

Data report: Pleistocene planktonic foraminifers from the Kumano forearc basin, IODP Expedition 338 Holes C0002K and C0002L¹

Hiroki Hayashi,² Koji Suzuki,^{3,4} and Maya Fujimoto²

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Abstract

This study describes the planktonic foraminiferal assemblages of Holes C0002K and C0002L drilled during Integrated Ocean Drilling Program Expedition 338 in the southern part of the Kumano forearc basin, northwestern Pacific Ocean. The stratigraphic interval of the studied holes is constrained within the Calabrian stage of the Pleistocene by onboard stratigraphic data. Thirty-six taxa belonging to fifteen genera of planktonic foraminifers were detected from the studied interval. Three biostratigraphic events of planktonic foraminifers were newly constrained at the present site. The planktonic foraminiferal assemblages mainly consist of mixed-water and cosmopolitan species associated with tropical and subtropical taxa.

Introduction

The Nankai Trough Seismogenic Zone Experiment (NanTroSEIZE) was designed to investigate the fault mechanics and seismogenesis of the repeated mega-earthquake zone along the subduction boundary of the Philippine Sea plate. Site C0002 is the centerpiece of this project to access the seismogenic zone beneath the Kumano forearc basin. Integrated Ocean Drilling Program (IODP) Expedition 338 was conducted as part of the third stage of the NanTroSEIZE project. The main purpose of the expedition was to extend and case riser Hole C0002F from 856 to 3600 m core depth below seafloor (CSF-A). However, because of damage to the riser system under severe weather conditions during the expedition, riser operations were canceled. Contingency riserless coring at Site C0002 was conducted to sample the upper part of the forearc basin sediment (see the “[Expedition 338 summary](#)” chapter [Strasser et al., 2014a]).

Precise stratigraphic correlation is required to reconstruct the deformation processes of the Nankai Seismogenic Zone. Planktonic foraminiferal biostratigraphy is a powerful tool for correlating marine strata. In previous NanTroSEIZE expeditions, planktonic foraminifers provided stratigraphic datums (e.g., Hayashi et al., 2011, 2014). For Site C0002, 14 biohorizons were recognized in Hole C0002B from 478.28 to 1052.40 m CSF-A during Expedition 315 (Expedition 315 Scientists, 2009). For Hole C0002D of Expedition 315, detailed chemostratigraphy was constructed from

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²Shimane University, Department of Earth Sciences, Interdisciplinary Graduate School of Science and Engineering, 1060 Nishikawatsucho, Matsue City, Shimane 690-8504, Japan.

Correspondence author:

hayashi@riko.shimane-u.ac.jp

³Chiba University, Department of Earth Sciences, Graduate School of Science, Chiba City, Chiba 263-8522, Japan.

⁴Present address: Kanto Natural Gas Development Co., Ltd., Mobara City, Chiba 297-8550, Japan.



0 to 100 m CSF-A, reaching marine isotope Stage (MIS) 23 (Matsuzaki et al., 2015).

During Expedition 338, the D/V *Chikyu* drilled at Site C0002 (33°18'N, 136°38'E; 1937.5 m water depth) in the southern part of the Kumano forearc basin in the northwest Pacific Ocean (Fig. F1). In Holes C0002K and C0002L, a total of 35 cores were cut from 200 to 505 m CSF-A. Two of those cores were recovered with the hydraulic piston coring system (HPCS), four with the extended punch coring system (EPCS), and 29 with the extended shoe coring system (ESCS). The average recovery for the holes was 69% and 79%, respectively. This coring interval was chosen to provide data within the gap (200–500 m CSF-A) between Holes C0002D and C0002B.

