

The San Juan Basin, a Complex Giant Gas Field, New Mexico and Colorado*

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Abstract

The San Juan Basin of northwest New Mexico and southwest Colorado is the second largest gas basin in the United States, second to the greater Hugoton Field of Texas, Oklahoma, and Kansas. Until the 1970s, most of the gas produced in the basin came from the three major fractured-sandstone reservoirs: the Dakota Sandstone, the Mesaverde Group, and the Pictured Cliffs Sandstone, all of Late Cretaceous age. Starting in the late 1970s, and accelerating in the 1980s to the present, production from coal-bed methane (CBM) reservoirs in the basin has gone from virtually none to around one trillion cubic ft of gas (TCFG)/year, making the San Juan Basin's Fruitland CBM field the largest CBM field in the world. Through September 2009, the basin's fractured-sandstone reservoirs produced 24.4 trillion cubic ft of gas (TCFG) from 24,000 wells: 7.0 TCFG from the Dakota Sandstone, 12.9 TCFG from the Mesaverde Group, and 4.5 TCFG from the Pictured Cliffs Sandstone. These three reservoirs have also produced 98.2 million barrels of natural-gas liquids (condensate). Fruitland Formation CBM production is 15.7 TCFG from 7,700 wells. Cumulative gas production from these natural-gas reservoirs is 40.1 TCFG. Cumulative gas production from all of the nearly 40,000 wells in the basin totals 42.7 TCFG with the additional 2.6 TCFG coming from the basin's many scattered oil fields and smaller gas fields.

The fractured-sandstone gas reservoirs of the San Juan Basin were once thought to represent a gas-trapping model that came to be called the "basin-centered gas" model. This model was characterized by sheet sandstone bodies with total hydraulic connectivity containing natural gas trapped in the center of a structural basin by water seals around the periphery of the basin holding the gas captive in the basin's center. This model has now been disproven for the San Juan and other Western Interior structural basins, where it has been clearly shown that gas trapped in the central parts of these basins is sealed in conventional stratigraphic traps characterized by stratigraphic pinch-outs. The term "basin-centered" is the only accurate remaining remnant of the "basin-centered" model, because the gas reservoirs in these basins are indeed located geographically in the central parts of these basins, albeit in conventional stratigraphic traps.

The San Juan Basin has also produced a total of 281 million barrels of oil (MBO) from a large number of relatively small oil fields. Nearly 175 MBO have come from the Tocito Sandstone Lenticle of the Mancos Shale (sometimes called "Gallup Sandstone"); these fields are all

stratigraphic traps, consisting of marine sandstone lenses incased in impervious marine mudstones. The two largest Tocito oil fields are the Bisti and Horseshoe fields that have produced about 42 MBO and 40 MBO, respectively.

Paleozoic rocks have only been tested by about a dozen test holes in the central San Juan Basin; thus these rocks may still have gas potential at depths down to 14,000 ft or so.

References

Deischl, D.G., 1973, The characteristics, history, and development of the Basin Dakota Gas field, San Juan basin, New Mexico, *in* Cretaceous and Tertiary rocks of the southern Colorado Plateau: Four Corners Geological Society, p. 168-173.

Fassett, J.E., 1977, Geology of the Point Lookout, Cliff House and Pictured Cliffs Sandstones of the San Juan Basin of New Mexico and Colorado, *in* J.E. Fassett, ed., Guidebook of San Juan Basin III, Northwestern New Mexico: New Mexico Geological Society, 28th field conference, p. 193-198.

Fassett, J.E., 2000, Geology and coal resources of the Upper Cretaceous Fruitland Formation, San Juan Basin, New Mexico and Colorado, *in* M.A. Kirschbaum, L.N.R. Roberts, and L.R.H. Biewick, eds., Geologic Assessment of Coal in the Colorado Plateau: Arizona, Colorado, New Mexico, and Utah: U.S. Geological Survey Professional Paper 1625-B, Chapter Q, p. Q1-Q131.

Fassett, J.E., and B.C. Boyce, 2005, Fractured-sandstone gas reservoirs, San Juan Basin, New Mexico and Colorado: Stratigraphic traps, no basin-centered gas deposits – with an overview of Fruitland Formation coal-bed methane, *in* M.G. Bishop, S.P. Cumella, J.W. Robinson, and M.R. Silverman, eds, Gas in Low Permeability Reservoirs of the Rocky Mountain Region: Rocky Mountain Association of Geologists, p. 109-185..

Whyte, M.R., and J.W. Shomaker, 1977, A geological approach of the deep coals of the Menefee Formation of the San Juan basin, New Mexico, *in* San Juan basin III: New Mexico Geological Society, Twenty-Eighth Field Conference Supplement to Guidebook, p. 41-48.

A vertical strip on the left side of the slide shows a topographic map of the San Juan Basin, with contour lines and a color gradient from brown to green.

THE SAN JUAN BASIN, A COMPLEX GIANT GAS FIELD, NEW MEXICO AND COLORADO

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A vertical strip on the left side of the slide shows a topographic map of the San Juan Basin, with contour lines and a color gradient from green to brown.

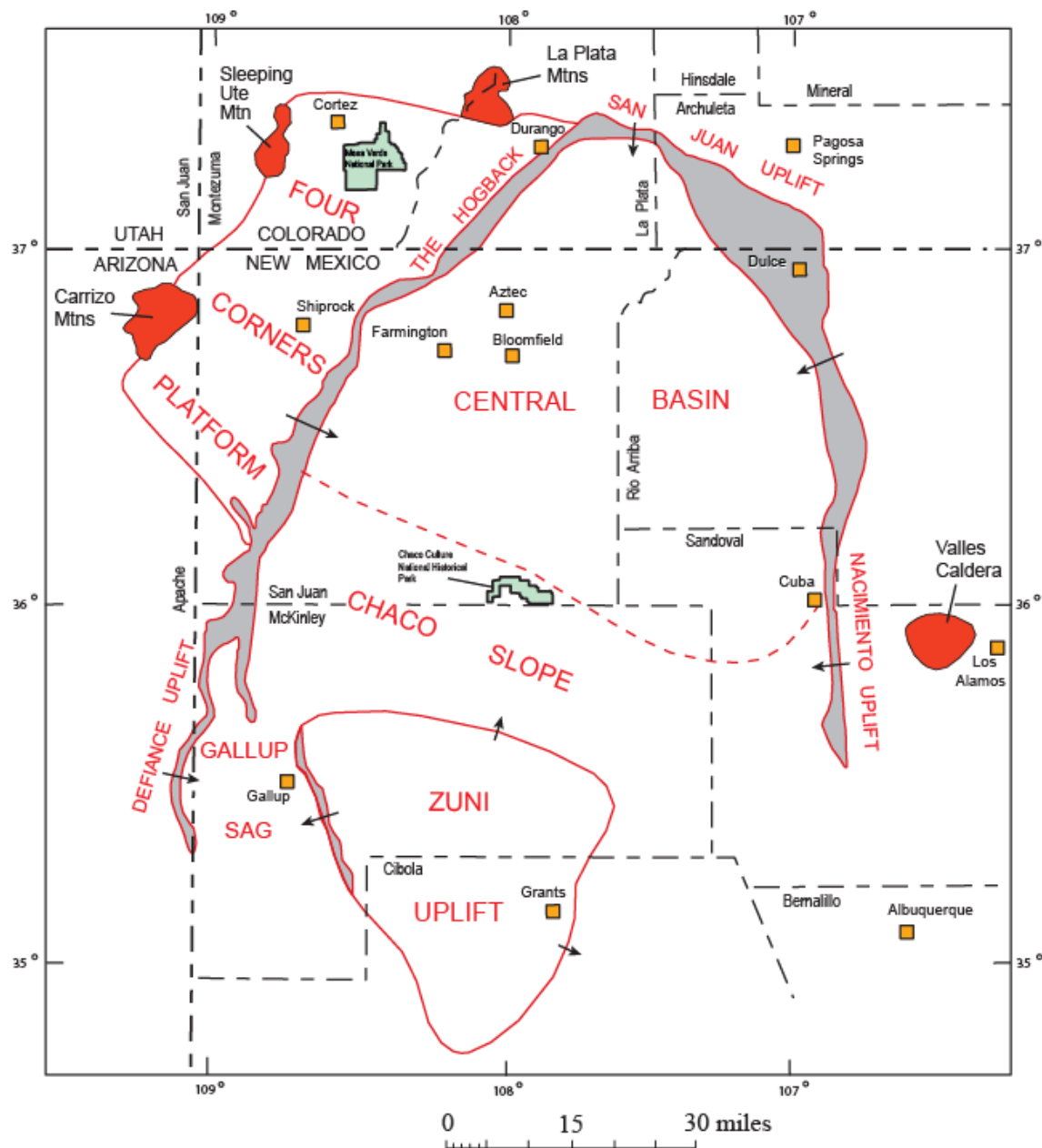
SAN JUAN BASIN OIL AND GAS FIELDS

**MORE THAN 150 GAS FIELDS
(43 TCG of gas)**

**MORE THAN 170 OIL FIELDS
(381 Million barrels of oil)**

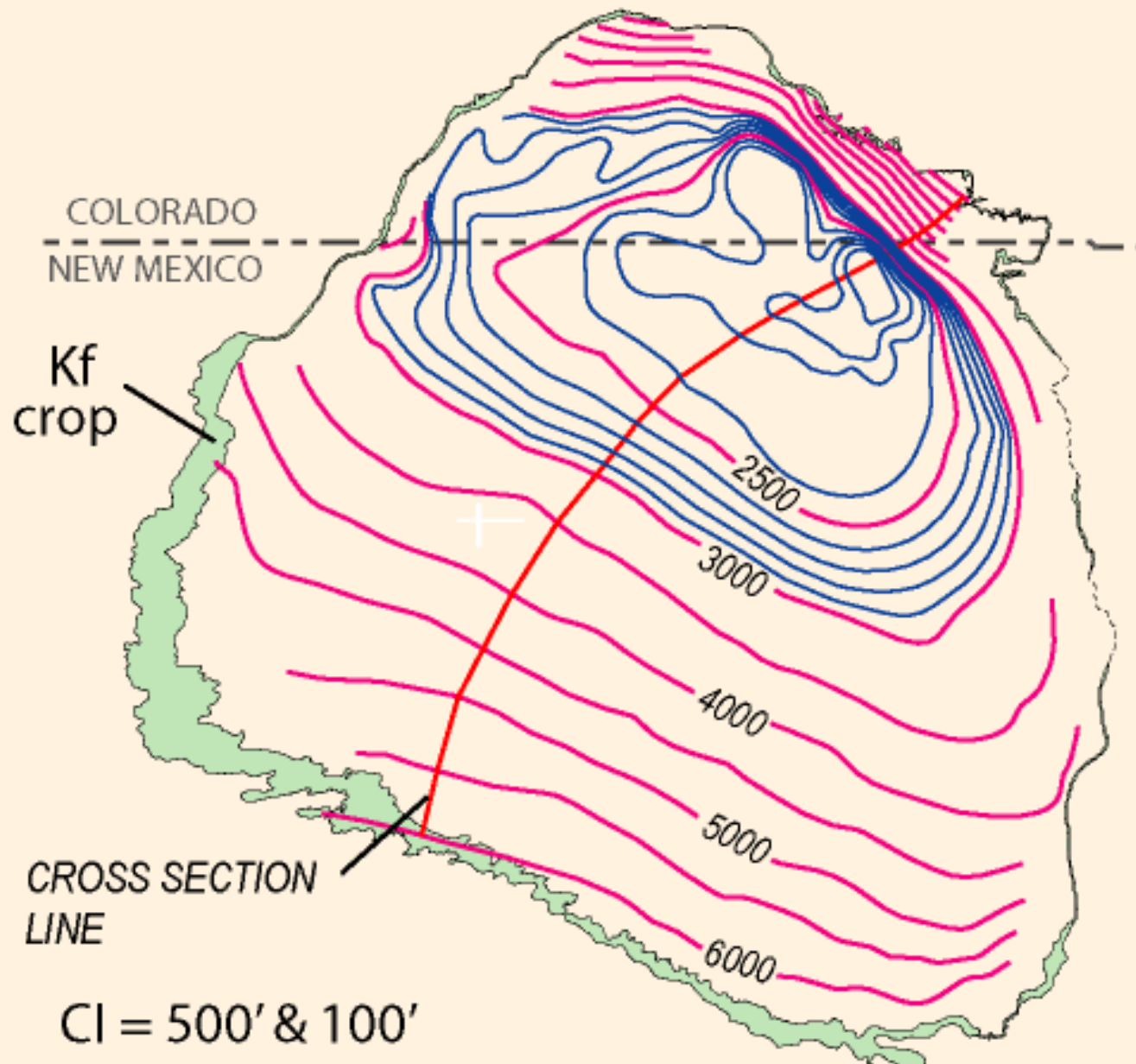
**THIS REPORT – 4 MAJOR
U. CRETACEOUS GAS FIELDS**

