

# EPMA characterisation of *amang* minerals of Peninsular Malaysia — a preliminary study

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**Abstract:** Samples of *amang* were collected from Upper Perak, Kinta Valley, Klang Valley and the Pelepah Kanan areas for characterisation, both physically and chemically, using the EPMA (Electronprobe Microanalyser).

This preliminary study shows that *amang* samples from Klian Intan show less ilmenite compared to the other areas. The Klian Intan samples, however, have higher contents of wolframite, pyrite, zircon, arsenopyrite, and rutile. The presence of rooseveltite ( $\text{BiAsO}_4$ ) is a significant characteristic for the Klian Intan *amang*. One rooseveltite sample shows inclusions of silica.

The *amang* samples from the Kinta Valley are very rich in ilmenite grains. Studies show 91% ilmenite in *amang* from Keramat and 93% ilmenite in *amang* from Air Kuning, and 91% in *amang* from Bidor. Struverite [ $\text{Fe}_x^2(\text{Ta}, \text{Nb})_{2x}\text{Ti}_{60-x}\text{O}_{120}$ ] was found with exsolution bodies of wolframioxiolite [ $(\text{Nb}, \text{W}, \text{Ta}, \text{Fe}, \text{Mn})_3\text{O}_4$ ] and columbite/tantalite. Wolframioxiolite is a black, opaque, monoclinic mineral. This is the first time it is found in Malaysian *amang*.

*Amang* from Bidor shows intergrowth relationships of ilmenite with monazite, xenotime and zircon. The studied *amang* sample from Dengkil, Klang Valley shows the highest content of ilmenite compared to the other areas. It contains 98% ilmenite, 1% xenotime, and 1% zircon. On the other hand, the wolframite concentrate from Tekka shows 53% wolframite, 33% ilmenite, 12% silicates, and 2% zircon. EPMA studies of *amang* sample from Pelepah Kanan shows 81% iron oxides, 8% silicates, 6% silica, and 5% cassiterite.

**Abstrak:** Sampel *amang* telah dikutip dari kawasan-kawasan Perak Utara, Lembah Kinta, Lembah Klang dan Pelepah Kanan untuk pencirian, dari segi fizikal dan kimia, dengan menggunakan EPMA (Electroprobe Microanalyser).

Kajian awal menunjukkan sampel *amang* dari Klian Intan adalah kurang ilmenit berbanding dengan kawasan-kawasan lain. Sampel Klian Intan, walau bagaimanapun, mempunyai kandungan yang lebih tinggi bagi wolframit, pirit, zirkon, arsenopirit, dan rutil. Kehadiran rooseveltit ( $\text{BiAsO}_4$ ) adalah satu ciri khas bagi *amang* Klian Intan. Satu sampel rooseveltit menunjukkan inklusi silika.

Sampel *amang* dari Lembah Kinta adalah sangat kaya dengan butiran ilmenit. Kajian menunjukkan 91% ilmenit di dalam *amang* dari Keramat dan 93% ilmenit di dalam *amang* dari Air Kuning, serta 91% di dalam *amang* dari Bidor. Struverit [ $(\text{Fe}_x^2(\text{Ta}, \text{Nb})_{2x}\text{Ti}_{60-x}\text{O}_{120})$ ] telah dijumpai dengan badan-badan eksolusi wolframioxiolit [ $(\text{Nb}, \text{W}, \text{Ta}, \text{Fe}, \text{Mn})_3\text{O}_4$ ] bersama-sama dengan columbit/tantalit. Wolframioxiolite adalah mineral hitam legap yang bersistem monoklin. Ini adalah pertama kali mineral ini dijumpai di dalam *amang* Malaysia.

