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Hydrogen geochemical characteristics at different geological backgrounds in the Tarim Basin, China

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From the perspective of energy system, natural hydrogen (H_2) is a carbon-free energy carrier that costs to nothing, which plays a central role in reducing the carbon footprint of our economy and is closely related to carbon peaking and carbon neutrality goals. It is imperative to perform exploration activities that specifically design for natural H_2. In this study, we reported three H_2 anomalous (Ake, Hade and Shunbei zones) in the Tarim Basin, China. H_2 concentrations in these three zones are between above 0.1% and 2.41%. H_2 isotopes (δ^2H-H_2) show different ranges in different zones, indicating that H_2 origins are different, which is associated with unique geological backgrounds. Specifically, R/Ra ratios, where R and Ra are the helium isotopes of samples and atmosphere respectively, are above 0.5 in the Ake zone, and δ^2H-H_2 is enriched, ranging from -550‰ to -500‰, which is due to mantle-derived degassing process. For the Shunbei zone, R/Ra ratios are far below 0.1, but some samples have enriched H_2 isotopes, between -580‰ and -550‰. It is attributed to the charging of deep hydrothermal fluids according to the evidences from biomarkers. In general, the stronger the charging of deep hydrothermal fluids, the enriched the H_2 isotopes. For the Hade zone, R/Ra ratios are far less than 0.1, some samples show carbon isotope reversal of alkane gases, H_2 content correlates roughly with He content, and δ^2H-H_2 is depleted, ranging from -790‰ to -590‰. It is reasonably deduced that H_2 is mainly sourced from the water-rock reaction because this zone overlies the magma intrusion. To sum up, this study provides a profound insight for the identification of H_2 origin.