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Data report: middle Miocene planktonic foraminifers from the eastern equatorial Pacific, IODP Expedition 321 Site U1338[1]

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Keywords: Integrated Ocean Drilling Program, IODP, *JOIDES Resolution*, Expedition 321, Site U1338, equatorial Pacific, middle Miocene, planktonic foraminifers

Contents

Abstract

Middle Miocene planktonic foraminiferal assemblages are reported using core samples from Site U1338, which was drilled during Integrated Ocean Drilling Program (IODP) Expedition 321 in the eastern equatorial Pacific. A total of 63 species belonging to 20 genera were classified from 98 samples. In addition, we reexamined biostratigraphic events of the *Fohsella* lineage following recently proposed taxonomic criteria. We recognized 10 biohorizons of the *Fohsella* lineage. Among them, the numerical ages of eight events are restricted by orbitally tuned ages.

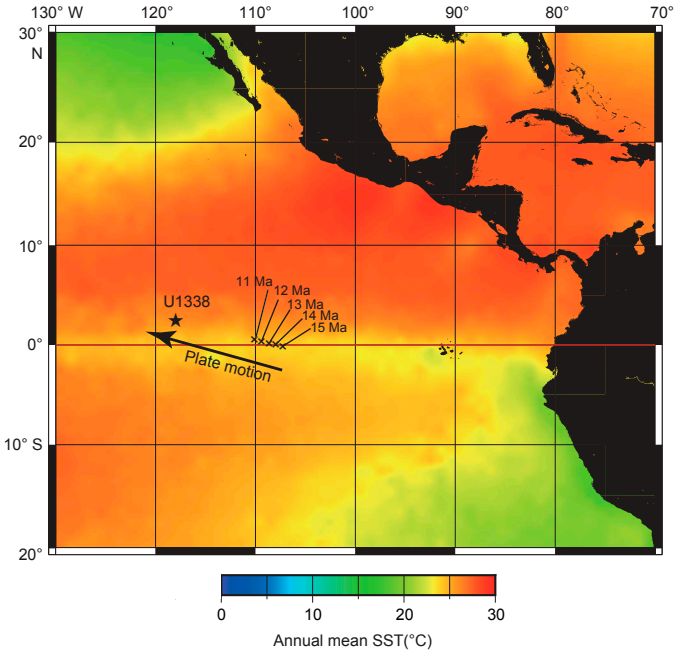
Introduction

The Pacific Equatorial Age Transect (PEAT), which included Integrated Ocean Drilling Program (IODP) Expeditions 320 and 321, was designed to obtain sediments throughout the Cenozoic. From 5 March to 22 June 2009, Sites U1331–U1338 were drilled in the eastern equatorial Pacific (Figure **F1**). At Site U1338 (2°30.469′N, 117°58.178′E; 4200 m water depth), a continuous succession of sediments from the latest Oligocene to the present were obtained (**Pälike et al.**, 2010).

The shipboard composite depth scale for Site U1338 (**Pälike et al.**, 2010) was revised by **Wilkens et al.** (2013). On the new depth scale, **Backman et al.** (2016) proposed a revised biomagnetostratigraphic age model for Site U1338. For the interval from 16 to 13 Ma at the site, Holbourn et al. (2014) made an orbitally tuned age model by integrating high-resolution benthic foraminiferal stable isotope data and X-ray fluorescence scanner–derived biogenic silica and carbonate accumulation. The integration of such recent works enables us to determine the precise numerical ages of biohorizons.

Hayashi et al. (2013) reported the middle Miocene to Pleistocene planktonic foraminiferal biostratigraphy at Site U1338. They investigated Cores 321-U1338B-1H through 40H at a sampling interval of one per section and recognized 60 biohorizons. The assemblage data have not yet been published. Thus, the first purpose of this data report is to describe the assemblage data of Hayashi et al. (2013) for the middle Miocene interval.

