Japan Geoscience Union Meeting 2011
(May 22-27 2011 at Makuhari, Chiba, Japan)

SCG067-01 Room:105 Time:May 26 08:30-08:45

Chromite and uvarovite in rodingite from the lowermost crust of Oman ophiolite: Cr mobility in hydrothermal condition

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Uvarivite-rich garnets have been commonly reported as a secondary mineral from chromitites. We found rodingites that contain uvarovite-rich garnets from layered gabbros, located about 50 m above the gabbro/peridotite boundary (= possible Moho) along Wadi Fizh of the northern Oman ophiolite. The rodingite from Wadi Fizh contains relic cpx gabbro clasts, and is mainly composed of Ca-rich plagioclase (An, 97-100), diopside (Mg#, 0.87-0.97), uvarovite, chromite and titanite. Both chromite and uvarovite are euhedral and fine-grained ($<$0.1 mm across); they are concentrically zoned and partly skeletal. Unlike the frequent occurrence of uvarovites, which overgrow on chromite documented from chromite-bearing rocks, some uvarovite and chromite occur as discrete grains in the Fizh rodingite. Chromite has a high Cr# (Cr/(Cr + Al) atomic ratio; around 0.8), which is one of the highest Cr# chromian spinels reported from Oman. Fe3+/(Cr + Al + Fe3+) (= YFe) increases from the core ($<$0.1) to the rim (0.2) in chromite. MnO and TiO2 contents (wt%) of the chromite are 0.5-0.6 and 0.2-0.3, respectively. Cr/(Cr + Al + Fe3+) atomic ratio of uvarovite ranges from 0.5 to 0.6. The YFe of uvarovite is from 0.05 to 0.2.

It is noteworthy that chromite appears authigenic together with other minerals in this rodingite. Chromites or chromian spinels are totally absent in relic cpx gabbro clasts or in neighboring layered gabbros. The euhedral and partly skeletal chromite contains inclusions of pumpellyite. These indicate that Cr was transported with a hydrothermal aqueous solution, which metasomatized the layered gabbro to rodingite. A highly oxidation condition was possible for such high Cr mobility.

Keywords: uvarovite, rodingite, Oman ophiolite, hydrothermal alteration, chrome mobility

SCG067-02 Room:105 Time:May 26 08:45-09:00

Phase equilibria and mineral paragenesis on crustal materials under ultrahigh-pressure metamorphic conditions

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We carried out the ultrahigh-pressure experiments at 8.0 GPa under dry condition on the pelitic granulite from Hidaka metamorphic belt, Hokkaido to clarify the phase changes.

We found the assemblage of the Al2O3-deficient garnet with pyroxene components, significantly SiO2-oversaturated clinopyroxene containing a large amount of jadeite, kyanite and coesite in the charges. We obtained the following results from chemical and microscopic analyses of these minerals:

1. Contents of Na2O and K2O in clinopyroxene at UHP conditions should be constrained by the bulk composition of the system.
2. The amount of clinopyroxene increases with increasing SiO2, simultaneously with decreasing Na2O and K2O.
3. The tschermak content in clinopyroxene depends on the amount of kyanite in the system.
4. Coesite and kyanite buffer the solubility of Na2O and K2O in clinopyroxene at ultrahighpressure metamorphic conditions.

Keywords: ultrahigh-pressure metamorphism, garnet-clinopyroxene-kyanite-coesite coexistence, Al2O3-deficient garnet, SiO2-oversaturated clinopyroxene

SCG067-03 Room:105 Time:May 26 09:00-09:15

A kelyphite produced by isochemical breakdown of garnet in a garnet peridotite from the Czech Moldanubian Zone

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Kelyphite, a symplectitic mineral intergrowth of Opx, Cpx and spinel that developed around garnet in peridotite, is not a simple breakdown product of garnet but a reaction product between garnet and olivine. It is typical that such kelyphite has a bulk chemical composition show higher Mg and lower Al than garnet (e.g. Obata, Spengler, 2010 JpGU). We report a different kind of kelyphite (kelyphite II) that appeared to have formed by an isochemical breakdown of garnet inside of an ordinary kelyphite (kelyphite I) from a garnet peridotite of Czech Moldanubian Zone (Plesovice peridotite , Naemura et al 2009). The garnet peridotite once equilibrated at 2.3-3.5 GPa, 850-1030C intruded into lower continental crust and got partially equilibrated in spinel lherzolites facies. The temperature of the kelyphite formation has been estimated to be 730-770C (at 0.8-1.5 GPa). Kelyphite II occurs inside the ordinary kelyphite I adjacent to a relict garnet. It is revealed that the kelyphite II has nearly the same composition as the garnet by EPMA X-ray mapping. The kelyphite consists of Opx, Sp and anorthite (An). It has very well-defined lamellar structure that consists of Opx lamella containing very small spinel lamella (less than 0.2 micrometer) and plagioclase lamella that lack spinel lamella. There is a transitional zone of tens of micron width between the kelyphite I and kelyphite II domains.

The mineral assemblage Opx-Sp-An has been known to occur in kelyphite in mafic granulites and garnet pyroxenites that lack olivine (e.g. Obata, 1995) but have previously never been found in kelyphites in garnet peridotites.

Kelyphite I is produced by a reaction
Grt + Ol -> Opx + Cpx +Sp (1),
while kelyphite II is by
Grt -> Opx +An + Sp + Cpx (2)
(Kushiro & Yoder, 1966).

Reaction (2) occurs at lower pressures than reaction (1). Considering the textural relationship and phase equilibrium constraints, following scenario may be drawn. Upon decompression of garnet peridotite, kelyphite I is first developed by reaction (1). At further decompression, if garnet is still remained, it is converted to kelyphite II. This scenario assumes a time gap between kelyphite I and kelyphite II formations. But we cannot rule out a possibility that reaction (2) started before reaction (1) ceased.

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Keywords: kelyphite, symplectite, garnet peridotite, isochemical breakdown, Czech

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SCG067-04 Room:105 Time:May 26 09:15-09:30

Primary structures in Archean metamorphosed BIF: the SXAM analyses

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Precambrian banded iron formations (BIFs) are characterized by alternating Fe-rich and Si-rich layers and have been assumed to preserve primary structures formed on seafloor; physical sedimentation and chemical precipitation from seawater or from submarine hydrothermal fluids, and microbial activity have been generally considered as genetic processes of BIFs. Banded structures in the BIFs exhibit several different scales, from sub-millimeters to several tens of meters. Some of these hierarchy structures have been considered to periodic phenomena in different time scales, corresponding to seasonal cycles, tidal or solar cycles, and Milankovitch cycles. However, most BIFs have undergone various grades of metamorphism. To decode environmental changes in the Precambrian era recorded in BIFs, it is necessary to distinguish primary structures from secondary ones (compositional banding), which were formed after burial of the BIFs. We analyze the banded structures in the BIF samples in the Yellowknife greenstone belt, NWT, Canada. In this study, we investigated the influence of metamorphic reactions on the banded structures in an Archean BIF (2.9-2.8 Ga) comprised in the Bell Lake Group.

