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Miocene mollusca from the Tachikaraushinai Formation, northern Hokkaido, Japan

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Abstract

Miocene molluscs occurring with the marine mammal *Desmostylus mirabilis* Nagao in the Miocene Tachikaraushinai Formation, northern Hokkaido, are described taxonomically here for the first time. They are characterized by the dominance of the bivalve *Neogenella okadana* (Yokoyama), associated with many species in common with the Miocene Kakert and Etolon Formations in Kamchatka, Russia, and also with the lower Togeshita fauna of Hokkaido. This molluscan assemblage is assigned a Middle Miocene (around 14 Ma) age based on diatom biostratigraphy. It inhabited a sandy bottom in a very shallow marine environment in a mild- to cool-temperate realm.

Key words: Tachikaraushinai Formation, Miocene, Kamchatka, Hokkaido, *Desmostylus*

Introduction

The Tachikaraushinai Formation is well-known for its very well-preserved desmostylian fossils, which occur abundantly associated with many molluscan fossils (Akiyama and Kumano, 1973; Yamaguchi, 1978; Shibata and Tanai, 1982; Yamaguchi and Suda, 1981; Yahata and Kimura, 2000). However, although the molluscan fossils were reported preliminarily by Akiyama and Kumano (1973) and Ogasawara et al. (1981), detailed taxonomic studies have not been carried out on them. Subsequently, Ogasawara (1986, 1994) discussed the zoogeographical significance of this fauna as an ancestral parallel community of the Plio-Pleistocene Omma-Manganjian Fauna.

Fujimoto et al. (1998) described the Neogene stratigraphy of the Utanobori-cho area, including the Tachikaraushinai and Shibiutan Formations, and discussed the geological age of these strata. They provided a list of the molluscs of the Shibiutan Formation.

In the present paper, molluscs from the Middle Miocene Tachikaraushinai Formation are described taxonomically. Their paleogeographical significance is also discussed.

Geological setting

Neogene strata are well exposed along the Sea of Okhotsk borderland from the Shiretoko Peninsula through the Abashiri to Esashi areas in Hokkaido. However, there are few strata yielding abundant shallow-marine molluscs in the borderland area, such as the Tachikaraushinai, Shibiutan and Chirai Formations. The molluscs in these formations are very important for considering evolutionary changes in so-called cold-water molluscs, as well as paleobiogeographical changes in the Northwest Pacific during the Miocene.

Neogene strata distributed in and around the Utanobori-cho (Fig. 1) have been studied by several workers as well as being revised by Fujimoto et al. (1998) . They can be divided into the Ofuntarumanai, Tachikaraushinai, Tokushibetsu and Shibiutan Formations, in ascending order (Ogasawara et al., 1993; Fujimoto et al., 1998). Among these, stratigraphic relationships between these strata are unconformable, except for that between the Tokushibetsu and Tachikaraushinai Formations (Fig. 2), which is conformable.

The Ofuntarumanai Formation, unconformably overlain by the Tachikaraushinai Formation, is mainly composed of green felsic pyroclastic rocks and altered andesite. A 14.3 ± 1.0 Ma fission-track age was reported from the Ofuntarumanai Formation by Koshimizu and Kim (1986a, b).

The base of the Tachikaraushinai Formation is composed of welded tuff or basal conglomerate. The main portion of the formation consists of sandy tuff, which attains more than 100 m in thickness. The upper part of the formation is composed of medium-to fine-grained sandstone containing many molluscan and desmostylian fossils. A K-Ar age of 13.8 Ma was reported from this welded tuff by Shibata and Tanai (1982).

The Tokushibetsu Formation is composed of interfingering dark gray siltstone and andesitic subaqueous pyroclastics. A K-Ar date of 13.7 Ma was reported from the andesite by Shibata and Tanai (1982). The scaphopod fossil *Fissidentalium yokoyamai* (Makiyama, 1931) occurs commonly in the siltstone. Ogasawara and Masuda (1989) suggested that the formation was deposited in outer neritic conditions.

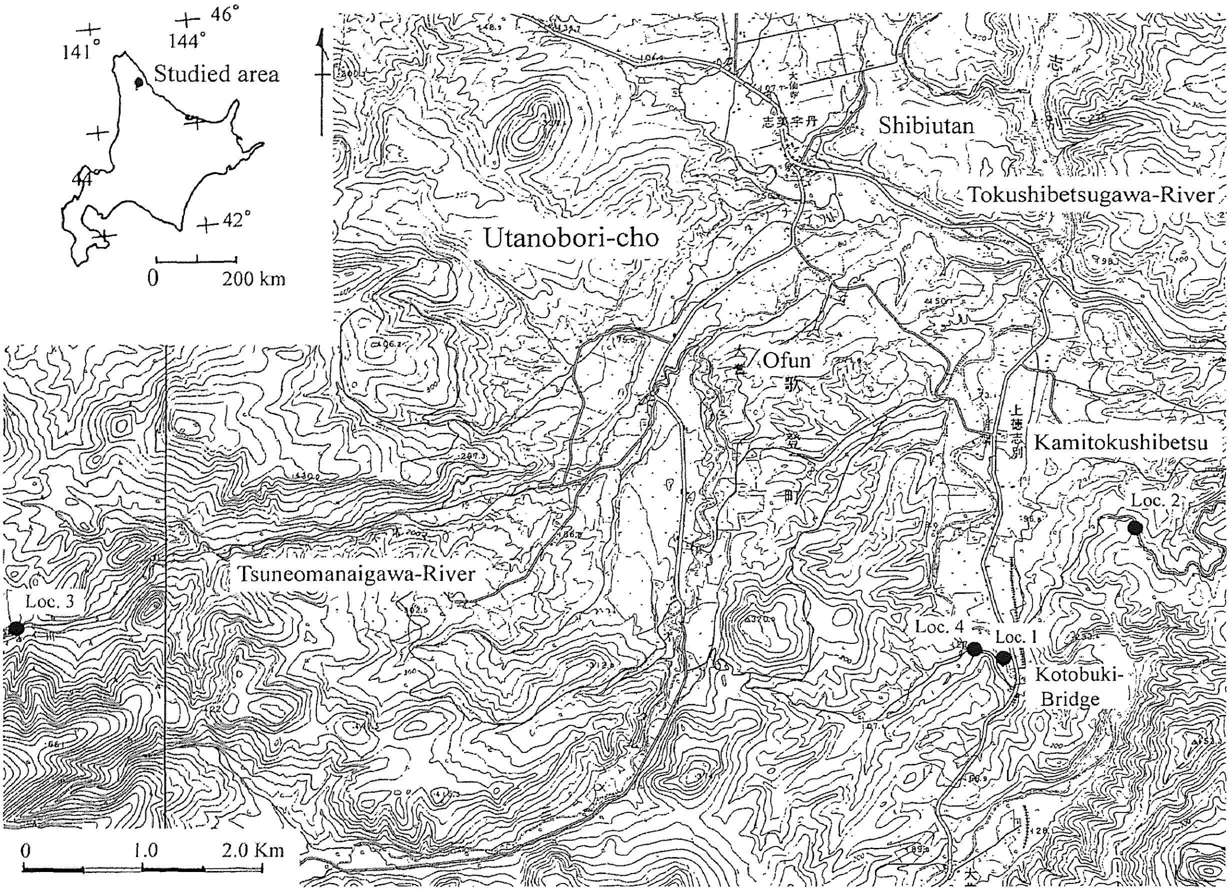

Fig.1. Fossil localities of the middle Miocene Tachikaraushinai Formation (from 1:50,000 maps "Occhuube" and "Otoinepu", Geographical Survey Institute of Japan).

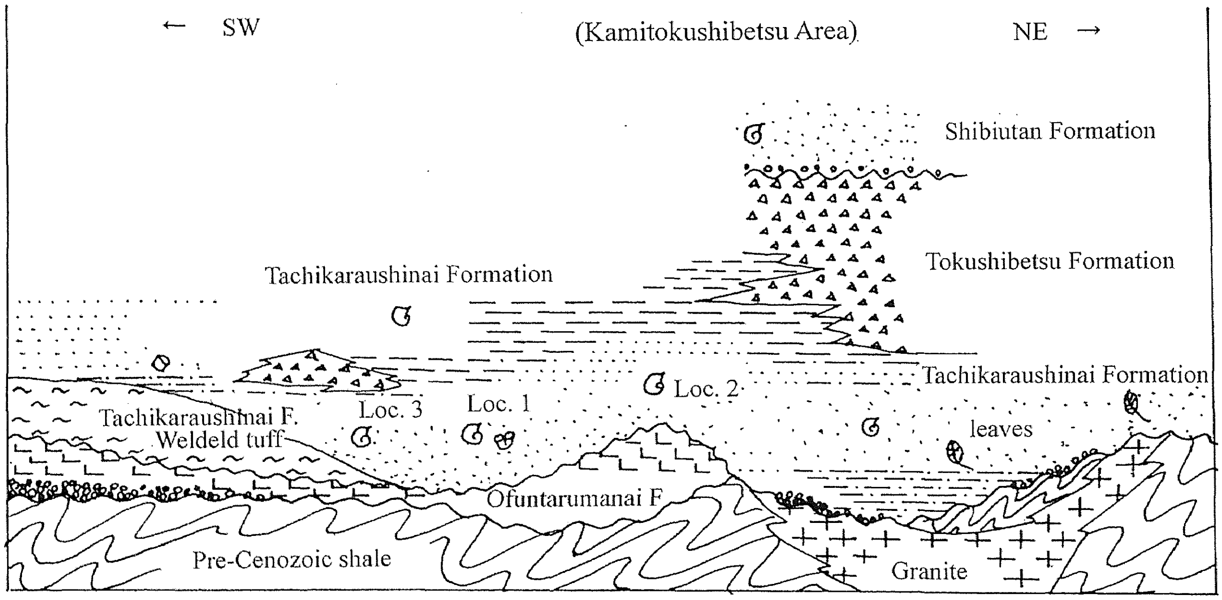

Fig. 2. Stratigraphy and generalized stratigraphic horizons of the fossil localities.

The Shibiutan Formation, unconformably overlying the Tachikaraushinai Formation, is mainly composed of conglomerate and sandstone. From the Shibiutan Formation, *Mizuhopecten slodkewitschi* Sinelinikova, 1969, has been recognized, associated with many molluscs such as *Anadara hokkaidoensis* Noda, 1966, *Dosinia kaneharai rumoiensis* Amano, 1983, and *Chlamys cosibensis* (Yokoyama, 1911) (Ogasawara et al., 1993; Fujimoto et al., 1998). *M. slodkewitschi* originally was described from the Miocene Etolon Formation in western Kamchatka. Sandstone of the middle to upper portion of the Shibiutan Formation exhibits large-scale cross stratification and foreset beds. These sedimentary facies suggest that the formation consists of deltaic deposits, corresponding to upwards shallowing through the formation.

According to Fujimoto et al. (1998), the Shibiutan Formation can be assigned to the *Denticulopsis praedimorpha* diatom zone of Koizumi (1985), which ranges chronologically from 12.9 to 11.5 Ma (Saito, 1999). Consequently, the geological age of the Tachikaraushinai Formation is regarded as early Middle Miocene (14-12 Ma).

Locality and mode of occurrence of molluscan fossils

Molluscan fossils of the Tachikaraushinai Formation have been collected from four localities (Fig. 2). Locality 2 is the oldest, and the others are stratigraphically higher. The main locality for molluscan fossils (locality 1) is the locality where *Desmostylus mirabilis* occurs (Yamaguchi, 1978) and is exposed along the bed of the Tokushibetsu River, about 100 m downstream from the Kotobuki Bridge, Kamitokushibetsu, Utanobori-cho. At this locality, very well preserved molluscs occur abundantly in a fine-grained sandstone bed a few meters thick, which lies about 100 m above the base of the formation. Bivalves at this locality mostly occur with conjoined valves, and many preserve their delicate surface sculpture.

Molluscan fossil locality no. 2 is in the basal part of the formation exposed in a roadside cutting about 2 km south of Tachikaraushinai town. In this area, the formation overlies the pre-Tertiary rocks, which are composed of granite and hornfelsic black shale. Molluscs from sandstone at this locality have a scattered mode of occurrence and are found as molds or casts. These molluscs, not abundant in either species or specimens, are distinguished from those at other localities by the occurrence of pectinids and limpets.

Locality no. 3 is a roadside cutting along the upper stream of the Tsuneomanai River, about 7 km west of Ofuntarumanai town. Here molluscs occur in bluish-gray, hard, fine-grained sandstone, again as casts and molds. This molluscan assemblage is very similar in species composition to that of the Kamitokushibetsu locality (locality 1).

