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The thermal history of Surtsey, explored using HYDROTHERM numerical simulations

Hannah I. Reynolds (1), Magnús T. Gudmundsson (1), Michael J. Heap (2), Marie D. Jackson (3), and Tobias B. Weisenberger (4)

(1) Institute of Earth Sciences, University of Iceland, Reykjavík, Iceland (hir@hi.is), (2) Géophysique Expérimentale, Institut de Physique de Globe de Strasbourg (UMR 7516 CNRS, Université de Strasbourg/EOST), Strasbourg, France, (3) Department of Geology and Geophysics, University of Utah, Salt Lake City, USA, (4) ÍSOR Iceland GeoSurvey, Reykjavík, Iceland

Surtsey is a volcanic island, formed in a series of eruptions between 1963 and 1967, off the south coast of Iceland. In 1979 a cored borehole drilled through the eastern crater provided structural and stratigraphic data for the young subaerial and submarine basaltic deposits. The hole was further utilised to conduct regular downhole temperature measurements. Three new cored boreholes were acquired in 2017 as part of the International Continental Scientific Drilling Program SUSTAIN project. Two vertical cores were retrieved, 152 and 181 m in length, and a 354 m inclined core which reached approximately 100 m depth below the pre-eruption seafloor and confirmed the existence of a diatreme excavated by the eruption into the seafloor sedimentary rocks. The cored boreholes provide an opportunity to explore the cooling of the island using numerical modelling, with constraints on the structural and material properties (density, porosity, permeability, thermal conductivity, thermal diffusivity, and specific heat capacity) of the basaltic tuff tested at five key depths representing different thermal regimes. In addition, the material properties of the seafloor sedimentary rocks were obtained, from samples excavated by explosive eruptions that were deposited on the subaerial tuff cone. Thermal measurements made in 2018 in the boreholes are in agreement with earlier observations from 1980. Temperatures of >120 °C occur within the submarine Surtsey deposits, more than 50 years after emplacement. Moreover, temperatures of 60 °C occur within the sub-seafloor diatreme. HYDROTHERM numerical simulations of fluid flow and heat transport are used to assess the relative significance of magmatic intrusions compared to erupted products in the heat budget of Surtsey.