[AV]Utah Shale Gas: A Developing Resource Play*

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Abstract

In Utah, several organic-rich shale units are in the early stages of natural gas production or are being seriously evaluated for their shale gas potential. Spurred by the availability of appropriate fracture stimulation technology, exploitation of Upper Cretaceous Mancos Shale gas already has begun. At present, Mancos shale gas is being produced from a number of wells in the southern Uinta basin, principally in the Natural Buttes and Flat Rock fields. In all instances, this is “add-on” gas, supplementing production from conventional sandstone reservoirs. Favorable gas tests from Mancos Shale completions, good DSTs, large to very large mud gas readings, and widespread gas shows all demonstrate the strong potential for widespread development of this shale gas reservoir. Whereas most of the good indications and current production are in the upper part of the 3000-3800 ft-thick Mancos Shale, principally in the Prairie Canyon Member, favorable indications and/or production exists in all of the other shaly and silty units, the Lower Blue Gate, the Juana Lopez, and the Tununk Members. The only remaining impediment to expanded development of the Mancos Shale gas resource is determination of operators to complete wells in the formation. Mississippian-Pennsylvanian black shales also are poised to make a significant contribution to natural gas production. In the more thermally mature northern and northeastern Paradox basin, significant gas discoveries recently have been reported from Hermosa Group black shales. In the western Book Cliffs area, several new wells are evaluating the shale gas potential of the Manning Canyon (Doughnut) Shale. Prospects are good for strong gas rates from these wells.

Utah Shale Gas:
A Developing Resource Play

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Synopsis

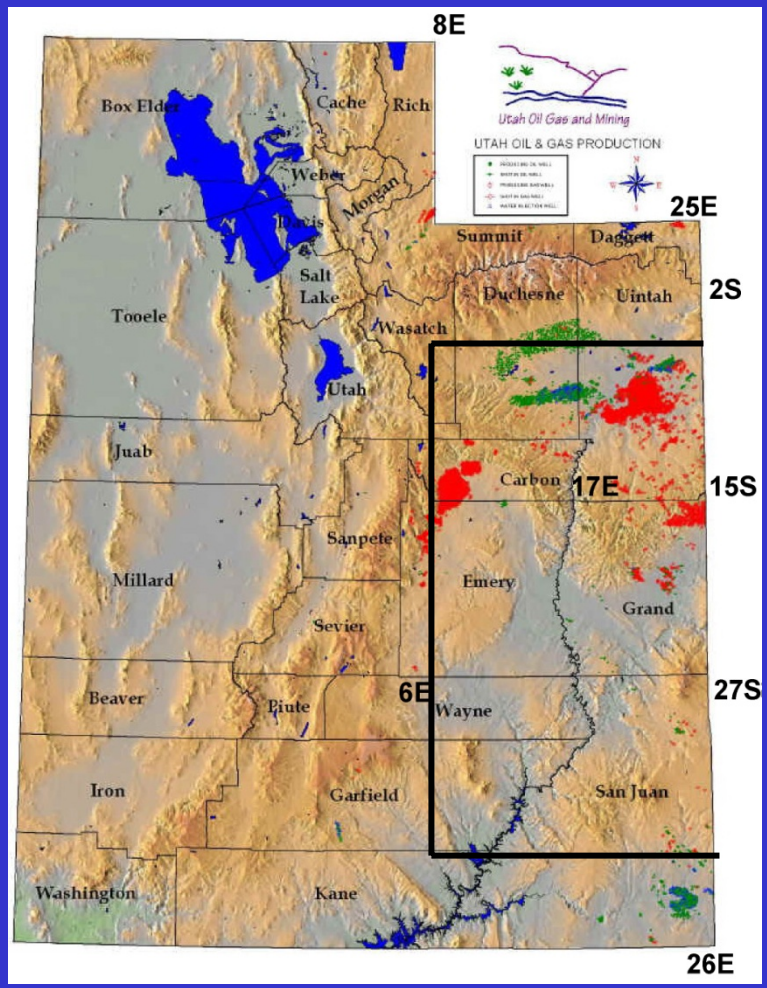
Three proven and potential shale gas plays in Utah are poised to make a significant contribution to natural gas production:

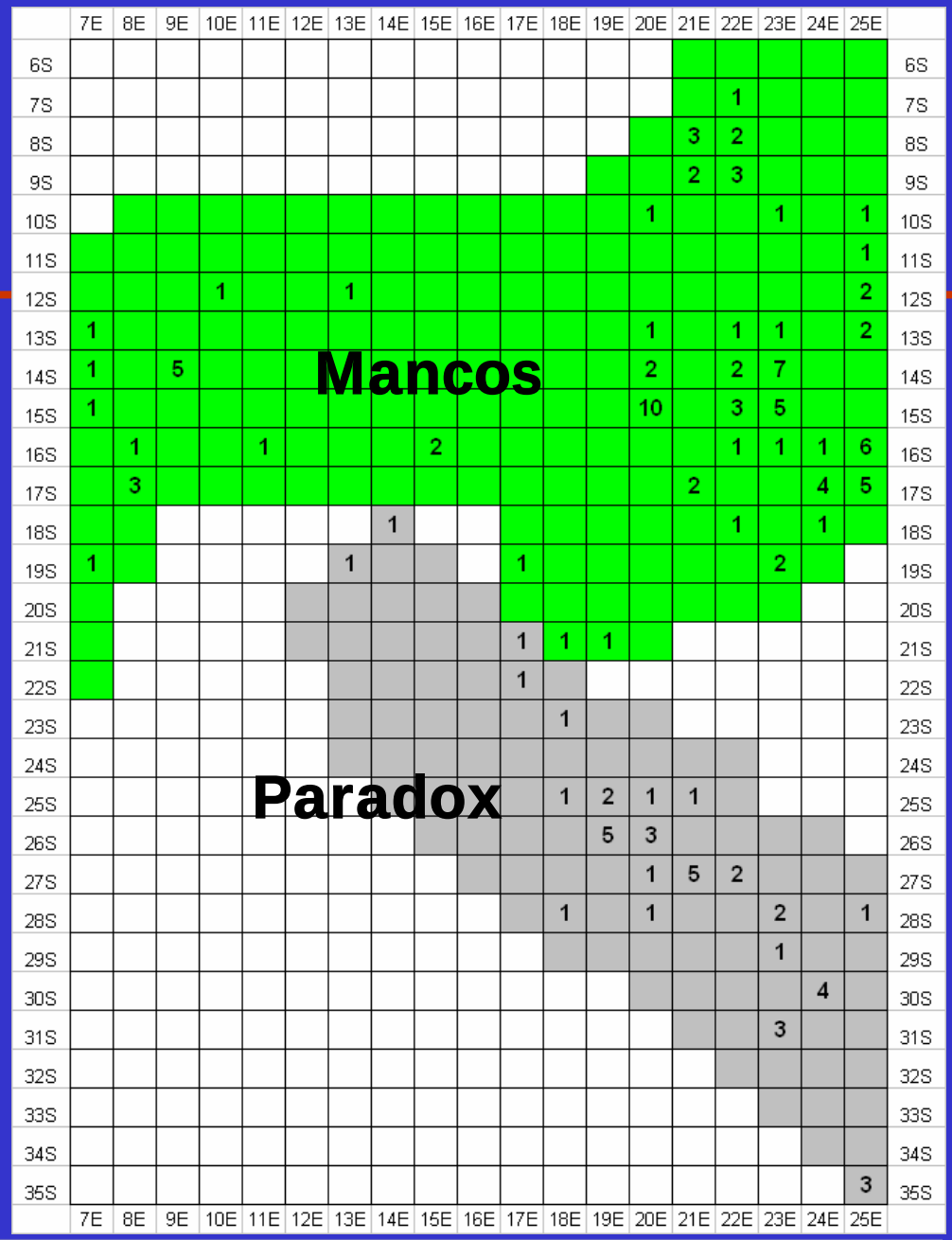
Mancos Shale: favorable gas tests, good DSTs, large to very large mud gas readings, and widespread gas shows recorded in all members. Mancos shale gas is being produced from a few wells in Greater Natural Buttes and Flat Rock fields. This is "add-on" gas supplementing production from conventional sandstone reservoirs. Currently a very active play in the Uinta basin.

Hermosa Group: "black shales" in the Paradox basin have good source potential and proven oil-associated gas production. In the more thermally mature areas of the basin, there is a strong potential for substantial shale gas development, which recent wells may have shown.

Manning Canyon or Doughnut Shale: good indications for shale gas in 1,000+ ft thick black shale, sandstone and limestone succession east of the Wasatch Plateau. Wells are currently testing the play in the Castle Valley, western Book Cliffs.

Utah oil and gas fields + wells with shale gas indications





Requirements for a shale gas reservoir

Goal: Shale with high gas content and deliverability to well bore.

- **Siliceous shales or silt- & fine sand-rich shales normally respond better to fracture stimulation than do clay-rich shales.**

- **Possible gas content can be deduced from TOC, kerogen type, maturity history and present depth of burial:**

Sapropelic kerogens generate twice the volume of gas as do humic kerogens, but residual oil can interfere with release of gas until 'gas window' and in situ cracking of oil is reached at >1.0 % Ro.

Humic (III) kerogen generates mainly gas starting at 0.5 % Ro.

Type I kerogen initiates gas generation at a higher maturity level than do type II and type III kerogens. At lower levels of organic maturity, oil shales are not ideal gas shales.

Siltstone-sandstone intervals interbedded with 'black shales' are capable of receiving an added gas charge from underlying gas sources.

- **Economics requires considerable thickness (>100 ft net) and surface extent (min. several sections) at a moderate depth (<8,000 ft).**

Mancos Shale

Four of the six members have potential for shale gas development:

Prairie Canyon – detached laminated silt and fine sand-bearing mudstone.

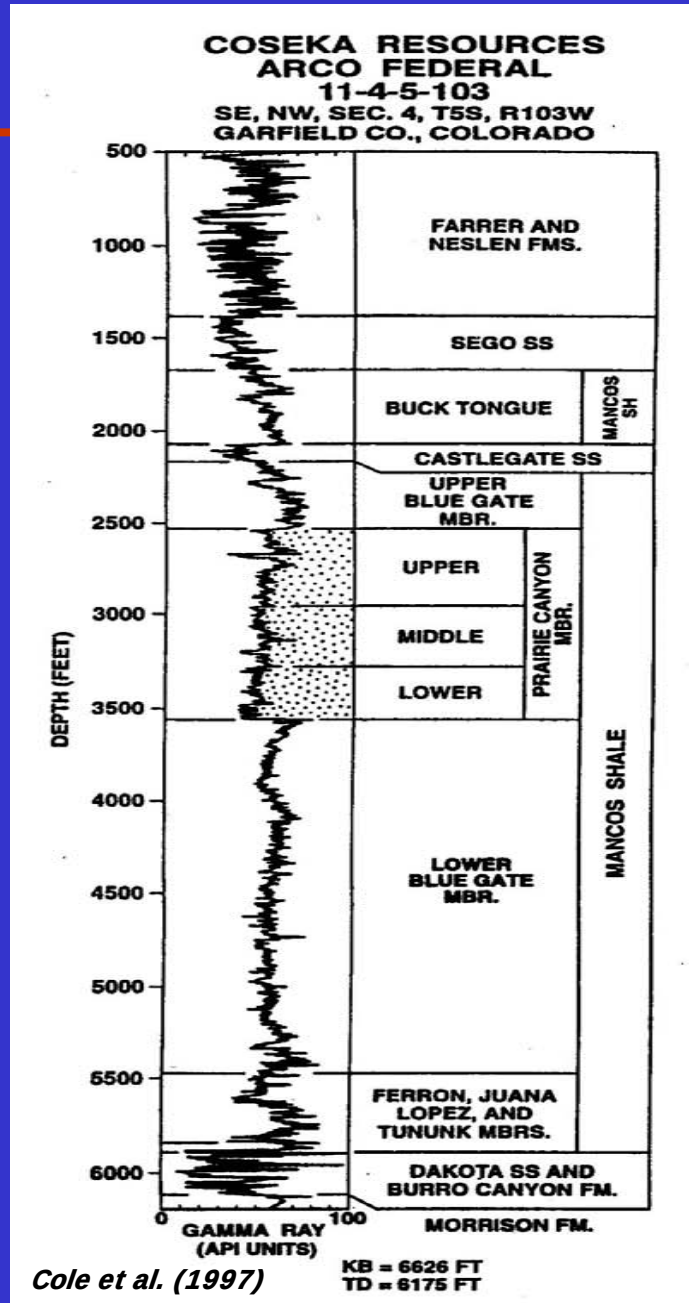
Lower Blue Gate – thick uniform calcareous shale.

