Late glacial dust patterns during the Mystery Interval: A study of Dead Sea sediments

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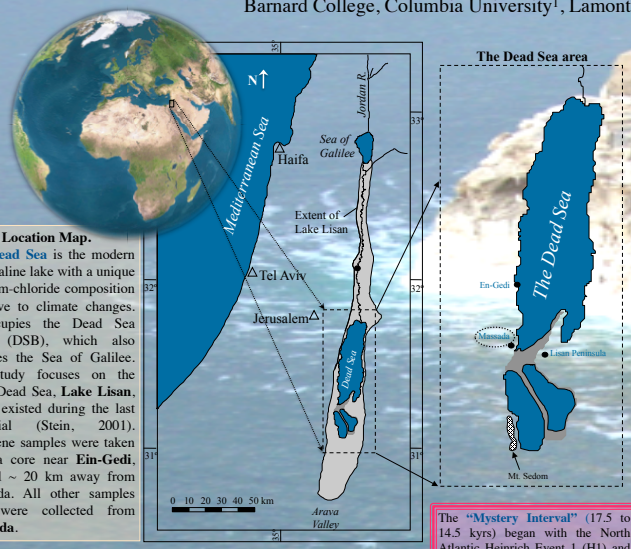


Fig. 1. Location Map.
The **Dead Sea** is the modern hypersaline lake with a unique Calcium-chloride composition sensitive to climate changes. It occupies the Dead Sea Basin (DSB), which also includes the Sea of Galilee. Our study focuses on the paleo-Dead Sea, **Lake Lisan**, which existed during the last deglacial (Stein, 2001). Holocene samples were taken from a core near **Ein-Gedi**, located ~ 20 km away from Massada. All other samples used were collected from **Massada**.

The **"Mystery Interval"** (17.5 to 14.5 kyrs) began with the North Atlantic Heinrich Event 1 (H1) and ended with the onset of the Bølling-Allerød (B/A). The interval spans a period of abrupt, contradicting climate oscillations reflected in the lithology of the Massada site.

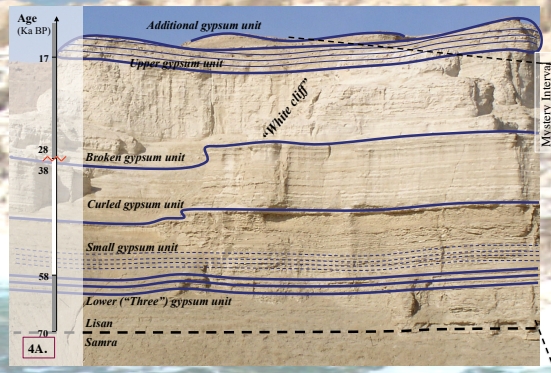
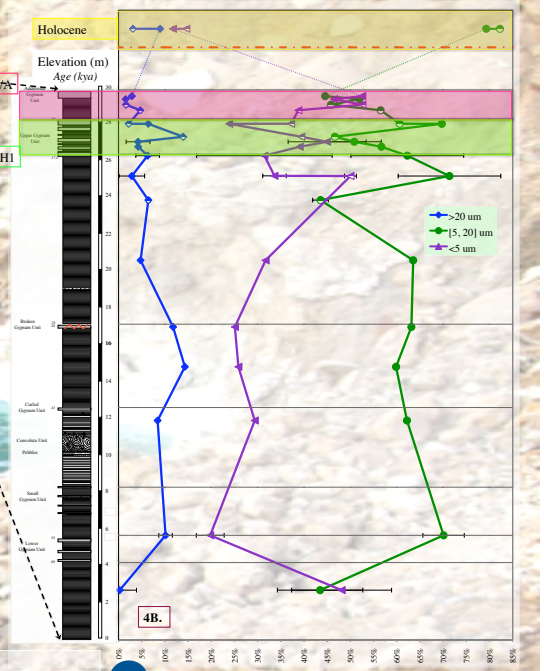


Fig. 4A. The Massada Column and paleoclimate. The Mystery Interval is represented by the Upper Gypsum Unit (UGU), a sequence of aad, and the Additional Gypsum Unit (AGU). The Upper Gypsum Unit is the thickest gypsum unit deposited ~17.4-16 kyr and consists of nine aragonite-gypsum sequences. The deposition of the Upper Gypsum Unit in the lake level record coincides with the North Atlantic Heinrich Event 1 (H1). ~2000 years following the deposition of the UGU, the lake deposited a sequence of ~1m of aad and the AGU, marking abrupt oscillations between a low lake level stand (UGU) to a high-stand (aad) and back to a low-stand.

Fig. 4B. Grain-size distribution. Sediments separated into yield 3 fractions shown in percent (%) portrayed relative to elevation. Elevation (m) is also correlated to a high-resolution depiction of the Massada column. The smaller, italicized numbers represent ages (kyr) of the sediments at the given elevation.



