Estimating the Age and Depth of Emplacement of the Woodstock Granite

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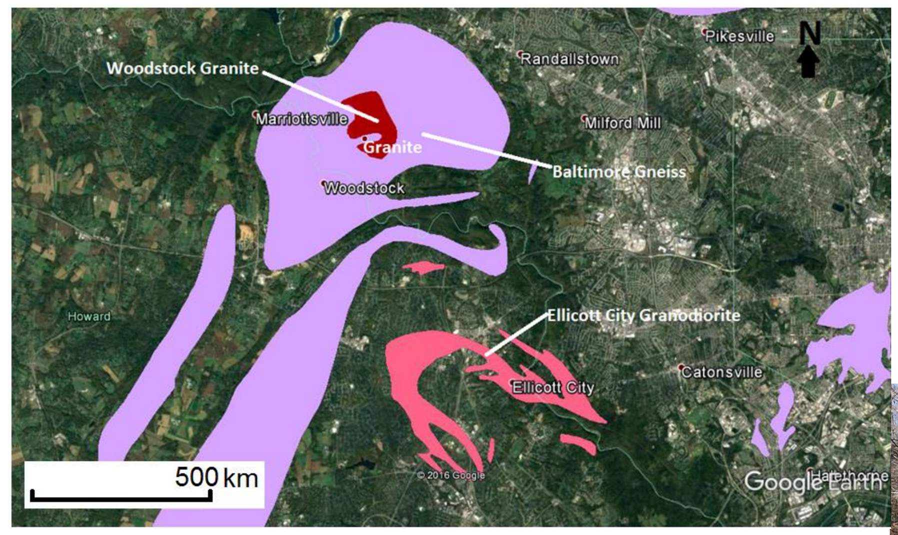
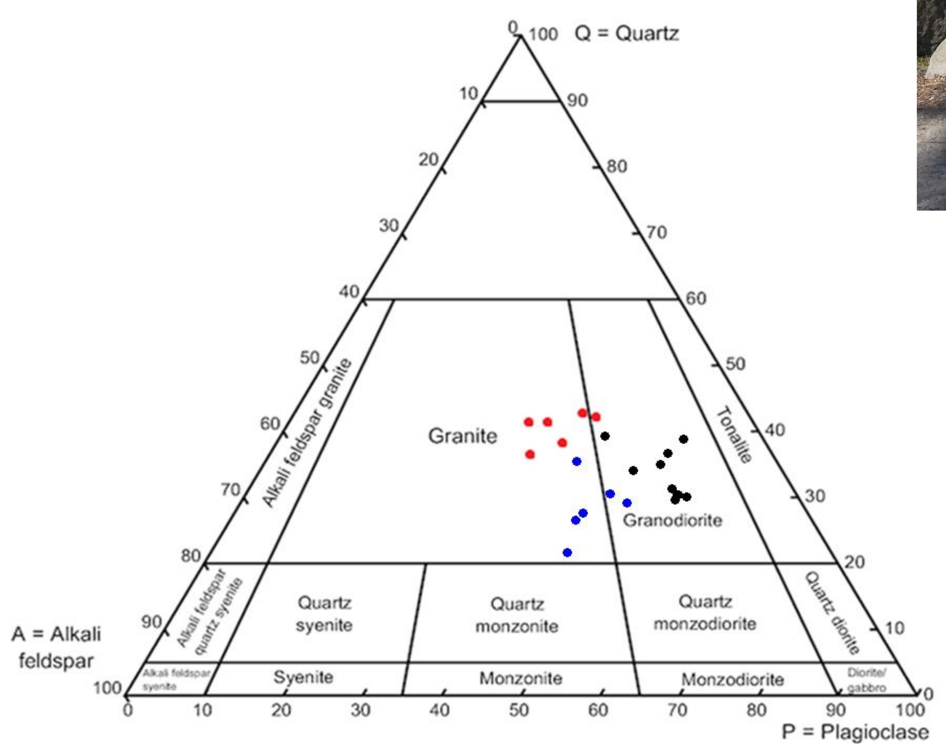
Abstract

