The Effect of Rock Composition on Faults and Shear Zones:
Case Study of the Norumbega Fault Zone, Mid-Coast Maine

Kevin McDonough, 2014

Faults at the surface of the Earth exist as predominantly planar features. At depths of greater than 5 kilometers, faults transition to shear zones, whereby deformation is accommodated in a volume of material as opposed to simply along a plane. What controls this transition remains a fundamental question that structural geologists and engineers are working to answer, in part because many earthquakes occur at these depths. The more we understand about the mechanics that govern how deformation is accommodated, the better we can model the development and evolution of fault systems, which can have implications for earthquake prediction.

Most scientists agree that temperature, pressure, fluid and rock composition are the major factors controlling how rocks accommodate deformation—along a plane (fault) or within a volume (shear zone). The focus of my research this summer was to examine the role of rock composition—specifically the proportion of platy minerals—on deformation accommodation. We tested the hypothesis that softer, platy sheet silicate minerals (i.e. biotite, muscovite, chlorite) create a plane of weakness within a rock, and therefore causes faults and shear zones to localize along this weakness. We predicted that there would be minimum and maximum threshold values for the proportion of sheet silicates that would localize faults and shear zones.

In order to assess the role of platy sheet silicate minerals of the localization of faults and shear zones, Professor Peterman and I collected samples from four different rock types that host faults and shear zones associated with the Norumbega Fault System—an inactive 350+ kilometer fault system that runs from southern Maine to Canada. We prepared thin sections from these field samples to calculate the proportion of platy sheet silicate minerals within these samples using both optical petrography and chemical analysis on a Scanning Electron Microscope. The data from both of these methods yielded a range of 12 to 73.5% sheet silicate minerals in these samples. Therefore, the presence of a sheet silicate mineral was necessary to provide a plane or volume for deformation to be accommodated. The modal percentage of sheet silicates, however, was not directly related to the amount of deformation. Instead, we noticed that all samples collected from fault or shear zones had continuous bands of platy sheet silicate minerals that likely provided a weak plane for strain to localize and deform the rock. Therefore, we suggest that the interconnection of the sheet silicate minerals into continuous bands might be the most important factor in how deformation is accommodated.

With continued research this fall, Professor Peterman and I will expand the study to investigate the role of the interconnection of sheet silicates and how deformation was accommodated in faulted rocks. We will look at samples collected from both deformed and not deformed rocks to see if there are significant relationships among the proportion of platy sheet silicates, their interconnections, and the amount and style of deformation recorded by the rocks.

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