



## Noble Gas Release during Reservoir Stimulation

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Gas-Equilibrium Membrane Inlet Mass Spectrometry (GE-MIMS) allows for on-sight, high temporal frequency sampling and analysis of dissolved gases. Measuring noble gas concentrations, including Ar, He and Kr can shed light on the origin of groundwater, from the conditions involved during recharge (temperature, excess air) to their residence time in the subsurface.

In May 2017, a decameter scale in-situ hydraulic stimulation experiment were performed at the Grimsel Test Site, an underground laboratory located in the Central Aar massif in the Western Alps (Switzerland) at approximately 500 m depth. The adopted stimulation protocol involved 5 main cycles with the goal to induce new fractures potentially connecting the pre-existing fracture network. Transient deformation during each injection stage was monitored using sixty high resolution fiber-optic based strain sensors (i.e. Fiber-Bragg-Grating sensors) installed across the support volume and three tiltmeters at the tunnel floor. A gas mass spectrometer was installed at a naturally seeping fracture located in the main research gallery at a distance ranging from 40 to 15 meters from the injection zones. Time series of both Helium and Argon concentrations monitored during throughout stimulation experiment are presented and discussed in this contribution.

Here we show that concentration anomalies provide compelling evidence that deformation induced by high pressure fluid injection promotes the remobilization of fluids trapped in different compartments of the host rock. The analysis of Ar/He ratios allows to distinguish between matrix and fracture-fluid releases during the different phases of each stimulation experiments. Our results demonstrate the strong potential in using He and Ar concentration anomalies to track transient mixing of resident fluids released in response to induced deformation in deep reservoirs and identify their origins. On-sight noble gas analyses using GE-MIMS therefore provide critical information for reservoir engineers and practitioners seeking for reservoir stimulation efficiency and better prediction of natural or induced seismic events.