Japan Geoscience Union Meeting 2012
(May 20-25 2012 at Makuhari, Chiba, Japan)

SCG71-01 会場:103 時間:5 月 21 日 15:45-16:00

カナダ，ネーンコンプレックスの初期太古代火成活動
Early Archean magmatic events of the Nain Complex, northern Labrador, Canada

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The Early Archean crustal records on Earth are rare, thus there are still many unsolved matters. The Early Archean crusts are still preserved only in northern Labrador, Northwest Territories of Canada and southern West Greenland. The Saglek-Hebron area in the Nain Complex, northern Labrador is located in the west end of the North Atlantic Craton, and is underlain by Eo-Paleoarchean (4.0-3.2 Ga) suites: the Nanok iron-rich monzodioritic gneiss, the Nulliak supracrustal assemblage, the Uivak I tonalite-trondhjemite-granodiorite (TTG) gneisses, the Uivak II augen gneisses and the Lister gneiss (e.g. Collerson, 1983; Schiotte et al., 1989). The emplaced or formed ages of these rocks are pre-3.8 Ga, *ca.* 3.8 Ga, 3.7-3.6 Ga, 3.5-3.4 Ga and *ca.* 3.2 Ga, respectively (e.g. Schiotte et al., 1989; Nutman and Collerson, 1991). The Nanok, Uivak and Lister orthogneisses occupy 80 percent or more in this area. The lithological similarity with those in southern West Greenland suggests that the Nulliak supracrustal assemblage and Uivak gneisses correspond to the Akilia association and Amitsoq gneiss complex, respectively (e.g. McGregor, 1973). However, the ages and origins of their protoliths are still obscure because of lack of detailed geochronological works, including comprehensive dating with LA-ICPMS and cathodoluminescence (CL) imaging .

We carried out geological survey and rock sampling, and conducted U-Pb dating of zircons from the Uivak I gneisses from Nulliak Island, Big Island, Tigigakyuk Inlet, the eastern and southern coasts of St. Johns Harbor and the surrounding areas in the Saglek-Hebron area. The CL images of zircon grains display internal structures of oscillatory zoning or of homogeneous core with overgrowth rim.

The distribution of their ages clearly shows presence of three groups. The first is characterized by both presence of older zircons than 3.8 Ga, with the maximum age of 3914 Ma in $^{207}Pb/^{206}Pb$ age, and apparent absence of the 3.6 to 3.8 Ga zircons, and is defined as the Nanok gneiss. The second and third groups have clear peaks of 3.7-3.6 and *ca.* 3.3 Ga in their age distribution of zircon cores, indicating the Uivak I gneiss and the Lister gneiss, respectively. All rims of the analyzed zircons show *ca.* 2.7 Ga overgrowths. The combination of age distributions of their zircons and their CL image observation differentiates three crustal events, and provides a very powerful tool.

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丹沢トーナル岩に含まれる苦鉄質包有岩中のジルコン U-Pb 年代とその意義
Zircon U-Pb dating from the mafic enclaves and tonalite in Tanzawa Plutonic Complex, Izu arc, Japan

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The study of the arc lower-crust is important for understanding the continental growth. The Izu-Bonin-Mariana (IBM) arc is known as typical intra-oceanic arc. It has been suggested that old IBM arc crust is exposed in the Izu-Collision-Zone due to the collision of the IBM arc against the Honshu arc. The Tanzawa Plutonic Complex, located in the Izu-Collision-Zone, has been regarded as the exposed upper- and middle-crust of the former IBM arc on the basis of the geochemical and seismic data (e.g. Kawate and Arima, 1998; Kitamura et al., 2003). However, petorological and geochemical data of arc lower-crust have not been obtained because it is not exposed on the ground.

To constrain the formation age of the arc lower crust, we applied a method of U-Pb zircon dating from mafic enclaves in granites using LA-ICP-MS. Zircons can survive and retain their formation ages even in the metamorphic overprints and magmatic modifications. We also analyzed trace elements in whole rock and zircons to estimate the origin of mafic enclaves and zircons in them.

