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

SMP046-P01 Room:Convention Hall Time:May 27 14:00-16:30

Deformation experiment of Serpentinite with preferred orientation

Yoshito Urata[1*], Jun-ichi Ando[1], yusuke soda[2]

[1]Graduate School of Hiroshima University, [2]Waseda University

We conducted constant strain rate experiment of antigorite serpentinite, in order to understand the effect of microstructural anisotropy on deformation behavior. The sample is naturally deformed foliated antigorite serpentinite which is characterized by preferential arrangement of (001) of antigorite parallel to the foliation. We prepared two types of oriented starting samples, whose foliations were set at 30 degree and 90 degree with respect to the axial stress. Experimental conditions were 500 C and 550 C at ca. 1 GPa confining pressure with 600 um/h displacement rate of piston. The experimental data indicate that the maximum and yield strengths of the 90 degree are ca. 40 % larger than those of 30 degree and that those of 500 C are 60 to 70 % larger than those of 550 C. The stress drop occurred at the final stage of all experiments. The microstructural observations with optical and scanning electron microscopes suggest that the yielding and stress drop in 30 degree experiments were due to kinking, and the deformation concentration on the axis of kink, respectively. On the contrary, those of 90 degree were due to plastic deformation of antigorite itself and extensional breakage of antigorite grains, respectively. All these behaviors are thought to be caused by two typical characters of foliated antigorite serpentinite; 1) easy to make open crack parallel to foliation if compression stress applies in the direction parallel to the foliation, and 2) weakness of (001) for extensional stress.

Keywords: Antigorite, Serpentinite, Solid medium deformation experiment, SEM

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SMP046-P02 Room:Convention Hall Time:May 27 14:00-16:30

Subduction related Antigorite CPO patterns from forearc mantle in the Sanbagawa belt, southwest Japan

Aya Nishii[1*], Simon Wallis[1], Tomoyuki Mizukami[2], Katsuyoshi Michibayashi[3]

[1]Earth & Planetary Sci., Nagoya Univ., [2]Nat. Sci. Tech., Kanazawa Univ., [3]Instit. Geosci. Shizuoka Univ.

Antigorite (Atg) is stable throughout large parts of the wedge mantle of most subduction zones. Atg shows very strong acoustic anisotropy, and recent studies have emphasized that the crystallographic preferred orientation (CPO) of Atg should be considered as a possible cause of seismic anisotropy in convergent margins.

Only a few Atg CPO patterns have been published (Bezacier et al., 2010; Hirauchi et al., 2010; Moortele at al., 2010; Soda & Takagi, 2010). From these limited data, two main types of Atg CPO pattern can be defined: one with an a-axis parallel to the stretching direction (A-type) and the other with the b-axis parallel to the stretching direction (B-type). In this study, we report antigorite CPO patterns from the Higashiakaishi (HA) body?a sliver of forearc mantle preserved in the Sanbagawa belt of southwest Japan. These CPO patterns are a further example of the B-type antigorite patterns.

Because Atg has a low plastic yield strength, it is possible that original orientations of the Atg crystals may be affected by mechanical damage caused by production of the thin sections used for measurement. However, statistical analysis using the eigen vector method of Atg CPO in two thin sections from two distinct directions in the same sample (YZ-section perpendicular to foliation and lineation and XZ-section perpendicular to foliation and parallel to lineation) shows no significant differences. Atg CPO developed during the same phase of deformation was also stronger in the sample with a greater proportion of Atg: the opposite to that expected if Atg CPO is disturbed by sample preparation. We conclude that sample preparation by standard polishing techniques has no significant affect on the resulting CPO.

Seismic anisotropy associated with the Atg-bearing HA peridotite calculated using the combined Olivine and Atg CPO patterns requires thicknesses of 1.47?4.6 km for a time delay of 0.1 s and 5.31?11.56 km for a time delay of 1 s. The large range of possible thicknesses represents the difference between Reuss and Voigt averages.

[References] Bezacier, L. et al. 2010, EPSL; Hirauchi, K. et al. 2010, EPSL 299. 196-206; Moortele, B. et al. 2010, J. Microscopy 239, 245-248; Soda, Y. and Takagi, H. 2010, J. Structural Geology 32, 792-802.

