Lithology of Cambrian to Ordovician radiolarian chert in Kazakhstan with special reference to trace fossils

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Introduction

Trace fossils have been examined in the upper Cambrian to upper Ordovician radiolarian bedded cherts in Australia, Scotland and Newfoundland to clarify both the evolution of benthic animals and the change in environment of pelagic realm (Kakuwa and John, 2001; 2010; Kakuwa, 2014a; Kakuwa, 2014b). The result is summarized that Darriwilian is the age when benthic animals colonized widely on the pelagic deep ocean bottom. The other important and well-dated successions of radiolarian bedded chert (ribbon radiolarite) in Kazakhstan are studied to verify the result.

Examined bedded chert belongs to the Burubaital Formation that exposed in the southwest of Lake Balkhash, southern Kazakhstan. Age constraints of the examined two successions of bedded chert are given by Tolmacheva et al. (2001; 2004; unpublished data) who studied conodont fossils in detail.

Outline of the examined successions

Locality 89101

Upper Cambrian and Lower Ordovician chert is measured as thick as 36 meters. The succession is divided into three. The lower part consists of pale gray crystalline chert of upper Cambrian. The middle part consists of red chert of Tremadocian, and the upper part consists of pale gray, red and black cherts of Tremadocian to Floian. Radiolarians and sponge spicules are observed under the microscope. Thin laminations consistently develop in the cherts of this locality.

Locality 9706

Lower to Middle Ordovician bedded chert continuously exposed as thick as 70 meters. The lower half of the section consists of pale to dark gray, black and red cherts. The upper half of this succession, Dapping and Darrwilian in age, consists of red chert with some intercalations of white crystalline chert.

Characteristic knobby bedding planes that are considered as trace fossils by Tolmacheva et al. (2001) develop in the middle to upper part of the section. Several beds and laminations of sandstone and oligomicitic conglomerate (breccia) occur in the same horizon. The grains of sandstone and conglomerate are composed of angular to subrounded chert, and are cemented by microcrystalline quartz. Sponge spicules are closely associated with the clastic rocks.

Trace fossils

No convincing trace fossils are found in the Upper Cambrian to Tremadocian chert of the locality 89101, while trace fossils are found in the Darriwilian red chert of the locality 9706. Trace fossils found are horizontal tunnel on bedding planes. They are as long as 10 cm and a few millimeters in diameter. Some tunnels are bifurcated and some are sinuous. Curious tubes are densely crowded in cherts of some limited horizons. They run oblique, parallel and vertical to the bedding plane. The tubes are 3 to 8 mm in diameter and as long as 2 cm in compacted length. The tubes are filled with chalcedonic quartz. Various relieves on the knobby bedding planes include probable trace fossils and diagenetic deformations.

Implications of trace fossils

Trace fossils are found in the radiolarian bedded chert of Darriwilian in Kazakhstan. This result is common to the other examined areas of Australia, Scotland and Newfoundland, but the trace

fossils found in Kazakhstan are different from those found in the aforementioned areas.

Acknowledgement

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Keywords: trace fossils, Cambrian, Ordovician, radiolarian chert, Kazakhstan, evolution

The origin of plate tectonics , the origin of the deep sea floor , elucidation of the driving force , with Multi- Impact Hypothesis

