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Seismic energy trapped in a low velocity zone: the effects of the Yogyakarta earthquake at LUSI, Indonesia

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On May 27, 2006, a M6.3 strike slip earthquake shook Yogyakarta, Java. Forty-seven hours later, hot mud reached the surface near Surabaya, 250 km far from the epicenter, creating several mud vents aligned along a NW-SE direction. The mud eruption reached a peak of 180.000 km3 of erupted material per day and it is still ongoing. The mud flooded several villages and caused a loss of approximately $4 billions to Indonesia. Geochemical analysis, geological data, and numerical simulations suggest that the earthquake may have initiated the liquefaction of the mud that then injected and reactivated a fault plane. However, the trigger mechanism of the eruption is still debated because a second hypothesis suggests that Lusi may have been triggered by a blowout following drilling problems in the nearby Banjar Panji-1 well.

The earthquake-triggering hypothesis is supported by the evidence immediately after the main shock ongoing drilling operations experienced a loss of the drilling mud downhole. In addition, the eruption of the mud began only 47 hours after the Yogyakarta earthquake and the mud reached the surface at different locations aligned along the Watukosek fault, a strike-slip fault system that bridges LUSI with the nearby volcanic complex. Moreover, the Yogyakarta earthquake also affected the volcanic activity of Mt. Semeru, located even further than Lusi from the epicenter of the earthquake. However, the drilling-triggering hypothesis points out that the earthquake was too far from LUSI for inducing relevant stress changes at depth and highlights how upwelling fluids that reached the surface first emerged only 200 m far from the drilling rig that was operative at the time. Hence, was LUSI triggered by the earthquake or by drilling operations?
We conducted a seismic wave propagation study on a geological model based on vp, vs, and density values for the different lithologies and seismic profiles of the crust beneath LUSI. Our analysis shows compelling evidence for the effects produced by the passage of seismic waves through the geological formations and highlights the importance of the overall geological structure that focused and reflected incoming seismic energy.