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Field constraints for modeling the emplacement of the 2010 Gigjökull lava flow, southern Iceland: interplay between subaqueous, ice contact and subaerial lava emplacement

B. Edwards (1), B. Oddsson (2), M.T. Gudmundsson (2), and R. Rossi (1)

(1) Dept of Earth Sciences, Dickinson College, Carlisle, PA, USA, 17013, (2) Institute of Earth Sciences, University of Iceland, Reykjavik, Iceland

One of the least accessible products of the 2010 Eyjafjallajokull eruption is the trachyandesite lava that flowed north from the summit eruption site down through Gigjökull glacier. Based on numerous overflights during 2010, syn-eruption satellite imagery and two on-site investigations in 2011, we have developed a preliminary model to illustrate the progressive movement of the complex lava flow down through Gigjökull. Previous workers have documented the events surrounding the explosive summit eruptions, including the flow path for the majority of the water derived from melting $\sim$0.1 cubic km of summit ice, which moved over, through and beneath Gigjökull producing a series of jokulhlaups during April and May 2010. Overflights in 2010 and 2011 show that most of the upper parts of the lava flow are surfaced by oxidized, blocky lava that appears very similar to what would be expected from an entirely subaerial lava flow. However, exposures at the lowest end of the flow preserve a record documenting lava emplacement in water and through ice tunnels. We describe 8 different components visible in this northernmost, lowest part of the lava flow, including: (1) upper subaerial levee-bounded lava flow, (2) subaerial blocky lava bench, (3) subaqueous/ice contact lava mounds, (4) subaqueous/ice contact sheet lava complex, (5) ponded, glaciolacustrine sediments, (6) subaerial slabby lava flow, (7) subaqueous pillow lava lobes, and (8) ice-tunnel confined lava flows. In combination these 8 components are consistent a model for lava emplacement through a valley glacier. We propose that the lava flow, which appears to have started moving down the glacier from a tephra cone immediately north of the main summit craters after the largest of the jokulhlaups, exploited newly formed and/or pre-existing sub-ice drainage systems along the base of Gigjökull. Initial meltwater from the eruption site created/enhanced basal ice drainage systems. Lava flows exploited these drainage systems, some of which appear to have been water filled (e.g. producing pillow lava lobes), and others of which may have only had intermittent water or none at all during lava emplacement. Progressive lateral melting of multiple ice tunnels allowed for coalescence of lava into wider flows that eventually melted enough ice to produce open cavities/cataracts. Once opened, subaerial lava flows covered much of the basal, ice-tunnel-confined and subaqueous eruption components. Development of a field-constrained, detailed model for within-ice lava flow emplacement has important implications for heat transfer during effusion dominated eruptions and for potential hazards from floods caused by melting during lava emplacement.