Slab-derived supercritical fluids beneath subduction zones: separation into aqueous fluid and hydrous melt during ascent

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Aqueous fluids dissolve significant amounts of silicates under high-temperature and high-pressure condition. Silicate components dissolved in aqueous fluids coexisting with mantle peridotite change their major element chemistry from andesitic at 1-2 GPa to peridotitic at 3 GPa and higher pressures (Ayers et al., 1997, Earth Planet Sci Lett; Stalder et al., 2001, Contrib Mineral Petrol; Mibe et al., 2002, Geochim Cosmochim Acta; Kawamoto et al., 2004, Am Mineral). In the present study, we show direct observations of unmixing and mixing between aqueous fluid and a high-magnesian andesite (Tatsumi, 1981, Earth Planet Sci Lett) and between aqueous fluid and an oceanic sediment (Ono, 1998, J Geophy Res) by use of synchrotron X-ray radiography with multi-anvil type high-T and high-P apparatus at SPring-8 (Mibe et al., 2004, Geochim Cosmochim Acta). We observed aqueous fluid and a high-Mg andesitic (HMA) melt coexisting in pressures lower than 2.7 GPa. While above 2.8 GPa, we observed only one fluid phase, suggesting that the HMA and aqueous fluids are completely mixing and become supercritical. Because subducting oceanic lithosphere has oceanic sediments on its surface, such oceanic sediments should inevitably be flushed with aqueous fluids liberated from dehydration reactions of hydrous minerals in basaltic and peridotitic layers underneath the sediment layer. In addition to the HMA, we determined a critical endpoint between an oceanic sediment and aqueous fluid, which is located at around 2.6 GPa. Mibe et al. (2007 J Geophy Res, in preparation) reported a second critical endpoint between aqueous fluids and a peridotitic/ a MORB melt at 3.8/ 3.0 GPa, respectively. Based on these available data, we suggest that slab-derived fluids should be under supercritical conditions at the downgoing slabs beneath the volcanic arcs (3 - 6 GPa, Tatsumi and Eggins, 1995, Subduction zone magmatism (Balckwell)). This means a continuous change from hydrous melts to aqueous fluids at the base of mantle wedge. Whether the slab-derived fluids have chemical characteristics like a partial melt or an aqueous fluid depends on the temperature; slab derived-supercritical fluids in relatively warm regions can dissolve more silicate components than slab derived-supercritical fluids in relatively cold regions.