Subsurface correlation and structure of the Mancos Shale, Uinta Basin, Utah

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Introduction

The University of Utah and the Utah Geological Survey (UGS) are starting the final year of a three-year, multidisciplinary study of the Upper Cretaceous Mancos Shale in the Uinta Basin of eastern Utah. The goals of this project are to provide the industry with an assessment of the natural gas potential of the Mancos and to define the most prospective zones within this 4000-foot-thick stratigraphic unit. The poster panels here represent the current status of the subsurface correlation component of the project.

The objective of the correlations is to construct a stratigraphic model in which to incorporate data and interpretations generated by other activities within the project. Specifically these include geochemistry, maturation modeling, petrophysical characterization, facies analysis, and seismic attribute determination. Our goal is to assign these geologic properties to specific stratigraphic units in order that these properties could be traced into parts of the basin where such data are scarce or expensive to acquire.

For additional information about the UGS/University of Utah Mancos Shale project, please visit the UGS exhibit booth or the project website at: http://geology.utah.gov/emp/shalegas/cret_shalegas/index.htm

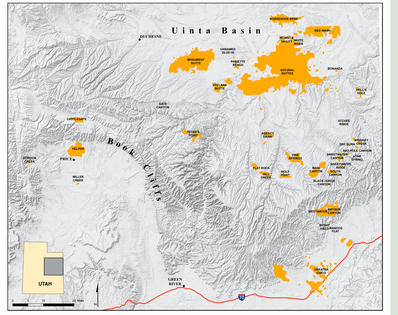
Methods

The data for the subsurface correlations come from more than 150 well records in UGS and Utah Division of Oil, Gas, and Mining (DOGM) files, supplemented with data donated by our industry partners. We downloaded tops of stratigraphic units into IHS Petra software. Most of the tops from IHS were taken from the well completion reports filed with the DOGM, and we used these for the initial correlations. We tied our correlations to published stratigraphic sections, mostly around the basin perimeter. Specific publications that proved useful by discussing log characteristics and/or providing insights into continuity of stratigraphic units were those by Molenaar and Wilson, 1990; Molenaar and Cobban,1991; Johnson, 2003; Anderson and Harris, 2006; McPherson and others, 2006; Hampson, 2010; and Anna, 2012.

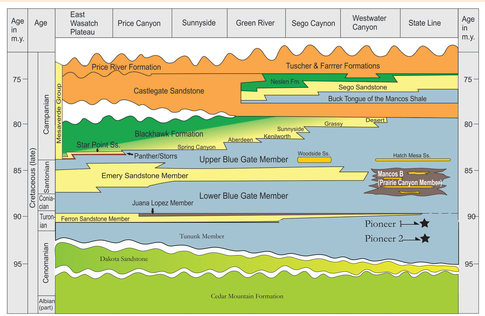
Gas & oil fields with Mancos reservoirs

The Uinta Basin is located in northeastern Utah, bounded by the Uinta Mountains to the north, which are a Late Cretaceous to early Tertiary Laramide uplift. The basin narrows and shallows to the west, and the basin fill gradually thins against the Wasatch Range where older Mesozoic and Paleozoic rocks crop out. The southern margin is the Book Cliffs where the Mancos crops out. The eastern margin is the Douglas Creek arch which separates the Uinta from the Piceance Basin in Colorado.

The DOGM has identified about three dozen oil and gas fields with Mancos production or potential Mancos reservoir. However a number of these fields are inactive, and in the majority of the active fields, Mancos production is comingled with production from lower reservoirs, commonly in the Dakota Sandstone, or overlying Cretaceous and Tertiary reservoirs, making it difficult to assess the Mancos productivity. Only the Atchee Ridge and Black Horse Canyon fields produce exclusively from the Mancos.



Stratigraphic framework



Stratigraphy based on Young, 1955; Hampson et al., 1999; Kirschbaum, 2003; Johnson and Roberts, 2003; Dubiel, 2003.

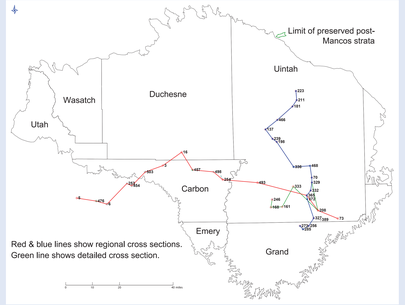
Shallow marine sandstone units | Offshore mudstone units | Fluvial to paralic coal bearing units | Terrestrial
Isolated sandstone bodies | Offshore heterolithic units | Fluvial

An east-west chronostratigraphic section of the Mancos and adjacent units shows these relationships:

The Mancos represents up to 15 million years of deposition. The Late Cretaceous Sevier orogen to the west shed clastics to the foreland basin in the east. Clastics became progressively finer-grained to the east and interfingered with deltaic and marginal marine sands (Ferron, Emery, and Blackhawk Formations), which in turn graded into the units of the Mancos Shale. The relatively coarser-grained, siltier to sandy members of the Mancos such as the Juana Lopez and Prairie Canyon (or Mancos B) probably represent shifts in the balance between relative sea level and sediment supply.

