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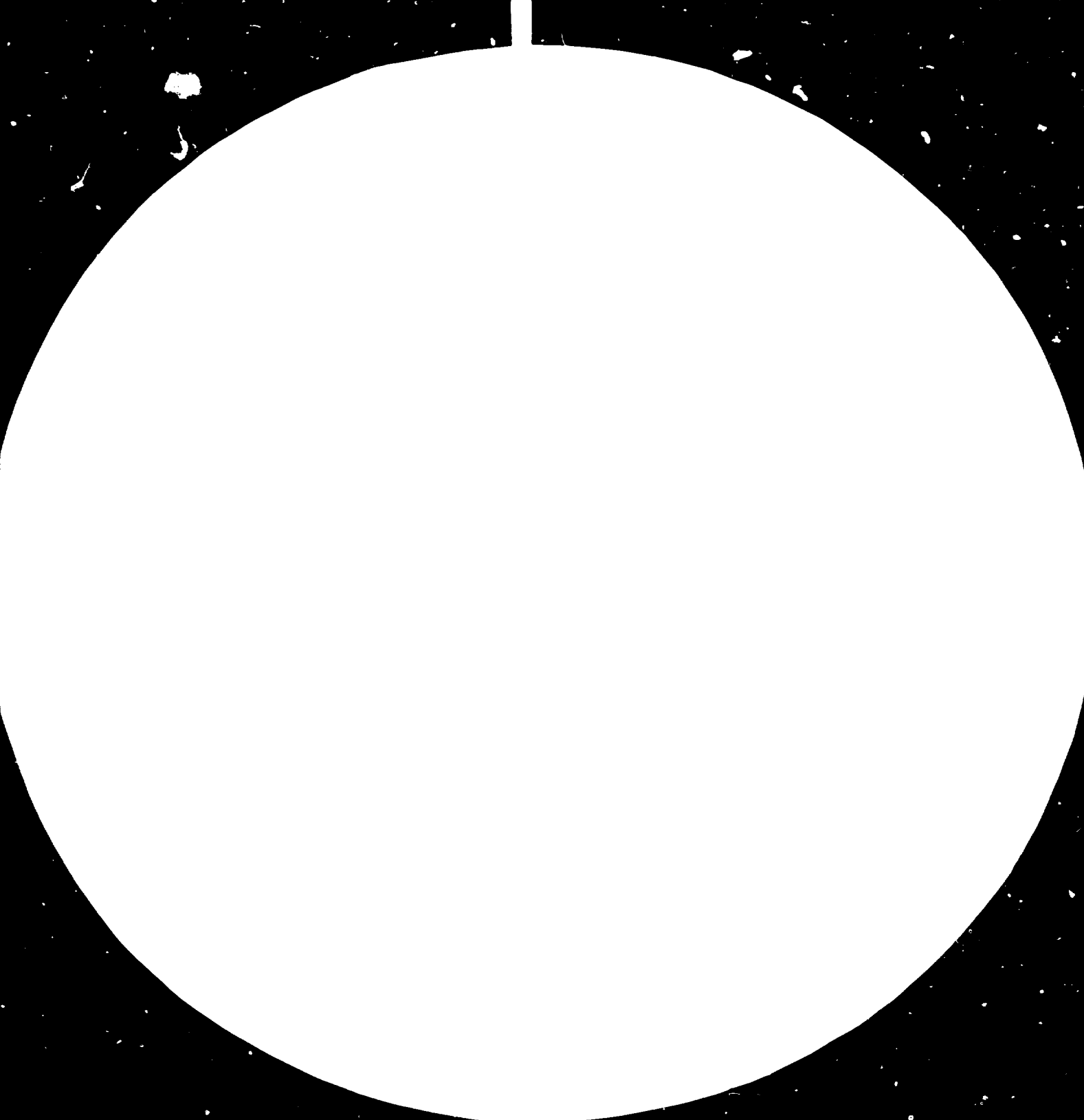

