

## Review of the potential and exploration of tin in Thailand

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**Abstract:** Thailand has been one of the world's leading tin producers for many decades. The major part of tin production is derived from the southern peninsula while a lesser amount is produced from the northern and central parts of the country. In Thailand, as in Malaysia and Indonesia, most of the tin is extracted by placer mining.

Tin exploration has been done primarily by the private sector. In accordance with the National Development Programme for Social and Economics, investigation of tin potential and exploration work has been conducted, since 1962, under the Tin Exploration Project of the Department of Mineral Resources. Prospecting has been carried out mainly on land. Statistics on production of tin ore up to the present have revealed a potential of tin in offshore areas. Offshore prospecting is being planned in the Tin Exploration Project.

### INTRODUCTION

Of the minerals produced commercially in Thailand, tin is of the greatest economic importance. It is exceeded in export income only by rice, corn and jute and contributes considerably toward the economic and social development of the country.

There is sound archaeological reason to believe that Thailand was the first site of the Bronze Age because it was one of a few areas in the world where both tin and copper were in adequate supply. Excavations in the village of Ban Chiang in northeast Thailand have revealed bronze objects in conjunction with pottery which, dated by the thermoluminescent dosimetry process, shows they were manufactured about 4,500 B.C.; more than six thousand years ago.

The first historical tin mining industry was located on Phuket Island about 450 years ago. Phuket, the first known trading post for tin, amber and pearls in Asia, was then controlled largely by Dutch, Chinese, French, British and Portuguese merchants. The island is situated off the southwestern shore of Thailand in the Indian Ocean. Since vessels plying between Chinese and Indian ports frequently called there it was sometimes known as "Junk Ceylon".

Prior to the second World War geologists believed that tin deposits occurred only in the younger (Cretaceous-Tertiary) granite in the South and that the older granites in other parts of the country bore no tin whatsoever. In 1947 wolframite deposits were found at Mae Lama District in Mae Hong Son Province in older granite and a few years later tin deposits were discovered in older granite at Mae Saeong District in Chiangmai Province, both in the North. Studies carried out have confirmed that these two deposits are definitely related to the older granites, thus firmly disproving the earlier belief that tin deposits are found only in the younger granites. Since these two deposits were found, investors from other parts of the country, especially those from the south, have been seeking further mineral deposits in the northern and central areas.

In Thailand, tin deposits are confined to the granite ranges that are exposed on land and extend into the offshore area. Prospecting and exploration work has been

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and is continuing to be done by the Tin Exploration Project of the Department of Mineral Resources in the northern, central and southern parts of the country. This step-by-step work is conducted in the following sequence: photogeology mapping, geochemical sampling, panning, in some cases geophysical surveying and, finally, pitting and drilling in specifically selected areas.

The geological environment shows a good potential for tin in the offshore area. The Tin Exploration Project is currently increasing the impetus of its prospecting effort toward the offshore rather than the inland area. The programme for the new prospecting plan is directed initially towards the exploration of the shallow areas and, as experience is gained, to later investigate the deeper zone.

### THE GENERAL GEOLOGICAL SETTING

The chief igneous rock in Thailand is granite which are exposed in batholithic masses and constitute the backbone of the mountain range which trends north-south. The tin metallogenetic province is closely associated with granite intrusions and tectonic activities (Fig. 1). The available data on radiometric dating suggests that there are four distinctive ages of granite within the plutonic belt in Thailand; Late Paleozoic, Triassic-Jurassic, Cretaceous and Tertiary (Suensilpong, 1977). Granite of any age can bear tin ore. Granite in the tin-rich area is generally subjected to pneumatolysis. The texture of the granite is normally porphyritic, sometimes coarse and, when in close contact with the country rock, the texture seems to be finer (Aranyakanon, et al, 1969).

Aranyakanon (1961) studied the altered granite of Ranong (Haad Som Pan type granite) as a good example of a pneumatolytic cassiterite deposit having no contact with calcium-bearing country rock. In the primary tin area, the pneumatolytic alteration of various granite shows similar effects, in that the amount of biotite is reduced and is, at times, not to be seen, whereas the amounts of tourmaline and muscovite increase.