According to onboard stratigraphic analyses, Holes C0002K and C0002L are constrained in age between 1.34 and 0.903 Ma and include the Jaramillo Subchron (0.988–1.07 Ma) in the upper part (Fig. F2). Onboard geochemical analyses detected a gas hydrate zone (200–400 m CSF-A) and a minimum concentration zone of salinity, chlorinity, and Na⁺ in pore water (300–500 m CSF-A) resulting from dissociation of methane hydrate (see the “Site C0002” chapter [Strasser et al., 2014c]). The purpose of this study is to describe the planktonic foraminiferal assemblages obtained from Holes C0002K and C0002L as a basic data set for the stratigraphy of the Kumano Basin region.

Materials and methods

The samples used for this research were collected from Holes C0002K and C0002L at an average interval of 3.5 m (1–3 samples per core). We treated 79 samples in the present study. The stratigraphy of the studied interval correlates to lithologic Unit II of previous drilling at Site C0002. Unit II is mainly composed of dark olive-gray silty claystone with subordinate sandstone, sandy siltstone, and volcanic ash (see the “Site C0002” chapter [Strasser et al., 2014c]). We generally followed the analytical techniques described in the “Methods” chapter (Strasser et al., 2014b). Sediment samples of 10–40 g dry weight were disaggregated using the sodium tetraphenylborate method (Hanken, 1979). After the samples had been macerated, each was wet-sieved through a 63 µm screen. Dried samples were then divided by a sample splitter into suitable volumes yielding ~200 planktonic foraminiferal specimens. Planktonic foraminiferal specimens larger than 125 µm were picked under a binocular microscope. We then conducted additional observations for all washed residues to detect index species. Species detected by the additional observation were recorded

as “+” in occurrence table (Table T1). Scanning electron microphotographs of important species were obtained with a JCM-5000 instrument (JEOL Co. Ltd., Japan).

Preservation of each sample was recorded using the following criteria:

- P = poor (dissolution of surface structure and fragmentation are observed; more than a half of the individuals cannot be identified at the species level).
- M = moderate (dissolution and fragmentation are commonly evident; some individuals are hard to identify).
- G = good (no dissolution; fragmentation of individuals has slightly occurred).

Taxonomic names and biochronology in this study generally follow the usage of Wade et al. (2011). Moreover, we distinguished the two morphotypes of *Globorotalia inflata* (i.e., transitional and modern forms by the number of chambers [Hayashi et al., 2003]). The modern form differs from the transitional form in having three chambers in its last whorl, in contrast to the four chambers of the transitional form.

Results

With the exception of several barren intervals, 36 taxa belonging to 15 genera of planktonic foraminifers were recognized in Holes C0002K and C0002L (Table T1). Fossil preservation is generally moderate to poor. In particular, sediment below ~300 m CSF-A have sparse occurrences of planktonic foraminifers with poor preservation and barren intervals (Table T1; Fig. F2). Most of these barren intervals contain only thick-walled benthic foraminifers with surfaces disfigured by dissolution.

Six age-diagnostic species were recognized in this study (Table T1). *Globorotalia tosaensis* sporadically occurs at 12 horizons between Samples 338-C0002L-21X-6, 45.0–47.5 cm (472.89 m CSF-A), and 338-C0002K-1H-5, 21.0–24.0 cm (203.57 m CSF-A). *Globorotalia truncatulinoides* was observed sporadically at 12 horizons between the same samples. Rare or few occurrences of *Globoturborotalita obliquus* were observed from only four samples (338-C0002K-7X-CC, 6.0–8.0 cm, and 338-C0002L-14X-8, 58.0–60.5 cm; 15X-1, 51.0–53.5 cm; and 19X-1, 43.0–45.5 cm). Among them, the uppermost occurrence in Sample 338-C0002K-7X-CC, 6.0–8.0 cm, might be reworked because the surface was brown and the test was filled by silty material (Plate P1; figs. 7a, 7b). Therefore, the top occurrence datum of this species (1.30 Ma; Wade et al., 2011) is suggested between Samples 338-

