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Laboratory earthquakes triggered during eclogitization of lawsonite-bearing blueschist

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The origin of intermediate-depth seismicity has been debated for decades. A substantial fraction of these events occurs within the upper plane of Wadati-Benioff double seismic zones believed to represent subducting oceanic crust. We deformed natural lawsonite-rich blueschist samples under eclogite-facies conditions, using a D-DIA apparatus installed at a synchrotron beamline continuously monitoring stress, strain, phase changes, and acoustic emissions (AEs). Two distinct paths were investigated during which i) lawsonite and glaucophane became gradually unstable while entering the stability field of lawsonite-eclogite and the breakdown reaction of lawsonite was only crossed in case of the highest final temperature; ii) lawsonite broke down and the sample successively entered the stability fields of epidote-blueschist and eclogite-amphibolite but not of lawsonite-eclogite. Upon entering the Lws-Ecl stability field, samples exhibited brittle failure, accompanied by the radiation of AEs. In-situ X-ray diffraction and microstructural analysis demonstrate that fractures are topologically related to the formation of omphacite. Amorphous material was detected along the fractures by transmission-electron microscopy without evidence for free-water. Since the newly formed omphacite crystals are small compared to the initial grains, we interpret the observed mechanical instability as a transformation-induced runaway under stress triggered during the transformation from lawsonite-blueschist to lawsonite-eclogite. In contrast, we find no microstructural evidence that the breakdown of lawsonite, and hence the liberation of water leads to the fracturing. Our experimental results challenge the concept of "dehydration embrittlement", which ascribes the genesis of intermediate-depth earthquakes to the breakdown of hydrous phases in the subducting oceanic plate. Instead we suggest that grain-size reduction (transformational faulting) during the transformation from lawsonite-blueschist to lawsonite-eclogite leads to brittle failure of the deviatorically loaded samples.