Newly proposed “Bacteria-first” phylogenetic tree of life with landmass and not ocean being the mother of life

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Progenote, LUCA, and Commonote are the terms commonly used for the ancestral life, whose definition slightly differs among the authors. Ancestral life is no longer present on Earth now, but most biologists have long believed that traces of the ancestral biomes remain in their genomes. The first successful tracing of ancestral life was through the structure of ribosomal RNA, showing three different domains such as Archean, Bacteria, and Eukaryote (Woese, 1998). Which one is the oldest life, Archaea, Bacteria, or an intermediate one?
Generally, Archaea is thought to be older or more primitive life than Bacteria, because Archaea prefers reductive conditions, such as observed for the Hadean contrasting with the oxidized environmental conditions of modern Earth. In addition, Archaea predominates in the mid-oceanic hydrothermal ecosystem, and hyperthermophiles are located near the bottom of the phylogenic tree of Archaea. Especially after the discovery of a H_2-producing (reductive) peridotite hydrothermal system, most people came to imagine that the birth place of life was a mid-oceanic ridge, and as such, Archaea being older than Bacteria; after all, Bacteria live under oxygenic environmental conditions and dominate on landmass. However, current habitat does not necessarily indicate the birth place of life, because it is possible to think life had migrated to a mid-oceanic ridge from a reductive on-land environment. Actually, a Hadean primordial continent could provide reductive circumstances like a nuclear geyser system where reducing gas could be concentrated along the ceiling of an underground cave, suggesting the possibility that the first life had emerged in an on-land reductive environment. Indeed, the bottom of the phylogenic tree of Bacteria has a branch of hydrogeno- and sulfur bacteria (Woese, 1998), which means that they lived under highly reduced environmental conditions such as in a serpentinized peridotite hydrothermal system, corresponding to OD1 microbes which survive in such modern on-land environments.
Considering the requirements to emerge life, some key conditions are the supply of clean water, nitrogen, nutrients like phosphorus, and cyclic environmental conditions such as a dry/wet cycle. The Hadean ocean was too toxic for life due to ultra-acidity, abundant heavy metal elements, and high salinity. In addition, there was no supply of nitrogen from magmatic gas to create the life body. Thus, life could not emerge from the ocean, but rather much more likely in an on-land nuclear geyser system.
I propose a new model of the phylogenetic tree of life as the Bacteria-first model, which emerged through three-step evolution (Maruyama et al., 2017). Consistent with my new model, Petrov et al. (2014) have speculated the ribosome-evolution model, based on the structural growth outwards of ribosome, suggesting that Archaea is secondary after Bacteria. The next target is to discover the core of RNA ribosome in Archaea from MOR is similar to ribosomal RNA of Bacteria. Or, we need to apply the retroposon (SINE) method to micro-organisms to determine whether Bacterial is older than Archaea, to avoid the lateral transfer of gene afterward.

Keywords: origin of life, Bacteria-first, Ribosomal RNA

Can speciation of early life be evidenced by morphological variation of Early Archean lenticular microfossils?