In this study, we collected mafic enclaves in the Tanzawa tonalite (4-5 Ma by SHRIMP: Tani et al., 2010), which is intrusive to gabbro (5-6 Ma: Tani et al., 2010) and Tanzawa group (basaltic-andesitic lava and detritus in 3-17 Ma: Aoike, 1997). The mafic enclaves have a doleritic texture. Their shapes are rounded or lenticular, and their contacts with host tonalite are sharp or partially obscure, indicating mafic magma injection into Tonalitic magma. SiO2 content in mafic enclaves varies from 46.99 to 58.26 wt%. We separated 333 zircon grains from 9 mafic enclaves and 46 grains from the host tonalite and analysed them using LA-ICP-MS at Kyoto University and Advanced Industrial Science and Technology. The REE patterns of zircons in mafic enclaves and tonalite show typical igneous ones. Most zircons in tonalite show clear Eu anomaly, but those in mafic enclaves rarely show. The zircon age population from tonalite indicates relatively narrow range distribution around 5 Ma, resulting in mean age of 4.7 ± 1.5Ma, similar to the U-Pb zircon ages previously determined by SHRIMP (Tani et al., 2010). While the zircon age population from mafic enclaves in tonalite shows wide range distribution from 5 to 43 Ma, most of zircons yielded U-Pb age around 5 Ma. These results imply that the mafic enclaves were affected by mingling/mixing with the tonalitic magma at ca. 5 Ma. Because the Tanzawa group is the juvenile arc basalt on the Philippine Sea Plate plate, there are three candidates for older than 5 Ma: Tanzawa group (3-17 Ma); the gabbro suite (5-6 Ma); the arc lower-crust. Therefore, the zircons with 18-43 Ma are interpreted to be xenocryst derived from the arc lower crust beneath Tanzawa tonalitic pluton. The oldest zircon age (42.9 ± 8.6 Ma) obtained from mafic enclaves suggests that the arc lower crust formed by at least 42.9 ± 8.6 Ma.

Our result implies that the zircon U-Pb dating for mafic enclave in continental crust can provide a new data for age distribution of the continental lower crust.

キーワード: 島弧下部地殻, 苦鉄質包有岩, 花崗岩, ジルコン, U-Pb 年代, LA-ICP-MS
Keywords: Arc lower crust, Mfaic enclave, Granite, Zircon, U-Pb dating, LA-ICP-MS

SCG71-03 会場:103 時間:5 月 21 日 16:15-16:30

領家変成岩に含まれる砕屑性ジルコンのU-Pb年代が意味するもの
U-Pb ages of detrital zircons in the Ryoke metamorphic rocks and their geological implication

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領家変成帯のミグマタイトから抽出したジルコンについて、LA-ICP-MS を用いて U-Pb 年代を測定した。結果は、領家帯の西部（柳井）東部（三河）いずれも約 1900Ma にディスコーディアを形成し，300?1850Ma の間はコンコーディア上にほとんどデータが存在しないという特徴を示す。一方、80-250Ma の間はコンコーディア上あるいはその近傍に多くのデータが集まり，有意なクラスターを判別するのが難しいが，領家変成岩の原岩の後背地に古生代後期以降原岩形成までの間に形成された花崗岩質岩が含まれていることはおそらく間違いない.

これらを中間ほか (2010) によって報告された西南日本の各地質体における砕屑性ジルコンの年代測定結果と比較すると、彼らのデータセットの中で領家変成岩の原岩相当と言われる丹波帯の砂岩では、1500-2000Ma の年代を示すジルコンがほとんどなく、今回報告する領家変成帯高温部とは後背地の地質が異なる。彼らのデータセットの中では、四国中央部の三波川変成帯および彼らの言う四万十変成帯に含まれる砕屑性ジルコンが 1500-2000Ma に年代分布の明瞭なピークを持ち、今回の領家変成岩と似た特徴を示すことが興味深い。

地質単元と後背地の地質構成が１対１対応すれば、砕屑ジルコンの年代分布を原岩堆積時の地質環境に結びつけて理解しやすいが、現実には同じ地質単元が全域同じ後背地を持つとは限らないし、異なる地質単元がほぼ同じ後背地を持つこともあり得るということを今回の結果は示しているのだろう。彼らの丹波帯砂岩は、日本海に面した同帯の北縁部から採取されており、今回の領家変成岩が MTL に近い高変成度部の試料であることを考えると、一連の地質体の中で、これら高度変成岩の原岩となっている美濃帯?玖珂帯のジュラ紀付加体堆積岩類の後背地あるいは堆積時期も、背弧側に現在地表露出している部分とは多少異なるのかも知れない。このような地域的な差異を広域的な地質体の中で検出することで、堆積当時の古地理・古地形や構造的侵食の規模、時期等を制約していくことができると思われる。

キーワード: U-Pb 年代, 砕屑性ジルコン, 領家変成岩, 構造的侵食, 後背地
Keywords: U-Pb age, detrital zircon, Ryoke metamorphic rock, tectonic erosion, provenance

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SCG71-04 会場:103 時間:5 月 21 日 16:30-16:45

大陸は現在、減少している
Negative growth of the continental crust at present: Significance of tectonic erosion and arc subduction

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Conventional views suggest that continental crust has gradually grown through the geologic time and finally reached the present volume. However, the thermal evolution of the earth proposes that huge amount of continental crust should be formed in the early Earth. This is the continental crust paradox.

