CHAPTER I

INTRODUCTION

Skarn is a lime-bearing silicate rock of any geological age derived from nearly pure limestone and dolomite with the introduction of large amounts of Si, Al, Fe and Mg (Bate and Jackson, 1980). Skarn mineralogy is a wide variety of calc-silicate and associated minerals but usually is dominated by garnet and pyroxene. Many skarns have economic mineralization. In most large skarn deposits, skarn and ore minerals result from the same hydrothermal system even though there may be significant differences in the time/space distribution of these minerals on a local scale.

Skarn deposits are the world's premier source of tungsten, a major source of copper, important sources of iron, molybdenum and zinc, and minor sources of cobalt, gold, silver, lead, bismuth, tin, beryllium and boron. They also serve as a source of industrial minerals such as graphite, asbestos, wollastonite, magnesite, phlogopite, talc and fluorite (Einaudi, 1981). When a skarn type deposit is formed along the boundary between a plutonic rock and carbonates a zonal arrangement of skarn minerals parallel to the boundary is often developed. The transfer of elements play an important role in the formation of this zonal arrangement (Uchida and Iiyama, 1982).

Extensive skarn rocks have been observed in Changwat Lopburi. Skarn formation was resulted from contact metamorphic processes related to intrusion of Permo-Triassic diotite and granodiorite into the Permian limestone belt. The skarn development in this zone is well-known for their coarsely crystalline aggregate of wollastonite, garnet, and quartz (some are of gem quality). Wollastonite has also been found scattering extensively in the Permian limestone belt which runs in a roughly NW-SE direction on the eastern half of the province (Utha-aroon et al., 1998). Iron mineralizations at Khao Thab Kwai, Khao

Phu Ka, and Khao Phra Bat Noi areas and copper mineralizations at Khao Phra Ngam, Khao Phu Ka, Khao Phra Bat Noi, Khao Thab Kwai, and Khao Sapan Nak areas, Amphoe Muang, Changwat Lopburi are also found in the skarns.

1.1 Previous works

A reconnaissance survey of the all known mineral occurrences in Thailand was carried out by the joint cooperation between the Department of Mineral Resources and U.S. Geological Mission (Brown et al., 1953). Geology and mineral deposits were compiled and published as a report including geologic map at scale 1:250,000. A brief account of the iron deposit at Khao Thab Kwai, Changwat Lopburi was also included in this report.

Hintong et al. (1981) reported the geology and mineral resources of Changwat Phranakorn Si Ayutthaya and compiled the geologic map (ND 47-8) at scale 1:250,000. The investigations included details on rock types, age, stratigraphy and structure as well as some chemical analyses of various rocks in this area.

Sindhusen (1986) made a preliminary petrographic study of the iron deposit at Khao Thab Kwai, Changwat Lopburi. Skarn rocks were classified into three types, namely, garnet skarn, garnet-clinopyroxene skarn and plagioclase-clinopyroxene skarn. Skarns belong to the plagioclase-grossularite-hedenbergite mineral assemblage of the hornblende-hornfels facies. Most of the exposed iron ores were hematite being the oxidation product of primary magnetite.

During 1984-1989, a nationwide high aeromagnetic survey of Thailand was conducted by the Department of Mineral Resources under the Mineral Resources Development Project (MRDP). The survey was flown by Kenting Earth Sciences

(International) Ltd.(KESIL). These surveys comprise high sensitivity magnetic, combined magnetic, radiometric and VLF-EM and electromagnetic (AEM follow up survey). The result of aeromagnetic survey in the Khao Phra Ngam area shows strong magnetic anomalies lied along outer edge of intrusion and often coincide with mapped limestone and skarn development. Radiometric survey suggested a moderate to high abundance in U but low in Th and K. It coincide with limestone unit (Wisedsind, 1994). The effectiveness of airborne gamma ray spectrometry as an indicator of strong potassic alteration may indicate hydrothermal mineralization (Darnley and Ford, 1987).

Following the airborne geophysical survey, the detailed geological mapping at scale 1:50,000 and geochemical exploration were conducted on airborne geophysical anomalies covered Khao Phra Ngam area (Yavichai, 1992). Three copper occurrences can be observed. The mineral zones range from 5 to 15 m wide and 50 to 150 m long with 1-3 % Cu content. Mineralization comprises of chalcopyrite associated with quartz veins filling in sheared and fracture of skarn rocks. Rocks chemical analysis revealed that gold and silver content mostly low. The high copper contents up to 1.04% appear in skarns with disseminated malachite.