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Organic-walled lenticular microstructures up to 100 μm along the major dimension were discovered from Early Archean (3.4 Ga) cherts of the Strelley Pool Formation in the Pilbara Craton, Western Australia (Sugitani et al., 2010, 2013). They have been extensively studied multi-disciplinarily, including classical microscopic observation, palynology, scanning electron microscope (SEM), transmission electron microscope (TEM), Raman spectroscopy, and secondary ion mass spectroscopy (SIMS) (Lepot et al., 2013; Sugitani et al., 2015a; Williford et al., 2015). Their biogenicity is now well established and appears to be widely accepted; however, their biological affinities are still poorly understood. Here we once keep away from this issue, and focus on their morphological variation in the context of taxonomy, base on new data of lenticular microfossils from the two remote localities of the 3.4 Ga Strelley Pool Formation, one in the Goldsworthy greenstone belt and the other in the Panorama greenstone belt.
The two fossil localities of the 3.4 Ga Strelley Pool Formation in the Goldsworthy and the Panorama greenstone belts are distinct in lithostratigraphy and trace element characteristics of fossil-bearing black cherts, suggesting that they represent different environments of habitat. Fossil-bearing black chert in the Goldsworthy greenstone belt had probably deposited in a terrestrial hydrothermal system, whereas that in the Panorama greenstone belt did in marine setting, probably intertidal to subtidal zone (Sugitani et al., 2013, 2015b). Measurement of major and minor dimensions of their polar views of over 1000 specimens indicates that lenticular microfossils from these two localities are statistically distinct in ellipticity.
Although SPF lenticular microfossils are thought to have had reproduced by binary fissions, higher ellipticity of the Panorama specimens cannot be explained by vegetative growth of circular type that dominates the Goldsworthy population, because there is no correlation between ellipticities and major dimensions. Also taphonomy cannot explain the difference in ellipticity between two populations.
Considering that both the elliptic and circular types have a common body plan (lenticular body and surrounding flange), the two populations of different ellipticities likely represent subgroups of the same taxon. Namely, the SPF lenticular microfossils have a common ancestor and thus could be the earliest evidence for speciation, possibly through adaptation to different environments. Although how the difference of ellipticity worked is unclear so far, we assume that it was related to different hydrodynamics of the habitats.

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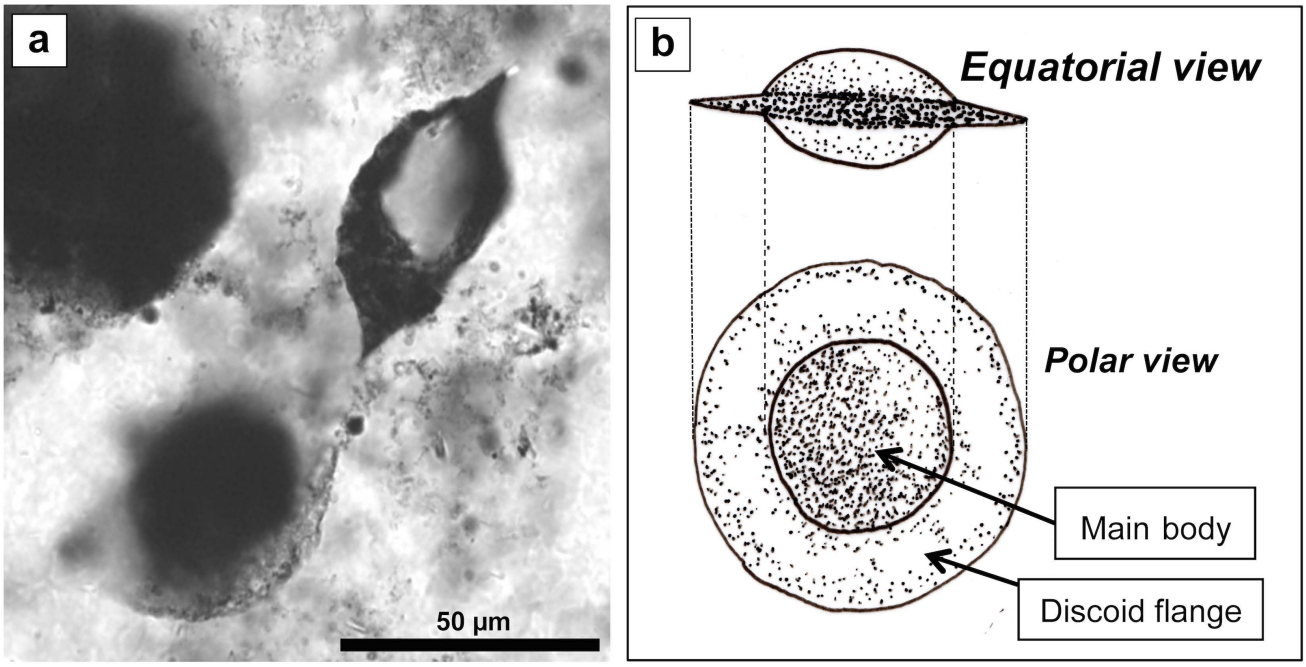
Keywords: Archean, microfossils, early life, morphology, speciation



