

MIS025-01

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時間:5月24日 08:30-08:45

## ジュラ紀古世後期 ( Pliensbachian 期後期 Toarcian 期 ) におけるアンモノイド相の変遷と Toarcian 期前期の海洋無酸素事変 Ammonoid faunal changes during late Early Jurassic (Late Pliensbachian-Toarcian) and Early Toarcian Oceanic Anoxic Event

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The time-interval of late Early Jurassic (Late Pliensbachian to Toarcian) has been characterized by some paleoceanographic events, especially represented by the Early Toarcian Oceanic Anoxic Event (OAE). The ammonoid faunas in the Northern Hemisphere were affected by these paleoenvironmental changes in this period. A dramatic diversity crisis of the ammonoid assemblages, biostratigraphically corresponded to the Exaratum Standard Subzone (middle Early Toarcian), was mainly recognized in the Submediterranean province including Apennines (central Italy), Subbetic (southern Spain) and High-Atlas (Morocco). This extinction event was considered to be caused by the coeval Early Toarcian OAE. The effects of this OAE have been also reported in North American Cordillera, North Tibet and pelagic areas (West Panthalassa and West Tethys). In contrast, a diversity fall at the Pliensbachian/Toarcian (P/T) boundary, which was characteristic in the extinction of Amaltheidae, the typical Boreal element in Late Pliensbachian, has been mainly distinguished in the Northwest European province, such as England, Paris Basin (northern France) and the Causses Basin (southern France). Moreover, an abrupt warming on the basis of the oxygen isotope fluctuation and the low stand of eustatic sea level analyzed by the Sr isotope ratio were also distinguishable around the P/T boundary through the Northwest European and the Mediterranean provinces.

In this study, a diversity fall of ammonoid assemblage from the Toyora Group is identified in the Paltarpites paltus Zone which is compared to the lower part of the Tenuicostatum Standard Zone, earliest Toarcian. This diversity crisis is characterized by the extinction of Harpoceratinae, and the survival of only a species of pandemic Arieticeratinae. Moreover, this event is stratigraphically corresponded to the anomalies of trace element concentrations (including V, Ni, Ba and Co), rare earth element (Ce) and carbon isotope fluctuation. Consequently, the ammonoid diversity crisis in the Paltarpites paltus Zone is perhaps reflected by the oxygen-deplete marine condition in East Asia, biostratigraphically earlier than the European Early Toarcian OAE. In contrast, some ammonoid bio-events during late Early Jurassic time are also recognizable in Japanese assemblages from the Toyora Group, the Early to Middle Jurassic epicontinental clastic sediments in southwest Japan, and the Kuruma Group, the Early Jurassic continental shelf deposits exposed in central Japan. A turnover from the Boreal fauna composed of Amaltheidae to the Tethyan fauna dominated by Arieticeratinae (Hildoceratidae) is distinguished mainly in the Kuruma Group during the Apyrenum Standard Subzone (latest Pliensbachian). This faunal change is chronologically discordant for the comparable faunal turnover in the almost equal paleolatitudinal areas of the Northwest European province, which is corresponded to the P/T boundary. The turnover recognized in the latest Pliensbachian ammonoid fauna from Japan seems to be mainly affected by the regression during latest Pliensbachian (Spinatum Standard Zone) to earliest Toarcian (Tenuicostatum Standard Zone), in addition to the starting of the warming event. The data of ammonoid faunal transition in East Asia enables to contribute to the discussion of global ammonoid paleobiogeography in late Early Jurassic time.

キーワード: ジュラ紀古世後期, アンモノイド, Toarcian 期前期海洋無酸素事変, 絶滅イベント, 古生物地理

Keywords: late Early Jurassic, ammonoid, Early Toarcian Oceanic Anoxic Event (OAE), extinction, paleobiogeography

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## ジュラ紀 Toarcian 海洋無酸素事件とアンモノイド/放散虫化石帯区分 Toarcian (late Early Jurassic) oceanic anoxic event and ammonoid/radiolarian biostrati- graphic framework worldwide

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The Early Toarcian oceanic anoxic event (OAE) is regarded as one of the most large-scale oceanographic changes through the Phanerozoic. This phenomenon has been analyzed in detail mainly in Europe from various viewpoints. It is essential to establish biostratigraphic frameworks applicable to both neritic and pelagic environments to clarify the exact timing and spatial extent of the event. Recent progress in ammonoid and radiolarian biostratigraphy encompassing the Toarcian interval is overviewed.

