Data report: Pliocene and Pleistocene deep-sea ostracods from Integrated Ocean Drilling Program Site U1426 (Expedition 346)[1]

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Chapter contents

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Abstract

Little is known about fossil ostracods from deep-sea drilling sites in the marginal sea bordered by the Eurasian continent, the Korean Peninsula, and the Japanese Islands. This report presents taxonomic descriptions for the Pliocene and early Pleistocene deep-sea ostracods at Integrated Ocean Drilling Program Expedition 346 Site U1426 on the Oki Ridge in the marginal sea. We found 23 species and 12 genera in discrete core samples. The ostracods constitute taxa that dwell under the Tsushima Warm Current and the Japan Sea Intermediate-Proper Water. We present taxonomic summaries of ostracod species distribution and ecology in addition to scanning electron microscopic images.

Introduction

Previously, Pliocene and Pleistocene ostracods from the marginal sea were investigated using specimens from mainly outcrops exposed in the marginal sea side of the Japanese Islands. Most of these studies examined shallow-marine ostracods from the Setana (Hayashi, 1988), Omma (Ozawa and Kamiya, 2001, 2005), Yabuta (Cronin et al., 1994), Mita (Goto et al., 2014b), Shichiba (Ozawa, 2010; Ishida et al., 2012), and Sasaoka (Irizuki, 1989; Yamada et al., 2002) formations. A few deep-sea ostracod faunas were recognized in the Kuwae (Yamada et al., 2005; Irizuki et al., 2007; Goto et al., 2014a) and Tentokuji (Irizuki, 1996; Irizuki and Ishida, 2007) formations (Fig. **F1**, Table **T1**). The deep-sea faunas contain the taxa that dwell in today's Japan Sea Intermediate-Proper Water. Further, the faunas were reported from strata whose geological age is between 3.5 and 2.7 Ma.

In 2014, Integrated Ocean Drilling Program (IODP) Expedition 346 cored 7 sites in the marginal sea and 2 sites in the South China Sea (Fig. **F1**). At IODP Site U1426, four holes were cored at 903 meters below sea level (mbsl). Here, we report on the ostracod taxa found in Pliocene to Pleistocene sediments and describe them taxonomically. Following the shipboard age model (see the **"Site U1426"** chapter [Tada et al., 2015]), the geological age of the sediment samples ranges from 4.8 to 1.2 Ma.

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Site location and setting

Site U1426, located at 37°2.00′N, 134°48.00′E; 903 mbsl, is near the top of the Oki Ridge, in the south central part of the marginal basin (Fig. F1). The second branch of the Tsushima Warm Current flows over this site. Physical properties of the water column enable four types of water masses to be characterized in the marginal sea (Ozawa, 2003): the Tsushima Warm Current Surface Water (water depth < 70 m), Tsushima Warm Current Core Water (water depth = 70–150 m), Japan Sea Intermediate-Proper Water (water depth > 170 m), and Japan Sea Central Water (water depth = 30–180 m in northern part of the marginal sea).

Of the four holes cored at Site U1426, Holes U1426A and U1426C were examined in the present study. Total core recoveries for Holes U1426A and U1426C were 418.78 m (105.6%) and 211.9 m (103.9%), respectively.

Material and methods

Two hundred and twenty eight samples were collected using 2 cm thick plastic scoops (individual sample volume 34 cm^3) in the interval of 120.5–199.7, 294.1–307.3, and 383.4–388.9 m core depth below seafloor (CSF) in Hole U1426A and of 113.4–178.1 m CSF in Hole U1426C. The sampled interval spans the Pliocene to the Pleistocene. All the discrete sediment samples were freeze-dried under vacuum and then washed with water through a 63 µm opening sieve screen. The residual sediments were dried at room temperature. All ostracod specimens were picked from the residues of the >150 µm grain size fraction and transferred to a slide. We identified the taxa using light microscopes and scanning electron microscopes, Miniscope TM-1000 (Hitachi Ltd., Tokyo) at Shinshu University and JSM-6500F (JEOL Ltd., Tokyo) at the Center for Advanced Marine Core Research, Kochi University. We counted specimens of each species without discriminating between valves and carapaces. Juvenile specimens of the genus *Krithe* were identified as *Krithe* spp. because early stage valves/carapaces are too similar to distinguish at the species level. The terminology for the morphology of *Krithe* follows Coles et al. (1994). The taxonomic classification for the rank higher than the genus follows Brandão et al. (2016).

Results

At least 23 species belonging to 12 genera were recognized from 90 samples from Holes U1426A and U1426C (Table T2). Sample 346-U1426A-18H-5, 75–77 cm (161.25 m CSF) had the most abundant specimens (50 specimens), whereas most of the discrete samples yielded <5 specimens each. *Acanthocythereis dunelmensis*, *Krithe* spp., and *Robertsonites tabukii* are dominant taxa. Most of the species are found in the Pliocene and Pleistocene strata in the marginal sea coast of the Japanese Islands and the modern seafloor sediments in the marginal sea. Some are reported from modern seafloor sediments in the Arctic Ocean (Gemery et al., 2015) and Alaska Bay (e.g., Brouwers, 1993, 1994). In the Pliocene samples from Cores 346-U1426A-37H to 40H, four taxa were identified: *A. dunelmensis, A. tsurugasakensis, Acanthocythereis* sp., and *Krithe* spp. Only three valves were found in the older samples examined (Cores 346-U1426A-57H to 59H): *Argilloecia lunata*, *Argilloecia* sp., and *Falsobuntonia taiwanica*. This is the first systematic report of the Pliocene and Pleistocene deep-sea ostracods in the marginal sea.

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References

Alvarez Zarikian, C.A., 2016. Pleistocene deep sea ostracods from the Bering Sea (IODP Expedition 323). *Deep-Sea Research, Part II: Topical Studies in Oceanography,* 125–126:96–106. **https://doi.org/10.1016/j.dsr2.2014.05.010**

Ayress, M.A., Barrows, T., Passlow, V., and Whatley, R., 1999. Neogene to Recent species of *Krithe* (Crustacea: Ostracoda) from the Tasman Sea and off southern Australia with description of five new species. *Records of the Australian Museum*, 51(1):1–22. **https://doi.org/10.3853/j.0067-1975.51.1999.486**

Baird, W., 1850. *The Natural History of the British Entomostraca:* London (The Ray Society).

Bonaduce, G., Ciampo, G., and Masoli, M., 1975. Distribution of Ostracoda in the Adriatic Sea. *Publicazioni della Stazione Zoologica di Napoli*, 40(Supplement).

Brady, G.S., Crosskey, H.W., and Robertson, D., 1874. A monograph of the post-Tertiary Entomostraca of Scotland including species from England and Ireland. *Palaeontographical Society Monographs,* 28:1–232.

Brandão, S.N., Angel, M.V., Karanovic, I., Perrier, V., and Yasuhara, M., 2016. World Ostracoda Database. **http://www.marinespecies.org/ostracoda**

Brouwers, E.M., 1993. Systematic paleontology of Quaternary ostracode assemblages from the Gulf of Alaska, Part 2. Families Trachyleberididae, Hemicytheridae, Loxoconchidae, Paracytherideidae. *U.S. Geological Survey Professional Paper,* 1531:1–47. **https://pubs.usgs.gov/pp/1531/report.pdf**

Brouwers, E.M., 1994. Systematic paleontology of Quaternary ostracode assemblages from the Gulf of Alaska, Part 3. Families Cytheruridae. *U.S. Geological Survey Professional Paper*, 1544:1–45. **https://pubs.usgs.gov/pp/1544/report.pdf**

Bubikyan, S.A, 1958. Ostracoda from Paleogene deposits of the Erevan Basin. *Izvestiya Akademii Nauk Armyanskoy SSR, Seriya Geologiya-Geografiya*, 11:3–16. (in Russian)

Coles, G.P., Whatley, R.C., and Moguilevsky, A., 1994. The ostracod genus *Krithe* from the Tertiary and Quaternary of the North Atlantic. *Palaeontology,* 37(1):71–120.

Cronin, T.M., and Ikeya, N., 1987. The Omma-Manganji ostracod fauna (Plio-Pleistocene) of Japan and the zoogeography of circumpolar species. *Journal of Micropalaeontology,* 6(2):65–88. **https://doi.org/10.1144/jm.6.2.65**

Cronin, T.M., Kitamura, A., Ikeya, N., Watanabe, M., and Kamiya, T., 1994. Late Pliocene climate change 3.4–2.3 Ma: paleoceanographic record from the Yabuta Formation, Sea of Japan. *Palaeogeography, Palaeoclimatology, Palaeoecology*, 108(3–4):437–455. **https://doi.org/10.1016/0031-0182(94)90245-3**

Frydl, P.M., 1982. Holocene ostracods in the southern Boso Peninsula. *In* Hanai, T. (Ed.), *Studies on Japanese Ostracoda*. University Museum, University of Tokyo Bulletin, 20:61–140.

Gemery, L., Cronin, T.M., Briggs, W.M., Jr., Brouwers, E.M., Schornikov, E.I., Stepanova, A., Wood, A.M., and Yasuhara, M., 2015. An Arctic and subarctic ostracode database: biogeographic and paleoceanographic applications. *Hydrobiologia*, 786(1):59–95. **https://doi.org/10.1007/s10750-015-2587-4**

Goto, T., Irizuki, T., Yanagisawa, Y., and Hayashi, H., 2014a. Microfossil biostratigraphy and paleoenvironments of the upper Pliocene Kuwae Formation, Northeast Japan. *Paleontological Research*, 18(3):150–168. **https://doi.org/10.2517/2014PR015**

Goto, T., Nasuno, S., Irizuki, T., Ohira, H., and Hayashi, H., 2014b. Fission track age for MT1 tuff bed and paleoenvironment in the upper Pliocene Mita Formation, Toyama Prefecture, central Japan. *Journal of the Geological Society of Japan*, 120(2):71–86. **https://doi.org/10.5575/geosoc.2014.0001** (in Japanese with English abstract)

Hanai, T., 1957. Studies on the Ostracoda from Japan: 3. Subfamilies Cytherurinae G.W. Müller (emend. G.O. Sars, 1925) and Cytheropterinae n. subfam. *Journal of the Faculty of Science, University of Tokyo, Section 2,* 11:11–36.

Hanai, T., 1959. Studies on the Ostracoda from Japan: historical review with bibliographic index of Japanese Ostracoda. *Journal of the Faculty of Science, University of Tokyo, Section 2,* 11:419–439.

Hayashi, K., 1988. Pliocene–Pleistocene paleoenvironment and fossil ostracod fauna from southwestern Hokkaido, Japan. *In* Hanai, T., Ikeya, N., and Ishizaki, K. (Eds.), *Evolutionary Biology of Ostracoda* (Volume 11): *its Fundamentals and Applications*: Tokyo (Elsevier), 557–568.

