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Dyke-path formation in relation to the eruptions of Eyjafjallajökull 2010 and Bardarbunga-Holuhraun 2014

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Dykes are extension fractures and form when the magmatic overpressure is high enough to rupture (break) the host rock. Their formation is entirely analogous to that of many joints and human-made hydraulic fractures, such as are used to increase permeability in reservoirs. When generating their paths, dykes use existing weaknesses (e.g., cooling joints) in the host rock. The maximum depth of large tension fractures below the surface of a rift zone, however, is mostly less than a few hundred metres. If the fractures extend to greater depths, they must change into closed normal faults which are generally not used as magma paths. There are thus no large tension fractures or wide-open faults at great depths ready to be filled with magma to form a dyke. While magma flow in dykes, as in other fluid-driven fractures, is at any point in various directions dyke segmentation may indicate the overall large-scale flow direction. Thus, dykes composed of large-spaced disconnected segments in lateral sections are primarily formed in vertical magma flow at segmentation depth whereas those composed of large-spaced disconnected segments in vertical sections are primarily formed in lateral magma flow. The far-field displacement and stress fields of segmented dykes are similar to those generated by single, continuous dykes of similar dimensions, particularly when the distances between the nearby tips of the segments become small in comparison with segment lengths. Most dykes become arrested and never supply magma to eruptions. Feeder-dykes normally reach the surface only along parts of their lengths (strike-dimensions). The volumetric flow or effusion rate of magma through a feeder-dyke or volcanic fissure depends on the aperture (opening) of the dyke or fissure in the 3rd power. All these theoretical and observational results are here applied to the dyke emplacements associated with the eruptions of Eyjafjallajökull 2010 and Bardarbunga-Holuhraun 2014. The results make it possible to (1) explain, broadly, the propagation-paths of the associated dykes, (2) the arrest and deflection (into sills) of many dyke segments, (3) the dimensions of the dykes, in particular (4) the dyke thicknesses, (5) the volumetric flow or effusion rates of the volcanic fissures, and (6) the location of the magma sources of the dykes.

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