

## Trace element composition in zircons from A-type granitoids in the Cape Ashizuri, SW Japan: Implications for new source rock index using zircon

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Trace element composition in zircon is expected to be an important indicator of composition of host magma, especially of Hadean detrital zircons (e.g. Grimes et al., 2007). Some Hadean detrital zircons are suggested to be formed in continental crustal magma (e.g. Valley et al., 2005; Grimes et al., 2007), however, detail composition of host magma is still unveiled. Recent discoveries of granitic clast in meteorites in Early Solar System (lunar, HED and LL meteorite) showing anhydrous, alkali-rich A-type granitic affinities (e.g. Warren et al., 1983; Bonin et al., 2002; Terada and Bischoff, 2009) implies that A-type granitic rocks were present in the Hadean Earth (Bonin et al., 2007). Therefore, it is important to know trace element characteristics in zircons from A-type granite for exploring evidence of the ancient A-type granitic rocks.

To obtain primary features of trace element composition in zircons from A-type granite, we conducted *in-situ* LA-ICP-MS trace element analysis for 47 zircon grains from 4 samples of rapakivi granite, Qtz-syenite and melanocratic syenite in the Ashizuri complex. These alkalic granitoids in Ashizuri complex have characteristics of A-type granite (Loiselle and Wones, 1979) and within-plate granite (Pearce et al., 1984), and is suggested to be formed dominantly by crystal fractionation process from OIB-type basaltic magma (Stein et al., 1996).

Zircons from the Ashizuri A-type granitoids show oscillatory zoning, homogeneous dark core, disturbed texture and patchy texture in Cathodoluminescence images. Based on the typical igneous REE patterns (HREE enrichment, negative Eu anomaly and positive Ce anomaly) and its similarity each other in zircons from rapakivi granite and Qtz-syenite, it is suggested that the trace element composition of the zircons reflect those of the host magma. On the other hand, some zircons in melanocratic syenite show large variations of REE pattern and include obvious inherited cores, which imply contamination of surrounding rocks to host magma. To clarify characteristics of zircons crystallized from A-type granitic magma, we only use data from the rapakivi granite and the Qtz-syenite for comparison with previous data from other type (S-, I-, M-type) granitic rocks.

The magmatic zircons from the Ashizuri A-type granitoids show large Eu negative anomalies ( $Eu/Eu^* = <0.004 - 0.070$ ), high Nb contents (2.85 -236 ppm), relatively high Y (423 -13520 ppm) and U contents (171 -7908 ppm), and relatively low Sr contents (0.08 -2.38 ppm). These trace element feature in the zircons probably reflect high HFSE, low Eu and Sr concentration in the host A-type granitic magma. The geochemical characteristics of the zircons from Ashizuri complex become more distinct in  $Eu/Eu^*$ , Nb/Sr, U/Sr, Y/Sr cross-plot diagram, showing lower  $Eu/Eu^*$ , higher Nb/Sr, U/Sr and Y/Sr ratio compared to those in zircons from other type granitic rocks. Previous trace element data in zircons from A-type granitoids in Delamerian Orogen, South Australia (Pankhurst et al. 2013) is also plotted on similar area to the Ashizuri A-type granitoids in  $Eu/Eu^*$  vs. Nb diagram. Because high HFSE, low Eu and Sr contents are common feature in the A-type granitic rocks, these diagrams are probably useful for distinguish zircons crystallized in A-type granite from those in other granitic rocks.

Keywords: Zircon trace element composition, A-type granite, LA-ICP-MS, the Cape Ashizuri, SW Japan



