Structure and function of a cold seep nurtured by seepage of heavy oil

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Petroleum seeps, accompanied by the presence of chemosynthetic life are a common characteristic of the Gulf of Mexico. In 2003 scientists discovered a distinct oil-driven cold seep ecosystem hosting diverse chemosynthetic fauna at the Campeche Knolls in 3000 m water depth. Here, seepage of asphaltene-rich heavy oil forms tar mounds at the seafloor by an unknown process termed asphalt volcanism [1]. Using a combination of molecular and isotopic methods we investigated the Chapopote Knoll, where asphalt deposits cover an area of about 1 km^2.

Analysis of the stable carbon isotopic composition ($\delta^{13}C$) of methane and higher hydrocarbon gases in oil-laden sediments suggests that the occurrence of oil stimulates methanogenesis and sulfate reduction. However, the vast majority of methane trapped as gas hydrates in the pores of the asphalts represents a mixture of both thermogenic and biogenic origin ($\delta^{13}C$ of -50‰). Dense microbial mats cover freshly erupted asphalts some of which were saturated with methane. The mats and the uppermost surface of the asphalt consist of aerobic methanotrophs, sulfate reducers, and sulfide oxidizers, some samples also contained anaerobic methanotrophs, comprised mainly of ANME-2 archaea. This assemblage of microbes indicates a steep oxygen gradient within the mat and is consistent with an anaerobic metabolism associated with the asphalts. Investigation of the different asphalt samples by comprehensive two-dimensional gas chromatography shows the selective loss of compounds like *n*-alkanes, isoprenoids and polycyclic aromatic hydrocarbons due to biodegradation and weathering processes, respectively. These post-depositional alteration processes ultimately resulted in a successive colonization of different cold seep fauna.

[1] MacDonald I.R *et al*. (2004), *Science* **304**, 999-1002.

Iron isotope fractionation in soil suspensions at controlled redox conditions

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Gleysols are characterised by a pronounced variation of the redox conditions due to fluctuations of the groundwater table (GWT) which result in oxidising (low GWT) and reducing conditions (high GWT), respectively. Analyses of Fe isotope compositions in a gleysol from NW Germany yielded $\delta^{57}Fe$ values of +0.3 ‰ (Ah horizon) to ca. -0.2 ‰ (Gor horizon). At reducing conditions, iron is mobile as Fe^{2+}. In an experimental study lasting 40 days, suspensions of gleysol horizons (Ah, Gor) were subject to controlled redox conditions ranging from oxidising ($E_{H,\ pH\ 7}$ > 550 mV), moderately reducing ($E_{H,\ pH\ 7} \approx$ 330 mV), and reducing conditions ($E_{H,\ pH\ 7}$ ≈ 100 mV). Temperature, pH, and Fe concentrations were also monitored, the suspensions were additionally stirred permanently to ensure homogenisation. Solutions taken every other day from the suspensions were membrane-filtered, Fe was separated from the matrix via anion exchange chromatography. Iron isotope measurements were conducted on the Neptune MC-ICP-MS at Universität Bonn using Cu for mass bias correction. The results show that the Fe isotope compositions vary with respect to the redox conditions. We noted light $\delta^{57}Fe$ values of ca. -0.4 ‰ in the solutions at moderately reducing conditions, and $\delta^{57}Fe$ values of around -1 ‰ for reducing conditions. At oxidising conditions, $\delta^{57}Fe$ values scattered around +0.3 ‰. As expected, Fe concentrations increased substantially at reducing conditions. This indicates a preferential mobilisation of ^{54}Fe into aqueous solutions at reducing conditions, leaving a residue enriched in heavy Fe isotopes.