CHAPTER III

GEOLOGY AND HEAVY MINERAL CHARACTERISTICS

3.1 General

Considering the general pattern and classification of tin deposits inside Kathu Valley as compared with those outside the Valley, it is apparent that at least three major types of tin-deposits are encountered, namely, pegmatitic, pneumatolitic/hydrothermal, and placer deposits. From the mineralogical point of view, the differences of heavy mineral associations and distribution from several tin-mines in the study area are influenced by the genesis of each deposit.

The mineralogical characteristics under the present investigation is considered to be the most fundamental approach for any other pure scientific and applied aspects of heavy minerals concerned. The following discussion will be dealt with the geological setting and the heavy mineral characteristics of each tin-mine where sampling programme of this study has covered.

3.2 Kathu Valley Area

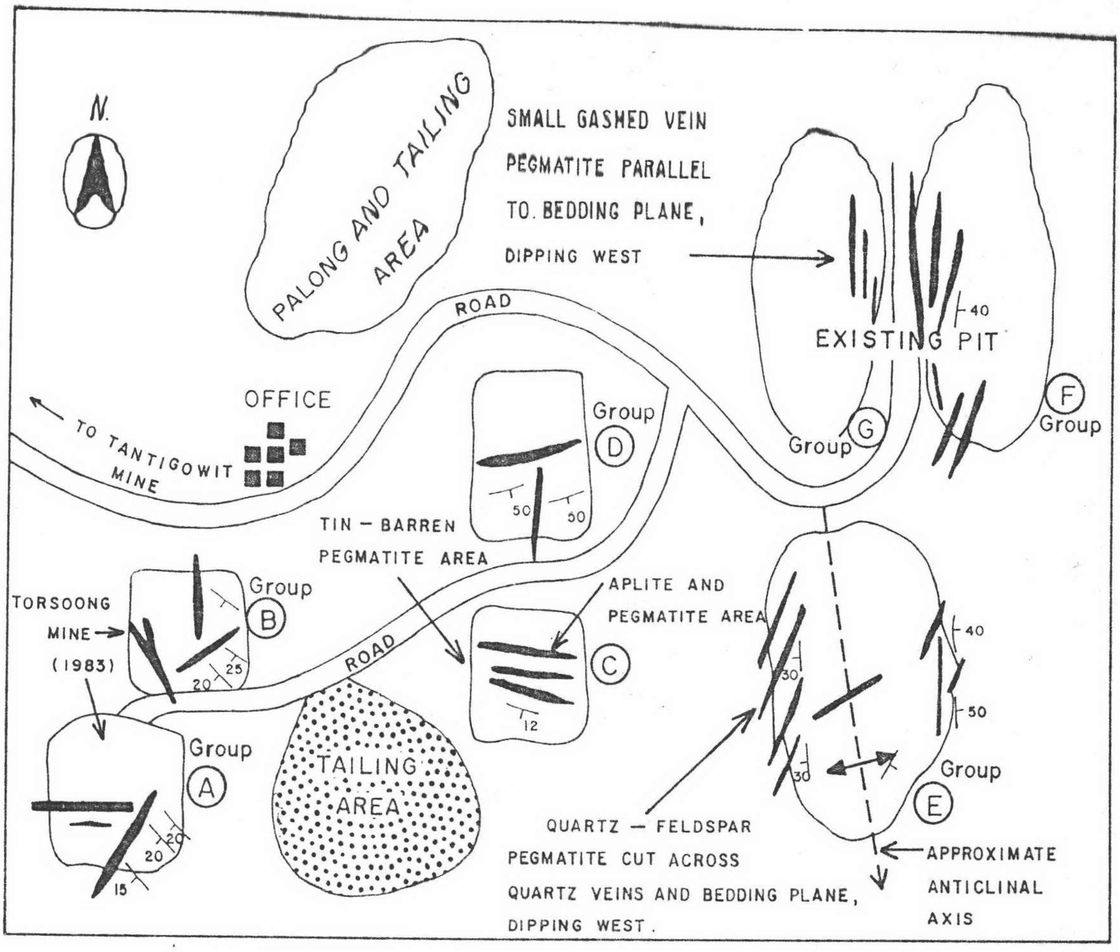
3.2.1 Tor Soong Mine (sample no.1 in the sampling location map)

(a) Geology

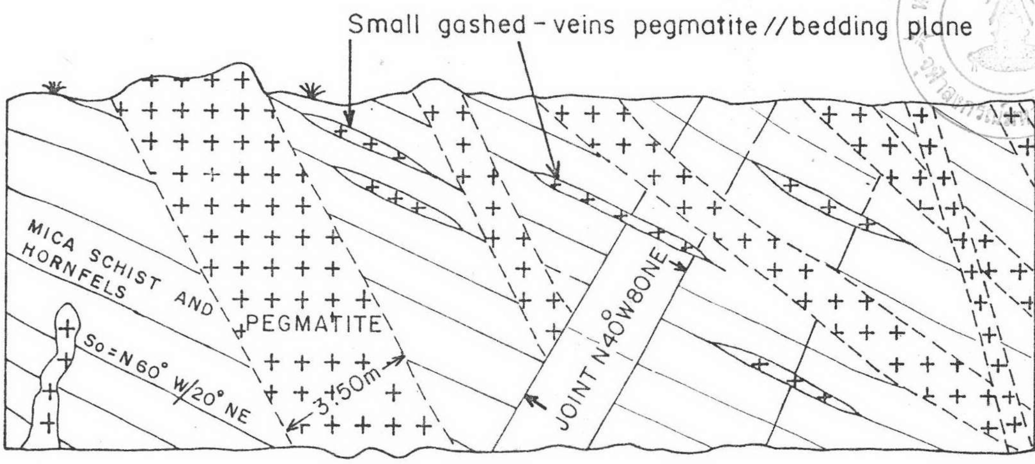
The mine is situated in the clastic sedimentary terrain of Phuket Group which have been heavily faulted and fractured. The rocks of Phuket Group in this locality are composed of greyish micaceous sandstone, meta-arkosic sandstone, brownish mudstone, pebbly mudstone, spotted slate, hornfels, and meta-siltstone. They are generally oriented in strike from N 5° W to N 75° E and in dip from 20°-70° to the east, and 10°-60° to the west. The N-S trending anticline is located in this mine which is evident from the bedding characteristics. It is also noted that the sedimentary rocks of Phuket Group in the vicinity of Tor Soong mine have been metamorphosed by presumably underlying granite and several clusters of pegamtite veins as well as by tectonic displacement, in places, which are indicated by the contact zone of hornfelsic rocks, spotted slate, and fault plane.

The attitude of two joint sets, in general, oriented in strike from NE to NW and in dip from 65° E to 80° W. The faults in NE to NW directions cut across this area which are indicated by the brecciation of host rocks and development of small quartz and pegmatite veins as well as the offset of pegmatite.

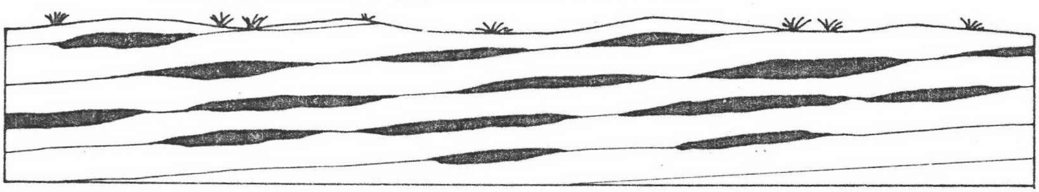
There are 7 clusters of pegmatite (Fig. 3.2.1 A) in the existing excavated trench. The excavated trench extends toward the south and the thickness of overburden is approximate 20-40 metres. All of these pegmatites are oriented in two main directions. The first one is the tin-bearing pegmatite orientating in the NS to NE and steeply dipping to the east. The other, tin-barren pegmatite, is oriented in the NS to NW to EW and moderately dipping to the west. The tin-bearing pegmatite is quartz-feldspar pegmatite or mica-free pegmatite (Gocht, 1982) associated with tourmaline-muscovite pegmatite which are highly kaolinized and always associated with quartz veins and aplite dikes. They are about 0.3-5 metres thick. The tin-barren pegmatites are less weathered than the tin-bearing one and are also associated with quartz veins and aplite dikes. The thickness never exceeds 1 metre. Both pegmatite varieties have the same major mineral assemblages comprising coarse-grained quartz, orthoclase and albite with small amount of tourmaline crystals and muscovite. Muscovite is richer in tin-barren pegmatite than in the tin-bearing one. The tourmaline-muscovite pegmatite is composed of medium-to fine-grained quartz,



(A) Sketch enlargement showing the orientation of pegmatites in various parts of Tor soong mine.
(prepared on Dec 31, 1983)



(B) Sketch eastern flank section of Torsoong mine (Facing N 20° E) showing the oreintation of pegmatites in various directions and sizes, relating to bedding planes and fractures.



(C) The typical small gashed vein pegmatites (5 – 7 cm thick) parallel to the bedding planes of country rocks (western flank of mine)

Figure. 3.2.1 Sketched map and geological cross – sections of Tor Soong Mine.

feldspar, tourmaline, muscovite,and highly kaolinized. These pegmatites occur as succession of injections in the country rocks located adjacent to the granite intrusion. The exocontact of pegmatite are generally characterized by thermal alteration zone indicated in the country rocks as quartzite,hornfels with intense tourmalinization of the wall rocks. The tin-bearing pegmatite cut across the tin-barren one of late magmatic product of coarse-grained porphyritic biotite granite (tin-barren granite). The tin-bearing one may be derived from late magmatic solution of medium- to fine-grained biotite muscovite granite (tin-bearing granite) (Charusiri, 1980).

The pegmatites in the vicinity of this mine form dikes, sills, lenticular sheet-like body and small parallel gashed vein swarms intruded along the bedding planes, fractures, and cut across the bedding planes of the country rocks (Fig. 3.2.1 B., 3.2.1 C)

(b) Heavy mineral association

The principal ore minerals in Tor Soong mine are cassiterite, including a varieties of cassiterite, namely, cassiterite interlocking with quartz,cassiterite bearing inclusion, cassiterite with manganese coated,and wolframite.

The associated heavy minerals are garnet, topaz, zircon, tourmaline, mangan-tantalite, columbite-tantalite, spinel, monazite, xenotime, limonite, and manganese oxide.

The abundance of each heavy mineral in this mine is illustrated in the pie-diagram (Fig. 3.2.1 b). Besides, the characteristics and the assemblages of heavy mineral from Tor Soong mine are summarized and presented in Tables 3.4.1 and 3.4.2 I.

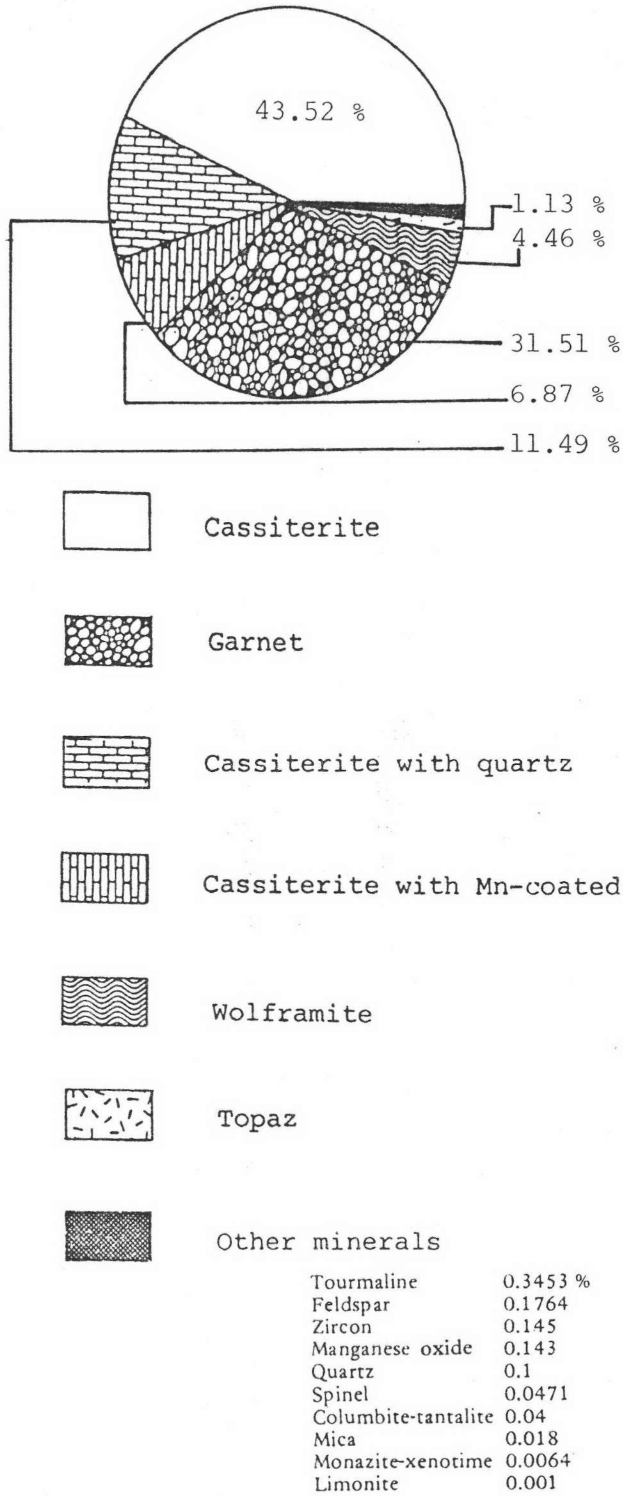


Figure 3.2.1b Pie diagram illustrating the abundance of each heavy mineral of Tor Soong Mine

(c) Heavy mineral distribution

The heavy minerals are most abundant in the medium-sand (1.25 ø) fraction and the abundance of heavy minerals in each size fraction will be discussed in detail in Chapter IV. However, the data on the degree of abundance of each heavy mineral with respect to grain size are summarized in Table 3.2.1. c.

Cassiterite are most abundant in the coarse-sand (0.25 ø) fraction.

Other economic minerals, such as, columbite - tantalite are in the fine-sand (2.5-2.75 ø) fraction and mangan-tantalite is also in the fine-sand (2.0 ø) fraction. Wolframite is distributed in every grain size and most abundant in the very coarse-sand (-1 ø) fraction.

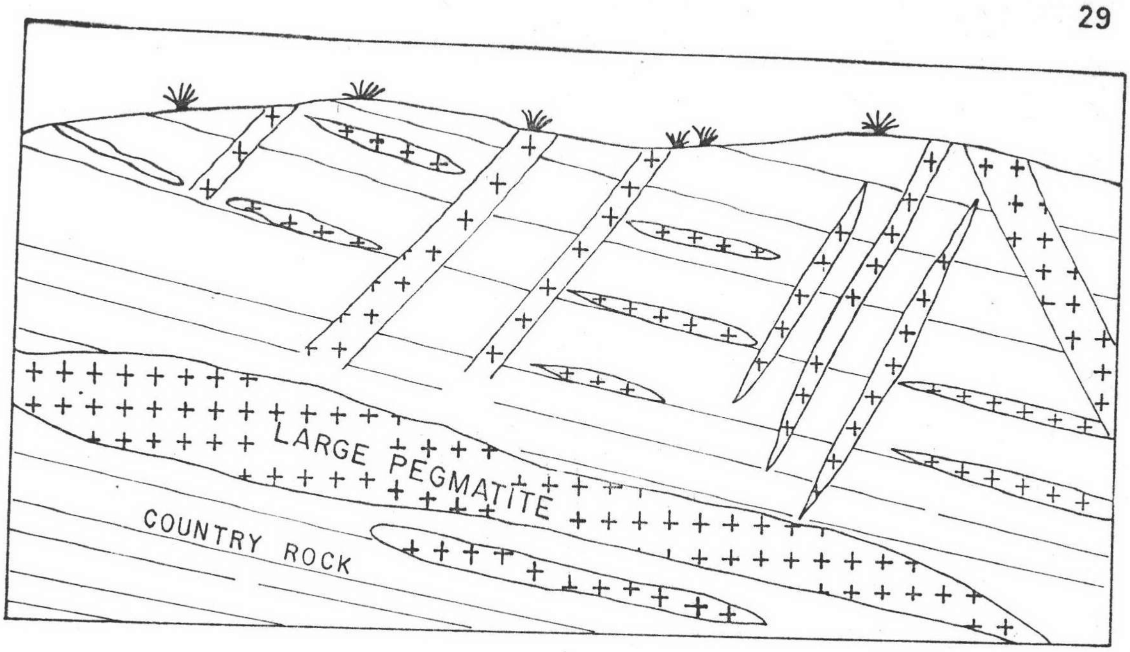
3.2.2 Tantikovit Mine (sample no.2 in the sampling location map)

(a) Geology

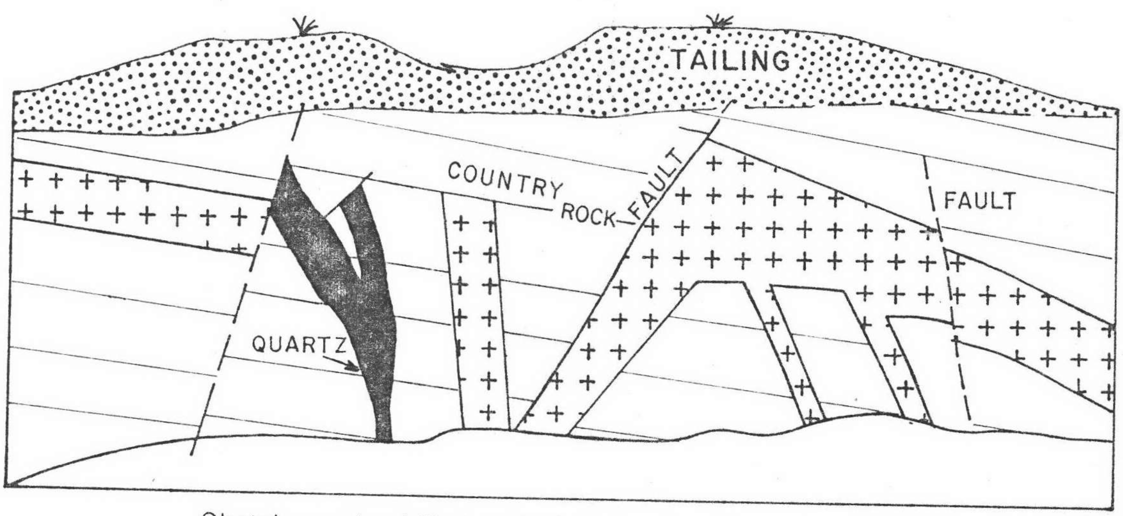
The mine is situated at the slope of Khao Che Tra in the clastic sedimentary rocks of Phuket Group. The rock of Phuket Group at this locality are composed of reddish brown mudstone, yellowish brown pebbly mudstone with scattered pebble of mostly pegmatitic quartz and granite of various sizes imbricated parallel with the bedding (Fig. 3.2.2 A(III)). These rocks are metamorphosed to some extent as either light coloured phyllite to mica schist or hornfels. The beddings are oriented in strike from NS to NW direction, and dipping to the west and the east directions. It is also noted that the contact metamorphism are conspicuous in the vicinity of Tantikovit mine which is indicated by the characteristics of greenish to brownish massive hornfelsic mud-stone, locally by fine-grained brownish yellow quartzite with plexus of quartz veins, small pegmatites, and some sharp contact between

Table 3.2.1c The degree of abundance of heavy minerals with respect to grain size of Tor Soong mine.

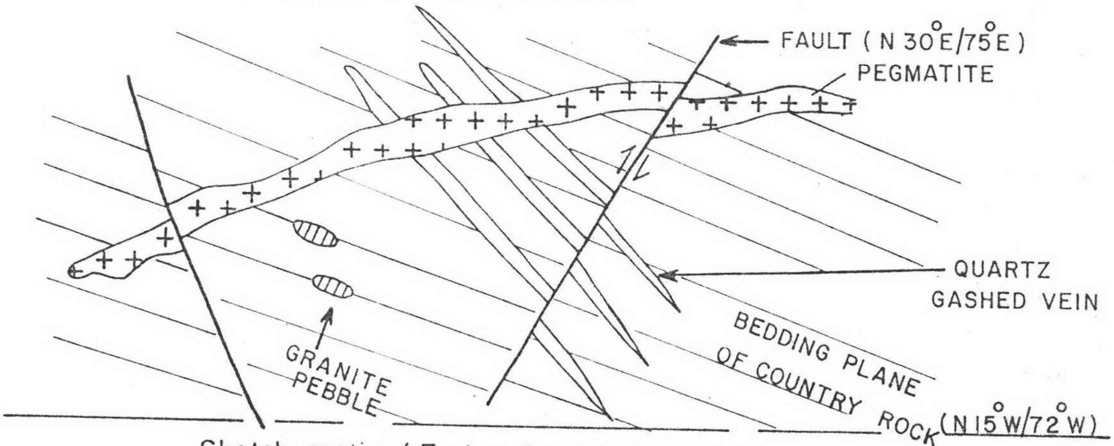
Mineral name	Weight percentages of heavy minerals in different size fraction							Total weight percentages
	10mesh	20mesh	40mesh	60mesh	80mesh	100mesh	-100mesh	
Cassiterite	-	21.89	13.68	5.82	1.385	0.389	0.359	43.523
Cassiterite with quartz	11.37	0.12	-	-	-	-	-	11.49
Cassiterite with manganese coat	6.87	-	-	-	-	-	-	6.87
Columbite-tantalite	-	-	-	-	0.019	0.001	-	0.002
Feldspar	-	0.17	-	-	0.006	0.0004	-	0.1764
Garnet	1.16	3.69	19.38	5.8	1.16	0.2095	0.106	31.5055
Limonite	-	-	-	-	0.001	-	-	0.001
Manganese oxide	-	0.12	-	0.02	0.003	-	-	0.143
Monazite-xenotime	-	-	-	-	-	0.0007	0.0057	0.0064
Mica	-	-	0.01	-	0.003	0.005	-	0.018
Quartz	-	-	0.1	-	-	-	-	0.1
Spinel	-	-	-	0.04	0.004	0.0031	-	0.0471
Topaz	-	0.41	0.37	0.34	0.003	0.002	0.0073	1.1323
Mangan-tantalite	-	-	-	0.02	-	-	-	0.02
Tourmaline	-	0.07	0.06	0.12	0.033	0.0103	0.052	0.3453
Wolframite	2.16	1.75	0.25	0.26	0.008	0.003	0.026	4.457
Zircon	-	-	0.07	0.04	0.005	0.016	0.014	0.145



(i) Sketch section (Facing East) showing the orientation of pegmatites in various attitudes, occurring in the eastern flank of former pit of Tantikowit mine.



(ii) Sketch section (Facing West) showing the orientation of pegmatites and quartz veins in the western flank of existing pit of Tantikowit mine.



(iii) Sketch section (Facing South) showing the relation between pegmatite, quartz gashed veins and faults, southern flank of existing pit

Figure. 3.2.2 (A) Geological cross – section of Tantikowit mine.

pegmatite and country rocks.

There are various directions of joint developed in this locality which varying in strike from NNE to NNW directions, dipping to the east and west. The fault in NE and EW directions cut across the pegmatite and quartz vein, quartz gashed veins (Fig. 3.2.2 A(II), (III)) indicated by the offset of the pegmatite and quartz veins.

There are two main types of pegmatite in this mine, namely, tourmaline-muscovite pegmatite, and lepidolite pegmatite. The tourmaline-muscovite pegmatite is highly leucocratic, predominantly composed of coarse-grained quartz, feldspar, tourmaline, muscovite, and highly kaolinized. The thickness varies from 0.5 metres to more than 10 metres and this pegmatite extends for at least 300 metres along the excavated trench. The lepidolite pegmatite is composed of pale to purple lepidolite, altered feldspar, quartz with minor amount of muscovite and tourmaline. It occurs as small irregular pods.

The pegmatite in the vicinity of this mine forms dikes, sills, parallel vein swarms, and irregular pods penetrating along the bedding plane, fractures, and fault zones. These pegmatites are generally oriented in strike from NNW to NNE, and in dip from 30° west to 70° east (Fig. 3.2.2 A(I),(II)). The sketch enlargement showing the orientation of pegmatite is illustrated in Figure 3.2.2 B.

(b) Heavy mineral association

The principal ore mineral in Tantikowit mine is cassiterite including a variety of cassiterite with manganese coated, cassiterite with mica, cassiterite with quartz.

