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The Lithology of the 2017 Surtsey Volcano Drill Cores

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Surtsey is the type example of emergent volcanism, characterized by the pervasive interaction of water with erupting magma that results in steam driven explosive activity and higher degrees of magma fragmentation. In 2017 the International Continental Scientific Drilling Program SUSTAIN project drilled three cored boreholes at Surtsey, acquiring two vertical cores (SE-02a, SE-02b) a few meters from the 1979 cored borehole, and one inclined core (SE-03) angled at 35° from vertical towards the center of Surtsey's first established vent, Surtur I.
The 354 m inclined core penetrates lapilli tuff and dikes beneath the center of Surtur I at a vertical depth of ca. 283-290 m, ca. 100 meters below the pre-eruption seafloor, demonstrating substantial syn-eruptive excavation of the crater floor. Logging of this core reveals that there is an inward and downward change from clear tuff-cone deposits to vent-filling, diatreme, deposits cut by dikes. Nowhere in any of the cores is there any evidence of a pillow mound, in the form of intact pillows or pillow lava fragments, from either the original seafloor or early phase of Surtsey's growth.
The vertical and inclined cores mostly transect a single lithofacies of variably altered lapilli tuff based on visual estimates and observations of the fragment assemblages. Different lithofacies present in the lower parts of the inclined hole comprise fluidal-fragment lapilli tuff and lapilli tuff breccia. The fluidal-fragment lapilli tuff occurs over a single ∼30 m interval, below the pre-eruption seafloor, and is characterized by lapilli and bombs with irregular fluidal morphologies and a very coarse to medium ash matrix with blocky, arcuate, platy, irregular and globular grain shapes. This fluidal-fragment lapilli tuff is not found elsewhere in the cores. The fluidal clasts indicate fragmentation in the ductile regime during this stage of the eruption, implying that these clasts were derived from fragmenting magma that was at least briefly isolated from seawater. One explanation is that magma-water interaction formed vapor-dominated water-exclusion zones where ductile fragmentation could occur. An alternative origin is that non-explosive mingling of magma with a tephra slurry formed fluidal peperites extending from a nearby but un-cored dike.
The lapilli tuff breccia occurs over three intervals, ∼18.5 m above the sea floor and at ∼67 m and 91 m below the seafloor within the diatreme structure. Lithic fragments derived from the pre-eruption seafloor are rare, and do not form a volumetrically significant fragment population, yet their presence in the uppermost lapilli tuff breccia may suggest excavation began relatively early in the eruption. These lithics are small in comparison to the large blocks found on the tuff cone today. It remains unclear whether excavation was continuous or intermittent throughout the eruptions.