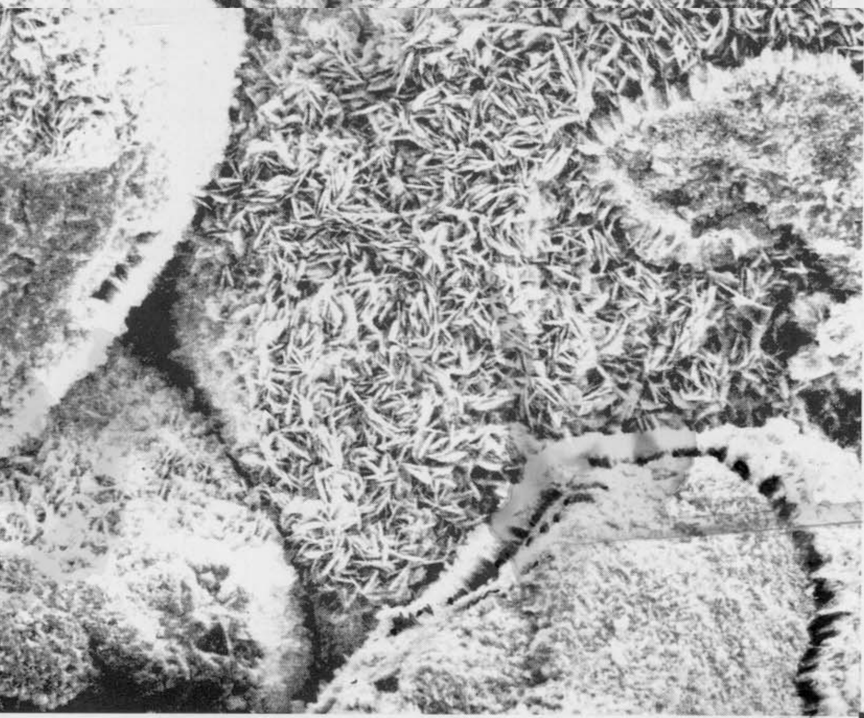
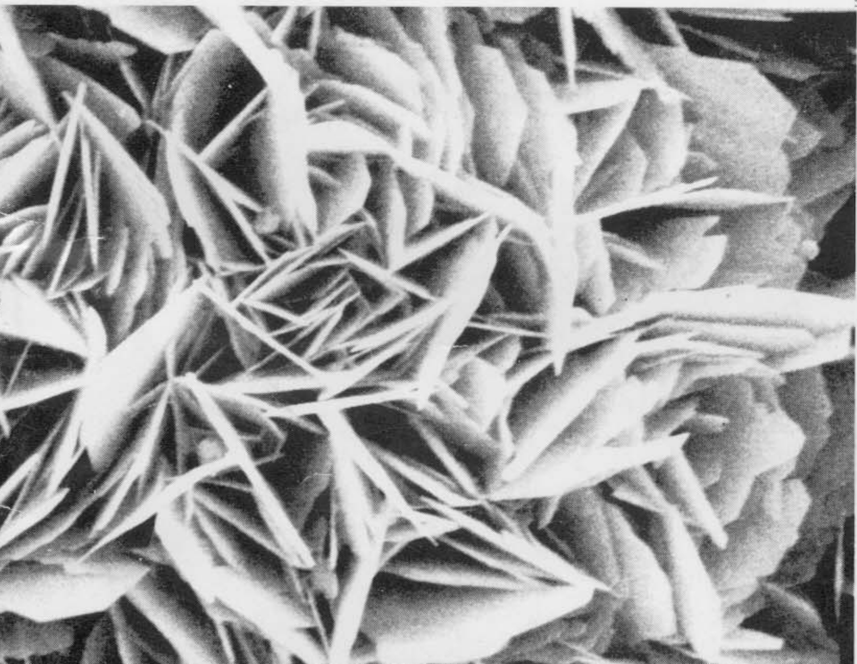


GEOLOGY OF
THE WOODBINE AND TUSCALOOSA
FORMATIONS

PROGRAM AND ABSTRACTS

FIRST ANNUAL
RESEARCH CONFERENCE

GULF COAST SECTION
SOCIETY OF
ECONOMIC PALEONTOLOGISTS
AND MINERALOGISTS



Marriott Hotel West Loop
Houston, Texas
November 30 - December 3, 1980

Cover Photographs

Scanning electron photomicrographs of chlorite coatings on quartz grains from Woodbine-Tuscaloosa sandstone, Chevron Crochet No. 1, Pointe Coupe Parish (False River Field), Louisiana; 19,929 ft; porosity = 29%, permeability = 680 md; approximate magnifications: upper left, X550; middle right, X2200; lower left, X5500.

(Photographs from Alan Thomson (see abstract, p. 32).

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Forward

The purpose of the Gulf Coast Section of the Society of Economic Paleontologists and Mineralogists is specified in its constitution: "to promote the science of stratigraphy in the Gulf Coast states through *research* in paleontology and sedimentary petrology, especially as it relates to petroleum geology." This First Annual Research Conference is devoted to the study of geology of the Woodbine and Tuscaloosa formations and initiates the realization of the GCS-SEPM's purpose on a scale not attempted previously.

All of the world possess in wealth and other satisfactions and all that any country or individual has exists only as a result of fundamental discoveries made sometime in the past. In no area is the relationship between present success and past discovery of fundamental facts and principles more apparent than in the cost and the rate of increase in costs and intensity of competition in the search for natural resources and their development increase, *research* and *communication of its results* become increasingly important. This conference is intended to contribute to the communication of research results, to the encouragement of exchange of information and ideas, and to the stimulation of further research in the discovery and development of hydrocarbons and other natural resources of the Gulf Coast region.

Exploration for hydrocarbons and other economic mineral deposits is becoming increasingly difficult and costly; and the successful explorationist and producer is keenly aware of the economic importance of understanding the whole-rock history of such deposits, In recent decades, great strides have been made in petroleum geology, but many important questions are yet unsolved. Fruitful areas of research still remain in paleontology and sedimentary petrology, especially in studies of oil and gas migration, development, distribution, preservation, and destruction of porosity and permeability, lithic and stratigraphic interpretation of geophysical data, and many other problems related to the origin, occurrence, and development of hydrocarbon-bearing rocks.

We hope this research conference will be the first of many annual research conferences and the beginning of an expanded research effort sponsored by the Gulf Coast Section of the SEPM. We expect this sponsorship to include eventually the financial support of university-based research throughout the Gulf Coast region. The generous and extensive support of this conference by individuals and industry attests to the general recognition of the value of the GCS-SEPM's sponsorship of research activities and portends success for its ambitious plans for the future.

Gene B. Martin
ARCO oil and Gas Company
Houston, Texas

Bob F. Perkins
The University of Texas at Arlington
Arlington, Texas

October 25, 1980

BACK TO THE FUTURE: A NOTE FROM THE FOUNDATION

In 1980, the GCSSEPM Foundation did not exist, and no one knew whether this series of conferences would be given more than once. Thanks to the vision, the extremely hard work of a few good people, and industry support, this year (2003) the twenty-third research conference will be held.

The program and abstracts of the first conference have been long unavailable. It would be prohibitively expensive to do it again in hard copy, and frankly, I have been unable to find a truly clean copy for scanning; it appears that everyone who attended took copious notes on/in their copy. Therefore, the program and abstracts have been retyped and the figures scanned from an original copy. Thus the exact look and layout is not the same as the original copy, but the words and figures are.

One key difference is that I have not retyped the program schedule; I assume that when the paper was given in the conference is not important but the abstract itself. A second key difference is that after the authors, I have **included the original page numbers in the hard copy**, so that the indicated page numbers may not reflect where it is at in this electronic copy. If you reference the abstract, **these page numbers should be used**, not the position of the paper in this copy.

Why has this been done? The last paragraph of the introduction by Gene Martin and Bob Perkins explain it all; the goals of the Section and Foundation have not changed. There is also a second reason: this has been done in tribute to those of the 1980 Section: what we have today is because of your hard work.

Thank you.

Dr. Norman C. Rosen,
Executive Director,
GCSSEPM Foundation

June, 2003

Petrography and Origin of Lower Tuscaloosa Sandstones, Mallalieu Field, Lincoln County, Mississippi

Berg, R.R. Dept. of Geology, Texas A&M University, College Station, TX, and **B.C. Cook**, Louisiana Land & Exploration, New Orleans, LA (p. 9-11)

Upper Cretaceous sandstones of the lower Tuscaloosa Formation in southwestern Mississippi are part of a fluvial-deltaic depositional system. At the Mallalieu Field, lower Tuscaloosa sandstones are of two types: (1) channel-fill sandstones: thin, lenticular bodies which have irregular distribution across the field; and (2) point-bar sandstones: thick, more continuous bodies which have a ridge and swale pattern of sand distribution and are abruptly terminated laterally by narrow, broadly arcuate, shale-filled channels. These fluvial interpretations are supported by mineralogy, textural gradation, internal structures, and sand-body geometry.

The average composition of lower Tuscaloosa sandstone is quartz (60%), matrix (325), calcite cement (4%), feldspar (1%), muscovite (1.5%), and other minerals (1.5%). Average mean grain size of quartz is 0.24 mm (fine-grained); mean grain size decreases upward within individual sandstone beds.

Four distinct sandstone zones produce oil at Mallalieu. The lower two zones are characterized by more extensive point-bar sandstones whereas the upper two zones are narrow channel-filled sandstones. The producing sandstones are within an overall transgressive sequence with an upward gradation from fluvial meander-belt deposition; through deltaic distributary deposition; to inner neritic deposition of overlying shales. The change from meandering below to braided above probably resulted from a change in stream gradient by basin subsidence.

Abstract and illustrations reprinted with permission from the Gulf Coast Association of Geological Societies Transactions, vol. 18, p. 242-255, 1968.