Reduced iron and molybdenum in the end-Permian sulphidic sedimentary rocks

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The presence of reduced iron (Fe) and significant increases in molybdenum (Mo) concentration in sedimentary rocks have been taken as evidence of reducing and highly reduced sulphidic depositional conditions, respectively. We performed extended X-ray absorption fine structure (EXAFS) analyses of Fe and X-ray absorption near edge structure (XANES) and Mo in lithified silicic sedimentary rocks from the pelagic deep-sea Permian–Triassic boundary section to determine their oxidation states and the bonding environments of the host phase of each element. The most dominant Fe-bearing minerals were pyrite and illite. Ferric minerals such as hematite were absent, which suggested reducing depositional and/or post-depositional conditions throughout the Permian–Triassic transition. On the other hand, tetravalent and hexavalent Mo (Mo(IV) and Mo(VI), respectively) were observed in the studied section by the XANES analysis. It is impossible to rule out the oxidative weathering in the outcrop and/or following experimental procedures for the presence of Mo(VI)-O species. However, Mo(IV)-S species dominates in the end-Permian horizons, which suggests that any post-depositional oxidative effect did not occur significantly at least for these samples and originated from sulphidic depositional environment with following diagenetic effects. Considering features of matured rock samples, preservation of Mo(IV) species would be helped by molybdenite formation during thermal late diagenesis and dense cementation by silicic materials forming matured sedimentary rocks. The absolute concentrations of Fe hosted in pyrite (Fe-pyrite) and S-bonding Mo(IV) (Mo(IV)-S) increased in the siliceous claystone beds just below the mass extinction boundary. However, the Fe-pyrite concentrations decreased while those of Mo(IV)-S species increased across the mass extinction boundary. This trend reflects decreased reactive Fe in bottom waters, likely caused by massive pyrite formation and increased reduced Mo(IV) under the prolonged stagnation of sulphidic deep water and ambient continental margin regions at the end-Permian.

Keywords: iron, molybdenum, X-ray absorption near edge structure (XANES), X-ray absorption fine structure (XAFS), the end-Permian mass extinction, pelagic deepsea

Toarcian redox history and biotic response in NW Panthalassic margin: Multiproxy analysis of the Nishinakayama Formation

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The early Toarcian (Early Jurassic) oceanic anoxic event (T-OAE) was a significant palaeoenvironmental perturbation that led to marked changes in ocean redox condition and ecosystem. This event is characterized by the widespread occurrence of a ~3–7‰ negative excursion in the carbon-isotope ($\delta^{13}C$) composition of marine organic and inorganic matter and terrestrial plant material. In addition, one of the distinct phenomena during the early Toarcian is the abrupt rise of pCO_2 and consequent global warming, which led to enhanced hydrological cycles and ocean anoxia. Despite such global impacts of the event, the precise palaeoenvironmental and palaeoecological changes during the event from sections outside of the Boreal and Tethys realms are uncertain. To address this issue and further expand our understanding of the nature of the event, we investigated the Nishinakayama Formation of the Toyora area, southwest Japan, which represents an organic-rich silty mudstone-dominated succession deposited at the shallow margin of the northwestern Panthalassa Ocean. In particular, we focused on the reconstruction of ocean redox history and biotic response, based on available new data. As a result, pyrite framboid size analysis suggested that water-column euxinia occurred during the negative $\delta^{13}C$ excursion, although available geochemical data suggested suboxic bottom water. According to our results and previous studies that indicate a pelagic euxinia in the central Panthalassa, widespread euxinic condition was achieved in the Panthalassa Ocean during the T-OAE. Detailed sedimentological analysis of silty mudstones and sandstones revealed that terrigenous material input was increased during the negative $\delta^{13}C$ excursion. In addition, at least in some cases during the negative $\delta^{13}C$ excursion, terrigenous material was directly delivered from river floods by hyperpycnal flows, which may have provided oxic water into bottom water. Ammonite (e.g., *Dactylioceras* and *Harpoceras*) size analysis suggested that ammonites were, in general, negatively affected by water-column euxinia, although there were species-specific differences in biotic response between *Dactylioceras* and *Harpoceras*. Namely, the size of *Dactylioceras* decreased during the interval of water-column euxinia and its aftermath. On the other hand, the size of *Harpoceras* also decreased during the interval of water-column euxinia, but increased directly after the termination of the euxinic interval. The same pattern was also recognized in *Dactylioceras* and *Harpoceras* in Tethys realm, suggesting the global nature of biotic response to the Toarcian palaeoenvironmental perturbations.