Four stratigraphic intervals are potential targets as shale-gas reservoirs: the Prairie Canyon, the Lower Blue Gate, the Juana Lopez, and the Tunuk. Approximate well locations are represented by black stars.

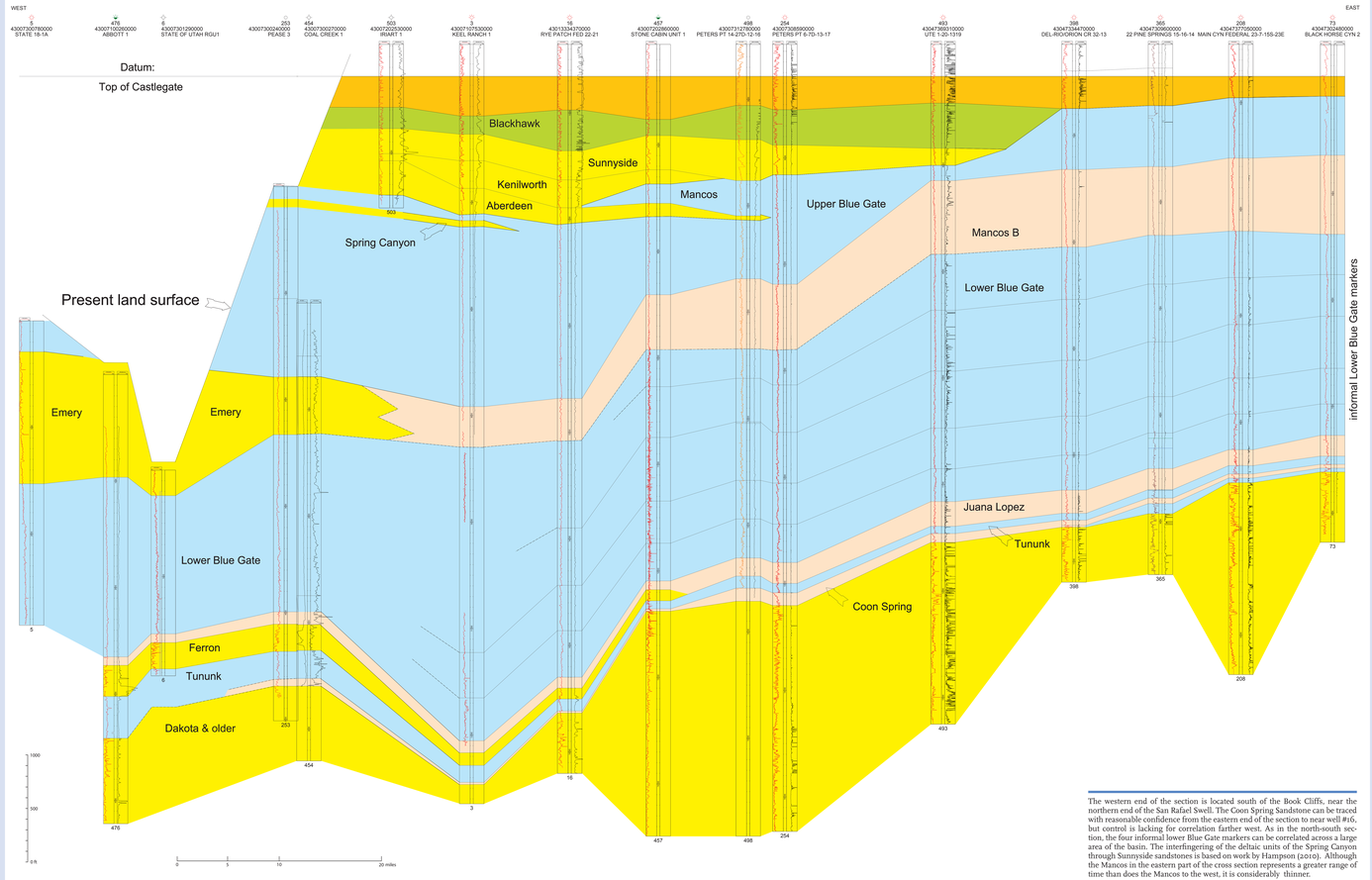
Cross section explanation



Red & blue lines show regional cross sections.
Green line shows detailed cross section.

