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Elevated marine deposits in Bermuda record a late Quaternary megatsunami

Gary M. McMurtry [a,1], David R. Tappin [b,*], Peter N. Sedwick [c], Ian Wilkinson [b,2], Jan Fietzke [d], Bruce Sellwood [e]

[a] School of Ocean and Earth Science and Technology, University of Hawaii, Manoa, Honolulu, Hawaii 96822, USA
[b] British Geological Survey, Kingsley Dunham Centre, Keyworth, Nottingham NG 12 5GG, UK
[c] Bermuda Biological Station for Research, St George's, GE01, Bermuda
[d] Biogeochemie Leibniz-Institut für Meereswissenschaften, IFM-GEOMAR Dienstgebäude Ostufer, 8E-105 Wischhofstraße 1-3, D-24148 Kiel, Germany
[e] Department of Geography, School of Human and Environmental Sciences, The University of Reading, Whiteknights, Reading RG6 6AB, UK

Abstract

Deposits of coral-bearing, marine shell conglomerate exposed at elevations higher than 20 m above present-day mean sea level (MSL) in Bermuda and the Bahamas have previously been interpreted as relict intertidal deposits formed during marine isotope stage (MIS) 11, ca. 360–420 ka before present. On the strength of this evidence, a sea level highstand more than 20 m higher than present-day MSL was inferred for the MIS 11 interglacial, despite a lack of clear supporting evidence in the oxygen-isotope records of deep-sea sediment cores. We have critically re-examined the elevated marine deposits in Bermuda, and find their geological setting, sedimentary relations, and microfaunal assemblages to be inconsistent with intertidal deposition over an extended period. Rather, these deposits, which comprise a poorly sorted mixture of reef, lagoon and shoreline sediments, appear to have been carried tens of meters inside karst caves, presumably by large waves, at some time earlier than ca. 310–360 ka before present (MIS 9–11). We hypothesize that these deposits are the result of a large tsunami during the mid-Pleistocene, in which Bermuda was impacted by a wave set that carried sediments from the surrounding reef platform and nearshore waters over the eolianite atoll. Likely causes for such a megatsunami are the flank collapse of an Atlantic island volcano, such as the roughly synchronous Julan or Orotava submarine landslides in the Canary Islands, or a giant submarine landslide on the Atlantic continental margin.

Keywords: Bermuda; Tsunami deposit; Interglacial; Submarine landslide

1. Introduction

One of the most important impacts of the anticipated climate warming due to human activities is the potential for rise in global sea level, as a result of the thermal expansion of seawater and the melting of high-latitude ice caps (Watson, 2001; NAS, 2001). In order to accurately predict future sea level rise, it is critical that we understand how sea level has changed in the past,

* Corresponding author. Fax: +44 115 9363200.
E-mail addresses: garym@soest.hawaii.edu (G.M. McMurtry), drta@bgs.ac.uk (D.R. Tappin), psedwick@bbsr.edu (P.N. Sedwick), ipw@bgs.ac.uk (I. Wilkinson), jfietzke@ifm-geomar.de (J. Fietzke), B.W.Sellwood@reading.ac.uk (B. Sellwood).
[1] Fax: +1 808 956 9225.
[2] Fax: +44 115 9363200.

