Marine Geology 348 (2014) 52–62

Contents lists available at ScienceDirect

Marine Geology

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

Missing evidence for stepwise postglacial sea level rise and an approach to more precise determination of former sea levels on East China Sea Shelf

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ARTICLE INFO

Article history:
Received 5 September 2012
Received in revised form 2 December 2013
Accepted 5 December 2013
Available online 12 December 2013

Communicated by J.T. Wells

Keywords:
Postglacial
Sea level rise
Sea level indicator
Peaty layer
Tidal flat
East China Sea Shelf

ABSTRACT

The vertical range of past sea level indicated by tidal flat deposits is equal to the sum of the sediment thickness and tidal range. Defining position of the dated sample in tidal flat deposits can increase the accuracy of former sea level determinations. The salt-water peaty layer often contains mixtures of autochthonous and allochthonous organic carbon and the tidal flat deposits may contain biological remains transported from shallow marine sources. These allochthonous remains have older ages than those of the layers containing the dated materials. Most published ^{14}C data on the East China Sea Shelf are inadequate to define a precise postglacial sea level rise curve. Good results in determining both precise former sea levels and reliable ^{14}C ages can be provided by selecting large plant roots and wood fragments from peaty layers, and selecting less worn foraminifera tests and mollusk shells of dominant species in modern equivalent environments (such as foraminifera *Ammonia beccarii* vars. or mollusk *Corbicula fluminea*) from the peaty layer, its close overlying deposits and the base of tidal flat deposits without a basal peaty layer. The stepwise model for postglacial sea level rise on the East China Sea Shelf (Liu, 2001; Liu et al., 2004) was mostly determined by freshwater peat, shallow marine and subtidal samples, which cannot provide precise water levels. The reliability of many ^{14}C ages used is also questionable due to unknown proportions of allochthonous material. Thus the stepwise model is unsupported by available data. A rough sea level curve in last 13,000 yr on the East China Sea Shelf is herein proposed. It seems simple but is effective based on valid data.

1. Introduction

The eustatic sea level curve on the East China Sea and Yellow Sea (including the Bohai Sea) was proposed by Liu (2001) and was formally published later, referred as stepwise postglacial sea level rise in the western Pacific (Liu et al., 2004). Using an extensive sea level database, it was demonstrated that the postglacial transgression in the East China Sea Shelf was step-like: long periods of slow transgression (2–8 mm/yr) punctuated by several short, rapid flooding events (~80 mm/yr). The stepwise sea level rise curve since 15.0 ka is based on data of 79 samples from the East China Sea Shelf, 15 samples from the Sunda Shelf (the shallow sea bed of the western South China Sea and surrounding coastal areas) and one sample from the Bonaparte Sea. Among the 15 samples from the Sunda Shelf, 10 samples are restricted to the time interval of 14.0–15.0 ka (Hanebuth et al., 2000; Liu et al., 2004). The sea level curve since 15.0 ka is decided with the data of the East China Sea Shelf rather than those of the Sunda Shelf (Fig. 1). Therefore, the Western Pacific postglacial sea level curve since 15.0 ka actually is stepwise sea level rise on the East China Sea Shelf.

The Shandong mud wedge was deposited in the Early Holocene, during a relatively slow rise of sea level and the onset of the Asian summer monsoon (Liu et al., 2002). The Shandong clinoform (mud wedge) was considered to be the Yellow River subaqueous delta, which is closely related to the stepwise postglacial sea level rise (Liu et al., 2004). Recent study has demonstrated that the Shandong clinoform is not a delta (Liu et al., 2007). But this evidence does not contradict the model of a stepwise sea level rise.

This paper evaluates sea level indicators and the reliability of published ^{14}C data in cores, improving sample collection methods to obtain more reliable ages and discussing the validity of the stepwise model for postglacial sea level rise on the East China Sea Shelf.

2. Indicators of sea level and reliability of published ^{14}C data

2.1. Indicators of sea level: salt-water peaty layer and tidal flat deposits

Coastal salt marshes may be divided into two fundamental zones: low marsh and high marsh. The low marshes correspond to about mean high-water neap on the Pacific coast. High marshes occupy the

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0025-3227/$ – see front matter © 2014 Elsevier B.V. All rights reserved.
http://dx.doi.org/10.1016/j.margeo.2013.12.004