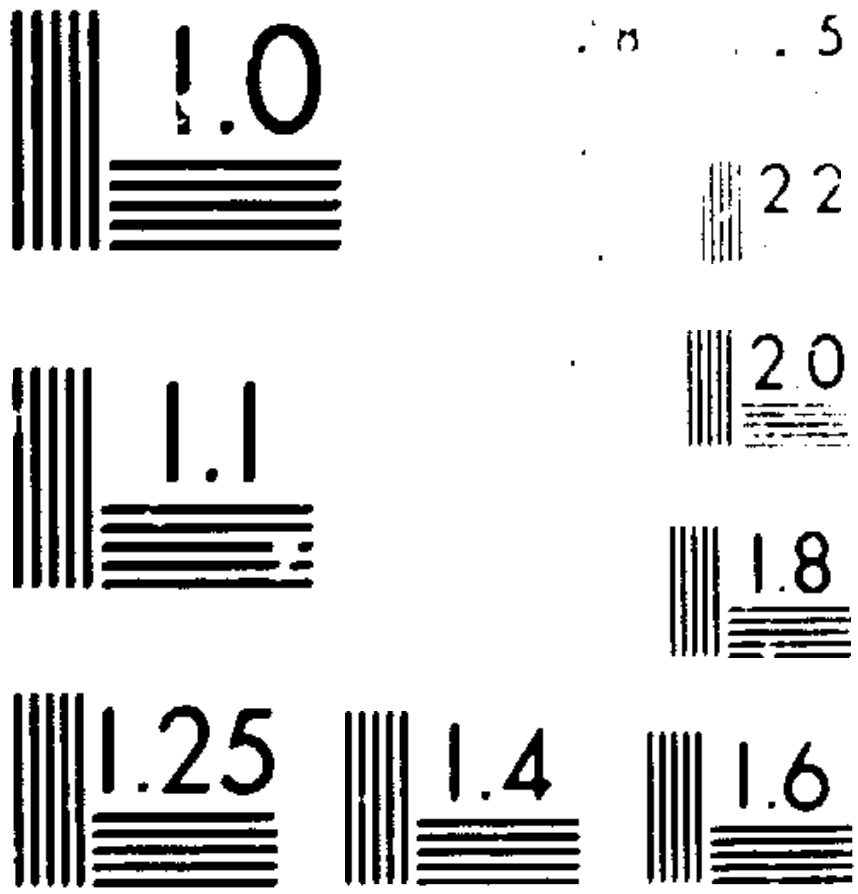
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KAOLIN DEPOSITS OF THAILAND**

by

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* Organized by the United Nations Industrial Development Organization (UNIDO) in co-operation with the Government of the Socialist Republic of Yugoslavia.

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Kaolin is a common raw material in Thailand. Pure and impure kaolin has been mainly used in ceramic industry, and to a lesser extent, in paper, paint, refractory, and insecticide industries. There are tens of deposits which have been exploited throughout the country to meet the industrial needs.

It is certainly not possible to describe in this paper all occurrences of the kaolin deposits existing in Thailand. Therefore, only significant deposits of economic interest will be presented as examples of each type of deposits.

The kaolin deposits of Thailand are genetically classified as (1) hydrothermal deposits, (2) sedimentary deposits and (3) residual deposits. Kaolin deposits of hydrothermal origin occur as irregular zone, vein type and massive deposits and mostly embody granitic and rhyolitic rocks.

The bedded kaolinitic clay occurs in Tertiary and Quarternary terrigenous sediments. It is attributed to sedimentation of clay particles. Several small Quaternary kaolin deposits are ball clay (plastic clay). They occur as thin to moderately thick (0.5-6 m.) beds of black to buff color ball clay. Residual deposits are massive and form mainly by in situ weathering of granitic, rhyolitic and schistose rocks.

The distribution of the major kaolin deposits of Thailand is shown in Fig. 1.

Hydrothermal deposits

This type of deposits was formed by hydrothermal alteration of rhyolite intrusive of post-Triassic age. The rhyolite intruded into

sedimentary rocks of Lampang group (Triassic) and Ratburi group (Permian). It underwent silicification following with kaolinization. Kaolinized rhyolite formed as irregular zone alternating with silicified rocks.

The kaolinized rhyolite is composed mainly of quartz kaolinite and illite, which together comprise from 70 to 90 peroent of the kaolinized rock. Fine mica, partial altered feldspar and rarely mafic minerals make up the remainder of the decomposed rock.

