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Continuous deformation versus episodic deformation at high stress – the microstructural record

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The microstructural record of continuous high stress deformation is compared to that of episodic high stress deformation on two examples:
1. Folding of quartz veins in metagreywacke from Pacheco Pass, California, undergoing deformation by dissolution precipitation creep at temperatures of 300 ± 50°C. The microfabric of the folded quartz veins indicates deformation by dislocation creep accompanied by subgrain rotation. The small recrystallized grain size of $\tilde{8}\pm6$ μm in average implies relatively high differential stresses of a few hundred MPa. The stress concentration in the vein is due to a high contrast in effective viscosities between the single phase material and the polyphase fine-grained host metagreywacke deforming by dissolution precipitation creep. Smoothly curved, but generally not sutured, grain boundaries as well as the small size and a relatively high dislocation density of recrystallized grains suggest that strain-induced grain boundary migration was of minor importance. This is suspected to be a consequence of low strain gradients, which are due to the relative rates of dynamic recovery and continuous dislocation production during climb-controlled creep, at high stress and the given low temperature. Subgrain rotation recrystallization is thus proposed to be characteristic for continuous deformation at high differential stress.
2. Episodic deformation in the middle crust at the tip of a seismic active fault zone. The microfabric of mid-crustal rocks exhumed in tectonically active regions can record episodic high stress deformation at the base of the seismogenic layer. The quartz veins from St. Paul la Roche in the Massif Central, France, are very coarse grained. On the scale of a thin section they are basically single crystalline. However, they show a very heterogeneous microstructure with a system of healed microcracks that are decorated by subgrains and more rarely by small recrystallized grains. Undulating deformation lamellae that do not show a preferred crystallographic orientation are found by transmission electron microscopy to represent dislocation walls with a high density of dislocations. They are interpreted as a modified microstructure that reflects a stage of initial high stress deformation with restricted dynamic recovery. The missing aggregates of recrystallized grains rule out dynamic recrystallization, which is proposed to be due to a high strain rate, preventing effective dislocation climb. Instead, localized single grains in random orientations that are aligned along fractures indicate quasi-static recrystallization and recovery at a subsequent stage of low stress and temperatures of $\tilde{3}00 \pm 50$°C. Such a microstructure is characteristic of initial short-term high stress glide-controlled deformation accompanied by microcracking during coseismic loading and subsequent modification by recovery and recrystallization at rapidly decreasing stresses during postseismic relaxation in the middle crust below the seismogenic layer.
Both examples indicate deformation of quartz at similar conditions in terms of temperature ($\tilde{3}00 \pm 50$°C) and high stress. However, the deformation and recrystallization processes and the resulting microfabrics are completely different due to the different loading time and rate.