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DETECTION OF ZONING IN ORTHORHOMBIC AND UNIAXIAL COLORLESS MINERALS

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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 rarely, for some olivines. For the most rocks of the area, the differences in the interference colors between the successive zones in these minerals are too slight to be detected by simple observation between crossed nicols. In such cases the rotating (elliptical) mica compensator manufactured by E. Leitz, Wetzlar, was found useful.

The rotating (elliptical) mica compensator is mostly used in detecting and measuring very small retardations such as they are found in biological materials. As an accessory of the petrographic microscope in thin section mineralogy it is mostly neglected. The compensator is usually delivered with a mica plate having a retardation of 1/10 λ to 1/30 λ or, on the other hand, of 1/4 λ. Also thicker plates, up to 1 λ, may be used. The compensator is inserted in the usual slit under the analyzer and the mica plate may be rotated around the microscope axis. The angle of rotation can be accurately read. By turning the compensator plate and the analyzer of the microscope, the retardation may be measured according to the known methods of H. H. Senarmont or D. B. Brace. Provided that the retardation in the mineral does not exceed that of the compensator plate, the method is very accurate and sensitive and, therefore, is recommended especially for minerals with very low birefringence. Because, in contrast to the Berek compensator, the plate of the rotating (elliptical) mica compensator is turned around the microscope axis, it affects the interference color in the same amount throughout the entire crystal.

At this Institute, a 1/4 λ plate was used in the compensator. A plate thinner than that is not suitable for the purpose of studying zoning. In the elliptically polarized light caused by the compensator, the interference colors are very highly sensitive to the positions of the compensator and of the analyzer as well as to the position of the mineral itself. This high sensitivity makes it possible to detect and visualize the extremely slight differences in birefringence between the successive zones. The experience gained has shown that, once the correct positions for the mineral, for the compensator and for the analyzer have been found, a zoning often becomes visible even in crystals that, without the compensator, look completely homogeneous. If, without the compensator, a very slight indication of zoning is observed, the compensator will quite considerably strengthen it.

Because the compensator just causes a detectable difference in the colors between the successive zones, the effect is difficult to show in black-and-white photographs. In a thin section of a tinguaite from Toror Hills, Karamoja, Uganda, a nepheline phenocryst was selected that seemed suitable for photographic illustration of the effect. Fig. 1 reproduces the crystal between crossed nicols without the compensator. The zoning is extremely weakly seen in the section and hardly at all in the photograph.

Fig. 2 shows the same crystal with the same magnification and with the compensator, analyzer and crystal all turned in a most suitable position. The zoning is very strong in the section and well visible in the photograph. Measured with the Berek compensator, the maximum difference in retardation between successive zones was found to be ca. 13 mμ. Taking the thickness of the section as 0.04 mm., this difference in retardation would correspond to ca. 0.0003 in birefringence. It may be added that the differences in retardation between successive zones in nepheline, melilite etc. in the Nyiragongo area lavas that are still detectable, are considerably smaller than in the Toror Hills nepheline crystal photographed.

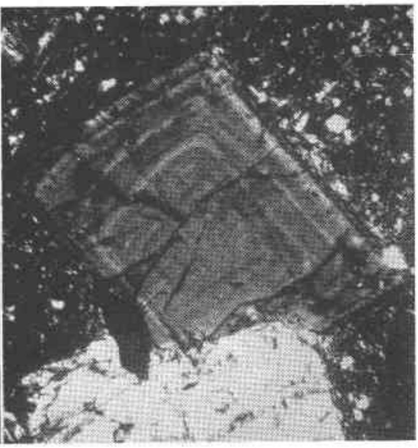

FIG. 1 (Left). Nepheline phenocryst in tinguaite, Toror Hills, Karamoja, Uganda. Nicols+. No compensator. Magnification ca. 25×. Zoning hardly visible in the photograph.

FIG. 2 (Right). The same crystal as in Fig. 1. Nicols slightly inclined. Rotating (elliptical) mica compensator in most suitable position to make the zoning visible.

In some instances it was found useful to place a gypsum plate (first order red) between the polarizer and the thin section so that it could be turned around the microscope axis. The simultaneous use of the two compensators, one below and the other above the section, was used especially on studying the zoning of higher birefringent minerals like olivine.