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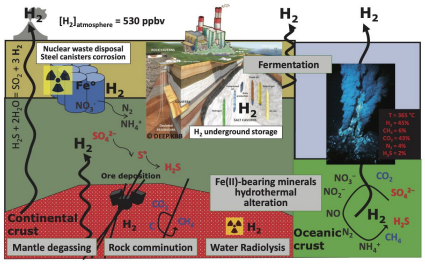
Geo-sourced hydrogen fuels the deep biosphere, could it be a giant leap for mankind?

LAURENT TRUCHE[1], FRÉDÉRIC VICTOR DONZÉ[1], HUGO DUTOIT[1], DIMITRI LAURENT[1], LORELLA MASCI[1], AUDREY TAILLEFER[1], ROBIN HINTZEN[2], MANOLIS GIAMPOURAS[3] AND CAMILLE DUSSÉAUX[4]

[1]University Grenoble Alpes
[2]ISTerre - University Grenoble Alpes
[3]University Granada
[4]University Franche Comté

Presenting Author: laurent.truche@univ-grenoble-alpes.fr



Hydrogen (H_2) behavior in the Earth's crust, from its deepest sources to its degassing from mid-ocean ridges or from specific continental settings, is a scientific and industrial hot topic. Based on fundamental research on H_2 generation mechanisms, abiotic synthesis of organic molecules, and the development of a deep biosphere, one may now question if this H_2 can play a role in the energy transition? Hydrogen can react with oxidized elements - mineralized or dissolved in geological fluids - or diffuse toward the surface and degases into the oceans or the atmosphere. Hydrogen is then seen alternately as an energy source for bacterial developments, as a reagent for the generation of abiotic hydrocarbons, and possibly, if ever, as a carbon-free energy resource. The high mobility of hydrogen combined with its high reactivity, both at high and low temperatures, are supposed to prevent its accumulation in the subsurface or its concentration in geological fluids except in rare occurrences. However, this paradigm is now shifted by the recent discoveries of geological environments suitable for hydrogen trapping and of several continental zones where natural hydrogen is released. It now appears necessary to methodically and reasonably evaluate the sources, sinks, flows and stocks of this potential primary natural production. Even if the phenomena controlling the generation (redox reactions, radiolysis, fermentation), migration (solubility, clathrates, diffusion, adsorption) and reactivity (microbial or surface catalysis) of H_2 in the Earth's crust are now quite well understood, their interplays remain to be unraveled. We will show how some recent observations made from the nanoscale up to the basin scale using experimental, numerical and field approaches can provide new insights into the hydrogen system.