HELIUM RETENTIVITIES OF MINERALS

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About four years ago the writer commenced critical researches to determine the limitations of the helium-radioactivity method of age determination. The first results on separated minerals from rocks disclosed the important fact that some minerals do not retain all of the helium generated within their structures during geological time.[1]

It was suggested that "it might prove advisable to direct future work to certain unaltered minerals from rocks" and that if, as indicated by the two cases presented at the time, "feldspars permit the escape of helium, absolute helium age determinations will be obtained only from certain minerals." Similarly, in a theoretical investigation[2] it was recommended that the best crystalline material available be studied, since in the absence of alteration and crystal imperfections, "ages obtained on carefully selected minerals should not differ from the true values by more than the present experimental errors of measurement." These latter were the subject of an investigation following the experiments on separated minerals.[3]

Since the preparation of these papers, more than a hundred age determinations have been made by the writer. The results on minerals separated from fifteen different rocks have confirmed the earlier conclusions and have given an idea of relative helium retentivities of different minerals. A brief summary of results is presented herewith, and when time permits, the data will be discussed in greater detail.

The ability to retain helium varies from mineral to mineral. All of the feldspars investigated by the writer were found to have lost more than half of their helium, sometimes more than ninety per cent. On the other hand, certain minerals with close-packed structures such as magnetite and unaltered pyroxenes and amphiboles, appear to retain helium. Quartz showed variable retentive properties, the least loss being found in younger unmetamorphosed granites. Preliminary average retentivities, calculated from the relative retentivities combined with geological and reliable radioactivity age data are as follows: feldspars, $\frac{1}{4}$; quartz, $\frac{1}{3}$; mica, $\frac{1}{2}$; rocks, $\frac{2}{5}$; pyroxenes, $\frac{3}{4}$; hornblende and magnetite, about 1. The actual helium retentivity of one type of mineral may, however, vary over fairly wide limits. The changes in retentive properties from mineral to mineral, and even in the same mineral under similar conditions, explain some ap-

[1] Keevil, N. B., *Am. Jour. Sci.*, **46**, 406–416 (1938); *Nature*, **143**, 324 (1939).

[2] Keevil, N. B., *Proc. Am. Acad. of Arts and Sci.*, **73**, No. 11, 311–359 (1940).

[3] Evans, R. D., Goodman, C., Keevil, N. B., Lane, A. C., and Urry, W. D., *Phys. Rev.*, **55**, 931–946 (1939).

parently spurious helium values found for rocks in the writer's laboratory and elsewhere.[4,5,6]

Some measurements after various mechanical and thermal treatments of rocks over periods of time, have indicated a surprising degree of retention of helium, while others have shown a pronounced loss. Some of these discrepancies can be traced to differences in the mineral assemblages and in the geological histories of the rocks.

While some ferromagnesian minerals and magnetite yield results which seem to approximate the true age most closely, some evidences of excess helium, whether original magmatic helium or otherwise, have been found in these minerals, so that even these age results must be interpreted with care.

To get the most from helium-radioactivity studies, detailed investigations of the separated minerals should be made, but in many cases the geochronological problem does not require such effort. The type of specimen to be studied, the type of problem to be solved, often suggests a simpler approach. With the data accumulated in the writer's laboratory it has been found that the helium index of the rock is sometimes sufficient, at least for the initial approach, although in other cases studies of specific unaltered minerals are necessary.

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[4] Holmes, Arthur, and Paneth, F. A., *Proc. Roy. Soc. London,* **A154,** 385–413 (1936).

[5] Urry, W. D., *Chem. Rev.*, 305–343 (**1933**).

[6] Keevil, N. B., *Trans. Roy. Soc. Canada,* Sec. 4, **32,** 123–150 (1938); *Bull. Geol. Soc. Am.*, December meetings, **1938,** and unpublished data.

Dr. Kenneth K. Landes, Professor of Geology at the University of Kansas since 1933 and Director of the Kansas Geological Survey, has been appointed Chairman of the Department of Geology, at the University of Michigan.

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