

Numerical age of the planktonic foraminiferal zonal boundary between N.15 and N.16 in the mid-latitude northwest Pacific region

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Hiroki Hayashi and Masaki Takahashi (2008) Numerical age of the planktonic foraminiferal zonal boundary between N.15 and N.16 in the mid-latitude northwest Pacific region. *Bull. Geol. Surv. Japan*, vol. 59, (7/8), 415-422, 6 figs, 1table.

Abstract: The first occurrence of the planktonic foraminiferal species *Neogloboquadrina acostaensis*, which defines the zonal boundary between zones N.15 and N.16, was precisely determined just above the KT-1 Tuff in the lower part of the Kubota Formation in the Tanagura area, Northeast Japan. According to radiometric ages of the KT-1 Tuff, this biohorizon is estimated at 10.6 Ma. Compiling deep-sea drilling data demonstrates that the biohorizon is synchronous at least in the mid-latitudes.

Keywords: biostratigraphy, planktonic foraminifera, upper Miocene, Kubota Formation, Northeast Japan

1. Introduction

The geologic timescale is one of the most important frameworks for discovering Earth history. When we construct a geologic timescale, we tie many chronostratigraphic data such as that from biostratigraphy, magnetostratigraphy, stable isotope stratigraphy, and so on, to chronometric data, including radioisotope dating, sea-floor spreading interpolation and astronomical tuning methods. For refining a geologic timescale, each component of those should be critically tested and updated by new data.

A new geologic timescale (GTS2004; Lourens *et al.*, 2004) has been recently published. The new timescale is constructed by astronomically-tuned biostratigraphy throughout the Neogene period. However, only a few sites, namely, Atlantic ODP Sites (925 and 926), Sicily (Italy, Mediterranean) and Morocco, were used in the late Miocene interval of the timescale. Therefore, we should test the diachroneity of each biohorizon in Pacific region by correlating biostratigraphic and chronometric data.

The planktonic foraminiferal species *Neogloboquadrina acostaensis* is one of the most famous marker species for Late Miocene. The first occurrence (FO) of *N. acostaensis* defines the zonal boundary between zones N.15 and N.16 of Blow (1969). This biohorizon has been used for identifying the Tortonian/Serravarian boundary for a long time. In the new timescale GTS2004, the first regular occurrence (FRO) of *N. acostaensis* is proposed as an index datum of the Tortonian/Serravarian boundary (Hilgen *et al.*, 2000; Lourens *et al.*, 2004). However, the

FO of *N. acostaensis* has been reported as being diachronous between low and middle latitudes (e.g. Hilgen *et al.*, 2000). Therefore, we need to confirm the availability of this biohorizon for Pacific Neogene stratigraphy.

The Miocene Kubota Formation of the Tanagura area, northeast Japan (Fig.1) yields abundant planktonic foraminifers. In addition, this sequence is intercalated with many volcanoclastic layers, some of which have been dated by radiometric methods (Takahashi *et al.*, 2001a, b). The FO of *N. acostaensis* is restricted in the lower part of the formation (Hayashi *et al.*, 2002).

We examined the planktonic foraminiferal biostratigraphy of the lower part of the Kubota Formation for a precise determination of the FO of *N. acostaensis* defining the N.15/N.16 boundary. Furthermore, we demonstrate the reliability of the biohorizon for dating Neogene marine strata.

2. Geologic setting of the Tanagura area

Neogene sequences are distributed as a half-basin structure in the Tanagura area (Fig. 1). The tectonic deformation is very slight except for the western margin of the basin, which was deformed by Miocene tectonic activity along the Tanagura Tectonic Line.