In the Bell Lake BIF, there are centimeter-scale alternating Fe-rich and Si-rich bands. Under a microscope, this BIF is now completely recrystallized into medium-grained metamorphic minerals. The Fe-rich band is mainly composed of magnetite, green hornblende, and colorless Fe-Mg-amphibole (grunerite). The Si-rich band constitutes of quartz, magnetite, and a small amount of actinolite. The schistosity defined by orientation of amphiboles is almost parallel to the Fe-rich and Si-rich bands, but an intrafolial fold is locally developed, where the schistosity plane clearly intersects the banded structures. These observations indicate that the alternation of Fe-rich and Si-rich bands already existed at the time of metamorphism.

X-ray fluorescence (XRF) element mappings of the BIF samples were conducted with a Horiba XGT-2000V scanning X-ray analytical microscope (SXAM). The SXAM makes possible acquisition of XRF intensity maps of samples up to 20$*$20 cm2. The SXAM analyses found over the entire sequence that Ca concentrate at the middle parts of the Fe-rich bands and are sandwiched with Fe and Mg. These element distributions correspond that hornblende is observed at the center of Fe-rich band and is sandwiched with magnetite layers and Fe-Mg amphibole layers. As no exsolution lamellae are found in these co-existing amphiboles and the hornblendes have larger grain size compared with the Fe-Mg amphiboles, we consider that such sandwich structures were formed via nucleation-growth during prograde metamorphism. An incompatible element of Mn is considered to have diffused out to the margin of Fe-rich band and finally recrystallized as grunerite. On the other hand, Ti-spots are uniformly distributed in Fe-rich band. The SEM-EDS and XANES analyses appeared that Ti-spots are locally hosted in hornblende. Since titanium is generally known to be immobile in in metasomatic and metamorphic processes, primary structure of Fe-rich and Si-rich bands may be defined by the Ti-spots distribution.

The Si-rich bands are intercalated with thin magnetite-rich layers with the thickness of sub-millimeters, each of which contains several to tens of magnetite-rich layers. Laminations of this scale (microbands) are commonly observed in low-metamorphic grade Hamersley BIF (Western Australia). It is likely that these laminations record primary structures formed during the sedimentation and precipitation processes. In the Bell Lake BIFs, grain size of magnetite-rich layers is much larger than that in quartz-rich matrix, suggesting the role of Ostwald ripening in their development.

Keywords: banded iron formation, banded structure, metamorphic differentiation, primary structure, Scanning X-ray Analytical Microscope, element mapping

SCG067-05 Room:105 Time:May 26 09:30-09:45

Magnetically-induced free motions of dia- & para-magnetic mineral grain and a novel method of its mineral identification

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The origin of minor mineral phases (including biological remnants) contained in various semimetal and igneous rocks has become one of the major interests in various fields of earth science. The development of a simple and nondestructive method to identify the material of a single fine particle is desired in various research fields that are concerned with micro- and nano-materials. Here, a new method of material identification is proposed which is based on magnetization data; the data is obtained from magnetically induced motions of the single grain that is observed in micro-G condition. Specifically, diamagnetic susceptibility is obtained from translation of the single mineral grain caused by field-gradient force; anisotropy of susceptibility can be obtained from period of rotational oscillation of magnetically stable axis with respect to field direction. According to a data book that compiles published susceptibility values [1], an intrinsic diamagnetic susceptibility and its anisotropy are assigned to almost all the rock forming mineral. Hence identification of a mineral (or material) is possible from the measured values of susceptibility and anisotropy. This attempt does not appear in previous literatures.

Free translation due to field-gradient force was previously reported for various diamagnetic and paramagnetic crystals [2][3]. Rotational oscillation was observed as well for a number of diamagnetic crystals in a homogeneous field located in micro-gravity [4]. The susceptibility and its anisotropy obtained from the above motions agreed well with their published values.

The terminal velocity of the above-mentioned translation at zero field area is observed in the present work. Through these measurements, the field-induced potential at initial position was completely converted to kinetic energy out-side the magnetic field. The mass independent property of terminal velocity, deduced from the above-mentioned energy conservation, is examined in wide range of sample size between 1.0 and 0.005cm in diameter. A compact microgravity system, which is introduced in an ordinary laboratory, was newly developed. This was because the conventional facilities of microgravity were not suitable for a routine analysis such as the present magnetization measurement; a large facility system requires a long machine time, and their running costs are high. In the compact system, length of the drop shaft is 1.5m, and micro-G duration was below 0.7 seconds. The experimental setup was contained in a wooden box (30cm in diameter), which was dropped from the sealing of our laboratory. The micron-sized samples were released in the area of field-gradient; the field was produced by a by a small NdFeB magnetic-circuit (maximum field 0.7 T). The introduction of the small circuit enabled the development of the compact drop system.

The above-mentioned free motion is expected to be a breakthrough to detect susceptibility (& material identification) of limitlessly small particles, because the method is free of both sample holder and mass measurement. Magnetization is measured on any sample irrespective of its size, provided that motion of the sample is observable.

At the first stage of analyzing geological materials, the sample should be separated to a single grain size. Secondly, the material of individual grain will be identified nondestructively by the above-mentioned free motions; then it can be put to various refined analysis based on chemical, isotopic or optical probes, etc. The method is applicable to search biological remnants as well as micro-meteorites from semimetal rocks. It may be effective to identify a new type of exotic grain from primitive meteorites.

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Keywords: material identification, magnetic ejection, diamagnetic susceptibility, paramagnetic susceptibility, micro-gravity, nano-science

SCG067-06 Room:105 Time:May 26 09:45-10:00

Mineral chemistry of pyroxene megacrysts from Japanese island arc: Contribution of Mn-pyroxene end-member to Island arc

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The chemical compositions of both augite (4 to 8 mm long) and enstatite (4 mm in size) megacrysts from the pyroxene-andesites, south-Yatsugatake volcano, central Japan, were determined by electron microprobe analysis (EMPA). This determination led to accurate expression of the pyroxene end-members obtained by calculation based on the assumption of charge equilibrium and the site occupancy as full as possible, represented as follows: $MgSiO_3$ (enstatite), $Fe^{2+}SiO_3$ (ferrosilite), $MnMgSi_2O_6$ (kanoite), $CaTiAl_2O_6$, $CaFe^{3+}AiSiO_6$ (esseneite), $CaSiO_3$ (wollastonite), $CaAl_2SiO_6$ (Ca-Tschermak's molecule) or $Ca_{0.5}[]_{0.5}AlSi_2O_6$ (Ca-eskolite), $NaAlSi_2O_6$ (jadeite), $NaCr^{3+}Si_2O_6$ (kosmochlor) and $Mg_{1/2}[]_{1/2}Mg_{1/2}Si_{1/2}Si_2O_6$ (a new end-member). Furthermore, calculation of the above end-members is also applicable to the chemical compositions of common pyroxenes, resulting in the determination of Fe^{2+} and Fe^{3+} contents in the analyzed pyroxenes.

