Modeling radiolytic natural hydrogen from fractured basement: Generation, migration, and sequestration potential in the western platform, offshore Taranaki Basin, New Zealand

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Résumé

The search for natural hydrogen (H2) in sedimentary basins is gaining increasing recognition due to its environmental friendliness. Therefore, as an alternative energy source, it could address the issue of environmental challenges and participate in the energy mix necessary for the energy transition. Despite ongoing research, many uncertainties remain, and H2 exploration is still at an early stage. In this work, we provide, for the first time, a numerical model of radiolytic natural H2 generation from the fractured basement based on the Taranaki Basin example (New Zealand). This approach uses conventional hydrocarbon exploration techniques, with some adjustments to the source kinetics, fluid migration method, and pressure-temperature parameters to properly reproduce the subsurface natural H2 behavior. We calculated the potential radiolytic H2 production rate to be approximately 12.8 mg/g/Ma. This value was used as a constant rate input in the model. Potential reservoirs within the optimal H2 sequestration thermal window (100-200∘C) include the Tane formation sandstone as well as the Taimana and Tikorangi carbonate formations. The model exposes that natural H2 accumulation may have started when rock density of the seal became higher than the density of the underlying reservoirs (approximately 2.4 kg/m^3). This density inversion, began at 9.4 Ma and 6.8 Ma in the Witiora and Taranga boreholes respectively, due to the northwestward progradation of the Mohakatino Formation. The model also reveals that H2 mass concentration in water is higher along the faults and in interbedded sand facies of the Rakopi and Wainui formations, indicating both diffusion and advective migration. The Tane formation gas anomaly reported during the drilling could be due to the conversion of CO2 into abiotic CH4 via Sabatier reaction at depth (> 200∘C) when H2 has migrated through coal-rich facies of graben-filled Rakopi formation. Consequently, abiotic CH4 could be an accurate proxy for depicting natural H2 generation.

Mots-Clés: Natural H2, Radiolysis, basin modelling, abiotic CH4

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