The Jackson Gas Rock, a Unique Upper Cretaceous (Selma Chalk) Lithofacies, Mississippi

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EXTENDED ABSTRACT

The Jackson Gas Field was officially discovered in 1930 with the drilling and completion of the Jackson Oil & Gas Co. #1 Mayes in Section 2, Township 5 North, Range 1 East, Hinds County, Mississippi, in a carbonate reservoir informally named the “Jackson Gas Rock.” The discovery well flowed gas with an open-flow potential of 15 million cubic feet of gas per day (MMCFGPD) from a heavily karsted interval at the top of the Upper Cretaceous (Selma) Chalk. Since 1930, three distinctly different porosity types have been encountered within the Selma Chalk interval, including the heavily karsted interval encountered just beneath the K/T unconformity atop the Jackson Gas Field structure; a series of relatively thin leached rudist-dominated bioherms, developed on the flanks of the uplift; and isolated lenses of loosely-cemented, highly porous and permeable quartzitic sand that are erratically distributed within the Upper Gas Rock facies just north of the Jackson Dome, the large oval-shaped structural uplift centered under the cities of Jackson and Clinton, Mississippi.

While the heavily karsted chalk reservoir produced 119 billion cubic feet (BCF) of methane gas at Jackson Gas Field, quartzitic sand lenses deposited within the top fifty feet of the Selma Chalk comprise the 7.6 thousand barrels of oil (MMBO) (26° American Petroleum Institute [API] gravity) oil reservoir that is stratigraphically trapped within the Gas Rock facies equivalent in the Flora Field area, just north of the Jackson Dome. A small volume of heavy (13.6° API gravity) oil has also been produced from the karsted Gas Rock chalk reservoir on the southern flank of the Dome, near the city of Pearl. In 1957, two years after the last producing Gas Rock gas well had been shut in, the crestal area of the Jackson Gas Field was converted to a gas storage reservoir and is still used for that purpose today, 61 years later.

The study area encompassed 808 wells located within an area of approximately 1465 square miles located in Hinds, Madison, Rankin, and Yazoo counties in west-central Mississippi. Lithology data pertaining to the Jackson Gas Rock facies was derived from the analysis of a subset of 121 wells for which mudlog, sample log, and core and sidewall core descriptions or analyses were available. Bottom-hole temperature data that was available for 446 of the 808 wells (as recorded in the log header) was also collected and analyzed to determine if a significant deviation from the “normal” subsurface geother-
mal gradient was present within the study area, and specifically, within the perimeter of the Jackson Dome uplift. It should be noted that most (approximately 141) of the wells drilled in the Jackson Gas Field were drilled in the 1930s and were not logged with open-hole electrical logging tools; of those shallow Gas Rock test wells that were later drilled and logged in that area, most did not record the actual bottom-hole temperature but simply reported (estimated) that it was less than 100° Fahrenheit.

Subsurface control and modern 3D seismic data (Figs. 1 and 2) indicates the Jackson Gas Rock facies represents a relatively pure chalky limestone deposited in a persistent syncline that had initially formed in the area in late Jurassic time. While there have been a few reports of framestones and boundstones having been encountered within the Jackson Gas Rock facies, such reefal occurrences are sporadic and rare, and the most common fossiliferous intervals appear to be comprised of rudist shell fragments. The thickest Gas Rock facies encountered to date (1762 feet) was deposited within the lowest portion of the syncline located within Township 8 North, Range 1 East, in southern Madison County (Fig. 3). The Gas Rock facies abruptly pinches out at the edge of the syncline as the entire Chalk interval thins from over 2000 feet to approximately 500 feet on the southeastern flank of the Sharkey Platform.

Following a prolonged period of structural uplift, lowered sea level and subaerial exposure associated with the end of the Cretaceous, a thin marl of Lower Tertiary Paleocene age, the Clayton Marl, was deposited unconformably atop the Gas Rock facies at the K/T boundary. It is difficult in many instances to use electric logs to distinguish the boundary between the Clayton Marl and the underlying Cretaceous carbonates. Locally irregular paleotopography at the top of the K/T unconformity is attributed to the collapse of karsted cavities (sinkholes) within the underlying Gas Rock, and the Clayton Marl is observed to thicken from a few feet to as much as fifty feet in many of those areas. Overlying the Clayton Marl is the Paleocene Midway Shale, which is observed to thin dramatically over the thickest Jackson Gas Rock facies, from a regional thickness of approximately 1000 feet outside the syncline to less than 60 feet atop the thickest Gas Rock facies. The significant isopachous change in the thickness of the Midway Shale is attributed to drape over the Gas Rock facies, which was apparently more dense and resistant to compaction than the surrounding shale-rich facies of the upper Selma Chalk lateral equivalent that was deposited outside of the syncline.