Juana Lopez – detached laminated silt and fine sand-bearing mudstone.

Tropic-Tununk – laminated calcareous shale and silty mudstone.

Total thickness: 3,000 to 3,800 ft.

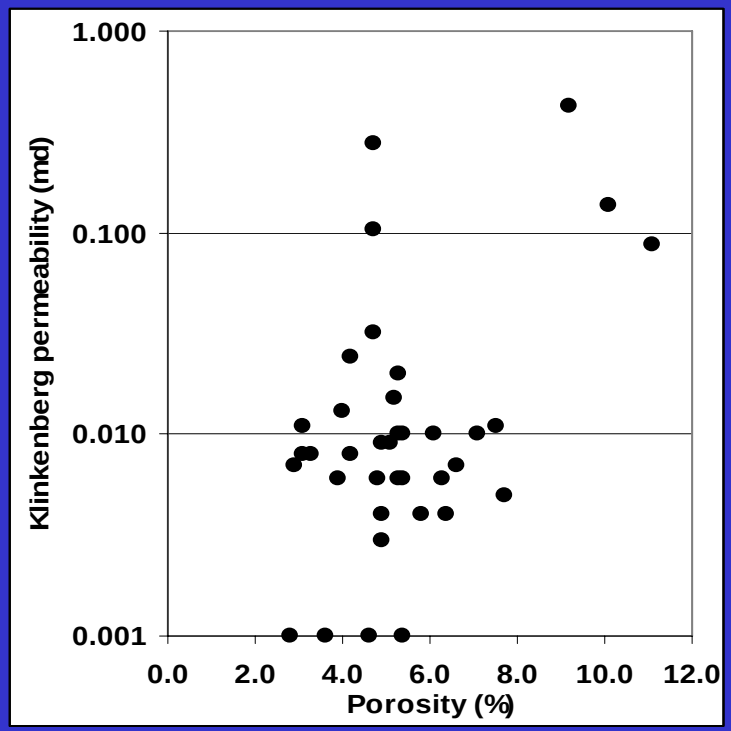
Overlain and underlain by established sandstone gas reservoirs.



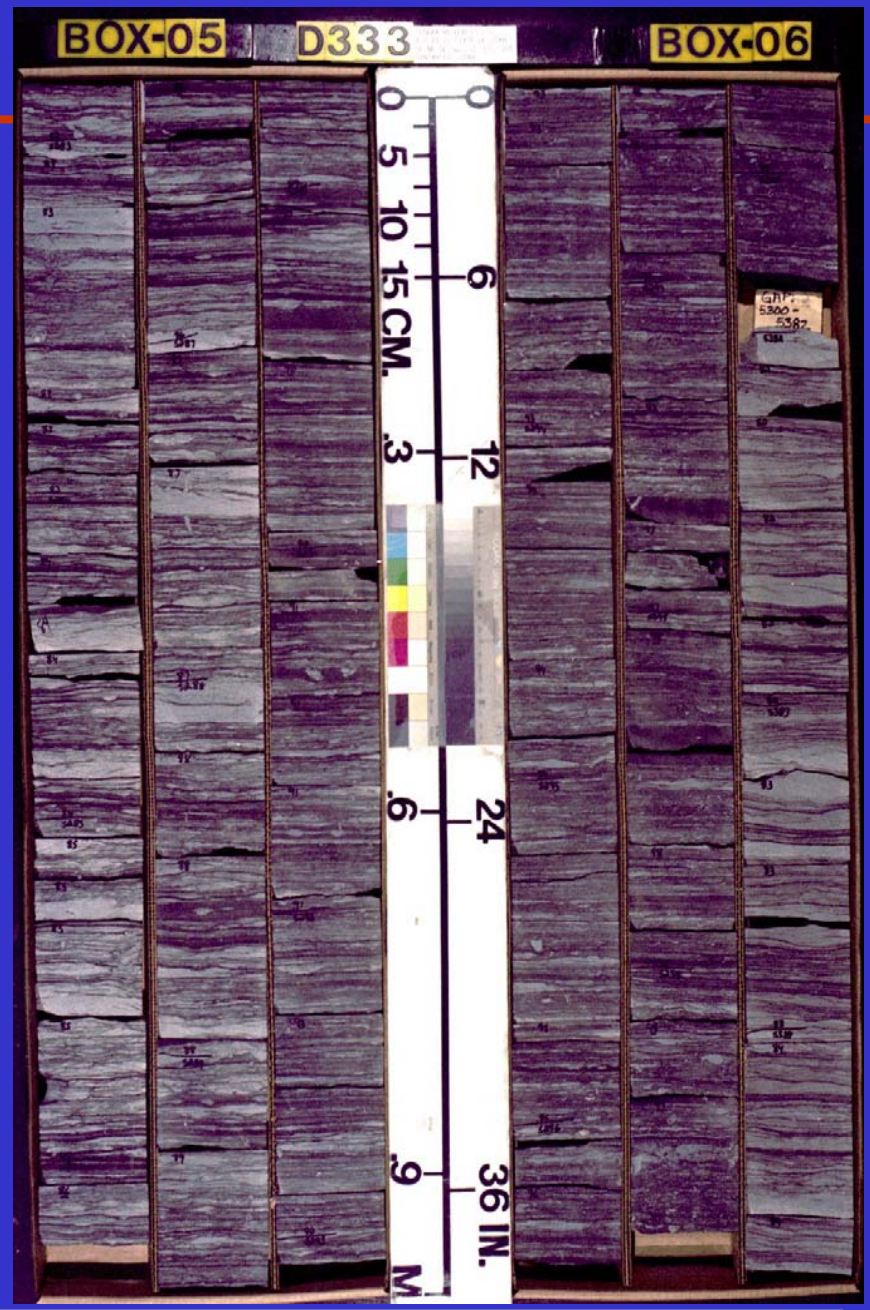
Cole et al. (1997)

Prairie Canyon Member

Interlaminated siltstone and organic rich shales with TOC 1.0-4.0 % and petrophysics consistent with storage of migrated natural gas.

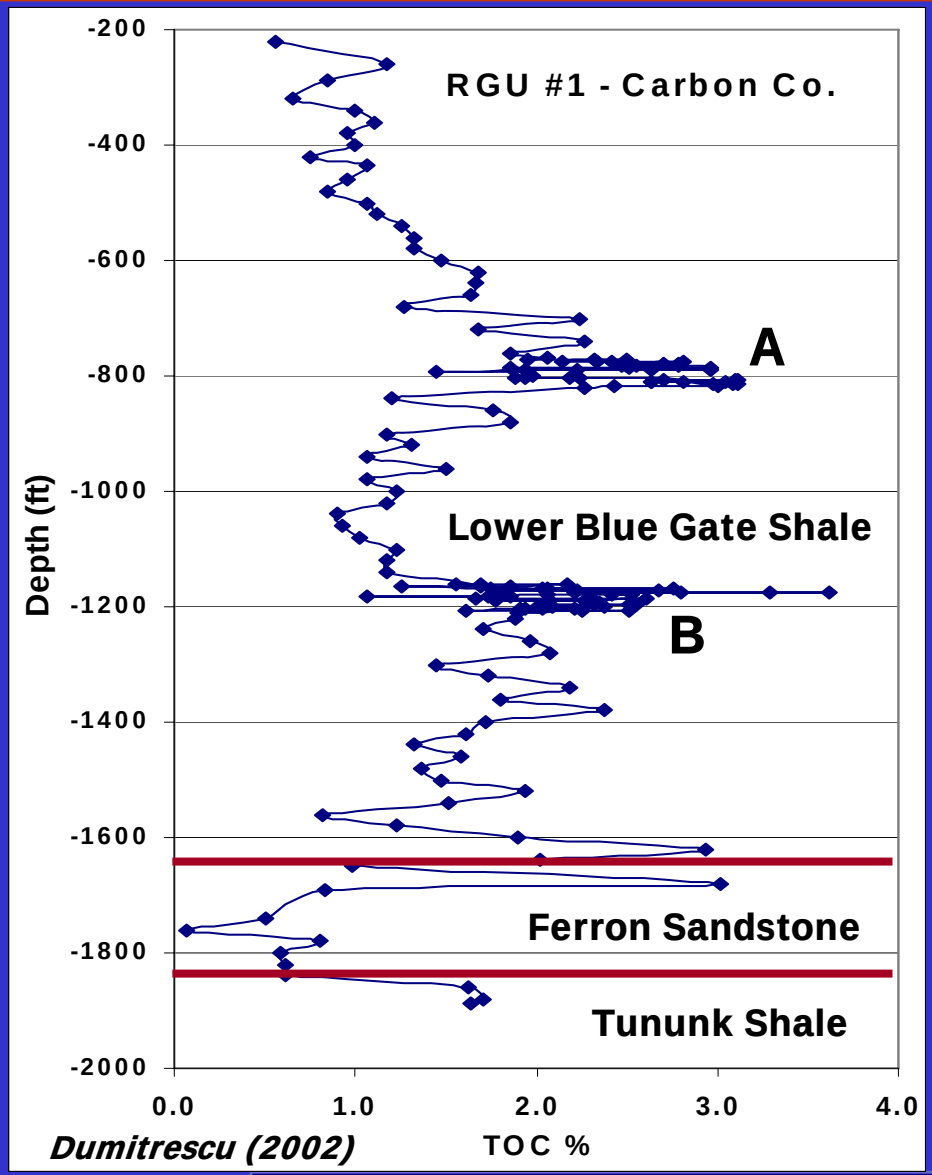


Porosity vs. Klinkenberg permeability (md) for 36 core samples from 4 wells in SE Uinta basin-Douglas Creek arch.



Conseka Resources Trap Springs 8-2-15-22, 5283-5300 ft.

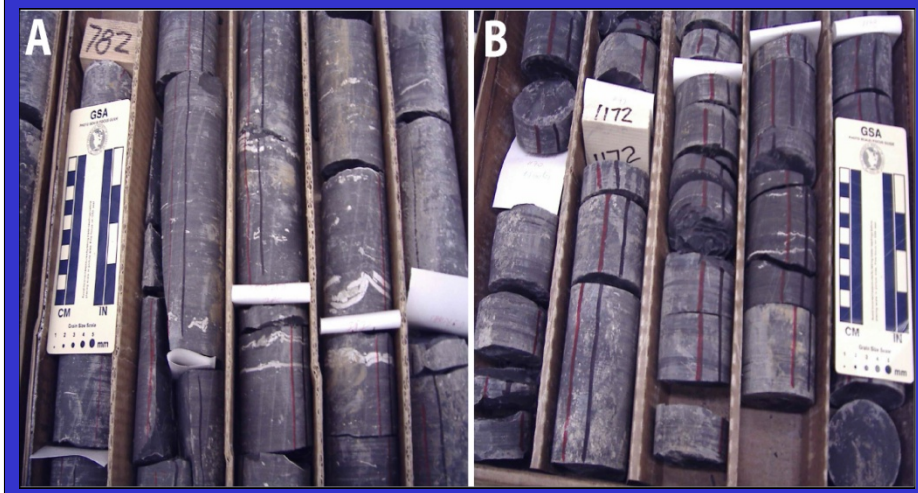
Lower Blue Gate Member organic-rich intervals



Uniform dark to medium gray claystone with scattered bivalve fragments, silty laminae and rare bentonite and very fine grained sandstone beds < 1 ft.

