Expanding the CarbFix CCS method beyond Icelandic geothermal power plants

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The CarbFix approach has been demonstrated to be a safe and cost-effective approach to limiting carbon dioxide (CO_2) and hydrogen sulphide (H_2S) emissions by their capture in water and the subsequent mineralization in subsurface basalts. The goal of this study is to assess if the same approach can be used worldwide for the simultaneous capture and storage within different scenarios, such as in presence of SO_2 bearing gas streams commonly emitted from coal fired power plants.

A set of reaction path models was created using the PHREEQC software package (v3), together with its new thermodynamic database, carbfix.dat. Thermodynamic calculations were performed to i) quantify the likely compositions of aqueous fluids (either groundwater or seawater) after the capture of typical gas streams including SO_2 and ii) the efficiency of dissolved gas mineralizaion after injection of these gas charged fluids into subsurface basalts as a function of reservoir temperature. The models were validated using results obtained from the ongoing CarbFix2 injections (Hellisheiði, SW Iceland, 1).

Preliminary results show that carbon and sulfur readily mineralize as calcite and Fe-sulfides (pyrite or pyrrhotite, depending on temperature), respectively, in all tested scenarios. During the simulations using fresh water for gas capture, additional predicted secondary phases are zeolites, smectites, amphibole, clay minerals, clynopyroxene, Fe-Ti oxides, and feldspars. If seawater is used for gas capture, the formation of anhydrite is also predicted. Overall, carbon sequestration is limited by the competition of carbonates with silicic minerals for the availability of Ca^{2+}, and the most optimal conditions were found at temperatures between 100 and 170 °C, and high pCO_2. On the other hand, in the presence of SO_2, the potential precipitation of elemental sulfur due to sulfur disproportionation reactions at acidic pH could clog the pipelines used for fluid transport to subsurface storage reservoirs, warranting further investigation.

(1) Gunnarsson et al. (2018) The rapid and cost-effective capture and subsurface mineral storage of carbon and sulfur at the CarbFix2 site. IJGCC 79, 117–126.