Howe, H.V., 1951. Paleontologic studies: Part 1. New Tertiary ostracode fauna from Levy County, Florida. *Florida Geological Survey Bulletin,* 34(1–2):1–43.

Howe, R.C., 1963. Type saline bayou Ostracoda of Louisiana. *Louisiana Geological Survey Bulletin*, 40.

Hu, C.-H., 1978. Studies on ostracodes from the Toukoshan Formation (Pleistocene), Miaoli District, Taiwan. *Petroleum Geology of Taiwan*, 15:127–166.

Hu, C.-H., and Tao, H.-J., 2008. Studies on the ostracod fauna of Taiwan and its adjacent seas, Part 1 and 2. *Journal of the National Taiwan Museum, Special Publication Series*, 13. (in Chinese)

Huh, M., and Paik, K.-H., 1992a. Miocene Ostracoda from the Pohang Basin, Korea. *Paleontological Society of Korea, Special Publication*, 1:101–119.

Huh, M., and Paik, K.-H., 1992b. Miocene Ostracoda from the Seojeongri area, Pohang Basin, Korea. *Journal of the Geological Society of Korea*, 28:273–283.

Ikeya, N., and Suzuki, C., 1992. Distributional patterns of modern ostracodes off Shimane Peninsula, Southwestern Japan Sea. *Reports of Faculty of Science, Shizuoka University,* 26:91–137.

Irizuki, T., 1989. Fossil ostracode assemblages from the Pliocene Sasaoka Formation, Akita City, Japan - with reference to sedimentological aspects. *Transactions and Proceedings of the Palaeontological Society of Japan,* 156:296–318. **https://doi.org/10.14825/prpsj1951.1989.156_296**

Irizuki, T., 1994. Late Miocene ostracods from the Fujikotogawa Formation, northern Japan - with reference to cold water species involved with trans-Arctic interchange. *Journal of Micropalaeontology*, 13:3–15. **https://doi.org/10.1144/jm.13.1.3**

Irizuki, T., 1996. Lithology and Ostracoda from the Pliocene Tentokuji Formation along the southern marginal area of Mt. Taiheizan, Akita Prefecture, Northeast Japan. *Bulletin of the Aichi University of Education, Natural Science*, 45:23–32.

Irizuki, T., and Ishida, K., 2007. Relationship between Pliocene ostracode assemblages and marine environments along the Japan Sea side regions in Japan. *Fossils*, 82:13–20. (in Japanese with English abstract)

Irizuki, T., Ishizaki, K., Takahashi, M., and Usami, M., 1998. Ostracode faunal changes after mid-Neogene climatic optimum elucidated in the middle Miocene Kobana Formation, central Japan. *Paleontological Research*, 2:30–46. **https://www.jstage.jst.go.jp/article/prpsj1997/2/1/2_1_30/_pdf**

Irizuki, T., Kusumoto, M., Ishida, K., and Tanaka, Y., 2007. Sea-level changes and water structures between 3.5 and 2.8 Ma in the central part of the Japan Sea borderland: analyses of fossil Ostracoda from the Pliocene Kuwae

Formation, central Japan. *Palaeogeography, Palaeoclimatology, Palaeoecology*, 245(3–4):421–443. https://doi.org/10.1016/j.palaeo.2006.09.007

Irizuki, T., Yamaguchi, T., Takahashi, M., and Yanagisawa, Y., 2001. Miocene temperate Ostracoda from the Tochigi and Fukushia districts, central to northeastern Japan. *In* Ikeya, N. (Ed.), *Guidebook of Excursions, 14th International Symposium on Ostracoda,* 5–72.

Ishida, K., Yoshida, K., and Matsuoka, A., 2012. Fossil ostracode assemblages in the middle Pleistocene upper part of the Sawane Formation on Sado Island, Niigata Prefecture, central Japan and surface water freshening of the Sea of Japan. *Journal of the Geological Society of Japan*, 118(8):476–492. https://doi.org/10.5575/geosoc.2012.0024 (in Japanese with English abstract)

Ishizaki, K., 1966. Miocene and Pliocene ostracodes from the Sendai Area, Japan. *Science Reports of the Tohoku University, Series 2: Geology,* 37: 31–163.

Ishizaki, K., 1981. Ostracoda from the East China Sea. *Science Reports of the Tohoku University, Series 2: Geology,* 51:37–65.

Ishizaki, K., and Irizuki, T., 1990. Distribution of bathyal ostracodes in sediments of Toyama Bay, Central Japan. *Courier Forschungsinstitut Senckenberg*, 123:53–67.

Ishizaki, K., and Matoba, Y., 1985. Akita (early Pleistocene cold, shallow water Ostracoda). *In* Ikeya, N. (Ed.), *Guidebook of Excursions, 9th International Symposium on Ostracoda*, 1–12.

Jones, T.R., 1901. On some carboniferous shale from Siberia. *Geological Magazine*, 8(10):433–436. https://doi.org/10.1017/S0016756800179749

Kamiya, T., Ozawa, H., and Kitamura, A., 1996. Paleo-water mass structure during the depositional of middle part of the Omma Formation based on the change of ostracode assemblage. *Hokuriku Geological Institute Report,* 5:145–165 (in Japanese with English abstract).

Kamiya, T., Ozawa, H., and Obata, M., 2001. Quaternary and recent marine Ostracoda in Hokuriku district, the Japan Sea coast. *In* Ikeya, N. (Ed.), *Guidebook of Excursions, 14th International Symposium on Ostracoda*, 73–106.

Latreille, P.A., 1802. Histoire naturelle, générale et particulière des crustacés et des insectes. *Histoires des Cypris et des Cytherées,* 8(4):232–254. https://doi.org/10.5962/bhl.title.15764

Malz, H., 1982. Plio-/Pleistozane Buntoniini von SW-Taiwan. *Senckenbergiana Lethaea*, 63:377–411. (in German)

Müller, G.W., 1894. *Fauna und Flora des Golfes von Neapel* (Volume 21): *Die Ostracoden des Golfes von Neapel und der Angrenzenden Meeres-Abschnitte*: Berlin (Verlag). https://doi.org/10.5962/bhl.title.7419

Nakao, Y., Tanaka, G., and Yamada, S., 2001. Pleistocene and living marine Ostracoda in Shizuoka district, Japan. *In* Ikeya, N. (Ed.), *Guidebook of Excursions, 14th International Symposium on Ostracoda*, 127–147.

Norman, A.M., 1865. Report on the Crustacea. *In* Brady, G.S. (Ed.), *Reports of the Deep-Sea Dredging off the Coasts of Northumberland and Durham.* Transactions of the Natural History Society of Northumberland, Durham and Newcastle-upon-Tyne, London, 12–29.

Ozawa, H., 1996. Ostracode fossils from the late Pliocene to early Pleistocene Omma Formation in the Hokuriku district, central Japan. *Science Reports of Kanazawa University*, 41:77–115.

Ozawa, H., 2003. Japan Sea ostracod assemblages in surface sediments: their distribution and relationships to water mass properties. *Paleontological Research*, 7(3):257–274. https://doi.org/10.2517/prpsj.7.257

Ozawa, H., 2004. Okhotsk Sea ostracods in surface sediments: depth distribution of cryophilic species relative to oceanic environment. *Marine Micropaleontology*, 53(3–4):245–260. https://doi.org/10.1016/j.marmicro.2004.06.002

Ozawa, H., 2009. Middle Pleistocene ostracods from the Naganuma Formation, Sagami Group, central Japan: significance of the occurrence for the bay fauna along the northwest Pacific margin. *Paleontological Research*, 13(3):231–244. https://doi.org/10.2517/1342-8144-13.3.231

Ozawa, H., 2010. Preliminary report on the middle Pleistocene ostracods from the Shichiba Formation on Sado Island in the eastern Japan Sea. *Nihon-Kaiiki Kenkyu, Kanazawa University*, 41:15–36.

Ozawa, H., and Domitsu, H., 2010. Early Pleistocene ostracods from the Hamada Formation in the Shimokita Peninsula, northeastern Japan: the paleobiogeographic significance of their occurrence for the shallow-water fauna. *Paleontological Research*, 14(1):1–18. https://doi.org/10.2517/1342-8144-14.1.001

Ozawa, H., and Kamiya, T., 2001. Palaeoceanographic records related to glacio-eustatic fluctuations in the Pleistocene Japan Sea coast based on ostracodes from the Omma Formation. *Palaeogeography, Palaeoclimatology, Palaeoecology*, 170(1–2):27–48. https://doi.org/10.1016/S0031-0182(01)00225-5

Ozawa, H., and Kamiya, T., 2005. The effects of glacio-eustatic sea level change on Pleistocene cold-water ostracod assemblages from the Japan Sea. *Marine Micropaleontology*, 54(3–4):167–189. https://doi.org/10.1016/j.marmicro.2004.10.002

Ozawa, H., Kamiya, T., Kato, M., and Tsukawaki, S., 2004. A preliminary report on the recent ostracodes in sediment samples from the R/V *Tansei-maru* Cruise KT01-14 in the southwestern Okhotsk Sea and the northeastern Japan Sea off Hokkaido. *Bulletin of the Japan Sea Research Institute*, 35:33–45.

Ozawa, H., and Tsukawaki, S., 2008. Preliminary report on modern ostracods in surface sediment samples collected during R/V *Tansei-maru* Cruise KT04-20 in the southwestern Okhotsk Sea and the northeastern Japan Sea off Hokkaido, north Japan. *Bulletin of the Japan Sea Research Institute*, 39:31–48. http://hdl.handle.net/2297/9650

Paik, K.-H., and Lee, E.-H., 1988. Plio-Pleistocene ostracods from the Sogwipo Formation, Cheju Island, Korea. *Developments in Palaeontology and Stratigraphy*, 11:541–556. https://doi.org/10.1016/S0920-5446(08)70207-3

Ruan, P., and Hao, Y., 1988. Systematic description of microfossils. 2. Ostracoda. *In* Rong, L., and Shu, Z. (Eds.), *Quaternary Microbiotas in the Okinawa Trough and*

Their Geological Significance: Beijing (Geological Publishing House), 227–395.

