

## Chemical compositions and age of the Yusubaru Granite, eastern part of northern Kyushu

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The Yusubaru Granite, distributed in the eastern part of the Cretaceous granitic rocks in northern Kyusyu, is divided into main facies, melanocratic porphyritic facies and leucocratic facies. The main facies is fine-grained massive biotite to two-mica granite. The melanocratic porphyritic facies consists of medium-grained porphyritic hornblende-biotite granodiorite. The leucocratic facies mainly consists of fine- to coarse-grained massive two-mica granite, and rarely contains garnet. The main and leucocratic facies show continuous chemical change trends. Thus, they were derived from same magma. The melanocratic porphyritic facies show big change of texture and modal composition in a body, and show chemical compositions between main facies and hornblende-biotite granodiorite distributed in the Masaki Granite. Thus, this facies was formed by mixing main facies magma and granodioritic magma intruded into magma chamber of the former. The main facies and granodiorite distributed in the Masaki Granite give zircon U-Pb ages of 98.6 +/- 0.9 Ma and 98.7 +/- 0.6 Ma, respectively. These ages are clearly younger than that of the Soeda Granodiorite (107.4 and 103.1 Ma) and Masaki Granite (103.7 Ma) reported by Yuhara et al.(2015). This suggests that both magma intruded at same time during the last stage of granitic activity in the Cretaceous granitic rocks in eastern part of northern Kyusyu.

Keywords: Yusubaru Granite, Zircon U-Pb age, Cretaceous granitic rocks in northern Kyusyu

## Heterogeneity of source material beneath an ocean island: A preliminary case study of Rarotonga Island

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### [Introduction]

Geochemical endmembers of Earth's mantle, such as HIMU and enriched mantles (EM1 and EM2), have been identified based on the systematics of radiogenic isotopes such as Sr, Nd and Pb isotopes in ocean island basalts (OIBs). Instead of previous whole-rock geochemical studies of OIBs, melt inclusions in OIBs are intensively analyzed to constrain the concentration and isotopic composition of volatiles in primitive melt derived from each geochemical endmember in the mantle. Here, we report the preliminary analytical results of melt inclusions collected from Rarotonga Island of the Cook-Austral archipelago in the South Pacific.

### [Studied samples and analytical methods]

We analyzed olivine-hosted melt inclusions in Rarotonga basalts that erupted during an earlier stage of volcanism at 2.3-1.6 Ma. Melt inclusions were found to be suffering from 5-15 wt.% post-entrapment overgrowth of olivine and post-entrapment crystallization of daughter minerals such as clinopyroxene. We examined the analytical results, taking such post-entrapment geochemical modifications into consideration.

First, we analyzed the volatile concentrations and Pb isotopic compositions of the glass phase of five melt inclusions using a secondary ion mass spectrometer (SIMS). Then, we analyzed the major element compositions of the glass phase of melt inclusions using an electron probe micro analyzer (EPMA). Finally, we analyzed the trace element compositions and Pb isotopic compositions of melt inclusions using a laser ablation inductively coupled plasma mass spectrometer (LA-ICP-MS).

### [Analytical results]

Various geochemical data (major elements, trace elements, volatiles and Pb isotopic compositions) have been obtained from two melt inclusions (rtg13-mi2 and rtg41-mi1) to date. The saturation pressures of rtg13-mi2 and rtg41-mi1 are >10 MPa and >12 MPa, respectively, based on systematics of CO<sub>2</sub> and H<sub>2</sub>O concentrations of the melt inclusions, which suggests that these degassed melt inclusions were trapped in olivine at shallow crustal levels. We cannot exclude the possibility that Cl and H<sub>2</sub>O concentrations were modified to a greater or lesser extent due to assimilation by seawater and/or brines and degassing. In this paper, we focus on the ratio of F to Nd (F/Nd), because F is unlikely modified by assimilation and/or degassing, and Nd has a similar mineral-melt partition coefficient to F during mantle melting and magmatic differentiation processes. The values of F/Nd are 17 and 28 for the melt inclusions rtg13-mi2 and rtg41-mi1, respectively, which differ significantly from each other (Figure).

