Magma path of rise and crystal size distributions

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During its path of rise a magmatic body may experience a significant degassing whose effects are recorded by its crystal population due to the strong control exerted by volatile content on the liquidus temperature. At Mt Etna we can rely on precise evaluations of initial water contents and on accurate models of water solubility: this offers a key to investigate the relationship between ascent rate of magma and the Size Distribution of its populations of crystals.

The main steps of pressure , water contents and temperature (*P-XH$_2$O-T*) are estimated from mineral-liquid thermobarometry, the link between the velocity of rise v and P-T-time conditions is made explicit by the relation $v = \frac{1}{\rho g}\left(\frac{dP}{dT}\right)\left(\frac{dT}{dt}\right)$, where ρ is magma density and g is the acceleration of gravity. This allows to model the dependence of the evolution of melts undercooling with time for recent Mt. Etna lava flows in wich both *dP*/*dT* and d*T*/*dt* have been well characterized based on clinopyroxene thermobarometry and clinopyroxene CSDs.

Deep-level (>20 km) magma ascent rates range from practically 0 (where clinopyroxene *P-T* estimates form a cluster, and so $dP/dT \approx 0$), to about 10 m/hr for flows that yield very steep *P-T* trajectories. Many lava flows at Mt. Etna yield *P-T* paths that follow a hydrous (about 3% water) clinopyroxene saturation surface, which closely approximates water contents obtained from melt inclusions.

In these conditions the number of crystals of given size L (N(L)) is controlled by the ratio between the nucleation density J and the growth rate G experienced at the time when crystal of size L were formed: N(L)= J(L)/G(L) where both J and G depend on undercooling. In this work it will be shown how to use the condition that all the minerals occurring on the liquidus experience the same variation of undercooling to derive the values of the thermodynamic constants that explicit the dependence of J and G from undercooling (ΔT). Results will be used to decipher Crystal Size Distributions in terms of magma path of rise (P-T-t) trough explicit forms of the equation that provide the crystal size : $L = \int_0^t G\left(\Delta T(X_{H_2O}(P(t))\right)dt$.