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Anatomy of amphibolite facies strain gradients in granitoids of the Grenville Front Tectonic Zone, Ontario, Canada

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Observations of physical and chemical changes across strain gradients can provide information about the processes that lead to localization and therefore provide better tools for prediction of spatial and temporal strain patterns. Much of orogenic crust comprises granitoid lithologies, yet mechanisms for viscous localization at the kilometer scale in these rock types remain poorly documented. In contrast to mafic and pelitic compositions, granitoids have little capacity for changes in phase assemblage that can drive localization, so strain must focus due to other, mainly microstructural, factors. We describe microstructural and compositional data across several kilometer-scale amphibolite facies strain gradients from middle levels of the Grenville Front Tectonic Zone, Ontario, Canada. Whole rock analyses reveal only minor heterogeneity in major element distribution in the granite – attributable to the protolith – and homogeneity in the trace elements, indicating that strain did not affect the bulk rock composition. In contrast, microstructures and mineral chemistry vary with strain, in particular biotite, hornblende, and plagioclase compositions, the fraction of recrystallized grains, and the development of a mixed-phase matrix. The spatial distribution of the microscale changes indicates an evolution of deformation mechanisms with increased localization. Stress concentrations at the unit boundaries were insufficient to cause the strain gradient alone, but were sufficient to initiate the microstructural processes leading to rheological change. Homogenization algorithms based on phase assemblage, phase morphology, and intracrystalline deformation mechanisms do not predict the strength reduction indicated from the macroscale strain patterns. Thus, dynamic rock strength is likely lower than is immediately apparent from exhumed tectonites.