Source-rupture process of the intraplate earthquake; its diversity related to the fault geometry and damaged fault zone

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Supershear rupture is one of the features that characterizes the earthquake-rupture complexity. Both the theoretical analyses and the laboratory experiments suggests that the rupture-front propagation can exceed the shear wave velocity of the medium due to the excess of the energy flux into the rupture tip. However in real earthquakes, extrinsic factor that controls the manner of supershear rupture has yet been well captured and a relationship between the geometric complexity of the fault and the supershear rupture propagation has been elusive. Geometrical complexity of the fault system is a challenging feature against a reliable estimate of kinematic slip evolution on the basis of finite-fault inversion, since the presumed, fixed rectangle-fault plane or even configuration of the multiple rectangles may not necessarily, fully represent a real fault geometry. Especially for the strike-slip (mode-II rupture) earthquake, the radiation pattern of the wave is sensitive around nodal-shear planes, and if the earthquake involves the geometric complexity in the fault system, the radiation pattern at a certain location on a fault cannot be reproduced when the presumed model fault geometry deviates from the real one. Although supershear-rupture propagation has often been observed in the large strike-slip earthquake (e.g. Mw 7.8 2001 Kunlun, Tibet and Mw 7.9 2002 Denali, Alaska earthquakes), such limitations of finite-fault modeling has prevented us to discuss a relationship between supershear rupture and the fault geometry.

Here we present a kinematic rupture model for the intraplate, Mw 7.5 2018 Palu, Indonesia, earthquake. The 2018 Palu earthquake occurred along the strike-slip Palu-Koro fault zone, which is located around the triple junction of the Australia, Eurasia, and Philippines sea plates. The trace of the surface rupture of the 2018 Palu earthquake, mapped by the Interferometric Synthetic Aperture Rader (InSAR), shows the geometric complexity around the epicenter and south of the Palu bay. We inverted the teleseismic waveforms to resolve both the spatiotemporal evolution of shear slip and the variation of fault geometry by representing slip with five-basis potency-density tensors, without forcing a shear plane to be consistent with a pre-fixed model plane. A possibility of supershear rupture was taken into account by resolving slip in a wide parametric-model space with longer duration of slip-rate function and faster maximum rupture velocity.

The resultant model showed that a rupture front persistently propagated at a high speed (~5 km/s) that exceeds the local shear wave velocity throughout 200-km long within 40 s, but also showed the transient deceleration and acceleration of slip migration, which can be seen as an inchworm walking. The transient deceleration and acceleration of the slip migration was resolved in the area where the strike angle was rotated from the reference-model strike (358°), which also coincides with the geometric discontinuity of the surface rupture resolved by the InSAR analyses. We will then discuss possible roles of geometric discontinuity that develops inchworm-like slip evolution and damaged fault zone that enables long-lived supershear rupture propagation, which may be characteristic factors that control diverse rupture process of the intraplate earthquake.

Keywords: Intraplate earthquake, Waveform inversion, Fault geometry, Supershear rupture, source rupture process

