Application of Hf Isotopes to Mantle Source Origin and Paleo-Tectonic Setting of the Baltimore Mafic Complex, Central Appalachian Orogen.

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ABSTRACT

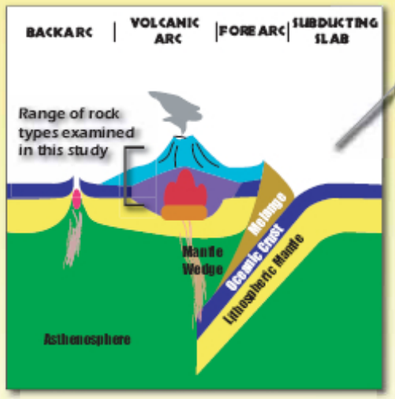
Mafic rocks preserved in accretionary mountain belts often provide significant geologic information on the paleo-tectonic setting of the host litho-tectonic block. In the Appalachian orogen, studies of multiple generations and varieties of mafic rocks support models of the accretion of oceanic ophiolites, oceanic arcs, continental margin arcs as well as intrusive/extrusive complexes associated with post-orogenic extension. However, the highly tectonized structures and polymetamorphic histories of many of these mafic complexes make geochemical characterization the primary key for understanding their tectonic affinities. Sr-Nd-Pb isotope systematics of these complexes have probed the magmatic source region, but have been modified to some extent by metamorphic overprinting related to the emplacement of the mafic complex or later collisional events. One of the largest and enigmatic mafic complexes in the Appalachian orogen, the Baltimore Mafic Complex, has been interpreted both as an obducted oceanic crust, and as an intrusive complex associated with a continental-margin arc. This complex ranges from ultra-mafic to mafic and is tectonically juxtaposed against metasedimetary rocks. Published isotopic data (Pb, Sr, and Nd) support a continental margin arc setting, but are not conclusive because of chemical alterations associated with metamorphism. We present the first Hf isotope data for this complex, and utilize these data to characterize the mantle source region and its paleo-tectonic setting. Hafnium isotopes were measured using the NU 1700 at SDSU and measured $^{176}Hf/^{177}Hf$ ratios range from 0.28244 to 0.28340. Of the four isotopic systems examined, a strong negative correlation is observed between $^{87}Sr/^{86}Sr$ and $^{176}Hf/^{177}Hf$. Additionally, strong positive correlations between Hf-Nd-Sr elemental abundances preclude decoupling through metamorphism, an observation supported by the lack of correlation between LOI (an indicator of hydrous metamorphism) and elemental abundances. These data suggest Sr-Nd-Hf isotopes have not been perturbed by metamorphism and likely reflect magmatic signatures.

INTRODUCTION

Paleozoic Events in the Appalachians

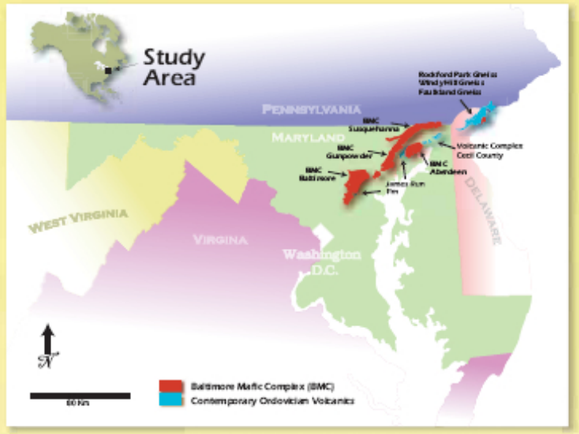
(Faill, 1997)

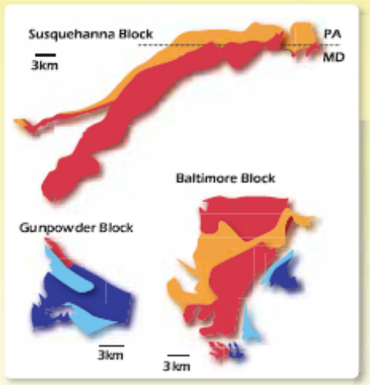
Taconic Orogeny caused by collision of Island Arc Terranes with the Laurentian margin. This study examines one such arc terrane.



Typical cross section through an island arc system.

LOCATION





PETROLOGY

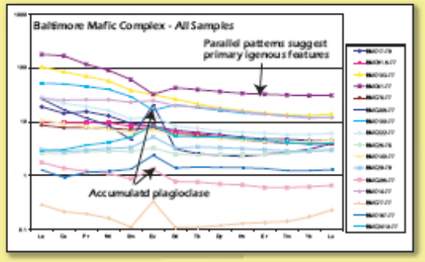
Photomicrographs of the Baltimore Mafic Complex (BMC) samples (Hanan, 1980).

A) Olivine Gabbro (partially serpentinized)

B) Meta-gabbro. Note 120° triple junctions.