Most tin deposits in Thailand are partly derived from pegmatite veins. Tin bearing pegmatites are generally found in all granite masses such as Tantikowit Mine (Kratoo), Phuket Province; Shone Mine, Surat-Thani Province; number of localities at Takua Pa District and Phangnga Province; Pato-Paksong, Chumphon Province; Mae Chaem, Chiangmai Province; etc. Quartz-lode is another source of tin and is found in many localities such as Ronpibul, Khao Khiam and Sichon, Nakhon Si Thammarat Province; localities at Surat-Thani Province; localities at Yala Province (Table 1). The cassiterite hydrothermal lodes are closely associated with greisen. Greisen may be found as pure veins intruding other rocks. Pneumatolytic minerals such as topaz, fluorite, apatite and tourmaline etc., are usually found in greisen. The greisen which occurs adjacent to quartz veins yields a considerable amount of tin such as at Klong Sra, Kanchanadit District, Surat Thani Province; Khao Manora, Ban Ronglek, Tha Sala District, Nakhon Si Thammarat Province, etc. Disseminated cassiterite in the country rock is found adjacent to tin lodes or stringers of the area. At Hin Tak Mine, Na San District, Surat-Thani Province, fine grained cassiterite is disseminated in the schist country rock. At Thai San Mine, Na Thawi District, Songkhla Province, the cassiterite is impregnated in sandstone with tourmaline as gangue mineral. In Thailand, the cassiterite deposit of contact metasomatic type is of minor occurrence and may be found only at the contact zone of limestone and granite such as Pin Yoh at Tam Talu, Yala Province, etc.

