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COMMENT

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Comment on “Post-impact event bed (tsunamite) at the Cretaceous-Palaeogene boundary deposited on a distal carbonate platform interior”

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Korbar, McDonald, Fućek, Fuček, and Posilović (2017) report a tsunamite, triggered by the Chicxulub impact on Yucatan, from the Likva Cove carbonate platform of the Island of Brač, Croatia, which is similar to that in an earlier report from the nearby Island of Hvar (Korbar et al., 2015). If true, such deposits in the Adriatic Sea would be truly anomalous given that no tsunamites are identified in well-preserved Cretaceous–Palaeogene (K–Pg) sections from the Basque-Cantabric Basin (Bidart, Zumaia, Hendaye and Sopelana sections), which are located more proximal and towards the hypothetical tsunami wave propagation front. We strongly question the authors’ criteria for identifying the presumed “tsunamite” as well as the K–Pg boundary (KPB) age attributed to these deposits based on planktic foraminifera.

1 | TSUNAMI BENCHMARKS

Identification of tsunami-induced deposits is not straightforward because their composition is strongly source-dependent, but they usually display common characteristics with thin (<30 cm) normally graded sand and mud layers related to decreased hydrodynamic energy (Chague-Goff, Schneider, Goff, Dominey-Howes, & Strotz, 2011; Font et al., 2013; Goff, Chague-Goff, Nichol, Jaffe, & Dominey-Howes, 2012; Morton, Gelfenbaum, & Jaffe, 2007). Distinct lower and upper sub-units representing run-up and backwash can sometimes be identified. Other benchmarks supporting a tsunami origin include rip-up and gravel clasts (granule to boulder size), organic entrainment (e.g. organic matter, leaves, roots), an unconformable or erosional lower contact and liquefaction structures caused by earthquakes. In carbonate-dominated settings, such as Brač and Hvar islands, tsunami deposits are mainly composed of upward-fining layers of coarse to medium sand-sized carbonate material (e.g. corals, shells) as documented from the December 2004 Indian Ocean tsunami recorded in the South Baa Atoll (Nichol & Kench, 2008), Maldives, and from the October 2010 Mentawai tsunami in the North Pagai coral reef Islands (Putra, Nishimura, & Yulianto, 2013). However, sediments at Likva (interval 4) and Hvar share none of these typical tsunami features. Instead, they consist of very fine-grained carbonate (limestone) with no stratification or grading.

Based on the presence of a basal erosional contact, rip-up clast and bioclastic lag, the authors suggest that interval 4 is “an event bed — possibly a distal carbonate platform tsunamite…”. However, the erosional nature of the basal contact is very similar to contacts at the bases of intervals 1, 2, 5, 6 and 7 in Fig. 2a,b. Actually, in platform bank-top successions such as these, bedding planes are rarely completely planar (which is more commonly realized in pelagic, pure limestones). In this respect, the lower contact of interval 4 is characteristic of platform successions rather than a tsunamite. Alternatively, bed 4 may have accumulated after intermittent bank-top exposure where intraclasts formed by desiccation and/or bioturbation rather than being restricted to rip-up clasts. Korbar et al. (2017) interpret a bioclastic lag at the base of bed 4 (Fig. 3b) as supporting evidence for a tsunamite. But this lag deposit shows just a few angular rudist fragments, which are widespread in Upper Cretaceous platform successions and unrelated to impact-generated tsunami deposits.

In addition, the authors interpret the presence of calcispheres as additional evidence supporting an impact-generated tsunami event (p. 141): “spherules from the event bed are probably of biogenic origin, possibly fresh-water or hypersaline calcispheres displaced from a pond by the tsunami”. However, such calcite spherules are generally algal spores (e.g. dasyclads) typical of shallow subtidal habitats and are common during the Maastrichtian and early Tertiary; they are not necessarily related to the Chicxulub impact.

