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Implications for future activity of Grímsvötn volcano, Iceland, from compositional time series of historical tephra

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The nature of future eruptions of active volcanoes is hard to predict. Improved understanding of the past volcanic activity is probably the best way to infer future eruptive scenarios. The most active volcano in Iceland, Grímsvötn, last erupted in 2011 with consequences for habitants living close to the volcano and aviation in the North-Atlantic. In an effort to better understand the magmatic system of the volcano, we have investigated the compositions of 23 selected tephra layers representing the last 8 centuries of volcanic activity at Grímsvötn.

The tephra was collected in the ablation area of outlet glaciers from Vatnajökull ice cap. The ice-conserved tephra are less prone to alteration than those exposed in soil sections. Major element analyses are indistinguishable and of quartz-normative tholeiite composition, and Sr and Nd isotope ratios are constant. In contrast, both trace element concentrations (Th range from 0.875 ppm to 1.37 ppm and Ni from 28.5 ppm to 56.6 ppm) in the basalts and Pb isotopes show small but significant variations. The high-precision analyses of Pb isotope ratios allow the identification of tephra samples (3 in total) with more radiogenic ratios than the bulk of the samples. The tephra of constant isotope ratios show linear increase in incompatible element concentrations with time. The rate of increasing concentrations permits exploring possible future scenarios assuming that the magmatic system beneath the volcano follows the established historical evolution.

Assuming similar future behaviour of the magma system beneath Grímsvötn volcano, the linear increase in e.g. Th concentration suggests that the volcano is likely to principally produce basalts for the next 500-1000 years. Evolution of water concentration will most likely follow those of incompatible elements with consequent increases in explosiveness of future Grímsvötn eruptions.