CHAPTER III

FIELD AND LABORATORY WORKS

Paleomagnetic procedure in this study consists of two stages - field investigation and laboratory works. Field mapping is required to study the rock sequence of the Phu Thok area and to collect the oriented rock samples. The laboratory works are required to record the paleomagnetic data. The flow chart of the procedure and result is shown in Fig.3.1. The overall process is modified from Bunopas (1981), Maranate, (1982), Pattarametha (1988), Enkin (1990), Yang (1992) and Bhongsuwan (1993).

Field Investigation

1. Field Mapping

Literature review of Khorat Group and previous paleomagnetic works form the first step of this study since the paleomagnetic studies are quite complicated, not only for the fact-finding and gathering but also for the interpretation. Regional geology (at scale of 1:50,000 by Pattarametha and others, 1988) was redone using air-photo interpretation such as boundaries and structural features of the rock units. Field mappings were launched several times between June, 1994 and March, 1995. This work is aimed to study the lithological units of the Phu Thok and the mudstone-clastic units and some semi-unconsolidated sediments. Detailed lithostratigraphy of the Phu Thok Formation together with sample collection from individual strata were the main objective. The suitable strata for paleomagnetic studies were also marked to sample collection.

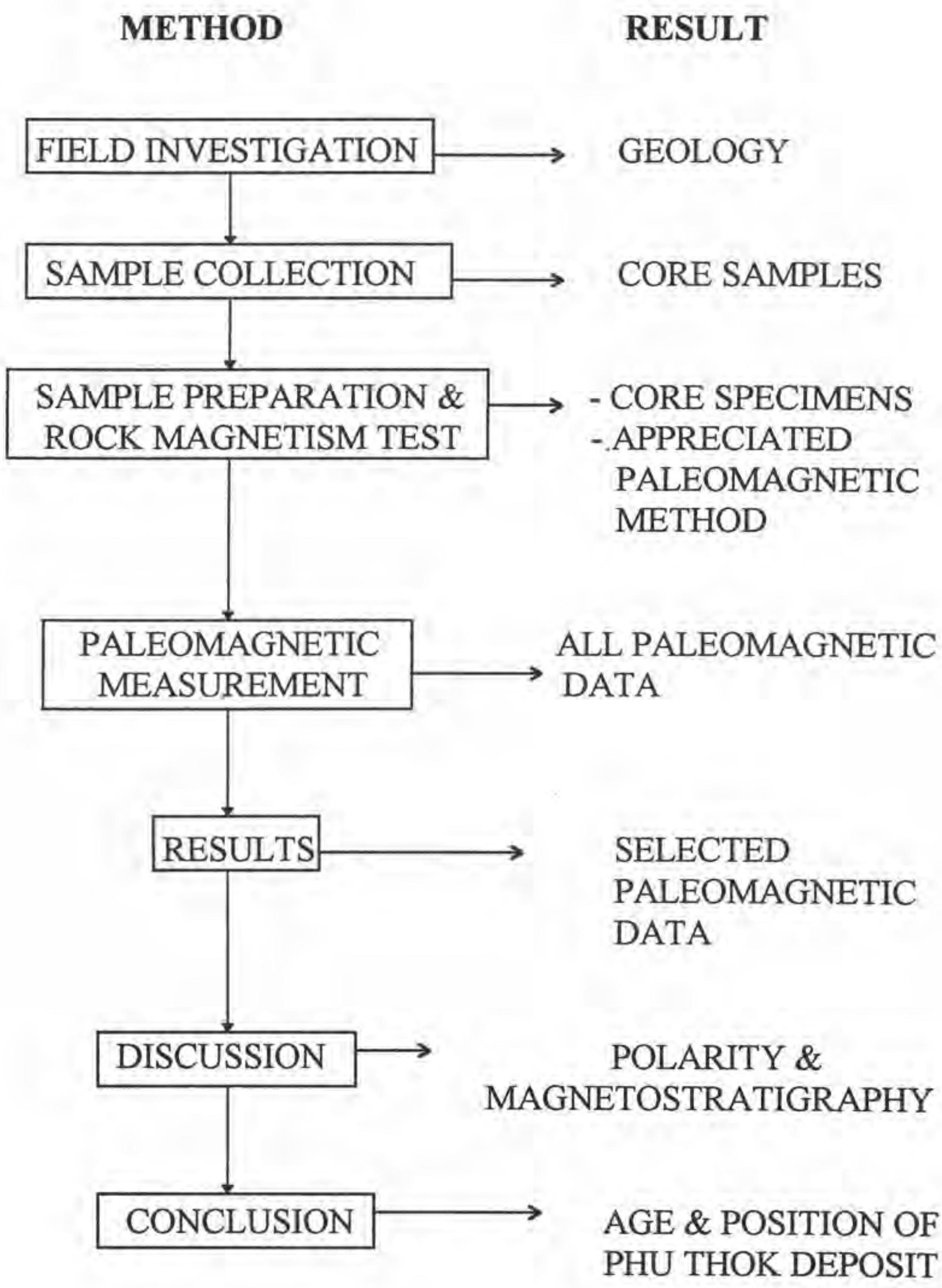

Figure 3.1 Flow chart of the overall methodology of this study.

2. Sampling Technique

Samples were systematically and selectively collected at sites by a hand-drilling machine and were oriented with a Brunton magnetic compass. Core samples of continuous Phu Thok (72 samples) and Phu Wua (68 samples) sections were collected from undisturbed or metamorphosed red bed strata. Approximately spacing interval of sampling is about 1-2 m. The required spacing was received from Pattarametha and others's studied for cover all of the alternation of magnetic polarities. However, the strong weathering and denudation of the soft rocks in the Phu Thok sequence is reasonable of the irregularly interval of sample collection. Therefore, in the thick soft-rock sequence, samples being collected are missing. The portable drilling machine is modified from the wood-cut machine, to allow water to flow passing through inside of core barrels to cool the diamond drill bits (the machine is obtained from DMR). Average times of collection of each core is ranging from 10 to 30 second. The direction of the core samples are acquired into three directions - X, Y and Z. Declination of the core-drilling is presented in +X direction and inclination of the drilling is recorded in +Z direction. The core sample is generally 2.5 cm in diameter and 8-15 cm in length depending on rock hardness. Usually 8-10 cores were drilled per sample site. They are labeled the inclination direction by the long scribe line and declination direction by the short line. The error of the core sample direction is not more than 2-3 degree.

