Reservoir Architecture and Heterogeneity of Multistorey Fluvial Sandstones of the Mississippian Cypress Formation, Illinois, USA: Implications for CO₂ Storage and EOR

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INTRODUCTION

The Cypress Formation is the most oil-productive unit in the Illinois Basin, USA. In the central part of the basin, the Cypress contains sandstones up to 60 m thick that contain relatively thin main pay zones (MPZs - shown in green in figure on the left) that may be underlain by a residual oil zone (ROZ) and a significant column of brine.

Thick Cypress sandstones have potential for nonconventional carbon dioxide enhanced oil recovery (CO₂-EOR) and storage, whereby CO₂ injection aims to store appreciable volumes of anthropogenic CO₂ and produce incremental oil and storage.

This study focuses on the geologic characterization of the thick Cypress sandstones, which has important implications for CO₂ storage and EOR.

METHODOLOGY

Geophysical logs are the most common data type for oil field studies. Understanding macro-scale features improves our ability to interpret log signatures.

Diagenetic clay minerals occlude pore space and contain micropores saturated with fluid that is immobile during hydrocarbon emplacement and production. Microporosity can have a significant impact on geophysical logs, including resistivity logs, and is important for proper log interpretation.

Diagrammatic cross section showing interpreted genetic unit boundaries within the Cypress.

Outcrop and core show channel element geometry and permeability zonation within genetic units. Mean cross-set thickness is 0.29 m, and cross-sets are superimposed on bar-scale accretion surfaces or low amplitude - high wavelength dunes. Unit bars are ~4 m thick and channel fill stores are up to ~20 m thick. Such dimensions are used to ensure the geocellular model properly represents genetic flow units.

Principal sandstone lithofacies include unidirectional cross-bedding (A), asymmetric ripple cross-bedding (B), and planar bedding (C), all of which contain exceptionally low volumes of detrital clay. Subtle lags with clay clasts and/or fossil fragments occur at channel bases (D). There are relatively few widespread baffles within genetic units.

Static, three-dimensional, geocellular models are used to simulate hypothetical CO₂ injection scenarios and ultimately predict CO₂-EOR performance and CO₂ storage efficiency. Development of such models requires a firm understanding of all scales of heterogeneity to infer internal characteristics and properly represent porosity/permeability relationships. This knowledge is also used to incorporate small-scale features that influence fluid flow, that are poorly represented by logs into the model.

Their spatial extent and thickness, high porosity and permeability, and limited internal baffles make thick Cypress Sandstones excellent targets for CO₂-EOR and storage.

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For project information, including reports and presentations, please visit: http://www.isgs.illinois.edu/research/ERD/NCO2EOR