The associated minerals are garnet, ilmenite, wolframite and huebnerite, manganese oxide, columbite-tantalite, tourmaline,

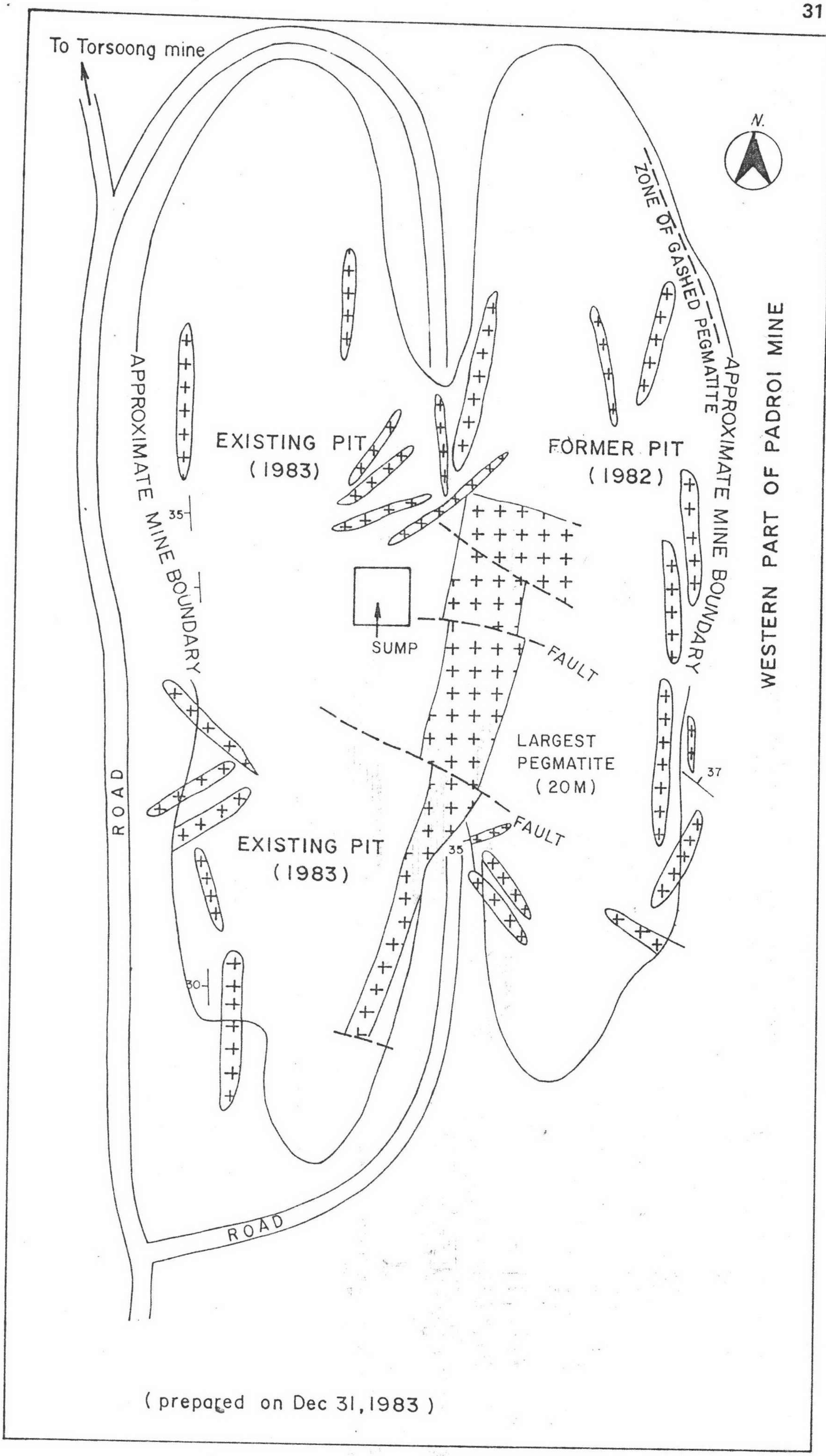
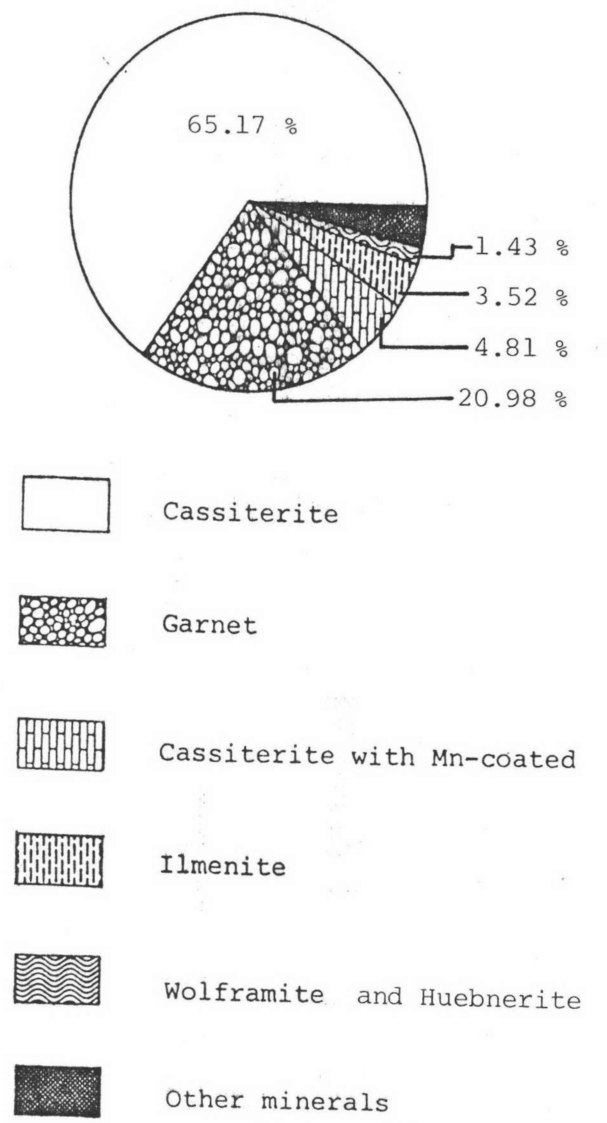


Figure.3.2.2 (B) Sketch enlargement showing the orientation of pegmatites in various directions and sizes within existing pit and adjacent area of - Tantikowit Mine.



Manganese oxide	0.84 %
Cassiterite and muscovite	0.7
Columbite-tantalite	0.61
Tourmaline	0.451
Fe-oxide	0.36
Cassiterite with quartz	0.46
Pyroxene or amphibole	0.4
Rutile	0.168
Zircon	0.054
Spinel	0.01
Monazite-xenotime	0.005
Apatite	0.002
Mica	0.034

Figure 3.2.2b Pie diagram illustrating the abundance of each heavy mineral of Tantikowit Mine

Fe-oxide, rutile, zircon, spinel, monazite, xenotime, and apatite.

The abundance of each heavy mineral in this mine has been shown in pie diagram (Fig. 3.2.2 b). Besides, the characteristics and the assemblages of heavy mineral from Tantikowit mine are summarized and presented in Tables 3.4.1 and 3.4.2 I.

(c) Heavy mineral distribution

The heavy minerals are most abundant in the medium sand (1.25 ø) fraction.

The abundance of heavy minerals in each size fraction will be discussed in detail in Chapter IV. However, the data on the degree of abundance of each heavy mineral with respect to grain size are summarized in Table 3.2.2. c.

Cassiterite is most abundant in the medium sand (1.25 ø) fractions.

Some other economic minerals, namely, columbite-tantalite are in the medium to fine sand (2.0-2.5 ø) fraction. Wolframite is distributed in the coarse-sand to very fine sand (0.5 ø to more than 2.75 ø) fraction.

3.2.3 Pad Roi Mine (sample no.3 in the sampling location map)

(a) Geology

The mine is situated at the slope of Khao Che Tra The country rocks in this locality are the sedimentary rocks of Phuket Group consisting of greenish black mudstone, shale, reddish brown pebbly sandstone, spotted slate with scattered pebbles of quartz, granite, tourmaline schist, mica schist in various sizes. The attitude of bedding varies in strike from NS to NW directions, and in dip from 20° to 30°

Table 3.2.2c The degree of abundance of heavy minerals with respect to grain size of Tantikowit mine.

Mineral name	Weight percentages of heavy minerals in different size fraction							Total wight percentages
	10mesh	20mesh	40mesh	60mesh	80mesh	100mesh	-100mesh	
Apatite	-	-	0.002	-	-	-	-	0.002
Cassiterite	9.73	16.12	17.48	13.40	5.94	1.304	1.20	65.174
Cassiterite with manganese coat	4.81	-	-	-	-	-	-	4.81
Cassiterite with quartz,muscovite	0.46	0.7	-	-	-	-	-	1.16
Columbite - tantalite	-	-	-	0.45	0.15	0.01	-	0.61
Fe-oxide	-	0.36	-	-	-	-	-	0.36
Garnet	-	0.78	11.29	7.29	1.07	0.46	0.09	20.98
Ilmenite	-	0.22	0.91	1.94	0.34	0.08	0.028	3.518
Manganese oxide	-	0.08	0.76	-	-	-	-	0.84
Mica	-	-	-	-	0.03	-	0.004	0.034
Monazite-xenotime	-	-	-	-	-	-	0.005	0.005
Pyroxene	0.4	-	-	-	-	-	-	0.4
Rutile	-	-	0.168	-	-	-	-	0.168
Spinel	-	-	-	-	0.01	-	-	0.01
Tourmaline	-	-	0.25	0.12	0.06	0.01	0.011	0.451
Wolframite and Huebnerite	-	0.37	-	1.02	0.03	0.003	0.002	1.425
Zircon	-	-	-	0.02	0.02	0.003	0.01	0.053

to the east and west direction, respectively. These rocks have undergone metamorphism to either phyllite/mica schist or hornfels/tourmaline schist. The rocks of Phuket Group in this locality are strongly deformed and heavily fractured in NE to NW directions. Some minor faults in NS direction are noted.

The pegmatites in the vicinity of this mine can be classified into 3 main types, namely, tourmaline-muscovite pegmatite, lepidolite pegmatite, and quartz-muscovite pegmatite. The tourmaline-muscovite pegmatite is oriented in N 5° to 10° E in strike, dipping to the east. This rock is highly leucocratic, composed of medium - to fine - grained quartz, feldspar, tourmaline, muscovite, and highly kaolinized. The thickness is about 3-9 metres. The lepidolite pegmatite is oriented in strike from NNW to NNE directions, dipping to the east and west directions. This pegmatite is locally kaolinized, composed of medium - grained pale purplish pink colour of lepidolite mica, quartz, feldspar, epidote, muscovite with thickness of approximately 0.3-3 metres. The quartz-muscovite pegmatite is oriented in NNW to E-W directions, dipping to the south. This pegmatite is composed of coarse-grained quartz, feldspar, muscovite and less weathered than tourmaline muscovite pegmatite with thickness of about 1.0-4.5 metres.

The pegmatites in the vicinity of this mine form dike and sill with lenticular sheet like body, and some irregular pod (Fig. 3.2.3 B). All of them penetrate along the bedding planes and fractures.

There are 5 clusters of pegmatite in this mine as shown in the sketch enlargement (Fig. 3.2.3 A).

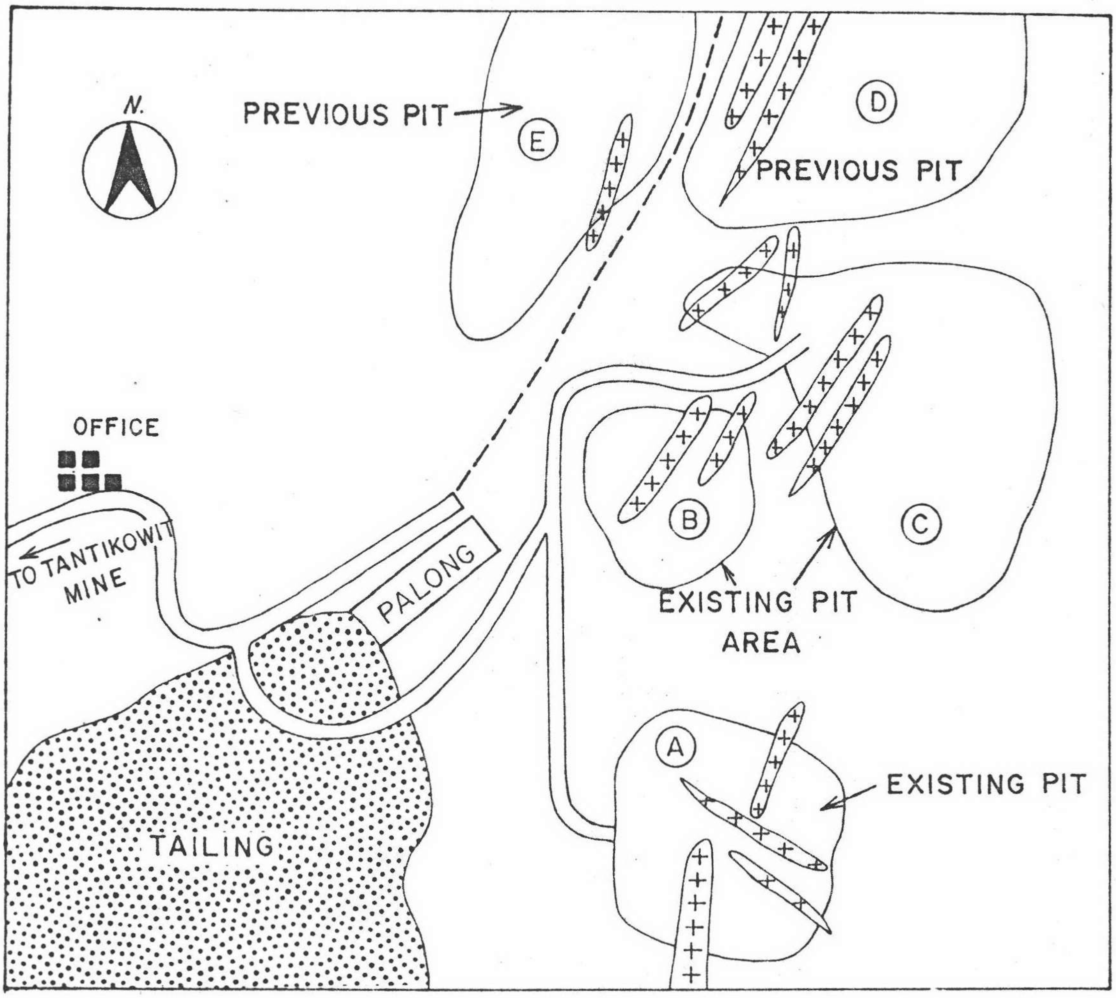
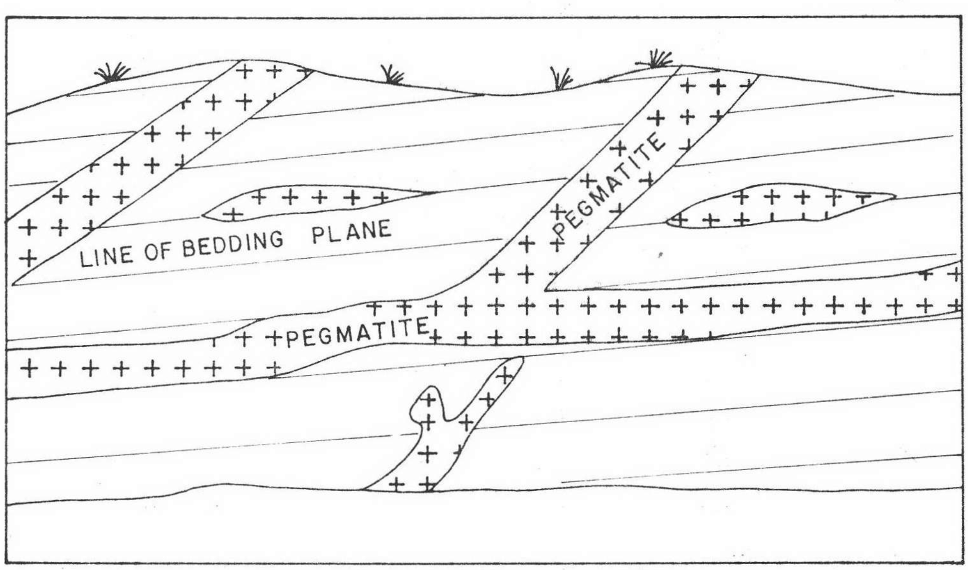


Figure.(A) Sketch enlargement showing the major orientations of pegmatites, exposing in the existing and previous pit of Pad Roi Mine (prepared on Dec.30, 1983)



(B) Sketched section showing the typical orientation of pegmatites, which have been found in various areas of Pad Roi Mine.

Figure .3.2.3. Sketched map and geological cross – section of Pad Roi Mine.

Pegmatite cluster A is tourmaline-muscovite pegmatite associated with quartz-muscovite pegmatite. Cluster B-C is tourmaline-muscovite pegmatite, whereas cluster D-E is lepidolite pegmatite associated with tourmaline-muscovite pegmatite.

All of these pegmatites are the tin-bearing one except the quartz-muscovite pegmatite which contains only rare amount of cassiterite.

(b) Heavy mineral association

The principal ore mineral in Pad Roi mine is cassiterite, and its varieties, namely, cassiterite with quartz, and cassiterite with manganese coated.

The associated minerals are topaz, garnet, rutile, tantalite, zircon, tourmaline, spinel, and Fe-oxide.

The abundance of each heavy mineral in this mine has been shown in pie diagram (Fig. 3.2.3 b). Besides, the characteristic and the assemblages of heavy mineral from Pad Roi mine are summarized and presented in Tables 3.4.1 and 3.4.2 I.

(c) Heavy mineral distribution

The heavy minerals in this mine are abundant in the medium sand (1.25 ø) fraction.

The abundance of heavy minerals in each size fraction will be discussed in detail in Chapter IV. However, the data on the degree of abundance of each heavy mineral with respect to grain size are summarized in Table 3.2.3 c.

Cassiterite is most abundant in the medium sand (1.25 ø) fraction.

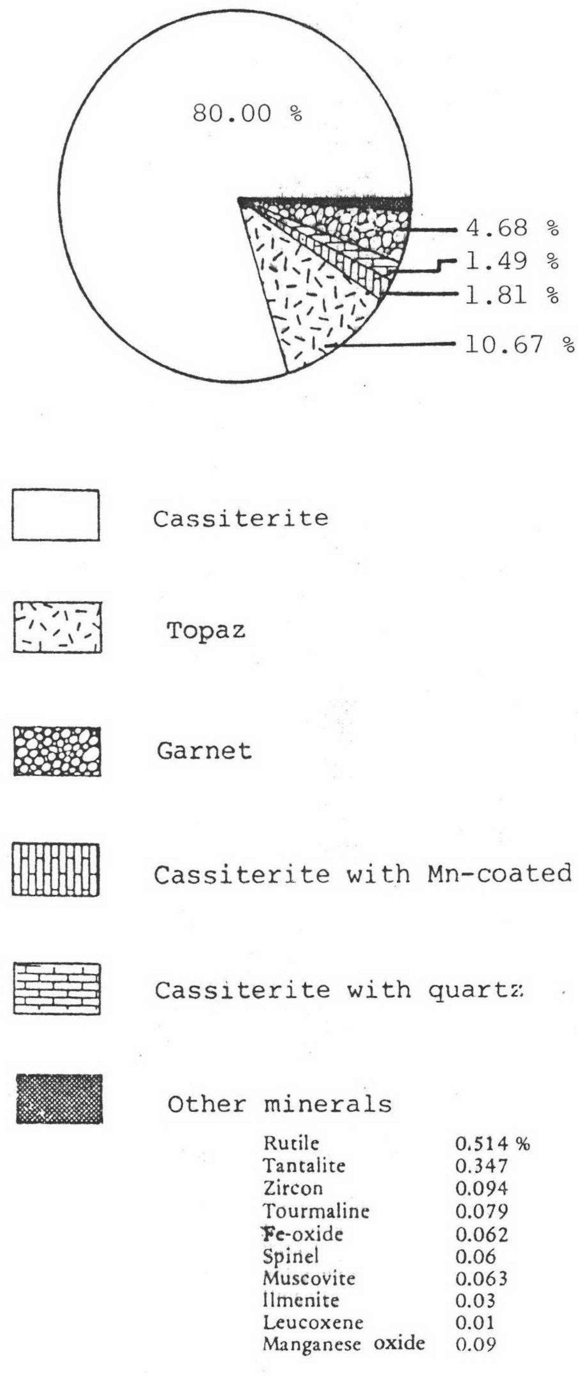


Figure 3.2.3b Pie diagram illustrating the abundance of each heavy mineral of Pad Roi Mine.

Table 3.2.3c The degree of abundance of heavy minerals with respect to grain size of Pad Roi mine.

Mineral name	Weight percentages of heavy minerals in different size fraction							Total weight percentages
	10mesh	20mesh	40mesh	60mesh	80mesh	100mesh	-100mesh	
Cassiterite	4.98	22.54	26.64	17.356	5.9	1.516	1.071	80.003
Cassiterite with manganese coat	1.81	-	-	-	-	-	-	1.81
Cassiterite with quartz	1.49	-	-	-	-	-	-	1.49
Fe-oxide	-	-	0.06	0.002	-	-	-	0.062
Garnet	-	1.29	2.09	1.05	0.2	0.026	0.002	4.678
Ilmenite	-	-	0.03	-	-	-	-	0.03
Leucoxene	-	-	-	-	0.01	-	-	0.01
Manganese oxide	-	0.09	-	-	-	-	-	0.09
Mangan-tantalite	-	-	-	0.27	0.04	0.018	0.019	0.347
Muscovite	-	-	0.01	0.05	-	-	0.003	0.063
Rutile	-	-	0.51	-	-	0.004	-	0.514
Spinel	-	-	-	0.004	-	0.014	0.042	0.06
Topaz	-	1.18	5.63	3.524	0.22	0.086	0.03	10.67
Tourmaline	-	-	-	0.034	0.03	0.012	0.003	0.079
Zircon	-	-	-	-	0.05	0.004	0.04	0.094

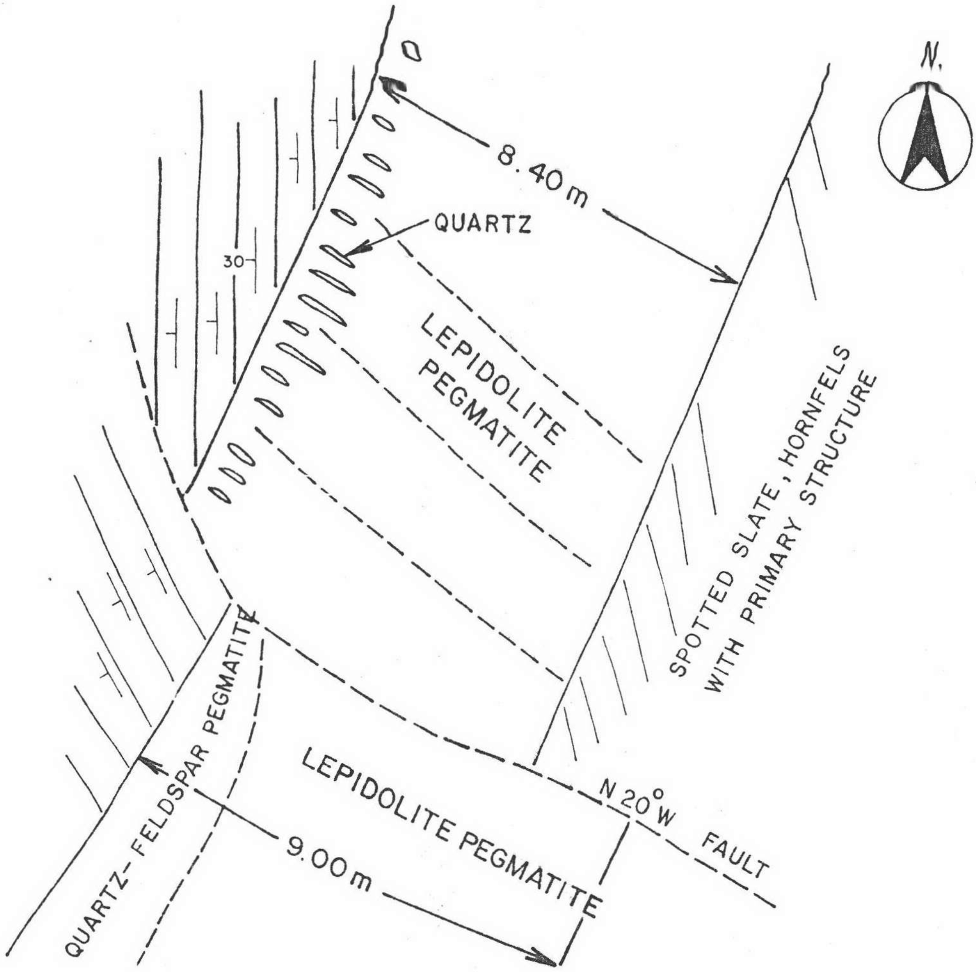
Other economic mineral, namely, mangan - tantalite is in the medium to very fine sand (2 ø to more than 2.75 ø) fraction and it is most abundant in 2 ø fraction.

3.2.4 Ban Nguan Mine (sample no.4 in the sampling location map)

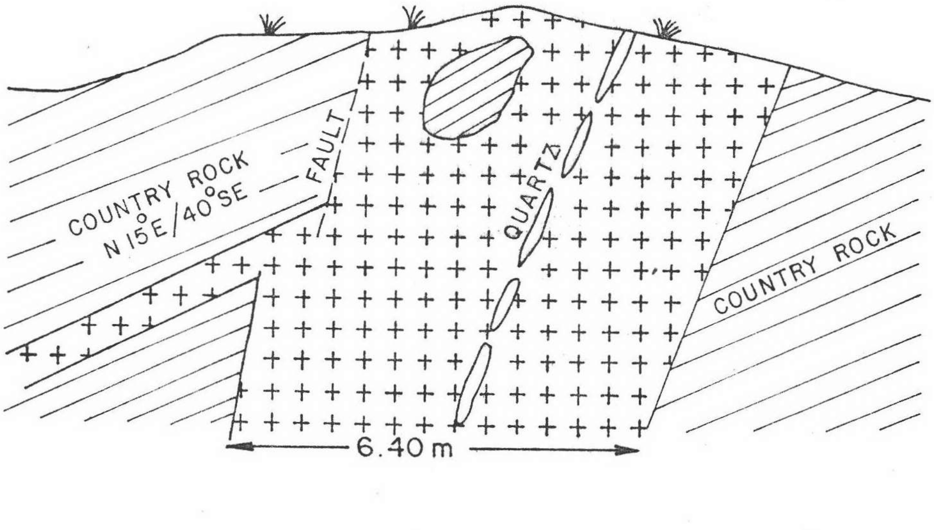
(a) Geology

This mine is situated in the southeastern part of Khao Che Tra which is essentially underlain by the clastic sedimentary rocks of Phuket Group. The rocks of Phuket Group in this locality are composed of reddish brown pebbly mudstone, grayish black shale, micaceous sandstone with scattered pebbles of granite in various sizes and spotted mica schist, spotted hornfels with slump unit and cross bedding. They are generally oriented in strike from NNE to NS and dipping 20°-40° to the east. They are thermally metamorphosed in some parts. The country rocks are metamorphosed to schist, hornfels. Contact of the pegmatite vein is sharp, and quartz crystals in the pegmatite body are protruded from the wall of the pegmatite vein (Fig. 3.2.4A(I)).The NE to NW and EW faults are present in this mine. The N 20° W fault cuts across the lepidolite pegmatite indicated by the offset of this pegmatite (Fig. 3.2.4A (I)).The major joint set in this mine is oriented in NNE to NNW and the minor one in NE to NW direction, dipping steeply to the east and west directions.

