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SCG05-01 Room:106 Time:May 23 09:00-09:15

Space and Temporal change of Provenance for the Permian to Jurassic Formations in the Inner zone of SW Japan

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Detrital zircon and monazite in sandstones corrected from Permian to Jurassic Formations in the Inner Zone of SW Japan has been dated over 5, 000 grains from thirty or more samples using SHRIMP, LA-ICP-MS and EPMA. Detrital zircon and monazite usually show the different age population even for the same sample. This can be attributed to difference of their original host rock distributed in its provenance. Zircon crystallizes in wide range of silica-saturated igneous rocks and high-grade gneiss while the crystallization of monazite is restricted in hornblende-free granites and pelitic gneiss. This difference enables us to analyze the constituent rock types of provenance by chronology of detrital grains. For example, fertility of zircon and absence of monazite may show the dissected island arc as its provenance.

Total age population of detrital zircons from Permian to Jurassic Formations in the Inner Zone of SW Japan shows the age clusters at around 2600-1700 Ma (Pt1 peaks), 1400-700 Ma (Pt2-3 peaks), 550-360 peaks (C-D peaks), 300-270 Ma (P1 peak), 260-240 Ma (PT peak), 220-200 Ma (T3 peak), 200-165 Ma (J1-2 peak), 160-140 Ma (J3 peak). And monazite predominates in short lived peak at around 1860 +/- 100 Ma, 500 +/- 50 Ma, 250 +/- 20 Ma, 190 +/- 10 Ma and barren in the periods before 2000 Ma, 1500-600 Ma and 420-300 Ma. Appearance and absence of each peak change depend on space, time and Terrane of which sample belongs. This difference and change can be key to study of tectonic evolution. Age populations of detrital zircon and monazite and their tectonic interpretation for each Terrane are summarized as bellows.

1) Akiyoshi Terrane and Ultra-Tamba Terrane are characterized by two age clusters of P1 and PT peaks. And they do not contain monazite at all. This means the provenance of both terranes could not be mature continental crust but island arc formed during early Permian. 2) Triassic Formations in the eastern part of the Inner Zone of SW Japan show the age clusters of C-D peak and PT peak, and former contains much of monazite. Such character may be correlated to Khanka-Jamusi-Bureya Massif of western Primorye, Far East Russia as its provenance. 3) Lower to Middle Jurassic Formations in the Inner Zone of SW Japan predominate detrital zircons belongs to Pt1 peaks with abundant monazite at around 1860 Ma. And they luck in Pt2-3 peaks and C-D peaks. This means that their provenance is North China Craton. 4) First appearance of Pt1 peak is Early Triassic time, especially in the western part of the Inner Zone of SW Japan like Suo Terrane. This time marked by the collision of North China and South China Brocks near the Proto-Japan. Suo metamorphism is thought to start coeval with this collision and subsequent mountain building.

Keywords: detrital zircon, detrital monazite, LA-ICP-MS, Inner Zone of SW Japan, Permian, Jurassic

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SCG05-02 Room:106 Time:May 23 09:15-09:30

Detrital zircon chronology of Mesozoic sediments from Khabarovsk area, Russian Far East, and SW Japan

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Mesozoic formations are widely distributed in the southern part of Primorye, Far East Russia. A part of them is suggested as a Jurassic accretionary complex named the Khabarovsk-Nadanhada-Samarka Terrane. Because of their lithological similarity, ages, radiolarian assemblages and geologic structure, this Terrane has been thought to be the eastern extension of the Tamba-Mino-Ashio Terrane in the Inner Zone of SW Japan, though they are separated by Japan Sea (Kojima, 1991). To restore the primary continuation and reconstruct the geological structure around them, we compared their provenance detected by the detrital zircon U-Pb chronology. Sandstones were corrected from the Triassic to Cretaceous Khabarovsk, Amur and Bureya Groups around Khabarovsk City, and the Tamba-Mino-Ashio Terrane as a Jurassic accretionary complex distributed in the Inner Zone of SW Japan. Separated detrital zircons were analyzed using LA-ICP-MS (80-120 grains for each sample). They show space and temporal change of their provenance reflecting the tectonic event during their deposition. Sample KHB-1 is pale greenish gray sandstone corrected from the chart-shale melange in the Jurassic Khabarovsk complex at the Amur riverside in Khabarovsk City. Sample KHB-5 is pale greenish gray sandstone corrected from the Pioner Formation as a Cretaceous fore arc basin deposit at the Petropavlovka lake side ca. 35 km NE of Khabarovsk City. Sample BRB-1 is light gray sandstone corrected from the Cretaceous non-marine Bureya Basin at ca. 370 km NNW of Khabarovsk City. Sample DLM-3 is dark gray sand fine-grained sandstone corrected from the Early Cretaceous marine Assikaevka Formation at ca. 120 km SSE of Khabarovsk City. This Formation rests on the Nadanhada Terrane unconformity. Sample ASI-1 is grey sandstone corrected from the Hakonoguchi Formation, Ashio Terrane, at Oguni-Cho, Yamagata Prefecture. Sample INY-1 is medium grained sandstone corrected from the Kamiaso section of the Mino Terrane at Inuyama City, Gifu Prefecture.

