Evolution of the Alu-Dalafilla and Borale Volcanoes, Afar, Ethiopia

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The Danakil depression in the Afar region of Ethiopia marks the change from subaerial continental riftting to seafloor spreading further north in the Red Sea [1]. Extension and volcanism in this incipient spreading centre is localised to the ~70-km-long, 20-km-wide active Erta Ale volcanic segment (EAVS), with multiple volcanic centres consisting of a combination of fissures, shield volcanoes and stratovolcanoes [2]. This study aims to better understand the nature of interaction between three volcanoes with the EAVS (Alu, Dalafilla and Borale) while also investigating their evolution during the transition from continental to oceanic crustal production.

Here we combine results of mapping, using remote sensing, and geochemical analysis of Alu, Dalafilla and Borale in the northern half of the EAVS. Multispectral images were used to create a high-resolution map and establish a relative chronology of lava flows. Our results show that the majority of flows are sourced from a combination of scoria cones and fissures, representing in total 15 phases of volcanism within four major eruptive stages.

The first stage represents large-scale fissure volcanism comprising basaltic phases that erupted in a submarine environment. Stage two involves basaltic fissure volcanism centred around the Alu dome. The third stage is dominated by trachy-andesite to rhyolitic (SiO$_2$ of 59-70%) volcanism sourced from the volcanic edifices of Alu, Dalafilla and Borale. The fourth and final stage is characterised by a resumption of small-scale basaltic/trachybasalt (SiO$_2$ of 49-55%) fissure eruptions.

Geochemical modelling indicates a paucity of crustal assimilation and mixing within the sub-volcanic magmatic system. Spatial analysis of volcanic cones and fissures within the area indicate the presence of a cone sheet and ring faults. The fissures are likely fed by sills connecting the magma source with the volcanic edifices of Alu and Borale. Our results reveal the cyclic nature of both eruption style and composition of major volcanic complexes in rift environments, prior to the onset of seafloor spreading.

References