冥王代大陸地殻の主成分元素組成：含水コマチアイトの高圧融解実験からの制約

Major element composition of the Hadean continental crust: constraints from high-pressure melting experiments of hydrous komatiite

*近藤 望[1]、小木曽 哲[1]
*Nozomi Kondo[1], Tetsu Kogiso[1]

1. 京都大学大学院人間・環境学研究科
1. Graduate School of Human and Environmental Studies, Kyoto University

The major element composition of the Hadean crust is an important clue to reveal the early stage of the Earth’s evolution. The chemical and dynamical evolution of the mantle has controlled by the formation and recycling of the crust, which is controlled by the physical properties of the crust such as density and viscosity. Since the physical properties are controlled by the major element composition, the major element composition of the Hadean crust controls the initial condition and subsequent evolution of the mantle chemical and dynamical evolution. The major element composition of the Hadean crust also controls the concentration and supply of the primary elements for life (nutrients) such as potassium (K) and phosphorous (P) at the surface, which controls the habitable environment and origin and evolution of life.

Analyses of the Hadean zircons (<4.4Ga) in previous studies have provided isotopic and trace element data. The Hadean zircons have higher oxygen isotope ratios than zircons equilibrated with mantle rocks, that sugges the surface water-rock reaction in the pre-existing crust and re-melting of the hydrated crust to generated the source melt (Cavosie e al. 2006), and have lower initial $^{176}Hf/^{177}Hf$ ratios than the chondritic evolution line, that suggest the formation of a low Lu/Hf oceanic crust and re-melting of it to generate the zircon source melt (Harrison et al. 2005; Kemp et al. 2010; Iizuka et al. 2015). The trace element composition of the Hadean zircons suggests generation of the zircon source melt at high pressures where garnet is stable (Burnham and Berry 2017). Since we have investigated the major element composition of the Hadean oceanic crust (4.47-4.42 Ga) with Sm-Nd systematics in the Archean rocks and high-pressure melting experiments, we next focused on the partial melting of the hydrous Hadean oceanic crust and estimated the major element composition of the melt.

The major element composition of the Hadean oceanic crust depends on the Hadean mantle potential temperature (MPT) that has been estimated to be in the range of 1500-1700 ˚C (Silver and Behn 2008; Korenaga 2011). Because the Archean mantle potential temperature was estimated to be 1500-1600 ˚C (Hertzberg et al. 2010) and the Hadean MPT could have been higher than the Archean MPT, the Hadean MPT would have been about 1700 ˚C. At the MPT of 1700 ˚C, the Hadean oceanic crust should have been the Fe-Ti-alkali-rich komatiite. Then, we performed melting experiments of the hydrous Fe-Ti-alkali-rich komatiite with Boyd-England type piston-cylinder apparatus at Graduate School of Human and Environmental Studies, Kyoto University. The experimental conditions were 0.7-3.0 GPa, 1000-1300 ˚C, and 1.5% water (water saturated). The oxygen fugacity was carefully controlled to Ni-NiO buffer in the triple-capsule cell assembly in Matjuschkin et al. (2015), and assessed by using a method in Barr and Grove (2010), in which the oxygen fugacity can be calculated from the Fe-exchange reaction

between the AuPd sample capsule and melt. As the result, it was revealed that the solidus of the hydrous komatiite is just above the solidus of the water-saturated peridotite (Iwamori et al. 1998), and that the experimental melts had Ti-P-rich mafic composition.

The water content in the experimental melts were calculated from the bulk water content and melt fraction, except for the experiment where the hydrous mineral appeared in residual phases. The density of the hydrous experimental melts were estimated from their compositions and water contntes by using density calculator developed by Ueki and Iwamori (2016), and the viscosity of the experimental melts were also estimated from their compositions and water contents. The density and viscosity of the experimental melts would be lower than the density and viscosity of the Hadean lithosphere, and the melts could have been ascended in the lithosphere and formed the Hadean continental crust of Ti-P-rich mafic composition. The P-rich Hadean continental crust would have performed important role on the habitable environment in the Hadean.

Zr saturation in the Ti-P-rich mafic melts were assessed from Zr satulation model in Bohenke et al. (2013) and Zr concent in the melts calculated from mineral-melt Zr partition coefficients in previous studies (Fujimaki et al. 1984; Johnson 1994; Green et al. 2000; McCallun and Charette 1978; Brenan et al. 1995) and melting phase relations in Kondo et al. (2016) and in this study, with Zr content in primitive mantle of 10.8 ppm (O’Neil and Palme 2014). Zircons would not have been crystallized from the Ti-P-rich mafic melt, and re-melting of the Hadean continental crust is needed for generation of more evolved melt.

キーワード：冥王代、大陸地殻、主成分元素組成、コマチアイト、高圧融解実験
Keywords: Hadean, continental crust, major element composition, komatiite, high-pressure melting experiments

