CHAPTER 1

INTRODUCTION

1.1 General

By and large, geophysical methods have played an important role in present-day exploration, particularly in areas where no surface expression is visible. Various geophysical methods may serve different purposes in order to achieve a specific objective in the exploration. For instance, a general reconnaissance survey may be done by gravity or magnetic methods, or both. The result of one technique may provide information that leads to application of another technique as an aid to the interpretation. Applying multiple techniques provides different types of information that results in a better interpretation compared to a single one, especially in areas lacking basic geological information.

Gravity survey is commonly used extensively in the investigation of large and medium-scale geologic structures. For example, Wattananikorn and others (1995) were able to identify a number of subbasins in Chiang Mai Basin, northern Thailand, and Bashara (1995) used the data set of land gravity in combination with Lansat imagery to investigate subsurface structures along the eastern edge of the Zagros Basin, Iran. Gravity methods are also useful in mineral exploration, such as in detection of massive sulfide bodies, and the detection of buried channels that might contain gold or uranium minerals (Dobrin and Savit, 1988).

In most gravity surveys, the quantity actually observed is not the Earth's true gravitational attraction, but its variation from one point to other. Small differences or distortions from point to point over the surface of the Earth are caused by any lateral inhomogeneities in the distribution of mass in the Earth's crust. Such lateral differences can be measured more easily than the total gravitational field, and sensitive instruments are designed to measure relative value of gravity.

1.2 Concepts and purpose of the study

In order to find economic mineral deposits such as gypsum in areas lacking rock exposures, the gravity method was chosen as one of an exploration method in this study. At the beginning, exploration method that was used by the exploration team from Economic Geology Division, Department of Mineral Resources (DMR), was resistivity survey, using Wenner's Configuration. This is because gypsum is a naturally poor conductor when compared with the associated rocks in the area such as limestone and anndesite. Therefore, the presence of gypsum bodies at shallow depths should have produced areas of markedly high apparent resistivity in the profiles.

Application of resistivity was successful to an extent, and several new gypsum bodies were found . However, there were locations where the high resistivity anomalies turned out to be relatively dense limestone instead, and it was clear that the high resistivity values could have been resulted from parameters other than shallow gypsum exclusively. Therefore, the need for additional method that would make it possible to differentiate the resistivity anomalies was apparent.

Cores from exploratory wells show that the gypsum in the mining area is not a direct precipitation from seawater as previously thought but is the topmost portion of an anhydrite mass which was rehydrated in geologically recent time. This is testified by the crosscutting relationship of gypsum/anhydrite phase boundary and the lamination in the core (Figure 1.1), and this is the key for the solution. Having anhydrite which has comparatively higher density than other rocks (Table 1.1) at these shallow depths should have resulted in positive anomalies in a gravity profile. A conceptual modeling showing the relationships among gypsum, anhydrite and limestone is illustrated in Figure 1.2.

Table 1.1 Density of rocks and minerals (Telford and others, 1990)

Non-metallic minerals	***Average (g/cm³)***
1. Gypsum	2.33
2. Anhydrite	2.93
Sediment (wet)	
1. Overburden	1.92
2. Soil	1.92
3. Limestone	2.55
Igneous	
1. Andesite	2.61

With the unique characteristics of the gypsum-anhydrite, the following objectives were established for the gravity program:

