

Relationship between the Kamiaso unit and the Nabi unit in the Mino terrane of the Mino-Seki area, Gifu Prefecture

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The Mino terrane, one of the disrupted terranes in central Japan, is divided into several tectonostratigraphic units on the basis of composition, fabric and age. However, there is a problem that these data are biased, because detailed studies have been conducted only in limited areas. The Mino-Seki area of the central part in Gifu Prefecture is one of such area. According to Wakita (1988b), this area is occupied by the Kamiaso unit characterized by repeating coherent chert-clastic sequences and the Nabi unit characterized by broken formation composed of sandstone / mudstone and melange. The Wadano Conglomerate (Kanuma, 1956), characterized by breccias of chert, siliceous claystone, limestone and basaltic rocks, is also distributed in the study area. Here, I will discuss relationship between the Kamiaso unit and the Nabi unit in the Mino terrane.

As a result of a detailed field work, accretionary complexes in the Mino-Seki area are divided into a coherent unit (Kamiaso unit), melange unit (Nabi unit) and the Wadano Conglomerate. The Kamiaso unit is characterized by a tectonic pile composed of chert-clastic sequences that retain the oceanic plate stratigraphy. Chert samples yield Middle Triassic to Early Jurassic radiolarians, while mudstone samples yield Early Bathonian radiolarians. The Nabi unit includes melange and alternating beds of chert and siliceous micrite. There are also differences in the lithology of chert. Black chert with weathered red surface is commonly found in the Nabi unit especially along the Nagara River. These lithofacies generally are not recognized in the Kamiaso unit. Chert samples yield Middle Triassic to Early Jurassic radiolarians, while siliceous mudstone samples yield Middle Jurassic radiolarians. A chert sample in alternating beds of chert and siliceous micrite yields of Late Triassic radiolarians. Igo and Koike (1975) reported Late Norian conodonts from a limestone sample in alternating beds of chert and limestone. The Wadano Conglomerate consists mainly of conglomerate and massive sandstone. It is characterized by blocks of basaltic rock chert, siliceous claystone, and limestone. The Upper Triassic siliceous micrite-chert facies of the Nabi unit differs in containing siliceous micrite from the coeval chert of the Kamiaso unit. This relationship has already been pointed out by Sano et al. (2010).

Keywords: Mino terrane, Kamiaso unit, accretionary complex, chert-clastic sequence, radiolaria

Recognition of the Olenekian-Anisian Boundary Sequence from Ogama, Ashio Belt

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Pre-Jurassic pelagic sedimentary sequences are known to have accumulated in the pelagic Panthalassa over millions of years (Matsuda and Isozaki, 1991; Ando et al., 2001). These pelagic sequences are considered to preserve environmental record of the pelagic Panthalassa. However, spatial variations of pelagic sequences are not fully understood, due to the scarcity of well-preserved sequences. In order to face this problem, this study reconstructed the stratigraphic sequence ranging from Lower to Middle Triassic with high resolution at the Ogama section of the Ashio Belt, which is located in Tochigi, Japan (Kamata, 1996; Kamata 1997).

The section consists of three parts, which occur in separate outcrops; Og-A section, Og-B section and Og-C section. The boundaries of these outcrops were not directly observed, but the major difference in lithology suggests that these outcrops are in contact with faults. The Og-A section consists of approximately 2.5 m thick black claystone overlain by bedded chert. The Og-B section consists of alternating claystone and chert. Claystone in the Og-B section has two types: black claystone and grey siliceous claystone. The Og-C section consists entirely of bedded chert. Components of bedded chert are 1 to 10 cm thick chert beds and 2 to 25 mm thick intercalated claystone beds.

Age diagnostic conodonts were recovered from the Og-B section. Spathian conodonts indicating the *Triassospathodus homeri* zone (*Neospathodus homeri* zone; Koike, 1981), early Anisian conodonts indicating the *Chiosella timorensis* zone (*Neogondolella timorensis* zone; Koike, 1981), Middle Anisian conodonts indicating the *Neogondolella bulgarica* zone (Koike, 1981) were recovered. Radiolarian fossils were recovered from the Og-C section. Early-middle Anisian radiolarian *Triassocampe eruca* (Sugiyama, 1997) and late Anisian radiolarian *Triassocampe coronata* (Bragin) group were recovered.

