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Nannofossil paleofluxes during the Aptian: proxies for paleo-CO2, climate, fertility and chemistry of the oceans.

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Calcareous nannoplankton are brown algae that developed the ability to secrete tiny calcite crystals, arrange them to build coccoliths/nannoliths and, ultimately coccospheres. They are widespread from coastal areas to open ocean settings, and are responsible for primary productivity, energy transfer to higher trophic levels, export of biogenic particles to the deep-sea and exchanges between surface ocean and the overlying atmosphere. Calcareous nannoplankton are effective producers of calcite, and are responsible for shifting the $CaCO_3$ deposition from primarily continental margins to the open ocean, thus, affecting the C cycle on both long- and short-term time scales. The abundance and extreme morphological variability of coccoliths/nannoliths are related to expansions of nannofloras into latitude-, depth-, and nutrient- related niches.

During the Cretaceous major changes in abundance and composition of calcareous nannofossils as well as large variations in their biogenic fluxes seem correlatable with large magmatic events and presumably with major increases in atmospheric CO_2, changes in climatic conditions, seawater composition and structure, and oceanic fertilization.

A high-resolution quantitative study of nannofossil distribution was performed on the Aptian interval to decipher links between biotic evolution, biocalcification and environmental pressure. Two large C isotopic anomalies are associated with episodes of supposed high primary productivity, changes in alkalinity, anoxia, speciations and extinctions in planktonic communities. Ontong Java-Manihiki and Kerguelen Plateaus formed in the Aptian under submarine and subaerial conditions, respectively, affecting the ocean-atmosphere system with excess CO2, changes in Ca2+ and Mg2+ concentrations, and varying nutrient cycling.

The early Aptian C isotopic anomaly interrupts a speciation episode in calcareous nannoplankton paralleled by a drastic reduction in nannofossil paleofluxes culminating in the nannoconid crisis associated with the Oceanic Anoxic Event (OAE) 1a and the onset of the mid Cretaceous greenhouse climate. In the early late Aptian resumption of nannoconid production and appearance of several taxa are coeval with a return to normal C isotopic values. Nannofossil paleofluxes increase in the late Aptian, reaching maximum values during the *N. truittii* acme interval, coeval with the occurrence of calpionellids and diversified planktonic foraminifers indicating successful biocalcification and restoration of the thermocline. Nannofossil indices of paleotemperature and paleofertility point out an eutrophication episode under warm-water conditions following the Selli Event. A cooling interlude is identified in the late Aptian and correlates with other paleontological evidence, oxygen isotopic results and glendonite occurrences. The temperature response to large magmatic events is poorly understood. Excess volcanogenic CO_2 is usually interpreted as a trigger of global warming, however, high levels of carbon dioxide and other volatiles such as S and particulate material in the atmosphere and stratosphere can induce global cooling. The late Aptian cooling is associated with a drop in nannofossil paleofluxes, accelerated extinction rates and with another C isotopic excursion. Cooler conditions are possibly due to a prolonged volcanic winter or reversed greenhouse conditions resulting from a drawdown of carbon dioxide after accelerated weathering and massive burial of organic carbon-rich sediments in the oceans during OAE1a.

Our results indicate that nannofossils are useful paleoenvironmental proxies and suggest complex relationships between paleoclimate and productivity. The Aptian C isotopic anomalies are not satisfactorily explained by changes in paleofertility and burial of organic matter.