The Woodstock Granite and Ellicott City Granodiorite both crystallized some time after the Taconic Orogeny. Both plutons contain zircon which can be used for radiometric dating. However, past attempts of radiometric dating have been unsuccessful due to loss of lead and zoning in zircon grains. Sinha (2012) determined an age of 369±4 Ma for the Ellicott City Granodiorite and an age of 371±11 Ma for the Woodstock Granite using SIMS U-Pb dating of zircon grains. In this proposal, zircon grains from samples of Woodstock Granite are dated using U-Pb LA-ICP-MS.

The depth of crystallization of the Woodstock Granite has not been quantified. The Woodstock Granite and Ellicott City Granodiorite both contain epidote that has been interpreted to be magmatic. It has been recognized that the presence of magmatic epidote in felsic rocks is an indicator of crystallization at high pressure (Zen and Hammarstrom, 1984). It was subsequently found, in an experimental study, that the pistacite content of magmatic epidote can be related to pressure (depth of emplacement). Coyne (1999) determined pistacite values between 0.22 ± 0.03 to 0.26 ± 0.008 on samples of Ellicott City Granodiorite. The Woodstock Granite may also contain magmatic muscovite. The presence of primary epidote and muscovite have only been reported to occur in the same granite in a few instances. An evaluation of the 'magmatic' nature of the muscovite will also be evaluated as part of this project.



Map (left) showing the Woodstock Granite, at the center of the Woodstock Dome, a Baltimore Gneiss dome, north of the Ellicott City Granodiorite. Field site (below).



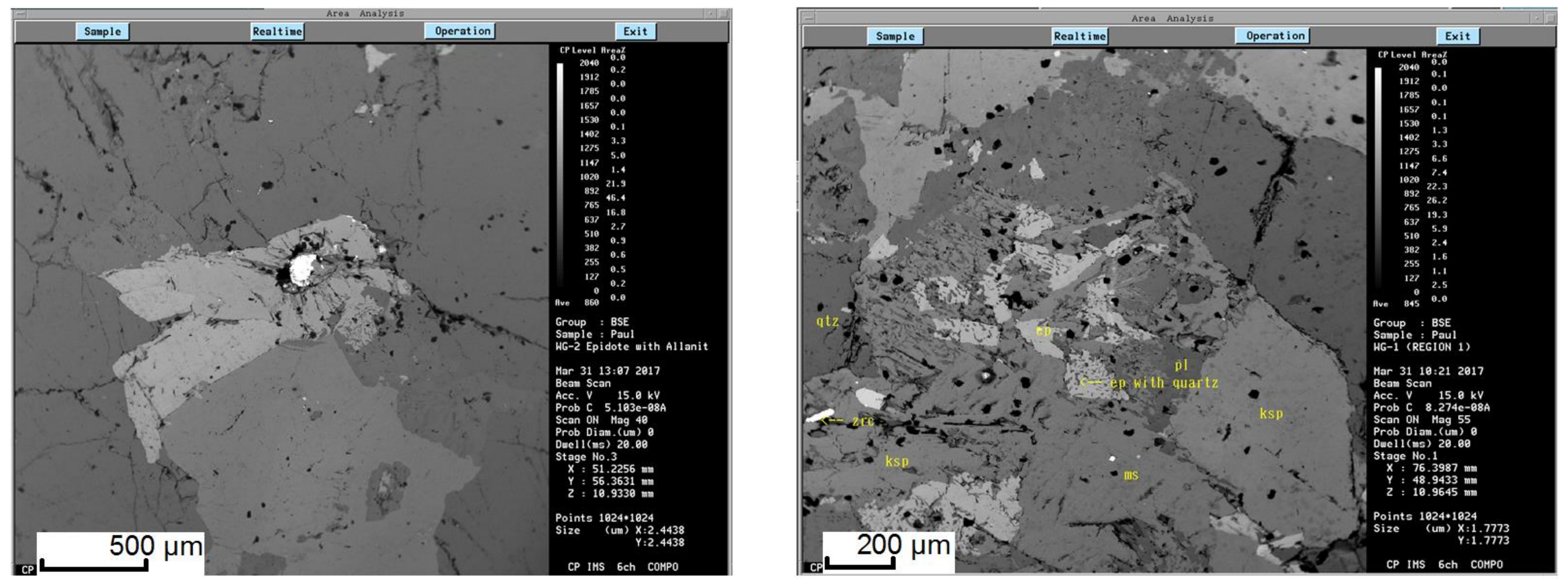
Mineralogy from Hopson (1964) plotted on IUGS ternary diagram (left). The samples plotted are from the Woodstock Granite (red), the porphyritic interior of the Ellicott City Granodiorite (blue), and the aphanitic margins of the Ellicott City Granodiorite (black).

