Low-temperature hydrothermal fluids in the oceanic crust – a case study from Surtsey volcano, Iceland

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Surtsey is a young volcanic island consisting of hylaoclastites, basaltic tuff, tephra and basaltic lava flows. The young island grew from the seafloor upon a volcanic eruption from 1963 to 1967. Access to the island is restricted due to its unique location and formation history. Surtsey has a low-temperature geothermal system and is an excellent locality to study the formation and evolution of geothermal systems within the oceanic crust. In 1979, a drill hole was sunk into the subsurface of the island that offered important insights into the character and development of the hydrothermal system. On the 50th aniversary of Surtsey, three additional drill holes were made as a part of the ICDP SUSTAIN project: two (SE-2a, SE-2b) paralell to the 1979 drill hole (SE-1) and one with a dip of 55° (SE-3) that cuts through the diatreme beneath the crater Surtur and extends further into the seafloor.

In this study, geothermal water in drill holes SE-1 and SE-3 were sampled along depth intervals to investigate the impact of water-rock interaction on water chemistry in low-temperature seawater geothermal systems. Elemental concentrations of Si, Na, Ca, and Cl were similar to corresponding seawater concentrations whereas concentrations of B, Mg, F, CO_2 and SO_4 were depleted. Concentrations in SE-1 varied strongly from those measured in SE-3 indicating signs of evaporation. Both chemical and isotopic data showed that the Surtsey geothermal waters were of seawater origin which has reacted with the surrounding basaltic rock, causing secondary mineral formation and corresponding depletion of certain elements in the waters. This implies that low-temperature seawater geothermal systems within the oceanic crust may be signifcant sinks of seawater derived Mg, CO_2 and SO_4 which could have large effects on the global elemental budgets of these elements.