Quaternary Research 74 (2010) 227–234

Contents lists available at ScienceDirect

Quaternary Research

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

Holocene beach deposits for assessing coastal uplift of the northeastern Boso Peninsula, Pacific coast of Japan

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A R T I C L E I N F O

Article history:
Received 15 September 2009
Available online 9 August 2010

Keywords:
Beach
Earthquake
Ground-penetrating radar
Japan Trench
Marine terrace
Sagami Trough
Philippine Sea plate
Sea level
Tectonics
Western Pacific

A B S T R A C T

This paper presents a case study that assessed spatial variations in the tectonic uplift rates of beach deposits in the relict Kujukuri strand plain, situated on the northeastern coast of the Boso Peninsula, eastern Japan. The southern Boso Peninsula is tilted downward to the northeast due to plate subduction along the Sagami Trough. However, the cause of the northeastern coast uplift creating the relict strand plain is unclear, due to the absence of a Holocene raised marine terrace sequence. Elevations and ages of beach deposits were collected from drilled cores and ground-penetrating radar profiles along three shore-normal sections in the southern Kujukuri strand plain. From this, alongshore variations in the relative sea level since the mid-Holocene could be seen. These corresponded to north-to-northeast downward tilting at a rate of 0.4 m/ka for an interval 10 km and are concordant with the longer term tilting of the last interglacial marine terrace surrounding the plain. Although it is difficult to assess shore-normal variations of uplift based on the present dataset, the recognized tilting apparently continues to the tilting of the southern Boso Peninsula, implying the Sagami Trough probably affects the uplift of the Kujukuri coast.

Introduction

In tectonically active margins, past relative sea-level changes provide important information on tectonic activity. Coastal uplift/subsidence is an expression of crustal deformation and is often recorded as a relative sea-level fall/rise observed in sediments and landforms. The rate, frequency, and spatial distribution of the vertical motion of the coast have been regarded as criteria for tectonic activity (e.g., Chappell et al., 1996; Ota and Yamaguchi, 2004). Observed sea-level changes reflect both glacio-isostatic and tectonic components of vertical crustal movements as well as eustatic sea level. Thus, the accurate assessment of the tectonic component requires exclusion of glacio-isostatic component and eustatic sea level from the observed sea level (Nakada et al., 1991), which are more predictable than the spatially irregular tectonic component (e.g., Lambeck et al., 2004).

Several studies have numerically estimated these predictable components to extract the tectonic component (e.g., Sato et al., 2003, 2006). The predicted sea-level changes inherently have uncertainty, depending on the model used (e.g., Nakada et al., 1991; Lambeck et al., 2004). Thus, calibration of the model results needs to be practiced by referring observed sea-level history in a tectonically stable point where the mean sea level recorded by the last interglacial terrace is supposed to be several meters above the present sea level (e.g., Rohling et al., 2008). Such a locality is not easy to find in a tectonically active area. In this paper, we propose an effective method for assessing spatial variations in tectonic uplift/subsidence rate that can be applied to the coastal barrier and strand plain characterized by a sequence of beach ridges, showing a case study in a raised strand plain in the Boso Peninsula, central Japan.

The Boso Peninsula on the Pacific coast of central Japan is a tectonically uplifted region close to the convergent boundaries between the Philippine Sea, Okhotsk, and Pacific plates (Fig. 1A). This peninsula is tilted northeast downward, and the mid-Holocene marine terrace at its southern tip is over 25 m higher relative to the present sea level (Fig. 2; e.g., Nakata et al., 1980). The spatial distribution of the Holocene marine terraces is accountable by net uplift caused by two different types of historical great earthquakes that occurred in AD 1703 and AD 1923, both due to the subduction of the Philippine Sea plate below the Okhotsk plate along the Sagami Trough (Sugimura and Naruse, 1954, 1955; Matsuda et al., 1974, 1978; Shishikura, 2000, 2001; Shishikura and Miyauchi, 2001). Shishikura and Miyauchi (2001) suggested that the 1703- and 1923-type earthquakes have occurred 4 and 11 times since the mid-Holocene, respectively, based on coastal landforms and the sediment record of uplifts. Ota and Yamaguchi (2004) compared the Holocene and last interglacial marine terraces to assess the difference between short- and long-term rates of crustal deformation rates along the Pacific Rim, but not for the southern edge of

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0033-5894/$ – see front matter
doi:10.1016/j.yqres.2010.07.009

