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The DemoUpStorage Project: monitoring mineral carbonation in Icelandic basalts

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Mineral carbonation (MC) has long been suggested as a potential way to permanently store CO_2 captured from smaller/medium emitters, as alternative to conventional geological sequestration in depleted oil and gas fields. MC consist in CO_2 reacting with calcium-, magnesium- and iron-rich minerals to form carbonates. MC is a promising option in terms of available resources and security of permanent storage. Nevertheless, this technology, tested in laboratories and small projects, has not yet taken off on a large scale. In situ large scale projects can contribute in reducing the knowledge gaps on MC fundamentals and allowing cost analyses and optimization. Since almost a decade CO_2 is injected in Icelandic basalts, providing a field scale laboratory for testing MC.

The DemoUpStorage, together with its partner project DemoUpCARMA, is a pilot project by ETH Zurich (http://www.demoupcarma.ethz.ch), EAWAG, EPFL and University of Geneva that aims to demonstrate the implementation and scale—up of CO_2 geological storage using MC. The project investigates the fate of CO_2 transported from an emitter in Switzerland to Helguvik (Iceland), where it is then mixed with oceanic water and injected in basalts at a depth of c.a. 400m. The monitoring involves a combination of technologies that independently but synchronously observe changes in underground. In particular time-lapse acquisitions of different physical parameters (electrical resistivity, seismic P- and S-wave velocity, attenuation factor Q) will be conducted in parallel with fluid geochemistry monitoring and dissolved gas sampling in boreholes. Repeated cross-hole Vertical Seismic Profiling (VSP) will be performed across an array of three boreholes, of which one is the injection and two are monitoring boreholes. Fiber optic technology will be used in parallel to conventional hydrophones. Additionally, a dense, regular grid of seismic sensors will be deployed at the surface during VSP acquisitions with the goal to provide a high-resolution 3D imaging of the subsurface at the reservoir scale. Downhole Electrical Resistivity Tomography logs in one of the two monitoring wells will be repeatedly performed to constrain the build-up of CO_2-related resistivity signatures in conjunction with CO_2 saturation levels monitored by regular fluid sampling. A portable mass spectrometer connected to a borehole will provide continuous gas analysis to determine the temporal evolution of the local fluid dynamics, to validate permanent storage and to monitor for potential leakage. Risk mitigation actions comprise monitor the background seismicity before, during and after the whole injection operations. Laboratory observations on rock samples from the Helguvik area complete the set of observation and offer

the possibility to model at small scale porosity changes due to MC. Predictive numerical simulations at reservoir scale are performed and will be continuously updated with the acquisition of the data. The start of the injection is foreseen in Spring 2023.

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