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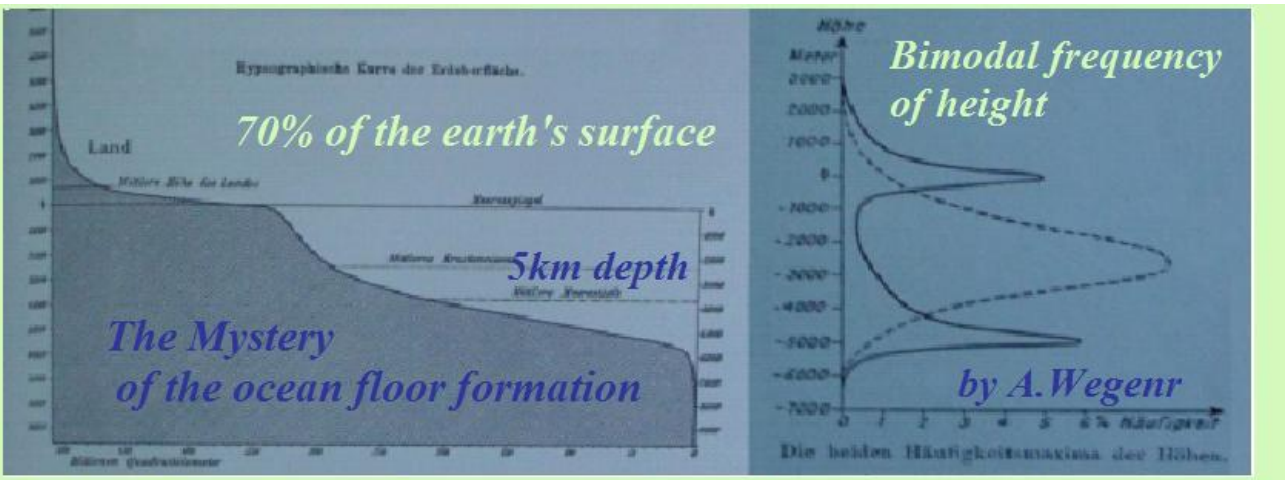
From the fact that A Wegenr is in North and South America's and Africa coastal profile of the continent to match, and advocates the continental drift hypothesis,I was trying to prove the continuity of the paleontology and geology in the grounds.Now it has become plate tectonics in the empirical observations such as inversion and seabed tape recorder hypothesis of seafloor spreading hypothesis and mantle convection hypothesis and of the Mid-Atlantic Ridge discoveries and transform fault of discoveries and geomagnetism is almost dogma.However, the driving force of continental drift, which failed to show is Wegener remains still a mystery even in plate tectonics. Wegener had been pointed out, the origin of the formation origin and plate boundary of the deep sea floor, which accounts for 70% (-5km), efforts to explore the origin of plate tectonics had been forgotten.Arc-shaped archipelago and the basin of origin is also remains a mystery. The new paradigm can clarify this all unified manner has been desired.

It was mentioned in the "elucidation of the Earth and the moon of the missing link" from the earth physics and solar system planets science by the multi-impact hypothesis by abduction.According to it, in addition to the origin of this plate tectonics, the origin of the formation and deep sea Yosoko of the month, the origin of the origin or Mercury or Pluto of eccentricity or Jupiter large red rice of the core, meteorites and even more was the origin and differentiation of the asteroid belt also of origin is a proposal of a new paradigm that can be unified elucidated.Abduction is the idea that conclusion, according to some hypotheses about possible if you can explain the multiple of the current situation the correctness of the hypothesis is guaranteed.In the hypothesis that there is a physical meaning, If it is correct ideas, dramatic progress can be obtained.

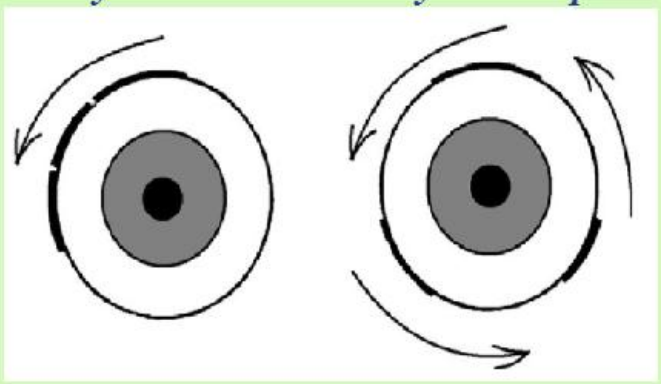
CERRA passed since the birth of the solar system up to about 40 billion years ago and track deformed by Jupiter perturbations, when the tearing with tension of Jupiter and the sun, CERRA and the earth had been differentiated coagulation.In this hypothesis that multiple mantle debris collides almost the same orbit around briefly to Earth, it became a repeated species large extinction of the rationale, and stripped of mantle and the sea of 5km depth by isostasy.When Darwin raised happened to collision mantle defect by isostasy, plate the surrounding crust was peeling is recessed concave, the boundary cracks to form an arcuate archipelago.Arc-shaped archipelago and Tethys Java island, etc. at the time of the formation of the sea, which was centered on the Pacific Ocean, trench arc connected to the outside of the arc-shaped archipelago plate shows the dive under the arc-shaped archipelago.Plate boundary is due to the cracking of the time in which a plurality of cross-sectional mantle lobe collides with the Earth.In this hypothesis , because the Earth is rotating on its axis , when the mantle was missing by the collision became convex in isostasy , moment of inertia in the earth that became non-uniform (unbalanced) , the driving force for the moment of inertia to the minimum occurs .

