Shale Gas Resources of Utah: Assessment of Previously Undeveloped Gas Discoveries

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Cover photo: Upper Mancos Shale northeast of Grand Junction, Colorado. Photo by Steven Schamel.

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Table of Contents

Executive Summary 6
Introduction 8
  Scope of the project 8
  Data sources and methods 9
  Production and drill-stem tests 12
  Monitoring natural gas during drilling 14
Mancos Shale 15
  Stratigraphy of the Mancos Shale 15
    Prairie Canyon Member 13
    Lower Blue Gate Shale Member 14
    Juana Lopez Member 15
    Tropic/Tununk Shales 16
  Setting for natural gas in the Mancos Shale 22
  Well completions, tests and production 23
  Mud gas and other gas shows 30
Hermosa Group 37
  Stratigraphy of the Hermosa Group 37
  Setting for natural gas in the Hermosa Group 43
  Well completions, tests and production 48
  Mud gas and other gas shows 51
Assessment of Undeveloped and Underdeveloped Gas Discoveries 54
Acknowledgements 56
References Cited 56
Appendix A 61
Appendix B 62
Appendix C 63
Appendix D 64
Appendix E 65
Appendix F 66
Appendix G 67
Appendix H 68

List of Figures

Figure 1: Map showing the counties and the oil (green) and/or gas (red) fields of Utah 11
Figure 2: Diagrammatic map of the township-range grid showing the regions in which wells with shale gas indications were sought in the Mancos Shale (green) and the Hermosa Group (gray) 12
Figure 3: Schematic DST time-pressure plot showing the principal elements of a dual-flow test 13
Figure 4: Stratigraphy of the Mancos Shale over the Douglas Creek arch 20

Figure 5: Generalized stratigraphy of the Cretaceous foreland basin in southern and east-central Utah ... 21
Figure 6: Generalized regional stratigraphic cross section from Price, Utah to Palisade, Colorado showing the relationship between the prograding Star Point-Blackhawk highstand shoreline stages and the 'detached' siltstone-sandstone deposits of the Prairie Canyon (Mancos B) Member ... 21
Figure 7: Thermal maturities at the base of the Mesaverde Group or top of the Mancos Shale beneath the Uinta Basin ... 23
Figure 8: Map of the Uinta-Piceance Basins showing the location of wells producing gas and oil from the Dakota Sandstone ... 28
Figure 9: Photograph of Prairie Canyon Member immediately below the interval testing 91 Mcfgpd in the Crooked Cyn 10-10-14-23 well, the 6,197-6,217 ft interval. The interval actually tested, 6,237-6,380 ft, was not cored ... 29
Figure 10: Segment of the mud gas log for well N Hill Creek 4-10-15-20 ... 32
Figure 11: Segment of the mud gas log for well N Hill Creek 4-1-15-20 ... 33
Figure 12: Segment of the mud gas log for well N Hill Creek 4-13-15-20 ... 34
Figure 13: A deeper segment of the mud gas log for well N Hill Creek 4-13-15-20 ... 35
Figure 14: Segment of the mud gas log for well N Hill Creek 2-12-15-20 ... 36
Figure 15: Segment of the mud gas log for well Rock House 11-31 ... 37
Figure 16: Sturctural elements of the Paradox basin and surrounding areas ... 39
Figure 17: Generalized Pennsylvanian stratigraphy of the Paradox basin ... 40
Figure 18: Stratigraphy of the Hermosa Group, Paradox basin ... 41
Figure 19: Distribution of TOC values with depth in the Gibson Dome #1 well ... 42
Figure 20: Distribution of TOC values measured in various stratigraphic intervals of the Hermosa Group, Paradox basin ... 43
Figure 21: Modified van Krevelen plot of samples from the Ismay-Desert Creek interval showing that the kerogen is mainly type III and mixed type II-III ... 44
Figure 22: Distribution of Ro values measured in the Ismay-Desert Creek and Cane Creek intervals of the Paradox Formation ... 45
Figure 23: Thermal maturity map of the Paradox basin at the level of the Ismay-Desert Creek interval ... 46
Figure 24: Salt walls in the fold and fault belt of the Paradox basin ... 47
Figure 25: Structural cross section of the west limb of the Lisbon Valley anticline showing the deformed Paradox Formation cycles in the anticline and apparent absence of deformation beneath the adjacent 'syncline' ... 48
Figure 26: GR-density/neutron log for a segment of the Skyline Unit 1 well ... 52
Figure 27: GR-density/neutron log for a segment of the Skyline Unit 1 well (API 4301930796; 5-26S-20E) passing through the relatively thin #19 clastic interval ... 53
Figure 28: A portion of the mud gas log in the Headwaters Fed 7-15 well ... 54

List of Tables

Table 1: Wells completed in the Mancos Shale for gas testing and/or production ... 24
Table2: Gas rates reported for intervals within the Mancos Shale arranged from highest to lowest ... 26

Table 3: Wells for which the well completion report indicates the Mancos Shale as a "porous zone", but no other information to support this assertion............................ 27
Table 4: Well having DSTs within portions of the Mancos Shale exclusive of the sandstone and coal-bearing Ferron Sandstone and Emery Sandstone Members 27
Table 5: Wells having mud gas readings for the Mancos Shale interval......................... 30
Table 6: Wells having gas flare observations within the Mancos Shale interval 31
Table 7: Wells completed in Hermosa Group black shale intervals for which gas test data are available.. 49
Table 8: Gas rates reported for intervals within the Mancos Shale arranged from highest to lowest 49
Table 9: Wells having DSTs in the Hermosa Group black shale ("clastic") intervals 50
Table 10: Wells having mud gas measurements in the Hermosa Group black shale intervals 51

Executive Summary

It is very likely that shale gas has already been discovered in Utah that could be developed commercially under current market conditions and utilizing improved reservoir stimulation technologies. It is the goal of this project to identify those older wells that have had significant indications of natural gas within prospective shale gas reservoirs. The data compilation and interpretative report generated by this project should encourage future development in the shale gas reservoirs of Utah. This project not only catalogues undeveloped natural gas 'discoveries' in potential shale gas reservoirs, but it reveals patterns of encounters that can guide both operators desiring to develop this energy resource specifically and those seeking add-on gas in wells targeted for deeper objectives. This project builds on an earlier study for the Utah Geological Survey of the geologic and geochemical characteristics of potential shale gas reservoirs in Utah (Schamel, 2005).

The project has entailed the systematic search of drilling records at the Utah Division of Oil, Gas and Mining (DOGM), the Denver Energy Resource Library (DERL) and the U.S. Geological Survey Core Research Center (USGS). It has involved the gathering relevant drilling records, DSTs and scout tickets associated with potential shale gas reservoir intervals. The project focused first on the Mancos Shale (Upper Cretaceous) in northeast and east-central Utah and, subsequently as time permitted, the Hermosa Group (Pennsylvanian) of the Paradox basin in east-central and southeast Utah.

The information assembled for this project demonstrates that significant quantities of natural gas has been discovered in the Mancos Shale across a broad area of the southern Uinta Basin. In the past, the impediments to production of this gas has been existing market conditions and the inadequate fracture stimulation technologies employed in the Mancos shale intervals. Until very recently, it was standard practice to use same light gel, KCL-foam or acid fracture stimulations that were employed in the sandstone reservoir objectives. These undoubtedly caused more damage to the shales than if the interval had not been stimulated.

However, favorable gas tests from Mancos completions, good drill-stem tests (DSTs), large to very large mud gas readings and widespread shows demonstrate the strong potential for development of this shale gas reservoir. Whereas most of the good indications were in the upper part of the 3,000-3,500 ft thick Mancos Shale, principally in the Prairie Canyon Member, favorable indications were found in all of the other shaly units, the Blue Gate Shale, Juana Lopez and Tununk Shale Members.

At the present time Mancos shale gas is being produced from a small number of wells in the Flat Rock and greater Natural Buttes fields. In all instances this is add-on gas, supplementing the larger production from conventional sandstone reservoirs. At Flat Rock, there are five deep wells completed in the Mancos Shale that are contributing as much as one-fifth of the total gas output of the wells. In the greater Natural Buttes area, a few operators have started to drill into the upper few hundreds of feet of the Mancos

Shale underlying the Mesaverde sandstone objectives. These wells have demonstrated good gas rates, even in very thin and inadequately completed shale intervals.

It is obvious that the Mancos Shale needs to be treated as the significant gas reservoir that it is. In the greater Natural Buttes field, wells targeting the lower Mesaverde sandstones should also be deepened and tested in the upper 1,000 ft or more of the Mancos Shale, at least through the full thickness of the Prairie Canyon Member. Likewise, all wells targeting the Ferron Sandstone for CBM in Carbon and Emery Counties and the Wingate-Entrada-Dakota sandstones in Uintah and Grand Counties should test the Mancos Shale. Clearly, improved methods for fracture stimulation tailored to the specific rock characteristics of the Mancos lithologies are required. The well completion technologies used in the sandstones cannot be applied to the shaly rocks without some reservoir damage.

In the Paradox basin no wells were identified that adequately tested the assertion (Schamel, 2005) that the productive shale gas reservoirs will be in the interdome depressions along and northeast of the axis of the salt basin. However, the good associated gas tests and strong mud gas values in the wells drilled for the Cane Creek play in the cluster of townships near the basin center do give support for the shale gas potential of the Hermosa Group black shales. Off of the crests of the salt-cored growth anticlines tested by this play, natural gas, not the light oil and associated gas discovered in the Cane Creek interval, can be expected to be the resource in all of the “clastic intervals” intercalated in the thick halite succession. This is a potentially large energy resource still waiting to be discovered and developed.

Introduction

It is very likely that shale gas has already been discovered in Utah that could be developed commercially under current market conditions and utilizing improved reservoir stimulation technologies. It is the goal of this project to identify those older wells that have had significant indications of natural gas within prospective shale gas reservoirs. The data compilation and interpretative report generated by this project should encourage future development of the shale gas reservoirs of Utah. This project not only catalogues undeveloped natural gas 'discoveries' in potential shale gas reservoirs, but it reveals patterns of encounters that can guide both operators desiring to develop this energy resource specifically and those seeking add-on gas in wells targeted for deeper objectives. This project builds on an earlier study for the Utah Geological Survey of the geologic and geochemical characteristics of potential shale gas reservoirs in Utah (Schamel, 2005).

In many parts of the United States and Canada, a reexamination of old drilling records is opening up opportunities for the "rediscovery" of gas and oil resources that were passed over at an earlier time of lower resources prices and/or more limited recovery technology. This is especially true with natural gas, which in many instances was a "stranded" resource having little or no market value. Also until quite recently with improvements in recovery technology, natural gas in tight sand or shale reservoirs could not be produced at commercial rates.

The review and assessment of old drilling records is very tedious and time-consuming, yet in regions with a long history of exploration drilling it is vastly more cost-effective method for "discovery" of hydrocarbon resources than drilling and testing new wells.

The study has attempted to identify patterns of prior gas discoveries in Utah's 'black shales' and recognize possible shale gas fairways. This report describes the project methods, the structure and general contents of the electronic database, the main findings of the study, and predictions based on reservoir characteristics and prior 'discoveries' for where in Utah the prospects are great for developing shale gas resources.

Scope of the project

The goal of the intensive 3.5-month project has to develop a comprehensive database of significant gas shows and tests that can guide exploration and development into those specific parts of Utah where shale-hosted natural gas has been encountered previously, but not yet fully tested and developed. This project has not just cataloged undeveloped natural gas 'discoveries' in potential shale gas reservoirs, but it has attempted to identify patterns of encounters that can guide operators desiring to develop this energy resource specifically and those seeking add-on gas in wells targeting for deeper objectives. This project builds on an earlier study for the Utah Geological Survey of the geologic and geochemical characteristics of potential shale gas reservoirs in Utah (Schamel, 2005).

There are two main products generated by this project:

1. A searchable georeferenced catalog in Microsoft Excel of natural gas indications within the potential Mancos Shale and Hermosa Group shale gas reservoirs. The database contains results of production and DSTs, depths and character of gas shows, mud gas observations, and other information related to gas discoveries in the well. Selected non-DOGM paper records are included in the database as scanned images identified by the API well number. The database is constructed to facilitate merger with existing fossil energy resource relational databases, as well as future updating as a permanent information resource within the UGS.

2. A report describing the methods and majors findings of the study. This includes the locations, geologic settings and circumstances of natural gas encounters in the two most prospective shale gas reservoirs in Utah. The report attempts to draw out the larger patterns of previous discoveries and the underlying reasons why the discoveries are likely to have been ignored. This report is prescriptive, laying out strategies for exploitation of the undeveloped gas discoveries in the Mancos and Hermosa shales.

Data sources and methods

The project has entailed the systematic search of drilling records at the Utah Division of Oil, Gas and Mining (DOGM), the Denver Energy Resource Library (DERL) and the U.S. Geological Survey Core Research Center (USGS). It has involved the gathering relevant drilling records, DSTs, and scout tickets associated with potential shale gas reservoir intervals. The project focused first on the Mancos Shale (Upper Cretaceous) in northeast and east-central Utah and, subsequently as time permitted, the Hermosa Group (Pennsylvanian) of the Paradox basin in east-central and southeast Utah.

The area of interest for the Mancos Shale is the southern two-thirds of the greater Uinta Basin, including the northern parts of the Wasatch Plateau. In the northern one-third of the basin there have been two few well penetrations of the Mancos Shale, and it is too deep to warrant commercial exploitation of a “low density” resource such as shale gas. The area is within Duchesne, Uintah, Grand, Carbon and the northern part of Emery Counties (Fig. 1), encompassing the townships indicated in green in Figure 2.

The area of interest for the Hermosa Group black shales is the northeast half of the Paradox basin, the portion referred to as the “fold and fault” belt. This is the area of thick halite deposits in the Paradox Formation, and consequently narrow salt walls and broad interdome depressions. To the southwest of this stratigraphically controlled structural zone the black shale intervals are fewer and thinner, and they lack the excellent seals provided by the halite. The area encompasses eastern Wayne and Emery Counties, southern Grand County and the northeast third of San Juan County (Fig. 1). The townships of interest for the Hermosa Group are indicated in gray in Figure 2.

Obviously only wells penetrating significant portions of the Mancos Shale or Hermosa Group are relevant to the study. These were searched out systematically for the Mancos Shale by first determining the depth range of the shales on a township-by-township basis using contour maps on the base of the Mesaverde (NETL, 2004) and top of the Dakota (Roberts, 2003). The DOGM on-line *well history* records were examined also on a township-by-township basis to identify those wells with TDs sufficiently deep to have penetrated the Mancos Shale. Then, the on-line or paper well files for those wells were reviewed for information related to natural gas tests or shows in the Mancos Shale. Also the mudlogs for the wells of interest were examined, when available on-line or in paper from DOGM. A similar screening process was used to identify relevant well records for the Hermosa Group black shales. However, given the complex structure of the area the process involved a high degree of trial-and-error in the screening routine.

In the search for relevant information at the Denver Earth Resources Library and the U.S. Geological Survey (Denver), all of the materials in the Utah file cabinets were examined. DERL maintains separate files for well reports and for DSTs. However, many DSTs are in the well reports that are not part of the dedicated DST files. Only a limited amount of relevant information was obtained at the USGS.

After examining in excess of 800 well files, 99 wells were identified having natural gas indications in the Mancos Shale and 43 wells with gas indications in the Hermosa Group black shales. These wells are listed in Appendix A with the type(s) of gas indication identified. Figure 2 shows the number of wells with gas indications identified in each township.

Information from these sources related to natural gas indications has been compiled in four separate *flat-file* databases (Excel spreadsheets), one each for (1) production tests, (2) DSTs, (3) mud log measurements, and (4) natural gas shows, mainly gas flares. Printouts of the files are presented in Appendices B through H. The common *field* in each database is the API well number. This field serves as the link for merging these databases with existing databases maintained by DOGM, the Utah Geological Survey, and other organizations. Several of the project databases provide township-range geographic references to aid in the review of the information in the database. However, the comprehensive relational DOGM well database, also linked internally by means of the API well number, provides precise locations of the wells in several geographic systems. This database also provides information on well history, status, production, and other information not reproduced in the databases for this project.

Supplementing the four flat-file databases are the electronic (.pdf) well file records for the project wells downloaded from the DOGM web site (*www.ogm.utah.gov*), and scanned (.jpg) images of DST reports obtained as paper copies from DERL.

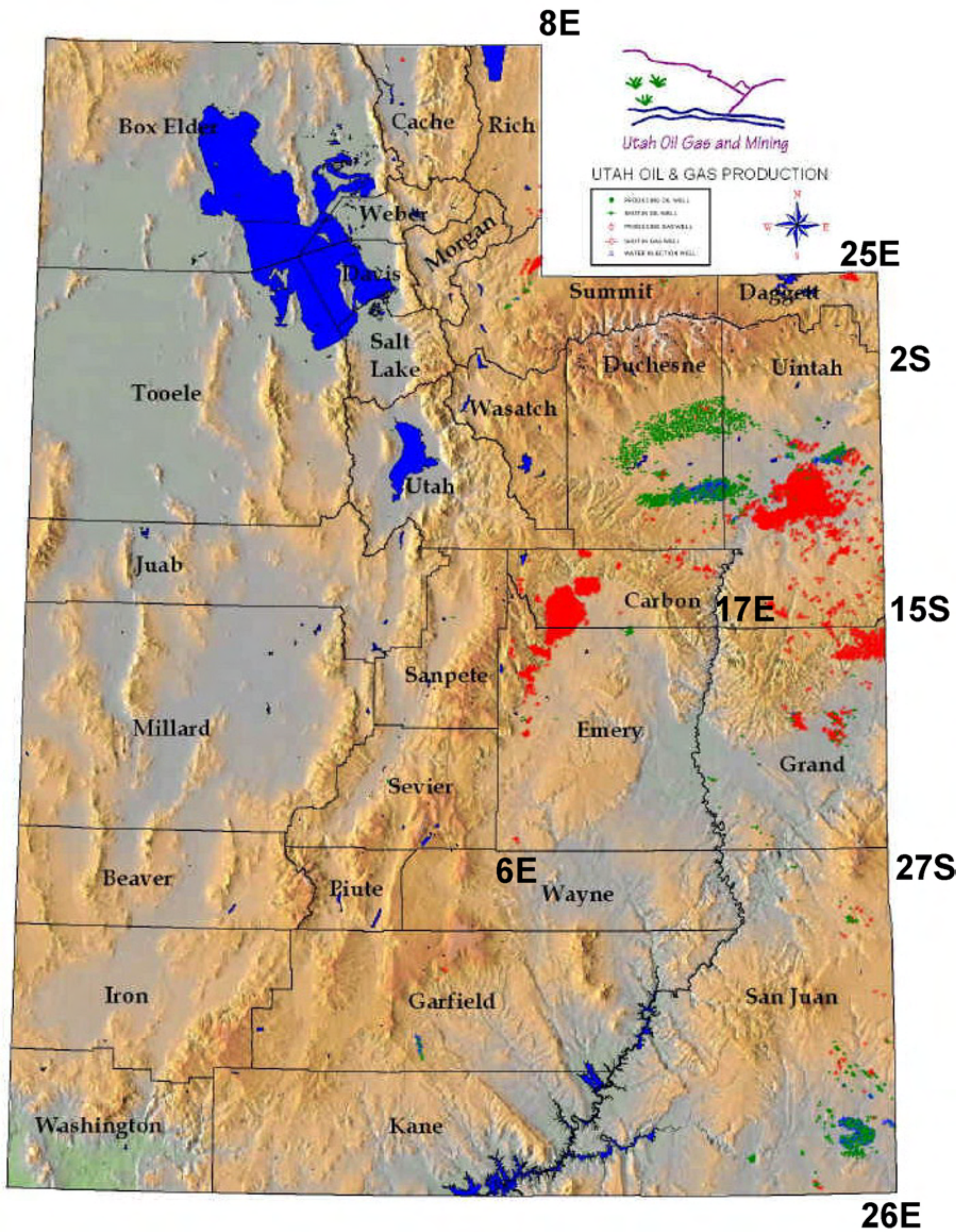

Figure 1: Map showing the counties and the oil (green) and/or gas (red) fields of Utah. The numbers on selected county lines serve as a general reference to the state-wide township and range grid.

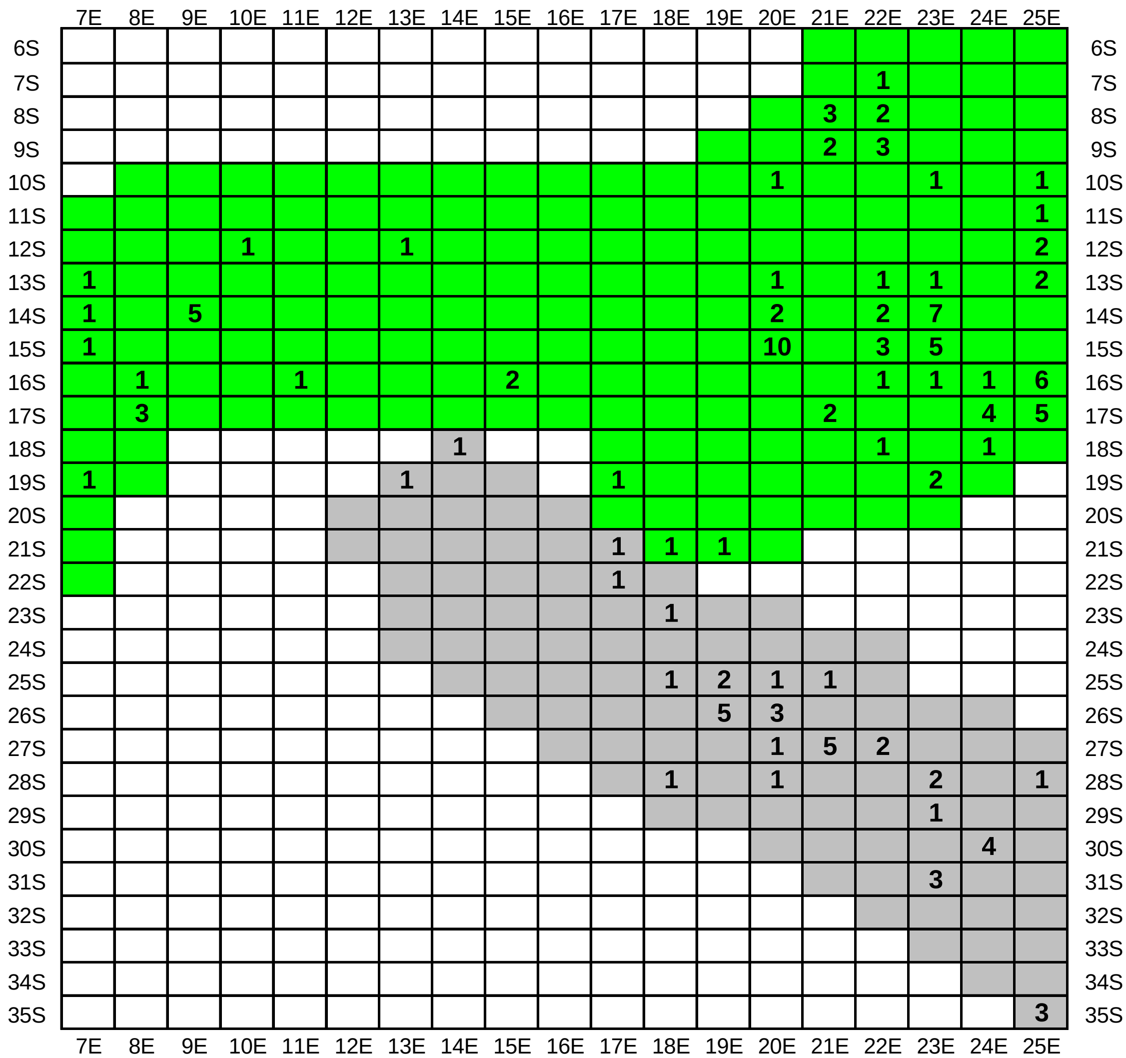

Figure 2: Diagrammatic map of the township-range grid showing the regions in which wells with shale gas indications were sought in the Mancos Shale (green) and the Hermosa Group (gray). Shown is the number of wells with shale gas indications within individual townships. See Appendix A for the list of wells.

Production and drill-stem tests

The production test provides the optimal initial indication of the commercial potential of a reservoir. After casing is set, the reservoir interval of interest is opened to the well bore through perforations and the well is allowed to flow for a period of time ranging from a few hours to several days. The fluids produced and the rates of recovery are used to make the judgement as to whether the interval constitutes a "discovery" or a commercially "dry hole." In wells penetrating several potential producing horizons, the lower reservoirs are opened first for flow testing. It is this fact that has resulted in many Utah wells having tested the Mancos interval, even if the well was plugged back above the top of the Mancos Shale. In situations where production from the well commingles fluids from more than one producing horizon, a production logging tool, commonly a "spinner" device, can determine the relative contributions to total production rates of the several perforated intervals. The well records searched for this project contained virtually no production logging data.

The DST is a temporary well completion made prior to setting casing in which a formation of interest is sealed off from the rest of the well-bore with packers and the formation pressure and fluids are measured (Borah, 1992). The information collected by the DST includes fluid samples and flow rates from the reservoir, initial reservoir pressure, and formation properties, such as permeability and skin factor. DSTs are normally done to decide if a well, or intervals in the well, have commercial potential and should be permanently completed. It has been common practice in the past for wells or intervals testing only gas not to have been completed.

The DST string is run into the hole on the end of the drill pipe. It consists of a pair of packers that isolate the interval being tested, a shut-in valve to permit or stop flow of fluids out of the test interval, and an array of pressure gauges located above the shut-in valve and below the lower packer both inside and outside the test string (Borah, 1992). During the test run each pressure gauge yields a different *time-pressure plot* that collectively are analysed for reservoir characteristics and fluid flow rates. Dual flow-dual shut-in tests (Fig. 3) are now the standard DST. Different types of information are derived from the *initial* time-pressure curves versus the *final* time-pressure curves. The produced fluids can be collected either at the surface or for nonflowing DSTs downhole in sampling jars positioned in the tool string.

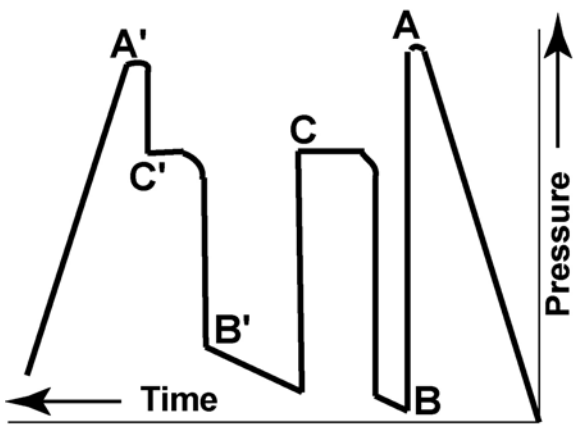

Figure 3: Schematic DST time-pressure plot showing the principal elements of a dual-flow test. The pressure in pounds per square inch (psi) of the elements recorded in the project database are indicated by the letters:

A: Initial hydrostatic pressure (IHP)
A': Final hydrostatic pressure (FHP)
B: Initial flow pressure (IFP)
B': Final flow pressure (FFP)
C: Initial shut-in pressure (ISIP)
C': Final shut-in pressure (FSIP).

The overall quality and/or limitations of a DST are determined by a variety of factors (Earlougher, 1977; Erdle, 1984):

- the type of DST, whether flowing or nonflowing,
- the immediacy of the DST following the initial drilling through the interval tested,
- the thickness of the interval tested (shorter is better),
- the type and snugness of the packer seat sealing off the zone tested, and
- the absolute and relative durations of the flow and shut-in periods during the test.

Incomplete or careless analysis of even good DST records has commonly lead to misinterpretation of the test, and either abandonment of a potential discovery well or completion of a subsequently non-commercial well (Borah, 1992). This project accepted for the database only reasonably good tests that sampled some quantity of natural gas in either the recovered fluids or in the sample chamber.

Monitoring natural gas during drilling

It has been common practice in the past to monitor natural gas during the drilling operation both out of concern for the safety of the drilling crew and to evaluate the hydrocarbon resources of the strata penetrated (Whittaker, 1991, 1992; Darling, 2005). Gas shows encountered during drilling may point to intervals that should be tested, but that might otherwise have been overlooked as non-productive. At the very minimum, samples of gas are extracted continuously from the drilling mud using a *gas trap*, a metal container actually immersed in the shale shaker. Gas released from the mud is carried through a vacuum line to the logging shed for analysis by a *hot-wire detector*. In more advanced logging units, a pair of hot-wire detectors is used to measure methane (C_1) and all other combustible hydrocarbon gases separately (Exploration Logging, Inc., 1985). The hot-wire detectors record percentage of gas or "gas units" when properly calibrated against samples of known gas content. One gas unit is equivalent to 1,000 ppm of gas. Once a gas-bearing zone is encountered it is common practice to pass the gas stream through a *gas chromatograph* to measure the relative proportions of methane through pentane (C_5). Also when natural gas is encountered at specific depths in the well and flared, this information is a standard part of the drilling report.

Elevated readings of natural gas in the drilling mud may relate to penetration of a gas-saturated reservoir unit or a gas-filled fault-fracture zone during drilling (Whittaker, 1991). However, mud gas spikes can be an artifact of the drilling operation itself (Jorden and Campbell, 1984). Pulling the drill string out of the hole can lead to trip gas (TG) or connection gas spikes, which normally are identified as such on the mudlog. Also restarting drilling mud circulation after an extended period of idle time on the rig can produce a down-time gas (DTG) spike. To measure the time it takes for the drilling mud to circulate through the well and back to the surface, carbide is periodically put into the injected mud which results in a carbide methane (CG) spike serving as the tracer. In reading the mud gas logs for this project only the values (in gas units) of the "background" log trace were recorded ignoring the artificially induced gas spikes indicated on the log. Where available as numerical values, the gas compositions from the chromatograph are recorded in the comment field of the mud gas database.

Mancos Shale

All of the potential shale gas reservoirs of Cretaceous age in Utah are portions of the extremely thick Mancos Shale (or Mancos Group) deposited in a basinward position within the Western Interior Seaway, the foredeep basin to the Sevier thrustbelt. Most of the units represent transgressive episodes within the depositional history of the basin, but several of the higher units appear to have been deposited during times of overall regression. In every case, the organic-rich shale was deposited several tens of miles eastward of the coeval wave-dominated, sand-rich, fluvial-deltaic shoreline deposits and widespread peat mires. Deposition in proximity to these heavily vegetated high-stand shorelines resulted in a substantial humic (terrigenous) component of organic matter in the basinal shales.

Stratigraphy of the Mancos Shale

The four members of the Mancos Shale identified by Schamel (2005) as having shale gas potential are:

1. the *Prairie Canyon (Mancos B) Member* (Fig. 4), a second 'detached' siltstone-sandstone body coeval with the Emery Sandstone-Star Point-Blackhawk (Campanian) highstand shoreline successions.
2. the *Lower Blue Gate Shale Member* (Fig. 4), a thick uniform dark gray shale succession of Santonian age,
3. the *Juana Lopez Member* (Fig. 4) of upper Turonian-Santonian age, a probable 'detached' siltstone-sandstone body enclosed within the Mancos Shale and in part coeval with the Ferron Sandstone, and
4. the *Tropic-Tununk Shale* (Fig. 5) of lower and middle Turonian age and widely distributed across the eastern half of Utah.

The **Prairie Canyon Member** of the Mancos Shale (Cole and others, 1997) is the principal gas reservoir on the crest and western flank of the Douglas Creek arch along the Utah-Colorado state line (Noe, 1993). The unit consists of claystone, siltstone, and very fine- to fine-grained sandstone interbedded on a scale of inches or less. Sandstone beds are rarely thicker than one foot. The average petrophysical properties on the crest of the arch are comparable to those of the Lewis Shale with porosity and permeability of 2-8% and less than 0.01 md, respectively. Like the Lewis Shale, the Prairie Canyon Member is very sensitive to formation damage by introduced water. The unit has become a significant gas producer only through the introduction of air drilling techniques (Kellogg, 1977). Due to the extensive network of fractures and faults on the crest and tested flanks of the Douglas Creek arch and the general gas-saturated nature of the siltstone-sandstone reservoir, the nearly 40 separate gas fields through time have converged into essentially a single field.

Historic per well gas recovery from the Prairie Canyon reservoir has ranged from 1.5 Bcf in naturally fractured areas on the crest of the Douglas Creek arch to 0.25 Bcf on the apparently less-fractured flanks (Noe, 1993). After initial production is stabilized, 6%

annual decline rates are usual, similar to those of the Lewis Shale (Dube and others, 2000). The natural gas produced has a high heating value of 1,100-1,200 BTU/ft^3, but oil production is both rare and very minor (Noe, 1993).

The Prairie Canyon Member was deposited more than 30 miles seaward of coeval Star Point-Blackhawk highstand shorelines (Fig. 6). The silt and fine-grained sand successions were laid down either below the storm-wave base (Cole and others, 1997) or as low-stand shoreline deposits resulting from a forced regression on a shallow ramp basin margin (Hampsen and others, 1999).

The Prairie Canyon Member is about 1,000 ft thick at the type locality near the Utah-Colorado state line, but it thins westward towards Green River and presumably also eastward. Cole and Young (1991) recognize five distinct lithofacies within the Prairie Canyon Member: silty claystone, sandstone-claystone, sandy siltstone, bioturbated muddy sandstone, and sandy dolomite. Chan and others (1991) and Hampson and others (1999) describe a sixth lithofacies, *channelized sandstone and shale*.

The Prairie Canyon Member is organized into several coarsening-upward sequences, some capped by sandy dolomite lithofacies. These mark distinct transgressive-regressive cycles, some perhaps ending in brief subaerial exposure before the next flood event. In contrast to the high-energy, wave-dominated, sand-rich shorelines of the Emery Sandstone-Star Point-Blackhawk highstand system tracts, the correlative Prairie Canyon forced-regressive, lowstand and transgressive shorefaces are sand-poor and weakly wave-storm influenced.

Organic matter is present in the sandstone-siltstone facies of the Prairie Canyon Member as dark microlaminae or as descrete plant fragments (Gautier, 1983). Organic richness has not been reported for the shales or shaly siltstone-sandstone lithofacies, but it can be presumed to be similar to those of the underlying Blue Gate Shale Member, in the range 1.0-2.0% TOC. The presence of plant debris suggests that the kerogen is Type II-III. The vitrinite reflectance in the upper Mancos Shale across the crest of the Douglas Creek arch is reported as 0.6-0.7% Ro (Gautier, 1983; Kirschbaum, 2003).

