WORKSHOP ON STRATIGRAPHIC CORRELATION OF
THAILAND AND MALAYSIA

Haad Yai, Thailand
8-10 September, 1983

GEOLOGY AND MINERAL RESOURCES OF SONGKHLA PROVINCE, THAILAND

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ABSTRACT

Conglomerate, sandstone, siltstone, shale, mudstone, limestone, and their metamorphic equivalents ranging in age from Cambrian to Triassic, are found in Songkhla Province. Of these the rocks of Carboniferous and Triassic ages are most abundant. Granite intrusions of late Triassic to early Jurassic age are found. Pegmatite, aplite, and quartz veins locally cut the granites and sedimentary rocks. Cassiterite is the most important ore mineral mined. Wolframite, barite, manganese, glass sand, heavy clay, crushed stone, gravel, and construction sand are occasionally produced.

INTRODUCTION

Songkhla province covers approximately an area of 7,580 sq. km, situating between latitude 6° 15' to 8° oo' N. and longitude 100° oo' to 101° 15' E. In Thailand about 87-90% of tin - concentrates are produced in the southern provinces. Songkhla ranks seventh, producing about 5-7% of the total southern output. Beside tin, other mineral commodities are wolframite, barite, glass sand and manganese. Rock aggregates, sands and heavy clays are also produced for local consumption.

The purpose of this paper is to present a brief account of the geology and mineral resources of this province. The information is drawn mainly from published works, with field data collected by the author. Special attention is given to deposits of tin and tungsten, the most important mineral products of the province.

PREVIOUS REPORTS

Grant - Mackie et al. (1980) described some Triassic strata of the Songkhla

area. Ishihara (1978, 1980), Geological Research Project team of Prince of Songkhla University (1979), and Pitakpaivan (1969) presented some petrographic and chemical data and radiometric ages of the granites of Songkhla area. Fossils from some localities were identified by Kobayashi (1959, 1966) and Igo (1973).

Trangcotchasan (1980) briefly described the geology and mineral deposits of Songkhla province. Suthakorn (1967, 1970, 1973) described the tin and manganese deposits of the area. Information on mineral deposits and given by Aranyakanon (1956, 1969), Kumanchan (1974), Angkatavanich (1975), Kuentag et al. (1977, 1978, 1982), Triyan (1972), Trangcotchasan (1975), and Pungrassami et al. (1983).

The 1:250,000 geologic map of Southern Thailand, was complied by Udomratn et al. (1980).

GEOLOGIC SETTING

Figure 1 shows the geology and mining areas of the Songkhla province. The geology of the western part of the map from 100^{0} 30' westward, was taken from the geologic map of Udomratn et al. (1980), while the geology of the eastern part where differences in geology are noted, was modified by the author.

Tarutao Group (Upper Cambrian)

The oldest rock unit which is exposed along the southwest corner of the Songkhla province is composed of sandstone, shale, quartzite and phyllite. This unit is known as Tarutao Group, the type section of which is found in the western part of the Tarutao island (Bunopas, 1974, 1976; Teraoka et al., 1982).

