Proceedings of the International Symposium on: Stratigraphic Correlation of Southeast Asia
15-20 November 1994, Bangkok, Thailand

MAGNETOSTRATIGRAPHY OF PHU THOK MESOZOIC DEPOSIT, NE THAILAND : A PRELIMINARY INVESTIGATION

S. IMSAMUT[1], S. BUNOPAS[2], V. DAORERK[1], M. PATTARAMETHA[2] S. MARANATE[2], V. THOTOSAWAM[2] and P. CHARUSIRI[1]
[1] Department of Geology, Faculty of Science, Chulalongkorn University, Bangkok 10330 Thailand
[2] Department of Mineral Resources, Bangkok 10400 Thailand

Abstract

The result of the new paleomagnetic study, together with that of the previous information, on the red bed in Khao Phu Thok Noi, Changwat Nong Khai reveals that the probable age of this rock unit is Middle to Late Mesozoic Era. The red bed consists predominantly of cross-strata, yellowish red, medium- to coarse-grained sandstone, interbedded with reddish yellow, massive, very fine-grained sandstone. Field and remote-sensing data indicate a broad syncline whose regional strike is in NW-SE direction.

Detailed petrographic and XRD examinations indicate the preservation of Detrital Remanent Magnetization by the presence of hematite fragments. The paleomagnetic measurements of the new 5 sandstone samples and the previous 44 samples of the Phu Thok Formation, confirm the alternation of at least 6 normal and 7 reverse polarities. This can be related to the Late Jurassic to Early Cretaceous Period of the Geomagnetic Polarity time scale. Several sedimentological criteria including various scale, multi-direction, cross-bedding, lithological characteristics of rock unit, sphericity and roundness parameters, as well as scarcity of fossils, support the aeolian environment of deposition with minor interfingering fluvial facies system. Our preliminary study indicate that the Phu Thok rock unit can be magnetostratigraphically correlated with those of the Phu Phan Formation usensu strictoû.

INTRODUCTION

Paleomagnetic and geochronological evidences in Thailand accumulated during the past 20 years have led to a detailed understanding of the geotectonic evolution of Thailand and mainland SE Asia. The result of the paleomagnetic data reveals two major categories. The first is the position of paleo-latitude and -longitude of paleopoles. Furthermore, the paleolatitude of the rock formation can be recognised. The second involves the magnetostratigraphy, a branch of stratigraphic study based upon magnetic signatures, particularly remanent magnetisation. It consists of the alternation of normal and reverse polarities of the area concerned and compared them with the standard lithostratigraphy of the known ages. The aim of this study is to preliminarily investigate the chronology of rocks of unknown age of the Phu Thok area, NE Thailand using paleomagnetism, and to visualise a magnetostratigraphy of the area which reveals the probable age of this rock unit, and is the basis data for tectonic movement of the area.

PREVIOUS STUDY

Paleomagnetic studies in Thailand were started in 1975 by Tarling (1975) who reported results from 9 samples of Khorat red-beds of Jurassic Period. Barr *et al.* (1976) presented some result from the Cenozoic basalts from Northern Thailand. Paleomagnetic studies of Barr *et al.* (1978) were concentrated to Jurassic red beds and some Triassic rocks. Bunopas *et al.* (1978) concluded that the Mesozoic continental red-beds of the Khorat Group could be paleomagnetically the most reliable rocks. Later on, Bunopas (1981) reported paleomagnetic measurements from 33 Khorat Group sites with in and near Khorat Plateau. Achache and Courtillot (1985) reported a preliminary paleomagnetic study of the Upper Triassic sedimentary rocks from Northeast Thailand by the 39 orientated sample from 5 site in Huai Hin Lat Formation. Maranate and Vella (1986) reported the result from Maranate (1982) based on samples from 179 sites of rocks from six widely separated sections in Khorat Plateau. Pattarametha *et al.* (1988) studied a

preliminary magnetostratigraphy of Phu Thok Formation at Khao Phu Thok Noi, which are interested paper. Recently, Yang *et al.* (1993) studied the paleomagnetic of Permian and Mesozoic rocks of Northern Thailand.

GEOLOGIC SETTING

The investigated area is located in Khao Phu Thok Noi, King Amphoe Sri Wilai, Changwat Nong Khai (Figure 1). It is bounded by longitude 103° 52' 49" E to 103° 53' 24" E and latitude 18° 07' 26" N to 18° 07' 59" N. The rock formation or the so-called "Phu Thok Formation" (Sattayarak, 1983) in the area is believed to be a youngest part of the Khorat Plateau and is located in Indochina massif. It is divided into 3 members based on fossil-barren lithostratigraphic cycle. Detailed stratigraphy the area can be found in Imsamut (1994) and will not be specified herein. The summary of the stratigraphy is depicted in Figure 2. The Lower member consists of thick bedded, yellowish red, fine- to medium-grained, lithic arkosic sandstone (>3m thick), which have cross-beddings, intercalated with minor whitish purplish red, very fine-grained, calcareous sandstone (1 m thick). Some parts of this member shows desiccation-crack and ripple structures at surface. The Middle member comprises interbeds of whitish yellowish red, medium-to coarse-grained arkosic sandstone (>2m thick), which have large- scale cross-bedding (Figure 3.), and intercalated with very gently-dipping, whitish purplish red, very fine-grained, calcareous sandstone, 2-4 m thick (Figure 4). The Upper member consists of whitish yellowish red, fine- to medium-grained arkosic sandstone which have large scale cross-beddings (>5m thick). The total thickness of this section is about 139 m. Field and remote-sensing data reveal a broad syncline whose regional strike is in the NW-SE direction N-S direction for most parts of the sequence. However, a deviation in strike to N-S direction was found in the upper part of the sequence. The dipping of this formation is in general less than 15° and present as undisturbed beds.

