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Mechanisms of grain size reduction in layer-parallel brittle shear zones

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In carbonates affected by layer-parallel shear fault zone development starts with the generation of fracture zones with an internal lamellae structure of R‘-orientation. These evolve from transfer zones between layer-parallel shears. The consequent synthetic rotation of lamellae results in the development of pervasive kink zones with an axial plane sub-parallel to the shear zone boundary. Kinking results from the longitudinal constraint of lamellae associated by impeded shear zone widening. Rupturing along kink bands and breaking-up to smaller fragments with rotational and translational displacement may mark the transition to the formation of cataclastic fault rocks. Subsequent shear is assumed to be localized along these brecciated zones, including the evolution of a fault core. The aspect ratios of host rock fragments decrease continuously towards the fault core. These structures are assumed to represent the initial states in shear zone development. The lamellae bound by main high-angle fractures seem to approach a constant shape and geometry, defined by the Fmax / Fmin ratio. In general, this ratio lies between 2,8 and 2,1 with a mean value of approximately 2,3. Towards the fault core this ratio decreases both along strike and perpendicular to the SZB. Within these domains, Fmax and Fmin of main-fracture bound lamellae are significantly smaller. In particular Fmax shows strong decrease related to the fragmentation of lamellae along minor fractures. Accordingly, the Fmax/Fmin ratio decreases down to 1,7 within distinct domains. The fragments bound by minor fractures show constant Fmax/Fmin ratios as well, ranging from 1,6 to 2,4, with a mean value of 1,99. The rather low single value of 1,6 is assumed to be related to the quite low number of fragments counted. The aspect ratio of fragment sizes remains constant within the damage zone - core transition and the tip - core transition as well, showing a Fmax/Fmin of 1,99. The size of these fragments does not seem to depend on the distance to the assumed fault core and remains constant along strike and across the section described. Towards the fault core and within the fault core breccias the mean aspect ratio decreases to ˜1,7. By the detection of isolated lamellae fragments within the fault breccia it can be assumed that these were progressively incorporated into the fault core. Following Billi et al. (2003), rocks in damage zones adjacent to fault cores show very similar structural fabrics consisting of nearly isometric lithons having a cross-sectional aspect ratio of about 1,4 (despite different sizes, kinematics, and inherited structural fabrics of the protolith). This value is interpreted as the shape upper limit for the systematic initiation of particle rotation and grinding.

References: Billi, A., Storti, F., and Salvini, F., 2003. Particle size distributions of fault rocks and fault transpression: are they related? Terra Nova 15, 61-66.