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Decrypting the role of shallow crustal fluid-rock interaction on fault mechanics and seismicity in the Koyna-Warna Seismogenic Region, Western India

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The Koyna-Warna Region is a small intraplate area bordered by the Koyna and Warna Dams over the Deccan Volcanic Province in Western India. The dam impoundment in this plate interior has amplified the transmitted plate boundary stress and resulted in numerous low-magnitude earthquakes, along with a few devastating ones since 1967. The present study deals with the core and cutting samples collected from the faults and fractures present in the granitoid basement rocks upto 3 km depth in this region. Petrographic and SEM-EDS observations find the fault slip surface and micro-fractures filled with secondary minerals like chlorite, epidote, and calcite, inferring fluid-rock interaction along the mechanically weak planes. The elemental geochemistry further unravels that the fluid interaction dissolves the K interlayer sheets of biotite grains of the host granitoids and incorporates Mg-rich brucite-like sheet, producing chlorite. Similarly, the dissolution of alkali feldspar explains the formation of illite and albite. However, the Mg^{2+} (66pm), being smaller than K^{+} (138 pm), can be fitted well into the ditrigonal cavities of the neoformed chlorite and reduces the interaction between the top and bottom layers of the crystal. Thus, the chlorite provides less frictional resistance on the fault slip surface. On the other hand, the FTIR investigations on the separated clay fraction identify a 1649 cm^{-1} peak, which dictates the H–O–H bending mode of the weak intermolecular O···H hydrogen–bonds of the water molecules attached to the clay surface. Such weaker hydrogen bonds of the silanol (Si–O–H) trapped on the slip surface are easily broken in response to the increasing charge due to continuing fluid interaction. So, the clay-bound water may later get expelled into the fault zones, resulting in a further reduction of frictional resistance that promotes fault slip. However, due to the strength of the hydrogen bonds connecting the talc-like sheet and brucite-like sheet in the chlorite crystals, they can accommodate stress through ripplocations like-intracrystalline deformation mechanism upto a threshold, beyond which they release stress intermittently through fault creep. Thus, fluid-rock interaction may influence the mechanical properties of a fault zone, controlling the nature and extent of earthquakes.