

## Reconstruction of seepage site with *Calyptogena* colonies in the Upper Miocene Morai Formation, Hokkaido, Japan

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The Upper Miocene Morai Formation, Hokkaido, Japan, consists of alternating beds of semi-consolidated and hard mudstone, and intercalates calcareous concretions associated with abundant fossils of *Calyptogena pacifica*. This study reconstructs habitat conditions of *Calyptogena pacifica* on the basis of field observation of a 20-m-high sea-cliff outcrop.

The calcareous concretion blocks bearing *Calyptogena pacifica* fossils are restricted in several horizons in the upper part of the sea cliff. We surveyed the shape, size and distribution of the concretions and observed the carbonate lithology and modes of fossil occurrence, hanging from the cliff with a rope. The concretion blocks are lenticular in shape, attaining over 10 m in horizontal length and less than 2 m in thickness, and laterally changed into hard mudstone beds which also yield abundant *Calyptogena* shells. The concretion blocks have nearly flat roof and base, but its sides sometimes interfinger with neighboring mudstone.

The concretion blocks consist of monotonous muddy dolomicrite, associated with small calcitic nodules, several centimeters in diameter, just below the blocks. The dolomicritic concretions sometimes show auto-brecciation, which shows break of mudstone into angular pieces to form jigsaw-puzzle fabric. The space between breccia was filled with dolosparitic cement. It is noted that the brecciated fabric is restricted to interior of the concretion blocks and does not continue to the surrounding mudstones, which does not show any fracturing. These suggest that the auto-brecciation was not due to hydrofracturing by pore-fluid pressure, but was maybe caused by contraction during dolomitization.

*Calyptogena* fossils form shell concentrated beds associated with *Conchocele bisecta*, *Acharax johnsoni*, and *Lucinoma* sp. The shell beds continue laterally more than 20 m. The thickness attains more than 50 cm in the concretion blocks, but becomes thinner (ca. 15 cm) in the surroundings. It is noted that all the bivalve species show high ratio of conjoined valves (ca. 60 % in case of *Calyptogena pacifica*). In particular, almost all of *Conchocele bisecta* fossils preserved their life position. Most of *Calyptogena* conjoined valves show life position or reclining orientation with their commissural plane horizontal, but some show an inverted orientation from life position, maybe fossilized on the way to escape from rapid burial. These suggest that the *Calyptogena* shell concentrations were not due to transportation, but preserved the original colony condition due to rapid burial maybe by muddy turbidity current.

Localized distribution of carbonate concretions and *Calyptogena* shell beds indicate that the *Calyptogena* colony was not formed by reducing mud due to oxygen-depleted water-mass, but was supported by methane seepage. The outcrop observation suggests that the seepage was not channelized but diffusive. The seepage influence expanded the bottom surface area over 20m in diameter, but was repeatedly interrupted by rapid burial of muddy turbidite.

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