Abstract
Strain localization 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 granite 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 during the upper-crustal emplacement of the Naxos granodiorite below the north-Cycladic detachment (Aegean arc, Greece). Based on detailed microstructures, we document 1) high-temperature (> 400-500 °C) lattice preferred orientation (LPO) and dislocation slip systems (mostly prism [a] and prism [c]), 2) a fabric strength and misorientation axes distribution (MAD) that respectively weakens and randomizes with decreasing size of recrystallized grains (< 20 µm), 3) the occurrence of four-grain junctions where strain has localized, and 4) local changes of dislocation slip system and phase mixing depending upon the above features. Evidence of strain-related myrmekite and amphibole also indicate the presence of fluids during deformation. Wherous prismatic slip LPO results from dislocation creep, the three other points suggest a significant contribution of grain boundary sliding (GBS). Although such a mixed slip system has been already documented in recent studies (Fukuda et al., 2018; Richter et al., 2018; Tokle et al., 2019), the source of GBS still remains unexplained. Using available flow laws for wet quartz (Hirth et al., 2001; Rutter & Brodie, 2004; Grandier et al., 2009), and at conditions of the Naxos granodiorite (3 kbar and 800 °C), we highlight pressure-solution creep as a relevant candidate for grain sizes lower than 20 µm. This predicts a substantial weakening that may account for the occurrence of strain localization in granite plutons and plutons that provided fluid-assisted dissolution-precipitation is activated.

Four-grain junctions and local phase mixing

The granodiorite of Naxos (Greece)

Towards detachment

Strain gradient

Towards pluton core

Grade 5

Grade 4

Grade 3

Grade 2

Grade 1

Source of GBS

Pressure-solution creep

Dislocation creep

Grain boundary sliding (GBS) + dislocation creep

Grain boundary sliding (GBS) only

Dynamic recrystallization

Prism [a + c]

Prism [a] + GBS

Dislocation creep (all grains)

Prism [a]