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New insights from summer paleotemperatures deduced from stable isotope (δ^{18}O) composition of shallow-marine and freshwater algae in the Paleogene of the Paris Basin

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The Paleogene constitutes the climatic transition between the Paleocene – Early Eocene greenhouse world and the icehouse period entirely established since the Eocene – Oligocene cooling event ($\sim$ 34 Ma). For this period, paleoclimatic data originate mainly from the δ^{18}O of deep-sea benthic foraminifers and to a lesser extent from planktonic foraminifers. These previous works have successfully documented the climatic evolution in oceanic domain. However, the deep-sea record presents some limitations because only mean annual temperatures can be estimated from these proxies and important climate parameters such as the seasonal gradient of temperatures cannot be adequately informed. Moreover, oceanic environments are less sensitive to short duration and low intensity climatic events, giving a partial vision of the Cenozoic climate. Thus, it would be particularly significant to characterize how other environments like coastal and non-marine domains have been affected by these temperature fluctuations during this major climatic transition.
In this study, we test the potentiality of using dasycladales and charophytes, calcareous shallow-marine and freshwater algae respectively as palaeoclimatic recorders. These algae mineralize their carbonate during short periods in summer. Throughout the Palaeogene, we compare the δ^{18}O record of these two taxa to identify a possible common factor influencing their isotopic composition, i.e. temperatures variations, from a local environmental signal (δ^{18}O of water). We sampled and isotopically analyzed eight species of charophytes and seven species of dasycladales from 23 formations ranging from the Palaeocene to the Oligocene deposits of the Paris Basin. By comparing the δ^{18}O of these two groups living in different environment with that of shallow-marine mollusks from a previous study, we show that temperature variations are the main factor influencing their δ^{18}O compositions and that local environmental effects do not disturb the overall thermal signal. Maximum annual palaeotemperatures are calculated from the δ^{18}O of the dasycladales and indicate by comparison with the data of previously analyzed mollusks that these algae probably mineralized their carbonate in equilibrium with sea-water. Dasycladales recorded the global climatic events already known for the Palaeogene, with high temperatures reached during the Early Eocene and Middle Eocene climatic optimums and relative cooling intervals during the Lutetian, the Priabonian and the Rupelian. Charophyte gyrogonites also recorded temperature variations in their δ^{18}O compositions but reconstituting reliable temperature values in non-marine environments is not directly possible and requires constraining δ^{18}O of local continental water using other proxies. These promising results show that carbonates biomineralized from algae constitute a reliable support for palaeoclimatic information and should be more widely used in the fossil record.