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Application of geochemistry in natural hydrogen prospect identification: a study from the NW Himalayas, India

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Natural hydrogen (H_2) has emerged as a promising carbon-free energy resource, with reported occurrences in geological settings across Mali, Turkey, Spain, Australia, China, and the USA. Unlike fossil fuels, natural hydrogen can form through both abiotic and biotic processes, including serpentinization, water-rock interactions, radiolysis, and microbial activity. Understanding the geochemical controls on hydrogen generation and accumulation is essential for identifying prospective regions and optimizing extraction methods. India has significant potential for natural hydrogen exploration, particularly in its oil and gas fields, hot springs, and basement rocks.

This study investigates the geochemical characteristics of geothermal systems in Uttarakhand to assess their potential for hydrogen generation. Thermal waters in the geothermal areas exhibit moderate EC (346–879 µS/cm) and TDS (228–596 ppm), with sodium- and calcium-rich waters (Na: 268–369 ppm) indicating deep fluid circulation and extensive geochemical reactions. The geothermal waters, with temperatures ranging from 38 to 102°C, suggest active water-rock interactions facilitating hydrogen formation via thermal decomposition and water-gas interactions. The presence of significant Mg (15–68 ppm) and Ca (22–88 ppm) further indicates possible ultramafic lithologies undergoing serpentinization, a key process in natural hydrogen production.

Additionally, this study explores low-temperature geothermal hydrogen production technologies and their direct utilization. The integration of geochemical data with advanced analytical tools enhances reservoir screening for natural hydrogen exploration. The findings highlight India's geothermal systems as a probable source of natural hydrogen, contributing to the global transition towards sustainable energy solutions.