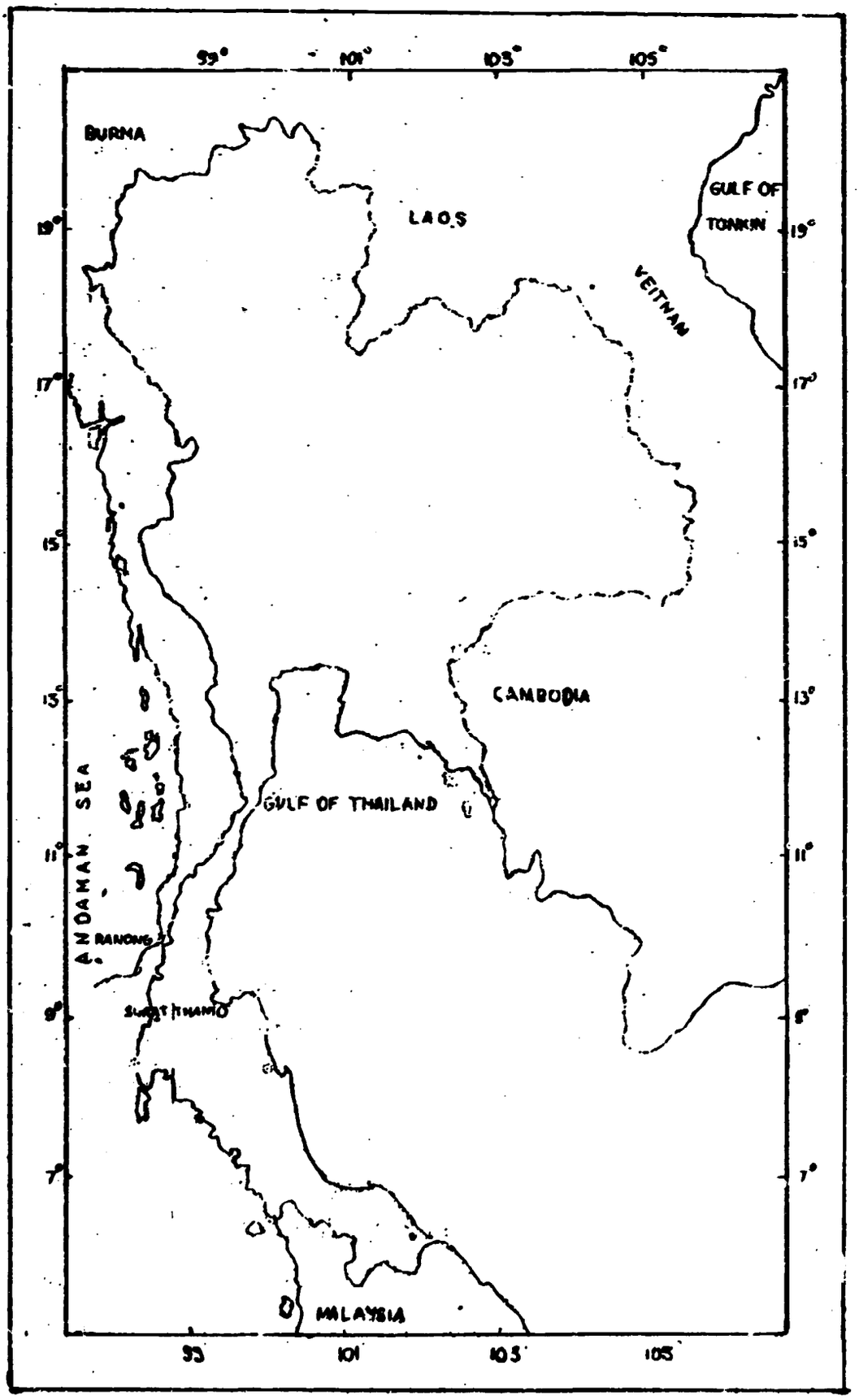
One of the adjacent deposits of economic interest, Pangka, located 26 km north of Lampang province, northern Thailand is the biggest known kaolin deposit of this type. It occurs as irregular zone of kaolin alternating with silicified rock within the 1 km long rhyolite body. The probable ore reserve is over 5 million tons. The other one, Huai-pan deposit, similar deposit of smaller size, has the probable ore reserve over 1 million ton.

