Unusual calcareous nannofossil assemblages from the Cenomanian–Turonian (93.9Ma) of North America: Implications for nannofloral response to Oceanic Anoxic Event 2

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Oceanic Anoxic Event 2 (OAE2), a period of global marine anoxia and black shale deposition, took place across the Cenomanian/Turonian boundary (CTB; 93.9 Ma). Biomarkers, along with many microfossil groups, indicate that there was elevated paleoproductivity during OAE2. However, previous studies of calcareous nannofossils show a shift to oligotrophic assemblages, especially in Europe and North America. It is important to understand this apparent disconnect between nannofossil and other productivity proxies as it may provide insights into how modern nannoplankton will respond to anthropogenically induced oceanographic changes such as elevated nutrient levels and loss of oxygen.

Here we describe the results of recent investigations of calcareous nannofossils from the CTB across the USA and Canada. We used novel integrated statistical techniques that combine geochemical proxies with nannofossil assemblages to reinterpret the paleoecology. We also observed several taxa that are generally rare in, or absent from, other Upper Cretaceous sections. Overall, the assemblages have high species richness, sometimes exceeding 60 species in a sample, which is likely due to enhanced preservation from a high clay content. The statistical analysis and subsequent revision in paleoecologic interpretations indicate that primary productivity may have been elevated in nannoplankton across the CTB, in contrast to other studies. However, there is a notable spatial heterogeneity in the nannofloral assemblages that likely is related to local paleoenvironmental factors. It is possible that previous interpretations of nannofloral oligotrophy may reflect these small-scale heterogeneities.

We also suggest that such shallow shelf settings were centers of evolutionary innovation in the Late Cretaceous and acted as refugia from harsh marine environments, as they did after the mass extinction at the end of the Cretaceous. We describe some rare and newly discovered taxa that have higher occurrences in these shallow shelf environments. We note a rapid expansion of the nannoliths in Canada in the earliest Turonian and comment on the possible evolution of the widespread Turonian nannolith genus *Marthasterites*. Overall, our results show the importance of focused studies of Cretaceous marginal marine environments as a way to gain a better understanding of the evolutionary history of calcareous nannoplankton and their response to global climate change.