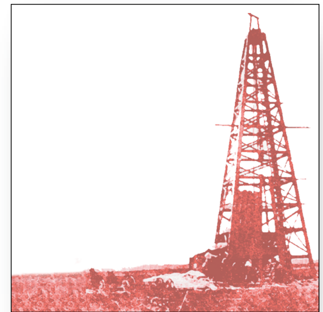
Chapter 5

Assessment of Undiscovered Conventional Oil and Gas Resources—Lower Cretaceous Travis Peak and Hosston Formations, Jurassic Smackover Interior Salt Basins Total Petroleum System, in the East Texas Basin and Louisiana-Mississippi Salt Basins Provinces



Click here to return to
Volume Title Page

By T.S. Dyman and S.M. Condon

Chapter 5 of
Petroleum Systems and Geologic Assessment of Undiscovered Oil and Gas, Cotton Valley Group and Travis Peak–Hosston Formations, East Texas Basin and Louisiana-Mississippi Salt Basins Provinces of the Northern Gulf Coast Region
By U.S. Geological Survey Gulf Coast Region Assessment Team

U.S. Geological Survey Digital Data Series DDS–69–E

U.S. Department of the Interior
U.S. Geological Survey

U.S. Department of the Interior
Gale A. Norton, Secretary

U.S. Geological Survey
P. Patrick Leahy, Acting Director

U.S. Geological Survey, Reston, Virginia: 2006

For product and ordering information:
World Wide Web: http://www.usgs.gov/pubprod
Telephone: 1–888–ASK–USGS

For more information on the USGS—the Federal source for science about the Earth, its natural and living resources, natural hazards, and the environment:
World Wide Web: http://www.usgs.gov
Telephone:1–888–ASK–USGS

Suggested citation:
Dyman, T.S., and Condon, S.M., 2006, Assessment of undiscovered conventional oil and gas resources—Lower Cretaceous Travis Peak and Hosston Formations, Jurassic Smackover Interior Salt Basins Total Petroleum System, in the East Texas Basin and Louisiana-Mississippi Salt Basins Provinces: U.S. Geological Survey Digital Data Series DDS–69–E, Chapter 5, 39 p.

ISBN=1411309960

Contents

Plates

Figures

Tables

Assessment of Undiscovered Conventional Oil and Gas Resources—Lower Cretaceous Travis Peak and Hosston Formations, Jurassic Smackover Interior Salt Basins Total Petroleum System, in the East Texas Basin and Louisiana-Mississippi Salt Basins Provinces

By T.S. Dyman and S.M. Condon

Abstract

The Lower Cretaceous Travis Peak Formation of east Texas and southern Arkansas (and the correlative Hosston Formation of Louisiana and Mississippi) is a basinward-thickening wedge of terrigenous clastic sedimentary rocks that underlies the northern Gulf of Mexico Basin from east Texas across northern Louisiana to southern Mississippi. Clastic detritus was derived from two main fluvial-deltaic depocenters, one in northeastern Texas and the other extending from southeastern Mississippi northwestward into northeastern Louisiana. Across the main hydrocarbon-productive trend in east Texas and northern Louisiana, the Travis Peak and Hosston Formations are about 2,000 ft thick.

The most likely sources for hydrocarbons in Travis Peak and Hosston reservoirs are two stratigraphically lower units, lime mudstones of the Upper Jurassic Smackover Formation and organic-rich shales of the Upper Jurassic Bossier Shale of the Cotton Valley Group. As a result of the absence of proximal source rocks and a lack of effective migration pathways from stratigraphically or geographically distant source rocks, hydrocarbon charge is sufficient for development of conventional gas accumulations but insufficient for development of basin-centered gas.

The petroleum assessment of the Travis Peak and Hosston Formations was conducted by using a total petroleum system model. A total petroleum system includes all of the important elements of a hydrocarbon fluid system needed to develop oil and gas accumulations, including source and reservoir rocks, hydrocarbon generation, migration, traps and seals, and undiscovered accumulations. A total petroleum system is mappable and may include one or more assessment units. For each assessment unit, reservoir rocks contain similar geology, exploration characteristics, and risk. The Jurassic Smackover Interior Salt Basins Total Petroleum System is defined for this assessment to include (1) Upper Jurassic Smackover carbonates and calcareous shales and organic-rich shales of the Upper Jurassic Bossier Shale of the Cotton Valley Group and (2) Lower Cretaceous Travis Peak and Hosston Formations. The Jurassic Smackover Interior Salt Basins Total Petroleum System includes three conventional Travis Peak–Hosston assessment units: Travis Peak–Hosston Gas and Oil (AU 50490205), Travis Peak–Hosston Updip Oil (AU 50490206), and Travis Peak–Hosston Hypothetical Updip Oil (AU 50490207). A fourth assessment unit, the Hosston Hypothetical Slope-Basin Gas Assessment Unit, was named and numbered (AU 50490208) but not geologically defined or quantitatively assessed owing to a lack of data. Together, assessment units 50490205 to 50490207 are estimated to contain a mean undiscovered conventional resource of 29 million barrels of oil, 1,136 billion cubic feet of gas, and 22 million barrels of natural gas liquids.

Introduction

The U.S. Geological Survey (USGS) is currently assessing the oil and gas resource potential of 25 priority provinces in onshore areas of the United States and in State offshore waters. The National Oil and Gas Assessment (NOGA) Project also includes an evaluation of continuous basin-centered gas systems in these high-priority basins in order to accommodate changing energy perspectives and new data since the last USGS assessment published in 1995.

NOGA assessments are based on a total petroleum system–assessment unit model. A total petroleum system is a mappable hydrocarbon-fluid system with all of the essential elements and processes needed for oil and gas accumulations to exist, including the presence of source and reservoir rocks, hydrocarbon generation and migration, traps and seals, and undiscovered accumulations. An assessment unit is a mappable volume of rock within a total petroleum system that contains discovered and undiscovered fields that are relatively similar with respect to geology, exploration strategy, and risk characteristics (Ahlbrandt, 2000). NOGA assessments are quantitative and probabilistic, and they rely on petroleum geologic and engineering data. U.S. Geological Survey Uinta-Piceance Assessment Team (2003) reports provide details on NOGA methodology.

The purpose of this report is to identify, describe, and quantitatively assess assessment units of the Lower

Cretaceous Travis Peak and Hosston Formations within the Jurassic Smackover Interior Salt Basins Total Petroleum System. For this assessment, the East Texas Basin (5048) and Louisiana-Mississippi Salt Basins (5049) Provinces have been combined under Province 5049. The Travis Peak Formation of Texas and southern Arkansas (and the correlative Hosston Formation of Louisiana) is composed of a basinward-thickening wedge of terrigenous clastic sedimentary rocks that underlies the northern Gulf of Mexico Basin from east Texas across northern Louisiana to southern Mississippi, southern Alabama, and the Florida panhandle. For simplicity, we use the name Travis Peak in our discussion, but include the name Hosston in our assessment-unit names.

As part of the 1995 National Assessment of United States Oil and Gas Resources by the USGS, Schenk and Viger (1996) identified three conventional oil and gas plays within the Travis Peak Formation sandstone trend in the Louisiana-Mississippi Salt Basins Province. This assessment is an update of part of the work of Schenk and Viger (1996).

Acknowledgments

We acknowledge the helpful manuscript reviews of Timothy Klett, Gordon Dolton, Thomas Judkins, and Douglas Nichols of the U.S. Geological Survey. The USGS Gulf Coast Region Assessment Team comprised T.S. Dyman, S.C. Condon, T.A. Ahlbrandt, R.R. Charpentier, T.A. Cook, R.A. Crovelli, T.R. Klett, M.E. Lewan, R.M. Pollastro, and C.J. Schenk.

Data Sources And Digital Maps

Interpretations, conclusions, digital maps, and resource estimates presented in this report are based on data from the published literature, conversations with industry personnel, and geologic and engineering data in publicly available commercial databases. Well and reservoir information were compiled from digital data files of IHS Energy Group (PI/Dwights PLUS on CD-ROM) (PI/Dwights PLUS, a trademark of Petroleum Information/Dwights, d.b.a. IHS Energy Group). PI/Dwights data used in this study are current as of April 2001.

Examples of queries from the data sets include (1) all wells that report a formation top for the Travis Peak Formation or Hosston Formation, (2) all wells that report tops of the Smackover Formation, and (3) all wells that report oil or gas production (or both) from the Travis Peak or Hosston. These data were then imported into ArcView (version 3.2, Environmental Systems Research Institute, Inc., Redlands, CA) and displayed in map formats. Other map data—such as the distribution of environments of deposition of the Travis Peak Formation—were scanned from the published literature, imported into ArcView, and registered to a digital base map. GIS (geographic information system) layers of these data were made by tracing over the scanned images with ArcView drawing tools.

The contour maps are presented as plates in this report. The maps were made by creating thickness and subsea formation tops files consisting of longitude, latitude, and either the thickness of the Travis Peak and Hosston or the depth below sea level of the top of the Travis Peak and Hosston. These files were then read into EarthVision (version 7, Dynamic Graphics, Inc., Alameda, CA) and were gridded and contoured. Preliminary maps were examined for areas that included potentially incorrect data. Incorrect data were removed from the data sets, and the maps were redrafted. This process was repeated until we were satisfied that obvious errors were corrected. A data problem was noted in east Texas where 152 wells (and one well in Louisiana) showed the top of the underlying Cotton Valley Group to be below the top of the Bossier Formation, which is the lowest formation of the group. Calculations of the isopach of the Travis Peak or Hosston were affected by this data anomaly, and these wells were not used to produce the maps. The contour maps were then imported into ArcMap (version 8.3, Environmental Systems Research Institute, Redlands, CA); they were added to other layers, such as the base map, and were finally exported to Adobe Illustrator for final preparation.

Because of the proprietary nature of the database, the exact locations of wells could not be shown on our maps. Instead, the map area was divided into cells, 0.5 mi on a side (four cells per square mile). Data from all wells within a cell are shown at the center point of the cell. This technique allows us to show the general distribution and density of well control points without revealing the proprietary locations of individual wells.

Oil and gas field data for discovered fields used in this assessment were compiled from "The Significant Oil and Gas Fields of the U.S." database by NRG Associates (1999). Data in NRG compilations are proprietary and include field and reservoir identification and location, geologic characteristics of each reservoir, and total recoverable petroleum volumes for oil and gas fields having at least 0.5 million barrels of oil equivalent (MMBOE). These data are commercially available through NRG Associates.

Geologic Setting

The Travis Peak Formation of Texas and southern Arkansas and the correlative Hosston Formation of Louisiana form a basinward-thickening wedge of terrigenous clastic sedimentary rocks that underlies the northern Gulf of Mexico Basin from east Texas across northern Louisiana to southern Mississippi, southern Alabama, and the Florida panhandle. The thickness of the Travis Peak Formation ranges from less than 1,000 ft in southern Arkansas to more than 3,200 ft in north-central Louisiana (pls. 1, 2). The downdip limit of the

Travis Peak Formation has not been delineated by drilling to date. Travis Peak strata crop out in parts of Brown, Mills, McCulloch, San Saba, and Lampasas Counties in east-central Texas (west of the area covered in this report) (Hartman and Scranton, 1992). Across the hydrocarbon-productive trend of the Travis Peak Formation (figs. 1*A*–1*C*), the depth to top of the Travis Peak ranges from about 4,000 ft subsea in southern Arkansas to more than 18,000 ft subsea in north-central Louisiana and southern Mississippi (Saucier, 1985) (pl. 3). Although Travis Peak sandstones produce gas from drilling depths of more than 16,000 ft in southern Mississippi (Thomson, 1978), most Travis Peak production across the main producing trend in east Texas and northern Louisiana is from drilling depths between 6,000 and 10,000 ft (Dutton and others, 1993). Travis Peak production across east Texas and northern Louisiana is primarily gas, but includes some oil (figs. 1*A* and *B*).

The Travis Peak is the lowest formation of the Lower Cretaceous Trinity Group, which overlies the Upper Jurassic–Lower Cretaceous Cotton Valley Group (fig. 2). The Cotton Valley Group and Travis Peak Formation represent the first two major sequences of terrigenous clastic sediment shed into the Gulf of Mexico Basin following its initial formation during continental rifting in Late Triassic time (Salvador, 1987; Worrall and Snelson, 1989). The oldest sedimentary deposits in the northern part of the Gulf of Mexico Basin (figs. 2 and 3) include Upper Triassic and Lower Jurassic nonmarine red beds of the Eagle Mills Formation, the thick Middle Jurassic evaporite sequence known as the Werner Anhydrite and Louann Salt, and the nonmarine Jurassic Norphlet Formation (Shreveport Geological Society, 1987). Following a major regional marine transgression across the Norphlet, regressive carbonates of the Upper Jurassic Smackover Formation were deposited. The Smackover was capped by red beds and evaporites of the Buckner Formation (fig. 2). A subsequent minor marine transgression is recorded by the Gilmer Limestone (“Cotton Valley limestone”) in east Texas, although equivalent facies in northern Louisiana and Mississippi are terrigenous clastic rocks known as the Haynesville Formation. The marine Bossier Shale, lowermost formation of the Cotton Valley Group (fig. 2), was deposited conformably atop the Gilmer or Haynesville, followed by progradation of the major fluvial-deltaic sequence known locally as the “Cotton Valley sandstone” or Schuler Formation.

A significant marine transgression that halted Cotton Valley fluvial-deltaic sedimentation is recorded by the Knowles Limestone, the uppermost formation of the Cotton Valley Group (figs. 2 and 4). Prodelta and fluvial-deltaic deposits of

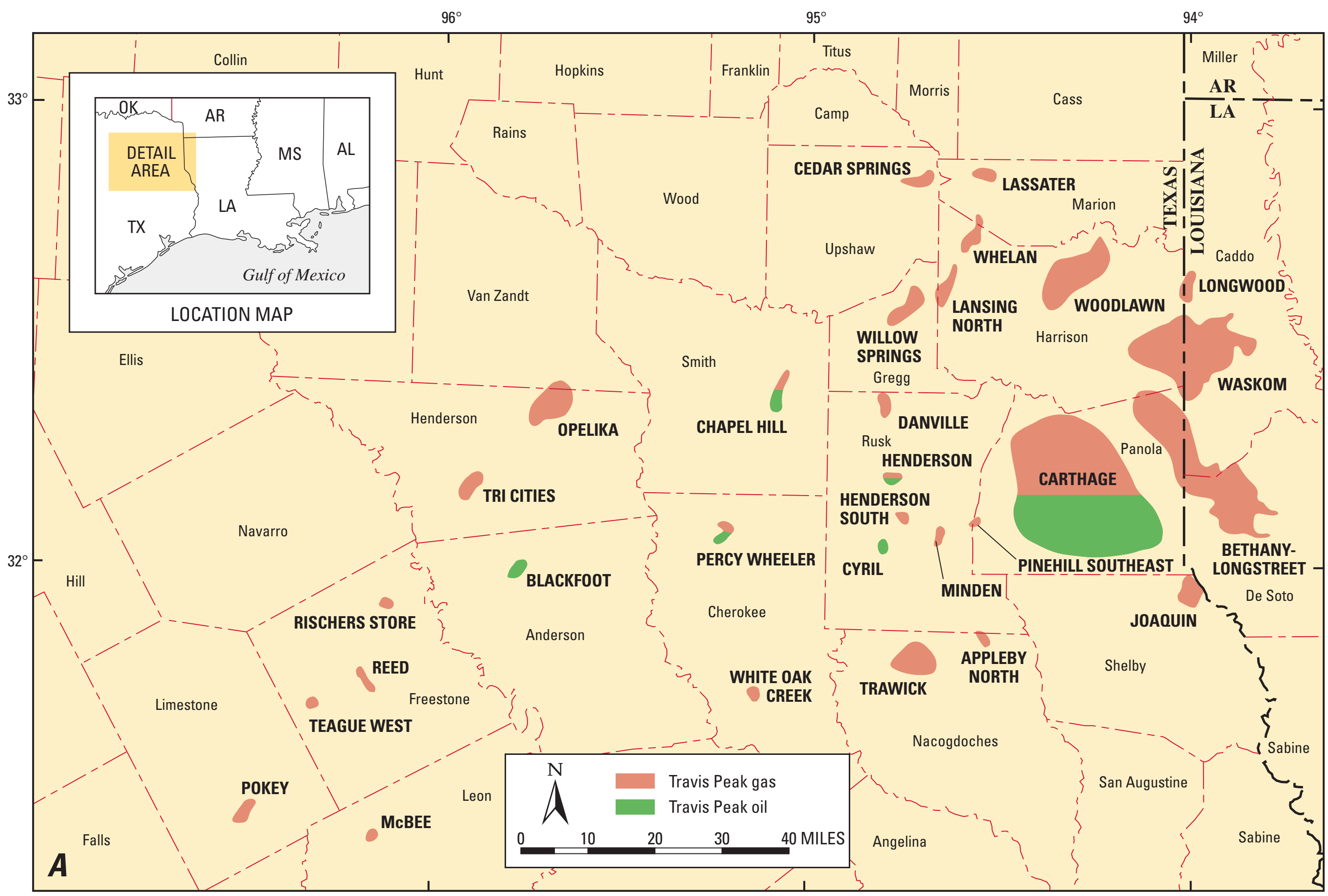


Figure 1. Maps showing major fields that have produced hydrocarbons from Travis Peak and Hosston Formation sandstone reservoirs. Modified from Bebout and others (1992). ***A***, norheast Texas.

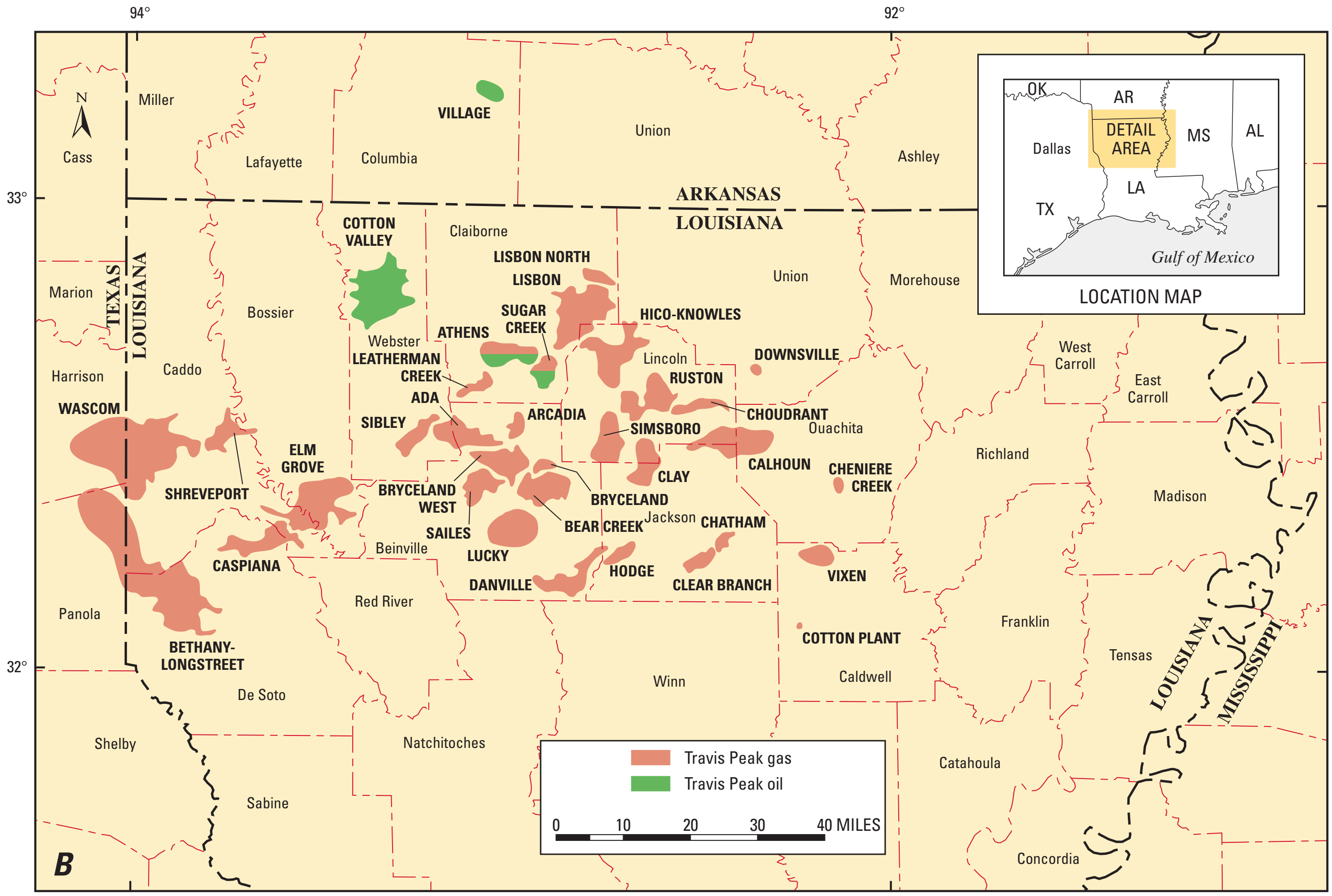


Figure 1—Continued. Maps showing major fields. ***B***, northern Louisiana and southern Arkansas.

the Travis Peak Formation overlie the Knowles Limestone and mark the second major influx of terrigenous clastic sediments into the northern Gulf of Mexico Basin. In updip parts of the Gulf of Mexico Basin, the Knowles Limestone pinches out, and Travis Peak fluvial-deltaic strata rest directly on Schuler Formation fluvial-deltaic units of the Cotton Valley Group (fig. 4). Whereas most workers consider the Knowles/Travis Peak contact to be conformable, controversy exists regarding the presence or absence of an unconformity between the updip Schuler and Travis Peak Formations. McFarlan (1977), Todd and Mitchum (1977), and Tye (1989) identified a major unconformity between the Schuler and Travis Peak, whereas Nichols and others (1968) and Saucier (1985) considered the contact to be conformable. Most workers agree that the upper contact of the Travis Peak with overlying shallow-marine carbonates of the Lower Cretaceous Sligo Formation is conformable. Most of the 15-m.y. period of Travis Peak deposition occurred during a relative rise in sea level (McFarlan, 1977; Vail and others, 1977), and the Travis Peak/Sligo contact is a time-transgressive boundary such that the Sligo oolitic and micritic limestones onlap the Travis Peak coastal and marine clastic rocks to the north out of the Gulf of Mexico Basin (Tye, 1991) (figs. 2 and 4).

The thick Jurassic Louann Salt became mobile as a result of sediment loading and associated basinward tilting in Late Jurassic and Early Cretaceous time. Salt movement was initiated during deposition of the Smackover Formation and became more extensive with influx of the thick sequence of Cotton Valley and Travis Peak clastic sediments (McGowen and Harris, 1984). Many Cotton Valley and Travis Peak fields in east Texas, Louisiana, and Mississippi have structural or combination traps associated with Louann Salt movement. Salt structures range from small, low-relief salt pillows to large piercement domes (McGowen and Harris, 1984; Kosters and others, 1989).