The last locality (locality 4) is specimens from a reworked block of the formation that slid into the basal part of the Shibiutan Formation about 100 m northwest of locality 1. This block may have been derived from a similar horizon to that of locality 1, because the lithofacies and molluscan assemblages of the block closely resemble those at locality 1. However, some peculiar species such as *Glycymeris cisshuensis* occurred only in this block.

Molluscan associations

Molluscan fossils from the Tachikaraushinai Formation are shown in Table 1. *Glycymeris cisshuensis* specimens that occurred at locality 4 are included in locality 1, as noted above. The Tachikaraushinai assemblage is characterized by the abundant occurrence of *Neogenella okadana* (Yokoyama, 1932), *Felaniella usta* (Gould, 1861) and *Panopea nomurae* Kamada, 1962, in association with *Thracia, Mercenaria, Nuttallia, Macoma* and *Tectonatica* species, and also *Desmostylus* species (locality 1). The dominant species in this assemblage are shallow-marine dwellers of sandy mud bottoms (Habe, 1977), mainly inhabiting the temperate realm. In particular, species of *Anadara* and *Dosinia* are regarded as belong to the temperate realm from molluscan biogeography (Kuroda and Habe, 1952; Higo, 1973; Habe, 1977). Other taxa that occur with *Anadara* and *Dosinia* species, such as *Chlamys* (*C.* aff. *strategus* Dall, 1898), *Thracia, Clinocardium, Spisula* and *Boreotrophon* species, live mainly in the subarctic realm in modern seas (Scarlato, 1981). This Tachikaraushinai molluscan association also resembles those of the Plio-Pleistocene Omma-Manganijian fauna (Otuka, 1939; Ogasawara, 1977) from the view point of a parallel community.

Species / Locality no.	Loc. 1	Loc. 2	Loc. 3
Glycymeris idensis Kanno	C	R	C
Glycymeris cisshuensis Makiyama	R	–	–
Arca aff. *boucardi* Jousseaume	R	–	–
Anadara hokkaidoensis Noda	F	–	R
Chlamys otukae Masuda and Sawada	F	–	–
Chlamys aff. *strategus* (Dall)	F	–	–
Chlamys sp.	–	R	–
Anomia chinensis Philippi	C	–	–
Fellaniella usta (Gould)	VA	F	–
Lucinoma annulata (Reeve)	C	–	–
Thracia kakumana (Yokoyama)	A	–	C
Clinocardium ponchibaense Amano	C	R	F
Neogenella okadana (Yokoyama)	VA	–	VA
Mercenaria yiizukai (Kanehara)	C	–	C
Dosinia (*Phacosoma*) *owadaensis* Amano	F	–	F
Protothaca nodai Amano	F	–	–
Ezocallista aff. *kavranensis* (Ilyina)	R	–	–
Megangulus tmatumotoi (Otuka)	C	C	F
Macoma incongrua (v. Martens)	A	–	–
Macoma calcarea (Gmelin)	A	–	–
Macoma tokyoensis Makiyama	F	–	–
Macoma cf. *nipponica* (Tokunaga)	R	–	–
Macoma sp.	R	F	F
Rexithaerus sectior (Oyama)	C	–	–
Nuttallia ezonis Kuroda and Habe	C	–	–
Spisula onnechiuria (Otuka)	F	–	F
Solen cf. *krusensterni* Schrenck	F	–	–
Panopea nomurae Kamada	A	–	C
Anisocorbula venusta (Gould)	R	–	–
Mya japonica Jay	C	–	–
Teredo sp.	F	–	–
Compressidens kikuchii (Kuroda and Habe)	–	C	–
Collisella cassis shirogai Habe and Ito	–	R	–
Acmaea (*Niveotectura*) *pallida* (Gould)	F	–	–
Littorina squalida (Broderip and Sowerby)	R	–	–
Tectonatica janthostomoides Kuroda and Habe	C	–	F
Nuccella freycineti saitoi Hatai and Kotaka	F	–	–
Crepidula grandis Middendorff	C	–	–
Buccinum sp.	R	–	–
Sydaphera sp.	R	–	–
Boreotrophon cf. *beringi* Dall	R	–	–
Olivella sp.	F	–	–
Rectiplanes sp.	R	–	–

R: Rare (1 individual), F: Few (2-3 individ.), C: Common (4-9 individ.),
A: Abundant (10-29 individ.), VA: Very abundant (more than 30 individ.)

Table 1. Molluscan fossils from the Tachikaraushinai Formation.

Geological age and correlation

Molluscan associations of the Tachikaraushinai Formation can be correlated with those of the Kakert and Etolon Formations of western Kamchatka (Gladenkov et al.,1984), in general. Molluscs of these strata are characterized by the dominance of *Neogenella* species. *Neogenella gretschischkini* Slodkewitsch, 1938, and *N. kavranensis* Slodkewitsch, 1938, described from the Miocene of Kamchatka (Slodkewitsch, 1938), are considered to be part of the intraspecific variation of *Neogenella okadana* (Yokoyama, 1932), which was described from Hokkaido. In addition, pectinid and venerid species are similar to each other. These molluscs from the Tachikaraushinai Formation are also correlatable with the lower assemblage of the Togeshita fauna (Amano, 1983) and the Atsunai-Togeshita fauna (Uozimi and Akamatsu, 1988; Suzuki, 2000).

Molluscan fossils of the Shibiutan Formation, which overlies the Tachkarauchinai Formation, were listed and their paleontological significance discussed by Fujimoto et al. (1998). Molluscs of the Tachikaraushinai Formation also resemble those of the Shibiutan Formation.

According to Fujimoto et al (1998), the Shibiutan Formation can be assigned to the *Denticulopsis praedimorpha* Zone. Some fission-track ages and K-Ar dates have also been reported from the Tachikaraushinai Formation and adjacent strata (Shibata and Tanai, 1982; Koshimizu and Kim, 1986a, b). As a result, the geological age of the Tachikaraushinai Formation can be assigned to around 14 Ma (Fujimoto et al., 1998).

Paleoenvironment

As noted above, molluscan fossils of the Tachikaraushinai Formation mainly consist of very shallow marine dwellers (Ogasawara and Masuda, 1989). However, the formation does not contain any elements indicating brackish conditions. I consider that the assemblage inhabited mainly the sandy bottom of a coastal area in waters shallower than 20-30 m depth.

Shallow marine temperatures during the Early to Middle Miocene in northern Japan are considered to have lain in the warm to mild-temperate zones rather than the cool-temperate zone (Ogasawara, 1994). According to Ogasawara (2000), the living conditions of *Desmostylus* were warm-temperate to cool-temperate (15°C mean annual temperature). The occurrence of mild-temperate elements such as *Olivella, Anadara* and *Dosinia* suggests that marine temperatures were mild-temperate during the deposition of the Tachikaraushinai Formation. It is also considered that the mild to cool-temperate zone occupied the northern Pacific area widely during the Middle Miocene, including in Sakhalin and Kamchatka.

Zoogeographical significance

The Middle Miocene Tachikaraushinai assemblage is characterized by the dominant occurrence of *Neogenella* species, in association with typical warm-water genera such as *Anadara, Dosinia* and *Olivella*. However, it is not similar to assemblages of the Kadonosawa fauna, because it has not yielded important elements of the early Middle Miocene Chikubetsu and Takinoue faunas, such as species of *Vicarya, Vicaryella*, and *Mytilus*, and such species as *Siratoria siratoriensis* (Otuka, 1934) *Dosinia nomurae* Otuka, 1934, *Anadara watanabei* Kanehara, 1935, and so on. It is also very similar to that of the Kakert and Etolon Formations of western Kamchatka (Ogasawara, 2005). This fauna is slightly younger than the early Middle Miocene one known as the Kadonosawa (Nishikurosawa) and/or Moniwa Formations that were deposited at around 16.4 and 15.3 Ma. The Tachikaraushinai fauna possibly corresponds to the typical Middle Miocene shallow molluscan association that occupied the northern part of the subtropical front, which has been located around central Hokkaido (Ogasawara et al., 2008). As a result, *Neogenella* species may be the key to recognizing molluscs of Middle Miocene age in the northern Pacific region. I consider that Tachikaraushinai-type molluscan associations possibly are rather widely distributed from Hokkaido to Sakhalin and Kamchatka in the northern Pacific.

When comparing the shallow marine Middle Miocene molluscs shared between the Honshu and Hokkaido-Kamchatka areas, some species of *Mizuhopecten, Chlamys, Modiolus,* and *Mytilus* and genera of Veneridae such as *Mercenaria, Neogenella, Dosinia, Protothaca* and *Ezocallista* are seen to be remarkable elements in the northern Pacific. These taxa succeeded in arriving in the north during cooling events of the Middle to Late Miocene in the northern Pacific region. In particular, *Mytilus* species are very abundant in the northern Pacific during the Miocene, and some species can be useful for molluscan biostratigraphy during late Cenozoic time (Uozumi and Akamatsu, 1988).

The Tachikaraushinai molluscan fauna is considered to be a descendent of the Chikubatsu-Takinoue fauna and also the ancestral one to some of the Miocene Togeshita (Shiobara-Yama) fauna and the Plio-Pleistocene Omma-Manganji molluscan fauna (Ogasawara et al., 2008).

Systematic palaeontology

Glycymeris idensis Kanno

Fig. 5-6

Glycymeris idensis Kanno, 1956, p. 267, pl. 38, figs. 1a-5; Masuda and Takegawa, 1965, pl. 1, figs, 2, 3; Mizuno et al., 1969, pl. 28, fig. 10; Gladenkov and Sinelinikova, 1990, p. 43, pl. 13, fig. 13, pl. 14, fig. 18.
Glycymeris (*Glycymeris*) *idensis* Kanno, Amano, 1986, p. 41, pl. 2, fig. 7; Amano et al., 1996, fig. 4,
Glycymeris i-idensis Kanno, Gladenkov et al., 1984, p. 177, pl. 31, figs. 9, 10.

Remarks: From a block of the Tachikaraushinai Formation reworked into the basal part of the Shibiutan Formation (locality 4), some articulated valves are at hand and have been examined. They are characterized by a small, flat shell about 30 mm in length. The surface is sculptured with about 45 radial ribs divided by shallow but distinct furrows, and also with many commarginal lines. These specimens of *Glycymeris idensis* Kanno, 1956 most nearly resemble those from the Ishiizawa Formation, Urahoro-Shiranuka district, Hokkaido.

Glycymeris cisshuensis Makiyama

Fig. 4-4a-b

Glycymeris cisshuensis Makiyama, 1926, p. 155-156, pl. 13, figs. 2, 3; Matsukuma, 1986, pl. 5, figs. 7-8; Iwasaki, 1970, p. 393, pl. 4, figs. 6, 7; Amano et al., 1996, figs. 4, 13.

Remarks: Two well-preserved left valves were collected with poorly preserved specimens. One of these is characterized by an asymmetrical form at a moderate size. It is 59.1 mm in length, 57.45 mm in height, and 19.2 mm in depth, and is characterized by strong teeth that are continuously arranged along the hinge plate, about 12 in number on both sides, by its prominent beak, and by having about 40 crenulations around the inner ventral margin. These characters are most closely similar to those of *Glycymeris cisshuensis* Makiyama, described from the Early Miocene of North Korea. The present species also resembles *Glycymeris matsumoriensis* Nomura and Hatai, 1937, described from the Miocene Otsutsumi Formation in the environs of Sendai, Miyagi Prefecture (Nomura and Hatai, 1937). However, this species can be distinguished from G. *matumoriensis* by having simple ligamental grooves. In addition, the size and grooves of the ligamental area match well with those of the type specimens of the present species. Some of the poorly preserved specimens are also able to be identified as the present species, although they are small.

Glycymeris slodkewitschi Sinelinikova, 1984, described from the Etolon Formation of Kamchatka, also resembles the present species. However, it can be discriminated by having a narrower umbonal angle. *Glycymeris idensis*, reported from the Ishiizawa Formation by Amano (1986), also can be distinguished from the present species by having a narrower umbonal angle, fewer marginal crenulations and a less prominent umbonal area.

Fossil records of *Glycymeris* by Masuda and Noda (1976, pp. 77-78), Matsukuma (1986, p. 90) and Kafanov et al. (2001, p. 37) should be referred to *G. cisshuensis*. As a result, the present species is recorded from Oligocene to Middle Miocene rocks from Kyushu to southern Sakhalin in warm-temperate to mild-temperate realms.

