Water Content of the Mantle Wedge

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Subduction zone magmas are characterized by high concentrations of H_2O, presumably derived from the subducted plate and ultimately responsible for melting within the mantle wedge. Quantifying the amount of water and degree of melting in the mantle wedge, however, is one of the challenges facing the Subduction Factory initiative. In order to provide context for the more complex dynamic region beneath volcanic arcs, we have examined the region beneath back-arc basins, where the mode of mantle flow and thermal structure are better known. We have used TiO_2 as a proxy for F (degree of melting), and then use F to calculate H_2O_o (the water content of the source) from measured H_2O concentrations in submarine basalts (Kelley et al., 2006). Back-arc basins define positive, approximately linear relationships between H_2O_o and F that vary regionally in slope and intercept, possibly related to differences in mantle potential temperatures. Such relationships provide a means of separating the effects of water, potential temperature and decompression on melt generation within the mantle wedge. We also document for the first time the increase in water concentrations in mantle sources toward the trench (see Figure), where water contents exceed 3000 ppm, well beyond the storage capacity of anhydrous mantle minerals at those depths. Such water contents and distribution patterns provide baseline data for developing dynamic models of water supply and transport to the mantle wedge (e.g., Langmuir et al., 2006*; Cagnioncle et al., 2007*; Sadofsky et al., 2008*; Gorczyk et al., 2007*), and for interpreting seismic observables (e.g., Wiens et al., 2006*; Wiens et al., 2008*; Zheng et al., 2007*).

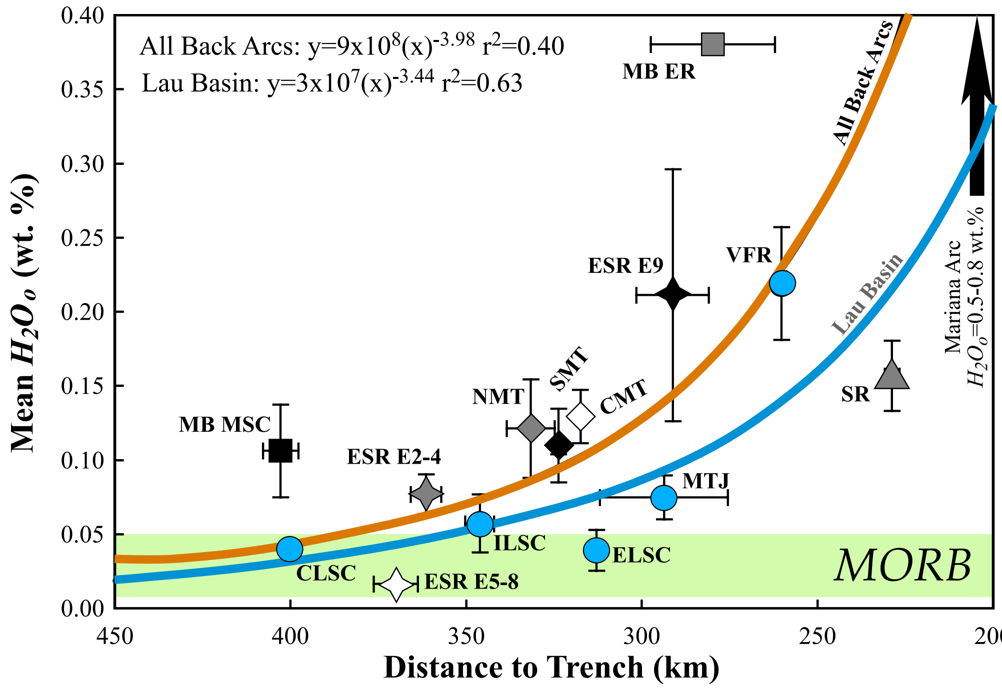

Figure: Mean water content of the mantle source of back-arc basin basalts (H_2O_o) versus distance to the trench. The back-arc basin data are regional averages of the Manus basin Eastern Rifts (MB ER) and the Manus spreading center/eastern transform zone (MB MSC), the Lau basin central Lau spreading center (CLSC), the intermediate Lau spreading center (ILSC), the Mangatolu triple junction (MTJ), the eastern Lau spreading center (ELSC) and the Valu Fa ridge (VFR), the East Scotia ridge (ESR) segments E2–E4, E5–E), and E9, and the Mariana trough northern third (NMT, 19N–21N), central third (CMT, 17N–19N) and southern third (SMT 15N–17N). Error bars are 1s deviations from the small-scale averages. The shaded field is the range of H_2O_o in MORB. The black arrow in the upper right indicates the direction that volcanic arcs are predicted to plot (off-scale). The range for the Mariana arc is from Kelley et al. [2003]. Curves are power law regressions through the five Lau basin segment averages (blue) and all of the back-arc segments (orange). Figure from Kelley et al. (2006).*

Kelley, K.A., Plank, T., Newman, S., Stolper, E. Grove, T.L. and Hauri, E. (2006) Mantle melting as a function of water content at subduction zones. I: Back-arc Basins. J. Geophysical Research, 111: B09208.

 *References listed in appendix A.