Neogene sequences in the Tanagura area are divided into three formations: the Akasaka, Kubota and Nikogi Formations, in ascending order (Fig. 2). These formations unconformably cover basement rocks belonging to the Abukuma and Yamizo belts. The Akasaka Formation is mainly composed of medium-grained sandstone with a basal conglomerate. The Kubota Formation conformably

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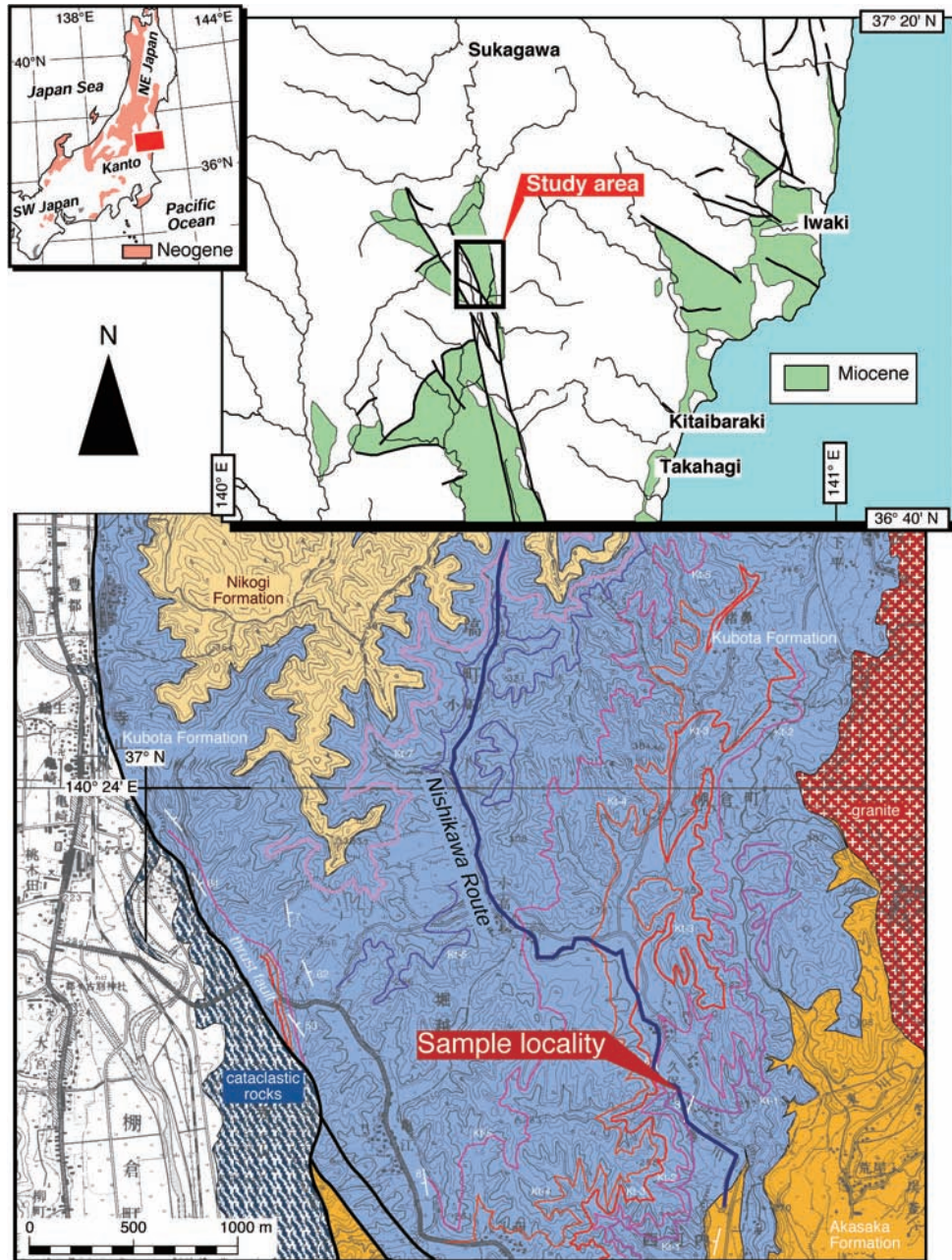


Fig. 1 Sample locality on Geologic map of the Tanagura area (modified after Shimamoto *et al.*, 1998 and Hayashi *et al.*, 2002). Topographic maps “Tanagura” and “Hanawa”, 1:25000 in scale published by the Geographical Survey Institute of Japan.

covers the Akasaka Formation and consists of silty fine-grained sandstone. This formation yields abundant marine fossils including mollusks, foraminifers, diatoms, and so on. The Nikogi Formation unconformably overlays the Kubota Formation and mainly consists of tuffaceous sandstone with a thick basal conglomerate.

