

## ガスキエス氷期の続成痕跡とそのエディアカラ紀層序に対する意義 Diagenetic signatures of the Gaskies glaciation and their implication to the Ediacaran stratigraphy

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地球史を通じて頻繁に生じた無機炭素同位体のエクスカーションは、生物進化と絶滅イベントと同調する一方で、大規模環境変動にも対応する。多細胞動物が大きく進化したエディアカラ紀 (635 ? 542 Ma) においても、いくつかのエクスカーションが記録されている。南中国に分布するエディアカラ系堆積岩である揚子プラットフォームは変成度が低く、解像度の高い無機炭素同位体比プロファイルが多く報告されている (e.g. Sawaki et al., 2010)。その多くは汎世界的であると認定できるが、Doushantuo 層中部に確認された負のエクスカーションは南部中国に特有のものであり、ガスキエス氷期に対比される (Tahata et al., 2013)。本研究では、湖南省北西部 Yangjiaping セクションで確認された約 15 % で細かな変動を持つ負のエクスカーション (Kunimitsu et al., 2011) について、セメントなどの続成成分を詳細に検討した。特異なエクスカーションが確認されたのは、Yangjiaping セクションの Doushantuo 層 Unit 3 中部? 上部である。ここでは、方解石セメントの無機炭素同位体が ~25 ‰、酸素同位体が ~2 ‰ ほど全岩の値より低いことが分った。これを説明するための最も有力なプロセスは、天水続成環境での有機物酸化である。方解石セメントを生成するためには、やや嫌気的な環境で起こる硫酸還元とのカップリングが想定され、共産するパイライトはそれを支持している。Yangjiaping セクションは化石産出で有名な貴州省 Wengan とともに南中国プラットフォーム内でも最も浅い位置にあり、海水準低下により堆積場は陸上に露出したと思われる。この負のエクスカーションのいくつかの特徴は模式値の Doushantuo 層中部や Wengan の古土壌層下位のエクスカーションとも共通する。すなわち陸上露出はエディアカラ紀中頃 (580 Ma) に起きたガスキエス氷期にともなうものと考えられる。Doushantuo 層 Unit 3 にはリン酸に富む堆積物があり、氷期に伴う湧昇水強化を暗示する。ガスキエス氷期は栄養塩と酸素を海洋に効率的に循環させ、その後の動物進化を促したと考えられる。

## 「カンブリア紀の農耕革命」はいつ始まったのか？ When did the "Cambrian agronomic revolution" start?

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カンブリア紀に多様な底生生物が出現し、海底の堆積物は攪拌され始め、エディアカラ紀に広く海底を覆っていた微生物マットが衰退した。この現象は「カンブリア紀の農耕革命」(Seilacher and Pflüger, 1994)と呼ばれ、エディアカラ紀からカンブリア紀に入る際に起きた、底質、底生動物活動の大きな変化と捉えられている。従来の研究ではエディアカラ紀に農耕革命が始まっていた明確な証拠は見出されていない。しかし我々はモンゴル西部のエディアカラ系から、海底下に深く潜入した動物活動の証拠を得ることができ、当時活発な底生動物活動が明瞭に始まっていたことが明らかになったので、ここに報告する。

モンゴル西部の Govi Altay 地域には原生代後期～カンブリア紀の地層が広く分布する。その中で Bayan Gol 溪谷南部に発達するエディアカラ系上部の層状石灰岩中の 11 の層準から垂直かつ大型の穿孔痕 *Arenicolites* isp. を多数確認することができた。*Arenicolites* isp. は最深で約 4 cm 垂直方向に潜入している。同地域において 2 m 間隔で資料サンプルを採集し、炭素同位体比の測定を行い、他地域との対比を行った。

*Arenicolites* isp. が含まれる層準は Tsagaan Oloom Formation 上部にあり、カンブリア紀の基底を示す生痕化石 *Treptichnus pedum* が初産出する層準よりも 190 - 140 m 下位に位置する。炭素同位体比測定の結果から、*Arenicolites* isp. が含まれる層準は Pc/C 境界付近に対比される BACE event より 120 - 70m 下位に位置すると判断される。したがって *Arenicolites* isp. を産する層準はエディアカラ系上部と考えられる。これらの結果から、「カンブリア紀の農耕革命」が地域によってはエディアカラ紀にすでに始まっていたということが考えられる。モンゴル西部で他地域より早く「カンブリア紀の農耕革命」が始まったのはおそらく地理的な理由、すなわち当時モンゴルが低緯度に位置していたことと関係していたと推察される。