Terrestrial environmental reconstruction by biomarker analyses of coaly sediments in the Cretaceous Hakobuchi Formation, Yezo Group, Hokkaido, Japan

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Paleoenvironmental studies were extensively carried out in Cretaceous marine sediments in Hokkaido, Japan. However, there have been few paleoenvironmental investigations for Cretaceous terrestrial area. We focus coal and coaly sediments in terrestrial formations distributed in Hokkaido to reconstruct the variations in terrestrial environment and climate. The Hakobuchi Formation belongs to the Yezo Group in Hokkaido, Japan. This formation consists of sandstones and sandy siltstones in the Campanian to Maastrichtian. Some thin coal beds are lying the formation. Each coal bed thickness is about 2 m so the information about a cycle of the peat bog formation is preserved in narrow area. In the present study, we analysed biomarkers in the coal beds and the upper or lower sediments from the Hakobuchi Formation in the Campanian to Maastrichtian to improve the analyses for peat bog formation and coalification process and to examine variations of terrestrial environments.
Biomarkers such as *n*-alkane, hopanoid, steroid, sesquiterpenoid, and diterpenoid are mainly detected. Organic matter in coals in the Hakobuchi Formation are confirmed to be immature (sub-bituminous coal). The distribution patterns of *n*-alkanes show strong odd carbon number preferences. Each samples indicate different distribution patterns which maximising at *n*-C25, *n*-C27 or *n*-C29, and their averaged chain length (ACL) values are 26.7 - 28.4. Short chain *n*-alkanes (*n*-C23, *n*-C25) are known to be related to the aquatic ecosystem. The sample showing low ACL may have been deposited under strong aquatic ecosystem. Most samples indicate α- and β-hopanes distribution maximising at C31. We found that C31/C30 and C31/C32 hopane ratios are well linearly correlated to ACL values. The relationships suggest that microbial degradation causes important role for peat bog ecosystem and coalification processes. Sesquiterpenoids and diterpenoids, which are derived from gymnosperm, are mainly detected. However, triterpenoids, which are originated from angiosperm, are not much detected. Thus, it is possible that gymnospermous plants were dominant in the paleovegetation in Hokkaido Island during the Campanian to Maastrichtian.

Keywords: terrestrial paleoenvironment, biomarker, Cretaceous, coal

The history of life changeable by asteroid impact site: low probability of appearance of humans

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An asteroid 9 km in diameter hit the hydrocarbon- and sulfur-rich sedimentary rocks in present-day Mexico 66 million years ago. Recent studies showed that the impact at Yucatan Peninsula burned hydrocarbon and sulfur in the target rocks forming stratospheric soot and sulfate aerosols, which caused extreme global cooling and draught, and in turn to a mass extinction including dinosaurs, leading to appearance of humans. The amount of hydrocarbon and sulfur in rocks varies widely depending on location, which suggests that cooling and extinction level was dependent on impact site. Here we show that probability of the significant global cooling, the mass extinction, and subsequent appearance of humans was 13% when the asteroid hit the Earth. This significant event could have occurred when the asteroid hit hydrocarbon-rich areas occupying 13% of the Earth surface. The history of life is changeable by asteroid impact sites.