*Amang* dari Bidor menunjukkan hubungan saling pertumbuhan ilmenit dengan monazit, xenotim dan zirkon. Sampel *amang* yang dikaji dari Dengkil, Lembah Klang menunjukkan kandungan ilmenit yang tertinggi berbanding dengan kawasan-kawasan yang lain. Ia mengandungi 98% ilmenit, 1% xenotim, dan 1% zirkon. Dalam pada itu, padatan wolframite dari Tekka menunjukkan 53% wolframit, 33% ilmenit, 12% silikat, dan 2% zirkon. Kajian EPMA bagi sampel *amang* dari Pelepah Kanan menunjukkan 81% oksida besi, 8% silikat, dan 5% kasiterit.

## INTRODUCTION

*Amang* is a local term used for the heap of heavy material left behind after mining activities, in particular tin mining. Peninsular Malaysia has a good reservoir of *amang* minerals since it used to be world largest tin producer in last century and the first half of this century. This *amang* reservoir can still generate further economic interests if its minerals and their relationship are well-studied. In this sense, a research study of *amang* minerals from Peninsular Malaysia is being carried out to characterize the *amang* minerals in Peninsular Malaysia. This includes the tin fields in the Klian Intan, Kinta Valley, Klang Valley, and

Pelepah Kanan areas, among others.

The purpose of this paper is to present the initial findings of the research study. This preliminary study will serve to highlight the framework for a detailed study of the *amang* minerals from the different localities to recognize local differences and characteristics. Essentially, the study is to characterize the *amang* minerals, both physically and chemically, aided by the different analytical capabilities of the EPMA (Electronprobe Microanalyser).

Previous investigations on *amang* in the country include Lau (1979), and Irdawati (2001) in the Kinta Valley and Klang Valley areas, and Jamlus (1979) in the Klang Valley area.

## MATERIAL AND METHODS

*Amang* samples were collected either from abandoned mines or mines that are still operating from various locations in Peninsular Malaysia (Fig. 1). However, for this paper, the discussion would be centred mainly on samples collected from several selected localities only. This includes the Klian Intan area in Upper Perak, Tekka, Air Kuning, and Keramat in the Kinta Valley, Dengkil in the Klang Valley, and Waterfall Mine in Pelepah Kanan, Johore.

Samples collected were initially concentrated using a dulang first. Next, a small dulang, made out of coconut shell, shaped as a bowl, was used to get a final concentrate. The panned concentrate was mounted in aradite and later polished. Well-polished samples were then analysed using the Cameca SX100 Electronprobe Microanalyser (EPMA) for both physical and chemical characterisation of the *amang* minerals.

The electronprobe microanalyser, a Cameca SX100, was operated at 20 kV with 20 nA beam current. The secondary electron (SE) image was utilized for the study of the morphology of the mineral grains while the backscattered electron image (BSE) was used to differentiate the minerals with different mineral compositions. X-ray mapping was performed on the various *amang* samples to accurately determine the percentages of the various *amang* minerals present for each sample or area.

## RESULTS AND DISCUSSIONS

Initial observations show that the *amang* from the study area are essentially abundant with heavy minerals that include ilmenite, monazite, zircon, xenotime, rutile, cassiterite, wolframite, arsenopyrite and pyrite among others. *Amang* samples from different localities show different dominant heavy minerals. *Amang* samples from

