沉积岩数据库及有关计算机程序在泰国北部南邦班塔西地区地质研究中的应用

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南邦湄莫班塔西地区（370km²）是用矿产资源开发计划署提供的各种计算机程序进行首次地质综合研究的地区。通过 SEDBA 程序，150 个以上数据组已被输入数据库。本文的地质图主要是由 SUTOCAD 程序完成的，磁性和放射性测量图主要是用 GEOSOFT 绘图系统软件包来处理和修饰的，而陆地卫星图象和投影图象是由 MERIDIAN 程序制备和修饰的。

各种现有的信息，包括通过当前现有程序所获得的地质和遥感信息的数据汇编、提纯和解译，提高了地质制图及研究的质量。研究区主要由沉积于南部构造盆地中的沉积物两个群组成：时代最早的群为二叠纪叻丕群（厚 400m），产于东部，主要由开阔海陆架被动大陆边缘灰岩组成；二叠—三叠纪湄莫群（厚达 200m）主要分布于东部，多数由东倾的与俯冲消减有关的火山岩和火山碎屑岩组成。时代最晚且分布最广的地层单元——三叠纪南邦群（3700m 厚）为弧后沉降盆地的红-灰层、台地灰岩和厚层浊积岩。构造上，该区由一个在西北部和东部有小背斜的大向斜构成。航空地球物理数据和浅航天图象资料表明，该区曾属于与湄他和程逸主断层相平行的北东向断裂带。该区位于深浅不一的断裂基底之上。

SEDBA AND RELATED COMPUTER PROGRAMMES IN THE GEOLOGICAL STUDIES OF BAN THA SI AREA, LAMPANG, NORTHERN THAILAND

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ABSTRACT

The Ban Tha Si area (370km^2), Mae Moh, Lampang, was selected for the first geological studies using various computer programmes provided by the Mineral Resources Development Project. More than 150 data entries have been stored in the data bank using the SEDBA programme. Geological maps presented were produced mainly using the AUTOCAD programme. The magnetic and radiometric maps were processed and enhanced principally using GEOSOFT Mapping System software package. The Landsat and SPOTS images were prepared and enhanced using Meridian programme.

Data compilation, enhancement and interpretation of available information, including geological and remotely sensed data via current available programmes, improve geological mapping and studies. The study area comprises mainly two major sedimentary groups deposited in the tectonic Lampang basin. The Permian Ratburi Group (400m thick), the oldest group, occurs in the eastern part and comprises mostly limestones of open marine-shelf passive continental margin. The Permo—Triassic Mae Moh Group (up to 200m thick) is predominated in the eastern part and consists largely of E-dipping subduction-related volcanics and volcanic clastics. The Triassic Lampang Group (3,700m thick), the youngest and most widely distributed stratigraphic unit, comprises red-gray beds, platform limestones and thickly bedded turbidites, of a back-arc subsiding basin. Structurally, the area forms a large syncline with small anticlines in the northwest and eastern parts. The airborne geophysical data together with the space-borne images indicate that the area has been subjected to the NE-trending fault zone conformable to the majo- Mae Tha and the Uttaradit Faults. The area is situated on the faulted basement with varying depths.

INTRODUCTION

The area under study (370km^2) is located in Mae Moh District of the Lampang Province, northern Thailand (see Fig. 1). Physiographically, the area is undulating and mountainous landform with a large low land between the NE-trending mountain range. Geology of the area was done by Piyasin (1972), Chonglakmani (1983), Chaodumrong (1992), and Supananthi (1993). The aims of the study are to present maps and interpreted results using the available computer programmes and to improve the geological interpretation gathered from current and various geological information.

