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Deep-sea fossil molluscan assemblages from a new locality in the lowest Miocene Tsubetsu Formation in the Tsubetsu area, eastern Hokkaidō, Japan

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1. Introduction

The upper Oligocene–lower Miocene Tsubetsu Group (Yamaguchi and Sawamura, 1965; redefined by Morita *et al*., 1996) is widely developed in the Tsubetsu area, eastern Hokkaidō, Japan (Figure 1A). The Group is wholly composed of marine sediments and is known to yield the Tatsukobu-Tsubetsu molluscan fauna (Uozumi *et al*., 1986; Morita *et al*., 1996).

Uozumi (1955) is the first to illustrate a fossil from the Tsubetsu Group; he (Uozumi, 1955: p. 31, pl. 23, fig. 31) explained and figured a specimen of bivalve "*Yoldia* (*Orthoyoldia*) *sagittaria* (Yokoyama)" from the "Hard-shale formation of Kitami". Uozumi (1957: p. 557, pl. 6, fig. 10) redescribed and refigured the same specimen in addition to other specimen from the same formation. He revised the locality data as "Bihoro-Machi [*sic*, Bihoro-chō], Abashiri-Gun, Kitami Province (in detail unknown)".

Subsequently, fossils from the Tsubetsu Group were listed in the explanatory texts of the geological maps "Kitami", "Bihoro" and "Honki" published during 1965 and 1970 (Yamaguchi and Sawamura, 1965; Ishida and Sawamura, 1968; Ishida and Sato, 1970). Afterword, Narita and Omi (1975) reported and illustrated several molluscan and echinoid fossils probably from the Tsubetsu Group, in addition to many mollusk, plant, insect and fish fossils from other Oligocene–Miocene formations in Kitami City and its surroundings. Masuda *et al*. (1981) and Matsui and Ganzawa (1987) also reported some molluscan fossils from the Tsubetsu Group.

Morita *et al*. (1996) made a comprehensive geological and paleontological study of the Tsubetsu Group. They revised the definition of the Tsubetsu Group, and taxonomically described and illustrated 9 species of Gastropoda and 66 species of Bivalvia including 4 new species from the Group. Morita *et al*. (1996) also discussed on the paleoenvironment and biogeographic characteristics of the molluscan fauna.

On the other hand, Oligocene/Miocene boundary is estimated to be located near the boundary between the Tatsukobu and Tsubetsu formations on the basis of diatom and silicoflagellate assemblages (Sawamura, 1984; Morita *et al*., 1996; Kurita *et al*., 1998). As marine fossiliferous

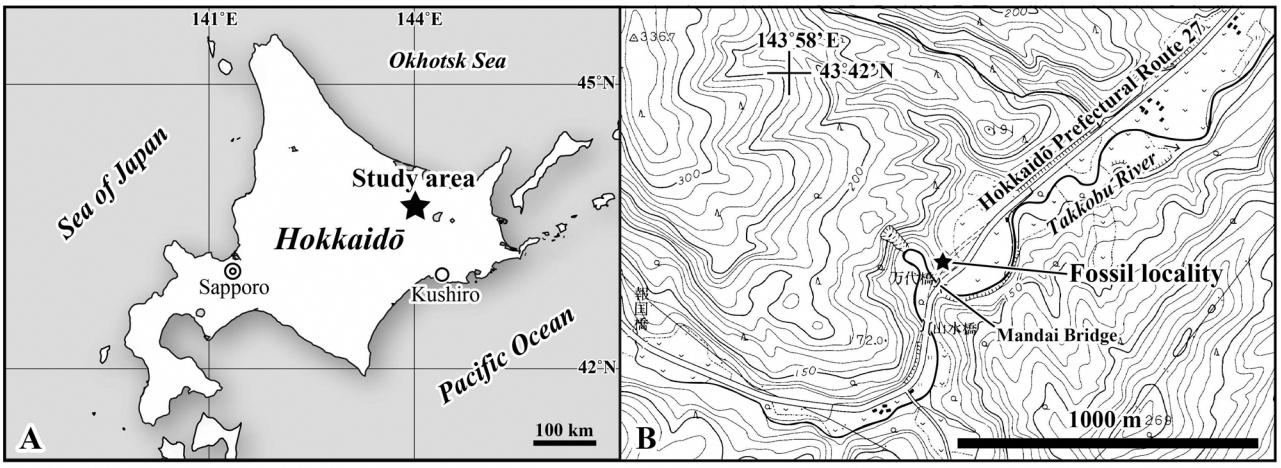


Figure 1. **A**: Location of Tsubetsu area. **B**: Fossil locality (adopeted from 1:25,000-scale "Kaisei" quadrangle published by the Geospatial Information Authority of Japan).

sediments across the Oligocene–lower Miocene boundary are very restricted in the Japanese Islands, the molluscan fauna of the Tsubetsu Group provides the important data for reconstucting the paleobiogeography and paleoenvironments in the Northwest Pacific at the time (Morita *et al*., 1996).

In the autumn of 2018, we obtained a lot of molluscan fossils from a new locality in the Tsubetsu Group distributed in the northwestern part of Tsubetsu Town (Figure 1B). The aim of the present study is to clarify the stratigraphic position of the fossil horizon and discuss the depositional environment and the paleobiogeographic implication of the Tatsukobu-Tsubetsu molluscan fauna.

2. Geologic setting

The Tsubetsu Group is exclusively composed of marine sediments. This group is in fault contact with the Jurassic to Cretaceous Nikoro Group and unconformably overlies the lower Oligocene Wakamatsuzawa Formation [including Sakaemori Formation: Ishida and Sawamura, 1968] or Futamata Andesite. This group is composed of two formations: the Tatsukobu and Tsubetsu formations in ascending order (Figure 2). The Tatsukobu Formation (Chiji *et al*., 1952) is lithostratigraphically subdivided into the "Sandstone Member", "Lower Hard Shale Member", "Sandy Siltstone Member" and "Upper Hard Shale Member" in ascending order (Morita *et al*., 1996). The Tsubetsu Formation conformably overlies the Tatsukobu Formation and subdivided into the "Fine Sandstone Member", "Conglomeratic Sandstone Member", "Hard Shale Member" and "Siltstone Member" in ascending order (Morita *et al*., 1996). The member names of these two formations are informal under the International Stratigraphic Guide (Salvador, 1994), and need to be revised. The Tsubetsu Formation is unconformably overlain by the upper Miocene Mito Formation or younger sediments.

The Tatsukobu Formation is correlated with the diatom *Rocella gelida* to *Thalassiosira praefraga* zones of Gladenkov and Barron (1995), indicating the late Oligocene to earliest Miocene age (Morita *et al*., 1996). The Tsubetsu Formation is correlated with the *Thalassiosira praefraga* to *Thalassiosira fraga* zones indicating the earliest Miocene age. In addition, Matsui and Ganzawa (1987) reported a fission track age of 23.8 ± 2.0 Ma (error: 1σ), indicating a latest Oligocene age, from a tuff bed in the lowest part of the Tsubetsu Formation. However, this F-T age should be treated as reference data, because it was not calibrated according to the recommendation by the I.U.G.S. Subcommission on Geochronology (Hurford, 1990). Therefore, re-dating of this tuff bed is necessary in the near future.