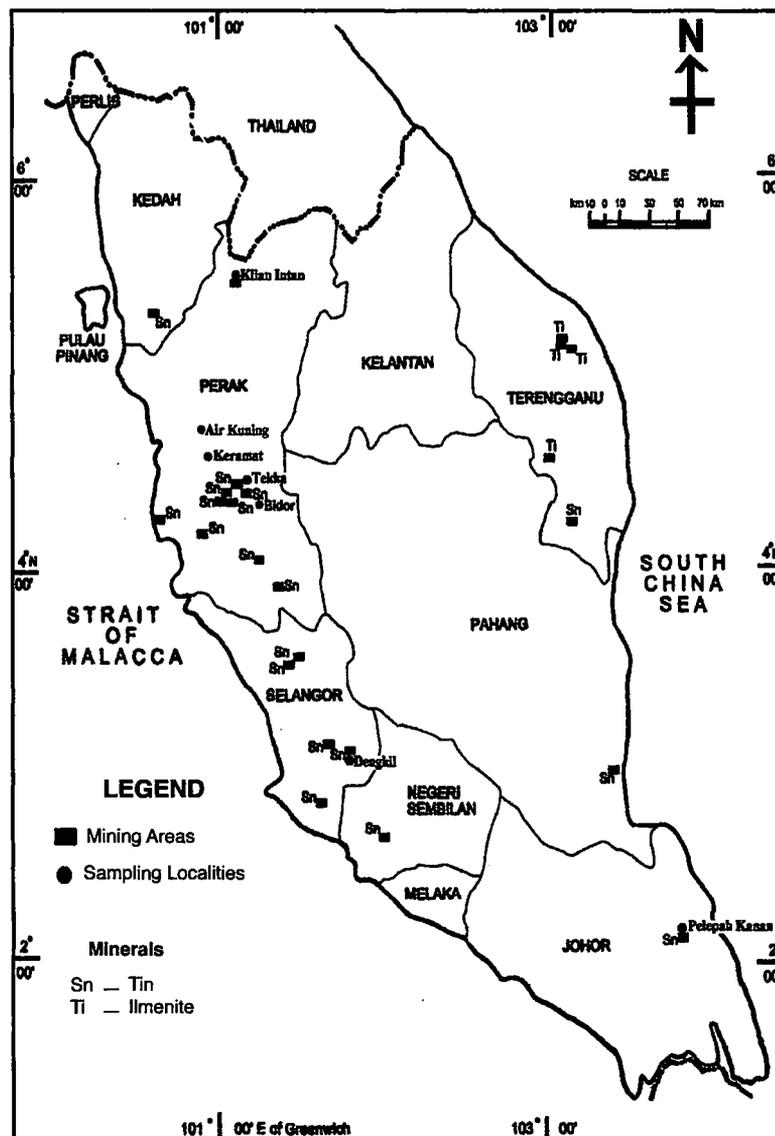
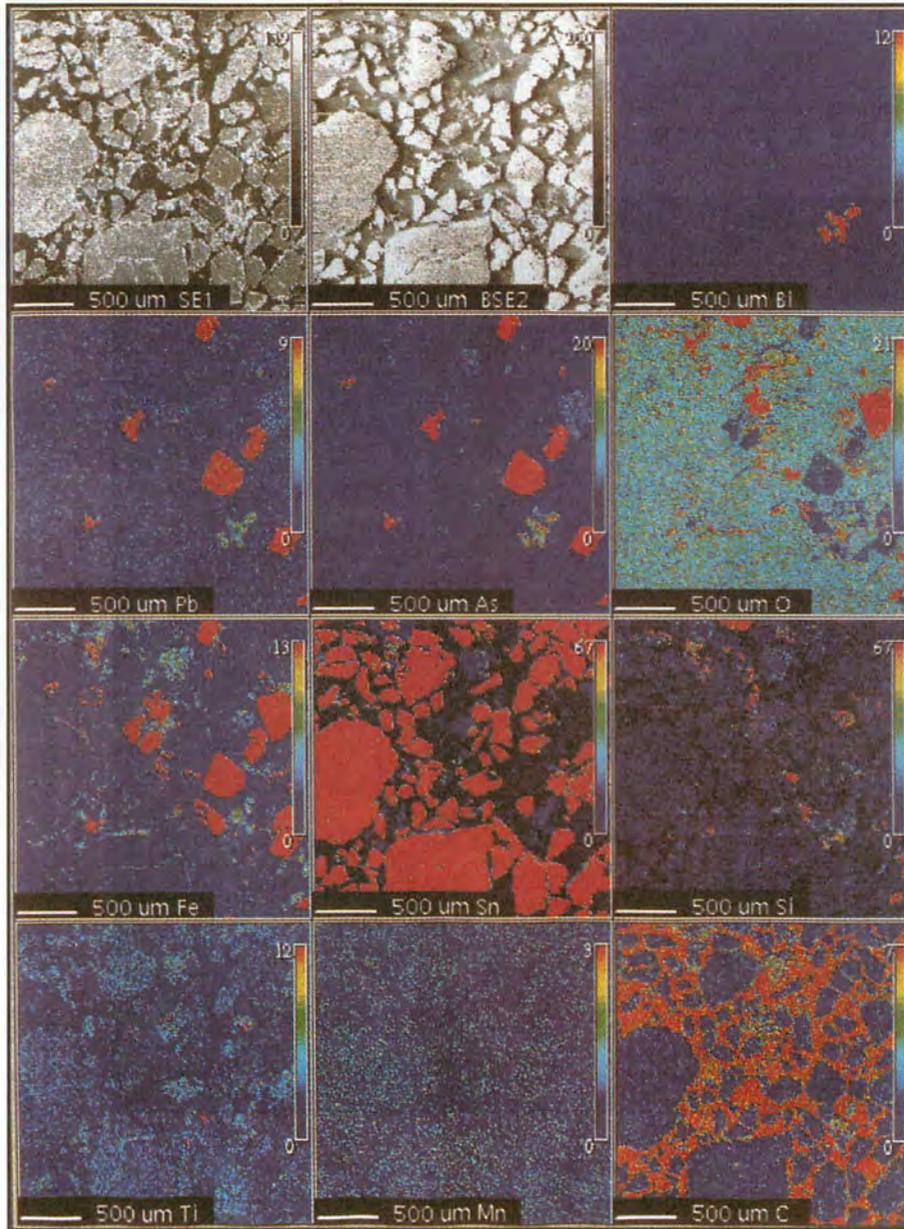