A distinct negative spontaneous potential (SP) curve profile characterizes the porous facies of the Selma Chalk in the greater Jackson area, and typically consists of two thick units separated by a thin layer of impermeable limestone. A third unit that directly underlies the porous Selma Chalk on the west and northwest flanks of the Jackson Dome is a crescent-shaped siliciclastic apron comprised of older uplifted Cretaceous and Jurassic sediments eroded off the top of the Dome prior to the deposition of the Upper Chalk. Geologists unfamiliar with the lithology and provenance of the lower redeposited unit often misinterpret its SP curve profile as being a part of the overlying Upper Chalk lithofacies. This siliciclastic unit in turn directly overlies a black micaceous clay that contains abundant water-lain volcanic sediments and thin beds of ash associated with a period of vulcanism that was widespread across the northeastern Louisiana / central Mississippi area during Austin Chalk time. This vulcanism appears to have been centered in the East Monroe Uplift / Sharkey Platform area, northwest of the Jackson Dome.

While igneous intrusions have been encountered frequently in the Cretaceous and Jurassic strata penetrated beneath the Jackson Gas Rock facies atop the Jackson Dome, there are no locally thick igneous extrusive deposits that would indicate a volcano of any significance existed in the Jackson area at any time in the stratigraphic record. At the crest of the Jackson Dome, the base of the Jackson Gas Rock facies unconformably overlies a succession of progressively older rocks as one approaches the apex of the structure, where sandstones of the Cotton Valley Formation are encountered just beneath the steep oval angular unconformity. Deep wells drilled within the perimeter of the Jackson Dome have encountered highly dipping but otherwise unaltered Cretaceous and Jurassic strata with relatively minor thicknesses of igneous intrusive dikes and sills. This observation is confirmed by modern high-resolution residual Bouguer gravity data, which further suggests there is no substantive plutonic mass underlying the Jackson Dome.
The Jackson Gas Rock
A Unique Upper Cretaceous (Selma Chalk) Lithofacies

Steve Walkinshaw
OBJECTIVES

- Investigate the carbonate facies developed within the Upper Cretaceous Chalk in the vicinity of Jackson, Mississippi (the “Jackson Gas Rock”)

- Any investigation of the Jackson Gas Rock must incorporate a concurrent investigation of the underlying structure known as the “Jackson Dome”

- Examine the influence of the underlying Gas Rock facies on the Paleogene sediments that have been deposited unconformably atop the K/T boundary

- Review the reservoir characteristics and developmental history of the Jackson Gas Field and the adjacent (but unrelated) Flora Oil Field

- Analyze the subcrop of the Cretaceous and Upper Jurassic sediments that have been encountered in crestal wells drilled beneath the Gas Rock

- Determine the most likely origin of the Jackson Dome, in a regional context
ASSOCIATED EVENTS

K/T - End of Cretaceous (66 MA)
Deccan Traps (66.25 MA)
Chicxulub Bolide Impact (66 MA)

OO - End of Ouachita Orogeny
Initial Formation of Jackson Dome Horst Block (~270 MA)

After Walkinshaw (2001); Modified from USGS
Monroe Gas Rock: Selma Eq. Chalk was "severely leached, and a high degree of porosity was developed by the removal of calcium carbonate" - Fergus (1935)

**REGIONAL MAP ILLUSTRATING NE LA / CENTRAL MS BASEMENT FEATURES & STUDY AREA**

**STRUCTURAL DATUM - CONTOURED AREA**
SOUTH ARKANSAS - NORTH LOUISIANA
TOP SMACKOVER LIMESTONE

**MONROE FIELD**

**EPPS FIELD**

**CARY FIELD**

**JACKSON DOME (WEST)**

**ANALOGOUS LEACHED UPPER CRETAUSEOUS (SELMA EQUIV.) CHALKS WERE ENCOUNTERED ATOP MONROE PALEOHIGH, EPPS DOME AND CARY DOME**

**331’**

**THINNEST GAS-ROCK PENETRATION ATOP DOME**

**LOWER CRETAUSEOUS (UNDIFFERENTIATED)***

**FURRH #1 Houston 23-3 (23-11N-7W)**

**Caldwell #1 Hemphill (4-19N-10E)**

**RELCO #1 Ga. Pacific (28-22N-5E)**
SUBSURFACE STRUCTURE
TOP GAS ROCK

DISOLUTION OF THE UPPER DOMAL SALT FOLLOWING SUBAERIAL EXPOSURE (KARSTING, LEACHING) OF GAS ROCK (AT END OF CRETACEOUS TIME) LED TO SUBSEQUENT COLLAPSE OF THE CRESTAL AREA OF THE BROWNSVILLE SALT DOME
FERRY LAKE ANHYDRITE
(150' - 200'; Density ~2.97 g/cm³)

BOLTON - THOMPSON SALT RIDGE
A prominent syncline that developed in the area north/west of the Jackson dome during Smackover depositional time led to extensive deposition of thick Jurassic and Cretaceous sediments in that area. The rising Selma Sea eventually filled the syncline with thick carbonate (gas rock, eq. chalk and limestone).
THE MAXIMUM GAS ROCK THICKNESS IS ENCOUNTERED IN THE SYNCLINAL AREAS NORTH/WEST OF THE JACKSON DOME CREST.

