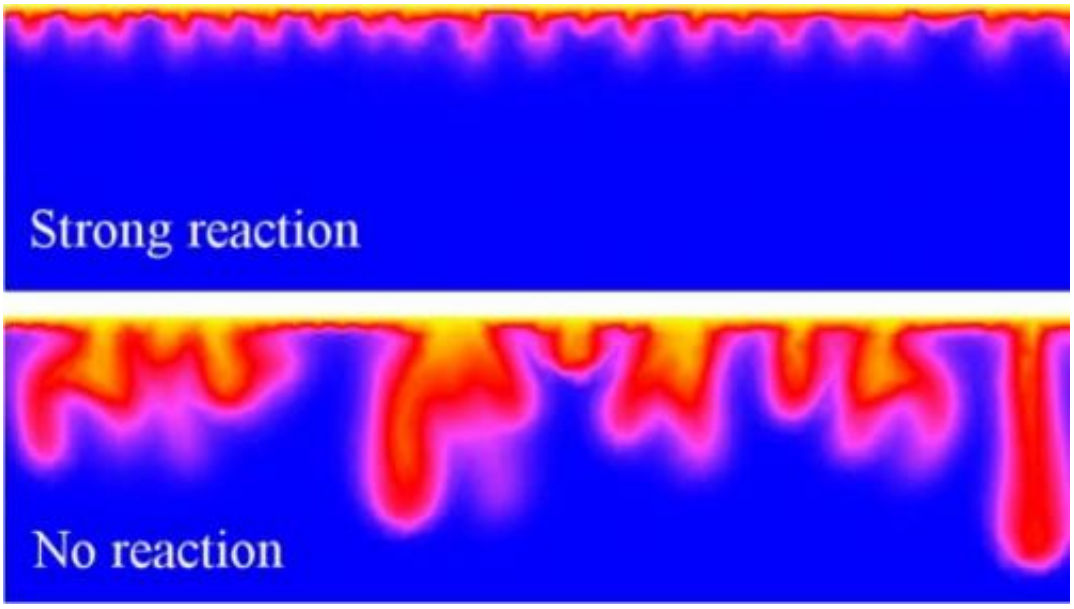
Chemistry curbs spreading of carbon dioxide

May 6 2011



(PhysOrg.com) -- The presence of even a simple chemical reaction can delay or prevent the spreading of stored carbon dioxide in underground aquifers, new research from the University of Cambridge has revealed.

The findings may have implications for carbon sequestration in saline aquifers – one of the many methods being explored to mitigate rising CO_2 levels in the atmosphere.

Depending on the strength of the reaction between dissolved CO_2 and porous rock, the new research shows that distinct scenarios of CO_2

transport may occur in deep saline rock formations.

Jeanne Andres, a Schlumberger Foundation PhD researcher at the Department of Chemical Engineering and Biotechnology at the University of Cambridge, said: "If one knows the physical properties of the aquifer, one can now calculate the movement of CO_2 across it, and when it will begin to mix with the brine. In theory, one can manipulate the strength of reactions, thereby engineering the movement of CO_2 – keeping it in one area or moving it to another within the aquifer - to enhance its storage underground."

CO_2 fingers. Strong chemical reactions between dissolved carbon dioxide and porous rock (top) may stop CO_2 fingers from spreading from the top throughout an aquifer's depth, in contrast to systems with no reaction (bottom).

With weak reactions, the CO_2 will spread from the top throughout the depth of the aquifer, but with stronger reactions, the CO_2 remains near the top of the reservoir, leaving the deeper part inactive.

The strength of these reactions can vary significantly among deep saline reservoirs - rock formations possess a wide range of chemical reaction rates depending on the mineralogy (e.g. calcite, dolomite, etc) as well as other factors such as temperature and pressure,. With the new insight this research provides, it would now be feasible to consider creating and injecting compounds which could alter the strength of reactions in the aquifer.

To arrive at their conclusions, the researchers established that the basic interaction between fluid flow and the rate of chemical reactions (chemical kinetics) in a deep porous medium is governed by a single dimensionless number, which measures the rate of diffusion and reaction compared to that of the natural mixing of fluids (convection).

As applied to the storage of CO_2 underground, the scientists demonstrate how this new parameter controls CO_2 flow and mixing in briny porous rock. Through numerical simulations, the researchers found that above this parameter's critical value, reaction stabilizes the CO_2 system and convection no longer occurs. Below the parameter's critical value, stronger reactions result in longer delays in the onset of convective mixing throughout the reservoir.

For systems with similar convective mixing strengths, stronger reactions, indicated by rising values of the new parameter, can increase the minimum rate at which pure, lighter CO_2 dissolves into the brine, enhancing storage and reducing the risk of leakage.

Dr Silvana Cardoso, Reader in the Department and project leader, said: "This research shows how rigorous mathematical analysis coupled with strong physical understanding can help us grasp the complex interactions of flow and reaction in a carbon reservoir. Such knowledge will be valuable in guiding future approaches to carbon storage."

More information: The paper 'Onset of convection in a porous medium in the presence of chemical reaction' was published in the journal *Physical Review E*, Vol.83, No.4. Authors: J.T.H. Andres and S.S.S. Cardoso , DOI: 10.1103/PhysRevE.83.046312

Provided by University of Cambridge