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Boehmite exsolution in corundum

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Abstract

The pronounced parting observed in much corundum has traditionally been attributed to twinning. This study identifies boehmite as occurring in seams along the $\{10\bar{1}1\}$ parting directions. Corundum's parting is, therefore, due to the weakness of the boehmite–corundum contact. The boehmite is believed to be a product of exsolution.

Introduction

Judd (1895) precisely described the partings of corundum and classified them into three distinct sets: a basal {0001} (Judd's {111}), a rhombohedral $\{10\bar{1}1\}$ (Judd's {100}), and a hexagonal prismatic $\{11\bar{2}0\}$ (Judd's $\{10\bar{1}\}$). He disputed the then widely published view that these partings were cleavages. Because of the lack of X-ray diffraction and the electron microprobe, and because the range of samples available was somewhat limited, Judd failed to recognize the true nature of the parting in corundum. He was also, unfortunately, preoccupied with the effect of weathering, attributing the parting to this process.

In his summary Judd states "Taking all these facts together, we are led to conclude that corundum has at least three sets of structure-planes, but that none of these can be regarded as true *cleavage*. Two of these structure-planes, those parallel to O*R* {111} and to OO*P*2 $\{10\bar{1}\}$, are normal solution-planes; the third set of structure-planes, those parallel to *R* {100}, are gliding planes, which, when developed, become secondary solution-planes."

Modern textbook descriptions of the physical properties of corundum do not differ greatly from one another. Thus it is common to find a statement such as "Parting ... on $\{10\bar{1}1\}$ due to twin lamination, often prominent" (Palache *et al.*, 1944, p. 522) or "Twinning on $\{10\bar{1}1\}$ is common, often in lamellar seams or as glide twins ... Twinning also occurs on {0001}, and this plane is sometimes visible as a basal parting." (Deer *et al.*, 1962, p. 14). The familiar rhombohedral and basal parting of some corundum is, therefore, tersely dismissed as being a product of twinning.

I have examined a great number of twins of many, many species over many years. One feature characterizing all of these twins is the tenacity of the bond along the twin plane. Twin planes are not planes of weakness along which parting may be expected to occur, let alone to occur with ease. On the contrary, most twinned crystals that have been broken have ruptured at points other than along the twin plane. One must question, then, the theory that the easy parting of much corundum is in any way related to twinning.

Investigation

Three localities in the United States have been prolific sources of large corundum crystals with prominent rhombohedral and/or basal parting: Hogback Mountain (Jackson County) and Buck Creek (Clay County), North Carolina, and Laurel Creek mine (Rabun County), Georgia. Specimens from all three localities were examined under magnification. The traces of the incipient parting planes formed a network of parallelograms (inclined nets) on any surface along which parting had occurred (Fig. 1). Most striking is the near uniform width of the rows of rhomboid segments in any one direction. This uniformity is unlike that of bands attributed to twinning through gliding in the rhombohedral carbonates, which appear to be completely random in their widths.

In this section, the parting surfaces are not simply planar fractures but are actually thin seams of what appears to be another mineral. The interference colors of the mineral comprising the seams are different from those of corundum. The mineral also shows an

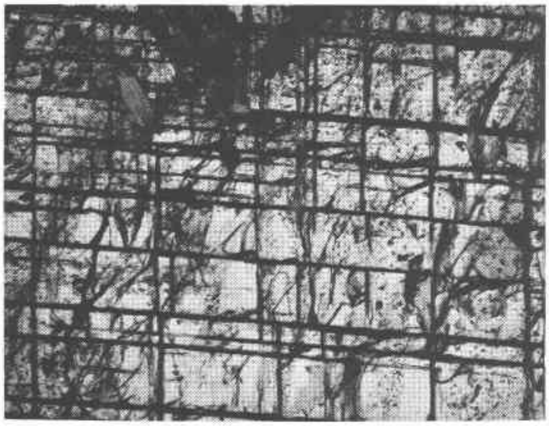

Fig. 1. Corundum in thin section showing the network of boehmite seams. The light-colored chlorite crystal (upper left) is about 0.5 mm long. Smithsonian specimen NMNH #81922 from Hogback Mountain, North Carolina.

aggregate structure and does not go uniformly to extinction when the stage is rotated.

Within the thin-section are several crystals of chlorite completely surrounded by corundum. The parting seams end abruptly at the chlorite/corundum interface, which is not interrupted, indicating a lack of mechanical deformation of the corundum. Therefore, it seems apparent that the parting is not related to twin gliding.

The seams along the parting surfaces are extremely thin, mostly from 0.01 to 0.05 mm. One, nearly 0.1 mm thick, was analyzed with the electron microprobe. Elements sought included Si, Al, Fe. Mg, Ca, K, Cu, Sn, and S. The data were corrected with Bence/Albee factors.

The corundum is relatively pure; four different points gave Al_2O_3 analyses of more than 99 percent. Traverses of the sample which passed across several of the seams produced lower alumina analyses, ranging from a low of 74 to a high of 92.7 weight percent, with an average value of approximately 87 percent (Fig. 2). Only very minor amounts of other metals were detected in either phase, yet a definite enrich-

