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Low temperature accumulation of hydrogen through incubation of forsterite in buffered water.

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Abstract

In order to test whether or not methane producing archaea may survive solely on the products forming through the hydration of olivine, we have analyzed the products formed from the low temperature incubation of natural forsterite sand in buffered water. Already after one month of incubation, the molecular hydrogen concentration was high enough to theoretically sustain the survival of methanogenic archaea at temperatures above 30˚C. Also, many important trace elements were present as well as a low enough redox potential.

Introduction

Hydrocarbons are known to be formed through the reduction of CO_2 by H_2 in the so called Fischer-Tropsch Type or Sabatier reaction in hydrothermal systems (Charlou 2002; Holm 1998; Rushdi A. 2001), but the temperatures used are often higher than at least 100˚C. (McCollom 2009). Hydrocarbon and/or hydrogen formation in lower temperature environments would expand the plausible sites for the existence and growth of microbial communities and possibly also the abiotic formation of organic compounds. Therefore we have tested the potential abiotic H_2 and CH_4 production in a mixture of forsterite and buffered water at temperatures ranging from 30˚C to 70˚C.

Discussion

We have analyzed the methane and hydrogen formation coupled to the hydration of forsterite in three different temperatures, 30˚C, 50˚C and 70˚C. In all temperatures, there is a consistent and temperature dependent release of methane into the headspace of the reaction cells. Even at temperatures as low as 30˚C there is a clear methane and hydrogen release already after one month of incubation. This indicates that reactions coupled to the hydration of natural forsterite are forming or releasing methane and hydrogen at very low temperatures. Therefore, environments in which methane and hydrogen may be released and thus also sustain the growth or survival of certain microorganisms, might be more widespread than previously thought. Also, reactions such as the Fischer-Tropsch type or Sabatier reaction may have a great potential for hydrocarbon formation in natural, forsterite-rich systems at near surface conditions.

Implications

This study shows that interactions between water and olivine result in the release of significant amounts of hydrogen and methane, the latter corresponding to olivine dissolution rates, at temperatures ranging from 30 to 70 ºC. This has important implications regarding several aspects. First, regarding questions about early life on Earth this study shows that high quality electron donors (H_2 and CH_4) can be released when water interacts with very common minerals also at temperatures suitable for living cells, and not just at temperatures above 100 ºC as previously reported. This substantially expands the range of environments suitable for chemosynthetic organisms on the early Earth and there may be a much more widespread and extensive subsurface biogeochemical cycling of hydrogen and methane than previously believed.

References

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