Manning Canyon Shale: Utah's Newest Shale Gas Resource*

Steven Schamel[1] and Jeffery Quick[2]

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[1]GeoX Consulting Inc, Salt Lake City, UT. (geox-slc@comcast.net)
[2]Utah Geological Survey, Salt Lake City, UT.

Abstract

The Manning Canyon Shale in north-central Utah, which has had good gas shows in the past, once again has attracted industry attention. At the north end of the San Rafael Swell, the 22 exploration wells that fully penetrate the Manning Canyon Shale, two of which were drilled in 2008, define a 600-square mile potential shale gas play area. Average depth to the top of the formation is 7,470 feet. Manning Canyon Shale deposition straddled the Mississippian-Pennsylvanian boundary. In the play area approximately between Helper and Woodside, Utah, the formation is up to 1,200 feet thick, of which approximately two-thirds is a dark gray shale, commonly calcareous and carbonaceous. At this location, the formation was deposited in a shallow structural depression on the craton margin between the incipient Uncompaghre uplift to the northeast and the Emery arch to the south. The organic-rich shale is characterized by high gamma ray, neutron porosity and interval velocity log values. Associated intercalated lithologies include limestone, dolomite, and varicolored fine-grained sandstone and siltstone. Strata alternate between marine and non-marine. RockEval geochemistry and vitrinite reflectance (R_0) analyses of the organic-rich shale indicate that it is uniformly in the "dry gas" generative window. Measured R_0 values from many wells are in the range 1.3% to 1.4%. Many factors point to the excellent gas potential of the Manning Canyon Shale: net organic-rich shale thicknesses on the order of 500 feet and greater, "dry gas" thermal maturities, observed gas during drilling, numerous intercalated brittle lithologies for supporting fracture stimulation of the reservoir, reasonable operating depths, and a relatively large area for the gas play.

References

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Manning Canyon Shale

Utah's Newest Shale Gas Resource

Steven Schamel
GeoX Consulting Inc

Jeffery Quick
Utah Geological Survey

Salt Lake City, Utah

Manning Canyon Shale: Key Observations

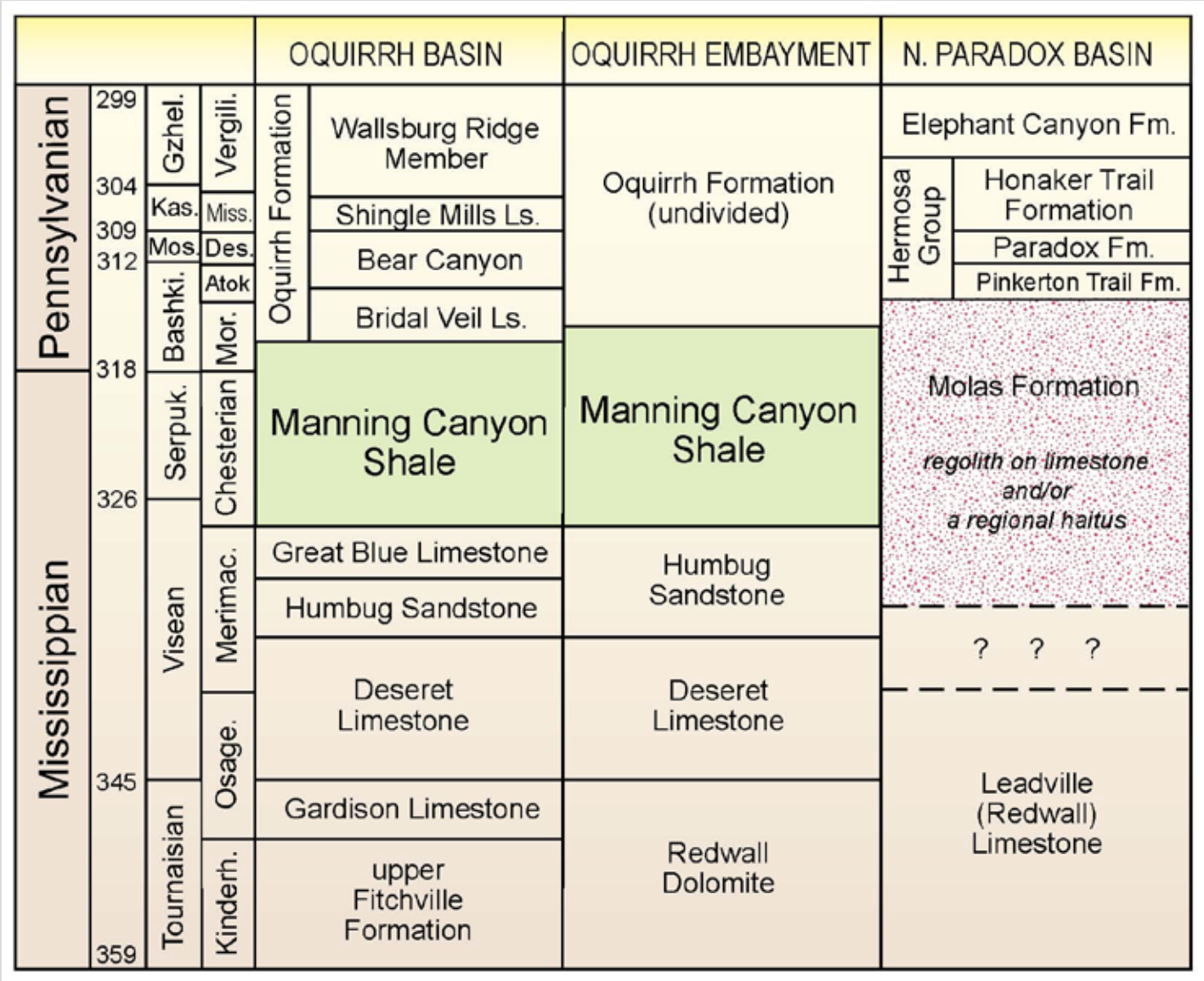
1. The Manning Canyon Shale in north-central Utah has had good gas shows in the past and once again has attracted industry attention. Since 2008 two vertical wells and one horizontal well have been completed and have tested gas. The wells are still tight pending further evaluation of the gas discoveries.

2. At the north end of the San Rafael Swell, 22 exploration wells fully penetrating the Manning Canyon Shale define the potential area for this gas play of 600 square miles. In this area the unit is 300-1,500 feet thick.

3. Organic matter of terrestrial origin and of good to excellent richness is distributed throughout the shales, limestones and even siltstones that comprise the unit. Vitrinite reflectance measurements by the UGS indicate that the kerogen is in the dry gas thermal maturity window.

4. The Manning Canyon Shale appears to lack the cyclicity and lateral continuity associated with many Carboniferous cyclothem units. It may have been deposited in a shallow restricted carbonate- and organic-rich marine, brackish and fresh-water setting not unlike the modern Everglades and Florida Bay.

Late Mississippian-Early Pennsylvanian Age

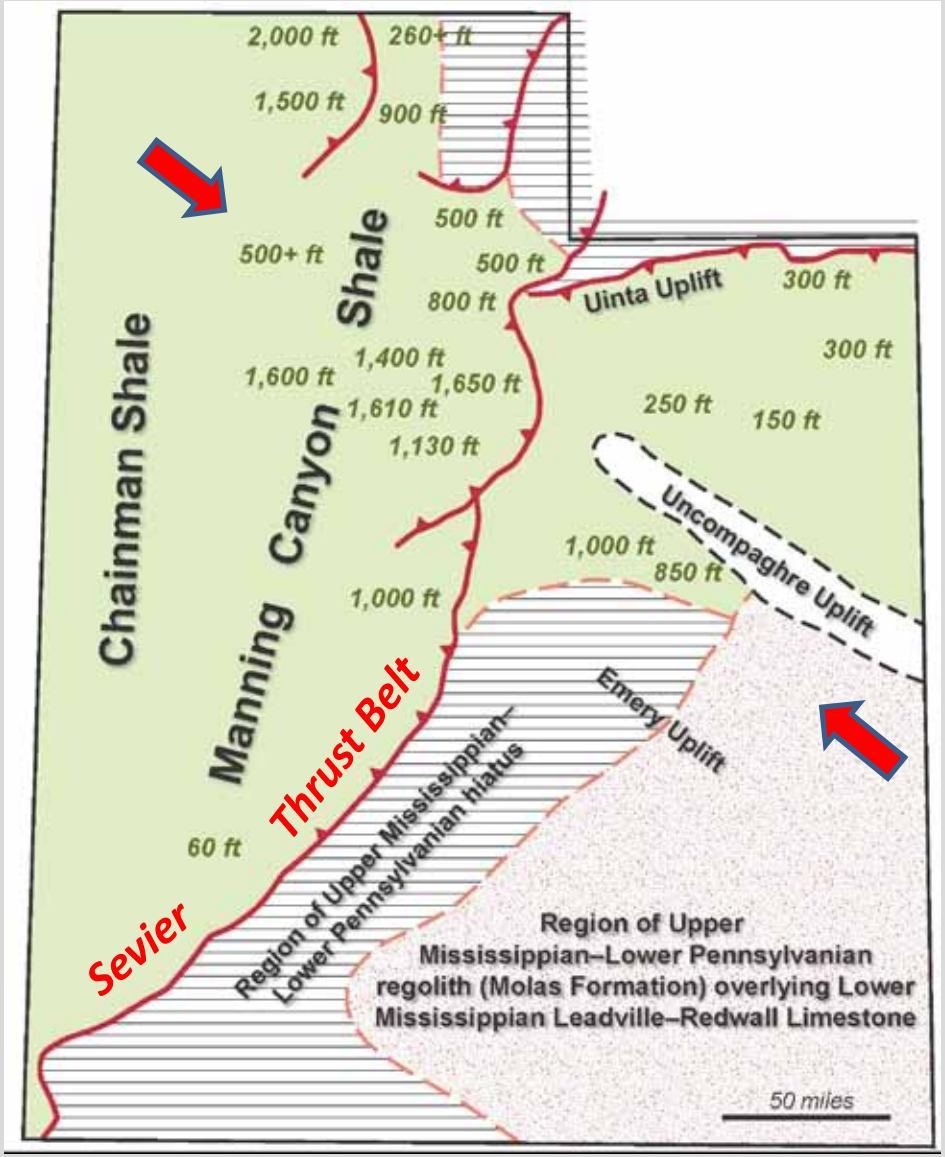


Regional Distribution of the Manning Canyon Shale

The Manning Canyon Shale is an organic-rich limestone-shale and sandstone unit of late Mississippian-earliest Pennsylvanian age found in many of the ranges west of the Sevier Thrust Front and Hingeline, on the flanks of the Uinta Mountains, and in the subsurface in the Book Cliffs area near Price, Utah.