The reconstructed stratigraphic sequence spans from upper Spathian of Lower Triassic to upper Anisian of Middle Triassic. The Spathian-Anisian boundary determined by the first occurrence of conodont *Ch. timorensis* is placed at the lower part of the Og-B section. The Lower to Middle Triassic pelagic sequence of the Ogama section has two important characteristics. One is the lithofacies change from claystone dominant facies of upper Spathian to bedded chert facies of middle Anisian. The other is the 4 m thick interval of black claystone and black chert, which spans from uppermost Spathian to lower Anisian.

Lower to Middle Triassic pelagic sequences are also exposed in other Jurassic accretionary complexes. A particularly well-studied sequence belongs to the Mino Belt, and is situated in the Inuyama area, Gifu, Japan. This area has been the target of intensive biostratigraphical examinations (Sugiyama, 1997; Yao and Kuwahara, 1997) and cyclostratigraphical researches (Ikeda et al., 2010). The comparison of the two pelagic sequences from the Ashio Belt and the Mino Belt revealed the common general trend of increasing chert content within the lower to middle Anisian interval. However, it is also noteworthy that the interval consisting of black claystone and black chert is remarkably thicker in the Ogama section than in the Inuyama area. Takahashi et al. (2009) indicated the uppermost Spathian interval consisting of black claystone and black chert in the Inuyama area is the result of an oceanic anoxia. The thicker interval at Ogama section may represent longer duration of this event, or a greater sedimentation rate during the event, at the depositional setting than that of Inuyama area. Further correlations by biostratigraphy and carbon isotope stratigraphy are required to compare the onset and offset timing of this event in both depositional settings. The comparison of timing between the two sections may reveal the cause of this regional difference in pelagic sequences.

Keywords: Ogama section, Ashio Belt, Olenekian-Anisian Boundary, Conodont, Radiolarian, Equatorial Panthalassa

Upper Triassic conodont, ammonoid, and radiolarian biostratigraphy in a pelagic sequence of Japan

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The chronology for the Triassic pelagic deposits in the Panthalassa Ocean is based on the radiolarian zonation, which is well studied in the Middle and Upper Triassic bedded chert successions in the Japanese accretionary complex. Although accurate calibration for the chronostratigraphic stages and substages are established basically by means of ammonites and conodonts, most of the Japanese radiolarian zones were calibrated through correlation with zonal schemes in other regions, and have not been calibrated with ammonoid and conodont biostratigraphy. Here we present the results of Late Triassic (Carnian-early Norian) conodont biostratigraphy from the two pelagic sections in the Jurassic accretionary complex of southwest Japan. Samples for this study were collected from the Sakahogi section of a bedded chert sequence in central Japan and the Nakijin Formation of a pelagic limestone sequence in the northern tip of the Okinawa Island. We found 56 platform conodonts from 36 samples in the Sakahogi section, where the radiolarian biostratigraphy have previously been investigated. The biostratigraphy of the Carnian-Norian sequence of the Nakijin Formation is based primarily on ammonites, since the rare occurrence of conodonts minimizes the stratigraphic potential of these groups. However, our study revealed that the clastic limestones intercalated within the Nakijin Formation contain rich conodonts assemblages. Based on detailed study of the conodont biostratigraphy from the interval of the Carnian and the early Norian in the Sakahogi section and the Nakijin Formation, three conodont zones are recognized in ascending order as follows: lower Carnian *Paragondolella praelindae* - *Metapolygnathus polygnathiformis* zone, upper Carnian *Metapolygnathus lindae* - *Metapolygnathus primitius* zone, and lower Norian *Epigondolella quadrata* zone. This result is consistent with the presence of the lower to upper Carnian ammonites assemblages in the Nakijin Formation.

Keywords: Late Triassic, Carnian to early Norian, conodont, ammonoid, and radiolarian biostratigraphy, Sambosan Terrane, Mino Terrane, Panthalassa Ocean

Toward reconstruction of oceanic plate paleogeography in the NW Pacific: a subject from the NE Japan arc.

