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A global budget of abiotic hydrogen production at mid-ocean ridges for the past 200 Ma

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Hydrogen production at mid-ocean ridges occurs through serpentinisation of mantle peridotites exhumed at slow and ultraslow spreading ridges. The abiotic hydrogen produced by this mechanism is used in the synthesis of methane, and both compounds sustain deep microbial life in the subsurface seafloor. However, the estimation of hydrogen flux through geological time has not been established as it has no known proxies in the geological record and there is no detailed geological description of oceanic lithosphere away from present-day ridge axes. Here we present a model for calculating the primary, abiotic production of elemental hydrogen from the serpentinisation of oceanic lithosphere using a global plate tectonic reconstruction for the last 200 Ma. Our results indicate significant variability in hydrogen fluxes, between 10e11-10e12 mol/a, arising from the coupled effect of evolving ocean basins and variations in spreading rates. Calculating hydrogen production at one million-year increments suggests that both ultraslow (<20 mm/a) and slow (20–40 mm/a) ridges release similar volumes of hydrogen. Additionally, we correlate hydrogen excursions with the opening of key ocean basins during the breakup of Pangea, where the most productive ocean basins are located on overriding plates and have a large fraction of continental lithosphere present. This correlation is because plate velocity is inversely related to the proportion of continental lithosphere and the perimeter of subducting oceanic lithosphere. The initial opening of the Central (ca. 180 to 170 Ma) and Southern (ca. 145 Ma) Atlantic Oceans and the transition to ultraslow spreading in the Central Atlantic Ocean and Labrador Sea (ca. 70 to 55 Ma) all result in up to a doubling of the hydrogen flux (4 x 10e17 mol/Ma). In addition to calculating hydrogen flux, our method can be used to estimate methane production from serpentinisation. Our results show that elevated rates of hydrogen and associated methane between 60 and 56 Ma could be significant components of the driving force for the Palaeocene-Eocene Thermal Maximum.