Trapped bubbles keep pumice afloat and gas diffusion makes pumice sink

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Pumice can float on water for months to years –long enough for pumice to travel across oceans and facilitate the spread of species. Long-lived pumice floatation is unexpected, however, because pumice pores are highly connected and water wets volcanic glass. As a result, observations of long floating times have not been reconciled with predictions of rapid sinking. We propose a mechanism to resolve this paradox - the trapping of gas bubbles by water within the pumice. Gas trapping refers to the isolation of gas by water within pore throats such that the gas becomes disconnected from the atmosphere and unable to escape. We use X-ray microtomography to image partially saturated pumice and demonstrate that non-condensable gas trapping occurs in both ambient temperature and hot (500˚C) pumice. Furthermore, we show that the size distribution of trapped gas clusters matches predictions of percolation theory. Finally, we propose that diffusion of trapped gas determines pumice floatation time. Experimental measurements of pumice floatation support a diffusion control on pumice buoyancy and we find that floatation time scales as L^2/DF^2 where L is the characteristic length of the pumice, D is the gas-water diffusion coefficient, and F is pumice water saturation. A mechanistic understanding of pumice floatation is a step towards understanding how pumice is partitioned into floating and sinking components and provides an upper bound on the lifetime of pumice rafts in the ocean.