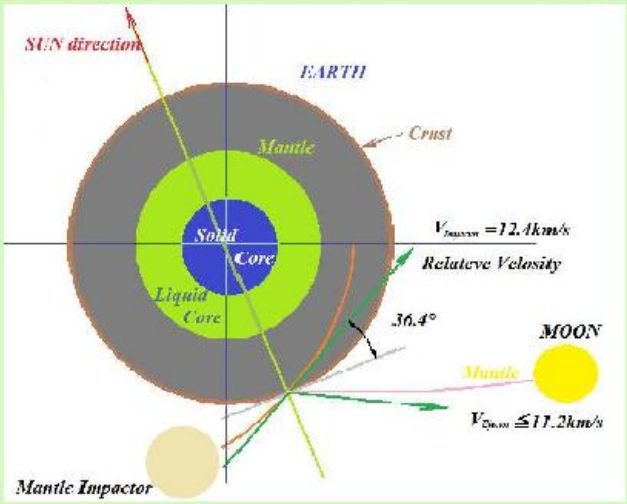
Only one of the hypothesis, that can be described as evolution unified all of the mystery is the result of the abduction.

Keywords: The origin of plate tectonics , The origin of the deep sea floor, Elucidation of the driving force, Multi- Impact Hypothesis, Bimodal frequency of earth height, The moon formed by collision of CERRA mantle Ruptured debrislobe



Origin of Deep Ocean floor by MIH and Isostasy 5km depth





Minimization of the moment of inertia ▶ Driving force

Multi-Impact Hypothes by mantle Impactor

Reconsideration of sedimentary place of the Triassic Muyinhe Formation in the Changning-Menglian belt of Southwest China

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Siliceous rocks of the Triassic Muyinhe Formation in the Changning-Menglian belt in southwestern Yunnan Province in Southwest China had been considered to be pelagic deposits. We observed them and analyzed their geochemistry, and recosidered the sedimentary place.
The observation revealed that the siliceous rocks are characterized by inclusion of abundant radiolarian test (e.g., *Triassocampe* Dumitrica, Kozur, and Mostler, *Pseudostylosphaera* Kozur and Mostler, *Eptingium* Dumitrica, and *Paroertlispongus*) and the lack of rhythmical bedding. The geochemical results are as follows: the samples have high concentrations of SiO_2; most of the samples were plotted in the non-hydrothermal field on the Al-Fe-Mn diagram; most of the samples were plotted in the continental margin field on the Fe_2O_3/TiO_2-$Al_2O_3/(Al_2O_3+Fe_2O_3)$ and (La/Ce)N-$Al_2O_3/(Al_2O_3+Fe_2O_3)$ diagrams. In addition, the samples show a flat rare earth element pattern normalized to North America shale composite.
These observational and geochemical results strongly suggest that the siliceous rocks are unlikely to represent pelagic deposits, indicating that the extent of the pelagic ocean basins in the Paleotethys during the Triassic is probably less than previously believed. These non-pelagic deposits may represent the closure stage of the Paleotethys.

Keywords: Geochemistry, Triassic, siliceous rock, radiolaria, Paleotethys, Changning-Menglian belt

Micrometeorites from Triassic and Jurassic bedded cherts of the Mino and Chichibu belts, Southwest Japan.

