Baseline study on sub-surface petroleum occurrences at the CO2CRC Otway Project, western Victoria

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Abstract

A sub-surface petroleum audit has critical provided baseline geochemical data for the CO2CRC Otway Project in the eastern Otway Basin, Victoria. The chemical and isotopic compositions of gaseous and liquid hydrocarbons and non-hydrocarbon gases were analysed from Buttress-1 (supply well; ~80% CO2 and ~20% methane), CRC-1 (injection well) and Naylor-1 (monitoring well), as well as from the nearby CO2 storage plant at Boggy Creek-1.

Natural gas reservoir in the Waarre Formation from the Naylor-1 monitoring well contains <1% CO2 (sampled at the wellhead, which is isotopically depleted in 13C (δ13C -15.8‰) compared to CO2 (δ13C -6.8‰) at the Buttress-1 supply well. The CO2 from the CRC-1 mud gas is isotopically similar to CO2 from the Naylor-1 well-head gas. However, the CO2 encountered downhole at Naylor-1 is -10.7 ‰. Thus, the carbon isotopes of CO2 can only act as a low resolution, primary natural tracer for monitoring purposes. The carbon and hydrogen isotopes of methane, wet gases and higher hydrocarbons are all very similar between Buttress-1, CRC-1 and Naylor-1. The newly drilled CRC-1 injection well has provided an opportunity to measure and collect downhole mud gases over many formations within the Early Cretaceous–Tertiary succession. A maximum total hydrocarbon concentration of 0.97% was found in the Waarre Formation near C and free gas was collected during MDT testing in the overlying Flaxman Formation. Little downhole variation was seen in the carbon isotopes for the hydrocarbon gases between 1907 and 2249 mRT. The δ13C CO2 in CRC-1 MDT test (δ13C -11.0‰) was very similar to CO2 in the Naylor-1 downhole gas. However, the CO2 taken directly from the reservoir provides the most accurate carbon isotopic value for CO2. Condensate and wax recovered from the local wells show carbon and hydrogen isotopic compositions of the Cn-alkanes consistent with regional distribution of liquid hydrocarbons in the eastern Otway Basin sourced from the Early Cretaceous Eumeralla Formation.

The results of this pre-injection sub-surface petroleum audit have proven pivotal in demonstrating the need for the addition of external tracers, especially for the hydrocarbon components. As such, they form an integral part of the storage integrity monitoring, as well as assurance monitoring in the near-surface, soil gas and atmospheric monitoring activities of the CO2CRC Otway Project.

Introduction

The CO2CRC Otway Project, the flagship of the Cooperative Research Centre for Greenhouse Gas Technologies (CO2CRC), in western Victoria (Fig. 1), is the first demonstration project in Australia involved with the geological storage of CO2. Injection of supercritical CO2 began in April 2008 into a depleted natural gas reservoir. The CO2CRC Otway Project uses the CO2-rich natural gas (containing ~80% CO2 and ~20% methane) from the non-commercial Buttress-1 well, where approximately 100,000 tons of gas will be produced and then continuously injected in a supercritical state over a period of approximately 18 months. The gas mixture is being injected, down the recently drilled CRC-1 well, into the Waarre Formation unit ‘C’ sandstone at a depth of ~2000 m and below the present-day gas-water contact in the Naylor structure (Figure 2). From CRC-1, the injected fluid is anticipated to migrate up-dip and accumulate at the top of the structure, around the Naylor-1 well (Figure 2). This well, abandoned in early 2004 following production of approximately 4 Bcf of natural gas, still contains a remnant gas cap (~1.4 Bcf); Tess Dance, CO2CRC, personal communication, July 2008) at the top of the Waarre Formation. The Naylor-1 well has been re-completed in the Waarre C Formation with an integrated Bottom Hole Assembly (BHA) incorporating a tri-level U-Tube sampling system to collect fluid and gas samples at reservoir pressure from multiple levels for geochemical analyses (Freifield et al. 2005; Underschultz et al. 2008).

Geochemistry forms a critical component of the overall monitoring and verification (M&V) strategy being implemented for the CO2CRC Otway Project. The composition of the well bore fluids, sampled via the U-tubes in the BHA, provide information on temporal sub-surface geochemical interactions of the CO2, methane, formation water and rock (Underschultz et al. 2008). An integral part of the geochemistry M&V program involved conservative tracers, perdeuterated methane (CD4), krypton (Kr) and sulphur hexafluoride (SF6), being added to the Buttress-1 feed gas at the CRC-1 well-head, which separately tagged the injected CO2 and methane components. Projected detection of these tracers at Naylor-1, both in the free gas phase and as dissolved gas in the aqueous samples, are likely to reflect exchange between the added and ubiquitous sub-surface methane, mark the arrival of the dissolved CO2 front and eventually the arrival of a supercritical CO2 phase. Furthermore, the tracers can provide assurance of safe geological storage of CO2 (Nimz & Hudson, 2005; Wells et al. 2007; Stalker et al. in press) through the operation of environmental monitoring systems in the near-surface and atmospheric (Hennig et al. 2008).

Although the content of liquid hydrocarbons in the gases is very low (<1%) for the CO2CRC Otway Project wells, there is the potential for supercritical CO2 extraction of these high molecular weight components that can be either advantageous (lubrication by

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