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Geomorphometric reconstruction of post-eruptive surfaces of the Virunga Volcanic Province (East African Rift), constraint of erosion ratio and relative chronology

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Quaternary volcanic landforms result from a complex evolution, involving volcanic constructional events and destructive ones by collapses and long-term erosion. Quantification, by morphometric approaches, of the evolution through time of the volcano shape allows the estimation of relative ages between volcanoes sharing the same climate and eruptive conditions. We apply such method to six volcanoes of the Virunga Volcanic Province in the western branch of the East African Rift Valley that still has rare geochronological constraints. As they have comparable sizes, volcanic history and erupted products, these edifices may have undergone comparable conditions of erosion which justify the deduction of relative chronology from their erosion pattern.

Our GIS-based geomorphometric approach, the SHAPEVOLC algorithm, quantifies erupted or dismantled volumes by numerically modeling topographies resulting from the eruptive construction of each volcano. Constraining points are selected by analyses of morphometric properties of each cell of the current DEM, as the loci where the altitude is still representative of the un-eroded volcanic surfaces. A primary elevation surface is firstly adjusted to these constraining points by modeling a first-order pseudo-radial surface defined by: 1. the curve best fitting the concave-upwards volcano profile; 2. the location and elevation of the volcano summit; and 3. the possible eccentricity and azimuth parameters that allow to stretch and contract contours to adjust the shape of the model to the elliptically-shaped surface of the volcano. A second-order surface is next computed by local adjustment of the first-order surface to the constraining points to obtain the definitive primary elevation surface of the considered volcanic construct. Amount of erosion is obtained by summing the difference in elevation between reconstructed surfaces and current ones that allows to establish relative ages of volcanoes.

For the 6 studied Virunga volcanoes, the ratio of the dismantled volume vs. initial volume ranges between 5 to 30 % and up to almost 40 % if volumes removed by landslides are considered. The most preserved volcano is the New Mikeno erupted inside the landslide having affected the older stage of this volcano, whereas the most dismantled one is the Sabinyo volcano. The three-pointed star-like erosion pattern with main valleys having more or less the same orientation, which was observed on four volcanoes, may point to a strong constraint of the erosion processes by the regional tectonic pattern.