Magma genesis in Hawaii plume: melting experiments on basalt/peridotite layered sample up to 8 GPa

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Eclogite component entrained in ascending plume is essentially important in producing flood basalts (e.g., Columbia River basalt, Takahashi et al., 1998), alkalic OIBs (e.g., Kogiso et al.,2003), ferro-picrites (Tuff et al.,2005) and Hawaiian shield lavas (e.g., Hauri, 1996; Takahashi & Nakajima, 2002, Sobolev et al.,2005). Various melting models of Hawaiian plume have been proposed with entrained mafic components (e.g., Farnetani & Hofmann 2009; 2010). Size of the entrained eclogite, which controls the reaction rates with ambient peridotite, however, is very difficult to constrain using geophysical observation. Based on reconstruction of Koolau volcano by submarine study on Nuuanu landslide (AGU Monograph vol.128, 2002), Takahashi & Nakajima (2002) concluded that the Makapuu stage lava in Koolau volcano was supplied from a single large eclogite block of the order of 1000km^3.

In order to study melting process in Hawaiian plume with large blocks of recycled mafic component, high-pressure melting experiments were carried out using a multi-anvil press under dry and hydrous conditions with layered eclogite/peridotite starting materials. Combined previous field observation with new set of experiments, we propose that variation in SiO_2 among Hawaiian tholeiite represent varying degree of wall-rock interaction between eclogite and ambient peridotite at 80-120km depth.

Melting study of alkali-basalt/peridotite layered sample showed much lower solidus temperature than MORB/peridotite sample mainly due to K_2O. Melting would start as deep as 200km depth and composition of initial melts at pressures higher than 120km are K-rich alkali acidic rocks (phonolite, hawaiite) whereas silica-poor alkali magmas (basanite, nephelinite) are produced in the presence of volatiles which widen partial melting of peridotite as well as mafic component. Iron rich-nature of Hawaiian tholeiite is difficult to reproduce by reaction melting of MORB/peridotite samples. Recycled mafic component in Hawaii plume may be higher in FeO than modern MORB which is consistent with Fe-rich nature of mafic rocks in early Earth.

Post shield stage phonolite and hawaiite magmas were considered to be fractionation product of alkali basalts under crustal magma chambers (e.g., Frey et al, 1990). However, our experimental results revealed alternative scenario that phonolite and hawaiite magma were derived from partial melting of alkali basaltic blocks at deeper part of the plume. On the other hand, basanite and nephelinite which appears in rejuvenated stage may represent partial melt of peridotite portion of the plume. We discuss magma genesis in Hawaii plume based on our melting experiments and occurrence of diverse magma types both geographically and in growth history of a given shield volcano.

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