C0002L-14X-8, 58.0–60.5 cm (409.25 m CSF-A), and 14X-5, 81.0–83.5 cm (405.44 m CSF-A) (Table T2). A few specimens of *Neogloboquadrina inglei* were obtained from 18 samples between Samples 338-C0002L-21X-6, 45.0–47.5 cm (472.89 m CSF-A), and 338-C0002K-1H-5, 21.0–24.0 cm (203.57 m CSF-A). This species was reported from the deeper interval drilled in Hole C0002B (Expedition 315 Scientists, 2009). Thus, the base occurrence datum of this species should be located below Sample 338-C0002L-21X-6, 45.0–47.5 cm (472.89 m CSF-A) (Table T2). *Pulleniatina obliquiloculata* was found in 19 samples, and its coiling direction is exclusively dextral throughout the section. *Pulleniatina finalis* was detected at only four horizons in Hole C0002L (Samples 338-C0002L-5X-1, 20.0–22.5 cm; 13X-7, 7.0–9.5 cm; 14X-5, 81.0–83.5 cm, and 15X-1, 51.0–53.5 cm). This species was detected from only one sample in deeper interval obtained from Hole C0002B (Expedition 315 Scientists, 2009). The base occurrence datum of this species (2.04 Ma; Wade et al., 2011) is hard to recognize because of its sparse occurrence.

The first occurrence of *G. truncatulinoides* is at 1.98 Ma (Wade et al., 2011) and defines the base of Zone N22 of Blow (1969). This biohorizon was previously recognized at deeper depths (753.86–767.20 m CSF-A) in Hole C0002B during Expedition 315. In addition, the last occurrence of *G. tosaensis* is at 0.61 Ma (Wade et al., 2011). Therefore, the interval below the top occurrence of *G. tosaensis* (Sample 338-C0002K-1H-5, 21.0–24.0 cm; 203.57 m CSF-A) (Table T2) should be restricted to within the lower part of Zone N22. This correlation is consistent with onboard calcareous nannofossil and paleomagnetic data (see the “Site C0002” chapter [Strasser et al., 2014c]) (Fig. F2).

Planktonic foraminiferal assemblages in the study interval are characterized by dominant occurrences of mixed-water and cosmopolitan species such as *Neogloboquadrina incompta*, *Neogloboquadrina pachyderma* (dextral), *Globigerinita glutinata*, *Globigerina bulloides*, and *Globigerina falconensis* associated with tropical to subtropical taxa including *Globoconella inflata*, *Neogloboquadrina dutertrei*, and *Globigerinoides ruber* (Table T1; Fig. F2). Currently, the study area lies beneath mixed water caused by the upwelling of cold water near the Kuroshio Current. Therefore, the foraminiferal composition of the studied interval is generally consistent with present-day oceanographic conditions.

The most noteworthy feature of the planktonic foraminiferal assemblages is cyclic changes of relative abundance in cold versus cosmopolitan components (Fig. F2). We can observe five 40–60 m thick cycles throughout the study interval. The precise correla-

tion of the cycles with global events requires further studies including stable isotope analyses.

