

## Supplementary Materials for **A laboratory nanoseismological study on deep-focus earthquake micromechanics**

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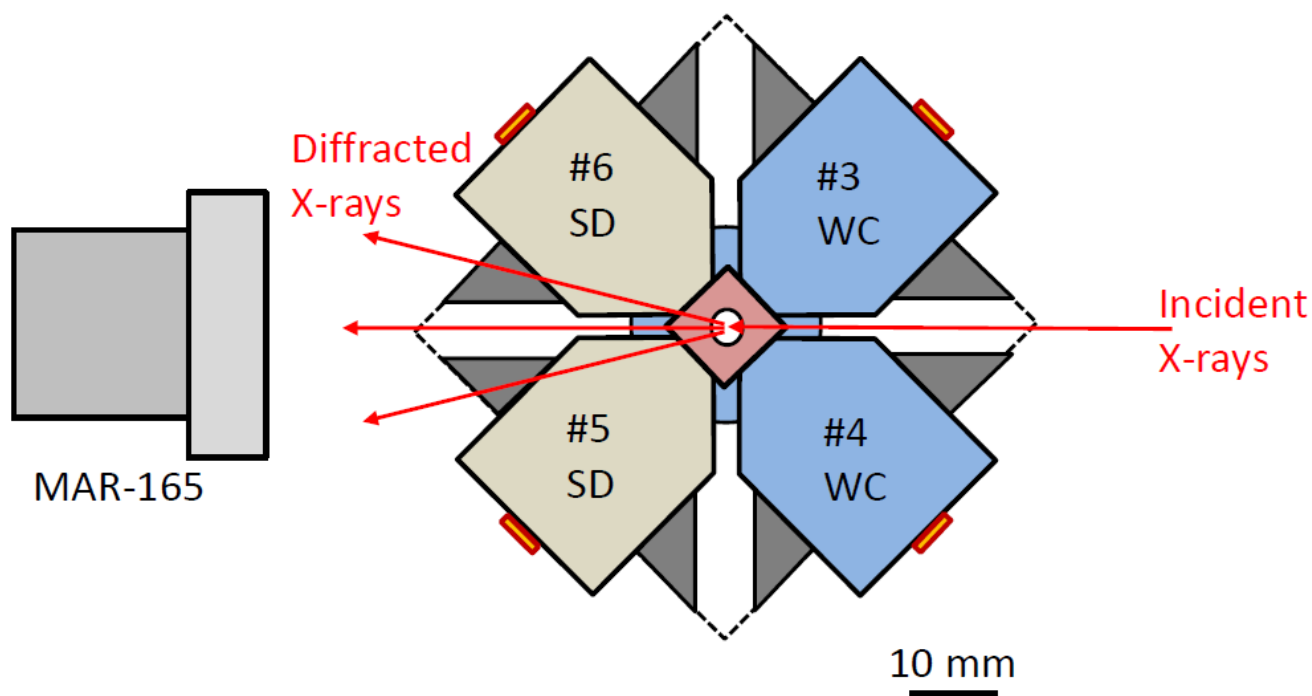
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- fig. S8. Orientation relations between olivine grains and NSBs.
- fig. S9. BSE micrographs of recovered samples.
- Legends for movies S1 to S6

