LABORATORY CONSTRAINTS ON THE MECHANISM OF DEEP CRUSTAL EARTHQUAKES UNDER SOUTHERN TIBET

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Abstract

Deep crustal earthquakes under Southern Tibet occur to depths of _˜ 100 km, within the subducted Indian continental plate, where the lower crust is considered hot and dry [Hacker et al., Science, 2000]. Such seismicity cannot be produced by simple brittle shear fracture or frictional sliding, because of the high pressure conditions. Pseudotachylytes, "fossilized" fault zones of past earthquakes, were found in western Norway under conditions corresponding to the eclogite facies stability field [Austrheim & Boundy, Science, 1994], suggesting that eclogitization is potentially involved in deep crustal seismicity: faulting took place in metastable granulite (the main constituent of lower continental crust) at pressures approaching _˜3 GPa (i.e., depths of 100 km), inducing melting in the fault zone that crystalized into pseudotachylites. Here we conduct deformation experiments on natural and nominally dry granulite in a deformation-DIA (DDIA) apparatus within the stability fields of both granulite and eclogite. The D-DIA, installed at beamline 13-BM-D of GSECARS at the Advanced Photon Source, is interfaced with an acoustic emission (AE) monitoring system, allowing in-situ detection of mechanical instability along with the progress of eclogitization (by x-ray diffraction). We found that granulite deformed within its own stability field (< 2 GPa and 1000○C) behaved in a ductile fashion without any AE activity. In contrast, numerous AE events were observed during deformation of metastable granulite in the eclogite field above 2 GPa. Correlating closely with AE burst episodes, measured differential stresses rose and fell during deformation, suggesting unstable fault slip. Microstructural observation on recovered samples shows that strain is localized around grain boundaries, which are decorated by eclogitization products. Cavitation along the grain boundaries suggests significant grain boundary sliding. Thus, metastable dry granulite fails by grain boundary weakening. Ruptures originate from weakened grain boundaries, propagate through grains, and self-organize into macroscopic fault zones. No melting is required in the fault zones to facilitate brittle failure. This process may be responsible for the deep crustal seismicity in Southern Tibet and other continental-continental subduction regions.

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