There are 3 clusters of pegmatites in this mine. The first cluster is quartz-muscovite pegmatite associated with lepidolite pegmatite. The second cluster is lepidolite pegmatite associated with quartz-muscovite pegmatite, and the third cluster is lepidolite pegmatite associated with quartz-muscovite pegmatite and quartz-feldspar pegmatite. The third cluster is most extensive in aereal extent in this mine. This cluster is composed of seven pegmatite dikes which



(I) Sketched section showing the typical lepidolite pegmatite (N 30°E), pegmatite E (see fig. A)



(II) Sketched section (Facing South) showing the lepidolite pegmatite (F), relating to the country rocks and quartz veins, southern part of Ban – Nguan mine.

Figure .3.2.4(A) Geological cross – section of Ban Nguan mine.

are pegmatite A to pegmatite G (Fig. 3.2.4 B). The pegmatite A is a tin-barren quartz-muscovite pegmatite composing mainly of fine-to medium-grained quartz, feldspar, and minor amount of muscovite, Fe-oxide, manganese oxide, and highly kaolinized. It is oriented in the NNW direction, and steeply dipping to the east. The thickness is not exceed 3 metres. The pegmatite B,C,D are tin-bearing quartz-feldspar pegmatite composing mainly of fine-to medium-grained quartz, feldspar, muscovite with small amount of tourmaline, and highly kaolinized. They are oriented in the NNE direction, and steeply dipping to the southeast. The thickness is about 0.8-2.3 metres. These pegmatite exhibit a fine-grained aplitic texture in the central part, whereas the coarse-grained texture appears along the contact zone with hornfelsic rocks. All of these pegmatites cut across the country rocks. The pegmatites E,F,G are tin-bearing lepidolite, and composed mainly of light purple lepidolite, quartz, mica, feldspar, minor amount of tourmaline, and locally kaolinized. The thickness is about 6.8-8.4 metres. These pegmatite are oriented in NNE direction and moderately dipping to the east. The sketch enlargement of pegmatite clusters is shown in Figure 3.2.4 B.

All of these pegmatites intruded along the bedding plane and penetrated along fractures which cut across the bedding plane in forms of dikes, parallel veins swarm, and lenticular sheet-like bodies associated with quartz veins. The fault controlled pegmatite body and the xenolith of the country rock in pegmatite are illustrated in Figure 3.2.4 A(II).

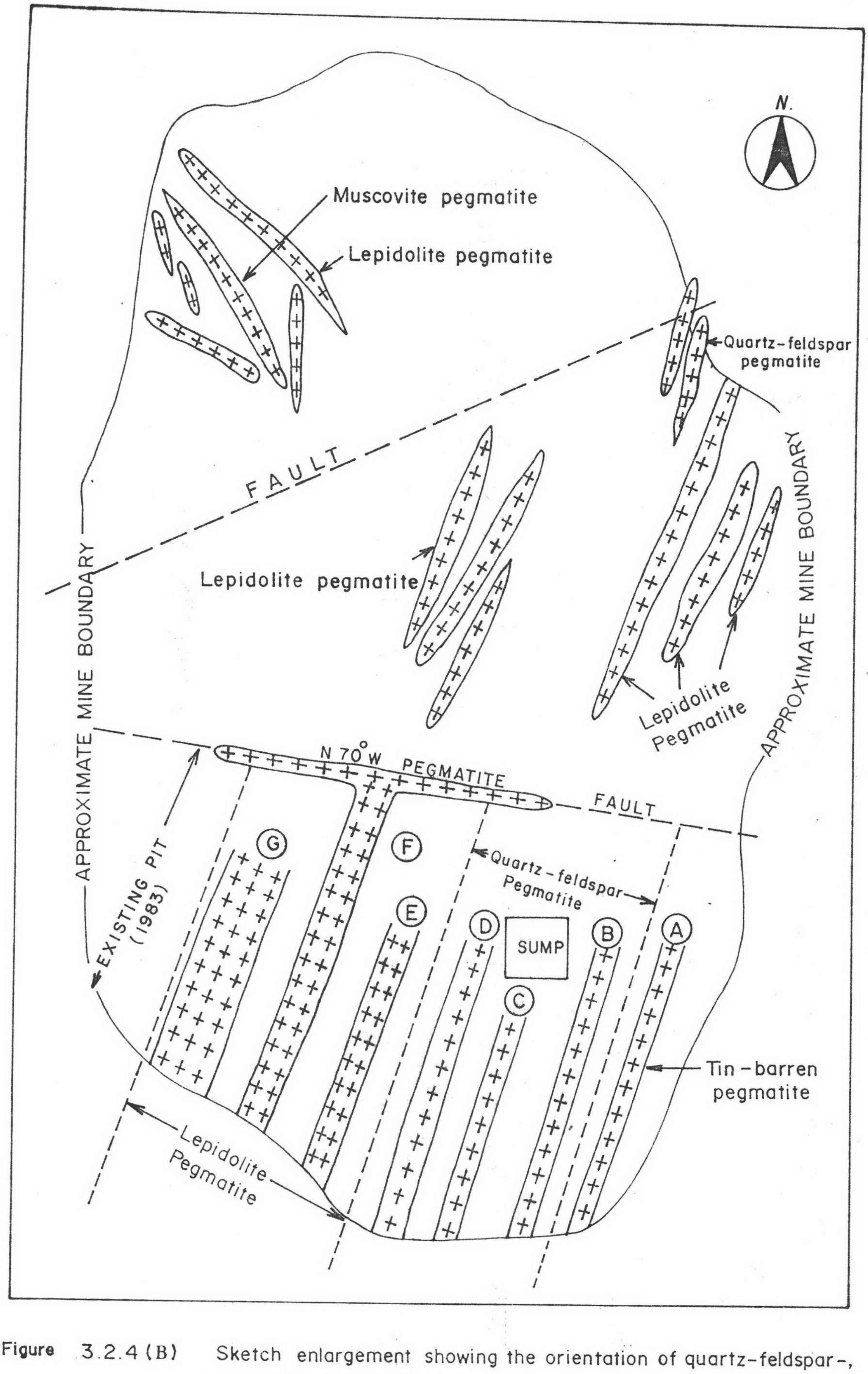


Figure 3.2.4 (B) Sketch enlargement showing the orientation of quartz-feldspar-, muscovite-, and lepidolite pegmatites in various zones, Ban Nguan mine. (prepared on Dec 30, 1983)

(b) Heavy mineral association

The principal ore mineral in Ban Nguan mine is cassiterite, and its varieties, namely, cassiterite with manganese coated, and cassiterite interlocking with quartz.

The associated minerals are topaz, Fe-oxide, garnet, manganese oxide, tourmaline, limonite, ilmenite, zircon, spinel, multiple oxide containing Nb-Ta, monazite, xenotime, apatite, allanite.

The abundance of each heavy mineral in this mine is illustrated in the pie diagram (Fig. 3.2.4 b). Besides, the characteristics and the assemblages of heavy minerals from Ban Nguan mine are summarized and presented in Table 3.4.1 and 3.4.2 I.

(c) Heavy mineral distribution

The heavy minerals in this mine are most abundant in the medium sand (1.25 ø) fraction.

The abundance of heavy mineral in each size fraction will be discussed in detail in Chapter IV. However, the data on the degree of abundance of each heavy mineral with respect to grain size are summarized in Table 3.2.4 c.

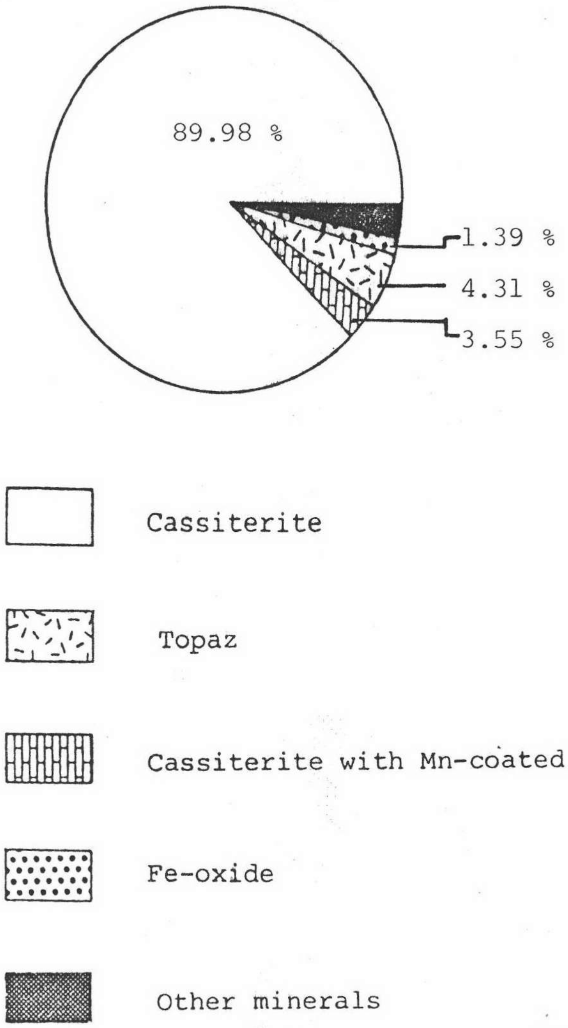
Cassiterite is most abundant in the medium sand (1.25 ø) fraction.

Some other economic minerals, such as, multiple oxide containing Nb-Ta are only present in the medium sand(1.25 ø) fraction.

3.2.5 Pin Yoh Mine (sample no.5 in the sampling location map)

(a) Geology

This mine is situated at the northern part of Kathu Valley. In the olden day, this mine was operated in the alluvial deposit.



Garnet	0.76 %	
Mica	0.605	
Manganese oxide	0.37	
Quartz	0.19	
Tourmaline	0.182	
Quartz+mica	0.075	
Ilmenite	0.096	
Zircon	0.058	
Spinel	0.053	0.053
Cassiterite+quartz	0.05	
Allanite	0.07	
Multiple oxide	contain	
Columbite-tantalite	0.04	
Monazite-xenotime	0.03	
Apatite	0.027	
Limonite	0.16	
Wolframite	0.01	

Figure 3.2.4b Pie diagram illustrating the abundance of each heavy mineral of Ban Nguan Mine

Table 3.2.4c The degree of abundance of heavy minerals with respect to grain size of Ban Nguan mine.

Mineral name	Weight percentages of heavy mineral in different size fraction							Total weight percentages
	10mesh	20mesh	40mesh	60mesh	80mesh	100mesh	-100mesh	
Allanite	-	-	-	0.04	0.03	-	-	0.07
Apatite	-	-	-	0.02	0.005	-	0.002	0.027
Cassiterite	8.78	25.92	28.15	16.03	5.56	2.13	1.405	87.975
Cassiterite with manganese coat	3.2	0.35	-	-	-	-	-	3.55
Cassiterite with quartz	-	0.05	-	-	-	-	-	0.05
Fe-oxide	1.3	-	0.06	0.01	0.01	0.001	0.006	1.387
Garnet	-	0.09	0.33	0.21	0.12	0.01	-	0.76
Ilmenite	-	-	0.07	-	0.01	0.012	0.004	0.096
Limonite	-	0.14	0.02	-	-	-	-	0.16
Manganese oxide	0.2	0.17	-	-	-	-	-	0.37
Mica	-	-	0.53	0.07	-	-	0.005	0.605
Monazite-xenotime	-	-	-	0.01	0.01	-	0.01	0.03
Multiple oxide contain Cb-Ta	-	-	0.04	-	-	-	-	0.04
Quartz,quartz+ mica	-	0.14	-	0.08	-	-	0.045	0.265
Spinel	-	-	-	0.04	-	0.01	0.003	0.053
Topaz	-	0.99	3.47	0.6	0.145	0.05	0.057	4.312
Tourmaline	-	-	0.08	0.02	0.04	0.019	0.023	0.182
Wolframite	-	-	-	-	0.01	-	-	0.01
Zircon	-	-	-	-	0.05	0.008	-	0.058

However, at present it is being operated in pegmatite bodies which intruded in the sedimentary country rocks of Phuket Group. The country rocks are composed of grey micaceous sandstone, brown to greenish yellow to maroon pebbly mudstone with various sizes of granite pebbles, schist, hornfels, and quartzite which have been thermally metamorphosed. The bedding plane is oriented in strike from NE to NW to EW directions, and dipping in various directions, notably, 15°-16° to the west, 37° to the east, and 35° to the north. These rocks are heavily fractured and faulted as indicated by the offset of pegmatite bodies and fracture zones in the country rocks. The fault direction is in the NW, and dipping to the east. Fold plunging to the NE direction, is present at this locality. The joint set in this mine is oriented in strike NE to NW and steeply dipping to the west and southeast directions.

There are 2 main types of pegmatite, namely, muscovite pegmatite which is dominant in this mine, and less abundant quartz-feldspar-muscovite pegmatite associated with quartz veins and aplite. The muscovite pegmatite is oriented in NS to NE directions, dipping to the east and west. The small gashed muscovite pegmatite is oriented in EW direction, dipping to the north. These pegmatites are composed mainly of quartz, feldspar, large plate of muscovite with small amount of acicular tourmaline, and highly kaolinized. The thickness is about 0.2-3.5 metres. The tin-barren quartz-feldspar muscovite pegmatite is oriented in NW direction, dipping to the east. This pegmatite is composed mainly of quartz, feldspar with minor amount of muscovite, and tourmaline. It is less weathered than the muscovite pegmatite. The thickness is less than 1 metre. Quartz veins and aplite dikes associated with quartz-feldspar-muscovite pegmatite are oriented in the NS to NE directions. The thickness is about 0.2-0.5

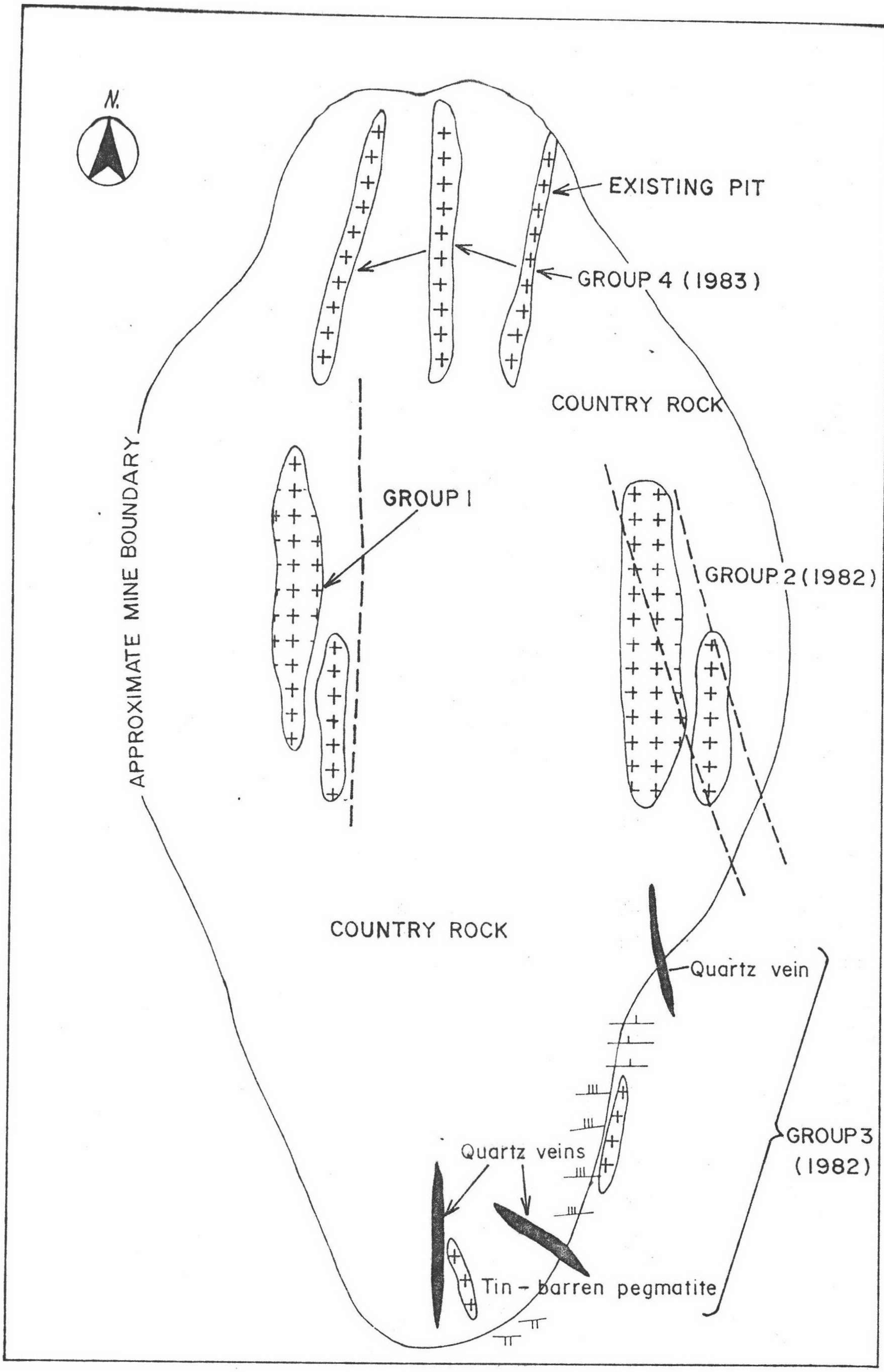


Figure 3.2.5 Sketch enlargement showing the orientation of pegmatites and — quartz veins sketched from Oct. 1982 to Dec. 1983, of Pinyoh mine (prepared on December 30, 1983)

metre.

The pegmatites in this locality form irregular bodies, dikes and sills intruded along the fracture zone cross cutting the bedding plane of country rocks. There are 4 clusters of pegmatite in this mine, cluster 1,2,4 are muscovite pegmatites, whereas the cluster 3 is quartz-feldspar-muscovite pegmatite associated with muscovite pegmatite, quartz veins, and aplite dikes (Fig. 3.2.5).

(b) Heavy mineral association

The principal ore minerals are cassiterite, cassiterite interlocking with quartz,cassiterite with manganese coat.

The associated minerals are manganese oxide, garnet, ilmenite, columbite-tantalite, zircon, mangan-tantalite, tourmaline, wolframite, monazite, xenotime, rutile, Fe-oxide.

The abundance of each heavy mineral in this mine is shown in the pie diagram (Fig. 3.2.5 b). Besides, the characteristics and assemblages of heavy minerals from Pin Yoh mine are summarized and presented in Table 3.4.1 and 3.4.2 I.

(c) Heavy mineral distribution

The heavy minerals are most abundant in the medium sand (1.25 ø) fraction.

The abundance of heavy minerals in each size fraction will be discussed in detail in chapter IV. However, the data on the degree of abundance of each heavy mineral with respect to grain size are summarized and presented in Table 3.2.5 c.

Cassiterite is most abundant in the medium sand (1.25 ø) fraction.

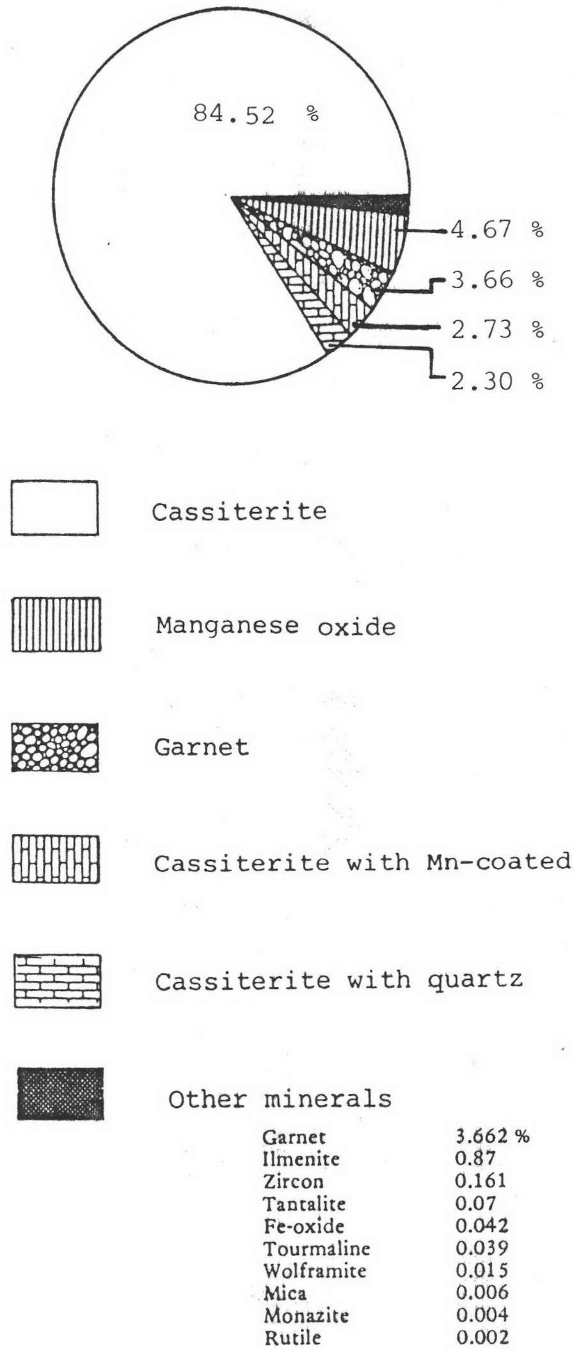


Figure 3.2.5b Pie diagram illustrating the abundance of each heavy mineral of Pin Yoh Mine.

Table 3.2.5c The degree of abundance of heavy minerals with respect to grain size of Pin Yoh mine

Mineral name	Weight percentages of heavy mineral in different size fraction							Total weight percentages
	10mesh	20mesh	40mesh	60mesh	80mesh	100mesh	-100mesh	
Cassiterite	8.21	17.24	26.74	19.85	7.88	2.233	2.363	84.516
Cassiterite with manganese coat	2.73	-	-	-	-	-	-	2.73
Cassiterite with quartz	-	2.30	-	-	-	-	-	2.30
Columbite-tantalite	-	-	0.19	0.12	-	0.01	0.023	0.343
Fe-oxide	-	-	0.03	0.003	0.001	0.004	0.004	0.042
Garnet	-	1.86	0.88	0.771	0.11	0.03	0.011	3.662
Ilmenite	-	-	0.32	0.42	0.13	-	-	0.87
Manganese oxide	-	4.54	0.13	-	-	-	-	4.67
Manganese oxide+ quartz	0.57	-	-	-	-	-	-	0.57
Mangan-tantalite	-	-	-	-	0.07	-	-	0.07
Mica	-	-	-	0.005	-	-	0.001	0.006
Monazite-xenotime	-	-	-	0.001	-	0.001	0.002	0.004
Rutile	-	-	-	-	-	0.002	-	0.002
Tourmaline	-	-	-	-	0.009	0.001	0.029	0.039
Wolframite	-	-	-	-	-	0.008	0.007	0.015
Zircon	-	-	0.02	0.01	0.03	0.041	0.06	0.161

Some other economic minerals, namely, columbite-tantalite, mangan-tantalite, wolframite, columbite-tantalite are in the medium sand and fine to very fine sand (1.25 ø - 2 ø, 2.75 ø to more than 2.75 ø) fraction, whereas mangan-tantalite is only present in the fine sand (2.5 ø) fraction, and wolframite is present in the fine to very fine sand (2.75 ø to more than 2.75 ø) fraction.

3.2.6 Kathu Mine (sample No.6 in the sampling location map)

(a) Geology

The mine is situated in the alluvial deposit of the eastern part of Kathu Valley. In the past, this deposit was exploited by the dredging operation. However, reconsideration of the relatively lower cut-off of the tailings under the present economic condition enable the operator to rework the dumping area. At present, the gravel-pump mining technique is employed to recover pre-existing tailing. The nature and characteristics of the deposit is therefore, considered to be "reworked alluvial deposit".

This alluvial deposit was primarily derived from the tin-bearing pegmatite stockworks which occurred along the granitic margin and in the country rocks of Phuket Group.

(b) Heavy mineral association

The principal ore minerals are cassiterite and cassiterite interlocking with quartz.

The associated minerals are garnet, topaz, zircon, ilmenite, spinel, limonite, monazite, xenotime, magnetite, tourmaline, rutile, columbite-tantalite, struverite, mica, and Fe-oxide.

