CHAPTER I

INTRODUCTION

1.1 Location of the Area

The studied area is located about 160 km to the northwestern part of Changwat Kanchanaburi, and lies between the Kwae Yai and Kwae Noi River (Figure 1). It is bounded by lattidudes 14° 47' 24" and 14° 51' 45" N and longitudes 98° 46' 32" and 98° 50' 32" E and occupies approximately 52 km^2. The mapped area covers the southwestern part of 1:50,000 topographic map of the Khao Bo Ngam, sheet no 4738 I, series L 7017. The Song Toh mine is located in the northern part of this mapped area at lattitude 14° 50' 00" N and longitude 98° 48' 00" E in Tambol Chalae, Amphoe Thong Pha Phum, Changwat Kanchanaburi.

1.2 Climate and Vegetation

The Kanchanaburi Province has a tropical savanna climate. Temperature ranges from as low as 5.5°C in January to as high as 43.5°C in April. Rainfall is generally heavy to moderate with long duration. The mean annual precipitation is above 1,000 mm. Wet season extends from May to about the end of October. The coldest and driest season are from November to February and February to May, respectively. Details of climate in Kanchanaburi are shown by Climatological Data of Thailand for the 25 Year's Period 1951-1975 (Table 1).

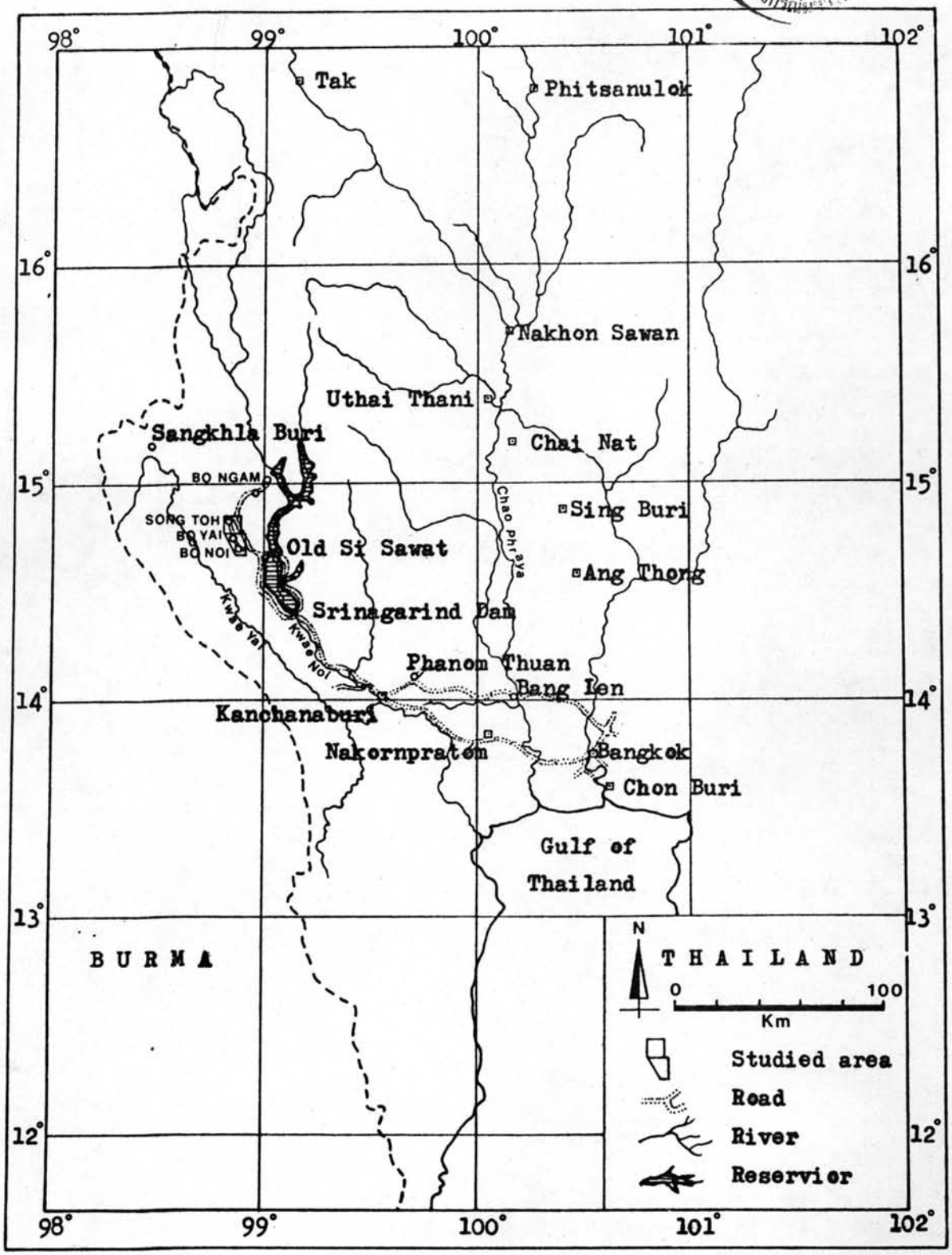

Figure 1 Location of the studied area.