Sars, G.O., 1866. Oversigt af Norges marine Ostracoder. *Forhandlinger i Videnskabsselskabet i Kristiania*, 1865(1):1–130. (in Norwegian)

Sars, G.O., 1869. Nye dybvandscrustaceer fra lofoten. *Forhandlinger i Videnskabsselskabet i Kristiania,* 572:147–174. (in Norwegian)

Sars, G.O., 1925. *An Account of the Crustacea of Norway, with Short Descriptions and Figures of all the Species* (Volume 9): *Ostracoda:* Copenhagen, Norway (Alb. Cammermeyers Forlag), 1:33–277. **https://doi.org/10.5962/bhl.title.1164**

Stepanova, A.Y., 2006. Late Pleistocene–Holocene and recent Ostracoda of the Laptev Sea and their importance for paleoenvironmental reconstructions. *Paleontological Journal,* 40(S2):91–204. **https://doi.org/10.1134/S0031030106080016**

Swain, F.M., 1963. Pleistocene Ostracoda from the Gubik Formation, Arctic coastal plain, Alaska. *Journal of Paleontology*, 37(4):798–834. **http://www.jstor.org/stable/1301282**

Swain, F.M., and Gilby, J.M., 1974. Marine Holocene Ostracoda from the Pacific coast of North and Central America. *Micropaleontology,* 20(3):257–353. **https://doi.org/10.2307/1484940**

Swanson, K.M., and Ayress, M.A., 1999. *Cytheropteron testudo* and related species from the SW Pacific with analyses of their soft anatomies, relationships and distribution. *Senckenbergiana Biologica,* 79(2):151–193.

Sylvester-Bradley, P.C., 1946. Some ostracod genotypes. *Annals and Magazine of Natural History, Series 11,* 13(99):192–199. **https://doi.org/10.1080/00222934608654541**

Sylvester-Bradley, P.C., 1948. The ostracod genus *Cythereis*. *Journal of Paleontology*, 22(6):792–797. **http://www.jstor.org/stable/1299620**

Tabuki, R., 1986. Plio-Pleistocene Ostracoda from the Tsugaru Basin, North Honshu, Japan. *Bulletin of the Faculty of Education, University of the Ryukyus*, 29(2):27–160.

Tada, R., Murray, R.W., Alvarez Zarikian, C.A., Anderson, W.T., Jr., Bassetti, M.-A., Brace, B.J., Clemens, S.C., da Costa Gurgel, M.H., Dickens, G.R., Dunlea, A.G., Gallagher, S.J., Giosan, L., Henderson, A.C.G., Holbourn, A.E., Ikehara, K., Irino, T., Itaki, T., Karasuda, A., Kinsley, C.W., Kubota, Y., Lee, G.S., Lee, K.E., Lofi, J., Lopes, C.I.C.D., Peterson, L.C., Saavedra-Pellitero, M., Sagawa, T., Singh, R.K., Sugisaki, S., Toucanne, S., Wan, S., Xuan, C., Zheng, H., and Ziegler, M., 2015. Site U1426. *In* Tada, R., Murray, R.W., Alvarez Zarikian, C.A., and the Expedition 346 Scientists, *Proceedings of the Integrated Ocean Drilling Program,* 346: College Station, TX (Integrated Ocean Drilling Program). **https://doi.org/10.2204/iodp.proc.346.107.2015**

Tanaka, G., 2008. Recent benthonic ostracod assemblages as indicators of the Tsushima Warm Current in the southwestern Sea of Japan. *Hydrobiologia*, 598(1):271–284. **https://doi.org/10.1007/s10750-007-9162-6**

Tanaka, G., 2009. Re-examination of type specimens, Miocene and Pliocene ostracods from the Sendai area (by Ishizaki, 1966). *Bulletin of the Gunma Museum of Natural History*, 13:35–45.

Tanaka, G., 2016. Redescription of two Krithid species (Crustacea, Ostracoda) from the Sea of Japan, with a comment on the taxonomic characters of Krithidae. *Paleontological Research*, 20(1):31–47. **https://doi.org/10.2517/2015PR022**

Tanaka, G., and Nomura, S., 2009. Late Miocene and Pliocene Ostracoda from the Shimajiri Group, Kume-jima Island, Japan: biogeographical significance of the timing of the formation of back-arc basin (Okinawa Trough). *Palaeogeography, Palaeoclimatogy, Palaeoecology*, 276(1–4):56–68. **https://doi.org/10.1016/j.palaeo.2009.02.023**

Tanaka, G., and Seto, K., 2010. Description of appendages from three marine trachyleberidid species (Ostracoda, Crustacea) from Japan. *Journal of Micropaleontogy*, 29:5–16. **https://doi.org/10.1144/jm.29.1.5**

Tanaka, G., Seto, K., Mukuda, T., and Nakano, Y., 2002. Middle Miocene ostracods from the Fujina Formation, Shimane Prefecture, southwest Japan and their paleoenvironmental significance. *Paleontological Research*, 106:1–22.

Tanaka, G., Zhou, B.-C., Ikeya, N., and Hasegawa, Y., 2012. Recent ostracod assemblages from Suruga Bay, central Japan. *Bulletin of the Gunma Museum of Natural History*, 16:1–30.

Tsukawaki, S., Ozawa, H., Domitsu, H., Kamiya, T., Kato, M., and Oda, M., 2000. Preliminary results from the R.V. *Tansei-maru* Cruise KT98-17 in the southwestern marginal part of the Japan Sea: sediments, benthic and planktonic foraminifers, and ostracodes. *Bulletin of the Japan Sea Research Institute*, 31:89–119.

Van Den Bold, W.A., 1946. Contribution to the study of Ostracoda with special reference to the Tertiary and Cretaceous microfauna of the Caribbean region [Ph.D. thesis]. Utrecht University, Amsterdam.

Van Den Bold, W.A., 1957. Ostracoda from the Paleocene of Trinidad. *Micropaleontology*, 3(1):1–18. **https://doi.org/10.2307/1484324**

Van Den Bold, W.A., 1958. Ostracoda of the Brasso Formation of Trinidad. *Micropaleontology,* 4(4):391–418. **https://doi.org/10.2307/1484268**

Whatley, R., and Zhao, Q., 1993. The *Krithe* problem: a case history of the distribution of *Krithe* and *Parakrithe* (Crustacea, Ostracoda) in the South China Sea. *Palaeogeography, Palaeoclimatology, Palaeoecology,* 103(3–4):281–297. **https://doi.org/10.1016/0031-0182(93)90146-A**

Yajima, M., 1982. Late Pleistocene Ostracoda from the Boso Peninsula, central Japan. *In* Hanai, T. (Ed.), *Studies on Japanese Ostracoda*. University Museum, University of Tokyo Bulletin, 20:141–227.

Yamada, K., 2003. New ostracod (Crustacea) species of genus *Robertsonites* from the upper Pliocene Kuwae and Sasaoka formations, central and northeast Japan. *Journal of Micropaleontology*, 22(2):169–182. **https://doi.org/10.1144/jm.22.2.169**

Yamada, K., Irizuki, T., and Tanaka, Y., 2002. Cyclic sea-level changes based on fossil ostracode faunas from the upper Pliocene Sasaoka Formation, Akita Prefecture,

northeast Japan. *Palaeogeography, Palaeoclimatology, Palaeoecology*, 185(1–2):115–132. https://doi.org/10.1016/S0031-0182(02)00281-X

Yamada, K., Tanaka, Y., and Irizuki, T., 2005. Paleoceanographic shifts and global events recorded in late Pliocene shallow marine deposits (2.80–2.55 Ma) of the Sea of Japan. *Palaeogeography, Palaeoclimatology, Palaeoecology*, 220(3–4):255–271. https://doi.org/10.1016/j.palaeo.2005.01.006

Yasuhara, M., Okahashi, H., and Cronin, T.M., 2009. Taxonomy of Quaternary deep-sea ostracods from the western North Atlantic Ocean. *Palaeontology*, 52(4):879–931.

Yasuhara, M., Stepanova, A., Okahashi, H., Cronin, T.M., and Brouwers, E.M., 2014. Taxonomic revision of deep-sea Ostracoda from the Arctic Ocean. *Micropaleontology*, 60(5):399–444.

Zhao, Q., and Whatley, R., 1997. Distribution of the ostracod genera *Krithe* and *Parakrithe* in bottom sediments of the East China and Yellow Seas. *Marine Micropaleontology*, 32(1–2):195–207. https://doi.org/10.1016/S0377-8398(97)00020-0

Zhao, Q., Whatley, R., and Zhou, B., 2000. The taxonomy and distribution of recent species of the ostracod genus *Cytheropteron* in the South China Sea. *Revista Espanola de Micropaleontologia,* 32(2):259–281.

Zhou, B.C., and Ikeya, N., 1992. Three species of *Krithe* (Crustacea: Ostracoda) from Suruga Bay, central Japan. *Transactions and Proceedings of the Palaeontological Society of Japan*, 166:1097–1115.

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Figure F1. Map showing Site U1426 and the other Expedition 346 sites. Locations of the Pliocene and Pleistocene strata and bays referred in the present study are also shown. See Table T1 for a list of sites that include the period and formation of sample locations a–p. The first, second, and third branches of the Tsushima Warm Current (TWC-1, TWC-2, TWC-3) are also shown.

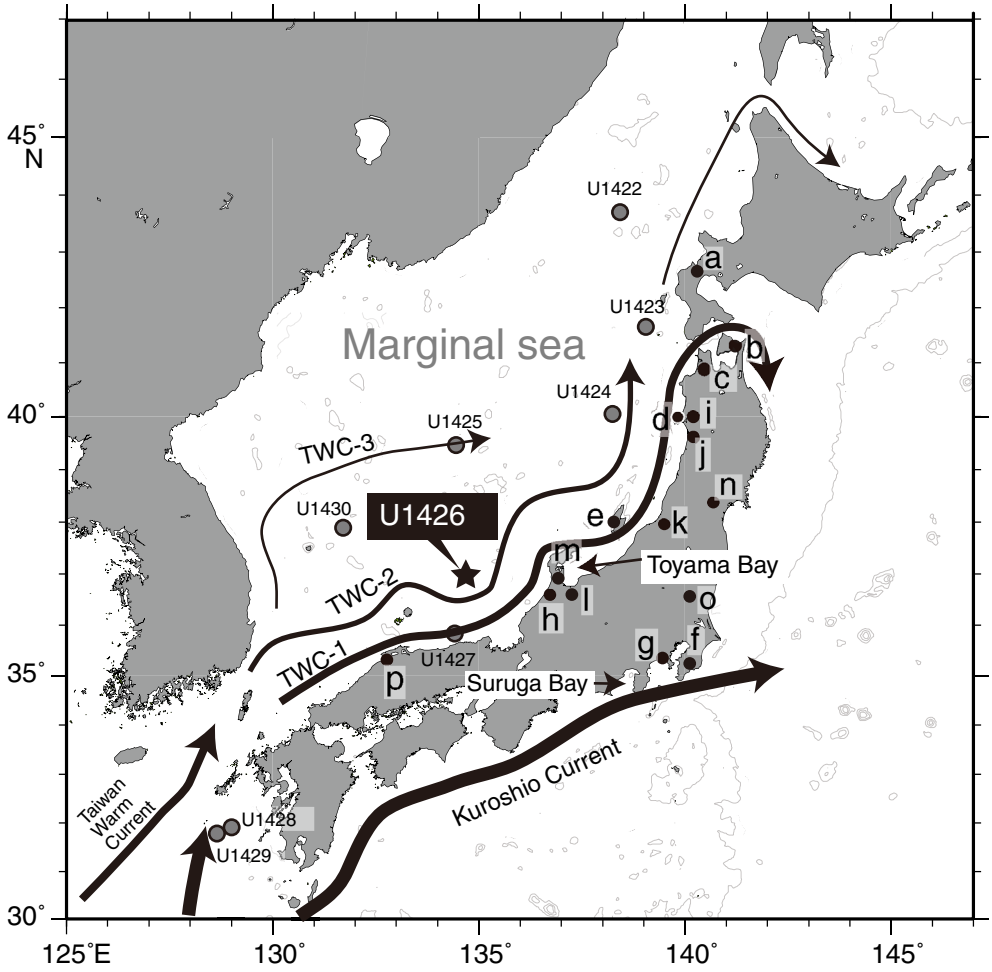

Table T1. List of the Pliocene and Pleistocene strata referred to in Figure F1 around the Japanese Islands.

