Quaternary International 383 (2015) 116–135

Contents lists available at ScienceDirect

Quaternary International

journal homepage: www.elsevier.com/locate/quaint

Stratigraphy of the Kazusa Group, Boso Peninsula: An expanded and highly-resolved marine sedimentary record from the Lower and Middle Pleistocene of central Japan

Osamu Kazaoka [a], Yusuke Suganuma [b, c, *], Makoto Okada [d], Koji Kameo [e], Martin J. Head [f], Takeshi Yoshida [a], Manami Sugaya [d], Shun Kameyama [a], Itaru Ogitsu [a], Hisashi Nirei [g], Nobuyuki Aida [h], Hisao Kumai [i]

[a] Research Institute of Environmental Geology, Chiba, 3-5-1 Inagekaigan, Mihama, Chiba 261-0005, Japan
[b] National Institute of Polar Research, 10-3 Midoricho, Tachikawa, Tokyo 190-8518, Japan
[c] Department of Polar Science, The Graduate University for Advanced Studies (SOKENDAI), Tokyo 190-8518, Japan
[d] Ibaraki University, 2-2-1 Bunkyo, Mito, Ibaraki 310-8512, Japan
[e] Chiba University, 1-33 Yayoi, Inage, Chiba 263-8522, Japan
[f] Department of Earth Sciences, Brock University, 500 Glenridge Avenue, St. Catharines, Ontario L2S 3A1, Canada
[g] Japan Branch of Geoscience for Environmental Management, International Union of Geological Sciences, 1277-1 Kamauchiya, Motoyahagi, Katori City, Chiba 287-0025, Japan
[h] Shumei University, 1-1 Daigaku-cho, Yachiyo, Chiba 276-0003, Japan
[i] Osaka City University, Tukuno-minami 1-204, 1800 Kusabe, Nishi, Sakai, Osaka 593-8312, Japan

ARTICLE INFO

Article history:
Available online 7 May 2015

Keywords:
Lower–Middle Pleistocene GSSP
Marine sediments
Biostratigraphy
Magnetostratigraphy
Tephrostratigraphy
Chiba composite section

ABSTRACT

Major climatic reorganizations, including changes in the nature of glacial–interglacial cycles through the Pleistocene, are a key issue for improving the understanding of Earth's climate system. Highly resolved marine sedimentary records are essential to reconstruct the details of these past climatic changes and investigate the mechanisms responsible for them. The Kazusa Group, located in the central part of the Japanese island chain, is well-exposed and contains a remarkably continuous and thick, deep- and shallow-water marine sedimentary succession. This group also contains well-preserved marine microfossils, pollen, paleomagnetic reversal events, geochemical signatures, and a large number of tephra beds. These features allow us to establish a robust chronological and stratigraphic framework for the Kazusa Group, and provide a rare opportunity to study oceanic and terrestrial climatic and environmental changes at high resolution especially through the Lower and lower Middle Pleistocene. In the Boso Peninsula, Chiba Prefecture, the Kazusa Group is deeply incised, yielding spectacular river-cut exposures. The Matuyama–Brunhes paleomagnetic reversal is observed immediately above the widespread Byakubi-E (Byk-E) tephra in the Chiba composite section within the Kokumoto Formation (Kazusa Group). Because the Matuyama–Brunhes boundary customarily serves as the primary guide for the Lower–Middle Pleistocene Subseries boundary, the Chiba composite section is considered an excellent candidate for its global boundary stratotype section and point (GSSP). This study reviews the published data for the Kazusa Group (hitherto almost exclusively in Japanese) in order to place the Chiba composite section within its broader depositional and chronostratigraphic context.