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Spatial distribution of oceanic plates in the Mesozoic NW Pacific has been indirectly assumed extrapolating from magnetic anomalies tracked back to the mid-Pacific. However, common occurrences of suprasubduction ophiolites and arc terranes, existence of the Philippine Sea plate originated in the Jurassic, and lower mantle tomography suggesting remnants of subducted slab in the mid-Pacific all imply that plates occupied NW Pacific were distinct from those in the middle to east Pacific in the Mesozoic. To test this possibility, it is important to reconstruct oceanic plates from geology and chronology of accretionary complexes and ophiolites independently from the traditional methods based on magnetic anomaly. Here we present a subject for the oceanic plate reconstruction raised from NE Japan.

In this study, we determined U-Pb ages of zircons extracted from a tuff bed in a coherent clastic sequence of the Cape Shiriya accretionary complex (Shimokita Peninsula) at the northeastern tip of the North Kitakami belt. These zircons yielded a mean age of ca. 130 Ma (about Hauterivian / Barremian boundary). Almost identical ages were also obtained from the youngest zircon grains in sandstone. The 130 Ma age is concurrent with (a) Trench sedimentation in the Idonnappu accretionary zone, (b) high-P/T metamorphism in the Kamuikotan zone, and (c) island arc volcanism in the upper Sorachi Group, all in the central Hokkaido far in the east. A shift of the NE Japan trench from the North Kitakami belt to central Hokkaido has been assumed, with contemporaneous onset of arc volcanism in central Hokkaido. However, our result implies dual subduction in the both areas at 130 Ma. If this hypothesis stands, arc-trench system in central Hokkaido could have formed not along the Eurasian continental margin but belonging to another plate.

We also dated a diorite dike as a member of microdiorites, which commonly occur associated with serpentinites in central Hokkaido. These rocks have been attributed to Cretaceous arc magmatism based on chemistry and K-Ar ages. The diorite sample yielded a 160 Ma zircon U-Pb age of Late Jurassic, within the period of trench accretion in the North Kitakami belt. This age thus also suggest the hypothesis of dual subduction, where arc activity occurred outside the trench of Eurasian continental margin.

NE Japan has been held other problems difficult to be explained by simple, single subduction schemes. For example, adakite magmatism (suggesting slab melting) in the Kitakami mountains occurred contemporaneously with lawsonite-blueschist metamorphism (suggesting very cold subduction) in the Kamuikotan zone. Our new age data encourages to test possibilities that another subduction zone existed in the NW Pacific distinct from Eurasian active continental margin at least during Late Jurassic to middle Early Cretaceous.

Keywords: Pacific, oceanic plate paleogeography, zircon, U-Pb age, accretionary complex, ophiolite

Philippine sea plate motion since the Pleistocene viewed from deformed conglomerates of the Ashigara group

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On the northern convergence border of the Philippine Sea plate, Pleistocene Ashigara group (1.6-0.5Ma) filled a trough. Miocene Tanzawa group is distributed on the north side, and both are bounded with the Kannawa fault system. The Kannawa fault system is divided into the Kannawa fault (E-W direction, dextral sense) of the narrow sense, Hisari fault system (NE-SW, sinistral-normal), Nakatsugawa fault system (NW-SE, dextral-reverse), Shiozawa fault system (NE-SW, sinistral-reverse), etc. The Shiozawa formation (conglomerates) which is the high-end strata of the Ashigara group is distributed over the southeastern side of the Shiozawa fault. Parts of the conglomerates are deformed remarkably. These deformation zones are divided into six types (P-R1 cataclasite: A, B, C; fault gouge: Dr, Dg, Db) based on the fault rock property, shear sense, cutting relations. The cataclasites are distributed over the range of 600m from the Shiozawa fault. The shear sense is reverse fault mainly, but shows sinistral in a part of the B and Db type. Quartz grain becomes fine fragment by crush, and biotite does basal slip, it is thought that this cataclasite was formed under environment of 150-300 oC, and 5-10km in depth. The influence of the subducting Philippine Sea plate might have increased. In addition, the moving direction was not constant, northwest and north might be mixed in the Pleistocene age.

