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SCG065-01 会場:301B 時間:5 月 23 日 14:15-14:30

# 大陸地殻の形成とその沈み込み：セッション説明
# The formation and subduction of continental crust: session scope

山本 伸次 [1*], 小宮 剛 [2], 河合 研志 [1]
Shinji Yamamoto[1*], Tsuyoshi Komiya[2], Kenji Kawai[1]

[1] 東京工業大学, [2] 東京大学大学院総合文化研究科広域科学専攻
[1]Tokyo Institute of Technology, [2]The University of Tokyo

Previous studies of Archean geology, geochemistry of detrital materials and comprehensive investigations of subduction zones have provided great insights into the evolution of continental crust and mantle, but simultaneously raising another questions, thus offering new perspectives. Especially, subduction of continental material into the mantle is a key to better understand the evolution of continents and mantle. Here I briefly overview continental growth and destruction models ever proposed, and introduce for the session scope.

There is a long-standing controversy when and how continents formed. Recent active studies on U-Pb and Lu-Hf systematics of detrital zircons reveal the processes of crustal evolution on a global scale from the Hadean to the present. They propose that the formation of continental crust started from 4.4 Ga and that at least 70% volume of the existing continental crust were produced from the mantle before 2.5 Ga. Moreover, considerations of thermal evolution for the Earth mantle have proposed that rapid continental growth happened in the Hadean to Archean because higher mantle temperature in the Hadean to Archean must produce extensive amounts of TTG magma and that presumably more than 100% of the present continental crust must have been formed on the ancient Earth. However, Archean crust is preserved only in small portion (-10%) of Earth surface, and vestiges of Hadean crust are only Acasta gneiss complex and Jack Hills detrital zircons. To explain little preservation of ancient crust, it is suggested that the small areal preservation of Archean crust is a result of reworking of older crust and/or long term subduction of Archean TTG into the mantle.

Subduction and recycling of differentiated material into the mantle are of considerable significance for making mantle heterogeneity. Continental crust has been returned to the mantle at subduction zones, in the styles of sediment subduction, subduction erosion, arc subduction and continental subduction. Geophysical and geological investigations at modern subduction zones document that the amount of subducting continental material versus arc produced at the subduction zone have been balanced, resulting in no volumetric growth of continental crust, probably from Archean to present. Applying Cenozoic recycling rates of continental crust into the mantle (2.5-3.7 km{sup}3{/sup}/yr), a volume of crust equal to the standing inventory of -7 x 10{sup}9{/sup} km{sup}3{/sup} can be removed from the surface during past 1.9-2.8 G.y. However, the above-mentioned estimates still remain unclear because the supply rate of juvenile crust from the mantle and subducted continental material into the mantle in the ancient Earth are poorly constrained.

Previous isotopic and trace element studies of OIBs have suggested the presence of long-lived recycled components related to ancient continental crust stored in the deepest mantle. However, subducted granitic material is expected to be trapped at the bottom of the upper mantle. Because, subducted granitic material is no longer buoyant over a depth of 250 km in the mantle. Thereafter, continental material will be buoyant again compared to surrounding mantle at the base of the transition zone. However, there is no geophysical observation for the accumulation of the granitic material at the mantle transition zone. There has been controversial what produces anomalous seismic-wave velocity and density changes at depths of 400 to 700 km. Recent experimental and theoretical studies suggested that the PREM velocities are higher than those of both adiabatic pyrolite and piclogite in the lower part of the mantle transition region. Subducted granitic material can produce anomalous velocity and density discrepancy in the lowermost transition zone.

キーワード: 大陸形成, 沈み込んだ大陸地殻, 冥王代から現代へ, 沈み込んだ花崗岩の運命
Keywords: formation of continental crust, subducted continental crust, Hadean to present, fate of subducted granitic material

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SCG065-02 会場:301B 時間:5 月 23 日 14:30-14:45

# ジャックヒルズジルコン（>4 Ga）中の包有物から解読する冥王代のダイナミクス
# Mineral inclusion thermobarometry in >4 Ga Jack Hills zircons provides constraints on Hadean geodynamics

ホプキンス ミッシェル[1*], マーク　ハリソン[2], クレイグ　マニング[2]
Michelle Hopkins[1*], T. Mark Harrison,[2], Craig E. Manning[2]

