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Application of Airborne Geophysics to the Interpretation of Geologic Setting in Nan-Uttaradit Area, Northern Thailand

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ABSTRACT

This investigation is aimed to process airborne magnetic and radiometric data by various techniques. We applied RTP, vertical derivative for airborne magnetic data and Cooking Technique for airborne radiometric data. Three magnetic domains have been identified, namely northern, central and southern domain. The central domain is a significant highly anomalous NE-SW trending narrow zone, possesses high magnetic and low radiometric intensities. This central high is enveloped by very low magnetic and high radiometric intensities. Both of the north and south domains, which roughly orient in the N-S trend, exhibit low magnetic and various radiometric intensities with the sporadic high magnetic patterns. The high magnetic anomalies in this area has been recognized in 2 patterns, elongate pattern located in central high and circular pattern located in the northernmost area. The polarity of magnetic bodies was identified by magnetic modeling program and shows the well-defined east-dipping direction. It can be summarized that the Nan suture shows eastward-dipping anomaly indicating the eastward polarity of the plate, by the collision tectonic setting. Therefore, it is ascertained that the Nan suture zone can be well delineated from this study.

Keywords: Tectonic, Nan Suture, Airborne Geophysics, Remote Sensing, Subduction

1. Introduction

Nan suture in northern Thailand is a complex zone with intricate geology and structures (Figure 1). It has been selected for petrochemical and geophysical investigations. Nan suture is first mentioned by a pioneer Thai geologist (Bunopas, 1981) to be a continent-continent collision between Shan-Thai and Indo-China blocks. Barr and Macdonald (1987) suggested that the Nan-River Suture zone consists of ophiolite suit dominated by ultramafic rocks. The zone formed in back-arc or inter-arc setting in Pre-Permian age. Panjasawatwong (1991) studied chromian spinel in this area and the spinel also indicated arc-related magma that was crystallized from highly refractory melt, probably generated in a suprasubduction zone. Singharajwarapan and Berry (2000) conclude that Nan Suture is a serpentinitic mélange, thrust slice, accretionary complex occurring during Late Permian. They also mentioned that the suture is an oceanic crust subduction with westward dipping.

Department of Mineral Resources (DMR, 1988) has launched a nationwide airborne geophysical survey including magnetic, radiometric and electromagnetic surveys in order to locate potential areas. This survey is target to find anomalies related with the potential areas of mineral resources. After finishing airborne magnetic survey, there are many follow-up field studies to identify what was affected to anomalies and to find potential area for detail study. Two areas of chromite prospects were found in Ban Had Ngew and Ban Huay Phung in Uttaradit province.

Dechawan (1992) operated ground survey exploration by using MaxMin-I EM magnetometer and Induced polarization in Sirikit dam area (Map Sheet 5144-IV). There are some potential areas for chromites, magnesite and talc were encountered in mafic and ultramafic rocks. Neawsuparp (1997) applied airborne magnetic data with Landsat Thematic map to study relationship between structural geology and mineral occurrences in Uttaradit area nearby Sirikit Dam area. Therefore the DMR airborne geophysical interpretation was mainly focusing on defining potential mineral areas and Nan Uttaradit area is one of the target areas. In this study, the purpose of this investigation is to use airborne geophysical data to interpret essential geological structures to clarify the understanding of tectonic settings along the Nan suture zone.

2. Geologic Setting

Bunopas (1978) named "Nan-Uttaradit Geosuture" whereas Barr and Macdonald (1991), and Metcalfe (1997) concluded that Nan-Uttaradit Suture is formed by continental collision of Shan Thai and Indochina continents in Late Triassic. Charusiri (1997) believe that there are one more sutures between two continents (Loei Suture in the east and Chiang Mai suture in the west). They also considered that there was paleotethys developed between Shan Thai and Indochina continents, which were terminated in Late Triassic.

