those which are nonfabric related. Primary fabric-related types consist of intraparticle and interparticle. Primary intraparticle porosity, openings within the body chambers of the rudists, is present in the caprinid-coral wackestone, coral-caprinid boundstone, and requienid boundstone. Primary interparticle porosity was originally very high (greater than 30 percent) in the rudist grainstone facies but cementation soon after deposition—submarine, phreatic, and meteoric—reduced the porosity to less than 10 percent, and late subsurface cementation filled the remaining porosity. Primary interparticle porosity now is present only in a few very thin intervals.

Secondary fabric related porosity consists of solution-enlarged interparticle and moldic. Both occur in the boundstone and grainstone facies but in very thin restricted units. The poor development of solution enlarged interparticle and moldic porosity reflects the minor role that subaerial exposure played during the development of Stuart City trend.

Nonfabric related porosity consists of vertical fractures. This type of porosity is present in abundance in several studied wells in the form of open, nonlined, vertical fractures.

The low porosities along the Stuart City Trend are the result of two processes—(1) lack of significant periods of subaerial exposure for development of secondary porosity types and (2) massive cementation which destroyed primary porosity. Further exploration along this trend should be aimed at identifying areas which may have been exposed soon after deposition and developed secondary porosity or areas which subsided more rapidly and have preserved primary porosity.

BERGQUIST, C. R., and W. F. TANNER, Geology Dept., Florida State Univ., Tallahassee, Fla.

Analysis of Water-Level-Rise Effects on Littoral Transport

A computer project has included evaluation of the effects of changes in wave height, wave period, wave-approach angle, bottom slope, and water depth on beach erosion. This work is primarily applicable to large lakes where long-term changes in water level may be as much as one or two m. The change in potential erosion is expressed as a ratio of littoral power values. The most important independent variable entering into this ratio is the change in water level. An increase in level of one or two m can give ratios in the range of 100 to 250 and even higher. A ratio of 100 means that, after the rise in level, the littoral component of power, and hence the amount of sand eroded and transported, is initially 100 times as great as prior to the rise.

BROWN, L. F., JR., and W. L. FISHER, Univ. Texas, Austin, Tex.

Environmental Geologic Atlas, Texas Coastal Zone: Role of Geology in Land-Use Planning

The *Environmental Geologic Atlas of the Texas Coastal Zone*, which required 25 man-years of research, was initiated in 1969 to meet a growing need for basic land resource information about one of the most rapidly developing regions of Texas. The coastal zone, covering about 20,000 sq mi, is not only an area of accelerating, competitive, and, sometimes, conflicting land use, but it is also a region of dynamic natural processes and delicately balanced environments. The coastal zone is underlain by a wide variety of Pleistocene and Holocene/modern facies with differing physical properties and land-use capabilities. Large-scale mapping (1:24,000) of first-order units, including substrates, biology, processes, and man-made features, resulted in the principal environmental resource document—the Environmental Geology Map. This map, at a scale of 1:125,000, displays the distribution of 130 units, which comprise both Pleistocene and Holocene/modern fluvial, deltaic, barrier-strandplain-chenier, offshore, bay-lagoon-estuary, marsh-swamp, eolian, and man-made coastal systems.

A series of 8 Special-Use Environmental Maps at a scale of 1:250,000 were, in part, derived from the Environmental Geology Map, and, in part, compiled from other extensive data sources. The special-use map series includes: Physical Properties; Environments and Biologic Assemblages; Current Land Use; Mineral and Energy Resources; Active Processes; Man-Made Features and Water Systems; Rainfall, Stream Discharge, and Surface Salinity; and Topography and Bathymetry. These maps, which contain about 150 units, were designed for the special requirements of various users; an almost unlimited number of such special-use and thematic maps can be generated from the basic map data.

A further step toward application of environmental geologic information in land-use planning was derivation of fundamental planning units based on carrying capacity. These units alternately have been termed resource-capability units and land-resource units. Each land-resource unit is an areally defined entity that exhibits a unique set of properties, which limits or sustains its use for the wide variety of human activities. The properties of land-resource or resource-capability units, which can be quantified and digitized, may serve as principal input into land-use inventory and planning systems being devised to support future land-use decisions. A land-use planning system that is based realistically upon the nature and variability of natural systems and coastal substrates can provide a commonsense, flexible, and fair approach to land-use planning. Such a system provides potential users with options long before development becomes a reality, enabling users to plan for necessary engineering improvements and/or economic trade-offs. Fundamental geology is a critical element in such a land-use decision system.

