CHAPTER I

INTRODUCTION

The uses of china clay and ball clay for ceramics in Thailand have long been dated back to the end of the 13th century during Sukhothai period. At the time the chinese-type glazed stoneware, known as Sawankaloke-ware, were first appeared in this country and neighboring areas. Unfortunately, the production had terminated by the middle of the 15th century due to the internal conflict of the kingdom (Wasuwanich and Kuentag, 1983).

The name "ball clay" is derived from an early custom in the United Kingdom of excavating clay by cutting it into one-cubic foot blocks, which eventually became rounded to form balls. "Plastic clay" is a term used to describe fine-grained, highly plastic, principally kaolinitic sedimentary clays. However, the principal type of plastic clay, used in the whiteware industry because it fires to a white or near white colour, is called "ball clay" (Harben and Bates, 1990).

Ball clay is highly regarded in the ceramic industry because of its high plasticity, good dry strength, and long vitrification range. Besides, the firing of ball clay produce a white or near-white product. High-quality ball clay can make up 30 per cent of the body mix of wall tiles, vitreous china, sanitary ware, and insulator porcelain, and 5 to 25 per cent of earthernware and ordinary porcelain. Plastic clays of lower grade are used in heavy products such as pipe, brick, and tile. Ball clays are also used in refractories, as anti-caking agents in animal feedstuffs, and as fillers in rubber and plastics.

Ball clay or plastic clay is one type of secondary kaolin (Bristow, 1989) formed by the weathering of granitic rocks or other felsic rocks which was subsequently transported by aqueous agent and deposited in a sedimentary basin. Ball clay normally laid down by fresh water in a young sedimentary basin and frequently intercalated with coal seams. The major composition of the ball clay is clay minerals in which disordered kaolinite is usually the chief constituent, while illite, chlorite and montmorillonite are subordinate to minor components. Other non-clay minerals include minor quartz and trace amount of iron-oxide minerals. Another important component of the ball clay is carbonaceous material, which might have caused a dark colour in the ball clay, but it helps enhance the plasticity.

In Thailand there are many Cenozoic intermontane sedimentary basins from the north to the south. They are non-marine sedimentary basins that were deposited by sequences of sandstone and mudstone with intercalated coal beds similar to those at Devon and Dorset of England, where one of the best ball clay has been produced. Among those intermontane basins, the ball clay-bearing basins are Chiang Mai basin (Mae Rim and Muang localities), Mae Tha basin in Lampang, Prachinburi basin (Muang locality), Surat Thani basin (Wieng Sa locality) and Nakorn Sri Thammarat basin (Chawang, Pibun, and Thuang Yai localities), etc. For the Mae Than ball clay of the Mae Than basin in Lampang, both ball clay and coal have been commercially exploited.

The total inferred reserves of ball clay from three localities in Thailand are 6,380,000 tons with details as shown in Table 1.1.

The significance of ball clay as a raw-material for ceramic industry in Thailand is rather obvious especially after 1987. However, high quality ball clay has to be imported to strengthen the ever-increasing industrial demand particularly, after 1988. The production, export, and import statistics of ball clay of Thailand are shown in Table 1.2.

Table 1.1 Inferred reserves of ball clay from three localities in Thailand (Kuentag, 1995).

	Deposits	Type of Clay	Inferred reserves (ton)	Remarks
1	Ban Mae Than, Mae Tha, Lampang	Ball Clay	1,300,000	25.4% Al_2O_3 58.3% SiO_2 2.6% Fe_2O_3
2	Surat Thani, and Nakhon Sri Thammarat	Ball Clay	80,000	31.1% Al_2O_3 49.8% SiO_2 2.1% Fe_2O_3
3	Ban Khok Mai Lai, Muang, Prachinburi	Semi-Ball Clay	5,000,000	33.6% Al_2O_3 46.1% SiO_2 1.7% Fe_2O_3
			6,380,000	

Table 1.2 Production, export, and import of ball clays of Thailand. (metric tons)

