Geophysical Research Abstracts,
Vol. 11, EGU2009-4258, 2009
EGU General Assembly 2009

F-enriched magmas at Mt. Etna (Italy) and related volcanological implications

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The occurrence of halogen-bearing fluids in magmatic systems has been frequently recognized from fluid inclusion studies in volcanoes chiefly erupting evolved products (e.g., trachytes, rhyolites), but their role in basaltic magmas has been comparatively less investigated. Recent findings of F-bearing mineral phases, namely fluorophlogopite and fluorapatite, in a benmoreite lava flow related to ancient volcanic activity at Mt. Etna (Ellittico-Mongibello transition phase), indicate specific physical and chemical conditions of crystallization. Beyond their mineralogical interest, their occurrence, exceptional in Etnean products, could provide important clues for assessing some geochemical processes leading to fluorine enrichment in the feeding system as well as the possible role on the assessment of the eruptive styles. Textural evidence suggests a late-stage crystallization of F-bearing minerals, since fluorapatite is found in the groundmass and fluorophlogopite within lava vesicles. Furthermore, a limpid Si-rich glass, characterized by multi-stage deposition, has overgrown the fluorophlogopite crystals. Geochemical simulations demonstrated that differentiation processes, such as fractional crystallization or crustal assimilation, are not able to produce compositions consistent with those observed in the F-enriched lava. Conversely, we propose that non-traditional differentiation processes, ruled by elemental transfer (as halogen complexes/compounds) in gas phase, are able to account for the observed selective enrichments in some major and trace elements, and particularly of fluorine and other volatiles. The occurrence of Si-rich glass surrounding the fluorophlogopite crystals also fits its condensation under cooling conditions from halogens-complexes/compounds accompanied by separation of a F-rich component into the gas phase. Due to its depolymerizing effects, the anomalous F concentration in the thin lava flow bearing these minerals may also account for rather low yield strength. Furthermore, this elemental and volatile enrichment can strongly increase fluids pressure and consequently the magma overpressure. This matches the highly explosive dynamics of extrusion just observed for products emitted during the Ellittico-Mongibello transition phase. Our results, here focused on a specific eruptive phase, may have important implications for understanding some recent geochemical and volcanological developments occurred at Mt. Etna, providing hints to answer similar problems also at other basaltic volcanoes.