Keywords: mass extinction, Cretaceous-Paleogene boundary, asteroid impact, appearance of humans , extinction of dinosaurs

Faunal dynamics of photosymbiotic planktic foraminifers in the Eocene thermal event

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Planktic foraminifers, which appeared in the middle Jurassic and have been flourished until Recent, have acquired photosymbiotic ecology in its evolutionary history. Some extant species also develop those symbiotic consortia with chrysophytes, dinoflagellates, etc. The photosynthates produced by symbiotic algae provide additional nutrition to host foraminifers, allowing foraminifers inhabit in the oligotrophic open ocean. Not only for the nutrition, but algal photosynthesis also enhances calcification of hosts, indicating that the photosymbiosis is critically important for the evolution of planktic foraminifers. Recently, it is reported from the investigation of modern corals that the symbiosis between algae and calcifiers can be damaged, or even destroyed by the global warming event. The deterioration of photosymbiosis has also been observed in the geological global warming events. Edgar et al. (2013) reported that significant decrease in relative abundance and test sizes of photosymbiotic planktic foraminifers at the hyperthermal event in the Middle Eocene Climatic Optimum (MECO; ~40Ma). While geological thermal events are thought to affect the diversity and abundance of photosymbiotic planktic foraminifers, mechanisms in assemblage dynamics and/or sensitivity to hyperthermal events in each species are still not well known.

In this study, we examined fossil assemblages and accumulation rates (specimens/cm^2/k.y.) of planktic foraminifers to discuss assemblage dynamics of photosymbiotic species in a hyperthermal event occurred in the early Eocene. The samples are recovered by Integrated Ocean Drilling Program Expedition 342, Site U1407 at Southeast Newfoundland Ridge, Atlantic Ocean, and dated at 45–50 Ma. Abrupt decrease in carbonate content from ~80 wt% to ~40 wt% is observed in the middle of the interval analyzed. The decrease in carbonate content is accompanies by sharp decrease in $\delta^{18}O$ of bulk carbonate by 0.6 ‰, indicating the decrease in this carbonate content occurred with warming . It is assumed that this decrease in carbonate content shows shoaling of the carbonate compensation depth (CCD). Additionally, two other warming events have been found prior to the decrease in carbonate content. There were three hyperthermal events within ~1.5 m.y., and the youngest one was accompanied by the shoaling of CCD. At the oldest event, accumulation rate of total planktic foraminifers, including both symbiotic and asymbiotic genera, decreased significantly. Since both mixed layer and thermocline/subthermocline dwellers were depressed, the oldest event represents changes in some sysmtems in the whole water column. The simultaneous decrease in $\delta^{13}C$ of bulk carbonate with $\delta^{18}O$ possibly indicates decrease in primary production. While the accumulation rates of total planktic foraminifers were small and unchanged at the second event, the accumulation rate of *Morozovella* and *Morozovelloides* further decreased down to almost zero (specimen/cm^2/k.y.) at the youngest event. On the other hand, asymbiotic species markedly increased. These observations indicate that photosymbiotic genera are selectively affected by the youngest event, which implies the collapse of photosymbiotic consortia caused by the global warming. In contrast to these two symbiotic genera, the accumulation rate of symbiotic *Acarinina* increased. Considering that *Acarinina* and *Morozovella* inhabited at the same depth within a mixed layer (Pearson et al., 2001), this difference against the hyperthermal event may indicate that *Acarinina* utilized different

algae from that in *Morozovella*, or was less dependent on the photosymbiosis than *Morozovella*.