	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
Production	3,276	720	N/A.	1,766	1,557	1,856	2,200	4,960	2,520	7,988
Export	N/A.	N/A.	N/A.	N/A.	N/A.	N/A.	N/A.	N/A.	N/A.	728
Import	N/A.	764	783	616	648	450	N/A.	N/A.	N/A.	533

	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
Production	11,203	57,719	86,890	134,941	183,313	178,192	224,254	345,846	329,286	308,001	386,334
Export	260	1,210	1,799	1,180	4,278	5,223	7,282	9,398	12,659	12,053	12,894
Import	502	610	1,787	2,550	2,553	4,778	N/A.	N/A.	5,363	1,308	10,779

(N/A. : not available)

(Source : Department of Mineral Resources)

The Mae Than ball clay appears to be the largest deposit in Thailand with inferred reserves of 1,3000,000 tons (Kuentag, 1995). At this deposit, the total thickness of ball clay is approximately 10 metres intercalated with two coal seams. Average chemical composition is 58.34 per cent SiO_2, 25.36 per cent Al_2O_3, 2.58 per cent Fe_2O_3, 0.09 per cent CaO, 0.25 per cent MgO, 1.36 per cent K_2O, 0.19 per cent Na_2O, 0.03 per cent MnO, 0.24 per cent TiO_2 and 10.82 per cent LOI, Loss on Ignition (Kuentag, 1995). This ball clay has yellowish-white or pinkish-white fired colour and is refractory until about 1,640°C. They are used in the ceramic industry, i.e., sanitary ware, tableware, tiles mosaic and electrical insulators.

The study area

The study area is situated at Ban Mae Than, Tambon San Don Kaew, Amphoe Mae Tha, Changwat Lampang in the northern part of Thailand (Fig. 1.1). The reference topographic maps of the scale 1:250,000 is NE 47-11 (Changwat Uttaradit), and of the scale 1:50,000 series L7017 is 4844 I (Amphoe Sop Prab). The area covers 50 square kilometres and lies approximately between the latitude of 17°57′N to 18°02′ N, and longitude 99°26′E to 99°32′E.

Accessibility

The study area can be conveniently accessed from Bangkok by many routes to Changwat Nakorn Sawan. Then took the Highway no. 1 to Changwat Tak, Amphoe Thurn, Amphoe Sop Prab, Amphoe Ko Kha and Amphoe Mae Tha, Changwat Lampang (Fig. 1.1). At Km 560 on the Highway no. 1 turn right along a paved road for approximately 10 kilometres to Ban Mae Than. The total distance from Bangkok to the study area is around 570 kilometres.

