

Global change of carbon isotopic composition of the biosphere during the Cenozoic

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Data on isotopic composition of marine organic carbon reveal a clear change toward the more negative values (in terms of $\delta^{13}\text{C}$) with the geological age. A major 2–4‰ shift in $\delta^{13}\text{C}$ values of organic carbon occurs between the Late Eocene and Early Miocene. At the same time, the isotopic composition of land derived organic carbon remained relatively constant during geological time. Thus the commonly accepted idea that terrestrial carbon is isotopically lighter than marine carbon is valid only for the recent environments and for sediments not older than Miocene. For older sediments the reverse situation takes place.

The 'age-phenomenon' for organic carbon in

marine sediments is not only a matter of change in the isotopic composition of total organic carbon, but is also manifested in a major change in the isotope distribution pattern between fractions of organic matter. Aquahumic type (Galimov, 1985) becomes dominant in the Late Cenozoic.

The carbonate carbon also shows a trend with age, and it is the most striking fact that the trends for the isotopic composition of organic and carbonate carbon during the Late Cenozoic are opposite.

Previously, relative enrichment of Cretaceous black shales in the light carbon isotope has been noted and explained as a specific feature of Cretaceous sedimentary basins due to higher

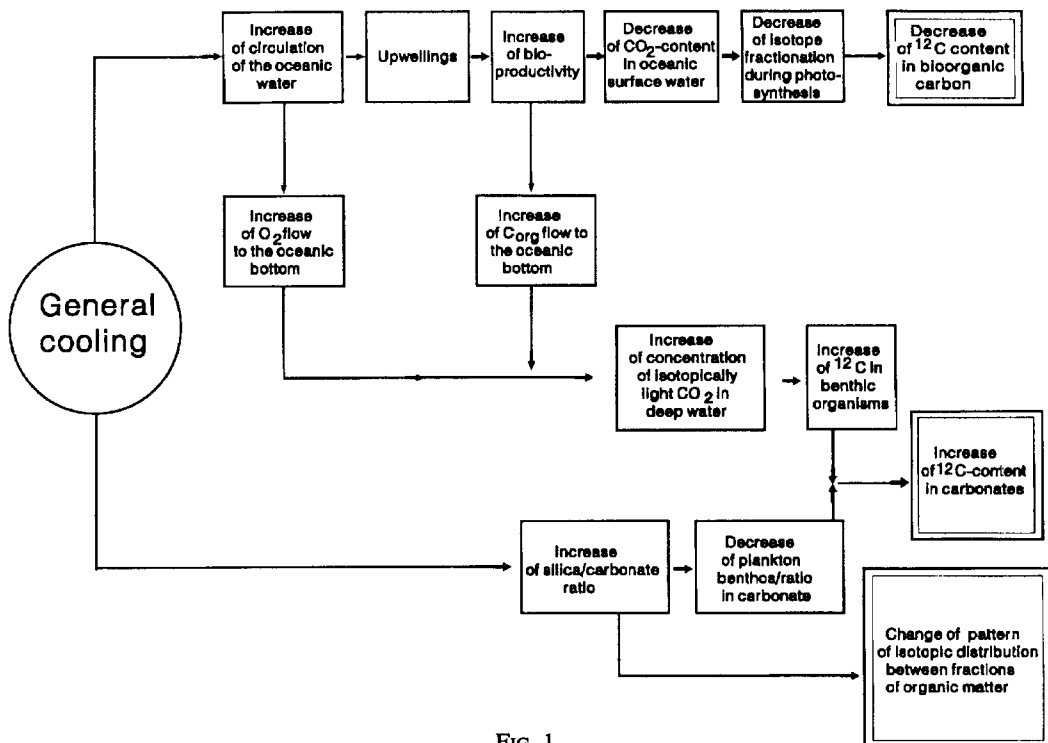


FIG. 1.

concentration of CO₂ in the coeval atmosphere (e.g. Popp *et al.*, 1989). However, it seems to be that the 'age-phenomenon' is not a Cretaceous age-effect, but rather an effect which is related to events of the Late Cenozoic.

I believe that a continuous global cooling during the Cenozoic was a primary factor that triggered processes that affected the carbon isotope cycle. Warm conditions prevailed during the Palaeocene and the earliest Eocene. Then a cooling trend began, which has characterised the last 50 m.y. of Earth history.

General cooling led to increased ocean water circulation and as a consequence to the higher bioproductivity in the ocean (Fig. 1). In turn, increase in bioproductivity led to higher consumption of CO₂ from the surface layer of oceanic waters. As a result, dissolved inorganic carbon in the surface layer was depleted in the light isotope. Permanent decrease of average concentration of CO₂ in the surface waters may cause decrease of isotope fractionation during photosynthetic assimilation of CO₂. Eventually organic carbon produced by planktonic marine organisms becomes isotopically heavier.

At the same time, due to the increase of bioproductivity followed by increased flux of organic carbon to the bottom and with enhanced circulation of the oceanic water during cooling, an increased flux of isotopically light CO₂ reaches the seafloor. Hence, benthic organisms produced

carbonate that was enriched in the light carbon isotope.

There is evidence that mineral composition of planktonic organisms shifted during the Late Cenozoic from carbonate to siliceous material. This may have two important consequences. The first is a decrease in the contribution of relatively isotopically heavy planktonic carbonate into the total carbonate sedimentation, thereby maintaining the trend to depletion of carbonate sediments in the heavy isotope during the Late Cenozoic. The second is a better preservation of organic carbon related to siliceous skeletal material and hence dominance of the aquahumic type of inter-fraction isotope distribution during the Late Cenozoic.

Thus global change of climate and associated change of mineral composition in marine organisms may have caused the observed isotope trends and relationships.

References

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