Faunal references

- Globigerina bulloides* d’Orbigny, 1826; Banner and Blow, 1960, pl. 1, figs. 1–4 (Pl. P1, figs. 1a, 1b).
Globigerina falconensis Blow, 1959, p. 177, pl. 9, figs. 40a–40c, 41.
Globigerinella calida (Parker), 1962, p. 221, pl. 1, figs. 9–13, 15.
Globigerinella siphonifera (d’Orbigny), 1839a, p. 83, pl. 4, figs. 15–18; Banner and Blow, 1960, p. 22–23, figs. 2a–2c.
Globigerinita glutinata (Egger), 1893, p. 371, pl. 13, figs. 19–21 (Pl. P1, figs. 2a, 2b).
Globigerinita iota Parker, 1962, p. 250, pl. 10, figs. 26–30.
Globigerinita uvula (Ehrenberg), 1861, pl. 2, figs. 24–25.
Globigerinoides conglobatus (Brady), 1879, p. 28; Brady, 1884, pl. 80, figs. 1–5.
Globigerinoides elongatus (d’Orbigny), 1826, p. 277; Banner and Blow, 1960, p. 12–13, pl. 3, figs. 10a–10c.
Globigerinoides ruber (d’Orbigny), 1839a, p. 82, pl. 4, figs. 12–14 (Pl. P1, figs. 3a, 3b).
Globigerinoides sacculifer (Brady), 1877, p. 535; Brady, 1884, pl. 80, figs. 11–17; Banner and Blow, 1960, p. 21, pl. 4, fig. 1.
Globoconella inflata (d’Orbigny), 1839b, p. 134, pl. 12, figs. 7–9 (Pl. P1, figs. 4a, 4b).
Globoconella punctulata (Deshayes), 1832, p. 170; Banner and Blow, 1960, pt. 1, p. 15, pl. 5, figs. 7a–7c.
Globorotalia crassaformis crassaformis (Galloway and Wissler), 1927, p. 41, pl. 7, fig. 12.
Globorotalia crassaformis viola Blow, 1969, p. 397, pl. 5, figs. 4–9.
Globorotalia tosaensis Takayanagi and Saito, 1962, p. 81, pl. 28, figs. 11a–12c (Pl. P1, figs. 5a–5c).
Globorotalia truncatulinoides (d’Orbigny), 1839b, p. 132, pl. 2, figs. 25–27 (Pl. P1, figs. 6a–6c).
Globorotalia tumida (Brady), 1877, p. 535; Brady, 1884, pl. 103, figs. 4–6.
Globorotaloides hexagona (Natland), 1938, p. 149, pl. 7, figs. 1a–1c.
Globorotaloides variabilis Bolli, 1957, p. 117, pl. 27, figs. 15a–20c.
Globoturborotalita obliquus (Bolli), 1957, p. 113, pl. 25, figs. 10a–10c (Pl. P1, figs. 7a–8b).
Globoturborotalita rubescens (Hofker), 1956, p. 234, pl. 32, fig. 26.
Globoturborotalita tenella (Parker), 1958, p. 280, pl. 6, figs. 7–11.
Hirsutella scitula (Brady), 1882, p. 716; Banner and Blow, 1960, pt. 1, p. 27, pl. 5, fig. 5.
Menardella cultrata (d’Orbigny), 1839a, p. 76, pl. 5, figs. 7–9; Banner and Blow, 1960, pl. 6, fig. 1.
Menardella menardii (Parker, Jones and Brady), 1865, Pt. XII; Stainforth et al., 1978, pl. 1, fig. 1.
Neogloboquadrina dutertrei (d’Orbigny), 1839a, p. 84, pl. 4, figs. 19–21; Banner and Blow, 1960, pt. 1, pl. 2, fig. 1 (Pl. P1, figs. 10a, 10b).

Neogloboquadrina incompta (Cifelli), 1961, p. 83, pl. 4, figs. 1–7 (Pl. **P1**, figs. 11a, 11b).
Neogloboquadrina inglei Kucera and Kennett, 2000 (Pl. **P1**, figs. 9a, 9b).
Neogloboquadrina pachyderma (Ehrenberg), 1861, p. 276; Banner and Blow, 1960, pt. 1, p. 4, pl. 3, figs. 4a–4c (Pl. **P1**, figs. 12a, 12b).
Orbulina universa d'Orbigny, 1839a, p. 3, pl. 1, fig. 1.
Pulleniatina finalis Banner and Blow, 1967, p. 140, pl. 2, figs. 4–10 (Pl. **P1**, fig. 14).
Pulleniatina obliquiculata (Parker and Jones), 1865, p. 368, pl. 19, figs. 4a–4b (Pl. **P1**, figs. 13a, 13b).
Sphaeroidinella dehiscentis (Parker and Jones), 1865, p. 369, pl. 19, fig. 5.
Turborotalita quinqueloba (Natland), 1938, p. 149, pl. 6, figs. 7a–7c.