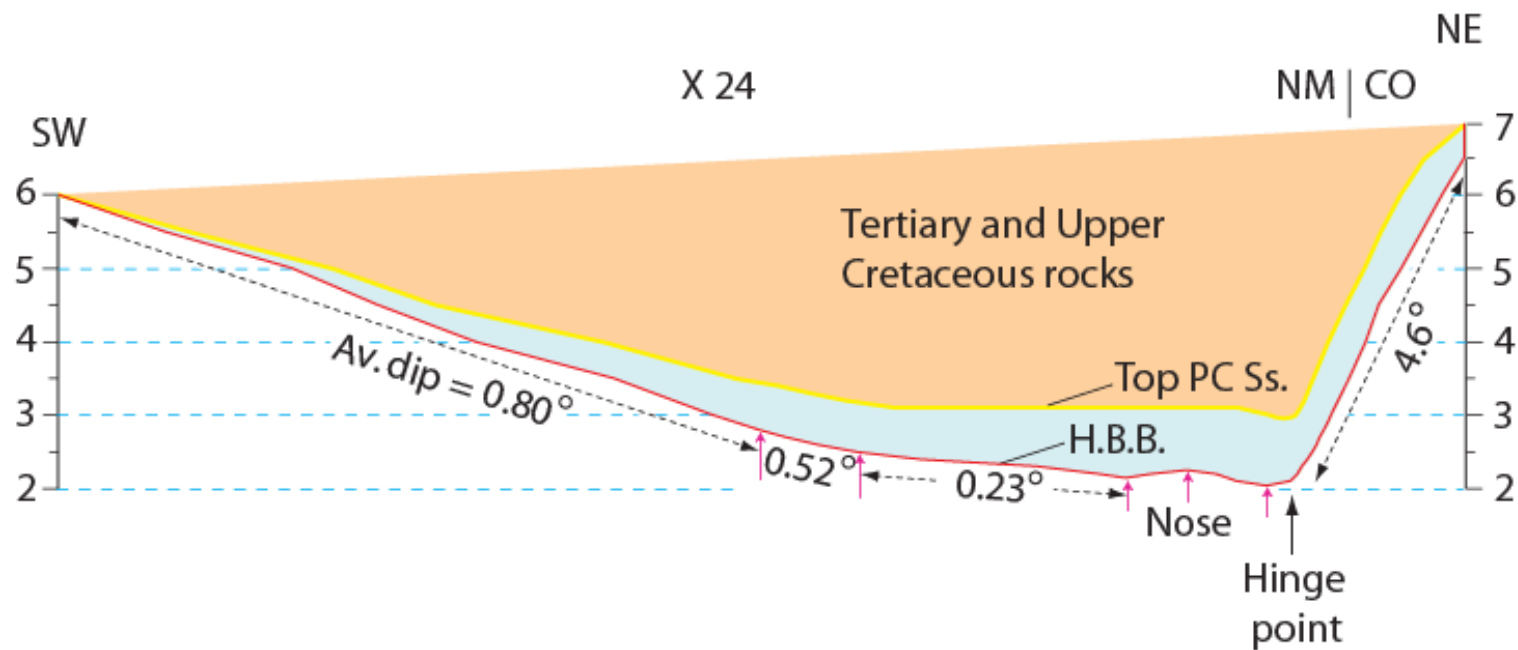
INDEX MAP AND STRUCTURAL ELEMENTS OF THE SAN JUAN BASIN



STRUCTURE MAP OF SAN JUAN BASIN

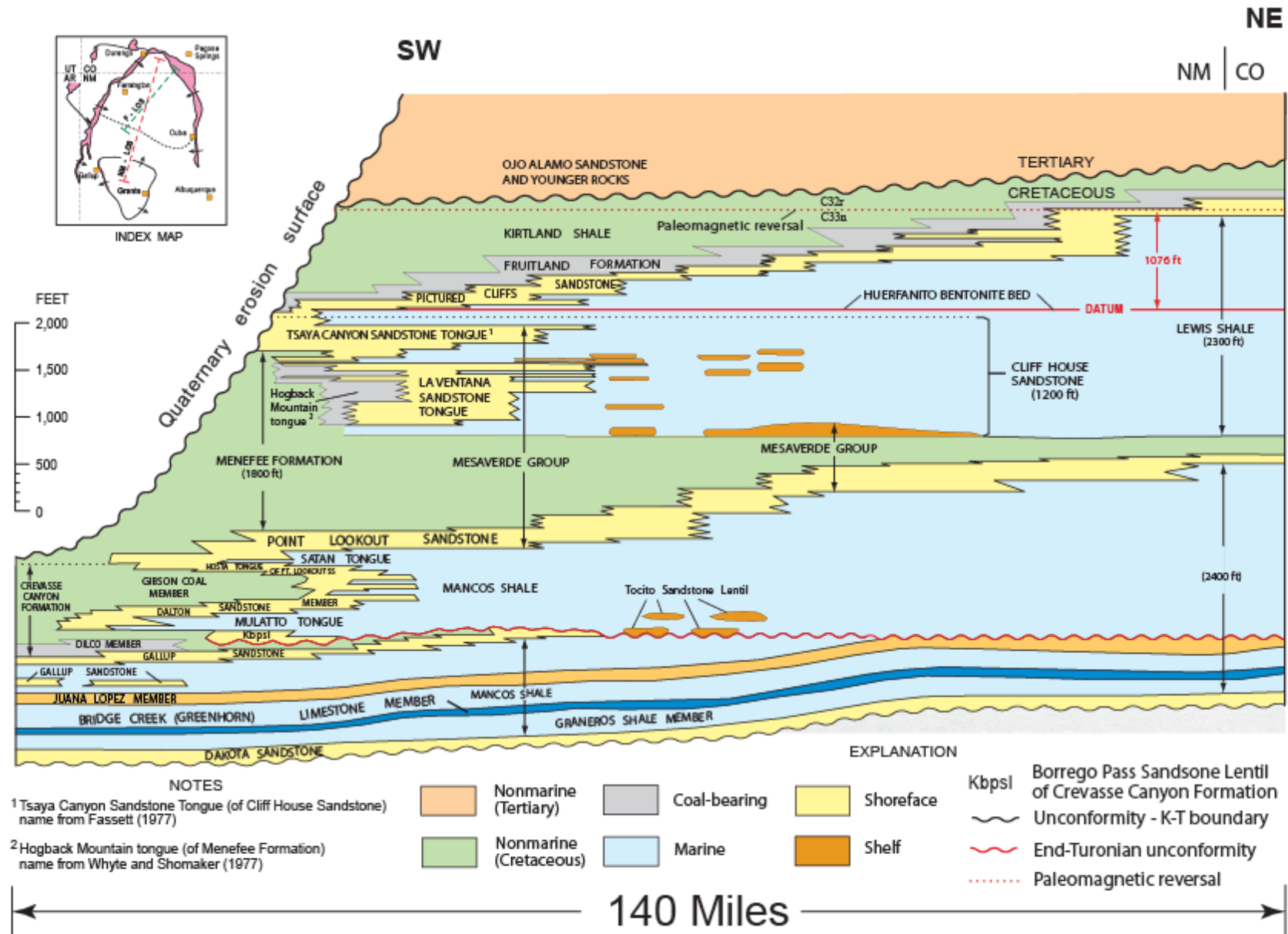
(Contoured on Huerfanito Bentonite Bed)