キーワード: エディアカラ紀, カンブリア紀, 生痕化石, カンブリア爆発, カンブリア紀の農耕革命  
Keywords: Ediacaran, Cambrian, ichnofossil, Cambrian explosion, Cambrian agronomic revolution

## GSSP セクションに記録された後期デボン紀大量絶滅時の土壌浸食事件 Soil erosion event during the Late Devonian mass extinction recorded at the GSSP section

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The Late Devonian mass extinction occurred in a stepwise manner and culminated close to the Frasnian-Famennian (F-F) boundary (372 million years ago). Organic-molecular indices from marine sedimentary rocks at the GSSP section at Coumiac, France, indicate that the sequence of soil erosion and euxinia occurred close to this boundary. The increased concentrations of organic molecules indicating combustion and soil erosion measured in the Coumiac section suggest that terrigenous organic matter flowed into the ocean at this time, leading to reduction of the ocean that caused marine extinctions. Since this soil erosion event simultaneously occurred at the Sinsin section in Belgium (Kaiho et al., 2013), expansion of the reducing environment of the ocean due to soil inflow is thought to have occurred in a wide area. The study of sedimentary organic molecules presents several lines of evidence to link reduction of the ocean due to soil erosion to the Late Devonian mass extinction.

Kaiho, K., Yatsu, S., Oba, M., Gorjan, P., Casier, J.-G., Ikeda, M., 2013. A forest fire and soil erosion event during the Late Devonian mass extinction. *Palaeogeogr. Palaeoclimatol. Palaeoecol.* 392, 272-280.

キーワード: 大量絶滅, デボン紀, 土壌浸食

Keywords: mass extinction, Devonian, Soil erosion

形態空間分布パターンと種 - 個体数関係に基づく絶滅・回復イベントの様式の評価方法  
Assessment of mode of extinction and recovery based on changes in morphospace and species-abundance relationship

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Morphological disparity has been attracting attention as a clue for understanding mode of mass extinction because selective extinctions readily reduce the disparity than do random extinctions. In recent years, changes in morphospace occupation are also used to assess selectivity of extinction and subsequent recovery. However, hitherto approaches to this subject have been based on among-species variation and have omitted abundance of each species. Recent developments of database systems such as the Paleobiology Database allow us to utilize data of collection-based occurrences as a proxy of abundance of each species. Here I would propose a method to determine which model of extinction and recovery best explains the observed data on species-abundance relationship as well as on the patterns of morphospace occupation. In the present method, the mode of mass extinction and subsequent recovery is categorized into three models: 1) random extinction and random recovery, 2) selective extinction and random recovery and 3) selective extinction and selective recovery. The method is based on a statistical model selection in which each model is rated in terms of congruence with observed data according to an information criterion. Likelihood functions are computed for various model conditions through simulations of extinction and origination. Prior to the simulations, the morphological values and the number of fossil occurrences are provided for each species through measurements and tabulation of database information. In the simulation of mass extinction, a given percentage of actual occurrences are stochastically removed from the morphospace. In the case of selective extinction, fitness is defined as a function of a morphological variable to determine the probability of removal for each occurrence with a value of the variable. The recovery process is simulated by adding new hypothetical occurrences to the morphospace such that the total number of species is same as the actual data. An addition of new occurrence originates a new species or just increases abundance of a preexisting species randomly chosen. In the former case, morphological values of the new species are stochastically determined so that the new species is located in the neighborhood of the ancestral species in the morphospace. In the selective recovery model, the fitness function defined above also determines where a new occurrence is likely to be introduced in the morphospace. Maximum-likelihood estimation of model parameters requires vast number of simulations with various conditions for each model. In order to select the best model among the three scenarios, the present method refers to the Akaike Information Criterion and its modified version for a small sample sizes.

