

Some characteristics of the heavy detrital minerals from Peninsular Malaysia

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Abstract: Over a hundred samples of alluvial concentrates, taken from mines and streams that represent the various tinfields of Peninsular Malaysia have been examined. Concentrates from known pegmatitic areas show abundance of columbite-tantalite, the hydrothermal concentrates with a variety of minerals from sulphides to oxides and pyrometamorphic concentrates with magnetite. The form of individual mineral grains shows variation and they are also related to the types of tin deposit. Cassiterite in particular shows a variety of forms. In addition to the common tetragonal habit, pegmatitic cassiterite from Semiling and Bakri have peculiar shapes of i) squat bipyramid ii) wedge terminated prism and iii) rhombohedral pyramid-terminated prism. Wood-tin was found in the east coast tinfields. Characteristics of other detrital minerals are also discussed. These detrital mineral characteristics are useful guides that could be used to characterise the various tinfields of Peninsular Malaysia, in view of the difficulty in obtaining fresh primary ore samples due to the deep tropical weathering conditions.

Abstrak: Lebih daripada satu ratus sampel padat aluvium, yang diperolehi daripada lombong-lombong dan anak-anak sungai yang mewakili kawasan-kawasan timah Semenanjung Malaysia telah diteliti. Sampel padatan daripada kawasan pegmatit mengandungi kolumbit-tantalit, padatan hidrotermal mengandungi aneka mineral dari sulfida hingga oksida dan padatan pirometasoma pula mengandungi magnetit. Bentuk butiran mineral individu memperlihatkan kepelbagaian dan berkait rapat dengan jenis-jenis longgokan bijih timah. Kasiterit khususnya menunjukkan pelbagai bentuk. Selain daripada tabiat tetragonnya yang biasa, kasiterit pegmatit daripada Semiling dan Bakri mempunyai bentuk-bentuk yang aneh, iaitu i) dwipiramid cakah ii) prisma berhujung baji dan iii) prisma berhujung piramid rombus. Timah kayu di jumpai di kawasan timah pantai timur. Ciri-ciri mineral gersik lain juga dibincangkan, dan ciri-ciri tersebut berguna untuk mencirikan kawasan-kawasan timah Semenanjung Malaysia, memandangkan sampel bijih yang segar amat sukar diperolehi disebabkan oleh keadaan luluhawa tropika yang begitu mendalam.

INTRODUCTION

During the years 1979 and 1980, the writer collected geological samples, which included alluvial concentrates, for his doctoral project. These concentrates have been systematically examined, and the results of the examinations are presented in this paper.

MINERALOGICAL ASSOCIATIONS

The samples show distinct mineralogical associations which are related to the types of deposits predominant to the area. Typical associations are given in Table 1.

Pegmatitic Associations

Two types of associations are recognised from the Malaysian tin pegmatites, namely the Semiling-Bakri association and the Chenderiang association (Fig. 1). The Semiling-Bakri type contains abundant columbite-tantalite in addition to cassiterite. Also identified in small amounts were wodginite, fersmite, tapiolite, euxenite, and gahnite together with the normal rutile, monazite, xenotime, tourmaline, etc. Indeed, columbite-tantalite is a major by-product of the tin mining operations in Semiling and Bakri.

Between the Semiling and the Bakri pegmatites themselves, some mineralogical differences are noted. The Semiling samples are relatively rich in gahnite (Wan Fuad Hassan, 1985a), while the Bakri samples contain more varieties of the niobium-tantalum minerals, such as wodginite, fersmite, and tapiolite.