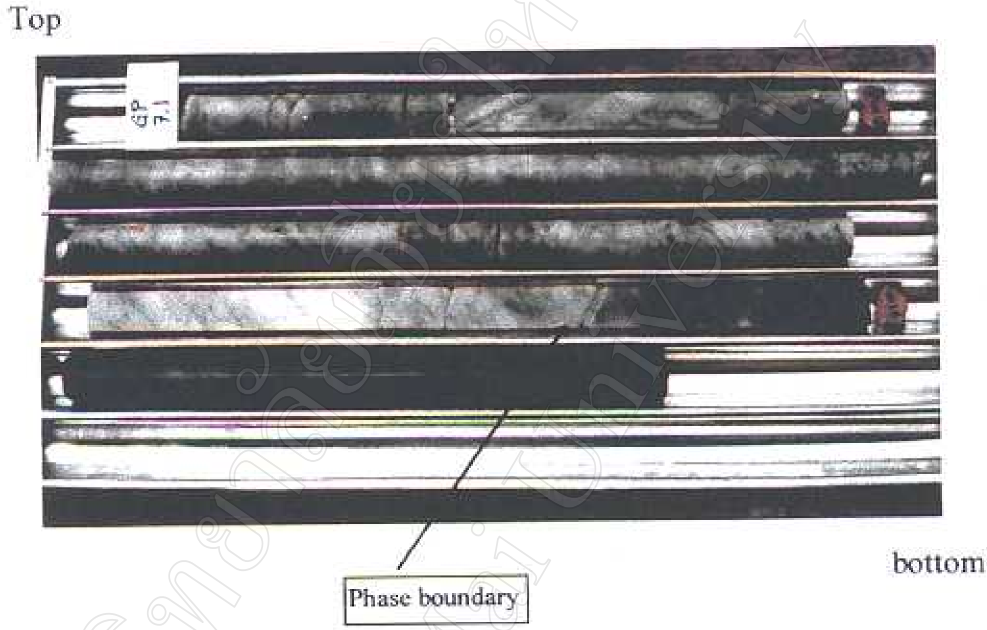

Figure 1.1 Cores from exploration well.
The figure shows the relationship of gypsum and anhydrite in the area. Gypsum overlies anhydrite with an abrupt change (arrow), and the phase boundary crosscuts the lamination which is continuous across both rock types.

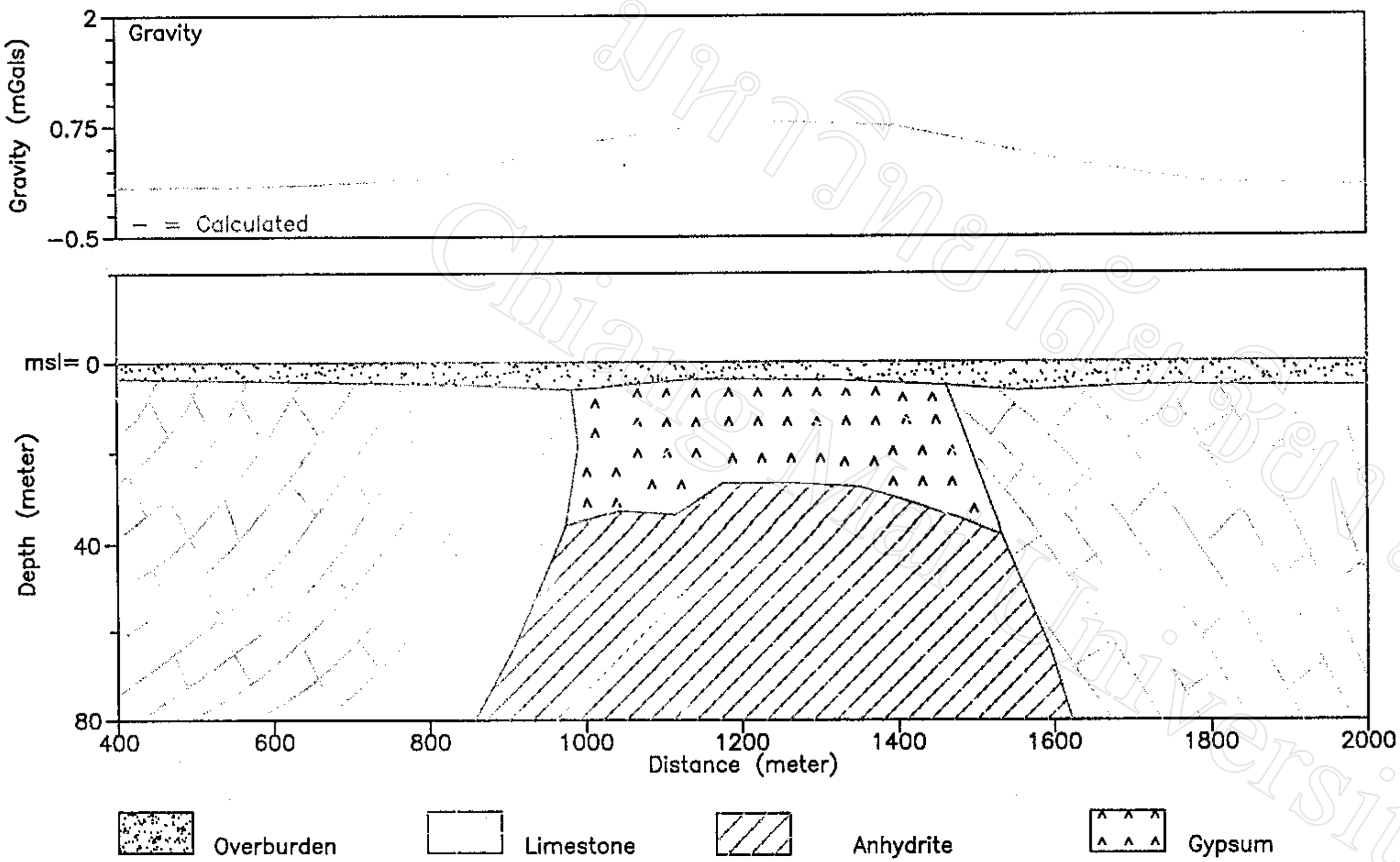

Figure 1.2 Conceptual modeling of gypsum-anhydrite relationship and the gravity response

