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Explosive Volcanism in Iceland: Three Examples of Hydromagmatic Basaltic Eruptions on long Volcanic Fissures within the past 1200 Years.

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Explosive basaltic eruptions are the most common volcanic activity in Iceland during the Holocene, with at least 120 known eruptions in the last twelve centuries. Ice caps cover parts of the volcanic zones in Iceland and ground water level is high in many areas. Magma-water interaction is therefore common, but the volume of most basaltic tephra layers produced by such hydromagmatic eruptions is <1 km^3 as freshly fallen tephra.

Occasionally, much larger basaltic tephra layers are emitted, with volumes ranging from 5 to >10 km^3 as freshly fallen. Three eruptions on volcanic systems in South Iceland have produced such tephra deposits: the 1477 AD Veidivötn eruption, which may be the largest explosive eruption in Iceland during the last 1200 years; the partly explosive 934 AD Eldgjá eruption; and the predominantly explosive Vatnaöldur eruption $\sim$ 870 AD. A common feature of these larger-scale events is that the volcanic fissures are tens of km in length, being 75 km, 67 km and 60 km, respectively. High ground water level, lakes and partial ice-cover provided water for explosive interaction with the basaltic magma in the surface or near-surface environment.

Over 10 km^3 of basaltic tephra were emitted in the phreatomagmatic phase of the 1477 AD Veidivötn eruption. The source area of the Veidivötn tephra is a 31-km-long near-continous fissure segment that opened up within a large lake basin. The tephra consists of highly fragmented juvenile lapilli and ash with a variety of non-juvenile lithics from the alluvial and lacustrine sediments in the lake basin. The tephra was dispersed towards E, NE and NNE and covers an area of 53,000 km^2 on land. The offshore dispersal area is expected to be several times larger. The total tephra volume

is difficult to estimate because the 1 and 0.5 cm isopachs lie mostly offshore. Minimum duration of the explosive phase on the 31-km-long fissure in the basin is estimated to have been 12 hours. Dispersal of lithics from a single crater indicates that the height of the eruption column at that location reached $>$18 km during the peak of the eruption. The dispersal pattern of the tephra is attributed to high degree of fragmentation, a high eruption column that was also of great width, and strong winds blowing at low angles towards and along the erupting fissure. Maximum thickness of the tephra layer is 12 m, which together with its extensive dispersal, indicates an eruption of phreatoplinian intensity.

About 15 km long segment of the 75 km long Eldgjá fissure opened up below ice and emitted $>$5 km3 of basaltic tephra, covering 20,000 km^2 within the 0.5 cm isopach on land. A large fall area at sea makes estimates of volume difficult. The grain size of the tephra ranges from fine ash to coarse lapilli and it consists of both juvenile clasts and wall-rock lithics in higly variable proportions. The deposits indicate spatial and temporal variations in magma-water mass ratio, resulting in complex fragmentation mechanisms of the juvenile magma and, at times, extensive spalling of wall-rock. The Eldgjá eruption also produced about 18 km^3 of lava on the subaerial part of the fissure.

A 25 km long segment of the Vatnaöldur fissure opened up alongside a lake basin. About 5 km^3 of basaltic tephra were emitted in a phreatomagmatic eruption on this part of the fissure, covering an area of 50,000 km^3 and 2500 km^3 within the 0.5 and 10 cm isopachs, respectively. The tephra layer is an important marker horizon in Iceland, also known as the Settlement layer. Over 80% of the basaltic tephra is sub-millimetre ash. The high degree of fragmentation of this tephra is attributed to shallow-level interaction between ground water and degassing basaltic magma. The wide dispersal of the tephra was aided by $\sim$270 degree change in wind direction during its emission and a long linear source. As in the case of the Veidivötn eruption, the extensive dispersal and the 12 m maximum thickness of the tephra layer indicate an eruption of phreatoplinian intensity.

Tephra from all these three eruption caused severe damage in the central highlands of Iceland, creating a volcanic desert that has not been re-vegetated. The Veidivötn and Vatnaöldur eruptions caused temporal and permanent changes of the hydrology of the areas proximal to the volcanic fissures, including the formation of unstable tephra-dammed lakes. The effects of similar future eruptions on modern day community would be extensive and not limited to Iceland. However, the recurrence time of eruptions producing $>$10 km^3 of basaltic tephra may be as low as 2-4 eruptions in 10 ka. A large enough interface between erupting basaltic magma and water is only provided by very long volcanic fissures located in suitable hydrological environment, a condition that is seldom met.