EGU21-1469, updated on 18 May 2022
https://doi.org/10.5194/egusphere-egu21-1469
EGU General Assembly 2021

How much energy for life (H_2) is generated by serpentinization at passive continental margins?

Elmar Albers[1], Wolfgang Bach[1,2], Marta Pérez-Gussinyé[1,2], Catherine McCammon[3], and Thomas Frederichs[2]
[1]MARUM – Center for Marine Environmental Sciences, University of Bremen, Bremen, Germany (e.albers@uni-bremen.de)
[2]Faculty of Geosciences, University of Bremen, Bremen, Germany
[3]Bayerisches Geoinstitut, University of Bayreuth, Bayreuth, Germany

Molecular hydrogen (H_2) released during serpentinization of oceanic mantle is one of the main fuels for chemosynthetic-based deep life. Hydrogen is produced during the oxidation of ferrous to ferric iron, and the amount of H_2 generated strongly depends on rock type, fluid composition, alteration temperature, and water-to-rock ratio.

Progress has been made in understanding serpentinization and related H_2 production at slow-spreading mid-ocean ridges (MORs). Less attention has been paid to the hydration of mantle rocks at passive continental margins where different rock types are involved (lherzolite instead of harzburgite/dunite at MORs) and the alteration temperatures tend to be lower (<200°C vs. >200°C). To close this knowledge gap we investigated serpentinization and H_2 production using drill core samples from the West Iberia margin (Ocean Drilling Program Leg 103, Hole 637A).

Lherzolitic compositions indicate that the exhumed peridotites represent sub-continental lithospheric mantle. The rocks are strongly serpentinized and mainly consist of serpentine with little magnetite and are generally brucite-free. Serpentine can be uncommonly Fe-rich, with X_{Mg} = Mg/(Mg+Fe) < 0.8, and shows distinct compositional trends towards a cronstedtite endmember. Bulk rock and silicate fraction Fe(III)/∑Fe ratios range from 0.6–0.92 and 0.58–0.8, respectively. Our data show that more than 2/3 of the ferric Fe is accounted for by Fe(III)-serpentine. Mass balance and thermodynamic calculations suggest that the initial serpentinization of the samples at temperatures of <200°C likely produced about 100–250 mmol H_2 per kg rock, which is 2–3 times more than previously estimated.

These results lead us to suggest that the generation potential of H_2 evolves from continental break-up to ultraslow and eventually slow MOR spreading. The observed metamorphic phase assemblages systematically vary between these different settings, which has consequences for H_2 yields during serpentinization. At passive margins and ultraslow-spreading MORs, the main phase hosting Fe(III) appears to be serpentine, and H_2 yields of 100–250 mmol and 50–150 mmol H_2 per kg rock, respectively, may be expected at temperatures of <200°C. At slow-spreading MORs, in contrast, serpentinization of harzburgite may produce 200–350 mmol H_2 per kg most of which is related to the formation of magnetite at >200°C. Within the same (low) temperature range, larger

volumes of serpentinite should form at passive margins than at slow-spreading MORs, owing to lower geothermal gradients. Relative to both slow- and ultraslow-spreading MORs, serpentinization at passive margins likely produces more H_2 and under conditions closer to/within the habitable zone. These sites may hence be suitable environments for hydrogenotrophic microbial life.