Figure F1. Location of Site U1338 (star) in eastern equatorial Pacific with backtracked positions from 15 to 11 Ma (crosses) calculated using the pole from Koppers et al. (2001). Background map shows modern annual mean sea-surface temperature (SST) generated by World Ocean Atlas 2013 data set (**https://www.nodc.noaa.gov/OC5/woa13**).



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After the completion of the biostratigraphic work by Hayashi et al. (2013), a new classification for the *Fohsella* lineage was proposed by Si and Berggren (2017). They reconsidered the type specimens and specimens from continuous deep-sea sediments (Ocean Drilling Program Site 806 at Ontong Java Plateau) and recognized two branched evolutionary transitions: *Fohsella peripheroacuta–Fohsella praefohsi–Fohsella lobata* and *F. peripheroacuta–F. "praefohsi"–Fohsella fohsi–Fohsella robusta*. The second purpose of this report is to reexamine the *Fohsella* lineage biohorizons of Hayashi et al. (2013) by applying Si and Berggren's (2017) classification.

Methods and materials

A total of 104 samples were collected from Cores 321-U1338B-25H through 40H (228.9–371.3 m core composite depth below seafloor, Method B [CCSF-B]) at an average depth interval of 1.5 m (one sample per section). These samples correspond to the lower samples of Hayashi et al. (2013) but were newly treated in the present study. The depth scale references are based on **Wilkens et al.** (2013).

Sediment samples of 1–5 g dry weight were disaggregated using a 3% hydrogen peroxide solution. After the samples had been macerated, each sample was wet sieved through a 63 µm screen. The dried samples were then divided into suitable volumes using a sample splitter, yielding approximately 200 planktonic foraminiferal specimens. Planktonic foraminiferal specimens larger than 125 µm were observed under a binocular microscope. We conducted classifications of each counting split to identify all planktonic foraminifers. We then made additional observations of the washed residue for important horizons to detect index species. Species detected by additional observations are recorded as "+" in the occurrence table (Table **T1**). Scanning electron photomicrographs of *Fohsella* species were obtained with a JCM-5000 (JEOL Co. Ltd., Japan).

Preservation of each sample is recorded in Table **T1** using the following criteria (see **Expedition 320/321 Scientists**, 2010a):

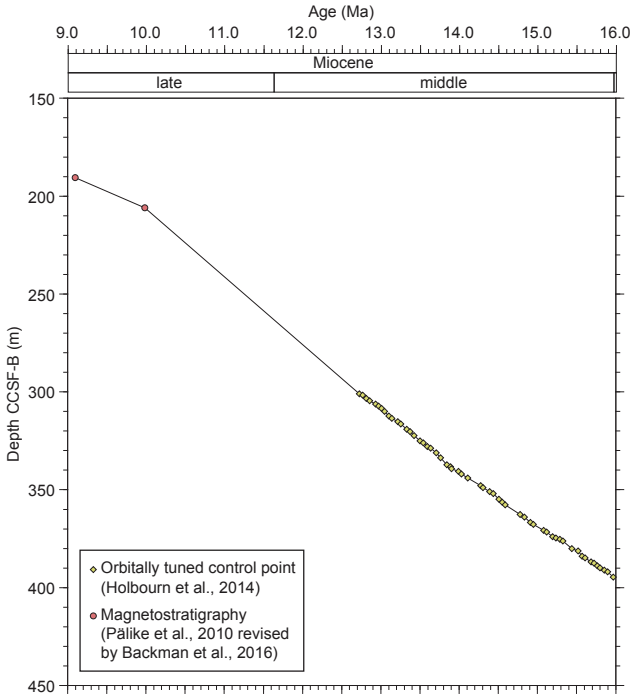
- VG = very good (no evidence of overgrowth, dissolution, or abrasion).
- G = good (little evidence of overgrowth, dissolution, or abrasion).
- M = moderate (calcite overgrowth, dissolution, or abrasion is common but minor).
- P = poor (substantial overgrowth, dissolution, or fragmentation).