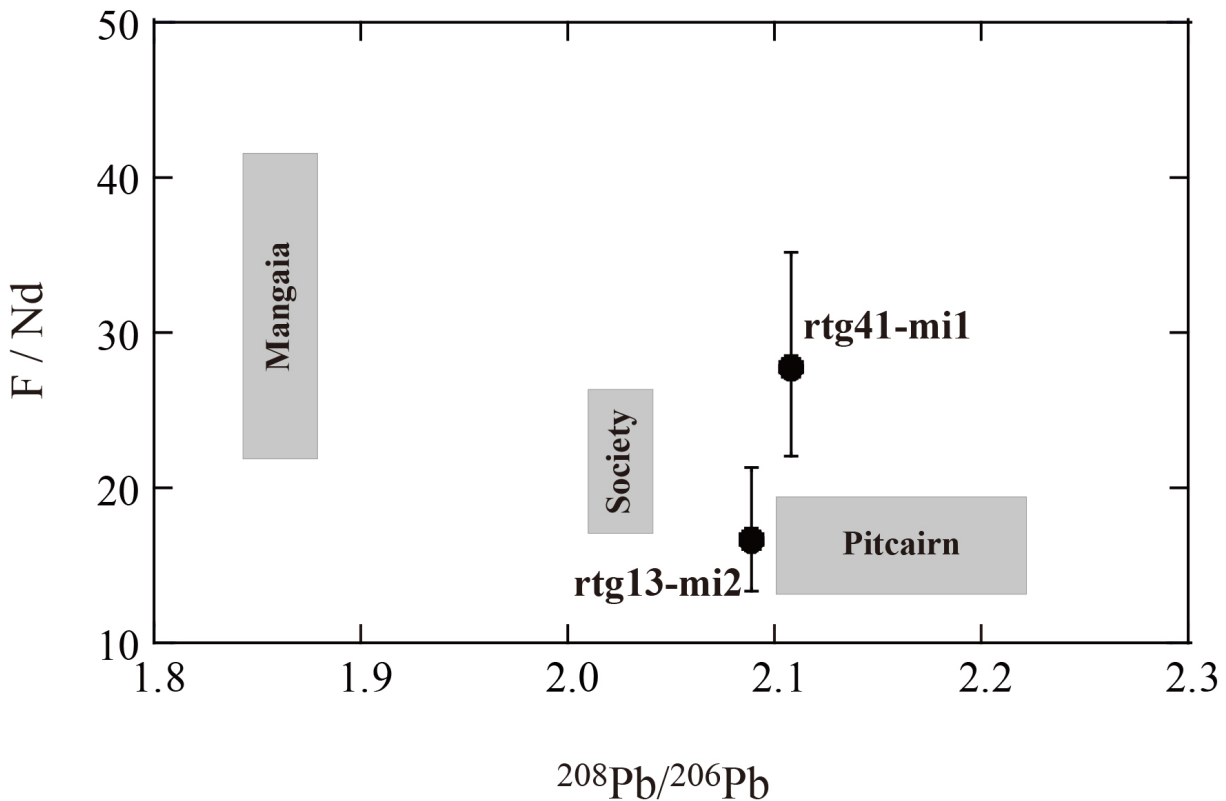
As regards Pb isotopic compositions,  $^{208}\text{Pb}/^{206}\text{Pb}=2.0888\pm 0.0026$  and  $^{207}\text{Pb}/^{206}\text{Pb}=0.8355\pm 0.0015$  for rtg13-mi2 and  $^{208}\text{Pb}/^{206}\text{Pb}=2.1078\pm 0.0035$  and  $^{207}\text{Pb}/^{206}\text{Pb}=0.8504\pm 0.0029$  for rtg41-mi1. These values are also significantly different from each other, though they are within the reported variation of whole-rock Pb isotope compositions of Rarotonga basalts (Figure).

### [Discussion]

The difference in F/Nd values for two melt inclusions cannot be explained by differences in the degree of melting and/or degree of crystallization, but could reflect differences in F

concentration in the source materials. A possible explanation for the differences in the F/Nd ratio and the Pb isotopic compositions between the two melt inclusions is that recycled slabs with different degrees of dehydration are involved with source materials beneath Rarotonga Island, which produces geochemical heterogeneity of volatile and Pb isotopic compositions. The two melt inclusions from Rarotonga Island have similar geochemical features to those of Pitcairn Island (EM1) but could also be influenced by other geochemical endmembers such as EM2 (e.g., Society Islands) and/or HIMU (e.g., Mangaia Island) (Figure).

