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Quaternary caldera-forming eruptions from north to south Sumatra (Indonesia)

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Large volumes of silicic tuffs deposited during highly explosive eruptions associated with caldera-collapses are widespread on the island of Sumatra (Indonesia) from north to south. Among them, only the Toba tuffs have been studied in great detail, while others have so far received less attention.

This study is aimed at determining the age and characteristics of a number of these tuffs from northern Sumatra (Singkut and Hopong-Sapiro), central Sumatra (Maninjau and Kerinci-Lempur) and southern Sumatra (Pasomah, Ranau and Lampong), in order to reconstruct the distribution and frequency of caldera-forming eruptions in the region. Furthermore, since most of the information about the volcanic activity in Sumatra comes from marine tephra layers with unknown sources, linking the temporal and compositional information to the terrestrial sources contributes a foundation for tephrostratigraphic correlations in south-east Asia.

We performed textural and geochemical analyses to characterize the crystallinity and major and trace element compositions of bulk-rock, matrix glasses and mineral phases from the studied ignimbrites and derive information about the pre-eruptive conditions. We used a variety of geochronological methods (including U/Th, U/Pb and U/Th-He zircon dating together with ¹⁴C and ⁴⁰Ar/³⁹Ar) and statistical analyses to estimate the eruption ages and magma residence times. Multiple dating methods were often applied to the same deposits thus allowing comparison between independent age results.

Our research indicates that between ~1200 and 30 ka the region experienced at least 10 caldera-forming eruptions, in addition to 4 from Toba (between ~1.2 Ma and 74 ka) and 1 from Masurai (~33 ka): 3 from northern Sumatra at ~44 ka (Singkut), ~400 ka and ~580 ka (Hopong-Sapiro), 5 from central Sumatra at ~51 ka (Maninjau), ~150, 210, and 220 ka (Kerinci-Lempur) and 3 from southern Sumatra at ~35 ka (Ranau), ~480 ka (Pasomah), and ~1200 ka (Lampong). Each of these eruptions involved tens to hundreds of km³ of rhyolitic magmas (VEI>6) and produced calderas with diameters between ~5 and 30 km. Geothermobarometers and hygrometers indicate that prior to eruption, magmas were stored in the upper crust in similar conditions but the

geochemical signatures (in particular the K₂O content), mineral assemblages and mineral chemistry define clear differences between the northern, central and southern sectors of the Sumatran volcanic arc, presumably linked to the regional geodynamics and structural setting.

This study allows to redefine the number of caldera-forming eruptions in Sumatra from 7 (previously dated) to 15 over the last 1.2 Ma. A similar frequency of VEI>6 eruptions during the Quaternary is reported for the Japan arc [1]. However, a significant number of eruptions, potentially better preserved in the marine record, might still be missing from our reconstruction.

[1] Schindlbeck, J. C. et al. One Million Years Tephra Record at IODP Sites U1436 and U1437: Insights into explosive volcanism from the Japan and Izu arcs. *Isl. Arc.* <https://doi.org/10.1111/iar.12244> (2018).