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Iron redox state of serpentinized mantle rocks through a Wilson cycle: implications for serpentinization-sourced hydrogen systems

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Climate-CO_2 emission models point to the urgency for European society to transition from high to low carbon energy sources. In this frame, H_2 could be a key component of the decarbonization strategy. Among the various colours of H_2, white (i.e., native) H_2 is one of the most promising. The most efficient way to produce native H_2 is serpentinization, a high temperature hydrothermal process that forms serpentinites from Earth mantle rocks. This hydrothermal alteration transforms primary magmatic Fe-Mg-bearing silicates (olivine, pyroxenes) into secondary hydrous minerals (e.g. serpentine, brucite) and oxides (magnetite). Serpentinization also produces molecular hydrogen (H_2) through oxidation of ferrous Fe (FeII) released from the dissolving primary minerals, to ferric Fe (FeIII) that precipitates in serpentine and magnetite. The serpentinization process has been extensively documented at various geological settings such as mid-ocean ridges or subduction zones. In contrast, it has received much less attention at rift inverted orogens and continental rifts, representing classical sources of oil and gas, but nowadays being at the forefront of carbon capture, geothermal energy, and new decarbonated energy resources such as native hydrogen. In conclusion, understanding the iron redox state in a Wilson cycle will allow us to predict when, where and how serpentinized sourced hydrogen is produced, which is a prerequisite to develop a successful exploration strategy.

Our approach to achieve this goal is based on a representative sampling area, state-of-the-art analyses and modelling (the evolution of redox and the production of H_2). A series of analytical methods will be conducted on serpentinites from well-defined sites (Tasna, Platta, Totalp, Val Malenco and Lanzo) documenting the Wilson cycle of the Alpine-Tethys system. The analysis will constrain the conditions of serpentinization, i.e., temperature of fluid-rock interactions, PT paths recorded by mantle rocks, and redox state. Finally, the new data will constrain the evolution of iron speciation and H_2 production during serpentinization and may be used to either test or calibrate numerical modelling results used for the quantification of H_2 production.