Timescales of magma storage and dynamics of volcanic unrest at Vulcano island (southern Italy) during the last 1000 years

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At Vulcano Island, Aeolian archipelago (Italy), two eruptive centers have been active during the last 1000 years: Vulcanello, where poorly evolved shoshonitic magmas were erupted, and La Fossa Cone, which erupted more differentiated high-K products (latites to rhyolites). On selected plagioclase crystals of the products of the two eruptive centers we integrated petrological and geochemical analyses with the aim: 1) to draw a detailed model of the internal structure of the magmatic system; 2) to estimate the timescales of pre-eruptive magma storage; and 3) to better understand the mechanisms of volcanic unrest at Vulcano Island.

Results of this study indicate that magmatic processes, such as magma storage and mixing, occur into an articulated plumbing system, which extends from the mantle-crust boundary to the surface. At La Fossa cone and Vulcanello, eruptive activity was fed by a magma rising from a common basaltic-shoshonitic reservoir, probably located at the depth of the Moho (18-21 km). At Vulcanello, the first stages of activity were fed by poorly differentiated melts that directly rose from the deep basaltic-shoshonitic reservoir. For these melts, Sr diffusion modeling in plagioclase indicates limited residence times (<2 years) into the crust before the eruption. Above the magma reservoir located at the Moho depth, at La Fossa cone our data indicate the occurrence of three main magma ponding levels at different depths (12-17 km, 3-3.5 km and 1.2 km below sea level), which were variously reactivated over the whole period of activity. The composition of such magmas varies from shoshonitic to rhyolitic, with differentiation degree that increase toward the surface. Plagioclase crystals registered both the ascent and continuous episodes of recharge and mixing into the shallower reservoirs. Timescales of pre-eruptive magma storage retrieved from the diffusion of Sr in these crystals are between 2 and 10 years. By comparing these residence time estimations with the temporal gap between eruptions at La Fossa during the last 1000 years (50-120 years), it becomes clear that magmas have been stored for most of the time in reservoirs located below the plagioclase nucleation depth (~11 km of depth), and were intruded at shallower levels only few years before the eruption onset.

According to our model, magmatic eruptions at Vulcano could be related to the ascent of deep-seated mafic magma able to trigger a sort of “reaction chain” through subsequent episodes of recharge and mixing toward the upper magmatic reservoirs.