THE STRATIGRAPHY AND STRUCTURE OF THE SIMSBORO GAS FIELD LINCOLN PARISH, LOUISIANA

John Edward Atkins

Senior thesis submitted in partial fulfillment of the degree
requirements of Bachelor of Science in Geology.

Washington and Lee University
Lexington, Virginia
December 19, 1986

Dr. Edgar W. Spencer, Advisor

ACKNOWLEDGEMENTS

I would like to express my sincere appreciation to my thesis advisor, Dr. Edgar W. Spencer, for his direction and critical review throughout this study.

A special thanks to the members of Harry M. Jarred and associates for exposing me to the industrial views of the geologic world. I would like to show my appreciation to Steve Cowgill for his expertise and infinite patience while instructing me on the interpretation of well logs, Harry Jarred for his constant encouragement, and Joe McDuff and Charlotte Norman for their support in writing this paper.

TABLE OF CONTENTS

page

LIST OF FIGURES

ABSTRACT

Well logs have been used to interpret the structure and stratigraphy of the Simsboro Gas Field of Lincoln Parish, Louisiana. A variety of subsurface maps have been constructed in an attempt to interpret the depositional environment of this prolific gas field. These maps lead the author to believe that the earliest Cretaceous gas sands of the Simsboro Field, the Hosston "H" sand thru the Gardner sand, were deposited in a lower deltaic plain environment and the later Cretaceous gas sands, the James sand thru the Fowler sand, were deposited in a prodelta environment by longshore currents. Later in the Cretaceous, after the deposition of the Rodessa Formation, the area was warped into a domal feature by the development of a salt pillow at greater depth. These warped sands provide an excellent trap for migrating hydrocarbons.

PURPOSE AND METHODOLOGY

The Simsboro Gas Field of north central Louisiana has been a prolific producer of hydrocarbons for the past fifty-one years. Since the first well pierced the structure in late November of 1935, the field has produced in excess of 197.913 BCF of gas. Following the drilling of the discovery well, the area was explored by a multitude of petroleum companies in search of oil and gas. The field was drilled and redrilled through several separate periods of development, resulting in thirty-six productive wells and nine dry holes distributed over an area of thirty square miles. This high concentration on wells leads to fairly good well control in this area.

Since there are few outcrops in the area, information acquired from sonic logs of wells in this area is used to interpret the subsurface structure and the depositional environment. In this way, we get a sense of what type of structure and stratigraphy are likely to be productive in areas.

In interpreting the subsurface structure of the area, certain regionally extensive formations were located on a specific, centrally located well log that is designated as the "type log"(Fig. 1; Ark. La. Gas, #3 Fowler;sec. 15). This log was then correlated with the nearest neighboring log and the same formation was marked on this second log. This process was continued in a radial fashion until all logs in the area of interest had been correlated with formations. The elevation of the derrick floor was then subtracted from the log depth of the formation in order to get the true depth of each formation. The true depth of the formation was recorded for at the location of each well, and these depths were used to construct a contour map of each datum. Subsurface contour maps have been constructed for three distinct regionally extensive formations.

Faulting in the Simsboro Field area was also inferred from well logs. A large portion of a section is missing between two marker formations in some of the wells. Missing sections indicate that the well probably cuts through a fault plane(Fig. 2). The depth to these fault planes were marked on the structure maps and their heave was calculated using trigonometry.

The interpretations of the depositional environments of the producing formations were made by studying the morphology, vertical associations and composition of these formations. Core data was used to determine the composition and vertical associations for each body, and the spontaneous potential curve and micro log data was used to construct isopach maps of the productive sands. These maps possess a gross sand figure over a net sand figure, and all isopachs are drawn using the gross figure. In estimating the thickness of various sands using spontaneous potential curves (sp curves) we can expect to have an error of plus of minus one or two feet. Nonetheless, these isopach maps give a fair interpretation of the distribution of these sands.

Because more core data is available on the productive sands of the Hosston Formation special attention will be given to the depositional environment of these sands. Depositional environments of these other sands is inferred from the shape of the units.

REGIONAL GEOLOGY

The Simsboro Field area is located in Louisiana on the north edge of the Gulf Coast Geosyncline at the intersection of Township 17 north and Range 4 west. The region is characterized by alternating series of marine shelf, deltaic, and fluvial deposits resting upon the irregular surface of a gulfward sloping Permian Basement. The regional dip is towards the south as it has been since Jurassic time.

