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DISSOLVED HYDROGEN IN LORRAINE COAL BASIN (FRANCE)

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The Lorraine Carboniferous Basin, located on the France-Germany border and dating from the Westphalian to Stephanian age, is covered by the Mesozoic Paris Basin. Our study combines petrographic observations with hydro-geochemical data using the innovative SysMoG™ probe system, developed by Solexperts and CNRS/University of Lorraine. This system was deployed in the Folschviller borehole FOLS1A (Moselle, France), drilled in 2006 by La Française De l'Energie (LFDE[2]). Simultaneously, rock samples were collected from core drillings, revealing siliciclastic sediments with pores and fractures cemented by diagenetic minerals such as siderite, ankerite, quartz, dickite, sphalerite, and barite. Current fluid gases are dominated by CH_4, resulting from the thermal maturation of coal over time. At a depth of 1250 m, H_2 constitutes approximately 18 mol% of the gas mixture, with a dissolved H_2 concentration in water around 3 $mg.L^{-1}$. This concentration increases with depth, suggesting potential concentrations of about 30 $mg.L^{-1}$ at 3 km depth. Siderite and ankerite (Fe(II)) may reduce water to hydrogen in deeper compartments of the Carboniferous sediments. Additionally, H_2 genesis from coal is not ruled out. Both hypotheses are temperature-dependent, requiring over 150°C, corresponding to a depth of 5 km, for initiation. Isotopic analyses of H_2 revealed remarkably light isotopic signatures (−700‰ to −765‰), consistent with a crustal origin of natural gases dissolved in the groundwater of the Lorraine Carboniferous Basin when combined with He data and compared to literature.The linear hydrogen concentration profile measured in the FOLS1A vertical borehole suggests a hydrogen diffusion profile with a source likely deeper than 5 km. The H_2 plume is governed by P-T conditions and H_2 consumption through oxidation or bacterial activity in Mesozoic sediments or soil. Detectors located at -24 m and -1 m depth away from FOLS1A do not detect hydrogen, indicating that natural hydrogen exploration cannot rely solely on surface measurements and requires drilling. Furthermore, H_2 resources in the form of dissolved gas should not be overlooked to estimate the resources.

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