HIGH-LEVEL SCREENING FOR WILLISTON BASIN RESIDUAL OIL ZONES USING LOCATION-INDEPENDENT DATA


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Abstract

This paper describes a high-level screening method used to locate residual oil zones (ROZs) in the sedimentary basins, which could potentially be used as targets for CO₂ storage through CO₂ enhanced oil recovery in the future. This effort is part of a 3-year project sponsored by the U.S. Department of Energy and being conducted by the Energy & Environmental Research Center to locate ROZs in the Williston and Powder River Basins of central North America. ROZs are atypical reservoirs having relatively high oil saturations (15%-40%) that have been effectively waterflooded by natural processes. ROZs are reservoirs that are at irreducible oil saturation with respect to water. However, through the use of CO₂ injection as a primary means of oil recovery, large amounts of CO₂ could be stored in these ROZs in addition to the possibility of oil recovery that may not be otherwise economic.

The described methodology attempts to identify ROZs through a basin evolution modeling approach, which differs from other hydrocarbon exploration techniques used to identify oil fields. In this approach, the entire geologic basin is modeled in order to simulate its geologic history and predict where ROZs may occur. To date, ROZ exploration throughout the United States has primarily consisted of manual matching of hydrodynamics with structural data in a particular location, assessing well- or field-scale analyses, and making a determination. The process described here has the potential to aid in the screening of structures based on the changing hydrodynamic and pressure history of the basin using basin modeling.

Basin modeling (also called basin history or basin evolution modeling) is the process of understanding the depositional and structural history of a geologic basin and the generation and migration of hydrocarbons through time. Inputs for this process include structural data for the overburden, underburden, source, and reservoir stratigraphic units and their bounding seals; ages of deposition for the modeled units; lithologic composition and facies maps; periods of erosion; basal heat flow history; paleo-water depth; maps of total organic carbon and hydrogen index values; and calibration data such as vitrinite reflectance and T_max of produced hydrocarbons and measured pressure and temperature from well tests.

Schlumberger’s Petrel software was used to build a 3-D geocellular model of the Williston Basin, and Schlumberger’s PetroMod was used to populate the model and simulate hydrocarbon generation and migration. PetroMod simulation of a basin model produces output maps of several dozen
variables, as well as hydrocarbon accumulation drainage areas and migration flow path maps. After calibration of the model, model outputs (particularly oil saturation and flow path maps) were compared with the locations of known oil pools in each of the target units. Hydrocarbon accumulations located outside of productive oil pools, as well as migration flow paths representing significant masses of oil, were selected as targets for resimulation using local grid refinement around areas of interest to increase the resolution of the estimated morphology and mass of each target accumulation. Field-scale Petrel geocellular models were used to estimate the CO₂ storage resource in these potential ROZs.

Although basin modeling production is time- and resource-intensive, once the basin model is constructed and calibrated, it can be simulated relatively quickly and is simple to iterate using new data. The use of location-independent data for basin modeling allows for model building to commence without requiring an area or stratigraphic interval of interest. These initial results are a positive indicator that the approach used in this effort will identify multiple ROZs and may be effective for identifying ROZs in other basins, potentially leading to an increase in total available CO₂ storage resource.

**Theme:** CO₂ Utilisation Options

**Subtheme:** Advances in CO₂ Geological Storage

**Subtheme:** Modeling tools and approaches