The Nan and Uttaradit area is mostly covered by sedimentary rocks of Late Paleozoic to Holocene. Sedimentary Stratigraphic listed from Phasom Group, Lampang Group, Nakhon Thai Group and Cenozoic Sediments and Rocks (Oldest to youngest respectively). Igneous and Metamorphic rocks listed from Pha Som Igneous Rocks, Mae Man Volcanics, Nan–Uttaradit Plutonics, Nam Nan Volcanics and Huai Krai Volcanics (Oldest to youngest respectively).

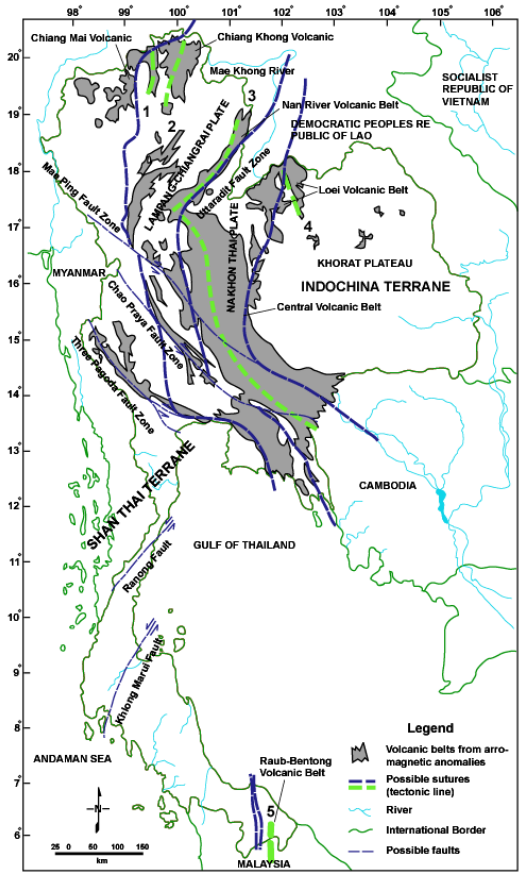

Figure 1. Tectonic map showing major tectonic blocks (or plates) and faults in Thailand (Modified after Tulyatid and Charusiri, 1999 and Charusiri et al., 2002).

3. Data Processing

3.1 Airborne Magnetic data

Airborne magnetic data interpretation of the study area is aimed to analyze anomalies, patterns and variation, correlated with geologic structures obtained from other data to comprehend the geologic and tectonic settings in this area. The sources of airborne magnetic data in this study are based on nationwide database. Many enhanced techniques are applied to display the magnetic body characteristic (pattern, amplitude, trending and boundary). Several enhancement methods have been applied for the airborne magnetic data of the study area. There are

reduction to the pole technique (Figure.2-a), first vertical derivative technique (Figure.2-b), secondary vertical derivative technique (Figure.2-c).