[1] コロラド大学, [2] カリフォルニア大学
[1]University of Colorado, [2]University of California

Detrital zircons from the Jack Hills of Western Australia provide an important record of terrestrial conditions during the Hadean Eon (ca. >4 Ga). Mineral inclusions captured in these ancient zircons add an extra dimension to our knowledge of Hadean Earth. The inclusion population is dominated by the presence of quartz and muscovite, most apparently primary to these igneous zircons. Several lines of evidence support this view and argue against widespread exchange between most of these inclusions and their environment: (i) lack of association with cracks; (ii) magmatic crystal forms; (iii) absence of exchange with fuchsitic (Cr-rich) micas in the host conglomerate; and (iv) the heterogeneity in Sipfu values. We report new data on Ti concentration in quartz inclusions within Hadean zircons. The factor-of-10 difference in Ti content among included quartz grains is evidence against chemical communication between the host quartzite and inclusions, since the Jack Hills quartzite contains rutile which was mobile during metamorphism at ca. 2.5 Ga. Using the recently calibrated Ti-in-quartz thermobarometer yields a narrow range of pressure (20+/-2 kbar) for the three samples.  This is in broad accord with the pressure range estimated for included muscovites with ˜3.4 Sipfu (18+/-9 kbar). Taken together, the Hadean zircon inclusion assemblages yield estimates of magmatic P-T conditions from 5 to ca. 20 kbar at 700;/-40 C further supporting their formation under geotherms of ?60 C/km thus implying conductive near-surface heat flow of ca. 20 to 80 mW/m2. Of all formational environments that satisfy the spectrum of geochemical constraints available and the inference of melt generation under suppressed heat flow, the most plausible appears to be partial melting of both juvenile and mature continental sediment via continuous underthrusting beneath a stable upper plate.  We postulate that this melting could occur two different ways: fluxed melting of underthust sedimentary material, or fluxed melting of the upper plate due to plate dehydration or degassing of hydrous magma in the underthrust environment.

キーワード: ジルコン, 冥王代, 包有物, 温度圧力計, U-Pb 年代, ジャックヒルズ
Keywords: zircon, Hadean, inclusion, thermobarometry, U?Pb age, Jack Hills

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SCG065-03 会場:301B 時間:5 月 23 日 14:45-15:00

# モナザイトから得られた冥王代花崗岩質地殻の否定的な証拠
# No evidence of Hadean granitic crust from monazites

飯塚 毅[1*], ネーベル　オリバー[1], マッカラック　マルコム[1]
Tsuyoshi Iizuka[1*], Oliver Nebel[1], Malcolm McCulloch[1]

[1] オーストラリア国立大学
[1]Australian National University

The oldest identified terrestrial materials are Hadean (>4.0 Gyr ago) detrital zircons from Mount Narryer and Jack Hills metasediments in the Narryer Gneiss Complex, Western Australia, that potentially contribute to our understanding of the evolution of the early Earth. The zircons have been documented to contain inclusions of muscovite, quartz, K-feldspar, biotite and monazite. The hydrous, peraluminous inclusion assemblage has been taken as evidence that the zircons crystallized from granitic (sensu stricto) melts, with implications for the existence of plate boundary interaction and sedimentary recycling in the Hadean era. However, neither monazite inclusions in the zircons nor detrital monazites from the metasediments have U-Pb ages older than 3.6 Gyr, requiring either that the inclusions are not primary origin but grew along cracks in the zircons or that Hadean igneous monazites were preferentially recrystallized during later metamorphism. Here we present micrometre-scale, in situ Sm-Nd isotopic ratio measurements of the detrital and metamorphic monazites from the Mount Narryer and Jack Hills metasediments. The data reveal that older monazites are source of light rare earth elements for younger metamorphic monazite formation and, therefore, that monazite could inherit its primary Sm-Nd isotopic signature during the recrystallization processes. These findings, combined with the U-Pb and Sm-Nd isotope systematics of the detrital and metamorphic monazites, indicate that no igneous monazites older than 4.0 Gyr were recrystallized to form the monazites. Our results therefore suggest that the source rocks of >4.0-Gyr-old detrital zircons contained few monazites and the inclusions are secondary origin, eliminating the evidence for Hadean granitic crust.

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SCG065-04 会場:301B 時間:5 月 23 日 15:00-15:15

# 大陸地殻とマントル端成分「EM1 と EM2」の起源としてのスラブ融解
# Slab melting as a key to understand origins of continental crust and mantle reservoirs ”EM1 and EM2”

