



SPE 115789

CO₂ Injection for Enhanced Gas Recovery and Geological Storage of CO₂ in the Long Coulee Glauconite F Pool, Alberta

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This paper was prepared for presentation at the 2008 SPE Annual Technical Conference and Exhibition held in Denver, Colorado, USA, 21–24 September 2008.

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Abstract

Impure CO₂ containing less than 2% H₂S has been injected since 2002 into the depleted Long Coulee Glauconite F gas Pool in southeastern Alberta. Breakthrough was observed within one to three years in producing wells, leading to their abandonment. Simulation studies reported in this paper indicate that additional gas was recovered as a result of CO₂ injection. An interesting observation at the breakthrough wells was that the CO₂ broke through ahead of the H₂S. The partitioning of the H₂S and CO₂ as they flow through the reservoir was studied in detail. One objective of the reported work is examination of interactions of the injected gas with the in-situ fluids and the displacement of the in-situ gas by the injection gas, for better understanding of the mechanisms involved in enhanced-gas recovery. Another objective of the work is to study factors that affect the spread of the injected gas in a depleted oil and gas reservoir and its implications with respect to CO₂ geological storage. The results of this study indicate that at low pressures, the injected gas occupies a large reservoir volume and exhibits little density difference with the in-situ fluids, leading to rapid spread of the injected gas and early breakthrough. Also, it was found that in the case of Long Coulee Glauconite F gas Pool the well-spacing used for production did not allow a detailed geological characterization that was required for accurate prediction of breakthrough as a result of gas-gas displacement. Simulation studies, together with displacement experiments in the laboratory reported elsewhere, confirmed that the preferential solubility of H₂S in the reservoir water led to stripping of the H₂S at the leading gas front and it delayed its breakthrough relative to that of CO₂. The implications of such chromatographic partitioning of H₂S and CO₂ in geological storage of impure CO₂ streams are discussed.

Introduction

Carbon dioxide capture and storage in geological formations is considered to be one of the practical options for reducing atmospheric greenhouse gas emissions. A number of operators in Alberta have implemented injection into depleted gas and oil pools as a means of disposal and storage of acid gas, which is a mixture of H₂S and CO₂ stripped off produced sour gas before sending the natural gas to markets (Bachu and Gunter 2005). In many cases the composition of the injected gas is similar to that of impure CO₂ in that the majority of the injected gas is CO₂. For example, in the Long Coulee Glauconite F Pool in southeastern Alberta (Figure 1), CO₂ concentration in the injected gas is about 98% (with H₂S making up the majority of the balance). Significant interest has been shown in the study of these reservoirs as commercial-scale analogues for geological storage of CO₂ (Bachu and Gunter 2005, Bachu and Haug 2005). The authors have studied five of these projects where either breakthrough of the injected gas in producing wells, or significant pressurization was observed. One objective of this paper is to examine the behavior of the Long Coulee Glauconite F Pool for the purpose of better understanding the spread of impure CO₂ in a depleted oil and gas reservoir and its implications with respect to CO₂ geological storage. In addition, CO₂ injection could provide the opportunity for enhanced gas recovery (Mamora and Seo 2002, Oldenburg 2003, Sim et al. 2008). As we shall see, the modeling study indicates that additional gas was recovered as a result of the injection process. The second objective of this paper is to investigate enhanced gas recovery as a result of displacement of the in-situ gas by the injected gas. Special attention was given to better understanding of the mechanisms that lead to mixing of the injected gas and the in-situ fluids as this affects the spread of the injected gas and the recovery of the in-situ fluids.

In the following the history of Long Coulee Glauconite F Pool is presented briefly, followed by basic fluid and reservoir characterization. The simulation and associated sensitivity studies, as well as their use for better understanding of the spread of the injected gas and displacement of the in-situ gases, are then presented.