proportions of fossils (planktonic and benthonic forams, bryozoans, echinoderm debris, mollusk debris, brachiopod fragments, calcareous algae, sponge spicules), glauconite, tuff fragments, quartz, feldspar, rare pyroboles, clay minerals, intraclasts (probably mostly from older dike layers), and rare pellets.

The polyphase dikes are interpreted as infillings of fissures that repeatedly opened on the flanks of volcanic mounds. Infillings appear to be more varied than the possible source rocks and probably record transient sedimentation.

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PETROLEUM EXPLORATION WITH RADAR—EASTERN PANAMA AND NORTHWESTERN COLOMBIA

Petroleum exploration in eastern Panama and northwestern Colombia has gained impetus from recent side-looking radar mapping. Radar-derived geologic information is now available for approximately 40,000 sq km where previous reconnaissance investigations have been extremely limited because of inaccessibility and perpetual cloud cover.

With radar imagery as the sole source of remote sensing data, the distribution, continuity, and structural grain of key strata provide evidence that the eastern Panamanian Isthmus can be divided into 3 main physiographic-structural parts. Two composite coastal mountain ranges are separated by the Medial Basin which trends southeastward from the mouth of the Bayano River to the Atrato River valley of northwestern Colombia. Within the Medial Basin, the most obvious site for petroleum exploration, the majority of clearly exposed surface structures are not particularly attractive prospects because prime reservoir strata have been stripped from their crests. However, several large geomorphic anomalies which have been mapped in the Medial Basin may be reflections of subsurface structures having a complete stratigraphic section. The possibilities of gravity-type entrapment in fractured organic shales, siltstones, and carbonates have been suggested along the southern synclinal trends of the Medial Basin. The southwestward extension of the Medial Basin trend, coincident with unique beach ridges from a possible granitic source, provides an attractive petroleum prospect in the western part of the Gulf of Panama. The occurrence of active shell bars in the Bay of San Miguel and present reef trends on the northern Caribbean coast suggest possible offshore sites for geophysical surveying.

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GYPIDULID BRACHIOPODS: THEIR LIFE POSITION AND PALEOENVIRONMENT

Life assemblages of 2 species of gypidulid brachiopods, preserved in their original positions of growth, have been collected from Upper Silurian and Lower Devonian limestones of the Appalachian basin. The 2 assemblages inhabited the same environmental locus at different times in a transgressing carbonate sea. The earlier *G. prognostica* is in the Keyser Formation in Pennsylvania, Maryland, Virginia, and West Virginia, and the later *G. coeymanensis* is found in the Coeymans Formation of New York state.

The gypidulids, in both cases, lived clustered in a beak-down position on poorly sorted skeletal sand substrates in association with a diverse faunal assemblage of brachiopods, bryozoans, crinoids, and trilobites. The specimens appear to have no pedical openings, indicating lack of pedical development in mature forms. The inner prismatic shell layer in the pedical umbo is many times thicker than the total shell elsewhere on the organism. The resulting weighting of the pedical umbo and lateral contact with other individuals in the cluster promoted an upright, posterior down orientation.

Gypidulids are restricted to shallow (near, but above wave base) shelf environments. Onshore skeletal barrier sands and skeletal lagoonal muds, as well as offshore fossiliferous muds, are barren of gypidulids. The gypidulid environmental position occurs only in transgressive stratigraphic sequences.

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TOWARD A MORPHOLOGICAL CLASSIFICATION OF ORGANIC REEFS AND REEF COMPLEXES

Most of the literature concerning the definition of organic reefs (bioherms and biostromes) and of similar carbonate accumulations emphasizes the genetic and biostratigraphic classification of these features. To the writer's knowledge, no previous attempt has been made at a purely morphological classification. "Reef complexes" have in recent years been called "bank atolls," "reef-fringed carbonate banks," and "biohermal flanked biostromes." Such hybrid names appear to impose a dualistic origin on a reef complex, although it is obviously a genetic unit, and they should therefore be avoided. Henson's "reef complex" included the sediments genetically associated with the reef *sensu stricto;* these are not "banks" or "biostromes" within the generally accepted meaning of these terms. The writer therefore has introduced the term "cycloherms" (circular reefs) for the gigantic shelf atolls such as those in the Devonian of western Canada, in the Permo-Pennsylvanian of West Texas, and in the Cretaceous of Mexico. In addition, the term "phragmoherms" (wall reefs) was introduced for fringing reefs and barrier reefs such as those in the Triassic of the Alps.

In recent years bioherms proper have been called "pinnacle reefs," "haystack reefs," and other such terms which bear little relation to their actual morphologic proportions. Such names are based on the reef shapes commonly seen in cross sections of exaggerated vertical scale, and create erroneous impressions of their true relative dimensions. The new, unequivocal names proposed for these bioherms are "aspiherms" (shield reefs) for the pinnacle type and "trapeziherms" (table reefs) for the flat-topped haystack type.

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EXPLORATION ON CONTINENTAL SHELF OFF NORTHWEST AUSTRALIA

Exploration of a 144,000-sq mi rank wildcat area in offshore northwestern Australia began in 1964 with analog seismic surveys. Each year additional surveys have been carried out with a steady improvement in data quality due to advantage being taken of technological advances of the industry.