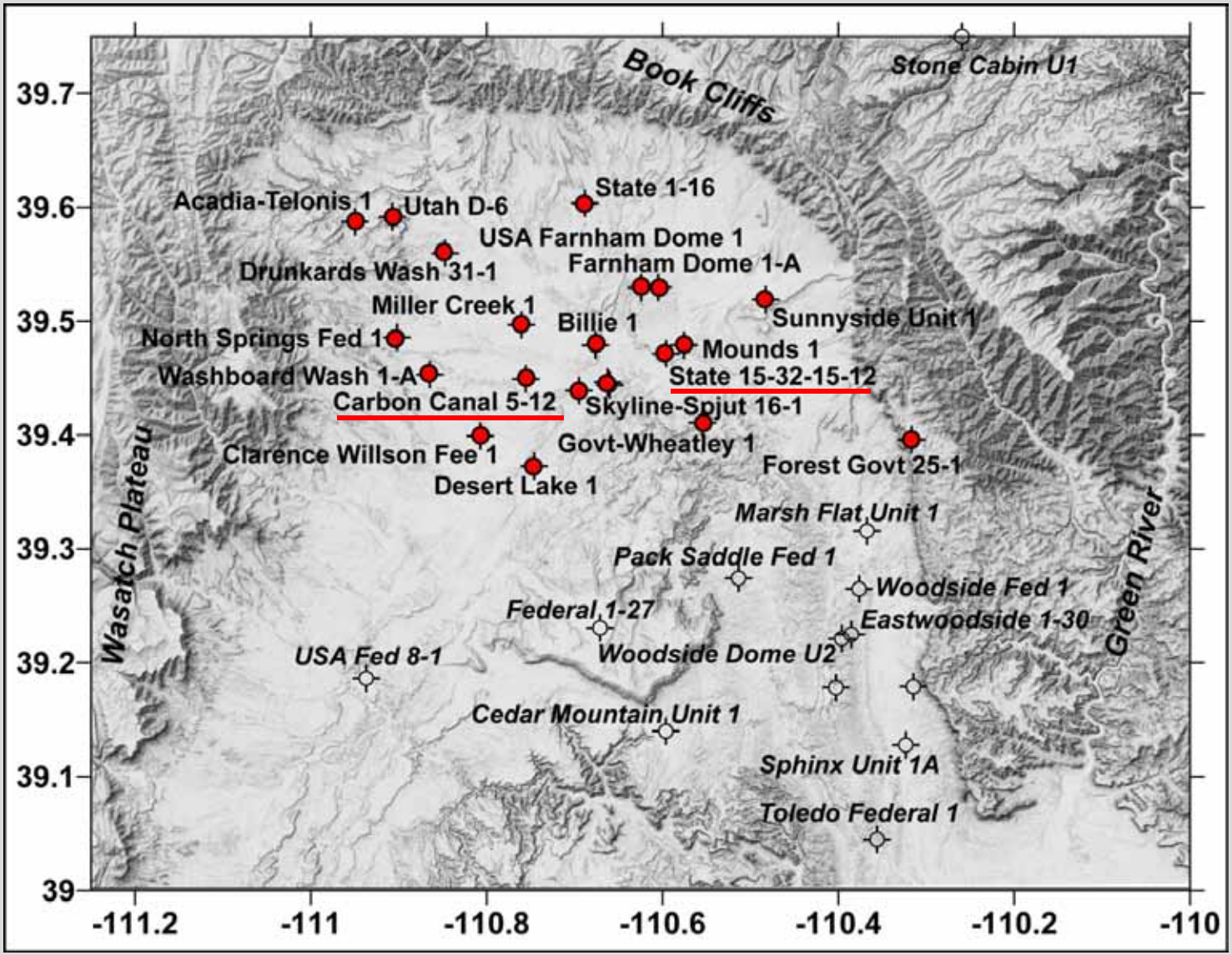
The unit is thickest in the Oquirrh Basin and in the Oquirrh Embayment south of the Uncompaghre Uplift. The depositional thicks relate to the onset of Ancestral Rockies tectonism.

The Manning Canyon Shale is coeval with a regolith red bed unit, the Molas Formation, that is preserved in southeast Utah. It contains sediments eroded from this regolith.

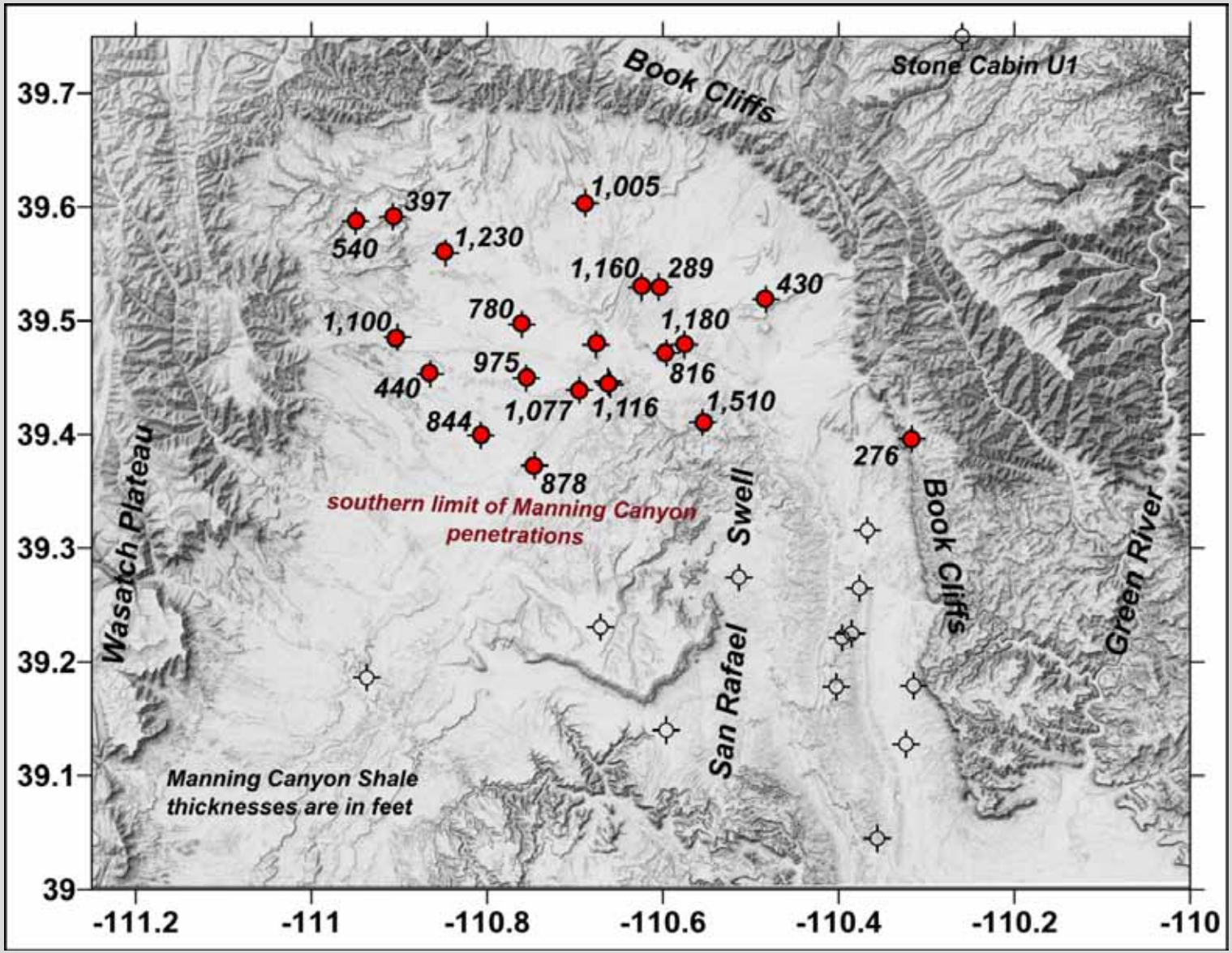


Sources: Hintze and Kowallis (2009), Long and Link (2007), this study.

Twenty-two Wells Penetrate the Manning Canyon Shale



Reported Well Thickness of Manning Canyon Shale



Manning Canyon Shale: Gas Shows and Tests

The Manning Canyon Shale was a specific exploration target for many wells drilled in the 1960-1980s. Attracted by potential limestone and sandstone reservoirs embedded in a good source rock.

Federal Mounds 11-1 tested 759 Mcfgpd from "stray sands". Other wells, such as Skyline-Spjut 16-1, Mounds 1, and Washboard Wash USA 1-A, encountered gas in DSTs and in cuttings.

After a two decade hiatus industry returned, drilling two vertical wells and one horizontal well near the nose of the San Rafael Swell.

Shell Western E&P (SWEPI) completed the Carbon Canal 5-12 well in April, 2008 with four frac stages. One was plugged off due to heavy water flow. The other three had an IP of 178 Mcfgpd and 667 Bwpd. 1,052 BTU gas. Currently shut-in.

Bill Barrett Corporation's Deep Hook project drilled State 15-32-15-12 in 2008 recovering 422 feet of core for gas and reservoir analysis. State 16H-32-15-12 was completed in late 2009, testing 225 Mcfgpd and 120 Bwpd. Currently shut-in.

Clearly, water is a problem in these wells near the crest of the San Rafael Swell.

