MAGMA DYNAMICS ON THE MOON: A COMPUTED TOMOGRAPHY INVESTIGATION OF APOLLO BASALT VESICULARITY

A. J. Gawronska[1], C. L. McLeod[1], E. H. Blumenfeld[2], R. Hanna[3], R. A. Zeigler[4]. [1]Dept. Geology & Envt. Earth Sciences, Miami Univ. Oxford OH, 45056. (gawronaj@miamioh.edu). [2]LZ Technology, JETS Contract, NASA Johnson Space Center, Houston TX, 77058, [3]Jackson School of Geosciences, University of Texas at Austin, Austin TX, 78712. [4]NASA Johnson Space Center, Houston TX, 77058.

INTRODUCTION

The presence of vesicles in volcanic rocks can be used to investigate the potential location of a given sample within a lava flow, the emplacement mechanism of that sample (i.e., explosivity), and the relative influence of volatiles on sample composition and permeability [1-2]. The shape of vesicles can also be associated with the nucleation and collision rates of bubbles, as well as deformation as a result of local stress(es) [3-5].

Here, we use nondestructive X-ray computed tomography (XCT) to investigate the vesicle volume, shape, and distribution in 3D within Apollo basaltic samples to create vesicle size distributions (VSDs). We aim to use VSDs to interrogate the dynamics of magma ascent and lava emplacement on the Moon at a given time [e.g., 2-3].

METHODS

Scans of samples are generated [6-9] (fig. 1), and inner components are separated using Blob3D [8]. Length, width, height, volume, and orientation of vesicles with respect to the sample is extracted using Blob3D [8].

These characteristics were used to determine vesicle shape and volume. Vesicle population density was calculated, and used to infer the degree of degassing and potential stage of eruption experienced by each respective magma.

RESULTS AND DISCUSSION

Vesicles are easily distinguished in all samples due to their low grayscale values (generally ~50 and below), which allows easy extraction of data. Vesicle size and population density can be plotted to visualize the VSDs, in a process comparable to crystal size distributions (we acknowledge that vesicles develop due to different phenomena than crystals, but they occupy a physical space within a magma, just like crystal populations do).

All VSDs show a similar pattern, where vesicles of larger sizes exist at lower density than relatively medium-sized ones. The low distribution of the smallest vesicles is likely due to unsuccessful separation and extraction of data of small volumes. With regards to sample vesicularities, 10057,19 has a vesicularity of 7.24%, 12043,0 has a vesicularity of 1.25%, and 15085,0 has a vesicularity of 0.27%.

In these basalts, vesicularity increases with decreasing grain size, interpreted to be due to the movement of vesicles closer to the surface and a faster rate of cooling in magmas experiencing more extrusive environments. Alternatively, the more vesiculated sample (10057,19) may also be one that formed during a stage of greater magma degassing, while the others formed at later stages of the eruption or from a magma that contained lower dissolved volatile content to begin with [e.g. 1, 3]. The distributions shown in figs. 2, 4, 6 all appear to stabilize above vesicle volumes of ~0.1 mm3, which may be due to the coalescence of bubbles into larger bubbles [3]. Based on these scans, the distribution of vesicle orientations in these sample appears random [9], suggesting there was little to no flow fabric preserved, and therefore insufficient shear stress to affect vesicle coalescence (as preserved).

