Geological Society of Malaysia, Bulletin 46
May 2003; pp. 217–221

On some ore and skarn minerals of Langkawi

WAN FUAD WAN HASSAN

School of Environmental and Resource Sciences, Faculty of Science and Technology
Universiti Kebangsaan Malaysia, 43600 UKM Bangi, Selangor
wafutu@pkrisc.cc.ukm.my

Abstract: This paper describes the sulphide and skarn mineral occurrences in Langkawi, formed with relation to the Triassic granite intrusions. The minerals are distributed along the granite-limestone contacts and are well developed in the southeastern part of the island, especially in Bukit Panchor and Teluk Apau for the sulphides and Bukit Panchor and Pulau Bumbon Besar for the skarns. The sulphides, of copper-bismuth type, consist of chalcopyrite, pyrite, galena, sphalerite, pyrrhotite, arsenopyrite, bismuth and bismuth sulphosalt of emplectite and joseite, while the skarn consists of tremolite-actinolite, diopside, grossularite-andradite garnet, vesuvianite, and occasionally accompanied by malayaite and scheelite.

Abstrak: Kertas ini memerihal kewujudan mineral-mineral sulfida dan skarn di Langkawi, terhasil daripada rejahan granit berusia Trias. Mineral-mineral tersebut tertabur sepanjang kawasan sentuhan antara granit-batu kapur dan jelas terbentuk di bahagian tenggara Langkawi, terutamanya di Bukit Panchor dan Teluk Apau bagi mineral sulfida, dan Bukit Panchor serta Pulau Bumbon Besar bagi mineral skarn. Mineral sulfida adalah jenis kuprum-bismut, terdiri daripada kalkopirit, pirit, galena, sfalerit, pirotit, arsenopirit, bismut dan sulfosalt bismut iaitu emplektit dan joseit, manakala mineral-mineral skarn pula terdiri daripada tremolit-aktinolit, diopsid, garnet grosularit-andradit, vesuvianit, dan kadang-kala malayait serta syilit.

INTRODUCTION

Langkawi Island group forms a geologically interesting place for field excursions, long before its present state as a tourist destination. It has the oldest sedimentary rock sequence in the country with excellent exposures along the coast. Its igneous geology is no less interesting as the granite intrusion produced among the best tourmalinization, greisenization and skarn formations, and associated mineralization which is no less significant. This paper will highlight the ore and skarn minerals in the island group. The information for this paper is mostly taken from the writer's earlier work (Wan Fuad Wan Hassan, 1973), and the writers subsequent numerous later visits to the island.

GEOLOGY AND MINERALIZATIONS OF LANGKAWI ISLANDS

The geology of Langkawi is well described in Jones (1981). Basically the oldest sedimentary sequence in the island is the clastic upper Cambrian Machincang formation to the west, which is then overlain by the Ordovician-Silurian carbonate Setul Formation, clastic Devonian-Carboniferous Singa and finally by the Permian Chuping limestone (Fig. 1). The sedimentary sequence shows an eastward younging direction. It was intruded by the Triassic Langkawi granite giving the Gunung Raya batholith, Tuba and Dayang Bunting stocks. A major structure of the island is the acuate roughly north-south trending Kisap Thrust cutting the eastern part of the main island trough Pulau Dayang Bunting, resulting in some places the resting of the older Setul formation on top of the younger Chuping formation. Associated with the granitic intrusions are the mineralization and tourmaline greisenization. Tourmaline greisenization was described in Hutchison and Leow (1963) and Khoo (1984), and good examples of such phenomena were observed on the shoreline of Kuah, Pulau Dayang Bunting and Teluk Ewa.

Reports of early mining activities and mineralizations in Langkawi are found in Scrivenor and Willbourn (1923), Wan Fuad Wan Hassan (1973) and Jones (1981). The mineralization is associated with the skarn formed at the granite-limestone contacts. Jones (1981) mentioned the Langkawi Bismuth and Copper Company formed in 1922 to prospect and mine the enriched zone of sulphides along the granite-limestone contact to the east of Kuah. The work carried out by the company soon proved unprofitable and was closed within a year. Wan Fuad Wan Hassan (1973) found beside the mineralization at the granite-limestone contacts to the east of Kuah and to the south of Teluk Apau, traces of mineralization was also found in Bagan Nyior, Pulau Dayang Bunting.