Anadara (*Anadara*) *hokkaidoensis* Noda

Fig. 4-1a-b, 4-2a-b

Anadara (*Anadara*) *hokkaidoensis* Noda, 1966, p. 90-91, pl. 4, figs. 18-19, pl. 5, fig. 14, pl. 8, figs. 1, 8; Amano, 1983, p. 39-40, pl. 1, figs. 5, 9, 11-12.
Anadara ninohensis (Otuka), Gladenkov et al., 1984, p. 176, pl. 31, figs. 2, 3.
Anadara (*Anadara*) *ninohensis* (Otuka), Gladenkov and Sinelinikova, 1990, p. 342, pl. 20, figs. 4, 6, 10.

Remarks: Small *Anadara* specimens, less than 40 mm in length, were collected commonly from locality 1. These specimens are characterized by about 31–34 bifurcated radial ribs. Although there are some other Miocene species that bear more or less than 30 bifurcated radial ribs, such as *Anadara ogawai* Makiyama, 1926, *A. tsudai* Noda, 1966, *A. arasawaensis* Noda, 1966, *A. iwatensis* Noda, 1966, *A. watanabei* (Kanehara, 1935) and *Anadra hidakaensis* Kubota, 1953, these specimens can be identified as immature ones of *Anadara hokkaidoensis* by having the radial ribs noted above, the umbonal area not prominent, and a narrow ligamental area. According to the original description by Noda (1963), *Anadara hokkaidoensis* has about 28–29 radials, but it has a wider range of 26–33 ribs according Amano (1983). Some specimens reported as *Anadara ninohensis* (Otuka, 1934) from Kamchatka (Gladenkov et al., 1984, pl. 31, figs. 2-3) have been examined and are considered to belong to the present species, judging from their characteristic radial ribs.

Arca aff. *boucardi* Jousseaume

Fig. 5-1.

Compared with: *Arca* (*Arca*) *boucardi* Jousseaume, Noda, 1966, p. 55-57, pl. 6, figs. 12, 19; *Arca boucardi* Jousseaume, Gladenkov et al., 1984, p. 175, pl. 31, figs. 6a-6b.

Remarks: This specimen is sculptured with about 45 smooth radial ribs, which are subdivided by narrow, shallow furrows. These characters are similar to those of *Arca minoensis* Itoigawa and Shibata, 1975, described from the Mizunami Group (Itoigawa and Shibata, 1975, p. 19, pl. 6, figs. 15-17; Itoigawa et al., 1982, p. 15, pl. 2, figs. 1a-b, 3a-b). However, this species differs from *A. minoensis* by having a narrower ligamental area. The specimen is most closely similar to *Arca boucardi*, living around the Japanese Islands.

Chlamys otukae Masuda and Sawada

Fig. 4-3

Chlamys otukae Masuda and Sawada, 1961, p. 19, pl. 4, figs. 1-5; Sawada, 1962, p. 71, pl. 1, figs. 5-7; Shikama and Ikeya, 1964, p. 39, text-figs. 5-4.
Chlamys (*Chlamys*) *otukae* Masuda and Sawada, Masuda, 1962, p. 182, pl. 19, figs. 13, 14, pl. 21, fig. 12.

Remarks: A few poorly preserved specimens are examined. The surface is sculptured with about 20–22 bifurcated radial ribs, with one scaly radial ribs in each interspace. These specimens are most closely similar to *Chlamys otukae*, which was described from the Miocene Oido Formation in Miyagi Prefecture.

Chlamys aff. *strategus* (Dall)

Figs.5- 4, 5-5, 5-20

Compared with: *Chlamys strategus* (Dall), Scarlarto, 1981, p. 185, photo. 185-187.

Remarks: Some fragmentary mouldic specimens are at hand. The shell is moderate in size, about 43 mm in height, with a large anterior ear. The surface is sculptured with about 10 radial ribs in the young stage, but their ribs are diversified towards the ventral margin, corresponding with growth. Some specimens show bifurcated primary ribs associated with the intercalation of secondary ribs in their interspaces.

These specimens resemble *Chlamys strategus* (Dall). However, they differ slightly in having more diversified radial ribs compared with those of *Chlamys strategus*. This species may be a form ancestral to *C. strategus*.

Chlamys sp.

Figs. 5-12, 5-13, 5-16.

Remarks: A few imperfect specimens are at hand. The shell is moderate in size, attaining about 50 mm in height, and sculptured with many fine ribs. The surface has about 18 primary ribs, which trifurcate towards the ventral margin, associated with intercalations in their interspaces.

This species resembles *Chlamys rosealbus* Scarlato, 1986, which was described on the basis of living specimens from the Japan Sea. However, it can be distinguished from *C. rosealbus* by having finer radial ribs. These specimens are identified here only to the generic level.

Felaniella usta (Gould)

Figs. 5-2, 5-3

Felaniella usta (Gould), Habe, 1977, p. 135, pl. 24, fig. 9, 10; Ogasawara, 1977, p. 112-113, pl. 11, figs. 7, 18; Amano, 1983, p. 44, pl. 1, figs. 6, 10a-b.

Measurements (in mm)

IGUT no.	Length	Height	Depth	H/L	D/L
50015-1	8.30	7.30	3.40/2	0.88	0.205
50015-2	11.0	9.85	4.80/2	0.90	0.218
50015-3	12.10	11.65	4.80/2	0.96	0.20
50015-4	13.00	11.60	5.0/2	0.89	0.192
50015-5	13.40	12.00	5.50/2	0.90	0.162
50015-6	16.25	14.50	6.80/2	0.89	0.209
50015-7	17.35	15.50	7.20/2	0.89	0.207
50015-8	18.10	16.80	7.75/2	0.93	0.215
50015-9	18.70	16.70	6.90/2	0.89	0.184
50015-10	19.10	17.00	7.80/2	0.89	0.204
50015-11	19.40	18.00	8.80/2	0.93	0.227
50015-12	19.30	17.70	8.90/2	0.02	0.231
50015-13	22.10	19.30	9.35/2	0.87	0.213

IGUT no.	Length	Height	Depth	H/L	D/L
50015-14	21.70	20.20	9.6/2	0.93	0.221
50015-15	22.60	20.20	10.00/2	0.92	0.221
50015-16	23.20	20.85	10.0/2	0.90	0.216
50015-17	22.60	20.00	10.10/2	0.89	0.223
50015-18	24.00	21.50	9.85/2	0.90	0.205
50015-19	23.85	23.10	ca.10/2	0.97	0.21
50015-20	25.75	23.60	5.75	0.92	0.223
Etolon F.	35.00	34.40	16.5/2	0.98	0.223

Remarks: The Utanobori specimens are rather small and weakly convex compared with those of the Etolon Formation of Kamchatka, and also with those from the Plio-Pleistocene Omma Formation, which have a depth/length ratio about 0.25. However, they cannot be discriminated from the living species *Felaniella usta* (Gould, 1861). This species has a time range from Oligocene to Recent. It has been recorded from the Togari Formation (Itoigawa et al., 1974), Kubota Formation (Iwasaki, 1970), Horomui Formation (Kanno et al., 1968), and so on. The present species is known from various strata in the early Middle Miocene to Recent of the northern Pacific (see Amano, 1983).

Thracia kakumana (Yokoyama)

Figs. 6-9, 6-11, 6-12

Tellina kakumana Yokoyama, 1927, p. 177, pl. 47, fig.14
Thracia kakumana (Yokoyama), Ogasawara, 1977, p. 102, pl. 17, figs. 8, 13
Thracai (*Homoedesma*) *kakumana* (Yokoyama), Matsubara, 2009, p. 183-185, figs. 8-2, 8-3, 8-5.

Measurements (in mm)

IGUT no.	Length	Height	Depth	H/L	D/L
50016-1	29.20	21.90	8.6/2	0.75	0.15
50016-2	40.0	ca.27	10.0/2	0.68	0.13
50016-3	36.90	26.15	9.8/2	0.71	0.13
50016-4	41.50	29.55	12.7/2	0.71	0.15
50016-5	ca.43.5	30.40	12.5/2	0.70	0.14
50016-6	40.90	30.0	10.6/2	0.73	0.13
50016-7	42.50	33.0	12.0/2	0.78	0.14
50016-8	41.50	30.10	13.2/2	0.73	0.16
50016-9	46.70	32.30	12.5/2	0.69	0.13
50016-10	45.30	33.50	13.9/2	0.74	0.15
50016-11	47.40	35.30	13.4/2	0.75	0.15

Remarks: Specimens of *Thracia kakumana* from the Omma Formation have a height/length ratio of 0.775 and a depth/length ratio of 9.16. The Utanobori specimens are rather small in general, but are difficult to discriminate from *Thracia kakumana*. These ratios in *Thracia kavranensis* Ilyina, 1963, are 0.78 and 0.105 and in *Thracia schencki* Clark, 1932, are 1.25 and 0.214, respectively. Both species were reported from the Ilvin Formation of Kamchatka by Gladenkovet al. (1984). These species are rather easily discriminated from the present species by having a more inflated shell and a higher form. The present species is easily distinguished from *Thracia itoi* Habe, 1961, which is known from the northern Pacific, in having a less inflated umbonal area and a higher shell form. For a full synonymy list for the present species, refer to Ogasawara (1977, p. 102) and Matsubara (2009).

Clinocardium ponchibaense Amano

Fig. 5-10

Clinocardium (*Keenocardium*) *ponchibaense* Amano, 1983, p. 47, pl. 3, figs. 1, 3, 12.

Remarks: The specimens from locality 1 are characterized by their moderate size, less than 50 mm in length, and their thin shell with more than 30 radial ribs and a few commarginal lines. The radials are convex-crested and are separated by very shallow, flat-bottomed interspaces, and attain at least 37 in number in rather well-preserved large specimens, although they are missing some ribs in the marginal area. So, it is certain that the total number of radial ribs attains more than 40.

These characters suggest that the present specimens can be identified as *Clinocardium* (*Keenocardium*) *ponchibaense*, described from the Togeshita Formation by Amano (1983). However, some of the type specimens of *Clinocardium ponchibaense* have narrower interspaces than those of the present specimens and also a greater number of radial ribs (37–48). These characters are considered to vary intraspecifically.

The present species resembles the living species *Clinocardium* (*Keenocardium*) *californiense* (Deshayes, 1841) which has about 40–45 radial ribs. However, *C. californiense* can be distinguished from *C. ponchibaensis* by having a more anteriorly situated beak and a less produced umbonal area.

Keenocardium menneri Kafanov, 1984 (in Gladenkov et al., 1984; Gladenkov and Sinelinikova, 1990, p. 70, pl. 1, figs. 1, 10), described from the Miocene of Kamchatka, is allied to the present species, but has fewer radial ribs.

Macoma calcarea (Gmelin)

Fig. 7-12, 7-17

Macoma (*Macoma*) *calcarea* (Gmelin, 1791), Habe, 1977, p. 207-208, pl. 46, figs. 2, 3.
Macoma calcarea (Gmelin), Habe and Ito, 1979, p. 145, pl. 50, fig. 11.

Measurements (in mm)

IGUT no.	Length	Height	Depth	H/L	D/L	Remarks
50018-12	26.30	20.90	-	0.79	-	right
50018-11	27.70	21.30	-	0.77	-	left
50018-10	33.65	26.20	-	0.78	-	left
50018-9	36.00	27.90	10.3/2	0.78	0.14	conjoined
50018-8	36.30	28.80	-	0.79	-	left
50018-7	41.00	32.20	-	0.79	-	left
50018-6	45.00	33.20	-	0.74	-	left
50018-5	ca,46.5	38.20	14.2/2	-	-	conjoined
50018-4	53.30	41.50	-	0.78	-	left
50018-3	52.20	41.50	ca.17/2	0.80	0.16	conjoined
50018-2	50.55	41.15	15.4/2	0.81	0.15	conjoined
50018-1	52.20	42.10	-	0.81	-	left

Remarks: The many specimens of *Macoma calcarea* can be divided into at least two forms. One is elliptical and the other is trigonal in shape. However, some specimens are intermediate in form. In general outline, some specimens closely resemble *Macoma inquinata* (Deshayes, 1854) and *Macoma contabulata* (Hanley, 1855). Tachikaraushinai specimens have a different, more deeply incurved pallial sinus from these two species.

Macoma incongrua (von Martens)

Figs. 7-10, 7-13, 7-14. 7-15, 7-18

Macoma incongrua (von Martens, 1865) (*non vide*); Habe and Ito, 1979, p. 145, pl. 50, figs. 9, 10.

Measurements (in mm)

IGUT no.	Length	Height	Depth	H/L	D/L	Remarks
50035-1	21.20	15.30	3.0	0.72	0.14	left
50035-2	29.00	21.00	8.3/2	0.72	0.14	conjoined
50035-3	32.40	26.0	4.0	0.80	0.12	right
50035-4	38.80	31.0	10.7/2	0.82	0.14	conjoined
50035-5	36.40	29.10	-	0.80	-	conjoined
50035-6	37.20	29.70	6.0	0.80	0.16	right
50035-7	38.30	30.30	-	0.79	-	left

Rexithaerus sectior (Oyama)

Figs. 7-6, 7-7, 7-8, 7-9

Macoma (*Rexithaerus*) *sectior* (Oyama), Habe, 1977, p. 210, pl. 42, figs. 11, 12.
Rexithaerus sectior (Oyama), Ogasawara, 1977, p. 122-123, pl. 14, figs. 5, 7.