Samples and data available in the public domain

Well completion reports, driller logs and e-logs available on-line from the Utah Division of Oil, Gas and Mining (www.ogm.utah.gov)

Internal files of the Utah Geological Survey and well cuttings in the Utah Core Research Center

Cores available from the U.S. Geological Survey Core Depository (Denver) and the Texas Bureau of Economic Geology

Published literature

We gratefully acknowledge the assistance of many colleagues in the Utah Geological Survey:
Thomas Chidsey, Jr., Craig Morgan, Michael Laine, Stephanie Carney, and Ammon McDonald

Technology transfer contribution to Paleozoic Shale Gas Resources of the Colorado Plateau and Eastern Great Basin, Utah: Multiple Frontier Exploration Opportunities, an Unconventional Onshore Program of the Research Partnership to Secure Energy for America (RPSEA) research project, 2008-2011

Lithotypes are mix of four sedimentary components

Forest Govt 25-1 11,540 0.7X

Arcadia-Telonis 1 12,020 1.0X

Miller Creek 1 8,780 1.0X

Carbonate

Dominantly calcite microbioclasts and shelly debris organized into packstone, wackestone and limy mudstone.

Silt and Sand

Fine- and very fine-grained quartz sand (subrounded to subangular) and angular silt.

Clays

Reported to be a mature assemblage of smectite-illite, illite, kaolinite and chlorite.

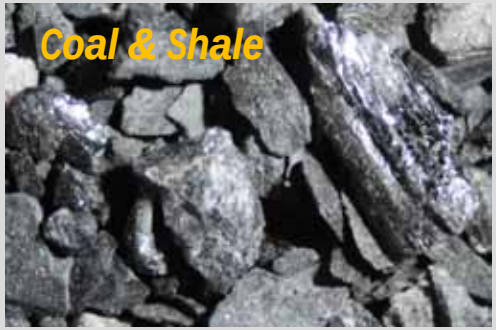
Organic Matter

Dominantly degraded fragments of terrestrial plants found as disseminated micron-size grains or as discrete plant parts.

Siliciclastic rocks that are poor in organic matter are commonly light red to maroon, similar to the Molas redbeds.

Sunnyside 1 7,730 1.0X

Miller Creek 1 8,610 1.0X



Farnham Dome 1-A 7,440 1.0X

North Springs Fed 1 core: 10,739-10,757 feet

This 18 foot core contains a variety of lithotypes:

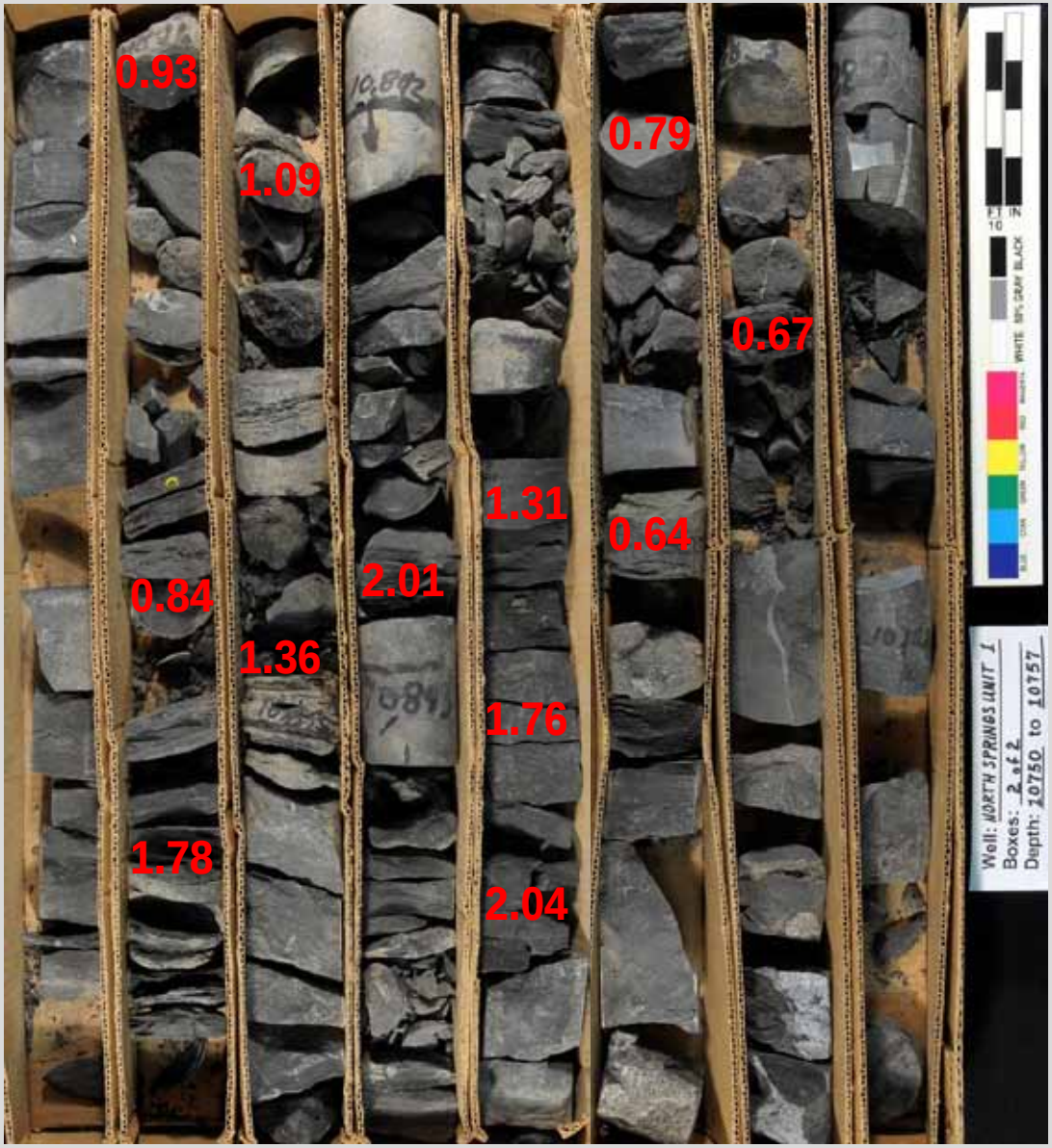
- silty and/or sandy carbonate packstone and wackestone
- calcareous fine-grained sandstone and siltstone
- silty calcareous shale.

The various lithotypes alternate on a centimeter and even a millimeter scale.

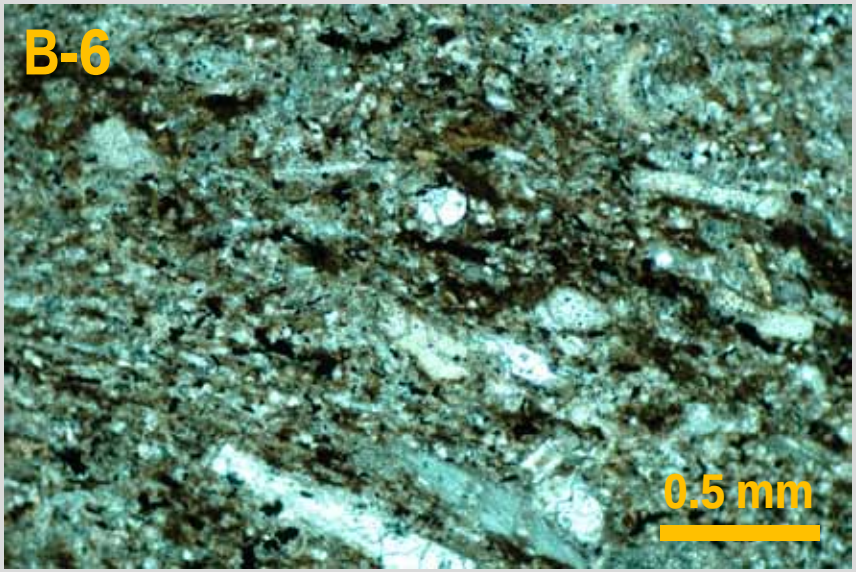
Burrowed intervals are common, as are thin- and thick-walled shell debris in all of the lithotypes.

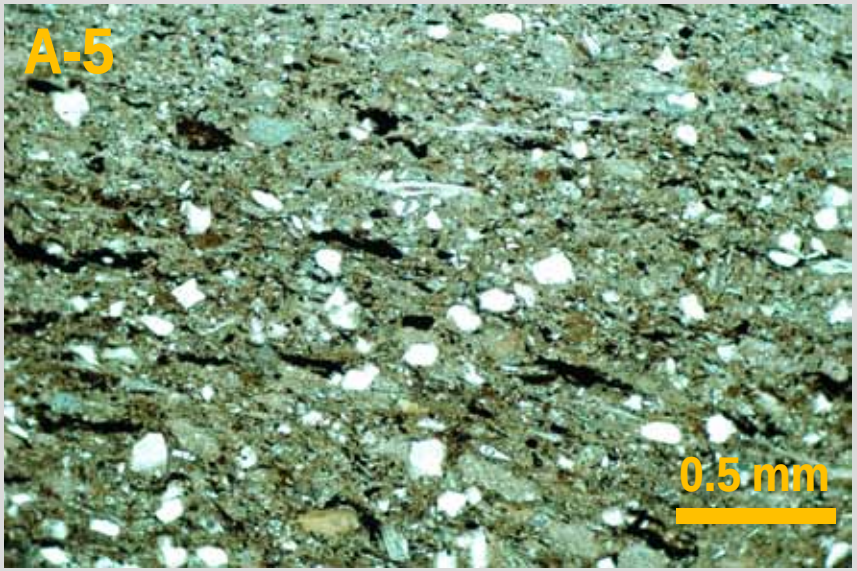
Access to the core courtesy of the Texas Bureau of Economic Geology.