キーワード: 形態空間, 異質性, 大量絶滅と回復, 統計的モデル選択  
Keywords: morphospace, disparity, mass extinction and recovery, statistical model selection

ペルム紀中期末の生相・環境変化：中緯度での応答  
Changes in biofacies and environments at the end-Gudalupian: response in mid-latitude

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The Guadalupian-Lopingian boundary (Permian) recorded the most significant environmental change in the Paleozoic on all aspects; i.e. major global cooling, biodiversity decline, ocean chemistry, and even geomagnetism. Previous studies focused mostly on the fossiliferous limestones deposited in low-latitude domains both in peri-Pangean shelves and mid-oceanic atoll complexes. In order to check the relevant environmental changes in mid-latitude, the Iwaizaki Limestone in the South Kitakami Belt, NE Japan, was analyzed in litho-, bio-, and isotope stratigraphy. In particular, the top part of the limestone, ca. 50 m-thick interval, recorded the collapse of a patch reef complex. Except the Capitanian fusulines from the basal part of this interval, most of the interval lacks index fossil. The present Sr isotope analysis newly identified the uniquely low Sr-ratio, as low as 0.7068, throughout the interval, confirming the Capitanian age. The collapse of reef occurred during the Capitanian in accordance with the Kamura cooling event, but probably much earlier than the low-latitude domains.

キーワード: ペルム紀, キャピタン世, 寒冷化, Sr 同位体比, 南部北上, 陸棚石灰岩

Keywords: Permian, Capitanian, cooling, Sr isotope ratio, South Kitakami, shelf limestone

ペルム紀中期末における陸棚礁の崩壊：北上山地岩井崎石灰岩のSr同位体層序  
The collapse of a Capitanian (Middle Permian) reef: Sr-isotope profile at Iwaizaki, NE  
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The Iwaizaki Limestone in the South Kitakami Belt, NE Japan, represents shallow-marine shelf carbonates deposited along the Guadalupian (Middle Permian) South China margin. The main part of the limestone is composed of massive fossiliferous limestone (ca. 100 m) of reef complex, while the upper part (ca. 35 m thick) consists of interbedded limestone and mudstone. This facies transition corresponds to the onset of reef collapse, and the disappearance of tropical fauna. The main part and the lowermost upper part yielded Capitanian (Upper Guadalupian) fusulines but the rest of the upper limestone is barren of index fossils. As the overlying black mudstone yields Late Permian (Lopingian) ammonoids, the extinction-related G-L boundary exists somewhere within the uppermost limestone or in much higher mudstones. In order to constrain the age of the fossil-free uppermost limestone, we analyzed <sup>87</sup>Sr/<sup>86</sup>Sr stratigraphy of the Iwaizaki Limestone, and correlated with the global secular trend. The present results confirmed that the topmost Iwaizaki limestone, as well as the main part, has the same low <sup>87</sup>Sr/<sup>86</sup>Sr ratio of 0.7068-0.7069. The extremely low <sup>87</sup>Sr/<sup>86</sup>Sr ratio (<0.7069; the lowest values of the Phanerozoic) continued to the topmost bedded limestone in the section. The coeval limestones in the world, including those at Akasaka and Kamura in Japan, recorded a unique interval of extremely low <sup>87</sup>Sr/<sup>86</sup>Sr ratio (0.7068-0.7070) as called the “Capitanian minimum”. Therefore, the topmost Iwaizaki Limestone no doubt belongs to Capitanian, suggesting that the collapse of reef started clearly before the G-L boundary, probably by the onset of the putative Capitanian cooling.

Keywords: Permian, Sr isotope, shelf, South Kitakami belt, reef



## 硫黄・炭素同位体組成で推定するペルム紀中 - 後期境界における海洋環境変遷 Sulfur and carbon isotope study for understanding environmental changes across the Middle/Late Permian boundary

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ペルム紀末の大量絶滅は顕生代最大規模であったとされているが、この絶滅イベントは単一の事象ではなく、ペルム紀中期-後期 (Guadalupian-Lopingian; G-L) 境界、狭義のペルム紀-トリアス紀 (Permian-Triassic; P-T) 境界の二つのイベントからなることが指摘されている [1, 2]。生物相が回復するよりも前に次のイベントが起こったことで、絶滅の規模が拡大したと考えられている [3]。これまで狭義の P-T 境界に関わる研究は精力的に進められてきているが、G-L 境界に関わる研究例は少なく、何が起きたのかについては不明な点が多い。しかし、ペルム紀末の大量絶滅を本質的に理解するためには、G-L 境界に関する研究は不可欠であり、本研究でもこの境界について取り扱う。硫黄・炭素同位体比に関する議論を組み合わせて G-L 境界における海洋環境の変遷を議論する。

