Probing subsurface life with intact membrane lipids

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Studying prokaryotic life in deeply buried sediments and rocks is a challenging task due to extremely low population densities and activities. Intact Polar Lipids (IPLs), i.e., lipids that comprise the membrane of every cell, are very labile against hydrolytic cleavage of their polar headgroup and thus, when found in environmental samples, considered as reliable indicators for live organisms. Using a high-performance-liquid-chromatograph coupled to an ion-trap multistage mass-spectrometer (HPLC-IT-MS^n) we examined IPL distributions from deeply buried, cold sediment and rock collected from the Peru Margin (Eocene to Pleistocene) and the Demerara Rise (Paleocene to Late Cretaceous). Miniscule quantities of IPLs are consistent with generally low cell counts ranging from $>10^9$ to $<10^6$ cells per mL. The lowest concentrations were observed in Cretaceous (marls, carbonates, black shales) suggestive of about 10^5 cells/mL. Compared to surface sediments where arrays of structurally diverse IPLs signify complex microbial communities, the diversity of lipids in deeply buried strata is very low. Independent of the location and geological age of the sediment, the identifiable compounds are dominated by archaeal glyceroldialkylglyceroltetraethers with glycosidic headgroups. The presence of mesophilic crenarchaea is indicated by distinct structural features such as a calditol-based headgroup and the presence of crenarchaeol-derived alkyl chains. Unambiguous bacterial signals were only detected in a small fraction of deeply buried samples. Unlike some molecular-genetic techniques applied by our collaborators in parallel on comparable samples, IPLs suggest the presence of a deep biosphere dominated by archaea.