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Fault instability and slipping in thermally unstable rock

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Faults that cut carbonate rocks are the most important seismogenic sources worldwide, while the fault weakening and recovery mechanism in carbonate fault rock still remains controversial. In this study, the structures of an exposed normal fault zone hosted in dolostones with chert bands from the Yuguang basin southern marginal fault (YBSMF), northeast of the Shanxi graben system, North China, was studied by field-based structural analysis, microstructural and fabric investigations. The microstructural observations show that the fault slip surface exhibits a range of slip-related structures including slickenlines, truncated clasts and nano-scale amorphous materials/fragments. On the fault slip surface, the carbonate fault rock contains a large number of nanoparticles. These nanoparticles were shaped into two forms, single spherulitic nanoparticle and agglomerated nanoparticles. The slip zone, under the slip surface, is characterized by cataclasite, with various foliatization in red injection band. EBSD analysis results show weak CPOs, with the (0001) planes of the dolomite fragments nearly parallel to the slip surface. Our microstructural investigations in the dolomite fault rocks, combined with previous publications, suggest the single spherulitic nanoparticles can be the result of thermal decomposition of dolomite along the major slip surface of the normal fault. Nano powder lubrication caused by the rolling of single spherulitic nanoparticle plays a key role during carbonate fault slipping. The thermal pressurization of pore fluid leads to laminar grain flow along the fracture and finally forms foliations in the red injection layers. The transformation from single spherulitic nanoparticles to agglomerated nanoparticles by superplastic diffusive mass transfer results in the recovery of friction strength at the fault plane. After the coseismic slip (or during afterslip), a relatively thick portion in the principal slip zone suffers a temperature increase, leading to the plastic deformation and formation of CPOs of dolomite in the principal slip zone. We inferred that nanoparticles can be produced by thermal decomposition transformation, which facilitate and inhibit earthquake behavior on fault surfaces. The postseismic strength recovery can be generated partly by agglomerated nanoparticles. We consider that nanoparticles produced by thermal decomposition of dolomite play a key role in carbonate fault instability during coseismic slip.