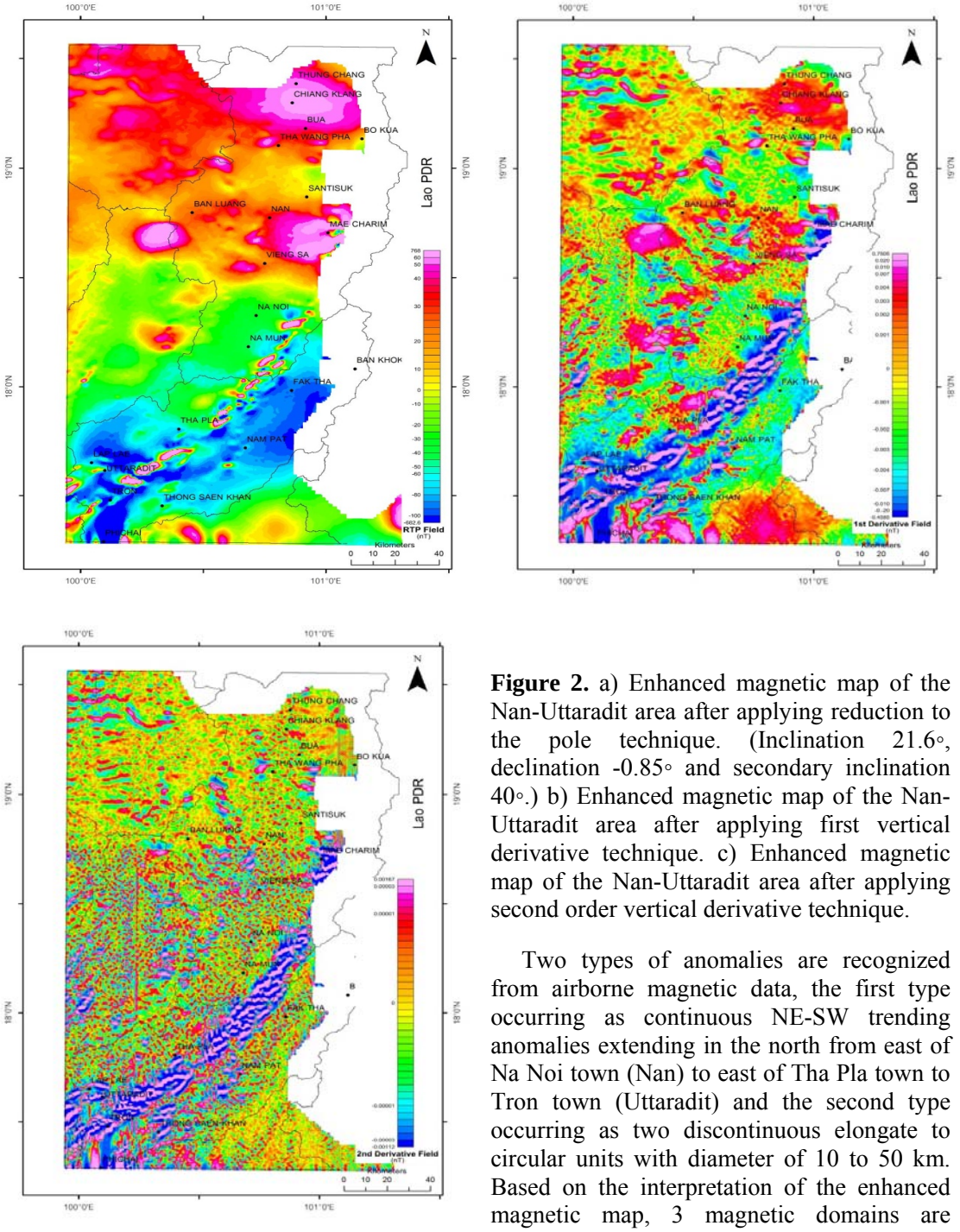

Figure 2. a) Enhanced magnetic map of the Nan-Uttaradit area after applying reduction to the pole technique. (Inclination 21.6◦, declination -0.85◦ and secondary inclination 40◦.) b) Enhanced magnetic map of the Nan-Uttaradit area after applying first vertical derivative technique. c) Enhanced magnetic map of the Nan-Uttaradit area after applying second order vertical derivative technique.

Two types of anomalies are recognized from airborne magnetic data, the first type occurring as continuous NE-SW trending anomalies extending in the north from east of Na Noi town (Nan) to east of Tha Pla town to Tron town (Uttaradit) and the second type occurring as two discontinuous elongate to circular units with diameter of 10 to 50 km. Based on the interpretation of the enhanced magnetic map, 3 magnetic domains are identified.

The northern domain with low to moderate values, the central domain with very high values and the southern domain with low magnetic values.