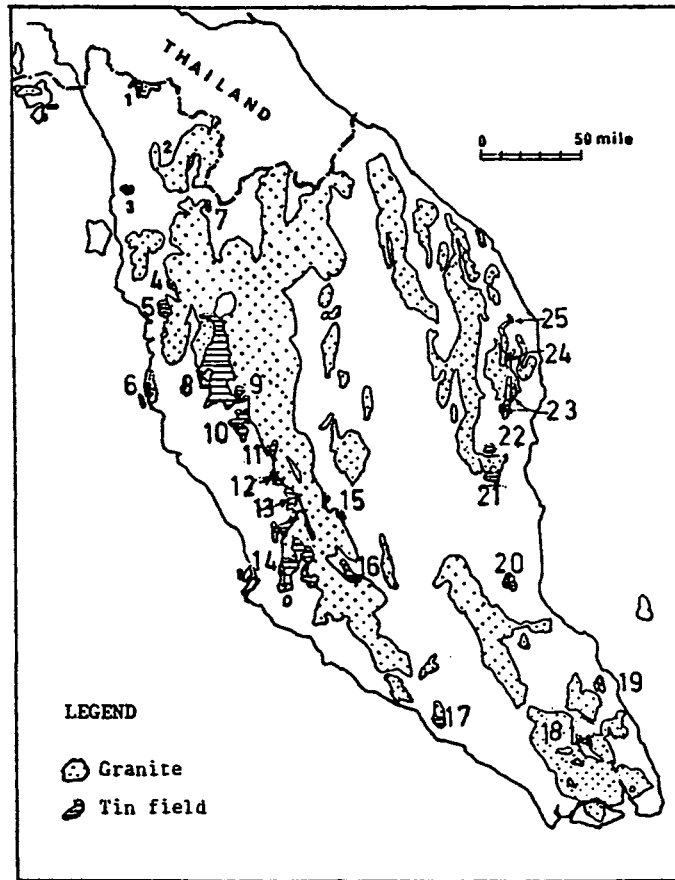
Chenderiang tin deposit was described as pegmatitic by Ingham and Bradford (1960). During the writer's visit to the area, the pegmatite outcrops are no longer available. Examination of the coarse amangs from the mines show the presence of coarse pebbles of tourmaline, struverite, cassiterite, topaz and quartz, which convinced the writer of their pegmatitic origin. A single quartz crystal observed has a diameter of about 10 cm.

Cassiterite is the dominant economic mineral. Columbite-tantalite, which is abundant in Semiling and Bakri, is notably rare in Chenderiang. Lepidolite, a lithium mica, is reported to occur in the pegmatite. The rarity of columbite-tantalite and the presence of topaz and lepidolite differentiate the Chenderiang pegmatite from the Bakri-Semiling type.

Hydrothermal Associations

Hydrothermal vein is the most common type of deposit in the Malaysian tinfields. The mineralogy of the detrital minerals associated with the veins varies; some are immensely rich in sulphides, while others contain oxides (Table 1).

Concentrates overlying the limestone in Puchong-Sungai Way areas are extremely rich in sulphides. This reflects the nature of the parent magma. Occurrences of sulphide-rich cassiterite pipes and veins were observed at Bylco Azira Mine and Ramuda Mine, Puchong. In the neighbouring mines, such as Seng Mine and Unitin Mine, similar mineralogy was observed.



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|------------------|-----------------------|----------------------|
| 1 Sintok | 11 Selim | 21 Gambang |
| 2 Baling | 12 Kelian-Kalumpang | 22 Sungei Lembing |
| 3 Semiling | 13 Serendah - Ulu Yam | 23 Bandi |
| 4 Selama | 14 Kuala Lumpur | 24 Bukit Tulis, Paka |
| 5 Taiping | 15 Bentong - Karak | 25 Bukit Besi |
| 6 Segari | 16 Titi | |
| 7 Klian Intan | 17 Bakri | |
| 8 Kinta Valley | 18 Pelepah Kanan | |
| 9 Chenderiang | 19 Jemaluang | |
| 10 Tapah - Bidor | 20 Bukit Payong | |

Figure 1 : Sketch map showing distribution of various tinfields in Peninsular Malaysia

Table 1: This table lists the important minerals easily identified from the various areas. There may be other minerals present, but they have not included due to identification difficulties.

