

The interstitial and replacive allanite in the main body of the intrusion has identical optical properties to that which occurs in the veins and cavities and it is almost certain that they were both formed during the same phase of crystallization.

Its petrogenic importance lies in its replacement of the K-feldspar component of the microperthite. Many forms of microperthite of igneous origin are believed to have formed by solid unmixing of a high temperature, homogeneous alkali feldspar during the post-magmatic phase (Tuttle and Bowen, 1958). Previously, little evidence has been forthcoming regarding the precise stage at which such unmixing occurs or the length of time which the process requires. The allanite replacements in the Tan-y-Grisiau microgranite suggest that unmixing was completed before hydrothermal minerals began to crystallize and suggests, therefore, that in some instances, at least, unmixing may belong to an early, relatively high temperature post-magmatic phase.

The reason for the selective replacement of K-feldspar by allanite in the Tan-y-Grisiau microgranite is uncertain, but it is significant that near the northwestern margin of the intrusion, where volatiles were concentrated, all of the K-feldspar is converted into muscovite, indicating its complete instability in the presence of large quantities of volatiles.

ACKNOWLEDGEMENTS

I wish to express my thanks to Professor A. Wood and Dr. W. J. Phillips, Department of Geology, University College of Wales, Aberystwyth, for their helpful discussion.

REFERENCES

- FEARNSIDES, W. G. (1910) Report of excursion to North Wales. *Proc. Geol. Ass.* **21**, 368-390.
- RANKAMA, K. (1954) *Isotope Geology*. London.
- SILVER, L. T. AND M. GRUNENFELDER (1957) Alteration of accessory allanite in granites of the Elberton area, Georgia. (abs.) *Geol. Soc. Am., Bull.* **68**, 1796.
- TUTTLE, O. F. AND N. L. BOWEN (1958) *Geol. Soc. Am. Mem.* **74**.

THE AMERICAN MINERALOGIST, VOL. 49, NOVEMBER-DECEMBER, 1964

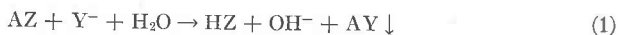
A SIMPLE IDENTIFICATION REACTION FOR ZEOLITES (MOLECULAR SIEVES)

F. HELFFERICH, *Shell Development Company, Emeryville, California.*

Natural zeolites such as chabazite, phillipsite, clinoptilolite and erionite as well as synthetic zeolites such as Linde's "Molecular Sives"

types A and X are aluminosilicates containing exchangeable cations. The crystal lattices of the zeolites have cavities and channels several Angstrom units wide, so that large cations and molecules are sterically excluded whereas small ones can pass and thus penetrate the crystals (Barrer, 1958, 1959). By conventional chemical analysis the zeolites cannot be distinguished from other aluminosilicates, for example, from clays. Distinction is possible by other techniques, particularly by *x*-ray diffraction, but these are lengthy. The unique combination of ion-exchange and molecular-sieve properties of the zeolites, however, can serve for their identification by a simple, rapid, and highly specific test reaction. The test requires only a few reagents and is readily carried out in the field.

The basis of the test is as follows. The zeolite containing an exchangeable cation A is brought in contact with a solution of salt BY, where B is a cation excluded by the zeolite and Y is an anion which forms a precipitate with A. Under these conditions, hydrolysis occurs and the solution becomes alkaline:



(Z symbolizes the aluminosilicate lattice.) Other ion-exchange materials without molecular-sieve properties do not exclude B and react without hydrolysis:



Materials without ion-exchange properties do not react at all. A pH increase thus proves the presence of zeolitic materials. Since hydrolysis occurs only if B is excluded, one can even determine the approximate channel width of a zeolite by using a scale of reagents with cations of different sizes.

Hydrolysis according to Equation 1 has been reported by Barrer and Falconer (1956) with analcite in silver form and CsCl solutions; Cs⁺ is excluded by analcite. For zeolites with larger channels, however, reagents with larger cations must be chosen. Tetraalkylammonium bromide solutions, used after silver-nitrate treatment of the sample, are suitable. If clays are present, tetra-*n*-butylammonium bromide (TBAB) should be used since N(Bu)₄⁺ exchanges most readily with clays and thus keeps interference at a minimum.

TEST PROCEDURE

Grind ca 1 g of sample and shake in test tube with 5 ml water for 1 minute. If pH is above 7, adjust with a few drops of HNO₃ under continued shaking to pH 6 to 7. Separate solid from liquid, wash with water, then shake solid with 2 ml 1 M AgNO₃ solution and let stand for 20 to

30 min (or 5 min at $>80^{\circ}\text{C.}$). Separate solid from liquid and wash solid with 5 ml water; shake solid for 5 min with 2 ml 0.5 M TBAB solution (adjusted to pH 5 to 6). Let solid settle out and measure pH of supernatant liquid. With zeolites the pH is 9 to 11, and with clays about 6.5 to 7.5.

The test described has been used with success by Dr. H. D. Curry on natural zeolites.

I am indebted to Dr. D. L. Peterson for his valuable assistance, and to Dr. E. A. Jenne for pointing out that certain nonzeolitic aluminosilicates give positive reactions with tetraethylammonium bromide reagents.

REFERENCES

- BARRER, R. M. (1958) *Proc. Chem. Soc.* 99.
——— (1959) *Brit. Chem. Eng.* 4, 267.
BARRER, R. M. AND J. D. FALCONER (1956) *Proc. Roy. Soc.* A236, 227.

THE AMERICAN MINERALOGIST, VOL. 49, NOVEMBER-DECEMBER, 1964

MAGNESIUM VERMICULITE FROM THE TWIN SISTERS MOUNTAINS, WASHINGTON

HENRI E. GAUDETTE, *Department of Geology, University of Illinois, Urbana, Illinois.*

INTRODUCTION

A micaceous mineral vein in close association with a massive chromite deposit in the Twin Sisters mountains of northwestern Washington, was found to be composed exclusively of vermiculite. This is one of a small number of occurrences of this mineral (Bennett, 1964) in the Twin Sisters range which has been formed from a relatively unaltered, coarse-grained dunite body. This vermiculite occurrence is also of interest due to its unusual mode of origin.

The general geology of the Twin Sisters area, in Whatcom and Skagit counties, Washington, and the petrology and emplacement mechanics of the Twin Sisters dunite body have been reported by Ragan (1963). The author previously has studied the compositional variations and the geochemistry of elemental distributions within the constituent mineral phases of the dunite mass (Gaudette, 1963). It was during this latter investigation that the field occurrence of the vermiculite vein was noted.