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Storage and ascent history of magmas at Mt. Etna traced by crystal zoning: comprehension of the spatial-temporal magma relationships across an articulated plumbing system

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Tracking the timescales of volcanic processes at very active volcanoes is becoming an important approach of modern volcanology to solve main goals, such as temporal relationships between magma recharge and eruption, duration of magma storage and final ascent upward to the surface. These issues are particularly relevant at Mt. Etna, where the style of volcanic activity during the last years showed drastic variations in duration and intensity even when magmas rather similar in compositions were involved. The post-2011 paroxysmal activity has given us the opportunity to investigate the volcanic processes feeding the activity, finding their spatial-temporal relationships into the plumbing system. Specifically, we used an extensive compositional dataset of plagioclase and olivine crystals from selected Etnean lavas emitted between January 2011 and April 2013 to constrain modes and timescales of magma storage and transfer to the surface. Textural features of plagioclase put into evidence complex histories of crystallization. They display either near-equilibrium textures or variable extent of disequilibrium at the core and rim, as well as growth textures developed at different degrees of undercooling. Anorthite contents at the core cover a wide range between ca. An90 and ca. An50 that led to the identification of distinct magmatic environments were plagioclase cores grew. Through Sr-diffusion modelling in plagioclase we have evaluated the maximum time of magma storage during the considered eruptive period. Timescales of crystal residence in the plumbing system are short (years to few decades), suggesting limited storage and fast transfer dynamics to the surface. The compositional record preserved in olivine crystals has been used to draw simplified schemes of magma pathways that provide histories of storage and recharge across distinct magmatic environments of the Etnean plumbing system. Six olivine core populations have been recognized, with rims showing normal or reverse zoning patterns. Fe-Mg diffusion modelling on olivine normal and reverse zoning defines the timescales of magma storage and recharge (days to months) into at least six magma environments, characterized by variable differentiation degrees. Correlation between the retrieved time calculations with depths and spatial distribution of ponding levels highlights that dynamics of volcanic processes at Mt. Etna are currently variable and very fast. Relevance of this study relies on the quantification of volcanic processes at depth that can have considerable consequences in development of unusual, high-energy eruptions characterizing the Mt. Etna activity.