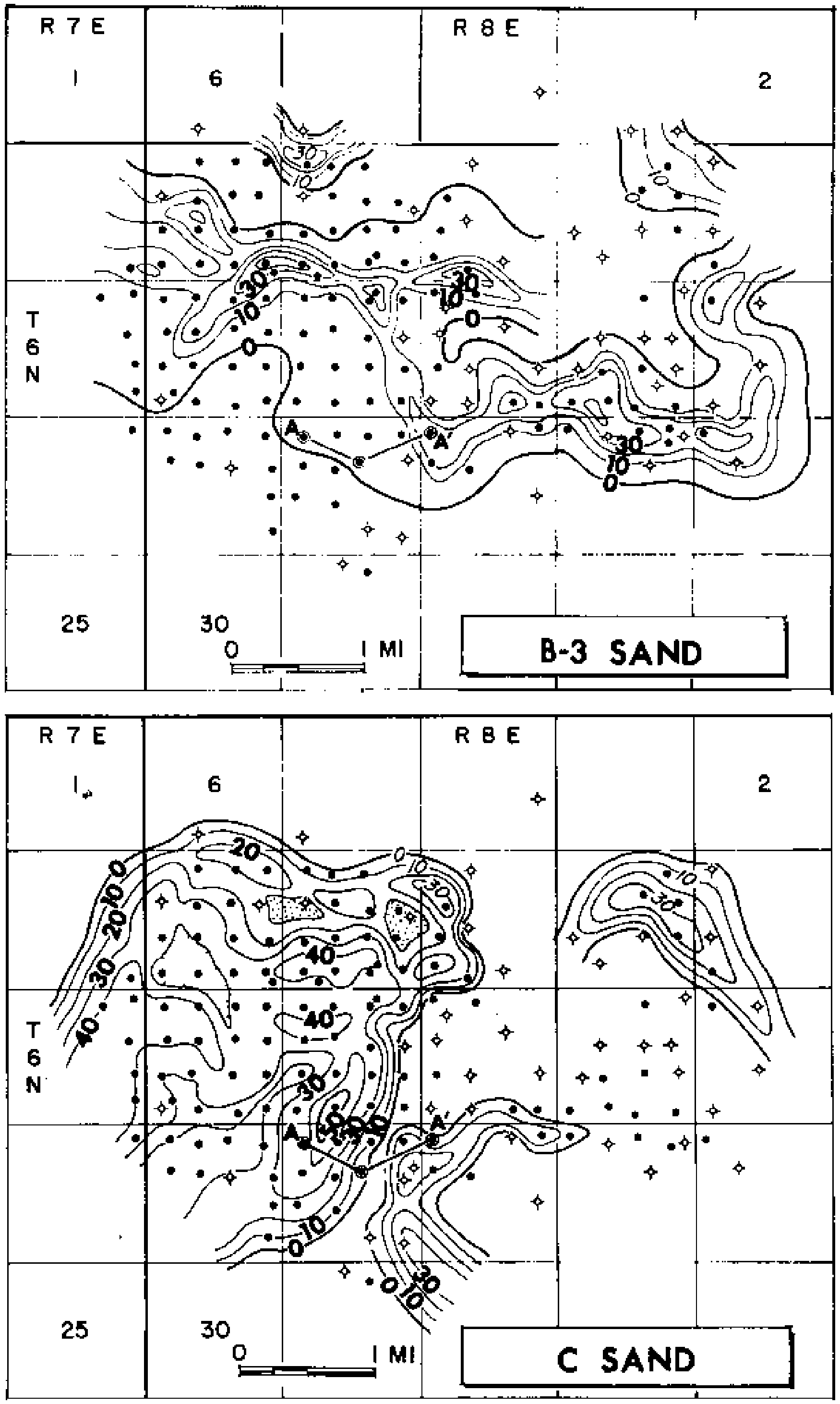


Figure 1. Net sandstone isoliths of Lower Tuscaloosa "C" and "B" sandstones, Mallalieu field, Mississippi.

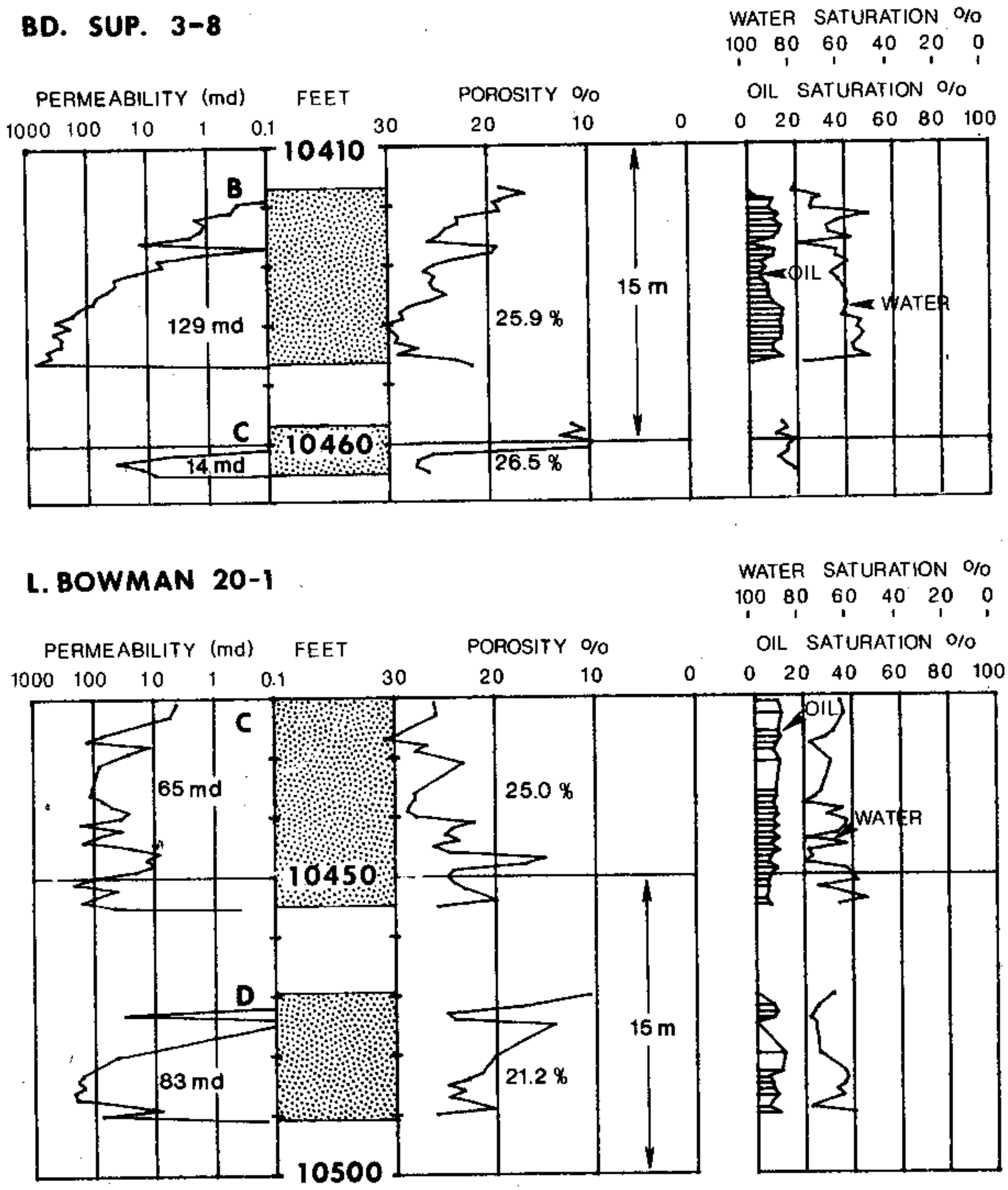


Figure 2. Permeabilities, porosities, and fluid saturations of Lower Tuscaloosa "B", "C", and "D" sandstones, Mallalieu field, Mississippi.

The Deep Tuscaloosa Gas Trend of Southern Louisiana.

Bland, F.X., Chevron USA, New Orleans, LA (p. 11-12)

The discovery in May, 1975, of the deep, high pressured gas reservoirs in the Chevron No. 1 Alma Plantation well, located just northwest of Baton Rouge in south-central Louisiana, has sparked the most intensely competitive exploration play in the country today. The combined attractions of the discovery of a new trend of deep Tuscaloosa age sandstone objectives deposited south of the underlying Lower Cretaceous shelf edge in a lightly explored and essentially non-productive portion of the state, in conjunction with indicated high gas flow potentials, initially high exploratory success ratios, available land, and most significantly, rising gas prices, afforded an opportunity (for as many as 100 different operating, investment, and service companies, major and independent alike) to accept the formidable challenges of the exploration of the hostile pressure and temperature environments of the deep Tuscaloosa formations.

The geological and geophysical work, directed specifically toward the discovery of this trend, commenced by Chevron in 1963 and spanned over 11 years before the first discovery was made. The evolution of Chevron's geological and geophysical thinking during this period is reviewed, as well as an outline of some of the major problems involved with the exploitation of this trend. A summary of results during the initial five years of development is presented.

Palynologic Evidence for Assigning an Eaglefordian Age (Late Cretaceous) to the Tuscaloosa Group of Alabama

Christopher, R.A., U.S.G.S., Reston, VA. (p. 12-14)

The outcropping Tuscaloosa Group of Alabama and westernmost Georgia is generally characterized as a series of fining-upward arkosic sands and mottled clays that contain rare and poorly preserved marine invertebrates. However, scattered lenses of carbonaceous clay within the Tuscaloosa Group contain an abundance of well preserved and diverse spores and pollen. The palynologic assemblages recovered from these clay lenses are distinctive, and representatives of the pollen genera *Complexiopollia* and *Atlantopollis* are the most striking elements. These two genera are morphologically so distinct and are sufficiently abundant that they serve as the nominate taxa of the *Complexiopollia-Atlantopollis* Assemblage zone. In addition to occurring in the outcropping Tuscaloosa Group of Alabama and westernmost Georgia, this zone also occurs in the subsurface Atkinson Formation of coastal Georgia and South Carolina; Unit F of North and South Carolina; the Woodbridge Clay and Sayreville Sand members of the Raritan Formation of New Jersey (the stratotype of the zone); and unnamed outcropping and subsurface units on Martha's Vineyard and Nantucket islands, Massachusetts.

