

Paleoecology of the Upper Cretaceous echinoderms from cold seep carbonates in South Dakota, USA

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Echinoderms were thought to be rare in a cold seep environment and had not been considered as a member of the chemosynthetic community until recent years, whereas the chemosynthesis community consists of a variety of other taxa. In the last 10 years, some species of echinoderms have been reported as a member of the modern chemosynthetic community, and some fossil echinoderms have also been found from or near carbonate mounds associated with cold seep. However the taxonomic and paleoecologic studies about these echinoderms have not been sufficiently done, and the ecologic relationship between these echinoderms and cold seeps has been also unsolved. The purposes of this study is to discuss paleoecology and process of adaptive evolution of echinoderms associated with a cold seep environment found from the Upper Campanian Pierre Shale in South Dakota, by field surveys, taxonomic of and morphological observation of fossil echinoderms. Chemical analyses of fossil echinoderm skeletons were also conducted, including element analysis for estimating the degree of diagenesis, and stable carbon isotopes analysis for clarifying the degree of relation between the echinoderms and the seep hydrocarbon.

As a result of field surveys, it is proved that the diversity of fossil species from carbonate mounds associated with cold seeps is different among mounds, even between adjacent mounds. Such a difference of species diversity is considered to reflect the difference of environments during the time when the carbonates were formed. It is presumed that the carbonate mounds with high diversity were exposed on the sea floor for a long time and provided a suitable environment for epifauna such as many echinoderms. Fossil crinoid from seep carbonates has low values of $\delta^{13}\text{C}$ (-20 ‰ or less). These values are considerably lower than modern crinoids which inhabit non-seep environments, and are also lower than the values of other fossil echinoderms from seep carbonates of the Pierre Shale. The crinoid from seep carbonates also has very strange, characteristic morphology, not seen in other stalked crinoids. Considering these chemical and morphological data, the crinoid from seep carbonates had probably adapted to the environments of cold seeps. On the other hand, echinoids from cold seeps do not have low values of $\delta^{13}\text{C}$, and morphologically they are not significantly different from those found from non-seep environments. Therefore, it is considered that the echinoids from seep carbonates are not regarded as a true member of chemosynthetic community, but they came into cold seeps to benefit irregular, hard substrate to live on, or to obtain ample food sources from this cold seep environment.

The degrees of adaptation to cold seeps are therefore different among echinoderm species.

Keywords: cold seep, echinoderms, paleoecology, chemosynthetic community