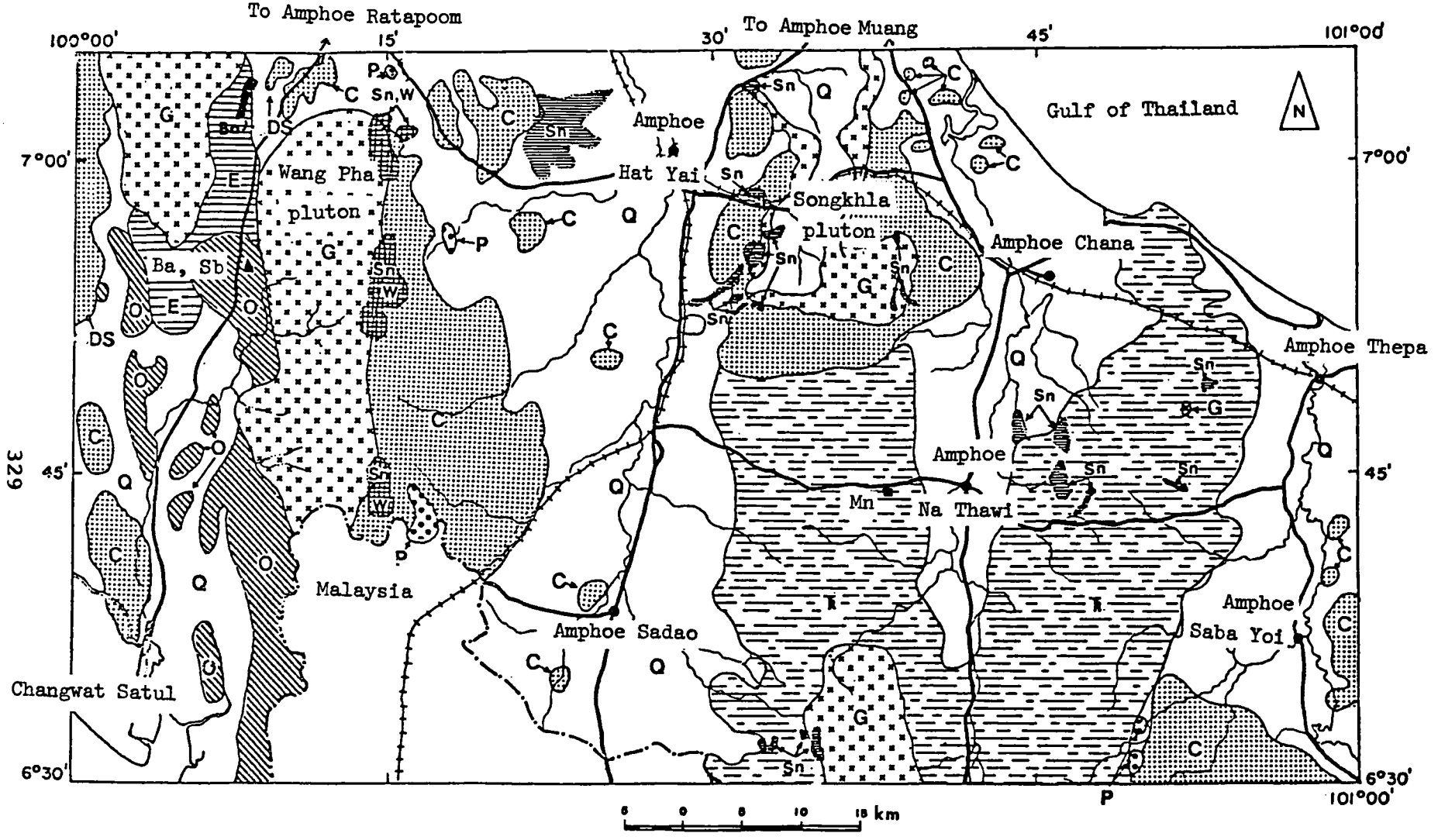
Thung Song Group (Ordovician to Lower Silurian)

The Thung Song Group is exposed along southwest section of Songkhla province along both sides of the highway to Satun. It consists of light to dark gray, massive to thin-bedded limestone; locally alternating with argillaceous layers.

Tanaosri Group (Silurian to Lower Carboniferous)

The Tanaosri Group was subdivided into two formations, viz., Kanchanaburi Formation (Silurian to Devonian) and Kaeng Krachan Formation (Devonian to Lower Carboniferous). The Kanchanaburi Formation is exposed in a small area to the west. It consists of sandstone, black shale, with some argillites.

Carboniferous rock which is the subordinate rock type in Songkhla area consists of sandstone, siltstone,shale, mudstone, chert, and argillite. Igo (1973) identified conodonts found in shale, and chert from the northern end of Ko Yo as Lower Carboniferous species.