Keywords: Antigorite, CPO, seismic anisotropy, Higashi Akaishi body

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SMP046-P03 Room:Convention Hall Time:May 27 14:00-16:30

The deepest peridotites in ocean floor: Tonga trench peridotites revealing forearc extension

Yuri Shinkai[1*], Katsuyoshi Michibayashi[1], Shigeki Uehara[1], Teruaki Ishii[2]

[1]Instit. Geosci. Shizuoka Univ, [2]Fukada Geological Institute

The Tonga trench is one of the deepest trenches in the world. We used peridotite samples collected from dredge hauls by Boomerang Leg 8 Cruise aboard R/V Melville in 1996 at the deep landward trench slope (19'15.19S, 172'56.29W; depth 8,194-9,371m; Bloomer et al., 1996, Fall Meeting, Abstract, OG32B-01). Most of samples are remarkably fresh, indicating that tectonic erosion is active in the Tonga trench. The samples are harzburgites and show some variations in microstructure consisting of dominantly coarse (>5mm) granular texture to minor fine-grained (~0.5mm) parts. They contain high-Cr# spinels in a range between 0.5 and 0.8 with very low Ti contents, suggesting that these peridotites were derived from the Tonga forearc. Equilibrium temperatures estimated by Ca in orthopyroxene geothermometer are approximately 900-1250. Olivine fabrics are characterized by intense [100]-fiber pattern, which could be developed by transtension type of strain (Tommasi et al., 1999, EPSL, 168, 173-186). These indicate that the Tonga trench peridotites have probably been derived from the lithospheric mantle due to the forearc extension during slab rollback (Smith et al., 2001, Science, 292, 713-716).

Keywords: Tonga Trench, peridotite, crystal-preferred orientation, forearc, slab rollback

SMP046-P04 Room:Convention Hall Time:May 27 14:00-16:30

Elastic Wave Velocities of Antigorite-Bearing Serpentinite Mylonites

Yuto Shirasugi[1*], Tohru Watanabe[1], Katsuyoshi Michibayashi[2]

[1]University of Toyama, [2]Shizuoka University

The relationships between elastic wave velocities and petrofabrics were studied in antigorite-bearing serpentinite mylonites. Rock samples with antigorite content from 40 to 80 vol.% were collected from the Happo ultramafic complex, Central Japan. Compressional and shear wave velocities were measured by the pulse transmission technique at room temperature and confining pressures of up to 180 MPa. Petrofabrics were examined by optical microscopy and SEM-EBSD. Olivine a- and c-axes are weakly oriented perpendicular to the foliation and parallel to the lineation, respectively. Antigorite b- and c- axes are distinctly oriented parallel to the lineation and perpendicular to the foliation, respectively. Samples show strong anisotropy of velocity. The compressional wave velocity is fastest in the direction parallel to the lineation, and slowest in the direction perpendicular to the foliation. The shear wave oscillating parallel to the foliation has higher velocity than that oscillating perpendicular to the foliation. As the antigorite content increases, the mean velocity decreases but both azimuthal and polarization anisotropies are enhanced. Measured velocities were compared with velocities calculated from petrofabric data by using Voigt, Reuss and VRH averaging schemes. All averaging schemes show velocity anisotropy qualitatively similar to measurements. There are large velocity differences between Voigt and Reuss averages (0.7~1.0 km/s), reflecting the strong elastic anisotropy of antigorite. Measured velocities are found between Reuss and VRH averages. We think that the relatively low velocity is due to the platy shape of antigorite grains, the well developed shape fabric and their strong elastic anisotropy. Measured velocities will be compared with calculation considering layered structures in serpentinite mylonites.