Encompassment of the end-members by the pyroxene has yielded two significances in pyroxene chemistry: (1) pyroxene megacrysts from Japanese island arc are always richer in $MnMgSi_2O_6$ content than those from all the other world, and (2) a negative correlation between $NaAlSi_2O_6$ (jadeite) and $Mg_{1/2}[]_{1/2}Mg_{1/2}Si_{1/2}Si_2O_6$ contents (a new end-member) implies that the presence of the latter in pyroxene requires high-pressure conditions for the formation. Stability of jadeite at high pressure, the silicon coordinated by six oxygens contributing to its genetic environment of high-pressure (Larry et al., 1991), and the success in synthesizing high-pressure pyroxene with octahedrally coordinated silicon, $Na(Mg_{0.5}Si_{0.5})\ Si_2O_6$ at 1873 K and 15 GPa (Angel et al., 1988), all support the utility behavior of a new end-member of pyroxene at high-pressure.

Most significantly, as the allanites in granitic rocks from Japanese island arc are always more enriched in Mn compared to those in the other worldwide granites, so the present pyroxene megacryst containing $MnMgSi_2O_6$ end-member is an eloquent example of "Island arc mineralogy".

Keywords: Pyroxene megacrysts, end-member expression, $MnMgSi_2O_6$, "island arc mineralogy", new emd-menber

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SCG067-07 Room:105 Time:May 26 10:00-10:15

Geochemical characteristics of Nanzaki Basanite, Izu peninsula, Japan

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We report results of detailed petrological and geochemical analyses carried out for Nanzaki basanite in the southern most part of the Izu peninsula, which locates 50km toward back-arc from the present volcanic front of Izu-Bonin volcanic arc.

Nanzaki volcano erupted 0.43 Ma (Kaneoka et al.,1982). We identified two types of basanitic rock (Massive Lava; Scoria and Layered Lava) based on, composition of phenocryst (Cpx+Olivine) and bulk rock chemistry. Massive lava contains more or less differentiated olivine (Fo=77-90), nepheline micro-phenocryst, and higher Ba/Sr values. $FeO*/MgO$ value is 0.96-1.08. Scoria and layered lava have primitive composition of olivine (up to Fo=0.91), lower $FeO*/MgO$ values (0.81-1.01), and lower Ba/Sr values. Other major elements composition shows no clear differences between both magmas (SiO2=42.1-44.5 wt.%, CaO=12.1-13.4 wt.%). Chemical characteristics of scoria and layered lava may indicate character of primary (undifferentiated) magmas generated in the upper mantle.

We also found xenolith in layered lava, which contains clino-pyroxene ($>$95%), olivine ($<$5%) and chromian micro-phenocrysts. 0.1-2mm Vugs are observed dominantly. Composition of phenocryst does not distinguishes xenolith from host rock. Although the origin of this xenolith is still unspecified, it was thought to have captured during the upward movement of layered basanite lava.

Both types of rock have same patterns of REE and trace element. Nanzaki basanite is abundant in REE, especially in LREE. It has approximately same value of La/Yb with basanites in SW Japan (e.g. Iwamori, 1992; Tatsumi et al., 1999) and in Hawaii (e.g. T. W. Sisson et al., 2009; 2002). Aoki et al. (1986) suggested that Nanzaki basanite is resemble to alkali basalts in oceanic island tectonic setting. However, there is a significant differences in some elements concentration, such as anomaly in Ba, Sr, Pb and negative anomaly in Rb, K, Zr) recognizable. Such unique magmas could be generated from carbonate-metasomatized mantle in subducting slub tectonic setting.

Keywords: Basanite, Izu-Bonin volcanic arc, major and trace element geochemistry, back-arc rift, ocean island basalt, Sr isotopes

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SCG067-08 Room:105 Time:May 26 10:15-10:30

There is sea uranium for 1000 years to 1.8 billion years

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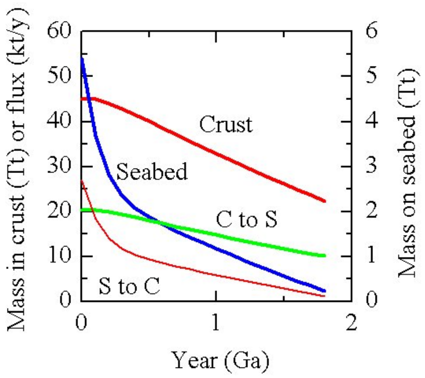
Proven reserves of energy resources will be exhausted in 74 years if primary energy consumption is kept constant. This is a very rough estimation because the exhaustion of reserves does not mean exhaustion of resources and R/P ratio varies with price, discovery of new reservoirs, development of new technology, population increase, economic growth etc. This R/P ratio does not seem to be enough, however, it will increase to 153 years by including probable reserves of oil shale, shale gas and methane hydrate (Ishimoto, 2011 in Japanese). Dependency on gas energy will dominate in several ten years because R/P ratio of petroleum is just 43 years. R/P ratio of uranium is 744 years if only fast breeder reactors are employed instead of light water reactors.

It might be meaningless to worry about human society more than 100 years from now considering the human society 100 years ago and the above energy seems enough. The current author, however, would like to mention that there are a large quantity of thorium and sea uranium.

Thorium is a nuclear fuel and can be smelted from monazite with rare earths. It has been not widely used because it does not produce plutonium which can be used for nuclear weapons. It is found in Turkey, Australia, India (already using), Norway, US, Canada etc. and its proven reserves are 1.58 Mt (MacKay, 2010). The reserves are for 58 years supplying primary energy for the whole world. Thorium has such advantages as most parts fission so that nuclear waste is much less than uranium, fuel has to be changed just once a 30-year period and serious accidents are not expected by its fission mechanisms although the smelting cost is higher than uranium. Thallium in nuclear waste radiates intense Gamma-ray and the half-life is 30 years. It is impossible to significantly increase R/P ratio by the mechanism which is similar to fast breeder reactors because most parts fission.