Subduction and recycling of differentiated material into the mantle are of significance not only for creating mantle heterogeneities but for continental growth models. Continental crust is returned to the mantle through sediment subduction, tectonic erosion and continental subduction. Oceanic arcs, primary form of continental crust, have been thought to be entirely accreted during arc-collision due to its buoyant nature. Modern oceanic arcs are, however, mostly subducted into the mantle. The best examples of arc subduction are observed around the Japan islands. Among the more than 15 examples of arc-arc collision in the western Pacific, arc-arc amalgamation is possible only in the case of parallel collision. Parallel collision of two arcs is rather rare case, compared to the normal arc?arc collision, therefore these observation imply that the predominant subduction of arc crust is in general and that a majority of the intra-oceanic arc in the Earth history must have been subducted into the mantle.

Over the past three decades, marine geophysicists and geologists have documented tectonic erosion as a more common process than the formation of an accretional complex in subduction zones, and speculate that a large volume of the continental crust is subducted into the mantle at both accretionary and erosive convergent margins. Comprehensive studies on the rate of continental reduction versus production suggest a balance, resulting in no growth of continental crust at present. However, these estimates do not take into account the amount of arc subduction. Considering direct subduction of oceanic arcs into the mantle, we conclude negative growth of the continental crust on the Earth at present.

Keywords: continental growth, tectonic erosion, sediment subduction, arc subduction

SCG71-05 会場:103 時間:5 月 21 日 16:45-17:00

大陸地殻の３層モデルと全地球ダイナミクスの経年変化
Three-layers model of continent and whole mantle dynamics through time

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A huge continental crust covers the solid Earth, ca. 35 km in average and 1/3 of the Earth's surface. Geologists have long considered that granite cannot subduct into deep mantle by its buoyancy, hence accumulated through geologic time. However, ubiquitous occurrence of sediment-trapped subduction, tectonic erosion at trenches and direct subduction of arc itself as seen now in Japan and other subdduction zone around the Pacific clearly document the idea is wrong. Moreover, the Archean geology for the mechanism to make a continent suggests the extensive amounts of arc asuduction in the Archean. Moreover the recently obtained growth curve of continental crust through time indicate 7 times more TTG crust subducted by 2.5Ga (Rino e al., 2008).

Following these works, Kawai et al. (2009) and Tsuchiya et al. (2009) have calculated density contrasts in mantle depth down to CMB pressure at elevated temperature, and concluded that TTG crust is gravitationally stable at mantle transition zone (MBL) depth, and never subducts into lower mantle. Moreover, once subducted into MBL, it cannot rise up hence stagnant forever and grows bigger through time.

Another conclusion by First Principle Calculation by above authors is fate of anorthosite. As an evidence of thick (50-60km) anorthosite layer on the Moon, as a fossil record of magma ocean at 4.5Ga, an argument of fate of anorthosite on the Earth occurred during early 1970s. One conclusion was density cross-over of anorthosite vs basaltic or komatiitic magma is not possible at shallow depths on the wet Earth. If so, anorthosite must have subducted into deep mantle, or to make a layer at depths. Calculated density structure in deep mantle indicates that the anorthosite could be most probable candidate in the D" layer on the CMB. We here define these continents as, First (surface), Second (MBL) and Third (D" layer) Continents.

As the First continent has a Wilson cycle, Second and Third Continents would have such a cycle, reflecting preferential arrangement of trenches on the surface, controlled by the birth of strong mantle down-flow, and afterwards by the birth of superplume and continental dispersion. Fate of First supercontinent would be strongly controlled by the stagnant Second supercontinent in MBL by radiogenic heating.