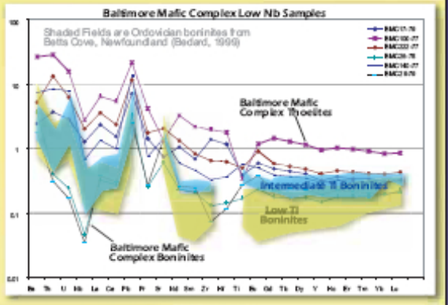
C) Plagioclase lherzolite, with cumulate texture.

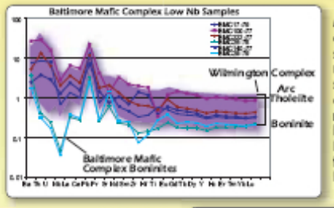
RESULTS



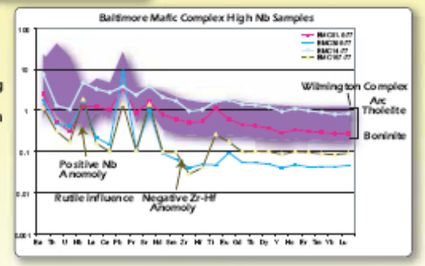
C1 chondrite normalised (Sun & McDonough, 1990) REE pattern. Remarkably undisturbed patterns indicate a lack of metamorphic remobilisation for REE. Positive Eu anomaly indicative of cumulate plagioclase.

MORB normalised incompatible trace element profile. We have shown samples with a negative Nb anomaly on this figure. There is clear evidence of low Ti boninites (25-87; 29-79). These boninites grade into intermediate Ti boninites and into finally to tholeiites (most enriched). The Ba, Sr and Pb peaks are suggestive of a re-fertilisation by a metasomatic fluid.

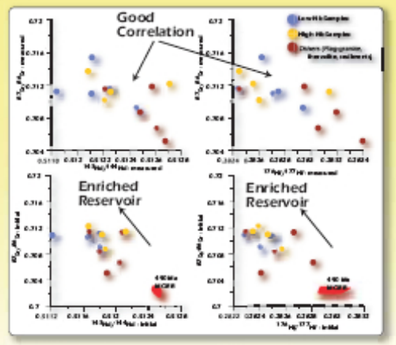




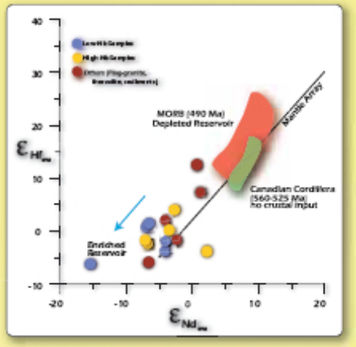
MORB normalised incompatible trace element profile. Negative Nb anomaly samples shown again but in relation to nearby Ordovican volcanic arc sequences in Delaware (Wilmighton complex; Plank et al., 2001). The relationship also shows similarities between BMC boninites and those in Delaware. The transition from boninites to tholeiites is also seen in the Delaware samples.



MORB normalised trace element diagram showing samples with a positive Nb anomaly coupled with negative Zr-Hf. These samples likely reflect the influence of Rutile (e.g. Foley et al., 2000).

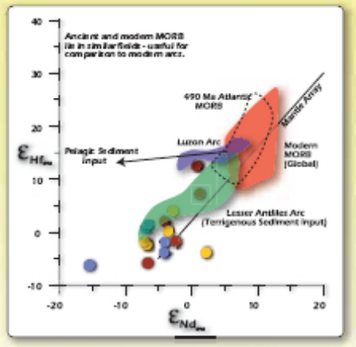


Initial values corrected to 490 Ma. Notice a strong correlation between Sr-Hf-Nd isotopes in measured values that is less clear in age corrected values - reflects possible Rb loss from the rocks. BMC also plots away from 490 Ma MORB. MORB field are Atlantic samples from Chauvel & Blichert-Toft, (2001).



eNd- eHf plot showing 490 Ma MORB field (PetDB; Chauvel & Blichert-Toft, 2001), 500-600 Ma mantle derived arc rocks and the mantle array (Vervoort & Blichert-Toft, 1999). BMC samples trend towards more enriched values. BMC values corrected to 490 Ma.

eNd- eHf plot showing 490 Ma MORB field (dotted), modern MORB field and two arc lava series (Marini et al., 2005 and references therein). The coincidence of the 490 Ma MORB and modern MORB suggests we can use the vectors from modern arc processes. BMC samples plot towards the field of terrigenous sediment input. BMC samples corrected to 490 Ma .



CONCLUSION

- Boninites are clearly identified in the BMC, confirming arc affinity.
- These boninites transition to arc tholeiites.
- Similar trace element patterns to contemporaneous arc series at Betts Cove (Newfoundland) and Wilmington Complex (Delaware).
- Hf and Nd isotopes suggest terrigenous input.
- Source of this terrigenous component could be subducted sediment or fragments of the continental lithosphere contaminating the upper mantle (e.g. Hanan et al., 2004).

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