Measurements (in mm)

IGUT no.	Length	Heigh	Depth	H/L	Valve
50021-1	21.90	15.85	-	0.72	right
50021-2	24.70	18.40	-	0.75	left
50021-3	28.10	21.30	-	0.73	left

Remarks: Although they are rather small and slightly taller in form compared with those of the early Pleistocene Omma Formation, the Tachikaraushinai specimens can be identified as *Rexithaerus sectior*. I regard the differences between these forms as intraspecific variation. For a full synonymy list of this species, refer to Ogasawara (1977).

Megangulus tmatumotoi (Otuka)

Figs. 6-4, 6-6, 6-7, 6-8

Tellina (*Peronidia*) *lutea t-matsumotoi* Otuka, 1940, p. 96, pl. 11, figs. 7, 8.
Peronidia t-matsumotoi (Otuka), Kanno et al., 1968, p. 10-11, pl. 1, figs. 9-10.
Megangulus tmatsumotoi (Otuka), Ogasawara, 2001, p. 331.

Measurement (in mm)

IGUT no.	Length	Heigh	Depth	Height /Length	Depth /Length	Valve
50022-1	Ca.70.0	38.80	12.8/2	ca.0.55	0.091	conjoined
50022-2	58.70	31.90	-	0.54	-	left
50022-3	65.00	36.10	-	0.56	-	left
50022-4	52.70	31.30	-	0.59	-	left
50022-5	ca.50	ca.27	-	ca.0.54	-	left
50022-6	47+	29.30	9.2/2	-	-	conjoined
50022-7	54.80	ca.27.3	-	0.50	-	left
50022-8	47.80	24.60	-	0.52	-	right
50022-9	47.0	24.85	-	0.53	-	left

Remarks: The Utanobori specimens show a rather wide range of variation, both in general shape and in surface sculpture. They are characterized by lacking a lunule, having a protruding ligament, and a ratio of ligament length/shell length of 0.35. This species is allied to *Megangulus luteus* (Wood, 1828), *M. elongatus* Uozumi, 1966, and *M. protovenulosus* Nomura, 1935. However, it can be discriminated from these species by having a more slender shell and a centrally situated beak.

Ezocallista aff. *kavranensis* (Ilyina)

Fig. 5-15

Compared with: *Macrocallista kavranensis* Ilyina, 1963, p. 105, pl. 44, figs. 4. 4a (*non vide*); *Callista kavranensis* (Ilyina), Gladenkov et al., 1984, p. 222, pl. 54, figs. 4, 6-9.

Measurements (in mm)

IGUT no.	Length	Height	Depth
50024	64.00	50.00	ca.14.0

Remarks: Compared with *Ezocallista brevisiphonata* (Carpenter, 1865), the Tachikaraushinai specimens have a less inflated shell and less prominent umbonal area. These characters closely resemble those of *Ezocallista kavranensis* (Ilyina, 1963), reported from the Etolon Formation, western Kamchatka.

Ezocallista kurodae Kamada, 1962, which was originally described from the Oligocene Iwaki Formation, Joban Coal-field, can be discriminated from the present specimens by having a more anteriorly situated beak with a quadrate shell outline. However, specimens from the Sankebetsu Formation, described by Noda (1992) as *Ezocallista kurodae*, are similar to the present specimens, as is shown by their rather low shell and their less anteriorly situated beak compared with the type specimens. But they also can be distinguished from the Tachikaraushinai specimens by having a more anteriorly situated beak.

Dosinia (*Phacosoma*) *owadaensis* Amano

Figs. 5-11, 5-14

Dosinia (*Phacosoma*) *owadaensis* Amano, 1983, p. 50, pl. 5, figs. 6a-8.

Measurements (in mm)

IGUT no.	Length	Height	Depth	Remarks
50023-1	32.30	29.90	11.50/2	conjoined
50023-2	39.40	36.85	-	right
50023-3	54.00	51.30	-	right
50023-4	41.25	42.80	9.5	right
50023-5	34.70	34.80	9.0	right
50023-6	40.00	36.80	9.2	right
50023-7	28+	25.7+	-	left

Remarks: This species from the Tachikaraushinai Formation is characterized by its deep pallial sinus, its distinct but small lunule, its narrowly developed eschutcheon, its flat shell, and its *Phacosoma*-type commarginal ribs. The ribs are about 26 in number within 10 mm near the ventral marginal. These characters suggest that this species is closely related to *Dosinia tugaruana* Nomura, 1935, which was described from the Miocene Tanosawa Formation, Aomori Prefecture.

Mercenaria yiizukai (Kanehara)

Figs. 5-18, 5-19

Venus (*Chione*) *securis* Schumacher, Slodkewitsch, 1938, p. 162-163, pl. 87, figs. 3-4b.
Venus (*Chione*) *y-iizukai* Kanehara, 1937, p. 794-796, pl. 25, figs. 1-4.
Mercenaria y-iizukai (Kanehara), Hayasaka and Uozumi, 1954b, p. 168-169, pl. 22, figs. 3-4; Kanno and Matsuno, 1960, pl. 5, fig. 5; Tanaka, 1960, p. 139, fig. 13; Mizuno et al.,1969, pl. 27, fig. 2.
Mercenaria yiizukai (Kanehara), Amano, 1983, p. 51, pl. 2, figs. 10-11, pl. 4, fig. 10.

Measurements (in mm)

IGUT no.	Length	Height	Depth	Remarks
50000-1	ca.69.0	ca.58	19.3	left
50000-2	56.70	46.30	ca.18.5	right
50000-3	67.0	53.4	ca.14	conjoined
50000-4	63.4	54.4	-	right
50000-5	ca.47	40.4	-	right
50000-6	61.80	55.30	-	left
50000-7	69.40	64.60	-	left
50000-8	ca.63	ca.54	-	right

Protothaca nodai Amano

Fig. 5-7

Protothaca nodai Amano, 1983, p. 52-53, pl. 3, figs. 5, 9, 13.

Measurements (in mm)

IGUT no.	Length	Height	Depth	Valve
50026-1	12.80	11.10	3.6	left
50026-2	13.50	11.50	-	left
50026-3	12.30	12.50	-	left
50026-4	10.20	8.70	-	right
50026-5	7.4	6.4	-	left

Remarks: This species is characterized by its small shell with 24–25 radial ribs, which are mostly bifurcated and crenulate the inner ventral margin. The present specimens are most similar to *P. nodai*, described from the Miocene Togeshita Formation. This species is similar to *Protothaca tateiwai* (Makiyama, 1926), *P. yanagawaensis* Nomuea and Zinbo, 1936, *P. jedoensis* (Lischke, 1874) , and *P. staleyi* (Gabb, 1866) described by Sinelinikova et al. (1976, p. 42-43) from the Pliocene Enemten Formation, western Kamchatka. However, *P. nodai* is characterized by its smaller shell and its large number of radial ribs.

Neogenella okadana (Yokoyama)

Figs. 6-1a-b, 6-2a-c, 6-3

Venus? *okadana* Yokoyama, 1932, p. 240, pl. 2, figs. 8, 9.

Pitaria gretschischkini Slodkewitsch, 1938, p. 434 (Russian), p. 165 (English), pl. 89, figs. 2, 2a, 1, 3-4; pl. 88, figs. 6a-b, pl. 90, figs. 1-2; Ilyina, 1957, p. 227, pl. 18, figs. 6. 6a

Pitaria kavranensis Slodkewitsch, 1938, p. 429 (Russian),164(English),pl.90,figs.3,3a,4;Simonova, 1941, p. 44, pl.17, fig. 9, pl. 18, fig. 8; Ilyina, 1957, p. 227, pl. 18, fig. 5; Krishtofovich and Ilyina, 1961, p. 19, pl. 19, fig. 7; Ilyina, 1963, p. 78, pl. 35, fig. 1.

Pitar okadana (Yokoyama), Uozumi, 1953, p. 357, pl. 22, fig. 178: Hayasaka and Uozumi, 1954a, p. 381-389, pl. 24, figs. 1-5, 7, 8.

Pitar (*Neogenella*) *gretschischkini* Slodkewitsch; Zhidkova et al., 1968, p. 109, pl. 28, figs. 3, 3a, pl. 34, fig. 3, pl. 35, figs. 1, 2, 6; Arkhipova et al., 1994, p. 225, pl. 42, fig. 5

Pitar (*Neogenella*) *uandiensis* Lautenshlager in Zhidkova et al., 1968, Gladenkov and Sinelinikova, 1990, p. 63, pl. 28, figs. 3a-b, 6, 9, 11.

Pitaria (*Neogenella*) *gretschischkini* Slodkewitsch var. *uandiensis* Lautenshlager, Zhidkova et al., 1968, p. 109, pl. 35, fig. 3, 4, 5.

Pitaria (*Neogenella*) *kavranensis* Slodkewitsch, Zhidkova et al., 1968, p. 110, pl. 4, fig. 5, pl. 47, fig. 2

Pitar cf. *kavranensis* Slodkewitsch, Zhidkova et al., 1972, p. 129, pl. 40, figs. 5, 6; Gladenkov et al., 1999, pl. 7, fig. 27

Pitar (*Neogenella*) *gretschischkini* (Slodkewitsch), Sinelinikova, 1976, p. 41, pl. 6, fig. 10; Gladenkov et al, 1987, pl. 5, fig. 4

Pitar kavranensis Slodkewitsch, Devjatilova and Volobueva, 1981, p. 93, pl. 52, figs. 7-9.

Pitar gretschischkini Slodkewitch, Devjatilova and Volobueva, 1981, p. 92, pl. 51, figs. 6, 7.

Pitar kavranensis (Slodkewitsch), Gladenkov et al., 1984, p. 221, pl. 54, figs. 2a-b, pl. 55, figs. 2a-b, 4a-b

Pitar gretschischkini (Slodkewitch), Gladenkov et al., 1984, p. 221, pl. 54, figs. 1a-b, 10, pl. 56, fig. 12

Neogenella okadana (Yokoyama), Uozumi et al., 1986, pl. 8, figs. 2, 4, pl. 10, figs. 1, 3a-b, 4: Noda,1 1992, p. 86-87, pl. 4, figs. 6a-b, 8a-b.

Measurements (in mm) (see table 2)

Table 2. Measurements of shell length, height and depth of *Neogenella okadana* (Yokoyama)

IGUT no.	Length	Height	Depth	Height/Length	Depth/Length	Valve
50027-1	20.85	17.20	6.30	0.82	0.30	left
-2	20.00	18.05	6.60	0.90	0.33	left
-3	24.00	22.60	11.50	0.94	0.48	left
-4	22.60	19.55	9.55	0.87	0.41	left
-5	20.40	21.85	10.55	1.07	0.52	left
-6	24.40	22.60	9.70	0.93	0.40	left
-7	26.00	23.30	ca.11	0.90	-	left
-8	22.35	25.20	-	1.13	-	left
-9	27.40	24.60	12.30	0.90	0.45	left
-10	28.15	25.55	10.70	0.91	0.38	left
-11	30.60	26.90	9.80	0.88	0.32	left
-12	28.85	28.00	12.30	0.97	0.43	left
-13	34.55	29.10	13.30	0.84	0.38	left
-14	35.65	29.50	12.30	0.83	0.35	left
-15	33.70	34.70	16.70	1.03	0.50	left
-16	40.30	36.10	15.40	0.90	0.38	left
-17	40.80	36.20	13.40	0.89	0.33	left
-18	38.50	33.80	15.30	0.88	0.40	left
-19	39.70	34.20	16.00	0.86	0.40	left
-20	40.85	35.60	16.30	0.87	0.40	left
-21	44.80	38.50	15.00	0.86	0.33	left
-22	40.80	36.90	18.00	0.90	0.44	left
-23	43.00	35.50	16.30	0.83	0.38	left
-24	45.20	37.40	15.50	0.83	0.34	left
-25	49.00	40.80	17.40	0.83	0.36	left
-26	50.10	45.00	17.30	0.90	0.35	left
-27	58.30	56.20	26.20	0.96	0.45	left
-28	44.30	51.70	23.70	1.17	0.53	left
-29	24.10	23.00	8.90	0.95	0.37	right
-30	27.30	25.00	7.15	0.92	0.26	right
-31	27.40	26.90	13.00	0.98	0.47	right
-32	28.50	23.70	9.30	0.83	0.33	right
-33	30.40	26.85	10.80	0.88	0.36	right
-34	31.75	29.30	13.20	0.92	0.42	right
-35	32.50	27.20	10.05	0.84	0.31	right
-36	33.10	31.10	15.00	0.94	0.45	right
-37	33.40	29.50	11.85	0.88	0.35	right
-38	32.80	29.30	13.80	0.89	0.42	right
-39	36.80	31.40	14.20	0.85	0.39	right
-40	33.00	28.85	13.40	0.87	0.41	right
-41	36.70	36.60	17.00	1.00	0.46	right
-42	37.60	36.50	16.00	0.97	0.43	right
-43	39.20	35.70	15.80	0.91	0.40	right
-44	45.35	38.10	15.80	0.84	0.35	right
-45	40.60	38.90	17.10	0.96	0.42	right
-46	39.85	36.20	17.00	0.91	0.43	right
-47	38.85	36.50	16.30	0.94	0.42	right
-48	42.80	37.40	16.00	0.87	0.37	right
-49	42.60	42.40	18.00	1.00	0.42	right
-50	41.20	39.65	16.80	0.96	0.41	right
-51	44.55	43.00	19.30	0.97	0.43	right
-52	47.50	41.70	17.00	0.88	0.36	right
-53	54.70	59.00	26.00	1.08	0.48	right
-54	34.60	32.80	26.0/2	0.95	0.38	conjoined
-55	39.85	36.70	32.5/2	0.92	0.41	conjoined
-56	43.00	35.20	23.5/2	0.82	0.27	conjoined
-57	45.70	38.30	31.6/2	0.84	0.35	conjoined
-58	43.10	38.20	36.0/2	0.89	0.42	conjoined
-59	45.20	42.50	37.0/2	0.94	0.41	conjoined

