

4) and the theoretical composition of the first balanced formula as it appeared in Chemical Index of Minerals (column 5).

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### STRONTIOHILGARDITE-1Tc and TYRETSKITE, A STRUCTURAL PAIR

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A new formula for tyretskite,  $[\text{Ca}_2[\text{B}_5\text{O}_8(\text{OH})_2]\text{OH}]$ , is deduced which is shown to correspond closely to that of strontiohilgardite-1Tc. (Although the mineral name strontiohilgardite-1Tc (Braitsch, 1959) was disapproved of by the IMA Commission on New Minerals and New Mineral Names in 1959, no alternative name has been proposed for what is certainly a valid new mineral in the hilgardite-heidornite group.) A comparison of the unit-cell dimensions of strontiohilgardite-1Tc (Braitsch, 1959) and tyretskite (Kondrat'eva, 1964) [setting changed to follow the standard convention] (Table 1) reveals a similarity which favors an analogy between them. The unit-cell content of strontiohilgardite-1Tc is  $[(\text{Ca},\text{Sr})_2\text{B}_5\text{O}_8(\text{OH})_2\text{Cl}]$ , and the Ca: Sr ratio in analyzed

TABLE 1. CELL DIMENSIONS

Strontiohilgardite-1Tc (Braitsch, 1959)	Tyretskite (Kondrat'eva, 1964)
(triclinic, $Z=1$ )	(triclinic, $Z=1$ )
$a=6.48 \text{ \AA}$	$a=6.44 \text{ \AA}$
$b=6.608 \text{ \AA}$	$b=6.45 \text{ \AA}$
$c=6.38 \text{ \AA}$	$c=6.41 \text{ \AA}$
$\alpha=61^\circ 12'$	$\alpha=61^\circ 46'$
$\beta=60^\circ 30'$	$\beta=60^\circ 15'$
$\gamma=75^\circ 24'$	$\gamma=73^\circ 30'$

crystals is 1.08:0.92 (Braitsch, 1959, p. 239). The formula of tyretskite deduced from analysis is  $\text{Ca}_3\text{B}_8\text{O}_{13}(\text{OH})_4$  (Kondrat'eva, 1964), which is clearly unlike that of strontiohilgardite-1Tc.

Table 2 shows the analysis by M. M. Vil'ner (nee Stukalova) (*in* Ivanov and Yarzhemskii, 1954) for tyretskite and our recalculation of the formula.

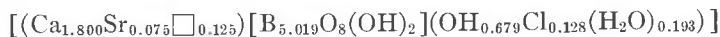
TABLE 2. RECALCULATION OF CHEMICAL ANALYSIS OF TYRETSKITE

Component	1	2	3	4	5	6	7	8
CaO	29.77	0.5308		-0.0297	-0.0531	-0.0013	0.4467	32.08
SrO	1.94	.0187					0.0187	2.49
MgO	2.14	.0531			-0.0531		—	—
Na <sub>2</sub> O	3.50	.0565	-0.1130				—	—
B <sub>2</sub> O <sub>3</sub>	43.36	.6227					0.6227	55.54
SO <sub>3</sub>	2.38	.0297		-0.0297			—	—
Cl	5.13	.1447	-0.1130				-0.0317	1.44
CO <sub>2</sub>	4.73	.1075			-0.1062	-0.0013	—	—
H <sub>2</sub> O	6.85	.3802					0.3802	8.77
Insolubles	0.54	—					—	—
R <sub>2</sub> O <sub>3</sub>	0.36	—					—	—
	100.70							100.32
--O=Cl	1.16							0.32
Total	99.54							100.00

Explanation of columns.

1. Analysis by M. M. Vil'ner.
2. Atomic proportions.
3. Halite contribution.
4. Anhydrite contribution.
5. Dolomite contribution.
6. Calcite contribution.
7. Tyretskite contribution.
8. Recalculated analysis for tyretskite after deduction of impurities.

From column 6, on the basis of 11(O, OH, Cl), the composition of tyretskite is



where  $\square$  represents unfilled cation positions with compensating water replacing (OH, Cl). Ideally, the deficiency of the divalent metals (Ca, Sr) would be accompanied by twice this amount of water in the OH positions to maintain neutrality, but this value is not obtained in our calculated formula due to the boron content deviating from 5.000. The calculated specific gravity from the cell dimensions for this composition is 2.571.

