

Carbon-bearing materials formed by state-change: Earth, Moon and Meteorites

*Yasunori Miura¹

1. Visiting (Yamaguchi, In & Out Universities)

Introduction:

The volatile element performs stably three macro-state-changes in the water-planet Earth and life continuously. However, reaction at extreme conditions is difficult to be observed generally.

Present study proposes solidified model from fluid-state during extreme conditions on water-planet Earth and extraterrestrial celestial bodies.

Carbon contents of various Earth's rocks:

Representative rocks of global Earth's rocks (mainly from the Japan) selected to igneous rocks (plutonic and volcanic) have been analyzed carbon contents by the XRF instruments., where rocks are selected finally for significant carbon contents. The result shows that higher carbon contents are obtained at volcanic rocks (quenched) than plutonic rocks (slow cooled), and blackish colored rocks (mafic) than whitish feldspar-rich (felsic) rocks. It's obtained in this study that carbon contents are richer in colored mineral contents.

Carbon contents of lunar rocks:

The lunar samples are used reported data of the Apollo (U.S.A.) rocks and lunar meteorites. It has been explained that significant carbon contents of the brecciated rocks are caused by extra-lunar meteorites with higher carbon contents. In this study, however, lunar brecciated rocks have higher carbon contents (not by mineral kinds) than basalts less brecciated relatively. This shows in this study that lunar breccias formed rapid cooled by impacts contain much carbon contents on the Moon.

Carbon contents of meteorites and fluid-solidification:

It's reported previously that carbonaceous chondrites contain much higher carbon and water contents than ordinary chondrites. Present model explains that volatile molecules (water and carbon dioxides) of chondrites, however, have produced at extreme condition by collisions, followed material changes from fluids to solidified groundmass texture to combine with chondrule grains formed primordial carbonaceous materials finally. Fluid-state cannot be observed to be solidified quickly during shocked impact reaction, which is mixed with chondrules and crystalline grains to be formed fluid-solidified texture of chondrite meteorite.

Laser experiment for fluid-solidification:

Author has performed a laser sputter experiment on a target rock, to produce the rock texture with fluid-solidified micro-grains, which indicates that fluid-liquid phase is quenched to be solidified grains after laser irradiation. It's obtained in this study that carbon-bearing molecules are remained as solidified grains after quenched shocked impact process.

Shocked formation of carbon-bearing materials on Earth, Moon and Asteroids:

Carbon-bearing materials have been remained by fluid-to-solidified process at extreme condition of meteoritic collisions (on Earth, Moon and Asteroids). On the Earth, shocked reactions by earthquake and volcano produce carbon separation from carbon-rich rocks.

In this sense, huge amounts of global air and water of planet Earth are required to be formed by huge planetary collisions.

Summary:

Carbon-bearing solids remained at extreme condition are explained by fluid-solidified process on primordial Earth, the Moon and Asteroids, which has been confirmed in this study by sample analysis, carbon reported data, TEM observation and laser shocked experiments. The present results indicates that impact generation of carbon and fluid molecules (of carbon etc.) is obtained newly

on the Earth and the celestial bodies.

Keywords: State-change, Carbon bearing-materials, Earth, Moon and Meteorites

Partial melting experiments of CO₂-H₂O-bearing peridotite: Genesis of carbonatite as an inorganic source of phosphorus

Aya Ozawa¹, *Tetsu Kogiso¹, Tetsuo Kawakami¹

1.Kyoto Univ.

Phosphorus is one of the biologically essential elements. Because phosphorus is nonvolatile and insoluble to water on the Earth's surface, all phosphorus available for the biosphere should have been supplied from the solid Earth. Thus the supply of phosphorus from the solid Earth has been one of the essential mechanisms that have had a great influence on the birth and evolution of life. On the modern Earth, weathering and erosion of continental rocks are the main process of phosphorus supply to the biosphere. However, it is not certain how much and what kind of continental rocks existed on the early Earth, and therefore it's difficult to know the main process of phosphorus supply then.

On the other hand, there are several types of rock that contain much more abundant phosphorus than ordinary continental rocks. One of the phosphorus-rich rocks is carbonatite, which consists mainly of carbonate minerals and contains up to > 10 wt.% of P₂O₅. Although the abundance of carbonatite is very small, it can be a main source of phosphorus on the Earth's surface because it is easy to be weathered due to vulnerability of carbonate minerals to weathering. Previous experimental studies have demonstrated that carbonatite melt can be generated from peridotite at pressures higher than 2 GPa under CO₂-H₂O saturation, but it's not clear whether such mantle-derived carbonatite melt could have phosphorus concentration as high as in natural carbonatites. In this study, we determined phosphorus concentration in mantle-derived carbonatite melt by high-pressure melting experiments on CO₂-H₂O-bearing primitive peridotite, and examined probable processes that lead to very high concentration of phosphorus in carbonatite melt like observed in natural carbonatites.

