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Holocene sea-level history of the northern coast of South China Sea

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ABSTRACT

This study has collected and analyzed seven sediment cores from the Pearl River delta, from which 16 new and high-quality sea-level index points are generated using a new approach. This study has also re-checked and re-calibrated the previously published sea-level data from China's southeast coast with corrections made for tectonic subsidence and sediment compaction factors. These sea-level data indicate a rise of relative sea level from -49.3 ± 0.8 m to the present height between 10,500 and 7000 cal. a BP. This sea-level history is similar to those recorded from other far-field locations and ice-volume equivalent sea-level models. The early to early-middle Holocene sea-level history in the study area shows a phase of accelerated rise at a rate increasing rapidly from 16.4 ± 6.1 mm/a at 10,500 cal. a BP to 33.0 ± 7.1 mm/a at 9500 cal. a BP. This phase was followed by a period of rapid decrease in the rate of sea-level rise to 8.8 ± 1.9 mm/a at 8500 cal. a BP and 1.7 ± 1.3 mm/a at 7500 cal. a BP. During the past 7000 years, the relative sea level in the study area changed very little. This new and complete history of Holocene sea-level change supports the following findings: (1) no obvious higher-than-present sea-level highstand in the Holocene is found from the northern South China Sea; (2) certain proportion of the effects of the predicted glacial isostatic adjustment were cancelled out by the effects of the weak upper mantle viscosity in the study area; (3) meltwater pulse 1b likely exists spanning into the early Holocene; (4) there are significant misfit between sea-level data and glacial isostatic adjustment models, and a revision to the existing ice melting history for the early Holocene is possibly needed.

1. Introduction

The first 1500 years of the Holocene took place in the last stage of the postglacial global temperature rise (e.g. Stuiver and Grootes, 2000; Grootes et al., 2001; Shakun et al., 2012; Marcott et al., 2013), which coincided with rapid changes in moisture supply and biomass across the world (e.g. Griffiths et al., 2009). In coastal areas worldwide, as polar ice sheets and glaciers continued to melt, ice-volume equivalent sea level (ESL) continued to rise rapidly during this time period (e.g. Lambeck et al., 2014). This period of post-glacial sea-level rise has resulted in marine inundation across the extensive upper continental shelves, such as the west coast of the North Pacific for instance (e.g. Smith et al., 2011), which coincided with a complex process of glacial isostatic adjustment (GIA) across the globe. By the end of this period, sea water had penetrated into the most landward location of many river valleys of East and Southeast Asia (e.g. Tamura et al., 2009; Zong et al., 2012), and about 2000 years after which, many deltaic plains started to prograde seawards (e.g. Hori et al., 2004; Tanabe et al., 2006; Zong et al., 2009a). In other words, sea-level change in the early Holocene has been a key driver for coastal change. Therefore, the early Holocene sedimentary archives can provide important information for understanding postglacial sea-level change (e.g. Smith et al., 2011).

Despite the fact that the early Holocene is an important period for coastal environmental changes, there are only limited data available from previous studies in East and Southeast Asia, and they were mainly from the southern part of the South China Sea region (Fig. 1a). For example, Linsley (1996) reconstructed the sea-level history for the past 150,000 years from the Sulu Sea, and Hanebuth et al. (2000) reported in much greater detail the post-glacial sea-level history from the Sunda Shelf. But both records provide little detail on the early Holocene. In the Malacca Strait, Geyh et al. (1979) illustrated a more complete history of relative sea level (RSL) for the early Holocene, and Bird et al. (2007) showed