Although the occurrence of the *Complexiopollia-Atlantopollis* Zone throughout the eastern Gulf and Atlantic coastal plains suggests a biostratigraphic correlation among the lithologic units mentioned above, the assignment of a precise age to the zone, and hence to the Tucaloosa Group, has been hampered by the lack of taxonomic work on the consituent species of the assemblage. In Europe, the genus *Complexiopollia* ranges in age from middle Cenomanian to early Campanian, and *Atlantopollis* ranges from middle Cenomaina to middle Turonian; hence, the age of the *Complexiopollia-Atlantopollis* Zone is estimated to be somewhere between the beginning of the middle Cenomanian and the end of the middle Turonian.

Because the problem of the age of the Tuscaloosa Group of Alabama and westernmost Georgia is directly related to the age of the pollen zone within the unit, I examined a complete core of the Eagle Ford Group and adjacent strata of Texas in order to assign a more precise age to the *Complexiopollia-Atlantopollis* Zone. In this core, the *Complexiopollia-Atlantopollis* Zone occurs within the upper half of the Britton Formation and possibly within the basal part of the Arcadia Park Formation of the Eagle Ford Group. In terms of North American provincial stages, the *Complexiopollia-Atlantopollis* Zone is middle Eaglefordian in age, not Woodbinian as has been suggested previously by both molluscan and plant megafossil data. Ammonites in the Britton and Arcadia

Park formations indicate that the stratigraphic interval containing the *Complexiopollia-Atlantopollis* Zone can be assigned to the upper Cenomanian and lowermost Turonian stages of Europe. The lower part of the Britton Formation, however, is poorly fossiliferous with respect to pollen. Mollusk and ostracode data suggest that the *Complexiopollia-Atlantopollis* Zone should occur in these beds, which are of middle Cenomanian age. The underlying Tarrant and Woodbine formations are richly palyniferous and are definitely of pre-*Complexiopollia-Atlantopollis* age.

The occurrence of the *Complexiopollia-Atlantopollis* Zone in the Eagle Ford Group of Texas not only indicates that the previously suggested correlations of the Tuscaloosa Group of Alabama with the Woodbine Formation of Texas should be re-examined, but it allows the establishment of biostratigraphic relationships between the pollen zone and zones based on other fossil groups. The lithologic units in which the *Complexiopollia-Atlantopollis* Zone occurs in the eastern Gulf and Atlantic coastal plains are typically marginal marine or nonmarine in origin, and zonal relationships established on the few marine fossils that do occur in this region are tenuous at best. However, the Eagle Ford Group of Texas contains a diverse marine invertebrate fauna for which zonations have been proposed, zonations that can now be related to the *Complexiopollia-Atlantopollis* Zone. The core data suggest that the *Complexiopollia-Atlantopollis* Zone correlates at least with (1) the entire *Sciponoceras gracile* Zone and possibly with the basal part of the *Mytiloides "labiatus"* and the upper part of the *Ostrea beloiti* zones (mollusks), (2) the upper part of the *Rotalia cushmani-greenhornensis* Subzone and possibly the basal part of the *Whiteinella archaeocretacea* Subzone (foraminifers), and (3) the *Cythereis eaglefordensis* and *Fossocytheridea lenoirensis* range-zones (ostracodes).

Diagenesis of Woodbine Sandstones, East Texas: Significance to Formation Interpretation, Evaluation, and Field Development

Davies, D.K. and **W.R. Almon** Davies, Almon and Associates, Houston, TX (p. 14-17)

Post depositional modifications (diagenesis) of Woodbine sandstones play an important role in controlling hydrocarbon discovery and production in East Texas. Diagenesis can affect the ways in which geologists and engineers interpret, evaluate, and develop Woodbine reservoirs. In particular, diagensis has a significant effect on several topics of importance to the oil industry including (1) petrophysics, (2) fluid system compositions, (3) drill stem testing, (4) well production, and (5) enhanced recovery.

Petrophysics: Diagenesis can control log shapes, leading to erroneous interpretations of depositional environment. It is important that the impact of diagenesis on log shape be understood so that accurate assessment of depositional environment can be made. Depositional environment governs reservoir orientation, morphology, and at times, dimensions and quality. It is therefore of importance to formation evaluation and field development. The importance of this control is heightened because of our necessary dependence on logs in the Woodbine. The two electric logs presented (Fig. 1) show a general "channel" SP shape. Detailed rock examinations show that the sandstones become coarser grained and cleaner upward (quite the opposite of a normal channel). The upward reduction in SP is a result of an upward increase in silica cement which occludes most of the pores in uppermost portions of the sandstone sequence. These logs are recording what may be termed a diagenetic overprint on the sediment. Thus the log shape is indicative of diagenesis, not depositional environment. Additions of clay and cements other than silica significantly affect gamma-ray log shape, porosity calculations from neutron and density logs and also S_w calculations from Archie's equation resulting in pessimistic interpretations of water saturations.

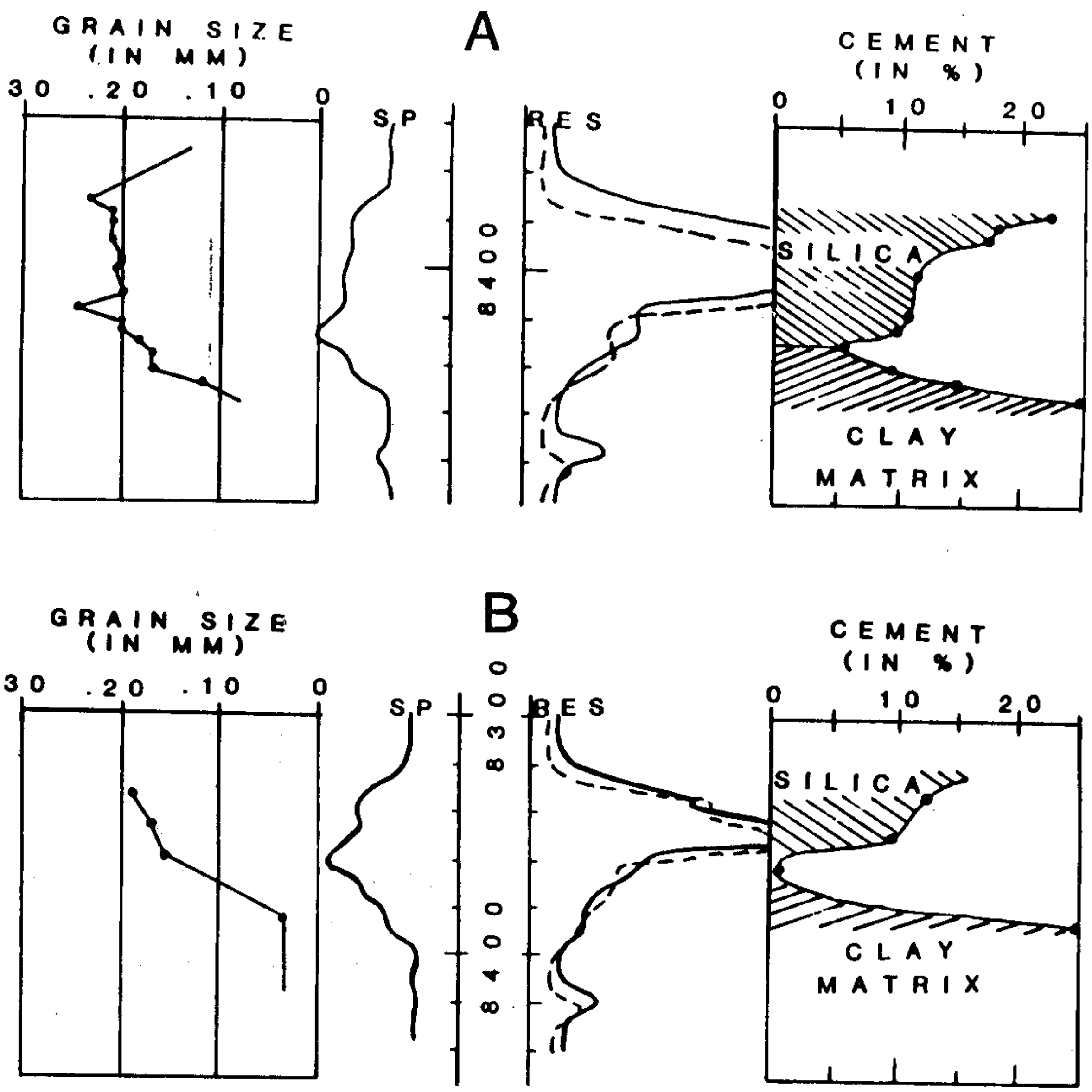
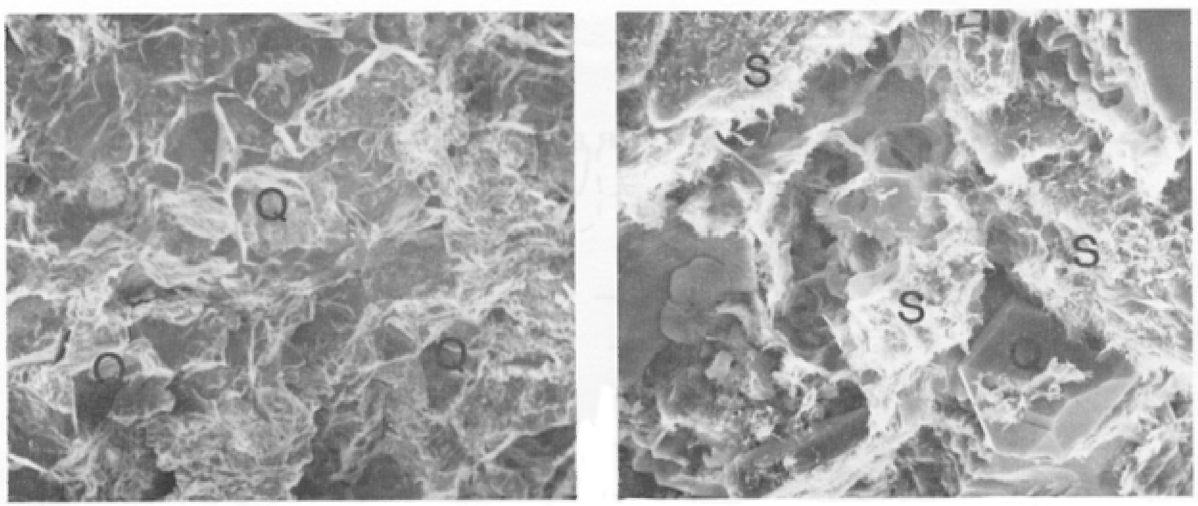


Figure 1. Grain size, electric log and abundance of silica cement and clay matrix in Woodbine sandstones penetrated in two wells in East Texas. The sandstones are rich in detrital clay (matrix) at the base. As sand grain size increases the amount of clay matrix decreases. The abundance of silica cement starts to increase once the amount of clay has dropped to approximately 5% (in these samples). The SP decreases as the amount of silica cement in the sandstones increases. Note that the plot of silica and clay abundance is similar to both the SP and the resistivity curves.