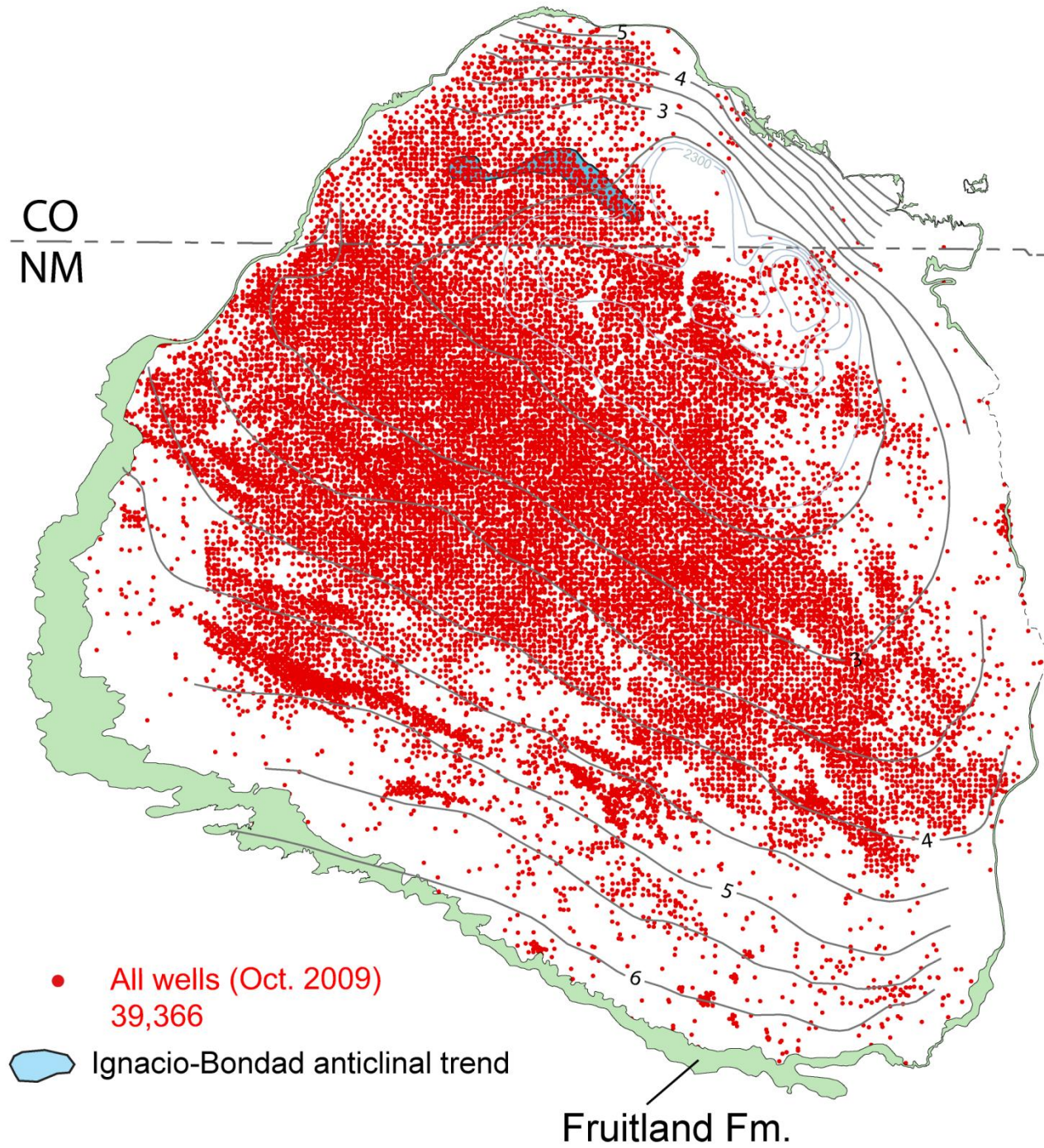


1 to 1 profile - no vertical exaggeration

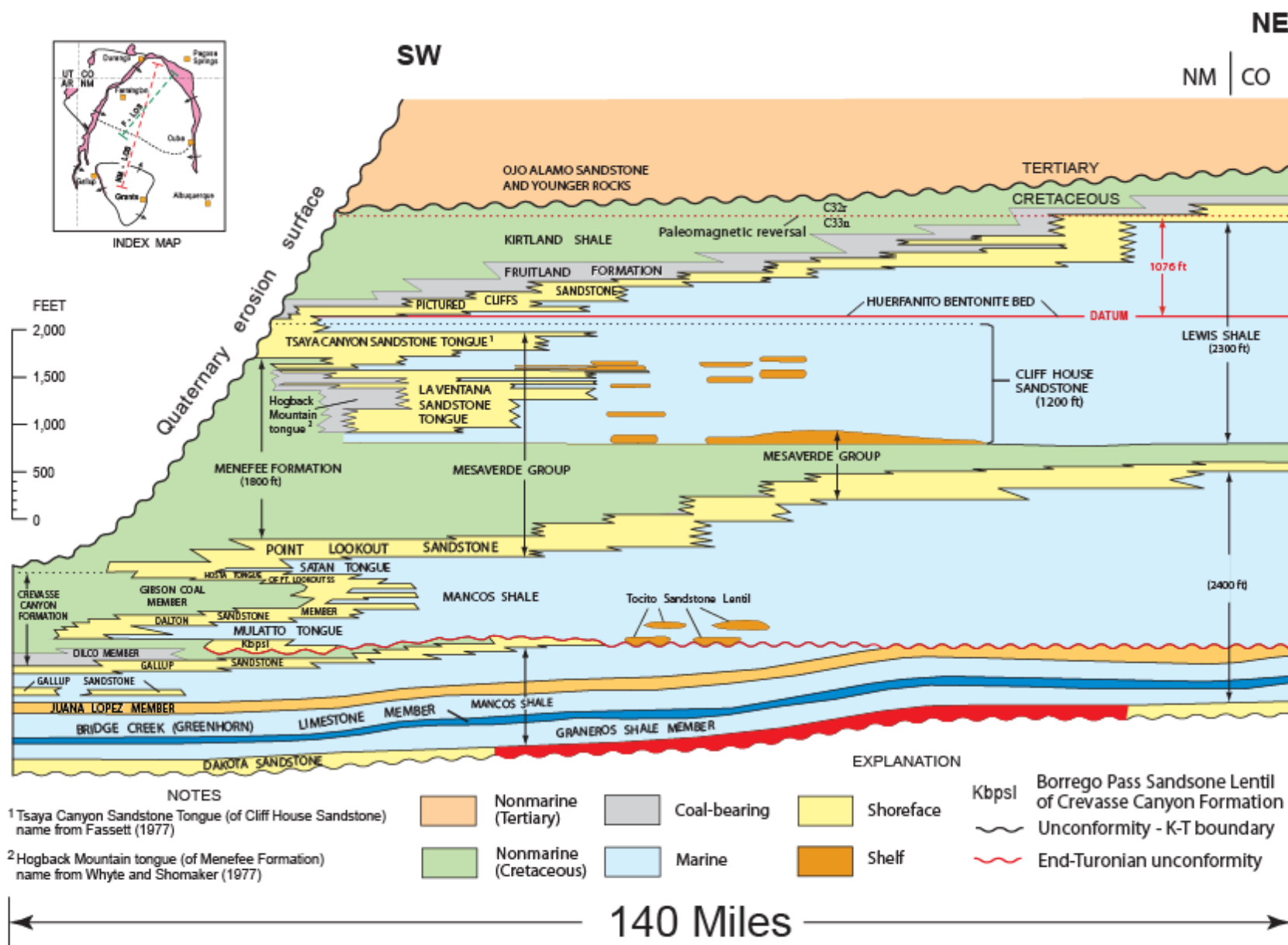
UPPER CRETACEOUS STRATIGRAPHY, SJ BASIN



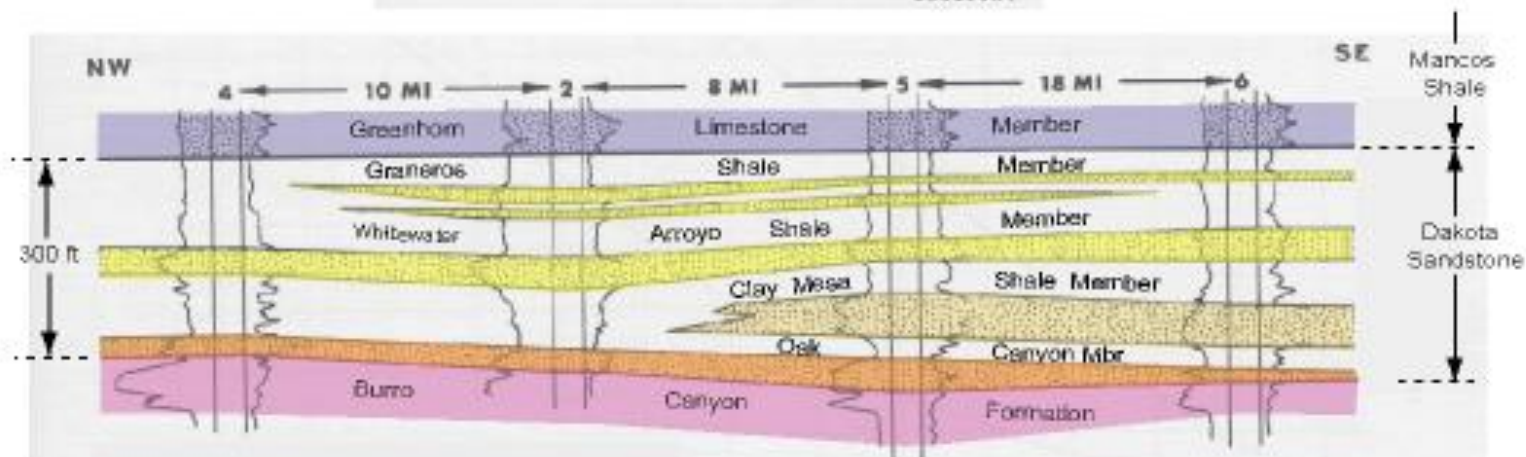
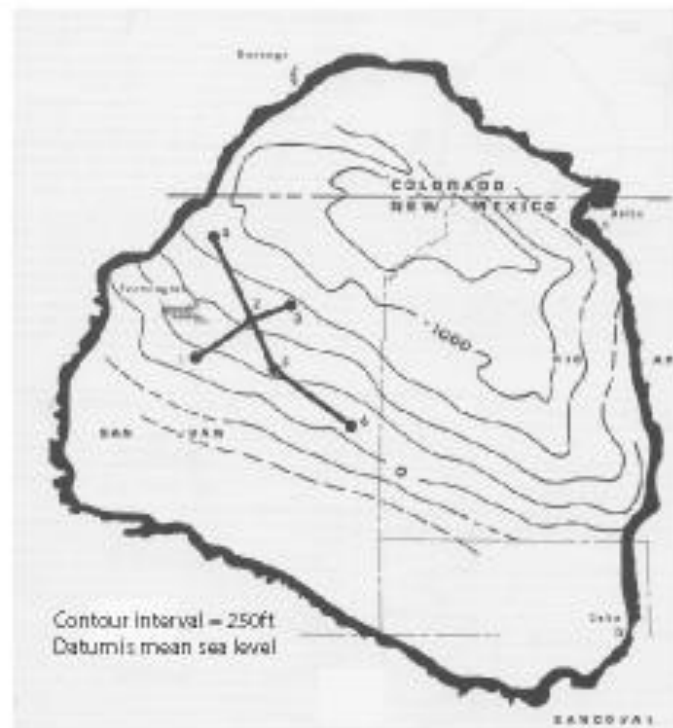
CO
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GAS-PRODUCTIVE AREA - DAKOTA SANDSTONE

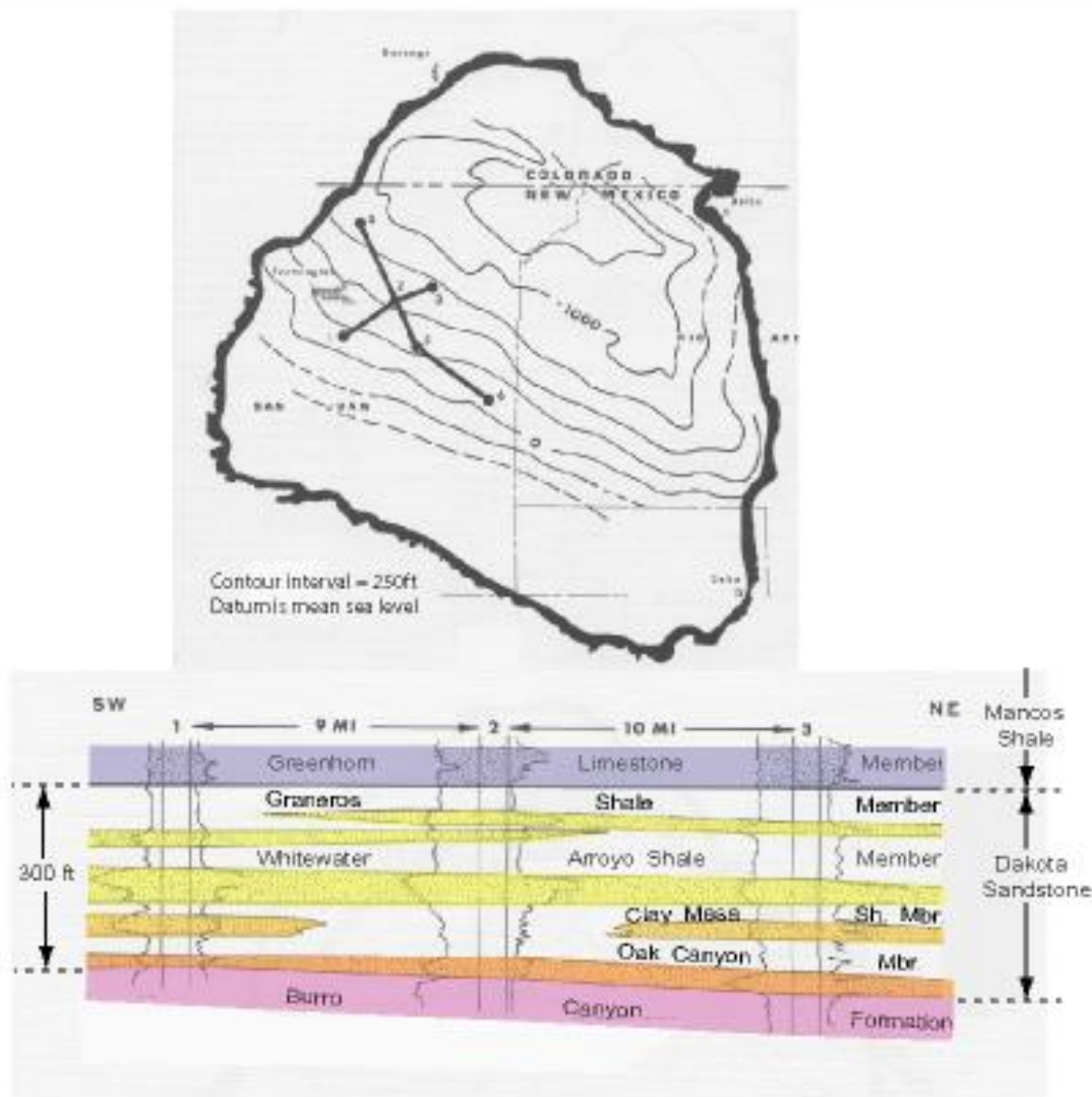


DAKOTA STRATIGRAPHY



From Deischl (1973)

