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Last interglacial sea levels and regional tectonics from fossil coral reefs in the northeast Gulf of Aqaba

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ABSTRACT

Elevated reef terraces in the northeast Gulf of Aqaba (GOA) constrain the history of tectonic uplift and local relative sea level changes during the last interglacial period. These relative sea level changes were inferred from measured elevations coupled with U-Th ages of aragonite precipitation and recrystallization to calcite. All studied reef terraces were formed, and the corals comprising them were recrystallized from aragonite to calcite, when sea-level was at or close to its stable MIS5e elevation a few meters above the modern GOA level. The terraces comprise fringing reefs, some with clear reef structure consisting of a reef flat and a shallow back lagoon accurately marking sea levels at low tide. Terrace R3 probably formed at the earlier stage of MIS5e at ~130–132 ka and recrystallized to calcite at 124 ± 8 ka. Terrace R2, comprising a wide and developed reef flat, formed during the stable sea-level of peak MIS5e at ~129–121 ka and was recrystallized to calcite at 104 ± 6 ka. Terrace R1 formed during a short still-stand at 117 ± 3 ka. The recrystallization age of Terrace R2 implies that at around 104 ± 6 ka (MIS5c) sea-level was close to its MIS5e elevation. The elevation and ages of the reef flats indicate a slow average uplift, 0.13 ± 0.05 m/kyr, similar to rates inferred for other last interglacial reef terraces along GOA and the Red Sea. This suggests an overall long-term slow uplift of the Arabian lithosphere at the flanks of the Dead Sea Transform during the late Quaternary.

1. Introduction

Coral reefs are restricted to a narrow range of living conditions and their morphology is controlled by sea-level: they grow to or develop at the sea surface (Kennedy and Woodroffe, 2002; Montaggioni, 2005). Therefore, coral reefs tend to mark the sea level during their life span. The fossil corals within the reefs are potentially suitable for radiometric dating by the U-Th disequilibrium method (e.g., Edwards et al., 1987a,b; Chen et al., 1991; Stein et al., 1993; Gallup et al., 1994, Yehudai et al., 2017). These properties are the reason that fossil coral reefs are widely used as geological markers for sea level changes and vertical displacements along coastlines (e.g., Chappell, 1974; Lajoie, 1986; Yokoyama and Esat, 2011; Dutton and Lambeck, 2012).

Observed changes in sea-level reflect changes in the relative position of sea and land surfaces that are the combined result of changes in ocean volume, isostatic adjustment, and tectonic movements (Mitrovica and Peltier, 1991; Lambeck and Chappell, 2001; Mitrovica and Milne, 2002; Dutton and Lambeck, 2012). The dominant contributions to sea level changes during the Quaternary have been the periodic exchanges of water-masses between ice sheets and oceans: glacial periods have been times of sea-level lowstands and interglacials have been times of relative highstands, reflecting the increase in ocean volume due primarily to ice melting. Glacio-hydro-isostatic effects include the gravitational and rotational and deformation responses of the solid earth and ocean surfaces to changes in ice and water loads (Mitrovica and Peltier, 1991; Mitrovica and Milne, 2002; Dutton and Lambeck, 2012). Superimposed on the global signals are more regional and local changes caused by uplift and subsidence of the coastal zone (Lambeck and Chappell, 2001; Lambeck et al., 2011).

Most Pleistocene sea-level studies have focused on the main stage of the last interglacial period, which is termed in the marine stratigraphy as MIS5e (Marine Isotope Stage 5e) extending from ~132 to 130 to ~116 ka BP (Fig. 9, Chen et al., 1991; Stein et al., 1993;