1. To test the possibility of using gravity survey as a clue to find, indirectly, gypsum ores in an area where exposures are sparse.

2. To determine aerial subsurface extent of gypsum/anhydrite and possible buried structural features which are relevant.

3. To establish guidelines for further exploration which would aid the interpretation of both geophysical and geological data in other potential areas.

4. To enhance the scant geological knowledge of subsurface geology of exploration area and its vicinity.

1.3 Study area

The study area is located in the northern segment of central Thailand in which comprises 3 administrative subdivisions. A large part of the area is in Amphoe Chon Daen, Changwat Phetchabun, and its southernmost portion extends farther into Amphoe Bang Mun Nak, Changwat Phichit, and just across the provincial boundary into Amphoe Nong Bua of Changwat Nakhon Sawan. It encompasses an area of about 70 km^2 and lies between latitudes 15°59′N to 16°05′N and longitude 100° 44′E to 100°50′E. In the UTM grid system, it is 686000E/1768000N and 693000E/177800N which is covered by parts of four topographic map sheets (Figure 1.3) of 1:50,000 scale Series L 7017 (Armed Forces Survey Department, 1969).

The study area is flat-lying, with an average elevation of about 100 m above mean sea level. Noticeable topographic reliefs of the area are small isolated hills, e.g., Khao Khan Tha, Khao Thep Phanom, and Khao Cha-Ngok, which have elevations of 150 m, 100 m, and 200 m

