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Formation of Lava Samples Collected by Three Alvin Submersible Dives at 14°N on the Mid-Atlantic Ridge

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Abstract

In 2018, a research cruise investigated the Mid-Atlantic Ridge at 14°N. During this expedition the seafloor was mapped using the AUV *Sentry* and basaltic lavas were collected using the HOV *Alvin*. To better understand the origin of these lavas, major element compositions of 40 basaltic glasses from three *Alvin* dives were measured using the BSU SXFive Electron Microprobe and trace element contents were measured on 33 samples using solution ICP-MS. Trace element ratios and patterns are important tools for investigating magmatic processes because they can be used to evaluate different magmatic processes; such as the amount of melting of the Earth's mantle that produces the magma and the extents of crystallization prior to eruption. Lavas collected on dives AL4953 and AL4954 have similar Rare Earth Element patterns, but variable elemental abundances, suggesting fractional crystallization was an important process in their formation. By contrast, lavas collected on dive AL4955 have variable trace element patterns and ratios, indicating a change in the extents of mantle melting. To further investigate the differences in these compositions, we will use numerical models to quantify the percent of mantle melting and extents of crystallization that led to the formation of lavas erupted in this region.

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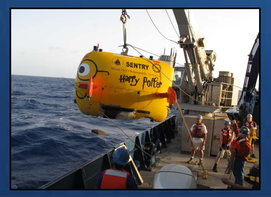

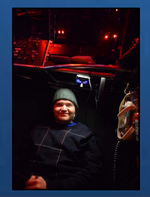

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Background

During the summer of 2018, a research cruise conducted an investigation of the Mid-Atlantic Ridge segment at 14°N, an area known as "Popping Rocks Region". This expedition mapped the seafloor using the AUV *Sentry* and physical samples were collected using the HOV *Alvin* submersible. To understand the origins of lavas at this site, we conducted geochemical analyses of the lavas and ran computer models.

The goal of this research is to:

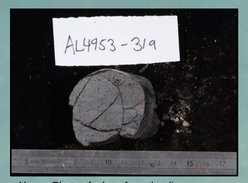
Determine which processes (fractional crystallization and melting) are involved in the formation of the lavas at 3 locations on the Mid-Atlantic Ridge using geochemical analyses and numerical modeling.

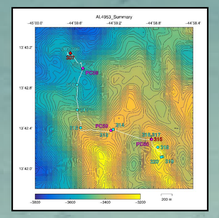
Methods

- This study focused on 36 samples collected on three *Alvin* dives.
- Samples were collected between 13'44'' and 13'36'' N.
- Samples were analyzed using the Boise State University SXFive Electron Microprobe using polished epoxy mounted glass samples.
- Fractional crystallization trends in major element compositions were run using Petrolog version 3.1.1.3
- Trace element analysis were measured using liquid solution ICP-MS.
- Trace element fractional crystallization and melting models were done in excel.

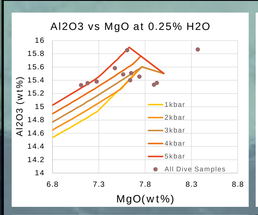
Fractional Crystallization of Major Elements

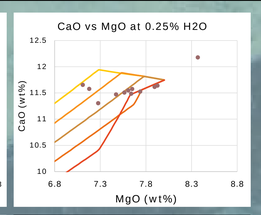
Dive AL4953

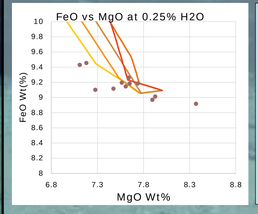




Above: Photo of a lava from the dive
Right: Bathymetric map showing the dive track and sample locations

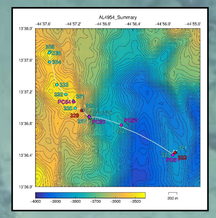




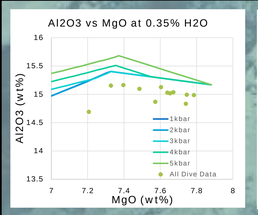


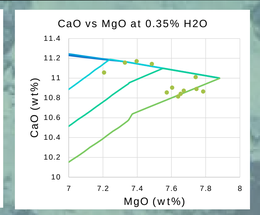
- Major element diagrams showing compositions (circles) and results of fractional crystallization models
- Models were run at multiple pressures using a water content of 0.25 wt %
- Fractional crystallization at variable pressures can explain many of these trends

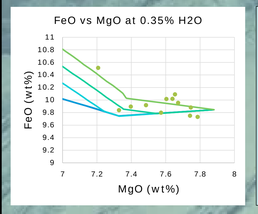
Dive AL4954



Above: Photo of a lava from the dive
Right: Bathymetric map showing the dive track and sample locations