To Amphoe Ratapoom
To Amphoe Muang
100°00'
15'
30'
45'
101°00'
7°00'
6°30'
45'
Gulf of Thailand
N
Amphoe
Hat Yai
Songkhla
pluton
Wang Pha
pluton
Amphoe Chana
Amphoe Thepa
Amphoe
Na Thawi
Amphoe
Saba Yoi
Amphoe Sadao
Malaysia
Changwat Satul
Ba, Sb
DS
Mn
Sn
Sn,W
W
P
C
Q
G
E
O
329
0 5 10 15 km

EXPLANATION

Sedimentary Rocks	*Age*
Q — Alluvium, eluvium, river gravel, terrace, local lateritic soils	QUATERNARY
R — Red bed of conglomerate, sandstone, mudstone and limestone	TRIASSIC
P — Massive and bedded limestone, light to dark gray with chert nudules interbedded with sandstone and shale with fossils	PERMIAN TO UPPER CARBONIFEROUS
C — Mudstone, sandstone, shale with fossils and cross-bedded chert and quartzitic sandstone	LOWER CARBONIFEROUS
DS — Sandstone, shale, chert, metatuff, black shale, bedded limestone, mudstone, schist and quartzite.	LOWER DEVONIAN TO SILURIAN
O — Light to dark gray, bluish gray, massive to thin bedded limestone with argillaceous layer and fossils	ORDOVICIAN
E — Mostly brownish gray, brown sandstone shale, quartzite and phyllite, local red sandstone, siltstone, shale with fossils	CAMBRIAN

Igneous Rocks	*Age*
G — Biotite granites, biotite hornblende granites, porphyritic biotite granites and tourmaline granites	JURASSIC TRIASSIC
Geologic boundary	
International boundary	
Railway	
Roads, hard surface, two or more lanes wide	
Stream	
Sn — Tin	
Sn,W — Tin - tungsten	
Barite	
Stibnite - barite	Manganese

(Modified after Udomratn et al., 1980)

Ratburi Group (Upper Carboniferous to Permian)

The Ratburi Group consists of massive and bedded limestone, light to dark gray with chert nodules, interbedded with sandstone and shale. It occurs as isolated hills extending northward to Pattalung, and to the southeast of the province near Amphoe Saba Yoi.

Triassic Rocks

Grant - Mackie et al. (1980) studied the marine Triassic rocks along the highway from Khlong Ngae - Amphoe Na Thawi - Amphoe Thepa to Amphoe Saba Yoi. This is the most extensive rock unit found in the eastern part of the province. It consists of sandstone, siltstone, mudstone, conglomerate, massive limestone, and chert.

Kobayashi et al. (1966) identified *Daonella sumatriensis* in siltstone from Khlong Mak, Amphoe Na Thawi and placed the rock in the Upper Triassic (Karnian) age.

The discovery of *Daonella* at 14 Km east of Khlong Ngae (Grant - Mackie et al., 1980) indicated a Ladino - Karnian age.

Tertiary Rocks

Sedimentary rocks of Tertiary age were reported near the Thai-Malay border (Scrivenor, 1913; Stauffer, 1973). No exposures are observed in Amphoe Sadao, but drilled hole and pit data show the existence of lignitic coal at Bukit Arang in Kedah and Perlis. The Tertiary basin extends from Amphoe Sadao into Malaysia.

Quaternary Deposits

Quaternary deposits consist of alluvium, eluvium, beach and terrace deposits including boulder, cobble, pebble, sand, and clay beds, occupying the coastal lowlands and floors of some inland valleys and are locally found on terraces or as erosional remnants of higher level deposits.

Granitic Rocks

Two N-S trending ranges of granite occurs in Songkhla province. They are the western and eastern ranges. Geological Project Research team (1979) and Ishihara et al. (1980) named the western one Wang Pha pluton and the eartern one, which extends into northern part of Malaysia, as Songkhla pluton. The granites intruded the surrounding Paleozoic and Triassic sedimentary rocks and thermally metamorphosed the sedimentary rocks to quartzite, metasiltstone, and hornfels.

The granites are mainly coarse - grained porphyritic biotite granite with some fine-to medium-grained, muscovite-biotite granite. Pegmatite, aplite and, quartz veins of various widths filled fractures in the granites or in the sedimentary rocks. Tourmalinization, greisenization, sericitization and argillization occurred in the cassiterite or wolframite mineralized areas.

