

Sandbody Architecture and Sequence Stratigraphy of the Lower Permian Decie Ranch Member of the Skinner Ranch Formation, Lenox Hills, West Texas

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Summary

The focus of this study was to characterize the sedimentology and sandbody architecture of the coarse-grained Decie Ranch Member of the Skinner Ranch Formation in order to better understand the origin and deposition of this interpreted lowstand deposit. The Lower Permian (Kungurian) Skinner Ranch Formation is exposed within the Lenox Hills (Glass Mountains) in Brewster County, Texas. In these outcrops, an alternation of conglomerate-rich (lowstand), and organic-rich mudstone-rich (transgressive/highstand) units are present. These exposures provide a unique opportunity to view strata interpreted to be coeval to portions of the economically important "Wolfcamp A" reservoirs in the subsurface of the adjacent Delaware Basin.

Introduction

The study area is in the Glass Mountains just west of the town of Marathon, in Brewster Texas. In this area, Pennsylvanian and Permian strata are exposed along the Glass Mountains, including the Wolfcamp Group which is generally accepted as a standard section for the lower Permian Wolfcampian Series in North America.

Cooper and Grant (1964) divided the Wolfcamp Group in this region into three formations. A (lower) Neal Ranch Formation, (middle) Lenox Hills Formation, and a(n) (upper) Skinner Ranch Formation. They also divided the uppermost Skinner Ranch Formation into four units, which from the base up were termed the Decie Ranch, Poplar Tank, Sullivan Peak, and Dugout Mountain Members. Within this succession, the Decie Ranch and Sullivan Peak Members were conglomerate-rich, while the Poplar Tank and Dugout Mountain Members were more mudstone-rich. The basal conglomerate-rich Decie Ranch Member is the focus of this study.

Methodology

A field-based outcrop study was undertaken with the goal of describing the sedimentological and architectural characteristics of the Decie Ranch Member in the Lenox Hills Formation. In this study, digital drone photography was collected to create a 3D model of the study area to assist with mapping and characterization of sandbody distribution. This was followed by measuring five detailed stratigraphic sections for the Decie Ranch Member using a Brunton and a Jacob staff to obtain true stratigraphic thicknesses. Detailed observations of variations in grain size and lithofacies were also made, and hand samples were collected.

Sedimentology

This study revealed that the Decie Ranch Member of the Skinner Ranch Formation contains abundant coarse-grained channels. These channels consist of blocky, massive, calciclastic sand-sized grains with common bioclastic and mudstone rip-up clasts. The 1) massive to structureless texture of the calciclastics; 2) paucity of tractional features such as trough crossbedding, and 3) lack of evidence of waves such as wave ripples or hummocky cross stratification are all consistent with rapid deposition from suspension by sediment gravity flows deposited below storm wave base. The coarser-grained material, such as the large clasts and pebbles, are interpreted to have been deposited as bedload associated with the gravity flows based on their strong alignment and common clast supported texture. Furthermore, these coarse-grained deposits would be classified as a mixture of Bouma Ta deposits comprised of massive, medium grained sandstones and S3 coarse-grained massive sandstones and R1 pebbly sandstones from the Lowe's classification for coarser-grained high density turbidites (Bouma, 1962 & Lowe, 1982).

Depositional Setting

The original interpretation for the Decie Ranch Member in the study areas was that they were deposited in a deepwater basinal setting. Based on sedimentological analysis the dominant depositional process is sediment gravity flows but these types of deposits can accumulate in many locations on a shelf to basin profile including a basinal setting. The outcrops of these coarse-grained deposits display distinct evidence of erosional and channelization with as much as 100 feet of incision at the base of the Decie Ranch Member (Figure 1). The coarse-grained nature of the member, the dominance of channels, and the deep incision into the underlying units suggest the unit was deposited in a proximal and high depositional gradient setting. In fact, the amount of incision observed in the outcrops would be unlikely to occur in a low gradient, basal setting and is more typical of a more proximal and higher gradient setting. Based on these observations the Decie Ranch Member is interpreted to have been deposited as part of a relatively confined system such as a slope valley commonly observed on the slope.

Channel Architecture

The Decie Ranch Member in the study area is comprised of five channel elements which form a channel complex. The individual channels themselves are deeply incised and range in thickness from 58 to 75 feet, suggesting they formed on a relatively steep gradient. This is further supported by the

Stratigraphy and Sedimentology of the Skinner Ranch Formation

channel fill which is dominated by thick-bedded, structureless, sand-sized calciclastic with common cobble- to bolder-sized bioclastic and mudstone rip-up clasts. Channels range in width from 500 to 1800 feet. Only minimal changes are observed from axis to margin indicating that these are amalgamated channel-fills (Figure 1).

Each successively younger channel is laterally offset to the southwest by 500 to 1000 feet and do not appear to cut into each other (Figure 2). This “organized” stacking of these non-amalgamated channels is commonly observed in systems with muddy overbanks and could be attributed to a possible leveed system. Not only are the channels laterally offset to the southwest, but they also get progressively wider moving from east to west. This is interpreted to reflect ranges in the “apparent” widths of the channels intersecting the outcrop at progressive more oblique angles through time related to channel migration.

