Boulders in the Bahamas

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We posted our response to the first comment on our paper (Ice Melt, Sea Level Rise and Superstorms)[1] on the ACPD (Atmospheric Chemistry and Physics Discussion) website. Our response is freely available from ACPD or here.

In plain English, the boulders are old rock of "hammer-ringing" hardness. They sit on younger softer ("punky") Eemian-era substrate. The boulders are limestone formed on the floor of the North Atlantic Ocean at least 300-400 thousand years ago.

The boulders had to be placed there (on the cliff facing the North Atlantic) in the late Eemian or immediately thereafter before sea level had fallen much from its high Eemian level. It required powerful long-period waves from the Northeast to scour the ocean floor and lift the boulders. The boulders are all located at the apex of a narrowing horseshoe-shaped embayment; ocean waves funneled into this embayment generate huge surge and splash as they reach the cliffs.

One might have guessed that the boulders were deposited by a tsunami, but accompanying (V-shaped) "chevron" ridges and run-up deposits suggest otherwise. The chevron ridges and run-up deposits are located along the 900 kilometer eastern front of the Bahamian Islands at places most susceptible to ocean incursion. The power of the storms is indicated by the fact that the chevrons extend as much as several kilometers inland and the run-up deposits on hills immediately adjacent to the chevrons reach heights as great as 30-40 m above today's sea level.

The suggestion in Revkin's comment on our paper that the boulders were instead remnants of erosion is dismissed readily. The "simple drawing…explaining boulder formation through chemical weathering" can be dismissed by going to Eleuthera and examining the boulders. One of them is shown in Fig. 1. Appearance might be enough, but there is ample scientific evidence. The boulders are much older than the substrate on which they rest. Also the orientation of the original bedding planes of the boulders (i.e., the horizontal level at the time the limestone was formed from carbonate sediments on the ocean floor) can readily be discerned. The bedding planes are at a variety of angles, as expected for boulders tossed from the ocean.

An important characteristic of the chevrons is imbedding of lesser younger chevrons within those that penetrated furthest inland. This is an expected result of storms while sea level was falling, as Earth moved into the post-Eemian ice age. If, instead, the imbedded chevrons were caused by a tsunami, a series of tsunamis would be required.

I took the photo in Fig. 1 in January 2011 when Anniek and I visited the place, which is quite remarkable (yikes, 4½ years ago – shows how slow I am in writing a paper). The boulders are near the "Glass Window" bridge (see Fig. 2 in Hearty's 1997 paper). Standing on the bridge and looking northeast you see the dark blue North Atlantic (Fig. 2). Looking southwest you see the turquoise Caribbean (Fig.3). On the same photo chip I found grandsons Connor and Jake (cousins) studying an "Urgent!" pronouncement in an Indiana Jones book (Fig. 4). What is the relevance of that? Come on, you don't need a Ph.D. to figure that out.

[1] A PDF of our paper with the figures imbedded in the text is available here. Another advantage of this version is that its length in only 66 pages. The published version, freely available here, is 121 pages.

Fig. 1. One of the Hearty boulders, with 1.6 m yardstick walking away from her measuring duty.

