Testing the Distributary Channel Model Against Predicted Changes in Fluvial Reservoir Geometry During Transitions From Low to High Accommodation Settings: Upper Pennsylvanian of the Central Appalachian Basin*

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Abstract

Models for distributary channel networks argue that rapidly aggrading systems that are presumably high accommodation will convert from low-accommodation single channel to distributary systems as they encounter the new conditions. If distributary channel systems are also bifurcating systems, it follows that channel size should reduce from low-accommodation to high-accommodation settings. Poorly drained floodplains with a lower energy regime and relatively high water table should record very high accommodation conditions and should particularly be susceptible to developing bifurcating distributary systems. We tested this hypothesis by comparing channel dimensions and lithofacies in high- vs. low- accommodation deposits in the Pennsylvanian strata of the Princess and Conemaugh Formations of eastern Kentucky. A valley complex 5–8 m thick typifies the low-accommodation setting with individual channel belts ranging from 0.75–1.5 m thick. Channels are highly amalgamated, are composed of fine to medium grained sands, and become heterolithic towards the top. Distributary channels, lake strata and smaller tie channels dominate the high accommodation floodplain settings. Distributary channels exhibit lateral accretion elements and are typically 1–3 stories, with individual channels being 0.4–1 m thick. Tie channels are 14–40 cm thick, very fine grained, and cross-cut floodplain lake strata. Thin, discontinuous, fine to very fine grain sand sheets connected to isolated tie channels represent pulses of deposition from channel propagation across the lake as a overbank sheet. Our data indicates a change in channel size, range of channel size, and channel geometry changes with an increase in accommodation state from low to high that is consistent with an upward change to a bifurcating system. This observation confirms the prediction of vertical change in geometry and size/size range of channels with change in accommodation state and supports the hypothesis that channels become bifurcated with sufficiently increased accommodation state. As well, the high accommodation condition is unpredictably well connected through tie channel propagation across the floodplain and distributary channel incision into these tie channel bodies and their overbank sands. Basin-fill models should thus consider the contingency that channel-belt reservoirs can change attributes with aggradation state and need not retain the sizes they possessed in the low-accommodation condition.
Abstract

Recent studies have demonstrated the dynamic nature of the Earth's crust, with many high accommodation conditions and occasional, significant events in the surrounding environments. The distribution of accommodation structures is a complex system that is influenced by a variety of factors, including tectonic activity, climate change, and human activities. This study aims to test the Distributary Channel model against predicted changes in fluvial reservoir geometry during transitions from low to high accommodation settings in the Upper Pennsylvanian of the Central Appalachian Basin.

Methods

The study area is located in the Central Appalachian Basin, which spans parts of Kentucky, West Virginia, and Pennsylvania. The basin is characterized by a series of longitudinal and transverse folds, and a complex system of faults. The sedimentary fill of the basin is dominated by fluvial and lacustrine deposits, with a variety of sedimentary structures and lithofacies associations.

Stratigraphy

The study area is dominated by the Conemaugh Group, which is a sequence of fluvial and lacustrine deposits. The group is divided into several members, each with distinct sedimentary characteristics. The most prominent member is the Princeville Fm., which is characterized by a series of channel abandonment cycles.

Lithofacies Associations

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Purpose of Study and Introduction

This study aims to test the Distributary Channel model against predicted changes in fluvial reservoir geometry during transitions from low to high accommodation settings in the Upper Pennsylvanian of the Central Appalachian Basin. The basin is characterized by a series of longitudinal and transverse folds, and a complex system of faults. The sedimentary fill of the basin is dominated by fluvial and lacustrine deposits, with a variety of sedimentary structures and lithofacies associations.

Location, Tectonic and Paleogeographic Setting

The study area is located in the Central Appalachian Basin, which spans parts of Kentucky, West Virginia, and Pennsylvania. The basin is characterized by a series of longitudinal and transverse folds, and a complex system of faults. The sedimentary fill of the basin is dominated by fluvial and lacustrine deposits, with a variety of sedimentary structures and lithofacies associations.

Lithofacies Interpretations

This study aims to test the Distributary Channel model against predicted changes in fluvial reservoir geometry during transitions from low to high accommodation settings in the Upper Pennsylvanian of the Central Appalachian Basin. The basin is characterized by a series of longitudinal and transverse folds, and a complex system of faults. The sedimentary fill of the basin is dominated by fluvial and lacustrine deposits, with a variety of sedimentary structures and lithofacies associations.

Conclusions

This study aims to test the Distributary Channel model against predicted changes in fluvial reservoir geometry during transitions from low to high accommodation settings in the Upper Pennsylvanian of the Central Appalachian Basin. The basin is characterized by a series of longitudinal and transverse folds, and a complex system of faults. The sedimentary fill of the basin is dominated by fluvial and lacustrine deposits, with a variety of sedimentary structures and lithofacies associations.
Sedimentary Structures

Correlation of Louisa Outcrops

Paleoflow

Legend for Lithofacies map

Generalized Lithofacies Diagrams

Quantitative Analysis

Schematic Logs

Fluvial and deltaic channel systems in the central Louisa area show well-developed channel stratigraphic successions with unimodal paleoflow as indicated by cross-bedding. The mean flow direction is toward the north-northwest, which is consistent with the direction of the Alleghanian orogen and the fluviodeltaic reconstructions of earlier workers (Arkle, 1974; Donaldson, 1979; Donaldson et al., 1985). Local flow directions range from west to northeast, such variability is likely in high-sinuosity channel systems and radiating deltaic distributaries. Channel sandstones commonly exhibit large-scale bar accretion surfaces that commonly dip at a high angle with respect to the paleoflow directions indicated by internal cross-strata, a feature that is common in meandering channel systems. Mud-filled channels resulted from avulsion and channel deactivation. In meandering systems, this produces oxbow lakes (Martino, 2004).