## Geochemistry of monazite in granitic rocks from Japanese island arc

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Monazite is a one of rare earth element (REE)-rich phosphate mineral and commonly occurs in pelitic metamorphic rocks and peraluminous igneous rocks (Williams et al., 2007). Geochemistry of metamorphic monazite has been intensively investigated using laser ablation-inductively coupled plasma-mass spectrometry (LA-ICPMS) and its REE pattern, especially Eu negative anomaly ( $[Eu/Eu^*]_N$ ) and heavy REE (HREE) depletion ( $[Gd/Lu]_N$ ), is linked to the crystallization condition (e.g., Rubatto et al., 2006). In contrast, the geochemical investigation of igneous monazite has been mainly carried out using electron-microprobe analysis (EMP) (e.g., Kelts et al., 2008). Hoshino et al. (2012) analyzed the monazites in granites and pegmatites from Japan by EMP. They found that the ratios of light REE (LREE) to middle REE (MREE) on the monazites are different between ilmenite- and magnetite- series granitic rocks, which was interpreted to reflect the different degree of differentiation. Yet, the determination of Eu and HREE abundances have not been carried out due to the interference and low-concentrations during EMP analysis. In this study, we have used LA-ICP-MS to measure Eu and HREE abundances in the monazites and examined whether Eu anomaly and HREE depletion exhibit consistent variations with LREE or not. The results of monazite REE analysis using LA-ICPMS shows distinct REE patterns between the monazites from ilmenite-series and magnetite-series granitic pegmatites. The Eu negative anomalies of the igneous monazites were significantly large ( $[Eu/Eu^*]_N < 10^{-3}$ ) relative to those of metamorphic monazites. This feature may be used as indicator to distinguish between a monazite in pegmatite and a one in metamorphic rock. Among the monazites of the two series, the  $[Eu/Eu^*]_N$  values of ilmenite-series monazites are larger by one or two orders of magnitude than those of magnetite-series monazites. The REE patterns of monazites in ilmenite-series rocks display moderate decrease from La to Gd relative to those of monazites in magnetite-series rocks; in contrast, the monazite REE patterns of ilmenite-series rocks show prominent decrease from Gd to Lu relative to those of magnetite-series rocks. These different features in REE patterns between monazites from ilmenite-series and magnetite-series would reflect the degree of differentiation and imply that the formation of ilmenite-series rocks is attributed to not only assimilation of sediments but also crystal fractionation, especially the fractionation of minerals incorporating HREEs relative to MREEs. The relatively enriched MREE and depleted HREE abundances in ilmenite-series monazite cannot be explained simply by assimilation of subducted sediments, which are enriched in both MREE and HREE (Plank and Langmuir, 1998). This inference is consistent with the differences of O, Sr and Nd isotopic features between two-series granitic rocks (Takagi, 2004). We consider that fractional crystallization of the minerals enriched in HREE relative to MREE (e.g., garnet) subsequent to sedimentary assimilation defines the characteristic monazite REE patterns of the magnetite-series and ilmenite-series granitic rocks in Japanese island arc.

Keywords: REE, trace element, LA-ICP-MS

## Highly siderophile element variations in the Ontong Java Plateau basalts

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The Early Cretaceous Ontong Java Plateau is widely recognized as a product of the largest igneous activity on the Earth, and its formation and evolution has been investigated by multidisciplinary approaches in order to understand large igneous provinces (LIPs) in general. Recent geochemical studies suggest that the Ontong Java Plateau has sampled a near-primitive, less degassed deep mantle reservoir that has remained isolated from convecting upper mantle shortly after the formation of the Earth. Since such primitive reservoir is possibly only available at the base of lower mantle in the modern Earth, the plateau-forming lavas may have characteristic compositions of highly siderophile elements reflecting the deep-plume source likely influenced by core formation or core-mantle interaction. Here we report comprehensive dataset of Re-Os isotopes and highly siderophile element (HSE: Os, Ir, Ru, Pt, Pd and Re) concentrations for all three distinct geochemical types of the Ontong Java Plateau basalts. They are comprised of 11 samples of the less evolved Kroenke-type lavas (>8 wt.% MgO) from two deep sea drill sites (ODP Sites 1185 and 1187), 22 samples of the more dominant Kwaimbaita-type basalts (<8 wt.% MgO) from three drill sites (ODP Sites 1183, 1185 and 1186) and on-land exposure in Malaita, Solomon Islands and 22 samples of less voluminous Singgalo-type basalts (<8 wt.% MgO with a few exceptions) forming younger cover on the Kwaimbaita-types lavas at an ODP Site 807 and Malaita. All of Kroenke- and most of Kwaimbaita-type basalt data yield a linear array on the Re-Os isochron diagram corresponding to an age of  $121.5 \pm 3.1$  Ma and initial  $^{187}\text{Os}/^{188}\text{Os}$  ratio of  $0.1304 \pm 0.0049$ , almost identical to those reported in previous studies. Singgalo-type basalts tend to show variably radiogenic initial  $^{187}\text{Os}/^{188}\text{Os}$  ratios, indicating contributions of enriched components either derived from surficial environments or from radiogenic pyroxenitic source. Significant contributions of pyroxenitic source is inferred from the observation that Singgalo-type lavas have distinctively lower platinum-group element (PGE) abundances when compared with similarly evolved Kwaimbaita-type basalts, although sulfide-fractionation may have played a role on their depletions. The chondrite-normalized HSE patterns of Kroenke- and Kwaimbaita-type basalts show broadly similar IPGE-depleted and PPGE-enriched patterns typical of sulfur-undersaturated tholeiitic basalts. However, the two types can be distinguished by contrasting Os and Ru abundances (Kroenke: high, Kwaimbaita: low) probably reflecting the different degrees of olivine/spinel fractionation. Since the observed HSE fractionation trend (particularly Ir variation) is significantly different from those identified for Hawaiian picrites or Archean komatiites, further constraints on HSE behavior during magma evolution are clearly required for estimating HSE compositions of primitive magma and source mantle.