The major positive structural feature in this area is the Monroe Uplift, covering most of the northeast corner of Louisiana as well as parts of southeast Arkansas and westcentral Mississippi. This uplift is flanked on the west by a large negative structural feature known as the North Louisiana Syncline. This downwarp extends from the western edge of the Monroe Upliftacross north central Louisiana into western Louisiana where it is replaced by the Sabine Uplift. The Sabine uplift is another large positive structural feature that is similar to the Monroe uplift, and extends throughout northwest Louisiana, northeast Texas and southwest Arkansas(Fig. 3).

The Monroe Uplift is in the form of a large flat-topped dome with a northwest tending axis. It is a positive anomaly and is believed to be of Mesozoic-Cenozoic age. The uplift is not expressed in the topography, however, because vast quantities of Quaternary deposits that overlie the area.

Contours drawn on the Comanchean and younger strata indicate that the North Louisiana Syncline is triangular shaped with its open end plunging toward the southeast and its axis striking in a northwest-southeast direction. Regional structure contours corresponding to the base of the Ferry Lake anhydrite indicate approximately 3000 feet of relief between the axis of the syncline and the crest of the Sabine Uplift and about 4500 feet of relief from the axis to the crest of the Monroe Uplift. By the end of Gulfian time, as sediment inundated the basin, this relief had been reduced to approximately 1000 feet. Each stratigraphic unit exhibits thicker than normal units in the interior of the syncline.

The overall simplicity of the North Louisiana syncline is thoroughly disrupted by the growth of numerous salt structures throughout the area. Various structural uplifts and their corresponding negative features almost destroy the overall unity of the structure. These features, which are believed to be formed by movement within an underlying bed of Late Permian or Early Jurassic salt, increase in size and abundance with sediment thickness. Thus, they are most abundant near the axis of the syncline, decreasing in number until they become virtually absent in the crestal areas of the Sabine and Monroe Uplifts.

The North Louisiana Syncline does not appear to have been formed as a result of compressive structural deformation. The downwarping of this negative structural feature in coincidence with the rise of adjacent positive structural features lead most geologists to believe that a cause-and-effect relationship involving isostatic adjustment is responsible for the Sabine and Monroe uplifts and the North Louisiana Syncline. However, the presence of positive gravity anomalies over the two uplifts have lead some geologists to suggest that these bodies were once island arc complexes that were accreted during the collision of the North American and the Africa-South American continental masses during late Paleozoic time.

GEOLOGIC HISTORY

During the Early Paleozoic, the southern margin of the North American continent was marked by the Ouachita Geocline of Southern Arkansas and Oklahoma - much of the area which currently lies to the South of this geocline, including the Simsboro Gas Field, had not yet been formed (Fig.4). None the less, during the early Paleozoic, the Ouachita Geosyncline "quietly accumulated several thousand kilometers of limestone, sandstone and shale"(Eicher, 1984) on what appeared to be a tectonically dormant shelf. However, during the Early Mississippian small amounts of volcanic sediment began occurring in the geosyncline from a volcanic source that appeared to lie to the South. Larger quantities of ash and tuff were found in progressively younger Mississippian shales, suggesting the approach of a continental block and it's accompanying volcanic arc and subduction zone.

During Late Pennsylvanian and Early Permian time large scale thrusting and folding began to take place as a result of regional compression in the area of the Ouachita Geosyncline. With the collision of a portion of ancestral North America with what is now South America, the Ouchita Geosyncline became a folded mountain belt(Eicher). Gas wells drilled in North Louisiana have reached sequences that appear to be of Permian age, and if so, may have been involved in this Ouchita Deformation.(Murray, 1961)

After the formation of the Ouchita Fold Belt, the topographically high areas of southern Arkansas and northern

Louisiana were exposed to extensive periods of erosion. This area appeared to be tectonically dormant until local mantle activity was again rejuvenated during the early Jurassic. With the restoration of large convection currents in the mantle underlying what is now Louisiana and Texas, the lithosphere rose and stretched causing diverging zones of maximum uplift to travel outward from the axis of the orogen that was taking place as North America separated from the combined continents of South America, Africa and Europe. These divergent zones were succeeded by zones of collapse, forming large graben systems as the ancient Gulf of Mexico began to form. The ancient Gulf of Mexico, which would eventually develop into the modern Gulf of Mexico, formed through a process similar to the process that is currently forming the Modern Red Sea (Fig. 5).