The Akasaka and Kubota formations yield Shiobara-type fauna (Iwasaki, 1970; Chinzei, 1986), which is one of typical Japanese Miocene molluscan faunas. In addition, the Kubota Formation yields abundant microfossils. Aita (1988) is the first to report planktonic foraminifers

from the Kubota Formation. Subsequently, Taketani and Aita (1991) studied the radiolarian biostratigraphy of the Kubota Formation. Shimamoto *et al.* (1998) examined planktonic foraminifera, calcareous nannofossils and radiolarians of the Kubota Formation. More recently, Hayashi *et al.* (2002) re-examined its planktonic foraminiferal biostratigraphy and Yanagisawa *et al.* (2003) conducted detailed diatom biostratigraphy of the Kubota Formation. According to those previous studies, the Kubota Formation corresponds to planktonic foraminiferal zone N.16 of Blow (1969), calcareous nan-

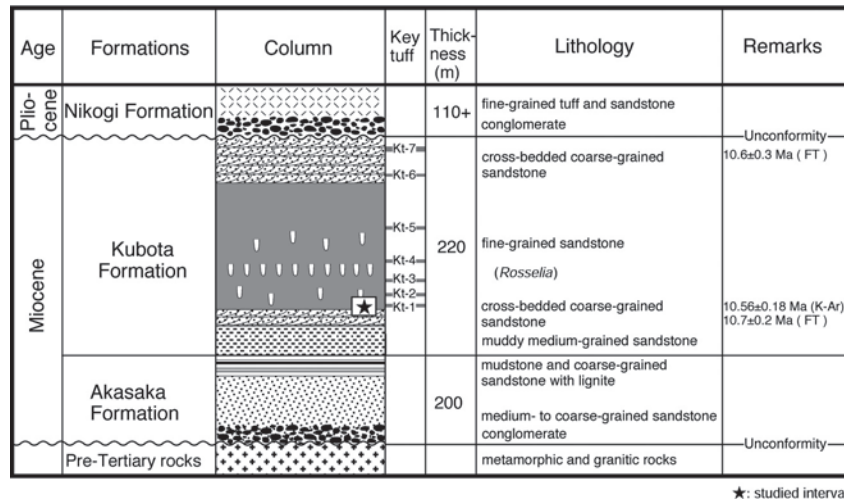


Fig. 2 Schematic geologic column of the Neogene sequences in the Tanagura area.

nofossil zones CN5b to CN7b of Okada and Bukry (1980), diatom zone NPD6 of Yanagisawa and Akiba (1998) and the radiolarian *Lychnocanoma magnacornuta* Zone of Motoyama and Maruyama (1996). In addition, radiometric ages have been obtained from two tuff layers, namely, KT-1 and KT-7 Tuffs (Takahashi *et al.*, 2001a, b) (Fig. 2).

3. Material and method

Based on previous studies (Shimamoto *et al.*, 1998; Hayashi *et al.*, 2002), we presumed that the FO of *N. acostaensis* would be located around the KT-1 Tuff in the lower part of the Kubota Formation. In order to determine the precise position of the biohorizon, we collected eleven sandstone samples around the KT-1 Tuff at an interval of 0.2-1 m (Fig. 3). Rock samples (80 grams of dry weight) were disaggregated using the sodium sulfate solution and naphtha methods, and wet-sieved over a 250-mesh (63 micrometers opening). The residue was oven-dried and divided with a sample splitter. Planktonic foraminifers were picked from fractions coarser than 125 micrometers. SEM microphotographs of important species were taken by a scanning electron microscope (JSM-T220A; JEOL Co. Ltd., Tokyo, Japan).

4. Result

Thirty-four planktonic foraminiferal taxa from nine samples were detected (Table 1; Fig. 3). Two samples above key bed Kt-1, namely, NK7.81 and NK7.83, contain no foraminiferal fossils. The fossil preservation was generally poor, owing to the dissolution of shell surface structures and the accretion of sand grains. The maximum value for the planktonic foraminiferal number was observed at the sample NK7.8 (369 individuals / g).

Neogloboquadrina acostaensis successively occurs from sample NK7.85 and upward. *Globorotaloides falconarae* is found in sample NK7.88. Three biohorizons are detected in this interval; the FO and FRO of *N. acostaensis* is recognized between samples NK7.8 and NK7.85. The FO of *G. falconarae* is placed below sample NK7.88.

