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Shallow conduit processes during the 1158 AD explosive eruption of Hekla volcano, Iceland

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Hekla is one of the most frequently active silicic volcanic systems in the world, with multiple pre-historic large Plinian eruptions and 18 historical subplinian-Plinian eruptions. The common view is that the Plinian phases of the largest Hekla eruptions are all relatively homogeneous in style. Of the historical eruptions, only two were silicic: a Plinian eruption in 1104 and a smaller, less well characterized, eruption in 1158. We examine the dynamics of the 1158 eruption in detail with focus on the modulating role of shallow conduit processes. Grain size analysis, componentry, and density were used to characterize gradual and abrupt changes during the course of the eruption and quantitative vesicularity analysis was used to constrain the influence of bubble nucleation and coalescence. The 1158 eruption was a relatively steady, dry eruption with a more powerful opening phase followed by a lower intensity, waning phase accompanied by destabilization and collapse of the conduit walls. The juvenile pyroclasts are comprised of three types of microvesicular ragged pumice: white, grey, and banded. The abundance of grey pumice decreases as the eruption reaches maximum intensity, and then increases again during the waning phase of the eruption. The white pumices are more vesicular than the grey pumice, and the banded pumices have vesicularities that span predictably the range of the two end-members. The macroscopic differences between the white and grey pumice are accompanied by differences on a microscopic scale, most notably in a decrease in vesicle number density (VND) and a broadening of the vesicle size distribution, as well as increased crystal content. VND values of 0.5 to 1 E+6 mm-3 are similar to those recorded for the more powerful and sustained Plinian phases of the Novarupta 1912 and Taupo 181 eruptions in our laboratory. The 1158 pumice clasts display complex textures with adjacent domains of contrasting texture, alluding to complex nucleation, growth and collapse histories for melt in the shallow portions of the conduit and the development of textural heterogeneity, leading to simultaneous fragmentation of melt of contrasting conduit residence time and hence maturity. We infer that the grey pumice reflects those pockets of magma that had slowed or stalled in the shallow conduit permitting some of the small-to-moderate-sized bubbles to undergo enhanced coalescence and limited development of vesicle pathways and open-system degassing. In this regard, the 1158 eruption contrasts with the relative homogeneity of the melt phase involved in the more powerful earlier Plinian silicic eruptions of Hekla, for which we can infer a more simple conduit history accompanying higher average ascent rates.