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Foraminifera and tidal notches: Dating neotectonic events at Korphos, Greece

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ABSTRACT

Fossil assemblages of foraminifera and thecamoebians from three salt-marsh cores recovered at Korphos, Greece, provided evidence for five transgression events since the mid Holocene. Marsh accretion rates based on radiocarbon-dated peat and geomorphic evidence from a series of discrete, v-shaped, submerged tidal notches indicated that these transgression events were rapid and episodic. Correlation of the tidal notches with the transgression horizons in the salt-marsh stratigraphy revealed a stepwise pattern of relative sea-level change at Korphos, which is best explained by coseismic subsidence related to fault displacement (earthquakes) associated with the Hellenic subduction zone. A comparison between the Korphos data and a model of Holocene sea-level change for the Peloponnesus reinforces this interpretation as sea-level rose in a series of jumps by amounts greater than accounted for by eustatic and glacio-hydro-isostatic factors (up to ~2.0 m). This study illustrates that by combining microfossil, sedimentary and geomorphic records of past sea-level change, problems frequently encountered with each record individually (e.g. dating submerged notches and autocompaction of marsh sediments) may be overcome.

1. Introduction

In seismotectonically-active coastal regions sudden relative sea-level (rsl) changes occur before, during and after earthquake events (e.g. Hawkes et al., 2005; Shennan and Hamilton, 2006). Relict beaches and other products of rsl change, such as raised or submerged notches, benches, and caves, provide valuable data for detecting earthquake events older than historical records. Geomorphic evidence alone may lead to ambiguous interpretations however, as the effects of an instantaneous movement cannot always be distinguished from the effects of events lasting for decades to centuries. Furthermore, dating relict shorelines is often difficult, especially when they fall below modern sea-level and are subjected to encrustation or bio-erosion by organisms that live below the tidal range.

Salt-marshes preserve a more continuous record of rsl change compared with patchy geomorphic evidence and often contain abundant, in situ material for dating. Furthermore, detailed descriptions of foraminiferal zones, whose species compositions are strongly related to elevation, have been reported for salt-marshes worldwide (e.g., Scott and Medioli, 1978; Patterson, 1990; Jennings and Nelson, 1992; Gehrels, 1994; Jennings et al., 1995; Scott et al., 1996; Hayward et al., 1999; Edwards and Horton, 2000).

Many researchers have reconstructed past rsl histories by documenting vertical changes in species assemblages sampled from salt-marsh stratigraphy and comparing these to modern salt-marsh foraminiferal zones (Scott and Medioli, 1978, 1980, 1986; Williams, 1999). Along tectonically active plate-boundary coastlines Holocene earthquake histories have also been developed using subsurface sedimentological and foraminiferal evidence of rsl change (e.g. Clague and Bobrowsky, 1994; Long and Shennan, 1994; Mathewes and Clague, 1994; Atwater et al., 1995; Nelson et al., 1996; Cundy et al., 2000). The general hypothesis is that a sudden acceleration in the rate of rsl rise relative to the rate of marsh accretion caused by coseismic subsidence would result in low-elevation intertidal or subtidal foraminifera colonizing formerly higher and more inland reaches of the marsh. In the sedimentary record, this event would be represented by a biofacies contact of freshwater or high-marsh peats with their characteristic mixed thecamoebian and foraminiferal assemblages overlain by low-marsh, tidal flat or subtidal assemblages (Fletcher et al., 1993). A problem with this method, particularly if correlating sections or sediment cores from different areas, is that the original elevations of the biofacies contacts may be altered by autocompaction, with the oldest and deepest sediments being the most affected (Kaye and Barghoorn, 1964; Cahoon et al., 1995). Additionally, the interpretation of past rsl change as coseismic should not rely solely on the microfossil record of the salt-marsh, but rather include several converging indicators, all of which point to rapid shoreline displacement.

In this study, we document foraminiferal zones from a salt-marsh near Korphos, Greece, both in the surficial environment (modern marsh) and in the subsurface (sediment cores). To enhance this reconstruction, we compare evidence for rsl change from the salt-

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marsh record to that from the local geomorphic record. To further refine our understanding of rsl change at Korphos, we compare our results to a model of Holocene eustatic and glacio-hydro-isostatic rsl for this region (Lambeck and Purcell, 2005).

2. Regional setting

Korphos is located in the region of Korinthia, Greece, along the northwestern shore of the Saronikos Gulf (Fig. 1). The Korphos area was originally selected as part of a larger project, the Eastern Korinthia Archaeological Survey, which aimed to predict the locations of undocumented, prehistoric harbours and anchorages using GIS, geomorphology, seismology, and archaeology (Rothaus and Reinhardt, in press; Rothaus et al., 2003; Tartaron et al., 2006). An additional goal of this survey was to reconstruct landscape evolution histories for the ancient harbour sites, including anticipated impacts from earthquakes and coseismic land-level changes. Evidence for past earthquakes at Korphos included a series of laterally continuous, submerged tidal notches (Fig. 2; Table 1). The tidal notches, which were eroded into resistant limestone cliffs, were discrete and v-shaped with unaltered roof profiles, suggesting rapid and episodic sea-level changes by amplitudes that exceeded the local tidal range (Neumann, 1966; Neumann and Hearty, 1996; Pirazzoli, 1996; Benac et al., 2004).