REFERENCES

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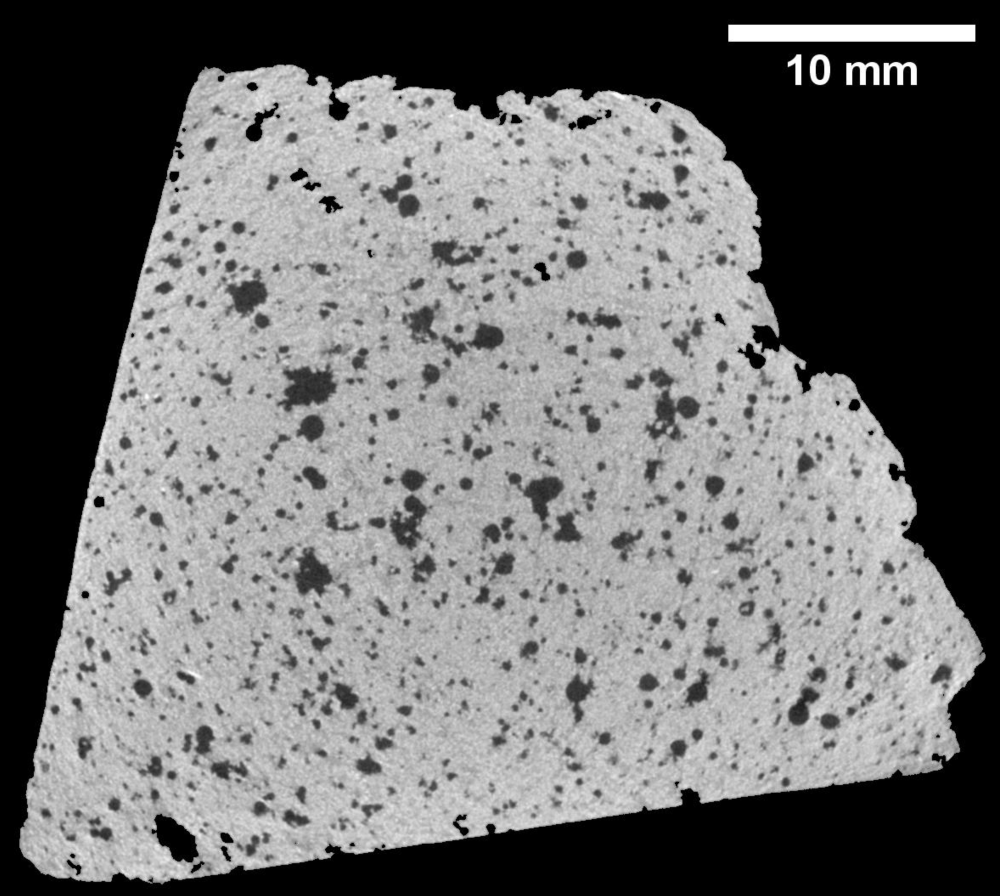

Figure 1: XCT scan (34.3 µm/voxel) of basaltic sample 10057,19 (high-Ti, relatively fine grained). Dark gray material is vesicles.

