Rheological properties of the shallow subduction interface: insights from the Chugach Complex, Alaska

Zoe Braden and Whitney Behr  
ETH Zürich, Geological, Earth Sciences, Zürich, Switzerland (zoe.braden@erdw.ethz.ch)

The plate interface in subduction zones accommodates a wide range of seismic styles over different depths as a function of pressure-temperature conditions, compositional and fluid-pressure heterogeneities, deformation mechanisms, and degrees of strain localization. The shallow subduction interface (i.e. ~2-10 km subduction depths), in particular, can exhibit either slow slip events (e.g. Hikurangi) or megathrust earthquakes (e.g. Tohoku). To evaluate the factors governing these different slip behaviors, we need better constraints on the rheological properties of the shallow interface. Here we focus on exhumed rocks within the Chugach Complex of southern Alaska, which represents the Jurassic to Cretaceous shallow subduction interface of the Kula and North American plates. The Chugach is ideal because it exhibits progressive variations in subducted rock types through time, minimal post-subduction overprinting, and extensive along-strike exposure (~250 km). Our aims are to use field structural mapping, geochronology, and microstructural analysis to examine a) how strain is localized in different subducted protoliths, and b) the deformation processes, role of fluids, and strain localization mechanisms within each high strain zone. We interpret these data in the context of the relative ‘strengths’ of different materials on the shallow interface and possible styles of seismicity.

Thus far we have characterized deformation features along a 1.25-km-thick melange belt within the Turnagain Arm region southeast of Anchorage. The westernmost melange unit is sediment poor and consists of deep marine rocks with more chert, shale and mafic rocks than units to the east. The melange fabric is variably developed (weakly to strongly) throughout the unit and is steeply (sub-vertical) west-dipping with down-dip lineations. Quartz-calcite-filled dilational cracks are oriented perpendicular to the main melange fabric.

Drone imaging and structural mapping reveals 3 major discrete shear zones and 6-7 minor shear zones within the melange belt, all of which exhibit thrust kinematics. Major shear zones show a significant and observable strain gradient into a wide (~1 m) region of high strain and deform large blocks while minor shear zones are generally developed in narrow zones (~10-15 cm) of high strain between larger blocks. One major shear zone is developed in basalt and has closely-spaced, polished slip surfaces that define a facoidal texture; the basalt shear zone is ~1 m thick. Preserved pillows are observable in lower strain areas on either side of the shear zone but are deformed and indistinguishable within the high strain zone. The other two major shear zones are developed in shale and are matrix-supported with wispy, closely-spaced foliation and rotated porphyroclasts of
chert and basalt; the shale shear zones are ~0.5-2 m thick.

Abundant quartz-calcite veins parallel to the melange fabric and within shale shear zones record multiple generations of fluid-flow; early veins appear to be more silicic and later fluid flow involved only calcite precipitation. At the west, trench-proximal end of the mélange unit there is a 5-10 m thick silicified zone of fluid injection that is bound on one side by the basalt shear zone. Fluid injection appears to pre-date or be synchronous with shearing.