The Sabine uplift (fig. 3) is a broad, low-relief, basement-cored arch separating the East Texas and northern Louisiana Salt Basins. With vertical relief of about 2,000 ft, the Sabine uplift covers an area of more than 2,500 mi^2 (Kosters and others, 1989). Isopach data across the uplift indicate that it was a positive feature during deposition of Louann Salt in the Jurassic, but that primary uplift occurred in the late mid-Cretaceous (101–98 Ma) and again in the early Tertiary (58–46 Ma) (Laubach and Jackson, 1990; Jackson and Laubach, 1991). As a relatively high area during the past 60 m.y., the Sabine uplift has been a focal point for hydrocarbon migration in the

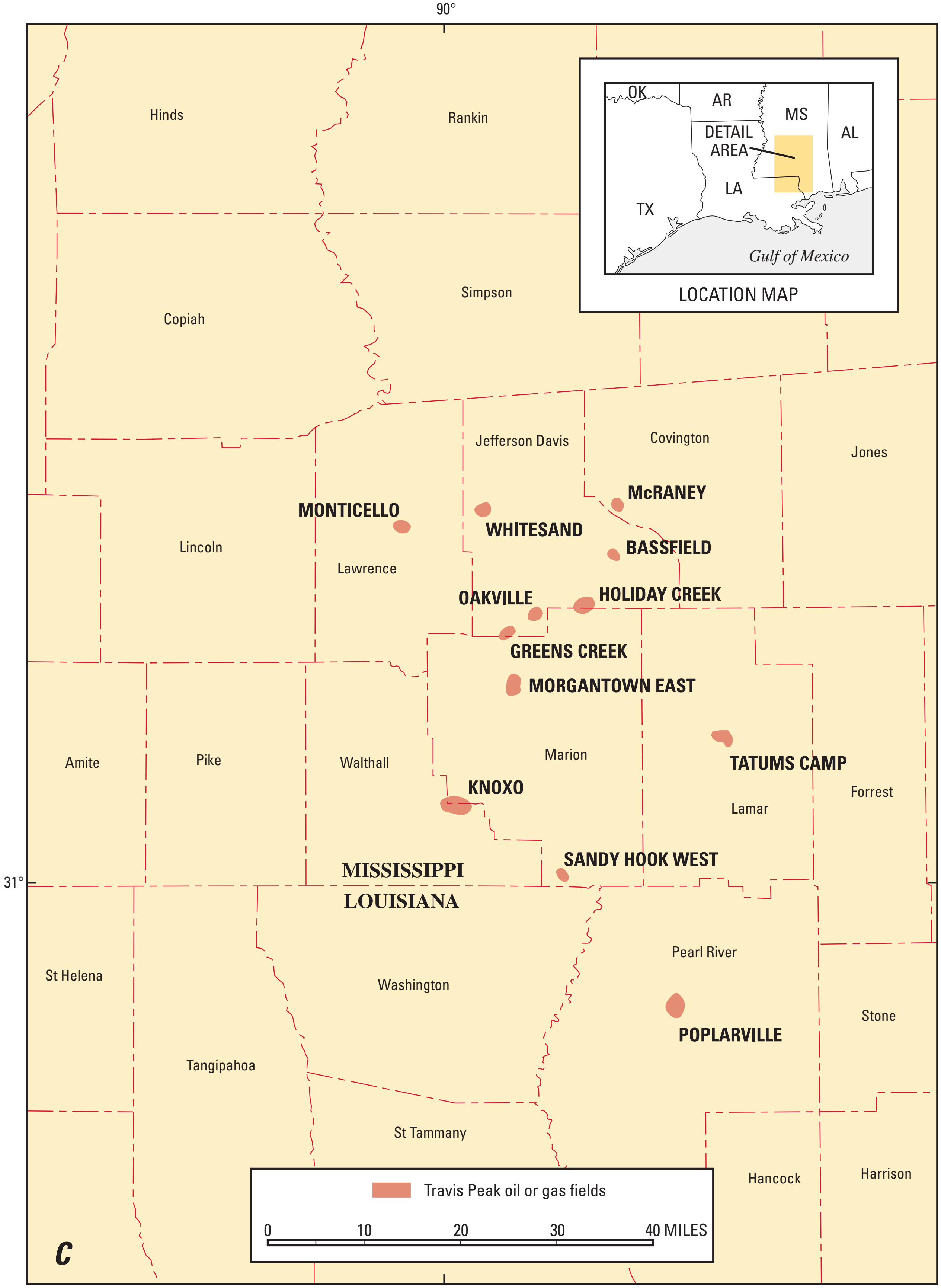


Figure 1—Continued. Maps showing major fields. ***C***, central Mississippi.

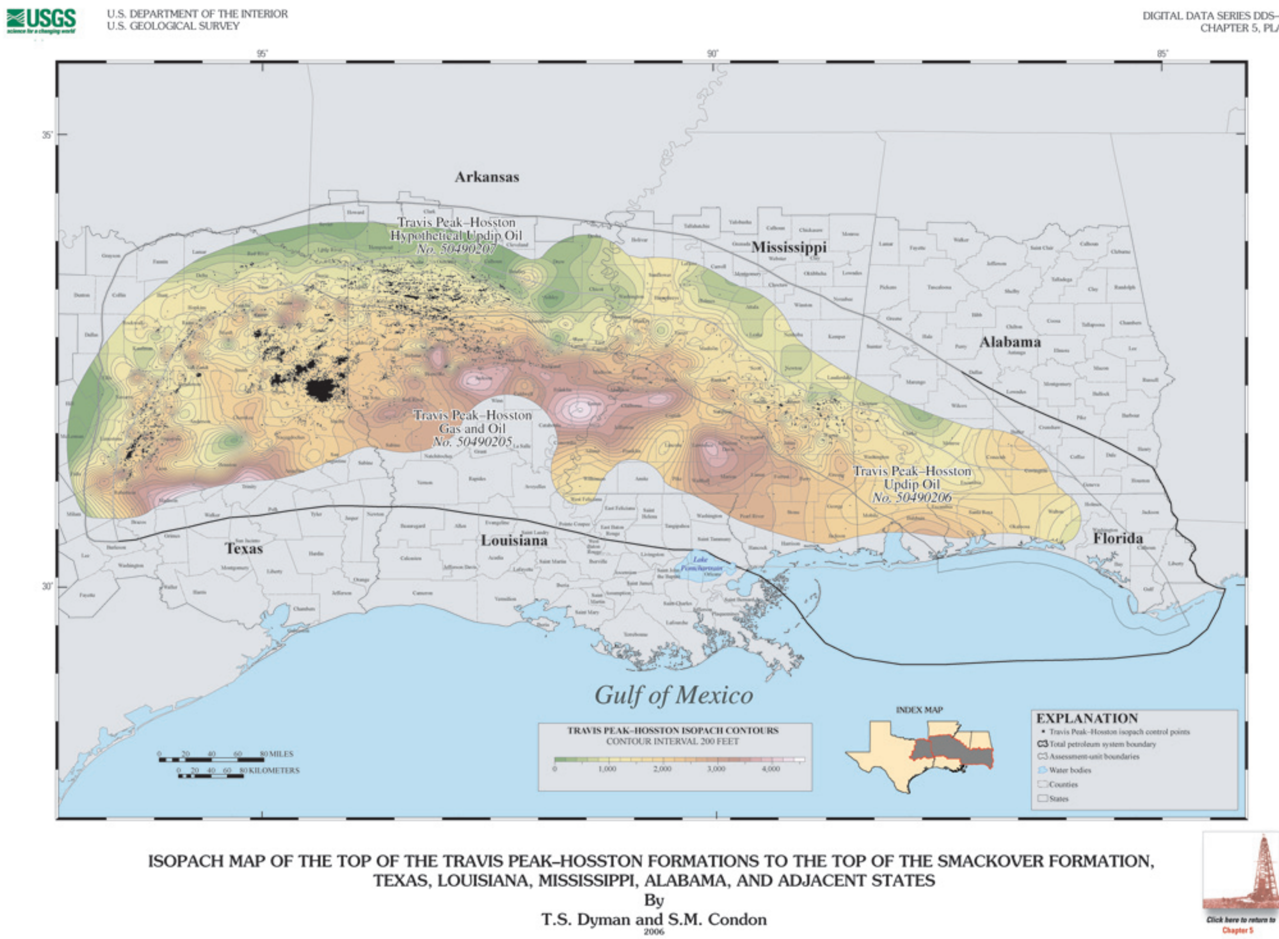


Plate 1. Isopach map of the interval from the top of the Travis Peak Formation (or Hosston Formation) to the top of the Smackover Formation. This map is an isopach showing the thickness of the interval from the top of the Travis Peak Formation or Hosston Formation to the top of the Cotton Valley Group. The map was produced by first subtracting the values of the top of the Travis Peak or Hosston from those of the top of the Cotton Valley Group. This process resulted in a data set of 8,585 values for which locations were available. The data were then gridded and contoured in the EarthVision software package (version 7, Dynamic Graphics, Inc., Alameda, CA), and the contours were exported into ArcMap (version 8.3, Environmental Systems Research Institute, Redlands, CA). The thickness data range from 12 to 5,570 ft, and the contour interval is 200 ft. As noted in the text, those wells for which the top of the Cotton Valley Group was reported to be below the top of the Bossier Shale were filtered from the data set and not used. Other areas of anomalously thick or thin reported Travis Peak or Hosston were also examined. A total of 8,414 wells was used for the map.The map displays an irregular pattern of thick and thin areas; the thickest regions are in south Texas and in a broad area extending across north-central Louisiana into southern Mississippi. One particular area in east-central Louisiana is anomalously thick, but several wells were checked that form the basis for the thickness interpretation in this area, and no errors in the database were noted. Perhaps there is thickening due to repeated section from faulting, but a more likely cause is that the area received a large input of sediment from the ancestral Mississippi River. Syndepositional movement of salt in underlying Jurassic units may have also contributed to the localization of depocenters.

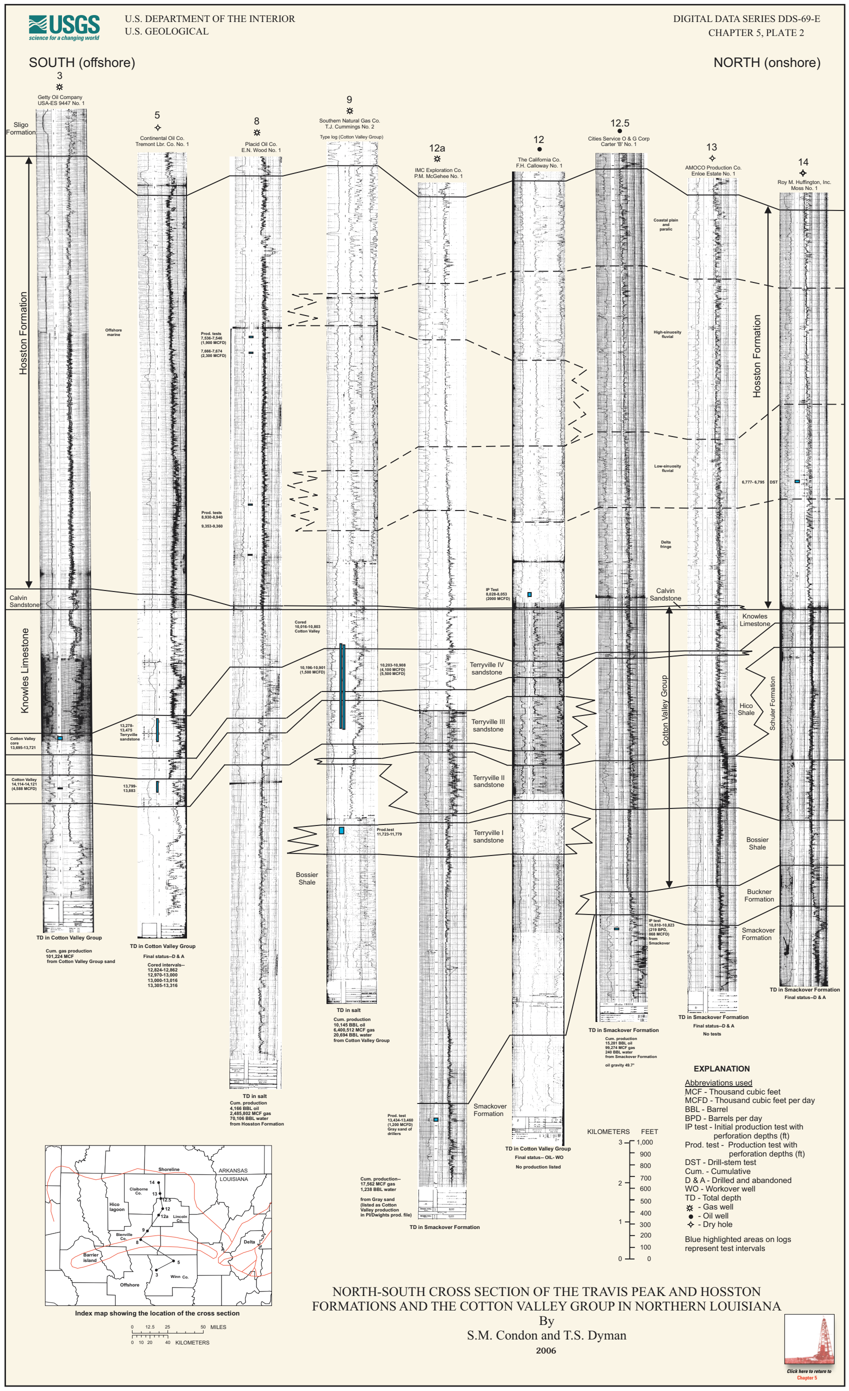


Plate 2. North-south cross section of the Travis Peak and Hosston Formations and the Cotton Valley Group in northern Louisiana. This plate is a north-south cross section that extends from northern to about central Louisiana (see index map on plate for exact location). It is based on a cross section published by Coleman and Coleman (1981; no datum identified in original figure). Finding all the logs for wells used by Coleman and Coleman (1981) proved to be impossible. Some of the logs are neither available commercially nor in the collection of well logs in a microfiche library maintained by the U.S. Geological Survey in Denver, Colo. Two additional wells were added to the cross section because they filled gaps in the original cross section. As many good-quality logs as were available were pulled from the microfiche library and scanned, and the correlations were made by using the top of the Cotton Valley Group as a datum. In this area of northern Louisiana, only the Hosston Formation is recognized, whereas the correlative Travis Peak Formation is recognized to the west in Texas. Depositional environments of the Hosston Formation, interpreted from well-log responses, are shown on the cross section. Typical log responses for certain depositional environments of the Travis Peak and Hosston are shown on a composite log in Bartberger and others (2002). The cross section shows the north to south pinch-out of fluvial depositional units into the coastal marine part of the section. Terryville I to IV sandstones are informal subdivisions of the Terryville Sandstone of Coleman and Coleman (1981).

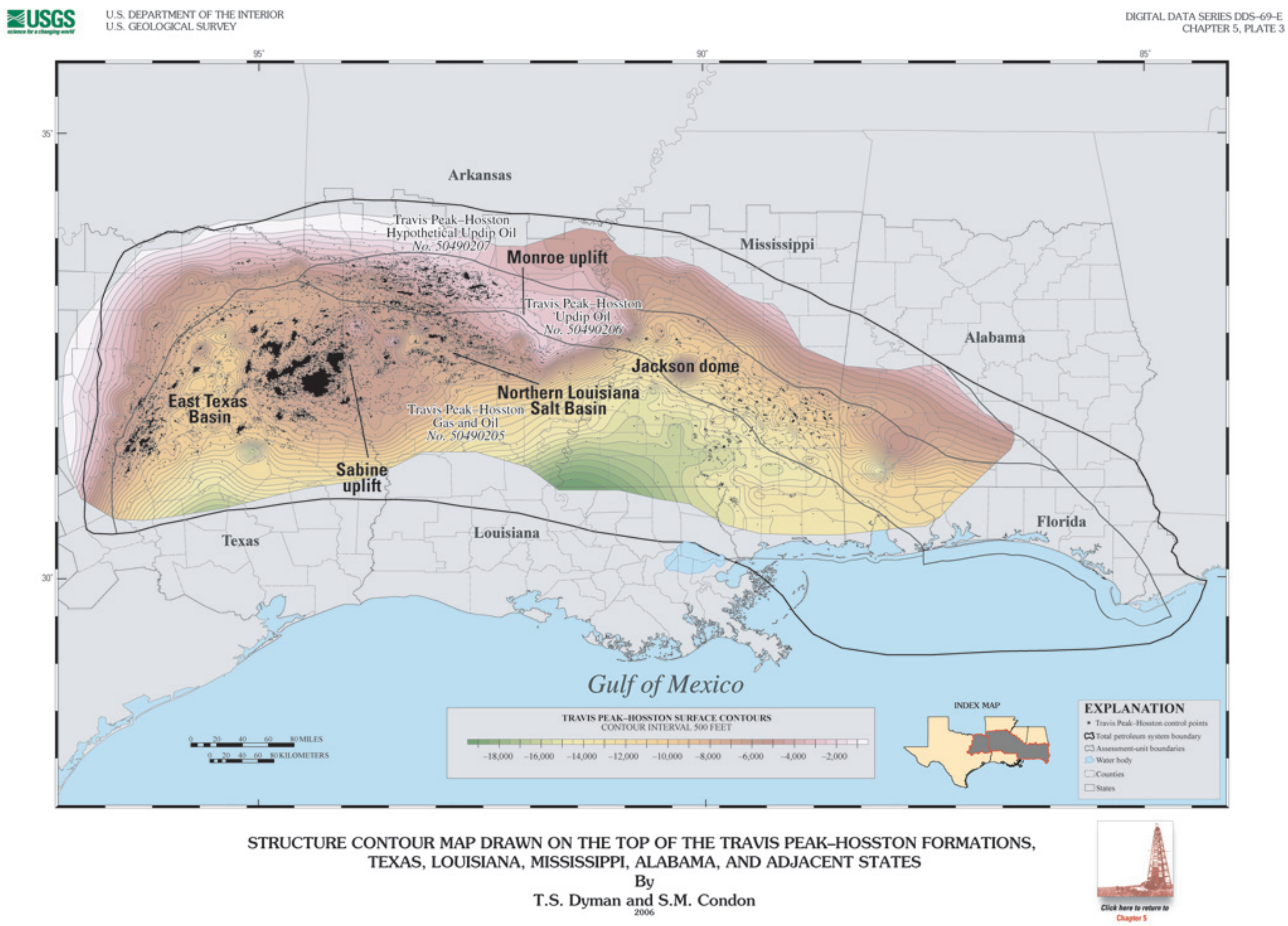


Plate 3. Structure contour map drawn on the top of the Travis Peak Formation (or Hosston Formation). This map shows the structural configuration of the top of the Travis Peak Formation or Hosston Formation in feet below sea level. The map was produced by calculating the difference between a datum at the land surface (either the kelly bushing elevation or the ground surface elevation) and the reported depth of the Travis Peak or Hosston. This effort resulted in 18,941 wells for which locations were available. The data were gridded and contoured in the EarthVision (version 7, Dynamic Graphics, Inc., Alameda, CA) software package, and exported to ArcMap (version 8.3, Environmental Systems Research Institute, Redlands, CA). The values range from 253 to 19,080 ft below sea level; the contour interval is 500 ft. Some data were examined in areas where "bulls-eyes" were evident, and some were found to be in error, but others just indicated small anticlines. A total of 18,933 wells were used for the map. The map shows a gradual southward deepening of the top of the Travis Peak and Hosston; deepest tops are in the East Texas Basin and in southern Mississippi. Major regional features shown by the map are the East Texas Basin, the Sabine uplift that straddles the Texas-Louisiana State line, the northern Louisiana Salt Basin, the Monroe uplift in northeastern Louisiana, and Jackson dome in Mississippi. Many smaller anticlines and synclines are superimposed on these larger features, some clearly delineated by concentrated patterns of drilling.

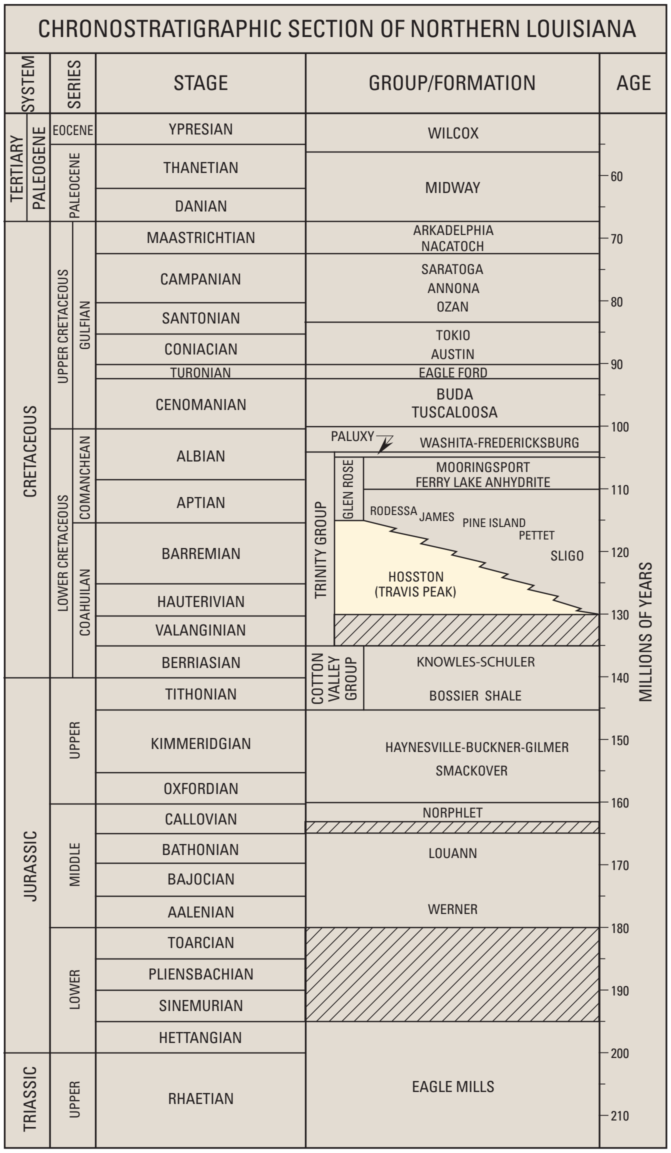


Figure 2. Chronostratigraphic section of northern Louisiana from Shreveport Geological Society (1987), showing general stratigraphic succession of selected units for northern Gulf of Mexico Basin. Travis Peak Formation (in parentheses), lowermost formation of the Trinity Group, is designated as Hosston Formation (shading) on this diagram. Upper contact of Travis Peak and Hosston Formation is time-transgressive. Diagonal pattern, hiatus.

northern Gulf of Mexico Basin. Numerous smaller structural highs on the Sabine uplift in the form of domes, anticlines, and structural noses provide traps for hydrocarbon accumulations, including many oil and gas fields with Travis Peak reservoirs.

Stratigraphy and Sedimentology

Following the regional marine transgression (recorded by deposition of the Knowles Limestone) at the end of the Cotton Valley deposition, fluvial-deltaic systems now forming the Travis Peak Formation prograded basinward across surfaces of the Schuler Formation and Knowles Limestone (fig. 4). Two main Travis Peak fluvial-deltaic depocenters (fig. 3) have been documented along the arcuate northern Gulf of Mexico Basin (Saucier, 1985; Tye, 1989). One depocenter was located in east Texas where the ancestral Red River flowed into the area of the East Texas Basin through a structural downwarp in the Ouachita thrust belt. The drainage area of the ancestral Red River most likely spanned a large part of the present-day southwestern and midwestern United States. Coarse clastic sediment was probably derived from highlands in present-day western Utah and southern Arizona. Triassic red beds were exposed in the provenance area during deposition of the Travis Peak and resulted in abundant red siltstones within the Travis Peak Formation in east Texas (Saucier, 1985).

The second Travis Peak depocenter was situated in an arc that stretched northwestward from southern Mississippi to northeastern Louisiana where the ancestral Mississippi River—which had developed as a major fluvial system during the time of Cotton Valley deposition (Coleman and Coleman, 1981)—continued to transport clastic sediment to constructive, elongate deltas in the northeastern Gulf of Mexico Basin (Reese, 1978; Saucier, 1985; Tye, 1989). Evidence for the presence of these two depocenters is provided by sandstone isopach patterns from Saucier (1985), who divided the Travis Peak section at its midpoint and mapped gross sandstone thickness of the lower and upper parts of the formation.

The Travis Peak Formation is not divided formally into members. However, Saucier (1985) and Saucier and others (1985) distinguished three separate stratigraphic intervals within the Travis Peak across east Texas and northern Louisiana on the basis of relative amounts of sandstone and shale, as reflected in the resistivity and gamma-ray character of sandstones on wireline logs. A basal interval of mixed sandstones and shales interpreted as delta-fringe deposits is gradationally overlain by a thick, sandstone-rich interval of fluvial and flood-plain deposits that grades upward into another interval of coastal-plain sandstone and mudstone (figs. 5 and 6; Saucier, 1985; Fracasso and others, 1988; Tye, 1989, 1991). The middle fluvial and flood-plain interval—which is the thickest interval and forms the bulk of the Travis Peak—consists of stacked, aggradational, braided-channel sandstones that grade upward into more isolated meandering-channel sandstone deposits (fig. 6). Sandstones are interpreted as braided, on the basis of blocky SP (spontaneous potential) curves, bedforms observed in conventional cores, and sandstone-body geometries. Stacked, braided channel units generally are 12–45 ft thick, but because of the absence of preserved shales, amalgamated channel sandstones occur in places as massive-sandstone units as much as 250 ft thick with blocky SP curves (Saucier, 1985).

