Neodymium isotopic evidence for oceanographic change during the collapse of the Cretaceous hothouse

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After the peak hothouse of the Late Cretaceous, ending at ~91 Ma, climate was characterised by a gradual decrease in temperatures and CO_2 levels, an absence of major carbon cycle perturbations, and a reorganisation of deep-water circulation patterns. The role of surface-water oceanography in the long-term Late Cretaceous climatic cooling is poorly understood, as reconstructed upper-ocean circulation patterns are based on relatively low-resolution records, often assembled from multiple localities. Here we present a ~28 Myr continuous record of neodymium-isotope ratios (ε_{Nd}) of fish debris from the Trunch borehole of Norfolk, England, to reconstruct the evolution of upper ocean waters of the Boreal-Tethyan epicontinental shelf during the Late Cretaceous.

During the Cenomanian–Turonian, background ε_{Nd} values are in the range of -9 to -10, comparable to published high-resolution datasets from southern England. Unfortunately, OAE 2 is marked by a disconformity in the Trunch core. Surprisingly, our record shows a ~5 unit positive excursion during the mid–late Turonian, a larger shift than recorded in England during OAE 2. The εNd excursion coincides with cooling observed in oxygen-isotope and faunal records in the Chalk Sea, a positive $\delta^{13}C$ excursion, and sea-level change, suggesting a global driver of climate- and circulation change. High ε_{Nd} values up to -5.9 suggest that basalt-seawater interaction, probably in the Boreal Sea, accompanied the cooling.

After the late Turonian, Nd-isotope values return to relatively steady background levels of -11 to -12 in the Coniacian–Campanian; this long-term stability of circulation in the Chalk Sea suggests that circulation in this region was neither driving nor responding to the long-term global cooling trend. Further, the strongly unradiogenic signature of the Trunch record suggests a decline in influence from other water masses—Boreal or Tethyan—consistent with a restriction of low-latitude Pacific–Tethyan gateways.

Our ε_{Nd} data, particularly the unexpected Nd-isotope variability in the Turonian, highlight the necessity to look beyond abrupt climate perturbations and to generate long-term continuous proxy records to gain a thorough understanding of climate processes in a greenhouse world.