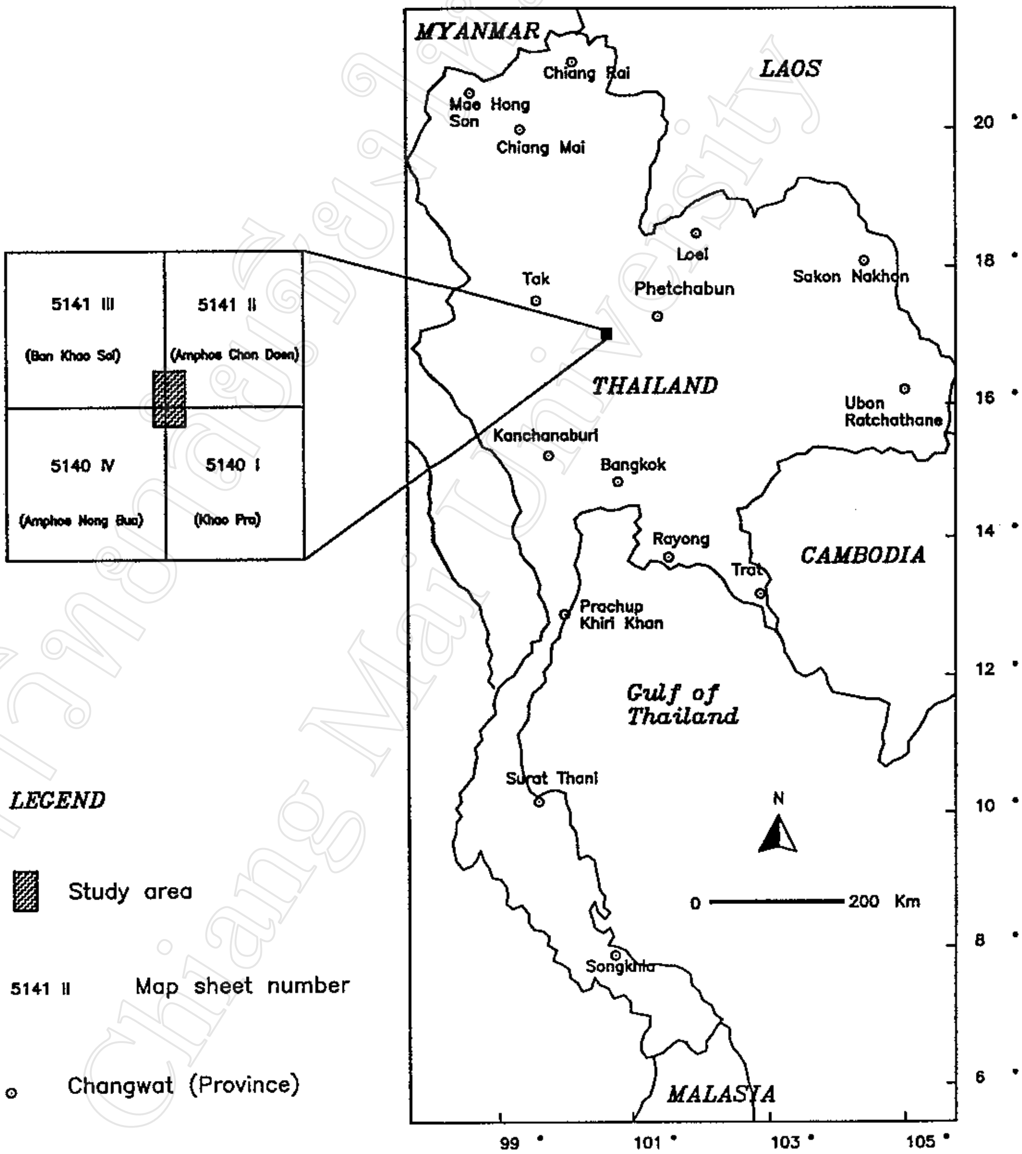

Figure 1.3 Index map of the study area

above mean sea level respectively (Figure 1.4). Khao Khan Tha is made up of andesitic tuff while the latter two are limestone (Jungyusuk, 1985). Land-use is rather limited because of dryness, and most of the natural streams are intermittent.

A large part of the study area is covered with both Quaternary alluvial sediments and latterite crusts (Figure 1.5) and bordered to the SW by the gypsum-producing district where mining has been active since 1975 (Figure 1.6). Regional trend of the gypsum ores runs in a roughly N-S direction, and it is anticipated that the gypsum would extend northward into the area. The gypsum is generally dull white, massive alabaster with thin, grey carbonate lamination. Topographic tops of the gypsum as observed in several mines are very rugged due to extensive karstification (Utha-aroon, 1991).

There is some indication of faults on the geological map of the area. Two sets of faults in NE-SW direction and in NW-SE direction are observed. The first set strikes in a direction along Khlong Boraphet which probably conjugates the second runs at Ban Taling Chan.

1.4 Literature review

There are no known publications concerning large-scale geophysical application or detailed structural studies of the area. However, some previous geologic and geophysical information in the vicinity by some workers are as follows:

Rocks of the study area can be grouped into two main categories, sedimentary rocks and volcanic rocks. Sedimentary rocks found at the northeast portion of the study area consist of limestone, sandstone, and

