Statement of Research Interests and Qualifications
Northern Arizona University Postdoctoral Scholar Application

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The primary focus of my research concerns the evolution of the Earth's lithosphere at tectonic plate boundaries. My PhD research is motivated by the paradox that the stresses required to rupture intact lithosphere (either in compression or extension) are generally far greater than the available forces, leading to the proposition that breaking the lithosphere likely takes advantage of weakening processes (e.g. fluids) and/or re-using older weak plate boundaries. My work has helped close the knowledge gap in this area of research by investigating the mechanisms that assist lithospheric failure during two fundamental tectonic processes – (1) the separation of continents and (2) the initiation of subduction zones. As demonstrated below, my research experiences have equipped me with the skills necessary to make significant contributions to all aspects of the Aleutian Island Arc project. In addition, this new project is also a great fit for my science goals that I would want to pursue as a postdoctoral researcher at Northern Arizona University.

Over the course of my graduate career at UTIG I have developed strong skills and expertise in seismic data acquisition and processing. My extensive field experience is capped by participation in two major expeditions aboard the R/V *Marcus G. Langseth*, the premier academic vessel for marine seismic data collection. During the Seismogenesis at Hikurangi Integrated Research Experiment (SHIRE), I assisted with the deployment of the hydrophone streamer, with quality control on incoming seismic shot data, and I processed the new marine seismic data to produce initial reflection images. During the South Island Subduction Initiation Experiment (SISIE), I was actively involved in the programming, assembly, deployment, and recovery of ocean-bottom seismometer (OBS) instruments, and I also participated in the multichannel seismic (MCS) reflection data acquisition and processing. Following the SISIE voyage, I spearheaded post-cruise processing of the entire MCS dataset, which consists of ~1250 km of data across eight 2-D profiles. Marine mammal shutdowns, rough weather conditions, and complex subsurface architecture provided significant challenges, which I overcame by utilizing advanced algorithms and testing novel routines that are outside of the typical seismic processing workflow. Furthermore, I optimized deep crustal imaging by constructing a seismic velocity model for pre-stack depth migrations by combining sedimentary velocities derived from moveout analysis of CMP gathers from streamer data with seismic velocities of the crust and upper mantle from wide-angle OBS tomography. These experiences have solidified my foundation in seismic data acquisition and analysis, and I am eager to apply these skills to the Aleutian Island Arc dataset.

After we have taken a seismic data set through basic processing steps, I always appreciate how much progress we can make with the integration of different data sets and an objective approach to seismic data analysis and interpretation. In the ENAM project, I interpreted reflected and refracted compressional-wave phases on short-period OBSs and performed tomographic inversion on three profiles to constrain the subsurface seismic velocity structure. These tomography models also incorporated key stratigraphic horizons from coincident MCS lines to improve the layered representation of the subsurface as well as onshore-offshore data to increase velocity resolution across the shoreline. Additionally, I interpreted shear-wave phases and performed travel-time tomography to constrain the Vs structure along a transect on anomalous oceanic crust. The seismic velocity models I produced were critical to assess the architecture and composition of the crust across the transition from rifting to initial seafloor spreading. My work at the Puysegur margin has primarily involved structural seismic characterization from the mantle to the seafloor. High-quality seismic images from my processing routine facilitated my interpretation of crustal structures (i.e. faults, magmatic intrusions, volcanic flows) and corresponding features in the overlying stratigraphic architecture (i.e. folds, faults, pinch-outs, thickness variations, unconformities). By utilizing chronostratigraphic seismic horizons tied biostratigraphy data at a nearby petroleum borehole, I was able to place absolute age constraints on structures throughout the margin, thus elucidating the tectonic history of deformation, magmatism, and basin fill along the plate boundary. Integrating OBS tomography models was key to determining the tectonic affinity of the crust (i.e. continental and oceanic domains) and estimate the amount of crustal extension and magmatic additions. The joint interpretation of MCS and OBS data established major scientific breakthroughs in our understanding of the Puysegur margin, including an updated tectonic reconstruction and new insights about the structure, composition, and thickness of the crust along both plates at the site of subduction initiation.