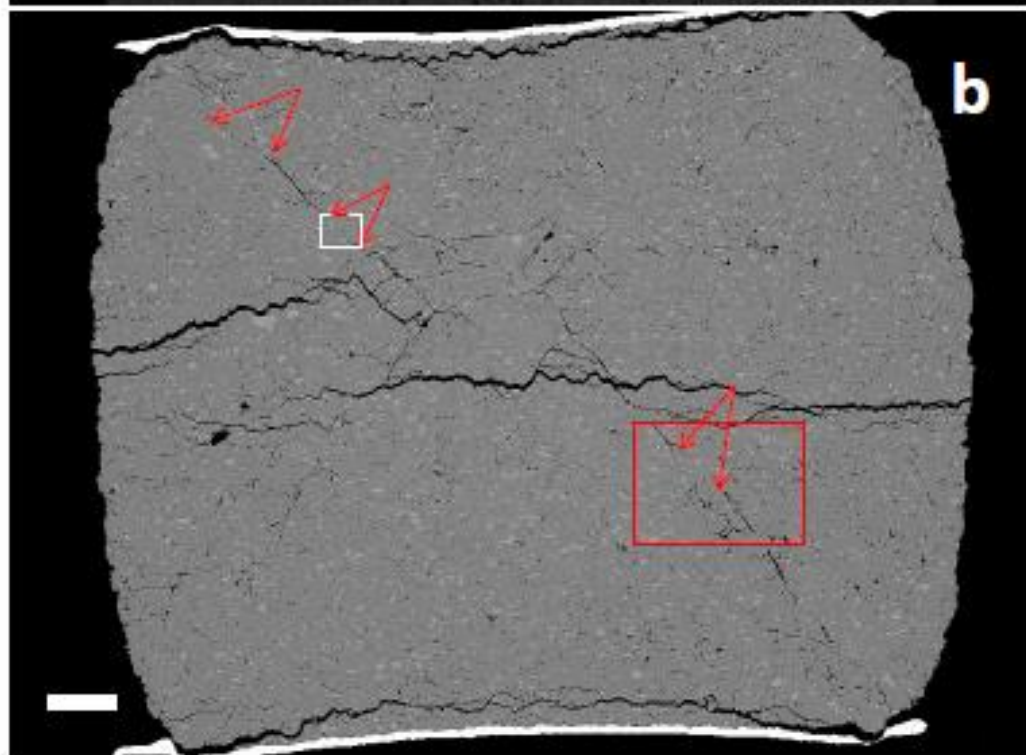
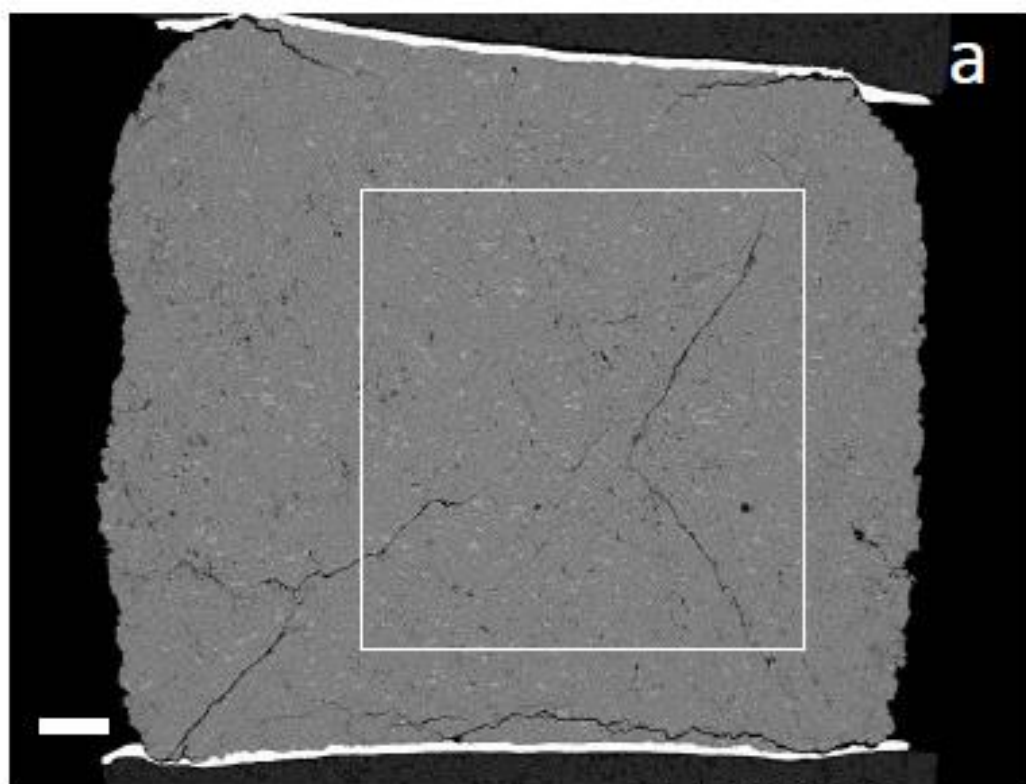
**Other Supplementary Material for this manuscript includes the following:**  
(available at [advances.sciencemag.org/cgi/content/full/3/7/e1601896/DC1](http://advances.sciencemag.org/cgi/content/full/3/7/e1601896/DC1))

- movie S1 (.mov format). XMT image of the recovered sample D1247.
- movie S2 (.mov format). XMT image of the recovered sample D1247.
- movie S3 (.avi format). Relocated AE events in group 1 superimposed with the digitized faults, as shown in movie S2.
- movie S4 (.avi format). Relocated AE events in group 2 superimposed with the digitized faults, as shown in movie S2.