宮崎県高千穂町の上村地域に分布する古海山起源のペルム系中部上部統石灰岩を対象とした。海洋硫酸の硫黄同位体比の復元に使われる炭酸塩構造置換態硫酸 (carbonate-associated sulfate; CAS) は文献 [4] にある方法に従って回収した。酸処理後の残渣を回収し、その硫黄・炭素同位体比分析も行った。残渣の硫黄・炭素同位体はそれぞれ硫化物・有機物の同位体を表す。炭酸塩鉱物の同位体に関しては、すでに Isozaki et al. [5] に報告があり、本研究でもその値を議論に用いる。

G-L 境界を挟む上位下位両方で、 $\delta^{34}\text{S}_{\text{CAS}}$  と  $\delta^{13}\text{C}_{\text{carbonate}}$  の逆相関を見出した。通常の海洋では、堆積物への有機物供給量の増加に伴い硫化物埋没量が増加する。前者は  $\delta^{13}\text{C}_{\text{carbonate}}$ 、後者は  $\delta^{34}\text{S}_{\text{CAS}}$  として記録されるので、これらの指標は正相関を示すことが多い。硫酸還元が堆積物内で起こっている酸化海洋では、バクテリアの利用可能な有機物のほとんどは堆積物に供給される前に (沈降中に) 酸化されている。したがって、有機物供給量が増加すると (濃度が低いがわずかに残る) バクテリア利用可能な有機物量が増加する。このために硫酸還元量は有機物供給量と相関する。一方で、硫化水素が海水に存在するような貧酸素状態の海洋では、バクテリアによる硫酸還元によって沈降中の有機物が酸化分解される。このために硫化物生成量が増えると有機物埋没量は減少し、 $\delta^{34}\text{S}_{\text{CAS}}-\delta^{13}\text{C}_{\text{carbonate}}$  の逆相関を示すことになる。この逆相関の存在は、G-L 境界前後の海洋ですでに貧酸素環境が生じていたことを示している。

G-L 境界では  $\delta^{34}\text{S}_{\text{CAS}}-\delta^{13}\text{C}_{\text{carbonate}}$  逆相関の傾きが変化している。これは海洋に供給される C/S 比が変化したことを示し、火山活動様式の変化を示している。境界後には  $\text{CO}_2$  により富んだ火山活動へと変化したことを示している。

[1] Jin, Y.G., Zhang, J. and Shang, Q.H. (1994) Can. Soc. Petr. Geol. Mem., 17, 813-822. [2] Stanley, S.M. and Yang, X. (1994) Science, 266, 1340-1344. [3] Isozaki, Y. (2009) J. Asian Earth Sci. 36, 459-480. [4] Kampschulte, A., Bruckschen, P., Strauss, H. (2001) Chem. Geol. 175, 165-189. [5] Isozaki, Y., Kawahata, H. and Ota, A. (2007) Global Planet. Change 55, 21-38.

キーワード: ペルム紀中 - 後期境界, 大量絶滅, 海洋無酸素, 炭酸塩置換体硫酸, パンサラッサ

Keywords: Guadalupian-Lopingian boundary, mass extinction, oceanic anoxia, carbonate-associated sulfate, Panthalassan paleoatoll carbonates

## ペルム紀中期末における超海洋パンサラッサの窒素循環変動 Perturbations of the nitrogen cycle in mid-Panthalassa in the Late Guadalupian (Middle Permian)

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To examine the changes in the oceanic N cycle and their possible relationships to the extinction at the end-Guadalupian (Middle Permian), we analyzed the N isotopic compositions ( $d^{15}N$ ) of the upper Guadalupian paleo-atoll limestone, accumulated on the top of a mid-oceanic seamount in the superocean Panthalassa, at Akasaka in central Japan. The  $d^{15}N$  values of the limestone are substantially high (ca. +20 permil on average) throughout the analyzed interval. These values are the highest in the previously reported  $d^{15}N$  records throughout the entire Phanerozoic. The substantially high  $d^{15}N$  values suggest enhanced oceanic denitrification/anammox in the Capitanian (Late Guadalupian). Moreover, the present results revealed remarkably large  $d^{15}N$  fluctuations in the analyzed limestone at Akasaka. We interpret that periodic expansion and reduction of the oxygen minimum zone (OMZ) in mid-Panthalassa caused the observed  $d^{15}N$  fluctuations in the Capitanian. The suggested OMZ expansions may have been attributed to the high productivity 'Kamura event' in the surface oceans enhancing a biological pump. Chemostratigraphic correlations imply that the enhanced denitrification in the expanded OMZ may have been a global phenomenon in the Capitanian. Widespread developments of the anoxic deep-waters prior to the extinction may have stressed the shallow-marine biota by upwelling at the end-Guadalupian.



