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Experimental measurements of CO_2 solubility in salt solutions at high temperatures and high pressures

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For many years, global warming had led to unprecedented climate change. One of the objectives of the Paris agreement is to keep global warming below 2°C.

Nowadays, the main problem is the steadily increase in carbon dioxide emissions into the atmosphere. To reduce the emissions of this greenhouse gas and thus reduce global warming, the capture, recovery and storage of carbon dioxide is an increasingly studied option. Carbon dioxide could be stored in deep saline formations which have a large capacity. The amount of carbon dioxide dissolved in the water depends on the pressure, temperature and composition of the water.

Another studied option to reduce global warming is to develop renewable energy. The use of geothermal energy in the world is still in development, both for the production of electricity and heat. So, it is important to be able to characterise vapour-liquid equilibrium in geothermal process. For instance, it allows to predict degassing phenomena when the fluid rise. A good knowledge of gas solubility is also important to develop models.

In the literature, many data are available for the carbon dioxide solubility in pure water. Nevertheless, there was a lack of data for the CO_2 solubility in salt solutions. The determination of gas solubility in aqueous phase at high temperature and high pressure is quite complex.

The aim of our work was to develop a simple method to measure the carbon dioxide solubility at high temperature, from 323.15 to 423.15 K, and high pressure up to 20 MPa.

Previous published work in our group have been carried out on the CO_2-H_2O-NaCl [1] and CO_2-H_2O-$CaCl_2$ [2] systems. In this papers, carbon dioxide solubility have been measured by a titration method coupling conductimetric and pH-measurements. These investigations have shown the evolution of the CO_2 solubility with the temperature, the pressure and the salinity. It also led to a better understanding of the "salting-out-effect".

In this new work, we use the same analytical method to characterize a new system. Saturation data of CO_2 in mixed salts solution containing NaCl, $CaCl_2$ and KCl were acquired at high temperatures (323.15, 373.15 and 423.15 K) and in the pressure range from 1 to 20 MPa. It allows to highlight the influence of each salts on the carbon dioxide solubility.

In order to better describe the vapour-liquid equilibrium in the aquifers, investigations will also be led on the solubility of other gas (CH_4, N_2…) in salt solutions and on the solubility of gas mixture (CO_2 + CH_4…) in salt solutions. Another part of this work will be dedicated to study materials corrosion in these environments (high temperature, high pressure, salt solutions…). Surface analytical techniques (XPS, AES…) will be used to characterize materials corrosion. The aim of the corrosion study is to select the more appropriate material in geothermal equipment.

[1] Messabeb, H.; Contamine, F.; Cézac, P.; Serin, J. P.; Gaucher, E. C. Experimental Measurement of CO2 Solubility in Aqueous NaCl Solution at Temperature from 323.15 to 423.15 K and Pressure of up to 20 MPa. J. Chem. Eng. Data 2016, 61, 3573−3584.

[2] Messabeb, H.; Contamine, F.; Cézac, P.; Serin, J. P.; Pouget, C.; Gaucher, E. C. Experimental Measurement of CO2 Solubility in Aqueous $CaCl_2$ Solution at Temperature from 323.15 to 423.15 K and Pressure of up to 20 MPa Using the Conductimetric Titration. J. Chem. Eng. Data 2017, 61, 4228-4234.