Chapter 1

Introduction

Airborne magnetic and electromagnetic and remote sensing methods are used for geological exploration to get information about subsurface geology under vegetation and regolith cover. These types of methods can be used to identify rock units and major structures by applying filter enhancements, image processing and interpretation methods. In addition, these types of data are useful for identifying target areas for mineral explorations.

1.1 Background and problems

Loei area, the major province located in the northeastern Thailand, has been a focus of interest due to its significant mineral resources. This area is selected to search for mineral deposits by using airborne geophysical surveys performed by the Department of Mineral Resources (DMR) (Galong et al., 1999). Heliborne geophysical surveys flown at 60m terrain clearance and 400m-line spacing measuring frequency domain electromagnetic (EM) and magnetic fields was surveyed by Kenting Earth Science International Limited (KESIL), Canada, in 1987-1988. These geophysical data were used for mineral exploration (Galong and Tulayatid, 1992; Rangubpit, 2003), and for preliminary study structural interpretation in the Loei area (Neawsuparp and Charusiri, 2002)

The Loei area is an eroded collision zone and consists of complex rocks and structures. Geological mapping and mineral exploration are problematical because Cenozoic sediments and high rugged topography cover most of the area. Previous studies include ground geological mapping, geochemistry and geophysical surveys in the area, which are scattered and restricted to areas of outcrop. It is necessary to explore vest areas of cover to make new discoveries. To explore covered areas, we need to rely on modern techniques to identify target area for mineral exploration and to redefine the tectonic elements.

Airborne geophysical data, can be used to identify rock units and major structures by applying various filter enhancements to display anomalies as an image with obviously improved information content. In addition these images, data can be used to study the tectonic setting (Gunn, 1997; Milligan and Gunn, 1997).

Understanding the geology and tectonics of region is crucial to mineral exploration area selection. Tectonic settings are related to the major geological features, which can be associated with economic mineral deposits depending on the styles and types of mineralization (e.g., Mitchell and Garson, 1984; Hutchison, 1985).

The tectonic evolution of Thailand has been studied by several geologists, such as Bunopas (1981, 1988, 1991), Bunopas and Vella (1983, 1992); Chuaviroj (1997); Meesook (1994); Intasopa (1993) and Charusiri et al. (1994, 1997). The models of Bunopas (1981, 1988, 1991) are based on accretion of micro-continents and are accepted in principle.

Thailand consists of two main micro-continental plates, the Shan-Thai and Indochina plates, which collided in the Late Palaeozoic. The Shan-Thai plate is located in the eastern part of Myanmar and the western part of Thailand, continuing in a north-south trend and can be traced to the eastern side of Sumatra. The Indochina plate covers the northeastern part of Thailand, Laos (Lao PDR), Cambodia, and Vietnam. The contact between the Shan-Thai and the Indochina plates is represented by the Nan Suture Zone. Charusiri et al. (1997) has described the Chiang Mai Suture in the Shan Thai micro-plate and the Loei suture in the Indochina plate. Two-fold belts called the Sukhothai and Loei fold belts are located to the west and east of the Nan Suture, respectively.

The Loeí area is located in the western part of the Indochina plate (Bunopas, 1992). The Shan-Thai and Indochina plates moved together in an east-west direction, therefore the sedimentary rock units are pressed into fold and faults trending north-south. Palaeozoic sedimentary rocks occur in the passive continental margin of the Indochina plate (Bunopas, 1981; Workman, 1975) and the paleo-environment is dominantly marine. The main rock types are shale, sandstone, silstone, chert, and limestone of Silurian to Permian age. These rock units are distributed widely in the central and eastern part of the area trending north-south. Some of these rock units are metamorphosed to quartzite and phyllite. In the Mesozoic to Cenozoic, non-marine sediments are deposited due to land uplift. Red-bed continental sedimentary rocks such as sandstone and siltstone were deposited in the Triassic to Cretaceous, and are distributed in the southern and southwestern part of the area. Plutonic igneous rocks occur as stocks and dykes, and mostly consist of granite, granodiorite and hornblendite. Volcanic rocks are found as lava flow and phyroclastic rocks consisting of basalt, andesite, rhyolite and tuff. Igneous rocks are Permian to Triassic. The volcanic rocks may relate to tectonic activities, especially from subduction and collision between the Shan-Thai and the Indochina plates.

However, the most studies of tectonic evolution in Thailand are based on the stratigraphy rocks and biogeography. Moreover, the considerations are concentrated in the Shan-Thai plate. There is little publish information on the Indochina plate, and the tectonic model is not understood.