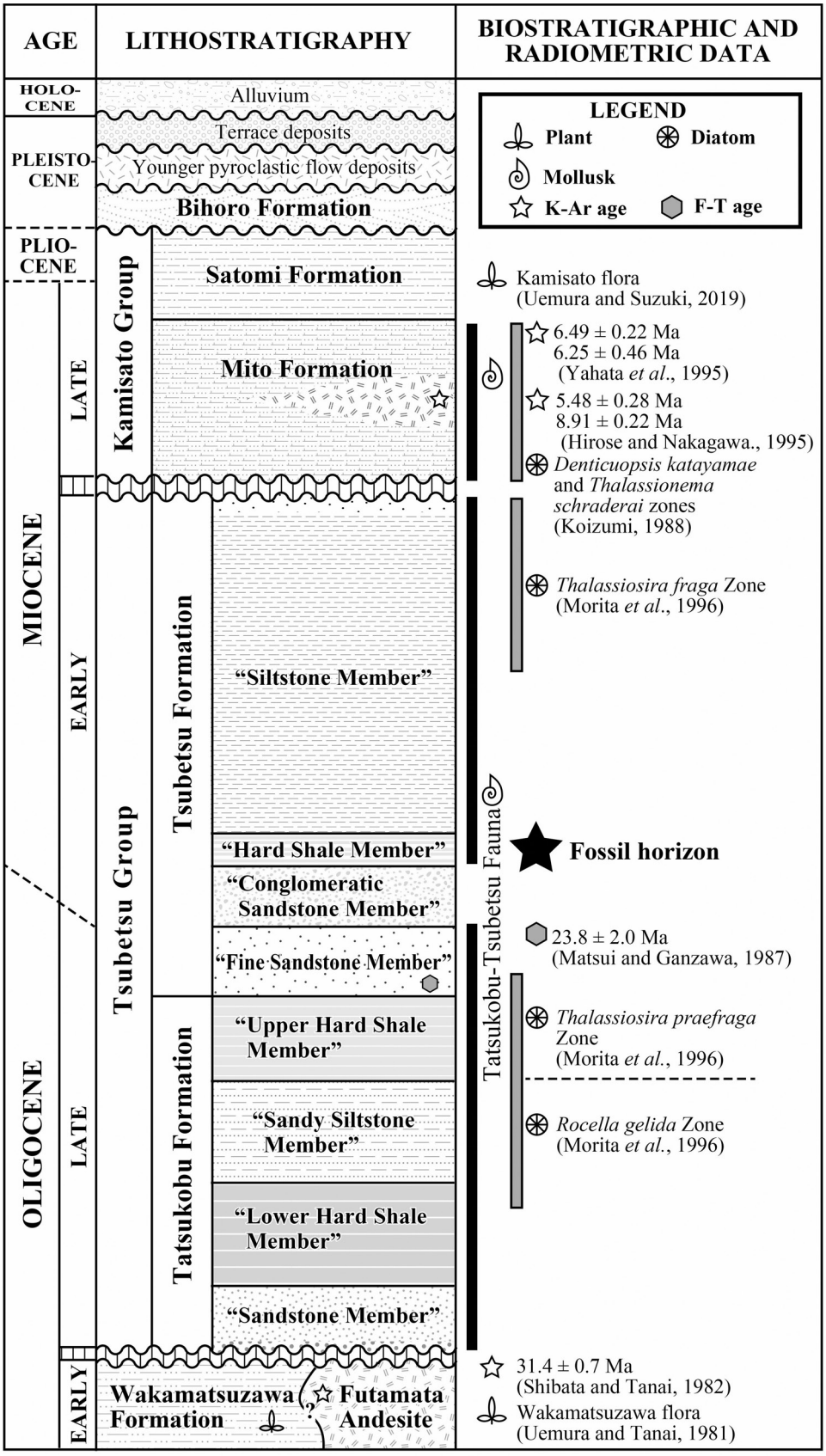


Figure 2. Cenozoic stratigraphy of the Tsubetsu area. Lithostratigraphy after Morita *et al*. (1996).

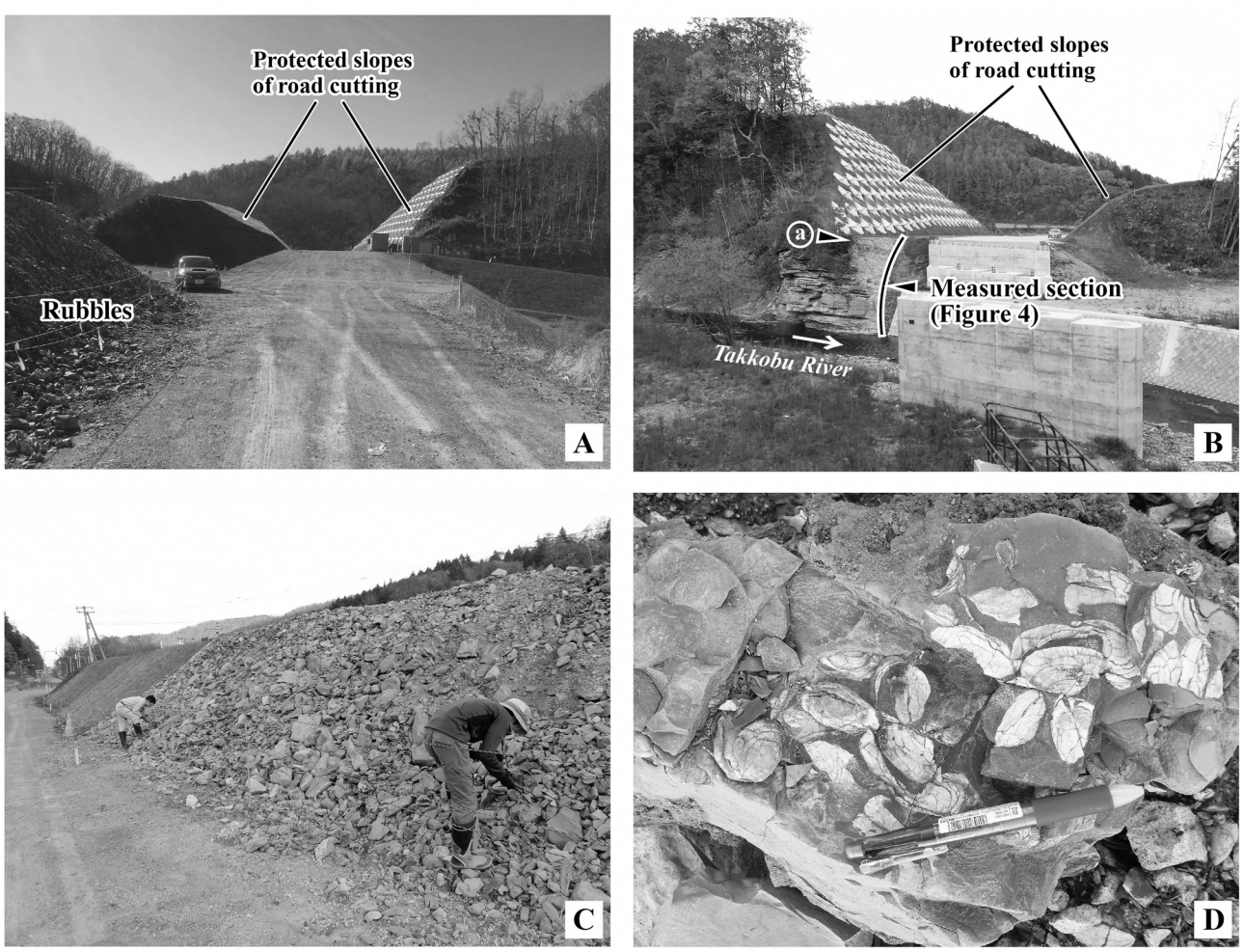


Figure 3. Photographs of the fossil locality and mode of occurrence. **A**: Distant view of constructing site from northeast, showing relationship between road cutting and heap of rubbles (by T.M. on 4 November, 2018). **B**: Distant view of constructing site from southwest, indicating measured section of column shown in Figure 4.ⓐ: Lithologic boundary shown in Figure 4. **C**: Mode of fossil hunting from heap of rubbles. **D**: Mode of occurrence of shells of *Malletia tsubetsuensis* Matsubara, n. sp. in siltstone rubble. Length of pencil is 10 cm. All photographs taken by N.K. on 25 October, 2018, unless otherwise stated.

On the basis of above data, the Oligocene/Miocene boundary (23.03 Ma: Hilgen *et al*., 2012) is considered to be settled near the boundary between the Tatsukobu and Tsubetsu formations (Morita *et al*., 1996). Kurita *et al*. (1998) estimated a hiatus near the boundary between these two formations on the basis of the dinoflagellate biostratigraphy.

3. Materials and methods

A new fossil locality of the Tsubetsu Group was exposed in a construction site of a road cutting in the Hokkaidō Prefectural Route 27 at Mogami, Tsubetsu Town (43˚41'39.9"N, 143˚58'22.7"E; Figure 1; Figures 3A, B). Unfortunately, the outcrop exposure on the cutting slopes has already been protected by using the ground anchor method when we visited the site on October, 2018. Thus, we could neither directly observe the mode of occurrence of fossils and their stratigraphic distribution, nor could collect fossils on the cutting slopes. However, a lot of rubbles derived from the site were heaped near the construction site (Figures 3A). Therefore, all of the fossil specimens

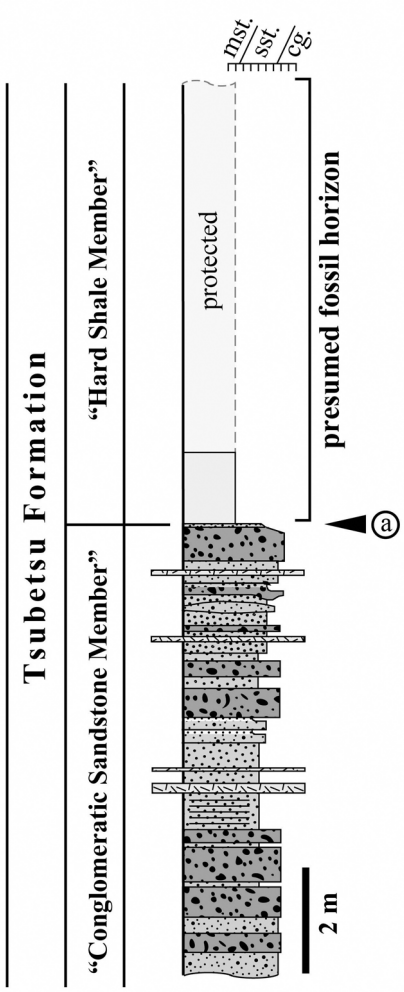


Figure 4. Columnar section showing probable fossil horizon. ⓐ: Boundary between "Conglomeratic Sandstone Member" and "Hard Shale Member" of Tsubetsu Formation indicated in Figure 3B. Abbreviations for sedimentary rocks: mst mudstone; sst sandstone; cg. conglomerate.

examined herein have been collected from these rubbles (Figures 3C, 3D).

The fossil specimens were prepared by a fine chisel, a small hammer and air tools (Paleotools® Microjack 2 and 4).

The fossil specimens were not preserved well, and the most of specimens occurred as compacted and deformed molds. Thus, a silicon vinyl dental impression material (Kulzer Provil Novo Putty®) was used for the examination of the precise morphological characters. The fossil specimens and silicon vinyl casts were blackened with graphite powder, and then were whiten with magnesium oxide (Rasetti, 1947; Matsubara, 2003). Photographs of specimens were taken by using a digital mirrorless camera (Olympus Pen E-P5), and plate figures were prepared by using Adobe® Photoshop® CS6.

