Snaking Through the Pennsylvania Piedmont: Serpentinites of Southeastern Pennsylvania

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Abstract

A petrographic and geochemical assessment of a suite of serpentine rocks from the Piedmont region of southeastern Pennsylvania was conducted to delineate their likely source and determine if any trends could be noted that could suggest spatial differences in tectonic history. The area is host to rocks that are metamorphosed to amphibolite facies accreted onto the continental margin during the Taconic orogeny (450-470 Ma) that overlay a basement composed of higher grade granulite facies metamorphic rocks of Grenville age (1.0-1.2 Ga). Serpentinites were collected from several pod-shaped bodies in southeastern Pennsylvania with some of these bodies adjacent to NE-SW trending shear zones.

Distinct differences were seen in field relationships and petrography whereas geochemical signatures remained uniform. Geochemical trace element data suggests that the sampled serpentinites were affected by subduction and refertilization of ultramafic protoliths during tectonic emplacement. The geochemistry of relatively immobile trace elements plotted on petrogenetic discrimination diagrams suggest an arc setting for the protolith. Examined bodies towards the east exhibited a zoned morphology with multiple rock types (talc, anthophyllite, chlorite, including serpentine) whereas bodies towards the west exhibited near complete serpentinization. Evidence of shear is present in all serpentinite samples and is particularly pronounced in the samples collected in the west.

Introduction

Serpentinites are rocks composed of serpentine minerals which form by metamorphism of mantle material. This process can show various degrees of completion and this can either alter the original mineralogy completely or leave relict grains that are similar to original optical mineralogic properties. If the process is complete these properties are typically lost and the new textures present in the rock must be used to deduce the original minerals present. The origin and tectonic history of the Pennsylvania Piedmont's serpentinites has remained controversial in the available literature with three distinct hypotheses put forward to explain the genesis of these rocks: hydrothermally altered oceanic crust; hydrothermally altered mantle material; or hydrothermally altered arc related magma chamber.

Methods & Materials

- Samples were collected from the Piedmont physiographic province of southeastern Pennsylvania.
- Geochemical analysis was conducted through X-Ray Fluorescence (XRF) as well as Inductively Coupled Plasma Mass Spectroscopy (ICP-MS).
- Results were plotted on discrimination diagrams presented in Deschamps (2013) as well as Pearce and Cann (1971).
- Rock thin sections were generated and analyzed based off of optical mineralogic and micro-textural properties of the samples.

Geologic Setting

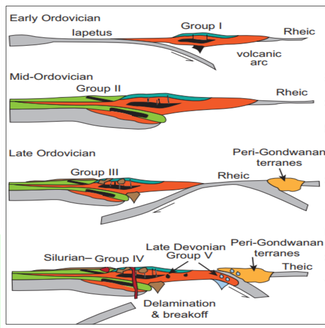
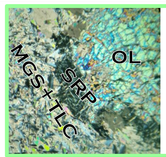


Figure 1: Animation showing the accretion of the Taconic terrane onto the margin of Laurentia (Sinha et al. 2012). This event led to metamorphism in the region and contributed to the formation of the Appalachian mountain belt. The manner in which serpentinites came to be, however, has not been well explained in this region.

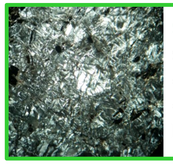
Petrography of Samples

SRP16-002: Sample taken from bike path near Soapstone Rd. Serpentine pods within the sample are surrounded by carbonate material.



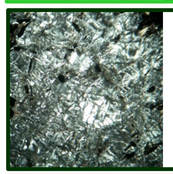
SRP16-005: Nearly completely unserpentinized sample with unaltered olivine surrounded by thin reaction rim of serpentine and interstitial carbonate material.

SRP16-011A: Partially serpentinized sample with large euhedral opaque oxide minerals.



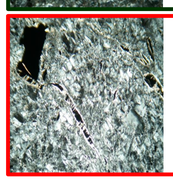
SRP16-008: Completely serpenentinized samples with appearance of some grains possibly after amphibole based off of preserved cleavage pattern

SRP16-019: Type II Hourglass non-pseudomorphic texture with abundance of oxide minerals and appearance of a few serpentinized pyroxenes



SRP16-007: Completely serpentinized sample with large amount of opaque oxide minerals.