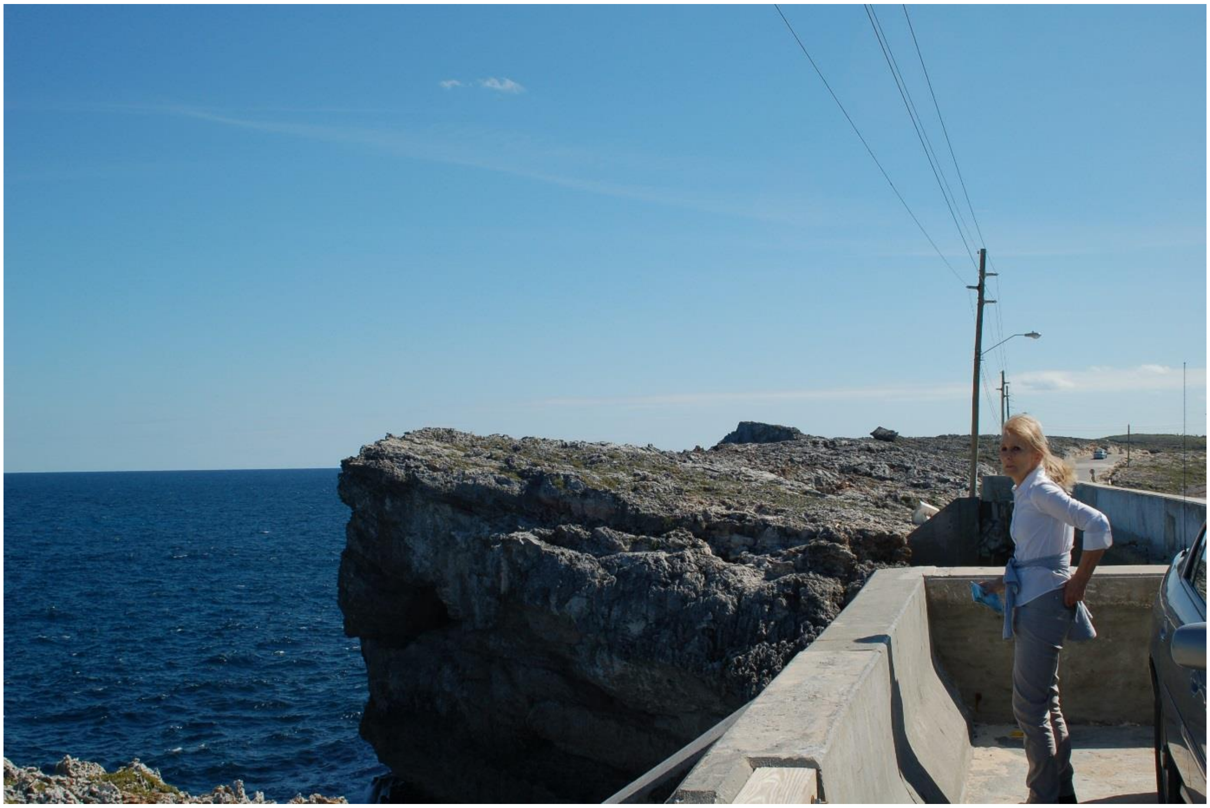

Fig. 2. Looking from Glass Window bridge onto dark blue North Atlantic

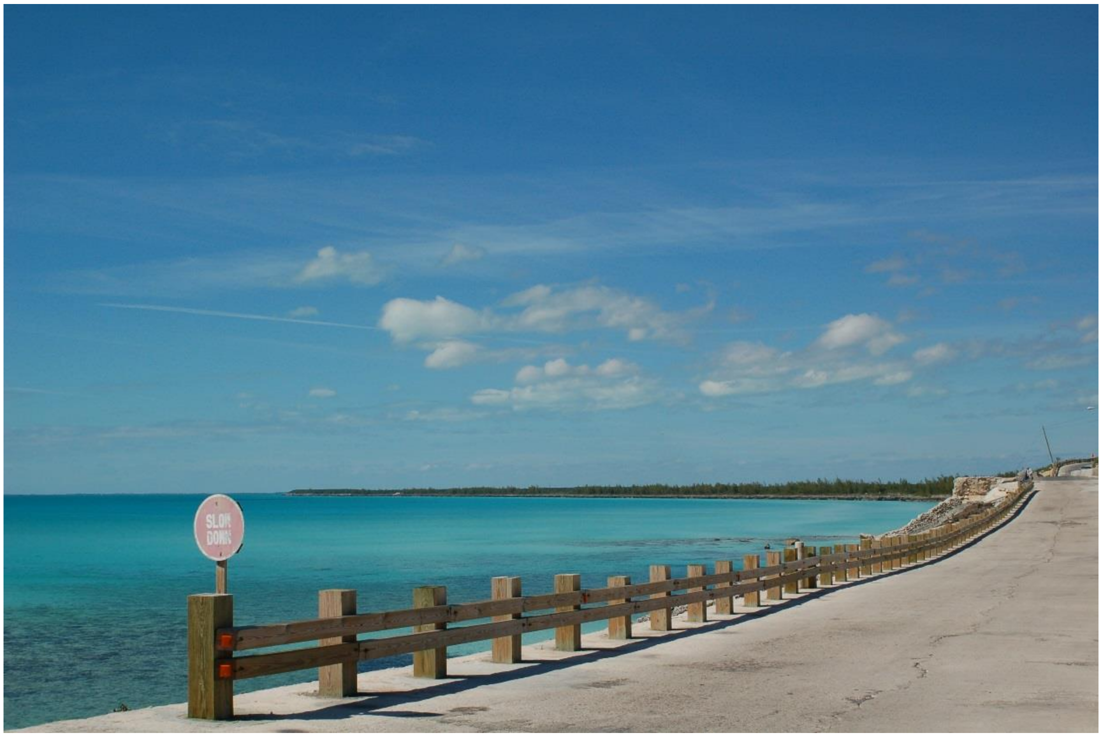

Fig. 3. Looking the other direction, from