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The evolution of pore connectivity in magma: Insights on eruptive processes

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The evolution of pore space in magma as well as its connectivity is subjected to continuous changes over an eruptive cycle from magma ascent to eruption and emplacement. Main processes contributing to this evolution are vesiculation (bubble nucleation, growth, coalescence) and densification (bubble collapse, crystallization, compaction, sintering). The evolution of connectivity with respect to porosity during these processes is investigated based on a database compiled from new data acquired by Helium pycnometry and literature data. The database comprises more than 2500 analyses of rock samples covering a broad range of eruptive styles and incorporates the effects of crystallinity, glass H_2O content and chemistry. Further it is supplemented by textural images in 2D and 3D and permeability data. We evaluate the trends of the natural samples from our database in the light of experiments on vesiculation (Okumura et al. 2008) and densification (Okumura et al. 2013; Vasseur et al. 2013).
In general, we find that pumices from Plinian, sub-Plinian and Phreatoplinian eruptions and scoria from Hawaiian and Strombolian eruptions plot together at high porosity and cover a broad range of connectivity. The high porosity and the abrupt increase of connectivity with porosity observed for these datasets suggest a high percolation threshold above 40 %. Pumices and breadcrust bombs from Vulcanian eruptions form a cluster at intermediate porosities. They follow the experimental vesiculation trend with an increase of connectivity with porosity suggesting much a lower percolation threshold at around 20-30%. Finally, dense volcanic rocks from lava domes, lavas and block and ash flow deposits follow the experimental densification trend.
In contrast with permeability, connectivity is not sensitive to pore aperture and tortuosity but only depends on the degree of pore nucleation, coalescence and collapse. We propose that this metric of connectivity permits diagnostic differentiation of eruptive style and processes recorded in eruption products.