3.2. Airborne Radiometric data

Radiometric survey is aimed to detect the natural radioactive emanations from rocks and soils. All detectable radiation come from the natural decay products of only three elements, uranium, thorium, and potassium at the surface of the ground. The radiometric survey is aimed to determine relative amounts of U, Th and K in the surface rocks and soils. This study used Cooking technique to determine the intensity of radioactive elements. The red color is assigned to uranium, green and blue are to thorium and potassium respectively. Pairing of U, Th and K are examined to see how they relate to each other and how they are different from the total count (Figure 3-a).

From the enhancement ternary map (Figure 3-b). The very low content on scale bar are in dark blue and blue green colors and the very high content shows in red and pink color. The interpretation of the total counts contents map shows various values of content, which can divide into 3 different domains. The southern domain shows low to very low contents, the central domain shows very low content incorporated with moderate to high content. It can be spitted into three sub domains (upper, central and eastern sub domains) with the lineaments similar to those of the other previously shown uranium, thorium and potassium maps. The central sub domain shows outstanding low contents. The northern domain showing high to very high total counts contents. This domain is separated into three major sub domains with actuate boundaries similar to those of the other maps. The high contents show as large spots within the N-S trending actuate zone in the western sub domain. The eastern and central sub domains displays smaller patch of high content.

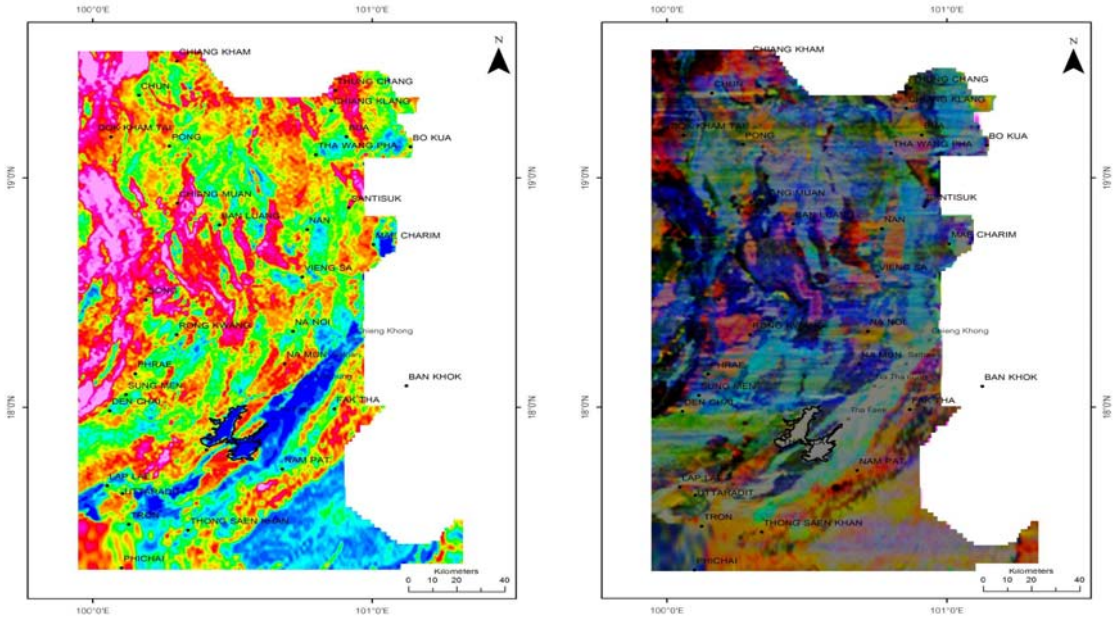

Figure 3. a) Airborne radiometric map of study area showing the Total Count (TC). (Sirikit reservoir boundary in black). b) Ternary map of the Nan-Uttaradit area. Noted that Sirikit reservoir is boundary in black.

3.3. Geophysical Cross Section

After the division of magnetic domains, cross-sections of the magnetic data were made in the NW-SE direction as shown in Figure 4. Special attention is focused on the central domain where structures and geology are much outstanding (see earlier section). Nine lines of sections were constructed from Na Noi in the north to Phi Chai in the south perpendicular to the main or regional trend of the central domain. It is quite interesting to note that all the sections show quite similar orientation of anomalous bodies in that they are dipping to the east (Figure 5a-c).