METHODOLOGY

This study commences with an interpretation of the area using remote-sensing images. The regional geology are checked by field works (in June, 1995) and detailed stratigraphy are recorded. Samples are collected at site from bottom to top of this formation by a hand-drilling machine. The cores are oriented with a Brunton magnetic compass. At present, about 60 samples of the clastic rocks mostly sandstone rocks are studied. Samples are collected for each 1 m spacing from bottom to top. No deformation and weathering effects are recognised in the rocks. . For the laboratory investigation, 3 individual specimens (2.5 cm in diameter and 2.5 cm in length) are performed from each sample. Natural remanent magnetisation (NRM) are measured with a DSM-2 spinner magnetometer. Some specimens were selected for demagnetisation using stepwise incremental heating technique in TSD-1 temperature-controlled oven at the temperatures ranging from 100 C to 600 C with an increase of 50 C step. The propose of this thermal analysis is to acquire the most appropriate temperature for demagnetisation. In order to perform such analysis, intensity and zijderveld component plots and equal area projections are used to assess the directional stability of the individual specimens. The cleaned specimens are measured in the measurement again. The final data of each specimen are corrected declination (D), corrected inclination (I) and magnetic intensity. Inclination and declination data of at least 3 specimens of each sample are then calculated. The results involving paleo-latitude, paleo-longtitude of paleopoles and paleolatitude of the rock sequences and accepted parameters (such as A95 or cone of confidence) of each sample are recorded. Polarity of poles are contributed by stereo plots which indicate both normal and reverse polarities. In microscopic study, characteristics of the fossil magnetism are considered. Both polished and thin-sections reveal the presence of iron-oxide minerals. For extracted powder samples obtained by magnetic method, SEM observations (Figure 5) and X-ray diffraction (Figure 6) were used to further confirm the result from the above method.

RESULT

CHARACTERISTIC OF FOSSIL MAGNETISM

Microscopically, hematite occurs in matrix of lithic arkosic sandstone. It forms irregular to slender shapes in thin sections and shows bright light purplish grey in polished sections. XRD method of the powdered samples shows small peaks

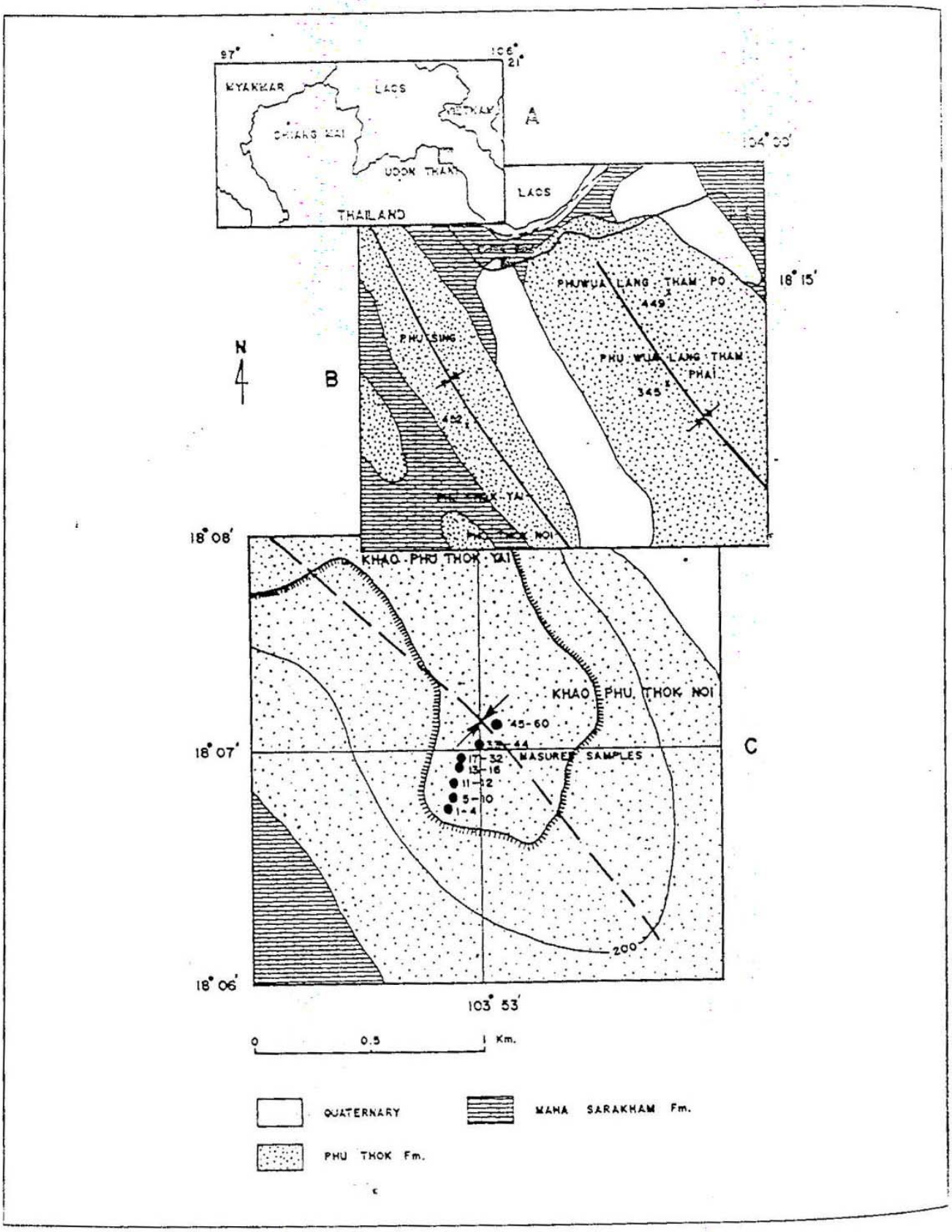


Figure 1 A. Route map of NE Thailand showing the Phu Thok Noi area
B. Regional Geology of the Phu Thok Noi area (at scale of 1:250,000) from remote sensing and field interpretation showing the boundary of Phu Thok Formation and Maha Sarakham Formation and a broad NE-trending syncline
C. Detailed map of the Phu Thok Noi area showing the samples location for this study.