5. Discussion

The previous study has detected the FOs of *N. acostaensis* and *G. falconarae* in the lower part of the Kubota Formation (Hayashi *et al.*, 2002). In the present study, we determined detailed positions for these biohorizons.

The FO and FRO of *N. acostaensis* are placed between samples NK7.85 and NK7.8. The sample NK7.8 is only 8 cm below the KT-1 Tuff, in turn the sample NK7.85 is 90 cm above the tuff. We consider that the FO and FRO of *N. acostaensis* in the Kubota Formation should be located just above the KT-1 Tuff.

The K-Ar and fission track (FT) ages of the KT-1 Tuff were determined as 10.56 ± 0.18 Ma and 10.7 ± 0.2 Ma (error in 1 sigma), respectively (Takahashi *et al.*, 2001a). In addition, key tuff KT-7, about 170 m upward of the Kt-1 Tuff, was dated as 10.6 ± 0.3 Ma (error in 1 sigma) by the FT method (Takahashi *et al.*, 2001b). These radiometric ages indicate a high sedimentation rate for the Kubota Formation. Accordingly, we consider that the numerical ages of the FO and FRO of *N. acostaensis* in the Tanagura area are given by the radiometric age of the KT-1 Tuff (about 10.6 Ma). This age corresponds to the middle part of geomagnetic subchron C5n.2n of both the CK95 and GTS2004 timescales (Fig. 4). The difference between the numerical ages of C5n.2n in CK95 and GTS2004 is less than 0.1 Ma. Therefore, it is hard to determine which timescale is more concordant with the