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SCG71-06 会場:103 時間:5 月 21 日 17:00-17:15

遷移層付近の熱源が大陸移動に与える影響
Contribution of heat source around the mantle transition zone on continental drift

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Distribution of heat source in the mantle is still poorly known in spite of its importance on the mantle convection. Here we consider a case where the heat source is concentrated around the mantle transition zone and upper part of the lower mantle. The candidate heat source materials are basalt and granite. Radioactive isotopes are highly concentrated on these rocks because they are incompatible implying that they can be strong heat sources if they have been buried somewhere in the deep mantle.

Recent geological studies have suggested that the huge amount of crustal materials have sunk from the surface aboard subducting slabs. For example, studies on the elastic properties show that granite is heavier than the ambient mantle rock around the transition zone and upper part of the lower mantle. Therefore continental materials are considered to be distributed somewhere around the mantle transition zone. In addition, the extensive mass of basalt had been accumulated at the base of the upper mantle if the mantle would have had double layered convection in Archean.

In this study, we conducted numerical experiments of mantle convection with chemically distinct heat source at around the mantle transition zone together with drifting motion of surface supercontinent. Here, in order to focus on the interplay between the heat source and supercontinent, we assumed that the chemically distinct heat source is initially located below the continents. This is because the heat source, either basaltic or granitic, is expected to accumulate below the supercontinent, considering that the subduction occurs around the continents. The aim of this study is to see the effect of the heat source on the drifting motion of the continent and thermal structure.

キーワード: 花崗岩, マントル対流, 大陸移動
Keywords: granite, mantle convection, continental drift

SCG71-P01 会場:コンベンションホール 時間:5 月 21 日 17:15-18:15

カナダラブラブラドル地方、ネーン岩体の地質：最古の海洋地殻の発見に向け
Geology of the Nain complex in Labrador, Canada: Discovery of the oldest oceanic crust

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The Hadean is the most mysterious period because no rocks and geologic bodies are preserved except for only the zircons in Western Australia, Canada, China and Greenland (Froude et al., 1983, Nature; Nelson et al., 2000, EPSL; Mojzsis & Harrison, 2002 EPSL; Iizuka et al., 2006, Geology; Wang et al., 2007, CSB). But, it is the most important period because the early evolution possibly clinched the history of the earth. We try to find the earliest supracrustal rocks in the world to investigate the Hadean tectonics and decode surface environments. As far, the oldest supracrustal rocks are found in Akilia association in West Greenland, Nuvvuagittuq in Quebec, and Nain Complex in Labrador (Nutman et al., 1996, Precamb. Res.; O'Neil et al., 2008, Science; Schiotte et al., 1989, Can Jour Earth Sci.). Because the Akilia association suffers from severe metamorphism and alteration, the precursors are highly in debate (e.g. Fedo & Whitehouse, 2002, Science). Recent geological works in the Nuvvuagittuq, Quebec showed the sequence contains amphibolite with a pyroclastic rocks affinity, ultramafic sills, felsic sediment, BIF and conglomerate. Although a pseudoisochron age of ^{147}Sm/^{144}Nd-^{142}Nd/^{144}Nd implies the Hadean age (O'Neil et al., 2008, Science), the supracrustal belt possesses 3811 Ma by conventional U-Pb zircon ages (David et al., 2009, GSAB).

We made geological survey in the Nain Complex, and reinvestigated the occurrence of the supracrustal rocks and their relationship with the ambient orthogneisses. Previous works focused on distribution of the supracrustal belts within the orthogneisses (e.g. Bridgwater et al., 1974 Geol Surv Canada, Paper), but the detailed field occurrence of the supracrustal rocks within the belts is still ambiguous. Therefore, we focus on their internal structures.

The supracrustal belts are repeatedly intruded by granitic intrusions with some ages and their original structures are obscured, but their lithostratigraphies are relatively well preserved in Nulliak, Big and Shuldham islands and St Jones Harbor. The supracrustal belts in Nulliak and Big islands comprise ultramafic rocks, mafic rocks and mafic sediments intercalated with feldspathic sediments and banded iron formations in ascending order. In the St Jones Harbor, it is composed of ultramafic rocks, mafic rocks, banded iron formation, and clastic sediments, intercalated with chert in the middle and with bedded carbonate rocks in the upper part, respectively, in ascending order. In the Shuldham Island, it consists of ultramafic rocks, layered gabbro with precursors of plagioclase and pyroxene accumulation layers, mafic rocks and terrigenous sediments in ascending order. The lithostratigraphies are very similar to oceanic plate stratigraphy. The fact that some supracrustal belts are intruded by Uivak I orthogneisses, and presence of $>$3.86 Ga zircons in the supracrustal rocks suggest that the supracrustal belts have early Archean ages. In addition, despite of the still ambiguous relationship between Nanok Gneiss and supracrustal rocks, presence of Nanok Gneiss (3.85 to 3.91 Ga) in this area (Collerson, 1983 in Abstracts for Early Crustal Genesis Field Workshop, LPI, Technical Report 83-03; Shimojo et al., 2012, Goldschmidt Conf.) implies that the supracrustal belts date back to the earliest Archean.