U-Pb ages are analyzed on over 800 zircon grains. The samples from Khabarovsk area and SW Japan show their depositional ages as Triassic to Middle Cretaceous and early to middle Jurassic, respectively. Despite the diversity of depositional ages and tectonic settings, all Khabarovsk samples show the similar age population consisting the age clusters at around 230-280 Ma and 420-490 Ma. This chronological feature can be also found in the Bureya Basin sample and they can be correlated to the Khanka, Jamsui and Bureya massive as their porvenance. On the other hands, zircons of all samples corrected from Tamba-Mino-Ashio Terrane of SW Japan show the age clusters at around 190-280 Ma and 1.8 Ga. And they don't contain the middle Proterozoic to early Paleozoic zircons at all. Such the age population shows that the provenance of the Tamba-Mino-Ashio Terrane can be correlated to the North China Craton. On the other hand, the age population of detrital zircons from Khabarovsk area is quite similar to that of the Lower Triassic Moribu Formation of the Hida Terrane, and the Upper Triassic Nabae Group and Lower Triassic Miharaiyama Formation of the Maizuru Terrane (Nakama et al., 2010). This suggests that the Maizuru Terrane was located near the Khanka-Jamusi-Bureya massif at the Triassic time. And this agree with the assumption by Fujii et al. (2008), that the Northern zone of the Maizuru Terrane was displaced by dextral strike-slip fault split from Khanka Massif. This might have been lead the change of provenance for the Inner Zone of SW Japan during Late Triassic to Early Jurassic time.

Keywords: LA-ICP-MS, Pleogeography, Jurassic Accretionary Complex, Southwest Japan, Sikhote-Alin

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SCG05-03 Room:106 Time:May 23 09:30-09:55

SHRIMP U-Pb dating of zircons related to the partial melting in deep subduction zone ?case study from the Sanbagawa quar

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Dehydrated fluid from the subducting cold slab is considered to cause deep focused earthquake and Island Arc volcanism. The Sanbagawa high P/T metamorphic rocks have been considered as typical cold subducted ocenic material at Cretaceous. However, we have discovered an eclogite outcrop exhibiting partial melting texture from the Sanbagawa high P/T metamorphic belt in Central Shikoku, Japan. The discovery is significantly important because the melt may play an important role in deep focused earthquake and the melt itself directly may contribute to the origin of Island Arc magma. In order to confirm the age of partial melting of Sanbagawa metamorphic rocks, we had separated zircons from both the melted portion and the host eclogite and dated U-Pb age using the SHRIMP at the Korean Basic Science Institute.

The zircons from the melted portion (SHT16&75) are rounded and have sector zoning. The core and mantle yield U-Pb age in the 130-113 (120 in average) Ma range, and the rim ages are in the 115-104 Ma range. The zircons from the eclogite (SHT15&76) have homogenous core with thin mantle and rims. The U-Pb ages are concentrated to 123 - 112Ma. The ages are identical to the zircon U-Pb ages (120-110 Ma) reported by Okamoto et al (2004). Above these evidences suggest that eclogite metamorphism was occurred at 120Ma. Subsequent partial melting was happened at 110Ma.

Keywords: Sanbagawa high P/T metamorphic rocks, eclogite, partial melting, zircon U-Pb age, Zircon REE, subducion zone

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SCG05-04 Room:106 Time:May 23 09:55-10:10

Three different types of events along the Sagami trough and objectives of the Kanto Asperity Project

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The Kanto region is one of the most densely populated urban areas in the world. Complicated plate configurations are due to T-T-T type triple junction, island arc-island arc collision zone, and very shallow angle between axis of the Sagami trough and subducting direction. Great earthquakes along the Sagami trough have repeatedly occurred. The 1703 Genroku and 1923 (Taisho) Kanto earthquakes caused severe damages in the Tokyo metropolitan area. Intriguingly slow slip events have also repeatedly occurred in an area adjacent to the asperities of the great earthquakes, off Boso peninsula (e.g., Ozawa et al 2007). In the cases of the Nankai and Cascadia subduction zones, slow slip events occur at deeper levels than the asperity, in a transition zone between the asperity and a region of steady slip. In contrast, slow slip events in the Kanto region have occurred at relatively shallow depths, at the same level as the asperity, raising the possibility of friction controlled by different conditions to those (temperature and pressure) encountered at Nankai and Cascadia.

We focus on three different types of seismic events occurring repeatedly at the almost same depth of the seismogenic zone along the Sagami trough (5-20 km)

(1) The 1923 M˜7.9 Taisho earthquake, located in Sagami Bay. Maximum slip is about 6 m, the recurrence interval is 200-400 yr, and the coupling rate is 80-100% ("coupling rates" = "slip amounts during earthquakes or slow-slip events" / ["rate of motion of the Philippine Sea Plate" - "recurrence interval"]) .

