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Strain localization and rheological weakening of a high-grade metamorphic massif

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We present a detailed case study of Diancang Shan high-grade metamorphic massif, to investigate how deformation promotes strain localization, and how weak secondary phases and hydrous fluids trigger rheological weakening during retrogression near the ductile to brittle transition zone during exhumation. In the Diancang Shan metamorphic massif, high-temperature ductile deformation (D1) pervasively occurred during shearing and exhumation since late Oligocene. The high-temperature microstructures and textures are in part or entirely altered by subsequent low-temperature shearing (D2) since late Miocene, which is under transitional frictional-viscous conditions of K-feldspar during further exhumation to the upper crustal levels. D2 microstructures and shear bands overprinted high-temperature intracrystalline plasticity phases (D1) in mylonitic rocks. Depending on the main rock-forming minerals, the results also demonstrate that the brittle–ductile transition involves a combination of different deformation mechanisms and possible rheological paths. As a result, grain-size reduction associated with fluids circulating within the Diancang Shan metamorphic massif at brittle–ductile transition level leads to reaction and texture weakening. Rheological weakening is the consequence of the syntectonic deformation, fluid flow, reaction softening, and textural softening. The hydrous fluids resulted in hydration of silicates. Decompression occurred during shearing and as a result of tectonic exhumation. All these results demonstrate that the exhumation of Diancang Shan metamorphic massif through the ductile to ductile-brittle transition involves a combination of different deformation mechanisms, rheological transition features and feedbacks between deformation, decreasing temperature and fluids. Discussed rheological softening mechanisms, particularly fluid flow, lead to shear concentration along the boundary of the hot metamorphic massif to overlying cool units, which always remained in upper crustal levels.