Hydrothermal deposit (Pneumatolysis)

One of the most important kaolin deposits originated from pneumatolytic alteration of granitic rocks. Most of them are closedly associated with cassiterite formation. As a matter of fact, kaolin is a common gangue mineral in pneumatolytic cassiterite type deposits. They have been exploited as secondary mineral or as by product and in some case as essential mineral. Kaolinized rocks mainly occurred as zones conformable to the contact plane and also adjacent to quartz vein.

The major kaolin deposit of this type occurs in a 60 km long and 15 km wide granitic range in Ranong province, southern Thailand. The batholith trends north-south with steep contact to the country rock. The country rocks are sedimentary and metasedimentary rocks of Kang Krachan Group (Carboniferous-Devonian). The granite is of Cretacious in age and underwent strong pneumatolysis.

There are three distinct types of granites in the area : those are porphyritic (biotite) granite, coarse-grained (tourmaline) granite



Kaolin Deposits of Thailand

and medium-grained granite. Porphyritic (biotite) granite is the original source or the parent rock forming mountain range. Coarse-grained (tour-maline) granite is the transition rock of the middle zone between the parent rock and the altered rock. The medium-grained granite is the real source rock of cassiterite and kaolin. It apparently spreads as a sheet-like mass forming at the upper zone of the contact and grading to the other two mentioned rock types. Kaolinized rock is usually confined to the upper part of the contact zone along which it sporadically spreads within the altered granite mass. The kaolinized zone varies in depth ranging from 15 meters up to 50 meters.

In general, kaolinitic clay is creamy white in color with occasionally pale yellow to yellowish brown, especially that occurs along the minor fracture zones. The clay is mainly composed of quartz, kaolinite and mica.. Tourmaline and cassiterite are the minor constituents of the decomposed rock.

At present, there are only three active mines in the area. Kaolins of Haad Sompan area are as by-product of tin mining whereas at Bangrin is mined solely for kaolin.

The estimated total kaolin reserves may reach 20 million tons.

Hydrothermal deposit (replacement)

Dickite, one of the rare clay minerals, emplaced sporadically along the west and the northwest rims of volcanic rock suite. It is located in western Nakorn-Nayok and southern Saraburi provinces, central Thailand. The volcanic rocks are dominantly of intermediate and felsic varieties. They are Permo-Triassic in age.

The dickite is attributed to hydrothermal replacement of rhyolitic rock ; where as the fracture filling is locally seen as the remnant of the up-coming solution. The ore occurs as irregular vein in the rnyolite body. The biggest known dickite dyke, Khao Changok, is reported as 40 m wide, 200 m long and 80 m deep.

The dickite is massive and exhibits a variety of colors. Replacement type is mainly recognized as light gray and greenish gray, and subordinately bluish gray and pinkish gray. One the other hand, fracture filling type is uniquely green.

Sedimentary deposits

A number of known kaolin deposits in Thailand are of sedimentary origin. They are predominantly flood plain deposits and subordinately lacustrine deposits. All of them are restricted to Tertiary and Quaternary time. Tertiary kaolins usually occur as thick bedded (10 m) with varying size, where as Quaternary kaolins are generally blanket deposits (0.5 - 6 m thick). In general, the clays are fine to very fine grained with various colors : white, creamy, gray and black. They are semiplastic to plastic with considerable iron and titania content.

"Maethan Clay" occurs in a small Tertiary basin in the Metha district of Lampang province, northern Thailand. Quaternary gravel bed of 2 to 5 meters thick unconformably overlies the clays and exists as overburden. The clay beds invariably trend along the rim of the basin with moderate dips. The total thickness is about 10 meters. The probable reserve is over 5 million tons. According to plasticity, considerable content of contaminant oxides and high refractoriness, the clay is suitable for the manufactures of ceramics and refractories.

