Investigations of Radiohalos from the Galway Batholith in Ireland

Sara A. Mitchell, Junior B.S. Geology Student | saraamitchell@cedarville.edu | Department of Science and Mathematics | Cedarville University | Ohio Space Grant Consortium

Abstract

Granite often has an abundance of biotite. Zircon crystals can be embedded within the biotite, and these crystals can have a high percentage of uranium in them. This makes them highly susceptible to radioactive decay. As the uranium undergoes alpha decay, the alpha particles scar the surrounding biotite and leave a spherical ring around the parent material. Radiohalos (sometimes called pleochroic halos) are, then, these radioactive scars on grains of biotite. The radiohalos, though, can only form at temperatures less than 150° C. If the temperature of the rock rises above this, the radiohalos will be essentially erased. Thus, all of the scarring must take place after the granite has cooled sufficiently. The granite under study is from a batholith near Galway, Ireland and is late-Caledonian. Under a petrographic microscope, different types of radiohalos will be counted and logged. Then a statistical analysis will be done to understand the abundance and distribution of these radiohalos. This study could have implications for the speed of cooling of the studied plutons, the nature of radioactivity, and the history of heating of the granite.

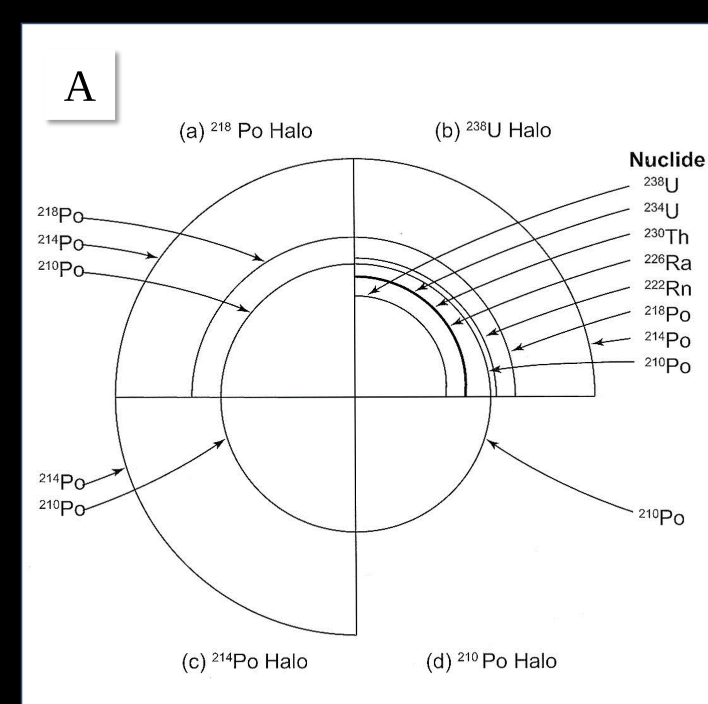
Sample	Name	Description
GBLLG-1	Lough Lurgan Granite	grayish-pink granite with approximately 1-6mm crystals
GBMMZG-1	Mixing-Mingling Zone Granodiorite	gray granodiorite with approximately 1-4mm crystals
GBMMZG-2	Mixing-Mingling Zone Granodiorite	gray granodiorite with approximately 1-8mm crystals
GBCMG-1	Costeloe Murvey Granite	pink granite with small, approximately 1-4mm crystals
GBCG-1	Carna Granite	light-colored granite with small, approximately 1-3mm crystals
GBMG-1	Megacrystic Granite	gray granite pegmatite with large distinctive K-feldspar crystals
GBETG-1	Errisberg Townland Granite	grayish-pink granite pegmatite with large (>1cm) K-feldspar crystals