The Prairie Canyon Member is ideally suited as a shale gas reservoir similar to the Lewis Shale in the San Juan Basin. It is a succession of thinly intercalated kerogen-rich shale and siltstone-sandstone up to 1,000 ft or more thick. Being quartz-rich and heterogeneous, it should fracture easily, both naturally and hydraulically induced.

In the Castle Valley and south of the Book Cliffs up to 2,000 ft of dark shales, the **Lower Blue Gate Shale Member**, separate the Ferron and Emery Sandstone Members of the Mancos Shale (Witkind, 1988; Weiss and others, 1990). The poorly exposed succession is uniform dark gray, thin- to medium-bedded shale and shaly siltstone with a few thin beds of fine-grained sandstone and rare bentonites. Along the Utah-Colorado state line, the Lower Blue Gate Shale Member is about 1,900 ft thick (Cole and others, 1997).

The River Gas of Utah #1 well (36-14S-9E) is located in the Drunkards Wash CBM field near the northern end of Castle Valley. The well is spudded into the upper part of the Lower Blue Gate Shale Member, 50-100 ft below ledges supported by the Garley Canyon Beds of the Emery Sandstone Member, which directly overlies the Lower Blue Gate Shale Member (Weiss and others, 1990). The well penetrates 1,621 ft of dark gray shales overlying coal-bearing Ferron Sandstone. The well was continuously cored from 212 ft to 1,889 ft; the TD is at 1,931 ft depth. The core through the Blue Gate Shale Member reveal a very uniform succession of dark gray (N3) to very dark gray (N2) dense and nonfissile calcareous claystone with scattered light to medium gray laminae of siltstone. Fragments of heavy shelled bivalves are common. Some intervals are mottled and exhibit birdseye structures, but on the whole these shales are largely unstructured and lack obvious burrowing. A single 0.5 ft thick very fine-grained sandstone bed is penetrated at 799 ft depth. Also, there is a scattering of shaly bentonite beds each less than 1.0 ft thick. A scattering of subvertical fractures is observed throughout the core, but in general the shales are unfractured.

The organic richness and elemental chemistry of the rocks penetrated by the River Gas of Utah #1 well was investigated by Dumitrescu (2002). A plot of TOC with depth indicates that, on the whole, the Lower Blue Gate Shale Member is organic-rich, with over 1,000 ft of the 1,409 ft cored interval having TOC greater than 1.0% and 680 ft net section having TOC greater than 1.5%. Two intervals of about 100 to 200 ft thickness have TOC values greater than 2.0 %. The kerogen in these two high-organic carbon intervals is type II to mixed type II-III based on their atomic hydrogen and oxygen compositions. The upper of the two intervals has dominantly type II kerogen.

The Lower Blue Gate Shale Member is a prospective reservoir for shale gas development in northeast Utah due to its substantial thickness of kerogen-rich shale and level of organic richness/maturity.

The **Juana Lopez Member** of the Mancos Shale is widespread across the central and southern Colorado Plateau. In the eastern San Juan Basin, the type locality (Dane and others, 1966; Hook and Cobban, 1980), the unit is a distal, deep-basin deposit composed of interbedded dark gray claystone and thin beds of calcarenite. However, in central Utah the Juana Lopez Member is represented by a more proximal, terrigeneous facies deposited closer to the western margin of the Western Interior Seaway.

The variety and abundance of fossils in the Juana Lopez Member dates the unit as upper Turonian, which makes it coeval with the upper half of the Ferron Sandstone. Yet, nowhere on the north plunge of the San Rafael Swell do rocks of the Juana Lopez Member interfinger with the delta front or shoreface strata of the Ferron Sandstone (Molenaar and Cobban, 1991). The Juana Lopez Member appears to be a 'detached' siltstone-sandstone body enclosed within the Mancos Shale. The unit underlies the southeast Uinta Basin, the Douglas Creek arch, and at least portions of the Piceance Basin. Along the Grand Valley south of the eastern Book Cliffs, Gualtieri (1988) maps an 80-foot thick ledge-forming unit within the lower Mancos Shale characterized by interbedded very fine- to fine-grained sandstone and silty shale, but he incorrectly identifies the unit as the Ferron Sandstone. In the older well logs examined for this project, this unit also has been identified as Frontier.

The Juana Lopez Member, where it is exposed south of the Book Cliffs, is 80-100 ft thick (Molenaar and Cobban, 1991). The unit consists of thinly interbedded dark gray claystone, coarse siltstone and very fine- to fine-grained sandstone, with a few thin beds of bentonite. The lower 10-20 ft interval is dominated by dark gray to black fissile shale, possibly deposited during the transgression at the middle-to-upper Turonian boundary. The thicker upper interval is principally thinly interbedded dark gray noncalcareous claystone and coarse siltstone to fine-grained sandstone in beds less than a few inches thick. The siltstone-sandstone beds have sharp bases against the underlying claystone, and they exhibit current- and wave-ripple bedding. In general, grain-size decreases towards the east. Calcarenite beds are relatively rare, but they increase in abundance eastward.

The **Tropic Shale** of the Kaiparowits Plateau region (Fig. 5) of southern Utah (Lawrence, 1965) is correlative with the **Tununk Shale** of east-central and northeast Utah (Molenaar and Cobban, 1991). The Tropic-Tununk Shales are composed primarily of dark gray calcareous claystone and mudstone with numerous bentonite beds that can serve as regional markers. Except in east-central and northeast Utah, where a regional hiatus is present, both shales are of latest Cenomanian to upper middle Turonian age, form the base of the Mancos Shale, and rest conformably on the Dakota Sandstone of Cenomanian age.

In east-central Utah (Castle Valley and Book Cliffs areas) the Tununk Shale is about 300-650 ft of dark gray calcareous claystone with bentonite beds passing upward into interbedded dark gray silty mudstone and bioturbated siltstone (Molenaar and Cobban, 1991). The Tununk Shale thins eastward towards the Utah-Colorado border, possibly on to a reactivated Uncompahre uplift. The unit is reported to be 400-650 ft thick in the Castle Valley (Witkind, 1988; Weiss and others, 1990), 400 ft thick immediately east of Price, and about 300 ft thick east of the Green River (Gualtieri, 1988; Molenaar and Cobban, 1991). The base of the Tununk Shale is a regional unconformity on the Cedar Mountain Formation.

In the vicinity of the Uinta Mountains, the base of the Tununk Shale is of lower or middle Turonian age (Molenaar and Cobban, 1991). The Tununk Shale passes upward into upper shoreface or delta front sandstones (Ryer and McPhillips, 1983) of the Ferron Sandstone of late middle Turonian age. The Ferron Sandstone is the facies and approximate age equivalent of the Straight Cliffs Formation in southern Utah (Ryer, 1984).

With a single notable exception, detailed core-based stratigraphic descriptions and quality geochemical analyses of the Tropic-Tununk Shale are absent in the public domain. The 901 ft Escalante #1 well (36-35S-2E, Garfield County) was drilled and cored in June 1992 by the U.S. Geological Survey as a stratigraphic well under the auspices of the U.S. Continental Scientific Drilling Program (Dean and Arthur, 1998). The core has been described by several groups and no fewer than three independent geochemical studies of the core material exist. At present, this core is the best window available into the character of this lowest portion of the Mancos Shale in Utah.

In describing the lithology of the Tropic Shale in the Escalante #1 core, Leithold and Dean (1998) distinguish a calcareous, organic-lean lower unit from a less calcareous, organic-rich upper unit. The upper unit (341-459 ft depth) is thinly interlaminated siltstone and silty claystone grading upward into silt-free claystone. This unit is dominated by 1-2 cm thick, graded, ripple-cross-laminated siltstone beds with sharp bases against scoured dary gray claystone. The lower unit (459-689 ft) is dominantly finely laminated marlstone and calcareous claystone with scattered fecal pellets, foraminiferal tests and fine shell debris. Laminae commonly are concentrations of fecal pellets, and they may be disrupted by burrows.

The organic richness of the Tropic Shale in the Escalante #1 well is variable ranging up to 3.86% and averaging 1.40±0.52% (White, 1999). Bojesen-Koefoed and Nytoft (2003) cite a slightly higher average of 1.56% and a range of 0.89% to 2.64%. The values are lowest in the lower carbonate-rich portion of the section, but then increase upward as the carbonate-content diminishes in the upper section. The profile of hydrogen index (HI) with depth mirrors the TOC profile with the highest values of 200-250 occurring near the top of the Tropic Shale. The general low values of HI, however, are indicative of a type II and mixed type II-III kerogen. In the upper 75 feet of the Tununk Shale penetrated by the River Gas of Utah #1 well in Carbon County, Dumitrescu (2002) reports three TOC values in the range 1.62-1.71%. Here the rock is a dark gray calcareous mudstone with silt to very fine sand laminae and interbeds, and silt-filled burrows.

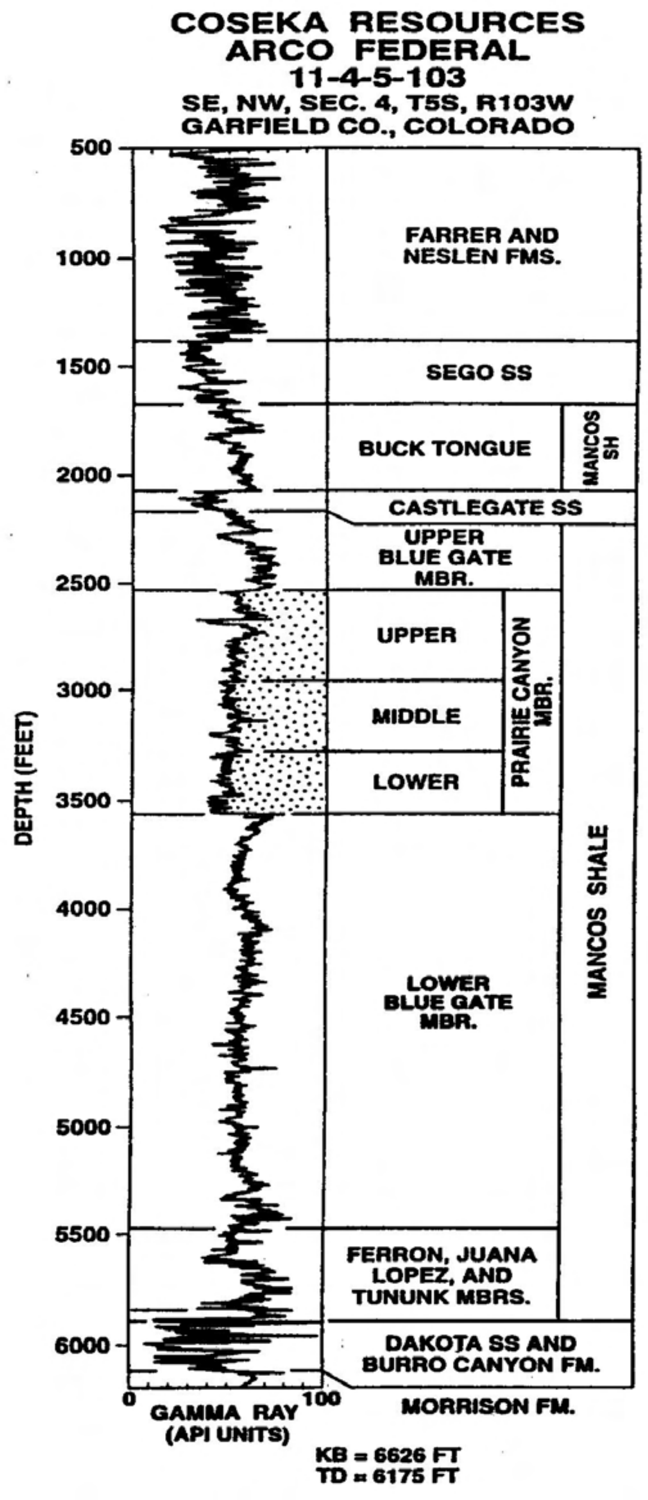

Figure 4: Stratigraphy of the Mancos Shale over the Douglas Creek arch (from Cole and others, 1997).

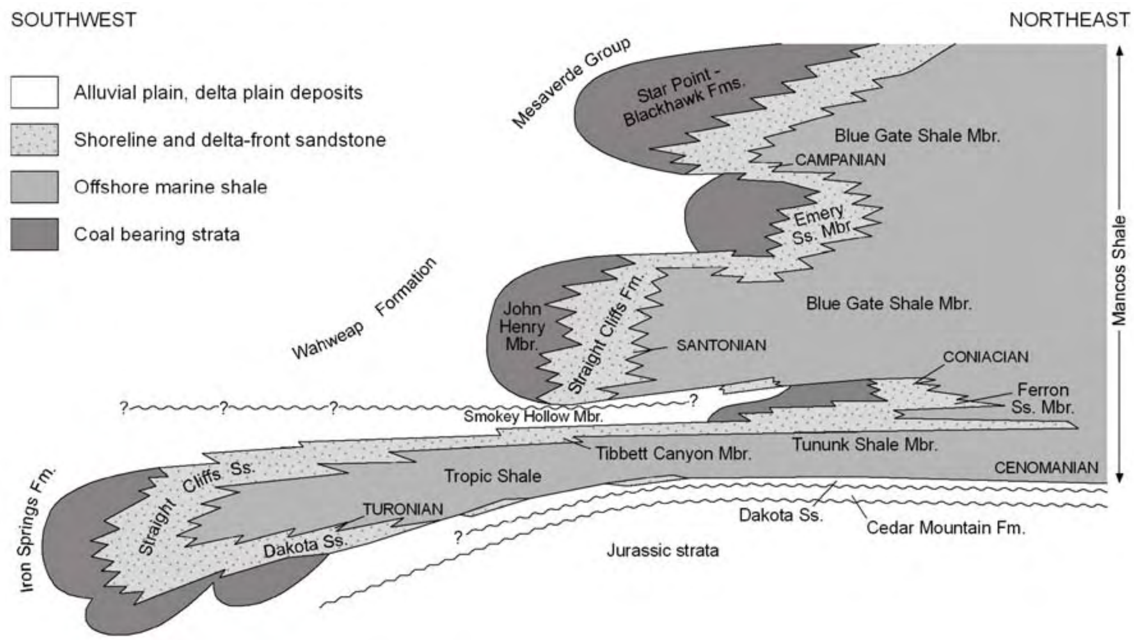

Figure 5: Generalized stratigraphy of the Cretaceous foreland basin in southern and east-central Utah (modified from Ryer, 1984).

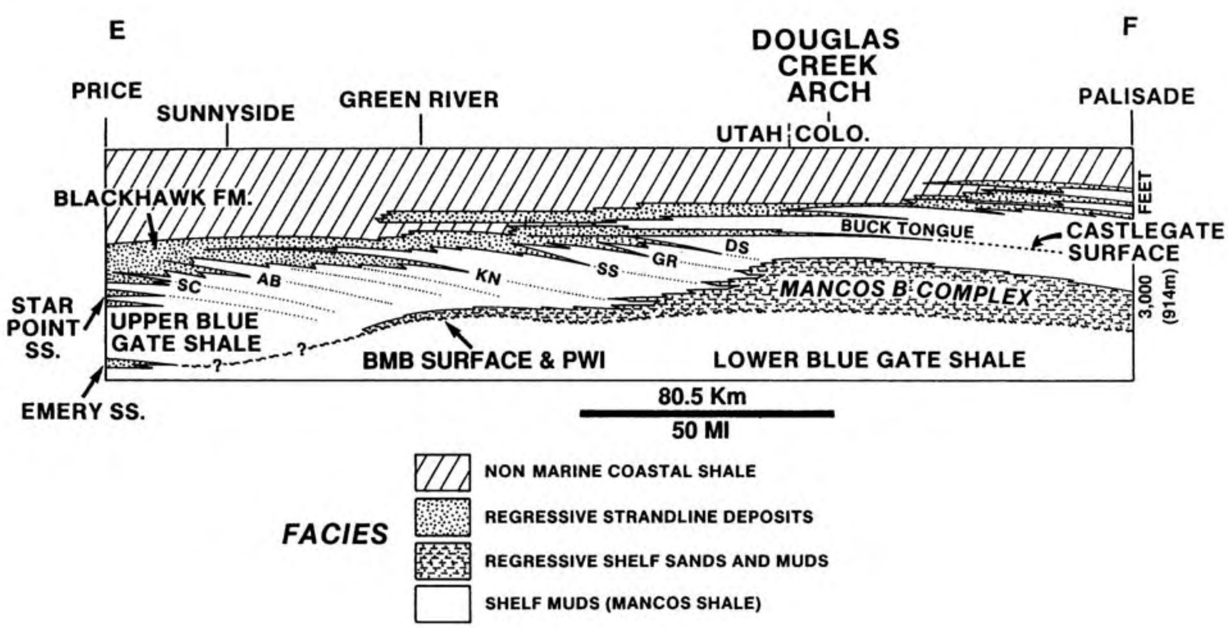

Figure 6: Generalized regional stratigraphic cross section from Price, Utah to Palisade, Colorado showing the relationship between the prograding Star Point-Blackhawk highstand shoreline stages and the 'detached' siltstone-sandstone deposits of the Prairie Canyon (Mancos B) Member (Cole and Young, 1991).

Setting for natural gas in the Mancos Shale

Across most of Utah the Mancos Shale has not been sufficiently buried to have attained the levels of organic maturity required for substantial generation of natural gas, even in the humic kerogen-dominant (type II-III) shales that characterize this group. Refer to Schamel (2005) for a full discussion of the conditions leading to natural gas generation and retention in shales. However, vitrinite reflectance values beneath the central and southern Uinta Basin (Fig. 7) are well within the gas generative window at the level of the Tununk Shale, and even the higher members of the Mancos Shale. In addition to the in situ gas within the shales, it is likely that some of the gas reservoired in the silty shale intervals has migrated from deeper source units, such as the Tununk Shale or coals in the Dakota.

Organic maturity of the Blue Gate Shale Member in the Castle Valley can be estimated by the coal rank and/or vitrinite reflectance observed in the underlying Ferron Sandstone and overlying Star Point-Blackhawk Formation. The rank of Ferron coals in the northern Castle Valley is high-volitile B bituminous (0.6-0.7% Ro); these coals are currently generating thermogenic gas (Montgomery and others, 2001). The vitrinite reflectance observed in the Blackhawk Formation, at the base of the Mesaverde Group, in the Book Cliffs is 0.65% and these coals also are generating small quantities of thermogenic gas. It can be expected that beneath the southern Uinta Basin and possibly also beneath parts of the Wasatch Plateau the Lower Blue Gate Shale Member has a residual gas content.

The Tropic-Tununk Shales at the base of the Mancos Shale appear to have relatively low thermal maturities throughout southern and east-central Utah. In the Escalante #1 core, Tmax values average 424.2 ±3.7°C, increasing slightly with depth in the well (Bojesen-Koefoed and Nytoft, 2003). These values are approximately equivalent to a vitrinite reflectance (Ro) of 0.5-0.6% and in line with the maturity of coal in the region. The rank of Straight Cliffs coal in the Carcass Canyon coal area (Doelling, 1968) on the Kaiparowits Plateau about 10 miles southeast of the Escalante #1 well is high volatile C bituminous, equivalent to 0.6% Ro. To the north in the Emery coalfield (Emery County) the coals in the Ferron Sandstone also are high volatile C bituminous rank (Gloyn and others, 2003), but farther north in the Drunkards Wash CBM field (Carbon County) the rank of the Ferron coals (Montgomery and others, 2001) is high volatile B bituminous (0.7-0.8% Ro). Across southern Utah the Tropic Shale may be generating little natural gas, but in east-central Utah the Tununk Shale is likely a significant gas generator. This is especially true beneath the Wasatch Plateau and Uinta Basin.

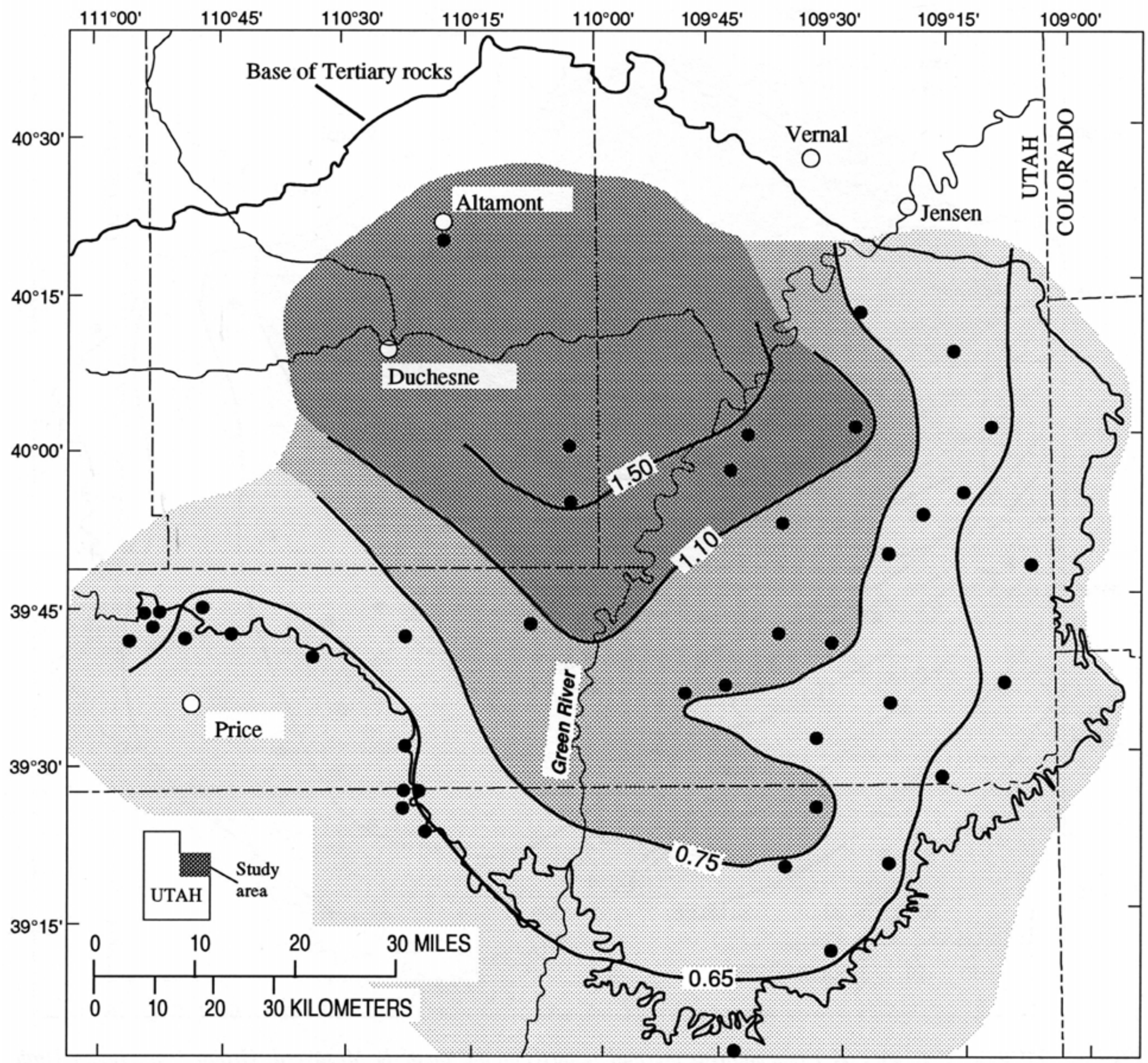

Figure 7: Thermal maturities at the base of the Mesaverde Group or top of the Mancos Shale beneath the Uinta Basin (Nuccio and others, 1992).

Well completions, tests and production

Only a small number of wells in Utah appear to have specifically targeted the Mancos Shale. These are primarily Coseka Resources (USA) Ltd wells drilled in the 1980s to the Prairie Canyon Member (Mancos B) on the west flank of the Douglas Creek arch. By this time, Mancos B gas and minor oil production was well established across the arch (Kellogg, 1977), so these wells merely extended the play into eastern Utah. This group of wells includes Pine Springs 13-26-14-22, Crooked Cyn 10-10-14-23, Trapp Springs 8-13-14-23, and Trapp Springs 8-36-14-23 (see Table 1 for API numbers and locations).

Table 1: Wells completed in the Mancos Shale for gas testing and/or production.

API well number	*Well name*	*Sec*	*T*	*R*	*Unit*
43-047-34280	WV 14M-11-8-21	11	08S	21E	MB
43-047-35248	GB 14M-28-8-21	28	08S	21E	MB
43-047-34719	OU SG 10W-15-8-22	15	08S	22E	M
43-047-34019	PAWWINNEE 3-181	3	09S	21E	MB
43-047-33924	WEEKS 6-154	8	09S	21E	MB
43-047-34581	CWU 819-15	15	09S	22E	MB
43-047-34510	CHAPITA WELLS UNIT 810-23	23	09S	22E	MB
43-047-15643	ISLAND UNIT 3	8	10S	20E	MB
43-047-34941	BONANZA FED 15-27-10-25	27	10S	25E	MB
43-047-32693	TEXAS CREEK 14-22	22	11S	25E	M
43-007-10753	KEEL RANCH UNIT 1-16	16	12S	13E	M
43-047-32660	SEEP CANYON ST 19-12-25 1	19	12S	25E	MB
43-047-32605	EVACUATION CREEK 24-12-25 1	24	12S	25E	MB
43-047-31510	AGENCY DRAW 16-3	3	13S	20E	MB
43-047-30323	SEEP RIDGE U 8	14	13S	22E	M
43-047-30386	CROOKED CYN U 2	34	13S	23E	M
43-047-32618	DAVIS CANYON 12-13-25 1	12	13S	25E	MB
43-047-32659	ATCHEE RIDGE 15-13-25 1	15	13S	25E	MB
43-047-34675	PINE SPRINGS FED 3-23-14S-22E	23	14S	22E	MB
43-047-31074	PINE SPRINGS 13-26-14-22	26	14S	22E	MB
43-047-30708	CROOKED CYN 10-10-14-23	10	14S	23E	MB
43-047-31055	TRAPP SPRINGS 6-13-14-23	13	14S	23E	MB
43-047-30975	TRAPP SPRINGS 1-25-14-23	25	14S	23E	MB
43-047-30944	TRAPP SPRINGS 8-36-14-23	36	14S	23E	MB
43-047-35140	NHC 1-6-15-20	5	15S	20E	M
43-047-35390	NHC 9-11-15-20	11	15S	20E	M
43-047-35054	NHC 4-13-15-20	13	15S	20E	M
43-047-34954	NHC 8-13-15-20	13	15S	20E	M
43-047-30746	PINE SPRINGS ST 11-2-15-22	2	15S	22E	MB
43-047-31135	MAIN CYN 8-2-15-22	2	15S	22E	MB
43-047-31091	WOLF POINT FED 2-18-15S-22E	18	15S	22E	MB
43-047-30735	MAIN CYN 2-8-15-23	8	15S	23E	MB
43-047-30736	MAIN CYN 7-17-15-23	17	15S	23E	MB
43-019-30169	ANSCHULTZ STATE 428-1	5	16S	22E	M
43-019-30179	FEDERAL 33-11	11	16S	24E	M

All other Mancos Shale penetrations are wells targeting sandstone reservoir objectives below, or above, the 3,000 to 3,500 ft thick Mancos succession. These fall into the following five groups, listed in approximate order of the number of such penetrations.

- Wells targeting the coal-bearing fluvial-deltaic Ferron Sandstone in the Castle Valley and east Wasatch Plateau (Carbon and Emery Counties). These wells penetrate the Blue Gate Shale Member, and a few continue through the Ferron Sandstone and CBM reservoirs into the underlying Tununk Shale Member. The earliest of the wells date to the 1950s, but the vast majority were spudded in the 1990s to present.

- Wells targeting the Lower Cretaceous-uppermost Jurassic Dakota, Cedar Mountain, and/or Morrison Sandstone reservoirs. A small number of these wells were extended slightly deeper into the Entrada Sandstone. In Utah this group of wells, drilled mainly in the 1970s and 1980s, lie along the west flank of the Douglas Creek arch, the southwest part of the West Tavaputs Plateau, and the Grand Valley (Fig. 8).

- Wells targeting the lower Mesaverde Group (Castlegate or Blackhawk) that were extended downward a few hundreds of feet to establish the base of the sandstone reservoir objectives. Wells of this group are mainly in the greater Natural Buttes gas field and date from the 1960s to the present, but the large majority are younger than 5 years. Nearly all of these wells were immediately plugged back to the lowest producing sandstone interval. However, as discussed below, a few have been completed in the upper Mancos Shale, possibly the Prairie Canyon Member, as well as higher sandstone reservoirs.

- Wells centered in the Flat Rock field area (west-central West Tavaputs Plateau; 15S-20E) that targeted the Jurassic Wingate and Entrada Sandstone gas reservoirs, as well as the Dakota and Mesaverde immediately below and above the Mancos Shale, respectively. As discussed below, many of these wells are completed in and are currently producing add-on gas from the Mancos Shale. Most of the wells of this group were drilled in just the past few years.

- Rank wildcats drilled in the 1950s to 1970s that for the most part were very deep and targeted common Rocky Mountain Paleozoic carbonate and sandstone objectives, such as the Madison and Weber. A few of these wildcats ran DSTs in the Mancos Shale after encountering gas shows, but most of the wells for which adequate records exist in DOGM were abandoned soon after testing.

A total of 35 wells have been identified as having been completed in the Mancos Shale Table 1), in most instances in what was identified as the Mancos B. Of these, 12 wells are in the greater Natural Buttes field, 18 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 (API 4300710753, Keel Ranch Unit 1-16).

Production tests in the Mancos Shale are available for just 22 wells (Table 2; Appendix B). The location of these wells is shown in Table 1. 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 Shale Member and two apparently were completed in the Juana Lopez Member near the base of the Mancos Shale interval.

Two of the highest producers, Pawwinnee 3-181 (API 4304734019; 3-9S-21E) and Weeks 6-154 (API 4304734019; 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, Anschutz State 428-1 (API 4301930169; 5-16S-22E) is on the West Tavaputs Plateau above the Garmisa fault (Stone, 1977) and on trend with the Flat Rock field. All of these wells are completed in and producing from the conventional sandstone reservoirs as well.

Table 2: Gas rates reported for intervals within the Mancos Shale arranged from highest to lowest. For the full set of information for the tests see Appendix B. Unit codes: M = generic Mancos Shale, PC = Prairie Canyon Member, BG = Blue Gate Shale Member, JL = Juana Lopez Member.

API well number	*Well name*	*Unit*	*Mancos top*	*Mancos base*	*Top interv*	*Base interv*	*Gas mcfpd*
43-047-34019	Pawwinnee 3-181	PC			12,049	12,144	2,079.0
43-019-30169	Anschutz State 428-1	BG	5,070	8,760	7,638	7,638	1,450.0
43-047-33924	Weeks 6-154	PC	11,770	12425 TD	12,244	12,258	1,002.0
43-047-31074	Pine Springs 13-26-14-22	PC	5,737	6515 TD	5,737	6,399	515.0
43-047-34510	Chapita Wells Unit 810-23	JL	10,493	10,912 TD	10,671	10,807	500.0
43-007-10753	Keel Ranch Unit 1-16	M	na	12,000	8,084	8,134	444.0
43-047-31091	Wolf Point Fed 2-18-15S-22E	PC	6,240	7169 TD	6,255	6,495	433.0
43-047-34675	Pine Springs Fed 3-23-14S-22E	PC	5,252	6300 TD	6,004	6,106	390.0
43-047-31135	Main Cyn 8-2-15-22	PC	5,156	5,940	5,228	5,398	283.0
43-047-30944	Trapp Springs 8-36-14-23	PC	5,230	8,279	5,238	5,599	253.0
43-047-30735	Main Cyn 2-8-15-23	PC	5,358	8,396	5,536	5,637	150.0
43-047-34719	OU SG 10W 15-8-22	PC	12,396	12580 TD	12,401	12,496	116.0
43-047-30746	Pine Springs ST 11-2-15-22	PC	5,186	6010 TD	5,375	5,439	100.0
43-019-30179	Federal 33-11	JL	2,700	6,227	5,747	6,032	91.1
43-047-30708	Crooked Cyn 10-10-14-23	PC	6,188	6,880	6,237	6,380	91.0
43-047-34941	Bonanza Fed 15-27-10-25	PC	3,145	4490 TD	4,080	4,262	84.0
43-047-30736	Main Cyn 7-17-15-23	PC	5,356	8,376	5,366	5,606	80.0
43-047-31510	Agency Draw 16-3	PC	7,620	11,576	8,398	8,414	64.0
43-047-30975	Trapp Springs 1-25-14-23	PC	5,390	8,415	6,100	6,100	59.0
43-019-30179	Federal 33-11	BG	2,700	6,227	4,816	5,747	25.6
43-019-30179	Federal 33-11	PC	2,700	6,227	3,781	4,090	20.3
43-019-30179	Federal 33-11	BG	2,700	6,227	4,090	4,816	10.5
43-047-34581	CWU 819-15	PC	10,853	11,153	10,903	10,980	4.0
43-047-31055	Trap Springs 6-13-14-23	PC	6,058	6855 TD	6,125	6,551	trace

For the wells with gas rates in the range 50-1,000 Mcfgpd, 13 are located on the West Tavaputs Plateau and 5 are in the Natural Buttes field. The Crooked Cyn 10-10-14-23 well (API 4304730708; 10-14S-23E) with a gas rate of 91 Mcfgpd was cored and provides insight into the character of the Prairie Canyon reservoir interval (Fig. 9). A full discussion of this core can be found in Schamel (2005).

The Keel Ranch Unit 1-16 well (API 4300710753; 16-12S-13E) in the Nine Mile Canyon area, Carbon County, was first drilled in 1963. A set of DSTs indicated modest gas production from the Mancos Shale, as well as the Star Point (probably Blackhawk) Sandstone. The well was recompleted for deep Ferron and Dakota objectives in 1981 and flowed on a 7 hour test 444 Mcfgpd from the Mancos Shale at 8,084-8,134 ft depth.

Gas production from the Flat Rock field (15S-20E) is not separated by producing reservoir. The average commingled gas rate for the group of wells completed in the Mancos Shale, as well as lower and higher sandstone reservoirs, is 4,588 Mcfgpd. A production log has been run on two wells measuring 570 Mcfgpd at 1,840 psi for the Mancos Shale or 13% of the total production rate in one well, and 97 Mcfgpd or 8% of the total production rate in the other (M. Eckles, pers. com.). The Mancos Shale has been completed over only thin intervals of elevated mud gas shows just a few hundred feet above the Dakota Silt. The narrow targeted placement of the completions may relate to the concentration of fracturing in the lower Mancos Shale related to the Garmisa fault that underlies the Flat Rock field (Stone, 1977; Eckels and others, 2005).

