included in the basal limestone and the variations in the underlying volcanic rocks and serpentinite complex.

Tectonic isolation of the Parguera Limestone is suggested by the internal consistency of the unit, as opposed to the internal abrupt changes which characterize other rock types surrounding the Parguera, and by the contemporaneity of adjacent volcanic units. Contemporaneous tectonism and sedimentation as shown not only by the volcanic flows included in the Parguera but also by the thinning of the Parguera Limestone toward structurally high areas.

Vertical and lateral shifting of upper crustal blocks probably took place in response to deeper crustal movements. In a carbonate-producing environment, carbonate-rich sediments would accumulate on the higher standing blocks while lower areas would be flooded with volcanic debris. Such tectonic isolation of neighboring crustal blocks may have permitted adjacent and contemporaneous development of limestones and volcanic sequences throughout the developing Caribbean island arc.

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ORDOVICIAN CHITINOZOANS FROM FLORIDA WELL SAMPLES

Ordovician chitinozoans recovered from a grayish-black shale are described for the first time for subsurface north-central Florida. The lowest sample of the Sun Oil Company, Earl Odom No. 1 well, Suwannee County, Florida, is dated between late Arenigian and early Caradocian. The Ordovician is overlain directly by Silurian rocks. A new chitinized species is described.

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GEOPHYSICAL STUDIES OF NORTHERN FLORIDA PLATFORM, GULF OF MEXICO

The western edge of the North Florida platform has been delineated in some detail by seismic-reflection investigations. The platform boundary is not apparent from topographic surveys because of the thick sediment cover. The platform edge appears to coincide with the trend of a probable offshore extension of the Lower Cretaceous (Washita-Fredericksburg) reef trend.

The presence of a more recent reef, normal to the lower Cretaceous reef, is indicated from interpretation of additional reflection records. This feature trends almost east-west and crosses the buried edge of the North Florida platform. It can be traced for approximately 30 mi and can be aligned with an old buried shoreline on the east.

The top of the Upper Cretaceous has been traced over most of the continental slope south of the Florida Panhandle by seismic-reflection profiling. Studies on the outer slope indicate that this horizon rises near the center of the platform, along long. 86°30′, to less than 5,000 ft below sea level. On the west, near the edge of the platform at long. 87°30′, the top of the Upper Cretaceous is at 7,000 ft whereas on the east where the Florida escarpment intersects 85°30′ long., the indicated depth is more than 5,700 ft below sea level.

The reflection surveys show that erosion has played a very important role in the formation of the western part of the platform. It is evident that erosional processes have been active at least since the Late Cretaceous. This can be interpreted to indicate that the circulation in the Gulf of Mexico, and the loop current in particular, has been essentially the same during the entire Cenozoic Era.

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GEOLOGIC HISTORY OF NICARAGUAN RISE

A study of refraction-seismic velocity data beneath the Caribbean Sea and nearby areas of the Atlantic Ocean reveals that the thickest crust is in the Antillean island belts and the Nicaraguan Rise. In the Nicaraguan Rise, the maximum thickness is about 22 km and is south of the present topographic crest. Isopach maps of total crustal thickness indicate that the Caribbean crust is intermediate between average oceanic and continental crust.

The oldest dated rocks in the Caribbean are Jurassic, a fact which is consistent with the idea that the region had its origin in early Mesozoic time as a result of rifting and subsequent drift between the American and Afro-European continental blocks.

Throughout Jurassic and Early Cretaceous time, the Nicaraguan Rise was a mobile belt associated with vast submarine lava flows and mafic intrusives. Volcanism gradually decreased during the Late Cretaceous. Terrigenous clastic and carbonate strata alternated with tuff, agglomerate, and mixed-origin volcanic-sedimentary units. The first phase of the Laramide orogeny occurred at the end of the Cretaceous, and it may have been at this time that a rift along the southern flank of the rise separated it from the Beata Ridge which now is south of Hispañola.

Normal marine sedimentation—clastic and chemical—prevailed during the Tertiary. Islands emerged and sank as movement occurred between crustal blocks. Tectonism beginning in middle Miocene time markedly altered the topography and depositional pattern of the rise. The Cayman Trough rift formed as a result of left-lateral displacement of at least 250 mi. The Nicaraguan Rise was tilted southward, with the result that the topographic crest was shifted 50–100 mi north.

Recent geophysical work related to petroleum prospecting has aided in interpreting the structure and stratigraphy of the rise. Cross sections and a map of depth to magnetic basement are presented.

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ORIGIN OF GULF OF MEXICO AND CARIBBEAN SEA; IMPLICATIONS REGARDING OCEAN RIDGE EXTENSION, MIGRATION, AND SHEAR

The Gulf of Mexico and Caribbean Sea are a zone of north-south extension and left-lateral shear opened between the Americas as those continents moved westward from Africa. The movements are related to ocean-floor spreading from the mid-Atlantic ridge. To accommodate spreading, the ridge itself migrates westward from Africa. Ridge migration is radial outward from Africa and results in opening triangular sheared grabens with apexes against Africa. A new ridge segment extends across these openings. Spreading rates vary and the migrating and extending ridge is sheared on fracture zones in response to these variations.

The currently popular related concepts of plate tectonics and transform faults are inconsistent with ridge migration and shear because those concepts do not allow for shear on fracture zones beyond ridge offsets and in the directional sense indicated by the position of ridge segments. Ridge migration and shear are a

necessary complication of the spreading hypothesis. T-intersections of ridges are explained as intersections between a spreading and migrating ridge with a shear. The shear is only active on the side of the ridge toward which the migration is taking place. The junction of the mid-Atlantic ridge with the Azores-Gibraltar ridge is an example of such a feature.

