Raymond's Folly: The Codell Play of the Denver Basin*

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Search and Discovery Article 70303 (2017)**
Posted November 13, 2017

*Adapted from article, by the same author with the same title, in *THE AAPG EXPLORER*, Historical Highlights, May 2017.

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Early Years

The present-day Cretaceous Codell oil and gas development in the central portion of the Denver Basin of Colorado (Figure 1) can be attributed to an earlier effort in bringing the Codell to the attention of the industry. The origins of this play have been lost in history and its start can be attributed to the geological work I conducted in the early 1980s. As a student at the University of Northern Colorado (UNC) from 1978 to 1980, I was looking at outcrops of the Cretaceous along the foothills in the Loveland, Colorado, area and came across the Fort Hays Limestone and a series of silty sandstones and shales at the base. The sandstone at the base of a deep-marine cold-water limestone indicated an unconformity, which was the reason for the interest in collecting a sample. While collecting a rock sample of the sandstone, I could smell the occurrence of hydrocarbons, knowing at the time that this rock was the Codell Sandstone.

I started correlating from outcrop to the subsurface and across the Loveland Field into the deeper portions of the basin in the heart of the Wattenberg Field (Figure 2), using resistivity and density logs from previously drilled wells. The wellbore signature of the Codell in open-hole logs indicated a high gamma-ray, high-density porosity and low-neutron porosity which, when the two are combined, yield the conventional gas-effect cross-over. The resistivity was low, similar to the Carlile Shale below. It was also noteworthy that the caliper log everywhere seemed to indicate a washout, and upon asking a petrophysicists about this, I was informed that the high porosity was probably due to the washout, and the density tool did not read correctly.
Initial mapping of the gross Codell thickness indicated that it covered many townships and was very extensive throughout the Wattenberg Field area and beyond.

Ongoing Study of the Codell

After graduating from UNC, I went to work for Cities Service Company in Denver and was allowed under the exploitation manager, Vernon Hill, to continue working on the Codell investigation. Continued correlation indicated that the Codell pinches-out going updip and east from the basin axis at the Codell horizon, which more or less parallels Highway 85 going north from Brighton to Greeley, Colorado. This would result

in a stratigraphic, pinch-out type of trap in the updip direction, perfect for creating a big field. Further correlation to the west indicated a more or less full section of the eroded section existing all the way to outcrop along the Front Range.

Conventional log analysis indicated that the Codell was more or less 100 percent water-saturated. To understand the rock, Cities Service Company needed a core, but they were not active in the Denver Basin. So in order to obtain a core for analysis, an independent, Centennial Petroleum, was contacted. Cities offered to cover all costs associated with rig time and vendors if Centennial would agree to stop their drilling operations and core the Codell at a depth determined by Cities Service. Centennial agreed and a whole core of the Codell sandstone was obtained from their Futhey No. 2 well in Boulder County, Colorado (cf. Figure 3). The core was then sent to Roger Slatt at the Cities Service Research laboratories in Tulsa and then on to Core Labs. This occurred on July 28, 1981.

In the interim, Centennial drilled their Futhey No. 1 well to the targeted "J" sandstone for completion. One of the requested studies on the Codell core was initiated by Bob Colby, the petrophysicist working with me on the project. He wanted the true a, m, and n's for the formation resistivity factor at various brine saturates as well as core porosity and permeability. With these parameters, Bob felt that log analysis would be more descriptive than just using an Archie-type water saturation calculation. Initially when Bob conducted log analysis on the Codell, he asked me what the file name should be for storage. I left that up to Bob who jokingly named the file "Raymond's Folly."

A few months passed and Centennial petroleum called me and expressed interest in the core results. Centennial's Futhey No. 1 "J" sandstone well had experienced mechanical completion difficulties, resulting in tubing and a packer being stuck in the hole. If there was potential in the Codell, then Centennial wanted to attempt a completion before junking and abandoning the well. The core results had arrived a few weeks prior to Centennial's call, and they were surprising in content. Bob Colby had already begun using the new a, m, and n values to recompute the water saturation calculations from selected logs across the basin.

