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Strain localization mechanisms (or lack thereof) in a ∼10 km wide, syn- to post-magmatic mylonite zone in the Famatinian arc

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Numerous mechanisms have been proposed to localize strain in crustal rocks (e.g. grain size reduction). In contrast, mechanisms also exist that could act against strain localization, leading to unusually wide shear zones, (e.g. reaction hardening). Several of these processes may be active in a single shear zone, as a function of temperature, composition and time.

The ∼10 km wide Cuesta de Randolfo Mylonite Zone (CRMZ), is one of numerous km-scale shear zones in the central, intrusive-rock dominated part of the Ordovician Famatinian arc, NW Argentina. We use structural mapping, microscopy, U-Pb geochronology and MELTS modeling to understand the structural evolution of the CRMZ. This shear zone provides an excellent case study to investigate the interplay between processes localizing strain, and processes acting against strain localization, because it comprises two distinct structural, compositional and temporal domains: (1) a western domain, dominated by younger two-mica, K-feldspar and tourmaline-rich granite, which displays distributed moderate strain (i.e. less localized); and (2) an eastern domain, comprising older, biotite-plagioclase-rich granite, with narrow ultramylonites along contacts with dikes, veins, pegmatites, or rafts of volcanic rock (i.e. highly localized). A narrow fault occurs at the contact between the two domains. Deformation was likely coeval across the two domains, as structures are parallel, and structures in the older eastern domain lack an overprint due to a younger deformation event.

During arc-wide regional shortening, the younger 2-mica-K-feldspar granite intruded the older, solidified biotite-plagioclase-granite. At this time, the hypersolidus younger granite was the weakest phase, and shortening was taken up preferentially by the melt. Upon cooling of the younger granite below its solidus (∼630 [U+1D52]C, lowered due to boron), quartz (across both domains) became the weakest phase, and underwent dislocation creep and subgrain rotation (SGR) recrystallization. Strain localization by reaction weakening (plagioclase sericitization) only had a major effect in the plagioclase-rich older granite, which developed narrow, highly localized ultramylonites (quartz dislocation creep, and slip on bands of newly-formed mica), whereas the younger granite formed a broad zone of distributed strain (quartz dislocation creep only). With further cooling, strain localized along the contact between the two domains, and along the existing ultramylonites in the older granite. This lower-T strain was accompanied by bulge (BLG) recrystallization in quartz, and slip along mica-rich shear bands.

Several strain localization processes have been active, dependent on compositional and temporal characteristics of the two domains. During emplacement of the younger granite, strain localized in the melt of this unit due to its relative rheological weakness. Subsequently, strain was accommodated by quartz dislocation creep in both domains; however, strain localization only occurred in the E domain, where the plagioclase-rich composition allowed reaction softening. Thus, the broad, distributed strain in the W domain does not necessarily reflect an active mechanism acting against strain localization. Rather, we suggest a lack of a strain localization mechanism within this domain causing broad strain distribution (insufficient grainsize reduction by SGR or BLG to lead to a mechanism switch, and an unsuitable composition for reaction weakening).