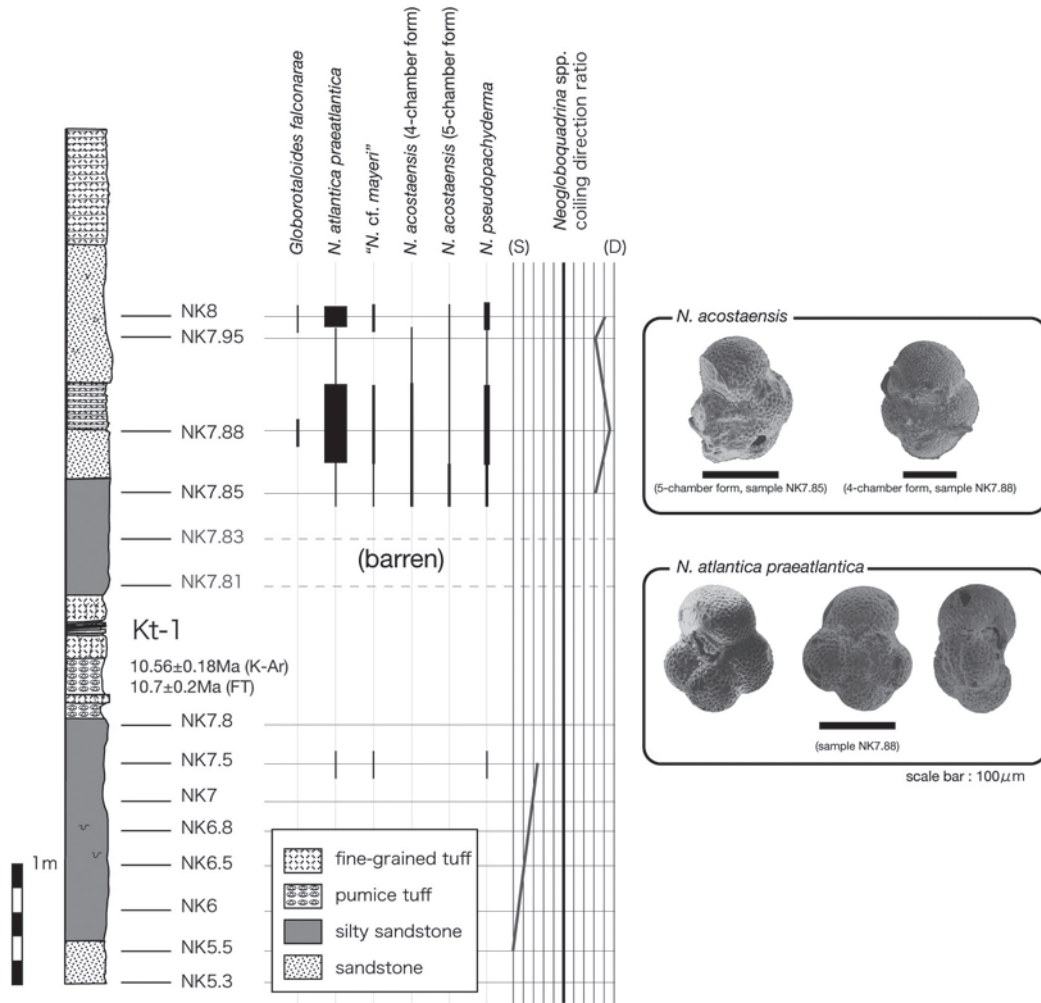


Fig. 3 Stratigraphic distribution of selected species in the lower part of the Kubota Formation. Samples in bold characters were examined in the present study, whereas others were examined by Hayashi *et al.* (2002).

present data.

In previous studies of deep sea cores, the FO of *N. acostaensis* has been calibrated to the lower part of subchron C5n.2n in the middle-latitude regions of the North Atlantic and the South Pacific (DSDP Sites 563, 588 and 608; compiled by Berggren *et al.*, 1995) (Fig. 5). Considering the analytical error for radiometric ages of the KT-1 Tuff, the geomagnetic correlation of Berggren *et al.* (1995) is concordant with the present study.

Astronomical calibration of biohorizons has been conducted for Miocene sedimentary sequences in Sicily, in the Mediterranean (Hilgen *et al.*, 2000; Sprovieri *et al.*, 2002). According to these results, the FO and FRO of *N. acostaensis* are numerically dated to 11.80 Ma and 10.554 Ma, respectively (Sprovieri *et al.*, 2002). The former age is significantly older than Pacific and Atlantic ages proposed by Berggren *et al.* (1995) and in the present study. On the other hand, the latter age shows good agreement with the present study. The inconsistency could result from dispersal of this species from the high-

latitude North Atlantic to other areas (Zachariasse and Aubry, 1994). We point out that the FO of *N. acostaensis* in DSDP Sites 588 (Jenkins and Srinivasan, 1986) and 608 (Weaver, 1987) may correspond to the FRO, like the Tanagura area. Consequently, the FO of *N. acostaensis* might be globally synchronous in mid-latitude regions such as the North Atlantic, South Pacific and Northwest Pacific.

Astronomical calibration was also been conducted at equatorial Atlantic ODP Sites 925 and 926 (compiled by Lourens *et al.*, 2004). At those sites, the FO of *N. acostaensis* was calculated as 9.83 Ma and located in subchron C5n.1n of both CK95 and GTS2004. This age is about 1 Ma younger than in mid-latitude regions. As previously reported, the FO of *N. acostaensis* is diachronous between low-latitudes and mid-latitudes (Hilgen *et al.*, 2000; Turco *et al.*, 2002). However, the Neogene magneto-biostratigraphic timescale of GTS2004 (Lourens *et al.*, 2004, Fig. 21.1) is based only on low-latitude ages (Fig. 4). For mid-latitude Miocene sequences,