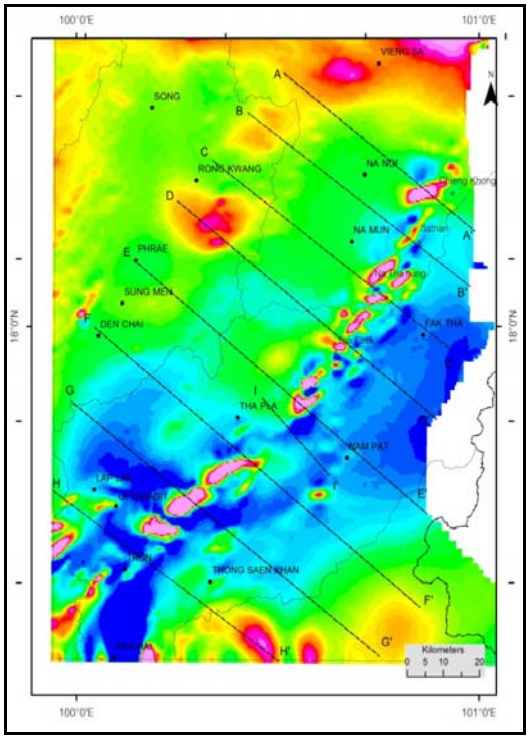

Figure 4. The aeromagnetic RTP map of the Nan-Uttaradit area showing selected lines of cross sections used for interpretation shown in Figure 5.

From previous studies of the Nan Suture, not many geoscientists described and delineated the location of the Nan suture correctly. There are still unclear to locate the boundary of Nan Suture. However, in this study the location and boundary by magnetic data of anomalies zone is better defined. Figure 6 show the "Real" location and Boundary of Nan Suture.

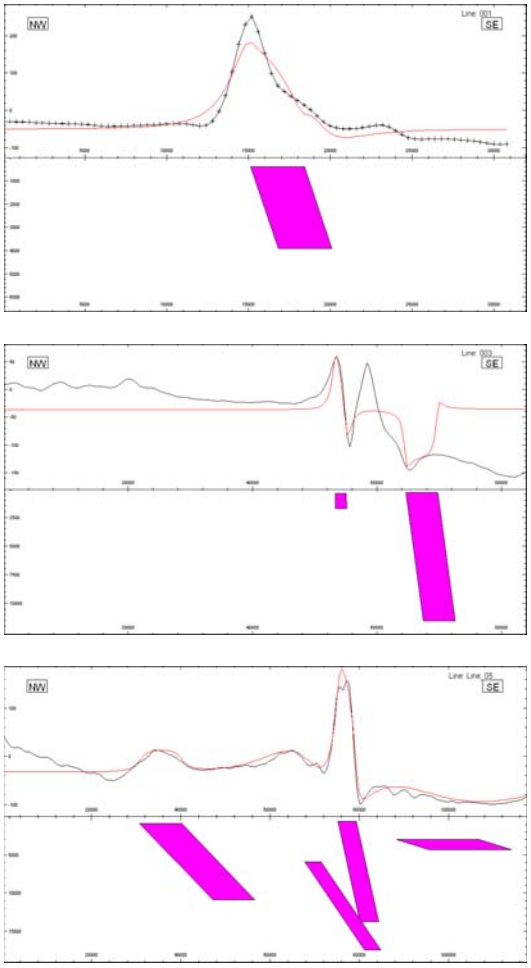

Figure 5. a) airborne magnetic cross section of the Nan-Uttaradit area showing the interpreted magnetic anomaly bodies of line A-A'. b) airborne magnetic cross section of the Nan-Uttaradit area showing the interpreted magnetic anomaly bodies of line C-C'. c) airborne magnetic cross section of the Nan-Uttaradit area showing the interpreted magnetic anomaly bodies of line E-E'.

