

sist of bundles of fibers, rather than fragments of single crystals, with common *b*-axes and *a* and *c* in disorientation. Measurements of the rotation films gave an uncorrected value of 5.77 Å, but Weissenberg films for the same axis of rotation could not be interpreted.

ACKNOWLEDGMENTS

The writer is much indebted to Mr. Annan Cook and to the Directors of the Kennecott Copper Corporation for permission to record the data set out herein.

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THE AMERICAN MINERALOGIST, VOL. 44, NOVEMBER-DECEMBER, 1959

ON THE STABILITY AND SYNTHESIS OF UVAROVITE, $\text{Ca}_3\text{Cr}_2\text{Si}_3\text{O}_{12}$ *

F. P. GLASSER, *Pennsylvania State University, University Park, Pa.* †

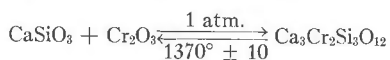
Although uvarovite is not one of the common garnets, even a relatively scarce mineral may be a valuable indicator of P-T conditions prevailing during the formation of assemblages containing that mineral. The stability limits of the indicator mineral must, of course, be known. Thus the experimental mineralogist has advanced his goal from the mere synthesis of naturally-occurring minerals to determining the P-T-X stability limits of the phase. To this end, experimenters have a wide variety of equipment permitting studies to be made at high temperature, high pressure, or at simultaneous high pressures and high temperatures. The synthesis of a mineral at some convenient pressure and temperature, however, does not necessarily provide any meaningful information. This is true in the case of several recent reports dealing with the synthesis of uvarovite.

* Contribution Number 58-127, Mineral Industries Experiment Station, College of Mineral Industries, Pennsylvania State University, University Park, Pennsylvania.

† Present address, Chemistry Dept., University of Aberdeen, Old Aberdeen, Scotland.

Synthesis of uvarovite was first reported by Hummel (1) who prepared it by heating an oxide mixture at several temperatures between 885° and 1490° C. Uvarovite was produced at temperatures up to 1400° C., but not at 1490° C. In a later investigation, Glasser and Osborn (2) confirmed this synthesis of uvarovite, and delineated its stability role in the system CaO-Cr₂O₃-SiO₂. The following facts were established:

1. The maximum stability temperature of uvarovite is 1370° ± 10° C. It is readily synthesized from a variety of starting materials, including crystalline mixtures of (CaO+SiO₂+Cr₂O₃) or (CaSiO₃+Cr₂O₃), or a gel of appropriate composition. The reaction



is readily reversible with only a small hysteresis. The temperatures reported were measured with calibrated platinum vs. platinum rhodium thermoelements, using controlled temperature furnaces for the equilibration runs.

2. No appreciable solid solution exists between uvarovite and any other component in the CaO-Cr₂O₃-SiO₂ system.
3. No evidence was found to indicate that uvarovite would again break down at lower temperatures.

This work is in contradiction with that of Geller and Miller (3), who report the synthesis of uvarovite. They prepared uvarovite from oxide mixtures at 1400° C, and also at a lower temperature. This apparently duplicates the results of Hummel, although Geller and Miller state: "The direct synthesis of this garnet has been reported by Hummel, whose results we have corroborated only in part." The more detailed study by Glasser and Osborn is not mentioned.

Hall (1958) states: "Naturally occurring high pressure minerals other than diamond that have been synthesized in recent years include the garnets: pyrope, andradite, almandite, spessartite, grossularite, and uvarovite. These garnets are easily synthesized from the metallic oxides in the presence of water at pressures ranging from 20,000 to 35,000 atm. at temperatures near 1000° C." The implication that uvarovite, like diamond, is stable only at high pressures is unfounded. Uvarovite—and several other members of the garnet series mentioned above—are "pressure independent" minerals, inasmuch as they also have a thermodynamic stability range at 1 atm. pressure. Hall was apparently unaware of the work of Hummel.

It is hoped that this note will reduce the possibility of confusion arising from recent contradictory reports in the literature concerning the stability of uvarovite, Ca₃Cr₂Si₃O₁₂.

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THE AMERICAN MINERALOGIST, VOL. 44, NOVEMBER-DECEMBER, 1959

DETECTION OF ZONING IN ORTHORHOMBIC AND
UNIAXIAL COLORLESS MINERALS

TH. G. SAHAMA, *Institute of Geology, University of Helsinki, Finland*

In minerals that are colorless or nearly so in thin section, zoning may be revealed by slight differences in refractive indices between the successive zones, by zonal arrangement of inclusions, etc. In monoclinic and triclinic crystals the zoning usually is easily seen between crossed nicols because the position of extinction varies from zone to zone. In orthorhombic and optically uniaxial crystals the detection of slight zoning is often more difficult, especially if the zone boundaries are not quite sharp but gradual. The symmetry of such crystals does not allow any variation in the position of extinction. The use of phase contrast optics with or without nicols will in some instances make the zoning more visible. A successful use of the phase contrast optics is, however, largely limited to cases where the refractive indices of the mineral do not deviate too much from that of the Canada balsam. The applicability of the phase contrast optics into the thin section mineralogy would be greatly facilitated if balsams of different refractive indices would be available. Then the thin section could be made with a balsam that gives the lowest relief with the mineral to be studied.

For studying the minerals contained in the lavas of the Nyiragongo area in the Belgian Congo, a method for detecting and visualizing zoning has been used since some time at this Institute. The method is not new in principle, but is not generally employed. The zoning in many of the main constituents, like in olivine, melilite and nepheline, is very common in the rocks of the area and is petrographically and mineralogically important. Because these minerals are orthorhombic, tetragonal or hexagonal, the zoning is visible between crossed nicols only if the variation of the birefringence is large enough to cause a detectable change in the interference color. This is the case for some of the melilites and, very