Table 1 Climatological data for the period 1951-1975 (Meteorological Department, Ministry of Communications).

Station KANCHANABURI
Index Station 48 450
Latitude 14° 01' N.
Longitude 99° 32' E.

Elevation of station above MSL. 28.00 meters
Height of barometer above MSL. 29.39 meters
Height of thermometer above ground 1.20 meters
Height of wind vane above ground 11.40 meters
Height of raingauge 0.64 meters

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Pressure (+ 1000 or 900 mbs.)													
Mean	13.24	11.45	10.11	08.80	07.06	07.12	07.08	07.53	07.94	10.48	12.61	13.41	09.77
Ext. Max.	24.34	22.15	20.53	20.18	15.08	15.76	14.25	14.38	15.03	18.34	21.49	23.62	24.34
Ext. Min.	04.71	03.34	01.62	00.28	99.37	99.82	99.95	99.88	98.50	01.85	04.59	04.02	98.50
Mean daily range	5.06	5.64	5.89	5.70	4.91	4.02	3.89	3.97	4.59	4.63	4.66	4.84	4.82
Temperature (°C.)													
Mean	25.5	28.1	30.2	31.4	29.9	28.7	28.2	28.1	27.9	27.1	26.1	24.8	28.0
Mean Max.	32.1	34.9	37.0	37.8	35.4	33.5	33.3	32.7	32.5	31.4	30.8	30.4	33.5
Mean Min.	17.5	20.4	22.8	24.7	24.9	24.5	24.0	24.0	23.7	23.0	20.8	17.9	22.3
Ext. Max.	37.2	40.3	41.7	43.5	41.6	38.4	37.8	37.5	37.6	37.3	37.5	35.5	43.5
Ext Min.	5.5	12.1	11.2	17.2	21.5	22.0	20.8	21.5	20.8	18.0	11.6	6.8	5.5
Relative Humidity (%)													
Mean	63.0	60.0	58.0	60.0	70.0	73.0	74.0	74.0	78.0	80.0	75.0	67.0	69.0
Mean Max.	87.8	85.4	82.6	82.4	87.3	88.2	88.9	89.5	91.8	93.3	91.7	89.4	88.2
Mean Min.	41.9	39.2	36.4	39.4	52.6	58.1	58.5	58.9	61.8	65.0	58.6	49.5	51.7
Ext. Min.	11.0	15.0	14.0	15.0	24.0	32.0	34.0	35.0	36.0	37.0	27.0	21.0	11.0
Dew Point (°C.)													
Mean	17.2	18.8	19.9	21.7	23.4	23.2	22.9	22.9	23.2	23.2	20.9	18.0	21.3
Evaporation (mm.)													
Mean – Piché	97.0	112.2	133.5	128.0	98.3	85.1	78.1	77.9	61.6	54.3	64.1	80.2	070.3
– Pan						No	Observation						
Cloudiness (0–8)													
Mean	3.2	3.4	3.6	4.3	5.8	6.6	6.8	7.0	6.7	5.8	4.5	3.5	5.1
Visibility (Km.)													
0700 L.S.T.	4.6	4.1	5.2	7.6	9.4	9.8	9.2	9.0	8.4	7.8	6.3	5.9	7.3
Mean	8.3	7.1	7.2	9.4	11.0	11.5	10.7	10.6	10.3	10.2	10.3	9.6	9.7
Wind (Knots)													
Prevailing wind	NE	SE	W	W	W	W	W	W	W	W	NE	NE	–
Mean Wind Speed	3.4	3.8	4.2	4.5	4.3	4.3	4.7	4.6	3.8	3.3	>3.6	3.8	–
Max. Wind Speed	25 ENE	25 SE	40 N	50 SE	33 E,W	33 W, WNW	55 SW	40 NW	40 W	30 W	30 NE	30 N	–
Rainfall (mm.)													
Mean	5.6	18.8	37.4	76.6	154.5	90.0	106.7	106.3	241.0	238.2	60.6	9.1	1144.8
Mean rainy days	1.2	1.8	3.5	6.7	13.9	13.5	16.0	17.1	18.6	15.3	5.4	1.8	114.8
Greatest in 24 hr.	54.4	82.0	133.9	75.8	95.4	74.1	64.7	99.5	165.5	162.8	117.6	45.6	165.5
Day/Year	11/75	14/70	23/74	10/71	4/63	26/72	23/57	3/74	6/72	12/70	3/69	21/66	9/72
Number of days with													
Haze	22.2	24.3	26.6	14.0	5.1	2.9	2.7	2.9	2.5	4.8	8.4	14.9	131.2
Fog	5.7	6.1	2.3	1.6	1.6	0.4	0.7	0.9	1.3	1.8	2.9	3.4	28.7
Hail	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.4
Thunderstorm	0.2	1.7	4.8	10.0	13.4	5.0	6.3	5.0	9.6	7.7	1.8	0.5	66.0
Squall	0.0	0.0	0.0	0.5	0.1	0.1	0.1	0.1	0.2	0.0	0.0	0.0	1.1

