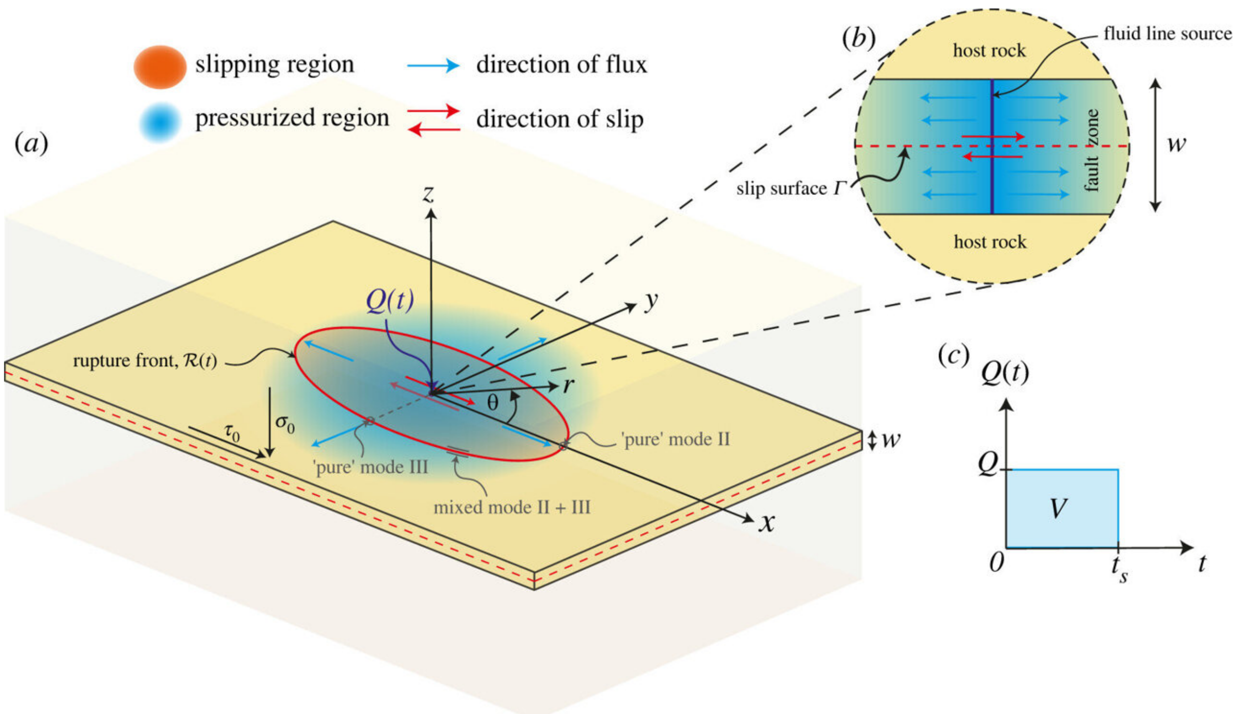
Scientists gain insight into geothermal-technology-induced seismicity

July 19 2023, by Rebecca Mosimann



Model schematics. (a, b) Fluid is injected into a permeable fault zone of width *w* via a line-source that crosses the entire fault zone width. The fault is planar and embedded in an unbounded linearly elastic impermeable host rock. The initial stress tensor is uniform. (c) Fluid is injected at a constant rate Q until $t = t_s$ at which the injection is instantaneously stopped. Credit: *Proceedings of the Royal Society A: Mathematical, Physical and Engineering Sciences* (2023). DOI: 10.1098/rspa.2022.0810

EPFL scientists have developed a model that sheds light on the seismic risks arising from subsurface fluid injections carried out as part of geothermal energy extraction.

To support the shift to a carbon-free economy, energy producers are eagerly looking for ways to safely extract geothermal energy from deep underground. EPFL associate professor Brice Lecampion, who heads the Laboratory of Geo-energy (GEL) and holds the Gaznat Chair on Geo-Energy at the School of Architecture, Civil and Environmental Engineering (ENAC), is contributing to these efforts through the work being done by his research group. They're developing models for describing the behavior of the subsurface, with a specific focus on the consequences of subsurface fluid injections—that is, how fluid flow interacts with fractures in rocks.

Their research is important because underground water injection plays a key role in the extraction of geothermal energy, a renewable source. The scientists' latest findings appear in *Proceedings of the Royal Society A* and pave the way to a better understanding of the underlying physical mechanisms that trigger seismicity during geothermal operations.

In Switzerland and elsewhere, geothermal wells that run deep underground (4–6 km below the surface) are controversial due to the potential for a seismic event and subsurface pollution. One recent example is the local opposition to plans to build a geothermal power plant in Haute-Sorne, in Jura Canton.

Geothermal wells that don't run very deep remain in permeable layers of rock where water circulates easily. But as they get further below the surface, they enter impermeable rock, meaning engineers must either artificially create fractures in the rock where water can flow or stimulate existing fractures to increase their permeability. This is done through a process known as hydraulic stimulation. While this process enhances rock permeability, it also has the potential to trigger earthquakes. That's what happened during a pilot project in Basel in 2006, for example, when fluid-injection operations led to a magnitude 3 earthquake—and the project being abandoned.

The risk of an induced earthquake is especially problematic since it doesn't go away once the fluid injection stops, but rather continues for quite some time afterwards. Alexis Sáez, a Ph.D. student at GEL and a co-author of the study, explains, "We looked particularly at earthquakes that occur between a few days and a few months after the end of fluid injection. Our research sheds light on a new physical mechanism that can trigger these delayed earthquakes."

He and Lecampion developed a 3D computer model and ran comprehensive technical analyses of how the fluid injection and fractures interact. They described in great detail how fractures keep deforming after the fluid injection has ended, and how this delayed deformation process may promote the triggering of an earthquake.

"Our model gives engineers guidance and new calculation methods that can be integrated into more general strategies to mitigate the seismic risk associated with these operations," says Sáez.

"For now, it's really hard to predict the occurrence of injection-induced earthquakes—engineers rely mostly on statistical approaches, similar to what they do for natural earthquakes. Our research provides a better understanding of the physical forces at work. This is a step forward in the implementation of physics-based approaches to manage the inherent seismic risk of these operations and to ultimately unlock the vast potential of geothermal energy to facilitate the decarbonization of our energy system."

More information: Alexis Sáez et al, Post-injection aseismic slip as a

mechanism for the delayed triggering of seismicity, *Proceedings of the Royal Society A: Mathematical, Physical and Engineering Sciences* (2023).
DOI: 10.1098/rspa.2022.0810

Provided by Ecole Polytechnique Federale de Lausanne