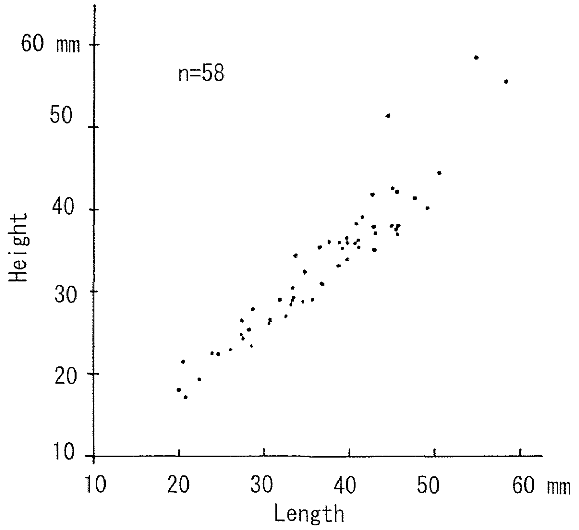

Fig. 3. Relation of height to length of *Neogenella okadana* (Yokoyama) obtained from the loaclity 2, of the Tachikaraushinai Formation

Remarks: *Venus*? *okadana* is now included in *Neogenella*, which was proposed by Krishtofovich (1955 *fide* Zhidkova et al., 1968) as a subgenus of *Pitaria*. The hinge structure of *Neogenella* is the same as that of *Pseudamiantis,* proposed by Kuroda (1933). *Pseudamiantis* is characterized by having radial striations on the central part of the shell surface. Some well-preserved specimens of *V. okadana* from the Tachikaraushinai Formation bear the same radial striations as *Pseudamiantis*. However, they are very faint. Therefore, this species should be included in *Neogenella*.

The shell form of this species has been compared in many well-preserved specimens, mainly from locality 1. This species shows a rather wide range of variation in shell form, particularly in adult specimens. For example, the ratios of height/length and depth/length of studied specimens range from 0.82–1.17 (average around 0.90) and 0.27–0.53 (average around 0.40), respectively (Table 2, Fig. 3).

The forms described as the supposed species *Pitar gretschischkini* and *P. kavranensis* from the Miocene strata of Kamchatka are included within the variation of *Neogenella okadana* from the Tachikaraushinai Formation. All of the forms listed in the synonymy therefore are considered to be synonymous with *N. okadana*. The present species is closely allied to *P. hokkaidoensis* (Nomura, 1935) which was described from the Miocene Togeshita Formation, Hokkaido, and also *P. itoi* (Makiyama, 1926) which is described Miocene of North Korea, however, it can be discriminated from *N. hokkaidoensis* and *N. itoi* in having elongated shell form.

Spisula onnechiuria (Otuka)

Fig. 7-16

Mactra (*Mactromeris*) *californica onnechiuria* Otuka, 1937, p. 168, figs. 1-3.
Spisula onnechiuria (Otuka), Otuka, 1940, p. 94, fig. 2, text-fig. b; Kanno and Matsuno, 1960, pl, 4, fig.7; Fujie et al.,1964,pl.7,fig.7;Uozumi,1966,p.130-131, pl. 10, figs, 1, 6; Kanno et al., 1968, p. 11, pl. 2, figs. 1-2.
Spisula (*Mactromeris*) *voyi onnechiuria* (Otuka), Amano, 1983, p. 53, pl. 6, figs. 6, 11.

Measurements (in mm)

IGUT no	Leength	Height	Depth	Remarks
50008-1	62.50	45.30	23.0/2	mold specimen
50008-2	51.2+	32.3+	ca.21.1	left

Nuttallia ezonis Kuroda and Habe

Figs. 6-10, 6-13, 7-11

Nuttallia ezonis Kuroda and Habe in Habe, 1955, p. 17-18, pl. 1, figs. 12-13; Habe, 1977, p. 224, pl. 46, figs. 11, 12.

Measurements (in mm)

IGUT no.	Length	Heigh	Depth	Height /Length	Depth/L	Remarks
50009-1	53.70	42.50	16.4/2	0.791	0.153	conjoined
50009-2	50.70	38.60	12.7/2	0.761	0.125	conjoined
50009-3	51.45	38.10	14.3/2	0.741	0.139	conjoined
50009-4	44.50	35.45	12.1/2	0.797	0.136	conjoined
50009-5	ca.55	39.45	-	-	-	left
50009-6	28.85	20.60	6.4/2	0.714	0.111	conjoined
50009-7	ca.30.2	23.10	8.7/2	0.765	0.144	conjoined
50009-8	35.60	25.00	9.4+/2	0.702	-	conjoined
50009-9	ca.31.5	23.80	-	-	-	left
50009-10	37.10	27.30	10.2/2	0.736	0.137	conjoined
50009-11	42.00	30.60	10.1/2	0.729	0.120	conjoined
50009-12	42.25	ca.27	-	-	-	right
50009-13	44.30	33.20	-	0.749	-	left
50009-14	49.0	36.00	13.4/2	-	-	conjoined

Remarks: The present species was described on the basis of Recent specimens from Akkeshi Bay, off Nemuro, Hokkaido (Habe, 1955). *Nuttallia ezonis* can be distinguished from *N. olivacea* (Jay, 1857) by having a truncated posterior margin. Radial striae on the posterior surface are preserved in only one specimen among the many Tachikaraushinai specimens. This species is allied to *N. commoda* (Yokoyama, 1925), recorded by Amano (1983) from the Togeshita Formation. However, it differs from the Togeshita specimens by having a smaller and more posteriorly elongated shell form.

Anisocorbula venusta (Gould)

Fig. 6-5

Anisocorbula venusta (Gould, 1961)、Habe, 1977, p. 282, pl. 59, fig. 9 ; Habe and Ito, 1979, p. 149, pl. 51, figs. 19, 20.

Measurements (in mm)

IGUT no	Length	height	Depth	Remarks
50032-1	10.60	6.90	3.6/2	about 30 concentric line
50032-2	10.00	6.60	3.8/2	same above

Panopea nomurae Kamada

Figs. 7-19, 7-20, 7-21

Panopea nomurae Kamada, 1962, p. 135-136, pl. 16, figs. 9-12; Habe, 1977, p. 285, pl. 60, fig. 16; Habe and Ito, 1979, p. 154, pl. 53, fig. 7; Suto et al., 2005, pl. 2, fig. 6.

Measurements (in mm)

IGUT no.	Length	Height	Depth	Valve
50012-1	78.00	43.80	29.1/2	conjoined
50012-2	71.00	43.90	24+/2	conjoined
50012-3	71.40	38.30	24.6/2	conjoined
50012-4	57.50	36.70	-	right
50012-5	64.00	38.90	-	ventral gaped
50012-6	69+	40.80	26.3/2	conjoined
50012-7	61.40	35.40	-	conjoined
50012-8	62.90	36.20	-	left
50012-9	62.50	35.50	20.6/2	
50012-10	51.90	35.20	23.7/2	
50012-11	59.50	32.00	22.0/2	
50012-12	48.70	28.90	17.6/2	conjoined
50012-13	51.10	30.50	17.1/2	deformed
50012-14	54.00	33.30	20.3/2	ventral gaped

Remarks: *Panopea nomurae* was reported from the Middle Miocene Numanouchi Formation of the Joban coal-field. The present specimens from the Tachikaraushinai Formation are characterized by their transversely elongated outline and anteriorly situated beak. These specimens are very similar to the type specimens (Kamada, 1962). This species can be discriminated from *P. japonica* A. Adams, 1850 by the larger shell, truncated posterior margin, rather high form, and centrally situated beak of *P. japonica.*

Littorina (Ezolittorina) squalida (Broderip and Sowerby)

Figs. 7-2a-b

Littorina (Ezolittorina) squalida (Broderip and Sowerby, 1829) (*non vide*), Habe and Ito, 1979, p. 25, pl. 7, fig. 8; Bracheva et al., 1984, p. 238, pl. 60, fig. 5, pl. 62, fig. 3

Remarks: This species has been reported from the Miocene Kakert and Etolon Formations, western Kamchatka (Bracheva et al., 1984).

Tectonatica janthostomoides Kuroda and Habe

Fig. 7-3

Tectonatica janthostomoides Kuroda and Habe, 1949, p. 71-72, text-figs. 1c, d.; Oyama, 1973, p. 32-33, pl. 7, figs. 12; Habe and Ito, 1979, p. 32, pl. 8, fig. 12.

Remarks: This species can be discriminated from *Tectonatica janthosotoma* by having two grooves along the outer margin of the operculum, whereas *T. janthostoma* has no groove (Kuroda and Habe, 1949; Habe and Ito, 1979)

Sydaphera sp.

Figs. 7-1a-b

Remarks: The specimen has 6 whorls with 8 spiral cords, of which 3 are situated on the shoulder, and about 12 longitudinal grooves (diameter 8.6 mm, height 15.6 mm). This species is allied to *Cancellaria* (*Sydaphera*) *fukushimana* Nomura and Hatai, 1936. It may be an immature specimen of *S. fukushimana,* however, it is identified only to the generic level because of its small size.

Compressidens kikuchii (Kuroda and Habe)

Fig. 7-5

Compressidens kikuchii (Kuroda and Habe), Habe, 1977, p. 337, pl. 70, figs. 9, 10.

Remarks: This species was named as *Dentalium kikuchii* by Kuroda and Habe (1952) for *Dentalium* (*Compressidens*) *stearnsii* Pilsbry and Sharpe, 1897, reported from Toyama Bay, as it was regarded as not conspecific with *D. steansii* Pilsbry and Sharpe. The species is distributed geographically from Toyama Bay, through off Sanriku, to the Kurile Islands and Sakhalin, and ranges in water depth from 100 to 500 m and/or 200 to 1250 m (Higo, 1973; Habe, 1977).

