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The dynamic magma mixing during the 2010 eruption of Eyjafjallajökull, Iceland.

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The 2010 eruption of Eyjafjallajökull, Iceland, started with an effusive flank eruption of relatively primitive basalt, whereas delayed injection of more evolved basalt into pre-existing silicic intrusion and resulting magma mingling caused the explosive summit eruption. The magma erupted show a large range of compositions, from transitional and alkaline basalt during the fissure eruption and benmorite to trachyte at the very end of the summit eruption. Whole-rock and in-situ analysis of major- and trace-element contents as well as several stable and radiogenic isotope ratios and U-series radioactive disequilibria have been measured in a temporally controlled sample suite covering the entire eruption.

The basalts are of similar major (SiO_2: 45.9-46.3 %; MgO: 8.2–9.05 %; CaO/Al_2O_3: 0.66-0.67) and trace element compositions as the early Surtsey magma from the neighbouring volcanic system Vestmannaeyjar. The first tephra emitted during the explosive phase (14-19 April) is composed of silicic, intermediate and basaltic glasses, which are respectively indistinguishable from tephra of the penultimate 1821 A.D. eruption at Eyjafjallajökull (SiO_2: 68.7%), the 2010 whole-rock compositions (SiO_2: 55.0-61.4%) and the adjacent Katla basalts (SiO_2: 48-50%). These compositional ranges, together with those of the variable minerals present (olivine, feldspar, clinopyroxene, magnetite, apatite, sulphide, fluorite), illustrate mechanical mixing, or magma mingling, prior to the explosive eruption.

During the summit eruption the composition of the tephra varied from benmorite at the beginning to trachyte at the end (SiO_2: 55.0-61.4 %; MgO: 3.60-2.21 %; CaO/Al_2O_3: 0.48-028). The major element variations were subtle but significant, even on a day to day basis, whereas trace element concentrations display more regular pattern due to amplified variability. The compositional changes with time strongly suggest that both the proportions and the composition of the basaltic and silicic end-members in the magma mingling varied. With time (1) the basaltic pole became more primitive, evolving from Katla-like composition (FeTi-rich basalt; MgO: 4.5 -5.0%) towards the alkali basalt of Fimmvörðuháls, (2) the silicic pole changed from rhyolite to trachyte and (3) the proportion of basalt in the mixture decreased. The magma mixing process was clearly very dynamic and compositional changes occur on a short timescale of a few hours to days. The results of this study clearly show that analysis of temporally controlled samples representing the overall compositional range are needed for improved understanding of the underlying magmatic processes that trigger explosive eruptions.