Carbon Dioxide Enhanced Oil Recovery and Sequestration in the Beaver Lodge Oil Field Williams County, North Dakota

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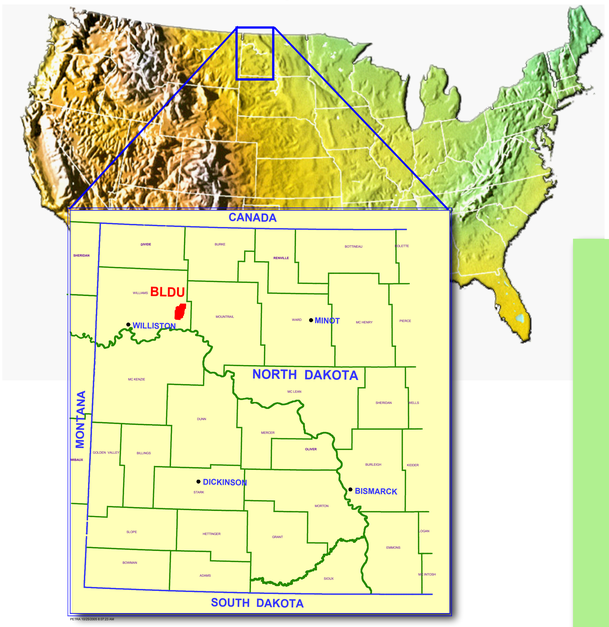
Location

BLDU – Beaver Lodge Devonian Unit

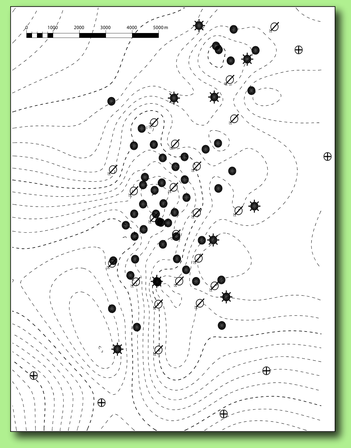


Abstract

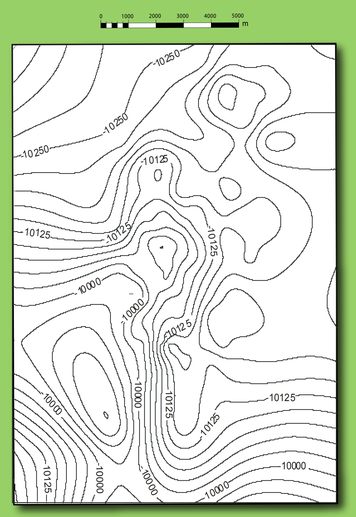
Geologic carbon sequestration has become a viable method to reduce anthropogenic carbon dioxide (CO_2) emissions and effects to the atmosphere. Permanent storage of CO_2 in mature petroleum reservoirs and saline aquifers allows for continued use of fossil fuel energy while reducing the environmental impacts. Combining CO_2 sequestration and CO_2-enhanced oil recovery (EOR) in mature oil and gas reservoirs allows more hydrocarbon to be retrieved than previously possible, which also offsets part or all of the sequestration cost. The purpose of this project is to develop the most effective method of producing hydrocarbon beyond secondary recovery from mature oil fields and store a significant amount of CO_2 in the process. The identification and classification of suitable sites for this method are necessary to ensure the method does not damage producing pools or allow CO_2 to be released to the atmosphere during or after injection. The Beaver Lodge oil field in Williams County, North Dakota, is selected as the case study for the identification of sequestration and EOR potentials. The Beaver Lodge is a multiple-pay field located along the N–S trending Nesson anticline in western North Dakota. Production occurs in nine separate horizons, but the Devonian Duperow Formation was selected for initial modeling based on higher porosity, production history, and good well control. The industry software, ECLIPSE, is used to model the field in three dimensions incorporated with well log data. Porosity, permeability, and rock strength measurements were independently verified from core plug analysis to ensure accurate modeling data for both reservoir and cap rocks. Physical modeling of the core samples under in situ pressure and temperature is used to measure the changes of rock properties as nitrogen and CO_2 gas are injected into the sample. After completion of the Duperow Formation modeling and sample analysis, work on the other eight horizons will be conducted.

Well Control

84 Total Wells
Currently
28 Oil Production Wells
21 Injecting Wells



Duperow Formation Surface in Beaver Lodge Field



Duperow Formation

The Duperow Formation is the most productive oil horizon in the Beaver Lodge field. It consists of shallowing upward carbonate cycles deposited on the shelf of the Elk Point Basin. Primary production is from the subtidal stromatoporoid bank boundstone facies and secondary from the intertidal laminated mudstone facies. The supratidal anhydrite or dolomite beds are the cap rock to the structural trap.

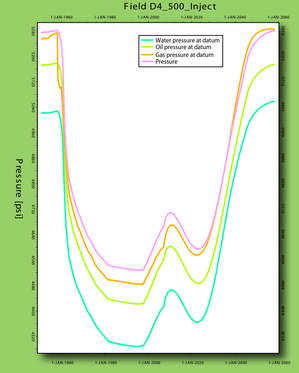
Assumptions

A homogeneous, isotropic reservoir is assumed since the Duperow is stratigraphically complex to simplify the flow in the initial model. Top of the Reservoir is assumed to be 100 feet below the Duperow surface based on well perforation data. Since sample analysis has not been completed, PVT properties were assumed to be similar to a sandstone that has similar porosity (13.7%), permeability (3.6 mD), and other rock properties to allow the interconnectivity of small pores in the initial model.

