-grained sandstone in the lower part may have higher sedimentation rate (about 50-60 m/Ma.).

Magnetostratigraphic characters of the composite section with tectonic evidence in that time indicate that the Phu Thok Formation in the study area were deposited and lithified before the regional uplift of western edge of Khorat took place. The activities of tectonic movement in late Early to Early Cretaceous created the folding and faulting in the area and rare of sedimentary deposit. The evidence should be conformed with the alternating of normal and reverse polarities in Aptian-Berremian. The Maha Sarakam Formation was deposited during Middle Cretaceous with low energy during the unchanged polarity of the earth. In addition, tectonic evidence and direction of secondary magnetization suggested that the highest uplift of Khao Phu Thok and Phu Wua should have been occurred during Tertiary (Miocene?) and remagnetization of the Phu Thok rocks were therefore recorded.

The mean VGP of the Phu Thok Formation is 61.9° N, 189.9° E with K=1006.0, A_{95} =1.8 and is similar the overall VGP of the average Khorat Group, Jurassic to Cretaceous VGP of Shan-Thai and Jurassic VGP of South China, implying the less movement of Indochina until Phu Thok was deposited and the amalgamation of three plates occurred during Jurassic. Northeast declination of primary magnetism in the rocks possibly advocates the rotation of Indochina taking place after the cessation of Phu Thok deposit. Phu Thok rocks in the area was deposited in the middle part of the Indochina block at latitude of 17.8 °+_ 1.2° after the separation of Indochina and South China blocks. The clockwise rotation of at least 20° may have occurred during Late Cretaceous to Early Neogene.