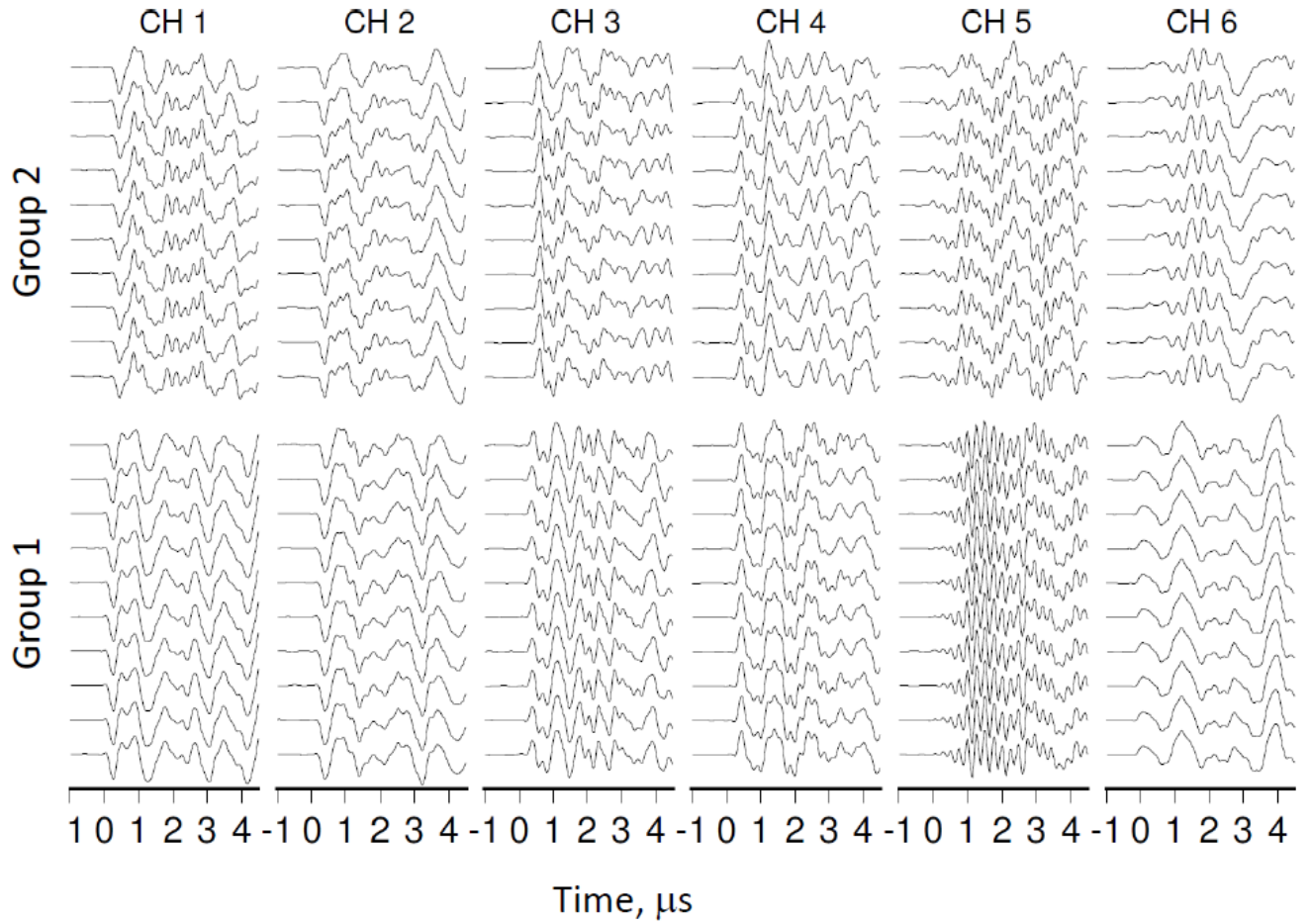
- movie S5 (.avi format). Group 1 events viewed along the strike of fault plane 1, throughout the deformation/transformation history.
- movie S6 (.avi format). Group 2 events viewed along the strike of fault plane 2, throughout the deformation/transformation history.



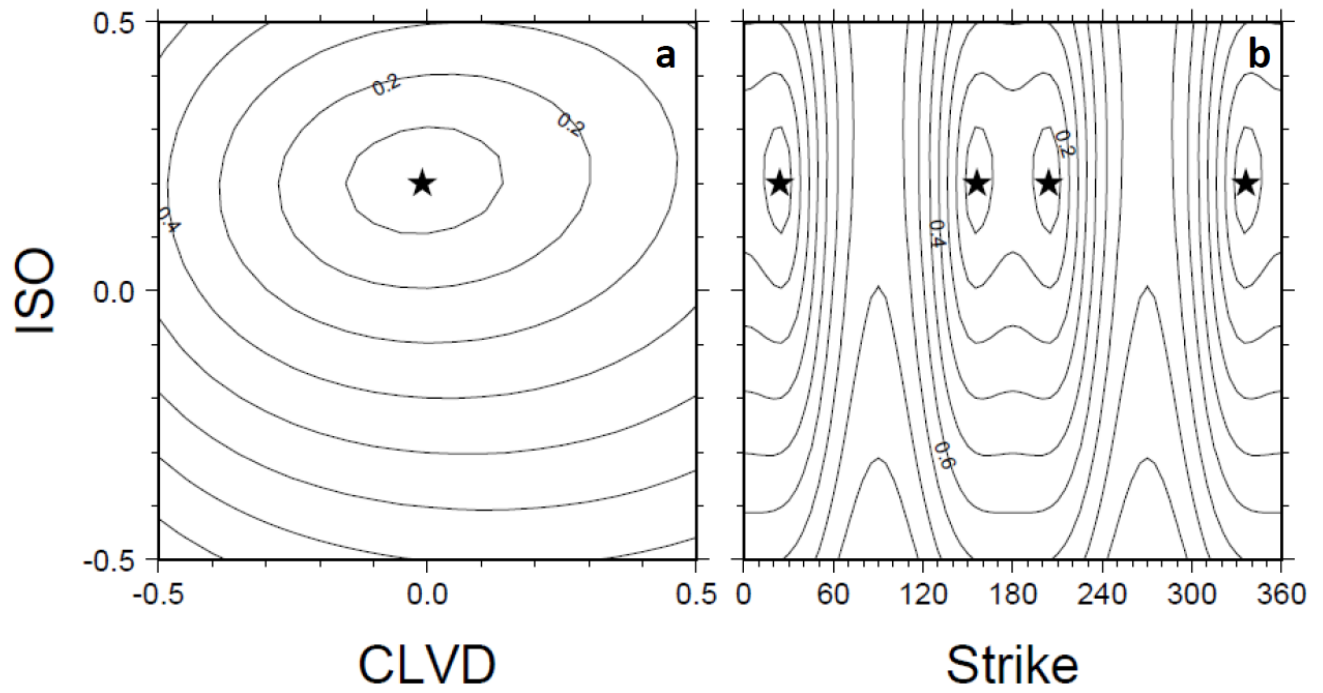
**fig. S1. Top view of the experiment setup.** Tungsten carbide (WC) and sintered diamond (SD) anvils are indicated. Acoustic transducers are attached to the back side of the anvils (small red rectangles) with channel numbers identical to anvil numbers. Anvils 1 (bottom) and 2 (top) are also made of WC, with acoustic transducers #1 and 2, respectively, attached. The sample (cylindrical sintered rod) is located in the center of the cubic cell assembly (square in the center).