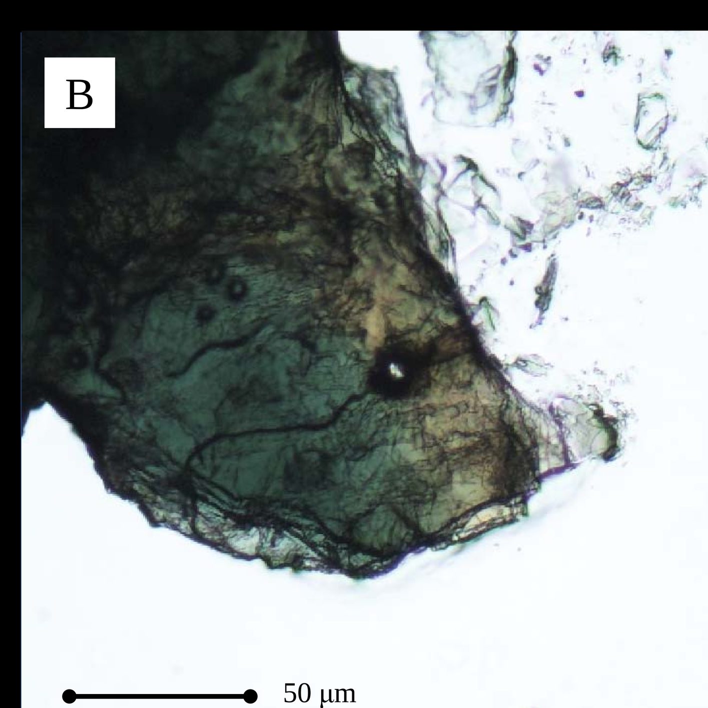
Table 1. Sample names and descriptions.

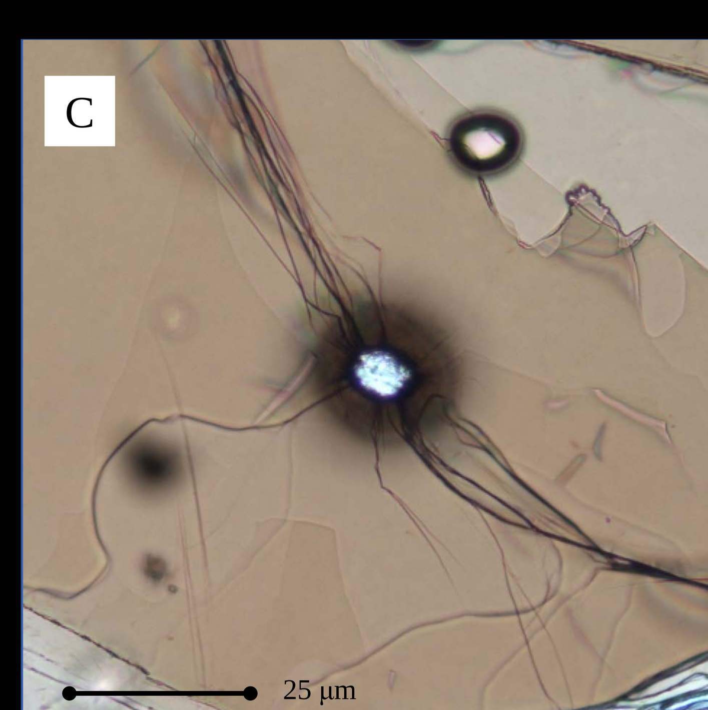
Methods

Seven granite samples have been collected from their respective locations in Ireland, as labelled in Figure 1, which all represent a part of the vast batholith in Galway. Names and descriptions of each sample are described in Table 1. Each sample was crushed into small particles. Under a binocular microscope, the flakes of biotite were picked out and set aside. Each sample had fifty slides associated with it, and each slide had approximately twenty flakes of biotite on it. Then, the twenty flakes were placed on a transparent piece of tape. Using another piece of tape on top of them, the biotite was separated into thinner sheets. This process was repeated until the flakes were sufficiently thin, or only one layer thick. Once this was complete, the tape with the flakes was placed on a slide and labelled. Under a petrographic microscope, different types of radiohalos were counted and logged by measuring the diameters of the bullseye-like scars. Then an analysis was done to understand the abundance and distribution of these radiohalos.

Figure 1. Locations of collected samples near Galway, Ireland. Note that GBMMZG-1 overlaps with GBMG-1 on map.







Sample	# of Slides	^{210}Po	^{214}Po	^{238}U
GBLLG-1	30	15	7	14
GBMMZG-1	30	3	2	4
GBMMZG-2	30	0	1	0
GBCMG-1	30	5	2	3
GBCG-1	30	14	5	9
GBMG-1	30	2	1	2
GBETG-1	30	1	1	2

Table 2. Distributions of the halo types by sample.

