Geochemistry and Tectonic Origin of the Barnard and Shaw Mountain Amphibolites, Vermont

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The Ordovician Barnard Formation (Ob) and the Sil urian Shaw Mountain Formation (Ssm) of the Chester Dome, in south-eastern Vermont are each composed of amphibolite-grade mafic schists and are separated by a thin quartzite conglomerate layer. The Ob contains thin, ten centimeter to a meter thick, felsic schist interlayered with thicker, thirty centimeters to a few meters thick, mafic schist bands. The Ssm is a massive pyrite rich mafic schist. Whole rock chemical analysis of these metavolcanics and the interpretation of discriminant diagrams provide constraints on the tectonic origin of the units. The combination of these data, taking into account the known regional metamorphic, stratigraphic and structural studies, indicate that the Ob and Ssm were formed in a back arc basin tectonic environment.

The Chester Dome experienced two intense tectonic events, the Ordovician Taconic orogeny and the Devonian Acadian orogeny, which regionally metamorphosed and domed the units. The extensive metamorphism altered the rocks from greenschist to amphibolite-grade in the cover units across the dome and granulite grade in the core of the dome. Structurally the units are domed and folded around the Precambrian Mount Holly Complex resulting in the ten-kilometer wide and fifty-kilometer long Chester and Athens Domes. The Ob experienced both the Taconic and Acadian orogenies while the Ssm experienced only the Acadian metamorphic environment. The orogenic events deformed and eliminated many primary textures, mineralogy and igneous structures in both units. Some pillow structures and amygdaloidal structures were preserved in the Ob. The quartzite conglomerate member of the Ssm contains flattened quartz clasts. Based on the mineralogy and metamorphic conditions of amphibolite-grade the units has been altered according to the pressure and temperature regime of 500 and 700 degrees C and three to seven kilobars of pressure.

PETROGRAPHY

The mafic layers of the Ob contain hornblende, actinolite, plagioclase, opaques and biotite. The felsic bands are primarily recrystallized quartz and lathes of plagioclase. Millimeter and smaller Actinolite and hornblende comprise ten to forty percent of both units. The Ob contains coarser groundmass then the Ssm. Untwinned and twinned plagioclase feldspars are present but difficult to identify due to the optical similarities between quartz, k-spar and plagioclase. Altered phenocrysts of pyroxenes indicate the previous igneous history of the units. Minor sphene is also present. Mineralogy and large scale structures indicate a basaltic origin of both units. A north-south lineation of amphibole crystals is found in both units. The felsic member of the Ob contains the most pronounced lineation at the felsic/mafic contacts. Prograde metamorphism produced syn and pretectonic garnets in the Barnard while retrograde metamophism altered the amphiboles to biotite and chlorite.

GEOCHEMISTRY

Major and trace element analysis by XRF provided the geochemical data for classification and tectonic origin diagrams. Neutron activation analysis in progress will add considerable certainty to the identification of an origin for the units. Samples were crushed and melted into a lithium tetraborate discs at the Colorado College.

The extent of the alteration experienced by the units is observed in both mineralogy and geochemisty. The alteration diagrams Log Al2O3-Log SiO2/K2O, MgO/10-CaO/Al2O3-SiO2/100 and Log Al2O3/K2O-Log SiO2/K2O indicate that the units are not extensively altered. The mobility of sodium in the unit is high compared to other elements as shown by Na2O+K2O-SiO2 diagrams and the nepheline normative samples. Garnets were found in some thin sections, but they were small and not abundant. Ternary ACF diagrams, discriminant alteration diagrams and the lack of high alluminous metamorphic minerals indicate that isochemical metamorphism is more likely then large scale mobilization and alteration of the units.

XRF analysis was performed by a Rigaku XRF instrument also at the Colorado College. SiO2 weight percentages range from 48% to 54%, MgO percentages from 6.4% to 8.6%, TiO2 from 1.4% to 1.8% and FeO(total Fe) from 9% to 12% are common. Immobile element data for both units plots in the ocean tholeitic to alkalic basalt fields in MgO-FeO, Zr/P2O5-TiO2, Cr-TiO2 and Nb/Y-SiO2 diagrams. The Ssm and Ob plot on Zr-TiO2, V-TiO2 and the ternary diagrams ZR/4-2Nb-Y, Zr-Ti/100-Y*3 and Ti-Mn*10-P2O5*10 tectonic environment diagrams in the MORB and IAB zones. The transitional nature of both units is evident in all the discriminant plots, however the titanium contents are high compared to modern back arc basins. CIPW norms of the Ob and Ssm are nepheline, hypersthene normative basalts but not quartz nomative.

CONCLUSION

The geochemical and petrographic analyses of the Shaw Mountain Formation and the Barnard Formation plot in transitional fields on all discriminant diagrams. The lack of alteration and use of immobile elements provides significant confidence in these plots. Tectonic models of the area by Aleinioff(1977) and Ratcliff(1985) propose that an island arc collided with the Ordovician North American Continent producing the Taconic Orogeny. The Acadian Orogeny event is attributed to later subduction mountain building tectonics. The transitional nature of the Ob and Ssm metavolcanics suggests a back arc basin environment or thrust faulted sheets of MORB oceanic crust. Stratigraphic correlations with other units are also consistent with this analysis. Further analysis of INAA and isotopic data is needed to confirm this hypothesis.