Two radiometric ages were reported by Pitakpaivan (1969) for adamellite at Khao Rup Chang (7° 8' N/ 100° 37' E) and Ban Nam Noi (7° 3' N/ 100° 32' E) of Songkhla pluton, using K/Ar method on biotite. The ages obtained were 181 ± 6 and 171 ± 5 M.Y. respectively.

Ishihara et al. (1980) determined the K - Ar age of biotite in the corundum-bearing, pale brown biotite granite from Thung Pho mine (6° 55' 50" N/ 100° 31' 42" E) to be 191 ± 6 M.Y. and the K-Ar age of muscovite in the tourmaline - muscovite - quartz rock from Wang Pha Mine (6° 53' 47" N/ 100° 14' 22" E) was 187 ± 6 M.Y. They concluded that the granites near the *Daonella* fossil locality probably have their intrusion age close to their K-Ar ages, i.e., late Triassic to early Jurassic.

Toward the east of the Songkhla pluton (southwest of Kha Sa Ba mine; west of Amphoe Thepa) a small granite mass, about 4 x 5 m., crops out in the valley. This granite was earlier reported by Aranyaganon (1956) and was recently revisited by the author. It is fine-grained, leucocratic, porphyritic biotite granite with potash feldspar phenocrysts ranging from 4 to 7 mm in diameter. This is the only granite exposure found outside the Songkhla pluton.

MINERAL RESOURCES

The locations of the mines or mining districts of cassiterite, wolframite, barite, manganese, and silica sand are shown in Figure 1. The data on ore reserves of each deposit are questionable. Only production data from the past reflect the quantities of ores in the deposits.

Cassiterite

Most of the tin produced in Songkhla province is from placer deposits especially the alluvial placer. However, disseminated tin in granite, tin - bearing quartz veins, pegmatite and aplite dikes are also yield some tin. Tin is recovered as a by-product of wolframite mining along the eastern margin of the Wang Pha pluton.

Areas of significant tin production are:

1) Ban Tha Chang and Ban Cha Lung, Amphoe Haad Yai
2) Ban Tha Mo Sai, Amphoe Chana and Ban Chang, Amphoe Na Thawi
3) Ban Na Mom, Ban Thung Khamin (King Amphoe Na Mon), and Ban Phru, Amphoe Haad Yai
4) Ban Nam Noi, Amphoe Haad Yai
5) Ban Kho Saba, Amphoe Thepa
6) Ban Thap Chang, Amphoe Na Thawi and Ban Samnuk Taeo, Amphoe Sadao

Occurrence

Cassiterite generally occurs as primary and secondary deposits. They are found in altered granite as dissemination and pocket bodies; in quartz veins, pegmatite and aplite dikes; and as eluvial and alluvial placer deposits. The primary tin deposits can be classified into pneumatolytic and hydrothermal deposits.

Pneumatolytic deposits

The cassiterite deposits occur in the apical parts or cupola of the granite. Mineralization are confined to fine-to medium-grained muscovite - biotite granite which is intensely altered by the actions of volatile matters. The alterations are kaolinization, sericitization, and greisenization.

Thung Pho mine

(6° 55' 50" N/ 100° 31' 42" E) is a deposit of this type. Cassiterites are disseminated in the altered granite that intruded quartzite and shale. Ore pockets of 6 by 3 meters were reported (Somboonkul, personal communication). Cassiterite - bearing quartz veinlets and quartz - feldspathic lode were also found in the altered granite. the attitude of quartz veins are 230° to 295° and dip 30° to 78° (average 55°). Arsenopyrite and pyrite are common. Torbernite can locally be seen along fractures of the granite. Purple fluorite veinlets are present. Production of tin concentrates from this mine, between 1967 to 1982 is shown in Table 1.