Upper Pliensbachian-Toarcian ammonoid stratigraphy in East Asia is recently revised based on a detailed biostratigraphic re-examination in the Toyora Group, Yamaguchi Prefecture. Six ammonoid zones are proposed as follows, in ascending order: the *Amaltheus stokesi* Assemblage Zone, the *Canavaria japonica* Zone, the *Paltarpites paltus* Zone, the *Dactylioceras helianthoides* Zone, the *Harpoceras inouyei* Zone, and the *Pseudogrammoceras-Phlyseogrammoceas* Assemblage Zone. The base of the *Paltarpites paltus* Zone corresponds to the base of the Toarcian.

Global radiolarian zonation for the Pliensbachian, Toarcian and Aalenian is proposed as a result of international collaboration (Carter et al., 2010). Nine zones are set up for this interval. The Early Toarcian zone (*Eucyrtidiellum nagaiae* - *Praeparvicingula tlellensis* Zone) is recognized in the Queen Charlotte Islands (Canada), Slovenia, Oman and Japan.

Our analysis on the Pliensbachian-Toarcian stratigraphy of the Toyora Group reveals that the Early Toarcian OAE is not distinctive in the neritic environment of the eastern margin of Asia. On the other hand, a remarkable faunal turnover of radiolarians related to the OAE has been pointed out in pelagic chert sequences in the Panthalassa (Hori, 1997). A precise timing and magnitude of the OAE in the Panthalassa can be clarified by using the newly established radiolarian zonal scheme.

キーワード: 中生代, ジュラ紀, トアルシアン海洋無酸素事件, アンモノイド, 放散虫, 生層序

Keywords: Mesozoic, Jurassic, Toarcian oceanic anoxic event, ammonoid, radiolaria, biostratigraphy

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## 美濃帯坂祝セクションにおける後期トリアス紀放散虫生層序の再検討 Detailed examination on upper Triassic radiolarian biostratigraphy in the Sakahogi section of the Mino Terrane, Japan

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The Sakahogi section, exposed along the Kiso River, has continuous Panthalassa sedimentation records in the Triassic (Nikaido and Matsuoka, 2007). The interval is litho-stratigraphically divided into three (lower, middle and upper) parts. Three claystone layers that named CS-1, 2 and 3 (Sugiyama, 1997) of 2-8cm thick limit the top of each part. The lower part of the section (21 m in thickness) is mainly composed of rhythmical bedded brick-red chert. This part is characterized by late Anisian to early Carnian (TR 2C to 5A) radiolarian assemblage. Conical Nassellarians are dominant in lower horizons of this part. The middle part of 22 m thick is dominated by amalgamated greenish gray chert. The common occurrence of the striped cherts characterizes the middle part. These striped cherts occur the most commonly in the midst of the middle part and decrease in number downward and upward. The assemblage from this part indicate early Carnian to early Norian (TR 5A to 6B). Spherical Spumellarians are dominant in the midst of this part. The upper part (12 m in thickness) is alternation of rhythmical bedded red chert and amalgamated greenish gray chert. The rhythmical bedded chert sequence is similar to the lower part. The amalgamated bedded chert sequence looks like the middle part, however, the striped chert is very few. Three white chert layers are observed. Radiolarian assemblages from the upper part indicate early Norian to early Rhaetian (TR 6B to 8C). Characteristic radiolarian taxa include Japonocampe nova (Yao), Podobursa sp., Syringocapsa batodes De Wever, Paronella norica Kozur and Mostler, Poulpus curvispinus Dumitrica, Kozur and Mostler, P. piabyx De Wever, Sarla vetusta Pessagno, Capnuchosphaera deweveri Kozur and Mostler, C. sagaris Sugiyama, C. colemani De Wever, Capnodoce anapetes De Wever, C. sarisa De wever, Praeheliostaurus laevis Kozur and Mostler, Xipha nodosa Sugiyama, Trialatus robustus (Nakaseko and Nishimura), Lysemelas olbia Sugiyama, Parentactinocarpus sevaticus Kozur and Mostler, P. tetracanthus Dumitrica, Praemesosaturnalis multidentatus (Kozur and Mostler), P. pseudokahleri Sugiyama, P. heilongjiangensis Yang and Mizutani and Dreyericyrantium ithacanthum Sugiyama. The TR6B-7 radiolarian Zonal boundary is situated slightly above CS-2. TR6B assemblage is dominated by spherical Spumellarians. On and above the top of TR6B, saturnalid Spumellarians are strongly diversified. This saturnalid high diversity continues to late Norian. Rhaetian assemblages are characterized by Deflandrecyrtiidae Nassellarians.