PEGMATITIC ASSOCIATIONS	HYDROTHERMAL ASSOCIATIONS	PYROMETASOMATIC ASSOCIATION
<p><i>Slah Guan Mine, Bakri</i> ilmenite columbite-tantalite, allanite monazite, xenotime, gahnite cassiterite, zircon, euxenite (wodginite, fersmite, and tapiolite have been observed from nearby mines)</p> <p><i>Weng Fong Mine, Semiling</i> magnetite, ilmenite columbite-tantalite, garnet, xenotime, tourmaline, gahnite monazite (green and yellow), struverite cassiterite, pyrite, zircon, anatase</p> <p><i>Fook Wan Foh Mine, Chenderiang</i> magnetite ilmenite, columbite-tantalite (trace amount) monazite, xenotime, struverite, tourmaline cassiterite, pyrite, blue sapphire, anatase, rutile, zircon (coarse amang was rich in tourmaline and clear euhedral topaz)</p>	<p><i>Seng Mine, Puchong</i> ilmenite monazite, xenotime sphalerite, chalcopyrite, pyrite, pyrrhotite, galena jamesonite, stannite, stannoidite, tetrahedrite, enargite cassiterite, blue sapphire, zircon</p> <p><i>Unitin Mine, Puchong</i> ilmenite, garnet, tourmaline pyrite, arsenopyrite jamesonite, galena cassiterite, blue sapphire, zircon</p> <p><i>Yen Fong Mine, Bandi</i> ilmenite, magnetite monazite, xenotime, wolframite cassiterite, wood-tin, zircon, rutile, blue sapphire</p> <p><i>Galian Changlin, Air Putih</i> ilmenite wolframite, tourmaline cassiterite, wood-tin, zircon, blue sapphire</p> <p><i>Lian Pong Mine, Gambang</i> magnetite, ilmenite, garnet monazite, xenotime, allanite, gahnite, chromite cassiterite, zircon, blue sapphire, pyrite, anatase</p>	<p><i>Waterfall Mine, Pelepah Kanan</i> magnetite skarns: andradite, diopside, tremolite, axinite sulphides: chalcopyrite, pyrrhotite, arsenopyrite, pyrite cassiterite (downstream from this mine, the following minerals were observed) magnetite, ilmenite monazite, xenotime cassiterite, wood-tin</p>

The abundance of sulphide is also attributed to the nearness of the source material. In tropical climate, given enough time, all the unstable magmatic sulphides would have been weathered away. Examination of fresh detrital grains in polished sections show amongst others, the presence of galena, jamesonite, stannite, tetrahedrite enargite, and tetrahedrite. Stannite from this area can be further differentiated into stannite, *sensu stricto* and stannoidite (Wan Fuad Wan Hassan, 1984). Examination of cassiterite handspecimens show that they are of at least two types, viz., the normal brown variety and the glassy black variety. In weathered sulphides, normally the glassy black cassiterite stands out as it is not affected by weathering. A noticeable absence is struverite, for this mineral is never economically recovered from Puchong.

Common sulphides such as pyrite, arsenopyrite and chalcopyrite are ubiquitous and are found in almost all the tin veins in the country, but their abundance are nowhere comparable to those of Puchong.

Among the oxide minerals, wolframite is rather fragile and are not expected to survive in tropical alluvial concentrates. But surprisingly quite a number of concentrates show the presence of this mineral. In the Western Tin Belt, samples from Sintok and Tekka for example contain pebbles of wolframite, but in the Eastern Tin Belt, wolframite pebbles are more common.

A sample from Lian Pong Mine, Gambang contains wolframite, gahnite and chromite in addition to the common ilmenite, monazite, xenotime and zircon. Gahnite is not a common mineral in Malaysian alluvial concentrates; it has been observed only in association with the pegmatitic cassiterites in Semiling. Chromite is least expected, since there is no known ultrabasic rocks in the area.

Pyrometasomatic Associations

Two mines in the Eastern tin belt, Pelepah Kanan Mine and Bukit Besi Mine, have been classed as pyrometasomatic deposits (Hosking, 1973). Stream concentrates obtained downstream from the mines show the presence of common detrital minerals such as ilmenite, magnetite, rutile and cassiterite. The sulphides were presumably washed away by the severe tropical weathering. Magnetite has mostly been altered to hematite.

MINERALOGICAL CHARACTERISTICS

Cassiterite

Cassiterite, despite its simple looking character, shows important variations in forms, physics and in chemistry. Pegmatitic cassiterite is known to have the squat bipyramidal habit (Hosking, 1979) in addition to the usual tetragon. Such habit is noted in samples from the Semiling and the Bakri pegmatites. During

an examination of the concentrates from these two areas, the present writer found yet a new additional habit which apparently has not been described before. This new habit is an elongation along either the *a* or *b* axes producing either a prism with rhombohedral pyramidal termination or wedge-shaped termination. The writer has also examined some pegmatitic cassiterites from Bukulu Mine, Ruanda and noted the presence of a similar habit. Struverite, a Ta-Nb rutile and belonging to similar tetragonal system also display such similar character.

