Chapter3

Data sets

The purpose of this study is to present a detailed geological interpretation of the Loei area by using enhanced airborne geophysical data integrated with remote sensing data, previous geological mapping and GIS information (Fig.3.1). The airborne geophysical and geological data are selectively acquired the Department of Mineral Resources (DMR) of Thailand. The main data set used in this study is comprised of a high-resolution airborne geophysical survey which has 400m line-spacing and at 60 m above ground level that was used by the Mineral Resources Development Project in 1984 to interpret basement geology. It is expected that the result of interpretations should help developing and evaluating the structural features in deep part as well as for understanding of regional geology related to tectonic history in the Loei study area.

3.1 Airborne geophysical data

3.1.1 Previous airborne geophysical data

Regional airborne geophysical data in Thailand has been surveyed in early 1984. Survey methods include magnetics, radiometrics and electromagnetics at different line spacings and elevations, depending on the purpose of work. All of the airborne geophysical surveys were performed by the Department of Mineral Resources of Thailand.

The first airborne geophysical surveys measuring aeromagnetic data were flown in some parts of Thailand area in 1984 (called Survey A). These surveys were flown by fixed wing aircraft at 1 km line spacing in the north-south direction at elevations ranging from 305 m to 2,286 m above Mean Terrain Clearance (MTC). Sampling interval survey was flown with 0.25s (=25m) by using Varian Optically Pumped Cesium Vapor sensor, with a total of 439,599 line–km covered over areas totalling 440,000 km^2.

In 1985-1987, the geophysical survey B and survey C were operated with a total of 300,000 line-km, covering an area of 430,000 km^2 by using magnetometer of Geometric G813 proton precession with noise envelope less than 1 nT. The main aim of this survey was for radiometric measurements. This survey was flown at 120 m MTC with 1, 2 and 5 km line spacing in an east-west direction. The difference between Survey B and Survey C indicates the types of aircraft used in the surveys. Survey B was flown by twin engine fixed wing aircraft over low relief terrain while Survey C was helicopter-flown over rugged terrain mostly in the west of the country. Aircraft used on the radiometric surveys were also equipped with magnetometer and VLF-EM sensors.

For this study, radiometric data from the survey B and C are used for identifying rock types. However, the line spacing and survey elevations are too large, so the radiometric data are useful for recognizing the boundary of rock units.

3.1.2 Airborne electromagnetic (AEM) follow-up survey

Airborne geophysical surveys in 1988 were conducted over five selected areas in Thailand. Loei is one of selected areas for mineral prospecting in Thailand. The AEM Follow-up survey of the Loei area was applied by using helicopter to measure electromagnetic responses at three specific frequencies and to map the magnetic field. This survey was performed by the Mineral Resources Development Project (MRDP) of DMR, and surveyed by Kenting Earth Sciences International (KESIL) in Canada using a Bell 412-helicopter system.

The survey area covered the northern part of Loei province and Nong Bua Lumphu Province, Northeastern Thailand. A total of 13,265 line-kilometers covered approximately 5,280 square-kilometers with flown at 60m (196.85 ft) above the ground level. The nominal flight lines traverse in an east-west direction, which has spacing of 400 meters for the entire survey. The control lines were oriented orthogonal to the traverse lines and spaced at approximately 5.5 kilometers.

The field operation was extended from January 29 to March 24, 1988. Data compilation, processing and pre-interpretation report were done in Canada in June 1988 until December 1989. The raw data, final map, digital products and report were completed in December 31, 1989.

3.1.2.1 Aeromagnetic data acquisition

Aeromagnetic measurements collected using a proton precession magnetometer model G-803 manufactured by Geometrics of California, USA. The console was housed in the equipment rack, and the magnetic sensor was towed in a 2 m bird towed at 10 m below the helicopter. This instrument measures the earth's total magnetic field strength by means of the precession of spinning protons, which have magnetic moment in a hydrocarbon fluid. The spin axes are normally oriented and process about the earth' magnetic field direction. To make a measurement of the earth's magnetic field, a polarizing field at a high angle to the earths is impressed on the nuclei for a short period aligning or polarizing the magnetic moments. When the field is removed the moments process around the direction of the earth's magnetic field with a frequency that is proportion to the earth's magnetic field strength. This frequency is sensed by the same coil as that used to generate the polarizing field and is of the order of 1,700 Hz in a 40.000nT field. The constant of proportionality is 23.4874nT per Hz (KESIL, 1989).

The output of the magnetometer was non-continuous, and the sampling interval was chosen as a multiple of the scan rate of the digital acquisition system. All of the sampling interval was set at 1.0 second combining with the average forward helicopter speed (62.0 knots or 32 m/sec), the sampling interval along the flight line was approximately 32 meters.

The survey navigation was primarily by visual means from 1:50,000 topographic maps. At the field operational base, flight path recovery began with matching at intervals along the fight line and tracking film images to topographic map features. The accuracy of the location of the aircraft is limited by accuracy of topographic maps, camera image scale and aircraft altitude. The navigation position information recorded into the database resulted in each database record having a position LAT/LONG geographic coordinate in the IND74 datum. The processing of the data involved the calculation of UTM coordinates for each point in the database.

