# Tracking $CO_2$ leakage with noble gases

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The geological storage of greenhouse gases such as $CO_2$ in saline aquifers is an active research topic. By this way, effects of these gases on the environment may be significantly reduced. One limiting parameter of this type of storage is actually the hypothetical $CO_2$ leakage through the caprocks. Some studies of natural $CO_2$ gas fields have shown that noble gases are able to trace $CO_2$ origins and physical processes which have occurred in the subsurface (Gilfillan, 2006). Unfortunately, the migration of noble gases through low permeability media is still poorly constrained.

Here, we describe experimental results concerning the diffusion of gases through different porous clayey media. The experimental setup is a diffusion reactor composed of two gas reservoirs separated by a water saturated clay membrane. Initially, one side is filled with $CO_2$ mixed with trace amounts of noble gases (He, Ne, Ar, Kr and Xe), the other side is filled with pure oxygen to equilibrate pressures on both sides of the membrane.

Unexpectedly, diffusion of $CO_2$ is faster than those of He and any of the other noble gases. This result points to the effect of the solubility in the migration process, allowing $CO_2$ to migrate faster as it is highly soluble in water. In addition, in clay rocks, the "bound water" plays a role in this migration because solubility and diffusion factors contrast with those associated with "free water". We used a 2D diffusion model at the pore scale (Kara, 2004) to determine diffusion and partition coefficients of noble gases between free and bound water as a function of petrographical parameters (mineralogy, porosity, tortuosity). The behavior of noble gases during a diffusion process will be presented in order to highlight the main parameters likely to control their migration.

## References

Gilfillan S. (2006), *Deep magmatic degassing and the Colorado plateau uplift*, PhD thesis, University of Manchester.

Kara S. (2004), *Quantification des fractionnements physiques affectant le gaz naturel lors de sa migration dans les systèmes pétroliers*, PhD thesis, Université de Paris VI.

# A $\delta^{13}C$ depth gradient from a mid-Cryogenian platform margin: Evidence for Neoproterozoic ocean stratification

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A $\delta^{13}C$ depth gradient of at least 8‰ between shallow and deep water is evident in Neoproterozoic carbonates from the Umberatana Group in the northern Adelaide Fold Belt, South Australia. The progradation of an extensive mid-Cryogenian platform margin allows direct isotopic comparison between shallow-water reef carbonates and synchronous deep-water slope and basinal sediments. With over 1 km of relief this platform margin allows an estimation of seawater $\delta^{13}C$ in the upper 1000-1400 m of the water column.

We suggest that the observed $\delta^{13}C$ gradient is the result of poor ocean circulation brought about by salinity stratification that persisted at least for the progradational history of the Oodnaminta platform margin. Such conditions enhanced the effect of the 'biological pump' by drawing $^{12}C$ out of the surface ocean and accumulating it in the deep ocean. After prolonged stratification, the vertical $\delta^{13}C$ gradient increased to the observed magnitude.

Furthermore, we propose that stratification was persistent throughout Neoproterozoic time, and can explain many of the unusual features that characterise this era – large-scale $\delta^{13}C$ variation, extreme climatic fluctuations, and the presence of cap carbonates. Stratification creates an unstable climate system in which gradual accumulation of $CO_2$ in deep waters eventually leads to global glaciation due to the lack of deep ocean ventilation. Subtle changes in ocean circulation ventilate the deep ocean and rapidly transfer large amounts of $CO_2$ to the surface ocean and atmospheric reservoirs, leading to greenhouse temperatures, and facilitating rapid global deglaciation and cap carbonate deposition. Additionally, oxygen accumulated in the surface ocean and atmosphere during prolonged periods of stratification may have triggered the evolution of the Ediacaran fauna during the terminal Neoproterozoic.

The results also imply that the use of carbon isotope chemostratigraphy as a high-resolution chronostratigraphic correlation technique for the Neoproterozoic may be invalidated by evidence for strong facies-dependant $\delta^{13}C$ variation.