The role of fault damage zone in the supershear rupture of the 2018 Mw 7.5 Palu earthquake

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The powerful M 7.2 earthquake that shock the Sulawesi island of Indonesia on September 28, 2018, was a seismic standout for many reasons, not the least of which is that it triggers tsunami and landslides and causes major life and economic loss in the city of Palu. In this study, integrated geophysical observations of the 2018 Mw 7.5 Palu, Indonesia earthquake, provide robust evidence of an early and persistent supershear rupture speed. Slowness-enhanced back-projection (SEBP) of teleseismic data provides a sharp image of the rupture process, consistently across multiple arrays. The inferred rupture path agrees with the surface rupture trace inferred from the net surface displacement field derived by sub-pixel InSAR image correlation. The SEBP results indicate a sustained rupture velocity of 4.1 km/s from the rupture initiation to the end, despite large fault bends. The persistent supershear speed is further validated by evidence of far-field Rayleigh Mach waves in regional seismograms. Supershear earthquakes with rupture velocity exceeding shear-wave speeds, previously observed in laboratory experiments and large strike-slip events, often have an initial sub-shear stage before they transition to supershear. The rupture speed of the 2018 Palu earthquake is supershear from very early on. The short or absent supershear transition distance can be caused by high initial shear stress or short critical slip-weakening distance, and promoted by fault roughness near the hypocenter. Steady rupture propagation at a supershear speed considered to be unstable, lower than the Eshelby speed, could result from the presence of a damaged fault zone.

Keywords: Palu Earthquake, Supershear, Fault Damage Zone