(2) The 1703 M˜8.2 Genroku earthquake, located in Sagami Bay, but also extending to the southern part of Boso Peninsula. Maximum slip is 15-20 m, the recurrence interval is ˜2000 yr, and the coupling rate at the southern part of the Boso Peninsula is 10-30%.

(3) Boso slow-slip events, located southeast of Boso Peninsula. Maximum slip is 15-20 cm over ˜10 days, the recurrence interval is 5-6 yr, and the coupling rate is 70-100%.

Proposals of the Kanto Asperity Project (KAP) have been submitted to the Integrated Ocean Drilling Program (IODP) to investigate the three patches. The scientific objectives are

Objective 1: To understand why the three different types of events occur side by side at almost same depth (in same P-T conditions), and

Objective 2: To establish realistic earthquake-generation models using data on each step of the process of natural earthquakes.

The KAP consists of three research programs for these objectives. In Program A we propose coring and logging plate boundaries in asperity to measure physical properties (particularly frictional parameters) and pore pressures to establish a realistic earthquake cycle model. In Program B, we propose long-term monitoring with wide area network to observe 2-3 cycles of slow slip events and to verify a model of earthquake generation cycle through model of slow slip event cycle. In Program C, we will propose shallow drilling, coring, and logging at several sites to get input materials on the Philippine sea plate.

Keywords: the 1923 Kanto earthquake, the 1703 Genroku earthquake, asperity, slow slip event

SCG05-05 Room:106 Time:May 23 10:10-10:25

The 23 October 2011 Van Earthquake (Mw=7.2) : Eastern Turkey

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ABSTRACT

On 23 October 2011 at 13:41(local time) a strong earthquake (Mw=7.2) occurred in east of Lake Van. The earthquake destroyed the regions especially between the cities of Van and Ercis, and East of Lake Van-Lake Ercek region. It caused deaths of more than 660 people.

After the main shock 11 important earthquakes (5.0<M<6.0) were occurred in the region which have hypocentral distances of 8-38 km. from the main shock location. After the main shock 2305 aftershocks were recorded during the two week period in the region. 160 earthquakes have occurred within magnitude range of 4.0<Ml<4.9 in 60 days after the mainshock. The initial rapid fault solution shows that the rupture started at 43.41 North -38.72 East coordinates. The fault that caused the Van earthquake is a reverse fault with a northward dipping fault plane. The main shock triggered mass movement, spreading, and local liquefaction. Van earthquake and aftershock fault mechanism solutions show that the region is under compression and reverse faulting is a result of this regime which is effective on the active tectonics of the region. The results of strain analysis show that the general alignment of the largest strain axis (P-compressional) has N-S (NNW/SSE) and tensional axis (T-dilatation axis) has E-W (ENE-WSW) direction. The distribution of the important earthquakes and the aftershock distribution shows that the E-W and NE-SW oriented fault segments cause the earthquake activities. After the main shock, 8 Broad Band (BB) seismic stations were established by the National Earthquake Monitoring Center (NEMC) as a temporary network in the region. The Van earthquake activity initiated and caused an increase in seismic activity of the region. This may be explained by the triggering of small faults by the Van Earthquake. The Van earthquake is a good example of compressional deformation and the activity of blind reverse faulting. b-value analysis shows the relation between the faulting type in the region and tectonic regime, the compressional regime in the region is tested by b-value and small b-value is found.

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Keywords: reverse faulting, aftershock, focal mechanism, seismic activity, b-value

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SCG05-06 Room:106 Time:May 23 10:45-11:10

Ontong Java Plateau lithosphere and its relation to craton formation

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While there is general agreement that the roots of cratons formed in Archean times, there has been considerable debate as to whether the very high-degrees of melt extraction accompanying their formation was accomplished via deep plume melting or shallow melting in subduction environments. Increasing geochemical evidence from cratonic peridotites now suggests a low-pressure melting origin, favoring the subduction-stacking model for craton formation. However, the plume model is also an attractive scenario in that it provides a straightforward explanation for the widespread occurrence of ultradeep diamonds. Hence the role of mantle plumes in the lithosphere formation remains an important issue to understand. A suite of mantle xenoliths from Malaita, Solomon Islands provides a rare opportunity to investigate how normal oceanic lithosphere was subsequently influenced by large-scale plume activity, because these peridotites were derived from beneath the most voluminous large igneous province on the Earth - the Ontong Java Plateau (OJP). Accumulated geological evidence suggests that the OJP lithosphere was created essentially in an oceanic environment at Jurassic-Cretaceous time and is not associated with any known subducting slab or subduction-related structures (e.g. accretion/stacking). Hence the characteristic features of the OJP peridotitic lithosphere may dominantly reflect plume-related lithosphere generation and hence can be used to test the plume hypothesis for cratonic mantle formation.

