REFERENCES

HARKER, R. I., D. M. ROY AND O. F. TUTTLE (1962) Melting phenomena in the system $CaO-SiO_2-H_2O$: I. The join $Ca_2SiO_4-Ca(OH)_2$. *Jour. Am. Ceram. Soc.* **45**, 471–473.

WYLLIE, P. J. AND O. F. TUTTLE (1960) The system $CaO-CO_2-H_2O$ and the origin of carbonatites. *Jour. Petrol.* **1**, 1–46.

——— (1963) The quenching technique in non-quenchable systems: A discussion concerning the alleged thermal decomposition of portlandite at high pressures. *Am. Jour. Sci.* **261**, 983–988.

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

ALLANITE IN THE TAN-Y-GRISIAU MICROGRANITE, MERIONETHSHIRE, NORTH WALES

A. V. BROMLEY, *Dept. of Geology, University College of Wales, Aberystwyth, Wales.*

INTRODUCTION

The occurrence of allanite in veins and cavities in the northern margin of the Tan-y-Grisiau microgranite, N. Merionethshire, was noted by Fearnsides (1910). During a recent investigation of the microgranite the author has found that the mineral is not confined to such veins and cavities but occurs in reasonable abundance in accessory amounts throughout the microgranite. It has been encountered in about 50% of thin sections examined and has been found in all heavy mineral concentrates.

The physical and optical properties of the allanite are extremely variable. Much of it is partly metamict and some of that occurring in veins is altered to a number of unidentified secondary minerals, one of which strongly resembles the yellow isotropic mineral described by Silver and Grunenfelder (1957) from the Elberton granites of Georgia. The physical and chemical properties of the allanite will be described later when more work has been completed but the textural relationships of the mineral are constant and of sufficient importance to warrant separate consideration.

MODES OF OCCURRENCE OF THE ALLANITE

Allanite in the Tan-y-Grisiau Microgranite has two major modes of occurrence.

1. Allanite occurs with quartz, chlorite, calcite and locally epidote and ore minerals, in narrow veins (up to 1 inch across) and cavities (up to 1 foot across) in and adjacent to the northern margin of the intrusion. The vein and cavity fillings have a drusy texture. Individual crystals of

allanite, prismatic or tabular parallel to (b), vary in length between about 1 and 10 mm, with the larger sizes predominating. They are usually zoned (progressive or oscillatory) and many have simple twins. Some crystals have partial or complete rims of pale-coloured epidote which are in crystallographic but not in optical continuity with the allanite.

The following sequence of crystallization has been established in the veins and cavities.

i. Quartz.
ii. Allanite.
iia. Epidote (not always present)
iii. Chlorite.
iv. Calcite.
v. Ores. (Micaceous hematite, galena, sphalerite.) Not always present.
vi. Calcite.

Certain allanite crystals in the veins have suffered partial replacement by quartz and calcite. Replacement by quartz is irregular but calcite has generally selectively replaced certain zones in the allanite.

Extensive metamictization is ample evidence of the presence of radioactive elements in the allanite. Where allanite is surrounded, partly or wholly by chlorite strong pleochroic halos (about 0.1 mm wide) are developed in the latter mineral. They are so intense that nothing of their structure can be established. By far the most interesting radioactive effect associated with the allanite is the alteration of adjacent calcite (Fig. 1). In thin sections fine black "lines," originating from the margins of the allanite crystals can be seen in the calcite. They vary in length between 0.05 mm and 1.50 mm, and those originating from any one allanite are parallel and of approximately equal length. They are always closely parallel to the *b*-axes of the allanite crystals with which they are associated (Fig. 1). They vary in abundance around different allanite crystals and in some cases are so numerous and closely spaced that they render the surrounding calcite black and opaque. Generally the lines are more intense and broader at the end furthest away from the allanite crystals. In places there is a clear rim of calcite around allanite crystals (up to 0.2 mm wide) and the lines originate beyond this (Fig. 1).