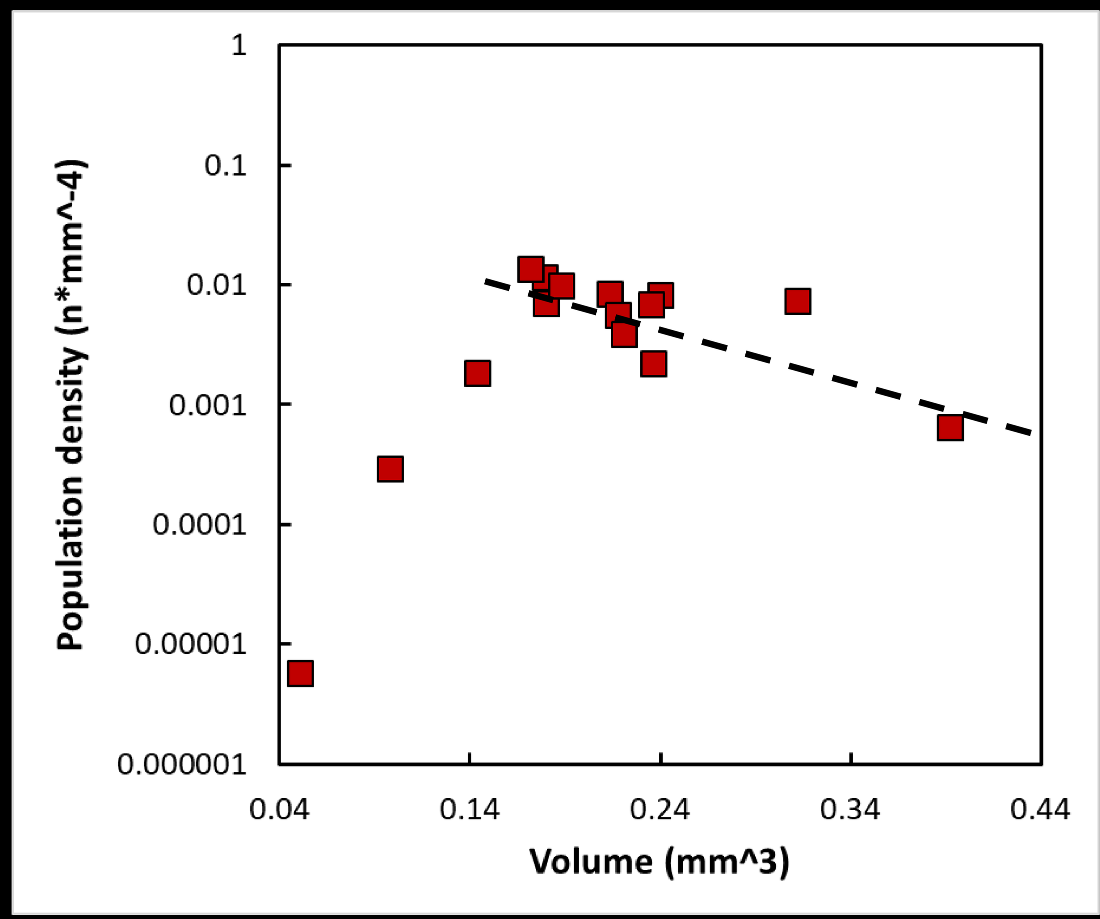

Figure 2: Vesicle size distribution of basaltic sample 10057,19 (high-Ti, relatively fine grained). Approximate trend line does not include low volumes due to high variability.