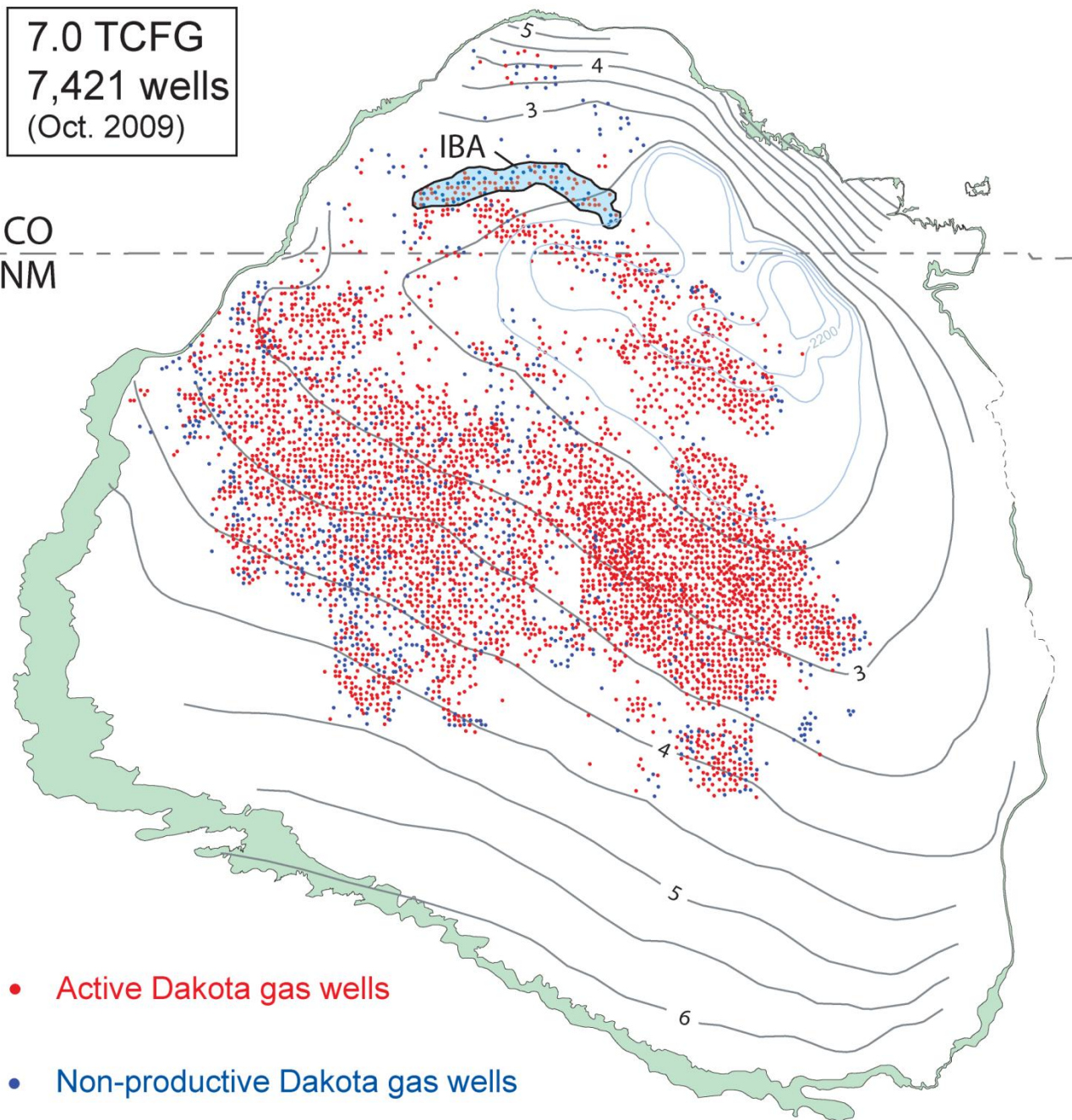
DAKOTA STRATIGRAPHY



From Deischl (1973)

7.0 TCFG
7,421 wells
(Oct. 2009)

CO
NM

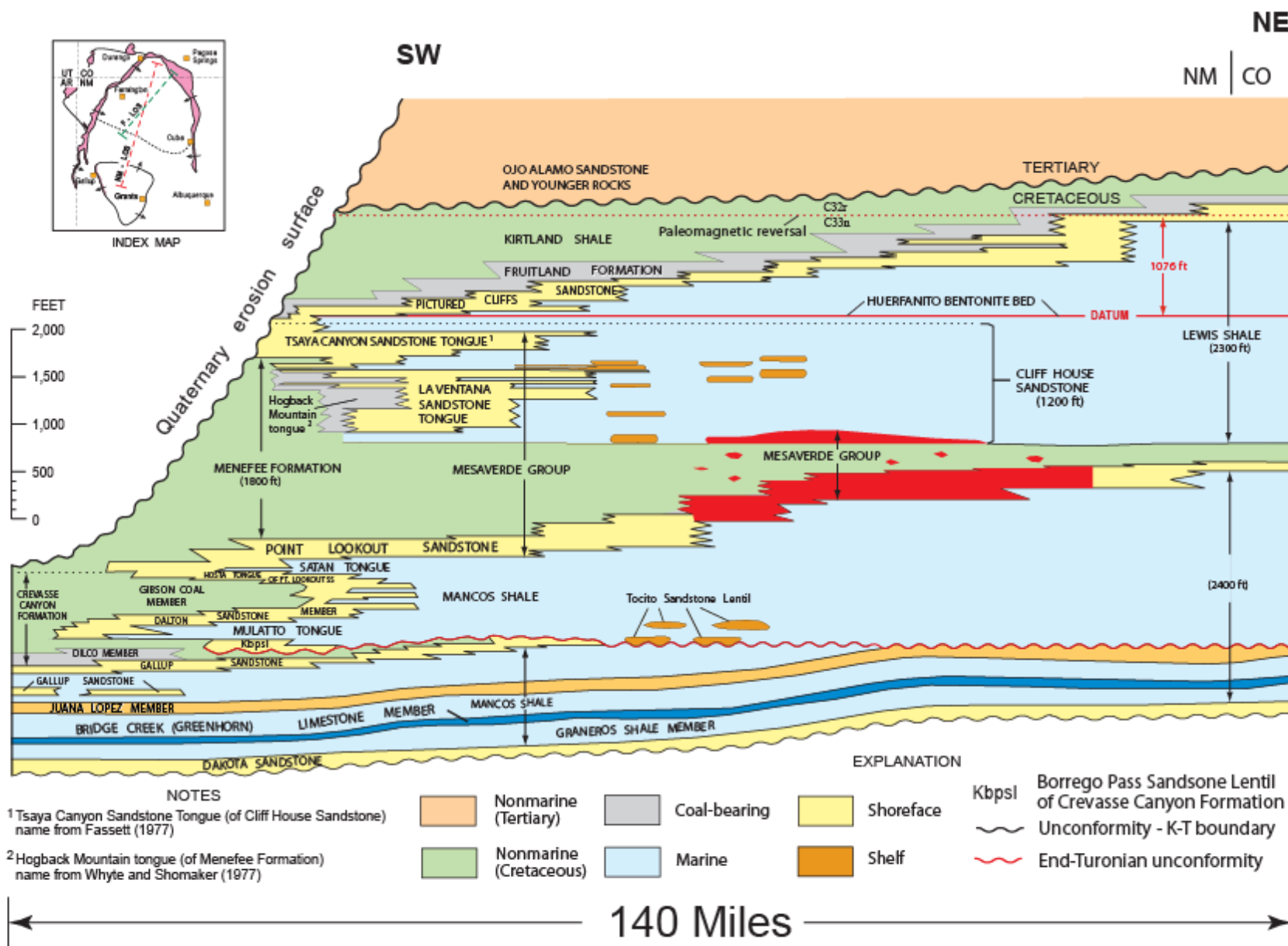


A vertical strip on the left side of the slide shows a topographic map with contour lines and a road network.

DAKOTA PRODUCTION FACTS:

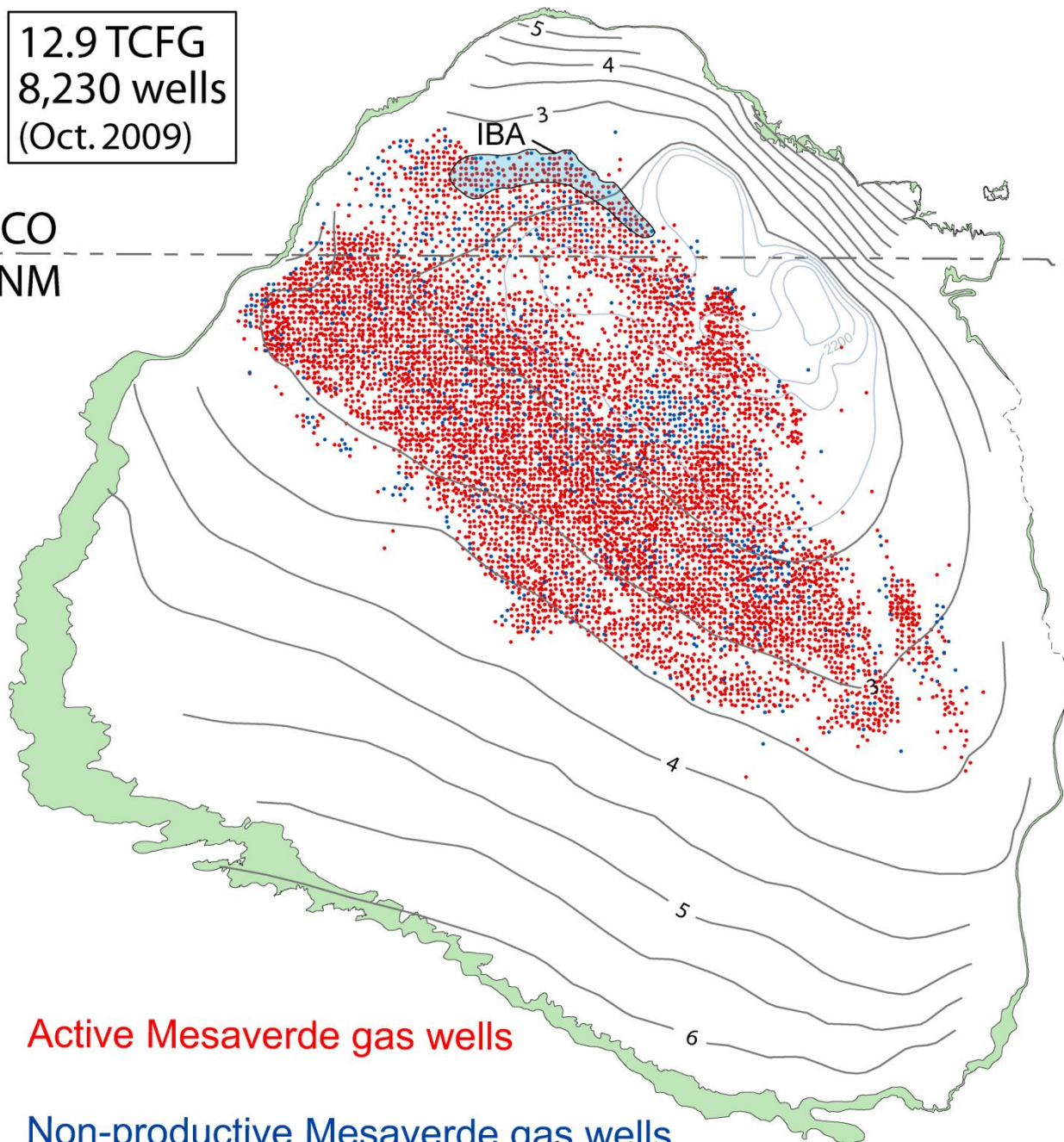
- ★ 7.0 TCFG from 7,421 wells – Av. >1BCFG/well
- ★ 49.6 MB condensate
- ★ 35.2 MB water – Av. 4.7 KBW/well
- ★ Well spacing has gone from 320 acres, to 160 acres, to 80 acres

