Magmatic Processes in the Bishop Tuff Rhyolitic Magma Based on Trace Elements in Melt Inclusions and Pumice Matrix Glass

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Abstract

To investigate the origin of compositional zonation in the Bishop Tuff magma body, we have analyzed trace elements in the matrix glass of pumice clasts and in quartz-hosted melt inclusions. Our results show contrasting patterns for quartz in different parts of the Bishop Tuff. In all samples from the early part of the eruption, trace element compositions of matrix glasses are similar to but slightly more evolved than quartz-hosted melt inclusions. This indicates a cogenetic relationship between quartz crystals and their surrounding matrix glass, consistent with in situ crystallization. The range of incompatible element concentrations in melt inclusions and matrix glass from single pumice clasts requires 16-20 wt.% in situ crystallization. This is greater than the actual crystal content of the pumices (<15% crystals). In contrast to the pattern for the early pumices, pyroclastic flow samples from the middle part of the eruption show contrasting trends: in some clasts the matrix is more evolved than the inclusions whereas in other clasts the matrix is less evolved. In the late Bishop Tuff all crystal-rich samples have matrix glasses that are less evolved than the melt inclusions. Trace element abundances indicate that the cores of quartz in the late Bishop Tuff crystallized from more differentiated rhyolitic magma that was similar in many ways, yet distinct from, the early erupted Bishop Tuff. Our results are compatible with a model of secular incremental zoning (Hildreth and Wilson, 2007), in which melt batches from underlying crystal mush rise to various levels in a growing magma body according to their buoyancy. Early and middle erupted quartz crystallized from highly evolved rhyolitic melt, but then some parts of the middle erupted magma were invaded by less differentiated rhyolite such that the matrix melt at the time of eruption was less evolved than the melt inclusions. A similar process occurred but to a greater extent in magma that erupted to form the late Bishop Tuff. In addition, there was a final, major magma mixing event in the late magma that formed Ti-rich rims on quartz and Ba-rich rims on sanidine, trapped less evolved rhyolitic melt inclusions, and resulted in dark and swirly crystal-poor pumice that is a rare type throughout much of the Bishop Tuff.

$(^{231}Pa_{ex}/^{230}Th_{ex})_0$ records from a depth transect in the NE Atlantic 0-20 ka

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Paleoclimate proxy records of $(^{231}Pa_{ex}/^{230}Th_{ex})_0$ have been used to infer past changes in deep water-mass advection rates in the North Atlantic [1, 2]. However, data from several studies suggest changing particle flux and composition may cause complications to the use of the sedimentary $(^{231}Pa_{ex}/^{230}Th_{ex})_0$ solely as an advection rate proxy [3, 4, 5]. Modelling studies have also shown that values of $(^{231}Pa_{ex}/^{230}Th_{ex})_0$ recorded in shallow cores differ from deep cores [6, 7], and may also be a function of distance of a core from the deep-water formation region [6], as well as possible effects from sea-ice [8]. It is therefore essential to monitor changes in the local environment and sedimentary parameters as closely as possible in order to accurately interpret $(^{231}Pa_{ex}/^{230}Th_{ex})_0$ measured in marine sediment cores.

Here I will present $(^{231}Pa_{ex}/^{230}Th_{ex})_0$ records from four cores, spanning between 1 and 4 km water depth, in close proximity to each other in the eastern North Atlantic and thus approximating a true depth transect. All four cores have therefore experienced similar changes in productivity and particle composition through time. This allows us to easily account for shared changes in sediment production above the sites and to interpret these records in terms of depth-dependent water column processes. I will present sediment data, including opal and $CaCO_3$ fluxes, along with measured $(^{231}Pa_{ex}/^{230}Th_{ex})_0$ from the last glacial maximum (20 ka) to the present. I will interpret the $(^{231}Pa_{ex}/^{230}Th_{ex})_0$ results, some of which are above the production ratio, in the context of changing sedimentary parameters, changing environmental influences, and ocean advection rates, giving further insight into the controls on $(^{231}Pa_{ex}/^{230}Th_{ex})_0$ and its use as a geochemical proxy.

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