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Micrometeorites, which are submillimeter-sized extraterrestrial particles that survive atmospheric entry, originate from dust-producing objects such as comets and asteroids. Ancient micrometeorites found in sedimentary rocks are of key interest as a historical record of meteoroid populations in the solar system. We report the recovery of well-preserved micrometeorites, older than 240 Ma, in radiolarian chert from the Chichibu Belt on Ajiro Island (Middle Triassic) and Mino Belt on Inuyama area (Late Triassic to Early Jurassic). These study sections consist of rhythmic alternations of chert and shale beds. Samples were mechanically crushed and passed through 1.0 mm mesh sieve until less than 5 g of the fine fraction was collected. We also used a hydrofluoric acid dissolution method for determining micrometeorite content of chert samples. However, no micrometeorites have been recognized using this method. Magnetic components were separated using the method for liquid-suspended particles with a magnetic field strength of ~500 mT. Micrometeorites were handpicked from the magnetic components. The collection of micrometeorites comprised 72 cosmic spherules, which are particles that totally melted during atmospheric entry. Analysis of the accretion rate for cosmic spherules reveals high accretion rates of small spherules in the Middle Triassic (Anisian) and Early Jurassic (Hettangian). However, the possible link between the enhancements in the accretion rate of cosmic spherules and variations in the flux of extraterrestrial matter to the Earth requires further scrutiny.

Keywords: micrometeorite, Middle Triassic, Early Jurassic, Chichibu Belt, Mino Belt, beded chert

Marine osmium isotope record across the Middle-Upper Norian transition in the Upper Triassic deep-sea deposits from the Mino Belt, Japan

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Instead of a single mass extinction at the Triassic-Jurassic boundary, extinctions in major pelagic groups, such as radiolarians and conodonts, occurred stepwise during the last 15 Myr of the Triassic. Although a marked diversity decline on such pelagic fauna began in the end of Middle Norian, the cause of this extinction has been uncertain. In order to assess the Middle to the Late Norian environmental changes in the Panthalassa Ocean, we examined secular changes in the marine osmium isotope compositions ($^{187}Os/^{188}Os$) recorded in the Triassic bedded chert succession of the Mino Belt, central Japan. The osmium isotope compositions of seawater reflect contributions of the riverine ($^{187}Os/^{188}Os$ ≈1.4), hydrothermal, and extraterrestrial ($^{187}Os/^{188}Os$ ≈0.12–0.13) inputs of osmium to the global ocean. Given the distinctive $^{187}Os/^{188}Os$ compositions of these inputs and the relatively short residence time of Os in the ocean (several tens of thousand years), seawater $^{187}Os/^{188}Os$ compositions are highly sensitive to changes in these fluxes. The Os isotope compositions show a gradual increase in $^{187}Os/^{188}Os$ during the Middle Norian. Two negative Os isotope excursions are observed within a ~2 m stratigraphic interval located between the Middle and the Upper Norian. The onset of the first negative Os excursion is roughly located at the base of the *Epigondolella bidentata* conodont zone in the late Middle Norian. The timing of this Os isotope excursion coincides with both the abrupt increase in Os concentration and low Re/Os ratios, all of which suggest a significant input of extraterrestrial Os into the sediments. The Os isotope compositions exhibit the second negative Os isotope excursion from the initial Os isotope composition of ~0.7 to unradiogenic values of ~0.4 in the early Late Norian. However, it is difficult to specify the cause for the second negative excursion with the dataset acquired in this study. Additional research is needed to clarify the cause for this record in the upper Norian.

Keywords: osmium isotope, chert, Upper Triassic, Mino Belt

Origin of the Lower Triassic deep-sea chert gap

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Carboniferous to Jurassic pelagic deep-sea sediments that accumulated in the pelagic Panthalassa Ocean are mostly composed of bedded chert lithofacies (Matsuda and Isozaki, 1991). Among them, the Lower Triassic interval is characterised by siliceous claystone dominant lithofacies instead of bedded chert lithofacies (the deep-sea chert gap) (Ishiga and Yamakita, 1993; Isozaki, 1997). The age of the deep-sea chert gap (ca. 252–247 Ma) corresponds to the time interval of ecosystem recovery from the end-Permian mass extinction, the largest mass extinction event in the Phanerozoic (Chen and Benton, 2012). Therefore, the deep-sea chert gap may reflect anomalous environmental conditions during the Early Triassic that possibly delayed the re-establishment of complex ecosystems after the mass extinction. The deep-sea chert gap may either be a result of an increase in burial flux of fine clastic material, or a decline in burial flux of biogenic silica in the Early Triassic pelagic Panthalassa. However, previous studies have not calculated burial fluxes of fine clastic material and biogenic silica based on well-dated sedimentary sequences. In order to identify the mechanism that led to the formation of the deep-sea chert gap, we estimated the burial fluxes of clastic material and biogenic silica in deep-sea sedimentary sequences, which were newly described in this study.