This phenomenon is unlike any pleochroic halos normally associated with radioactive minerals. Indeed it resembles nothing more strongly than the alpha particle tracks seen on certain autoradiographs. Allanite is known to contain several alpha emitters including thorium and rarely uranium isotopes and the alpha active samarium isotope ^{147}Sm (Rankama, 1954). It is suggested that the lines in the calcite which enclose the allanite may represent the tracks of alpha particles. Several of their features support this hypothesis. Alpha particles are known to travel in

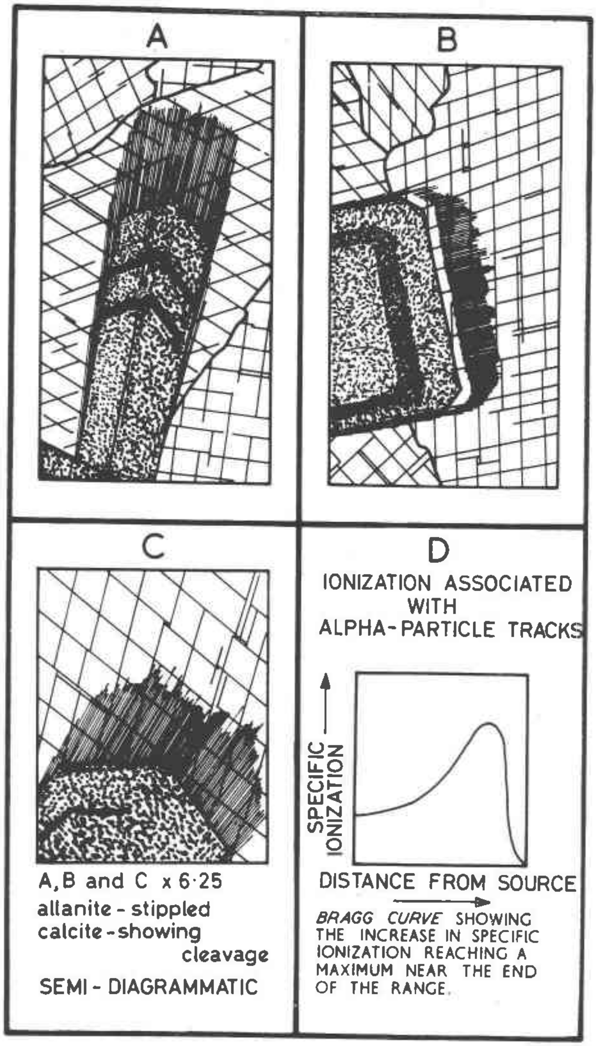

FIG. 1. (A) Zoned and twinned allanite crystal, prismatic parallel (b), surrounded by calcite in a vein pegmatite. The dark lines surrounding the allanite crystal are thought to represent the tracks of alpha particles. They are closely parallel to the (b) axis of the allanite and are of equal length.

(B) Zoned allanite crystal, tabular parallel to (b), around which the alpha particle tracks are separated from the margin of the crystal by a zone of clear calcite about 0.2 mm. wide (from the same pegmatitic vein).

(C) Zoned allanite crystal around which the alpha particle tracks are broader at the end furthest away from the crystal. This is thought to be the result of the type of ionization associated with alpha particles which reaches a maximum near the end of their range.

straight lines and the lines in the calcite are both straight and parallel. The ionization caused by alpha particles reaches a maximum near the end of their tracks (Fig. 1) (Rankama, 1954). The lines in the calcite increase in width and intensity at the end furthest away from the allanite. Whether the lines have been produced by the effect of alpha particle bombardment of the calcite itself or of some impurities contained in it (possibly iron) is not known at the present time.

2. Allanite has two closely related modes of occurrence in the main body of the microgranite.

A. It forms small, euhedral crystals, up to 1 mm in length, which are surrounded, partly or wholly, by masses of pale green chlorite. The chlorite, itself, shows evidence of having crystallized at a late stage in small cavities in the microgranite.

B. Large, irregular, interstitial masses of allanite, in a few cases up to 4 mm across, are fairly common in the main body of the microgranite.

