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Pressure-solution creep as a source for strain localisation during late emplacement of granite: The case of Naxos (Greece)

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Strain localisation is a fundamental process that largely contributes to the dynamics of the lithosphere. This includes the development of shear bands and large-scale strain gradients in granitic plutons at near solidus to sub-solidus conditions, the source(s) of which remains unresolved. Here we focus on quartz-rich shear bands that developed within the granodiorite of Naxos emplaced below the north-Cycladic detachment (Aegean arc, Greece). Based on detailed microstructures, we document 1) a well-defined prismatic slip lattice preferred orientation (LPO), 2) a fabric strength that weakens with decreasing size of recrystallized grains, 3) local phase mixing of fine-grained feldspar and quartz without any LPO, and 4) the occurrence of four-grain junctions where strain has localized. Evidence of strain-related myrmekite and fluid inclusions also indicate the presence of fluids during deformation. Whereas prismatic slip LPO results from dislocation creep, the three other points suggest a significant contribution of grain-size-sensitive creep, including grain boundary sliding (GBS). Such a mixed rheology has been already documented for natural quartzite (Tokle et al., 2019) and during experiments (Fukuda et al., 2018; Richter et al., 2018), but it still remains unexplained. Based on available flow laws (Gratier et al., 2009; Hirth et al., 2001), we here attribute this peculiar rheology to long-term feedbacks between dislocation creep and fluid-assisted pressure-solution creep, so that quartz aggregates stabilize at conditions that involve equal contribution of these two processes. Because pressure-solution creep is highly sensitive to grain size, partly owing to GBS, it provides a suitable alternative to account for the occurrence of strain localisation in granitic rocks.

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