aries (main growth layers) and many individual screw dislocations which are widely distributed (local growth layers), whereas those of natural emeralds originate from either clusters of screw dislocations (basal faces) or a few single screw dislocation points (prism faces).

4. Growth spirals of the two show different morphologies.
5. Many impurity crystals are observed on the surfaces of natural crystals, but not on the synthetic crystal.

From these observations the differences in growth conditions between the two emeralds can be conjectured as follows:

1. Since spiral growth layers will have closer spacings when spirals are formed under higher supersaturation and *vice versa,* it is concluded that synthetic emerald has grown under much higher supersaturation conditions than natural emeralds.
2. Closer spacings of growth layers also suggest that synthetic emerald has grown more rapidly than natural emerald.
3. Synthetic emerald has grown from purer solutions than has the natural species.
4. Synthetic emerald has undergone stronger stresses than natural ones during growth.

In conclusion, synthetic emerald can be easily distinguished from natural crystal under the reflection or phase contrast microscope, so far as they show growth crystal faces. Such differences in surface structures of crystal faces are derived from the differences in growth conditions between the two emeralds.

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REFERENCES

SUNAGAWA, I. (1962) Mechanism of growth of hematite. *Am. Mineral.* **47,** 1139–1155.

TOLANSKY, S. AND I. SUNAGAWA (1959) Spiral and other growth forms of synthetic diamonds; A distinction between natural and synthetic diamond. *Nature,* **184,** 1526–1527.

——— (1960) Interferometric studies on synthetic diamonds. *Nature,* **185,** 203–204.

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RE-EXAMINATION OF "STRUVERITE"—A FURTHER NOTE

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In a paper on "struverite" from Malaya published in *The American Mineralogist* (Flinter, 1959) I found (p. 622–3) that although the original assay by Crook and Johnstone showed the mineral to be Ta-rich, my material was Nb-rich. From this I concluded that either my material was not representative of the original sample or that the original analysis was incorrect, and ventured the opinion that "all available evidence indicates the latter possibility."

However, an additional sample (Federation of Malaya GS No. 3220) from the same area was located more recently by my colleague, Mr. S. MacDonald. This sample consists of single crystals and parts of crystals of cassiterite (60%) and Ta/Nb-rutile (40%), ranging in size from 1–5 mm, but averaging 2–3 mm. Separate analyses of twelve of the grains confirm the original analysis by Crook and Johnstone and make it sufficiently evident that this is the same material as their original sample, differing from the samples I used in my earlier paper. The analyses gave the following ranges:

TiO_2	38.00–55.07%
Ta_2O_5	16.14–38.56%
Nb_2O_5	8.83–13.30%
FeO	9.22–10.58%
SnO_2	1.41– 3.32%

In all cases Ta_2O_5 exceeds Nb_2O_5.

The question of the SnO_2 content is interesting. While Crook and Johnstone dismissed as a mechanical impurity the 2.67% SnO_2 they found therein, and I did the same from lack of evidence to the contrary, Mr. MacDonald, who had been studying the ionic substitution of Sn in various minerals, felt this to be incorrect. It is interesting to note that, although mechanical admixture does occur in many of the grains in sample GS: 3220, it is essential to include with the $(Ta, Nb)_2O_5$ much, if not all, the SnO_2 found in the twelve analyses, in order to obtain anything like a good fit in the structural formulae.

The rediscovery of the original sample material of Crook and Johnstone, however, does not invalidate my findings regarding the original ASTM powder data card 2-1354, for "struverite" (p. 626). It is evident that the sample used for this card was the same as that used by me and the pattern remains discredited as a mixture of rutile and ilmenite, the correct pattern being a rutile one with a slightly increased and c_0 increasing with Ta/Nb content, thus being similar to the "ilmenorutile" pattern given in ASTM 2-1353. This has now been published as ASTM powder data card 11-396 which, however, fails to emphasize the fact that it is basically a rutile pattern.

In addition to the normal rutile pattern I found (p. 626–631), with a higher Ta/Nb content, a more complex pattern, which I considered to be a bi-rutile one, but which could equally be interpreted as a mixture of rutile and columbite phases (ASTM 11-397). Although all the twelve samples analyzed from GS: 3220 were within the compositional range in which this more complex pattern would be expected, not one of them showed it. They all gave normal rutile patterns, with slight increases in d-spacings.

The interesting point that emerges here is that it would appear that a considerable amount of Ta can occur in the rutile structure without affecting it in any way, whereas an appreciable amount of Nb affects it considerably and, in fact, could lead to a breakdown into a rutile (tetragonal) phase and a columbite (orthorhombic) phase, a point which, unfortunately, I have been unable to resolve as yet. If this is the case, that while Ta can tolerate a tetragonal structure, Nb cannot, we have a strong pointer, well worth further investigation, to the reason why $FeTa_2O_6$ can occur as the tetragonal form tapiolite, but that mossite, the niobium equivalent, is unknown. It would further appear, from published literature (Berry and Mason, 1959, p. 370) that a similar state of affairs also applies to Mn in the (Fe, Mn) $(Ta, Nb)_2O_6$ series.

In conclusion I wish to thank Mr. S. MacDonald, Principal Geologist (Economic Geology), for drawing my attention to this rediscovered sample, Mr. Leong Pak Cheong, Acting Assistant Director (Geochemistry), for providing the chemical analyses, and Dr. J. B. Alexander, Director, Geological Survey of the Federation of Malaya, for permission to publish this note.

REFERENCES

BERRY, L. G. AND MASON, B. (1959) *Mineralogy.* W. H. Freeman and Co., San Francisco.

FLINTER, B. H. (1959) Re-examination of "struverite" from Salak North, Malaya: *Am. Mineral.* **44,** 620–632.

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ON THE ORIGIN OF ANOMALOUS ETCH PITS IN MINERALS

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In their studies of etch figures on mineral surfaces, crystallographers have long been puzzled by so-called "anomalous" etch pits which extend deeper below the surface than is usual. Honess (1927) reviewed some of the earlier observations. Since then, Lovell (1958) has reported etched "beaks" in apatite, and Patel and Tolansky (1957) and Patel and Ramanathan (1962, 1963) have studied and suggested origins of isolated, deep etch pits in mica. It has been recently discovered that linear regions of radiation-damaged material are naturally produced and preserved in many minerals, and that these regions have an enhanced chemical reactivity (Price and Walker, 1962, 1963; Fleischer and Price,