

EGU21-16038

<https://doi.org/10.5194/egusphere-egu21-16038>

EGU General Assembly 2021

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Deciphering the fallout of tephra on glaciers in past eruptions, the case history of the Katla 1918 eruption

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Explosive eruptions in ice-covered volcanoes may deposit large volumes of tephra on the glaciated slopes. The tephra can influence surface ablation and alter mass balance. Ice melting by an eruption can change glacier geometry and temporarily alter the flow of outlet glaciers. Conversely, when assessing the size of past tephra-producing eruptions in an ice-covered volcano the glacier complicates such estimates. The effects of ice flow, dilation and shear need to be considered. A tephra layer may get buried in the accumulation area, be transported by glacier flow and progressively removed over years-to-centuries by ice flow, eolian transport of exposed tephra and sediment transport in glacial rivers. Here we report on a case study from the Mýrdalsjökull ice cap that covers the upper parts of the large Katla central volcano in south Iceland. Most eruptions start beneath the 300-700 m thick ice cover within the Katla caldera, melt large volumes of ice and cause major jökulhlaups. They also produce tephra layers that are preserved in soils around the volcano. The most recent eruption in Katla occurred in October-November 1918, when a large tephra layer was deposited in a 3-weeks long eruption. By using a combination of (1) data obtained at or near the vent area within the SE-part of the Katla caldera in the year following the eruption, (2) mapping of the tephra as exposed at the present time in the ablation areas in the lower parts of the outlet glaciers, and (3) simple models of ice flow based on balance velocities and knowledge of mass balance, we estimate the location of fallout and the original thickness of the presently exposed tephra. Photos taken in the vent area in 1919 indicate a tephra thickness of 20-30 m on the ice surface proximal to the vents. The greatest thicknesses presently observed, 30-35 cm, occur where the layer outcrops in the lowermost parts of the ablation areas of the Kötlujökull and Sólheimajökull outlet glaciers. A fallout location within the Katla caldera is inferred for the presently exposed tephra, as estimates of balance velocities imply lateral transport since 1918 of ~15 km for Kötlujökull, ~11 km for Sólheimajökull and about 2 km for the broad northern lobe of Sléttjökull. The calculations indicate that ice transport with associated dilation of the glacier through the accumulation areas has resulted in significant thinning. Thus, the layer that is now 0.3-0.35 m thick in the fastest flowing outlets is estimated to have been four to seven times thicker when it fell on the accumulation area within the ice-filled caldera. In contrast, changes have been minor in the slowly moving Sléttjökull. These findings allow for the construction of an isopach map for the glacier. The results indicate that just under half of the total airborne tephra produced in the eruption fell within the Mýrdalsjökull glacier, with the remaining half spread out

over a large part of Iceland. These methods potentially allow for reconstruction of several tephra layers from ice-covered volcanoes in Iceland and elsewhere.