Keywords: Ocean Island Basalt, Rarotonga Island, Secondary Ion Mass Spectrometry



Hydrothermal alteration of andesite from the Hatoma Knoll in the southern Okinawa Trough at 325 C, 300 bars: Comparison of chemical composition of hydrothermal fluid in the laboratory experiment and in the natural system

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The formation of seafloor massive sulfide deposits is closely related to the chemical compositions of (sub)seafloor hydrothermal fluid. Water-rock interaction between hydrothermal fluid and intermediate to felsic rocks is a dominant process that controls the fluid compositions in the arc and back-arc hydrothermal systems, although the process has not been experimentally examined yet in detail. Therefore, we reacted the NaCl solution with an andesite collected from the Hatoma Knoll field in the southern Okinawa Trough during the KY14-02 Cruise by R/V Kaiyo under high-pressure and -temperature conditions. The results show that the concentrations of selected elements (e.g., K, Si, and Ca) in the reacted fluid obtained by the experiment are inconsistent with those of the previously reported hydrothermal fluids from the Hatoma Knoll whereas the pH value in the reacted fluid is similar to the observed value in the hydrothermal field. The discrepancies in the fluid composition between the laboratory experiment and the Hatoma Knoll field suggest that the reaction zone of the field is not only composed of andesite.

Keywords: the Hatoma Knoll hydrothermal field, andesite, Hydrothermal alteration

## TEM observation of rainbow garnets from Tenkawa, Nara Prefecture, Japan

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Grossular ( $\text{Ca}_3\text{Al}_2\text{Si}_3\text{O}_{12}$ ) - andradite ( $\text{Ca}_3\text{Fe}^{3+}_2\text{Si}_3\text{O}_{12}$ ) garnet solid solutions, termed grandite series, generally occur in skarns. Grandites often exhibit optical birefringence, iridescence, and oscillatory zoning. "Rainbow garnet" is a variety name for the iridescent  $\text{Fe}^{3+}$ -rich grandite. Shimobayashi et al. (2005) examined the iridescent garnets (rainbow garnets) from Tenkawa, Nara Prefecture, Japan. They reported that they consist of  $\{110\}$  growth sectors with banding textures parallel to  $\{110\}$  faces that looks like the oscillatory zoning, and that wavy lamellae (ca. 10-20  $\mu\text{m}$  in thickness) across the  $\{110\}$  bandings were observed. In addition, their TEM observation revealed the presence of fine lamellar texture (ca. 100-300 nm in thickness) with small differences in chemical composition (Al/ $\text{Fe}^{3+}$  ratio) within the wavy lamellar zone. Shimobayashi et al. (2005) demonstrated that the multilayer interference of light with these periodic fine lamellae originate the iridescence. They also suggested that the thinner lamella (ca. 20 nm in thickness) in the fine lamellar texture should be reduced in symmetry from cubic system, but they did not show the direct evidence of the symmetry reduction. Crystalline symmetry of the iridescent garnets is still uncertain. In this study, we analyzed the microstructures in iridescent garnets from Tenkawa. We used optical microscope, SEM (JEOL: 7001F, JXA-8105) and TEM (JEOL JEM-2100F) with EDS detector to investigate the symmetry reduction of the rainbow garnets. A thin section (100 $\mu\text{m}$  in thickness) cut parallel to the (001) face through the center of the crystal was prepared from an euhedral single crystal of rainbow garnet with well-developed rhombic dodecahedral  $\{110\}$  facets from Tenkawa, Nara Prefecture, Japan. A TEM specimen perpendicular to the  $\{110\}$  growth bands was prepared from the thin section by using a focused ion beam technique (FIB, FEI: Quanta 200 3DS). The present (001) thin section consists of four  $\{110\}$  growth sectors. We observed  $\{110\}$  growth bands with wavy lamellae across them and  $\{110\}$  fine lamellae in each sector, as well as reported by previous researchers (Shimobayashi et al., 2005). The wavy lamellae texture consist of thicker Al-rich lamellae (widths of approximately 10-20  $\mu\text{m}$ ) and thinner Al-poor lamellae (widths of approximately 1-2  $\mu\text{m}$ ). Part of fine lamellae parallel to the  $\{110\}$  growth bands has been observed within in wavy lamellar zone. The fine lamellae texture also consists of thicker Al-rich lamellae (100-300 nm in thickness) and thinner Al-poor lamellae (ca. 20 nm in thickness). The fact that the fine lamellae cut across the interfaces of wavy lamellae and continuously elongate shows that the former should be formed after the latter, as pointed out by Shimobayashi et al. (2005). There is a clear zone (widths of approximately 3  $\mu\text{m}$ ) in which the fine lamellae could not be clearly observed in the present TEM specimen used. Electron diffraction patterns obtained from this lamellar-free zone reveals that the Ia-3d symmetry retains as the usual garnet and extra reflections did not appear. On the other hand, in the electron diffraction patterns from the area with the  $\{110\}$  fine lamellar texture, extra reflections 110, 200, 411 and so on to break the symmetry of space group (Ia-3d) can be detected, indicating that a-glide and d-glide planes should be lost. The dark-field imaging using a 110 reflection shows that only Al-rich fine lamellae have the bright contrast. Therefore, thinner Al-rich fine lamellae should be changed to lower symmetry from Ia-3d. The symmetry inferred from the diffraction pattern with these extra reflections is considered as I23, Im3, I2<sub>1</sub>3, I43m, I432, or Im3m under the condition of cubic and I-lattice.