In the northern portion of Khao Phra Ngam, the ground geophysical surveys, such as magnetic and electromagnetic surveys, was carried out with the purpose of verifying the mineralized zones by Lueiningasoot (1996). The result suggested the intrusion body underneath and structural feature delineated the lineaments trending in N-S and E-W direction.

1.2 Purpose of study

As have been outlined in aforementioned paragraphs, most of the previous studies are reconnaissance in nature. No detailed study has been carried out on the skarn formation

yet. Hence, the objective of this work is to study in details on the mineralogy, petrography and mineral chemistry of skarn rocks. The petrological and geochemical characteristics will be used to delineate the genesis of skarn formation. The occurrence of Copper and iron mineralization and other gem and precious stones will also be explained by relating to the genesis of skarn.

1.3 The location and accessibility of the study area

The study area, covering approximately 12 sq. km, is located at the northern part of Changwat Lopburi (Figure 1.1). The area is bounded by vertical grid from 673000 E to 676000 E and horizontal grid from 164700 N to 1651000 N as shown in the topographic map scale 1:50,000, series L 7017, sheet 5138IV, Changwat Lopburi (Figure 1.2). The area is accessible conveniently from Bangkok heading north along the Phahonyothin highway (Highway no. 1) to Rangsit–Wang Noi–Saraburi township then further west to Phaputhabat–Lopburi township and further to Ban Sam Yaek Khao Phra Ngam. It is about 170 kms from Bangkok to the study area.

1.4 Climate and Vegetation

Changwat Lopburi is influenced by a tropical climate. Temperature ranges from as low as 17 $^{\circ}$C in January to as high as 40 $^{\circ}$C in April. An average temperature is 28°C. Rain fall is generally moderate to low with long duration. The mean annual precipitation is about 850 mm. The wet season extends from May to about the end of October. The cold and dry season starts from November till February and the hot and dry season is from March to May.

The study area is covered by a tropical rain forest. The dominant tree family encountered is that of shrubs and bamboos. In these areas on the lowlands they are replaced by the mixed deciduous forests and cultivated farmland.