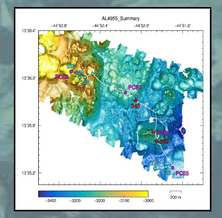




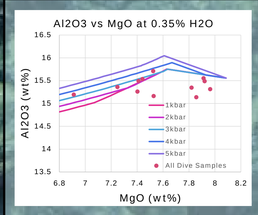


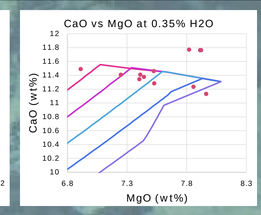
- Major element diagrams showing compositions (circles) and results of fractional crystallization models
- Fractional crystallization at various pressures and water content of 0.35 wt%
- Multiple parent magmas are required to explain compositions

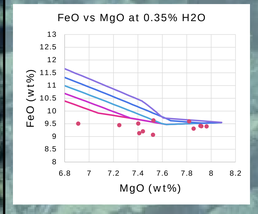
Dive AL4955



Above: Photo of a lava from the dive
Right: Bathymetric map showing the dive track and sample locations



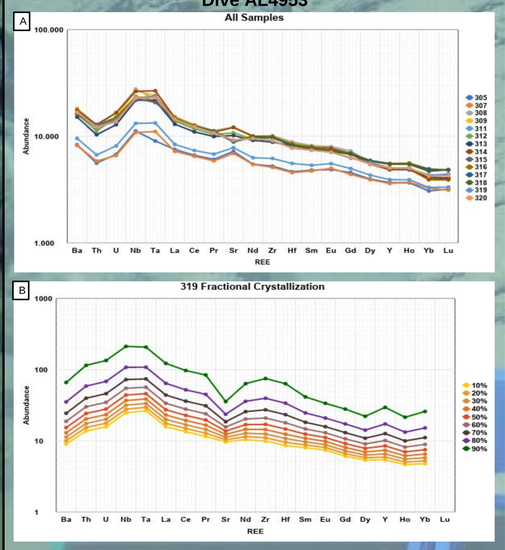




- Major element diagrams showing compositions (circles) and results of fractional crystallization models
- Fractional crystallization can explain some but not all of the major element compositions
- This may suggest variations in melting is required account for lava compositions

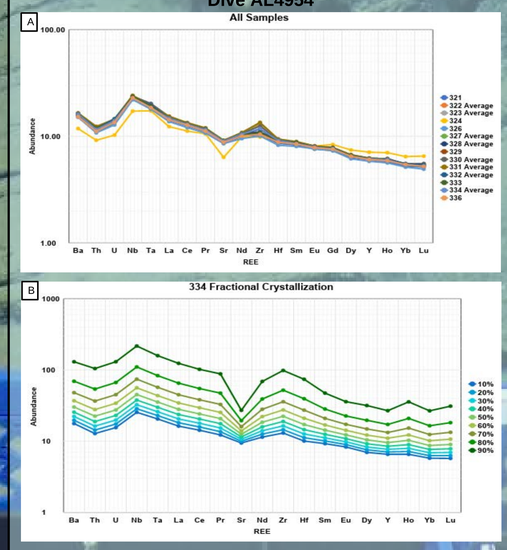
Modeling Fractional Crystallization versus Degree of Melt

Dive AL4953



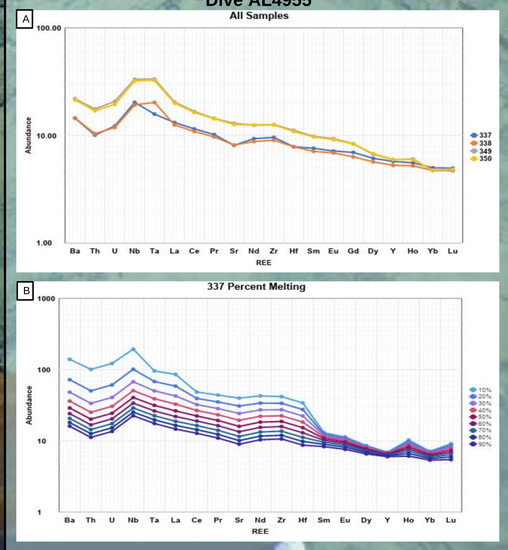
A: A chondrite normalized trace element diagram showing results of samples collected.
B: Numerical model of fractional crystallization of trace elements using the fractional crystallization equation.

Dive AL4954



A: A chondrite normalized trace element diagram showing results of samples collected.
B: Numerical model of fractional crystallization of trace elements using the fractional crystallization equation.

Dive AL4955



A: A chondrite normalized trace element diagram showing the results of varied percent of melting.
B: Numerical model for varied percent of melt using the bulk melting equation.

Results

- Modeling fractional crystallization at various pressures and water contents can produce a wide range of compositions erupted at Mid-Ocean Ridges
- Fractional Crystallization can explain lavas formed at dive AL4953 and some of the lavas erupted on dive AL4954.
- Variations in degree of melting can explain lavas formed at dive AL4955.
- These results suggest that evaluating both the extent of crystallization and degree of mantle melting is important when investigating mid-ocean ridge magmatism.

Future Work

- Further refine fractional crystallization models.
- Refine melting models to account for differences in degree of melt.
- Further ICP-MS analysis on Dive AL4955 samples.

Acknowledgements

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