THE RED SEA SURVIVED THE LAST GLACIAL MAXIMUM

Morgan I. Chakraborty, Arash Sharifi, Francois Tissot, Ali Pourmand, Bolton Howes, Peter K. Swart, Chaojin Lu, and Sam J. Purkis

PROJECT OBJECTIVES

- To investigate the prevailing hypothesis of Red Sea basin-wide ecological collapse during glacial sea-level lowstands

PROJECT RATIONALE

The Red Sea connects to the Indian Ocean via the Bab-el-Mandeb Strait, a narrow and shallow passage that controls water exchange between the two basins. Due to high evaporation rates and minimal freshwater input, the Red Sea is one of the warmest and saltiest marine basins on Earth. During glacial periods, lower sea levels further restricted this connection, leading to extreme salinity increases. Evidence from seabed cores shows that during the Last Glacial Maximum (LGM), when sea-level fell 110-m below present, salinity rose to at least 50 PSU, possibly making conditions uninhabitable for marine organisms (Hemleben et al., 1996; Arz et al., 2003; Biton et al., 2008). The absence of microfossils, like planktonic foraminifera, suggests that parts of the Red Sea may have undergone total ecological collapse (Reiss et al., 1980; Fenton et al., 2000). Some researchers argue that during extreme lowstands, the Red Sea functioned more like a hypersaline lake, with recolonization only occurring after sea levels began to rise back to present day levels around 15,000 years ago (Klausewitz et al., 1989).

However, the notion of complete ecological collapse is debated. Some species, such as foraminifera, coccolithophores, and pteropods, may have survived in the northern Gulf of Aqaba and southern Red Sea (Locke et al., 1988). The high level of endemism among Red Sea fish and invertebrates also suggests that at least some marine life persisted through glacial sea-level lowstands (DiBattista et al., 2016). Two main hypotheses explain these refugia: one proposes that increased rainfall at the end of the glacial period reduced salinity, while another suggests that a narrow but continuous connection to the Indian Ocean remained open (de Lattin, 1967;

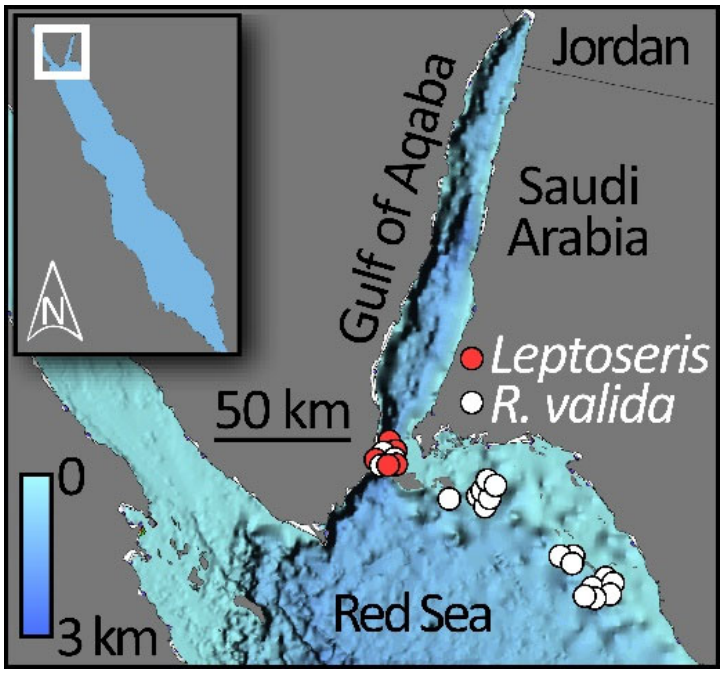

Figure 1. Locations of sampled corals and seawater in the northern Red Sea. Two coral species were collected: Rhizosmilia valida from 20 sites at depths of 400-720 m, and Leptoseris cf. striatus from six sites at depths of 80-90 m.

Bailey et al., 2007; Lambeck et al., 2011). To test these theories, we will analyze deep-water coral skeletons from the northern Red Sea, using geochemical dating and isotopic analyses. Our findings will provide critical insight into how rift-basin ecosystems respond to extreme environmental shifts and whether the modern biodiversity of the Red Sea developed only after the last deglaciation or persisted through past glacial period.

APPROACH

The study will employ a multidisciplinary approach to investigate the survival of deep-water corals in the Red Sea during the last glacial lowstand. Fossil coral skeletons of Rhizosmilia valida and Leptoseris cf. striatus have already been collected from 26 sites in the northern Red Sea using submersibles from the R/V OceanXplorer (Fig. 1). To establish the chronology of coral growth, Uranium-Thorium (U-Th) dating will be used. Geochemical analyses will be conducted to assess the environmental conditions, including clumped isotope (Δ47) thermometry to estimate past seawater temperatures, radiogenic strontium isotopes (87Sr/86Sr) to assess water-mass exchange between the Red Sea and the Indian Ocean, and stable oxygen isotopes (δ18O) to infer changes in salinity and evaporation rates.

Additionally, a meta-analysis of 27 deep-sea sediment cores from previous studies will be conducted to evaluate the presence or absence of microfossil groups, such as planktonic foraminifera, pteropods, and coccolithophores, through the last glacial period. This combined dataset will be used to test the hypothesis of basin-wide extinction during the lowstand and to explore the ecological dynamics of the Red Sea under orbital sea-level oscillations.

SIGNIFICANCE

The prevailing hypothesis suggests that life was extinguished in the Red Sea when sea level fell at least 110-m below present at the end of the Last Glacial period. This sterilization is thought to have occurred because that drop restricted the basin from the Indian Ocean, inducing a hyper-salinity crisis. If true, this scenario suggests that carbonate deposition in rift basins proceeds in a punctuated, staccato, fashion, with implications for the vertical and lateral continuity of facies belts.

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