Foam collapse in conduits and its implications for eruption transitions and volcano monitoring.

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The inflation and contraction of magmatic foam may control the permeability of the volcanic conduit and the ability of the gas to pressurise pores and drive eruptions. Following an explosive eruption, pores depressurize and outgas as magmatic foam densifies to form a plug. Constraints on this mechanism are recorded in, (1) typical textures of dense magmatic plugs and domes, (2) timescales between explosive and effusive eruptive episodes, (3) deflation of active dome surfaces, and (4) deflation of volcanic edifices measured between vulcanian eruptive episodes. Here, we integrate this set of constraints with a series of foam collapse experiments. We heated cylindrical rhyodacitic pumice samples (20mm by 40mm and 10mm by 20mm), from the Pebble Creek Formation, Mt Meager, British Columbia, Canada, until collapse occurred. The original sample contained sheared connected bubbles 5 mm- 5 microns with a large proportion connected below 30 microns.Two types of experiment were performed; at atmospheric pressures in air at temperatures of 950-1000C for 30 mins to 10 hrs, and in autoclaves with water pressures of up to 10 MPa at 300 to 700C for 4 hrs. Samples variably dehydrated or hydrated, and deformed.Video during the experiments, 3D tomography, thin sections, SEM images, and helium pycnometry record the bubble textures, porosities and volumes during the densification process. As the sample densifies, the rate of porosity reduction decreases proportionally to the decrease in volume and this rate decreases as densification proceeds. Volume reduction is manifested by similar shrinkage in both diameter and length. The rate of shrinkage reduces with decreasing temperature. The samples hydrated in the pressurized steam environment collapsed at lower temperatures compared to the dehydrated samples in the dry oven, but the collapsed textures and final porosities were similar. The densified samples show a decrease in the number of small and intermediate connected bubble sizes (between 10-30 microns), thickening of bubble walls, and distortion of large connected bubbles. Gas escape pathways become simpler and fewer in the densified sample. We interpret the porosity reduction (up to approx. 50%) as outgassing from collapsing small connected bubble pathways. We hypothesize that surface tension drives connected small-intermediate sized bubbles to collapse and coalesce with larger bubbles. This outgassing drives volumetric reduction by up to 50% in a few hours. The volumetric reduction has important implications for the interpretation of deformation of the lava surface and volcano edifice. The change in vesicle structure affects (1) the permeability of the magma and degassing, and (2) fluid flow associated seismicity in the interval between explosive, and effusive eruptions. The texture produced replicates those seen in natural samples and the experimental timescale allows reinterpretation of historic eruptions and prehistoric deposits.