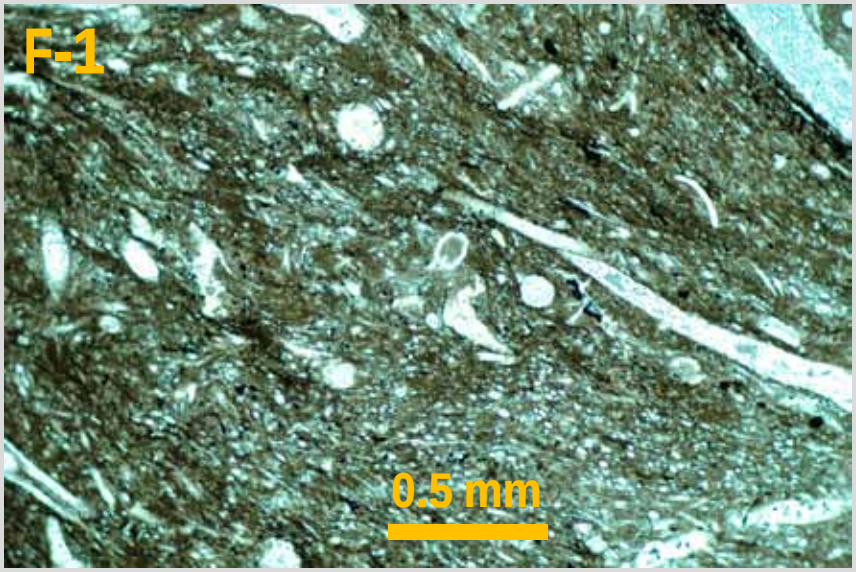
TOC (wt%) shown in red

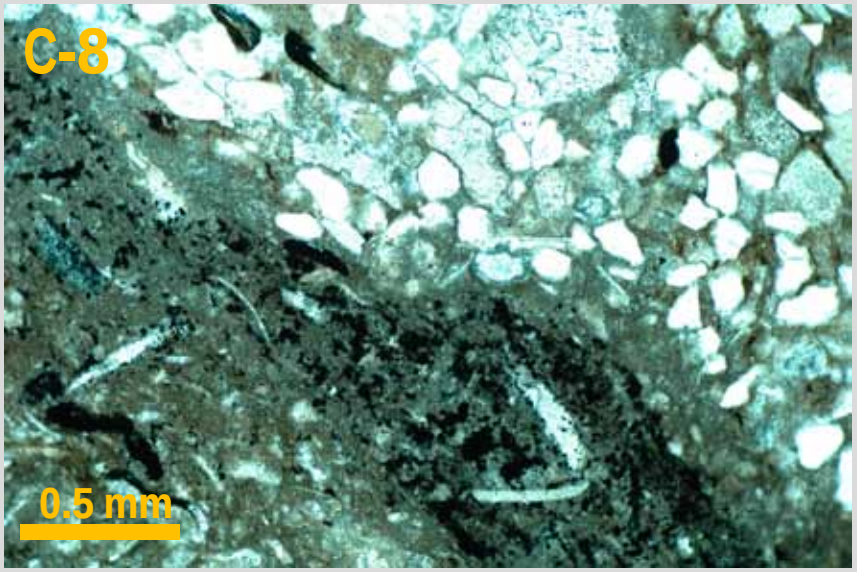


North Springs Fed 1 core: Thin-sections









State 1-15 core: 10,263-10,290 feet

All gradations between silty and/or shaly calcareous packstone and wackestone and calcareous siltstone.

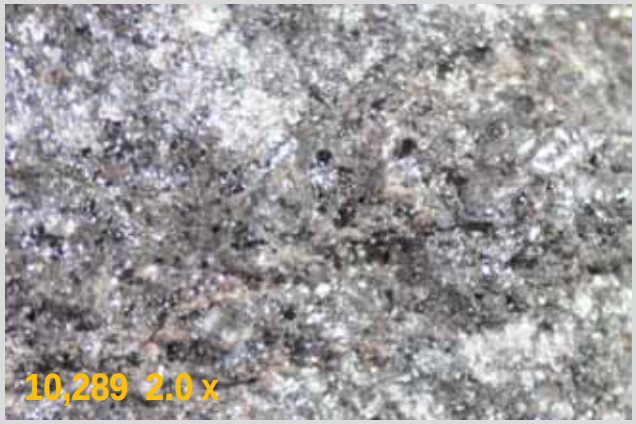
There is a strong planar lamination marked by millimeter-scale variations in calcareous vs. siliciclastic components. Small-scale cross-bedding is present in some intervals. No burrows are observed.

Coaly organic matter is present throughout, especially concentrated in dark laminations that form parting surfaces.

Access to the core courtesy of the US Geological Survey Core Center (Denver).

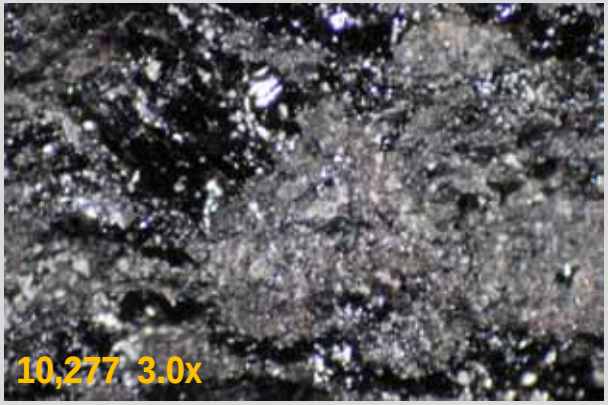
Photographs by Craig Morgan (UGS)

State 1-15 core: Details



Laminar alternations of siltstone and calcareous packstone/wackestone, all containing disseminated OM. Parting surfaces formed by concentrations of plant debris and coal.

Ripple-drift cross-bedding.



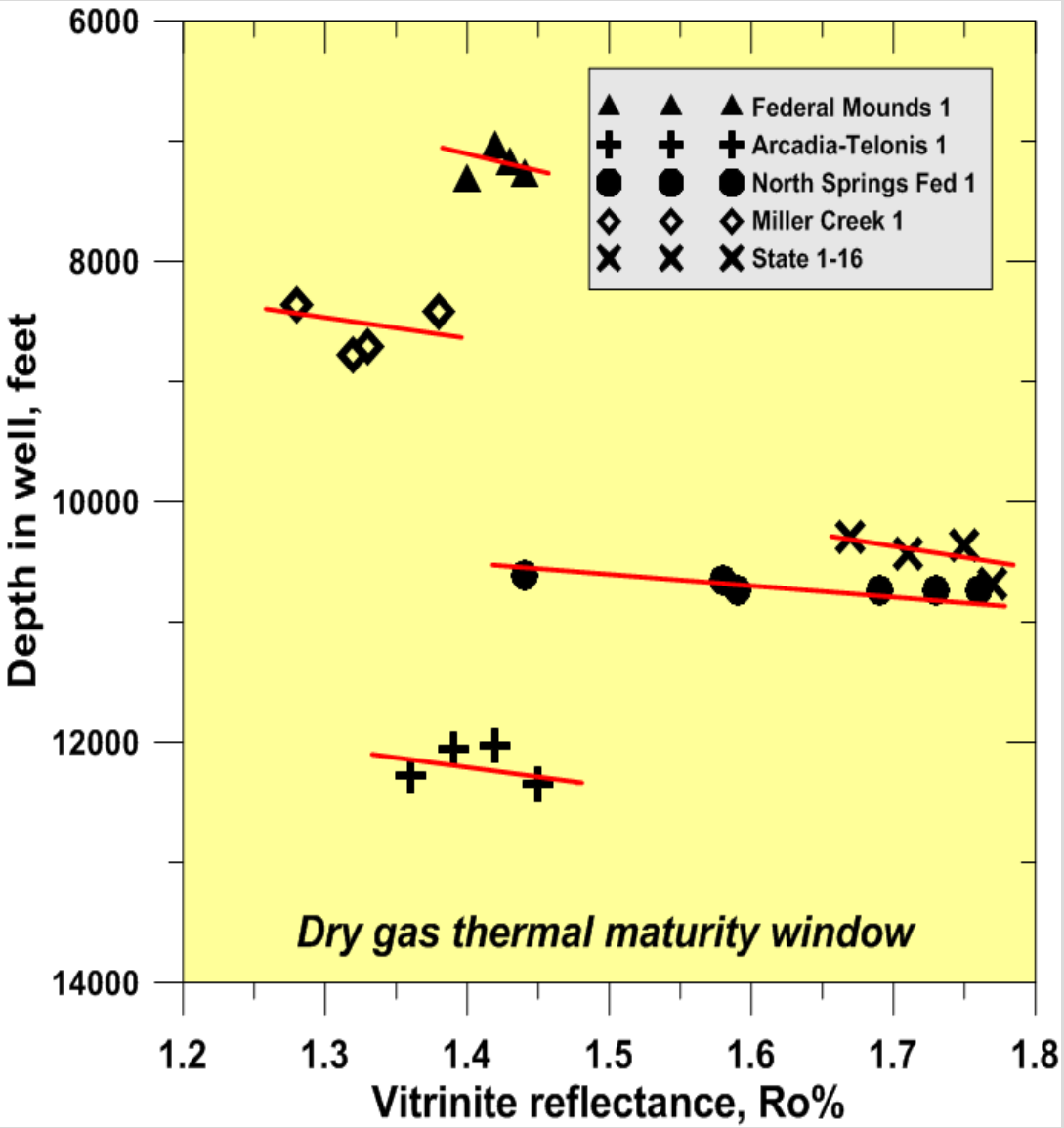
Thermal Maturity of Kerogen

Samples are cuttings and core from both flanks of the north-plunging San Rafael Swell representing a range of present depths of burial.