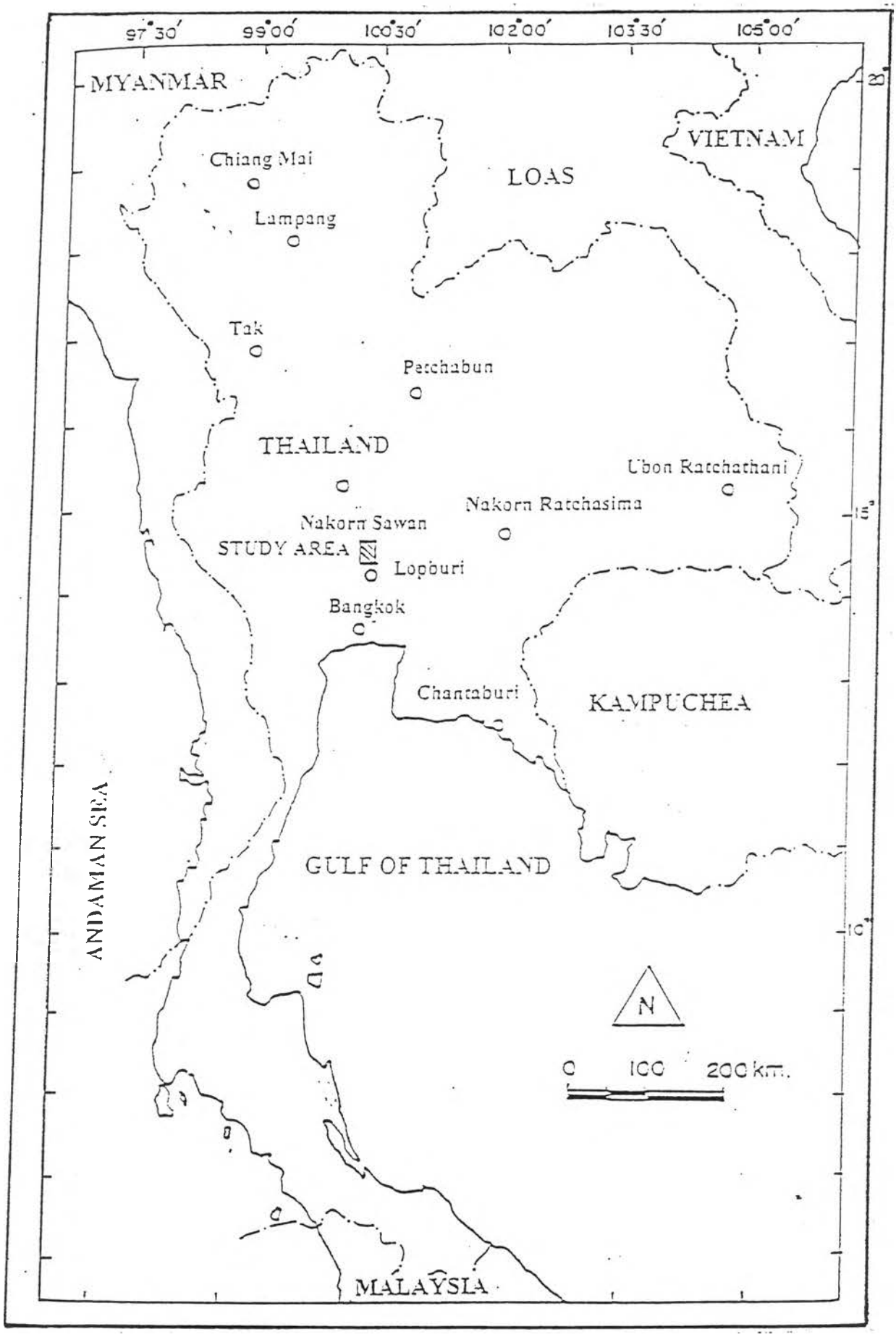

Figure 1.1 Index map of Thailand showing locality of the study area in Changwat Lopburi, Central Thailand.

