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Plagioclase as a record of the magma ascent dynamics during 2001-2006 eruptions at Mt. Etna (Italy)

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In the last decade Mount Etna activity was characterized by different eruptive styles, from effusive to highly explosive, involving both central and lateral feeding systems, not accompanied by significant variation in lava compositions. The most important parameter in determining the eruptive styles are therefore the dynamic of magma uprising within the feeding systems.
Plagioclase is the most common phenocrysts in all terms of the etnean magmatic suite ($\sim$50% in volume). Its stability field is dependent on chemico-physical variations of the melt and it can be used as a tool to record the processes occurring during the magma uprising.
Textural and compositional study of plagioclases has thus been performed on the products emitted during the 2001-2006 eruptive period, and compared with theoretical models that constrained its stability field.
During 2001-2006 eruptions plagioclase with an average length of about 1mm present i) clear crystals (about 800μm in size), rich in An (An90-85) with oscillatory zonation pattern or ii) phenocrysts with clean or dusty cores lower in An content (An85-75) with complex dissolution textures (4-500μm): when simple dissolution occurs cores are rounded and clear, while if partial dissolution occurs cores are dusty due to numerous glassy inclusions (coarsely sieved cores) (Tschuyama 1985b). In the latter case both cores are followed by a lower An overgrowth ranging in size from 100 to 400 microns (based on an average crystal size of 1mm). Finally two types of rims (max 100μm) can be also recognized: i) partially dissolved dusty rims, with An-rich composition and ii) a more albitic rims characterized by alignments of melt inclusions along crystallographic planes.
MELTS calculations have been performed to constrain the crystallization conditions, starting from the most primitive magma (2004/2005 eruption) under different pressure (2500-0 bars) and water contents (3.5-0 wt%). Based on whole-rock composition the program estimates the liquidus temperature, which were decreased by step of 20°C down to 1030°C which is the lowest T recorded by etnean erupted products. Volatile saturation depths were estimated using VolatileCalc and water content in Etnean lavas by the plagioclase-liquid hygrometer/thermometer of Lange et al. (2009).
These simulation indicate that An-poor (An75-85) plagioclases crystallized at about P=2500 bars and 1 wt% H2O, while An-rich (An85) plagioclases is stable only at P=800 bars and 2.5 wt% H2O.
Thus clear An-rich (>An85) crystals can be obtained only at very shallow pressure (<1000 bars) with water content of about 2.5-3.3 wt%.
Clean or dusty dissolved cores An85-75 in composition cannot be in equilibrium with high water content at depth greater than 3km. Dissolution processes suggest disequilibrium conditions within the deep magma reservoir which can be related to an input of new undegassed magma or decompression during magma ascent which rise the water pressure. The more albitic overgrowth probably occurs develops at shallower level where the magma can rest, followed by water oversaturation and degassing. The outermost narrow rims can be explained by i) input of new basic magma or ii) rapid growth due to degassing just prior to the eruption.
Textural and compositional study reveals a dependence of plagioclase liquidus on water content dissolved in the melt. Furthermore, the textures at the crystal rims suggest different trigger mechanism of the eruption: an active one, induced by magma mixing and a passive one, promoted by decompression due to fracture opening, associated to regional tectonics.

Tsuchiyama, A., 1985b. Dissolution kinetics of plagioclase in the melt of the system diopside–albite–anorthite, and the origin of dusty plagioclase in andesites. Contributions to Mineralogy and Petrology 89, 1–16.