METHODOLOGY

Three periods of fieldwork were performed during the summer (March—May) in 1989, 1991 and 1992. Lithological and paleontological data were described in the field. More than 300 sampies were collected and described, and nearly 150 selected thin-sections were petrographically studied under microscope. About 15 chemical analyses (major

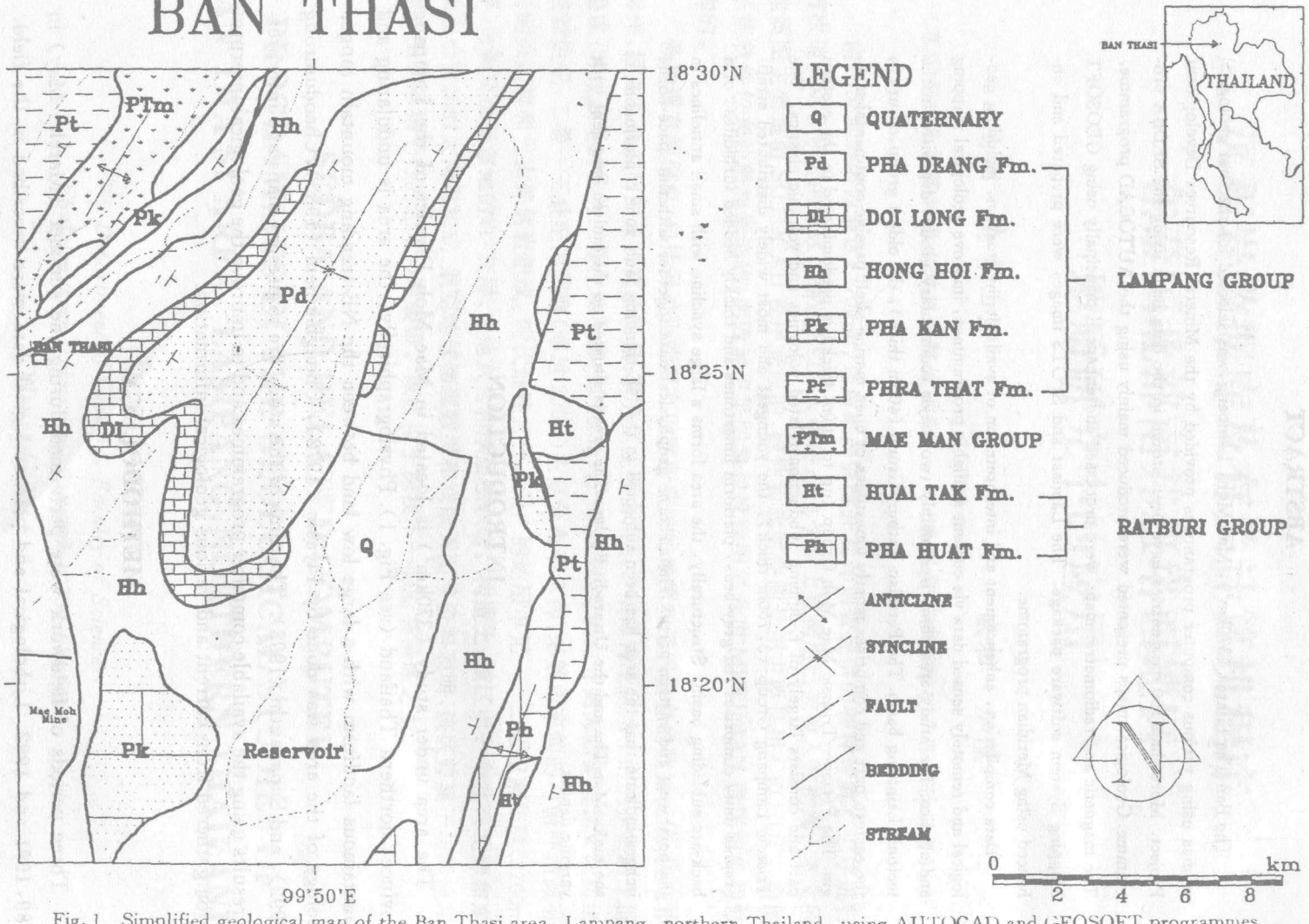


Fig. 1 Simplified geological map of the Ban Thasi area, Lampang, northern Thailand, using AUTOCAD and GEOSOFT programmes

oxides) of some carbonate rocks were performed using XRF at the Department of Mineral Resources.

