The Tetartohedrism of Ullmannite.

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ALTHOUGH all the modes of hemihedrism possible in the cubic system have been found to occur among minerals, no mineral belonging to that system has yet been proved to be tetartohedral like sodium chlorate, and the nitrates of barium, strontium and lead.

There has, however, been some evidence in favour of the tetartohedral character of Ullmannite since the examination of the crystals from Lölling in Carinthia, and those from Sarrabus in Sardinia. The former were found by Zepharovich[1] to be distinctly tetrahedral in form and habit, the latter were found by Klein[2] to be distinctly pyritohedral. Zepharovich found the specific gravity of the Lölling Ullmannite to be 6·72, while Klein found that of the Sardinian crystals to be 6·803 – 6·883, and for this reason it was at first thought that the two occurrences might be different modifications of the antimono-sulphide of nickel; there was also considerable discrepancy between the two analyses.

But subsequently Klein and Jannasch[3] re-examined the Ullmannite from both localities, and found them to be identical both in composition and specific gravity. This necessitates one of two conclusions: either NiSbS is dimorphous, occurring both in a tetrahedral and also in a pyritohedral modification, or the mineral is tetartohedral. The latter is the more natural supposition; but it is not easy to understand why the crystals should be so distinctly tetrahedral in one locality and pyritohedral in the other, without combining the two characters in either.

I have had no opportunity of examining crystals from Lölling, but the description of Zepharovich makes it perfectly clear that they are not only tetrahedral but are also interpenetrating twins in which the mode of

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[1] *Lotos* (1870), 20, p. 4.

[2] *Neues Jahrbuch*, 1883 (1), p. 180.

[3] *Neues Jahrbuch*, 1887 (2), p. 169.

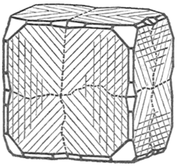
twinning restores a holohedral aspect to the tetrahedron as in the case of diamond.

Now, it is evident that this complementary twinning about the dodecahedral axes will simulate the holohedral character both in the tetrahedron and the pyritohedron ; the latter is exemplified by the interpenetrating twins of iron pyrites.

It seemed probable, therefore, that a more careful examination might reveal traces of tetartohedrism and of twinning on the crystals from Sarrabus.

Here, as in the case of other opaque minerals, the surface striæ afford the most available clue to the compound nature of the crystals. In his first description of the cubes of Ullmannite from Sardinia, Klein mentions a well-marked striation similar to that of pyrites. In the second description he mentions that there is also to be seen here and there a striation parallel to the octahedron, and this was also observed by Seligmann.

The Sardinian specimens in the British Museum show the above characters, but the octahedral or diagonal striations on the cube faces exhibit the following peculiarities :—The faces are broken up into a number of distinct fields, upon some of which the striæ are parallel to one diagonal alone, while upon the remainder they are parallel to the other diagonal. It is evident then that each of these fields is a portion of a single crystal of at most tetrahedral symmetry, and that these crystals are twinned together about the dodecahedral axes.



The external appearance of the Sardinian cubes is represented, somewhat idealised, in the adjoining figure, which sufficiently explains the structure of the crystals. The diagonal striæ are always perpendicular to the edge of combination with the tetrahedron. The junction of the individuals is sometimes irregular, but is more usually parallel to the cube faces, so that the crystals appear to be built up of rectangular plates. At the points of junction the cube edges have a re-entrant angle formed by small striated faces of a triakis-octahedron, having indices near $\{27.27.1\}$, inclined to the tetrahedron at an angle of 37°—40° ; these are often the only faces on the cube edges even when the latter appear to be truncated by the dodecahedron.

Since the pyritohedral striæ upon each cube face are only in one direction and traverse all the individuals, it follows that the crystals are not only tetartohedral and twinned about the dodecahedral axes, but that they consist of enantiomorphous individuals ; thus in all respects resembling the right and left handed twin crystals of sodium chlorate, in which one individual of the twin crystals exerts a dextro-rotatory and the other a lævo-rotatory action on polarised light. If two identical crystals of Ullmannite were twinned together, the pyritohedral striæ would be reproduced parallel to all the edges on each cube face.

The tetartohedrism of Ullmannite does not make it necessary to remove the mineral from the group of isomorphous disulphides and arseno-sulphides to which it is always referred, although so far as is known the remainder are pyritohedral, with the possible exception of gersdorffite and corynite. Dolomite, ilmenite and dioptase are analogous cases.

Becke[1] has suggested that the tetartohedrism of dolomite, which has been proved, both in its crystalline form and elastic properties,[2] to possess a lower degree of symmetry than calcite, is due to the lower symmetry of the molecule $\mathrm{Ca\ Mg\ (CO_3)_2}$ as compared with the molecule $\mathrm{Ca\ Ca\ (CO_3)_2}$.

But Ullmannite in its composition offers no such want of symmetry as compared with cobaltite, gersdorffite or corynite. It would be interesting should these three minerals also exhibit evidences of tetartohedrism, since their composition is less symmetrical than that of the disulphides or diarsenides. The specimens in the British Museum do not exhibit a tetartohedral character.

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[1] *Min. Mitth.* XI. p. 255.

[2] *W. Voigt. Ann. Phys. Chem.* XL. p. 642.