

The ratios of the analysis of kernite are:  $\text{Na}_2\text{O}:\text{B}_2\text{O}_3:\text{H}_2\text{O}$  = 365 : 729 : 1472 or 1.00 : 1.99 : 4.02, the formula for kernite being  $\text{Na}_2\text{O}\cdot 2\text{B}_2\text{O}_3\cdot 4\text{H}_2\text{O}$ . Not quite half the water is readily given off at  $110^\circ$  and only three-quarters of the total water is lost up to  $200^\circ$ , there being no swelling of the mineral at this temperature.

The relationships of the water content and physical and optical properties of kernite and the other hydrates of  $\text{Na}_2\text{O}\cdot 2\text{B}_2\text{O}_3$  (borax and "octahedral" borax, the 5-hydrate) are being studied. Crystallization of a water solution of kernite yields 1.39 times as much borax.

---

## NOTES AND NEWS

### THE CRYSTAL STRUCTURE OF SILVER SULFIDE

L. S. RAMSDELL, *University of Michigan.*

X-ray data indicate that at ordinary temperatures the two minerals argentite and acanthite, both with the composition  $\text{Ag}_2\text{S}$  and supposedly dimorphous, have identical structures,<sup>1</sup> which are probably orthorhombic.  $\text{Ag}_2\text{S}$  has an inversion point at about  $180^\circ\text{C}$ ., and a recent experiment<sup>2</sup> indicates that above this temperature the substance gives a cubic diffraction pattern. The described pattern appears to agree with a body-centered cubic structure, and it is assumed, therefore, that the heavier Ag atoms occupy positions at the corners and center of the unit cube. Because of their relatively slight diffraction effects the positions of the lighter S atoms could not be determined. The length of the unit cube is given as 4.84 A. U., and the calculated density is 7.2 (Dana 7.2-7.3)

It is evident from an examination of the data that this structure cannot be correct. The coordinates of the two Ag atoms would be 000 and  $\frac{1}{2}\frac{1}{2}\frac{1}{2}$ , and the one S atom would be in some other position. But due to the symmetry the only possible points where a single atom could be located in a cube are either 000 or  $\frac{1}{2}\frac{1}{2}\frac{1}{2}$ . Since these positions are already occupied by Ag atoms, the structure is impossible. In addition to this, if the density is 7.2, a cube of the dimensions stated must contain two molecules of  $\text{Ag}_2\text{S}$ , or four atoms of Ag and two of S, and some arrangement other than a body-centered cube would be necessary to provide the necessary number of positions for the Ag.

The comparatively meagre data (only four lines were measured in the pattern) are hardly sufficient for a satisfactory proof of the structure, but there are indirect means of determining at least a probable structure. Although  $\text{Cu}_2\text{S}$  is orthorhombic at ordinary temperatures,  $\text{Cu}_2\text{Se}$  is cubic, and could reasonably be supposed to be isomorphous with the cubic form of  $\text{Ag}_2\text{S}$ . Davey has shown that  $\text{Cu}_2\text{Se}$  has the  $\text{CaF}_2$  type of structure,<sup>3</sup> which requires four molecules in the unit cube.

<sup>1</sup> Ramsdell, L. S.: Crystal structure of metallic sulfides. *Am. Mineral.*, **10**, 286 (1925).

<sup>2</sup> Emmons, R. C., Stockwell, C. H., and Jones, R. H. B.: Argentite and acanthite. *Am. Mineral.*, **11**, 326 (1926).

<sup>3</sup> *Phys. Rev.*, **21**, 380 (1923).

Assuming this structure to be the correct one for  $\text{Ag}_2\text{S}$ , there would be four atoms with a face-centered cubic arrangement, but they would be too light to materially affect the pattern. The eight Ag atoms would be located at the centers of the eight small cubes made by dividing the unit cell by the three principal planes of symmetry. These heavier Ag atoms by themselves possess a simple cubic arrangement, with the side of the cube one-half that of the true unit cell. The four lines of the diffraction pattern fit this simple cubic structure equally as well as they do the body-centered cube, with a value of 3.40 A. U. for the side of the small cube, or 6.80 A. U. for the side of the true unit cell.

However, a cube of this size, containing four molecules, gives a calculated density of about 5.2, as compared with 7.2 for  $\text{Ag}_2\text{S}$  at room temperatures. There is no justification for using the value of 7.2 as the density of the cubic form, for not only would there be some decrease in density with the increased temperature, but there would probably be a greater change due to the structural inversion. However, this change from 7.2 to 5.2 does seem abnormally large. The writer made several attempts to determine the density of  $\text{Ag}_2\text{S}$  above  $180^\circ\text{C}$  by a modified pycnometer method. The results did not check very closely, but all indicated a considerable decrease in density, with an average of about 6. Until a better determination of the density at  $180^\circ\text{C}$  can be made, there can be no direct proof of any structure.

The relative intensities of the four lines of the pattern are estimated to be 3, 10, 6, and 2, while the calculated intensities for this  $\text{CaF}_2$  type of structure are 5.5, 10, 2, and 2. With the exception of the third line, this is an excellent agreement. Intensities have been calculated for the  $\text{Cu}_2\text{O}$  and  $\text{FeS}_2$  types of structure (both of which have the same number of atoms in the molecule as  $\text{Ag}_2\text{S}$ ) and for a cube-centered arrangement of Ag atoms, and none are in agreement. For example, the  $\text{Cu}_2\text{O}$  type would have two intense lines from planes 111 and 311, in addition to the four actually present, while with a body-centered type the first line would be four times, and the third line two times as intense as the second line. Accordingly, if the  $\text{CaF}_2$  type is not correct, then  $\text{Ag}_2\text{S}$  must possess a structural arrangement different from anything yet found for a compound of the type  $\text{R}_2\text{X}$ .

Since  $\text{Ag}_2\text{S}$  does exist in a cubic form, it has been suggested<sup>4</sup> that argentite and acanthite represent distinct mineral species. Both names are so well established that it may be desirable to retain them, but it should be pointed out that although it is possible to consider  $\text{Ag}_2\text{S}$  above  $180^\circ\text{C}$  as a separate mineral to which the name argentite is to be applied, this is of theoretical interest only. The practical conclusion to be drawn is that all specimens which are labelled "argentite" are in reality acanthite, paramorphs after argentite.

---

#### ARTIFICIAL FLUORITE

DONALD C. STOCKBARGER, *Rogers Laboratory of Physics,*  
*Massachusetts Institute of Technology.*

The value of fluorite having high transparency to ultraviolet radiation of short wave lengths is great enough to warrant an attempt to produce it in the laboratory. To this end the writer and his students have made several trials by fusing chemically pure calcium fluoride in an electric furnace.

<sup>4</sup>Emmons, Stockwell, and Jones: *Am. Mineral.*, 11, 326 (1926).