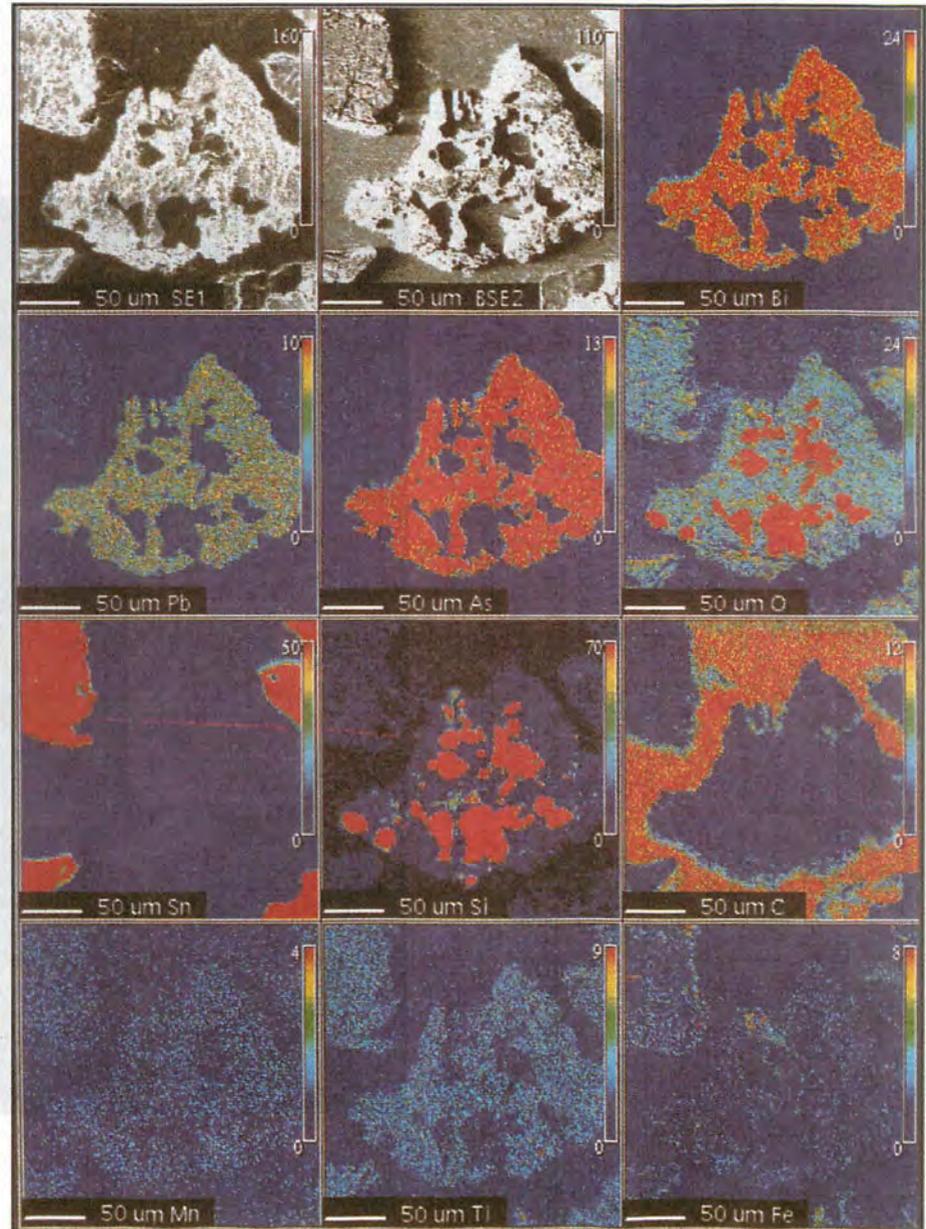


