

sandstones are excellent potential reservoirs for hydrocarbons. They were deposited in close proximity to source beds, the marine shales, and in many places their plano-convex geometry makes them "natural" traps.

R. W. SABATE, Shell Oil Co., New Orleans, La.

#### PLEISTOCENE OIL AND GAS IN COASTAL LOUISIANA

Louisiana onshore marine Pleistocene reservoirs more commonly contain gas than oil. However, total reservoir volume and cash value of the oil greatly exceed those of the gas. Most of the Pleistocene oil is in southeastern Terrebonne Parish in a small dipwise trend containing Caillou Island, Lake Barre, and Golden Meadow fields.

JOHN D. MYERS, Phillips Petroleum Co., Houston, Tex.

#### DIFFERENTIAL PRESSURES: A TRAPPING MECHANISM IN GULF COAST OIL AND GAS FIELDS

The term "differential pressures" as used in this paper, refers primarily to lateral changes in subsurface fluid pressures. These pressure changes generally take place across faults or across lithologic barriers. The magnitude of these differential pressures can be quite large, and the changes can occur within a very short distance.

A systematic study of the subsurface fluid pressures in several Gulf Coast oil and gas fields indicates that differential pressures strongly influence the accumulation of oil and gas. The influence that fluid pressures were found to have on the accumulations of hydrocarbons in the Gulf Coast seems to conform with the hydrodynamic principles developed and outlined by M. King Hubbert (1953).

More specifically, this paper illustrates some practical examples of fault and stratigraphic entrapment of hydrocarbons under hydrodynamic conditions. The application of the principles demonstrated by these examples to subsurface studies should prove useful in the geological evaluation of oil and gas prospects. Subsurface-pressure studies are recommended as a routine method in exploration geology.

STEWART H. FOLK, Mineral Resources Consultants, Houston, Tex.

#### SULFUR DEPOSITS OF ISTHMUS SALT BASIN, SOUTHEASTERN MEXICO

Large deposits of elemental sulfur have been found in several areas in the southwestern part of the Isthmus Salt basin. Sulfur is being produced by the Frasch process from three of those deposits and at least one more probably will be put into production in the near future.

A large part of the Isthmus Salt basin has not yet been thoroughly explored for sulfur. There are good possibilities for finding additional commercial sulfur deposits in the southwestern part of the basin and also in other sectors. Ten private companies, financed largely by United States capital, currently are exploring for sulfur in the southwestern sector.

Stratigraphic conditions throughout the Isthmus Salt basin, and structural conditions in the eastern part, generally are similar to those in the Louisiana-Texas Gulf Coast region which is characterized by a thick section of Mesozoic-Tertiary sediments having a regional gulfward dip and pierced locally by salt domes. Structural conditions in the western part, however,

differ markedly from those at comparable depths elsewhere in the Gulf Coast region: there are several large complex anticlines, or anticlinoria, with salt cores, and the salt is shallow in large areas along the crests of the anticlines. Present thickness of the salt in those areas probably exceeds 10,000 ft.

The sulfur deposits are present in so-called cap rock which overlies the salt. There is considerable lateral variation in composition and thickness of the cap rock; in some areas it consists of limestone, sulfate rocks (principally anhydrite and gypsum), and shale; however, in most of the region, insofar as is known, the cap rock consists only of sulfate rocks and shale. Thickness of the cap rock generally is 100-500 ft; in some places it is absent entirely, and in others its thickness reaches more than 1,600 ft (probably involving some duplication by complex folding and/or faulting).

The cap rock outcrops are covered by only a thin mantle of Quaternary continental sediments in several areas on the crests of the anticlines. Elsewhere it is overlain by marine clastic sediments of various ages ranging from Late Cretaceous to Miocene.

The age and origin of the cap rock, and also the age of the underlying salt, are controversial. In the writer's opinion most of the cap rock, including the limestone, consists of Late Jurassic and/or Early Cretaceous sediments deposited in a restricted marine environment. Other writers, following the prevailing hypothesis for the origin of the cap rock of Louisiana and Texas salt domes, have attributed the anhydrite beds to residual accumulation of disseminated anhydrite grains leached from the salt; the gypsum to alteration of the anhydrite; and the limestone and sulfur to alteration of the anhydrite and gypsum. However, the character of much of the cap rock in the large salt anticlines in the western sector of the Isthmus Salt basin indicates that it consists largely of primary sediments rather than of products of residual accumulation.

The elemental sulfur in the Isthmus deposits, like the elemental sulfur in Louisiana and Texas and other regions where it is present in carbonate and sulfate rocks, probably was formed by a complex process involving (1) reduction of the sulfates by bacteria and/or hydrocarbons, yielding hydrogen-sulfide; and (2) oxidation of the hydrogen-sulfide, yielding elemental sulfur.

Production of sulfur from deposits in the Isthmus Salt basin presently amounts to about 5,000 tons per day. Cumulative production to the end of 1967 was approximately 17.1 million tons. The remaining recoverable reserves in known deposits probably amount to more than 50 million tons.

ROBERT R. BERG, Texas A&M Univ., College Station, Tex., AND BILLY C. COOK, Chevron Oil Co., Jackson, Miss.

#### PETROGRAPHY AND ORIGIN OF LOWER TUSCALOOSA SANDSTONES, MALLALIEU FIELD, LINCOLN COUNTY, MISSISSIPPI

Upper Cretaceous sandstone of the lower Tuscaloosa Formation in southwestern Mississippi is part of a fluvial-deltaic depositional system. At the Mallalieu field, lower Tuscaloosa sandstone is of two types: (1) channel-fill sandstone—thin, lenticular bodies which have irregular distribution across the field; and (2) point-bar sandstone—thick, more continuous bodies which have a ridge-and-swale pattern of sandstone distribution and which laterally are terminated

abruptly by narrow, broadly arcuate, shale-filled channels. These two fluvial interpretations are supported by mineralogy, textural gradation, internal structures, and sand-body geometry.