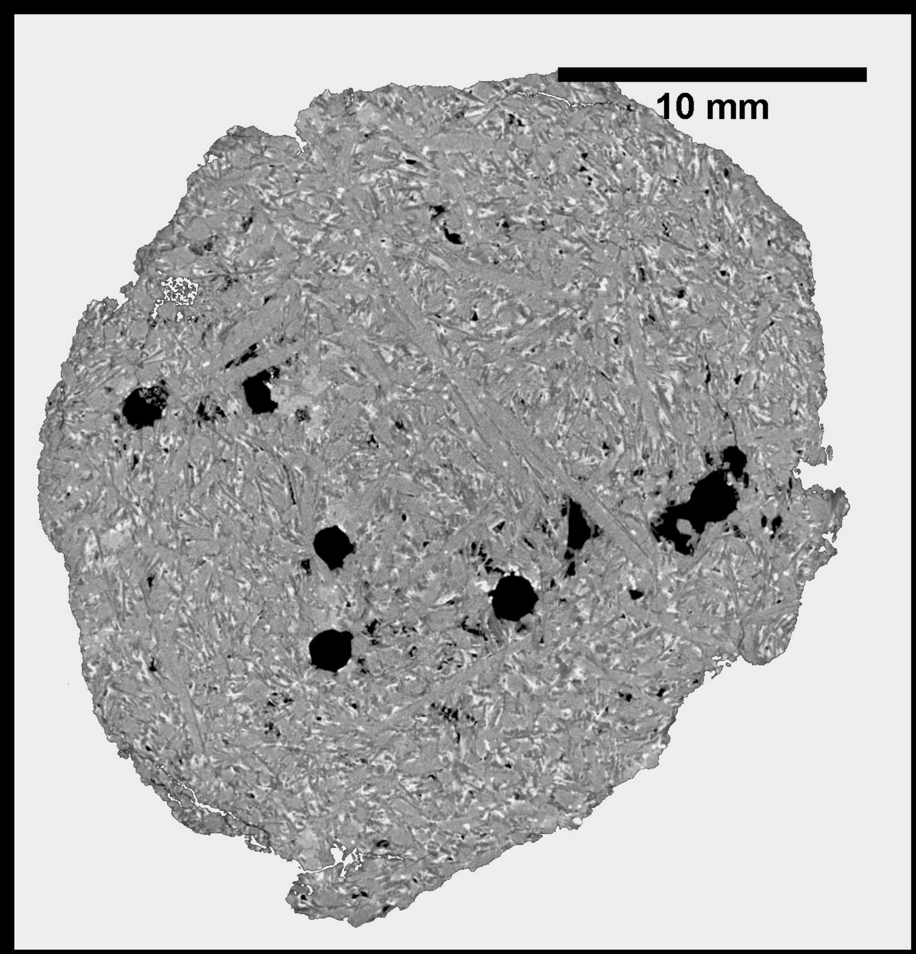

Figure 3: XCT scan (23.5 µm/voxel) of basaltic sample 12043.0 (low-Ti, relatively medium grained). Black/dark gray material is vesicles.

