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Mechanisms of Carbon Sequestration within the Organic Rich Miocene Monterey Formation

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Table of Contents

Table of Tables

Table of Figures

ABSTRACT

Carbon preservation in the geological past has been an important process for global climate and the onset of glacial events. The majority of carbon preservation occurs in marine continental margin settings that consist of fine grained sediments like the Monterey Formation, California, USA. The mechanisms driving carbon preservation remain highly controversial and the Monterey Formation has served as a prominent test case used to determine these mechanisms. Organic-carbon rich deposits in this formation have been attributed to high organic productivity enhanced fluxes of organic matter (OM) to the sea floor and/or enhanced OM preservation through anoxia. In this study, the Monterey Formation was used as a natural experiment to focus on a new mechanism of carbon preservation, in the form of mineral surface area (MSA) as a control on total organic carbon (TOC). Mineral surface area was determined using the Ethylene Glycol Monoethyl Ether free surface procedure and TOC was derived from high temperature combustion. The relationship between the OM and the surface of the shale samples was viewed using an environmental scanning electron microscope (ESEM) with micron resolution. The major findings indicate a first-order relationship between MSA and TOC, where the mineral surface area adsorption of organic carbon offers an alternative mechanism and control for carbon preservation. This relation is held most strongly in bioturbated intervals as it is indicating oxygenated bottom waters and lower biological productivity intervals which are indicated by carbonate microfossils. Intervals with laminated siliceous sediment reflective of alternative oceanographic hypotheses (linking high productivity and anoxia with organic enrichment) showed lower carbon preservation. Ash beds derived from volcanic glass deposition in the water column showed high surface area from post alteration to bentonite but had low TOC indicating that the association with TOC and MSA occurred in the water column or early diagenetic environment. The MSA within the Monterey Formation is controlled by the abundance of detrital smectitic clays initially formed in hydrologic equilibrium within soils at the prevailing continental climate conditions. Organic matter enrichment in these (marine) continental margin sediments, is thus a function of continental climate. Carbon preservation in the Monterey Formation and similar black shales is not an oceanic mechanism as widely believed, but rather derived through continental controls. An implication of this conclusion is that climate influences detrital clay formation and carbon burial in marine sediments thereby providing a feedback to climate cooling through CO_2 drawdown during high carbon burial events.

KEY WORDS: Monterey Formation, Black Shale, Carbon Preservation, Mineral Surface Area (MSA), Total Organic Carbon (TOC), Smectite.