Keywords: Planktic foraminifer, Photosymbiosis, Eocene, Thermal event, Faunal dynamics

Late Eocene–early Oligocene deep-sea ostracode faunas at Integrated Ocean Drilling Program Site U1411, off Newfoundland, northwestern Atlantic

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Under the North Atlantic Deep Water (NADW), modern ostracode faunas are characterized by *Krithe*, *Poseidonamicus*, and *Henryhowella* (Dingle and Lord, 1990, Palaeogeogra., Palaeoclimat., Palaeoeco., 80, 213–235). The NADW faunas are called the “psychrosphere” fauna and considered to have appeared during the Eocene–Oligocene climatic transition (e.g., Benson, 1975, Lethaia, 8, 69–83). Using foraminiferal carbon stable isotopes and Nd isotopes, some studies hypothesize that the NADW was initially formed during the early Oligocene (e.g., Via and Thomas, 2006, Geology, 34, 441–444; Katz et al., 2011, Science, 332, 1076–1079). The formation of the NADW may link with the ” psychrosphere” fauna. The formation of the “psychrosphere” fauna is still in controversy (e.g., Dall’ Antonia et al., 2003, Mar. Micropal., 48, 91–106). In the North Atlantic, any studies have not studied changes in deep-sea ostracode faunas during the Eocene–Oligocene climatic transition. Here I report ostracode taxa from the late Eocene–early Oligocene ostracodes from Integrated Ocean Drilling Program (IODP) Site U1411, off Newfoundland, North Atlantic, and discuss the faunal changes during the Eocene–Oligocene climatic events.

At Site U1411 (41˚37’ 5.94” N, 48˚59’ 59.94” W), three holes were drilled on the seafloor of the Southeast Newfoundland Ridge at 3299 m depth (Norris et al., 2014, Proc. IODP, 342). I took 132 sediment samples of ~20 cm^3 volume from silty clay with nannofossils (140 to 235 m CCSF) and nannofossil chalks with foraminifers (235 to 266 m CCSF). Using the planktic foraminferal and calcareous nannofossil biostratigraphy, the core sediments are dated to be ~37.9–33.4 Ma, the late Eocene to early Oligocene (Norris et al., 2014).

Entirely 332 specimens were obtained from 67 of 132 sediment samples. 23 taxa were identified. Through the late Eocene to the early Oligocene, *Krithe crassicaudata* occurs most frequently. *Henryhowella asperrima* and *Platyleberis* sp. are often found. The samples contain *Poseidonamicus pseudorobustus*. The faunas contain the genera diagnostic for the NADW. At ~36.4 Ma, the ostracode abundance dropped off from 1–27 to 1–9 specimens, indicating changes in export productivity. The decrease in the abundance fell in the Late Eocene warming event of Bohaty and Zachos (2003, Geology, 31, 1017–1020). The faunas show no clear changes in taxonomic composition at and above the E/O boundary (33.7 Ma). At ~33.7 Ma, an increase in abundance of *Krithe* is observed and is coincidently with “*Krithe* pulse” in the Massignano Global Stratotype Section and Point in the Tethys Ocean (Slotnick and Schellenberg, 2013, Mar. Micropal., 103, 68–84).

Keywords: Eocene, Expedition 342, Integrated Ocean Drilling Program, North Atlantic, Oligocene, Ostracoda

