RESERVOIR CHARACTERISTICS OF MORROW/INCISED-VALLEY FILL PLAYS

TECHNOLOGY CONNECTIONS
PETROLEUM TECHNOLOGY TRANSFER COUNCIL

BOTTOM LINE

Identifying certain Morrow and related-age reservoirs in Kansas as fluvial origin in spite of their occurrence in a marine shale context, gives operators the needed perspective to successfully explore for similar reservoirs and develop existing reservoirs more efficiently.

PROBLEM ADDRESSED

Exploration for and development of elongate reservoirs encased in fine-grained marine sediments of the Pennsylvanian Morrow in Kansas has resulted in remarkable success in recent years, but a better understanding of the depositional context and internal architecture is needed for continuing success in exploration and increasing recovery from existing reservoirs.

KEY WORDS:

- Cherokee Group
- Incised valley fill
- Log interpretation
- Morrow
- Petrophysical methods
- Seismic interpretation
- Sequence stratigraphy
- Waterflooding

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SPEAKERS:

Tonganoxie IVF System, Northeastern Kansas and Modern Estuarine Analogs
Allen Archer, Kansas State University

Routine and Special Core Petrophysical Properties of Kansas IVF Reservoirs
Allen Byrnes, Kansas Geological Survey

Integrated Petrophysical Methods for Analysis of Reservoir Microarchitecture
John Doveton, Kansas Geological Survey

Oil and Gas Production from Kansas IVF Reservoirs
Paul Gerlach, Kansas Geological Survey

Evaluation of Morrow Reservoirs by Modern Wireline Logging Tools
Bill Guy, Kansas Geological Survey

Chester Formation in South Eubanks Field
Ernie Morrison, Kansas Geological Survey

Interpretive Aspects of Seismic Coherence and Related Multitrace Attributes
Susan Nissen, Kansas Geological Survey

Waterflood Characteristics of the Morrow, Stewart Field, Kansas
Rodney Reynolds, TORP

Analysis of Morrow Incised Valley Reservoirs
Roderick Tillman, Consulting Geologist

Incised Valleys in the Cherokee Group, Southeastern Kansas
Anthony Walton, Univ. of Kansas

Sequence Stratigraphic Framework of IVF Systems
Lynn Watney, Kansas Geological Survey

TECHNOLOGY OVERVIEW

Incised-valley fill (IVF) reservoirs in Kansas occur in Permian to Mississippian sediments at depths from 2,000 to 6,000 feet. IVF oil reservoirs are found in rocks of Morrow, Cherokee and Chester age, and IVF gas reservoirs occur in Morrow, Atoka and Cherokee rocks. Both oil and gas reservoirs are common in the Morrow. About 15% of all oil-producing reservoirs and 28% of all gas-producing reservoirs in the state are of IVF origin, and of recently discovered oil and gas reservoirs, 50% and 70%, respectively, are in IVF deposits. Most IVF reservoirs are attractive waterflood candidates.

Developing a better understanding of IVF reservoirs relies on application of both new ideas and new technologies, as well as judicious application of traditional knowledge. Sequence stratigraphic concepts applied on regional, subregional and local (field) scales lead to defining the circumstances of formation of these porous and permeable rocks encased in tight marine sediments as fluvial to estuarine origin. Paleogeographic studies, coupled with studies of modern depositional analogs, make the stratigraphic occurrence of IVF reservoirs predictable. Emerging 3-D seismic techniques can pinpoint reservoir boundaries.

IVF reservoirs are associated with rapid sea level fall exposing previously deposited marine sediments to subaerial weathering and erosion/incision by fluvial processes. Therefore the key to searching for IVF reservoirs, in a stratigraphic sense, is identifying the stratigraphic occurrence of sudden drops in sea level through larger scale paleographic studies based on wireline log and regional seismic data. In some instances, such as in the Cherokee Group, definitive thin and consistent sequences of varying lithologies that represent the sudden change from submarine to subaerial conditions mark the prospective stratigraphic interval for IVF development on a regional scale. Numerous analogous examples of IVFs in modern Quaternary environments can be identified to help understand the internal and external geometries of the sediment bodies. Notable among these are deposits found in Nigeria, the North Sea, New Zealand, Trinidad, the Bay of Fundy, the Gulf of Mexico, and the East Texas Coastal Plain.

The workshop included a review of 3-D seismic interpretation as applied to IVF reservoirs with emphasis on the application of multi-trace attributes and seismic coherence. Multi-trace attribute technology is simply the use of more than a single trace line as input to seismic attribute defintion. Seismic coherence is a measure of the trace-to-trace similarity of seismic waveform within a defined window. These approaches have several advantages in delineating lateral boundaries (e.g., faults, lateral stratigraphic contacts) and are particularly rapid ways to extract critical information from large seismic datasets. IVF reservoirs are particularly amenable to detection because of the sharp lateral changes in lithology associated with their scour and fill origin. Time-slice versus horizon-slice approaches to 3-D seismic interpretation each have characteristic advantages and disadvantages. The time-slice approach has best application in doing reconnaissance and structural mapping, while the horizon-slice approach has more application in detailed stratigraphic analysis, particularly in areas of strong regional dip.

Fluvial and related estuarine/intertidal sediments that characteristically fill incised valleys have internal reservoir properties consistent with their origin. Fluvial facies in general have higher permeabilities and lower clay content than estuarine sediments, but they are highly heterogeneous, both laterally and vertically. Fluvial deposits tend to be less calcareous and often exhibit fining-upward sequences.

In analyzing Morrow logs in IVF reservoirs, the Archie equation generally is applicable without serious complications. Traditional values of a=1, m=1.8, and n=2 are almost always valid. In only a few cases do anomalous water resistivities or the occurrence of pyrite or clays cause problems. Simple log analysis procedures and use of simple crossplots, such as Pickett plots, which are crossplots of porosity and resistivity, can be implemented from inexpensive spreadsheet-based programs (such as Excel®)to define electrofacies for mapping of internal reservoir compartments.

LESSONS LEARNED:

Poor waterflood recovery from a typical Morrow IVF reservoir at Stewart field in Finney Co., Kansas, was a function of unrecognized reservoir heterogeneity, channeling of injected water, and clogging of injection wells by solids in the injection water. Problems in most IVF reservoirs in Kansas can be attributed to poor reservoir management practices: poor data collection, no integrated analysis of data, multiple operators, and failure to identify optimum recovery techniques. Reservoir characterization (with laboratory work) is a necessary component and volumetric analyses are necessary first steps. Reservoir modeling and identification of appropriate recovery processes should follow, along with identification and correction of operational problems. The Stewart field went from 270 BOPD to 3150 BOPD by optimizing the waterflood using this approach.

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