Suprageneric classification of the Mollusca follows World Resister of Marine Species (WoRMS, 2019).

All the specimens examined herein are housed at the Laboratory of Earth Sciences, Kushiro Campus, Hokkaido University of Education, Kushiro (abbreviated as HUEK, with prefix "CF" which refers to Cenozoic fossils) and Kitami Region Museum of Science, History and Art, Kitami (abbreviated as KRMSHA with prefix "2-4-MG" which refers to paleontological specimens from Mogami, Tsubetsu Town).

4. Result

4.1. Stratigraphic position of the fossil horizon

As above-mentioned, the road cutting slopes have already been protected. However, about 10 m-high, small outcrop was exposed just below the southwest of the constructing site along the left bank of the Takkobu River (Figures 3B). Morita *et al*. (1996) mapped the area including the constructing site and this outcrop as the "Conglomeratic Sandstone Member" of the Tsubetsu Formation. Indeed, its lower portion is composed of 8 m-thick, alternating beds of medium- to coarse-grained sandstone and granule conglomeratic sandstone, and intercalates several pumice tuff beds. However, the uppermost part of the outcrop is composed of 1.4 m-thick, massive gray siltstone, which conformably overlies coarse-grained sandstone. The siltstone bed can be correlated with the basal part of the "Hard-Shale Member". Since this siltstone closely resembles rubbles derived from the constructing site situated just above the outcrop. Therefore, the fossil horizon is

Table 1. Mollusca from the Tsubetsu Formation.

Species name / mode of occurrence in rubble	sporadic	shell bed
Gastropoda		
Turcica? sp.	R	R
Cryptonatica cf. *janthostoma* (Deshayes, 1839)	C	
Aulacofusus? sp.	R	
Neancistrolepis? sp.	R	
Cylichna cf. *multistriata* Takeda, 1953	F	
Scaphopoda		
Dentaliidae, gen. et sp. indet.	R	
Bivalvia		
Acila (*Acila*) sp.	F	
Acharax tokunagai (Yokoyama, 1925a)	F	
Malletia tsubetsuensis Matsubara, n. sp.	A	VA
Yolidia sagittaria (Yokoyama, 1925b)	F	
Yoldia sp.	R	
Lucinoma sp.	C	
Conchocele bisecta (Conrad, 1849)	F	
Macoma (*Macoma*) *izurensis* (Yokoyama, 1925a)	A	F

R: 1, F: 2–3, C: 4–9, A: 10–27; VA: ≥28

estimated to be in the lower part of the "Hard-Shale Member" of the Tsubetsu Formation (Figure 2, 4).

4.2. Molluscan assemblage

Five species of Gastropoda, one species of Scaphopoda and eight species of Bivalvia were discriminated as a result of taxonomical examination (Table 1). Among them, one bivalve species, *Malletia tsubetsuensis* Matsubara, n. sp., is new to science. In addition, *Acharax tokunagai* (Yokoyama, 1925) and *Conchocele bisecta* (Conrad, 1849) are for the first time recorded from the Tsubetsu Group.

Although the molluscs occurred in rubbles derived from the road cutting, the following two molluscan assemblages can be discriminated:

a) *Macoma-Malletia* assemblage:

The *Macoma-Malletia* assemblage is characterized by the abundant occurrences of *Macoma* (*Macoma*) *izurensis* (Yokoyama, 1925) and *Malletia tsubetsuensis* n. sp., and is associated with *Lucinoma* sp. and *Cryptonatica* cf. *janthostoma* (Deshayes, 1839). The bivalve fossils are sporadically contained in massive or weakly bedded siltstone, and show an articulated or butterfly position. Therefore, this assemblage is considered to be autochthonous.

b) *Malletia* assemblage

The *Malletia* assemblage is characterized by abundant occurrence of *Malletia tsubetsuensis* Matsubara, n. sp. in the siltstone to sandy siltstone rubble making a shell bed. Associated molluscs include a few *Macoma* (*Macoma*) *izurensis* and one specimen of *Turcica*? sp. Bivalve shells occurred in an articulated or butterfly position, but did not show original life position (Figure 3D). On the basis of the

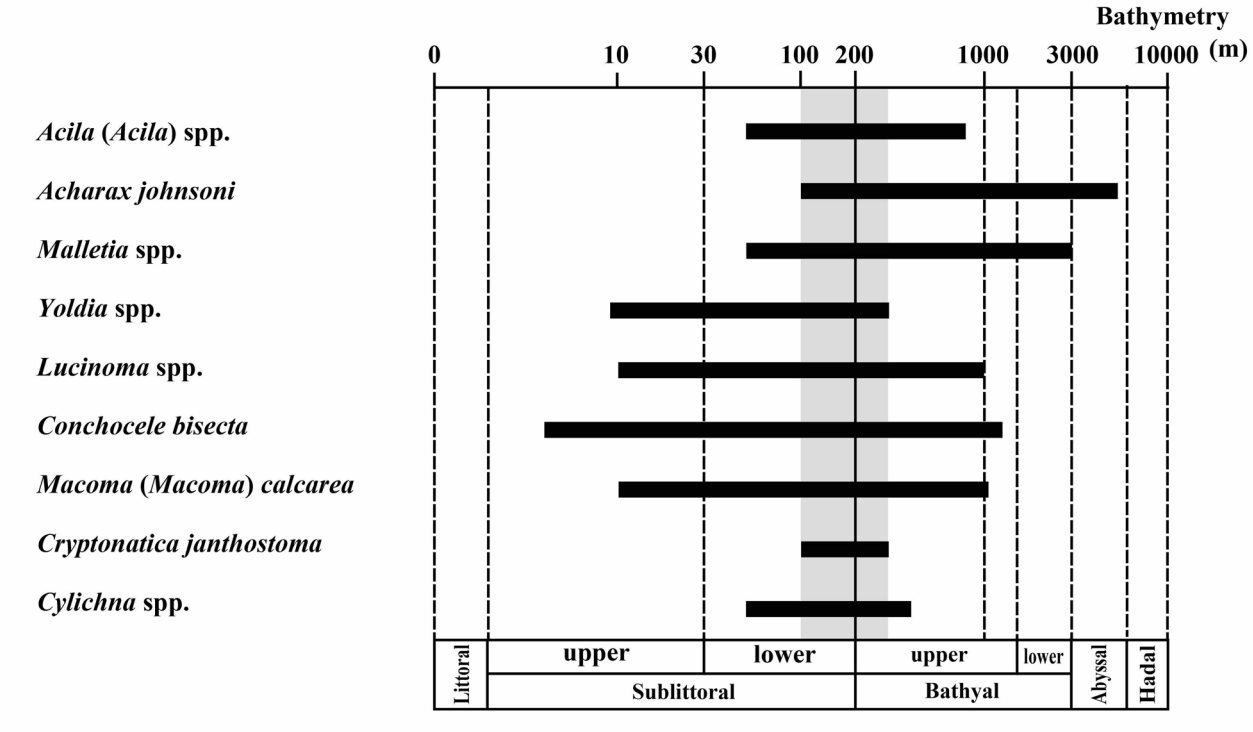


Figure 5. Paleodepth of "Hard Shale Member" of Tsubetsu Formation estimated from molluscan fossil assemblages.

mode of occurrence in rubbles, this assemblage is thought to be parautochtonous.

5. Discussion

5-1. Depositional environment

Among the constituents of the *Macoma-Malletia* and *Malletia* assemblages in the lower part of the "Hard Shale Member" of the Tsubetsu Formation, nine genera or species can be used for the paleodepth estimation. Here, bathymetric data for *Cryptonatica* cf. *janthostoma*, *Acharax tokunagai* and *Macoma* (*Macoma*) *izurensis* are substituted by those of the Recent equivalents *Cryptonatica janthostoma*, *Acharax johnsoni* and *Macoma* (*Macoma*) *calcarea*, respectively. Based on the bathymetric data of these Recent allies (Higo *et al*., 1999), bathymetry of habitat of all genera or species overlaps between 100 m and 300 m (Figure 5). Therefore, the "Lower Hardshale Member" of the Tsubetsu Formation is estimated to have been deposited in the lower Lower Sublittoral to upper Upper Bathyal zones.

Morita *et al*. (1996) discriminated six molluscan assemblages in the Tsubetsu Formation.—the *Macoma-Periploma*, *Limopsis*, *Acilana-Megayoldia*, *Nuculana* (*Nuculana*), *Macoma-Mya* and *Zirphaea* assemblages. They discussed bathymetric change in the depositional age of the Tsubetsu Group. However, Morita *et al*. (1996) could not recognize any molluscan assemblage in the "Conglomeratic Sandstone Member" and "Hard Shale Member" of the Tsubetsu Formation due to few occurrence of molluscs. Therefore, *Macoma-Malletia* and *Malletia* assemblages in the "Hard Shale Member" give a new knowledge for the depositional environment of the lower part of the Tsubetsu Formation.