Alluvial ilmenite was briefly worked from the beach sand of Pasir Hitam prior to the Second World War, but the reserve was quickly exhausted (Jones, 1981). However, Wan Fuad Wan Hassan (1987) found that the mineral causing the black colour of the Pasir Hitam sand was not ilmenite but tourmaline, and felt the real reason for the reserve to be quickly exhausted was because in the first place there was not much ilmenite but plenty of tourmaline. Traces of non-sulphide occurrences, i.e. primary hematite in Teluk Apau (Jones, 1981) and secondary manganese oxide in Tanjung Peluru, Pulau Tuba (Wan Fuad Wan Hassan, 1973) were also reported.

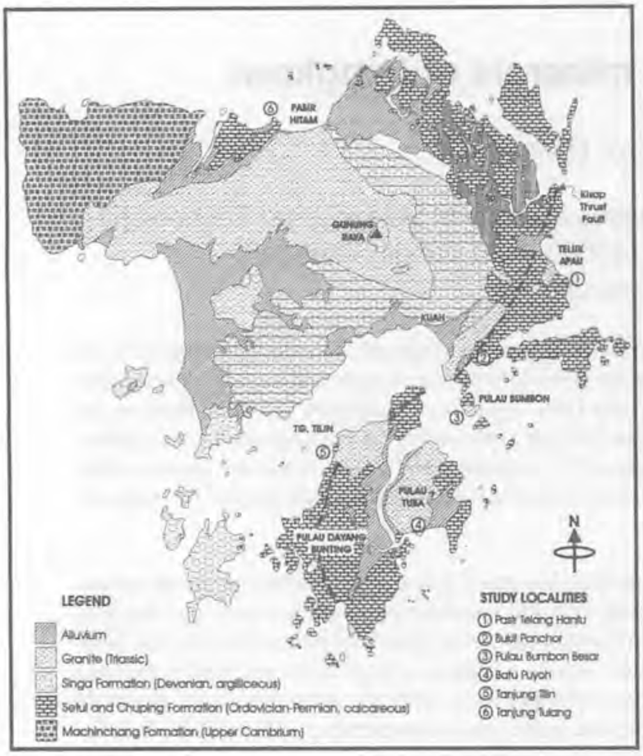

Figure 1. Geological map of Langkawi islands. Sample localities are shown by the circles.

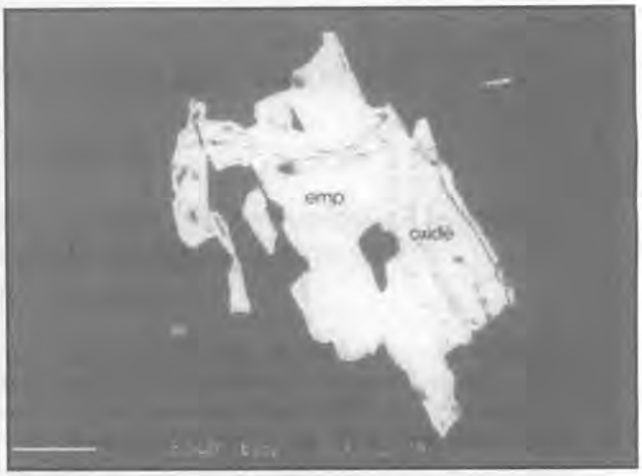

Figure 2. Backscattered electron image of emplectite (emp), $CuBiS_2$ from Bukit Panchor. The right hand part of the mineral is altered to a bismuth oxide mineral. Elemental composition for this mineral is given in Figure 3.

The sulphide mineralization in Langkawi is likely a pyrometasomatic type, or skarn mineralization type. The old exploratory pits observed in Bukit Panchor were made in the limestone or the skarn side, the part usually associated with mineralization. The skarn mineral association is in favour of skarn type mineralization. No mineralization were exposed on the surface. Scrivenor and Willbouurn (1923) writing at the time of the mining operation, noted that "so far the evidence does not indicate that the deposit occur as a lode with strongly marked walls. There is evidence of faulting but it appears that the fault was subsequent to the ore deposits"