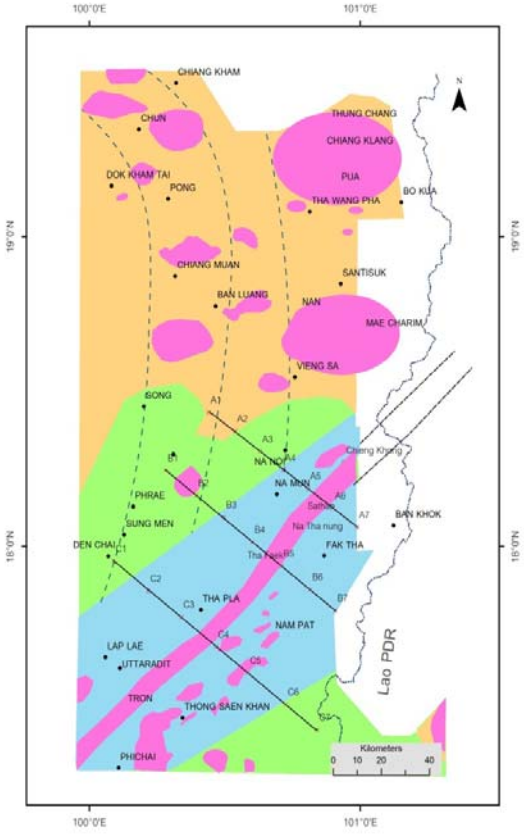

Figure 6. A more-well-defined boundary of the Nan suture (or tectonic line) identified from this study (pink zone). Noted that the more suitable technical term is "the Nan tectonic line".

The airborne geophysical survey result implies that the central domain of high magnetic and low radiometric intensities has been identified clearly. However, if the enhanced RTP maps have been applied, then the central domain can extend extensively southwestward and northeastward. To the south, the possible extrapolation is that this tectonic line appears along the Sukhothai River and is later obscured by the disturbance of the Mae Ping Fault movement. The suture zone of Thailand earlier reported by Tulyatid &Charusiri (1993) can help to define this suture after using the present enhancement process. The high magnetic and low radiometric intensities in the Mae Cha Rim district may be due to the branching of the central domain "a tectonic line" due to the effect of up thrusting similar to the southern part of the central domain. Charusiri et al. (2000) suggested a new micro plate between Shan Thai and Indochina plates, namely Nakhon Thai in the east and Lampang Chiangrai plate in the west separated by Nan suture (or tectonic line) and the associated arc-trend and back-thrust unit.

4. Discussion and Conclusion

Airborne geophysical interpretation of the Nan-Uttaradit reveals 3 contrasting domains, namely Northern, Central and Southern domains. The Northern domain is characterized by low magnetic intensities with sporadic high circular anomalies of various sizes (5 – 50 km radius). The largest anomaly is on the eastern domain in Chiang Klang district and Mae Charim district. They align in the N-S direction. The central domain consists of 3 sub parallel zones with the high magnetic spots in the inner zone and the other zones are the upper and lower zones, which show weak magnetic and high radiometric intensities. The high magnetic bodies have the average radius of 5.6 km. They align in the NE-SW direction. The inner zone of the central domain extends northeastward to Lao and southeastward to Sukhothai area. The southern domain generally shows low magnetic responds with the N-S trending pattern and few bodies (3-5 km radius) of high magnetic signatures. This research is mainly focused on the result from airborne magnetic and airborne radiometric data interpretation to delimitate the boundary of the Nan-Uttaradit area. Further work should be placed on the field evidence to verify the real structure, which can be, validated the geology more clearly.