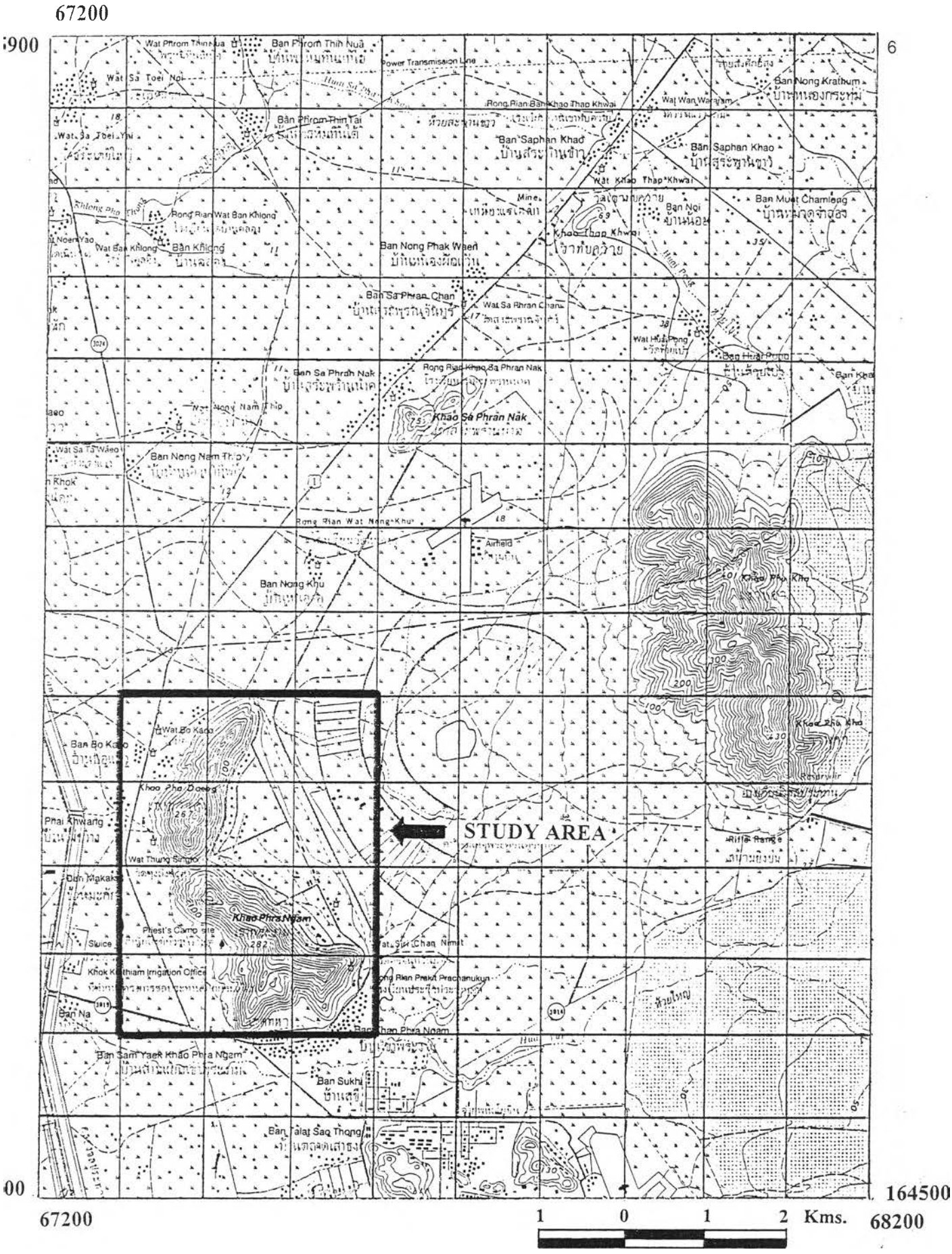

Figure 1.2 Topographic map showing the location and accessibility of study area.

1.5 Physiography

The area under investigation is underlain by roughly NS trending mountain range and surrounding low terrain. The highest peak is about 282 meters, whereas the low lying area is about 20 meters above mean sea level.

Drainage system developed in the area consists of subparallel to dendritic types. A small creek can be observed on the topographic map which runs southerly through the east of the area and join the Huai Yai at Ban Sam Yeak Khao Phra Ngam. The exposures are excellent on the mountains but the low lying areas are covered by thick soil and vegetation.

1.6 Method of Investigation

The method of study can be summarized as a flow chart shown in Figure 1.3. The first phase of study was the literature survey of previous works on the geology of Khao Phra Ngam area, models of skarn formation and related mineralization. The photo-geological work was also undertaken to define the geomorphic features and geological structures during this phase of study.

The second phase of study was the field investigation which was carried out during March to April, 1999 and again in December, 1999. The fieldwork included geological mapping and sample collection. Altogether 120 rock samples were collected including igneous rocks, skarns and carbonate rocks. Each rock sample weighted approximately 1-2 kg was collected for petrographic study and chemical analysis. Systematic sampling was performed where a good transition was observed from carbonate host passing skarns into intrusive rocks. However, part of the study area was inaccessible because It was the military restricted compound.