下田 玄 [1]*
Gen Shimoda[1]*

[1] 産業技術総合研究所
[1]Geological Survey of Japan, AIST

It has been widely accepted that at least three enriched geochemical reservoirs must exist in the mantle to explain the isotopic diversity of ocean island basalts (OIBs). These reservoirs are known as enriched mantle 1 (EM1), enriched mantle 2 (EM2) and high-u (HIMU; u = 238U/204Pb) (e.g., White, 1985; Zindler and Hart, 1986). Understanding the origins of these reservoirs is essential for understanding Earths chemical evolution and thus many studies have been conducted. Proposed origins for HIMU (and FOZO) is recycling of oceanic crust, namely, single process has been widely accepted. Origins of EM1 and EM2, on the other hand, are still divergent: (1) recycling of oceanic crust with variable amounts of continental crustal materials via sediment subduction or tectonic erosion, (2) delamination of continental crust, or (3) recycling of metasomatized oceanic lithosphere (e.g., McKenzie and O Nions, 1983; Weaver, 1991; Chauvel et al., 1992; Hofmann, 1997; Stracke et al. 2003, 2005; Workman et al., 2004; Willbold and Stracke, 2006). Recent studies of the origin of EM1 and EM2 suggest that the source materials of these magmas have variable chemical and isotopic compositions, suggesting that continental crustal material recycling via tectonic erosion can be a suitable origin of these magmas, because chemical variations of continental crust are much greater than those of oceanic crust (Willbold and Stracke, 2006). Although the proposed models successfully explain the origin of EM1 and EM2 reservoirs, a study that examines the relationship between ancient subduction zones, production of continental crust, and isotopic variations between EM1 and EM2 reservoirs could yield significant information. Geochemical modeling of the origin of EM1 and EM2 is, therefore, conducted from the perspective of slab melting, i.e., adakite production. For the model, the average composition of adakites is estimated from literature data for 18 trace elements. The estimated adakite composition can be explained by melting of oceanic crust without sediment contribution. The compiled data further suggest that the mantle-slab melt reaction would play a major role in the production of basic adakites. In addition, crystal fractionation in the magma chamber should produce additional chemical variations in adakites, in particular for acidic adakites. To test the effect of chemical variations on the isotopic composition of recycled adakites, correlations between trace elements and SiO2 concentrations, and the MELTS program are employed. The results suggest that recycling of a basic adakite (SiO2 = 55%) can account for EM1 isotopic signatures with age of about 2.0 Gyr. The isotopic compositions of less-basic adakites and their evolved magmas shift towards EM2 values with increasing SiO2 concentrations. In particular, evolved acidic adakite can yield EM2 isotopic signatures. These lines of evidence suggest that the recycling of adakites at various stages of evolution can conceivably produce the entire isotopic range between EM1 and EM2 reservoirs. Consequently, adakite recycling via sediment subduction or subduction erosion can account for the origins of EM1 and EM2 reservoirs. In this context, residual garnet under high pressure and plagioclase fractionation at low pressure might play an essential role in producing the chemical variations among adakites that ultimately govern the isotopic compositions of these geochemical reservoirs.

キーワード: スラブ融解, アダカイト, EM1, EM2, 大陸地殻
Keywords: slab melting, adakite, EM1, EM2, continental crust

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# TTG 質花崗岩の結晶分化作用に伴う組成変化についての再検討
# Crystal differentiation trend of TTG rocks

昆 慶明[1*], 小宮 剛[2]
Yoshiaki Kon[1*], Tsuyoshi Komiya[2]

[1] 独立行政法人産業技術総合研究所, [2] 東京大学大学院総合文化研究科広域科学専攻
[1]Geological survey of Japan, AIST, [2]University of Tokyo

大陸地殻は地球を特徴づける重要なシステムであり，その形成と成長は固体地球ダイナミクスのみならず、表層環境や生命進化に強く影響を及ぼし，非常に重要な問題である．TTG 質花崗岩は初期大陸地殻形成に於いて重要な役割を果たしていたと考えられており，その成因についてこれまで多くの研究がなされてきた．花崗岩質マグマの成因と密接に関連する初生マグマ組成を推定する為には，マグマ生成後の地殻への貫入・固結に伴う組成変化に関する理解が重要である．本発表では，TTG 質花崗岩の全岩組成を用いた結晶分化作用に伴う組成変化のコンパイルを行い，従来の結晶分化トレンドの再検討を試みた．

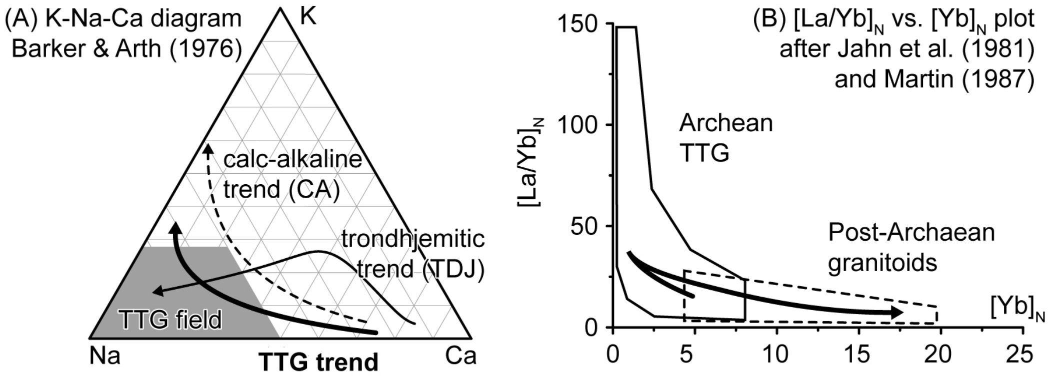
**主成分元素組成：** TTG 質花崗岩は広義のカルクアルカリ系列花崗岩に属するが，Na に富む主成分元素組成によって狭義のカルクアルカリ系列花崗岩 (Nockolds and Allen, 1953) とは区別されている（図 A）．一般に狭義のカルクアルカリ系列花崗岩は，Si や Ca の減少に伴って K/Na が増加する傾向を示す．このトレンドは，安山岩質~花崗岩質な岩石の Ca-Na-K 比を用いて定義されている (Nockolds and Allen, 1953; Barker and Arth, 1976).