There is uranium of 4.2 Gt as uranyl carbonate, $UO_2(CO_3)_3{}^{4-}$, at 3.34 ppb in sea water (Davies et al., 1964). Blade type-extracting system using tannin collectors and installed on continental shelves with warm current is under development and the cost is 3 times the uranium from ore (Tamada et al., 2006 in Japanese). The cost for power generation will increase by only 20% if the cost for uranium is 3 times because cost for uranium is just 10% the cost for power generation for light water reactors. Assuming that one quarter of the resources can be collected, probable reserves would be 1 Gt and this is for all primary energy for the whole world of 1000 years. Continental shelves along Indonesia, Philippines, Taiwan, Okinawa-Tosa bay, East coast of Australia, Florida, East coast of Africa would be suitable for collection. However, 110,000 km^2 wide system is necessary and this does not seem practical.

Assuming that only fast breeder reactors are used, all primary energy for the whole world can be supplied by uranium of 10 kt and the necessary area is just 1100 km^2. The cost can be several 100 times the ordinary uranium. Sea uranium is flowed from rivers and dissolute in sea water and precipitate on sea bed. The inflow rate is 27 kt/y (Davies et al., 1964). Apparently, precipitated uranium is subducting to mantle at 27 kt/y. Uranium amount in continental crusts is roughly estimated as 45 Tt based on the volume of continental crust and average concentration (3 ppm). Assuming that a constant portion of uranium in continental crust inflows into sea, a constant portion of uranium in sediments on sea bed subducts to mantle and is supplied to continental crust as magma, plate will stop in 6 Gy at a constant deceleration, sea uranium of 10 kt/y is extracted and considering the half-life time of 238U (4.5 Gy), sea uranium can be extracted for 1.8 Gy. It is supposed that human cannot survive till the time because of the predicted extreme climate change and water shortage at that time if the morph and function of the human is similar to present ones.



Keywords: energy resources, thorium, sea uranium

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SCG067-P01 Room:Convention Hall Time:May 26 10:30-13:00

Petrogenesis of the axis stage and late stage felsic rocks in the Oman ophiolite

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The presence of felsic rocks in ohiolite suites has been reported by numerous authors, and are called plagiogranite (Coleman and Peterman, 1975). Lippard et al. (1986) classified the felsic rocks in the Oman ophiolite into three stages; High-level intrusives (axis stage), Late intrusives, and younger granites associated with emplacement. Rollinson (2009) described similar classification of the felsic rocks in the Oman ophiolite, and discussed petrogenesis of these felsic rocks. This paper describes field occurrences, petrography, and petrochemistry of the felsic rocks in early (axis stage) intrusive rocks and late (associated with detachment) intrusive rocks. In this study, we investigate felsic rocks from the Lasail complex as an example of late intrusive rocks.

Lasail complex, dimension of 4.7 x 3.8 km, consists of gabbroic and tonalitic rocks. The gabbroic rocks are composed of layered gabbro and massive gabbro. The layered gabbro is intruded by the massive gabbro, and often occurs as large blocks in the massive gabbro. The layered gabbro is composed mainly of gabbronorite and leucogabbronorite associated with dunite, lherzolite, websterite, olivine gabbronorite. The massive gabbro consists of hornblende gabbronorite, hornblende gabbro, and hornblende diorite. These gabbroic rocks are intruded by small intrusions of hornblende diorite to hornblende tonalite. The quartz diorite consists of hornblende diorite to hornblende tonalite, and intrudes into the gabbroic rocks.

We also investigate felsic rocks associated with the sheeted dike complex from eastern margin of the Lasail complex and Wadi Barghah, and those associated with upper gabbro from Wadi Rajimi (Rollinson, 2009) as examples of early intrusive rocks. Sheeted dike complex is intruded by upper gabbroic rocks in eastern margin of the Lasail complex and Wadi Barghah, and upper gabbro includes sheeted dikes as large blocks less than 10 m in Wadi Rajimi. These sheeted dikes are infiltrated by quartz dioitic vein networks. In some places, sheeted dike complex is composed of hornblende and pyroxene hornfels cut by quarts dioritic vein networks. These occurrences resemble to the anatectic migmatites of axial magma chamber roof exposed in the Troodos ophiolite, Cyprus, described by Gillis and Coogan (2002).

Bulk chemical compositions of the felsic rocks from the late intrusive rocks are characterized by extreme depletion in incompatible elements compared with the early intrusive rocks; K2O, P2O5, TiO2, and REEs. In the case of REEs, felsic rocks from the early intrusive rocks are clearly richer in REE contents than those from the late intrusive rocks. Rollinson (2009) explains that early felsic rocks were produced by the partial melting of hornblende gabbros (cumulate gabbros) in the roof zone of an axial magma chamber, facilitated by the influx of seawater. He also describes that late gabbro-trondjhemite complex, which formed from a mafic magma by the remelting of previously depleted mantle harzburgite followed by fractional crystallization. Explanation of Rollinson (2009), however, is inconsistent with the occurrence interpreted as anatexis of sheeted dike complex.

Gillis and Coogan (2009) describes disequilibrium melting models to explain relatively lower REE concentrations in early felsic rocks. Disequilibrium melting models assume that the concentration of an element in a melt is simply controlled by its concentration in the constituent minerals and the relative proportions in which they dissolve into the melt (e.g., Bea, 1996). This paper will discuss the possibility of disequilibrium melting by using the newly collected samples of the early felsic rocks, and detailed petrogenesis of the late felsic rocks.

Keywords: Oman ophiolite, plagiogranite, oceanic crust, petrochemistry

SCG067-P02 Room:Convention Hall Time:May 26 10:30-13:00

Magma genesis of Quaternary volcanic rocks from Futagoyama volcano, Kunisaki Peninsular, northeast Kyushu, Japan