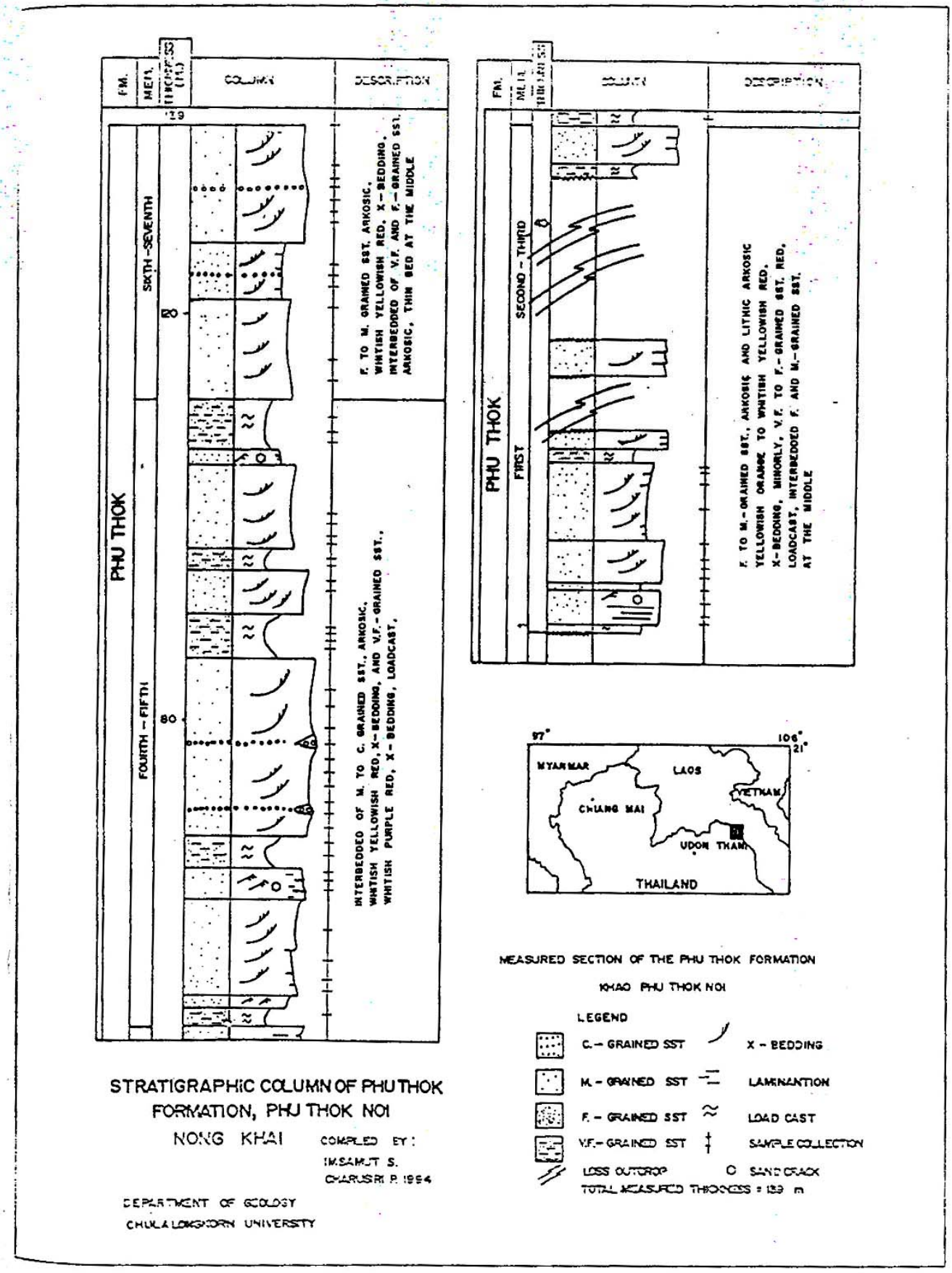


Figure 2 A summary of stratigraphy of the Phu Thok area, NE Thailand.

Figure 3 Natural exposure of reddish to yellowish brown, arkosic sandstones showing variously-scaled cross-bedding (looking northeast).

Figure 4 Natural exposure of whitish purplish red, very fine-grained calcareous sandstone (looking north).

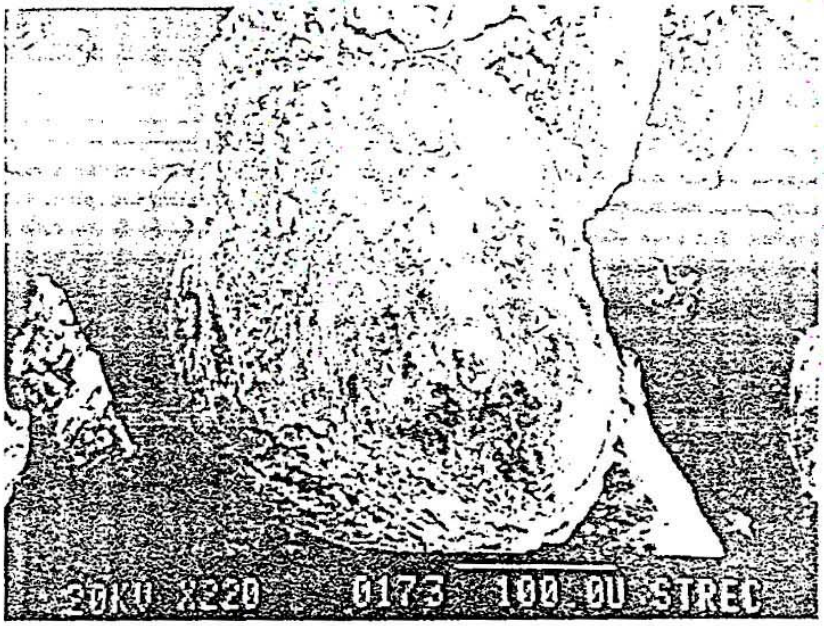
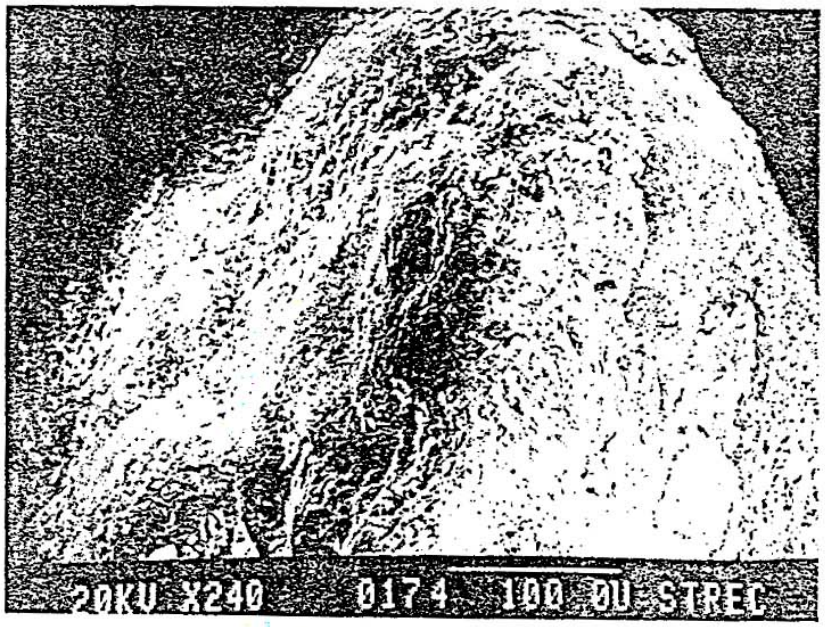


Figure 5 SEM images of subrounded phenoclasts of arkosic sandstone showing small (40 m) pits, suggestive of an eolian effect.
A) x220 single-grain.