The analyzed mixture contained, after recalculating to 100 percent:

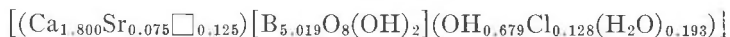
Tyretskite	78.42
Dolomite	9.84
Halite	6.64
Anhydrite	4.07
Calcite	0.13
Insolubles	0.54
R <sub>2</sub> O <sub>3</sub>	0.36
	100.00%

Table 2, column 7, gives values of the recalculated analysis for tyretskite after deduction of impurities. The empirical formula  $(\text{Ca},\text{Sr})_3\text{B}_8\text{O}_{13}(\text{OH},\text{Cl})_4 \cdot \frac{1}{2}\text{H}_2\text{O}$  agrees closely with the data in column 7, but this leads to  $Z$  being nonintegral and hence this formula is discarded. (The data in column 7 compares with that obtained by Ivanov and Yarzhemskii (1954), but the Russian workers omitted the chlorine contribution in reaching essentially the same conclusion in their recalculated analysis.) The molecular formula of tyretskite should clearly be  $(\text{Ca},\text{Sr})_2\text{B}_5\text{O}_8(\text{OH},\text{Cl})_3$ .

The structural relationship of tyretskite to strontiohilgardite-1Tc would seem to be that of: (1) substitution in part of Ca by Sr but to a smaller degree than in strontiohilgardite-1Tc, and (2) partial substitution of Cl by OH, although it is evident from this interpretation that this OH group is not present in the borate polyanion group, the complex being as in heidornite (von Englehardt *et al.*, 1956; Burzlaff, 1967).

#### DISCUSSION

The specific gravity calculated from the unit-cell dimensions for the composition



is 2.571, whereas the measured specific gravity is only 2.189. It is possible that the experimental value is in error. The molecular weight calculated from the cell volume of 203.2 Å<sup>3</sup> and the measured specific gravity (2.189) is 267.9. This is essentially the same as that required by a hydrated calcium borate of composition  $[\text{Ca}_2\text{B}_4\text{O}_7(\text{OH})_2]$ , namely 269.5. This formula is similar to that proposed for kurgantaite,  $(\text{Sr},\text{Ca})_2\text{B}_4\text{O}_7(\text{OH})_2$ , but the X-ray powder data of tyretskite are in better agreement with those of strontiohilgardite than those of kurgantaite. Hence, greater similarity is to be expected between the structures of tyretskite and strontiohilgardite than between tyretskite and kurgantaite. The published analytical data, suitably processed to deduct impurities, are unlikely to be in such error that  $[\text{Ca}_2\text{B}_4\text{O}_7(\text{OH})_2]$  becomes more accept-

able than  $[\text{Ca}_2\text{B}_4\text{O}_8(\text{OH})_3]$ . Nevertheless, a discrepancy in the density measurement coupled with a smaller error in the chemical analysis could satisfactorily produce the ideal formula  $[\text{Ca}_2[\text{B}_5\text{O}_8(\text{OH})_2]\text{OH}]$  for tyretskite.

The presence of 6.64 percent halite seems curious in a water insoluble mineral, and it may be that in tyretskite, as in heidornite, NaCl is present as a part of the structure and not as halite impurity. The similarity in the cell dimensions of tyretskite and strontiohilgardite-1Tc suggests, however, that this is unlikely and that the error lies in the experimentally determined specific gravity.

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## MORE DATA ON GREIGITE

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It seems likely that many more occurrences of greigite ( $\text{Fe}_3\text{S}_4$ ) will be found until the species is quite well known. A specimen of the mineral of superior quality was recently obtained from a mineral dealer in Agua Prieta, Sonora, and the information obtained from the sample is the subject of this brief note. The locality of the specimen was given only as Zacatecas.

The paragenesis in this specimen is as follows: early pyritohedral pyrite gradually becoming more cubic in habit is followed by marcasite and then greigite. The early pyrite is associated with sphalerite and galena in a gangue of creamy dolomite. Pyrite in the gangue is partly replaced by very fine grained marcasite whereas pyrite euhedrons on the dolomite are partly replaced by well crystallized marcasite. Calcite