Geophysical Research Abstracts
Vol. 12, EGU2010-12943, 2010
EGU General Assembly 2010

Pathways of sulfur release and redox state track the change from low-energy to highly-explosive eruptions at Mt. Etna (Sicily)

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Many basaltic volcanoes are characterized by large amounts of volatiles, most often reflecting fluid release from subducting slabs and consequent injection in the above mantle wedge. Because of this, basaltic volcanoes can experience a wide spectrum of activity, up to Plinian. At Mt. Etna, high-energy Plinian eruptions took place in the past (e.g., 122 BC), and still represent the major volcanic threat for the town of Catania and its surroundings. Joint melt inclusion-based investigation of sulfur release and bulk rock S-isotope study from classic Strombolian or lava-fountain based activity to Plinian eruptions may provide useful indications to discriminate the evolution to either high or low-energy eruptions. We show here that different Etna magmas follow different paths of sulfur elimination. Depending on initial water contents and oxidation states, Etnean magmas can soon reach the limit of sulfide saturation or get rid of sulfur on degassing only. Melt inclusion data indicate that the magma involved in the high-energy Plinian eruption of 122 BC is richer in sulfate than other magmas. The relationship between the high sulfate contents in melts, hence system oxidation, and the energy of the eruption does not seem to be fortuitous and reflects involvement of the hydrous-rich and oxidized parental source of magma, deep seated in a fluid-contaminated mantle. Consistent with melt inclusion findings, S-isotope data support the idea that most oxidized conditions known for Etna could be considered as a proxy for the most violent explosive eruptions, such as the 122 BC Plinian event.

Because the whole plumbing system is dominated by CO2 and invested by gas-fluxing, melt dehydration is a common process. Dehydrated magma portions are also more reduced than those ascending from the water-rich source. In light of this, and due to the clear role of water as oxidizing agent, we propose that the explosivity associated with oxidized Etna magmas reflects the fast ascent of deep batches from the water-rich source. Unsteady CO2 fluxing and consequent dehydration of the deep parental magma may switch Etnean activity from effusive or mild-explosive to violent highly explosive eruptions.