All these informations, particularly field, petrographic, and geochemical data, are stored in the data bank system using the SEDBA data-base programme developed by IGCP 269(Ploquin, 1991; Nichiwaki-Nakajima, 1994). Detailed description will not be discussed herein but it can be found in Ploquin (op. cit.). Most recently some modification and limitation of using this database programme have been reviewed by Paliwal (1994).

The geological map of the study area has been recently compiled by Supananthi (1993) and Charusiri et al. (1994) based upon field, laboratory, and remote-sensing investigations. Fig. 1 illustrated the symplified geological map of the Ban Thasi area which is drawn using the AUTOCAD programme release 12 at the Mineral Resources Development Project (MRDP), Royal Thai Department of Mineral Resources, Bangkok. Perhaps this geological map was done for the first time in Thailand using this computer programme in combination with the GEOSOFT programme. The geological information especially the stratigraphic boundaries was verified using the remotely sensed images. The space-borne SPOT and LANDSAT images of the study area (Fig. 2A) were enhanced using the MERIDIAN programme at the Thailand Remote Sensing Center, Bangkok. All of the 3 microwave bands (i.e., 1, 2, and 3 of SPOT and 4, 5, and 7 of LANDSAT) were chosen, and false colour combination of red, green and blue was simulated for individual bands, respectively. Image rectification, i.e., radiometric correction, and image enhancement including spatial filtering, principal component analysis and contrast stretching, were proved to be most appropriate for aiding visual interpretation (Charusiri *et al.*, 1994). The interpretation map mostly shown as lineaments and bedding traces is shown in Fig. 2B. In addition, airborne geophysical information including radiometric and magnetic data are served as basis for both surface and subsurface geological information.

The airborne geophysical data comprising radiometric and magnetic-coloured grids are used to demonstrate the advantage of using other geological information. Three different grids of potassium, equivalent uranium, and equivalent thorium, are combined spatially into a single grid, called Ternary Radiometric map (Fig. 3A). The total field airborne grid is also shown in Fig. 3B. The interpretation maps of Figs. 3 A and B along with the superimposed geological map are illustrated respectively in Figs. 4 A and B. The striking feature obtained from radiometric data indicate a roughly wide, linear zone exhibiting comparatively high elemental concentrations of all main channels (the R1 unit). There are also several radiometric zones which have different characters (as those low in all characters, the R2 unit), however they tend to align themselves as of the R1 unit. They are interpreted as representing the units of structural control rather than those of lithological control. The result of the magnetic data interpretation depicts variation in depths to magnetic basement upderlying the sedimentary covers described in the geological map. Dashed lines in the magnetic interpretation map represent magnetic discontinuity (Fig. 4B) such as major