In addition to the line data obtained from the measurements, map sheet at scale 1:50,000 have been produced from interpolation and gridding of measured data. The total-field magnetic line data were gridded using a minimum curvature routine technique. Then, the contour isopachs of the magnetic total filed have been created from the gridded magnetic total field. Stacked magnetic profiles were generated from the final digital data for verification of data. All productions based on scale 1:50,000 consist of aeromagnetic map are shown in Table 3.1

Table 3.1 Specification of the Loei AEM high-resolution aeromagnetic survey (KESIL, 1989).

Dates of acquisition	January 29-March 24, 1988
Line spacing	400m, line trend E-W direction perpendicular to regional structures
Tie lines	5,500m, lines trend N-S-parallel to the regional structures
Observation high above ground (average)	50 m
Instrument / Aircraft	Proton precession magnetometer model G-803 with sampling rate 1.0 seconds towed below a Bell Helicopter model 412
Area surveyed	5,280 square kilometers
Total flight-line length	13,265 line-kilometers

3.1.2.2 Electromagnetic data acquisition

The electromagnetic system used for the AEM survey was a modified REXHEM-3 manufactured by Geotech Ltd., Canada. The modified REXHEM-3 is an EMEX-1 prospector system with particular coil configurations and frequencies. This is a frequency domain system composed of two major parts: transmitter-receiver system housed in an 8 m long rigid towed below the helicopter, as described above, and a console housed in the geophysical equipment rack mounted in the cabin of the helicopter. This survey employed three frequencies in coil pairs measuring inphase and quadrature parameters as given in Table 3.2.

Table 3.2 Electromagnetic system configuration of AEM survey (KESIL, 1989).

Frequency (Hz)	Coil pair Orientation	Coil Separation (m)	Output Filter Time constant (sec)
736	Vertical coaxial (x-x)	6.43	0.1
912	Horizontal coplanar (y-y)	6.43	0.1
4200	Horizontal coplanar (y-y)	6.42	0.1

The conventional unit of measurement in a frequency domain system is the ratio of the anomalous received signal amplitudes to the transmitted signal amplitude for both the in phase and quadrature components. It is convenient to express this ratio in term of parts per million (ppm).

The aircraft was maintained at a nominal 60 meters above the ground. The electromagnetic bird was 30 meters below the helicopter. During the survey, a radar altimeter was used to measure the flight altitude above the ground surface. Radar altimeters emit radar waves, which were reflected by the ground surface and processed to altitude. Since the EM bird was a moving object under the helicopter, it sometimes altered the radar wave that reflected off the bird, resulting in an inaccurate altitude values.

The high frequency data (4200 Hz) were complied into the apparent resistivity contour maps. Resistivity was processed for each data point, except where power line and cultural interference has disturbed the EM signal. Once resistivity was computed, the data were gridded and contoured to create maps. All electromagnetic data were also plotted as profiles maps for each frequency. Profile maps of in-phase and quadrature combined were created at scale of 1:50,000 using the flight path as the data zero.

The electromagnetic data for this study was converted into XYZ format files. Then, these data were created to a grid file by using the ChrisDBF software program by using spline technique for data processing (described in next chapter).

3.2 Other data sets

3.2.1 Geological map

Geological mapping in the Loei area was complied from the 1: 50,000 scale geology map from Chairangsee et al. (1990), and at 1:100,000 scale from Geological Compilation and Edition Section, Mineral Resource Development Project (MRDP, 1988). Geological outlines were digitized and attributed to the Arcview GIS format, in such a way that they could be overlaid on the geophysical map. The image products on the PC computer screen can assist lithological identification and correlation with mapped structures.

3.2.2 Remote sensing data

Satellite remote sensing technology has played an increasing important role in the search for major structures and mineral resources over the past two decades. This has been primarily through the use of Landsat Multispectral Scanner (MSS) imagery and more recently Landsat Thematic Mapper (TM) imagery. TM data has been acquired since 1982.

Thematic Mapper is a high-resolution sensor of Landsat satellite. Landsat TM data has 30m pixel resolution in six spectral bands ranging from blue to middle infrared and 120m resolutions in the thermal infrared band. Image size of TM Landsat at Loei is 185x170 km. The seven bands cover the following spectral rage:

Landsat TM Band 1: 0.45-0.52 μm (blue),

Landsat TM Band 2: 0.52-0.60 μm (green),

Landsat TM Band 3: 0.60-0.69 μm (red),

Landsat TM Band 4: 0.76-0.90 μm (infrared),

Landsat TM Band 5: 1.55-1.75 μm (mid-infrared),

Landsat TM Band 6: 10.4-12.5 μm (thermal-infrared),

Landsat TM Band 7: 2.08-2.35 μm (mid-infrared).

Landsat TM data are particularly useful for detecting surface color information because it has seven spectral bands that extend beyond the visible and into infrared region of the electromagnetic spectrums. It was chosen to suit the intended application and bring out information not visible to the eye. Additionally, they can be used to complement aerial photography and geophysical data in geological mapping.

