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Searching for the Mesozoic pelagic carbonate revolution

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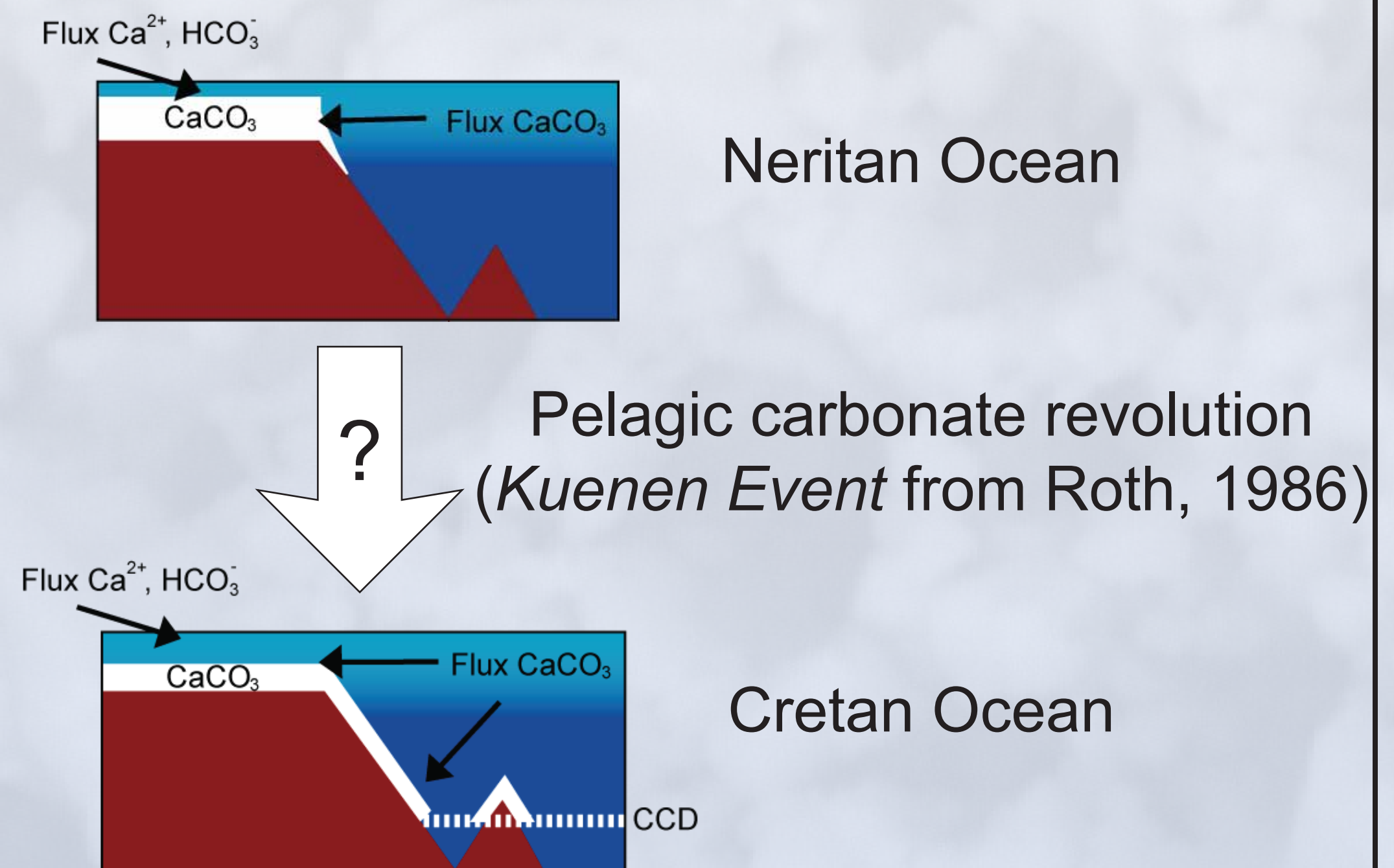
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Introduction :