Reference

Shimobayashi et al. (2005) Abstracts of Annual Meeting of the Mineralogical Society of Japan ,p80.



## Maturity evaluation of source rocks using Raman and fluorescence spectroscopy

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Petroleum source rocks containing carbonaceous materials are called kerogens. There are some conventional methods to evaluate maturity of kerogens. For example, vitrinite reflectance ( $R_0\%$ ) has been widely used to evaluate maturity of carbonaceous materials. However, vitrinite reflectance has a limitation in a spatial resolution (10 micrometers) and requires time-consuming sample preparations.

As a complementary method, Raman spectroscopy has been applied to evaluate maturity of carbonaceous materials. Kouketsu et al. (2014)<sup>[1]</sup> proposed an analysis to separate Raman spectra of low-maturity carbonaceous materials into four bands (D1-, D2-, D3-, and D4-bands). However, it is extremely difficult to observe Raman spectra of much lower maturity carbonaceous materials because of fluorescence interference caused by functional groups and conjugated systems. This study aims to develop the versatile measure applicable to low-mature carbonaceous materials using complementary spectroscopic methods.

Kerogens extracted from cuttings and core samples from two wells (Shin-Ayukawa AK-1<sup>[3]</sup> and MITI Yurioki-Chubu, Akita prefecture) were analyzed. It was reported that the maturity data<sup>[3]</sup> of samples from Shin-Ayukawa increase drastically in the depth region (1550 m ~ 1950 m) because of dolerite intrusions (Waseda et al., 1995). The values of vitrinite reflectance data were measured over 100 points per sample. Raman spectra were measured on the same points where vitrinite reflectance values were measured using a 514.5 nm Ar<sup>+</sup> laser for excitation with a power of 0.2 mW at the sample surface. Fluorescence spectra were obtained on a compact spectrometer (USB 2000, Ocean Optics) in a range of 515 nm ~ 850 nm. Infrared spectra of carbonaceous materials were obtained with a transmittance mode using an IR microscope. Mass spectra of hydrocarbons were extracted from cuttings samples.

Vitrinite reflectance data from Shin-Ayukawa ranged from 0.1% to 3.7% with increasing depth except for samples affected by dolerite intrusions. The slope values of Raman baseline decreased from 100 to 0.1 (counts / cm<sup>-1</sup>) with increasing vitrinite reflectance values in the whole range (Fig. 1). The values of full width at half maximum (FWHM) of Raman D2-band decreased from 110 to 50 (cm<sup>-1</sup>) with increasing vitrinite reflectance from 0.3% to 3.7%. The Raman bands of kerogens less than 0.3% of vitrinite reflectance cannot be detected. Fluorescence intensities of kerogens from Yurioki-chubu decreased with increasing vitrinite values reflectance from 0.1% to 0.6% (Fig.2). It should be noted that fluorescence spectra can apply for samples with low vitrinite reflectance where Raman bands cannot be detected. With increasing depth, intensities of infrared absorption bands assignable to amides and ethers became weak, while those of alkenes and aromatic rings became strong.

In summary, the fluorescence spectra inferred from the slopes of Raman spectra and its intensities show correlation with the vitrinite reflectance in the ranges of  $R_0 = 0.1\% \sim 3.7\%$  and depth of 1050 m ~ 4900 m. This study proposes a spectroscopic method applicable to lower maturity carbonaceous materials.

