Do we have any evidence of the existence of bilaterian animals in the Ediacaran? New trace fossil data from the Ediacaran of western Mongolia

*Tatsuo Oji[1], Stephen Dornbos[2], Keigo Yada[3], Hitoshi Hasegawa[1], Sersmaa Gonchigdorj[5,4], Takafumi Mochizuki[5]

1.Nagoya University Museum, Nagoya University, 2.University of Wisconsin-Milwaukee, 3.Graduate School of Environmental Sciences, Nagoya University, 4.Mongolian University of Science and Technology, 5.Iwate Prefectural Museum

Although a lot of arguments exist as to the existance or absence of bilaterians in the Ediacaran, no conclusive evidence has so far been obtained. There are a variety of trace fossils from the Ediacaran, but no deeply penetrative, or U-shape burrows have been discovered. Therefore, these Ediacaran traces should be made by protozoans or cnidarians. We found vertically penetrative burrows, presumably assigned to *Arenicolites,* from multiple horizons of the upper Ediacaran of western Mongoliia. These presumably have U-shape form, and the animal that lived in the burrow should have longitudinally elongate form, probably assignable to bilaterian animals. Mongolia was located in low-lattitudinal area in the late Ediacaran, and animal evolution is thus thought to have proceeded earlier than other areas.

Keywords: Ediacaran, bilaterians, Mongolia

A study of sulfur and carbon isotopes for understanding environmental changes in the Ordovician-Silurian extinction event

*Teruyuki Maruoka[1], Sachiko Agematsu[1], Katsuo Sashida[1], Mat Niza[2]

1.Faculty of Life and Environmental Sciences, University of Tsukuba, 2.Geological Survey of Malaysia

The end-Ordovician mass extinction was the first of the “Big Five” mass extinctions in the Phanerozoic and the first that affected animal-based communities. This event was likely related to the glaciation of Gondwana; however, the exact mechanisms that led to widespread death are still unclear. The elevated extinction rates were accompanied by a positive carbon isotope excursion. Therefore, not only climatic cooling or a major sea level drop can be related to this mass extinction, both of which are directly connected to glaciation, but also a major perturbation of the global carbon cycle may have been involved. However, it is very difficult to draw conclusions about what actually happened in the oceans only from carbon isotope data. Therefore, a multi isotope approach should be applied in order to understand paleoenvironmental change in oceans around the end-Ordovician mass extinction event.
In this study, isotope ratios and concentrations of carbon and sulfur were analyzed for Upper Ordovician to Lower Silurian shale at the Langkawi Islands in Malaysia. The results revealed that the carbon/sulfur ratio (wt%/wt%) varied periodically from less than 1 to ~30. Such periodical variation was interrupted by the position of the positive carbon isotope excursion. Such excursion was accompanied by C/S ratios of less than 0.1, lower than the minimum values during the periodical variation. This means that the depositions of organic carbon and pyritic sulfur occurred in highly anoxic oceans that might have contained hydrogen sulfide in the water column. At the onset of the end-Ordovician mass extinction, which can be characterized by the carbon isotope excursion, highly anoxic waters containing hydrogen sulfide likely expanded to shallow oceans where sand deposition occurred.

Keywords: Ordovician-Silurian boundary, Carbon stable isotopes, Sulfur stable isotopes, Mass spectrometry

The Carbon isotope stratigraphy of the upper part of the Iwaizaki limestone in the middle permian.

*Tomoyo Tobita[1], Yukio Isozaki[1], Miyuki Tahata[2], Yohei Matsui[3], Manabu Nishizawa[3], Naohiro Yoshida[2]

1.Department of General Systems Studies Graduate School of Arts and Sciences The University of Tokyo, 2.Tokyo Institute of Technology, 3.JAMSTEC

The largest mass extinction event of marine life started immediately before the Guadalupian-Lopingian boundary (G-LB), i.e., at the end of Capitanian. Previous studies were carried out mostly for fossiliferous strata deposited in low latitudes, e.g. Texas, Penglaitan in China, Kamura and Akasaka in Japan etc. The coeval global sea-level drop and the extinction of tropical fauna in the late Capitanian was documented; nonetheless, the response of animals in the mid-latitude is almost unknown to date. The Iwaizaki limestone in NE Japan represents a shelf sequence deposited on the northeastern extension of South China, likely in higher latitudes within the tropic/subtropics. The limestone is composed of reef (Unit 3-7 by Kawamura & Machiyama, 1995) and the overlying collapsing-reef facies (Unit 8). The Capitanian large-tested fusuline genus *Lepidolina* occurs from the upper part of Unit 7 to lower part of Unit 8. Strontium isotope ratio of limestone stays in extremely low values of 0.7068~0.7069. These confirm that the interval of upper Unit 7 and the entire Unit 8 correspond to Capitanian. It is confirmed that G-LB horizon itself is not contained in Iwaisaki limestone. This study, however, clarified the extinction pattern of shallow marine fossils during the late Capitanian by observing 200 thin sections, and measured carbon isotope ratio at 42 horizons for that interval, i.e. in the Unit 7 and 8.