Keywords: Kanagawa Prefecture, Ashigara group, Shiozawa formation, cataclasite, fault gouge, Philippine sea plate

Radiolarian morphology as a proxy for reconstructing pelagic environments: problem and perspective

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Late Paleozoic and Mesozoic radiolarian cherts are widely distributed within accretionary complexes in the Circum-Pacific and Alps-Himalaya orogenic belts. These cherts are materials for reconstructing the paleoenvironment of the Panthalassa and the Tethys. Many proxies have been developed to elucidate the environment of the past pelagic realm. Species diversity in radiolarian assemblages is expected to be one of proxies for monitoring paleoenvironmental change. However, the species concept of radiolarians is not always consistent throughout the Phanerozoic time. This makes a serious problem to use radiolarian diversity for elucidating environmental fluctuations. This paper documents the present status of taxonomy for Mesozoic and recent radiolarians. Detailed morphological analysis of radiolarian tests and the understanding of the morphogenesis through culture work are clues toward reconstructing pelagic environments in the past oceans.

Keywords: radiolarians, taxonomy, species concept, morphological diversity, pelagic realm

Lifestyle of adherent benthic foraminifers in the open ocean based on stable of isotope records

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Colonization of new habitat of benthic foraminifers is related to their diversion, survival strategies and evolutions. However their dispersal mechanisms are not well documented and still poorly understood. Last year, we reported a new lifestyle of neritic benthic foraminifera: They had lived on the stems of hydrozoan attaching to observational moorings in the Pacific Ocean. This is a new insight of dispersal strategy of benthic foraminifera to the open ocean. However there are no evidences whether benthic foraminifera developed their calcareous shells in the water column or not. Here we report the new evidences of benthic foraminiferal lifestyles based on micropaleontological and geochemical methods.

Physical and biogeochemical observational mooring systems (POPSS & Sediment trap) were deployed on July, 2012 at the Station S1 (30N, 145E, water depth: 5,900m). Moored periods were from July 2012 to July 2013 (1 year). Hydrozoan attaching on the both mooring systems were observed at the surface of the winch, sensor buoy, sediment trap and float at shallower depths (~200 m) and we could not observed hydrozoan at the 500 m water sediment trap. More than 300 individuals of benthic foraminifers attached of the surface of hydrozoan body. At least, fourteen living benthic foraminifers were identified under the microscope and faunal assemblages were basically same (calcareous, agglutinated, and sessile) with that of previous year. We performed the stable isotope analysis for these calcareous specimens including some porcellanic benthic and planktic foraminifera. As the results, oxygen and carbon isotopes of calcareous benthic foraminifera showed remarkably lighter and heavier values than planktic foraminifera, respectively. It suggested that calcareous benthic foraminifera in this study built their calcareous shells at shallower water depth than planktic species.

Keywords: adherent benthic foraminifera, Stable isotopes, Lifestyle, Hydrozoan

Comparison between morphological dissimilarity and morphological richness

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Morphological disparity, another look at biodiversity, has recently attracted attention of paleontologists in the context of mass extinction and recovery. The measure of disparity has commonly been based on morphological dissimilarity between objects, e.g., sum of variance, mean pairwise distance, range of variation etc. It is widely known that this sort of disparity is robust against sample size and is not seriously affected by a nonselective extinction, whereas selective extinctions should readily reduce the disparity. On the other hand, another aspect of disparity is morphological richness, which is assessed through compilations of the number of character states; e.g., number of pairwise character-state combinations and number of morphospace divisions occupied by observation. Unlike the morphological dissimilarity, the morphological richness appears to be fairly sensitive to nonselective extinctions as well as to selective ones.

The comparison among the diversity measures based on the morphometric data obtained from the ammonoids revealed that the patterns of disparity change were totally different between dissimilarity and richness, while comparison within the same categories tended to indicate a consistent result. This result suggests that comparison between morphological dissimilarity and morphological richness provides a powerful tool to assess the selectivity of an extinction event.

Keywords: disparity, biodiversity, morphological dissimilarity, morphological richness