ERVING GRANULITE, WEST-CENTRAL MASSACHUSETTS: DETRITAL ZIRCONS SUGGEST A LOCHKOVIAN MAXIMUM DEPOSITIONAL AGE

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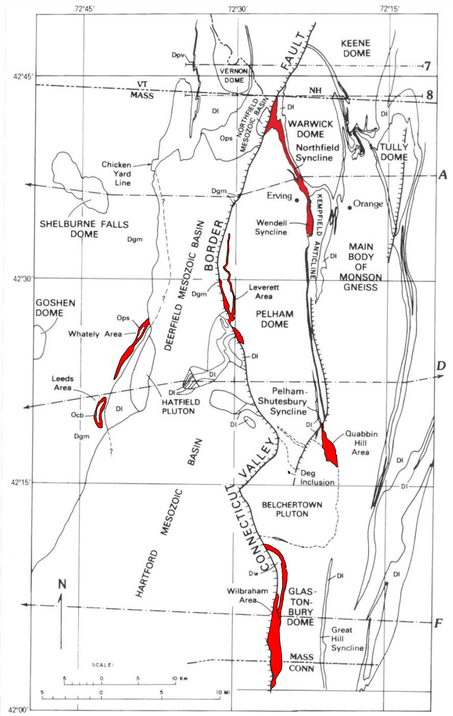
ABSTRACT

Emerson (1898) described amphibolite interbedded with "whetstone" near Erving, MA, later called Erving Hornblende Schist, in contact with graphitic schist to the east. Robinson (1959-61) mapped these rocks as Erving and Littleton Fms. Erving consists of plagioclase-quartz granulite with non-graphitic kyanite schist and calc-silicate beds, epidote amphibolite, coticule with discrete magnetite octahedra, and rare zoisite calc-silicate and marble.

Field relations alone have not been able to resolve questions of Erving's correlation with other units and the nature of its basal contact. For example, in the core of the Northfield-Wendell Syncline, Erving displays different relationships on each limb: to the E it lies above Littleton and Fitch, which is linked to Bernardston Lochkovian conodonts. To the W it lies locally against Littleton, but elsewhere on Clough, Partridge or even Fourmile Gneiss, suggesting an onlapping unconformity or a thrust fault. Robinson and Rosenfeld (1960) recognized similarities between the Erving and Gile Mountain granulite and Standing Pond amphibolite in the "fish hook" of SE VT, linking the Erving to questions about "VT" and "NH" Silurian-Devonian strata. Published detrital zircon maximum depositional ages from the Littleton and Gile Mtn, as well as zircon ages from metavolcanics in the Littleton and Meetinghouse Slate, all fall within the range from 407 to 412 Ma.

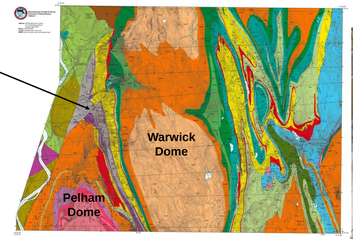
In order to address the depositional age of the Erving, we chose a W-facing section of Clough, Littleton and Erving granulite at Round Mountain, on the E limb of the Northfield Syncline. The collected samples of Erving granulite lie approximately along the axis of the Northfield Syncline at the highest stratigraphic level within a section involving as many as 9 amphibolite layers interpreted as basaltic flows or ash falls. Our results indicate a maximum depositional age of ca. 419 Ma, which suggests these strata are coeval with or younger than the Littleton. They can be no younger than the 380 +/- 5 Ma Belchertown Pluton. Further work by TIMS dating of youngest grains may refine the results. We propose that the apparent onlap of Erving granulite in the Northfield-Wendell Syncline is a primary depositional relationship that reflects synorogenic sedimentation, perhaps as a coarse-grained submarine fan complex within the Littleton.



Map showing distribution of Erving Formation (red) in central Massachusetts relative to Bronson Hill domes and Mesozoic basins.

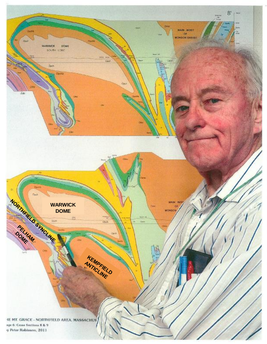
Northfield Syncline
Quartz-plagioclase biotite granulite (gray on the map) dominates the Erving in the Northfield-Wendell Syncline. Amphibolite (violet on map) is subsidiary on the east limb, but very thick on the west limb.

Littleton (yellow) is thick east of the Erving, but thin and discontinuous between Clough and Erving on the complexly folded west limb. Locally Erving rests directly on Ordovician Fourmile Gneiss of the Pelham Dome.

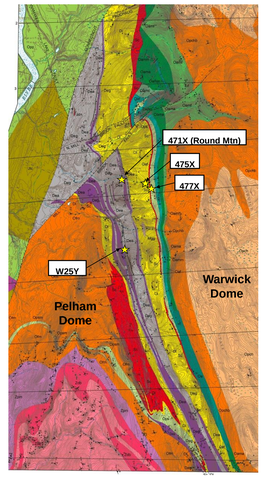


Mt.Grace/Northfield map area (Robinson, 2011)

W25Y Erving Formation granulite, west side of Gulf Road, Northfield, MA.



Peter Robinson points to the Northfield syncline in cross-section view.



Sample locations in the Northfield syncline.

471X Erving Formation granulite, Round Mountain, Northfield, MA.

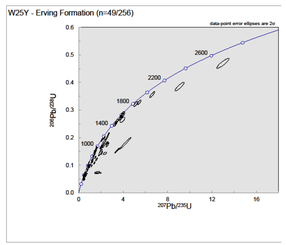
475X Littleton Formation with graded beds, east of Round Mountain.