The thick middle fluvial and flood-plain interval gradationally overlies a much thinner basal interval with considerably higher mudstone content in which discrete sandstones

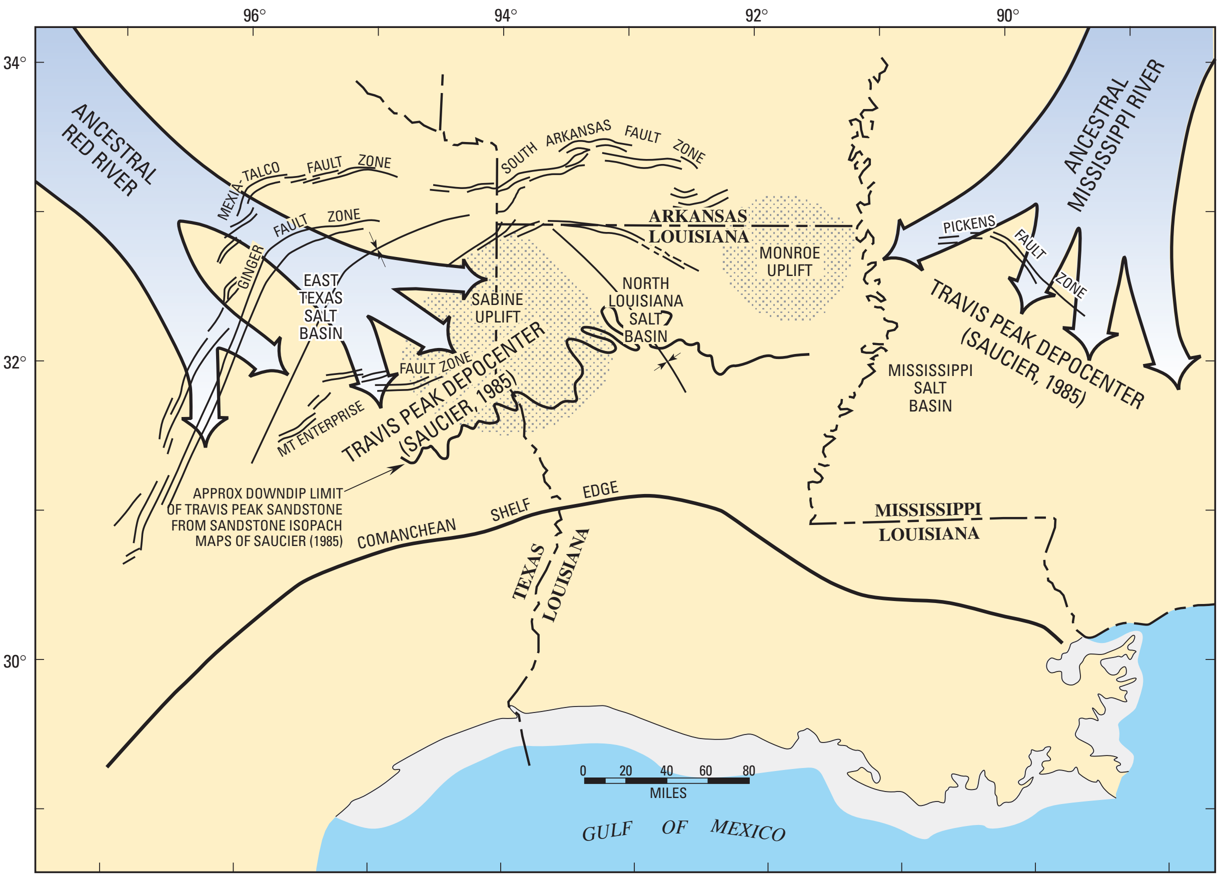


Figure 3. Map of northern Gulf of Mexico Basin, showing two main depocenters and major tectonic features, including Sabine uplift and salt basins of east Texas, northern Louisiana, and Mississippi (modified from Dutton and others, 1993). Sabine and Monroe uplifts were not positive features during deposition of the Lower Cretaceous Travis Peak Formation. Movement of salt in the salt basins commenced during deposition of Upper Jurassic Smackover Formation carbonates and became more extensive with influx of thick sequence of Cotton Valley Group and Travis Peak terrigenous clastic sediment.

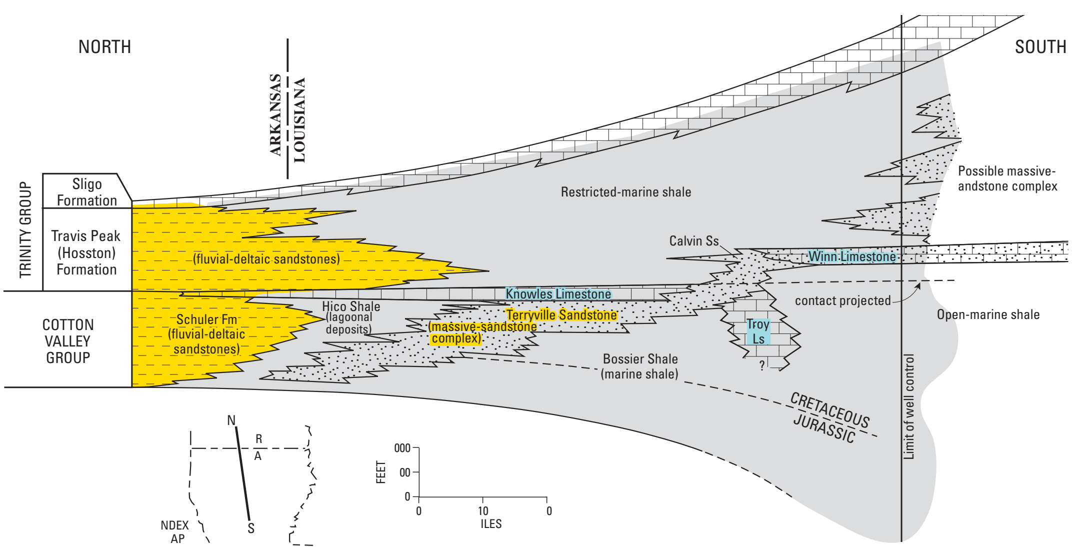


Figure 4. Diagrammatic north-south stratigraphic cross section across southern Arkansas and northern Louisiana, showing depositional relationships among units of Cotton Valley Group and Travis Peak Formation (from Saucier, 1985). Datum is top of Cotton Valley Group. Relatively thick sequence of Terryville Sandstone, interbedded shales, and Knowles Limestone separates Bossier Shale source rocks from Travis Peak sandstone reservoirs. Coleman and Coleman (1981) considered Calvin Sandstone and Winn Limestone to be part of Cotton Valley Group.

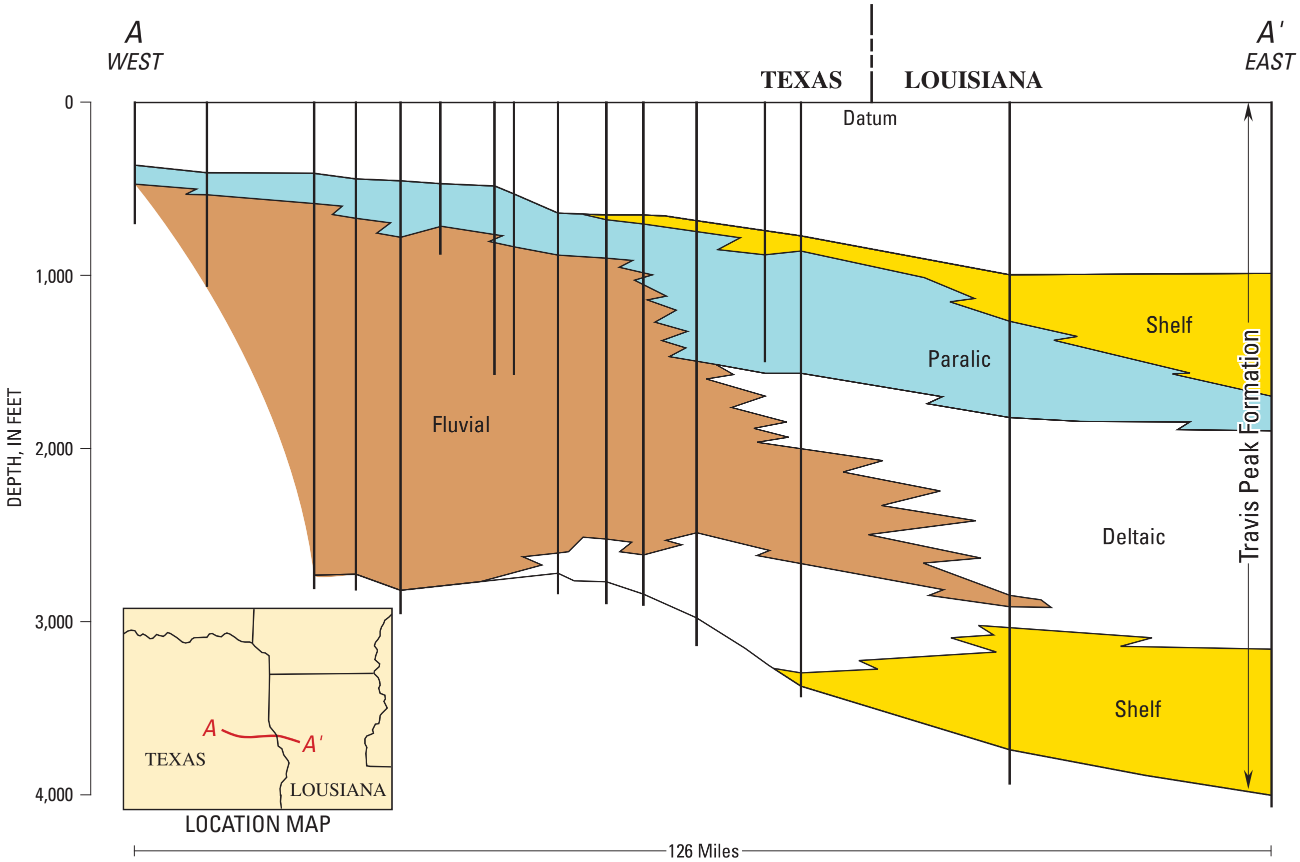


Figure 5. West-east stratigraphic cross section of Travis Peak Formation across northeast Texas into west Louisiana, showing major Travis Peak depositional systems (modified from Dutton, Laubach, and Tye, 1991). Cross section oriented parallel to depositional dip. Threefold division of Travis Peak Formation across hydrocarbon-productive trend includes basal deltaic unit overlain by thick fluvial sequence that grades upward into paralic deposits. Vertical lines represent locations of oil and gas wells. Datum is top of Lower Cretaceous Pine Island Shale (see fig. 2 for stratigraphic context).

are separated by thicker mudstones. Sandstones in this lower Travis Peak interval are interpreted as delta-fringe deposits.

The middle fluvial and flood-plain interval grades upward into the third interval recognized by Saucier (1985), which forms the uppermost part of the Travis Peak. Like the lower Travis Peak delta-fringe interval, this upper interval is characterized by discrete sandstones separated by thicker mudstones. Many sandstones in the upper interval display thin, spiky, upward-coarsening or upward-fining serrated SP signatures, which are interpreted as coastal-plain deposits. Upper Travis Peak coastal units interfinger with, and are gradationally overlain by, shallow-marine shelf carbonates of the Sligo Formation (Fracasso and others, 1988). Sligo carbonates thin updip to the northwest as they lap onto Travis Peak coastal deposits. Contact of the Travis Peak with the overlying Sligo Formation, therefore, is time transgressive.

South of the main area of Travis Peak fluvial-deltaic sedimentation, in the region of the Early Cretaceous (Comanchean) shelf edge (fig. 3), a slope-basin sandstone trend has been proposed by Zimmerman and Goddard (2001) on the basis of limited well data to the north of this trend in shelf-slope facies. This slope-basin sandstone trend includes an area of as much as 5,600 mi^2 where sand was transported downslope from the shelf and slope areas to the north. Through the use of well-log interpretations, they identified four facies according to relative amounts of siltstone, shale, and sandstone that they attributed to turbidite deposition. Their shaly sandstone facies included massive-sandstone bodies as thick as 20–60 ft encased in thick basinal shales.

Petroleum System Framework

Source Rocks

Dutton (1987) showed that shales interbedded with Travis Peak sandstone reservoirs in east Texas were deposited in fluvial-deltaic settings where organic matter commonly was oxidized and not preserved. Because measured values of total organic carbon (TOC) in Travis Peak shales are generally less than 0.5 weight percent, these shales are not considered to be important hydrocarbon source rocks, according to Tissot and

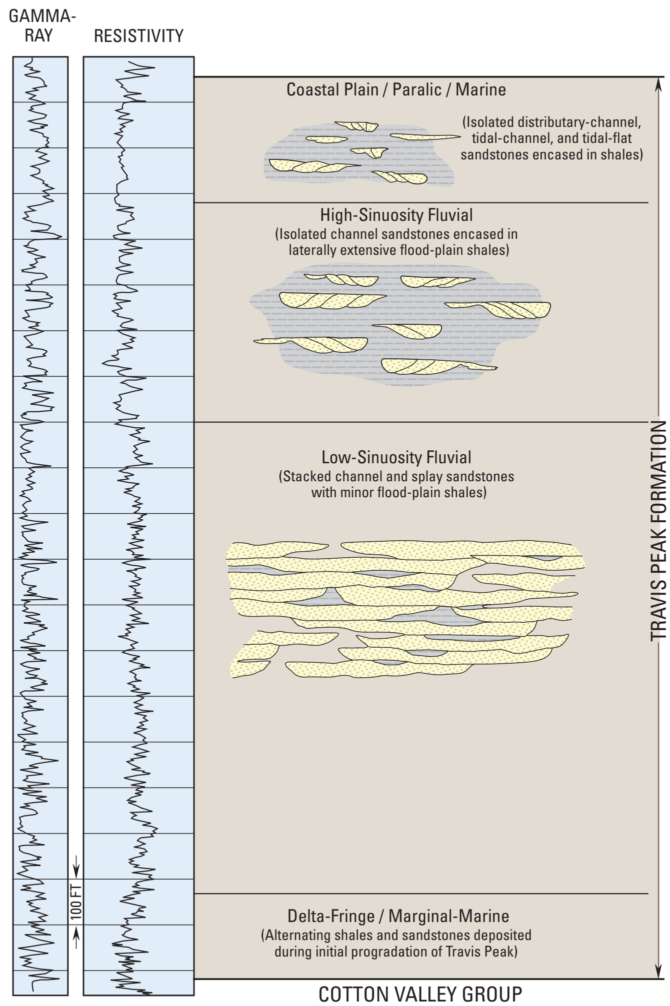


Figure 6. Composite wireline log, showing gamma-ray and resistivity responses through complete section of Travis Peak Formation in east Texas (modified from Davies and others, 1991). Gamma-ray and resistivity characters distinguish basal deltaic sequence, thick middle fluvial sequence, and thin upper paralic interval. Log responses within thick fluvial sequence also distinguish lower interval of stacked braided-channel sandstones with minor flood-plain mudstones from upper interval of meandering-channel sandstones encased in thicker overbank mudstones. Most Travis Peak hydrocarbon production in northeast Texas comes from sandstones encased in shales within the upper 300 ft of the Travis Peak Formation. Depth increments on log are 100 ft.

Welte (1978). Dutton (1987) suggested that the most likely sources for hydrocarbons in Travis Peak reservoirs in east Texas are (1) prodelta and basinal marine shales of the Upper Jurassic Bossier Shale of the Cotton Valley Group and (2) laminated, lime mudstones of the lower member of the Jurassic Smackover Formation (fig. 2). Sassen and Moore (1988) demonstrated that Smackover carbonate mudstones are a significant hydrocarbon source rock in Mississippi and Alabama. Wescott and Hood (1991) documented the Bossier Shale as a major source rock in east Texas. Presley and Reed (1984) suggested that gray to black shales interbedded with Cotton Valley sandstones could be a significant source for gas in addition to the underlying Bossier Shale. Coleman and Coleman (1981, p. 76) stated that “hydrocarbons were generated from neighboring source beds.”

In summary, despite limited source-rock data, it seems likely that significant hydrocarbon source rocks occur in lower Smackover carbonate mudstones and the Bossier Shale of the Cotton Valley Group (fig. 2). We support a strong Smackover component for Cotton Valley hydrocarbons, particularly for oil-bearing reservoirs in the northern part of the region because of the known regional source potential of the Smackover (Lewan, 2002). Because of the fluid behavior and complex history of gases, multiple source rocks and oil sources are considered likely.

The Jurassic Smackover Interior Salt Basins Total Petroleum System is defined for this assessment to include both Upper Jurassic Smackover carbonates and calcareous shales and Upper Jurassic–Lower Cretaceous Cotton Valley Group organic-rich shales (fig. 2; pl. 4). This total petroleum system could also include Travis Peak organic-rich shales, but we support Dutton’s (1987) interpretation of these sources as oxidized and not well preserved (see the next section).

Burial History and Timing of Hydrocarbon Generation

In studying diagenesis and burial history of the Travis Peak Formation in east Texas, Dutton (1987) reported that measured vitrinite reflectance (Ro) values for Travis Peak shales generally range from 1.0 to 1.2 percent, indicating that these rocks have passed through the oil window (Ro = 0.6–1.0 percent) and are approaching the level of onset of dry-gas generation (Ro = 1.2 percent) (Dow, 1978). A maximum Ro value of 1.8 percent was measured in the deepest sample from a downdip well in Nacogdoches County, Texas. Despite the relatively high thermal maturity levels reached by Travis Peak shales, the small amount and gas-prone nature of organic matter in these shales preclude generation of oil, although minor amounts of gas might have been generated (Dutton, 1987).

In the absence of actual measurements of Ro, values of Ro can be estimated by plotting burial depth of a given source-rock interval vs. time in conjunction with an estimated paleo-geothermal gradient (Lopatin, 1971; Waples, 1980). Dutton (1987) presented burial-history curves for the tops of the Travis Peak, Cotton Valley, Bossier, and Smackover for seven wells on the crest and western flank of the Sabine uplift. Two of these burial-history curves are reprinted with minor modification in figure 7. The burial-history curves show total overburden thickness through time and use present-day compacted thicknesses of stratigraphic units. Sediment compaction through time was considered insignificant because of the absence of thick shale units in the stratigraphic section. Loss of sedimentary section associated with late middle Cretaceous and middle Eocene erosional events was accounted for in the burial-history curves.

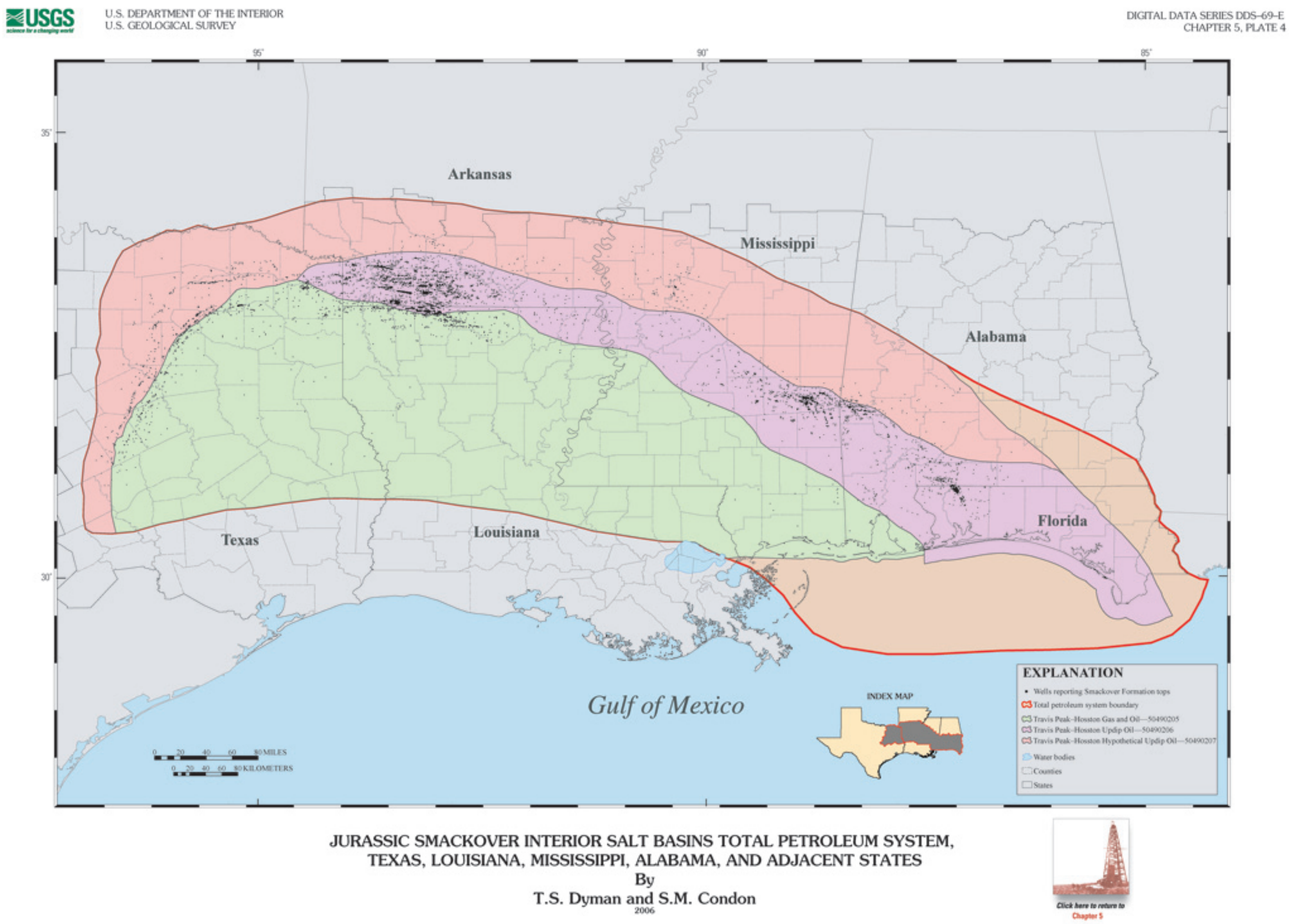


Plate 4. Jurassic Smackover Interior Salt Basins Total Petroleum System. This map shows the location of the Jurassic Smackover Interior Salt Basins Total Petroleum System and the three assessment units of the Travis Peak–Hosston depositional system within the area of this assessment. The total petroleum system boundary is not complete because the Smackover Formation extends into the western Gulf Coast region beyond the area of this assessment. The boundary was drawn to include all wells that reported the presence of the Smackover Formation—which are shown on the map—and associated reservoir rocks of the Travis Peak Formation. Wells reporting Smackover tops are arrayed in an arcuate pattern extending from east Texas to the northwestern part of the Florida panhandle. Over this entire area there are 6,764 wells that report Smackover tops. The wells are clustered in east Texas, in northwestern Louisiana and southern Arkansas, in southeastern Mississippi, and straddling the State line between Alabama and Florida. The Smackover is present in areas south of the clusters, but the formation is buried deeply in the subsurface and has not been reached by drilling in most areas. Depths to the top of the Smackover reported in the database range from 1,394 to 23,554 ft in the subsurface. The southern boundary of the total petroleum system was drawn at a facies change in the Smackover from a shelf facies in the north to a deeper-marine-basin facies in the south (Salvador, 1987).

