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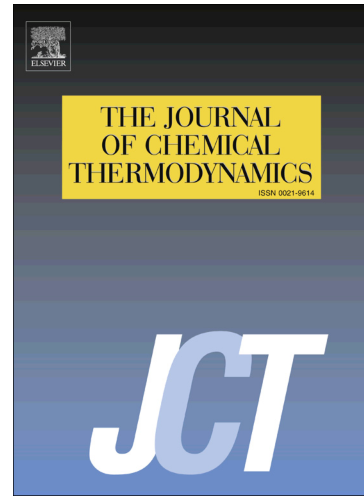

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Demonstration of Gas-Hydrate Assisted Carbon Dioxide Storage through Horizontal Injection in Lab-Scale Reservoir

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ABSTRACT

Depleted hydrocarbon reservoirs are known to provide an opportunity for CO_2 sequestration. A new 5300 cm^3 stainless steel high pressure chamber (crystallizer), employing horizontal CO_2 injection, is used to demonstrate the sequestration of CO_2, via hydrate crystallization, in depleted hydrocarbon reservoirs. The crystallizer was employed to carry out laboratory injection trials. A bed of silica sand with a porosity of 0.35 and a water saturation of 0.22 was used in these experiments. CO_2 is sequestered into the crystallizer by constant flow rate (1200 cm^3/h) followed by constant pressure CO_2 injection. This method has been shown to increase CO_2 hydrate formation compared to only using constant pressure CO_2 injection. Experimental pressures (pressure targets) ranging from 2.2 MPa to 3.2 MPa at 277 K are investigated. A total storage density of 126.6 kg·m^{-3} is found 24 hours after the start of injection at a pressure target of 3.2 MPa.

Keywords: CO_2 Storage, CO_2 Sequestration, Clathrate hydrate, Depleted Reservoir.

1. INTRODUCTION

Canada is projected to emit 768 megatons of CO_2e greenhouse gases (GHGs) by 2020 and 815 megatons of CO_2e GHGs by 2030 (Environment Canada, 2016). The projections are higher than Canada's reduction targets, set at the 2009 Copenhagen Accord, by 146 megatons of CO_2e GHGs for 2020 and by 291 megatons of CO_2e GHGs for 2030.

One approach to mitigate CO_2 emissions is to sequester CO_2 in porous and permeable reservoir rock (Holloway, 2001). The CO2CRC Otway Project has demonstrated the safe CO_2 storage in depleted oil and gas fields (Jenkins et al., 2011). Carbon dioxide capture from biofuels production and sequestration into the Mt. Simon Sandstone and for CO_2 capture from steam methane reforming and sequestration into the West Hastings Field in Texas have been studied and the environmental impact is not a significant risk (U.S Department of Energy, 2011a; 2011b).

The risks associated with leakage of stored CO_2 have been quantified through simulations which showed that for all the cemented wellbores considered, cumulative leakage is estimated to be below the IPCC's goal of 99 % from the start of injection to 1000 years after (Pawar et al., 2014). Regulators require that the conductor pipe and surface casing in a borehole must be fully cemented to secure the integrity of the groundwater (Alberta Energy Regulator, 1990).

When sequestering CO_2, the formation of CO_2 hydrates may be desirable. Gas hydrates are ice like crystalline compounds in which proper sized molecules, such as CO_2, are entrapped in hydrogen-bonded water molecules. They are stable under proper thermodynamic conditions i.e. high pressures and low temperatures. CO_2 sequestered as CO_2 hydrates have reduced mobility (Wright et al., 2008), further reducing the risk of leakage from an injection site. It is also known that 1m^3 of CO_2 hydrate can contain up to 162 m^3 of CO_2 at standard T-P conditions (Wright et al., 2008). The amount of CO_2 that can be stored within a reservoir depends on temperature, pressure, salinity of the reservoir, as well as the purity of injected CO_2 gas and the method of CO_2 injection (Sun and Englezos, 2016). The feasibility of gas hydrate sequestration in