Fluid System Compositions: Drilling, completion, and enhanced recovery fluids react with natural (authigenic) cements in rock pores and these reactions can affect the quality and production of any reservoir. This effect is particularly true in the Woodbine in East Texas where a wide variety of natural cements are present (Fig. 2). In some locations, Woodbine sandstones are sensitive to fresh or sodium-based drilling and completion fluids because of the presence of the swelling clays illite-smectite or smectite. In other areas these clays are absent and no swelling problems exist. Certain areas are characterized by sensitivity to either HCl or HF acids (whether used in mud clean-up or stimulation) due to the presence of specific sulfides or oxides in the pore systems. The sensitivities of Woodbine sandstones to waters and acids are not uniform across East Texas but vary from area to area and from zone to zone. Thus drilling and completion fluids should be designed on a local regional scale.



A B

Figure 2. Scanning Electron Micrographs of Woodbine Sandstones from East Texas.
A. Individual quartz grains (Q) with well-developed silica overgrowths resulting in development of flat crystal faces and interpenetration of adjacent grains and causing an occlusion of original porosity in this tight, fine-grained sandstone sample. Silica cementation, as illustrated in this example, is a common mechanism of porosity occlusion in Woodbine sandstones.
B. Higher magnification view of pore in a second sample. Pore is lined and partially blocked with swelling clays (S). A well developed quartz crystal (Q) is shown also.

Drlll Stem testing Results: Diagensis can have a significant effect on drill stem testing results. The presence of authigenic cements often causes poor drill stem test results. There are instances when DST results should be ignored and well completion encouraged. Poor DST's in the Woodbine result from any or all of the following: (1) secondary porosity, (2) silica overgrowths [Fig. 2A], and (3) illitic minerals. Thus, poor DST results should be used to condemn a well only after the diagenesis of the sandstones is understood.

Well History: Both the rate of production decline and the ultimate productivity of a Woodbine well are linked to diagenesis. Rapid initial production declines are not always caused by the presence of migrating fines. At times, rapid decline rates are due to the type of pore system dominant in the sands. Clay stabilizing treatments (for purposes of preventing or arresting production declines) can at times be worthless and even damaging to the formation if they are applied without a detailed knowledge of the pore system and its morphology.

Enhanced Recovery: Nothing is more important to the success of EOR than a detailed understanding of the pore systems of a sandstone. The number of locations of injectors, the composition of the flood fluid, and the treatment of injection and production wells should be biased on an understanding of the morphology of the pore system. At least three distinct varieties of pore systems occur in the Woodbine of East Texas: [1] pore systems dominated by fractures, [2] pore systems dominated by large, irregularly shaped secondary pores, and [3] pore systems lined with cements of variable composition. The success of any enhanced recovery project will be dependent, to a large extent, upon the compatibility of project design and pore system morphology.

Depositional Environment of Woodbine Sandstones, Polk County, Texas

Foss, D.E., Chevron USA, Denver, CO (p. 17-19)

Woodbine sandstones produce mostly natural gas in stratigraphic traps at Seven Oaks, Hortense, Leggett, and R.B. fields in Polk County, Texas. The Woodbine section can be divided into lower, middle, and non-bioturbated and bioturbated upper units of interbedded sandstones and shales. Strike-trending pod-shaped concentrations of bioturbated upper Woodbine sandstones are the principal reservoirs in these fields.

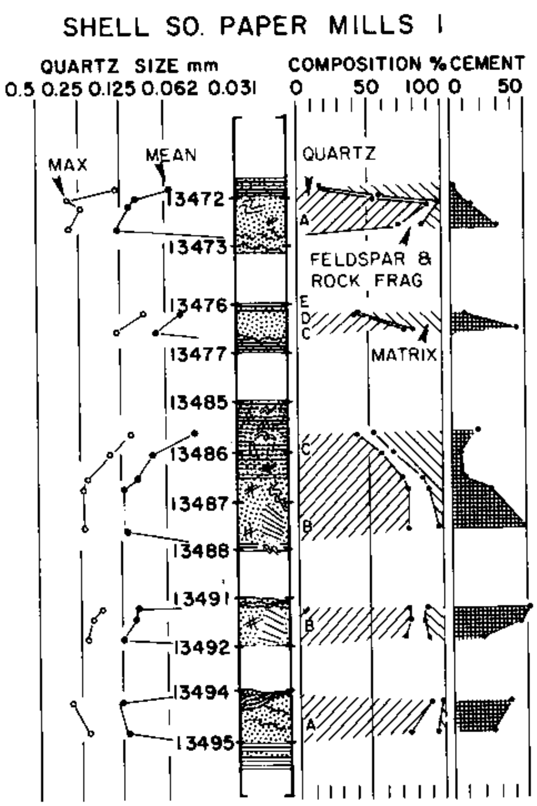


Figure 1. Grain size, composition, and bedsets in the lower Woodbine sandstones in Shell Southland Paper Mills 1, Polk County, Texas. Letters at right indicate turbidite units.

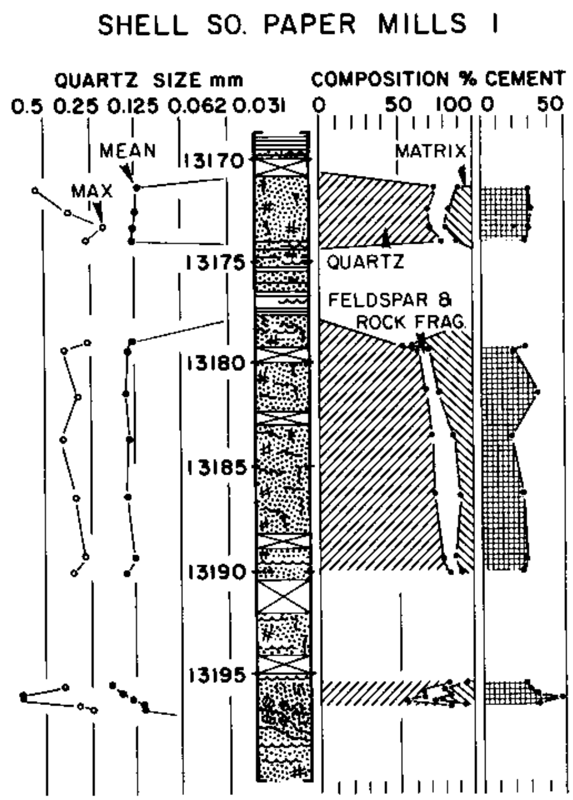


Figure 2. Grain size, composition, and bedsets in the bioturbated upper Woodbine sandstones in Shell Southland Paper Mills 1, Polk County, Texas.

Lower and middle Woodbine sandstones are thinly to thickly bedded and isolated in black non-bioturbated shales. Thinner sandstones average 0.25 ft and typically consist of more complete turbidite sequences (*i.e.*, ABCE, ABCDE, BCDE, and CDE). Thicker sandstones that range from 0.5 ft to as much as 2.5 ft contain less complete sequences (*i.e.*, A, AB, B, and BC). Thicker sandstones with less complete bedsets represent channel deposits while the thinner sandstones with more complete bed sets represent overbank deposits. Thinly bedded, non-bioturbated upper Woodbine sandstones are gradational upward into the thickly bedded, bioturbated sandstones. The non-bioturbated sandstones contain only turbidite bedsets reflecting overbank deposition. Ordered sequences are absent in the bioturbated upper Woodbine sandstones. A few relict ripple-laminated intervals suggest that the bioturbated sandstones were deposited by more persistent low flow regime, possibly geostrophic currents, rather than by turbidity currents.

19

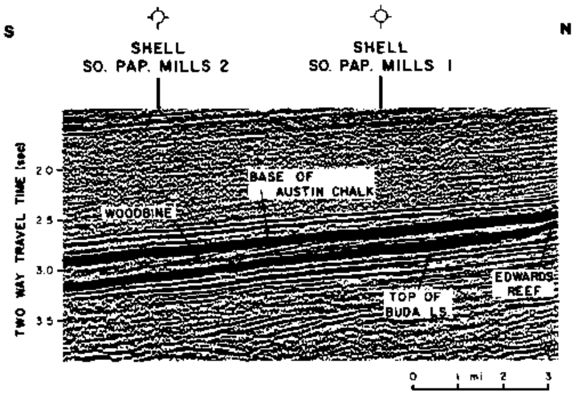


Figure 3. Seismic section extending north-south through the Seven Oaks producing area shows inclined "prograding" reflectors within the Woodbine section downdip from the Edwards Reef.

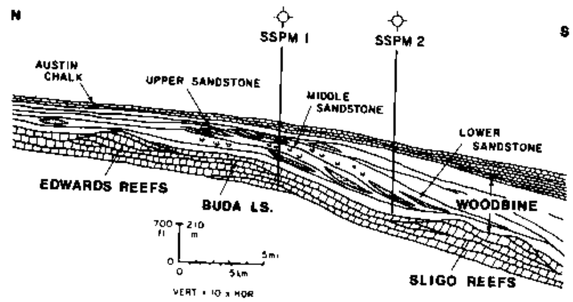


Figure 4. Diagrammatic Woodbine cross section extending north-south through Polk County based on available seismic sections and well control. Section shows Woodbine sandstone depositional environments associated with dominant slope shale deposition; stippled areas are locations of sandstone deposition. Cored wells are projected into the section.