キーワード: チャート, 後期トリアス紀, 放散虫化石, 坂祝セクション, 美濃帯, パンサラサ

Keywords: chert, Late Triassic, radiolarian fossils, Sakahogi section, Mino Terrane, Panthalassa

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## 美濃帯坂祝セクションに産するチャート試料から復元した三畳紀古海水のOs同位体比変動と古海洋環境変動

### Reconstruction of Os isotope record of the Triassic seawater based on chert samples from the Sakahogi Section, Mino Belt

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We reconstruct the secular change of the Triassic marine Os isotope record based on the chert samples, Sakahogi Section, Mino Belt. The Sakahogi section is one of the most suitable sections in order to decipher paleo-ocean environmental change due to its perfectly continuous stratigraphy ranging from the Early Anisian to Early Rhaetian (ca. 40 Myr). Our main goals are (1) understanding the amplitude of the Os isotope variation in the Triassic seawater, (2) comparing the marine Os isotope record with that of Sr isotope and (3) elucidating the paleo-ocean environmental change based on the Os isotope record together with whole-rock major and trace element geochemistry.

キーワード: Os 同位体比, 三畳紀, 古海洋環境, チャート, 坂祝セクション, 美濃帯

Keywords: Os isotope composition, Triassic, paleo-ocean environment, chert, Sakahogi Section, Mino Belt

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## 美濃帯南部，上部トリアス系層状チャートからみつかったイリジウム異常，Niに富むスピネル粒子，マイクロスフェルール

## Iridium anomaly, Ni-rich spinels, and microspherules in Upper Triassic chert of the Mino Terrane, Central Japan

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An important ~30 Myr interval during the Late Triassic is marked by the formation of several large impact structures on Earth, including the 100-km-diameter Manicouagan crater in Canada, which is one of the largest known Phanerozoic impacts. Although the age of the Manicouagan structure is well constrained by U-Pb dating (~215.5 Ma), deposits containing its ejecta are known only from southwestern Britain. Here, we report that an Upper Triassic chert in Japan, deposited within the Paleo-Pacific (Panthalassa) pelagic basin, contains Iridium anomaly, Ni-rich spinels, and microspherules that are characteristic of impact ejecta.

Microspherules were discovered from a claystone layer (~5 cm thick) in an Upper Triassic bedded chert succession of the Sakahogi section, Mino Terrane, Japan. An analysis of radiolarian fossils reveals that the claystone layer is correlated with the early to middle Norian stage of the Upper Triassic. The base of the layer contains 10-15% (by rock volume) green microspherules. Microspherules range in size from 200 to 300 microns. Synchrotron X-ray diffraction analysis indicates that the microspherules are composed mainly of clinoclore. Some microspherules contain a high proportion of small, euhedral to subhedral crystals of oxidized Ni-rich spinels. They are distinguished from typical igneous spinels by high contents of NiO and Fe<sup>3+</sup>. The geochemical signals of extraterrestrial impact are recorded in the claystone layer. Examination of the clay layer using a multiple gamma-ray analysis system after neutron activation reveals that microspherules and Ni-rich spinels occur associated with an iridium anomaly, which levels comparable with those at the Cretaceous-Paleogene boundary. A scanning X-ray analytical microscope analysis shows high concentrations of siderophile elements such as nickel and cobalt, which would be expected from an extraterrestrial source.

The discovery of Iridium anomaly, microspherules, and Ni-rich spinels in early to middle Norian claystone from Japan suggests an important sedimentary record of an extraterrestrial impact in the Late Triassic. Although the Manicouagan impact structure would appear to be related to deposition of the claystone, based on an age for the crater of ~215.5 Ma, the chemical composition and mineral assemblage of the microspherules differ from those of hollow illitic microspherules reported from southwestern Britain, which are considered to be derived from the Manicouagan. Additional research is needed to confirm the source for the early Norian claystone layer in Japan, as well as to constrain the origin of the clinoclore microspherules and Ni-rich spinels.

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## 美濃帯坂祝セクションの上部トリアス系チャートからみつかったイジェクタ層の堆積年代

### Stratigraphic age of the ejecta deposit from the Sakahogi section in the Mino Terrane, central Japan

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The Late Triassic is marked by four impact craters, including the 100-km-diameter Manicouagan crater, which is second largest impact crater in the Phanerozoic. Previous researchers suggested that these Late Triassic impact craters could be associated with an extinction event at the Triassic/Jurassic boundary or with an earlier extinction at the Carnian/Norian boundaries in the Late Triassic. In order to investigate the possible connection between the Late Triassic extinctions and the impact events, it is necessary to date the crater formation age and to find the stratigraphic record of the impact ejecta layer within a fossil-bearing stratigraphic sequence. Although, the age of the Late Triassic impact structures has been constrained by U-Pb dating, deposits containing their ejecta are known only from non-marine section in southwestern Britain.