SMP046-P05 Room:Convention Hall Time:May 27 14:00-16:30

Elastic wave velocity and petrofabric of amphibolites and eclogite from the Sanbagawa metamorphic belt

Tohru Watanabe[1], kenya ono[1*], Motoki Kitano[1], Akiyoshi Higuchi[1], Yuto Shirasugi[1], Katsuyoshi Michibayashi[2]

[1]University of Toyama, [2]Shizuoka University

Hydration and dehydration processes in the oceanic crust materials play important roles in subduction zone processes as water transportation and slab earthquakes. Seismological constraints to constituent materials and their water content in the slab crust should lead to further understanding of subduction zone processes. It is thus essential to understand elastic properties of slab crust materials. We have made velocity measurements and petrofabric observations on amphibolites and an eclogite from the Sanbagawa metamorphic belt, which might have been subducted oceanic crust.

Rock samples are amphibolite schist, garnet amphibolite (Iratsu amphibolite body, Shikoku-chuou, Ehime Pref.), and eclogite (Higashi-Akaishiyama peridotite body, Shikoku-chuou, Ehime Pref.). The density are 3120, 3250, 3460 kg/m3, respectively at room conditions. A rectangular parallelpiped (the edge length ˜ 30 mm) was cut from each rock sample for velocity measurements. Two faces are parallel to the foliation plane, two faces perpendicular to the elongation direction, and the remaining two faces perpendicular to the foliation plane and parallel to the elongation direction. Preliminary velocity measurements were made at room conditions by the pulse transmission technique using Pb(Zr, Ti)O3 transducers with the resonant frequency of 2 MHz. One compressional wave velocity and two shear wave velocities were measured in each of three orthogonal directions. Two shear waves propagating in one direction oscillate in mutually orthogonal directions. Arithmetic means of Vp and Vs are 5.70 km/s and 3.60 km/s for amphibolite schist, 3.92 km/s and 2.69 km/s for garnet amphibolite and 5.50 km/s and 3.60 km/s for eclogite. The azimuthal anisotropy of Vp is around 10% for amphibolite schist and eclogite, whereas it is 36% for garnet amphibolite. However, these velocity values cannot be compared with petrofabrics, because they must be affected by pores in rock samples. We are now conducting velocity measurements under the confining pressures of up to 180 MPa to remove the influence of pores. The relationship between velocity under the confining pressure and petrofabrics will be presented in our poster.

Keywords: amphibolite, eclogite, elastic wave velocity, petrofabric

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SMP046-P06 Room:Convention Hall Time:May 27 14:00-16:30

Application of Micro-XRF analysis for estimation of igneous mineral compositions from subduction zone meta-peridotites

Tatsuya Hattori[1*], Tomoyuki Mizukami[1]

[1]Natural Science, Kanazawa university

Ultramafic rocks in the metamorphic belt have been generally re-crystallized into fine-grained aggregates and the elemental components in the rocks have been re-distributed into newly formed minerals including hydrous phases. In order to discuss the igneous processes related to the origins, we have to estimate such chemical and modal modification. For examples, Ni, Mg and Fe are important indicators of fractional crystallization and partial melting but they are expelled out from olivine and pyroxene into magnetite (Mag), antigorite (Atg) and sulfides (pentlandite (Pn) etc.). The precise modal compositions of the metamorphic constituents are necessary for reproduction of the igneous mineral compositions.

We test an elemental mapping using a Micro-XRF Analyzer (XGT-5000, HORIBA) to determine modal compositions of metamorphic minerals. In this system, an X-ray beam is focused on a polished thin section (30 micron thick) in a diameter of 0.1 mm and fluorescent X-ray maps (512 x 256 pixels for a region of 2 x 1 cm2, for example) of elements with higher atomic number than Ca are gained using an EDS detector.

Analytical samples are ultramafic rocks in Higashi-akaishi peridotite body (HA) in Sanbagawa metamorphic belt, southwest Japan. They have been a part of olivine (Ol)-clinopyroxene (Cpx) cumulate composed of dunite and Cpx-bearing rocks. The present constituent minerals are Ol, Cpx, Atg, Cr-Spl, ferricht Chr, Mag, Pn. The modal compositions of Cpx, Mag, Cr-Spl/ ferricht Chr and Pn are determined using Ca map, Fe map, Cr map and Ni map, respectively. Proportions between Ol and Atg are determined by point counting. As a result, modal compositions are determined to one place of decimal, for example: Ol (4.2%), Cpx (32.1%), Spl (0.5%), Mag (2.6%), Pn (0.1%) and Atg (60.5%).

