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Triggering of the 2016 MJ7.3 Kumamoto earthquake by fluid intrusion of Unzen magma, Southwest Japan

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Fluid intrusions into the seismogeneic faults play a crucial role in triggering earthquakes and controlling their rupture process. Here we present new seismic signatures of fluids triggering the 2016 M_J7.3 Kumamoto earthquake associated with magma penetration in Kyushu, southwest Japan. Our seismic imaging reveals a slow seismic velocities (Vp, -2.0% and Vs, -3.0%) and high Poisson's ratio (σ, +3.0%) belt in the crust under the Unzen volcano that has an lateral extension into the hypocentral area of the 2016 Kumamoto earthquake underneath the Beppu-Shimabara Graben zone. These variations, in particular the high σsgannot be explained by temperature anomalies alone because σ values associated with these Vp and Vs anomalies are not as large as would be expected if this were the case. We also reveal cracks around the 2016 hypocenter that are not fully saturated with fluids and formed via the processes of north-south extension of the Beppu-Shimabara Graben. The incomplete saturated cracks might provide the most favorable passages for fluids to penetrate into the earthquake source area through crack closing, opening, and extending which are actuated by high pore pressure accumulated in the Unzen magmatism. Fluids intruding into the faults in the source area can lead to stress concentration in the seismogenic layer. Such fluid-pressurized regimes are likely to be turned into the fracture front and then to initiate a rupture. We, therefore, speculate that fluids ascending from Unzen magma penetration into the source faults via cracks acts as the key factor that has more likely triggered the Kumamoto earthquake. The unsaturated cracks in the extensional rift zones could play an essential role in fluid migration, contributing to initiation, development, and migration of seismic activity across the global.