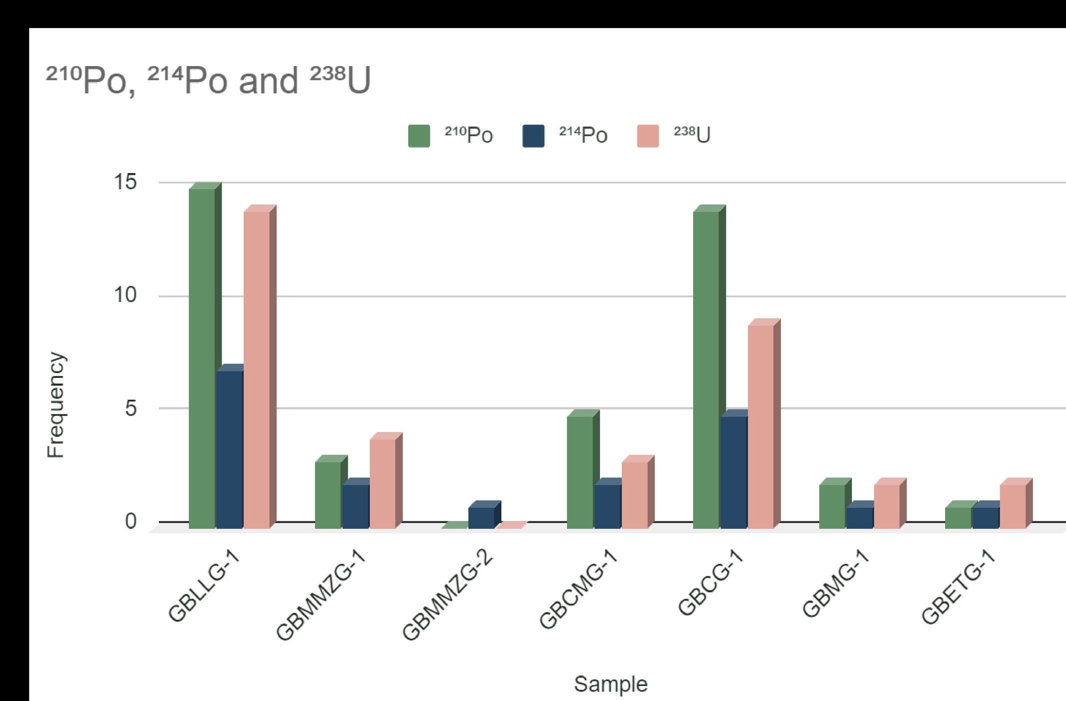


Figure 2. Histogram that shows the distribution of the various isotopes of interest and their frequencies per sample. Data indicates a lower frequency of ^{214}Po in all samples in relation to the other isotopes.

Image Description: A) Figure from Gentry (1967) that shows halo type and the nuclides that are responsible for the decay rings, B) ^{238}U halo encircling a zircon from sample GBMMZG-1, C) ^{238}U halo encircling a zircon next to a smaller ^{210}Po halo from sample GBCG-1.

Results

All of the samples were found to have at least one radiohalo in them, however the numbers were lower than perhaps expected. GBMMZG-2 and GBETG-1 primarily had micaceous minerals that had a greenish tint (as can be seen in image B), which could be due to alteration. GBMMZG-1 and GBLLG-1 also had some, but were still predominantly biotite. The greenish micas tended to have less radiohalos in them. Additionally, it was difficult during the crushing process to extract flakes of a large enough size to be used, which could contribute to the smaller numbers of halos found. Different disaggregation methods might yield better flakes, which would also show more halos. See Figure 2 for distribution of the types of halos found.

Conclusions

The reason for a lack of halos (especially in GBMMZG-2, GBMG-1, AND GBETG-1) could be, in part, due to the fact that the region has been quite active in its past. There could have been a lot of low-grade metamorphism occurring which could have erased the halos, so that they would be found in less abundance. Both GBMMZG-1 and -2 are Mixing-Mingling Zone Granodiorite, so it is likely that temperatures would have risen above 150 ° C in some areas of the body that would have erased some of the previously-formed halos. Indeed, some of the granites studied have been observed to have foliation, possibly giving credence to that hypothesis. Of interest is that sometimes ^{214}Po and ^{210}Po are found with ^{238}U, even though they have vastly different half-lives—164.3 µs, 138.4 days, and 4.6Ga, respectively. This could be due to the mingling of the different granites. Hydrothermal fluids moving through the granites could also play a factor as they transport radioactive elements like uranium or polonium and their daughter products. More research needs to be done to better understand this batholith, to determine why these different halos are occurring, and how they could be used in the study of the cooling rates of the batholith.

Acknowledgements

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