一方で，TTG 質花崗岩の組成変化を説明するトレンドとして，Si や Ca 減少に伴い K/Na も減少するトロニエマイト系列 (TDJ trend: Barker and Arth, 1976) が提案された（図 A）．しかしながらこのトレンドは斑レイ岩〜花崗岩の組成を繋いだものであり，花崗岩のみに限った場合には Ca 減少に伴い K/Na の減少する系統的なトレンドは観察されない．そのため，Martin (1994) は Na に富む花崗岩の組成領域をトロニエマイト領域 (TDH field: Martin, 1994) とした（図 A）．しかし，現在においても TTG 質花崗岩の結晶分化トレンドを議論する際には TDJ 系列が引用されている．

しかしながら個々の TTG 岩体の組成は，狭義のカルクアルカリ系列と同様に Ca の減少に伴って K/Na が増加する傾向を示すことが多い (e.g. Kleinhanns et al., 2003)．この事は TTG 質花崗岩にも組成トレンドがある事を支持し，その TTG トレンドは狭義のカルクアルカリ系列同様に Si や Ca の減少に伴って K/Na が増加する傾向を持つ（図 A）．

**希土類元素組成：** 太古代 TTG は重希土類元素 (HREE) に枯渇した組成を持つことが知られており，その成因はザクロ石安定領域での含水玄武岩の部分溶融によって説明されている (e.g. Arth and Hanson, 1972)．HREE 枯渇度の判別図として，縦軸に $[La/Yb]_N$，横軸に $[Yb]_N$ をとったプロット（図 B）が一般に用いられる (Jahn et al.,1981)．一般に，太古代花崗岩は $[La/Yb]_N$ 値が高く (5-150)，$[Yb]_N$ 値が低い (<8.5) 傾向がある (Martin, 1987) とされているが，その大部分は $[La/Yb]_N$ 値が 50 以下である．各岩体で報告されている $SiO_2$ 量に対する $[La/Yb]_N$ 値の変化をプロットすると，$SiO_2$ の低い未分化なマグマ中の $[La/Yb]_N$ 値は比較的低く，結晶分化の初期段階で $[La/Yb]_N$ 値が上昇し，その後減少する傾向が見られる (e.g. Richards and Kerrich, 2007)．その際に $[Yb]_N$ 値は一旦減少してから増加するトレンドを示す．このトレンドは晶出鉱物が角閃石から斜長石へ変化することで説明できる．この場合，一連の分析値の中に $[La/Yb]_N$ 値が高い試料があったとしても，それは必ずしも未分化なマグマの組成が HREE に枯渇していたことを意味しない．今回コンパイルに用いたデータの中で，未分化なマグマの組成を反映している可能性の高い試料についてのみのデータを図 B に示す．今回の結果は，従来考えられていた値よりも太古代 TTG の $[La/Yb]_N$ 値が系統的に低くなる可能性を示唆する．

**参考文献：** Arth and Hanson (1972) *Contrib. Min. Pet.*, **37**, 161-174., Barker and Arth (1976) *Geology*, **4**, 596-600., Jahn et al (1981) *Geochim. Cosmochim. Acta*, **45**, 1633-1652., Kleinhanns et al (2003) *Contrib. Min. Pet.*, **145**, 377-389., Martin (1987) *Precam. Res.*, **35**, 257-276., Martin (1994) *Archean Crustal Evolution*, 205-259., Nockolds and Allen (1953) *Geochim. Cosmochim. Acta*, **4**, 105-142. , Martin (1994) *Archean Crustal Evolution*, 205-259., Richards and Kerrich (2007) *Economic Geol.*, **102**, 537-576.




キーワード: 花崗岩, TTG, カルクアルカリ系列, 希土類元素
Keywords: granite, TTG, calk alkaline, REE

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# 丹沢トーナル岩類中の苦鉄質包有岩に含まれるジルコンの U-Pb 年代から推測する島弧下部地殻の年代
# Age of the arc lower crust from mafic enclaves in the Tanzawa tonalites, Izu Arc, Japan

鈴木 和恵 [1*], 山本 伸次 [1], 李　毅兵 [1], 平田 岳史 [2], 昆 慶明 [3], 大森 聡一 [1], 丸山 茂徳 [1]
Kazue Suzuki[1*], Shinji Yamamoto[1], Yibing Li[1], Takafumi Hirata[2], Yoshiaki Kon[3], Soichi Omori[1], Shigenori Maruyama[1]

[1] 東京工業大学大学院地球惑星科学専攻, [2] 京都大学大学院理学研究科地球惑星科学専攻, [3] 独立行政法人産業技術総合研究所
[1]Tokyo Institute of Technology, [2]Kyoto University, [3]AIST

The continental lower crust comprises approximately half of the bulk continental crust and plays a significant role in making the continents. According to seismic observations and studies of crustal xenoliths, the continental lower crust is thought to consist of amphibolites and/or granulite (Christensen and Moony, 1995). However, petrology and chronology of the continental lower crust still remain open questions because it is usually not exposed on the surface of the continent.