Detailed geological mapping and reconstruction of lithostratigraphy was carried out at Ogama in the Kuzuu area, Tochigi Prefecture, and in the Tsukumi area, Oita Prefecture, and consequently, several continuous sections were identified. Based on conodont biostratigraphy, the studied sections are correlated to the *triangularis-collinsoni* Zone, the *homeri* Zone, the *timorensis* Zone and the *bulgarica* Zone of Koike (1981), which corresponds to the Spathian (upper Olenekian; uppermost Lower Triassic) to middle Anisian (lower Middle Triassic). Using the conodont biostratigraphic framework, absolute ages of volcanic tuff beds in South China were projected onto the reconstructed lithostratigraphic columns of the deep-sea sections. Consequently, the lower limit of the linear sedimentation rate (LSR) was obtained for the Spathian and lowermost Anisian siliceous claystone dominant lithofacies.

In addition, major element concentrations were measured for rock samples obtained from the studied sections by X-ray fluorescence (XRF) analysis. The SiO_2 and Al_2O_3 concentrations were were combined with measured rock density data and the lithostratigraphic data of the studied sections to calculate the burial fluxes of clastic material and biogenic silica for the stratigraphic intervals for which LSR was estimated. For the lowermost Anisian in Ogama, the minimum burial fluxes of clastic material and biogenic silica are 1030 g/cm^2·m.y. and 1040 g/cm^2·m.y., respectively. For the Spathian in the Tsukumi area, the minimum burial fluxes of clastic material and biogenic silica are 960 g/cm^2·m.y. and 1130 g/cm^2·m.y., respectively. The estimated minimum burial flux of clastic material for the deep-sea chert gap greatly exceeds the burial flux calculated for the Anisian bedded chert lithofacies in the Tsukumi area (80 g/cm^2·m.y.), calculated based on LSR by Soda et al. (2015). The estimated minimum burial flux of biogenic silica for the deep-sea chert gap is also higher than that of Anisian bedded chert in the Tsukumi area (390 g/cm^2·m.y.), calculated based on LSR by Soda et al. (2015). These results indicate that, during the deposition of sediments in the deep-sea chert gap, burial fluxes of clastic material and biogenic silica were both elevated, but

the increase is greater in the former. Hence, the deep-sea chert gap is a result of anomalously high flux of clastic material to the pelagic realm, which diluted biogenic silica in deep-sea sediments.

Keywords: Lower Triassic, deep-sea chert gap, conodont, clastic burial flux, biogenic silica burial flux

Phylogeny of Middle Jurassic *Striatojaponocapsa* and middle Cretaceous *Turbocapsula*, and potential of reliable radiolarian zonation

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The four-segmented *Stichocapsa tegiminis* Yao group gave rise to three-segmented *Striatojaponocapsa plicarum* (Yao). The evolutionary first appearance biohorizon defines the base of the *Striatojaponocapsa plicarum* Zone of Bajocian-early Bathonian age. In turn, *Striatojaponocapsa plicarum* (Yao) evolved into *Striatojaponocapsa conexa* (Matsuoka) through *Striatojaponocapsa synconexa* O'Dogerty, Gorican and Dumitrica. The evolutionary first appearance biohorizon of *Striatojaponocapsa conexa* defines the base of *Striatojaponocapsa conexa* Zone of late Bathonian-early Callovian age. This is a well-known evolutionary lineage of Middle Jurassic radiolarians and contributes to offer a reliable chronological framework. An evolutionary trend similar to the *Striatojaponocapsa* lineage is recognized in middle Cretaceous radiolarians belonging to the genus *Turbocapsula*. Four-segmented forms of *Turbocapsula* evolved into three-segmented *Turbocapsula figitiva* O'Dogerty by reducing segment number. *Turbocapsula figitiva* gave rise to *Turbocapsula costata* (Wu) by acquiring widely-spaced costae. This speciation is characterized by cladogenesis. The *Turbocapsula* lineage has a potential to produce a reliable radiolarian zonal scheme for the middle Cretaceous (Barremian-Aptian).

