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Geological Storage Forms of Injected CO_2 and Variation with Time: A Case Study for Ordos Deep Saline Formation

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Carbon dioxide (CO2) geological storage is one of the most directly and efficiently ways to rapidly reduce atmospheric emissions of greenhouse gases. The injected CO2 will be sequestered in deep Saline formation by three forms: supercritical CO2 storage (gas storage), dissolution into saline water (solubility trapping), reaction to form carbonate mineral precipitation (mineral trapping). These storage forms dynamically change with time. To study the transformation of the CO2 storage form, we have performed a large of numerical simulations using a wide range of storage conditions of a storage reservoir, such as temperature, pressure, porosity/permeability, water salinity, and mineral composition of host rock. Geological and geochemical conditions from a deep saline formation of Ordos Basin were used for a 2D reactive geochemical transport model. Results indicate that the CO2 mineral trapping amount increases with the temperature, water salinity, initial volume fraction of chlorite and oligoclase. While increases in pressure and porosity/permeability lead to more CO2 dissolution into formation saline water. But the CO2 mineral trapping amount increases firstly and then decreases when the porosity/permeability increases. The research presented here will be useful to guide future selection of suitable CO2 storage formation and evaluation of long-term performance.

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Key words: Carbon dioxide, Geological storage, Saline formation , Storage forms, Transformation, Numerical model

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References

Audigane P., Gaus I., Pruess K., Xu T. F.,2006. A long term 2D vertical modelling study of CO2 storage at Sleipner (North Sea) using TOUGHREACT. Proceedings of TOUGH Symposium.

Bachu S. , Adams J. J., 2003. Sequestration of CO2 in geological media in response to climate change: capacity of deep saline aquifers to sequester CO2 in solution. *Energy Convers. Manage*, 44 :3151–3175.

Bacu S., Gunter W.E., Perjins E. H.,1994. Aquifer disposal of CO2: hydrodynamic and mineral trapping. *Energy Convers. Manage*, 35: 269-279.

Baehu S., Bonijoly D., Bradshaw J.,2007. CO2 storage capacity estimation: methodology and gaps. *International Journal of Greenhouse Gas Control*, 430-443.

Bai B., Li X. C., Liu Y. F., Zhang Y.,2006. PRELIMINARY STUDY ON CO2 INDUSTRIAL POINT SOURCES AND THEIR DISTRIBUTION IN CHINA. *Chinese Journal of Rock Mechanics and Engineering,* 25(1):2918-2923.(in chinese)

Freifeld B. M. , Trautz R. C., Kharaka Y. K., et al.,2005. The U-tube: a novel system for acquiring borehole fluid samples from a deep geologic CO2 sequestration experiment. *J. Geophys. Res*.,110, B10203.

Gaus I., Azaroual M., Czernichowski-Lauriol I.,2005. Reactive transport modelling of the impact of CO2 injection on the clayey cap rock at Sleipner (North Sea) . *Chem. Geol.,* 217:319–337.

Gunter W. D. , Perkins E. H. , Hutcheon I.,2000. Aquifer disposal of acid gases: modeling of water–rock reactions for trapping of acid wastes. *Appl. Geochem*, 15: 1085–1095.

Gunter W. D., Bachu S., Benson S.,2004. The role of hydrogeological and geochemical trapping in sedimentary basins for secure geological storage of carbon dioxide. *Geological Society,* 233: 129–145.

Hepple R. P. , Benson S. M.,2005. Geological storage of carbon dioxide as a climate change mitigation strategy: performance requirements and the implications of surface seepage. *Environ. Geol.*, 47: 576–585.

Hitchon B., Gunter W. D. ,Gentzis T. , Bailey R. T.,1999. Sedimentary basins and greenhouse gases: a serendipitous association. *Energy Convers. Manage,* 40: 825–843.

Holloway S, 2001. Storage of fossil fuel-derived carbon dioxide beneath the surface of the Earth. *Annual Reviews of Energy and the Environment*, 26: 145–166.

Holloway S.,1997. An overview of the underground disposal of carbon dioxide. *Energy Conversion and Management*, 38: 193-198.

Holloway S.,2002. Underground sequestration of carbon dioxide-a viable greenhouse gas mitigation option. *Proceedings of the 5th International Symposium on CO2 Fixation and Efficient Utilization of Energy and the 4th International World Energy System Conference: Tokyo Institute of Technology, Tokyo, Japan*, March 4-6, 373-380.

IPCC. Proceedings of the IPCC Workshop on carbon dioxide capture and storage. *Regina, Canada*, 18-12 November 2002.