There are several small and medium size of Quaternary ball clay deposits in the low land along the western and southwestern sides of Khao Luang granite range of Nakorn Sri Thammarat and Surat Thani provinces, southern Thailand. They are alluvium deposits. In general, the clay conformably overlies gravel bed. The thickness varies from 2 to 6 meters. The overburden is normally Sandy clay of 1 to 2 meters thick. Khu Dindam, one of the deposits, is an example of ball clay in this area.

Residual deposits

This type of deposits was formed by in situ weathering of various rock types. The important ones are granite, rhyolite and schist. Among these, weathered granite seems to be the most significant host in both quality and quantity.

Residual kaolin derived from the weathering of Triassic granite occurs in Todeng village, Su-ngai Padi district of Narathiwat province, southernmost Thailand. The weathered granite situates along the plain at the foot of granite range. Surprisingly, the texture of granite is still preserved in the weathered rock. It is soft, friable and white color. The beneficiated kaolin is high in quality and suitable to use as paper filler and fine cermic manufactures. The possible reserve of high quality kaolin amount to over 10 million tons.

The weathered rhyolite of post-Triassic is the host for illite formation. It occurs in Wangyang village, Muang district of Uttaradit province, northern Thailand. The illite is along the plain and on the slope of rhyolitic hills. It is very fine grained and of white color. The washed illite is used as filler in paint, paper and insecticide manufactures. The probable reserve is over 5 million tons.

Residual clay derived from the weathering of schist (Devonian-Carboniferous) occurs in Khokmailai village of Prachinburi province, central Thailand. It situates along the wavy plain adjacesent to volcanic plateau and covers the area about 2 km long and 0.5 km wide ; where as the thickness varies from 1 to 10 meters. The white kaolin formation overlies the red kaolin formation under which the basement is shist. The top soil is 1-3 meters thick. The whole area is probably a product of lateritic weathering where lateritic crust is eroded. The washed kaolin is used in the manufactures of pottery and refractory and as the filler in fertilizer industry. The probable reserve of white kaolin is about 5 million tons.

Mineralogical, geochemical and physical conditions

The mineral compositions, chemical compositions, physical conditions and the kinds of kaolin minerals are shown according to the types of the deposits.

Mineral composition

Type of deposit	Name of deposit	Main	Accessories
Hydrothermal deposit			
Rhyolite	Khao Pangkha	K, I, q	-
Rhyolite (replacement)	Khao Cha-ngok	D	py
Granite (pneumatolysis)	Bangrin	K, q	I
Sedimentary deposit			
Ball clay	Khu Dindam	K, q	I
Maethan clay	Maethan	K, q	I
Residual deposit			
Weathered rhyolitic rocks	Wangyang	I, q	K (m)
Weathered granite	Todeng	K, q	I
Weathered schist	Khokmailai	K, q	

D - dickite I - illite K - kaolinite
q - quartz m - montmorillonite py - pyrite

Chemical composition

	Hydrothermal deposits		Sedimentary deposits			Residual deposits		
	Bangrin (washed)	Khao Cha-ngok (grade A)	Khao Pangkha (washed)	Khu Dindam	Maethan	Mangyang	Todeng	Khokmailai
SiO_2	48.25	43.86	69.5	51.85	60.57	68.56	46.08	49.29
Al_2O_3	35.93	40.74	21.1	32.80	26.28	19.32	36.90	34.42
Fe_2O_3	1.39	0.05	0.85	2.14	1.72	2.21	1.67	1.77
CaO	0.08	0.08	0.55	0.10	0.07	0.05	0.05	0.33
MgO	0.05	0.13	1.5	0.52	0.29	0.53	0.11	0.05
K_2O	1.20	0.24	–	2.24	2.01	4.99	0.10	0.17
Na_2O	0.13	0.12	2.0	0.14	0.27	0.22	0.98	0.06
MnO	0.01	0.13	–	0.01	0.02	0.04	0.01	0.01
TiO_2	0.08	0.18	–	0.30	0.17	0.21	0.88	0.93
H_2O (–)	0.13	0.39	–	nil	0.65	0.21	0.11	0.49
In. Loss	12.59	12.16	4.5	10.06	7.72	3.01	13.50	12.56
Total	99.89	98.08	100	100.16	99.77	99.35	100.39	100.08

