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Discovery of Eemian marine deposits along the Baeksu tidal shore, southwest coast of Korea

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ABSTRACT

This is the first report of an OSL (optically stimulated luminescence) -dated Eemian marine deposit along the southwest coast of Korea. It was discovered on the Baeksu intertidal shoreface/tidal flat system. Based on the analysis of (up to 46-m-long) drilled cores, the Baeksu tidal deposits can be divided into four sedimentary units. In ascending order these are: 1) basal fluvial gravels, 2) Eemian tidal mud, 3) gravel lag/paleosol, and 4) Holocene tidal deposits. The Eemian tidal sequences were encountered at a core interval of −20 to −38 m below mean sea level, the OSL ages ranging from 138 to 110 ka. Pollen analyses reveal a higher AP (arboreal pollen) to NAP (nonarboreal pollen) ratio, suggesting warm climate conditions similar to that of the Holocene. In addition, marine dinoflagellates and salt marsh pollen were found, these palynofloral records thus also attesting to marine influence in the deposits. In expectation that the Eemian tidal mud succession occurs on a wider geographic scale, the deposit is allocated the stratigraphic name Baeksu Formation (Eemian), the stratotype locality being situated at −20 m below the surface at the Baeksu borehole site. The presence of Eemian tidal muds along the west coast of Korea, which correlate with marine strata in the western Yellow Sea and Bohai Sea, explicitly reveals the occurrence of marine incursions into the eastern margin of the paleo(?)-Yellow Sea land during the last interglacial.

1. Introduction

The last interglacial period or MIS 5e (the Eemian Stage), was a period not only of generally higher global sea level but also higher temperature than at present (Chappell and Shackleton, 1986; Shackleton, 1987; Waelbroeck et al., 2002; Shackleton et al., 2003; Siddall et al., 2010; Grant et al., 2012, Fig. 1A). Chronologically, the time period spans approximately from 110 to 130 ka (Fig. 1A), although substage boundaries are not formally defined because of discrepancies between terrestrial and ocean sedimentary sequences, as well as regional differences (Gibbard, 2003; Shackleton et al., 2003; Muhs et al., 2011). The Eemian Stage holds a key position in paleoceanographic and -climate studies during the Quaternary because it can serve as a barometer for the Holocene to Recent climate.

Terrestrial records in the Eemian Stage have previously been extensively reported from continent to the continent, a multidisciplinary effort having specifically been made in East Asia over past decades (Kukla et al., 1988; An, 2000; Wu et al., 2002; Chen et al., 2003; Liu et al., 2005; Yang and Ding, 2008; Kim et al., 2010). In contrast to terrestrial records, marine deposits of the same stage have been widely reported from northern Europe (Knudsen, 1984; Fronval and Jansen, 1997; Seidenkrantz et al., 2000; Knudsen et al., 2012). The correlative marine strata in East Asia have been documented from the western Yellow Sea, East China Sea, the Bohai Sea of China, Taiwan, and Ryukyu Islands of Japan (Ota and Omura, 1991; Yang, 1994; Pedoja et al., 2008; Zhao et al., 2008; Yi et al., 2012, 2013; Yao et al., 2014), their counterparts having thus far not been reported from the Korean west coast (eastern Yellow Sea).

The Yellow Sea is a shallow epicontinental shelf with an average water depth of 55 m. It has a broad and gently sloping sea floor. The tide propagates rapidly, tidal energy fluxes being generally very high. Although the Yellow Sea has received high sediment inputs from major rivers along the Korean and Chinese coasts also during Pleistocene interglacials, marine deposits of Eemian age have hitherto not been reported from the Korean west coast, i.e. the eastern Yellow Sea coast.

Over the past two decades, sediment core analyses and related age datings from the Korean west coast have provided a

