DIPARTIMENTO
DI SCIENZE DELLA TERRA
SAPIENZA
UNIVERSITÀ DI ROMA

DOTTORATO DI RICERCA
IN SCIENZE DELLA TERRA

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1. Research activity

Short abstract

With this PhD project, I will provide new tools for interpreting polybaric-polythermal changes in the plumbing system of Mt. Etna performing microanalyses of major/trace elements in natural/synthetic clinopyroxene, plagioclase and coexisting glasses. With the application of thermobarometers, hygrometers and geospeedometers it will be possible to characterise the intensive variables involved in the evolution of both crystals and plumbing system. The application of a novel chronometric model (NIDIS) on the crystals will be useful to retrieve the timescales of pre-eruptive processes that will be integrated with monitoring signals allowing to provide a conceptual model of the temporal evolution of magma dynamics.

Description of the project

Basaltic volcanoes (e.g., Etna, Hawaii, etc.) are characterised by a range of effusive to explosive activities with variable intensity, which can pose different type of threats to the local population. In addition, eruptions can occur both at the summit and on the flank of the volcano, affecting different portions of the surrounding environment. Mt. Etna volcano in Sicily (Italy) with a population of ~900,000, is one of the best monitored volcanoes but the link between sub-surficial magma movement and surficial manifestations (seismic, ground deformation, gas geochemistry) is yet to be understood. This volcano is characterised by open-conduit conditions with persistent degassing and periodic effusive to explosive activity.

There is an exceptional record of monitoring data and a collection of rock samples of the recent eruptions, making the volcano a valuable template for open-conduit basaltic systems worldwide. In this PhD project, I will focus on the SEC summit eruptions of 2007-08 and 2011-12, as well as I will expand my interest to the 2008-09 flank eruption which started just three days after the conclusion of the 2007-08 eruption. Despite the recent literature has provided scientific advances several key questions remain unanswered. In particular, the identification of nature and timescales of key controlling parameters modulating frequency and energy of explosive events as opposed or associated to effusive activity and mechanisms of eruption from the summit or from the flank of the volcanic edifice. Moreover, the understanding of how magma is stored, migrates and feeds eruptions is not a trivial task, requiring for constant improvements over the years.

Beneath Mt. Etna volcano there are complex networks of melt, mush and crystals that extend throughout the crust and into the uppermost mantle. This network plays an integral role in eruption dynamics where influx of fresh, hot deeper magmas into a shallower reservoir accompanied by mixing may trigger volcanic eruptions. Timescales of such pre-eruptive magmatic processes are recorded by chemically zoned minerals within volcanic rocks and will be unlocked during my PhD project by means of experimental volcanology and diffusion chronometry. The crystal cargo from summit lava fountaining (2007-08 and 2011-12) and from the 2008-2009 lateral lava flow will be investigated via experiments and textural/mineralogical analyses, evaluating frequency and volume of magma mixing events, crystal transfer between different melt environments, mush remobilization and eruption-triggering events. Thermobarometric constrains will be obtained through isothermal-isobaric and decompression-cooling experiments in order to elucidate the crystallisation conditions typically inferred for the Etnean plumbing system. I will conduct experiments on the natural starting materials by means of piston cylinder, internally heated pressure vessel and vertical furnace apparatus. The run products will be equilibrated under anhydrous/hydrous (0-5 wt.% H2O) conditions, as well as variable temperatures (1100-1250 °C) and pressures (0.1-400 MPa) deduced for the Etnean plumbing system. With this approach I will provide constrains on the textural and chemical maturation of crystals and feeding melts. Thus, I will parameterise the magnitude of the crystal growth rate during magma decompression and cooling, as well as the progressive change of major and trace elements in chemically zoned crystals and

coexisting glasses. The experimentally-derived intra-crystal compositional variations will be analysed in detail by FE-SEM, EMPA and LA-ICP-MS. With these data I will calibrate highly precise clinopyroxene-plagioclase thermobarometric and hygrometric models and calculate magma ascent velocity through the algorithm of Armienti et al. (2013). By combining P-T-H2O-sensitive major and trace cation substitution mechanisms with the lattice strain theory, I will constrain the geochemical evolution of the plumbing system by stepwise polybaric-polythermal Rayleigh fractional crystallisation modelling. I will recover the timescales of pre-eruptive processes by elemental diffusion chronometry using the NIDIS model by Petrone et al. (2016), a novel approach that allows the reconstruction of the core-rim elemental diffusion stratigraphy of complex zoned minerals. It will be also possible to elucidate the timescales of magma hybridization and volume of magma injections, which can be combined with experiments and thermobarometric constrains, thus evaluating the temporal evolution of magma dynamics. Crucially, the relationship between timescales, eruption triggering factors and the coeval monitoring signals will be carefully investigated to determine type and role of major controlling factors on the eruptive styles, providing a conceptual model of the temporal evolution of magma dynamics at Mt. Etna.

2. Research products

a) Publications (ISI journals):
Deep versus shallow sources of CO2 and Rn from a multi-parametric approach: the case of the Nisyros caldera (Aegean Arc, Greece) / Bini, Giulio; Chiodini, Giovanni; Lucchetti, Carlo; Moschini, Piergiorgio; Caliro, Stefano; Mollo, Silvio; Selva, Jacopo; Tuccimei, Paola; Galli, Gianfranco; Bachmann, Olivier. - In: SCIENTIFIC REPORTS. - ISSN 2045-2322. - 10:1(2020).

b) Publications (NON ISI journals)

c) Manuscripts (submitted, in press):
Carrier and dilution effects of CO2 on thoron emissions from a zeolitised tuff exposed to subvolcanic temperatures/ Mollo, Silvio; Moschini, Piergiorgio; Galli, Gianfranco; Tuccimei, Paola; Lucchetti, Carlo; Iezzi, Gianluca; Scarlato, Piergiorgio. (Submitted)

d) Abstracts