Location	Period	Formation	References
a	Pleistocene	Setana	Hayashi (1988)
b	Pleistocene	Hamada	Ozawa and Domitsu (2010)
c	Pleistocene	Daishaka	Tabuki (1986)
d	Pleistocene	Wakimoto	Ishizaki and Matoba (1985)
e	Pleistocene	Shichiba (Sawane)	Hanai (1957), Ozawa (2010), Ishida et al. (2012)
f	Pleistocene	Kioroshi	Yajima (1982)
g	Pleistocene	Naganuma	Ozawa (2009)
h	Pleistocene	Omma	Kamiya et al. (1996), Ozawa (1996), Ozawa and Kamiya (2001, 2005)
i	Pliocene and Pleistocene	Sasaoka	Irizuki (1989), Yamada et al. (2002), Yamada (2003),
j	Pliocene	Tentokuji	Irizuki (1996), Irizuki and Ishida (2007)
k	Pliocene	Kuwae	Yamada (2003), Yamada et al. (2005), Irizuki et al. (2007), Goto et al. (2014a)
l	Pliocene	Mita	Goto et al. (2014b)
m	Pliocene and Pleistocene	Yabuta	Cronin et al. (1994)
n	Miocene	Hatatate	Ishizaki (1966), Tanaka (2009)
o	Miocene	Kobana	Irizuki et al (1998, 2001)
p	Miocene	Fujina	Tanaka et al. (2002)

Table T2. List of ostracod taxa in Holes U1426A and U1426C. (Continued on next five pages.)

Hole, core, section, interval (cm)	Top depth (m) CSF-A	Top depth (m) CCSF-D	*Acanthocythereis dunelmensis*	*Acanthocythereis tsurugasakensis*	*Acanthocythereis* sp.	*Argilloecia lunata*	*Argilloecia toyamaensis*	*Argilloecia* sp.	*Cytheropteron* cf. *carolae*	*Cytheropteron eremitum*	*Cytheropteron* cf. *perlaria*	*Cytheropteron* sp.	*Falsobuntonia taiwanica*	*Hirsutocythere* ? *hanaii*	*Kobayashiina hyalinosa*	*Krithe antisawanensis*	*Krithe dolichodeira*	*Krithe reversa*	*Krithe* spp.	*Loxoconchidea dolgoiensis*	*Munseyella oborozukiyo*	*Palmoconcha saboyamensis*	*Palmoconcha* sp.	*Propontocypris uranipponica*	*Robertsonites hanaii*	*Robertsonites tabukii*	Total number of specimens	Total number of species
346-																												
U1426C-14H-1, 35–37	113.35	123.49																									0	0
U1426C-14H-1, 85–87	113.85	125.22																									0	0
U1426C-14H-2, 35–37	114.35	125.72																									0	0
U1426C-14H-2, 85–87	114.85	126.22															1										1	1
U1426C-14H-3, 35–37	115.58	126.95																									0	0
U1426C-14H-3, 85–87	116.08	127.45																									0	0
U1426C-14H-4, 35–37	116.90	128.27														2		3	5								10	3
U1426C-14H-4, 85–87	117.40	128.77							1				2								1		1				5	4
U1426C-14H-5, 25–27	118.27	129.64												2					4	1							7	3
U1426C-14H-5, 75–77	118.77	130.14																									0	0
U1426A-14H-4, 35–37	120.54	130.33																									0	0
U1426C-14H-5, 125–127	119.27	130.64																									0	0
U1426A-14H-4, 85–87	121.04	130.83																									0	0
U1426C-14H-6, 25–27	119.78	131.15																									0	0
U1426C-14H-6, 75–77	120.28	131.65																									0	0
U1426C-14H-6, 125–127	120.78	132.15																									0	0
U1426C-14H-7, 25–27	121.28	132.65																									0	0
U1426C-14H-7, 75–77	121.78	133.15																									0	0
U1426C-14H-7, 125–127	122.28	133.65																									0	0
U1426A-14H-5, 35–37	121.93	133.78																									0	0
U1426A-14H-5, 85–87	122.43	134.28																									0	0
U1426A-14H-6, 25–27	123.17	135.02																									0	0
U1426A-14H-6, 75–77	123.67	135.52															2										2	1
U1426A-14H-6, 125–127	124.17	136.02																									0	0
U1426A-14H-7, 35–37	124.77	136.62																									0	0
U1426A-14H-7, 85–87	125.27	137.12																									0	0
U1426C-15H-2, 35–37	124.35	137.72																									0	0
U1426C-15H-2, 85–87	124.85	138.22																									0	0
U1426C-15H-3, 25–27	125.68	139.05																									0	0
U1426A-15H-2, 25–27	127.47	139.32	2																								2	1
U1426C-15H-3, 75–77	126.18	139.55																									0	0
U1426C-15H-3, 125–127	126.68	140.05																					1		2		3	2
U1426C-15H-4, 25–27	127.18	140.55	3																						1		4	2
U1426C-15H-4, 75–77	127.68	141.05	1																1								2	2
U1426C-15H-4, 125–127	128.18	141.55																									0	0
U1426A-15H-2, 75–77	127.97	141.85																									0	0
U1426A-15H-2, 125–127	128.47	142.35	3																								3	1
U1426A-15H-3, 35–37	129.07	142.95																									0	0
U1426A-15H-3, 85–87	129.57	143.45	1																			2					3	2
U1426A-15H-4, 25–27	130.26	144.14																									0	0

Table T2 (continued). (Continued on next page.)

Hole, core, section, interval (cm)	Top depth (m) CSF-A	Top depth (m) CCSF-D	*Acanthocythereis dunelmensis*	*Acanthocythereis tsurugasakensis*	*Acanthocythereis* sp.	*Argilloecia lunata*	*Argilloecia toyamaensis*	*Argilloecia* sp.	*Cytheropteron* cf. *carolae*	*Cytheropteron eremitum*	*Cytheropteron* cf. *perlaria*	*Cytheropteron* sp.	*Falsobuntonia taiwanica*	*Hirsutocythere* ? *hanaii*	*Kobayashiina hyalinosa*	*Krithe antisawanensis*	*Krithe dolichodeira*	*Krithe reversa*	*Krithe* spp.	*Loxoconchidea dolgoiensis*	*Munseyella oborozukiyo*	*Palmoconcha saboyamensis*	*Palmoconcha* sp.	*Propontocypris uranipponica*	*Robertsonites hanaii*	*Robertsonites tabukii*	Total number of specimens	Total number of species
U1426A-15H-4, 75–77	130.76	144.64																									0	0
U1426A-15H-4, 125–127	131.26	145.14																									0	0
U1426A-15H-5, 25–27	131.76	145.64																									0	0
U1426C-17H-2, 35–37	132.44	145.81																									0	0
U1426A-15H-5, 75–77	132.26	146.14			1																					1	2	2
U1426C-17H-2, 85–87	132.94	146.31																									0	0
U1426A-15H-5, 125–127	132.76	146.64																								1	1	1
U1426C-17H-3, 35–37	133.52	146.89	5												1			2								3	11	4
U1426A-15H-6, 25–27	133.26	147.14																1								1	2	2
U1426C-17H-3, 85–87	134.02	147.39	5										2						6							1	14	4
U1426A-15H-6, 75–77	133.76	147.64																									0	0
U1426A-15H-6, 125–127	134.26	148.14																3									3	1
U1426A-15H-7, 25–27	134.76	148.64														1	1	1								1	4	4
U1426A-15H-7, 75–77	135.26	149.14	2		1											1			2								6	4
U1426A-15H-7, 125–127	135.76	149.64			1														4						6		11	3
U1426C-17H-4, 35–37	134.59	150.16													1												1	1
U1426C-17H-4, 85–87	135.09	150.66																									0	0
U1426A-16H-2, 25–27	137.19	151.07																									0	0
U1426C-17H-5, 35–37	135.95	151.52																									0	0
U1426A-16H-2, 75–77	137.69	151.57																									0	0
U1426C-17H-5, 85–87	136.45	152.02																									0	0
U1426A-16H-2, 125–127	138.19	152.07																									0	0
U1426C-17H-6, 25–27	137.05	152.62																									0	0
U1426C-17H-6, 75–77	137.55	153.12																									0	0
U1426C-17H-6, 125–127	138.05	153.62																									0	0
U1426C-17H-7, 25–27	138.55	154.12																									0	0
U1426C-17H-7, 75–77	139.05	154.62																									0	0
U1426C-17H-7, 125–127	139.55	155.12											2											1			3	2
U1426A-16H-3, 25–27	138.69	155.59																									0	0
U1426A-16H-3, 75–77	139.19	156.09																	1								1	1
U1426A-16H-3, 125–127	139.69	156.59														1										1	2	2
U1426A-16H-4, 25–27	140.19	157.09										1							6	1				1			9	4
U1426A-16H-4, 75–77	140.69	157.59																									0	0
U1426A-16H-4, 125–127	141.19	158.09								1									1							1	3	3
U1426A-16H-5, 25–27	141.73	158.63																									0	0
U1426A-16H-5, 75–77	142.23	159.13																									0	0
U1426A-16H-5, 125–127	142.73	159.63																									0	0
U1426A-16H-6, 25–27	143.23	160.13																									0	0
U1426A-16H-6, 75–77	143.73	160.63																									0	0
U1426A-16H-6, 125–127	144.23	161.13																									0	0
U1426C-18H-4, 35–37	143.52	161.27																									0	0
U1426C-18H-4, 85–87	144.02	161.77																									0	0

Table T2 (continued). (Continued on next page.)