5-2. Paleobiogeographic implication

The elements of the *Macoma-Malletia* and *Malletia* assemblages in the Tsubetsu Formation are often associated with the "*Acilana tokunagai* fauna" (Shikama and Kase, 1976; originally named the "*Portlandia* (*Hataiyoldia*)

tokunagai fauna"). This fauna is characterized by such the deep-sea protobranch bivalves as "*Acilana*" spp. [=*Hataiyoldia* spp.], *Acila* spp., *Malletia inermis*, *Neilo* (*Multidentata*) spp. and *Yoldia sagittaria*. The "*Acilana tokunagai* fauna" should be changed its name to the *Hataiyoldia tokunagai* Fauna, because *Acilana* Khomenko, 1937 is unavailable (under ICZN Arts. 13.3 and 67.4.1), and *Hataiyoldia* Kamada, 1962 has the precedence over *Acilana* Krishtofovich, 1964 (see Kafanov and Savizky, 1995 for discussion). As already discussed by Morita *et al*. (1996), the Tatsukobu-Tsubetsu Fauna includes the characteristic elements of the *Hataiyoldia tokunagai* Fauna.

The *Hataiyoldia tokunagai* Fauna has been recorded from the late Oligocene–late Miocene formations in Hokkaidō and northwards in the Northwest Pacific (*e.g*. Kanno and Akatsu, 1972; Morita *et al*., 1996). Therefore, it is considered to be a cold, deep sea molluscan association (Shikama and Kase, 1976; Chinzei, 1981; Morita *et al*., 1996). Its oldest records can be traced back to the late Oligocene on the basis of the occurrence from the Tatsukobu Formation (Morita *et al*., 1996). On the other hand, it's distribution is restricted from the upper lower–lower middle Miocene in the Pacific coast of Honshū. Based on the temporal and spatial distribution of the *Hataiyoldia tokunagai* Fauna, Chinzei (1981) estimated the existence of the cold-water *Oyashio-senryū* (Oyashio undercurrent) below the tropical–subtropical Proto-Kuroshio Current during the Mid-Neogene Climatic Optimum (MNCO; Tsuchi, 1986). However, the latest planktonic microfossil biostratigraphy and radiometric data indicate that MNCO has caused at ca. 17 Ma, whereas the geologic age of the formations yielding *Hataiyoldia tokunagai* Fauna in the Pacific coast of Honshū is mostly ca. 18 Ma and is older than MNCO (*e.g*. Ito *et al*., 1999; Yanagisawa, 2011). This age is nearly contemporaneous with the stable oxygen isotope maximum in the base of the zone Mi1b (Wright and Miller., 1992), which is correlated with the magnetic polarity zone C5Dr (18.056–17.533: Hilgen *et al*., 2012). Irizuki *et al*. (2004) pointed out that the ancestors of the Recent cryophilic or circum-polar ostracod species in the genera as *Celtia*, *Kotorcythere*, *Laerousecythere*, *Elofsonella*, *Acanthocythereis* and *Robertsonites* expanded their distribution as south as central Honshū during this global cooling event. Kurihara *et al*. (2005) also considered that the southward migration of a cold-water, shallow marine bivalve *Mytilus tichanovitchi* Makiyama as south as the Kantō Region in central Honshū is probably contemporaneous with this event. The southward expansion of the *Hataiyoldia tokunagai* Fauna during the late early Miocene indicate that the Mi1b cooling event influenced not only the upper sublittoral environments but also the lower sublittoral to upper bathyal depths in the middle latitude of the Northwest Pacific.

6. Systematic description

(by T. Matsubara)

Phylum Mollusca
Class Gastropoda
Subclass Vetigastropoda
Order Seguenziida
Superfamily Seguenzioidea
Family Eucyclidae
Genus Turcica H. Adams and A. Adams, 1854 in 1853–1858

***Turcica*? sp.**

マキアゲエビス属？の一種

Figure 6.6

Material examined.—HUEK CF-00165; KRMSHA 2-4-MG-001.

Remarks.—A single external mold of the spire and an external mold of the base were collected. The shell size and external sculpture are closely similar to species belonging to the genus *Turcica* H. Adams and A. Adams, 1854 in 1853–1858. However, its precise generic position can not be determined because inner lip characters are not available.

Subclass Caenogastropoda

Order Littorinimorpha

Superfamily Naticoidea

Family Naticidae

Subfamily Naticinae

Genus *Cryptonatica* Dall, 1892

***Cryptonatica* cf. *janthostoma* (Deshayes, 1839)**

チシマタマガイに比較される種

Figures 6.4a–b

Compare.—

Natica janthostoma Deshayes, 1839, p. 361.

Material examined.—HUEK CF-00166, CF-00167; KRMSHA 2-4-MG-002-1 through 2-4-MG-002-5.

Remarks.—Some deformed specimens have been collected. They have a rather small, naticoid shell with rounded whorls. One specimen has a half-moon shaped umbilical callus surrounded by the umbilical groove (Figure 6.4b). Although the umbilical hole and a shallow notch in the upper part of the umbilical callus can not be seen, I herein compare the species from the Tsubetsu Formation with *Cryptonatica janthostoma* (Deshayes, 1839).

Morita *et al*. (1996) identified a naticid from the upper part of the Tsubetsu Formation as "*Tectonatica ezoana* (Kanno and Matsuno, 1960)", originally described from the upper Eocene or lower Miocene Sankebetsu Formation in the Haboro area, Hokkaidō. However, this species name is invalid because it is a primary junior homonym of *Natica* (*Lunatica*) *ezoana* Yabe and Nagao, 1928 from the Upper Cretaceous Yezo Group in Hokkaidō (Majima, 1989).

Kanno and Matsuno's (1960) species was discriminated from the Recent *Cryptonatica janthostoma* and *Cryptonatica janthostomoides* (Kuroda and Habe, 1949) [=*Cryptonatica andoi* (Nomura, 1935)] by having a higher shell with shouldered whorls, and a smaller umbilicus callus. On the other hand, Majima (1989) considered that these differences fall within the intraspecific variation of *Cryptonatica janthostoma*. I herein support Majima's (1989) opinion and refrain from proposing a new replacement name for Kanno and Matsuno's species.

Order Neogastropoda

Superfamily Buccinoidea

Family Buccinidae

Genus *Aulacofusus* Dall, 1918

***Aulacofusus*? sp.**

イトマキツムバイ属？の一種

Figure 6.5

Neptunea koromogawana Nomura: Narita and Omi, 1975, pl. 4, figs. 3a–b. [not of Nomura, 1937]

Siphonalia sp.: Narita and Omi, 1975, pl. 4, fig. 4.

Material examined.—HUEK CF-00168.

Remarks.—Only a single, compressed specimen has been obtained. It has a small, fusiform shell with about five, rounded whorls, and external surface sculptured by nineteen and eight, rounded, regular spiral cords on body and penultimate whorls, respectively, and feeble, densely curled growth lines, and a short siphonal canal. Based on these characteristics, it is tentatively referred to the genus *Aulacofusus* Dall, 1918 (redefined by Kosyan and Kantor, 2013).

This species is probably conspecific with "*Neptunea koromogawana* Nomura" and "*Siphonalia* sp." by Narita and Omi (1975) from the lower Miocene Tokoro Formation at Chūshi, Kitami City. However, additional materials are necessary to clarify its identity.

Genus *Neancistrolepis* Habe and Sato, 1973 ["1972"]