超海洋中央部起源の G-L 境界石灰岩に挟在されるクロムに富む層について  
A unique Cr-enriched bed across the Guadalupian-Lopingian boundary (Permian) in mid-Panthalassan paleo-atoll carbonates

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We examined in detail the chemical composition of a thin clayey bed (~1 cm) recognized at the Guadalupian-Lopingian boundary (G-LB) in the mid-oceanic paleo-atoll limestone in Japan (Kamura and Akasaka sections), to clarify whether or not the clayey bed is the product of a large-scale explosive volcanism that led to the end-Guadalupian mass extinction (Isozaki and Ota, 2001; Isozaki, 2007). Results of X-ray mapping and ICP-MS analyses revealed that the clay materials both in Kamura and Akasaka are roughly identical in compositions and are characterized by high-chromium contents (ca. 3000 ppm in anhydrous basis). This contradicts the previous notion that the bed represents rhyo-dacitic tuff brought by explosive eruption of acidic magma. Despite this, the widespread occurrence of Cr-enrichment at the G-LB horizon is inferred from the fact that the G-LB mudstones in continental shelf limestone in South China (Wangpo Bed at Chaotian and Shangsi sections) have geochemical affinity to the Cr-rich clayey bed at Kamura and Akasaka sections deposited in western Panthalassa. From these data, together with the normal platinum-group element signatures throughout the G-LB samples, we invoke a global fall-out of Cr-rich air-borne ash originated from mafic or ultramafic magma, most likely related to the mantle plume-derived large igneous provinces (LIPs). This might be possible at the initial phase of intrusion/eruption of basaltic to picritic magma that formed the Emeishan LIP in South China (~260 Ma) or other continental LIPs emplaced during the breakup of the supercontinent Pangea, if such high-temperature magmas were effectively carbonated and hydrated through the reaction with the thick sedimentary piles of limestones and shales.

キーワード: 地球化学, ICP-MS, 粘土層, ペルム紀中-後期, 大量絶滅, 峨眉山洪水玄武岩

Keywords: geochemistry, ICP-MS, clayey bed, Guadalupian-Lopingian boundary, mass extinction, Emeishan flood basalts

## 岐阜県郡上八幡地域でのペルム紀三畳紀境界の有機炭素同位体比変化 Organic carbon isotope changes at P-T boundary in Gujohachiman, Japan

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There was large extinction from Guadalupian- Lopingian boundary (GLB) to Permian- Triassic boundary (PTB), ca. 260- ca. 251Ma (Sepkoski, 1984; Knoll et al., 1996; Isozaki, 1997; Stanley and Yang, 1994; Kaiho et al., 2005). The extinction will have correlation with Oceanic environment (e.g. oxic level in ocean, climatic change). Black shale layer is observed in chert of accretionary complex in Japan and Canada. The layers indicate anoxic in entire Ocean (Oceanic Anoxic Events) (Isozaki, 1997). However, the correlation between extinction and environmental changes is not known. Therefore, we need to study life cycle changes and influence to oceanic environment in extinction by changes of carbon isotope ratio.

The stable isotope ratios  $\delta^{13}\text{C}_{\text{carb}}$  and  $\delta^{13}\text{C}_{\text{org}}$  are believed to reflect the change in the global status of photosynthesis, since biological organisms preferentially use light carbon during photosynthesis. When the biological mass with light-carbon content becomes large, the inorganic carbon (mantle  $\text{CO}_2$ ) in the atmosphere and ocean become heavier. In other words, carbon isotope changes in carbonate and organic carbon will reflect carbon cycle changes by extinctions (Rothman et al., 2003; Tahata et al., 2014).