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It is well known that the slab melting is one of the important mechanisms transporting the materials from subducting slab to the mantle wedge, in addition to the dehaydration of the slab (e.g. Defant & Drummond, 1990). It is belived that the origin of the magma produced adakite is genrated by the slab melting. However, the detailed genesis of adakite is still under the issue (e.g. Castillo, 2006). Thus, the accumration of the study for adakite is considered to be important. From the Southwestern Japan arc where Philippine Sea plate is subducting, many Quaternary adakitic magmas are observed. Futagoyama volcano is situated at Kunisaki Peninsular, Kyushu Island, Japan, and belongs to the Southwestern Japan arc, and the volcanic activity was occurred at 1.5 to 1.1 Ma (e.g. kamata, 1998). We determined the major and trace element and Sr, Nd and Pb isotopic compositions of six (biotite) +hornblend dacites from Futagoyama volcano. Range of SiO2 content was 63 - 66 wt%. From the MORB normalized trace element pattern, depletion of Nb and enrichment of LIL are observed, which indicate the geochemical characteristics of island arc magma. Most of the Sr/Y ratios are $>$40, and the concentrations of Y are $<$ 17ppm indicating the signature of adakite. 87Sr/86Sr, 143Nd/144Nd, 206Pb/204Pb, 207Pb/204Pb and 208Pb/204Pb ratios are 0.7036 - 0.7041, 0.5126 - 0.5129, 18.1 - 18.3, 15.5 - 15.6 and 38.1 - 38.5, respectively. MgO concentrations and Sr/Y and 143Nd/144Nd ratios increase, and ratios of 87Sr/86Sr decrease with increasing the SiO2 concentrations. This may indicates that the magma with higher SiO2 keeps characteristics of primary magma of Futagoyama volcanoe. The Sr-Nd-Pb isotopic compositions are plotted on the tow component mixing curve in between the fields of Shikoku Basin basalts (Hickey-Vargas, 1991) and terreginious sediments on Philippine Sea plate (Shimoda et al., 1998). Shikoku Basin basalt is considered to be a constituent of oceanic crust of the Philipine Sae plate. Therefore, the origin of adakitic magma from Futagoyama volcane can be explained by the slab melting of the Philippine Sea plate together with the tereginious sediments on the plate. The enriched Sr, Nd and Pb isotopic compositions of the samples with relatively low SiO2 compared to those with high SiO2 may suggest the involvement of mafic crustal materials.

Keywords: slab melting, Philippine Sea plate, kyushu, trace elements, Sr-Nd-Pb isotopic compositions

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Analogue experiments of columnar jointing: Focus on entablature

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Columnar joint is the fracture in igneous rocks or welded tuffs, which is formed by volume contraction due to temperature decrease during cooling. There are two types of forms: colonnade and entablature. Colonnade consists of relatively wide and straight columns, whereas entablature consists of relatively narrow and curved columns. The fractures in colonnade are formed perpendicular to the isotherm, and propagate inwards as the cooling proceeds. On the other hand, the formation process of entablature is still unclear.

The formation of fractures in desiccation experiments using starch-water mixture so far is well analogous to colonnade formation. In this study, we tried to reproduce entablature structure by the analogue experiments in which we changed some experimental conditions: the direction of vaporized water and the desiccation rate. From the observational fact of a threefold structure with upper-colonnade, entablature and lower-colonnade, we presume that the fractures develop from top and bottom, and the approach of both-side-columns at the central part causes entablature. At first, to reproduce this threefold structure, we set up the direction of vaporized water not only from the top but also from the bottom. In addition, in previous experiments, some of cracks stop advancing inwards and the coarsening of columns occurs because the desiccation rate decreases with the advancement of cracks. In threefold structure in natural examples, however, even though entablature is located in inside, the width is smaller than colonnade suggesting the sudden increase of cooling rate. So we tried to change the desiccation rate abruptly increased during desiccating on the basis of the analogy between the desiccation rate and cooling rate. During the experiment, we control the desiccation rate controlled by the distance between the lamp and the surface of the starch mixture. In order to abruptly increase the desiccation rate, we shorten the distance. In the case that the desiccation rate is kept at constant until complete desiccation, it is observed that a lot of narrow columns near the upper surface became wider by column coarsening. All columns are straight forms. In the case that the desiccation rate abruptly increased after the elapse of a certain period of time, we found a discontinuous plane near the upper surface and curved columns at the upper side of the contact of both-side-columns.

Because the horizon of the discontinuous plane corresponds to the point of fracture proceeded before the desiccation rate change, it is plausible that the discontinuous plane was formed by the change of the desiccation rate on the column formation. Curved columns develop by the difference between the upper and lower desiccation rates.

Comparing this results to the natural columnar joint structure, in the case of the constant desiccation rate, colonnade structure occur that columns contact from the top and from the bottom, and in the case of the abrupt change of the desiccation rate, curved columns form after the rate change and we believe that they are analogous to entablature structure.

Keywords: columnar joint, morphology, analogue experiment, formation process, crack, fracture

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P-T-deformation history of the northern part of the Horoman Peridotite Complex, Hokkaido, Japan

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It is important to know the chemical composition of the bulk silicate earth (BSE) for understanding the formation and evolution of the earth and other planet of the solar system. There have been many studies to estimate the BSE composition on the basis of chemical models, such as Pyrolite model (e.g., Ringwood, 1962) and CI chondrite model (e.g., MacDonough & Sun, 1995). However, each model is based on critical assumptions. In the pyrolite model, the BSE is assumed to be a mixture of the current upper mantle and a basalt with an appropriate ratio. In the CI chondrite model, the chemical diversity of the upper mantle represents that due to the BSE differentiation. Moreover, in the CI chondrite model, the estimated chemical composition has a large uncertainty due to the large scatter in chemical compositions of the upper mantle peridotites. In order to critically evaluate the assumptions and to resolve the last issue, we adopt a strategy searching for a mantle fragment having the deeper and older information of the upper mantle. The Horoman peridotite complex, Hokkaido, Japan is known to be as old as ˜830 Ma in its formation of one of the chemical diversities (Yoshikawa and Nakamura, 2000) and derived from the depth of ˜70km as a solid state (Ozawa, 2004) and is suited for the purpose of this study.

The Horoman peridotite complex is located in the northern end of the Hidaka belt, which is a low P and high T type metamorphic belt. The complex occurs in the highest-grade region of the metamorphic belt mostly consisting of pelitic rocks and mafic rocks and is divided to Upper Zone and Lower Zone based on features of deformation microstructures. It is composed mostly of plagioclase lherzolite, spinel lherzolite, and harzburgite, which show layering on various scales. The layering is dipping to the north in the southern part and to the south in the northern part, thus the structurally lower Lower Zone appears in the northern and southern ends of the complex. On the basis of the study in the southern part, Ozawa (2004) shows that the Lower Zone ascent from the depth of ˜60km and temperature of 950?C almost adiabatically. We focused on the northern part of the complex, the pressure-temperature history of which has never been scrutinized yet.

