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High water concentrations in a primitive Deccan lava: evidence from clinopyroxene crystals

Sheila Seaman
Department of Geosciences, University of Massachusetts, Amherst, MA 01003 United States (sjs@geo.umass.edu)

Measurements of water concentrations in clinopyroxene phenocrysts in the Powai ankaramite flow, located near Mumbai, west of the Western Ghats escarpment of the Deccan province, India, indicate that the parent magma of the flow hosted at least 4.3 wt.% water, an unusually high water concentration for a continental flood basalt magma. However, similar water concentrations (3.39 to 6.61 wt.%) were calculated by Xia et al. (2016), also on the basis of water concentrations in clinopyroxene crystals, for continental basalts of the Tarin basin in northwestern China, which hosts >200,000 km3 of flood basalts (Xia et al., 2016). In the Powai ankaramite flow, textural and compositional features of clinopyroxene phenocrysts further support crystallization in a water-rich melt. The flow hosts clinopyroxene and olivine phenocrysts. Chatterjee and Sheth (2015) showed that phenocrysts in the flow were part of a cumulate layer intruded by high-temperature basaltic melt at $\sim$ 6 kb and $\sim$1230oC, so the phenocrysts record characteristics of the cumulate parent melt. Clinopyroxene phenocrysts are large (to$\sim$ 0.5 cm diameter), euhedral, are oscillatorily zoned in water, Mg, Fe, and Ca concentrations, and have concentric bands 100-200 microns thick of fine (10-20 micron diameter) melt inclusions. Olivine phenocrysts are smaller (to $\sim$0.1 cm diameter, are unzoned, and host only larger isolated melt inclusions. Zones in the cpx phenocrysts where melt inclusion-rich concentric bands occur have higher concentrations of water than inclusion-free zones. Water concentrations of cpx were used to calculate water concentrations in the melt from which the crystals formed using partition coefficients of Hauri et al. (2004). Water concentrations in the parent magma were between 4.35 and 8.26 wt. % based on water concentrations in cpx. Both Mg and Fe are relatively depleted in the water- and melt inclusion-rich zones in cpx, and Ca is enriched in these zones. Oscillatory zoning in cpx may be a result of repeated growth of cpx in water-richer and water-poorer boundary layers in which water lowered melt viscosity and enhanced diffusion and crystal growth rates. Water-enhanced growth rates may have resulted in capture of melt inclusions preserved in water-rich cpx zones. Mg was preferentially incorporated into the cpx, causing Ca and water to build up in the boundary layer, and Mg and Fe to become relatively depleted in the boundary layer, as discussed for oscillatorially-zoned minerals by Wang and Merino (1993). These apparently water-dependent variations in crystal growth processes ugsuggest that at least this Deccan magma was relatively hydrous. Melt inclusions in olivine phenocrysts, however, preserve lower water concentrations ($\sim$1.2 wt. %) than those indicated by water concentration in cpx phenocrysts. This disparity may be evidence of water loss from melt inclusions in olivine (Gaetani et al., 2009) or may indicate that cpx and ol crystals did not crystallize from the same parent at the same time.