[1] Kouketsu *et al* (2014), *Island Arc*. 23, 33-50.

[2] Koutetsu *et al* (2015), *JpGU*.

[3] Waseda *et al.* (1995), *Res. Org. Geochem.* 10, 1-5.

Keywords: Raman spectroscopy, fluorescence spectroscopy, kerogens, carbonaceous materials

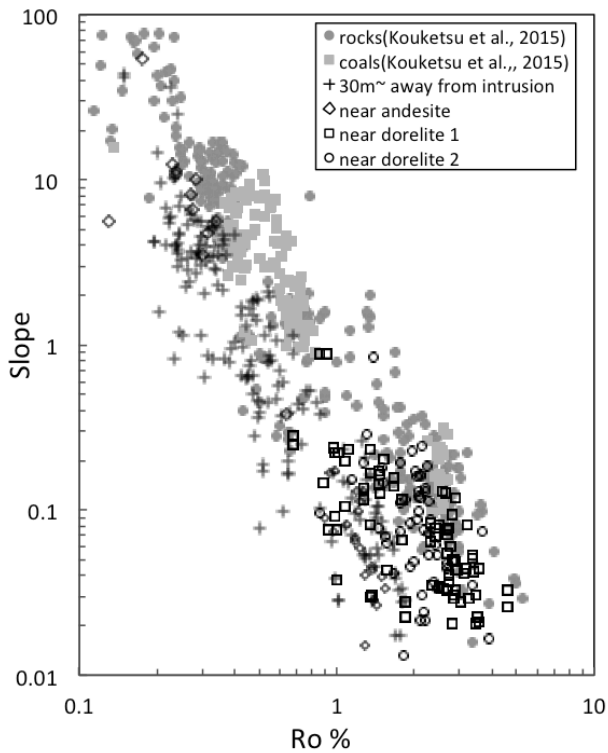


Fig.1 Correlation of vitrinite reflectance and slope of Raman baseline of kerogens from Shin-Ayukawa and previous study

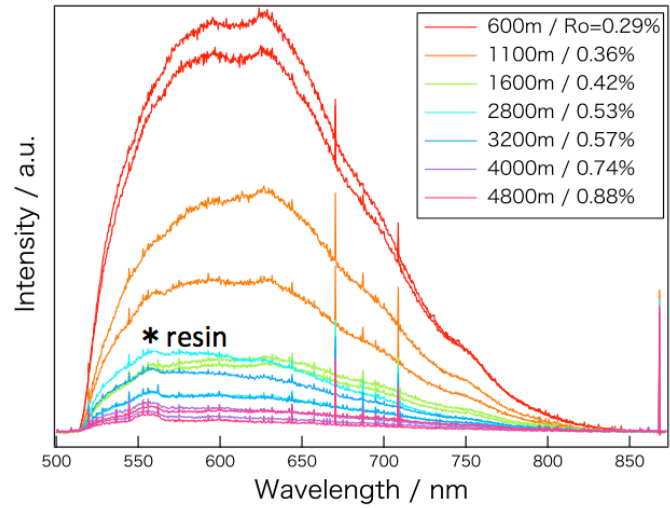


Fig.2 Fluorescence spectra of kerogens from Yurioki-Chubu



Occurrence and distribution of zeolites from Chichijima and Anijima, Ogasawara Islands, Japan.

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Ogasawara Islands located in the southern most area of the Izu-Bonin arc. It was known of occurring volcanic rocks with specific chemical composition and the various kinds of zeolites. These zeolites are formed by the hydrothermal alteration associated with the sea floor volcanic activity in Ogasawara Islands.

In this study, a boninite pillow lava in Chichijima and Anijima, Ogasawara Islands was focused. Sampling points were as follows: Chichijima (Miyanoama, Tsurihama, Hatsuneura and Kitabutakaigan), Anijima (Takinoura and the another point). At the sampling points, zeolite minerals and their host rocks were collected. The samples were characterized by XRF, XRD and SEM-EDS methods.

Chemical analysis shows Al/Si ratio range of the zeolite samples was 0.18-0.32, and that of the collected host rocks was 0.18-0.26. As the result of chemical analysis, it was considered that the zeolite minerals had been strongly influenced by the chemical compositions of the host rocks in Chichijima and Anijima.

Most of the zeolite minerals were classified to Ca-dominant type, and some of zeolite samples collected at coast areas were Na-dominant type. Later zeolite samples seems to have been replaced their exchangeable cations by seawater.