The taxonomic names and biochronology in this study generally follow Hayashi et al. (2013), partly modified to agree with recent taxonomic studies (Fox and Wade, 2013; Spezzaferri et al., 2015; Si and Berggren, 2017; Poole and Wade, 2019).

The age model for the present study was established by the astronomically tuned age model of Holbourn et al. (2014) before 12.72 Ma and the shipboard biomagnetostratigraphic age model of **Expedition 320/321 Scientists** (2010b) revised by **Backman et al.** (2016) after 12.72 Ma (Figure **F2**). To calculate the planktonic foraminiferal flux (number/cm^2/ky) for each sample, we assumed the dry density of each sediment using the average of the two nearest horizons (above and below the sample) of the shipboard moisture and density measurements (**Expedition 320/321 Scientists**, 2010b). The planktonic foraminiferal flux and the planktonic foraminifer ratio (P/T) are shown in Table **T1**.

Table T1. Planktonic foraminifer occurrence, Hole U1338B. **Download table in CSV format.**

Figure F2. Age-depth model for Site U1338 studied interval based on astronomically tuned age model of Holbourn et al. (2014) before 12.72 Ma and shipboard biomagnetostratigraphic age model of Backman et al. (2016) after 12.72 Ma.



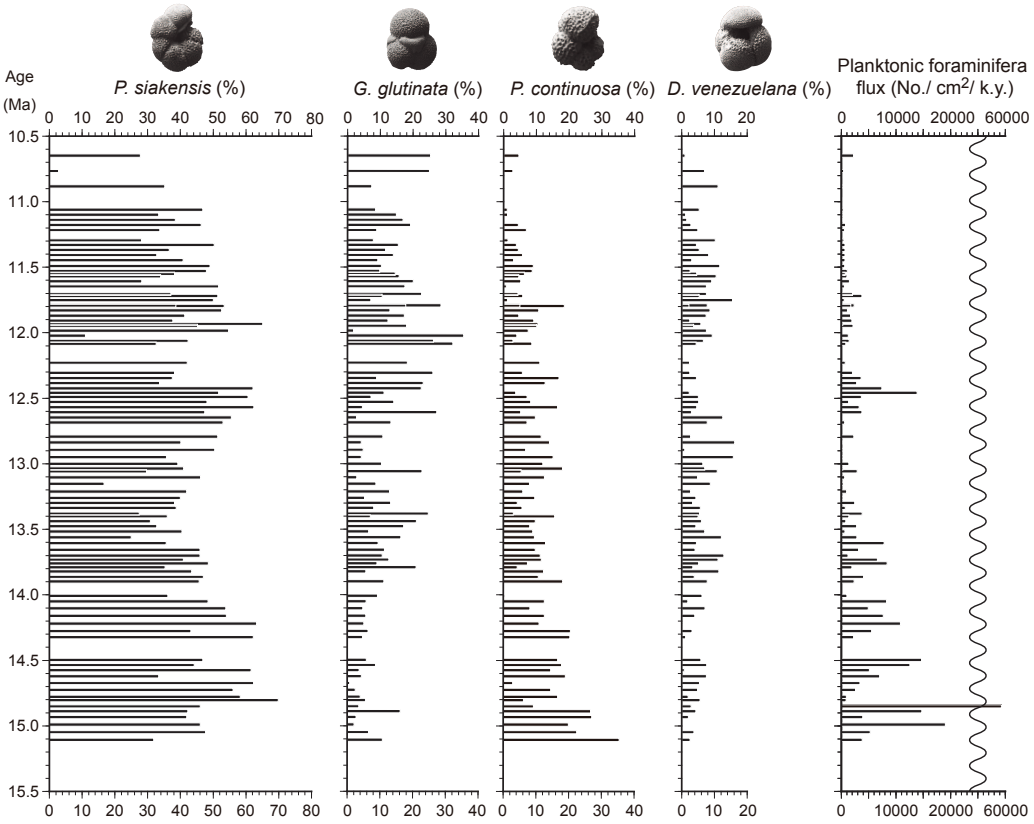
Results

A total of 16,323 planktonic foraminiferal individuals were collected from 98 samples and classified into 63 species belonging to 20 genera. Preservation of the tests was generally good. However, in the lower part of the studied interval, preservation became relatively poor owing to the fragmentation of the tests and dissolution on the surface of the test.

In the relative abundance of all samples, *Paragloborotalia siakensis* sinistral form had the highest occurrence (37.5%) (Figure **F3**). The top 10 species other than *P. siakensis* were *Globigerinita glutinata* (12.4%), *Paragloborotalia continuosa* sinistral form (8.2%), *Dentoglobigerina venezuelana* (6.0%), *P. siakensis* dextral form (3.8%), *Neogloboquadrina* cf. *pseudopachyderma* sinistral form (3.4%), *Sphaeroidinellopsis seminulina* (2.8%), *Globorotalia praemenardii* (2.6%), *Dentoglobigerina altispira altispira* (2.2%), *Globigerinita uvula* (2.0%), and *Neogloboquadrina praeatlantica* sinistral form (1.7%). Species belonging to the *Fohsella* linages were commonly observed (2.6%) below Sample 321-U1338B-27H-6, 38–40 cm, and the highest occurrence of 19.6% was in Sample 35H-2, 37–29 cm. The mean planktonic foraminiferal flux was 3494 (number/cm^2/ky). The maximum value was 71,806 in Sample 40H-2, 37–39 cm, and the minimum value was 0 in Sample 25H-6, 38–40 cm.