Thickness of organic-rich beds:

- **1.5% TOC = 680 ft net**
- **> 1.0% TOC = 1,000 ft**



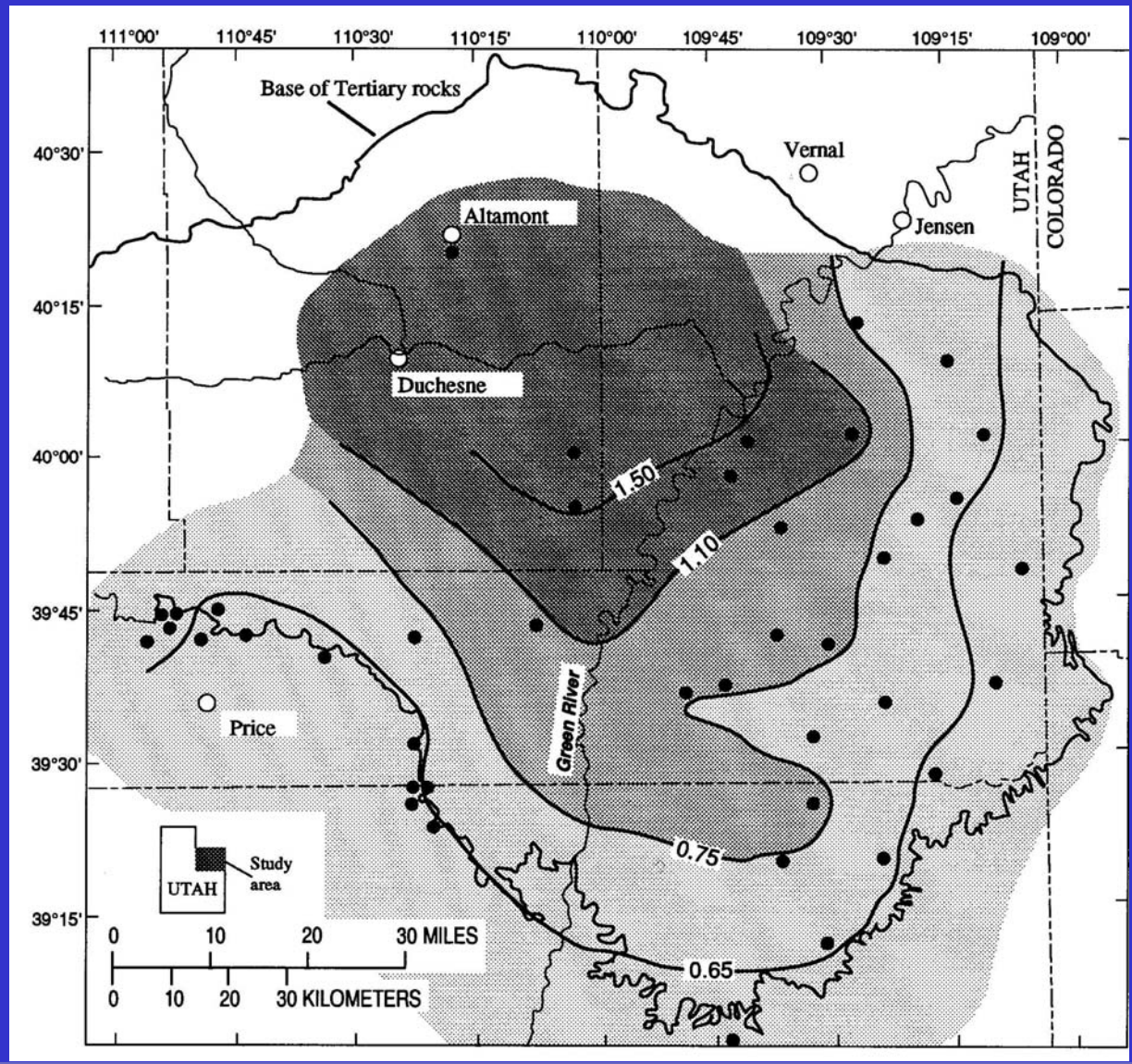
Thermal maturity (Ro) at the top of the Mancos Shale

Mancos Shale shale gas targets will have maturity greater than shown on the map.

The gas-content will depend on gas source: self-sourced or charged from a deeper source interval.

Can be easily tested by wells drilled to objectives below the Mancos Shale.

Very large area and thickness for this play.



Nuccio et al. (1992)

Mancos Shale production tests

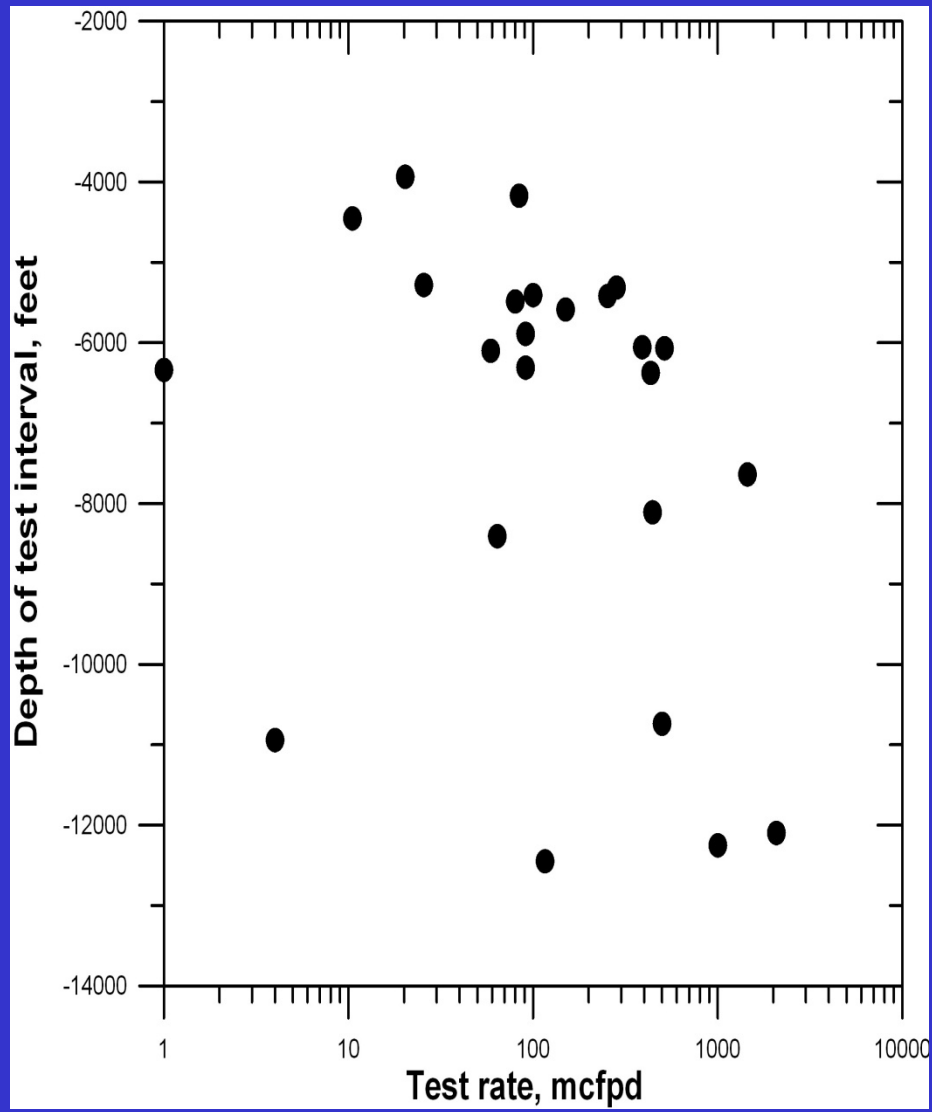
A total of 47 wells has been identified as having been completed in the Mancos Shale, in most instances in what was identified as the Prairie Canyon (Mancos B). Of these, 21 wells are in the greater Natural Buttes field, 12 are in the eastern West Tavaputs plateau on the west flank of the Douglas Creek arch, and the remaining are in the Flat Rock gas field area, or along trend near Nine-Mile Canyon (Keel Ranch Unit 1-16 well), or near Price.

Production tests in the Mancos Shale are available for 22 wells. Three of the wells have rates greater than 1,000 Mcfgpd and another 9 wells have rates between 500-1,000 Mcfgpd. Six wells have rates in the range 50-100 Mcfgpd. Nearly all of the wells were completed in the Prairie Canyon Member, although one was completed in the Blue Gate Member and two apparently were completed in the Juana Lopez Member near the base of the Mancos Shale interval.

Mancos Shale gas test rates by depth

Two of the highest gas tests, Pawwinnee 3-181 (3-9S-21E) and Weeks 6-154 (6-9S-21E), are adjacent wells in the Natural Buttes field completed in the upper Mancos Shale at 12,049-12,144 ft and 12,244-12,248 ft, respectively. The third well, Anschultz State 428-1 (API 4301930169; 5-16S-22E) is on the West Tavaputs plateau above the Garmisa fault and on trend with the Flat Rock field.

All of theses well are completed in and producing from the conventional sandstone reservoirs, as well as from the Mancos Shale.



Mancos Shale mud gas logs

A total of 39 wells have mud gas logs through at least a portion of the Mancos Shale. These wells are widely distributed across the southern half of the greater Uinta basin. Eight of the wells (red text), mainly in the Flat Rock field, have exceptionally high mud gas values in the range of thousands of gas units. Other wells (blue text) have mud gas values in the hundreds of gas units, with occasional spikes in the thousands.

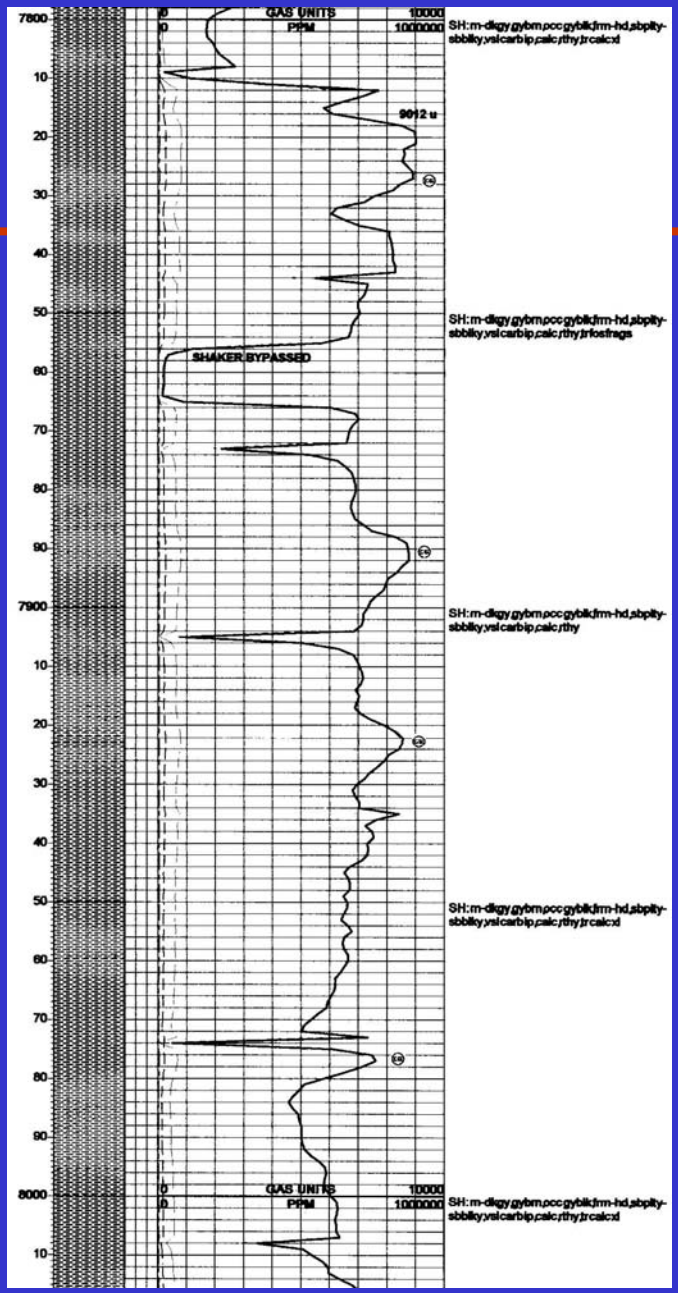
API well number	Well name	Sec	T	R	Unit
43-047-33312	ROCK HOUSE 11-31	31	10S	23E	PC
43-007-30786	JENSEN DEEP 7-15-12-10	15	12S	10E	BG
43-047-32605	EVACUATION CREEK 24-12-251	24	12S	25E	PC
43-007-30289	OMAN 2-20	20	13S	07E	M
43-007-30314	UTAH 0-4	24	14S	09E	M
43-007-30130	ST OF UT 25-9-1	25	14S	09E	M
43-007-30156	ST OF UT 25-7-6	25	14S	09E	M
43-007-30157	ST OF UT 25-11-7	25	14S	09E	M
43-007-30129	RGU 1	36	14S	09E	M
43-047-35442	NHC 3-6-15-20X	31	14S	20E	M
43-047-30978	TRAPP SP 13-25-14-23	25	14S	23E	M
43-015-30064	POLE CANYON U 1	17	15S	07E	M
43-047-34922	N HILL CREEK 4-1-15-20	1	15S	20E	M
43-047-35140	NHC 1-6-15-20	5	15S	20E	M
43-047-34742	N HILL CREEK 1-9-15-20	9	15S	20E	M
43-047-34552	N HILL CREEK 4-10-15-20	10	15S	20E	PC
43-047-34953	N HILL CREEK 14-11-15-20	11	15S	20E	M
43-047-35283	N HILL CREEK 2-12-15-20	12	15S	20E	M
43-047-35054	NHC 4-13-15-20	13	15S	20E	M
43-047-35685	HORSE POINT ST 43-32	32	15S	23E	PC
43-019-31397	HORSE POINT ST 1-34	34	15S	23E	M
43-015-30607	ST OF UT QQ 31-201	31	16S	08E	M
43-015-30022	NELSON UNIT 1	3	16S	15E	M
43-015-30080	WILCOX 1-24	24	16S	15E	M
43-019-30169	ANSCHULTZ STATE 428-1	5	16S	22E	M
43-019-30758	UTAH STATE 1	32	16S	25E	M
43-015-30620	ST OF UT 17-8-4-21	4	17S	08E	M
43-015-30480	ST OF UT BB 05-108	5	17S	08E	M
43-015-30439	ST OF UT DO 31-98	31	17S	08E	M
43-019-31241	FEDERAL 11-10	11	17S	24E	M
43-019-31231	FEDERAL 8-10	8	17S	25E	M
43-019-31237	FEDERAL 16-3	16	17S	25E	M
43-019-31236	FEDERAL 17-3	17	17S	25E	PC
43-019-30770	DIAMOND CANYON II 15-15	15	18S	22E	M
43-019-30835	BUTLER CYN UNIT USA 33-12	33	19S	17E	M
43-019-30735	LONG CANYON UNIT ST 16-4	16	19S	23E	M
43-019-31 063	FEDERAL 12-42	12	21S	18E	M
43-019-31394	STATE 1-32	32	21S	19E	M
43-041-11136	EMERY UNIT FED 1	34	22S	05E	BG