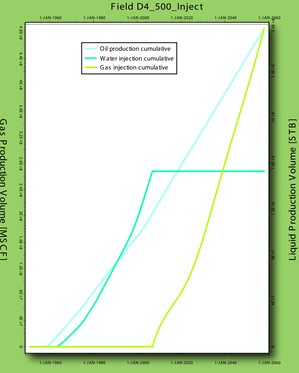
Model Parameters

- Model Start 1951
- Model End 2057
- CO_2 Injection Start 2007
- Water Flood 1951 to 2007
- In Field Drilling 1951 to 2007

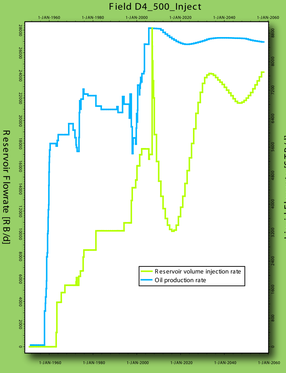
Pressure



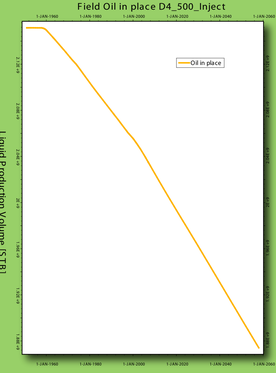
Production Volume



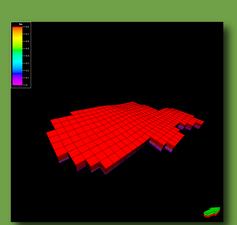
Flow Rate



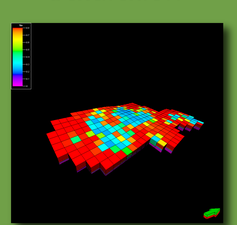
Oil in Place



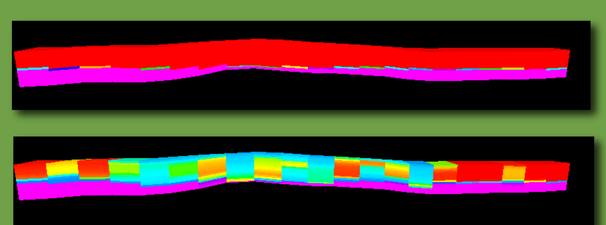
Initial Oil Saturation



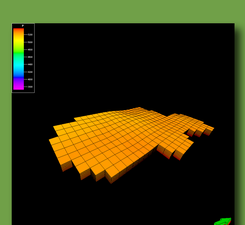
End Oil Saturation



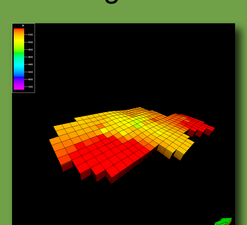
Initial and End Oil Saturation for Cross-Section View from West



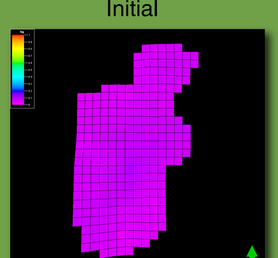
Initial Pressure



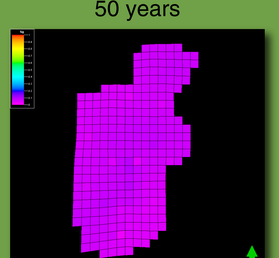
Ending Pressure



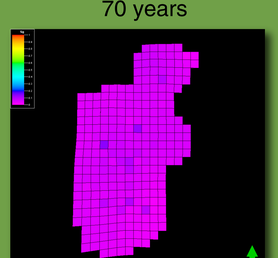
Model Time Steps Gas Saturation Initial



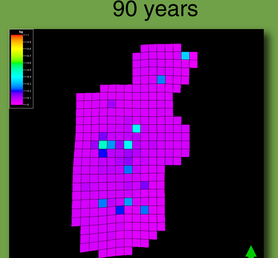
Model Time Steps Gas Saturation 50 years



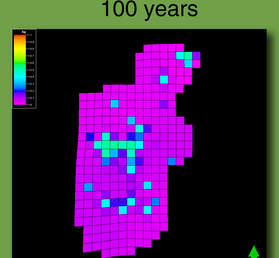
Model Time Steps Gas Saturation 70 years



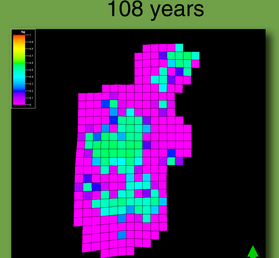
Model Time Steps Gas Saturation 90 years



Model Time Steps Gas Saturation 100 years



Model Time Steps Gas Saturation 108 years



Results

- 480,000,000,000 cubic feet of CO_2 injected over 50 year injection
- Total of 280,000,000 STB Oil Produced

Future Work

Sample analysis for the Duperow Formation is still ongoing. Rock properties and PVT data collected from this analysis will be applied to the model. History matching will be applied to the completed model to improve model accuracy. The remaining horizons will also be modeled for possible CO_2 enhanced oil recovery and sequestration.

Special Thanks

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