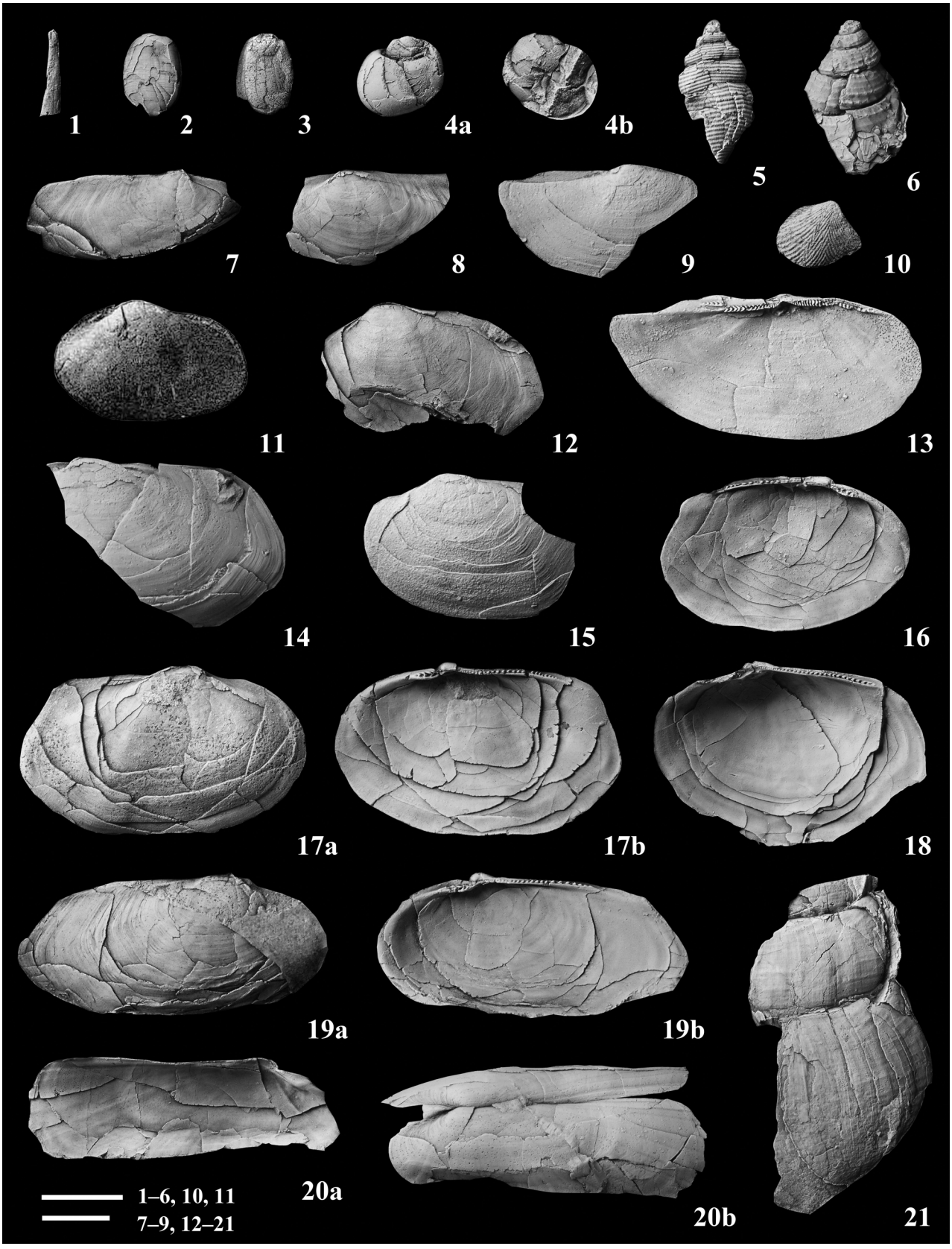
***Neancistrolepis*? sp.**

オホーツクバイ属？の一種

Figure 6.21

Material examined.—KRMSHA 2-4-MG-003.

Remarks.—A single, badly compressed specimen was obtained. It has a moderate-sized fusiform shell with more than 2 1/2, weakly rounded whorls, and the external sculpture consisting of feeble, rather regular, rounded spiral threads and very fine growth lines. It is tentatively referred to the genus *Neancistrolepis* Habe and Sato, 1973 ["1972"] on the basis of the resemblance to the Recent *Neancistrolepis glabra* Habe and Sato, 1973 ["1972"]. However, additional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19a
19b
20a
20b
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1–6, 10, 11
7–9, 12–21

materials are necessary to clarify its precise morphological characters.

Subclass Heterobranchia

Order Cephalaspidea

Superfamily Cylichnoidea

Family Cylichnidae

Genus *Cylichna* Lovén, 1846

***Cylichna* cf. *multistriata* Takeda, 1953**

フトスジナツメガイに比較される種

Figures 6.2, 6.3

Compare.—

Cylichna multistriata Takeda, 1953, p. 61–62 (Eng. pt.), p. 24 (Jpn. pt.), pl. 2, figs. 19, 11.

Material examined.—HUEK CF-00169; KRMSHA 2-4-MG-004-1 through 2-4-MG-004-4.

Remarks.—The species from the Tsubetsu Formation has a small, subcylindrical shell with very low, numerous, flat spiral cords separated very shallow spiral grooves. Because all Tsubetsu Formation are compressed, it is tentatively compared with *Cylichna multistriata* Takeda, 1953, from the lower Oligocene Charo Formation in the Kushiro Coal Field in eastern Hokkaido.

The generic position of *Cylichna multistriata* Takeda, 1953 is controversial. Matsui (1959) transferred it to the genus *Scaphander* de Montfort, 1810, whereas Oyama *et al*. (1960) and Honda (1989) allocated it to the genus *Eocylichna* Kuroda and Habe, 1952. However, species in the genus *Scaphander* de Montfort, 1810 differs from *Cylichna mustistriata* by having an ovoidal shell with the aperture becoming broader anteriorly. On the other hand, *Eocylichna* Kuroda and Habe, 1952 is unavailable because it is a *nomen nudum* (Hanai and Konishi, 1963; Valdés, 2008) (under ICZN Art. 13.1), and its authorship should be attributed to Kuroda and Habe in Kuroda *et al*. (1971) (under ICZN Art. 50.1). Moreover, it is considered a synonym of *Cylichna* Lovén, 1846 (*e.g*. Valdés, 2008).

I tentatively referred *C. multistriata* to the genus *Cylichna* Lovén, 1846 as done in the original description. However, further study is necessary to settle its precise genetic position.

← **Figure 6**. Mollusca from Tsubetsu Formation (1).

1: Dentaliidae, gen. et sp. indet. ツノガイ科の一種 HUEK CF-00170, silicon vinyl cast. **2**, **3**: *Cylichna* cf. *multistriata* Takeda. フトスジナツメガイに比較される種．2: HUEK CF-000169; 3: KRMSHA 2-4-004-1, silicon vinyl cast. **4a**–**b**. *Cryptonatica* cf. *janthostoma* (Deshayes). チシマタマガイに比較される種．HUEK CF-00166 (4a: dorsal view; 4b: apertural view), silicon vinyl casts **5**: *Aulacofusus*? sp. イトマキツムバイ属？の一種．HUEK CF-00168, silicon vinyl cast. **6**: *Turcica*? sp. マキアゲエビス属？の一種．HUEK CF-00165, silicon vinyl cast. **7**, **8**, **12**, **14**–**19**. *Malletia tsubetsuensis* Matsubara, n. sp. ツベツスミゾメソデガイ（新種, 和名新称）. 7: KRMSHA 2-4-MG-009-3b; 8: KRMSHA 2-4-MG-009-3a; 12: KRMSHA 2-4-MG-009-2c; 14: HUEK CF-00173; 15: HUEK CF-00174; 16: KRMSHA 2-4-MG-009-4; 17: KRMSHA 2-4-MG-009-1 (holotype); 17a: external view; 17b: internal view; 18: KRMSHA 2-4-MG-009-2b; 19: HUEK CF-00172. 19a: external view; 19b: internal view. All specimens are silicon vinyl casts. **9**, **13**: *Yoldia sagittaria* Yokoyama. ユナガヤソデガイ．9: HUEK CF-00177; 13: HUEK CF-000176. Both specimens silicon vinyl casts. **10**: *Acila* (*Acila*) sp. オオキララガイ亜属の一種．KRMSHA 2-4-MG-005, silicon vinyl cast. **11**. *Malletia inermis* (Yokoyama) カメノオスミゾメソデガイ（和名新称）． University Museum, University of Tokyo (UMUT) CM22422 (lectotype). Reproduced from Yokoyama (1925a: pl. 2, fig. 5); shown for comparison. **20**: *Acharax tokunagai* (Yokoyama). トクナガキヌタレガイ．KRMSHA 2-4-MG-006-1 (20a: internal view of right valve; 20b: external view of right valve with oblique-dorsal view of left valve), silicon vinyl casts. **21**: *Neancistrolepis*? sp. オホーツクバイ属？の一種．KRMSHA 2-4-MG-003, silicon vinyl cast. Scale bar: 10 mm.

Class Scaphopoda

Order Dentaliida

Family Dentaliidae

Dentaliidae, gen. et sp. indet.

ツノガイ科の一種

Figure 6.1

Material examined.—HUEK CF-00170.

Remarks.—A single, small external mold has been obtained. It has a small, dentaloid shell with smooth external surface. It is tentatively referred to the family Dentaliidae because its apical characters were unavailable.

Class Bivalvia

Subclass Protobranchia

Order Nuculida

Superfamily Nuculoidea

Family Nuculidae

Genus *Acila* H. Adams and A. Adams, 1858 in 1853–1858

Subgenus *Acila* H. Adams and A. Adams,

1858 in 1853–1858

***Acila* (*Acila*) sp.**

オオキララガイ亜属の一種

Figure 6.10

Material examined.—HUEK CF-00171; KRMSHA 2-4-MG-005.

Remarks.—Two specimens have been collected. These specimens can be referred to the subgenus *Acila* (*Acila*) H. Adams and A. Adams, 1858 in 1853–1858 by having a small, subtrigonal shell with a rostral sinus in the posterior part of the shell and the external surface sculptured by fine, double-divaricate ribs. Their unfavorable preservation makes difficult to the species-level identification.

Order Solemyida

Superfamily Solemyoidea

Family Solemyidae

Subfamily Acharacinae

Genus *Acharax* Dall, 1908

***Acharax tokunagai* (Yokoyama, 1925)**

トクナガキヌタレガイ

Figures 6.20a–b

Major synonyms.—

Solemya tokunagai Yokoyama, 1925a, p. 31, pl. 6, figs. 1–3.

Solemya (*Acharax*) *tokunagai* Yokoyama: Kuroda, 1929, p. 5.

Solemya (*Acharax*) *yessoensis* Kanehara, 1937, p. 155–156, pl. 15, fig. 12.

Solemya (*Acharax*) *tibai* Kuroda, 1948, p. 29–30, 32, figs. 1–3.

Acharax tokunagai (Yokoyama): Habe and Ito, 1965, p. 100, pl. 33, fig. 1; Matsubara *et al*., 2013, p. 47, 49–50 (extensive synonymy), figs. 2A–D.

Material examined.—KRMSHA 2-4-MG-006-1, 2-4-MG-006-2.

Remarks.—Internal and external molds of a single butterflied specimen and a badly deformed molds of an articulated specimen have been obtained.

The specimens from the Tsubetsu Formation have a rather small, elongate subrectangular shell with posteriorly situated beaks, long, subtruncated anterior margin, short, rounded posterior margin, external sculpture consisting of some shallow radial furrows extending from beak to ventral margin and rather strong opisthodetic external ligament. Based on these characters, the Tsubetsu specimens are safely identified as *Acharax tokunagai* (Yokoyama, 1925a).

