X-RAY DETERMINATION OF THE SILICA MINERALS IN SUBMICROSCOPIC INTERGROWTHS

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When tridymite and cristobalite are found in isolated grains or in relatively coarse intergrowths, they can easily be identified with the microscope. But, when they occur in submicroscopic intergrowths with feldspar, as often found in spherulites and the groundmass of lavas, they defy the ordinary means of identification; and whether a given rock is reported to contain cristobalite or tridymite may be largely a matter of personal opinion or prejudice. The purpose of this paper is to outline a method of determining the silica minerals when found in these intimate intergrowths, and to show the applicability of the method in analyzing the submicroscopic groundmass of lavas.

X-ray powder photographs[1] taken of quartz, tridymite, and cristobalite are shown in Fig. 1. Each gives a pattern that is sufficiently characteristic to distinguish it from the others. Consequently, the identification of an undetermined form of silica may be made merely by the direct comparison of its powder-picture with those of the known minerals. If the unknown mineral is part of an intergrowth, identification is less certain, for a more complex pattern results. However, each of the silica minerals gives one or more strong lines characteristically spaced, and may be recognized even when the picture is complicated by other lines. In this manner Kuno[2] was able to point out the presence of cristobalite in the groundmass of certain Japanese volcanics.

In order to make a graphic comparison of the powder photographs, photodensitometer records were made of them which are reproduced in Fig. 2. The line at the left of the figure marks the centers of the pictures, and each curve represents the indicated portion of the corresponding powder picture of Fig. 1. The higher the curve, the greater the blackening of the film, and thus the general downward trend of each indicates merely the tendency of the films to become less dense, due to scattered radiation, from the center outward. A sharp rise in a curve marks the position of a dark line on the film, and its height and width give respectively the density and width of the line. The density represented by a peak cannot easily be interpreted in absolute units because of the many variables that enter in, but the significant things are its distance from the center

[1] The x-ray powder photographs were taken with copper radiation. Inasmuch as they are for comparison, no filter was used, and the length of exposure was thereby reduced.

[2] Kuno, Hisashi, On silica minerals occurring in the groundmass of common Japanese volcanic rocks: *Bull. Earthquake Research Institute, Tokyo Imperial Univ.*, vol. **11**, Part 2, 1933.

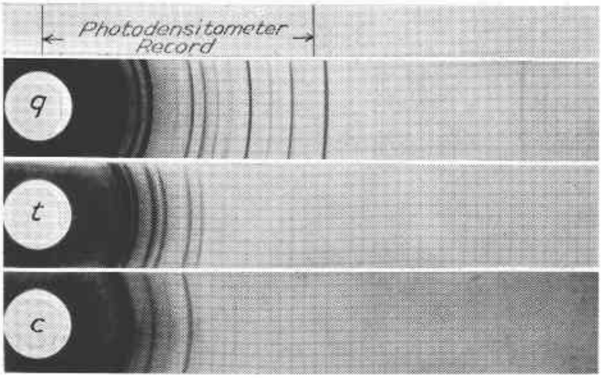

FIG. 1. X-ray powder photographs of the silica minerals taken with unfiltered copper radiation. q, Quartz; t, Tridymite; c, Cristobalite

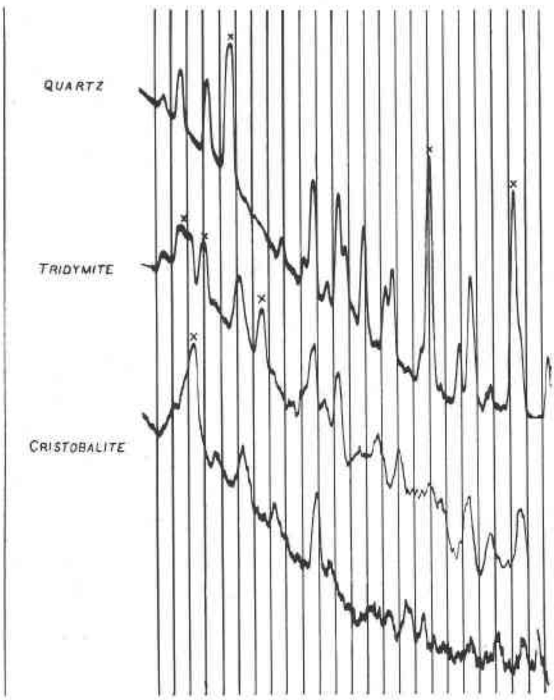

FIG. 2. Photodensitometer records of the x-ray powder photographs shown in Fig. 1.