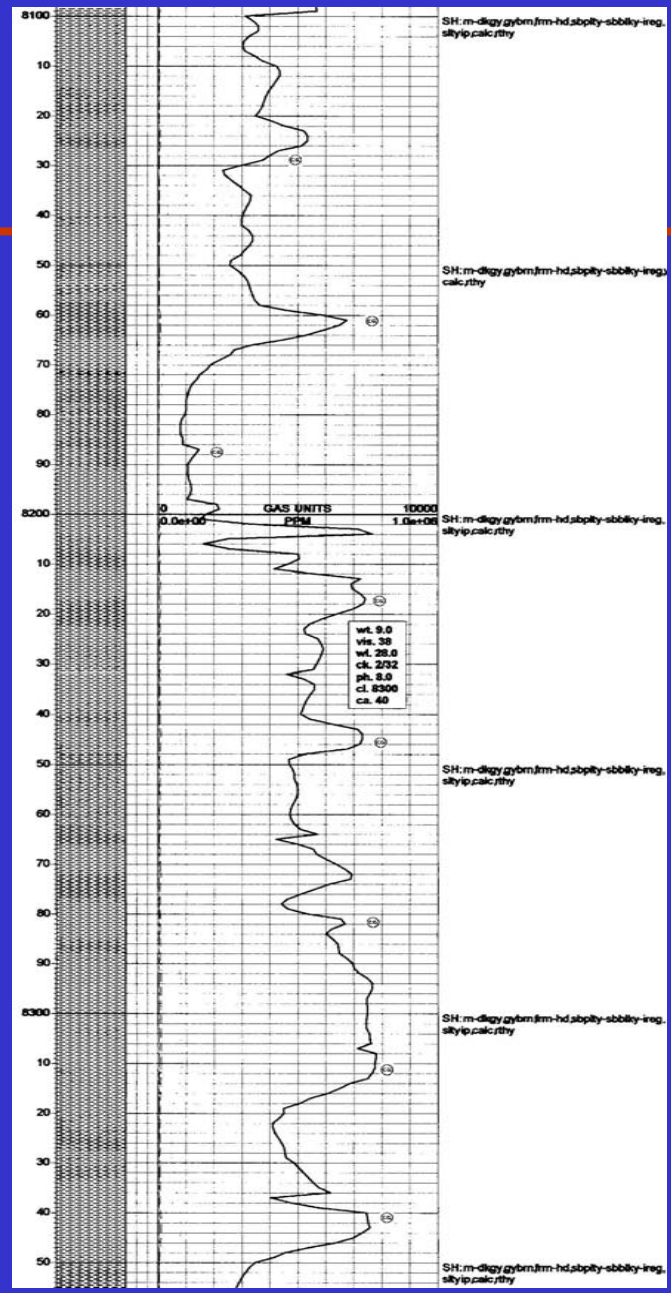
Flat Rock Field

Representative Mancos Shale mud gas logs, scale 10,000 units

← NHC 2-12-15-20
7800-8015 ft

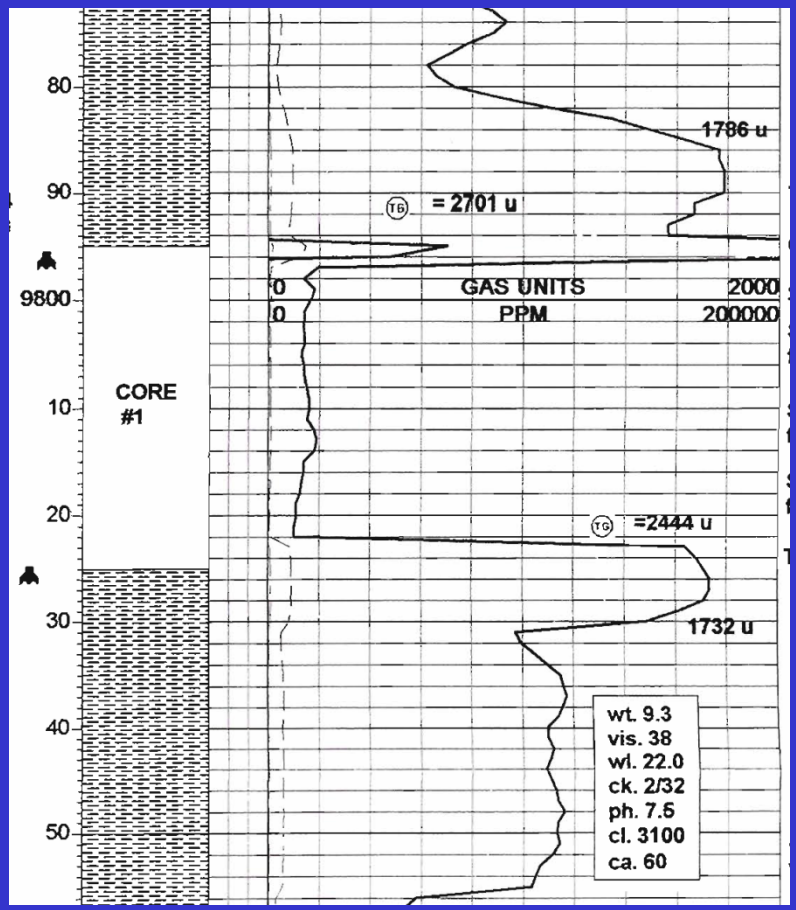
NHC 4-13-15-20 →
8100-8350 ft

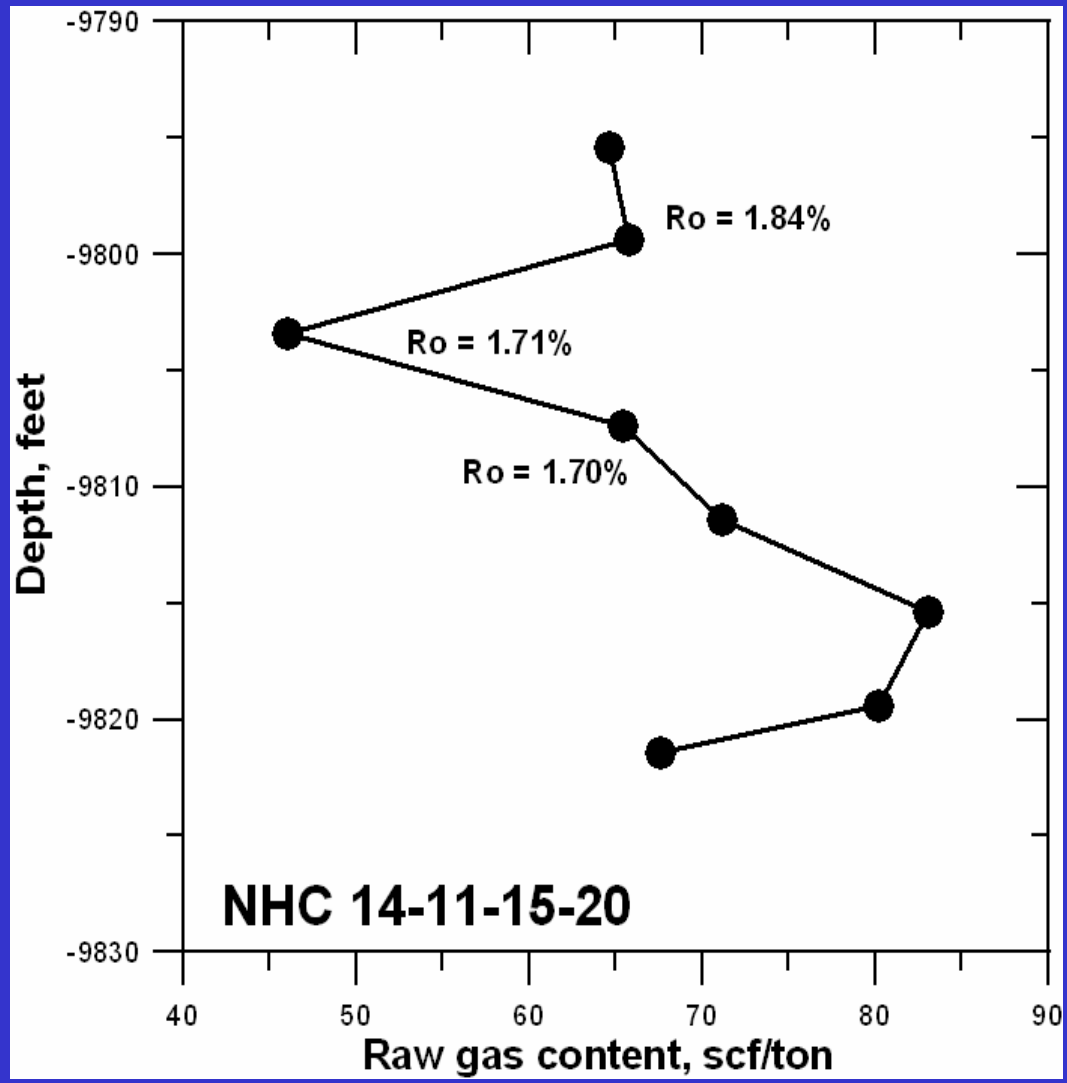




Gas content of lower Mancos Shale : NHC 14-11-15-20 well

Good gas content in core and large mud gas readings near the cored interval.