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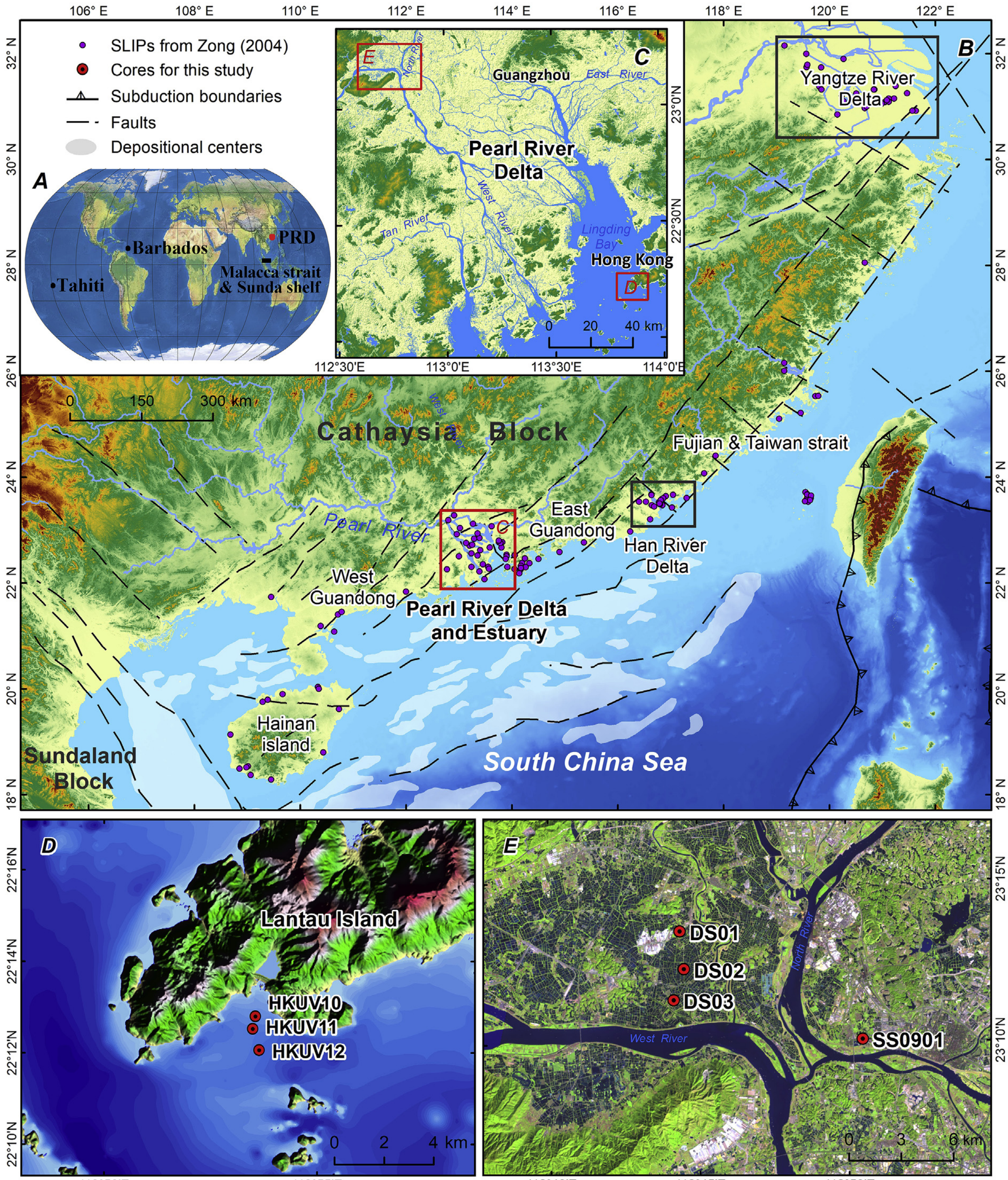

Fig. 1. Map A shows source locations of far-field sea-level data. Map B illustrates the landscape of northern South China Sea, major faults on land and under the sea, the subduction boundary and locations of the pre-existing sea-level data in southeast China. Map C presents the landscape of the Pearl River deltaic plain, the head and mouth areas. Map D reveals the small catchment on the Lantau Island and the locations of the three sediment cores. Map E provides an aerial view of the head area of the deltaic plain and the locations of the four sediment cores.

some details of RSL change between 9000 and 7000 years BP from Singapore. Along the coast of the Western North Pacific between 10° and 40° N, a large amount of middle to late Holocene sea-level data was published (e.g. Zong, 2004; Horton et al., 2005; Li et al., 2015). However, very few high-quality sea-level data points are available to show the rate and magnitude of RSL rise for the early Holocene, which has limited our ability to constrain the solid Earth and ice components of GIA models. With the limited data for this time period, debates about whether the early Holocene experienced a smooth sea-level rise at a relatively constant rate, or a punctuated rise with pulses of rapid sea-level change have continued (e.g. Smith et al., 2011; Cronin, 2012).

One important factor has hindered the production of sea-level index points (SLIPs) for the early Holocene in the northern South