Woodbine clastic deposition is associated with a prograding shelf margin. Electric log correlation and seismic sections suggest that the lower Woodbine sandstones were deposited as a group of channel and overbank turbidites on the lower slope. Middle Woodbine sandstones were deposited in isolated feeder channels located farther up the slope and closer to the shelf break. The thick section of slope shale containing the lower and middle turbidite sandstones is overlain by thinly to thickly bedded upper Woodbine sandstones interpreted to be shelf margin sandstones that cap the prograding slope sequence. A turbidite origin for most Woodbine sandstones in the Seven Oaks producing area suggests that channel sandstones associated with submarine fans located farther downdip, possibly over the Sligo reef break, may form extensive dip-trending reservoir bodies.

Origin of Porosity in Deeply Buried Tuscaloosa Sandstones, False River Field, Louisiana

Franks, S.G., ARCO O&G, Dallas, TX (p. 20-21)

Deeply buried Tuscaloosa sandstones in the False River Field, Pointe Coupee Parish, Louisiana, have unusually high porosity and permeability for their age (Upper Cretaceous), depth of burial (20,000 feet), and temperature (350° - 400° F). Permeabilities up to 1200 millidarcies and porosities as high as 27% have been reported.

Petrographic analysis of Woodbine-Tuscaloosa sandstones, from the outcrop and from 24 wells ranging in depth from 2900 to grater than 20,000 ft, suggests that porosity in the deep Tuscaloosa of Louisiana is mostly of secondary origin. Present evidence indicates that the porosity is due to leaching at depth of early iron-rich calcite cement and basic rock fragments derived from an Upper Cretaceous volcanic terrain extending from central Mississippi into southern Arkansas.

The interpreted diagenetic sequence is as follows:

- Stage 1: Precipitation of authigenic smectite clay rims at shallow depths (converted to chlorite during burial).
- Stage 2: Cementation of some sandstones by ferroan calcite, which post-dates clay rims and replaces many framework grains.
- Stage 3: Progressive silica cementation by quartz overgrowths in sandstones not cemented by early ferroan calcite (Stage 2). Sandstones with more than 10-15% volcanic clasts generally do not develop quartz overgrowths.
- Stage 4: Dolomite cement post-dates silica cement and fills remaining porosity between quartz overgrowths.
- Stage 5: Dissolution of iron-rich calcite and volcanic rock fragments produces abundant secondary porosity.
- Stage 6: Following and accompanying dissolution, additional iron-rich chlorite and minor quartz overgrowths were precipitated.

Depth of appearance and oxygen and carbon isotope data indicate that silica and dolomite cement formed at temperatures probably greater than 80° C. Early carbonate cement has re-equilibrated isotopically and has values similar to that of the late dolomite cement. Leaching of the calcite cement probably is due to enrichment of the pore fluids in carbon dioxide evolved during maturation of the organic matter in the sediments. Some of this isotopically light carbon is incorporated in the late stage dolomite cement and in re-equilibrated calcite.

The Deep Tuscaloosa Gas Trend of South Louisiana

Funkhouser, L.W., Standard Oil of California, San Francisco, CA, **F.X. Bland**, Chevron USA, New Orleans, LA, and **C.C. Humphris, Jr.** Chevron USA, New Orleans, LA (p. 21)

The deep Tuscaloosa gas trend of south Louisiana is one of the most significant exploration plays in the United States in recent years. This trend, productive from an expanded Tuscaloosa sand-shale sequence of Late Cretaceous age, covers a band approximately 30 miles wide and 200 miles in length, from the Texas line on the west and extending past Lake Pontchartrain on the east.

Regional studies begun by Chevron in 1964 demonstrated the probability of an unexplored sedimentary section lying just to the south of the Lower Cretaceous carbonate bank edge which crosses south Louisiana. Improved regional seismic data later verified the presence of such a unit, termed "the wedge," located between reflectors identified as Upper Cretaceous chalk and Lower Cretaceous carbonates.

The discovery well of the Tuscaloosa wedge was drilled at False River area in May, 1975, when Chevron tested 20 MMCFGD from a sand at 19,800 feet in the No. 1 Alma Plantation, 15 miles northwest of Baton Rouge. Chevron confirmed the trend discovery in December, 1975, at Rigolets Field, 125 miles southeast of False River Field.

The productive section of the Tuscaloosa is interpreted to be a shallow water deposit that has been built by progradation southward across the Lower Cretaceous carbonate bank edge. Down-to-the-south faulting in this expanded section, along with deep salt movement, has produced most of the structural features that are now productive from the Tuscaloosa.

Seventy exploratory wells have been completed to-date along the Tuscaloosa trend, resulting in the discovery of sixteen fields. Proven plus potential reserves discovered through May, 1980, are estimated to be approximately five TCF. This reserve estimate should increase significantly with continued drilling.

The East Texas Field

Halbouty, M.T. and **J.T. Halbouty** Michael T. Halbouty O&G Interests, Houston, TX (p. 22-23)

There is no doubt that the single greatest event in the history of the American petroleum industry and our profession was the discovery of oil at Spindletop, near Beaumont, Texas, on January 10, 2902. The second great event which had worldwide implications for our industry and profession was the discovery of the East Texas Field, October 5, 1930. Because the huge oil accumulation in the East Texas Field is contained in a simple stratigraphic trap (wherein the Woodbine sandstone pinches out --actually it is truncated-- in an easterly direction on the west flank of the Sabine Uplift) the discovery and size of the field dramatically brought to the attention of geologists the great significance and possibilities of stratigraphic type traps.

The East Texas Field has two outstanding features -- its unbroken tremendous size and the simplicity of its geologic trap. Conclusions of this study are based on a single electric log dip cross-section, which extends from the East Texas basin in northern Cherokee County, Texas, to the crestal area of the Sabine Uplift near the Texas-Louisiana state boundary. Two other similar sections trending through Gregg and northern Rusk counties were used to confirm observations. Conclusions reached by this study are:

(1) An ancient north-south trending anticlinal feature of regional size possibly occurred at the end of Buda time in older Lower Cretaceous beds. Any hydrocarbon accumulations in this feature for the most part migrated eastward into higher elevations as the Sabine Uplift emerged and tilted out the east flank of the old anticline. Relic accumulations of hydrocarbons possibly remain where perme>>ability barriers and stratigraphic changes prevented migration.

(2) In the period between Buda time and the beginning of Woodbine deposition, the present crestal area of the Sabine Uplift rose approximately 1000 ft. Uplift was probably equaled by and contemporaneous with erosion, so that at the beginning of Woodbine of Woodbine deposition the Lower Cretaceous erosional surface had been peneplaned.

(3) Woodbine deposits from the Ouachitas were deposited on top of and on the flanks of the present Sabine Uplift on the peneplaned Lower Cretaceous surface.

(4) A second period of uplift removed Woodbine sediments from the elevated areas. Underlying Lower Cretaceous beds were not subjected to much erosion, if at all, because vertical uplift probably was approximately equal to the thickness of removed Woodbine.

(5)The absence of large concentrations of calcitic material in Woodbine sandstones underscores the probability that simultaneous erosion of Lower Cretaceous limestone and deposition of Woodbine sands sis not occur to any great extent on the west flank of the Sabine Uplift.

No. 1 Play in the U.S.A., South Louisiana Tuscaloosa Trend 1975-1980

Harrison, Jr., F.W. Petroleum Geologist, Lafayette. LA. (p. 23)

Since the discovery of Tuscaloosa hydrocarbon production at False River Field in West Baton Rouge Parish, Louisiana, on May 31, 1975, the Tuscaloosa trend of south central Louisiana has developed into the most active deep exploratory play in the U.S.A. Drilling activity since the discovery of the False River Field has resulted in an additional discovery of 13 Tuscaloosa gas-condensate fields, one Tuscaloosa oil field, three Austin Chalk discoveries, and one Wilcox discovery. As of March, 2980, 241 permits have been issued by th estimated Louisiana Department of Conservation. Of this number, 119 are wildcats which have been drilled or are drilling below a depth of 15,000 feet. The success ratio for wildcats is one in six, or 16.67%, and field extension and development drilling has resulted in a success ratio of one in two, or 50%.

More than 4,000,000 acres are under lease in the trend, and 129,680 acres have been placed in Tuscaloosa drilling units by the Louisiana Department of Conservation. Some of the most significant fields discovered along the trend are the False River Field in West Baton Rouge Parish; the Moncrief, Judge Digby, and Moore-Sams fields in Pointe Coupee Parish; the Port Hudson, Irene, and Profit Island fields in East Baton Rouge Parish; and the Lockhart Crossing Field in Livingston Parish, Louisiana. Proven reserves of 4 TCF gas and 400 MMBC have been established. In addition, available seismic and subsurface data indicate the future reserve potential of the Tuscaloosa to be estimated at 16 TCF gas.

A detailed subsurface and stratigraphic study of the existing fields should serve as a guide for locating other major reserves along the trend.

Geologic Age and Depositional Environment of the "Pilot Sand" and "Marine Shale" Tuscaloosa Group, South Carlton Field, South Alabama

Mancini, E.A., University of Alabama, **C.C. Smith**, U.S.G.S., Washington D.C., and **J.W. Payton**, University of Alabama (p. 24-25)

The lower Tuscaloosa Group is potentially one of the major petroleum reservoirs in the subsurface of southern Alabama, and yet little is known about the geologic age or depositional setting of the producing horizons. Lower Tuscaloosa production in southern Alabama has exceeded 15.9 MMBO from South Carlton and Pollard fields since drilling of the respective discovery wells in 1950 and 1952. Within the South Carlton Field, the producing horizons include the "Pilot Sand" and "Massive Sand." The "Pilot Sand" and the overlying "Marine Shale" were cored (-5720 ft to -5322 ft) in the Belden & Blake Corporation *et al.* Unit 3-9 well located in 3-T3N-R2E, Clarke County, Alabama. The "Marine Shale" within the cored interval consists of 10.5 ft of laminated, dark gray, silty, micaceous, fossiliferous claystone. Observed macro-invertebrates include open-marine shelf species of ammonites, inoceramids, and other bivalves. The claystone also contains a relatively diverse calcareous microfossil fauna and flora, suggesting open-marine middle shelf sediment accumulation. Planktic foraminifers and calcareous nannofossils present in the "Marine Shale" indicate that the unit is assignable to the *Rotalipora cushmani-greenhornensis* Subzone of Pessagno and suggest that the "Marine Shale" is of middle to late Cenomanian age. This particular subzone is recognized in the upper part of the Woodbine Formation and lower part of the Eagle Ford Group in exposures located in central and north-central Texas. The "Marine Shale" of southern Alabama, therefore, is in part age equivalent of a portion of the Woodbine Formation and/or Eagle Ford Group of Texas.