Primary compositions are calculated from the present mode and mineral chemistry assuming a primary assemblage of Ol + Cpx + Cr-Spl, a semi-closed system with additions of H2O and SiO2 and KD(Ol-Cpx) = 0.8. Resultant Mg# and NiO content in Ol show significant effect of metamorphic changes from 0.862 to 0.822 and from 0.17 to 0.11, respectively. Our calculation indicates that a modal composition of Pn should be determined with a precision to two places of decimals. Measuring sizes and numbers of sulfide grains under a reflecting microscope will be the best way to make reliable estimation of primary NiO in Ol instead of a XRF mapping.

Keywords: Micro-XRF analysis, modal composition, pentlandite, subduction zone, meta-peridotites

Japan Geoscience Union Meeting 2011
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SMP046-P07 Room:Convention Hall Time:May 27 14:00-16:30

Mode of occurrence of chlorine-rich biotite and zircon in the pelitic gneiss from Sor Rondane Mountains, East Antarctica

Fumiko Higashino[1*], Tetsuo Kawakami[1], M. Satish-Kumar[2], Noriyoshi Tsuchiya[3], Masahiro Ishikawa[4], Geoff Grantham[5]

[1]Kyoto University, [2]Shizuoka University, [3]Tohoku University, [4]Yokohama National University, [5]Council for Geoscience, South Africa

The Bt-Grt-Sil gneiss from northern Balchenfjella, Sor Rondane Mountains, East Antarctica contains Grt porphyroblast (5-10 mm in diameter) and fine-grained Grt (100-200 um in diameter). The Grt porphyroblast has characteristic zoning in P. The core is P-rich with oscillatory zoning in P, and the rim is P-poor without oscillatory zoning. In this way, the core-rim boundary is defined by the discontinuous P zoning. This discontinuity suggests that the Grt porphyroblast has experienced resorption and recrystallization (e.g., Kawakami & Hokada, 2010). The Grt core is homogeneous in composition while Fe and Mn increase and Mg and Ca decrease toward the rim. This trend is significant where the Grt is in contact with matrix Bt. The fine-grained Grt has similar composition with the Grt porphyroblast rim, suggesting that the rim and the fine-grained Grt crystallized simultaneously.

Chlorine-rich Bt (0.08-1.08 wt%) and coarse Zrn (100 um in diameter) are included exclusively in the rim of the Grt porphyroblast. Bt in the matrix and that included in the core of the Grt porphyroblast are Cl-poor ($<$ 0.06 wt%). Coarse-grained Zrn is present in the matrix and also included in the fine-grained Grt. Only one grain of tiny Zrn (20 um in diameter) is found included in the core of the Grt porphyroblast so far.

Almost all of the Cl-poor Bt grains in the matrix give lower X_{Mg} [= Mg/(Mg+Fe_{total})] (X_{Mg} = 0.56 +/- 0.03) than the Cl-rich Bt included in the P-poor rim of the Grt (X_{Mg} = 0.60 +/- 0.04). Detailed examination of retrograde Fe-Mg exchange between the inclusion Bt and the host Grt revealed that the Cl-rich Bt was originally as Mg-rich as the matrix Bt and changed its composition to the Mg-rich one through the retrograde Fe-Mg exchange reaction between Grt. There is a possibility, therefore, that matrix Bt was once Cl-rich and lost Cl via interaction with the Cl-poor fluid that subsequently infiltrated into the matrix.

The presence of resorption texture at the core-rim boundary of the Grt porphyroblast, and the intimate coexistence of Cl-rich Bt and coarse-grained Zrn in the rim of the Grt porphyroblast implies the genetic relationship between them. The Cl-rich Bt may be formed through the effect of Cl-rich fluids during metamorphism (e.g., Sisson, 1987) or through magmatic-hydrothermal evolution (e.g., Coulson, 2001). Therefore, it is likely that the Cl-rich Bt included in the garnet rim is the evidence for the infiltration of Cl-rich fluid, and coarse-grained Zrn (at least the rim part) and the Cl-rich Bt were formed almost simultaneously, during or after the Grt porphyroblast resorption. Future dating of included Zrn may help constrain the timing of Cl-rich fluid infiltration during the metamorphism in the Sor Rondane Mountains.