The biohorizons of the study interval were reported by Hayashi et al. (2013). It should be noted that the taxonomic criteria for the important evolutionary lineage *Fohsella* spp. have been controver-

Figure F3. Relative abundance of top four planktonic foraminifer species through middle Miocene at Site U1338 with planktonic foraminiferal flux. Relative abundance of each species is presented for containing >50 individuals. Squiggly line = scale gap between 25,000 and 60,000.



sial for a long time, as reviewed by Wade et al. (2011). Recently, the classification of the lineage was revised by Si and Berggren (2017) using type specimens together with deep-sea samples. We reexamined our *Fohsella* specimens using the Si and Berggren (2017) classification (Figure **F4**). The newly proposed classification is highly adaptable to the present sequence. A total of 10 biohorizons of *Fohsella* chronospecies were recognized in the quality criteria (A–C) of Hayashi et al. (2013). The numerical ages of the 10 biohorizons at Site U1338 were calculated by using the revised age-depth model (Table **T2**).

Among the 10 biohorizons (Figure **F5**), 3 biohorizons are newly distinguished in this study: the base occurrence of *F. praefohsi*, the top occurrence (TO) of *Fohsella peripheroronda*, and the top common occurrence of *Fohsella* spp. Another three biohorizons (2, 7, and 9 in Table **T2**) were reported by Hayashi et al. (2013), but their stratigraphic positions were revised by the taxonomic reexamination. Based on comparison with the Geologic Time Scale 2012 (GTS2012; Hilgen et al., 2012), the numerical ages calculated in the present study are slightly older than those of GTS2012, except for the TO of *F. peripheroronda*, which is significantly younger than GTS2012. This biohorizon has been regarded as latitudinal diachrony in previous studies (e.g., Takayanagi et al., 1984; Spencer-Cervato et al., 1994). This revised data set of biohorizons will provide a good framework to establish the standard timescale for the eastern equatorial Pacific region.

