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Methanol on the rocks: Green rusts promote redox cycling of greenhouse gasses

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Structural homology between reactive minerals and enzymatic metal cofactors hints at mechanistic and possibly evolutionary links between reactive abiotic structures and biological metabolism. The octahedral coordination of reactive $Fe^{2+/3+}$ minerals such as green rusts, endemic to anoxic sediments and the early Earth's oceans, mirrors the di-iron reaction center of soluble methane monooxygenase (sMMO), responsible for methane oxidation in methanotrophy. We show that methane oxidation occurs in tandem with the oxidation of green rust to lepidocrocite and magnetite, mimicking radical mediated methane oxidation found in sMMO to yield not only methanol but also halogenated hydrocarbons in the presence of seawater. This naturally occurring geochemical pathway for CH_4 oxidation elucidates a previously unidentified carbon cycling mechanism in modern and ancient environments and reveals clues into mineral-mediated reactions in the synthesis of organic compounds necessary for the emergence of life