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Characterization of fluids and fluid-fluid interaction by fiber optic refractive index sensor measurements

C. Schmidt-Hattenberger (1), M. Weiner (2), A. Liebscher (1), and E. Spangenberg (1)

(1) Helmholtz Centre Potsdam, GFZ German Research Centre for Geoscience, Germany (conny@gfz-potsdam.de), (2) Technical University Berlin, Germany

A fiber optic refractive index sensor is tested for continuous monitoring of fluid-fluid and fluid-gas interactions within the frame of laboratory investigations of CO2 storage, monitoring and safety technology research (COSMOS project, "Geotechnologien" program). The sensor bases on a Fabry-Perot white light interferometer technique, where the refractive index (RI) of the solution under investigation is measured by variation of the liquid-filled Fabry-Perot optical cavity length. Such sensor system is typically used for measuring and controlling oil composition and also fluid quality. The aim of this study is to test the application of the fiber optic refractive index sensor for monitoring the CO2 dissolution in formation fluids (brine, oil, gas) of CO2 storage sites. Monitoring and knowledge of quantity and especially rate of CO2 dissolution in the formation fluid is important for any assessment of long-term risks of CO2 storage sites. It is also a prerequisite for any precise reservoir modelling.

As a first step we performed laboratory experiments in standard autoclaves on a variety of different fluids and fluid mixtures (technical alcohols, pure water, CO2, synthetic brines, natural formation brine from the Ketzin test site). The RI measurements are partly combined with default electrical conductivity and sonic velocity measurements. The fiber optic refractive index sensor system allows for RI measurements within the range 1.0000 to 1.7000 RI with a resolution of approximately 0.0001 RI. For simple binary fluid mixtures first results indicate linear relationships between refractive indices and fluid composition. Within the pressure range investigated (up to 60 bar) the data suggest only minor changes of RI with pressure. Further, planned experiments will focus on the determination of i) the temperature dependency of RI, ii) the combined effects of pressure and temperature on RI, and finally iii) the kinetics of CO2 dissolution in realistic formation fluids.