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Figure F1. Map with Site C0002 and previous IODP sites around the Nankai Trough in the northwestern Pacific Ocean (modified after the Figure F1 in the “Expedition 338 summary” chapter [Strasser et al., 2014a]).

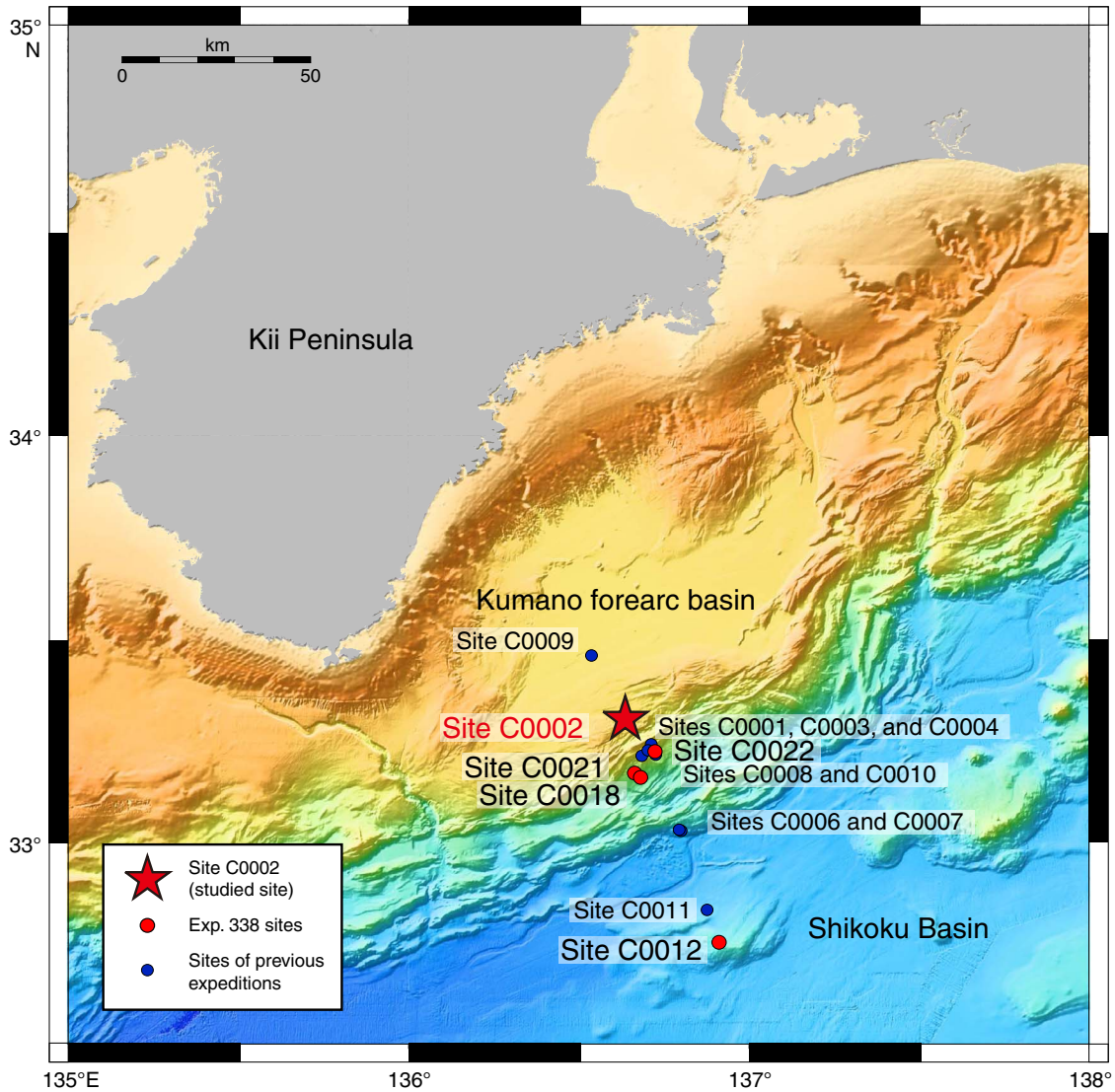




Figure F2. Stratigraphic changes in planktonic foraminiferal (PF) numbers, planktonic/total foraminiferal (P/T) ratio, and selected planktonic foraminiferal species. The P/T ratio and relative abundance of each species are presented for samples containing >100 individuals. The “*N. pachyderma* group” consists of *Neogloboquadrina incompta* and *Neogloboquadrina pachyderma*. Lithology, paleomagnetic polarity, and nannofossil biohorizons (*) are defined from onboard data (see the “Site C0002” chapter [Strasser et al., 2014c]).

