Determination of the petrophysical characteristics of caprock samples for carbon dioxide storage in deep saline aquifers

P. Bachaud (1,2), Ph. Berne (1), J.P Leclerc (2) and F. Renard (3,4)

(1) CEA – DRT/LITEN/DTNM/L2T, CEA-Grenoble, 17 rue des Martyrs, 38054 Grenoble cedex 9, France (pierre.bachaud@cea.fr), (2) LSGC, Nancy-Université, CNRS, 1 rue Grandville, BP 20451, 54001 Nancy Cedex, France (leclerc@ensic.inpl-nancy.fr), (3) Laboratoire de Géodynamique des Chaînes Alpines, LGCA-CNRS-OSUG, Université of Grenoble, BP 53, 38041 Grenoble, France (francois.renard@ujf-grenoble.fr), (4) Physics of Geological Processes, University of Oslo, Oslo, Norway

Storage of carbon dioxide in deep saline aquifers is one of the very promising solutions to reduce greenhouse gas emissions. A problem of particular importance is the behavior of caprocks in contact with CO_2, in supercritical state, due to high temperature and pressure conditions, or dissolved in the brine aquifer. Many phenomena can lead to a CO_2 leakage and, in order to guarantee the safety of the storage, a detailed characterization of the caprock petrophysical properties should be performed before any injection. A good knowledge of unaltered samples has been judged indispensable to start with, so all the tests reported here have been done without CO_2.

Three caprock samples, from the Charmottes field in the Paris basin, were collected from 1900 m to 2000 m depth. These are mainly composed of marls with varying clay content. The transport properties of these samples were characterized using two complementary techniques: mercury porosity measurements, and gas percolation experiments.

The sample porosity varies between 2% and 5%. The intrusion of mercury into a dry rock shares some similarities with the percolation of a gas into a water-filled sample. The capillary pressure was estimated through the Laplace law, and the mercury cu-

mulative pore volume was converted into rock water content. One therefore obtains a portion of the capillary pressure vs. saturation curve, corresponding to pores larger than 3 nm since mercury cannot access finer structures. This curve has two main interests. On the one hand, it characterizes the rock sample, since it depends of the porous network and its connectivity. On the other hand, it can be used to estimate capillary properties, as entry pressure.

Permeability experiments with gas have also been carried out, using triaxial cells with a confinement pressure of 90 bar. The intrinsic permeabilities, corrected for the Klinkenberg effect, were measured and found very low (under 10 μDarcy). Another transfer mechanism through the caprock is molecular diffusion of CO_2 after its dissolution in the site water. The water self-diffusion coefficient has thus been measured using tritiated water as tracer, since it might be equivalent to dissolved CO_2 diffusion coefficient. The results vary from 1.10^{-11} m^2/s to 6.10^{-12} m^2/s. Finally, we propose a model to estimate the liquid relative permeability in a two-phase system, using our experimental measurements.

The samples studied are very tight rocks with a low porosity and it made all the measurements difficult and time-consuming. However, it gave us a good knowledge of the unaltered rocks. Similar tests will be carried out in presence of CO_2 and under more realistic storage conditions (higher pressure and temperature).