B) x240 close-up view.

of hematite (Fe_2O_3 see Figure 6) and titanomagnetite ?($FeTiO_4$) and large peaks of quartz and feld spar. Semi-quantitative analysis of some specimen indicate Fe_2O_3 (total) up to approximately 3-5 %. Alternating Field Demagnetisation was, however, proved not to be as applicable as Thermal Demagnetisation (Pattarametha *et al.*, 1988). These evidence reveal that the detrital remanent magnetisation can be recognised in the rocks.

PALEOMAGNETIC RESULT

Paleomagnetic data including 3 specimens of sample Nos. 31004D, 31014D and 310025D, with 15 remeasured specimens of samples Nos. 31004, 31005, 31014, 31018 and 31025A,B,C show a significant paleomagnetic result. However, the interpretation also needs to consider the previous data samples of Pattarametha *et al.*, 1988 for the

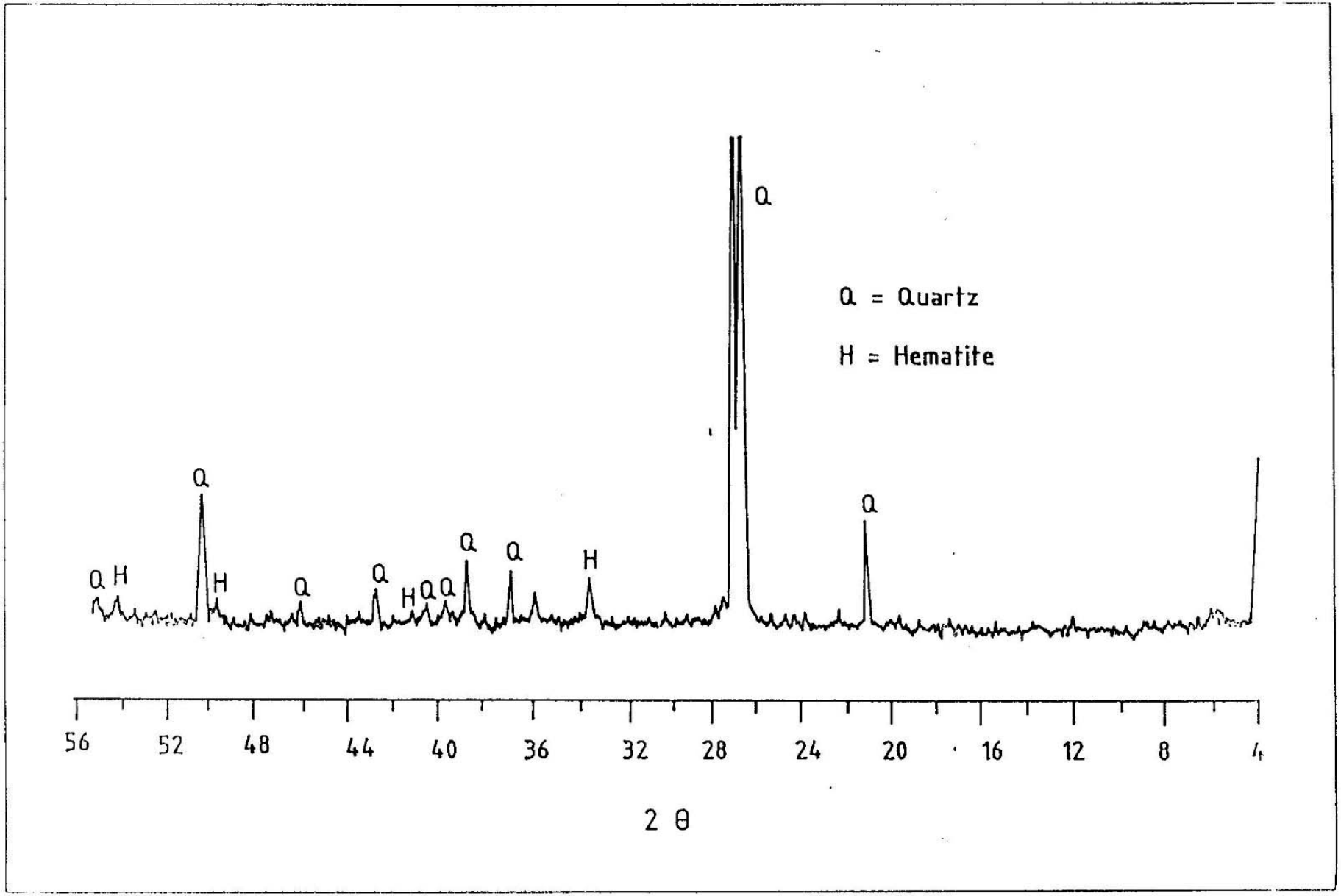


Figure 6 X-ray diffraction of the selected powder Phu Thok Noi Area, showing the small peaks of hematite (H) and large peaks of quartz (Q).

accuracy of the result (see Table 2). Thermal treatment reveals that at about 250 °C, the secondary magnetism is almost cleaned (Pattarametha et al., op. cit.), as supported by a tendency of the intensity and zijderveld plots. Both plots show that each specimen is one-component magnetisation which is destroyed between 100 °C and 250 °C (or so-called LT components or thermally distributed components). The NRM of each specimen ranges from 0.39 to 1.25 mA and magnetic intensity of the cleaned specimens ranging from 0.36 to 1.06 mA. Moreover, Pattarametha *et al.* (1988) cleaned their samples by thermal demagnetisation until temperature up to 600 °C. They recognised two-components magnetisation such as LT components (or thermally distributed components) which were destroyed between 100 °C and 250 °C and HT com-ponents (or discrete components) which were destroyed between 450 °C and 500 °C. They suggested the appropriated temperature treatment about 250 °C (Figure 7). Using a computer programme attached to the instrument, the mean direction of 5 measured samples (I = 39.8°, D = - 46.7°, A95 = 29°) cannot be accepted as a primary paleomagnetic direction. However, stereo plots of most measured sample still revealed a normal polarity. The result of 5 collected samples are summarised in Table 1.