As mentioned above, the main hypothesis of this study is to use the airborne geophysical data integrated with remote sensing, geological mapping and digital elevation data to identify tectonic settings related to the structures and mineral deposits in the Loei area. A new advanced processing and interpretation of the magnetic, electromagnetic radiometric, gravity, and remote sensing data, by using new software programs, has been performed and field verification is also presented in this study.

1.2 Literature review

Geophysical survey data have been used to study structural geology and tectonic setting covered by sediments and/or in rugged topography. To study a characteristic of subsurface features, magnetic and gravity data are used to interpret geometry of structures and rock units. Gunn (1997a) used magnetic and gravity data to construct a model of rifting related with the tectonic process and summarized magnetic and gravity responses in relation to the tectonic setting locations (Gunn, 1997b). Moreover, Milligan and Gunn (1997) reviewed processing enhanced methods for airborne geophysical data prior interpretation. Lemixex et al. (2000) presented an integration of seismic and potential data for studying crustal geometries and tectonic evolution. Naidu and Mathew (1998) used directional filtering and angular spectrum methods of aeromagnetic data to identify faults. Rybokov et al. (2000) observed structural features in subsurface geology by using 3-D forward and inverse magnetic and gravity modelling with updated petrophysical data. Fedi and Rapolla (1999) proposed novel 3-D inversion techniques to identify a depth resolution for the potential field methods. Pilkington et al. (2000) used the integration of enhanced magnetic and gravity data to interpret structures and rock domains of a basin by applying reduction to the pole, Euler deconvolution, pseudogravity gradients and analytic signal processing. Besides the geophysical data, remote sensing data are also used to study major structures, geological mapping and mineral exploration. Lineaments on the Landsat imagery can map faults affected from tectonic activities. Abrams et al. (1988) enhanced the thematic mapper (TM) Landsat data to identify boundary around ophiolite complexes. Crosta and Moore (1989) applied the TM Landsat images for geological mapping in Oman. Katz (1982) presented the lineament analysis from TM Landsat for mineral prospecting in humid areas.

The Loei area has been surveyed and studied by several geoscientists in the context of geological mapping, geochemistry, structural geology and mineral deposits. Geological mapping of the Loei area is presented at several scales, such as 1:250,000 by Chareonpawat et al. (1975), 1:100,000 by Mineral Resources Development Project (1988) and 1:50,000 by Chairangsee and Machareon (1985); Chairangsee et al. (1986); Silapalit and Chairangsee (1982,1983); Nakhonsee and Silapalit (1986), and Kittisan (1985). In addition, Intasopa (1993) and Charusiri (1989,1994) studied the age of igneous rocks in this area by dating and geochemical methods. Regional structural geology in the Loei area was reported by Workman (1975); Bunopas and Vella (1983); Altermann (1989) and Tanomsup (1990). Mineral prospecting reports by Bleakley et al. (1965); Jacopson et al. (1969); Chaodumrong et al. (1983); Laosu (1988); Phuttapiban (1987) and Kulmarajan (1987), show that the Loei area is a high potential area for mineral deposits. Jantaranipa et al. (1981) applied multispectral scanner (MSS) space-borne images to visualize lineaments for mineral target areas. Neawsuparp and Charusiri (2000) studied lineament analysis determined from Landsat TM in the Loei area. Seusutthiya and Maopeth (2001) studied petrography and geochemistry of ultramafic rocks in Ban Bun Tan, Suwan Khuha, Nong Bua Lumphu Province. Moreover, Panjasawatwong et al. (1997) studied geochemistry and the tectonic setting of eruption of central Loei area volcanics in the Pak Chom area.

Two researches were carried out using airborne geophysical information in the Loei area. Firstly, Galong and Tulyatid (1992) presented airborne radiometric data for adding geological mapping and electromagnetic data for mineral exploration in the eastern part of the Loei area. Secondly, Rangubpit (2003) applied image processing and interpretation of aeromagnetic and resistivity data in Ban Yuak and Ban Sup, located between Loei and Udonthani provinces. However, these papers are mainly concerned with delineation of new geological boundaries and suggest the occurrence of possible mineral deposits.

Tectonically, the Loei area is situated in the "Loei Fold Belt" (Bunopas, 1992) or the easternmost part of the Nakhon Thai tectonic block (Charusiri et al., 2002). They also proposed the Loei suture within the Loei area for the boundary between the Indochina and the Nakhon Thai tectonic plates. However, the Loei Suture as proposed by Charusiri et al. (2002) is under the thick regolith. Therefore, it is difficult to confirm the subsurface geometry of the Loei Suture.

It is clear that the Loei area has been surveyed and studied by several geoscientists, particularly during surface geophysical mappings and only some subsurface mappings. Subsurface geologic mapping has never been performed by integrating of geological and geophysical results, and no attempt has been made to understanding the detailed relationship between structural features observed on the ground and the subsurface structural features observed in geophysical data.

