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Interplay between grain size reduction, chemical reaction, and shear localization in lower crustal rocks: a case study from Archaean Bundelkhand Craton, North-Central India

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Weakening of the rocks is pronounced during the formation of shear zone. Crustal scale shear zones at the plate boundary develop due to grain size reduction, either by mechanical breakdown of minerals or by the development of new minerals due to change in pressure (P) - temperature (T) conditions. In either of the mechanisms for grain size reduction, the Gibb's free energy of the system should be minimum in value to stabilize the mineral.In this contribution, we have studied the deformation mechanism and P-T conditions from acrustal scale shear zone, in the North Central Part of Archaean Bundelkhand Craton.
In the Archaean Buldelkhand craton, tens of kilometre wide E-W trending shear zone developed in the sodic-potassic granite. The undeformed rock (protolith) is characterized by euhedral to subhedral sodic feldspar (XAb =0.80) and subordinate quartz, whereas the deformed rock is characterized by the development of extremely deformed feldspar and quartz associated with chlorite. The onset of the strain localization and shear zone formation in the proto-mylonite has been accompanied by developing brittle fractures in the euhedral feldspar grains. In contrast to the brittle deformation in feldspar, quartz grains are characterized by development of small bulges around the grain boundary. Chlorite develops at the fractures in the feldspar that are indicative of fluid infiltration in the proto-mylonite.In the extremely deformed samples (ultramylonite) grain size reduction occurs by bulging recrystallization in quartz. Flow stress obtained from grain size analysis of quartz indicates that the palaeo-stress varies from $\sim$44-46 MPa in proto-mylonite to $\sim$ 61-63 MPa in Ultra-mylonite.
Mineral chemical analysis of undeformed feldspar grains in the protolith and mylonite indicate significant changes in the chemical composition that leads to minimum Gibbs energy. Also the presence of chlorite indicates hydration reaction, which has reduced the chemical energy of the system. Petrographic study, mineral chemical analysis and thermodynamic calculations indicate that shear zone nucleates by developing cracks in the feldspar. The cracks act as pathways for water infiltration and formation of fine grained chlorite. The grain size reduction by developing new metamorphic mineral in conjunction with the bulging recrystallization in quartz weakens the rock further and promotes the development of ultramylonite.