We report that an Upper Triassic deep-sea deposit (bedded chert) in Japan, deposited within the Paleo-Pacific (Panthalassa) pelagic basin, contains microspherules, Ni-rich spinels, and iridium anomaly that are characteristic of distal impact ejecta. These indicators of extraterrestrial impact were discovered from a claystone layer in an Upper Triassic bedded chert succession of the Sakahogi section, Inuyama area, central Japan. The age of the impact-related claystone is constrained by the presence of radiolarians and conodonts. We recognized 18 radiolarian species across the claystone. The claystone layer lies between pelagic chert layers of the radiolarian zones *Capnodoce-Trialatus* and *Trialatus robustus-Lysemelas olbia*. The last occurrence of *Trialatus robustus*, which indicates the Lacian (Early Norian), is a good indicator of the ejecta deposit. *Capnodoce serisa* and *Xiphosphaera fistulata* and the co-occurrence of these taxa clearly indicate the late Lacian to early Alaunian (Middle Norian) age for the examined part of the Sakahogi section. Small numbers of conodonts from the claystone include *Mockina medionorica*, indicating an early Alaunian age (*Mockina medionorica* Zone). Therefore, the Lacian-Alaunian boundary in the Sakahogi section can be located around the *Capnodoce-Trialatus* and *Trialatus robustus-Lysemelas olbia* Zone boundary.

An analysis of microfossils reveals that the ejecta deposit occurs around the Lacian/Alaunian boundary of the Norian Stage of the Late Triassic. Although there are no radiometric age data for the Lacian/Alaunian boundary, it has been assigned an age of ~215 Ma based on the astronomically tuned geomagnetic polarity time scale. The stratigraphic age of this ejecta deposit also reveals that this impact event is not related to either the Triassic/Jurassic or Carnian/Norian boundary extinction, but its age explains significant biotic turnovers and environmental changes occurred around the Lacian/Alaunian boundary.

## 日本海佐渡沖の表層～亜表層水における2005年・2006年(6月～9月)の放散虫の深度分布と季節変化 Depth distribution and seasonal faunal change of living radiolarians in the Japan Sea off Sado Island (2005-2006 years)

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日本海の佐渡島付近は、年間における海水表層の温度差が15℃に達し、夏季～秋季には対馬暖流の影響を強く受けている。そのため、佐渡沖の表層～亜表層水における放散虫の生息深度と群集の種構成は、季節によって大きく変化する(例えば、Matsuoka et al., 2001; Kurihara et al., 2006, 2007; Kurihara and Matsuoka, 2009, 2010)。すなわち、これを定点観測すれば、季節の変化に応じてその時々海水温やその他諸々の物理化学的条件を好む多様な放散虫が見られるということになる。それらの情報を蓄積することにより、日本海の表層～亜表層水に棲む放散虫の生態やプランクトン生態系における挙動の一端を知ることができよう。演者らは佐渡市達者の新潟大学理学部附属臨海実験所を拠点とし、2005年および2006年の6月～9月に水深100m以浅の表層～亜表層水において深度別のプランクトンサンプリング(水深100～70m, 70～40m, 40～0m)を行い、放散虫の深度分布と月毎の群集の変化を検討した。

2005年・2006年とも6月の表層海水温は約17℃(水深100mで約11℃)で、夏季には表層の水温が上昇し25℃を越える(水深100mで約14～15℃)。6月の放散虫群集は両年とも同様な種構成で、*Cyrtidosphaera reticulata*, *Larcopyle buetschlii*が見られる。7月には表層(40m以浅)で*Spongospaera streptacantha*が現れ(データは2005年のみ)、8月・9月(2005年・2006年)には本種が群集中で卓越するようになる。これまでの研究から、*S. streptacantha*は対馬暖流により流入する種と考えられている(Kurihara et al., 2008)。ただし、*S. streptacantha*以外は2005年と2006年で大きく種構成が異なっており、2005年では*Pseudocubus*属の放散虫が、2006年では*Heliosphaera radiata*, *Stylosphaera melpomene*が卓越している。6月の放散虫群集が2005年と2006年で同様な種構成(日本海での好寒冷種が卓越)であるのに対し、8～9月(両年とも水温等はほぼ同様)で群集構成にかなりの差異が出るのは、おそらく対馬暖流の勢力や流路に影響されているであろう。また、ある限定的な海域での小規模なブルーミングを捕らえている可能性もある。いずれにしても、海流で運ばれてくるような放散虫については、短期間のサンプリングではその時々条件に左右されてしまい、全体像を捉えることが難しいと思われる。佐渡沖の例を見る限り、少なくとも数年の傾向は見る必要がある。