As the experimental results, it has been found that a zeolite which has been described as heulandite should be identified as clinoptilolite.

Keywords: zeolite, boninite, hydrothermal alteration, heulandite, clinoptilolite

## Sulfur Systematics in the Izena Hole Seafloor Hydrothermal Systems, Okinawa Trough: Stable Isotope, Mineralogy and Redox Equilibria

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Understanding of sulfur sources in seafloor hydrothermal systems is essential for the discussion of formation mechanisms of seafloor hydrothermal deposits. Sulfur sources in the Okinawa Trough seafloor hydrothermal systems, however, have been poorly discussed, because hemipelagic sediments cover makes the fluid-sediment interaction complicate compared with the sediment-starved hydrothermal systems. The Izena Hole in the mid-Okinawa Trough (27°15'N, 127°04'E, ~1500m in depth) has two active hydrothermal fields: thinly sedimented JADE-site and thickly sedimented HAKUREI-site. Comparing geochemical characteristics between these two sites enables us to evaluate the effect of fluid-sediment interaction (Kawagucci et al., 2010; Ishibashi et al., 2014). This study aimed to elucidate the sulfur sources and sulfur isotopic systematics in the Izena Hole by comparing the hydrothermal precipitates in JADE and HAKUREI-sites in terms of mineral assemblage, chemical composition and sulfur and oxygen isotope.

The active chimneys in JADE-site have Kuroko-type sulfide mineral assemblage including Fe-poor sphalerite, tennantite, galena, pyrite and chalcopyrite. In contrast, the active chimneys in HAKUREI-site are mainly composed of euhedral pyrrhotite, Fe-rich sphalerite, galena and isocubanite with chalcopyrite lamellae, in which mineralogical characteristics resemble those of sediment-covered Guaymas Basin and Middle Valley rather than JADE-site.

It is possible to calculate  $f_{O_2}$ - $f_{S_2}$  conditions of hydrothermal fluids around 300°C using appropriate thermodynamic data and compare them with mineralogically estimated redox conditions in  $f_{O_2}$ - $f_{S_2}$  diagram of Fe-Cu-S systems. The calculated redox conditions are in accord well with those based on mineral assemblages and Fe% in sphalerites in both JADE and HAKUREI-sites. In contrast to JADE-site with higher  $f_{O_2}$ - $f_{S_2}$  comparable with sediment-starved PACMANUS, HAKUREI-site indicates lower  $f_{O_2}$ - $f_{S_2}$  corresponding to Guaymas Basin and Middle Valley. Therefore, HAKUREI-site is in relatively reducing hydrothermal environment because of organic matter decompositions in the sediment layer, whereas, the thin sediment layer in JADE-site does not affect the redox state of the hydrothermal field.

The  $\delta^{34}S$  values of chimney sulfides 1.8-4.2‰ in HAKUREI-site is lower than those (5.1-6.7‰) in JADE-site. That is not attributed to sulfur isotope equilibrium between seawater sulfate and hydrothermal  $H_2S$ , because  $\delta^{18}O$  values of barite and anhydrite show oxygen isotopic disequilibrium with hydrothermal  $H_2O$  at the fluid venting temperature and sulfur isotope exchange reaction rate is much slower than oxygen isotope exchange rate. In addition, relatively high  $\delta^{34}S$  and  $f_{S_2}$  state in JADE-site cannot be accounted by leached  $H_2S$  from sulfur-poor island-arc volcanic rocks, suggesting the presence of another sulfur source.

Although magmatic degassing  $SO_2$  contribution has been reported in some island-arc and back-arc seafloor hydrothermal systems, no sign of magmatic  $SO_2$  degassing has been found in the Izena Hole despite the large magmatic  $CO_2$  contributions. Assuming  $SO_2$ - $H_2S$  gas equilibrium and hematite-magnetite buffer, most of degassed  $SO_2$  are predicted to be converted into  $H_2S$  at equilibrium temperature <400°C, producing  $H_2S$  with relatively high  $\delta^{34}S$  of island-arc melt signature. The HAKUREI-site sulfides with lower  $\delta^{34}S$  would be caused by contributions of isotopically light  $H_2S$  generated by bacterial activities in the sediment layer or by contributions of low  $\delta^{34}S$   $H_2S$  produced by hydrolysis with larger  $SO_2$  proportion at higher equilibrium temperature

in HAKUREI-site than in JADE-site.