キーワード: 冥王代, ラブラドル・ネーン岩体, 初期地球, ジルコン, 表成岩, 縞状鉄鉱層
Keywords: Hadean, Nain Complex, Labrador, Early Earth, zircon, supracrustal rocks, banded iron formation

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貫入岩体周辺の面構造ダイヤグラムに基づく東ピルバラの花崗岩複合岩体の貫入様式について
Type of granite complex intrusion in East Pilbara terrane based on foliation pattern diagram around intrusion body

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Theoretical analysis of stressed two-dimensional elastic material with a circular hole filled with a viscous material revealed that three types (TT, TX and XX types) of distribution pattern of maximum principal stress orientation around the hole can be produced as a function of far-field stress S1 ,S2 and internal pressure of viscous material p. The TT type is characterized by tangential orientation of S2 axis in all directions around the hole, while the TH is characterized by S2 axis of tangential and normal orientations to the circular hole in orthogonal orientations. The XX type is characterized by normal orientation of foliation all around the hole. Assuming that S2 axis is parallel to the foliation, we consider the stress state for actual foliation patterns in aureoles of granitic intrusions. We can find some natural examples of TT and TX type patterns, whereas we have never found the XX type patterns in nature. In this poster we present TT a type foliation pattern around the Mount Edgar Batholith in Pilbara area, Western Australia, and discuss how the TT type pattern foliation can be produced as a function of internal pressure of granitic body.

キーワード: ピルバラ, バソリス, 太古代, 貫入イベント
Keywords: Pilbara, batholith, Archean, intrusion event

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中央海嶺沈み込みに伴うタイタオ半島花崗岩の岩石学的研究
Petrogenesis of the ridge subduction-related granitoids from the Taitao Peninsula, Chile Triple Junction Area

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It is the essential to study the geochemical evolution of the solid earth to understand the growth and origin of granitic continental crust. The Taitao Peninsula is the youngest site of ridge subduction in the world, where a young oceanic plate subducts, possibly equivalent to an Archean subduction zone environment. It is proposed that granitic magmatism in the Taitao Peninsula is closely concerned with the subduction of young oceanic crust. This paper presents REE from whole rock analyses of the granitic rocks so that we obtain the detailed compositional characteristics of the granitic magmas. There is a triple-junction (Trench-Trench-Ridge) off the Taitao Peninsula, southern Chile. The compositions of the Taitao granitoids are tonalitic to granitic with SiO2 ranging from 64% to 78%. Trace elements are characterized by low Sr (50-300 ppm) contents, moderately both high Y (10-45 ppm) and Yb contents (1-5 ppm) and low Sr/Y ratios (1-25). Chondrite-normalized REE patterns are characterized by moderately high [La/Yb]N ratios (5-20). These chemical characteristics are similar to typical calc-alkaline arc magmas rather than adakitic granitoids. The characteristics suggest that the magma was generated by partial melting of amphibolite rather than eclogitic rocks. These geochemical compositions suggest that the granitic magma was generated under 10 km depth below the fore-arc region. Contrary to previous belief, our result suggests that Taitao granitoids, which possibly generated by partial melting of subducted oceanic-crust, have TTG composition in major element, but no HREE-depleted signature in trace elements.