Here is a summary of the core results:
The core of the Codell Sandstone is 90-percent quartz, fine-grained silt and sand and heavily bioturbated. Clays appear to be dominantly smectite, illite, and chlorite. These clay minerals bioturbated into and mixed with the terrigenous grains have reduced the permeability to less than 0.01 millidarcies – basically to a level almost too low to measure. The individual quartz grains were observed to contain "anastomosing fractures," which can best be described as what would happen if you took a glass marble, heated it and then dropped it into cold water. The marble fractures but does not fall apart. Some tectonic event combined with frictional heat was the suggested cause. This would generate enough heat and stress to cause the anastomosing fractures.

The a, m, and n values at various saturates from the core were determined to vary. The sample saturated with the lower salinity brine exhibited a lower formation factor than the sample saturated with a higher salinity brine. Hence, it was concluded that fresh water drilling fluids affected the true resistivity observed in open-hole well logs, and this was attributed to the "conductive solids" and the cation exchange capacity of the rock matrix. In addition, hydrocarbons were present in the Codell core.

Bob Colby and I had access to hundreds of "J" sandstone well logs throughout the Wattenberg Field, which were initially drilled on 320-acre spacing. Bob initially used a formation factor of $1.00/\phi^{1.40}$ and an Rw of 0.11, but a more accurate formation factor was later determined. The

water saturation calculations yielded values of less than 20 percent, field-wide. In addition, Bob used the available sonic logs to calculate Q, or clay content, and found that the percent of clay was almost the same value as the water saturation and concluded that if water existed, it was bound in the clay minerals and would never be produced. It was concluded that the net pay covered an area no less than six townships wide and eight townships long, roughly equal to 1728 square miles.

Productivity

What was not known was the productivity potential of the Codell. Based on the core results of the Futhey No. 2 and the new log analysis, it was recommended to Centennial Petroleum that the Futhey No. 1 Codell was worth a completion attempt and could perhaps prevent junking and abandoning the well. The Futhey No. 1 is located in the northeast and southeast portion of Section 26, Township 1N, Range 69 West in Boulder County, Colo. and was completed in the Codell interval. After fracturing treatment, the well tested 262 BOPD of 52-degree gravity condensate and 1.3 MMCFGPD on May 27, 1981. At about the same time, Martin Exploration Management Corporation completed its No. 1 Ertl, located in the southeast and northwest Section 17, T1N-R69W by commingling the “J” and Codell sandstones and reported an IP of 250 BBLS condensate and 1.6 MMCFGPD. It is not known how much oil and gas came from which zones, but these two wells started the development of the Codell.

Amoco Production Company’s first Codell completion was a recompletion of an uneconomical “Muddy J.” The well was the Frank Boulter No. 1, located in the southwest quarter of Section 14, T1N-R66W. On December 16, 1981, during a 24-hour test, the well flowed 102 BOPD and 1.05 MMCFGPD. Amoco with their large acreage position was in an excellent position to develop the Codell, but never did.

I later began consulting and putting together an extensive mapping project of the Wattenberg Codell. I contacted Champlin Petroleum Company and met with Allen Vandevelde and Chuck Traxler and requested a farmout of acreage in the Wattenberg Field. Champlin, at the time, understood that all the acreage was held by production by Amoco and/or Champlin due to the existing “J” gas wells on 320-acre spacing. I had read the original farmout agreement between Champlin and Amoco and pointed out to Champlin that they had retained all the northeast quarter sections for themselves and only committed the “J” sandstone rights to a 320-acre spaced unit, leaving all other mineral rights to Champlin. I requested a farmout of the Codell-Niobrara minerals in every northeast quarter section of every odd-numbered section in the Wattenberg Field on the UPRR right-of-way. Figure 4 shows the major source and reservoir units in the Denver Basin.

Then in early 1985, I contacted a company in Fort Collins, Colorado, Basin Exploration Incorporated, and brought to them the basic farmout proposal. Basin met with Champlin and a farmout proposal was drafted on March 21, 1985. Basin agreed to drill 20 drill-to-earn wells and have a continual drill-to-earn right on the approximately 7000 net mineral acres in the Wattenberg Field. I became the vice president of exploration and production for Basin Exploration.