Landsat Thematic Mapper (TM 5) data from Thailand Remote Sensing Center, National Research Council of Thailand (NRC) were used in this study. The TM digital data were recorded on 24 January 1999 containing 7,035 space columns and 3,730 rows.

3.2.3 Radiometric data

Radiometric surveys involve the physical measurement of gamma radiation, which reflects the geochemical variation of potassium (K), uranium (U) and thorium (Th) in the upper 30 cm of the earth's surface.

For this study, radiometric data from surveys B and C (as described in section 3.1.1) are used to for identifying rock and soil types. However, the line spacing and survey elevations are very large, so the radiometric data are very low resolution and not optimal for recognizing the boundary of rock units.

3.2.4 Gravity data

Gravity data acquisition in the Loei area was taken from the South East Asia Gravity Project (SEADP), This project was done by Geophysical Exploration Technology (GETECH, 1995), University of Leeds, UK in 1991-1994, using the extensive national gravity data set, commercial data and satellite derived marine gravity data. Most data in Thailand are supplemented in certain area provided by DMR and several oil companies.

However, most of gravity stations were outside the Loei area. Dense station spacing was measured on the road cut in southern part of Loei area, but only recorded 5 stations. The database was used to generate a 5'x5' grid (approximately 10 km x 10 km), so, the gravity data are not enough for the modelling. These data are too widely spaced to provide any reliable intrusion at less than 1:50,000 scale.

3.2.5 Digital elevation data

A digital elevation image (DEM) was produced by using the digital contour topography. Data were gridded using minimum curvature. DEM data images were useful for correlating topography with magnetic and electromagnetic features, and mineral occurrences, which assisted interpretation.

3.2.6 Mineral occurrences

Digital mineral occurrence data were selected from the database of the Economic Division of the DMR over the Loei area for prominent minerals such as gold, lead, copper, barite, manganese and iron. The characteristics and locations of each mineral is described in Chapter 2.

3.2.7 Magnetic susceptibility data

The aim of magnetic interpretation is to elicit geological information from magnetic survey results. Magnetic survey map contrasting magnetization between rocks containing different concentrations of magnetic minerals. There is a need for magnetic petrophysical studies of rocks to constrain the interpretation of magnetic survey results and for fundamental research in magnetic petrology to improve understanding of the geological factors that create, alter and destroy magnetic minerals in rocks.

A crucial limitation of 3D magnetic models is controlled by the information on magnetic properties. Understanding of factors that determine magnetization intensities and directions (remanent magnetization) for the geological units within the survey area is essential for resolving geological ambiguity in order to produce a reliable interpretation of subsurface geology.

In this study, the rock samples from the field representing all rocks types of the area were selected to measure magnetic susceptibilities and density. The magnetic susceptibility data are used to compare with the geology and the modeling.

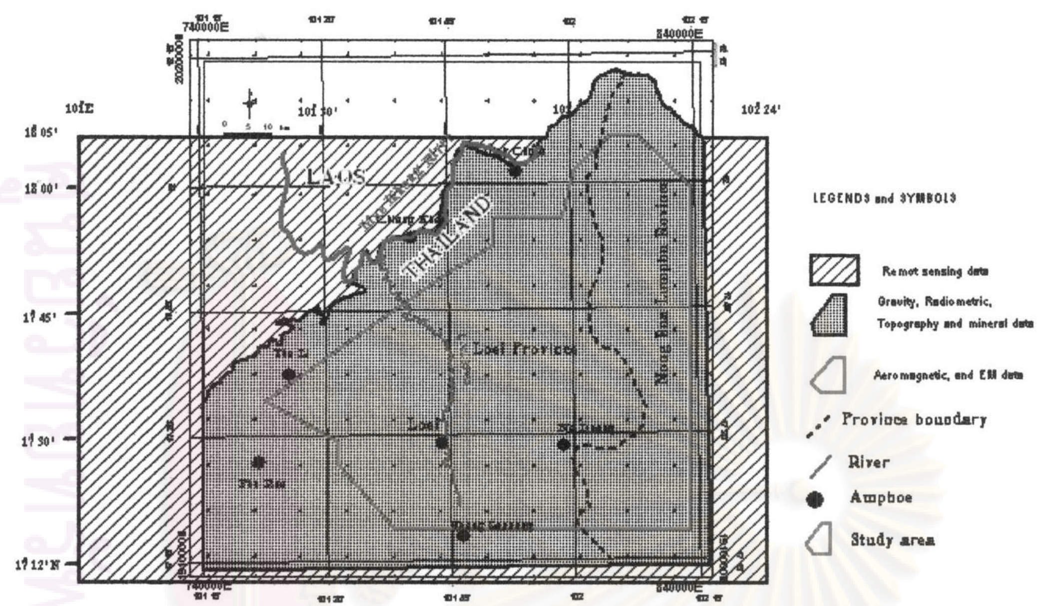

Figure 3.1 Index map of the Loei study area showing different kinds of data set applied in this study.