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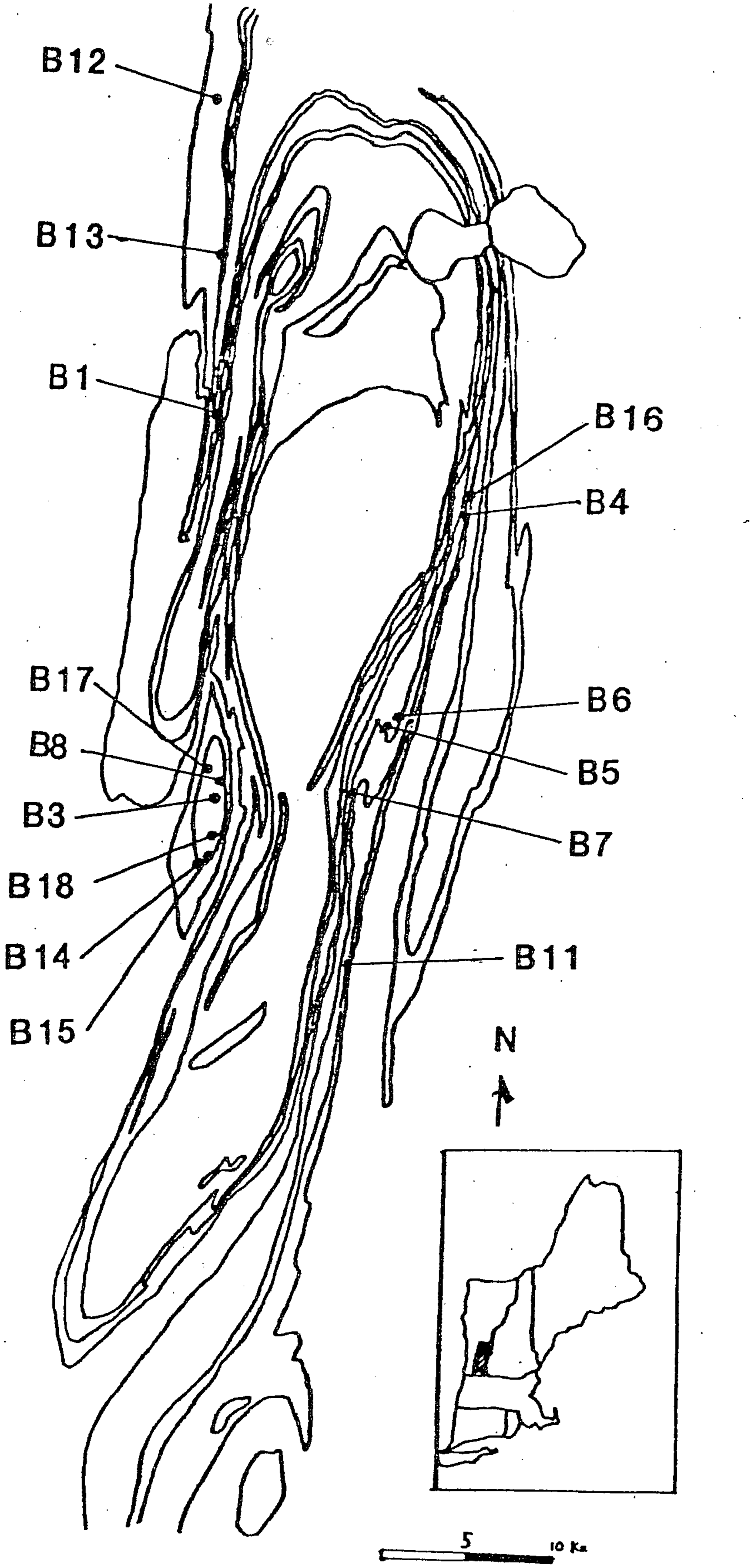
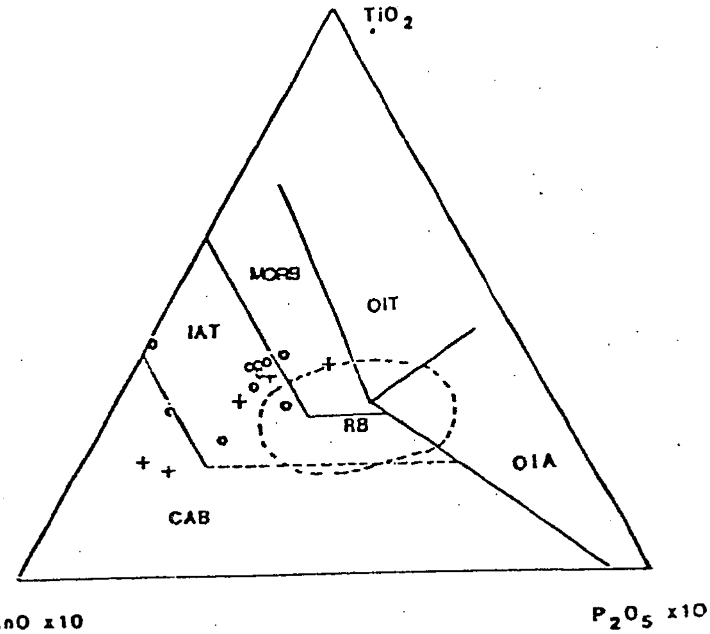


Figure 1. Map of traverse locations in the Chester and Athens Domes (Doll et. al. 1961)

Figure 2. TiO2/MnO/P2O5 discriminant diagram distinguishing oceanic basalts in ocean environments (Mullen 1983)



Barnard Fm. +

Shaw Mtn. Fm.o

Figure 3. TiO2/Zr plot for identifying basalt origins