Within South Carlton Field, the "Marine Shale" is underlain by the "Pilot Sand." Immediately underlying the claystone of the Marine Shale" is a six-inch, light gray, silty, oyster-bearing limestone. The contact between the limestone and the "Pilot Sand" is sharp. The "Pilot Sand" includes 41 ft of massive, dark brown to greenish-gray, friable, micaceous, subangular to subrounded, moderately sorted to moderately well sorted, fine- to medium-grained, quartzose sand. The upper 16 ft of the sand is oil-saturated. The sand body displays an overall decrease in grain size, sorting, and roundness from the base to the top of the unit. The lower seven feet of the sand is glauconitic, calcareous, and fossiliferous.

The SP pattern for the sand illustrates a gradational lower contact with the underlying strata and a sharp contact with the "Marine Shale." Such an SP pattern is typical for the "Pilot Sand" throughout the South Carlton Field. The sedimentary rock characteristics, including geometry, and the electric log properties of the "Pilot Sand" suggest it accumulated as a marine bar. Knowledge of the geologic age, sedimentary characteristics, and depositional setting of this sand body should enhance petroleum exploration for this economically important "Middle" Cretaceous unit.

Tuscaloosa Formation (Cenomanian) from Eastern Alabama to Central Georgia- Its Stratigraphic Identity and Sedimentology

Reinhardt, Jürgen, USGS, Reston, VA (p. 25-26)

The basal outcropping Cretaceous sediments in the eastern Gulf Coastal Plain previously have been defined and mapped as the Tuscaloosa Group or Formation. The outcrop belt narrows from about 48 km (30 mi) wide in the type area in western Alabama to zero in central Georgia. The degree of stratigraphic resolution between the Tuscaloosa and the overlying Eutaw Formation decreases from west to east as Eutaw facies change from marginal marine to fluvial. East of the Ocmulgee River in central Georgia, the Tuscaloosa is overlapped by sediments of the Santonian age (Austinian), which in turn is overlapped by Eocene-aged sediments.

From the Chattahoochee River Valley (lee and Russell counties, Alabama) in the west to the Ocmulgee River (Bibb County, Georgia) in the east, the Tuscaloosa can be mapped as a single stratigraphic unit (formation) composed of several characteristic lithologies. At many localities, these lithologies are seen arranged into fining-upward sequences or cycles three to six meters thick. From base to top, a cycle typically contains: (1) massive or medium to thickly cross-bedded, very coarse-grained feldspathic grit to conglomeratic sand, (2) thinly cross-bedded to planar laminated, medium-grained to fine-grained commonly micaceous sand, and (3) massive to mottled (red-green) clayey silt and silty kaolinitic clay. The base of the cycle is highly irregular; sediment from the underlying lithofacies is commonly incorporated into the basal part of the cycle. Within the cycle, lithologies and primary sedimentary structures (mostly unidirectional cross beds) generally record an upward decrease in current energy. Sparse leaf accumulations, lignitized wood, and rare networks of back-filled burrows are the biogenic features in the Tuscaloosa Formation; marine invertebrates are found in outcrop and shallow subsurface in part of the Tuscaloosa Group in western Alabama.

The primary sedimentary structures, vertical and lateral bedding relationships, and biogenic features all indicate deposition within the continental environments, more specifically in a meandering stream-point bar complex. Overall, cross bedded sand, representing subaqueous channel fills, is the best preserved of the lithofacies. Subaerial floodplain deposits and cut-off meander fills are also preserved but are thinner locally and less significant areally. The small amount of clay in numerous fining-upward sequences and the lensoid geometry of many sand bodies indicate that the lateral accretion and channel aggradation were the dominant processes in these meandering streams.

Local highs on aeroradioactivity maps coincide with outcropping Tuscaloosa sediments. Field measurements indicate that both reduced and oxidized floodplain clays produce 13-18 μR/hr, and channel bar sands produce a wider range of values (10-20 μR/hr), depending largely on sediment sorting and heavy mineral content. Preliminary chemical studies and spectrometry suggest that gamma radiation in the clays results from concentrations of both uranium and potassium, whereas thorium accounts for significant gamma radiation in certain sand intervals.

The geographically extensive fluvial facies represented by the Tuscaloosa in the eastern Gulf Coastal Plain suggest considerable relief and probable uplift in the southeastern United States during the Cenomanian, a time of worldwide marine transgression. The formation of an extensive coastal plain during this period profoundly affected the composition and supply of sediment along the margin of this basin for the balance of the Cretaceous.

Updip Facies Along the Tuscaloosa Outcrop in Mississippi, Tennessee, and Alabama

Russell, E.E., D.N. Keady, and **T.W. Lins**, Mississippi State University, University, MS 39762 (p. 27-28)

The Tuscaloosa Group at the latitude of the type locality consists of a lower sequence of coastal clastics (Coker Formation) and an upper sequence of delta distributary and trunk stream deposits (Gordo Formation). The Coker Formation pinches out along strike to the northwest. In northeastern Mississippi and western Tennessee (adjacent to the Tennessee River), latest Tuscaloosa sediments are represented largely by trunk and tributary stream deposits. Within the latter area, two distinct lithofacies are present: northwestern chert gravel and clay lithofacies and southeastern quartz sand and chert gravels lithofacies (also of fluvial origin).

The northwestern (or Tennessee) lithofacies, present in (1) the shallow subsurface and outcrop of northeastern Mississippi, (2) the outcrop of northwest Alabama, and (3) the western highland rim of western Tennessee, consists chiefly of chert gravel up to cobbles and, locally, silts and kaolinitic clays and rarely chert sand. Sorting is very poor. Bedding is lenticular and cross-bedding is common. In most areas, the sediments are preserved in what appear to be northwest-trending paleovalleys developed in the Mississippian Ft. Payne Chert. Marcher and Stearns (1962) have shown that many of the pebbles are not indigenous and had a source area to the northwest. The Tennessee lithofacies overlies the Alabama lithofacies in northeast Mississippi.

The southwestern (or Alabama) lithofacies present in northeast Mississippi and northwest Alabama, southeast of the Tennessee lithofacies, consists predominantly of chert gravel and quarztitic pebbles in a matrix of quartz sand and, locally, kaolinitic and lignitic clays. The beds tend to be lenticular and cross-bedding is common. Cut and fill structures are present. A short distance to the south in Itawamba County, Mississippi, thick graveliferous sands (channel deposits) are overlain by point bar sands and overbank silts and clays, all part of a fluvial system. The presence of the quartz sand and quartzite pebbles as well as some of the chert indicate that the Alabama lithofacies was derived, in large part, from a distinct and different source area than the Tennessee lithofacies. The plateau and fold belt of the Appalachians was the likely source of this lithofacies.

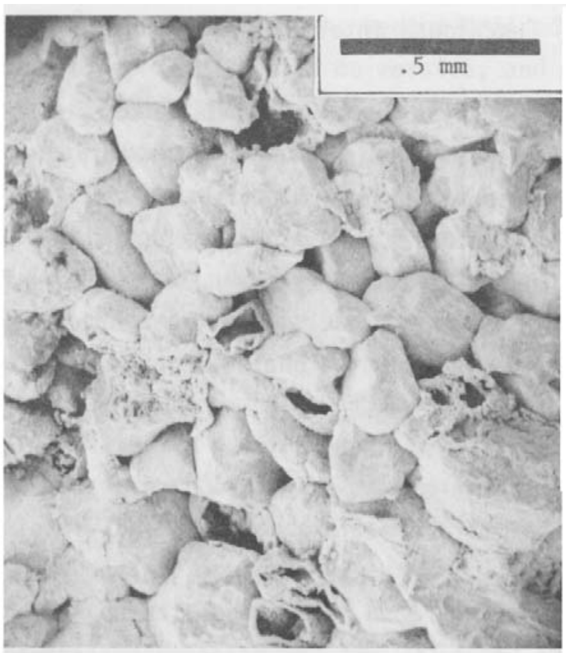
Sedimentary relationships within and thickness of the Alabama lithofacies suggest that it was deposited in the alluvial plain of meandering stream system which drained the Appalachians northeast of this area and fed sediments southeastward into the northern Mississippi and northwest Alabama. These sediments overlie the Alabama lithofacies.

Secondary Porosity in the "19,800 Foot" Tuscaloosa Sandstone, False River Field, Pointe Coupee and West Baton Rouge Parishes, Louisiana

Smith, G.W., Chevron USA, New Orleans, LA (p. 28-31)

False River Field, discovered by Chevron in 1975, established the initial production in the currently active deep Tuscaloosa gas trend which extends for 200 mi (322 km) across southern Louisiana. The field is located on an anticlinal structure developed downthrown to a large growth fault, just south of the Lower Cretaceous carbonate shelf edge. Production is from an expanded Tuscaloosa sandstone and shale sequence of Upper Cretaceous age. Lithology, sedimentary structures, and paleontology of the adjacent shales indicate that the reservoir sandstones encountered at approximately 20,000 ft (6098 m) were deposited in a shallow marine environment. These sandstones are interpreted to be offshore bars.

A typical sequence in the productive interval consists of an upward coarsening gradational succession of gray shale, ailtstone, and very fine-grained argillaceous sandstones, overlain by clean, moderately well to well sorted, medium-grained sandstones. Cements, in order of their introduction into pore space, are chlorite, silica, and ferroan calcite. Grain coating chlorite is abundant in the reservoir sands and has an adverse effect on both porosity and permeability, but also may have had a beneficial effect by protecting detrital quartz from pervasive cementation by quartz overgrowths.