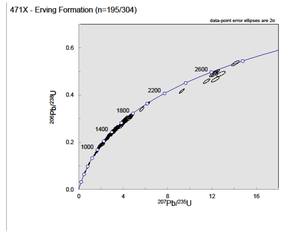
477X Clough Quartzite east of Littleton Formation.

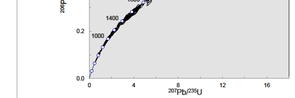
Discussion

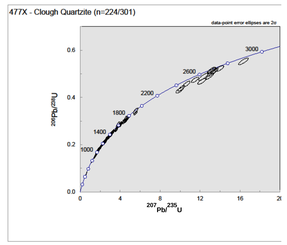
- Detrital zircons indicate that the Erving Formation is no older than about 419 Ma, or Lochkovian (early Devonian).
- Erving may correlate with parts of the Waits River Formation in VT, which contain detrital zircons as young as ca. 418 to 415 Ma (McWilliams et al., 2010). If so, what is mapped as Littleton in the Northfield Syncline beneath Erving also correlates with Waits River.
- Erving could be as young as Gile Mountain Formation, from which McWilliams et al. (2010) estimated maximum deposition ages of ca. 411 to 409 Ma.
- Amphibolite in the Erving might correlate with Standing Pond Volcanics. Depleted LREE patterns are quite similar between Erving and Standing Pond of the Guilford Dome, but other Standing Pond samples were more enriched (Robinson and Hepburn, 2013). Further geochemical analysis of these rocks may shed light on this question.
- We envision the Littleton and Erving in this area as an early onlap facies of Acadian flysch and associated volcanics advancing toward the west, which culminated in Emsian time (Bradley and Tucker, 2002). The Erving may represent a somewhat sandier facies than the Littleton, deposited in a submarine fan.

Concordia Plots

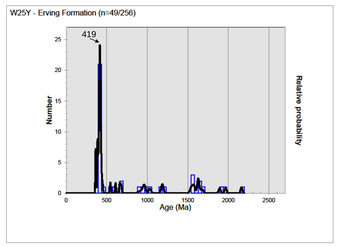


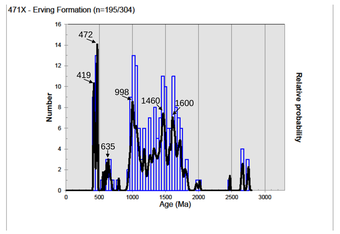


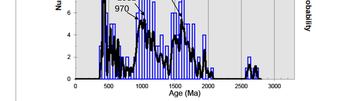


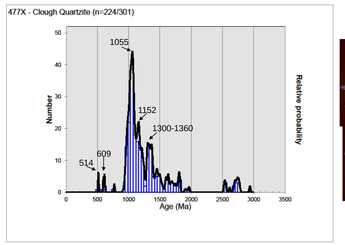


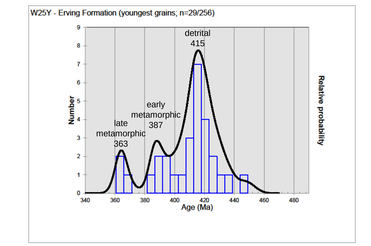
U-Pb Age Histograms and Probability Density Plots



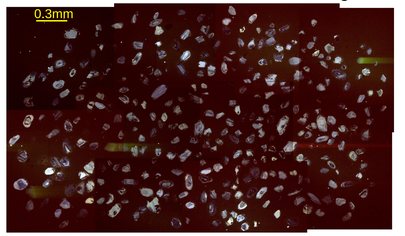




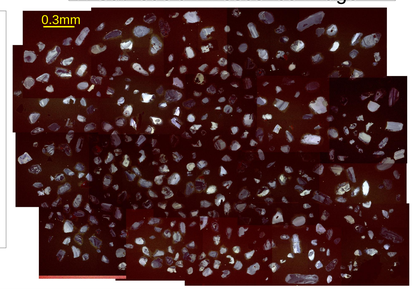




W25Y Cathodoluminescence image



477X Cathodoluminescence image



Methodology

3-5 kg samples were crushed and separated using standard gravimetric and electromagnetic techniques at Dartmouth College. Zircon grains were mounted in epoxy with the standards R33, FC1, and SL (Black et al., 2004; Gehrels et al., 2008; Mattinson, 2010) and then polished to expose the interiors for cathodoluminescence (CL) imaging. This imaging was done by Dr. Bill McClelland and his students at the University of Iowa. Selected zircons were run for U-Pb laser ablation-inductively coupled plasma mass spectrometry (LA-ICPMS) at the University of Arizona Laserchron Center in Tucson, AZ, following methods outlined in Gehrels et al. (2006; 2008) and Gehrels and Pecha (2014).

Background-corrected analytical data were then reduced from raw ratios to $^{206}Pb/^{238}U$, $^{207}Pb/^{235}U$, and $^{207}Pb/^{206}Pb$ ratios and ages using the AgeCalc macro and then assigned a $^{206}Pb/^{238}U$ "Best Age" if this result was <1200 Ma, or a $^{207}Pb/^{206}Pb$ "Best Age" if the $^{206}Pb/^{238}U$ result was >1200 Ma. Following these data reduction steps, we excluded analyses from our plots based on the following criteria: 1) >10% 2σ uncertainty in $^{206}Pb^*/^{238}U$ or $^{206}Pb^*/^{207}Pb^*$ age, 2) >10% discordance or >5% reverse discordance, 3) analyses whose 2σ error ellipse did not overlap with concordia, and 4) >500 cps 204 intensity. All plots were made using Isoplot 3.0 (Ludwig, 2003).

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