"splinters" a producing upthrown block is present. The closures developed on the regional fault splinters appear to be related to domal growth older than that accounting for the other two producing structures at the south.

Sand development throughout the middle Miocene is best in upper parts of this interval, for deeper in the section some sands lose the blanket characteristic found in shallower zones and instead exhibit a channel-like geometry. The origin of deposition of any particular potential reservoir sand provides the limitations for the shape and extent of the bed and probably is a controlling factor in hydrocarbon accumulation.

J. A. Gilreath, Schlumberger Well Surveying Corporation, New Orleans, Louisiana

Interpretation of Dipmeter Surveys in Mississippi

The study of patterns of closely spaced dip computations throughout the length of continuous dipmeter surveys is producing greatly increased geological information in Mississippi wells. Structural dip (or regional dip if no structure is present) is the basic dip shown by the dipmeter. Superimposed on the basic dip are the dips resulting from faults, unconformities, and local depositional features. These are generally greater than structural dips and in random directions.

Faults are most commonly shown by the increasing dip in the drag zone as the bore-hole approaches the fault plane from the downthrown side. Complex faulting over shallow ridges or domes may be recognized by the change in dips between faulted blocks. Buried bars are detected in wells drilled on the steep slopes by the decreasing dips exhibited by the successively younger beds deposited above them. Other changes in dip indicate the location of unconformities, most of these being reasonably easy to recognize, since they appear at the same general position in the geological column. Cross-bedding shows as erratic dips within sands.

It is emphasized that detailed geological interpretations of the dipmeter survey require numerous closely spaced computations studied in relation to the well log.

Warren A. Grabau, Midwest Research Institute, Kansas City, Missouri

Geology as an Historical Tool

Geology is at best a synthetic science; the general geologist must have a working knowledge of chemistry, physics, biology, mathematics, and many other sciences. This training in a spectrum of skills makes the geologist peculiarly fitted to deal with multiple-variable problems, especially those which can be reduced only to qualitative solutions. Such problems are numerous in historical criticism; history, like geology, is a reconstructive art involving the interplay of large numbers of variables. Many otherwise incomprehensible events, particularly in military history, become logical and understandable when methods of inquiry based on geological information and techniques are applied. Such examples from the Civil War in the Vicksburg area include the location of the ironclad gunboat *Cairo*, the non-intervention of the Confederate trans-Mississippi armies in Grant's march through Louisiana, Grant's decision to march far inland in Mississippi after the battle of Fort Gibson, and several others. Based on such examples, it seems obvious that geologists are not exploiting their peculiar skills to a maximum.

C. C. M. Gutjahr, Shell Development Company, Houston, Texas

Palynology and Its Application in Petroleum Exploration

Palynology, the study of pollen and spores, is the only known universal method by which marine sediments can be correlated with fresh-water sediments. Study of the history of pollen analysis shows a rapid expansion in the use of this technique from 1916 onward. The Royal Dutch Shell Group initiated palynological studies in 1938, and many oil companies now have palynological laboratories.

Pollen and spores can undoubtedly be preserved because the outer wall of the grains is extraordinarily resistant. The chemistry of this outer wall (exine) is unfortunately very poorly understood. Relation to terpenes or similar compounds has been suggested.

Although exact information concerning the distribution of pollen and spores by wind is difficult to obtain, there is considerable evidence that they can be transported very great distances. Transportation by water is important, and examples of Recent studies in the Orinoco Delta, Volga River, and Gulf Coast are discussed.

Pollen and spores can not withstand prolonged oxidation. The spore and pollen wall takes up oxygen (autooxidation). This photo-chemical process adds oxygen molecules to double linkages in the pollen and spore wall, with the formation of peroxides. Since oxygen is the main enemy of the spore and pollen wall, it is obvious that strata deposited in reducing environments commonly contain well preserved pollen and spores.

Determination of ancient shorelines, age determination of Gulf Coast salt, and palynological correlations in Venezuela, Canada, and France are examples of practical applications of the palynological method.

Dudley J. Hughes, Triad Oil and Gas Company, Triad Drilling Company, Inc., Jackson, Mississippi

Faulting Associated with Deep-Seated Salt Domes in Northeast Part of Mississippi Salt Basin

Faulting in the northeast part of the Mississippi salt basin is principally of the local graben-type resulting from salt doming. On deep-seated salt-dome structures, the faulting appears to exhibit common characteristics throughout the area which can be applied to great advantage in subsurface interpretations.

The strike of the faults associated with deep-seated salt domes through this area does not exhibit a consistent regional alignment, as the faults are localized over each dome. The general fault strike is usually parallel with the long axis of the deep-seated dome with which it is associated.

Faulting over deep-seated salt domes can usually be related to derivative gravity minimums which are expressions of the salt uplifts causing the faulting. The primary faults generally strike parallel with the long axis of the derivative gravity minimum, and faults on the outer margin of a graben structure are usually downthrown toward the long axis of the minimum. Generally, the relative intensity of the derivative gravity minimum becomes greater as the complexity of the faulting becomes greater.

On complexly faulted structures in this area, the outer faults of a graben system are considered to be the primary faults as they were usually the first faults initiated and they predominate with depth.

Fault dips over deep-seated domes in the northeast part of the Mississippi salt basin average approximately 45° in the Upper Cretaceous and 60° in the Lower Cretaceous.

An increase in throw with depth is exhibited by faults over deep-seated domes at a rate determined principally by the rate of differential uplifting which the salt exhibited during deposition of the sediments through which the faults cut. The increase in throw with depth is principally a result of lengthening of stratigraphic section in the downthrown block relative to the same section in the upthrown block. This lengthening of section is caused by thickening of downthrown beds, and by preserved wedges below unconformities in the downthrown block which are absent in the upthrown block.