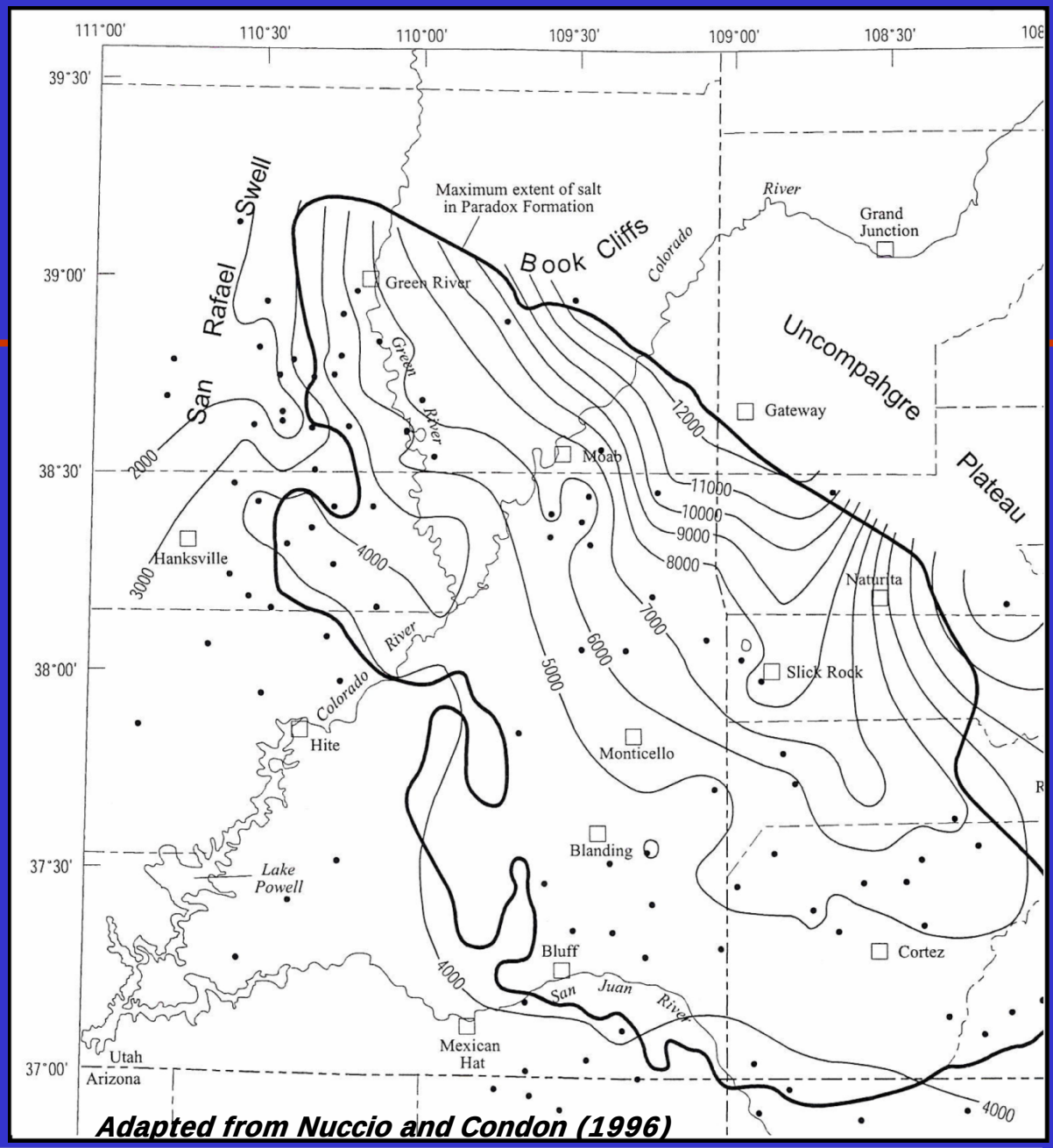


Data from Wind River Resources and Utah DOGM

Paradox basin Pennsylvanian-Permian isopach map

A strongly asymmetric transpressional basin with syn- and immediate post-orogenic sediments thickening toward the Uncompahgre uplift, which is thrust to SW over the basin.

Heavy line shows limits of salt.



Adapted from Nuccio and Condon (1996)

Paradox Fold and Fault Belt

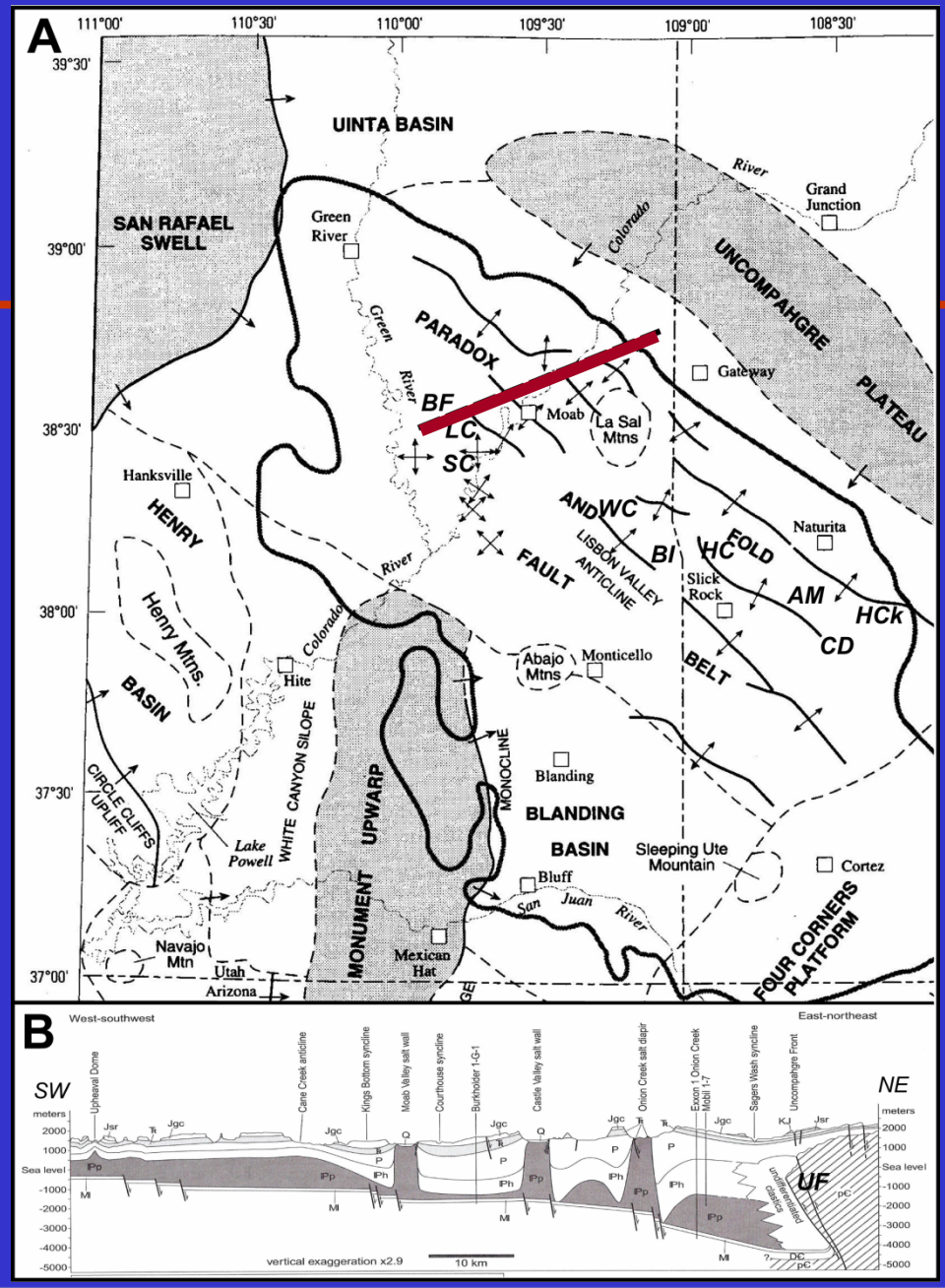
Series of salt walls exist in the region of thick salt in the Paradox Formation.

These salt walls begin forming already in late Pennsylvanian-early Permian as “growth anticlines”.

Upturned limbs are structure-stratigraphic traps for gas.

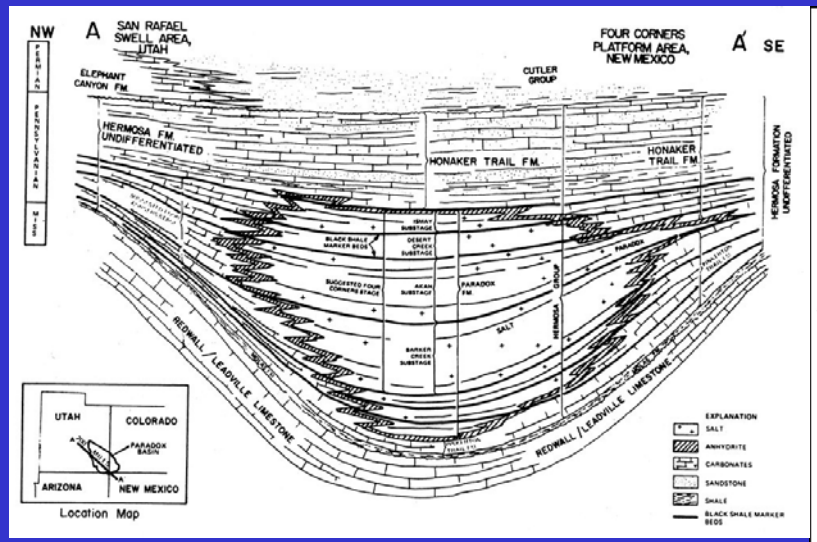
Location of cross section (B) is shown in heavy red line.

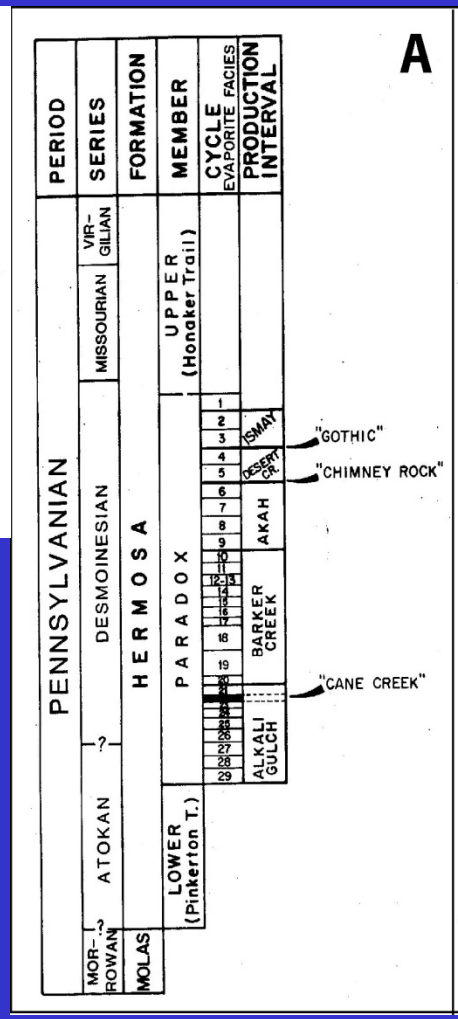
Adapted from Nuccio and Condon (1996) and Matthews et al. (2007)

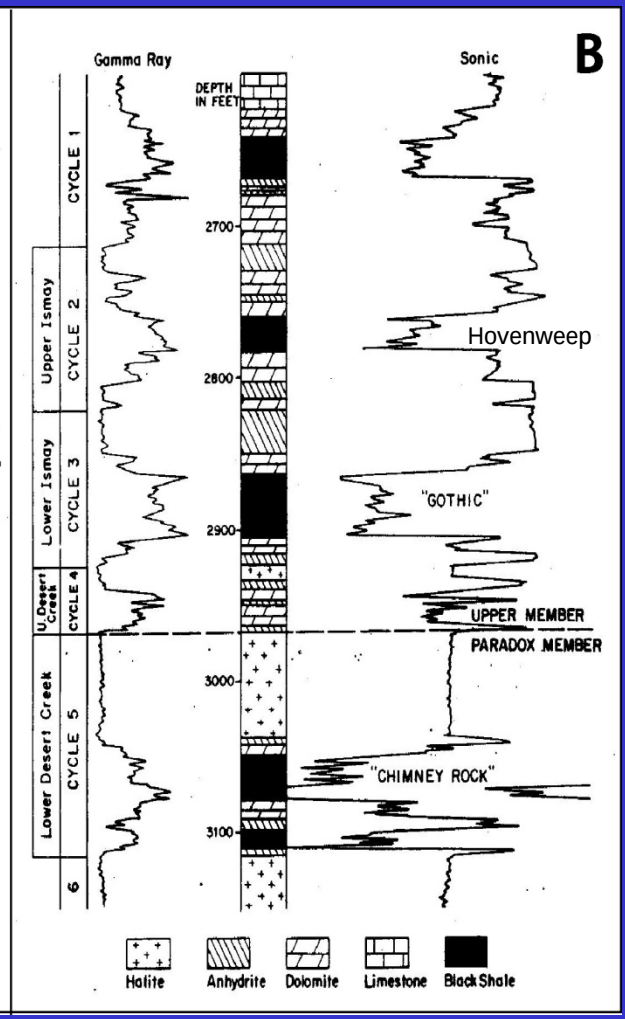


Hermosa Group – Paradox Basin

The Hermosa Group (Pennsylvanian) is the principal synorogenic fill of the transpressional Paradox basin, an Ancestral Rockies depression.