The average composition of lower Tuscaloosa sandstone is quartz, 60 percent; matrix, 32 percent; calcite cement, 4 percent; feldspar, 1 percent; muscovite, 1.5 percent; and other minerals, 1.5 percent. 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 sandstone whereas the upper two zones are narrow, channel-fill sandstone. This vertical sequence suggests an upward gradation from fluvial meander-belt deposition, through deltaic distributary deposition, to inner neritic deposition of the overlying marine shale—an overall transgressive sequence. The change from meandering below to braided above probably resulted from a change in stream gradient by basin subsidence.

JAMES W. COLLINS, Tenneco Oil Co., Corpus Christi, Tex.

#### GEOLOGY OF McALLEN-PHARR FIELD AREA, HIDALGO COUNTY, TEXAS

The McAllen-Pharr field produces gas and gas condensate from the lower, middle, and upper Frio Sandstone between the depths of 5,800 and 13,765 ft. The Frio is a regressive offlap sequence. Consequently, the environment of deposition of the productive sandstone bodies ranges from very shallow marine in the lower Frio through brackish and transitional to continental in the upper Frio. Hydrocarbon entrapment is in a simple faulted anticline in the upper Frio, a large stratigraphic trap in the Hansen sand, and many small complex fault blocks in the lower Frio. Structurally, the McAllen-Pharr field changes from a simple downthrown fault closure with basinward regional dip to a complexly faulted structure with steep, away-from-the-basin dips.

The great amount of deposition associated with the Rio Grande embayment, and the major contemporaneous McAllen fault system, have created two significant features in the McAllen-Pharr field that are characteristic of this area. They are the stratigraphic nature of the Hansen sand "fairway" and the development of "reverse dip" into the McAllen fault. A knowledge of these phenomena will aid in a clearer understanding of the overall geology and can be the key to future deep exploration in the area.

HENRY L. BERRYHILL, JR., U. S. Geological Survey, Corpus Christi, Tex.

#### FEDERAL ACTIVITY IN MARINE GEOLOGY IN GULF OF MEXICO

Seven agencies of the federal government are involved either directly or indirectly in marine geologic research in the Gulf of Mexico. These are: Naval Oceanographic Office; Office of Naval Research; Army Corps of Engineers, Department of Defense; Environmental Sciences Services Administration, Department of Commerce; Water Pollution Control Administration; Bureau of Commercial Fisheries; and Geological Survey, Department of Interior.

Activities by NOO and ONR are related to national defense and the development of undersea technology and include regional studies of sediments on the sea

floor and the strata beneath by coring and by acoustic profiling. Corps of Engineers studies are concerned with the mass movement of sediments and erosional patterns along the coastline as they relate to marine processes.

ESSA is concerned primarily with charting and mapping the coastal and deep-ocean waters. Programs of ESSA are providing detailed bathymetry of the sea floor and regional surveys of bottom conditions.

Agencies of Interior are engaged in research that bears on both the stewardship of resources on public lands and exploration and development of both renewable and nonrenewable resources of the marine environment. WPCC, through the Office of Estuarine Studies, is establishing a program for the investigation of pollution and sedimentation in the inshore waters of lagoons and estuaries. BCF is studying intensively the environmental factors controlling the proliferation and movement of edible sea life, including the effect of sediments on bottom dwellers. USGS, through its Water Resources, Conservation, and Geologic Divisions is the federal agency most heavily engaged in marine geologic research in the Gulf. The Water Resources Division is studying the effect of flooding in coastal bays and will have a leading role in estuarine studies. The Conservation Division acts in a managerial capacity in evaluating, on geologic grounds, prospective lease property on the continental shelf. The Geologic Division, through the Office of Marine Geology, is engaged in a broad research program that includes study of sedimentation and diagenesis processes in the nearshore and shelf environments, heavy metals content of sediments, geochemistry of sediments, and crustal structure of the Gulf basin. The Survey's overall program in the Gulf is following the pattern established for other marine provinces—the extension of geologic knowledge from peripheral land areas seaward as the public needs require.

J. W. ANTOINE, Texas A&M Univ., College Station, Tex.

#### A STUDY OF WEST FLORIDA ESCARPMENT

Two magnetic models of the West Florida escarpment have been constructed. These models represent a synthesis of seismic reflection data recorded on the continental slope of western Florida by Texas A&M University, information from numerous oil companies, and early refraction results from the Gulf of Mexico basin. Theoretical magnetic anomalies computed from these models are consistent with previously published magnetic data for the slope, scarp, and basin.

These models show that the presence of a fault with a throw of 10,000 ft in the basement under the Florida escarpment can be reconciled with the essentially smooth magnetic field shown in previously published charts. These magnetic data had been interpreted earlier to indicate that no basement fault could be associated with the escarpment. In the models presented here, subsidence of both the platform and basin is considered, the assumption being made that the basin has subsided more rapidly.

On the basis of these data and the magnetic models, a geologic cross section is presented which includes basement faulting, reef buildup, and volcanic rocks. The volcanic rocks, although probably present, are not related to the origin of the scarp. This geologic model consists of a continental platform with an upper section of limestone, dolomite, and anhydrite deposited in a shallow-water environment. The outer edge of the slope is bordered by buried reefs and the