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Geomorphological evolution through time of southern Basse-Terre volcanoes inferred from DEM-based reconstructions as estimations to the construction rates and magma production

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We present an integrated approach combining radiometric ages and geomorphological investigations, based on both modeled and preserved stage surfaces, to reconstruct the southern Basse-Terre palaeo-geography evolution through time (Guadeloupe, Lesser Antilles Arc). It provides estimations of both the landscape evolution of the Guadeloupe and the volumes of lava emitted during the last 1 Myr of volcanic activity with a relatively high time-resolution covering three orders of magnitude, from 0.01 to 1 Myr. The volcanic evolution has been constrained by recently obtained unspiked K-Ar ages (Cassignol – Gillot technique) on ground mass separated fraction of lava flows and domes from the volcanic massifs of the Axial Chain (1 – 0.435 Ma) and from the Grande Découverte Volcanic Complex (0.250 Ma – present). Based on the construction of a 250,000 points database inferred from the analysis of French Institut Géographique National DEM of Guadeloupe Archipelago, 3D reconstructions of the landforms of the ten main volcanic stages were calculated and the correlated geochronological maps drawn using ArcGIS softwares. For each stage, we performe the following six-step process: 1) extraction, from the present-day topography, of the points whose altitude are significant to the uppermost surface of the considered volcanic stage; 2) modeling of the uppermost volcanic surface of the considered stage; 3) independently, modeling of the evolution by erosion of the previous stages landforms; 4) modeling of flank-collapse scarps evolutions; 5) comparison of 2^{nd} and 3^{rd} steps modeled surfaces in order to define the actual extent and geometry of the modeled surface of the new volcanic stage and to create a new geochronological unit map; 6) calculation of the volume of the considered volcanic stage, and estimation of both construction and height increase rates. Our approaches allow us to provide results with confidence intervals, which are often ignored in many quantitative geomorphological studies. Calculated average construction rates are 0.24 ± 0.03 km^3/kyr for the last 1 Myr, 0.09 ± 0.03 km^3/kyr for the last 100 kyr, and 0.09 ± 0.02 km^3/kyr for the last 15 kyr. These estimates should be regarded as minimum eruptive rate values because the material dispersed by explosive events or washed out into the sea could not be taken into account. However, considering construction rates as a proxy for eruptive rates, a significant decrease in the magma production is proposed since 650 ka, except for the 630-600 ka period. During this latter time interval, the Icaques volcano was emplaced within the depression formed after a large-scale flank collapse affected southern Basse-Terre. The relatively high construction rate (0.45 ± 0.13 km^3/kyr) associated with this volcano can therefore be related to favoring conditions for an ascent of magma due to the release of lithostatic load induced by the mass-wasting event. The sudden release of the lithostatic load induced by the mass-wasting event could explain this value, which is significantly higher than the average value of 0.08 ± 0.01 km^3/kyr obtained for the last 650 kyr. Finally, the comparison with other analogous volcanic massifs from islands and continental arcs points to a relatively low magmatic production for southern Basse-Terre, which could be tentatively related to the relatively slow subduction rate of the Atlantic plate.