During the initial rifting stage, as the upthrown blocks of the Paleozoic basement were eroded away during the Early Jurassic, red bed deposits of the Eagle Mills formation were deposited as continental rift fill. Later, as the basin began to take on the form of the ancient Gulf Coast Basin, post-orogenic sediments of Lower Jurassic age (ie. the Morehouse and Werner Formations) accumulated. The boundaries of this ancient Gulf Coast Basin are presently marked by Paleozoic fold belts on the north, south and west sides, and by a gravity maxima on the east side which probably represents ancient downfaulting along the edge of the old platform. This ancient gulf was probably somewhat similar in size and shape to the modern Gulf of Mexico(Fig. 6).

During the beginning of the Upper Jurassic, large halite deposits (the Louann Salt) were precipitated throughout this basin. Many geologists believe that these massive evaporite deposits were formed through Bronson's model of separating a large enclosed basin from a body of normal marine water by one or more smaller barred-basins. In such a model, as the normal marine water entered the primary barred-basin, evaporation would lead to the precipitation of the lower solubility salts such as carbonate and sulfate. This high-salinity water would then be transported into a secondary basin where further evaporation would lead to the deposition of upper salinity salts such as halite. In the case of the ancient Gulf of Mexico, these evaporites were deposited on a mature surface that had been exposed to erosion for much of lower Jurassic time(Saucier, 1985).

The Louann Salt is thought to underlie much of the ancient Gulf Coast basin (Fig. 7), except for a few limited areas where the salt is now absent due to either post-depositional erosion or plastic flow. Within this large basin, there are a number of sub-basins, including the East Texas Embayment, the Rio Grande Embayment and the North Louisiana Basin. These sub-basins, which probably developed through crustal "weaknesses caused by arching in the Ouchita fold belt"(Halbouty,1979), are the scene of extensive salt dome formation. The Louann is much thicker in these salt dome basins than it is in the neighboring domeless regions.

By Late Jurassic time, the cooling of the crust that underlies these Late Permian to Early Jurassic sediments led to the subsidence of the region. This subsidence allowed the massive terrigenous clastic deposits of the Schuler and Hosston

Formations to progress across the area, triggering the growth of salt diapirs. These diapirs have significantly changed the geology of the sub-basins in which they are located.

North Louisiana, and the Simsboro Field area, continued to be the site of marine sedimentation until the Quaternary. During this time the waters of the now fully developed Gulf of Mexico slowly receded southward, relieving the area of it's subaqueous environment, and allowing it to be covered with recent alluvial sand, clay and silt.

STRATIGRAPHY

The deepest wells in the Simsboro Field area fail to penetrate the Louann Salt. This formation lies at a depth of about 12,400 feet (Mead 1961). The salt, which contains spore and pollen of Jurassic age(Murray 1961), appears to be the material responsible for the numerous salt domes in north Louisiana. Although these spore and pollen samples give us a general age for the Louann, the precise age of this salt may vary. Much of the salt may be younger than the Jurassic, but some is probably older.

Although there is no well data of sufficient depth in the Simsboro Field area to indicate what formations lie beneath the Louann, regional stratigraphy suggests that the salt is probably underlaid by the Werner Formation(see strat. column, Fig.8). This formation , in turn, is most likely underlaid by the Morehouse Formation and the red bed deposits of the Eagle Mills Formation. All three of these formations are of Permian age, and the red bed deposits are thought to be associated with continental rift margins (see geologic history).

An Upper Jurassic series unconformably overlies the Louann Salt. This series is divided into the Louark Group and the Cotton Valley Group. Each group is further divided into formations, with the Louark Group consisting of the clays, limestones and sandstones of the Norphlet, Smackover, and Haynesville Formations, and the Cotton Valley Group containing the marine sandstone and shale of the Bossier Formation and the continental sandstone and shale of the Schuler Formation. These two groups, which are separated by an unconformity, are both prolific oil producers. The Cotton Valley group has been a gas producer as well.

The Upper Jurassic series is superseded by the Cretaceous age Comanchean Series. The two series are separated by an unconformity, and the Comanchean is divided into two groups, the Coahuilan Group and the Trinity Group. The Coahuilan Group consists of the continental sandstones and shales of the Hosston Formation and the shale and sandy limestone of the Sligo Formation. The Trinity Group, on the other hand, consists of five formations, extending from the dark calcareous shale of the Pine Island Formation to the gray calcareous shale of the Paluxy Formation. Located between these two formations are the limestones, dolomites and shales of the James, Rodessa, Ferry Lake and Mooringsport Formations. Although the Ferry Lake contains some dolomite, it is primarily known as an anhydrite deposit. All of these formations are hydrocarbon producers.