To obtain the relevance and age constraints of the continental lower crust from common occurrence of granitic rocks, we propose a new method of U-Pb zircon dating from mafic enclaves in granites with LA-ICP-MS. Zircons can survive and retain their crystallization ages even in the metamorphic overprints and magmatic modifications. In this study we collected the mafic enclaves in Tanzawa tonalites (4-5 Ma by SHRIMP: Tani et al., 2010), in the Izu collision zone, Japan. The Tanzawa tonalites are intrusive to gabbro (5-6 Ma: Tani et al., 2010) and Tanzawa group (basalt detritus in 3-17 Ma: Aoike, 1997). The mafic enclaves show textures, which suggest mixing with the surrounding tonalite. $SiO_2$ content in mafic enclaves varies from 46.99 to 58.26 wt%. The enclaves are considered to have two or more origins because of their various lithologies from amphibolite to doleritic basalt. We separated 355 zircon grains from nine 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 zircon age population from tonalite show relatively narrow range distribution around 5 Ma, resulting in mean age of 4.7 $\pm$ 1.5Ma, which corresponds to the U-Pb zircon ages previously determined by SHRIMP (Tani et al., 2010). While the zircon age population from mafic enclaves in tonalite show wide range distribution from 5 to 43 Ma, most of zircons yielded around 5 Ma.This result implies that the mafic enclaves were affected and/or mixed with the tonalitic magma at when the mafic enclaves were incorporated. Zircons of ages older than 5 Ma in the mafic enclaves would be originated from rocks surrounding the Tanzawa tonalites. Because the Tanzawa group (3-17Ma) and the gabbro suite (5-6Ma) are intruded by the Tanzawa tonalites, they are probably the origin of the zircons which yielded around 6-20Ma. On the other hand, the zircons showing older than 20Ma have to be originated except from the Tanzawa group and the gabbro suite. Because Tanzawa group is the juvenile arc basalt on the Philippine Sea Plate plate, there is nothing except the arc lower crust beneath Tanzawa tonalitic pluton which is older than Tanzawa group.Thus, the zircons which yielded 20-43Ma must be originated from the arc lower crust. The oldest zircon age (42.9 $\pm$ 8.6Ma) implies that the arc lower crust formed by at least 42.9 $\pm$ 8.6Ma. It is correspond to the estimate that proto-Izu-Bonin arc had initiated subduction by 48Ma (Seno and Maruyama, 1984). Our result from this study 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: 大陸下部地殻, 苦鉄質包有岩, ジルコン, U-Pb 年代, LA-ICP-MS, 花崗岩
Keywords: continental lower crust, mafic enclave, zircon, U-Pb dating, LA-ICP-MS, granite

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# 西グリーンランドにおける島弧地殻ブロック：太古代の地殻成長
# Arc-generated blocks with crustal sections in the West Greenland: Crustal growth in the Archean with modern analogues

Windley Brian[1*]
Brian Windley[1*]

[1] レスター大学
[1]University of Leister

The ca. 700 km long, Archean craton of West Greenland consists of six Meso - Neoarchean (ca. 3000 - 2720 Ma) shear zone - bounded crustal blocks that display similar cross-sections; from south to north Ivittuut, Kvanefjord, Bjornesund, Sermilik, Fiskefjord, Maniitsoq. Each block has a southerly upper and a northerly lower zone, thus each faces upwards to the south. Upper zones have prograde amphibolite facies mineralogy and have never been in the granulite facies, whereas lower zones reached granulite facies and were partly retrogressed to amphibolite facies. Upper and lower zones consist predominantly of tonalite - trondhjemite - granodiorite (TTG) orthogneisses; geochemistry suggests generation by slab melting in subduction settings of island arcs and active continental margins. These crustal blocks provide an exceptional example of how continents evolved in the Meso?Neoarchean. Comparable Archean examples in Kapuskasing and Pikwitonei (Canada) and modern analogues in Fiordland (New Zealand), Kohistan (Himalayas), Southern California batholith, Peruvian Andes, and Hidaka (Japan) demonstrate that processes of continental growth from island arc to continental arc magmatism (and by implication to continental collision) were broadly similar throughout most of Earth history.

キーワード: 地殻ブロック, 角閃岩, 斜長岩, TTG, 島弧, 太古代
Keywords: crustal block, amphibolite, anorthosite, TTG, island arc, Archean

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# 真の大陸成長
# True Continental growth

小宮 剛 [1*]
Tsuyoshi Komiya[1*]

[1] 東京大学大学院総合文化研究科
[1]Komaba, University of Tokyo

Continental crust is very important for evolution of life because most bioessential elements are supplied from continent to ocean. In addition, the distribution of continent affects climate because continents have much higher albedo than ocean, equivalent to cloud. Conventional views suggest that continental crust is gradually growing through the geologic time and that most continental crust was formed in the Phanerozoic and late Proterozoic. However, the thermal evolution of the earth implies that much amounts of continental crust should be formed in the early Earth. This is Continental crust paradox.