Table 1 - Production of tin concentrates, in m.t. of Thung Pho mine

1967*	1968	1969	1970	1971	1972	1973	1974	1975	1976
12.55	74.10	60.18	44.60	40.07	33.95	37.86	33.71	49.97	37.39
1977**	1978**	1979**	1980	1981	1982				
35.20	43.95	14.55	33.66	27.24	33.32	Total 612.3 m.t.			

* operated in October
** Production from old tailings

Thung Khamin mine

(Pak Song mine) lies north of Thung Pho mine on the same granite stock which is 1 km long. At the lower level the occurrence of cassiterite is similar to that of the Thung Pho mine, but the upper level contains numerous tin - bearing quartz veinlets along fractures of the overlying quartzite, metasiltstone and shale sequence. The thickness of the veinlets is commonly less than

1 mm. up to a few millimeters. Attitude of the mineralized quartz vein varies from 230° to 310°, the majority of them are around 285°-295°dipping about 30°to 65° (average 50°). Wolframite - bearing quartz veins were reported from this locality. The production from this mine is not consistent. The available record for two years (1980-1981) is 63.78 m.t. This mine has been operated intermittently since 1970.

Hydrothermal deposits

Hydrothermal lodes play an important role as a source of tin. Tin - bearing quartz veins are the most common type and occur in every tin producing areas. They are the main source of alluvial and eluvial tin deposits.

Deposits of this type are those of Thung Khamin mine, Kuan Jong deposit, Kho Saba mine, Saha Phon mine (Muang Mark mine) and Kit Jong mine.

Kho Saba mine

(6° 49' 26" N/ 100° 52' 55" E) This mine is located on the eastern margin of the mountain range. Operation strated by underground mining method before the World War II. Now open pit mining method is used.

The rocks consist predominantly of quartzite, metasiltstone, and argillite locally intercalated with 1 foot long chert lenses. These rocks are invariably fractured. Argillization and sericitization occurred along fractured zone where ron oxide stains are generally found. Cassiterite occurs as tiny grains associated with pyrite and arsenopyrite in fractures, or where argillization developed. Tin-bearing quartz veinlets are common. Locally cassiterite is found associated with sericite in veinlets. Attitudes of mineralized quartz veins are 100° to 140° dip 38° to 75°. Aranyakanon (1956) reported the occurrence of ore body along a fault of 340° dip 70°, and galena was found in the lower level of the deposit.

Table 2 - Production of tin concentrates* in m.t. at Kho Saba mine

1975	1976	1977	1978	1979	1980	1981	1982
161.34	145.68	149.58	96.66	78.12	66.36	61.53	43.5

Total 802.77 m.t.

* Tin concentrates containing about Sn 60-63%

Saha Phon mine

(6° 44' 07" N/ 100° 45' 56" E) is on the western margin of the same range as Kho Saba Mine. The country rocks are quartzite interbedded with argillite. Mineralization occurs along a fractured zone (1 meter in thickness), consisting

of cassiterite, pyrite, galena and chalcopyrite. Silicification and argillization are conspicuous. Monthly production of tin concentrates is about 20-30 piculs. The mine has been in operation since 1965.

Eluvial deposits

The deposits of this type have nearly all been mined out. The mines that initially produced eluvial tin are now working on primary tin ore. They include Kuan Jong deposit, Kho Saba deposit, Thung Pho and Thung Khamin deposits and, the Liwong area (east of Amphoe Na Thawi).

Alluvial deposits

Alluvial tin producing areas are:

1) Ban Tha Chang and Ban Cha Lung, Amphoe Haad Yai. There are 12 tin mines, one of which is dredging on land. The others are gravel pump mines.

Table 3 - Production of tin concentrates in m.t. at Ban Tha Chang and Ban Cha Lung

1975	1976	1977	1978	1979	1980	1981	1982
155.7	300.6	416.28	502.44	519.06	440.13	404.76	185.3
		Total	2,924.25 m.t.				

2) Ban Tha Mo Sai, Amphoe Chana and Ban Chang, Amphoe Na Thawi. There are 9 tin mines, two of which (one by small tunnelling and other by open pitting) are now operating from primary deposits with low production (less than 50 m.t. per year). The rest are gravel pump mines.