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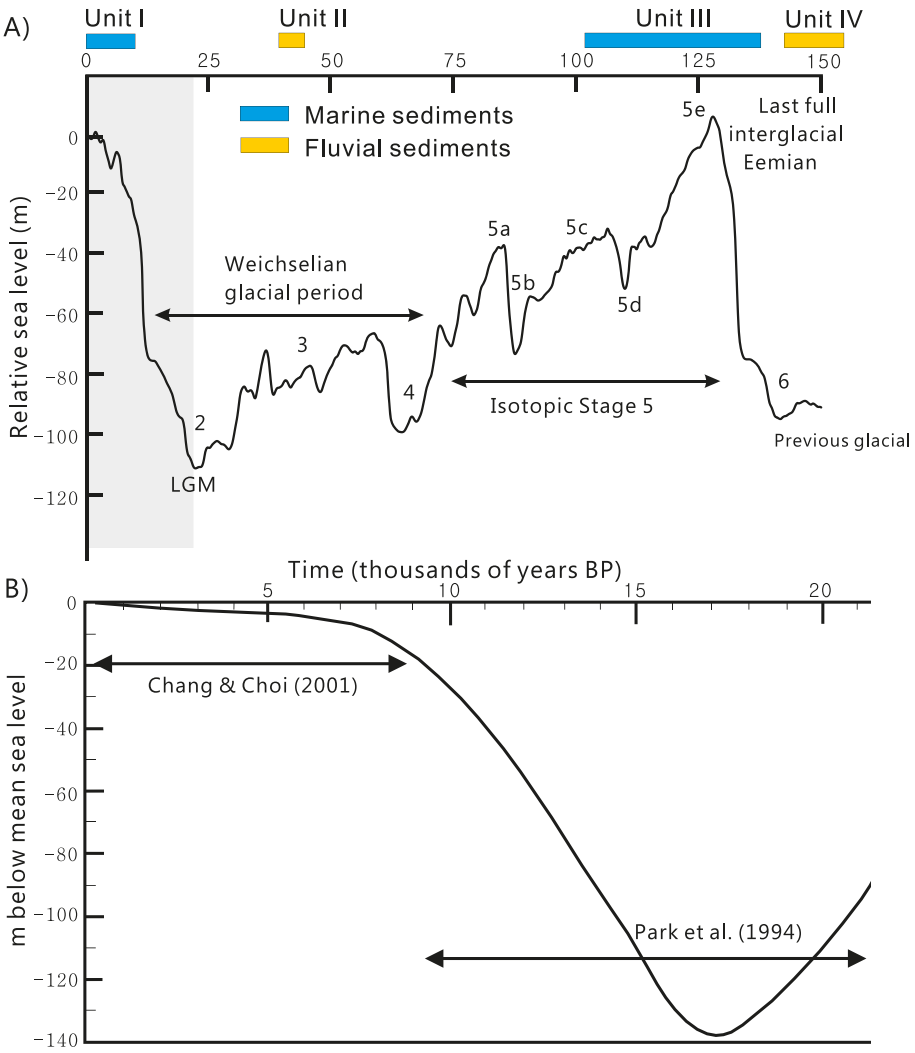

Fig. 1. (A) High-resolution global sea-level curve for the past 150 ka (after Martinson et al., 1987; Chappell et al., 1996; Grant et al., 2012). The major isotopic stages are numbered. Note the higher than present Eemian sea level. Four sedimentary units are marked on the upper panel. (B) Post-glacial/Holocene sea-level curve for the Korean west coast (extracted from Park et al., 1994; Chang and Choi, 2001).

comprehensive local sea-level curve established almost exclusively from tidal sediments, although the dates essentially cover the Holocene period only (Park et al., 1994; Chang and Choi, 2001, Fig. 1B). In recent deep borehole studies, oxidized layers were found below Holocene tidal deposits, followed by another tidal mud succession below some paleosol layers. Based on both OSL and ^{14}C AMS (accelerator mass spectrometry) datings, all of these apparently fall into MIS 3 to 4 (Lim and Park, 2003; Choi and Dalrymple, 2004; Lim et al., 2004; Choi and Kim, 2006; Choi et al., 2012; Kwon, 2012). However, because of significant inconsistencies between available age datings and their stratigraphic positions relative to the accepted sea-level curve, there was considerable debate about the accuracy and upper limits of the various dating techniques, the interval between the pre-Holocene and the Eemian Stage presenting an unexplained large dating gap.

Within this context, the present study for the first time documents the actual existence of Eemian marine deposits along the southwest coast of Korea. The Eemian tidal succession discovered in drill cores from the Baeksu shore occurs in the downcore interval from −20 to −38 m below modern mean sea level. The chronological ages were determined using an OSL dating method, the marine nature of the sedimentary succession being further supported by palynofloral records. The study highlights implications of the Eemian tidal deposits for regional stratigraphic correlations and the applicability of the Asian monsoon climate model and eustatic sea-level curves to the Yellow Sea, East Asia.

2. Study area

The Baeksu shore, which is located on the southwest coast of Korea, is divided into an intertidal shoreface and a nearshore tidal flat proper (Chang and Flemming, 2006), the system as a whole here called “tidal flat” for simplicity. It is at present 4–6 km wide and 8–10 km long at low tide (Fig. 2). Facing north-west, it directly borders on the Yellow Sea without an intervening barrier. Over the last three decades, almost half of the nearshore estuarine tidal flat was reclaimed for agricultural purposes (Chang and Flemming, 2006). Topographic profiles show that the seaward-fining upper intertidal shoreface is characterized by a smooth, concave-up morphology, which grades into a shoreward-fining convex-up tidal flat, the intertidal surface as a whole having a very gentle slope with a gradient of 0.05–0.07° on average (Yang, 2006).