Hole, core, section, interval (cm)	Top depth (m) CSF-A	Top depth (m) CCSF-D	*Acanthocythereis dunelmensis*	*Acanthocythereis tsurugasakensis*	*Acanthocythereis* sp.	*Argilloecia lunata*	*Argilloecia toyamaensis*	*Argilloecia* sp.	*Cytheropteron* cf. *carolae*	*Cytheropteron eremitum*	*Cytheropteron* cf. *perlaria*	*Cytheropteron* sp.	*Falsobuntonia taiwanica*	*Hirsutocythere* ? *hanaii*	*Kobayashiina hyalinosa*	*Krithe antisawanensis*	*Krithe dolichodeira*	*Krithe reversa*	*Krithe* spp.	*Loxoconchidea dolgoiensis*	*Munseyella oborozukiyo*	*Palmoconcha saboyamensis*	*Palmoconcha* sp.	*Propontocypris uranipponica*	*Robertsonites hanaii*	*Robertsonites tabukii*	Total number of specimens	Total number of species
U1426C-18H-5, 35–37	144.87	162.62												1						1						2	4	3
U1426C-18H-5, 85–87	145.37	163.12											3			1			1								5	3
U1426A-17H-2, 25–27	146.58	163.48																									0	0
U1426C-18H-6, 25–27	146.04	163.79												1													1	1
U1426C-18H-6, 75–77	146.54	164.29																1	5							1	7	3
U1426C-18H-6, 125–127	147.04	164.79																								1	1	1
U1426A-17H-2, 75–77	147.08	165.28																									0	0
U1426A-17H-2, 125–127	147.58	165.78																									0	0
U1426A-17H-3, 25–27	148.03	166.23											1					1						1			3	3
U1426A-17H-3, 75–77	148.53	166.73																									0	0
U1426A-17H-3, 125–127	149.03	167.23	1														1										2	2
U1426A-17H-4, 25–27	149.53	167.73																									0	0
U1426A-17H-4, 75–77	150.03	168.23																									0	0
U1426A-17H-4, 125–127	150.53	168.73																									0	0
U1426A-17H-5, 25–27	151.03	169.23																									0	0
U1426A-17H-5, 75–77	151.53	169.73																									0	0
U1426A-17H-5, 125–127	152.03	170.23	2		1													1									4	3
U1426C-19H-2, 50–52	151.20	170.70	1											1		1			1							1	5	5
U1426A-17H-6, 25–27	152.53	170.73	2																								2	1
U1426A-17H-6, 75–77	153.03	171.23	2																								2	1
U1426C-19H-3, 35–37	151.93	171.43	2						1																	1	4	3
U1426A-17H-6, 125–127	153.53	171.73	1																								1	1
U1426C-19H-3, 85–87	152.43	171.93	2						1																		3	2
U1426C-19H-4, 35–37	153.26	172.76												1													1	1
U1426C-19H-4, 85–87	153.76	173.26																									0	0
U1426C-19H-5, 35–37	154.59	174.09																									0	0
U1426A-18H-2, 25–27	156.25	174.45	1																								1	1
U1426C-19H-5, 85–87	155.09	174.59												1													1	1
U1426A-18H-2, 75–77	156.75	174.95	2																								2	1
U1426C-19H-6, 25–27	155.70	175.20																									0	0
U1426C-19H-6, 75–77	156.20	175.70	2							1																	3	2
U1426C-19H-6, 125–127	156.70	176.20	1																								1	1
U1426C-19H-7, 25–27	157.20	176.70																									0	0
U1426C-19H-7, 75–77	157.70	177.20																									0	0
U1426C-19H-7, 125–127	158.20	177.70								1																	1	1
U1426A-18H-2, 125–127	157.25	178.09																									0	0
U1426A-18H-3, 25–27	157.75	178.59																									0	0
U1426A-18H-3, 75–77	158.25	179.09																									0	0
U1426A-18H-3, 125–127	158.75	179.59																									0	0
U1426A-18H-4, 25–27	159.25	180.09																									0	0
U1426A-18H-4, 75–77	159.75	180.59											1											1		1	3	3
U1426A-18H-4, 125–127	160.25	181.09																									0	0

Table T2 (continued). (Continued on next page.)

Hole, core, section, interval (cm)	Top depth (m)		*Acanthocythereis dunelmensis*	*Acanthocythereis tsurugasakensis*	*Acanthocythereis* sp.	*Argilloecia lunata*	*Argilloecia toyamaensis*	*Argilloecia* sp.	*Cytheropteron* cf. *carolae*	*Cytheropteron eremitum*	*Cytheropteron* cf. *perlaria*	*Cytheropteron* sp.	*Falsobuntonia taiwanica*	*Hirsutocythere* ? *hanaii*	*Kobayashiina hyalinosa*	*Krithe antisawanensis*	*Krithe dolichodeira*	*Krithe reversa*	*Krithe* spp.	*Loxoconchidea dolgoiensis*	*Munseyella oborozukiyo*	*Palmoconcha saboyamensis*	*Palmoconcha* sp.	*Propontocypris uranipponica*	*Robertsonites hanaii*	*Robertsonites tabukii*	Total number of specimens	Total number of species
	CSF-A	CCSF-D																										
U1426C-20H-3, 35–37	161.87	181.37														1				1						1	3	3
U1426A-18H-5, 25–27	160.75	181.59	2																2							1	5	3
U1426A-18H-5, 75–77	161.25	182.09	5				1			3								14	17					1		9	50	7
U1426A-18H-5, 125–127	161.75	182.59																								1	1	1
U1426C-20H-3, 85–87	162.37	182.85												1					2								3	2
U1426C-20H-4, 35–37	163.00	183.48																	2				1		2		5	3
U1426C-20H-4, 85–87	163.50	183.98	1			1													2								4	3
U1426C-20H-5, 35–37	164.43	184.91	1										1							1							3	3
U1426C-20H-5, 85–87	164.93	185.41				4										2			1								7	3
U1426C-20H-6, 25–27	165.75	186.23																									0	0
U1426C-20H-6, 75–77	166.25	186.73																									0	0
U1426A-19H-3, 25–27	165.90	186.74	1															1									2	2
U1426C-20H-6, 125–127	166.75	187.23																								1	1	1
U1426A-19H-3, 75–77	166.40	187.24											1						1			1					3	3
U1426C-20H-7, 35–37	167.36	187.84	3															1	2				1				7	4
U1426C-20H-7, 85–87	167.86	188.34																									0	0
U1426A-19H-3, 125–127	166.90	188.65									1						1	6	4						1	2	15	6
U1426A-19H-4, 25–27	167.40	189.15																									0	0
U1426A-19H-4, 75–77	167.90	189.65																									0	0
U1426A-19H-4, 125–127	168.40	190.15																									0	0
U1426A-19H-5, 25–27	168.90	190.65																									0	0
U1426C-21H-2, 35–37	170.47	190.95																									0	0
U1426A-19H-5, 75–77	169.40	191.15	1												1				3						1		6	4
U1426A-19H-5, 125–127	169.90	191.65	2							2								3	3								10	4
U1426A-19H-6, 35–37	170.50	192.25	1						2	1								2							3	2	11	6
U1426C-21H-2, 85–87	170.97	192.74																								1	1	1
U1426A-19H-6, 85–87	171.00	192.75																1							2		3	2
U1426C-21H-3, 35–37	171.79	193.56																									0	0
U1426C-21H-3, 85–87	172.29	194.06																	1	1						4	6	3
U1426C-21H-4, 35–37	173.21	194.98			1																					3	4	2
U1426C-21H-4, 85–87	173.71	195.48																								2	2	1
U1426C-21H-5, 25–27	174.55	196.32																									0	0
U1426C-21H-5, 75–77	175.05	196.82																									0	0
U1426C-21H-5, 125–127	175.55	197.32																									0	0
U1426A-20H-4, 25–27	176.04	197.79	3																1							1	5	3
U1426C-21H-6, 25–27	176.05	197.82																									0	0
U1426A-20H-4, 75–77	176.54	198.29	1		1																					1	3	3
U1426C-21H-6, 75–77	176.55	198.32																									0	0
U1426A-20H-4, 125–127	177.04	198.79																								1	1	1
U1426C-21H-6, 125–127	177.05	198.82	4							1									2							1	8	4
U1426C-21H-7, 35–37	177.62	199.39																	2							2	4	2
U1426C-21H-7, 85–87	178.12	199.89																								1	1	1

Table T2 (continued). (Continued on next page.)

Hole, core, section, interval (cm)	Top depth (m) CSF-A	Top depth (m) CCSF-D	*Acanthocythereis dunelmensis*	*Acanthocythereis tsurugasakensis*	*Acanthocythereis* sp.	*Argilloecia lunata*	*Argilloecia toyamaensis*	*Argilloecia* sp.	*Cytheropteron* cf. *carolae*	*Cytheropteron eremitum*	*Cytheropteron* cf. *perlaria*	*Cytheropteron* sp.	*Falsobuntonia taiwanica*	*Hirsutocythere* ? *hanaii*	*Kobayashiina hyalinosa*	*Krithe antisawanensis*	*Krithe dolichodeira*	*Krithe reversa*	*Krithe* spp.	*Loxoconchidea dolgoiensis*	*Munseyella oborozukiyo*	*Palmoconcha saboyamensis*	*Palmoconcha* sp.	*Propontocypris uranipponica*	*Robertsonites hanaii*	*Robertsonites tabukii*	Total number of specimens	Total number of species
U1426A-20H-5, 25–27	177.54	200.20																									0	0
U1426A-20H-5, 75–77	178.04	200.70	1										2													2	5	3
U1426A-20H-5, 125–127	178.54	201.20	1						2									2	1								6	4
U1426A-20H-6, 25–27	179.04	201.70																									0	0
U1426A-20H-6, 75–77	179.54	202.20																									0	0
U1426A-20H-6, 125–127	180.04	202.70																									0	0
U1426A-20H-7, 35–37	180.64	203.30																									0	0
U1426A-20H-7, 85–87	181.14	203.80																									0	0
U1426A-21H-3, 25–27	184.38	207.04																									0	0
U1426A-21H-3, 75–77	184.88	207.54	1		4																					1	6	3
U1426A-21H-3, 125–127	185.38	208.04																	2			1					3	2
U1426A-21H-4, 25–27	185.88	209.40	1		4				2							1											8	4
U1426A-21H-4, 75–77	186.38	209.90			1																				2		3	2
U1426A-21H-4, 125–127	186.88	210.40	4						1										1								6	3
U1426A-21H-5, 25–27	187.38	210.90	2			1	1		2										1								7	5
U1426A-21H-5, 75–77	187.88	211.40	5		4				1								1		2								13	5
U1426A-21H-5, 125–127	188.38	211.90	3		1				2		2															1	9	5
U1426A-21H-6, 25–27	188.88	212.40																									0	0
U1426A-21H-6, 75–77	189.38	212.90																									0	0
U1426A-21H-6, 125–127	189.88	213.40																									0	0
U1426A-21H-7, 35–37	190.48	214.00																									0	0
U1426A-21H-7, 85–87	190.98	214.50																									0	0
U1426A-22H-4, 25–27	194.63	218.15																									0	0
U1426A-22H-4, 75–77	195.13	220.10																									0	0
U1426A-22H-4, 125–127	195.63	220.60																									0	0
U1426A-22H-5, 25–27	196.13	221.10																									0	0
U1426A-22H-5, 75–77	196.63	221.60																									0	0
U1426A-22H-5, 125–127	197.13	222.10																									0	0
U1426A-22H-6, 25–27	197.63	222.60																									0	0
U1426A-22H-6, 75–77	198.13	223.10																									0	0
U1426A-22H-6, 125–127	198.63	223.60																		2							2	1
U1426A-22H-7, 35–37	199.23	224.20																									0	0
U1426A-22H-7, 85–87	199.73	224.70																									0	0
U1426A-37H-1, 25–27	294.05	319.79																									0	0
U1426A-37H-1, 76–78	294.56	320.30																									0	0
U1426A-37H-1, 125–127	295.05	320.79																									0	0
U1426A-37H-2, 25–27	295.55	321.29	2																								2	1
U1426A-37H-2, 84–86	296.14	321.88	3	4																							7	2
U1426A-37H-2, 125–127	296.55	322.29	2	2																							4	2
U1426A-37H-3, 35–37	297.15	322.89																									0	0
U1426A-37H-4, 34–36	297.78	323.52																									0	0
U1426A-39H-1, 35–37	298.35	324.09																									0	0

Table T2 (continued).