The main extinction of well-adapted tropical fauna, such as large-tested fusuline (*Lepidolina*), occurred particularly during the deposition of Unit 8. On the other hand, isotope ratios of organic carbon for Unit 8 range in -25.4 to -22.3‰. A preliminary reported isotope ratio of inorganic carbon from the same section was about +4‰ (Zakharov et al., 2000); thus the gap between the two is about 26~29‰. The isotopic fractionation was probably induced by normal photosynthesis in the shallow marine setting under which the Iwaizaki limestone was deposited. The relatively high values of both inorganic and organic carbon isotope ratios likely recorded the “Kamura event” (Isozaki et al., 2007, 2011). So far, the evidence for the “Kamura event” was limited solely to the strata deposited in tropical settings, such as the Iwato and Akasaka limestones in Japan, and the Velebit limestone in Croatia. This study first suggests that the collapse of warm-water reef community in the relatively high latitude domain was related also to a global cooling. The Capitanian Chandalez limestone of the Senkina Shapka section in Primorye, Far East Russia, was deposited probably next to the Iwaizaki limestone, and its carbon isotope signature is also under analysis.

Keywords: mass extinction, Permian, limestone, G-L boundary

Oxygen and bioessential element-depleted surface waters with massive soil intrusion in the end-Permian mass extinction

*Kunio Kaiho[1], Ryosuke Saito[1], Kosuke Ito[1], Miyaji Takashi [1], Li Tian[2], Hiroyoshi Sano[3], Zhiqiang Shi [4], Satoshi Takahashi[6], Jinnan Tong[2], Lei Liang[2], Masahiro Oba[1], Fumiko W. Nara[5], Noriyoshi Tsuchiya[5] , Zhong-Qiang Chen[2]

1.Graduate School of Science, Tohoku University, 2.China University of Geosciences, 3.Kyushu University, 4.Chengdu University of Technology, 5.Graduate School of Environmental Studies, Tohoku University, 6.University of Tokyo

The largest mass extinction of biota in Earth’s history consisted of two extinctions; a main extinction followed by a second extinction, occurred at the Permian-Triassic transition. Siberian volcanism is the most likely cause of this extinction event. However, the direct causal mechanism for the biotic crisis has long remained a matter of some dispute. We reconstructed the ocean redox structure in the low latitudes before, during, and after the main extinction event, including the second extinction event, using sedimentary organic biomarker proxies, redox-sensitive elements, and pyrite morphology. The results indicated that anoxic-suboxic or euxinic conditions developed in all waters in the low-latitude Panthalassa and Paleotethys during the main extinction event. In particular, there was massive soil and mud intrusion and an abrupt decrease in oxygen in the surface waters in both the Paleotethys and Panthalassa. Exhaustion of bioessential elements (molybdenum [Mo] and vanadium [V]) in the ocean occurred during and just after the main extinction event. The main extinction horizon in the shallowest section is marked by a peak in oxygen depletion and a marine productivity proxy of biomarkers, indicating that maxima of marine productivity coincided with the peak of oxygen depletion and the main marine extinction event. The high flux of soil and rock-derived nutrients leading to algal blooms could have caused oxygen depletion in the shallow surface water. Expansion of the oxygen minimum zone could have induced deep-surface water anoxia. Massive soil and mud intrusion alone may have damaged sedentary organisms. The low oxygen surface water accompanied by the shortage of bioessential elements and massive soil, mud, and nutrient intrusion in the oceans contributed to the main extinction. Recovery of oxygen in the surface waters occurred just after the mass extinction, suggesting that global warming and ocean acidification may have caused the second extinction in the early Triassic.

Keywords: mass extinction, Permian-Triassic, oxygen, minor element, soil, productivity

Orbitally-paced biogeochemical cycles recorded in the Triassic bedded chert sequence from the Mino Belt, central Japan

*Katsuhito Soda[1], Tetsuji Onoue[1]

1.Department of Earth and Environmental Sciences, Faculty of Science, Kumamoto University