Carbonate accumulation is largely sustained by **pelagic carbonate producers**, in the form of calcite platelets (calcareous nanofossils including coccoliths) produced by calcifying haptophyte algae and the calcite tests of planktic foraminifera. Although deep-sea carbonates (calcareous oozes or chalks) have production and accumulation rates that are orders of magnitude lower than shallow water carbonates, they cover a basin area that is orders of magnitude larger. Pelagic carbonate producers were not present all along the Phanerozoic. The first part of the Phanerozoic is considered as a time interval where the **carbonate production was supported by benthic producers** in carbonate platforms and is referred as *Neritan Ocean* (Zeebe and Westbroek, 2003). The second part of the Phanerozoic is referred as *Cretan Ocean* where the **carbonate production was supported by pelagic producers** still relevant in modern oceans. The transition from Neritan to Cretan oceans is considered to be an important **revolution in oceans** history, deeply changing the organization of the carbonate system and, among other, leading to the formation of the carbonate compensation depth (CCD). This pelagic carbonate revolution, named by Roth (1986) the *Kuenen Event* is supposed to occur during the Mesozoic in relation with the emergence of calcareous nanofossil. In this study, we explore the **timing of the Kuenen Event** based on **quantification of calcareous nanofossils accumulation and mass accumulation**, calcareous nanofossil diversity and assemblage mean size and qualitative observations of pelagic carbonate deposits.