Innovative evolutions in the skeleton of Mesozoic aquatic amniotes

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Amniota, a clade including mammals, reptiles, and birds, appeared as vertebrates that were adapted to life on the dry land during Carboniferous Period. In the Permian, however, some amniote clades including mesosaurs (Mesosauria) and eosuchians (Eosuchia) secondarily returned to the life in water. Various marine amniotes appeared after the Permian/Triassic boundary and flourished so much that they replaced top predators niche, which had been occupied by fishes. Mesozoic marine amniotes are often introduced as typical examples for structural evolution functionally constrained by swimming and diving, which may show viviparity, streamlined body, dorsal and caudal fins like those of fishes, or flippers like those of penguins and drastic change in bone compactness. On the other hand, being relieved from constraints of life on land, some marine amniotes acquired a characteristic body that is far different from basic terrestrial amniote body plan. For instance, placodonts (Placodontia) and saurosphargids (Saurosphargidae), which are found from the Triassic of Tethys, acquired osteoderms covering their body, and in some cases bones form exoskeleton-like structure, which is comparable to the turtle shell. Ichthyopterygians (Ichthyopterygia) appeared in the Early Triassic and showed outstanding hyperdactyly (excess number of digits), hyperphalangy (excess number of phalanges) or mesopodialization (loss of morphological identity of limb bone elements). Plesiosaurs appeared in the Late Triassic possessed a long neck with high number of cervical vertebrae, and finally acquired 76 cervicals in the Late Cretaceous. Hupehsuchians (Hupehsuchia) is known only from the Lower Triassic of China and possessed unique skeletal structures such as 1-3 layers of overlapped massive osteoderms along the dorsal midline, broad ribs without any intercostal spaces, a longitudinal low of osteoderms (or gastralia) like the scutes of carangid fishes along the body sides, and the neural spine of vertebrae segmented into dorsal and ventral parts. As above examples, the skeletal evolution of the Mesozoic aquatic amniotes took place with quite a high flexibility, and especially in the Triassic ocean, their skeleton may have deviated from the basic body plan of amniotes. Reconstructing the skeletal structure of these animals and their developmental mechanisms might be a key to revealing true plasticity in the morphological evolution of amniotes and understanding the constraints that selected the amniote morphology.

Keywords: Paleontology, Vertebrata, morphology, adaptation, Amniota, P/T boundary

Spatial and temporal distribution of Desmostylia (Mammalia) and implications on its evolution and extinction

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Desmostylia is one clade of extinct aquatic mammals with no close living relative. Its fossil records are known from the uppermost Eocene to Miocene marine strata in the North Pacific Rimand its paleoecology is still debated. One reason of this was due to a paucity of available data concerning geographic distributions and time ranges of its taxon. However, currently, more data have become available, making analyses of spatial and temporal distributions of various desmostylians possible. Accordingly, we summarize occurrence records of desmostylians and discuss the significance and implications of their spatial and temporal patterns for their paleoecology. We reviewed previous reports of desmostylian occurrences based on the literature and a database and mapped them by stage and taxon. The result showed that the temporal range of definite desmostylian records is from around the Eocene/Oligocene boundary through 10 Ma. Furthermore, it was confirmed that Desmostylidae had a wider geographic distribution than Paleoparadoxiidae and was adapted to very cold environments. In addition, it was suggested that *Cornwallius*, a basally-diverging member of Desmostylidae, went extinct possibly through competition with more derived *Desmostylus*. The last desmostylian that survived into the late Miocene in the North Pacific Rim was *Desmostylus* spp. *Desmostylus* became completely extinct likely due to a rapid decrease of shallow marine areas associated with a major marine regression at around 10 Ma.

Keywords: Oligocene, Miocene, Desmostylia

Isotopic dietary evolution linking with lineage evolution and interspecific competitions in small mammals, using Miocene rodents as a case study

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Abiotic forces, including climate change, continental drift, and geographic barriers, have been viewed as the major driver of macroevolutionary change in organisms, evidenced by various studies from empirical, ecological, phylogenetic, and paleontological approaches on different time/spatial scales and resolutions. On the other hand, biotic interactions such as predator-prey interactions, interspecific competition for food, density-dependent natural selection has been limitedly recognized as a factor for shaping evolutionary patterns. In vertebrates, biotic interactions can be directly observable in field studies. However, the nature of long generation times in animals makes it difficult to obtain general patterns of biotic interactions apart from seasonal variations in the relatively short-term studies. In vertebrate paleontology, despite the advantage of the long-term time scales, possible morphological diversification and/or constraints due to the presence of competitors or competitive lineages is rarely documented.