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GRAVITY SURVEY OF FLORIDA BAY AND LOWER KEYS

A Bouguer gravity map of the southern part of Florida, including stations ranging from about 24° to 26° N lat., and 80° to 83° W long., is presented.

The salient features depicted are: (1) the western rim of the South Florida basin, with gravity values increasing toward the basin's center; (2) a large minimum anomaly centered near Homestead in Dade County; (3) an elongate gravity minimum extending from the area of Barnes Sound southwestward over most of Florida Bay; and (4) a minimum indicated by two gravity readings obtained in the Marquesas Keys, suggesting a need for further investigation.

Examination of cuttings and cores recovered from oil tests drilled on or near the minimum anomalies indicates that if salt is present, it is deep seated (below 11,000 ft). Wells near Homestead show that the area is structurally high at levels ranging from Eocene to Lower Cretaceous. The preponderance of anhydrite, dolomite, and dense aphanitic limestone in more than 4,000 ft of Lower Cretacous rocks penetrated in the area suggests that the average density of this section may exceed that of the underlying basement. If true, a minimum anomaly would occur over an uplifted or topographically high area of the basement.

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PLEISTOCENE PALEOTEMPERATURE RECORD BASED ON PLANKTONIC FORAMINIFERS, GULF OF MEXICO

Planktonic foraminifers from deep-water sediment cores in the northern Gulf of Mexico indicate alternating cold- and warm-water faunas, and are interpreted to represent glacial and interglacial stages of the Pleistocene. *Globorotalia menardii* (warm) and *Globorotalia inflata* (cold) are the most sensitive indicators for delineating severe changes in Pleistocene temperature in the Gulf of Mexico.

Based on planktonic datums the cold-warm cycles are correlated with water-depth changes in the shallower shelf environment which are interpreted to represent eustatic sea-level changes. The cold intervals represent times of lowered sea level and are correlated with the glacial stages of North America. Age relations of the glacially related events recognized in the marine Pleistocene section with the continental glacial stages are well documented to about 35,000 years ago based on carbon 14 dates. Age relations between the older part of the marine Pleistocene and the continental glacial stages are not as well documented but can be inferred from correlation between the glacial-interglacial cycles and paleomagnetic reversal events which are well dated by potassium-argon.

Onset of severe climatic deterioration and beginning of the Quaternary (Nebraskan Stage) in the Gulf of Mexico corresponds with the extinction horizon of *Globoquadrina altispira*. Correlation of this horizon with the paleomagnetic reversal events indicates an age of about 2.8 m.y. ago for the Pliocene-Pleistocene boundary.

Placement of the Pliocene-Pleistocene boundary at 2.8 m.y. ago allows recognition of five major glacially-related events in the marine Pleistocene based on climatic and eustatic criteria. Faunal data indicate that the Nebraskan, Illinoian, and Wisconsin were severely cold periods, whereas, the Aftonian, Kansan, and Yarmouth were warmer, the Aftonian being the warmest. Carbon 13/12 isotope data support these conclusions.

Foraminifera and discoasters from the marine Calabrian Stage of southern Italy at Santa Maria di Catanzaro indicate a correlation with the marine Nebraskan Stage, as here defined, in the Gulf of Mexico. Paleontologic evidence indicates that the Pliocene-Pleistocene boundary falls near the base of the Kansan. The cold and warm interval shown below the Pliocene-Pleistocene boundary of Glass and his co-workers is interpreted to represent the Nebraskan and Aftonian Stages. Paleomagnetic evidence indicates that the Olduvai magnetic event probably represents the Gilsa event at about 1.6 to 1.8 m.y. ago.

Advances in paleomagnetic stratigraphy clearly indicate that the magnetic reversals facilitate dating and correlation of marine stages at latitudes where differing paleontologic criteria must be used to delineate the glacial and interglacial episodes. The major paleomagnetic epochs apparently are reliable for stratigraphic correlation; however, the minor events of relatively short duration appear to be less reliable as stratigraphic markers.

A new species of the *Globorotalia menardii* group is described.

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ENVIRONMENTAL CONTROL OF POROSITY IN UPPER SMACKOVER LIMESTONE, NORTH HAYNESVILLE FIELD, CLAIBORNE PARISH, LOUISIANA

Present porosity of the reservoir rock in North Haynesville field is limited to primary intergranular pore space. Certain facies contained larger, better connected pores as a result of deposition in a higher energy environment, but preservation of this porosity against cementation and pressure solution makes the diagenetic environment equally critical.

Regionally, Smackover porosity is confined to a coastal shelf where calcarenites with primary intergranular porosity were widespread, and to a shelf slope where the calcarenites were confined largely to local shoals resulting from contemporaneous uplift. A calcarenite bar along the seaward edge of the shelf slope restricted circulation. North Haynesville field is behind this barrier.

Because of hypersalinity, Smackover allochems are almost entirely nonskeletal, and deposition resembled that of the Bahama Banks. Pelletal mud was deposited in quiet, shallow water with probable periods of subaerial exposure. Slight differential structural movement permitted turbulence in local areas where a mixed facies was deposited. Further movement, probably including lowering of the seaward barrier, created conditions favorable for extensive oölitic accretion during deposition of the reservoir facies. This turbulent shoal environment produced clean, well-sorted calcarenite with excellent porosity, much of which was destroyed through cementation with sparry calcite, possibly under subaerial conditions. A completely cemented zone at the top of the reservoir facies prevented further entry