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THE CLEAVAGES OF BeO AND OTHER MINERALS  
HAVING THE WURTZITE STRUCTURE<sup>1</sup>

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In the course of studies on the mechanical properties of minerals having the wurtzite structure, cleavages were encountered which were in disagreement with those described by Palache *et al.* (1944, Vol. I) and more recently by Wolff and Broder (1959, 1960). A re-examination of the cleavage behavior was undertaken on single crystals of five wurtzite-type compounds by orienting and embedding them in Canada balsam and subjecting them to percussion normal to the base and again normal to the prism. In each case the pattern of cracks radiating outwards from the point of impact was examined under the microscope at magnifications up to 1000 $\times$ . In general, a particular crack was found to follow a curving path with discontinuities in course which indicated preferred directions of fracture. The angular bearings of these preferred directions were tabulated and plotted together with the traces of the crystal faces indexed by x-ray diffraction. The cleavages inferred from such data for the several compounds are listed in Table 1 together with published data for comparison.

The most striking result centers around the  $\{11\bar{2}0\}$  cleavage which appeared in all of the crystals examined. In ZnS(H) it is the dominant cleavage, as Palache *et al.* also note, without, however, observing the second prismatic cleavage  $\{10\bar{1}0\}$ . Wolff and Broder, on the other hand, finding only one of the prismatic cleavages in ZnS(H), described it as  $\{10\bar{1}0\}$ , but did not explain how they indexed it. In all of the other minerals, the order of the prismatic cleavages is reversed, the  $\{10\bar{1}0\}$  being much easier than the  $\{11\bar{2}0\}$ , which Palache *et al.* do not mention at all, but which Wolff and Broder observe in every case but that of zincite.

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TABLE 1. CLEAVAGES IN MINERALS OF THE WURTZITE STRUCTURE

Compound	Palache <i>et al.</i>	Wolff and Broder	This work
BeO (bromellite)	{10 $\bar{1}$ 0} distinct		{10 $\bar{1}$ 0} good {11 $\bar{2}$ 0} poor {0001} poor
ZnS (wurtzite)	{11 $\bar{2}$ 0} easy {0001} difficult	{10 $\bar{1}$ 0} {0001}	{11 $\bar{2}$ 0} good {10 $\bar{1}$ 0} poor {0001} poor
ZnO (zincite)	{10 $\bar{1}$ 0} perfect, difficult {0001} parting, sometimes distinct	{10 $\bar{1}$ 0} {0001}	{10 $\bar{1}$ 0} good {11 $\bar{2}$ 0} poor {0001} poor
CdS (greenockite)	{11 $\bar{2}$ 2} distinct {0001} imperfect	{10 $\bar{1}$ 0} {11 $\bar{2}$ 0} {0001}	{10 $\bar{1}$ 0} good {11 $\bar{2}$ 0} poor {0001} poor
CdSe		{10 $\bar{1}$ 0} {11 $\bar{2}$ 0} {0001}	{10 $\bar{1}$ 0} good {11 $\bar{2}$ 0} poor {0001} poor

The BeO and ZnO crystals were obtained from Dr. Herbert Newkirk of Lawrence Radiation Laboratory and were prepared using a flux technique. The ZnS, CdS and CdSe were obtained from Harshaw Chemical Company (courtesy Dr. Gunther Wolff).

The poor {0001} cleavage is common to all of the minerals studied, in agreement with Wolff and Broder. Palache *et al.* do not list the {0001} cleavage for bromellite. For zincite they describe it as parting. Inasmuch as the rigorous criterion of symmetry is not applicable to the base, this distinction between parting and cleavage in zincite must be assumed to rest on observation of specimens which did not appear to show the basal effect.

Differences are to be expected in the cleavage behaviors observed when fracture is effected by different methods, as Tertsch (1949) has pointed out. Most methods of test strain the structure prior to failure; consequently the fractures obtained indicate the directions of weakness of distorted structures. Percussion most nearly reveals the bonding strengths in the unstrained crystal. This difference may sometimes reverse the relative importance of cleavages. In the case of halite, for example, the well-known cubic cleavage predominates in fracture by pressure, while dodecahedral cleavage is easiest under percussion. The method of study by which the data of Palache *et al.* were obtained is not known. Wolff and Broder bounced crystal spheres off the interior wall of a SiC wheel in the

case of CdS and CdSe but they do not specify which of their three methods were used with the other crystals.

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## APPARATUS FOR CONTROLLED-ATMOSPHERE DIFFERENTIAL THERMAL ANALYSIS OF CORROSIVE MATERIALS

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## INTRODUCTION

While investigating the effects of regional metamorphism on sulfide minerals, the writer had occasion to design equipment with which to obtain differential thermal analyses of sulfide minerals in a controlled atmosphere. Although Stone (1952, 1954, 1960) has developed equipment for dynamic controlled-atmosphere differential thermal analysis, and Kopp and Kerr (1957) and Dunne and Kerr (1960) have devised equipment which enabled them to obtain differential thermal analyses of corrosive materials such as sulfides and arsenides in a non-dynamic system, there have been few differential thermal analyses of corrosive materials in continually-replenished atmospheres of controlled compositions. It is hoped that the following description of the equipment developed by the writer will be of some value to others engaged in differential thermal analysis work with corrosive compounds.

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## DESCRIPTION OF APPARATUS

Because of the corrosive effect of the sulfur gases on metals, both the sample block and the thermocouple beads were designed so no metal surfaces would be in contact with the internal atmosphere of the reaction chamber during a "run." The two cylindrical sample wells in the type 304 stainless steel sample block (Fig. 1) were lined with 97.6% alumina ceramic ("Wesgo AL-300") tubing which was internally tapered at both ends and cemented in place with alumina ("RA 1355 Alundum") cement. The thermocouple wells, which were cylindrical openings in the sides of