Principal thermal/compositional characteristics of the OJP lithosphere constrained from xenolith thermobarometry and geochemistry are clearly different from those of typical Archean cratons. The OJP lithosphere mainly comprises fertile lherzolites with subordinate clinopyroxene-bearing harzburgites (degree of melt extraction ~30%), with a thickness of only ~120 km. The thermal state is consistent with that expected for old oceanic lithosphere whose geothermal gradient is significantly higher than that of cratonic mantle. However, several features could be shared by other on- and off-craton continental lithosphere, for instance the occurrence of low-Cr megacrysts and two-groups of garnet pyroxenite (low- and high-Mg). The most salient feature of the OJP lithosphere is the marked stratification in lithological composition. Re-Os isotope studies of Malaita peridotite/pyroxenite xenoliths demonstrate that vertical Os isotopic variations correlate with compositional stratigraphy. The shallow lithosphere ($<$85 km) is dominated by fertile lherzolites showing a restricted range of $^{187}Os/^{188}Os$ (0.1222 to 0.1288), consistent with an origin from ~160 Ma Pacific lithosphere. The mid-section of lithosphere (85-95 km) is comprised of Os-depleted harzburgites interpreted as residues from plateau magma production. The basal section (95-120 km) shows strong heterogeneity in rock types, containing (1) refractory harzburgites with highly unradiogenic $^{187}Os/^{188}Os$ (0.1152 to 0.1196), which yield Proterozoic model ages of 0.9-1.7 Ga, and (2) low-Mg garnet pyroxenites with highly radiogenic $^{187}Os/^{188}Os$ ratios up to 5. From these observations, we propose that the OJP lithosphere forms a genetically unrelated two-layered structure, comprising shallower, typical oceanic lithosphere underpinned by deeper impinged plume material, which included a component of recycled Proterozoic mantle-crust section. The significance of this variability will be discussed in terms of observations from cratonic lithosphere.

Keywords: Ontong Java Plateau, lithosphere, craton, plume, peridotite

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SCG05-07 Room:106 Time:May 23 11:10-11:25

Origin of fertile peridotite body in the middle Andaman ophiolite, India: A Paleo-Indian Ocean?

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We examined petrology and mineralogy of peridotite bodies exposed in the middle Andaman Island, India. The peridotite bodies mainly consist of lherzolite with small amount of dunite bands/pods and clinopyroxenite/gabbric veins. Major and trace element compositions of minerals in the samples suggest that lherzolites are of simple residue after low-degree of partial melting and are similar to those recovered along the present (Central) Indian Ridges.

The middle Andaman peridotites are thus interpreted to be an example of Paleo (probably Cretaceous age) upper mantle materials beneath the Indian Ocean, now tectonically exposed as a member of the dismembered ophiolite in the Andaman Island. We will also report results of Sr-Nd isotopic compositions of clinopyroxene in the samples.

Keywords: Mid-ocean ridge, melt, peridotite, fertile

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How can podiform chromitites tell us about the mantle dynamics?

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The UHP chromitites, which contain UHP minerals such as diamond and moissanite, are possibly of deep recycling origin (Arai, 2010, 2011 JpGU presentation). They sometimes show an orbicular texture (e.g., Zhou et al., 1996; Yamamoto et al., 2009), one of typical shallow igneous textures; it can be preserved even after deep recycling, because no reaction cannot be expected between olivine and chromian spinel or their high-pressure polymorphs. The UHP orbicular texture is, however, slightly but clearly different from low-P one; the orbicular spinel aggregates of the former are frequently fractured and invaded by olivine. This can be seen in deserpentinized chromitites (Arai, 1978), but this is not the case for Tibetan UHP chromitites. This may be due to a possible difference in compressibility between the two minerals (or their polymorphs). Although the chromitites could be a good indicator for mantle dynamics, it is still difficult to distinguish two types of mantle convection, whole-mantle convection and two-layer convection, for the UHP recycling involved.

Two structural types of podiform chromitite from Oman ophiolite were examined in detail in comparison with the UHP chromitites. They are different from each other in involved magma chemistry in addition to the duration of cooling. Both of them are clearly different from UHP chromitites in the absence of primary hydrous minerals in the latter (Miura et al., submitted). The depth limit for magmatic generation of chromitite may be an important question now.

