[JJ] Evening Poster | S (Solid Earth Sciences) | S-CG Complex & General

[S-CG63]Rheology, fracture and friction in Earth and planetary sciences

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The aim of this session is to join people from various research area in the earth and planetary sciences and to stimulate discussion beyond the boundaries of each research area. Our goal is to deepen our understanding of dynamics in geosciences by looking over whole areas in the earth and planetary sciences from the viewpoint of PHYSICS OF DEFORMATION, FLOW, AND FRACTURE. We welcome any field (e.g., earthquake, volcano, earth surface, crust, mantle and the core, and other planets and satellites) and any approach (e.g., laboratory experiments, numerical simulations, field observations, and theories).

[SCG63-P10]Bubble shapes deformed by pure shear: insights from a deformation experiment of solidifying foam

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Tube pumice is characterized by bubbles which elongate in one direction, and is a common product of explosive silicic eruptions forming calderas. We expect that tube pumice records information about processes leading to a caldera eruption. It has been suggested that tube pumice can be generated either by pure or simple shear of magma containing originally spherical vesicles (Dingwell., et al 2016). Pure shear may be dominant beneath a fragmentation surface where the ascent velocity is steeply accelerated, while simple shear may be dominant near a conduit wall where strain rate is localized. Ohashi et al. (2016, JpGU) performed simple shear experiments on polyurethane foam (PUF) and observed deformed bubble shapes. PUF is a suitable analogue material to simulate the formation process of pumices because it undergoes bubble nucleation/growth, flow, and solidification at ordinary temperature and pressure. Although deformed bubbles were produced by the simple shear experiments, they were not uniformly elongated like those in tube pumice. Here, we investigate pure shear deformation by uniaxial tensile experiments on the same PUF.

Using a creepmeter, we applied tensile deformation at a constant speed on PUF before solidification. Experiments were conducted with different tensile speeds and instantaneous viscosities at the onset of deformation. After solidification, we observed the bubble shapes in the samples with X-ray computed tomography (CT) and analyzed size and deformation degree, D, of bubbles in the 3-D images. D is defined as D=(a-c)/(a+c), where a and c are the semi-major and the semi-minor axes of a deformed bubble. The strain profile applied to a bubble was estimated from the video images during deformation in the following way. A Matlab free tool, PIVlab (Thielicke, 2014), was used to obtain velocity vectors on a side surface of the sample from successive images, with which the strain rate field at each time was calculated. In addition, position tracking was performed manually for a representative bubble. Then the

amount of strain experienced by the bubble was estimated.

With the largest applied tensile speed (10 mm/s), we obtained a thinned sample containing uniform tubular bubbles. The structure is very similar to tube pumice. With the smaller tensile speeds, we obtained a relationship between bubble deformation degree D and equivalent radius R as in the figure. D rapidly rises with R, and then gradually approaches a constant value. The constant values that limit the deformation depend on the tensile speeds: about 0.2 at 1 mm/s, about 0.5 at 3 mm/s, and about 0.75 beyond 0.5 mm/s.

If bubble deformation reaches a steady state, D depends only on the capillary number, Ca, and approaches unity at large Ca. Because Ca is proportional to R, D=1 is the only possible deformation limit with increasing R in the steady state. The deformation limit in D<1 can be explained by the transient effect of finite strain. Namely, the bubbles satisfying D<1 are considered to have stopped deformation before reaching the steady state. In the transient region, D depends only on strain when Ca>1. According to the load measured by the creepmeter and the radius of the deformed part of the sample measured from the video images, we confirmed that the bubbles in the analyzed range of R had Ca>10. The values of D calculated by a simple model increases with R in a similar way as the experimental data, supporting that the bubble deformations in the experiments were transitional. On the other hand, D in the experiments is saturated at less than 1 that is expected by the model. The discrepancy might suggest important effects which are lack in the simple model. Deformation limit in D<1 is also observed in some natural samples (Rust and Cashman, 2007). Further understanding the transitional effect on bubbles deformations will help identifying the mechanism of bubble deformation forming tube pumice.