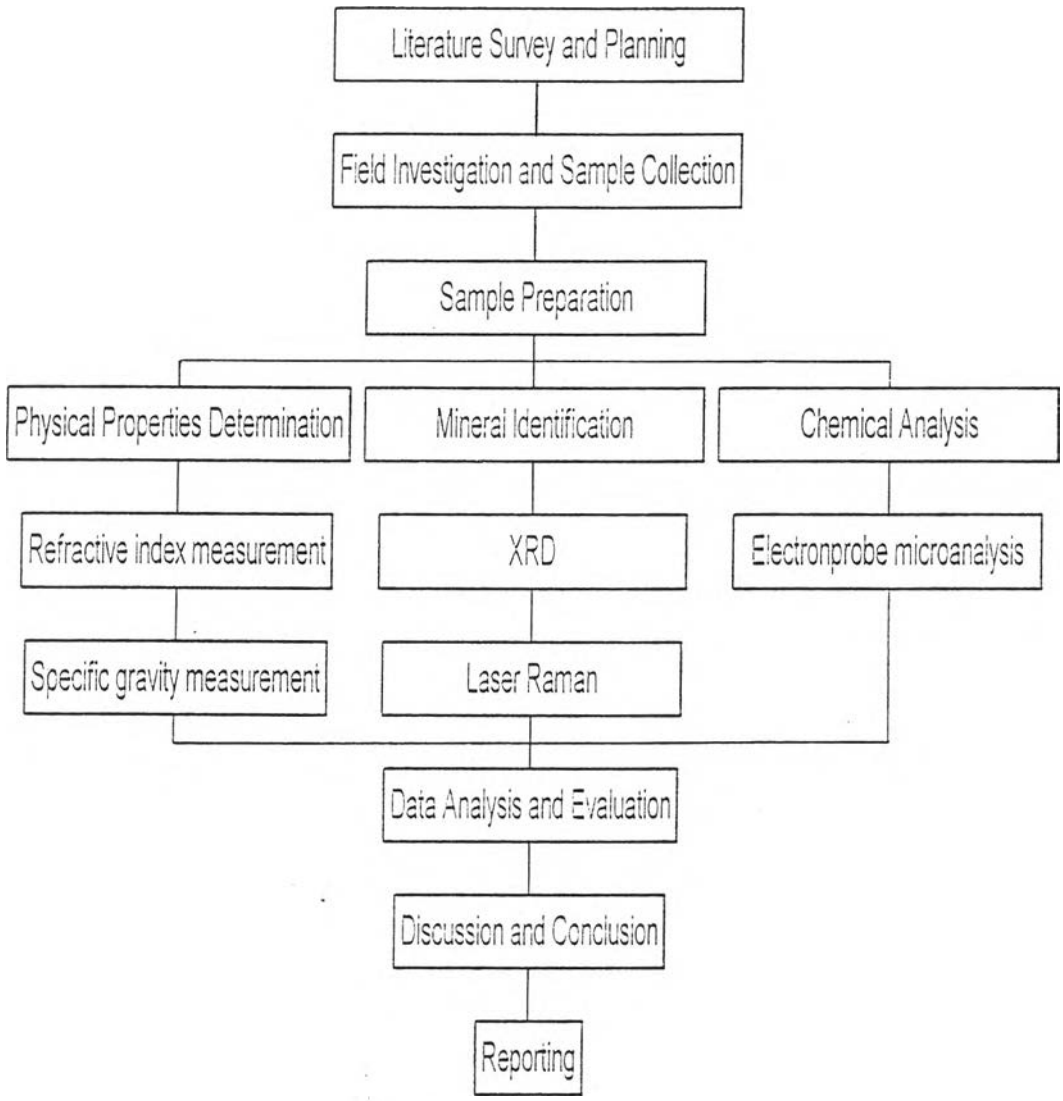

Figure 1.3 Flow chart summarized the method of study.

The third phase of study was the field data compilation and laboratory works. Data and information obtained from the field investigation were complied and presented as the geological map on the scale of 1:10,000. The rock samples were slab-cut for general observation and for making standard thin-sections. Altogether 120 thin-sections and 40 polished thin-sections were made from rock samples. Preliminary mineral identification and texture relationships were observed under a transmitted and reflected light microscope. Mineral identification in rocks and selected garnet grains was also carried out by using Phillips PW 1710 diffractometer (XRD) at Department of Geology, Chulalongkorn University. Nickel filtered Cu Kα radiation was used in all samples and run at the scanning speed of 1°per 2θ/minute. Identification of garnet and opaque minerals was also carried out by using Rainshaw Laser Raman Spectroscope at the Gem and Jewelry Institute of Thailand (GIT). Chemical compositions of minerals were analyzed by electronprobe microanalysis (EPMA) at Department of Earth Sciences, University of Manchester. A rebuilt GEOSCAN with an energy dispersive X-ray spectrometry (EDX) system was predominately employed for this study. Operating parameters were 15 kV accelerating voltage with counting time of 40 seconds. The instrument was calibrated using recognized international natural mineral standards. Data were reduced on-line using ZAF correction procedures. The Fe^{2+} and Fe^{3+} values were recalculated from total FeO following Droop (1987). In addition, some physical properties, such as specific gravity and reflective indices of 15 garnet samples separated from rock specimens were determined by basic gem identification equipment.

The final phase was data analysis and evaluation. All geological and analytical data were integrated and displayed in forms of tables, graphs and diagrams. Finally, an attempt has been made to reconstruct the model of skarn formation and associated mineralization in the study area.