Reply to:

Comment by Eric Font, Gerta Keller, Diethard Sanders and Thierry Adatte

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

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We disagree with many of the concerns raised by Font et al., (submitted) and take this opportunity to clarify matters. We wish to emphasise that in our paper (Korbar et al., 2017), as well as in the first report on the "potential" Cretaceous-Palaeogene (K-Pg) tsunami in Adriatic region (Korbar et al., 2015), we reported on *rare shallow marine* distal K-Pg records that differ from *dominantly deep marine* records commonly reported in other papers. We did not include more references on the latter, since that was not a goal of our paper and we encourage the authors of the Comment themselves to make additional research of the Likva section, especially the issues that are criticised.

The authors of the Comment note that none of the well defined K-Pg successions paleogeographically located along the eastern Atlantic (today Bay of Biscay) region *"(Bidart, Zumaia, Hendaye and Sopelana sections), which are located more proximal and towards the hypothetical tsunami wave propagation front*", include a tsunamigenic record on the K-Pg boundary. However, all the listed successions were deposited within deeper bathial (1000-1500 m) water depths and were located at least 50 to 100 km from the shallow platforms (cf. Alegret, 2007; Rodríguez-Tovar et al., 2011). When later later orogenic shortening is accounted for the original distance would have been even greater. Furthermore, there is a lack of any seismogenic evidence (liquefaction, slumping, etc.) in the sedimentological records from very distal K-Pg deep-marine successions. We discussed that issue in Korbar et al. (2015), especially with respect to Gubbio as the closest reported deep-marine K-Pg record to the Adriatic platform and the shallow-marine K-Pg successions of Hvar and Likva. Thus, neither the giant hydrodynamical perturbations expected in a K-Pg tsunami nor attenuated seismic energy would be expected toaffect the deep-water sediments in very distal regions.
Considering the explanations above, such a criticism is not accepted. It would be much more useful to see published reports on possible shallow-platform or coastal K-Pg records from the eastern Atlantic paleo-margin. Such an analysis requires systematic fieldwork and focussed geological mapping of the

region, similar to that we have performed in Adriatic region before making conclusions about an issue of almost global significance.

1. Tsunami benchmarks – highlights on unknown tsunami effects in modern isolated carbonate platform interiors

The major issue underestimated by Font et al. (submitted) is that there is no modern analogue for an isolated carbonate platform tsunamite (e.g. Shiki et al., 2008; Korbar et al., 2015 and references therein). Major modern tsunamis are documented either from coral-reef dominating atolls and small intraoceanic islands or coastal regions encompassing broad open shelves (Shiki et al., 2008). Conversely, the intra-oceanic Adriatic carbonate platform (ACP) was a shallow and flat, few hundereds kilometers wide mud-dominating rimmed carbonate bank without coral reefs, while the Likva locality was situated in the central part of it in a sheltered lagoon. Thus, one cannot expect all the features typical for modern tsunamis in such an environment.

Concerning criticism on the composition of the tsunamite, Font et al. (submitted) compiled the expected redeposited components from various modern settings. For example, there is no sedimentological evidence for the statement that "*bed 4 may have accumulated after intermittent bank-top exposure where intraclasts formed by desiccation and/or bioturbation", since such features are common deeper downsection (not reported in Korbar et al. (2017). There are also not "just a few angular bioclasts*" in a lag, since we reported also on rounded mud intraclasts that originated from bed 3. Besides, there are clear sediment loading structures observed in bed 4 (Fig. 2c of Korbar et al., 2017). It should be highlighted that our study documents a *relatively* high-energy event in very low-energy setting of a very distal and broad carbonate platform interior (tidal flat) lacking sands, characterized by monospecific skeletal material (requieniid-rudist bivalves). Thus, there is a thin but relatively coarse-grained bioclastic lag of 10-12 cm thick sediment deposited after the attenuated tsunami surge. Apart from obviously abundant soft-tissue worms, other biological debris was also probably minor and was mostly decomposed by diagenetic processes during subsequent regional Cretaceous-Palaeogene platform emersion phase and orogenic burial (Korbar, 2009).

Modern tsunami records on atoll-fringing narrow carbonate platforms (eg., Nichol and Kench, 2008), and various continental marginal marine environments (eg., Font et al., 2013) certainly differ significantly from the record on ACP. This is becausea carbonate platform interior tsunami record must be completely different than preserved in open shelves (Smit et al., 2011). That is why many features described in modern tsunamites (Morton et al., 2007; Goto et al., 2012) cannot be used for ancient mud-dominated intra-oceanic flat and broad carbonate platform interiors, until the characteristic tsunamigenic record is documented from similar modern settings (e.g., Bahamas).