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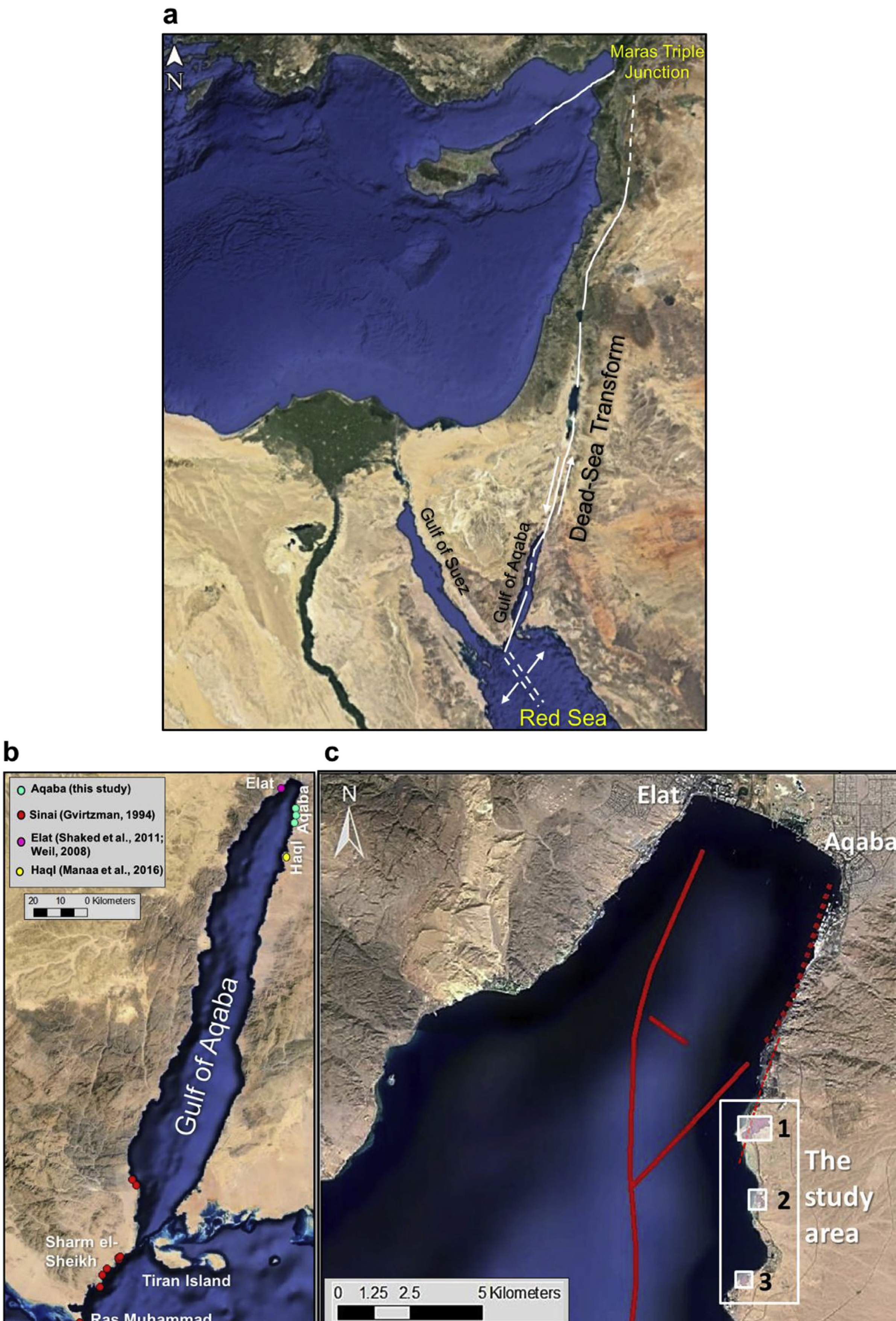
a
N
Maras Triple Junction
Dead-Sea Transform
Gulf of Suez
Gulf of Aqaba
Red Sea
b
Aqaba (this study)
Sinai (Gvirtzman, 1994)
Elat (Shaked et al., 2011; Weil, 2008)
Haql (Manaa et al., 2016)
20 10 0 Kilometers
Elat
Aqaba
Haql
Gulf of Aqaba
Sharm el-Sheikh
Tiran Island
Ras Muhammad
c
N
Elat
Aqaba
1
2
3
The study area
0 1.25 2.5 5 Kilometers