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Hazard implications of phreatomagmatism along the urbanised Lake Kivu Northern shoreline, D.R.Congo

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The Virunga Volcanic Province (VVP) is a transfer zone within the Eastern branch of the East-African rift, and hosts eight central volcanoes. The recently active Westernmost Nyamulagira volcano has erupted lava flows with a recurrence rate of ~2 years. The neighbouring Nyiragongo volcano hosts an active crater lava lake, drained in 2002 into a fissure and lava flow invading the city of Goma to the South, a densely populated area with ~one million inhabitants at present.

Many satellite volcanic cones are scattered within the lava fields of Nyamulagira and Nyiragongo, with multiple large cones distinctly present along the Lake Kivu Northern shoreline (Figure 1). We studied the stratigraphy of the best exposed cones in the field to support the volcanic hazard assessment of explosive eruptions in the Goma-Saké urban area.

Mont Goma cone is a dissected, asymmetric edifice constructed around at least three eruptive craters (Figure 1.A). A well-defined contact between consolidated hyalotuff and above-lying ash-and-lapilli tuff suggests distinct eruptive episodes, with an undefined time lag in between. Indicators of wet syn-depositional conditions and the occurrence of base surge deposits, testify the phreatomagmatic nature of the complex eruptive history.

Lac Vert (Figure 1.B), ~11 km to the North-East of Goma, is a maar crater with an ejecta rim of chaotic lithic breccia, overlain by bedded lithic breccia and finally by black laminated ash-and-lapilli tuff with minor cross-bedding. The sequence mirrors an eruptive evolution from phreatic excavation of volcanic country rock with the occurrence of base surge events and a final phase of magmatic activity with minor influence of external water.

To the South-East of Lac Vert at least six other tuff cones occupy the Lake Kivu shoreline (Figure 1.C), and are made up of massif to bedded hyalotuffs, with additional ash-and-lapilli tuffs. Within the same area, we identified at least two post-cone-building eruptive episodes, which formed freshy-looking, vesicular spatter cones and small-volume lava flows. These eruptions were associated with the opening of fissures in the surrounding cones.

Overall, a marked progression exists from phreatomagmatic tuff cones and small maar volcanoes close to the lake shoreline, to magmatic spatter-and-scoria cones at few kilometers away from the lake. These satellite cones are all concentrated within well-defined alignments related to the Nyiragongo and Nyamuragira rift zones, and concur spatially with the so-called ‘mazukus’ – gas emissions - and sublacustrine volcanic vent structures on the Lake Kivu floor. Based on the variations of the Lake Kivu level as assembled from the literature, at least 11 phreatomagmatic tuff cones and maar craters, identified along the actual Lake Kivu shoreline, were constructed during separate eruptions in the past 15,000 years.

Bedding structures in cone deposits suggest the occurrence of base surge events, with a plausible devastating impact on the area surrounding the eruptive vents. Due to the dense urbanization surrounding all observed phreatomagmatic deposits, the intermediary explosive nature of such eruptive events is a key element in the volcanic risk assessment of the Saké-Goma-Gisenyi urban area.

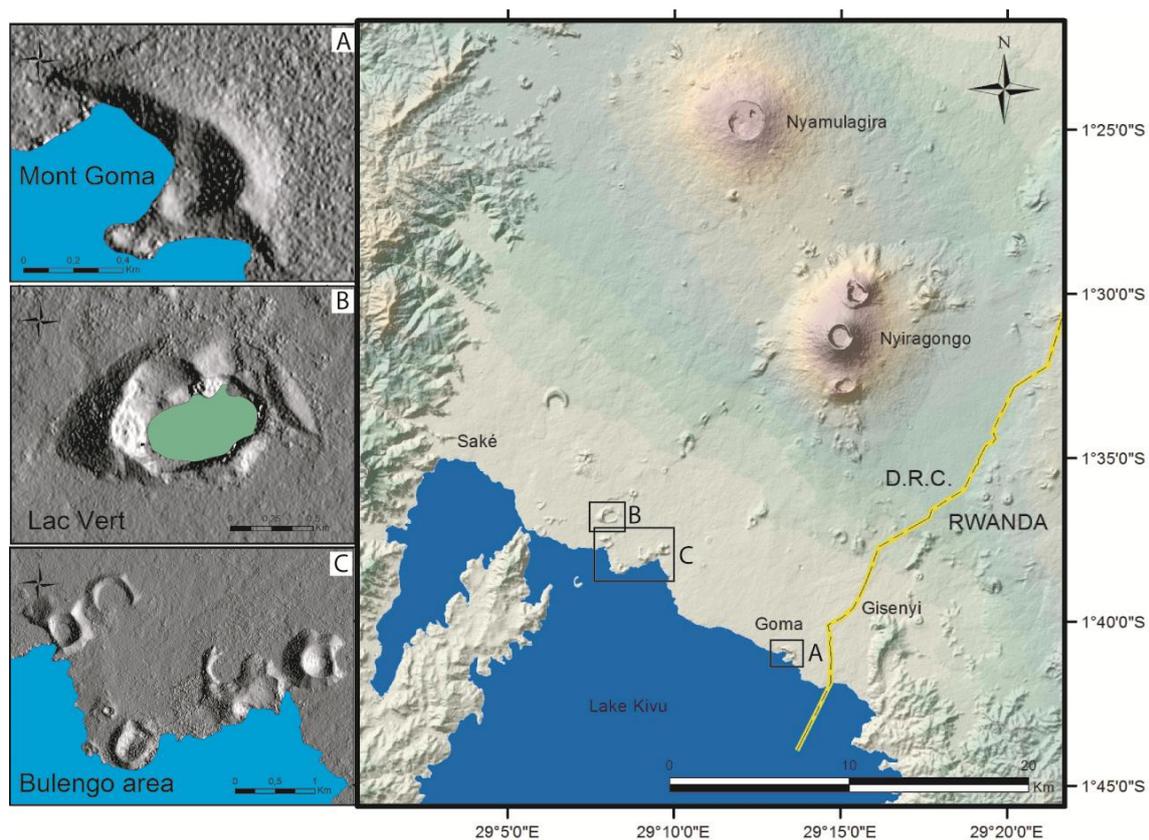


Figure 1: The Lake Kivu Northern shoreline with Nyiragongo and Nyamulagira volcanoes and hillshade images at 5 m resolution of A. Mont Goma cone; B. Lac Vert maar with ejecta rim; and C. the Bulengo area with at least six partially coalescing tuff cones.