The Comanchean Series is separated from the overlying Gulfian Series by another unconformity. The Gulfian Series, which is also Cretaceous in age, is divided into five groups: Woodbine, Eagle Ford, Austin, Taylor and Navarro. Each group is separated from the others by an unconformity. The top three groups, the Austin, the Taylor and the Navarro, are each subdivided into formations, whereas the Eagle Ford and Woodbine groups are undifferentiable. The calcareous sandstones, shales and chalks of these formations are known to have produced hydrocarbons in all but the Austin group.

The Paleocene Series consists only of one group, the Midway. This group is divided into the calcareous shales and calcareous sands of the Clayton Formation and dark black to gray shales of the Porters Creek Formation. The Midway serves as a transitional zone between the Cretaceous and Tertiary systems.

The Eocene Series contains two groups, the Wilcox and Claiborne. The Wilcox, which lies beneath the Claiborne, is undifferentiated and is separated from the Claiborne by an unconformity. The Claiborne is separated into the Cane River, Sparta Sand, Cook Mountain and Cockfield Formations. These formations consist of shales, marine sands and massive continental sands. The marine sands and shales of the Cook Mountain Formation make up the surface formation in about 70% (Mead 1961) of Lincoln Parish.

Pleistocene sands and gravels unconformably overlie the Claiborne. These sands and gravels are correspondingly overlain by the alluvial sand, clay and silt of recent channel and flood plain deposits. These deposits are quite thin, seldom exceeding twenty feet in thickness(Mead 1961).

SAND DISTRIBUTION

In studying the aerial distribution of the various productive sands in the Simsboro Field area, as they are shown by isopach maps (Figs. 9 - 22), special attention is given to the the Hosston Formation. The majority of the sand bodies in this formation possess a channel-like distribution. In general, the sands that are higher in the formation have more defined, linear channels, and the sands located closer to the base of the formation tend to have more complicated, braided channels. This trend is illustrated by the isopach maps of the Hosston Formation(Figs. 13-22), as well as the cross section in figure 23. This cross section, which was constructed using core data from the Wheeles- T.L. James well (9-17N-4W) and the Murphy-Givens #1 well (11-17N-4W), illustrates the complexity of the Hosston sands. These sands are not laterally extensive, and exhibit a great deal of thickness variation from well to well. Also, the isopach maps of many of these sand bodies exhibit small point bar deposits, and often times the boundaries of a given channel are not clear cut. Thin remnant sands are often found outside of the channel boundaries. These sands are probably the result of crevasse splay deposits.

When the thicknesses for all of the Hosston sands are added together, a gross-sand isopach map can be drawn(Fig. 24). This isopach map illustrates that the thickness of the Hosston sands is fairly well distributed over the map area, thus there must have been no prominent structural highs or lows in the Simsboro Field area during the early Cretaceous when the Hosston sands were deposited.

STRUCTURE

The Simsboro Gas Field is located on a large, nearly symmetrical dome (Figs. 25,26+27). The dome is nearly circular; the east-west diameter is about seven miles across, and the north-south diameter extends over a length of about six miles. Additional subsurface structures are also apparent in the map area. Additional domes are located directly to the north and east of the prominent Simsboro dome. The West Simsboro Field and the Clay Field are situated on these domes. Also, there is a small structure located to the southeast. This structure conforms to the Clay Field extension.

Through studying the relief of the Simsboro structure at various datums, it becomes apparent that the relief increases with depth. The structure map of the Hosston "L" Marker exhibiting much greater relief than the structure map of the Sligo. The Hosston "L" Marker possesses relief greater than 4500 feet on the southern and western flanks of the dome, 450 feet on the eastern flank and a relief of about 350 feet on the northern flank(Fig. 25). As one proceeds up the stratigraphic column, the structural relief decreases. At the Sligo, the dome displays about 1000 feet of relief on it´s southern and western slopes, with about 250 to 200 feet of relief on the eastern and northern slopes respectively(Fig.26); The relief exhibited by the base of the Ferry Lake Anhydrite is even less pronounced, decreasing to about 900 feet to the south and west, and about 150 feet to the north and east(Fig. 27).

