Magmatic water contents recorded by hydroxyl concentrations in plagioclase phenocrysts from Mount St. Helens, 1980-1981

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Magmatic water contents could potentially be determined by measurement of OH concentrations in nominally anhydrous phenocrysts, assuming an equilibrium partitioning of water between the phenocrysts and melt. In this study, the OH concentrations of plagioclase phenocryts from nine eruptions of Mount St. Helens between May 18, 1980 and April 1981 were measured using infrared spectroscopy, in order to evaluate this method of determining magmatic water content. The eruption temperature, oxygen fugacity, and bulk chemical composition were all fairly constant through the eruption sequence from 1980-1981 at Mount St. Helens. The water content of melts from successive eruptions decreased from 4.6 wt% H_2O for the Plinian eruption on May 18, 1980 (Rutherford et al. 1985, JGR 90, 2929-2947), to less than 1 wt% H_2O for the latest dome-forming dacites. There is a linear relationship between the water content of melt inclusions (Melson, 1983, Science, 221, 1387-1391) and the average OH concentration of plagioclase from each eruption, with the OH concentration of plagioclase ranging from 200 ppm H_2O for the May 18, 1980, eruption, down to 20 ppm for the April 1981 dome-building eruption. The partition coefficient of hydrogen between plagioclase and melt was determined to be 0.004 for this system, and is similar to other estimates of partition coefficients of water between anhydrous minerals and melt (Dobson et al., 1995, Contrib Min Pet, 118, 414-419). Homogeneous distribution of OH in feldspar grains >100 micrometers is observed even for those grains with pronounced major element zoning. The estimated diffusion rate of hydrogen at 930°C is 1.1×10^{-13} m^2/sec (Johnson, 2003, Caltech thesis), and estimates of magma ascent rates from 8 km depth are on the order of days to weeks (Rutherford and Hill, JGR, 98, 19667-19685). On these time scales, OH in feldspars had time to reequilibrate with the magma during ascent, whether or not it was temporarily stored at shallow (<4.5 km) depths (Cashman, 1992, Contrib Min Pet, 109, 431-449). These data show that, in the absence of large changes in oxygen fugacity or eruption temperature, the water contents of silicic melts immediately prior to eruption are recorded in the OH concentration of volcanic plagioclase.

Water, decompression, and mantle melting at Galunggung, Indonesia

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Galunggung, western Java, is one of the few arc-front volcanoes where decompression melting has been indentified as an important magma-generating process. Here, we present new SIMS measurements of volatile and trace elements in olivine-hosted melt inclusions (n=60) from two high-Mg basalt bombs from its 1982-83 eruption. The inclusions are <100 µm in diameter and each consists of naturally clear, brown glass with a single vapor bubble. A prior melt inclusion study using these bombs revealed H_2O-poor basaltic melts atypical of many arc-front volcanoes (Sisson & Bronto, 1998), but the new data resolve three distinct populations of magmatic volatile compositions. Most abundant are nearly dry (0.3-0.5 wt.% H_2O) melts similar to those of Sisson & Bronto (1998), with trace element signatures indicative of some involvement of slab-derived material into the magma source (e.g. Th/La=0.15-0.16) despite low H_2O. The new SIMS data also reveal two smaller populations of melt inclusions, one that is ultra-dry, similar to MORB in both H_2O content and trace elements (0.08-0.3 wt.% H_2O; Th/La=0.12-0.16), and one that is wetter (1.4-2.5 wt.% H_2O), with trace element characteristics similar to the whole rock lava (Th/La=0.16-0.20). Water-fluxed and decompression melting are thus both significant melting processes beneath Galunggung. The distinct juxtaposition of low H_2O and slab-derived signatures, however, further suggests that the mantle experiencing decompression melting beneath Galunggung may also be infiltrated by H_2O-poor brines (H_2O/Cl=0.7-3.9) that impart slab-derived signatures without dominating the melting process or adding significant H_2O to the melt. The volcanic arc in western Java consists of northern (rear-arc) and southern (arc-front) volcanic groups separated by the Bandung depression, which is probably an axial graben. The two volcanic groups converge eastward and join near Galunggung. This intra-arc extension may allow such a broad spectrum of primitive melts, generated by distinct processes, to reach shallow levels within a single arc magmatic system.