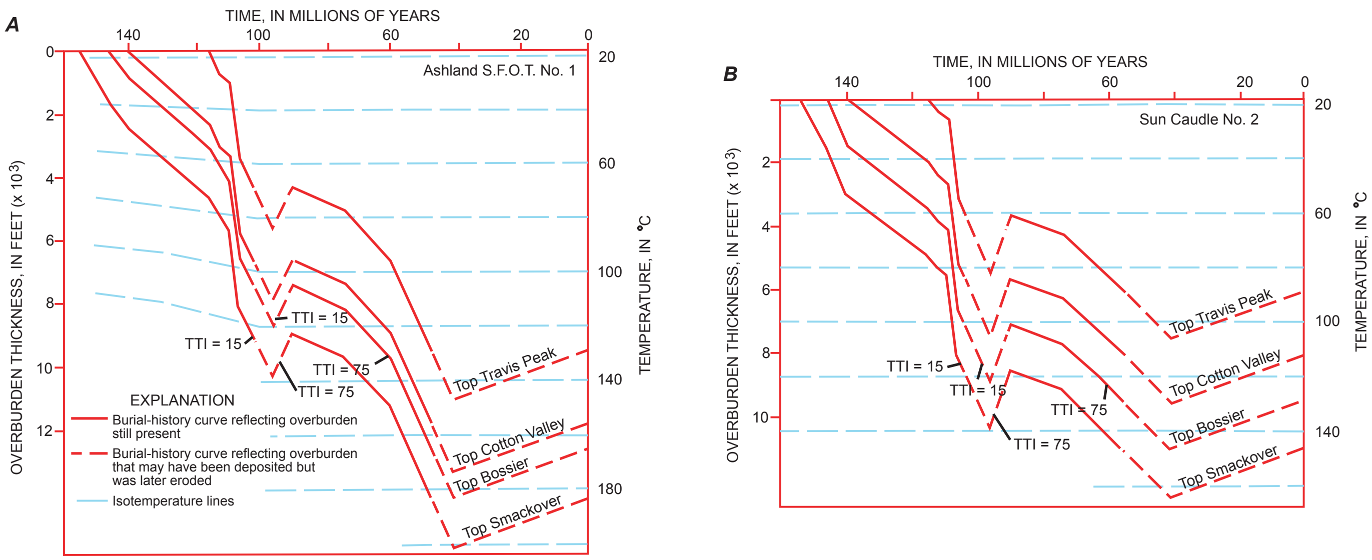


Figure 7. Burial-history curves for the tops of the Travis Peak Formation, Cotton Valley Group, Bossier Shale, and Smackover Formation for (***A***) Ashland S.F.O.T. No. 1 and (***B***) Sun D.O. Caudle No. 2 wells from Dutton (1987). Time-temperature index (TTI) values were calculated according to the method of Waples (1980). The times at which the Bossier and Smackover reached TTI values of 15 (onset of oil generation) and 75 (peak oil generation) are shown. See Dutton (1987) and this report for details of paleo-geothermal gradients.

Dutton (1987) provided justification for using the average present-day geothermal gradient of 2.1°F/100 ft for the paleo-geothermal gradient for the five northernmost wells. Paleo-geothermal gradients in the two southern wells probably were elevated temporarily because of their proximity to the area of initial continental rifting in the Triassic. Dutton (1987) used the crustal-extension model of Royden and others (1980) to estimate values for elevated paleo-geothermal gradients for these two wells for the 80 m.y. following the onset of rifting; after that, Dutton reverted to the present-day gradient for the past 100 m.y.

By using estimated paleo-geothermal gradients in conjunction with burial-history curves, Dutton (1987) found that calculated values of Ro for Travis Peak shales agree well with measured values. Because of this agreement, Dutton used the same method to calculate Ro values for tops of the Cotton Valley, Bossier, and Smackover in east Texas (fig. 7). Estimated Ro values for the Bossier and Smackover in seven wells range from 1.8 to 3.1 percent and 2.2 to 4.0 percent, respectively, suggesting that these rocks reached a stage of thermal maturity in which dry gas was generated. Under the assumption that high-quality, gas-prone source rocks exist within these two formations, one or both of these units likely generated gas found in Travis Peak reservoirs.

No such regional source-rock and thermal-maturity analysis is known for the Travis Peak in northern Louisiana. Scardina (1981) presented burial-history data for the Cotton Valley Group, but included no information on geothermal gradients and thermal history of rock units. Present-day reservoir temperatures in Travis Peak sandstones of both east Texas and northern Louisiana range from 200° to 250°F (table 1). It is likely that Bossier and Smackover source rocks in northern Louisiana have a thermal history relatively similar to that of their stratigraphic counterparts in east Texas and, therefore, may be sources for Travis Peak gas in northern Louisiana. Herrmann and others (1991) presented a burial-history plot for Ruston field in northern Louisiana. At Ruston field, they suggested that Smackover gas was derived locally from Smackover lime mudstones and that Cotton Valley gas was derived from Cotton Valley and Bossier shales. Their burial-history plot shows that onset of generation of gas from Smackover and Cotton Valley source rocks at Ruston field occurred at about 80 Ma and 45 Ma, respectively. These estimates are reasonably consistent with Dutton's (1987) date of 57 Ma for onset of dry gas generation from the Bossier Shale in east Texas. Most salt structures in the East Texas Basin were growing during the deposition of the Travis Peak Formation (McGowen and Harris, 1984), and presumably they were growing in the northern Louisiana Salt Basin as well. Therefore, these structures would have provided traps for hydrocarbons generated from Smackover, Bossier, and Cotton Valley source rocks. Also, as noted earlier in this report, the Sabine uplift has been a positive feature for the past 60 m.y. (Kosters and others, 1989; Jackson and Laubach, 1991). The uplift would have been a focal area for gas migrating from Smackover, Bossier, and Cotton Valley source rocks in the East Texas and northern Louisiana Salt Basins.

Reservoir Rocks

Although clean, coastal Travis Peak Formation sandstones at any given depth have an order-of-magnitude poorer permeability than clean, fluvial sandstones, most hydrocarbon production from the Travis Peak in east Texas has come from coastal and high-sinuosity fluvial sandstones in the upper 300

Table 1. Geologic and production data for Travis Peak (TP) (and Hosston) fields in east Texas, northern Louisiana, and southern Arkansas.

[Data primarily from Shreveport Geological Society Reference Reports, Herald (1951), Kosters and others (1989), Shoemaker (1989), and Bebout and others (1992). Abbreviations: Ext., extension; Struct, structural trap; Strat, stratigraphic trap; Comb, combination structural and stratigraphic trap; A, anticline; FA, faulted anticline; FC, facies change (sandstone pinch-out); N, structural nose; FN, faulted structural nose; BHT, bottom-hole temperature (°F); BHP, bottom-hole pressure (psi); FPG, fluid-pressure gradient (psi/ft); L, lower; U, upper; uL, upper part of lower; Sw, water saturation (decimal); GOC, gas-oil contact; OWC, oil-water contact; GWC, gas-water contact; MCFD, thousand cubic feet per day (gas); BOPD, barrels of oil per day; BCPD, barrels of condensate per day; BWPD, barrels of water per day]

Name of field producing from TP Fm. sandstones	Location of oil or gas field		Date of discovery of oil or gas in TP ss	Trapping mechanism for field	Depth to particular TP ss reservoir (ft)	Porosity of ss (decimal)	Permeability (mD)	BHT (oF)	BHP (psi)	FPG (psi/ft)	Position of reservoir within TP Fm.	Sw	Elevation of gas-oil, oil-water, and gas-water contacts (ft below sea level)	Initial production rate for specific TP Fm. sandstone reservoirs			
	County or parish	State												(MCFD)	(BOPD)	(BCPD)	(BWPD)
Appleby North	Nacogdoches	TX		Strat (FC)	8,872	0.11	0.015 (avg)	254	3,890	0.44	L	0.28					
Bethany	Panola, Harrison	TX	1940	Comb (FA, FC)	6,024				2,295	0.38	U			60,000		720	
			1948		6,300	0.15	115	206	3,113	0.49	uL	0.34					
Blackfoot	Anderson	TX	1948	Comb (A, FC)	9,918						U		Bottom of oil: -9,589		63		
Carthage	Panola	TX	1942	Struct (A)	6,128								Lenticular sandstones with complex GWCs	5,900	147.5		
			1944		6,439										26.7		
			1945		6,230	0.15	10.8		3,350	0.54	U	0.24					
Cedar Springs	Upshur	TX	1967	Struct (A)	8,960	0.10		240	4,409	0.49	L	0.30					
Chapel Hill	Smith	TX	1947	Comb (A, FC)							U		Bottom of gas: -7,835				
Cyril	Rusk	TX	1963	Strat (FC)	7,650	0.09-0.18	<1 to 200	200	3,550	0.46	U	0.25 to 0.55	OWC: -7,125 (north reservoir)		20		
													GOC -7: 100, OWC -7: 125 (south reservoir)				
Danville	Rusk	TX	1959	Comb (FA,FC)	7,606												
Henderson	Rusk	TX	1950	Struct (A)	7,457	0.18	72	185	3,186	0.43	U	0.26	GOC: -6,995; OWC: -7,005	1,500	49		
Henderson South	Rusk	TX	1946	Struct (A)							U		Bottom of gas: -7,020	655		13	
Joaquin	Shelby	TX	1968	Struct (A)	6,300												
Lansing North	Harrison	TX	1950	Struct (A)	7,606								Lowest gas: -7,314	2,100			
Lassater	Marion	TX	1948	Struct (A)	9,035								Lowest gas: -8,730	2,540		243.7	
Longwood	Harrison	TX	1948	Comb (N, FC)									Lowest gas: -5,754				
McBee	Leon	TX	1955	Comb (N, FC)	10,100	0.07-0.10		216	3,625	0.36	U	0.31 to 0.38		1,650			
Minden	Rusk	TX	1953	Comb (N,FC)	7,372												
Opelika	Henderson, Van Zandt	TX	1944	Strat (FC) ?													
Percy Wheeler	Cherokee	TX	Gas 1979	Comb (FN, FC)	9,100	0.10 (avg)	0.076 (avg)	245	4,843	0.53	U	0.33		3,200			
			Oil 1980	Comb (FN, FC)	9,159									180	62		23
Pinehill Southeast	Rusk, Panola	TX		Strat (FC)	7,155	0.08	1.3 (avg)	199	3,071	0.43	U	0.42					
Pokey	Limestone	TX	1959	Strat (FC)	7,084	0.08-0.20		190	3,250	0.46	U	0.36 to 0.45		4,700			
Reed	Freestone	TX	1945								U		Bottom of gas: -7,860				
Rischers Store	Freestone	TX	1967	Comb (A, FC)	7,236	0.10-0.23		240	3,000	0.41	U	< 0.45		1,900		43	
Teague West	Freestone	TX	1951	Comb (FC, FA)	7,680												
Trawick	Nacogdoches, Rusk	TX	1963	Comb (A, FC)	8,561	0.08-0.12	0.1 (avg)		3,720	0.43	uL	0.20 to 0.45		7,600			
Tri-Cities	Henderson	TX	1950	Comb (FC, FA)	8,496	0.10	0.01 to 85	240	4,500	0.53	U	0.32					
Waskom	Harrison	TX	1939	Comb (A,FC)	6,185						U		GWC: -5,880	5,040			
			1973		7,404	0.17	65	198	2,795	0.38	L						
Whelan	Harrison	TX	1946	Comb (FC, FA)	8,036	0.13	0.05 to 83	220	3,076	0.38	uL						
White Oak Creek	Cherokee	TX	1976	Srtuct (FA)	10,024												
Willow Springs	Gregg	TX	1954	Struct (A)	7,812	0.13	20 (1.48 avg)	229	3,421	0.44	uL						
Woodlawn		TX															
Ada-Sibley	Webster	LA	1951	Struct (FA)	6,900	0.19	131										
Arcadia	Bienville	LA	1965	Srtuct (FA)	7,050												
Athens	Claiborne	LA	1941	Comb (FA, FC)	6,172									8,000		192	
			1943		6,400									4,000		20	
			1948		7,240									11,600		23	
			1949		7,696										118		

Table 1. Geologic and production data for Travis Peak (TP) (and Hosston) fields in east Texas, northern Louisiana, and southern Arkansas—Continued.

Name of field producing from TP Fm. sandstones	Location of oil or gas field: County or parish	Location of oil or gas field: State	Date of discovery of oil or gas in TP ss	Trapping mechanism for field	Depth to particular TP ss reservoir (ft)	Porosity of ss (decimal)	Permeability (mD)	BHT (oF)	BHP (psi)	FPG (psi/ft)	Position of reservoir within TP Fm.	Sw	Elevation of gas-oil, oil-water, and gas-water contacts (ft below sea level)	Initial production rate for specific TP Fm. sandstone reservoirs (MCFD)	(BOPD)	(BCPD)	(BWPD)
Bear Creek-Bryceland	Bienville	LA	1937	Comb (A, FC)	7,240000	0.16	170						Multiple sands with separate GWCs	5,000 to 165,000			
Bethany-Longstreet	DeSoto, Caddo	LA	1954	Struct (A)	7,000								Flank wells tested water without gas				
Bryceland West	Bienville	LA	1952	Comb (FA,FC)	6,900												
Calhoun	Ouachita	LA	1936	Comb (FA,FC)	6,900												
Caspiana	DeSoto, Caddo	LA											Flank wells tested water without gas				
Chatham	Jackson	LA	1945		9,620				3,700	0.38				8,000			
Chenier Creek	Ouachita	LA	1949	Comb (N, FC)	7,782	0.16	6	211	3,050	0.39		0.34	Flank wells tested water without gas	2,700		2.7	0
Choudrant	Lincoln	LA	1959	Struct (A)	8,568	0.19	250										
Clay	Lincoln	LA	1958	Struct (A)	7,305												
Clear Branch	Jackson	LA	1975	Comb (N, FC)	9,000	0.07	3.8	191	4,190	0.47		0.53		4,088		2	
					10,000	0.08	1.4	205	4,785	0.48		0.37					
					10,100	0.07	0.6	218	4,865	0.48		0.38					
					11,900	0.05	0.3	282	9,450	0.79		0.31					
Cotton Plant	Caldwell	LA	1984	Comb (N, FC)	10,200	0.15	166	258	4,884	0.48			GWC: -10,163 and -10,592	3,803			
					10,600	0.13		272	5,078	0.48				4,569			
Cotton Valley	Webster	LA	1936	Struct (A)	5,550										240		
Danville	Bienville	LA	1966	Struct (A)	7,700												
Downsville	Union	LA	1948	Comb (A, FC)	7,390				3,375	0.46				4,093		4.5	
			1962	Comb (A, FC)	7,819				3,840	0.49				4,100		16.4	
			1978	Comb (A, FC)	7,652	0.17		177	3,550	0.46		0.25	GWC: -7,441	2,000		6	
Driscoll	Bienville	LA	1937	Struct (A)	7,200									25,000			
Elm Grove	Bossier	LA	1975	Struct (FA)	5,852												
Elm Grove (Ext.)	Caddo, Bossier	LA	1984	Struct (FA)	5,956				2,739	0.46				2,675			0
Hico-Knowles	Lincoln	LA	1959	Comb (A,FC)	6,600												
Hodge	Jackson	LA	1961	Struct (A)	7,900												
Holly	DeSoto	LA	1974	Strat (FC)	7,000												
Leatherman Creek	Claiborne	LA	1975	Comb (FA, FC)	8,387-9,614	0.10	0.7	215		0.47		0.30		5,585		24	
Lisbon	Claiborne	LA	1941	Strat (FC)	5,100	0.23	500										
Lisbon North	Claiborne	LA	1941	Struct (A)	5,112									3,840		56	
Lucky	Bienville	LA	1943	Struct (FA)	7,900	0.15			2,800	0.35				2,000			
Ruston	Lincoln	LA	1943	Comb (A, FC)	5,896				2,400	0.41			Multiple sands with separate GWCs	45,000			
			1944		5,745									25,000			
Sailes	Bienville	LA	1945	Comb (FA, FC)	8,847	0.14						0.3		432			
Shreveport	Caddo, Bossier	LA	1951	Struct (A)	6,238									2,080			
Simsboro	Lincoln	LA	1936	Struct (FA)	6,571	0.22	500						Multiple sands with separate GWCs	67,634			
			1951	Struct (FA)	8,069	0.15	2 to 50							16,500			
Sugar Creek	Claiborne	LA	1936	Comb (FA, FC)	5,600	0.19	65		2,300	0.41				20,000			
			1937		5,718								Multiple sands with separate GWCs & OWCs		205		
Vixen	Caldwell	LA	1945	Struct (A)	9,700				3,600	0.37				9,000			
Waskom	Caddo	LA		Comb (A,FC)													
Village	Columbia	AR	1946	Struct (A)	4,800	0.26	706		1,300	0.27							

ft of the formation (Fracasso and others, 1988; Dutton, Laubach, Tye, and others, 1991; Dutton and others, 1993).

Multistory and multilateral fluvial-channel belts afford a highly interconnected network of sandstones that provides effective migration pathways for hydrocarbons. Additionally, hydrocarbon migration through this sandstone network is enhanced by the presence of natural fractures, which are significantly more abundant in the quartz-cemented, sandstone-rich, low-sinuosity fluvial sequence than in overlying paralic sandstones (Dutton, Laubach, Tye, and others, 1991). Consequently, most hydrocarbons migrating upward into the Travis Peak Formation may have passed through the sandstone-rich fluvial section and were subsequently trapped in upper Travis Peak coastal and high-sinuosity, fluvial sandstones, which are encased in mudstones that provide effective hydrocarbon seals. Primary reservoirs within the coastal sequence include tidal-channel and tidal-flat sandstones and high-sinuosity, fluvial-channel sandstones deposited in coastal-plain settings (Tye, 1989; Dutton, Laubach, and Tye, 1991). Bartberger and others (2002) have given a detailed discussion of the sedimentology and reservoir character of Travis Peak sandstones.

Diagenesis

In east Texas, Travis Peak sandstones have had a complex diagenetic history involving (1) mechanical compaction, (2) precipitation of cements and authigenic minerals, including dolomite, quartz, illite, chlorite, and ankerite, (3) generation of secondary porosity through dissolution of feldspar, and (4) formation of reservoir bitumen (Dutton and Diggs, 1992). Loss of primary porosity in near-surface settings following deposition was negligible in most fluvial sandstones. Minor porosity loss occurred in coastal sandstones from precipitation of dolomite cement. From surface deposition to a burial depth of about 3,000 ft, Travis Peak sandstones lost primary porosity mainly through mechanical compaction. Further compaction was halted by extensive quartz cementation that occurred between depths of 3,000 and 5,000 ft.

The next significant diagenetic event was the creation of secondary porosity through dissolution of feldspar. Additional minor porosity reduction occurred to a depth of about 7,500 ft from precipitation of authigenic chlorite, illite, and ankerite. Sandstones on higher parts of the Sabine uplift did not undergo further porosity reduction from cementation. However, in Travis Peak sandstones buried below about 8,000 ft on the west flank of the uplift, a second episode of extensive quartz cementation occurred in which silica was generated from pressure solution associated with development of stylolites.

A late-stage diagenetic event that significantly reduced porosity and permeability in some Travis Peak sandstones in east Texas was the formation of reservoir bitumen (Dutton, Laubach, Tye, and others, 1991; Lomando, 1992). Reservoir bitumen is a solid hydrocarbon that lines and fills both primary and secondary pores in Travis Peak sandstones. Formation of reservoir bitumen occurred after precipitation of quartz and ankerite cement (Dutton, Laubach, Tye, and others, 1991), and its occurrence is limited to primarily coastal sandstones within the upper 300 ft of the Travis Peak Formation. Among sandstones in the upper Travis Peak that contain reservoir bitumen, average and maximum bulk volumes of bitumen are 4 percent and 19 percent, respectively. Geochemical analyses suggest that reservoir bitumen formed from (to use the term of Dutton and others) “deasphalting” of oil trapped in pores of upper Travis Peak sandstones (Rogers and others, 1974; Dutton, Laubach, Tye, and others, 1991; Dutton, Laubach, and Tye, 1991). The oil probably was similar to oil currently being produced from some Travis Peak sandstone reservoirs in fields in east Texas. According to Tissot and Welte (1978), deasphalting commonly occurs in medium to heavy oil when large amounts of gas dissolve into the oil. Gas that dissolves into an oil to cause deasphalting can be generated from either thermal alteration of the oil itself or introduction of gas from outside the reservoir. The level of kerogen maturity in mudstones interbedded with Travis Peak sandstone reservoirs suggests that oils in Travis Peak sandstones were subjected to temperatures sufficient to generate gas internally (Dutton, 1987).

Porosity and Permeability

Porosity and permeability of Travis Peak reservoir sandstones are controlled by both depositional environments and diagenetic factors as already described, which in turn strongly affect the reservoir quality. From an assessment perspective, these variables will have a significant effect on the sizes and numbers of undiscovered accumulations.

Most hydrocarbon production from Travis Peak sandstones in northeast Texas is from drilling depths between 6,000 and 10,000 ft, and sandstone porosity decreases significantly with depth through that interval (Dutton and Diggs, 1992). For all Travis Peak sandstones (clean and shaly), average porosity decreases from 10.6 percent at 6,000 ft to 4.4 percent at 10,000 ft (fig. 8). This depth-related decrease in porosity is not caused by increased compaction (Dutton, Laubach, Tye, and others, 1991; Dutton and Diggs, 1992), but rather by (1) an increase in quartz cement and (2) a decrease in secondary porosity. Secondary porosity was generated almost exclusively from dissolution of feldspar, and the original feldspar content of Travis Peak sandstones decreases systematically with depth (Dutton and Diggs, 1992). High initial porosity together with high degree of connectivity of multilateral, multistory braided-channel sandstones permitted large volumes of diagenetic fluids to move through the thick Travis Peak fluvial-sandstone interval. As a result, the thick fluvial section lost most of its primary porosity to extensive quartz cementation. However, because sandstones in the upper 300 ft of the Travis Peak are encased in mudstones, smaller volumes of diagenetic fluids moved through those sandstones, and they commonly retain significant primary porosity (Dutton and Land, 1988).

According to Dutton and Diggs (1992), average stressed permeability of clean Travis Peak sandstones in northeast Texas decreases by four orders of magnitude, from 10 mD

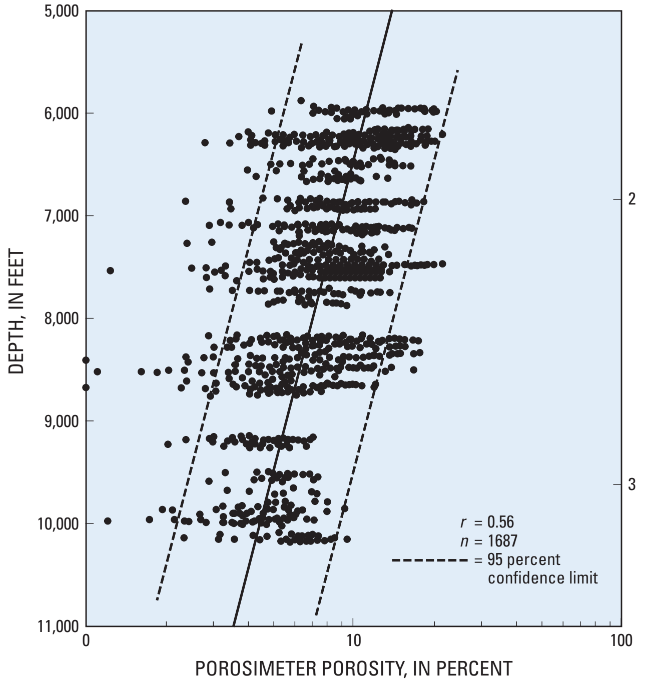


Figure 8. Semilog plot of porosimeter porosity vs. depth for 1,687 Travis Peak Formation sandstone samples from wells in east Texas (from Dutton, Laubach, Tye, and others, 1991). Samples include both clean and shaly sandstones.