‘Contiguous’ or ‘Continuous’?

Since that time, thousands of Codell-Niobrara wells have been drilled in the Denver Basin, and it is still being heavily developed to this very day. In an article that appeared in the business section of the Denver-based *Rocky Mountain News* on Sunday, July 4, 1982, I was quoted during

an interview as saying “I predict that the Codell will be the largest continuing producing reservoir in the Rocky Mountains.” What I actually said was “contiguous,” not “continuous,” but the Codell play is now 35 years old and thousands of wells have been drilled and thousands more are scheduled to be drilled along with the emerging Niobrara play. The Codell was considered to be a non-typical reservoir from the beginning, and it has proved to be all that it was determined to be at the onset of the study more than 36 years ago.

Thus, what I began as a study of “Over Looked Oil and Gas in the Loveland Area” at the University of Northern Colorado under the guidance and supervision of William Nesse and Lee Schropshire became the Codell play that has endured until now. There have been many players and the industry has changed over time, but the initial geological interpretation was sound and over time it has proved to be all that it was initially determined and suggested to be, even if at first it might have seemed to be “Raymond’s Folly.”

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Author

Raymond Pierson began his career in Geology in the early '70s and earned a bachelor’s in Earth Sciences-Geology from the University of Northern Colorado in Greeley, Colorado. He then worked for many firms as a consultant or directly during his lengthy career and retired in 2013.

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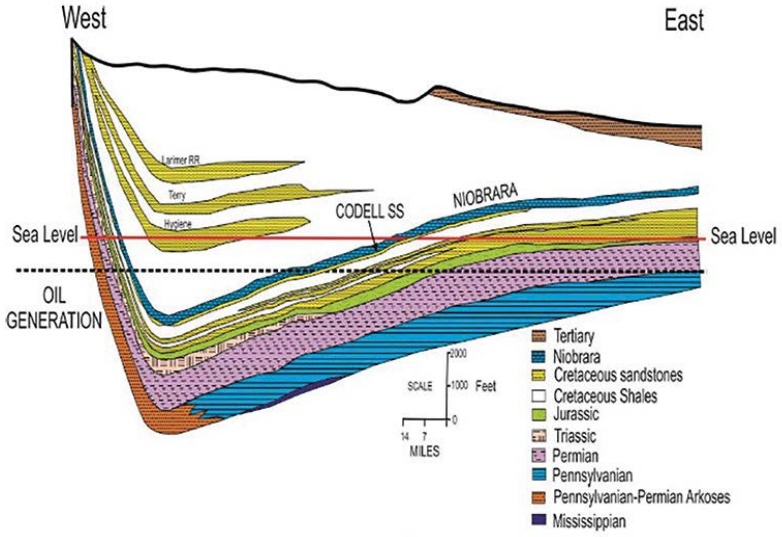

Figure 1. Diagrammatic cross section A-A' (west to east) illustrating the asymmetric nature of the Denver Basin and the occurrence of the Codell Sandstone beneath the Niobrara Formation (adapted from Gustason and Sonnenberg, 2003; Sonnenberg and Weimer, ~2005).

