

# THE MEETING OF TWO MICROBIAL WORLDS: GEOCHEMISTRY OF THE SULFATE METHANE INTERFACE

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Ocean drilling cores reveal information on biological and chemical processes that occur through time. Two metabolically and genetically distinct groups of microbes: Bacteria (sulfate consuming microbes) and Archea (methane consuming microbes) interact within a relatively thin zone in anoxic marine sediments. Here the microbes co consume sulfate and methane dissolved in pore waters (see figure) producing a unique pore water and sediment chemistry best observed in regions where large amounts of methane move upward toward the seafloor (Borowski et al ). Such localities often occur within deep water continental margin sediments that contain methane gas hydrate (ODP Legs and )

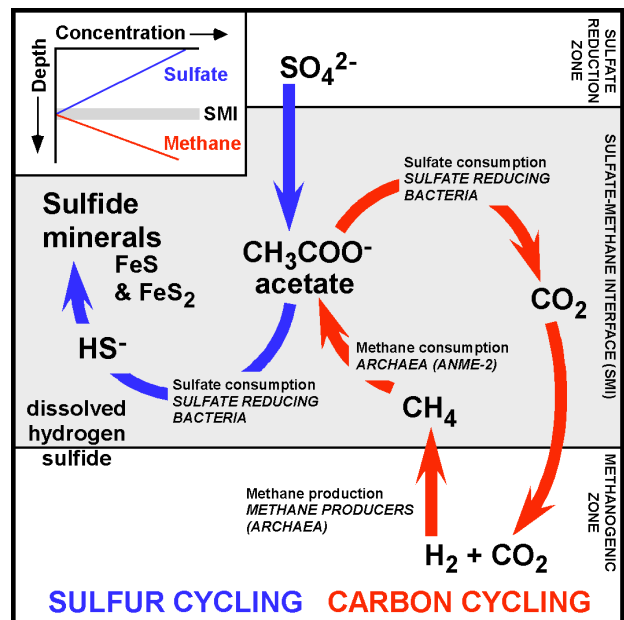
These organisms work together as a consortium (Hoehler ; Orphan et al ) to take advantage of pore waters bathed in both sulfate and methane. Co consumption of methane and sulfate focuses production of dissolved carbon dioxide and sulfide at the sulfate methane interface.

Sulfate at the interface is enriched in heavy sulfur (  $^{34}\text{S}$  ) so that the resultant dissolved sulfide and sulfide minerals are also enriched in  $^{34}\text{S}$  (Borowski et al ). These sulfide minerals and their heavy sulfur isotope signature are preserved in the sediment and rock record. Rock layers with sulfide minerals enriched in  $^{34}\text{S}$  imply methane rich conditions, co consumption of methane and sulfate and the specific co metabolism between sulfate consumers and methane consumers in the past.

In modern sediments the consortium acts to create a dynamic interface that is able to climb or descend within the sediment column (Borowski et al ). The movement of the interface depends upon the rate of upward methane transport, usually through molecular diffusion. More methane delivery requires the interface to move upward to balance the amount of sulfate being delivered to sulfate consumers. Conversely, if methane supply

diminishes the interface moves downward and sulfate penetrates deeper into sediments. Identifying heavy sulfur enrichments within sulfide minerals is a means to track past movements of the sulfate methane interface.

Borowski et al *GSA Abstracts Programs* ( ) A  
Borowski et al *Marine Geology* :  
Borowski et al *Geology* ( ):  
Hoehler et al *Global Biogeochemical Cycles* ( ):  
Orphan V J et al *Science* :



The consortium converts reduced carbon of methane into organic foodstuffs (e.g. acetate) that are ultimately oxidized to form carbon dioxide. The  $\text{CO}_2$  produced by the combined action of methane and sulfate consumers is free to cycle back into the methane pool through methane producing microbes or exit the sediment by diffusing upward into ocean waters.

As sulfate reducers apparently consume organic molecules produced by Archaea they create dissolved hydrogen sulfide ( $\text{HS}^-$ ) as a byproduct. Typically  $\text{HS}^-$  quickly forms sulfide minerals like iron monosulfides ( $\text{FeS}$ ) and pyrite ( $\text{FeS}_2$ ) thus sulfur is removed from pore water and locked into sediment minerals effectively terminating the cycling of sulfur.