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Lipid composition and methanotrophic diversity in different fluid venting environments of the Nile deep-sea fan, Eastern Mediterranean.

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A comprehensive study of fluid seepage through the seabed has been performed during the NAUTINIL cruise (September-October 2003) in the Nile deep-sea fan. The aim of this study was to identify and to compare the occurrence of specific archaeal and bacterial lipids in the sediments and methane-related carbonates collected from venting sites which differ in the chemicals emitted (methane, wet gas, oil, sulfide, brines, etc.).

Our results show the presence of anaerobic methanotrophs (ANME) at all studied MVs. Based on the biomarker concentrations, the highest methane-derived biomass signal was detected in the methane-related carbonates and surrounding sediments from the North Alex MV, the site where spontaneous free-gas emanations have been observed. The distributions of specific ^{13}C-depleted archaeal biomarkers (isoprenoidal dialkyl glycerol diethers, glycerol dialkyl glycerol tetraethers, pentamethylicosane, crocetane) indicate a variability of the archaeal populations in the sediments with depth whereas carbonates show more stable composition, which, based on the lipid composition, could relate to both ANME-1 and ANME-2 archaeal groups. Biomarkers of sulfate-reducing bacteria (non-isoprenoidal diethers) were detected only in the carbonates. The hosting sediments show the presence of other ^{13}C-depleted bacterial lipids (hopanols). This does not necessarily mean that sulfate-reducing bacteria are absent in this environment; it may indicate that the occurrence of non-isoprenoidal diethers is limited to a specific group of sulfate reducers.

A novel association of archaeal lipids was found in the Chefren MV, where a new type

of ecosystem with “iron” and “sulfur” precipitates and microbial mats was discovered during the cruise. Besides methane, this setting is characterized by the emanation of brine fluids. The distribution of isoprenoidal tetraethers from both the “iron” and the “sulfur” mat settings showed the dominance of a tetraether containing four cyclopentane moieties. This specific archaeal tetraether is not abundant in membranes of methanotrophic archaea thriving in cold-venting environments and may be an indicator of AOM at higher temperatures (Schouten et al., 2003). An independent 16S rDNA study of the same samples from the Chefren MV revealed two archaeal guilds, the ANME-2 archaeal group and a group of archaea in the Thermoplasmales lineage. The latter are known to possess such four cyclopentane-bearing tetraethers in their cell membrane (Macalady et al., 2004). Hence, both biomarker and 16S rDNA data indicate the co-occurrence of two contrasting archaeal groups in the same fluid venting environments.

Bacterial biomarkers such as diplopterol (aerobic methanotrophic bacteria) and tetrahymanol (bacterial ciliates) were only found in the Chefren MV, in both “iron” and the “sulfur” mat settings. Furthermore, specific sterols, previously only found in cultures of aerobic methanotrophic bacteria *Methylococcus capsulatus* (Bird et al., 1971) and *Methylosphaera hansonii* (Schouten, et al., 2000), were detected in these sediments, indicating the presence of aerobic methanotrophs. This was confirmed by analysis of bacterial 16S rDNA from this setting. The δ^{13}C values of the sterols, diplopterol, and archaeal lipids are all depleted (-60‰ to -90‰), confirming that carbon from methane is used for biomass production.