The abundance of each heavy mineral in this mine is shown in the pie diagram (Fig. 3.2.6 b). Besides, the characteristics

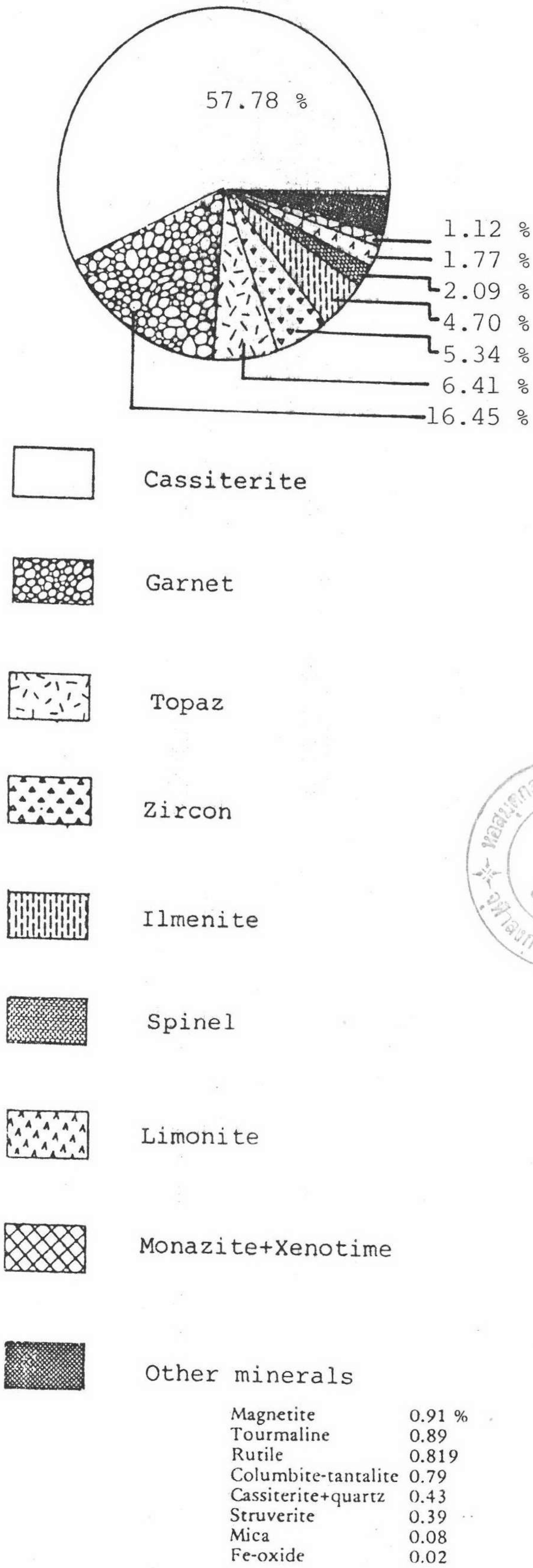


Figure 3.2.6b Pie diagram illustrating the abundance of each heavy mineral of Kathu Mine

and assemblages of heavy minerals from Kathu mine are summarized and presented in Table 3.4.1 and 3.4.2 I.

(c) Heavy mineral distribution

The heavy minerals are most abundant in the very fine sand (more than 2.75 ø) fraction.

The abundance of heavy mineral in each size fraction will be discussed in detail in chapter IV. However, the data on the degree of abundance of each heavy mineral with respect to grain size are summarized and presented in Table 3.2.6 c.

Cassiterite is most abundant in the very fine sand (more than 2.75 ø) fraction.

Some other economic minerals, namely, columbite-tantalite are present in the medium and fine sand (2.0 ø, 2.75 ø) fraction, whereas struverite is only present in the medium sand (1.25-2.0 ø) fraction.

3.2.7 Tung Tong Mine (sample no.7 in the sampling location map)

(a) Geology

This mine is situated at the southern part of Kathu Valley. In the past this mine was operated in the alluvial deposit where tin was derived from the erosion of stockworks of the margin of coarse-grained biotite granite. Nowaday, the mine is being operated in pegmatite and old gravel bed. The deposit is floored with coarse-grained biotite granite which has been highly weathered.

The pegmatite in the vicinity of this mine are tin-bearing muscovite pegmatites. They are oriented in NS to NE directions, and dipping to the east. The thickness is about 0.3-3 metre. These pegmatites are composed of quartz, feldspar, muscovite, minor amount

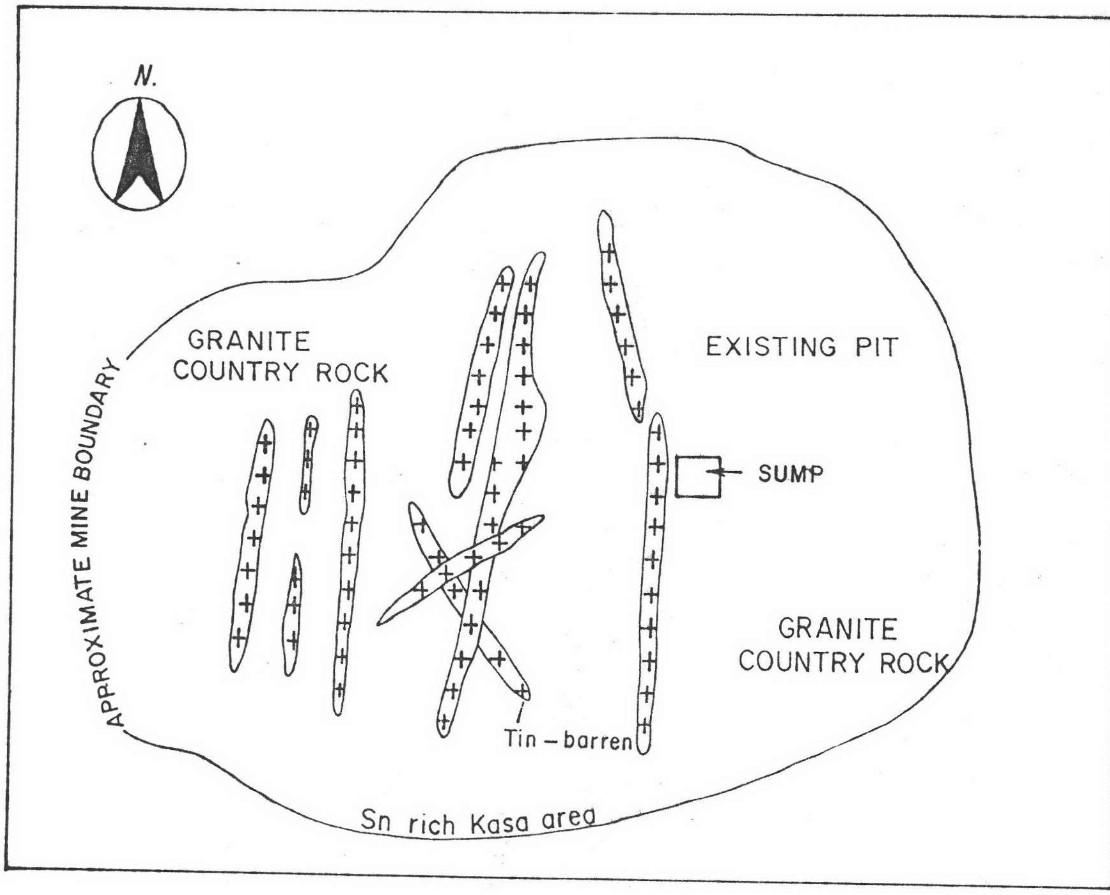
Table 3.2.6c The degree of abundance of heavy minerals with respect to grain size of Kathu mine

Mineral name	Weight percentages of heavy mineral in different size fraction							Total weight percentages
	10mesh	20mesh	40mesh	60mesh	80mesh	100mesh	-100mesh	
Cassiterite	-	1.75	1.06	2.413	10.74	16.29	25.53	57.783
Cassiterite with quartz	0.43	-	-	-	-	-	-	0.43
Columbite-tantalite	-	-	-	0.09	-	0.7	-	0.79
Fe-oxide	-	-	-	0.01	0.01	-	-	0.02
Garnet	0.17	1.86	7.21	4.49	2.22	0.45	0.05	16.45
Ilmenite	-	-	1.15	0.82	1.55	0.76	0.42	4.7
Limonite	0.52	0.89	0.27	-	0.09	-	-	1.77
Magnetite	0.5	-	0.28	-	-	0.13	-	0.91
Mica	-	-	0.08	-	-	-	-	0.08
Monazite-xenotime	-	-	-	-	0.22	0.15	0.75	1.12
Rutile	-	0.66	0.13	0.029	-	-	-	0.819
Spinel	-	-	-	0.003	0.05	1.42	0.62	2.093
Struverite	-	-	0.26	0.13	-	-	-	0.39
Tourmaline	-	-	0.33	0.12	0.19	0.14	0.11	0.89
Topaz	1.25	2.84	1.7	0.262	0.01	0.35	-	6.412
Zircon	-	-	-	0.003	0.59	1.87	2.88	5.343

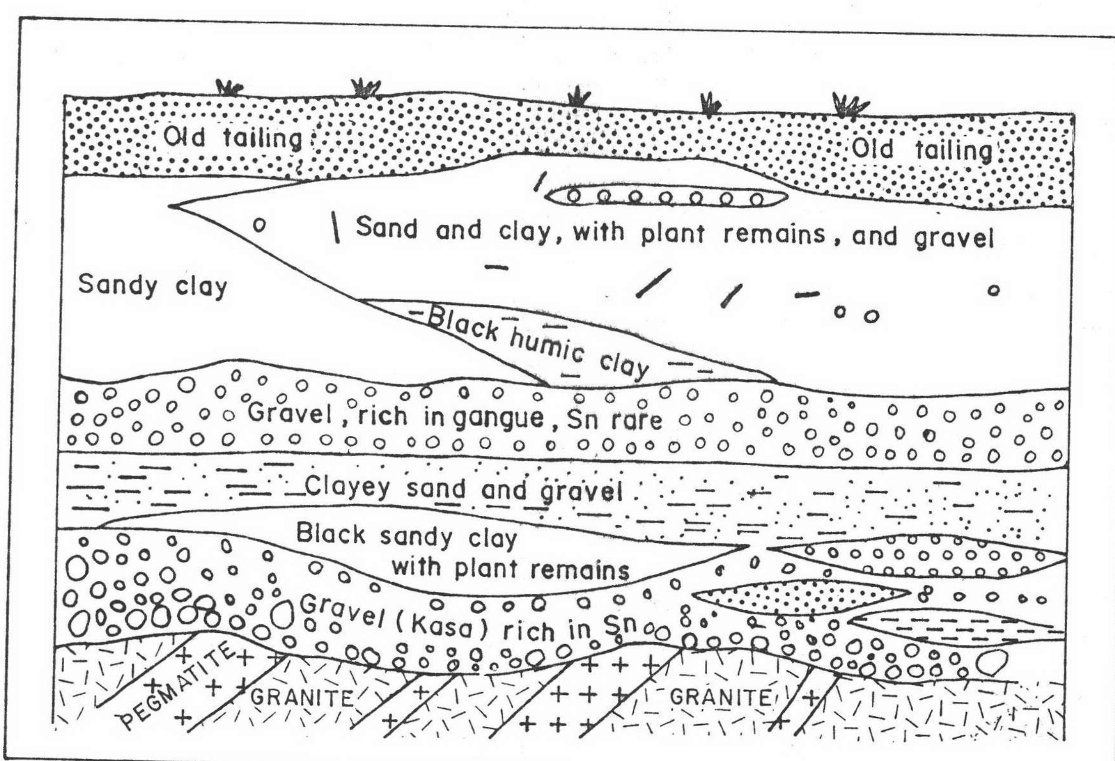
of biotite, and highly kaolinized. The tin-barren pegmatites which are quartz-feldspar pegmatites oriented in the NW direction, dipping to the west. It is composed of quartz, feldspar, minor amount of muscovite, and slightly kaolinized. The thickness is about 0.2-0.3 metre. There are 3 phases of pegmatites oriented in different directions, namely, NS, NW, and NE. Among these, the NE oriented pegmatite appears to be the youngest one considering from the cross-cutting relationships with the other two. The sketch enlargement of the geological setting of the deposit is presented in Figure 3.2.7 A.

The gravel bed at this locality is composed of quartz, aplite, graphic quartz, granite. The martix is sand and clay mixture. The sizes of gravel vary from 0.5 to 20 centimetres. The sorting is poor, and the roundness is subangular. This gravel bed is rich in tin content. The thickness is approximately 1 metre. This bed overlies the granitic bed rocks. The black to dark grey humic clay occurs as lenses intercalated in clayey sand and gravel overlying the tin-bearing gravel bed. There are some plant remains in this bed. The thickness is about 0.5 metre. The upper gravel bed overlying the clayey sand and gravel, is composed of fragments of quartz, shale, hornfels with sand and clay matrix. The roundness is subangular, and the sorting is moderate. This bed contains only gangue minerals. The thickness is about 1.2 metres. On top of the tin-barren gravel bed is the mixed layer of sandy clay, sand and clay with some gravels and plant remains, black humic clay lenses, and small lenses of gravel. The thickness is about 2.5 metres. The upper most layer is the old tailings of approximately 1.5 metres thick.

The sketch section showing the whole sequence is presented in Figure 3.2.7 B.



(A) Sketch enlargement showing the orientation of pegmatites in existing pit. Tung Tong mine (1983)



(B) Sketched section (Facing South) showing the gravel (Sn – rich and Sn – free) of New Tung Tong mine. (prepared on Dec 29, 1983)

Figure 3.2.7 Sketch enlargement and geological cross – section of Tung – Tong mine.

(b) Heavy mineral association

The principal ore mineral is cassiterite, and its varieties, namely, cassiterite interlocking with quartz, cassiterite with manganese coat, and cassiterite with Fe-oxide.

The associated minerals are manganese oxide, ilmenite, columbite-tantalite, rutile, garnet, tourmaline, monazite, xenotime, mica, zircon, Fe-oxide, and topaz.

The abundance of each heavy mineral in this mine is illustrated in the pie diagram (Fig. 3.2.7 b). Besides, the characteristics and assemblages of heavy minerals from Tung Tong mine are summarized and presented in Table 3.4.1 and 3.4.2 I.

(c) Heavy mineral distribution

The heavy minerals are most abundant in the very coarse sand (-1.0 ø) fraction.

The abundance of heavy minerals in each size fraction will be discussed in detail in chapter IV. However, the data on the degree of abundance of each heavy mineral with respect to grain size are summarized and presented in Table 3.2.7 c.

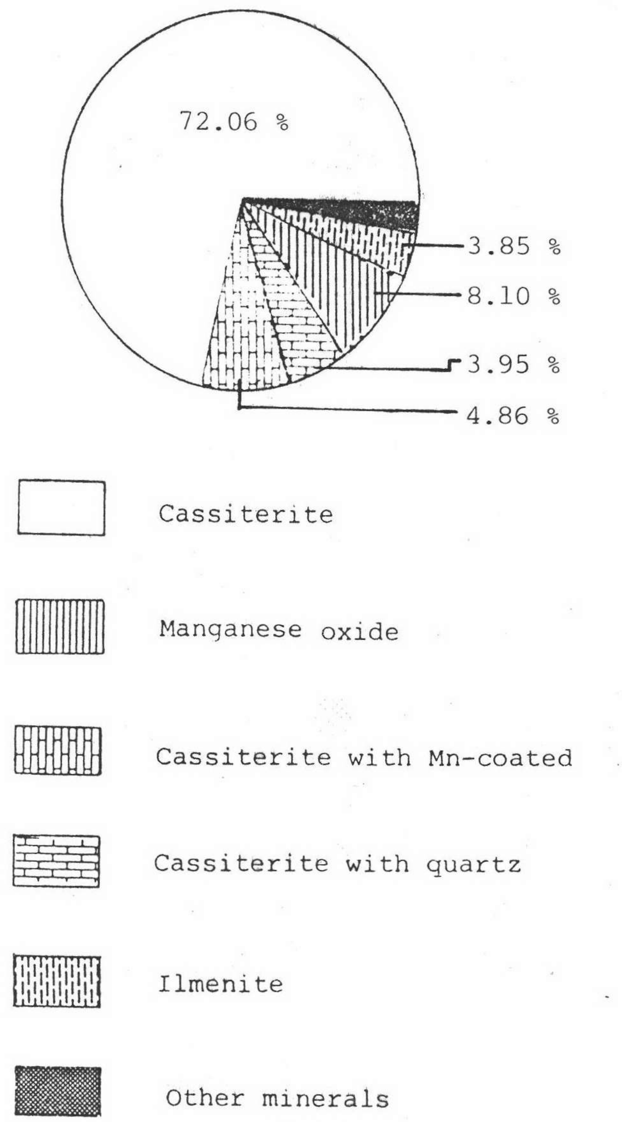
Cassiterite is most abundant in the very coarse sand (-1.0 ø) fraction.

Some other economic minerals, such as, columbite-tantalite are in the coarse sand to very fine sand (-1.0 ø to more than 2.75 ø) fraction.

3.2.8 Pol Thavee Mine (sample no.8 in the sampling location map)

(a) Geology

The mine is situated at the foot slope of Khao



Columbite-tantalite	0.793 %
Rutile	0.5712
Tourmaline	0.333
Garnet	0.32
Monazite-xenotime	0.31
Mica	0.1304
Zircon	0.117
Fe-oxide	0.1144
Topaz	0.048

Figure 3.2.7b Pie diagram illustrating the abundance of each heavy mineral of Tung Tong Mine.

Table 3.2.7c The degree of abundance of heavy minerals with respect to grain size of Tung Tong mine.

Mineral name	Weight percentages of heavy mineral in different size fraction							Total weight percentages
	10mesh	20mesh	40mesh	60mesh	80mesh	100mesh	-100mesh	
Cassiterite	28.82	19.62	15.04	4.54	2.29	1.155	0.591	72.056
Cassiterite with Fe-oxide	4.45	-	-	-	-	-	-	4.45
Cassiterite with manganese coat	4.86	-	-	-	-	-	-	4.86
Cassiterite with quartz	3.95	-	-	-	-	-	-	3.95
Columbite-tanta-lite	-	0.21	0.33	0.05	0.17	0.018	0.015	0.793
Fe-oxide	-	-	0.08	0.03	-	-	0.0044	0.1144
Garnet	-	-	0.10	0.10	0.10	0.02	-	0.32
Ilmenite	-	-	0.88	1.6	0.98	0.31	0.08	3.85
Manganese oxide	7.82	0.28	-	-	-	-	-	8.1
Mica	-	0.05	0.05	0.01	0.01	0.009	0.0014	0.1304
Monazite-xenotime	-	-	-	0.08	0.16	0.06	0.01	0.31
Rutile	-	0.48	0.09	-	-	-	0.0012	0.5712
Topaz	-	-	0.04	0.005	-	0.003	-	0.048
Tourmaline	-	-	0.06	0.17	0.08	0.02	0.003	0.333
Zircon	-	-	-	0.015	0.03	0.035	0.034	0.114

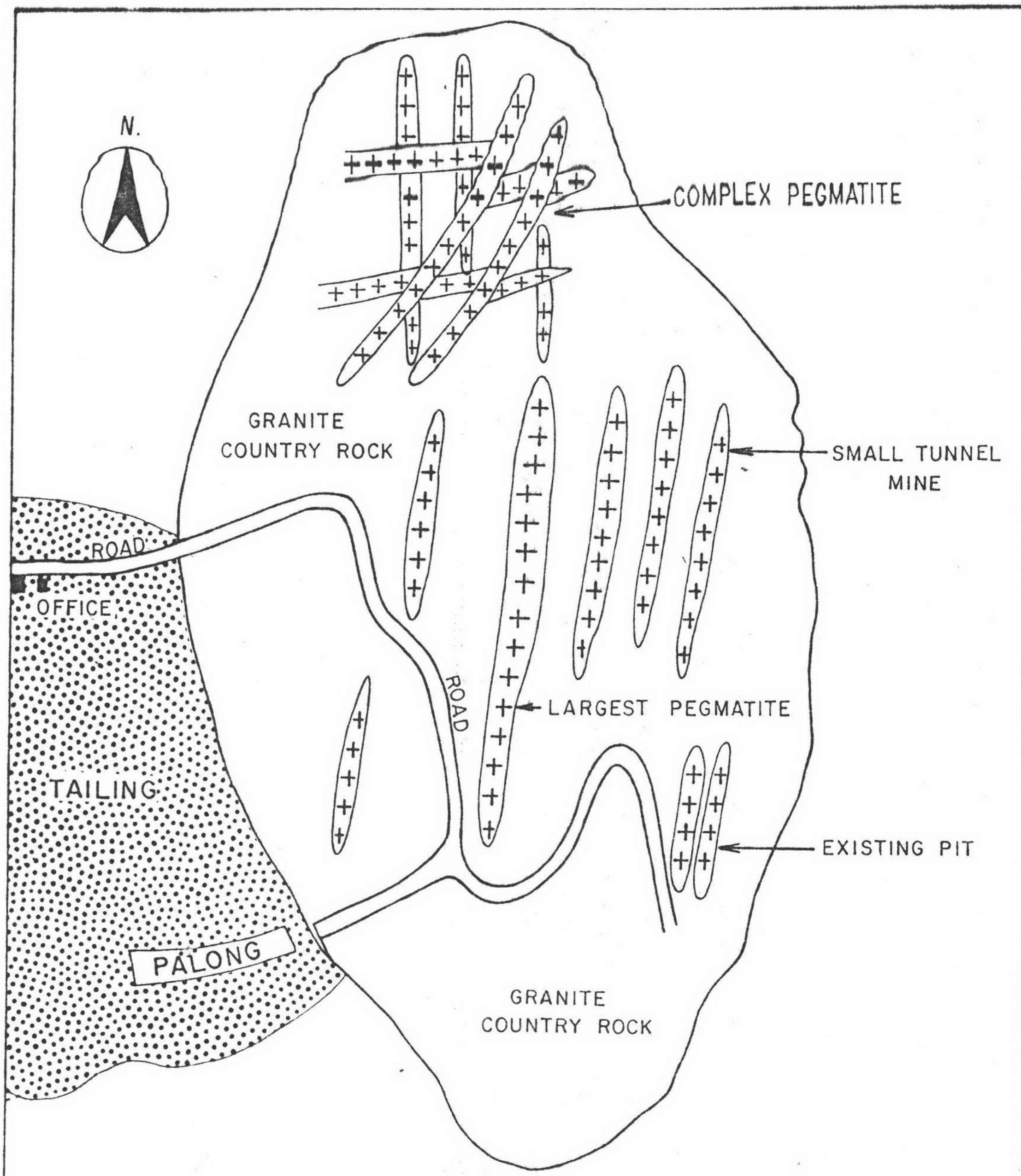
Nakha which is the coarse-grained porphyritic biotite granite. The granite is composed of quartz, potash feldpar, mafic minerals, and slightly to moderately weathered with porphyritic texture. The fault in the EW and NE directions are present at this mine. The joint in this granitic rock mainly developed in the NE-NW directions, with steeply dipping.

The pegmatites in the vicinity of this mine can be categorized into 2 main types, namely, tourmaline-muscovite pegmatite, and quartz-feldspar-muscovite pegmatite associated with aplite dike. The tourmaline-muscovite pegmatite associated with aplite is oriented in the NS-EW directions composing mainly of quartz,feldspar, muscovite, tourmaline. The thickness is about 3-5 metres. There are a variety of texture and composition of NS pegmatite ranging from pegmatitic to aplitic texture with some feldspar phenocrysts in the aplite (Fig. 3.2.8 B). These pegmatites contain low tin content. The tin-bearing quartz-feldspar-muscovite pegmatite is oriented in the NE direction, dipping to the east and composing mainly of medium-to coarse-grained quartz, feldspar, muscovite, minor amount of tourmaline, highly kaolinized. The thickness is about 0.5-6 metres. These pegmatites are the youngest ones indicated by the cross- cutting relationships with the NS-EW tourmaline-muscovite pegmatite associated with aplite (Fig. 3.2.8 B). The sketch enlargement showing the orientation and relationships of pegmatites is shown in Figure 3.2.8 A.

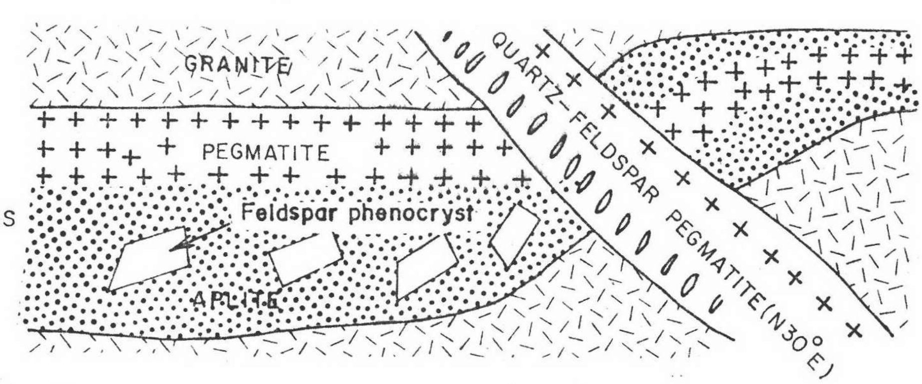
(b) Heavy mineral association

The principal ore minerals are cassiterite and cassiterite with manganese coat.

