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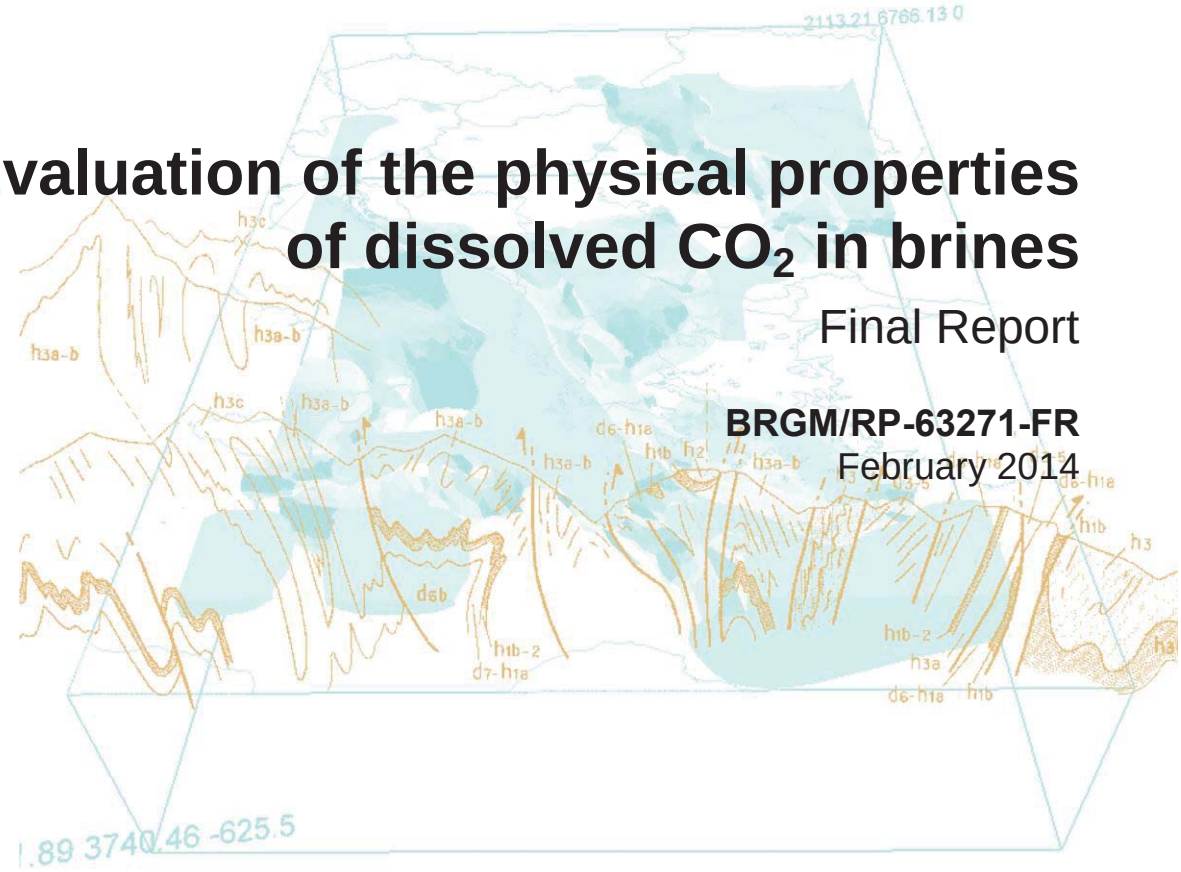

Evaluation of the physical properties of dissolved CO_2 in brines

Final Report

BRGM/RP-63271-FR
February 2014

PROJET FINANCÉ PAR L'ANR - PROJECT FUNDED BY THE ANR

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CO_2 dissolved

Geoscience for a sustainable Earth

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Study carried out as part of
the CO_2-DISSOLVED project, funded by the ANR
(agreement ANR-12-SEED-0009-01)

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Warning

This report is the result (deliverable D1.2) of part of the research work carried out in the framework of the CO_2-DISSOLVED project, funded by the ANR (agreement ANR-12-SEED-0009-01).

