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# Laboratory investigation of dissolution from a flowing gas phase: Novel experimental technique and implications for environmental expression of GHG

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The movement and interaction of flowing gases in shallow aquifers is of particular interest in energy development and geological storage. In these applications, gases such as carbon dioxide and methane can present a risk to both the aquifer and the atmosphere. Potential impacts of these gases can occur as one of two environmental expressions: i) aqueous expression, when the gas dissolves into the flowing groundwater affecting water quality and transporting dissolved gas components further from the source or ii) surface expression, where gas components of interest reach the ground surface and become an unaccounted contributor to total greenhouse gas emissions. Interactions between the gas, water and porous media in the subsurface will affect the relative magnitude of these expressions, including through the rate of mass transfer between the gas and water. The rate of leakage, porous media characteristics and the aqueous flow rate in an aquifer are major parameters affecting expression. To better quantify the coupled and highly dynamic gas movement and mass transfer processes in the subsurface, novel experimental methodologies are required.

Visualization is a powerful tool to qualitatively and quantitatively understand subsurface processes. To investigate the impact of mass transfer from a flowing gas phase a novel visual technique was used to track gas-to-water mass transfer in saturated sands. The high spatial and temporal resolution, visual technique allowed for the identification of injected $CO_2$ in well controlled two-dimensional homogeneous sand packs (25 x 25 x 1 cm3) and the subsequent mass transfer using pH sensitive dye. This innovative bench-scale experimental technique was coupled with continuous quantification (gas chromatography) of gaseous phase that reached a constructed "surface" to quantify and compare the aqueous and surface expression of $CO_2$. It was found that flowing gas could be vertically arrested, reaching a steady-state height, depending on the relationship between the gas injection rate and the aqueous flow rate. Further results of this study show the importance of considering multicomponent mass transfer in gas-water systems that contain dissolved background gases. The visualization revealed that although a gas channel of the injected component ($CO_2$) can be arrested, a gas channel of new composition, facilitated by the mass transfer of background dissolved gases, will continue to vertically migrate. The findings of this study provide insight of the competing processes in the subsurface at larger scales, not possible to observe at the field scale. Further research is being completed on the processes affecting expression using similar techniques for heterogeneous systems.