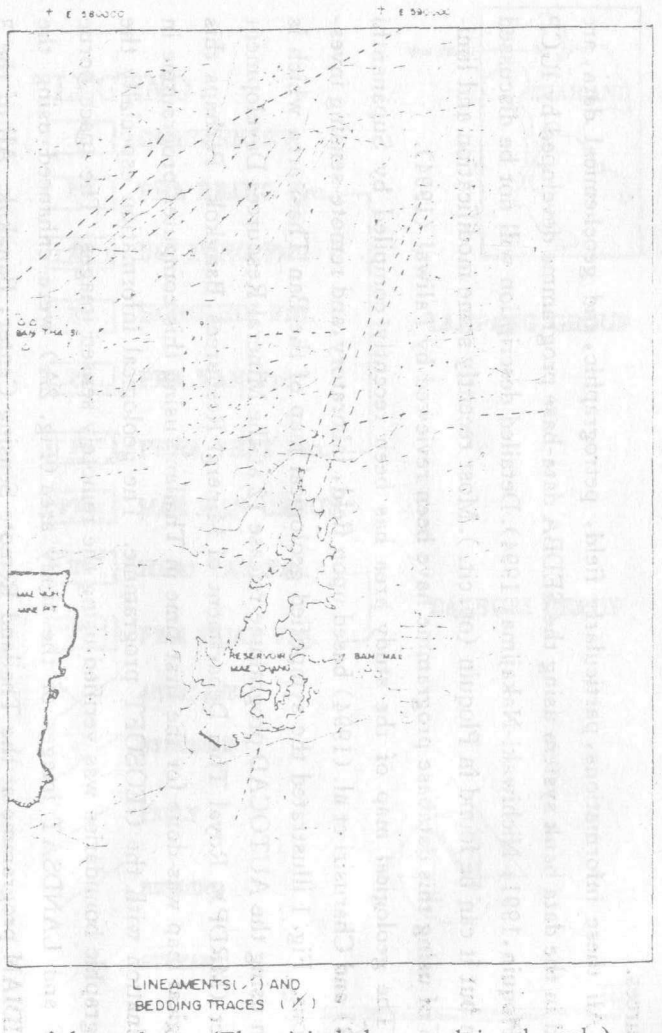


Fig. 2 A. Enhanced SPOT image of integrated bands 1, 2 and 3 with false colours of the study area (The original photograph is coloured.)
B, Interpretation map of SPOT image showing bedding traces and lineaments

