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# Multiple episodes of breccia formation by particle fluidization in fault zones: implications repeated, rupture-controlled fluid flow and seismicity styles

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Breccias in the Rusey Fault (Cornwall, UK) provide insights about the dynamics of fault behaviour, fluid flow and flow velocities when fault ruptures breach overpressured reservoirs of hydrothermal fluid. The 3 m wide fault core comprises a mix of breccias, banded cataclasites, probable psuedotachylites and extension veins. The damage products are dominated by high dilation breccias with cockade-like textures in which rock fragments are mantled by spheroidal overgrowths of quartz. Although none of the rock fragment cores of accretionary spheroids are in contact with their neighbours, the spheroidal overgrowths do contact each other and are at least partially cemented together. The hydrothermal overgrowths mostly comprise either outwards coarsening crystals that radiate from the surface of the core particle, or finer-grained, inequigranular to mesh-like intergrowths. Concentric textural banding and oscillatory growth zones are present in some hydrothermal overgrowths.

The breccias occur as fault-parallel layers and lenses, each up to several tens of centimeter thick. Adjacent layers are characterised by texturally-distinct ranges of clast sizes and different proportions of clasts to hydrothermal overgrowths. Many texturally-distinct breccia layers are present within the fault core. Some breccia layers truncate others and many breccia layers exhibit grainsize grading or banding. Clasts in the breccias include fragments of wall-rock, veins and various fault damage products, including fragments of earlier generations of cemented breccia. As brecciation was episodic and separated by periods of cementation, the breccias are interpreted to have formed as a consequence of repeated seismogenic failure.

The distinctive textures in the breccias are interpreted to have formed by fluidization of fault damage products in a high fluid flux regime, with each breccia layer being the product of one, rupture-related flow episode. Hydrothermal coatings developed while clasts were in a suspended state during fluid ascent through dilatant fault segments. Layered breccias record multiple episodes of particle fluidization and indicate that the faults provided conduits for repeated transitory fluid upflow. Particle size distributions indicate that fluid velocities during fluidization were in the range 0.1 ms-1 to 1 ms-1. The maximum flow rates correspond to fluid fluxes of 10 - 100 L.s-1 per meter strike length of fault through dilatant fault apertures up to several tens of centimeters wide. Such high flow rates characteristically induce intense swarm seismicity rather than mainshock-aftershock seismicity.