Interpretation of these data and incorporation of available drilling results have permitted structural and depositional models to be rationalized for post-Paleozoic time-rock sequences. Improvements in drilling technology have allowed locations to be sited in greater water depths confirming depositional and structural models.

To overcome seismic data problems associated with the high-speed Tertiary section, navigational problems due to the size of the area, drilling problems associated with geo-pressured shales and the highly porous Tertiary beds, new techniques constantly were required and introduced.

To integrate the interpretation of the large volume of data and to apply the maximum amount of geologic rationalization require the cooperation and mutual support of competent geologists and geophysicists. Large areas to be mapped and steadily increasing volume of data from this area required the utilization of computer-assisted mapping.

By mid-1971 approximately 40,000 mi of seismic data were in the files. At the same time wells 11 (Scott Reef No. 1) and 12 (North Rankin No. 1) were drilling and located what promise to be commercial accumulations of hydrocarbons. However, feasibility studies still are being evaluated and step-out wells have yet to be drilled. Since completion of these wells, other wildcats have been drilled resulting in several discoveries.

Future potential in the area looks very bright with source, reservoir, and cap rocks in Triassic, Jurassic, and Cretaceous rocks. The potential of the Paleozoic section is as yet virtually unknown.

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Systematic Geophysical Mapping of Continental Shelves and Deep Ocean Areas

The National Oceanic and Atmospheric Administration's National Ocean Survey program is mapping systematically the geophysical characteristics of the continental shelves of the U.S. and certain deeper ocean areas. Properties measured are bathymetry, geomagnetics, gravity, and seismic reflection profiles. The purpose of the program is to provide maps, data lists, reports, *etc.*, to meet requirements stated for coastal zone management and exploitation.

The map scales produced are 1:250,000 on shelves and 1:1,000,000 in deeper areas. Coverage now includes parts of the east and west coasts and Alaska. Work is underway off Oregon and Washington. The next year's program includes the west coast, Gulf of Alaska, and part of the Atlantic east of Bermuda.

The program objective is to produce data packages for each map unit. Survey control, line spacing, instrumentation, and collection accuracies vary according to the scale, area, and characteristics found. Critical to program development are the known and stated area and data requirements of major segments of the national economy such as the petroleum and other mineral industries, and fisheries. Recreational and environmental aspects are likewise important.

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Facies and Paleocurrents of Gallup Sandstone: Model for Alternating Deltaic and Strand-plain Progradation

The Upper Cretaceous Gallup Sandstone of northwestern New Mexico, is a regressive, shallow-marine to alluvial sequence up to 140 ft thick. Vertical and lateral facies sequence and orientation of current- and wave-produced structures show that the shoreline advanced by episodes of delta progradation, followed by minor erosional transgression and subsequent seaward accretion of surf-zone and beach deposits. Each episode is thought to be a reaction to stream positions on a broad coastal plain. In a 200-sq mi area, 2 delta progradations and 3 strand plains are recognized, each with some important variations.

The deltaic deposits consist of: (1) distributary-channel sandstones, entrenched in older beach deposits; and (2) more widespread marine sandstones, thinning and grading seaward. The marine deltaic sandstones are in tabular beds deposited from short-duration currents; these beds vary in thickness and bioturbation, depending upon distance from dispersal centers. There is little evidence of sand transport or reworking by waves.

The strand-plain units consist of: (1) coarser sandstones with high-angle cross-strata in trough-shaped sets and minor interbeds of siltstone, overlain by (2) finer sandstones with low-angle cross-strata in wedge-shaped sets and local seaward-sloping heavy mineral placers. The coarser sandstones rest on a basal scour surface cut on older deltaic deposits, probably representing adjustment of profile with decrease in sand supply and increased effectiveness of wave action. Cross-strata dip directions record sand transport parallel with shore but in frequently reversing directions, suggesting the influence of surf generated by seasonal or more frequent weather changes. Upward gradation to sandstones with the characteristics of beach foreshore deposits indicates beach progradation.

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Theory of Crustal Development Based on Analysis of Vertical Uplift Experiments

One of the most important concepts resulting from oceanographic data is the segmented nature of the oceanic ridge and rise areas. These segments are separated by transverse faults. Continental orogenic areas both past and present possibly may exhibit this same phenomenon.

Model studies using vertical uplift were conducted in an effort to duplicate the segments. The forces involved in the development of the individual segments were analyzed, as well as those caused by the interaction between segments resulting from differential uplift. By applying principles observed in the modeling, known first-order orogenic areas were modeled. These areas include parts of the Rocky Mountain system and the California system.

A theory is developed which mechanically relates the orogenic events of the past with those of the present. A proposed corollary relates the major transgressions and regressions of past geologic seas to the geographic distribution of the orogenic belts. During times of extensive oceanic orogenic activity, the belts were distended and the water was displaced onto the continents. The distention was followed by extrusion and collapse which resulted in regression of the seas.

The theory is applied to the continental United States, and a series of sketches shows the possible tectonic development of the southern part of the North American continent from the late Precambrian to the present.

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Relation between Texas Barrier Islands and Late Pleistocene Depositional History

The 400-mi-long Texas shoreline is characterized by barrier islands separated from the mainland by la-