GAS-PRODUCTIVE AREA - MESAVERDE GROUP



12.9 TCFG
8,230 wells
(Oct. 2009)

CO
NM



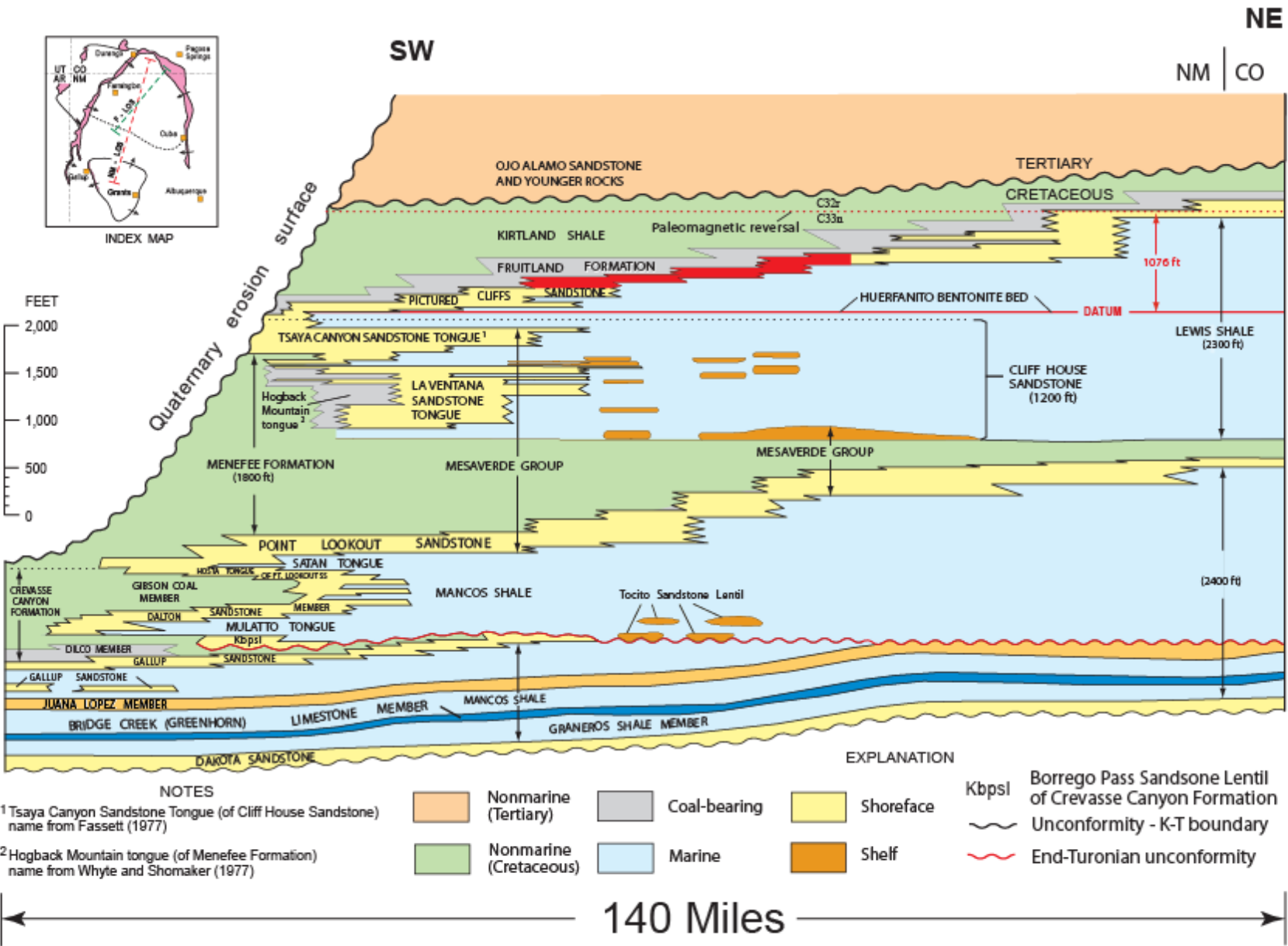
- Active Mesaverde gas wells
- Non-productive Mesaverde gas wells



MESAVERDE PRODUCTION FACTS:

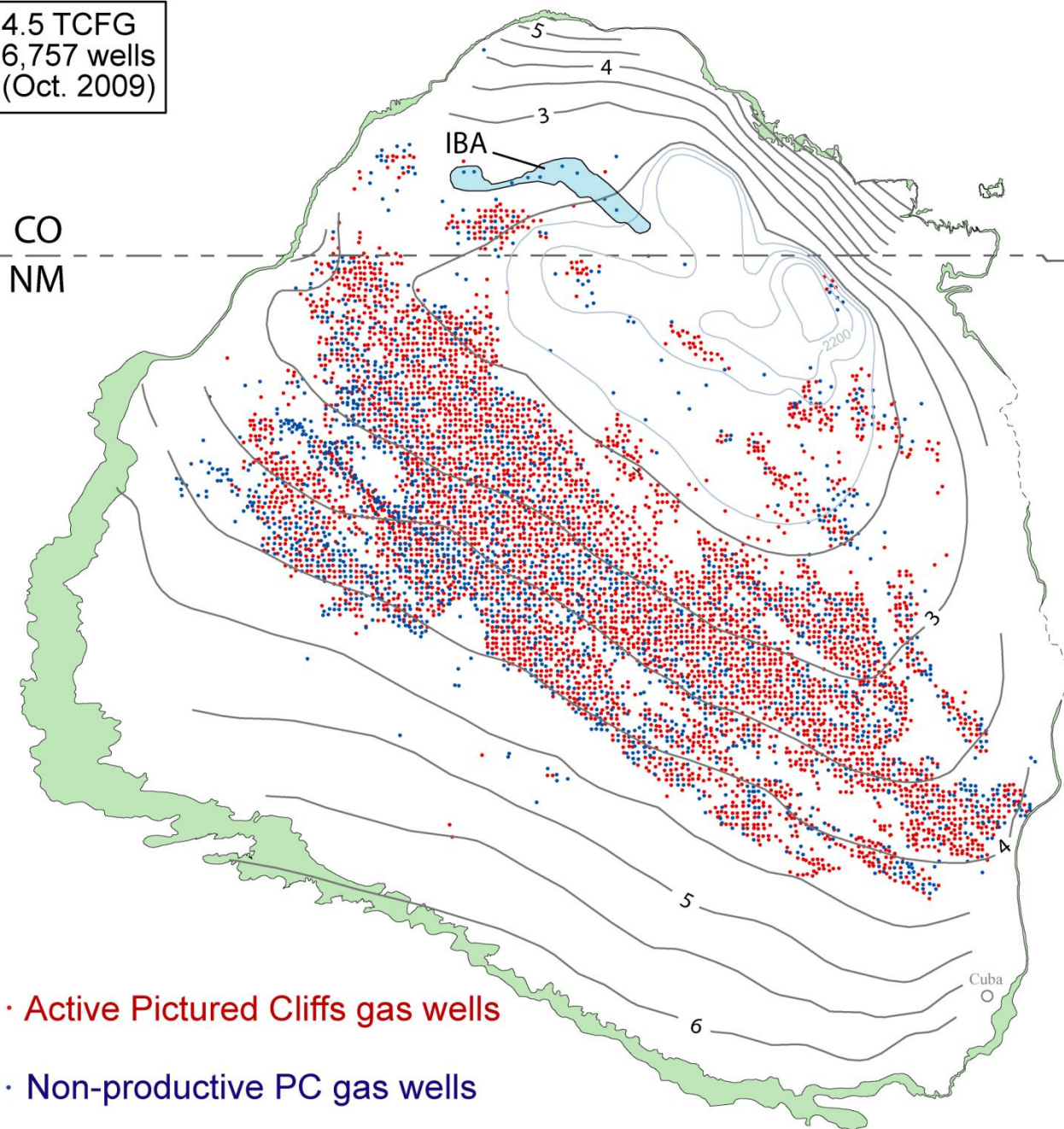
- ★ 12.9 TCFG from 8,230 wells – Av. >1.6 BCFG/well
- ★ 47.3 MB condensate
- ★ 24 MB water – Av. 2.9 KBW/well
- ★ Well spacing has gone from 320 acres, to 160 acres, to 80 acres