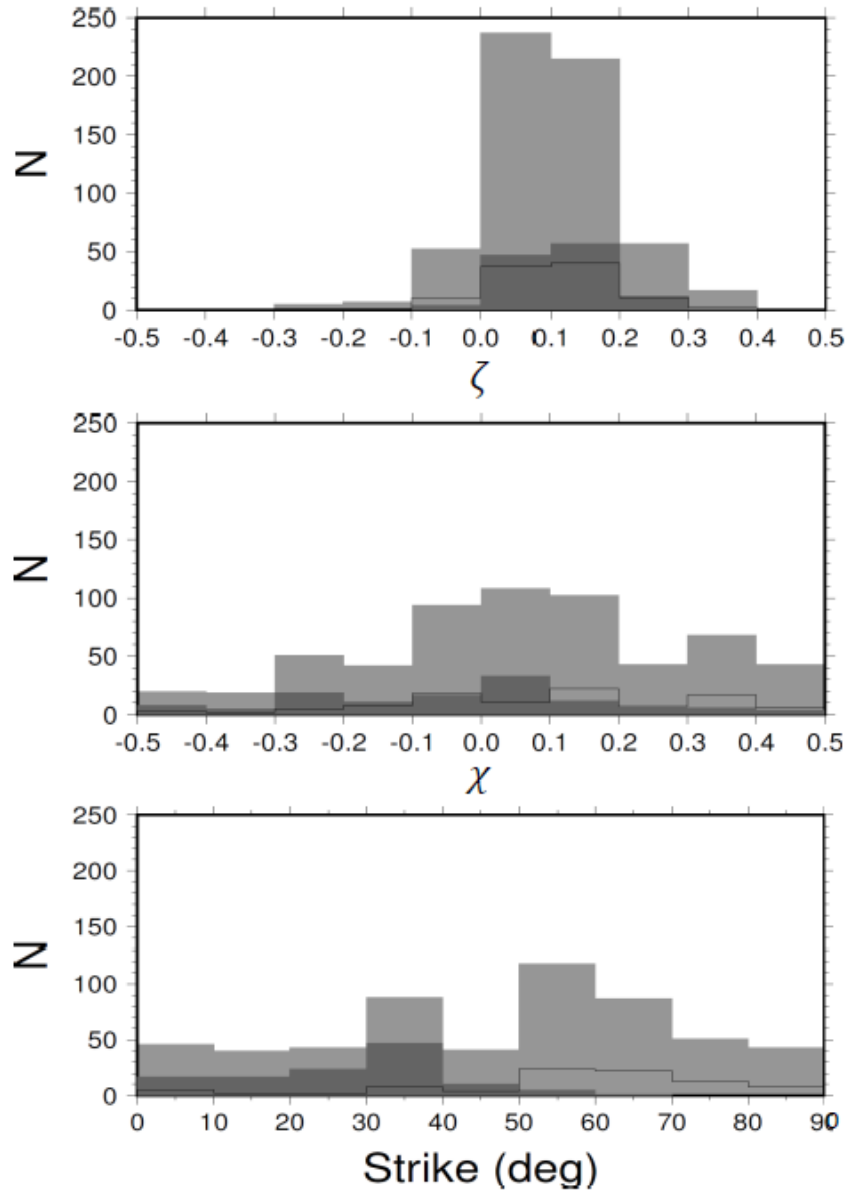
**fig. S2. Low-magnification SEM images showing cross sections of the entire samples of the experiments. (a) D1247 (4 GPa 1173 K). (b) D1253 (5 GPa, 1173 K).** Cross sections obtained after XMT imaging. Scale bars are 0.2 mm. Complex conjugated faults can be clearly seen with various widths. Some faults were initially too thin to be resolved by XMT, but later on opened up due to cutting and polishing (e.g., the faults in the lower-left side in (a)). Horizontal cracks in (b) are due to decompression at the end of the experiments. Several fault segments in (b) appear discontinuous (their gaps indicated by red arrow pairs). The white box in (a) corresponds to Fig. 6 in the main text. Two specific areas (white and red rectangles) are closely examined; they correspond to images in Fig. 7.