キーワード: 中央海嶺沈み込み, スラブ溶融, TTG, アダカイト, 希土類元素
Keywords: ridge-subduction, slab-melting, TTG, adakite, REE

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日本における白亜紀の構造浸食作用
Tectonic erosion in Pacific-type orogenic belt: zircon response to Cretaceous tectonics in Japan

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The U-Pb chronological analysis of detrital zircons for the Lower Cretaceous Sanbagawa and Upper Cretaceous Shimanto HP metamorphic rocks in Japan showed the abundant occurrence of Precambrian (ca. 1500-2000 Ma) grains. In contrast, the coeval non- to weakly metamorphosed accretionary complex and fore-arc basin sediments completely lack these older remnants that are common in the older Jurassic accretionary complexes that tectonically superpose above the Cretaceous accretionary complexes. This remarkable contrast in age spectrum likely indicates that tectonic erosion has occurred to recycle older detrital material twice along the active margin of Cretaceous East Asia; i.e. the first in the Early Cretaceous to tectonically remove the Jurassic accretionary complex from the sole of the hanging wall of the subduction zone, and the second in the Late Cretaceous to erode Lower Cretaceous accretionary complex together with the Sanbagawa high-pressure metamorphic rocks

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カナダ、ラブラドール地域に産する超苦鉄質岩の強親鉄性元素組成
Highly siderophile elements in 3.8 Ga ultramafic rocks from Labrador, Canada

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The overabundance of highly siderophile elements (HSEs) in the modern terrestrial mantle, relative to predicted composition is frequently attributed to the late influx of chondritic materials (late veneer) after the efficient stripping of HSEs to the metallic core. Although this model is not universally accepted due to insufficient knowledge of metal-silicate partitioning under high pressure and temperature conditions, broadly chondritic ratios of HSEs in fertile peridotites from a variety of tectonic settings provide strong support for the late veneer model. A recent discovery of ^{182}W enrichments in ~3.8 Ga crustal rocks from Isua, West Greenland suggests that this area of Earth's surface has escaped addition of the late veneer, and remained unaffected by subsequent replenishment. Furthermore, possible secular increase of HSE abundances for the komatiite source has been attributed to the progressive pollution of the HSE-poor deep mantle by the late veneer component between 3.5 and 2.9 Ga. These studies raise the possibility that ~3.8 Ga ultramafic rocks recognized from West Greenland and its eastern extension in Labrador, Canada, can be used to establish HSE abundances of the Earth's mantle before the arrival of the late veneer.

We present HSE abundances and Re-Os systematics for a set of ultramafic rocks from Saglek-Hebron area of northern Labrador. Based on field and geochemical data, they were classified into two suites: residual peridotites occurring as tectonically-emplaced slivers of lithospheric mantle, and metakomatiites comprising mostly pyroxenite layers in supracrustal units. The samples analysed here have been investigated previously for Sm-Nd and Pb-Pb systematics, supporting their $>$3.8 Ga formation. Thus, the primary aim is to test whether the meta-peridotites and komatiites record peculiar HSE signatures of the early Archean shallow and deep mantle, respectively. The two suites display contrasting HSE patterns that are consistent with their inferred protoliths. The harzburgitic to dunitic metaperidotites are typically marked by depletion of Pt, Pd and Re relative to Os, Ir and Ru, resulting from extensive melt extraction. In contrast, metakomatiites show smooth patterns with gentle positive slopes (except for Re). Overall, in terms of HSE patterns and abundances, both suites do not differ from their late Archean equivalents, such as the harzburgitic to dunitic xenoliths from North Atlantic Craton and the 2.7 Ga Belingwe/Abitibi komatiites. Moreover, a rare lherzolitic sample has a very similar HSE pattern to that of primitive upper mantle (PUM) estimated on the basis of dataset of post-Archean peridotites. These observations suggest that 3.8 Ga mantle has already been influenced by the late veneer. We will discuss the possible reasons for the decoupling between W isotope evidence from crustal rocks and HSE signatures in mantle-derived materials.

キーワード: 強親鉄性元素, かんらん岩, コマチアイト, 太古代, レイトベニア
Keywords: highly siderophile elements, peridotite, komatiite, Archean, late veneer

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第 2 大陸説
The second continent model

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At subduction zones continental crust is predominantly created by arc magmatism (Rudnick, 1995) and is returned to the mantle via sediment subduction, subduction erosion, and continental subduction (Scholl and von Huene, 2007). Granitic rocks, the major constituent of the continental crust, are lighter than the mantle at depths shallower than 270 km, but we show here, based on first principles calculations, that beneath 270 km they have negative buoyancy compared to the surrounding material in the upper mantle and transition zone and thus can be subducted in the depth range 270-660 km (Irifune et al., 1994). This suggests that there can be two reservoirs of granitic material in the Earth, one on the surface and the other at the base of the mantle transition zone (MTZ). The accumulated volume of subducted granitic material at the base of the MTZ might amount to a few times the present volume of the continental crust. Our calculations also show that the seismic velocities of granitic material in the depth range from 270 km to 660 km are faster than those of the surrounding mantle. This could explain the anomalous seismic-wave velocities observed around 660 km depth. The observed seismic scatterers and reported splitting of the 660 km discontinuity could be due to either jadeite dissociation and/or chemical discontinuities between granitic material and the surrounding mantle.

