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A seismic wave propagation study for the triggering of the Lusi mud-volcano, Indonesia.

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A long-standing debate began in May 2006 with the onset of the eruption of the Lusi mud volcano, near Sidoarjo, Indonesia. The controversy concerns the causes that initiated the discharge of the mud: was it triggered by the nearby drilling operations or was it caused by the occurrence of a M6.3 seismic event near Yogyakarta?

To shed light on the effects induced by the Yogyakarta earthquake we performed numerical investigations on the effects induced by the propagation of the seismic waves induced by this seismic event. To perform the analysis we used a finite-differences grid, which represents the first 3000 m of crust underneath Lusi. Our geological model is based on seismic profiles, geological logs and accounts for compressional wave speed, shear wave speed, and density of the geological layers. An important feature of the geological model is the occurrence of a relatively high P-wave velocity layer (approximately 6300 m s^{-1} located approximately 500 m above the geological formation that originated the mud.

We assumed a fundamental signal frequency of 0.5 Hz to calculate the maximum energy density distribution in the geological media and we performed seismic wave propagation analysis for three different sources: i) a plane P-wave arriving from depth, ii) a point source at the surface, iii) a point source located approximately 1000 m below the relatively high p-wave velocity layer. The first and the third case lead to similar results that indicate the occurrence of high energy density concentrations above and below the high velocity layer. The second case shows that a pure surface wave would not induce high energies below the relatively high p-wave velocity layer.

Our analysis shows that the relatively high P-wave velocity layer is key to understand the whole system. In addition, the simulations indicate that a wave that may have triggered the onset of the mud volcano could only have been a body wave coming from depth. Future simulations will include other geological structures, including faults, to determine under what conditions energy traps may have amplified the seismic energy within the mud layer.