Continental crust comprises granitoid, accretionary complex, sedimentary and metamorphic rocks. The latter three components originate from erosion of continental crust because the accretionary and metamorphic complexes mainly consist of clastic materials with minor basaltic oceanic crust. Granitoid has two components: juvenile component through slab-melting and recycling component by remelting of continental materials. Namely, only the juvenile component of granitoids contributes to net continental growth. The remains originate from recycling of continental crust. The estimate of continental growth is highly varied. Thermal history implied the rapid growth in the early Earth, whereas their present distribution suggests the slow growth. Mantle composition suggests the moderate increase in the Proterozoic to Phanerozoic. The former regards continental recycling as important whereas the latter regarded as insignificant. Continental recycling has three components: intracrustal recycling, crustal reworking, and crust-mantle recycling.

We calculate true continental growth including continental formation and recycling. We changed a recycling rate, and find an answer to satisfy five conditions: its present distribution (no continental recycling), geochronology of zircons (intra-continental recycling, redistribution of continental materials or formation of accretionary complex), Hf isotope ratios of zircons (remelting of continental materials), isotope evolution of upper mantle (return of continental materials to the mantle) and secular change of mantle temperature.

Subduction geotherm depends on the mantle temperature because thickness, size and life-span of oceanic plates are controlled by mantle temperature. Increase of mantle temperature leads to their short life-spans due to the smaller sizes, and results in hot subduction geotherm; thus, hotter mantle temperature allows more granitoid formation through subduction of thicker and younger oceanic crusts. The amounts of intra-continental recycling, redistribution of continental materials and deposition of clastic sediments in trenches depends on amounts of continental crusts. Especially, amounts of continental crusts and lengths of subduction zones control amounts of clastic sediments. More continental crusts lead to more sediment. Longer subduction zone leads to more sediments in trenches. Because the length of subduction zone depends on mantle temperature, high mantle temperature results in high crustal formation and deconstruction. We changed erosion rate of continental crust and calculated secular changes of continental formation and destruction to fit the five types of estimates of continental growth curves. The calculation shows the following. (1) The distribution of continental crust 2.7 Ga is equivalent to the modern amounts. (2) Especially, the distribution of continental crust from 2.7 to 1.6 Ga is much larger than at present, and the size around 2.4 Ga became maximum and decreases since then. More continental crusts were formed during the high mantle temperature at 2.7, 1.9 and 0.8 Ga, and more amounts were destructed after then. As a result, 2.4 Ga continental crust apparently became minor, and few Archean continental crust remained. The timing of large distribution of continental crust corresponds to the timing of icehouse, namely 2.4, 1.6 and 0.8 Ga in Precambrian.

キーワード: 大陸成長, 地球表層進化, リサイクル, 太古代, 初期地球, マントルオーバーターン
Keywords: Continental growth, evolution of Earth's surface, continental recycle, Archean, early Earth, mantle overturn

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SCG065-09 会場:301B 時間:5 月 23 日 16:45-17:00

# 構造浸食と日本列島形成史
# Tectonic erosion and geotectonic evolution of the Japanese Islands

磯崎 行雄 [1*], 丸山 茂徳 [2], 山本 伸次 [2]
Yukio Isozaki[1*], Shigenori Maruyama[2], Shinji Yamamoto[2]

[1] 東京大学, [2] 東京工業大学地球惑星科学教室
[1]Univ. Tokyo, [2]Tokyo Inst. Technology

The ca. 700 million year-long geotectonic history of the Japanese Islands comprises three distinct intervals; i.e., 1) the age of a passive continental margin off the South China continental margin (ca. 700-520 Ma), 2) the age of an active margin characterized by an arc-trench system (ca. 520-20 Ma), and 3) the age of an island arc off East Asia (20 Ma to the present). These three intervals are chronologically separated by two major boundaries with significant tectonic episodes; i.e., the ca. 520 Ma tectonic inversion from a passive to an active margin by the initiation of subduction from the Pacific side, and the ca. 20 Ma tectonic isolation of the modern island arc system from the Asian margin by the back-arc basin (Japan Sea) opening. Here, the evolutionary history of the Japanese Islands is revised significantly on the basis of new lines of information that derived from a new dating technique of detrital zircon in sandstone. Particularly noteworthy is the recognition of the Early Paleozoic to Middle Mesozoic arc batholiths that were exposed extensively in the past but not at all at present because the pre-Cretaceous granites merely occur as kilometer-size blocks in the modern Japanese Islands. As to these older granites, the remarkable disagreement between the current distribution and the predominance of their clastic grains in younger sandstones suggests the effectiveness of past tectonic erosion processes in the fore-arc domains. The newly documented historical change in sandstone provenance suggests that proto-Japan has experienced not only accretionary growth but also large-scale tectonic erosion in multiple stages. During the ca. 500 million-year history of the Japanese Islands, a large amount of juvenile arc (continental) crust was formed several times, however, most has already disappeared from the surface. In short, the orogenic growth of Japan, even in a long-lasting active continental margin setting, is explained as the intermittent repetition of ocean-ward continental growth and continent-ward contraction of an active arc-trench system.