Physical properties

	Fired color T 1200 °C	Total Shringkage % , T 1200 °C	Water absorption % , T 1200 °C	Refractoriness		Modulus of Rupture (lb/in^2)	Particle size distribution % ,	
				washed	unwashed		< 3 μ	< 3 μ
Hydrothermal deposit								
Khao Pongkha	white	8.6	13.1		1650	136		50.5
Bangrin	white	-	-	1765		150.1	25.7	
Sedimentary deposit								
Khu Dindam	white	-	-		1717	566.39	37.8	
Maethan	white	14.90	0.59		1760	310	77.2	
Residual deposit								
Ban Wangyang	gray	21.07	0.1	1348	1320	20	35.4	
Tedong	white	11.27	44.37	1768	1743	18	15.8	
Khaimailai	white	23.2	12.6	1760	-	115		59.1

Utilization of kaolin

the major uses of kaolin clays are as follows.

Various properties of the clays are omitted from the table :

Kinds of clay		Use
Hydrothermal kaolin	In rhyolitic rocks	Pottery, white ware, cer
	In granitic rocks	Pottery, white ware
Sedimentary kaolin	Ball clay	Pottery, white ware
	Macthan clay	Pottery, white ware
Residual deposit	Weathered rhyolitic rocks	Paint, paper filler, insecticide filler
	Weathered granite	Pottery, white ware paper filler
	Weathered schist	Pottery, fertilizer filler, refractories

Statistical data

Output of kaolin clay

tonnes

Year	1975	1976	1977	1978	1979	1980
kaolin	15,782	20,000	25,970	34,694	44,694	24,954
Ball clay	x	3,274	720	-	1,766	1,557

Export and import of kaolin clay

Year		1975	1976	1977	1978	1979	1980
Export (kaolin)		1,406	500	790	604	1,170	1,343
Import	kaolin	2,546	6,843	4,392	2,395	3,511	
	ball clay	-	-	764	783	615	

Economic evaluation of deposits

No detailed tonnage measurements were made, but probable reserves were estimated at 40 million tons, 10 million tons and 5 million tons for kaolin, ball clay and illite, respectively. In the authors' experience, if the other known deposits of non-detailed investigation are taken into account, the reserves may reach 2 to 3 time of that have been mentioned.

According to the above reserves, Thailand should be self-sufficient country for kaolin, at least for the decades to come. As a matter of fact, high quality kaolin, especially for paper filler, paper coating, medicine and cosmetic has been traditionally met by imports. Local kaolin shares only a small amount of total demand. Main factor which has so far hampered the production of high quality kaolin is beneficiation.

History of investigation and exploitation

Thailand has a long history of ceramics dating back to 7000 year ago when Banchiang earthenware appeared. More recent record is the production of Chinese-type glazed stoneware of Sukhothai reign at the end of the 13th Century. However, the active use of kaplin began in the last decade with regard to the rapid progress of ceramic industry.

The first systematic investigation of kaolin deposits has started in 1970 by Department of Mineral Resources. The data on the distribution, mineral composition and others are being accumulated.