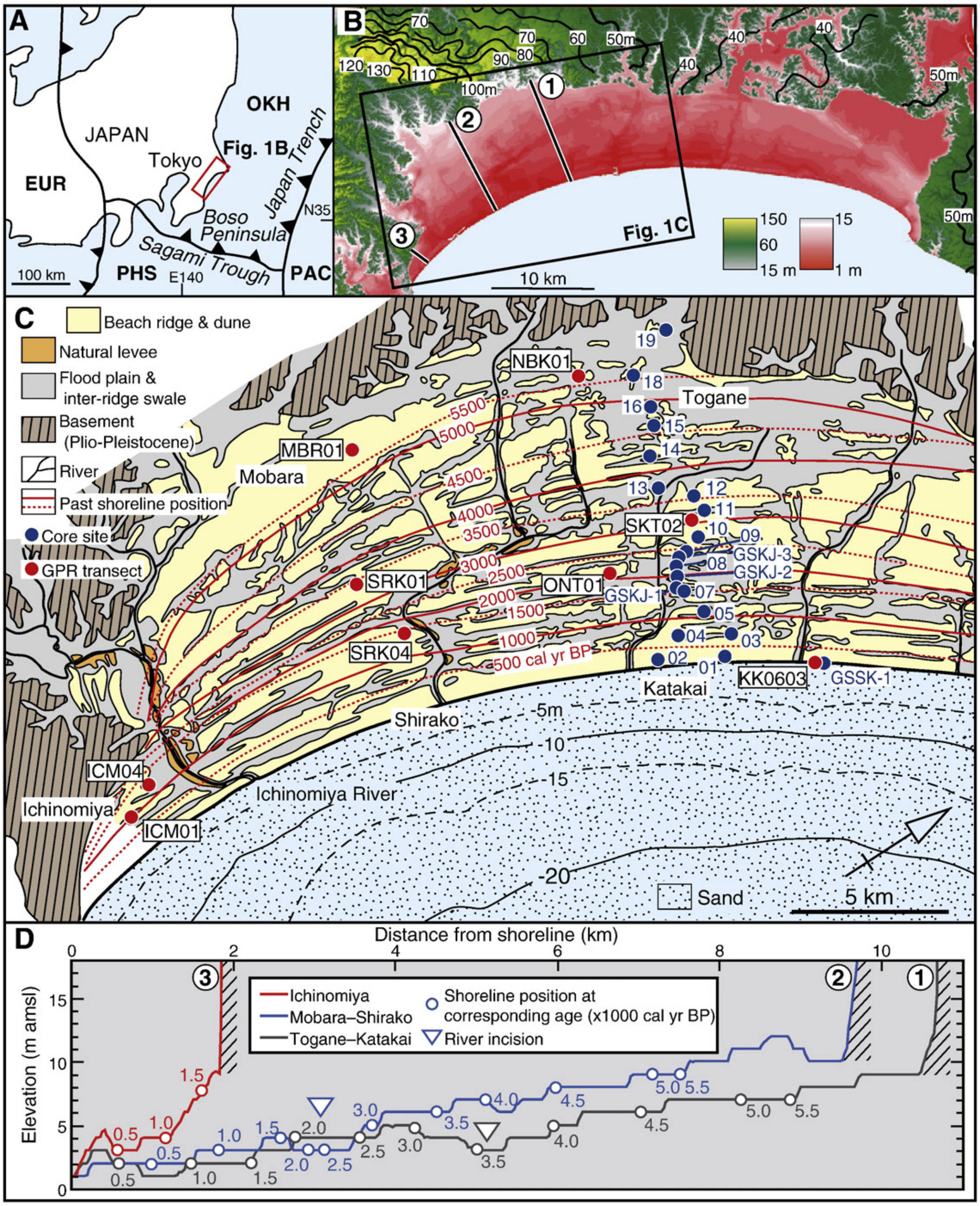

Figure 1. A: Location map of the Kujukuri strand plain. EUR, Eurasia plate; OKH, Okhotsk plate; PAC, Pacific plate; PHS, Philippine Sea plate. B: Digital elevation map of the Kujukuri strand plain and the surrounding area, based on the 50-m grid digital map of the Japanese Geographical Survey Institute. Contours show the elevation (m above mean sea level) of the marine terrace surface associated with Marine Isotope Stage 5e. C: Map showing the geomorphology of the Kujukuri strand plain (simplified from Moriwaki, 1979), the past shoreline positions at 500-yr intervals, and drill core (Masuda et al, 2001; Tamura et al., 2007) and GPR transect (Tamura et al., 2008) locations. All ages are expressed in cal yr BP. D: Elevation profiles in the Togane–Katakai, Mobara–Shirako, and Ichinomiya sections of the Kujukuri strand plain based on the digital elevation map. The locations of elevation profiles are shown in Fig. 1B.

the Boso Peninsula, where the last interglacial marine terrace is not preserved. The nearest marine terrace of MIS 5e is developed at the northeastern edge of the tilting zone, where the terrace lowers from +130 m to +30–40 m northeastward (Figs. 1B and 2; Kaizuka, 1987). The terrace surrounds the Kujukuri strand plain, in the central part of which there has been a 5-m relative sea-level fall since the mid-Holocene (Masuda et al., 2001).

The Kujukuri strand plain and its surrounding last interglacial marine terrace are located in the Kashima–Boso uplift zone (Kaizuka, 1974, 1987) with an inferred neighboring uplift axis trending NE–SW (Yachimata uplift in Fig. 2). This uplift zone shows a different trend from the southern Boso Peninsula, and contrasts with the subsidence of the Tokyo Bay to the west. Kaizuka (1974) proposed that the Kashima–Boso uplift is related to the subduction of the Japan Trench, over 200 km southeast from the coast (Fig. 1A). Shishikura (2001) compared the maximum mid-Holocene sea level to conclude that the uplift rate increases eastward in the northeastern Boso peninsula, which is consistent with the view of Kaizuka (1974). However, he pointed out that the Japan Trench is too far away to be a causal factor in the observed uplift. Uplift from faulting can also be rejected as there is no known effective fault in the area. Thus, the causes of the Kashima–Boso uplift zone still remain unclear.