In this study, we utilized two paleontological events of small mammals from in the Miocene Siwalik Group of northern Pakistan in order to evaluate isotopic dietary evolution in relation to (1) lineage evolution and (2) interspecific competitions. The first event is that murine rodents (true mice and rats) from the region record the earliest appearance of the group to its diversification into two sympatric lineages (here called *Karnimata* and *Progonomys* lineages), beginning before and continuing through a unidirectional shift from C_3- to C_4-dominated vegetation. The second event is that cricetid rodents (hamsters) were completely replaced by murine rodents (true mice and rats) at least within 5 million years after the earliest appearance of basal murines in Pakistan. Carbon and oxygen isotope values in enamel of first lower molars were obtained by laser-ablation GC-IRMS to infer dietary and habitat preferences, ranging from 15 to 6.5 Ma. Tooth shape of upper first molars was defined by morphometric distance of ecomorphological characters, 2D geometric morphometric analysis of tooth outline, and 3D GIS models.

For the topic of lineage evolution, our dataset demonstrates that murine rodents experienced a remarkable C_3-C_4 dietary shift with the *Karnimata* lineage consuming a greater percentage of C_4 grasses than the *Progonomys* lineage at any given time. In 2D analyses, adaptive change of tooth morphology in the *Karnimata* lineage is more strongly associated with increasing chewing efficiency in the propalinal direction of mastication. However, in both clades, preliminary 3D model analysis shows that more derived (and younger) species have average slopes of cusps directed more anteriorly than more basal (and older) species, which is also related to the propalinal chewing direction. These results indicate that while both clades morphologically adapted to varying contributions of C_4 grasses to their diets, selection pressure forcing dental adaptations was differentially greater in the *Karnimata* lineage.

For the topic of interspecific competition, our initial data suggest that the dietary conservation among the fossil rodents can be detected even in the C_3 plant-dominated region but that change in dietary niche breath could not be observed as the variance. Throughout the 5 million-year range of coexistence, mice have isotope values similar to phylogenetically closer taxa, whose size is smaller than more distant taxa

that are similar in size to the mice. Although the power of the statistics is still weak due to the small number of the samples, phylogeny is a more important factor than body size in the competition.

Keywords: Vertebrate Paleontology, isotopic paleoecology, evolutionary paleoecology

Larvae from deep-sea hydrothermal vents disperse in surface waters

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Larval dispersal significantly contributes to the geographic distribution, population dynamics and evolutionary processes of animals endemic to deep-sea hydrothermal vents. Benthic invertebrates with a pelagic larval period can be categorized as lecithotrophic or planktotrophic species. Among vent-animals, the former lecithotrophs generally disperse near the ocean floor while the latter planktotrophs have been considered to disperse in mid-water, above the influence of a hydrothermal plume.
However, surprisingly little is known as to the extent that the planktotrophic larvae migrate vertically to shallower waters to take advantages of richer food supplies and strong currents. Here, we first provide converging evidence from the taxonomy, phylogeny, population genetics, physiology and behaviour of the species of Shinkailepadinae (Gastropoda: Neritimorpha) for their vertical migration as long-lived planktotrophic larvae from deep-sea hydrothermal vents to the surface water.
Sixteen species were identified from global hydrothermal vent fields and cold methane seeps as the extant members of the subfamily. They generally show wide distribution ranges with their panmictic population structure. The culture experiments of larvae of the vent-endemic *Shinkailepas myojinensis* strongly suggested that their larvae grow and disperse in the surface water for an extended period of time. The oxygen isotopic analyses of the larval and adult shells of three *Shinkailepas* species, which is the first attempt for vent-endemic taxa, perfectly supported the vertical migration of larvae as an obligatory part of the species' life cycles. All settled juveniles collected from hydrothermal vent fields were found to have experienced the warm surface water during their larval period. Lastly, the geographic distributions and genetic population structures of four planktotrophic species of the shrimp family Alvinocarididae suggested that the vertical larval migration of vent animals can well be a widespread phenomenon, at least for those with planktotrophic early development.
Based on the new evidence and exploration of previous literature, we propose that the sea surface temperature represents a critical factor in determining the geographic distribution of many deep-sea vent endemic species with a planktotrophic early development. This finding sheds new light on the connectivity between photosynthetic and hydrothermal-vent ecosystems and has direct implications for the biogeography and evolution of vent faunas.

Keywords: Biogeography, early-life history, larval dispersal, vertical migration, SST