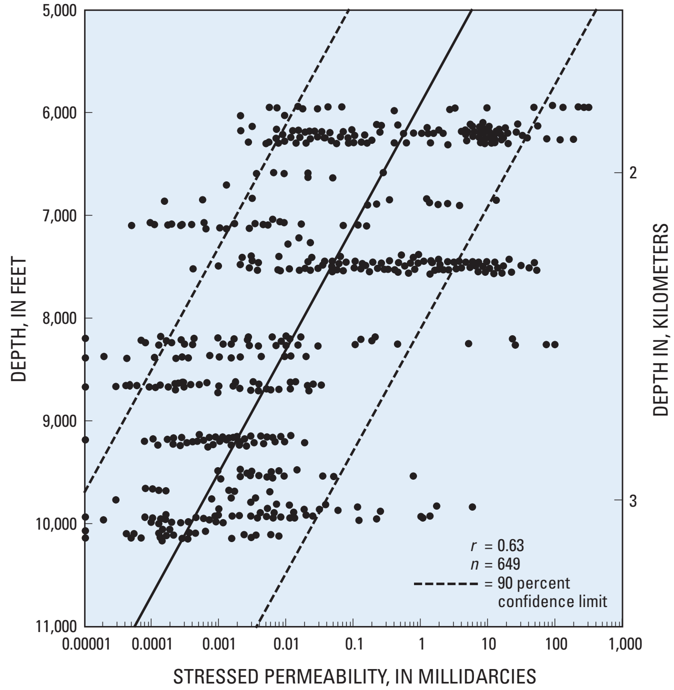


Figure 9. Semilog plot of stressed permeability vs. depth for 649 Travis Peak Formation sandstone samples from wells in east Texas (from Dutton, Laubach, Tye, and others, 1991). Samples include both clean and shaly sandstones. Note that in addition to decrease in permeability with depth, permeability also varies by four orders of magnitude at any given depth.

(millidarcy) at 6,000 ft to 0.001 mD at 10,000 ft. For all sandstones, average stressed permeability declines from 0.8 mD at 6,000 ft to 0.0004 mD at 10,000 ft (fig. 9). Decrease in permeability from 6,000 to 10,000 ft primarily is a function of (1) decrease in porosity, which in turn is caused principally by increasing quartz cement, and (2) increase in overburden pressure that closes narrow pore throats. Although this latter effect has a significant impact on permeability, it has little influence on porosity.

At any given depth within the Travis Peak Formation in northeast Texas, permeability ranges over approximately four orders of magnitude. Also, at any given depth, average permeability is 10 times greater in clean, fluvial sandstones than in clean, coastal sandstones. According to Dutton and Diggs (1992), inferior permeability of clean, coastal sandstones probably can be attributed to three factors. First, because coastal sandstones are finer grained, they had poorer permeability than coarser-grained fluvial sandstones at the time of deposition. Second, although coastal sandstones and fluvial sandstones contain similar amounts of quartz cement, coastal sandstones contain an average of 7 percent more total cement by volume than fluvial sandstones because they have significantly larger volumes of authigenic dolomite, ankerite, illite, chlorite, and reservoir bitumen. Third, much of the porosity in coastal sandstones is secondary porosity and microporosity associated with authigenic illite and chlorite that occurs within secondary pores. Secondary porosity and microporosity both contribute significantly less to permeability compared to primary porosity, in which pores are better connected.

Reservoirs examined by Dutton, Laubach, Tye, and others (1991) that contain bitumen had an average porosity of 7.5 percent prior to formation of bitumen. Formation of reservoir bitumen reduced that average porosity to 3.5 percent, a loss of 55 percent of the prebitumen pore space. Within the coastal facies, where most of the reservoir bitumen occurs, permeability patterns probably controlled the pore spaces into which oil originally migrated and in which reservoir bitumen eventually formed. Cross-bedded and rippled sandstones that are clean and well-sorted contain large volumes of reservoir bitumen, whereas burrowed, shaly, poorly sorted sandstones have little or no reservoir bitumen. Consequently, many sandstone intervals that had the highest initial porosity and permeability following compaction and cementation now have little or no porosity and permeability because of formation of reservoir bitumen.

Abnormal Pressures

Fluid-pressure gradients (FPGs) for Travis Peak sandstone reservoirs in oil and gas fields in east Texas and northern Louisiana (table 1) were calculated from initial shut-in pressures reported in Herald (1951), Shreveport Geological

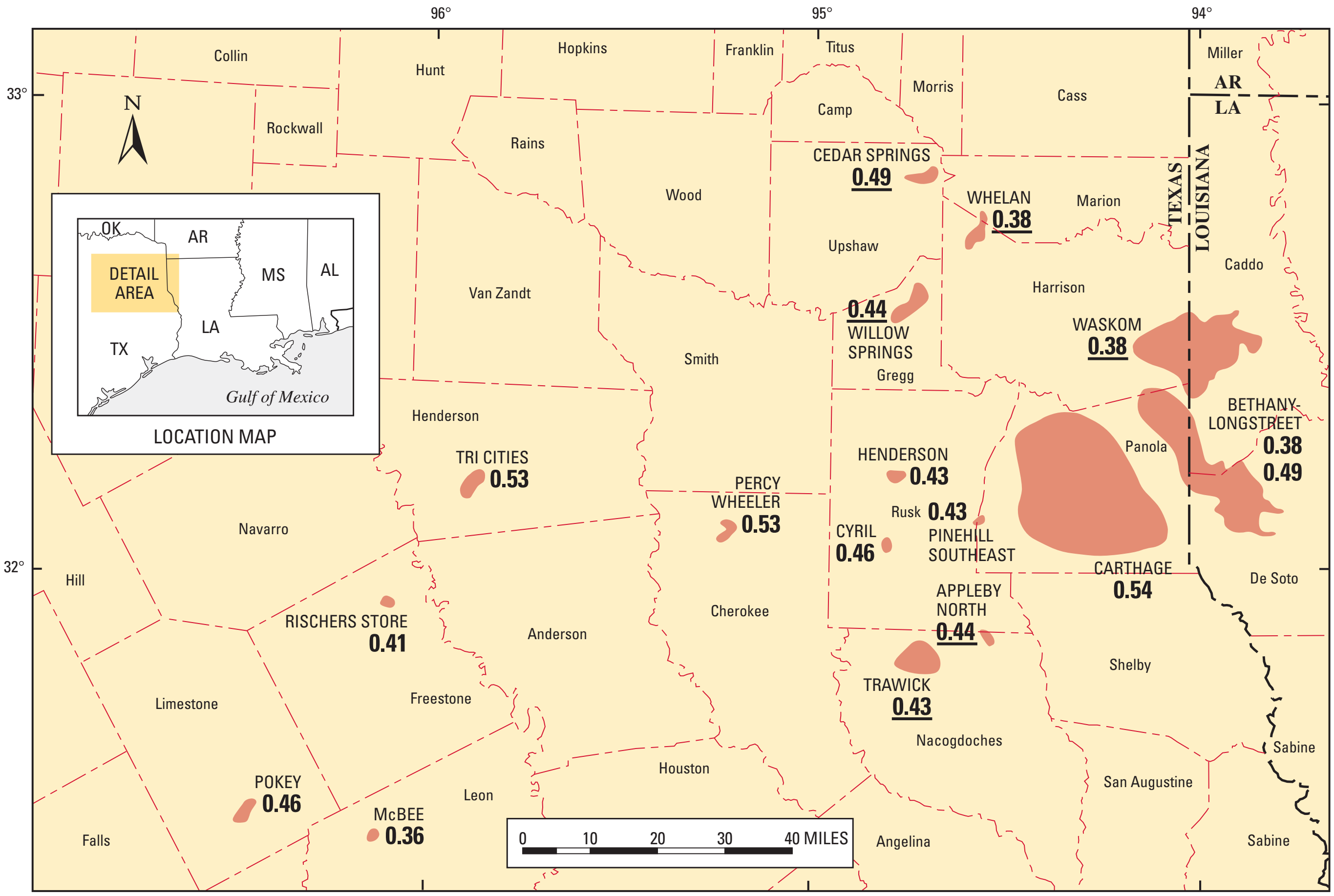


Figure 10. Map of northeast Texas, showing fluid-pressure gradients (FPGs; in psi/ft) calculated from original shut-in pressures in Travis Peak Formation sandstone reservoirs. Multiple pressure-gradient values for a particular field are gradients calculated for different stacked sandstone reservoirs in that field. Shut-in pressure data are shown in table 1 along with sources for those data. Underlined values indicate FPGs from depths at least 500 ft below top of Travis Peak Formation.

Society Reference Reports (1946, 1947, 1951, 1953, 1958, 1963, 1987), Kosters and others (1989), Shoemaker (1989), and Bebout and others (1992). Multiple FPG values for a single field in figures 10 and 11 refer to FPGs calculated for different, stacked Travis Peak sandstone reservoirs in that field. Most calculated FPGs are between 0.41 and 0.49 psi/ft. Higher FPGs were encountered in three fields in east Texas (fig. 10): 0.53 psi/ft at Tri-Cities and Percy-Wheeler fields and 0.54 psi/ft at Carthage field. A gradient of 0.79 psi/ft was calculated for one Travis Peak sandstone reservoir in Clear Branch field in northern Louisiana, although gradients in three other Travis Peak reservoirs within the same field were 0.47, 0.48, and 0.48 psi/ft (table 1; fig. 11). Other fields scattered geographically across east Texas and northern Louisiana exhibit below-normal FPGs ranging from 0.36 to 0.38 psi/ft. The lowest FPG in the Travis Peak field trend is 0.27 psi/ft in Village field, Columbia County, Arkansas (fig. 11).

In northern Louisiana where Travis Peak hydrocarbon production comes from various interdeltaic sandstones scattered throughout the Travis Peak section, shut-in pressure data are available from a variety of depths within the formation. In east Texas, however, most production comes from sandstone reservoirs in the upper 300 ft of the Travis Peak Formation. Consequently, shut-in pressure data are abundant for the upper 300–500 ft of the Travis Peak, but are limited in the lower three-fourths of the formation, which includes the thick fluvial sequence that characterizes the bulk of the Travis Peak in east Texas. Calculated FPGs from sandstone reservoirs at least 500 ft below the top to the Travis Peak are normal at Appleby North, Bethany, Cedar Springs, and Trawick fields and subnormal at Waskom and Whelan Fields (table 1; fig 10). Reservoirs in the middle and lower Travis Peak at Woodlawn and Carthage fields also are normally pressured, according to Albert Brake (BP Amoco engineer, oral commun., 2000), who reported no knowledge of any significant overpressure in Travis Peak reservoirs at any depth within the formation in east Texas. The best available data, therefore, suggest that significant overpressures do not occur within any reservoirs throughout the entire Travis Peak Formation in east Texas.

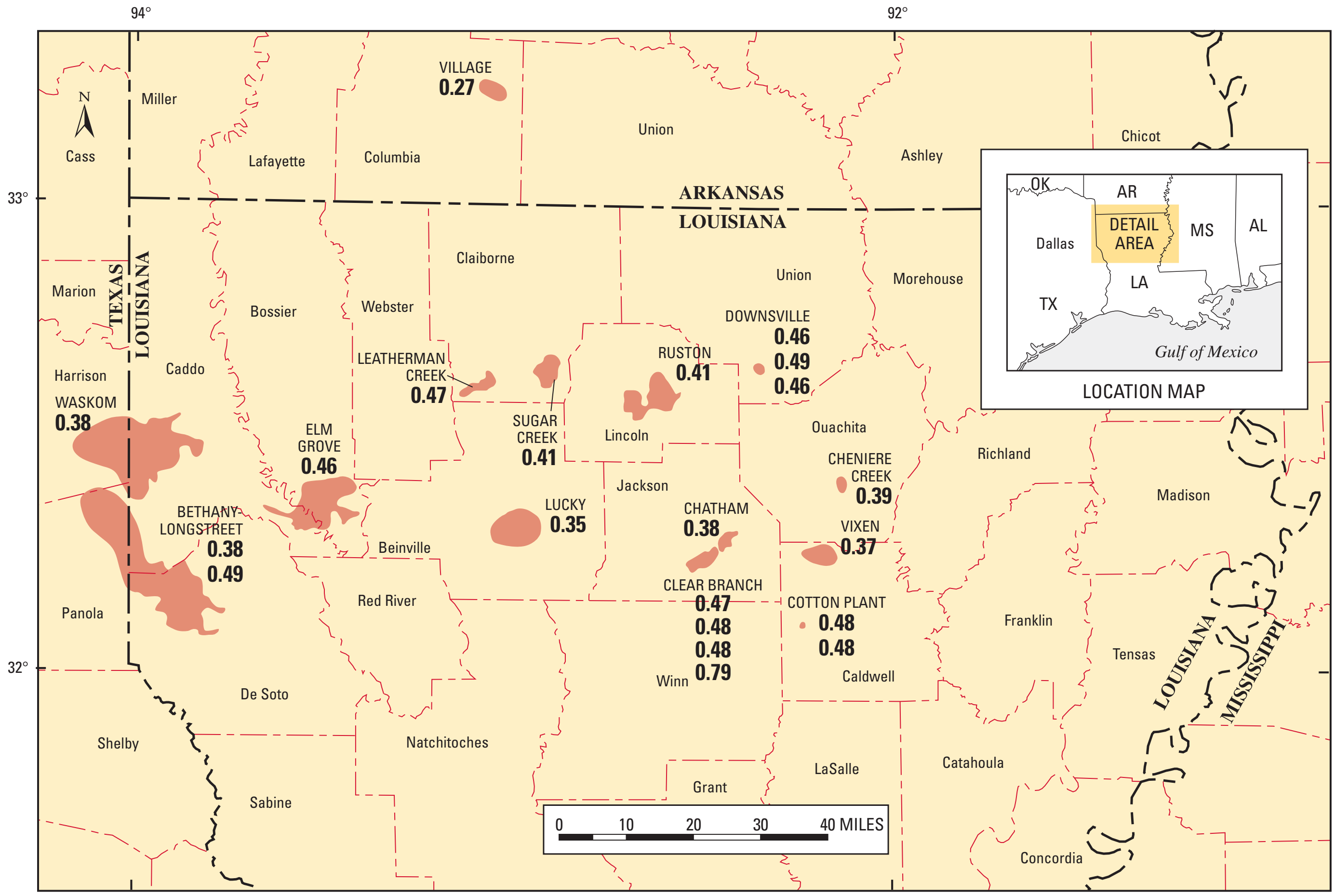


Figure 11. Map of northern Louisiana, showing fluid-pressure gradients (FPGs; in psi/ft) calculated from original shut-in pressures in Travis Peak Formation sandstone reservoirs. Multiple pressure-gradient values for a particular field are gradients calculated for different stacked sandstone reservoirs in that field. Shut-in pressure data are shown in table 1 along with sources for those data.

Traps and Seals

Many Travis Peak fields in east Texas, northern Louisiana, and Mississippi are structural or combination traps associated with Louann Salt structures. Salt structures range from small, low-relief salt pillows to large piercement domes (McGowen and Harris, 1984; Kosters and others, 1989). Early discoveries in the blanket-sandstone trend were in anticlinal traps associated with salt structures. Subsequent discoveries came from more complex and subtle traps, including (1) combination traps with blanket sandstones pinching out across anticlines or structural noses and (2) stratigraphic traps with blanket sandstones pinching out on regional dip (Pate, 1963; Coleman and Coleman, 1981).

Stratigraphic traps also occur where fluvial sandstones pinch out into flood-plain mudstones or where coastal sandstones pinch out into tidal-flat, estuarine, or shallow-marine mudstones across closures, noses, or on regional dip.

Numerous smaller structural highs on the Sabine uplift in the form of domes, anticlines, and structural noses provide traps for hydrocarbon accumulations. The origins of these smaller structures have been attributed to salt deformation and small igneous intrusions, as summarized by Kosters and others (1989). Because the Louann Salt is thin across the Sabine uplift, Kosters and others (1989) suggested that most of the smaller structures across the Sabine uplift developed in association with igneous activity.

The concentration of producible hydrocarbons in sandstones in the upper part of the formation probably resulted from the absence of effective traps and seals within the sandstone-rich, low-sinuosity fluvial sequence of the upper Travis Peak Formation.

Because the Travis Peak Formation is relatively mature with respect to drilling, undiscovered accumulations will be associated with structural traps smaller than many of those for previously discovered fields. The sizes and numbers of undiscovered accumulations for each assessment unit in appendix 1 reflect this exploration maturity.

Hydrocarbon-Water Contacts

Data for various Travis Peak oil and gas fields—reported primarily by the Shreveport Geological Society (1946, 1947, 1951, 1953, 1958, 1963, 1987), the East Texas Geological Society (Shoemaker, 1989), and the Texas Bureau of Economic Geology (Herald, 1951)—document hydrocarbon-water contacts in Travis Peak sandstone reservoirs in 10 fields across east Texas and northern Louisiana (figs. 12 and 13). Field reports edited by Herald (1951) do not use the terms "gas-water contact" or "oil-water contact," but do report "elevation of bottom of oil or gas" and "lowest oil or gas." It seems likely that "lowest gas" refers to the lowest elevation at which gas had been encountered by drilling at the time the report was written, whereas "elevation of bottom of gas" refers to an actual gas-water contact. Supporting that interpretation is the fact that the term "elevation of bottom of gas" clearly was used to indicate elevation of a gas-oil contact at Henderson field (Herald, 1951). If this interpretation of "elevation of bottom of gas" is correct, then hydrocarbon-water contacts are documented in Travis Peak sandstone reservoirs in four additional fields (Herald, 1951), as indicated in table 1 and shown by dashed field outlines in figure 12.

Hydrocarbon-water contacts documented in Travis Peak sandstone reservoirs in the seven Texas fields indicated in table 1 and figure 12 all occur within reservoirs in the upper part of the formation. No documentation for hydrocarbon-water contacts in middle or lower Travis Peak reservoirs in east Texas has been found. At Appleby North field, Nacogdoches County, Texas, Tye (1991) reported that gas seems to be present throughout the Travis Peak section, though not necessarily in commercial amounts, and discrete gas-water contacts do not exist.

An attempt was made to document presence or absence of hydrocarbon-water contacts in additional Travis Peak fields through analysis of data from drill-stem tests (DSTs) and production tests. The goal was to determine if fields that produce from Travis Peak sandstones are flanked by dry holes that tested water only without gas, which would be indicative of presence of a gas-water contact. Wells penetrating the Travis Peak Formation and Cotton Valley Group across much of east Texas and northern Louisiana were extracted from a

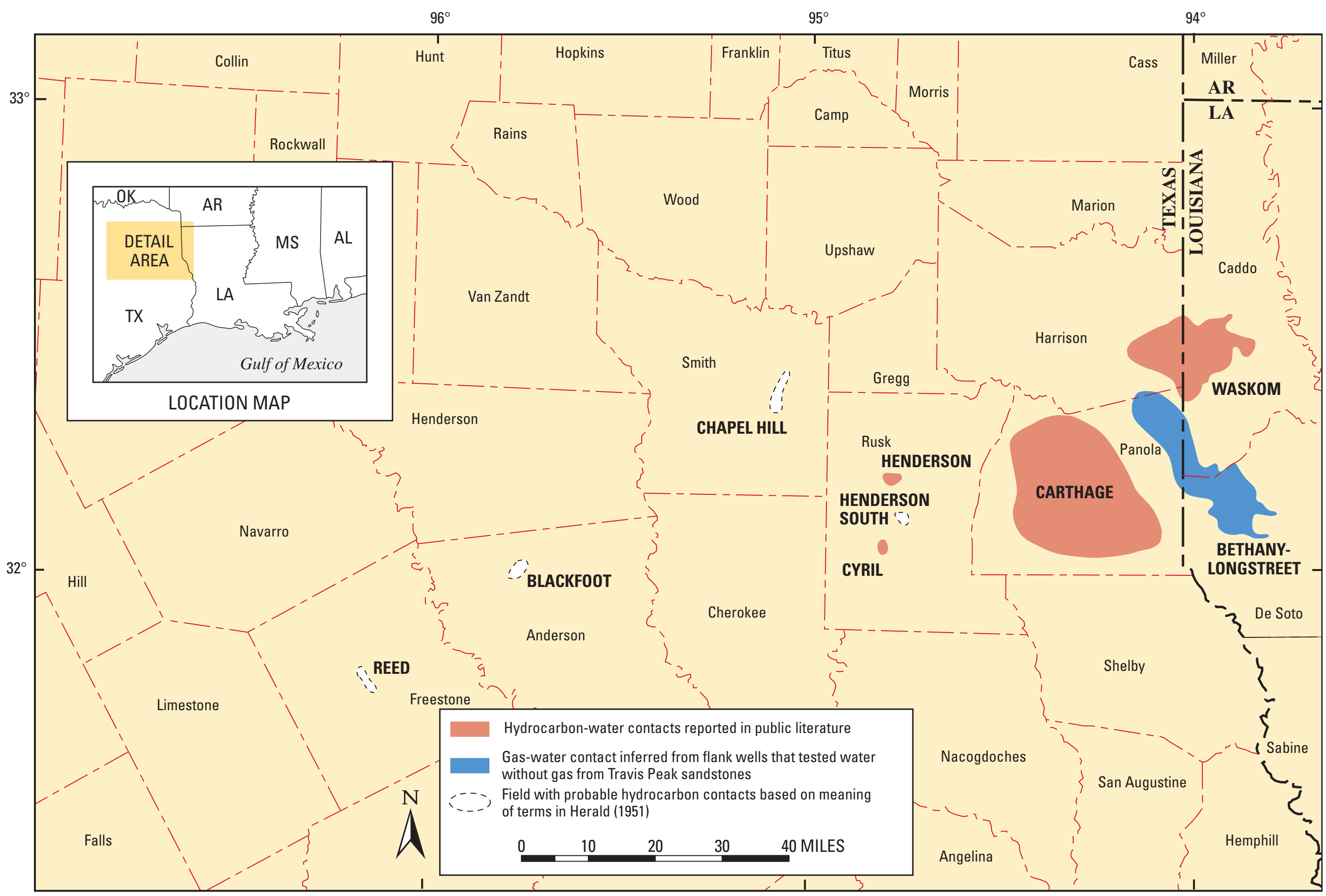


Figure 12. Map of northeast Texas, showing fields in which hydrocarbon-water contacts have been identified in Travis Peak Formation sandstone reservoirs. Brown shading indicates fields in which Travis Peak hydrocarbon-water contacts have been reported in public literature (see table 1). Blue shading indicates fields in which gas-water contacts are inferred on the basis of the presence of flank wells that tested water only, without gas, identified from IHS Energy data (2001). Fields with dashed outlines are those that probably have gas-water or oil-water contacts, depending on meaning of terms "elevation of bottom of gas" and "elevation of bottom of oil," as reported in Herald (1951) and discussed in this report. All Travis Peak hydrocarbon-water contacts in these fields occur within the upper 300–500 ft of the Travis Peak Formation.