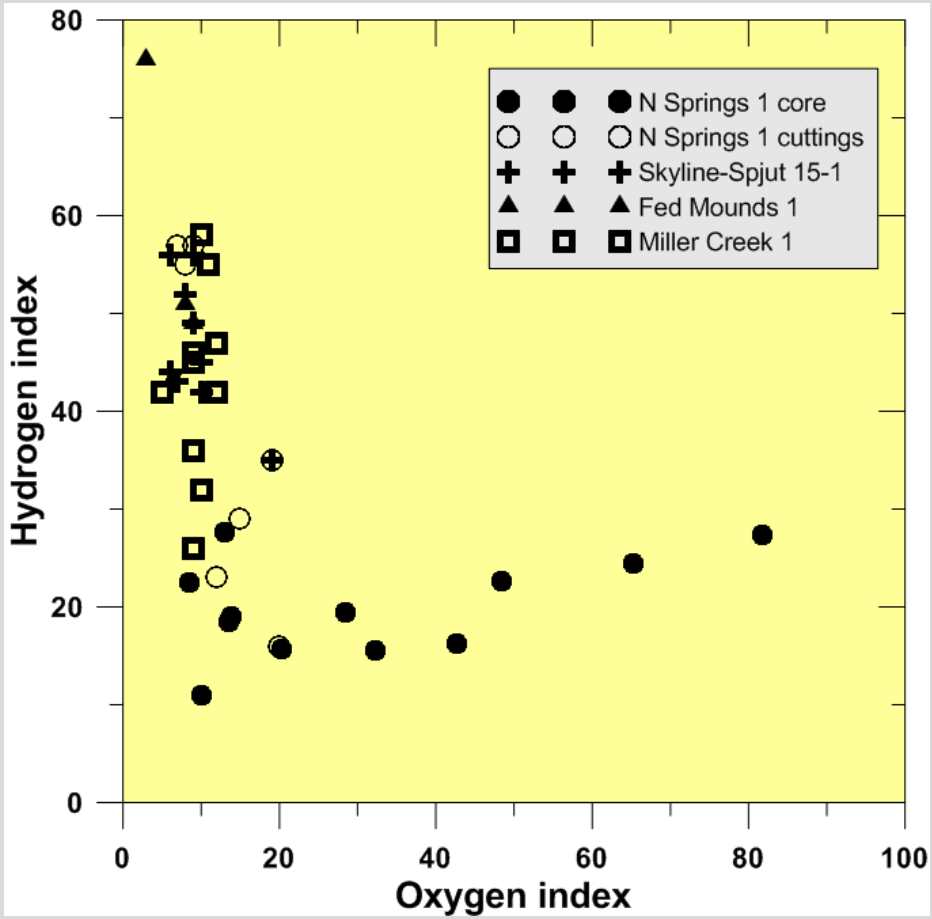
All vitrinite reflectance values are well within the dry gas thermal maturity window. The absence of a depth-Ro relationship indicates that peak of maturity was reached prior to uplift of the San Rafael Swell in latest Cretaceous-Paleocene time.

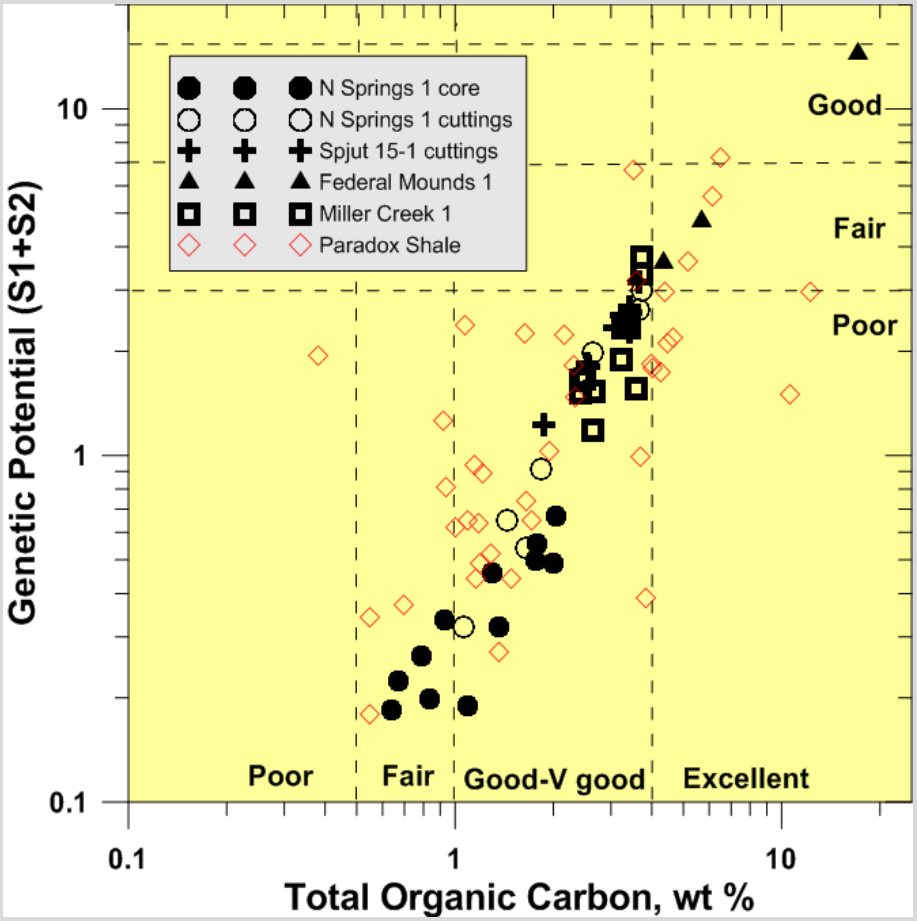
Inertinite is the dominant organic maceral type. Result of incomplete aerobic macrobial degradation of terrestrial plant matter and partial combustion by wildfires.