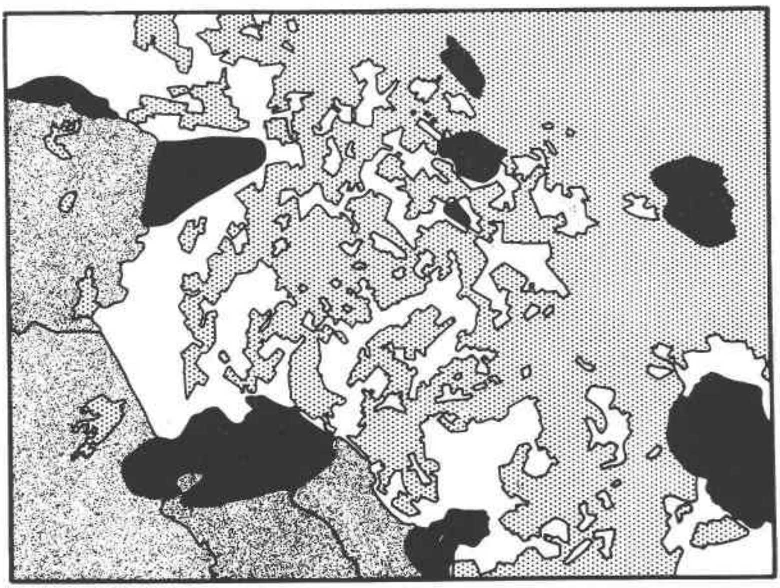

FIG. 2. (Semi-diagrammatic.) Margin of an allanite crystal in the body of the micro-granite. Internal euhedral zoning (not shown) and interstitial habit with respect to adjacent quartz and plagioclase feldspar suggest that initially the crystal had free space in which to grow. The orthoclase component of adjacent coarse textured microperthite has suffered complete replacement leaving an intergrowth of allanite and sodic plagioclase. The pre-existing microperthite texture is completely preserved.

(Allanite—dots; plagioclase component of microperthite—white; microperthite in which only a little of the Or component is replaced—stippled; quartz—black. ×6.)

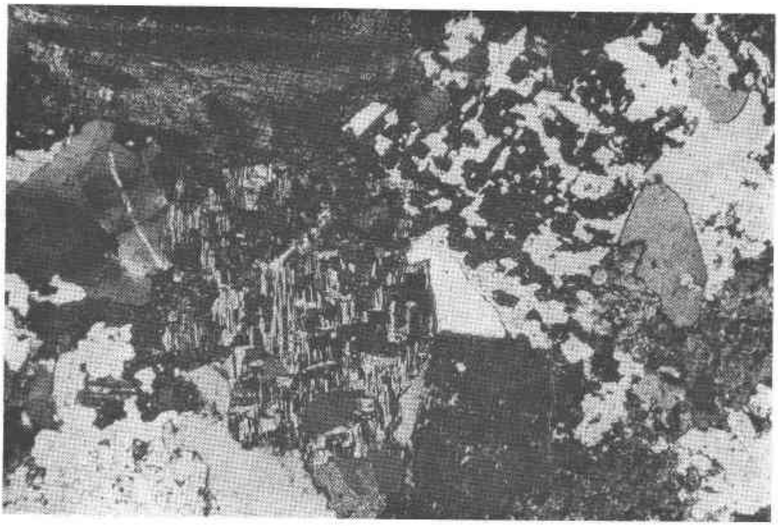

FIG. 3. Part of an interstitial and zoned allanite crystal is shown in the top, left-hand corner of the photomicrograph. The orthoclase component of two adjacent microperthite crystals has been completely replaced by allanite which is physically connected to and in optical continuity with the large interstitial crystal. (Crossed polars, ×4.8.)

Though the external morphology of these crystals is exceedingly irregular and determined by the enclosing minerals (mainly quartz and feldspars) they often have internal euhedral zones which suggest that during the initial stages of development they had free space in which to grow.

The most remarkable feature of these interstitial crystals is that allanite, optically continuous with the large masses, replaces the potash feldspar component of certain adjacent microperthite crystals (Figs. 2, 3). Such replacements only occur within 2–4 mm of the interstitial allanite. Coarse textured microperthites are most commonly affected. The allanite does not affect the plagioclase components of the microperthites except to produce faint hematitic oxidation halos in them.

Petrogenetic Considerations

A preliminary radiometric survey of the Tan-y-Grisiau microgranite, using an uncalibrated radiation monitor, has shown that radioactivity is strongest near the north-western margin of the intrusion where the allanite bearing veins and cavities occur. This seems to indicate that radioactive elements were concentrated in allanite which crystallized during the post-magmatic, volatile (probably hydrothermal) phase and not in early formed zircon which is abundant in the main body of the intrusion but extremely rare near the north-western margin.

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"