Hypotheses

- The Woodstock Granite and Ellicott City Granodiorite crystallized concurrently.
- The Woodstock Granite and Ellicott City Granodiorite crystallized at the same depth

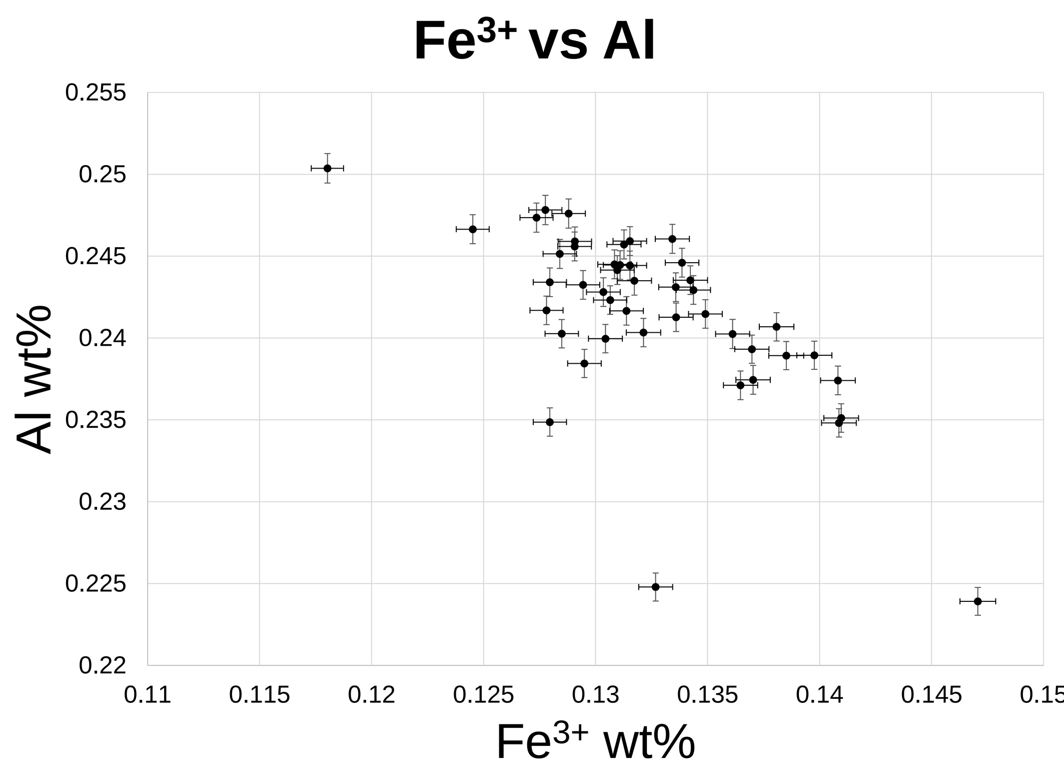
Given the common nature of epidote in metamorphic rocks and as an alteration product in magmatic rock, the suggestion of epidote in felsic igneous rocks comes under much scrutiny. Magmatic epidote will satisfy more than one of the criteria outlined below (Zen & Hammarstrom,1984). Any criterion alone is not sufficient evidence that epidote is magmatic. The criteria are:

