Observing how fissure systems are formed – thanks to the “gas sniffer”

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In order to increase the permeability of the rock for applications such as the use of geothermal energy, rock is artificially broken. Until now, there was a lack of methods to track this process in the field in real time. Thanks to a new technique, this gap can now be closed, as a study by Eawag and ETH Zurich shows.

The rock laboratory on the Grimsel Pass in the Bernese Oberland lies 400 metres deep in the mountain. There, geophysicists from the ETH Zurich have installed an experimental setup with which they agitate the rock, thereby systematically causing it to break. They want to find out how geothermal energy projects in Switzerland, for example, can be implemented safely in the future. Two scientists from the Swiss Federal Institute of Aquatic Science and Technology (Eawag) have now joined this project: geochemist Rolf Kipfer and environmental physicist Matthias Brennwald from the “Water Resources and Drinking Water” department.

Together with their colleagues from the ETH Zurich, they carried out six controlled fracture experiments in 2017. They pressed a liquid mixture of water and chemicals through boreholes into existing fault zones to create new pathways in the Grimsel rock.

Transport detected in the field in real time

With the aid of a mobile gas analysis device, the "Mini-Ruedi", Eawag researchers were able to demonstrate that gases and liquids, when released into the surrounding rock, can move along the fractures generated and get into already existing water-bearing layers. These results were recently published in the journal Scientific Reports. “Nobody has ever made this observation directly in the field before, simply because the equipment was missing," says Rolf Kipfer, co-author of the study. The Mini-Ruedi, which was developed by Matthias Brennwald and himself at Eawag several years ago and is today commercially sold via the Eawag spin-off "Gasometrix" now makes such investigations possible.

Argon and helium as tracers

Crucially, the suitcase-sized Mini-Ruedi measures autonomously, continuously and delivers new measurement values every few minutes. A thin membrane immersed in water transfers the gases to a kind of "trunk". This directs the gases to the compact Mini-Ruedi mass spectrometer, which analyses the gas mixtures. Until now, such analyses required months of laboratory work.

In the current study, the researchers focused on the rare gases argon and helium. These gases result from the decay of natural radioisotopes (uranium, thorium, potassium) and are trapped in the rock. They are only released when the rock is broken up.

During the fracture experiments, the water-gas mixture in the Grimsel granite enriched with helium and argon when new fractures connected with the water-bearing layer. "Our geochemical approach closes a gap for many applications that would remain open with conventional seismic methods," says Kipfer.

The mobile gas analyser is currently also being used for a project at the Mont Terri rock laboratory. Scientists there are investigating the potential of underground CO2 storage. Since the Mini-Ruedi also detects methane, it opens up the possibility of monitoring in real time unintended gas leaks into the groundwater by fracking during natural gas production. "With the help of our new technology, it will in future be possible to assess the consequences in groundwater better," says Rolf Kipfer.

Matthias Brennwald presents the mass spectrometer Mini-Ruedi during a field trip on Rotsee (LU).

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Original publication

In situ observation of helium and argon release during fluid-pressure-triggered rock deformation

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