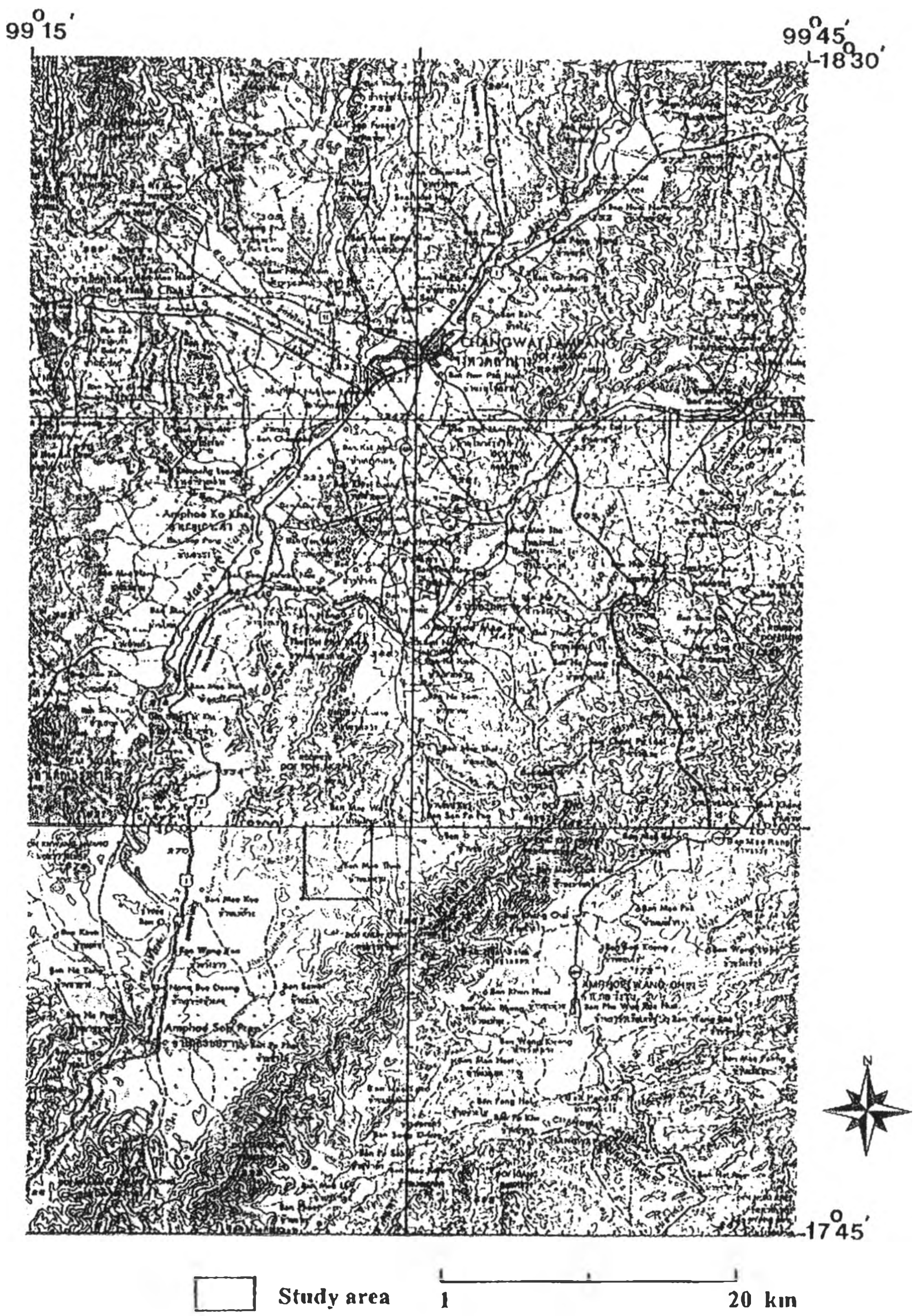

Fig. 1.1 Map showing the accessibility to the study area.

Objectives

The purposes of this study are 3 folds. Firstly, the detailed geology of the Mae Than basin with special emphasis on sedimentary sequence, lithological characteristics, and geological structures is assessed. Secondly, the mineralogical variation as well as the potential sources of ball clay is determined. Lastly, the appropriate utilization of the ball clay in accordance with its quality is proposed.

Method of investigation

The method of study in this project can be summarized as a flow chart shown in Figure 1.2. The first phase of study was the literature survey of the previous works on the geology of Mae Than basin and neighboring area, clay mineral classification and their origin, origin and evolution of Cenozoic basin in Thailand and other countries, techniques of clay mineral analysis and quantification, characterization of some ceramic and other properties of clay minerals to be used in various industries.

The second phase of study is the field investigation which was carried out during October to November 1996 and October 1997. The fieldwork included geological mapping and sample collection of the basement rocks surrounding the Mae Than basin, detailed lithological observation of the Cenozoic sequences in the mine pits of the Siam Cement Plc. and the Banpu Plc. and 5 drill-cores in the Banpu mining lease area. Systematic sampling was conducted on those drill-cores for further laboratory study. Drill-cores samples were splitted into two parts, one part was used for the detailed lithological observation with depth, whereas the other part was kept as a reference. Sampling method employed in this study is the combination between the continuous sampling and chip sampling so as to represent each individual sub-unit within the total unit (Compton, 1962). Bulk samples of interburden claystone and altered rhyolitic tuff were also collected for mineralogical, chemical and ceramic characterization.