Figure 1. Map showing sampling localities.



**Figure 2.** X-ray map of tin concentrate sample (K4) showing abundant cassiterite ( $\text{SnO}_2$ ), some arsenopyrite ( $\text{FeAsS}$ ), iron oxide ( $\text{FeO}$ ), and rooseveltite ( $\text{BiAsO}_4$ ). Rahman Hydraulic Mine, Klian Intan.



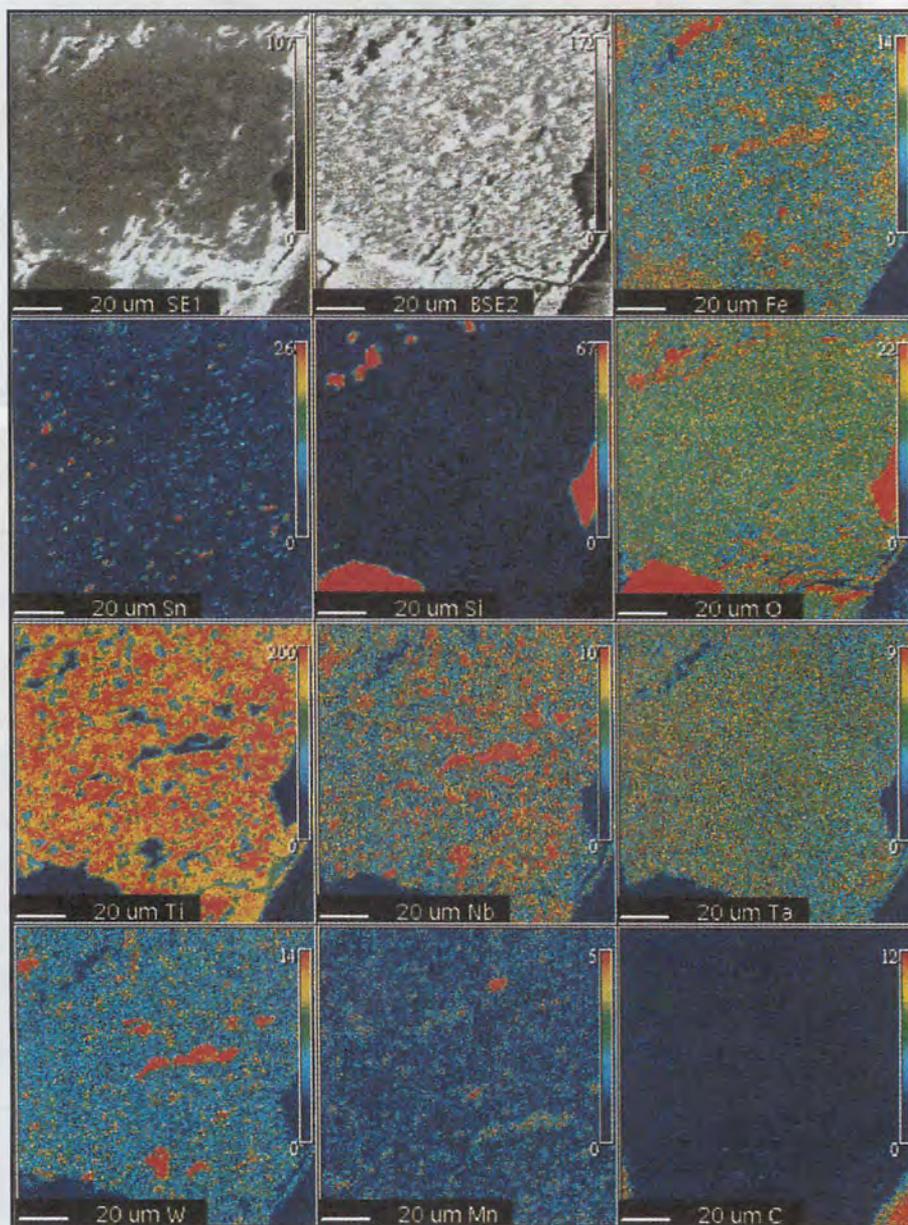
**Figure 3.** X-ray map showing quartz ( $\text{SiO}_2$ ) inclusions in rooseveltite ( $\text{BiAsO}_4$ ) in sample K4 from Rahman Hydraulic Mine, Klian Intan. Also present are cassiterite ( $\text{SnO}_2$ ) grains.