Keywords: chromitites, Oman ophiolite, UHP minerals, deep recycling, mantle dynamics

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Petrology and chemistry of lherzolites above metamorphic sole in North Oman (Sarami): evidence for mantle metasomatism

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The basal lherzolites above the metamorphic sole (mainly amphibolites) are scattered in several exposures from south to north Oman (e.g., Wadi Sarami). We recognized two types of lherzolites (A, B) based on the field occurrence, mineralogy and chemistry. The type-B lherzolite, rarely in occurrence and highly serpentinized, lies directly above the amphibolites and is underlain by the type A. Porphyroclastic textures are dominant in both types, but the type-B lherzolite sometimes shows cataclastic and mylonitic textures. Clinopyroxene (Mg#, 0.9-0.94) in the type-B lherzolite has high contents of Al2O3 (5.0-7.5 wt%), Na2O (0.6-1.2 wt%), Cr2O3 (0.7-1.4 wt%) and TiO2 (0.25-0.4) relative to that in the type A, reflecting the different origins for the two types of lherzolites from Sarami. There is no difference in chemical composition of orthopyroxene (Mg#, 0.89-0.92) and olivine in the studied lherzolites. The Opx is enriched in Al2O3, (up to 7.0 wt%), CaO (up to 3.0 wt%) and Cr2O3 ($<$1.0 wt%) in both types. The olivines (Fo89.5-Fo91) plot in the mantle olivine array, and indicate the residual character of these lherzolites. The Cr# of spinel ($<$0.18) in the type-B lherzolite is slightly lower than spinel (Cr#, 0.18-0.3) in the type A and lies in the lower end of abyssal peridotite field, suggesting that the former is more fertile than the latter. The degree of melting using Cr# versus TiO2 of chromian spinels is around 5-10% for the typ-B lherzolite and 10-15% for the type A, confirmed by spinel-Cr# versus olivine-Fo ($<$10% melting). There are two possibilities for the lherzolite origin; the Sarami lherzolites represent fertile abyssal peridotites along oceanic fracture zones where the type B lherzolite is more fertile than the type A or the former may be formed from the latter (type A) during refertilization (Na, Al, Ti-bearing fluid/melt metasomatism) processes by MORB-type melt. The formation of hornblende (Na2O, 2.5 wt%) inside and along the Cpx in the type-B lherzolite is evidence for Na-Al metasomatism affected on the type B. The Fe, S, Ni, Co-bearing phases as pentlandite, awaruite, heazlewoodite and violarite were formed in a late stage during serpentinization by hydrothermal solution. The assemblage of hornblende + chlorite + ferritchromite in Sarami lherzolites suggests that their rocks have been suffered from metamorphism under amphibolite facies during subduction stage.

Keywords: basal lherzolites, metasomatism, clinopyroxene, Wadi Sarami, Oman

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Compositional Variation of the Inclusions in Zircon and Matrix Minerals in the Himalayan HP and UHP Eclogites

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Chemical composition of the peak and retrograde stage minerals was determined from the inclusions in zircon and from the matrix assemblage of the Himalayan high- and ultrahigh-pressure (UHP) eclogites, Kaghan Valley of Pakistan in order to determine the metamorphic evolution of these rocks. The Himalayan eclogites were previously subdivided into two groups. Group I eclogites record high-pressure (HP) eclogite facies conditions with an average P-T estimate of 704 +/- 92 oC and 2.2 +/- 0.3 GPa. They are composed of garnet + omphacite + quartz + rutile + titanite + amphibole + apatite + epidote/allanite + symplectite with accessory ilmenite. At places these eclogites are strongly amphibolitized and contain abundant quartz-albite-amphibole symplectites. Group II eclogites are coesite-bearing (coesite occurs as relics within omphacite), recording an ultrahigh- pressure (UHP) conditions, show a P-T range of 2.7-3.2 GPa and 757-786 oC. They are composed of garnet + omphacite + phengite + quartz/coesite + titanite + amphibole + epidote + symplectite with accessory rutile, ilmenite, apatite and zircon. They are mostly fresh and the omphacite remains unchanged at the core or middle portions whereas rim portions are slightly retrogressed to quartz-albite-amphibole symplectites. Matrix minerals in both group eclogites are chemically distinct from the same minerals which occur as inclusions within zircon. Chemical composition of matrix clinopyroxene overlaps the composition of inclusions within zircons of Group I eclogites, however they do not contain symplectitic features or exsolution lamellae which is abundant in the matrix clinopyroxene. Chemical composition of clinopyroxene in matrix eclogite of Group II eclogites is different from the clinopyroxene inclusions in zircons. They contain abundant quartz rods and exsolution lamellae, and at places they are retrogressed to amphibole and quartz-albite-jadeite symplectites. In contrast, clinopyroxene inclusions in zircon do not contain quartz rods or exsolution lamellae and they are aegirine-poor and jadeite-rich. Chemical composition of garnet in the matrix of Group I eclogites show weak zoning with decreasing grossularite component from the core to rim. They are mainly almandine-rich. Chemical composition of garnet inclusions in zircons in Group I eclogites is also almandine-rich, however slightly different from the matrix garnet. Grossularite component is significantly higher in garnet inclusions in zircon compared with the matrix garnet. Similar increase in the spessartine component is also observed. Chemical composition of garnet inclusions in zircon from Group II eclogites is significantly different from the matrix garnet. They are mainly almandine-rich compared with matrix garnet.

