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Deriving spatial patterns from a novel database of volcanic rock geochemistry in the Virunga Volcanic Province, East African Rift

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The Virunga Volcanic Province (VVP) is situated within the western branch of the East-African Rift. The geochemistry and petrology of its' volcanic products has been studied extensively in a fragmented manner. They represent a unique collection of silica-undersaturated, ultra-alkaline and ultra-potassic compositions, displaying marked geochemical variations over the area occupied by the VVP.

We present a novel spatially-explicit database of existing whole-rock geochemical analyses of the VVP volcanics, compiled from international publications, (post-)colonial scientific reports and PhD theses. In the database, a total of 703 geochemical analyses of whole-rock samples collected from the 1950s until recently have been characterised with a geographical location, eruption source location, analytical results and uncertainty estimates for each of these categories. Comparative box plots and Kruskal-Wallis H tests on subsets of analyses with contrasting ages or analytical methods suggest that the overall database accuracy is consistent. We demonstrate how statistical techniques such as Principal Component Analysis (PCA) and subsequent cluster analysis allow the identification of clusters of samples with similar major-element compositions.

The spatial patterns represented by the contrasting clusters show that both the historically active volcanoes represent compositional clusters which can be identified based on their contrasted silica and alkali contents. Furthermore, two sample clusters are interpreted to represent the most primitive, deep magma source within the VVP, different from the shallow magma reservoirs that feed the eight dominant large volcanoes. The samples from these two clusters systematically originate from locations which 1. are distal compared to the eight large volcanoes and 2. mostly coincide with the surface expressions of rift faults or NE-SW-oriented inherited Precambrian structures which were reactivated during rifting. The lava from the Mugogo eruption of 1957 belongs to these primitive clusters and is the only known to have erupted outside the current rift valley in historical times.

We thus infer there is a distributed hazard of vent opening susceptibility additional to the susceptibility associated with the main Virunga edifices. This study suggests that the statistical analysis of such geochemical database may help to understand complex volcanic plumbing systems and the spatial distribution of volcanic hazards in active and poorly known volcanic areas such as the Virunga Volcanic Province.