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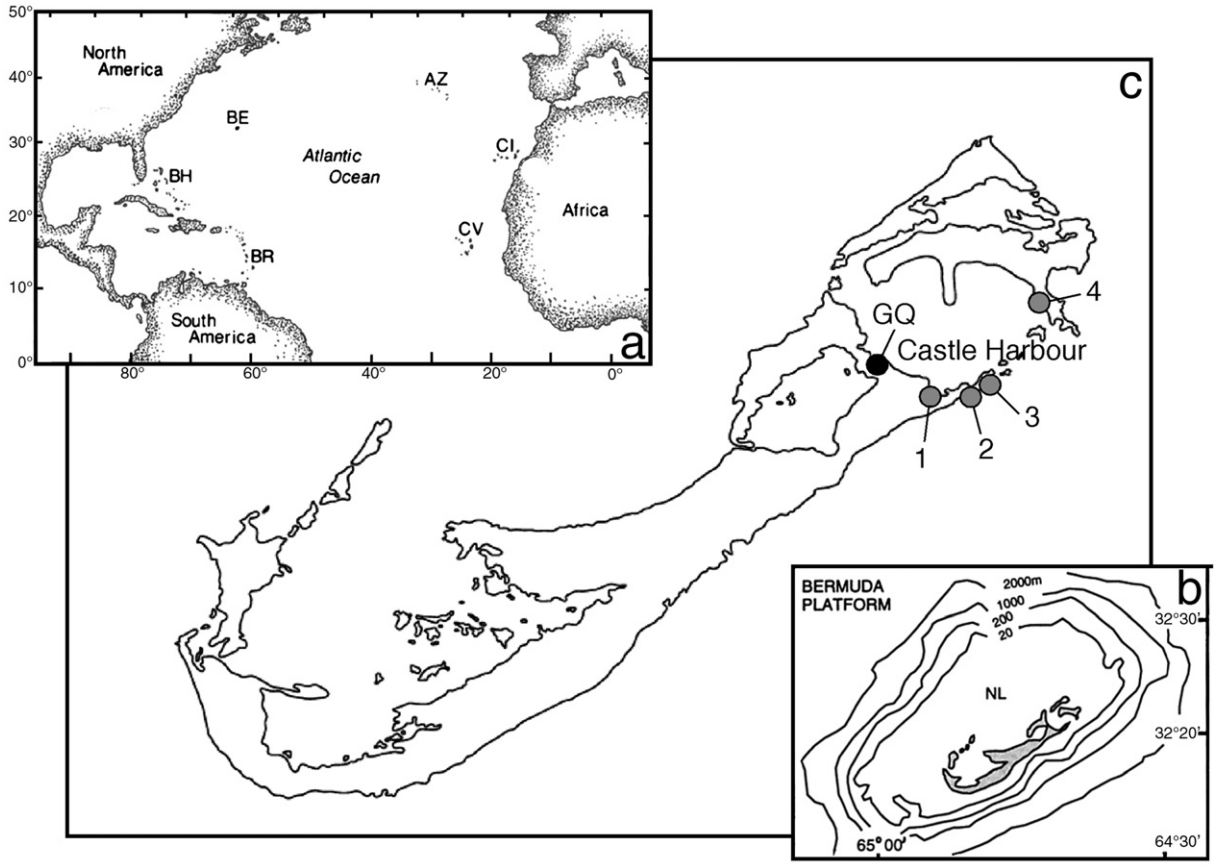

Fig. 1. (a) Location of Bermuda (BE) relative to other North Atlantic oceanic islands: Azores (AZ), Canary Islands (CI), Cape Verde Islands (CV), Bahamas (BH), Barbados (BR); (b) Bermuda Platform, with bathymetric contours in meters, North Lagoon (NL); (c) Location of Castle Harbour and the Government Quarry caves site (GQ). Table 1 sand sample locations: 1=Tucker's Town; 2=Windsor Beach, eolianite sample from cliff; 3=Howard Bay; 4=Cooper's Island. Maps modified after Herwitz and Muhs (1995) and Vacher et al. (1995).

including the maximum sea levels that were attained during Quaternary interglacial periods. Within this context, a very significant finding is the existence of coral- and shell-bearing marine conglomerates at elevations of more than 20 m above sea level (ASL) on the tectonically stable island platforms of Bermuda and Eleuthera (Bahamas) in the western North Atlantic. On the basis of these deposits, Hearty et al. (1999) have inferred a sea level highstand greater than 20 m ASL during marine isotope stage (MIS) 11, an interglacial period spanning 360–420 ka before present (BP). This proposition has profound implications for future sea level in the context of global warming, since marine-sediment and ice-core records suggest that MIS 11 was longer, but not significantly warmer, than the Holocene (Howard, 1997; Droxler and Farrell, 2000; Hodell et al., 2000; EPICA community members, 2004). Notably, however, the oxygen-isotope records from sea floor sediments, which provide a proxy for global ice volume, provide no clear evidence for such a sea level highstand during MIS 11 (Shackleton, 1987; Shackleton et al., 1990; Hodell et al., 2000; Shackleton, 2000; Lambeck et al., 2002). As further evidence of a towering sea level highstand during MIS 11, Hearty (2002) cites the Kaena marine deposits on Oahu, Hawaii, which contain corals dated at 400–550 ka BP that are exposed at up to 30 m ASL; however, these deposits may reflect the tectonic uplift of Oahu rather than a paleo sea level (McMurtry et al., 2004). These inconsistencies prompted us to re-examine the putative MIS11 highstand deposits on Bermuda.

2. Geological setting

Located about 1000 km east of North Carolina in the western North Atlantic (Fig. 1), the island of Bermuda is a highly eroded karst of Pleistocene eolianite limestone resting on a 650 km^2 coralgal reef platform. The reef