REPLY TO COMMENT ON KATO et al. (2017) “PALEOECOLOGY OF ECHINODERMS IN COLD SEEP ENVIRONMENTS REVEALED BY ISOTOPE ANALYSIS IN THE LATE CRETACEOUS WESTERN INTERIOR SEAWAY”

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New studies employing different approaches are always necessary in science, and therefore, we conducted a chemical approach to the peculiar crinoids (Kato et al. 2017), for which morphological study was already published by Hunter et al. (2016). Comments by Hunter et al. (2018) to our paper (Kato et al. 2017) pointed out that the conclusion and interpretation of Kato et al. (2017) have omitted or restated the discussion in Hunter et al. (2016) without citation. However, we did cite their paper multiple times and our study was based on a different approach, so this is not the duplication of the results by Hunter et al. (2016), even if a similar conclusion was obtained. We respond below to comments by Hunter et al. (2018) and explain the method and discussion of Kato et al. (2017) in more detail. Comments by the authors to criticism raised by Hunter et al. (2018) are developed below.

Hunter et al. (2018) pointed out that “the evaluation of the diagenetic effect that affected echinoderm fossils was not sufficiently evaluated in Kato et al. (2017)”. The effect of the diagenetic processes to the echinoderm skeleton is difficult to assess because the complex three-dimensional microstructure of the echinoderm skeleton (stereom) is difficult to separate from the cement or matrix filling skeletal interspaces. In early stages of diagenesis, it is known that high-Mg calcite can rapidly lose Mg and change to low-Mg calcite (e.g., Hover et al. 2001), or even recrystallize to dolomite. And, in the case of echinoderms, “the paradigm that Mg calcite transforms to calcite with perfect textural preservation is untrue” (Dickson 2001). Gorzelak et al. (2016) also mentioned that “Echinoderm ossicles with preserved stereom structure without any major signs of internal change display nearly all geochemical (i.e., specific distribution of sulphates) and micro/nanostructural details (stereom structure, relics of growth layering, nanograins) which are comparable to those observed in Recent skeletons”. Thus, it is possible to consider that the diagenetic alteration for echinoderm skeleton is not so intense if stereom structure and highly concentrated Mg were still preserved in the fossil skeletons. This aspect of preservation of stereom structure and Mg content is absent from the comments raised by Hunter et al. (2018).

Kato et al. (2017) provides a new method to evaluate diagenetic effect in echinoderm skeletons (high-Mg calcite) first by microscopic observation and then by measurement of Mg content. This method shows almost all the fossil echinoderm specimens with preserved stereom structure also retained relatively high-concentration Mg in skeletal remains. Therefore, in Kato et al. (2017), the preservation of stereom structure was concluded to have a low-degree of diagenetic alteration based on the criterion developed by Gorzelak et al. (2016), and the isotope ratio data was discussed based on the results. The method, however, is not quantitative but relative, and it is thought the method is effective to grasp a rough degree of diagenetic alteration. Thus, we maintain that isotope data from these well-preserved fossils can be used as reliable signatures.

Hunter et al. (2018) suggested that “the discussion based on the stable carbon isotope data in Kato et al. (2017) was not sufficient to conclude that Lakotacrinus lived in, and was a member of the seep community”. It is certainly very difficult to measure accurate original values of stable carbon isotope ratio ($\delta^{13}C$) in just the echinoderm skeleton because the porous structure of stereom is filled with cement. In Kato et al. (2017), the measured $\delta^{13}C$ values of echinoderm fossils were the combined values from the skeleton and the matrix or cement which filled stereom pores. It is possible to calculate the original values of echinoderm skeleton provided the isotope data of the combined values and that of the matrix or cement, and the volume ratio of skeleton and matrix/cement are known. The volume ratio of skeleton and its pores (interspace) is approximately 1:1 (Savarese et al. 1996). Thus, the isotope values of the mixture of skeleton and matrix or cement are almost the same as the average of echinoderm skeleton and the matrix (cement). For example, when mixture $\delta^{13}C$ value is hypothetically $-20\%$ and matrix value is $-15\%$, original $\delta^{13}C$ value of echinoderm skeleton should be estimated $-25\%$ ($= 15 + 20/2$).

Additionally, when echinoderm fossils have been subjected to a diagenetic alteration and the $\delta^{13}C$ values have changed, the values of fossil skeleton tend to approach those of matrix around the fossils. In other words, if obtained $\delta^{13}C$ values of echinodermics (the mixture values) were lower than that of matrix, the obtained $\delta^{13}C$ values suggest that the original $\delta^{13}C$ values of the echinoderm skeletons must have been much lower than the measured values. This point was stated in Kato et al. (2017) but the comments by Hunter et al. (2018) omitted mention of this important discussion.

A third criticism by Hunter et al. (2018) pointed out that “Kato et al. (2017) concluded that Lakotacrinus might have been a member of a chemosynthetic community only based on isotopic data and ignore the discussion on morphology and taphonomy of Lakotacrinus in Hunter et al. (2016)”. The study done by Kato et al. (2017) focused on discussion to the paleoecology of cold seep echinoderms by using a “geochemical method”, and mentioned morphology and taphonomy of the echinoderms only briefly. Hunter et al. (2016) focused and discussed the morphology and taphonomy of Lakotacrinus in detail already, and Kato et al. (2017) thus followed their conclusion. Kato et al. (2017) did not ignore the discussion by Hunter et al. (2016), but refer the morphological information of Lakotacrinus from Hunter et al. (2016); for example, “The crinoid corresponds to a new species of the order Comatulida that displays a very unusual morphology (Hunter at al. 2016)”.

Hunter et al. (2018) stated that “The Triassic crinoid Traumatocrinus (e.g., Hess 2011, fig. 19b) has perforations (or tubuli) in the stalk that may have had the same function as for Lakotacrinus (Hunter et al. 2016)”.

However, the diameters of the tubulis in Lakotacrinus are two or three times bigger than those in Traumatocrinus or other crinoids, whereas the