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Fluid injection and induced seismicity

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The link between fluid injection, or extraction, and induced seismicity has been observed in reservoirs for many decades. In fact spatial mapping of low magnitude events is routinely used to estimate a stimulated reservoir volume. However, the link between subsurface fluid injection and larger felt seismicity is less clear and has attracted recent interest with a dramatic increase in earthquakes associated with the disposal of oilfield waste fluids. In a few cases, hydraulic fracturing has also been linked to induced seismicity.

Much can be learned from past case-studies of induced seismicity so that we can better understand the risks posed. Here we examine 12 case examples and consider in particular controls on maximum event size, lateral event distributions, and event depths.

Our results suggest that injection volume is a better control on maximum magnitude than past, natural seismicity in a region. This might, however, simply reflect the lack of baseline monitoring and/or long-term seismic records in certain regions. To address this in the UK, the British Geological Survey is leading the deployment of monitoring arrays in prospective shale gas areas in Lancashire and Yorkshire.

In most cases, seismicity is generally located in close vicinity to the injection site. However, in some cases, the nearest events are up to 5km from the injection point. This gives an indication of the minimum radius of influence of such fluid injection projects. The most distant events are never more than 20km from the injection point, perhaps implying a maximum radius of influence.

Some events are located in the target reservoir, but most occur below the injection depth. In fact, most events lie in the crystalline basement underlying the sedimentary rocks. This suggests that induced seismicity may not pose a leakage risk for fluid migration back to the surface, as it does not impact caprock integrity.

A useful application for microseismic data is to try and forecast induced seismicity during injection, with the aim of mitigating large induced events before they happen. Microseismic event population statistics can be used to make forecasts about the future maximum event magnitude as the injection program continues. By making such forecasts, mitigating actions may be possible if forecast maximum magnitudes exceed a predefined limit.