THE AMERICAN MINERALOGIST, VOL. 42, SEPTEMBER-OCTOBER 1957

IMAGE PROJECTION BY FIBROUS MINERALS

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An optical property of ulexite, $NaCaB_5O_9 \cdot 8H_2O$, was brought to the writers' attention by Mr. John Harmon in the summer of 1956. Transverse sections of parallel fibrous aggregates of ulexite project an image of an object against one surface to the opposite surface. This effect is shown in Fig. 1. Since we could find no reference in the mineralogical literature to this phenomenon, although known for synthetic fibers; it was thought desirable to report on this optical property.

Microscopic studies of the images made it evident that the optical effect was due to the reflections along the twinned fiber interfaces. The most prominent twinning plane in ulexite is (010) with its poles intersecting at an angle of 35°. Narrower and more closely spaced twins may be superimposed on the former and are possibly twinned on (100). Width of the twins ranges from 0.06 mm. for the widest to 0.005 mm. for the narrowest. A thin-section cut perpendicular to the fibers shows the fibers to have an irregular serrated outline giving a mosaic texture. The areas of the fiber cross-sections vary from 0.06 mm.^{2} to 0.75 mm.^{2} The interfaces act as reflecting surfaces due to the different indices of refraction that exist across them. The light rays which impinge on the interface well below the critical angle, emerge from the side of the crystal aggregate; so when viewed from the side near the transverse surface, the aggregate is translucent.

The image is projected (*a*) whether the light comes from above only with the object on an opaque surface and with the sides of the crystal aggregate covered, (*b*) whether the light comes only from below through a partly transparent object, or (*c*) whether the light is reflected off the surface and to the transverse surface of the tilted section. In cases (*a*) and (*b*) the image is not changed in size; in case (*c*) the height of the image is reduced as a function of the angle of inclination. If the object is colored, all colors are reproduced in the image. The surfaces do not have to be parallel, but if they are not, a distortion in size of the image will result. Parallel surfaces cut perpendicular to the fibers will produce the best image, but a rough image can be seen even on the as-found mineral specimen.

Once it was noted that the image resulted from reflections along the fiber interfaces, other fibrous minerals were sought which exhibited the same optical effect. Such minerals were found in trona, $Na_2CO_3 \cdot HNaCO_3 \cdot 2H_2O$, and halotrichite, $FeSO_4 \cdot Al_2(SO_4)_3 \cdot 22H_2O$, and undoubtedly there are many others. The mosaic texture of the compact fiber aggregates of trona was very similar to that of the ulexite. The width of the twins and the areas of the fiber cross-sections in the trona specimen cover the same range as the ulexite, and the image produced was identical.

The image projected by the halotrichite was much sharper and darker than those of the ulexite and trona. However, the fiber aggregate was very friable and only small transverse sections were obtained for examination. The twins in the halotrichite range in width from 0.001 mm. to 0.005 mm., and the areas of the cross-sections of the fibers ranged up to only 0.007 mm.^{2} maximum.

Discussion

It seems unusual that this optical phenomenon of fibrous mineral aggregates had not been noted and described previously, but such seems to be the case. It is unlikely that these three fibrous minerals are the only ones that will project an image. Satin spar gypsum crudely exhibits the effect, but in the specimen at hand the fibers were too coarse to transmit a good image. The sharpness of the image will be a function of the thickness of the fibers, and the best images will be projected by those aggregates with fibers of small cross-sectional area. The halotrichite with very fine fibers showed a much better image than the trona and ulexite with coarser fibers. This also can be noticed in different areas of a crystal aggregate where there are patches of fine and coarse fibers. The sharpest image is observed when looking directly down the fibers. The image becomes progressively more diffuse, and finally disappears to the eye, as the angle from the vertical is increased.

The effect of transmitting light along a bundle of synthetic fibers is by the same mechanism. If the end of a glass rod is placed on an object, a badly distorted image can be noticed on the opposite end. The essential factors are the existence of different indices of refraction at the fiber interfaces to produce reflection of the majority of the light rays; and that the fibers are of small enough diameter to produce a good image, since the resulting image is the sum total of images produced by each fiber.

Acknowledgments

We gratefully acknowledge the persons who generously gave of their specimens, M. E. Blessing, U.S.G.S., Salt Lake City, Mr. Carl Austin, Mr. M. Leonardi, American Potash Corp., Trona, Calif., Mr. G. Dub, California Borate Co., Boron, Calif., and especially Mr. Harmon, who made us aware of this phenomenon in minerals. Mr. D. A. Buckner, graduate student in the Department of Mineralogy, assisted in the field collections. The photographic work was done by Mr. J. Nelson. Project

G-2934 of the National Science Foundation and the University of Utah Research Fund provided financial support for the study.

Addendum

Since this manuscript was submitted, an article describing and illustrating this effect has appeared, as follows:

Dietz, Ralph W. (1957), Television ulexite: Gems and Minerals, No. 232, 16–17.

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THE HYDRATION OF KERNITE ($Na_2B_4O_7 \cdot 4H_2O$)[1]

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New observations and other data from the literature have led us to conclude that kernite ($Na_2B_4O_7 \cdot 4H_2O$) hydrates directly to borax ($Na_2B_4O_7 \cdot 10H_2O$) without going through the tincalconite ($Na_2B_4O_7 \cdot 5H_2O$) phase, and that the many specimens of kernite that seem to have altered directly to tincalconite all once contained borax, which itself has dehydrated to tincalconite. Our evidence for these conclusions is presented below.

In their study of the system $Na_2B_4O_7$—H_2O, Menzel, Schulz, and others (summarized by Menzel and Schulz (1940)), showed that kernite hydrates to borax without going through the tincalconite phase, which is metastable. Gale (1946), in his work in the Kramer district, where kernite occurs, noted that kernite "is . . . altered to a later regeneration of tincal [sic] in places, especially as seen in zonal envelopes surrounding and retaining the outer forms of individual kernite crystals." Gale's observation serves as a starting point for our work.

In the mines at Kramer, most of the kernite crystals have a crystalline shell (Gale's envelope) around them. In the older workings, these shells, as seen in cross section on mine walls, are nearly all tincalconite that is white and easily distinguished from the clear cores of kernite. In more recent workings and in fresh cuts made into older mine walls, however, the shells are clear borax. We dug into the walls where kernite was rimmed with tincalconite and found that these shells gradually passed into massive clear borax farther away from the mine walls. All this sug-

[1] Publication authorized by the Director, U. S. Geological Survey.

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