voir and from structural closures coexistent with the rudistid facies. Initial production and productive history of reservoirs in the rudistid-bearing rocks have been disappointing.

Exploration in the trend has been based on close correlation of seismic field efforts and regional stratigraphic studies. Detailed studies of the "reef complex" in an attempt to determine areas of best porosity and engineering studies related to reservoir stimulation, are necessary before this trend becomes economically more attractive.

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DEEP HUNTING GROUNDS

Assessment of the possible economic importance of the world's petroleum resources at great depth requires a reconnaissance study of the areas in which accumulations of petroleum can exist at such depths. The areal extent, volume, and general character of the sedimentary rocks between the depths of 15,000 feet and effective basement throughout the world are reported. The results of drilling to date together with some of the exploration, development, and production problems are discussed.

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EXPLORATION OF THE LOWER FRIO FORMATION OF CALHOUN, JACKSON, AND MATAGORDA COUNTIES, TEXAS

Exploration of the Frio Formation in the Upper Gulf Coastal Plain of Texas, from the past to the present, can be divided into three eras: (1) the early piercement salt-dome era, (2) the era of upper Frio exploration, and (3) the present era of lower Frio exploration.

Northeastern Calhoun County, southern Jackson County and southern Matagorda County exhibit similar structural and stratigraphic conditions in the lower Frio and are considered in this report.

Near the southern limit of the Frio trend in this area, the gently dipping coastal monocline is broken by large regional down-to-the-coast strike faults which form an *en échelon* pattern. The upper Frio in these fault segments dips southeast, except for a high structural ridge in the Palacios-Appling area where the upper Frio dips northwest. The lower Frio in the same fault segments shows northwest dip, with the Frio section shorter on the upthrown side of the regional faults and thickening greatly into the downthrown side of the next fault on the northwest. Well data indicate that the Palacios-Appling high is probably underlain by a salt ridge. This ridge has influenced the structure of the lower Frio in the updip area.

In a part of northeastern Calhoun County and southern Jackson County the lower Frio is unusually thick, the section being predominantly poorly sorted lignitic sands with minor shale breaks. These are probably deltaic deposits laid down by an ancestral Lavaca River. To the east and into Matagorda County, the lower Frio consists of interbedded sands and shales indicating deposition in an area of littoral and lagoonal environments.

The combination of northwest dip of lower Frio beds, numerous major and minor faults, along with lenticular sands caused by thinning of beds, adds up to a variety of traps for the accumulation of hydrocarbons. Discoveries in the lower Frio have been predominantly gas with high yield of distillate.

Because of the complexity of the structures, exploration has been hazardous, particularly when the high cost of drilling is considered. However, discoveries with thick pay sections have been recorded in the area and they are expected to stimulate exploration for lower Frio reservoirs in the future.

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GEOLOGIC RESEARCHES AND SCIENTIFIC MANPOWER

It is a truism, if all too lately recognized, that the more fruitful geological researches today (and tomorrow) depend to an increasing degree on the techniques of the sister sciences and mathematics. So much is this the case that a number of quasigeological "Earth and Space Science" departments or divisions have been created and others are springing up not only at universities but also in private industrial and governmental research complexes, as well. The pendulum has now swung so far from the geologists *per se* that these organizations are being staffed to a large degree by non-geologists trained in one of the more fundamental, yet supporting, sciences. The advantages are obvious. The disadvantages, which may be equally great, are as yet only dimly perceived. Despite the paradoxical stigma now attached to the use of the time-honored and appropriately descriptive word "geology," the Earth Science Institutes and Departments are still chiefly engaged in *geological* researches. In such investigations it is just as short-sighted to expect first-rate results from a staff member who has little or no geological background, as to expect outstanding contributions to stem from the "geologist" who does not have considerable mastery of at least one of the more basic scientific disciplines. As an additional adverse factor, we see fewer students entering undergraduate geological studies and, if the trend continues, fewer "genuine" geologists will be available for geological positions in teaching or in industry. In short, the situation feeds on itself. The possible over-all effects on the science of geology, on the broadly ramifying profession of "petroleum geologist" and on the A.A.P.G. are considered. The serious, national problem of scientific and technical manpower inadequacies is also closely involved in the geological research dilemma, and is discussed in some detail.

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THE AGE OF ENERGY

Progress through the ages has been measured by man's mastery over minerals. In the present century, a most significant achievement has been development of abundant supplies of energy that multiply productivity and transform transportation.

Mineral energy makes it possible to reach and utilize resources previously unaccessible or non-commercial. The building blocks for an industrial civilization are thus expanded enormously to keep pace with the population explosion.

Progress in the development and utilization of inanimate energy has created unlimited horizons for science and technology. For example, today we speak confidently of reaching the moon and drilling through the crust of the earth, whereas, less than a century ago, the fantasies of Jules Verne seemed unattainable dreams.

Any fears that may have existed in the past that we will run out of energy can now be set aside. The mind of man has opened limitless energy resources, including nuclear fission and fusion. Wise and efficient use of our resources will continue to be good business, but we can proceed confidently to use all the energy needed to promote economic progress throughout the world so that all mankind may enjoy a better and richer life.