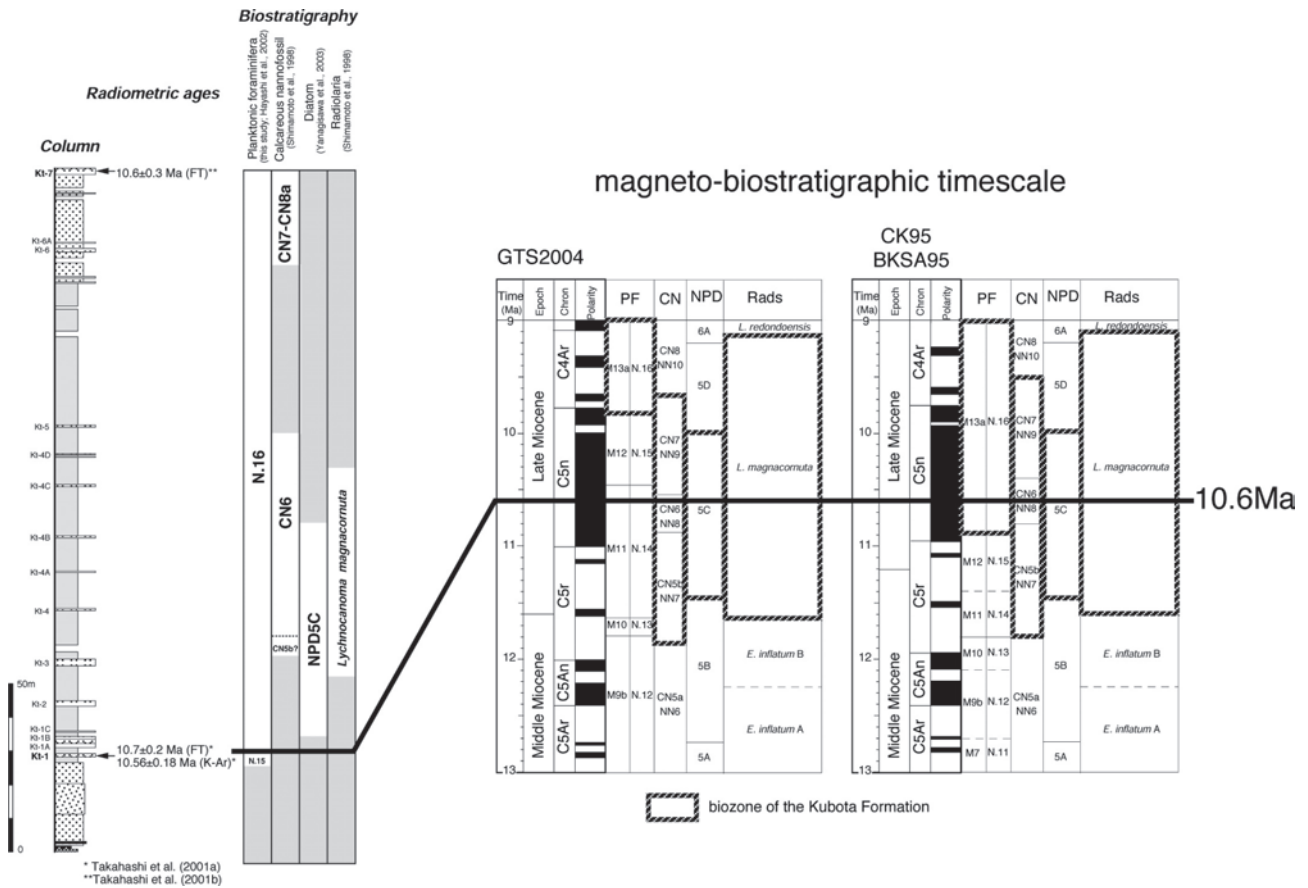


Fig. 4 Correlation of two timescales (CK95 and GTS2004) with results from the Kubota Formation. Almost all zonal correlations are concordant with the results from the Kubota Formation. However, the base of planktonic foraminiferal zone N.16 in GTS2004 is an exception and is significantly discordant with the present results.

Hilgen *et al.*, 2000, pl.2, figs. 1-4.

Remarks: More than 200 specimens were obtained. This subspecies differs from *N. continua* in having a widely varying position of the aperture, which is often umbilical to extraumbilical position (Hayashi *et al.*, 2002). Foresi *et al.* (2002) regarded this subspecies as an ancestor of *N. acostaensis*. We consider that *Neogloboquadrina cf. mayeri* (Cushman and Ellis) sensu Hayashi *et al.* (2002; fig. 3, 8a-c) and the present study might be an intermediate form between *N. atlantica praeatlantica* and *N. acostaensis*.

