Teleconnections and environmental determinism: Was there really a climate-driven collapse at Late Neolithic Çatalhöyük?

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In PNAS, Roffet-Salque et al. (1) present an innovative paleoclimatic reconstruction using biomarkers to suggest that δ^2H measurements on animal fat residues from pottery vary through time at the important Neolithic site of Çatalhöyük. The interpretation of these changes in relation to a teleconnection with the 8.2-kyBP climate event is problematic.

First, a *t* test is used to suggest that $\delta^2H_{18:0}$ values in the phase TP-O are significantly different from the values in the other archaeological levels; however, the result of this test is insignificant ($P = 0.10$). Analysis of variance of the samples from the different levels is a more appropriate test but suggests no significant variability between the levels ($P = 0.385$). Temporal and measurement uncertainties suggest that variability within the data is more important than the mean values and that there is a clear overlap throughout the data series (Fig. 1*A*).

Second, this apparent deviation in $\delta^2H_{18:0}$ is related to the 8.2-kyBP signal from Greenland (Fig. 1*B*). It is suggested that this signal is represented in both the on-site proxy and off-site proxy data from Nar Lake. Nar $\delta^{18}O$ does show a deviation of 1.5‰ at around 8.2 kyBP (2), but viewed longer-term, this signal is part of a set of oscillations starting at around 8.5 kyBP (Fig. 1*C*). Thus, there is no foundation for a teleconnection between Greenland and Nar. Furthermore, using proxy estimates (2), this deviation at 8.2 kyBP at Nar would suggest a warming of summer maximum temperatures of about 0.22 °C, rather than the cooling implied by the link to Greenland (Fig. 1*D*). However, this variability—in the context of oscillations from around 8.5-kyBP and the error margins on the proxy—again suggests that although marginally cooler, the summer maximum temperatures were not significantly different from the present day. Moreover, the pattern after 8.2 kyBP is one of lower maximum temperatures and thus lower water stress.

Third, summer rainfall at Nar is only around 5% of the total annual rainfall, so to expect a significant deviation in $\delta^{18}O$ from the variation suggested by climate models (figure 3 in ref. 1) is unrealistic. Fourth, the extraction of one example from an ensemble of model results is questionable (3).

Thus, not only is the attribution of the 8.2-kyBP event not supported by the data of Roffet-Salque et al. (1), the regional paleoclimate does not seem to be significantly linked to the event (Fig. 1 *C* and *D*). It is hard to justify a link to the purported social collapse. Our interpretation of the site's paleoenvironment (4) suggests that there were no significant changes at this time, and there is now evidence for an overlap in settlement between the East and West Mounds at Çatalhöyük (5), which conflicts with the interpretation of a collapse (1).

Therefore, the environmental determinism that attempts to correlate "the apparent weakness of the climate signal" with "profound human responses [that] are clearly visible in the archaeological record" is unsupported. Reassessment of the innovative proxy data suggests no link to the 8.2-kyBP event and that the regional paleoclimate variability is also unrelated to the event. More nuanced approaches are needed to interpret human–climate interactions.

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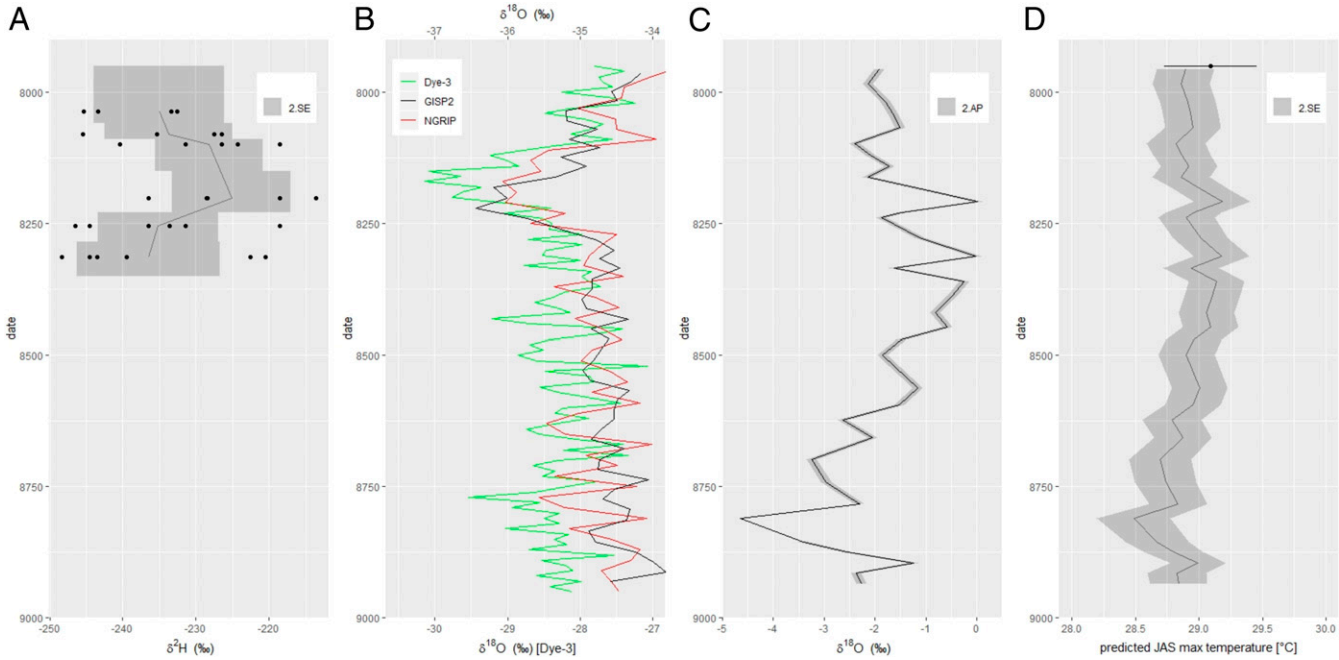

