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

SCG06-01 Room:301A Time:May 25 13:45-14:00

Unravelling metamorphic-fluid events in Gondwana collision: U-Pb-REE constraints from Sor Rondane Mountains, Antarctica

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Assembly of Gondwana supercontinent has been argued in numerous studies. Generally the reported ages of Gondwana collision zones are in the range of 750-500 Ma, and two main age groups of 750-620 Ma and 570-530 Ma are estimated (e.g., Meert, 2003). The first episode (~620Ma) is mainly reported from eastern Africa to East Antarctica, and the second episode (~530Ma) is dominated in southern Africa through East Antarctica-Sri Lanka-southern India to eastern Australia. It is, however, not yet fully understood the superimposition of these two events in the crossing region.

Sor Rondane Mountains in East Antarctica is one such area where 640-630 Ma and 550-520 Ma metamorphic-fluid events are recorded (e.g., Shiraishi et al., 2008. Adachi, 2010). Greenschist-facies through amphibolite-facies to granulite-facies metamorphic rocks occupy the area, and the granulite-facies rocks are dominated in the northeastern-central part of the area (e.g., Shiraishi et al., 1992; Osanai et al., 1992). Multiple leucocratic veins and granitic intrusives are also developed. We present zircon and monazite U-Th-Pb and REE analyses by using ion microprobe and electron microprobe applying to garnet-biotite-sillimanite gneiss and associated leucoveins in the central part of Sor Rondane Mountains. Zircon in garnet-sillimanite-biotite gneiss yields c.640-630 Ma with minor >700 Ma and 550-520 Ma ages, and gives clear age-chemistry relation that HREE/MREE ratios drop in c.640-630 Ma zircon crystals compared with older and younger grains that are presumably controlled by REE partitioning with the coexisting garnet. Zircon and monazite in multiple generations of leucoveins also yield >700 Ma, 640-630 Ma and 550-520 Ma ages. Combined rare earth elements (REE) chemistry with the U-Th-Pb age domains in syn- and post-metamorphic leucoveins suggests contrasting isotopic and chemical signatures, and could provide constraints for decoding Neoproterozoic-Cambrian metamorphic-fluid regimes in the Gondwana collision zone.

Keywords: Gondwana, East Antarctica, Sor Rondane Mountains, metamorphism, zircon, monazite

SCG06-02 Room:301A Time:May 25 14:00-14:15

Evolution of continetal lithosphere in the Sor Rondane Mountains, East Antarctica

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The Sor Rondane Mountains is situated within the collision zone between the West and East Gondawana and the time of collition is regarded as the late Proterozoic (650-600 Ma). The mountains consist of greenschist- to granulite-facies metamorphic rocks and various kinds of intrusive rocks. The tonalite complex is exposed in the southern part of the mountains and its magmatic age is considered to be at the middle Proterozoic (990-920 Ma). This tonalite would originaly be formed at the subduction related tectonic setting priore to the collision event. Large amouts of microgabbro occure as mafic magmatic enclaves (MMEs; 990 Ma) and dikes (950 Ma) in the tonalite complex. Unmetamorphosed lamprophyre dikes intrude the tonalite complex and gneisses during the late- to post-collisional stages. The intrusive age of the lamprophyre is of 560 Ma. The magma processes of the tonalite complex together with the late- to post collisional lamprophyre dikes, therefore, provide us useful information of the evolution of continental lithosphere during the formation of Gondwana supercontinent.

The microgabbro represents the low-K and tholeiitic series, and is geochemically classified into Low-Ti and High-Ti microgabbros. The MMEs and dikes of microgabbros are equivalent to the Low-Ti and the High-Ti microgabbros, respectively. The Low-Ti and High-Ti microgabbros shows geochemical signature similar to the Oceanic Arc Basalts and the Back-Arc Basin Basalts, respectively. The middle Proterozoic magma processes would, therefore, proceed at a subduction zone with back arc spreading in an oceanic arc environment. The lamprophyre corresponds to alkaline rocks in the TAS diagram, and are characterized by high abundances of LIL elements and REE, especially Rb, Ba, Sr and LREE. The trace element abundances normalized to primitive mantle display enrichment of LILE and depression of HFSE with Nb and Ta negative anomalies. The lamprophyre is plotted in the within-plate field and a part of the island arc field that is close to the within-plate field on some discrimination diagrams. Considering the geochemical features, the lamprophyre was formed in a within-plate tectonic setting by the mixing of subduction-related materials.The initial Sr isotopic ratios (SrI) range from 0.7022 to 0.7040 (epsilon SrI = -14 to 12) for the Low-Ti microgabbro and from 0.7024 to 0.7030 (eSrI = -14 to 1) for the High-Ti microgabbro. The initial epsilon Nd values for the Low- and High-Ti microgabbros are calculated within the same range (eNdI = -0.1 to +0.5). On the other hand, the isotopic compositions of the lampropyre show SrI = 0.7043 - 0.7044 (eSrI = +7.6 to +9.2) and eNdI = -0.62 to -0.34.