In addition to the wells mentioned above, there are 8 other wells (Table 3), all on the west flank of the Douglas Creek arch, in which the "Mancos B" and/or other members of the Mancos Shale are identified in the well completion report as a "porous zone". The well reports, which in all cases are sketchy, provide no additional information to support this assertion.

Table 3: Wells for which the well completion report indicates the Mancos Shale as a "porous zone", but no other information to support this assertion. PC is the Prairie Canyon Member and M indicates several members within the Mancos Shale.

API well number	Well name	Sec	T	R	Unit
43-047-30445	DRY BURN UNIT 2	35	13S	25E	PC
43-047-30978	TRAPP SP 13-25-14-23	25	14S	23E	PC
43-047-31003	TRAPP SPRINGS 3-26-14-23	26	14S	23E	PC
43-047-30791	TRAPP SPRINGS 6-35-14-23	35	14S	23E	PC
43-047-31043	MAIN CYN 4-4-15-23	4	15S	23E	PC
43-047-30674	MAIN CYN 15-8-15-23	8	15S	23E	PC
43-047-30639	MAIN CYN 11-10-15-23	10	15S	23E	PC
43-047-31247	FEDERAL 7-30-15-23	30	15S	23E	M

DSTs within the Mancos Shale exist for only 8 wells (Table 4; Appendix C). Virtually all are in older wells that were exploratory in character. Those with the strongest gas indications are Island Unit 3 (API 4304715843; 8-10S-20E), Keel Ranch State 1-16, and Anschutz State 428-1. The other five wells had good gas returns, but no gas to the surface.

Table 4: Well having DSTs within portions of the Mancos Shale exclusive of the sandstone and coal-bearing Ferron Sandstone and Emery Sandstone Members.

API well	Well	Sec	T	R	Unit
43-047-33291	OURAY 34-79	34	08S	21E	M
43-047-15643	ISLAND UNIT 3	8	10S	20E	PC
43-007-30786	JENSEN DEEP 7-15-12-10	15	12S	10E	BG
43-007-10753	KEEL RANCH UNIT 1-16	16	12S	13E	M
43-007-15922	GORDON CREEK 5	25	14S	07E	M
43-047-30271	CROOKED CANYON U 1	20	14S	23E	PC
43-015-10825	FEDERAL MOUNDS 1	11	16S	11E	M
43-019-30169	ANSCHUTZ STATE 428-1	5	16S	22E	M

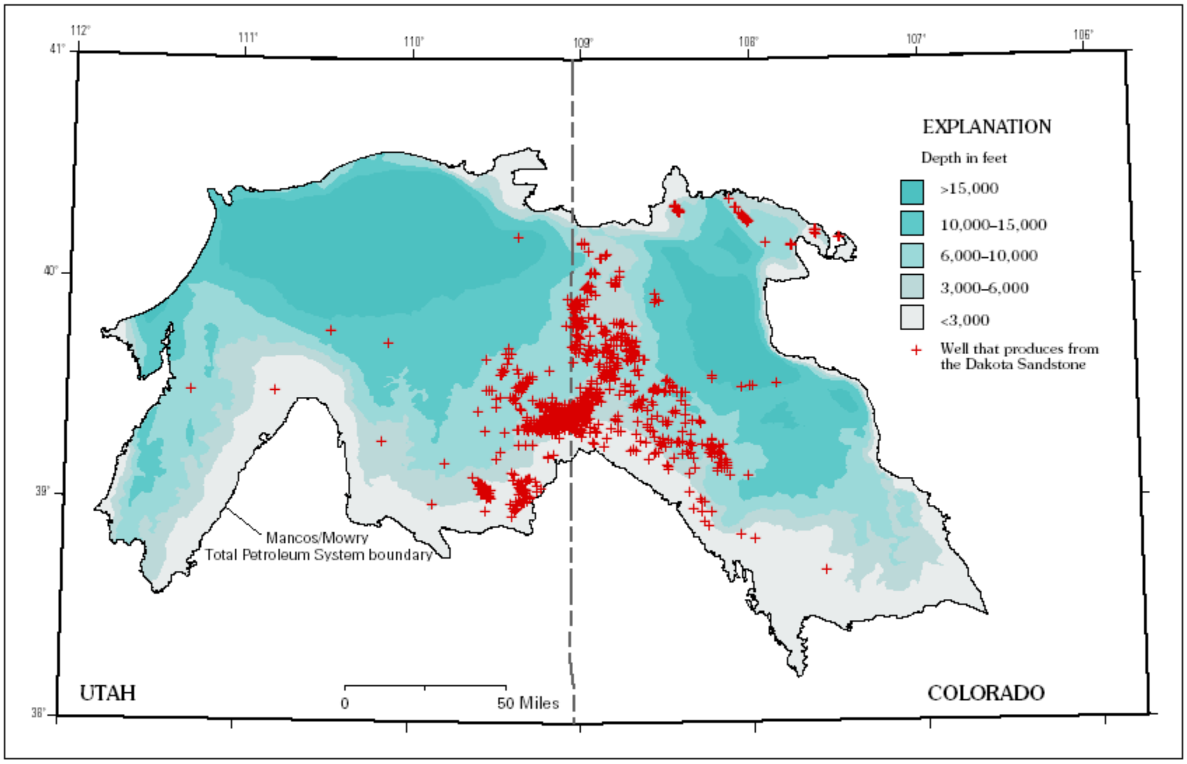

Figure 8: Map of the Uinta-Piceance Basins showing the location of wells producing gas and oil from the Dakota Sandstone (Roberts, 2003). Indicated also is the depth to the top of the Dakota Sandstone.

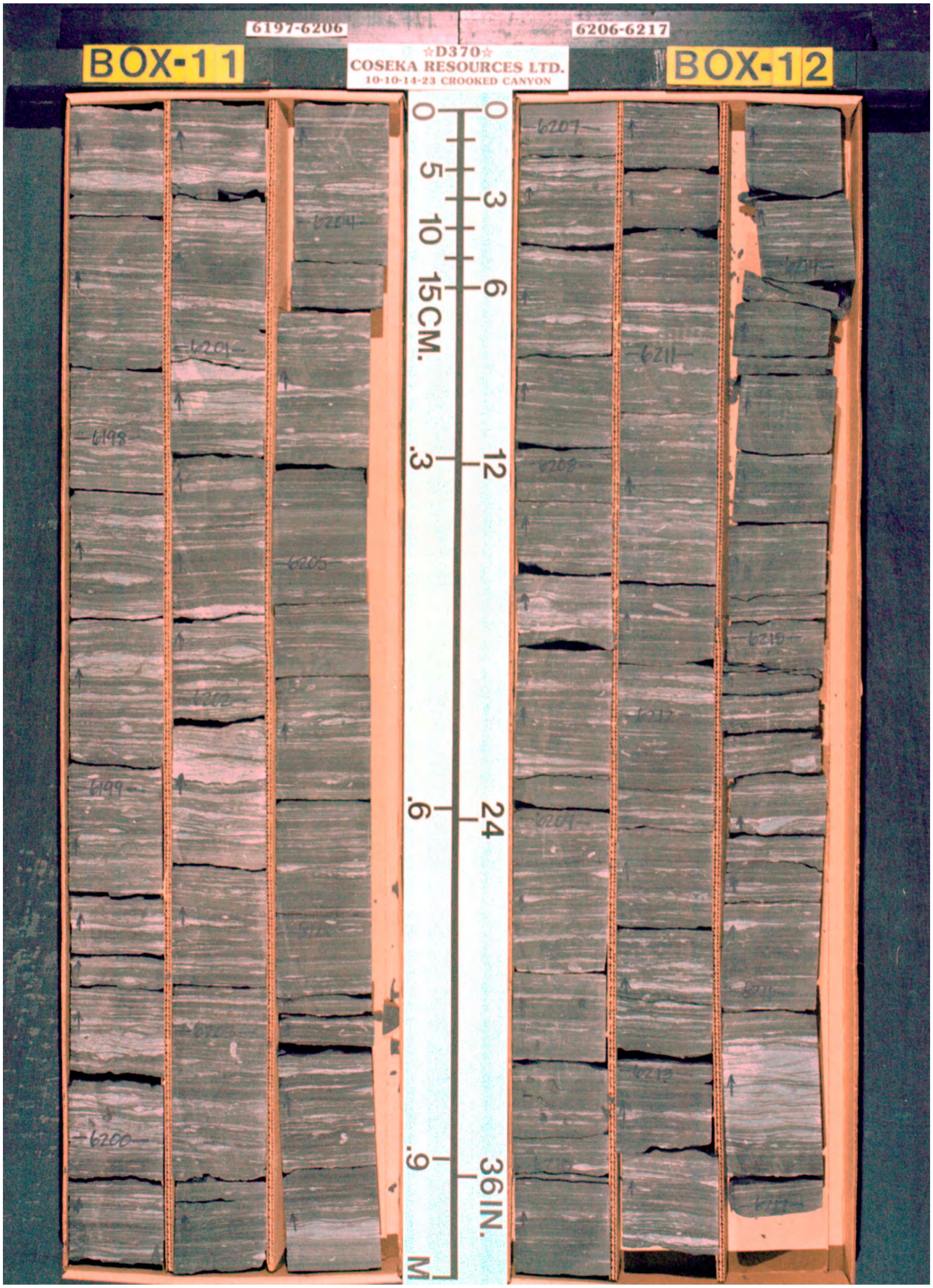

Figure 9: Photograph of Prairie Canyon Member immediately below the interval testing 91 Mcfgpd in the Crooked Cyn 10-10-14-23 well, the 6,197-6,217 ft interval. The interval actually tested, 6,237-6,380 ft, was not cored. The rock is finely interlaminated dark silty shale and siltstone. Note the absence of fractures in this interval.

Mud gas and other gas shows

A total of 39 wells have mud gas logs through at least a portion of the Mancos Shale (Table 5; Appendix D). These wells are widely distributed across the southern half of the greater Uinta Basin (Fig. 2).

Table 5: Wells having mud gas readings for the Mancos Shale interval.

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 24-12-25 1	24	12S	25E	PC
43-007-30289	OMAN 2-20	20	13S	07E	M
43-007-30314	UTAH D-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 DD 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
43-019-31063	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

Several of the wells, mainly in the Flat Rock field, have exceptionally high mud gas values in the range of thousands of gas units. These include:

- Horse Point ST 1-34 (34-15S-23E)
- N Hill Creek 4-10-15-20 (10-15S-20E; Fig. 10)
- N Hill Creek 1-9-15-20 (9-15S-20E)
- N Hill Creek 4-1-15-20 (1-15S-20E; Fig. 11)
- N Hill Creek 14-1-15-20 (11-15S-20E)
- NHC 4-13-15-20 (13-15S-20E; Figs. 12 and 13)
- N Hill Creek 2-12-15-20 (12-15S-20E; Fig. 14)
- NHC 3-6-15-20 (10-15S-20E).

Other wells have mud gas values in the hundreds of gas units, with occasional spikes in the thousands. These include:

- Rock House 11-31 (31-10S-23E; Fig. 15)
- Horse Point St 43-32 (32-15S-23E)
- Wilcox 1-24 (24-16S-15E)
- Jensen Deep 7-15-12-10 (15-12S-10E)
- Oman 2-20 (20-13S-7E)
- ST of UT 25-7-6 (25-14S-9E).

Table 6: Wells having gas flare observations within the Mancos Shale interval.

API well number	Well name	Sec	T	R	Unit
43-047-30386	CROOKED CYN U 2	34	13S	23E	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
43-047-35442	NHC 3-6-15-20X	31	14S	20E	M
43-047-34830	NHC 10-10-15-20	10	15S	20E	M
43-047-35390	NHC 9-11-15-20	11	15S	20E	M
43-047-30639	MAIN CYN 11-10-15-23	10	15S	23E	M
43-019-30169	ANSCHULTZ STATE 428-1	5	16S	22E	M
43-019-31151	LITTLE BERRY ST C 1	2	16S	23E	M
43-019-30656	NICOR FEDERAL 1	28	16S	25E	M
43-019-30572	FEDERAL C-1	35	16S	25E	M
43-019-30639	VALENTINE FED 1	35	16S	25E	M
43-019-31009	VALENTINE FEDERAL 3	35	16S	25E	M
43-019-30204	FEDERAL 614-1	3	17S	21E	M
43-019-30706	PETERSON SPRINGS UNIT 1	14	17S	21E	PC
43-019-30799	HOUGEN FED A-1 ST 1	14	17S	24E	PC
43-019-31225	FEDERAL 14-2	14	17S	24E	M
43-019-30892	WESTWATER FED B-1	17	17S	24E	M
43-019-30425	BAR CREEK UNIT 5	30	17S	26E	M
43-019-30343	FEDERAL 258	5	18S	24E	M
43-039-30004	UNITED STATES E 1	27	19S	03E	TU
43-015-30221	ORANGEVILLE FEDERAL UNIT 4-1	1	19S	07E	BG
43-041-11136	EMERY UNIT FED 1	34	22S	05E	BG

Wells reporting gas flares while drilling through the Mancos Shale are identified in Table 6. The actual log observations with drilling depths are reported in Appendix E.

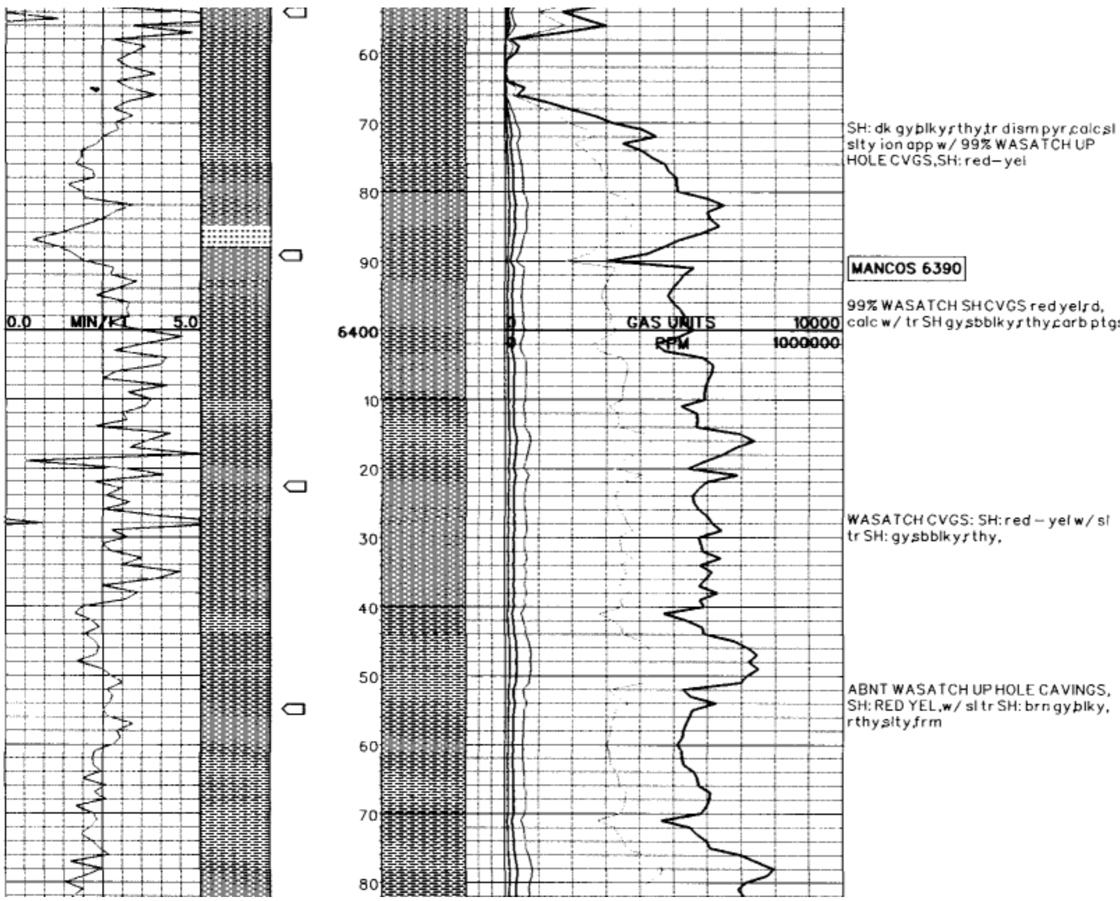

Figure 10: Segment of the mud gas log for well N Hill Creek 4-10-15-20 (API 43-047-34552) showing consistent values in the thousands of gas units.

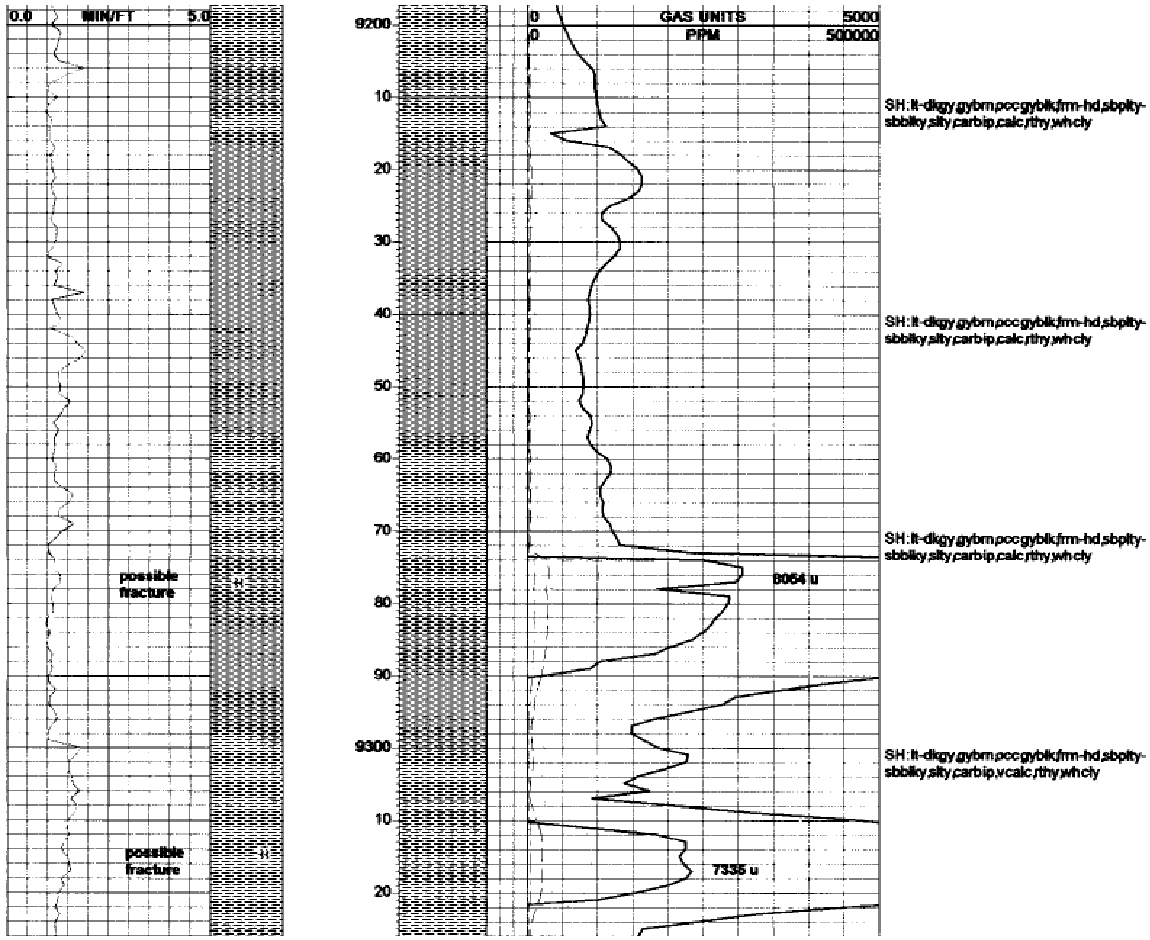

Figure 11: Segment of the mud gas log for well N Hill Creek 4-1-15-20 (API 43-047-34922) showing consistent values in the thousands of gas units.

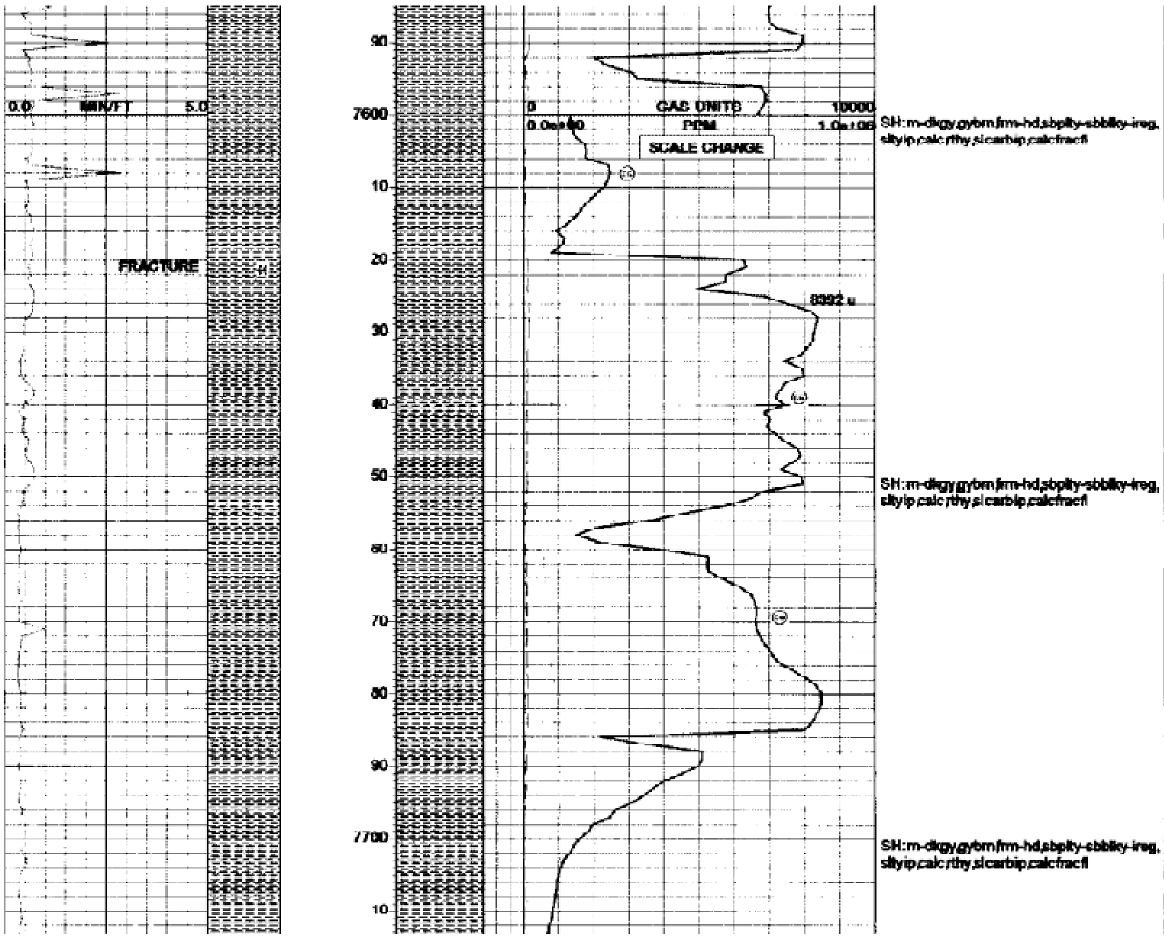

Figure 12: Segment of the mud gas log for well N Hill Creek 4-13-15-20 (API 43-047-35054) showing consistent values in the thousands of gas units.

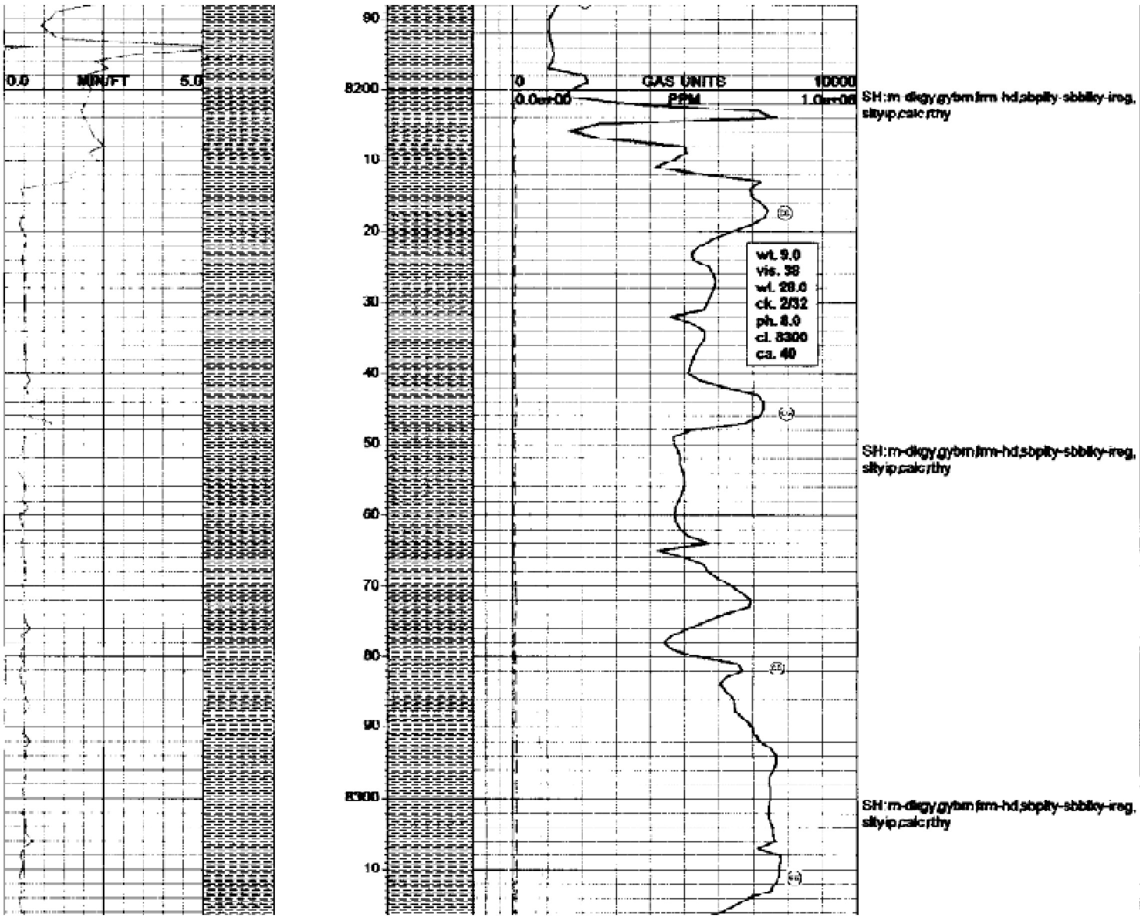

Figure 13: A deeper segment of the mud gas log for well N Hill Creek 4-13-15-20 (API 43-047-35054) showing consistent values in the thousands of gas units.

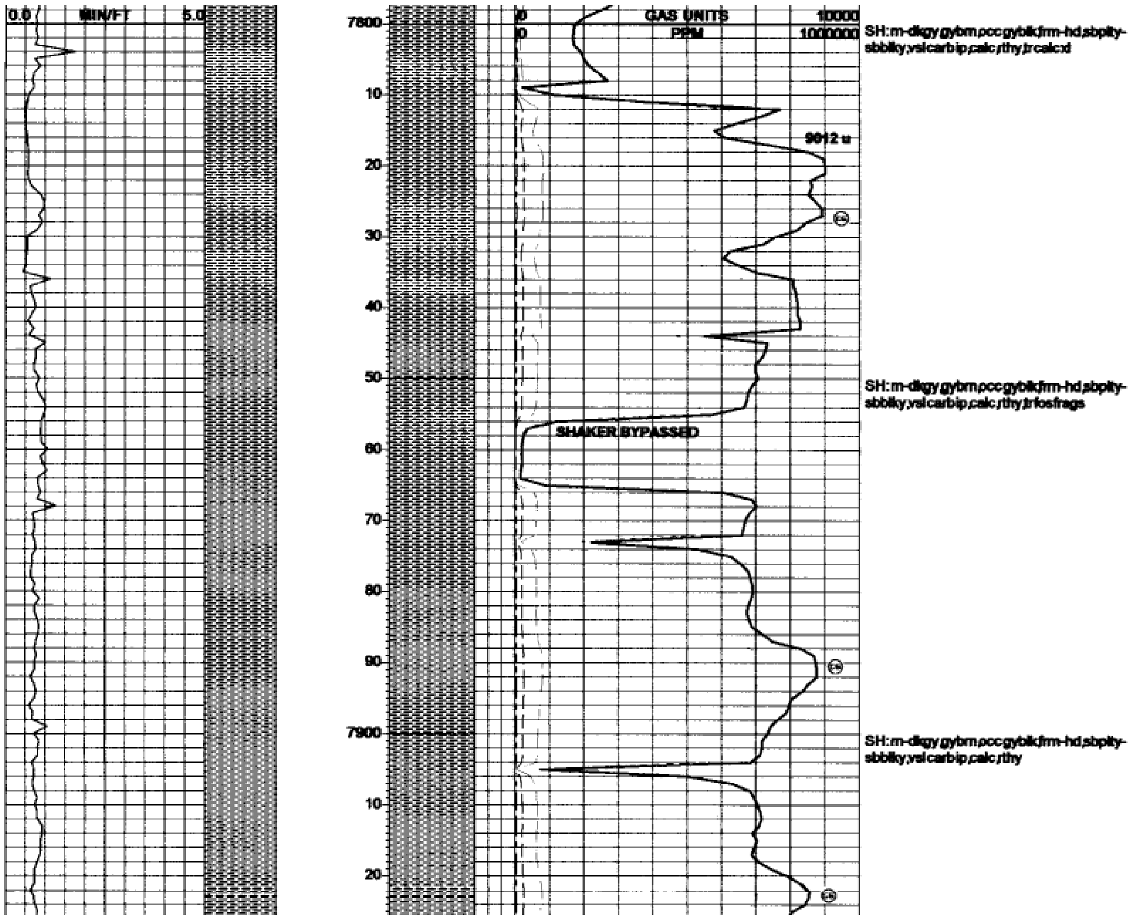

Figure 14: Segment of the mud gas log for well N Hill Creek 2-12-15-20 (API 43-047-35283) showing consistent values in the thousands of gas units.

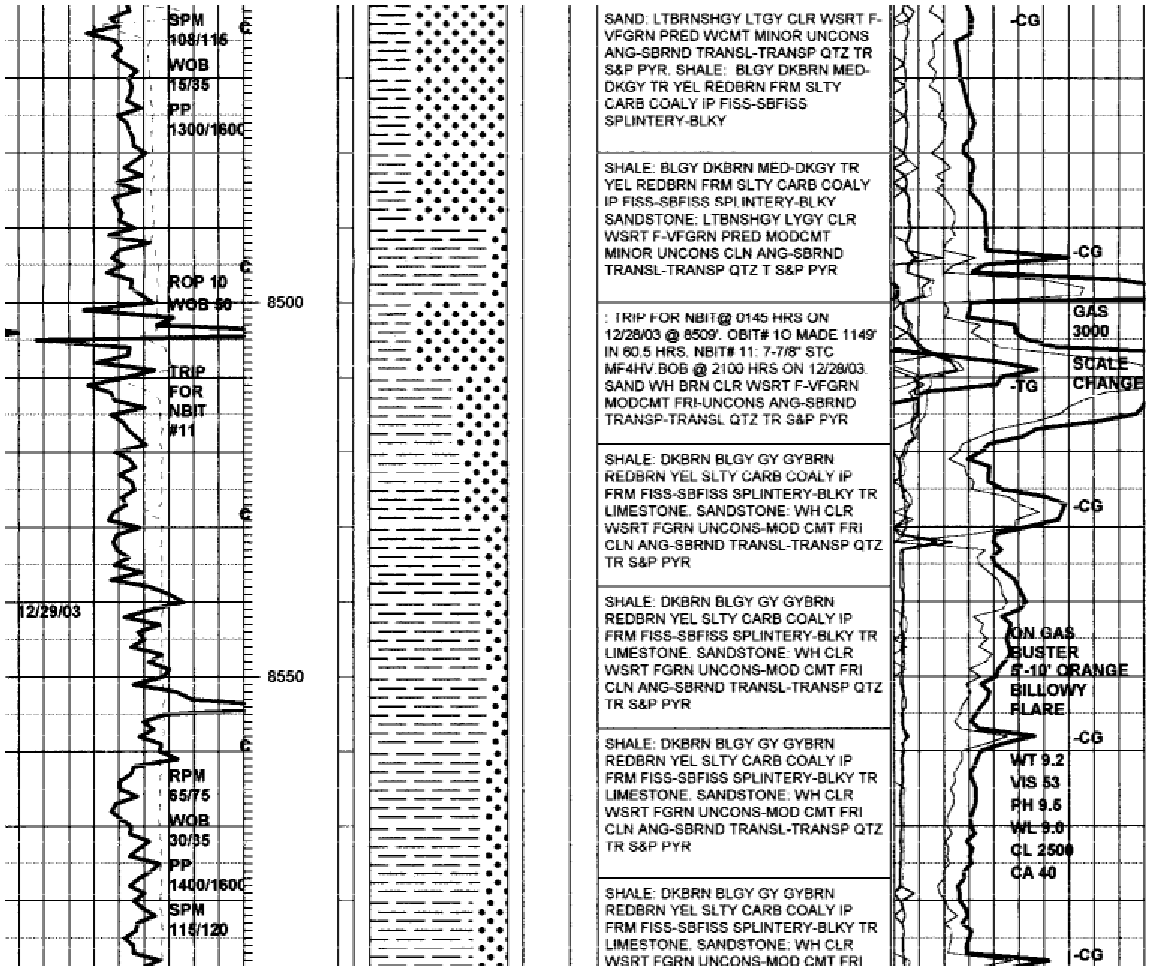

Figure 15: Segment of the mud gas log for well Rock House 11-31 (API 43-047-33312) showing consistent values in the hundreds to thousands of gas units.

Hermosa Group

The Paradox basin is a nearly elliptical depression in southeast Utah and southwest Colorado (Fig. 16) formed in the Pennsylvanian by the transpressive rise of the northwest-trending Uncompaghre uplift (Stone, 1977). During the Pennsylvanian, the basin accumulated a thick evaporate succession, including halite and potash, that soon deformed into a variety of domes and linear salt walls in the deeper northeast half of the basin, the fold and fault belt (Fig. 17).

