

Project Summary

Despite ample evidence that volcanic arcs arise from melting in the underlying mantle wedge, it remains unclear where and why such melting takes place. The geochemistry of arc lavas reveals large variations in the environment of melting, yet these variations have not been correlated with source-region structure as imaged geophysically. Lack of such correlation reflects both the poor seismic sampling of many arcs and the complexity of volcanic rocks in the few places where imaging has been good. Because of this lack, many basic questions remain unanswered. Is the locus of melting controlled by wedge thermal structure, or by the onset of slab dehydration? Is dehydration continuous or discrete? Does melt ascend primarily vertically, or via substantial lateral focusing, and by what mechanism? What controls the location of arc volcanoes?

The Central American convergent margin is an excellent target for seismic imaging because the arc exhibits nearly the complete global range in geochemical indicators of the subducting plate (e.g., ^{10}Be , Ba/La) as well as some of the largest variations in indicators for degree of mantle melting. Nearly all of these changes occur between western Nicaragua and central Costa Rica, the MARGINS Focus Area for the Central American Subduction Factory. We propose a comprehensive seismic investigation of the Central American upper mantle and subducting slab. We seek information on the geometry and structure of the region in which melting is taking place, the pathways and abundances of fluids, and the thermal structure of the melting region. We also seek first-order constraints on arc growth. These studies are addressed through an 18-month deployment of 43 PASSCAL broadband seismometers to densely sample structure below the arc in both Nicaragua and Costa Rica. This deployment is designed to overlap with the SEIZE experiment in Costa Rica, as well as recent and planned active source experiments. At its most basic, this project aims to discover along-strike changes in the melting regime, using seismic imaging to test predictions based on magma composition. Specifically, we seek to answer the following questions:

A. Is the degree of melting larger beneath Nicaragua than beneath Costa Rica? Geochemical indicators suggests greater depth and degree of melting beneath Nicaragua, and the depth to the Wadati-Benioff zone beneath the arc similarly increases. Is this variation caused by hotter mantle, a greater depth extent of melting, or greater slab water fluxes? More generally, where does melting occur beneath arcs? Integrated imaging of seismic wave velocities and attenuation will provide constraints on melt, fluids and temperature, and the overall pathway by which melts may be ascending to the arc. Receiver functions and other converted wave analyses will provide local information on the boundaries of the mantle wedge and their variation across the arc, as will regional waveform modeling and surface wave inversion.

B. Is slab fluid flux greater beneath Nicaragua than Costa Rica? Specifically, is the subducted crust more hydrated beneath Nicaragua than Costa Rica? Is intermediate-depth seismicity triggered by dehydration? Subducting crust at Nicaragua may represent a greater net fluid flux to arc magmas than at Costa Rica, reflected in the globally-maxima of subducted sediment tracers. Such a contrast may be reflected in structure of the downgoing plate, and in the intermediate-depth earthquakes that appear related to fluid loss. The structure of the top of the downgoing slab can be interrogated through converted phases and waveform distortion techniques; preliminary results suggest the Nicaragua slab may represent a global endmember in its retention of fluids.

C. What is the pattern of mantle flow? Anisotropy will be measured by shear-wave splitting, and will be assessed both as an indicator of mantle flow and as a possible auxiliary constraint on the presence of fluids and melt.

D. What are the along-arc variations in arc growth rates and composition? Along- and across-strike variations in crustal structure, primarily delineated by receiver functions, should provide interface constraints that can be integrated with other active-source studies being done in the region.

MARGINS Relevance: This study is directed at one of the two Subduction Factory Focus Sites (Central America), and addresses head-on one of the three main themes of the Subduction Factory Science Plan: the physical forcing functions that affect magma production within the factory. This project would provide the main mantle framework for Subduction Factory studies in Central America.