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The Northern DJ Basin: Distribution of Rock Properties

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ABSTRACT:

Since the early 1980s, the Codell Sandstone member of the Carlile Shale has received much attention from the petroleum industry for its productive potential in the Northern DJ Basin. Academic focus has been on the depositional environment of the Codell, and its place in the Turonian Stage Greenhorn Marine Cycle. There have been differences of opinion regarding the sediment source and depositional environment of the Codell, with an eastern source and shelf area favored mostly by recent petroleum industry workers. Also complicating the provenance interpretation is the relatively contemporaneous deposition of Frontier Formation clastic wedge sediments sourced from the west. Vertical juxtaposition of Codell and Frontier units is seen across several unconformable sequence boundaries dividing both units (Figure 1).

The purpose of this study is to add to the understanding of regional Codell Sandstone distribution, particularly with respect to discriminating Codell facies from those of the Frontier. A brief review of the existing literature is provided, and used to inform the construction of fence diagrams using open-hole well logs. Log correlations benefitted from the presence of laterally extensive bentonite markers, as well as relatively unambiguous log properties seen for shale and carbonate units in the lower part of the Carlile Shale, underlying the Codell Sandstone.

Log correlations were augmented by data from public domain cores, from over 50 wells. The integrated data were used to categorize the Codell and associated facies into 5 general rock types, as follows:

1) Bioturbated sandstone – This rock type is dominant at Wattenberg, and southern Wyoming. The original depositional bedding has been disturbed by burrowing organisms, but the sandstone retains 12+ % porosity, and thicknesses >15-20 feet for much of the Wattenberg area. Poor log response due to high clay content and high bound water volume has contributed to the belated development of the play outside of Wattenberg field, but vertical production of bioturbated Codell has been ongoing since the 1980s.

2) Bedded sandstone - This rock type is similar to the bioturbated facies in mineralogical composition, but retains depositional bedding. In southern Wyoming, the bedding is generally horizontal to hummocky cross-stratified, usually associated with storm beds. These "laminated" facies are seen to exhibit higher permeability than the adjacent bioturbated facies. In Goshen County and north, the sandstone bedding is more commonly cross-stratified or crypto-bioturbated, and beds are more "massive" and lighter in appearance, which points to their deposition in an upper to middle shoreface environment, or

gradational delta front to delta plain environment.

3) Mud Drape - The dominantly mud-draped sandstone rock type typically occurs beneath, or within, the shoreface Bedded sandstone. As such, the Mud Drape rock type is seen as related to and deposited with other shoreface facies, supported by the fact that they are not seen in association with the Bedded or Bioturbated rock types to the south and east. The Mud Drape facies has not been identified to any significant extent east into Nebraska.

4) Layered sandstone - The Layered sandstone rock type consists of alternating thin (~1" thick) layers of sandstone and shale, and is generally devoid of bioturbation. The Layered sandstone rock type is seen primarily in Wyoming and has tentatively been identified in the lower portions of southwestern Nebraska cores. The preserved bedding in these rocks and lack of bioturbation is taken to indicate relatively rapid deposition in a pro-delta environment.

5) Shale - The Shale rock type has been identified in the most general of ways, principally to discriminate the facies from other rock types with easily identifiable sandstone components, as identified above.

The Codell of the Wattenberg Field area in Colorado is dominated by the Bioturbated rock type. Thickening and reservoir quality improvement to the west is believed to be an expression of increased shelf energy, and not necessarily an indication that these rocks were sourced from the west. Very little Layered rock type has appeared to have reached as far south as the Colorado State line, into the Wattenberg area. In southern Colorado however, outcrop studies verify the presence of Layered rock type in association with Bedded/Mud Drape rock type. These rock types in southern Colorado are believed to be associated with an eastern sediment source. Relevant features of the paleo-shelf are surmised to be related to some of the same processes which created the Wattenberg High and Morrill County High. General southeastward thickening of the Carlile, off the flanks of the aforementioned features, also supports this hypothesis.

In contrast, Bedded/Mud Drape and Layered rock types are dominant in the northernmost DJ Basin, in Goshen and Platte Counties, Wyoming. Together with isopach mapping of key units, rock type distribution suggests that the rocks in Wyoming show a greater influence from a western source area. This study supports the hypothesis that these northernmost DJ facies, generally identified as Codell in earlier work, are actually equivalent to the (Frontier) Wall Creek of the Powder River Basin.