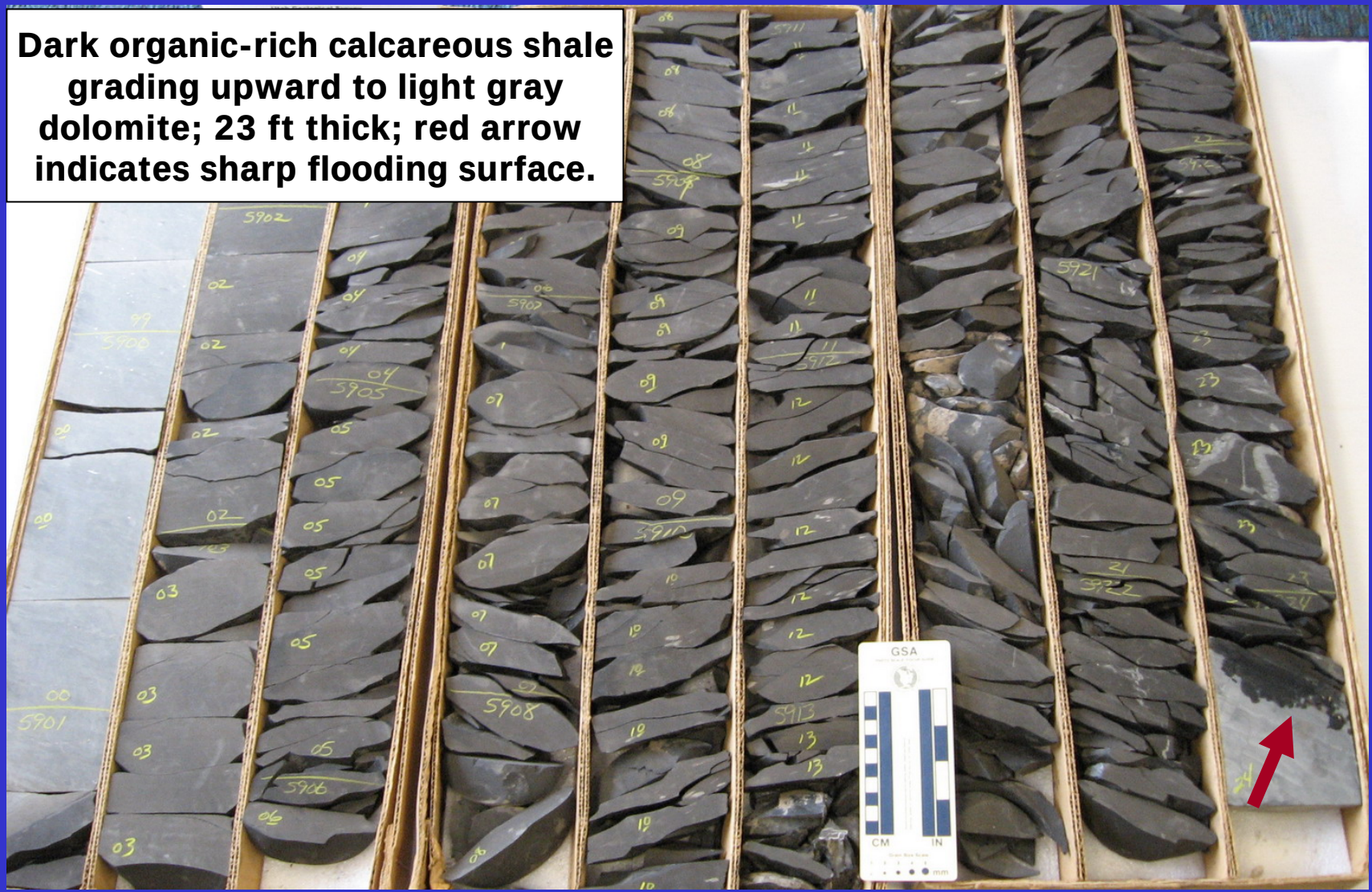


Black shales exist throughout the Hermosa Group, but are mainly in the 29 evaporite-shale cycles of the Paradox Formation.

The black shale intervals are normally less than 30 ft thick, but they are encased in thicker anhydrite, halite and dolostone.

Transgressive Gothic Shale: Mule 31K (N) well

Dark organic-rich calcareous shale grading upward to light gray dolomite; 23 ft thick; red arrow indicates sharp flooding surface.



Core located at Utah Core Research Center, SLC

Hermosa Group wells with gas indications

The 43 wells are identified as having natural gas indications within the black “shales” of the Hermosa Group.

API well number	Well name	Sec	T	R	Unit	Comp	Test	DST	MudGas	Shows
43-015-10506	WOODSIDE DOME U 2	30	18S	14E	H			X		
43-015-20312	WOODSIDE UNIT 1	12	19S	13E	H			X		
43-019-30029	FEDERAL 1-26	26	21S	17E	PX			X		
43-019-31357	GCRL SEISMOSAUR FED 1	20	21S	20E	PX			X	X	
43-019-11188	SALT WASH UNIT 22-34	34	22S	17E	HT			X		
43-019-30647	FEDERAL DE-1	20	23S	18E	PX			X		
43-019-31331	KANE SPRINGS FED 10-1	10	25S	18E	CC	X	X			
43-019-31310	KANE SPRINGS FED 27-1	27	25S	19E	CC	X	X			
43-019-31334	KANE SPRINGS FED 25-19-34-1	34	25S	19E	CC	X	X		X	
43-019-30910	MOAB FED 16-9	9	25S	20E	CC			X		
43-019-31018	ARCHES FEDERAL 1	18	25S	21E	CC			X		
43-019-31396	CANE CREEK 2-1	2	26S	19E	CC	X	X			
43-019-31119	MINERAL CANYON FED 1-3	3	26S	19E	CC			X		
43-019-31364	CANE CREEK FED 11-1	11	26S	19E	CC	X	X			
43-019-31156	MINERAL CANYON U 1-14	14	26S	19E	PX	X	X	X	X	
43-019-30357	SUNBURST 1	14	26S	19E	CC				X	
43-019-30796	SKYLINE UNIT 1	5	26S	20E	CC			X		
43-019-15925	LONG CANYON 1	9	26S	20E	CC	X	X			
43-019-31324	KANE SPRINGS FED 19-1A	19	26S	20E	CC	X	X			
43-037-31631	CANE CREEK ST 1-36	36	27S	20E	CC			X		
43-037-10573	WEST BRIDGER JACK U 3	3	27S	21E	H			X		
43-037-30617	FEDERAL 4-26	26	27S	21E	PX			X		
43-037-30518	HATCH POINT 27-1A	27	27S	21E	CC	X		X	X	
43-037-30650	LION MESA UNIT 5-28	28	27S	21E	H					X
43-037-30559	LION MESA 2-34	34	27S	21E	PX			X		X
43-037-10519	BRIDGER JACK 1	17	27S	22E	H			X		
43-037-10652	BRIDGER JACK UNIT 2	27	27S	22E	PX			X		
43-037-10859	MURPHY RANGE UNIT 1	12	28S	18E	PX			X		
43-037-10849	US LOCKHEART 1	23	28S	20E	IS			X		
43-037-10196	MULESHOE 7	2	28S	23E	H			X		
43-037-31822	HEADWATERS FED 7-15	15	28S	23E	GO			X	X	X
43-037-30923	TXC/HUBER FEDERAL 1-15	15	28S	25E	HT			X	X	X
43-037-30044	STATE GULF 1	36	29.5S	23E	H					X
43-037-30010	DIRTY DEVIL 1	4	30S	13E	H			X		
43-037-11339	NW LISBON USA C-2	3	30S	24E	H	X		X		
43-037-16470	NW LISBON USA C-3	3	30S	24E	H			X		
43-037-16250	LISBON UNIT D-84	4	30S	24E	H			X		
43-037-16471	NW LISBON USA A-2	10	30S	24E	H			X		
43-037-31453	TRUDI FEDERAL 2-17	17	31S	23E	PX			X		
43-037-31479	MAJOR MARTIN FEDERAL 1	22	31S	23E	PX			X		
43-037-10616	COAL BED CANYON UNIT 6	14	35S	25E	PX			X		
43-037-30786	CEDAR PT FED 1-25	25	35S	25E	HT			X		X
43-037-30927	UCOLO 1-32	32	35S	26E	HT			X		

Wells with Hermosa black shale gas tests

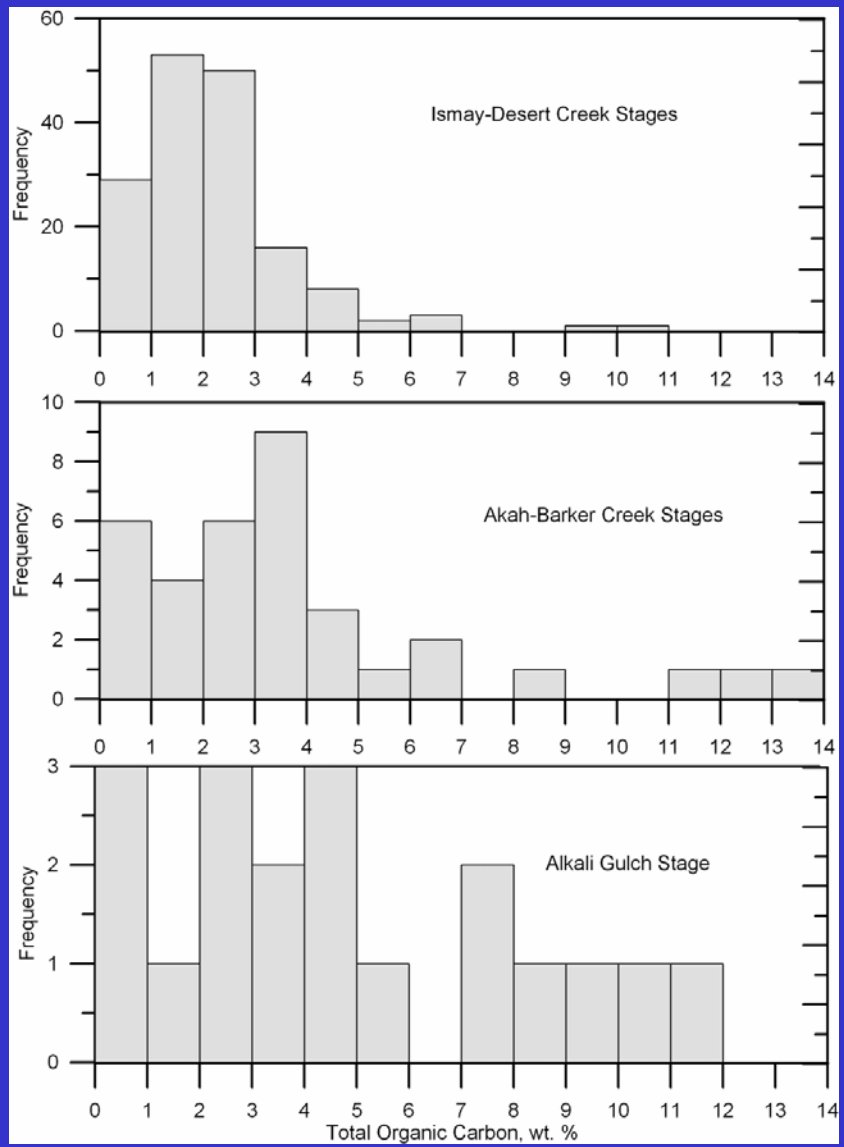
API well number	Well name	Unit	Hermosa top	Paradox	Hermosa base	Top interv	Base interv	Gas mcfpd
43-019-31331	Kane Springs Fed 10-1	CC	na	4,768	9080 TD	8,083	9,080	757
43-019-31396	Cane Creek 2-1	CC	na	na	7220 TD	6,968	7,038	657
43-019-31310	Kanes Springs Fed 27-1	CC	na	na	8244 TVD	7,510	8,244	627
43-019-31364	Cane Creek Fed 11-1	CC	na	4,261	7554 TVD	7,702	9,892	560
43-019-31334	Kane Springs Fed 25-19-34-1	CC	na	3,977	7988 TD	7,580	7,985	328
43-019-31310	Kanes Springs Fed 27-1	CC	na	na	8244 TVD	7,510	8,244	290
43-019-31324	Kanes Springs Fed 19-1A	CC	2,582	4,319	7420 TVD	7,340	7,420	234
43-019-31156	Mineral Canyon U 1-14	PX	4,406	7330 CC	7,482	6,055	6,063	139

