**Deep Ocean Exploration Institute**
**Final Report: 2005 Funded Research Project**

# Experimental Investigation of Fluid-Mobile Element Transport in the Upper Mantle

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**What were the primary questions you were trying to address with this research? (Or, if more appropriate, was there a hypothesis or theory that you were trying to prove or disprove?)**

Convergent margins are portions of Earth's crust where tectonic plates collide. The denser of the two plates, typically composed of old ocean floor, is thrust underneath the less dense one forming a subduction zone. As the old ocean floor descends into the mantle, water-rich material is released and travels up into the overlying rock. This process leads to the formation of magmas that feed volcanoes on the upper tectonic plate. Our goal was to carry out experiments that would allow us to identify whether the water-rich material is an aqueous fluid derived from the breakdown of water-bearing minerals in the subducted ocean crust, or a water-rich magma derived from melting of rocks that make up the subducted ocean crust. We had originally intended to investigate the geochemistry of aqueous fluids, but during the early stages of our work a group from University of California at Berkeley published a study identical to the one we had undertaken. We then refocused our efforts on the geochemistry of magmas formed by partial melting of rocks from the ocean floor.

**What have you discovered or learned that you didn't know before you started this work?**

We studied a group of elements known as "high field strength elements". These elements behave similarly during magmatic processes, and are strongly concentrated in the mineral rutile. High field strength elements are depleted in lavas erupted from volcanoes at convergent margins, and this is thought to result from the presence of rutile in the subducted ocean crust. We studied how high field strength elements are distributed, or partitioned, between rutile and magma. Our work demonstrates that within this group of elements there are actually two subgroups with distinctly different behaviors. These differences appear to be a clear signal for melting of the subducted oceanic crust.

**What is the significance of your findings for others working in this field of inquiry and for the broader scientific community?**

Results from our work help to define how high field strength elements behave during melting of subducted oceanic crust. This provides geochemists with a tool that they can use to identify when and where melting has taken place.

**What is the significance of this research for society?**

Convergent margin volcanoes are located in highly populated parts of the world, such as Japan, the Philippines, Indonesia and the western United States. It is therefore imperative that we understand the processes that lead to the formation and eruption of the lavas associated with these volcanoes.

**What were the most unusual or unexpected results and opportunities in this investigation?**

**What were the greatest challenges and difficulties?**

We faced our greatest challenge when we discovered that the study we were conducting was also being done by another group, and that they had a large head start! This required us to look at the problem we were interested in from a very different perspective, but we were able to design new experiments that addressed the question we were originally interested in.

**When and where was this investigation conducted? (For instance, did you conduct new field research, or was this a new analysis of existing data?)**

The experiments were carried out at WHOI and the compositions of the experimental products were analyzed at WHOI and the Massachusetts Institute of Technology.

**What were the key tools or instruments you used to conduct this research?**

Experiments were carried out using high-pressure experimental equipment in the experimental petrology lab at WHOI. The compositions of experimental products were determined in two ways. For elements present in high concentrations, analyses were carried out using the electron microprobe at the Massachusetts Institute of Technology. For elements present in low concentrations, analyses were carried out using the ion microprobe at WHOI.

**Is this research part of a larger project or program?**

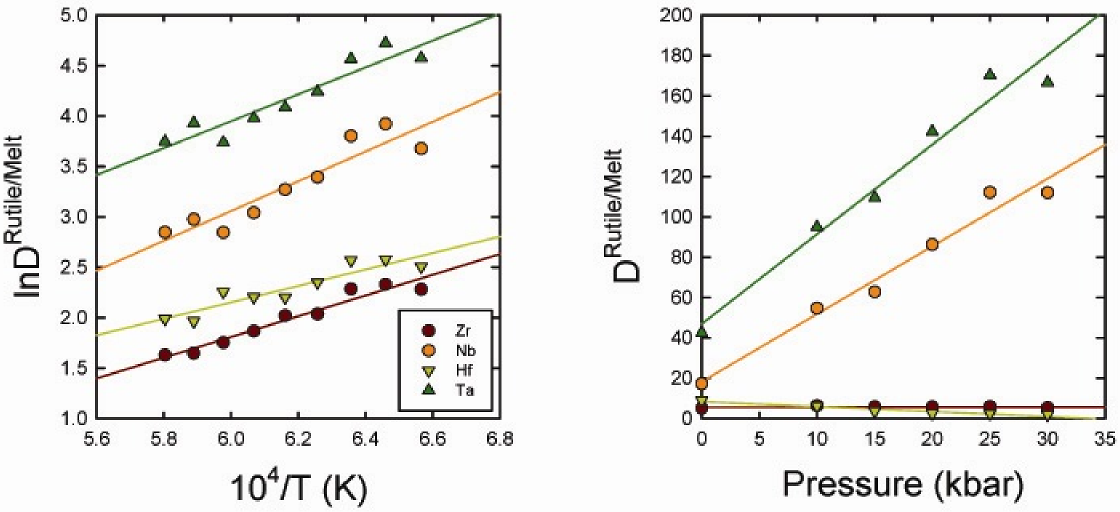
This research is part of a larger effort to better understand the origin of lavas erupted from volcanoes at convergent margins.

**What are your next steps?**

Now that we understand how this group of elements behaves in magmas, we would like to improve our understanding of how they behave in aqueous fluids.

**Have you published findings or web pages related to this research? Please provide a citation, reprint, and web link (when available).**

We convened a special session at the Fall Meeting of the American Geophysical Union, held in San Francisco California, to investigate the question of whether the material released from subducted ocean floor is an aqueous fluid or a water-rich magma. Results from our study were presented in that session.




Above is a figure that shows how the distribution (represented by the letter "D") of the high field strength elements zirconium (Zr), hafnium (Hf), tantalum (Ta), and niobium (Nb) between rutile and silicate melt changes with changing temperature and pressure. Larger "D" values indicate the more of the element is distributed, or partitioned, into the mineral rutile relative to the silicate melt. Our most important discovery is that Ta and Nb behave very differently from Zr and Hf as pressure increases, as shown in the panel on the right.