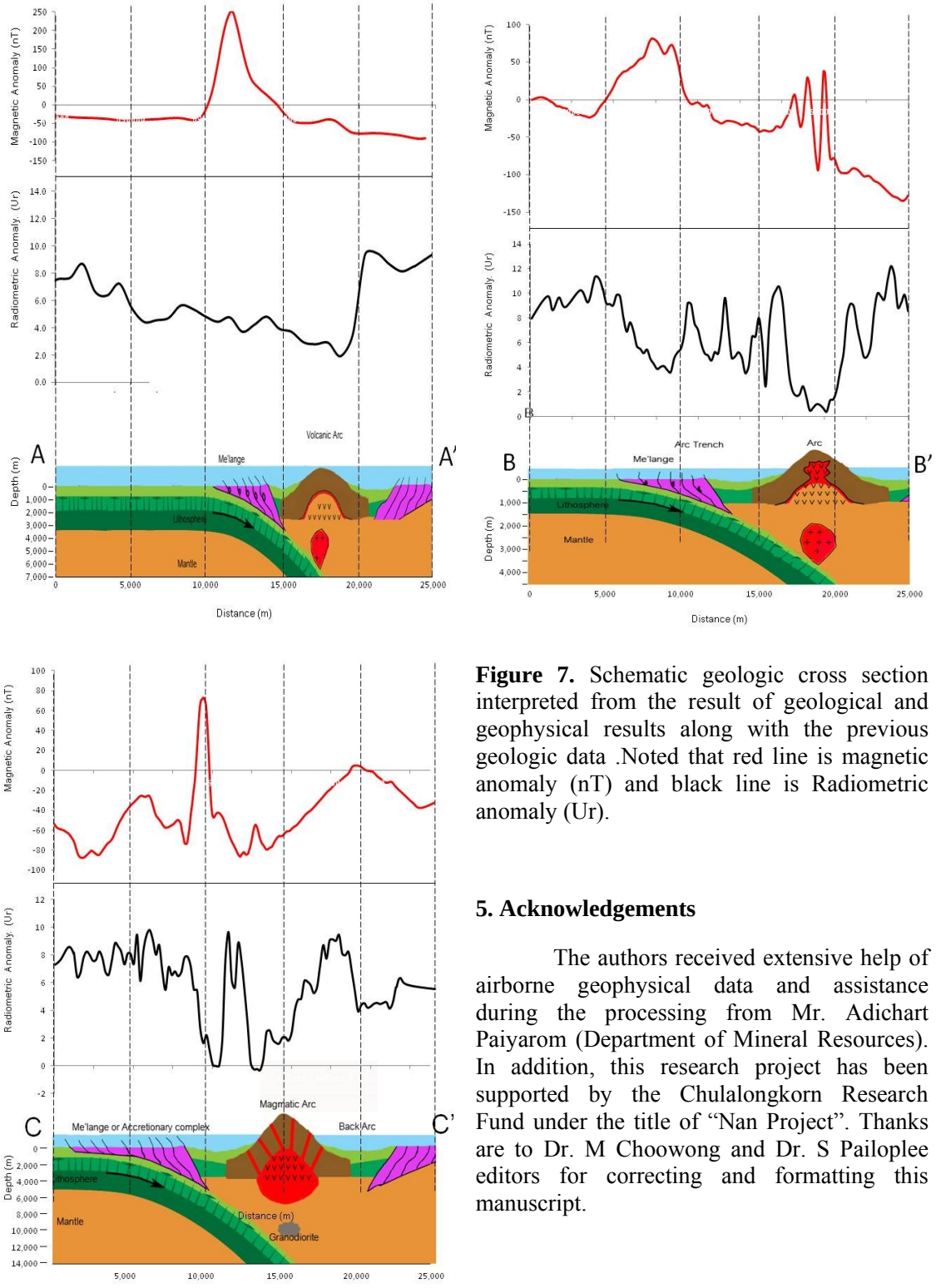

Figure 7. Schematic geologic cross section interpreted from the result of geological and geophysical results along with the previous geologic data .Noted that red line is magnetic anomaly (nT) and black line is Radiometric anomaly (Ur).

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