Cassiterite from Bandi, Terengganu, in the east coast is mostly fine-grained. The writer on a number of visits to the Chye Heng Loong Mine and Hong Yong Fah Mine failed to find a good hand specimen with reasonably coarse cassiterite crystals. An examination of the cleaned concentrates from Hong Yong Fah Mine shows that most of the cassiterites are fine-grained and light yellow in colour. Some coarse-grained dark brown variety was also present but it constitutes only a small fraction.

The Sungai Lembing cassiterite similarly shows two size ranges, i.e. the fine and the coarse though the coarse variety is predominant. This probably reflects that the cassiterites were introduced into the veins in more than one episode. The earlier cassiterite which is less abundant is relatively coarse-grained and dark brown in colour while the latter cassiterite is pale yellow and fine-grained.

Cassiterite which is usually nonmagnetic also shows variation in magnetic properties. Those in Sungai Lembing mine were separated into the magnetic fraction due to the presence of chlorite (Hosking and Yeap, 1977). A small proportion of the Semiling and Bakri pegmatitic cassiterite is magnetic and is described by Bradford (1972) as paramagnetic. Paramagnetic cassiterite is permanently magnetic, as opposed to ferromagnetic cassiterite, which is temporarily magnetic and easily destroyed by heat. The present writer have examined the paramagnetic cassiterite (Wan Fuad Wan Hassan, 1982) and found that among others, the magnetism is due to the presence of foreign magnetic minerals, such as columbite-tantalite, magnetite and ilmenite either as inclusions or as exsolved bodies. Cassiterites from Gambang, Sungai Besi, and Pelepah Kanan, which are not at all associated with any pegmatite, are also magnetic to a certain degree. Magnetism in cassiterite is known as ferromagnetism. Cassiterite with such magnetism is usually black in colour. During a magnetic separation such cassiterite is usually lost because it tends to go together with the ilmenite. The seriousness of the loss of this magnetic cassiterite is seen in a mine in Gambang, Pahang, where the writer observed a sizeable dump of black magnetic cassiterite was being thrown out, presumably mistaking it for the non-valuable ilmenite. An examination of polished sections of this cassiterite under an electron microprobe shows it is entirely homogeneous, but may contain up to 1% FeO as solid solution in the crystal lattice.

Due to the mineral inclusions, the specific gravities of the cassiterites, espe-

cially those from the pegmatites are variable. The pegmatitic cassiterite from Semiling has specific gravities ranging from 6.5 to 7.5. However, specific gravities of pure hydrothermal cassiterites are usually constant.

Variation in shades of colour of the cassiterites is common. Most cassiterites are dark brown. Those associated with iron deposits are reddish black, whereas those found in sulphide rich pipes are glassy greyish black. The two generations of cassiterites observed in Ramuda Mine, Puchong is easily distinguished by their colour difference and grain-size. The earlier cassiterite is coarse-grained, highly zoned, and brown in colour whereas the later cassiterite is fine-grained, and has a glassy, greyish black appearance.

Wood-tin

This cassiterite species was previously thought to be very rare in the Southeast Asian tin province. A study by the writer (Wan Fuad Hassan, 1985b) proved wood-tin of this region is not rare after all, as he had found several new localities of the tin species in the peninsula, mostly from the Eastern Tin Belt.

Struverite

Struverite or niobium-tantalium rutile is rather limited in distribution; it is mainly found in the Western Tin belt of the peninsula, and is rather rare in the east coast. It is particularly common in Kinta Valley, especially at Tanjung Tualang, Kampong Gajah, and Chenderiang. The struverite occurrence dies away towards the south of Kinta Valley so that in the Kuala Lumpur tinfields, except for some isolated occurrence, it is virtually absent. In the present samples, the only struverite collected from the Kuala Lumpur area comes from Yew Hing Mine, located on the road to Ulu Langat.

This mineral, similar to that of cassiterite, display a number of crystal habits (Fig. 2 and 3). The usual habit is the bipyramid and prismatic forms conforming to the tetragonal system. The bipyramid form is often elongated along *a* or *b* axes to produce prismatic crystals with either rhombohedral bipyramidal or wedge-shaped terminations.

Struverite is fairly magnetic and is mainly found in the magnetic fraction together with monazite and tourmaline. The magnetic property of this mineral is governed by its iron content.