This process of decreasing relief continues upward until topographic maps of the surface indicate no evidence of the underlying domal feature(Fig. 28). This progressive decrease in relief as one moves up the stratigraphic column is often indicative of salt doming(Fig. 29).

More careful study of the well logs in this area indicate that two normal faults cut across the domal structure of Simsboro Field(Figs.25,26+27). These faults, which appear to have dips of about 60 degrees each, combine to form a graben. This graben possesses a northeast-southwest strike and appears to run over the crest of the Simsboro structure and down onto it´s western flank. Inside the graben, there is a small fault paralleling the larger faults. This fault is believed to dip to the northwest.

The degree of throw on these faults varies. Through trigonometric calculations it was found that at the points where the fault-plane of the fault forming the northwestern boundary of the graben is intersected by the well bores of the two wells in section eight, the throw of these faults is about 240 feet. Likewise, calculations performed on the well logs cutting the fault-plane on the southeastern boundary of the graben indicate that the throw on this fault ranges from 75 feet on the western end of the fault to over 200 feet near the center. The small fault towards the middle of the graben appears to have a throw of about 25 feet.

Cross sections A-A´ and B-B´(Figs. 30,31,32+33) are helpful in making further observations of the structure and faulting of Simsboro Field. The structural version of these cross sections (Figs. 31+33) are beneficial in that they enhance the view of the domal structure of the field by illustrating the increase in depth of the Hosston "L" Marker and the Sligo Formation as one proceeds from the flanks of the dome towards the crest. The stratigraphic cross section A-A´(Fig. 30) is particularly useful because it illustrates a thickening in the interval between the Sligo and the Hosston "L" Marker. This indicates that the graben is bounded by growth faults.

Halokinesis

Halokinesis, the movement of salt bodies, is thought to be responsible for most of the subsurface topography found in Northern Louisiana. The structural developments indicated in the subsurface structure maps of this region are believed to be related to the movement of the underlying Louann Salt. Spore and pollen data indicate that this salt is of Mid Jurassic age, and all of the salt taken from known structures appears to be of the same general character, usually being compact, granular, and having a texture of interlocking, unoriented, elongate halite crystals about 1/2 to 1/4 inch in diameter(Murray, 1961). If one single, continuous bed is the source for all of the salt structures in the Northern Gulf, it must extend over an area of about 200,000 square miles(Murray). However, this bed varies in thickness. According to seismic data, the thickness of the Louann is 3000 feet or more in the North Louisiana basin, but thins to less than 500 feet above the Sabine and Monroe Uplifts(Laws Engineering Testing company, 1979). Additionally, the Louann appears to be totally absent in some parts of the Sabine Uplift. This absence is due to either non-deposition, erosion or plastic flow of previously existing salt. Unfortunately, the original thickness of the salt may never be known due to post-depositional movement and the loss of salt to diapirs.

As previously stated in the chapter pertaining to the geologic history of the area, the Louann Salt was probably deposited during the Mid Jurassic as great amounts of sea water were evaporated from some sort of isolated basin over extensive periods of time. In order to produce an environment conducive to the deposition of such large quantities of salt, Haggard, Blanpied and Spooner(1947) concluded that the Louann must have formed in "a large enclosed basin separated by one or more basins from a body of normal marine water." In this way, the receiving basin, by being connected to a series of linked basins, would receive waters with high salt concentrations rather than normal sea water. This salt would be able to precipitate out in large quantities, forming layer after layer of halite. A large number of thin layers were eventually compacted to form one massive body of salt, the Louann.

During the Late Jurassic, the North Louisiana Salt Basin was apparently the dominant negative structural feature in the region, and all of the interior drainage systems began piling sedimentary clastics onto the Louann. As the sediments of the Louark, Cotton Valley and Coahuilan Groups were heaped into the basin (see stratigraphic column), there began a contemporaneous withdrawal of the salt into high-relief salt structures.

With the deposition of the Hosston and the Schuler clastic sediments in the Upper Jurassic and Lower Cretaceous, a row of thick, sand-rich deltas began to progress across the paleo-gulf. As a function of differential loading, frontal bulges formed before these deltas in the form of salt anticlines. These anticlines served as the sources from which the majority of the salt structures would grow. These first structures were in the form of pillows and diapirs which trended along a northwest striking axis (Saucier,1985) that extended from Winn to Webster Parish (Fig. 34).

