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On the morphometry of terrestrial shield volcanoes

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Shield volcanoes are described as low angle edifices that have convex up topographic profiles and are built primarily by the accumulation of lava flows. This generic view of shields' morphology is based on a limited number of monogenetic shields from Iceland and Mexico, and a small set of large oceanic islands (Hawaii, Galapagos). Here, the morphometry of over 150 monogenetic and polygenetic shield volcanoes, identified inthe Global Volcanism Network database, are analysed quantitatively from 90-meter resolution DEMs using the MORVOLC algorithm. An additional set of 20 volcanoes identified as stratovolcanoes but having low slopes and being dominantly built up by accumulation of lava flows are documented for comparison. Results show that there is a large variation in shield size (volumes range from 0.1 to >1000 km3), profile shape (height/basal width ratios range from 0.01 to 0.1), flank slope gradients, elongation and summit truncation. Correlation and principal component analysis of the obtained quantitative database enables to identify 4 key morphometric descriptors: size, steepness, plan shape and truncation. Using these descriptors through clustering analysis, a new classification scheme is proposed. It highlights the control of the magma feeding system – either central, along a linear structure, or spatially diffuse – on the resulting shield volcano morphology. Genetic relationships and evolutionary trends between contrasted morphological end-members can be highlighted within this new scheme. Additional findings are that the Galapagos-type morphology with a central deep caldera and steep upper flanks are characteristic of other shields. A series of large oceanic shields have slopes systematically much steeper than the low gradients (<4-8°) generally attributed to large Hawaiian-type shields. Finally, the continuum of morphologies from flat shields to steeper complex volcanic constructs considered as stratovolcanoes calls for a revision of this oversimplified distinction, taking into account the lava/pyroclasts ratio and the spatial distribution of eruptive vents.