The associated minerals are garnet,ilmenite, tourmaline, monazite, xenotime, biotite, zircon, mangan-tantalite, manganese



(A) Sketch enlargement showing the orientation and relation of pegmatites (main direction N 30° E) of Polthavee mine – (prepared Jan I, 1984)



(B) Sketched plane view of northern part of Polthavee mine showing the difference in texture and composition of NS pegmatite and latest N 30° E pegmatite .

Figure 3.2.8. Sketch enlargement and geological cross-section of Polthavee mine.

bearing mica, columbite-tantalite, rutile, manganese oxide, apatite struverite, spinel, and topaz.

The abundance of each heavy mineral in this mine is illustrated in the pie diagram (Fig. 3.2.8 b). Besides, the characteristics and the assemblages of heavy minerals from Pol Thavee mine are summarized and presented in Table 3.4.1 and 3.4.2 I.

(c) Heavy mineral association

The heavy minerals in this mine are most abundant in the very coarse sand (-1.0 ø) fraction.

The abundance of heavy minerals in each size fraction will be discussed in detail in chapter IV. However, the data on the degree of abundance of each heavy mineral with respect to grain size are summarized in Table 3.2.8 c.

Cassiterite is most abundant in the very coarse sand (-1.0 ø) fraction.

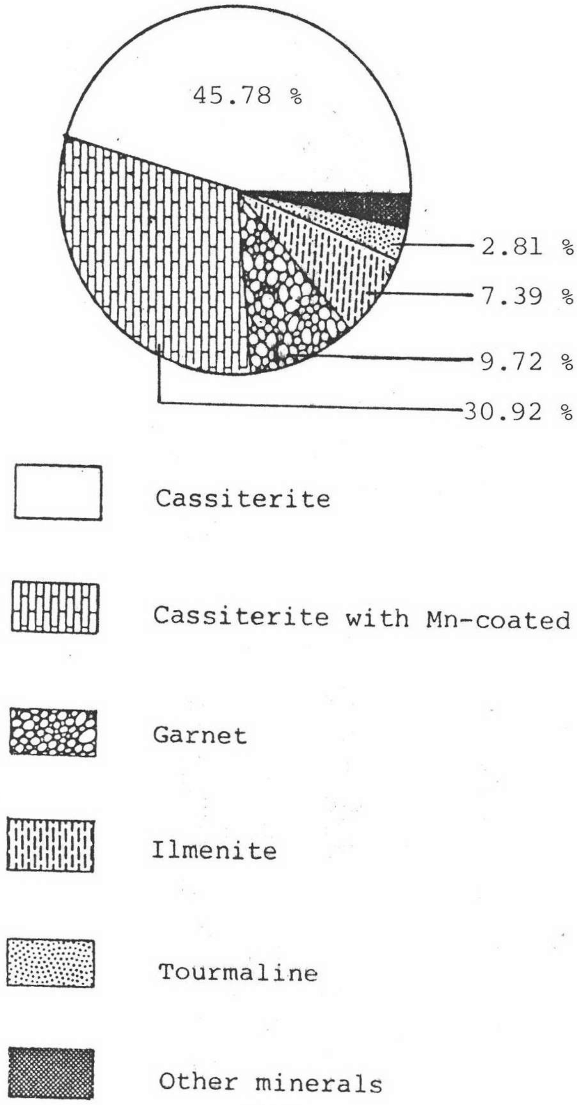
Some other economic minerals, namely, columbite-tantalite are present in the medium to very fine sand (1.25 ø to more than 2.75 ø) fraction, whereas mangan-tantalite is only present in the coarse sand (0.5 ø) fraction, and struverite is present in the fine sand (2.5 ø) fraction.

3.3 Area Outside Kathu Valley

3.3.1 Sapayakorn Mine (sample no. 9 in the sampling location map)

(a) Geology

The mine is situated in the small valley between Khao Bang Nieo Dam and Khao Che Tra. The valley is mainly floored



Biotite	0.769 %
Monazite-xenotime	0.829
Zircon	0.569
Mangan-tantalite	0.52
Mica with manganese	0.42
Columbite-tantalite	0.182
Feldspar	0.026
Rutile	0.024
Manganese oxide	0.011
Struverite	0.007
Spinel	0.006
Topaz	0.002
Apatite	0.01

Figure 3.2.8b Pie diagram illustrating the abundance of each heavy mineral of Pol Thavee Mine.

Table 3.2.8c The degree of abundance of heavy minerals with respect to grain size of Pol Thavee mine

Mineral name	Weight percentages of each heavy mineral in different size fraction							Total weight percentages
	10mesh	20mesh	40mesh	60mesh	80mesh	100mesh	-100mesh	
Apatite	-	-	0.01	-	-	-	-	0.01
Biotite	-	0.06	0.56	0.02	0.06	0.03	0.039	0.769
Cassiterite	18.35	15.76	6.07	2.15	1.69	1.09	0.67	45.78
Cassiterite with manganese coat	30.92	-	-	-	-	-	-	30.92
Columbite-tantalite	-	-	0.07	0.05	0.04	0.015	0.007	0.182
Feldspar	-	-	-	0.014	-	-	0.012	0.026
Garnet	-	0.52	2.77	3.59	2.1	0.6	0.142	9.722
Ilmenite	-	-	2.64	2.08	1.51	0.9	0.262	7.392
Manganese oxide	-	-	-	-	-	0.01	0.001	0.011
Mangan-tantalite	-	0.52	-	-	-	-	-	0.52
Manganese-bearing mica	-	0.42	-	-	-	-	-	0.42
Monazite-xenotime	-	-	-	0.21	0.31	0.18	0.129	0.829
Rutile	-	-	0.02	-	0.002	-	0.002	0.024
Spinel	-	-	-	0.006	-	-	-	0.006
Struverite	-	-	-	-	-	0.007	-	0.007
Topaz	-	-	-	-	0.002	-	-	0.002
Tourmaline	-	0.07	1.45	0.774	0.37	0.07	0.077	2.811
Zircon	-	-	-	0.026	0.056	0.068	0.419	0.569

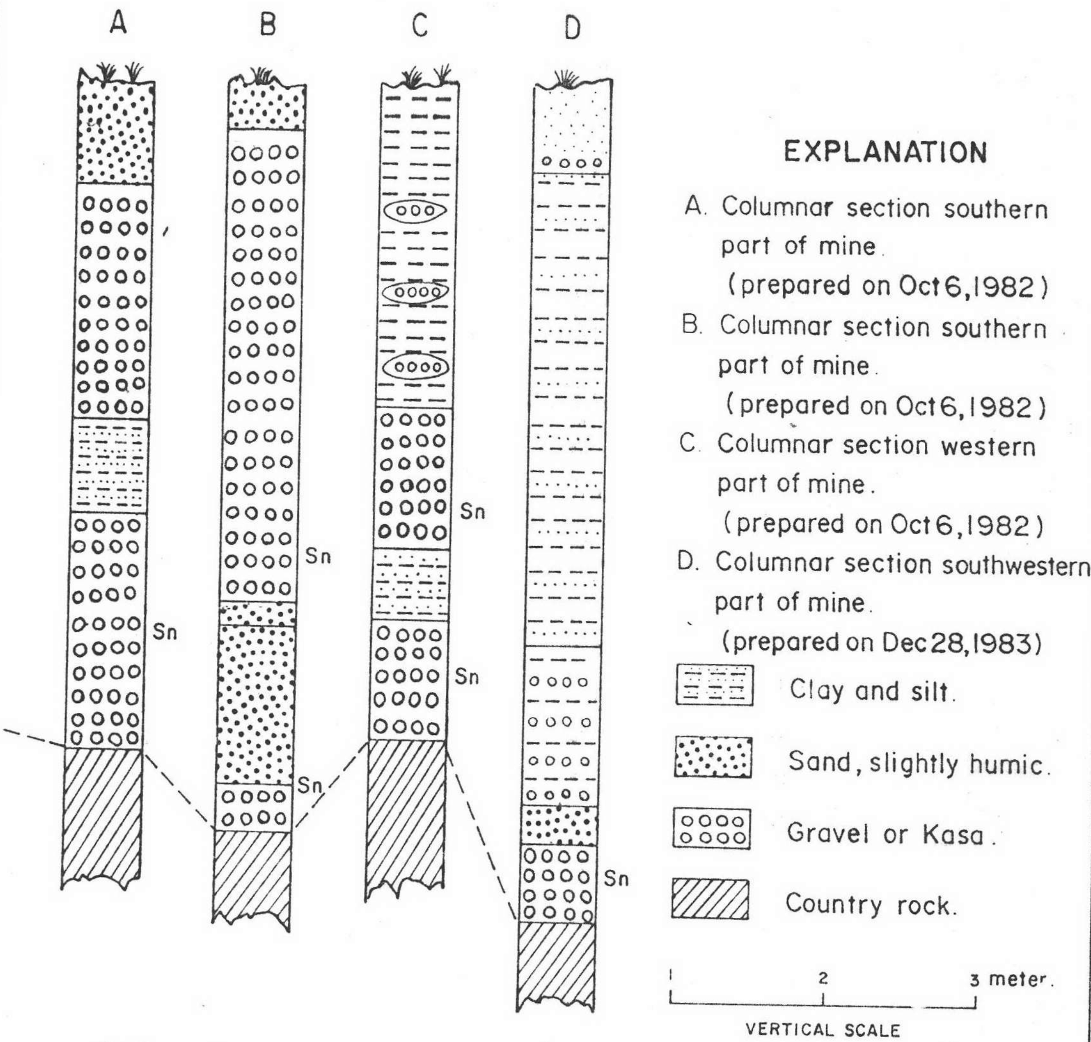
with the sedimentary rocks of Phuket Group with rolling topographic expression of approximately 20 metres relief. The sedimentary rocks of Phuket Group in this locality is composed of reddish brown mudstone, siltstone, micaceous sandstone which are highly weathered. The attitude of bed rocks is in the NW direction, dipping to the east. The tin-barren pegmatites, intruded in the sedimentary rocks, are oriented in NE direction, dipping to the east. These pegmatites are quartz-feldspar pegmatite with aplitic texture forming dikes and sills. The thickness is about 10 centimetres. A fault in the NE direction is present at this mine indicated by some sheared zones in the country rocks.

The nature of tin-deposits of this mine is of colluvial origin. The sedimentary sections of the deposit is characterized by the coarse fluviatile facies overlying a mass movement deposit which have undergone transportation down valley (Kruse,1982). The gravel beds are mainly composed of fragment of mica schist,sandstone,mudstone, shale, quartz, granite. The thickness varies from 0.3-3 metres. The gravels vary in sizes from 50-100 centimetres with poor sorting. The light bluish grey clay, sand, silt, as well as lenses of gravel overlying the gravel bed probably indicate the deposit in closed basin or channel deposit.

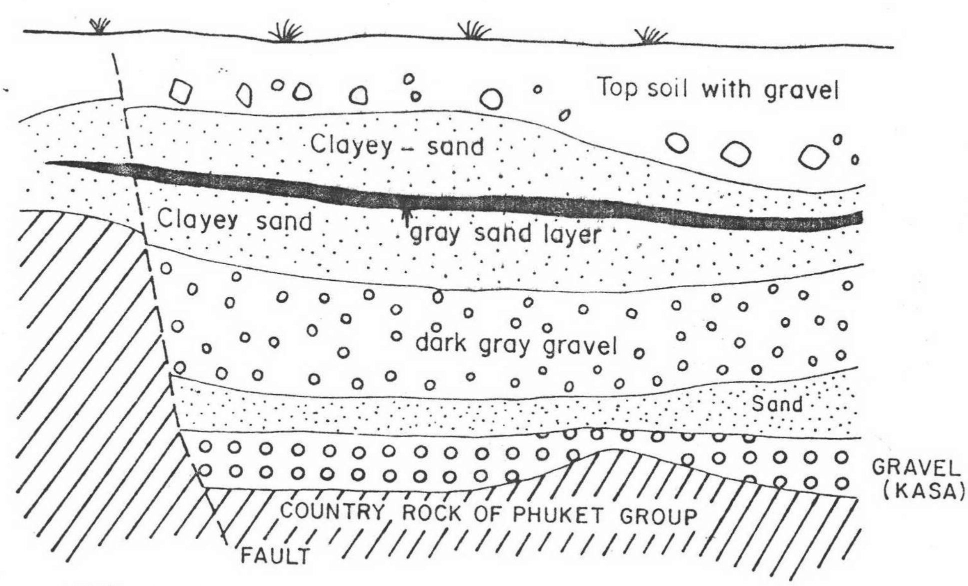
The columnar section of Sapayakorn mine and the sketched section of gravel bed associated with country rocks are shown in Figure 3.3.1 A, 3.3.1 B.

(b) Heavy mineral association

The principal ore minerals in Sapayakorn mine are cassiterite, and cassiterite interlocking with quartz.



(A) Columnar sections of southern and western part of - Sapayakorn mine, showing the difference of gravels (kasa), associated with country rocks, clay and humic sand.



(B) Sketch southern section (Facing South) showing the typical gravel (kasa) associated with country rock and structure. (prepared on Dec 28, 1983)

Figure 3.3.1 Sketch columnar sections and sketch geological cross-section of Sapayakorn Mine.

The associated minerals are ilmenite, zircon, spinel, tourmaline, rutile, struverite, Fe-oxide, siderite, garnet, monazite, xenotime, thorite, multiple oxide containing Nb-Ta, siderite interlocking with quartz, and fluorite.

The abundance of each heavy mineral in this mine is illustrated in the pie diagram (Fig. 3.3.1 b). Besides, the characteristics and assemblages of heavy minerals from Sapayakorn mine are summarized and presented in Table 3.4.1 and 3.4.2 II.

(c) Heavy mineral distribution

The heavy minerals in this mine are most abundant in the medium sand (1.25 ø) fraction.

The abundance of heavy minerals in each size fraction will be discussed in detailed in chapter IV. However, the data on the degree of abundance of each heavy mineral with respect to grain size are summarized in Table 3.3.1 c.

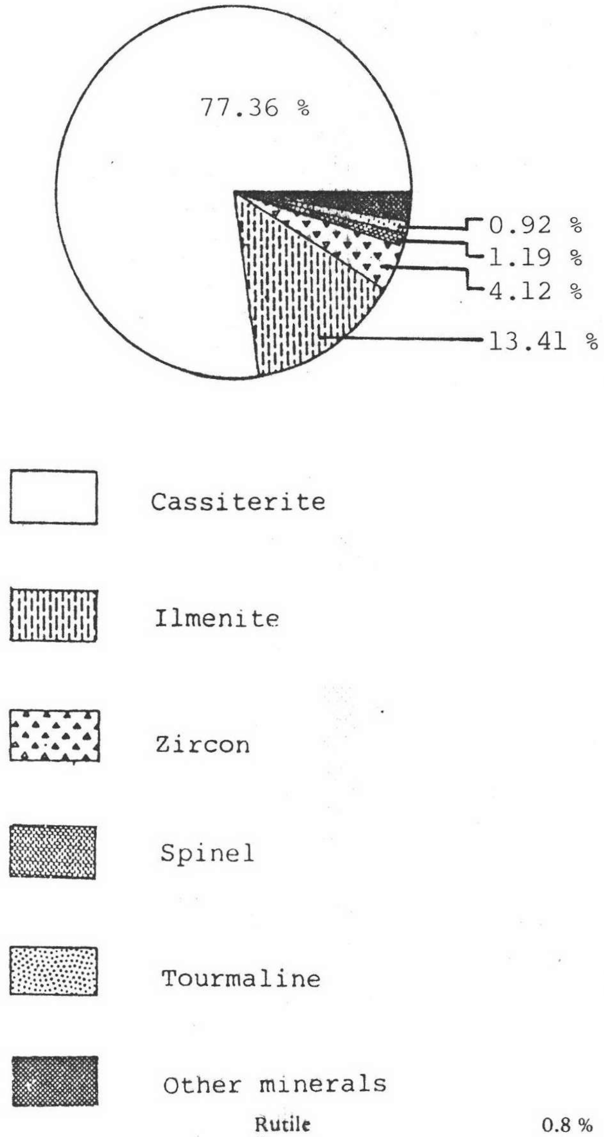
Cassiterite is most abundant in the medium sand (1.25 ø) fraction.

Some other economic minerals, such as, multiple oxide containing Nb-Ta is only present in the medium sand (2.0 ø) fraction, whereas struverite is present in the medium sand (1.25 ø) fraction.

3.3.2 Sinpatana Mine (sample no. 10 in the sampling location map)

(a) Geology

This mine is situated in colluvial deposit between Khao Bang Nieo Dam and Kho Che Tra. In the past this mine was operated in gravel bed but at present day this mine is being operated in pegma-



Rutile	0.8 %
Quartz	0.8
Cassiterite with quartz	0.395
Struverite	0.33
Fe-oxide	0.13
Siderite	0.13
Garnet	0.102
Monazite-xenotime	0.1
Thorite	0.1
Multiple oxide (Cb-Ta)	0.06
Machine waste	0.033
Siderite with quartz	0.02
Fluorite	0.007

Figure 3.3.1b Pie diagram illustrating the abundance of each heavy mineral of Sapayakorn Mine.

Table 3.3.1c The degree of abundance of heavy minerals with respect to grain size of Sapayakorn mine.

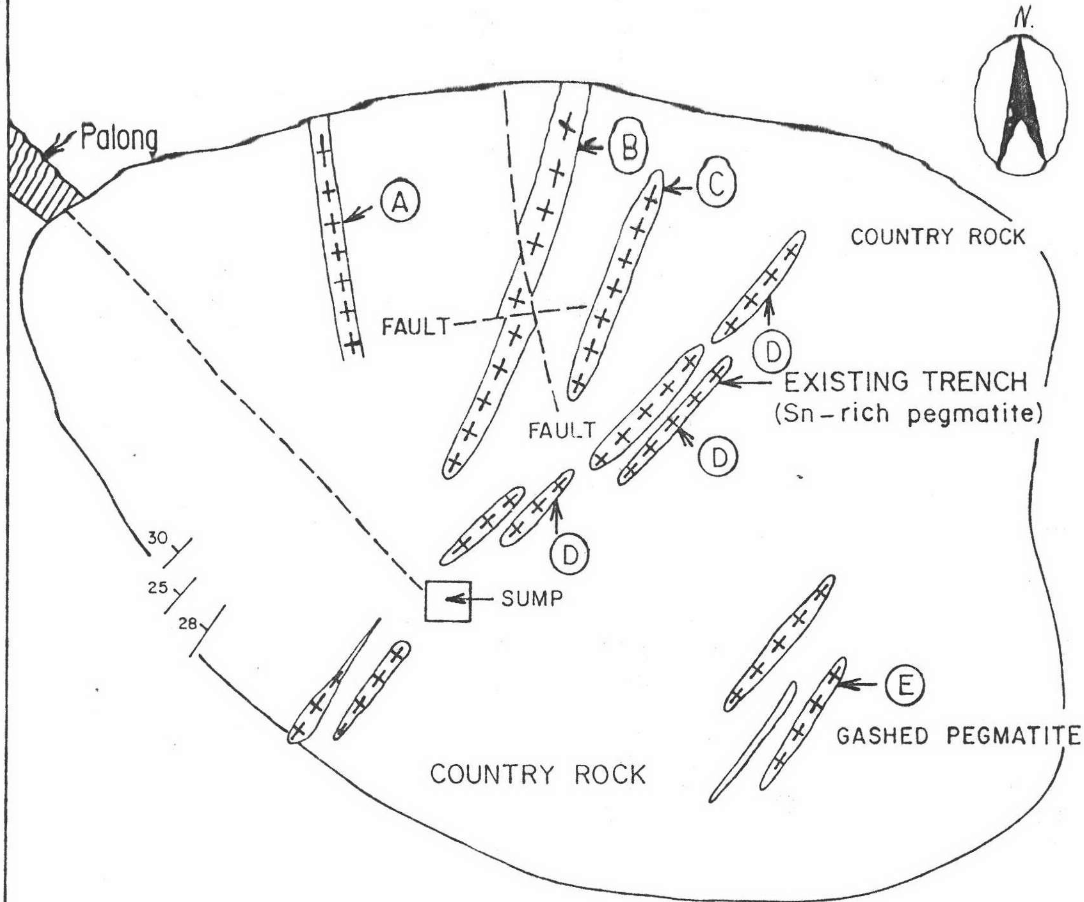
Mineral name	Weight percentages of heavy minerals in different size fraction							Total weight percentages
	10mesh	20mesh	40mesh	60mesh	80mesh	100mesh	-100mesh	
Cassiterite	0.492	13.24	28.57	18.15	10.75	3.893	2.262	77.357
Cassiterite with quartz	0.085	0.31	-	-	-	-	-	0.395
Fe-oxide	-	-	0.04	0.09	-	-	-	0.13
Fluorite	-	-	-	-	-	0.006	0.001	0.007
Garnet	-	-	0.03	0.03	0.03	0.011	0.001	0.102
Ilmenite	-	-	2.8	4.22	3.74	1.85	0.803	13.413
Machine waste	0.033	-	-	-	-	-	-	0.033
Monazite-xeno - time	-	-	-	-	0.01	0.06	0.03	0.1
Multiple oxide contain Cb-Ta	-	-	-	0.06	-	-	-	0.06
Quartz	-	-	0.58	0.13	0.07	0.02	-	0.8
Rutile	-	-	-	0.42	0.38	-	-	0.8
Siderite	-	-	-	0.03	0.06	0.03	0.01	0.13
Siderite+quartz	-	-	0.02	-	-	-	-	0.02
Spinel	-	-	-	-	0.26	0.7	0.23	1.19
Struverite	-	-	0.33	-	-	-	-	0.33
Thorite	-	-	-	-	-	-	0.1	0.1
Tourmaline	-	-	0.5	0.17	0.14	0.08	0.025	0.915
Zircon	-		-	0.17	1.03	1.14	1.778	4.118

tite bodies. The country rocks in the vicinity of this mine are the clastic sedimentary rocks of Phuket Group composing of reddish brown mudstone, siltstone, pebbly shale with pebbles of granite, quartz and spotted slate. The country rocks are heavily fractured and faulted due to subsequent deformation. The bedding plane of country rock is oriented in NE direction with slightly dipping to the west. The joint set developed in this rocks oriented in NW to NE direction, and steeply dipping to the east and west. The faults in NW/NS/EW directions are located at this mine indicated by offset of the pegmatite bodies (Fig. 3.3.2 B).

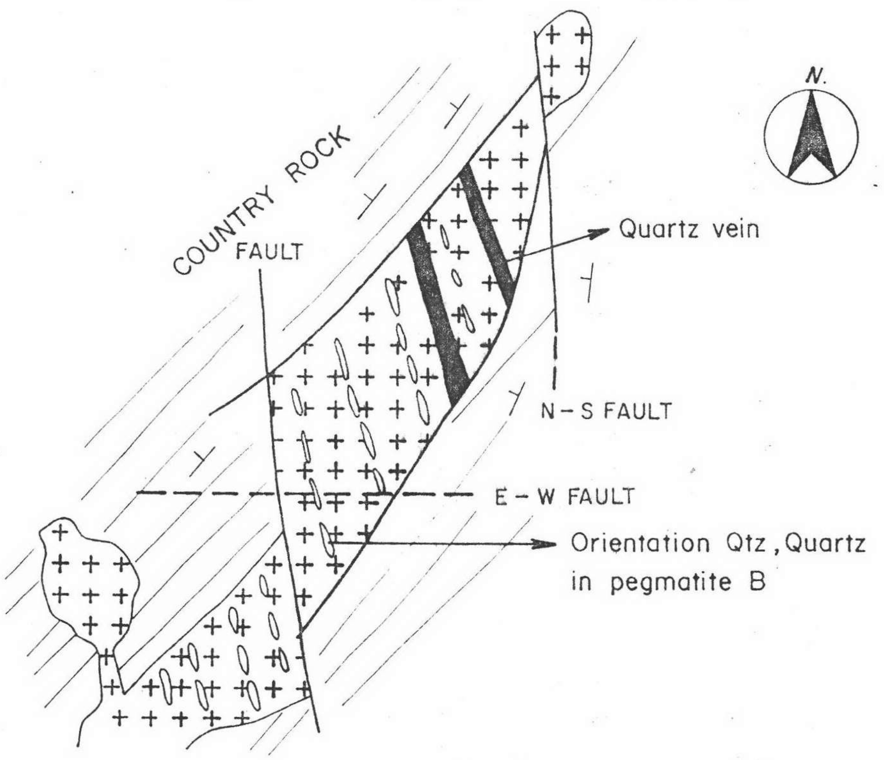
The pegmatite in the vicinity of this mine are quartz-feldspar pegmatite oriented in NE direction, dipping to the east. These pegmatites are composed of fine-to medium-grained quartz, feldspar with minor amount of muscovite, and highly kaolinized. The thickness is about 0.3-0.5 metre. The small gashed pegmatite vein swarm oriented in EW direction are located in the southern part of this mine and the thickness is about 0.2-0.3 metre. The pegmatite form dikes, sills, irregular pods intruded along the fractures, bedding planes and fault zones. In the pegmatite body, there are some small quartz veins and the quartz crystals show parallel orientation (Fig. 3.3.2 B). The faults in NW/NS/NE directions cut across the pegmatite body. All of the pegmatites in the vicinity of this mine are tin-bearing pegmatites, and the Sn-rich pegmatite is in the middle part of this mine (group D, Fig. 3.3.2 A). The sketch enlargement showing the orientation of pegmatites in this mine is illustrated in Figure 3.3.2 A.

(b) Heavy mineral association

The principal ore mineral in Sinpatana mine is cassiterite including cassiterite interlocking with quartz.



