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Dynamics of bubble-bubble interaction in sheared low-viscosity magma imaged by X-ray computed micro-tomography

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X-ray computed tomography of vesicles in basaltic pyroclastic glass fragments has been used to investigate the syn-eruptive shear environment and resulting bubble-bubble interaction during mild pyroclastic eruptions in a mid-ocean ridge environment. We have imaged vesicles present in two different types of pyroclastic fragments produced by mildly explosive activity on Axial Seamount, limu o Pele, that is, thin glass films often described as bubble walls, and tube scoria fragments. Rapid quenching of the glass has prevented extensive bubble relaxation preserving the syn-eruptive geometry of the bubbles in these fragments. Isolated, ellipsoid-shaped vesicles in low-vesicular limu o Pele indicate deformation in a simple shear environment. Under these shear conditions higher vesiculated parts of the erupting magma show strong bubble-bubble interactions partially leading to coalscence and formation of tubular vesicles. These tubular vesicles can reach significant lengths, exceeding the dimensions of the small glass fragments (2 mm). Their unreformed radius can be more then one order of magnitude larger than that of the isolated vesicles in the limu o Pele fragments. We can distinguish two principle modes of interaction based on the relative orientation of the bubbles. Interaction along the sidewalls of two bubbles, and tip-to-tip interaction. At interdistances of less than a few tens of micrometre, interaction of the sidewalls results in deformation of the bubbles to more irregular shapes, with depressions caused by close, small bubbles or in some cases bubbles being partially mantled around tubular bubbles. This often leads to a more close packing of bubbles. At distances of less than a few microns, the melt films between the bubbles destabilize leading to coalescence. This mechanism appears to involve a bulging of the larger bubble into the smaller, followed by melt film rapture and coalescence. The complete digestion of one bubble by the other is the slow rate determining process, whereas bulging and rapturing are fast. Tip-to-tip interaction is demonstrated by strings of ellipsoidal bubbles connected along their tips. These structures are often caught in between bigger existing tubular bubbles. We interpret this as tip-to-tip coalescence of isolated bubbles that are vertically aligned by shearing in between adjacent tubular bubbles. Shearing can therefore be an effective mechanism facilitating bubble coalscence and degassing in stronger vesiculated parts of the ascending magma, by locally increasing the permeability through a vertically orientated network of connected tubular bubbles.