1. Introduction

The Earth experienced fundamental changes in oceanic and atmospheric circulation, ice sheet distributions, and biotic evolution from the Early to Middle Pleistocene (e.g., Head et al., 2008; Head and Gibbard, 2015). The Early–Middle Pleistocene transition, also known as the "mid-Pleistocene climate transition" (MPT; Raymo et al., 1997; Mudelsee and Schulz, 1997), was characterized

* Corresponding author. National Institute of Polar Research, 10-3 Midoricho, Tachikawa, Tokyo 190-8518, Japan.
E-mail addresses: o.kzok@pref.chiba.lg.jp (O. Kazaoka), suganuma.yusuke@nipr.ac.jp (Y. Suganuma), okada@mx.ibaraki.ac.jp (M. Okada), kameo@faculty.chiba-u.jp (K. Kameo), mjhead@brocku.ca (M.J. Head), t.yshd61@pref.chiba.lg.jp (T. Yoshida), 13nd403y@vc.ibaraki.ac.jp (M. Sugaya), s.kmym4@pref.chiba.lg.jp (S. Kameyama), i.ogts@pref.chiba.lg.jp (I. Ogitsu), nireihisashi@msn.com (H. Nirei), bk003769@ni.bekkoame.ne.jp (N. Aida), hkumai@sakai.zaq.ne.jp (H. Kumai).

http://dx.doi.org/10.1016/j.quaint.2015.02.065
1040-6182/

by a progressive shift in periodicity of the dominant glacial–interglacial cycles from 41 ky to ca. 100 ky. Numerous hypotheses have attempted to explain the causes of this shift (e.g., Head and Gibbard, 2005; Maslin and Ridgwell, 2005; Head and Gibbard, 2015), and reorganizations of oceanic circulation help to account for the variation in glacial amplitudes within a consistent range of atmospheric pCO^2 (e.g., Bard and Rickaby, 2009). Continuous deep-ocean records across the transition are plentiful, but constructing links between atmospheric circulation, terrestrial environmental change, and evolution of the biota has been hampered by a scarcity of sedimentary records from nearshore areas. Therefore, continuous and highly-resolved marine records that capture both terrestrial and marine environmental change with well-developed chronological control are needed urgently to improve understanding of the Earth's climate system.

The International Commission on Stratigraphy (ICS) has been charged by the International Union of Geological Sciences to recommend global boundary stratotype sections and points (GSSPs) for all undefined major boundaries in the international geologic time scale, including the Lower–Middle Pleistocene Subseries boundary. This boundary should be defined in a marine section exposed on land, and within plus or minus one marine isotope stage of the Matuyama–Brunhes (M–B) geomagnetic reversal boundary (Head et al., 2008). The M–B boundary should serve as the primary chronostratigraphic guide for the Lower–Middle Pleistocene boundary because it represents a brief and synchronous event and can be observed both in marine and terrestrial records, but multiple criteria must be recognized close to this boundary in order to maximize correlation potential (Richmond, 1996; Head et al., 2008). Because the interval containing the GSSP for the Lower–Middle Pleistocene boundary will be crucial in identifying lead–lag relationships for abrupt environmental changes around the globe, the section should have well-preserved microfossils that are related to global oceanic circulation coupled with a chronological framework provided by magnetostratigraphy, marine isotope stratigraphy, and where possible by absolute ages of tephra beds.

Thick, deep- and shallow-water marine successions of the Kazusa Group were deposited in the Kanto Tectonic Basin in the central part of the Japanese islands during the Pleistocene (Fig. 1). The Kazusa Group is well exposed and contains a remarkably continuous stratigraphic succession, especially in the Boso Peninsula (part of the Chiba Prefecture). In particular, the group contains well-preserved marine microfossils, pollen, paleomagnetic reversal events, and a large number of tephra layers, allowing us to establish a robust chronological and stratigraphic framework. These characteristics also provide a rare opportunity to study oceanic and terrestrial climatic and environmental changes at high resolution, especially from the Lower to the lower Middle Pleistocene. Furthermore, the M–B boundary, as the primary guide for the Lower–Middle Pleistocene, clearly occurs immediately above a widespread tephra bed, the Byakubi-E (Byk-E) in the Chiba composite section of the Kokumoto Formation, Kazusa Group. Therefore, the Byk-E tephra serves as an excellent local stratigraphic marker for the Lower–Middle Pleistocene boundary.

