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The range of dynamic recrystallization of quartz - An updated correlation between nature and experiment

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Several microstructural correlations between natural and experimental conditions for dynamic recrystallization of quartz have been proposed (e.g., Hirth et al. 2001; Stipp et al. 2002), but an attempt to unify the different results and data sets is missing. Based on additional experiments and a statistical analysis of microstructural data (e.g., Stipp et al. 2006, 2010) four characteristic microstructural zones with corresponding recrystallized grain size (D) ranges can be identified. (I) D < 3 μm: Experimental dislocation creep regime 1 of Hirth and Tullis (1992). Microstructures are characterized by porphyroclasts with serrations, bulges and very small recrystallized grains along the grain boundaries. Electron backscatter diffraction data indicate that both local grain boundary migration and subgrain rotation contribute to recrystallization, and that grain boundary sliding may operate at high strain (Stipp and Kunze, 2008). Comparable microstructures have not been observed in natural shear zones; their formation is not possible at greenschist facies conditions, because the required differential stresses would be larger than the confining pressure and so in conflict with the Goetze criterion (Kohlstedt et al. 1995). (II) D $\sim$3–35 μm: Experimental dislocation creep regimes 2 and 3 (Hirth and Tullis 1992), corresponding to the natural BLG zone of Stipp et al. (2002). Microstructures are again characterized by porphyroclasts with grain boundary bulges and small recrystallized grains. Compared to zone I, less strain is required to produce a considerable amount of recrystallized grains, forming “core-mantle microstuctures”. (III) D $\sim$35–120 μm: Upper experimental dislocation creep regime 3, and natural SGR zone (Stipp et al. 2006, 2010). Microstructures are characterized by porphyroclastic ribbon grains and recrystallized grains which are about the same size or slightly larger than optical subgrains. Subgrain formation and dynamic recrystallization are initiated at low strain yielding “polygonization microstructures”. (IV) D > 120 μm: The natural GBM zone (Stipp et al. 2002). Comparable microstructures have not been attained in experimentally deformed samples, because the required high temperatures and/or water contents cause partial melting. Microstructures are characterized by very large recrystallized grains with lobate boundaries and irregular grain shapes. Fast grain boundary migration produces amoeboid and island-grains (“dissection microstructures”). When using this recrystallized grain size dependent classification, natural and experimental microstructures bear a striking resemblance as long as the natural microstructures were not modified by annealing or retrograde overprinting. Recrystallized grain size transitions between the zones indicate changes in the dominant deformation or recrystallization processes as proposed by Stipp et al. (2010).

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