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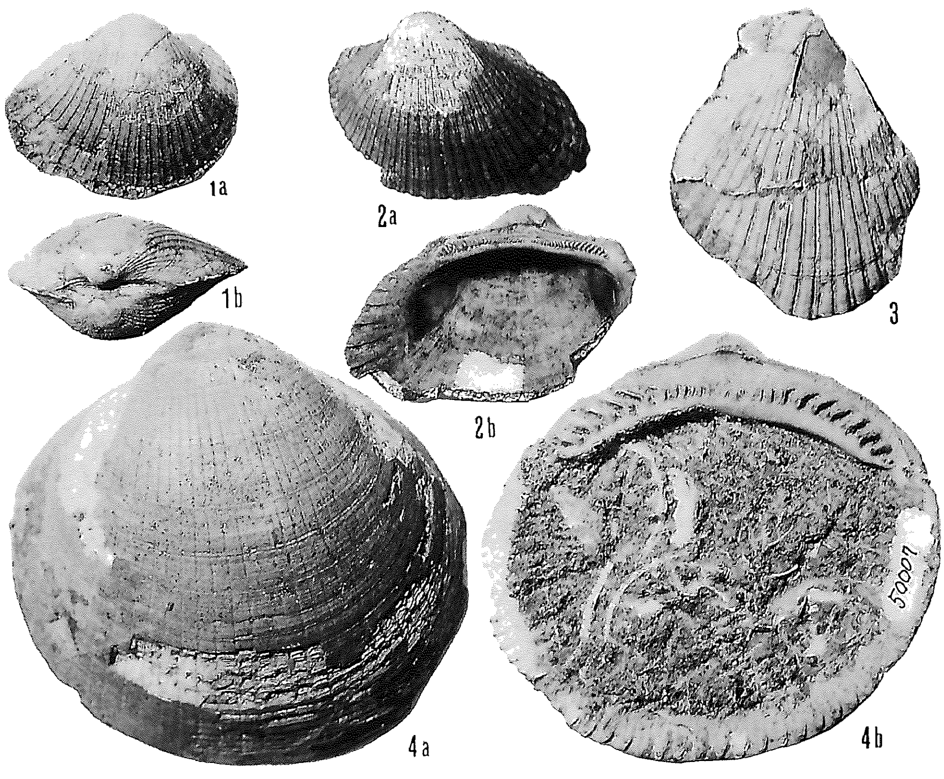

Fig. 4. (all specimens at natural size)

Fig.4-1a-2b. *Anadara hokkaidoensis* Noda , IGUT coll. cat. no. 50008, 4-3. *Chlamys otukae* Masuda and Sawada, IGUT coll. cat. no. 50010, 4-4a-b. *Gycymeris cisshuensis* Makiyama, IGUT coll. cat. no. 50007

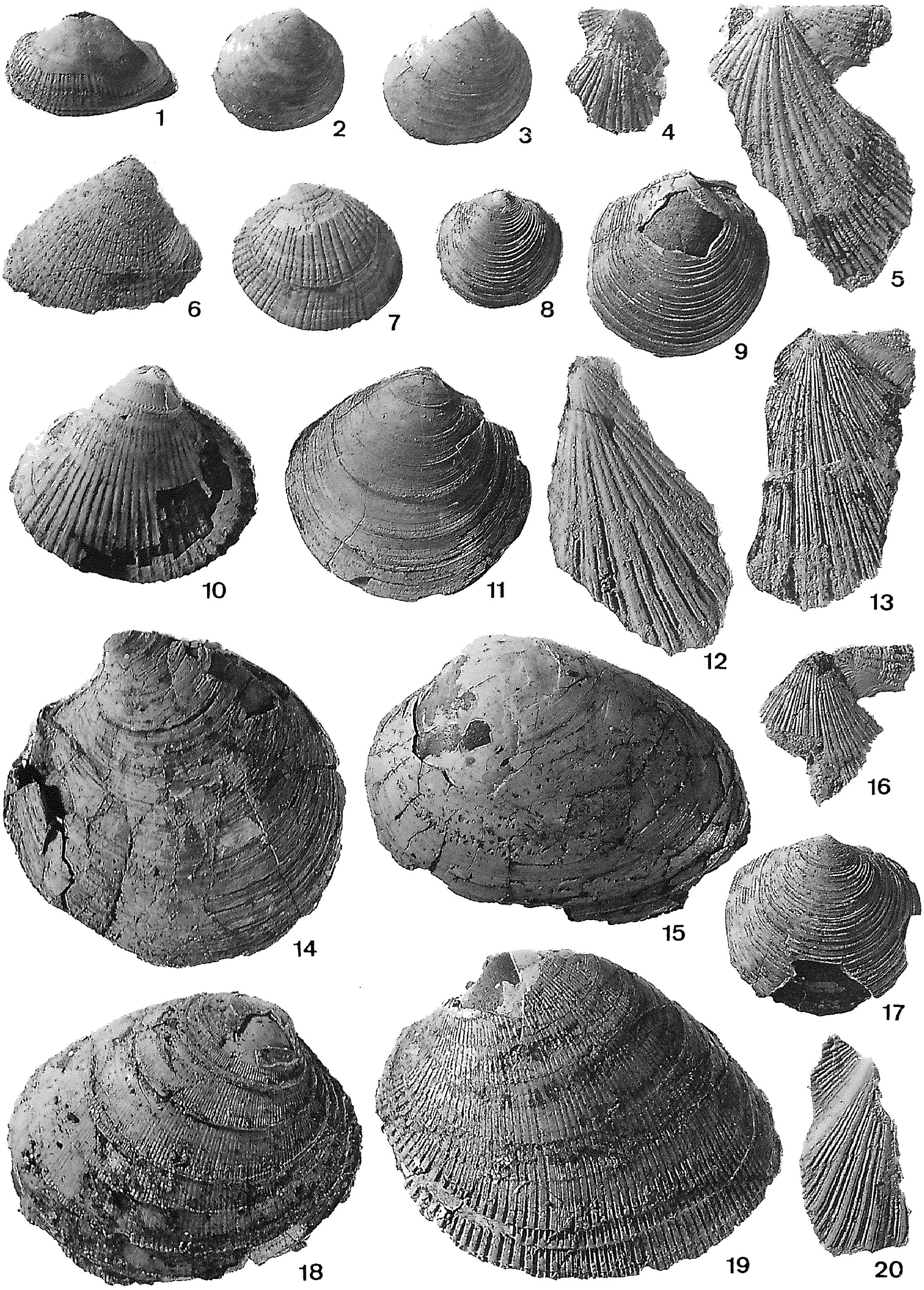

Fig. 5 (all specimens are in natural size otherwise stated)

Fig. 5-1. *Arca* aff. *boucardii* Jousseaume, IGUT coll. cat. no. 50009, Loc. 1
Figs. 5-2, 5-3. *Fellaniella usta* (Gould), IGUT coll. cat no. 50015, Loc. 1
Fig. 5-4, 5-5, 5-20. *Chlamys* aff. *strategus* (Dall), IGUT coll. cat. no. 50010, Loc. 1
Fig. 5-6. *Glycymeris idensis* Kanno, IGUT coll. cat. no. 50006, Loc. 1
Fig. 5-7. *Protothaca nodai* Amano x 2, IGUT coll. cat. no. 50026, Loc. 1
Figs. 5-8, 5-9, 5-17. *Lucinoma annulata* (Reeve), IGUT coll. cat. no. 50014, Loc. 1.
Fig. 5-10. *Clinocardium ponchibaenses* Amano, IGUT coll. cat. no. 50017, Loc. 1
Figs. 5-11, 5-14. *Dosinia* (*Phacosoma*) *owadaensis* Amano, IGUT coll. cat. no. 50023, Loc. 1
Figs. 5-12, 5-13, 5-16. *Chlamys* sp., IGUT coll. cat. no. 50012, Loc. 1
Fig. 5-15. *Ezocallista* aff. *kavranensis* (Ilyina), IGUT coll. cat. no. 50024, Loc. 1
Figs. 5-18, 5-19. *Mercenaria yiizukai* (Kanehara), IGUT coll. cat. no. 50025, Loc. 1

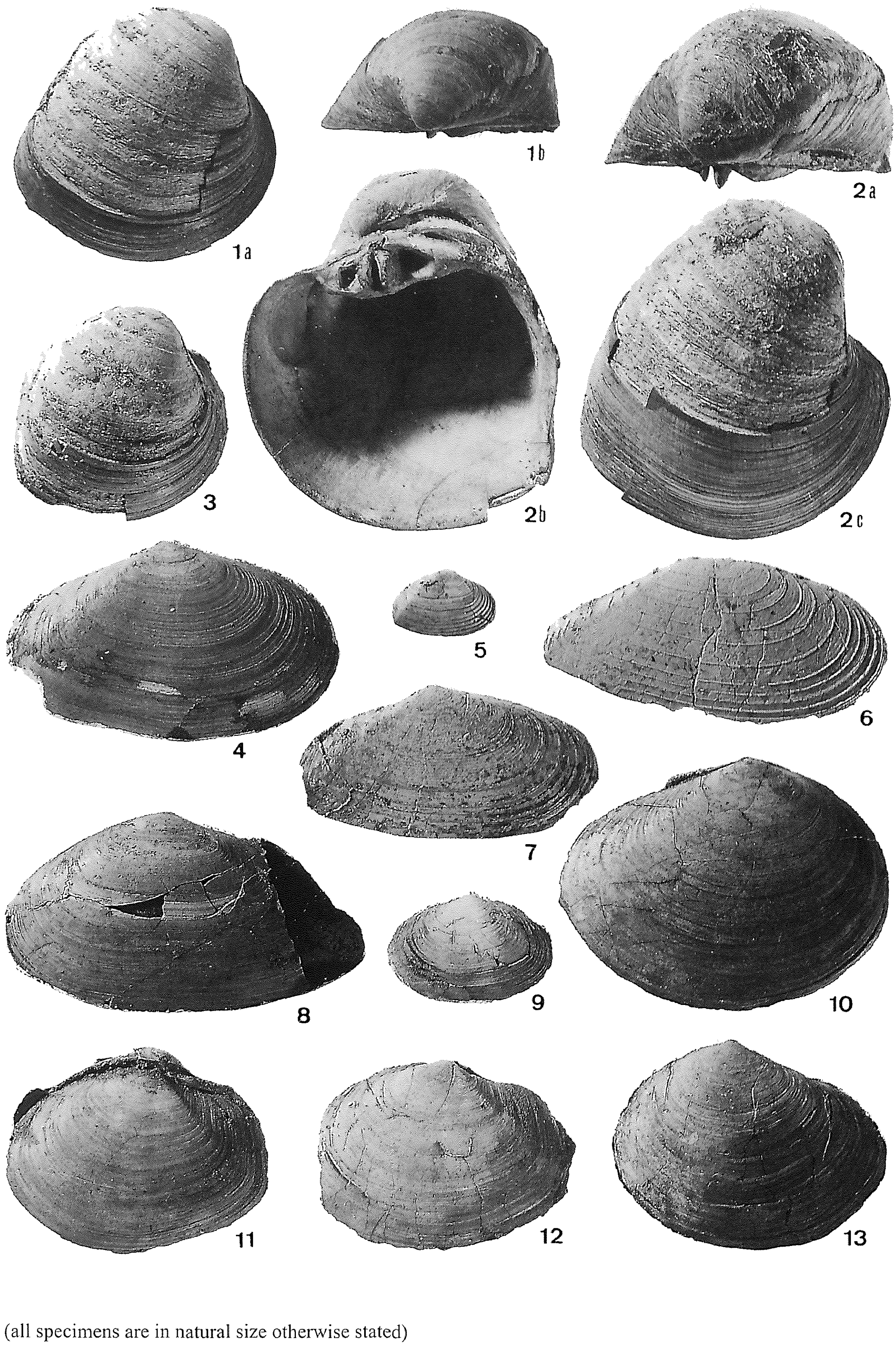

Fig. 6 (all specimens are in natural size otherwise stated)

Figs. 6-1a-c, 6-2a-b, 6-3. *Neogenella okadana* (Yokoyama), IGUT coll. Cat. no. 50027, Loc. 1
Figs. 6-4, 6-6, 6-7, 6-8. *Megangulus tmatsumotoi* (Otuka), IGUT coll. cat. no. 50022, Loc. 1
Fig. 6-5. *Anisocorbula venusta* (Gould), IGUT coll. cat. no. 50032, Loc. 1
Fig. 6-9, 6-11, 6-12. *Thracia kakumana* (Yokoyama), IGUT coll. cat. no. 50016, Loc. 1
Figs. 6-10, 6-13. *Nuttallia ezonis* Kuroda and Habe, IGUT coll. cat. no. 50030, Loc. 1

