Are we able to distinguish natural from injection-induced earthquake sequences in areas where both are plausible?

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Abstract

Determination of whether a seismic sequence is in response to natural tectonic processes or to human influences (e.g. fluid injection), especially when the sequence occurs close to anthropogenic activities, is important for hazard and risk assessments. Here, we investigate a sequence of seismicity that produced a M5.3 mainshock event on 30 November 2022 close to Peace River, Alberta. Several significant foreshocks and an extensive aftershock sequence is evident, producing several events of >M5 in March 2023, months after the mainshock event. The events occurred within a formally seismically quiescent region of Alberta, but in close proximity to brine disposal wells associated with in-situ bitumen production. Determination of whether this sequence was induced or natural could have significant ramifications for regulations in Alberta, but the sequence also highlights challenges in discriminating natural from injection-induced events, particularly when rapid characterization following a felt mainshock is ideal. Criteria for recognizing injection-induced earthquakes, established over three decades ago, consider factors such as spatio-temporal correlation with injection operations, locations of known faults, prior levels of seismicity activity, modelled stress changes at the hypocenter, existence of permeable pathways, focal depth and source mechanism. This approach has been refined in several recent publications. An expert panel of 10 inter-disciplinary scientists was convened to use several new schemes to evaluate if the Peace River earthquake sequence was natural or induced, based on publicly available data in March 2023. Results suggest that the majority of the experts believe the sequence to be induced by ongoing operations in the area, although there is some ambiguity, in particular relating to poor/missing data. This is the first instance (that we are aware of) where such a scheme has been applied to a sequence where data and analysis is ongoing, and as such highlights many of the difficulties of undertaking such analysis in "near real-time".

Biography:

Dr. Rebecca O. Salvage is a Research Associate at the University of Calgary. Her research focuses on fault and fracture activation and propagation over different temporal and spatial scales. In particular, she is interested in better understanding slow-slip phenomena identified using fibre optic networks integrated with microseismic analysis, as well as discerning why (and how) the generation of seismicity in resource development projects is often offset from the timing (and location) of injection. She obtained her Ph.D. in Geophysics from the University of Leeds, UK in December 2015 and holds a Masters degree in Geology from the University of Bristol, UK (2011). From 2016-2018 she was a Profesor Visitante at the Observatorio Vulcanologico y Sismologico de Costa Rica, undertaking real-time monitoring, processing and analysis of tectonic and volcano seismicity in Costa Rica and Central America.