The first salt structures were formed in the middle of the basin where the salt was the thickest and the sediment accumulation mostrapidly. Structures continued to form on the flanks of the basin until the salt layer and/or overburden became too thin to produce more structures, at which time they died out. For this reason, the most mature, most highly developed salt domes are usually found towards the center of the basin, decreasing in development towards the edges (Saucier, 1985).

As stated above, the earliest type of deformation is usually in the form of a salt anticline or ridge. As this body is buried under more and more sediment, and it´s overburden increases the salt contracts into smaller, higher relief structures. As the structure becomes more mature, the salt body becomes less linear and more domal in map view. The structural relief of this salt-cored body increases with maturity until the diapir stage is reached. At this stage, the length of the vertical axis is much greater than the length of the two equant horizontal axes (Saucier, 1985).

Movement of salt can be attributed to the density differences between the salt and the surrounding sediments. Salt has a nearly constant density of 2.2, whereas sediments in the Gulf Coast area have a density of about 1.9 at the surface, nearly 2.2 at 2000 feet and about 2.4 at a depth of 10,000 feet. Due to the fact that the sediments have a specific gravity greater than the salt at depths below about 2000 feet, deepseated salt experiences a buoyant force upwards and begins to slowly rise through the overlying sediments (Murray).

Geometric techniques performed on salt domes in this region by Jackson and Seni (1982) indicate that the "maximum rates of gross diapiric growth (from 400 to 530 meters/million years) coincided with maximum regional accumulation rates from 112 m.y. to 104 m.y. ago (Lower Cretaceous); a resurgence of growth(180 to 460 meters/million years) occured during basin edge tilting and erosion from 86 to 56 m.y. ago." Most of these salt features have risen very slowly since the end of the Mesozoic; and there have been no effects of salt withdrawal transmitted to the surface. since the Paleocene. However, basal necking of some salt structures lead to continued deformation. This continued disfigurement of the overlying strata appears to have effected surface deposition well into the Eocene, with Wilcox fluvial channel systems stacking sands around the margins of domal mounds.

Early experiments on salt movement performed by Parker and McDowell indicated that the first salt diapir to form in an area will develop a peripheral sink around itself as salt is drawn from the surrounding basin and into the structure. As this sink is filled with sediment, the weight of the overlying load forces additional salt inward towards the developing stock, as well as exerting an outward pressure on the salt lying outside of the sink. This pressure leads to the development of a circular salt anticline which continues to grow by absorbing salt from the surrounding undisturbed beds. With continued growth, this anticline breaks up into a doughnut shaped structure, made up of individual salt pillows, which surrounds the model salt stock. Some of these daughter pillows can become diapirs themselves and this genetically related group becomes a "salt-stock family"(Finley, 1985). It apears that the salt domes related to the Simsboro, West Simsboro and Clay fields may all be part of such a family.

Pillows and diapirs may be distinguished from one another by comparing axle lengths, however the relationship of peripheral sinks and strata thickness can also be useful in this respect. The peripheral sink of a pillow is usually an arcuate structure located ten to twenty kilometers updip from the pillow crest. It can be as large as 300 square kilometers and exhibit strata overthickening of 10% to 30%(Jackson and Seni, 1982). The peripheral sinks of diapirs, on the other hand, are usually quite a bit larger. These structures, which often flank or surround the diapir, are commonly up to 1000 square kilometers in area and possess strata overthickening by 50% to 215%(Jackson and Seni,1982).

Fracture patterns can also be helpful in distinguishing pillows and diapirs. Experiments using asphalt rising in a weak mud overburden indicate fracture patterns similar to those often found over actual salt bodies (Parker and McDowell,1955). Most of the models produced in these studies indicated a series of normal faults forming over the crest of a domal structure. These faults ordinarily have a dip of about 60 degrees, and commonly serve as the boundary for a central graben that is present in many models. As in nature, this graben is usually a complex structure cut by several small faults. These faults are thought to be caused, not by regional stresses, but by the stresses produced by the rising salt mass.