SOME ORE MINERALS OF LANGKAWI

Sulphide mineralization of Bukit Panchor, Kuah

Bukit Panchor is a locality to the east of the Kuah town. It can be accessed through a foot path that passes a Chinese cemetery. A number of pre-war exploration pits were observed in the marble bedrock along the granite-limestone contact. On the side of each pit was a mound of rock dug from the pit. Hand specimens taken from a mineralized pit contain patches of yellow sulphide minerals. Polished section study of the samples show the presence of dominant chalcopyrite, pyrite, sphalerite, galena, some bismuth, pyrrhotite and mackinawite, its alteration product. Pyrite grains are square shaped and show corrosion by later minerals. Chalcopyrite is a late mineral as it cuts through or corrodes most of the earlier minerals. Sphalerite do not show exsolution with chalcopyrite. Pyrrothite is preferentially replaced by galena along certain cleavage planes. Where fractures or partings occur in the pyrrhotite, mackinawite is formed. Subordinate galena is observed as a late mineral, and it surrounds, engulf or veins earlier minerals. Bismuth, a native metal that the mining company was looking for, occurs in small quantity together with galena and appears as droplets or rounded bodies. Tin mineral in the form of stannite has been positively identified from this area (Singh and Bean, 1967), but samples collected by the present writer failed to detect any of the mineral.

Another mineralized pit about a half a kilometer to the north of the previous pit yielded a different assemblage. A specimen from this pit show minute silver-gray specks in creamy white, greenish and transparent background of skarn minerals. The transparent mineral is recognised as fluorite and it contains silvery flaky mineral. Wan Fuad Wan Hassan (1973), by X-ray diffraction, identified it as emplectite, a bismuth-copper sulphosalt ($CuBiS_2$, orthorhombic). Now, using an electronprobe microanalyzer (EPMA), the present writer found it to be composed of three separate bismuth minerals, which are emplectite, joseite and a bismuth oxide mineral which is an alteration product of emplectite (Figs. 2 and 4), surrounded by fluorite. The copper-bismuth-sulphur elements in the emplectite are clearly seen (Fig. 3). Alteration by oxidation of emplectite gives a rim of the bismuth oxide (Fig. 2) and its oxygen content is clearly shown in Figure 3. Joseite ($Bi_{4+x}Te_{1-x}S_2$) is a bismuth-tellurium-sulphur mineral (Uytenboogardt *et al.*, 1971) and its composition is given in Figure 4.

Sulphide mineralization in Teluk Apau

Indication of sulphide mineralization at Teluk Apau granite-limestone contact was not found at the contact itself but to the south, at a placed marked in the Langkawi map as Pasir Telang Hantu, about two kilometers south of