Some authors considered *Solemya tokunagai* Yokoyama, 1925a [=*Acharac tokunagai*] a junior synonym of *Acharax johnsoni* (Dall, 1891), originally described from the off Lower California (*e.g*. Kafanov and Lutaenko, 1997; Coan *et al*., 2000). However, Neulinger *et al*. (2006) showed that two genetically distinct groups can be discriminated within the genus *Acharax* in the Pacific and Indian oceans. Therefore, I herein use *Acharax tokunagai* for the Neogene fossil and Recent large-sized *Acharax* in the Northwest Pacific as done by Matsubara *et al*. (2013).

Geologic distribution.—Lower Miocene–lower Pleisto-

cene formations as far south as Taiwan in the northwestern Pacific.

Order Nuculanida

Superfamily Malletioidea

Family Malletiidae

Genus *Malletia* Des Moulins, 1832

Type species.—*Malletia chilensis* Des Moulins, 1832, by monotypy. Off Chile, Recent.

***Malletia tsubetsuensis* Matsubara, n. sp.**

ツベツスミゾメソデガイ（新種，和名新称）

Figures 6.7, 6.8, 6.12, 6.14–6.19a–b

Type specimen.—Holotype KRMSHA 2-4-MG-009-1.

Other material examined.—Paratypes HUEK CF-00172 through CF-00175; KRMSHA 2-4-MG-009-2a through 2-4-009-2d; 2-4-MG-009-3a–b.

Type locality and horizon.—A constructing site of a cutting along the Hokkaidō Prefectural Route 27 at Mogami, Tsubetsu-chō, Abashiri-gun, Hokkaidō (43˚41'39.9"N, 143˚58'22.7"E). Lower part of “Hard Shale Member” of Tsubetsu Formation. Earliest Miocene (Aquitanian).

Diagnosis.—A large-sized *Malletia* with transversely elongate elliptical, weakly inflated shell; rounded, short anterior margin; broader posterior margin; obliquely subtruncated posterior end; two blunt ridges extending from beak to posterior ventral margin and to posterior corner; growth lines strengthen on posterior ridges; anterior hinge series with 5–7 teeth; posterior hinge series with 29–35 teeth.

Description.—Shell large for genus (shell length to 53.5 mm), longer than high (H/L ratio 0.60–0.69), elliptical, inequilateral, weakly inflated; beaks small, prosocline, situated at about one-third to two-fifths anteriorly for shell length (BP/L ratio 0.32–0.38); anterior margin evenly rounded; posterior dorsal margin longer than anterior one, nearly straight; posterior end subangulated; posterior margin obliquely truncated, may have a shallow notch near dorsal margin. External sculpture consisting of weak, fine, rather irregular commarginal growth lines and a few, feeble to weak radial ridges on the posterior portion of shell; two blunt posterior ridges extending from beak to posterior ventral corner and from beak to posterior end; a few feeble radial ridges may be appeared in front of posterior ridge; growth lines becoming coarser on posterior ridges. Anterior hinge series with 5–7, hook-shaped teeth; posterior hinge series with 29–35, smaller teeth; anterior adductor muscle scar ovate, weakly impressed; posterior adductor muscle scar and pallial line indistinct; ventral margin smooth.

Remarks.—*Malletia tsubetsuensis* Matsubara, n. sp. closely resembles *Malletia pacifica* Dall, 1897, living in the off western coast of North America, in having a truncated posterior end and cardinal properties (see Coan *et al*., 2000: p. 101: pl. 10). However, *M. tsubetsuensis* n. sp. has a larger shell with more rounded, broader anterior margin, and lacking a shallow notch in the posterior ventral margin in front of posterior ridge.

Malletia inermis (Yokoyama, 1925b) (Figure 6.11), originally described from the upper lower Miocene Kamenoo Formation in the Jōban Coal Field in Fukushima Prefecture, is another allied species. However, *M. inermis* differs from *M. tsubetsuensis* n. sp. by having a smaller shell with higher umbones, rounded posterior margin and the anterior hinge series with more numerous teeth (about 10: Yokoyama, 1925b; 9: Kanno, 1967) and posterior hinge series with smaller numbers of teeth (about 20: Yokoyama, 1925b; 24: Kanno, 1967). Oyama (1961: p. 415) pointed out that among the type specimens of *Leda inermis* Yokoyama, 1925 [=*Malletia inermis*], only three specimens figured by Yokoyama (1925b: pl. 2, figs. 3, 5, 6) can be referred to this species, whereas other specimens should be identified as certain different ones. The type specimens of *Leda inermis* are inner molds and are missing (Ichikawa, 1983: p. 309). In addition, no redescriptions of *M. inermis* have been made on the basis of the additional specimens from the Kamenoo Formation. Therefore, the neotype designation and redescription of *M. inermis* based on the Kamenoo specimens are necessary to clarify its precise morphological characters.

Table 2. Measurements of *Malletia tsubetsuensis* Matsubara, n. sp.

Reg. no.	L	H	BP	NTAHS	NTPHS	H/L	BP/L	Remarks
KRMSHA 2-4-MG-009-1	51.8 mm	31.1 mm	19.9 mm	7	35	0.60	0.38	Holotype
KRMSHA 2-4-MG-009-2a	53.2 mm	34.4 mm	—	—	—	0.65	—	Paratype
KRMSHA 2-4-MG-009-2b	48.7 mm	33.8 mm	17.3 mm	—	34	0.69	0.36	Paratype
KRMSHA 2-4-MG-009-4	44.4 mm	27.4 mm	14.1 mm	5	29	0.62	0.32	Paratype
KRMSHA 2-4-MG-009-5	40.4 mm+	25.4 mm	12.6 mm	7	30	—	—	Paratype
HUEK CF00172	46.8 mm	21.9 mm	14.9 mm	5	31	—	0.32	Paratype, deformed
HUEK CF00174	32.0 mm+	21.6 mm	10.6 mm	—	—	—	—	Paratype
HUEK CF00175	11.1 mm	6.8 mm	3.9 mm	—	—	0.61	0.35	Paratype

BP: Beak position from anterior end. H: Height. L: Length.NTAHS: Numbers of teeth on anterior hinge series. NTPHS: Numbers of teeth on posterior hinge series.

Krishtofovich (1957 [“1954”]) discriminated two variations of *Malletia inermis*: *M. inermis* var. *egregia* Krishtofovich, 1957 [“1954”] and *M. inermis* var. *triangula* Krishtofovich, 1957 [“1954”] from the lower Miocene Kholmskaya Formation of Sakhalin. In addition, he proposed two new species, *Malletia longa* and *M. kitaensis* from the same formation. Among them, *M. inermis* var. *egregia* and *M. inermis* var. *triangula* were considered synonyms of *M. inermis* by Kafanov *et al*. (2000). Although *M. longa* has the nearly the same size (shell length to 48 mm) as *M. tsubetsuensis* n. sp., it is discriminated from the latter species by having a more inflated shell with more centrally situated beaks, longer anterior margin and two, more distinct posterior ridges.

Malletia tsubetsuensis n. sp. is separated from *Malletia wajampolkensis* L. Krishtofovich in Zhidkova *et al*., 1972, from the lower Miocene Kuluvenskaya Formation in western Kamchatka, by its larger shell, more anteriorly situated beaks, two, rather distinct posterior ridges, obliquely subtruncate posterior end, and smaller numbers of teeth on the anterior hinge series.

Malletia epikorniana Krishtofovich in Gladenkov *et al*., 1984, from the Oligocene Gakkhinskaya Formation in western Kamchatka, resembles *M. tsubetsuensis* n. sp. in having a few feeble radial ridges in front of the posterior ridge (see Morita *et al*., 1996). However, it is distinguished from *Malletia tsubetsuensis* n. sp. by having a smaller shell with more centrally situated beaks.

The Recent *Malletia takaii* Okutani, 1968, originally described from the off Miyake Island (depth 1,080–1,205 m) and also recorded from the Okhotsk Sea (depth 135–700 m: Scarlato, 1981), is easily distinguished from *M. tsubetsuensis* n. sp. by having a smaller (shell length to 13 mm), anteriorly narrowed shell.

Measurements.—Table 2.

Superfamily Nuculanoidea

Family Yoldiidae

Genus *Yoldia* Möller, 1842

***Yoldia sagittaria* Yokoyama, 1925**

ユナガヤソデガイ

Figures 6.9, 6.13

Yoldia sagittaria Yokoyama, 1925b, p. 10, pl. 2, figs. 10, 11; Khomenko, 1937, p. 10–11 (*pro parte*), pl. 2, figs. 3, 4, 6, 7 (*non* figs. 1, 2, 5); Slodkewitsch, 1938a, p. 98–100 (*pro parte*); Slodkewitsch, 1938b, p. 91 (*pro parte*), pl. 2, fig. 9 (*non* figs. 7, 8); Watanabe *et al*., 1950, pl. 1, fig. 9; Hatai and Nisiyama, 1952, p. 160; Makiyama, 1957, pl. 23, figs. 10, 11; Shikama, 1964, p. 128, pl. 35, fig. 37; Fujié *et al*., 1964, pl. 5, fig. 4; Kanno and Arai, 1964,

pl. 1, fig. 10; Yamaoka, 1993, pl. 1, fig. 15 (?fig. 14).