Three candidate sections are currently under consideration for the Lower–Middle Pleistocene GSSP: the Montalbano Jonico and Valle di Manche successions in Italy, and the Chiba composite section in Japan. The Chiba composite section, and indeed the Kazusa Group in general, has received limited international attention because most previous investigations have been published only in Japanese. The aim of this study is to review the published data from the Kazusa Group, describe its global relevance to chronostratigraphy from the Lower Pleistocene to lower Middle Pleistocene, and hence place the Chiba composite section within a broader temporal context.

2. Geological setting

The Kanto Tectonic Basin is a forearc basin that developed in response to the west-north-westward subduction of the Pacific plate beneath the Philippine Sea plate along the Japan and Izu-Bonin trenches (e.g., Seno and Takano, 1989), and contains the Kazusa Group, one of the thickest (approximately 3000 m) Lower and Middle Pleistocene sedimentary successions in the Japanese islands (e.g., Mitsunashi et al., 1959; Ito, 1998b) (Fig. 1). The Kazusa Group is mainly exposed in two hilly areas separated by Tokyo Bay, the middle part of the Boso Peninsula and several hills fringing the Kanto Mountains (Fig. 1) (Suzuki et al., 2011). The depth variation of the base of the Kazusa Group shows the relief of the Kanto Tectonic Basin. The depositional setting of the Kazusa Group varies from beach to deep sea generally from northwest to southeast in response to the tectonic setting. The southeastern part of the Kanto Tectonic Basin commenced uplift from ca. 1 Ma (Kaizuka, 1987) at a rate of 3.3 m/ky during the Holocene (Naruse, 1968). Thus, the Kazusa Group provides a rare opportunity to study a Lower to Middle Pleistocene sedimentary successions on land (e.g., Nozaki et al., 2014).

The Kazusa Group, in the Boso Peninsula, unconformably overlies the Miocene and Pliocene Miura Group (e.g., Mitsunashi et al., 1979), which constitutes older forearc basin fill that developed in response to the northward to northwestward subduction of the Philippine Sea plate beneath the Eurasia plate along the Sagami trough (Ogawa et al., 1985). The Kazusa Group is overlain by the Middle and Upper Pleistocene Shimosa Group. The Shimosa Group, deposited during the Middle and Late Pleistocene (ca. 0.45–0.08 Ma), comprises shallow marine to paralic sediments that represent the infilling of the paleo-Tokyo Bay, which is a relict of the Kanto Tectonic Basin (e.g., Watanabe et al., 1987; Ito et al., 1999). The margins of the Kanto Tectonic Basin have been uplifted, and the marine strata dip gently northwestward and are well exposed on land. The exposures are particularly good in the central part of the Boso Peninsula and include the type sections for the Kazusa Group along the Yoro River (Fig. 2).

The Kazusa Group strikes NE–SW and dips gently to the northwest (Fig. 2). The angle of dip gradually decreases from 20° in the lower part of the group to several degrees in its upper part. Many NNE–SSW-trending normal faults are located in the eastern part of the Boso Peninsula; the faults step down toward the sea. This structure is interpreted to have originated from long-term uplift around the central part of the Peninsula based on the surface topography of the Peninsula and the elevations of key beds in the Shimosa Group (e.g. Mitsunashi et al., 1979).

The stratigraphy of the Kazusa Group has been described by Kanehara et al. (1949), Shinada et al. (1951), Mitsunashi et al. (1961), Ishiwada et al. (1971), and Mitsunashi et al. (1979). Several interpretations have been published regarding its contact with the superjacent Shimosa Group. Mitsunashi (1973) recognized the Kasamori Formation as being unconformably overlain by the Kongochi Formation (Fig. 2). Although an unconformity can be observed in several locations, Tokuhashi and Endo (1984) considered the Kasamori and Kongochi formations to be basically interfingered, based on the continuity of tephra beds between them. They also found fluvial conglomerate beds just above the Kongochi Formation, indicating the initiation of a non-marine sedimentary environment. Based on these phenomena, they concluded that the boundary between the Kazusa and Shimosa groups should be located above the Kongochi Formation. In contrast, Nirei (2004) recognized an unconformity at the base of the Mandano Formation. Because this unconformity is clearly recognized in seismic profiles throughout the Kanto Tectonic Basin (Fig. 3), he claimed that the boundary between the Kazusa and Shimosa groups should