(A) Sketch enlargement showing the orientation of pegmatites in Sinpatana mine (prepared on Jan 1, 1984)



(B) Sketched geological cross-section pegmatite B (See fig. A) in relation to N-S and E-W faults with the orientation of quartz in pegmatite and quartz veins.

Figure 3.3.2 Sketch enlargement and geological cross-section of Sinpatana Mine.

The associated minerals are zircon, topaz, columbite-tantalite, garnet, mangan-tantalite, pyrite, manganese oxide, Fe-oxide, spinel, monazite, xenotime, tourmaline, ilmenite, mica, and limonite.

The abundance of each heavy mineral in this mine is illustrated in the pie diagram (Fig. 3.3.2 b). Besides, the characteristics and the assembalges of heavy minerals from Sinpatana mine are summarized and presented in Table 3.4.1 and 3.4.2 II.

(c) Heavy mineral distribution

The heavy minerals in this mine are most abundant in the medium sand (1.25 ø) fraction.

The abundance of heavy minerals in each size fraction will be discussed in detailed in chapter IV. However, the data on the degree of abundance of each heavy mineral with respect to grain size are summarized in Table 3.3.2 c.

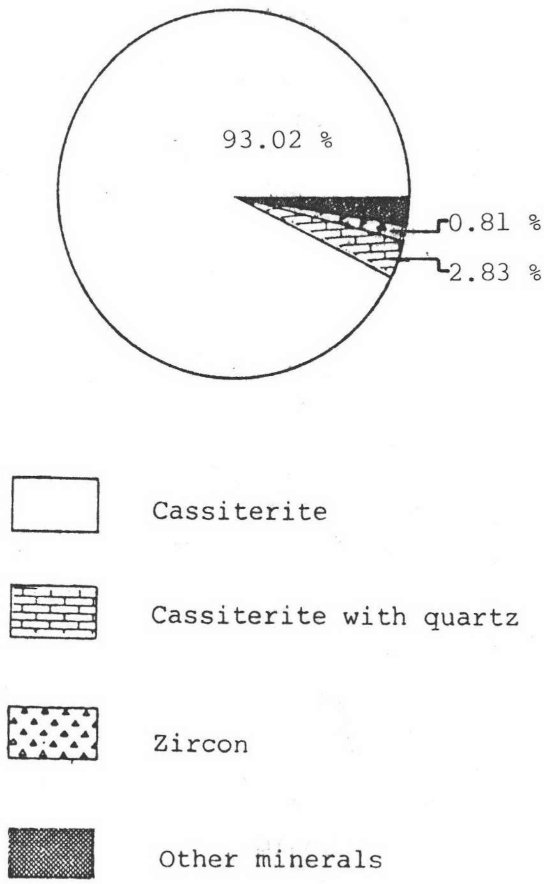
Cassiterite is most abundant in the medium sand (1.25 ø) fraction.

Some other economic minerals, such as, columbite-tantalite are present in the medium to fine sand (1.25 ø-2.5 ø) fraction, while mangan-tantalite is present in the fine to very fine sand (2.5 ø to more than 2.75 ø) fraction.

3.3.3 Sap Bangku Mine (sample no. 11 in the sampling location map)

(a) Geology

This mine is situated at the northern slope of Khao Phanthurat, and the deposit is of colluvial origin. The country rocks in the vicinity of this mine are the sedimentary rocks of Phuket Group



Topaz	0.584 %
Columbite-tantalite	0.526
Garnet	0.464
Quartz	0.43
Machine waste	0.23
Mangan-tantalite	0.216
Pyrite	0.2
Manganese oxide	0.199
Fe-oxide	0.15
Spinel	0.11
Monazite-xenotime	0.084
Tourmaline	0.047
Ilmenite	0.037
Mica	0.015
Limonite	0.007

Figure 3.3.2b Pie diagram illustrating the abundance of each heavy mineral of Sinpatana Mine.

Table 3.3.2c The degree of abundance of heavy minerals with respect to grain size of Sinpatana mine.

Mineral name	Weight percentages of heavy minerals in different size fraction							Total weight percentages
	10mesh	20mesh	40mesh	60mesh	80mesh	100mesh	-100mesh	
Cassiterite	2.82	17.42	28.65	23.18	11.89	4.32	4.54	93.02
Cassiterite with quartz	1.07	1.76	-	-	-	-	-	2.83
Columbite-tantalite	-	-	0.24	0.14	0.141	-	0.005	0.526
Fe-oxide	-	-	0.08	0.06	0.01	-	-	0.15
Garnet	-	-	0.17	0.19	0.07	0.02	0.014	0.464
Ilmenite	-	-	-	-	0.014	0.01	0.013	0.037
Limonite	-	-	-	-	0.007	-	-	0.007
Manganese oxide	-	-	0.1	0.08	0.009	0.01	-	0.199
Mangan-tantalite	-	-	-	-	0.079	0.06	0.077	0.216
Machine waste	0.23	-	-	-	-	-	-	0.23
Mica	-	-	-	-	0.015	-	-	0.015
Monazite-xenotime	-	-	-	-	0.052	0.011	0.021	0.084
Pyrite	-	-	-	0.18	0.02	-	-	0.2
Quartz	-	0.19	0.22	-	0.02	-	-	0.43
Spinel	-	-	-	-	0.05	0.02	0.04	0.11
Topaz	-	-	-	0.49	0.083	0.011	-	0.584
Tourmaline	-	-	-	0.01	0.02	0.005	0.012	0.047
Zircon	-	-	0.12	0.33	0.19	0.083	0.128	0.851

comprising grey to greenish brown mudstone, shale, pebbly mudstone. They are oriented in NW direction, and dipping to the west. These rocks are heavily fractured and jointed. The joint set developed in these country rocks are oriented in NE to NW directions, and steeply dipping to the east and west. The faults in NE and EW directions cut. across the pegmatite bodies.

There are pegmatite associated with aplite intruded along the bedding plane and fracture of country rocks. These pegmatites associated with aplite are oriented in NE and EW directions dipping to the east, and all of them are the tin-barren ones. The thickness is approximately 0.3-0.4 metre.

The colluvial deposits in the vicinity of this mine are composed of the tin-bearing gravel bed overlying the bed rocks of Phuket Group. The bottom of the gravel bed is composed of quartz, schist, aplite, hornfels, spotted hornfels, and some pisolitic laterite. The size varies from 10-20 centimetres. In the upper part of this gravel bed, the gravels are similar in nature to the bottom but they are better sorted. Some lenses of fine mottled clay with some gravels, and lenses of mottled clay rich in gravels are intercalated in this gravel bed The tin content is high at the bottom part of this gravel bed. This gravel bed is 2.2 metres thick. The bed of mottled clay with some gravels overlies the gravel bed intercalated with clayey sand. The thickness of the mottled clay is about 1.25 metres. The mottled clay rich in lenses of gravel at the bottom overlies the bed of mottled clay with some gravel. The thickness is about 1.2 metres. The concretionary lateritic soil overlies the mottled clay rich in gravel. The thickness is about 0.5 metre. The upper most part is top soil and old tailings of

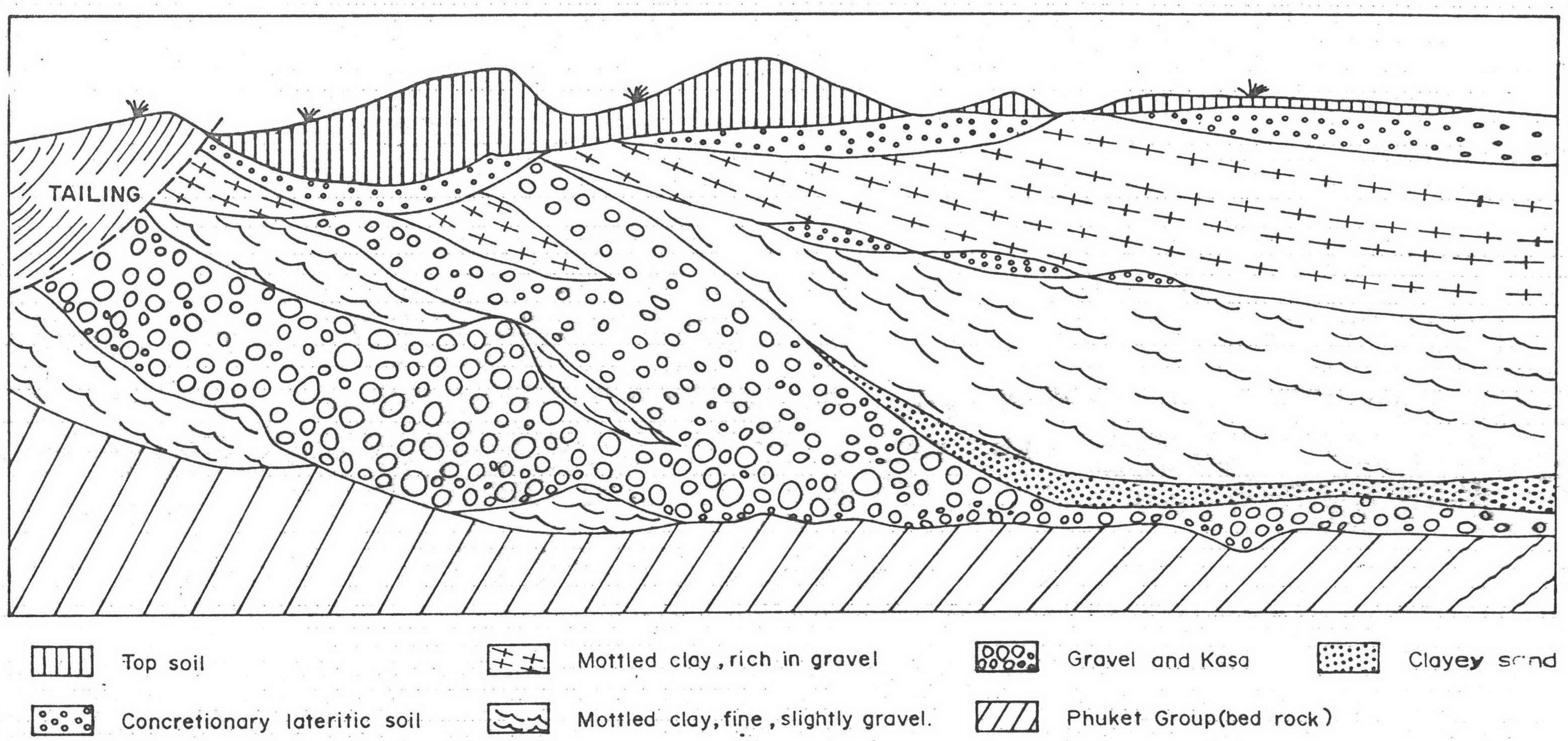


Figure 3.3.3 Sketched geological cross section (Facing north) of the northern part of Sap Bangku mine showing the gravel bed or **kasa** relating to the bedrock and the upper layer (prepared on Dec 27, 1983)

approximately 0.5 metre thick. The sketched section of gravel bed and bed rock is shown in Figure 3.3.3.

The environment of deposition in the vicinity of this mine is probably channel filling and terrace deposit.

(b) Heavy mineral association

The principal ore mineral is present only cassiterite.

The associated minerals are ilmenite, limonite, tourmaline, topaz, zircon, garnet, monazite, xenotime, siderite, Fe-oxide, spinel, columbite-tantalite, rutile, wolframite, and apatite.

The abundance of each heavy mineral in this mine is illustrated in the pie diagram (Fig. 3.3.3 b). Besides, the characteristics and the assemblages of heavy minerals from Sap Bangku mine are summarized and presented in Table 3.4.1 and 3.4.2 II.

(c) Heavy mineral distribution

The heavy minerals in this mine are most abundant in the medium sand (1.25 ø) fraction.

The abundance of heavy minerals in each size fraction will be discussed in detail in chapter IV. However, the data on the degree of abundance of each heavy mineral with respect to grain size are summarized in Table 3.3.3 c.

Cassiterite is most abundant in the medium sand (1.25 ø) fraction.

Some other economic minerals, such as, columbite-tantalite are present in the fine to very fine sand (2.5 ø to more than 2.75 ø) fraction.

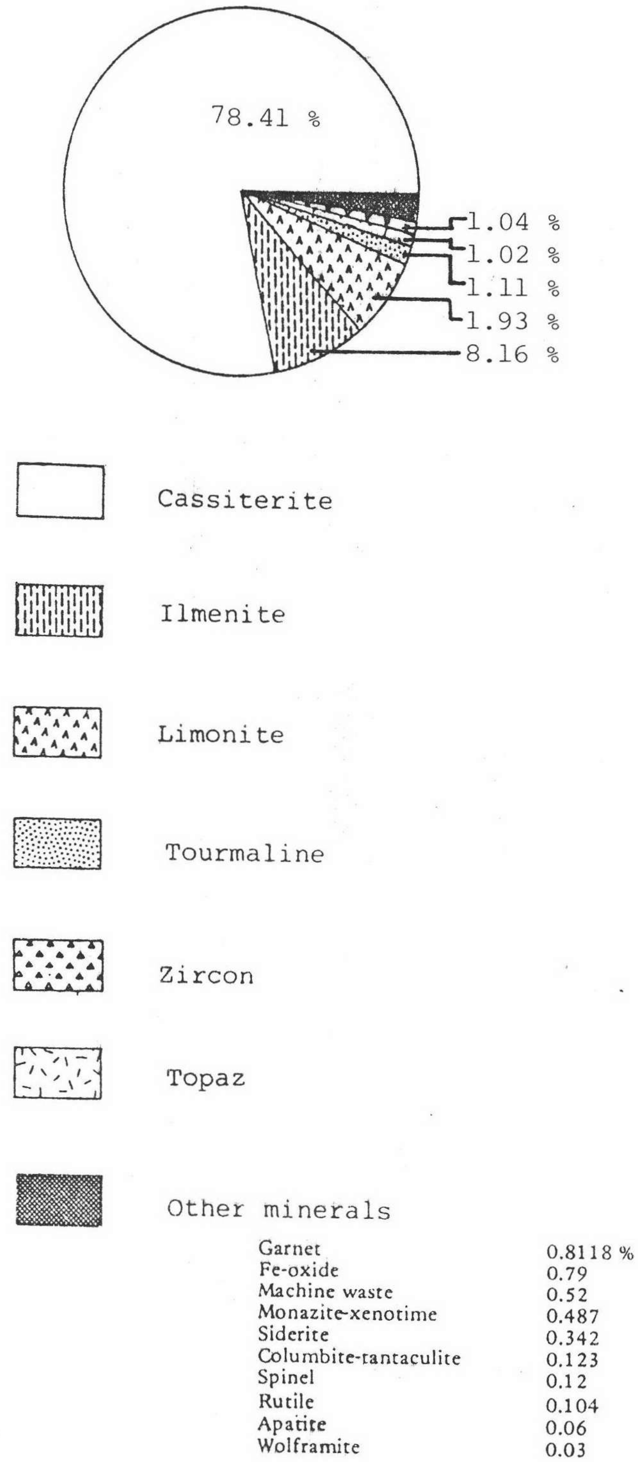


Figure 3.3.3b Pie diagram illustrating the abundance of each heavy mineral of Sap Bangku Mine.

Table 3.3.3c The degree of abundance of heavy minerals with respect to grain size of Sap Bangku mine.

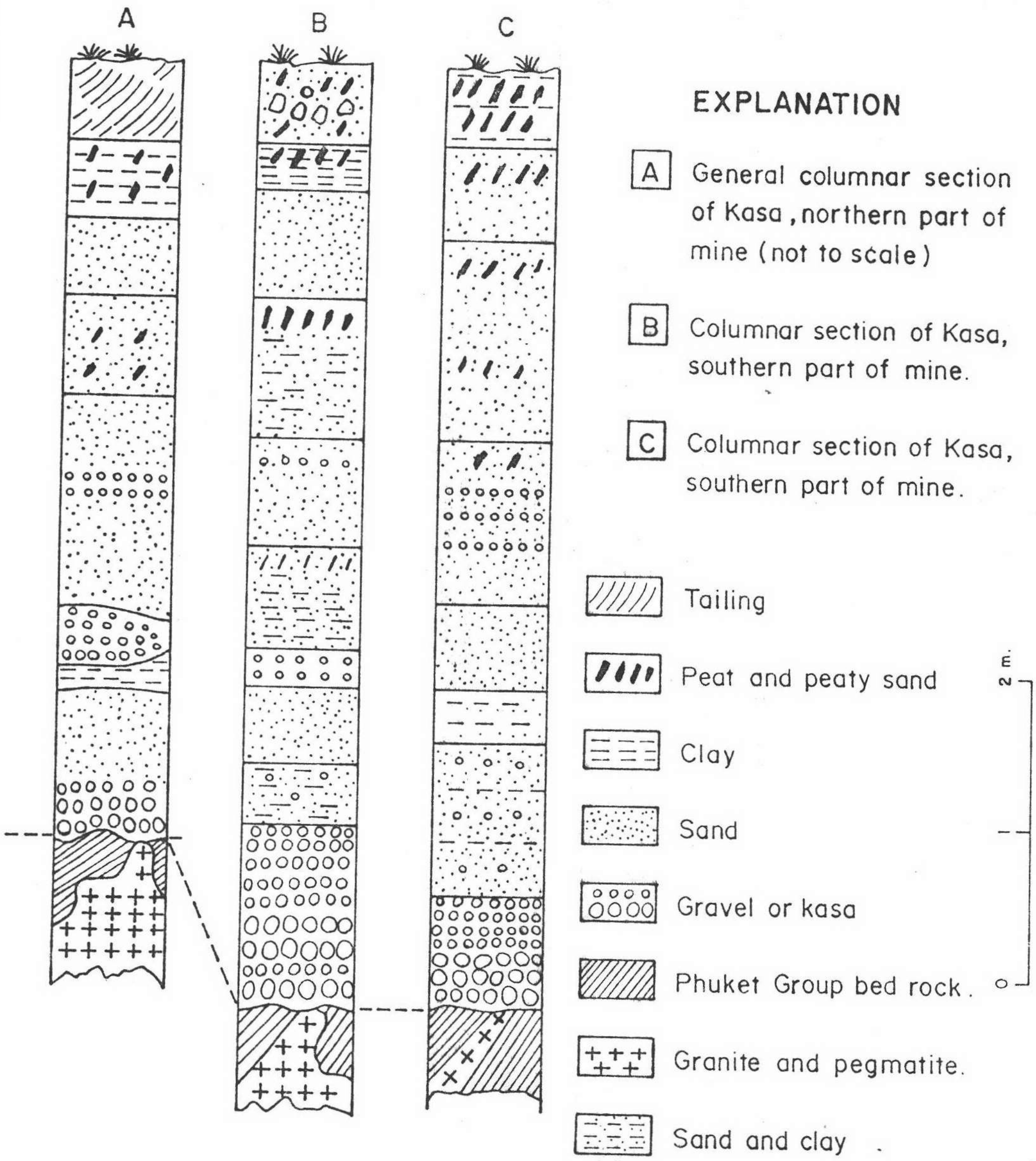
Mineral name	Weight percentages of heavy minerals in different size fraction							Total weight percentages
	10mesh	20mesh	40mesh	60mesh	80mesh	100mesh	-100mesh	
Apatite	-	-	0.06	-	-	-	-	0.06
Cassiterite	0.68	7.92	33.12	15.65	11.07	5.257	3.715	78.412
Columbite-tantalite	-	-	-	-	0.08	0.03	0.013	0.123
Fe-oxide	-	0.26	0.21	0.25	0.037	0.002	0.031	0.79
Garnet	-	-	0.2	0.28	0.277	0.04	0.014	0.811
Ilmenite	-	-	0.8	1.89	2.897	1.828	0.742	8.157
Limonite	3.33	3.29	0.3	0.01	-	-	-	6.93
Machine waste	-	0.52	-	-	-	-	-	0.52
Monazite-xenotime	-	-	0.05	0.05	0.18	0.121	0.036	0.437
Rutile	-	-	-	0.05	0.03	0.013	0.011	0.104
Siderite	-	-	-	0.23	0.089	0.02	0.003	0.342
Spinel	-	-	-	-	0.02	0.07	0.03	0.12
Topaz	0.11	0.33	0.5	0.04	0.03	0.01	-	1.02
Tourmaline	0.3	0.33	0.34	0.04	0.08	0.011	0.004	1.105
Wolframite	-	-	-	-	0.03	-	-	0.03
Zircon	-	-	-	-	0.15	0.408	0.481	1.039

3.3.4 Lun Seng Mine (sample no. 12 in the sampling location map).

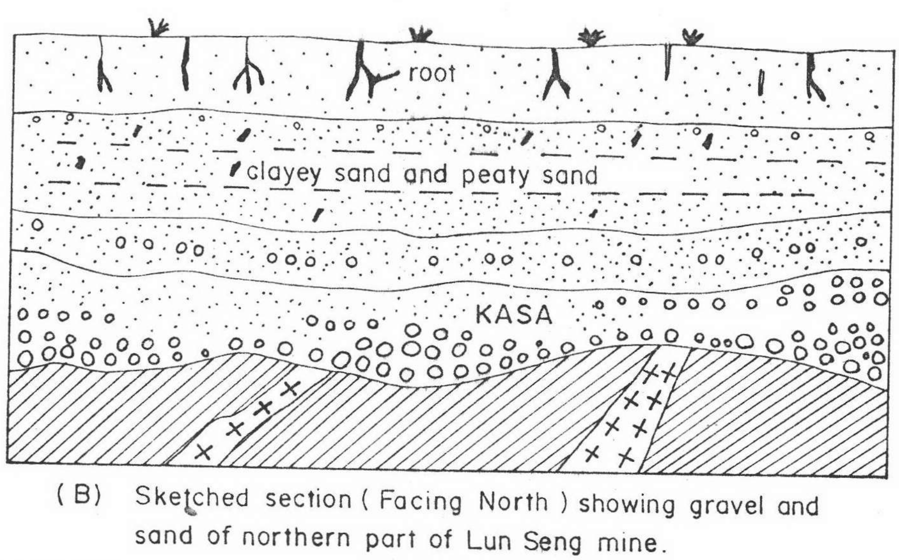
(a) Geology

This mine is situated in alluvium and coastal plain deposits. The mine is floored with highly weathered equigranular medium- to coarse-grained biotite granite and the sedimentary rocks of Phuket Group which are heavily fractured. The bedding plane of the sedimentary rocks is oriented in the NE direction, and dipping to the east. The joint set in granite is oriented in the NS direction, dipping to the west. Those open joints are infilled by gravels. The joint in the sedimentary rocks is oriented in the NW direction, dipping to the east.

The base of the succession of this mine is gravel bed composing of large quartz, micaceous sandstone varying in size from 1-13 centimetres with poor sorting. The upper part of this gravel bed is composed of quartz, pebbles of the sedimentary rocks of Phuket Group with size range of 0.2-1.2 centimetres, and the matrix of clay, sand with moderately sorting. The pebbles of the gravel bed are relatively less abundant in the upper most part. This gravel bed is 1.2 metres thick. The overlying layer is clayey sand and peaty sand. The thickness is about 2.5 metres, with some gravels in the upper most part of this layer. The top of the succession is sandy clay with peat, root, peaty sand, and humic sand. The thickness is about 2.5 metres (Fig. 3.3.4 B). The enrichment of the peat and humic products are due to the very poor drainage condition in the soils which are prevailing in the coastal plain. The absence of the reddish colour in the sediment succession which is assoicated with tropical weathering, make it likely that wide-spread reworking and erosion have occurred. Moreover, burrows found in the bed rocks indicate the existing of marine conditions prior



(A) Sketched columnar sections of southern and northern parts of Lun Seng mine. (prepared on Dec 27, 1983)



(B) Sketched section (Facing North) showing gravel and sand of northern part of Lun Seng mine.

Figure 3.3.4 Sketched columnar sections and geological cross-section of Lun Seng mine.

to the deposition of gravel bed. The environment of deposition of this deposit is swampy coastal plain and tidal flat (Kruse, 1982).

The sketched columnar section of this mine showing gravel bed and overburden related to bed rocks from southern and northern part of this mine is shown in Figure 3.3.4 A.

The general sketched section showing gravel bed and overburden of this mine is show in Figure 3.3.4 B.

(b) Heavy mineral association

The only principal ore mineral is cassiterite.

The associated minerals are ilmenite, altered pyrite, tourmaline, leucoxene, pyrite, garnet, zircon, topaz, rutile, monazite, xenotime, limonite, spinel, Fe-oxide, columbite-tantalite, manganese oxide, and struverite.

The abundance of each heavy mineral in this mine is illustrated in the pie diagram (Fig. 3.3.4 b). Besides, the characteristics and the assemblages of heavy minerals from Lun Seng mine are summarized and presented in Table 3.4.1 and 3.4.2 II.

(c) Heavy mineral distribution

The heavy minerals in this mine are most abundant in the fine sand (2.5 ø) fraction.

The abundance of heavy minerals in each size fraction will be discussed in detail in chapter IV. However, the data on the degree of abundance of each heavy mineral with respect to grain size are summarized in Table 3.3.4 c.

Cassiterite is most abundant in the fine sand (2.5 ø) fraction.