the road toward the turquoise Caribbean (the bridge and yardstick are at the extreme right)

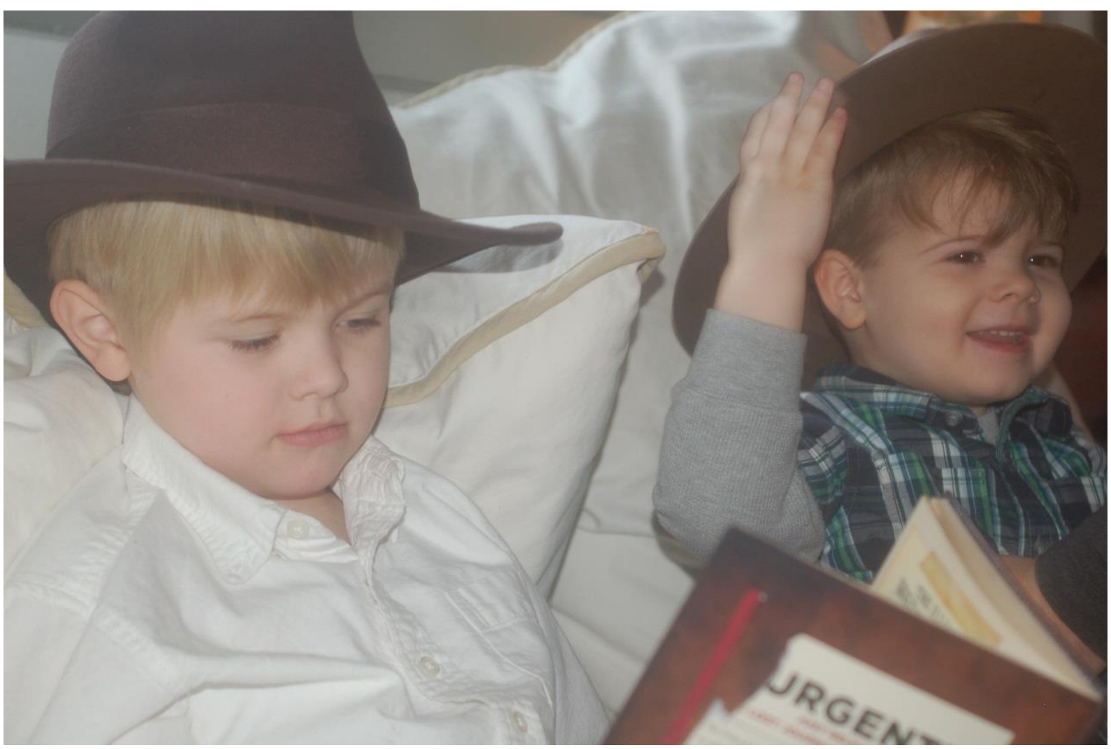

Fig. 4. Connor and Jake reading Indiana Jones book.