7,000 years in which to remove 1,500 to 2,000 km^3 of material. It is highly probable, therefore, that the canyon originated from massive shelf-edge slope failure on an unstable continental margin. A series of successive failures, each one creating an upslope instability that triggered the next failure, caused an elongate trough to form that excavated the canyon to a depth of 4,000 ft (1,220 m) below present sea level. Once the canyon had formed, its steep side walls continued to be unstable, and sediments slumped into the canyon axis, forming the initial canyon fill. This phase is well documented: the lowermost sediment fill is composed of displaced material similar to that now found on the canyon rim.

Large scars from sidewall failures can also be easily mapped on the seismic data. From 20,000 years to approximately 5,000 years B.P., a series of late Wisconsin and Holocene delta lobes formed, which were responsible for the remainder of the fill of the canyon. During the past 5,000 years only a thin deep-water pelagic drape has been deposited within the canyon. Maps have been constructed that depict the various horizons, and the geometry of these horizons verify this mode of formation.

COLEMAN, NEIL M. , Somerset, PA, and MARK T. STEWART, Univ. South Florida, Tampa, FL

Basement Structure in Northwest Peninsular Florida

Results of a recently completed gravity investigation suggest that basement offsets produced by normal faulting are the sources of observed gravity and magnetic anomalies in northwest peninsular Florida (Lafayette, Dixie, Gilchrist, and Levy Counties). A series of parallel fault-block basins and uplifts is proposed as the dominant basement structure. These basins and uplifts and the Southwest Georgia Embayment developed in response to the same regional stress field in early Mesozoic time.

Two-hundred sixteen gravity stations have been established and correlated with the International Gravity Standardization Net. Bouguer anomaly values have been derived for each station and regional gravity components analyzed, using trend-surface analyses. Geologic cross sections have been made on the basis of available stratigraphic information. The gravity effect for each section was calculated, using the method of polygons. Basement structural interpretations were iteratively adjusted within geologic constraints until close agreement was achieved between calculated and observed gravity profiles.

CONTI, ROB, Bur. Econ. Geology, Univ. Texas at Austin, Austin, TX

Stratigraphic Distribution of Hydrocarbons with Differing API Gravities in East Texas Basin

In studying the stratigraphic and geographic distributions of oils initially produced from seven East Texas Cretaceous formations, the effects of depth, temperature, and rate of burial on increasing hydrocarbon maturation, expressed as increasing API gravity, can be determined statistically. Analysis of both linear-regression and data-density trends indicates that API gravity increases as the oil matures during burial. Linear-regression analyses yield positive API-gravity gradients and low correlation coefficients for the data populations. Data-density trends show well-delineated and differing API-gravity gradients with ordinal and abscissal limits.

From younger to older formations, there are two main trends of increasing API gravity. The oil from sub-Clarksville reservoirs, showing the best-delineated high API-gravity gradient, represents one main trend. The oils from Woodbine and Paluxy reservoirs show both main trends; API gravity increases rapidly, then slowly, as burial continues. The oils from Glen Rose, Rodessa, Pettet, and Travis Peak reservoirs show the second main trend, that is, a low API-gravity gradient. A composite plot for the seven formations, showing one curvilinear trend, with both high and low API-gravity gradients, implies different radiocarbon maturation rates tor the East Texas oils. Almost all maturation trends are within a temperature range of 110 to 250°F (43 to 121°C), which falls below the theoretical temperature window of 250 to 350°F (121 to 177°C) for maximum hydrocarbon generation.

For each formation, the geographic distributions of API gravity, depth of burial, and formation temperature establish a stratigraphic, geographic, and tectonic framework for studying the statistical distributions. Generally, high API gravity oils have been produced from the deep southern and shallow eastern parts of the basin. Lower API gravity oils are produced from the northern and western shallow parts of the basin.

