Facies and Facies Architecture of the Codell Sandstone, Northern Colorado Front Range and Adjacent Denver Basin, CO

Edmund R. Gustason[1], Topher Lewis[1], and Marshall Deacon[2]

[1]Enerplus Resources, Denver, CO
[2]Edge Oil and Gas, LLC, Denver, CO

ABSTRACT

The Codell Sandstone Member (Codell) of the Carlile Shale has been producing large quantities of oil and gas in the northern Denver Basin, Colorado since the early 1980s. Until recently, the Codell was developed as a vertical play in Wattenberg Field. Today, aided by 3D seismic data, operators have successfully drilled horizontal wells up to two miles long in Wattenberg and throughout the northern Denver Basin. However, very little is known about the vertical and lateral facies changes or facies architecture of the Codell over these distances and the impact they have on production. In the northern Denver Basin, the Codell unconformably overlies the Fairport Member of the Carlile Shale and is unconformably overlain by the Niobrara Formation. The Codell ranges in thickness from approximately 40 feet in outcrops north of Fort Collins, CO to 0 feet along the southeastern part of Wattenberg Field; largely due to the interplay (truncation and/or preservation) between the two unconformities. Based on descriptions of more than 60 cores and several outcrops, the Codell consists predominantly of bioturbated sandy mudstone and muddy sandstone with rare thin beds of planar parallel laminated (SPPL) to low angle laminated (HCS) sandstone and ripple cross lamination over much of Wattenberg Field. To the north and northeast of Wattenberg Field, in northern Weld County, Colorado and Laramie County, Wyoming, SPPL and HCS facies are more common. Recent workers have demonstrated that these laminated sandstone facies have significantly better reservoir properties, especially permeability, than bioturbated sandstone and bioturbated muddy sandstone facies. Thicker, more complete vertical facies successions suggest the Codell was deposited by a prograding marine shoreline. The application of Walther's Law to predict the continuity and connectivity of facies, especially the better reservoir quality facies, and facies architecture along a horizontal wellbore is dependent on an accurate interpretation of these vertical facies successions. For example, if clinoforms are present, what is their dip angle and azimuth? In addition to measured sections of outcrops from widely spaced road cuts, gullies, and irrigation ditches, we present the results of a detailed characterization of a three- mile-long, north-south oriented, continuous outcrop of the Codell, located north of Fort Collins, where the authors used photomosaics and closely spaced measured sections to trace out facies and their bounding surfaces and create a database of the dimensions, continuity and connectivity of facies. Inasmuch as most horizontal wells in the northern Denver Basin are also oriented north-south, the results of this study could provide operators with a direct analog for the facies and facies architecture of the Codell in the adjacent subsurface. The Codell Sandstone Member (Codell) of the Carlile Shale has been producing large quantities of oil and gas in the northern Denver Basin, Colorado since the early 1980s. Until recently, the Codell was developed as a vertical play in Wattenberg Field. Today, aided by 3D seismic data, operators have successfully drilled horizontal wells up to two miles long in Wattenberg and throughout the northern Denver Basin. However, very little is known about the vertical and lateral facies changes or facies architecture of the Codell over these distances and the impact they have on production. In the northern Denver Basin, the Codell unconformably overlies the Fairport Member of the Carlile Shale and is unconformably overlain by the Niobrara Formation. The Codell ranges in thickness from approximately 40 feet in outcrops north of Fort Collins, CO to 0 feet along the southeastern part of Wattenberg Field; largely due to the interplay (truncation

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