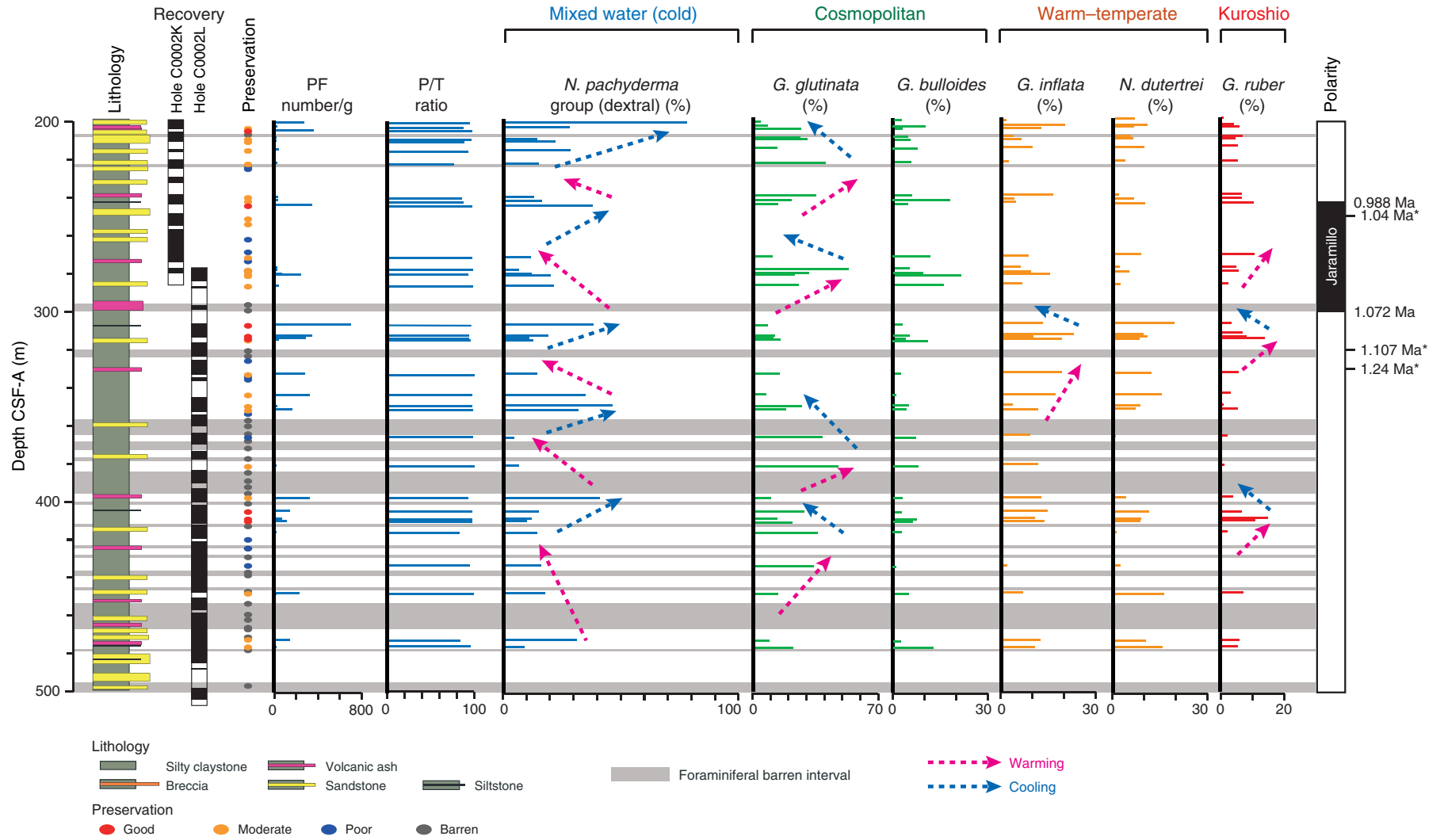


Table T1. Planktonic foraminifer range chart, Holes C0002K and C000L. This table is available in an [oversized format](#).

Table T2. Planktonic foraminiferal events, Expedition 338.

Event (base of zone)	BW11 age (Ma)	Top hole, core, section, interval (cm)	Depth CSF-A (m)	Bottom hole, core, section, interval (cm)	Depth CSF-A (m)	Mean depth CSF-A (m)	Depth range (\pm m)
		338-		338-			
T <i>Globorotalia tosaensis</i> (PT1b)	0.61	—	—	C0002K-1H-5, 21.0–24.0	203.57	203.57	—
T <i>Globoturbotalita obliquus</i>	1.30	C0002L-14X-5, 81.0–83.5	405.44	C0002L-14X-8, 58.0–60.5	409.25	407.35	1.91
B <i>Neogloboquadrina inglei</i>	—	C0002L-21X-6, 45.0–47.5	472.89	—	—	472.89	—

BW11 = Wade et al. (2011), B = base occurrence, T = top occurrence. — = not applicable.

Plate P1. 1a–b. *Globigerina bulloides* d'Orbigny; Sample 338-C0002L-2X-1, 45.0–48.0 cm. **2a, 2b.** *Globigerinita glutinata* (Egger); Sample 338-C0002K-2H-1, 45.0–48.0 cm. **3a, 3b.** *Globigerinoides ruber* (d'Orbigny); Sample 338-C0002L-2X-1, 45.0–48.0 cm. **4a, 4b.