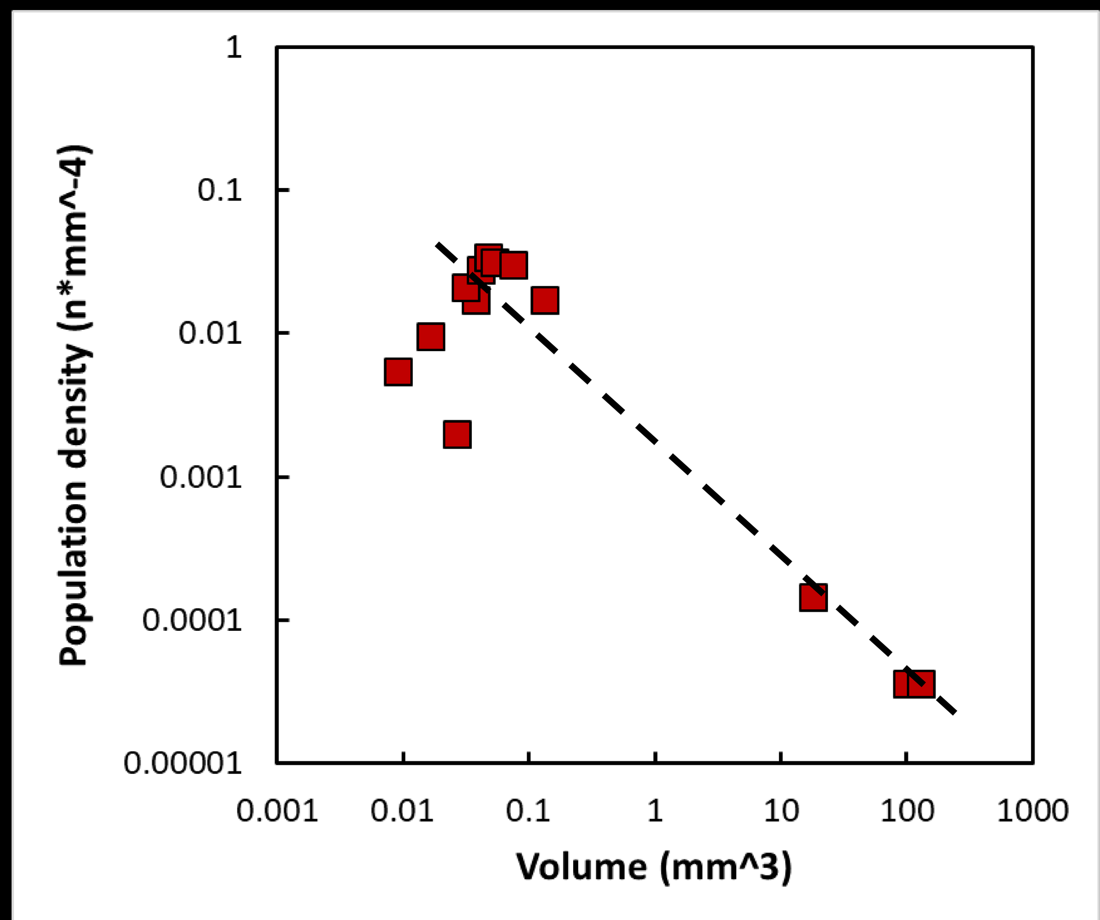

Figure 4: Vesicle size distribution of basaltic sample 12043.0 (low-Ti, relatively medium grained). Approximate trend line does not include low volumes due to high variability.

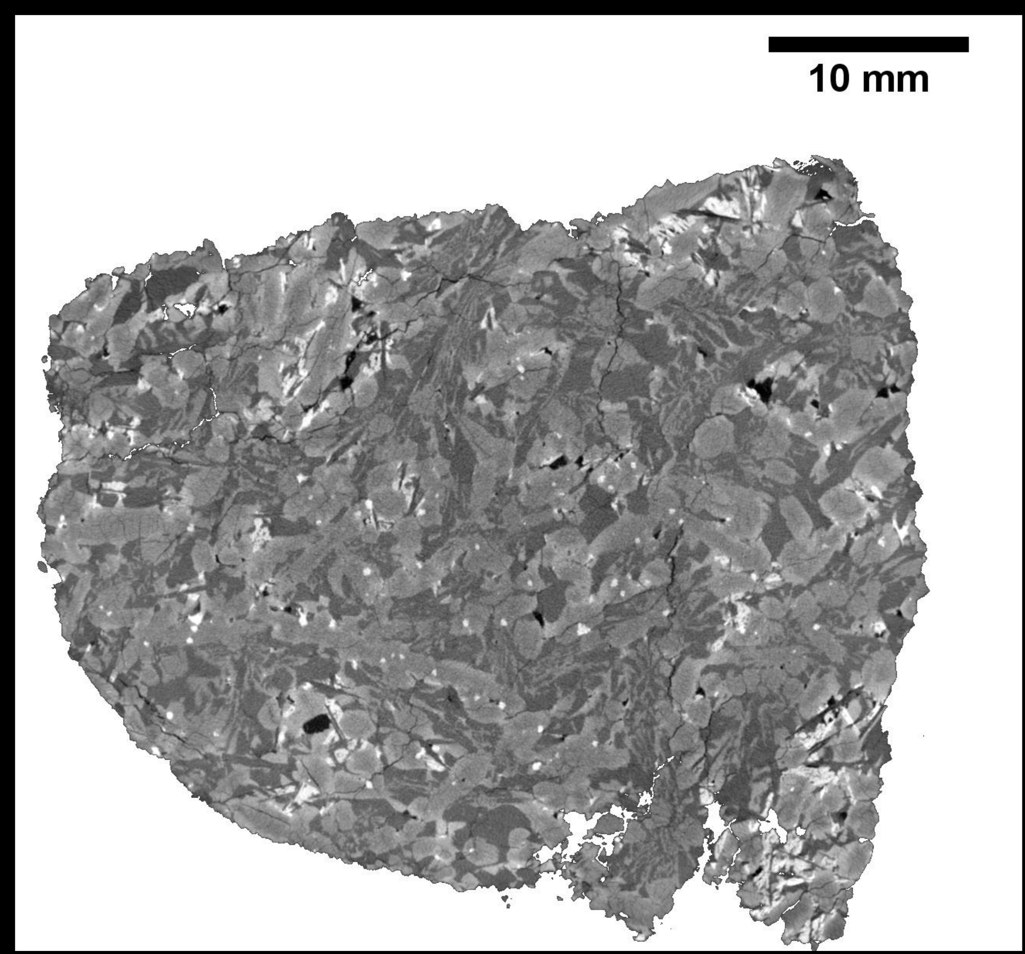

Figure 5: XCT scan (38.6 µm/voxel) of basaltic sample 15085,0 (low-Ti, relatively coarse grained). Black/dark gray material is vesicles.