BRYANT, W. R., WILLIAM E. HOTTMAN, and PETER K. TRABANT

Permeability of Unconsolidated and Consolidated Marine Sediments, Gulf of Mexico

Permeability of a large number of natural marine sediment samples from the Gulf of Mexico was determined through the use of laboratory consolidation tests. The samples were divided into groups as follows. Group 1, sediment consisting of more than 80 percent clay (material 2μ or less in size); Group 2, sediment containing from 60 to 80 percent clay-size material; Group 3, silty clays with less than 60 percent clay; Group 4, silts and clays that have a significant sand-size fraction present (more than 5 percent sand). The permeabilities of the groups ranged from 10^{-5} to 10^{-10} cm/sec with 35 ppm normal seawater being used as the saturating fluid.

A statistical analysis of the natural log of permeability versus porosity was used to develop the permeability prediction equation for each of the groups listed. The equation for Group 1 is $k = e^{P(15.05) - 27.37}$, for Group 2 $k = e^{P(14.18) - 26.50}$, for Group 3 $k = e^{P(15.59) - 26.65}$, for Group 4 $k = e^{P(17.51) - 26.93)}$, and for all data $k = e^{P(14.30) - 26.30}$, where P is the porosity (in decimal) and k is the coefficient of permeability.

These equations are useful for predicting changes in permeability with depth in fine grained sediments of the Gulf of Mexico. The ability to predict permeability in a continuous sequence, where the deposition history is known, may explain the large variations that we see in the physical properties in sediments similar in grain size and mineralogy.

CARTER, P. H., Sun Oil Co., Houston, Tex.

Recognition of New Potential of Swan Lake Field, Jackson County, Texas

A new geologic evaluation of Swan Lake field led to the discovery of 24 new reservoirs. The field originally was found in March 1950; initial development drilling ended in 1957. Sun Oil Co. took over operations in 1970. A new lower Frio structural interpretation indicated the crest of a deep closure had not been penetrated. The Sun 27 G. T. Brooking, drilled in December 1972, found new deep production. New reservoirs also were discovered in the previously drilled upper part of the Frio section.

The improved logging techniques used in the wells allowed a more quantitative look at all the sandstones. Combination logging tools providing a simultaneous recording of induction resistivity, acoustic velocity, and computed Rwa curve were used exclusively. Using the Rwa curve as a hydrocarbon indicator, low resistivity sandstones that appeared wet from casual examination were tested and found productive. Other sandstones which appeared to have no vertical separation from overlying water sandstones were tested and found productive.

Twelve new wells were drilled from 1972 through 1974. The drilling program resulted in a significant increase in the daily gas and oil production. Multiple recompletion opportunities also were recognized.

COLEMAN, J. M., and L. D. WRIGHT, Coastal Studies Inst., Louisiana State Univ., Baton Rouge, La.

Deformational Processes in Delta-Front Deposits

River-mouth depositional patterns are modified by sediment deformational processes of sufficient magnitude to endanger severely bottom-supported structures. Several types of deformations are present and include (a) peripheral slumping, (b) differential weighting and diapirism, (c) graben faulting, (d) mass wasting by sediment degassing, and (e) deep-seated flowage. High depositional rates are present near the river mouth and decrease seaward; with time, the bar front oversteepens and rotational slump planes form peripheral to the bar front, moving sediment into deeper water. These blocks have longitudinal dimensions of approximately 200 to 2,000 ft and lateral dimensions of 600 to greater than 2,000 ft. Differential loading by denser bar sands overlying low-density clays results in vertical and seaward flowage of the clays contemporaneously with seaward bar progradation. Diapiric folds and spines (mudlumps) intrude into delta-front sediments on the seaward side of the deforming load, vertical movement affecting sediments to depths in excess of 500 ft. The seaward extrusion and continued movement of clays arch the overlying delta-front sediments, and this stress is relieved by small graben faults oriented radially to the deforming load or delta lobe. The grabens have widths from 150 to 1,500 ft and lengths of several miles. The finer grained river-mouth sediments contain high percentages of methane and CO_2 gases, formed by bacterial decomposition of organics. Passage of hurricane waves produces bottom-pressure perturbations, forcing the entrapped gas upward, causing loss of sediment strength and allowing mass movement. The weight of the modern delta has depressed underlying Pleistocene sands about 400 ft, causing squeezing and flowage of clays onto the continental shelf at water depths greater than 300 ft. Large-scale slumping and faulting near the continental shelf result from this clay flowage. These processes are contemporaneous with deposition and play an important role in initiating a depocenter.

