

Early Eocene global gross primary production from triple oxygen isotope measurements of fossil teeth

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Global gross primary production (GPP) is the rate of carbon fixation by all primary producing organisms globally, and as such is a measure of the vitality of life on Earth. GPP is an important but understudied aspect of the Earth system, with few estimates for time periods earlier than the Pleistocene. However, triple oxygen isotopes offer a new approach for estimating ancient GPP based on empirical evidence [1]. Mass independent photochemical reactions in the stratosphere yield O₂ with a strongly negative triple oxygen isotope anomaly ($\delta^{17}\text{O}_{\text{O}_2}$). The magnitude of the anomaly is dependent on three first-order parameters: atmospheric O₂ concentration, CO₂ concentration, and GPP. The relationship between these variables has been extensively modelled [2,3] which enables constraints to be placed on GPP given reconstructed values for $\delta^{17}\text{O}_{\text{O}_2}$, [CO₂], and [O₂].

Vertebrate bioapatites record $\delta^{17}\text{O}_{\text{O}_2}$ because they form in equilibrium with body water, which includes the products of respiration [4]. Here we present GPP reconstructions from the Early Eocene Climate Optimum (EECO) informed by $\delta^{17}\text{O}$ measurements of fossil mammal teeth from the Willwood Formation in Wyoming, USA. We use triple oxygen isotope enabled animal body water models and a multi-taxon approach to constrain the $\delta^{17}\text{O}_{\text{O}_2}$ signal recorded by these animals. With these data and recent estimates of [CO₂] from boron isotopes and alkenone proxies [5], we place constraints on GPP during the EECO.

References

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