Table 4 - Production of tin concentrates in m.t. at Ban Tha Mo Sai, and Ban Chang

1975	1976	1977	1978	1979	1980	1981	1982
227.64	270.12	310.2	238.38	332.58	317.81	324.99	261.0
		Total	2,282.72 m.t.				

Another area of tin production normally included in Amphoe Chana is Ban Na Wa, which is lying on the eastern margin of Songkhla pluton. There were two small gravel pump mines. The total past production was 41 m.t. (1975-1979).

3) Ban Na Mom, Ban Thung Khamin King Amphoe Na Mon and Ban Phru, Amphoe Haad Yai.

There are nine gravel pump mines (except Thung Pho mine)

Table 5 - Production of tin concentrates in m.t. at Ban Na Mom, Ban Thung Khamin, and Ban Phru

1975	1976	1977	1978	1979	1980	1981	1982*
228.67	158.87	173.54	187.53	180.15	219.65	313.34	114.21

* Production from Jan. - Sept., 3 mines not operating.

4) Ban Nam Noi, Amphoe Haad Yai

There is only one mine (gravel pump) in this area which strated working since 1968,

Table 6 - Production of tin concentrates in m.t. at Ban Nam Noi, Amphoe Haad Yai

1968	1969	1970	1971	1972	1973	1974	1975
130.74	129.3	100.38	91.08	78.12	98.76	94.44	79.02
1976	1977	1978	1979	1980	1981	1982	
88.38	83.82	59.46	78.18	87.49	124.98	130.59	

Total 1,454.74 m.t.

5) Ban Thap Chang, Amphoe Na Thawi and Ban Samnuk Taeo, Amphoe Sadao

These two areas lie on the eastern and the western margins of the southern most pluton in Songkhla province close to Thai-Malay border. It is probably the south extension of the Songkhla pluton. The pluton is in between Amphoe Na Thawi and Amphoe Sadao. Due to its remoteness and being a sensitive area, little is known about the mines over there. Now the area is under military control.

Trangcotchasan (1980) reported that the deposit occurred near the contact of granite and quartzite, sandstone and shale. Cassiterite and wolframite in quartz were reported along the banks of Ton Sathorn creek.

These areas produced tin and tungsten. The available records of production is given in Table 7.

Table 7 - Production of tin and tungsten concentrates in m.t. at Ban Thap Chang, Amphoe Na Thawi and Ban Samnuk Taeo, Amphoe Sadao

	1975	1976	1977	1979
Ban Thap Chang				
Cassiterite	8.7	4.56	-	-
Wolframite	22.26	6.3	-	-
Ban Samnuk Taeo				
Cassiterite	112.5	36.6	32.76	-
Wolframite	2.28	4.8	-	-

Wolframite

Wolframite in Songkhla province is produced mainly from cassiterite - wolframite bearing quartz veins. Most of the productions are from three areas laying on the eastern margin of Wang Pha pluton; they are Khao Kaeo. Wang Pha mine and Ban Thung More. Wolframite is also mined as a by-product of cassiterite in certain areas, particularly at Ban Thap Chang, Amphoe Na Thawi and Ban Samnuk Taeo, Amphoe Sadao. Other wolframite producing areas include Thung Pho. Thung Khamin, the hill just north of Kuan Jong and the granite - quarry near Ban Nam Noi.

Khao Kaeo, Amphoe Haad Yai

(7^{o} 00' N/ 100^{o} 15'E) The deposit lies in the eastern margin of the northern end of Wang Pha pluton. Suthakorn (1973) reported the occurrence of cassiterite - wolframite bearing quartz veins filling fractures in graphic granite. Zone of mineralized quartz veins is about 1.5 m. in width and 47 m. in length. Beryl, tourmaline, and pyrite are associated minerals. Trungcotchasan (1980) measured the attitude of the quarth vein as N 50^{o} W dip 28^{o} S.W. Scheelite, molybdenite and arsenopyrite are also found.

