Dynamic magma mixing during the 2010 Eyjafjallajökull eruption, Iceland

Olgeir Sigmarsson

Laboratoire Magmas et Volcans, CNRS-Université Blaise Pascal, Clermont-Fd., France.

Institute of Earth Sciences, University of Iceland, Reykjavik, Iceland

After more than a decade of seismic unrest and significant deformation, Eyjafjallajökull volcano remained fairly calm until end of 2009. From December 2009 until 20 March 2010, the volcano experienced unrest (up to 14 km deep earthquakes) and sustained inflation. Seismic activity migrated upwards towards the surface, ending with a somewhat surprising lateral eruption on the Fimmvörðuháls pass, mid-way between Eyjafjallajökull and the more active Katla central volcano. Relatively primitive basalts with narrow MgO-concentration range (8-9 wt%) were emitted. They are comprised of homogeneous phenocryst (olivine, plagioclase and Cr-rich spinel). The highly vesicular texture of these basalt show abundant microlite crystallization most likely caused by degassing. Measured volatile concentrations in melt inclusions are high. The gas-rich Fimmvörðuháls basalt represents the parental magma of the Eyjafjallajökull volcano. A day after the last basalt emission on 14 April its summit crater became active. Vulcanian eruption produced fine-powdered tephra of trachy-andesitic composition that plots on a binary mixing-line between the 1821 trachy-dacite and evolved basalt composition similar to the groundmass glass of the Fimmvörðuháls basalts. The tephra from the 17 April is composed of three magma types having glass compositions of 49-51%, 60-61% and 69-70% SiO_2 that illustrates a mechanical magma mingling without enough time for homogenization before eruption. After 27 April only glass with SiO_2 of 58-60% is observed. On 4 Mai a deep seismic swarm occurred with consequent higher magma output as measured from the height of the eruption column on 5 Mai. The tephra from 5 Mai is comprised of well-mixed glass with SiO_2 of 62-63% but has 50µm zoned-olivines with 10 µm tick rim having a composition of Fo_{48-50}. The core has Fo_{80}, a composition similar to the olivines of the Fimmvörðuháls basalts. These results indicate a direct link between the arrival of primitive basalts, deep seismicity, increased magma pressure in the plumbing system, and higher magma output rate. Taken together, the second phase of the Eyjafjallajökull eruption is caused by dynamic magma mixing of older silicic intrusion remobilized by the crystallizing primitive basalt. The mafic end-member appears of deeper origin with time sustained by episodic inflow of mantle-derived basalts.