Keywords: radiolaria, phylogeny, zonation

Lithostratigraphy and radiolarian age of pelagic sediments in the Wadi Hilti area of the Oman Ophiolite: age constraint for eruption of the V2 lava

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The Oman Ophiolite is the most complete preserved section of upper mantle to oceanic crust worldwide (e.g., Lippard et al., 1986). The ophiolite forms a huge thrust sheet that crops out for a length of 500 km and a width of approximately 80 km in the Oman Mountains. Ernewein et al. (1988) summarized the subdivision of volcanic rocks and recognized that V1, which has a normal MORB (N-MORB)-like signature, was erupted around a spreading ridge and that V2 formed by intra-oceanic arc volcanism. In addition, thick lava flows of V3, ascribed to intra-plate volcanism, were emplaced onto pelagic sediments (Umino, 2012).
The V2 and V3 lavas are widely distributed in the Wadi Hilti area, about 25 km west of Sohar, northern Oman Mountains. Recently, Kusano et al. (2014) reexamined the volcano-stratigraphy of the V2 lava in this area, consisting of lower LV2 (IAT) and upper UV2 (boninite) units, based on their geochemical composition and stratigraphic relationship. The eruption and emplacement mechanism of the V3 lava were studied by Umino (2012). Metalliferous and pelagic sediments overlie the UV2 lava and are covered by the V3 lava. Based on our field examination for several sections in the Wadi Hilti area, the stratigraphy of the sediments on the UV2 lava consists of metalliferous sediments, red mudstone and micritic limestone, in ascending order. We obtained *Guttacapsa gutta* and *Thanarla pulchra* from red mudstone. According to O'Dogherty (1994), the co-occurrence of these species is restricted to be middle to late Cenomanian. From red mudstone and micritic limestone, *Rhopalosyringium scissum* and *Hemicryptocapsa polyhedra* were recovered, which can be assigned to a Turonian age (O'Dogherty, 1994).
Very recently, high-precision U-Pb zircon datings were conducted by Rioux et al. (2012, 2013, 2014) on gabbros, tonalites, and trondhjemites. According to them, the rocks fall into two groups in terms of their structural positions, dates, and isotopic composition: the older group, dated at ca. 96.5-95.5 Ma, is attributed to ridge magmatism (V1 lave), whereas the younger group (ca. 95.5-95.0 Ma) is related to post-ridge magmatism (V2 lava). Hara and Kurihara (2015) reported the maximum age of sediments on the V1 lava to middle-late Cenomanian. In the present study, the sediments on the UV2 lava can be correlated with the middle to late Cenomanian. These findings reveal that the activity from the V1 to UV2 lavas was terminated in late Cenomanian. In addition, these radiolarian ages are consistent with the high-precision U-Pb zircon ages of crustal rocks formed by ridge and post-ridge magmatisms. These age constraints imply that the change of tectonic setting progressed rapidly in a short period of middle-late Cenomanian.

Keywords: Oman Ophiolite, radiolarians, Cretaceous, Cenomanian

Radiolarian biostratigraphy of Late Cretaceous pelagic sediments in the Wadi Jizzi area of the Oman Ophiolite