In contrast to these arc batholiths, the terrigenous flux from the neighboring two major continental blocks (South and North China) was less significant than previously imagined, except for the Jurassic to Early Cretaceous time when the collisional suture between North and South China blocks was selectively eroded to produce abundant terrigenous clastics. It is also significant that the eastern extension of this collisional suture was recognized in Japan as a chain of fragmentary remnants of the Triassic medium-pressure metamorphic belt. On the basis of these new lines of information, the South China-related origin of the main part of Japan is confirmed, whereas the Hida and Oki belts along the Japan Sea are identified as detached fragments of North China block. Summarizing all of these results, a series of paleogeographic maps of Japan from the Late Neoproterozoic to the Miocene is revised and illustrated.

キーワード: 日本列島, 付加, 花崗岩バソリス, 砕屑性ジルコン年代, 構造浸食, 弧地殻
Keywords: Japanese Islands, accretion, granite batholith, detrital zircon dating, tectonic erosion, arc crsut

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SCG065-10 会場:301B 時間:5 月 23 日 17:00-17:15

# マントル深部へ沈み込む大陸地殻の量の推定
# Supply rate of subducting continental crust to the deep mantle

市川 浩樹 [1*], 河合 研志 [2], 亀山 真典 [1], 土屋 卓久 [1]
Hiroki Ichikawa[1*], Kenji Kawai[2], Masanori Kameyama[1], Taku Tsuchiya[1]

[1] 愛媛大学地球深部ダイナミクス研究センター, [2] 東京工業大学大学院理工学研究科
[1]GRC, Ehime University, [2]Tokyo Institute of Technology

Subductions of granitic materials by tectonic erosion, sediment-trapped subduction, and direct subduction of immature oceanic arcs are indicated by recent geological and geophysical surveys. Geological studies have estimated the volume of subducted tonalite-trondhjemite-granodiorite (TTG) materials is 7 times larger than the volume of the present continental crust. Such a huge volume of subducted granitic materials have a large influence on the chemical evolution of the Earth, and therefore their destination in the mantle has long been debated.

A recent study indicates the TTG materials are gravitationally stable in the mantle transition zone. Capacity of this layer is large enough to reserve subducted continental crust, which might control the mantle convection to some extent. However, it is unclear how and how much they subduct dynamically through the mantle under the lithosphere.

In this study, we conducted a numerical and an analytical approach on an entanglement of a granitic layer by a slab. Sustainable thickness of the subduction channel and supply rate of the granitic materials to the deep mantle are estimated.

キーワード: 大陸地殻, スラブ
Keywords: Continental crust, slab

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# マントル遷移層の地震学的構造
# Seismic structure of the mantle transition zone

末次 大輔 [1*]
Daisuke Suetsugu[1*]

[1] 海洋研究開発機構
[1]IFREE/JAMSTEC

The two main global discontinuities in the mantle are located at depths of around 410 and 660km (called the 410 and 660 in this paper), though their depths vary slightly in different tectonic zones (e.g., Flanagan and Shearer, 1998). The 410 and 660 are considered to be due to the olivine to wadsleyite and postspinel phase transformations, respectively (e.g., Ito and Takahashi, 1989). The pressure of both transformations is thermally controlled because the olivine to wadsleyite and post-spinel phase

transformations are exothermic (positive Clapeyron slope) and endothermic (negative Clapeyron slope) reactions, respectively (e.g., Bina and Helffrich, 1994). In a cold (hot) environment such as a subduction zone, the 410 and 660 should be elevated (depressed) and depressed (elevated), respectively, which should generate temperature-related topography in the mantle transition zone (MTZ).

However, recent mineralogical studies suggest that phase transformations related to garnet, the other major component of the mantle, are involved, in addition to the olivine-related post-spinel transformation, at depths from 600 to 750km (e.g., Vacher et al., 1998), and should therefore appear as multiple seismic discontinuities in that depth range. Recent seismological studies have detected such multiple discontinuities (Simmons and Gurrola, 2000; Deuss et al., 2006; Tibi et al., 2007; Schmerr and Garnero, 2007; Andrews and Deuss, 2008). For subduction zones in particular, the relationship between subducted slabs and multiple phase transformations has been investigated in order to understand the fate of subducted slabs. In the session, I will review recent seismic results mainly on the 660.

