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.

**Acknowledgment**

The writer expresses his thanks to Prof. Z. Harada, Drs. K. Sakurai and R. Weiner for the loan of the specimens.

**References**


correct, 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:

<table>
<thead>
<tr>
<th>Element</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>TiO₂</td>
<td>38.00–55.07%</td>
</tr>
<tr>
<td>Ta₂O₅</td>
<td>16.14–38.56%</td>
</tr>
<tr>
<td>Nb₂O₅</td>
<td>8.83–13.30%</td>
</tr>
<tr>
<td>FeO</td>
<td>9.22–10.58%</td>
</tr>
<tr>
<td>SnO₂</td>
<td>1.41–3.32%</td>
</tr>
</tbody>
</table>

In all cases Ta₂O₅ exceeds Nb₂O₅.

The question of the SnO₂ content is interesting. While Crook and
Johnstone dismissed as a mechanical impurity the 2.67% SnO₂ 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 sam-
ple GS: 3220, it is essential to include with the (Ta, Nb)₂O₅ much, if not
all, the SnO₂ 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 John-
stone, 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 c₀ in-
creasing 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 FeTa₄O₈ 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)₂O₈ 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


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ON THE ORIGIN OF ANOMALOUS ETCH PITS IN MINERALS


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,