

## Comparison of fossil echinoderms from Upper Cretaceous cold seep environments between Japan and central United States

KATO, Moe<sup>1\*</sup> ; OJI, Tatsuo<sup>2</sup>

<sup>1</sup>Graduate School of Environmental Studies, Nagoya University, <sup>2</sup>Nagoya University Museum

Echinoderms were thought to be rare in a cold seep or hydrothermal vent environments and had not been considered as a member of the chemosynthetic community until recent years (Grassle 1985; Laubier 1989; Desbruyères et al. 2006), whereas echinoderms are one of the main groups in marine invertebrates especially in deep sea. In the last 10 years, some species of echinoderms have been reported as a member of the modern chemosynthetic community (Pawson and Vance, 2004; Stöhr and Segonzac, 2005). However ecology of these echinoderms and the process of adaptation to environments of cold seep or hydrothermal vent still remain to be clarified. The purpose of this study is 1) to clarify the process of adaptive evolution of echinoderms associated with a cold seep environment and 2) to discuss to what extent the life of the echinoderms was related to reducing substances from cold seeps.

Fossil echinoderms from seep carbonate have been reported from some localities (Gaillard et al., 2011; Landman et al., 2012). Fossils from coeval two formations, one is the Pierre Shale (South Dakota, USA) and the other Osoushinai Formation (Hokkaido, Japan), both the upper Campanian have been studied to compare regional differences of these localities and to discuss the factors that cause such differences.

From the Pierre Shale, at least 5 species of echinoderms are found, comprising mainly crinoids and irregular echinoids. The crinoids from South Dakota have unique morphology, suggesting that these crinoids had adapted to environment of cold seeps (Hunter et al., in progress). On the other hands, from Osoushinai Formation, only 1 species crinoid was found. The carbonates associated with cold seeps are found as boulders and include tube worms and crinoid columnals. The crinoids from Hokkaido are assigned to the family Isocrinidae, very common to "normal" non-seep environments and thus are not regarded as the specialized form for a seep environment.

To discuss the degree of linkage between echinoderms and methane released from cold seeps, the stable carbon isotope ratio ( $\delta^{13}\text{C}$ ) of echinoderm skeleton were measured. Before analyzing  $\delta^{13}\text{C}$ , microstructure of echinoderm skeleton was observed with a polarizing microscope to estimate the degree of diagenesis, and spots of the skeleton considered to be not strong effect of diagenesis were measured selectively. As a result, the crinoids from both the Pierre Shale and Osoushinai Formation have almost comparable to or lower  $\delta^{13}\text{C}$  values than seep carbonate matrix around the fossils. The effect of diagenesis is not fully examined at this stage, but these results suggest that the crinoids from both localities had lived nearby cold seep environments. Therefore, it is thought that the crinoids from the Pierre Shale were adapted to cold seep environment with highly specialized morphology, and the Isocrinidae from Osoushinai Formation lived around cold seeps at least but they did not change them morphology notably.

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