Sea-level changes across the Cenomanian/Turonian boundary and their relation with orbitally driven turbidite cycles in Hokkaido

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The Oceanic Anoxic Event at the Cenomanian/Turonian boundary (C/T-OAE or OAE-2 of Schlanger and Jenkyns, 1976) is the best-studied OAE with respect to the distribution of black shale and the positive excursion of delta 13C both in carbonate and organic carbon (e.g. Jenkyns et al., 1994, Hasegawa, 1997). The cause of C/T-OAE is considered as related to changes in climate and sea-level (e.g. Arthur et al., 1990; Jenkyns, 1980). Sea-level changes around the C/T boundary have been investigated by many (e.g. Haq et al., 1988, Voigt and Hilbrecht, 1997), but the exact relationship between sea-level changes and other C/T boundary events is still controversial because the difficulty in reconstructing of sea-level changes with the demanded time scale of 100 kyrs; it is usually difficult to determine the exact ages for shallow marine sequences, while they well represents their depositional depths.

Matsushita (2001, MS) examined the Middle Cenomanian to the Upper Turonian hemipelagic sequence in Oyubari section, which is characterized with cm-scale turbidite intercalations, and found that the turbidite frequency during the Middle to Late Cenomanian shows the periodicities of about 1000 ky, 100ky, 40 ky, and 20 ky, which are consistent with those of Milankovitch cyclicities. Stable carbon isotope ratio of terrestrial organic carbon is correlated with the 1000 ky turbidite cyclicity.

Ando (1987, 1990a, b) reconstructed depositional depth changes within the stratigraphic interval --equivalent to the Oyubari section-- for the shallow-marine sequences in Pombetsu section (about 20 km northwest of the Oyubari section) based on sedimentary facies analysis, but the position of the C/T boundary is not well constrained in Pombetsu section due to rare fossil occurrences.

In order to investigate the relation between the turbidite frequency and sea-level changes, we correlated Pombetsu section with Oyubari section using variation pattern of delta 13C of the terrestrial organic carbon and the detrital grains characteristic of certain stratigraphic intervals. The sedimentary sequence is divided into 6 facies that correspond to specific depositional depths, mostly according to Ando (1987).

As a result, gradual regression during the Cenomanian, sea-level highstand at the latest Cenomanian, and an abrupt regression in the earliest Turonian are demonstrated. Lowstand of sea-level in the Early to Middle Turonian, and a transgression in late Early Turonian are also recognized. Sea-level lowstands in the Middle to Late Cenomanian seem to correspond to the high turbidite frequency interval, and they also correspond to low delta 13C intervals at Oyubari section. Reconstructed relative sea-level changes are compared with other sections in Egypt and Europe.

The result suggests that the Middle to Late Cenomanian turbidite cycles in Oyubari area are probably caused by the sea-level oscillations with high turbidite frequency intervals corresponding to lowstand of sea-level. The results also suggest that the third-order sea-level changes in the Cenomanian, including the sea-level highstand at the latest Cenomanian, are caused by orbitally driven eustatic sea-level changes, and the global carbon cycle reflected in delta 13C variations seem to be influenced by the eustatic sea-level changes; depletion of organic (isotopically light) carbon is promoted during sea-level highstand. Orbitally driven eustatic sea-level changes suggest the existence of the polar ice in the Middle to Late Cenomanian.