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The Cenomanian–Coniacian radiolarian biostratigraphy of pelagic sediments overlying basaltic extrusive lavas of the Oman Ophiolite was studied in the Wadi Jizzi area, about 40 km west of Sohar, northern Oman Mountains. Pelagic and metalliferous sediments commonly occur on lavas and at the boundaries between different volcanic units. The most thickly accumulated sediments, which rest directly on the V1 lava formed by ridge magmatism, were named the Suhaylah Formation (Fleet and Robertson, 1980; Woodcock and Robertson, 1982). The Suhaylah Formation is overlain by the Zabyat Formation (Woodcock and Robertson, 1982; Robertson and Woodcock, 1983). This formation consists of ophiolite debris, redeposited sandstone- to siltstone-sized volcaniclastic rocks, and pelagic mudstone. From the occurrence patterns and stratigraphic ranges of radiolarians, the species clearly make up three distinct assemblages. Based on the occurrences, we defined the following three biostratigraphic zones (interval zones): *Guttacapsa gutta* zone (basal part of the Suhaylah Formation; middle Cenomanian to latest Cenomanian), *Rhopalosyringium scissum* zone (main part of the Suhaylah Formation; latest Cenomanian to Turonian), and *Archaeospongoprunum bipartitum* (Zabyat Formation; Coniacian). In previous studies (e.g., Tippit et al., 1981), the Suhaylah Formation was dated as early Cenomanian to Coniacian–Santonian. We revised the age of this formation to middle–late Cenomanian to Turonian. The radiolarian age of the sediments overlying the V1 lava (ca. 96 Ma) is consistent with the high-precision U–Pb zircon age of crustal rocks formed by ridge magmatism (96.0-95.5 Ma) (Rioux et al., 2014).

Keywords: Oman Ophiolite, radiolarians, biostratigraphy, Cretaceous

Ecology and diversity of phaeodarians (unicellular zooplankton) around Japan

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Phaeodarians are a group of unicellular zooplankton dwelling in pelagic ocean from the at least Triassic to the present. Phaeodaria have long treated as members of “Radiolaria”, however molecular studies revealed that the group in question belongs to Cercozoa. Phaeodarians occasionally become abundant in ocean, and they are thought to have important roles in the marine food web and the material cycles. We will present the results of our investigations concerning this group during the last five years and discuss about the importance of phaeodarians.
Plankton were sampled from several depths at ca. 40 stations around Japan during 2011–2015. The zooplankton in the samples were sorted and identified under a stereomicroscope in order to clarify the composition of each sample. The 18S rDNA sequences of phaeodarians were determined by single-cell PCR method. Some phaeodarians caught in the East China Sea were cultured to observe their behavior.
The microscopic and genetic analyses revealed that two undescribed phaeodarians live in the deep waters in the Sea of Japan, and they were described as *Aulographis japonica* and *Auloscena pleuroclada*. The former species was abundant through the year, occupying ca. 22% of the total zooplankton biomass on average. The abundance of phaeodarians was also seen in the Kuroshio region, where two species, Aulosphaeridae sp. 1 and Sagosphaeridae sp. 1, occupying 10.2–13.9% of the zooplankton biomass. Another unicellular zooplankton, *Thalassothamnus* sp. 1, was also found in this region. This genus is classified as Entactinaria (Radiolaria) in the current classification system. Our molecular and morphological analyses, however, revealed that the present species is a member of Phaeodaria. Thus, phaeodarians can occasionally become abundant around Japan, but their information is still limited. Further research on unicellular zooplankton near the Japanese Archipelago is necessary for considering the evolution of unicellular organisms in the pelagic ocean.

Keywords: Cercozoa, Phaeodaria, plankton, present, protist, silica

Parameter identification of mathematical models based on three dimensional information of planktic foraminiferal shell structure obtained by Microfocus X-ray CT

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Morphological variations in microfossils like foraminifers and radiolarians might have the meaning of various functions for their evolution and adaptation in the geological history. In order to quantitatively understand such morphological variations, it is important to parameterize the morphological features in microfossils. We obtained precise morphology of a modern planktic foraminifera Globigerinoides ruber (d'Orbigny) using Micro-Xray Computed Tomography (Micro-XCT) technique, and developed numerical approximate models to validate the parameterization by experimental rules used the sequentially connected spheres. Our approximate spherical model clarified that several parameters including radius ratio, distances of geometric centers in each chambers are almost constant, and others such as revolving angle between adjacent chambers are gradually transformed associated with growth of G. ruber, It indicates that previous numerical model could not interpret whole morphology of this species. The coupling of mathematical model and Micro-XCT technique has the great potential to realize various forms of microfossils and understand its functional morphology.

Keywords: Microfocus X-ray CT, Mathematical Model, functional morphology, Planktic foraminifera