GAS-PRODUCTIVE AREA - PICTURED CLIFFS SS



4.5 TCFG
6,757 wells
(Oct. 2009)

CO
NM



· Active Pictured Cliffs gas wells

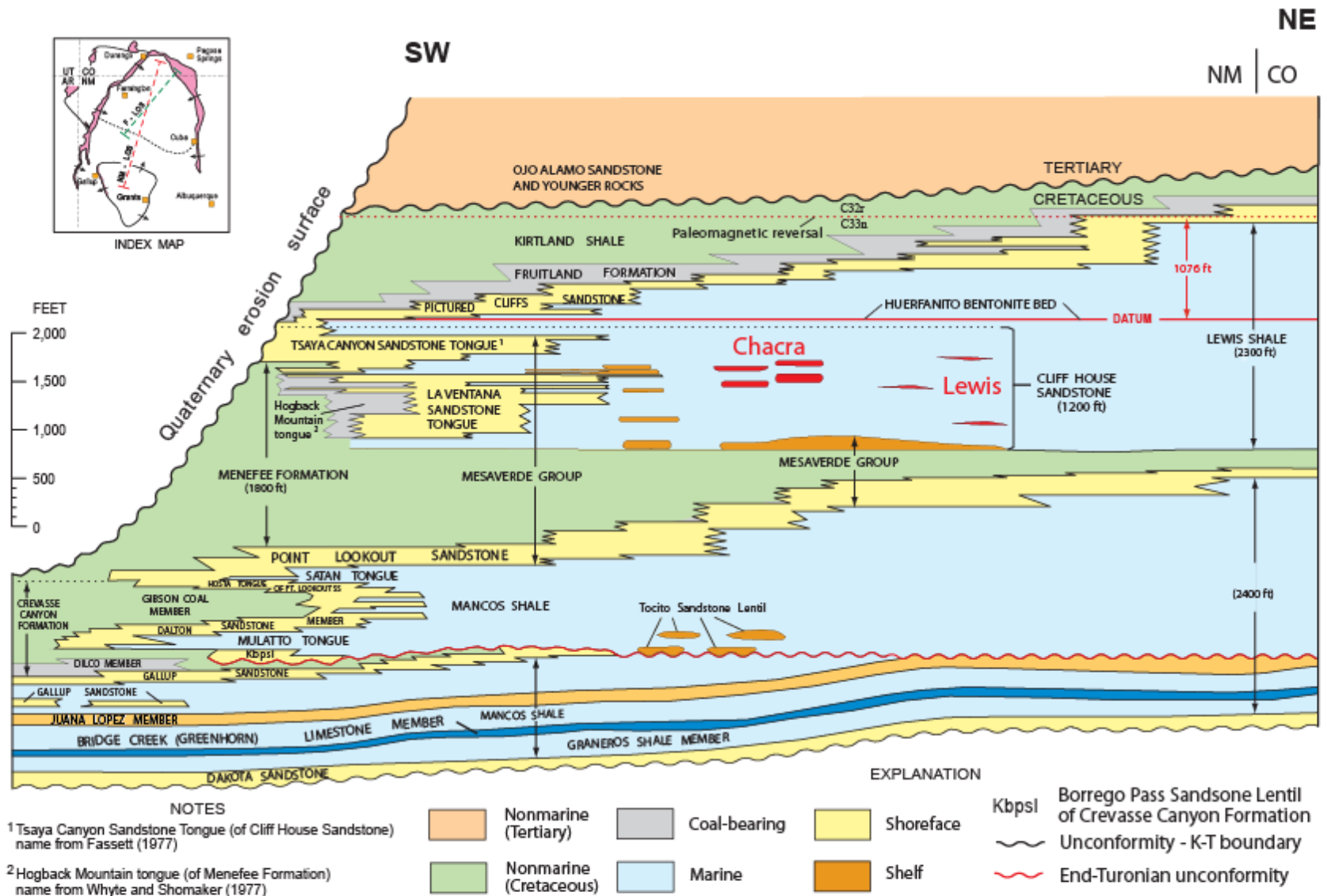
· Non-productive PC gas wells



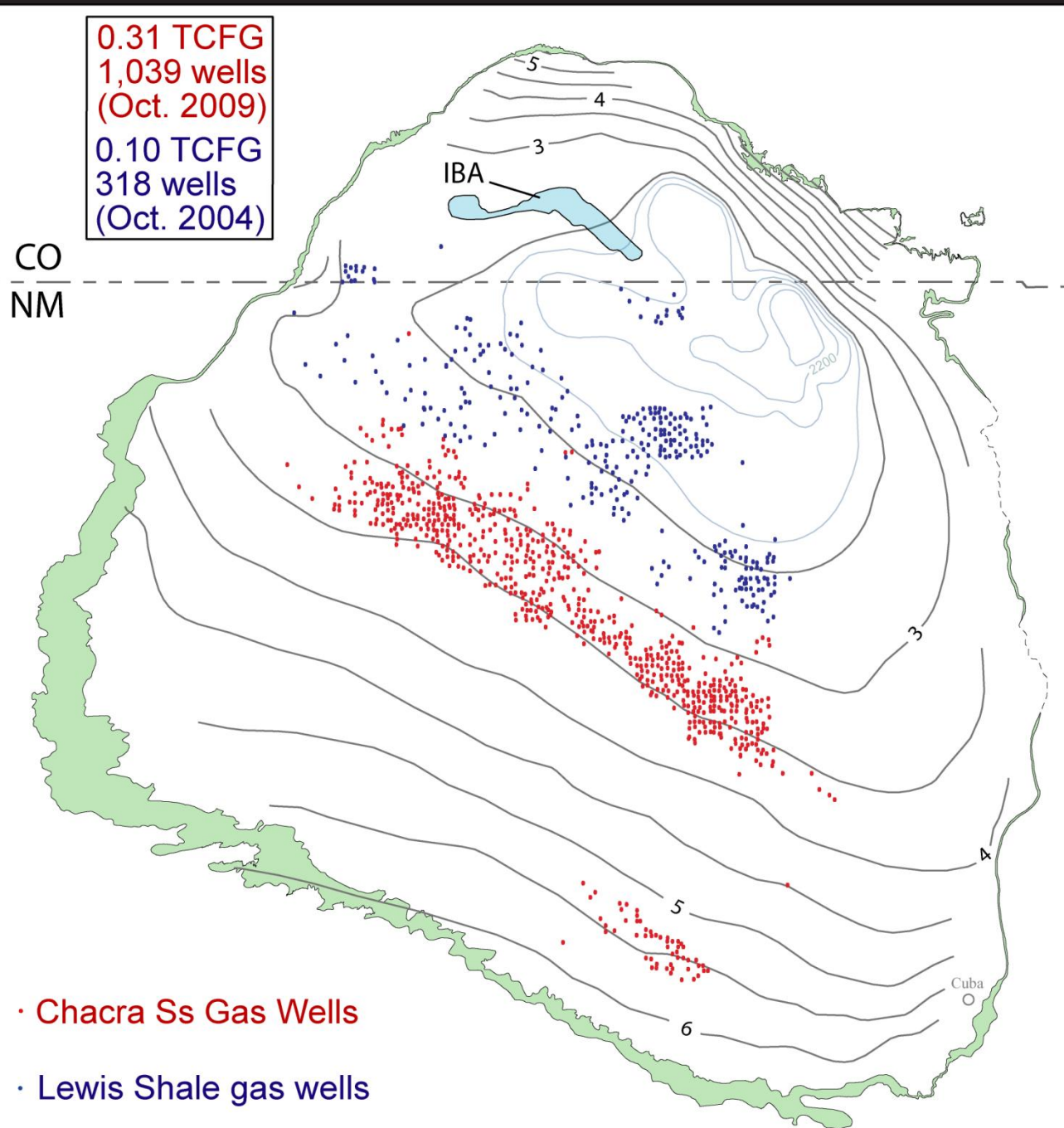
PICTURED CLIFFS PRODUCTION FACTS:

- ★ 4.5 TCFG from 6,757 wells – Av. < 0.7 BCFG/well
- ★ 1.3 MB condensate
- ★ 25.2 MB water – Av. 4.8 KBW/well
- ★ Well spacing has gone from 320 acres to 160 acres

GAS-PRODUCTIVE AREA - CHACRA SS/LEWIS SH



140 Miles






CHACRA SS/LEWIS SH. PRODUCTION FACTS:

Chacra: 306 BCFG from 1,039 wells – Av. 297
MMCFG/well

Lewis: 1.0 BCFG from 318 wells – Av. 3.2 MMCGF/well
(estimate because of comingling with MV gas)

Totals: 307 BCFG from 1,357 wells

A vertical strip on the left side of the slide shows a topographic map of the San Juan Basin, featuring contour lines and a grid.

**SAN JUAN BASIN
SANDSTONE GAS
RESERVOIRS HAVE BEEN
CALLED “BASIN-
CENTERED” GAS
DEPOSITS**

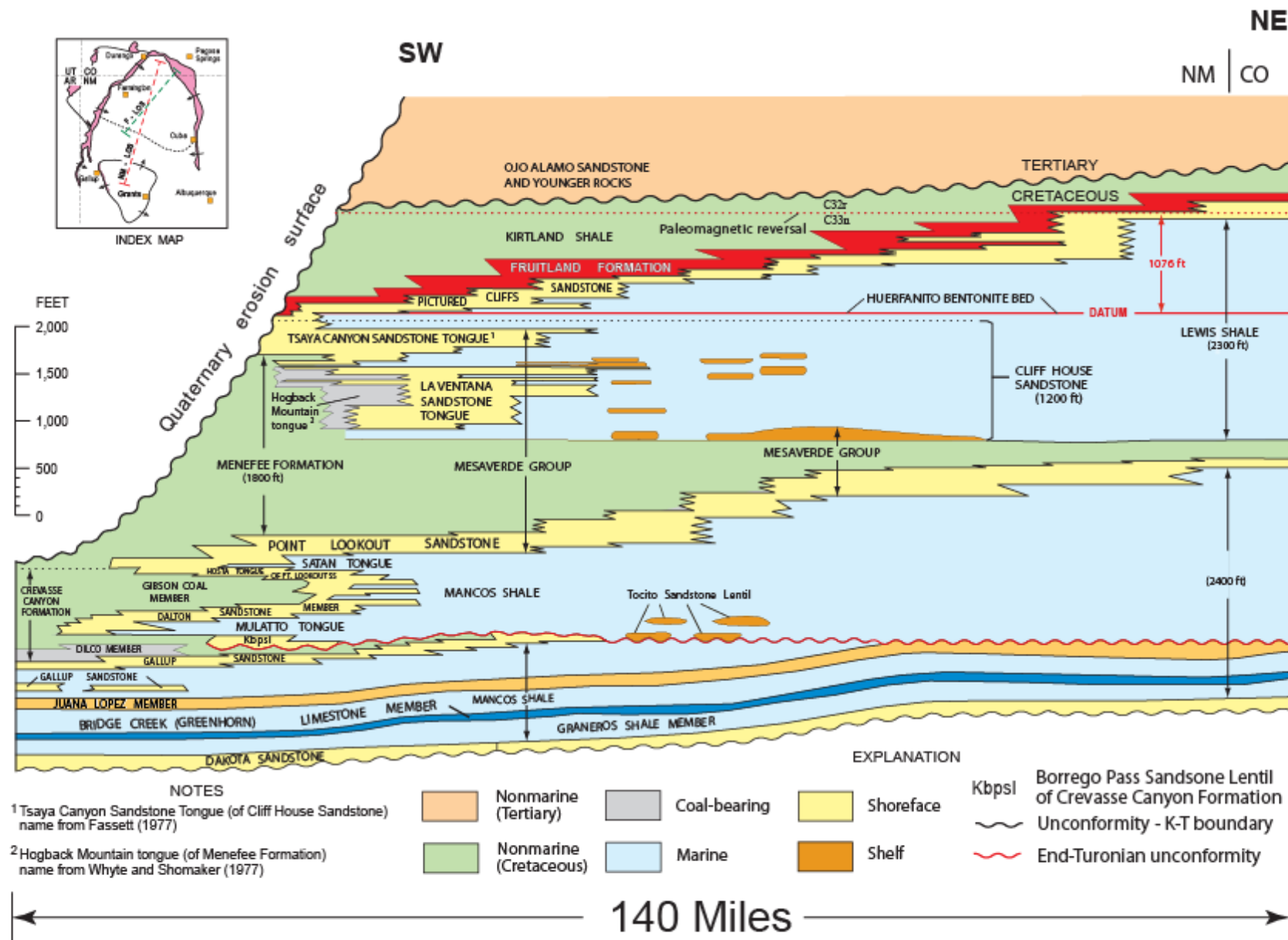


**THAT CHARACTERIZATION IS
INCORRECT:**

**THESE RESERVOIRS ARE ALL
STRATIGRAPHIC TRAPS WITH
FRACTURE PERMEABILITY**

(See Fassett and Boyce, 2005)

