

*A note on varlamoffite and associated minerals from the
Batang Padang district, Perak, Malaya,
Malaysia¹*

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[Taken as read 4 November 1965]

Summary. A new occurrence of varlamoffite is described, and the status of this species is considered; the term is best employed for cryptocrystalline yellowish material consisting predominantly of Sn and H₂O that may yield a diffuse powder pattern comparable to, or closely resembling that of cassiterite, but does yield a powder pattern identical with that of cassiterite after heat-treatment at about 1200° C. A new mineral, malayaite, CaSnSiO₃, is briefly described; it is isostructural with sphene.

IN January 1953, a fragment of a cassiterite crystal coated with a pale lemon, soft, amorphous material, obviously derived therefrom, was presented by Mr. J. D. Hellings of Messrs. Osborne and Chappel (Mining and Consulting Engineers), to the Director of Geological Survey, Federation of Malaya. The specimen (no. 19384) came from an open-cast mine (lat. 4° 15¼' N., long. 101° 14' E.) in the valley of the Sungei Lah, Chenderiang, Perak. Chemical analysis by Mr. W. A. Tooke of a very small quantity of the specimen indicated that it was a hydrated oxide of tin and the sample, which was not reduced to Sn when treated with hydrochloric acid in a zinc dish, was thought to be varlamoffite.

Additional specimens (19384-A to F) were collected by Flinter in January 1953; others (grouped as 19384-G) were supplied by Messrs. Osborne and Chappel in October 1954 and July 1955; all these specimens were recovered from clays (in some places notably reddish) lying in north-south trending troughs between caps of limestone in Mining Lease No. 2485. Flinter collected other specimens (grouped as 18951 and 18951-A) which he found scattered, together with diaspore, in alluvium lying above limestone near a north-south granite/limestone

¹ Compiled from material included in a cyclostyled circular issued by the Director of the Geological Survey, Malaysia, for internal distribution.

contact exposed in the Kean Sang Mine No. 2 (lat. $4^{\circ} 14\frac{1}{2}'$ N., long. $101^{\circ} 12\frac{1}{4}'$ E.), Temoh, Perak, only $2\frac{1}{4}$ miles WSW. from the first locality. Another unnumbered specimen was found in the collection of spars at Geological Survey headquarters.

The specimens, which ranged in colour from very pale creamy-yellow to deep orange-yellow, formed as a coating on cassiterite in every case. They were tested for fluorescence (short-wave ultra-violet, 2537 \AA) before being sent to the Principal of the Mineral Resources Division, Overseas Geological Surveys, in London, for determination. Two of the specimens (19384-A, 19384-B) gave a bright yellowish-green fluorescence and this material has been proved recently, by Dr. G. F. Claringbull and Dr. R. J. Davis of the Natural History Museum in London, to be a new calcium-tin-silicate mineral species with the composition $\text{CaO} \cdot \text{SnO}_2 \cdot \text{SiO}_2$ (CaSnSiO_5). This mineral, which Alexander has named *malayaite*, was first mentioned when still unnamed in Malayan Geological Survey Memoir no. 9 (p. 105) (abstr. Amer. Min. **46**, 768-769) and a full description will be published shortly. Optically malayaite appears colourless in the crush, biaxial negative with a large optic axial angle, and with a mean refractive index of about 1.78. Three of the other specimens (19384-C, 19384-D, 19384-F) gave no fluorescence and qualitative tests showed the material here to be a silicate containing appreciable quantities of alumina; spectrographic examination revealed the presence of Al, Si, Mg, Li, Na, and (?)Be as major constituents. Optically this mineral appeared colourless in the crush, but biaxial negative with a small optic axial angle, high birefringence, and a mean refractive index of about 1.62. With cleavage at right angles to the optic plane, and approximately straight extinction, these specimens were concluded to be representatives of the mica group.

The Mineral Resources Division (personal communications) found difficulty from the outset in confirming the tentative identification of varlamoffite for the remaining non-fluorescent encrustation specimens (19384, 19384-E, 19384-G, 18951, 18951-A, and unnumbered) because of the 'indefinite nature of varlamoffite itself'. They stated that: from the published descriptions available it is evident that X-ray data are by no means conclusive [in proving varlamoffite to be a distinct mineral species] and the semi-colloidal nature of analysed varlamoffites is confirmed by ill-defined optical characteristics; the chief evidence for its identity as a separate mineral species appears to rest largely on its chemical composition. The non-fluorescent yellow encrusting material from Malaya was found to contain about 79 % SnO_2 and 11 % H_2O ,

with subsidiary amounts of silica, alumina, and ferric oxide, and the unnumbered specimen of the mineral darkened to a rusty-red colour on calcination, 'probably due to the dehydration of limonitic or ochreous impurity, which seems to be irregularly distributed'. Optically, the mineral appeared as a fine-grained birefringent aggregate with an average refractive index of about 1.81. The Mineral Resources Division concluded that tentatively it could be referred to as varlamoffite, and later X-ray diffraction work has shown that the Malayan material is the same as the type varlamoffite, giving a poorly defined X-ray diffraction pattern similar to that of cassiterite, but showing certain minor differences identical with those reported by Niggli (1953) in his diffraction work on type varlamoffite from the Congo.

However, this investigation has thrown some doubt as to the validity of varlamoffite as a mineral species, an opinion expressed by Prof. C. O. Hutton (Stanford) in 1956 (personal communication) after he had been presented with a specimen of Malayan varlamoffite similar to that studied in London. Having examined this briefly, he wrote: I am beginning to wonder if varlamoffite should be considered a valid species and if instead it is not merely microcrystalline cassiterite.

