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Lipid biomarker record in surface sediments at three sites of contrasting productivity in the tropical North Eastern Atlantic

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Abstract

Selected lipid biomarkers were analyzed in modern aerobic surface sediments from the tropical NE Atlantic off the Mauritanian coast, in the frame of the JGOFS EUMELI program. This paper explores how sedimentary molecular proxies record productivity and vascular plant inputs. Dry weight-normalized concentrations and TOC-normalized concentrations of biomarkers poorly matched the gradient of higher-plant inputs and of primary productivity. In contrast, mass accumulation rates of long-chain *n*-alkanols and *n*-fatty acids (80–710 and 210–1750 μg m^{-2} yr^{-1}, respectively) showed good agreement with dust inputs transported between 15 and 24°N by NE trade winds, whereas long-chain *n*-alkanes showed a distinct pattern. At the coastal site, *n*-alkanols and *n*-fatty acids predominated over long-chain *n*-alkanes. Cross-shelf changes in proportions of *n*-fatty acids and *n*-alkanols relative to *n*-alkanes point to an increased degradation of terrigeneous waxes when going offshore. The cross-shelf C/N ratio poorly registered vascular plant inputs, most probably because denitrification influenced C/N values at the eutrophic site.

Mass accumulation rates of phytoplanktonic biomarkers declined from the eutrophic to the oligotrophic site, reflecting the primary productivity variation. Mass accumulation rates of highly branched isoprenoid hydrocarbons, C37 *n*-alkenones, *n*-alkyl diols and dinosterol varied from 3 to 410, 9 to 1600, 12 to 360 and 7 to 320 μg m^{-2} yr^{-1}, respectively. They target the productivity of *Haslea*-type diatoms, coccolithophorids, eustigmatophytes and dinoflagellates. While the results encourage the development of molecular proxies of palaeoproductivity and of palaeophytocommunities, progress is still needed to deconvolute the impact of degradation on mass accumulation rates and to move towards quantitative calibrations.

Keywords: North Eastern tropical Atlantic; Hydrocarbons; *n*-Alkenones; *n*-Alkanols; *n*-Alkyl diols; Sterols; Higher plants; Primary productivity

1. Introduction

Marine sediments are sinks for organic carbon produced by marine phytoplankton and land plants, the latter by aeolian and river transport. Lipid biomarkers in marine sediments can be used to infer past variation of important drivers of the climate system. For instance, higher-plant cuticles contain waxes, corresponding to long-chain *n*-alkanes, *n*-alcohols and *n*-fatty acids, which are transported over remote ocean areas by aerosols (Simoneit, 1977; Simoneit et al., 1991, 1977). These lipids preserved in sediments have helped to reconstruct past variations of land vegetation coverage combined with wind direction and intensities (Simoneit and Eglinton, 1977; Poynter et al., 1989; Sicre et al., 2000; Pancost and Boot, 2004). Community structure of

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Table 1
Benthic characteristics and bulk composition of the studied sediments at the three EUMELI sites

	Eutrophic site	Mesotrophic site	Oligotrophic site
Primary productivity (mg C m^{-2} yr^{-1})	47[a]; 100[b]	125[a]; 250[b]	47[a]; 100[b]
Bottom currents			
Mean speed (cm s^{-1})[c,d]	20	5	3
Max speed (cm s^{-1})[c,d]	40	15	10
Sediment dynamics and characteristics			
Accumulation rates (cm/1000 yr)[e]	4.4	1.5	0.5
Measured ^{210}Pb vertical fluxes/expected flux near the sea floor[f]	5.3–6.3	1.18	0.68
Bioturbation rates (cm^2 s^{-1})[g]	(50–200) 10^{-9} (homogeneous layer)	(30–70) 10^{-9} (homogeneous layer)	(0.3–0.6) 10^{-9} (sediment depth 0–2 cm)
Mixing layer thickness (cm)[g]	12–15	8–9	2
Annual OC flux at the sediment interface (g C m^{-2} yr^{-1})[h]	6	1.8	0.4
$CaCO_3$ (%)	40[e]; 45[i]	62[e]; 65[i]	72[e]
Dissolved SiO_2 in interstitial waters at 30 cm depth (mmol L^{-1})[g]	350	250	80

Sample location and bulk content

Sample name	ES	ED		M1	M2			O1	O2	
EUMELI Sample code	KGS37	KTB9		KGS11	KTB6			KTB10	KTB3	
Latitude	20°28.42′N	20°31.97′N		18°30.17′N	18°31.96′N			21°02.51′N	21°00.61′N	
Longitude	18°04.61′W	18°35.90′W		20°59.71′W	21°03.12′W			31°11.39′W	31°13.75′W	
Depth (m)	1069	2030		3124	3121			4593	4589	
Organic carbon (mg g^{-1})	17.48	25.36	27.0[j]	3.44	4.09	3.73–4.29[d]	2.0[j]	2.42	2.46	2.33–2.69[d]
Organic nitrogen (mg g^{-1})	0.83	1.56		0.42	0.33			0.32	0.29	
C/N weight ratio (relative units)	21.1	16.3		8.1	12.4			7.6	8.5	
∑Free lipids/TOC (%)[k]		3.5			5.4	4.6–8.9			3.7	3.46–9.96

[a] Auffret et al., 1992.
[b] Morel, 1996.
[c] Cosson et al., 1997.
[d] Galéron et al., 2000.
[e] Auffret et al., 1992.
[f] Legeleux et al., 1996.
[g] Legeleux et al., 1994.
[h] Modelled by Rabouille et al., 1993.
[i] Stein, 1991.
[j] Stein, 1991 (surface values).
[k] From Relexans et al., 1996 (0–1 cm).