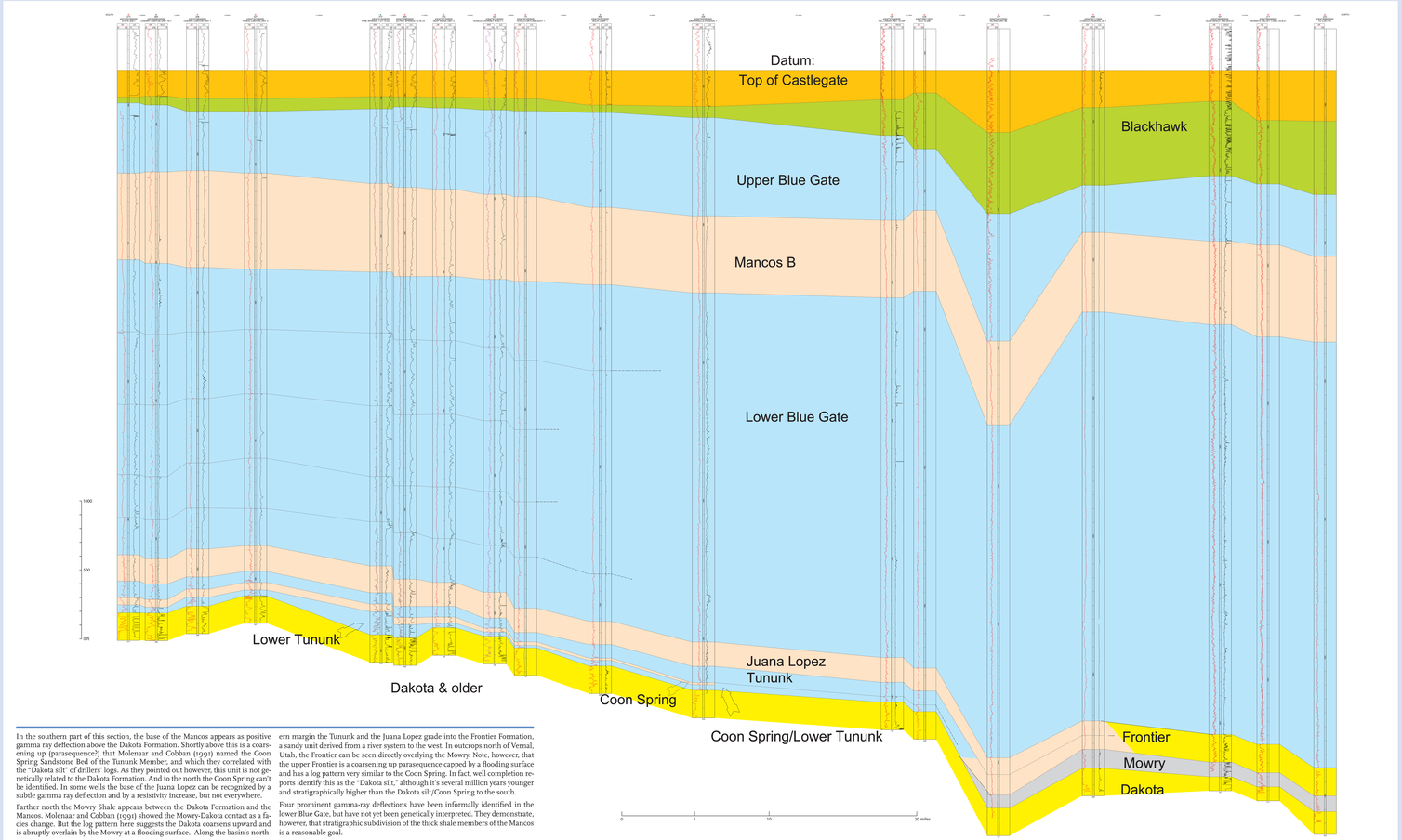
Wells in the cross sections are identified by (from top down): a one- to three-digit well sequence number assigned by the software, API number, and well name. The datum for all sections is the top of the Castlegate Sandstone. Diagonal patterns in wells 6, 181, and 208 show locations of cores studied by Kennedy (2011) and Horton and others (2012).

