Lower crustal seismicity of Southern Tibet: mechanical instability of metastable granulite within subducted Indian plate

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Deep crustal earthquakes have been recorded under Southern Tibet down to depths of ~ 100 km, within the subducted Indian continental plate, where the lower crust is considered hot and dry [1]. Because of the high pressures involved, deep crustal seismicity cannot be produced by simple brittle shear fracturing or frictional sliding. Pseudotachylites, "fossilized" fault zones of past earthquakes, were found in western Norway under conditions corresponding to the eclogite facies stability field [2], 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 later 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 real-time detection of mechanical instability along with the progress of eclogitization (by x-ray diffraction). Granulite deformed within its own stability field (< 2 GPa and 1000°C) behaves in a ductile fashion without any detectable 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, resulting in macroscopic faults. Microstructure of failed specimens is characterized by weakened grain boundaries and nano-shear bands filled with eclogitization products, predominantly omphacite. Grain boundary cavitation and intra-grain micro-ruptures assist the formation of macroscopic Riedel shear zones. We argue that this mechanism explains the deep crustal seismicity beneath southern Tibet.

References

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