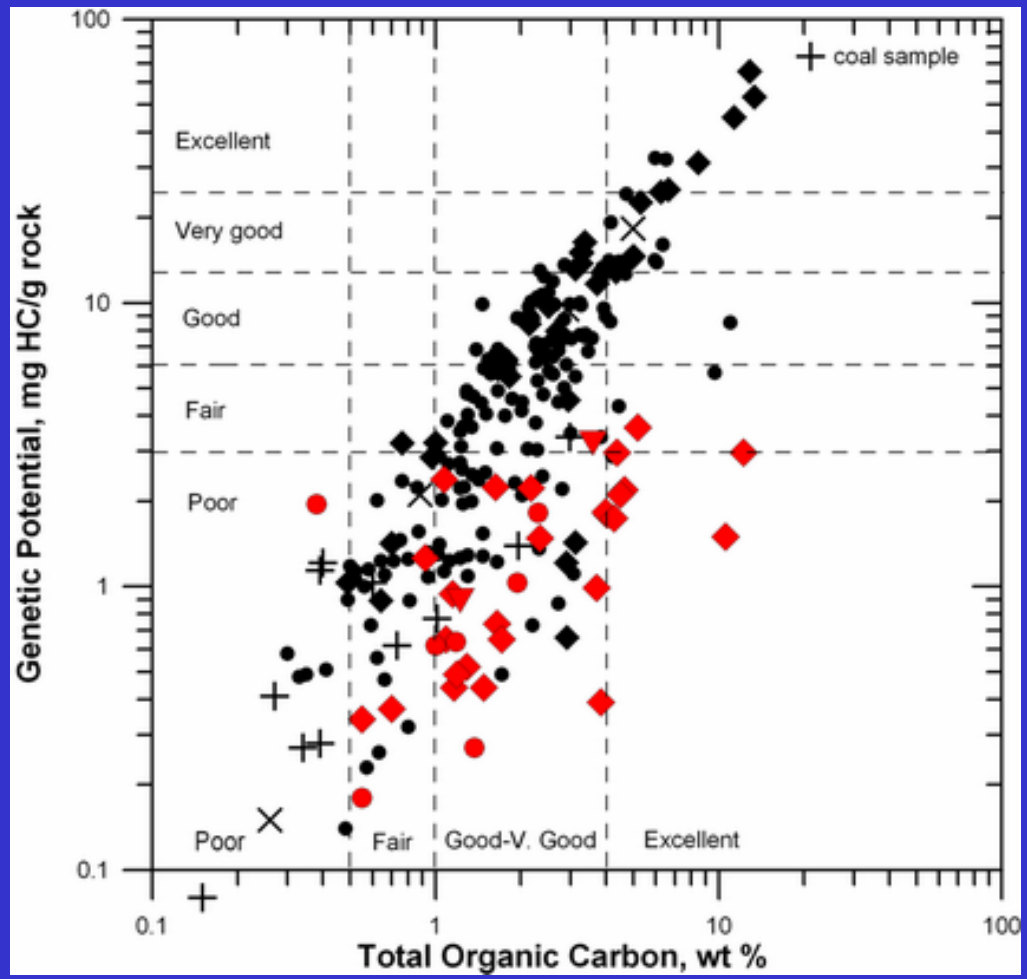
The gas rates range from a high of 757 Mcfgpd in the Kane Springs Fed 10-1 well to a low of 139 Mcfgpd in the Mineral Canyon U 1-14 well.

The average of the 8 tests is 452 Mcfgpd. This is associated gas coproduced with a relatively waxy oil having an average API gravity of 41.3°.

The GOR ranges between 202 and 1,281 and averages 579. The associated oil rates range between 197 and 2,302 bopd. Low oil and gas rates may explain why this "hot" play was short-lived. Production is continuing to present time.

Paradox “black shale” is a good source rock

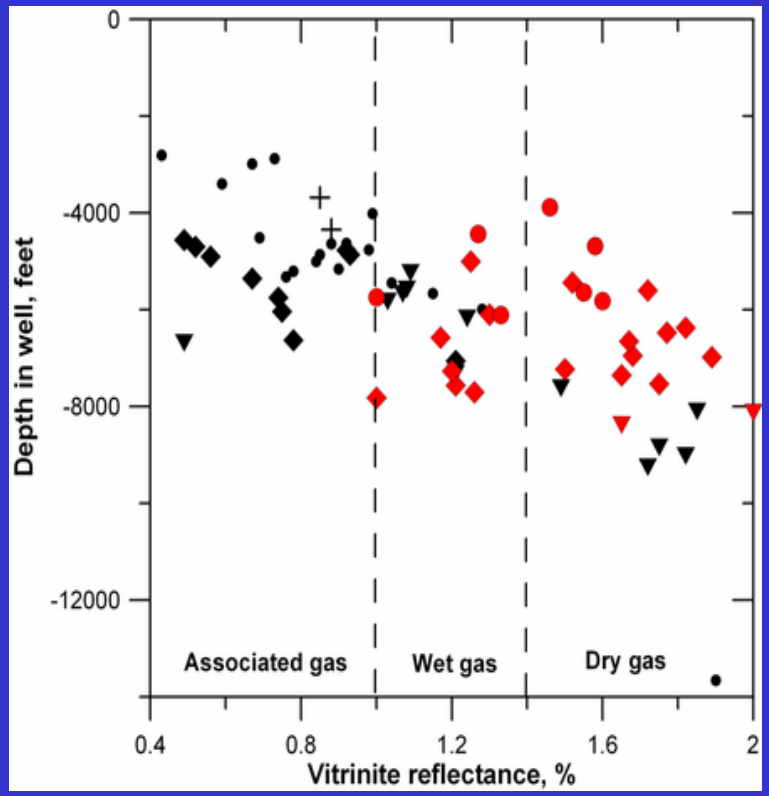


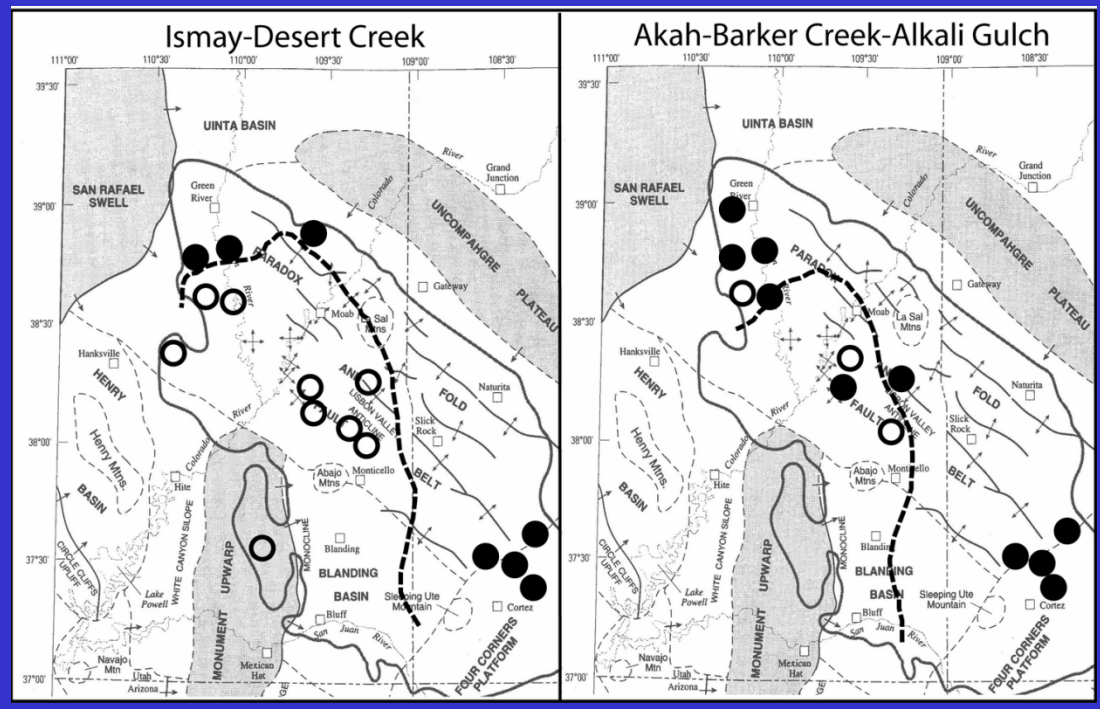


Black symbols indicate samples in Utah; red symbols indicate samples in Colorado.

Data from Schamel (2008); RMAG Paradox Basin Guidebook

Paradox shale gas province limited to north and east





Organic maturity increases with depth.

Black symbols indicate samples in Utah; red symbols indicate samples in Colorado.

Dots indicate Ismay-Desert Creek shales; inverted triangles are Cane Creek Shale.

Open circles indicate Ro<1.0% and black dots indicate Ro>1.0%, the gas maturity window.

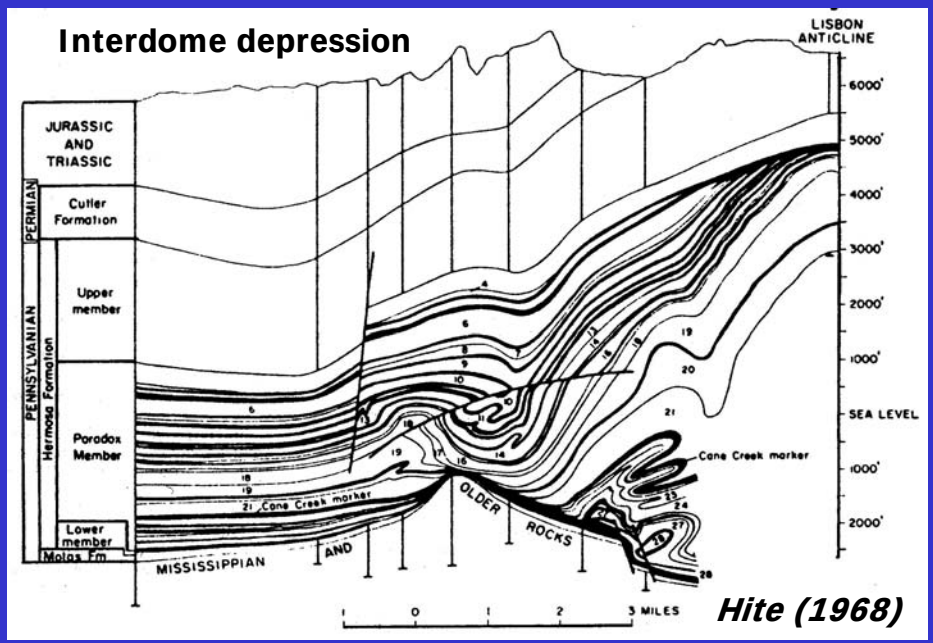
PI from RockEval may serve as a proxy for Ro. PI = 0.3 appears to be a proxy for the Ro = 1.0% isopleth. This would confirm the presence of prime shale gas areas in north and east of basin.