As the unconformable contact between the Upper and Lower Cretaceous is the only horizon at which a large increase in throw on faults is evident, it appears that this unconformity is the only one of significant hiatus between Wilcox to basal Hosston time.

The crest of structures at Lower Cretaceous horizons through this area are commonly located near one side of a graben system. The faults on this side, termed *axial faults*, generally bisect the anticlinal crest so that closure is present on both their upthrown and downthrown sides. Lower Cretaceous production is most commonly found along the structural crest on both sides of the axial faults.

Faults with opposing dip on the opposite side of the graben, termed *flank faults*, are farther removed from the structural crest and exhibit closure only on the upthrown side. Flank faults provide potential traps if upthrown reservoir beds remain against impervious strata in the downthrown segment during growth of the fault.

Lateral changes in the throw of faults takes place more rapidly on progressively older horizons. The lateral termination of a primary fault off the flanks of a deep-seated salt dome appears to take place on all horizons approximately the same distance from the apex of the dome.

RICHARD R. MCLEOD, Gulf Coast Corporation, New Orleans, Louisiana

Theory for Formation of Limestone Cap Rock of Salt Domes

Osmosis, a new concept in subsurface fluid flow, is applied to the field around a shallow piercement-type salt dome. In the process, ground water circulating under the influence of osmotic pressure deposits the limestone cap rock on the top of the dome. Limitations of the osmotic theory are discussed.

GENE B. MARTIN, paleontologist, Gulf Oil Corporation, New Orleans, Louisiana

Prelimiary Investigation of Upper Ordovician Bryozoa of Northwestern Alabama

An attempt is made to clarify the subdivision of the upper Ordovician strata in northwestern Alabama by the use of Bryozoa and associated fauna. The upper Ordovician limestone exposed in northwestern Alabama (and extending into the northeastern Mississippi subsurface) contains abundant fossils, mainly Bryozoa. These may be used to subdivide this section and to correlate the subdivisions with named units recognized in Tennessee.

The upper part of the "Chickamauga" limestone a catch-all term, may be divided into the Leipers and Fernvale formations on the basis of diagnostic bryozoan species. The Leipers formation is recognized by the diagnostic species *Monticulipora molesta* Nicholson and the absence of *Richmond* species. The Fernvale formation is charaterized by the presence of six species that are restricted to that formation out of twenty-four species identified. The writer recommends that the use of the name "Chickamauga" be avoided in favor of the more specific Leipers and Fernvale formations.

The geographic area of study has been restricted to Limestone County, Alabama, which lies within a section of the Black Warrior Basin.

Measured sections of six outcrops are presented as a columnar section. A description of the Fernvale and Leipers formations of northwestern Alabama is given with a list of Bryozoa species identified at each collecting locality.

HAROLD OWENS, Humble Oil and Refining Company, Tallahassee, Florida

Florida-Bahama Platform

The Florida-Bahama platform covers 200,000 square miles, encompassing the Bahama Islands and most of the Florida peninsula and shelf. The 35,000 square miles of emerged surface has little relief; however, relief found in deep-water channels on the submerged part of the platform exceeds 6,000 feet. Geologically, the area is bounded by the Ocala uplift, the overthrust sheet of the Greater Antilles, the possibly faulted west edge of the Florida shelf, and the North Atlantic Ocean deep.

Mesozoic and Cenozoic carbonates and evaporites form a southward-thickening wedge of sediments that attain maximum known thickness of 19,000 feet in the Cay Sal Bank area. The youngest Paleozoic rocks encountered have been identified as Devonian; however, Ordovician clastics are usually found directly underlying Cretaceous sediments in north Florida. Total thickness of the flat-lying unmetamorphosed Paleozoic section is estimated at slightly more than 6,000 feet. Pre-Cambrian age determinations have not been made on igneous rocks encountered in the province: however, in some places igneous rocks probably pre-date the early Paleozoic sediments.

Major structural features within the province are the South Florida basin and the Bahama basin; these are separated by a more stable area that may be the southeast extension of the Ocala uplift. Local structures in Mesozoic and Cenozoic sediments should be of the basin type as there are no indications of major post-Paleozoic orogenic movements within the province.

The Sunniland field in south Florida, the only producing oil field in the province, has produced about 6 million barrels of oil from a Lower Cretaceous bioclastic zone at 11,600 feet. Problems confronting the oil seeker include shallow high-velocity and cavernous formations that make seismic and core-drill prospecting difficult.

CLYDE A. PINE, Plymouth Oil Company, Midland, Texas

Subsurface Structure of Lake Arthur Field, Jefferson Davis Parish, Louisiana (By title)

Lake Arthur field is in T. 10 S., R. 4 W., Jefferson Davis Parish, Louisiana, just north of the city of Lake Arthur. This field was discovered as a result of the drilling of the Joe Sturdivant No. 1 by the Shell Oil Company in 1937. During World War II and immediately thereafter the principal development of the field took place. The discovery of the "Main *Camerina* sand" in 1953 initiated the greatest drilling activity in the history of the field, and it became the most important producing sand.

The sediments encountered by wells drilled in the field are all Cenozoic in age, ranging from Recent to Miocene.

Subsurface studies of the field show it to be a deep-seated domal structure, fractured by many normal, down-to-the-basin faults; the complexity of which increases with depth.

It is a combination of the domal uplift and the complex fault patterns that form structural traps for petroleum. Much of the production is from beds on the downthrown side of the faults, where the sands are thicker because of rapid deposition of sediments con-