Remark :
1. Pressure 1955–1975
2. Temperature 1952–1975
3. Evaporation 1958–1975

The area examined is covered by primary jungle of the tropical rain forest type. In both high grounds and hills up to the mountain tops, the dominant tree family encountered is that of the Dipterocarpaceae intermingled with many kinds of climbers, shrubs, bamboos and canes. The general growth and the undergrowth are dense often impenetrable. In these areas on the low lands they are replaced by the mixed diciduous forests.

1.3 Physiography

The area under investigation is mainly built up by high land with mountain ranges and hills with a regional NNW trend, lowering to the east. Narrow intermountain plains less than a kilometer wide are developed locally. The summit of the area is at Khao Ling i.e.,938 m above mean sea level. Rough karst topography is a common feature in the western half because of predominating carbonates there. Intermountain plains have been developed by the influence of faulting such as at Huai Chani, 3 km to the east of Song Toh mines, and also been developed by stream cut along the geological boundaries.

Drainage systems developed in the studied area consist of subparallel to dendritic types. The subparallel type occurs in clastic sediments while the dendritic type is formed in carbonate sediments. The three main perennial creeks to be observed on the topographic map are Huai Chani, 3 km east of Song Toh mines, Huai Ong Pho or Huai Ban Khao, 3 km east of Bo Yai mine, and Huai Takhro, 3 km southeast of Bo Yai mine. Some of the tributaries flow into sinkholes in the karst

area and vanish with unknown destination in caves. These subterranean watercourses are the main problems in underground mining of lead-zinc orebodies occured in the carbonate sediments here.

1.4 Accessibility and Communication

Travelling to the Pb-Zn mining area of Song Toh may be subdivided into two sections, i.e., from Bangkok to Kanchanaburi Province and from Kanchanaburi Province to the mining area.

Travelling from Bangkok, two routes may be followed to the city of Kanchanaburi :

1. To the west along the Petchakasem Highway, pass Nakornpratom Province then reach the city of Kanchanaburi covering a distance of 130 kilometers.
2. To the north to Pathum Thani Province cross the Chao Phraya River at the Nonthaburi Bridge, then go to Bang Len, Phanom Thuan and finally reach Kanchanaburi Province. This route covers a distance of 155 kilometers.

Travelling to Song Toh mines from the city of Kanchanaburi can be done by both pick-up car and Land Rover in all seasons. Again there are two possibilities for reaching the mines :

1. Travel through Lat Ya District along the eastern bank of the Kwae Yai River and crossing the river at the Old Si Sawat District by ferry boat, proceeding on laterite road

to the Pb-Zn mines. Time spent is about 4 hours to the Bo Noi and Bo Yai mine and 5 to 6 hours to the Song Toh mine respectively.

2. Travel through Lat Ya District and crossing the Kwae Yai River at the Srinagarind Dam procedding along the western bank of the river. This track will join the lateritic mine-road at the Old Sri Sawat District. However, this route at present is not recommended during wet season.

At Song Toh mine, a Radio-Telecommunication is installed which makes the communication between the Song Toh mine and home-office in Bangkok possible all day round.

1.5 Previous Works

In 1949, a reconnaisance survey of the all known mineral deposits in Thailand was carried out by the joint cooperation between the Department of Mineral Resources and U.S. Geological Mission. The report was written by Brown, et al., 1953. A brief account of the lead-zinc deposits at Nong Phai (Bo Yai), Changwat Kanchanaburi was included in it.

Subsequently, Smith and Rachadawong (1960) studied and made a report of the Nong Phai and of the Bo Ngam lead-zinc deposits, Amphoe Sri Sawat.