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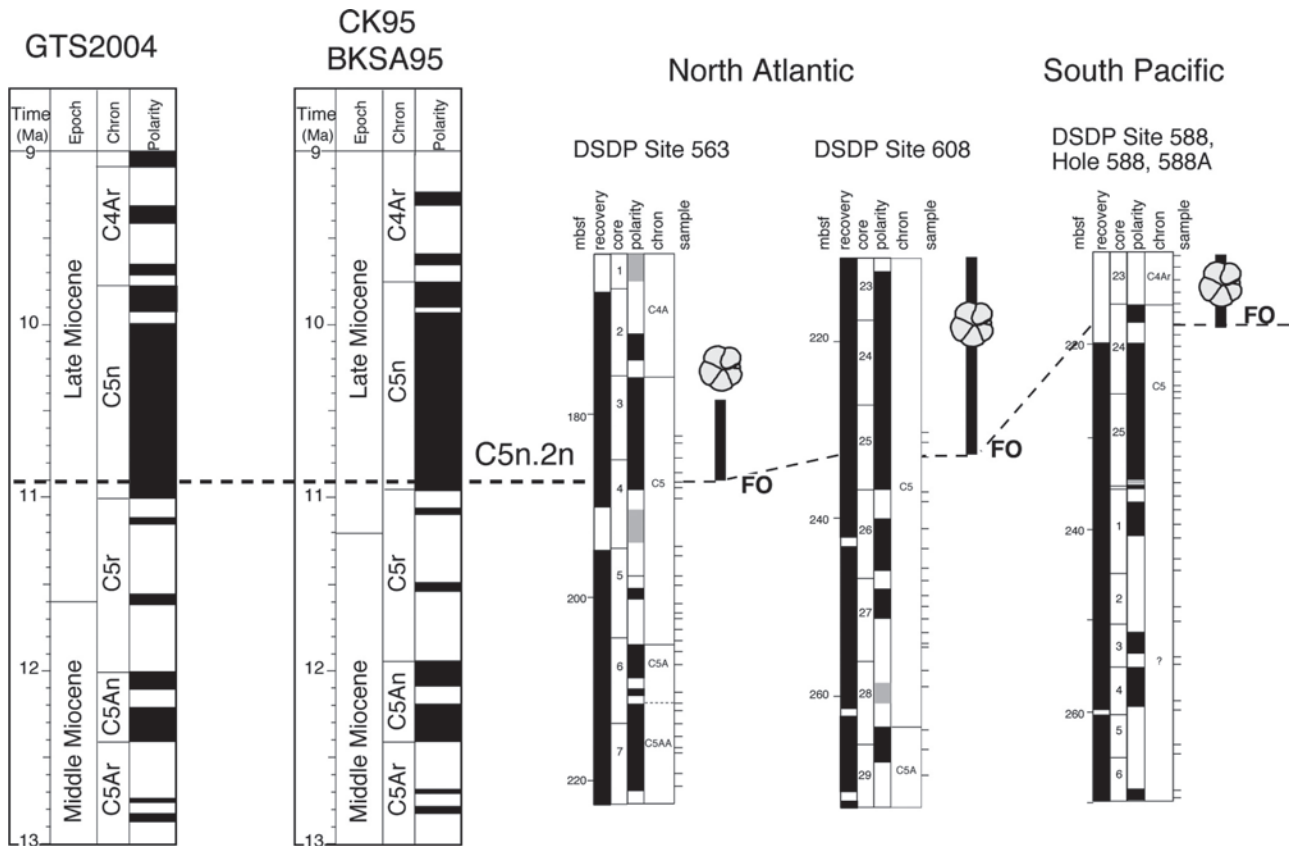


Fig. 5 Magneto-biostratigraphic correlation of the FO of *Neogloboquadrina acostaensis* at DSDP Sites in the North Atlantic and South Pacific.

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北西太平洋中緯度地域における浮遊性有孔虫化石帯 N.15 帯と N.16 帯境界の数値年代

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要 旨

福島県棚倉地域の久保田層下部について詳細な浮遊性有孔虫生層序を検討した結果、化石帯 N.15 帯と N.16 帯の境界を定義する生層準 *Neogloboquadrina acostaensis* の初産出を凝灰岩鍵層 KT-1 の直上に認めた。この凝灰岩鍵層の放射年代に基づき、本地域における *N. acostaensis* の初産出年代を 10.6 Ma と見積もった。これまでに報告されている深海掘削のデータから判断すると、この生層準は少なくとも中緯度地域では同時性を示し、年代対比に有用であると考えられる。