Yoldia (*Orthoyoldia*) *sagittaria* Yokoyama: Uozumi, 1955, p. 31, pl. 23, fig. 191; Uozumi, 1957, p. 557–560, pl. 6, figs. 10, 11, pl. 7, fig. 25.

Yoldia (s.s.) *sagittaria* Yokoyama: Shikama and Kase, 1976, p. 18, pl. 1, figs. 13, 14, pl. 2, fig. 13.

?*Yoldia sagittaria* Yokoyama: Yokoyama, 1926, p. 247, pl. 32, fig. 4; Yokoyama, 1927, p. 203, pl. 51, fig. 8; Mizuno *et al*., 1969, pl. 27, fig. 4; Shibata and Ina,1983, p. 34, pl. 1, fig. 14.

Material examined.—HUEK CF-00176, CF-00177; KRMSHA 2-4-MG-007.

Remarks.—Three, incomplete specimens have been obtained. The species from the Tsubetsu Formation is identified as *Yoldia sagittaria* Yokoyama, 1925b from the lower Miocene Mizunoya Formation of the Yunagaya Group in the Jōban Coal Field, on the basis of a rather large-sized, lanceolate shell with low, centrally situated beaks and nearly parallel dorsal and central ventral margins.

Yoldia sagittaria has often been confused with *Yoldia laudabilis* Yokoyama, 1924 from the lower Oligocene Asagai Formation in the Jōban Coal Field. However, it differs from *Y. laudabilis* in having a broader posterior margin.

Distribution.—The present species is known from the lower Miocene formations in the Pacific side of central Honshū to Hokkaidō (Morita *et al*., 1996).

***Yoldia* sp.**

ナギナタソデガイ属の一種

Material examined.—KRMSHA 2-4-MG-008.

Remarks.—A rather large, fragmental external mold of right valve has been obtained. Based on the lanceolate shell form estimated from the growth lines, it can be referred to the genus *Yoldia* Möller, 1842. Although it may be conspecific with *Yoldia* (*Yoldia*) cf. *tchekhovi* Krishtofovich of Morita *et al*. (1996), the precise identification can not be made because the precise shell form and cardinal properties are not known.

Subclass Heterodonta

Infraclass Euheterodonta

Order Lucinida

Superfamily Lucinoidea

Family Lucinidae

Subfamily Codakiinae

Genus *Lucinoma* Dall, 1901

***Lucinoma* sp.**

ツキガイモドキ属の一種

Figures 7.2, 7.3, 7.10

Lucinoma sp.: Morita *et al*., 1996, p. 153–154, pl. 8, figs. 20–25.

Material examined.—HUEK CF-00178 through CF-00182, KRMSHA 2-4-MG-010-1 through 2-4-MG-010-1-11.

Remarks.—The present species from the new locality in the Tsubetsu Formation is safely referred to the genus *Lucinoma* Dall, 1901 and is conspecific with "*Lucinoma* sp." of Morita *et al*. (1996) on the basis of the small to rather large, orbicular shell with a subtruncated posterior end, distinct posterior flexure, and external sculpture consisting of broadly spaced, lamellate commarginal ribs and a few, feeble interstitial threads. However, its species-level identification can not be made due to the compaction and deformation of the specimens.

Superfamily Thyasiroidea

Family Thyasiridae

Genus *Conchocele* Gabb, 1866

***Conchocele bisecta* (Conrad, 1849)**

オウナガイ

Figures 7.1, 7.11a–b

Major synonyms.—

Venus bisecta Conrad, 1849, p. 724, pl. 17, figs. 10, 10a.

Cyprina bisecta (Conrad): Conrad, 1865, p. 153.

Thyatira? [sic] *bisecta* (Conrad): Meek, 1864, p. 8, 29–30. [*Thyasira*?]

Conchocele bisecta (Conrad): Gabb, 1868, p. 99.

Cryptodon bisectus (Conrad): Dall, 1895, p. 713, pl. 26,

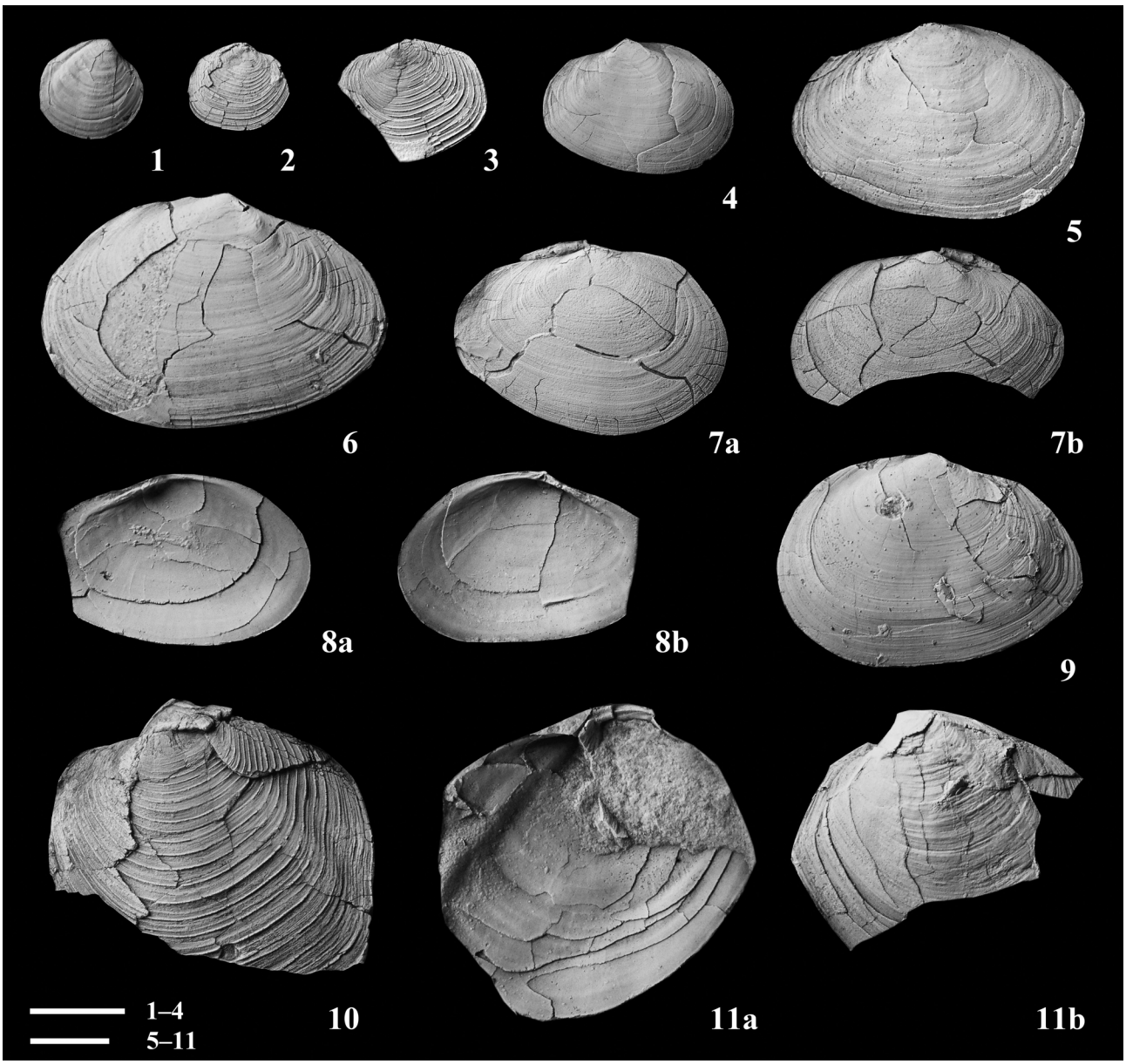

Figure 7. Mollusca from Tsubetsu Formation (2)

1, **11**: *Conchocele bisecta* (Conrad) オウナガイ. 1: HUEK CF-00184; 11: HUEK CF-00183 (11a: internal view; 11b: external view), silicon vinyl casts. **2**, **3**, **10**: *Lucinoma* sp. ツキガイモドキ属の一種. 2: HUEK CF-00180; 3: HUEK CF-00179; 10: KRMSHA 2-4-MG-010-1. All specimens silicon vinyl casts. **4**–**9**: *Macoma* (*Macoma*) *izurensis* (Yokoyama). イヅラシラトリ. 4: KRMSHA 2-4-MG-012-2; 5: HUEK CF-00187; 6: HUEK CF-00185; 7: KRMSHA 2-4-012-1 (7a: external view of right valve; 7b: external view of left valve). 8: HUEK CF-00188 (8a: internal view of left valve; 8b: internal view of right valve); 9: HUEK CF-000186. All specimens silicon vinyl casts. Scale bar: 10 mm.

figs. 2, 5.

Thyasira bisecta (Conrad): Dall, 1901, p. 817–818, pl. 40, fig. 8, pl. 42, fig. 5.

Conchocele disjuncta Gabb, 1866, p. 28, pl. 7, figs. 48–48b.

Lucina poronaiensis Yokoyama, 1890, p. 196, pl. 25, figs. 5a–c.

Thyasira bisecta var. *nipponica* Yabe and Nomura, 1925, p. 84–85, pl. 23, fig. 3, pl. 24, figs. 2–4.