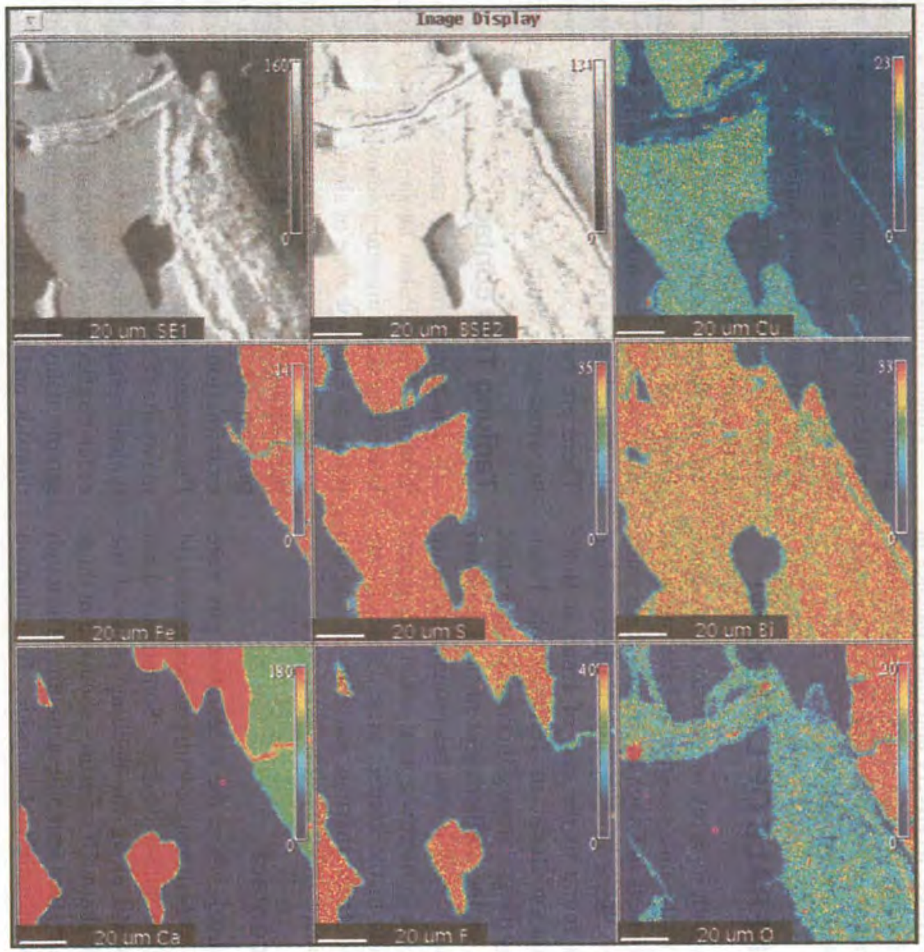

Figure 3. Microprobe analysis giving elemental composition of emplectite and the bismuth oxide from Bukit Panchor.

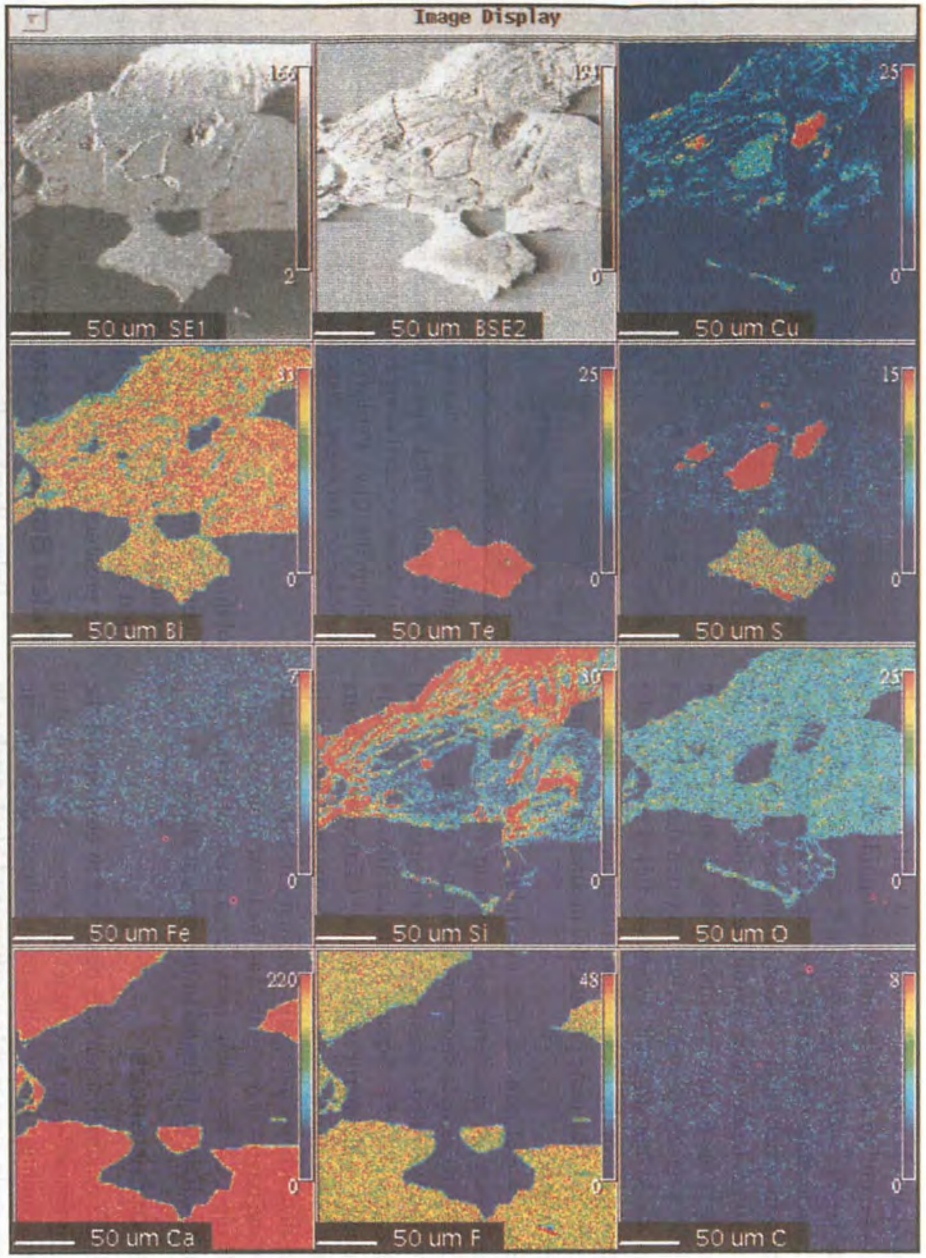

Figure 4. Joseite from Bukit Panchor. It is a Bi-Te-sulphide and its composition is shown by the Bi, Te and S images. It is surrounded by fluorite.

