Eclogitization of granulite can trigger instability in deep continental crust: the case of Southern Tibet

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Intermediate-depth earthquakes (IDEQs) occur at focal depths from about 50 km to 300 km. Their physical mechanism has been enigmatic, because as pressure and temperature increase with depth, brittle failure should be suppressed, and rocks tend to flow plastically. IDEQs have been recorded down to depths of 80 - 100 km in Southern Tibet, where the lower crust is considered hot and dry [1]. It is questionable whether such seismicity can be produced by unassisted brittle shear fracture or frictional sliding. Pseudotachylytes that formed under conditions corresponding to the eclogitic facies are ubiquitously observed in western Norway [2], demonstrating that faulting took place in granulite, which is the main constituent of lower continental crust at pressures approaching 3 GPa. These observations suggest strongly that eclogitization is potentially involved in the seismicity in the deep continental crust. Here we conduct deformation experiments on natural and nominally dry granulite in a deformation-DIA (DDIA) apparatus and Griggs apparatus within the thermal stability fields of both granulite and eclogite, to investigate the mechanism of intermediate earthquake. The D-DIA, installed at the synchrotron beamline of GSECARS, is interfaced with an acoustic emission (AE) monitoring system, allowing in-situ detection of mechanical instability along with the progress of eclogitization based on 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. Unstable fault slip, on the other hand, occurred during deformation of metastable granulite in the eclogite field above 2 GPa. Numerous AE events were observed. Microstructural observation on recovered samples shows conjugated macroscopic faults. Strain is highly localized along the fault, and microcracks observed along grain boundary likely involve with eclogitization products. The fault zones consist of fine-grained (<1 micron) angular fragments likely to be eclogitic phase transformation products. However, no pseudotachylyte has been found in these samples so far. Therefore, we conclude that eclogitization of deforming metastable dry granulite can produce mechanical instability. No formation of pseudotachylytes is required for brittle failure. We suggest that syn-deformational eclogitization of dry granulite may be responsible to the lower crustal seismicity in Southern Tibet.

References

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