キーワード: 花崗岩, 構造浸食, 遷移層
Keywords: granite, tectonic erosion, mantle transition zone

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隠岐島後・吉備の捕獲岩ジルコン年代から推定される西南日本下部地殻の発達過程
Evolution of the lower crust under southwest Japan constrained from ages of zircon in the xenolith

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The present-day continental crust contains a very large proportion, about 20-70%, of the incompatible elements by mass in the Earth (Rudnick and Fountain, 1995). Therefore, it should have enormous effects on evolution of the Earth both chemically and physically. Although the upper crust has been investigated extensively in terms of its composition, structure, and evolution process, those of the lower crust which extends to 35 km depth on average has been poorly investigated.

The main purpose of this study is to decipher process of formation and evolution of the lower crust, aiming at understanding the evolution of continental crust and the Earth. As a first case study, we try to constrain the evolution process of the lower crust in SW Japan, the Oki-Dogo and Kibi areas, based on zircon ages and geothermometers in the xenoliths.

These two areas are located on the continental margin, and may provide useful insights regarding how the lower crust is formed or destructed associated with subduction.

At Oki-Dogo, peridotite, pyroxinite, gabbro and granulite were found as xenoliths in alkali olivine basalts (Takahashi, 1978) erupted at 3.61Ma (whole rock K-Ar age, Kaneoka et al., 1977). At Kibi, peridotite, pyroxinite and granulite are found as xenoliths in alkali olivine basalts (Iwamori, 1985) erupted at around 9 Ma (Uto, 1989).

To estimate the equilibrium temperature and the U-Pb age of zircon, we sampled gabbros from Oki-Dogo and granulites fromat Kibi, and analyzed them by using EPMA and LA-ICP-MS.

Major constitutent minerals in the gabbros from Oki-Dogo are olivine (ol), clinopyroxene (cpx) and plagioclase (pl), and they have a diameter of 1˜2mm. Equilibrium temperature estimated by ol-cpx geothermometer (Loucks, 1996) is approximately 1100^o+-50^oC. Zircon grains have been obtained from only one gabbro (out of total seven gabbros processed), and are almost anhedral and homogeneous. The total forty grains have been dated to give ages approximately ranging from 2 to 4 Ma, which are broadly the same with that of the host alkali basalt and indicates that zircon grains lost almost all Pb during the magmatic event exceeding the closure temperature for zircon U-Pb dating (i.e., above 900^oC).

Major constitutent minerals in the granulite from Kibi quartz, K-feldspar, garnet, kyanite and spinel are the major constituent minerals, and they have a diameter of 500˜1000 um. Based on the stability of kyanite and assuming the maximum depth of 30 km based on the present-day Moho depth estimated from the seismic profile (Ito et al., 2010), the equilibrium temperature is constrained to be less than 800^oC. Zircons obtained from the granulites are various in shape, exhibiting a wide age range from 420 to 10 Ma. We classified these zircons into igneous and metamorphic origins based on the U/Th ratio, and distinguish the overlapping events recorded in the grains. Bulk rock composition of this granulite from Kibi is aluminous and pelitic (Kushiro, 1987). From these results, we propose a model that a sedimentary material subducted with an oceanic plate, and accreted the material to the continental crust. Then at 28Ma, a part of the Philippine Sea Plate started spreading to create the Shikoku Basin and the spreading ridge had subducted. Because of this, the subduction angle became gentler and accrete more materials and push the formerly accreted sedimentary material further to the reararc region at the same time, accreted prism was metamorphosed by the heat.

In summary, these two examples from Oki-Dogo and Kibi suggest that (1) the lower crust beneath Oki-Dogo were heated by magmatic events that erupt alkali basalts and may reset the U-Pb age of zircon now found in the xenolith, and (2) subducted sedimentary materials can accrete to the lower crust at deep levels, which may be promoted by ridge subduction. Therefore, at this area, a part of lower crust develop independently of the upper crust.

キーワード: 下部地殻, ジルコン, 年代, 捕獲岩, 西南日本
Keywords: Lower Crust, zircon, age, xenolith, southwest Japan