Developing Phase Interaction Models to Apply Noble Gases to the Problem of Carbon Dioxide Sequestration

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Within the framework of simple hydrodynamic models and phase interactions, key quantitative information can be gained from noble gases about deep fluid systems. Examples include the volume and age of groundwater systems, the origin of different fluids, and the extent and the relative timing of phase interactions. This is exactly the information required to ensure safe geological disposal of anthropogenic CO_2. Recent work on coalbed methane systems, a proposed target for CO_2 injection, highlights the importance of considering the effect of both dynamic systems and non-groundwater sources of atmosphere-derived noble gases in constructing a quantitative fluid interaction model [1].

New data from four CO_2-dominated natural gas fields provides an important natural analogue for understanding the detailed subsurface behavior of CO_2. These fields are associated with the volcanism related to the Colorado Uplift, USA (Bravo Dome, NM; St John’s Dome, AZ; Sheep Mountain, CO; McElmo, CO). $CO_2/^3He$ ratios indicate the origin of the CO_2 to be dominantly magmatic and provide CO_2 residence information. Groundwater-derived $^{20}Ne/^{36}Ar$ ratios are not achievable through single stage gas/water solubility equilibrium processes. We model this as a two stage process in which CO_2 filling of the reservoir dynamically strips the ground-water system of noble gases. Subsequent re-equilibration of the gas field with noble gas-stripped water then accounts for all the groundwater-derived noble gases, allows us to quantify the re-dissolution of noble gases and identify open system behavior. A key parameter is identifying the mechanism of CO_2 undersaturation that results in concomitant CO_2 loss relative to ^3He. Changes in $\delta^{13}C(CO_2)$ only identify precipitation to cause partial CO_2 undersaturation in one field. Changing reservoir conditions (temperature-pressure) resulting in CO_2 undersaturation comnbined with groundwater migration is the dominant control. $CO_2/^3He$ ratio variations suggest that CO_2 re-dissolution may result in between 50-90% loss of the original field CO_2 gas charge. The challenge is now how to transfer this conceptual framework to real time sequestration targets, such as three phase (oil-water-gas) depleted oil reservoirs. This will constrain the temporal/dynamic controls of phase interaction and quantify the role of the groundwater contact as an additional CO_2 sink or possible migration pathway [2].

References

[1] Zhou Z. et. al. (2005) *GCA* **69**, 5413-5428.
[2] Mackintosh S. et al., (2006) presentation this conference.