DISCUSSION

MAGNETOSTRATIGRAPHY

According to the work of Pattarametha et al. (1988), the Phu Thok Noi posses 27 normal and 17 reverse polarities. However, when taking into

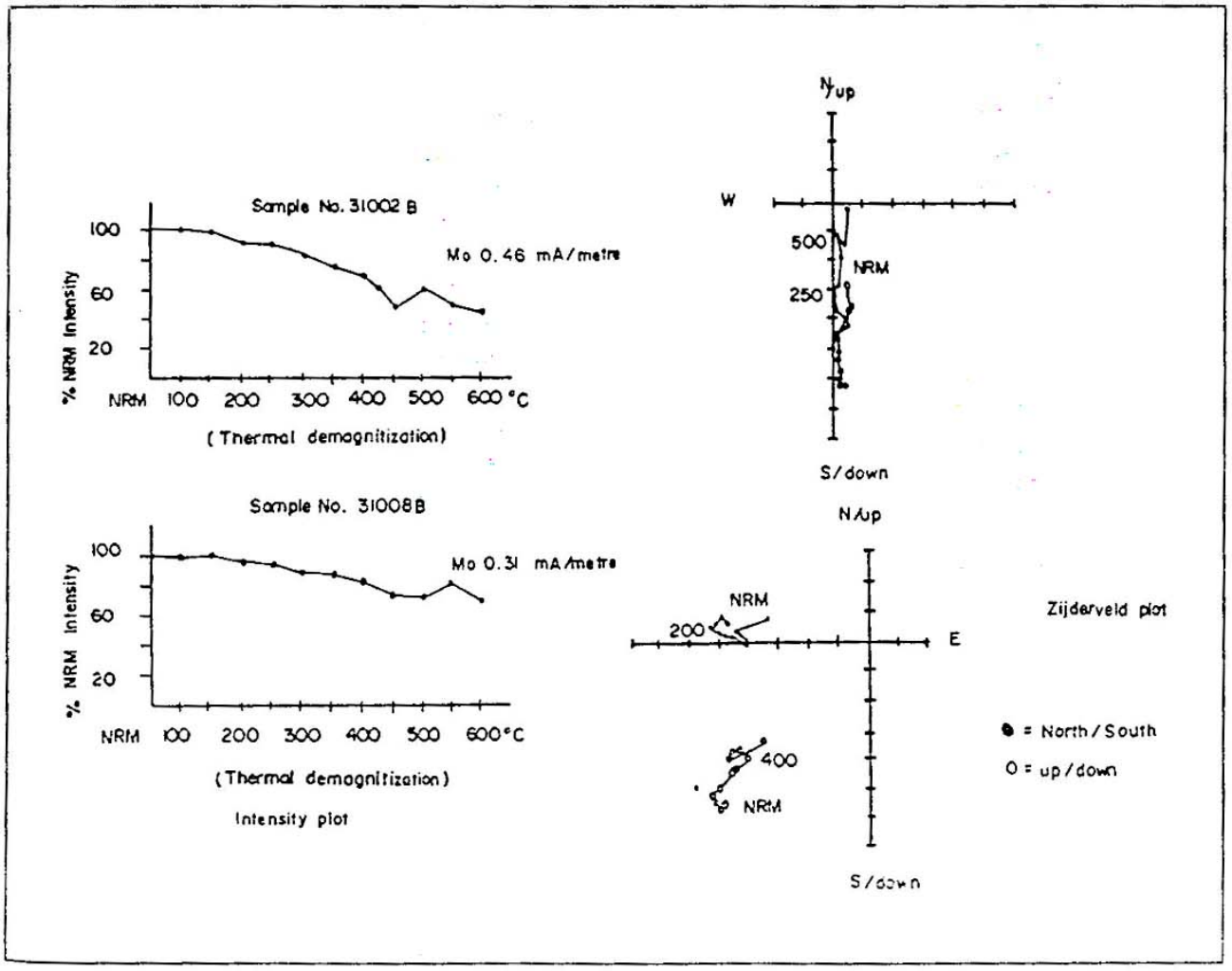


Figure 7 Intensity and zijderveld plots of sample Nos. 31002B and 31008B showing the two-component magnetisation in the rock sample (after Pattarametha et al., 1988).

account the accepted value at A95, only 20 % of the samples are qualified. The result, therefore, reveals only 12 normal and 3 reverse polarities. At present, it is difficult to interpret the accurate rotation of lithospheric plates. However, the result gives some idea about age of rocks in the area. Our result is that the previous 44 samples of the Phu Thok Noi, confirm the alternation of at least 6 normal and 7 reverse polarities. This result can give rise to magnetostratigraphy of the area (Figure 8). It can be related to the Late Jurassic to Early Cretaceous Period of the Geomagnetic Polarity time scale. It is also indicated that the rock unit may be magnetostratigraphically correlated with those of the Phu Phan Formation.

POSITION OF SEDIMENTARY DEPOSIT

Result from this study together with that of 15 selected samples of Pattaramaeha et al. (1993) show the mean inclination of 45.9° and declination of 11.4° (A95 = 22.6°). When calculated for the Phu Thok present site (18.2° N, 104° E), it is found that the paleopole position of Phu Thok was about 76° N and 151° E. In addition, the paleolatitude of the Phu Thok deposit is suggest to 27° N. It can be correlated with Khorat plateau position in Jurassic to Cretaceous Period (see Yang *et al.*, 1993). The paleopole position during that time is 74.3° N, 215.7° E (A95 = 6.5°) and the paleolatitude of the