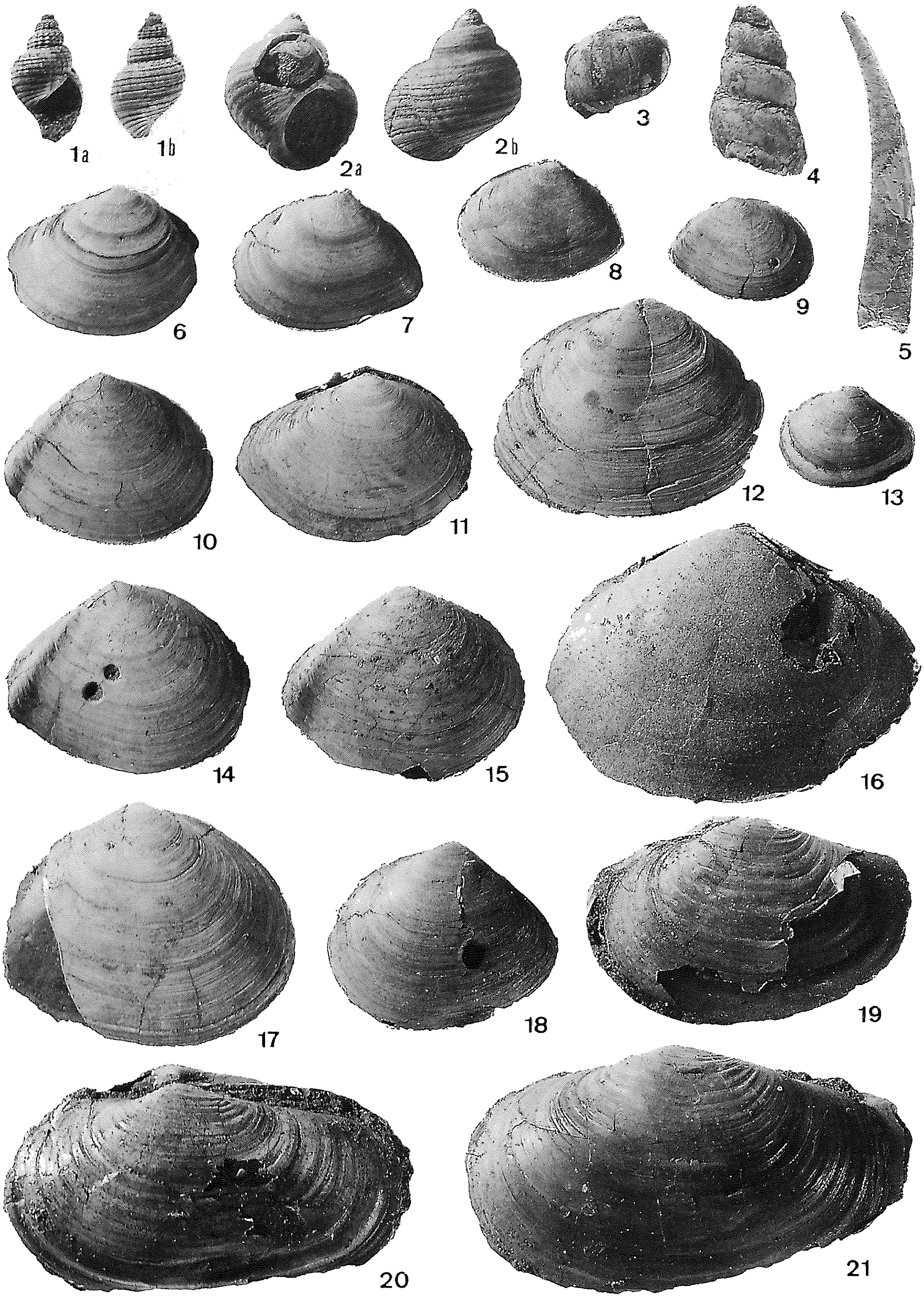

Fig. 7 (all specimens are in natural size otherwise stated)

Figs.7-1a-b. *Sydaphera* sp., IGUT coll. cat. no. 50044, Loc. 1
Figs.7-2a-b. *Littorina* (*Ezolittorina*) *squalida* (Broderip and Sowerby), IGUT coll. cat. no. 50039, Loc. 1.
Fig. 7-3. *Tetonatica janthostomoides* Kuroda and Habe, IGUT coll. cat. no. 50040, Loc. 1
Fig. 7-4. *Rectiplanes* sp. loc. 1.
Fig. 7-5. *Compressidens kikuchii* (Kuroda and Habe), IGUT coll. cat. no. 50047, Loc. 1
Figs.7- 6, 7-7, 7-8, 7-9. *Rexithaerus sectior* (Oyama), IGUT coll. cat. no. 50021, Loc. 1
Figs.7-10, 7-13, 7-14, 7-15, 7-18. *Macoma incongra* (v. Martens), IGUT coll. cat. no. 50019, Loc. 1
Fig. 7-11. *Nuttallia ezonis* Kuroda and Habe, IGUT coll. cat. no. 50030, Loc. 1
Figs. 7-12, 7-17. *Macoma calcarea* (Gmelin), IGUT coll. cat. no. 50015, Loc. 1
Fig. 7-16. *Spisula onnechiuria* (Otuka), IGUT coll. cat. no. 50029, Loc. 1
Figs. 7-19, 7-20, 7-21. *Panopea nomurae* Kamada, IGUT coll. cat. no. 50033, Loc. 1

References

Akiyama, M. and Kumano, S., 1973, A new occurrence of *Desmostylus* teeth from Kamitokushibetsu, Hokkaido: *Jour. Geol. Soc. Japan,* **79**, 781-786 (in Japanese with English abstract).

Amano, K., 1983, Paleontological study of the Miocene Togeshita molluscan fauna in the Rumoi district, Hokkaido: *Sci. Rep., Inst. Geosci., Univ. Tsukuba, Sec. B*, **4**, 1-72, pls. 1-8.

Amano K., 1986, Age and characteristics of the so-called "Atsunai-Togeshita fauna" in Hokkaido: *Palaeont. Soc. Japan, Spec. Pap.*, (29), 187-198, pl. 18.

Amano, K., Khudik, V. D. and Narita, K., 1996. An early Middle Miocene warm-water molluscan fauna in southwestern Sakhalin – Molluscs from the Ausinskaya Formation around Novoselovo: *Trans. Proc. Palaeont. Soc. Japan, N. S.,* (184), 651-661.

Arkhipova, A. D., Brutman, N. Y., Zhidkova, L. S., Ivan'shina, L. P., Kafanov, A. I., Korobkov, A. I., Kusnetzova, V. N., Moiseeva, A. I., Popova, L. A., Pronina, I. G., Remizovsky, V. I., Runeva, N. P., Savizky, V. O., Sal'nikov, B. A., Utkina, A. I., Shainyan, S. K. and Schmidt, O. I., 1994, *Reference section of Paleogene-Neogene deposits of South-East Sakhalin (Makarov section):* All-Russian Peteroleum Scientific Research Geological-Exploration Institute, St-Petersburg, 358 pp, 68 pls (in Russian with English title, summary and contents).

Devjatilova, A. D. and Volobueva, V. I., 1981, *Atlas of Paleogene and Neogene fauna of North East of the USSR:* Nedra Publ. House, Moscow, 220 pp, 55 pls (in Russian, title translated).

Fujie, T., Matsui, M. And Uozumi, I., 1964, *Fossils from Hokkaido*: 1-99, pls. 3-12. Geol. Educ. Assoc. Hokkaido (in Japanese).

Fujimoto, E., Shimamoto, M., Noda, Y. and Ogasawara, K., 1998, Stratigraphy and geologic age of the Neogene formations in the Kamitokushibetsu district, northern Hokkaido: *Jour. Geol. Soc. Japan,* **104** (7), 425-441 (in Japanese with English abstract).

Gladenkov, Y. B., Gladikova, V. M., Kafanov, A. I., Konova, L. N., Krishtofovich, L. V., Sinelinikova, V. N. and Popov, S. V., 1984, *Marine mollusks*: In V. V. Menner ed., Atlas of fauna and flora of the Neogene sediments of the Far East. Tochilinski key section of Western Kamchatka: Moscow, Nauka Publ., 152-251, 307-324, pls. 27-65 (in Russian with English contents).

Gladenkov, Y. B., Bratzeva, G. M. and Sinelinikova, V. N., 1987, The *Marine Cenozoic of the Korf Gulf in eastern part of Kamchatka*: In Pushcharovsky Y. M., ed., *Essays on geology of the Northwest section of the Pacific tectonic belt.,* Nauka Moscow, 5-73, pls. 1-16 (in Russian).

Gladenkov, Y. B., Sal'nikov, B. A., Barinov, K. B., Brutman, N. Y., Vitukhin, D. I., Grechin, V. I., Ivan'shina, L. P., Margulis, L. S., Oreshkina, T. V., Radchenko, V. G., and Stupin, S. I, 1999, *Cenozoic ecosystems of the Okhotsk Sea region. The Paleogene and Neogene Key section of North Sakhalin (Shmidt Peninsula): stratigraphy, paleogeography, and geological events*: GEOS Publ. House, Moscow, 132 pp, 30 pls (in Russian with English title).

Gladenkov, Y. B. and Sinelinikova, V. N., 1990, Miocene molluscs and climatic optimum in Kamachatka: *USSR Academ. Sci., Geol. Inst., Trans.* **453**, 1-172, pls. 1-32 (in Russian).

Habe T., 1955, Fauna of Akkeshi Bay XXI. Pelecypoda and Scaphopoda. *Publication of the Akkeshi Marine Laboratory, Kyoto University*, (4), 1-31, pls. 1-7.

Habe, T., 1977, *Systematics of Mollusca in Japan: Bivalvia and Scaphopoda*: Zuka-no-Kokuryukan, Tokyo, 372pp, 72 pls (in Japanese).

Habe, T. and Ito, K., 1979, *Shells of the World in Colour vol. 1. The northern Pacific*: Hoikusha Pub. Co. Ltd., Osaka, 176pp, 56 pls (in Japanese),

Hayasaka, I. and Uozumi, S., 1954a, Palaeontological note on the two fossil species of genus *Pitar* in Hokkaido: *Jour. Fac. Sci., Hokkaido Univ., Ser. 4*, **8**, (4), 381-389, pl. 24.

Hayasaka, I. and Uozumi, S., 1954b. Fossil species of genus *Mercenaria* from the Cenozoic deposits of Hokkaido: *Trans. Proc. Palaeont. Soc. Japan N. S.*, (15), 165-172, pl. 22.

Higo, S., 1973, *A catalogue of molluscan fauna of the Japanese Islands and the adjacent area*: Nagasaki Biol. Assoc., Nagasaki, 397pp (in Japanese).

Ilyina, A. O., 1957, Molluscs of the Neogene deposits of South Sakhalin: *Transact. VNIGRI, Special Series, 10*, 188-253, pls. 1-30 (in Russian).

Ilyina, A. O, 1963, Neogene molluscs of Kamchatka: *Transact. VNIGRI, Fasc. 202,* 1-242, 54 pls (in Russian, title translated).

Itoigawa, J. and Shibata, H., 1975, New Miocene pelecypods from the Mizunami Group, Mizunami City, central Japan: *Bull. Mizunami Fossil Mus.*, (2), 15-34.

Itoigawa, J., Shibata, H. and Nishimoto, 1974, Molluscan fossils of the Mizunami Group: *Bull. Mizunami Fossil Mus.*, (1), 433-203, pls. 1-63. (in Japanese)

Itoigawa, J., Shibata, H., Nishimoto, H. and

Okumura, K., 1982, Miocene fossils of the Mizunami Group, central Japan. 2. Molluscs (continued): *Bull. Mizunami Fossil Mus.*, (3), 1-330, pls. 1-52 (in Japanese).

Iwasaki, Y., 1970, The Shiobara-type molluscan fauna. An ecological analysis of fossil mollusks: *Jour. Fac. Sci., Univ. Tokyo, Sec. 2,* **17**, pt 3, 351-444, pls. 1-7.

Kafanov, A. I., Ogasawara, K. and Marincovich L. Jr., 2001, Checklist and bibliography of the Cenozoic marine Bivalvia (Mollusca) of northeastern Asia (Russian Far East), 1968-1999: *Bull. Mizunami Foss. Mus.*, (28), 1-138.

Kamada, Y., 1962, Tertiary marine Mollusca from the Joban coal-field, Japan: *Palaeont. Soc. Japan, Sec. Pap.*, (8), 1-187, pls. 1-21.

Kanehara, K., 1937, Neogene shells from the Etaibetsu oil-field, Hokkaido: *Jour. Geol. Surv. Japan,* **27,** 1-21, pls. 1-5.

Kanno, S., 1956. On some new glycymerid molluscs from Japan: *Trans. Proc. Palaeont. Soc. Japan, N. S.*, (24). 267-272, pl. 8.

Kanno, S., Ohara, S. and Kaiteya, H., 1968. The "Asahi Fauna" from the Miocene formation developed near the Asahi coal-mine, Iwamizawa City, Hokkaido: *Sci. Rep., Tokyo Univ. Education, Sec. C* (*Geol. Geogr.*), **10**, (94), p. 1-14, pls. 1-2.

Kanno, S. and Matsuno, K., 1960, Molluscan fauna from the Chikubetsu Formation, Hokkaido, Japan: *Jour. Geol. Soc. Japan,* **66**, 35-45, pls. 4-5.

Koimizu, I., 1985, Diatom biostratigraphy for late Cenozoic northwestern Pacific: *Jour. Geol. Soc. Japan*, **91**, 195-211,

Koshimizu, S. and Kim, C. W., 1986a, Fission-track dating of the Cenozoic formations in Central-Eastern Hokkaido: *Japan Jour. Geol. Soc. Japan,* **92**, 477-487 (in Japanese with English abstract).

