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Adsorption of molecular hydrogen on clay minerals under conditions relevant to its natural and artificial geologic occurrence

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Physical interactions of molecular hydrogen (H_2) with rocks and minerals have become an aim of multi-disciplinary studies after H_2 gas was identified in various geological environments (Truche et al., 2020). The interactions especially apply to industrial H_2 injection into suitable geological traps as seasonally-stored energy and to high pressure of H_2 that will build up in the bentonite buffer materials of underground nuclear waste repositories.

Regardless of its origin, under high-pressure conditions in a geologic environment, a significant portion of H_2 can be physisorbed on surfaces and in micropores of clay minerals, which were proven to control the gas adsorption properties of rocks.

In this study, we are interpreting the high-pressure adsorption isotherms of H_2 on various cationic forms and hydration states of smectites and illites at ambient and elevated temperatures. The study investigates the textural and structural control of H_2 adsorption on clay minerals, by combining the high-pressure H_2 adsorption with low-pressure adsorption of N_2 and CO_2 techniques, transmission electron microscopy, and X-ray diffraction analyses.

We found that H_2 intercalates smectitic interlayers under high pressure. Despite that interlayer adsorption might account for the majority of gas uptake, H_2 adsorption depends also on the mineral texture, e.g., crystallite planar dimensions. Most of H_2 is adsorbed in the micropores accessible for CO_2. Despite weak interactions of H_2 with minerals, the density of adsorbed H_2 is about double of that for free H_2 gas under given pressure and temperature in geologic conditions, effectively increasing the gas storage capacities in sedimentary rocks and decreasing the H_2 pressure buildup in geotechnical barriers of nuclear waste repositories.

Truche, L., McCollom, T.M., Martinez, I., 2020. Hydrogen and abiotic hydrocarbons: Molecules that change the world. Elements 16, 13–18.