In 1960, summarizing the results of his studies, Hutton wrote (priv. comm.): Several years ago I made a very brief and incomplete study of varlamoffite, but the inadequate data obtained will not permit me to be dogmatic about the problem. However, let me outline the data that I do have recorded in my notebook under the commencing date October 15, 1954.

First of all I studied a golden yellow mineral from France that was amorphous (no diffraction phenomena), and under the mistaken assumption that I was dealing with a metamict mineral, I provided heat-treatment in vacuo. After treatment at 840° C for one hour, the product yielded a good, but diffuse pattern. When this was carefully measured, taking into account the diffusivity of the lines, the *d*-spacings did not depart significantly from those determined for pure tetragonal SnO₂ or cassiterite. After a second sample of the amorphous golden yellow mineral had been heated in vacuo at 1280° C for one hour, it yielded a powder pattern that was identical with cassiterite in every respect. This would suggest that the yellow mineral was varlamoffite, but of course, I did not have any indication of the *exact* constitution of the mineral. Following this, I X-rayed a yellow coating on a sample of cassiterite from Sungei Lah, Chenderiang, Perak, and without heat-treatment I obtained a diffuse powder pattern with *d*-spacings and

relative intensities identical to those yielded by the yellow French mineral after having been heated to the lower temperature. High-temperature treatment in vacuo of the Perak mineral gave a perfect cassiterite pattern. Accordingly, I came to a tentative conclusion that the original yellow minerals were microcrystalline or cryptocrystalline cassiterite. This is as far as my own work went.

Previously Buttgenbach (1950) had concluded that the available description of the Congo varlamoffite (Buttgenbach, 1947) was much more complete and authentic than the Bolivian souxite of Herzenberg (1946) and remarked that X-ray patterns obtained from the Congo varlamoffite were identical with those of synthetic metastannic acid. Gastellier (1950) gives an account of the chemical composition and properties of the Congo material and suggested that some of the ferric iron may exist in some sort of combination with stannic oxide. Russell and Vincent (1952) remarked that all the materials contain comparable amounts of ferric oxide, which may have some significance, and the authors agreed that further research would be most desirable.

As far as can be ascertained from the few published works on varlamoffite the following facts emerge: the mineral is essentially a hydrous oxide, with as much as (so far known) 10 % Fe_2O_3 and minor amounts of Al_2O_3 and SiO_2 ; the specific gravity is approximately 3; and the X-ray powder diffraction pattern is very similar to that of cassiterite, although the lattice parameters are measurably distinct; however, the lines are broad, ill-defined and diffuse.

Russell and Vincent (1952, pp. 823-824), studied material from Cornwall as well as Varlamoff's type material from the Congo, both of which were derived from stannite. Commenting on the Cligga mine (Cornwall) material, they say: As far as can be made out, the pattern of the analysed material from the Cligga mine shows no lines which are not part of the cassiterite pattern.

Although they apparently regard varlamoffite as a valid species, they conclude (p. 824) that: some degree of hydration of stannic oxide, then, *does not cause a re-arrangement of the cassiterite crystal structure* [our italics], and it seems probable that the 'combined' water in these materials is held by a tenacious surface absorption on to particles of stannic oxide of almost colloidal dimensions. . . .

Niggli (1953), on the basis of extensive experimental work, subscribes to the view that the iron and water are present as partial replacements of Sn by Fe and O by OH respectively, and that, to the limited extent so far found (10 % Fe_2O_3), this partial replacement does not destroy the

cassiterite structure, although there is a measurable distortion, a being increased and c decreased. From this and other evidence he considers varlamoffite to be a legitimate distinct mineral species with the formulae $(\text{Sn,Fe})(\text{O,OH})_2$. From Niggli's work it appears certain that partial replacement, and not mechanical admixture (of Fe_2O_3 and H_2O), does occur, but the presence of some Fe and (OH) replacing Sn and O respectively, does not provide the licence to establish a new mineral, provided structures are comparable, and this appears to be the case.

It is obvious that much more work is needed to resolve this whole question, and it is the purpose of this note to bring out this need in the hope that further work will be undertaken by those familiar with the subject. In the meantime, it appears that the term 'varlamoffite' will continue to be used. The following criterion, adapted from a proposal in 1960 by Hutton (pers. comm.), seems to be an excellent one—to employ the term varlamoffite for cryptocrystalline yellowish material consisting predominantly of Sn and H_2O that may yield a diffuse powder pattern comparable to, or closely resembling that of cassiterite but does yield a powder pattern identical to that of cassiterite after heat-treatment at about 1200°C .

Acknowledgements. In conclusion the authors wish to record their appreciation of assistance given by Mr. J. D. Hellings of Messrs. Osborne and Chappel in presenting the first specimen of Malayan varlamoffite and allowing the subsequent collection of additional mineral specimens, some of which have proved to be other minerals, including the hitherto unknown species of calcium-tin-silicate; by Mr. W. A. Tooke, Chief Chemist, Geological Survey, for doing the chemical analysis on the first specimen; by Mr. G. E. Howling and Mr. E. H. Beard, consecutive Principals of the Commonwealth Institute, Overseas Geological Surveys, for arranging over a period of several years the confirmatory identification by chemical, optical, and X-ray work; by Prof. C. O. Hutton, Stanford University, for his laboratory work and subsequent comments; by Prof. A. Safiannikoff in providing a sample of type varlamoffite to the Commonwealth Institute for standard comparison; by Dr. Nagelschmidt of the Safety in Mines Research Establishment for doing X-ray powder photographs; and by Dr. G. F. Claringbull and Dr. R. J. Davis of the Natural History Museum, London, for much detailed confirmatory X-ray work.

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[*Manuscript received 21 April 1965*]
