Salinity and Na/K Ratios of Subduction Zone Fluids

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John Requa Holloway and I had worked on the melting temperature of H_2O-saturated mantle peridotite and found that there was no void in the quenched experimental products that contain >50 wt% H_2O at 5 GPa (Kawamoto and Holloway 1997 Science). This finding suggests that ultramafic melts and aqueous fluids can mix together at 5 GPa. Synchrotron X-ray radiography allowed us to determine the critical endpoints between aqueous fluids and peridotite, basalt, high-Mg andesite, and sediment at 2.5-3.7 GPa (Mibe et al. 2007 JGR, 2011 PNAS, Kawamoto et al. 2012 PNAS). This pressure range is shallower than or close to the depths of subducting oceanic plate underneath volcanic fronts. This indicates that slab-derived fluids can be under supercritical fluids and separate into aqueous fluids and silica-rich melts in the mantle wedge. We suggest that such separation can explain the decoupling of slab-melt and fluid components (Elliott et al. 1997 JGR). Partitioning of Pb, alkaline and alkaline-earth elements between aqueous fluids and haplogranite/jadeite melts suggests that saline fluids are likely to deliver those trace elements to the partial melting source (Keppler 1996 Nature, Kawamoto et al. 2016 Earth Planet Space).

This experimental suggestion of the importance of being salty is consistent with findings of saline fluid inclusions in mantle peridotite xenoliths and jaditites in serpentine mélanges (4-5 wt% NaCl equivalent; Kawamoto et al. 2013 PNAS, Kumagai et al. 2014 CMP, Fukuyama et al. 2017 J Mineral Petrol Sci, Kawamoto et al. 2018 Lithos). Using LA-ICP-MS, Drs. Kimura and Chang have determined the Na/K ratios of sulfate bearing saline fluid inclusions in Pinatubo harzburgite xenoliths (Kawamoto et al. 2018 JpGU abstract SGC45-07). The obtained ratios ($Na_{73}K_{27}$) are comparable with those of aqueous fluids in the generation of the Mariana trough (back-arc) magmas ($Na_{82}K_{12}$; Stolper and Newman 1995 EPSL), H_2O-rich components in Mt. Shasta ($Na_{77}K_{23}$; Grove et al. 2002 CMP), and two H_2O-rich components in Mt. Shasta ($Na_{70}K_{30}$ of melt or supercritical fluid components and $Na_{87}K_{12}$ of aqueous fluid components; Le Voyer et al. 2010 J Petrol). Such Na-K-rich fluids can be formed through "seawater and rock interaction".