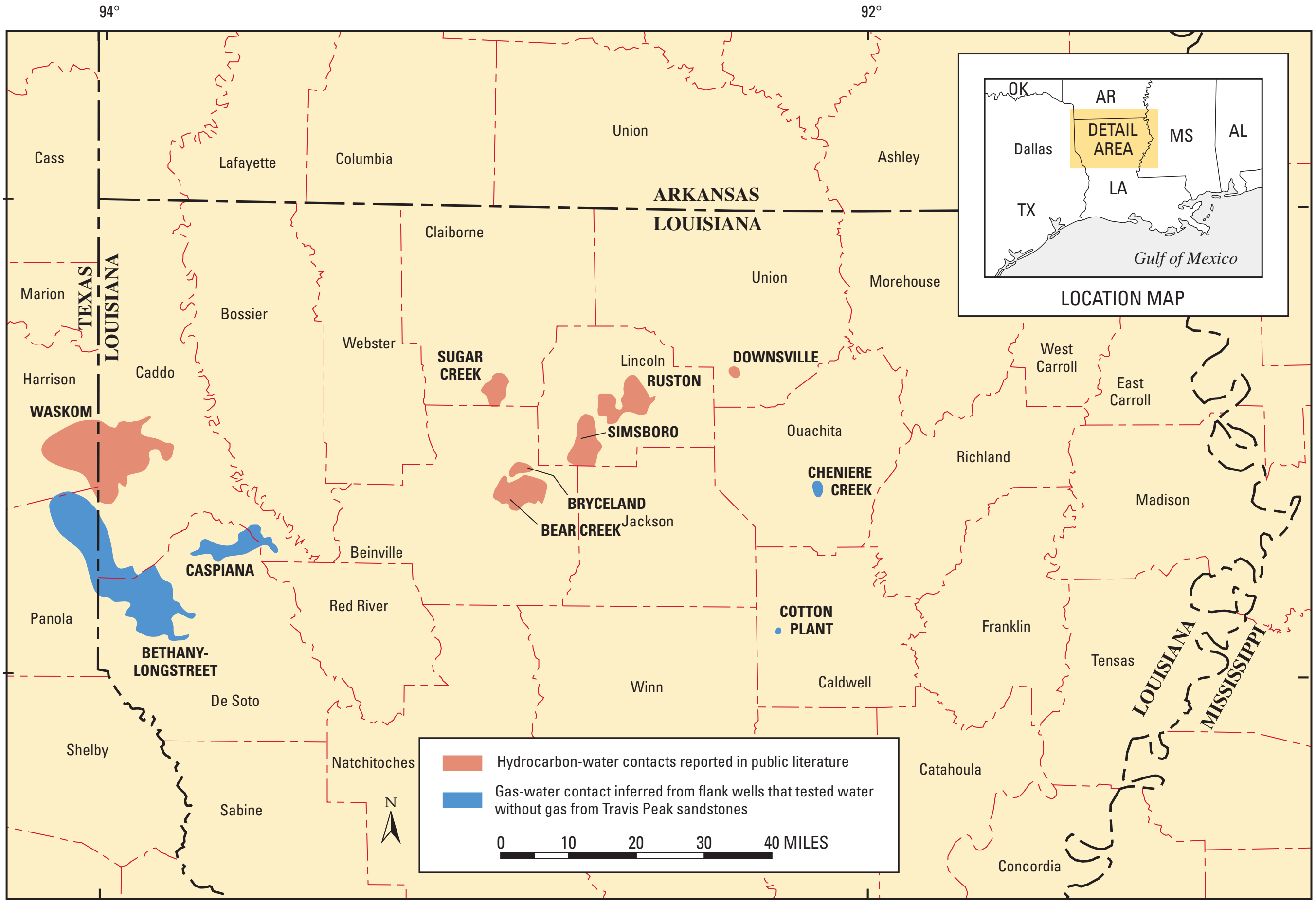


Figure 13. Map of northern Louisiana, showing fields in which hydrocarbon-water contacts have been identified in Travis Peak Formation sandstone reservoirs. Brown shading indicates fields in which Travis Peak hydrocarbon-water contacts have been reported in public literature (see table 1). Blue shading indicates fields in which gas-water contacts are inferred on the basis of the presence of flank wells that tested water only, without gas, identified from IHS Energy data (2001).

database provided by IHS Energy Group (petroROM version 3.43) for analysis of DST and production-test data by using ArcView (version 3.2, Environmental Systems Research Institute, Redlands, CA). Well data were sorted and displayed with ArcView software such that wells that produce from Travis Peak sandstones could be distinguished from Travis Peak dry holes. While viewing the map display, test results from any particular well could be examined. Reconnaissance analysis of test data show that water was recovered without gas from production tests or DSTs in Travis Peak sandstone reservoirs in wells on one or more flanks of Bethany-Longstreet, Cheniere Creek, and Caspiana fields in northern Louisiana (fig. 13). These data indicate the presence of gas-water contacts within Travis Peak sandstone reservoirs in those fields.

Summary of Reservoir Properties

Reservoir properties of many Travis Peak sandstones are significantly better than those characteristic of basin-centered gas reservoirs in which inherent, ubiquitous, low permeability provides an internal seal for thermally generated gas. Travis Peak sandstones have received tight-gas designation across parts of east Texas and northern Louisiana. At depths of less than 7,500 ft in east Texas, however, sandstones often exhibit permeabilities well above the 0.1-mD cutoff for qualification as a tight-gas reservoir. At depths of less than 6,000 ft, permeability can exceed 100 mD. At depths below 8,000 ft, where matrix permeability generally is less than 0.1 mD as a result of extensive quartz cementation, natural fractures are common, imparting fracture permeability to the reservoir. In northern Louisiana where interdeltaic sandstones are separated by shale intervals, hydrocarbon production comes from sandstones throughout the Travis Peak. In east Texas, most production of oil and gas from the Travis Peak comes from sandstone reservoirs in the upper 300 ft of the formation. This production pattern seems to reflect a concentration of hydrocarbons in the upper Travis Peak, though in some fields, sandstones throughout the Travis Peak Formation are reportedly gas-charged. Concentration of oil and gas probably occurs in upper Travis Peak sandstones because these meandering fluvial-channel, tidal-channel, and tidal-flat sandstones are encased in thick shales that provide effective seals. Because of their inherent multistory, multilateral sand-body geometries and abundant vertical fractures, underlying low-sinuosity fluvial sandstones—which constitute the bulk of the Travis Peak Formation—form a highly interconnected network. Thus, the thick fluvial sequence with its lack of thick, widespread shale barriers seems to provide an effective upward-migration pathway for gas rather than affording the inherent sealing capabilities typical of reservoirs harboring basin-centered gas accumulations.

On the basis of this analysis of reservoir properties of discovered accumulations including reservoir pressures, gas-water contacts, permeability, and traps and seals, we think that undiscovered accumulations in Travis Peak reservoirs will be conventional rather than continuous basin-centered. Schmoker (1996) provided a detailed discussion of the characteristics of basin-centered gas accumulations.

Production Characteristics

According to IHS Energy Group data (PI/Dwights PLUS on CD-ROM), more than 10,000 wells are identified as producing from Travis Peak reservoirs in the East Texas and northern Louisiana Salt Basins as of April 2003 (pl. 5). Significant exploration drilling began in the late 1930s when more than 100 wells were completed each year. Exploration efforts rose through the mid 1980s when annual completions totaled about 375 wells, and peak drilling occurred in the mid 1990s when more than 400 wells were completed each year.

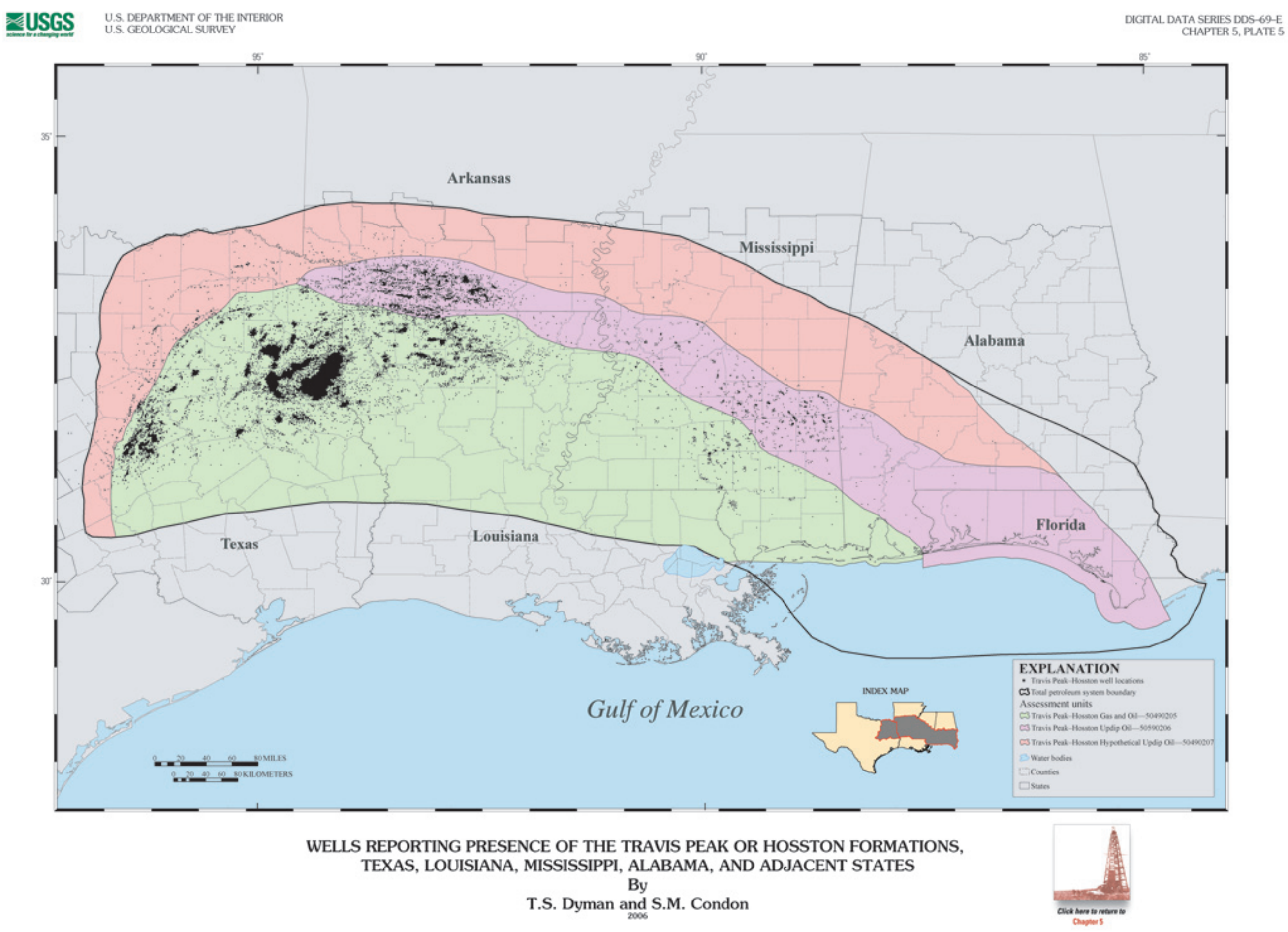


Plate 5. Wells reporting presence of the Travis Peak Formation or Hosston Formation. This map shows the location of wells that have a reported occurrence of the Travis Peak Formation or Hosston Formation. The locations of 24,064 wells in the database are represented. Drilling is concentrated in four areas across the map: (1) in east Texas along the west side of the East Texas Basin, (2) in east Texas along the east side of the East Texas Basin (southwestern Sabine uplift), (3) in northern Louisiana and southern Arkansas, and (4) in southeastern Mississippi. Reported depths range from 747 to 19,500 ft. Boundaries for the Travis Peak–Hosston assessment units are also shown on this map.

According to the IHS Energy Group (2001) production data file, 151 reservoirs in 114 fields are reported as producing from the Travis Peak and Hosston Formations for those fields having more than 15 producing wells. These 151 reservoirs report total cumulative production of 9.9 trillion cubic feet of gas (TCFG), 179 million barrels of oil (MMBO), and 667 million barrels of water (MMBW) (pls. 6, 7). These reservoirs are primarily gas producing and have a mean size (cumulative production plus proved reserves) of 65.6 billion cubic feet of gas (BCFG). Out of 151 reservoirs, 108 are classed as gas producing; these have an average gas-oil ratio (GOR) of 750 thousand cubic feet per barrel (MCF/B). The USGS criterion for a gas field or reservoir is 20 MCF/barrel. Reported GORs range from 0 (which is unrealistic) to more than 26,000 MCF/B for all Travis Peak and Hosston reservoirs.

Resource Assessment

Assessment-Unit Definitions, Boundaries, and Exploration Histories

The Jurassic Smackover Interior Salt Basins Total Petroleum System includes three conventional Travis Peak–Hosston assessment units: Travis Peak–Hosston Gas and Oil (AU 50490205), Travis Peak–Hosston Updip Oil (AU 50490206), and Travis Peak–Hosston Hypothetical Updip Oil (AU 50490207) (pl. 8). A fourth assessment unit, the Hosston Hypothetical Slope-Basin Gas Assessment Unit (AU 50490208), was identified but not assessed owing to a lack of petroleum geologic data.

Travis Peak–Hosston Gas and Oil (AU 50490205)

This assessment unit has a moderate exploration drilling history (pls. 6–8). Oil and gas fields exceeding the minimum size of 0.5 million barrels of oil or 3 billion cubic feet of gas (0.5 MMBO or 3 BCFG) occur in this assessment unit downdip from the Travis Peak–Hosston Updip Oil Assessment Unit (AU 50490206). The updip assessment-unit boundary is located at the northern limit of known gas fields that attain the minimum size (pls. 6–8). The southern assessment-unit boundary is located where sandstone reservoirs of fluvial and deltaic origin decrease in abundance downdip along the Early Cretaceous shelf-slope edge (fig. 3). The assessment unit lies entirely within the Jurassic Smackover Interior Salt Basins Total Petroleum System and has a probability of 1.0 that undiscovered fields of minimum size or larger exist (appendix 1).

On the basis of data from the database “Significant Oil and Gas Fields of the U.S.” (NRG Associates, 1999), we identified 163 fields as producing from the Travis Peak–Hosston Gas and Oil Assessment Unit. Of these 163 fields, 108 were classified as gas fields and 8 were classified as oil fields. The remaining fields were not classified as either gas or oil in the NRG database. Field discovery dates for these NRG fields range from 1904 to 1995. New field discoveries peaked at 60 during the 1970s. Mean gas field size is 96.8 BCFG, and mean oil field size is 2.9 MMBO.

All fields together have a grown ultimate recoverable resource of 23.3 MMBO and 10.46 TCFG. Carthage, with an estimated recoverable volume of 1,041 BCFG, is the largest field. A median of 50 undiscovered gas accumulations and four undiscovered oil accumulations are expected to exist. The median undiscovered field sizes are 10 BCFG and 0.75 MMBO (appendix 1). The sizes and numbers of undiscovered accumulations presented in appendix 1 are strongly related to sedimentologic and diagenetic interpretations in which accumulations of oil and gas occur primarily in meandering-channel, tidal channel, and tidal-flat facies in the upper part of the Travis Peak with preferential diagenetic alteration. Drilling depths range from 5,600 to 18,000 ft for undiscovered gas fields and from 5,600 to 14,800 ft for undiscovered oil fields. The assessment unit covers an area of 66,282 mi^2.

Travis Peak–Hosston Updip Oil (AU 50490206)

This assessment unit has a moderate exploration drilling history (pls. 6–8) and the presence of primarily oil fields exceeding the minimum size (0.5 MMBO) updip from the Travis Peak–Hosston Gas and Oil Assessment Unit (AU 50490205) (pls. 6–8). The updip boundary occurs in east Texas, southeastern Oklahoma, northern Louisiana, central Mississippi, central Alabama, and the westernmost part of the Florida panhandle where the Travis Peak Formation has been eroded or was not deposited. The southern assessment-unit boundary is defined by the occurrence of producing fields of the Travis Peak–Hosston Gas and Oil Assessment Unit. The assessment unit lies entirely within the Jurassic Smackover Interior Salt Basins Total Petroleum System.

Forty-five fields were identified as producing from the Travis Peak–Hosston Updip Oil Assessment Unit through the use of the database “Significant Oil and Gas Fields of the U.S.” compiled by NRG Associates (1999). Of these 45 fields, 39 were classified as oil fields and 2 were classified as gas fields. The remaining fields were not classified as either gas or oil in the NRG database. Field discovery dates for these NRG fields range from 1930 to 1997. New field discoveries peaked during the 1950s when 17 fields were discovered. Mean oil field size is 4.2 MMBO, and mean gas field size is 8.7 BCFG.

All fields together have a grown ultimate recoverable resource of 166.8 MMBO. Raleigh field, with an estimated total recoverable volume of 32.6 MMBO, is the largest field. The median undiscovered field size is 1 MMBO and 6 BCFG. The sizes and numbers of undiscovered accumulations for the Travis Peak–Hosston Updip Oil Assessment Unit are related to sedimentologic and diagenetic interpretations in which

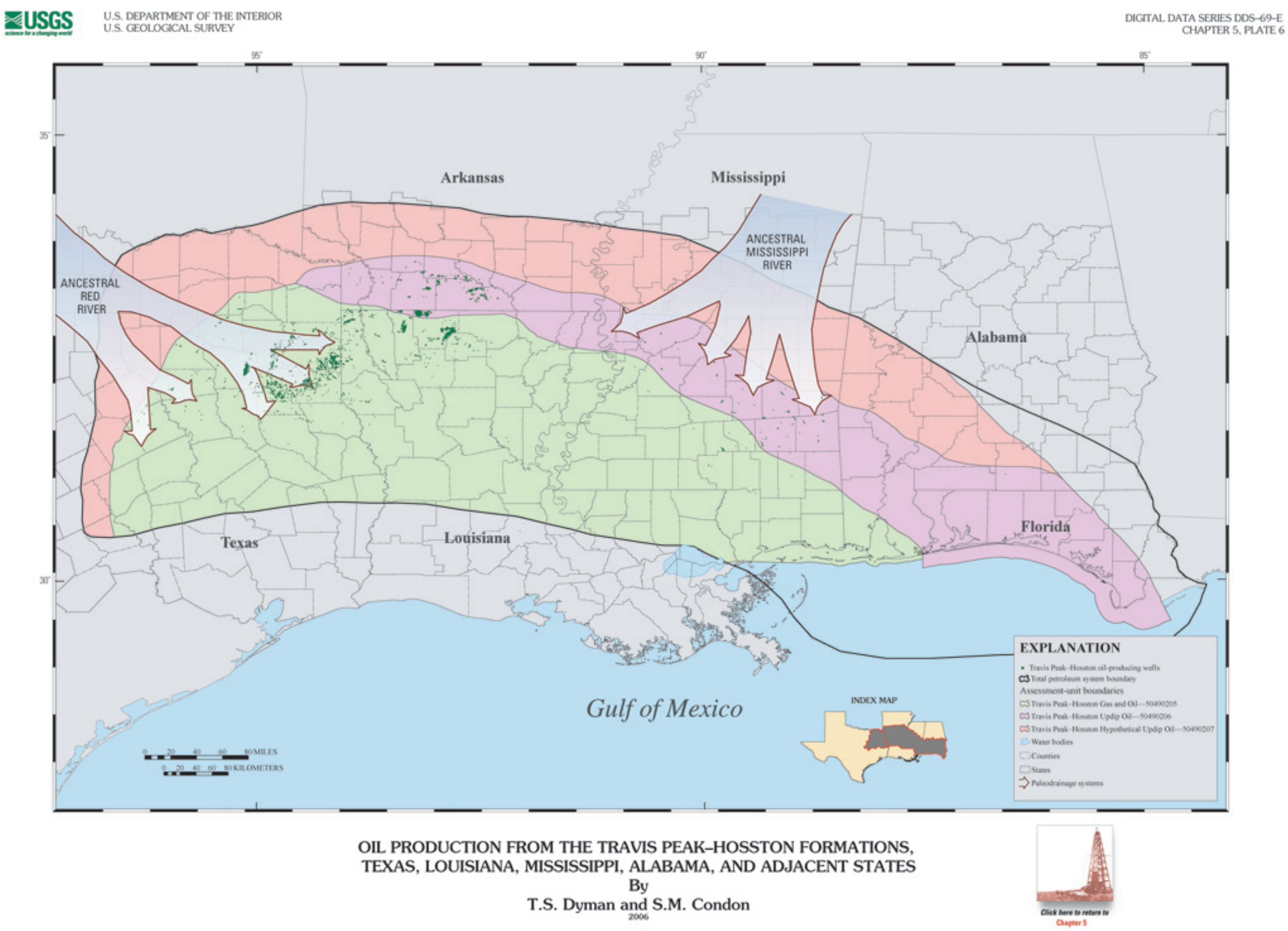


Plate 6. Oil production from the Travis Peak Formation or Hosston Formation. This map shows the location of 3,350 wells that reported oil production from the Travis Peak Formation or Hosston Formation. Main areas of production have been in east Texas on the southwest side of the Sabine uplift, in northern Louisiana in the northern Louisiana Salt Basin, in southern Arkansas, and in southeastern Mississippi. Boundaries for the Travis Peak and Hosston assessment units are also shown on this map, as well as regional depositional environments of the Travis Peak and Hosston Formations. Oil production on the Sabine uplift is from an area that has been interpreted as a major depocenter of the Travis Peak, and production in Mississippi is also associated with a depocenter. Production in northern Louisiana and southern Arkansas has been from the area between major depocenters. The synthesis of regional depositional environments is modified from Bartberger and others (2002).

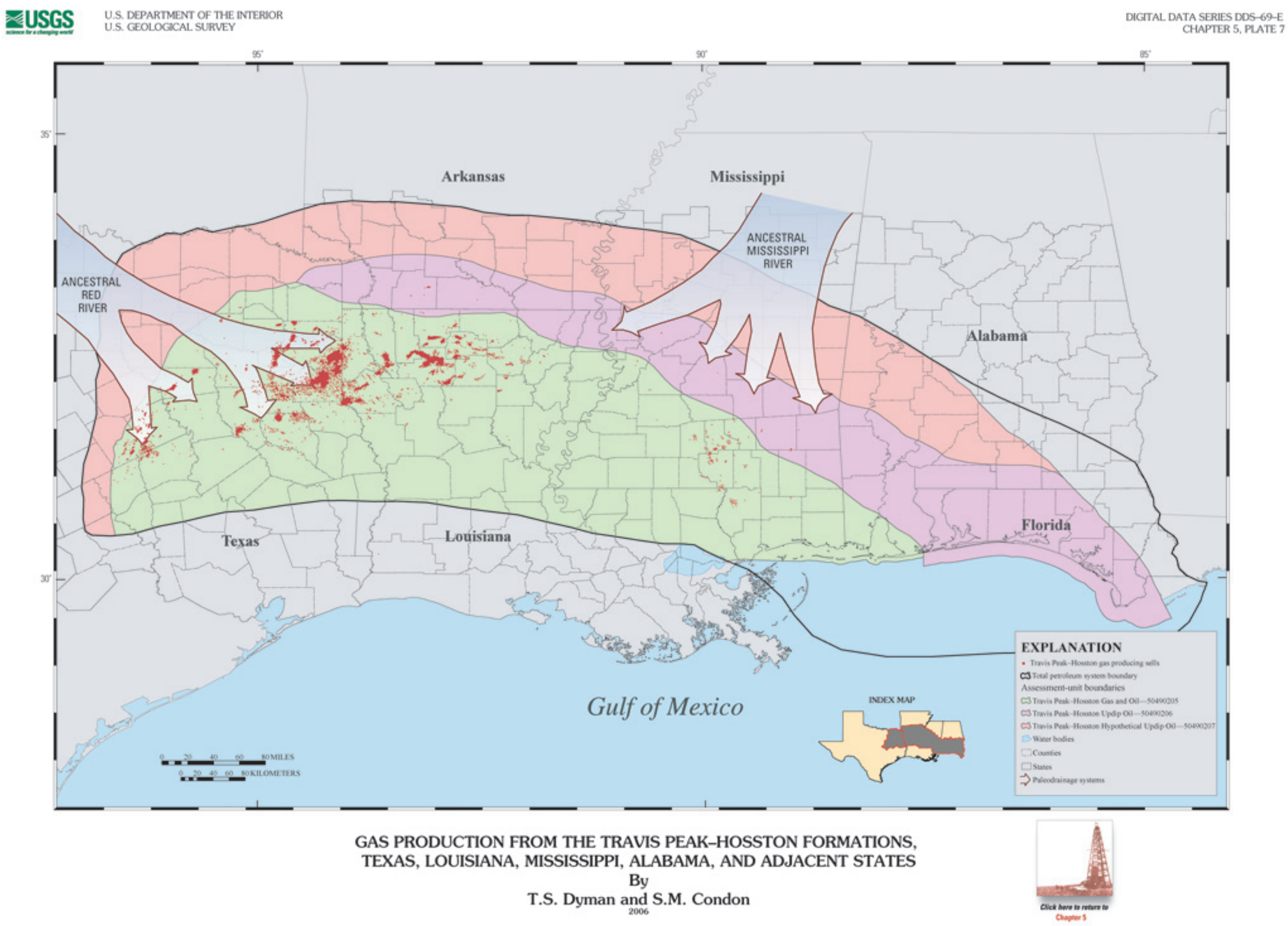


Plate 7. Gas production from the Travis Peak Formation or Hosston Formation. This map shows the location of reported gas production from the Travis Peak Formation or Hosston Formation. Data were retrieved from the PI/Dwights PLUS production database by querying the fields Producing Zone and Product Code. The map shows 6,883 wells, most of which are along the west side of the East Texas Basin, on the Sabine uplift, in the northern Louisiana Salt Basin, and in southwestern Mississippi. Boundaries for the Travis Peak and Hosston assessment units and regional depositional environments for the Travis Peak and Hosston Formations are also shown. In east Texas, much of the gas production has been in areas of major influx of sediments; however, production in northern Louisiana appears to be from an area between main depocenters. Production in southwestern Mississippi is in an area where the Hosston is relatively thick (pl. 1), but in a position representing depositional environments farther offshore than those of the main producing area in east Texas. The synthesis of regional depositional environments is modified from Bartberger and others (2002).