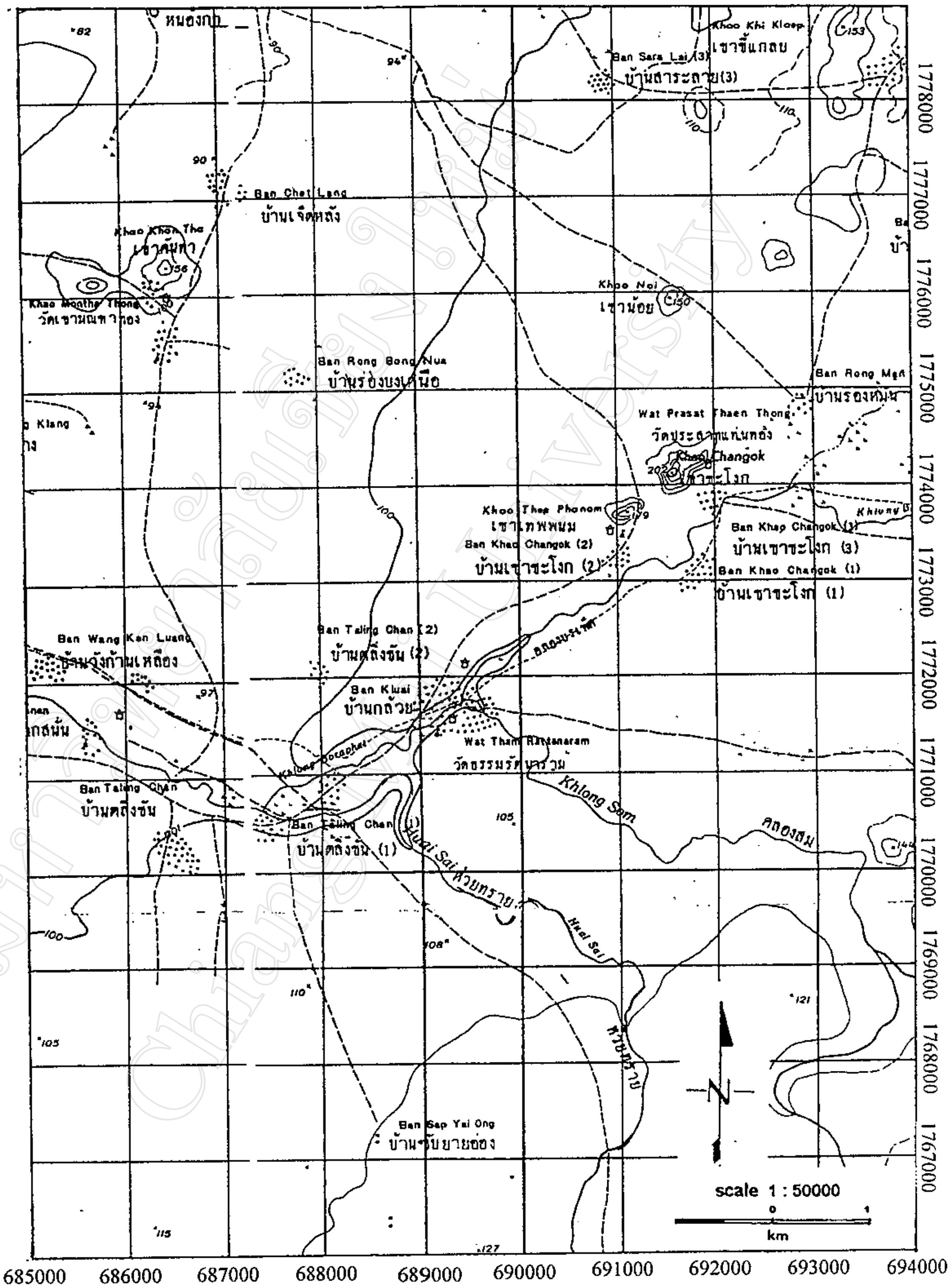

Figure 1.4 Topographic relief of the study area

The figure shows flat-lying area with an average elevation of about 100 m above mean sea level.