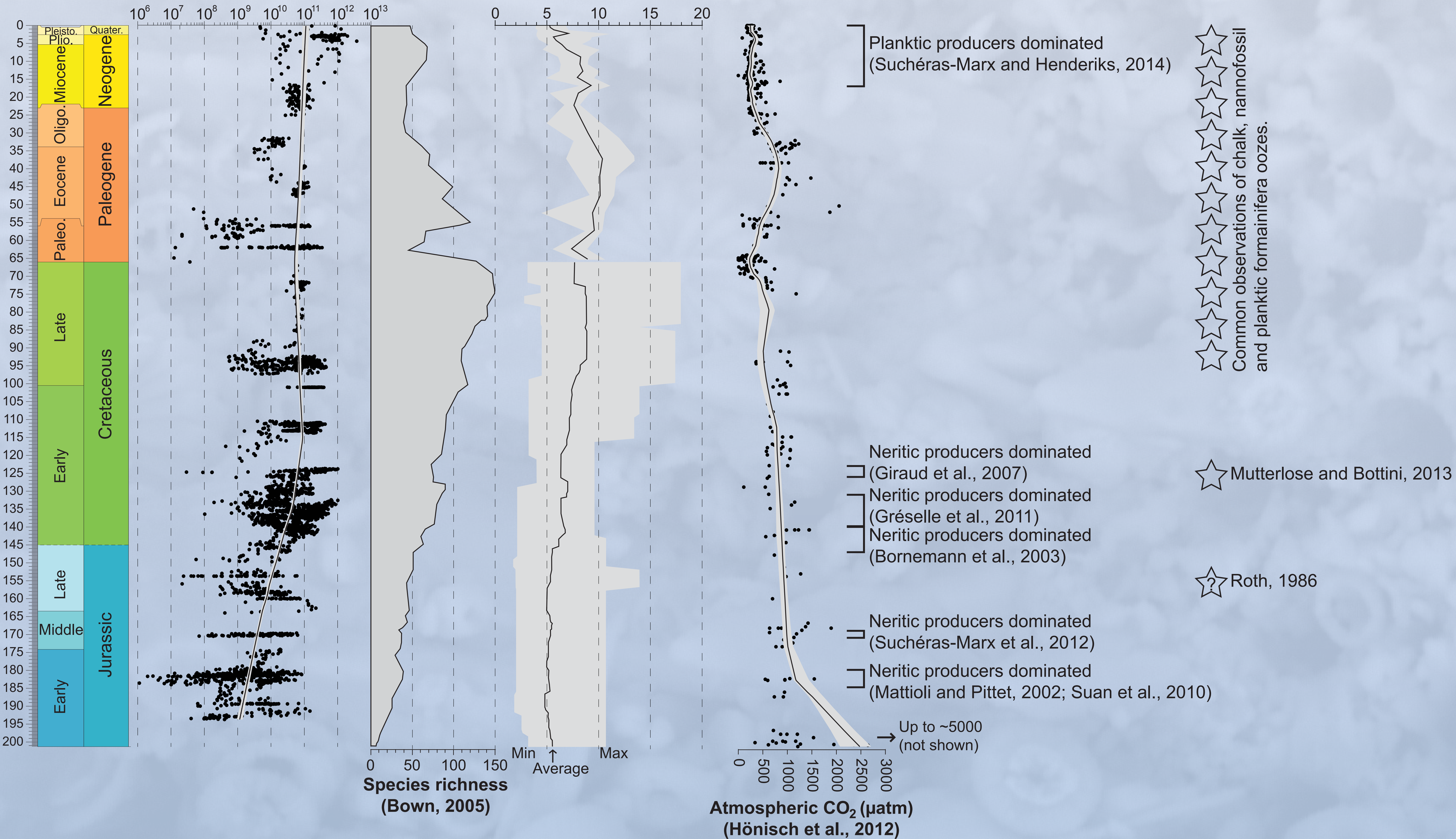


Nannofossil flux (nannofossil/m²/yr)

Coccolith assemblage mean size (µm) (Cenozoic; Herrmann and Thierstein, 2012) (Mesozoic; Aubry et al., 2005)

Quantitative studies of carbonate producers in pelagic/hemipelagic deposits

Qualitative observations of planktic producers dominated carbonate deposits



Nannofossil flux evolution :

We have compiled **quantitative data** of absolute abundances and burial **fluxes** of calcareous nanofossils over the past **200 Myr**. The nannofossil burial flux **increases** from the Early Jurassic up to a **maximum during the Early Cretaceous**. After, the burial fluxes fluctuate but maximum values are stable. Meanwhile, the **nannofossil diversity increases** during the Mesozoic up to a maximum at the K/Pg boundary. After high diversity during the Paleocene/Eocene interval, nannofossil species abundance decreases reaching minimum and relative low diversity in the Neogene. The coccolith assemblage size mean has the same evolution as diversity suggesting **dependence** of size from diversity. Comparing those three records, we propose a model of nannofossil evolution for the Mesozoic in two steps: 1) **Invasion** of environments from the Early Jurassic to the Early Cretaceous; 2) **Specialization** of nannofossils leading to compartmentalization of ecological niches until the K/Pg boundary.

Carbonate production revolution :

Calcareous nanofossils first occurrence is observed during the **Late Triassic** but with low diversity and abundance. According to qualitative observations, **nannofossil-dominated deposits** only occurred during the **Late Jurassic** or the **Early Cretaceous**. But both observations are challenged by quantitative studies. Common occurrence of chalk or carbonate oozes produced by planktic producers started during the **Late Cretaceous**. The occurrence of pelagic sediments resulting from planktic producers is **not synchronous** with the Early Cretaceous nannofossil flux maximum. The **planktic foraminifera** diversified and increased in abundance at the **end of the Early Cretaceous**. Hence, the emergence of pelagic carbonate accumulation in the Late Cretaceous is related to the **concurrent nannofossil and planktic foraminifera productions**. We consider the *Kuenen Event* to correspond to a **long term event** started with the appearance of calcareous nanofossils and ended with planktic foraminifera diversification.

Perspectives :

There is **no clear abiotic forcing** identified that has led to the increase in nannofossil and the emergence of pelagic carbonate accumulation. Despite relative similarities between nannofossil flux and pCO₂, the **mechanistic link** between both is not yet identified. The carbonate pelagic revolution may be the results of **concurrent biotic evolution and abiotic changes** that need further explorations.