

A New Look at the Mississippian System in the Permian Basin: Facies, Depositional Environments, and Comparisons to Adjacent Basins

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Abstract

Introduction

The Mississippian System is perhaps the most poorly known succession in the Permian Basin. This is due largely to a lack of information about the rocks related to historically limited successes in hydrocarbon exploration and production. Here we present new data and interpretations based on description and analysis of new and archival cores from the Permian Basin and from analogous successions in adjacent areas of the southern midcontinent.

Facies and Depositional Environments

Mississippian deposition in the Permian Basin can be easily subdivided into a northern region characterized by the by shallow water platform carbonates and a southern areas dominated by deeper water, slope and basin carbonate and mudrock deposition. The platform margin that separates these environments can be traced east-west through the Permian Basin, into the Ft. Worth Basin and northward into the Hardeman Basin.

The Northern Carbonate Platform

The ages and facies of the rocks that comprise the northern platform are not well known. Faunal data suggest that earliest Mississippian deposition of this carbonate platform began during the Late Kinderhookian following regional exposure and erosion of the underlying Upper Devonian Woodford Formation. Kinderhookian rocks, whose distribution is incompletely known, comprise a complex mixture of burrowed siltstones, skeletal wackestones, and siliceous mudrocks that resemble the underlying Woodford in their dark color.



These rocks are temporally equivalent to shallow platform carbonates in the southwestern Ft. Worth Basin and Sacramento Mountains and define overall upward-deepening deposition.

Overlying carbonate platform facies are very poorly known but are best interpreted, based on limited well sample data in the Permian Basin and in the Palo Duro Basin to the north, to comprise cherty wackestones and mudstones. Limited palynological data suggest these deposits are of Osagean age. Regional data (from the Sacramento Mountains and Ft. Worth Basin) suggest a hiatus following deposition of these rocks.

Detailed faunal and facies studies in the Palo Duro Basin suggest that the upper part of the Mississippian section in the northern Permian Basin carbonate succession comprises Meramecian crinoidal and ooid packstones and grainstones and overlying Chesterian cyclic, organic matter poor mudrocks and shallow water carbonates. In the Hardeman and Ft. Worth basins, deposits of this age consist of proximal platform margin buildups and flanking skeletal debris and more distal and overlying organic rich mudrocks of the Barnett Fm. These buildups have not been defined in the Permian Basin area.

The Southern Slope and Basin

The Mississippian section in the southern Permian Basin comprises basal carbonates ("Mississippian Limestone") and overlying mudrocks of the Barnett Fm. The basal carbonates exhibit similar complex upward deepening facies successions and age relationships to the Kinderhookian deposits documented in the northern part of the basin.

Overlying Barnett mudrocks are generally similar to those observed in the Ft. Worth Basin, being composed of complex stacks of siliceous, argillaceous, and dolomitic mudstones that can be defined only by closely spaced XRF or XRD analysis. Barnett rocks differ from those in the Ft. Worth Basin by displaying much more limited and variable patterns of organic matter abundance and related



euxinia. This suggests the Permian Basin area may have been much more frequently oxygenated than the Ft. Worth Basin during Barnett time.

Depositional History

Integration of regional data suggest that Mississippian deposition began in the Permian Basin region during the middle Kinderhookian following regional uplift and erosion of the underlying Woodford Fm. Where these rocks have been observed they define a gradual flooding succession that may well have extended over the entire region. There is good evidence across the southern midcontinent that this initial phase of Mississippian deposition was interrupted during the late Osagean when another episode of uplift and erosion took place. Whether this event resulted in exposure of the central Permian Basin region or not is unclear. Reflooding of areas exposed at this time took place in the Meramecian with the deposition of slope and basin siliceous muds (Barnett Fm) across the southern areas of the southern midcontinent including the Permian Basin. Northern parts of the Permian Basin area were characterized by shallow shelf carbonate deposition at this time. Although Barnett sediments continued to be deposited into the Chesterian in distal and platform marginal areas, there is evidence in the northern Permian Basin area of continued upward-shallowing of shallow shelf carbonate deposition to the end of the Mississippian. Later, at some time in the early Pennsylvanian (Morrow to Atoka time), large parts of the Permian Basin and surrounding areas were uplifted and Mississippian rocks were removed or truncated over much of the region.

Reservoir Development

Mississippian rocks have produced hydrocarbons in limited amounts from both carbonate and mudrock (i.e., Barnett Fm) facies. Significant, though small, production from carbonate fields has been restricted to areas along the carbonate platform margin in what is now the Midland Basin. Well records and facies reconstructions suggest that much of this production has come from interbedded cherty carbonates and organic matter (OM) rich mud-



rocks along this margin.

Production from the Barnett has been limited to small volumes from individual wells scattered across both the Delaware and Midland basins. Although these rocks are locally similar in lithology, thickness, and maturity to the highly productive Barnett in the Ft. Worth Basin there are some key differences that may account for the lack of major successes in the Permian Basin. Available data suggest that much of the upper Barnett section is poor in OM and that even the more OM rich lower Barnett contains lower and more variable amounts of OM than present in the Ft. Worth Basin. Additionally, scanning electron microscope studies reveal that even in very mature areas (i.e., in the Delaware Basin), the Permian Basin Barnett contains comparatively few of the organic matter pores that are abundant and support gas production in the Ft. Worth Basin.