1) Epidote is euhedral with an allanite core
2) There is a wormy intergrowth of quartz in epidote in contact with plagioclase
3) Epidote is euhedral against biotite
4) Epidote contains a pistacite component of 23% to 27%
5) Epidote is similar in grain size to other mafic minerals
6) There is a lack of alteration minerals
7) Epidote shows fine scale oscillatory zoning (Evans & Vance, 1987)



Backscatter electron photos showing epidote in samples WG-1 (left) and WG-2 (right)

Pressure (kb)	Pistacite component in Epidote
2.5	-
3.5	-
4.5	-
6	Ps_{21}
7.5	Ps_{17}
9.5	Ps_{13}
11.5	Ps_{11}
13	Ps_{10}
14	Ps_{09}
15	Ps_{09}
16	Ps_{10}
17	Ps_{08}
18	Ps_{08}
20	Ps_{08}
22	Ps_{09}
24	Ps_{08}

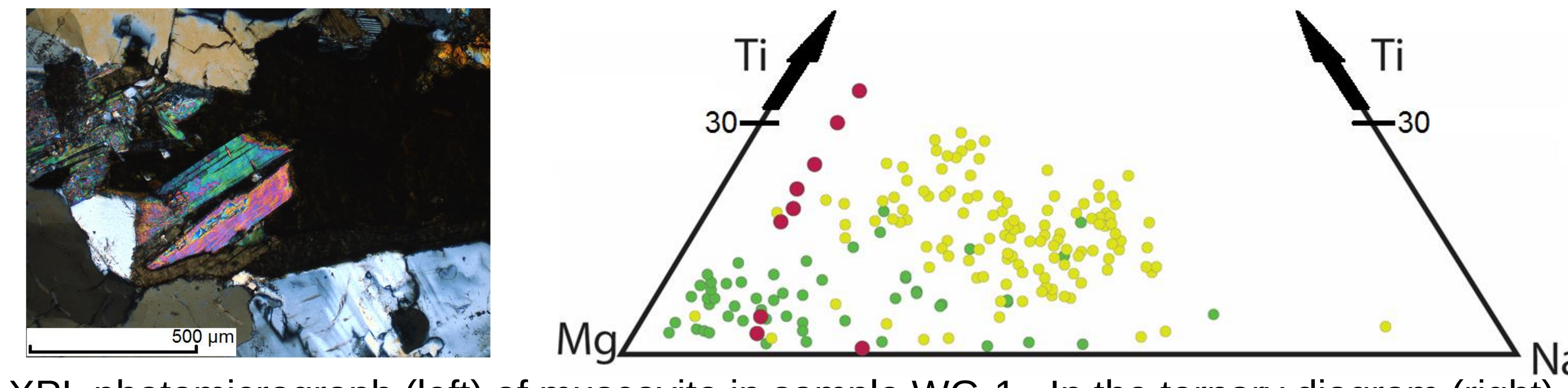


Graph (above) showing variation in chemical composition of epidote grains determined by EPMA. Epidote geobarometer (left). Chart (below) showing average pistacite component calculated using compositions determined by EPMA. The pistacite component is the proportion of ferric iron in epidote.

