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| **Testo di partenza**  **\*Non tradurre il testo evidenziato in giallo** | **Testo tradotto dal candidato** | **Spazio a disposizione del correttore** | **Punteggi** |
| ***How earthquakes are induced*** |  |  |  |
| Conditions within Earth’s crust determine whether human subsurface activities lead to earthquakes. |  |  |  |
| Since 2009, the Midwestern United States has seen a dramatic rise in earthquakes induced by human activities. Most of these events were caused by massive reinjection of wastewater produced during oil and gas extraction. In February 2016, regulators in Oklahoma called for an injection rate reduction after several major events up to moment magnitude 5.8 occurred. |  |  |  |
| On the other side of the Atlantic, an unprecedented number of earthquakes has followed gas extraction from the Groningen field in the Netherlands. The Dutch government imposed production cuts after a Mw 3.6 event in August 2012 caused structural damage to houses. Intensive research of these two instances of induced seismicity points to contrasting mechanisms, but in both cases, the natural conditions prior to subsurface activities plays a dominant part. |  |  |  |
| Fifty years ago, Healy *et al.* determined that fluid injection at depth causes the pore pressure to rise in a preexisting fault, reducing its strength and potentially leading to its failure. In contrast, fluid extraction at depth reduces the pore pressure, leading to compaction of the rock mass; the increased rock stress can drive a preexisting fault to failure. In both settings, the two factors that control induced earthquakes are operational parameter, such as the volume that is injected or produced, and natural conditions, such as the presence of preexisting faults and their ambient stress level. Operational parameters are often assumed to dominate, but that notion may reflect limited knowledge of the locations of preexisting faults and their ambient stress level. |  |  |  |
| For regulatory measures to be effective in mitigating induced seismicity, it is crucial to understand the role of the natural conditions that existed before human activities.  Recent studies have started to collect measurements that help to validate hydromechanical modeling results of changes in pore pressure and stresses after fluid injection or production. |  |  |  |
| For example, time-lapse shear-wave anisotropy analysis has provided direct evidence linking earthquake occurrences to pore pressure increase in the Midwestern United States. Measurements of surface deformation derived from InSAR (Interferometric Synthetic Aperture Radar) have linked swarms of induced events 10 to 30 kilometers from the injection well to pore pressure increases of only ~0.1 MPa, even though pore pressure increases are predicted to be higher close to the well. |  |  |  |
| These data point to a mechanism through which wastewater injection induces seismicity. During wastewater injection, the pore pressure front diffuses away from the injection wells along highly permeable channels in the disposal aquifers. Once the pressure front reaches large faults that intersect the basement below the reservoir and that are close to their point of tectonic reactivation, even a small pressure increase can trigger earthquakes. In support of this conceptual model, statistical assessment has shown that seismic activity is more highly correlated with the distance between the injection point and the basement than with the net injected volume. |  |  |  |