Generalized lithofacies diagrams were constructed to aid in visualizing the nature of the lithofacies relationships. The vertical sections from the cross-section above give a relative idea to how these outcrops relate in a vertical sequence.

The Princess #9 coal is the contact between the Breathitt Group and Conemaugh Group. About 8 m above this coal is the amalgamated channels of the incised valley complex. We interpret the well-drained interfluves from the base of the Louisa 1A, 1B, and 1C outcrops to be the time equivalent floodplain of the axial channels that were confined within the valley from the Louisa 2A, 2B, and 3A outcrops. There is a substantial change in the size, geometry, stacking patterns and drainage of the correlatable floodplain going up through the section which we interpret to reflect an increase in accommodation, a leveling of the slope of the alluvial plain, and a transition to distributary from axial channels.

## Channel Assemblage

<table>
<thead>
<tr>
<th>Channel Type</th>
<th>Width (meters)</th>
<th>Thickness (meters)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amalgamated Axial Channel Complex</td>
<td>200-350</td>
<td>7-11</td>
</tr>
<tr>
<td>Individual Channel within Amalgamated Valley Complex</td>
<td>15-60</td>
<td>1.5-4</td>
</tr>
<tr>
<td>Clustered Proximal to Medial Distributary System</td>
<td>300-500</td>
<td>2-4</td>
</tr>
<tr>
<td>Individual Proximal to Medial Distributary Channel</td>
<td>4-6</td>
<td>.8-2.5</td>
</tr>
<tr>
<td>Distal Sheet Distributive Units/Channels</td>
<td>200-300</td>
<td>.4-.8</td>
</tr>
<tr>
<td>Wings</td>
<td>300-500</td>
<td>.2-.6</td>
</tr>
</tbody>
</table>

Typical vertical sections going through the amalgamated channels in an incised valley (lower-left) and through the medial channels of the distributary system (lower-right). Sedimentary structures are well developed in the amalgamated channels where they range from trough cross-bedding, to stacked channel-fill dunes with scour bases. The distributary channels were never observed to have more than 2 channels in communication and the channel fill typically consists of siltstones and silty mudstones. The sequence is capped by more isolated single body channels separated by laminated poorly drained mudstones.

Representative vertical sections going through the amalgamated channels in an incised valley (lower-left) and through the medial channels of the distributary system (lower-right). Sedimentary structures are well developed in the amalgamated channels where they range from trough cross-bedding, to stacked channel-fill dunes with scour bases. The distributary channels were never observed to have more than 2 channels in communication and the channel fill typically consists of siltstones and silty mudstones. The sequence is capped by more isolated single body channels separated by laminated poorly drained mudstones.
Architectural Analysis

Infered Filling Assemblage

The incised valley fill complex consists of incised channels filled with channelized fines, terraces, abandoned channels, and associated topographic lows. These topographic lows were isolated, cut off, and abandoned during the avulsion events. They often occur at the point of channel abandonment, where a new channel forms. These deposits consist of fine-grained, poorly sorted sediments that are characteristic of floodplain environments.

Element 1: Bars

The distributive system assemblage consists of three main elements: channel fill elements (both sandy filled and abandoned), bars, and wings. The channel belt is characterized by lateral accretion elements that migrate laterally and vertically. The wings extend laterally from the tops of channels. There are no more than two sets of parallel laminations within the channel belt, indicating a high proportion of bedload transport.

Element 2: Channels

These channel elements are characterized by the presence of well-laminated mudstones and siltstones deposited under standing water conditions. The channels are laterally equivalent and have a well-defined inner and outer margin. The channels show evidence of avulsion and incision, with the presence of incised valley fills.

Element 3: Wings

The wings are characterized by the presence of fine-grained sediments that migrate laterally from the tops of channels. They are laterally equivalent and show evidence of avulsion and incision, with the presence of incised valley fills.

Discussion

The models for Distributive Fluvial Systems exhibit a reduction in channel size and increase in number of channels. These changes are due to an increase in terrestrial accommodation space during transitions from low to high accommodation settings. This change is evident in the study area and is due to an increase in terrestrial accommodation space during transitions from low to high accommodation settings.

Conclusions

The change in channel belt morphology is due to an increase in terrestrial accommodation space during transitions from low to high accommodation settings. This change is evident in the study area and is due to an increase in terrestrial accommodation space during transitions from low to high accommodation settings.

References


Sedimentological Analysis

The nature of the floodplain indicates poorly drained conditions where there was standing water or possibly ephemeral lakes. The floodplain environment is characterized by well-laminated mudstones and siltstones deposited under standing water conditions.

Interpretation:

- Sandy channel fill elements are adjacent to lateral accretion elements and divert around migrating side-attached bars.
- Lateral accretion elements are formed by bedload bedforms indicative of flows of varying energy.
- Lower plane beds produced parallel laminations and anti-dunes formed during supercritical flow. Multiple flooding events smeared individual units into the floodplain.
- The nature of the floodplain indicates poorly drained conditions with standing water or possibly ephemeral lakes.