Recrystallized Olivine Grain Size Showing Tectonic Emplacement History of Ultramafic Rocks in the Blue Ridge Mountains of Western North Carolina

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Introduction and Background

The peridotites in the Blue Ridge metamorphic suite were formed from the collision of an island arc and North America during the Taconic orogeny. The dominant theory on the formation of the Ashe Metamorphic suite is that it was previously an ophiolite suite[1]. This model explains how the basalt from the sequence was metamorphosed to the amphibolite surrounding the ultramafic bodies, which were part of the oceanic lithosphere as peridotites. The emplacement history from the oceanic lithosphere to the crust of North Carolina however, is not well understood. Ophiolites generally are emplaced by scraping the bottom of the oceanic crust from the subducting material onto the continental crust it is subducting beneath[2].

Diverse textures and grain sizes in several closely spaced ultramafic bodies in Western North Carolina were observed. This study aims to quantify those observations and determine whether they indicate varying stress conditions during the Taconic orogeny.

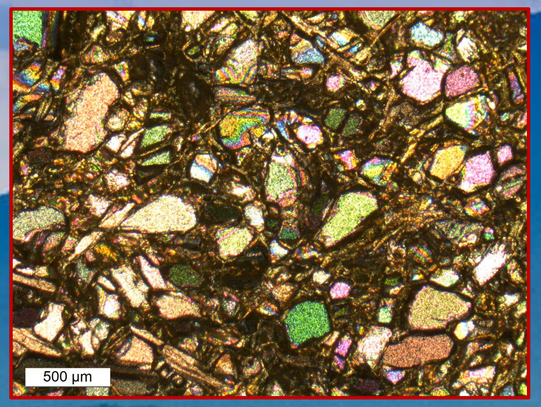

Fig. 2: Representative photomicrograph of the grain sizes present in the sample from the Frank ultramafic body.

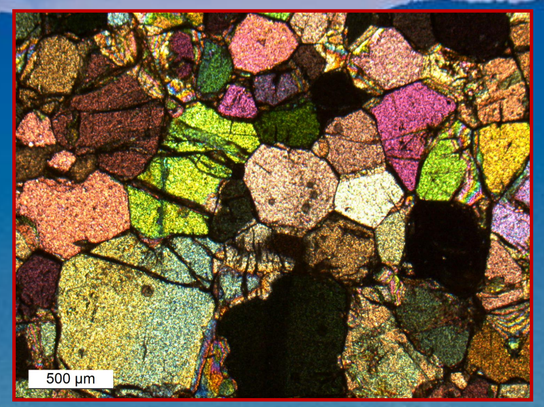

Fig. 3: Representative photomicrograph of the grain sizes present in the sample from the Daybook ultramafic body.

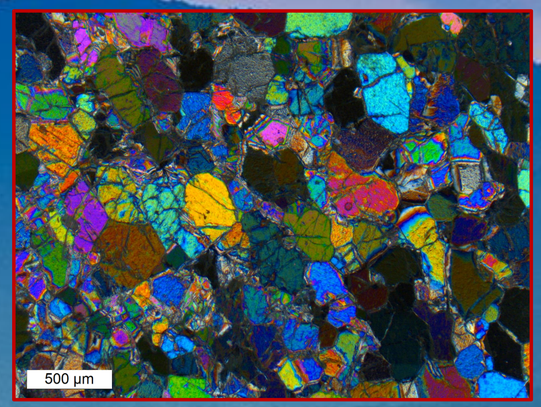

Fig. 4: Representative photomicrograph of the grain sizes present in the sample from the Webster-Addie ultramafic body.

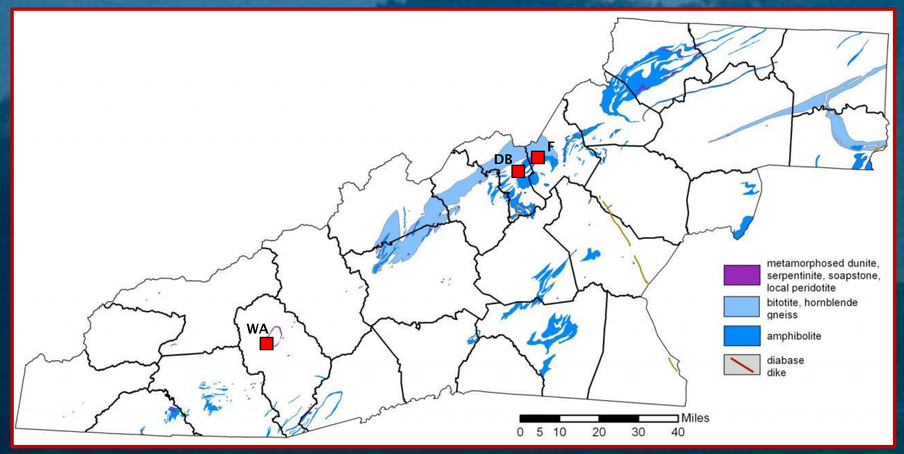

Fig. 1: Map[3] of mafic and ultramafic rocks in western North Carolina with county lines. Samples indicated by red squares: F-Frank, DB-Daybook, WA-Webster-Addie.

