



Active hydrocarbon (methane) seepage at the Alboran Sea mud volcanoes indicated by specific lipid biomarkers.

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Mud volcanoes (MVs) and pockmark fields are known to occur in the Alboran Basin (Westernmost Mediterranean). These MVs occur above a major sedimentary depocenter that includes up to 7 km thick early Miocene to Holocene sequences. MVs located on the top of diapiric structures that originated from undercompacted Miocene clays and olistostromes. Here we provide results from geochemical data-analyses of four gravity cores acquired in the Northern Mud Volcano Field (north of the 36°N): i.e. Perejil, Kalinin and Schneiders' Heart mud expulsion structures. Extruded materials include different types of mud breccias. Specific lipid biomarkers (n-alkanes, hopanes, irregular isoprenoid hydrocarbons and Dialkyl Glycerol Diethers (DGDs) were analysed by gas chromatography (GC) and gas chromatography mass spectrometry (GC-MS). Determination of Glycerol Dialkyl Glycerol Tetraethers (GDGTs) by high performance liquid chromatography-spectrometry (HPLC-MS), and analysis of biomarker $\delta^{13}C$ values were performed in selected samples. Lipid biomarker analysis from the three MVs revealed similar n-alkane distributions in all mud breccia intervals, showing significant hydrocarbon-derived signals and the presence of thermally immature organic-matter admixture. This suggests that similar strata fed these MVs. The hemipelagic drapes reveal comparable n-alkane distributions, suggesting that significant upward diffusion of fluids occurs. Distributions of GDGTs are generally accepted as useful biomarkers to locate the anaerobic oxidation of methane (AOM) in marine sediments. However, our GDGT profiles only reflect the marine thaumarchaeotal signature. There seems to be no archaea producing specific GDGTs involved in AOM in the recovered interval. Evidence of recent activity (i.e. methane gas-bubbling and chemosynthetic fauna at the Perejil MV) and the presence of specific lipid biomarker related with methanotropic archaea (Irregular Isoprenoids and DGDs), however, suggest the existence of AOM in the mud breccias. Preliminary $\delta^{13}C$ measurements of crocetane/phytane reveal depleted values (from -65.4‰ to -36.6‰, supporting the existence of AOM in these MVs. The absence of the specific GDGT signal in combinations with other indications for AOM may suggest that predominantly ANME-2 archaea, which do not produce GDGTs, are responsible for AOM in the Northern Mud Volcano Field from the Alboran Sea. In summary, our biomarker study reveals: 1) the northern Alboran mud volcanoes derives from similar source rocks containing thermally immature organic-matter; 2) The organic-matter present in the extruded materials is affected by methane-rich fluids from low-activity seepage.

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