Studied samples were collected along Chiyanbetsu-zawa running nearly perpendicular to the layered structure in the northern part of the Horoman complex. Mineral compositions were measured with EPMA, and three-dimensional morphology of fine-grained seams consisting of pyroxenes and spinel was quantified. By applying a geothermobarometer based on Lindsley (1983), Gasparik (1987), Nickel and Green (1985), and Ozawa (2004) to the core of orthopyroxene, the deepest P-T conditions were estimated. The result shows that the northern part tends to give lower temperature and similar depth to the southern part studied by Ozawa and Takahashi (1995). The seams contain orthopyroxene and clinopyroxene as inclusions and contain many islands of very fine-grained pyroxene-spinel symplectite. Along the margin of the seam, plagioclase grains, as large as several tenths of microns occur. The aspect ratio of seams in symplectite-bearing spinel lherzolite was found to be ˜5:2:1, indicating very weak deformation as compared with those measured by Sawaguchi (2001). These features suggest that the northern part of the Horoman complex is a suitable for the search of the mantle fragments for constraining the BSE composition. The difference in temperature between the northern and southern Lower Zone may be explained by the lateral variation in lithospheric geotherm.

Keywords: Horoman, Peridotite, P-T-deformation history

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Toward estimation of the tectonic setting for the Horoman peridotite

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The tectonic setting of the mantle from which the Horoman peridotite complex derived has not been thoroughly examined. Rocks of SDW suite can be representative of cumulates from the final melt extracted from the Horoman peridotites (MHL suite). Clinopyroxenes (cpxs) in SDW dunites were examined to estimate chemical properties of equilibrated melt.

Cpxs show modal and chemical heterogeneity in the thickest layer of SDW within the MHL harzburgite, possibly indicating the SDW were not simple cumulates from a batch of melt within a crack. The cpx mode is correlated positively with HREE and Al contents of cpx, and negatively with Fo and Ni content of olivine, indicating crystallization toward cpx-rich parts. The LREE content of cpx increases with an increase of the cpx modal amount, which possibly indicates chemical modification of cpx by interstitial melt. REE contents of cpx also appear changeable depending on the distance from the MHL wall, suggesting reaction with the wall harzburgite.

The melt in equilibrium with cpx shows REE patterns not exactly the same as those from any tectonic settings although a similarity to MORB and IAT was recognized. This is due to chemical modification (enhancement in LREE contents) of cpx by the interstitial melt. We need examine cpx grains from cpx-rich parts (wehrlites).

SCG067-P06 Room:Convention Hall Time:May 26 10:30-13:00

Rare earth element composition of the Sori granodioritic body, Ashio Mountains

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The Sori body indicating biotite K-Ar and Ar-Ar ages of 86 to 93 Ma consists of homogeneous biotite granodiorite. Initial Sr isotopic ratios calculated using 98 Ma for the body range from 0.7063 to 0.7074. The body is divided into three facies (central, transitional and marginal) based on the initial ratios. The transitional facies of the body suggests the isochron ages of 98+/-11 Ma.

The central facies indicating lower initial Sr isotopic ratios has slightly higher Rb/Sr, Rb/Ba and Rb/Zr ratios than those of the marginal facies. The marginal facies has lower Rb content and higher initial Sr isotopic ratios than the central facies. Then, it is suggested that the Sori body may have been formed by magma mixing.

Ce/U and Th/U ratios are thought to be oxidation condisition and if these ratios rise with redox state. Ce/U and Th/U ratios are thought to depend on redox condition, high ratio indicates oxidation state. The central and transitional facies have low Ce/U and Th/U ratios, whereas the marginal facies has slightly higher ratios.

In chondrite normarized REE patterns, the central facies indicates wider composition of the light rare earth element than other two facies. In heavy rare earth elements, positive tetrad effects are remarkable in the central ficies, whereas they are unremarkable in other two facies. It can be considered that the redox condition and the source material are different between the central and marginal facies. This harmonizes to result of review from the initial Sr isotopic compositions.

Keywords: Sori body, Granodiorite, Rare earth element

SCG067-P07 Room:Convention Hall Time:May 26 10:30-13:00

Development of Heavy Minerals and Trace Heavy Elements Database of Soils from Japan by Using SR X-ray Analysis.

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Since Heavy minerals are an important component of soils, mineralogical examination is essential in forensic soil identification. Besides, trace elements of soils will usually reflect their geographical origin and has long been used as provenance indicator in forensic investigation. In this study, we aim to develop heavy minerals and trace elements database of soils that collected from 3024 sampling points across Japan by using Synchrotron Radiation (SR) X-ray analysis. The soil samples were supplied by the Geological Survey of Japan (AIST) and they were the same samples used to produce the geochemistry map of Japan. In our experiment, the heavy mineral composition of the soils were determined by using SR X-Ray Diffraction (SR-XRD) analysis while the trace heavy elements data were obtained by using High-Energy SR X-Ray Fluorescence (HE-SR-XRF) analysis. Both analyses were carried out at SPring-8. Since a very large number of soil samples need to be analyzed before creating the database, a high-through put measurement system with enough measurement speed and experiment efficiency is thus required. Recently, a highly automated system that allows us to analyze 30 samples continuously in one measurement run with the large Debye-Scherrer camera was installed at the SR-XRD experiment hutch of BL19B2 beam line by Osaka. Besides, an automated Sample X-Y stage that allows us to analyze 25 samples continuously in one measurement run was also installed to the HE-XRF experiment hutch of BL08W beam line. These newly automated systems were applied to our measuremenst and we have successfully analyzed a very large quantity of samples within a limited beam time (approximately 130 samples in 24 hours). This indeed, is the world first attempt of creating a large forensic database by using SR X-ray analytical techniques.

For the SR-XRD experiment, heavy mineral components of the soil samples were separated by using Tetrabromoethane with the specific gravity of 2.82. The heavy mineral fractions were then ground and filled into a glass capillary (0.3 mm). Measurements were carried out by using Debye-Scherrer method with a synchrotron X-ray beam of 1angstrom in wavelength at BL19B2 beam line. The exposure time was 10 minutes per sample. As for the HE-XRF experiment, the soil samples were ground into fine powder to obtain a homogeneous composition. Measurements were carried out by using a high energy X-ray beam with an excitation energy of 116keV at BL08W beam line. The measurement time was 10 minutes per sample.

As an example of the results, the interpretation of the heavy minerals and trace heavy element distribution in Kanto region is shown as below. The Kanto plain is covered with thick quaternary sediments including a large amount of volcanic ash derived from volcanoes to the west of the plain, while the Kanto Mountains is dominated by a complex mixture of metamorphic, granitoid and volcanic rocks. The XRD patterns of the heavy minerals of soils from Kanto plain show that they were dominated by clinoypyroxene, orthopyroxene and amphiboles, minerals of volcanic origin while the heavy minerals of the soils from Kanto mountain were dominated by a great variation of heavy mineral components which include epidote, amphibole, clinopyroxene and others. As for the HE-XRF data, the XRF spectra of the samples of Kanto plain also exhibited large differences in the heavy element compositions from those of the samples collected from Kanto mountain. Besides, there were also such cases that the SR-XRD patterns of the soils within an area were similar while the HE-XRF spectra differ. An example was given in Fig.1, which shows the XRF spectra of four different sampling points in Chiba area yielding similar XRD patterns. The sampling points of Chiba1 and Chiba2 have higher concentration of Hf and W than Chiba3 and Chiba4. This infers that in certain cases the HE-XRF data can provide further provenance information that SR-XRD data cannot provide, and vice versa.