Sequence Stratigraphy

The Decie Ranch is interpreted as an early lowstand deposit associated with the initial stages of a relative lowstand in sea level (Figure 3). Locally, the basal contacts of the channels in the member are erosional and incise into the underlying mudstones. Very coarse-grained facies of both members also sharply overlie thick mudstone intervals. This abrupt

juxtaposition of high-energy coarse-grained facies and low-energy mud-rich facies is interpreted as a basinward shift in facies. These observations, in combination with the incision at the base of the channels suggests there is a sequence boundary at the base of the Decie Ranch Member. The coarse-grained, channelized deposits of the Decie Ranch Member is interpreted as a lowstand deposit associated with these relative falls in sea level. The overlying fine-grained, facies of the Poplar Tank Member are interpreted as transgressive to highstand deposits

Conclusions

The Decie Ranch Member in the study area was originally interpreted to have been deposited in a basinal setting. The relatively coarse-grained and channelized nature of the outcrop, however, suggests a more proximal setting and it is now interpreted as having been deposited in a more confined system, typical of a slope setting. The laterally offset, organized stacking of the channels is interpreted as an indication of a non-amalgamated, possibly leveed depositional system, with the individual channels being comprised of amalgamated channel fill. Finally, the alternation of conglomerate-rich and organic-rich mudstone-rich units are interpreted to reflect relative changes in sea level with the Decie Ranch Member interpreted to be a lowstand deposit.

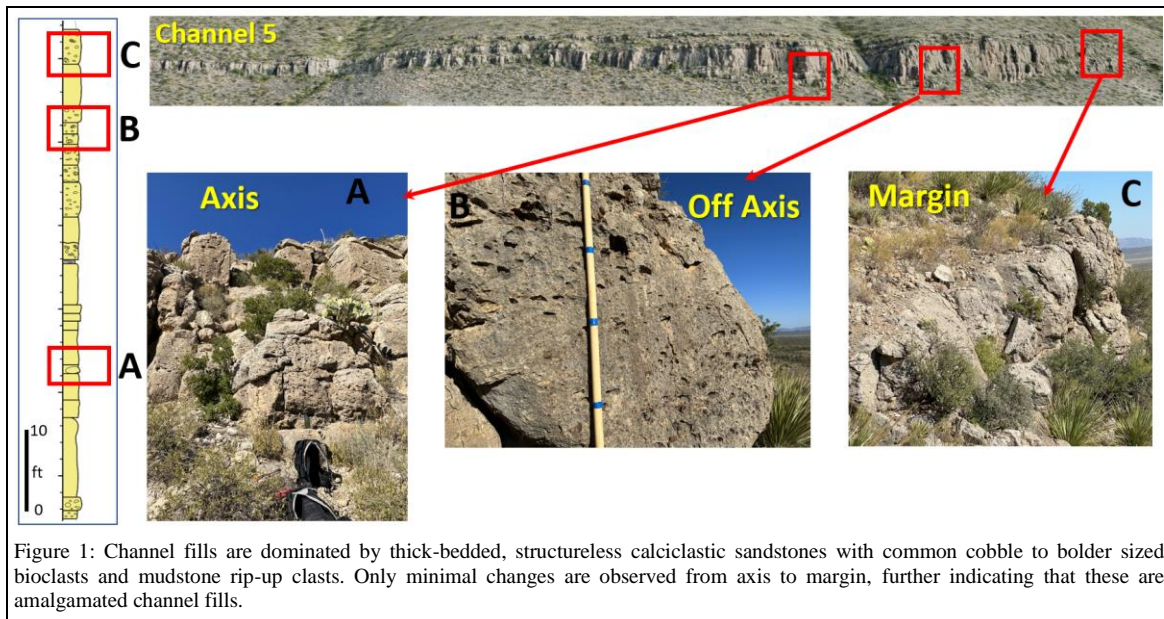


Figure 1: Channel fills are dominated by thick-bedded, structureless calciclastic sandstones with common cobble to bolder sized bioclasts and mudstone rip-up clasts. Only minimal changes are observed from axis to margin, further indicating that these are amalgamated channel fills.