There are also differences concerning various peri-Adriatic Late Cretaceous shallow-water carbonate environments. For example, relatively small (narrow and thin) carbonate ramps/banks developed within mixed carbonate-siliciclastic Gosau-type settings (Polšak, 1981; Sanders and Pons, 1999; Moro et al., 2016) are rich in siliciclastic material and various macrofosills, including corals. The tsunami effects on these small fringing carbonate bodies attached to the exhumed oceanic and/or continental basement cannot be compared to the broad and flat ACP interior characterized by deposition of almost pure carbonate mud. Similarly, the Adriatic platform differs also from Maiella (Apenninic) platform that was characterised by ramp-like geometry and relatively open high-energy environments and flourishing rudist communities in the marginal areas (Eberli et al., 1993; Sandres, 1996).

Another criticised issue are calcispheres shown on Fig. 2D and 3A of Korbar et al (2017). . It would have been helpful if Font et al. (submitted) provided a reference (with figures of that type of calcisphere) to support their statement that the calcispheres at Livka are“a common feature...“ in Late Cretaceous carbonate platform deposits.

2. Bioturbation

Sub-horizontal to sub-vertical burrowings are not interpreted by Korbar et al. (2017) to be formed only during escape of light-body animals (probably polychaete worms), but were predominantly formed hours-to-days after the deposition of the event bed, as excellently illustrated by modern laboratory research (Herringshaw et al., 2010), giving the idea for reconsiderations on many conventional/traditional ichnological interpretations. Font et al. (this issue) stated that *„bioturbation illustrated is characteristic of a hardground or firmground burrow network slightly modified by compaction, rather than softground bioturbation*“. Our interpretations are based on analyses of tens of slabs and thin-sections from the bed, confirmed also by a reviewer who is an authority on ichnology. We offer collected material for further ichnological research. Considering criticism on habitat of modern polychaetes (annelide worms) we can only repeat the discussion on the topic in Korbar et al. (2017), including references therein.

3. Shocked-quartz

We neither “*claim additional support for tsunami interpretation from PDFs“* nor analyze *“a single shocked quartz grain*“and the grains are used for correlation with the K-Pg impact rather than for the tsunami. We analysed tens of quartz grains and provided quality SEM images for two with multiple features that were both straight and regularly and closely spaced.
We accept that it would be useful to make crystallographical measurements on the quartz grains to confirm that the features are genuine PDFs, and we offer the material to any interested and experienced scientist. However, suggestions on a possible terrigenous origin and redeposition of shocked quartz are highly unlikely, since the grains occur in a lagoon within an isolated carbonate platform that was situated far from possible terrigenous sources .

4. Planktonic foraminifera

The specimens are rare, very small and not very well preserved, however they present valuable evidence on the Early Paleocene evolution of the planktonic foraminifera. We explain our determination for specimens where we disagree, and accept suggestion of Font et al. (this issue) for the species *Chiloguembelina midwayensis*.

Thus, the Fig. 5 SEM images (in Korbar et al., 2017) of the basal Paleocene (P0-Pα zones) planktonic foraminifera isolated from the K–Pg boundary “clay” of the Likva section are as follows:
(A-B) *Guembelitria cretacea* CUSHMAN
(C) *Parvularugoglobigerina* cf. *longiapertura* BLOW
(D) *Eoglobigerina eobulloides* (MOROZOVA)
(E) *Woodringina claytonensis* LOEBLICH and TAPPAN
(F) *Parvularugoglobigerina* cf. *extensa* (BLOW) – We agree that this specimen is difficult to determine because the previous chambers are visible only in part.

(G, H, I) *Praemurica taurica* (MOROZOVA) – wall textures indicate that these specimens belong rather to *Praemurica taurica*, than to microperforate *Parvularugoglobigerina eugubina*. Spiral side also implies genus *Praemurica*.
(J-K) *Globoconusa daubjergensis* (BRÖNNIMANN)- due to very small test size and very thin wall we consider that these specimens belongs to *Globoconusa*. Our specimens could belong to *Globoconusa victory* KOUTSOUKOS (2014).
(L) *Chiloguembelina* cf. *morsei* (KLINE)- The upper layer of the test is dissolved and determination is difficult. We accept the suggestion that it could be *C. midwayensis*.

5. Correlation with the Hvar section

Considering criticism of Font et al. (submitted) on correlation with Hvar section, we can only repeat our arguments from Section 1. Namely that there is knowledge on tsunami effects on mud-dominated carbonate platform tidal-flat interiors that are modern analogues for the Livka and Hvar sections.

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