Keywords: Large Igneous Provinces, basalt, Platinum-group elements

## Os isotope ratios and PGE abundances of the Pitcairn basalts: Implication for the EM-1 source

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It is widely known that subduction recycled materials are involved in producing the chemical and isotopic heterogeneities observed in oceanic island basalts (OIB). The type of recycled material present in the Enriched Mantle 1 (EM-1) source, which have radiogenic Sr, unradiogenic Nd, and unradiogenic Pb isotope compositions compared to those of depleted mantle source, has been widely debated. Oceanic crust with pelagic sediment (e.g., Chauvel et al., 1992), delaminated subcontinental lithospheric mantle (SCLM) (e.g., Hauri and Hart, 1993), subducted oceanic plateaus (Gasperini et al., 2000) and just single melting process involving pristine mantle (Collerson et al., 2010) have all been invoked as the EM-1 source. The rocks from Pitcairn hotspot are well known to have a strong EM-1 flavor. Recently, Garapic et al. (2015) suggested that the high Ti abundances in the Pitcairn basalts are possibly related to recycled pyroxenites in the Pitcairn mantle source. We have measured Os isotope ratios and major and trace element abundances including the platinum group elements (PGE) in the basalts from Pitcairn Island to elucidate the origin of the EM-1 signature of these basalts.

The Os isotope ratios for the samples with Os > 20 pg/g range from 0.135 to 0.152 and are similar to those measured in previous studies on EM-1-type basalts (~0.150 for samples with Os > 50 pg/g and ~0.180 with Os > 20 pg/g from Reisberg et al., 1993; Eisele et al., 2002; Garapic et al., 2015). The Os, Ir and Ru concentrations of the Pitcairn basalts are roughly correlated with MgO and Ni contents and tend to be lower than those of other OIB such as Hawaii and Canary Islands. Whereas Pd and Re concentration are similar to those for other OIBs. The chondrite-normalized PGE patterns of studied samples show systematic variation with or against the degree of the EM-1 flavor (e.g., decreasing of the  $^{206}\text{Pb}/^{204}\text{Pb}$  and  $^{143}\text{Nd}/^{144}\text{Nd}$  isotope ratios). Since crustal materials normally show large fractionation between I-PGE and P-PGE and the crustal materials have higher Os isotope ratios than mantle, the simple assimilation of crustal materials cannot explain our data. We carefully try to make an assumption of the source magma components to explain the genesis of Pitcairn Island basalts based on our data combined with previous studies.