Wang Pha mine, Amphoe Haad Yai

(6^{o} 53' 47" N/ 100^{o} 14' 22" E) This is an underground mine lying approximately in the middle of the eastern margin of the pluton. It is owned by the Yip in Tsoi Mining Co. The ore are mined at three levels: 50 m., 80 m., and 120 m. above the sea-level.

Country rocks are shale, mudstone, siltstone and sandstone of Carboniferous age (udomratn et al., 1980). The rocks are intruded by granite. Mineralized quartz veins cut into fine-to medium-grained, porphyritic, two - mica granites (Geological Research Project, 1979) and hornfels. Greisenization is the typical alteration found along wolframite bearing quartz veins. Geological Research Project (1979) reported hundreds of quartz veins in the mine area. The mineralized area extends 3.5 km. in N - S direction. The veins occur within 150 m.

to 300 m. from the contact. Strike of the veins are 180° - 195° dip 60° - 90°. Thickness of the veins varies from 15-50 cm (Trangcotchasan, 1980) to 1 m. Ishihara et al. (1980) reported various vein-minerals including : quartz, muscovite, potash feldspar, fluorite, chlorite, wolframite, cassiterite, arsenopyrite and pyrite.

The monthly production is about 80-170 piculs (average at 140 piculs ca. 8.4 tpms) of wolframite concentrates (70% WO_3).

Ban Thung Mor, Amphoe Sadao

(6° 43' N/ 100° 13' 45" E) The deposit lies in the eastern margin of the southern end of Wang Pha pluton close to the Thai-Malay border. Angkatavanich (1975) reported the intrusion of granite into quartzite and slate with quartz veins in the country rocks. She also found that cassiterite is more abundant than wolframite in the granite but wolframite is predominant near the contact zone. Associated minerals are molybdenite, pyrite, chalcopyrite, arsenopyrite and gilbertite.

Trangcotchasan (1980) measured strikes of two wolframite - bearing quartz veins in the quartzite, as N 15°E 30°NW; each has the thickness of 15 cm. In other locality he found three quartz veins with the direction of E - W 50°N, 50 - 75 cm in thickness.

Table 8 - Production of tungsten - tin concentrates in m.t. at Khao Kaeo, Wang Pha mine, and Ban Thung Mor

Khao Kaeo	1975	1976	1977	1978	1979	1980	1981	1982
Wang Pha								
cassiterite	1.38	2.58	1.08	12	24.0	-	-	-*
wolframite	75.42	102.72	98.46	116.7	106.8	91.08	86.34	63.56
Total wolframite 741.08 m.t. cassiterite 41.94 m.t.								
Ban Thung Mor								
cassiterite	14.58	17.94	8.52	15.18	11.34	-	-	-
wolframite	15.6	15.24	7.8	10.68	11.88	-	-	-
Total wolframite 61.2 m.t. cassiterite 67.56 m.t.								

* - not available

Manganese

The only manganese deposit known in Songkhla province is lcoated in Ban Mai, Tumbon Khlong Sai, Amphoe Na Thawi (6° 44' N/ 100° 37'E). Mining started

in 1965-1968 and 1972-1973, and 140,068 m.t. of silicomanganese ores were produced. Suthakorn (1967) investigated the area in details, including 140 tests - pittings (30 m. interval) and geophysical exploration. The manganese mineralization occurred in sandstone, siltstone, and shale of Triassic age. Argillization was found associated with the ore. High grade ore float were mined.

Table 9 - Chemical analysis of high grade Mn ore in percentages, Amphoe Na Thawi

MnO_2	Mm	Fe	F	S	SiO_2	Fe_2O_3	Cu	Pb	Zn
81.98	54.60	0.79	0.11	0.05	2.42	1.08	0.17	0.08	6.76

Sample collector: T. Pungrassami
Analyst: Mukda Suwana
Department of Mineral Resources

Barite

Barite from Ban Khao Phra, Tumbon Tha Chamuang, Amphoe Ratapoom (6^{o} 3' 30" N/ 100^{o} 8' E) is exposed at two localities at Kuan Huai Yai and Kuan Din Daeng. They are one km aprt in a northeast direction.