DOKKA, ROY K., Louisiana State Univ., Baton Rouge, LA

Implications of Fission-Track Ages from Kaplan Geothermal-Geopressure Zone, Vermilion Parish, Louisiana

Apatite and zircon mineral separates were extracted from cores from near the bottom of two geopressured-geothermal wells in Vermilion Parish, southern Louisiana, and dated by the fission-track method. Samples were taken in the sandstone units of the Oligocene age Frio Formation. The purpose of the study was to determine if fission-track clocks had been affected by long-term heating within the zone. Downhole temperature measurements indicate that the samples are currently at ~277°F (136°C) and ~338°F (169°C). Fission-track clocks, such as apatite and zircon, lose their tracks when subjected to temperatures of ~212°F (100°C) and ~ 347°F (175°C), respectively, for geologically significant periods of time (1 m.y.).

Results show that apatite clocks were reset to 0 m.y. whereas zircon yielded ages of 82 and 88 m.y. (Cretaceous). If bottom-hole temperatures are reliable, then the data suggest the following. (1) Zircon ages are relict, reflecting times of cooling of the volcanic, plutonic, or metamorphic source. The Frio Formation in southern Louisiana was at least in part derived from a Cretaceous or older source. Such cooling ages are common in the Ouachitas, southern Appalachians, and the Gulf coast plain. (2) Reset apatite and relict zircon ages suggest that temperatures within the geopressured zone have probably not been any higher than the 347°F (175°C) they are today.

EVERETT, ROBERT W., JR., Texaco Inc., New Orleans, LA

Using Nannofossil Counts in Interpretation of Subsurface Deltas

The Balize delta in Plaquemines Parish, Louisiana, and the six preceding Holocene deltas offer models for subsurface interpretation. Nannoplankton counts were made from 65 bottom samples from the shelf area of the Gulf of Mexico off Louisiana. This work indicated a correlation between surface salinity and nannoplankton counts. In the subsurface, an ecology of outer middle neritic (water depth approximately 120 ft; 37 m) or deeper, accompanied by low (less than 5,000 per slide) nannofossil counts, indicates a deltaic environment. The Miocene *Cristellaria* "I" Hollywood and Krumbhaar sands, which were deposited by prograding deltas, are examples of nannofossil counts applied to subsurface deltaic interpretation. The major hydrocarbon reserves at the Hollywood and Houma fields are attributed to thick prodelta shale (low nannofossil counts) prior to sand deposition. This thick shale triggered faults and diapiric structures that were timed perfectly for receiving the early-migrating hydrocarbons.

The Hollywood and Krumbhaar deltas prograded over the thick shale depositing distributary-mouth bar sands. Accumulation in the Krumbhaar sand at the Hollywood and Houma fields was controlled by the lenticular nature of the distributary-mouth bar sand. Distributary-mouth bar sand "E" contains most of the reserves discovered to date in the Krumbhaar sand. Perfectly timed structure, faulting, and lenticular deltaic sand are responsible for this geographic concentration of hydrocarbons in a sand covering an area of 50 by 100 m (80 by 160 km).

The Krumbhaar sand was deposited by two distinct and separate deltas. The deltaic environmental setting for hydrocarbon accumulation in the Houma embayment area compares favorably with a similar Oligocene Vicksburg-Frio delta in Jefferson County, Texas. Deltaic information obtained from this study may serve as a subsurface model for discovering large reserves hidden by subtle deltaic traps.

EWING, THOMAS E., and S. CHRISTOPHER CARAN, Bur. Econ. Geology, Univ. Texas at Austin, Austin, TX

Late Cretaceous Volcanism in South and Central Texas—Stratigraphic, Structural, and Seismic Models

Since their discovery in 1915, hydrocarbon traps in and around "serpentine plugs" have produced about 47 million bbl of oil, and have significant potential for additional small discoveries. Production is from isolated reservoirs within mounds of altered volcanic tuff and associated shoal-water carbonates. A review of the more than 200 volcanic centers and intrusive bodies of south and central Texas has led to development of stratigraphic, structural, and seismic models useful in exploration and production.

The so-called serpentine plugs are largely tuff mounds formed by accumulation of volcanic ash (altered to palagonite) on the sea floor around a submarine volcanic vent. Volcanic activity peaked during deposition of the upper Austin Chalk and lower Taylor Marl (about 80 m.y. ago). After their eruption, the tuff mounds localized the deposition of shoal-water carbonates with good porosity and permeability. Low-permeability, organic-rich marine shale and marl of the Taylor Group capped the carbonates, serving as both a hydrocarbon source and a stratigraphic seal. Compactional draping of overlying San Miguel and Olmos sands, with minor offset faulting, created important additional traps in south Texas.