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キーワード: 放散虫, 日本海, 深度分布, 季節変化

Keywords: radiolaria, Japan Sea, depth distribution, seasonal faunal change

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## 太平洋外洋域に産出した2列状旋回浮遊性有孔虫とその意義 The occurrence of living biserial planktic foraminifera from offshore in the Pacific ocean

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2列状旋回 (Biserial) 浮遊性有孔虫は, 化石記録によると白亜紀後期に出現し, 現在まで間欠的にその産出が報告されている。現在の海洋に生息する2列状旋回浮遊性有孔虫は, *Streptochilus globigerus* と *Streptochilus globulosus* の2種のみが知られているが, その海洋における分布・生態はほとんど知られていない。その理由としては, 1) 2列状旋回種は長径が150-200  $\mu\text{m}$  程度であるが短径が60-80  $\mu\text{m}$  と細長い形状をしているため, 通常, 浮遊性有孔虫の群集解析に用いる125  $\mu\text{m}$  以上のフラクシオンに入ってくる事がほぼないこと, 2) 仮に採取できてもその数が非常に少ないことから, 全浮遊性有孔虫フラックスの中でほぼ無視し続けられてきたということがあげられる。昨年, Darlingら(2010)によってアラビア海より採取された *S. globigerus* の遺伝子配列が底生有孔虫 *Bolivina variabilis* と同一である事が確かめられ, 底生有孔虫でありながら浮遊生活を営む生態を有する可能性が示唆されている。これとほぼ同じ形態を有した浮遊性有孔虫 *Guembelitra* 属は, 6,550万年前の大量絶滅を免れており, この形態を有する現生浮遊性種の生態的特徴および, 分布を明らかにする事は, 底生有孔虫から浮遊性有孔虫への進化の方向性と, 適応戦略を解明するための大きな鍵となる可能性がある。

2010年10月-11月にかけて実施された海洋地球研究船「みらい」による研究航海MR10-06(研究テーマ:「生態系を介した物質循環変動と地球環境へのフィードバック」)において, 北緯30度, 東経145度のSta. S1海域で閉鎖型NORPAC(口径:45cm, 目合:63 $\mu\text{m}$ )による鉛直曳プランクトンネット観測を表層0-1,000mの水深で実施した。その結果, 200-300mの水深より2列状旋回の有孔虫の生体を2個体得ることができた。さらにその2日後に, 同じ海域で再度同じ観測を実施したところ, ふたたびおなじ水深から2列状旋回の有孔虫の生体を2個体得た。この水深よりも浅い, あるいは深い水深からの産出は認められなかった。下船後の走査電子顕微鏡(SEM)観察によると, この種は *S. globulosus* であることが確認された。また, 本海域では同年2月の冬期に同様の観測を行っているが, この水深のみならず, 水柱中に *S. globulosus* はまったく認められなかった。

これまで太平洋において本種の産出は表層堆積物のみからの報告であり, いずれも赤道域など熱帯の環境に限定されていた。しかしながらプランクトンネット観測で太平洋から生体を捕らえたとする公式な記録はない。今回, 本種を採取したS1海域は, 陸から700km以上離れている事に加え, 水深が5,900mと深い事から, 本種の沿岸からの移流は考えにくい。*S. globulosus* は本海域で浮遊生活を営んでいたと考えられる。S1海域は年間を通して低生物生産域であり, 本種の太平洋亜熱帯域, 且つ初冬における貧栄養海域での産出は, これまで想像されていたよりもより広範な環境に適応する能力を備えており, また有光層以深の亜表層での生息深度帯を示唆している。

キーワード: 浮遊性有孔虫, 二列状旋回, 底生有孔虫, 太平洋, 進化

Keywords: Planktic foraminifera, benthic foraminifera, biserial planktic foraminifera, Pacific ocean, evolution



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## 太平洋の進化を読む The evolution of the Pacific Ocean during the Cenozoic

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We are preparing to understand the evolution of the Pacific Ocean during the Cenozoic by the Deep Sea Drilling Project/Ocean Drilling Program (DSDP/ODP) cores obtained from more than 60 sites. Depth profiles of seafloor sediments which cover a major portion of the Pacific Ocean will give us temporal-spatial constraints on the evolution of the Pacific Ocean. Here we talk about our future plan to analyze these core samples.