Our results suggest that most of the matrix minerals were obliterated in chemical composition during retrograde stages of the metamorphism whereas the inclusions in zircon show peak eclogite facies stages.

Keywords: Himalaya, eclogites, matrix mineral, zircon inclusions, metamorphic evolution

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Lawsonite pseudomorphs and aqueous fluids in UHP talc-garnet-chloritoid schists of Makbal Complex, northern Tien-Shan

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The Makbal UHP metamorphic complex is situated in the western part of Kyrgyz Range, northern Tien-Shan Mts., and it composed mainly of quartzites, garnet-mica schist, marbles and carbonate-rich rocks. The talc-garnet-chloritoid schists (Tlc-Grt-Cld) occur as layers within quartzites and include lenses of eclogites and garnet amphibolites. Coesite has been found in garnets from both the Tlc-Grt-Cld schist layers ($P > 25$ kbar; $T < 600$ oC) and surrounding quartzites (Tagiri et al., 2010), suggesting that the Makbal complex suffered UHP conditions. In Tlc-Grt-Cld schist, garnet porphyroblasts (up to 1.5 cm in diameter) are set in the matrix consisting mainly of talc (XMg = 0.88-0.92) and Mg-rich chloritoid (XMg = 0.39-0.43) with minor glaucophane, quartz, chlorite (XMg = 0.77-0.80), paragonite, phengite (Si = 3.4-3.5), rutile, apatite and tourmaline. Garnet porphyroblast with a homogeneous composition (Prp20-22, Alm63-65, Grs12-15, Sps1-2) and the matrix phases are interpreted to be formed at UHP conditions and the retrograde reaction is minor in the studied sample (KA-2).

Multiphase solid inclusions (MSI) mainly composed of clinozoisite + quartz + kyanite + paragonite + chloritoid + margarite + chlorite are newly observed in garnet porphyroblast. These MSI, up to 0.1 mm, show idiomorphic-prismatic shapes. Some cracks, still visible under the microscope, appear around or in an area proximal to MSI. These cracks filled by chlorite, clinozoisite, quartz and chloritoid, and they are not connected to the fractures crosscutting garnet.

The estimated/reconstructed bulk composition of MSI indicates that they originated from former lawsonite, which can be stable under peak UHP stage. We suggest that lawsonite was stable along with garnet, chloritoid, talc and glaucophane at prograde and peak-UHP stages and it was decomposed to clinozoisite + quartz + kyanite + paragonite at lower pressures during the exhumation. The micro-cracks radiating from MSI may imply the possible pathway of fluids released due to the breakdown of lawsonite during decompression.

The fluid inclusions are distributed in quartz developed in pressure shadow around porphyroblastic garnet. They occur as negative-crystal shaped in clustering or as isolated inclusions. The Raman spectroscopy shows the presence of CO_2, H_2O, N_2, and CH_4 gas species in aqueous fluid inclusions. The compositions of fluid inclusions in quartz in 'pressure shadows' near garnet could be reasonably close to the fluid composition when the quartz was formed at near to peak metamorphic conditions, especially if the inclusions can be shown to occur as isolated inclusions or in clusters (Hollister, 1981).

References:

Tagiri et al., Jour. Min. Petr. Sci. 105, 233 (2010). Hollister, in Fluid inclusions: application to petrology, Short course handbook, Hollister & Crawford, Eds. (Miner. Assoc. Canada, 1981), pp. 1-12.

Keywords: lawsonite, aqueous fluids, UHP metamorphism, Makbal, Tien-Shan, Kyrgyzstan

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Tectonic evolution of the Kurosegawa tectonic zone with relation to the multiple collisions in East Asia

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In the collision boundary between the North and the South China blocks (e.g. north Dabie terrane, Imjingang belt), various kinds of Permo-Triassic collision zone metamorphic rocks are identified. The Higo metamorphic complex as well as the Hida-Oki terrane in Japan would also have belonged to this type of collision zone and which experienced a top-to-the-south displacement with forming a regional nappe structure before the Cretaceous granitic activities. The Kurosegawa tectonic zone in SW Japan is characterized by the serpentinite melange with various kind of blocks and lenses of metamorphic, plutonic and sedimentary rocks (e.g. Hada et al., 1979; Maruyama, 1981). The metamorphic rocks are Cambrian HP-granulite and amphibolite, Permo-Triassic granulite and gneiss and Triassic LTHP metamorphic rocks. The origin and related evolution process of the Kurosegawa tectonic zone have been considered by many authors, such as (1) paleo-microcontinent (e.g. Maruyama et al., 1984; Yoshikura et al., 1990; Miyamoto et al., 2000), (2) klippe (nappe) derived from Inner Zone of SW Japan (e.g. Isozaki and Itaya, 1991; Izozaki et al., 2010), (3) left-lateral strike-slip movement along the eastern margin of Asian continent with relation to the older rocks in Inner Zone of SW Japan (e.g. Tazawa, 1993; Yamakita and Ohtou, 2000), and (4) transform fault in relation with Izanagi-Kura ridge (Kato and Saka, 2003). Even though it would be able to explain the tectonic evolution of the Kurosegawa tectonic zone through these ideas, there are still remaining problems that why various kinds of metamorphic and plutonic rocks are mixed up in the unique serpentinite melange zone with having different metamorphic features and ages.