Fig. 1. Comparison of the $\delta^2H_{18:0}$ proxy of ref. 1 with global and regional climate records. Note that this plot uses a 1-ky window from 8950 calibrated B.P. to place the archaeozoological data in a longer-term context. (*A*) Replots the data of figure 1D in ref. 1 using shading to show the 2-SE variation of data around the mean (solid line); original data points are plotted at the midpoint of the archaeological phase, but shading is shown vertically to demonstrate the full uncertainty of the Bayesian estimates of these phases. There is clear overlap between the phases, and variability is more important than mean values. (*B*) Water $\delta^{18}O$ values of three Greenland ice cores (6–9) used to demonstrate the onset and duration of the 8.2-kyBP event. (*C*) $\delta^{18}O$ record from the sediments in Nar Lake (2), ∼150 km from Çatalhöyük, which provides the best available regional information for climate proxies. Shaded area shows 2× analytical precision (AP) of the measurements. (*D*) Estimate of summer maximum temperature for Nar Lake, based on the proxy derived by ref. 2 from modern climate measurements. The shaded area is 2 SEs, using a rms combination of the uncertainties from the measurement analytical precision and the SE from the proxy model. The point and error bar at the top of the plot show the mean and 2-SE range for the 1961–1990 climatic observations.

1 Roffet-Salque M, et al. (2018) Evidence for the impact of the 8.2-kyBP climate event on Near Eastern early farmers. *Proc Natl Acad Sci USA* 115:8705–8709.
2 Jones MD, Leng MJ, Roberts CN, Türkes M, Moyeed R (2005) A coupled calibration and modelling approach to the understanding of dry-land lake oxygen isotope records. *J Paleolimnol* 34:391–411.
3 Frigg R, Smith LA, Stainforth DA (2015) An assessment of the foundational assumptions in high-resolution climate projections: The case of UKCP09. *Synthese* 192:3979–4008.
4 Ayala G, et al. (2017) Palaeoenvironmental reconstruction of the alluvial landscape of Neolithic Çatalhöyük, central southern Turkey: The implications for early agriculture and responses to environmental change. *J Archaeol Sci* 87:30–43.
5 Orton D, et al. (2018) A tale of two tells: Dating the Çatalhöyük West Mound. *Antiquity* 92:620–639.
6 Rasmussen SO, Vinther BM, Clausen HB, Andersen KK (2007) Early Holocene Greenland Ice Core Chronology 2005 (GICC05) and 10 year means of oxygen isotope data from ice core DYE/3 *PANGAEA*, 10.1594/PANGAEA.586863.
7 NGRIP Dating Group (2006) Greenland Ice Core Chronology 2005 (GICC05). IGBP PAGES/World Data Center for Paleoclimatology Data Contribution Series #2006-118. NOAA/NCDC Paleoclimatology Program (Boulder, CO).
8 Vinther BM, et al. (2006) A synchronized dating of three Greenland ice cores throughout the Holocene. *J Geophys Res* 111:D13102.
9 Stuiver M, Grootes PM, Braziunas TF (1995) The GISP2 δ18O climate record of the past 16,500 years and the role of the sun, ocean and volcanoes. *Quat Res* 44:341–354.

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