The Sulphides

Pyrite is the commonest sulphide found in the concentrates. It is probably of secondary origin, formed in the alluvium for the primary sulphides are usually weathered away. The cubic habit predominates, while the pyritohedron habit is also common. Samples from Sintok and Semiling contain minute spherical grains of pyrite. Such pyrite spheroids have been termed as polyframboids (Love,

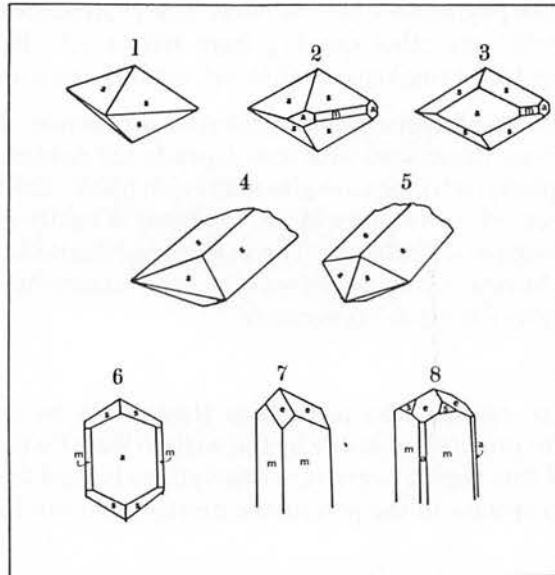


Figure 2: Crystal habits of struverite from Peninsular Malaysia
 1,2,3 - Squat bipyramid with faces s (111), a (100) and m (110);
 4 - Prismatic habit with 'wedge-shaped' termination;
 5 - Prismatic habit with rhombohedral - pyramidal termination;
 6, 7, 8 - Tetragonal prismatic habits with pyramidal terminations.

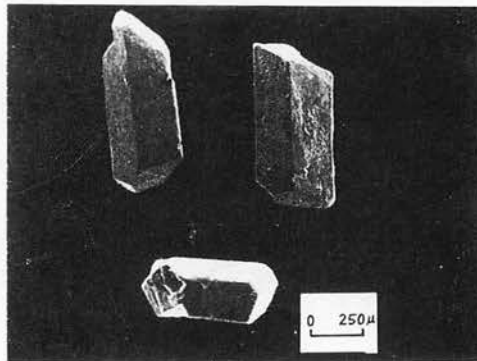


Figure 3: A microphotograph of some struverite grains

1969). Similar pyrite polyframboids has been described earlier from Air Hitam by Hosking (1980).

Topaz

Topaz is a common accessory mineral in the alluvial concentrates, and it is easily recognised as it remained together with the heavy mineral fraction after heavy liquid separation using tetrabromoethane. The alluvial samples from Western belt, e.g. from southern Kinta Valley, Segari and Kuala Lumpur contain topaz while those from the east coast are rare. Beautiful, clear, white and euhedral topaz crystals, with maximum size of about 0.75 cm, could be collected from the coarse among fractions in Chenderiang.

Monazite and Xenotime

These two minerals are found in small quantities in almost all the alluvial concentrates. They are abundant in samples overlying granitic rocks and are rather scarce in samples taken over limestone bedrocks. Monazite predominates over xenotime except in Gambang where the latter is more abundant. In Semiling, Bakri and occasionally in southern Kinta Valley especially in Kampung Gajah, green monazite is also observed. Monazite shows two habits; elongated rolled grains, which is the predominant form and the flattened form parallel to (100), which is the normal form for the green monazite.

Xenotime also has two main habits; the squat tetragonal bipyramid and a prism with double pyramidal terminations which appears to have developed from the squat bipyramid by elongation along the *c*-axis. The bipyramidal form is generally more common in the Western Tin Belt while the prismatic form is commonly observed in the Eastern Tin Belt, particularly in Gambang. Both forms, however may occur together, as has been mentioned by Ng (1971), in sample taken from Bukit Tinggi, Johor. The colour of xenotime is yellowish. The bipyramidal xenotime is usually opaque, with colours ranging from creamy white, greyish to yellowish while the prismatic crystals are usually subtransparent and brownish yellow in colour.

Frequently xenotime is seen intergrown with zircon possibly because the two minerals have a similar structure (Fig. 4a and 4b). Sketches in Figure 5 attempt to show these intergrowths.