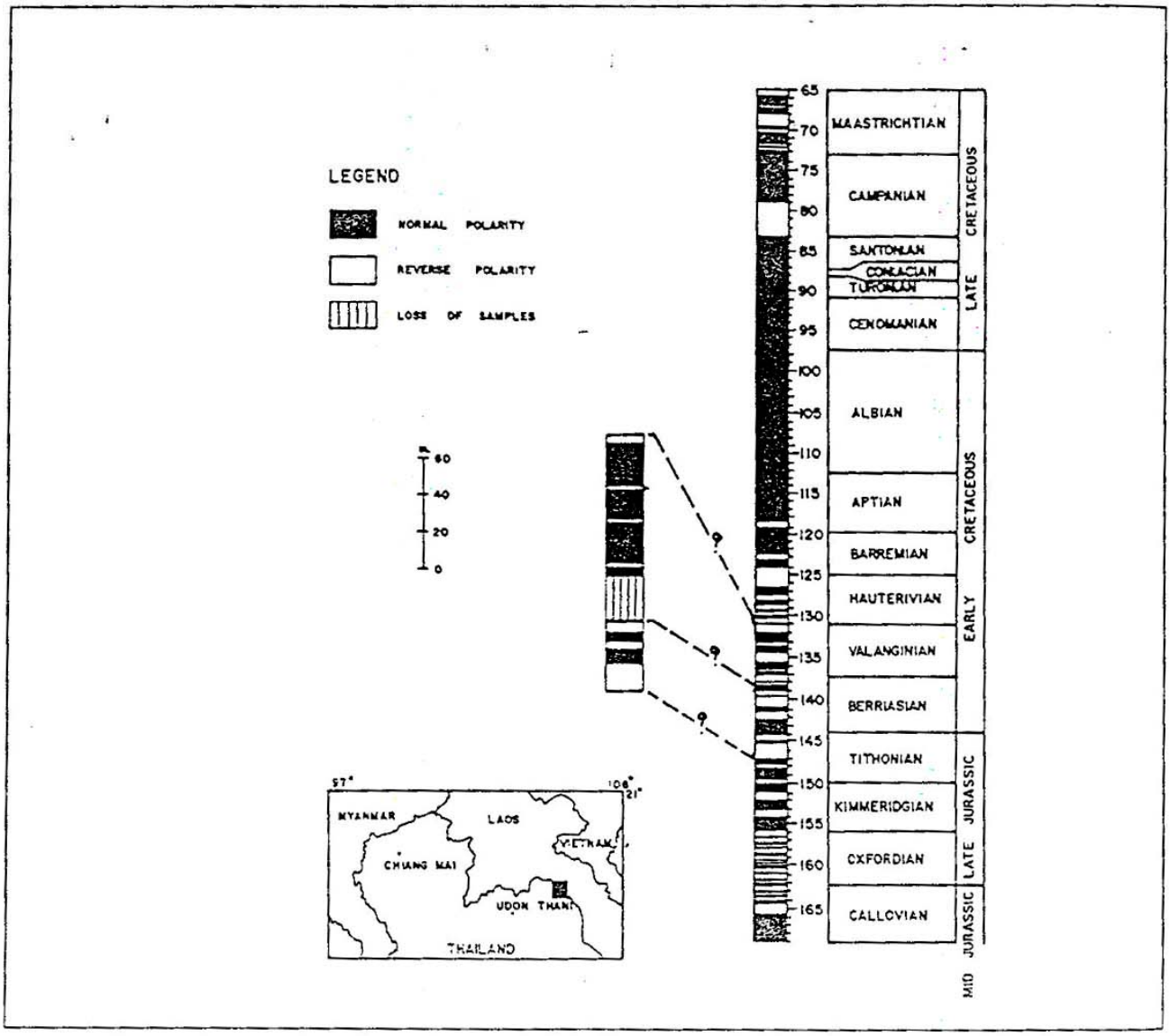


Figure 8 Magnetostratigraphy of the Phu Thok Noi area in a comparison with the geomagnetic polarity time scale, indicating the Late Jurassic to Early Cretaceous Period.

ble 1. Paleomagnetic result for the 5 samples of Phu Thok Formation, LT = single-component magnetisation destroyed at tively low temperature (150-200° C), D and I are declination and inclination, respectively, k is the Fisherian precision ameter, A95 is the radius of cone of 95 % confidence within site and overall mean.

Site	Demag. component	uncorrected D (°)	I (°)	k	A95 (°)	corrected D (°)	I	k	A 95 (°N)	Paleopole Lat. (°E)	Long.
Phu Thok Formation (Late Jurassic to Early Cretaceous)											
1	LT	233.0	5.4	32.4	14.2	335.0	22.9	17.3	16.8	65.0	2.9
2	LT	247.8	15.8	10.2	40.3	333.9	14.7	2.8	48.4	62.4	354.5
3	LT	194.6	72.8	14.1	18.6	38.8	68.8	13.1	19.1	44.5	136.6
4	LT	219.8	51.1	279.0	4.8	303.8	59.1	502.1	3.6	37.2	50.8
5	LT	208.1	38.4	12.6	22.7	88.5	9.0	17.2	19.5	190.2	4.5
Average	LT	218.6	42.9	7.4	25.7	313.3	39.8	3.9	29.0	46.1	28.0

Table 2. Paleomagnetic result for the 11 samples of Phu Thok Formation using Thermal demagnetisation, LT = component magnetisation destroyed at relatively low (150-200 C), temperature, HT = component magnetisation destroyed at relatively high temperature (450-500 C), D and I are declination and inclination, respectively, k is the Fisherian precision parameter, A95 is the radius of cone of 95 % confidence within site and overall mean (Modified from Pattarametha et al. (1988).

Site	Demag. component	correct D (°)	I (°)	k (°N)	A95 (°E)	Paleopole Lat.	Long.	Paleolatitude (°N)
31023	LT, HT ?	330.3	32.4	3.1	45.3	61.8	11.5	17.6
31024	LT, HT ?	64.8	6.0	30.7	17.5	24.9	199.2	3.0
31025	LT, HT ?	277.0	43.9	18.7	18.6	13.9	36.9	25.7
31026	LT, HT ?	309.4	26.8	2.5	50.8	41.4	17.1	14.2
31027	LT, HT ?	80.2	41.3	10.3	25.0	15.9	173.7	23.7
31028	LT, HT ?	343.9	61.2	14.4	21.2	62.3	77.8	42.3
31031	LT, HT ?	57.8	86.6	7.6	29.2	21.7	110.2	83.2
31033	LT, HT ?	65.0	13.4	9.3	26.4	25.8	195.2	6.8
31034	LT, HT ?	342.3	44.6	7.5	29.3	71.8	43.3	26.2
31037	LT, HT ?	20.5	5.2	63.3	10.1	64.6	229.4	2.6
31039	LT, HT ?	27.8	62.1	41.3	12.5	55.6	140.9	43.4
Average		11.4	45.9	5.2	22.6	76.1	151.1	27.3