Studies of fracture pattern models conducted by Saucier indicate that there are three evolutionary stages of fracture pattern development, each stage producing a different fracture orientation. In the first stage, the anticlinal stage, ridges form in the strata above the salt due to downdip lateral migration. This produces tension normal to the structure contours of the salt body. Therefore fractures often develop roughly parallel to the long axis of the fold. In the second stage of development, the pillow stage, the down dip movement of salt is greatly restricted, or even blocked, by the increasing weight of the sedimentary fill in the surrounding withdrawal basin. Therefore, as a pillow forms from an anticline the dominant direction of salt movement is converted to one parallel to the anticlinal axis. This movement produces tension in the strike direction, causing fractures to develop in a direction which crosses, or is transverse to , the fold axis. In the final stage of maturity, the salt pillows burst and form diapirs. These structures remove great amounts of salt from the areas surrounding them, causing the overlying strata to subside into the large peripheral sinks. This subsidence leads to the formation of a complex system of curved faults that are concave towards either the crest or the withdrawal basin.

PRODUCTION INFORMATION

Since drilling began in 1935, the Simsboro Field area has yielded thirty-six gas wells and nine dry holes. Only two wells produced out of this area until 1951 when a period of rapid exploration began. Drilling has been consistent since this time, and recently (within the last ten years) a number of older wells have been recompleted into productive zones higher up in the stratigraphic column. As of 1985, the Simsboro field had produced about 197.913 BCF of gas.

By 1985, gas had been found in seventeen distinct sand bodies(see type log, Fig. 1). These seventeen sands can be combined into eight separate groups, with some groups consisting of more than one sand. Sartor and Kidda (Sartor and Kidda, 1963) describe the lithology of each of these groups as follows:

Fowler sand- A lenticular sandstone occurring just below the lower anhydrite stringer comprised of from 5 to 25 feet of clean, white sand of fair permeability(up to 340 millidarcys) and average porosity of 16%.

Hill sand- The Hill is composed of the upper and lower Hill sands. The Upper Hill is a lenticular sandstone comprised of 8 to 12 feet of clean, white sand of fair permeability (up to 200 millidarcys) and average porosity of 22%. The Lower Hill sand is a blanket sand containing 20 to 30 feet of clean, white carbonaceous sand with poor to fair permeability (up to 100 millidarcys) and average porosity of 16%.

James sand- A sand body located at the base of the James Formation immediately overlying the Pine Island Shale. It is a clean, white sand of good permeability (up to 500 millidarcys) and average porosity of 23%.

Sligo- The Sligo has several thin porous zones of both sand and lime which have produced gas on the flanks of the structure.

Gardner sand- A sand approximately eight feet below the top of the Hosston formation which consists of several lenses of interconnected sand. The sand is medium- to fine-grained, light tan with good permeability (up to 500 millidarcys) and porosity of 22% average.

Hosston "K" Sand- A sandstone located about 950 feet below the top of the Hosston. It is about 15 feet thick and has fair to low permeability and fair porosity.

Hosston "L" Zone- This zone is divided into three members, the upper Hosston "L", the middle Hosston "L" and the lower Hosston "L". It occurs 1,250 feet below the top of the Hosston and consists of nine productive sands(see type log, Fig.) extending over a total interval of 350 feet. The fine-grained sands are white and of fair to low permeability(2 to 50 millidarcys) and have porosity of 15%.

Cotton Valley sands- The Cotton Valley Formation consists of a number of productive sand lenses. These sands are the deepest producers in the Simsboro Field. The Bodcaw sand produces out of one well in this field from a depth of 9460 feet.

A list of yearly production figures, and the respective productive zones, of all wells completed prior to 1985 can be found in table 1. An accompanying production map, illustrating the productive zones and the gross production of each well, is also available(Fig. 35). This information can be beneficial to the petroleum geologist in evaluating the production potential of a prospect. Production figures not only give the geologist an idea of the magnitude of the reserves in a reservoir, but a succession of yearly figures can give an indication of the location of a water-gas contact, or illustrate the amount of pressure remaining in a reservoir. For example, if a well has been producing at a fairly constant rate for a number of years and then all of a sudden the production drops to zero, the geologist knows that the gas-water contact has migrated up to the elevation corresponding to this well. It would now be foolish to test this reservoir at any location that is structurally lower (or equal to) this watered out well. However, a prospect could still be drilled up dip from this well because, at the time the well watered out, the productive reservoir appeared to have sufficient pressure to produce hydrocarbons.

The use of production figures as reservoir pressure indicators can be useful in another sense, as well. For instance, if a well once again produces steadily for a number of years, and then the production rate slowly begins to drop, the reservoir formation may be losing it´s reservoir pressure. If the production rate falls to nearly zero, it would be foolish to drill another well into this formation because the reservoir probably has insufficient pressure to make a productive well.

