New insights into lunar basalt flow emplacement from Apollo sample studies via X-ray computed tomography.

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Abstract. Magmatism and volcanism are fundamental processes associated with the evolution and resurfacing of planetary bodies. Both processes have been documented to occur on rocky objects (including moons) other than Earth in our Solar System. The nature of these processes on extraterrestrial objects, however, remains poorly constrained due to a lack of samples. The surface of the Moon in particular is characterized by basaltic lava flows. These flows are likely similar to terrestrial pahoehoe lava flows which grow by lava inflation and cool to form a crust and a core[1]. To date, the petrogenesis of lunar basalts has been primarily evaluated on a two-dimensional scale via extensive traditional thin section analysis. In this work, Apollo basaltic samples scanned via X-ray computed tomography (XCT) are analyzed for the first time in order to evaluate and improve our understanding of the volcanic processes that affected lunar lava flow morphology, as evidenced by their three-dimensional textural characteristics. Specifically, the use of XCT here has made it possible to view sample mineralogies, petrographies, and petrofabrics in 3D space. Samples have moderately high vesicle aspect ratios, but vesicle preferred orientations do not indicate that vesicles are foliated or lineated. The lack of correlation between vesicle shapes and preferred orientations reveals that vesicles did not experience elongation and the studied samples likely experienced little strain during emplacement and were emplaced passively. This is consistent with the extremely low viscosities attributed to lunar lavas[2]. This information was then used to infer the stratigraphic locations of each sample within its respective lava flow; samples 10057,19 (Apollo 11), 15556,0 (Apollo 15), and 70017,8 (Apollo 17) are inferred to have cooled within the lower lobe crust, sample 15085,0 (Apollo 15) is inferred to have cooled in the flow core, while samples 12038,7 and 12043,0 (Apollo 12) may mark the transition between these two lobe regions. The textural consistency of these samples is therefore consistent with what is expected of terrestrial pahoehoe lava flows. In summary, XCT data supports previous work that suggested lunar lava flows were emplaced as basaltic pahoehoe lobes of low viscosities. Future *in-situ* sampling of extraterrestrial basaltic products could focus on detailed documentation of, and collection from, stratigraphically well-characterized lava flows to further evaluate this inference.

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