SRP16-021: Highly sheared sample with predominantly pseudomorphic mesh texture



SRP16-024: Distinct shear indicators preserved in opaque stringers

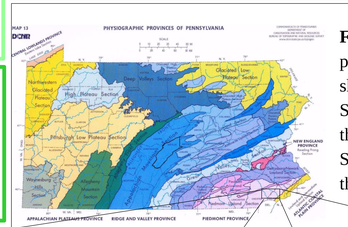


Figure 2A: Physiographic province map of Pennsylvania showing inset of study area, Samples were collected from the Piedmont Province of Southeastern Pennsylvania in the Appalachian Mountain Belt

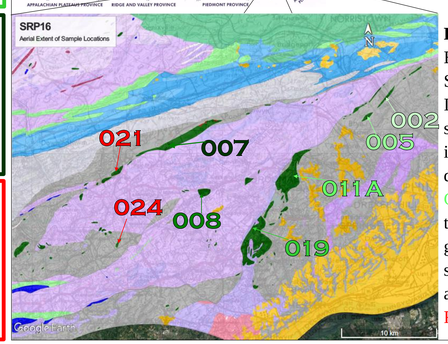


Figure 2B: Aerial Extent of Samples. Increasing serpentinization is indicated with darker shades of Green. Samples that showed the greatest internal shear indications are filled with Red.

Results & Conclusions

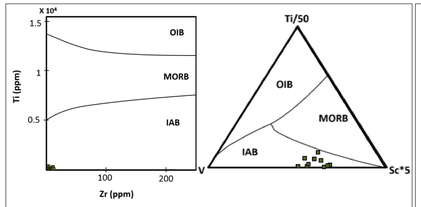


Figure 3: Discrimination diagrams after Pearce and Cann (1971) plotting composition of serpentinite samples in Island Arc Basalt region. Composition suggests that material serpentinized in southeastern Pennsylvania Piedmont is the hydrothermally altered remains of a magma chamber.

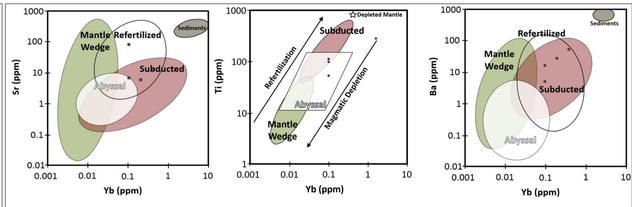


Figure 4: Discrimination diagrams after Deschamps (2013). Colors correspond to regions presented on map and sample descriptions. Geochemical analysis indicates that all samples with sufficient REE signatures plot in the subducted field indicating samples were subjected to burial and exhumation prior to eventual emplacement at current location.

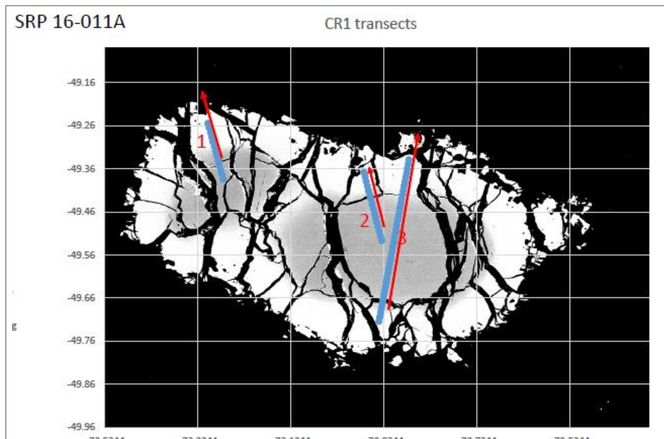


Figure 5: microprobe transects along chromite grain indicating difference in origin with dark igneous core and light metamorphic rim (values right)

Observations and Implications

- Modal abundance of serpentine was noted to increase across the study area with the least serpentinized samples to the east progressing to complete serpentinization to the west
  - Internal shear increased proportionally to modal abundance of serpentine in samples
- Geochemical analysis yielded the following results:
  - Samples were affected by subduction zone processes indicating an arc environment based on fields originally determined by Deschamps (2013).
  - Discrimination diagrams from Pearce and Cann (1971) typically used for igneous rocks showed evidence for island arc basalt protolith in samples.
- Microprobe analysis of chromites in SRP16-011A (Figure 3) indicate zoning with igneous cores and metamorphic rims.
  - Future research direction will look at in depth analysis of chromite cores and compositions.

Acknowledgements

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References

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