Stratigraphy of the Hermosa Group

The Hermosa Group (Figs. 18, A) is the principal syn-orogenic sedimentary fill of the Paradox basin. This succession spans nearly the entire Pennsylvanian (Atokan through Virgilian; Welsh and Bissell, 1979). Beginning with the onset of basin subsidence, it was deposited on variegated paleosols (Molas Formation) up to 260 ft thick of Morrowan-Atokan age formed by chemical weathering at the karstified surface of underlying Mississippian shelf carbonates. The Hermosa Group was deposited as a series of trangressive-regressive evaporate cycles dominated by restricted basin carbonates (Hite and others, 1984). It is divided into three formations with the middle unit, the Paradox Formation, differentiated by the presence of halite in each cycle. The lower and upper formations are salt-free. The Pinkerton Trail Formation consists of cyclically interbedded dark gray shale, anhydrites and dolostones. It is up to 400 ft thick around the basin margins, but thins towards the basin center where halite is co-deposited in with the other evaporate lithologies. The Paradox Formation contains 29 recognized cycles in a section up to 7,000 ft thick. The cycles (Fig. 18, B) are comprised of an alternation of halite through anhydrite, dolostone and limestone to a black shale, then reversing order back to halite. In most instances, the black shales, which are on the order of several tens of feet thick, are in the centers of the cycles as designated. Individual cycles may or may not include halite and in some the black shale may be quite thin. The Honaker Trail Formation is a 1,000-1,700 ft thick shoaling upward succession of carbonates of late Desmoinesian to Virgilian age. It represents the final filling of the actively subsiding transpressional basin.

Palynomorphs from the evaporate-black shale cycles of the Paradox Formation indicate a climatic oscillation between warm-wet and cool-dry periods corresponding to glacio-eustatic sealevel rise and fall with an approximately 100,000 year periodicity (Rueger, 1996). During the interglacials, seawater flooded the Paradox basin from the southeast ending deposition of evaporites. During these warm-wet periods, mud and terrigenous plant remains were transported into the basin from the Silverton delta, which was situated to the southeast in southern Colorado (Fetzner, 1960). With the onset of the next glacial period, sealevel dropped restricting seawater flux into the basin. The corresponding cool-dry climate promoted evaporation and closed off influx from the Silverton delta.

The black shales of the Hermosa Group consist of nearly equal portions of clay-sized quartz, dolomite and other carbonate minerals, and various clay minerals. The clay is mainly illite with minor amounts of chlorite and mixed layer chlorite-smectite (Hite and others, 1984).

The Gibson Dome #1 well (21-30S-21E, San Juan County) was drilled by the U.S. Department of Energy as a stratigraphic test and cored continuously from 200 to 6,500 ft depth. This well provides valuable information on the distribution of organic richness in the black shales in the Hermosa Group (Fig. 19). The TOC is seen to increase regularly downward through the Honaker Trail Formation from less than 1% to about 2%. The two 'spikes' in this part of the profile are in coaly shales. TOC increases to just over 4% in the Ismay-Desert Creek interval (cycles 1-5). Values in excess of 6% are present in the Akah interval (cycle 6-9). In the Barker Creek interval (cycle 10-20) very high TOC values are observed in the relatively thin cycles 10 and 13. Also high values up to nearly 6% and 4% are found in the Alkali Gulch interval (cycles 21-29) and Pinkerton Trail Formation, respectively.

A compilation of TOC data for 39 wells scattered across the Paradox basin provides a more comprehensive assessment of organic richness from various stratigraphic intervals (see Appendix A). The data set is from Table 1 in Nuccio and Condon (1996a) and the DOE Gibson Dome #1 and DOE Elk Ridge #1 wells (Hite and others, 1984). The TOC values are displayed in Fig. 20 as frequency distributions. The median and maximum values for the five stratigraphic intervals are:

- Honaker Trail — 0.97% and 2.97% (excluding coaly shales)
- Ismay-Desert Creek — 1.93% and 10.98%
- Akah-Barker Creek — 4.05% and 12.86%
- Cane Creek (cycle 21) — 3.96% and 11.06%
- Pinkerton Trail — 1.22% and 3.44%.

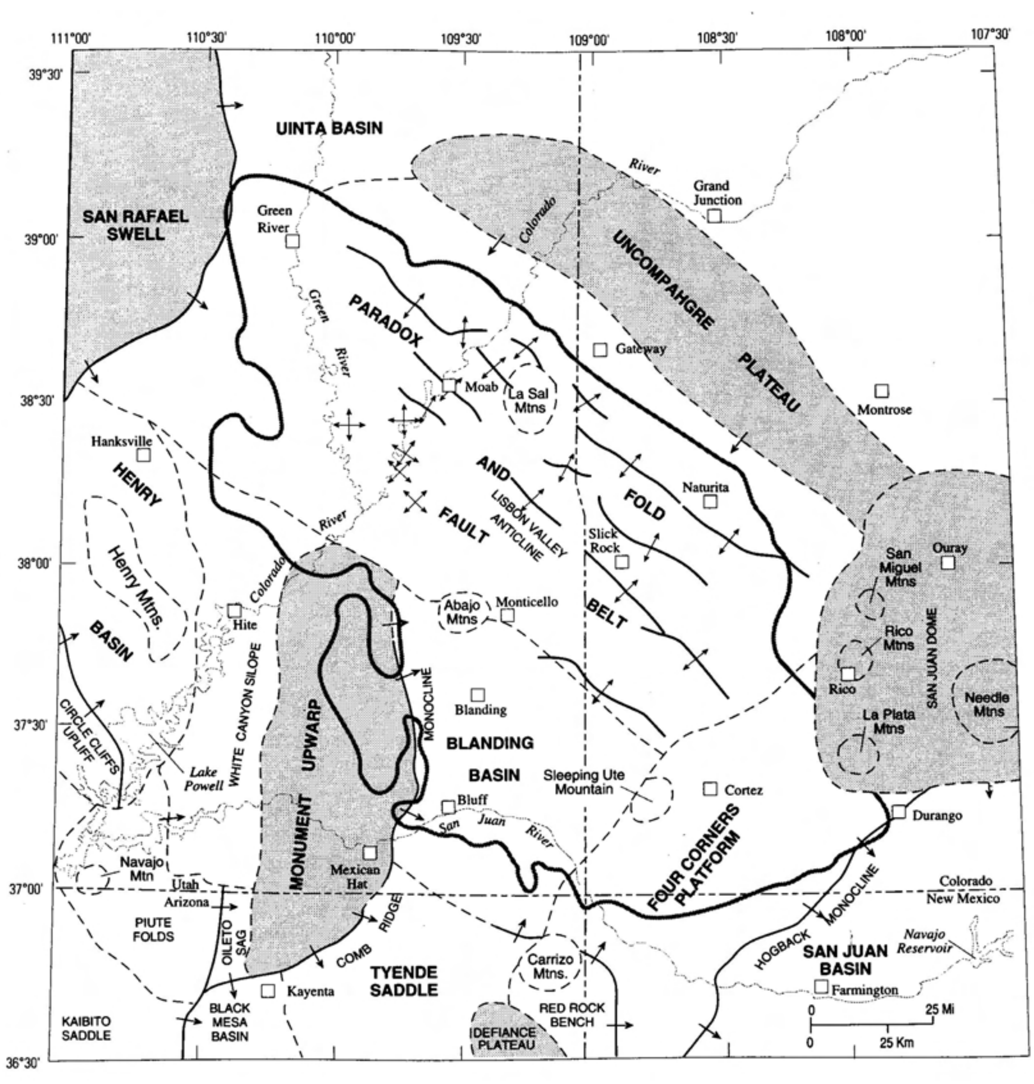

Figure 16: Structural elements of the Paradox basin and surrounding areas (Nuccio and Condon, 1996a).

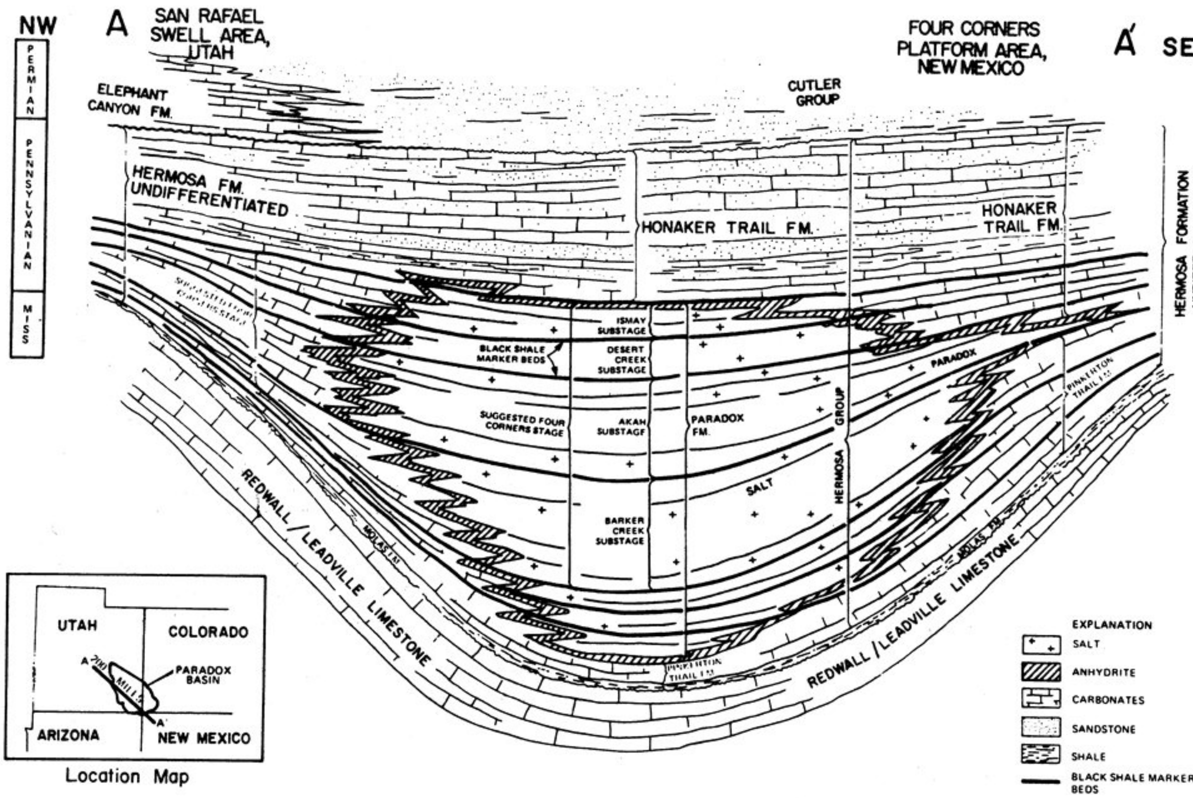

Figure 17: Generalized Pennsylvanian stratigraphy of the Paradox basin (Huntoon, 1988, redrawn after Baars and others, 1967).

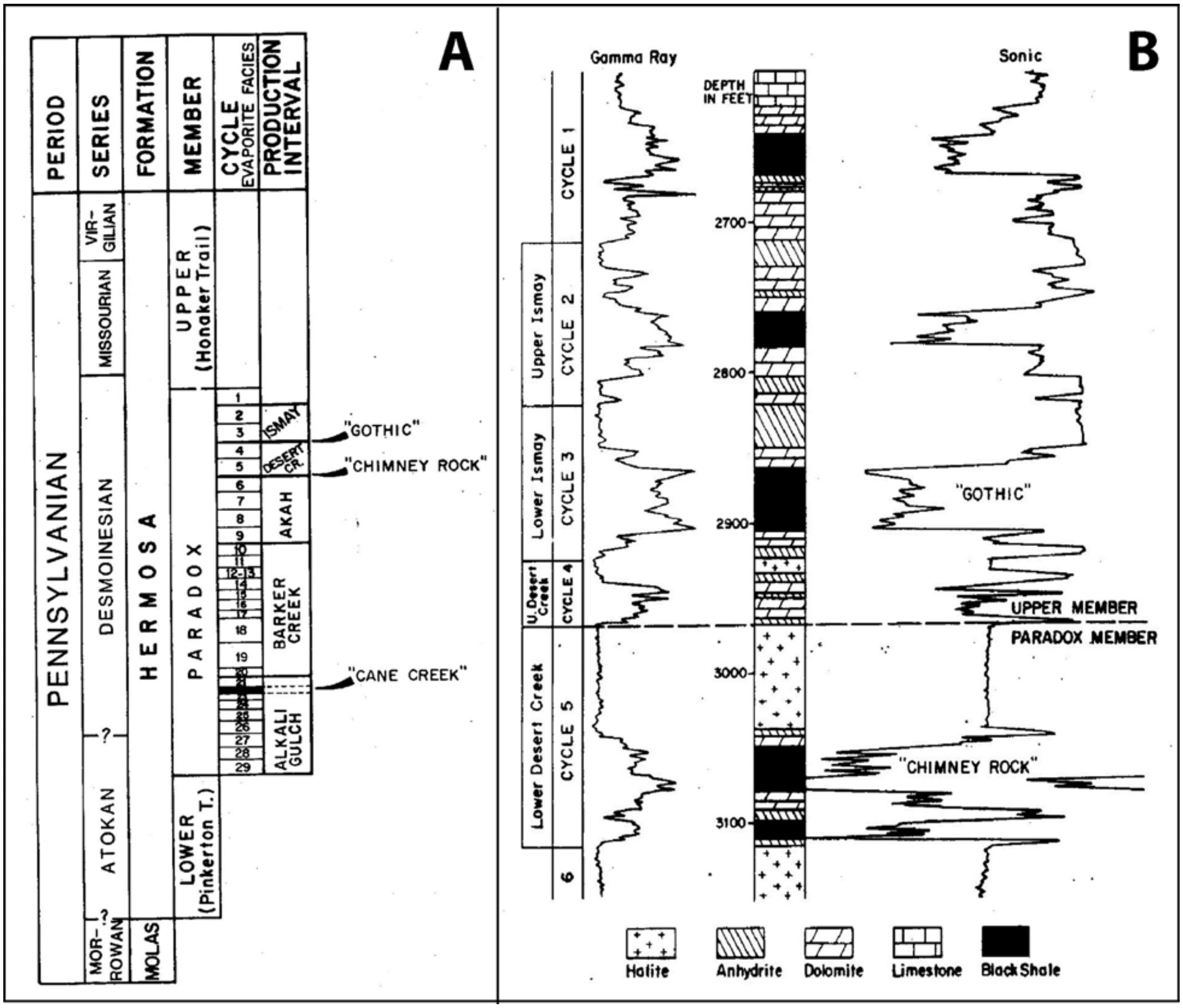

Figure 18: Stratigraphy of the Hermosa Group, Paradox basin (Hite and others, 1984).

A. Pennsylvanian stratigraphy of the Paradox basin showing the 'cycles' of the Paradox Formation, including the principal named black shale intervals. B. Detailed stratigraphy of the upper five cycles of the Paradox Formation, which include the Gothic and Chimney Rock black shale intervals.

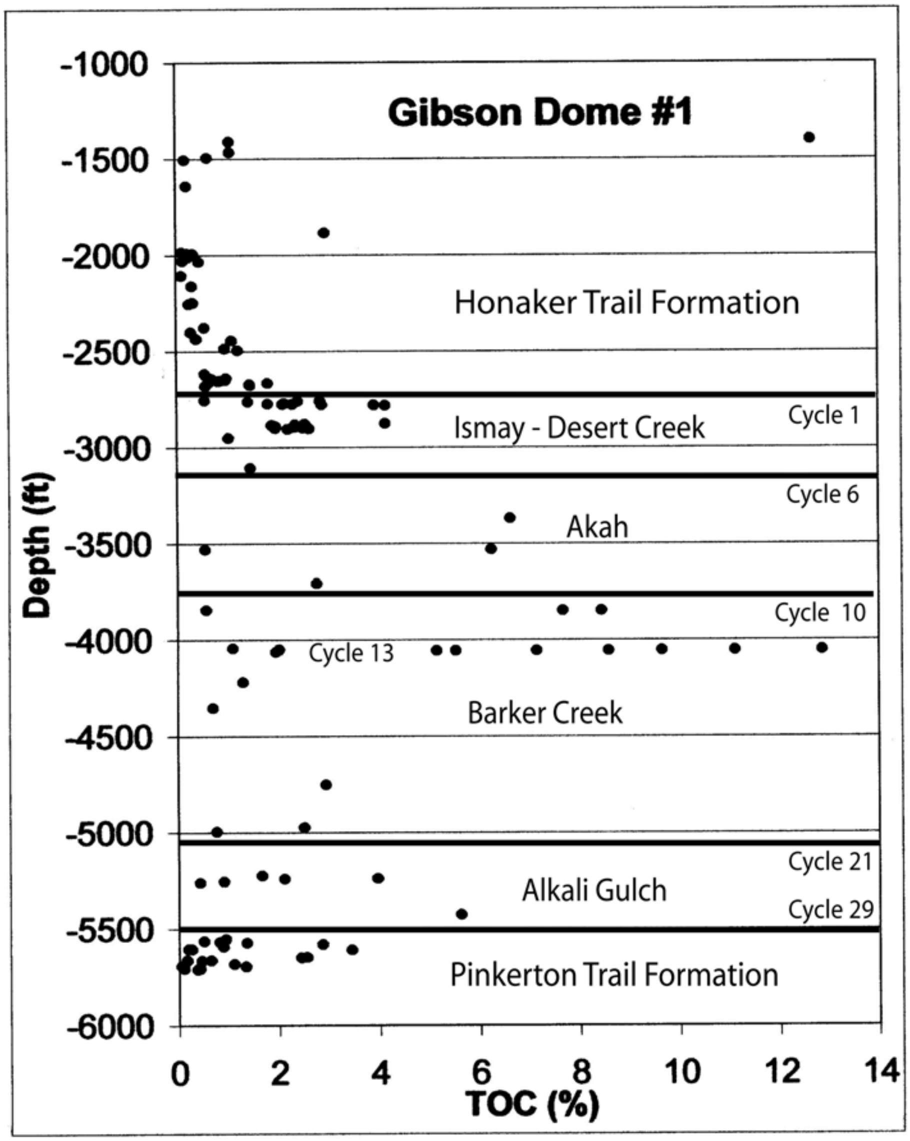

Figure 19: Distribution of TOC values with depth in the Gibson Dome #1 well (21-30S-21E, San Juan County). Data from Hite and others (1984).

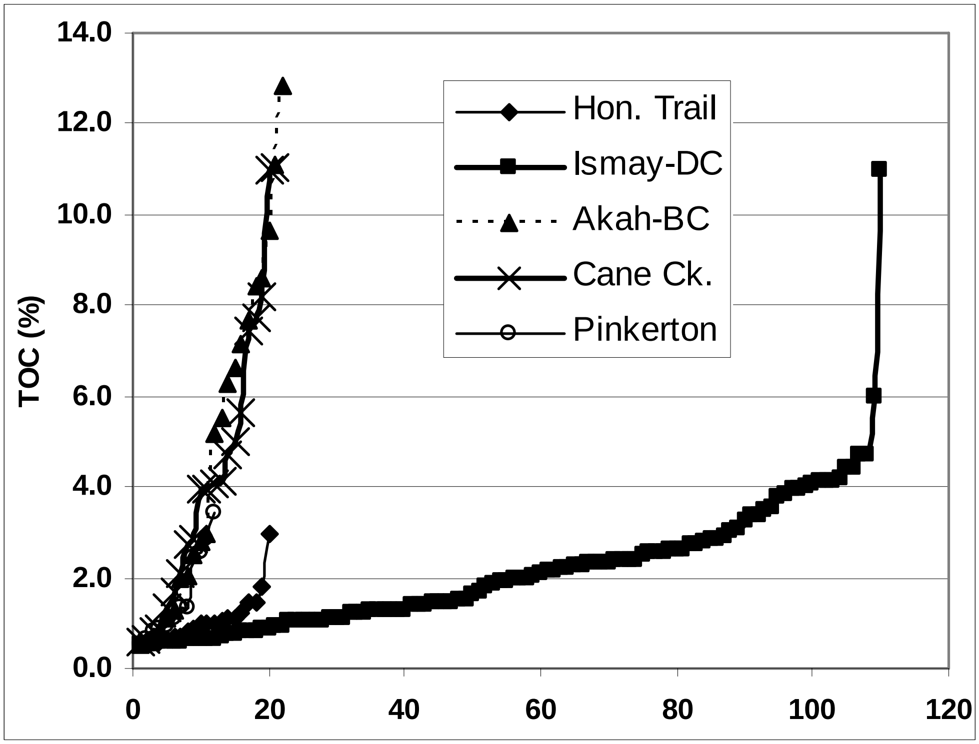

Figure 20: Distribution of TOC values measured in various stratigraphic intervals of the Hermosa Group, Paradox basin. Data from Nuccio and Condon (1996a) and Hite and others (1984).

Setting for natural gas in the Hermosa Group

The kerogen (Fig. 21) is largely gas-prone humic type III and mixed type II-III (Nuccio and Condon, 1996b). As would be expected, the thermal maturities are higher in the deeper Cane Creek cycle near the base of the Paradox Formation than in the Ismay-Desert Creek interval at the top (Fig. 22). Across most of the Paradox basin, the Cane Creek cycle is well within the gas generative window (> 1.1% Ro), even for a more oil-prone kerogen than is generally present in these black shales. It is probable that the wells preferentially have sampled Paradox black shales in the structurally higher, and thereby 'cooler', parts of the basin. If true, a substantial part of the Paradox Formation in the interdome 'synclines' has been or is still in the gas generative window.

Nuccio and Condon (1996b) offer a somewhat unconventional view of thermal maturity in a map (Fig. 23) contouring production index (PI) values derived from RockEval pyrolysis data. Production index is the measure of the ratio of free hydrocarbons in the source rock to the total hydrocarbons that can be generated by thermal breakdown of kerogen. For oil-prone source rocks, values in the range 0.1-0.4 are attributed to the oil generative window, and values greater than 0.4 are placed in the gas generative window. Given that the kerogen is dominantly humic, the gas threshold might better be set at a PI of 0.2, in which case a large volume of the Paradox Formation in the fold and fault belt would have been, or now is, generating natural gas.

Numerous factors favor the possible development of shale gas in the black shale intervals of the Hermosa Group. First, the shales are very organic-rich, on the whole the most carbonaceous shales in Utah, and they are inherently gas-prone. Second, they have reached relatively high degrees of thermal maturity across much of the basin center as evidenced by their present Ro and PI values. Third and perhaps most significant, the shales are encased in halite and anhydrite which retard gas leakage, even by diffusion. Yet it is curious that the Paradox basin is largely an oil province (Morgan, 1992; Montgomery, 1992) in which gas production is historically secondary and associated. Perhaps this relates to the concentration of petroleum development in the shallower targets on the southwest basin margin and in the salt-cored anticlines.

The salt structures in the Paradox basin were growing already in the Pennsylvanian as evidenced by the thinning of the Hermosa Group strata (Fig. 24, A) towards the structures (Doelling, 1988). The consequence in the Paradox basin is that the interdome 'synclines' (Fig.24, B) are likely sites for thicker accumulations of the black shale facies and less severe deformation of the Paradox Formation (Fig. 25). Here also the black shales are more likely to have generated and retained natural gas.

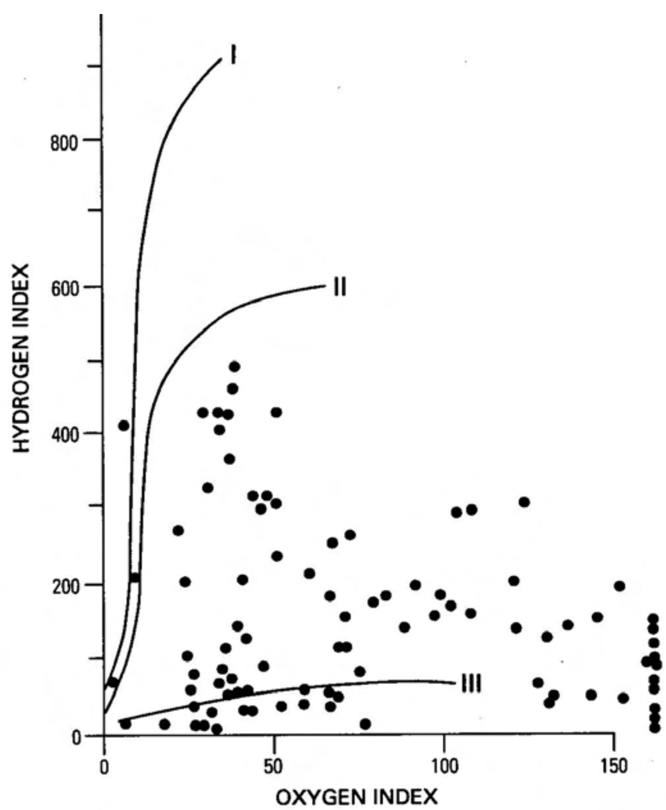

Figure 21: Modified van Krevelen plot of samples from the Ismay-Desert Creek interval showing that the kerogen is mainly type III and mixed type II-III (Nuccio and Condon, 1996b).

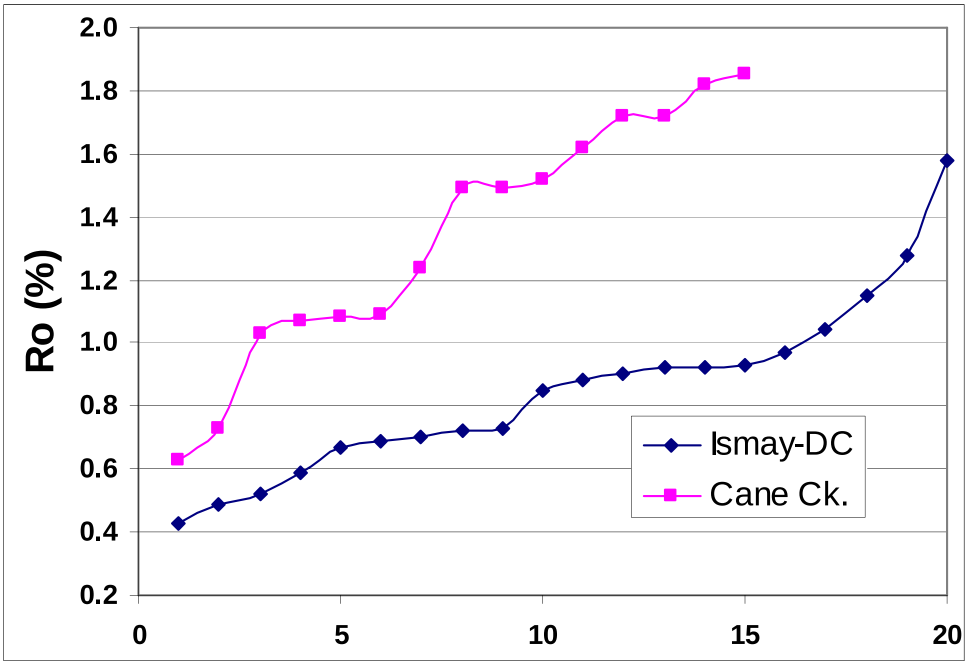

Figure 22: Distribution of Ro values measured in the Ismay-Desert Creek and Cane Creek intervals of the Paradox Formation. Rank (ascending) in the group is indicated in the X-axis. Data from Nuccio and Condon (1996a).

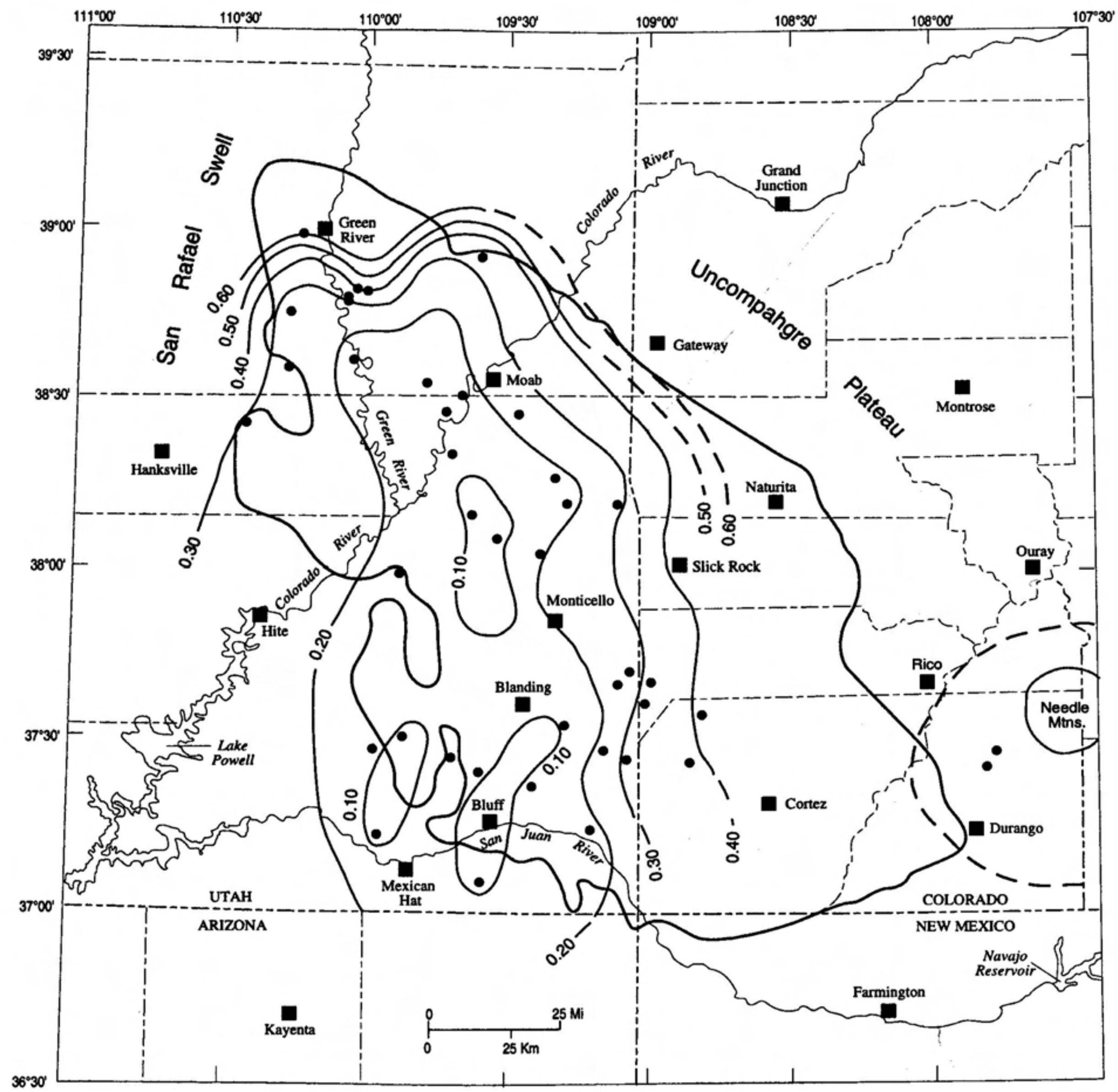

Figure 23: Thermal maturity map of the Paradox basin at the level of the Ismay-Desert Creek interval (Nuccio and Condon, 1996a). Contoured is production index (PI) at 0.10 contour spacing. The gas-dominant portions of the basin are likely to lie north and east of the PI = 0.30 contour.

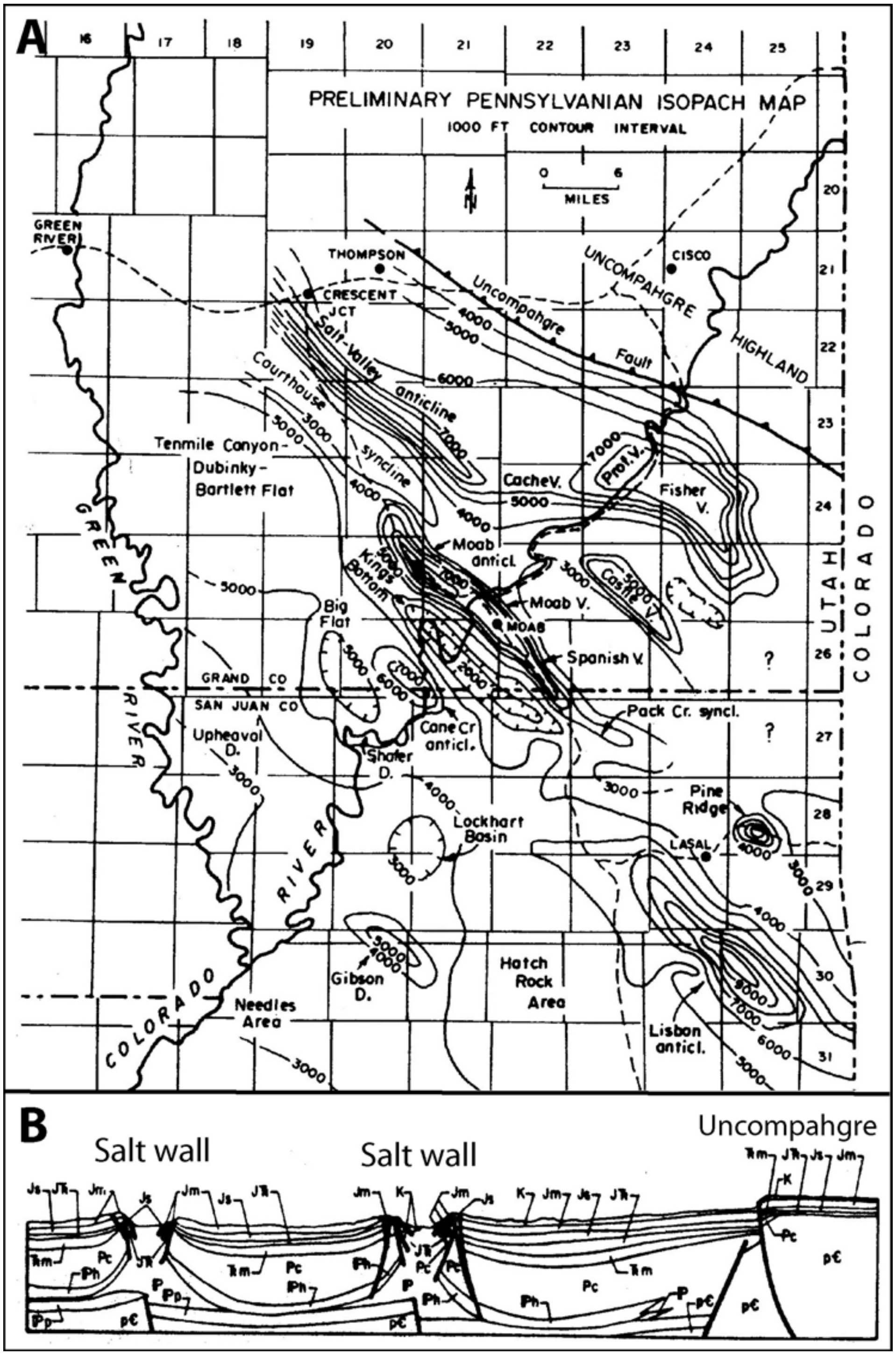

Figure 24: Salt walls in the fold and fault belt of the Paradox basin.