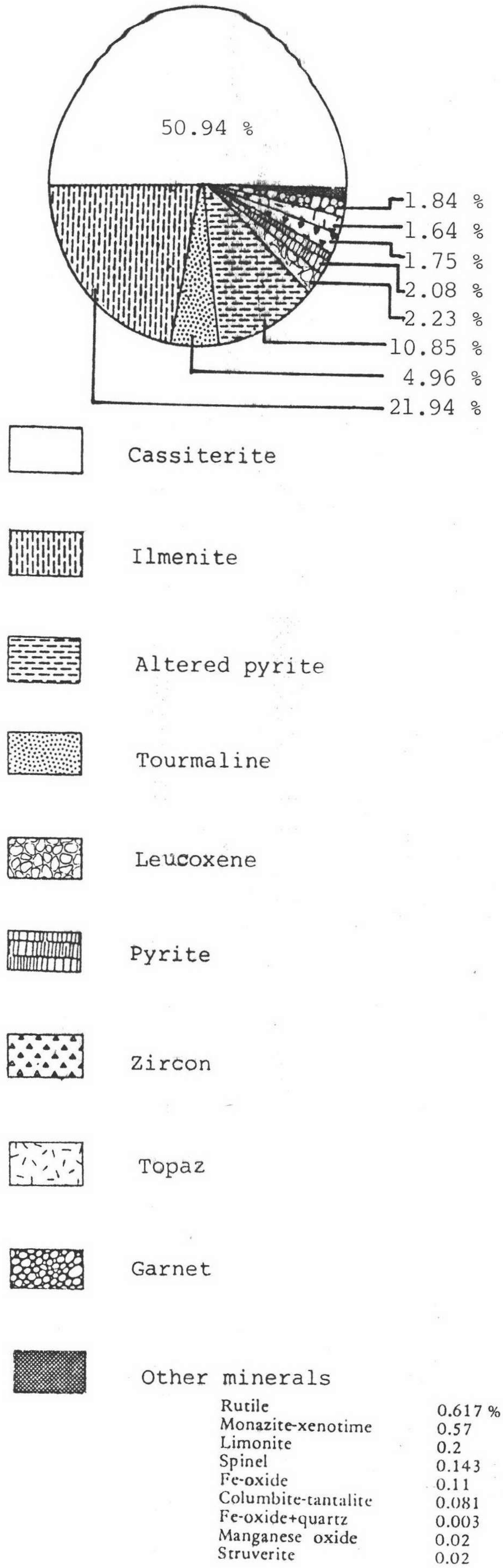


Figure 3.3.4b Pie diagram illustrating the abundance of each heavy mineral of Lun Seng Mine.

Table 3.3.4c The degree of abundance of heavy minerals with respect to grain size of Lun Seng mine.

Mineral name	Weight percentages of heavy minerals in different size fraction							Total weight percentages
	10mesh	20mesh	40mesh	60mesh	80mesh	100mesh	-100mesh	
Altered pyrite	-	1.14	3.07	0.99	3.73	1.87	0.05	10.85
Cassiterite	-	0.64	2.442	11.51	17.29	11.36	7.7	50.942
Columbite-tan-talite	-	-	0.081	-	-	-	-	0.081
Fe-oxide	-	0.07	-	-	0.04	-	-	0.11
Fe-oxide+Quartz	-	-	0.003	-	-	-	-	0.003
Garnet	-	0.01	0.062	1.43	0.23	0.09	0.02	1.842
Ilmenite	-	-	0.577	2.82	9.32	6.78	2.44	21.937
Leucoxene	-	-	0.844	1.39	-	-	-	2.234
Limonite	0.2	-	-	-	-	-	-	0.2
Manganese oxide	-	0.02	-	-	-	-	-	0.02
Monazite-xenotime	-	-	-	0.03	0.2	0.33	0.01	0.57
Pyrite	-	-	0.07	0.53	-	-	1.48	2.08
Rutile	-	-	0.15	0.06	0.2	0.2	0.007	0.617
Spinel	-	-	-	-	-	0.11	0.033	0.143
Struverite	-	-	-	-	-	0.02	-	0.02
Topaz	-	0.15	0.799	0.2	0.36	0.13	-	1.639
Tourmaline	-	0.26	2.042	1.4	1.13	0.06	0.07	4.962
Zircon	-	-	-	0.03	0.33	0.62	0.77	1.75

Some other economic minerals, such as, columbite-tantalite are present only in the medium sand (1.25 ø) fraction, whereas struverite is present only in the fine sand (2.75 ø) fraction.

3.3.5 V.I.P. Mine (sample no. 13 in the sampling location map)

(a) Geology

This mine is situated at the foot slope of Khao Sapam,(The local name is Khao Kao) which is the fine-to medium-grained biotite muscovite granite locally porphyritic. Quartz veins and quartz gashed veins intruded along the fractures of granite. They are oriented in NE to NW directions, dipping to the east. The thickness is about 0.1-0.3 centimetre. There are some wolframite in these quartz veins. These quartz are white to yellow fawn, dense, and show some Fe-oxide stain. The granite in the vicinity of this mine is composed of quartz, potash feldspar, plagioclase, muscovite, biotite, and highly weathered. The common accessory minerals are mainly tourmaline, garnet, pyrite, and arsenopyrite. Greisen is the typical characteristics of this granite, particularly the mineralized granite at this locality. It is manifested by the decomposition of feldspar and biotite and by the formation of quartz, mica, and some fluorite.

The greisen is suggested by Hosking (1967, 1969) to be probably formed by pneumatolitic alteration of granite in the roof zone of the intrusion during the final stage of the magma crystallization. Along the contact zone between the quartz veins and quartz gashed veins, the granite is altered and contain some cassiterite.

The colluvial deposit overlying the granitic rocks is composed of fine silt, clay, lateritic soil with pebbles of quartz,

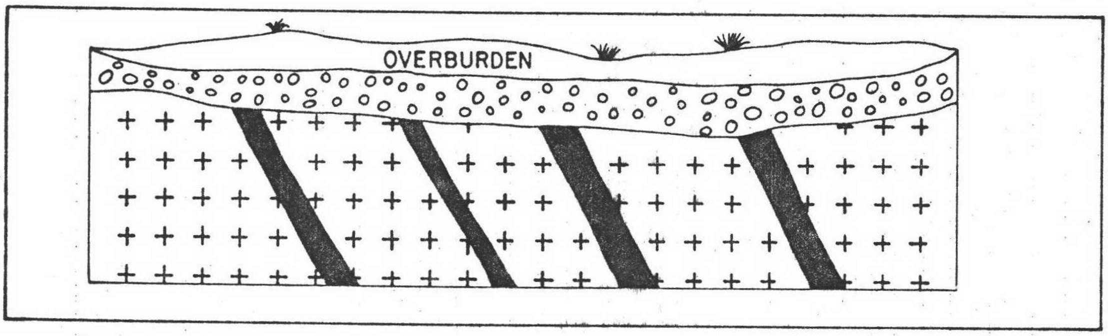


Figure 3.3.5 General sketched section(Facing west) showing the relation between wolframite – bearing quartz veins with granite and upper unconsolidated rock (V.I.P. mine)

granite, sandstone, shale, mudstone. The tin content in gravel bed is low and there are some quartz veins cut across this bed.

The general sketched section of this mine is shown in Figure 3.3.5.

(b) Heavy mineral association

The principal ore minerals are cassiterite including cassiterite interlocking with quartz,wolframite, and wolframite interlocking with quartz.

The associated heavy minerals are tourmaline, struverite, rutile, monazite, xenotime, muscovite, zircon, Fe-oxide, and spinel.

The abundance of each heavy mineral in this mine is illustrated in the pie diagram (Fig. 3.3.5 b). Besides, the characteristics and assemblages of heavy minerals from V.I.P. mine are summarized and presented in Table 3.4.1 and 3.4.2 II.

(c) Heavy mineral distribution

The heavy minerals in this mine are most abundant in the very coarse to coarse sand (-1.0 ø - 0.5 ø) fraction.

The abundance of heavy minerals in each size fraction will be discussed in detail in chapter IV. However, the data on the degree of abundance of each heavy mineral with respect to grain size are summarized in Table 3.3.5 d.

Cassiterite is most abundant in the coarse sand (0.5 ø) fraction.

Some other economic minerals, such as, wolframite is distributed in every grain size fraction and most abundant in the

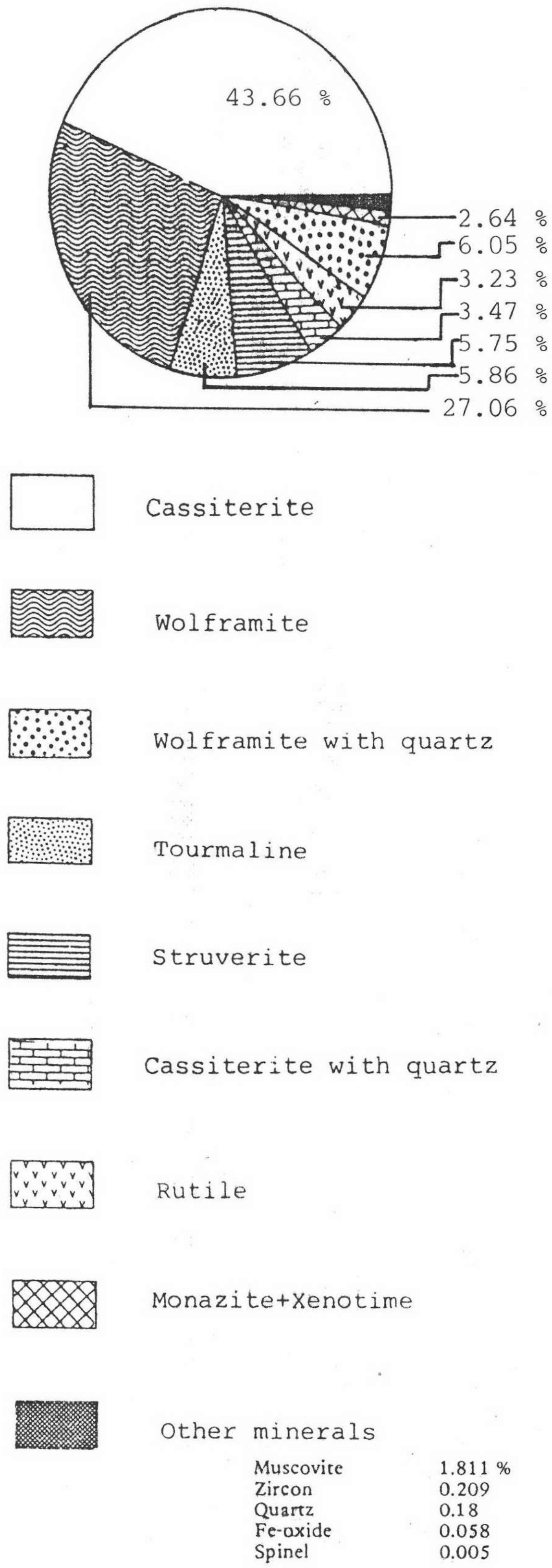


Figure 3.3.5b Pie diagram illustrating the abundance of each heavy mineral of V.I.P. Mine.

Table 3.3.5c The degree of abundance of heavy mineral with respect to grain size of V.I.P. mine.

Mineral name	Weight percentages of heavy minerals in different size fraction							Total weight percentages
	10mesh	20mesh	40mesh	60mesh	80mesh	100mesh	-100mesh	
Cassiterite	5.02	13.73	9.84	4.92	4.218	2.808	3.126	43.662
Cassiterite with quartz	3.47	-	-	-	-	-	-	3.47
Fe-oxide	-	-	0.05	-	0.008	-	-	0.058
Monazite-xenotime	-	-	0.1	0.45	0.63	0.793	0.666	2.639
Muscovite	-	-	0.57	0.48	0.58	0.119	0.062	1.811
Quartz	-	0.01	0.1	-	0.07	-	-	0.18
Rutile	-	-	0.17	0.9	1.77	0.29	0.1	3.23
Spinel	-	-	-	-	-	-	0.005	0.005
Struverite	-	-	-	1.15	2.72	1.48	0.402	5.752
Tourmaline	-	-	1.1	0.99	1.764	1.02	0.994	5.868
Wolframite	8.87	9.38	4.21	2.59	1.27	0.48	0.266	27.066
Wolframite with quartz	6.05	-	-	-	-	-	-	6.05
Zircon	-	-	-	0.02	-	0.02	0.169	0.209

coarse sand (0.5 ø) fraction, whereas struverite is present in the medium to very fine sand (2.0 ø to more than 2.75 ø) fraction and most abundant in the fine sand (2.5 ø) fraction.

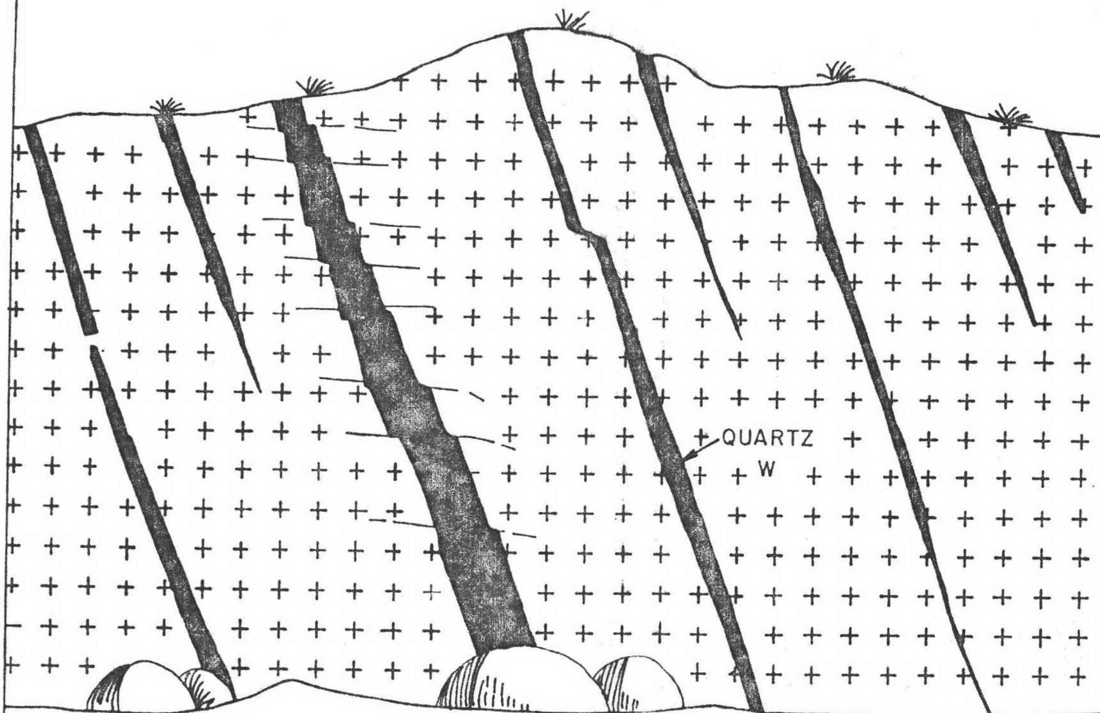
3.3.6 Sahakit Mine (sample no. 14 in the sampling location map)

(a) Geology

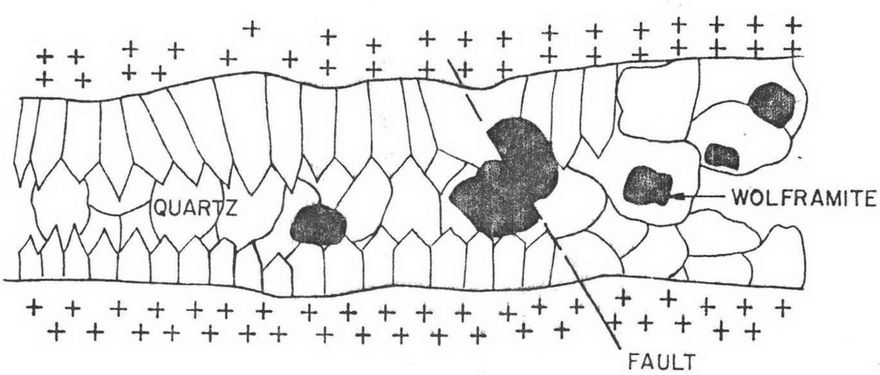
This mine is situated adjacent to V.I.P. mine at the slope of Khao Sapam. The rock in this locality is fine-to medium-grained tourmaline-muscovite granite. The rocks are composed mainly of quartz, potash feldspar, plagioclase, muscovite, tourmaline, and highly weathered. The accessory minerals are garnet, pyrite, arsenopyrite. The fractures are developed in both granite and quartz veins. The attitude of these fractures are NW direction, dipping to the northeast, Quartz veins and quartz gashed veins orientating in NE direction, dipping to the northwest cut across the granitic rocks. The wolframite-bearing quartz vein is milky with sugary texture. The NW fault cuts across this quartz vein (Fig. 3.3.6 B).

Some cassiterite disseminated in altered granite particularly at the contact zone with quartz and aplite. Aplitic vein is in the NE trend and is rather resistant with relative to the granitic host. Greisenization developed along the contact zone of quartz, aplite and granite. There are some xenoliths of altered granite in quartz veins. This type of deposit is pneumatolitic/hydrothermal origin with greisenization.

The colluvial deposit is located on some places in this mine. The gravel beds are composed of pebbles and boulders of granite, hornfels, and quartz in various colours.



(A) Sketched geological cross-section (Facing East) showing the typical wolframite – bearing quartzs, cutting in tourmaline muscovite granite, Sahakit mine.



(B) Sketched section (Facing North) of typical wolframite in a quartz vein, cutting tourmaline muscovite granite at Sahakit mine.

Figure 3.3.6 Sketched geological cross-section and sketched section of typical wolframite in quartz vein of Sahakit mine.

The sketched section showing the wolframite-bearing quartz cut across the granite is illustrated in Figure 3.3.6 A.

(b) Heavy mineral association

The principal ore mineral is cassiterite including cassiterite interlocking with quartz.

The associated minerals are tourmaline, mica, Fe-oxide, limonite, zircon, quartz interlocking with muscovite and feldspar, pyrite, manganese oxide, garnet, arsenopyrite, hematite, magnetite, ilmenite, and wolframite.

The abundance of each heavy mineral in this mine is illustrated in the pie diagram (Fig. 3.3.6 b). Besides, the characteristics and assemblages of heavy minerals from Sahakit mine are summarized and presented in Table 3.4.1 and 3.4.2 II.

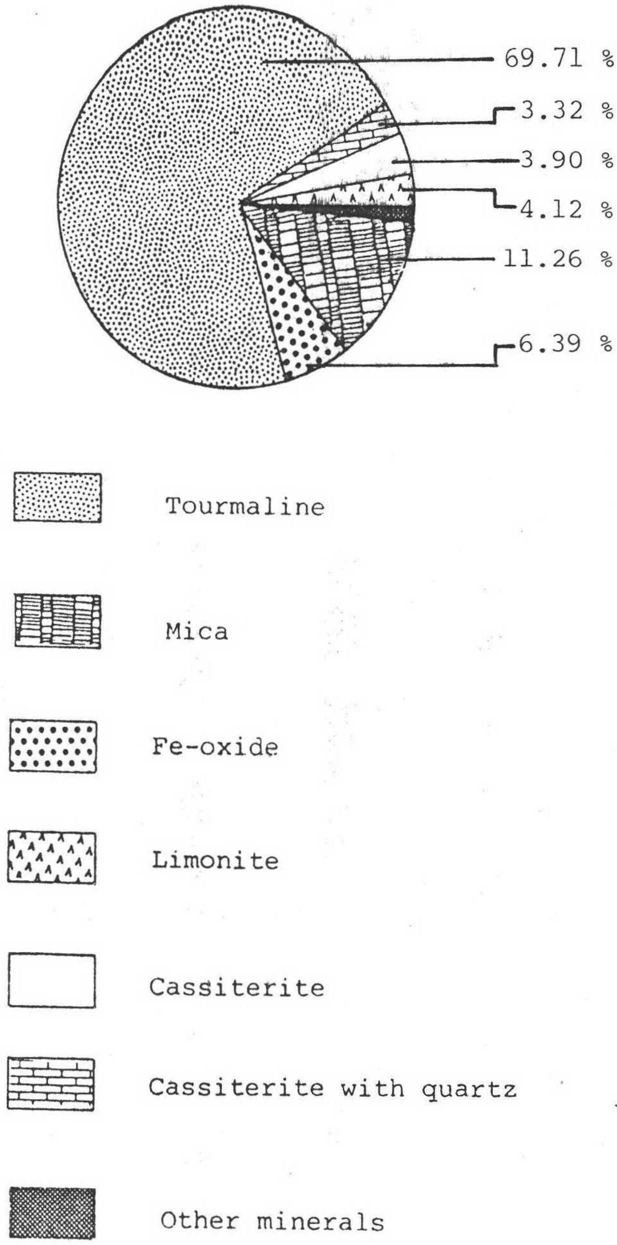
(c) Heavy mineral distribution

The heavy minerals in this mine are most abundant in the fine sand (2.5 ø) fraction.

The abundance of heavy mineral in each size fraction will be discussed in detail in chapter IV. However, the data on the degree of abundance of each heavy mineral with respect to grain size are summarized in Table 3.3.6 c.

Cassiterite is most abundant in the very fine sand (more than 2.75 ø) fraction.

Other economic mineral, such as, wolframite is present in small amount in the fine to very fine sand (2.75 ø to more than 2.75 ø) fraction.



Zircon	0.317
Monazite-xenotime	0.297
Scheelite	0.257
Pyrite	0.174
Machine waste	0.171
Manganese oxide	0.16
Quartz	0.123
Rutile	0.092
Quartz+Feldspar	0.09
Arsenopyrite	0.06
Muscovite+quartz	0.05
Garnet	0.04
Hematite	0.02
Magnetite	0.01
Quartz+Ilmenite	0.01
Fluorite	0.003
Ilmenite	0.005

Figure 3.3.6b Pie diagram illustrating the abundance of each heavy mineral of Sahakit Mine.

Table 3.3.6c The degree of abundance of heavy minerals with respect to grain size of Sahakit mine.

Mineral name	Weight percentages of heavy minerals in different size fraction							Total weight percentages
	10mesh	20mesh	40mesh	60mesh	80mesh	100mesh	-100mesh	
Arsenopyrite	-	0.03	0.03	-	-	-	-	0.06
Cassiterite	-	0.915	-	0.35	0.25	0.287	2.098	3.9
Cassiterite with quartz	-	-	2.2	0.12	-	-	-	2.32
Fe-oxide	-	-	-	1.09	4.03	0.63	0.643	6.393
Feldspar	-	-	-	-	-	0.028	0.388	0.416
Fluorite	-	-	-	-	-	0.003	-	0.003
Garnet	-	-	0.04	-	-	-	-	0.04
Hematite	-	-	-	0.02	-	-	-	0.02
Ilmenite	-	0.005	-	-	-	-	-	0.005
Limonite	0.03	0.254	3.84	-	-	-	-	4.124
Machine waste	-	0.021	0.15	-	-	-	-	0.171
Magnetite	-	-	-	0.01	-	-	-	0.01
Manganese oxide	-	0.12	-	-	0.04	-	-	0.16
Mica	-	0.01	0.59	4.67	5.37	0.365	0.255	11.26
Monazite-xenotime	-	-	-	-	0.12	0.017	0,16	0.297
Pyrite	-	-	-	0.1	0.02	0.026	0.028	0.174
Quartz	-	0.003	0.12	-	-	-	-	0.123
Quartz+Feldspar+ Muscovite	0.09	-	-	-	-	-	-	0.09
Quartz+Ilmenite	-	0.01	-	-	-	-	-	0.01
Rutile	-	0.082	-	-	0.01	-	-	0.092
Scheelite	-	-	0.02	0.1	-	-	0.137	0.257
Tourmaline	-	0.01	9.31	23.11	23.9	8.84	4.538	69.708
Wolframite	-	-	-	-	-	0.04	0.01	0.05
Zircon	-	-	-	0.18	-	0.004	0.133	0.317

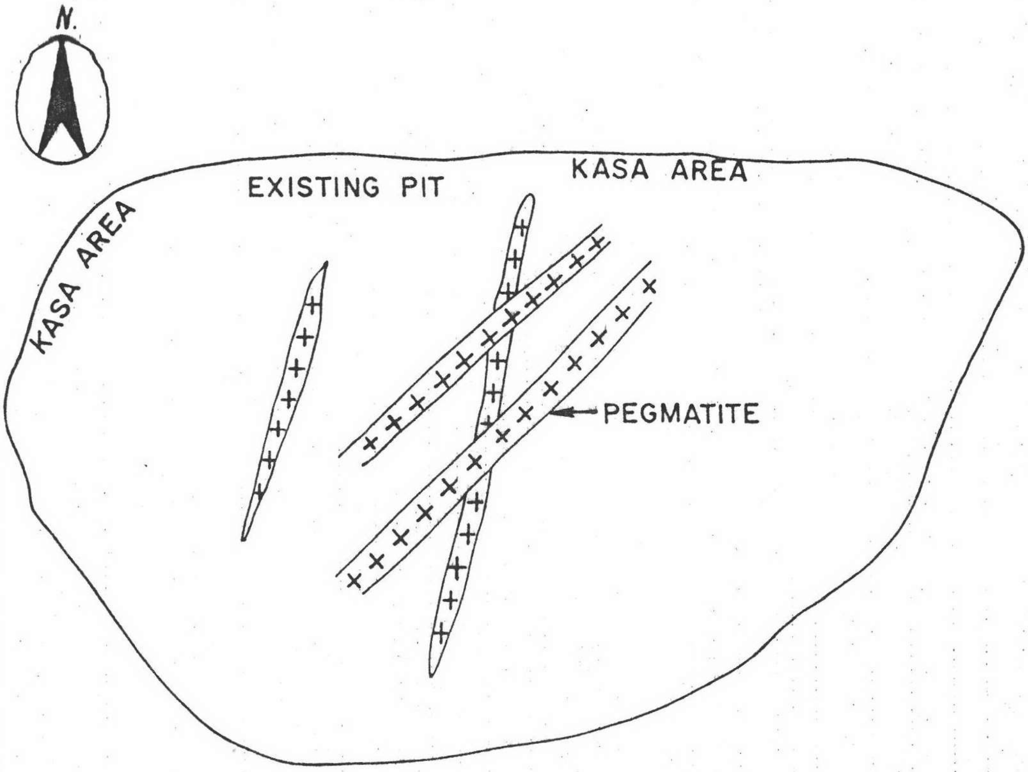
3.3.7 Chao Fah Mine (sample no. 15 in the sampling location map).