G. Waanders reports the presence of only terrestrial palynomorphs in these rocks.



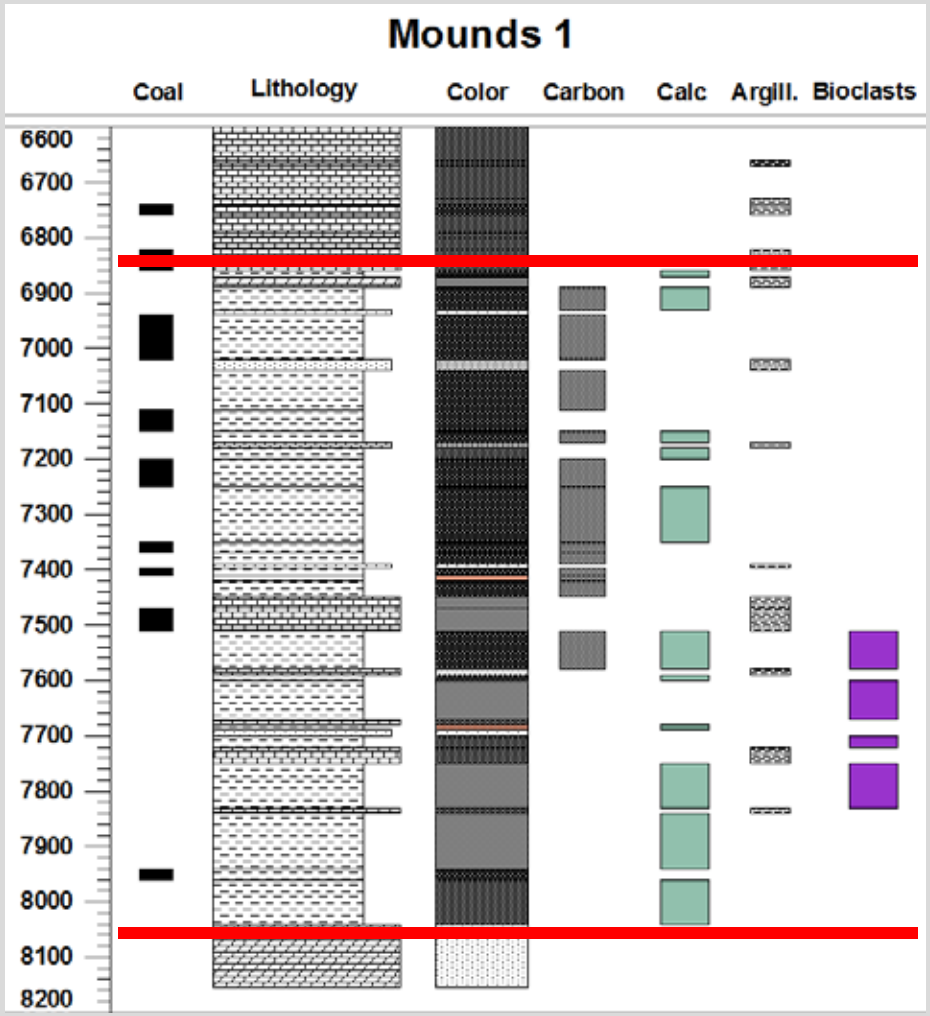
RockEval Geochemistry

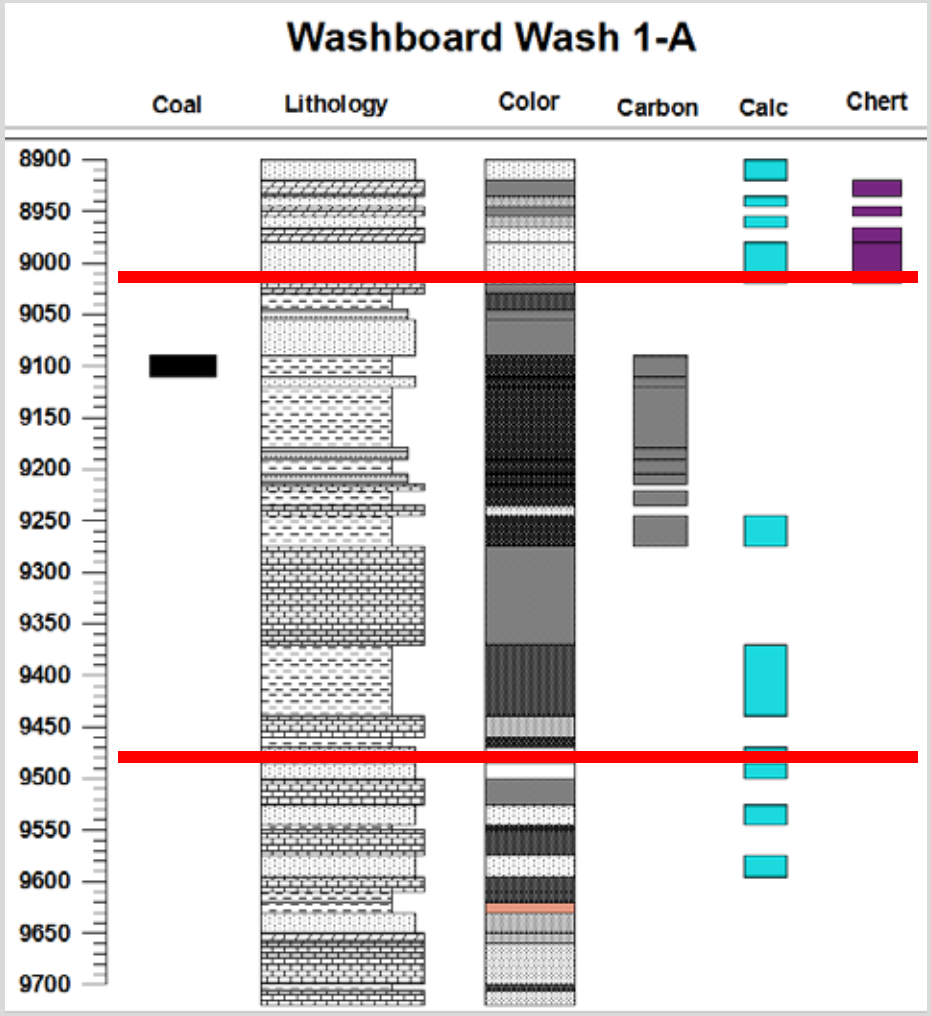




The low values of hydrogen index and genetic potential are consistent with the high thermal maturity of the kerogen and large inertinite content. If corrected for maturity, the TOC values would increase considerably. Coal-rich rocks are under-represented in the samples.

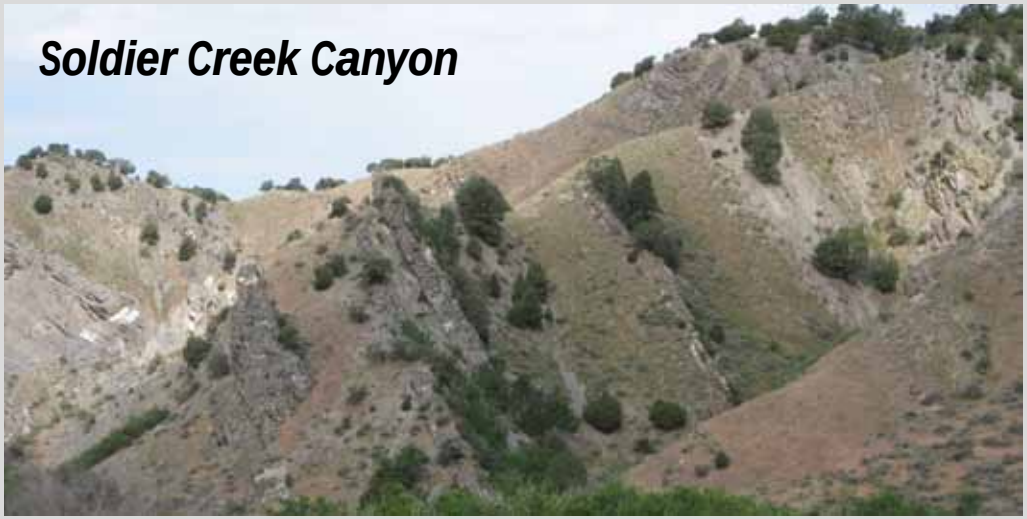
Representative Stratigraphic Columns from Well Reports

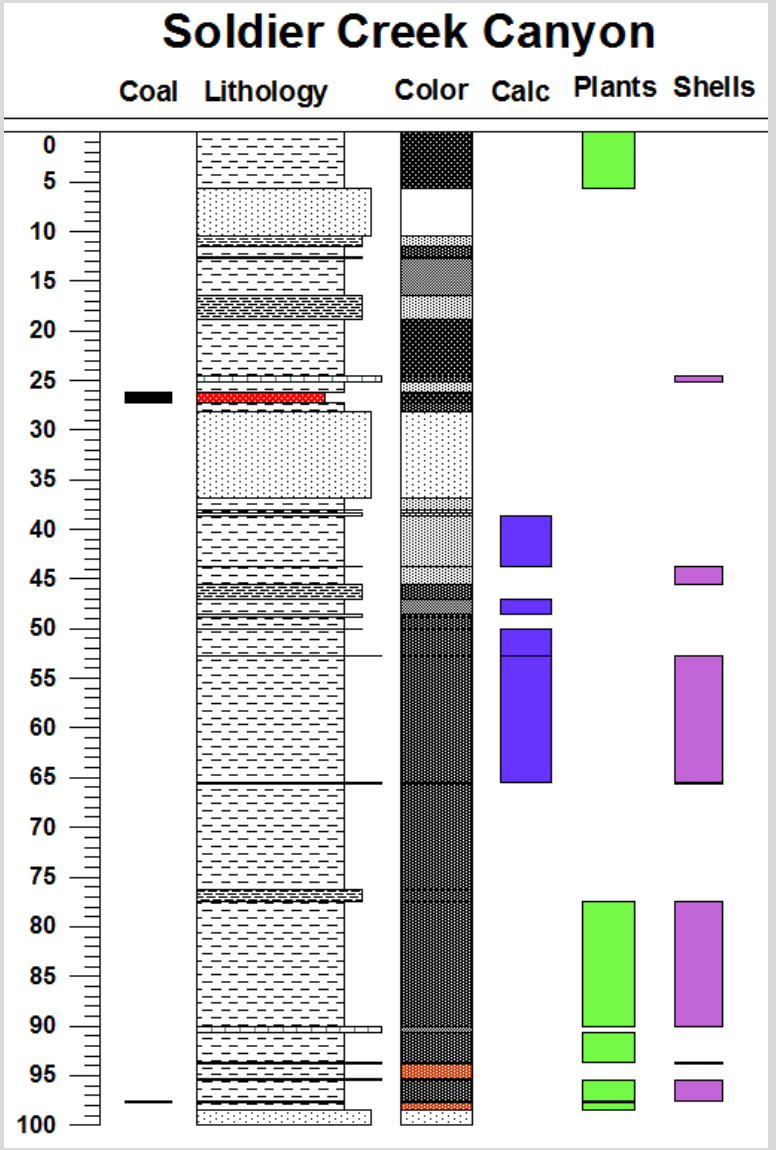




Drilling logs indicate the variability of lithotypes within the Manning Canyon Shale.

Variability in 100-foot Interval of Manning Canyon Shale





Data from Donald Prince (1964)

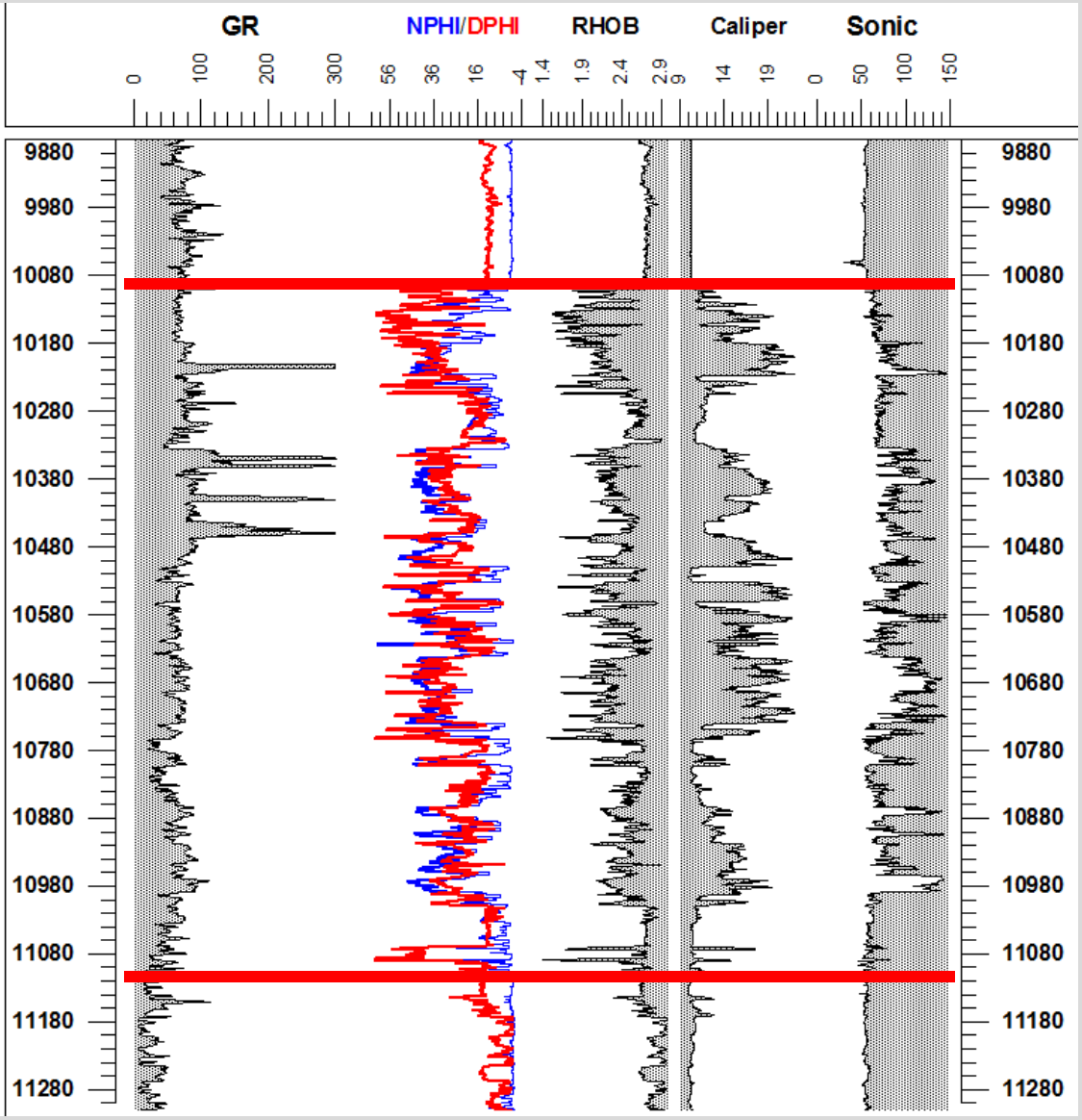
Stratigraphy from E-logs: State 1-16 well

E-log suites for wells penetrating the Manning Canyon Shale provide additional control on stratigraphic variability.

