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Catalysis of Methane Production in Serpentinization Systems

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Serpentinization is a geochemical process resulting in the inorganic synthesis of molecular hydrogen (H_2) where H_2 is capable of reducing carbon (i.e., CO_2) to form methane (CH_4). Although CH_4 formation is thermodynamically favorable over a wide range of pressure and temperature, the rate of CH_4 production via Fischer-Tropsch type (FTT) synthesis is slow without the aid of mineral catalyst(s). Chromium- and Fe-bearing minerals (e.g., chromite) have been shown to be effective aids in enhancing FTT synthesis. Here, we report serpentinization experiments at 200 ^{o}C and 300 bar demonstrating no difference in the rate of CH_4 production (~0.1 µmol kg^{-1} h^{-1}) with the addition of chromite comprising ~1 Wt. % of the total solids. The mass and low surface area of chromite utilized in our experiment, representative of mineral-fluid interactions in a peridotite-hosted hydrothermal system, was potentially below a threshold to cause any appreciable change in the CH_4 production rate. Residual end-member solids contain an abundance of fine-grained magnetite comprising ~3 Wt. % of the solids over ~850 h of reaction time where magnetite is also a mineral catalyst for advancing FTT synthesis. Based on our observations, high surface area magnetite may overshadow the effects of the Cr-bearing catalyst chromite, therefore, making serpentinization and the production of CH_4 autocatalytic.

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