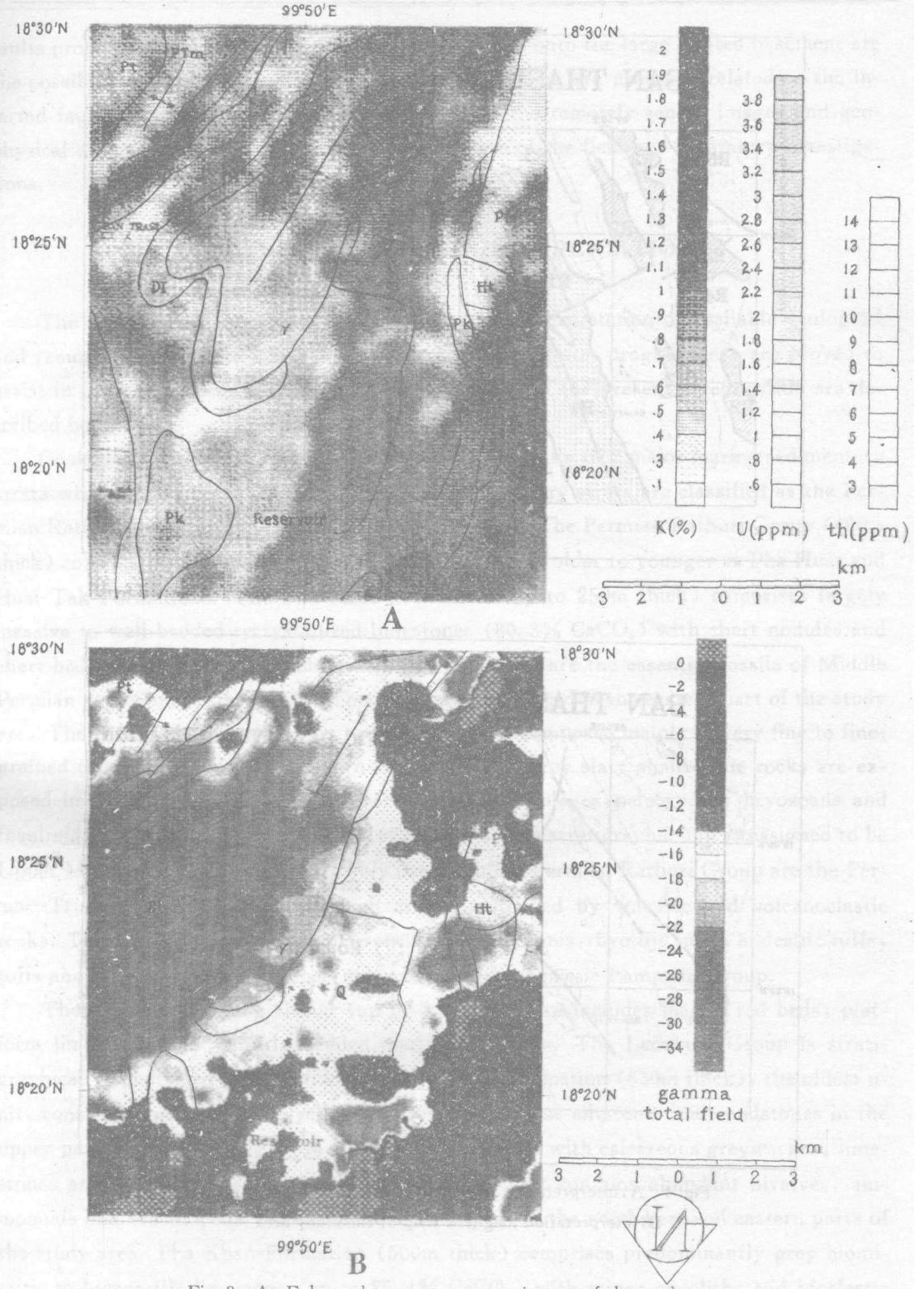
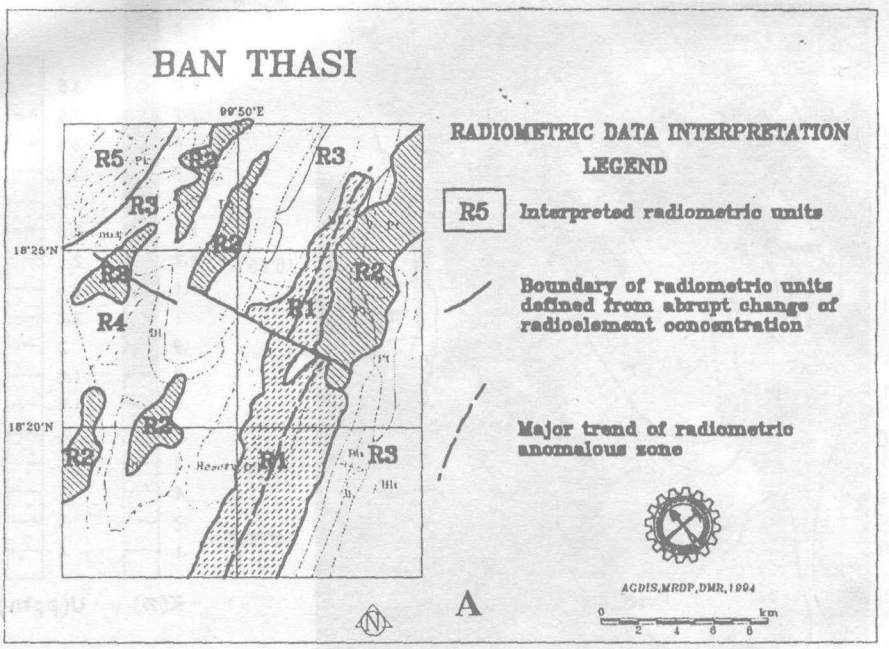


Fig. 3　A, Enhanced ternary radiometric map of the study area;
B, Enhanced total magnetic field map of the area (The original photographs are coloured.)