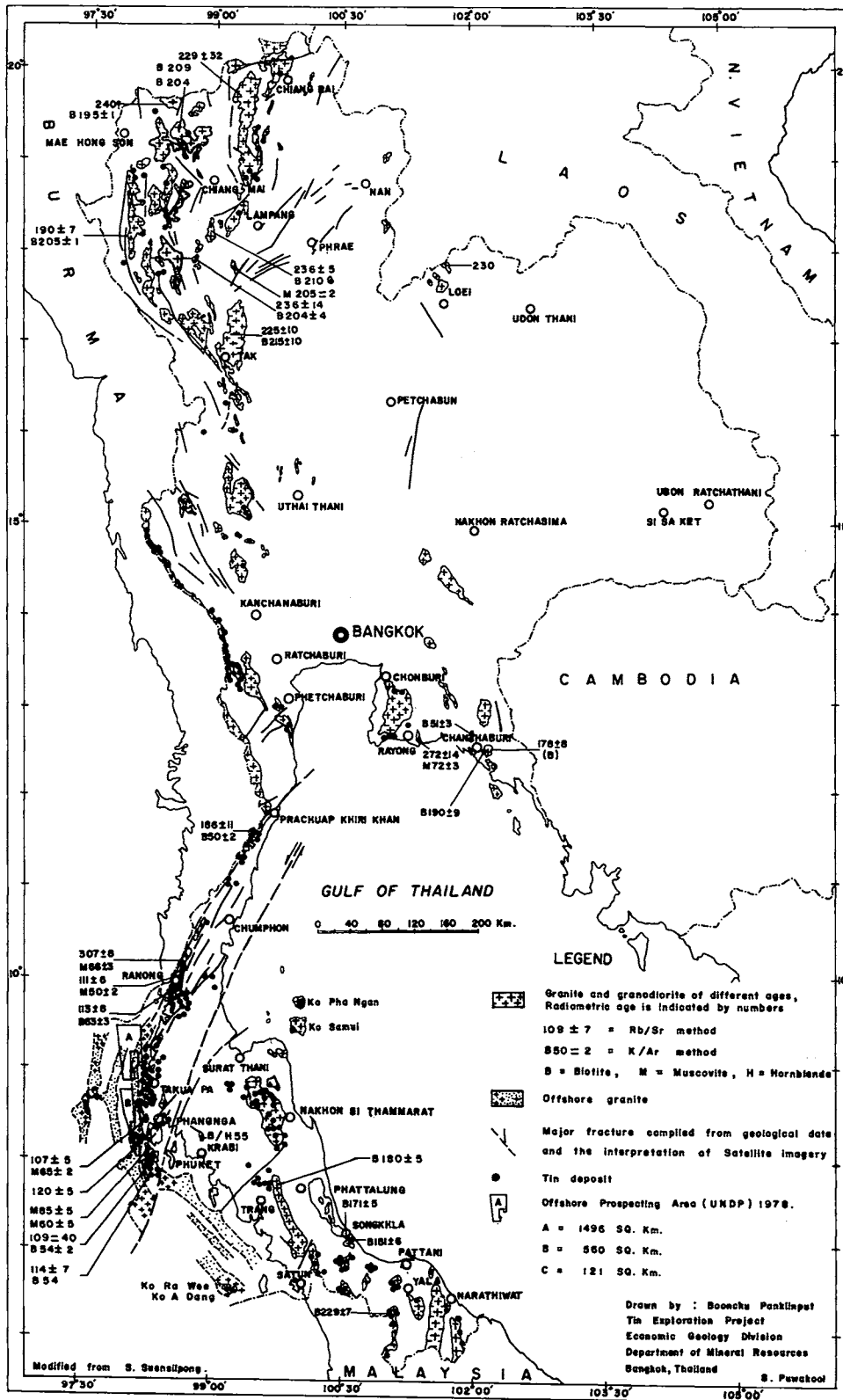


Fig. 1. Map of Thailand illustrating the tin deposits related to granitic rocks.

TABLE I  
TYPES OF TIN DEPOSITS FOUND IN VARIOUS PROVINCES

Province	Hydrothermal lode & greisen	Disseminated cassiterite in the country rock	Pegmatitic	Contact metasomatic	Disseminated cassiterite in the altered granite	Eluvial/ Alluvial
<b>Northern Region</b>						
Chiang Rai	x	—	—	—	x	x
Mae Hong Son	x	—	—	—	—	x
Chiang Mai	x	—	x	—	—	x
Lampang	x	—	—	—	—	x
Tak	x	—	—	—	—	x
Uthai Thani	x	—	x	—	x	x
<b>Central Region</b>						
Kanchanaburi	x	—	—	—	—	x
Ratchaburi	x	—	x	—	—	x
Phetchaburi	x	—	—	—	—	x
Rayong	x	—	—	—	—	x
Prachuap Khiri Khan	x	—	x	—	—	x
<b>Southern Region</b>						
Chumphon	x	—	x	—	—	x
Ranong	x	—	x	—	x	x
Surat Thani	x	x	x	x	—	x
Takua Pa	x	—	x	—	x	x
Nakhon Si Thammarat	x	x	x	x	—	x
Phangnga	x	—	x	—	—	x
Phuket	x	—	x	—	x	x
Trang	x	—	x	—	—	x
Songkhla	x	x	—	—	x	x
Pattani	x	—	—	—	x	x
Yala	x	—	—	x	x	x
Narathiwat	x	—	x	—	—	x

The secondary cassiterite deposits (eluvial, alluvial) were derived by weathering of the above mentioned primary sources. These types of tin deposits are the most important source of the tin produced in Thailand.

#### THE POTENTIAL OF THE TIN BELT

The tin bearing granite of Thailand lies in an arc of the Southeast Asian metallogenetic province which is the most important tin producer in the world. The major part of this province extends from North Burma via peninsular Burma, Thailand and peninsular Malaysia to the "Tin-Islands" of Indonesia (Singkep, Bangka and Billiton) covering in all, a distance of more than 1,800 miles (Hosking, 1969).

In the northern part of the country tin occurs in quartz lodes, pegmatites and less commonly, in altered granite. In the central and southern parts of the country, quartz lodes, pegmatites, greisen and altered granite are the major sources of tin. All the areas with tin potential are generally found in or near the contact zone of the gra-

nite and the country rocks. Eluvial and stream deposits of cassiterite are common in the north but only a few deposits are known to contain appreciable reserves, whereas placer tin deposits are most common in the South.

In Thailand, tin is mainly produced from placer deposits with small quantities produced from lodes or massive rock formations. Alluvial tin deposits produce several important by-products including monazite, xenotime, zircon, rutile, ilmenite, garnet, columbite-tantalite, columbian rutile and struverite. In 1977 the total production of tin concentrates was about 33,314 metric tons (Table 2).

