by the western sea resulted in deposition of red sandstones and conglomerates that lensed out on the positive eastern portion of the area. Resubmergence in the Lower Cretaceous accompanied by east-west faulting divided the area into a deeper southern structural element and a northern platform. Carbonate deposition was almost continuous for the southern element throughout the Cretaceous although embayments contemporaneous with the first stages of submergence resulted in local evaporite development. An extensive evaporite basin existed during the Lower Cretaceous in the shallower and stiller seas of the northern platform. Continued submergence in Middle and Upper Cretaceous resulted in the carbonate covering of the evaporite sequences. Continued deepening and turbidity during the Eocene resulted in the deposition of silty limestones, siltstones, and shales. A general re-emergence at the end of the Eocene is marked by localized occurrences of Oligocene and Miocene limestones and clastic sediments.

The Maya mountains are a positive element that remained static following the late Permian-Triassic emergence. Between the Maya mountains and the northern platform of the Peten lies the Chuquibul embayment, and area that may be of importance for the stratigraphic accumulation of oil.

The basin is buttressed southward by the Santa Cruz Mountains, and east-west Paleozoic range. In front of the mountains lies the Alta Verapaz thrust zone, the effect of Tertiary forces, terminating in an arcuate front extending across the southern portion of the Peten basin.

The southeast end of the Bartlett Deep is represented by Lake Izabel within the basin, and the shore areas of this trough have been filled with a great thickness of Upper Cenozoic sediments.

Oil impregnated rocks, in outcrop and in well cuttings have been found throughout the Cretaceous section and further accumulation is considered likely in the Jurassic redbeds and Permian limestones.

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Pre-Matawan Cretaceous Sediments

The record of the post-Jurassic transgression which caused the formation of the northern Atlantic Coastal Plain begins with the Potomac group, non-marine sediments of early Cretaceous age. Lithologically similar non-marine and transitional sediments of early late Cretaceous age, the Raritan and Magothy formations, overlie the Potomac group. The lithologic similarity of the several formations, and disagreement as to the significance of their contained plant fossils, which are the major means of dating the exposed deposits, have caused some recent confusion in their stratigraphic interpretation.

Recent laboratory and field studies show that heavy minerals are useful for local correlation, and permit the following conclusions.

1. A considerable wedge of Lower Cretaceous sediments is present in the shallow subsurface of southern New Jersey, and was derived principally from the crystalline Piedmont of Pennsylvania and Delaware.

2. During Raritan time the Piedmont was covered by Cretaceous sediments and the materials which make up the Raritan formation were supplied from older sedimentary terranes northwest of the Coastal Plain except in the northern New Jersey-Long Island area which received sediments derived from crystalline rocks exposed in southern New York and New England. Similar conditions prevailed during the deposition of the Magothy formation, but during Magothy time, the Cretaceous sediments were stripped from the Piedmont and it again became a site of active erosion.

3. The Potomac group and the Raritan formations are dominantly fluvial sediments at the outcrop and in the shallow subsurface, but marine facies of the Raritan are present only a few miles downdip from the outcrop areas. No marine Lower Cretaceous has been reported from the northern Atlantic Coastal Plain.The Magothy formation is transitional marine at the outcrop.

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Laboratory Experiments on Form and Structure of Offshore Bars and Beaches

Beaches and bars have been formed during experiments conducted in a 45-foot wave tank at the Sedimentation Laboratory of the U. S. Geological Survey in Denver. By changing one variable at a time, factors responsible for major differences in primary structure and in shape of sand body have been determined. These factors are: depth of water, intensity of wave action, and supply of sand. Stages in the development of the bars and beaches were marked with dark layers of magnetite and cross sections were preserved on masonite boards coated with liquid rubber, thus making a record of cross-stratification patterns and sand-body shapes.

Offshore bars develop at the point of wave break. Where this occurs in very shallow water an emergent bar commonly forms; where it is in somewhat deeper water a submarine bar is built; where still deeper no bar develops. Increase in intensity of waves tends to build a bar forward toward, and even onto the beach. Weaker waves build upward to form barriers with lagoons to shoreward. Abundant sand furnished on the seaward side of a developing bar, simultating conditions developed by some longshore currents, causes gently sloping, seaward-dipping beds to form. In contrast, shoreward-dipping strata of steeper angle are characteristic of bars developed where the sand supply is limited.

