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Eastern Mediterranean sea levels through the last interglacial from a coastal-marine sequence in northern Israel

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A B S T R A C T

A last interglacial (Marine Isotope Stage, MIS5e) marine-coastal sequence has been identified along the Galilee coast of Israel, with the type section located at Rosh Hanikra (RH). The microtidal regime and tectonic stability, along with the detailed stratigraphy of the RH shore, make the study region ideally suited for determining relative sea level (RSL) through the MIS5e interval in the eastern Mediterranean. The sequence contains fossilized microtidal subunits at a few meters above the current sea level. Unfortunately, all fossils were found to be altered, so that U-Th datings cannot be considered to represent initial deposition. We contend that U-Th dating of *Strombus bubonius* shells (recrystallized to calcite) suffices to indicate a lower limit of ~110 ± 8 ka for the time sea level dropped below the RH sedimentary sequence. The RH-section comprises three main subunits of a previously determined member (the *Yasaf Member*): (a) a gravelly unit containing the diagnostic gastropod *Strombus bubonius* Lamarck (*Persististrombus latus*), which was deposited in the intertidal to super-tidal stormy zone; (b) *Vermetidae* reef domes indicating a shallow-water depositional environment; and (c) coarse to medium-sized, bioclastic sandstone, probably deposited in the shallow sub-tidal zone. The sequence overlies three abrasion platforms that are cut by tidal channels at elevations of +0.8 m, +2.6 m and +3.4 m, and which are filled with MIS5e sediments. We present a detailed study of the sequence, with emphasis on stratigraphic, sedimentological, and palaeontological characteristics that indicate sea-level changes. Although without precise absolute dating, the stratigraphic sequence of RH through MIS5e allows us to identify a time-series of RSL positions, using the elevations of three stratigraphic subunits. Reconstructed RSL values range from +1.0 m to +7 m (with uncertainly < 1 m), and most fall within a narrow range of +1.0 to +3.3 m. Toward the end of MIS5e, RSL exceeded about +7 m. Glacial isostatic adjustment (GIA) modelling using multiple ice histories suggests that GIA corrections range between about −1.8 m and +5.4 m. This implies that global mean sea level resided between −0.8 m and +8.7 m during most of MIS5e. The absolute GIA correction would not be constant through the interglacial, and reduces to a range of −1.2 m to+ 2.4 m towards the end of the interglacial.

1. Introduction

Reconstructed sea-level elevations and their age constraints show remarkable differences for MIS5e around the world, as does

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Table 1
Selected data of MIS5e sea levels (SLs) presenting differences between various databases.

	SL indicators and its elevation	Dating method	Age	Age uncertainty	Inferred SLs' through MIS5e	Vertical uncertainty	Curve structure	References	Remarks
Deep sea cores									
N. Atlantic and Equatorial Pacific	Benthic foraminiferal $\delta^{18}O$	Records beyond 40 kyr are dated by correlation to SPECMAP	135-115ka	The average is on the order of 0.5–0.8 ka	Above present day (0 m)	±13m		Waelbroeck et al. (2002)	
Red Sea	Benthic foraminiferal $\delta^{18}O$	For MIS52: synchronization with the high-resolution Antarctic records	~129–110 ka	centennial-scale for 25–70 kyr, and less for the Last Interglacial	Above present day (0 m)	±12m	One peak around 122 kyr.	Siddall et al. (2003)	Uplifted rates in Bab el Mandab of 0.02 m ka^{-1}
Red sea	Planktonic foraminiferal $\delta^{18}O$	Combining coral data with a new, continuous, SL reconstruction from recent calibration method for stable oxygen isotope record	~124-119ka	±1 ka and even smaller	Above +10 m.	±6 m to ±6.3	Fluctuating SL rising to the highest peak around 123ka, a short drop and another peak at 121.5ka	Rohling et al. (2008)	
Red Sea	Planktonic foraminiferal $\delta^{18}O$	Chronology independent of ice cores. Tie points with Soreq Cave record.	133-120ka	(±0.5 and ± 1 ka).	>0 m 126 to 130 ka (probability maximum curve, 95% confidence limits)	Fully propagated uncertainties expressed as vertical uncertainties maximum values of+/−3.4 m.	The probability maximum curve contains one peak at 127.8 ka; the raw data contains multiple oscillations through MIS 5e.	Grant et al., 2012, Grant et al. 2014	
Coral reefs									
Northeast Yucatan peninsula, Mexico	Complete coral reef-crest sequence at +3 m and +5.8 m.	^{230}Th mainly of the coral A. palmata colonies	~132–125ka ~121–118ka	Ages with values of 149 ± 8% ∂^{234}Uwere considered accurate to ±2 kyr	Prolonged SL at +2.5 m and rapid rise up to +6 m or even +9m	+3 m between ~126ka and 122ka and +6 m (between ~120 and 117kar	Two steps of long highstands: between ~126ka and 122ka and ~120 to 117ka	Blanchon et al., 2009	Stable area
West Australia	Fossil coral reefs	^{232}Th > 0:5 ppb	127-116ka	>3 ka	Between +2.2 and + 3.4 m up to 119–120 kyr and a jump up to +9.5m	Min. coral paleo-depth is 0.4 m in in-situ corals.	Two peaks; at 127ka, a jump to +3.4, highstand to about 120ka and a jump to +9.5 m at 120ka.	O'Leary et al., 2013; Hearty et al., 2007	Stable areas. GIA corrected palaeo SL
W. Australia, and the Bahamas	Coastal structures	U-series on corals and AAR of marine shells and whole rock	130 to 119ka	±2ka	Rise to standstill at +2.5 m ~(132 –~125ka), a fall and rise to standstill at +3.0 m–124 to~121ka and a jump to +6m–121 to 119ka)	±1 m.	Two highstand and a jump at the end	Hearty et al., 2007 (and refs therein)	Stable areas
Great Bahama bank	Coral reefs: a rise to +2 m, a drop and tidal notches at +6m	U-Th dating	132-118ka.		A rise to +2 m –132ka, stable at +2 m, a fall in ~125 ka, and restraining of reef growth to ~+2 m, and a notch at +6 m–118ka.		Two highstand and a jump at the end	Chen et al., 1991; Neumann and Hearty, 1996;	Tectonically stable.
Hawaii and Bermuda	Coral reefs	U-Th (TIMS)	From ~134 to ~113 ka, with most ages	Between ±0.6ka to ±3ka	High stand at +8.5 to + 12.5 m			Muhs et al., 2002; Hearty et al., 2007	

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