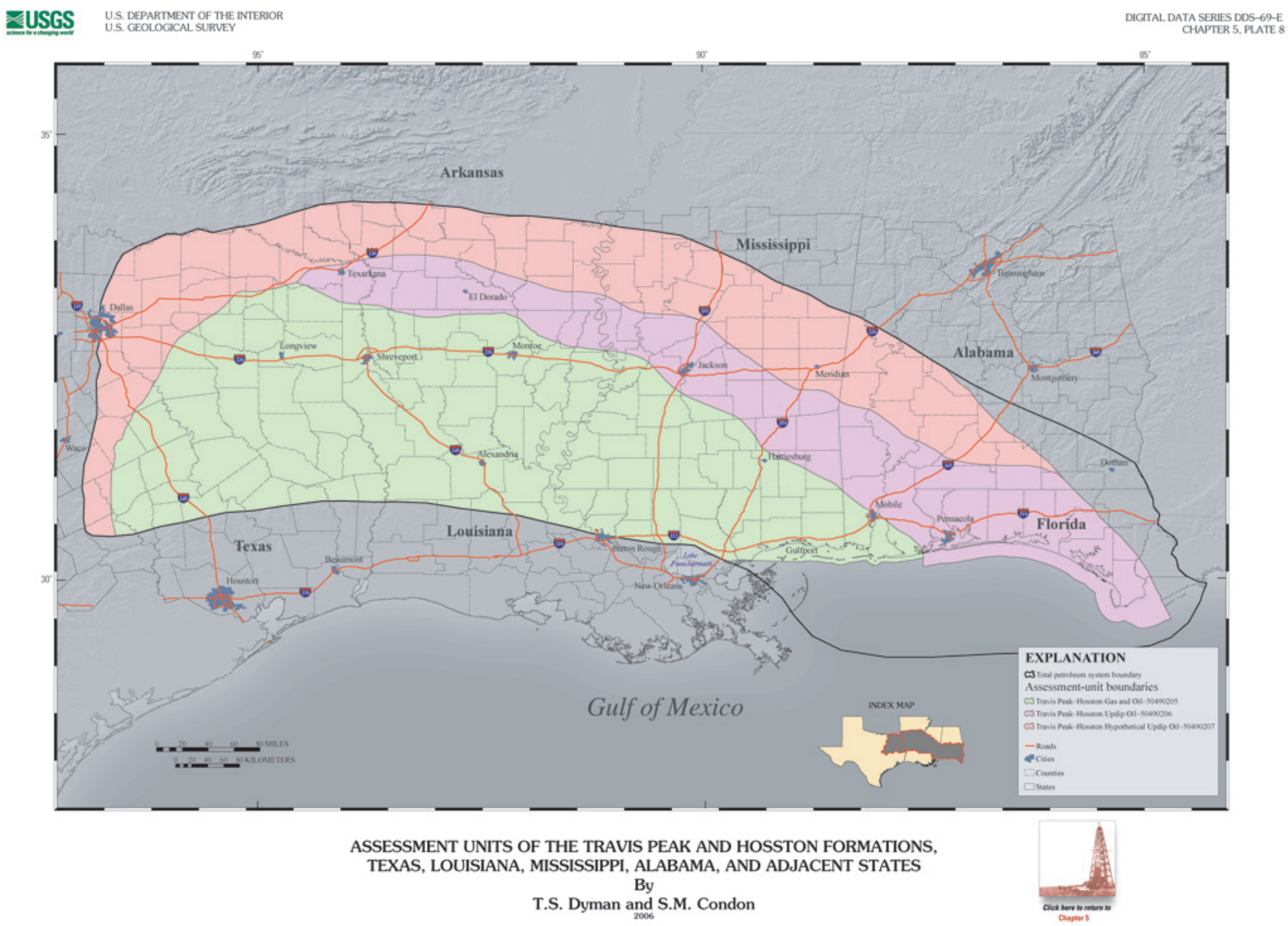


Plate 8. Travis Peak–Hosston assessment units. This map shows the assessment units of the Travis Peak Formation and correlative Hosston Formation on a detailed base map. The three assessment units are Travis Peak–Hosston Gas and Oil (AU 50490205), Travis Peak–Hosston Updip Oil (AU 50490206), and Travis Peak–Hosston Hypothetical Updip Oil (AU 50490207).The assessment units were defined by plotting the locations of all wells that have tops reported for the Travis Peak or Hosston and by plotting the location of wells that produce gas or oil. These well locations are shown on plates 5–7. The Travis Peak–Hosston Updip Oil Assessment Unit has reservoir properties similar to those of the Travis Peak–Hosston Gas and Oil Assessment Unit; however, the former is present at a shallower, updip structural position and mainly has oil production with some associated gas.The Travis Peak–Hosston Hypothetical Updip Oil Assessment Unit was defined as the area outside the Travis Peak–Hosston Updip Oil Assessment Unit where both the Smackover Formation and the overlying Travis Peak or Hosston Formation are present. Our rationale for defining this area was that both the potential source rock (Smackover) and the potential reservoir (Travis Peak or Hosston) needed to be present to delineate the hypothetical assessment unit, but there has been no significant production from this area to date.

accumulations of oil and gas occur primarily in meandering-channel, tidal channel, and tidal-flat facies in the upper part of the Travis Peak Formation that have preferential diagenetic alteration. Quality of reservoir rocks deteriorates updip where nonmarine facies dominate and thermal maturities are lower than in the main producing trends farther south. Drilling depths range from 1,970 to 16,400 ft. The assessment unit covers an area of 31,109 mi^2.

Travis Peak–Hosston Hypothetical Updip Oil (AU 50490207)

The existence of this assessment unit is based on a modest record of exploration drilling and the presence of oil shows updip from the Travis Peak–Hosston Updip Oil Assessment Unit (AU 50490206) (pls. 6–8). No fields larger than the minimum size are present, and thus this assessment unit is classified as hypothetical. The updip boundary is located at the edge of the outcrop belt of Travis Peak reservoir rocks in east Texas, southeastern Oklahoma, northern Louisiana, central Mississippi, central Alabama, and the westernmost part of the Florida panhandle (pls. 6–8). The southern assessment-unit boundary is defined by the occurrence of producing fields of the Travis Peak–Hosston Updip Oil Assessment Unit. The assessment unit lies entirely within the boundary of the Jurassic Smackover Interior Salt Basins Total Petroleum System. This assessment unit has been risked for charge (0.95) and adequate reservoir rocks, traps, and seals (0.8). The assessment-unit probability of having a field of the minimum size is 0.76 (appendix 1).

A median of four undiscovered oil accumulations are expected to exist. The median undiscovered field size is 0.9 MMBO (appendix 1). The sizes and numbers of undiscovered accumulations for the Travis Peak–Hosston Hypothetical Updip Oil Assessment Unit are related to sedimentologic and diagenetic interpretations in which accumulations of oil occur primarily in meandering-channel facies in the upper part of the Travis Peak Formation with preferential diagenetic alteration. The quality of reservoir rocks deteriorates updip because nonmarine facies dominate and thermal maturities are lower than those in the main producing trends farther south. Drilling depths range from 1,970 to 7,870 ft. The assessment unit covers an area of 38,896 mi^2.

Assessment Results

A summary of the assessment results for the three assessed Travis Peak–Hosston assessment units by resource type (that is, crude oil, natural gas, and natural gas liquids) is presented in table 2. The mean total estimated undiscovered conventional gas resource for Travis Peak–Hosston reservoirs in the Jurassic Smackover Interior Salt Basins Total Petroleum System is 1,135.72 BCFG with a range of 2,038.35 (F5) BCFG to 418.19 (F95) BCFG. This resource includes both nonassociated gas in gas fields and associated gas in oil fields. Only 5 percent (58.93 BCFG) of the mean total gas resource value (1,135.72 BCFG) represents associated gas in oil fields. The largest undiscovered conventional gas resource was estimated for the Travis Peak–Hosston Gas and Oil Assessment Unit (AU 50490205); this assessment unit is thought to contain a mean resource of 1,085.35 BCFG and a range of 1,930.96 BCFG (F5) to 404.69 BCFG (F95).

The mean total estimated undiscovered conventional crude oil resource for the Jurassic Smackover Interior Salt Basins Total Petroleum System in the Louisiana-Mississippi Salt Basins Province is 28.92 MMBO; the range is 58.29 (F5) MMBO to 7.44 (F95) MMBO (table 2). The largest undiscovered conventional crude oil resource was estimated for the Travis Peak–Hosston Updip Oil Assessment Unit (AU 50490206); it has a mean resource of 20.97 MMBO and a range of 39.49 MMBO (F5) to 6.18 MMBO (F95).

The mean total estimated undiscovered conventional natural gas liquids (NGLs) resource for Travis Peak–Hosston reservoirs in the Jurassic Smackover Interior Salt Basins Total Petroleum System in the Louisiana-Mississippi Salt Basins Province is 21.54 MMBNGL; the range is 41.76 (F5) MMBNGL to 7.18 (F95) MMBNGL (table 2).

Conclusions

1. The Travis Peak and Hosston Formations represent a Lower Cretaceous basinward-thickening wedge of terrigenous clastic sedimentary rocks that underlies the northern Gulf of Mexico Basin from east Texas and southern Arkansas across northern Louisiana into southern Mississippi and eastward. Clastic influx was focused in two main fluvial-deltaic depocenters associated with the ancestral Red River in east Texas and the ancestral Mississippi River in southern Mississippi and northeast Louisiana.

2. The Travis Peak Formation is divided into three informal depositional intervals across its hydrocarbon-productive trend in east Texas; the intervals are differentiated by the relative amounts of sandstone and shale. A thin lower interval consists of mixed sandstones and shales interpreted as delta-fringe deposits. It is gradationally overlain by a thick, sandstone-rich interval that forms the bulk of the Travis Peak section composed primarily of stacked, braided-channel sandstones grading up into meandering-channel deposits. The third and uppermost interval consists of mixed sandstone and mudstone interpreted as coastal-plain and marine deposits.

3. Most hydrocarbon production from the Travis Peak Formation in east Texas and northern Louisiana is from drilling depths of 6,000–10,000 ft. Throughout that interval, porosity and permeability of Travis Peak sandstones decrease significantly with depth. Decreasing porosity with depth results primarily from (1) increased quartz cement and (2) decreased secondary porosity, which was derived almost exclusively from dissolution of feldspar. Decreasing

Table 2. Assessment results for Travis Peak–Hosston Formation assessment units in the Jurassic Smackover Interior Salt Basins Total Petroleum System.

[Data primarily from Shreveport Geological Society Reference Reports, Bebout and others (1992), and Pate and Goodwin (1961). Totals do not reflect rounding]

Code and Accumulation Type	MAS	Prob. (0-1)	Total Undiscovered Resources											
			Oil (MMBO)				Gas (BCFG)				NGL (MMBNGL)			
			F95	F50	F5	Mean	F95	F50	F5	Mean	F95	F50	F5	Mean
Total: Undiscovered conventional resources in Travis Peak (Hosston) assessment units within the Jurassic Smackover Interior Salt Basins Total Petroleum System														
Oil Accums.	0.5	1.00	7.44	26.63	58.29	28.92	14.96	51.50	128.65	58.93	0.43	1.58	4.17	1.85
Gas Accums.	3.0						403.24	1,029.63	1,909.70	1,076.79	6.75	18.25	37.58	19.70
Total		1.00	7.44	26.63	58.29	28.92	418.19	1,081.13	2,038.35	1,135.72	7.18	19.83	41.76	21.54
Travis Peak-Hosston Gas and Oil Assessment Unit														
Oil Accums.	0.5	1.00	1.25	3.77	9.09	4.28	9.20	29.24	76.28	34.26	0.21	0.72	1.97	0.86
Gas Accums.	3.0						395.49	1,007.23	1,854.68	1,051.08	6.55	17.60	35.86	18.93
Total		1.00	1.25	3.77	9.09	4.28	404.69	1,036.47	1,930.96	1,085.35	6.76	18.32	37.83	19.78
Travis Peak-Hosston Updip Oil Assessment Unit														
Oil Accums.	0.5	1.00	6.18	19.74	39.49	20.97	5.76	19.24	42.23	21.01	0.21	0.75	1.78	0.84
Gas Accums.	3.0						7.74	22.40	55.02	25.71	0.21	0.66	1.73	0.77
Total		1.00	6.18	19.74	39.49	20.97	13.50	41.64	97.25	46.72	0.42	1.40	3.51	1.61
Travis Peak-Hosston Hypothetical Oil Assessment Unit														
Oil Accums.	0.5	0.76	0.00	3.13	9.72	3.66	0.00	3.01	10.14	3.66	0.00	0.12	0.42	0.15
Gas Accums.	3.0						0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total		0.76	0.00	3.13	9.72	3.66	0.00	3.01	10.14	3.66	0.00	0.12	0.42	0.15

permeability with depth occurs mainly because of (1) decreased porosity, which in turn is caused principally by increasing quartz cement, and (2) increased overburden pressure that closes narrow pore throats.

4. The most likely source rocks for gas and oil produced from Travis Peak sandstones are laminated carbonate mudstones of the Upper Jurassic Smackover Formation and organic-rich shales of the Upper Jurassic Bossier Shale of the underlying Upper Jurassic–Lower Cretaceous Cotton Valley Group. Burial- and thermal-history data for east Texas and northern Louisiana suggest that onset of dry-gas generation from Smackover mudstones and the Bossier Shale started at about 80 Ma and 57 Ma, respectively. Vitrinite reflectance (Ro) values of Travis Peak shales interbedded with reservoir sandstones in east Texas indicate that these rocks have passed through the oil window and are approaching the onset of dry-gas generation. However, these shales are primarily oxidized flood-plain shales with total organic carbon contents of less than 0.5 weight percent and consequently are not considered likely sources of oil and gas. Travis Peak marine shales downdip in the Gulf of Mexico Basin in central Louisiana might have generated hydrocarbons, but relatively long-distance lateral migration would be necessary.

5. The Jurassic Smackover Interior Salt Basins Total Petroleum System is defined for this assessment to include both Upper Jurassic Smackover carbonates and calcareous shales and Upper Jurassic–Lower Cretaceous Cotton Valley Group organic-rich shales. The Jurassic Smackover Interior Salt Basins Total Petroleum System includes three conventional Travis Peak–Hosston assessment units: Travis Peak–Hosston Gas and Oil (AU 50490205), Travis Peak–Hosston Updip Oil (AU 50490206), and Travis Peak–Hosston Hypothetical Updip Oil (AU 50490207). A fourth assessment unit, Hosston Hypothetical Slope-Basin Gas Assessment Unit (AU 50490208), was identified but not assessed owing to a lack of geologic data.

6. Together, the three assessment units (excluding the Hosston Hypothetical Slope-Basin Gas Assessment Unit) are estimated to contain a mean undiscovered conventional resource of 28.92 million barrels of oil, 1,135.72 billion cubic feet of gas, and 21.54 million barrels of natural gas liquids.

References Cited

Ahlbrandt, T.S., 2000, Introduction, *in* U.S. Geological Survey world petroleum assessment 2000—Description and results: U.S. Geological Survey Digital Data Series DDS-60, version 1.0, 4 CD-ROMs.

Bartberger, C.E., Dyman, T.S., and Condon, S.M., 2002, Is there a basin-centered gas accumulation in Travis Peak Formation sandstones, Gulf Coast Basin, U.S.A.?: U.S. Geological Survey Bulletin 2184-D; available at URL http://geology.cr.usgs.gov/pub/bulletins/b2184-d/ (last accessed 30 September 2005).

Bebout, D.G., White, W.A., Garrett, C.M., Jr., and Henz, T.F., 1992, Atlas of major central and eastern Gulf Coast gas reservoirs: Austin, Tex., University of Texas, Bureau of Economic Geology, 88 p.

Coleman, J.L., Jr., and Coleman, C.J., 1981, Stratigraphic, sedimentologic and diagenetic framework for the Jurassic Cotton Valley Terryville massive sandstone complex, northern Louisiana: Gulf Coast Association of Geological Societies Transactions, v. 31, p. 71–79.

Davies, D.K., Williams, B.P.J., and Vessell, R.K., 1991, Reservoir models for meandering and straight fluvial channels—Examples from the Travis Peak Formation, east Texas: Gulf Coast Association of Geological Societies Transactions, v. 41, p. 152–174.

Dow, W.G., 1978, Petroleum source beds on continental slopes and rises: American Association of Petroleum Geologists Bulletin, v. 62, no. 9, p. 1584–1606.

Dutton, S.P., 1987, Diagenesis and burial history of the Lower Cretaceous Travis Peak Formation, east Texas: Austin, Tex., University of Texas, Bureau of Economic Geology, Report of Investigations No. 164, 58 p.

Dutton, S.P., and Diggs, T.N., 1992, Evolution of porosity and permeability in the Lower Cretaceous Travis Peak Formation, east Texas: American Association of Petroleum Geologists Bulletin, v. 76, no. 2, p. 252–269.

Dutton, S.P., and Land, L.S., 1988, Cementation and burial history of a low-permeability quartzarenite, Lower Cretaceous Travis Peak Formation, east Texas: Geological Society of America Bulletin, v. 100, p. 1271–1282.

Dutton, S.P., Clift, S.J., Hamilton, D.S., Hamlin, H.S., Hentz, T.F., Howard, W.E., Akhter, M.S., and Laubach, S.E., 1993, Major low-permeability sandstone gas reservoirs in the continental United States: Austin, Tex., University of Texas, Bureau of Economic Geology, Report of Investigations No. 211, 221 p.

Dutton, S.P., Laubach, S.E., and Tye, R.S., 1991, Depositional, diagenetic, and structural controls on reservoir properties of low-permeability sandstone, Travis Peak Formation, east Texas: Gulf Coast Association of Geological Societies Transactions, v. 41, p. 209–220.

Dutton, S.P., Laubach, S.E., Tye, R.S., Baumgardner, R.W., and Herrington, K.L., 1991, Geologic characterization of low-permeability gas reservoirs, Travis Peak Formation, east Texas: Austin, Tex., University of Texas, Bureau of Economic Geology, Report of Investigations No. 204, 89 p.

Fracasso, M.A., Dutton, S.P., and Finley, R.J., 1988, Depositional systems and diagenesis of Travis Peak tight-gas sandstone reservoirs, Sabine uplift area, Texas: Society of Petroleum Engineers Formation Evaluation, v. 3, p. 105–115.

Hartman, B.M., and Scranton, D.F., 1992, Geologic map of Texas: Austin, Tex., University of Texas, Bureau of Economic Geology, scale 1:500,000.

Herald, F.A., ed., 1951, Occurrence of oil and gas in northeast Texas: Austin, Tex., University of Texas, Bureau of Economic Geology, 449 p.

Herrmann, L.A., Lott, J.A., and Davenport, R.E., 1991, Ruston field—U.S.A., Gulf Coast Basin, Louisiana, *in* Foster, N.H., and Beaumont, E.A., eds., Treatise of petroleum geology—Structural traps, Volume V: Tulsa, Okla., American Association of Petroleum Geologists, p. 151–186.

IHS Energy Group, 2001, PI-Dwights WHCS [Well History Control System] (through April 2001): Available from IHS Energy Group, Denver, CO 80112.

Jackson, M.L.W., and Laubach, S.E., 1991, Structural history and origin of the Sabine Arch, east Texas and northwest Louisiana: Austin, Tex., University of Texas, Bureau of Economic Geology, Geological Circular 91-3, 47 p.

Kosters, E.C., Bebout, D.G., Seni, S.J., Garrett, C.M., Jr., Brown, L.F., Jr., Hamlin, H.S., Dutton, S.P., Ruppel, S.C., Finley, R.J., and Tyler, N., 1989, Atlas of major Texas gas reservoirs: Austin, Tex., University of Texas, Bureau of Economic Geology, 161 p.

Laubach, S.E., and Jackson, M.L.W., 1990, Origin of arches in the northwestern Gulf of Mexico Basin: Geology, v. 18, p. 595–598.

Lewan, M.D., 2002, New insights on timing of oil and gas generation in the central Gulf Coast interior zone based on hydrous-pyrolysis kinetic parameters: Gulf Coast Association of Geological Societies Transactions, v. 52, p. 607–620.

Lomando, A.J., 1992, The influence of solid reservoir bitumen on reservoir quality: American Association of Petroleum Geologists Bulletin, v. 76, no. 8, p. 1137–1152.

Lopatin, N.V., 1971, Temperature and geologic time as factors of carbonification (in Russian): Izvestiya Akademii Nauk SSSR, Seriya Geologischeskaya, no. 3, p. 95–106.

McFarlan, E., Jr., 1977, Lower Cretaceous sedimentary facies and sea level changes, U.S. Gulf Coast, *in* Bebout, D.G., and Loucks, R.G., eds., Cretaceous carbonates of Texas and Mexico—Applications to subsurface exploration: Austin, Tex., University of Texas, Bureau of Economic Geology, Report of Investigations No. 89, p. 5–11.

McGowen, M.K., and Harris, D.W., 1984, Cotton Valley and Hosston depositional systems and their influence on salt tectonics in the East Texas Salt Basin: Austin, Tex., University of Texas, Bureau of Economic Geology, Geological Circular 84-5, 41 p.

Nichols, P.H., Peterson, G.E., and Wuestner, C.E., 1968, Summary of subsurface geology of northeast Texas, *in* Beebe, B.W., ed., Natural gases of North America—A symposium: American Association of Petroleum Geologists Memoir 9, p. 982–1004.

NRG Associates, 1999 [includes data current as of Dec. 1998], The significant oil and gas fields of the U.S.: Colorado Springs, Colo., NRG Associates Inc. (database available from NRG Associates, Inc., P.O. Box 1655, Colorado Springs, CO 80901, U.S.A.).

Pate, B.F., 1963, Significant northern Louisiana Cotton Valley stratigraphic traps: Gulf Coast Association of Geological Societies Transactions, v. 13, p. 177–183.

Presley, M.W., and Reed, C.H., 1984, Jurassic exploration trends of east Texas, *in* Presley, M.W., ed., The Jurassic of east Texas: Tyler, Tex., East Texas Geological Society, p. 11–22.

Reese, D., 1978, Pre–Ferry Lake Lower Cretaceous deltas of south Mississippi and producing trends: Gulf Coast Association of Geological Societies Transactions, v. 26, p. 59–63.

Rogers, M.A., McAlary, J.D., and Bailey, N.J.L., 1974, Significance of reservoir bitumens to thermal-maturation studies, western Canada Basin: American Association of Petroleum Geologists Bulletin, v. 58, no. 9, p. 1806–1824.

Royden, L., Sclater, J.G., and Von Herzen, R.P., 1980, Continental margin subsidence and heat flow—Important parameters in formation of petroleum hydrocarbons: American Association of Petroleum Geologists Bulletin, v. 64, no. 2, p. 173–187.

Salvador, A., 1987, Late Triassic–Jurassic paleogeography and origin of Gulf of Mexico Basin: American Association of Petroleum Geologists Bulletin, v. 71, no. 4, p. 419–451.

Sassen, R., and Moore, C.H., 1988, Framework of hydrocarbon generation and destruction in eastern Smackover trend: American Association of Petroleum Geologists Bulletin, v. 72, no. 6, p. 649–663.

Saucier, A.E., 1985, Geologic framework of the Travis Peak (Hosston) Formation of east Texas and northern Louisiana, *in* Finley, R.J., Dutton, S.P., Lin, Z.S., and Saucier, A.E., eds., The Travis Peak (Hosston) Formation—Geologic framework, core studies, and engineering field analysis: Austin, Tex., University of Texas, Bureau of Economic Geology, contract report prepared for the Gas Research Institute under contract no. 5082-211-0708, 233 p.

