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A field-based and 2D/3D stereological analysis of pyroclasts from the Ijen Caldera Complex: new insights into eruptive history and processes

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The Ijen Caldera Complex (ICC) in East Java, Indonesia is defined by 10+ eruptive centers distributed over 200 km^2. The eastern rim of the ICC hosts Kawah Ijen, an active stratovolcano with a hyperacidic brine crater lake. Despite close study over the last few decades, there lacks a systematic framework for integrating petrological, field, and geochemical insights across the ICC. In this work, we present the results of several phases of research conducted at the ICC since 2023, combining a range of geochemical, textural, field, and computational methods. We focused our attention on three ICC eruptive periods: (1) the caldera-forming eruption or CFE (2) the monogenetic scoria cones of the intracaldera (IC) series; and (3) the 1817 CE phreatomagmatic eruption of Kawah Ijen. The earlier eruptive periods have not been systematically mapped. This work presents the first phase of a revised stratigraphic column for the region, indicating a that the ICC grew out of five major ignimbrites with interspersed cyclic pumice falls. Furthermore, we evaluate the likely petrogenetic source of CFE vs. later magmas in relation to major regional geochemical reservoirs. We also show what eruptive processes predominate at monogenetic centers littering the caldera floor today. For the 1817 eruption, we have developed two complementary tools for analyzing vesicles in pyroclasts from the ICC. We introduce a Python-based reimplementation of the FOAMS framework [1] for stereological analysis of vesicle number and size distributions in 2D thin sections of deposits from the 1817 eruption. PyFOAMS replicates the original software's core functions while adding automated preprocessing and updated stereological formulas. We also compare these 2D results with 3D micro-computed tomography (micro-CT) data from select ICC samples. These were trained with deep learning models to segment the ICC rock volumes using the open-source Dragonfly program.

[1] Shea, Thomas, et al. (2010), *Journal of Volcanology and Geothermal Research* 190.3-4: 271-289.