Klian Intan show less ilmenite compared to the other areas studied. These samples, however, have higher contents of pyrite, wolframite, arsenopyrite and zircon. Here, we found significant rooseveltite ( $\text{BiAsO}_4$ ) (Fleisher, 1983). This is a significant characteristic for the Klian Intan *amang*. The studied cassiterite concentrate sample (K2) shows 66% cassiterite ( $\text{SnO}_2$ ), 16% silica (Si), 15% FeO, 2% arsenopyrite ( $\text{FeAsS}$ ) and 1% rooseveltite ( $\text{BiAsO}_4$ ), while another cassiterite concentrate sample (K4) shows 75% cassiterite ( $\text{SnO}_2$ ), 15% silica (Si), 12% arsenopyrite ( $\text{FeAsS}$ ), 4% FeO, 2% rutile ( $\text{TiO}_2$ ) and 1% rooseveltite ( $\text{BiAsO}_4$ ) (Fig. 2). Roosevelite has been reported as an inclusion in a cassiterite grain from the Ulu Klang area, Kuala Lumpur (Teh and Cheng, 2002). EPMA studies also revealed silica ( $\text{SiO}_2$ ) inclusions in the rooseveltite from

Klian Intan (Fig. 3).

Roosevelite was first discovered by Herzenberg in 1946 in three towns (Maragua, Santiaguilla, and Potosi) in Bolivia. It was named after United States President at that time, F.D. Roosevelt. Roosevelite, a monoclinic mineral, has been classed as an arsenate. It is grey or grey white in colour and having adamantine luster (Fleisher, 1947).

Samples from Kinta Valley are rich in ilmenite grains. EPMA X-ray mapping shows abundant ilmenite and wolframite in wolframite concentrates from the Tekka area. The sample (Z1) contained 53% wolframite [ $(\text{Fe}, \text{Mn})\text{WO}_4$ ], 33% ilmenite ( $\text{FeTiO}_3$ ), 12% silicate (Al, Si, O), and 2% zircon ( $\text{ZrSiO}_4$ ), while another sample (Z2) contained 45% wolframite [ $(\text{Fe}, \text{Mn})\text{WO}_4$ ], 29% ilmenite ( $\text{FeTiO}_3$ ), 20% silica (Si), 2% zircon ( $\text{ZrSiO}_4$ ), and 1% xenotime ( $\text{YPO}_4$ ).



