Review of the revised manuscript “Subaqueous speleothems (Hells Bells) formed by the interplay of pelagic redoxcline biogeochemistry and specific hydraulic conditions in the El Zapote sinkhole, Yucatán Peninsula, Mexico” by Ritter et al., submitted to Biogeosciences

General comment:

I thank the authors for their detailed response to my comments.

My major concern (and obviously of the other reviewer as well) was the hypothesis of the authors that the growth of the Hells Bells is controlled by the depth of the halocline and the redoxcline, which, in turn, are related to recharge. Based on this hypothesis, the authors suggested episodic rather than continuous growth of the Hells Bells (at different depth) and even proposed a relationship with extreme events, such as hurricanes.

In my comment, I stated: “Considering the enormous size of at least some of the bells, it is hard to believe that these should have developed due to seasonal or episodic changes in the depth of the halocline. I would rather believe that this requires a long-term shift in the depth of the halocline, for instance over several thousand years during the Holocene. I had a quick look at the previous paper of the same group (Stinnesbeck et al., 2017b), which presented a few U-series data and reported growth rates of ca. 10-100 µm/a. In case of such slow growth rates, it is hard to believe that a short-term decrease in the depth of the halocline due to a recharge event would have a visible effect. In contrast, growth of a really large bell, requires slow and progressive changes in the (mean) depth of the halocline. The U-series ages ranging from a few hundred to a few thousand years reported by the previous paper, actually seem to confirm this.”

I still think that the only way to test this hypothesis would be systematic U-series dating of several bells from various depths, which requires an enormous number of U-series ages. As far as I understand, this work is currently in progress, and the authors do not want to include these data in the current MS. This is OK, in particular in times where each PhD thesis must consist of several papers. It is still a bit unfortunate, however, for the reader of the current MS because the authors’ response to the reviews makes clear that their interpretations are – at least partly – based on these additional data.

In their revised MS, the authors estimate the potential growth rates of the Hells Bells (I very much appreciate that) and obtain results in agreement with their preliminary U-series data. This shows that the potential growth rates of the bells are in the range of a few hundred µm/a. In addition, they show data from their loggers suggesting changes in the range of 10-20 cm to recharge events. Finally, they state in their reply that “ … The main argument why we did not consider droughts as a mechanism of halocline elevation is U/TH age-dating on Hells Bells specimens of different water depths (MS currently in preparation) show approximately identical young ages (~150 a) at the lowermost crystal tips (1-2 mm) of the Bells. There is even a weak trend of the youngest samples found in the lowest water depths and the oldest samples found in greater water depths. This makes droughts or prolonged periods of time with an elevated halocline as the sole mechanism for the elevation of the halocline unlikely because this should be reflected in an age-zonation of the Hells Bells.”

Considering all these points, I tend to agree that short-term recharge events may have the potential to change the depth of the halocline (even if not in the range of several meters) and result in episodic growth of Hells Bells at different depths. Even if the growth rates were

much lower, this could still eventually result in large bells because you have a lot of time (thousands of years). This is comparable to a speleothem that is fed by a very slow and maybe episodic drip rate or only during a specific season of the year (e.g., winter). Growth is episodic, but you may still receive a large speleothem after sufficient time, which appears to have been grown continuously.

In summary, I tend to generally agree with the authors' hypothesis, now that I have seen the additional data. However, there are two important points, which should be added to the MS prior to publication to make the suggested process clear to reader:

1. Due to the slow growth rates of µm/a, it will not be possible to *reconstruct* the detailed episodic growth history of a single bell on the seasonal or even annual time scale by U-series dating. If the water level and the depth of the halocline fluctuates on a daily, weekly, seasonal or even annual time-scale, you will always have growth at different depths in the cenote throughout the year. Thus, a *reconstruction* of individual extreme events (e.g., hurricanes) by precise U-series dating will not be possible using the Hells Bells. It is, thus, misleading to state that extreme events, such as hurricanes, can be *recorded* by the bells. Therefore, I suggest to delete the reference to hurricanes.
2. As far as I understand, growth of the bells in the cenote is restricted to a relatively large range in depth of ca. 10 m. This seems to be a lot compared to the fluctuations of 10-20 cm observed in the logger data (Fig. 1 in the reply of the authors). Thus, larger changes in depth may be related to long-term processes (centennial to millennial scale) and minor changes to short-term events. This should be made clear in the text even if the logger data are not shown.

In summary, I recommend to accept the MS after the suggested changes have been made.