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STRATIGRAPHY OF THE VICKSBURG EQUIVALENT OF LOUISIANA

A study, extending from western Mississippi across Louisiana and into East Texas, of the surface stratigraphy of the Vicksburg (Oligocene) equivalent in Louisiana reveals that five units comprise the sequence from upper Jackson (Eocene) to lower Catahoula (Miocene): (5) massive quartzose sandstone; Cassels Hill Member of the Catahoula Formation (20–50 feet); (4) clays and silts, fossiliferous and calcareous; east of Sabine Parish designated Rosefield Formation and in Sabine Parish and farther westward called Nash Creek Formation (25–70 feet); (3) well sorted quartzose sand; Sandel Formation (20 feet); (2) chocolate clays and lenticular quartzose sands; Mosley Hill Formation (80 feet); (1) khaki-colored fossiliferous clays; Danville Landing Beds (100+feet).

These units remain consistent and persistent along strike across Louisiana. The three middle units represent the original Mosley Hill group thought to be Oligocene by Murray, but in this paper the Mosely Hill is restricted to the lower unit which is present at the type locality. The names Sandel and Rosefield are new. The maximum thickness of the total sequence is 180 feet in Catahoula Parish. The Cassels Hill Formation is separated from the Rosefield Formation by a disconformity beneath which the Rosefield decreases in thickness from 70 feet in Catahoula Parish to 7 feet in western Louisiana and East Texas.

The Mint Spring Marl of the lower Vicksburg sequence in Mississippi is subdivided into the underlying marl facies which extends westward and the overlying carbonate facies which extends eastward. The Rosefield Formation of Louisiana is thought to correlate with the entire Vicksburg sequence at Vicksburg plus the uppermost 15 feet of the Forest Hill of Mississippi. The Sandel and upper Mosley Hill represent the Forest Hill (restricted) of Mississippi and the Danville Landing is upper Yazoo equivalent. The Sandel pinches out westward into Texas so that there is no separation between the Mosley Hill and Rosefield clay and silt sequences, both of which are represented in the type Manning of Texas.

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EVOLUTION OF THE CONTINENTAL SHELF AND SLOPE

Further explanations of the origin of the continental slope, such as ascribing it to catastrophism, normal faulting, a wave-built terrace, or marginal downwarping, appear to be unsatisfactory. Instead, the writer considers continental slopes to have been constructed by the folding of the continental rise against the continental block, forming a eugeosynclinal orogen. Accordingly, continental slopes would be the flanks of such orogens; a secondary cause for some continental slopes may be the modified scarp left after a rifting-apart of a continental mass by continental drifting. Once formed, initial continental slopes undergo modification by erosion and sedimentation. A proposed mode for such geomorphic evolution is presented. Continental shelf formation is a part of this evolution.

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BIAS FACTORS IN LOOSE-GRAIN DATA

In loose-grain studies, sampling of grains by point-count or other conventional methods is never equivalent to sampling of the sediment by volume. This causes severe difficulties in comparison of Recent sediments, in which loose-grain data are frequently used, with older sediments, in which thin-section or chemical data are used. Even sieve data are not directly comparable. Correction of loose-grain data to a "volumetric" basis is surprisingly complex and uncertain.

Where a sediment must be described in terms of its volume, all loose-grain point-count data are systematically biased in favor of the finest grains present on any area. Given equal volumes, the frequency of encounter of any grain-size category is cut in half every time the grain diameter is doubled. This can be demonstrated with assorted spheres, by chopping a potato into successively smaller cubes, or by simple algebraic derivations. Shape factors may contribute an additional bias which is not considered here.

After transformation of the raw data to "volumetric" ratios by multiplication, a certain amount of bias is still present, or "uncorrectible," unless *every grain* in a sediment is counted. In statistical terms.

$\bar{\bar{X}} = \mu$ only if $n = \infty$ (where μ is the un-biased, "parent," "volumetric" model mean)

The "uncorrectible" portion of the original bias is a function of: (1) sorting or "Variance"; (2) the number of points counted, or "sample size"; and (3) Gaussian normality of the un-biased natural property with respect to volume. Bias (1) increases dramatically as the sorting gets poorer, (2) decreases asymptotically toward zero as the number of points is increased, and (3) becomes highly erratic for properties which are not "normal." The effect of this bias on polymodal properties is catastrophic.

Estimation of the "uncorrectible" portion of the bias, from the behavior of mathematical models, is a haphazard procedure at best. Only a few models have been worked out, due to the number of calculations which become necessary. In the model shown here, the "uncorrectible" bias is more than half of the total bias.

Until good methods of bias-correction can be developed, statistical comparisons of loose-grain properties must be considered either: (1) unrelated to sediment volumes, or (2) confounded with sorting and (or) normality. Hence, comparisons of size, and any property dependent upon ("interacting with" or "correlated with") size, must be accompanied by tests demonstrating complete uniformity of sorting ("Homogeneity of Variance", at the "point" or "error" level). Where this is impossible, interpretation of the test results becomes frustrating and virtually futile.

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ATLANTIC MARGIN OF NORTH AMERICA

Recent investigations in previously poorly covered areas and with new techniques have extended our knowledge of the structure of the continental margin of eastern North America. The sedimentary trough under the continental rise has been better defined by seismic profile data and structural trends have been followed by magnetic measurements. Among the features recently identified is a structural offset at 40° North Latitude which appears to be a transcurrent fault off-