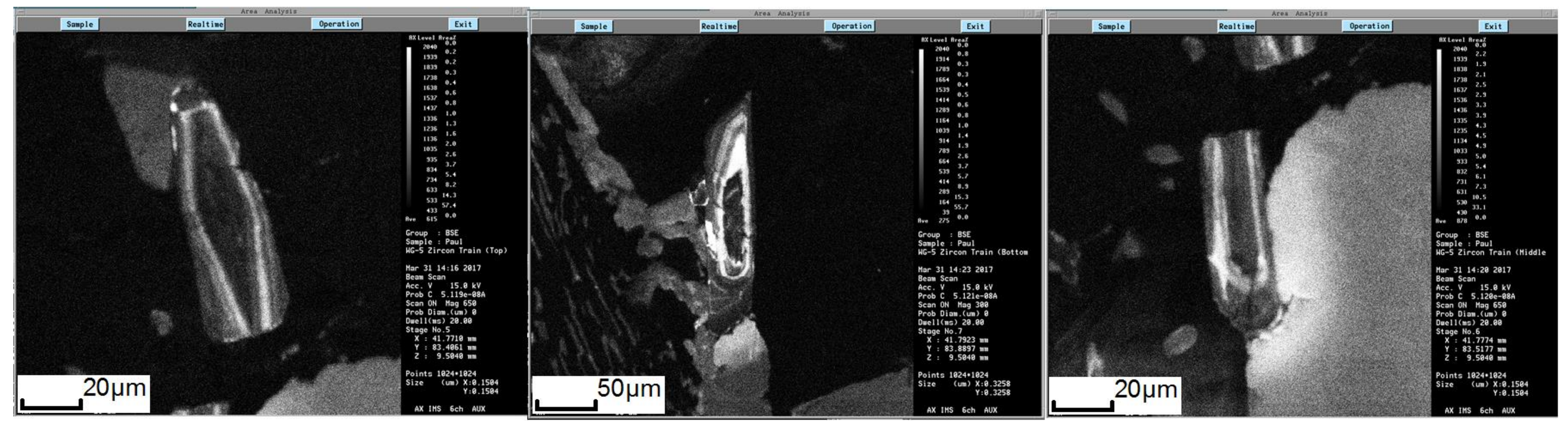
Sample ID : Number of Analyses Conducted	Average Pistacite Component $Ps = Fe^{3+}/(Fe^{3+}+Al+Mn^{3+}) \pm 2\sigma$ Stdev
WG-1 Grain 1: 10 analyses	Ps = 0.251 ± 0.016
Grain 2: 3 analyses	Ps = 0.256 ± 0.030
Grain 3: 6 analyses	Ps = 0.272 ± 0.026
WG-2 Grain 1: 10 analyses	Ps = 0.252 ± 0.008
Grain 2: 8 analyses	Ps = 0.254 ± 0.004

The occurrence of magmatic epidote and muscovite in a single granite is rare. Magmatic muscovite will satisfy more than one of the criteria outlined below (Deer ,1992). Any criterion alone is not sufficient evidence that muscovite is magmatic. The criteria are:

1) Grain size roughly equal to other magmatic minerals
2) No reaction texture with other minerals
3) Lack of alteration in host rock
4) Relatively abundant
5) Host rock contains peraluminous magma mineral assemblage; contains aluminous biotite, cordierite, garnet, aluminosilicates, topaz, and/or tourmaline
6) Lacks significant proportion of phengite, illite, and pyrophyllite
7) Magmatic muscovite contains high concentrations of Ti, Na, and Al and low concentration of Mg and Si and Al (Miller, 1981).



XPL photomicrograph (left) of muscovite in sample WG-1. In the ternary diagram (right) modified from Miller (1981), muscovite grains from Woodstock Granite (red) are plotted against primary (yellow) and secondary (green) muscovite.



Cathodoluminescence images of zircon grains from sample WG-5 used for U-Pb LA-ICP-MS dating

Summary

Woodstock Granite contains magmatic epidote and magmatic muscovite. Occurrence of both of these minerals in their primary state in felsic rocks is rare. Preliminary U-Pb LA-ICP-MS dating on a limited number of zircon grains did not yield an accurate age because zircon grains are zoned and have experienced a loss of lead. Epidote grains from samples WG-1 and WG-2 have pistacite components within the range of pistacite values in Ellicott City Granodiorite determined by Coyne (1999).

Bibliography

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