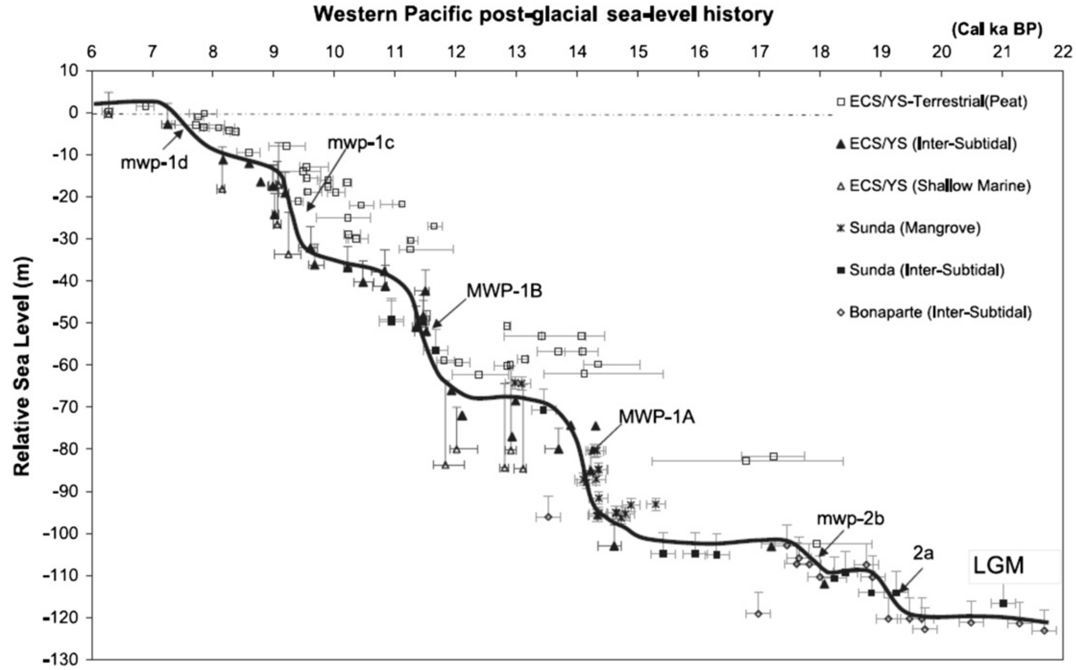

Fig. 1. Stepwise postglacial sea level rise in the western Pacific. The episodic sea level curve is defined based on extensive collection of sea level indicators (fresh water peat, brackish and shallow marine) from the nearshore and submerged East China Sea Shelf (Liu, 2001), Sunda Shelf (Hanebuth et al., 2000), and Banaparte Sea (Yakoyama et al., 2000) (after Liu et al., 2004).

uppermost part of the intertidal zone, terminating landward at, or slightly above, mean high water spring (Frey and Basan, 1985). According to my observations along the eastern China coasts, the coastal salt marshes are discontinuously distributed from the mean high water spring to the upper quarter of the intertidal zone and dense marshes in about mean high tidal level.

Numerically simulating or inferring former mean tidal ranges is necessary to determine former sea levels based on tidal flat deposits with or without a basal salt-water peaty layer. On the East China Sea Shelf, the salt-water peaty layer in a core has a narrow vertical range. The relationship between the elevation of a sample from tidal flat deposits in a core, the sedimentary environment position of formation and the indicated elevation of former sea level is shown in Fig. 2.

Above the mean high water line is the supratidal zone, which is submerged only during periods of elevated spring tide and storms. The intertidal zone is between mean high and mean low water (Klein, 1985). Tidal flats may include the supratidal zone and the intertidal zone, but exclude the subtidal zone. The modern tidal flat deposits form in the interval between mean high spring tidal level and mean low tidal level. On the east coast of China, deposition in the supratidal zone is not as important as in the intertidal zone and the thickness of deposits accumulated there is much thinner than that in the intertidal zone, because of the absence of the thick peat or peaty layer accumulation there. The thickness of the tidal flat deposits is close to or slightly more than the mean tidal range. However, the thickness of the tidal deposits formed during sea level rise depends on the tidal range, sediment supply, and sea level rise during the time of deposition. It may be equal to, smaller or greater than the contemporaneous tidal range.

Based on the content of organic carbon, sedimentary structures, macro- and micro-fossil remains, the boundaries of the tidal flat deposits with or without a basal salt-water peaty layer in cores on the East China Sea Shelf can be recognized (Xue et al., 1987, 1995; Liu

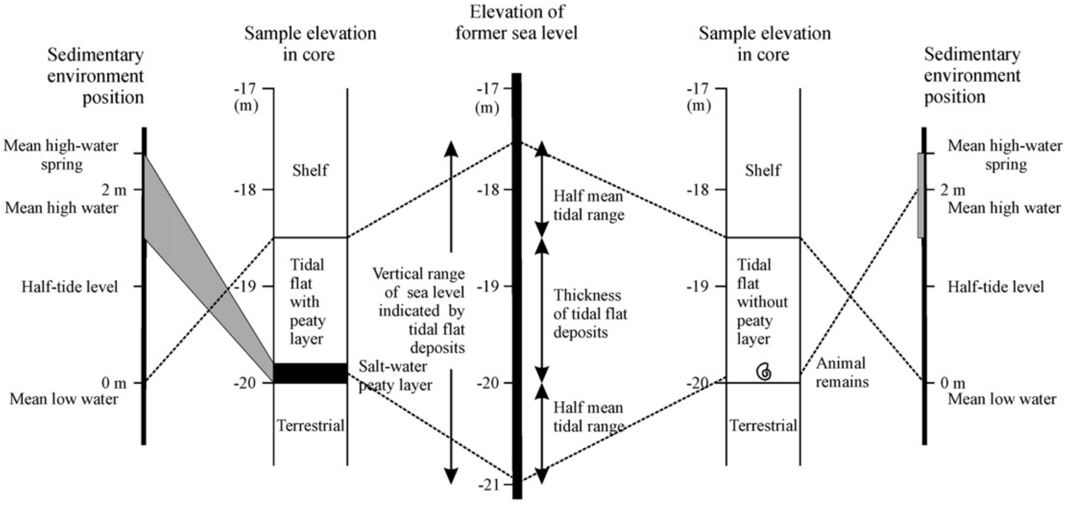

Fig. 2. Relationship between elevation of the sample from tidal flat deposits with or without salt-water peaty layer, former sedimentary environment position and elevation of the former sea level during the postglacial sea level rise. The former mean tidal range is assumed to be 2 m and the thickness of the tidal flat deposits to be 1.5 m. This diagrammatic explanation is applicable to varied thicknesses of tidal flat deposits and tidal ranges.