EMMERLING, M. D., and W. F. TANNER, Dept. of Geology, Florida State Univ., Tallahassee, Fla.

Sand Leakage around Rocky Headland at Niteroi, Brazil

A statistical study of foreshore sediments from two adjacent open-ocean pocket beaches near Niteroi, state of Rio de Janeiro, Brazil, was undertaken to investigate sand leakage around the rocky headland separating the beaches. According to May and Tanner, the rocky headland theoretically could act as a cell boundary. A statistical analysis should reveal whether or not the rocky headland is a cell boundary.

Three samples collected from beach 1 (NE of headland) and seven samples collected from beach 2 (SW of headland) were sieved and the four moment measures were determined for each of the samples. The moment-measure analysis was marked by the following pertinent points: (1) mean phi size increases in both directions away from the headland; (2) mean phi size for beach 1 (1.577 phi) is significantly different from the mean phi size for beach 2 (1.297 phi); (3) sorting for both beaches appears to improve weakly toward the headland (0.370 ± 0.020 to 0.450 ± 0.020); (4) skewness increases from a negative minimum (-0.150 ± 0.020) away from the headland to a positive maximum (0.100 ± 0.020) at the headland; (5) kurtosis decreases away from the headland (1.000 ± 0.020 to 0.200 ± 0.020); (6) two-factor regression analysis of the four moment measures (y) versus linear distance (x) away from the headland revealed a weak positive linear trend for mean phi size, a weak negative linear trend for sorting, and strong negative linear trends for skewness and kurtosis; (7) analysis of variance indicated that the variation in mean phi size is significantly different between the two beaches.

Interpretation of the statistical analysis forces one to conclude that the rocky headland is a cell boundary (*e.g.*, little or no leakage) separating two pocket beaches, each of which is in dynamic equilibrium.

FELDHAUSEN, P. H., Dames and Moore, Park Ridge, Ill., and S. A. ALI, Rensselaer Polytech. Inst., Troy, N.Y.

Multivariate Statistical Approach to Sedimentary Environmental Analysis

A multivariate statistical strategy employing cluster analysis, ordination, and gradient analysis was used to determine the depositional environment of Barataria Bay, Louisiana. Cluster analysis of sediments suggests the existence of five sedimentary facies: (1) beach sand, (2) foreshore sand, (3) silty channel sand, (4) silty channel-margin sand, and (5) organic silt and mud. Ordination was used to depict the gradational relations among individual samples and among facies defined by cluster analysis. Gradient analysis suggests a wide range of environmental conditions operating within the bay and substantiates Klovan's factor analysis.

Gradient analysis shows that ordination extracts, successively with each axis, the most variable combination of the original variates. The ordination coordinates become new objectively created variables which are efficient measures of the original grain-size curve.

This multivariate statistical approach to sedimentary environmental analysis may prove useful for partitioning other sediment samples into facies and for examining the interaction between these facies and their environment of deposition.

FEREBEE, T. W., JR., A. H. BOUMA, and G. L. HUEBNER, JR., Texas A&M Univ., Dept. of Oceanography, College Station, Tex.

Towed Horizontal Resistance and Spontaneous Potential Survey off Sabine Pass, Texas

A program of electrical measurements on unconsolidated marine sediments was started by the geologic oceanographers at Texas A&M University in 1968. It consisted of measuring resistance and spontaneous potential on extruded cores and *in situ* in the field, and correlating the electrical values with various sediment and geotechnical properties. The present phase of research concentrates on delimiting and defining sediment lithologies using a towed horizontal array. Several combinations and electrode spacings were tried across Heald Bank, off Sabine Pass, Texas. Bottom-water and sediment samples were collected from well-defined submarine lithologies.

Preliminary results indicate that the spontaneous potential is uniformly highest in mud and clay areas. Large variations occur over shelly sands and shell debris. Resistance is largely uniform across Heald Bank, with relative values depending on electrode