During 1968-1971, a regional geologic mapping of Kanchanaburi Province was carried out by a joint cooperation between the Department of Mineral Resources and the German Geological Mission. The report

was written by Koch in 1973; Hagen and Kemper in 1976.

Recently, Yokart (1977) has carried out a general mineragraphic and geochemistry study on various Pb-Zn deposits in Thailand. A limit number of specimens of the Pb-Zn ores from the Song Toh, Bo Yai, Bo Noi mines were also collected and described.

1.6 History of Mining and Its Stages of Development

Ancient mining activities in Kanchanaburi Province were abundant in the studied area. They could be traced back till the 14th century by mean of C^{14} -dating on charcoal of old smelters. The slag, left behind after the extraction of silver, consisted of up to 60 percents lead and silica (German Geological Mission, 1972).

The word "Song Tho" is originated from the characteristic of paired-pits to be found in abundance arround the present mining site. A single pit is about 5-10 m deep with a circular diameter of half a meter. A couple of them usually connect to each other at their bottoms. These pits were excavated by local people for several decades ago to search for lead slags (Figure 2).

Numerous evidence of medieval mining activities in the area are:

- Old mine tunnels and stopes occassionally showing remnants of simple tools such as hammers, crowbars, and chisels.
- Angular rock fragments-bearing sulfidic lead-zinc ore with their largest dimension of 2.5 cm floating in the lateritic soils.

Figure 2 Showing historical working of Lead slag deposits. These are located in the west close to Song Toh South mine.

- Charcoal-furnaces and lead casting moulds.
- Lead slags are oval-shaped containing in resinous brown siliceous matrix.
- Red lead-oxide is also found as broken sheets in the lateritic soils.

The earlier attempt to revive the lead mine made under the direction of Mr. Bhol Kleabbua and his brother in 1949.* Only high grade ores were mined. Later on the Canadian Mining Company(COMICO) was formed and worked the mine with minor production until 1953. Operations by this company ceased and the mine was disposed of to Mr.Bhol Klipbua. Though the work done reduced the hope and chance of developing worthwhile tonnages of ore from the known deposits, the hard fact of extensive minerization remained, and in 1969 the Kanchanaburi Exploration and Mining Company (KEMCO) was formed. A drilling programme was laid out to test for possible ore occurrences in depth The Company completed the diamond drilling campaign with encouraging results in 1977. Then development work commenced in 1978 and the output of concentrates is started to have an average of 15,000-22,000 tons per year.

1.7 Scope of Investigation and Method of Study

The scope of this study runs from broad point of view including :

- an extensive review of the regional geological setting of the lead-zinc deposits.
- detailed mapping and microscopic investigations of both mineralogy and textures in ores and host rocks.

In attempting to understand various aspects of the formation of ores, their post-depositional history and especially the spatial and chronological relations between ore and host rock, the types of ore mineral deposited and the relation between the ores and the regional metamorphism, special emphasis was placed on investigating the Pb-Zn deposit of Song Toh. It is not only the largest one known in the area, but also the one best exposed due to the present mining activities.

For this study, a selection of specimens of ores, host rocks, and country rocks was made from all levels at the mine. Where possible a series of specimens was collected across the lode at regular interval of approximately 5 meters. However, a narrow sampling spacing was employed where the lodes showed mineralogical and textural variations. Wall rock samples were also collected from the surface and underground outcrops to complete the lithological succession.

Moreover, diamond drill cores from exploratory bore holes in the Song Toh mine were logged to establish the lithological sequence of the mine. Some 300 thin sections and 130 polished sections were made and studied. Where ore and gangue minerals were unable to be recognized by optical means they were identified by X-ray diffraction method. Textural characteristics of some major sulfides and carbonates were revealed by etching and staining techniques.

Chemical reagents used for particular minerals are ;

Calcite and dolomite :- Staining with Arizarin Red-S solution (modified after Friedman, 1959) was employed to distinguish calcite and dolomite on uncovered thin sections. Calcite is stained and shows a red colouration while dolomite remain unchanged. The procedure is as follow :

- Pre-etching with 10% HCL. Etch for 5-10 seconds.
- Immerse thin section in 0.01% Arizarin Red-S solution : Dissolve 0.1 g in 100 ml 0.2% HCl (add 2ml of commercial grade conc. HCl to 998 ml of water). Stain for 40-60 seconds.

Galena and sphalerite :- Mixture of 5 parts of thiourea solution (100 g/l) and 1 part of conc. HCl. Etch for about 60°C for 8-20 minutes.

Pyrite :- Conc. HNO_3. Etch for 30-40 seconds.