Goldschmidt 2025 Abstract
https://doi.org/10.7185/gold2025.25054

Crystal fragmentation inducing euhedral crystal habits in volcanic rocks: fracture histories of crystals from various tectonomagmatic settings and implications for plumbing system processes

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Fracturing of crystals in volcanic rocks is a phenomenon that has been widely recognized [1]. However, the history of repeated crystal fragmentation as recorded by the phenocrysts carried in volcanic rocks is yet to be considered. We provide examples from hot spot (cf. Fig. 1), arc, back-arc and ocean ridge settings indicating that crystals often display linear fractures, some following cleavage planes, and show that elemental mapping is necessary to identify cryptic fractures by providing insights into cryptic zoning and evidence for fracture annealing. Crystal fragmentation appears to be a fundamental and recurrent process operating in magmatic systems, irrespective of tectonomagmatic setting or eruption style, and control both internal crystal zoning patterns as well as their final crystal habit in erupted rock samples. Euhedral crystal habits may frequently result from edge fracturing along cleavage planes, rather than unhindered crystal growth within a melt phase. Recent edge fractures in fact provide evidence that the time between crystal fragmentation and eruption is too short to allow the kinetic process of crystallization to operate, supporting recent models of dominantly subsolidus transcrustal plutonic systems (cf. Fig. 2). Crystal fracturing may impact the application of chronological methods, including geospeedometric and crystal size distribution studies directed at volcanic hazard mitigation. The use of advanced chemical imaging techniques to decipher pre-eruptive processes such as crystal fragmentation becomes paramount.

Figure 1 shows optical microscopy, SE, BSE, and EPMA mapping images of a crystal from Gran Canaria, first studied by Troll & Schmincke [2]. Figure 2, taken from [3], compares transcrustal magmatic and transcrustal plutonic system architectures.

[1] Taddeucci, Cimarelli, Alatorre-Ibargüengoitia, Delgado-Granados, Andronico, Del Bello, Scarlato, & Di Stefano (2021) *Nature Geosciences* 14, 248-254.
[2] Troll & Schmincke (2002), *Journal of Petrology* 43, 243-270.
[3] Zellmer, Iizuka, & Straub (2024), *Journal of Petrology 65: egae013.*