Hole, core, section, interval (cm)	Top depth (m) CSF-A	Top depth (m) CCSF-D	*Acanthocythereis dunelmensis*	*Acanthocythereis tsurugasakensis*	*Acanthocythereis* sp.	*Argilloecia lunata*	*Argilloecia toyamaensis*	*Argilloecia* sp.	*Cytheropteron* cf. *carolae*	*Cytheropteron eremitum*	*Cytheropteron* cf. *perlaria*	*Cytheropteron* sp.	*Falsobuntonia taiwanica*	*Hirsutocythere* ? *hanaii*	*Kobayashiina hyalinosa*	*Krithe antisawanensis*	*Krithe dolichodeira*	*Krithe reversa*	*Krithe* spp.	*Loxoconchidea dolgoiensis*	*Munseyella oborozukiyo*	*Palmoconcha saboyamensis*	*Palmoconcha* sp.	*Propontocypris uranipponica*	*Robertsonites hanaii*	*Robertsonites tabukii*	Total number of specimens	Total number of species
U1426A-39H-1, 87–89	298.87	324.61	4	2																							6	2
U1426A-39H-2, 25–27	299.43	325.17																									0	0
U1426A-39H-2, 75–77	299.93	325.67																									0	0
U1426A-39H-2, 125–127	300.43	326.17																									0	0
U1426A-39H-3, 35–37	300.99	326.73	1	1																							2	2
U1426A-39H-3, 85–87	301.49	327.23	4																								4	1
U1426A-39H-4, 35–37	302.37	328.11		2	2																						4	2
U1426A-40H-1, 25–27	302.95	328.69																									0	0
U1426A-40H-1, 76–78	303.46	329.20																									0	0
U1426A-40H-1, 125–127	303.95	329.69																									0	0
U1426A-40H-2, 25–27	304.44	330.18	4																								4	1
U1426A-40H-2, 75–77	304.94	330.68	2																1								3	2
U1426A-40H-2, 125–127	305.44	331.18	5																								5	1
U1426A-40H-3, 25–27	305.90	331.64																									0	0
U1426A-40H-3, 72–74	306.37	332.11																									0	0
U1426A-40H-3, 125–127	306.90	332.64																									0	0
U1426A-40H-4, 35–37	307.30	333.04																									0	0
U1426A-57H-1, 77–79	383.37	409.11				1																					1	1
U1426A-57H-2, 75–77	384.85	410.59						1																			1	1
U1426A-58H-2, 125–127	388.86	414.60											1														1	1

Plate P1. Scanning electron microscopy images of ostracod species (all external views), Hole U1426A unless otherwise specified. Scale bars = 300 µm. **1.** *Argilloecia lunata* Frydl, 1982, adult, left valve (LV) (21H-5, 25–27 cm). **2.** *Argilloecia toyamaensis* Ishizaki and Irizuki, adult, right valve (RV) (21H-5, 25–27 cm). **3.** *Argilloecia* sp., juvenile, carapace (27H-2, 75–77 cm). **4.** *Propontocypris uranipponica* Ishizaki and Irizuki, 1990, adult, RV (346-U1426C-17H-7, 125–127 cm). **5**. *Cytheropteron* cf. *carolae* Brouwers, 1994, adult, RV (21H-5, 125–127 cm). **6**. *Cytheropteron eremitum* Hanai, 1959, juvenile, LV (18H-5, 75–77 cm). **7.** *Cytheropteron* cf. *perlaria* Hao in Ruan and Hao, 1988, adult, LV (21H-5, 125–127 cm). **8.** *Kobayashiina hyalinosa* Hanai, 1957, adult, RV (19H-5, 75–77 cm). **9.** *Krithe antisawanensis* Ishizaki, 1966, adult, RV (21H-4, 25–27 cm). **10.** *Krithe dolichodeira* Van Den Bold, 1946, adult, RV (19H-3, 125–127 cm). **11.** *Krithe reversa* Van Den Bold, 1958, adult, RV (18H-5, 75–77 cm). **12.** *Loxoconchidea dolgoiensis* Brouwers, 1993, juvenile, RV (22H-6, 125–127 cm). **13.** *Palmoconcha saboyamensis* (Ishizaki, 1966), adult, LV (346-U1426C-15H-3, 85–87 cm). **14.** *Palmoconcha* sp., adult, LV (14H-4, 85–87 cm). **15.** *Munseyella oborozukiyo* Yajima, 1982, adult, RV (346-U1426C 14H-4, 85–87 cm). **16.** *Acanthocythereis dunelmensis* (Norman, 1865), adult, LV (15H-2, 25–27 cm). **17.** *Acanthocythereis tsurugasakensis* Tabuki, 1986, adult, LV (37H-2, 125–127 cm). **18.** *Acanthocythereis* sp., adult, RV (21H-5, 75–77 cm). **19.** *Falsobuntonia taiwanica* Malz, 1982, adult, LV (20H-5, 76–78 cm). **20.** *Hirsutocythere* ? *hanaii* Ishizaki, 1981, juvenile, RV (346-U1426C-14H-5, 25–27 cm). **21.** *Robertsonites hanaii* Tabuki, 1986, juvenile, LV (15H-7, 125–127 cm). **22.** *Robertsonites tabukii* Yamada, 2003, adult, LV (18H-5, 75–77 cm). (Figure shown on next page.)

Plate P1 (continued). (Caption shown on previous page.)

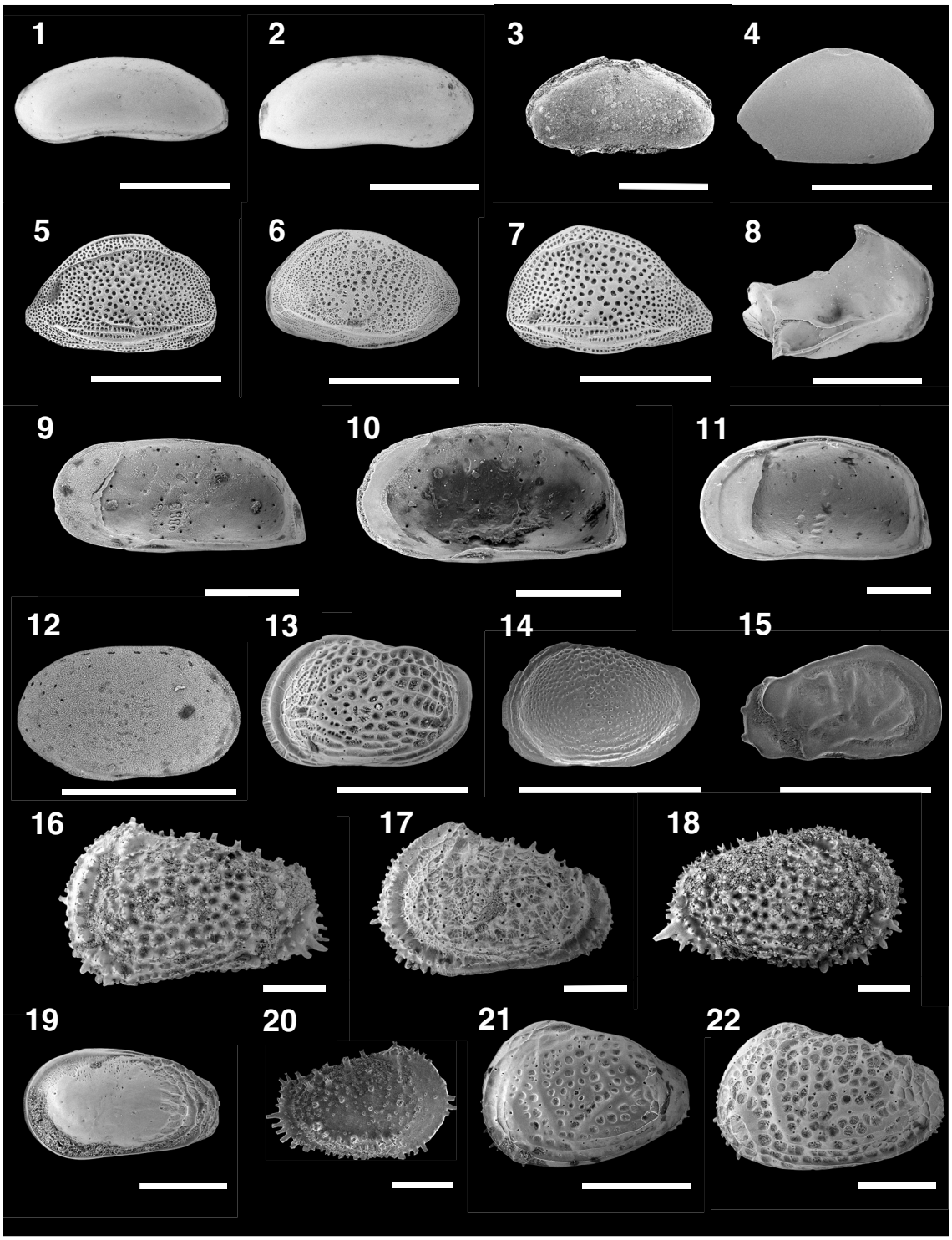

Plate P2. Stereomicroscope images of the genus *Krithe,* Site U1426 (internal views). Scale bar = 500 µm. **1.** *Krithe antisawanensis* Ishizaki, 1966, adult, LV (346-U1426C-14H-2W, 35–37 cm). **2.** *Krithe dolichodeira* Van Den Bold, 1946, adult, RV (346-U1426A-19H-3W, 125–127 cm). **3.** *Krithe reversa* Van Den Bold, 1958, adult, LV (346-U1426C-14H-2W, 35–37 cm).