** *Globoconella inflata* (d'Orbigny) transitional form; Sample 338-C0002K-2H-1, 45.0–48.0 cm. **5a, 5b.** *Globorotalia tosaensis* Takayanagi and Saito; Sample 338-C0002K-2H-1, 45.0–48.0 cm. **6a–6c.** *Globorotalia truncatulinoides* (d'Orbigny); Sample 338-C0002K-7X-CC, 6.0–8.5 cm. **7a, 7b.** *Globoturborotalita obliquus* (Bolli) reworked specimen; Sample 338-C0002K-8X-3, 79.0–81.5 cm. **8a, 8b.** *Globoturborotalita obliquus* (Bolli); Sample 338-C0002L-14X-8, 58.0–60.0 cm. **9a, 9b.** *Neogloboquadrina inglei* Kucera and Kennett; Sample 338-C0002K-2H-1, 45.0–48.0 cm. **10a, 10b.** *Neogloboquadrina dutertrei* (d'Orbigny); Sample 338-C0002L-19X-1, 43.0–45.5 cm. **11a, 11b.** *Neogloboquadrina incompta* (Cifelli) dextral; Sample 338-C0002K-2H-1, 45.0–48.0 cm. **12a, 12b.** *Neogloboquadrina pachyderma* (Ehrenberg) dextral; Sample 338-C0002K-2H-1, 45.0–48.0 cm. **13a, 13b.** *Pulleniatina obliquiculata* (Parker and Jones); Sample 338-C0002L-4X-7, 80.0–85.0 cm. **14.** *Pulleniatina finalis* Banner and Blow; Sample 338-C0002L-4X-CC, 45.0–48.0 cm. Scale bars = 100 μ m.