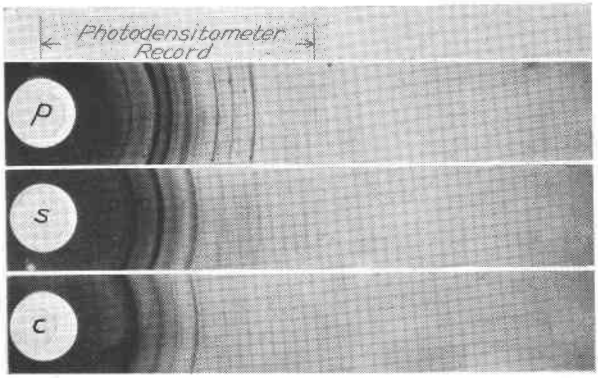

FIG. 3. X-ray powder photographs taken with unfiltered copper radiation. *p*, Perthite; *s*, Spherulite; *c*, Cristobalite.

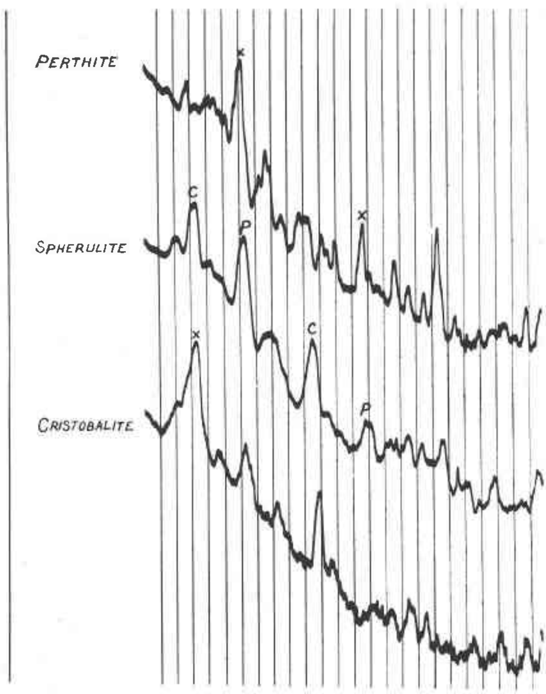

FIG. 4. Photodensitometer records of the *x*-ray powder photographs shown in Fig. 3.

and its relative height. The peaks of the curves in Fig. 2 marked with an x are considered diagnostic for each of the minerals.

X-ray powder photographs were taken of two spherulites found in New Mexican rhyolites and of the submicroscopic groundmass of two rhyolites from Colorado. In all four photographs the resulting pattern was identical, and is shown in Fig. 3(*s*).

It is generally agreed that, in addition to a silica mineral, feldspar of a composition approximating perthite is the chief constituent of these submicroscopic intergrowths. Accordingly, a powder photograph of perthite was made and is reproduced in Fig. 3(*p*) with those of the spherulite and cristobalite for comparison. The similarity of the spherulite and perthite powder pictures, as well as the corresponding photodensitometer records, Fig. 4, show that the assumed presence of feldspar is probably correct. A comparison of the photodensitometer curve of the spherulite with those of the silica minerals shows that it in no way corresponds to either quartz or tridymite, but a prominent peak in the spherulite curve falls exactly in the position of the diagnostic peak of cristobalite. The presence of cristobalite, therefore, may be reasonably inferred.

In Fig. 4, the major peaks on the spherulite curve that are believed to be caused by the presence of cristobalite are marked *c*, while those caused by the presence of perthite are marked *p*. In this manner all of the principal peaks on the spherulite curve are accounted for, and it may be concluded that felspar and cristobalite are the dominant constituents.

Acknowledgments

This study was undertaken at the suggestion of Professor E. S. Larsen with the hope of shedding light on the mineral composition of spherulites found in lavas in the San Juan Mountains of Colorado.[3] The photodensitometer records were made at the U. S. Arsenal, Watertown, Mass., through the courtesy of Dr. H. H. Lester. The writer wishes to express his appreciation for help rendered in various ways in the preparation of this paper by Dr. Harry Berman and Dr. M. A. Peacock of the Department of Mineralogy of Harvard University.

[3] Larsen, Esper S., and others. Petrologic results of a study of the minerals from the Tertiary volcanic rocks of the San Juan Region, Colorado: *Am. Mineral.*, vol. **21**, pp. 679–701, 1936.