Taxonomic notes

Class OSTRACODA Latreille, 1802
Subclass PODOCOPA Sars, 1866
Order PODOCOPIDA Sars, 1866
Suborder CYPRIDOCOPINA Jones, 1901
Superfamily PONTOCYPRIDOIDEA Müller, 1894
Family PONTOCYPRIDIDAE Müller, 1894
Genus *ARGILLOECIA* Sars, 1866

Argilloecia lunata Frydl, 1982
(Pl. P1, fig. 1)

Argilloecia lunata Frydl, 1982, p. 127, pl. 8, fig. 3–7; Paik and Lee, 1988, pl. 1, fig. 3; Ikeya and Suzuki, 1992, pl. 1, fig. 9; Tanaka, 2008, fig. 2, e; Ozawa, 2009, fig. 3, 3.

Remarks: This species occurs from the modern seafloor sediments in the Sea of Japan (e.g., Ikeya and Suzuki, 1992; Tsukawaki et al., 2000; Tanaka, 2008). Seven specimens are found at Site U1426.

Argilloecia toyamaensis Ishizaki and Irizuki, 1990
(Pl. P1, fig. 2)

Argilloecia toyamaensis Ishizaki and Irizuki, 1990, p. 63, pl. 1, fig. 1–6; Ozawa, 2003, fig. 7, 12; Ozawa, 2004, pl. 1–7; Ozawa et al., 2004, pl. 1, 2; Irizuki et al., 2007, fig. 5, 1; Ozawa and Tsukawaki, 2008, pl. 1, 2; Ozawa, 2010, pl. 1, 2; Alvarez Zarikian, 2016, pl. 1, 11a, 11b.

Remarks: This species is reported from the bottom sediments in water depth between 370 and 1153 m in the Toyama Bay (Ishizaki and Irizuki, 1990). The two specimens differ from the type-specimen in having a slightly less arched dorsal margin. This species is diagnostic for the Japan Sea Intermediate-Proper Water. It is found abundantly in the lower half of the water column (Ozawa, 2003).

Argilloecia sp.
(Pl. P1, fig. 3)

Remarks: The specimen has an oblong lateral shape and a moderate-rounded posterior margin. It resembles *Argilloecia toyamaensis* but differs from the latter species in having a more triangular lateral outline. Only one carapace was found.

Genus *PROPONTOCYPRIS* Sylvester-Bradley, 1946

Propontocypris uranipponica Ishizaki and Irizuki, 1990
(Pl. P1, fig. 4)

Propontocypris uranipponica Ishizaki and Irizuki, 1990, p. 62, pl. 1, fig. 7–12.

Remarks: This species is found in bottom sediments at water depths between 470 and 1265 m in the Toyama Bay (Ishizaki and Irizuki, 1990). It is an indicator of the lower half of the Japan Sea Intermediate-Proper Water mass (Ozawa, 2003). Six specimens were found at Site U1426.

Suborder CYTHEROCOPINA Sars, 1866
Superfamily CYTHEROIDEA Baird, 1850
Family CYTHERURIDAE Müller, 1894
Genus *CYTHEROPTERON* Sars, 1866

Cytheropteron cf. *carolae* Brouwers, 1994
(Pl. P1, fig. 5)

cf. *Cytheropteron carolae* Brouwers, 1994, p. 17, pl. 9, fig. 3, 4, pl. 10, fig. 12–14.
Cytheropteron carolae Brouwers, 1994; Irizuki et al., 2007, fig. 5, 11; Goto et al., 2014a, fig. 5, 8.
Cytheropteron sp., Ishizaki and Matoba, 1985, pl. 3, fig. 9, 10.
Cytheropteron sp. 3, Tabuki, 1986, p. 102, pl. 17, fig. 11, 12.
Cytheropteron sp. 2, Ozawa, 2010, pl. 1, 18.

Remarks: This species was originally described from the Gulf of Alaska (Brouwers, 1994) and reported from the Pliocene and Pleistocene strata exposed in the Sea of Japan coast (e.g., Tabuki, 1986; Irizuki et al., 2007; Ozawa, 2010). The specimens from Site U1426 sediments are slightly different from the type-specimen of *C. carolae* by having larger ovoid pits on the valve surface. The difference in the pit size might be caused by the thick calcified valve of the specimens.

Cytheropteron eremitum Hanai, 1959
(Pl. P1, fig. 6)

Cytheropteron rarum [sic] Hanai, 1959, p. 28, pl. 4, fig. 3.
Cytheropteron eremitum Hanai, 1959; Ishizaki and Matoba, 1985, pl. 3, fig. 5, 6.
Cytheropteron sp. D Alvarez Zarikian, 2016, pl. 1, fig. 5.

Remarks: This species was reported from the Pleistocene Sawane Formation in Sado Island, the eastern part of the Sea of Japan (Hanai, 1959), and the Wakimoto Formation in the Oga Peninsula, the northeastern part of the Japan Sea coast (Ishizaki and Matoba, 1985). Only juvenile specimens were found at Site U1426.

Cytheropteron cf. *perlaria* Hao in Ruan and Hao, 1988
(Pl. P1, fig. 7)

For comprehensive synonymy see Swanson and Ayress (1999), Stepanova (2006), and Yasuhara et al. (2009, 2014).
cf. *Cytheropteron perlaria* Hao in Ruan and Hao, 1988, p. 280, pl. 47, fig. 4–9.
Cytheropteron aff. *perlaria* Ruan and Hao, 1988; Swanson and Ayress, 1999, p. 155, pl. 7, fig. 1–6.
Cytheropteron carolae Brouwers, 1994; Ozawa and Kamiya, 2005, pl. 1, 6.
Cytheropteron testudo Sars, 1869; Zhao et al., 2000, p. 266, pl. 1, fig. 23, 24.

Remarks: The specimens are similar to *Cytheropteron perlaria* Ruan and Hao, 1988, in having a more triangular lateral outline and weaker alae. However, they have larger punctae than the types of *C. perlaria*. Swanson and Ayress (1999) recognized the intraspecific variations in size and number of punctation on the valve surface in *Cytheropteron sarsi* Swanson and Ayress (1999). Hence we consider that

this characteristic difference in the surface ornamentation is an intraspecific variation.

Genus *KOBAYASHIINA* Hanai, 1957

Kobayashiina hyalinosa Hanai, 1957
(Pl. P1, fig. 8)

Kobayashiina hyalinosa Hanai, 1957, p. 30, pl. 4, fig. 5a, 5b; Ishizaki and Matoba, 1985, pl. 4, fig. 13; Irizuki et al., 2007, fig. 5, 12; Ozawa, 2010, pl. 3, 4.

Remarks: This species was originally described from the Pleistocene Sawane Formation, Sado Island in the Sea of Japan (Hanai, 1957). Only fragments of three specimens were found at Site U1426.

Family KRITHIDAE Mandelstam in Bubikyan, 1958
Genus *KRITHE* Brady, Crosskey, and Robertson, 1874

Krithe antisawanensis Ishizaki, 1966
(Pl. P1, fig. 9; Pl. P2, fig. 1)

Krithe antisawanense [sic] Ishizaki, 1966, p. 137, pl. 18, fig. 17, 24, 25; Zhou and Ikeya, 1992, p. 1111, fig. 9, 4, 5, fig. 10, 4; Irizuki et al., 2007, fig. 5, 2; Tanaka, 2009, p. 37, pl. 3, fig. 1, 2; Tanaka et al., 2012, p. 16, pl. 2, 3; Tanaka, 2016, p. 33, fig. 2A–2N.

Remarks: In the internal view (Pl. P2, fig. 1), the specimens exhibit elongate pore canals in the third of the anterior marginal pore canals and pocket-shaped anterior vestibula. These characteristics are in agreement with *K. antisawanensis* (Tanaka, 2016). This species was originally described from the Miocene Hatatate Formation, northeastern Japan (Ishizaki, 1966). It is found in the Pliocene–Pleistocene strata such as the Kuwae Formation (Irizuki et al., 2007). This species lives in the Sea of Japan, Suruga Bay (Zhou and Ikeya, 1992), and Toyama Bay (Ishizaki and Irizuki, 1990) around the Japanese Islands.

Krithe dolichodeira Van Den Bold, 1946
(Pl. P1, fig. 10; Pl. P2, fig. 2)

Krithe dolichodeira Van Den Bold, 1946, p. 75, pl. 4, fig. 14a, 14b; Coles et al., 1994, p. 81, pl. 1, fig. 13–18; Ayress et al., 1999, p. 6, fig. 3, G, H.

Parakrithe hemideclivata Ruan in Ruan and Hao, 1988, p. 272, pl. 45, fig. 12–15.

Krithe hemideclivata (Ruan and Hao, 1988), Whatley and Zhao, 1993, fig. 3, 9; Zhao and Whatley, 1997, fig. 5, 4; Irizuki et al., 2007, fig. 5, 3.

Remarks: According to Coles et al. (1994), this species has a large valve, the right valve is overlapped by the left valve, an elongate pore canal in the second of the anterodorsal radial pore canals (type 2B in Coles et al., 1994), and a mushroom shaped anterior vestibulum (Zhao and Whatley, 1997). It was described from bottom sediments in the Okinawa Trough as *Parakrithe hemideclivata* (Ruan and Hao, 1988). Today this species occurs together with *Krithe antisawanensis* as dominant taxa in muddy substrate under water temperatures between 6° and 20°C in the East China Sea (Zhao and Whatley, 1997). In the Pliocene Kuwae Formation, both the species occur abundantly, indicating temperate intermediate water existence during the Pliocene (Irizuki et al., 2007).

Krithe reversa Van Den Bold, 1958
(Pl. P1, fig. 11, Pl. P2, fig. 3)

Krithe reversa Van Den Bold, 1958, p. 404, pl. 1, fig. 3–7; Coles et al., 1994, p. 77, pl. 1, fig. 1–6;

Krithe sawanensis Hanai, 1959, p. 301, pl. 18, fig. 3–7; Zhou and Ikeya, 1992, p. 1108, fig. 9, 1–3, fig. 10, 1–3; Ayress et al., 1999, p. 8, fig. 2F, 3O, 8M; Tanaka et al., 2012, p. 16, pl. 2, fig. 2.

Remarks: This species has an elongate pore canal in the third antero-dorsal radial pore canal and a pocket-shaped anterior vestibulum (Zhao et al., 2000). Further, it is characterized by the left valve overlapped by the right valve, that is the reversed valve overlap (Coles et al., 1994) to the other *Krithe* species. This species is characteristic of the lower half of the Japan Sea Intermediate-Proper Water mass (Ozawa, 2003). The specimens found have a slightly larger anterior vestibulum than *K. reversa* of Zhao et al. (2000).