Keywords: chlorine, zircon, resorption, metamorphic fluid

Japan Geoscience Union Meeting 2011
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SMP046-P08 Room:Convention Hall Time:May 27 14:00-16:30

Two modes of occurrence of "arrested charnockite" in Sri Lanka

Yukiko Yamasaki[1*], Takeshi Ikeda[1], Yoichi Motoyoshi[2], Yoshikuni Hiroi[3], Bernard Prame[4]

[1]Earth and Planet. Sci., Kyushu Univ., [2]National Institute of Polar Research, [3]Earth Sci., Chiba Univ., [4]Geological Survey of Sri Lanka

Felsic to intermediate lithologies charnockitized incompletely have been called as "arrested charnockite". These types of high-grade metamorphic rocks occur in Sri Lanka, as well as Antarctica and South India that formerly constituted Gondwanaland. We described the mode of occurrence and chemical composition of the constituent minerals of the arrested charnockite from two outcrops in Sri Lanka. In the first outcrop near Kurunegala, charnockite occurs as a number of patches with lentituclar to ovoidal shapes. The long axes of the patches are not parallel to the foliation defined in the surrounding felsic gneiss. The boundary between charnockite patch and surrounding gneiss is obscure. Compositional layerings composed of Hbl-rich domain and Hbl-poor domain disappear gradually into charnockite. In the second outcrop near Kandy, charnockite is developed as a vein along a fracture of Grt-Bt felsic gneiss. The boundary is obscure. The compositional layerings and mineral preferred orientation recognized in the host gneiss are preserved in the charnockite domain.

In the charnockite from the first outcrop, orthopyroxene occurs commonly. The orthopyroxene grains are locally replaced by cummingtonite along rim and cheavage. Orthopyroxene appears at inner portions of the boundary of charnockite patches recognized by naked eye. The modal abundance of orthopyroxene increases with increasing distance from the boundary. In contract, vein-like charnockite from the second outcrop, many symplectites occur while orthopyroxene is not found. The suroundring gneiss also has symplectites locally. The symplectites are composed of various mineral assemblages, such as Amp+Pl+Ilm+Mag+Cpx, Amp+Pl+Ilm+Mag and Pl+Ilm+Mag.

Amphibole can be divided into two based on the chemical composition. One has higher Ca and Al than another. The former occurs in the host gneiss and also in the charnockite that defines gneissosity. The latter amphibole (cummimgtonite) is recognized only in the charnockite and either replaces orthopyroxene in the patchy charnockite or consists of symplectite in the vein-like charnockite. The cummingtonite in the symplectite showing similar composition to that replacing orthopyroxene suggests that the symplectites in the vein-like charnockite were originally orthopyroxene which has broken down during retrograde metamorphism.

Keywords: charnockite, Sri Lanka

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SMP046-P09 Room:Convention Hall Time:May 27 14:00-16:30

Finding of brown hornblende bearing basic rock from Bungo-Ohno, Oita prefecture

Shunji Tojo[1*], DOHI, Shintaro[1]

[1]Fukuoka University of Education

The Asaji metamorphic rock have been studied by many authors (e.g. Ohshima et al., 1971; Fujii et al., 2008). As the result of field surveying, several basic rock samples which contain brown hornblende, size of up to 0.8 mm were collected. The sample localities are concordant to the area of basic rock belt, and belonged to the metamorphic zone B described by Ohshima et. al. (1971). However, the brown hornblende is characteristic mineral of the metamorphic zone C, and uniquely found in xenolith or roof pendant of the plutonic rocks. There have been no described plutonic rock near around the localities of these basic rocks we found. It is possibly suggested that the potentially underlaying of plutonic rocks at shallow depth.

