and slivers, presumed to be driftwood permineralized after burial. *Callixylon* fossils are most abundant in the upper part of the Clegg Creek Member of the New Albany shale ()Famennian) and equivalent strata in western New York, Ohio, and contiguous areas, perhaps because these Progymnosperms reached the zenith of their development at that time. They also occur sporadically throughout the New Albany shale and equivalent strata. The principal geographic concentration of *Callixylon* is in western New York, principally in marine sediments, and on the west side of the Cincinnati arch. *Callixylon* is also sparsely and sporadically distributed in nearly all areas of outcrop of the Devonian black shales including the New Albany, Antrim, Kettle Point, and Ohio shales, and is found in Kinderhookian age shales from Illinois and Tennessee.

A second, and later, flora consists principally of permineralized wood pieces (phosphatized free-wood or concretions) of stems, rachises, petioles, and possibly even mid-veins of pinnules of diverse members of the Lycopsida, Sphenopsida, Cladoxylales, Coenopteridales, Progymnospermae, and Pteridospermae. A few of these disjunct pieces have been reconstructed into more complete plants known from the Catskill delta in western New York, Pennsylvania, and West Virginia. The principal concentration of these stem and petiolar segments is in the Falling Run Member of Sanderson Formation of the New Albany shale on the west side of the Cincinnati arch in southern Indiana and Kentucky, and in central Kentucky in the low saddle between the Cincinnati arch proper and its southward extension as the Nashville dome. This abundant distribution of minute stem axes and other such small plat fragments strongly suggests the source of these palnts to be a nearby island (Cincinnatia?). Alternatively, it is proposed that they have been concentrated by currents on a very shallow choal on or near a structurally positive submarine rise of the Cincinnati arch, or by floating algal mats in which the water-worn wood and leaf fragments became enmeshed as flotsam near some shore and were transported by these mats to more distant sites before the disintegration of the mats.

The third type of macrofossil palnt assemblage is constituted of *Foerstia*. These plants are considered to be algal in origin and indicate no clear relationship either to distance from shore or depth of water. The main concentration is in middle and lower New Albany shale and equivalents. It is also found sparingly in West Virginia and Michigan and much farther west (one specimen from the Exshaw shale of Montana).

CURRAN, H. ALLEN, Smith College, Northamption, MA

Ichnology of Pleistocene Carbonates on San Salvador, Bahamas

Trace fossils, well preserved and in full relief, occur sporadically in Pleistocene carbonates of intertidal and shallow subtidal origin on San Salvador, Bahamas. Most prominent are irregular boxworks of *Ophiomorpha* sp., which occur in a subtidal, current-bedded, medium to coarse skeletal calcarenite facies associated with an underlying coral-algal reef facies. *Ophiomorpha* sp. also occurs in the form of more isolated shaft an dtunnel systems in cross-stratified, coarse *Halimeda*-rich calcarenites deposited in a tidal delta paleoenvironment. Burrow tues have thick walls (2 to 3 mm, .08 to .1 in.) of micritic material and distinctly mammillated to rugose exterior surfaces; tube outside diameters are 1 to 2.5 cm (.4 to 1 in.). Although *Ophiomorpha* sp. exhibits an obviously pelleted exterior surface, the pattern of pellet arrangements is not nearly as regular or distinct as that normally found in *Ophiomorpha nodosa* preserved in siliciclastic sediments. Occurring with *Ophiomorpha* sp., commonly in abundance, are vertical burrow tubes less than 1 cm (.4 in.) in outside diameter and with lengths of up to 15 cm (6 in.). These tubes are assigned to *Skolithos*, and two or more types are present.

Rhizocretions formed of calcrete and presumably initiated by the action of plant roots occur commonly in most facies on San Salvador, and they can easily be mistaken for trace ffossils of invertebrate origin, particularly *Ophiomorpha* sp. Criteria for distinguishing *Ophiomorpha* sp. from rhizocretions include the following. (1) *Ophiomorpha* sp. has a distinct lining of regular thickness, and individual segments of the burrow system have consistent diameter; rhizocretions do nto have a distinct lining and are irregular in diameter. (2) The interior surface of *Ophiomorpha* sp. is smooth and the exterior surface distinctly mammillated; rhizocretions have highly variable interior and exterior surface. (3) *Ophiomorpha* sp. compelxes have much more consistent patterns of shaft/tunnel arrangement than exhibited by rhizocretion systems.

