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Morphometric classification, evolution, and distribution of volcanic edifices in the Philippines

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Volcano morphometry provides evidence for the magmatic and tectonic factors that control the growth of edifices and their spatial distribution in volcanic fields. We identified 731 volcanic edifices in the Philippine island arc using SRTM 30 m digital elevation models, and quantitatively described their morphology using the MORVOLC algorithm and their spatial distribution using Matlab GIAS and three-point analysis codes. A hierarchical classification by principal component analysis (HCPC) was used to morphometrically classify the edifices into four classes, which we interpret as small flat cones, small steep cones, large cones, and massifs. This classification is mainly based on edifice size and irregularity (PC1) and steepness (mean slope and height/basal width ratio; PC2), and to a lesser extent on the size of the summit region and edifice truncation (PC3), and edifice elongation (PC4). Both small flat cones and small steep cones have volumes of <10 km^3 with means of <1 km^3. The small flat cones have mean slopes of <21° (mean = 13°), whereas the small steep cones have mean slopes of 14–37° (mean = 22°). The large cones have volumes mostly between 1 and 200 km^3 (mean = 29 km^3), whereas massifs have larger volumes: between 76 and 675 km^3 (mean = 267 km^3). Both classes have similar mean slopes with overall means of 15°.

The morphometric classification, complemented by previously published geochemical data from some edifices, indicates continuous variation between volcano classes, which represent stages along an evolutionary trend. The small flat cones are mostly monogenetic, whereas the small steep cones represent an early growth stage of stratovolcanoes. Some small cones develop into large polygenetic cones, and these can grow laterally into massifs. Both large cones and massifs are mostly found on thickened crust. There is a trend towards more silicic compositions from small to large cones, perhaps due to larger edifice loads preventing mafic dykes from reaching the surface, that in turn drives magmatic evolution. More evolved and explosive magmas cause more silicic volcanoes to be less steep than andesitic volcanoes. The distribution and alignment of smaller edifices within eight volcanic fields shows that the dominant regional or local stress conditions and pre-existing structures influenced magma propagation and their spatial distribution. Associating morphometric classification with the stages of volcano growth will help in

the initial assessment of the factors controlling volcano evolution, which might impact our assessment of hazards related to volcanoes.