Barite occurs as veins in Cambrian sandstone and shale (Udomratn et al., 1980). Kumanchan (1974) reported the length of the vein to be about 450 m. and 3.5-6 m. in thickness. The trend of the vein is N 50^{o}E and some argillization occurred alona the contact of the ore and sandy shale. The deposit at Kuan Din Daeng possibly contains 100,000 m.t. of ore assaying at 80-90 per cent $BaSO_4$ (Kumanchan, 1974).

The ore is used in drilling muds for petroleum exploration well drilling. Specification for drilling mud grade is at least 4.2, i.e. it should contain 92 to 94 per cent $BaSO_4$.

Table 10 - Production of barite in m.t. at Ban Khao Phra*

1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982
3,300	6,700	250	7,150	8,500	2,900	3,200	625	350	75	-

Total 33,050 m.t.

* mining started in 1972; no production in 1982

Silica Sands

Songkhla was know as silica sands producing area for glass industries

since 1969. After the discover of silica sands in Rayong province, most of the consumers which are either in Bangkok or nearby areas, decreased the order and the production was stopped in 1977.

Silica sands occurs along a northwesterly coastal plain of Songkhla province, from Amphoe Muang to Amphoe Chana (7^{o} 13' N/ 100^{o} 40' to $70^{o}00'$ N/ 100^{o} 45'), at 300-700 m. inland from the coast. Trangcotchasan (1975) estimated the length of the deposit at 12.5 km, 86-125 m. in width, and the average thickness of 0.8 m. (maximum 1.8 m.). Eighty five percent of the grain - size is between 48 mesh to 100 mesh. The top soil is 20-30 cm. thick. Kuentag (1977) believed that source of the silica sand is sandstone, but Trungkotchasan (1975) mentioned that the granite source should be added. Reserves are estimated up to 2,000,000 m.t. (Trangkotchasan, 1975).

Table 11 - Chemical analysis of silica sands, Songkhla province (after Triyan, 1972)

SiO_2	Fe_2O_3	Al_2O_3	CaO	MgO	Ignition Loss
98.89	0.08	0.7	0.004	0.01	0.11

Table 12 - Production of silica sands in m.t. of Songkhla province*

1969	1970	1971	1972	1973	1974	1975	1976	1977	1978
16,400	43,720	27,440	48,080	51,450	46,600	13,600	10,800	4,950	-

* Mining started in Aug. 1969 and ended in 1978

Construction Materials

The term construction material is used to denote all low - cost minerals and rocks which are extracted in bulk, and used for construction purposes. It includes heavy clays, crushed stone, gravel and sand. They are relatively low-cost commodities, but they are the fundamental prerequisites for virtually all forms of development (e.g. roads, railways, and building).

Heavy clay

This is the low - cost clay that is used for bricks, roof-tiles, and some ceramic wares (e.g. pot, earthen jar). It is the raw materials for local industries, no general specifications are applied to the heavy clay.

Kuentag et al. (1978) reported occurrences of heavy clay in Songkhla province at Ban Lo. Tumboon Na Thap, Amphoe Chana; Ban Bo Po, Tumbon Nam Noi, Ban Po Mor, Tumbon Ban Phru and Ban Khlong Pom Nork, Tumbon Ban Phru, Amphoe Haad Yai.

Crushed stone

Rocks suitable for use as concrete aggregates and road - base in Songkhla province are limestone and granite. The production is for local consumption.

Kuentag (1982) listed seven rock - quarries in this area. Most of them are in Amphoe Ratapoom where Permian limestone is exposed.

Gravel and sand

Gravel is used as concrete aggregates and sand is used in the production of concrete, sand - lime bricks and as filling materials in land reclamation.

River gravel and sand are supplied to the local construction markets. Another source of gravel and sand, is from the mine dumps of many gravel-pump tin mines.

CONCLUSIONS

Cassiterite and wolframite mineralizations in Songkhla province are the most important metallic mineral commodities. Others minerals are manganese and barite. The industrial rocks and minerals are limestone, granite, heavy clay, and silica sand.

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