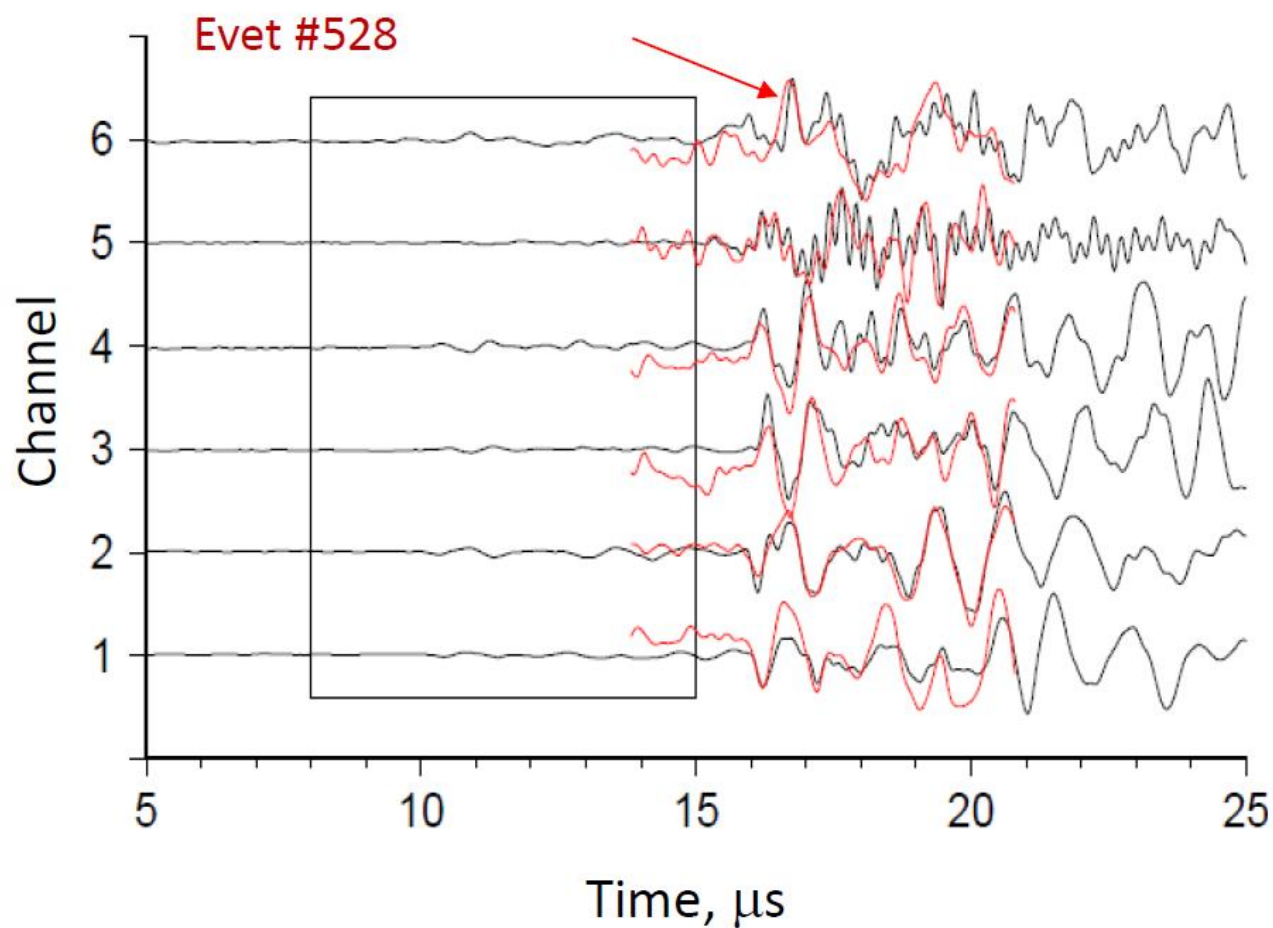
**fig. S3. Example waveforms of AE events in groups 1 and 2.** Waveforms recorded on channels 5 and 6, which involved with sintered diamond anvils, show different characteristics. Especially channel 5, which used a different transducer, shows higher frequency contributions. Therefore data from the last two channels were not use in waveform analysis.



**fig. S4. An example of grid search result.** Results are displayed for AE event #277, with  $\chi$  (CLVD) and strike  $\phi$  at various values of  $\zeta$  (the ISO parameter). Contours are levels of misfit. The best fit is located at ISO=0.2, CLVD=0.0, and Strike  $=\pm 28^\circ$  or  $180 \pm 28^\circ$ .

