Stress release process along a crustal fault during the foreshock-mainshock-aftershock sequence of the 2017 M5.2 Akita-Daisen earthquake

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Stress release process ongoing along a crustal fault examined through the foreshock-mainshock-aftershock sequence of the 2017 M5.2 Akita-Daisen, NE Japan, earthquake

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Stress accumulation and release processes in the crust are less understood compared to those in the plate boundary. One difficulty in examining the temporal evolution of stress along a crustal fault comes from weakness of geodetic signal due toaseismic slip possibly proceeding along a crustal fault. Spatiotemporal variations in foreshock and aftershock activities can provide key constraints on time-dependent stress and deformation processes in the crust.

The 2017 M 5.2 Akita-Daisen intraplate earthquake in NE Japan was preceded by an intense foreshock activity and triggered a remarkable sequence of aftershocks. In this study, we examine the spatiotemporal distributions of foreshocks and aftershocks and determine the coseismic slip distribution of this earthquake. In this study, we examine the spatiotemporal distribution of precisely relocated hypocenters of foreshocks and aftershocks and the coseismic slip distribution of the 2017 M5.2 Akita-Daisen earthquake in NE Japan, to shed light on processes that release stress in the crust.

Our result indicates that the seismicity concentrates forming a planar distribution with N-S strike dipping slightly eastward consistent with their focal mechanisms. We find a migration of foreshocks towards the mainshock rupture area, suggesting that they were triggered by aseismic phenomena such as fluid migrations and episodic aseismic slip events. Alternatively, the foreshock migration might be related to the quasi-static expansion of the slow slip associated with the nucleation phase of the mainshock.

The mainshock rupture was propagated primary toward north with lower coseismic slip in foreshock regions. Aftershocks were intensely triggered near the edge of large coseismic slip regions where shear stress increased after the mainshock. The aftershock region expanded along the fault strike with the logarithm of time, which would be attributed to the post-seismic slip of the mainshock.

The postseismic slip possibly triggered repeating earthquakes with M ~3. We applied the relationship between fault slip and earthquake magnitude proposed by Nadeau & Johnson (1996, BSSA) to the observed repeating earthquakes in this study for exploring post-seismic slip. The resultant post-seismic slip amount is comparable or slightly larger than the maximum coseismic slip amount of 28 cm. Our observation is consistent with previous work for California micro-earthquakes (Hawthorne et al.. 2016, JGR).

As a whole, foreshocks, the mainshock, aftershocks and post-seismic slip released stress at different segments on the fault, which might reflect the difference in frictional properties. Furthermore, there are probably aseismic slip behind the occurrences of aftershocks and foreshocks, which also contributed to the redistribution of stress. Such observations are similar to those observed for interplate earthquakes, which is consistent with the model that the deformation processes along plate boundaries and the crustal fault are not essentially different.

The static stress drop of the mainshock is estimated to be 4.7 MPa, the apparent stress is 1.3 MPa, and the radiation efficiency is 0.55. The radiation efficiency might be relatively high compared to recent observations of crustal earthquake. It might suggest that the present earthquake occurred on a rather mature fault. The similarity to interplate earthquake might be relevant to the maturity of the fault.