A. Pennslyvanian system isopach map delineates the salt walls, which began growing during or shortly after deposition of the Paradox Formation (Doelling, 1988). B. Structural cross section showing the broad, deep 'synclines' separating the salt walls (Huntoon, 1988).

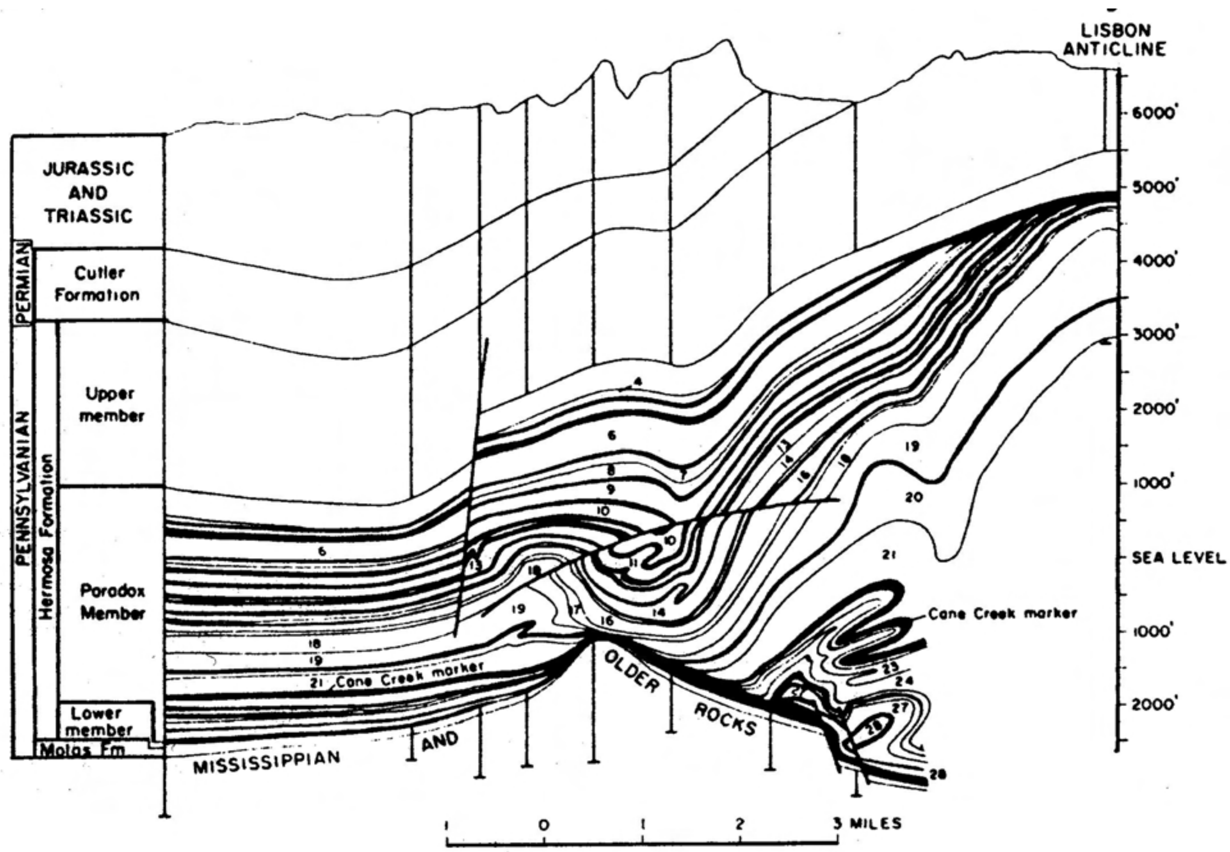

Figure 25: Structural cross section of the west limb of the Lisbon Valley anticline showing the deformed Paradox Formation cycles in the anticline and apparent absence of deformation beneath the adjacent 'syncline' (Hite, 1968).

Well completions, tests and production

The search for wells penetrating the Hermosa Group black shales was not as extensive as that for the Mancos Shale penetrations. This may explain why only 8 wells with shale interval completions and production test data (Table 7) were identified. However, the explanation may relate to a specific oil and gas play in the northwest Paradox basin that had a short period of popularity in the early 1990s. This play involved the drilling and fracture completion of horizontal laterals into the Cane Creek interval (No. 21) of the Paradox Formation near the basin axis where the salt section is very thick (Morgan, 1992; Montgomery, 1992). The Cane Creek interval in the area of the Cane Creek, Shafer Canyon and Big Flat fields is relatively thick compared to other “clastic” intervals within the Paradox Formation (Figs. 26 and 27), so a reasonable target for the placement of horizontal wells. All of the wells with test data (Table 7) are clustered in four adjacent townships that encompass these small fields. Three of the wells are spudded within anticlines, actually salt walls. Beyond this play and a few scattered DSTs, there appears to have been no serious, intentional testing of the oil or gas potential of the “clastic intervals” within the Paradox Formation.

Table 7: Wells completed in Hermosa Group black shale intervals for which gas test data are available.

API well number	Well name	Sec	T	R	Unit
43-019-31331	KANE SPRINGS FED 10-1	10	25S	18E	CC
43-019-31310	KANE SPRINGS FED 27-1	27	25S	19E	CC
43-019-31334	KANE SPRINGS FED 25-19-34-1	34	25S	19E	CC
43-019-31396	CANE CREEK 2-1	2	26S	19E	CC
43-019-31364	CANE CREEK FED 11-1	11	26S	19E	CC
43-019-31156	MINERAL CANYON U 1-14	14	26S	19E	PX
43-019-15925	LONG CANYON 1	9	26S	20E	CC
43-019-31324	KANE SPRINGS FED 19-1A	19	26S	20E	CC

The gas rates (Table 8; Appendix F) 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. These relatively low oil and gas rates may explain why this "hot" play was short-lived.

Table 8: Gas rates reported for intervals within the Cane Creek Shale arranged from highest to lowest. For the full set of information for the tests see Appendix F.

API well number	Well name	Unit	Hermosa top	Paradox	Hermoas 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-	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

Unfortunately for testing the potential of shale gas in the Hermosa Group, no wells were identified that tested "clastic intervals" other than the Cane Creek or that penetrated into the interdome depressions, the structural setting considered most prospective for shale gas development in the Paradox basin.

There is a large number of wells in the northwest half of the Paradox basin that have DSTs within shaly intervals of the Hermosa Group. The 33 wells with DSTs are listed in Table 9 and the data is presented in Appendix G. As can be seen from the locations in Table 9, the DSTs cover most of the area outlined for the Hermosa Group in Figure 2. Also the stratigraphic range is large, with nearly all stratigraphic divisions of the Hermosa Group represented.

One well in particular, Federal 4-26 (4303730617; 26-27S-21E) had a very strong return of natural gas from DSTs in the Paradox Formation, including one test in the Cane Creek interval. The other wells with notable gas returns are:

- Woodside Unit 1 (4301520312; 12-19S-13E)
- Federal DE-1 (4301930647; 20-23S-18E)
- West Bridger Jack U 3 (4003710573; 3-27S-21E)
- Hatch Point 27-1A (4303730518; 27-27S-21E)
- Headwaters Fed 7-15 (4303731822; 15-28S-23E)
- TXC/Huber Federal 1-15 (4303730923; 15-28S-25E)
- Trudi Federal 2-17 (4303731453; 17-31S-23E)
- Ucolo 1-32 (4303730929; 32-35S-26E)

Table 9: Wells having DSTs in the Hermosa Group black shale ("clastic") intervals. Key to units: H = Hermosa Group, HT = Honaker Trail Formation, PX = Paradox Formation, PT = Pinkerton Trail Formation. For the divisions of the Paradox Formation: IS = Ismay, GO = Gothic Shale, CC = Cane Creek Shale.

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

There is no obvious geographic concentration of the favorable DSTs, as there is with the production tests, except that three of the wells occur in the township 27S-21E.

Mud gas and other gas shows

Mud gas logs through just parts of the Hermosa Group succession were found for only 7 wells (Table 10). The generalized mud gas values extracted from the segments of the logs representing the "clastic intervals" in the Paradox Formation are tabulated in Appendix H.

Table 10: Wells having mud gas measurements in the Hermosa Group black shale intervals.

API well number	Well name	Sec	T	R	Unit
43-019-31357	GCRL SEISMOSAUR FED 1	20	21S	20E	PX
43-019-31334	KANE SPRINGS FED 25-19-34-1	34	25S	19E	CC
43-019-31156	MINERAL CANYON U 1-14	14	26S	19E	PX
43-019-30357	SUNBURST 1	14	26S	19E	CC
43-037-30518	HATCH POINT 27-1A	27	27S	21E	CC
43-037-31822	HEADWATERS FED 7-15	15	28S	23E	GO
43-037-30923	TXC/HUBER FEDERAL 1-15	15	28S	25E	HT

Wells with mud gas values in hundreds of gas units and spikes in the thousands are:

- GCRI Seismosaur Fed 1 (20-21S-20E)
- Kane Springs Fed 25-19-34-1 (34-25S-19E;lower part of log only)
- Sunburst 1 (14-26S-19E)
- Mineral Canyon Unit 1-14 (14-26S-19E).

The Headwaters Federal 7-15 well (15-28S-23E) has generally low mud gas values, except within the Gothic Shale interval (Fig. 28).

It may be significant that the four wells with especially large mud gas readings cluster towards the northwest end of the basin axis, in the same general area as the wells with production tests in the Cane Creek interval.

No observations of gas flares during drilling were discovered in the well reports.

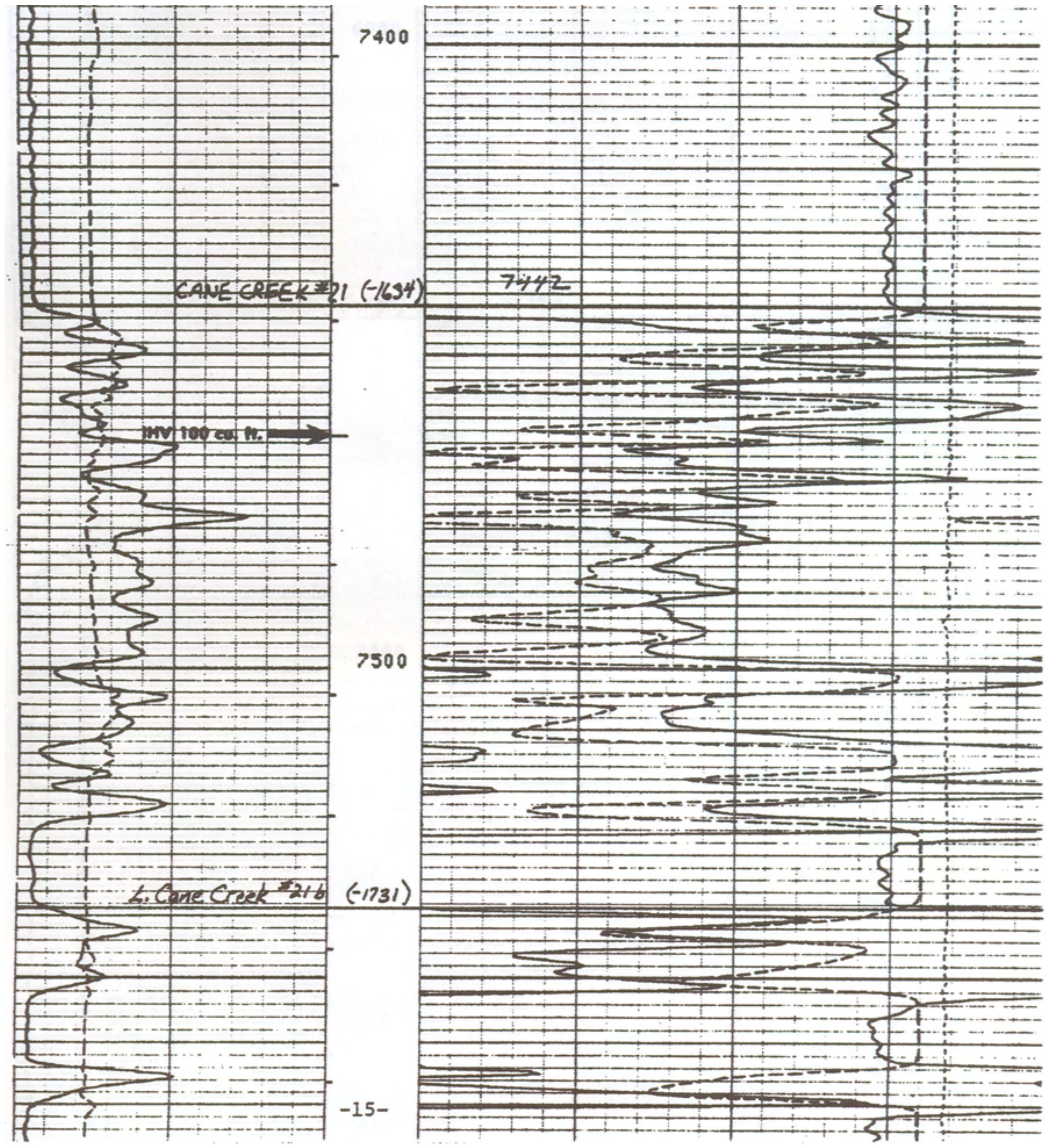

Figure 26: GR-density/neutron log for a segment of the Skyline Unit 1 well (API 4301930796; 5-26S-20E) passing through the relatively thick Cane Creek #21 clastic interval of the Paradox Formation. From the well completion report.

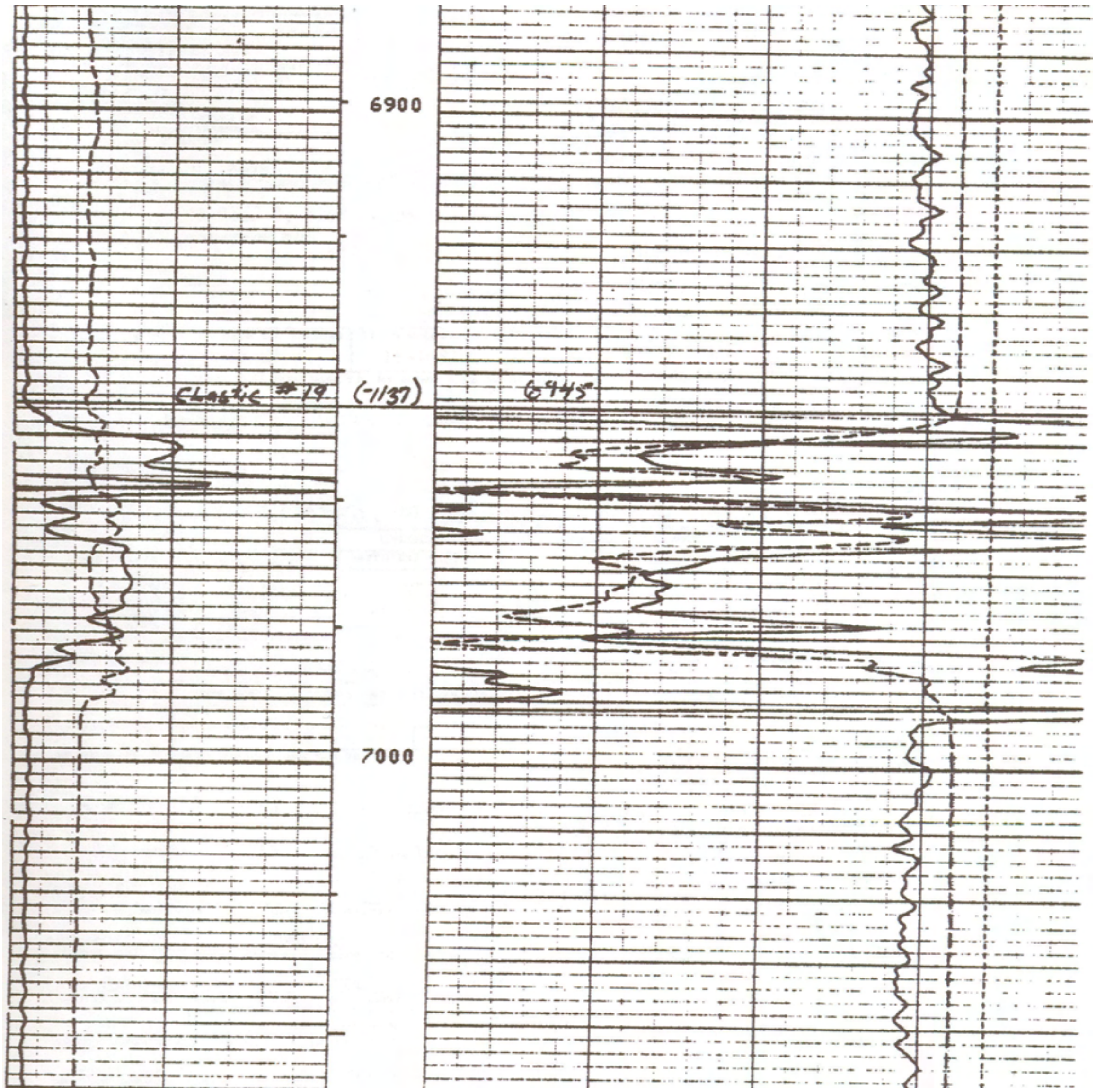

Figure 27: GR-density/neutron log for a segment of the Skyline Unit 1 well (API 4301930796; 5-26S-20E) passing through the relatively thin #19 clastic interval of the Paradox Formation. From the well completion report.

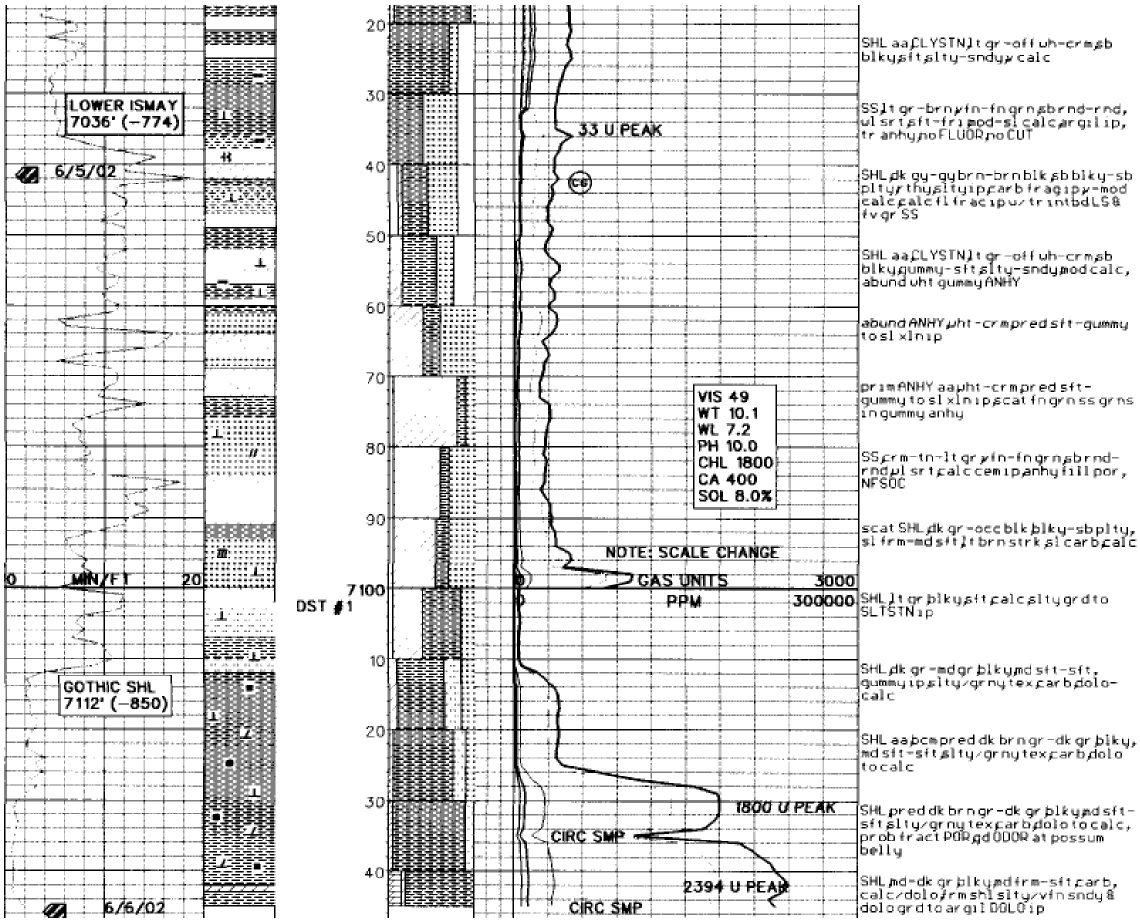

Figure 28: A portion of the mud gas log in the Headwaters Fed 7-15 well (43-047-31822). Especially high mud gas readings on the order of 1500-2500 gas units are associated with the Gothic Shale interval, cycle 3, near the top of the Paradox Formation.

Assessment of Undeveloped and Underdeveloped Gas Discoveries

The information assembled for this project demonstrates that significant quantities of natural gas has been discovered in the Mancos Shale across a broad area of the southern Uinta Basin. In the past, the impediments to production of this gas has been existing market conditions and the inadequate fracture stimulation technologies employed in the Mancos shale intervals. Until very recently, it was standard practice to use same light gel, KCL-foam or acid fracture stimulations that were employed in the sandstone reservoir objectives. These undoubtedly caused more damage to the shales than if the interval has not been stimulated.

A specific example is found in the well completion report for Evacuation Creek 24-12-25 1 (API 4304732605; 24-12S-25E), drilled in 1995. The well was completed and tested in the Prairie Canyon Member, but the test results are not presented in the well completion report. Rather, this explanation is provided therein: *"The Mancos B" was perforated and fracture stimulated with KCL-foam and sand resulting in little gas production due to suspected formation damage. Will hold well for possible repair. … Amoco requests permission for a long term SI.*"

However, favorable gas tests from Mancos completions, good DSTs, large to very large mud gas readings and widespread shows demonstrate the strong potential for development of this shale gas reservoir. Whereas most of the good indications were in the upper part of the 3,000-3,500 ft thick Mancos Shale, principally in the Prairie Canyon Member, favorable indications were found in all of the other shaly units, the Blue Gate Shale, Juana Lopez and Tununk Shale Members.

At the present time Mancos shale gas is being produced from a small number of wells in the Flat Rock and greater Natural Buttes field. In all instances this is add-on gas, supplementing the larger production from conventional sandstone reservoirs. At Flat Rock, there are five deep wells completed in the Mancos Shale that are contributing as much as one-fifth of the total gas output of the wells. In the greater Natural Buttes area, a few operators have started to drill into the upper few hundreds of feet of the Mancos Shale underlying the Mesaverde sandstone objectives. These wells have demonstrated good gas rates even in very thin and inadequately completed shale intervals (Table 2).

It is obvious that the Mancos Shale needs to be treated as the significant gas reservoir that it is. In the greater Natural Buttes field, wells targeting the lower Mesaverde sandstones should also be deepened and tested in the upper 1,000 ft or more of the Mancos Shale, at least through the full thickness of the Prairie Canyon Member. Likewise, all wells targeting the Ferron Sandstone for CBM in Carbon and Emery Counties and the Wingate-Entrada-Dakota sandstones in Uintah and Grand Counties should test the Mancos Shale. Placement of fracture completions over broad expanses of the Mancos Shale should be attempted, at least on a trial basis. Clearly, improved methods for fracture stimulation tailored to the specific rock characteristics of the Mancos lithologies are required. The well completion technologies used in the sandstones cannot be applied to the shaly rocks without some reservoir damage.

In the Paradox basin no wells were identified that adequately tested the assertion (Schamel, 2005) that the productive shale gas reservoirs will be in the interdome depressions along and northeast of the axis of the salt basin. However, the good associated gas tests and strong mud gas values in the wells drilled for the Cane Creek play in the cluster of townships near the basin center do give support for the shale gas potential of the Hermosa Group black shales. Off of the crests of the salt-cored growth anticlines tested by this play, natural gas, not the light oil and associated gas discovered in the Cane Creek interval, can be expected to be the resource in all of the "clastic intervals" intercalated in the thick halite succession. This is a potentially large energy resource still waiting to be discovered and developed.

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Appendix A

Utah wells having natural gas indications in the Mancos Shale and the black shale intervals of the Hermosa Group.

Mancos

API well number	Well name	Sec	T	R	Unit	Comp	Test	DST	MudGas	Shows	Flares	Chem
43-047-34837	SU BW 6M-7-7-22	7	07S	22E	PC					X		
43-047-34280	WV 14M-11-8-21	11	08S	21E	PC	X						
43-047-35248	GB 14M-28-8-21	28	08S	21E	PC	X						
43-047-33291	OURAY 34-79	34	08S	21E	M			X				
43-047-34719	OU SG 10W-15-8-22	15	08S	22E	M	X	X					
43-047-34019	PAWWINNEE 3-181	3	09S	21E	PC	X	X					
43-047-33924	WEEKS 6-154	8	09S	21E	PC	X	X					
43-047-34581	CWU 819-15	15	09S	22E	PC	X	X					
43-047-34510	CHAPITA WELLS UNIT 810-23	23	09S	22E	PC	X	X					
43-047-15643	ISLAND UNIT 3	8	10S	20E	PC	X	X	X				
43-047-33312	ROCK HOUSE 11-31	31	10S	23E	PC				X			
43-047-34941	BONANZA FED 15-27-10-25	27	10S	25E	PC	X	X					
43-047-32693	TEXAS CREEK 14-22	22	11S	25E	M	X						
43-007-30786	JENSEN DEEP 7-15-12-10	15	12S	10E	BG			X	X			
43-007-10753	KEEL RANCH UNIT 1-16	16	12S	13E	M	X	X	X				
43-047-32660	SEEP CANYON ST 19-12-25 1	19	12S	25E	PC	X						
43-047-32605	EVACUATION CREEK 24-12-25 1	24	12S	25E	PC	X			X			
43-007-30289	OMAN 2-20	20	13S	07E	M				X			
43-047-31510	AGENCY DRAW 16-3	3	13S	20E	PC	X	X					
43-047-30323	SEEP RIDGE U 8	14	13S	22E	M	X						
43-047-30386	CROOKED CYN U 2	34	13S	23E	M	X					X	
43-047-32618	DAVIS CANYON 12-13-25 1	12	13S	25E	PC	X						
43-047-32659	ATCHEE RIDGE 15-13-25 1	15	13S	25E	PC	X						
43-007-15922	GORDON CREEK 5	25	14S	07E	M			X		X		
43-007-30314	UTAH D-4	24	14S	09E	M				X			
43-007-30130	ST OF UT 25-9-1	25	14S	09E	M				X		X	
43-007-30156	ST OF UT 25-7-6	25	14S	09E	M				X		X	
43-007-30157	ST OF UT 25-11-7	25	14S	09E	M				X			
43-007-30129	RGU 1	36	14S	09E	M				X			
43-047-35442	NHC 3-6-15-20X	31	14S	20E	M				X	X	X	
43-047-33333	UTE TRIBAL 32-2A	32	14S	20E	M					X		
43-047-33618	UTE TRIBAL 32-7A	32	14S	20E	M					X		
43-047-34675	PINE SPRINGS FED 3-23-14S-22E	23	14S	22E	PC	X	X					
43-047-31074	PINE SPRINGS 13-26-14-22	26	14S	22E	PC	X	X					
43-047-30708	CROOKED CYN 10-10-14-23	10	14S	23E	PC	X						
43-047-31055	TRAPP SPRINGS 6-13-14-23	13	14S	23E	PC	X	X					
43-047-30619	CROOKED CYN 13-17-14-23	17	14S	23E	PC					X		
43-047-30271	CROOKED CANYON U 1	20	14S	23E	PC			X				X
43-047-30978	TRAPP SP 13-25-14-23	25	14S	23E	M				X			
43-047-30975	TRAPP SPRINGS 1-25-14-23	25	14S	23E	PC	X	X					
43-047-30944	TRAPP SPRINGS 8-36-14-23	36	14S	23E	PC	X	X					
43-015-30064	POLE CANYON U 1	17	15S	07E	M				X			
43-047-34922	N HILL CREEK 4-1-15-20	1	15S	20E	M				X			
43-047-35140	NHC 1-6-15-20	5	15S	20E	M	X			X			
43-047-34742	N HILL CREEK 1-9-15-20	9	15S	20E	M				X			
43-047-34830	NHC 10-10-15-20	10	15S	20E	M					X	X	
43-047-34552	N HILL CREEK 4-10-15-20	10	15S	20E	PC				X			
43-047-35390	NHC 9-11-15-20	11	15S	20E	M	X				X	X	
43-047-34953	N HILL CREEK 14-11-15-20	11	15S	20E	M				X	X		
43-047-35283	N HILL CREEK 2-12-15-20	12	15S	20E	M				X	X		
43-047-35054	NHC 4-13-15-20	13	15S	20E	M	X			X			
43-047-34954	NHC 8-13-15-20	13	15S	20E	M	X						
43-047-30746	PINE SPRINGS ST 11-2-15-22	2	15S	22E	PC	X	X					
43-047-31135	MAIN CYN 8-2-15-22	2	15S	22E	PC	X	X					
43-047-31091	WOLF POINT FED 2-18-15S-22E	18	15S	22E	PC	X	X					
43-047-30735	MAIN CYN 2-8-15-23	8	15S	23E	PC	X						
43-047-30639	MAIN CYN 11-10-15-23	10	15S	23E	M						X	
43-047-30736	MAIN CYN 7-17-15-23	17	15S	23E	PC	X						
43-047-35685	HORSE POINT ST 43-32	32	15S	23E	PC				X			
43-019-31397	HORSE POINT ST 1-34	34	15S	23E	M				X			
43-015-30607	ST OF UT QQ 31-201	31	16S	08E	M				X			
43-015-10825	FEDERAL MOUNDS 1	11	16S	11E	M			X				
43-015-30022	NELSON UNIT 1	3	16S	15E	M				X	X		
43-015-30080	WILCOX 1-24	24	16S	15E	M				X			
43-019-30169	ANSCHULTZ STATE 428-1	5	16S	22E	M	X	X	X	X		X	
43-019-31151	LITTLE BERRY ST C 1	2	16S	23E	M						X	
43-019-30179	FEDERAL 33-11	11	16S	24E	M	X	X			X		
43-019-30656	NICOR FEDERAL 1	28	16S	25E	M						X	
43-019-30657	GRYNBERG FEDERAL 1	28	16S	25E								
43-019-30758	UTAH STATE 1	32	16S	25E	M				X			
43-019-30572	FEDERAL C-1	35	16S	25E	M					X	X	
43-019-30639	VALENTINE FED 1	35	16S	25E	M						X	
43-019-31009	VALENTINE FEDERAL 3	35	16S	25E	M						X	X
43-015-30620	ST OF UT 17-8-4-21	4	17S	08E	M				X			X

API well number	*Well name*	*Sec*	*T*	*R*	*Unit*	*Comp*	*Test*	*DST*	*MudGas*	*Shows*	*Flares*	*Chem*
43-015-30480	ST OF UT BB 05-108	5	17S	08E	M				X			
43-015-30439	ST OF UT DD 31-98	31	17S	08E	M				X			
43-019-30204	FEDERAL 614-1	3	17S	21E	M						X	
43-019-30706	PETERSON SPRINGS UNIT 1	14	17S	21E	PC						X	
43-019-31241	FEDERAL 11-10	11	17S	24E	M				X			
43-019-30799	HOUGEN FED A-1 ST 1	14	17S	24E	PC						X	
43-019-31225	FEDERAL 14-2	14	17S	24E	M						X	
43-019-30892	WESTWATER FED B-1	17	17S	24E	M						X	
43-019-31231	FEDERAL 8-10	8	17S	25E	M				X			
43-019-15027	CRITTENDEN 1	12	17S	25E	M					X		
43-019-31237	FEDERAL 16-3	16	17S	25E	M				X			
43-019-31236	FEDERAL 17-3	17	17S	25E	PC				X			
43-019-30425	BAR CREEK UNIT 5	30	17S	26E	M						X	
43-019-30770	DIAMOND CANYON II 15-15	15	18S	22E	M				X	X		
43-019-30343	FEDERAL 258	5	18S	24E	M						X	
43-039-30004	UNITED STATES E 1	27	19S	03E	TU					X	X	
43-015-30221	ORANGEVILLE FEDERAL UNIT 4-1	1	19S	07E	BG					X	X	
43-019-30835	BUTLER CYN UNIT USA 33-12	33	19S	17E	M				X			
43-019-30735	LONG CANYON UNIT ST 16-4	16	19S	23E	M				X			
43-019-30337	FEDERAL 267-3	34	19S	23E	M							
43-019-31063	FEDERAL 12-42	12	21S	18E	M				X			
43-019-31394	STATE 1-32	32	21S	19E	M				X			
43-041-11136	EMERY UNIT FED 1	34	22S	05E	BG				X		X	

Hermosa

API well number	Well name	Sec	T	R	Unit	Comp	Test	DST	MudGas	Shows	Flares	Chem
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					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			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				

Mancos PZ

API well number	Well name	Sec	T	R	Unit	Prod	Test	DST	MudGas	Shows	Flares	Chem
43-047-30445	DRY BURN UNIT 2	35	13S	25E	PC					PZ		
43-047-30978	TRAPP SP 13-25-14-23	25	14S	23E	PC					PZ		
43-047-31003	TRAPP SPRINGS 3-26-14-23	26	14S	23E	PC					PZ		
43-047-30791	TRAPP SPRINGS 6-35-14-23	35	14S	23E	PC					PZ		
43-047-31043	MAIN CYN 4-4-15-23	4	15S	23E	PC					PZ		
43-047-30674	MAIN CYN 15-8-15-23	8	15S	23E	PC					PZ		
43-047-30639	MAIN CYN 11-10-15-23	10	15S	23E	PC					PZ		
43-047-31247	FEDERAL 7-30-15-23	30	15S	23E	M					PZ		

Appendix B

Natural gas tests in the Mancos Shale, exclusive of the sandstone- and coal-bearing Emery Sandstone and Ferron Sandstone Members.

