

The interrelationships among CO₂, CH₄ and N₂O of soil profile in Karst areas, southwest China

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Carbon dioxide (CO₂), methane (CH₄) and nitrous oxide (N₂O) are the three most important greenhouse gases (GHG) which contribute to global warming. Soil is the major biological sink or source for atmospheric GHG. Concentrations of GHG in the soil can provide some valuable information about production, consumption and transportation of gases through the subsurface. Although there are many researches on spatial variations of GHG in soil profile, few quantitative analyses on their interrelationships. Here, The monthly concentrations of CO₂, N₂O and CH₄ along with soil depth were measured for a year in karstic region, southwest China. The objective of this research was to better understand the interrelationships among CO₂, N₂O and CH₄ in soil. The results indicated that subsurface concentrations of CO₂, N₂O and CH₄ varied in 0.35~35.3mL·L⁻¹, 0.31~5.31μL·L⁻¹ and 0.1~4.7μL·L⁻¹, respectively. With the increment of soil depth, CO₂ and N₂O concentration increased firstly and then decreased or tended to be stable at 30~40cm depth, while CH₄ had an inverse trend. The variations in CO₂ along with soil depth was significantly positive correlated with that in N₂O (p<0.05~0.01) and negative correlated with that in CH₄ (p<0.01). The significant negative correlation between CH₄ and N₂O just was observed in some study sites (p<0.01). Such interrelationships among GHG in soil suggest that there may be some relationships between soil N and Soil C dynamics in soil, and some research in future would be deserved.

Multi-phase reactive flow and transport modeling of CO₂ sequestration in the Mt. Simon sandstone formation, Midwest USA

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Multi-phase reactive flow and transport modeling is an effective tool for monitoring, verification, and accounting of CO₂ sequestration in deep geological formations. In the current study, modeling is performed to simulate large scale CO₂ injection (one million tons per year for 100 years) into Mt. Simon sandstone, a major deep saline reservoir in the Midwest of USA. The long-term fate of CO₂ was simulated by extending the modeling period to 10, 000 years. The results indicate that most of the injected CO₂ remains within a radius of 3300 m lateral distribution. Four major trapping mechanisms and their spatial and temporal variations are evaluated in our simulations: hydrodynamic, solubility, residual, and mineral trapping. A strongly acidified zone (pH 3-5) forms in the areas affected by the injected CO₂ (0 – 3300 m), and consequently causes extensive mineral precipitation and dissolution reactions. The predicted long-term fate of CO₂ is closely linked to the geochemical reactions conceptualized in the models. In our model, the replenishing water continues to dissolve CO₂ long after the injection, which results in total dissolution of hydrodynamically trapped CO₂ at the end of 10, 000 years. In contrast, most previous models neglected the regional flow after injection and hence artificially limited the extent of geochemical reactions as if in a batch system. Consequently, a supercritical CO₂ plume (hydrodynamic trapping) would persist after 10, 000 years. The continued supply of acidified water from interaction between replenishing water and CO₂ also results in extensive dissolution of feldspars and precipitation of secondary clay minerals, to a much more extent than what predicted in models without including regional flow. However, the prediction of complete dissolution of feldspars in 10, 000 years can also result from the artifact that Transition State Theory (linear) rate laws are used in our model (as well as all previous work), which overestimates the rates of feldspar dissolution near equilibrium [1].

[1] Zhu, C. (2009) Geochemical modeling of reaction paths & geochemical reaction networks. In *Thermodynamics & kinetics of water-rock interaction* (eds Oelkers, E.H. & Schott, J.) vol. 70, pp.533-569, Mineralogical Society of America.