There were many previous studies of carbonate carbon isotope ratio from GLB to PDB. The carbon isotope records show over +6 permil before GLB, calling to Kamura event. The  $\delta^{13}\text{C}_{\text{carb}}$  after Kamura event decrease to ca. 0 permil around GLB. Moreover, the  $\delta^{13}\text{C}_{\text{carb}}$  decreases from ca. +3 permil to ca. -2 permil at PTB and shows large excursions from PTB to middle Triassic (Isozaki et al., 2007a,b; Korte et al., 2005a,b; Payne et al., 2008). As the carbonate carbon isotope records, there are no continuous carbon isotope records of organic carbon from GLB to PTB, because the carbonate-rich rocks have low organic contents and difficult to analyze organic carbon isotope ratio.

Accretionary complex in Gujohachiman, Gifu-ken, Japan constitute of alternation of chert and shale. The sediments show continuous depositions in deep sea from GLB to PTB. We analyze organic carbon isotope ratio from continuous shale layers in Gujohachiman, because the shale layers between chert layers have organic-rich.

The results of organic carbon ratio show coupling to carbonate carbon isotope changes, except for GLB. Organic carbon isotope records in GLB decouple carbonate carbon isotope ratio. The carbon isotope change indicate to reflect to carbon cycle changes by extinction.

キーワード: P-T 境界, 有機炭素同位体比, 炭素循環, 郡上八幡

ペルム紀末大量絶滅時の表層水還元化と大量土壌流入  
Abrupt surface-water reduction accompanied with massive soil inflow during the end-Permian mass extinction

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The largest mass extinction of biota in Earth history occurred at the end of the Permian Period, which led to a turnover of biosphere from Paleozoic Fauna to Modern Fauna. Siberian volcanism is the most possible cause, however, the direct causal mechanism for the mass extinction is unclear. We report that the worst redox condition in the shallow sea appeared during the mass extinction on the way to a gradual reduction of deep sea. An abrupt decrease in oxygen in the shallow sea is thought to be a direct cause of the marine mass extinction. A significant decrease in atmospheric oxygen should also have occurred during the mass extinction to explain the shallow surface water reduction and land mass extinction.

A soil erosion event occurring at the end-Permian mass extinction has already been reported. However, those records are restricted in a few near-shore sequences. We demonstrate that a organic-molecule soil-erosion proxies have peaks during the end-Permian mass extinction throughout the inner continental shelf to the upper continental slope in Paleotethys and a sea mount in the central Panthalassic ocean, and in contrast to this, no peaks at isolated platform area in Paleotethys and deep Panthalassic ocean. Furthermore, we found high DBF/Phe ratio values throughout the inner continental shelf to the upper slope and a sea mount, and low values at isolated platform, its slope, and in central deep ocean during the mass extinction. This phenomenon is supported by other organic molecule proxies sourced from land. The distribution of soil erosion proxies in the end-Permian sea clarifies that massive soil erosion event surly occurred during the end-Permian mass extinction.

In summary, abrupt surface-water reduction accompanied with massive soil inflow occurred during the end-Permian mass extinction.

キーワード: 海洋還元, 土壌, ペルム紀, 三畳紀, 大量絶滅

Keywords: oceanic reduction, soil, Permian, Triassic, mass extinction

## Os 同位体から探る超海洋パンサラッサにおけるトアルシアン海洋無酸素事変時の火成活動の影響 Osmium isotope composition in the deep pelagic Panthalassa ocean during the Toarcian Oceanic Anoxic Event

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The Toarcian Oceanic Anoxic Event (T-OAE) represents one of the most significant paleo-environmental perturbations in the Phanerozoic, which resulted in marked disruption to both the climate system and marine ecosystem. The causes for this widespread deposition of organic carbon-rich sediments under the reducing condition are still controversial. Several mechanisms have been proposed to explain the occurrence of T-OAE including; abrupt seawater warming, an increase in continental weathering rates, enhanced rates of biotic turnover, atmospheric pCO<sub>2</sub> changes, and ocean acidification. In particular, volcanic activities in the large igneous Karoo-Ferrar province have been considered as the most fundamental trigger for the Toarcian perturbations. Radiogenic Os isotope compositions of sedimentary rocks are useful for estimating the influx from both ancient basaltic magmatism and continental weathering. However, the relationship between biotic crisis, anoxic event, and the volcanic activity in the deep pelagic environment is still ambiguous because of the lack of detailed Os isotope records during T-OAE. In this study, we reconstructed a detailed lithological column in the Inuyama area where the Pliensbachian to Toarcian deep-sea cherts well crop out along the Kiso river. For Os isotope analysis, we collected 12 chert samples from a section where two black bedded chert intervals T-OAE1 and T-OAE2 were observed.

