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Setting upper limits on the natural hydrogen generation in intracratonic areas

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Most proposed exploration guidelines for natural H_2 exploration in intracratonic areas focus on geodynamics[1], seismics[1], mineralogical analysis[1] and mapping large scale H_2 seepages[2]. Here we present a complementary method of evaluating H_2 production potential based on X-Ray micro-computed tomography (micro-CT) and multi-modal imaging of the host-rocks. To obtain a first order estimation of H_2 generation, this method assumes that H_2 is generated via complete oxidation of Fe(II) in the Fe-rich minerals within the host-rock. This method neither considers the actual geochemical reaction/s that could yield different Fe(II): H_2 ratios nor the reaction kinetics. Micro-CT imaging combined with µRaman analysis is used to identify the Fe(II)-rich minerals in the imaged 3D micro-CT volume. However, one can also use quantitative electron microprobe (EMPA) maps or energy dispersive scanning electron microscopy (SEM EDS) maps to replace µRaman analysis, depending on the size of the sample to be analyzed. Once the Fe(II)-rich minerals are identified 2D micro-CT slice, the chemical and mineralogical information can be propagated within the imaged 3D micro-CT volume to obtain the volumes of Fe(II)-rich phases. Then, using the mineral density and theoretical or actual Fe(II) content in each phase, potential H_2 production in the host-rock can be obtained in H_2 (g)/host-rock (kg). Alternatively, this number can be calculated by obtaining the volumes using X-Ray powder diffraction (XRD) of the sample, but, the advantage here is the ability of analyzing a large sample such as a whole drill-core of the host-rock, non-destructively. Latest developments in spectral CT (Sp-CT) imaging allows better segmentation of Fe(II)-rich silicates, thus, allowing to model actual H2-producing reactions as well. This method could be used to set an upper limit on H_2 generation in intracratonic ophiolites, gabbros and banded iron formations reported in [3], [4] and [5].

References: [1] Dugamin et al (2019) ISRN Geonum-NST, 1, 16. [2] Moretti et al (2021) Geosciences, 11(3), 145. [3] Milcov (2022) Earth-Science Reviews, 230, 104063. [4] Combaudon et al (2023) Golschmidt abstract #18169. [5] Geymond et al (2022) Minerals 2022, 12(2).