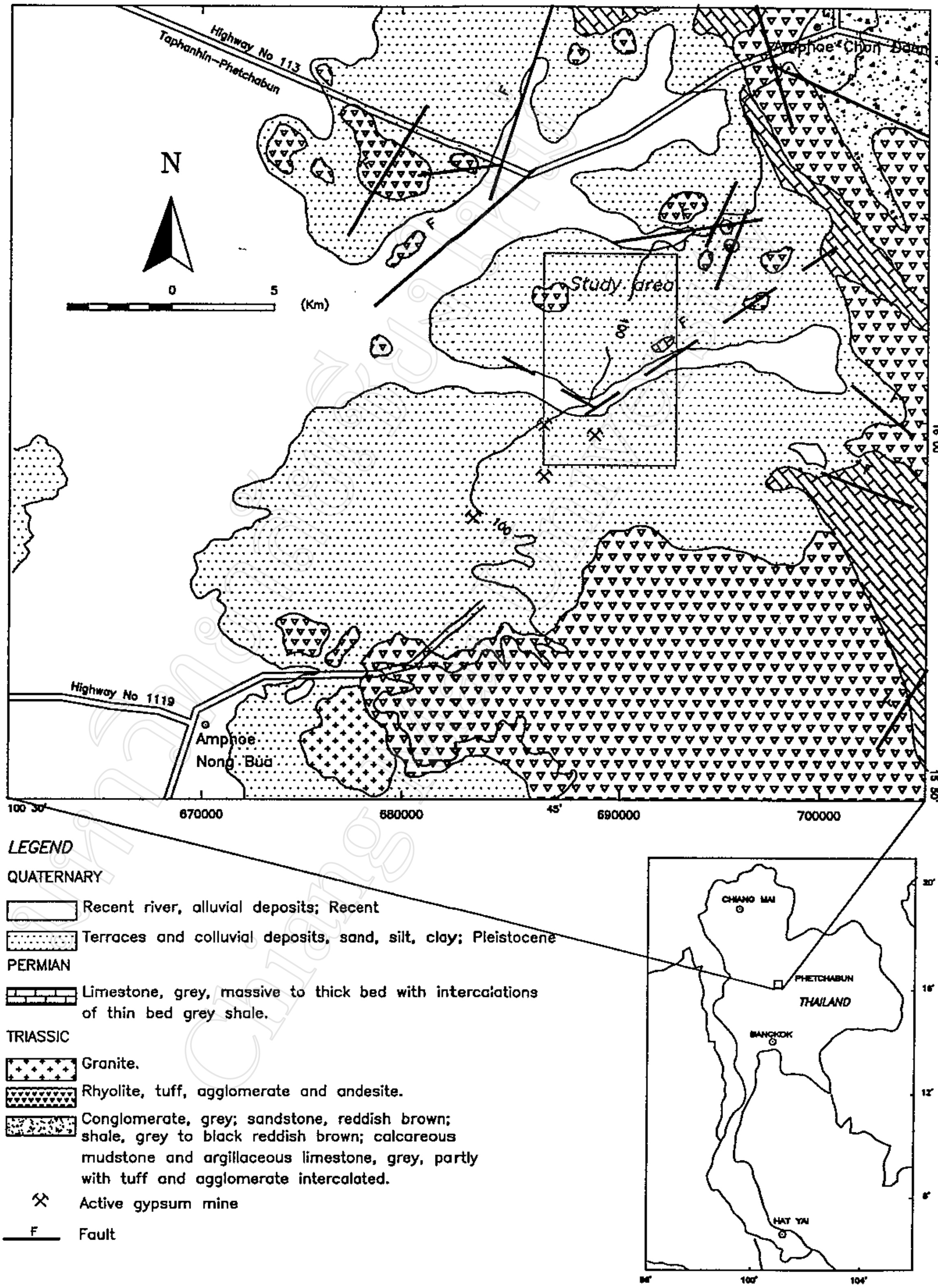

Figure 1.5 Geologic map of the triple junction area and location of the study area (Chonglakmani and Sattayarak, 1979, and Nakornsri, 1977).

shale of Upper Permian to Lower Jurassic. They are associated with andesitic tuff and agglomerate. Andesite dykes are found cross-cutting into some sedimentary beds, such as limestone at Khao Cha-Ngok (Yeamniyom, 1978, Jungyusuk, 1985, and Hongthong and Trabtaweewong, 1994).

Figure 1.6 Siam Cement gypsum mine located to the SW of the study area.

This area lies in the plain near western limit of the Phetchabun Range which runs in a roughly N-S trending and is composed dominantly of Permo-Triassic volcanic rocks and upper Paleozoic to Mesozoic sedimentary (Jungyusuk and Jingjitra, 1986). Volcanic rocks in this region show flow structure, dykes, and sills which dominantly of andesitic composition (Jungyusuk and Khositanont, 1993). Andesite dykes are also dykes are also commonly found cross cutting into the gypsum formation (Utha-aroon and Ratanajaruraks, 1996).

Preliminary attempt on application of gravity survey in gypsum exploration was conducted by Kuttikul and Utha-aroon (1995). The study was done along two survey lines, a N-S trending line of 1.7 km and an E-W of 3.6 km. After applying the gravity data reduction procedures, the result showed a distinct positive anomaly around the central of both lines. The result from subsequent drilling found thin bed of gypsum underlain by anhydrite.

To the best of the author's knowledge, publications which exclusively reported large-scale gravity application to gypsum exploration do not exist. However, some published papers that present various interesting method for gravity interpretation in sedimentary basins, as are follows:

The method of Fourier transforms has usually been used for interpretation of gravity anomalies. Odegard and Berg (1965) developed methods for analyzing gravity data in the frequency domain. Mathematics relations were formulated between the transform-versus-frequency relationships and the depths and sizes of the bodies such as sphere, cylinder, and fault. Rao and others (1993) solved this problem by using end corrections to the transform testing on simple geometrical models such as vertical prism, symmetric trapezoid and vertical fault models with exponential density contrast.

Chai and Hinze (1988) has extended both space-domain and wavenumber-domain techniques for mapping an interface above which the density contrast varies exponentially with depth. Their procedure is enhanced by a shift-sampling techniques based on the discrete Fourier deviation equation. Depth to the interface is determined by iterative adjustment of the vertical extent of the prism in accordance with observed gravity anomaly data. Talwani and Ewing (1960), and Talwani (1965) have developed the new method for easy and compatibility in use with computer. This method becomes a basic on which succeeding computer softwares use to calculate the gravity model response.