Mancos

API well number	Well name	Unit	Mancos top	Mancos base	Top interv	Base interv	Gas mcfpd	Time (hrs)	Orifice (in)	Water bwpd	Oil bopd	Oil °API	GOR	Source
43-007-10753	Keel Ranch Unit 1-16	M	na	12,000	8,084	8,134	444.0	7.00	na	0	tr			DOGM
43-019-30169	Anschutz State 428-1	BG	5,070	8,760	7,638	7,638	1,450.0	0.45						DERL
43-019-30179	Federal 33-11	JL	2,700	6,227	5,747	6,032	91.1	5.30	0.25					DOGM
43-019-30179	Federal 33-11	BG	2,700	6,227	4,816	5,747	25.6	1.00	0.13					DOGM
43-019-30179	Federal 33-11	PC	2,700	6,227	3,781	4,090	20.3	0.67	0.13					DOGM
43-019-30179	Federal 33-11	BG	2,700	6,227	4,090	4,816	10.5	0.17	0.13					DOGM
43-047-30708	Crooked Cyn 10-10-14-23	PC	6,188	6,880	6,237	6,380	91.0	24.00	0.25	2.3	0.0			DOGM
43-047-30735	Main Cyn 2-8-15-23	PC	5,358	8,396	5,536	5,637	150.0	24.00	open	0.0	0.0			DOGM
43-047-30736	Main Cyn 7-17-15-23	PC	5,356	8,376	5,366	5,606	80.0	24.00	0.50	0.0	0.0			DOGM
43-047-30746	Pine Springs ST 11-2-15-22	PC	5,186	6010 TD	5,375	5,439	100.0	24.00	0.25	0.0	0.0			DOGM
43-047-30944	Trapp Springs 8-36-14-23	PC	5,230	8,279	5,238	5,599	253.0	24.00						DOGM
43-047-30975	Trapp Springs 1-25-14-23	PC	5,390	8,415	6,100	6,100	59.0		0.25					DOGM
43-047-31055	Trap Springs 6-13-14-23	PC	6,058	6855 TD	6,125	6,551	trace	24.00	open	0.0	0.0			DOGM
43-047-31074	Pine Springs 13-26-14-22	PC	5,737	6515 TD	5,737	6,399	515.0	24.00	0.25	0.0	0.0			DOGM
43-047-31091	Wolf Point Fed 2-18-15S-22E	PC	6,240	7169 TD	6,255	6,495	433.0	23.00	0.25	0.0	5.7			DOGM
43-047-31135	Main Cyn 8-2-15-22	PC	5,156	5,940	5,228	5,398	283.0	24.00	0.38	0.0	0.0			DOGM
43-047-31510	Agency Draw 16-3	PC	7,620	11,576	8,398	8,414	64.0	24.00	0.22	10.0	5.0	51°	12,800	DOGM
43-047-34019	Pawwinnee 3-181	PC			12,049	12,144	2,079.0	24.00	0.22	200.0	0.0			DOGM
43-047-33924	Weeks 6-154	PC	11,770	12425 TD	12,244	12,258	1,002.0	24.00	0.63	60.0	0.0			DOGM
43-047-34510	Chapita Wells Unit 810-23	JL	10,493	10,912 TD	10,671	10,807	500.0	24.00	0.19	87.0	27.0			DOGM
43-047-34581	CWU 819-15	PC	10,853	11,153	10,903	10,980	4.0	7.00	0.25	0.0	0.0			DOGM
43-047-34675	Pine Springs Fed 3-23-14S-22E	PC	5,252	6300 TD	6,004	6,106	390.0	24.00	0.25	13.0	0.0			DOGM
43-047-34719	OU SG 10W 15-8-22	PC	12,396	12580 TD	12,401	12,496	116.0	24.00	0.20	35.0	10.0			DOGM
43-047-34941	Bonanza Fed 15-27-10-25	PC	3,145	4490 TD	4,080	4,262	84.0	24.00		20.0	25.0		3,360	DOGM

API well number	Well name	Unit	Mancos top	Mancos base	Top interv	Base interv	Gas mcfpd
43-047-34019	Pawwinnee 3-181	PC			12,049	12,144	2,079.0
43-019-30169	Anschutz State 428-1	BG	5,070	8,760	7,638	7,638	1,450.0
43-047-33924	Weeks 6-154	PC	11,770	12425 TD	12,244	12,258	1,002.0
43-047-31074	Pine Springs 13-26-14-22	PC	5,737	6515 TD	5,737	6,399	515.0
43-047-34510	Chapita Wells Unit 810-23	JL	10,493	10,912 TD	10,671	10,807	500.0
43-007-10753	Keel Ranch Unit 1-16	M	na	12,000	8,084	8,134	444.0
43-047-31091	Wolf Point Fed 2-18-15S-22E	PC	6,240	7169 TD	6,255	6,495	433.0
43-047-34675	Pine Springs Fed 3-23-14S-22E	PC	5,252	6300 TD	6,004	6,106	390.0
43-047-31135	Main Cyn 8-2-15-22	PC	5,156	5,940	5,228	5,398	283.0
43-047-30944	Trapp Springs 8-36-14-23	PC	5,230	8,279	5,238	5,599	253.0
43-047-30735	Main Cyn 2-8-15-23	PC	5,358	8,396	5,536	5,637	150.0
43-047-34719	OU SG 10W 15-8-22	PC	12,396	12580 TD	12,401	12,496	116.0
43-047-30746	Pine Springs ST 11-2-15-22	PC	5,186	6010 TD	5,375	5,439	100.0
43-019-30179	Federal 33-11	JL	2,700	6,227	5,747	6,032	91.1
43-047-30708	Crooked Cyn 10-10-14-23	PC	6,188	6,880	6,237	6,380	91.0
43-047-34941	Bonanza Fed 15-27-10-25	PC	3,145	4490 TD	4,080	4,262	84.0
43-047-30736	Main Cyn 7-17-15-23	PC	5,356	8,376	5,366	5,606	80.0
43-047-31510	Agency Draw 16-3	PC	7,620	11,576	8,398	8,414	64.0
43-047-30975	Trapp Springs 1-25-14-23	PC	5,390	8,415	6,100	6,100	59.0
43-019-30179	Federal 33-11	BG	2,700	6,227	4,816	5,747	25.6
43-019-30179	Federal 33-11	PC	2,700	6,227	3,781	4,090	20.3
43-019-30179	Federal 33-11	BG	2,700	6,227	4,090	4,816	10.5
43-047-34581	CWU 819-15	PC	10,853	11,153	10,903	10,980	4.0
43-047-31055	Trap Springs 6-13-14-23	PC	6,058	6855 TD	6,125	6,551	trace

Appendix C

Drill-stem tests in the Mancos Shale, exclusive of the sandstone- and coal-bearing Emery Sandstone and Ferron Sandstone Members.

Mancos

API well number	*Well name*	*Unit*	*Test #*	*Top test*	*Base test*	*IHP*	*FHP*	*IFP*	*FFP*	*ISIP*	*FSIP*	*Fluids*	*Source*
43-047-15843	Island Unit 3	PC	25	11,360	11,400	7,601	7,501	178	134	4,840	1,597	211 mcfpd (15min); 156 mcfpd (30 min)	DERL
43-019-30169	Anschutz State 428-1	BG	1	7592	7670	3729	3729	512	327	3554	3075	na	DERL
43-019-30169	Anschutz State 428-1	BG	4	7610	7706	3674	3669	849	310	2319	na	576' gas-cut mud	DERL
43-007-15922	Gordon Creek 5	BG	2	2550	3041	1165	1165	610	1065	0	0	2,520 ft slightly gas-cut muddy water	DERL
43-007-15922	Gordon Creek 5	BG	3	2470	2545	1170	1170	900	1060	0	0	900 ft slightly gas-cut water; 1,540 ft muddy wa	DERL
43-047-30271	Crooked Canyon U 1	M	1	5710	6000	2831	2836	71	107	194	211	150 ft mud; chamber 0.58 cf gas	DOGM
43-007-10753	Keel Ranch State 1-16	M	6	6570	6631	3450	3450	57	57	267	229	gas to surface 5.26 mcf; 90 ft gas-cut mud	DOGM
43-007-10753	Keel Ranch State 1-16	BG	8	7615	7635	4146	4127	38	38	567	265	gas to surface 18 mcf; 30 ft gas-cut mud	DOGM

Appendix D

Mud gas measurements in the Mancos Shale, exclusive of the sandstone- and coal-bearing Emery Sandstone and Ferron Sandstone Members.

Mancos

API well number	Well name	Top Mancos	Base Mancos	Zone top	Zone base	Gas units	Fm.	Comment	Sec	T	R
43-007-30129	RGU 1	0	1,932	1,530	1,590	30	BG		36	14S	9E
43-007-30129	RGU 1	0	1,932	1,590	1,620	60	BG		36	14S	9E
43-007-30129	RGU 1	0	1,932	1,860	1,932	400	TU		36	14S	9E
43-007-30130	ST OF UT 25-9-1	0	1,560	1,133	1,200	1,300	BG	numerous flares in interval	25	14S	9E
43-007-30130	ST OF UT 25-9-1	0	1,560	1,200	1,505	1,200	BG	numerous flares in interval	25	14S	9E
43-007-30156	ST OF UT 25-7-6	0	1,960	545	600	450	BG		25	14S	9E
43-007-30156	ST OF UT 25-7-6	0	1,960	600	640	400	BG		25	14S	9E
43-007-30156	ST OF UT 25-7-6	0	1,960	640	700	350	BG		25	14S	9E
43-007-30156	ST OF UT 25-7-6	0	1,960	700	800	300	BG		25	14S	9E
43-007-30156	ST OF UT 25-7-6	0	1,960	800	850	275	BG		25	14S	9E
43-007-30156	ST OF UT 25-7-6	0	1,960	850	920	250	BG		25	14S	9E
43-007-30156	ST OF UT 25-7-6	0	1,960	920	1,120	200	BG		25	14S	9E
43-007-30156	ST OF UT 25-7-6	0	1,960	1,120	1,200	100	BG		25	14S	9E
43-007-30156	ST OF UT 25-7-6	0	1,960	1,200	1,320	75	BG		25	14S	9E
43-007-30156	ST OF UT 25-7-6	0	1,960	1,320	1,470	50	BG		25	14S	9E
43-007-30156	ST OF UT 25-7-6	0	1,960	1,470	1,550	20	BG		25	14S	9E
43-007-30156	ST OF UT 25-7-6	0	1,960	1,910	1,960	100	TU		25	14S	9E
43-007-30157	ST OF UT 25-11-7	0	2,037	360	640	40	BG		25	14S	9E
43-007-30157	ST OF UT 25-11-7	0	2,037	640	820	50	BG		25	14S	9E
43-007-30157	ST OF UT 25-11-7	0	2,037	820	920	40	BG		25	14S	9E
43-007-30157	ST OF UT 25-11-7	0	2,037	920	1,060	20	BG		25	14S	9E
43-007-30157	ST OF UT 25-11-7	0	2,037	1,060	1,400	10	BG		25	14S	9E
43-007-30157	ST OF UT 25-11-7	0	2,037	1,400	1,665	20	BG		25	14S	9E
43-007-30157	ST OF UT 25-11-7	0	2,037	1,665	1,710	1,100	BG	"gas prob. from fractures"	25	14S	9E
43-007-30157	ST OF UT 25-11-7	0	2,037	1,940	2,037	40	TU	"720u during trip for logs"	25	14S	9E
43-007-30289	OMAN 2-20	2,200	4770 TD	2,260	2,490	100	M		20	13S	7E
43-007-30289	OMAN 2-20	2,200	4770 TD	2,490	2,530	2,000	M		20	13S	7E
43-007-30289	OMAN 2-20	2,200	4770 TD	2,530	2,610	200	M		20	13S	7E
43-007-30289	OMAN 2-20	2,200	4770 TD	2,610	2,670	400	BG		20	13S	7E
43-007-30289	OMAN 2-20	2,200	4770 TD	2,670	2,720	200	BG		20	13S	7E
43-007-30289	OMAN 2-20	2,200	4770 TD	2,720	2,840	150	BG		20	13S	7E
43-007-30289	OMAN 2-20	2,200	4770 TD	2,840	2,950	100	BG		20	13S	7E
43-007-30289	OMAN 2-20	2,200	4770 TD	2,950	3,240	90	BG		20	13S	7E
43-007-30289	OMAN 2-20	2,200	4770 TD	3,240	3,550	100	BG		20	13S	7E
43-007-30289	OMAN 2-20	2,200	4770 TD	3,550	3,780	200	BG		20	13S	7E
43-007-30289	OMAN 2-20	2,200	4770 TD	3,780	3,890	150	BG		20	13S	7E
43-007-30289	OMAN 2-20	2,200	4770 TD	4,640	4,770	30	TU		20	13S	7E
43-007-30314	UTAH D-4	1,160	2330 TD	1,200	1,350	2	BG		24	14S	9E
43-007-30314	UTAH D-4	1,160	2330 TD	1,350	1,420	15	BG		24	14S	9E
43-007-30314	UTAH D-4	1,160	2330 TD	1,445	1,455	80	BG	spike	24	14S	9E
43-007-30314	UTAH D-4	1,160	2330 TD	1,455	1,740	10	BG		24	14S	9E
43-007-30314	UTAH D-4	1,160	2330 TD	1,990	2,010	20	TU		24	14S	9E
43-007-30314	UTAH D-4	1,160	2330 TD	2,110	2,330	4	TU		24	14S	9E
43-007-30786	JENSEN DEEP 7-15-12-10	5,240	10,425	5,240	5,420	20	MB		15	12S	10E
43-007-30786	JENSEN DEEP 7-15-12-10	5,240	10,425	5,420	5,580	30	MB		15	12S	10E
43-007-30786	JENSEN DEEP 7-15-12-10	5,240	10,425	5,600	5,615	50	MB		15	12S	10E
43-007-30786	JENSEN DEEP 7-15-12-10	5,240	10,425	8,045	8,090	900	BG		15	12S	10E
43-007-30786	JENSEN DEEP 7-15-12-10	5,240	10,425	8,200	8,250	150	BG		15	12S	10E
43-007-30786	JENSEN DEEP 7-15-12-10	5,240	10,425	8,428	8,428	432	BG	peak in black shale interval	15	12S	10E
43-007-30786	JENSEN DEEP 7-15-12-10	5,240	10,425	8,440	8,630	150	BG	6,168u trip gas @ 8486'	15	12S	10E
43-007-30786	JENSEN DEEP 7-15-12-10	5,240	10,425	8,708	8,715	395	BG		15	12S	10E
43-007-30786	JENSEN DEEP 7-15-12-10	5,240	10,425	8,740	8,740	1,333	BG	connection gas	15	12S	10E
43-007-30786	JENSEN DEEP 7-15-12-10	5,240	10,425	8,960	9,050	150	BG		15	12S	10E
43-007-30786	JENSEN DEEP 7-15-12-10	5,240	10,425	9,133	9,133	1,074	BG	peak	15	12S	10E
43-007-30786	JENSEN DEEP 7-15-12-10	5,240	10,425	9,135	9,180	200	BG		15	12S	10E
43-007-30786	JENSEN DEEP 7-15-12-10	5,240	10,425	9,180	9,240	100	BG		15	12S	10E
43-007-30786	JENSEN DEEP 7-15-12-10	5,240	10,425	9,240	9,300	50	BG		15	12S	10E
43-007-30786	JENSEN DEEP 7-15-12-10	5,240	10,425	9,300	9,335	70	BG		15	12S	10E
43-007-30786	JENSEN DEEP 7-15-12-10	5,240	10,425	9,335	9,340	590	BG		15	12S	10E
43-007-30786	JENSEN DEEP 7-15-12-10	5,240	10,425	9,340	9,380	100	BG		15	12S	10E
43-007-30786	JENSEN DEEP 7-15-12-10	5,240	10,425	9,380	9,490	100	BG		15	12S	10E
43-007-30786	JENSEN DEEP 7-15-12-10	5,240	10,425	9,490	9,540	50	BG		15	12S	10E
43-007-30786	JENSEN DEEP 7-15-12-10	5,240	10,425	9,540	9,745	100	BG		15	12S	10E
43-007-30786	JENSEN DEEP 7-15-12-10	5,240	10,425	9,745	9,790	300	BG		15	12S	10E
43-007-30786	JENSEN DEEP 7-15-12-10	5,240	10,425	9,790	9,920	400	BG		15	12S	10E
43-007-30786	JENSEN DEEP 7-15-12-10	5,240	10,425	9,974	9,974	4,624	BG	trip gas peak	15	12S	10E
43-007-30786	JENSEN DEEP 7-15-12-10	5,240	10,425	10,340	10,340	1,540	TU		15	12S	10E
43-007-30786	JENSEN DEEP 7-15-12-10	5,240	10,425	10,350	10,425	40	TU	decreasing from 50u downward to 20u	15	12S	10E
43-015-30022	NELSON UNIT 1	4,313	8,389	5,550	5,570	30	M		3	16S	15E
43-015-30022	NELSON UNIT 1	4,313	8,389	5,578	5,581	100	M	spike	3	16S	15E
43-015-30022	NELSON UNIT 1	4,313	8,389	5,582	5,630	40	M		3	16S	15E
43-015-30022	NELSON UNIT 1	4,313	8,389	5,630	5,645	805	M	spike	3	16S	15E
43-015-30022	NELSON UNIT 1	4,313	8,389	5,645	5,685	30	M		3	16S	15E
43-015-30022	NELSON UNIT 1	4,313	8,389	5,685	5,985	25	M		3	16S	15E
43-015-30022	NELSON UNIT 1	4,313	8,389	5,985	6,000	570	M	C1: 8000; C2: 5000; C3: 2500; C4: 120(	3	16S	15E
43-015-30022	NELSON UNIT 1	4,313	8,389	6,000	6,030	110	M		3	16S	15E
43-015-30022	NELSON UNIT 1	4,313	8,389	6,030	6,260	20	M		3	16S	15E
43-015-30022	NELSON UNIT 1	4,313	8,389	6,270	6,470	70	M		3	16S	15E
43-015-30022	NELSON UNIT 1	4,313	8,389	6,470	6,670	50	M		3	16S	15E
43-015-30022	NELSON UNIT 1	4,313	8,389	7,000	7,080	35	M		3	16S	15E
43-015-30022	NELSON UNIT 1	4,313	8,389	7,080	7,200	20	M		3	16S	15E
43-015-30022	NELSON UNIT 1	4,313	8,389	7,200	7,250	30	M		3	16S	15E
43-015-30022	NELSON UNIT 1	4,313	8,389	7,252	7,270	1,540	M	C1: 90,000 ppm	3	16S	15E
43-015-30022	NELSON UNIT 1	4,313	8,389	7,270	7,460	30	M		3	16S	15E
43-015-30022	NELSON UNIT 1	4,313	8,389	7,460	7,470	1,100	M	C1: 46,000 ppm	3	16S	15E
43-015-30022	NELSON UNIT 1	4,313	8,389	7,470	7,520	35	M		3	16S	15E
43-015-30022	NELSON UNIT 1	4,313	8,389	7,520	7,640	25	M		3	16S	15E
43-015-30022	NELSON UNIT 1	4,313	8,389	7,770	7,920	50	M		3	16S	15E
43-015-30022	NELSON UNIT 1	4,313	8,389	7,920	8,030	70	M		3	16S	15E
43-015-30022	NELSON UNIT 1	4,313	8,389	8,030	8,160	100	M		3	16S	15E
43-015-30022	NELSON UNIT 1	4,313	8,389	8,160	8,290	80	M		3	16S	15E
43-015-30022	NELSON UNIT 1	4,313	8,389	8,290	8,370	40	M	log top of Dakota @ 8,370'	3	16S	15E
43-015-30064	POLE CANYON U 1	2,672	5,370	2,750	3,100	20	M		17	15S	7E
43-015-30064	POLE CANYON U 1	2,672	5,370	3,230	3,700	20	BG		17	15S	7E

API well number	Well name	Top Mancos	Base Mancos	Zone top	Zone base	Gas units	Fm.	Comment	Sec	T	R
43-015-30064	POLE CANYON U 1	2,672	5,370	3,700	3,795	30	BG		17	15S	7E
43-015-30064	POLE CANYON U 1	2,672	5,370	3,795	4,260	20	BG		17	15S	7E
43-015-30064	POLE CANYON U 1	2,672	5,370	4,260	4,240	10	BG		17	15S	7E
43-015-30064	POLE CANYON U 1	2,672	5,370	4,240	4,360	30	BG		17	15S	7E
43-015-30064	POLE CANYON U 1	2,672	5,370	4,360	4,410	20	BG		17	15S	7E
43-015-30064	POLE CANYON U 1	2,672	5,370	4,410	4,470	10	BG		17	15S	7E
43-015-30064	POLE CANYON U 1	2,672	5,370	4,900	4,930	30	TU		17	15S	7E
43-015-30064	POLE CANYON U 1	2,672	5,370	4,930	5,160	10	TU		17	15S	7E
43-015-30064	POLE CANYON U 1	2,672	5,370	5,160	5,340	30	TU		17	15S	7E
43-015-30080	WILCOX 1-24	5,460	7,200	5,460	5,504	70	BG		24	16S	15E
43-015-30080	WILCOX 1-24	5,460	7,200	5,504	5,510	750	BG	spike	24	16S	15E
43-015-30080	WILCOX 1-24	5,460	7,200	5,510	5,605	80	BG		24	16S	15E
43-015-30080	WILCOX 1-24	5,460	7,200	5,620	5,640	90	BG		24	16S	15E
43-015-30080	WILCOX 1-24	5,460	7,200	5,640	5,680	50	BG		24	16S	15E
43-015-30080	WILCOX 1-24	5,460	7,200	5,680	5,720	110	BG		24	16S	15E
43-015-30080	WILCOX 1-24	5,460	7,200	5,720	5,810	90	BG		24	16S	15E
43-015-30080	WILCOX 1-24	5,460	7,200	5,810	5,920	70	BG		24	16S	15E
43-015-30080	WILCOX 1-24	5,460	7,200	5,920	5,972	90	BG		24	16S	15E
43-015-30080	WILCOX 1-24	5,460	7,200	5,972	5,978	360	BG	spike	24	16S	15E
43-015-30080	WILCOX 1-24	5,460	7,200	5,978	6,116	90	BG	top of Ferron @ 6,117'	24	16S	15E
43-015-30080	WILCOX 1-24	5,460	7,200	6,810	6,820	360	TU	spike	24	16S	15E
43-015-30080	WILCOX 1-24	5,460	7,200	6,820	6,860	210	TU		24	16S	15E
43-015-30080	WILCOX 1-24	5,460	7,200	6,860	6,880	1,100	TU	spike	24	16S	15E
43-015-30080	WILCOX 1-24	5,460	7,200	6,880	6,980	100	TU		24	16S	15E
43-015-30080	WILCOX 1-24	5,460	7,200	6,980	7,020	2,300	TU		24	16S	15E
43-015-30080	WILCOX 1-24	5,460	7,200	7,020	7,200	40	TU		24	16S	15E
43-015-30439	ST OF UT DD 31-98	0	3,650	3,100	3,280	2	BG		31	17S	8E
43-015-30439	ST OF UT DD 31-98	0	3,650	3,280	3,310	12	BG		31	17S	8E
43-015-30439	ST OF UT DD 31-98	0	3,650	3,500	3,650	1	TU		31	17S	8E
43-015-30480	ST OF UT BB 05-108	0	3,735	3,100	3,150	1	BG		31	17S	8E
43-015-30480	ST OF UT BB 05-108	0	3,735	3,150	3,346	4	BG		31	17S	8E
43-015-30480	ST OF UT BB 05-108	0	3,735	3,654	3,735	17	TU		31	17S	8E
43-015-30607	ST OF UT QQ 31-201	1,700	4,850	1,700	2,650	20	BG		31	17S	8E
43-015-30607	ST OF UT QQ 31-201	1,700	4,850	2,650	3,100	30	BG		31	17S	8E
43-015-30607	ST OF UT QQ 31-201	1,700	4,850	3,100	3,200	20	BG		31	17S	8E
43-015-30607	ST OF UT QQ 31-201	1,700	4,850	3,200	3,460	50	BG		31	17S	8E
43-015-30607	ST OF UT QQ 31-201	1,700	4,850	3,460	3,480	100	BG	gas spike in dk gray shale	31	17S	8E
43-015-30607	ST OF UT QQ 31-201	1,700	4,850	3,480	3,750	25	BG		31	17S	8E
43-015-30607	ST OF UT QQ 31-201	1,700	4,850	3,750	4,020	80	BG		31	17S	8E
43-015-30607	ST OF UT QQ 31-201	1,700	4,850	4,020	4,290	30	BG		31	17S	8E
43-015-30607	ST OF UT QQ 31-201	1,700	4,850	4,560	4,850	500	TU	dk gray shale; silty	31	17S	8E
43-015-30620	ST OF UT 17-8-4-21	1,400	3,950	1,400	1,530	25	BG		4	17S	8E
43-015-30620	ST OF UT 17-8-4-21	1,400	3,950	1,530	1,770	10	BG		4	17S	8E
43-015-30620	ST OF UT 17-8-4-21	1,400	3,950	1,775	1,890	20	BG		4	17S	8E
43-015-30620	ST OF UT 17-8-4-21	1,400	3,950	1,890	2,300	12	BG		4	17S	8E
43-015-30620	ST OF UT 17-8-4-21	1,400	3,950	2,300	2,500	10	BG		4	17S	8E
43-015-30620	ST OF UT 17-8-4-21	1,400	3,950	2,500	2,600	20	BG		4	17S	8E
43-015-30620	ST OF UT 17-8-4-21	1,400	3,950	2,600	2,800	15	BG		4	17S	8E
43-015-30620	ST OF UT 17-8-4-21	1,400	3,950	2,800	2,950	20	BG		4	17S	8E
43-015-30620	ST OF UT 17-8-4-21	1,400	3,950	2,950	3,150	30	BG		4	17S	8E
43-015-30620	ST OF UT 17-8-4-21	1,400	3,950	3,400	3,480	30	TU		4	17S	8E
43-015-30620	ST OF UT 17-8-4-21	1,400	3,950	3,400	3,490	150	TU	connection gas spike	4	17S	8E
43-015-30620	ST OF UT 17-8-4-21	1,400	3,950	3,490	3,950	20	TU		4	17S	8E
43-019-30169	ANSCHULTZ STATE 428-1	5,070	8,760	7,630	7,640	220	BG	spike	5	16S	22E
43-019-30169	ANSCHULTZ STATE 428-1	5,070	8,760	7,668	7,678	1,000	BG	spike	5	16S	22E
43-019-30169	ANSCHULTZ STATE 428-1	5,070	8,760	7,762	7,785	700	BG	spike	5	16S	22E
43-019-30735	LONG CANYON UNIT ST 16-4	1,255	4,033	1,600	3,200	5	M		16	16S	23E
43-019-30735	LONG CANYON UNIT ST 16-4	1,255	4,033	3,200	3,620	10	M		16	16S	23E
43-019-30735	LONG CANYON UNIT ST 16-4	1,255	4,033	3,620	3,700	50	M	110u spike @ 3670'	16	16S	23E
43-019-30758	UTAH STATE 1	800	4,645	900	1,800	2	M		32	16S	25E
43-019-30758	UTAH STATE 1	800	4,645	1,850	1,850	10	MB	gas spike near top of Mancos B	32	16S	25E
43-019-30758	UTAH STATE 1	800	4,645	1,900	2,685	2	MB		32	16S	25E
43-019-30758	UTAH STATE 1	800	4,645	2,685	3,100	2	BG		32	16S	25E
43-019-30758	UTAH STATE 1	800	4,645	3,200	3,200	30	BG	trip gas spike	32	16S	25E
43-019-30758	UTAH STATE 1	800	4,645	3,250	4,360	2	BG		32	16S	25E
43-019-30758	UTAH STATE 1	800	4,645	4,370	4,610	25	TU	black shale above Dakota Silt	32	16S	25E
43-019-30770	DIAMOND CANYON II U USA 15-15	2,645	6,136	2,645	2,900	11	M		15	18S	22E
43-019-30770	DIAMOND CANYON II U USA 15-15	2,645	6,136	2,900	3,700	5	M		15	18S	22E
43-019-30770	DIAMOND CANYON II U USA 15-15	2,645	6,136	3,700	3,900	30	M		15	18S	22E
43-019-30770	DIAMOND CANYON II U USA 15-15	2,645	6,136	3,900	4,300	60	M		15	18S	22E
43-019-30770	DIAMOND CANYON II U USA 15-15	2,645	6,136	4,300	4,950	100	M		15	18S	22E
43-019-30770	DIAMOND CANYON II U USA 15-15	2,645	6,136	4,950	5,300	50	M		15	18S	22E
43-019-30770	DIAMOND CANYON II U USA 15-15	2,645	6,136	5,300	5,650	100	M	note: trip gas composition	15	18S	22E
43-019-30770	DIAMOND CANYON II U USA 15-15	2,645	6,136	5,650	6,050	500	M		15	18S	22E
43-019-30770	DIAMOND CANYON II U USA 15-15	2,820	6,139	4,450	4,450	900	M	connection gas	15	18S	22E
43-019-30770	DIAMOND CANYON II U USA 15-15	2,820	6,139	5,330	5,330	1,350	M	tg; C1:25,000; C2: 1,730; C3: 780; C4: 9	15	18S	22E
43-019-30835	BUTLER CYN UNIT USA 33-12	<2,800	4,492	2,800	4,200	20	M	uniform gas counts	33	19S	17E
43-019-30835	BUTLER CYN UNIT USA 33-12	<2,800	4,492	4,200	4,480	20	M	uniform gas counts	33	19S	17E
43-019-31063	FEDERAL 12-42	0	3,776	1,210	1,215	100	M		12	21S	18E
43-019-31063	FEDERAL 12-42	0	3,776	1,215	1,730	15	M		12	21S	18E
43-019-31063	FEDERAL 12-42	0	3,776	1,730	1,765	20	M		12	21S	18E
43-019-31063	FEDERAL 12-42	0	3,776	1,765	2,090	15	M		12	21S	18E
43-019-31063	FEDERAL 12-42	0	3,776	2,090	2,200	12	M		12	21S	18E
43-019-31063	FEDERAL 12-42	0	3,776	2,200	3,180	14	M		12	21S	18E
43-019-31063	FEDERAL 12-42	0	3,776	3,180	3,775	12	M		12	21S	18E
43-019-31231	FEDERAL 8-10	418	3,874	3,000	3,340	9	M		8	17S	25E
43-019-31231	FEDERAL 8-10	418	3,874	3,340	3,430	20	M		8	17S	25E
43-019-31231	FEDERAL 8-10	418	3,874	3,600	3,800	30	M		8	17S	25E
43-019-31236	FEDERAL 17-3	0	3,803	3,600	3,710	45	M		17	17S	25E
43-019-31237	FEDERAL 16-3	0	3,560	700	1,400	10	M		16	17S	25E
43-019-31237	FEDERAL 16-3	0	3,560	1,400	1,600	20	M		16	17S	25E
43-019-31237	FEDERAL 16-3	0	3,560	1,600	1,800	30	M		16	17S	25E
43-019-31237	FEDERAL 16-3	0	3,560	1,800	2,750	20	M		16	17S	25E
43-019-31237	FEDERAL 16-3	0	3,560	2,750	2,780	50	M		16	17S	25E
43-019-31237	FEDERAL 16-3	0	3,560	2,780	3,350	30	M		16	17S	25E