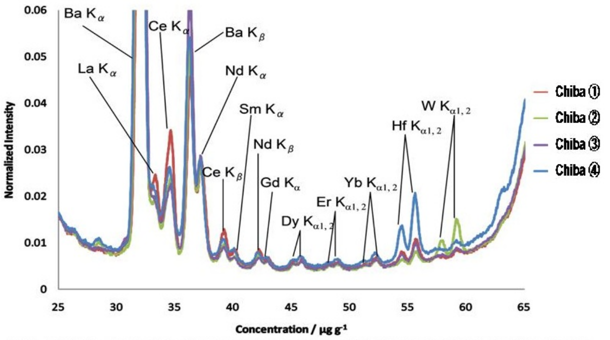

Fig.1 XRF spectra of four different sampling points (Chiba area)

Keywords: Synchrotron Radiation, soil, heavy minerals, heavy elements, XRF, XRD

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Zeolitization of nepheline in the contaminated rock from the Kushiro outcrop, Tojo-Cho, Hiroshima Prefecture, Japan

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The high-temperature skarn from the Uenotani outcrop of Kushiro, Tojo-Cho, Hiroshima Prefecture, Japan, was produced and then the cooling process accompanied the contaminated plutonic rock (Kusachi and Henmi, 1990). The comtaminated rock is mainly composed of pyroxenes and feldspars. The mineral assemblage as alkali feldspar + cancrinite + nepheline was reported by Kusachi and Henmi (1990). Of these minerals, only nepheline was assayed. Research on the elucidation of the formation mechanism of the present high-temperature skarn requires more elaborate studies of the contaminated rock.

Therefore this study proves that the present contaminated rock includes the relict of nepheline that is partially replaced by thomsonite, natrolite and analcime. Pectolite partially occur in the form of a strip line sandwiched between natrolite and analcime. although Kusachi and Henmi (1990) identified one of the zeolites as cancrinite. Production of zeolites from the Uenotani outcrop has never been reported up to now. This finding constitutes substantial evidence for the experience of hydrothermal alteration in addition to high-temperature skarn acting. As well, zeolitization of nepheline and feldspar in the alkaline rock complex was reported from Mitchell and Platt (1979) and Ross et al. (1992). However, the process of zeolitization remains unexplained.

This study was aimed at investigating the characteristics of zeolitization of nepheline, identifyng and describing the constituent mineral assemblage, and estimating the alteration process in the contaminated rock from the Uenotani outcrop of Kushiro, Hiroshima Prefecture, Japan.

The contaminated rocks from the Uenotai outcrop were examined using powder XRD for mineral identification, electron probe microanalyzer (EPMA) and LA-ICP-MS for chemical analysis, and micro-Raman spectroscopy and micro-FTIR for characterization of hydrous species.

From the above results, it is concluded that the present contaminated rock had experienced the following process of zeolitization:

1. Thomsonite could be produced from the reaction of nepheline with Ca-rich hydrothermal water (100-200 degree-C), which led to Na leached out by hydrothermal solution.
2. Na-rich hydrothermal solution reacted with thomsonite to cause the alteration into natrolite. In consequence Ca was eluted in the hydrothermal solution. The Ca- and Na-rich hydrothermal solution partially produces pectolite.
3. The analcime coexistent with the above minerals could be produced from alteration of the microcline reacting with Na-rich hydrothermal solution (100-200 degree-C)

Nepheline in the contaminated rock from the Uenotani outcrop occurred in accompany with the skarnization (Kusachi and Henmi, 1900). This study discovered that the nepheline in the comtaminated rock is defferent from that crystallized from alkaline magma, in chemical composition containing both trace elements and the existence or non-existence of water.

Keywords: high-temperature skarn, Kushiro, nepheline, micro-raman, hydrothermal alternation, zeolite

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Chemical formula of biotite deduced on the base of EMPA-WDS data:Crystal chemistry and genetic significance

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Micas are one of common rock-forming minerals in igneous and metamorphic rocks, and the structure has a general formula of $IM_{2-3}<>_{1-0}T_4O_{10}A_2$, where I is an interlayer cation(e.g.K,Na,Rb,Ca);M is an octahedral layer cation(e.g.Li,Fe(2+,3+),Mg,Mn(2+,3+),Al is a vacancy in the octahedral layer;T is a tetrahedral layer cation(Be,Al,B,Fe^{3+},Si);O is oxygen;and A is an anion not bonded to T(OH,F,Cl,O,S). Because of the complicated chemical composition, micas often have vacancies except T site, and examination of the crystal chemistry of mica is essential to determine the chemical formula. If the chemical data are available, commonly constructed by the procedure adopted by Rimsaite(1970), and so on. However, there is no previous study on the chemical formula of biotite deduced on the basis of only EMPA-WDS data. The present work focuses on the procedure to determine the chemical formulas of biotite, the representative of micas, on the basis of only EMPA-WDS data, and on discussing the crystal chemistry and the genetic significance.

The used samples are biotites from Tanakami granite, Shiga Prefecture, and those from the transition zone of pegmatite in its granite. Chemical analyses were performed using the JEOL-8530 electron microprobe equipped with five wavelength-dispersion spectrometers (WDS) at the Chemical Analysis Division, University of Tsukuba. The chemical formulas were obtained using the following procedure.

(1)The difference between the measured total <100 wt% and the ideal weight (100 wt%) was assumed as H_2O content, and the formula was calculated on the basis of 12(O,OH,F,Cl).

(2)If the procedure (1) resulted in the total anion charge >22, you use the following procedure:

(a)M site <3

The calculate formulas of (1) were used.

(b)M site >3

Combination of the result of (1) (all iron is calculated as Fe^{2+}) with that of all iron calculated as Fe^{3+} leads to the approach of the M site occupancy to 3 as full as possible.

(3)If total of the anion charge calculated was <22 after the procedure (1), an idealized anion group must be assumed, and the formula should be based on 22 positive charges (The content of OH was determined as (OH+F+Cl)=2). Then, this was combined with the calculated result based on the assumption of Fe^{3+}, following the approach of the total wt% to 100% as full as possible.