Khorat Plateau was 21.6°-25.6° N (Yang *et al.*, op. cit.). However, Bhongsuwan (1993), as referred from Enkin *et al.* (1992), gives the slightly different paleopole position at approximately 70° N ,158° E. In addition, several geoscientists (e.g. McElhinny, 1973) concluded that the average paleopoles during Late Jurassic-Early Cretaceous Period would have been located at 65° - 66° N and 138° - 166° E. Result from 14 Upper Jurassic rocks of Northeast Thailand by Bunopas (1981) revealed that the paleopoles position in Jurassic period was 67.2° N and 163.8° E (A95 = 13.6°). From this current result and the previous studies, it can be inferred that rocks of the Phu Thok Noi area would have formed during that period of time. The summary of all data of paleopole is shown in Figure 9

PALEOENVIRONMENT

Several outcrops of thick-bedded arkosic sandstone include various scale multi-direction cross-bedding structure with average dip angle of about 18°-26°. The textural characteristics of the arkosic sandstone indicates that the phenoclasts have subroundness and good sphericity and the rock has good sorting with the absence of fossils. Both sedimentary structures and structure reveal that the sediments were deposited by wind as dunes. Result from SEM also indicates another interesting support, i.e. some grains of quartz have small pits on surface, possibly caused by wind interaction. In addition, the best reason of characteristic from wind action include barchan dune recognised from angle

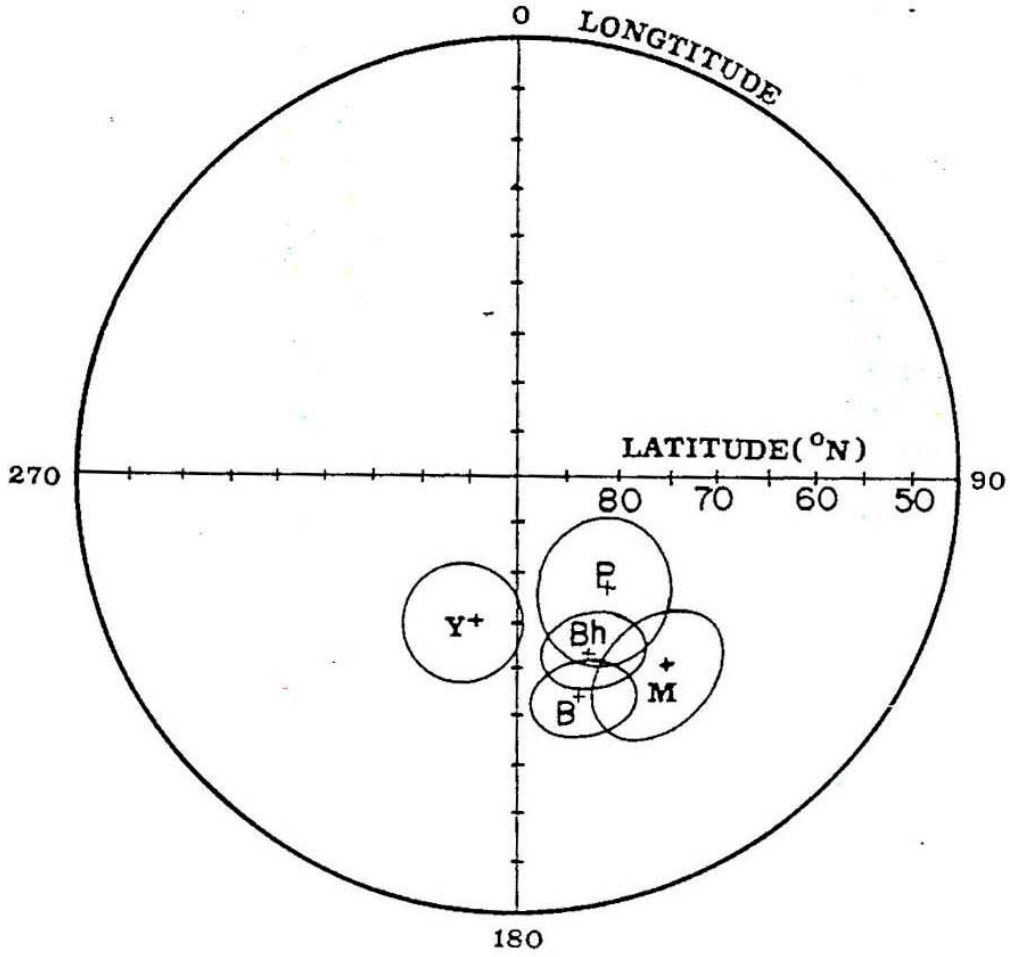


Figure 9 Equal-area projections showing the paleopoles during Late Jurassic to Early Cretaceous Period.

P	=	Pattarametha et al. (1988)	=	The Phu Thok Formation
Y	=	Yang et al. (1993)	=	The Khorat Plateau
Bh	=	Bhongsuwan (1993)	=	The Khorat Plateau
B	=	Bunopas (1981)	=	The Khorat Plateau
M	=	McElhinny (1973)	=	Average worldis data

of slope of cross-bedding. However, feldspar-rich phenoclasts present in some specimens may possibly point to the fluvial effect (Charusiri and Imsamut, 1994). It is likely that the Phu Thok Noi may have been derived from the nearby provenance. The surrounding land mass was, therefore, the older Sao Khua fluvial sandstone, and the Phu Thok Noi sandstone is a result of the rework of older strata nearby. Similar conclusion was also made for the Leshan Mesozoic sandstone in Sichuan Province, Central China, by Xinsheng *et al.* (1992). The red colour of the rocks indicated that the sediments were deposited in the oxidising environment.

Very fine-grained, calcareous sandstone are intercalated with thick beds of iron-stained arkosic sandstone. These finer-grained clastics are interpreted to represent the interdune feature. At macroscopic scale, the occurrences of coarse-ripples, discontinuous laminae, rock fragments in very fine-grained sandstone may support another phenomenon. Furthermore, ripple structures and sand cracks are usually found at top surfaces of medium grained sandstone, above the very fine-grained sandstone bed, possibly indicating very shallow-water environment. These are believed to have formed by the action of wet-interdune deposit which have avalanche toes or slumping sediments derived from barchan dune (Imsamut, 1994). The coarser-grained sediments were mixed with the finer-grained sediments as discontinuous horizontal beds. Such features are quite similar to the sedimentary structure of Albuquerque sandsheet deposit, New Mexico, USA (Scholle and Spearing, 1981). The sandsheet represents the eolian deposit occurring marginal to a dune complex that generally does not have definable dune forms (also called low-angle eolian deposits). Therefore, the environment of deposition of the Phu Thok formation could be an eolian environment which posses alternation of sand dunes, wet-interdunes of shallow fluvial deposit (wadi) and wet sandsheet environment.

