Listen to the whisper of the rocks, telling their ancient story

Paul J. Hearty^{a,1} and Blair R. Tormey^{b,1}

Rovere et al. (1) determine the mass of two megaboulders on Eleuthera and calculate hydrologic flow rates based on a tsunami wave model (2). The authors (1) suggest that a rate of ~10 m/s is required to “lift or roll” these boulders from the cliff-top strata. Their findings ostensibly dispute a superstorm wave hypothesis, which has been repeatedly challenged and defended over the past two decades (refs. 3–5 and references therein).

A synthesis of data from multiple disciplines has generated “fingerprints” of all rock units in the Cow and Bull cliff section on Eleuthera (6, 7). The cliff-top stratum at the site is composed of pristine aragonitic MIS 5e oolite (6) that is “punky” to hammer blows. In conspicuous contrast, the megaboulders are hammer-ringing hard, recrystallized, oolitic-peloidal, Middle Pleistocene (MIS 9/11) limestone bound by multiple generations of cements (6, 7). Nearly identical geological fingerprints of the megaboulders characterize the in situ rocks at the base of the same cliff near sea level (3–8).

Rovere et al.’s (1) assertion “based on controversial amino acid racemization dates” is misleading, and incorrectly suggests that amino acid racemization is the only criterion used in our research of the megaboulders. Amino acid racemization (e.g., table 3 in ref. 6; see also ref. 9) along with several physical criteria demonstrate that the megaboulders are lithologically distinct from the cliff-top strata. Despite this evidence, Rovere et al.’s (1) paper and supplement make no effort to reconcile with published site stratigraphy or the established lithologic provenance of the megaboulders. These rigorously documented details are fundamental

to understanding the mechanisms and thresholds of megaboulder transport and cannot be ignored.

Rovere et al.’s (1) premise that the megaboulders “were lifted or rolled from the cliff edge to their current position” is untenable, as the cliff-top stratum is 5e oolite, distinct from the megaboulders. Therefore, their estimate of ~10 m/s to transport the megaboulders is an absolute minimum. Far greater energy would be required to transport the megaboulders from the basal strata of the sea cliff during MIS 5e (3). Megaboulders lying tens to hundreds of meters landward of the modern coastline were also not considered.

The premise of waves peeling off cliff tops and depositing the megaboulders during higher sea levels does not accord with field observations. If correct, recent storm waves should be depositing similar sized megaboulders near present sea level on Eleuthera and along the rocky coastlines throughout the Bahamas, which is not the case (3, 4, 8). The Eleuthera megaboulders are one local example of deposits from MIS 5e superstorms. The chevron and run-up deposits, documented throughout the archipelago (4–10), comprise the bulk of evidence of superstorms.

Given the fundamentally flawed premise, and only two relevant data points (boulder mass), the calculations, interpretations, and conclusions that follow in Rovere et al. (1) are unsupportable and speculative. Without consideration of the local and regional geology and stratigraphic provenance of the megaboulders, it is not possible either to justify tsunami-based flow rates or to exclude superstorm waves as a mechanism for formation of a trilogy of deposits across the Bahamas.

1 Rovere A, et al. (2017) Giant boulders and Last Interglacial storm intensity in the North Atlantic. *Proc Natl Acad Sci USA* 114:12144–12149.

2 Nandasena NAK, Tanaka N, Sasaki Y, Osada M (2013) Boulder transport by the 2011 Great East Japan tsunami: Comprehensive field observations and whether model predictions? *Mar Geol* 346:292–309.

3 Hearty PJ (1997) Boulder deposits from large waves during the last interglaciation on North Eleuthera Island, Bahamas. *Quat Res* 48:326–338.

4 Hearty PJ, Tormey BR (2017) Sea-level change and superstorms; geologic evidence from late last interglacial (MIS 5e) in Bahamas and Bermuda offers ominous prospects for a warming Earth. *Mar Geol* 390:347–365.

^aDepartment of Environmental Sciences, University of North Carolina, Wilmington, NC 20403; and ^bProgram for the Study of Developed Shorelines, Western Carolina University, Cullowhee, NC 28723

Author contributions: P.J.H. and B.R.T. wrote the paper.

The authors declare no conflict of interest.

Published under the [PNAS license](#).

¹To whom correspondence may be addressed. Email: kaisdad04@gmail.com or btormey@wcu.edu.

Published online March 9, 2018.

- 5 Hansen J, et al. (2016) Ice melt, sea level rise and superstorms: Evidence from paleoclimate data, climate modeling, and modern observations that 2°C global warming could be dangerous. *Atmos Chem Phys* 16:3761–3812.
- 6 Hearty PJ (1998) The geology of Eleuthera Island, Bahamas: A Rosetta stone of Quaternary stratigraphy and sea-level history. *Quat Sci Rev* 17:333–355.
- 7 Kindler P, Hearty PJ (1996) Carbonate petrology as an indicator of climate and sea-level changes: New data from Bahamian Quaternary units. *Sedimentology* 43:381–399.
- 8 Hearty PJ, Neumann AC, Kaufman DS (1998) Chevron ridges and runup deposits in the Bahamas from storms late in oxygen-isotope substage 5e. *Quat Res* 50:309–322.
- 9 Hearty PJ, Kaufman DS (2000) Whole-rock aminostratigraphy and Quaternary sea-level history of the Bahamas. *Quat Res* 54:163–173.
- 10 Tormey BR, Donovan BG (2015) Run over, run up and run out: A storm wave origin for fenestral porosity in last interglacial eolianites of the Bahamas. *GSA Abstracts with Programs* 47:360.