Keywords: PGE abundances, Os isotope ratio, EM-1

## Geochemical study of melt inclusions in Pitcairn basalts, South Pacific

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The existence of water and volatile element is important in thinking about mantle dynamics, and a lot of trials limiting volatile element content and distribution in mantle from the volcanic rock from mantle are made. In this study, we analyzed major element, trace element, volatile element, lead isotope at local site for the olivine melt inclusions that they were thought that had volatile element. As a result, we obtained a preliminary result about melt inclusions from the Pitcairn island, South Pacific. The isotope composition of the volcanic rocks of Pitcairn island show composition range to EM1 from DM. We chose two EM1-like basalt rock samples of PC-41 and PC-87A in this study, and prepared melt inclusions more than 50 $\mu$ m to analyze a local site by some analyzers. Each melt inclusion varied in a characteristic, and there were two kinds which crystallized amphibole and ilmenite and crystallized euhedral clinopyroxene in melt inclusions of PC-41. Melt inclusion of PC-87A includes homogeneous glass or dendritic clinopyroxene equally. Therefore the analysis domain set it from the mineral which crystallized to the maximum in remote glass or the foundation stone domain. Firstly we measured volatile elements (H<sub>2</sub>O, CO<sub>2</sub>, F, P, S, Cl) at a 30 $\mu$ m diameter and lead isotope at a 30 $\mu$ m diameter using SIMS (IMS 1280-HR). In the next place, I measured main element at 10 $\mu$ m diameter using FE-EPMA. Finally I measured about a major element and trace element at 20 $\mu$ m or a 30 $\mu$ m diameter using LA-ICP-MS. There was not the difference with PC-41 and PC-87A about lead isotope ratio, and they were in the isotope ratio range same as all rocks. However, there was difference in both about the elementary composition. Compared with MgO and other major elements, PC-87A shows in same trend as all rock composition, but PC-41 clearly shows two different trends. Because these two trends of PC-41 relate to the difference in crystallized out minerals, they separated by crystallization after melt inclusions trapped by olivine. In adding PC-41 is congruent with crystallization advancing to MgO being lower than PC-87A more in PC-41. About trace elements, PC-87A accorded for the composition of all rocks, however there was different composition from like PC-87A in PC-41. Difference of two compositions in PC-41 were not concerned with crystallization and major elements. The latter has low HREE in characteristically, this seems that the melt coexisted with garnet under high pressure flows into the magma reservoir and produces heterogeneity of the composition in magma reservoir. About volatile elements, there is remarkable difference of quantity of H<sub>2</sub>O in PC-41 and PC-87A. PC-41 has 0.03-0.10 wt.% and a low value whereas PC-87A has 0.37-0.81 wt.% . CO<sub>2</sub> does not maintain original value by degassing and enrichment of the gas phase. Halogen elements is hard to relatively degass, for example Cl has high 570-1700ppm and correlates with H<sub>2</sub>O and other trace elements, and seems reflect composition of the mantle source. In conclusion, quenched homogeneous melt inclusions such as PC-87A seems maintain information of deep mantle, and are important in estimating H<sub>2</sub>O and volatile elements composition from melt inclusions in the mantle source. Melt inclusions crystallized out well such as PC-41, however, greatly lost H<sub>2</sub>O in degassing and diffusive process and are difficult to estimate composition of the primary magma.

## Origin of geochemical mantle reservoirs: Roles of subduction filter and thermal evolution of mantle

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Upwelling mantle melts at Mid-Ocean Ridges (MOR) to form basaltic igneous oceanic crust (IOC). IOC and overlying sediment (SED) descend into the mantle at subduction zones (SZ). The IOC, SED, and overriding mantle melt to form stable continental crust (CC) after crustal-level processing, whereas the residual slab is recycled into the lower mantle. We quantitatively explore the element re-distributions at MOR and SZ using numerical mass balance models, and we evaluate their roles in the Earth's geochemical cycle. Our models of slab residues differ from previous ones by being internally consistent with geodynamic models of modern arcs and successful explanations of modern arc magma genesis, and by including element fluxes from the dehydration or melting of each underlying slab component. We find that the upper mantle potential temperature ( $T_p$ ) was 1400–1650 °C from 3.5 to 1.7 Gyr before decreasing gradually to ~1300 °C today. Hot SZs with  $T_p$  ~1600 °C have a thermal structure like modern SW Japan where high-Mg andesite is formed that is like CC. Isotopically, residual IOC from hot SZ evolves to the HIMU OIB reservoir, residual SED to EMII, the residual base of the mantle wedge to EMI, and the residual top of the mantle wedge to the subcontinental lithosphere (SCLM) reservoir, after 1.7–2.5 Gyr of storage in the lower mantle. The Common (C) or Focal Zone (FOZO) reservoir is a stable mixture of the first three residues. Older recycled residues (~2.5 Gyr) form the DUPAL anomaly in the southern hemisphere, whereas younger ones (~1.7 Gyr) are in the northern hemisphere. These ages correspond to major CC forming events. We attribute the E-W heterogeneity of the depleted upper mantle (DMM) to involvement of sub-Gondwana SCLM except in the Pacific.

Keywords: Mantle reservoir, Subduction zone filter, Thermal evolution of mantle

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

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### 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 CO<sub>2</sub>-H<sub>2</sub>O-bearing peridotite: Genesis of carbonatite as an inorganic source of phosphorus

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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 P<sub>2</sub>O<sub>5</sub>. 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 CO<sub>2</sub>-H<sub>2</sub>O 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 CO<sub>2</sub>-H<sub>2</sub>O-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.% SiO<sub>2</sub> at 1150°C, and silicate melt with ~32 wt.% SiO<sub>2</sub> at 1200°C. The carbonate melt of 1150°C contained 0.15 wt.% P<sub>2</sub>O<sub>5</sub>. A mass balance calculation demonstrated that the degree of melting was ~ 10 wt.% and that the bulk partition coefficient of P<sub>2</sub>O<sub>5</sub> 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.% P<sub>2</sub>O<sub>5</sub>, which is much lower than the values observed in natural carbonatites. Thus, some process other than partial melting of CO<sub>2</sub>-H<sub>2</sub>O-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

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The early continental crust is characterized by the existence of tonalite-trondjemite-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

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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