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Reconstructing the architectural evolution of volcanic islands from combined K/Ar, morphologic, tectonic, and magnetic data: the Faial Island example (Azores)

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The morpho-structural evolution of oceanic islands results from competition between volcano growth and partial destruction by mass-wasting processes. We present here a multi-disciplinary study aimed at recovering the successive stages of development of Faial (Azores) during the last 1 Myr. Using high-resolution digital elevation model (DEM), new K/Ar, tectonic, and magnetic data, we reconstruct the rapidly evolving topography at successive stages, in response to complex interactions between volcanic construction and mass wasting, including the development of a graben. We show that: (1) sub-aerial evolution of the island first involved the rapid growth of a large elongated volcano at ca. 0.85 Ma, followed by its partial destruction over half a million years; (2) at ca 360 ka a new small edifice grew on the NE of the island, and was subsequently cut by normal faults responsible for initiation of the graben; (3) after an apparent pause of ca. 250 kyr, the large Central Volcano (CV) developed on the western side of the island at ca 120 ka, accumulating a thick pile of lava flows in less than 20 kyr, which were partly channelized within the graben; (4) the period between 120 ka and 40 ka is marked by widespread deformation at the island scale, including westward propagation of faulting and associated erosion of the graben rims, which produced sedimentary deposits; subsequent growth of the CV at 40 ka was then constrained within the graben, with lava flowing on the sediments up to the eastern shore; (5) the island evolution during the Holocene involves basaltic volcanic activity along the main southern faults and pyroclastic eruptions associated with the formation of a caldera volcano-tectonic depression. We conclude that the whole evolution of Faial Island has been characterized by successive short volcanic pulses probably controlled by brief episodes of regional deformation. Each pulse has been separated by considerable periods of volcanic inactivity during which the Faial graben gradually developed. We propose that the volume loss associated with sudden magma extraction from a shallow reservoir in different epochs triggered incremental downward graben movement, as observed historically, when immediate vertical collapse of up to 2 m was observed along the western segments of the graben at the end of the Capelinhos eruptive crises (1957-58).