When I work with seismic data, I am always eager to integrate complimentary data types and methodologies to broaden and enhance my research, such as geophysical, geochemical, geologic, geodynamic, and petrologic observations and modeling results. For example, to expand upon the insights from the subsurface velocity structure along the ENAM, I devised a suite of petrologic modeling routines using pMELTS software to explore the temperature and composition of the upwelling mantle and the melt generation, migration, and crystallization processes to form new igneous crust. Given an initial mantle temperature and composition, each model outcome yielded predictions about the thickness of new igneous crust and the proportions and chemistry of minerals phases comprising lower crustal gabbroic rocks. These values were then used as inputs into the Abers and Hacker (2016) toolbox to estimate the compressional and shear-wave velocities of the lower crustal gabbros. Finally, the predicted values for crustal thickness and lower crustal seismic velocities were then directly compared to measurements from the seismic tomography images. Because these modeling routines involve several poorly known parameters, they could be tainted by bad assumptions, or lead to non-unique results, thus making the predictions less robust. I therefore meticulously calibrated the petrological models to ensure predictions were accurate for normal oceanic crust, thus lending confidence to model outputs for abnormal, incipient oceanic crust in the ENAM study area. This calibration process involved testing depleted mantle compositions and normal mantle temperatures as inputs, and comparing the results to global compilations of oceanic crustal thicknesses from wide-angle seismic tomography, the modal mineralogy of oceanic gabbros from dredging, drilling, and ophiolites, and laboratory measurements of Vp and Vs of recovered gabbros under reasonable pressures and temperatures. Adjustments were included to account for the fractional crystallization of olivine cumulates beneath the Moho and hydrothermal alteration of olivine to phyllosilicates and pyroxenes to amphiboles, which are well known and persistent phenomena along mid-ocean ridges. Lastly, we tested the scenario that shallow melting was prevented and that mantle melts percolated diffusely through a finite pre-existing lithospheric lid to form new igneous crust atop a thermally eroding mantle. The thorough and innovative petrological modeling efforts led us to robustly conclude that the final lithospheric breakup was prolonged and that a mantle plume was not involved in the continental rifting process. In the recent manuscript on the Puysegur margin that I submitted to *Tectonics*, I incorporated seismic data, shipboard bathymetry, backscatter, magnetic anomaly, and gravity data along with reginal seismicity and geochemical signatures from dredged rock samples to support my interpretations, and made comparisons to regional plate kinematic reconstructions to place our tectonic results in broader context. During my undergraduate studies, I conducted geological field research consisting of measuring sections with outcrop descriptions, paleocurrent indicators, and thin section sedimentary provenance analysis. The interdisciplinary nature of my research has given me the background and toolset necessary to develop new approaches to investigate complex tectonic problems with a variety of methods.

Moving forward, I plan to investigate the feedbacks between melts/fluids, tectonic stresses, deformation, and mass fluxes along active plate boundaries. I am interested in understanding the manifestation of these processes throughout the lithosphere from the surface to the upper mantle, and across a diverse range of tectonic settings. Hence, my research interests strongly align with the proposed work along the Aleutian Island Arc as part of this postdoctoral opportunity, and I am ecstatic about the opportunity to investigate crustal formation processes in an active volcanic setting. The Aleutian Arc is an excellent location to study subduction arc volcanism because of its well-constrained tectonic history, abundant sampling and geochemical analyses, and mostly submarine setting to facilitate the collection of nearly continuous seismic transects across the arc. Furthermore, the Andreanof segment coincides with several great earthquakes, which offers the opportunity to examine the structure of the incoming mantle, crust, and sediments, and draw connections to seismic hazards.

Given my research experience and qualifications, I am confident in my abilities to contribute to all aspects of the Aleutian Island Arc project. My familiarity with the R/V *Marcus G. Langseth* will be valuable if given the opportunity to participate in the cruise, and otherwise still highly beneficial to understanding the format, strengths, and potential limitations of the collected data. I am particularly excited about the opportunity to expand upon my skills with wide-angle OBS and MCS streamer data, either in a leading or supporting role in collaboration with members of the research team. The seismic processing workflows I have developed will be useful to mitigate out-of-plane seismic noise from the rough seafloor fabric of the oceanic lithosphere on the Pacific Plate and to optimize velocity models for pre-stack depth migrations to best image the subducting plate interface and deep structures across the forearc to backarc region. Seismic reflection images and velocity models derived from wide-angle seismic tomography will be key to identifying deformation and hydration of the incoming slab, which has important implications for the volume of fluids subsequently released in arc magma genesis. I envision myself assisting with interpretations of the overall architecture of the arc, by using the seismic images to determine the crustal thickness and velocity structure, and make connections to laboratory and geologic field observations to constrain the bulk composition of the arc crust. My training with petrological modeling will be helpful to develop similar routines to explore the primary magma composition and crystallization processes throughout the crust. This project offers a unique opportunity to connect modeling results directly to the model mineralogy and mineral phase major and trace element chemistries from analyses of lava samples on the surface. Through collaborative efforts, I hope to play a significant role in achieving the project goals of understanding (1) the hydration state of the incoming lithosphere, (2) volatile flux and thermal state of the mantle wedge leading to arc magma genesis, (3) composition of primary magmas, and (4) melt fractionation processes from ultramafic cumulates beneath the petrologic Moho to shallow magma chambers near the surface.

In closing, the expertise I have developed during my undergrad and graduate career make me an excellent candidate for this postdoctoral scholar position. Both the ENAM and Puysegur margins were selected as GeoPRISMS primary sites, and I am ecstatic about the opportunity to pursue related research at another primary site in the Aleutian Arc to expand upon my existing connections within the community. Finally, attaining this postdoctoral scholar role fulfills my desire to conduct cutting-edge research in a supportive and inclusive environment and interact with geoscientists from diverse backgrounds.