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Quartz amorphization to produce porosity in crustal shear zones

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Micropores are commonly observed in quartz-rich rocks that deformed at depths of the viscous, metamorphic continental crust. Although the presence of such porosity – often occurring with angular, pyramidal shapes – has major implications for fluid circulations and rock strength, whether or not they are produced by deformation remains unclear. Here we provide detailed documentations of pure quartz aggregates decorated by micropores in granitic shear bands from Naxos (Greece). Through estimations of geometrically necessary dislocation densities, we first document very high values ($\gg 10^{15} \text{ m}^{-2}$) along intragranular boundaries, several of them containing micropores. We then performed focused ion beam (FIB) cross-sectioning and transmission electron microscopy to image pore shapes along all types of quartz boundaries. Pores do not necessarily arise with angular shapes, but they are systematically embedded within amorphous SiO_2 , i.e., silica glass, along both grain and intragranular boundaries. FIB volume reconstruction also revealed pyramid-like pits occurring with round-shape faceted pores, the shape of which challenges long-lasting hypotheses for pores to originate. Together with recent studies^[1,2], our findings support deformation to produce porosity through (1) mechanical amorphization where dislocations accumulate and (2) fluid exsolution from the resulting glass because of a pressure/stress drop, here attributed to grain boundary sliding.

[1] Idrissi, H., Carrez, P. & Cordier, P. On amorphization as a deformation mechanism under high stresses. *Current Opinion in Solid State and Materials Science* 26: 100976 (2022)

[2] Li, B. Y., Li, A. C., Zhao, S. & Meyers, M. A. Amorphization by mechanical deformation. *Materials Science & Engineering R* 149: 100673 (2022)