2 | BIOTURBATION

Korbar et al. (2017) contend that "Following the surge of the very distal and attenuated tsunami…, passively transported and temporarily buried animals would attempt to escape from the relatively thick sand blanket". This statement contradicts their evidence. Firstly, their "tsunamite" (interval 4) is a thin limestone layer, which the authors describe as containing "very rare detrital quartz grains", rather than a "relatively thick sand blanket". Secondly, although some burrows observed in their Fig. 2b,c are vertical, most are horizontal, which contradicts the idea of animal escape structures. It is strange that worms highly stressed upon forceful relocation within a tsunami deposit would have slowly eaten their way through the sediments rather than pushing their way rapidly up to the surface. In fact, the bioturbation illustrated is characteristic of a hardground or firmground burrow network slightly modified by compaction, rather than softground bioturbation. Hard/firmground burrows remain open for some interval of time and may be infilled from above; if decapod shrimps (similar to the extant ghost crabs) produced these burrows, they may even be actively backfilled by material. Thirdly, the authors assert that "soft–sediment burrowing by annelid worm — polychaetes, … non-selective surface deposit feeders" is indicative of a tsunami origin. However, polychaetes are known from shallow (Zalmon, Macedo, Rezende, Falcao, & Almeida, 2013) and deep-water (2,000 to -3,760 m, Perez-Mendoza, Hernandez-Alcantara, & Solis-Weiss, 2003) environments, which makes them unsuitable markers for tsunami deposits.

3 | SHOCKED QUARTZ

The authors claim additional support for their tsunami interpretation from planar deformation features (PDF) of a single shocked quartz grain, which they assume originated from the Chicxulub impact. However, their scanning electron microscope (SEM) illustration shows semi-perpendicular (v-shaped) lamellae that are unconvincing and unsuitable as shock deformation. Similar v-shaped cracks and lineations on mineral-grain surfaces are widely observed and documented from fluvial, subaqueous and high-energy beach environments where they result from transport and pedogenic processes (Krinsley & Doornkamp, 1973; Mahaney, 2002; Martignier, Adatte, & Verrecchia, 2013). The true nature of PDF with the c-axis of the quartz crystal must be measured under a plane-polarized light microscope (French, 1998). Even if rare true shocked quartz grains could be found in their bed 4, this would not support a KPB impact origin because erosion and redeposition of quartz grains is common throughout the geological column and their age indeterminate.

4 | PLANKTIC FORAMINIFERA IDENTIFICATION

The K–Pg boundary age tsunami interpretation of Korbar et al. (2017) and an earlier study from Hvar (Korbar et al., 2015) hinges on precise age control based on planktic foraminifera, but good age control is lacking and most species are misidentified. For example, in their Fig. 5 only *Guembelitria cretacea*, *Woodringina claytonensis* and possibly *Eoglobigerina eobulloides* are correctly identified, whereas illustration (c) is the Cretaceous species *Globigerinelloides yaucoensis*, (f) is indeterminate, (g–i) is likely *Parvularugoglobigerina eugubina*, (j,k) *Subbotina triloculinoides* and (l) *Chiloguembelina midwayensis*. All of these species, except for (a–c), evolved well after the K–Pg boundary and are indicative of the upper part of Pα. This means that the clay layer and platinum-group element (PGE) anomalies are of early Danian age, at least 200–300 ka after the K–Pg mass extinction. Similar early Danian age clay layers and PGE anomalies have been documented in Haiti, Belize, Guatemala and North Atlantic deep-sea localities (Keller et al., 2003, 2013). They reveal additional events unrelated to the mass extinction and/or redox concentration of PGEs eroded and redeposited from the boundary clay.

5 | CORRELATION WITH THE HVAR SECTION

One of the arguments used by Korbar et al. (2017) to support their impact-tsunami hypothesis is the correlation with a hypothetical tsunami deposit found on the Dalmatian island of Hvar (Croatia) (Korbar et al., 2015). The authors interpreted the presence of a ~5-m-thick intraformational massive deposit containing platform limestone lithoclasts, up to boulder sized, and polygenic microbreccia in a muddy matrix as a tsunami deposit generated by the Chicxulub impact. As with the unit on Livka Island, this unit shares none of the typical tsunami-deposit benchmarks mentioned above (no sand, no grading, no lamination, no exotic materials), while the facies and sedimentological features can be alternatively explained as a result of karstification or as debris flow deposition due to active faulting of the Adriatic platform.

In both studies, the authors fail to consider alternative interpretations of their inferred tsunamite, thus ignoring a wealth of studies from carbonate platform deposits. Paradoxically, they cite Morton et al. (2007) to support their hypothesis, although that study focused on a sandy tsunami deposit. For comparison with modern tsunamites (listed in Table 3 of Morton et al., 2003), their examples show poor or no correlation with the tsunami deposits inferred for the Adriatic Islands of Hvar and Brač.

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