IWR,2011. Zur Lage der Regenerativen Energiewirtschaft in Nordrhein-Westfalen 2010. *Münster, im Oktober* .

Kharaka Y. K. , Cole D. R. , Hovorka S. D. , Gunter W. D. , Knauss K. G. ,and Freifeld, B.M.,2006. Gas–water–rock interactions in Frio Formation following CO2 injection: implications for the storage of greenhouse gases in sedimentary basins. *Geology,* 34: 577–580.

Li X. C., Liu Y. F.,Bai B., Fang Z. M.,2006. Ranking and screening of CO2 saline aquifer storage zones in china. *Chinese Journal of Rock Mechanics and Engineering*, 25(5): 963-968.(in chinese)

Liu N., Liu L., Qu X. Y., et al.,2011. Genesis of the quthigene carbonate minerals in upper Cretaceous reservoir, Honggang anticline, Songliao Basin: a natural analogue for mineral trapping of natural CO2 storage. *Sedimentary Geology*,237:166-178.

Liu N.2011. Mineral trapping capacity estimation of CO2 in sandstones: Constraints from the dawsonite-bearing sandstone in Honggang, southern part of Songliao Basin. *Jilin University*,2011.(in chinese)

Pruess K., Garcı ´a J., Kovscek T., et al.,2004. Code intercomparison builds confidence in numerical simulation models for geologic disposal of CO2. *Energy* , 29:1431–1444.

Pruess K., Oldenburg C., Moridis G.,1999. TOUGH2 user's guide, Version 2.0. *Lawrence Berkeley Laboratory Report LBL-43134*, Berkeley, CA, USA.

Qu X. Y., Liu L., Hu D. Q., Ma R., You L.,2007. Study on the Dawsonite Sandstones Reformation with CO2 Fluid. *Journal of Jilin University(Earth Science Edition),*37(4):690-697.(in chinese)

Rochelle C. A., Czernichowski-Lauriol I., Milodowski A. E.,2004. The impact of chemical reactions on CO2 storage in geological formations: a brief review. *Geological Society*, 233:87–106.

Saeko M., Ziqiu X., Takashi O.,2008. Case Study of geochemical reactions at the Nagaoka CO2 injection site, Japan . *International Journal of Greenhouse Gas Control*,2 (3): 309–318.

Shao H. B. , Ray J., Youong S. J.,2010. Dissolution and Precipitation of Clay Minerals under Geologic CO2 Sequestration Conditions: CO2 -Brine-Phlogopite Interactions. *Environ. Sci. Technol*, 44: 5999–6005.

West J. M. , Pearce J. , Bentham M. , and Maul P.,2005. Issue profile: environmental issues and the geological storage of CO2. *Eur. Environ,* 15 :250–259.

Xu T. F. , Apps J. A. , Pruess K.,2004. Numerical simulation of CO2 disposal by mineral trapping in deep aquifers. *Applied Geochemistry,* 6: 917-936.

Xu T. F., Apps J. A. , Pruess K.,2003. Reactive geochemical transport simulation to study mineral trapping for CO2 disposal in deep arenaceous formations. *Journal of geophysical research,* 108(B2),2071, doi:10.1029/2002JB001979.

Xu T. F., Jin G. R., Yue G. F., Lei H. W., Wang F. G.,2012. Subsurface Reactive Transport Modeling: A New Research Approach for Geo-Resources and Environments. *Journal of Jilin University(Earth Science Edition)*,42(5):1410-1425.(in chinese)

Xu T. F., Pruess K.,2001. Modeling multiphase non-isothermal fluid flow and reactive geochemical transport in variably saturated fractured rocks:1. Methodology . *Am. J. Sci.*, 301:16–33.

Xu T. F., Sonnenthal E., Spycher N., Pruess K.,2006. TOUGHREACT—a simulation program for non-isothermal multiphase reactive geochemical transport in variably saturated geologic media: applications to geothermal injectivity and CO2 geological sequestration . *Comput. Geosci*, 32:145–165.

Xu T. F., Spycher N., Sonnenthal E. L., et al.,2011. TOUGHREACT Version 2.0: A simulator for subsurface reactive transport under non-isothermal multiphase flow conditions. *Computers & Geosciences*,37: 763-774.

Xu T. F., Yousif K. K., Christine D., et al.,2010. Reactive transport modeling to study changes in water chemistry induced by CO2 injection at the Frio-I Brine Pilot. *Chemical Geology*, 271:153–164.

Zhang W., Li Y. L., Xu T. F.,et al.,2009. Long-term variations of CO2 trapped in different mechanisms in deep saline formations: A case study of the Songliao Basin, China. *International journal of greenhouse gas control,* 3: 161–180.