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Mineral storage of carbon in basaltic rocks

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All the carbon on Earth is derived from rocks and will eventually end up in rocks, the largest carbon reservoir on Earth. Human activities have accelerated this carbon cycle by mining and burning of fossil fuel, causing a rise in atmospheric carbon dioxide (CO_2) concentrations, resulting in rapid warming of the Earth's surface. The reduction of CO_2 emissions to the atmosphere is vital to mitigate this global warming. One option is to capture CO_2 and store it in subsurface rocks. Identifying locations for safe and secure CO_2 storage is one of the most pressing scientific problems of our time.

The success of CO_2 storage depends on its long-term security. Injection of CO_2 into young basaltic formations provides significant advantages, including great storage potential and permanent storage by mineralisation, by combining the injected CO_2 with metals contained in the basalts to form stable carbonate minerals.

One method to assess both the storage potential and the risks associated with mineral storage of carbon in basalts is through the study of natural analogues. Volcanic geothermal systems serve as a useful analogue since these systems receive considerable amounts of CO_2 from magma in their roots. These systems have revealed the large storage potential of young basaltic rocks, where normal faults are common and pores have not yet been filled with secondary minerals: It is anticipated that >950 Gt of CO_2 could theoretically be stored within the active rift zone in Iceland. The largest storage potential lies offshore where CO_2 from burning of all fossil fuel on Earth could theoretically be stored as carbonate minerals within the oceanic ridges [1]. Studies on CO_2-water-basalt interaction in connection with magmatic input from active volcanos - Mt. Hekla and Eyjafjallajökull, Iceland - have revealed that toxic metals may be liberated by the initial dissolution of basalts in the acidic CO_2-rich water. However, their mobility is inhibited by their incorporation into the precipitating carbonates as the fluid is neutralised by further basalt dissolution [2,3].

The CarbFix project builds on these natural analogues, along with geochemical modelling, and lab experiments. The first pilot injections took place at Hellisheidi in SW-Iceland in 2012. There, rapid mineralisation of the injected CO_2 was demonstrated [4,5]. Building on the success of the pilot injections, the project was scaled up to an industrial level in 2014 and again in 2016. Currently about 12,000 tonnes of CO_2 from the Hellisheidi geothermal plant are injected annually into the basaltic subsurface for permanent storage in carbonate minerals.

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[5] Snæbjörnsdóttir et al., IJGGC 58 (2017), 87-102