API well number	Well name	Top Mancos	Base Mancos	Zone top	Zone base	Gas units	Fm.	Comment	Sec	T	R
43-019-31237	FEDERAL 16-3	0	3,560	3,350	3,520	40	M		16	17S	25E
43-019-31241	FEDERAL 11-10	<1950	4,483	1,950	4,450	20	M	uniform gas counts	11	17S	24E
43-019-31394	STATE 1-32	0	2,418	1,330	1,470	20	M		32	21S	19E
43-019-31394	STATE 1-32	0	2,418	1,470	2,275	10	M		32	21S	19E
43-019-31394	STATE 1-32	0	2,418	2,275	2,380	20	M		32	21S	19E
43-019-31397	HORSE POINT ST 1-34	4,496	7,431	4,550	4,580	1,600	M	2,700u peak value	34	15S	23E
43-019-31397	HORSE POINT ST 1-34	4,496	7,431	4,600	4,640	1,700	M	2,391u peak value	34	15S	23E
43-019-31397	HORSE POINT ST 1-34	4,496	7,431	4,650	4,700	2,100	M	2,483u peak value	34	15S	23E
43-019-31397	HORSE POINT ST 1-34	4,496	7,431	4,700	4,760	2,200	M		34	15S	23E
43-019-31397	HORSE POINT ST 1-34	4,496	7,431	4,880	4,940	1,900	M		34	15S	23E
43-019-31397	HORSE POINT ST 1-34	4,496	7,431	5,100	5,280	200	M		34	15S	23E
43-019-31397	HORSE POINT ST 1-34	4,496	7,431	5,320	5,720	1,500	M		34	15S	23E
43-019-31397	HORSE POINT ST 1-34	4,496	7,431	5,720	5,870	1,200	M		34	15S	23E
43-019-31397	HORSE POINT ST 1-34	4,496	7,431	5,870	6,020	1,500	M		34	15S	23E
43-019-31397	HORSE POINT ST 1-34	4,496	7,431	6,050	6,230	3,800	M		34	15S	23E
43-019-31397	HORSE POINT ST 1-34	4,496	7,431	6,275	6,320	2,200	M		34	15S	23E
43-019-31397	HORSE POINT ST 1-34	4,496	7,431	6,375	6,490	3,000	M		34	15S	23E
43-019-31397	HORSE POINT ST 1-34	4,496	7,431	6,610	6,980	2,900	M		34	15S	23E
43-019-31397	HORSE POINT ST 1-34	4,496	7,431	6,980	7,180	1,500	M		34	15S	23E
43-019-31397	HORSE POINT ST 1-34	4,496	7,431	7,180	7,220	3,000	M		34	15S	23E
43-019-31397	HORSE POINT ST 1-34	4,496	7,431	7,220	7,400	2,000	M		34	15S	23E
43-041-11136	EMERY UNIT 1	0	2,500	645	650	16	BG	spike	34	22S	05E
43-041-11136	EMERY UNIT 1	0	2,500	765	780	30	BG	spike	34	22S	05E
43-041-11136	EMERY UNIT 1	0	2,500	780	830	14	BG		34	22S	05E
43-041-11136	EMERY UNIT 1	0	2,500	830	960	6	BG		34	22S	05E
43-041-11136	EMERY UNIT 1	0	2,500	960	990	38	BG		34	22S	05E
43-041-11136	EMERY UNIT 1	0	2,500	990	1,020	20	BG		34	22S	05E
43-041-11136	EMERY UNIT 1	0	2,500	1,020	1,090	12	BG		34	22S	05E
43-041-11136	EMERY UNIT 1	0	2,500	1,090	1,095	20	BG	conn. Gas	34	22S	05E
43-041-11136	EMERY UNIT 1	0	2,500	1,095	1,165	10	BG		34	22S	05E
43-041-11136	EMERY UNIT 1	0	2,500	1,165	1,170	25	BG		34	22S	05E
43-041-11136	EMERY UNIT 1	0	2,500	1,170	1,240	6	BG		34	22S	05E
43-047-30978	TRAPP SP 13-25-14-23	5,634	8,886	5,640	5,780	10	M		25	14S	23E
43-047-30978	TRAPP SP 13-25-14-23	5,634	8,886	5,780	5,800	15	M		25	14S	23E
43-047-30978	TRAPP SP 13-25-14-23	5,634	8,886	5,800	5,824	90	M		25	14S	23E
43-047-30978	TRAPP SP 13-25-14-23	5,634	8,886	5,824	5,882	10	M		25	14S	23E
43-047-30978	TRAPP SP 13-25-14-23	5,634	8,886	5,882	5,892	80	M		25	14S	23E
43-047-30978	TRAPP SP 13-25-14-23	5,634	8,886	6,036	6056	60	M		25	14S	23E
43-047-30978	TRAPP SP 13-25-14-23	5,634	8,886	6,056	6,580	10	M		25	14S	23E
43-047-30978	TRAPP SP 13-25-14-23	5,634	8,886	6,580	6,850	75	M		25	14S	23E
43-047-30978	TRAPP SP 13-25-14-23	5,634	8,886	6,850	8,040	5	M		25	14S	23E
43-047-30978	TRAPP SP 13-25-14-23	5,634	8,886	8,040	8,050	100	M		25	14S	23E
43-047-30978	TRAPP SP 13-25-14-23	5,634	8,886	8,050	8,090	50	M		25	14S	23E
43-047-30978	TRAPP SP 13-25-14-23	5,634	8,886	8,090	8,510	5	M		25	14S	23E
43-047-32605	EVACUATION CREEK 24-12-25 1	3,364	4692 TD	3,370	3,500	15	M	conn. gas spikes to 60 u	24	12S	25E
43-047-32605	EVACUATION CREEK 24-12-25 1	3,364	4692 TD	3,500	3,700	20		conn. gas spikes to 90 u	24	12S	25E
43-047-32605	EVACUATION CREEK 24-12-25 1	3,364	4692 TD	3,700	3,860	20		conn. gas spikes to 85 u	24	12S	25E
43-047-32605	EVACUATION CREEK 24-12-25 1	3,364	4692 TD	3,860	4,100	200		conn. gas spikes to 1753 u; flares	24	12S	25E
43-047-32605	EVACUATION CREEK 24-12-25 1	3,364	4692 TD	4,100	4,380	200		conn. gas spikes to 1300 u; flares	24	12S	25E
43-047-32605	EVACUATION CREEK 24-12-25 1	3,364	4692 TD	4,380	4,690	200		conn. gas spikes to 680 u	24	12S	25E
43-047-33312	ROCK HOUSE 11-31	8,322	8600 TD	8,350	8,490	200	PC		31	10S	23E
43-047-33312	ROCK HOUSE 11-31	8,322	8600 TD	8,495	8,500	1,050	PC		31	10S	23E
43-047-33312	ROCK HOUSE 11-31	8,322	8600 TD	8,505	8,515	1,500	PC	spike	31	10S	23E
43-047-33312	ROCK HOUSE 11-31	8,322	8600 TD	8,515	8,550	500	PC		31	10S	23E
43-047-33312	ROCK HOUSE 11-31	8,322	8600 TD	8,550	8,560	325	PC		31	10S	23E
43-047-34552	N HILL CREEK 4-10-15-20	6,390	6513 TD	6,390	6,440	6,000	MB		10	15S	20E
43-047-34552	N HILL CREEK 4-10-15-20	6,390	6513 TD	6,446	6,452	7,400	MB		10	15S	20E
43-047-34552	N HILL CREEK 4-10-15-20	6,390	6513 TD	6,452	6,474	5,500	MB		10	15S	20E
43-047-34552	N HILL CREEK 4-10-15-20	6,390	6513 TD	6,476	6,480	8,000	MB		10	15S	20E
43-047-34552	N HILL CREEK 4-10-15-20	6,390	6513 TD	6,488	6,510	6,000	MB		10	15S	20E
43-047-34742	N HILL CREEK 1-9-15-20	6,360	10,210	6,440	6,570	200	M		9	15S	20E
43-047-34742	N HILL CREEK 1-9-15-20	6,360	10,210	6,570	6,576	748	M	spike	9	15S	20E
43-047-34742	N HILL CREEK 1-9-15-20	6,360	10,210	6,580	6,985	200	M		9	15S	20E
43-047-34742	N HILL CREEK 1-9-15-20	6,360	10,210	6,985	7,425	100	M		9	15S	20E
43-047-34742	N HILL CREEK 1-9-15-20	6,360	10,210	7,425	7,490	70	M		9	15S	20E
43-047-34742	N HILL CREEK 1-9-15-20	6,360	10,210	7,490	8,420	10	M		9	15S	20E
43-047-34742	N HILL CREEK 1-9-15-20	6,360	10,210	8,420	8,440	300	M		9	15S	20E
43-047-34742	N HILL CREEK 1-9-15-20	6,360	10,210	8,440	8,450	1,001	M	spike	9	15S	20E
43-047-34742	N HILL CREEK 1-9-15-20	6,360	10,210	8,450	8,470	600	M		9	15S	20E
43-047-34742	N HILL CREEK 1-9-15-20	6,360	10,210	8,475	8,480	6,574	M	spike	9	15S	20E
43-047-34742	N HILL CREEK 1-9-15-20	6,360	10,210	8,480	8,510	400	M		9	15S	20E
43-047-34742	N HILL CREEK 1-9-15-20	6,360	10,210	8,510	8,600	50	M		9	15S	20E
43-047-34742	N HILL CREEK 1-9-15-20	6,360	10,210	8,600	9,000	200	M		9	15S	20E
43-047-34742	N HILL CREEK 1-9-15-20	6,360	10,210	9,000	9,240	100	M		9	15S	20E
43-047-34742	N HILL CREEK 1-9-15-20	6,360	10,210	9,242	9,290	50	M		9	15S	20E
43-047-34742	N HILL CREEK 1-9-15-20	6,360	10,210	9,290	9,380	150	M		9	15S	20E
43-047-34742	N HILL CREEK 1-9-15-20	6,360	10,210	9,380	9,445	50	M		9	15S	20E
43-047-34742	N HILL CREEK 1-9-15-20	6,360	10,210	9,445	9,575	100	M		9	15S	20E
43-047-34742	N HILL CREEK 1-9-15-20	6,360	10,210	9,575	9,820	220	M		9	15S	20E
43-047-34742	N HILL CREEK 1-9-15-20	6,360	10,210	9,820	9,950	50	M		9	15S	20E
43-047-34742	N HILL CREEK 1-9-15-20	6,360	10,210	9,950	10,200	200	M		9	15S	20E
43-047-34742	N HILL CREEK 1-9-15-20	6,480	10,210	6,440	6,570	200	M		9	15S	20E
43-047-34742	N HILL CREEK 1-9-15-20	6,480	10,210	6,570	6,575	748	M	spike	9	15S	20E
43-047-34742	N HILL CREEK 1-9-15-20	6,480	10,210	6,575	6,985	200	M		9	15S	20E
43-047-34742	N HILL CREEK 1-9-15-20	6,480	10,210	6,985	7,440	100	M		9	15S	20E
43-047-34742	N HILL CREEK 1-9-15-20	6,480	10,210	7,440	7,490	60	M		9	15S	20E
43-047-34742	N HILL CREEK 1-9-15-20	6,480	10,210	7,490	8,420	10	M		9	15S	20E
43-047-34742	N HILL CREEK 1-9-15-20	6,480	10,210	8,420	8,440	350	M		9	15S	20E
43-047-34742	N HILL CREEK 1-9-15-20	6,480	10,210	8,445	8,450	1,011	M	spike	9	15S	20E
43-047-34742	N HILL CREEK 1-9-15-20	6,480	10,210	8,450	8,475	450	M		9	15S	20E
43-047-34742	N HILL CREEK 1-9-15-20	6,480	10,210	8,475	8,480	6,574	M	spike; DTG	9	15S	20E
43-047-34742	N HILL CREEK 1-9-15-20	6,480	10,210	8,480	8,510	400	M		9	15S	20E
43-047-34742	N HILL CREEK 1-9-15-20	6,480	10,210	8,530	8,605	40	M		9	15S	20E
43-047-34742	N HILL CREEK 1-9-15-20	6,480	10,210	8,605	8,810	300	M		9	15S	20E
43-047-34742	N HILL CREEK 1-9-15-20	6,480	10,210	8,810	9,000	220	M		9	15S	20E

API well number	Well name	Top Mancos	Base Mancos	Zone top	Zone base	Gas units	Fm.	Comment	Sec	T	R
43-047-34742	N HILL CREEK 1-9-15-20	6,480	10,210	9,000	9,070	150	M		9	15S	20E
43-047-34742	N HILL CREEK 1-9-15-20	6,480	10,210	9,070	9,200	100	M		9	15S	20E
43-047-34742	N HILL CREEK 1-9-15-20	6,480	10,210	9,205	9,215	755	M	spike	9	15S	20E
43-047-34742	N HILL CREEK 1-9-15-20	6,480	10,210	9,215	9,300	20	M		9	15S	20E
43-047-34742	N HILL CREEK 1-9-15-20	6,480	10,210	9,300	9,410	150	M		9	15S	20E
43-047-34742	N HILL CREEK 1-9-15-20	6,480	10,210	9,445	9,580	120	M		9	15S	20E
43-047-34742	N HILL CREEK 1-9-15-20	6,480	10,210	9,580	9,800	250	M		9	15S	20E
43-047-34742	N HILL CREEK 1-9-15-20	6,480	10,210	9,800	9,930	30	M		9	15S	20E
43-047-34742	N HILL CREEK 1-9-15-20	6,480	10,210	9,930	10,205	200	M		9	15S	20E
43-047-34922	N HILL CREEK 4-1-15-20	6,322	10,144	6,330	6,385	50	M		1	15S	20E
43-047-34922	N HILL CREEK 4-1-15-20	6,322	10,144	6,385	6,550	150	M		1	15S	20E
43-047-34922	N HILL CREEK 4-1-15-20	6,322	10,144	6,550	6,825	200	M		1	15S	20E
43-047-34922	N HILL CREEK 4-1-15-20	6,322	10,144	6,825	6,850	250	M		1	15S	20E
43-047-34922	N HILL CREEK 4-1-15-20	6,322	10,144	6,865	6,870	600	M		1	15S	20E
43-047-34922	N HILL CREEK 4-1-15-20	6,322	10,144	6,880	6,980	150	M		1	15S	20E
43-047-34922	N HILL CREEK 4-1-15-20	6,322	10,144	6,980	7,200	250	M		1	15S	20E
43-047-34922	N HILL CREEK 4-1-15-20	6,322	10,144	7,025	7,030	446	M	spike	1	15S	20E
43-047-34922	N HILL CREEK 4-1-15-20	6,322	10,144	7,035	7,265	150	M		1	15S	20E
43-047-34922	N HILL CREEK 4-1-15-20	6,322	10,144	7,268	7,272	2,112	M	spike	1	15S	20E
43-047-34922	N HILL CREEK 4-1-15-20	6,322	10,144	7,275	7,485	200	M		1	15S	20E
43-047-34922	N HILL CREEK 4-1-15-20	6,322	10,144	7,488	7,490	2,883	M	spike	1	15S	20E
43-047-34922	N HILL CREEK 4-1-15-20	6,322	10,144	7,490	7,800	250	M		1	15S	20E
43-047-34922	N HILL CREEK 4-1-15-20	6,322	10,144	7,800	8,100	500	M		1	15S	20E
43-047-34922	N HILL CREEK 4-1-15-20	6,322	10,144	8,100	8,140	750	M		1	15S	20E
43-047-34922	N HILL CREEK 4-1-15-20	6,322	10,144	8,140	8,170	1,000	M		1	15S	20E
43-047-34922	N HILL CREEK 4-1-15-20	6,322	10,144	8,170	8,230	1,800	M		1	15S	20E
43-047-34922	N HILL CREEK 4-1-15-20	6,322	10,144	8,230	8,305	1,200	M		1	15S	20E
43-047-34922	N HILL CREEK 4-1-15-20	6,322	10,144	8,305	8,320	7,485	M	spike	1	15S	20E
43-047-34922	N HILL CREEK 4-1-15-20	6,322	10,144	8,330	8,345	1,000	M		1	15S	20E
43-047-34922	N HILL CREEK 4-1-15-20	6,322	10,144	8,345	8,350	4,182	M	spike	1	15S	20E
43-047-34922	N HILL CREEK 4-1-15-20	6,322	10,144	8,350	8,380	750	M		1	15S	20E
43-047-34922	N HILL CREEK 4-1-15-20	6,322	10,144	8,382	8,385	2,644	M	spike	1	15S	20E
43-047-34922	N HILL CREEK 4-1-15-20	6,322	10,144	8,385	8,440	900	M		1	15S	20E
43-047-34922	N HILL CREEK 4-1-15-20	6,322	10,144	8,440	8,442	2,715	M	spike	1	15S	20E
43-047-34922	N HILL CREEK 4-1-15-20	6,322	10,144	8,445	8,640	1,500	M		1	15S	20E
43-047-34922	N HILL CREEK 4-1-15-20	6,322	10,144	8,640	8,925	1,300	M		1	15S	20E
43-047-34922	N HILL CREEK 4-1-15-20	6,322	10,144	8,925	8,935	3,962	M	spike	1	15S	20E
43-047-34922	N HILL CREEK 4-1-15-20	6,322	10,144	8,935	8,990	1,700	M		1	15S	20E
43-047-34922	N HILL CREEK 4-1-15-20	6,322	10,144	8,990	9,180	1,200	M		1	15S	20E
43-047-34922	N HILL CREEK 4-1-15-20	6,322	10,144	9,130	9,270	1,000	M		1	15S	20E
43-047-34922	N HILL CREEK 4-1-15-20	6,322	10,144	9,275	9,290	9,064	M	spike	1	15S	20E
43-047-34922	N HILL CREEK 4-1-15-20	6,322	10,144	9,305	9,325	7,335	M	image	1	15S	20E
43-047-34922	N HILL CREEK 4-1-15-20	6,322	10,144	9,330	9,525	500	M		1	15S	20E
43-047-34922	N HILL CREEK 4-1-15-20	6,322	10,144	9,530	9,545	2,664	M	spike	1	15S	20E
43-047-34922	N HILL CREEK 4-1-15-20	6,322	10,144	9,560	9,600	1,000	M		1	15S	20E
43-047-34922	N HILL CREEK 4-1-15-20	6,322	10,144	9,600	9,800	500	M		1	15S	20E
43-047-34922	N HILL CREEK 4-1-15-20	6,322	10,144	9,800	9,880	1,500	M		1	15S	20E
43-047-34922	N HILL CREEK 4-1-15-20	6,322	10,144	9,885	9,895	6,923	M	spike	1	15S	20E
43-047-34922	N HILL CREEK 4-1-15-20	6,322	10,144	9,895	9,955	6,000	M		1	15S	20E
43-047-34922	N HILL CREEK 4-1-15-20	6,322	10,144	9,960	10,035	4,500	M		1	15S	20E
43-047-34922	N HILL CREEK 4-1-15-20	6,322	10,144	10,035	10,100	400	M		1	15S	20E
43-047-34953	N HILL CREEK 14-11-15-20	6,275	10,100	6,230	6,390	50	M		11	15S	20E
43-047-34953	N HILL CREEK 14-11-15-20	6,275	10,100	6,390	6,425	600	M		11	15S	20E
43-047-34953	N HILL CREEK 14-11-15-20	6,275	10,100	6,425	6,495	400	M		11	15S	20E
43-047-34953	N HILL CREEK 14-11-15-20	6,275	10,100	6,495	6,555	100	M		11	15S	20E
43-047-34953	N HILL CREEK 14-11-15-20	6,275	10,100	6,555	6,570	600	M		11	15S	20E
43-047-34953	N HILL CREEK 14-11-15-20	6,275	10,100	6,570	6,740	220	M		11	15S	20E
43-047-34953	N HILL CREEK 14-11-15-20	6,275	10,100	6,750	6,765	1,475	M	spike	11	15S	20E
43-047-34953	N HILL CREEK 14-11-15-20	6,275	10,100	6,765	6,780	600	M		11	15S	20E
43-047-34953	N HILL CREEK 14-11-15-20	6,275	10,100	6,780	6,840	400	M		11	15S	20E
43-047-34953	N HILL CREEK 14-11-15-20	6,275	10,100	6,840	6,900	700	M		11	15S	20E
43-047-34953	N HILL CREEK 14-11-15-20	6,275	10,100	6,900	6,915	1,077	M	spike	11	15S	20E
43-047-34953	N HILL CREEK 14-11-15-20	6,275	10,100	6,920	7,100	400	M		11	15S	20E
43-047-34953	N HILL CREEK 14-11-15-20	6,275	10,100	7,100	7,335	200	M		11	15S	20E
43-047-34953	N HILL CREEK 14-11-15-20	6,275	10,100	7,335	7,395	350	M		11	15S	20E
43-047-34953	N HILL CREEK 14-11-15-20	6,275	10,100	7,395	7,600	200	M		11	15S	20E
43-047-34953	N HILL CREEK 14-11-15-20	6,275	10,100	7,600	7,635	1,000	M		11	15S	20E
43-047-34953	N HILL CREEK 14-11-15-20	6,275	10,100	7,635	7,650	1,800	M		11	15S	20E
43-047-34953	N HILL CREEK 14-11-15-20	6,275	10,100	7,650	7,660	5,405	M	spike	11	15S	20E
43-047-34953	N HILL CREEK 14-11-15-20	6,275	10,100	7,670	7,740	1,000	M		11	15S	20E
43-047-34953	N HILL CREEK 14-11-15-20	6,275	10,100	7,740	8,125	500	M		11	15S	20E
43-047-34953	N HILL CREEK 14-11-15-20	6,275	10,100	8,125	8,135	3,866	M	spike	11	15S	20E
43-047-34953	N HILL CREEK 14-11-15-20	6,275	10,100	8,145	8,325	500	M		11	15S	20E
43-047-34953	N HILL CREEK 14-11-15-20	6,275	10,100	8,325	8,450	1,000	M		11	15S	20E
43-047-34953	N HILL CREEK 14-11-15-20	6,275	10,100	8,450	8,540	1,500	M		11	15S	20E
43-047-34953	N HILL CREEK 14-11-15-20	6,275	10,100	8,540	8,750	1,000	M		11	15S	20E
43-047-34953	N HILL CREEK 14-11-15-20	6,275	10,100	8,765	8,775	4,559	M	spike	11	15S	20E
43-047-34953	N HILL CREEK 14-11-15-20	6,275	10,100	8,775	8,815	1,600	M		11	15S	20E
43-047-34953	N HILL CREEK 14-11-15-20	6,275	10,100	8,815	8,855	1,300	M		11	15S	20E
43-047-34953	N HILL CREEK 14-11-15-20	6,275	10,100	8,855	8,950	750	M		11	15S	20E
43-047-34953	N HILL CREEK 14-11-15-20	6,275	10,100	8,950	9,365	600	M		11	15S	20E
43-047-34953	N HILL CREEK 14-11-15-20	6,275	10,100	9,365	9,380	2,555	M	spike	11	15S	20E
43-047-34953	N HILL CREEK 14-11-15-20	6,275	10,100	9,380	9,430	1,000	M		11	15S	20E
43-047-34953	N HILL CREEK 14-11-15-20	6,275	10,100	9,430	9,465	650	M		11	15S	20E
43-047-34953	N HILL CREEK 14-11-15-20	6,275	10,100	9,465	9,680	200	M		11	15S	20E
43-047-34953	N HILL CREEK 14-11-15-20	6,275	10,100	9,680	9,745	400	M		11	15S	20E
43-047-34953	N HILL CREEK 14-11-15-20	6,275	10,100	9,745	9,750	1,844	M		11	15S	20E
43-047-34953	N HILL CREEK 14-11-15-20	6,275	10,100	9,750	9,780	750	M		11	15S	20E
43-047-34953	N HILL CREEK 14-11-15-20	6,275	10,100	9,780	9,795	1,786	M	spike	11	15S	20E
43-047-34953	N HILL CREEK 14-11-15-20	6,275	10,100	9,820	9,830	1,732	M	spike	11	15S	20E
43-047-34953	N HILL CREEK 14-11-15-20	6,275	10,100	9,830	9,885	1,300	M		11	15S	20E
43-047-34953	N HILL CREEK 14-11-15-20	6,275	10,100	9,890	9,910	500	M		11	15S	20E
43-047-34953	N HILL CREEK 14-11-15-20	6,275	10,100	9,910	9,920	1,308	M	spike	11	15S	20E
43-047-34953	N HILL CREEK 14-11-15-20	6,275	10,100	9,920	9,935	800	M		11	15S	20E
43-047-34953	N HILL CREEK 14-11-15-20	6,275	10,100	9,935	10,005	200	M		11	15S	20E

API well number	Well name	Top Mancos	Base Mancos	Zone top	Zone base	Gas units	Fm.	Comment	Sec	T	R
43-047-34953	N HILL CREEK 14-11-15-20	6,275	10,100	10,005	10,030	1,138	M		11	15S	20E
43-047-34953	N HILL CREEK 14-11-15-20	6,275	10,100	10,040	10,100	180	M		11	15S	20E
43-047-35054	NHC 4-13-15-20	6,209	9,896	6,210	6,302	100	M		13	15S	20E
43-047-35054	NHC 4-13-15-20	6,209	9,896	6,320	6,330	1,100	M		13	15S	20E
43-047-35054	NHC 4-13-15-20	6,209	9,896	6,330	6,340	2,345	M	spike	13	15S	20E
43-047-35054	NHC 4-13-15-20	6,209	9,896	6,340	6,410	800	M		13	15S	20E
43-047-35054	NHC 4-13-15-20	6,209	9,896	6,410	6,420	1,400	M		13	15S	20E
43-047-35054	NHC 4-13-15-20	6,209	9,896	6,420	6,485	1,000	M		13	15S	20E
43-047-35054	NHC 4-13-15-20	6,209	9,896	6,490	6,525	100	M		13	15S	20E
43-047-35054	NHC 4-13-15-20	6,209	9,896	6,535	6,660	800	M		13	15S	20E
43-047-35054	NHC 4-13-15-20	6,209	9,896	6,660	6,685	1,400	M		13	15S	20E
43-047-35054	NHC 4-13-15-20	6,209	9,896	6,685	6,820	1,000	M		13	15S	20E
43-047-35054	NHC 4-13-15-20	6,209	9,896	6,820	6,830	2,000	M		13	15S	20E
43-047-35054	NHC 4-13-15-20	6,209	9,896	6,830	7,160	600	M		13	15S	20E
43-047-35054	NHC 4-13-15-20	6,209	9,896	7,160	7,260	500	M		13	15S	20E
43-047-35054	NHC 4-13-15-20	6,209	9,896	7,260	7,515	1,000	M		13	15S	20E
43-047-35054	NHC 4-13-15-20	6,209	9,896	7,515	7,525	3,891	M	spike	13	15S	20E
43-047-35054	NHC 4-13-15-20	6,209	9,896	7,525	7,590	1,800	M		13	15S	20E
43-047-35054	NHC 4-13-15-20	6,209	9,896	7,625	7,685	8,390	M	spike; image	13	15S	20E
43-047-35054	NHC 4-13-15-20	6,209	9,896	7,700	7,725	1,500	M		13	15S	20E
43-047-35054	NHC 4-13-15-20	6,209	9,896	7,725	7,740	7,500	M	spike	13	15S	20E
43-047-35054	NHC 4-13-15-20	6,209	9,896	7,740	7,840	4,000	M		13	15S	20E
43-047-35054	NHC 4-13-15-20	6,209	9,896	7,840	7,915	1,500	M		13	15S	20E
43-047-35054	NHC 4-13-15-20	6,209	9,896	7,915	7,925	7,000	M	spike	13	15S	20E
43-047-35054	NHC 4-13-15-20	6,209	9,896	7,925	7,990	2,500	M		13	15S	20E
43-047-35054	NHC 4-13-15-20	6,209	9,896	7,990	8,005	7,800	M	spike	13	15S	20E
43-047-35054	NHC 4-13-15-20	6,209	9,896	8,030	8,165	4,000	M		13	15S	20E
43-047-35054	NHC 4-13-15-20	6,209	9,896	8,165	8,500	1,000	M		13	15S	20E
43-047-35054	NHC 4-13-15-20	6,209	9,896	8,200	8,345	7,000	M		13	15S	20E
43-047-35054	NHC 4-13-15-20	6,209	9,896	8,345	8,405	3,000	M		13	15S	20E
43-047-35054	NHC 4-13-15-20	6,209	9,896	8,405	8,415	7,500	M	spike	13	15S	20E
43-047-35054	NHC 4-13-15-20	6,209	9,896	8,420	8,425	8,000	M		13	15S	20E
43-047-35054	NHC 4-13-15-20	6,209	9,896	8,435	8,665	4,000	M		13	15S	20E
43-047-35054	NHC 4-13-15-20	6,209	9,896	8,665	8,680	8,000	M		13	15S	20E
43-047-35054	NHC 4-13-15-20	6,209	9,896	8,690	8,800	3,500	M		13	15S	20E
43-047-35054	NHC 4-13-15-20	6,209	9,896	8,800	9,165	4,000	M		13	15S	20E
43-047-35054	NHC 4-13-15-20	6,209	9,896	9,165	9,210	3,000	M		13	15S	20E
43-047-35054	NHC 4-13-15-20	6,209	9,896	9,210	9,235	7,000	M		13	15S	20E
43-047-35054	NHC 4-13-15-20	6,209	9,896	9,285	9,295	6,500	M		13	15S	20E
43-047-35054	NHC 4-13-15-20	6,209	9,896	9,300	9,550	2,000	M		13	15S	20E
43-047-35054	NHC 4-13-15-20	6,209	9,896	9,550	9,640	4,000	M		13	15S	20E
43-047-35054	NHC 4-13-15-20	6,209	9,896	9,640	9,680	6,000	M		13	15S	20E
43-047-35054	NHC 4-13-15-20	6,209	9,896	9,680	9,810	4,000	M		13	15S	20E
43-047-35054	NHC 4-13-15-20	6,209	9,896	9,810	9,880	2,000	M		13	15S	20E
43-047-35054	NHC 4-13-15-20	6,209	9,896	9,885	9,895	6,887	M	spike	13	15S	20E
43-047-35140	NHC 1-6-15-20	6,828	10,587	7,850	8,100	50	M	chromograph fixed, no data above	5	15S	20E
43-047-35140	NHC 1-6-15-20	6,828	10,587	8,100	8,630	30	M		5	15S	20E
43-047-35140	NHC 1-6-15-20	6,828	10,587	8,800	8,940	30	M		5	15S	20E
43-047-35140	NHC 1-6-15-20	6,828	10,587	9,660	9,720	100	M		5	15S	20E
43-047-35140	NHC 1-6-15-20	6,828	10,587	9,720	9,750	250	M		5	15S	20E
43-047-35140	NHC 1-6-15-20	6,828	10,587	9,770	9,800	150	M		5	15S	20E
43-047-35140	NHC 1-6-15-20	6,828	10,587	9,820	9,930	400	M		5	15S	20E
43-047-35140	NHC 1-6-15-20	6,828	10,587	9,930	10,000	300	M		5	15S	20E
43-047-35140	NHC 1-6-15-20	6,828	10,587	10,000	10,130	400	M		5	15S	20E
43-047-35140	NHC 1-6-15-20	6,828	10,587	10,130	10,500	500	M		5	15S	20E
43-047-35140	NHC 1-6-15-20	6,828	10,587	10,500	10,550	900	M		5	15S	20E
43-047-35140	NHC 1-6-15-20	6,828	10,587	7,850	8,100	50	M		6	15S	20E
43-047-35140	NHC 1-6-15-20	6,828	10,587	8,100	8,630	30	M		6	15S	20E
43-047-35140	NHC 1-6-15-20	6,828	10,587	8,800	8,940	30	M		6	15S	20E
43-047-35140	NHC 1-6-15-20	6,828	10,587	9,660	9,720	100	M		6	15S	20E
43-047-35140	NHC 1-6-15-20	6,828	10,587	9,720	9,750	250	M	spike	6	15S	20E
43-047-35140	NHC 1-6-15-20	6,828	10,587	9,770	9,800	150	M		6	15S	20E
43-047-35140	NHC 1-6-15-20	6,828	10,587	9,820	9,930	400	M		6	15S	20E
43-047-35140	NHC 1-6-15-20	6,828	10,587	9,930	10,000	300	M		6	15S	20E
43-047-35140	NHC 1-6-15-20	6,828	10,587	10,000	10,130	400	M	increase downward	6	15S	20E
43-047-35140	NHC 1-6-15-20	6,828	10,587	10,130	10,500	500	M	increase downward	6	15S	20E
43-047-35140	NHC 1-6-15-20	6,828	10,587	10,500	10,550	900	M	increase downward	6	15S	20E
43-047-35283	N HILL CREEK 2-12-15-20	6,312	10,039	6,350	6,450	250	M		12	15S	20E
43-047-35283	N HILL CREEK 2-12-15-20	6,312	10,039	6,450	6,455	1,500	M	spike	12	15S	20E
43-047-35283	N HILL CREEK 2-12-15-20	6,312	10,039	6,455	6,650	650	M		12	15S	20E
43-047-35283	N HILL CREEK 2-12-15-20	6,312	10,039	6,650	6,790	450	M		12	15S	20E
43-047-35283	N HILL CREEK 2-12-15-20	6,312	10,039	6,790	6,810	1,100	M	spike	12	15S	20E
43-047-35283	N HILL CREEK 2-12-15-20	6,312	10,039	6,810	7,100	900	M		12	15S	20E
43-047-35283	N HILL CREEK 2-12-15-20	6,312	10,039	7,100	7,200	600	M		12	15S	20E
43-047-35283	N HILL CREEK 2-12-15-20	6,312	10,039	7,200	7,260	500	M		12	15S	20E
43-047-35283	N HILL CREEK 2-12-15-20	6,312	10,039	7,260	7,285	750	M		12	15S	20E
43-047-35283	N HILL CREEK 2-12-15-20	6,312	10,039	7,300	7,630	1,000	M		12	15S	20E
43-047-35283	N HILL CREEK 2-12-15-20	6,312	10,039	7,630	7,810	2,200	M		12	15S	20E
43-047-35283	N HILL CREEK 2-12-15-20	6,312	10,039	7,810	7,900	9,000	M	image	12	15S	20E
43-047-35283	N HILL CREEK 2-12-15-20	6,312	10,039	7,900	7,980	7,000	M		12	15S	20E
43-047-35283	N HILL CREEK 2-12-15-20	6,312	10,039	7,980	8,400	7,500	M		12	15S	20E
43-047-35283	N HILL CREEK 2-12-15-20	6,312	10,039	8,400	8,580	6,500	M		12	15S	20E
43-047-35283	N HILL CREEK 2-12-15-20	6,312	10,039	8,580	8,760	6,000	M		12	15S	20E
43-047-35283	N HILL CREEK 2-12-15-20	6,312	10,039	8,760	9,040	5,000	M		12	15S	20E
43-047-35283	N HILL CREEK 2-12-15-20	6,312	10,039	9,040	9,200	4,000	M		12	15S	20E
43-047-35283	N HILL CREEK 2-12-15-20	6,312	10,039	9,200	9,340	3,000	M		12	15S	20E
43-047-35283	N HILL CREEK 2-12-15-20	6,312	10,039	9,340	9,365	7,000	M		12	15S	20E
43-047-35283	N HILL CREEK 2-12-15-20	6,312	10,039	9,365	9,475	5,000	M		12	15S	20E
43-047-35283	N HILL CREEK 2-12-15-20	6,312	10,039	9,490	9,760	2,500	M		12	15S	20E
43-047-35283	N HILL CREEK 2-12-15-20	6,312	10,039	9,760	9,840	5,000	M		12	15S	20E
43-047-35283	N HILL CREEK 2-12-15-20	6,312	10,039	9,840	9,975	6,000	M		12	15S	20E
43-047-35283	N HILL CREEK 2-12-15-20	6,312	10,039	9,975	10,020	3,500	M		12	15S	20E
43-047-35442	NHC 3-6-15-20X	6,550	10,422	9,320	9,330	1,532	M	gas show from fracture	6	15S	20E
43-047-35442	NHC 3-6-15-20X	6,550	10,422	9,974	9,978	6,415	M	gas show from fracture	6	15S	20E
43-047-35442	NHC 3-6-15-20X	6,550	10,422	10,129	10,133	6,884	M	gas show from fracture	6	15S	20E

API well number	Well name	Top Mancos	Base Mancos	Zone top	Zone base	Gas units	Fm.	Comment	Sec	T	R
43-047-35442	NHC 3-6-15-20X	6,550	10,422	10,213	10,218	3,918	M	gas show from fracture	6	15S	20E
43-047-35685	HORSE POINT ST 43-32	4,440	8,088	6,680	7,010	100	BG	range 80-120u	32	15S	23E
43-047-35685	HORSE POINT ST 43-32	4,440	8,088	7,010	7,020	143	BG		32	15S	23E
43-047-35685	HORSE POINT ST 43-32	4,440	8,088	7,020	7,150	20	BG		32	15S	23E
43-047-35685	HORSE POINT ST 43-32	4,440	8,088	7,150	7,510	100	BG	successive peaks >100u	32	15S	23E
43-047-35685	HORSE POINT ST 43-32	4,440	8,088	7,510	7,590	200	BG		32	15S	23E
43-047-35685	HORSE POINT ST 43-32	4,440	8,088	7,590	8,064	200	BG	peaks: 154u, 205u, 281u, 217u	32	15S	23E
43-047-35685	HORSE POINT ST 43-32	4,440	8,088	5,790	6,400	40	M	data below 5790' only	32	15S	23E
43-047-35685	HORSE POINT ST 43-32	4,440	8,088	6,660	6,730	60	M		32	15S	23E
43-047-35685	HORSE POINT ST 43-32	4,440	8,088	6,780	6,900	100	M		32	15S	23E
43-047-35685	HORSE POINT ST 43-32	4,440	8,088	6,990	7,020	140	M		32	15S	23E
43-047-35685	HORSE POINT ST 43-32	4,440	8,088	7,020	7,150	100	M		32	15S	23E
43-047-35685	HORSE POINT ST 43-32	4,440	8,088	7,480	7,510	100	M		32	15S	23E
43-047-35685	HORSE POINT ST 43-32	4,440	8,088	7,510	7,600	180	M		32	15S	23E
43-047-35685	HORSE POINT ST 43-32	4,440	8,088	7,600	7,680	110	M		32	15S	23E
43-047-35685	HORSE POINT ST 43-32	4,440	8,088	7,680	7,780	20	M		32	15S	23E
43-047-35685	HORSE POINT ST 43-32	4,440	8,088	7,780	7,980	250	M		32	15S	23E
43-047-35685	HORSE POINT ST 43-32	4,440	8,088	7,980	8,030	50	M		32	15S	23E

Appendix E

Natural gas flares in the Mancos Shale, exclusive of the sandstone- and coal-bearing Emery Sandstone and Ferron Sandstone Members.

