FAST ABIOTIC PRODUCTION OF METHANE AT TEMPERATURES <100°C

Fischer-Tropsch Type (FTT) reactions, e.g., the Sabatier synthesis between H2 and CO2, are considered a main source of abiotic methane (CH4) on Earth and other planets. Several laboratory FTT experiments demonstrated abiotic CH4 production at T > 200°C, by using Fe, Ni or Cr catalysts, simulating hydrothermal conditions in peridotite-hosted submarine systems. Nevertheless, Fe-Ni-Cr catalysts cannot support CH4 generation at T < 100-150°C, which are those of continental serpentinization systems.

In 2014 we reported rapid production of considerable amounts of CH4 (>800 ppmv in 155 mL bottles after 1 day, up to 6.5 vol% after 1 month) via Sabatier reaction at 90, 50 and 25°C, using concentrations of non-pretreated ruthenium equivalent to those occurring in ophiolites or continental igneous complexes (Etiope and Ionescu, 2015, Geofluids, 15, 438-452).

Our laboratory data are compatible with the isotopic patterns of naturally occurring CH4 in land-based seeps and hyperalkaline springs. Our experiments suggest that Ru-enriched chromitites could potentially generate methane at low T, which is the T of continental serpentinization.

The experiments so far performed show that:

1. large CH4 amounts can be produced in dry conditions below 100°C using extremely small quantities of ruthenium

2. under the same experimental conditions (<100°C), Fe, Ni and Cr oxides do not produce methane

3. low T FTT reactions can produce CH4 with a large C isotope fractionation between CO2 and CH4, leading to relatively “light” (13C-depleted) CH4, resembling microbial gas

4. CO2-CH4 isotope separation decreases over time and by increasing the temperature

5. minor amounts of C2-C6 hydrocarbons are also generated

In 2015 we repeated the experiments by using 13C-enriched CO2 and we confirm fast production of CH4 at percentage levels.

The “industrial catalysis” field is based on Wang et al. (2011) and references therein.

From Etiope and Ionescu (2015), the “industrial catalysis” field is relevant to ruthenium hosting ultramafic rocks, where minor amounts of CH4 generation can be produced at temperatures below 100°C. For example, since ruthenium was reported in Martian meteorites, low T Sabatier reaction may produce abiotic CH4 in Martian Ru-bearing rocks (Etiope, Ehlmann and Schoell, 2013, Icarus, 224, 276-285).