The geochemical studies including Sr-Nd compositions reveal that the microgabbros have been originated from a depleted source, whereas chemical compositions of the lamprophyre is more enrichment rather than those of the microgabbros. Consequently, the magma processes in the Sor Rondane Mountains reflect the evolution of lithosphere from the middle Proterozoic to the early Paleozoic; the depleted mantle at the initial subduction stage then changing to the enriched mantle at the continental collision stage. This lithospheric evolution can be explained by interaction between the depleted mantle and the enriched materials (e.g., slab-derived fluids, melting product of subducted crustal rocks, or reaction with fossil wedge mantle) during closure of the Mozanbique Ocean.

Keywords: Gondwana supercontinent, Antarctica, Sor Rondane Mountains, tonalite, microgabbro, lamprophyre

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SCG06-03 Room:301A Time:May 25 14:15-14:30

Occurrence of alkali ~ highly potassic dykes intruded into metamorphic rocks on Lutzow-Holm Complex, East Antarctica

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The Lutzow-Holm Complex (LHC) of Dronning Maud Land, East Antarctica, is a high grade metamorphic terrane within the East Antarctic Shield, situated to the west of Rayner Complex and to the east of the Yamato-Belgica Complex. Japanese Antarctic Research Expeditions (JARE) have carried out detailed surveys of its geology and tectonics for many coastal exposures, and have identified various kinds of metamorphic rocks. Subsequent igneous rocks as granites and pegmatites that intruded during and after the peak metamorphism, were also recognized.

Mafic dyke rocks, which discordantly intruded the surrounding gneisses, were already found in some localities. A few post-metamorphic mafic - intermediate rock dykes were newly found in Skallevikshalsen, Rundvagshetta, and Niban-Iwa as well as Innhovde and Austhovde in the LHC, during the geological survey by JARE-52. The dykes on Skallevikshalsen and Rundvagshetta were thin sheets with a few centimeters to half meter in thickness, and almost NS (to slightly NNE-SSW) trending with dipping east steeply. On the other hand, dyke from Niban-iwa on the Prince Orav Coast, has a ten to twenty centimeter thickness and dip to NE with WNW-ESE striking. Internal textures as mineral arranging and extension are parallel to the trend of the dyke intrusion. Dykes in Rundvagshetta were strongly related for the origin with post-genetic pegmatites, and partly modified to amphibolite with coarse hornblende by the pegmatitic activity.

The dyke rocks are holocrystaline and aphyric, and grain size is mostly between 0.1 and 2 mm. They consist dominantly of alkali-feldspar and subsequent biotite, augite, hornblende, titanite, apatite and minor amount of plagioclase and quartz: these mineral abundances vary according to their occurrences, and alkali-feldspar, apatite and quartz are commonly included in the dykes by all means more or less, and others are occasionally absence in some rock specimens. Minerals, especially biotite flakes, are commonly aligned to parallel to boundary between the dykes and the host gneisses.

Whole rock composition of dyke rocks are different in the 5 outcrops each; the SiO_2 and MgO contents range from 46.3 to 60.2 wt.% and from 9.48 to 0.69 wt.%, respectively. Their K_2O content reaches 3.42 - 10.83 wt.% with higher K_2O/Al_2O_3 and K_2O/Na_2O values than general igneous rocks. They are classified into tephrite, trachyandesite, and trachyte according to their total alkali versus silica characters. In them, dyke rocks in Skallevikshalsen resemble lamproite for their ultrapotassic characters (K_2O = 8.10 - 8.72 wt.%) with much MgO (= 7.92 - 9.48 wt.%) and abundance of typical minor elements (e.g., Ba, Sr).

In Rundvagshetta, host metamorphic rocks were partly metasomatized by hydrated reaction around the dykes, and garnet was broken down to biotite in the metasomatized domain: this hydration modification was stronger at close to the boundary, and garnet which far from the boundary was commonly survived. Since the dyke contains abundnat biotite and subsequent apatite as well as alkali feldspar, it is expected that the dyke supplied fluid for the metasomatism during its activity.

Keywords: alkali rock, ultrapotassic rock, dyke

SCG06-04 Room:301A Time:May 25 14:30-14:45

The stability of sapphirine + quartz in high/low oxygen fugacity rocks: a case study of Southern India/East Antarctica

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Sapphirine has been the focus of many petrological investigations for the last two decades as the mineral often occurs in Mg-Al rich and pelitic rocks formed at high temperature to ultrahigh temperature (UHT). Particularly, sapphirine coexisting with quartz is considered as one of the most diagnostic mineral assemblages of UHT metamorphism. It is also known that sapphirine often occurs in magnetite-bearing high oxygen fugacity rocks, and, in such cases, the mineral can incorporate considerable quantity of ferric iron as well as Fe^{2+}. It is therefore important to evaluate the effect of Fe^{3+} content on the stability of sapphirine-bearing assemblages for estimating peak conditions as well as constructing *P-T* paths. In this study, we compared the stability of sapphirine + quartz in magnetite-bearing high-oxygen fugacity rocks from India (Madurai Block in the southern granulite terrane) with that in magnetite-absent low-oxygen fugacity rocks from Antarctica (Bunt Island in the Napier Complex) using mineral equilibrium modeling technique. The calculations have been done in NCKFMASHTO system using THERMOCALC 3.33 with an updated version of the internally consistent data set.