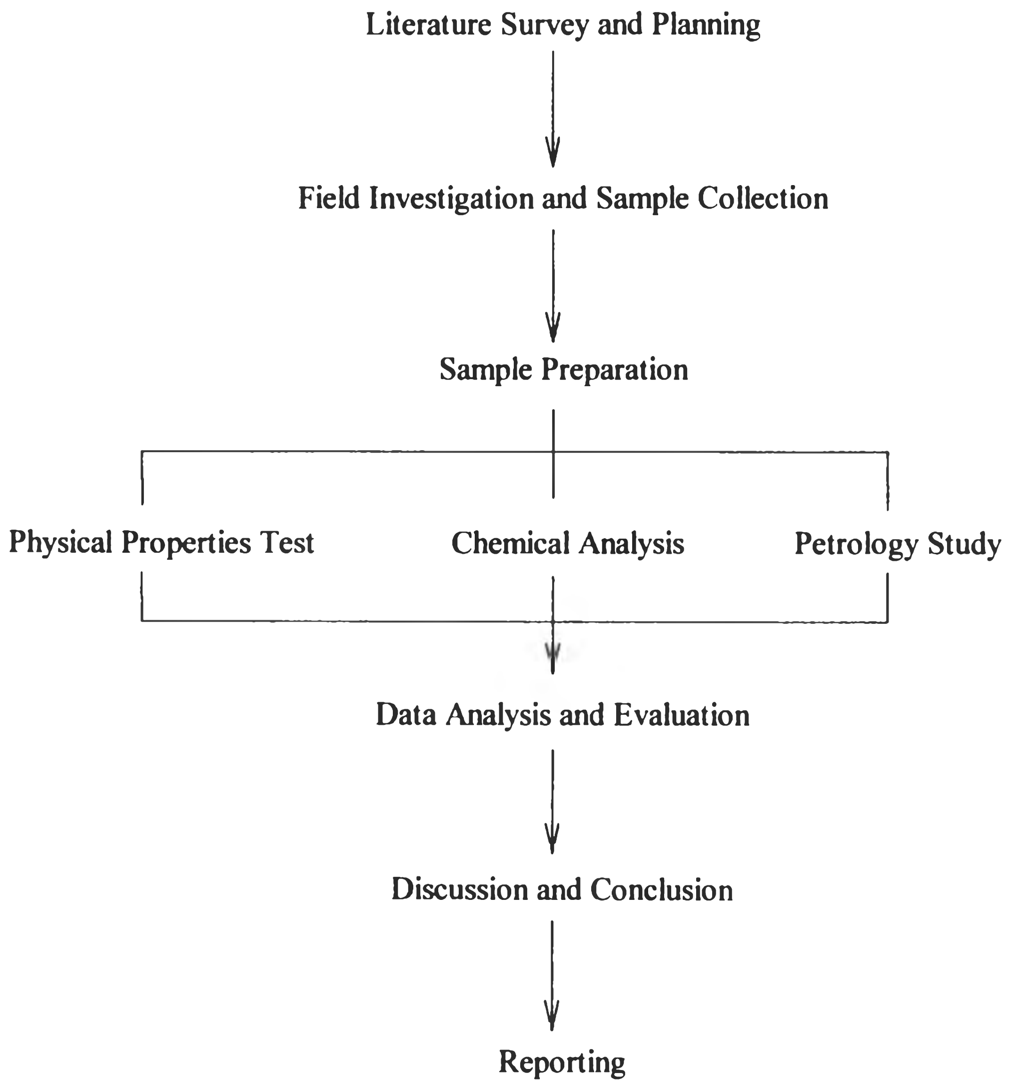

Fig. 1.2 Flow chart summarized the method of study.