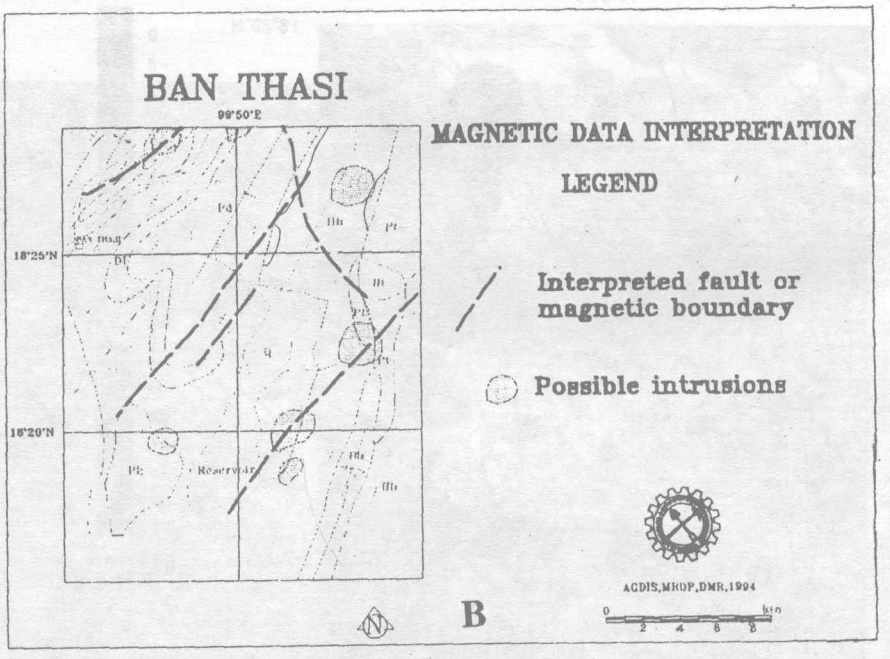


Fig. 4 A, Interpretation radiometric map of the study area;
B, Interpretation magnetic map of the study area

faults probably related to the basement. Superimposed onto the large faulted basement are the possibly small intrusions (Fig. 4B), several of which are probably related to the inferred faults. In general, the results analyzed from the remotely-sensed images and geophysical data are more or less compatible with those of the field and laboratory investigations.

GEOLOGY AND TECTONIC IMPLICATION

The current data integration, enhancement and interpretation of available geological and remotely-sensed data which were processed by computer programmes, are proved to assist in geological studies of the study area. Results of the present investigation are described below.

Geologically, the Ban Thasi area comprises principally of 2 major marine sedimentary strata with minor volcanic rocks. The marine sedimentary strata are classified as the Permian Ratburi Group and the Triassic Lampang Group. The Permian Ratburi Group (400m thick) consists mainly of two geological rock units from older to younger as Pha Huat and Huai Tak Formations. The Pha Huat Formation (up to 250m thick) comprises largely massive to well-bedded recrystallized limestones (80.3% $CaCO_3$) with chert nodules and chert beds. Brachiopods, crinoids, corals and fusulinids are the essential fossils of Middle Permian age (Supananthi, 1993). The rocks are distributed in the eastern part of the study area. The Huai Tak Formation (up to 100m thick) is composed mainly of very fine to fine-grained clastic rocks including brown shale and dark grey slaty shale. The rocks are exposed in small undulating areas. Several fossil assemblages, pelecypods, bryosoans and fusulinids, were reported by Piyasin (1972). Age of this stratigraphic unit is assigned to be Upper Middle Permian. Unconformably overlying the Permian Ratburi Group are the Permo—Triassic Mae Man Group which are characterized by volcanic and volcanoclastic rocks. These include dark brown to greenish gray rhyolites, rhyolitic tuffs, andesitic tuffs, tuffs and agglomerates. This rock unit underlies the Triassic Lampang Group.