Teluk Apau. During the writers first visit to the place in 1973, a mound of rocks containing sulphide minerals was located on the sandy beach near to the water's edge. No mine pit was observed nearby. Perhaps it was buried under the shifting beach sand. About 30 meters away from the coast is black moderately crystalline marble bedrock. No contact with the granite was seen in the vicinity. Later, in 1985 and 1999 the present writer revisited the locality for further work, but on both occasions, failed to locate the mineralization or the rock mound containing the sulphides. Most probably the mine pits and the mound are now buried under the sand.

Hand specimen of the available sample shows predominance of sphalerite and arsenopyrite. Polished sections of the sample show predominance of fine grained sphalerite and galena masses with interspersed euhedral pyrite cubes (Fig. 5). Square pyrite outlines are normally corroded by chalcopyrite or sphalerite. Chalcopyrite occurs as small blebs mostly in sphalerite. Some parts are rich in galena that occupy intergrain boundary in between calcite grains and galena is recognized as the latest mineral. Jones (1981) reported that galena in this area is argentiferous, but no such indication is found in the present study.

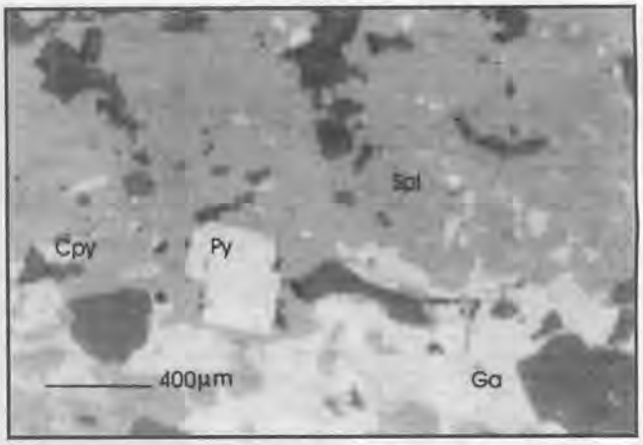

Figure 5. Polished section sample of sulphide minerals from Pasir Telang Hantu, Teluk Apau. Dominant mineral mass is sphalerite (Spl), being replaced along boundaries by galena (Ga) and some chalcopyrite (Cpy). Pyrite (Py) is the earliest mineral shown by the euhedral crystal shape. Plane polarised light.

Other occurrences

Some mineralization was observed in boulders at the Setul limestone-granite contact in Bagan Nyior, Pulau Dayang Bunting. In the collected specimen, aresenopyrite and sphalerite were visible as silvery and black patches in the dark green actinolite skarn. Flaky silvery bismuth mineral similar to that observed in Bukit Panchor were also observed together with the spahlerite.

SKARN MINERALS OF LANGKAWI

Skarn minerals with its array of varieties is always a fascinating subject to the mineralogist, and the numerous limestone-granite contacts in Langkawi makes skarn study an interesting subject. Skarn mineralization is widely spread in Langkawi. It is found to the east of Kuah at Bukit Panchor, Pulau Bumbon Besar, in Teluk Puyoh, Pulau Tuba as well as along the granite-argilliceous Singa contact in Tanjung Tulang, on the northern part of the Langkawi island. Contact zones vary in width, but pronounced skarn minerals usually occur in narrow zones, about 0.3 meters wide, as sill or veins in the contact area. Calc-silicate hornfels, developed from thermal reaction of impure limestone in the contact zone, has a broader zone.