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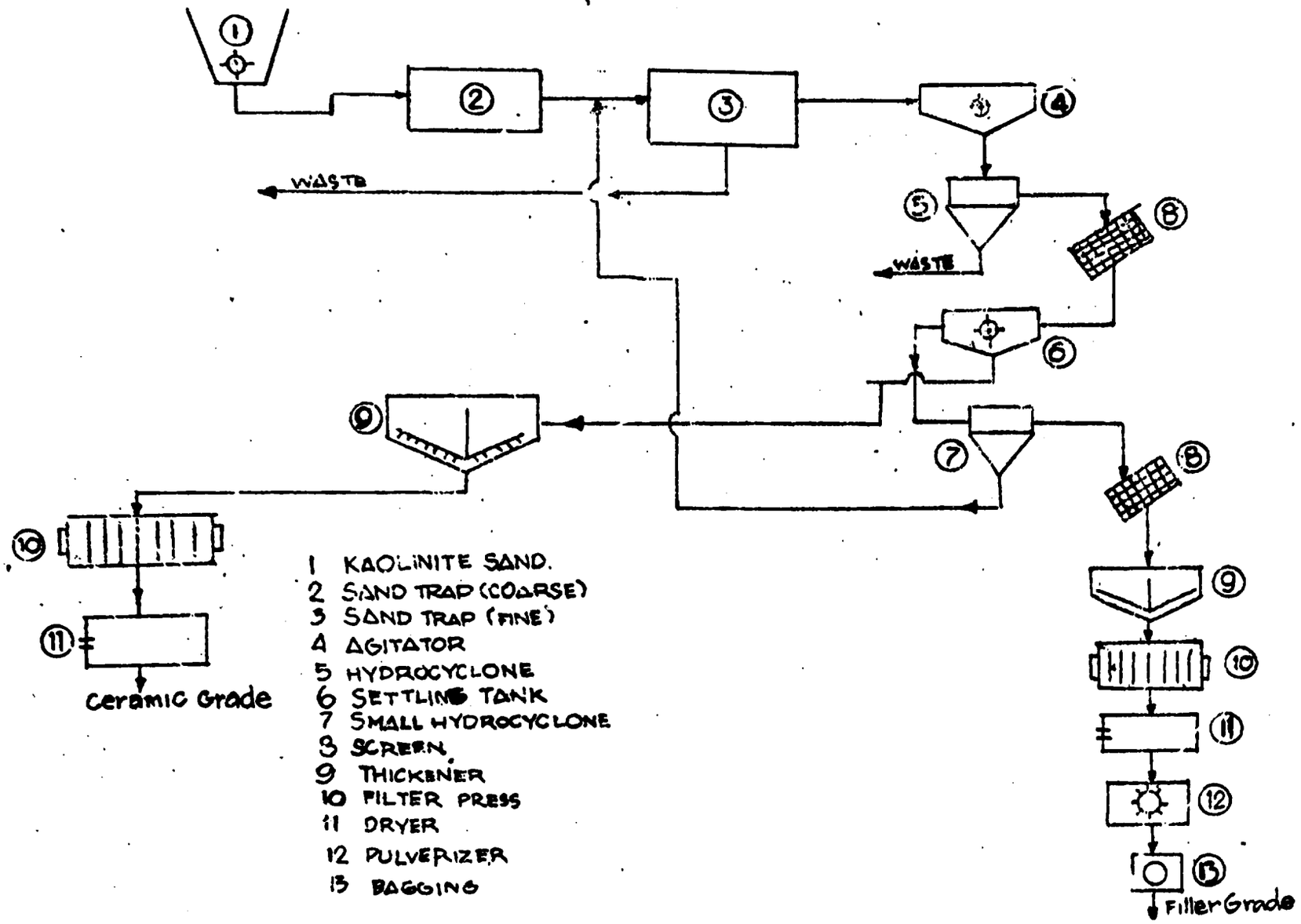
Kaolinite Separation

Kaolinite sand, after mixed with water, is fed to coarse sand trap to remove coarse sand and rejected as a waste. Then the slurry flows to fine sand trap and again finer sand is discarded as a waste. The slurry from fine sand trap is stored in an agitator and pumped to a hydrocyclone number one. The cyclone underflow is rejected as a waste and the overflow passes through the 100 mesh screen to remove leaves, wood, etc. and stored in the settling tank. From settling tank the underflow goes to thickener to remove the excess water and fed to a filter press, dryer to get a ceramic grade product. The overflow from settling tank is pumped to another hydrocyclone which is smaller than the first with higher pressure. The underflow is fed back to fine sand trap and the overflow passes through 325 mesh screen to remove a foreign material which is bigger than the mentioned size. The slurry is then fed to thickener, filter press, dryer, and pulverizer respectively to get a filler grade product.

Flowsheet of Kaolinite Separation



1 KAOLINITE SAND.
2 SAND TRAP (COARSE)
3 SAND TRAP (FINE)
4 AGITATOR
5 HYDROCYCLONE
6 SETTLING TANK
7 SMALL HYDROCYCLONE
8 SCREEN
9 THICKENER
10 FILTER PRESS
11 DRYER
12 PULVERIZER
13 BAGGING