Samples from Phu Thok section were situated in both natural and artificial exposures at western side of the Khao Phu Thok Noi. All samples were collected from the cliff near the wood- bridge of the Wat (temple) Phu Thok. Samples of the Phu Wua section were sampled along the way to the escarpment area located at the eastern side of the Khao Phu Wua range. A total of 41 samples are collected from natural and stream-cut outcrops at the cliffs or backslopes. The remaining 27 samples are collected from the dipslopes of the mountain near the top of the Phu Wua Lang Tam Pai hill. It is noted that the regularity of core samples of very fine-grained sandstone is better than the fine-to medium-grained sandstone.

Laboratory Work

In the laboratory investigation, at least four individual specimens (2.5 cm in diameter and 2.2 cm in length) were performed from each sample. Usually 1-2 specimens were obtained from each core sample. The 4-7 specimens is usually given of each sample site. The three individual specimens (assigned as A,B and C) were measured for paleomagnetic parameters. The other specimens prepared are for the petrographical, geochemical, mineralogical and magnetic susceptibility analyses. This laboratory investigation was prepared between April to December,1995. The flow chart of the laboratory method, which is separated into five stages below, is shown in Fig 3.2.

1. Magnetic Properties Determination

The first laboratory work is designed in order to visualize magnetic properties of the rocks in the mapped area. The result of this method can prove the existence of the magnetic minerals which carried paleomagnetism. The result also provide the determination of the suitable procedure for demagnetization. The remained specimens from paleomagnetic measurement were later identified for magnetic properties. Polished sections of 15 samples altogether from various types of rocks were determined petrographically for the magnetic minerals. Most of them were also analyzed quantitatively for major-oxide elements by XRF method, using the Philips instrument of the Mineral Resource Analysis Division, Department of Mineral Resources (DMR). The magnetic susceptibility of the overall 124 samples were measured by the MS2 Magnetic susceptibility at the Laboratory of the Geological Survey Division, DMR. This instrument is sensitively reported to be better than 1x 10^{-6}. For one measurement the rock specimen is oriented at 9 directions inside a instrument shield. The output can be chosen to be an integration over 10 or 20 seconds.