Keywords: Izena Hole seafloor hydrothermal systems, Okinawa Trough, sulfur isotope, redox conditions, mineral assemblage

Petrological feature of Nakanodake intrusion from Yoneyama area, northern Fossa Magna,  
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Early Pleistocene Nakanodake intrusion, 1.2-1.6 km diameter, is located in northern Fossa Magna. The intrusion, composed of inner gabbro and outer hornblende andesite, is intruded in the Yoneyama Formation. On the basis of petrography and geochemistry, the intrusion is divided into Opx-Cpx gabbro, Hor-Opx-Cpx andesite, and Hor-Cpx andesite. The rocks of the Nakanodake intrusion have high K content and tholeiitic characteristics, indicating a similar geochemical trend to that of the Yoneyama Formation. Mg value ( $100 \cdot \text{Mg}/(\text{Mg}+\text{Fe})$ ) of Opx and Cpx, and An content of plagioclase in gabbros are lower than those in hornblende andesites, which suggests that the rocks from the intrusion were not originated by fractional crystallization from the common source magma.

Keywords: Northern Fossa Magna, Yoneyama, Nakanodake intrusion, Crystallization differentiation, Tholeiitic rock series

## Partial melting and assimilation processes of granitic xenoliths

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Crustal assimilation is one of the important magmatic processes especially for arc magmas. In this study, partially melted granitic xenoliths in Miocene Setouchi volcanic rocks, SW Japan were examined in order to reveal the petrological and geochemical evolution during xenolith assimilation on sub-meter scale. The xenoliths (10-60 cm) contain 20-40 modal% of compositionally heterogeneous fresh glass. In addition, the xenoliths are surrounded by a glassy porphyritic zone where xenolith-derived melts and host andesitic magmas are mingled. Thus, these samples well preserve the melting-assimilation processes of crustal rocks incorporated in intermediate magma. In less-melted xenoliths, glass is distributed along the grain boundary between quartz and other phases such as plagioclase, alkali feldspar, and pseudomorph of hydrous mafic minerals. The glass changes its color and chemical composition depending on neighboring mineral phases. Transparent and brown glasses appear around felsic and mafic minerals, respectively. Overall glass composition varies, 73-79 wt% SiO<sub>2</sub> on anhydrous basis, and both Si/Al and K/Na ratios increase toward quartz within glass sandwiched by quartz and feldspar. On a normative Q-Ab-Or ternary diagram, the glass composition follows a nearly linear trend across the hydrous haplogranite cotectic line. These observations suggest that disequilibrium melting and chemical diffusion in melt played important role for producing the heterogeneity of glass. Minerals also change their texture and composition with melting. Mafic minerals, probably biotite or hornblende, are completely broken down to fine-grained aggregates of Fe-Ti oxide, orthopyroxene and plagioclase. Alkali feldspar (Or60) forms finger-print/sieve textured reaction zone with surrounding melt. The reaction zone is mainly composed of newly formed feldspar and interstitial glass. The new feldspars change their composition from anorthoclase to andesine as the reaction proceeds. In contrast, most plagioclase is simply melted without significant interaction with neighboring melt. These minerals in partially melted xenoliths are dispersed into the outer mingling zone surrounding each xenolith when melting degree exceeds about 50 modal%. This indicates that disaggregation of xenoliths begins at around the rigid percolation threshold (Vigneresse et al., Jour. Pet. 1996) during assimilation. Setouchi volcanic rocks, including high-Mg andesites, often contain quartz and feldspar xenocrysts, which are probably from Cretaceous granitic basement. Our observation suggests that the volume of granite-derived melts cryptically assimilated in host andesitic magma is more than double of the observed xenocryst abundance.

Keywords: granite, partial melting, assimilation

## Serpentine minerals from Irikura, Oita Prefecture, Japan

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Introduction

Serpentinites are valuable evidence of hydrothermal activity in deep earth. They are often made by hydrothermal alteration of peridotite, the main component of the mantle, at relatively low temperatures. They form in specific conditions, such as subduction zones and mid-atlantic ridges. Forming species differ, reflecting the environment at serpentinization, and show characteristic pseudomorph structures (e.g. Wicks and Whittaker, 1977).