(a) Geology

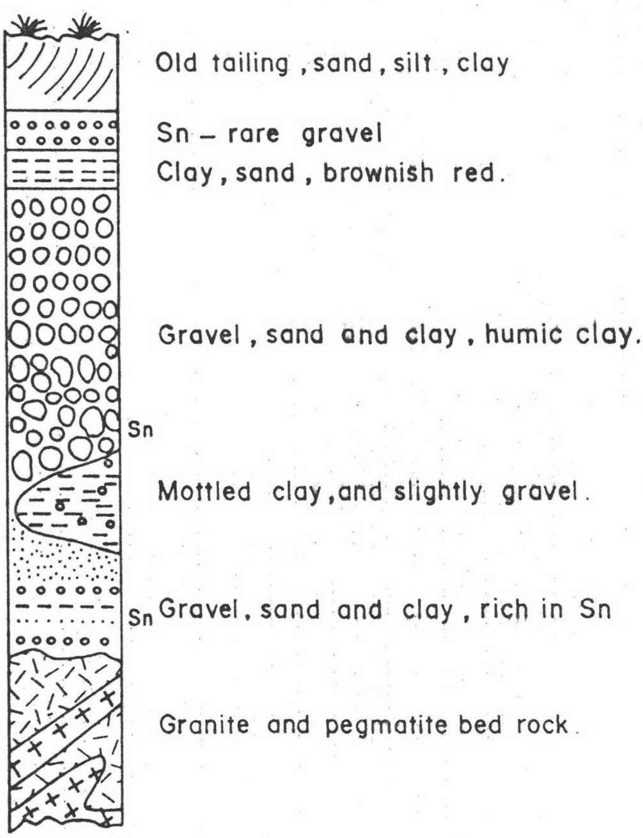
The mine is situated at the eastern part of Khao Nakha and floored with coarse-grained porphyritic biotite granite which is resemble to Pol Thavee mine. The coarse-grained biotite granite is composed of quartz, potash feldspar, and some mafic minerals. This granite is generally weathered and highly kaolinized. The joint set developed in this granite is oriented in NE to SE directions.

The type of deposit in this mine are colluvium and pegmatite. The pegmatites are quartz-feldspar-muscovite pegmatite orientating in NE to NS directions. Quartz vein in NE direction is associated with these pegmatites. The NE trending quartz-feldspar-muscovite pegmatite is composed of quartz, feldspar, minor amount of muscovite, and highly kaolinized. The thickness is about 0.5-1 metre. The NS trending quartz-feldspar-musvocite pegmatite is composed of fine- to medium-grained quartz, feldspar, tourmaline, muscovite, and slightly kaolinized. The thickness is about 0.5-10 centimetres. The NE trending pegmatites cut across the NS trending pegmatites (Fig. 3.3.7 A). All of these pegmatites are the tin-barren ones. The sketch enlargement showing the orientation of pegmatites is shown in Figure 3.3.7 A.

For the colluvial deposit, the upper most part is old tailings of sand, silt, clay mixtures. The thickness is about 1 metre. Underlying the tailing is tin-barren gravel bed composing of only quartz. The thickness is about 0.5 metre. Further below is brownish-red clayey sand. The thickness is about 0.5 metre. The bottom part of the succession is tin-bearing consolidated gravel bed with sand, clay, and humic clay matrix intercalated with gravelly mottled



(A) Sketch enlargement showing the orientation of pegmatite and kasa area, Chao Fa mine (prepared on Dec 28, 1983)



(B) Sketched columnar section of gravel (kasa) in northern and western flank of Chao Fa mine (prepared Dec 28, 1983)

Figure 3.3.7 Sketch enlargement showing the orientation of pegmatite and kasa and sketched columnar section of Kasa in Chao Fa mine.

clay. The bottom part is well sorted, whereas the upper part is moderately sorted and the roundness is subangular. The tin-bearing gravel bed is composed of the pebbles of quartz, greywacke, sandstone, granite, pegmatite varying in size from 2-25 centimetres. The base of this succession is granite bed rocks associated with pegmatites. The general columnar section of the gravel bed is shown in Figure 3.3.7 B. The environment of deposition in this mine is probably channel deposit with some influence of tidal flat environment.

(b) Heavy mineral association

The only principal ore mineral is cassiterite.

The associated minerals are ilmenite, tourmaline, garnet, monazite, xenotime, Fe-oxide, zircon, rutile, spinel, and columbite-tantalite.

The abundance of each heavy mineral in this mine is illustrated in the pie diagram (Fig. 3.3.7 b). Besides, the characteristics and assemblages of heavy minerals from Chao Fah mine are summarized and presented in Table 3.4.1 and 3.4.2 II.

(c) Heavy mineral distribution

The heavy mineral in this mine are most abundant in the medium sand (1.25 ø) fraction.

The abundance of heavy minerals in each size fraction will be discussed in detail in chapter IV. However, the data on the degree of abundance of each heavy mineral with respect to grain size are summarized in Table 3.3.7 c.

Cassiterite is most abundant in the coarse sand (0.5 ø) fraction.

Other economic mineral, such as, columbite -

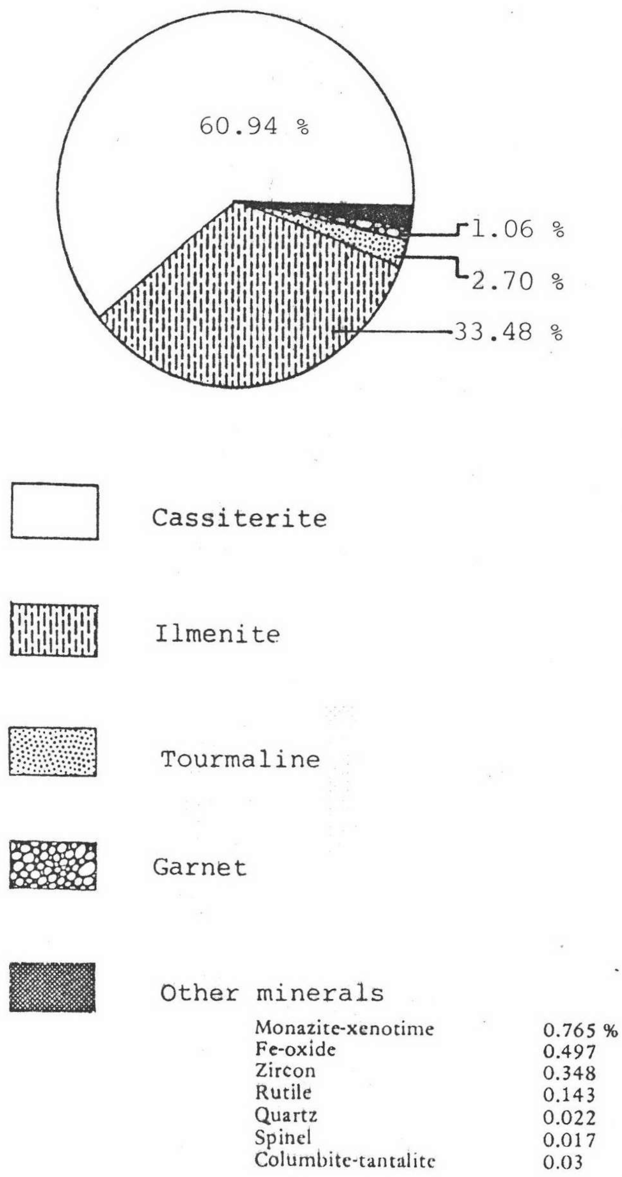


Figure 3.3.7b Pie diagram illustrating the abundance of each heavy mineral of Chao Fah Mine.

Table 3.3.7c The degree of abundance of heavy minerals with respect to grain size of Chao Fah mine.

Mineral name	Weight percentages of heavy minerals in different size fraction							Total weight percentages
	10mesh	20mesh	40mesh	60mesh	80mesh	100mesh	-100mesh	
Cassiterite	22.34	23.07	7.78	4.89	1.902	0.485	0.475	60.942
Columbite-tantalite	-	-	-	-	0.02	-	0.01	0.03
Fe-oxide	0.06	0.07	0.04	0.21	0.09	0.016	0.011	0.497
Garnet	-	-	0.05	0.79	0.2	0.018	0.001	1.059
Ilmenite	0.08	0.4	7.49	16.19	6.92	1.578	0.818	33.476
Monazite-xenotime	-	-	0.02	0.32	0.24	0.114	0.071	0.765
Quartz	-	-	0.02	-	0.002	-	-	0.022
Rutile	-	-	0.07	-	0.047	0.006	0.02	0.143
Spinel	-	-	-	-	0.007	-	0.01	0.017
Tourmaline	-	0.25	1.41	0.93	0.09	0.011	0.01	2.701
Zircon	-	-	-	0.08	0.062	0.032	0.174	0.348

tantalite are present in the fine sand and very fine sand (2.5 ∅ and more than 2.75 ∅) fraction.

3.4 Heavy Mineral Characteristics

The microscopic determination of 8 samples within the Kathu Valley as well as 7 samples outside the Valley has been made in order to study the physical and optical properties of all heavy minerals present. These properties include optical characteristics and physical characteristics, namely, colour, grain habit, magnetic susceptibility, alterations, grain size, and roundness.

The characteristics of altogether 27 heavy minerals are summarized and presented in Table 3.4.1.

Besides, additional attempt has been made to describe the genesis, principal ore minerals, and associated heavy minerals of each sampling location both inside and outside Kathu Valley under the present study. Data and information regarding this matter are summarized and presented in Table 3.4.2. I and 3.4.2 II.

Table 3.4.1 Brief description of heavy mineral characteristics and their genesis.

Origin / Mineral	Pegmatite: Colour	Pegmatite: Grain habit	Pegmatite: Most abundant size	Pegmatite: degree of abundance (locality of occurrence)	Surficial Deposit: Colour	Surficial Deposit: Grain habit	Surficial Deposit: Most abundant size	Surficial Deposit: degree of abundance (locality of occurrence)	Pneumatolitic/Hydrothermal: Colour	Pneumatolitic/Hydrothermal: Grain habit	Pneumatolitic/Hydrothermal: Most abundance size	Pneumatolitic/Hydrothermal: degree of abundance (locality of occurrence	Magnetic susceptibility
Allanite	black, brown	irregular grains, colour and physical properties vary in the same grain	medium sand	—(1), —(2), —(3) x(4), —(5), —(7) —(8), —(10)					—	—	—	—	(w) magnetic
Altered pyrite	—	—	—	—	grey to greyish black, greenish brown	botryoidal-prismatic, cylindrical shape, irregular aggregate	medium, fine sand	—(6), —(9) —(11), C(12), —(15)	—	—	—	—	(w) magnetic
Apatite	white to light brown	prismatic, thick tabular, oval shape	medium sand	—(1), x(2), —(3) x(4), —(5), —(7) —(8), —(10)	light brown	oval shape	medium sand	—(6), —(9) x(11), —(12), —(15)	—	—	—	—	(p) nonmagnetic
Arsenopyrite	—	—	—	—	—	—	—	—	silver white to grey	subangular, prismatic, irregular grain	medium sand	—(13), x(14)	(p) nonmagnetic
Cassiterite	black, brown, brownish black, yellowish brown, brown, light grey	angular to subangular, irregular blotchy grain, bipyramid, prismatic crystal	very coarse to medium sand	A(1), D(2), F(3), F(4), F(5), D(7), A(8), F(10)	black, brownish block, brown, honey, orange, pale pink, purple, reddish brown, yellow, light grey	subround to round, water worn, remnant of bipyramidal crystal, bipyramidal crystal and irregular grains are not common	medium to fine sand	D(6), F(9) F(11), D(12), D(15)	light brown, brownish black, colorless, grey, light grey, light yellow, pale pink	distorted bipyramidal and columnar crystal, angular to subangular, irregular grain	coarse, very fine sand	A(13), R(14)	(p) nonmagnetic
Cassiterite with Fe-oxide manganese and quartz	black, dark brown	angular to subangular inclusion of Fe-oxide, manganese coat, and intergrowth with quartz	very coarse to coarse sand	C(1), R(2), R(3) R(4), R(5), C(7) A(8), R(10)	black to brownish black	subangular, irregular grain, inclusion of Fe-oxide, intergrowth with quartz	coarse sand	x(6), x(9) —(1), —(12), —(15)	light grey, light brown, brownish black	irregular blotchy grain, intergrowth crystal	very coarse, medium sand	R(13), R(14)	(p) nonmagnetic
Columbite-tantalite	black, iron black	short prismatic, thin blade tabular, featherly cleavage, broken crystal	medium to fine sand	x(1), x(2), —(3) —(4), x(5), x(7) —(8), x(10)	black	short prismatic crystal with feathery characteristics, tabular	medium sand	x(6), —(9) x(11), x(12), x(15)	—	—		—	(w) magnetic
Fluorite	—	—	—	—	orange	small octahedral, broken grain	very fine sand	—(6), x(9) —(11), —(12), —(15)	white	broken grain octahedral crystal	fine sand	—(13), x(14)	(p) nonmagnetic
Garnet	colorless, pink, reddish brown, light yellow, light brown	well rounded dodecahedron irregular grains with curve surfaces	coarse to medium sand	A(1), C(2), R(3) T(4), R(5), x(7) P(8), x(10)	colorless, light brown pale pink	well rounded grain, broken dodecahedron crystal	medium sand	C(6), x(9) x(11), R(12), R(15)	colorless, pale pink	subround, irregular grain with curve surface	medium sand	—(13), x(14)	(m,w) magnetic
Ilmenite	black, purplish black	thick tabular crystal, irregular grains, conchoidal fracture	medium sand	—(1), R(2), x(3) x(4), x(5), R(7) P(8), x(10)	black	tabular, euhedral crystal subrounded grains are common	medium to fine sand	R(6), —(9) P(11), C(12), A(15)	black	tabular crystal	coarse sand	—(13), R(14)	(m) magnetic
Manganese oxide	black, dull black	botryoidal powderly aggregate, massive	very coarse to medium sand	x(1), x(2), x(3) x(4), R(5), P(7) x(8), x(10)	—	—	—	—	—	—		—	(p) nonmagnetic
Mangan-tantalite	reddish brown, orange, brownish black, sometime translucent	tabular, rectangular prismatic crystal, irregular grain	coarse to medium sand	x(1), —(2), x(3) —(4), x(5), —(7) x(8), x(10)	—	—	—	—	—	—		—	(w) magnetic
Monazite-xenotime	light brown, pale green, orange, light yellow, yellowish brown, creamy white	tabular, prismatic with rounded termination, sometime exhibit good bipyramidal crystal	medium to fine sand	x(1), x(2), —(3) x(4), x(5), x(7) x(8), x(10)	bright green, lemon yellow, light brown, reddish brown, orange, creamy white	rounded crystal, prismatic crystal with rounded termination	fine sand	R(6), x(9) x(11), x(12), x(15)	yellow, yellowish brown, orange	prismatic crystal, bipyramidal crystal	fine to very fine	R(13), x(14)	(w) magnetic
Magnetite	—	—	—	—	black	subangular grain	very coarse sand	x(6), —(9) —(11), —(12), —(15)	black	angular grain	medium sand	—(13), x(14)	(h) magnetic)
Multiple oxide contain Cb-Ta	black, dull black, some Fe-oxide stain	subround to irregular grain short prismatic	medium sand	—(1), —(2), —(3) x(4), —(5), —(7) —(8), —(10)	black, dull black	prismatic crystal with some Fe-oxide stain	medium sand	—(6), x(9) —(11), —(12), —(15)				—	(w) magnetic
Pyrite	pale brass yellow	subangular, irregular grain	medium sand	—(1), —(2), —(3) —(4), —(5), —(7) —(8), x(10)	pale brass yellow	irregular grain, broken crystal	medium sand	—(6), —(9) —(11), R(12), —(15)	pale brass yellow	aggregate grain	medium sand	—(13), x(14)	(p) nonmagnetic
Rutile	black, dark brown, dark red	prismatic crystal	medium sand	—(1), x(2), x(3) —(4), x(5), x(7) x(8), x(10)	black, reddish brown, dark red	broken prismatic crystal	medium sand	x(6), x(9), x(11), x(12), x(15)	black	prismatic crystal	fine sand	—(13), x(14)	(p) nonmagnetic
Scheelite	—	—	—	—	—	—	—	—	white	irregular grain	medium sand	—(13), x(14)	(p) nonmagnetic
Siderite	—	—	—	—	brown, reddish brown, orange	oolitic, powderly aggregate, well rounded, spherulitic dumb bell shape	medium sand	—(6), x(9), x(11), —(12), —(15)	—	—	—	—	(m) magnetic
Spinel	Clove brown, greenish black, black, orange yellow	octahedral, irregular broken grain	fine to very fine grain	x(1), x(2), x(3) x(4), —(5), —(7) x(8), x(10)	yellow, orange, white	octahedral, minute broken octahedral crystal	fine to very fine sand	R(6), R(9) x(11), x(12), x(15)	black	octahedral crystal	very fine sand	x(13), —(14)	(p) nonmagnetic
Struverite	black	priomatic with irregular surface	fine sand	—(1), —(2), —(3) —(4), —(5), —(7) x(8), —(10)	black	prismatic with irregular surface	medium sand	x(6), x(9) —(11), x(12), —(15)	black, greenish black	prismatic, irregular grain	fine sand	C(13), —(14)	(w) magnetic
Topaz	colorless, milky white, light yellow	subangular to subrounded irregular broken grain	coarse to fine sand	R(1), —(2), P(3) R(4), —(5), x(7) x(8), x(10)	colorless, milky white light yellow	subround, irregular to ragged grain	coarse to medium sand	P(6), —(9) R(11), R(12), —(15)	—	—	—	—	(p) nonmagnetic
Tourmaline	black, brownish black	prismatic crystal	medium to fine sand	x(1), x(2), x(3) x(4), x(5), x(7) R(8), x(10)	black, brownish black, greenish black, light brown	prismatic with striation, broken grains are common	medium sand	R(6), R(9) x(11), x(12), R(15)	black, brown, light brown	short prismatic crystal, intergrowth with quartz	medium, fine sand	A(13), x(14)	(w) magnetic
Thorite	—	—		—	red to orange	short prismatic crystal with rectangular characteristics	fine sand	—(6), x(9) —(11), —(12), —(13)			—		(p) nonmagnetic
Wolframite	black	blade like crystal, tabular, prismatic	coarse, medium sand	R(1), R(2), —(3) x(4), x(5), —(7) —(8), —(10)	black	tabular crystal	fine sand	—(6), —(9) x(11), —(12), —(15)	black	tabular, prismatic crystal, intergrowth with quartz	medium, fine sand	A(13), x(14)	(m) magnetic
Zircon	colorless, pink, yellow, purple pink, reddish brown, translucent and earthy grains are light grey, creamy white	well round, short and long prismatic stubby crystal	fine to very fine sand	x(1), x(2), x(3) x(4), x(5), x(7) x(8), x(10)	colorless, pink, red, orange, white, yellow (translucent)	well round, long prismatic with rounded termination, stubby crystal	fine to very fine sand	R(6), R(19) R(11), R(12), x(15)	colorless, pink, orange, yellow, light yellow	short and long prismatic, well rounded grain are not common	medium, very fine sand	x(13), x(14)	(p) nonmagnetic

EXPLANATION

No. 1	Tor Soong Mine	No. 5	Pin Yoh Mine	No. 9	Sapayakorn Mine	No. 13	V.I.P. Mine
No. 2	Tantikowit Mine	No. 6	Kathu Mine	No. 10	Sinpatana Mine	No. 14	Sahakit Mine
No. 3	Pad Roi Mine	No. 7	Tung Tong Mine	No. 11	Sap Bangku Mine	No. 15	Chao Fah Mine
No. 4	Ban Nguan Mine	No. 8	Pol Thavee Mine	No. 12	Lun Seng Mine		

PERCENT

Flood (F)	75 - 100	Common (C)	10 - 25	Trace (X)	less than 1	(w) magnetic	weakly magnetic
Dominant (D)	50 - 75	Present (P)	5 - 10	(h) magnetic	highly magnetic	(p) nonmagnetic	practically nonmagnetic
Abundant (A)	25 - 50	Rare (R)	1 - 5	(m) magnetic	moderately magnetic		

Table 3.4.2 I Heavy mineral assemblages of samples obtained from eight tin-mines within Kathu Valley

Location	Genesis	Principal ore minerals	Associated mineral
Tor Soong Mine	Quartz-feldspar pegmatite	cassiterite, cassiterite interlocking with quartz, cassiterite with manganese coat, wolframite	garnet, topaz, tourmaline, zircon, columbite-tantalite, mangan-tantalite, monazite, xenotime, spinel, manganese oxide, and limonite
Tantikowit Mine	Tourmaline-muscovite pegmatite	cassiterite, cassiterite interlocking with quartz, cassiterite with manganese coat, wolframite	garnet, ilmenite, columbite-tantalite, tourmaline, rutile, zircon, spinel, monazite, xenotime, apatite, manganese oxide, and Fe-oxide
Pad Roi Mine	Tourmaline-muscovite pegmatite, lepidolite pegmatite, and quartz-muscovite pegmatite	cassiterite, cassiterite with manganese coat cassiterite interlocking with quartz	topaz, garnet, rutile, mangan-tantalite, zircon, tourmaline, spinel, manganese oxide, Fe-oxide, ilmenite, and leucoxene
Ban Nguan Mine	Lepidolite pegmatite, quartz-muscovite pegmatite, and quartz-feldspar pegmatite	cassiterite, cassiterite with manganese coat, cassiterite interlocking with quartz	topaz, Fe-oxide, garnet, tourmaline manganese oxide, limonite, zircon spinel, multiple oxide contain Nb-Ta, monazite, xenotime, allanite, apatite, and wolframite
Pin Yoh Mine	Muscovite pegmatite and quartz-feldspar-muscovite pegmatite	cassiterite, cassiterite with manganese coat, cassiterite interlocking with quartz	manganese oxide, garnet, ilmenite, columbite-tantalite, zircon, mangan-tantalite, tourmaline, monazite, xenotime, Fe-oxide, wolframite, and rutile
Kathu Mine	Reworked/ alluvium	cassiterite, cassiterite interlocking with quartz	garnet, topaz, zircon, ilmenite, spinel, limonite, monazite, xenotime, magnetite, tourmaline, rutile, columbite-tantalite, struverite, and Fe-oxide
Tung Tong Mine	Colluvium/ muscovite pegmatite	cassiterite, cassiterite with Fe-oxide inclusion, cassiterite interlocking with quartz, cassiterite with manganese coat	manganese oxide, ilmenite, columbite-tantalite, rutile, tourmaline, monazite, xenotime, garnet, zircon, Fe-oxide, topaz
Pol Thavee Mine	Quartz-feldspar-muscovite pegmatite and tourmaline-muscovite pegmatite	cassiterite, cassiterite with manganese coat	garnet, ilmenite, tourmaline, monazite, xenotime, zircon, mangan-tantalite, columbite-tantalite, rutile, manganese oxide, struverite, spinel, topaz

Table 3.4.2 II Heavy mineral assembalges of samples obtained from seven tin-mines outside Kathu Valley.

Location	Genesis	Principal ore minerals	Associated minerals
Sapayakorn Mine	Colluvium	cassiterite, cassiterite interlocking with quartz	ilmenite, zircon, spinel, tourmaline, rutile, struverite, Fe-oxide, siderite, garnet, monazite, xenotime, thorite, multiple oxide containing Nb-Tb and fluorite
Sinpatana Mine	Quartz-feldspar pegmatite	cassiterite, cassiterite interlocking with quartz	zircon, topaz, columbite-tantalite, garnet, mangan-tantalite, pyrite, manganese oxide, Fe-oxide, spinel, monazite, xenotime, tourmaline, ilmenite, and limonite
Sap Bangku Mine	Colluvium	cassiterite	ilmenite, limonite, tourmaline, topaz, zircon, garnet, Fe-oxide, monazite, xenotime, siderite, spinel, columbite-tantalite, rutile, and wolframite
Lun Seng Mine	Fluvial and marine deposit	cassiterite	ilmenite, altered pyrite, tourmaline, leucoxene, pyrite, garnet, zircon, topaz, rutile, monazite, xenotime, limonite, Fe-oxide, columbite-tantalite, manganese oxide, and struverite
V.I.P. Mine	Pneumatolitic/ hydrothermal	cassiterite, cassiterite interlocking with quartz, wolframite, wolframite interlocking with quartz	struverite, tourmaline, rutile, monazite, xenotime, muscovite, zircon, Fe-oxide, and spinel
Sahakit Mine	Pneumatolitic/ hydrothermal	cassiterite, cassiterite interlocking with quartz, wolframite	tourmaline, muscovite, Fe-oxide, limonite, zircon, monazite, xenotime, scheelite, pyrite, manganese oxide, magnetite, rutile, arsenopyrite, wolframite, garnet, hematite, ilmenite, and fluorite
Chao Fah Mine	colluvium	cassiterite	ilmenite, tourmaline, garnet, monazite, xenotime, Fe-oxide, zircon, rutile, spinel, and columbite-tantalite