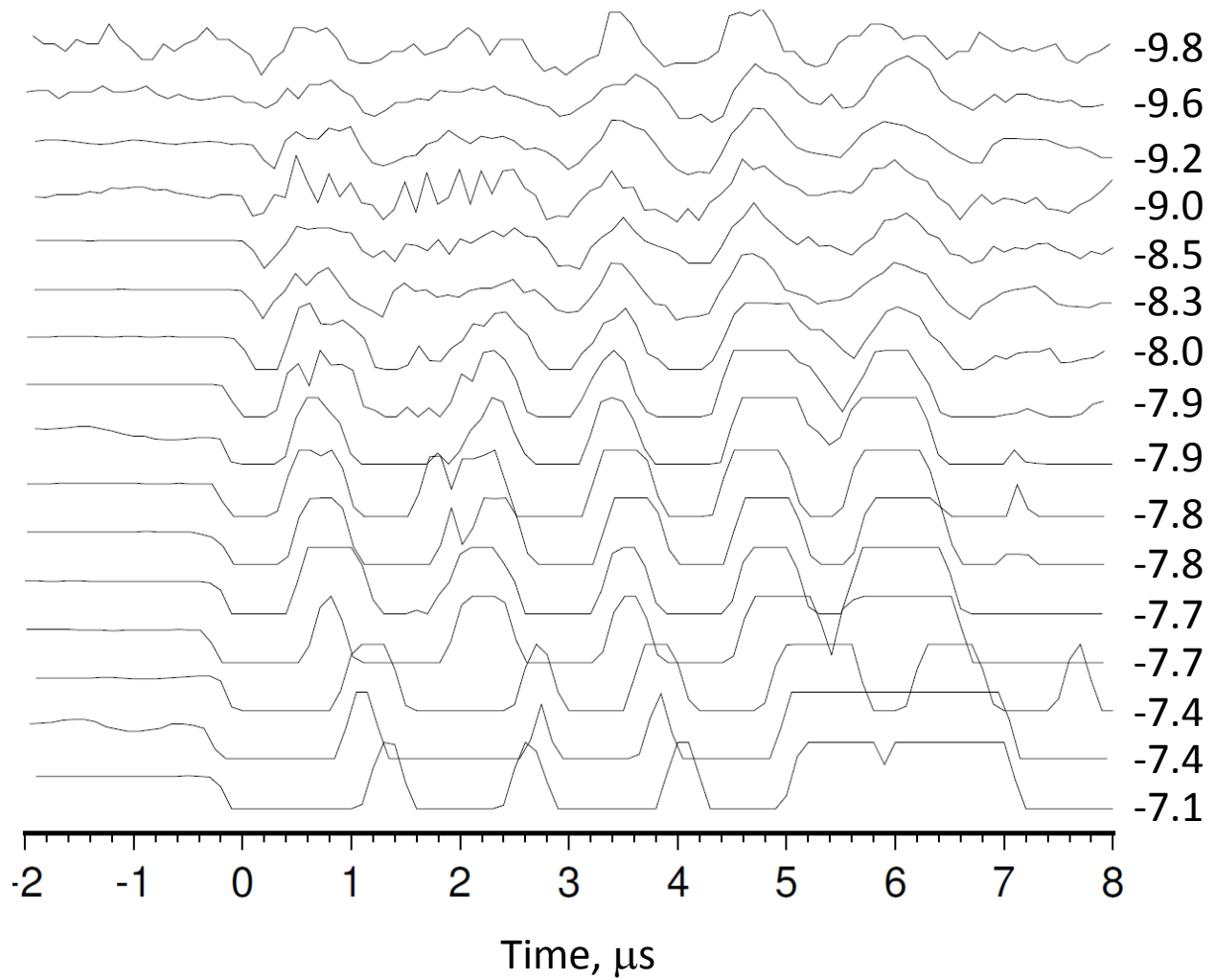


**fig. S5. Histograms of ISO parameter  $\zeta$ , CLVD parameter  $\chi$ , and strike  $\phi$  of 593 moment tensor solutions (light gray). Events in group 1 are shown in dark gray and those in group 2 in black lines.**