The Madurai Block is the largest granulite block in the Southern Granulite Terrane, India, which was formed by collisional orogeny related to the assembly of the Gondwana Supercontinent. The block contains granulites with various UHT mineral assemblages including sapphirine + quartz, orthopyroxene + sillimanite + quartz, and Al-rich orthopyroxene. Magnetite-bearing quartzo-feldspathic garnet-sillimanite granulites from Rajapalaiyam area in the southern part of the block, for example, contain sapphirine + quartz inclusion in garnet as a stable mineral assemblage at the peak of metamorphism. The calculated *T-X* pseudosections suggest that the stability temperature of sapphirine + quartz is lowered from 1000^{o}C at reduced condition (X_{Fe2O3} = 0.02) to 910^{o}C at oxidized condition (X_{Fe2O3} = 1.0).

The Napier Complex of Enderby Land, East Antarctica, underwent regional UHT metamorphism at ca. 2.5 Ga. Bunt Island in the Napier Complex, located in the highest-grade region of the complex, contains various kinds of UHT granulites including sapphirine-bearing rocks. Sapphirine + quartz assemblage, probably formed at the peak UHT condition, occur in sapphirine- and osumilite-bearing layers of the granulite. The absence of magnetite in the rocks indicates the sapphirine granulite was formed at reduced condition. *T-X* pseudosection of the rock suggests that the stability field of sapphirine + quartz is $T > 1050^o$C at X_{Fe2O3} = 0.04, while it will be lowered in more oxidized condition ($T > 800^o$C at X_{Fe2O3} = 0.24).

The results of this study demonstrated that the occurrence of sapphirine + quartz in UHT rocks is highly controlled by the oxidation state of the host rocks, particularly low oxygen fugacity rock is especially strongly influenced. In the case of Bunt Island, if X_{Fe2O3} increases by 0.04, the stability temperature of sapphirine + quartz will be lowered by 50^{o}C. It is therefore important to evaluate the effect of Fe^{3+} content of the stability of sapphirine-bearing granulites for estimating peak conditions as well as constructing *P-T* paths even if granulites were formed at reduced condition.

Keywords: sapphirine + quartz, Southern India, East Antarctica, pseudosection, THERMOCALC, oxygen fugacity

SCG06-05 Room:301A Time:May 25 14:45-15:00

Petrology of garnet-clinopyroxene rocks from the Gondwana suture zone in southern India

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The Palghat-Cauvery Suture Zone (PCSZ) in the southern granulite terrane, India, which separates Pan-African granulite blocks (e.g., Madurai and Trivandrum Blocks) to the south and Archean terrane (e.g., Salem Block and Dharwar Craton) to the north is regarded as a major suture zone in the Gondwana collisional orogeny. It probably continues westwards to the Betsimisaraka suture in Madagascar, and eastwards into Sri Lanka and possibly into Antarctica. The available geochronological data including U-Pb zircon and EPMA monazite ages indicate that the rocks along the PCSZ underwent an episode of high-grade metamorphism at ca. 530 Ma that broadly coincides with the time of final assembly of the Gondwana supercontinent. Recent investigations on high-grade metamorphic rocks in this region have identified several new occurrences of garnet-clinopyroxene rocks and associated meta-gabbros from Perundurai, Paramati, Aniyapuram, Vadugappatti, and Mahadevi areas in Namakkal region within the central domain of the PCSZ. They occur as elongated boudins of 1 m to 1 km in length within hornblende-biotite orthogneiss. The garnet-clinopyroxene mafic granulites contain coarse-grained (up to several cm) garnet (Alm30-50 Pyr30-40 Grs10-20) and clinopyroxene (XMg = 0.70-0.85) with minor pargasite, plagioclase (An30-40), orthopyroxene (hypersthene), and rutile. Garnet and clinopyroxene are both subidioblastic and contain few inclusions of clinopyroxene (in garnet) and plagioclase. Orthopyroxene occur only as Opx + Pl symplectite between garnet and clinopyroxene in almost all the localities, suggesting the progress of decompressional reaction: Grt + Cpx + Qtz => Opx + Pl, which is a dominant texture in the PCSZ. The prograde mineral assemblage of the rocks is therefore inferred to be Grt + Cpx + Qtz, although quartz was probably totally consumed by the progress of the reaction. The metamorphic P-T calculations using Grt-Cpx-Pl-Qtz geothermobarometers yield T = 850-900C and P $>$13 kbar, which is consistent with the occurrence of high-pressure Mg-rich staurolite in Mg-Al-rich rocks from this region. Fluid inclusion study of some garnet-clinopyroxene rock samples identified CO2-rich fluid inclusions trapped as primary phases within garnet, suggesting that prograde high-pressure metamorphism was dominated by CO2-rich fluids. The results therefore confirmed that the PCSZ underwent regional dry high-pressure metamorphism followed by the peak ultrahigh-temperature event probably associated with the continent-continent collisional and suturing history along the PCSZ.