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Petrological study of clinopyroxene phenocrysts from Mt. Etna volcano (Italy)

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A petrological study of clinopyroxene (Cpx) phenocrysts from both historical and recent eruptions of Mt. Etna volcano have carried out in order to investigate the processes occurring in the deepest portion of the feeding system and to constrain its chemical and physical variables.
Four distinct textures were recognized: i) normal oscillatory-zoned; ii) reverse oscillatory-zoned; iii) sieve-textured cores and iv) dusty rim. Electron microprobe analysis revealed an almost constant Diopside-Augitic composition, with a slight enrichment in the enstatitic component in Cpx from more recent eruptions. Core to rim compositional profiles have been performed along the recognized textures. Normal oscillatory zoning is characterized by a sharp increase in FeO ($\Delta\sim$2wt%) accompanied by a drop in $Al2O_3$ in the outermost 30 μm. On contrary, a drop in FeO, $Al2O_3$ ($\Delta\sim$2wt%) and a remarkable increase in MgO (up to 5wt%) at crystal rims marks reverse zoning. Similar compositional changes have been measured in dusty-textured rims, which are characterized by dissolution edges and crystal regrowth incorporating glass pockets and channels. No significant compositional variations have been observed across sieve-textured core.
Trace element and REE concentrations have been measured by laser ablation mass spectrometry, evidencing enrichment in Sr, La, Zr and REE, together with a lowering of the La/Yb ratio (from $\sim$7 to $\sim$4), at rims in normal zoning crystals. On contrary, Cpx with reverse zoning and dusty rims always presents low Sr, La, Zr and REE contents towards crystal rims.
Geothemobarometers of Putirka et al. (2003) and Putirka et al. (2004) have been applied to Cpx-melt pairs at crystal cores and rims after having checked the equilibrium conditions. Results evidence that Cpx cores start nucleating at 7.7 Kbar with the majority of them forming between 6.0 and 4.0 kbar and continue to crystallize until very shallow depth (<1 kbar). Normal oscillatory-zoned phenocrysts with Fe-rich rim form at pressure shallower than 4.0 kbar, while inverse zoning and dusty rims occur between 4 and 5 kbar.
Cpx are able to record changes in the physical-chemical conditions of the magmatic system and two main distinct processes could be responsible for the observed texture. Fe-rich rim in normal oscillatory zoned crystal can be related to a decompression-induced crystallization, while reverse zoning and dusty rims can be produced by mixing with a more basic melt, occurring between 4-5 kbar, corresponding to about $\sim$10 km of depth.

Putirka et al., (2003). American Mineralogist, Vol. 88; pp.1542-1554;
Putirka et al., (2008). Reviews in Mineralogy & Geochemistry, Vol. 69; pp. 61-120.