Saucier, A.E., Finley, R.J., and Dutton, S.P., 1985, The Travis Peak (Hosston) Formation of east Texas and northern Louisiana, *in* Proceedings, 1985 Society of Petroleum Engineers/Department of Energy Joint Symposium on Low-Permeability Reservoirs: Society of Petroleum Engineers/U.S. Department of Energy Paper No. 13850, p. 15–22.

Scardina, A.D., 1981, Tectonic subsidence history of the northern Louisiana Salt Basin: Baton Rouge, La., Louisiana State University, M.S. thesis, 103 p.

Schenk, C.J., and Viger, R.J., 1996, East Texas Salt Basin and Mississippi-Louisiana Salt Basins Provinces, Region 6—Gulf Coast, geologic framework, *in* Gautier, D.L., Dolton, G.L., Takahashi, K.I., and Varnes, K.L., eds., 1995 national assessment of United States oil and gas resources—Results, methodology, and supporting data: U.S. Geological Survey Digital Data Series DDS-30, Release 2, 1 CD-ROM.

Schmoker, J.W., 1996, Method for assessing continuous-type (unconventional) hydrocarbon accumulations, *in* Gautier, D.L., Dolton, G.L., Takahashi, K.I., and Varnes, K.L., eds., 1995 national assessment of United States oil and gas resources—Results, methodology, and supporting data: U.S. Geological Survey Digital Data Series DDS-30, Release 2, 1 CD-ROM.

Shoemaker, P.W., ed., 1989, Occurrence of oil and gas in northeast Texas: Tyler, Tex., East Texas Geological Society, 210 p.

Shreveport Geological Society, 1946, Reference report on certain oil and gas fields of north Louisiana, south Arkansas, Mississippi, and Alabama: Shreveport Geological Society Reference Volume I, 333 p.

Shreveport Geological Society, 1947, Reference report on certain oil and gas fields of north Louisiana, south Arkansas, Mississippi, and Alabama: Shreveport Geological Society Reference Volume II, 503 p.

Shreveport Geological Society, 1951, Reference report on certain oil and gas fields of north Louisiana, south Arkansas, Mississippi, and Alabama: Shreveport Geological Society Reference Volume III, no. 1, 42 p.

Shreveport Geological Society, 1953, Reference report on certain oil and gas fields of north Louisiana, south Arkansas, Mississippi, and Alabama: Shreveport Geological Society Reference Volume III, no. 2, 109 p.

Shreveport Geological Society, 1958, Reference report on certain oil and gas fields of north Louisiana, south Arkansas, Mississippi, and Alabama: Shreveport Geological Society Reference Volume IV, 204 p.

Shreveport Geological Society, 1963, Report on selected north Louisiana and south Arkansas oil and gas fields and regional geology: Shreveport Geological Society Reference Volume V, 202 p.

Shreveport Geological Society, 1987, Report on selected oil and gas fields, Arkansas, Louisiana, Texas and Mississippi: Shreveport Geological Society Reference Volume VII, 153 p.

Thomson, A., 1978, Petrography and diagenesis of the Hosston Sandstone reservoirs at Bassfield, Jefferson Davis County, Mississippi: Gulf Coast Association of Geological Societies Transactions, v. 28, p. 651–664.

Tissot, B.P., and Welte, D.H., 1978, Petroleum formation and occurrence: New York, Springer-Verlag, 538 p.

Todd, R.G., and Mitchum, R.M., Jr., 1977, Seismic stratigraphy and global changes of sea level, part 8—Identification of Upper Triassic, Jurassic, and Lower Cretaceous seismic sequences in Gulf of Mexico and offshore West Africa*, in* Payton, C.E., ed., Seismic stratigraphy—Applications to hydrocarbon exploration: American Association of Petroleum Geologists Memoir 26, p. 145–163.

Tye, R.S., 1989, Stratigraphy and depositional systems of the Lower Cretaceous Travis Peak Formation, East Texas Salt Basin: Austin, Tex., University of Texas, Bureau of Economic Geology, topical report prepared for the Gas Research Institute under contract no. 5082-211-0708, 80 p.

Tye, R.S., 1991, Fluvial sandstone reservoirs of the Travis Peak Formation, East Texas Salt Basin, *in* Miall, A.D., and Tyler, N., eds., The three-dimensional facies architecture of terrigenous clastic sediments, and its application for hydrocarbon discovery and recovery: SEPM (Society of Sedimentary Geology) Concepts in Sedimentology and Paleontology, v. 3, p. 172–188.

U.S. Geological Survey Uinta-Piceance Assessment Team, 2003, Petroleum systems and geologic assessment of oil and gas in the Uinta-Piceance Province, Utah and Colorado: U.S. Geological Survey Digital Data Series DDS-69-B, version 1.0, 1 CD-ROM.

Vail, P.R., Mitchum, R.M., and Thompson, S., 1977, Seismic stratigraphy and global changes of sea level, part 4—Global cycles of relative changes in sea level, *in* Payton, C.E., ed., Seismic stratigraphy—Applications to hydrocarbon exploration: American Association of Petroleum Geologists Memoir 26, p. 83–97.

Waples, D.W., 1980, Time and temperature in petroleum formation—Application of Lopatin's method to petroleum exploration: American Association of Petroleum Geologists Bulletin, v. 64, no. 6, p. 916–926.

Wescott, W.A., and Hood, W.C., 1991, Hydrocarbon generation and migration routes in the East Texas Salt Basin: Gulf Coast Association of Geological Societies Transactions, v. 41, p. 675.

Worrall, D.M., and Snelson, S., 1989, Evolution of the northern Gulf of Mexico, with emphasis on Cenozoic growth faulting and the role of salt, in Bally, A.W., and Palmer, A.R., eds., The geology of North America—An overview: Boulder, Colo., Geological Society of America, Geology of North America, v. A, p. 97–138.

Zimmerman, R.K., and Goddard, D.A., 2001, A north Louisiana gas-prone Hosston slope-basin sand trend: American Association of Petroleum Geologists Bulletin, v. 85, no. 9, p. 1689–1696.

Appendix 1. Basic input data for the Travis Peak–Hosston Gas and Oil Assessment Unit (50490205). SEVENTH APPROXIMATION DATA FORM (NOGA, Version 5, 6–30–01). [A.U., assessment unit; bcfg, billion cubic feet of gas; bliq/mmcfg, barrels of liquid per million cubic feet of gas; bngl/mmcfg, barrels of natural gas liquids per million cubic feet of gas; cfg/bo, cubic feet of gas per barrel of oil; m, meters; min., minimum; mmbo, million barrels of oil; ngl, natural gas liquids]

SEVENTH APPROXIMATION
DATA FORM FOR CONVENTIONAL ASSESSMENT UNITS (NOGA, Version 5, 6-30-01)

IDENTIFICATION INFORMATION

Assessment Geologist:……..	T.S. Dyman and S.M. Condon	Date:	12/10/2001
Region:………………………..	North America	Number:	5
Province:………………………	Louisiana-Mississippi Salt Basins	Number:	5049
Total Petroleum System:……	Jurassic Smackover Interior Salt Basins	Number:	504902
Assessment Unit:……………	Travis Peak-Hosston Gas and Oil	Number:	50490205
Based on Data as of:……….	PI/Dwights 04/01/2001 and NRG Assoc. 1998		
Notes from Assessor……….	Replaces plays 4926 and 4927 of the 1995 assessment		
	U.S. Lower 48 (e2) growth function		

CHARACTERISTICS OF ASSESSMENT UNIT

Oil (<20,000 cfg/bo overall) **or** Gas (≥20,000 cfg/bo overall):… Gas

What is the minimum accumulation size?………. 0.5 mmboe grown
(the smallest accumulation that has potential to be added to reserves in the next 30 years)

No. of discovered accumulations exceeding minimum size:…….. Oil: 8 Gas: 108
Established (>13 accums.) X Frontier (1-13 accums.) ____ Hypothetical (no accums.) ____

Median size (grown) of discovered oil accumulation (mmbo):
1st 3rd 1.5 2nd 3rd 0.96 3rd 3rd ____
Median size (grown) of discovered gas accumulations (bcfg):
1st 3rd 55 2nd 3rd 16.9 3rd 3rd 14.4

Assessment-Unit Probabilities:

Attribute	Probability of occurrence (0-1.0)
1. **CHARGE:** Adequate petroleum charge for an undiscovered accum. ≥ minimum size……………	1.0
2. **ROCKS:** Adequate reservoirs, traps, and seals for an undiscovered accum. ≥ minimum size……	1.0
3. **TIMING OF GEOLOGIC EVENTS:** Favorable timing for an undiscovered accum. ≥ minimum size	1.0

Assessment-Unit GEOLOGIC Probability (Product of 1, 2, and 3):……..……....…. 1.0

4. **ACCESSIBILITY:** Adequate location to allow exploration for an undiscovered accumulation ≥ minimum size………………………………………………..………………..……..………… 1.0

UNDISCOVERED ACCUMULATIONS

No. of Undiscovered Accumulations: How many undiscovered accums. exist that are ≥ min. size?:
(uncertainty of fixed but unknown values)

Oil Accumulations:…………………min. no. (>0)	1	median no.	4	max no.	10
Gas Accumulations:………………min. no. (>0)	10	median no.	50	max no.	100

Sizes of Undiscovered Accumulations: What are the sizes (**grown**) of the above accums?:
(variations in the sizes of undiscovered accumulations)

Oil in Oil Accumulations (mmbo):…...…min. size	0.5	median size	0.75	max. size	10
Gas in Gas Accumulations (bcfg):…..…min. size	3	median size	10	max. size	500

Appendix 1. Basic input data for the Travis Peak–Hosston Gas and Oil Assessment Unit (50490205). SEVENTH APPROXIMATION DATA FORM (NOGA, Version 5, 6–30–01). [A.U., assessment unit; bcfg, billion cubic feet of gas; bliq/mmcfg, barrels of liquid per million cubic feet of gas; bngl/mmcfg, barrels of natural gas liquids per million cubic feet of gas; cfg/bo, cubic feet of gas per barrel of oil; m, meters; min., minimum; mmbo, million barrels of oil; ngl, natural gas liquids]—Continued

Assessment Unit (name, no.)
Travis Peak-Hosston Gas and Oil, 50490205

AVERAGE RATIOS FOR UNDISCOVERED ACCUMS., TO ASSESS COPRODUCTS
(uncertainty of fixed but unknown values)

Oil Accumulations:	minimum	median	maximum
Gas/oil ratio (cfg/bo)……………………	4000	8000	12000
NGL/gas ratio (bngl/mmcfg)…………………	13	25	37

Gas Accumulations:	minimum	median	maximum
Liquids/gas ratio (bliq/mmcfg)………………	9	18	27
Oil/gas ratio (bo/mmcfg)……………………			

SELECTED ANCILLARY DATA FOR UNDISCOVERED ACCUMULATIONS
(variations in the properties of undiscovered accumulations)

Oil Accumulations:	minimum	median	maximum
API gravity (degrees)……………………	35	45	55
Sulfur content of oil (%)…………………	0	0.4	1.5
Drilling Depth (m) ………………………	1700	2400	4900
Depth (m) of water (if applicable)………………	0	10	20

Gas Accumulations:	minimum	median	maximum
Inert gas content (%)……………………	0	1	9
CO_2 content (%)………………………	0	1	7
Hydrogen-sulfide content (%)………………	0	0	0
Drilling Depth (m)………………………	1700	3000	5500
Depth (m) of water (if applicable)………………	0	10	20

Appendix 1. Basic input data for the Travis Peak–Hosston Updip Oil Assessment Unit (50490206). SEVENTH APPROXIMATION DATA FORM (NOGA, Version 5, 6–30–01). [A.U., assessment unit; bcfg, billion cubic feet of gas; bliq/mmcfg, barrels of liquid per million cubic feet of gas; bngl/mmcfg, barrels of natural gas liquids per million cubic feet of gas; cfg/bo, cubic feet of gas per barrel of oil; m, meters; min., minimum; mmbo, million barrels of oil; ngl, natural gas liquids]—Continued

SEVENTH APPROXIMATION
DATA FORM FOR CONVENTIONAL ASSESSMENT UNITS (NOGA, Version 5, 6-30-01)

Assessment Geologist:……..	T.S. Dyman and S.M. Condon	Date:	12/10/2001
Region:………………………..	North America	Number:	5
Province:………………………	Louisiana-Mississippi Salt Basins	Number:	5049
Total Petroleum System:……	Jurassic Smackover Interior Salt Basins	Number:	504902
Assessment Unit:……………	Travis Peak-Hosston Updip Oil	Number:	50490206
Based on Data as of:……….	PI/Dwights 4/01/2001, NRG Assoc. 1998		
Notes from Assessor……….	Replaces play 4925 of the 1995 assessment		
	U.S. Lower 48 (e2) growth function		
	Mean discovered gas accumulation size is 8.6 BCFG		

CHARACTERISTICS OF ASSESSMENT UNIT

Oil (<20,000 cfg/bo overall) **or** Gas (≥20,000 cfg/bo overall):… Oil

What is the minimum accumulation size?………. 0.5 mmboe grown
(the smallest accumulation that has potential to be added to reserves in the next 30 years)

No. of discovered accumulations exceeding minimum size:…….. Oil: 39 Gas: 2
Established (>13 accums.) X Frontier (1-13 accums.) ____ Hypothetical (no accums.) ____

Median size (grown) of discovered oil accumulation (mmbo):
1st 3rd 1.2 2nd 3rd 2.6 3rd 3rd 1.5
Median size (grown) of discovered gas accumulations (bcfg):
1st 3rd ____ 2nd 3rd ____ 3rd 3rd ____

Assessment-Unit Probabilities:

Attribute	Probability of occurrence (0-1.0)
1. **CHARGE:** Adequate petroleum charge for an undiscovered accum. ≥ minimum size……………	1.0
2. **ROCKS:** Adequate reservoirs, traps, and seals for an undiscovered accum. ≥ minimum size……	1.0
3. **TIMING OF GEOLOGIC EVENTS:** Favorable timing for an undiscovered accum. ≥ minimum size	1.0

Assessment-Unit GEOLOGIC Probability ____

4. **ACCESSIBILITY:** Adequate location to allow exploration for an undiscovered accumulation ≥ minimum size………………………………………………………………………… 1.0

UNDISCOVERED ACCUMULATIONS

No. of Undiscovered Accumulations: How many undiscovered accums. exist that are ≥ min. size?:
(uncertainty of fixed but unknown values)

	min. no. (>0)	median no.	max no.
Oil Accumulations:…………………	1	15	35
Gas Accumulations:……………….	1	3	7

Sizes of Undiscovered Accumulations: What are the sizes (**grown**) of the above accums?:
(variations in the sizes of undiscovered accumulations)

	min. size	median size	max. size
Oil in Oil Accumulations (mmbo):……..…	0.5	1	12
Gas in Gas Accumulations (bcfg):…..….	3	6	72

Appendix 1. Basic input data for the Travis Peak–Hosston Updip Oil Assessment Unit (50490206). SEVENTH APPROXIMATION DATA FORM (NOGA, Version 5, 6–30–01). [A.U., assessment unit; bcfg, billion cubic feet of gas; bliq/mmcfg, barrels of liquid per million cubic feet of gas; bngl/mmcfg, barrels of natural gas liquids per million cubic feet of gas; cfg/bo, cubic feet of gas per barrel of oil; m, meters; min., minimum; mmbo, million barrels of oil; ngl, natural gas liquids]—Continued

Assessment Unit (name, no.)
Travis Peak-Hosston Updip Oil, 50490206

AVERAGE RATIOS FOR UNDISCOVERED ACCUMS., TO ASSESS COPRODUCTS

Oil Accumulations:	minimum	median	maximum
Gas/oil ratio (cfg/bo)…………………………	500	1000	1500
NGL/gas ratio (bngl/mmcfg)…………………………	20	40	60

Gas Accumulations:	minimum	median	maximum
Liquids/gas ratio (bliq/mmcfg)…………………………	15	30	45
Oil/gas ratio (bo/mmcfg)…………………………			

SELECTED ANCILLARY DATA FOR UNDISCOVERED ACCUMULATIONS

Oil Accumulations:	minimum	median	maximum
API gravity (degrees)…………………………	25	35	55
Sulfur content of oil (%)…………………………	0.5	1	2
Drilling Depth (m) …………………………	600	2400	4900
Depth (m) of water (if applicable)…………………………	0	10	20

Gas Accumulations:	minimum	median	maximum
Inert gas content (%)…………………………	0.5	1	2
CO_2 content (%)…………………………	2	3	4
Hydrogen-sulfide content (%)…………………………	0	0	0
Drilling Depth (m)…………………………	600	3000	5000
Depth (m) of water (if applicable)…………………………	0	10	20

Appendix 1. Basic input data for the Travis Peak–Hosston Hypothetical Updip Oil Assessment Unit (50490207). SEVENTH APPROXIMATION DATA FORM (NOGA, Version 5, 6–30–01). [A.U., assessment unit; bcfg, billion cubic feet of gas; bliq/mmcfg, barrels of liquid per million cubic feet of gas; bngl/mmcfg, barrels of natural gas liquids per million cubic feet of gas; cfg/bo, cubic feet of gas per barrel of oil; m, meters; min., minimum; mmbo, million barrels of oil; ngl, natural gas liquids]—Continued

SEVENTH APPROXIMATION
DATA FORM FOR CONVENTIONAL ASSESSMENT UNITS (NOGA, Version 5, 6-30-01)

Assessment Geologist:……..	T.S. Dyman and S.M. Condon	Date:	12/11/2001
Region:………………………..	North America	Number:	5
Province:………………………	Louisiana-Mississippi Salt Basins	Number:	5049
Total Petroleum System:……	Jurassic Smackover Interior Salt Basins	Number:	504902
Assessment Unit:……………	Travis Peak-Hosston Hypothetical Updip Oil	Number:	50490207
Based on Data as of:……….	PI/Dwights 4/01/2001		
Notes from Assessor……….			

CHARACTERISTICS OF ASSESSMENT UNIT

Oil (<20,000 cfg/bo overall) **or** Gas (≥20,000 cfg/bo overall):… Oil

What is the minimum accumulation size?………. 0.5 mmboe grown
(the smallest accumulation that has potential to be added to reserves in the next 30 years)

No. of discovered accumulations exceeding minimum size:……… Oil: 0 Gas: 0
Established (>13 accums.) ____ Frontier (1-13 accums.) ____ Hypothetical (no accums X

Median size (grown) of discovered oil accumulation (mmbo):
1st 3rd ____ 2nd 3rd ____ 3rd 3rd ____
Median size (grown) of discovered gas accumulations (bcfg):
1st 3rd ____ 2nd 3rd ____ 3rd 3rd ____

Assessment-Unit Probabilities:

Attribute	Probability of occurrence (0-1.0)
1. **CHARGE:** Adequate petroleum charge for an undiscovered accum. ≥ minimum size……………	0.95
2. **ROCKS:** Adequate reservoirs, traps, and seals for an undiscovered accum. ≥ minimum size……	0.80
3. **TIMING OF GEOLOGIC EVENTS:** Favorable timing for an undiscovered accum. ≥ minimum size	1.0

Assessment-Unit GEOLOGIC Probability ____

4. **ACCESSIBILITY:** Adequate location to allow exploration for an undiscovered accumulation ≥ minimum size…………………………………………………………………………………… 1.0

UNDISCOVERED ACCUMULATIONS

No. of Undiscovered Accumulations: How many undiscovered accums. exist that are ≥ min. size?:
(uncertainty of fixed but unknown values)

	min. no. (>0)	median no.	max no.
Oil Accumulations:…………………	1	4	11
Gas Accumulations:……………….	0	0	0

Sizes of Undiscovered Accumulations: What are the sizes (**grown**) of the above accums?:
(variations in the sizes of undiscovered accumulations)

	min. size	median size	max. size
Oil in Oil Accumulations (mmbo):…..….	0.5	0.9	7
Gas in Gas Accumulations (bcfg):…..….			

Appendix 1. Basic input data for the Travis Peak–Hosston Hypothetical Updip Oil Assessment Unit (50490207). SEVENTH APPROXIMATION DATA FORM (NOGA, Version 5, 6–30–01). [A.U., assessment unit; bcfg, billion cubic feet of gas; bliq/mmcfg, barrels of liquid per million cubic feet of gas; bngl/mmcfg, barrels of natural gas liquids per million cubic feet of gas; cfg/bo, cubic feet of gas per barrel of oil; m, meters; min., minimum; mmbo, million barrels of oil; ngl, natural gas liquids]—Continued

Assessment Unit (name, no.)
Travis Peak-Hosston Hypothetical Updip Oil, 50490207

AVERAGE RATIOS FOR UNDISCOVERED ACCUMS., TO ASSESS COPRODUCTS

Oil Accumulations:	minimum	median	maximum
Gas/oil ratio (cfg/bo)…………………………………	500	1000	1500
NGL/gas ratio (bngl/mmcfg)…………………………	20	40	60

Gas Accumulations:	minimum	median	maximum
Liquids/gas ratio (bliq/mmcfg)………………………			
Oil/gas ratio (bo/mmcfg)…………………………………			

SELECTED ANCILLARY DATA FOR UNDISCOVERED ACCUMULATIONS

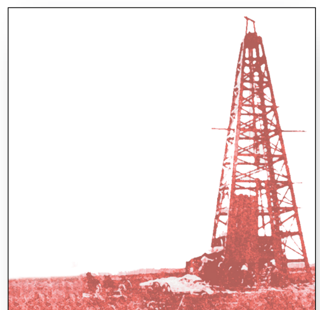
Oil Accumulations:	minimum	median	maximum
API gravity (degrees)…………………………………	25	35	55
Sulfur content of oil (%)………………………………	0.5	1	2
Drilling Depth (m) ………………………………………	600	1800	2400
Depth (m) of water (if applicable)………………			

Gas Accumulations:	minimum	median	maximum
Inert gas content (%)…………………………………			
CO_2 content (%)………………………………………			
Hydrogen-sulfide content (%)………………………			
Drilling Depth (m)………………………………………			
Depth (m) of water (if applicable)…………………			

Appendix 2. List of wells used on cross section shown in plate 2.

[D & A, drilled and abandoned]

Map No.	Location	State	County	Field	Operator	Lease	Well No.	API	Final Status	Total Depth (ft)	Completion Date
3	Sec. 30, T. 12 N., R. 4 W.	Louisiana	Winn	Calvin	Getty Oil	USA-ES 9447	1	17127205520000	Gas	15,020	1/1/1078
5	Sec. 20, T. 12 N., R. 2 W.	Louisiana	Winn	Wildcat	Continental Oil Co.	Tremont Lbr. Co.	1	17127202810000	D & A	16,155	5/8/1973
8	Sec. 6, T. 15 N., R. 6 W.	Louisiana	Bienville	Lucky	Placid Oil Co.	Wood E N	2	17013200350000	Gas	13,576	3/21/1978
9	Sec. 1, T. 16 N., R. 6 W.	Louisiana	Bienville	Bear Creek	Southern Nat. Gas Co.	T J Cummings	2	17013001830000	Gas	13,000	6/8/1966
12a	Sec. 34, T. 19 N., R. 4 W.	Louisiana	Lincoln	Terryville	IMC Exploration Co.	McGehee P M	1	17061202500000	Gas	13,995	10/11/1980
12	Sec. 11, T. 19 N., R. 4 W.	Louisiana	Lincoln	Hico-Knowles	The California Co.	F H Calloway	1	17061002700002	Oil	12,441	4/2/1967
12.5	Sec. 3, T. 20 N., R. 4 W.	Louisiana	Lincoln	Lisbon	Cities Service O&G Corp.	Carter 'B'	1	17061204730000	Oil	11,430	12/15/1986
13	Sec. 27, T. 21 N., R. 4 W.	Louisiana	Claiborne	Lisbon	Amoco Prod. Co.	Enloe Estate	1	17027204200000	D & A	11,000	1/31/1978
14	Sec. 5, T. 22 N., R. 4 W.	Louisiana	Claiborne	Wildcat	Roy M Huffington, Inc.	Moss	1	17027204490000	D & A	11,100	11/29/1977



Click here to return to
Volume Title Page