Tales of Black Shales

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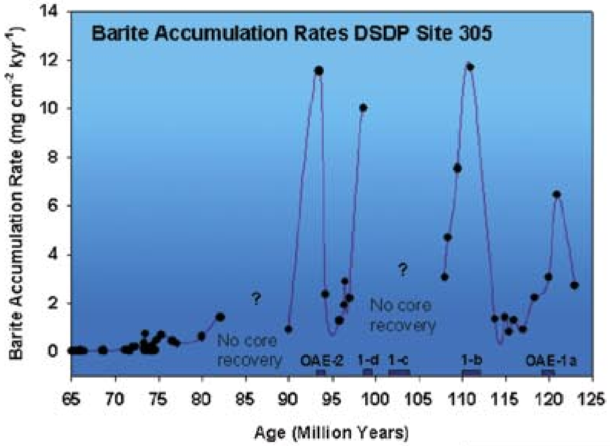
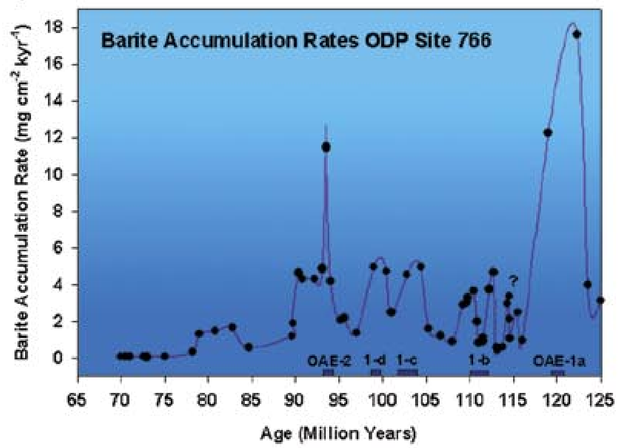
Barite Accumulation Rates in Cretaceous Sediments





Several times during the middle of the Cretaceous period, between 125 and 80 million years ago, organic-carbon-rich black shales were deposited over large areas of the ocean floor. These black shales provide valuable information about past climates. Organic matter is supplied to the sediment when ocean-dwelling organisms die and sink to the ocean floor — but the story doesn't end there. The organic matter is subsequently consumed via respiration — a process in which oxygen is used to burn-down organic molecules. Accordingly, organic matter accumulation in marine sediments depends on their production rate in the water column and on their destruction rate via oxidation, which in turn depends on the oxygen content of the oceans. During the mid-Cretaceous episodes described above, supply of organic matter to the sediment overwhelmed the process of respiration, which resulted in high organic carbon accumulation. Two opposing models have been offered to explain the increased burial rates of organic matter during these episodes: high biological productivity and ocean stagnation.

The high productivity model is based on the suggestion that a higher rate of oceanic biological productivity resulted in rapid supply of organic matter to the sediment. Moreover, extensive use of oxygen for consumption of these elevated levels of organic matter resulted in rapid lowering of the oceanic dissolved oxygen content, thereby producing a positive feedback and enhancing organic carbon accumulation. In contrast, the ocean stagnation model hinges on the suggestion that external physical processes — such as temperature and evaporation — induced intense vertical gradients of temperature and salinity, which resulted in stable stratification and reduced the oxygen supply to deep water thereby increasing preservation of organic matter.

To determine which one of these situations was prevalent in the mid-Cretaceous, scientists examined the accumulation rates of the mineral barite in several Deep Sea Drilling Program cores (see figures). Since barite forms in environments in association with decaying organic matter, its formation is directly related to productivity. The accumulation rate of barite has been found to peak during these mid-Cretaceous episodes, which implies that the high accumulation of organic matter during these episodes is a result of increased productivity that overwhelmed respiration in the open ocean environment. In contrast, no barite has been observed in the sediments in cores from shallow depth. This could be a result of either low productivity in coastal areas or from low barite preservation in sulfate reducing sediments, which are wide spread in shallow sites during the mid-Cretaceous.

The episodes of widespread organic carbon burial during the mid-Cretaceous most likely affected climate through sequestration of carbon dioxide, providing negative feedback to the greenhouse climate that was prevalent at that time. Similar processes may come into play in the assessment and regulation of potential future greenhouse conditions.