The third phase of this project is laboratory study. This includes standard thin-sectioning of the basement rocks for petrographic investigation under polarizing microscope. Altogether 40 thin-sections were made from rock samples. The systematic drill-hole samples were used for characterization their sand/silt/clay ratios by sieving and pipette analysis. Altogether 200 samples from drill-holes were carried out in this study. Each samples were splitted by coning and quartering for 200 grams (modified after Carver, 1971). They were dispersed in distilled water and was left overnight. Wet sieving technique is used for sand size separation and stainless sieve no. 230 mesh (62 micron) is employed. The fines passing this sieve were collected and determined the amounts of silt and clay size fractions by pipette technique (Carver, 1971 and Folk, 1968). Muds of each samples are poured into the 1,000 millilitres graduated cylinder and stir virgorously for uniform throughout the column. The elapsed time for withdrawal sample finer than 62 micron is 20 seconds at depth 20 centimetres (Carver, 1971). Then the elapsed time for withdrawal sample finer than 2 micron is 3 hours and 27 minutes at depth 5 cemtimetres (Carver, 1971). In this stage, all samples were also sucked, dropped on glass slide, and dried at room temperature for the determination of their relative clay mineral contents using peak area's following the technique of Weir et al. (1975). All separated samples are dried in the oven at 80° C, and then calculated the amounts of each fractions. The glass slide was used for clay mineral determination using X-ray 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. Four samples from 2 drill-cores, and 3 samples from the Banpu mine pit were studied under the scanning electron microscope (SEM) and thermal analysis (DTA/TG) at the Scientific and Technological Research Equipment Centre, Chulalongkorn University. Two bulk samples of the claystone layers between coal seams and weathered rhyolitic tuff from the Siam Cement and the Banpu mine pits, respectively, are separated in 2 sizes, -44 micron and -2 micron fractions, by sedimentation technique for characterization of their ceramic properties and chemical compositions. Four separated samples from the claystone between the major two coal seams and weathered rhyolitic tuff were tested for ceramic properties, namely, residue on sieve, particle size distribution, modulus of rupture, deflocculant demand, cast-rate, colour, shrinkage, water absorption, and chemical composition at Central Laboratory Department of MRD-ECC, Changwat Lampang.

Previous investigations

The preliminary geological investigation of the Lampang basin and neighboring area was systematically conducted by the Geological Survey Division, Department of Mineral Resources, in 1971. As a consequence, the regional geological maps in the 1:250,000 scale of Changwat Lampang and Changwat Uttaradit including geological reports were accomplished in 1971 and 1974, respectively (Piyasin, 1971; 1974). Later on the clay deposits in northern Thailand including the deposit at Ban Mae Than, Amphoe Mae Tha, Changwat Lampang was first investigated in more detailed under the Industrial Minerals Development Project of Department of Mineral Resources during the Third National Economic Development Plan (Wasuwanich, 1972). The genesis of clay deposit at this locality has been proposed, and ceramic properties of the clay have been fully characterized. In 1977, the clay reserves at Ban Mae Than deposit, has been reported to be 2.5 million metric tons (Kuentag, 1977). In 1980, the Economic Geology Division, Department of Mineral Resources, published the Economic Geology Bulletin No. 19 on the comprehensive Industrial Clay Deposit of Thailand (Kuentag et al. 1980). The Kaolin and related clay deposits of six main provinces, namely, Lampang, Uttaradit, Prachinburi, Nakhon Sri Thammarat-Surat Thani, Ranong and Narathiwat, have been studied particularly regarding the occurrences, production, and properties.

The detailed geological investigation of the Mae Than basin and neighboring was conducted by the Geological Survey Division, Department of Mineral Resources (Charoenpravat, 1986). In 1987, the geology of Amphoe Sop Prab and Amphoe Wang Chin have been once again studied and published in the Geologisches Jahrbuch Reihe B, Heft 65 (Wolfart, 1987). The coal geology of the Mae Than basin has been studied in details using drilled-hole data and the basin configuration as well as the lithostratigraphy have been accordingly proposed (Muenlek, 1992). The properties on grain size distribution, mineral and chemical compositions of some Mae Than ball clay samples obtained from four active mines have been investigated in 1995 (Suwanich, 1995). Recently, the Economic and Social Commission for Asia and the Pacific (ESCAP) published the report volume 8 on Industrial Minerals Development in Asia and the Pacific in 1995. In this report, the geology of ceramic raw materials in Thailand has been reviewed (Kuentag, 1995).

At present, there are five active mines in the Mae Than area producing both ball clay and/or coal, namely, Banpu Plc., Siam Cement Plc., Siam Carbon Co., Clays and Minerals (Thailand) Co., Ltd., and Thanasab (or Chew Kee Chan) Co.