Calcarenites of beach facies are widespread along the coastline of the island, but these facies do *not* contain *Ophiomorpha* sp. In few places, these facies have unlined vertical burrows of variable diameter and trails, both attributable to the activity of crabs. The modern marine carbonate environments surrounding SanSalvador exhibit much trace-making activity and provide analogs for further interpretation of the Pleistocene trace fossils and their associated paleoenvironments.

DAHL, H. M., C. A. CALLENDER, and P. A. SCHROEDER, Texaco, Inc., Bellaire, TX

Geologic Factors Influencing Reservoir Performance at Texaco's Salem Tertiary Recovery Project, Marion County, Illinois

A detailed lithologic reservoir study was conducted to aid Texaco personnel in designing and monitoring an experimental surfactant-polymer flood in the Mississippian Benoist Sandstone, one of several producing formations in the Salem field of south-central Illinois. Twelve elongated five-spot patterns are distributed over the 60-acre (24 ha.) project area. The Benoist Sandstone averages about 49 ft (15 m) of net pay at a depth of about 1,800 ft (550 m). Cores from eight wells were studied in detail. Particular attention was paid to variations in sedimentary structures, lithology, and mineralogy that could influence reservoir performance. Techniques employed in this study included examination of slabbed cores, thin-section petrography, X-ray diffraction (XRD) mineralogy, and scanning electron microscopy/energy dispersive spectrometry (SEM/EDS).

The Benoist Sandstone is one of several Late Mississippian deltaic sandstone units deposited in the subsiding Illinois basin. These sandstones are bounded above and below by fossiliferous marine limestone and shale. Delta-front sandstones, hereafter referred to as bar-finger sandstones, comprise the bulk of the formation. Channel-fill deposits are found near the base of the unit and nonreservoir, tidal-flat deposits near the top. The bar-finger deposits are moderately to well-sorted, fine to medium-grained sandstones with horizontal to inclined planar bedding and some ripple and planar cross-bedding. The planar bedding is accentuated by clay and mica-rich layers, one millimeter to several centimeters thick. These shale layers increase and thicken upward, and separate the bar-finger sands into several reservoir units.

The Benoist sandstones are quartzose, containing 70 to 98% monocrystalline and polycrystalline quartz and small amounts of detrital feldspar and shale clasts. Cement is predominantly quartz in the form of syntaxial overgrowths, with minor calcite. Small amounts of clay occur as detrital laminae, authigenic pore fillings, and sand-grain coatings. The percentage of detrital and authigenic clay increases near the top of the bar-finger sandstone and significantly reduces permeability. Illite, the dominant clay, occurs as both grain coats and pore bridgings, kaolinite forms scattered pore fills, and Fe-chlorite coats a few grains.

The channel-fill deposits are well to poorly sorted, very fine to medium-grained sandstones, commonly conglomeratic, and contain calcite-cemented zones. These deposits are mineralogically similar to the bar-finger deposits but contain abundant shale and fossil fragments at the base. Noncalcareous channel sandstones are characterized by scattered Fe-chlorite grain coatings and pore-filling illite.

Intergranular porosity is well developed and has not been severely reduced by the pervasive quartz overgrowth cementation. The eastern part of the project area contains a higher quality reservoir section because of the sparsity of clay zones in the bar-finger sandstone and the thicker channel-fill deposits in this area. Secondary porosity, produced by the dissolution of feldspar grains, has slightly enhanced the overall quality of the Benoist Sandstone.

D'ALUISIO-GUERRIERI, GARY, Aminoil USA, Inc., Lafayette, LA, and RICHARD A. DAVIS, JR., Univ. South Florida, Tampa, FL

Holocene Infilling of Coastal Lagoons by Mixed Terrigenous Siliciclastic and Marine Carbonate Sediments, Vieques, Puerto Rico

Infilling of coastal lagoons along the southern coast of Vieques, Puerto Rico, during the Holocene transgression is the result of contributions from both terrigenous siliciclastic and marine carbonate sources. Four lagoons displaying varying infilling and interaction with open marine waters were chosen for detailed stratigraphic study. Cores taken perpendicular to modern lithotope trends show a well-defined sequence that is similar throughout the lagoons. The stratigraphy also defines two distinct origins of the lagoonal basins: those resulting from sheltering provided by Oligocene-Miocene limestones and those developed by accretion of beach ridges seaward of shallow embayments.