Family LOXOCONCHIDAE Sars, 1925
Genus *LOXOCONCHIDEA* Bonaduce, Ciampo, and Masoli, 1975

Loxoconchidea dolgoiensis Brouwers, 1993
(Pl. P1, fig. 12)

Basslerites ? sp. Ishizaki and Matoba, 1985, pl. 2, fig. 2.

Loxoconchidea sp. Ishizaki and Irizuki, 1990, p. 64, pl. 1, fig. 14.

Loxoconchidea dolgoiensis Brouwers, 1993, p. 32, pl. 15, fig. 4–16; Irizuki et al., 2007, fig. 5, 13.

Remarks: This species occurs from the Gulf of Alaska (Brouwers, 1993), the Pliocene–Pleistocene strata in the Sea of Japan coast (e.g., Ishizaki and Matoba, 1985), and the modern sediments from the Toyama Bay (Ishizaki and Irizuki, 1990). Only juvenile specimens were obtained.

Genus *PALMOCONCHA* Swain and Gilby, 1974

Palmoconcha saboyamensis (Ishizaki, 1966)
(Pl. P1, fig. 13)

Loxoconcha saboyamensis, Ishizaki, 1966, p. 149, pl. 18, fig. 17, 24, 25.

Palmoconcha saboyamensis (Ishizaki, 1966); Irizuki et al., 2007, fig. 5, 14; Tanaka, 2009, p. 36, pl. 3, fig. 5, 6; Tanaka and Nomura, 2009, fig. 3, F.

Not *Palmoconcha saboyamensis* (Ishizaki, 1966); Ishizaki and Matoba, 1985, pl. 5, fig. 15.

Remarks: This species is found at water depth of 80–130 m in the Toyama Bay (Ishizaki and Irizuki, 1990). This species is an indicator of the lower half of the Japan Sea Intermediate-Proper Water mass (Ozawa, 2003). Only four specimens were obtained.

***Palmoconcha* sp.**
(Pl. P1, fig. 14)

Palmoconcha saboyamensis (Ishizaki, 1966); Ishizaki and Matoba, 1985, pl. 5, fig. 15.

Remarks: This species resembles *Palmoconcha saboyamensis* in the lateral outline but differs from the latter in having smaller punctae and lacking blunt horizontal muri in the postero-central area. Only three specimens were obtained.

Family PECTOCYTHERIDAE Hanai, 1957
Genus *MUNSEYELLA* Van Den Bold, 1957

***Munseyella oborozukiyo* Yajima, 1982**
(Pl. P1, fig. 15)

Munseyella oborozukiyo Yajima, 1982, p. 188, pl. 10, fig. 9, 12; Paik and Lee, 1988, pl. 1, fig. 8; Ikeya and Suzuki, 1992, pl. 6, fig. 8; Tanaka, 2008, fig. 2, f; Tanaka et al., 2012, p. 14, pl. 1, 12.

Remarks: This species was originally described from the Kioroshi Formation, in Boso Peninsula, the Pacific Ocean side of the central Japan (Yajima, 1982). It occurs from the modern bottom sediments in the Sea of Japan (Ikeya and Suzuki, 1992) and the Suruga Bay (Tanaka et al., 2012) as well as the Boso Peninsula.

Family TRACYLEBERIDIDAE Sylvester-Bradley, 1948
Genus *ACANTHOCYTHEREIS* Howe, 1963

***Acanthocythereis dunelmensis* (Norman, 1865)**
(Pl. P1, fig. 16)

For comprehensive pre-2002 synonymy see Tanaka et al. (2002).

Acanthocythereis dunelmensis (Norman, 1865); Ozawa, 2003, fig. 7, 11; Irizuki et al., 2007, fig. 5, 6; Tanaka and Nomura, 2009, fig. 3, J; Ozawa and Domitsu, 2010, fig. 3, 1.

Remarks: This species is commonly found in continental shelf sediments in mid to high latitudes of the Northern Hemisphere such as the Bering Sea and Arctic Ocean (Gemery et al., 2015) as well as the Sea of Japan (Ozawa, 2003). The fossil specimens occur from the outcrops of the Pliocene and Pleistocene strata along the coast of the Japanese Island (e.g., Irizuki et al., 2007). This species occurs abundantly under the Japan Sea Intermediate-Proper Water (Ozawa, 2003).

***Acanthocythereis tsurugasakensis* Tabuki, 1986**
(Pl. P1, fig. 17)

Acanthocythereis tsurugasakensis Tabuki, 1986, p. 85, pl. 11, fig. 2–10; Ozawa, 1996, pl. 1, 3; Tanaka et al., 2002, p. 13, fig. 8.5; Irizuki et al., 2007, fig. 5, 7; Tanaka and Nomura, 2009, fig. 3G; Ozawa and Domitsu, 2010, fig. 3.2.

Remarks: This species occurs from the Pliocene and Pleistocene sediments exposed in the Japan Sea coast. Most of the specimens are juveniles.

***Acanthocythereis* sp.**
(Pl. P1, fig. 18)

Acanthocythereis? sp. 1 Ikeya and Suzuki, 1992, pl. 1, fig. 4.

Remarks: This species resembles *Acanthocythereis dunelmensis* but differs from the latter species in having a smaller valve, a more rounded posterior margin, more spines, and more developed reticulation on the valve surface. It occurs from the bottom sediments off Shimane in the Sea of Japan (Ikeya and Suzuki, 1992).

Genus *FALSOBUNTONIA* Malz, 1982

***Falsobuntonia taiwanica* Malz, 1982**
(Pl. P1, fig. 19)

Ambocythere sp., Hu, 1978, p. 146, pl. 3, fig. 25.

Falsobuntonia taiwanica Malz, 1982, p. 392, pl. 8, fig. 51–56; Ishizaki and Matoba, 1985, pl. 3, fig. 11, 12; Huh and Paik, 1992b, pl. 2, fig. 15; Huh and Paik, 1992a, pl. 2, fig. 15; Ikeya and Suzuki, 1992, pl. 4, fig. 8, 9; Kamiya et al., 1996, pl. 3, fig. 1; Ozawa, 1996, pl. 4, 7; Irizuki et al., 1998, fig. 6, 9; Kamiya et al., 2001, fig. 15, 10; Irizuki et al., 2001, fig. 7, 16; Tanaka et al., 2002, p. 18, fig. 9, 5; Hu and Tao, 2008, p. 329, pl. 28, fig. 12; Tanaka et al., 2012, p. 17, pl. 3, 13.

Remarks: This species was first reported from the Pliocene and Pleistocene strata in the southwest Taiwan (Malz, 1982). It was widely reported from the strata around the Japanese Islands (e.g., Tanaka et al., 2002; Irizuki et al., 2007) and southwest Taiwan (Hu, 1978; Hu and Tao, 2008). It abounds at water depth of >150 m off Shimane, southwestern Japan (Ikeya and Suzuki, 1992).

Genus *HIRSUTOCYTHERE* Howe, 1951

***Hirsutocythere? hanaii* Ishizaki, 1981**
(Pl. P1, fig. 20)

Hirsutocythere ? *hanaii* Ishizaki, 1981, p. 46, pl. 9, fig. 4a, 4b, 5a, 5b, 6a, 6b, 7; Ozawa, 1996, pl. 5, 6; Irizuki et al., 1998, fig. 6, 7; Irizuki et al., 2001, fig. 7, 15; Nakao et al., 2001, fig. 11, 13; Ozawa, 2003, fig. 7, 9; Tanaka, 2008, fig. 2r; Ozawa, 2009, fig. 4, 1.

Hirsutocythere hanaii Ishizaki, 1981; Paik and Lee, 1988, pl. 2, fig. 17; Kamiya et al., 1996, pl. 4, fig. 9; Tanaka and Seto, 2010, p. 12, pl. 3, fig. 3; Tanaka et al., 2012, p. 29, pl. 3, 11.

Remarks: This species was first described from modern seafloor sediments in the East China Sea (Ishizaki, 1981). It is widely distributed in Miocene, Pliocene, and Pleistocene strata in Japan within the Naganuma Formation (Ozawa, 2009), Omma Formation (Ozawa, 1996), and Kobana Formation (Irizuki et al., 1998). This species is included in the assemblages that live in the Tsushima Warm Current Core water (Ozawa, 2003). It is also dominant at water depths of

~135 m in the outer sublittoral zone in the southwest part of the Sea of Japan (Tanaka, 2008). From the samples at Site U1426, eight juvenile valves were obtained.

Genus *ROBERTSONITES* Swain, 1963

Robertsonites hanaii Tabuki, 1986

(Pl. P1, fig. 21)

Robertsonites hanaii Tabuki, 1986, p. 90, pl. 13, fig. 1–12; Cronin and Ikeya, 1987, p. 84, pl. 2, fig. 11; Irizuki, 1994, pl. 2, fig. 7; Ozawa, 1996, pl. 8, 5; Yamada, 2003, p. 171, pl. 1, fig. 1, 2; Ozawa, 2004, pl. 1, 4; Ozawa et al., 2004, pl. 2, 20.; Tanaka et al., 2012, p. 18, pl. 3, fig. 17.

Remarks: This species was originally described from the Pleistocene Daishaka Formation, northeastern Japan (Tabuki, 1986) and is found abundantly in the Pliocene and Pleistocene strata along the Sea of Japan coast of the Japanese Islands. It is also reported from the modern bottom sediments under the upper half of the Japan Sea Intermediate-Proper Water (Ozawa, 2003). Only juvenile valves were identified.

Robertsonites tabukii Yamada, 2003

(Pl. P1, fig. 22)

Buntonia ? sp., Ishizaki and Matoba, 1985, pl. 2, fig. 6.
Robertsonites reticuliforma Ishizaki, 1966: Tabuki, 1986, p. 91, pl. 14, fig. 1–12; Cronin and Ikeya, 1987, p. 84, pl. 2, fig. 15; Irizuki, 1994, fig. 5–6; Irizuki, 1996, fig. 7, 3, 4.
Robertsonites tabukii, Yamada, 2003, p. 176, pl. 2, fig. 3–19; Irizuki et al., 2007, fig. 5, 10; Ishida et al., 2012, fig. 3, 16; Goto et al., 2014a, fig. 5, 18.

Remarks: Previously, the specimens of this species from the Pliocene and Pleistocene strata in the Sea of Japan were misidentified as *Robertsonites reticuliformus*, that was described from the Miocene strata in the northern part of Japan (Ishizaki, 1966). However, this species differs significantly from *R. reticuliformus* by its distinct murus below the eye tubercle extending into the ventral ridge at the anterior quarter of valve length. Tanaka (2009) displays scanning electron microscope (SEM) images of the types of *R. reticuliformus*, allowing us to distinguish these two species clearly. This species is one of the dominant species in the upper Pliocene Kuwae Formation (Yamada et al., 2005; Irizuki et al., 2007).