キーワード: マントル遷移層, 660km 不連続面
Keywords: Mantle transition zone, the 660-km discontinuity

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SCG065-12 会場:301B 時間:5 月 23 日 17:30-17:45

# 下部マントル最上部の小規模な不均質構造とその起源
# Origin of small-scale heterogeneity at the shallowest lower mantle

金嶋 聡 [1*]
Satoshi Kaneshima[1*]

[1] 九州大学　理学部　地球惑星科学科
[1]Kyushu Univ.

地球深部ダイナミクス特にマントルの下降流の研究において、大規模な地震波不均質、長波長ジオイド、プレート沈み込み間の密接な関係は、マントルの温度異常と関連させて解釈される事が多い。他方で、近年、下部マントルの最上部およそ３００ km において、単純な温度異常ではなく化学組成不均質などが関与する小規模な地震波散乱体が多数見つかっている。このような地震波散乱体あるいは速度異常構造は地震計アレイデータを用いた SP 変換波の検出により確認できる (Kaneshima, 2003)。そのため散乱体が深発地震の震源近傍つまりスラブ近傍に検出されやすいのは当然だが、スラブのかつての底部付近（スラブ下面付近）に検出される事が多いという傾向が最近分かってきた (Kaneshima, 2009)。このような不均質構造が形成されるメカニズムについては、沈み込んだ海洋地殻由来の玄武岩成分の関与、スラブのかんらん岩中のガーネット成分の相転移、スラブ内岩石の脱水反応、局所的異方性構造の形成、など色々考えられるが、現時点で確かな事は何も分かっていない。近年の高圧実験技術の進歩により、かんらん石のみならずそれ以外の重要な鉱物についても下部マントル条件における弾性的性質が明らかになりつつある。それらを、岩石のレオロジーに関する実験や理論モデル、スラブの沈み込みの数値シミュレーションなどと併せて、地震学観測を解釈する事が、これらの散乱体の正体を解明するために必要であろう。

キーワード: 下部マントル最上部, 地震波散乱体, スラブ底部, 組成不均質
Keywords: shallowest lower mantle, seismic scatterer, base of slab, compositional heterogeneity

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SCG065-13 会場:301B 時間:5 月 23 日 17:45-18:00

# 第 2 大陸
# The Second Continent

河合 研志 [1*], 山本 伸次 [1], 土屋 卓久 [2], 丸山 茂徳 [1]
Kenji Kawai[1*], Shinji Yamamoto[1], Taku Tsuchiya[2], Shigenori Maruyama[1]

[1] 東京工業大学, [2] 愛媛大学
[1]Tokyo Institute of Technology, [2]Geodynamics Research Center, Ehime Unive

Recent progress in our understanding of the consuming plate boundary indicates the ubiquitous occurrence of tectonic erosion of the hanging wall of the continental margin, sediment-trapped subduction, and direct subduction of immature oceanic arcs into deep mantle. Geological studies have estimated the volume of subducted tonalite?trondhjemite?granodiorite (TTG) materials to about seven times the surface total volume of continental crust. To reveal the fate of subducted crusts and how they recycle within the Earth, we studied high-pressure densities and elastic properties of TTG by means of the first principles computation method and compared them to those of peridotite. We found that TTG is gravitationally stable and its seismic velocities are remarkably faster than peridotite in the depth range from 300 to 800 km, especially from 300 to 670 km. We, therefore, propose SiO2-rich second continents in the mantle transition zone, which used to form the TTG crust on the Earth's surface. Our proposed model may provide reasonable explanations of seismological observations such as the splitting of the 670 km discontinuity and seismic scatterers in the uppermost part of the lower mantle. The difference in seismic velocities between PREM model and experimental results in the lower part of the transition zone can be explained by 25 volumetric% of TTG, which would correspond to about six times the present volume of the continental crust. Formation and dynamics of those second continents would have controlled the Earth's thermal history over geologic time.

キーワード: 花崗岩, 沈み込み, 第 2 大陸, 構造浸食, 第一原理計算
Keywords: granite, subduction, second continent, tectonic erosion, first-principle calculation

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# 表層地質からマントル対流３億年を説明する
# The 300 Ma mantle convection history is interpreted by the surface geology

丸山 茂徳 [1*]
Shigenori Maruyama[1*]

[1] 東京工業大学
[1]Tokyo Institute of Technology

マントル対流を駆動する原動力は主として核の貯蔵熱と考えられ、地球内部熱の廃熱過程がマントル対流と見なされ、多様な数値計算研究がなされてきた。近年、表層地殻を構成する花崗岩の質量の 10 倍がマントル内部に不均質に分布し、第２大陸を作り、それらの離合集散がマントルダイナミクスを支配した可能性が提案されている（Kawai et al., 2009; Senshu et al., 2009）。この講演では、マントルへ花崗岩を供給した過去のプレート収束場と構造侵食の程度を表層地質から復元し、それを、海洋底地磁気縞から復元された過去２億年のマントル対流の歴史と比較する。その結果、マントル対流が、第２大陸の発熱によって駆動されていることが導かれる。