**Figure 4.** X-ray map shows the presence of wolframioxiolite ( $(\text{Nb}, \text{W}, \text{Ta}, \text{Fe}, \text{Mn})_3\text{O}_4$  and columbite/tantalite as exsolution bodies in struverite ( $\text{Fe}_x(\text{Ta}, \text{Nb})_{2x}\text{Ti}_{60-x}\text{O}_{120}$ ) from Bidor, Kinta Valley.

Essentially, *amang* in the Kinta Valley contains more than 90% of ilmenite grains. The studied *amang* concentrate sample from Keramat shows 91% ilmenite ( $\text{FeTiO}_3$ ), 6% silicate (Al, Si, O) and 3% silica ( $\text{SiO}_2$ ) while the *amang* concentrate sample from Air Kuning shows 93% ilmenite ( $\text{FeTiO}_3$ ), 3% silica ( $\text{SiO}_2$ ), 2% pyrite ( $\text{FeS}_2$ ) and 2% of xenotime ( $\text{YPO}_4$ ).

The studied *amang* sample from Bidor shows 91% ilmenite ( $\text{FeTiO}_3$ ), 5% silicate (Al, Si, O), 2% silica ( $\text{SiO}_2$ ), and 1% zircon ( $\text{ZrSiO}_4$ ). BSE images have revealed interesting intergrowths textures among the *amang* minerals, which include ilmenite with monazite, xenotime and zircon.

*Amang* sample from Bidor is characterized by the presence of struverite [ $\text{Fe}_x^2(\text{Ta}, \text{Nb})_{2x}\text{Ti}_{60-x}\text{O}_{120}$ ] (Flinter, 1959). This mineral was discovered in 1907 by Zambonini in Craveggia and Piemont, Italy. In Malaysia, Beh Minerals Sdn. Bhd. was the first to separate struverite from the other *amang* minerals. The Bidor struverite sample has exsolution bodies of wolframioxiolite ( $\text{Nb}, \text{W}, \text{Ta}, \text{Fe}, \text{Mn}$ ) $_3\text{O}_4$  (Fleisher, 1983) and columbite/tantalite (Fig. 4). Wolframioxiolite is a black, opaque, monoclinic mineral (Jambor, 1990). This is the first time it is found in Malaysian *amang*.

The studied *amang* sample from Dengkil shows that *amang* from the Klang Valley is very rich in ilmenite grains. It contains 98% ilmenite, 1% xenotime, and 1% zircon.

*Amang* samples from Pelepah Kanan area are rich in Fe minerals. EPMA X-ray mapping show 81% iron oxides (Fe, O), 8% silicates (Al, Si, O), 6% silica ( $\text{SiO}_2$ ) and 5% cassiterite ( $\text{SnO}_2$ ).

## CONCLUSION

The study has shown that the *amang* from Peninsular Malaysia include ilmenite, wolframite, cassiterite, zircon, rutile, and xenotime among others. EPMA X-ray mapping was efficiently utilized to show various compositions of *amang* minerals from different localities.

This preliminary study confirms the presence of the heavy mineral rooseveltite ( $\text{BiAsO}_4$ ) in the Klian Intan area, and wolframioxiolite ( $\text{Nb}, \text{W}, \text{Ta}, \text{Fe}, \text{Mn}$ ) $_3\text{O}_4$  in the Bidor area. The presence of struverite [ $\text{Fe}_x^2(\text{Ta}, \text{Nb})_{2x}\text{Ti}_{60-x}\text{O}_{120}$ ] was also confirmed in the Bidor area, Kinta Valley.

Further study on the *amang* from different localities is on-going. It is hoped that this study of *amang* minerals would serve as a good data base for further studies or mining activities of *amang* in Peninsular Malaysia.

## ACKNOWLEDGEMENTS

The authors acknowledge the research grant provided by Vote-F (F0188/2002B), University of Malaya for this project.

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Manuscript received 31 March 2003