Intellectual Merit From academic institutions to pop culture, every American knows about the impending possibility of "The Big One"—a M8 or greater earthquake along the San Andreas Fault System (SAFS) in California. While strike-slip systems exist across the world, the SAFS is unique in that it terminates at the Mendocino Triple Junction (MTJ), which is the only known example of a modern FFT system—a tectonic triple point bounded by two transform (F) boundaries and a subducting trench (T)[1]. The MTJ formed at approximately 30 Ma when the Pacific-Farallon ridge system was subducted beneath the North American Pacific Trench, creating the northward migrating triple point, and changing the tectonic regime of the plate boundary from a convergent style to a current strike slip style at the latitude of the SAFS.[1]. This change has had drastic effects on the Pacific Coast ever since, resulting in high levels of deformation and seismic activity. The project proposed herein seeks to better understand this geologically complex and socially meaningful system, by aiming to identify and characterize the first recognized ancient equivalent of the MTJ at the southwestern extent of the Paleozoic-era Norumbega Fault System (NFS) of Maine. My PhD work will investigate a ridge-subduction model for the Norumbega Triple Junction (NTJ) put forth by Kuiper 2016[2] by **1) utilizing field and microstructural analysis to evaluate whether dextral faults that curve in a direction opposite to Riedel faults in the NFS are equivalent to stepover faults in the SAFS and 2) testing whether these faults are progressively younger to the southwest, indicating a southwestward migration of the NTJ, analogous to the modern northward migration of the MTJ.** If the southern terminus of the NFS is an appropriate type locality for the FFT style triple junction, then the region may provide insight into the evolution and behavior of strike-slip tectonics in the SAFS and around the world. The identification of such an analogue would be particularly significant given the strong outcrop exposure of structural features long the Maine coast in contrast to the more veiled features of the modern Mendocino Triple Junction. Regardless of model success, this work will provide a furthered paleogeographic model for the evolution of New England—a complex and meaningful region in its own right.

Context Along its ~300 km extent from SW New Brunswick to S Maine, the mid-Paleozoic NFS is a NE-trending right-lateral transpressive system that parallels the Appalachians[3]. The NFS terminates to the SW, along high grade metamorphic rocks and migmatites associated with the Nashoba terrane of Eastern Massachusetts[4]. The youngest age of partial melting in the Nashoba (~360 to 380 Ma) is coincident with ages of dextral shear in southern parts of the NFS obtained by Ar/Ar age-dating[5,3]. These coeval ages suggest that while dextral movement occurred along the NFS in Maine, convergent style tectonics were still taking place in the nearby Nashoba terrane, indicating a triple point existed between the two. Furthermore, work done by Gentry et al., 2016 illustrates a lack of dextral NE-trending subvertical lineaments, shear zones, and faults in Massachusetts. These observations suggest an abrupt southern termination of the NFS, not unlike the modern MTJ placement against the northern Cascade arc volcanoes in the SAFS[6,7].

Hypotheses Splay-shaped faults in the NFS and SAFS play a key role in testing the Kuiper 2016 model. These structures look like expected Riedel-shaped faults, but curve in a direction opposite to the expected Riedel orientation [2]. In the SAFS, these features are known to be associated with dextral activity, and are possibly either slip-transfer faults from the SAFS to the Mendocino Triple Junction or linkage faults between various strands of the SAFS[8]. If the subducted ridge model is correct, the Norumbega Triple Junction would have moved SW, mirroring the current northward migration of the MTJ. If this is the case, the splay-shaped dextral faults in the NFS should be younger to the south, paralleling the age pattern inferred from the slip-transfer and linkage faults in the northern SAFS[8]. Alternatively, such features in the NFS could be original sinistral (Riedel-expected-orientation) structures which were subsequently reactivated, resulting in dextral overprinting. This alternative will be investigated alongside the work proposed herein.

Methods and Work Plan Beginning in 2018, I will add to my background of coursework in high temperature geochemistry, structure, and geodynamics through graduate-level work in microstructure, kinematics, and geochemistry. During this time, I will identify optimal sites for mapping based on high quality LIDAR imagery in collaboration with previous workers and the Maine Geological Survey. Over the next two summers, I will mentor an undergraduate field assistant and conduct detailed structural mapping at sites across southern Maine, with the goal of identifying pre-NFS convergent folds displaying overprinted dextral shear indicators such as S-C fabrics, shear bands, and stretching lineations, all of which indicate the formation of the Norumbega Triple Junction.[9] Following sample acquisition, Backscattered Electron Imaging (BSE) analysis will be utilized to reveal spatial relationships between mineral assemblages and deformation fabrics sampled along the NFS (extending from the north towards hypothesized younger southwestern extents). This will allow for the selection of mineral candidates for U-Th-Pb age-dating. Analyses will be conducted using either an electron microprobe (EMP), or a laser ablation system coupled to a high-resolution, single collector inductively coupled plasma mass spectrometer (LA-ICPMS). Given that the EMP provides only an elemental age and has a smaller spot size than ICPMS, the exact methodology will depend on the size of the domains chosen for analysis. Both methods have been shown to display strong enough precision to resolve geological events in the study region (1-3% for the EMP and <3% for LA-ICPMS).[10] Results from each of the two field seasons will be synthesized and used to inform a workplan for future field and analytical work. Final results will take the form of my PhD dissertation and associated peer reviewed publications. Results will also drive the outreach campaign outlined in my Personal Statement. While this project is ambitious, my prior educational, professional, and research experiences pair with the resources available at Colorado School of Mines and elsewhere to ensure that I have the skillset, perspective, and support necessary to succeed.

Broad Impact The affirmation of a ridge-subduction model for the NFS not only has the potential to establish a type locality for the enigmatic FFT style triple junction, but moreover would inform scientists seeking to decipher the kinematics of the currently active MTJ by allowing for interpretations from well exposed outcrops along the NFS to be applied to the SAFS—extending our base of knowledge about an active and dangerous natural system. Even if the model cannot be confirmed, the completion of an in depth structural history of the region will enable a stronger understanding of the mid-crustal dynamics associated with the evolution of the New England Appalachians. Finally, the completion and communication of this work will not only be scientifically relevant, but will enable me to build upon the goals outlined in my personal statement by establishing a career that will impact public discourse and geoscience education.

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