We conducted melting experiments on KLB-1 peridotite composition with 10 wt.% oxalic acid, using a piston-cylinder apparatus at 2.5 GPa and 1100-1250°C. The experimental charges were analyzed with an EPMA and a SEM-EDS. We obtained carbonate melt with < 4 wt.% SiO₂ at 1150°C, and silicate melt with ~32 wt.% SiO₂ at 1200°C. The carbonate melt of 1150°C contained 0.15 wt.% P₂O₅. A mass balance calculation demonstrated that the degree of melting was ~ 10 wt.% and that the bulk partition coefficient of P₂O₅ was 0.11 at 1150°C. These results indicate that carbonatite melt, if it's generated at much lower degrees of melting, could have ~0.3 wt.% P₂O₅, which is much lower than the values observed in natural carbonatites. Thus, some process other than partial melting of CO₂-H₂O-bearing peridotite is necessary to explain the very high phosphorus concentrations in natural carbonatites. One of the possible processes is melting of phosphorus-rich peridotite metasomatized by mantle-derived carbonatite melt. This process could have occurred in subduction zone environments in the early Earth. The details of such a process will be discussed in the presentation.

Keywords: high pressure experiment, carbonatite, phosphorus

Effect of duplex slab melting for the production of mantle heterogeneity: implications from Sr, Nd and Pb isotope geochemistry for Aono volcanic groups in the SW Japan arc

*Gen Shimoda¹, Hironao Shinjoe², Tetsu Kogiso³, Osamu Ishizuka¹, Katsuyuki Yamashita⁴, Miwa Yoshitake⁵, Jun'ichi Itoh¹, Masatsugu Ogasawara¹

1.Geological Survey of Japan, AIST, 2.Faculty of Business Administration, Tokyo Keizai University, 3.Graduate School of Human and Environmental Studies, 4.Graduate School of Natural Science and Technology, Okayama University, 5.Tokyo Urban Tech

The early continental crust is characterized by the existence of tonalite-trondhjemite-granodiorite (TTG), thought to have formed in subduction zone either by melting of subducted oceanic crust or melting of thickened oceanic crust due to imbrication and accretion of oceanic crust. In the early '90s, modern equivalents of TTG were given the name "adakites", following the definition of magmas from Adak Island. As the adakites closely relate to hot subduction zones, they are considered to be products of slab melting. In addition to the oceanic crust, sediments are important constituents of the subducted slab. As the sediments have lower solidus temperature than the oceanic crusts, the sediments could melt before or during the adakite productions. If this is the case, both subducted oceanic crust and sediments could have melted beneath hot subduction zones. As melts can effectively remove incompatible elements from slab, melting of oceanic crust and sediments would profoundly affect how the mantle heterogeneity has evolved throughout the Earth's history. The SW Japan arc is characterized by active subduction of a relatively young (15-26 Ma) segment of the Philippine Sea plate, Shikoku basin, beneath the Eurasian plate and is known for the occurrence of adakites on the quaternary volcanic front. It is also likely that this subduction was accompanied by melting of sediments to induce the Miocene forearc volcanism. Hence, the SW Japan arc should be a suitable example to evaluate the role of melting of oceanic crust and sediments. In this paper, we will present new results of isotopic and trace element analyses of adakites from Aono volcanic group in the SW Japan and discuss behavior of the subducted crustal material at hot subduction zone.

Molybdenum isotope analysis using anion and cation exchange resins and MC-ICP-MS

*Kosuke T. Goto¹, Gen Shimoda¹, Shogo Aoki², Akira Ishikawa²

1.Geological Survey of Japan, 2.University of Tokyo

In the past 15 years, molybdenum stable isotope ($\delta^{98/95}\text{Mo}$) has become a valuable tool for assessing plaeo-ocean redox conditions (Arnold et al., 2004 Science; Dahl et al., 2010 PNAS). To measure Mo isotopic compositions in Fe and Mn rich samples, we conducted (1) chemical purification of reference Mn nodules (JMn-1, Nod P-1, and Nod A-1) by two-stage of ion exchange chemistry (AG1X-8 and AG50WX-8)(Barling et al., 2001 EPSL; Gordon et al., 2009 Geology), and (2) isotope measurements of spiked Mo standard solutions (NIST 3134 and Alfa Aesar Specpure standard solution), using multi-collector inductively coupled plasma mass spectrometry (MC-ICP-MS, Thermo Fisher Scientific Neptune) at Geological Survey of Japan. The yields during the column chemistry were better than 95%. Although isobaric interferences on Mo masses are possible from Fe (or Fe argide), Zr, and Ru (Siebert et al., 2001 G-cubed; Malinovsky et al., 2005 Int. J. Mass Spectrom.), their concentrations in the purified samples were comparable to our chemical procedural blank values. The difference in $\delta^{98/95}\text{Mo}$ between NIST 3134 and the Alfa Aesar standard solution was $0.17 \pm 0.14\%$. The observed offset was consistent with previously reported values ($0.12 \pm 0.11\%$; Greber et al., 2012 Geostand. Geoanal. Res.). Hence, accurate and high precision Mo isotope measurements of Fe-Mn oxides are possible using the anion and cation exchange resins and MC-ICP-MS. In the presentation, we will also report new $\delta^{98/95}\text{Mo}$ data of hydrothermal Mn and Fe crusts based on this method.

Keywords: Molybdenum