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Relationship between variabilities of orbital- and millennial-scale sedimentary rhythms in the Onnagawa Formation

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It is well known that Late Quaternary climate is characterized by millennial-scale abrupt changes known as Dansgaard-Oeschger cycle [Dansgaard et al., 1993], and the relationship between the millennial-scale variability and orbitally-driven ice volume changes has been explored [Zhang et al., 2014; Tada, 2012]. On the other hand, Tada [1991] demonstrated that the Middle Miocene cm-scale alternations of light- and dark-colored siliceous rocks widely distributed in the Pacific rim reflect millennial-scale paleoclimatic/paleoceanographic variability. Large and unstable ice sheets were present in Antarctica during the Middle Miocene and in the high-latitude northern hemisphere during the Late Quaternary, respectively [Tada, 1990; Zachos et al., 2001]. Because 100-kyr periodicity in the oxygen isotope records of benthic foraminifera, which appears as a result of nonlinear response of ice sheet to the Milankovitch forcing, became dominant in the both ages [Raymo and Lisiecki, 2005; Holbourn et al., 2013], the relationship between millennial-scale variability and 100-kyr periodicity in the oxygen isotope record is suggested. Examination of the relationship between the amplitude and frequency of millennial-scale variability and periodicity of orbitally-driven ice volume changes during the Middle Miocene is essential to better understand the generality and ultimate cause of millennial-scale variability of climate.

Tada [1991] suggested that bedded siliceous rocks observed in the Onnagawa Formation that is widely distributed in northern Japan reflect millennial-scale oceanic variability. However, the timing and duration of millennial-scale variability are not well understood, and the relationship between its variability and periodicities of orbital-scale ice volume changes is not clarified. In this study, we aim to clarify when the Middle Miocene millennial-scale variability became distinct and when it was faded out. We also examine its possible association with 100 ky cyclicity of ice volume changes.

We conducted a field survey in Yashima town, Akita Prefecture and reconstructed the continuous sedimentary records of the Middle Miocene. We constructed the age model based on biostratigraphy. In addition, we defined a silica rank based on the hardness and/or brittleness of the siliceous rocks, extracted cycles of silica rank changes, and applied cyclostratigraphy to fine-tuned the biostratigraphically constrained age model. Based on this age model, we specified the timing of appearance and disappearance of millennial-scale variability, correlated with oxygen isotope curve, and examined the relationship between millennial-scale variability of silica rank and 100-kyr periodicity of benthic oxygen isotope record.

In this presentation, we will demonstrate the applicability of cyclostratigraphy to the Onnagawa Formation to construct more precise age model. We also discuss the relationship between millennial-scale variability of silica productivity and 100-kyr periodicity of ice volume changes.