*This report remains **confidential** and its distribution is restricted to the project partners and to the ANR **until the end of the project (01/14/2016)**.*

***By the end of the project (from 01/15/2016)**, the status of this **report will become public**.*

Keywords: CO2-DISSOLVED project, carbon capture and storage (CCS), dissolved CO_2, brines, CO_2 solubility, viscosity, density, electrical conductivity.

In bibliography, this report should be cited as follows:

Trémosa J., André L., with the collaboration of **Kervévan C.** (2014) - Evaluation of the physical properties of dissolved CO_2 in brines. Final report. BRGM/RP-63271-FR. 59 p., 34 fig., 9 tab., 1 ann.

Synopsis

This report is the deliverable D1.2 of the CO_2-DISSOLVED project. This project is funded by the ANR (French National Research Agency) in the framework of the 2012 call for proposals of the SEED program (acronym - in French - for Energy Efficient and Decarbonized Systems). The CO_2-DISSOLVED project proposes to assess the feasibility of a novel CO_2 injection strategy in deep saline aquifers, combining injection of dissolved CO_2 (instead of supercritical CO_2) and recovery of the geothermal heat from the extracted brine. This combined CO_2 injection and heat extraction approach basically relies on a “classical” geothermal doublet system.

In this context, our capacity to calculate an accurate CO_2 solubility rate in brines at variable salinity, pressure, and temperature conditions is a key point for the reliability of the Thermo-Hydro-Chemical (THC) simulations to be performed to assess the technical viability of the concept.

Complementary to the calculation of CO_2 solubility, the requirement to investigate on the physical impact of dissolved CO_2 on the hydrodynamic behavior of the brine appeared to be indispensible to expect accurate 3D THC modeling results. The key physical parameters investigated in this study are: density, viscosity, and electrical conductivity of CO_2-rich solutions. These first two parameters are expected to potentially modify the dissolved CO_2 migration path between the injection and the production wells. The latter will be used in geophysical modeling of the electrical behavior of the CO_2-laden brine with respect to a CO_2-free brine, as a monitoring technology to be assessed in another task of this project.

The different models of CO_2 solubility tested all rely on the calculation of the CO_2 fugacity in the gas phase and its activity in solution. The comparison exercise between these models has highlighted:

- The importance of considering an equation of state to calculate the CO_2 fugacity in the gas phase, rather than using the ideal gas law, in particular when the pressure is higher than 20 bar;
- The importance of considering the Pitzer formalism to calculate the activity in solution of the dissolved CO_2, rather than using the extended Debye-Hückel activity models, when the salinity increases. The benefit of considering the Pitzer formalism is generally observed for salt concentration higher than 1 mol/kgw in solution.

It is worth noting that the data reproduction is not achieved in all conditions, including when an equation of state and the Pitzer formalism are both used. These deviations were particularly observed at temperatures different than 25 °C and are due to limitations in the databases that still need to be improved.

In the second part of this report devoted to determining the best “simple” models for calculating density, viscosity, and electrical conductivity, the following choices were made:

- For density, the models selected for pure water and CO_2-NaCl solutions are, respectively, those of Hu *et al.* (2007) and Duan *et al.* (2008);
- For viscosity, it appears that the models established by Mao and Duan (2009) for pure water and NaCl solutions, and Islam and Carlson (2012) for CO_2-NaCl solutions provide the best results;

- For electrical conductivity, the model of Ucok *et al.* (1980) was found to be valid for NaCl solutions (up to 4 molal). However, some contradictory results were obtained for CO_2-enriched solutions between the model of Fleury and Deschamps (2008) and the model implemented in PHREEQC. At this stage, we still lack experimental data to conclude on the best model to be used.