1.3 Aim and scope of work

The aim of this study is to locate and identify geologic features, tectonic setting, reconstruct geological and structural mapping, and create a subsurface structural model correlated with mineral deposits in. the Loei area by using the airborne geophysical and remote sensing data.

Airborne magnetic, electromagnetic and remote sensing (TM Landsat) data are enhanced by applying advanced processing and new software. The existing data such as gravity, radiometric, topography, geological map and mineral occurrences are integrated to interpret subsurface structures hosting mineral deposits in the study area. Interesting anomalies in the area are verified in the field and selected rock samples collected to determine physical properties. The modelling of subsurface structures, rock units and new interpretation map of the Loei area are carried out.

1.4 Location of study area

The area under investigation, covers about 5,280 sq km, is located between lat 17° 15'-18° 15' N and long 101° 15'-102° 15' E. The study area encompasses the northern part of the Loei and Nong Bua Lumphu provinces in northeastern Thailand (Fig.1.1).

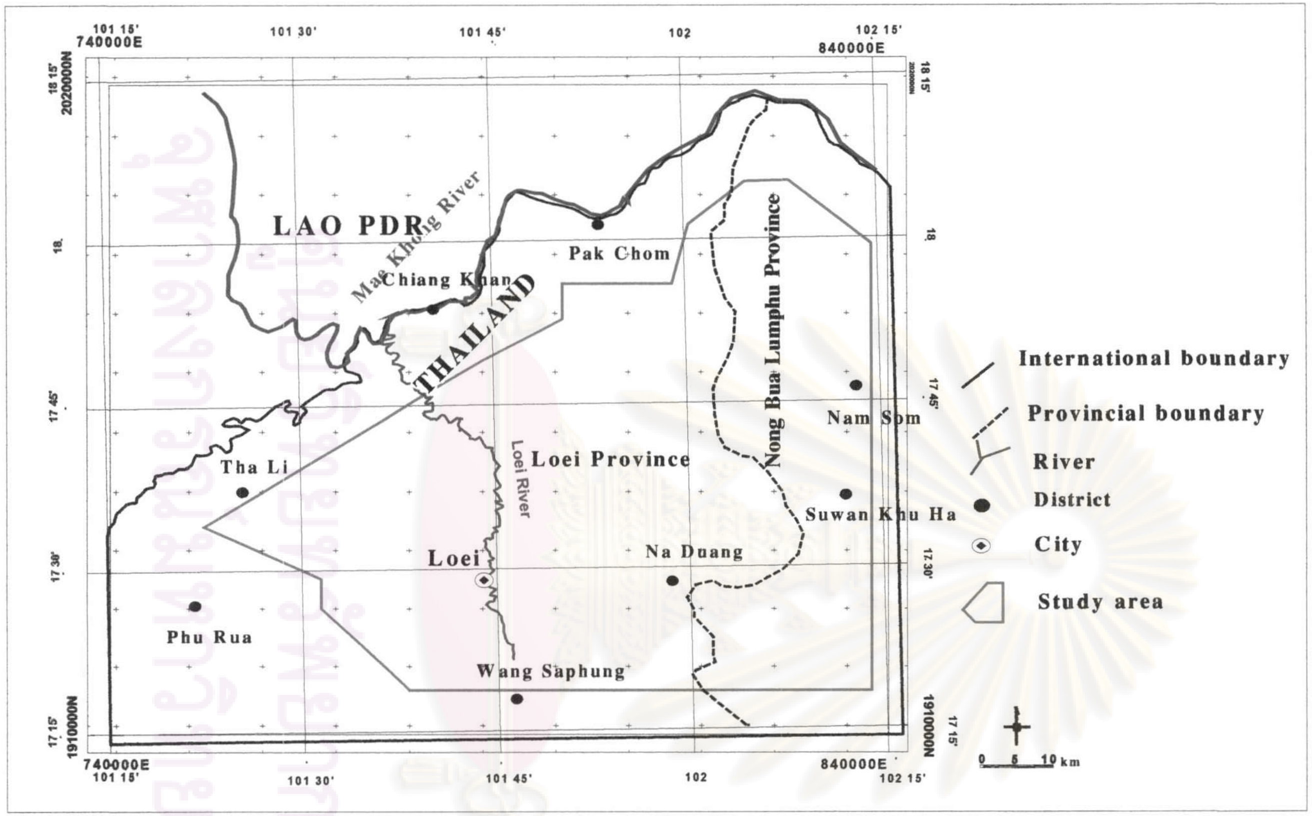

Figure 1.1 Index map and location of study area.