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Geochemical Investigations of Athabasca Oil Sands

Analyses were performed to evaluate the organic composition and the mineral content of the McMurray oil sands in northeastern Alberta, Canada. The samples came from the Abasand Quarry near McMurray and from three bore holes, drilled along a southwest-northeast cross section in the Fort MacKay and Bitumount area.

The bitumen content is related to the particle size of the rock. Impregnation is not restricted to one particular sediment type in the McMurray formation. For example, sandstone zones in the Bitumount core were found to contain as much as 17 per cent organic material soluble in methylene chloride; the bitumen content of the shale layers is lower. The elementary composition of the organic material was found to be uniform throughout the entire 246-foot section of the McMurray formation in the core. An organic sulphur content of approximately 5 per cent extends throughout the core. The aromatic character of the bitumen was shown by spectroscopic methods of analysis. The bitumen con-

tains approximately the same amount of those hydrocarbons that may be recovered by n-heptane elution on silica gel columns.

The abundantly available Abasand samples were subjected to detailed analysis. These samples represent the lower portion of the McMurray formation, lying a few feet above the Devonian limestone. The bitumen was found to be a complex mixture of hydrocarbon and non-hydrocarbon compounds; the character of a few of which can be indicated. The bitumen was observed to be susceptible to contaminations by microorganisms; this required precautions during analysis. The chemical composition of the samples indicates that the Athabasca bitumen is basically a crude oil.

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Exploration in Llanos of Colombia

The Llanos of Colombia, comprising the eastern portion of the country, is an alluvium-covered, featureless, grassy plain that covers an area of about 75,000 square miles. Except for a short dry season from December to March heavy rains occur almost every day. Access to the area is difficult and for the major portion of the year special track equipment or helicopters must be used for exploration operations. Structurally the Llanos form an asymmetrical basin similar to that of eastern Venezuela or western Canada. There is a shelf area to the east with sediments dipping uniformly off the Guiana shield and increasing in thickness to the west to form a major trough in front of the thrust faulted Eastern Cordillera. The entire geological sedimentary column outcrops along the western border of the Llanos with excellent reservoirs, source rocks, and attendant oil seeps. Approximately 26,500,000 acres are held in the basin by six major oil companies at this time. To date the geology of the bordering Eastern Cordillera has been mapped in considerable detail, reconnaissance seismograph, gravity, and local magnetometer surveys have been run over the more attractive portions of the basin, and 22 wells have been drilled. Although some encouraging oil shows have been encountered in wells in the southern margin of the basin, no commercial oil has been discovered to date.

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Florida-Bahama Platform

The emerged and submerged Florida-Bahama platform covers 200,000 square miles and encompasses the Bahama Islands and most of the Florida peninsula and shelf. The 35,000 square miles of exposed surface has little relief; however, relief found in deep water channels on the submerged part of the platform in many places 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 American ocean deep.

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

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Recent Developments in Lower Cretaceous Trend of Mississippi

The discovery of oil at Bolton in Hinds County, Mississippi, and Citronelle in Mobile County, Alabama, heralded a fairway of Lower Cretaceous production from the Rodessa, Sligo, and Hosston formations in the intervening area. To date, oil production has been established in 10 fields in Mississippi. All of the fields are within the salt basin and salt movement is believed responsible for most of the producing structures. The structures increase in complexity with depth.

Regional structure maps delineate the configuration on top of the Lower Tuscaloosa (Upper Cretaceous) and base of Ferry Lake Anhydrite (Lower Cretaceous). Structure maps and cross sections of Bolton field in Hinds County; Magee field in Smith and Simpson counties; Martinville field in Simpson County; Raleigh field in Smith County; Soso field in Jasper, Jones, and Smith counties, Mississippi; and Citronelle field in Mobile County, Alabama, are included to illustrate that most of the accumulations are controlled by structure. Reservoirs discovered thus far are a prelude to other Lower Cretaceous fields that will, no doubt, be discovered in the future.

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Yamacraw Ridge, Pre-Cretaceous Structure beneath South Carolina-Georgia Coastal Plain

In the process of making alongshore and offshore seismic refraction studies of the geologic structure beneath the submerged Atlantic Coastal Plain from north of the Cape Fear arch in North Carolina to the vicinity of the Florida-Georgia boundary, it was noted that the measurements between Charleston, South Carolina, and Doboy Sound, Georgia, indicated that the basement (pre-Cretaceous) surface sloped towards the continent rather than towards the ocean. This reversal in the normal seaward slope of the basement surface was interpreted as being caused by a basement ridge, and named the Yamacraw Ridge of Meyer and Woollard. This past year it was possible to investigate this area