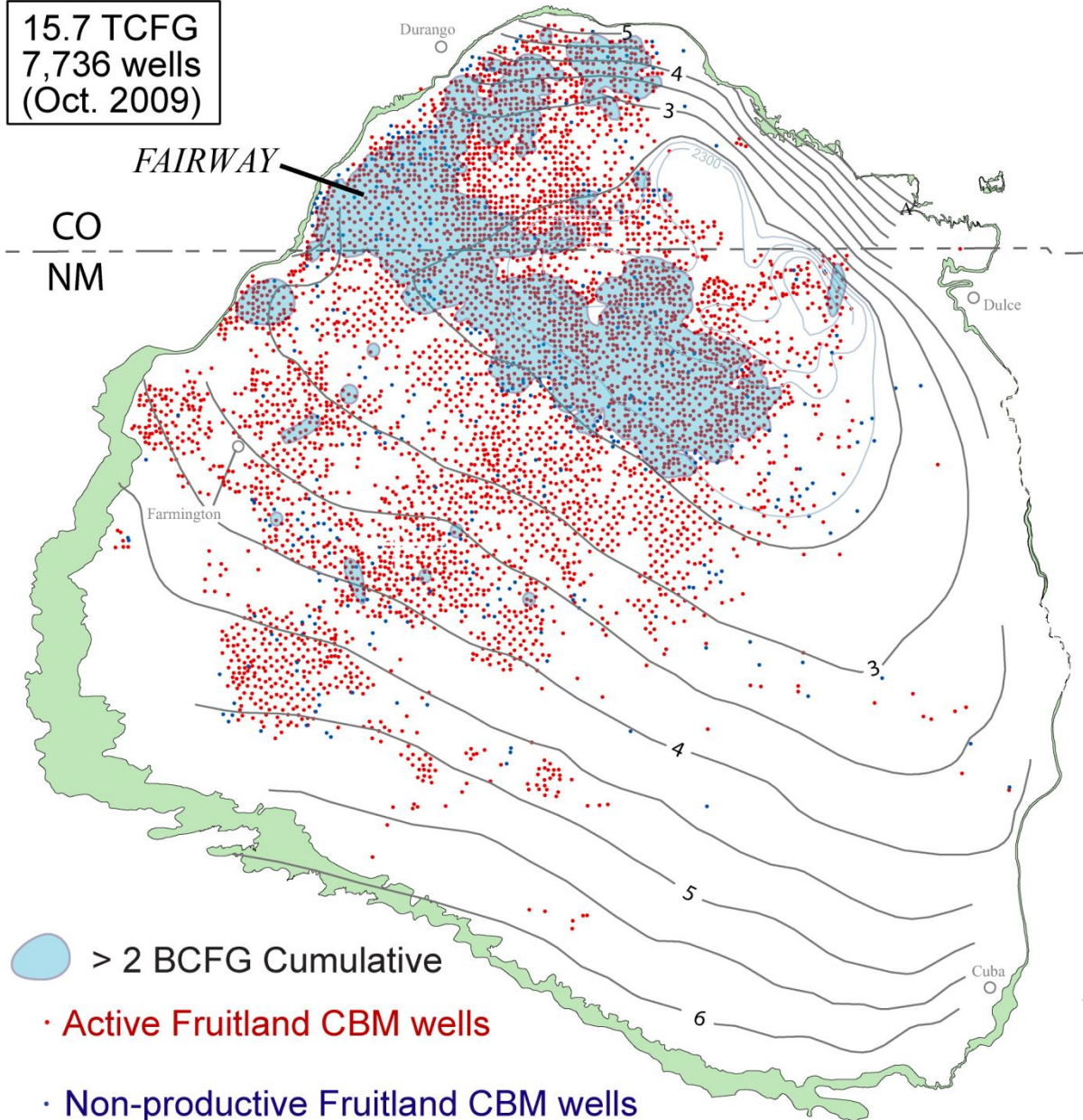
GAS-PRODUCTIVE AREA - FRUITLAND FM. CBM



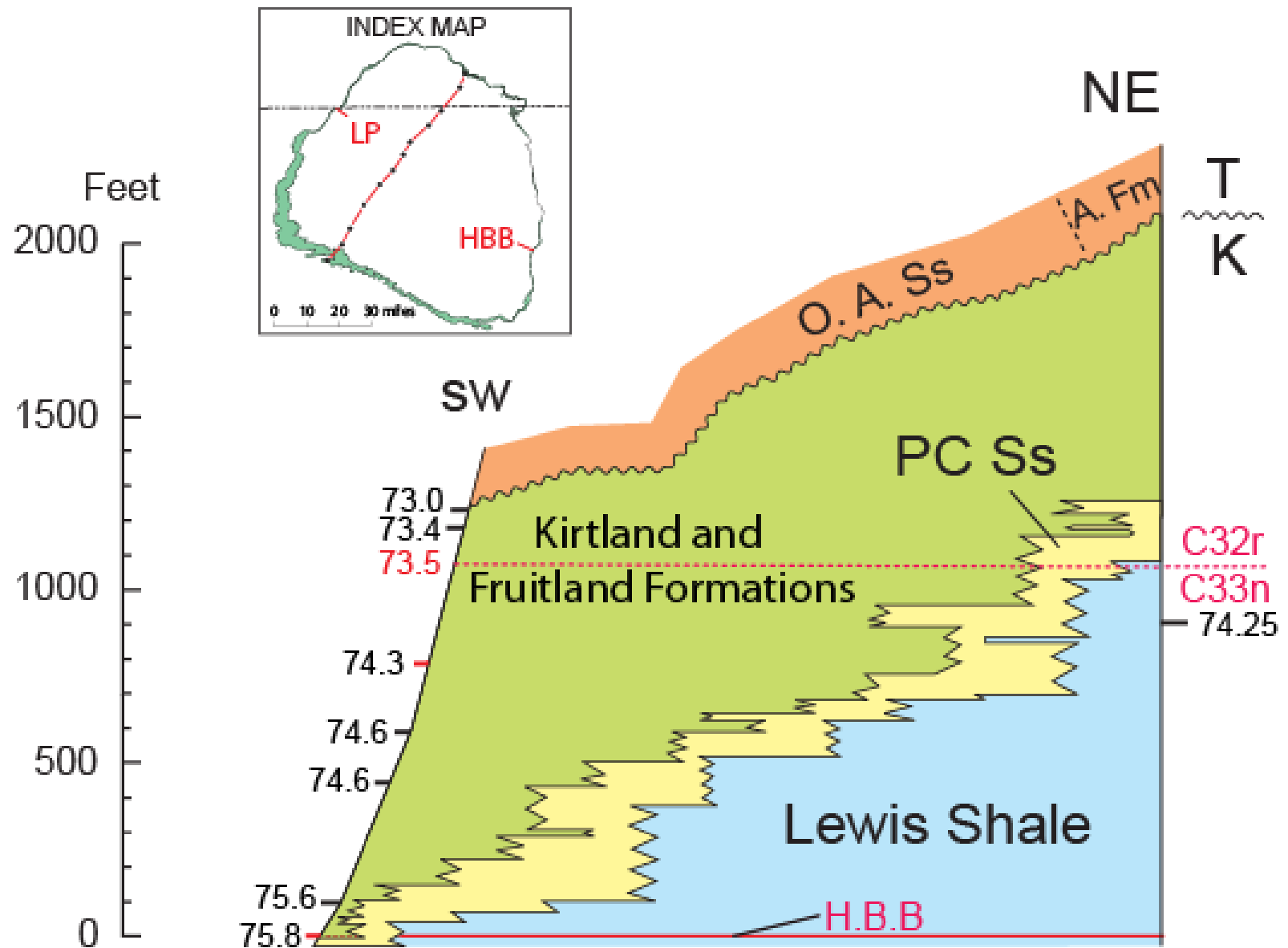
15.7 TCFG
7,736 wells
(Oct. 2009)

FAIRWAY

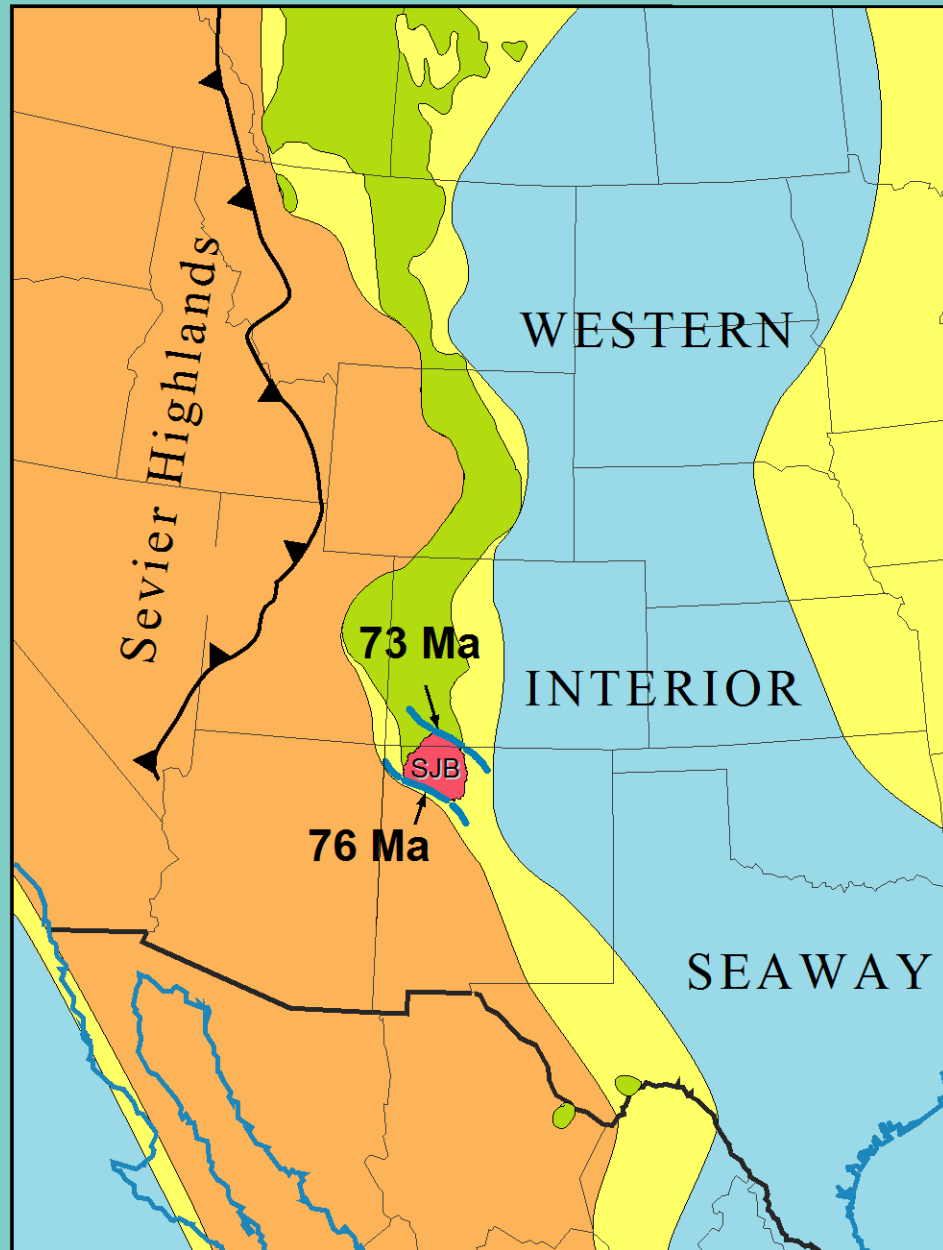
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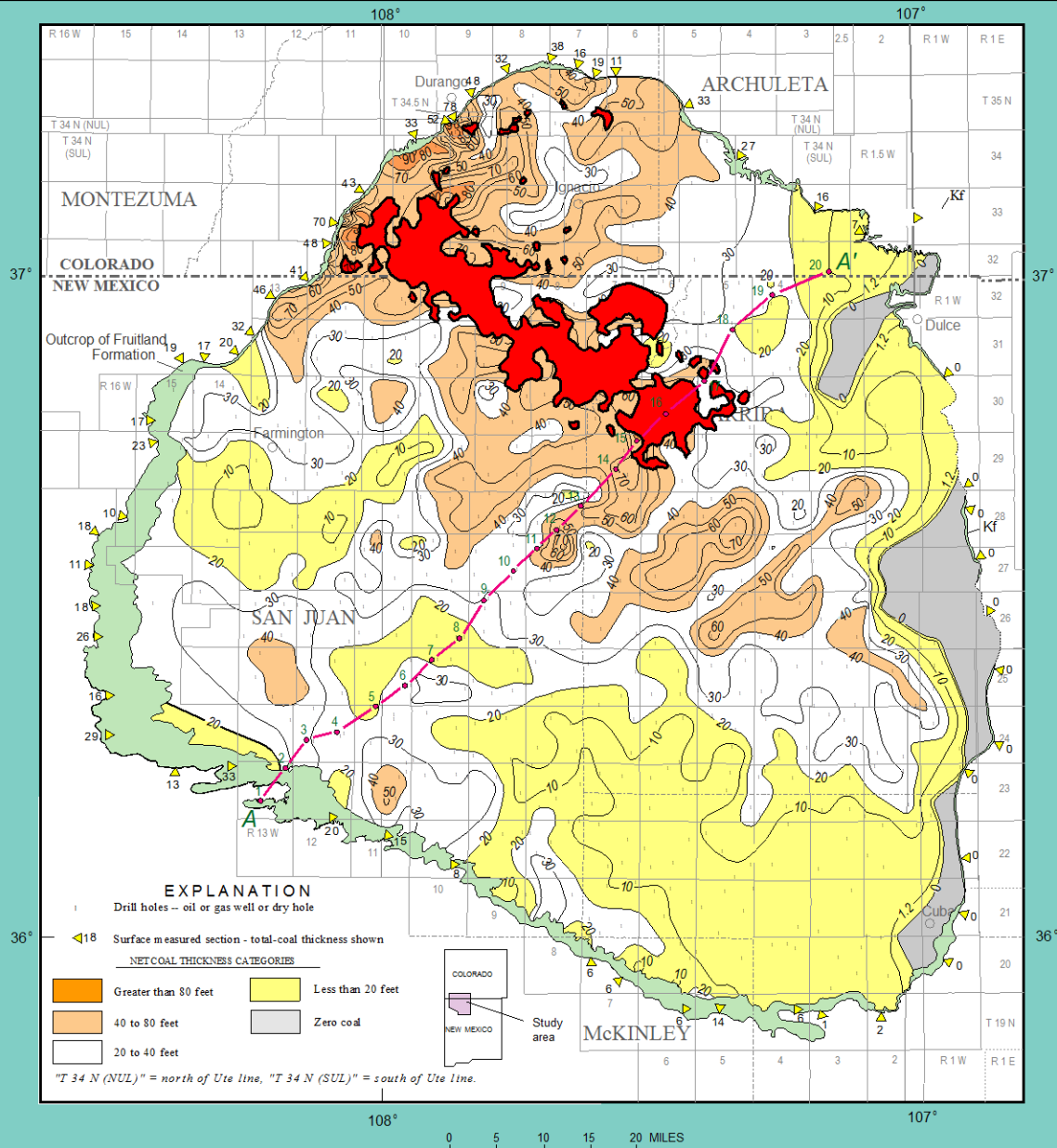
ASH-BED AGES - TIME-TRANSGRESSIVE PC



