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Lipid biomarkers fingerprint petrogenic organic carbon along the terrestrial-aquatic continuum in the past and present

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Petrogenic organic carbon (OC_{petro}) represents ancient and relatively thermally mature organic carbon. Exhumation and lateral transport exposes OC_{petro} to weathering along the terrestrial-aquatic continuum. If oxidised, OC_{petro} could become an important source of CO_2. The oxidation efficiency is strongly controlled by physical erosion and basin geomorphology, such that large meandering rivers are typically characterised by higher oxidation efficiency. Globally, the oxidation of OC_{petro} is estimated to release as much CO_2 annually as from volcanic degassing [1]. Yet despite its importance in the present, the role of this biogeochemical cycle in the geologic past is unknown due to the lack of suitable proxies.

Lipid biomarkers have shown promise as a proxy to fingerprint OC_{petro} in the geologic record, as they undergo structural alterations with increasing thermal maturation. Hopane-based thermal maturity ratios have long been utilised in the field of petroleum geochemistry to assess source rock potential. However, recent work has demonstrated that it can be applied to fingerprint OC_{petro} in shallow marine sediments dated to the Paleocene-Eocene Thermal Maximum (~56 Ma) [2]. The PETM is associated with global warming and an intensification of the hydrological cycle. We show that multiple sites exhibit a greater delivery of OC_{petro} into the ocean during the PETM [3]. Whilst hopanes can fingerprint OC_{petro} burial in the past, this organic geochemical proxy has yet to be validated in modern sediments. We compile and generate data from the Mackenzie River, the longest river in Canada. This site is an ideal testbed to evaluate the lipid biomarker approach because there is a mixture of both OC_{petro} and biospheric organic carbon, and this has been identified by other proxies (i.e. rhenium and radiocarbon content). To achieve this, we acquired suspended, bedload, and bank sediments from four localities along the Mackenzie River and its tributaries. Preliminary results indicate diagenetically altered compounds in tributaries with greater contributions of OC_{petro}. This work demonstrates that lipid biomarkers may be a novel tool to fingerprint OC_{petro} in past and present environments.

[1] Zondervan et al (2023), Nat., 623
[2] Lyons et al (2019), Nat. Geosci., 12
[3] Hollingsworth et al (2024), Paleoceanogr. Paleoclimatol., 39