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

SCG71-01 Room:103 Time:May 21 15:45-16:00

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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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.

Keywords: Arc lower crust, Mfaic enclave, Granite, Zircon, U-Pb dating, LA-ICP-MS

SCG71-03 Room:103 Time:May 21 16:15-16:30

U-Pb ages of detrital zircons in the Ryoke metamorphic rocks and their geological implication

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U-Pb ages of detrital zircons in migmatites from the Ryoke metamorphic belt with LA-ICP-MS. They made a discordia of ca.1900Ma besides plenty of data of 80-250Ma on the Concordia. There are nearly no data within 300-1850Ma.

This feature is similar to those from the Sanbagawa and Shimanto metamorphic belt (Aoki et al., 2008) recently documented by Nakama et al. (2010).

It is interesting that the age pattern of detrital zircon from sandstone from the Tanba belt, unmetamorphosed equivalent of the Ryoke metamorphic rocks, obtained by Nakama et al. (2010) do not have a concentration peak in 1500-2000Ma.

It may show that the age distribution pattern of detrital zircons does not always uniquely decide a geologic unit. There can be internal variation even in a geologic unit. Those local variations might help us to figure out the dynamic history of paleogeography of the sedimentation site or regional scale and timing of tectonic erosion.

Keywords: U-Pb age, detrital zircon, Ryoke metamorphic rock, tectonic erosion, provenance

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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

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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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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.

Keywords: granite, mantle convection, continental drift