

How Fast do Microbes Consume Organic Matter in Marine Sediments?

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Marine sediments are a significant reservoir of particulate organic carbon (POC) in the Earth's carbon cycle. As POC is deposited on the seafloor and buried, it is consumed by an active and diverse microbial community within the sediments. This POC remineralization drives a number of microbially-mediated reactions (including methanogenesis) and controls the amount of organic carbon that is ultimately buried for the long term. Different rate laws for POC remineralization in ocean sediments have been proposed, including a constant rate, one that diminishes with age, and one that increases with temperature. Few studies have considered a global data set when investigating organic carbon decay in sediments. Considering the worldwide data set can lessen local fluctuations in POC content and highlight the general trend of decreasing POC with depth and age due to remineralization. The goal of this project was to use the vast data set collected by scientific ocean drilling to investigate the remineralization rates of POC in marine sediments and the factors that determine these rates. Core data from the Deep Sea Drilling Project and the Ocean Drilling Program include measurements of POC content, age, and temperature of the sediment with respect to the sample depth. This data set was used to consider POC in sediments with respect to age by interpolating the age-depth models at each site. Sediment POC data were first examined in the 627 drill holes that had particulate organic carbon data as well as reliable age depth models. The POC content of samples younger than 1 Ma were plotted on a map to study the spatial distribution of POC deposition. 339 holes with high POC deposition in continental margins and high productivity regions were then considered independently to avoid skewing estimated remineralization rates with data from areas of very low POC content throughout the sediment core. The relationship between POC content and temperature was also explored in the 37 drill holes that had formation temperature measurements. Two dimensional histograms were produced from the data to visually inspect for effects of age and temperature on POC content in sediments. Trends of the mean and median of these histograms were considered. We observed clear decreasing trends of POC content with sediment depth and age. In the high POC data set, the overall time constant for an exponential decay (e-folding time) is about 4.8 million years. The POC amount that is not remineralized and is buried for the long term is about 0.25% of the sediment dry weight. The age plot shows features that were not detectable when considering organic carbon with depth (e.g., high POC deposition in Cretaceous black shales). The small data set with formation temperature data shows a decrease in POC content as T goes from approximately 15° to 20° C, suggesting temperature is also an important factor in POC remineralization.