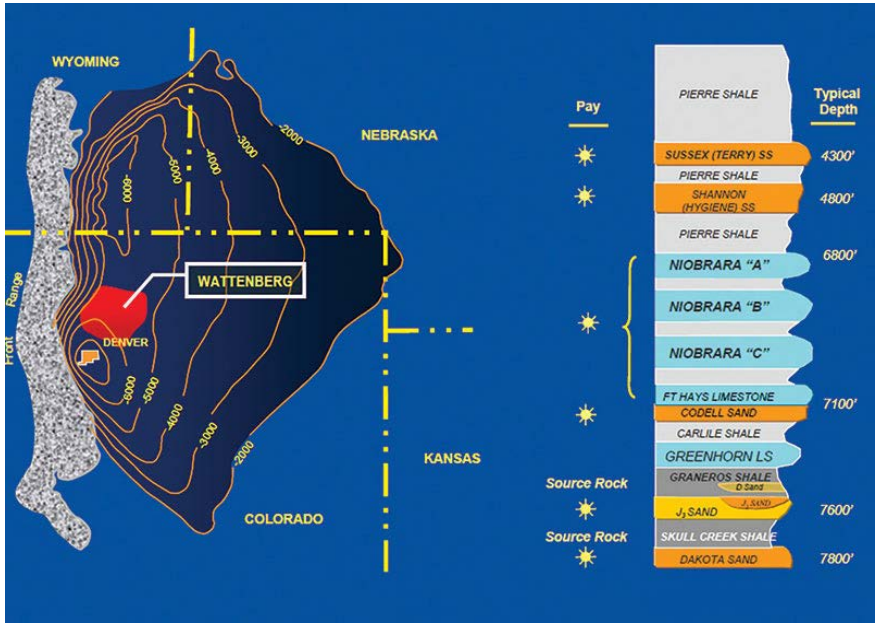

Figure 2. Map of Denver Basin, showing location of Wattenberg Field and stratigraphic column for the productive interval in the field (adapted from Sonnenberg.2002; Sonnenberg and Weimer, ~2005).