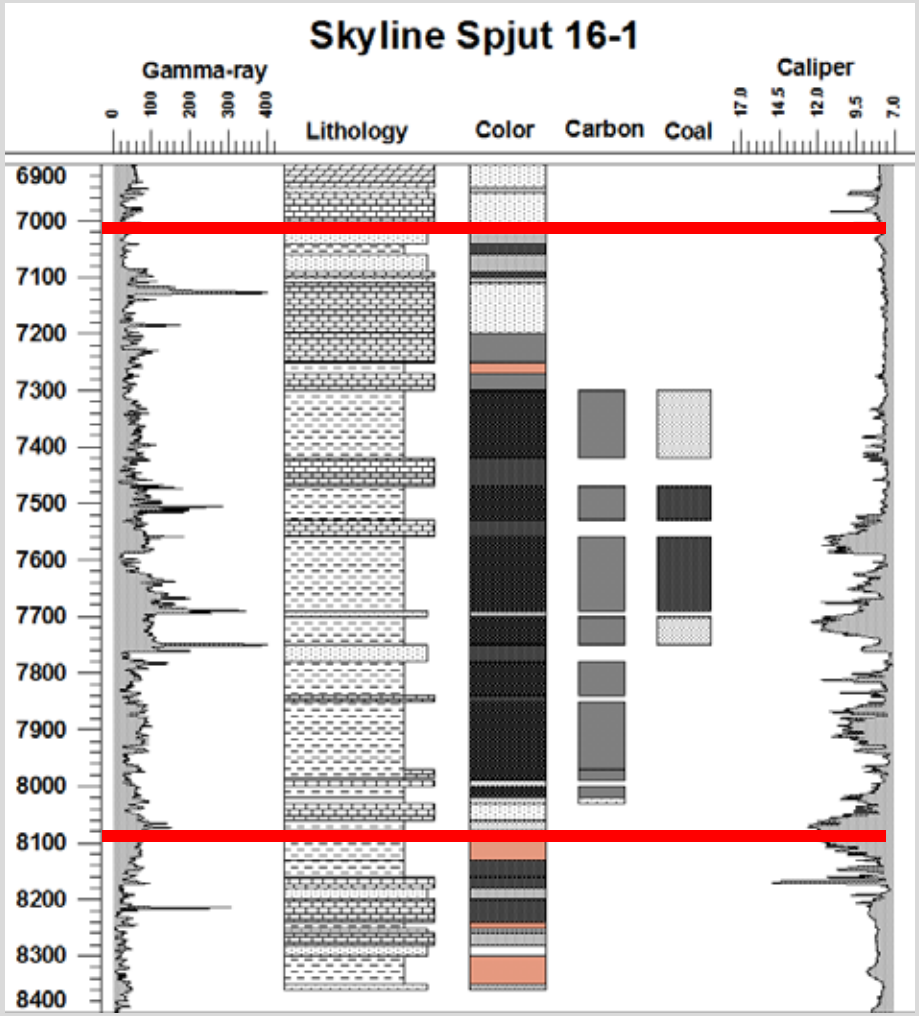
Gamma-ray values are normally less than 100 API units, even though intervals with good organic matter content. Exceptions are spikes with values in the 300-400 API unit range.

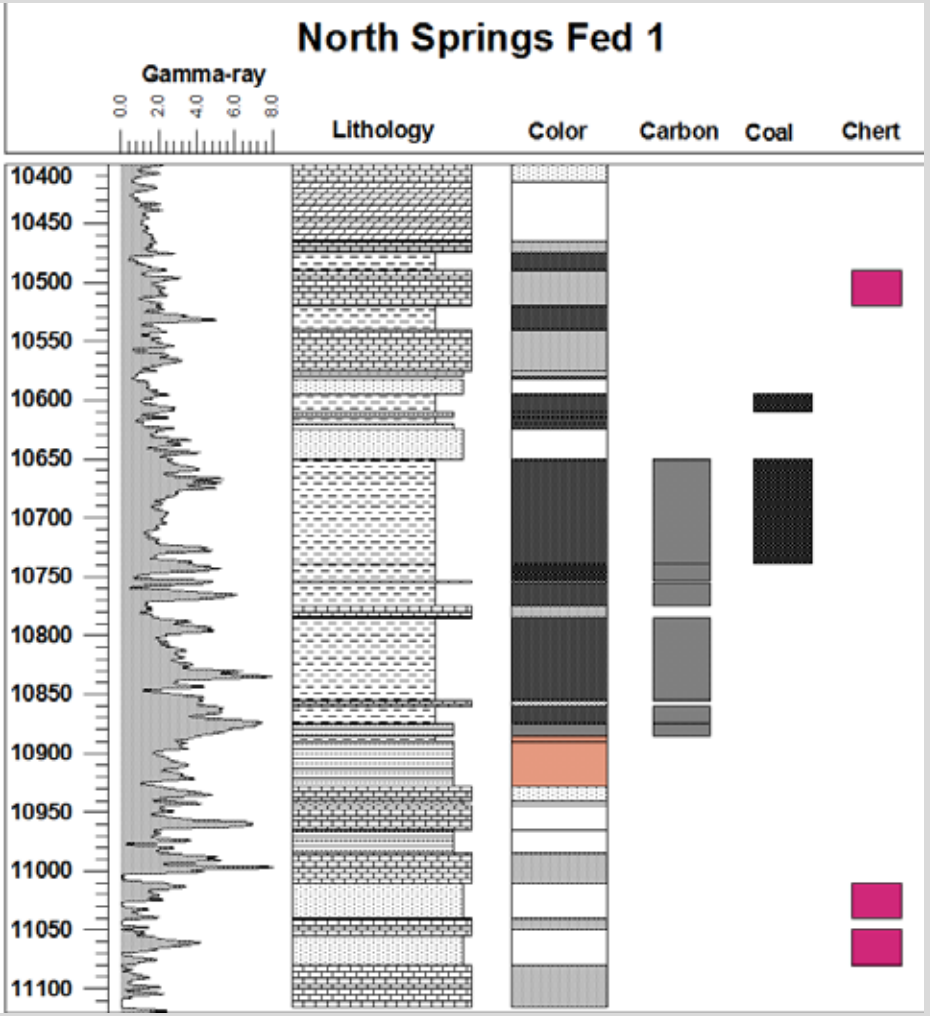
The caliper log indicates many zones of major washout, some more than doubling the diameter of the hole. These appear to be associated with shale and shaly limestone intervals.

Unfortunately, the washouts greatly limit the utility of density and sonic logs for correlation and lithology interpretation.



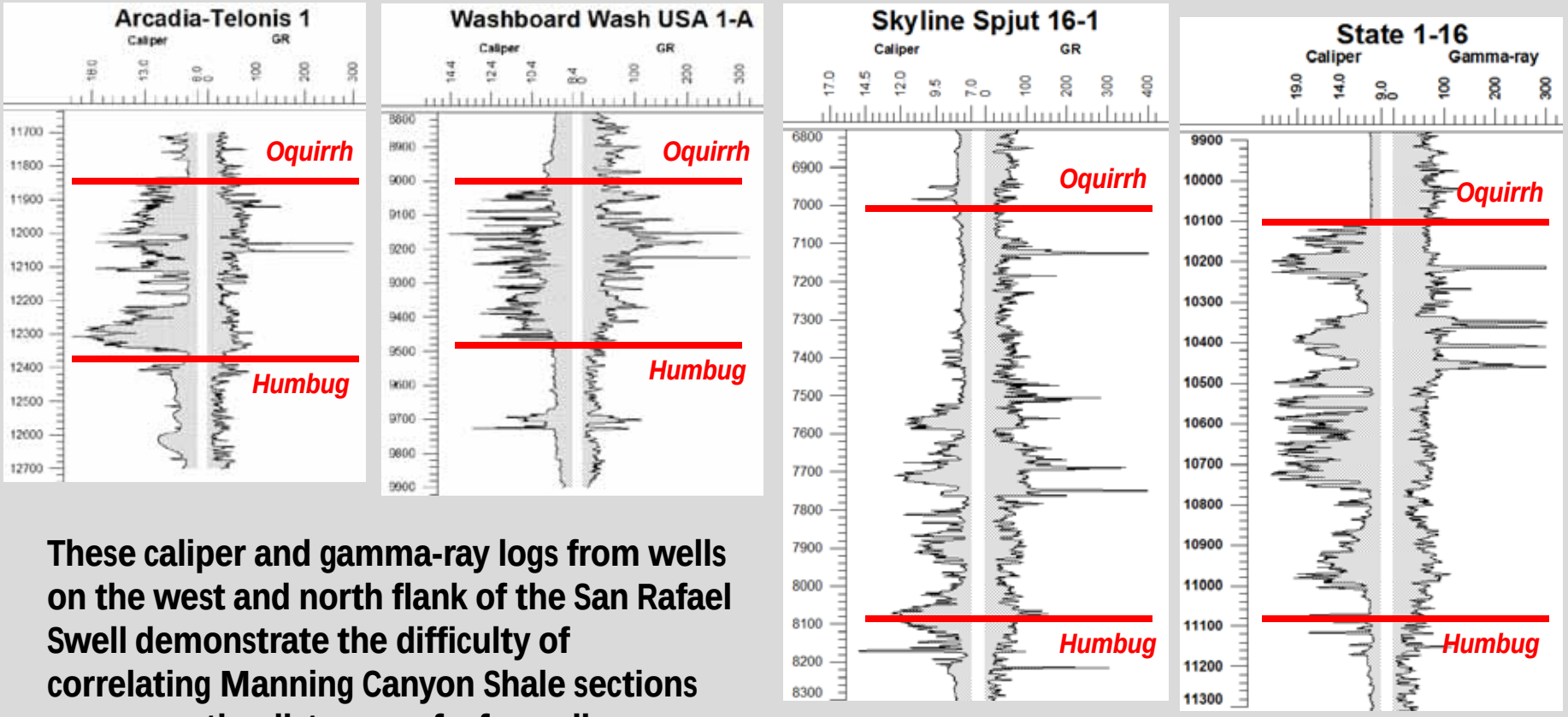
Stratigraphic Columns with E-logs





Only two wells permit comparison of a detailed drilling log with partial e-log suites.