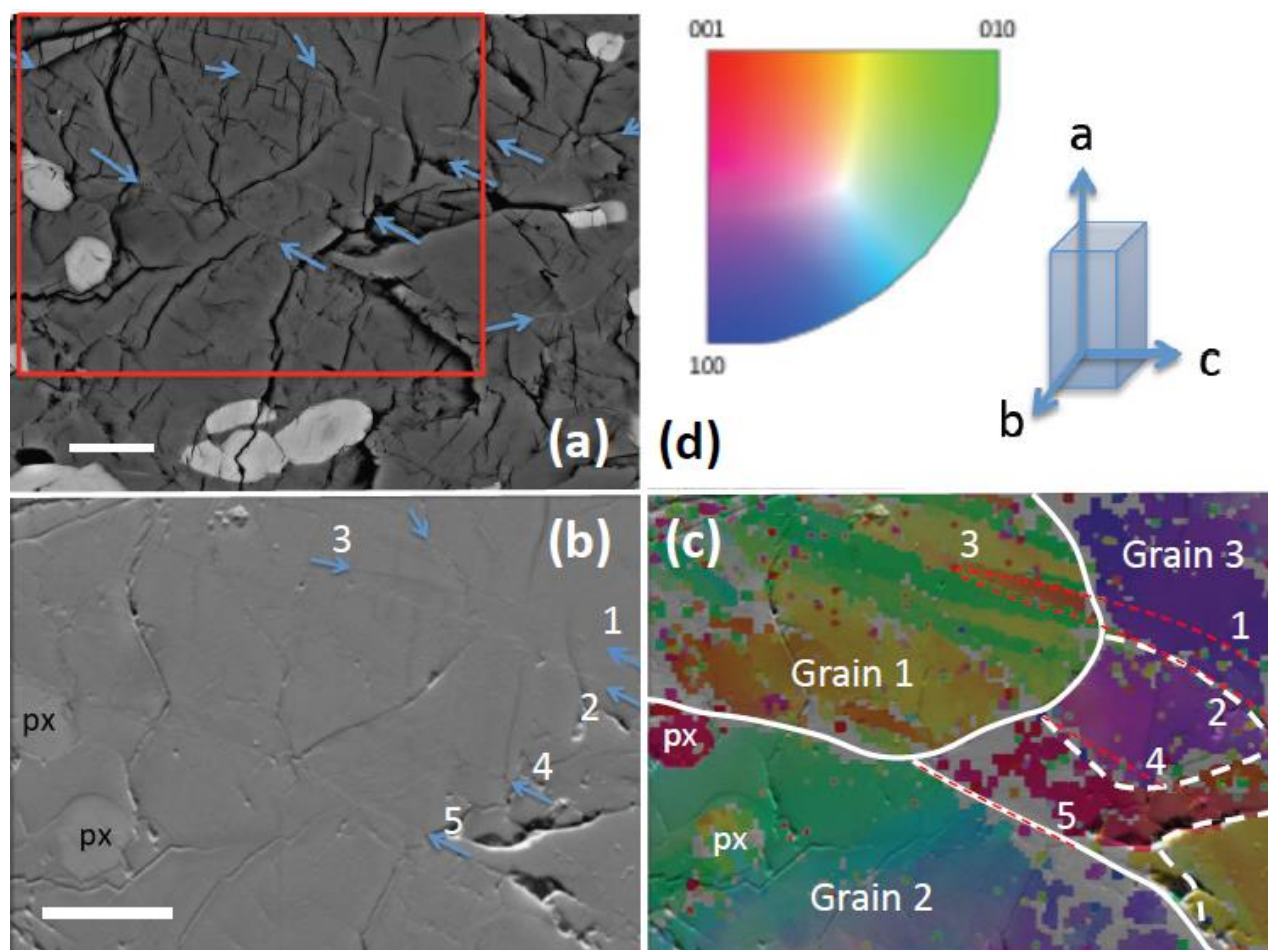


**fig. S6. An example of cross-correlation template searching results for smaller AE events.**

Using event 528 (trace after the 14  $\mu\text{s}$  mark) as a template, a smaller event is found between 8 and 14  $\mu\text{s}$  (the black box). The red traces are the smaller event magnified by a factor of 10, showing that its waveforms are highly correlated with the template.