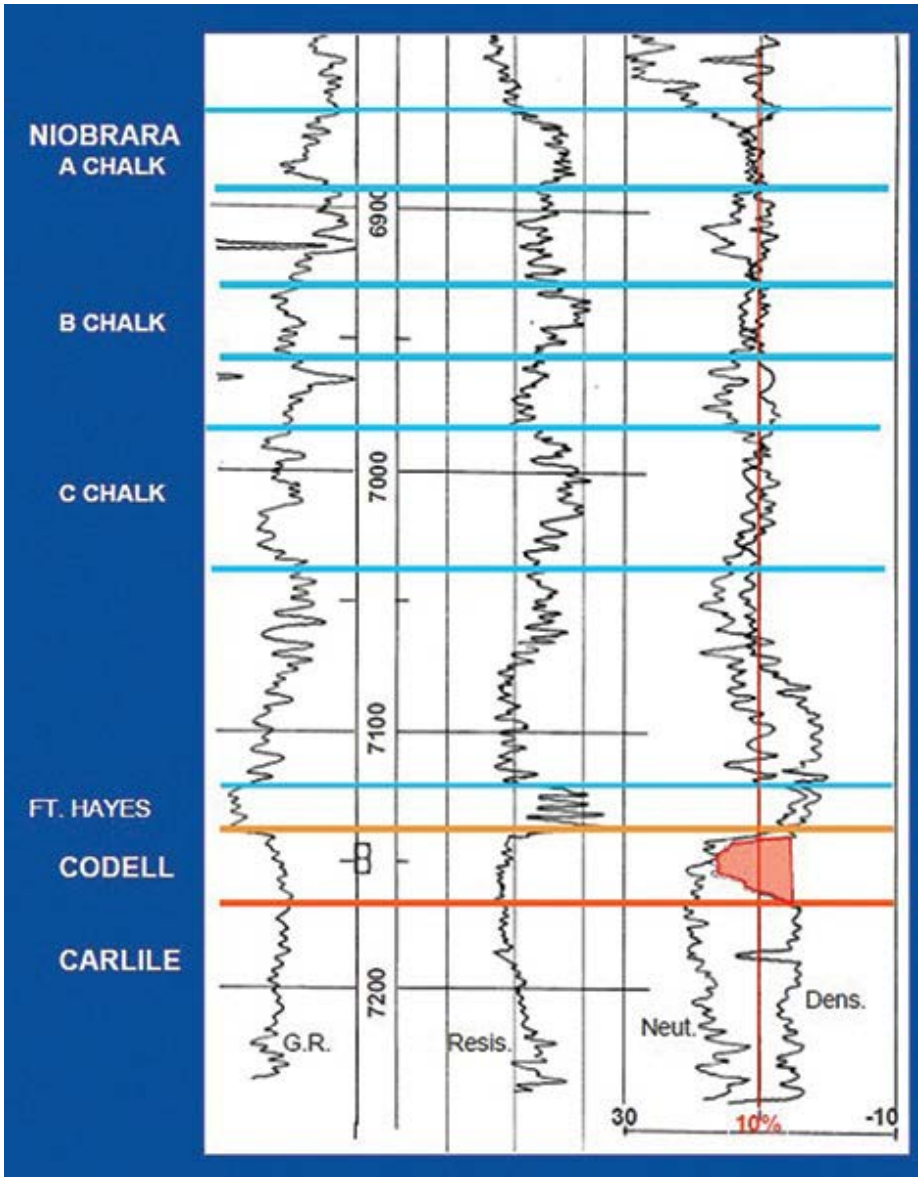

Figure 3. Niobrara and Codell type log, NW SE NW, Sec. 8, T3N-R67W (from Gustason and Sonnenberg, 2003; Sonnenberg and Weimer, ~2005).

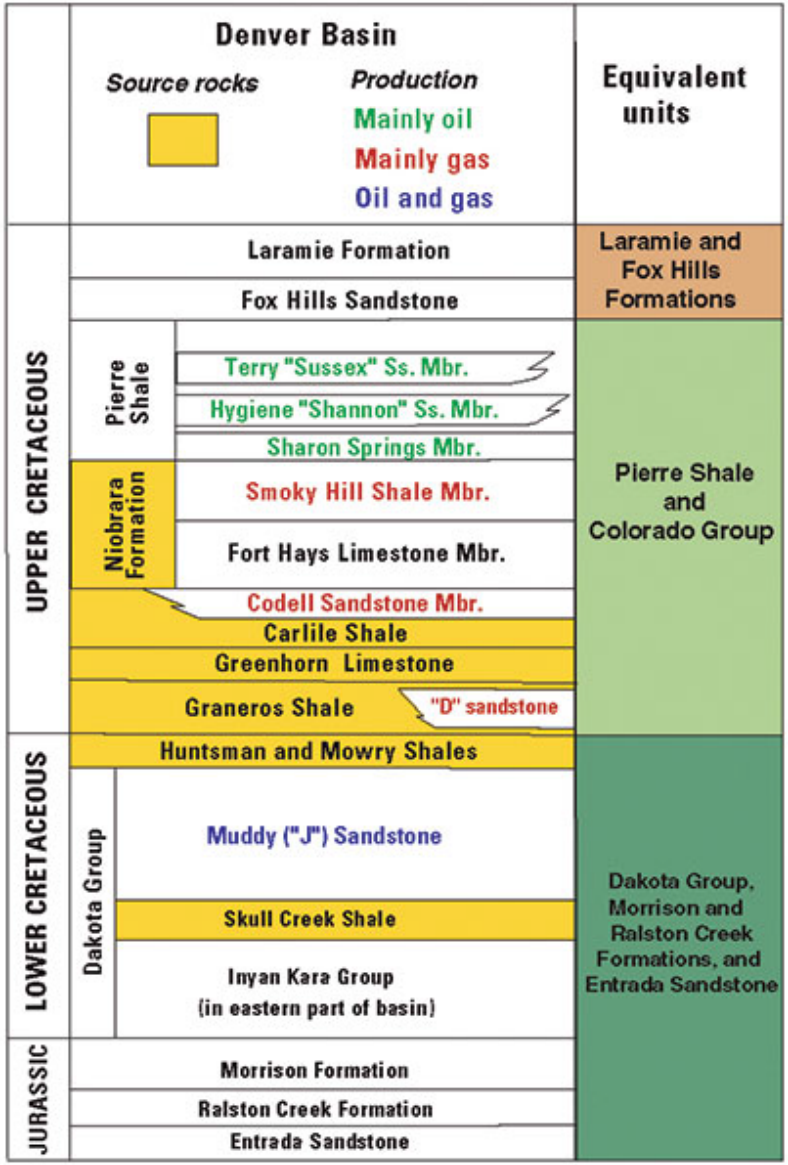

Figure 4. Stratigraphic column of major petroleum source and reservoir rocks in Denver Basin and equivalent units as shown in Figure 2. Formations labeled in green primarily produce oil; those labeled in red primarily produce gas. Rocks from which both oil and gas produced are labeled in blue.