The rock powder was spiked with <sup>190</sup>Os and <sup>185</sup>Re prior to digestion. The sample was digested by CrO<sub>3</sub>-H<sub>2</sub>SO<sub>4</sub> in a sealed Carius tube at 240 °C for more than 48 hours. Subsequently, Os was separated by solvent extraction using CCl<sub>4</sub> and back-extracted from CCl<sub>4</sub> into HBr, followed by the final purification using the micro-distillation method. The Os isotope ratios were determined by N-TIMS at Tokyo Tech. Re-bearing solution after the CCl<sub>4</sub> extraction was stored in a Teflon vessel, and Cr<sup>6+</sup> in the solution was completely reduced to Cr<sup>3+</sup> by the addition of ethanol in order to avoid the disturbance of the elution profile of the following chromatography due to the coexistence of Cr<sup>6+</sup>. After this process, Re was purified by chemical separation using an anion exchange resin, and the isotopic composition was determined using a quadrupole-type ICP-MS at Tokyo Tech. The Os and Re concentrations were determined by the isotope dilution method.

The Re and Os abundances in 12 chert samples across T-OAE varied from 2.1 to 128.6 ng/g, and from 32.8 to 2284.3 pg/g, respectively. The <sup>187</sup>Os/<sup>188</sup>Os ratio in the samples before T-OAE1 decreased from 0.44 to 0.27, resulting in the minimum value of 0.24 at the onset of T-OAE1. However, the <sup>187</sup>Os/<sup>188</sup>Os ratio increased abruptly to be 0.77 towards the end of T-OAE1, and decrease down to 0.30 at the interval between T-OAE1 and T-OAE2. During T-OAE2, the <sup>187</sup>Os/<sup>188</sup>Os ratio gradually increased up to 0.56. Take into account organic carbon isotope record in the same section by Grocke et al. (2011), we envisage the following scenario for the cause of Os and C isotopic variation during T-OAE observed in the chert samples: The Karoo-Ferrar volcanic activity induced an anoxic condition, which resulted in negative <sup>187</sup>Os/<sup>188</sup>Os before T-OAEs. The Karoo-Ferrar volcanism released significant amount of CO<sub>2</sub>, which triggered the global warming and continental erosion during T-OAE1. Subsequent gradual increase of Os isotope ratios most likely reflects its aftermath. These indicate that the Karro-Ferrar volcanism played an important role for inducing anoxic condition and global warming during Toarcian in the deep pelagic Panthalassa ocean.

Keywords: Toarcian Oceanic Anoxic Event, deep pelagic Panthalassa ocean, osmium isotope, Karoo-Ferrar volcanism

## 霊長類の誕生場に関する新モデルの提案 Birth place and migration history of primates: Proposal of new model

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The origin and evolution of ancestor of human being, so-called Primates, has not been well known yet, although several conflicting models were proposed so far. Here, a new model is proposed to satisfy (1) genomic phylogeny, (2) fossil evidence, and (3) paleogeographic constraints based on not only ocean-floor age constraints but also surface geology.

Birth place of Primates must have been a rift in the Gondwana ca. 100Ma, which was 25 m.y. earlier than 75Ma that was estimated by most genome biologists. The existence of new world monkey (Platyrrhini) in South America can be explained assuming the birth place of ancestor of new world monkey was between Antarctica and South America at 100Ma, migrated to South America and land bridge was disconnected at 34Ma between Antarctica and S. America. On the other hands, lemur and aye-aye in Madagascar could be migrated from northward-moving Indian continent around 65Ma to intercross with ancestral primates originated in Madagascar that was migrated southward from Northeastern margin of African continent. Land bridge between those two islands was generated as the result of rising plume at 65Ma between these two islands. Also, primates in the Indonesian region could have been transported by fragmented continents disconnected from Antarctica-Australia (origin of Borneo). Primates on the Indian continent arrived at Central South Asia at 50Ma, and highly diversified ecosystem was generated by crown evolution which is the most bio-diverse region since then.