THE THINNEST GAS ROCK INTERVAL ENCOUNTERED ATOP THE CREST OF THE DOME IS NOT LOCATED WITHIN THE JACKSON GAS FIELD (EASTERN CRESTAL) AREA.

IT WAS ENCOUNTERED IN A DRY HOLE DRILLED IN THE WESTERN CRESTAL AREA (NEAR THE CITY OF CLINTON), AN AREA NOT ASSOCIATED WITH ANY KNOWN FAULTING.
The Midway (Porters Creek) Shale thins over an area much larger in size than the crestal area of the underlying gas rock atop the dome.

This anomalously large area of thin Midway Shale is attributable to differential compaction and drape over the thicker gas rock carbonate deposited in the synclinal areas (as much as 1,400'+ thicker).
OLDEST STRATA ENCOUNTERED TO DATE (2018) DIRECTLY BELOW (SUBCROPPED BY) BASE GAS ROCK: COTTON VALLEY (UNDIFFERENTIATED)

AREA SHOWN AT RIGHT

DATA SOURCE
- SAMPLE LOG
- CORE DESC.
- MUDLOG

PROBABLE JURASSIC-AGED VOLCANO

“NORMAL” SEDIMENTARY CORE
Gas Analysis (1935)
- Methane 99%
- Nitrogen 0.21%
- CO₂ 0.34%
- Btu (Gr.) 1,000
- Sp. Gr. 0.595

Jackson Gas Field (1930)

RESERVOIR AREA:
~8,560 NET ACRES

DISCOVERED 1930
PRODUCED 119 BCF
GAS EXP. / WATER DRIVE
CONVERTED TO GAS STORAGE 1955

ORIGINAL GWC ~2,200'
ORIGINAL BHP 1,010 PSI
I.P.'s >50 MMCF/D (Karsts)

PRODUCING RESERVOIR (MUNROE, 1935):
“WHITE, POROUS, AND IN SOME PLACES CAVERNOUS CHALKS OR LIMESTONES, GENERALLY SOFT BUT IN SOME PLACES EXCEEDINGLY HARD...

Geomorphology and geophysical data indicate the Jackson Dome structure comprises a northwest/southeast oriented Paleozoic horst block that had been uplifted periodically throughout the Jurassic and Cretaceous periods. Structural strike suggests a causal relationship with the Ouachita Front.
THE (MINOR) IGNEOUS INTRUSIVE ACTIVITY AT THE JACKSON DOME HAD ESSENTIALLY CEASED AFTER EITAW (STRATIGRAPHIC EQUIVALENT OF UPPER EAGLEFORD) DEPOSITION.

A SHORT PERIOD OF SUB-REGIONAL VULCANISM THEN FOLLOWED, WHICH LED TO LIMITED DEPOSITION OF A THIN GREY / BLACK MICAEGEOUS SHALE (CONTAINING MOSTLY WEATHERED DEBRIS AND WATER-LAIN VOLCANIC MATERIAL) IN CERTAIN AREAS SURROUNDING THE FLANKS OF THE JACKSON DOME. THIS LAYER OF DARK VOLCANICLASTIC SEDIMENTS THICKENS TO THE NORTH / NORTHWEST.

THE CESSATION OF SUB-REGIONAL VULCANISM COINCIDED WITH THE DRAMATIC RISE IN GLOBAL SEA LEVEL DURING LATE CRETACEOUS TIME (ESTIMATED TO HAVE EXCEEDED 500'), WHICH THEN DROWNED THE ENTIRETY OF THE JACKSON DOME.

THE END OF THE CRETACEOUS IS MARKED BY A SUSTAINED SIGNIFICANT DROP IN (GLOBAL) SEA LEVEL THAT SUBJECTED THE SELMA CHALK TO SUBAERIAL EXPOSURE AND EROSION.
SUMMARY

- The Jackson Gas Rock is a leached and karsted Upper Cretaceous Chalk that thickens significantly in the synclinal areas around the Jackson Dome
- The Jackson Dome is interpreted to be a Paleozoic horst block caused by tectonic stress associated with or caused by the Ouachita Orogeny
- Limited igneous intrusive activity commenced soon after the horst block was formed, but current data does not support intrusion of a large pluton
- Subsequent upward movement, which occurred frequently until the end of the Late Cretaceous, subjected the crestal area of the Dome to erosion
- Igneous intrusive activity virtually ceased by Austin Chalk time; however, widespread regional vulcanism contributed to deposition of black micaceous shales that contained significant volumes of water-lain, weathered volcanics
- Dramatically rising sea level drowned the Dome in Upper Cretaceous time and heralded the end of widespread regional (and minor local) vulcanism
- Following a prolonged drop in sea level at the end of the Cretaceous, the thick Selma chalks and limestones deposited around and atop the Dome were subaerially exposed to intense erosion, leaching and karstification
- The weathered carbonates were then buried by Paleogene sediments that compacted differentially over both the Dome and its thickest flank deposits
References


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