Serpentinite is mostly composed of serpentine group minerals, which are formed by Si-rich tetrahedral sheet and Mg-rich octahedral sheet in one to one layer sequence. Between these sheets, interlayer stress are caused by the difference of their lattice dimensions. Serpentine group minerals can be classified into three species, lizardite, chrysotile, and antigorite, according to their crystal structures taken to compensate the dimensional misfits. Each species have several polytypes, and also there is a fibrous serpentine called polygonal serpentine whose classification is still under debate (e.g. Baronnet and Devouard, 2005). Despite their characteristic role in geology, the mineralogical analysis of serpentine group minerals is often imperfect, due to their difficulty in observation.

The ultramafic rock body in the Asaji metamorphic rocks is mainly composed of pyroxenites and serpentinites. The chemical trends of spinel in serpentinite show similarity to the Kurasegawa belt, suggesting similar tectonic setting for the formation of those ultramafic rocks (Sonoda and Takagi, 2004). In this study we report the property of serpentine group minerals and associating minerals, contained in serpentinite from Irakura, Oita prefecture, Japan.

Methods

In this study, the samples from ultramafic body in the Asaji metamorphic rocks, in Irikura, Oita prefecture, Japan were observed. The samples were collected from several points in a huge outcrop, with different appearance within one sampling point. The constituent minerals were determined by X-ray diffraction pattern, and texture observation and quantitative chemical analysis was carried out by scanning electron microscope.

Results and Discussion

In the studied locality, the out crop was mainly composed of serpentinite, including rodingite and albitite bodies of a few meters in size. The investigated samples were all completely serpentinized. The serpentinites can be roughly divided into three types from macroscopic feature and constituent minerals.

The first type is the blocky black serpentinite surrounding the rodingite and albitite bodies. They are either pure antigorite or lizardite with magnetite. They are mainly composed of reed type texture and fine grained fibers and grains filling the interspace. This type can be estimated to be formed by recrystallization.

The second type is spathic dark greenish serpentinite. It makes up the major part of the outcrop. They are antigorite or lizardite, with clinochrysotile and various carbonates. Magnesite, dolomite, and brucite were dominant and a small amount of hydrotalcite was observed. Carbonates exceed serpentine group minerals in some samples. Fractured aggregate of reed type texture make up most of the area, and fine grained fibers and grains fill the interspace.

The third type is splintery yellowish green serpentine which form aggregates in some points, and often occurs as veins in the type two serpentinite. They can be indexed clinochrysotile and / or

orthochrysotile by XRD, and further TEM observation is essential to determine whether it is polygonal serpentine or not. In the aggregate form, it accompanies greenish fibrous of low crystalline antigorite.

The chemical compositions of serpentine were near the endmember, slightly differing in Si component. The textures of serpentinites of Irikura suggest strong deformation and recrystallization after the first serpentinization.

Keywords: serpentine, serpentinite, Irikura, Asaji metamorphic rocks

## Experimental study on the petrogenesis of Middle Miocene granitoid plutons in the Ehime Prefecture

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The origin of continents with granitic upper crust enriched in incompatible elements is one of the fundamental questions in Earth's evolution. The Middle Miocene granitoid plutons (the Uwajima, Miuchi and Omogo plutons) are distributed in the Ehime prefecture, Southwest Japan. These plutons are composed of incompatible element-enriched granitoids including granodiorites, monzogranites and granites (*sensu stricto*). In order to constrain petrogenesis of the Middle Miocene granitoid plutons, we tried high-temperature melting experiments under deep crustal pressures.

The melting experiments are performed in a piston-cylinder type high-pressure apparatus with 12.7 mm borehole, under conditions at 900-1000 °C and 0.9 GPa. Starting materials prepared for the experiments were (1) powders of the Setouchi andesite (the JA-2 AIST geological standard sample), (2) fragments (~1mm) of Shimanto metasedimentary rocks (psammitic hornfels collected from the contact aureole of the Miuchi pluton), and (3) mixtures of them. The run-products were examined with SEM-EDS.

Experimental glass compositions were ranging from monzogranitic to granitic (*sensu stricto*) and are broadly comparable to the Middle Miocene granitoid plutons in Ehime Prefecture. Although most of the major element concentrations of the experimental glasses were similar to the granitoid plutons, the K<sub>2</sub>O contents of glasses were considerably higher than those of the plutons. Additional melting experiments on the starting material with the relatively low-K rocks would be required for a better understanding of the genesis of the Middle Miocene granitoid plutons.

Keywords: Granitoid plutons, Middle Miocene, Melting experiment