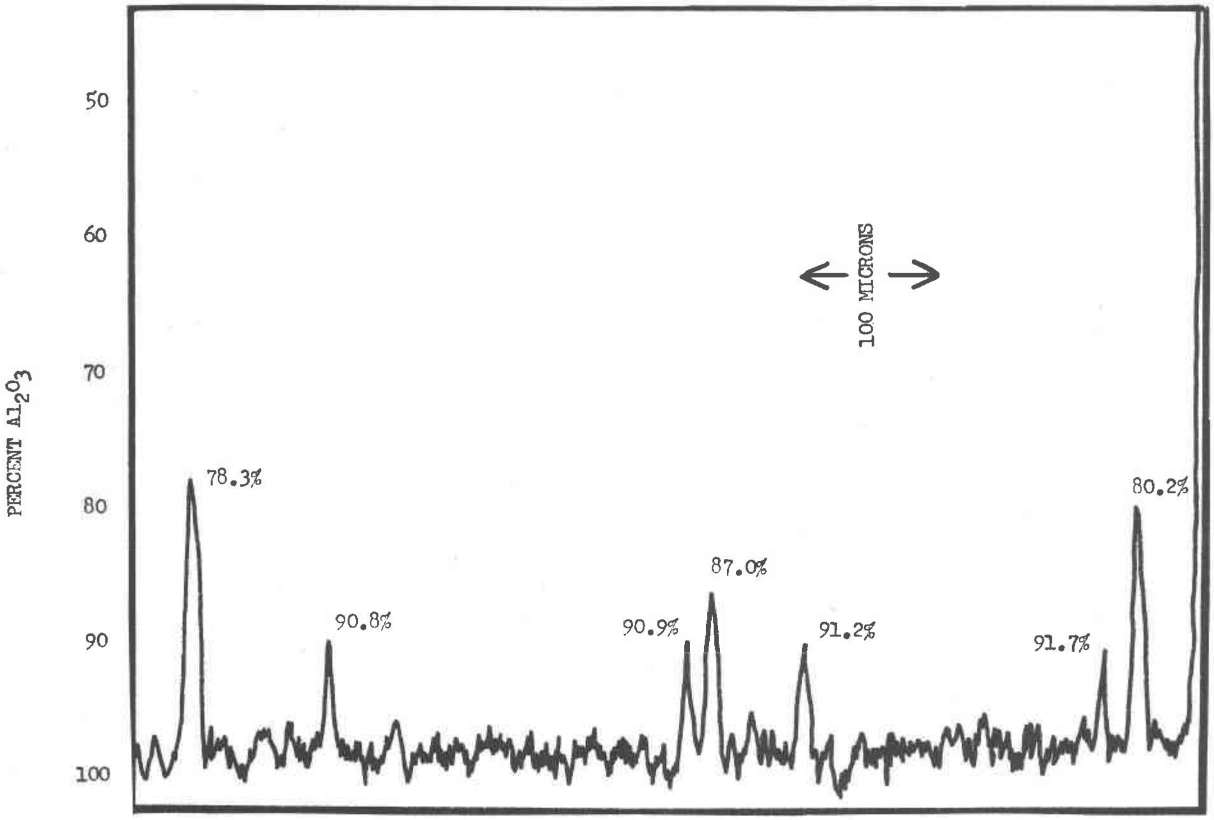

Fig. 2. Trace of a continuous microprobe analysis of Hogback Mountain corundum showing less alumina over boehmite seams.

ment of Si and Mg in the seam was noted (0.2 and 0.03 percent respectively, while essentially absent in the corundum). FeO, averaging 0.5 percent, was about equal in both phases.

Having failed to identify the mineral in the seams through chemical analysis, a search was made for a sample containing seam material thick enough to be sampled for X-ray diffraction. One specimen, also from Hogback Mountain (NMNH #81922), contained particularly promising seams, several of which could be loosened and crushed in place on the corundum surface with a fine probe. A sample was collected on a tiny fiber and X-rayed in a Gandolfi camera with nickel-filtered copper radiation. The pattern produced was that of corundum superimposed over boehmite. The boehmite lines were narrow and intense, allowing an unambiguous identification of the seam mineral.

Ideal boehmite [AlO(OH)] contains 85 percent Al_2O_3, which means that the 87 percent average we obtained by microprobe is high, but it is reasonable that corundum on either side of the narrower seams will have the effect of increasing the alumina values. The lower values (in the range of 74 percent) are problematic but may represent accumulations of other aluminum-poor phases within the seams of boehmite.

Discussion

This study shows that boehmite occurs in some corundum crystals in extremely thin films along the planes of the rhombohedron $\{10\bar{1}1\}$. These films comprise zones of weakness which produce a sharp and distinct parting in the three rhombohedral directions. There is no evidence to support the theory that twinning is responsible for the pronounced parting. If, on the other hand, the lamellae were produced by alteration, their contact with the corundum would not be fresh and sharp, and a higher degree of alteration would be seen on the outer portions of the crystals than in the middle. Therefore, it seems likely that these boehmite lamellae must result from exsolution. In this sense corundum may be analogous to magnetite with its {111} parting, which is likely due to exsolution of ilmenite and segregation along octahedral planes, and also analogous to ilmenite which is known to part on the rhombohedron $\{10\bar{1}1\}$ along what must certainly be segregations of exsolved magnetite, hematite, or rutile. A Smithsonian magnetite specimen (NMNH #134971) from New York (locality unspecified but probably Mineville, Essex County) which shows prominent octahedral parting also contains a network of lamellae in section. One lamella was X-rayed, giving an ilmenite pattern. The phenomenon is widely recognized in other species, particularly in augite where orthopyroxene lamellae are found parallel to {100} and pigeonite lamellae parallel to {001}, the latter often resulting in excellent parting.

Acknowledgments

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References

Deer, W. A., R. A. Howie and J. Zussman (1962) *Rock-Forming Minerals,* Vol. 5. Wiley, New York.

Judd, J. W. (1895) On the structure-planes of corundum. *Mineral. Mag., 11,* 49–55.

Palache, C., H. Berman and C. Frondel (1944) Dana's *System of Mineralogy,* 7th ed., Vol. 1. Wiley, New York.

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