Unusually shallow earthquake ruptures in Chinese fracking field

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An unusually shallow earthquake triggered by hydraulic fracturing in a Chinese shale gas field could change how experts view the risks of fracking for faults that lie very near the Earth's surface.

In the journal *Seismological Research Letters*, Hongfeng Yang of The Chinese University of Hong Kong and colleagues suggest that the magnitude 4.9 earthquake that struck Rongxian County, Sichuan, China on 25 February 2019 took place along a fault about one kilometer (0.6 miles) deep.

The earthquake, along with two foreshocks with magnitudes larger than 4, appear to be related to activity at nearby hydraulic fracturing wells. Although earthquakes induced by human activity such as fracking are typically more shallow than natural earthquakes, it is rare for any earthquake of this size to take place at such a shallow depth.

"Earthquakes with much smaller magnitudes, for example magnitude 2, have been reported at such shallow depths. They are understood by having small scale fractures in such depths that can slip fast," said Yang. "However, the dimensions of earthquakes are scale-dependent. Magnitude 4 is way bigger than magnitude 2 in term of rupture length and width, and thus needs a sizeable fault as the host."

"The results here certainly changed our view in that a shallow fault can indeed slip seismically," he added. "Therefore, we should reconsider our strategies of evaluating seismic risk for shallow faults."

Two people died and twelve were injured in the 25 February earthquake, and the economic loss due to the event has been estimated at 14 million RMB, or about $2 million. There have been few historic earthquakes in the region, and before 2019 there had been no earthquakes larger than magnitude 3 on the fault where the main earthquake took place.

Since 2018, there have been at least 48 horizontal fracking wells drilled from 13 well pads in the region, with three well pads less than two kilometers (1.2 miles) from the Molin fault, where the main earthquake took place.

Yang and his colleagues located the earthquakes and were able to calculate the length of the main rupture using local and regional seismic network data, as well as InSAR satellite data.

It is unusual to see clear satellite data for a small earthquake like this, Yang said. "InSAR data are critical to determine the depth and accurate location of the mainshock, because the ground deformation was clearly captured by satellite images," he noted. "Given the relatively small size of the mainshock, it would not be able to cause deformation above the 'noise' level of satellite data if it were deeper than about two kilometers."

The two foreshocks took place on a previously unmapped fault in the area, the researchers found, underscoring how difficult it can be to prevent fracking-induced earthquakes in an area where fault mapping is incomplete.

The researchers note that the Molin fault is separated from the geologic formation where fracking took place by a layer of shale about 800 meters (2625 feet) thick. The separating layer sealed off the fault from fracking fluids, so it is unlikely that the pressures of fluid injected into rock pores around the fault caused the fault to slip. Instead, Yang and colleagues suggest that changes in elastic stress in rock may have triggered the main earthquake on the Molin fault, which was presumed to be stable.

"The results here certainly pose a significant concern: we cannot ignore a shallow fault that was commonly thought to be aseismic," Yang said, who said more public information on fracking injection volume, rate and duration could help calculate safe distances for well placement in the future.

More information: Hongfeng Yang et al, A Shallow Shock: The 25 February 2019 ML 4.9 Earthquake in the Weiyuan Shale Gas Field in

Sichuan, China, *Seismological Research Letters* (2020). DOI: 10.1785/0220200202