Corundum

Tiny blue grains of corundum, about 5 mm diameter are common and widely distributed, and were observed in the coarse among fraction from Ulu Selim, Puchong, Gambang, Air Putih, etc. *In situ* blue sapphire from Chenderiang has been reported (Murthy, 1979).

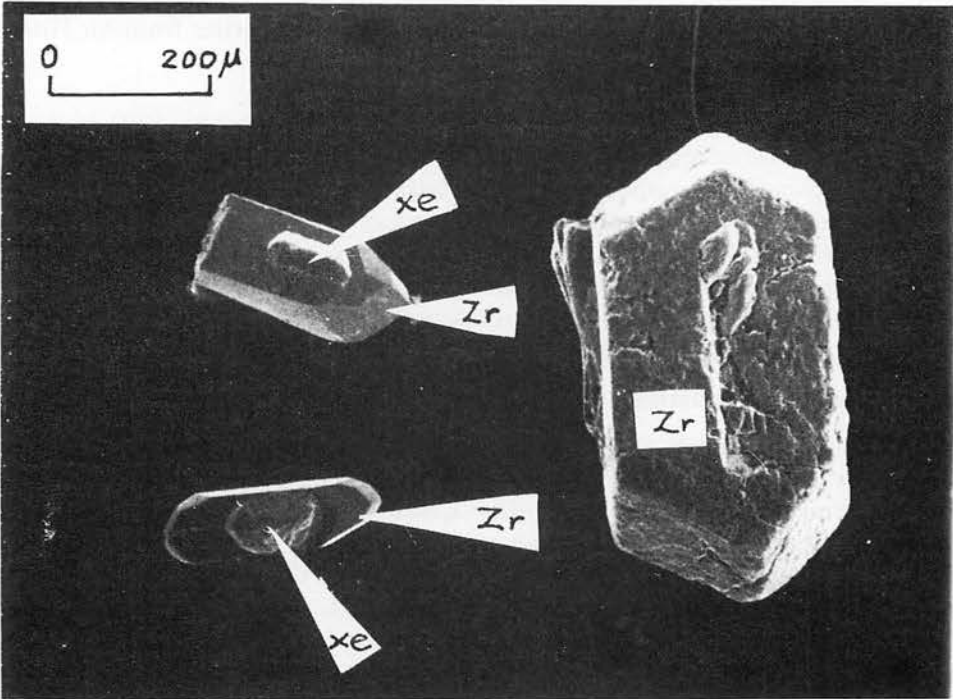


Figure 4a : Intergrowth of xenotime (xe) in zircon (zr) crystal

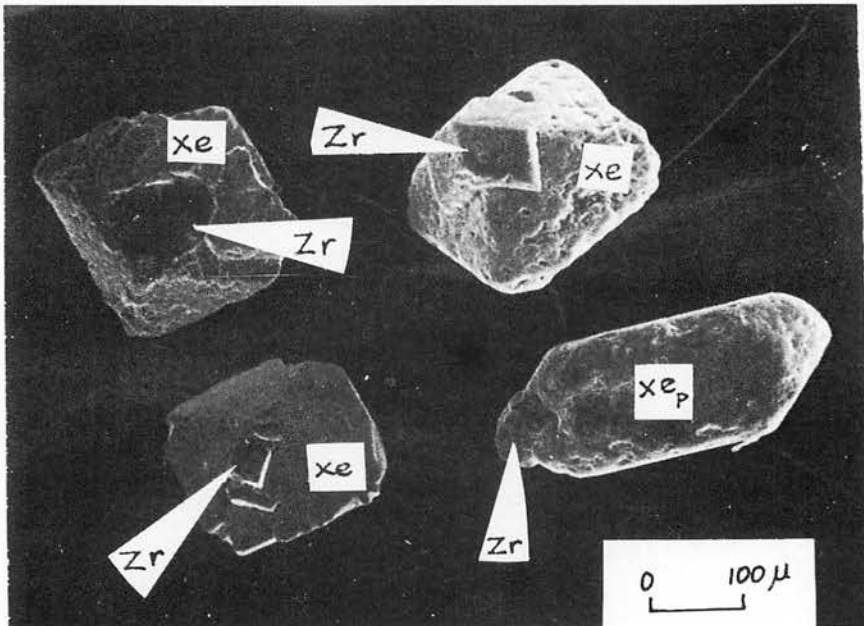


Figure 4b : Intergrowth of zircon (zr) in xenotime (xe) crystals

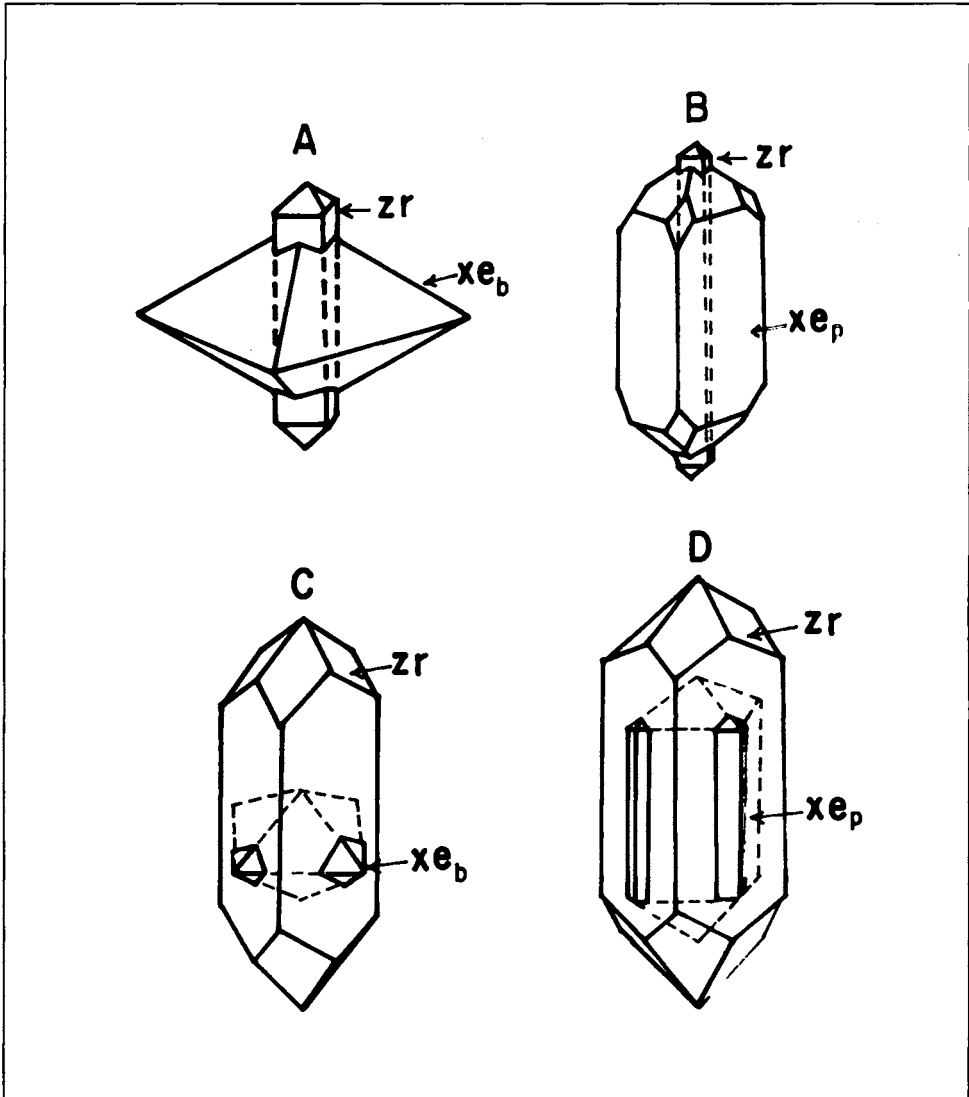


Figure 5 : Sketches which attempt to explain the xenotime-zircon intergrowth

Spinel

This mineral is limited in distribution, and is common only in Semiling. Other reported occurrences, in small amounts are Bakri, Gambang, Baling and Southern Kinta. Its form is octahedral. Those from Semiling have a bluish green colour, while in other samples, the colour is grass green.

CONCLUSION

Over 90% of the Malaysian tin ore is won from the alluvium, and this emphasises the importance of the study on detrital minerals. A systematic study of such mineral would not only identify the economically important minerals present but also reveal many significant points related to their types of deposits. The seemingly simple cassiterites, as revealed from this study, show important variations, in form and other physical properties which are related to their origin. Similar detail systematic studies are useful as it could be used to further characterise the various tinfields of Malaysia.

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