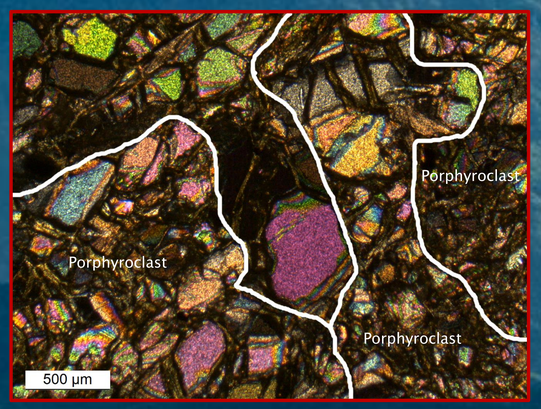

Fig. 5: Representative photomicrograph of the porphyroclast to neoblast ratio in the Frank ultramafic body. The sample was estimated to be 70% porphyroclasts.

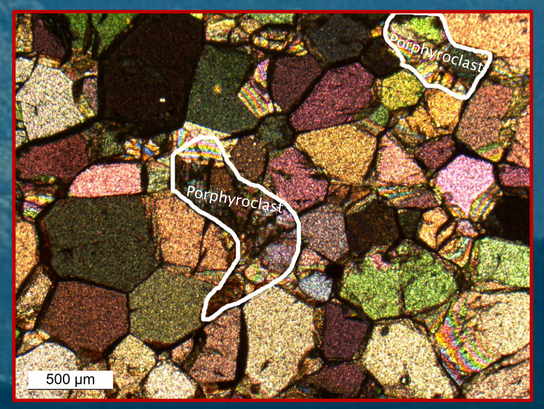

Fig. 6: Representative photomicrograph of the porphyroclast to neoblast ratio in the Daybook ultramafic body. The sample was estimated to be 8% porphyroclasts.

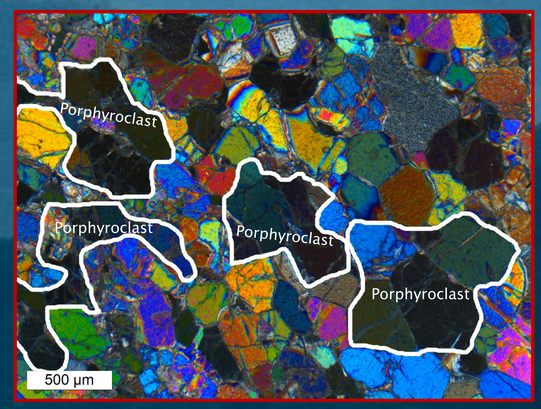

Fig. 7: Representative photomicrograph of the porphyroclast to neoblast ratio in the Webster-Addie ultramafic body. The sample was estimated to be 22% porphyroclasts.

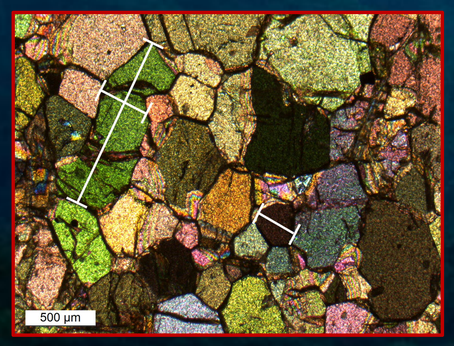

Fig. 8: The measurements for the diameter of circular neoblasts combined with the average of the long and short axis for any oblong neoblasts were averaged to find the mean recrystallized grain size.

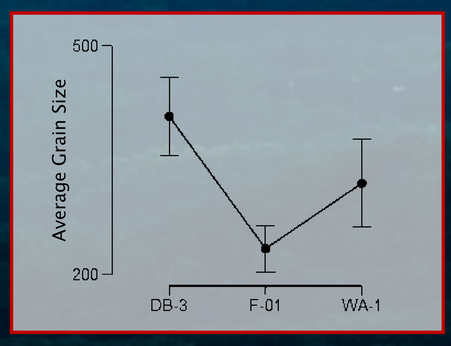

Fig. 9: Graph of the average grain sizes of each of the samples with a 95% confidence interval as their ranges. An ANOVA was used to show the grain sizes are significantly different as observed by the minimal graphical overlap.

Results and Further Work

The average recrystallized grain size of the Frank body was found to be 234±103 µm, Daybook to be 407±190 µm, and Webster-Addie to be 320±208 µm. The error was estimated at one standard deviation and by using an analysis of variance test, all of the bodies were determined to have statistically significantly different grain sizes (Fig. 9). Using these average grain sizes with the olivine grain size piezometer[4], $\sigma = e^{\frac{\ln(\frac{1.2 * D_g}{0.015})}{-1.33}}$, the paleo stress conditions of each body were found to be 20 MPa, 13 MPa, and 16 MPa respectively.

The Frank body has the highest estimated porphyroclast percentage at 70%, then the Webster-Addie at 22%, and finally Daybook has an 8% porphyroclast make-up. This is an inverse relationship to neoblast size.

Despite the bodies' close proximity, the smaller grain size and higher porphyroclast percentage indicate both more emplacement stress and a higher strain rate for the Frank body than the Webster-Addie and the Daybook. This asserts the emplacement conditions of these ultramafic bodies during the Taconic orogeny were not the same.

Acknowledgments and References

Thanks to the Collegiate Science and Technology Entry Program for funding this research, CSTEP program heads Teresa Van Damme and Kathleen Lesniak, the Dean's Office of Liberal Arts and Sciences at Fredonia for funding this research, Darrin Rogers for the statistical analysis, Gary Lash for advising and editing, Daniel Kaufman for photo emendations, and Matthew DeLorme for the Blue Ridge photograph.

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