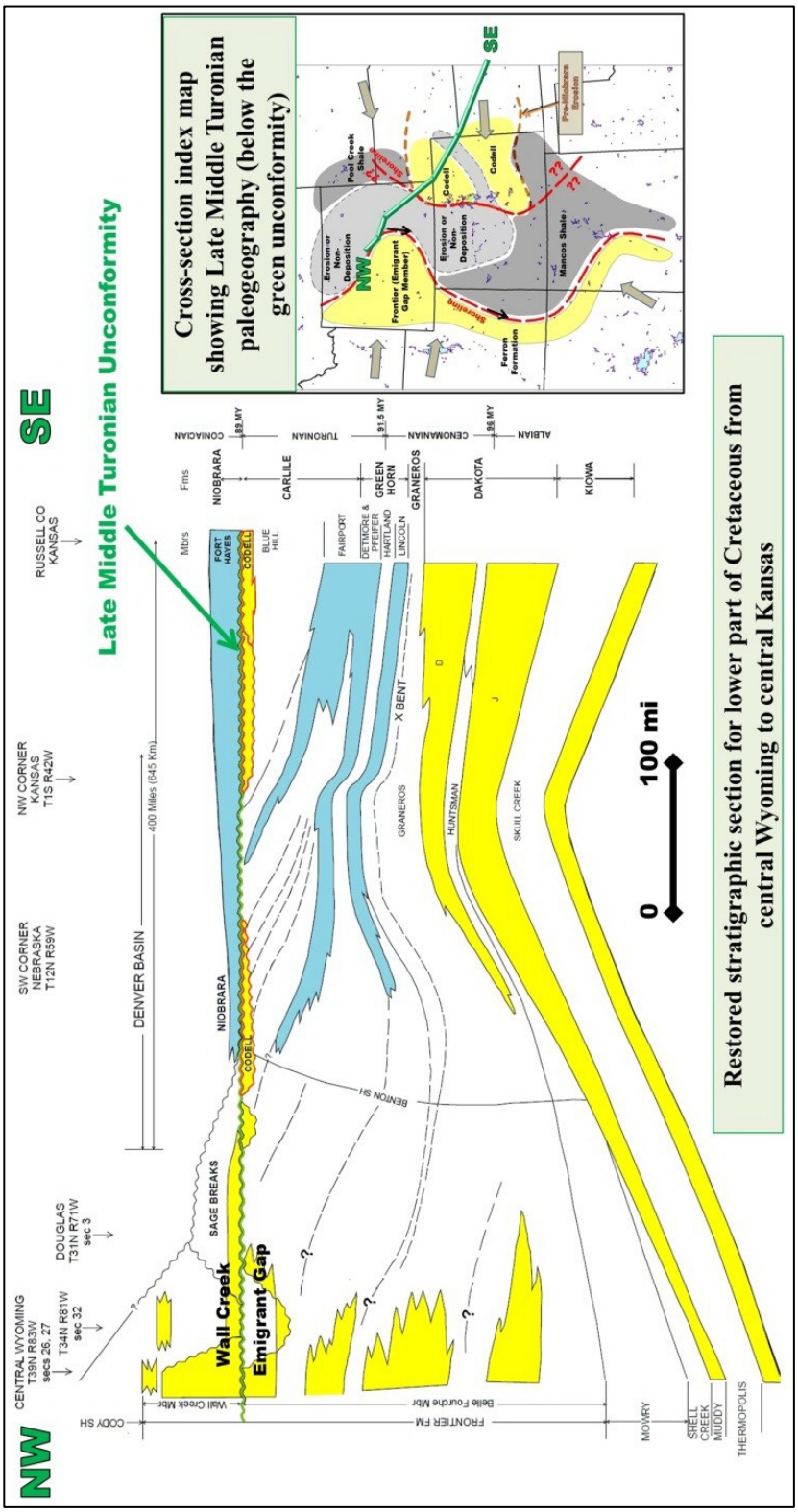

Figure 1: Stratigraphic Juxtaposition of Codell and Frontier Rocks Relative to the Late Middle Turonian Unconformity and Underlying Units (after Weimer, 1986, and Lewis, 2013)

Speaker Biography:

Michael A. Domenick (Mick) has over 30 years professional experience in the petroleum industry, based exclusively in Denver, and is currently consulting for several clients working in the Rockies. Mick's expertise extends from exploration to development and operations, with primary emphasis on Rocky Mountain basins but including experience in the Hugoton and Anadarko basins and the Texas and Louisiana Gulf Coast. Mick has focused on the Denver and Powder River Basins for the past ten years. Mick formed Slick Oil Limited in July 2015, in order to better position himself for the inevitable up-turn in petroleum commodity prices. Slick Oil's strategy includes the acquisition of mineral leases and equity interest, in collaborative efforts with other like-minded individuals and entities. Slick Oil anticipates increasing industry activity in 2017(!). Mick's technical areas of focus are 1) tight "halo" sandstone plays, including the DJ Basin Codell, as well as "migrated semi-conventional" plays throughout the Rockies; 2) hybrid reservoir full realization to define thicker total petroleum systems, as was done with the Bakken into the Three Forks; and 3) low-profile conventional plays situated in space and time as bridges to increased unconventional resource opportunities .

Mick strives to fully utilize the foundational wealth of work and knowledge which has come before, as viewed through the lens of modern technology and work-flows. As an improvisational jazz saxophonist, Mick plays his music and geology by the rules, respecting the conventions, but on the boundaries of the "chord structure" and with the ear of the audience in mind. As a small- to mid-cap employee throughout his career, Mick owes a debt of gratitude to mentors and colleagues too numerous to mention, who set high standards and provided constructive feedback on a diverse career arc.

Mick earned a Master of Science degree in Geology in 1981 and a Bachelor of Science degree in Geology/Biology in 1979 from the University of Rochester in New York. In addition, Mick completed post-graduate studies in Hydrogeology at the Colorado School of Mines, and Petroleum Geology at the University of Colorado.

Relevant speaking engagements include the keynote address at the Emerging North American Shale Conference in January 2012 (analyzing geologic anomalies in the Niobrara); the Tight Oil Niobrara Congress in May 2012 (regional geologic variability in the Niobrara); the Global Technology Conference in June 2012 (Niobrara sub-plays and fractured reservoir types); the Emerging Shale Plays USA in April 2013 (Des Moines hybrid reservoir properties); the RMAG Hot Play Symposium in September 2016 (Codell petrophysics and horizontal well production); and will speak at the upcoming SEPM luncheon in November 2016 (distribution of Codell reservoir properties).

RMS-SEPM Main Page

RMS-SEPM Luncheon Page

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