Stratigraphy and Sedimentology of the Skinner Ranch Formation

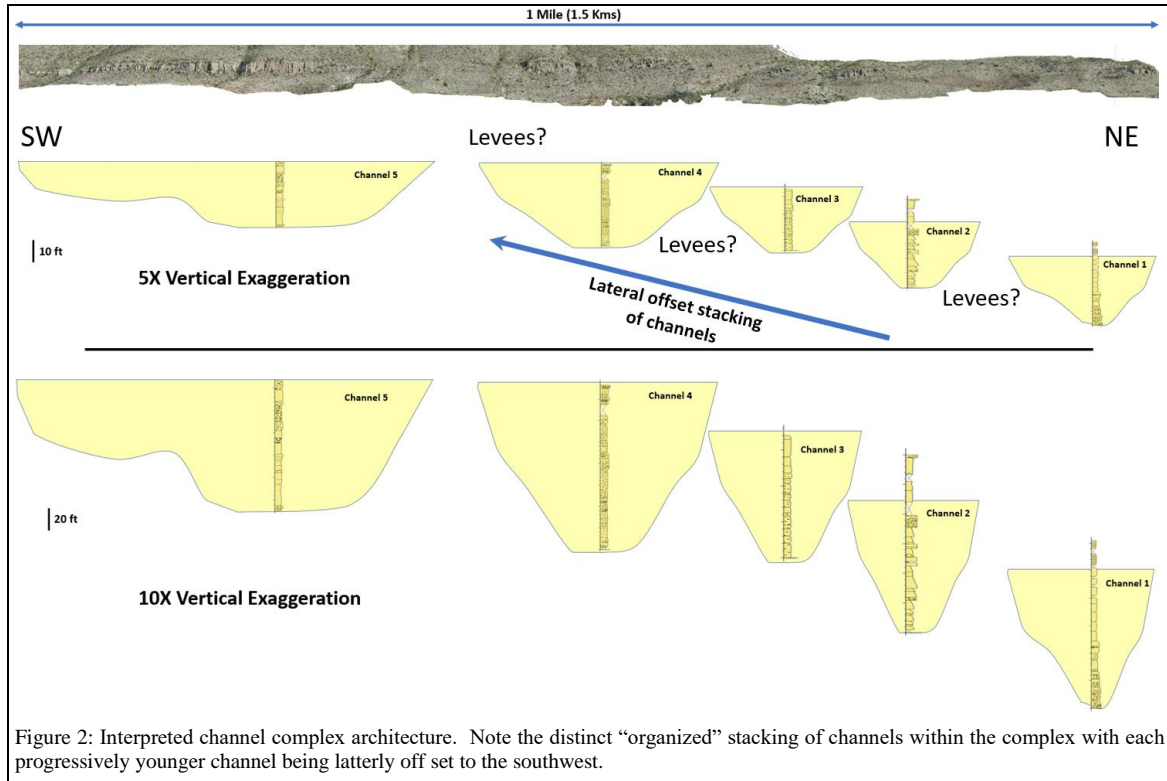


Figure 2: Interpreted channel complex architecture. Note the distinct “organized” stacking of channels within the complex with each progressively younger channel being laterally offset to the southwest.

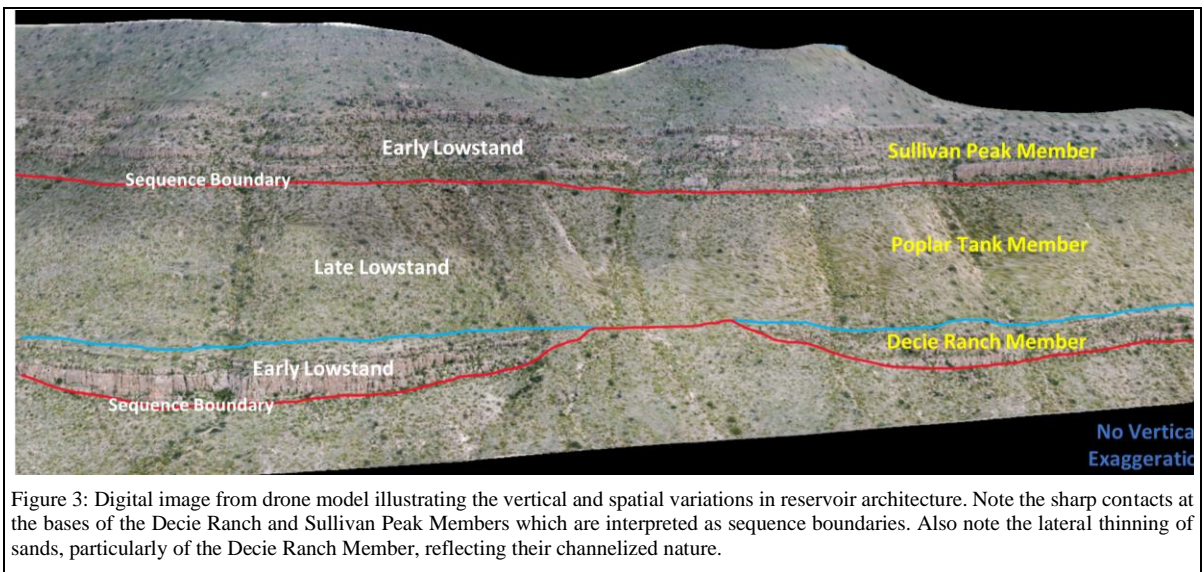


Figure 3: Digital image from drone model illustrating the vertical and spatial variations in reservoir architecture. Note the sharp contacts at the bases of the Decie Ranch and Sullivan Peak Members which are interpreted as sequence boundaries. Also note the lateral thinning of sands, particularly of the Decie Ranch Member, reflecting their channelized nature.