The newly determined geochemical characters of the LTHP metamorphic rocks from the Kurosegawa tectonic zone (from Kyushu to Kii-peninsula) analyzed by very precise techniques indicate that the precursors of blueschists and jadeite-glaucophane rocks are clearly classified into N-, E-, T-MORBs and OIB. LA-ICP-MS U-Pb zircon dating from the intercalated pelitic schists within the glaucophane schists show 520-480 Ma (Grt-Phn-Chl schist) and 490-430 Ma (Phn-Chl schist) as the detritus ages, in where inherited core ages of 1850 Ma and 2350 Ma are also determined. Therefore this LTHP metamorphism of the Kurosegawa tectonic zone is thought to be a later event after the Siluro- Ordovician zircon formation. Metamorphic age of 269 Ma is also defined by the Rb-Sr whole rock isochron method using 14 blueschits that having different chemical affinities. An Sm-Nd whole rock isochron for the Kurosegawa blueschits shows ca. 804 Ma, which may indicate the original magmatic activity and show some relations to the Yangtze-Cathaysia continental collision inside in the South China block. Palaeoproterozoic inherited ages also suggest that the precursors of the LTHP metamorphic rocks in the Kurosegawa tectonic zone would be derived from the South China block. Late Permian metamorphic age indicates that the main metamorphism of LTHP conditions took place during the continental collision between the North and the South China blocks slightly before the final continental collision at Triassic time (220-230 Ma).

In the presentation during the 2012 JpGU meeting, the authors will also present the tectonic evolution of the Kurosegawa tectonic zone and other LTHP metamorphic rocks in the Inner Zone of the SW Japan.

Keywords: Kurosegawa, geochemistry, U-Pb dating, collision tectonics, E-Asia

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Thermal overprinting of accretionary complex by a specific magma in Pacific type orogenic belt

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A Pacific-type orogenic system with oceanward growth has been documented in Southwest (SW) Japan and New England Fold Belt (NEFB), eastern Australia since Early Paleozoic time, as supported by geological, biostratigraphical, and geochronological data of weakly metamorphosed accretionary complexes. The growth history is essentially characterized by a series of orogen-parallel oceanward growth of accretionary complex and syn or post-orogenic activity of calc-alkaline plutons. It has been postulated that granitic magmatism accompanied with low pressure/temperature (P/T) type metamorphism enhanced growth and modification of continental arc crust in a Pacific-type orogen.

Since the paired metamorphic belt hypothesis of Miyashiro (1961), Japanese geologists have believed that the sillimanite-grade metamorphic rocks of the low P/T type metamorphic belt represented a part of lower crust beneath the active volcanic arc, where metamorphic recrystallization and partial melting had been caused by the arc-type magma activities. This idea suggested a continuous formation of low-P/T rocks and associated granitic rocks beneath an active volcanic arc. However, the geological evidence in SW Japan suggests episodic formation of low-P/T rocks and the associated granitic intrusions, and does not support the traditional idea.

We propose the following new scenarios: (1) peraluminus granitic rocks of Ryoke belt formed by the partial melting of the Jurassic accretionary complex; (2) the low P/T type metamorphism was caused by underplating of unusual magma activities (high-Mg andesite, high-Nb basalt, and adakite). This type of magma activities is distinct from a typical subarc magmatism produced by the steady-state subduction of oceanic plate. The new K-Ar dating of hornblende from the volcanic rocks yields about 100 Ma; they are coeval with a range of metamorphism and granitic activities of the Ryoke belt. The old and thick oceanic plate subducted under the SW Japan in early Cretaceous (100 Ma). The rollback or shift back of the subducting slab of oceanic plate and the subsequent upwelling of high-temperature asthenosphere might have changed environment of subarc mantle to produce the specific magma such as the adakites.

The Tia Complex in the southern NEFB is a poly-metamorphosed Late Paleozoic accretionary complex. It consists mainly of high-P/T type pumpellyite-actinolite facies (rare blueschist facies) schists, phyllite and serpentinite (T = 300 C-degree and P = 5 kb), and low-P/T type amphibolite facies schist and gneiss (T = 600 C-degree and P $<$ 5 kb) associated with S-type granodioritic plutons (Tia granodiorite). Biotite and white mica K-Ar ages distinguish Carboniferous subduction zone metamorphism and Permian granitic intrusions. The systematic K-Ar age mapping along a N-S traverse of the Tia Complex exhibits a gradual change. The white mica ages become younger from the lowest-grade zone (339 Ma) to the higher-grade zone (259 Ma). In contrast, Si content of muscovite changes drastically only in the highest-grade zone. The regional changes of white mica K-Ar ages and chemical compositions of micas indicate argon depletion from precursor high-P/T type phengitic white mica during the thermal overprinting and recrystallization by granitoids intrusions. Our new K-Ar ages and available geological data postulate a model of the eastward shift of a subduction zone in Permian time. The eastward rollback of a subduction zone system and subsequent magmatic activities of high-Mg andesite and adakite might explain formation of S-type granitoids (Hillgrove suite) and coeval low P/T type metamorphism in the Tia Complex.