Figure F4. Species belonging to *Fohsella* lineages identified during this study. Scale bars = 100 µm. 1a–1c. *F. peripheroronda* (321-U1338B-38H-6, 38–40 cm). 2a–2c. *F. peripheroacuta* (37H-3, 38–40 cm). 3a–3c. *F. praefohsi* (34H-1, 38–40 cm). 4a–4c. *F. lobata* (33H-7, 38–40 cm). 5a–5c. *F. "praefohsi"* (34H-4, 38–40 cm). 6a–6c. *F. fohsi* (32H-1, 38–40 cm). 7a–7c. *F. robusta* (28H-7, 38–40 cm).

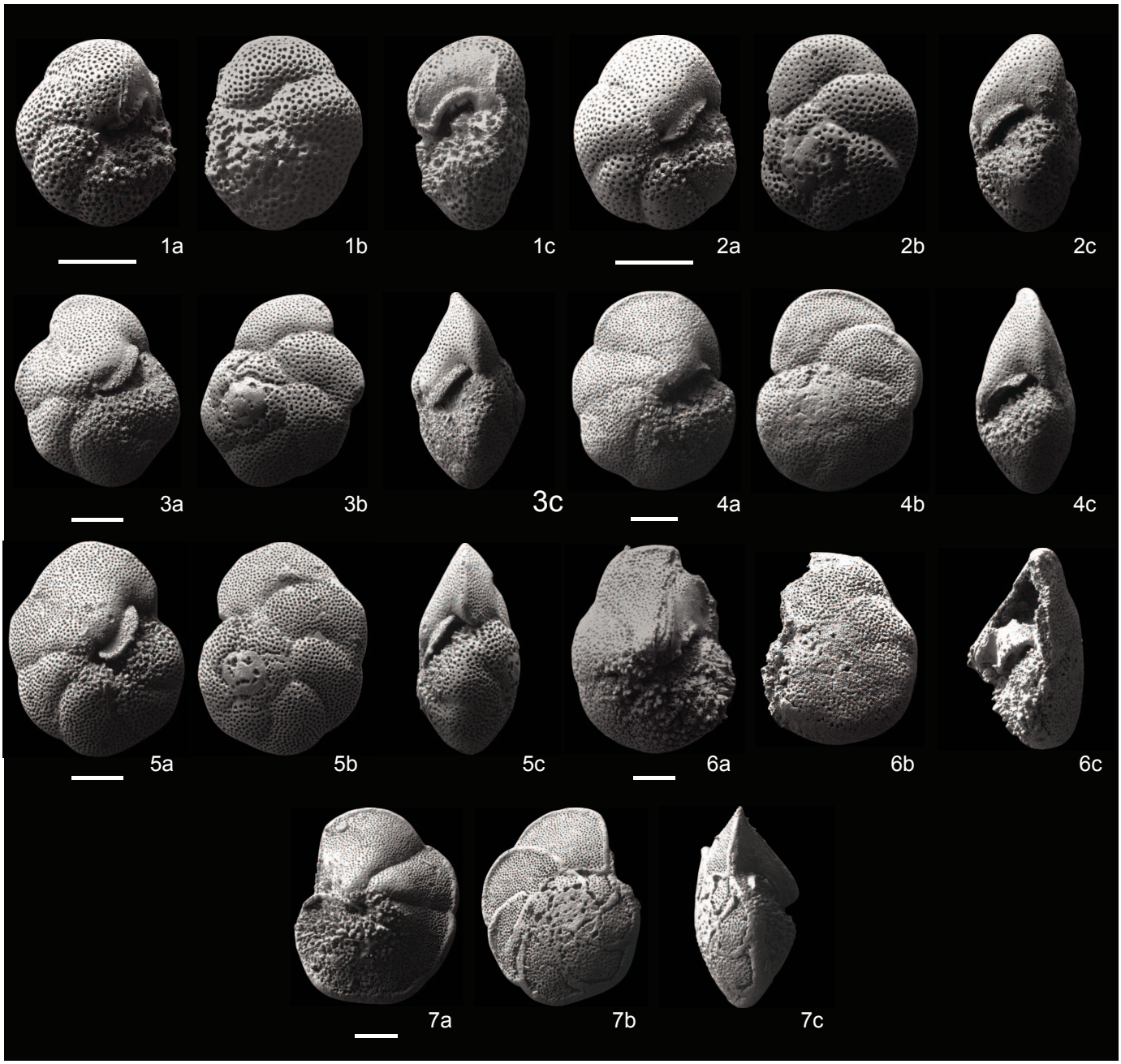
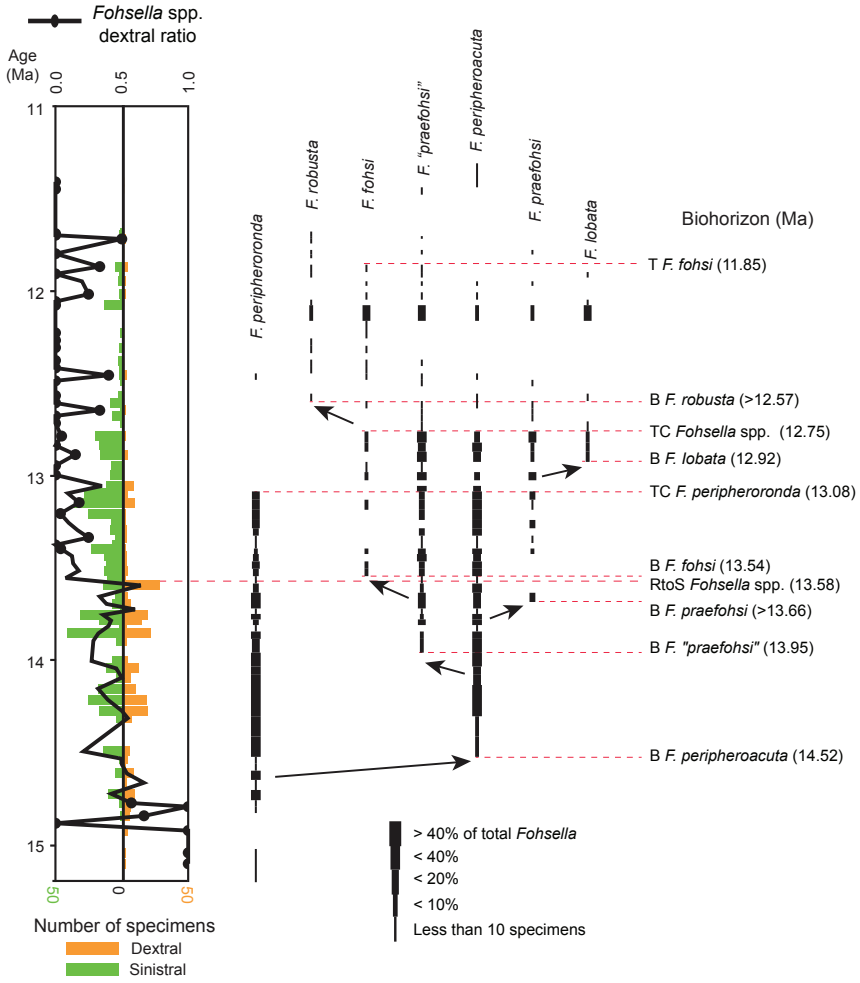


Table T2. Reexamined planktonic foraminiferal biohorizons from Site U1338 compared to GTS2012 ages. **Download table in CSV format.**

Figure F5. Temporal distribution of 10 biohorizons in Hole U1338B sediments related to *Fohsella* lineages based on new classification criteria proposed by Si and Berggren (2017). Numerical age of each biohorizon is recalculated by age-depth model (Figure F2). B = base occurrence, T = top occurrence, TC = top common occurrence, RtoS = dominant coiling direction change from random to sinistral.



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Appendix

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