Mancos

API well number	Well name	Top Mancos	Base Mancos	Depth	Observation	Sec	T	R	Source
43-007-30130	ST OF UT 25-9-1	0	>2200	1,130	30' flare from frac shale	25	14S	9E	DERL
43-007-30130	ST OF UT 25-9-1	0	>2200	1,160	25'-30' flare while drilling w/ 40' flare on conn.	25	14S	9E	DERL
43-007-30130	ST OF UT 25-9-1	0	>2200	1,220	flow calculated @ 3.2 mcfpd	25	14S	9E	DERL
43-007-30130	ST OF UT 25-9-1	0	>2200	1,225	30' flare while drilling w/ 40' flare on conn.	25	14S	9E	DERL
43-007-30130	ST OF UT 25-9-1	0	>2200	1,250	25'-30' flare while drilling w/ 40' flare on conn.	25	14S	9E	DERL
43-007-30130	ST OF UT 25-9-1	0	>2200	1,330	25'-30' flare while drilling	25	14S	9E	DERL
43-007-30130	ST OF UT 25-9-1	0	>2200	1,410	25'-30' flare while drilling	25	14S	9E	DERL
43-007-30130	ST OF UT 25-9-1	0	>2200	1,460	20'-25' flare	25	14S	9E	DERL
43-007-30156	ST OF UT 25-7-6	0	>2000	550	10' flare from CG gas	25	14S	9E	DERL
43-007-30156	ST OF UT 25-7-6	0	>2000	600	10' flare from CG gas	25	14S	9E	DERL
43-007-30156	ST OF UT 25-7-6	0	>2000	750	10' flare from CG gas	25	14S	9E	DERL
43-007-30156	ST OF UT 25-7-6	0	>2000	895	5'-10' flare from CG gas	25	14S	9E	DERL
43-007-30156	ST OF UT 25-7-6	0	>2000	1,030	5'-10' flare from CG gas	25	14S	9E	DERL
43-007-30156	ST OF UT 25-7-6	0	>2000	1,170	5'-10' flare from CG gas	25	14S	9E	DERL
43-007-30156	ST OF UT 25-7-6	0	>2000	1,260	5' flare from CG gas	25	14S	9E	DERL
43-015-30221	ORANGEVILLE U 4-1	0	3,060	1,036	15 ft flare 3 sec	1	18S	07E	USGS
43-015-30221	ORANGEVILLE U 4-1	0	3,060	2,404	20 ft flare for 8 sec; survey down 30 min	1	18S	07E	USGS
43-015-30221	ORANGEVILLE U 4-1	0	3,060	2,425	4 ft steady flare	1	18S	07E	USGS
43-015-30221	ORANGEVILLE U 4-1	0	3,060	2,435	39.2 mcfpd on 1/4' choke; 8 ft steady flare	1	18S	07E	USGS
43-019-30169	ANSCHUTZ STATE 428-1	5,070	8,760	7,638	flared 3.5 hours; gas trap on fire	5	16S	22E	DERL
43-019-30204	FEDERAL 614-1	5,910	9,441	8,521	5 sec gas flare	3	17S	21E	DERL
43-019-30204	FEDERAL 614-1	5,910	9,441	8,864	66 sec gas flare	3	17S	21E	DERL
43-019-30204	FEDERAL 614-1	5,910	9,441	8,964	20 sec gas flare	3	17S	21E	DERL
43-019-30343	FEDERAL 258	161	3,928	3,920	15 ft gas flare	5	18S	24E	DERL
43-019-30425	BAR CREEK UNIT 5	0	1,710	1,590	2 ft gas flare	30	17S	26E	DERL
43-019-30572	FEDERAL C-1	624	4,050	2,000	20-25 sec flare after trip	35	16S	25E	DERL
43-019-30639	VALENTINE FED 1	400	3,799	2,710	flare after survey 6 sec	35	16S	25E	DERL
43-019-30639	VALENTINE FED 1	400	3,799	2,960	flare after survey10 sec	35	16S	25E	DERL
43-019-30639	VALENTINE FED 1	400	3,799	3,240	flare after survey 5 sec	35	16S	25E	DERL
43-019-30639	VALENTINE FED 1	400	3,799	3,540	flare after fishing 20 hrs	35	16S	25E	DERL
43-019-30656	NICOR FEDERAL 1	na	5,825	3,905	also gas flares @ 5053', 5586' & 5734'	28	16S	25E	DERL
43-019-30657	GRYNBERG FEDERAL 1	2,300	5,664	3,145	flare while drilling 30sec; Prairie Canyon	28	16S	25E	DERL
43-019-30657	GRYNBERG FEDERAL 1	2,300	5,664	4,105	flare after trip 30; Blue Gate	28	16S	25E	DERL
43-019-30657	GRYNBERG FEDERAL 1	2,300	5,664	4,400	flare after trip 30 sec; Blue Gate	28	16S	25E	DERL
43-019-30657	GRYNBERG FEDERAL 1	2,300	5,664	5,395	flare after trip 30 sec; Blue Gate	28	16S	25E	DERL
43-019-30657	GRYNBERG FEDERAL 1	2,300	5,664	5,430	flare after survey 15 sec; Juana Lopez	28	16S	25E	DERL
43-019-30657	GRYNBERG FEDERAL 1	2,300	5,664	5,490	flare after survey 15 sec; Juana Lopez	28	16S	25E	DERL
43-019-30706	PETERSON SPRINGS UNIT 1	5,840	9,257	6,272	15 sec gas flare after 1 hr survey	14	17S	21E	DERL
43-019-30706	PETERSON SPRINGS UNIT 1	5,840	9,257	6,272	27 sec gas flare after 1 hr survey	14	17S	21E	DERL
43-019-30799	HOUGAN FED A-1 ST 1	2,040	5,015	2,960	flare after trip 45 sec	33	19S	24E	DERL
43-019-30799	HOUGAN FED A-1 ST 1	2,040	5,015	4,735	flare after trip 90 sec	33	19S	24E	DERL
43-019-30799	HOUGEN FED A-1 ST 1	2,040	5,015	2,950	flare after trip 45 sec; Prairie Canyon	14	17S	24E	DERL
43-019-30799	HOUGEN FED A-1 ST 1	2,040	5,015	4,740	flare after trip 90 sec; Juana Lopez	14	17S	24E	DERL
43-019-30892	WESTWATER FED B-1	3,270	5,240	4,650	8 ft flare for 30 sec	17	17S	24E	DERL
43-019-30892	WESTWATER FED B-1	3,270	5,240	4,895	8 ft flare for 45 sec	17	17S	24E	DERL
43-019-30892	WESTWATER FED B-1	3,270	5,240	4,955	6 ft flare for 45 sec	17	17S	24E	DERL
43-019-30892	WESTWATER FED B-1	3,270	5,240	4,985	6 ft flare for 30 sec	17	17S	24E	DERL
43-019-30892	WESTWATER FED B-1	3,270	5,240	5,015	8 ft flare for 45 sec	17	17S	24E	DERL
43-019-30892	WESTWATER FED B-1	3,270	5,240	5,050	8 ft flare for 45 sec	17	17S	24E	DERL
43-019-30892	WESTWATER FED B-1	3,270	5,240	5,120	15'-50' flare for 90 minutes	17	17S	24E	DERL
43-019-30892	WESTWATER FED B-1	3,270	5,240	5,125	20 ft flare for 90 sec	17	17S	24E	DERL
43-019-30892	WESTWATER FED B-1	3,270	5,240	5,235	22 ft flare for 115 sec	17	17S	24E	DERL
43-019-31009	VALENTINE FEDERAL 3	475	4,020	1,080	flare after survey 5 sec	35	16S	25E	DERL
43-019-31009	VALENTINE FEDERAL 3	475	4,020	2,880	flare after trip 15 sec	35	16S	25E	DERL
43-019-31009	VALENTINE FEDERAL 3	475	4,020	3,685	flare after trip 2 min	35	16S	25E	DERL
43-019-31009	VALENTINE FEDERAL 3	475	4,020	3,720	flare after trip 2 min	35	16S	25E	DERL
43-019-31151	LITTLE BERRY ST C 1	3,905	7,370	7,275	12 sec flare after air off for 45 min	2	16S	23E	DERL
43-019-31225	FEDERAL 14-2	<1000	4,355	4,109	10'-15' flare for 90 sec after bit trip	14	17S	24E	DERL
43-039-30004	UNITED STATES E 14171	4,171	9,758	8,804	gas kicks in Tununk Shale	27	19S	03E	DERL
43-041-11136	EMERY UNIT FED 1	0	2,500	980	1-2ft gas flame, blew down immediately	34	22S	05E	DERL
43-047-30619	CROOKED CANYON U 1	5,953	9,090	5,953	to 6,618 ft slight increase in background gas	17	14	23E	DOGM
43-047-30639	MAIN CYN 11-10-15-23	5,131	8,151	7,245	10 ft flare	10	15S	23E	DERL
43-047-34830	NHC 10-10-15-20	6,465	10,244	6,995	gas to 7009 ft; WCR	10	15S	20E	DOGM
43-047-34830	NHC 10-10-15-20	6,465	10,244	7,906	gas from fractures to 9173 ft; WCR	10	15S	20E	DOGM
43-047-34830	NHC 10-10-15-20	6,465	10,244	10,006	gas from fractures to 10,076 ft; WCR	10	15S	20E	DOGM
43-047-35442	NHC 3-6-15-20X	6,550	10,422	8,026	to 8,147 ft several gas shows to 1619 u	6	15S	20E	DOGM
43-049-35390	NHC 9-11-15-20	6,261	9,996	7,755	gas from fractures to 9156; WCR	11	15S	20E	DOGM

Appendix F

Gas tests in the black shale intervals of the Hermosa Group.

Hermosa

API well number	Well name	Unit	Hermosa top	Paradox	Hermoas base	Top interv	Base interv	Gas mcfpd	Time (hrs)	Orifice (in)	Water bwpd	Oil bopd	Oil °API	GOR	Source
43-019-15925	Long Canyon 1	CC	2,237	3,850	na	7,050	7,075	na	8.00	na	na	600	41.5°		DERL
43-019-31156	Mineral Canyon U 1-14	PX	4,406	7330 CC	7,482	6,055	6,063	139	22.00	0.11	0	197	37.5	702	DOGM
43-019-31310	Kanes Springs Fed 27-1	CC	na	na	8244 TVD	7,510	8,244	627	1.00	0.22	na	2302			DOGM
43-019-31310	Kanes Springs Fed 27-1	CC	na	na	8244 TVD	7,510	8,244	290	24.00	0.16	0	914	43	317	DOGM
43-019-31324	Kanes Springs Fed 19-1A	CC	2,582	4,319	7420 TVD	7,340	7,420	234	24.00	0.17	0	1158	40.6	202	DOGM
43-019-31331	Kane Springs Fed 10-1	CC	na	4,768	9080 TD	8,083	9,080	757	24.00	0.16	46.75	1272.9	41.4	594	DOGM
43-019-31334	Kane Springs Fed 25-19-34-	CC	na	3,977	7988 TD	7,580	7,985	328	24.00	0.47	0	731	42	448	DOGM
43-019-31364	Cane Creek Fed 11-1	CC	na	4,261	7554 TVD	7,702	9,892	560	3.00	0.22		1100		509	DOGM
43-019-31396	Cane Creek 2-1	CC	na	na	7220 TD	6,968	7,038	657	24.00	0.16	0	513	43	1281	DOGM

API well number	Well name	Unit	Hermosa top	Paradox	Hermoas 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-	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

Appendix G

Drill stem tests in the black shale intervals of the Hermosa Group.

Hermosa

API well number	Well name	Unit	Test #	Top test	Base test	IHP	FHP	IFP	FFP	ISIP	FSIP	Fluids	Source
43-015-10506	Woodside Dome U 2	H	5	5,560	5,415	2,576	2,554	23	25	321	331	slightly gas-cut mud	DERL
43-015-10506	Woodside Dome U 2	H	6	5,904	6,025	2,822	2,822	57	64	257	1,280	slightly gas-cut mud	DERL
43-015-20312	Woodside Unit 1	HT	6	5,080	5,115	2,401	2,353	33	35	1,656	1,751	heavy gas cut mud; 129 mcfpd (10 min) declining	DERL
43-015-20312	Woodside Unit 1	PX	9	5,540	5,700	2,685	2,685	17	13	301	767	slightly gas cut mud	DERL
43-015-20312	Woodside Unit 1	PX	10	5,718	5,892	2,759	2,759	46	46	265	1,991	slightly gas cut mud	DERL
43-019-11188	Salt Wash Unit 22-34	HT	2	4,331	4,370	na	na	55	160	95	2,220	20 ft slightly gas-cut mud	DOGM
43-019-30029	Federal 1-26	H	2	6,465	6,615	na	na	206	1,565	2,989	2,906	20 bbls gas+water-cut mud; 30 bbls salt water	DOGM
43-019-30029	Federal 1-26	H	3	8,236	8,271	na	na	1,737	1,774	2,126	2,033	18.6 bbls slightly gas-cut mud	DOGM
43-019-30647	Federal DE-1	PX	1	7,498	7,543	na	na	na	na	1,712	1,333	gas to surface; 41 mcfpd after 50 min; 620 ft gas-cut mu	DOGM
43-019-30796	Skyline Unit 1	CC	1	7,463	7,526	6,531	6,432	99	99	191	283	96 ft slightly gas-cut mud	DOGM
43-019-30796	Skyline Unit 1	CC	2	7,520	7,657	6,592	6,573	334	445	1,004	1,656	317 ft slightly gas-cut mud	DOGM
43-019-30910	Moab Fed 16-9	CC	2	8,473	8,574	4,789	4,789	77	102	498	485	150 ft slightly oil & gas-cut mud	DOGM
43-019-31018	Arches Federal 1	CC	1	7,704	7,792	5,267	5,248	99	534	4,278	3,384	937 ft water-cut mud with trace of gas	DOGM
43-019-31119	Mineral Canyon Fed 1-3	CC	1	7,375	7,440	na	na	205	225	na	253	254 ft mud	DOGM
43-019-31156	Mineral Canyon U 1-14	PX	1	4,810	4,854	na	na	na	83	na	741	na	DOGM
43-019-31156	Mineral Canyon U 1-14	PX	2	5,896	5,908	na	na	na	45	na	136	na	DOGM
43-019-31357	GCRL Seismosaur Fed :	PX	1	13,268	14,250	9,240	9,192	5,026	4,139	7,718	7,106	4,193 ft gas-cut mud	DOGM
43-037-10196	Muleshoe 7	H	1	7,994	8,012	3,863	3,803	164	200	2,128	918	210 ft gas & water cut mud; 323 ft gas-cut salt water	DERL
43-037-10519	Bridger Jack 1	PX	1	6,444	6,575	3,724	3,724	160	250	3,744	3,710	431 ft high gas-cut mud; 120 ft oil & gas-cut mud	DERL
43-037-10573	West Bridger Jack U 3	PX	2	4,447	4,607	2,410	2,410	88	88	88	130	slightly gas cut mud	DERL
43-037-10573	West Bridger Jack U 3	PX	3	4,860	4,913	2,868	2,868	515	630	1,925	1,340	1320 ft highly gas-cut drilling mud	DERL
43-037-10573	West Bridger Jack U 3	PX	6	4,848	4,913	2,963	2,963	810	828	1,627	1,477	588 ft heavy gas-cut mud; 672 very heavy gas-cut mud	DERL
43-037-10616	Coal Bed Canyon Unit 6	IS	1	5,646	5,695	na	na	10	29	290	135	20 ft slightly gas-cut mud	DERL
43-037-10652	Bridger Jack Unit 2	PX	1	6,462	6,533	3,475	3,514	95	92	310	141	200 ft slightly gas-cut mud	DERL
43-037-10849	US Lockheart 1	IS	1	2,312	2,370	1,108	1,105	18	19	126	120	10 ft slightly gas-cut mud	DERL
43-037-10859	Murphy Range Unit 1	PX	2	3,255	3,365	1,638	1,628	115	133	1,032	701	90 ft slightly gas-cut mud	DERL
43-037-10859	Murphy Range Unit 1	PX	3	3,553	3,713	1,714	1,714	38	71	990	543	80 ft slightly gas-cut mud	DERL
43-037-10859	Murphy Range Unit 1	PX	4	4,940	5,037	2,771	2,743	57	71	150	119	75 ft gas-cut mud	DERL
43-037-16250	Lisbon Unit D-84	PX	1	4,384	4,475	2,020	2,020	40	85	865	385	150 ft oil & gas-cut mud	DERL
43-037-11339	NW Lisbon USA C-2	IS	1	4,371	4,432	na	na	68	68	515	240	40 ft mud-cut oil; 30 ft slightly oil-cut mud	DERL
43-037-11339	NW Lisbon USA C-2	PX	2	6,095	6,132	na	na	131	131	295	230	60 ft oil-cut mud	DERL
43-037-16470	NW Lisbon USA C-3	PX	1	4,120	4,270	na	na	195	195	565	300	272 ft mud	DERL
43-037-16470	NW Lisbon USA C-3	PX	2	5,490	5,825	na	na	168	168	345	190	255 ft gas and salt water cut mud	DERL
43-037-16471	NW Lisbon USA A-2	PX	1	4,078	4,150	1,860	1,849	88	145	518	517	306 ft mud cut oil	DERL
43-037-30518	Hatch Point 27-1A	CC	1	7,389	7,450	4,018	3,995	300	355	3,990	3,370	strong blow: 360 mcf & 20 bbls 44° green oil	DERL
43-037-30559	Lion Mesa 2-34	PX	1	5,525	5,745	2,982	2,991	86	90	156	137	150 ft slightly oil & gas-cut mud	DOGM
43-037-30617	Federal 4-26	PX	1	6,050	6,818	3,333	3,305	245	284	571	447	5,200 ft gas; 650 ft highly gas-cut mud	DOGM
43-037-30617	Federal 4-26	CC	2	7,237	7,480	4,093	3,980	93	120	375	300	1,000 ft gas; 210 ft gas-cut mud Good blow	DOGM
43-037-30786	Cedar Pt Fed 1-25	HT	1	4,722	4,771	2,169	2,169	54	54	757	1,404	20 ft mud, no water or gas	DERL
43-037-30786	Cedar Pt Fed 1-25	HT	2	5,865	5,904	2,843	2,789	54	348	2,125	2,138	180 ft slightly gas-cut mud; 740 ft gas-cut salt water	DERL
43-037-30923	TXC/Huber Federal 1-15	HT	2	8,294	8,314	3,889	3,877	76	122	1,856	2,262	gas to surface; 10-12 ft flare for 15 min	DOGM
43-037-30923	TXC/Huber Federal 1-15	HT	3	8,423	8,471	3,966	3,950	241	560	1,593	1,727	gas to surface; 12-15 ft flare for 15 min	DOGM
43-037-30929	Ucolo 1-32	HT	2	4,973	4,990	2,331	2,331	27	27	1,911	1,938	gas to surface: 9.5 mcfpd on 1/8" choke	DERL
43-037-31453	Trudi Federal 2-17	IS	1	4,660	4,688	2,278	2,278	27	54	1,578	1,605	35 ft heavily oil & gas-cut mud	DERL
43-037-31453	Trudi Federal 2-17	DC	2	4,775	4,802	2,399	2,359	13	13	95	95	15 ft mud	DERL
43-037-31479	Major Martin Federal 1	DC	2	5,110	5,128	2,566	2,512	163	1,318	1,922	1,895	2475 ft slightly gas-cut salt water	DERL
43-037-31631	Cane Creek ST 1-36	CC	1	7350	7,878	3,787	3,731	294	606	1,588	1,141	1200 ft mud	DOGM
43-037-31822	Headwaters Fed 7-15	GO	1	7,102	7,145	3,866	3,680	100	119	241	161	gas to surface; 187 ft slightly gas-cut mud	DOGM
43-055-30010	Dirty Devil 1	PX	4	4,752	4,832	2,347	2,319	65	71	196	160	25 ft mud	DERL
43-055-30010	Dirty Devil 1	PX	5	5,261	5,325	2,646	2,601	54	56	88	77	20 ft mud	DERL
43-055-30010	Dirty Devil 1	PT	6	5,540	5,610	2,809	2,768	285	979	1,878	1,877	864 ft mud & water; 3164 ft salt water	DERL

Appendix H

Mud gas measurements in the black shale intervals of the Hermosa Group.

Hermosa

API well number	Well name	Top Hermosa	Paradox	Base Hermosa	Zone top	Zone base	Gas units	Fm.	Comment	Sec	T	R
43-019-30357	SUNBURST 1	2,836	4,395	7,890	4,600	4,620	450	PX		14	26S	19E
43-019-30357	SUNBURST 1	2,836	4,395	7,890	4,620	4,700	70	PX		14	26S	19E
43-019-30357	SUNBURST 1	2,836	4,395	7,890	4,740	4,760	140	PX		14	26S	19E
43-019-30357	SUNBURST 1	2,836	4,395	7,890	4,800	4,825	130	PX		14	26S	19E
43-019-30357	SUNBURST 1	2,836	4,395	7,890	4,850	4,860	125	PX		14	26S	19E
43-019-30357	SUNBURST 1	2,836	4,395	7,890	5,025	5,070	380	PX		14	26S	19E
43-019-30357	SUNBURST 1	2,836	4,395	7,890	5,340	5,350	800	PX		14	26S	19E
43-019-30357	SUNBURST 1	2,836	4,395	7,890	5,360	5,380	400	PX		14	26S	19E
43-019-30357	SUNBURST 1	2,836	4,395	7,890	5,550	5,565	800	PX		14	26S	19E
43-019-30357	SUNBURST 1	2,836	4,395	7,890	5,565	5,590	250	PX		14	26S	19E
43-019-30357	SUNBURST 1	2,836	4,395	7,890	5,705	5,725	1,200	PX		14	26S	19E
43-019-30357	SUNBURST 1	2,836	4,395	7,890	5,950	6,030	1,800	PX		14	26S	19E
43-019-30357	SUNBURST 1	2,836	4,395	7,890	6,250	6,260	2,000	PX		14	26S	19E
43-019-30357	SUNBURST 1	2,836	4,395	7,890	6,340	6,350	800	PX		14	26S	19E
43-019-30357	SUNBURST 1	2,836	4,395	7,890	6,400	6,430	1,000	PX		14	26S	19E
43-019-30357	SUNBURST 1	2,836	4,395	7,890	7,250	7,310	2,100	PX		14	26S	19E
43-019-30357	SUNBURST 1	2,836	4,395	7,890	7,430	7,460	2,500	PX		14	26S	19E
43-019-30357	SUNBURST 1	2,836	4,395	7,890	7,675	7,770	2,600	PX		14	26S	19E
43-019-31156	MINERAL CANYON UNIT 1-14	2,600	3,940	7,547	4,440	4,450	10	PX	top of log	14	26S	19E
43-019-31156	MINERAL CANYON UNIT 1-14	2,600	3,940	7,547	4,475	4,510	4	PX		14	26S	19E
43-019-31156	MINERAL CANYON UNIT 1-14	2,600	3,940	7,547	4,560	4,600	1	PX		14	26S	19E
43-019-31156	MINERAL CANYON UNIT 1-14	2,600	3,940	7,547	4,810	4,830	8	PX		14	26S	19E
43-019-31156	MINERAL CANYON UNIT 1-14	2,600	3,940	7,547	4,830	4,835	200	PX	C2: 8000 ppm; C4: 1140 ppm	14	26S	19E
43-019-31156	MINERAL CANYON UNIT 1-14	2,600	3,940	7,547	4,835	4,860	75	PX		14	26S	19E
43-019-31156	MINERAL CANYON UNIT 1-14	2,600	3,940	7,547	5,220	5,260	80	PX		14	26S	19E
43-019-31156	MINERAL CANYON UNIT 1-14	2,600	3,940	7,547	5,370	5,400	110	PX		14	26S	19E
43-019-31156	MINERAL CANYON UNIT 1-14	2,600	3,940	7,547	5,550	5,600	150	PX		14	26S	19E
43-019-31156	MINERAL CANYON UNIT 1-14	2,600	3,940	7,547	5,760	5,780	200	PX		14	26S	19E
43-019-31156	MINERAL CANYON UNIT 1-14	2,600	3,940	7,547	5,890	5,920	75	PX		14	26S	19E
43-019-31156	MINERAL CANYON UNIT 1-14	2,600	3,940	7,547	6,060	6,070	1,000	PX		14	26S	19E
43-019-31156	MINERAL CANYON UNIT 1-14	2,600	3,940	7,547	6,160	6,175	1,700	PX	C2: 48,750; C3: 58,000; C4: 142,5	14	26S	19E
43-019-31156	MINERAL CANYON UNIT 1-14	2,600	3,940	7,547	6,350	6,370	10	PX		14	26S	19E
43-019-31156	MINERAL CANYON UNIT 1-14	2,600	3,940	7,547	6,820	6,880	50	PX		14	26S	19E
43-019-31156	MINERAL CANYON UNIT 1-14	2,600	3,940	7,547	7,000	7,010	60	PX		14	26S	19E
43-019-31334	KANE SPRINGS FED 25-19-34-1	NA	4,440	7980 TD	4,420	4,440	60	PX		34	25S	19E
43-019-31334	KANE SPRINGS FED 25-19-34-1	NA	4,440	7980 TD	4,580	4,630	80	PX		34	25S	19E
43-019-31334	KANE SPRINGS FED 25-19-34-1	NA	4,440	7980 TD	4,770	4,800	60	PX		34	25S	19E
43-019-31334	KANE SPRINGS FED 25-19-34-1	NA	4,440	7980 TD	4,930	5,000	60	PX		34	25S	19E
43-019-31334	KANE SPRINGS FED 25-19-34-1	NA	4,440	7980 TD	5,260	5,290	20	PX		34	25S	19E
43-019-31334	KANE SPRINGS FED 25-19-34-1	NA	4,440	7980 TD	5,460	5,500	40	PX		34	25S	19E
43-019-31334	KANE SPRINGS FED 25-19-34-1	NA	4,440	7980 TD	5,640	5,680	40	PX		34	25S	19E
43-019-31334	KANE SPRINGS FED 25-19-34-1	NA	4,440	7980 TD	6,130	6,160	80	PX		34	25S	19E
43-019-31334	KANE SPRINGS FED 25-19-34-1	NA	4,440	7980 TD	6,940	6,990	60	PX		34	25S	19E
43-019-31334	KANE SPRINGS FED 25-19-34-1	NA	4,440	7980 TD	7,540	7,590	150	PX		34	25S	19E
43-019-31334	KANE SPRINGS FED 25-19-34-1	NA	4,440	7980 TD	7,590	7,640	50	PX		34	25S	19E
43-019-31334	KANE SPRINGS FED 25-19-34-1	NA	4,440	7980 TD	7,640	7,655	9,000	PX		34	25S	19E
43-019-31334	KANE SPRINGS FED 25-19-34-1	NA	4,440	7980 TD	7,655	7,665	5,000	PX		34	25S	19E
43-019-31334	KANE SPRINGS FED 25-19-34-1	NA	4,440	7980 TD	7,665	7,700	750	PX		34	25S	19E
43-019-31334	KANE SPRINGS FED 25-19-34-1	NA	4,440	7980 TD	7,700	7,740	200	PX		34	25S	19E
43-019-31357	GCRL SEISMOSAUR FED 1	11,574	12,864	15482 TD	13,340	13,350	40	PX		20	21S	20E
43-019-31357	GCRL SEISMOSAUR FED 1	11,574	12,864	15482 TD	13,350	13,360	110	PX		20	21S	20E
43-019-31357	GCRL SEISMOSAUR FED 1	11,574	12,864	15482 TD	13,360	13,380	300	PX		20	21S	20E
43-019-31357	GCRL SEISMOSAUR FED 1	11,574	12,864	15482 TD	13,380	13,385	1,000	PX		20	21S	20E
43-019-31357	GCRL SEISMOSAUR FED 1	11,574	12,864	15482 TD	13,380	13,400	250	PX		20	21S	20E
43-019-31357	GCRL SEISMOSAUR FED 1	11,574	12,864	15482 TD	13,600	13,655	100	PX		20	21S	20E
43-019-31357	GCRL SEISMOSAUR FED 1	11,574	12,864	15482 TD	13,655	13,670	900	PX		20	21S	20E
43-019-31357	GCRL SEISMOSAUR FED 1	11,574	12,864	15482 TD	13,670	13,690	2,500	PX		20	21S	20E
43-019-31357	GCRL SEISMOSAUR FED 1	11,574	12,864	15482 TD	13,690	13,735	2,000	PX		20	21S	20E
43-019-31357	GCRL SEISMOSAUR FED 1	11,574	12,864	15482 TD	13,735	13,775	900	PX		20	21S	20E
43-019-31357	GCRL SEISMOSAUR FED 1	11,574	12,864	15482 TD	13,775	13,840	600	PX		20	21S	20E
43-037-30518	HATCH POINT 27-1A		7382 CC	7,730	7,410	7,460	20	CC		27	27S	21E
43-037-30518	HATCH POINT 27-1A		7382 CC	7,730	7,490	7,510	400	CC		27	27S	21E
43-037-30518	HATCH POINT 27-1A		7382 CC	7,730	7,510	7,525	500	PT		27	27S	21E
43-037-30518	HATCH POINT 27-1A		7382 CC	7,730	7,525	7,560	350	PT		27	27S	21E
43-037-30518	HATCH POINT 27-1A		7382 CC	7,730	7,560	7,590	800	PT	spike	27	27S	21E
43-037-30518	HATCH POINT 27-1A		7382 CC	7,730	7,590	7,615	420	PT	spike	27	27S	21E
43-037-30518	HATCH POINT 27-1A		7382 CC	7,730	7,615	7,705	220	PT		27	27S	21E
43-037-30518	HATCH POINT 27-1A		7382 CC	7,730	7,705	800	800	PT	spike	27	27S	21E
43-037-30518	HATCH POINT 27-1A		7382 CC	7,730	7,710	7,720	600	PT	spike	27	27S	21E
43-037-30923	TXC/HUBER FEDERAL 1-15	7,670	8,807	12,132	10,065	10,070	16	PX	spike	15	28S	25E
43-037-30923	TXC/HUBER FEDERAL 1-15	7,670	8,807	12,132	10,130	10,135	55	PX	spike	15	28S	25E
43-037-30923	TXC/HUBER FEDERAL 1-15	7,670	8,807	12,132	10,172	10,180	350	PX	spike	15	28S	25E
43-037-30923	TXC/HUBER FEDERAL 1-15	7,670	8,807	12,132	10,228	10,232	350	PX	C1: 199,360; C2: 11,648; C3: 2,59	15	28S	25E
43-037-30923	TXC/HUBER FEDERAL 1-15	7,670	8,807	12,132	10,236	10,238	136	PX	spike	15	28S	25E
43-037-30923	TXC/HUBER FEDERAL 1-15	7,670	8,807	12,132	10,241	10,243	248	PX	spike	15	28S	25E
43-037-30923	TXC/HUBER FEDERAL 1-15	7,670	8,807	12,132	10,250	10,252	160	PX	spike	15	28S	25E
43-047-31822	HEADWATERS FED 7-15	5,385	6,406	7145 TD	5,380	5,390	17	HT		15	28S	23E
43-047-31822	HEADWATERS FED 7-15	5,385	6,406	7145 TD	5,390	5,630	5	HT		15	28S	23E
43-047-31822	HEADWATERS FED 7-15	5,385	6,406	7145 TD	5,630	5,665	12	HT		15	28S	23E
43-047-31822	HEADWATERS FED 7-15	5,385	6,406	7145 TD	5,665	5,745	5	HT		15	28S	23E
43-047-31822	HEADWATERS FED 7-15	5,385	6,406	7145 TD	5,745	5,760	130	HT	spike	15	28S	23E
43-047-31822	HEADWATERS FED 7-15	5,385	6,406	7145 TD	5,780	5,790	123	HT	spike	15	28S	23E
43-047-31822	HEADWATERS FED 7-15	5,385	6,406	7145 TD	5,790	5,988	7	HT		15	28S	23E
43-047-31822	HEADWATERS FED 7-15	5,385	6,406	7145 TD	5,988	5,995	207	HT	spike	15	28S	23E
43-047-31822	HEADWATERS FED 7-15	5,385	6,406	7145 TD	5,995	6,098	10	HT		15	28S	23E
43-047-31822	HEADWATERS FED 7-15	5,385	6,406	7145 TD	6,098	6,104	148	HT	spike	15	28S	23E
43-047-31822	HEADWATERS FED 7-15	5,385	6,406	7145 TD	6,104	6,112	56	HT	spike	15	28S	23E
43-047-31822	HEADWATERS FED 7-15	5,385	6,406	7145 TD	6,175	6,185	106	HT	spike	15	28S	23E
43-047-31822	HEADWATERS FED 7-15	5,385	6,406	7145 TD	6,185	6,230	10	HT		15	28S	23E
43-047-31822	HEADWATERS FED 7-15	5,385	6,406	7145 TD	6,240	6,250	1,800	HT	spike	15	28S	23E
43-047-31822	HEADWATERS FED 7-15	5,385	6,406	7145 TD	6,250	6,406	25	HT		15	28S	23E
43-047-31822	HEADWATERS FED 7-15	5,385	6,406	7145 TD	6,406	6,410	398	HT		15	28S	23E
43-047-31822	HEADWATERS FED 7-15	5,385	6,406	7145 TD	6,410	6,505	20	HT		15	28S	23E
43-047-31822	HEADWATERS FED 7-15	5,385	6,406	7145 TD	6,505	6,512	112	HT		15	28S	23E

API well number	Well name	Top Hermosa	Paradox	Base Hermosa	Zone top	Zone base	Gas units	Fm.	Comment	Sec	T	R
43-047-31822	HEADWATERS FED 7-15	5,385	6,406	7145 TD	6,512	6,548	50	HT		15	28S	23E
43-047-31822	HEADWATERS FED 7-15	5,385	6,406	7145 TD	6,548	6,554	255	HT		15	28S	23E
43-047-31822	HEADWATERS FED 7-15	5,385	6,406	7145 TD	6,554	7,125	40	HT		15	28S	23E
43-047-31822	HEADWATERS FED 7-15	5,385	6,406	7145 TD	7,125	7,185	1,800	HT	spike	15	28S	23E
43-047-31822	HEADWATERS FED 7-15	5,385	6,406	7145 TD	7,135	7,145	2,394	HT	spike	15	28S	23E