East-West section



The western end of the section is located south of the Book Cliffs, near the northern end of the San Rafael Swell. The Coon Spring Sandstone can be traced with reasonable confidence from the eastern end of the section to near well #16, but control is lacking for correlation farther west. As in the north-south section, the four informal lower Blue Gate markers can be correlated across a large area of the basin. The interfingering of the deltaic units of the Spring Canyon through Sunnyside sandstones is based on work by Hampson (2010). Although the Mancos in the eastern part of the cross section represents a greater range of time than does the Mancos to the west, it is considerably thinner.

NORTH-SOUTH SECTION

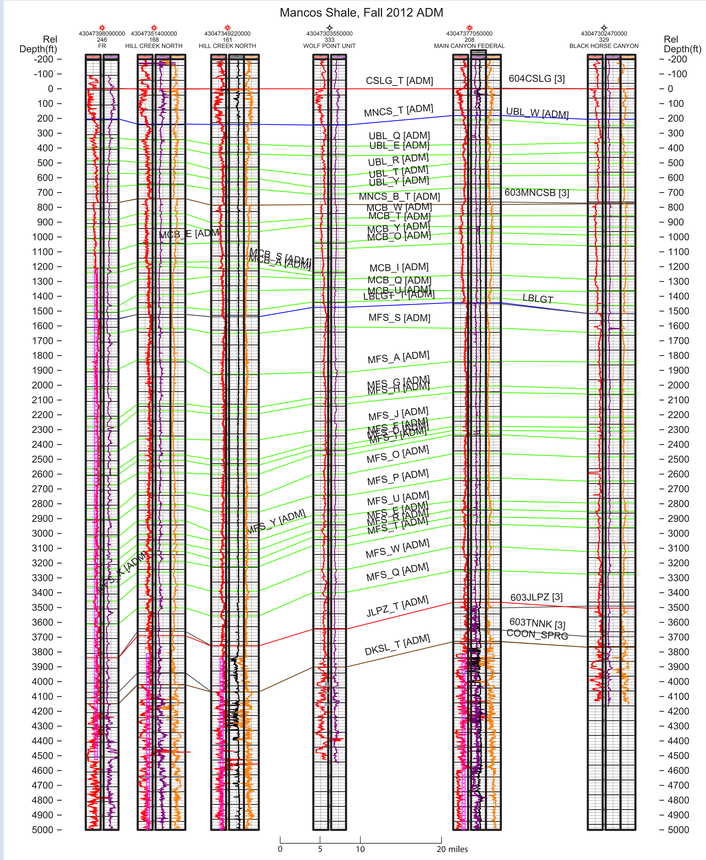


In the southern part of this section, the base of the Mancos appears as positive gamma ray deflection above the Dakota Formation. Shortly above this is a coarsening up (parasequence?) that Molenaar and Cobban (1991) named the Coon Spring Sandstone Bed of the Tununk Member, and which they correlated with the "Dakota silt" of drillers' logs. As they pointed out however, this unit is not genetically related to the Dakota Formation. And to the north the Coon Spring can't be identified. In some wells the base of the Juana Lopez can be recognized by a subtle gamma ray deflection and by a resistivity increase, but not everywhere.

Farther north the Mowry Shale appears between the Dakota Formation and the Mancos. Molenaar and Cobban (1991) showed the Mowry-Dakota contact as a facies change. But the log pattern here suggests the Dakota coarsens upward and is abruptly overlain by the Mowry at a flooding surface. Along the basin's northern margin the Tununk and the Juana Lopez grade into the Frontier Formation, a sandy unit derived from a river system to the west. In outcrops north of Vernal, Utah, the Frontier can be seen directly overlying the Mowry. Note, however, that the upper Frontier is a coarsening up parasequence capped by a flooding surface and has a log pattern very similar to the Coon Spring. In fact, well completion reports identify this as the "Dakota silt," although it's several million years younger and stratigraphically higher than the Dakota silt/Coon Spring to the south.

Four prominent gamma-ray deflections have been informally identified in the lower Blue Gate, but have not yet been genetically interpreted. They demonstrate, however, that stratigraphic subdivision of the thick shale members of the Mancos is a reasonable goal.

DETAILED CROSS SECTION



Working with closely spaced logs makes it possible to correlate a large number of surfaces within the Mancos Shale. The closely spaced correlations are made on gamma-ray spikes provisionally interpreted as flooding surfaces in the lower Blue Gate (prefixed MFS), the Mancos B (MCB), and upper Blue Gate (UBL). This east-west section in the southeastern basin shows the overall eastward thinning of the Mancos, in large part due to the lateral transition of a number of coarsening-up packages in the Lower Blue Gate Member in the West into bow patterns in the East. Otherwise the Blue Gate Member is characterized by layer-cake geometries, while the Mancos B (Prairie Canyon) member shows a more complicated internal stratigraphy.

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