Bedded chert sequences in the Jurassic accretionary complexes of Southwest Japan consist of the rhythmic alterations of chert and shale beds whose thickness variations have been interpreted as recording astronomical cycles. However, recent critical cyclostratigraphic examinations from Japan require identification of driving force for their sedimentary rhythms. In this study, geochemical analyses using X-ray fluorescence spectrometry (XRF) were performed on the Triassic (Anisian-early Carnian) bedded chert sequence in the Mino Belt, central Japan. Remarkable behaviors of redox sensitive elements in the black shales suggest that the oceanic anoxic events developed frequently in the Anisian, despite the fact that the Anisian was the time of the recovery stage from the Permian/Triassic boundary Superanoxia. Cyclic oscillations of the biogenic apatite abundances have maximum values after the OAEs. These observations might represent the high planktonic diversification in the early Middle Triassic that triggered the Mesozoic Marine Revolution. A spectral analysis of major element data revealed that the time-series fluctuations in the chemical weathering intensity were controlled by the Milankovitch cycles and probably affected the oceanic redox condition during the Triassic. Amplitude modulations extracted from the chemical weathering intensity in the Triassic suggest that the climate experienced a transition from a grand astronomical cycle world to a relatively short cycle world in the early Ladinian. This paper proposed that a mechanism for the transition was resulted in organic carbon burial during the Early to Middle Triassic anoxic events and consumption of atmospheric CO_2 by intensified chemical weathering.

Phylogenetic positions of the Middle Pleistocene otariid pinnipeds (Mamalia: Carnivora) from Japan and their implications

*motoki nagatsuka[1], Naoki KOHNO[2,1]

1.Graduate School of Life and Enviromental Sciences, University of Tsukuba, 2.Department of Geology and Paleontology, National Museum of Nature and Science

The Otariidae (7 extant genera and 14 extant species) belongs to the Pinnipedia in the Carnivora that suit both living on land and in water. Otariids are different from other pinnipeds (phocids and odobenids) by having distinctive sexual dimorphisms and forming large harems. Extant otariids live along the coast of the North Pacific and the coast of the Southern Hemisphere. The number of species and habitat ranges of the extant otariids in the North Pacific are smaller than those in the Southern Hemisphere. However, the number of fossil records of extinct otariids known from the North Pacific are larger than those from the Southern Hemisphere. It indicates that the North Pacific is more important to understand the initial stage of the evolutionary process of the otariids. Neverthless, the fossil record of the otariids were limited, and most of them were too incomplete to discuss their taxonomies and phylogenetic relationships.

Recently, almost complete skulls of the otariids were found from the Middle Pleistocene Mandano Formation (0.6 Ma) on the Boso Peninsula. central Japan. These specimens have been stored at the Natural History Museum and Institute, Chiba, where they now bear catalog numbers CBM-PV 7616 and 7617 respectively. CBM-PV7616 is a nearly complete skull except for the rostral tip. CBM-PV7617 preserves almost complete braincase. The cranial material of the Pleistocene otariids is the first to be reported from the Japanese Islands.

The Middle Pleistocene has been recognized as the transitional period to be established the extant fauna and flora. Also, the Middle and Late Pleistocene are transitional periods for the cyclic changes of climate and sea-level stands. Therefore, information of the otariids from the Middle Pleistocene is important to understand their “final” evolutionary process. This study aims, accordingly, to determine the taxonomic and phylogenetic positions of the above-mentioned new specimens to understand their evolutionary processes in the North Pacific. For this purpose, we prepared the data matrix for the phylogenetic analysis based mainly on the morphological characters. As a result, our analysis included 16 ingroup and 14 outgroup taxa, and we coded 150 morphological and morphometric characters including 132 cranial and 18 postcranial characters. Also, we constrained the relationships of extant pinnipeds with the results of molecular analyses of previous studies in our analysis.

Our analysis revealed that the new fossils belonged in the Family Otariidae. CBM-PV7616 was located most closely to the Middle Pleistocene extinct sea lion *Proterozetes ulysses* that was previously known only from the eastern North Pacific. Also, we did not find any autapomorphy on CBM-PV7616 and in *P. ulysses*. Therefore, CBM-PV7616 is identified as *P. ulysses*. In addition, *P. ulysses* were confirmed to be closely related to the Steller sea lion *Eumetopias jubatus*. On the other hands, CBM-PV7617 was located most closely to the species of *Zalophus* that is the sister taxon to the *Eumetopias* plus *Protherozetes* clade. However, we could not find any autapomorphy nor synapomorphy to unite CBM-PV7617 to *Z. californianus* or *Z. japonicas*. Therefore, it is plausible to identify CBM-PV7617 as *Zalophus* sp.

Our result also revealed that the number of species of otariids in the Middle Pleistocene of the western North Pacific was much more than in the Recent western North Pacific, and the distribution of the otariids during that time was extended much southerly unlike their present day northern distribution. Although *P. ulysses* is known only from the restricted age (Middle Pleistocene) and

area (mid-latitude of the North Pacific), their circum-North Pacific distribution suggests that the Middle Pleistocene pinniped fauna was once or temporarily much higher in variety during the Middle Pleistocene.

Keywords: Pleistocene, North Pacific, Kazusa Group, Mandano Formation, Otariidae, Phylogenetic analysis