Central Texas volcanic centers are highly aligned along strike-oriented regional faults and fractures of the Balcones and Luling systems. The magmas in both central and south Texas were ultramafic and alkaline, suggesting that partial melting occurred at depths of about 37 mi (60 km). The magma rose rapidly to the surface, probably in an extensional stress regime controlled by pre-Tertiary Balcones-Luling faults.

The palagonite tuff of a typical, productive volcanic center has low seismic velocity and is encased in high-velocity carbonates. The strong velocity contrast, coupled with the distinctive shape of the tuff mass, yields a characteristic seismic pattern. Modern acoustical techniques, coupled with stratigraphic data, allow accurate delineation of buried tuff mounds and prediction of productive carbonate facies.

FORTUNATO, K. S., Univ. New Orleans, New Orleans, LA (now with Shell Oil Co., New Orleans, LA), and W. C. WARD, Univ. New Orleans, New Orleans, LA

Upper Jurassic–Lower Cretaceous Fan-Delta Complex—La Casita Formation of Saltillo Area, Coahuila, Mexico

The La Casita Formation represents a major influx of terrigenous sediment on the epicontinental shelf of northeastern Mexico during the Late Jurassic and earliest Cretaceous. Near Saltillo, the La Casita can be divided into three major units: (1) a basal unit of carbonaceous siltstone and mudstone, (2) a middle unit which is predominantlv sandstone and pebble conglomerate, and (3) an upper unit of siltstone and fine-grained sandstone with thin limestone and dolomite layers becoming more abundant upward, and grading into the overlying Taraises Formation. The La Casita-Taraises terrigenous sequence is underlain and overlain by shallow-marine limestones.

In the Saltillo area, the La Casita crops out in narrow canyons in breached anticlines of the Sierra Madre Oriental. Consequently, interpretations concerning the depositional framework of the La Casita must be made from vertical sequences exposed in widely spaced canyons. A first-order, single-dependence Markov analysis aids in identifying preferred vertical transitions in lithologically variable parts of the section.

Important aspects of the La Casita in the Saltillo area include: (1) the large-scale depositional sequence of basal shallow-marine mudstones overlain by shallow-marine and alluvial sandstone, conglomerate, and mudstone, which are in turn, overlain by shallow-marine, fine-grained sandstone, mudstone, and carbonate rocks; (2) conglomeratic shallow-marine sediment; (3) textural and mineralogical immaturity; (4) the nonrandom nature of upward lithofacies transitions; and (5) a predominance of coarsening-upward sequences in the middle unit. These characteristics suggest that the La Casita in the Saltillo area records the progradation of a complex of fan deltas.

The lower, fine-grained unit represents Late Jurassic "prodelta" deposits that accumulated on the submarine shelf prior to the influx of coarse sediment. The middle, coarse-grained unit was deposited during the period of maximum seaward advance of the fan-delta complex during latest Jurassic time. This unit contains predominantly coastal and shallow-shelf conglomerate, sandstone, and mudstone, with some distal alluvial-fan conglomerate and sandstone. The upper La Casita records the waning input of coarse sediment as the fan-delta system retreated in earliest Cretaceous time.

FREDERIKSEN, NORMAN O., U.S. Geol. Survey, Reston, VA, THOMAS G. GIBSON, U.S. Geol. Survey, Washington, D.C., and LAUREL M. BYBELL, U. S. Geol. Survey, Reston, VA

Paleocene-Eocene Boundary in Eastern Gulf Coast

The Paleocene-Eocene boundary in Alabama has been placed at various levels within the Tuscahoma Formation and the overlying Bashi Formation. The location of this boundary is important because both lignite- and petroleum-bearing deposits occur within this sequence in the Gulf Coast, and the region appears to be a good locality to test the local coastal-onlap models.

The middle beds of the Tuscahoma Formation are upper Paleocene (calcareous nannofossil Zone NP9 and *Morozovella*