Sedimentation in both types of lagoons began with deposition of terrigenous colluvium. Rising sea level was accompanied by storm-generated marine derived gravels that accumulated above the colluvium. Intertidal mud-flat facies and subsequent *Diplanthera* peat deposits denote the existence of restricted intertidal and subtidal environments respectively. These facies were overlain by molluscan gravel and *Halimeda* sand indicating increased water depth and improved circulation with the open marine environment. Mangrove peats are prominent in cores from the lagoonal margins. They show seaward migration of this environment as terrigenous sediment continued to prograde into the lagoons.

Lagoonal margins display a terrigenous, siliciclastic-dominated progradational sequence, whereas the central and seaward portions display a mixed siliciclastic and carbonate transgressive sequence. These sequences occur in close geographic proximity and could provide problems of interpretation for the geologist concerned with the ancient record if detailed stratigraphic data were not available.

DAVIES, DAVID K., David K. Davies & Assocs., Inc., Kingwood, TX, and ROBERT B. TRUMAN, Res Tech, Inc., Houston, TX

Effects of Clays on Well Economics, Wire-Line Log Interpretation, and Completions

Composition and distribution of clays (both as clay minerals and true shales) can have a direct impact on the day-to-day and long-term economic performance of a well. Clays affect the following:

(1) Distribution and quantity of interstitial fluids (i.e., value of reserves in place). The specific composition of dispersed (authigenic) clays controls the surface area of the pore system. Water bound in micropores created by these dispersed clays can comprise $\pm 70\%$ of fluid volume, but the well may produce water-free hydrocarbons. In such shaly sands, calculation of S_w by itself often may not identify either the amount or type of fluid production. It can predict the presence of hydrocarbons, but is not an optimum indicator of fluid production.

(2) Rate of production (i.e., time value of reserves). The distribution of clays affects rate of production. Laminar clays will not reduce flow rates as significantly as dispersed clays. For example, a sand containing 20% clay distributed as laminae will have its net pay reduced by 20%. Production from the sand laminae is not affected by the clay. However, a sand with 20% clay dispersed in 30% pore space may not produce economic quantities of hydrocarbons. Furthermore certain clay minerals, such as fibrous illite, can significantly increase flow tortuosity and reduce daily flow rates.

(3) Wire-line log response (i.e., bypassed production). Calculated values of S_w, porosity, and V_{shale} must be interpreted considering clay type and shale distribution. High values of log derived S_w can indicate (a) highly productive laminated sand-shale sequences, (b) low permeability dispersed clay production, or (c) water production. Calculated porosities depend upon assumptions of rock density, which can be significantly altered by the presence of shales. V_{shale} is calculated from the gamma ray response, yet three of the four major families of clay minerals are nonradioactive and do not have any effect upon gamma response. Much production is bypassed due to inadequate knowledge of clay composition in potential horizons.

(4) Completion. The role of clay minerals on completion procedures is well documented. Clay minerals dispersed in pores can interact with common well-bore fluids and irreparably damage potentially productive sands. A knowledge of detailed clay compositions is vital to successful stimulation effects. Individual wells or whole zones can be written off as nonproductive if inappropriately designed stimulation efforts prove unsuccessful.

Identification of bypassed production and incorrectly stimulated zones are particularly important during field development because of the heavy front-end investment necessitated by development. Once this investment is made, then hydrocarbon-productive zones that were not obvious or considered uneconomic during exploratory evaluation, become important targets. Experience suggests that much bypassed production contains unusual clay content or clay distribution.

DAVIS, BARBARA A., and RAY E. FERRELL, Louisiana State Univ., Baton Rouge, LA

Fluid Movement and Diagenesis in Fine-Grained Geopressured Sediments of Frio Formation (Oligocene), Kaplan Field, Southwestern Louisiana

Investigation of structure, temperature, pressure, salinity, and core samples at Kaplan field yields information on diagenesis of fine-grained sandstones deposited in an outer shelf/upper slope depositional environment. Cross sections and structural maps reveal a domal structure at 15,000 ft (4,572 m) of depth and a northeast-striking growth fault. Post depositional faults occur at shallower depths (11,500 ft; 3,505 m). A large growth fault forms the northern border of the study area. The shallow occurrence of