Improving Arctic Quaternary geochronology and paleoceanographic reconstructions using calcareous nannofossils

Mohammad J. Razmjooei

Stockholm University, Department of Geological Sciences; Bolin Centre for Climate Research, Stockholm, Sweden; mohammad.razmjooei@geo.su.se

Matt O'Regan, Helen Coxall, Flor Vermassen, Martin Jakobsson

Stockholm University, Department of Geological Sciences; Bolin Centre for Climate Research, Stockholm, Sweden; matt.oregan@geo.su.se; helen.coxall@geo.su.se; flor.vermassen@geo.su.se; martin.jakobsson@geo.su.se

https://doi.org/10.58998/jnr3269

The challenges of dating Quaternary Arctic Ocean sediments continue to obscure paleoceanographic insights into the history of sea ice and the configuration and dynamics of past ice sheets. A key historical problem is that different geochronological tools provide widely different age estimates for the same sedimentary sequences. Calcareous nannofossils still provide the most robust biostratigraphic age markers for Quaternary Arctic Ocean sediments. However, Arctic sediments are dominated by fine-grained terrigenous material, and they commonly contain rare and poorly preserved coccolith specimens that can be difficult to identify under the light microscope (LM). By developing and applying a paired LM and scanning electron microscope (SEM) technique for observing the same nannofossil specimens (Razmjooei & O'Regan, 2024, preprint), we recently illustrated how poorly preserved nannofossils, which cannot easily be identified at the species level, were previously classified as *Gephyrocapsa huxleyi* using LM observations alone. Moreover, the visual resemblance between *G. huxleyi* and another Quaternary marker species, *Pseudoemiliania lacunosa*, had led to occasional misdiagnoses (Razmjooei et al., 2023). Proposed revisions to the placement of *G. huxleyi* and *P. lacunosa* in the stratigraphic framework of central Arctic sediment cores can resolve some of the disparity between different dating techniques and indicate a different chronostratigraphic framework than has been used for nearly two decades of paleoceanographic research. Two key questions that remain include: (1) when did *G. huxleyi* first enter the Arctic Ocean, and (2) where did it first appear in the lithostratigraphic framework of central Arctic sediments? Despite its relatively recent emergence (290 ka, Raffi et al., 2006), *G. huxleyi* exhibits significant morphological diversity. Recent research suggests that there were three episodes of evolutionary diversification within this species: before Marine Isotope Stage (MIS) 5, during MIS 5, and during MIS 1 (Bendif et al., 2023). Our LM-SEM imaging technique reveals two distinct morphotypes in central Arctic sediments. The first is exclusive to Holocene sediments, whereas the second appears in both Holocene and older intervals within the Arctic. The occurrence of these different morphotypes in Arctic Ocean sediments may provide additional important biostratigraphic age control. Testing this requires SEM-based analysis of the crystalline structures that form coccoliths in both central Arctic sediments with uncertain age control and better dated records from the Arctic–Atlantic gateway.

References:

Bendif, E.M., Probert, I., Archonitkis, O.A., Young, J.R., Beaufort, L., Rickaby, R.E. & Filatov, D. 2023. Rapid diversification underlying the global dominance of a cosmopolitan phytoplankton. *The ISME Journal*, **17**: 630–640. https://doi.org/10.1038/s41396-023-01365-5

Raffi, I., Backman, J., Fornaciari, E., Pälike, H., Rio, D., Lourens, L. & Hilgen, F. 2006. A review of calcareous nannofossil astrobiochronology encompassing the past 25 million years. *Quaternary Science Reviews*, **25**: 3113–3137. https://doi.org/10.1016/j.quascirev.2006.07.007

Razmjooei, M.J., Henderiks, J., Coxall, H.K., Baumann, K.-H., Vermassen, F., Jakobsson, M., Niessen, F. & O'Regan, M. 2023. Revision of the Quaternary calcareous nannofossil biochronology of Arctic Ocean sediments. *Quaternary Science Reviews*, **321**: 108382. https://doi.org/10.1016/j.quascirev.2023.108382

Razmjooei, M.J. & O'Regan, M. SSRN (Preprint) 16 March 2024. Improved paired light and scanning electron microscope imaging technique for identifying nannofossils in Arctic sediments. https://doi.org/10.2139/ssrn.4761224