

Formation of magmatic rift segments: evidence from the Ma'Alalta volcanic field (MVF) near the western margin of the Afar rift

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During continental rifting, strain and magmatism are believed to localize to narrow magmatic segments, while the rift margin is progressively abandoned. Here we use volcanological, geochemical, petrological and seismic data from the Ma'Alalta volcanic field (MVF) near the western margin of Afar, to understand the formation and evolution of this magmatic rift segment. Magmatism in MVF initiated with lava flows and large-volume, caldera-forming ignimbrites from a central edifice. However, the most recent magmatic activity shifted towards mafic lava fields, cinder cones and obsidian-rich silicic domes erupted from vents aligned NNW-SSE, defining a ~ 35-km-long magmatic segment. Along the same area, a NNW-SSE alignment of earthquakes was recorded by two local seismic networks (2005–2009 and 2011–2013) indicating ongoing faulting on the rift axis along en-echelon faults. The geochemistry of the mafic rocks is similar to those of nearby axial volcanoes. Inferred magma storage depth from mineral geobarometry shows that a shallow, silicic chamber existed at ~ 5-km depth below the stratovolcano, while a stacked plumbing system with at least three magma storage levels between 9 and 24 km depth fed the recent basalts. We interpret the wide set of observations from the MVF as evidence that the area is an active magmatic segment, showing that localised axial extension can be heavily offset towards the rift margin.