TABLE 2  
PRODUCTION OF TIN CONCENTRATES (METRIC TON)

Province	1972	1973	1974	1975	1976	1977
<b>Northern Region</b>						
Chiang Rai	98	123	153	37	72	46
Mae Hong Son	29	99	62	1	x	x
Chiang Mai	452	413	370	248	215	182
Lampang	301	179	149	61	17	29
Tak	184	218	267	206	200	231
Uthai Thani	122	167	83	93	79	131
<b>Central Region</b>						
Kanchanaburi	490	513	553	664	1,282	1,613
Ratchaburi	982	1,015	1,237	877	1,174	1,361
Phetchaburi	6	x	1	36	35	30
Rayong	x	x	8	12	x	x
Prachuap Khiri Khan	1,158	1,266	1,414	1,265	1,569	1,497
<b>Southern Region</b>						
Chumphon	1,231	802	847	741	558	538
Ranong	2,802	2,642	2,618	2,530	3,127	3,229
Surat Thani	1,568	1,594	1,624	1,099	1,101	1,172
Takua Pa	4,960	5,065	4,194	3,349	5,264	6,158
Nakhon Si Thammarat	1,464	1,483	1,537	1,339	1,640	1,843
Phangnga	3,889	3,713	4,462	1,837	4,807	8,070
Phuket	6,596	6,144	5,645	5,805	4,645	4,409
Trang	872	685	496	418	415	424
Songkhla	1,948	1,649	1,463	1,123	1,104	1,259
Pattani	x	x	1	2	3	10
Yala	877	704	563	607	608	459
Narathiwat	103	87	40	12	41	53
Unspecified origin	x	x	x	x	x	300
<b>Total Production</b>	<b>30,132</b>	<b>28,561</b>	<b>27,767</b>	<b>22,397</b>	<b>27,921</b>	<b>33,314</b>

About eighty four percent of the total production of tin is derived from mines in the southern region while the rest comes from the central and northern regions. Phuket, Phangnga, Takua Pa and Ranong are the major producer provinces of the country (Table 2). In 1977 Phuket Phangnga and Takua-Pa Provinces produced 18,637 metric tons of tin concentrates which were mined from offshore, nearshore and inland placer deposits, whereas in Ranong Province tin was mainly mined from altered granite and the amount of tin produced was 3,229 metric tons of tin concentrates. The

quantity of offshore tin when compared with the total production of tin from Phuket, Phangnga and Takua-Pa Provinces is about seventy percent (Table 3).

Total inland cassiterite reserves in the country were estimated, in 1961, to be about 1 million ton of tin in concentrates. From 1961 to 1977 the production of tin in concentrates was 325,250 tons. The offshore cassiterite reserves in the southern region are estimated in 1977 to be about 163,000 tons of tin in concentrates.

TABLE 3  
PRODUCTION OF TIN CONCENTRATES BY OFFSHORE-DREDGING  
& SUCTION BOATS (METRIC TON)

Province		1972	1973	1974	1975	1976	1977
<b>Southern Region</b>							
Takua Pa	Offshore-dredging	544	892	833	835	55	648
	Suction boat	—	—	—	—	2,855	3,261
Phangnga	Offshore-dredging	1,103	1,327	2,355	311		85
	Suction boat	—	—	—	—	3,525	5,362
Phuket	Offshore-dredging	3,039	2,997	2,982	3,015	1,886	2,282
	Suction boat	—	—	—	—	12	40
<b>Total Production</b>		<b>4,868</b>	<b>5,216</b>	<b>6,170</b>	<b>4,161</b>	<b>8,418</b>	<b>13,045</b>

(Table 2 & 3. From: Mineral Statistic of Thailand, Department of Mineral Resources, Bangkok, Thailand)

#### EXPLORATION WORK ON TIN IN THAILAND

Tin is commercially more important than any other mineral produced in Thailand. Tin lodes in the country are of minor importance and land reserves are depleting. Prior to 1961, the search for new tin deposits was carried out, mostly by private individuals and companies. In order to accelerate the implementation of various development policies, a need arose for the government to carry out its own prospecting. The Tin Exploration Project of the Department of Mineral Resources was proposed in the National Development Programme for Social and Economics in 1962. The Tin Exploration Project was operated jointly by the Economic Geology Division, Engineering Division and Mining Technology Division of the Department of Mineral Resources.

