



## RESEARCH ARTICLE

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## Evidence for Seawater Retreat With Advent of Meghalayan Era (~4200 a BP) in a Coastal Harappan Settlement

### Key Points:

- Evidence of seawater withdrawal in the downstream area of Indus habitation (NW India) at the dawn of Meghalayan Age (4150 yr BP)
- The lowering of sea stand dried the ancient dockyard at Lothal impeding the ship movement which likely had an adverse impact on trade
- Carbon-sulfur contents, their stable isotopes and foraminiferal assemblage proved to be effective in establishing past sea stand

### Supporting Information:

Supporting Information may be found in the online version of this article.

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**Abstract** The transformation of mature (urbanized) phase of the ancient Indus civilisation between ~4200 and 3800 years Before Present (yr BP) overlaps with the beginning of the Meghalayan Age (~4200 ± 100 yr BP). Though exact cause(s) for decline of urbanized Indus phase are not yet clear, researchers continue to debate whether monsoonal dryness was the sole cause or several other regional factors manifested in a compounding manner. Here, we show a regional relative sea level fall in the downstream area of Indus habitation (south-western Gujarat region) which initiated at 4150 ± 230 and continued up to 3625 ± 200 yr BP. We provide a multi-proxy (chronological, sedimentological, mineralogical, isotopic and elemental abundance) data set from a well-dated vertical sediment trench from Lothal (ancient dockyard area of Indus era) to support this inference. Chief proxies used for inferring the relative sea level fall were bulk sediment carbon and sulfur contents along with their stable isotopes ( $\delta^{13}\text{C}$  and  $\delta^{34}\text{S}$ ) and foraminiferal assemblage. The conspicuous shifts in majority of proxies hint at a lowering of sea stand at the regional level that likely dried this ancient Harappan dockyard (used for sea trade). Findings of our study possess implications for Holocene climate changes and their plausible impact(s) on Harappan trade and culture. Additionally, it invites evidences for large scale geological changes at ~4200 yr BP distinct to the Meghalayan era.

**Plain Language Summary** The Holocene epoch is known for stable climate and advent of organized lifestyle in human habitations. However, this time-window experienced several abrupt climatic changes at ~8.2 ka, ~4.2 ka, Medieval climate warmth, Little Ice age etc. We continue to debate whether these climatic shifts impacted the contemporary human habitations. Geologists have recently rechristened the last 4200 year period as a distinct sub-stage termed as the Meghalayan Age. The timing of the decline in trade and decentralization of the ancient Indus civilization coincides with the beginning of the Meghalayan Age; this provides an opportunity to revisit geological repositories of this timeframe to assess impact(s) of climate change on human culture. Meghalayan age is known to have begun with recurring monsoonal droughts. We provide here multi-proxy evidence for a regional fall in coastal southwestern Gujarat (India) area. We posit this regional sea level fall at Lothal (Gujarat) might have adversely impacted ancient maritime Harappan trade and contributed to the declining/decentralizing Indus civilization during the end part of its mature phase.

## 1. Introduction

The last 4200 years of geological history is currently demarcated as the “Meghalayan Age” in the geological time scale (Berkelhammer et al., 2012; Kathayat et al., 2018; Marshal, 2022; Walker et al., 2018; Zanchetta et al., 2016). The beginning of Meghalayan age is marked by the sharp abrupt event captured in the speleothem cave “Krem Mawmluh” near Cherrapunji, northeast India (Berkelhammer et al., 2012; Walker et al., 2018). The 4200-year time period has been defined as a period when Earth's climate recovered from the Mid-Holocene reorganization of climate forcing factors after the global sea levels stabilized. This epoch is considered to be relatively dry across the geological repositories (Berkelhammer et al., 2012; Dixit et al., 2014, 2018; Kathayat et al., 2018; Marshal, 2022; Staubwasser et al., 2003). The Meghalayan transition (its beginning phases) is reported to arrive with intense aridity that likely may have adversely impacted contemporary cultures in Mesopotamia, Egypt, and the Indus Valley Civilization (Geische et al., 2019; Marshal, 2022; Pokharia et al., 2017; Staubwasser & Weiss., 2006). In addition to the monsoonal dryness, what other regional changes occurred with beginning of the Meghalayan era remains to be explored and documented. For example, how regional sea levels responded to aforementioned climate swing (~4200-year BP) has not been documented well. Did the 4200-year BP event