Global serpentinization and H_2 production at mid-ocean ridges: 200 Ma to Present

PABLO GARCIA DEL REAL[1*], ISABELLE DANIEL[1], MURIEL ANDREANI[1], NICKY M. WRIGHT[2], AND NICOLAS COLTICE[1]

[1]Univ Lyon, Université Lyon 1, Ens de Lyon, CNRS, UMR 5276 Laboratoire de géologie de Lyon, F-69622, Villeurbanne, France

[2]EarthByte Group, School of Geosciences, The University of Sydney, NSW 2006, Australia

(*Correspondence: pablo.garcia-del-real@univ-lyon1.fr)

Serpentinization of ultramafic rocks at mid-ocean ridges contributes to global fluxes and transformations of molecular oxygen, carbon, and hydrogen. In these vast regions of seafloor spreading, serpentinization provides a pathway for elemental hydrogen (H_2) production, reduction of carbon (*e.g.* CH_4), and abiotic synthesis of organic compounds. Accurate quantification of global H_2 generation requires a physicochemical and temporal description of plate-tectonic configuration over geologic time. In this work, we integrate geochemical parameters with plate-tectonic reconstructions to quantify serpentinization and concurrent H_2 production at mid-ocean ridges from the Jurassic (200 Ma) to the present (0 Ma). Using high-resolution plate motion models within the GPlates infrastructure, we estimate the lengths in 1 Myr intervals for: (*1*) the global mid-ocean ridge plate boundary, which includes interconnected spreading and transform components; (*2*) spreading ridges only; and (*3*) slow- and ultraslow-spreading segments (<40 mm/yr). From these three groups of plate boundaries, we reconstruct the history of oceanic crust formation, which is often considered to be constant in previous serpentinization and H_2 production models. Our results indicate that the fragmentation of Pangea and formation of the Pacific plate at 190 Ma, which increased the length of mid-ocean ridges and generation of young oceanic crust, resulted in elevated H_2 rates ($>10^{12}$ to 10^{13} mol/yr) starting at ~160 Ma compared to Late Mesozoic (<160 Ma) rates ($<10^{11}$-10^{12} mol/yr). From 160 Ma to present, the coupled opening of the Atlantic and Indian oceans as well as the variation in spreading rates maintained H_2 generation in the ~10^{12} mol/yr level, but with significant excursions related to major tectonic reconfigurations (*e.g.* extinction of spreading ridges in the Pacific). This work offers an integrated approach to constrain H_2 production that captures the complexities of serpentinization reactions and the tectonic evolution of mid-ocean ridges over time.