1 Introduction:

Dust records can be used to gauge the factors that affect dust mobilization and the impact of abrupt global climate changes on dust emissions as dust transport and deposition reflect various processes in atmospheric circulation, including wind speed and wind patterns. This study focuses on the reconstruction of dust sources and fluxes during the Mystery Interval in the Dead Sea region. (Fig. 1). The sensitivity of the Dead Sea Basin to climate changes is reflected in the lithology of a high-resolution lake-record (~ 70 – 14 kyr) characterized by alternating aragonite-detritus (aad) laminae during high lake levels and gypsum deposits during low stands (Fig. 4). The results will improve our understanding of the complex climatic structure of the period. By analyzing the chemical composition of the smaller than 5 micron fraction during the Mystery Interval, we can develop a story of dust source, transport, and deposition. Previous studies have determined that the bulk of dust in this area displays grain sizes smaller than 5 μm (Fig. 2). Therefore, we focus our studies on the <5 μm fraction of our samples

2 Objectives:

① To reconstruct the dust record in the Dead Sea Basin during the last glacial period with emphasis on the Mystery Interval
② Establish a chemical fingerprint of dust in the region and establish possible sources of dust into the Basin
③ Interpret dust flux patterns to develop a greater understanding of the atmospheric configuration during the Mystery Interval

3 Methods :

Samples weighing ~1000 mg, were washed with quartz-distilled (highly purified) water 4 times and then leached using buffered acetic acid to remove salts and gypsum, and carbonates, respectively. 1N hydrocholoric acid and 1.7N acetic acid were also used to test leaching efficiency for 3 samples (see figure in results). The insoluble portion of each sample was separated into three grain-size categories by wet sieving and settling, following stokes settling procedures: > 20 um, between 5 and 20 um ([5, 20] um), and < 5 um. The samples were then digested using hydrofluoric acid (HF) and nitric acid (HNO_3) as well as a mixture of HF, HNO_3, and Perchloric acid ($HClO_4$) through microwave bomb digestion. The resulting solute was then transferred for element analysis using an Inductively Coupled Plasma Mass Spectrometer.

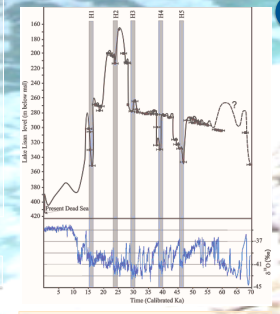


Fig. 5. Lake level curve. Correlation between Lake Lisan and Heinrich Events constructed using shore indicators (circles) and determined by radiometric (U-series and radiocarbon) ages on aragonite sediments (squares) (From: Bartov et al., 2003)

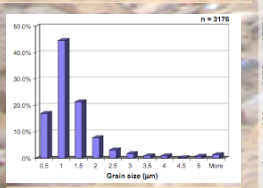


Fig. 2. Grain size distribution (in percent) of suspended dust particles based on scanning electron microscope image analysis of 3176 particles. (From: Kalderon-Asael et al., 2009)

4 Results:

Fig. 3
① Buffered Acetic Acid yielded ~3% of the >20 um fraction (A), ~50% of the [5, 20] um fraction (B), and ~45% of the <5 um fraction (C). A total yield of ~55-75% was noted with buffered acetic acid.
② 1.7N Acetic Acid yielded ~0-11% of fraction A, ~50-65% of fraction B, and ~20-55% of fraction C. A total yield of ~45-80% was noted with 1.7N acetic acid.
③ 1N Hydrochloric Acid yielded ~0-10% of fraction A, ~65-80% of fraction B, and ~15-35% of fraction C. A total yield of ~75-90% was noted with 1N HCl.

Fig. 4
① Sample fractions exhibit relatively constant percentages for most of the Massada column.
② Fraction concentrations oscillate throughout the Mystery Interval and into the Holocene: >20 um fraction increases about halfway through the UGU. The <5 um fraction decreases during H1 and increases towards the B/A period, while the [5,20] um fraction exhibited opposite patterns.
③ The [5,20] um fraction increases in concentration into the Holocene as the <5 um portion decreases.

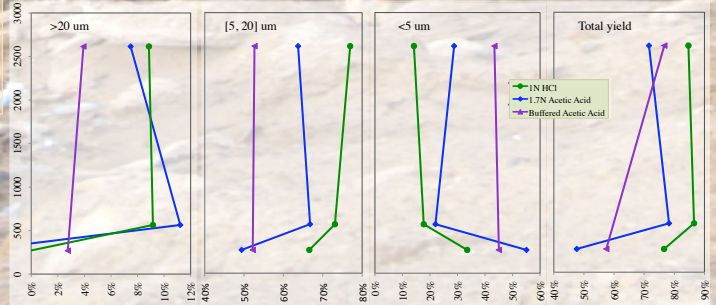


Fig. 3. Relative fraction and total yield of 3 acid leaches. Samples were leached with three different acids to test leaching efficiency. This was analyzed by looking at the sample leftover (in percent) after leaching and plotted based on the original sample elevation at Massada (cm). Normalized values were calculated relative to the total yield (the sum of the un-normalized fractions, > 20 um, [5,20] um, and < 5 um.

5 Conclusions:

① Sediments from the Massada column of the paleo-Dead Sea, Lake Lisan, were separated into three fractions, >20 um, [5,20] um, and <5 um. We used the <5 um fraction to represent the dust fraction.
② Different acids were used to leach carbonates, gypsum, and salts from the samples. Of the three acids used, 1N HCl seems to yield a higher fraction of sediment. 1.7N acetic acid was a close second. However, the buffered acetic acid yielded the greatest amount for the <5 um fraction.
③ Oscillations in sediment fractions were observed during the Mystery Interval (~17.5 – 14.5 kya), while the grain size distribution was constant during 70-20 ka ago.
④ Referring to the lake level curve of the Dead Sea Basin, the time period encompassing the grain-size distribution oscillations also coincides with a sharp decrease in the lake level during H1 followed by a rapid increase leading up to the B/A (Fig.)

References:

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http://wakatravel.org/uploaded/a/a7/DeadSeaShore.jpg