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Coupling volcanism and tectonics along divergent plate boundaries: collapsed rifts from Central Afar, Ethiopia

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Magma along divergent plate boundaries is erupted from fissures or vents from central volcanoes, with limited impact on rift architecture. Here I summarize the geological and structural features accompanying the eruption of part of a km-thick volcanic sequence ("Stratoids") along the Red Sea divergent boundary in Central Afar, in the area of Tendaho and Dobi grabens. More than 4700 km3/Ma (per 100 km of rift length) of magma have been produced by repeated fissure eruptions from within Tendaho Graben. The graben sides show distinctive structural features, as steep topographic gradients, coinciding with inward tilted blocks forming dominoes coeval to the emplacement of the km-thick volcanic sequence. Similar features are observed also in the Dobi Graben. This allows proposing an original mechanism, where the distinctive structure of the grabens results from the collapse at the surface induced by magma withdrawal during the emplacement of the volcanic sequence. This portion of Afar shows how rift architecture is shaped by voluminous fissure eruptions, forming collapsed rifts. These occur in continental domains, during the break-up stage (Central Afar) and in oceanic domains, where rifts narrow (East Pacific Rise). Collapsed rifts represent an end-member type of volcano-tectonic activity, where the width of the erupting reservoir balances that of the active rift zone. Along divergent boundaries, the width of the reservoir influences the style of surface deformation: a progressively higher ratio of the width of the reservoir emptied (Re) to that of the active rift zone (Ri) generates, in sequence, axial grabens, calderas and collapsed rifts.