Koshimizu, T. and Kim, C. W., 1986b, Fission-track dating of the Cenozoic formations in Central-Eastern Hokkaido (part II): *Jour. Geol. Soc. Japan,* **92**, 559-568 (in Japanese with English abstract).

Krishtofovich, L. V. and Ilyina, A. A., 1961, Biostratigraphy of the Paleogene and Neogene deposits of Tigilsky District of Western Kamcgatka. *The unified stratigraphic scheme of Neogene of the USSR,* pp. 170-180, pls. 1-20 (in Russian, title translated).

Kuroda, T., 1933, *Gastropoda and Lamellbranchiata.* Iwanami-Koza, Iwanami-shoten, Tokyo. 74 pp (in Japanese).

Kuroda, T. and Habe, T., 1949, On *Natica janthostoma* and allied species which was confused with it: *Jap. Jour. Malac. (Venus),* **15** (5-8), 69-72.

Kuroda, T. and Habe, T., 1952, *Check list and bibliography of the Recent marine Mollusca of Japan*: Leo. W. Stach, Tokyo, 210 pp.

Makiyama, J., 1926, Tertiary fossils from North Kankyo-do, Korea: *Mem. Coll. Sci., Kyoto Imp. Univ., Ser. B,* **2** (3), 143-160, pls. 12-13.

Masuda, K., 1962, Tertiary Pectinidae of Japan: *Sci. Rep., Tohoku Univ., 2^nd^ Ser.,* **33**, 117-238, pls. 18-27.

Masuda, K. and Noda, H., 1976, Check list and bibliography of the Tertiary and Quaternary Mollusca of Japan, 1950-1974: *Saito Ho-on Kai Mus, Spec. Publ.*, (1), 1-494.

Masuda, K. and Sawada, Y., 1961, Some new Tertiary pectinids from southwestern Hokkaido: *Japan. Jour. Geol. Geogr.*, **32**, 19-29, pl. 9

Masuda, K. and Takegawa, H., 1965, Remarks on the Miocene mollusks from the Sennan district, Miyagi Prefecture, Northeast Honshu, Japan: *Saito Ho-on Kai, Mus. Res. Bull.*, (34), 1-14, pls. 1-2.

Matsubara, T., 2009, Neogene Mollusca from the Yunokogawa Formation in the Shimokita Peninsula, northeast Japan: *Paleont. Res*,. **13**, 173-192.

Matsukuma, A., 1986, Cenozoic glycymeridid bivalves of Japan: *Palaeont. Soc. Japan, Spec. Pap.*, (29), 77-94, pls. 5-6.

Mizuno, A., Sumi, Y., Yamaguchi, S., 1969, Miocene stratigraphy of the Kushiro coal-field, eastern Hokkaido, with the special reference to the stratigraphic problem concerning the so-called Chokubetsu Formation: *Bull., Geol. Surv. Japan,* **20**, 633-649, pls. 27-29 (in Japanese).

Noda, H., 1966, The Cenozoic Arcidae of Japan: *Sci., Rep., Tohoku Univ., 2^nd^ Ser. (Geol.),* **38**, 1-161, pls. 1-14.

Noda, Y., 1992, Neogene molluscan faunas from the Haboro coal-field, Hokkaido, Japan: *Sci. Rep., Tohoku Univ. 2^nd^ ser (Geol.),* **62**, p. 1-140.

Nomura, S., 1935, A note on some fossil Mollusca from Takikawa beds of the northwestern part of Hokkaido: *Sci. Rep., Tohoku Imp. Univ., 2^nd^ Ser. (Geol.),* **18,** 31-39, pl. 4.

Nomura, S. and Hatai, K., 1937, A list of the Miocene Mollusca and Brachiopoda collected from the region lying north of the Nanakita River in the vicinity of Sendai, Rikuzen Province, Japan: *Saito Ho-on Ka, Mus., Res. Bull.*, (13), 121-145, pls. 17-21.

Ogasawara, K. 1977. Paleontological analysis of Omma fauna from Toyama-Ishikawa area, Hokuriku Province, Japan: *Sci. Rep., Tohoku Univ. 2^nd^ Ser. (Geol.),* **47,** 43-156、20 pls.

Ogasawara, K., 1986, Note on origin and migration of the Omma-Manganzian fauna, Japan: *Palaeont. Soc. Japan, Spec. Pap.*, (29), 227-244.

Ogasawara, K., 1994, Neogene paleogeography and marine climate of the Japanese Islands based on shallow-marine mollusks: *Palaeogeograr. Paleaoclimatol. Palaeoecol.*, **108**, 335-351.

Ogasawara, K, 2000, Paleoenvironments of desmostylids and Cenozoic events of the Northwestern Pacific: *Bull., Ashoro Mus. Paleont.*, (1), 25-34 (in Japanese with English abstract).

Ogasawara, K., 2001, Cenozoic Bivalvia. *In* Ikeya. N., Hirano, H. and Ogasawara, K. eds., The database of Japanese fossil type specimens described during the 20th Century: *Palaeont. Soc. Japan, Spec. Pap.*, (39), 223-373.

Ogasawara, K., 2005, Cenozoic paleoclimatic and paleoenvironmental changes in Sakhalin-Kamchatka region: *Jour. Japan. Assoc. Petrol. Technol.*, **70**, 15-23.

Ogasawara, K., Fujimoto, E., Noda, Y. and Shimamoto, M., 1993, Paleozoogeographic significance of *Mizuhopecten slodkewitschi* Sinelinikova from the Miocene Shibiutan Formation, northern Hokkaido: *Sci. Rep., Inst. Geosc., Univ. Tsukuba, Sec. B*, **14**, 65-76.

Ogasawara, K. and Masuda, K., 1989, Paleobathymetric indexes of the Neogene mollusks in Tohoku District and their implications: *Mem. Geol. Soc. Japan,* (32), 217-227 (in Japanese with English abstract).

Ogasawara, K., Masuda, K. and Kotaka, T., 1981, Neogene molluscan fossils from Bifuka-Utanobori area, Hokkaido: Tanai, T. edt., *Biostratigraphy of the Hokkaido Neogene*, Hokkaido Univ.,Sapporo, 22-23 (in Japanese)

Ogasawara, K., Takano, M., Nagato, H. And Nakano, T, 2008, Cenozoic molluscan faunas and climatic changes in the northern Pacific related to Pacific gateways: review and perspective: *Bull. Geol. Surv. Japan,* **59** (7/8), 355-364.

Otuka, Y., 1937, Middle Tertiary Mollusca from North Hokkaido and Zyoban coal-field, Japan: *Japan. Jour., Geol. Geogr.*, **14,** 101-171, pl. 16.

Otuka, Y., 1939, Tertiary crustal deformations in Japan (with short remarks on Tertiary paleogeography). *Jub., Publ., Prof. H. Yabe's 60th Birthday,* **2**, 481-519.

Otuka, Y., 1940, Miocene Mollusca from Tesio Province, Hokkaido: *Japan. Jour., Geol. Geogr.*, **17,** 91-99, pl. 11.

Oyama, K., 1973, Revision of Matajiro Yokoyama's type Mollusca from the Tertiary and Quaternary of the Kanto area: *Palaeont. Soc. Japan, Spec. Pap.*, (17), 1-148, pl. 1-57.

Saito T., 1999, Revision of Cenozoic magnetostratigraphy and the calibration of planktonic microfossil biostratigraphy of Japan against this new time scale: *Jour. Japan. Assoc. Petrol. Technol.*, **64**, 2-15 (in Japanese with English abstract).

Sawada, Y., 1962, The geology and paleontology of the Setana and Kuromatsunai areas in southwest Hokkaido, Japan: *Mem. Muroran Inst. Tech.*, **4,** 1-110, pls. 1-8.

Scarlato, O. A., 1981, *Bivalve Mollusca from mid-latitudes of the western Pacific Ocean*: Academy. Nauka, SSSR, Zool. Inst., 480 pp, 489 figs (in Russian).

Shibata, K. and Tanai, T., 1982. *K-Ar age of the Tertiary volcanic rocks of Hokkaid*: Tanai, T. edit., Problems of the Neogene Hokaido, Hokkaido Univ., Sapporo, 75-79.

Shikama, T. and Ikeya, N., 1964, On the variation of *Chlamys islandica* from a part of Setana Formation: *Sci. Rep., Yokohama Nat. Univ., Ser 2,* (11), 29-54, pls. 1-2.

Simonova, A. A., 1941, Fauna of the Tertiary strata from the south-eastern part of Soviet Sakhalin: *Transact. NGRI, New Series, Fasc.* **18**, 1-80, 25 pls (in Russian with English summary).

Sinelinikova, V. N., 1976, Marine mollusks of the Erman Suite: In Sinelinikova et al., Miocene-Pliocene of western Kamchatka. Academy Nauka, GIN, **294,** 24-53, pls. 6-9 (in Russian).

Slodkewitsch, W. S., 1938, Tertiary Pelecypoda from the Far East Part II: *Paleontology of USSR, vol. 10, part 3, Fasc. 19*, 1-275, pls. 1-61.

Suto, I., Yanagisawa, Y. and Ogasawara, K., 2005, Tertiary geology and chronostratigraphy of the Joban area and its environs, northeastern Japan: *Bull. Geol. Surv. Japan*, **56** (11/12), 375-409, 4 pls. (in Japanese with English abstract)

Suzuki, A., 2000, Paleoenvironmental significance of Miocene molluscan faunas in Hokkaido, northern Japan: *Bull. Ashoro Mus. Paleont.,* (1), 57-66 (in Japanese with English abstract).

Tanaka, K., 1960, Studies on the molluscan fossils from central Shinano, Nagano Prefecture, Japan (part 5) - Molluscan fossils from Uchimura Formation: *Jour., Shinshu Univ., Fac. Educ.*, (10), 131-148, pl. 1.

Uozumi, S., 1953, Illustrated Cenozoic fossils of northern Japan. 23. Miocene fossils from Hokkaido (Part 1.): *Cenozoic Res.,* (18), p. 356-358, pl. 22 (in Japanese)

Uozumi, S., 1966, Neogene molluscan fauna in Hokkaido. Pt. 1/ Description of the Asahi fauna associated with *Mytilus tichanovitchi* Makiyama from Ikushunbetsu district, central Hokkaido: *Jour., Fac. Sci., Hokkaido Univ. Ser 4*, **13** (2), 119-137, pls. 9-10.

Uozimi, S. and Akamatsu, M., 1988, Notes on the four diagnostic Miocene Mytilids of Hokkaido, North Japan: *Saito Ho-on Kai Spec. Pub. (Prof. T. Kotaka Commem. Vol.)*, 325-338, pls. 1-5.

Uozumi, S., Takagi, T. and Suzuki, A., 1986, *Yabepecten tokunagai* and *Mizuhopecten tokyoensis* of Hokkaido-characteristics of boreal mollusks and paleobiogeographic position of Hokkaido. *Monogr., Mizunami Fossil Mus.*, (6), 75-89, pls. 8-11 (in Japanese with English abstract).

Yahata, M. and Kimura, M., 2000, Modes of occurrence of desmostylian fossils in Hokkaido and Sakhalin, northwestern Pacific Ocean: *Bull. Ashoro Mus. Paleont.*, (1), 35-56 (in Japanese with English abstract).

Yamaguchi, S., 1978, Discovery of *Desmostylus* from the Kamitokushibetsu, Utanobori-cho, Hokkaido : *Geol. Surv. News*, (281), 15-19 (in Japanese, title translated).

Yamaguchi, S. and Suda, Y., 1981, *Geological map 1:200,000, Esashi*: Geol. Surv. Japan. (in Japanese).

Yokoyama, M., 1927, Fossil Mollusca from Kaga: *Jour. Fac. Sci., Imp. Univ. Tokyo, Sec. 2,* **2,** pt. 4, 165-182, pls. 47-49.

Yokoyama, M., 1932, Tertiary Mollusca from the Coal-field of Uryu, Ishikari: *Jour. Fac. Sci., Imp. Univ. Tokyo, Sec. II,* **3**, Part 6, 221-247, pls. 1-IV.

Zhidkova, L. S., Bevz, V. E., Ilyina, A. P., Krishtofovich, L. V., Neverova, T. I., Savizky, V. O. and Schremetjeva, G. N., 1972, *Atlas of Neogene molluscs of the Kuril Islands:* Nauka Publ. House, Moscow, 164 pp, 48 pls. (in Russian, title translated)

Zhidkova, L. S., Kuzina, I. N., Lautenschlager, F. G. and Popova, L. A., 1968, *Atlas of molluscs of the upper Miocene and Pliocene of Sakhalin*: Nauka Publ. Moscow, 180 pp, 50 pls. (in Russina, title translated).