Isotopic evidence for microbial oxidation of dissolved methane in the Gulf of Mexico oil spill deep plume

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The blowout of BP's Macondo well and subsequent sinking of the Deepwater Horizon drilling platform on April 20, 2010 led to one of the largest oil spills in history. By the time the well was capped on July 12, 2010, ~4.9 million barrels of oil are estimated to have leaked into the Gulf of Mexico. Accompanying this spill was the development of a deep plume of dispersed oil and dissolved gases at a depth of 1100-1200 mbsl that was detected at distances of up to 35 km from the wellhead. The $\delta^{13}C$ values of dissolved hydrocarbon gases (C1-C5) and BTEX compounds in 77 samples collected from in and around the deep plume between May 28, 2010 and August 24, 2010 were analyzed to track the fate and potential biodegradation of those compounds. C2 to C5 gases and BTEX compounds were only high enough for $\delta^{13}C$ analyses in samples collected before mid-June. The $\delta^{13}C$ values of these compounds remained within ±2‰ of $\delta^{13}C$ values of samples from the Macondo well. CH_4 concentrations in early plume samples (collected before mid-June) were as high as 300 μM, but dropped off significantly in later samples. The $\delta^{13}C$ of CH_4 in the early samples were between -57‰ and -59‰ compared to an average $\delta^{13}C$ value of -58‰ for samples from the Macondo reservoir. After mid-June, CH_4 from some of the samples had higher $\delta^{13}C$ values. The last two CH_4 samples with measurable $\delta^{13}C$ values were collected during early August, 3 weeks after the well was capped and had $\delta^{13}C$ values of -44‰ and -23‰. For a fractionation factor of 0.984 for microbial oxidation of CH_4, those values indicate 60% and 90% oxidation of the methane, respectively. These samples coincided with drops in the dissolved oxygen concentrations in the water column of ~1.5 mM also suggesting increased aerobic microbial activity. In addition, the $\delta^{13}C$ values of bacterial phospholipids extracted from a single sample were lower than normal background biomass, suggesting that the bacteria were consuming CH_4 and other hydrocarbons with lower $\delta^{13}C$ values than the background organic matter.

Dynamics of the Pliocene East Antarctic Ice Sheet revealed by isotopes in marine sediments

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Our understanding of the dynamics of the East Antarctic Ice Sheet (EAIS) during the climatically warm early Pliocene, and the transition to the cooler, but more variable late Pliocene, is limited. Integrated isotope analyses of detrital marine sediments from ODP Site 1165 (64°22-77S, 67°13-14E), Prydz Bay, East Antarctica, offer novel insights into the evolution of the East Antarctic Ice Sheet, and reveal the controls on sediment composition in a glacial environment. Here we investigate the $^{40}Ar/^{39}Ar$ ages of hornblende grains from ice-rafted detritus (IRD) (>150μm) and neodymium and strontium isotope fingerprints of detrital marine sediments (<63μm).

Early Pliocene sediments, deposited between 5.0 and 3.5 Ma, are dominated by hornblende IRD grains typical of the local Prydz Bay region ($^{40}Ar/^{39}Ar$ ages of ~500 Ma). However, fine-grained (<63 μm) material exhibits εNd values of -14, untypical of modern marine sediments in this area (εNd: -17 to -19). The source of these higher εNd values could be either the nearby Mawson coast (εNd: ~-15- to -14) or the distal Wilkes Land margin (-12.3 to -14.8), with sediments carried by bottom currents. Strontium isotopes, however, are more radiogenic than expected, an observation that could either be due to sedimentary sorting, continental weathering, or subtle shifts in provenance affecting Rb/Sr rations. Conversely, Late Pliocene sediments with depositional ages of 3.3 to 2.8 Ma display an increase in distally sourced Wilkes Land IRD ($^{40}Ar/^{39}Ar$ ages of 1100-1300 Ma). The IRD provenance signal is positively correlated to detrital $^{87}Sr/^{86}Sr$ and εNd signatures in the fine fraction of the same samples, indicating an increasing amount of material derived from the distal Wilkes Land margin (εNd: -12.3 to -14.8; $^{87}Sr/^{86}Sr$: 0.730-0.735). Our results imply that ice rafting played an important control on sediment composition in the late Pliocene, possibly related to the growth of the EAIS in a cooler Late Pliocene climate.

Overall, the radiogenic isotope composition of Pliocene detrital sediments in the Southern Ocean reflects changing environmental conditions as well as sedimentary processes. Interpretation of such data can provide a valuable framework for the interpretation of ice sheet instability events along the Antarctic continental margin.