Keywords: Asaji metamorphic rock, brown hornblende, contact metamorphism

SMP046-P10 Room:Convention Hall Time:May 27 14:00-16:30

Metamorphic and granitic tectonic blocks of the Atokura Nappe in the Yorii-Ogawa district, central Japan

Akira Ono[1*]

[1]None

The Atokura Nappe in the northeastern Kanto Mountains is composed of Yorii pyroclastic rocks, Yorii Formation, Atokura Formation, Kinshozan Quartzdiorite, Greenstone Merange and various small tectonic blocks (Figure 1). The geological bodies are usually in contact with each other by high-angle faults. Metamorphic and granitic rocks often occur as small tectonic blocks. The representative ones are (a) mid-Cretaceous metamorphic and granitic rocks, (b) early Paleogene Kiroko metamorphic rocks within the Greenstone merange (Ono, JpGU Meeting 2008, G122- P002), (c) late Cretaceous Yorii Granitoids in the Mure.

mid-Cretaceous metamorphic rocks

A small tectonic block of mid-Cretaceous metamorphic and granitic rocks is exposed between the early Paleogene Yorii Formation and the late-Permian Kinshozan Quartzdiorite near Mt. Kinshozan (Figure 1). Coarse-grained garnet-bearing gneisses are found in the southern part of the tectonic block. Fine-grained chlorite-muscovite schists and chlorite-amphibole schists are exposed in the northern part. Calcareous rocks of approximately 20m thick are exposed in the easternmost part of the block. The calcareous rocks show various rock textures. A few pelitic and tuffaceous thin layers are intercalated. Fusulinacean fossils are found in the calcareous rocks and pelitic rocks. Hence, the low-grade metamorphic rocks are metamorphosed Paleozoic formations. This fact suggests that highly metamorphosed calcareous rocks of the Atokura Nappe are also metamorphosed Paleozoic rocks. The mid-Cretaceous metamorphic rocks have properties similar with those of the Hitachi metamorphic rocks in the Abukuma belt.

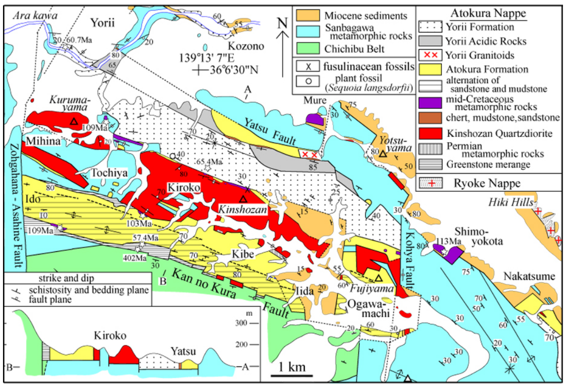
early Paleogene Kiroko metamorphic rocks

The Greenstone Merange which is exposed in the southernmost part of the Atokura Nappe (Figure 1) is mainly composed of the Kiroko metamorphic rocks, serpentinite, actinolite-rocks and various metamorphic and granitic rocks. Serpentinites are poor and granitic rocks are common in the eastern part of the Greenstone Melange. The Kiroko metamorphic rocks mainly consist of mafic rocks, pelitic rocks and psammitic rocks. They are well-recrystallized low-grade metamorphic rocks. There is no evidence for recrystallization and alteration after the main phase of the regional metamorphism.

The Greenstone Melange is in contact with the Atokura Formation by high-angle faults. Serpentinite is common adjacent to the Atokura Formation although serpentinite is rare in the eastern part of the Greenstone Melange. The common occurrence of serpentinite near the high-angle faults suggests that serpentinites played important roles in the formation of the high-angle faults in the root zone of the Atokura Nappe.

late Cretaceous Yorii Granitoids

The Yorii Granitoids consist of aplite and biotite tonalite which are exposed in the Mure. Biotite tonalite is massive and medium in grain sizes. Biotite is partly altered to chlorite. Magnetite is not observed. The biotite tonalite is in contact with a small tectonic block of chert, slate and sandstone by a high-angle fault. The biotite tonalite may be one of the late Cretaceous granitoids of the Southwest Japan judging from the lack of similar granitic rocks in the Atokura Nappe.



Keywords: Atokura Nappe, metamorphic rocks, serpentinite, granitoid, fusulinid