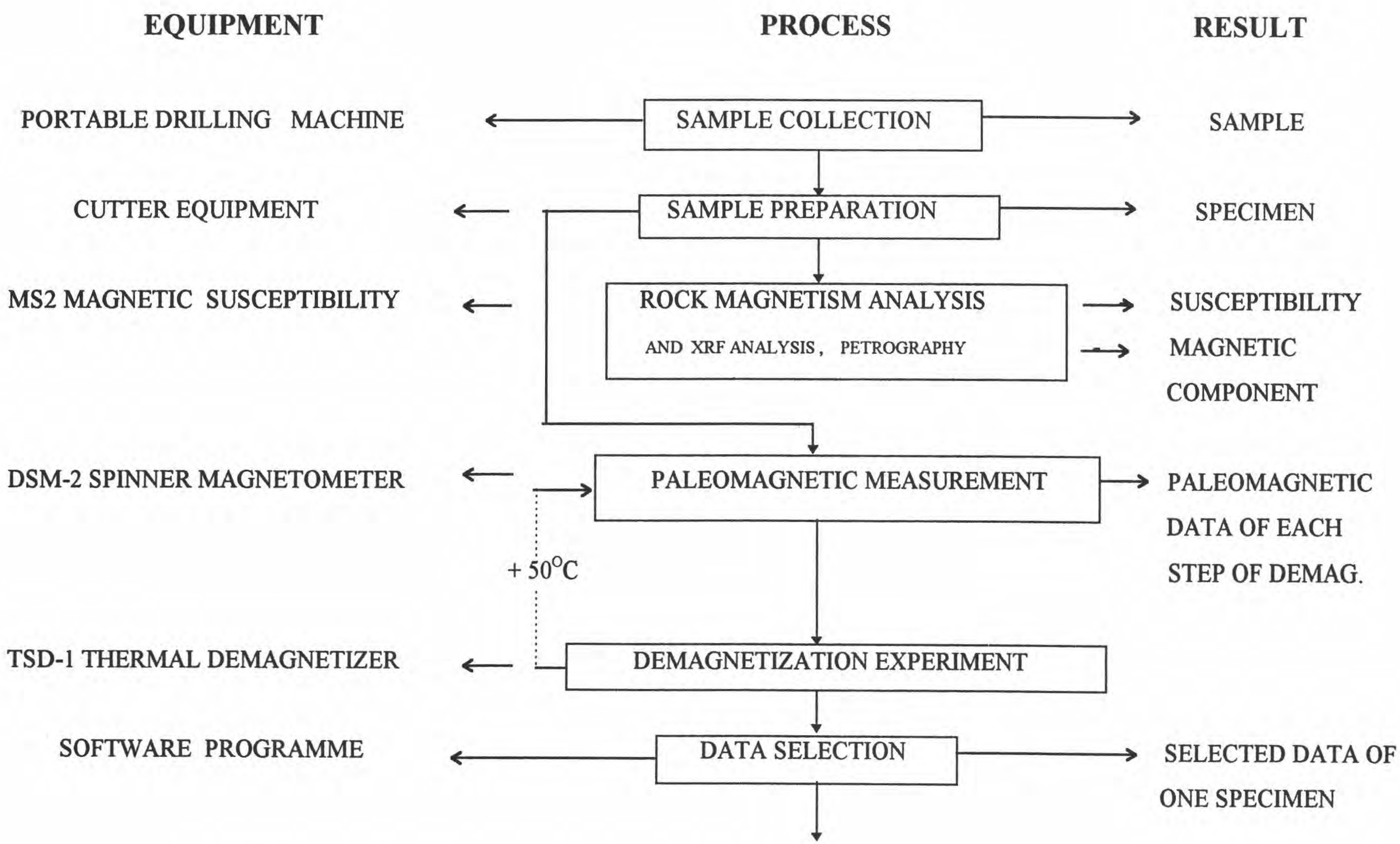

Figure 3.2 Detailed method for the laboratory work.

2. Paleomagnetic Measurement

Paleomagnetic work reported in this thesis has been performed at the paleomagnetic laboratory of DMR, Thailand and Chengdu Institute of Sichuan, China. All samples (140 samples or 361 specimens) were measured for the natural remanent magnetization (NRM) and detrital remanent magnetization (DRM), using the same equipment a Schonstedt DSM-2 spinner magnetometer. The instrument is sensitively reported to be better than 1x 10^{-7} Am^{-1}. The rock specimen is spun at 6 HZ about a horizontal axis inside a nongeomagnetic shield tube. The output can be chosen to be an integration over 6 or 20 seconds. The instrument is automatically controlled by means of an on-line computer programme. The values of electric current vector from the results of 6 spins corresponding to 6 faces of one specimen are calculated for the inclination (I) and declination (D) values, and the magnetic intensity. The final data were corrected by the directions of the drilling-holes, and the attitudes of the rock strata.

