

# THE AMERICAN MINERALOGIST

JOURNAL OF THE MINERALOGICAL SOCIETY OF AMERICA

VOL. 9

DECEMBER, 1924

No. 12

## ISOTROPIC QUARTZ<sup>1</sup>

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It is commonly stated that substances which are isometric and those which are amorphous are isotropic, while all other substances are anisotropic. The purpose of this note is to show that the second part of such a statement is not true in all cases, since hexagonal, and, doubtless all other types of crystals, may be isotropic.

A rock sample from the Bates iron mine at Iron River, Michigan, contained material, not easily recognized, which led to the discovery of isotropic quartz. A thin section showed that the rock was composed of some recognizable quartz in microscopic veinlets and in very small isolated irregular areas scattered through a groundmass which was in large part entirely isotropic. The recognizable quartz passed by all gradations of size into mere points of light in the groundmass. Measurement of the section by the Rosiwal method showed that more than half of it was isotropic.

In order to learn the nature of this isotropic material the rock was next studied in powdered form in immersion liquids and the index of refraction of the isotropic substance was found to be  $1.54 \pm 0.01$ . This result showed that the substance was not rhyolite glass (index 1.48–1.50), nor silica glass (index 1.46), nor opal (index 1.41–1.46). A partial chemical analysis of the rock was then carried out by Mr. H. G. Taylor, who found that it contained about 0.5% H<sub>2</sub>O, and that the anhydrous material contained about 98% SiO<sub>2</sub>, while the 2% residue was quite red with iron.

<sup>1</sup> If an isotropic substance is one which produces no visible double refraction when examined microscopically between crossed nicols, then this quartz is isotropic. On the other hand, if an isotropic substance is one whose smallest units, even though invisible, theoretically produce no double refraction then this quartz is doubtless only apparently isotropic. It is common practice to call substances isotropic, which produce no microscopically visible double refraction.

These results suggested that the isotropic substance might be quartz in such a fine state of division that it did not produce polarization, but nevertheless was distinctly crystalline and not amorphous. In order to test this idea the powdered rock (freed of the larger quartz units and, therefore, decidedly more than half isotropic) was next tested by X-ray methods. Since it was impossible to eliminate all the birefringent quartz from the powder the test was made by comparative methods. One half of the tube which was to be exposed to X-rays was filled with the powdered rock and the other half with pure powdered quartz. The first half of the tube produced the pattern shown in the upper part of Fig. 1, while the second half produced the X-ray pattern shown in the lower part of the same figure. It is evident that the powdered rock not only produced exactly the same X-ray pattern as the pure quartz, but actually produced sharper and brighter lines than the latter. From other X-ray work it is known that the finer the state of division of a powder, the sharper and brighter are the lines produced in the X-ray pattern. Also, any crystalline material in a powder in more than certain minimum amounts will give its own X-ray pattern, and the intensity of this pattern will depend upon the relative amount of the particular kind of crystal (which is producing it) present in the powder. Amorphous material like glass produces no X-ray pattern. If an amorphous powder is mixed with a crystalline powder the X-ray pattern of the latter is correspondingly reduced in sharpness and brightness.

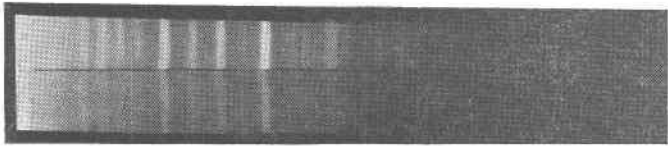


Fig. 1. X-ray patterns produced by powdered rock from the Bates mine (upper part) and by pure powdered quartz (lower part).

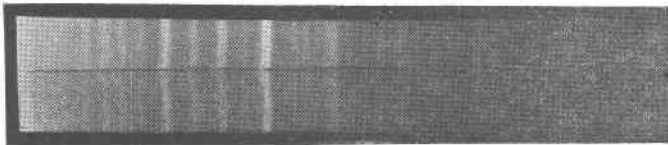


Fig. 2. X-ray patterns produced by pure powdered quartz (upper part) and a mixture of 50% quartz and 50% opal (lower part).

To make the conclusion plainer another tube was filled, one half with pure powdered quartz and the other half with a mixture in equal parts of powdered quartz and powdered opal. This tube gave the patterns shown in Fig. 2, the upper part being produced by the pure quartz and the lower half by the mixture of quartz and opal. It is easily seen that the pure quartz produces a pattern both sharper and brighter than the mixture, though the patterns are otherwise alike, since the mixture contains only one kind of *crystalline* powder.

It is believed that these results demonstrate that the isotropic portion of the rock in question is not amorphous, but is actually quartz, as truly crystalline as that which is anisotropic, although the crystal units must be too small to produce any birefringence, and must, therefore, be small as compared with the thickness (0.03 mm.) of a thin section; they are, however, large as compared with a wave length of the X-ray. Since the thickness of a thin section is about 50,000 times as great as an X-ray wave length, there is a wide range of sizes possible for isotropic quartz.

It is highly probable that many other substances which have been considered amorphous are actually well crystallized. In fact, Hull reported some time ago that many so-called amorphous substances gave good X-ray patterns. Limonite is an example of such a substance. So far as known to the writer, isotropic quartz has not been observed heretofore.

The rock from the Bates mine is not only the first rock known which consists in large part of isotropic quartz, but it is also the first "chert" known from the Lake Superior region which contains isotropic silica in any form.

Cherts of other regions commonly contain more or less isotropic material which has been referred to opal. The observations here recorded, together with the very low tenor of water in these cherts, suggest that isotropic quartz may be wide spread in such rocks.