Besides the type of zoning just described, which is not unusual, a type of zoning was noted in the more foliated types, dependent upon the localization of perthitic intergrowths. This was observed particularly in the feldspars from the sill rock close to granitic intrusions. This type varies from clearly defined zones to much more irregular intergrowths, which, nevertheless, maintain a general zonal relationship within the crystals. This type is shown in various degrees of development in the accompanying figures.

Origin of Perthitic Zoning

The author is frankly at a loss to account for the localization of the intergrowths along zones. It might be suggested, however, that the later intrusion of the granite, which probably followed closely after the intrusion of the syenite, either maintained the initial heat of the syenite or added new heat, so that the later cooling was delayed, with the resultant unmixing of the albite from solid solution forming the perthitic intergrowths along those zones particularly rich in the albite molecule. This suggestion is analogous to the suggestions of Harker[1] concerning the formation of perthitic intergrowths during retrograde metamorphism; and if the intrusion of the later granite was accompanied by differential stresses, as appears to be the case, this might favor the separation of the perthitic intergrowths.

Acknowledgement.—The author wishes to thank Professor A. N. Winchell for criticizing the manuscript.

[1] Harker, Alfred, *Metamorphism*, p. 351, 1932.

AMYGDALOIDAL DIKES

Robert S. Moehlman, *Harvard University, Cambridge, Mass.*

Although amygdules are much less common in dikes than in lava flows, amygdaloidal dikes have been described from various localities.[1] The Colorado occurrence here described is unusual in that plagioclase feldspar is present in some of the amygdules.

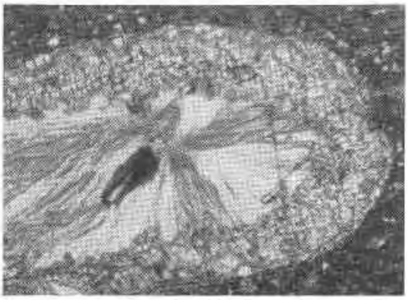
The San Juan mountains of southwestern Colorado are composed principally of Miocene volcanic rocks.[2] Seven miles west of the town of Ouray is the Stony Mountain-Sneffels Peak stock of gabbro-diorite. Associated with the stock are andesitic dikes one to fifty feet wide, intruding the volcanic rocks. Microscopic examination shows the dominant constituent of the dikes to be plagioclase feldspar in the andesine

[1] Morris, F. K., Amygdules and pseudo-amygdules: *Bull. Geol. Soc. Am.*, vol. **41**, pp. 383–404, 1930.

[2] Cross, W., and Larsen, E. S., *U.S. Geol. Survey*, Bull. **843**, pp. 50–53, 1935.

and oligoclase ranges. Some of the dikes contain minor amounts of quartz and orthoclase. The primary mafic minerals, hornblende and augite, have been almost completely altered to calcite and chlorite. Small amounts of secondary epidote and sericite occur locally.

Practically all the andesite dikes contain vesicles, most of which are filled with chlorite and calcite. In Fig. 1, a large, radial growth of calcite is in the center of the vesicle, surrounded by many rosettes of chlorite; on the border of the vesicle is more calcite.



1

2

FIG. 1. Vesicle filled with radial calcite surrounded by chlorite. Crossed nicols. ×8.
FIG. 2. Vesicle filled with calcite, quartz and plagioclase. Crossed nicols. ×10.

Plagioclase was observed in the vesicles of one member of the "Wheel of Fortune" composite dike, a porphyritic andesite exposed in Canyon Creek. Microscopic examination indicates this porphyritic andesite is really transitional between andesite and quartz latite, since the fine-grained groundmass consists of an intergrowth of quartz and orthoclase with some minute plagioclase laths and chlorite. The plagioclase phenocrysts are heavily sericitized oligoclase. The mafic minerals have well-nigh been completely altered to calcite and chlorite.

Locally, vesicles make up more than 5 per cent of the andesite porphyry. The plagioclase in the vesicles is albite-oligoclase and grows radially from the walls toward the center of the vesicle. In Fig. 2, the plagioclase crystals are perched directly on the dike material and also on an intermediate filling of quartz crystals; the interior of the vesicle is filled with calcite.

The presence of plagioclase in the amygdules suggests that higher temperatures prevailed than is ordinarily the case in the formation of amygdules. A deuteric, or late magmatic, origin with nearly magmatic temperatures seems likely for the minerals in the vesicles. The width of the dike in Canyon Creek where the plagioclase-bearing vesicles are found is several times greater than it is a few hundred feet up on the canyon walls. This rapid increase in width of the dike downward suggests that the Canyon Creek exposure is close to a larger intrusive body. Proximity to an underlying large body of magma would account for the higher temperatures prevalent when the vesicles formed. The exposure of the dike in Canyon Creek is nearly 4000 feet below Sneffels Peak, which is composed of a gabbro-diorite stock intruded at essentially the same time as the dikes. The minimum depth of cover was thus nearly a mile, making for a substantial confining pressure.

Morris has cited a number of amygdaloidal dikes and sills where the gases which made the vesicles were distilled from coals and other rocks rich in volatiles.[3] In the Colorado occurrence here described, no source is apparent for introduction of volatiles, and the gases are considered to be of magmatic origin.

[3] Morris, F. K., *op. cit.*, pp. 383–404, 1930.

BOOK REVIEW

ESSAI DE DÉTERMINATION DES PROPRIÉTÉS OPTIQUES D'UN MINÉRAL PAR LA MESURE, EN LUMIÈRE PARALLÉLE OBLIQUE, DES RETARDS EN DIFFÉRENTS POINTS D'UNE LAME CRISTALLINE. J. MÉLON. (Thése présentée à la Faculté des Sciences de l'Université de Liège.) Liège, **1934.** 108 pp., 21 figs.

In recent years American mineralogists and petrographers have begun appreciating the Fedorov stage as an excellent tool that can be put to use in various ways (optical determination of feldspars and of other minerals, double dispersion method, petrofabrics, etc.)

In the present treatise J. Mélon shows that the Fedorov stage can be utilized in still another way. He shows that it is practically possible to determine in thin sections the optical angle (2V) and all the refractive indices of a mineral, simply by measuring the retardation along several directions of the mineral. The measurements are made on a Fedorov stage with either a quartz wedge or Berek's compensator.

The exact formulae for the evaluation of the experimental data are very complicated, and in most cases only approximate formulae are therefore given. This has the advantage of materially simplifying the computations without much loss in accuracy (it should be borne in mind that the observations made with the Fedorov stage are accurate only to 1°).

Although theoretically the mineral grain may have any orientation, there are, nevertheless, distinct practical limits to the method. Results obtained from mineral grains in unsuitable positions are thus of little or no practical value. The method of Mélon cannot, therefore, generally replace any of the other methods of determining 2V and the indices of refraction, but everybody who works with the Fedorov stage should familiarize himself with the method, for it is as far as I know the only method permitting a determination of the refractive indices of a mineral *in a thin section.* A knowledge of this method may therefore, in special cases, prove itself very useful and convenient.

TOM. F. W. BARTH

Mineralogisk Institutt, Oslo.