Bukit Panchor contact

The marble bedrock where the exploration pits were dug consist of tough whitish marble with patches of emerald green probably wollastonite-andradite. Sometimes skarn minerals appears as sill along the bedding plane of the limestone. One such skarn sill measures about 0.5 m thick and contains columnar green tremolite-actinolite. The tough white marble consist of mainly of diopside. Examination of thin section reveals the presence of vesuvianite, diopside, actinolite-tremolite, in addition to tourmaline and fluorite. Examination of the skarn under short-wave length ultraviolet light show specks of bluish white fluorescence indicating the presence of scheelite.

Pulau Bumbon Besar contact.

Pulau Bumbon Besar represents a Setul limestone-granite contact. The contact itself is not exposed, but a well developed skarn zone is well observed in the limestone side of the contact, both on the northern and southern shores. Beautiful skarn minerals can be seen in boulders strewn along the beach on the southern shore, while *in situ* skarn is observed on the marble cliff on the northern shore. Among them, tremolite-actinolite is particularly well developed. It appears as dark green radiating acicular minerals, some reaching a few cm in length. Dispersed in the actinolite-tremolite suns were subhedral garnet grains. There are two varieties of garnet; the dominant type is brownish-grey while the other appears as reddish brown.

Tanjung Tilin contact

The granite-marble contact on a ridge to the south of Tanjung Tilin, Pulau Dayang Bunting Island yield an interesting skarn mineral assemblage. Skarn mineralization occurs in a narrow zone of about 1.5 m wide. The adjacent granite is fine grained, tourmaline rich and the marble is pure-white Chuping type. The skarn rock occurs as a tough pinkish to creamy white, fine grained rock. Upon examination in short wavelength U.V. light, yellow fluorescence spots were observed which turned out to be malayaite ($CaSnSiO_5$). In thin section malayaite assumes typical sphene shape, colourless, has high relief, high-order bireflectamce colour and has no cleavage. In this sample malayaite occurs together with apatite, vesuvianite, diopside and phlogopite.

Tanjung Tulang contact

Unlike other skarns in Langkawi, the skarn in Tanjung Tulang, developed at the granite-clastic sediment contact; the clastic sediment is an argillic member part of the Singa formation. The former argillic member usually dark in colour, is now a dark greenish rock, being veined by skarn minerals consisting of garnet (grossularite variety), quartz, hedenbergite and fluorite.

CONCLUSION

Langkawi island offers an interesting association of sulphide and skarn minerals related to the Triassic intrusion of the granite into its overlying calcareous and argillaceous sedimentary sequences. The sulphide mineralization is a copper-bismuth association of chalcopyrite, sphalerite, pyrite, pyrrhotite and sometimes with alteration products consisting of mackinawite, galena, bismuth and its subspecies of emplectite and joseite. Accompanying the sulphides are skarn minerals consisting of acicular tremolite-actinolite, andradite-grossularite garnet, diopside, vesuvianite, and significant traces of malayaite.

REFERENCES

AMIRULNAIM BIN AHMAD DAHLAN, 1997. *Geologi kawasan utara Tengah Pulau Langkawi.* Unpubl. SmSn dissertation, Universiti Kebangsaan Malaysia.

HUTCHISON, C.S. AND LEOW, J.H., 1963. Tourmaline greisenization in Langkawi, Northwest Malaya. *Econ. Geol., 58,* 587-592.

JONES, C.R., 1981. Geology of Perlis, North Kedah and Langkawi Island. *Geological Survey of Malaysia District Memoir 17.*

KHOO, T.T., 1984. Evidence of Polymetamorphism in the Rebak Island, Langkawi, Kedah. *Bull. Geol. Soc. Malaysia 17,* 265-281.

SCRIVENOR, J.B AND WILLBOURNE, 1923. The Geology of the Langkawi Island. *J. Mal. Br. Royal Asiatic Society, 1,* 338-347.

SINGH, S.B. AND BEAN, J.H., 1967. Some general aspects of tin minerals in Malaya. Prepared for the Technical Conference on Tin of the ITC.

UYTENBOOGARDT, W. AND BURKE, E.A.J., 1971. *Tables for Microscopic Identification of Ore Minerals.* Elsevier Publishing Company, Amsterdam.

WAN FUAD WAN HASSAN, 1973. *The Geology of Southeastern Langkawi.* Unpubl. B.Sc (Hons) thesis, Department of Geology, University of Malaya, 64p.

WAN FUAD WAN HASSAN, 1987. On the mineralogy of the black sand of Pasir Hitam, Langkawi. *Warta Geologi, 13,* 253-254.

Manuscript received 18 February 2003