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Final Report

Experimental Investigation: The Influence of Small Amounts Of Water On Peridotite Melting In The Oceanic Upper Mantle

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The research supported by this OEI grant focused on how small concentrations of water dissolved in mantle rock influences the depth at which it begins to melt beneath oceanic spreading centers. It has long been known that mantle rocks contain a small amount of water but – because the experiments are technically challenging – its effect on partial melting has never been experimentally determined. Controlling and quantifying small amounts of water in experimental charges is a challenging task because the crystals that grow during experimental runs are not large enough and do not produce enough melt to accurately analyze water concentrations using current analytical techniques. Funds from this award supported development of a new experimental approach to quantifying the influence of small amounts of water on melting of mantle rock.

Melting experiments were conducted in the experimental petrology laboratory in the McLean Building at WHOI, which is equipped with a piston-cylinder apparatus designed to achieve upper mantle pressures and temperatures. Initial characterization of each experiment was also completed at WHOI, followed by analysis of water contents using Secondary Ion Mass Spectrometry techniques at the Department of Terrestrial Magnetism, Carnegie Institution of Washington.

We faced many challenges throughout the development of our experimental approach, the greatest of which is that it is extremely difficult to control the amount of water our starting material adsorbs from the from the air while preparing each experiment. We overcame this challenge by reacting our starting materials at high temperatures and low pressures prior to performing the melting experiments. This step dehydrated the powders, limiting the amount of adsorbed water. Once this challenge was overcome, we were able to measure consistent amounts of water within each experiment. Identification of incipient melts in our experiments allowed us to determine the temperature at which the rock started to melt. Knowing the temperature of the onset of melting and the water content, we can compare our experimental results to theoretical calculations that predict how small amounts of water influence mantle melting.

Results from our study indicate that predicted theoretical mantle melting temperatures are too low. This would suggest that mantle melting beneath a mid-ocean ridge begins deeper than previously thought. Therefore, more of the oceanic mantle experiences some amount of partial melting, which impacts the geochemical and physical properties of the residual mantle. This research will be expanded to investigate how the controlled addition of small amounts of water to the mantle alters the temperature of melting. This will allow for a better understanding of mantle melting and allow for better estimates of the amount of melt under mid-ocean ridges and other volcanic systems.