Stratigraphy and paleoceanography of the Sea of Japan during the Pliocene–Pleistocene transition: the dinoflagellate cyst record at IODP Site U1424

Saif Al-Silwadi*†[1] and Martin J. Head[1,2]

[1]Department of Earth Sciences, University of Toronto – Canada
[2]Department of Earth Sciences, Brock University – Canada

Abstract

The Pliocene–Pleistocene transition marks a significant intensification of Northern Hemisphere glaciation (iNHG) and the beginning of high-amplitude glacial–interglacial cyclicity that characterises the Quaternary. While many mechanisms have been proposed for this change in climate state, including the closure of the Isthmus of Panama and the onset of ocean stratification in the Pacific at ˜2.7 Ma, the role of the Pacific Ocean remains poorly understood.
The largely enclosed Sea of Japan has been a sensitive recorder of climate change since its formation, owing to its: shallow connections to the Pacific and adjacent basins that prevent bottom water exchange; reliance on the Tsushima Warm Current as its major source of nutrients, salt and heat; proximity to the Westerly Jet; and position relative to the East Asian Summer and Winter Monsoon systems. This makes it ideally suited for understanding the role and response of East Asia and the Pacific Ocean across this interval of crucial climatic change. Dinoflagellate cysts, acritarchs, and other palynomorphs are here used to elucidate hydrographic changes during the Pliocene–Pleistocene transition at Integrated Ocean Drilling Project (IODP) Site U1424, east-central Sea of Japan. The study covers 2.85 Ma to 2.41 Ma with an average sample spacing of ˜4 kyr, allowing paleoenvironmental reconstructions at suborbital resolution. This is the first high-resolution study using dinoflagellate cysts for the Sea of Japan.

A total of 125 samples were analysed, and results reveal more than 60 marine palynomorph taxa and moderate to excellent preservation. Detrended Correspondence Analysis (DCA) was conducted on the total marine palynomorph assemblage to ascertain the relationship between environmental changes and sample distribution. The results of DCA show that the distribution of samples is influenced by the age of the material. Prior to 2.650 Ma, there appears to be significantly less distinction between glacial and interglacial samples. It is hypothesized that effect of the onset of iNHG became most prevalent at this time. After 2.650 Ma, changes in assemblages correspond to shifts in marine isotope stages (MIS). In particular, strong responses coincide with glacial MIS 100 (2.52 Ma) and 102 (2.57 Ma), these being characterized by higher numbers of *Corrudinium harlandii*, *Habibacysta tectata*, *Spiniferites elongatus*, and cysts of *Protoceratium reticulatum*. Although initially rare, the first appearance of the thermophilic species *Tuberculodinium vancampoae* at ˜2.814 Ma suggests the influence warm-water inflow to the Sea of Japan, probably from the southern strait.

*Speaker
†Corresponding author: saifsilwadi@gmail.com

Conversely, *Cymatiosphaera*? *invaginata* is abundant in some intervals, seemingly tied to specific glacial climate cycles. Although the paleoecology of this acritarch is not fully known, its prevalence elsewhere in the high- to mid-latitudes likely implies the flow of subarctic water masses into the Sea of Japan from its northern straits. Results of Canonical Correspondence Analysis (CCA) add support and show a strong relationship between the abundance of *C.*? *invaginata* and the distribution of samples representing glacial conditions. This acritarch has been found in other localities across the Pliocene–Pleistocene transition, including the North Atlantic and the Gulf of Alaska in similar high proportions. As such, it may usefully indicate the onset and prevalence of glacial conditions in higher northern latitudes. The position of the Pliocene–Pleistocene boundary at 2.580 Ma in the Sea of Japan is supported by that of the Gauss–Matuyama paleomagnetic reversal. Dinocyst assemblages close to the boundary are characterised by high abundances of *C. harlandii* and *Spiniferites* spp., and the presence of *Impagidinium* species (particularly *I. pallidum*), *Lingulodinium machaerophorum* and cysts of *P. reticulatum*, and low numbers of *C.*? *invaginata*. Being firmly within MIS 103, the assemblages reflect interglacial conditions.

Overall, the marine palynomorph assemblages record the fluctuating influence of these contrasting water masses during the iNHG. The shallow sills connecting the Sea of Japan to the North Pacific impose further controls on inflow during these times of strongly fluctuating global sea level.

Keywords: Pliocene, Pleistocene, Northern Hemisphere Glaciation, dinocysts, dinoflagellates, paleoceanography, paleoclimatology