RESEARCH STATEMENT

The Earth's mantle is chemically and isotopically heterogeneous, and the primary focus of my research is to quantify this geochemical heterogeneity to understand the dynamics and long-term evolution of the deep earth. In particular, I am interested in using the compositions of ultramafic xenoliths and oceanic lavas (and the melt inclusions they host) to quantify the chemical and isotopic variability in the mantle: these mantle-derived materials provide geochemical information about an otherwise inaccessible mantle. Beginning with primary observation that the mantle is heterogeneous, a goal of my research is to understand how the mantle became heterogeneous. Does injection of subducted materials responsible for the observable heterogeneity, or are more exotic (metasomatic) processes at work? Important corollary questions include understanding the ages of these heterogeneities and how long they survive in the Earth's chaotically convecting mantle. Following billions of years of convection, at what length scales is the mantle heterogeneous? How are these heterogeneities distributed in the mantle?

I approach these problems with a combination of geochemical modeling and a wide variety of analytical tools in geochemistry. My research interests are analytically intensive and focus on the measurement of a number of radiogenic isotopes (Sr, Nd, Pb and Os) in mantle-derived materials. However, it is important to couple information from these isotopic tools with major/trace element data other isotope systems (noble gas, oxygen, lithium), to maximally constrain the origins and histories of mantle-derived materials. I also use the chemical and isotopic composition of lava-hosted melt inclusions and phenocrysts to quantify the range of heterogeneous mantle sources sampled by a single lava. In order to measure the chemical and isotopic composition of extremely small quantities of material with a high degree of spatial resolution, I develop and employ *in situ* techniques utilizing secondary ion mass spectrometry and laser ablation ICP-MS.

Graduate Research

My thesis work in the MIT-WHOI Joint Program focused on the geochemistry of lavas from the Samoan hotspot, and provided some important clues about mantle dynamics and the origins of mantle heterogeneity. In Chapter 3 (Jackson *et al*., *Nature*, 2007) of the thesis, remarkably enriched Samoan lavas ($^{87}Sr/^{86}Sr$ up to 0.7214) hosting unambiguous recycled sediment signatures are reported. Such recycled sediment signatures are unprecedented, and indicate that, in spite of the tendency for the convective motions of the mantle to greatly attenuate subducted signatures, there must be regions of the mantle that escape chaotic mantle convection. This observation is important, as recycled sediment signatures are incredibly rare in hotspot lavas, in spite of the large quantities of sediment observed to enter the mantle at subduction zones.

Chapter 2 (Jackson et al., *Earth Planet. Sci. Lett.*, 2007) argues that heterogeneities can persist in the mantle at the largest length scales for (geologically) long time periods in the (deep?) mantle's ancient high $^{3}He/^{4}He$ reservoir. In this chapter I report $^{3}He/^{4}He$ ratios in Samoan lavas that are as high as Hawaii, Iceland and the Galapagos, and find that these new Samoan high $^{3}He/^{4}He$ lavas have much less depleted $^{143}Nd/^{144}Nd$ and $^{87}Sr/^{86}Sr$ signatures. In fact, the highest $^{3}He/^{4}He$ sample from each southern hemisphere high $^{3}He/^{4}He$ hotspot is less isotopically-depleted (generally higher

$^{87}Sr/^{86}Sr$ and lower $^{143}Nd/^{144}Nd$) than their counterparts in the northern hemisphere. The observation of a large-scale isotopic enrichment in the southern hemisphere high $^{3}He/^{4}He$ mantle compared to the northern hemisphere high $^{3}He/^{4}He$ mantle is similar to the DUPAL anomaly, a globe-encircling feature of isotopic enrichment observed primarily in southern hemisphere ocean island basalts. The origin and preservation of such large-scale (hemispheric) mantle heterogeneities remain a mystery.

Compared to the hemispheric-scale heterogeneities reported in Chapter 2, Chapter 1 (Jackson and Hart, 2006) reports significant $^{87}Sr/^{86}Sr$ heterogeneities in melt inclusions hosted in olivines from a single sample. This indicates that the mantle is isotopically heterogeneous at length scales smaller than the melting zones beneath hotspot volcanoes.

Other Research Interests

While my research interests focus primarily on the geochemistry of the deep earth, I am also interested in a wide variety of topics in the earth sciences. During my tenure as a Fulbright scholar in Iceland and continuing into my graduate studies in the MIT-WHOI Joint Program, I explored whether volcanic loess sequences in Iceland could provide paleoclimate information in the North Atlantic. I found that Holocene climate change in Iceland has been reasonably coherent with other North Atlantic climate records (Jackson *et al., Geology*, 2005), and I hope to return to this issue in my future research.

Anticipated Postdoctoral work at WHOI

I am also interested in using a confluence of geophysical and geochemical tools to help better understand the melting processes that operate beneath hotspots. Complementing my thesis work in Samoa, my current postdoctoral work at WHOI uses a combined seismological and geochemical approach to place constraints on the melting processes operating in the shallow mantle beneath the Samoan hotspot track. I will use receiver functions to determine the depth to the low velocity zone that defines the lithosphere-asthenosphere boundary, and determine whether variations in the thickness of the "lithospheric lid" can explain major element variations in basalts along the Samoan hotspot track. Both Fe_8 and Na_8 reveal systematic trends as a function of distance from the active (eastern) end of the hotspot track, suggesting that the depth of melting in the Samoan hotspot may have varied over time. Variations in the thickness of the oceanic lithospheric can affect the length of the melting column, and may help explain the variations that we observe in the major element geochemistry of the Samoan lavas.