In 1977 the Fourth National Development Programme for Social and Economics continued to include the Tin Exploration Project in the programme. The objectives of the project are as follow:—

1. To outline areas geologically favorable to tin deposits for present and future development.
2. To increase tin production and royalty income to the country.
3. To promote the living standard of the local people in the mining area.
4. To ensure proper utilization of the minerel.
5. To assist agencies in technological mining ventures, and engineering works.

The Tin Exploration Project has carried out the prospecting and exploration with the objectives of delineating the anomalous areas. Initial geological mapping to establish the stratigraphy and structural geology was followed by panning, stream sampling and geochemical prospecting (rocks, sand and soil samples). The final stages such as test pitting, banka and diamond drilling may be introduced to prospect further in depth. Sometimes geophysical prospecting is applied as an indirect method for finding the structure and type of bedrocks.

The boundaries of tin bearing granites that occur predominantly in the western and southeastern parts of the peninsula have been extended into the offshore area. Offshore placers were derived from nearby offshore granites rather than from those on the mainland (Aranyakanon, et al, 1969) at the time when they were exposed due to lower sea-levels during the Pleistocene; granite normally occurs as bedrock near these offshore placers. The Department of Mineral Resources has established an offshore exploration unit. To date some geological work has been done and this, combined with geophysical work to be undertaken, may result in new tin deposits being found (Aranyakanon, 1973).

In 1907 offshore exploration around Phuket Island was carried out by E.T. Miles who was the pioneer in offshore tin prospecting. A wooden Banka-drill platform on two small boats was used at that time. He found economically valuable tin deposits at Thungka harbour and the first tin dredge began operating in the same year.

In 1962 the modern technique of using seismic profiling survey for offshore tin prospecting was introduced by Alpine Geophysical Company. The investigation revealed buried channels and depths to bedrock in an offshore area Phuket (Aranyakanon, 1973). Another survey was undertaken in 1968 by Cesco N.V. (Coastal Engineering Survey Consultants), under contract to Billiton Company, off the east coast of the peninsula, northeast, west and south of Samui Island (Fig. 1). After the survey, 18 holes put down showed disappointing results, well below expectations.

In 1969 Thailand Exploration and Mining Company Limited (TEMCO) carried out a seismic survey along the west coast of the peninsula from Ranong Province to the vicinity of Chang, Pha-Yam, Kum-Yai and Phra Thong Islands in Takua Pa as far south as Phuket and around Phuket Island. Drilling on the west coast of Phangnga Province revealed the presence of rich tin placer deposits.

In 1971 the Department of Mineral Resources assisted the Continental Mining Company Limited to run a sparker survey in the Rawee-Adang Island area. The profiling records promised positive structure and a large placer area. In 1973 detailed geological mapping, geochemical study and panning for tin along various tributaries were carried out under the Tin Exploration Project. A year later offshore drilling was using the "Sea Crab" drilling ship of TEMCO. The tin pay-streaks of some holes showed considerable high value.

In 1972, the Department of Mineral Resources assisted a private company using a proton magnetometer to survey around the Samet Island, off the coast of Rayong Province. Tin ore was found in only a few of the 24 holes drilled.

From 1962 to 1977 the Tin Exploration Project prospected in many different inland areas, such as in the northern, central and southern parts of the country. The geologic information derived from different localities, is interpolated in the search

for new tin deposits. The south-eastern part of the country is another new region which was prospected by the Tin Exploration Project in 1974. There are two new deposits of tin at Khao Khieo Bang Phla Soi area, Chonburi Province which promise to be of economic importance in the future.

In 1977 the Tin Exploration Project began a new project of prospecting and exploration around and in the lake of Songkhla which covered Pattalung and Songkhla Province, hoping that it would reveal another source of tin for the future. Beside this, two areas in the north and one area in the south are being investigated.

During the past sixteen years the Tin Exploration Project has succeeded in carrying out the works planned by the National Development Programme for Social and Economics. Reports, in the Thai language, on specific prospected areas have been published by the Tin Exploration Project. Each publication was written by the geologist who work in the area.

#### CONCLUSIONS

1. The depletion of inland alluvial tin demands the prospecting and exploration for new tin deposits of the lode type and in offshore areas.
2. The potential of tin offshore in the future is of more economic importance than that of the inland area.

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