Value at Induced Risk: Managing injection-induced seismic risks based on low-probability, high-impact events

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The increasing number of damaging earthquakes induced by underground injection of fluids and the public concern they cause demonstrates the need for critical thinking about and clear communication of induced seismic risk. We present a new methodology for seismic risk assessment, communication and management for underground injection of fluids (Langenbruch, et al., Geophysical Research Letters, 2020). Our method is based on low-probability, high impact events that have been largely ignored in past approaches. It summarizes induced seismic risk in a single time-dependent number, the Value at Induced Risk (VaIR) which quantifies the amount of economic losses that will not be exceeded at a given confidence level. VaIR informs the operator, regulators and non-expert stakeholders at risk in a comprehensible and standardized way. Using the Pohang, South Korea, geothermal project and the damaging (US$75M) local magnitude M 5.35 earthquake it triggered in 2017 as an example, our method reveals that the EGS project exposed the city of Pohang to a 2% chance of economic losses of US$140M or more. The high risk could have been identified during the sequence of reservoir stimulation, lasting almost two years. Other fluid injection projects have been terminated due to seismic safety concerns. A geothermal reservoir stimulation project below the city of Basel, Switzerland, in 2006 was permanently terminated after a M 3.2 event occurred. Using the same analysis procedure, we found that up to the time of that earthquake the Basel project was characterized by a probability of about 0.3% to exceed M 5. The same probability level was exceeded after the first stimulation cycle at Pohang. It is remarkable, because the largest earthquake induced during the first stimulation in Pohang was only M 1.5, a magnitude which by itself would not terminate the project, as it was below the red traffic-light magnitude for the project. VaIR opens new ways to assess and communicate risk to all stakeholders for informed risk management decision making that can only be improved by further development of physical and statistical models of induced and triggered earthquakes. Together, they can provide more reliable assessment of magnitude probabilities and reduced uncertainties for inclusion in predictive risk assessments.

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