Caliper and Gamma-ray Log Correlations?



These caliper and gamma-ray logs from wells on the west and north flank of the San Rafael Swell demonstrate the difficulty of correlating Manning Canyon Shale sections even over the distances of a few miles.

The log depth scales are approximately identical. The top and base picks are from drilling records.

The Manning Canyon Shale sections are bounded by the Oquirrh and Humbug Formations and have no apparent structural discontinuities.

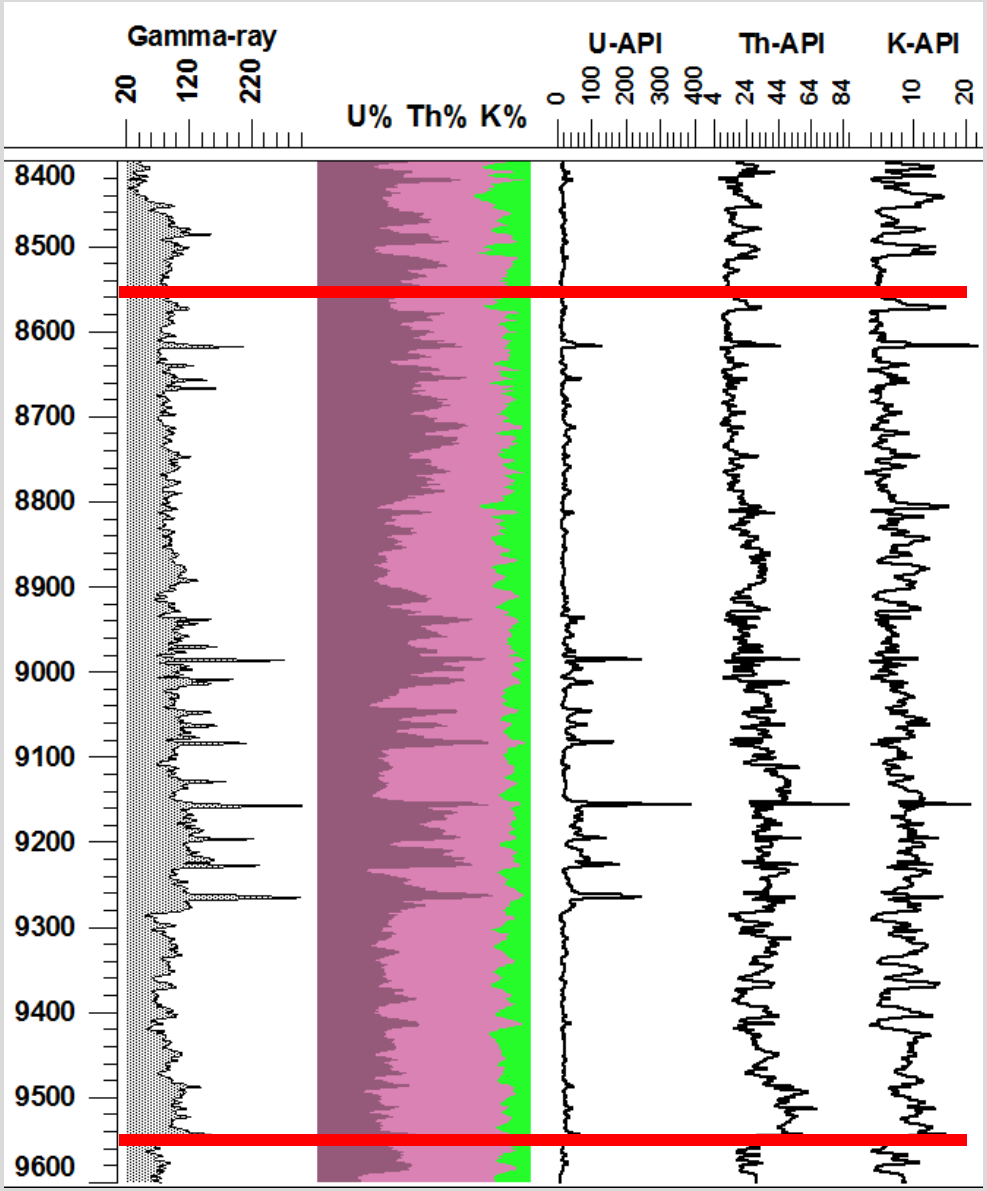
Strong lateral facies variations are indicated.

Spectral Gamma-ray Logs: Carbon Canal 5-12 well

Spectral gamma-ray logs indicate the source of GR radiation. U is normally associated with marine kerogen, whereas Th and K are due to siliclastic components in the sediment.

Remarkably for a section that contains appreciable organic matter, the radiation from U is generally less than half of the total GR signal. The exceptions are the GR spikes in which the relative contribution of U is closer to a "normal" value.

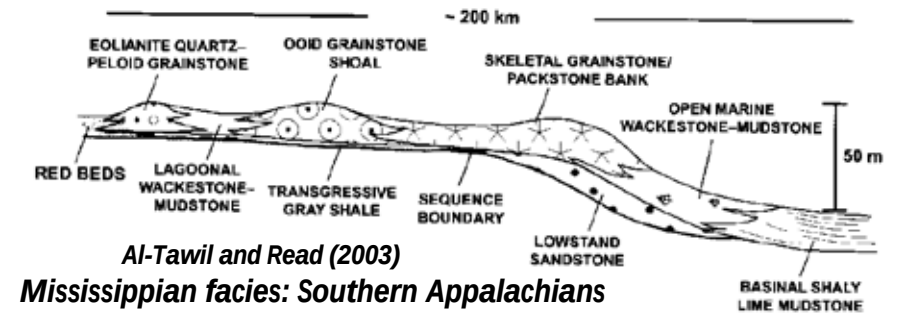
The GR spikes may mark thin intervals in which the kerogen is of marine origin in contract to the more common terrestrial or brackish origin.



Data source: Utah DOGM online LiveData

Depositional Setting: Tentative Models

Marine Shelf and Slope



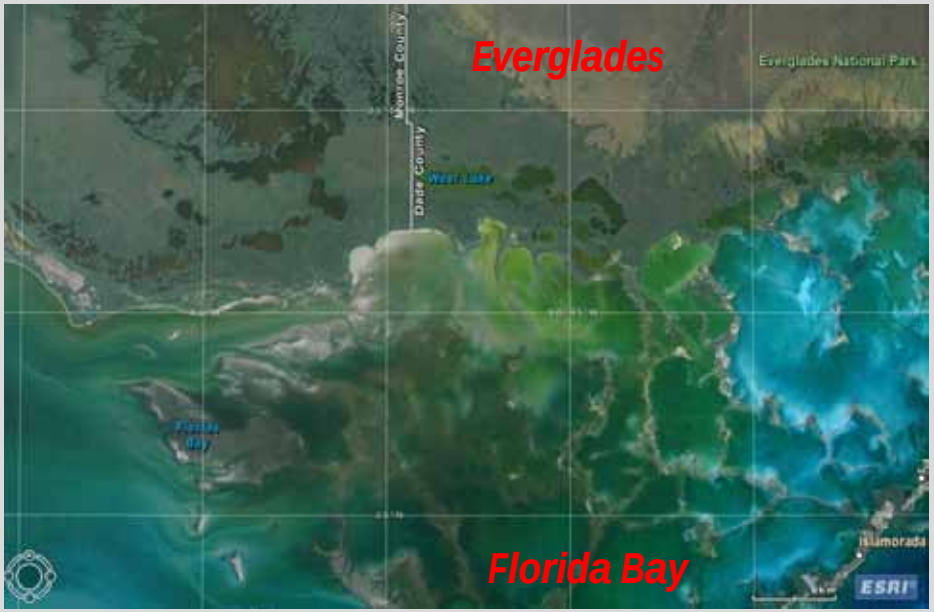
Al-Tawil and Read (2003)

Mississippian facies: Southern Appalachians

Carboniferous cyclothems operating on a marine shelf and slope setting is the model proposed for the cyclic limestone-shale of the Bridal Falls Limestone overlying the Manning Canyon Shale in the Provo Canyon (Shoore and Ritter (2007).

However, the Manning Canyon Shale appears to lack either vertical cyclicity or lateral continuity. Evidence points to a restricted, shallow-water depositional setting that is dominantly non-marine or brackish, with secondary marine influence. The organic matter is terrestrial.

Shallow Marine to Nonmarine Embayment



The marshes of the Everglades and shallow brackish to marine carbonate factory of the Florida Bay might serve as a conceptual model for the depositional setting of the Manning Canyon Shale. The hummocks and marshes formed on the carbonate mud mounds in the bay are an additional source of terrestrial organic matter.

Summary

1. At the north end of the San Rafael Swell, 22 exploration wells fully penetrating the Manning Canyon Shale define the potential area for a new shale gas play of approximately 600 square miles. In this area the unit is 300-1,500 feet thick.

2. Organic matter of terrestrial origin and of good to excellent richness is distributed throughout the shales, limestones and even siltstones that comprise the unit. Our vitrinite reflectance measurements (1.3-1.8 % Ro) indicate that the kerogen is in the dry gas thermal maturity window.

3. The Manning Canyon Shale appears to lack the cyclicity and lateral continuity associated with many Carboniferous cyclothem units. It may have been deposited in a shallow restricted carbonate- and organic-rich marine, brackish, and fresh-water setting similar to the modern Everglades and Florida Bay.

4. The low IP gas rates reported from the recent Carbon Canal 5-12 and State 16H-32 wells may be the consequence of water-saturated reservoirs, a common occurrence adjacent to the San Rafael Swell. The tests do, however, indicate the presence of a shale gas reservoir of considerable thickness that may be commercial outside of zones of high water-saturation.