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An empirical hygrometer for trachybasaltic melts: applications to the kinetics of magma ascent at Mt. Etna.

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Water is possibly the most important chemical component in magmas, affecting liquidus temperatures, crystal fractionation trends, melt rheology and in turn the dynamics of ascent and eruption of magmas. Hence, it is of broad interest to determine the initial abundances of water in magmas and its variations during magma ascent and differentiation. Solubility models satisfactorily account for the partitioning of water between exsolved vapor the water dissolved in silicate melts provided that magma water contents prior to exsolution are known. However crystal-hosted melt inclusions rarely capture the most shallow, late-stage episodes of magma ascent, just before water exsolution, when undercoolings are moderate and so provide little or no record of water content variations during the to be used for understanding the triggering mechanisms for volcanic erutpions.

Melt inclusions from different volcanic products erupted by Mt. Etna indicate that the primitive melts rising from the mantle are particularly rich in water (1 - 3.8 wt%) making this volcano a natural laboratory to investigate on relations between water variations and the relevant aspects of magma ascent. In this work we calculate P(H_2O)-T-t paths of magma ascent in the Mt. Etna volcanic feeding system, combining thermochemical and kinetic data on Mt. Etna clinopyroxene. Due to the its early appearance on the liquidus of Etnean magmas, clinopyroxene can be used as a tracer of polybaric crystallization processes that take place mostly well below depths of water exsolution. Since clinopyroxene abundances and compositions are controlled by magma water solubility we have developed a new hygrometer based on the composition of clinopyroxene phenocrysts. It links clinopyroxene compositions found in controlled experimental runs to H_2O concentration, temperature, pressure and melt composition. Our empirical method is calibrated with a resolution < 0.5 wt% H_2O, and relies on a set of experiments on hydrous liquids representative of Etnean volcanics.

The formulation of the model is:

K* Wt% H_2O_{melt} = a * DiHd b* EnFs + c * CaTs + d * Jd + e *CaTi + f * P + g /T (1)

where the end-member of clinopyroxene (DiHd, EnFs, CaTs, Jd, CaTi) are calculated following the Putirka et al.'s (2003) geothermometer. The parameters K, a,b,c,d,e,f,g were determined by regression are.:

K= 3.925495108; a= 19.44971977; b= -0.618948565; c= 8.387657214

d= 49.33424833; e= -86.02044893; f= -0.366040062; g= -0.3706621

P is in GPa and T is in ˚C.

This technique thus holds promise as a method for determining the water content of virtually any volcanic rock, whose composition is similar to those considered for the calibration of the hygrometer.