Based on this procedure, the representative calculated chemical formula of the biotites from Tanakami granite is $(K_{0.865}Na_{0.007}<>_{0.128})($ Though this formula has large vacancies at I site and M site, there are limited vacancies in I and M sites of the biotite crystal structure (Fleet & Howie, 2003). It is considered that undetectable elements or molecules with EMPA, such as Li and H_3O^+, affected the result with some error. The representative chemical formula of the biotites from transition zone of a pegmatite in Tanakami granite is $(K_{0.937}Na_{0.003}<>_{0.060})(Al_{0.349}Fe^{2+}{}_{2.000}Mg_{0.436}Mn_{0.041}Ti_{0.127}<>_{0.047})Si_{2.902}Al_{1.098}O_{10.353}F_{0.424}Cl_{0.020}(OH)_{1.203}$. Comparing these two formulas, the biotite from transition zone of the pegmatite is more enriched in Si and F than that from the host granite.

The validity of the present formulation procedure is examined by applying biotites from the pegmatite and metapelitic granulite of Kerala Khondalite Belt, southeast India (Cesare et al. 2008). In Cesare et al.(2008), in addition to EMPA, Mossbauer spectroscopy(Fe^{2+}-Fe^{3+} ratio) and SIMS(H_2O content) were performed. When the chemical formula of biotites from the pegmatite of Kerala Khondalite Belt calculated based on all analysis is compared with that of the chemical formula calculated from the present procedure, the difference in vacancy is calculated to be 0.198 and 0.146 at the I site and the M site, respectively.

Keywords: biotite, chemical formula, EMPA, anion charge, classification, genetic place

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”Nanogranites” enclosed within zircon in gneisses in the Nove Dvory, Czech Republic

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The inclusions enclosed within zircon in the Gfoehl migmatitic gneisses at the Nove Dvory area, Moldanubian Zone of the southern Bohemian Massif, Czech Republic were observed by transmission electron microscope (TEM) and ”nanogranites” are first found in the zircon. The specimens for TEM observation were prepared by focused ion beam (FIB). The phase of the inclusions were determined by the electron diffraction pattern and chemical analysis by TEM-EDX. Kobayashi et al. (2008) provided evidence of former coesite in SiO2 phase inclusions in zircon grains extracted from the Gfoehl migmatitic gneisses in the Nove Dvory area.

The inclusions enclosed within zircon consist of the various combination of minerals which are quartz, plagioclase feldspar, alkali feldspar, muscobite and so on. Inclusions has the size in the range 10 to 100um. The many composed minerals is submicronmeter to micronmeter and some is several ten nanometer. Moreover, one inclusion has negative crystal-like shape. These feature of the inclusions are similar to the inclusion encloased within garanet reported by Cesare et al. (2009) and Hiroi et al. (2010) and these were called ”nanogranites.” However, the glassy inclusions which were reported by them were not observed in the present study. Quartz did not have the microstructure such as Dauphine or Brazil twins and alkali feldspar also have nomicrostructures such as exsolution lamellae, twins and so on. On the other hand, plagioclase feldspar has only albite twins and does not have the exsolution lamellae and anti-phase buondary. Although these results indicate that these ”nanogranites” is the partial melt at the high temperature metamorphism, these have some important problems.

Keywords: Zircon, Nanogranites, TEM

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Reexamination of phases of feldspars at high temperature and pressure.

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The feldspar is common rock forming mineral composed by $CaAl_2Si_2O_8$(An)-$NaAlSi_3O_8$(Ab)-$KAlSi_3O_8$(Or). Although the chemical composition of feldspar is commonly in plagioclase (An-Ab) or alkali-feldspar (Ab-Or), the ternary composition (An-Ab-Or) is possible composition and these ternary feldspars have unique textures in the case of ultra high temperature metamorphism, such as Napier Complex. We researches the micro-textures of the ternary feldspars in the felsic gneiss (TH97012006, hereafter shortened to 12006) from Mt. Riiser-Larsen in Napier Complex, East Antarctica and revealed the formation process. But it became apparent that the chemical compositions did not agree with tielines of the geothermometer-model (Fuhrman et al., 1988) and some micro-textures were not explained by coherent elastic boundary model (Cahn, 1962; Willaime et al., 1974). Therefore, Kodama et al. (2010) suggested that the coherent elastic exsolution model used by Fuhrman et al. (1988) would not be explained the texture observed in this study and the phase transition from high temperature to low temperature phase were first order.

Therefore, we focus on the behavior of chemical composition in the high to low temperature phase transition at near $An_{30}Ab_{70}$ composition and run the high temperature and the high pressure experiments of ternary feldspars using piston cylinder apparatus to determine the order of the phase transition because there is discontinuity of chemical composition and volume when first-order transition occurs, on the other hand, there is no discontinuity of chemical composition or volume when second-order transition occurs. Scanning electron microscope and energy-dispersive X-ray spectroscopy were used to observe the textures and determine chemical composition of the feldspars obtained from the experiments. Transmission electron microscope was used to observe the microtextures and determine the space group of the feldspars. We observed the discontinuity of chemical composition as characteristic of the first-order transition is observed in an oligoclase experimented at 1300C, 10kbar for 24 hours and this result suggested that the phase transition between high and low temperature phase had the first order.

Keywords: ternary feldspar, high temperature and pressure experiment, ultra high temperature metamorphism

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Graphitization in contact metamorphism; Detailed mineralogical examination and suggesting catalysis reaction

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Carbonaceous Materials (CM) are well known to change degree of crystallization depending temperature, pressure, time, precursor materials, hydrothermal and shear stress (Large,1994). In the graphitization, Kerogen is needed 260kcal/mol to transform their structure into graphite's. Extrapolation of the Arrhenius plots suggest that the formation of graphite even at a temperature of even 973K would require some 10^{40} minutes have in all earth history(Bustin,1995). Thus, the other factors except of ”Temperature” and ”Time” are more important influences for graphitization in the natural metamorphism. This study aims to solve the other important factors for natural graphitization.

Raman spectroscopic measurements and XRD data yielded that a series of graphitization in the contact metamorphism. However, CM of the Biotite zone (673-723K) have two asymmetric peaks, which was interpreted as combination of graphitic carbon(0.3357-0.337nm) and amorphous carbon(0.342nm), HRTEM study revealed Catalytic carbon of Shell like structures and Filament like structures, which coexisted with amorphous carbon heterogeneously.

Such features of shell like and filaments structure with amorphous carbon in just corresponded the same of features by catalytic carbon (Oya,1982; Sevilla,2007,2010).

Then graphitization in contact metamorphism could be interpreted as the product by catalytic activity.

Keywords: Carbonaeous materials, Catalysis, Graphitization, Contact metamorphism, HRTEM, Micro Raman spectroscopy