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Process-based understanding of induced seismicity: a key step for public acceptance of geothermal power plants in urbanized areas

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Over the last century, the Earth's climate has been significantly impacted by the increasing levels of greenhouse gases in the atmosphere. To contrast this dangerous trend, the European Commission has committed approximately 17.5 billion euros to shift away from fossil fuels and embrace clean, sustainable energy sources. The ambitious goal is to achieve a substantial reduction of at least 55% in greenhouse gas emissions by 2030, while simultaneously boosting the use of renewable energy sources by approximately 40%. In this socio-cultural context, geothermal energy emerges as an promising, sustainable, and renewable resource that could potentially satisfy the world's escalating energy demand. Nevertheless, despite its considerable advantages, geothermal energy faces a challenge due to insufficient public backing. Among the main causes of this reluctance are the concerns about possible triggering of seismic events during geothermal operations. Recent studies reveal that more than half of anthropogenic activities leading to induced earthquakes are associated with the extraction or injection of underground fluids.

This phenomenon necessitates a detailed examination of the complex interplay between various physical and chemical factors influencing the subsurface dynamics. The complexities of induced seismicity go beyond singular mechanistic explanations. Temperature, volume, and multi-phase nature of the fluid have important physical-chemical implications for stimulated rock volume. These behaviors are well known to the scientific community, which has conducted multidisciplinary research to emphasize that the development of anthropogenic seismic events does not result from a single mechanism but from the interaction of multiple factors, such as perturbations of the stress state, changes in pore pressure, the interactions between pre-existing structures in the area or the dynamic weakening of seismogenetic faults. Despite extensive multidisciplinary research, the coexistence and influence of these processes on earthquake development remain unclear. Addressing this knowledge gap is crucial for developing effective prediction and mitigation strategies.

What are the most recent theories on the generation of anthropogenic earthquakes? Can physics-based models help us better understand the mechanics behind these events and mitigate their development?

This abstract aim is to collect and summarise the most recent information on anthropogenic earthquakes associated with geothermal activities. This review will be the basis for a three-year

PhD programme that will evaluate existing theories, compare proposed approaches, and determine the most viable avenues for developing prediction or mitigation techniques. The methodology will involve a comprehensive analysis, starting with structural and geophysical assessments, followed by numerical modelling to improve understanding of the underlying fluid and rock mechanics. The objective will be to develop effective and understandable strategies to address the problems associated with geothermal-induced seismicity.