INFERRED DEPOSITIONAL ENVIRONMENT AND STRUCTURAL DEVELOPMENT

The distribution of the various productive sands of the Simsboro Field is indicative of a deltaic environment. The large number of braided-channel deposits illustrated in figures 12-22, combined with the alternating sandstone/shale sequences illustrated in figure 23, present strong evidence that the productive sands of the Hosston Formation were deposited in the lower delta plain of an ancient early Cretaceous delta (Fig. 36).

The majority of these sands appear to be flowing out of the Northeast. Thus, during the early Cretaceous the Simsboro Field was probably located on the northeast shore of the ancient Gulf of Mexico. Later in the Cretaceous, however, there appears to be a gradual change in the flow direction of these channels from the Northeast to the Northwest. This change in flow direction could be a result of the westward migration of the delta-building trunk stream. Additionally, the high quartz content of the Hosston sands indicate that quartz-rich country rock was being eroded from the continental blocks to the north and northeast.

After the deposition of the Hosston, sea level rose. This led to the deposition of the deeper water sands of the James and Rodessa Formations(Figs. 9-12). These sands, which are often blanket sands, are found interbedded with oolitic limestone. The presence of these limestone interbeds indicates that the productive sands of the James and Rodessa Formations were most likely deposited by longshore currents flowing just seaward of the lower delta front (Fig. 36).

As these sands were deposited, differential loading led to movement in the underlying Louann Salt. However, due to the fact that none of the early Cretaceous sands exhibit thinning over the crest of the Simsboro structure, it appears that the deformation process did not begin until after the deposition of the Rodessa Formation. When deformation did begin, a northwest-southeast trending salt-cored anticline began to form. With additional loading, this anticlinalfeature matured, and developed into a number of separate salt pillows. Evidence indicates that the Simsboro Field area overlies one of these salt pillows.

The nearly symmetrical domal shape of the Simsboro structure, combined with the presence of a graben and moderate strata overthickening, help to support this theory. As salt structures mature into the pillow stage, the overlying strata is often deformed into a nearly symmetrical domal feature. This type feature is characteristic of the Simsboro Field(Figs. 25,26+27). Additionally, the deformation of the overlying strata often leads to the formation of a complex graben. In the pillow stage of deformation, this graben is usually transverse to the fold axis(see Halokenesis), and if the domal feature of Simsboro Field was formed from a salt pillow that developed from a Northwest-Southeast trending anticline, as postulated earlier, then the northeast-southwest trend of the graben located on the structure of the Simsboro Field fits this model(Figs. 25,26+27).

A domal feature formed from a salt pillow should exhibit strata thickening around it´s flanks. The isopach maps illustrated in figures 37 and 38 exhibit this thickening. According to Jackson and Sene(1983), this overthickening should be between 10% and 30%. Calculation performed on the Murphy-

Givens #1 (11-17N-4W) and the Sun-Davis Brothers #1 (27-17N-4W) indicate an overthickening of 11.7% between the top of the Hosston and the ground surface.

CONCLUSIONS

The early Cretaceous gas sands of the Simsboro Field area (see Fig. 8) were deposited in a deltaic environment that was being subjected to a transgressive sea. The oldest Cretaceous sands (Hosston"H" Sand - Gardner Sand), which are predominately interbedded with shales, were deposited among the interdistributary muds of the deltaic plain by large distributary channels during the early Cretaceous (Fig. 39). Later, as sea level rose and the ancient delta progressed northward, the Simsboro Field area began to occupy a more distal location closer to the lower delta front. As a result, the later Cretaceous gas sands (James Sand - Fowler Sand) were deposited in a prodelta environment by longshore currents. Thus, these deeper water sands are often found interbedded with marine limestones (Fig. 39).

After the deposition of the Rodessa Formation (see Fig. 8), differential loading lead to movement in the underlying Louann salt beds. This movement originally lead to the formation of a Northeast-Southwest trending salt-cored anticline, but with additional loading, this anticline matured into a series of salt pillows and diapirs. The presence of a nearly symmetrical domal feature, a properly oriented crestal graben and strata thickening around the flanks of the Simsboro Field indicates that this area is probably underlaid by a salt pillow.

FIGURE 1

TYPE LOG
ARK. LA. GAS-FOWLER #3

FIGURE 23

Please Fold Out ↓

C