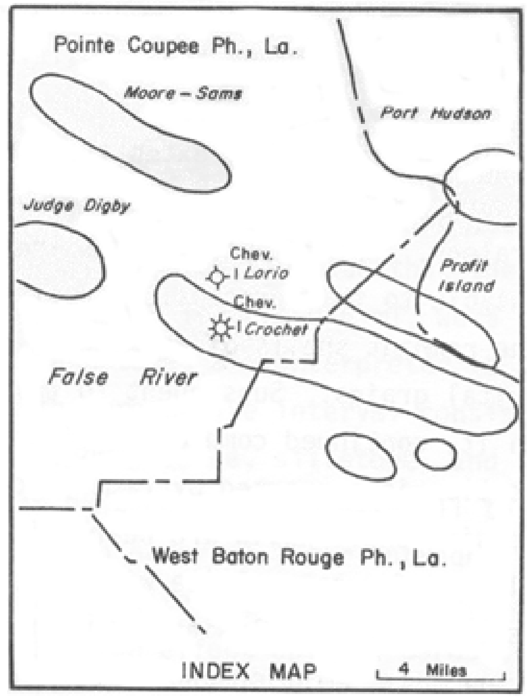
SEM micrograph of secondary porosity, Chevron No. 3 Alma Plantation, Pointe Coupe Parish, Louisiana. 20,139'; 25.3% porosity; and 307 md permability.

Original primary porosity in False River reservoir sandstones, estimated at 42%, has been reduced by early mechanical compaction, followed by pressure solution, cementation, and finally by late mechanical compaction, followed by pressure solution, cementation, and finally by late mechanical compaction. Present porosities of 20-25% in many of the fine- to medium-grained sandstones are much higher than would normally be anticipated, in view of the porosity reducing processes that can be identified and the great depth of burial. Examination of thin sections and scanning electron photomicrographs reveal extensive partial and total leaching of 15% to 20% of the framework grains. Most of the leached grains probably had an original silicate mineralogy. Point count studies indicate that 20% of the total porosity may be attributable to this process. Porosity created in this manner is easily identified by the remnant shells of authigenic chlorite which remains after dissolution of the detrital grains. Subsequent to this grain leaching, or most likely concomitant with it, continued compaction of the reservoir sandstones occurred. This interpretation is supported by remnant chlorite shells that were compacted until the opposing shell walls are nearly in contact. The occurrence of euhedral quartz crystals and ferroan calcite within many of the collapsed or crushed chlorite shells represent a closing stage of diagenesis. Continued porosity reduction through pressure solution and cementation would have destroyed reservoir capacity if geopressuring of the Tuscaloosa interval had not occurred soon after grain dissolution.

False River Field is an example of production from reservoir sandstones with a capacity greatly enhanced by secondary porosity. Mineralogical immaturity of the original Tuscaloosa sediment and geopressuring of sandstones that experienced a complex history of compaction, cementation, and dissolution are believed to be significant factors that have combined to produce this deep occurrence of unusually high porosity.

Sedimentology of the "19,800 Foot" Tuscaloosa Sandstone, False River Field, Pointe Coupee and West Baton Rouge Parishes, Louisiana

Smith, G.W., Chevron USA, New Orleans, LA (p. 30-31)



The "19,000 Foot" sandstone in False River Field has been cored in four of the productive wells and in two of the dry holes. Sedimentological studies of False River sandstones are based on these cores. From the total 994 ft of core, approximately 200 ft from the Chevron No. 1 W.A. Lorio, Jr and No. 1 Crochet have been selected for display to illustrate lithology, bed relationships, and sedimentary structures. Fine- to medium-grained moderately well to well sorted reservoir sandstones that tend to be massive, and occasionally friable, occur at the top of a gradational, coarsening upward sequence of shale, siltstones, and very fine- to fine-grained carbonaceous sandstone. Individual sandstones within the productive interval seldom exceed 40 ft. Wire-line log response can be generally be related directly to lithologic and grain-size changes.

Sandstone composition, determined by X-ray diffraction, has been correlated with standard porosity and permeability measurements. Reservoir porosities frequently exceed 20% and permeability measurements. Reservoir porosities frequently exceed 20% and permeabilities exceeding 100 md are common. Permeability rarely exceeds 0.1md when the porosity is less than 15%. High porosity values are related to minor cementation of the grain framework and selective grain dissolution which contributes significant secondary porosity. Thin section and SEM micrographs illustrate distribution and paragensis of the cements and the primary and secondary pore systems.

A depositional model based on the sedimentology and paleontology of the False River sandstones in the "19,800 Foot" interval proposes a possible interpretation of reservoir geometry and depositional environment.

Log Evaluation of Wells in the Tuscaloosa Trend of South Louisiana

Stevenson, John, Schlumberger Well Services, New Orleans, LA (p. 31-32)

The Tuscaloosa Trend of South Louisiana provides many challenges to oil and gas operators. The producing horizons are found below a depth of 16,000 ft where formation temperatures approach 400°F (204°C) and pressure gradients vary from 0.459 psi/ft to 0.96 psi/ft. Production tests have shown the presence of CO_2 and H_2S and have revealed that formation water salinities vary from 11,500 ppm NaCl to 120,000 ppm NaCl. Salinities vary both vertically and laterally within the formation.

The combination of depth, high temperature, and varying pressure gradients, along with the presence of CO_2 and H_2S, complicates drilling procedures, usually resulting in the need for oil based mud below a depth of about 16,000 ft. Logging tools used to evaluate these formations must operate in this hostile environment. Various combinations of tools applicable to Tuscaloosa evaluation are discussed, as well as their limitations. The difficulties in calculating formation water salinities from logs in an oil base mud are discussed.

Preservation of Porosity in the Deep Woodbine/Tuscaloosa Trend, Louisiana

Thomson, Alan, Shell Oil Company, New Orleans, LA (p. 32-34)

Cores of the Woodbine/Tuscaloosa Formation from False RIver Field, Pointe Coupee Parish, Louisiana, contain sandstones from 20,000 ft with anomalously high porosities and permeabilities. Porosities greater than 25% and permeabilities of hundreds of millidarcies are common. Scanning electron microscopy shows that individual grains of these olive-green, semi-friable sandstones are coated with chlorite. The chlorite occurs as 7-10μ-wide hexagonal plates which arrange themselves edgewise one crystal thick on grain surfaces. Sandstones with more or less continuous chlorite coatings around quartz grains display little framework compaction and minor development of secondary quartz overgrowths; however, interbedded sandstones with little or no chlorite are often completely cemented by secondary quartz. Intermediate between these extremes are sandstones with incomplete or poorly developed chlorite coatings; these display outgrowths of secondary quartz rather overgrowths of an envelope nature.

Petrographic and SEM data indicate an early diagenetic origin for the chlorite which apparently ceased to form once detrital grains were coated with a single layer of crystals. This layer was sufficient to mask nucleation sites for silica overgrowths, and in addition may have prevented compaction by pressure solution, thereby allowing the sandstones to be buried to great depths without appreciably reducing porosity.

The chlorite was probably derived from ultrabasic volcanic detritus which is present in the sandstones to varying degrees. The source of this detritus can be traced to the peridotite belt of southern Arkansas.

DEPTH [FT]	$_s$ (Millidarcies)	POROSITY (%)	Oil Sat. (% Pore)	Total Water (% Pore)
19,783	0.1	2.2	0.0	59.2
19.901	0.1	7.6	0.0	76.3
19,902	0.2	14.9	0.0	48.3
19,903	0.1	9.9	0.0	70.7
19,908	0.1	13.7	0.0	59.8
19,909	28.0	21.4	0.5	60.7
19,910	26.0	20.1	0.5	53.7
19,911	36.0	25.9	1.9	72.5
19,927	10.0	22.5	1.8	72.5
19,928	1249.0	26.0	1.9	74.6
19,929	680.0	29.0	1.4	81.0

19,930	150.0	28.7	1.0	53.0
19,931	0.1	22.4	0.0	63.8
19,932	6.1	21.3	0.5	54.5
19,933	13.0	21.8	0.0	46.3
19,934	4.1	20.2	0.5	51.5
19,935	9.3	18.0	0.6	48.3
19,936	1.3	16.7	1.8	55.0
19,937	0.3	16.1	1.9	51.6<
19,938	6.7	22.7	0.9	52.3
19,939	0.5	14.2	1.4	57.7
19,940	0.2	12.8	1.6	49.2
19,941	0.2	15.1	0.0	52.3
19,942	0.1	13.7	2.2	53.2
19,943	0.1	9.0	0.0	61.3
19,944	0.1	8.6	2.3	67.4
19,945	0.1	6.2	0.0	77.2
19,946	0.1	9.5	0.0	69.4
19948	0.1	5.3	0.0	68.0
19949.5	0.1	5.0	0.0	62.1

Figure 1: Core analysis of portion of cores from the Chevron Crochet No. 1 well.

DEPTH [FT]	K_s (Millidarcies)	POROSITY (%)	Oil Sat. (% Pore)	Total Water (% Pore)
21,180.5 - 81	2.8	20.7	68.1	19.3
21,181.5 - 82	1.2	26.0	54.6	14.2
21,182.5 - 83	0.5	15.1	40.4	23.8
21,183.5 - 84	0.1	14.3	14.7	41.8
21,184.5 - 85	0.1	9.7	21.7	36.0
21,185.5 - 86	0.1	4.1	26.8	46.3
21,186.5 - 87	0.1	16.4	12.2	42.7
21,187.5 - 88	0.1	16.3	10.4	36.2
21,188.5 - 89	0.1	4.1	17.1	41.6
21,189.5 - 90	21.0	23.9	37.2	19.2
21,190.5 - 91	72.0	24.1	67.7	22.4
21,191.5 - 92	27.0	25.6	68.2	21.9
21,192.5 - 93	0.6	16.1	29.2	32.3
21,193.5 - 94	0.7	20.4	28.4	28.4

21,194.5 - 95	0.9	14.4	20.2	29.9
21,195.5 - 96	1.1	20.0	48.5	17.5
21,196.5 - 97	0.1	7.8	11.6	34.6

Figure 2: Core analysis of portion of core from Chevron, Alma Plantation No. 1 well.