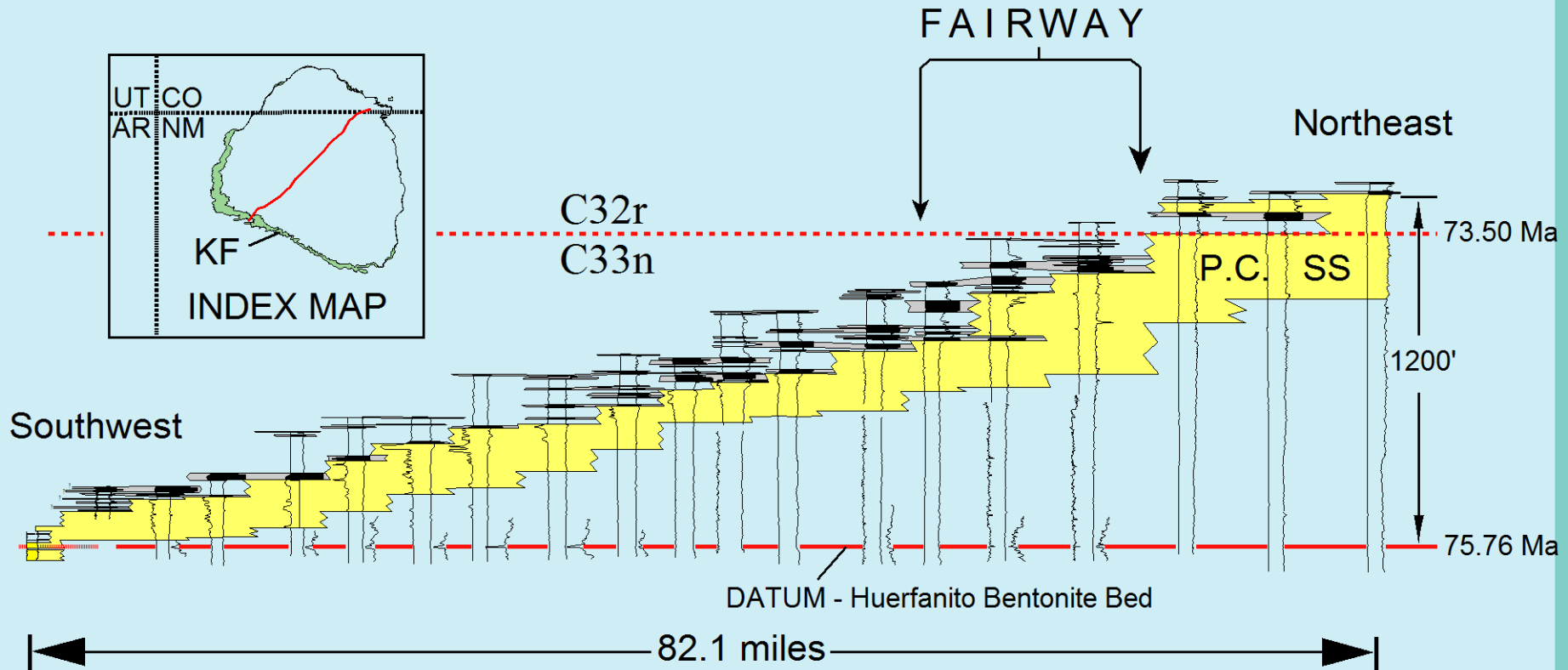
PALEOGEOGRAPHIC MAP -- ABOUT 72 MA



NET-COAL ISOPACH MAP FRUITLAND FORMATION COAL BEDS



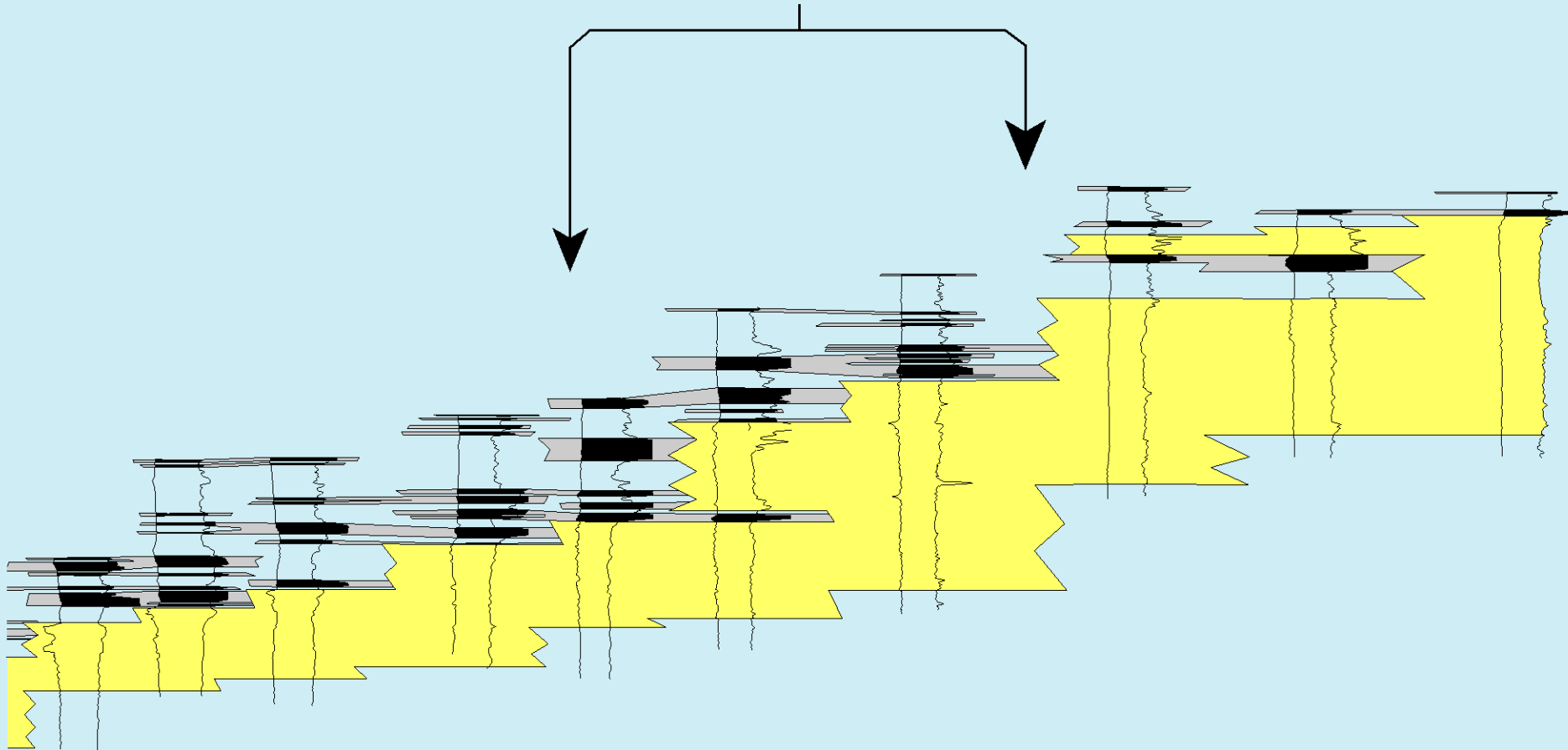
STRATIGRAPHIC CROSS SECTION SHOWING GEOMETRY AND DISTRIBUTION OF FRUITLAND FORMATION COAL BEDS



Modified from Fassett (2000), Chapter Q, USGS Professional Paper 1625-B

FRUITLAND COALS -- NE SJ BASIN

FAIRWAY

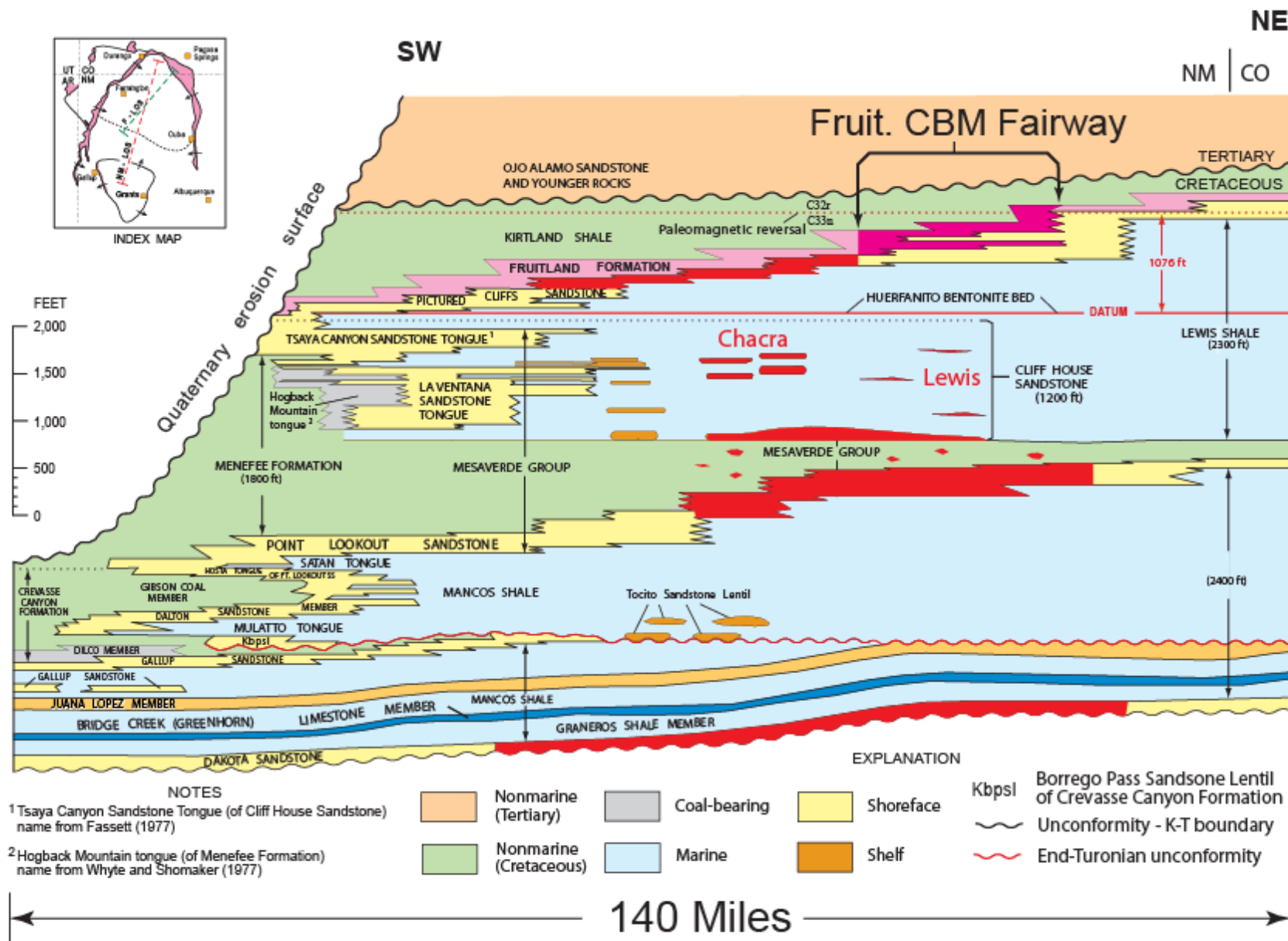




FRUITLAND FORMATION CBM PRODUCTION FACTS:

- ✳ 15.7 TCFG from 7,736 wells – Av. >2.0 BCFG/well
- ✳ Minimal condensate from < 400 wells
- ✳ 777 MBW – Av. 100 K BW/Well
- ✳ Well spacing has gone from 320 acres to 160 acres

GAS-PRODUCTIVE AREAS - ALL MAJOR GAS RESERVOIRS



DAKOTA SANDSTONE

7.0 TCFG
7,421 wells
(Oct. 2009)

CO
NM

- Active Dakota gas wells
- Non-productive Dakota gas wells

MESAVERDE GROUP

12.9 TCFG
8,230 wells
(Oct. 2009)

CO
NM

- Active Mesaverde gas wells
- Non-productive Mesaverde gas wells

PICTURED CLIFFS SANDSTONE

4.5 TCFG
6,757 wells
(Oct. 2009)

CO
NM

- Active Pictured Cliffs gas wells
- Non-productive PC gas wells

FRUITLAND FORMATION COAL-BED METHANE

15.7 TCFG
7,736 wells
(Oct. 2009)

CO
NM

- > 2 BCFG Cumulative
- Active Fruitland CBM wells
- Non-productive Fruitland CBM wells

GAS-PRODUCTION SUMMARY

Dakota Ss – 7.0 TCFG from 7,421 wells

Mesaverde – 12.9 TCFG from 8,230 wells

Pictured Cliffs – 4.5 TCFG from 6,757 wells

Chacra/Lewis – 0.32 TCFG from 1,357

Fruitland CBM – 15.7 TCFG from 7,736 wells

Total – 40.4 TCFG from 31,501 wells

RESOURCE COMPARISON (TCFG)

Formation	Cum.	USGS (2002)	This Report
Fruitland Fm.	15.7	23.6	30.0
Pictured Cliffs Ss.	4.5	5.6	1.0
Lewis Sh.	0.3	10.2	0.3
Menefee CBM	0.0	0.6	0.3
Mesaverde Group	12.9	1.3	4.0
Mancos Sh.	0.0	5.1	0.1
Dakota Ss.	4.0	7.0	3.0
	<u>40.4</u>	<u>50.4</u>	<u>38.7</u>
Ultimate Production		90.8	79.1

**“FRACTURED-SANDSTONE GAS RESERVOIRS, SAN JUAN BASIN,
NEW MEXICO AND COLORADO: STRATIGRAPHIC TRAPS, NOT
BASIN-CENTERED GAS DEPOSITS -- WITH AN OVERVIEW OF
FRUITLAND FORMATION COAL-BED METHANE”**

by

James E. Fassett and Bradford C. Boyce

in

