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A comparative study of the bioenergetic potential of intermediate compounds associated with the anaerobic oxidation of methane (AOM)

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The microorganisms responsible for the oxidation of methane in anoxic marine sediments constitute the largest sink of methane on Earth. It is generally accepted that the mechanism by which this process occurs involves a consortium of microbes that couple the reduction of sulfate to the oxidation of methane. However, whether this process occurs directly or through one of several reactive intermediate species such as hydrogen, acetate, and/or formate is a matter of debate. To better understand the biogeochemistry of the anaerobic oxidation of methane (AOM), we have compared the energetics of a number of candidate reactions that could supply AOM-microbial communities with enough energy to synthesize ATP in different environmental settings. We present the results of thermodynamic calculations quantifying the oxidation of methane to CO_2 and H_2, and, alternatively, to a variety of carbon species with intermediate nominal oxidation states. The potential role that these species have in the reduction of sulfate and oxidation of methane in three distinct organic-rich, anoxic sediment types is investigated in 1) a shallow, coastal lagoon (Cape Lookout Bight, North Carolina, USA), 2) deep Black Sea sediments, and 3) a hydrothermal system (Guaymas Basin, Gulf of California). Furthermore, we compare the energetics of these reactions to the energy required to synthesize ATP from ADP and monophosphate *in situ*. The results of these calculations can be used to better understand the temperature, pressure, and bulk compositional constraints on AOM.