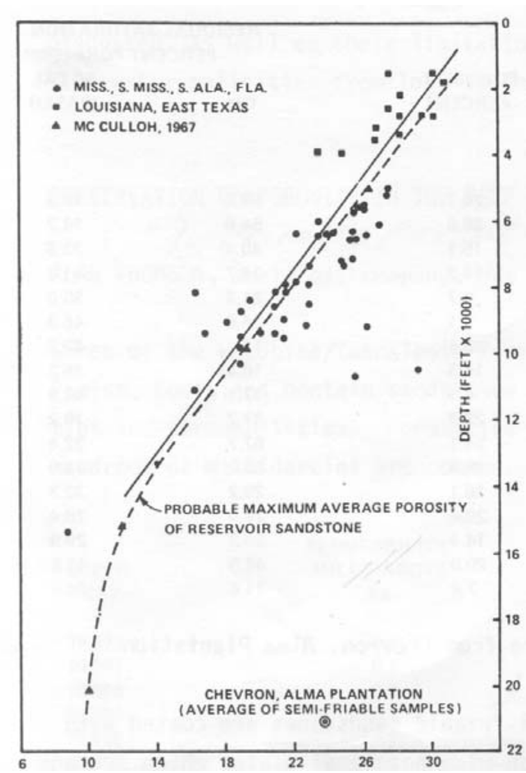


Figure 3: Porosity/ depth relationship for some typical Upper Cretaceous sandstones of the Gulf Coast (solid lines) compared to McCulloh's probable maximum average porosity of reservoir sandstone (dashed line). Note position of deep Woodbine-Tuscaloosa data.

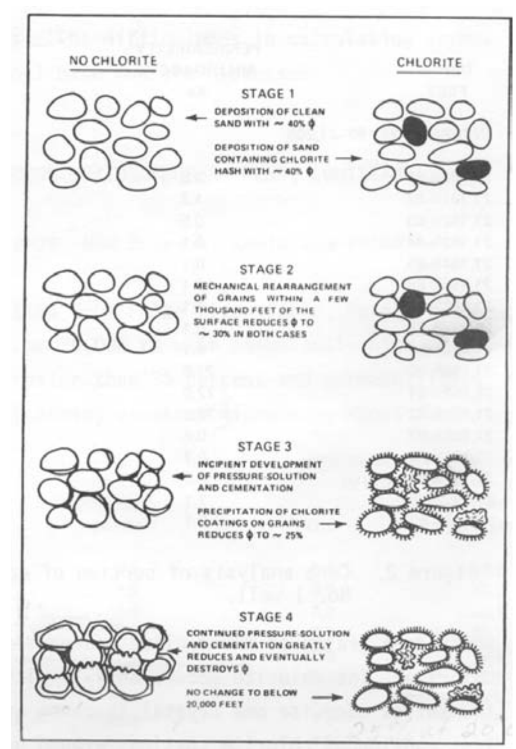


Figure 4: Summary of the diagenetic history of the deep Woodbine/Tuscaloosa sandstones in False River Field.

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Diagenesis of Deep Woodbine-Tuscaloosa Sandstones as Exemplified by a Core in Shell, Crown Zellerbach No. 1, Livingdton Parish, Louisiana

Thomson, Alan, Shell Oil Company, New Orleans, LA (p. 35)

This short core, along with core photographs, core analyses, isotope data, and thin section and SEM photomicrographs illustrates well the role played by diagensis in both the reduction and preservation of porosity in the deep Woodbine-Tuscaloosa sandstones. Porosity, as well as permeability, correlate closely with the physical appearance of the rocks; greenish-brown, semi-friable rocks have porosities and permeabilities averaging 24% and 227 md, respectively. White to gray, tight rocks have undergone a "normal" diagenetic history of loss of porosity at these depths by cementation and compaction. The porous rocks retain high porosities because of thin coatings of diagenetic chlorite around detrital quartz grains, which served to inhibit the development of quartz overgrowths. The chlorite formed when the rocks had been buried to a depth of about 5,000 ft, as shown by oxygen isotope data from associated calcite cements. The cements can be demonstrated petrographically to have formed both pre- and post-chlorite.

Environment of Deposition and Reservoir Characteristics of the Woodbine-Eagleford Sandstone, Kurten Field, Brazos County, Texas

Turner, J.R., Braddock Expl. Co., Shreveport. LA., and **S.J. Conger** Gulf Oil Co., Houston, TX (p. 35-36)

The Upper Cretaceous Woodbine-Eagleford sandstones produce oil and gas from a stratigraphic trap at Kurten Field located on the southwest flank of the East Texas Embayment in Brazos County, Texas. Total thickness of the sandstones is about 75 ft and consists of five sandstone units designated from top to bottom as "A" through "E." The "C" and "D" units are elongate north to south, about 4.5 mi wide and over 10 mi long. The "B" and "E" units consist of wider spread but thinner northeast-southwest trending sandstone units.

Overall, the "B," "C," and "D" sandstones show the following bedding sequence from bottom to top: (1) black marine shale with a gradational upper contact; (2) silt and very fine-grained sandstone interbedded with shale stringers, bedsets ranging from one-half to five inches thick, gradational upward; (3) intensely bioturbated silty, clayey, very fine-grained sandstone coarsening upward; (4) clean sparsely bioturbated sandstone coarsening upward with flaser-like cross-bedding; (5) slightly more clayey, finer grained, flaser cross-bedded sandstone with increasing amounts of bioturbation upward; and (6) gradational contact into marine shale. The "E" sandstone is characterized by repeating bedsets consisting of massive to indistinctly laminated beds that grade upward into distinct, wavy laminations that grade upward into distinct, wavy laminations that grade into marine shale.

The mean quartz grain size is 0.14 mm (fine-grained sand), with means ranging from 0.09 mm to 0.18mm, and sands are moderately sorted. Compositionally, the sandstones average 66% quartz, one percent feldspar, two percent rock fragments, and 28% matrix

The Kurten "B," "C," and "D" sandstones are interpreted as offshore bars which built to fair-weather wave base. Numerous arenaceous foraminifera, rare small planktonic foraminifera, and late Turonian nannofossils occur sporadically throughout, and trace fossils suggest a shelf environment. These sandstones were derived probably from the Harris Delta 12 mi to the east and reworked later by tidal currents and storms. The "E" sandstone is interpreted as a shelf turbidite probably generated by storm action. The surrounding marine shales contain numerous small, planktonic foraminifera, arenaceous foraminifera, mollusk fragments, and reworked Early Cretaceous palynomorphs.

Core analysis and thin-section examination shows that the maximum amount of porosity occurs in the muddy, bioturbated facies and is diagenetic; very little porosity occurs in the clean sand facies, which is cemented by quartz overgrowths. The sequence of diagenetic events appears to be (1) development of poikilotopic calcite cement, (2) dissolution of less stable components such as feldspar, volcanoclastics, and calcite cement, and (3) development of quartz overgrowths. Dissolution occurred probably as fresher water entered the sandstones during the development of the base of Austin unconformity, when Kurten was uplifted to the south, and the "A," "B," and "C" sand units were truncated The result is a more porous and permeable reservoir on the south end of the field which becomes progressively less permeable northward. The north limit of the field is defined by a combination of facies change and permeability occlusion due to the lack of secondary porosity, making Kurten Field a diagenetic as well as stratigraphic trap.

Seismic Stratigraphy of Seven Oaks Field, Polk County, Texas

Ward, J.A., Teknica, Inc., Houston, TX (p. 37)

Seven Oaks Field in Polk County, Texas produces from Woodbine sandstones at depths of 12,000 to 12,500 ft having 10 to 100 ft of net pay. Approximately 10 mi of geophysical data were processed by Teknica Inc. for a Seislog format to determine whether the trap could be mapped seismically. Explorationists are able to define general areas of Woodbine truncation on conventional seismic sections, although recognition of the precise subcrop edge of producing sandstones has not been possible. Geologic horizons can be identified by converting each seismic trace to an impedance log and using well data for calibration. In this manner, composite high velocity units interpreted as Woodbine sandstones can be mapped seismically. The Seislog section illustrates geologically angular discordance between the Woodbine and overlying Austin Chalk. Definition of the Woodbine subcrop updip from the Highland Resources No. 1 well provides excellent delineation of the producing sandstones. Genetic relationship of the Woodbine edge with underlying Edwards-Buda reefing is clear also because Woodbine truncation conforms closely with steep dips in the underlying Buda. South of the field, Seislog units show stratigraphy that could be interpreted as Woodbine truncation similar to that of the producing region. Alternatively, this feature could be interpreted as a pinch out of a basal Navarro limestone.

Woodbine Sandstones as a Geothermal Source<

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Woodbine sandstones are important aquifers in the shallow subsurface near the formation outcrop from Hill County, Texas, north of the Red River. The sandstones yielding potable water are locally thin and discontinuous and originated as barriers and other strike-oriented marine facies aligned roughly parallel to the outcrop trend. Hence, in this area, there are not well-developed dif-fed sand trends to serve as avenues for recharge and enhancement of well yield and water quality. Farther downdip, some wells produce ground water at temperatures in excess of 90°F (32°C), and despite elevated salinities, numerous towns and homes presently produce this water for domestic and municipal supplies, These warm water wells, producing from depths ranging from approximately 1600 ft (488 m) to more than 2300 ft (700 m), consitute a potential low grade energy resource for space heating and domestic hot water. Presently, a project is underway to use Woodbine ground water at 126°F (52°C) for heating one building at Navarro Junior College at Corsicana.

Warm water resources of this kind may be delineated and assessed in a preliminary fashion on the basis of traditional methods of basin analysis. In general, the Woodbine aquifer displays a negative correlation between sand thickness and concentration of dissolved solids. Water level, on the other hand, shows no consistent relation to sand distribution. Instead, water level contours follow closely the structural contours on the formation top with anomalously shallow water level closures that align with the Trinity and Red rivers. This pattern suggests that, even though the aquifer is under artesian conditions, there is some recharge through confining beds from superjacent perennial streams. Water temperature values also closely align with structural contours: the 90°F (32°C) contour generally lies close to the 1000 ft (below msl) datum. These data represent a geothermal gradient on the basis of water temperatures of approximately 1.6°F/100 ft (29.15°C/km)which is slightly higher than the 1.25° to 1.5°/100 ft (22.7° to 27.33°C/km) value computed on the basis of bottom hole temperatures.

In Delta County and adjacent areas along strike of the Talco Fault Zone, a combination of relatively shallow depth, thick dip-fed sandstones, and moderately high geothermal gradients (greater than 1.5°F/100 ft or 27.33°C/km) indicate promise for obtaining thermal water of moderate salinity in an area where the Woodbine is not presently tapped as a water supply.