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Reconstructing the Magmatic Evolution of Pico de Orizaba Volcano (Mexico) Through Automated Petrography

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Petrographic observations and quantification of mineral assemblages provide first order constraints on the temporal evolution of magmatic systems. Traditional methods for mineral phase quantification, such as point counting or QEMSCAN, can provide precise modal data but are time-consuming and costly, which limits the number of samples that can be analysed. Recent advances in deep learning image segmentation offer a promising alternative, enabling rapid, reproducible quantification of mineral phases from optical microscopy images while minimizing subjective interpretation.

Pico de Orizaba stratovolcano, situated at the eastern margin of the Trans-Mexican Volcanic Belt at a trench-normal distance of about 390 km, has been active at least since the Pleistocene (650 Ka) and likely last erupted in the 16th century. Over its four main volcanic stages (Torrecillas, Espolón de Oro, so-called Outer Domes and Citlaltépetl), it has erupted compositions spanning from basaltic andesite to rhyolite, alternating over time between higher and lower silica content lava.

We acquired high-resolution optical microscopy images (cross-polarized and plane-polarized light) of 52 thin sections spanning the entire eruptive history of Pico de Orizaba using a Zeiss Axioscan 7 scanner. We used these images as input for a deep learning image segmentation model to quantify the mineral phases proportions in each sample.We verify the accuracy of our method by comparing the result of our algorithm with QEMSCAN analyses of key samples.

The mineral assemblage data obtained through this automated workflow provide insights into magma storage conditions, crystallisation processes, and the long-term evolution of Pico de Orizaba volcanic plumbing system.