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Soil gas mapping as a tool for native H_2 exploration: a case study in the Western Pyrenean foothills (SW France)

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Native hydrogen (H_2) is usually considered as a possible energy resource for the development of a carbon-free society. Throughout the world, and since more than one century, lots of natural H_2-bearing seepages have been discovered [1, 2], but to date, neither nor any resource assessment exist, as practical guidelines for hydrogen targeting are still missing. Here, we propose of a new exploration prospection strategy dedicated to native H_2, using the Pyrenean orogenic belt and its northern foreland basin as a playground for the implementation of a regional campaign of soil gases analysis. Pyrenean geological setting represents a promising framework to investigate the potential of a native H_2 system because all the fertile conditions of production, migration, and trapping have been identified. Indeed, the North-Western Pyrenees and especially the Mauléon Basin, are characterized by the occurence of a massive fresh mantle body located under favorable P-T conditions (<10 km depth) allowing serpentinization processes. This crustal-scale architecture is also prone to drain deep-seated fluids along major faults suggested by geophysical data. Hydrogen traps remain poorly described and understood, but the presence of salt-related structures (domes and diapirs) and flysch correspond to lithologies that could play this role.

Based on geophysical, geological and seismic datasets, we carried out a large campaign of soil gas analyses (H2, CO2, CH4, ^{222}Rn, He) at the regional scale measured in the soil (mostly grassland). More than 1,100 in situ gas analyzes were carried out at ~1 m deep along a mesh of approximately 10 × 10 km spanning over 7,500 km^2. The campaign evealed several hotspots where H_2, CO2 and ^{222}Rn concentrations exceed 1000 ppmv, 10% and 50 kBq×m^{-3}, respectively. These hotspots are mainly located along major faults recognized and well-known in the Western Pyrenees. Isotopic analyzes of gases (CO2, CH4, He, Ar, Kr) are still ongoing in order to constrain and determine the origin of H2 detected at the surface.

[1] Truche et al., (2020). *Elements,* vol. 16, no 1, p. 13-18.
[2] Gaucher, E.C et al., (2020). *Elements*, vol. 16, no 1, p. 8-9.