CONCLUSION

This preliminary investigation forms part of a continuing studying on the chronology of Phu Thok Formation by paleomagnetic data. The data indicate the age of Phu Thok Formation between Jurassic and Cretaceous Period. The result gives rise to magnetostratigraphy and movement of paleopoles, and paleolatitude of the study area. The magnetostratigraphy shows the alternation of at least 6 normal and 7 reverse polarities which can be very well compared with the Cretaceous to Jurassic Period of Geomagnetic polarity time scale. Regarding position of paleopole of all samples, the mean inclination, declination, and paleopole are nearly similar to values of the Khorat Plateau reported by various scientists. Therefore, it can be possibly concluded that the age of Phu Thok is Upper Mesozoic Era. However, it is noted that a more detailed stratigraphic study should be concentrated and the orientated sampling are needed for the accuracy of the Phu Thok formation age in the future work. Furthermore, the more data are required for the calculations of the pole position.

Several sedimentological criteria support the aeolian environment of deposition with minor interfingering fluvial facies system. It is likely that the Phu Thok Noi area and nearby, the desert emergent landmass of the north of Khorat Plateau, was subsequently invaded by sea water during Cretaceous Period.

ACKNOWLEDGEMENTS

The authors would like to thank Mr. Charoen Butmuang and Mr. Somboon Khositanont, both generous field assistances for our field checking. Thanks are due to the Department of Mineral Resources for permitting the facility and Department of Geology, Faculty of Science, Chulalongkorn University for logistical support. Mr. Wattana Tuteechin and Mr. Vimon Ubolphuang are thanked for their drawing of all figures and Mr. Prasert Kiewpimpa for the XRD analysis, and Mr. Prachin Thongpasert for his thin-section preparation.

REFERENCES

Achache, J., Courtillot, V. and Besse, J., 1983. Paleomagnetic constraints on the Late Cretaceous and Cenozoic tectonics of Southeastern Asia. Earth Planet. Sci. Lett. 63, v. 123-136.

Achache, J. and Courtillot, A., 1985. A preliminary Upper Triassic paleomagnetic for the Khorat Plateau (Thailand) : Consequences for the accretion of Indochina against Eurasia. Earth Planet. Sci. Lett., v. 73, 147-157.

Barr, S. M. and Macdonald, S. A., 1976. Paleomagnetism age and geochemistry of the Denchai Basalt, Northern Thailand. Earth Planet. Sci. Lett. v. 46, 113-124.

Barr, S. M. and Macdonald, S. A., and Haile, N., 1978. Reconnaissance paleomagnetic measurements on Triassic and Jurassic sedimentary rocks from Thailand. Geol. Soc. Malaysia Bull. v. 10, 53-62.

Bhongsuwan, T., 1993. Paleomagnetic Investigation in Thailand. Ph.D. Thesis. Lulea University of Technology, 128 p.

Bunopas, S., 1981. Paleogeographic history of western Thailand and adjacent parts of Southeast Asia : A Plate Tectonic

interpretation. Geological Survey Paper Special Issue 5, Dept. of Mineral Resources of Thailand, Bangkok, 810 p.

Bunopas, S., Vella, P., Pitakpaivan, K. and Sukroo, J., 1978. Preliminary paleomagnetic results from Thailand sedimentary rocks. In: Proc. of the Third Regional Conf. Geol. and Min. Resources of Southeast Asia, Nutalaya, P. (editor), Bangkok, 24-32.

Haile, N. S. and Khoo, H. P., 1980. Paleomagnetic measurements on Upper Jurassic to Lower Cretaceous sedimentary rocks from Peninsular Malaysia. Geol. Soc. Malaysia. Bull. v. 12, 75-78.

Maranate, S., 1982a. Paleomagnetism of the Khorat Group in Northeast Thailand. M.Sc. thesis, Victoria University of Wellington, New Zealand, 398 p.

Maranate, S. and Vella, P.,1986. Paleomagnetism of the Khorat Group, Mesozoic Northeast Thailand. Jour. SE Asia Earth Sci., v. 1, 23-31.

McElhinny, M. W., 1973. Paleomagnetism and Plate tectonic, Cambridge University Press, 350 p.

Pattaramethа, M., Maranate, S., and Bunopas, S., 1988. Paleomagnetic study of Khan Phu Thok Noi and Phu Wua Lang Tham Pai, Amphoe Bung Kan, Changwat Nong Khai. Report of invest. No 12, Dept. of Mineral Resource, Bangkok, 135 p. (in Thai)

Peter A., Scholle and Darwin Spearing, 1981. Introduction to Eolian deposit. Butt ? of Sandstone Depositional Environments. The American Association of Petroleum Geologists, Tulsa, Oklahoma 74101, 11- 45.

Richter, B., Fuller, M., Schmidtke, E., Tin Myint, U., Tin Ngwe, U., Mya Win, U., and Bunopas, S., 1993. Paleomagnetic result from Thailand and Myanmar: implication for the interpretation of tectonic rotations in Southeast Asia. Jour. SE Asia Earth Sci., v. 8, 247-255.

Sattayarak, N., 1983. Review of continental Mesozoic stratigraphy of Thailand. In: Proc. Workshop on stratigraphic correlation of Thailand and Malaysia, Nutalaya, P. (editor), Hat Yai, v. 1, 127-149.

Shoubu Funahara, Nobukazu Nishiwaki, Fumiyuki Murata, Yoichiro Otofuji and Yi Zhao Wang, 1993. Clockwise rotation of the Red River fault inferred from paleomagnetic study of Cretaceous rocks in the Shan-Thai-Malay block of Western Yunnan, China. Earth Planet Sci. Lett. v. 117, 29-42.

Tarling, D.H., 1975. Development in Paleomagnetism. In : Geodynamics Today. Roy. Soc. London.

Xinsheng, J., Leyao, C., and Yuwen, L., 1992. Cretaceous-Tertiary Deserts in Southwestern China and Desert Sedimentology. Rept. of Invest., Chengdu Institute of Geology and Mineral Resources, 66 p.

Yang, Z., and Besse, J., 1993 Paleomagnetic study of Permian and Mesozoic sedimentary rocks from Northern Thailand supports the extrusion model for Indochina. Earth Planet Sci. Lett. v. 117, 525-552.

Zijderveld, j. D. A., 1967. A.C. Demagnetisation of rocks: analysis of results. In: Methods in Paleomagnetism. Collinson, D.W. et al. (editors), Elsevier, Amsterdam, 256-284