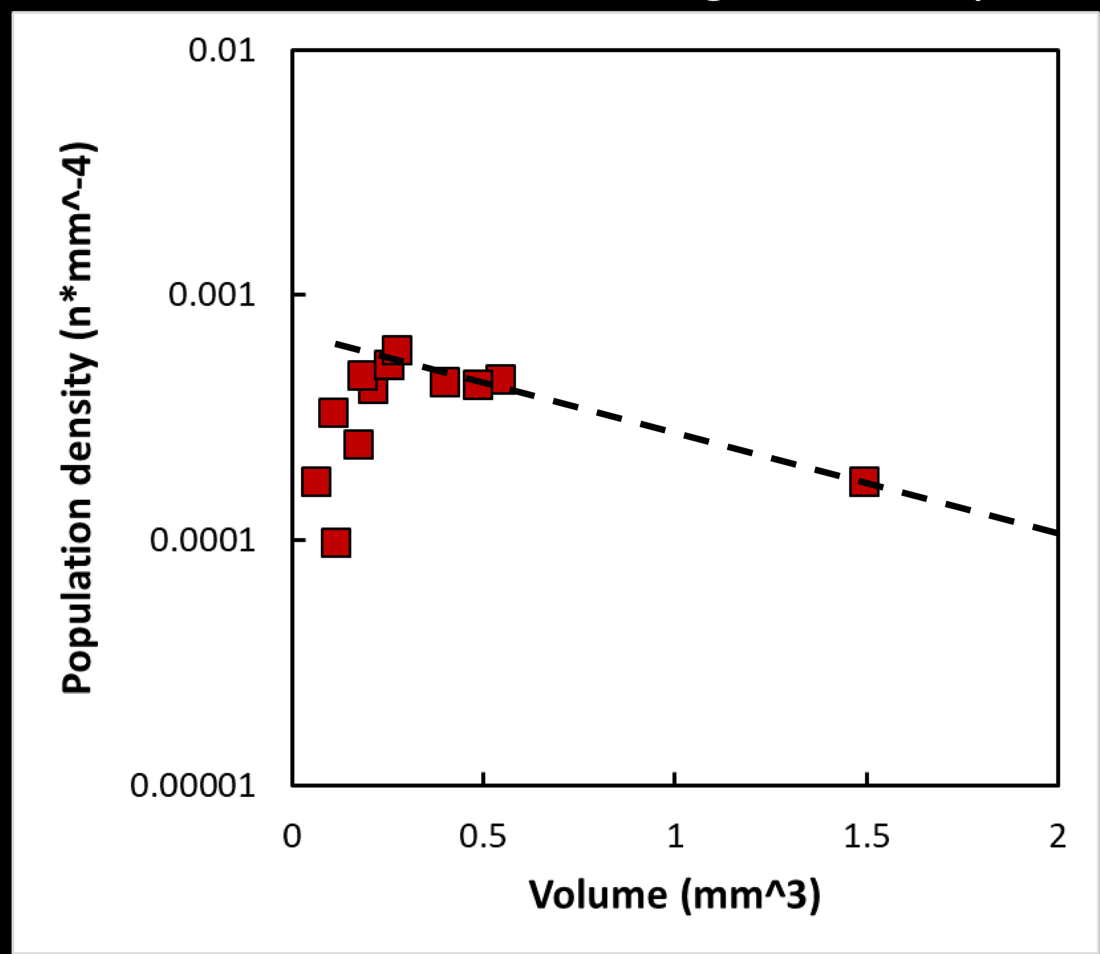

Figure 6: Vesicle size distribution of basaltic sample 15085,0 (low-Ti, relatively coarse grained). Approximate trend line does not include low volumes due to high variability.