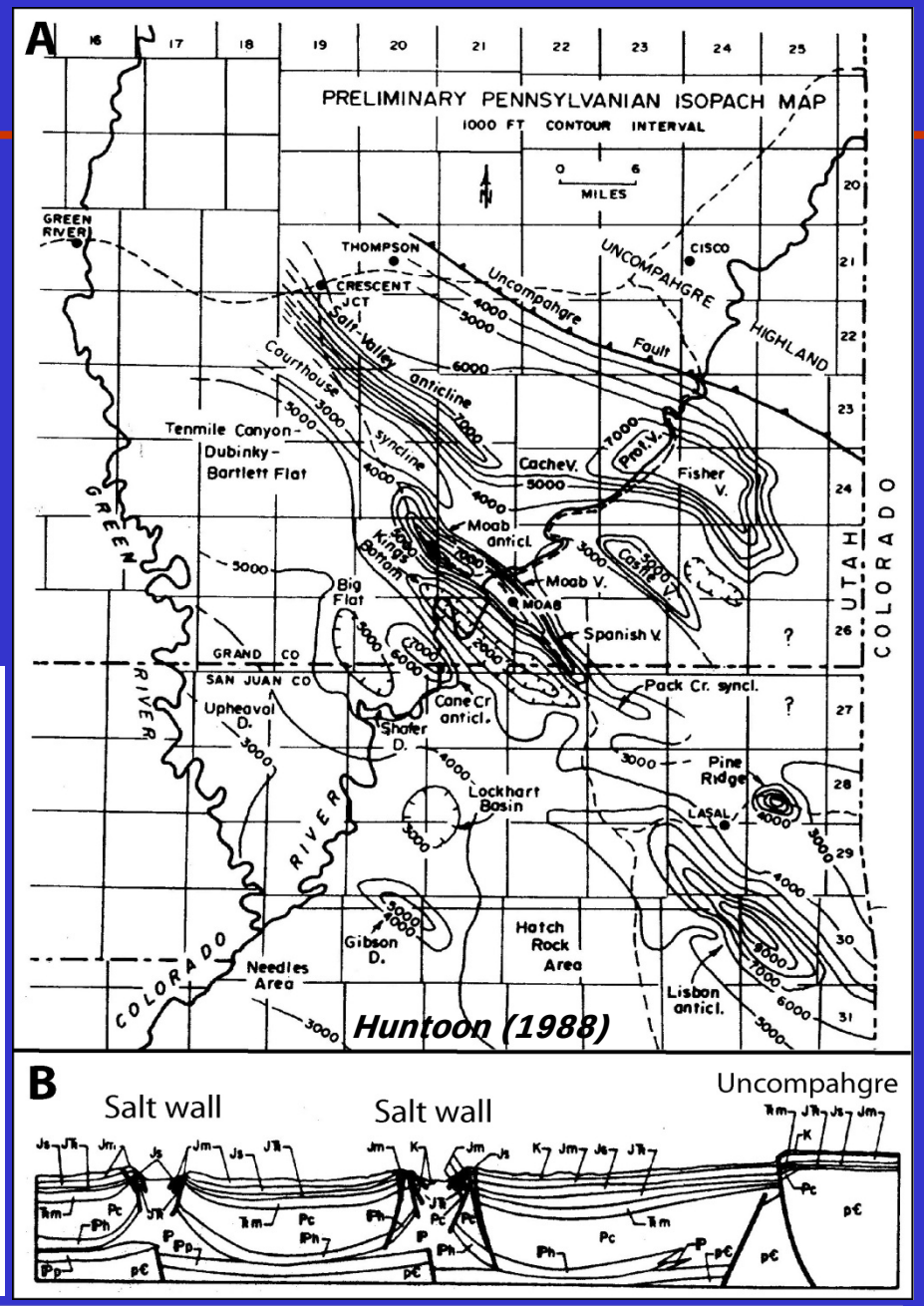
Basemap and PI modified from Nuccio and Condon, 1996

Paradox basin shale gas play

Prime candidate for shale gas due to many shale beds rich in high-TOC kerogen within the gas-window encased in excellent sealing rocks.

Large interdome depressions in the NE half of the basin are the prime sites for shale gas exploration.



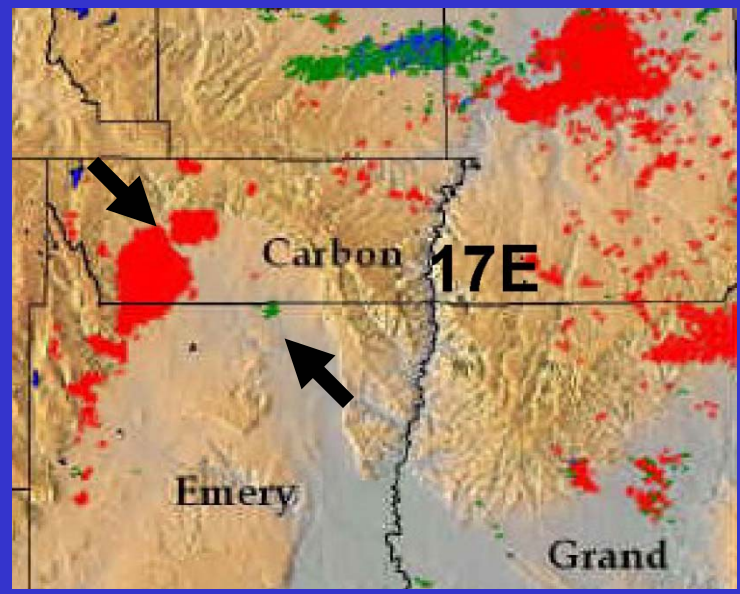


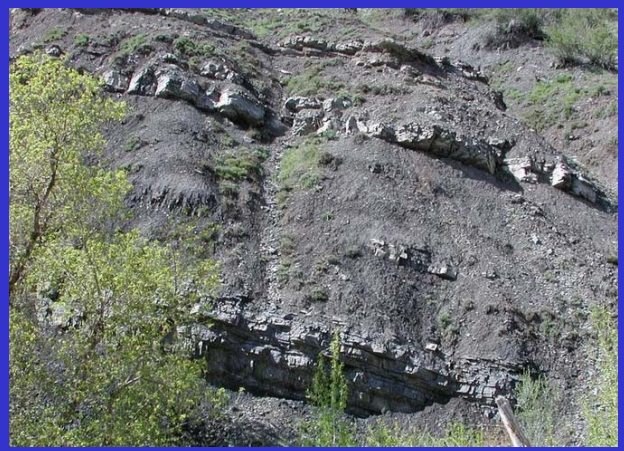
Manning Canyon Shale – Doughnut Shale Play

Interbedded dark, carbonaceous shale, sandstone, and limestone. Lower greenschist facies west of Wasatch Plateau, but in gas window in Castle Valley.

Belt of well penetrations with limited DSTs and gas shows in western Carbon and north-central Emery Counties.

This play is currently being tested.

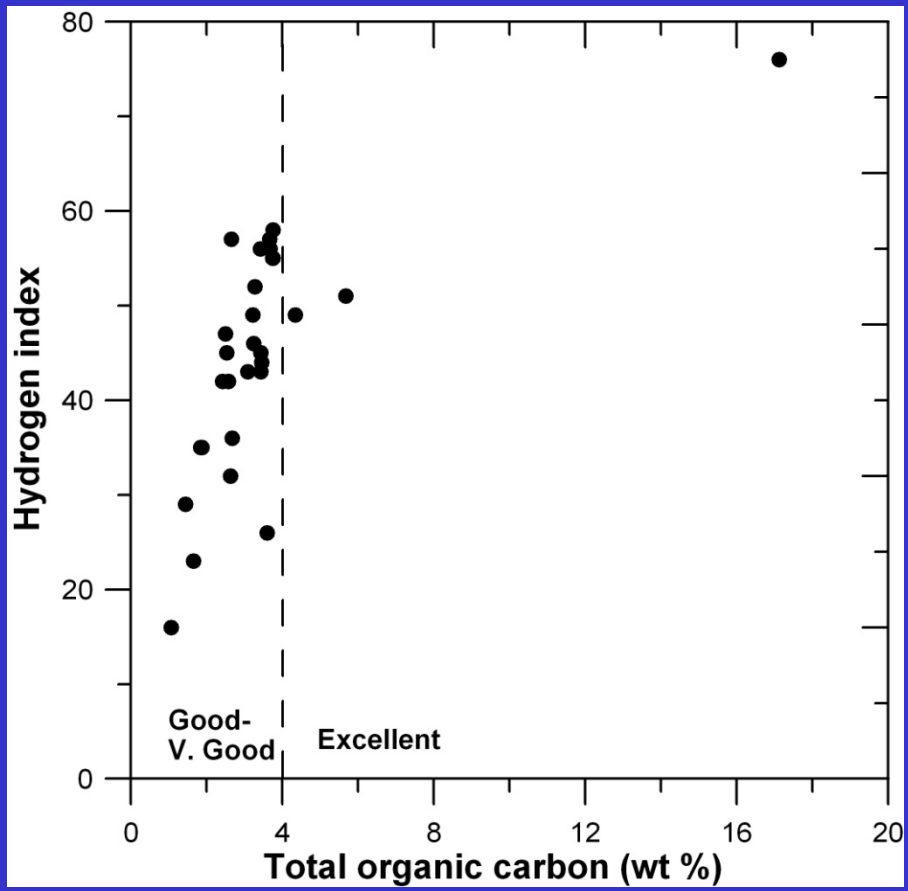


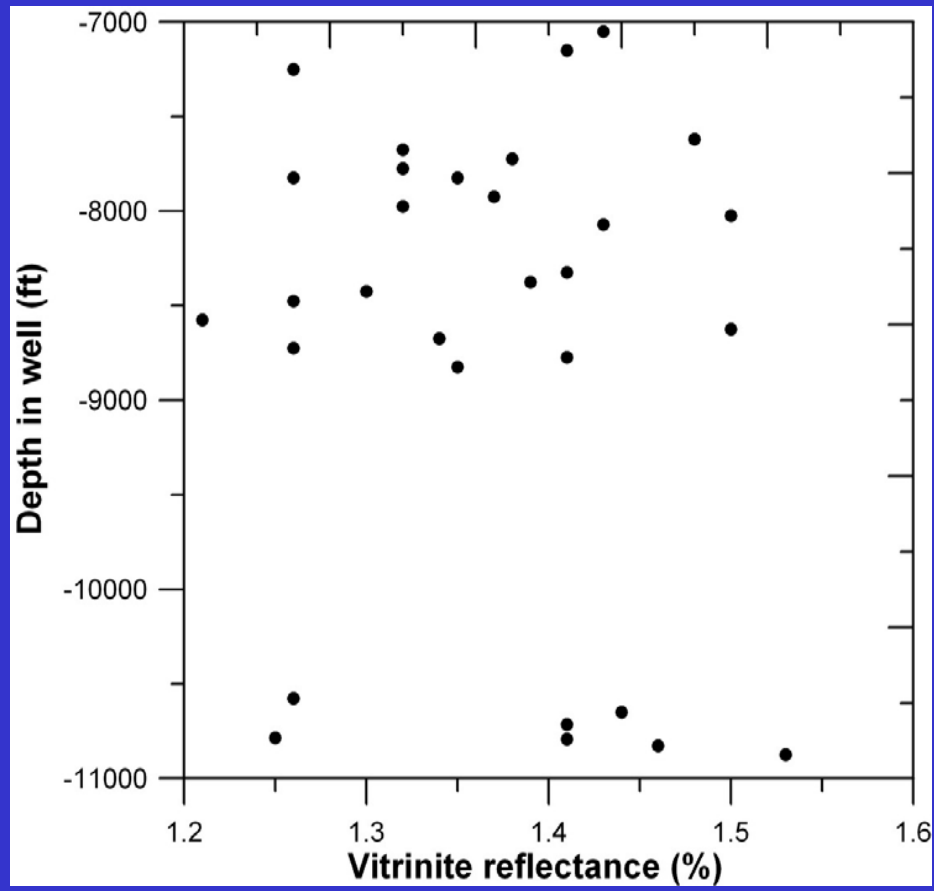


Doughnut Shale penetrations: Castle Valley

Well API No.	*Well Name*	*T-R*	*Depth, ft*	*Thickness*
4300730093	Arcadia-Telonis 1 (D-2)	14S-9E	11,836	540
4300730040	Drunkards Wash 31-1	14S-10E	11,620	1,230
4300710791	**North Springs 1**	15S-9E	10,345	1,100
4300711029	**Miller Creek 1**	15S-10E	8,950	1,813
4300711330	Washboard Wash USA 1-A	16S-9E	9,030	440
4301520190	Clarence Wilson Fee 1	16S-10E	8,506	844
4301530067	**Skyline-Spjut 16-1**	16S-11E	7,003	1,077
4301510825	**Federal Mounds 1**	16S-11E	6,608	1,004
4301530077	Federal Mounds 11-1	16S-11E	6,545	1,116

Doughnut Shale Geochemistry & Organic Maturity





Favorable organic content and Ro maturities in the gas window point to a potentially successful shale gas play.

Data from Utah Geological Survey open-file

Summary

Three proven and potential shale gas plays in Utah are poised to make a significant contribution to natural gas production:

Mancos Shale: favorable gas tests, good DSTs, large to very large mud gas readings, and widespread gas shows recorded in all members. Mancos shale gas is being produced from a few wells in Greater Natural Buttes and Flat Rock fields. This is "add-on" gas supplementing production from conventional sandstone reservoirs. Currently a very active play in the Uinta basin.

Hermosa Group: "black shales" in the Paradox basin have good source potential and proven oil-associated gas production. In the more thermally mature areas of the basin, there is a strong potential for substantial shale gas development, which recent wells may have shown.

Manning Canyon or Doughnut Shale: good indications for shale gas in 1,000+ ft thick black shale, sandstone and limestone succession east of the Wasatch Plateau. Wells are currently testing the play in the Castle Valley, western Book Cliffs.

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