Identifying Early Irrigation:

Stable isotope analysis of crops to explore water management in the Levantine Chalcolithic (4700-3800 BCE)

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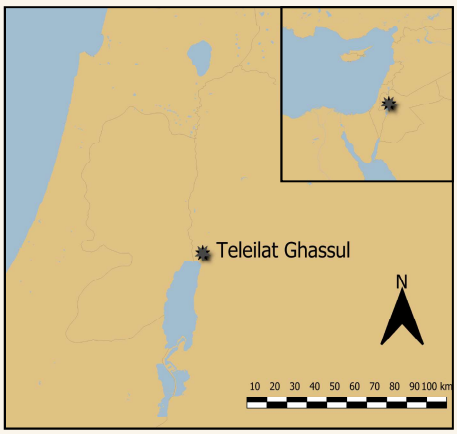
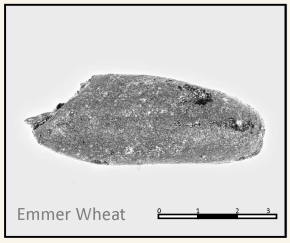
Irrigation and agricultural intensification were important technologies in the development of early urban and complex societies.

In semi-arid areas such as the Levant, irrigation increased the reliability and yield of food production systems. This was essential for feeding growing populations, and supporting the development of new and increasingly complex social and cultural systems (Scarborough 2003).

Teleilat Ghassul (ca.4700-3800 BCE) is the largest Chalcolithic site in the South Levant. It supported a rich culture of increasingly diverse and intense traditions through the period (Bourke 2008).

Previous analysis observed a similar diversification and intensification of agricultural strategies. Archaeobotanical evidence suggests that irrigation was gradually developed throughout the Chalcolithic as part of this process (Meadows 2005).





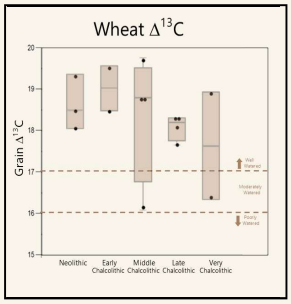
Isotope Discrimination Analysis measures the proportions of C^{12} and C^{13} isotopes within archaeobotanical remains, which reflects a plant's water availability during growth (Stokes et al. 2011).

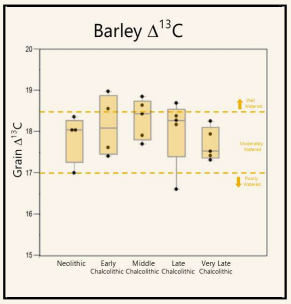
The method has been widely applied to archaeological materials and questions throughout the Mediterranean and Near East to identify irrigation throughout the Holocene (Styring et al. 2017).

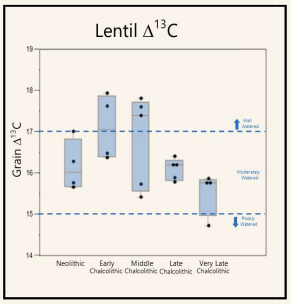
Methods

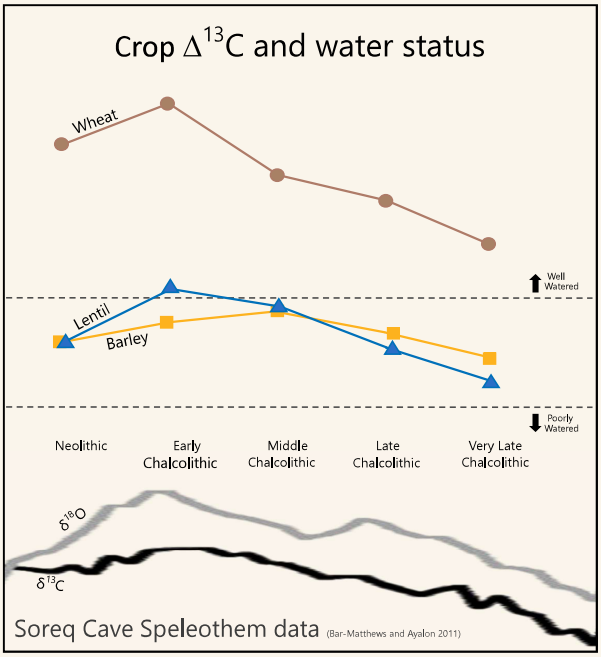
- Samples of emmer wheat, barley and lentil grains were analysed.
- Five phases spanning the occupation (ca.4700-3800 BCE).
- ABA pre-treatment was applied to remove contaminants.
- Isotope Ratio Mass Spectrometry (IRMS) analysis was conducted.
- Data was calibrated (Ferrio et al. 2005) and classified as poorly, moderately or well watered (Wallace et al. 2013).

RESULTS









Taxonomic Trends

Throughout all five periods:

- Lentil and barley are classified as moderately watered
- Wheat is falls within the very well watered zone

This differentiation indicates that different management strategies were applied to the crops, however its persistence suggests that these practices did not change throughout the site's occupation.

The higher water input of wheat could be a result of supplementary water provision through irrigation activities, or the selection of plots in naturally moister soils (Wallace et al. 2015).

Temporal Trends

All three crops show the same pattern of changing water access.

- $\Delta^{13}C$ increases from the Neolithic
- After the start of the Chalcolithic, $\Delta^{13}C$ decreases steadily

The progressively drier plant status is the opposite of what would be expected if irrigation were being introduced at the site.

The pattern is also reflective of in the general paleoclimatic trend towards more arid conditions at this time [Soreq Cave speleothem data displayed] (Bar-Matthews and Ayalon 2011). This correlation suggests that climatic factors, not irrigation practices, were the main force affecting changing crop water availability.

Conclusions

While different water management strategies were likely applied to the crops at Teleilat Ghassul, irrigation does not appear to have increased or intensified at the site throughout its occupation. Instead, climatic conditions seem to have been the main factor affecting crop water access throughout the Chalcolithic period.

The increase in diversity and intensity of agricultural activities previously identified throughout the Chalcolithic period may have consisted of new crop management strategies, however this isotopic evidence indicates that it did not include changes to water management practices.

It is also possible that the change in crop water access over time was associated with a shift or expansion of agricultural activities into drier upland areas. Future isotopic analysis of wood charcoal, which would certainly have been unirrigated, would be invaluable in exploring this theory further and examining the growing conditions of naturally rainfed plants at Teleilat Ghassul.

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