The Triassic Lampang Group (up to 3,700m thick) includes mainly red beds, platform limestones, and thickly bedded marine turbidites. The Lampang Group is stratigraphically subdivided into 5 formations. Phra That Formation (830m thick), the oldest unit, consists largely of red to yellowish brown tuffaceous siltstones and sandstones in the upper part and grey to pale green shales and mudstones with calcareous greywackes, limestones and conglomerates in the upper part. The unit contains abundant bivalves, ammonoids and brachiopods. The rock strata distribute in the northwest and eastern parts of the study area. Pha Khan Formation (500m thick) comprises predominantly grey biomicritic to biosparitic limestone (up to 85.4% $CaCO_3$) with minor oncoliths and bioclastic limestones, grey to green shales and sandstones. The unit contains characteristic fossils of Middle to Late Triassic, such as ammonoids, bivalves and brachiopods. The major ex-

posed areas are in southern and northwestern parts. Hong Hoi Formation (1,350m thick) is composed largely of turbidite sequences including grey to greenish grey shales, sandstones, siltstones and conglomerates with minor limestone lenses. The formation contains abundant bivalves and ammonoids, particularly in the central part. Doi Long Formation (200m thick) is composed mainly of grey to light grey lithographic to micritic limestones (av. 69.5% $CaCO_3$ and 8.9% $MgCO_3$). The unit contains few undeterminable faunas, brachiopods and gastropods of Late Triassic age. In several places the unit is interfingering with the Hong Hoi Formation. The unit is thought to form as large lenses lying at the uppermost part of the Hong Hoi Formation. Pha Daeng Formation (up to 850m thick) consists mostly of reddish brown shales and sandstones with multiscale cross beds in the upper part, and grey to red basal limestone topolymictic, para- to ortho-conglomerates with ripple marks and cross-beds in the lower part.

The regional structure of the area is a large syncline in the center with samll anticlines in the northwestern and eastern parts. The other important structural features detected from the enhanced images are the NE-trending fault system (Fig. 2). The main fault direction conforms with that of the major Mae Tha and the Uttaradit Faults in northern Thailand.

From the above geological information, paleoenvironments and tectonics of the area can be interpreted. All the rocks were deposited in the tectonic Lampang Basin at the easternmost part of the Shan-Thai craton. The Permian carbonates may have occurred in the shallow open marine shelf of the passive continental margin. Later volcanic activity may have taken place during Permo—Triassic period and produced rhyolitic to andesitic volcanics and volcanic clastics, possibly indicating the east-dipping subbuction zone beneath the Shan-Thai craton. Then, the back-arc basin deposition of the Phra That clastic sediments occurred in the basin as a shallow marine condition, in part with subaqeous nonmarine environment. Subsequently, deposition of the Pha Khan non-clastic sediments may have taken place in a shallow marine, ramp platform in a rift basin. Then the basin may have become closer and subsided as the Shan-Thai and Indochina blocks become closer and the deposition of the thick sequences of Hong Hoi clastic sediments developed in the rapidly subsiding basin. Non-clastic sediments of Doi Long Formation was deposited in the shallow marine drowned ramp platform basin. During the Late Triassic Shan-Thai may have collided with Indochina and the basin may have been closed and uplifted. As a result, the Pha Daeng clastic red beds, equivalent to the Khorat Group, may have taken place as non-marine, mollasse-type sediments either in the uppermost part of the Lampang Group or the lower Khorat Mesozoic Group.

CONCLUSION

1. The SEDBA Programme is considered to be a good, reliable programme for sedi-

mentary database and the AUTOCAD Programme is regarded as a fairly good programme for processing the geological maps. The MERIDIAN and GEOSOFT programmes are most appropriate for enhancement and compilation of the remotely sensed images and geophysical data, respectively. The combination of the enhanced remotely sensed images and geophysical data can decipher the subsurface geological features. Therefore, all the PC-type programmes are regarded to be successfully applied to geological studies.

2. The Permian to Triassic sediments and volcanics were recognized in the study area. They are mostly marine strata with minor nonmarine beds. They are believed to have formed in the tectonically subsiding Lampang Basin prior to the Late Triassic to Early Jurassic continental collision between Shan-Thai and Indochina blocks.

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