3. Demagnetization Experiment

All rock specimens were suitably demagnetized by thermal demagnetization which was suggested by the previous paleomagnetic studies of Bunopas (1981), Maranate (1982) and Yang (1992). Individual specimens were cleaned for the secondary magnetization by the TSD-1 thermal demagnetizer which has been calibrated to ensure that the temperature at the center of each specimen is known with an accuracy of 5 °C by alternating electric power. For the heating time of 5 minutes, this difference is within 50 °C. The cooling time, ranging from 20 to 45 minutes, is more or less the optimum time needed to decrease the temperature of specimens from 100-730 °C to room temperature (27°C).

After individual specimens are measured by the spinner magnetometer, they are demagnetized progressively in 13-14 steps of thermal demagnetization. After each step of demagnetization, the specimen is measured to observe changes in intensity as well as direction of the remanence vector. For the thermal demagnetizations, the temperatures are progressively increased in a series such as 100, 150, 200, 250, 300, 350, 400, 450, 500, 550, 600, 650, 680, and 700 or 730 °C. The output of most measurements has been regularly checked with a standard sample. However, some specimens were semi-progressively demagnetized in 5-9 steps, in a series ranging from 300, 350, 400, 450, 500, and/or 550 °C and may increase to 680-730 °C. All data of magnetization are kept in the "DSM" software (Enkin, 1990) and are available upon request. These raw data are calculated in the next stage.

4. Data Selection and Calculation

The data of successive demagnetizations (see Appendix D) were analyzed to define the direction (declination and inclination) of remanence magnetism in each specimen using computer. The analyzed measurements include intensity, stereo and zijderveld component plots using the "Kirsch" software programme (Enkin, 1990). Kirsch software includes the intensity, stereo and zijderveld plots. Intensity plot is the correlation of %NRM intensity (M/Mo) of each specimen at Y-axis and the temperature to demagnetization at X-axis. Mo is the magnetic intensity before cleaning and M is the magnetic intensity after cleaning in each demagnetization. The first benefit of the graph is to show the amount of magnetized component revealed by the slope of the curve line. The other is to appropriate the point of magnetic cleaning which most of secondary magnetization is completely destroyed. Stereo plot is the plot in the equal area net which comprises inclination and declination angles of the specimen before and after demagnetization in each temperature. The positions of each point are created from rotation declination degree's angle clockwise from the north and moving align to the center by inclination degree angle. The suitable point will show the pole of vector of primary and secondary magnetization. Zijderveld plot (Zijderveld, 1967) is regarded as the best and most essential plot. It is the plot in the equal area net comprising the combination of cosine and sine of inclination multiply the %NRM intensity and declination of the specimen before and after demagnetization in each temperature. The result of the plot is the magnetic vector of the specimen before and after cleaning in each temperature in horizontal and vertical planes. The last vector pointing to the center of both plane is suitable point of completely demagnetization of secondary magnetism. This process is to select the group of clean temperatures which can remove soft secondary components of magnetization.

Only average one computed data set (declination and inclination values) of individual specimens was proposed. The appropriated data of three specimens of each sample were calculated using the "Norton" software (Piaszezyk, undated). The results involving paleo-latitudes, paleo-longitudes of paleopoles and paleolatitudes of the rock sequences and accepted parameters (such as A_{95} or cone of confidence) of each sample, were recorded. Error data were resigned from the data interpretation.

5. Data Interpretation

All accepted samples data were identified for the polarity (normal and reverse) by the values of paleo-latitude of paleopoles. The magnetostratigraphy is subsequently created from the polarity zones of each sample in the rock sequence. The stratigraphic positions of the polarity are, therefore, based primarily upon the stratigraphic column of the samples. Polarity boundary is basically delineated on the basis of lithologic of the rock sequences (see also McElhinny,1973). The correlation of the magnetostratigraphy of the Phu Thok formation at Khao Phu Thok and Phu Wua with the standard geomagnetic polarity time scale is the final step of this study.

The accepted data of the Phu Thok samples were plotted by the "Pmstat" software (Enkin, 1990) and were calculated using the "Paleomagnetic" software (Piaszezyk, undated). The result was the paleolatitude of the depositional area and the direction of magnetic field during time of deposition. This forms the basic data for the discussion on plate motion and rotation of the study area.