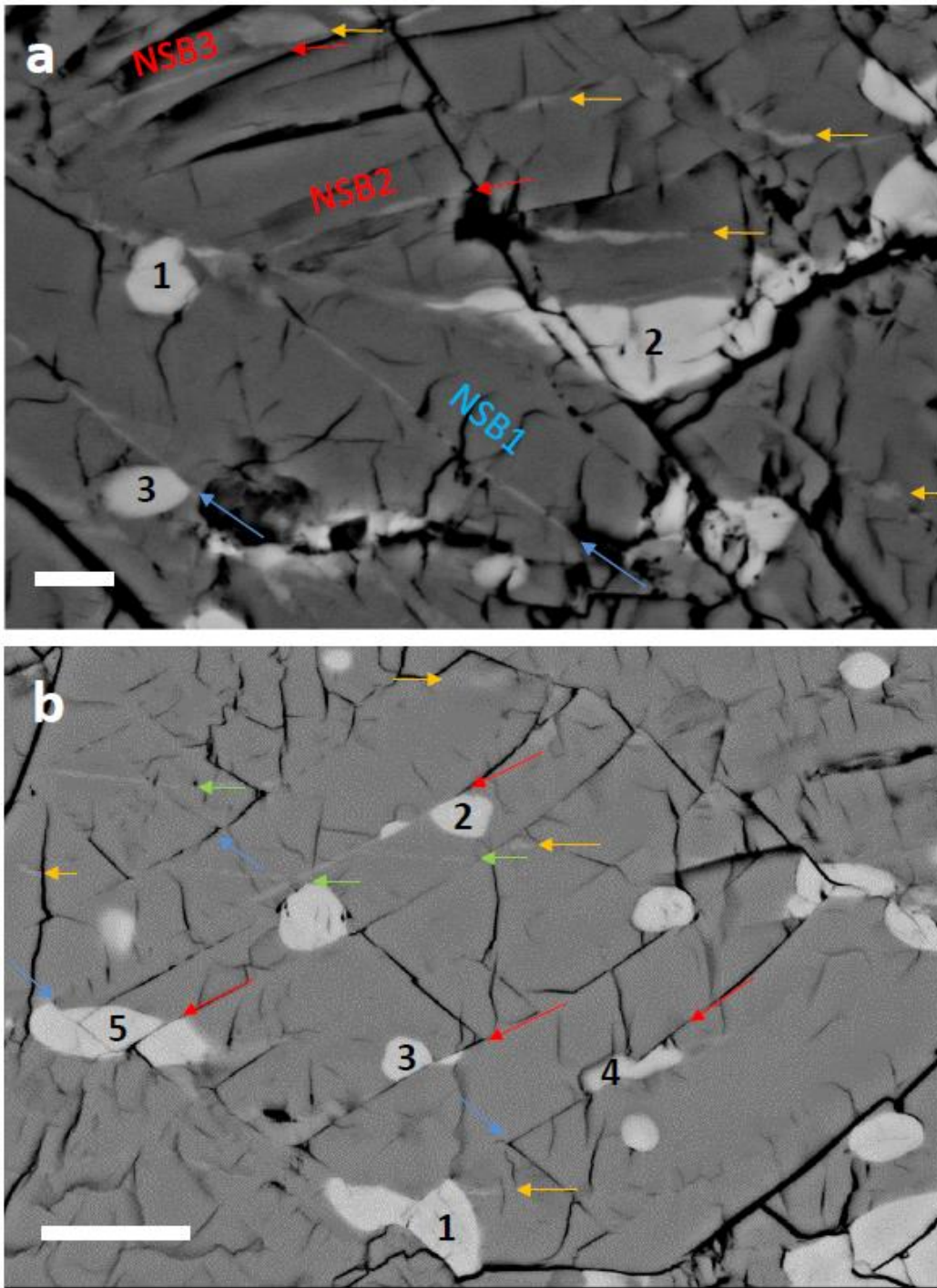


**fig. S7. Waveforms of events with different moment magnitudes.** Magnitudes are shown on the right hand side of the figure. Events with magnitude lower than -9 were detected by SCC using the waveform of Event 437 as the template (with a moment magnitude of -8.3). Waveforms of events with  $M_w$  greater than -8 are saturated in recording and their moment magnitudes are estimated using the width of direct  $P$ -wave pulse (see text for details).



**fig. S8. Orientation relations between olivine grains and NSBs.** (a) A Back scattered electron (BSE) image of an area in D1253. Several NSBs are indicated by blue arrows. (b) High-tilt secondary electron image of the area outlined by the red box in (a). Note slight surface relief of the NSBs relative to the olivine matrix. Several NSBs are labeled. NSBs 1 and 2 run subparallel and merge to a single one (3). NSBs 4 and 5 are also subparallel. (c) The same area of (b) showing olivine orientation difference based on electron backscattered diffraction (EBSD). Each grain contains some sub-grains with curved boundaries, which are associated with NSBs. Grain1 and Grain 2 show clearly defined grain boundaries (solid white lines). Grain 3 contains multiple irregular shaped sub-grains, whose boundaries are shown as dashed white lines. Traces of NSBs are plotted as red-dashed lines. Note that NSBs 1 and 2 penetrate the boundary between Grains 1 and 3; NSB 4 is within a subgrain, and NSB 5 is within the boundary between Grains 2 and 3. (d) In the EBSD analysis we use the Pnma spacegroup setting for olivine, with  $a=10.29\text{\AA}$ ,  $b=6.02\text{\AA}$ ,

$c=4.9\text{\AA}$ . Orientations of grains in (c), relative to the axial shortening direction, are indicated by the color code. Scale bars are  $10\text{ }\mu\text{m}$ .



**fig. S9. BSE micrographs of recovered samples. (a)** Sample D1247, **(b):** Sample D1253. Yellow arrows mark some of the LVRs, which are primarily horizontal with fuzzy boundaries. Two conjugated groups of NSBs can be identified which are indicated by the red and blue arrows. Many pyroxene grains, some numerically labeled, are sheared, showing significant offsets, clearly

caused by the fracturing process under pressure and temperature. In (a) the pyroxene grain #1 is the site where the NSB bifurcates into NSB1 and NSB2. A possible NSB may be present in between pyroxene grains #1 and 2. Also note the curvature for NSB2 and 3. In (b), a third group of NSBs with nearly horizontal traces (green arrows). These are the NSBs whose strikes are nearly parallel to the imaged surface. Pyroxene grains 1 – 4 have all been significantly sheared. Grain 5 has been sheared in two conjugated directions (blue and red arrows). Numerous faultlets and microcracks are also present, whose orientations are similar to the NSBs, suggesting that NSBs were present at the locations of the micro-cracks before pressure release. It is likely that most of the subparallel micro-fractures were caused by the NSBs. Scale bars are 5 and 10  $\mu\text{m}$ , respectively.

**movie S1. XMT image of the recovered sample D1247.** The 3D image has been tuned to 85% transparent to show the conjugated faults (dark linear features) throughout the sample.

**movie S2. XMT image of the recovered sample D1247.** The same image as in movie S1, but are cut through three orthogonal planes to display traces of a pair of faults, which are digitized and over plotted in movies S3 and S4.

**movie S3. Relocated AE events in group 1 superimposed with the digitized faults, as shown in movie S2.**

**movie S4. Relocated AE events in group 2 superimposed with the digitized faults, as shown in movie S2.**

**movie S5. Group 1 events viewed along the strike of fault plane 1, throughout the deformation/transformation history.** Vertical axis is distance to Fault plane 1.

**movie S6. Group 2 events viewed along the strike of fault plane 2, throughout the deformation/transformation history.** Vertical axis is distance to Fault plane 2.