Thyasira quadrata Yabe and Nomura, 1925, p. 92–93, pl. 23, figs. 1a–b.

Thyasira inflata Yabe and Nomura, 1925, p. 93–94, pl. 23, figs. 5a–b.

Thyasira (*Conchocele*) *bisectoides* Kuroda, 1931, p. 50–52, pl. 12, figs. 95–96.

Thyasira bisecta var. *humila* Krishtofovich, 1936, p. 24–28, pl. 2, figs. 1, 1a.

Thyasira bisecta var. *alta* Krishtofovich, 1936, p. 29, pl. 1, figs. 3, 4.

Thyasira disjuncta var. *ochotica* Krishtofovich, 1936, p. 35–39, pl. 3, fig. 2, pl. 4, figs. 1, 2, pl. 5, figs. 1–3.

Thyasira smekhovi Kogan, 1939, p. 16, pl. 2, figs. 5–9.

Thyasira bisecta omarui Oyama and Mizuno, 1958, p. 602–603, pl. 3, figs. 4a–7.

Conchocele scarlatoi Ivanova and Moskaletz, 1984, p. 46–48, fig. 1A–V.

Conchocele disjuncta explanata Korobkov in Zhidkova *et al*., 1994 [“1992”], p. 194–195, pl. 30, figs. 9, 10.

Conchocele bathyaulax Hickman, 2015, p. 10, 12, figs. 4A–F.

Conchocele taylori Hickman, 2015, p. 12, figs. 4E–G.

Conchocele kiritachiensis Hryniewicz, Amano, Jenkins and Kiel, 2017, p. 714, figs. 8, 9A1–H2.

Material examined.—HUEK CF-00183, CF-00184; KRMSHA 2-4-MG-011-1 through 2-4MG-011-3.

Remarks.—The specimens from the Tsubetsu Formation have a suborbicular shell in the juvenile stage (fig.7.1), and tending to become anteriorly oblique pentagonal with the shell growth (figs. 7.11a–b). The external shell surface is sculptured by shallow, commarginal wrinkles and very feeble growth lines. The posterior sulcus is distinct. These characters are well identical with the intraspecific variation of the Recent specimens of *Conchocele bisecta* (Conrad, 1849) described by Kharlamenko *et al*. (2016), the Tsubetsu specimens are safely identified as this species.

Although the classification of the fossil and Recent species/subspecies in the genus *Conchocele* Gabb, 1866 is controversial (*e.g*. Yabe and Nomura, 1925; Tegland, 1928; Khomenko, 1929; Grant and Gale, 1931; Kuroda, 1931; Makiyama, 1934; Krishtofovich, 1936; Kogan, 1939; Kamada, 1962; Kanno, 1971; Bernard, 1972; Moore, 1988; Honda, 1989; Noda, 1992; Squires and Gring, 1996; Coan *et al*., 2000; Kamenev *et al*., 2001; Lutaenko and Noseworthy, 2012; Hickman, 2015; Hryniewicz *et al*., 2017), I herein adopt the species concept by Coan *et al*. (2000), as listed in the synonymy.

Recently, Amano *et al*. (2019) proposed a new species, *Conchocele yatsuoensis*, from the upper lower Miocene Kurosedani Formation in Toyama Prefecture, central Japan. According to them, it differs from *Conchocele bisecta* in having a smaller, thinner shell with a deeply concave lunule.

Distribution.—The present species is recorded from the late Middle Eocene onwards in the North Pacific region (Coan *et al*., 2000).

Order Cardiida

Superfamily Tellinoidea

Family Tellinidae

Subfamily Macominae

Genus *Macoma* Leach in Ross, 1819

Subgenus *Macoma* Leach in Ross, 1819

***Macoma* (*Macoma*) *izurensis* (Yokoyama, 1925)**

イヅラシラトリ

Figures 7.4–7.9

Tellina izurensis Yokoyama, 1925a, p. 19, pl. 2, fig. 12.

Macoma (s.s.) *calcarea izurensis* (Yokoyama): Watanabe *et al*., 1950, pl. 4, fig. 9.

Macoma izurensis (Yokoyama): Hatai and Nisiyama, 1952, p. 140; Makiyama, 1957, pl. 17, fig. 12; Araki, 1960, p. 97–98; Kamada, 1962, p. 132–133, pl. 15, figs. 7–9; Itoigawa in Itoigawa *et al*., 1974, pl. 30, figs. 1–11; Yamaoka, 1993, pl. 3, figs. 6, 7; Morita *et al*., 1996, p. 156–157 [*pro parte*], pl. 9, figs. 5–10.

Macoma tokyoensis Makiyama: Shikama, 1954, pl. 5, fig. 8. [not of Makiyama, 1927]

Macoma calcarea (Gmelin): Oyama, 1961, p. 416. [not of Gmelin, 1791]

Macoma (s.s.) *izurensis* (Yokoyama): Shikama, 1964, p. 143, pl. 48, fig. 10.

Macoma sp.: Shikama and Kase, 1976, pl. 2, figs. 1, 2.

Macoma calcarea (Gmelin): Noda, 1992, p. 79–80 [*pro parte*], pl. 6, figs. 2, 5 [*non* pl. 16, figs. 2, 4] [not of Gmelin, 1791]

?*Macoma izurensis* (Yokoyama): Noda, 1992, p. 80–81, figs. 1a–b.

Non Macoma izurensis (Yokoyama): Tsuru, 1983, p. 65–66, pl. 14, figs. 6, 7. [=*Thracia* (*Homoeodesma*) *kamayasikiensis* Hatai, 1940]

Material examined.—HUEK CF-00185 through CF-00194; KRMSHA 2-4-MG-0012-1 through 2-4-MG-012-50.

Remarks.—*Macoma* (*Macoma*) *izurensis* (Yokoyama, 1925a) closely resembles the Recent *Macoma* (*Macoma*) *calcarea* (Gmelin, 1791), originally described from the sea around Iceland. Some authors considered it as a junior synonym or a subspecies of *M*. (*M*.) *calcarea* (*e.g*. Watanabe *et al*., 1950; Oyama, 1961). However, it is distinguished from *M*. (*M*.) *calcarea* by having a broader, obliquely truncated posterior margin (see Coan, 1971; Gladenkov *et al*., 1980; Coan *et al*., 2000).

The present species differs from *Macoma* (*Macoma*) *praetexta oinomikadoi* Otuka, 1939 from the lower Pleistocene Hamada Formation in Aomori Prefecture, northeast Japan, by having a smaller, longer shell with beaks situated more anteriorly, and a longer, more broadly truncated posterior margin.

The Recent *Macoma* (*Macoma*) *tokyoensis* Makiyama, 1927 is easily discriminated from *Macoma* (*Macoma*) *izurensis* by having a more oblique posterior dorsal margin, narrower posterior margin, sharper posterior ridge, narrower area between posterior ridge and posterior dorsal margin, much strongly flexed posterior dorsal area on the left valve, and deeper pallial sinus on the left valve.

Distribution.—Chikubetsu and Tsubetsu formations (Hokkaidō); Hon'ya Formation (Fukushima Prefecture); Kokozura Formation (Ibaraki Prefecture); Akabira Formation (Saitama Prefecture); Tomikusa Group (Nagano Prefecture); Morozaki Group (Aichi Prefecture); Yamanouchi Formation of Mizunami Group (Gifu Prefecture); Kaisekizan Formation of Ichishi Group (Mie Prefecture), early Miocene.

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北海道津別地域の最下部中新統津別層の新産地から得られた深海性貝類化石群集

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要旨: 北海道津別町の道道 27 号北見－津別線の切り通しの造成に伴い発生したズリから多数の貝類化石が得られた．ズリが発生した切り通しの法面はすでに工事の進行により被覆されていたが，周辺地域の調査から，化石の産出層準は津別層群津別層「硬質頁岩部層」下部（前期中新世最初期）であると推定された．分類学的な検討の結果，5 種の腹足綱，1 種の掘足綱，8 種の二枚貝綱が識別された．これらのうち，二枚貝綱の 1 種（*Malletia tsubetsuensis* Matsubara, n. sp. ツベツスミゾメソデガイ，和名新称）は新種である．また，*Conchocele bisecta* (Conrad) オウナガイと *Acharax tokunagai* (Yokoyama) トクナガキヌタレガイは津別層群から初めて記録される．岩塊中の産状と産出頻度から，*Macoma-Malletia* 群集と *Malletia* 群集の 2 つの貝類化石群集が識別される．これらの化石群集の構成要素に基づき，津別層「硬質頁岩部層」下部は下部浅海帯下部～上部漸深海帯上部（100 ～ 300 m）の水深で堆積したと推定される．これらの群集を含む達媚－津別動物群には *Hataiyoldia tokunagai* Fauna（サザナミソデガイ群集）を特徴づける属・種が知られており，本群集の産出層としては最古の一つとなる．本州における *Hataiyoldia tokunagai* 群集の産出は，かつては熱帯海中気候事件の時代（前期中新世末～中期中新世最初期）に北海道南部にまで達した表層の暖流の下に親潮潜流が舌状に張り出した証拠とされてきた．しかしながら，近年の浮遊性微化石層序および年代層序データから，この群集は前期中新世後期（約 18Ma）の汎世界的な寒冷イベントにより中部日本にまで南下した可能性が示唆される．

最後に，本新産地から産出した *Malletia tsubetsuensis* Matsubara, n. sp. を含む 14 種全種について，分類学的記載・考察を行った．