Other indicators that suggested local episodic subsidence included three submerged beachrock platforms at −1.2 m, −3.3 m, and −5.9 m, near Cape Trelli, a small, southward projecting promontory approximately

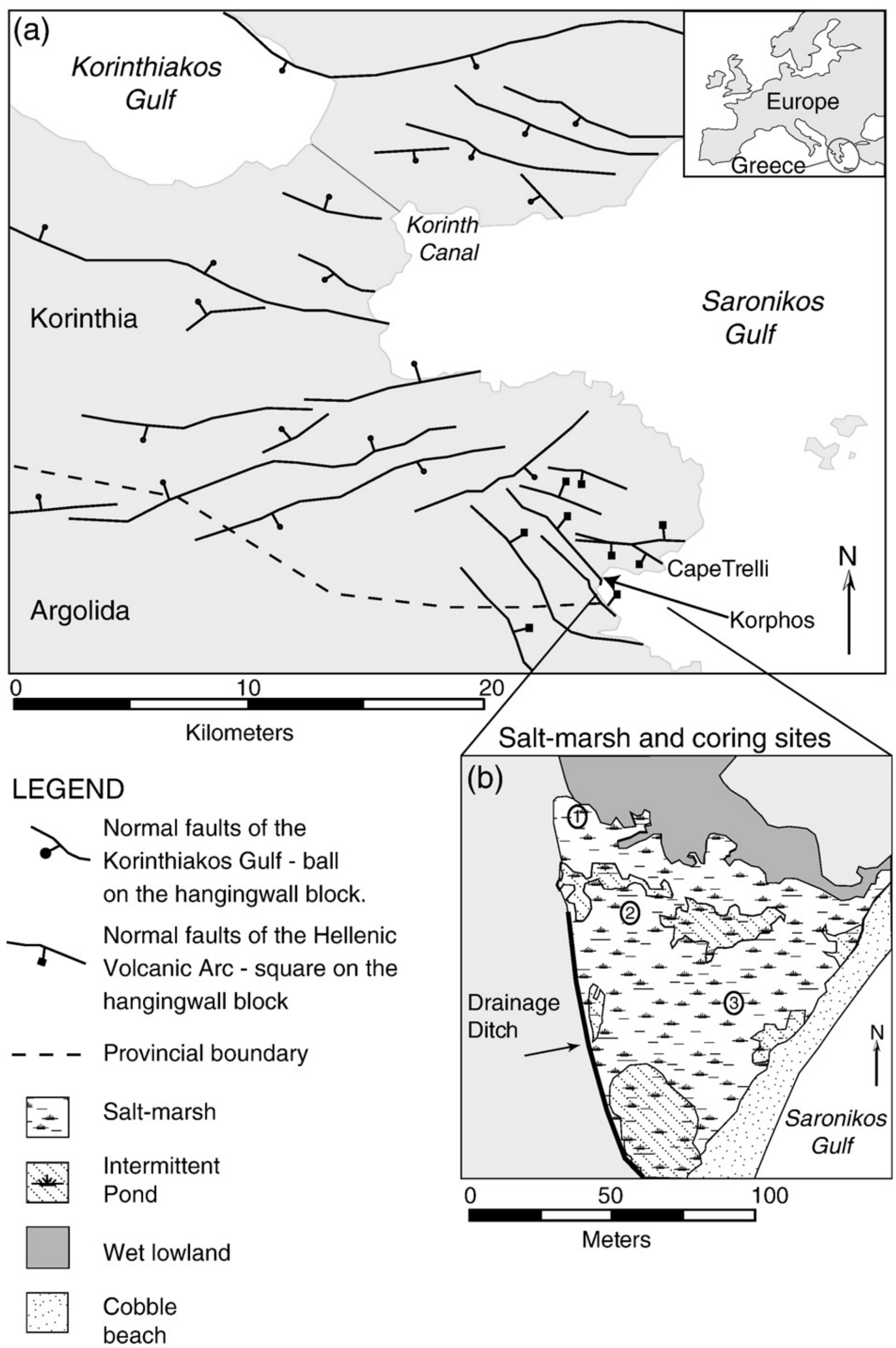

Fig. 1. (a) Location of Korphos, Greece, as well as the distribution of normal faults associated with the Hellenic subduction zone and Korinthiakos Gulf in the study region (adapted from Noller et al., 1997). (b) The study site with locations of vibracores 1–3.