Keywords: K-Ar geochronology, accretionary complexes, thermal overprinting, low-P/T metamorphism, S-type granites, adakitic magma

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Dynamics and evolution of Nansei Islands of Japan

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The Nansei Islands of Japan is located in the boundary between Ryukyu trench and Okinawa trough (back arc basin). The Philippine plate subducts through the Ryukyu trench beneath the Eurasian plate. The GPS measurement suggests that the Nansei Islands advances toward the Philippine Sea side, and that the Okinawa trough and branched Kagoshima graven are expanding since over than 2Ma,

The existence of earlier spacies, Amami rabbit (Pentalagus furnessi) on the Amamiohshima and Tiokunosima islands and the distribution of Habu (Protobothrops flavoviridis) in the southern Tokara volcanic island than Kodakara island can be interpreted that these islands have been connected together and with Eurasian continent at Miocene epoch. Different poisonous snake, pit viper (Gloydius blomhoffii) universally in major Japanese islands lives in only northern Nansei islands; Tanegasima and Yakushima, suggesting that these islands were connected with Kyushu. Yakushima is also characterized by granitic batholiths of Miocene.

Recent coastal terraces are well recognized in whole area of the Nansei islands, and the ascending rate is independence from each others.

Furthermore, the DNA sequencing of the microbes from the soil in Nansei Islands suggests that the ascending and descending records are individual.

These evidences suggest that just after the opening of Japan Sea, the Nansei island area changed to compressional field to form rather large elongated island from Taiwan to Kodakarajima, and the northern islands; Yakushima and Tanegasima, were connected to Kyushu. However after Pliocene period, the Okinawa trough began to open, and the area changed to a extensional field as a whole, and ascending and descending areas were blocked by transverse fault.

The surface structure and subduction pattern of Philippine plate might control the dynamics and evolution of the Nansei Islands area.

Keywords: Nansei Islands, Philippine plate, Eurasian plate, extensional field, conpressional field

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Exhumation of Triassic HP-LT rocks by upright extrusional domes and overlying detachment faults, Ishigaki-jima

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The following abstract after Osozawa and Wakabayashi, 2012, submitting to Journal of Asian Earth Sciences.

The Tomuru Formation of Ishigaki-jima in the southernmost part of the Ryukyu arc, comprises blueschist facies subduction complex rocks metamorphosed in Triassic time. D1 structures related to subduction, blueschist facies mineral growth, and possibly early stages of exhumation, are deformed by D2 structures that appear to reflect the last stage of exhumation. D2 structures define several anticlines with parasitic overturned folds verging away from anticlinal axes. The shortening recorded by this deformation appears to reflect upward extrusion relative to flanking material. The anticlines are flanked by detachment faults with normal sense-of-shear parallel to D2 vergence. Hanging wall rocks that include the Fusaki Formation, an accretionary prism with early Cretaceous metamorphic ages, and late Eocene limestone, conglomerate, and andesitic volcanics. The Eocene strata contain metamorphic detritus derived from the Tomuru and Fusaki Formations indicating pre-late Eocene surface exposure of these units. Ultramafic rocks and gabbro blocks of the Tomuru Formation were incorporated by sedimentary sliding into the trench prior to subduction and high-pressure metamorphism rather than being emplaced as diapirs along a post-metamorphic fault as previously proposed. Geochronologic, metamorphic, and thermal considerations suggest exhumation of the Tomuru Formation to relatively shallow crustal depths prior to or concurrent with early Cretaceous metamorphism of the Fusaki Formation. Arcward-vergent thrusting may have placed the younger, and formerly structurally lower, subduction complex (Fusaki Formation) over the older one (Tomuru Formation). D2 extrusional doming began after the emplacement of the Fusaki Formation at high structural levels. The D2 transport directions are subparallel to the strike of the orogen suggesting that the upright extrusion may have occurred along a forearc strike-slip fault system. This final stage of exhumation concluded in the late Eocene with extensional collapse and the development of detachment faults. The progression from initial exposure of the Tomuru and Fusaki Formations, deposition of late Eocene strata, extrusional doming and late detachment faulting may have been associated with migrating step-overs rather than changes in regional tectonics.

Keywords: Tomuru HP-LT metamorphic rocks, Jurassic Fusaki accretionary prism, Eocene Miyara limestone and conglomerate, Nosoko volcanic rocks, Upright extrusional domes, syn-subduction strike-slip faulting