Induced or triggered? The deadly February 2019 Rongxian-Weiyuan ML 4.9 earthquake in the shale gas field in Sichuan, China

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Coinciding with the extensive hydraulic fracturing activities in the southern Sichuan basin, seismicity in the region has surged in the past a few years, including a number of earthquakes with magnitudes larger than 5. On 25 February 2019, an ML 4.9 earthquake struck the Rongxian County, Sichuan, China and caused 2 fatalities and 12 injuries, the first deadly earthquake associated with shale gas production. The earthquake was preceded by two foreshocks with magnitudes of ML 4.7 and ML 4.3 within two days. We relocated the earthquake sequence using local and regional seismic network, and obtained the focal depths of the mainshock and two foreshocks at 1 and 3 km, respectively, much shallower than the report from catalogue. Most other smaller quakes were located at 2-6 km. The mainshock had also been well captured by InSAR images, which confirmed the shallow depth of ~1 km. Both seismic and geodetic data yielded thrust faulting mechanism for the mainshock, consistent with the mapped Molin fault in the region. The two foreshocks, however, occurred on an unmapped fault that has different orientation than the Molin fault. Injection wells are found in the vicinity of the two foreshocks and the fracking depth (~2.7 km) coincides with their focal depths, suggesting a possible causal relationship. The mainshock is located in the region with positive Coulomb failure stress caused the two foreshocks. The value of Coulomb failure stress change is 0.03 bar, smaller than the typical static triggering threshold. Therefore, the mainshock is likely caused by fracking by poroelastic stress transfer.