2. The paleogeography of the eastern Gulf Coast during Jacksonian (Late Eocene) times was reconstructed by a combination taxonomic-morphologic method. For Tertiary faunules some of the precision lost by using taxonomic data alone, by the change from specific to generic level, is restored by adding morphologic data. This treatment of Jacksonian faunules is an elaboration of one introduced by L. W. Stach in 1936 and consists of determining relative frequencies of zoarial growth forms. Coupled with taxonomic data, these frequencies suggest water depths of 20–50 fathoms in Alabama and western Florida and 5–20 fathoms in peninsular Florida.

The morphologic approach seems especially versatile and capable of extension, but for proper evaluation the adaptive significance of many features, e.g., avicularia and vibracula, must be ascertained.

CHISHOLM, WAYNE A., The Pure Oil Company, Crystal Lake, Illinois

### Effect of Climate and Source Area Location on Browns Park Formation Petrology

The Browns Park Formation of Miocene age consists dominantly of cross-bedded feldspathic sandstones and was deposited by a series of northward flowing rivers that headed in the vicinity of the San Juan Mountains. The sandstones were transported 150 to 250 miles to northwestern Colorado and south-central Wyoming.

Abundant plutonic and volcanic rock material show that the sandstones are largely first cycle sediments. The quartz, feldspar, volcanic rock fragments, and heavy minerals all are considerably rounded; some are very well rounded. The freshness of much of the feldspar demonstrates that corrosion at the source is not responsible for the rounding, but the distance of fluviatile transport is too short to explain the degree of rounding. The quartz grains are commonly frosted and pitted, considered to be due to eolian action. The rounding of the sand grains apparently took place during intermittent periods of eolian activity. Fluviatile transport associated with eolian activity suggests a semi-arid climate.

Volcanic centers in northern Utah and southern Idaho have been suggested as a source of the volcanic material which occurs abundantly in the Browns Park Formation. Grain size determinations of quartz, feldspar and volcanic rock fragments showed an increase in size of all components toward the south and not toward the suggested western area. The mean grain size, sorting coefficient, and other grain-size parameters are similar in the quartz, feldspar and volcanic material. This relationship suggests that volcanic material was carried an appreciable distance with the other components in the sandstone. The grain-size characteristics of the volcanic-rich Browns Park sandstones indicate that most of this material was derived from volcanic centers in the San Juan region.

COLEMAN, JAMES M., GAGLIANO, SHERWOOD M., and WEBB, JAMES E., Coastal Studies Institute, Department of Geology, Louisiana State University, Baton Rouge, Louisiana

### Minor Sedimentary Structures in a Prograding Distributary

Minor sedimentary structures were studied in cores taken at the mouth of a small prograding distributary within the Mississippi River delta. The mouth of Johnson's Pass in Garden Island Bay was mapped and the following environments were recognized: subaerial and subaqueous natural levee, channel, distributary mouth bar, interdistributary bay, and marsh. Oriented, undisturbed cores were taken from each environment. These cores were split, dried, and photographed and the types of minor sedimentary structures within each environment were tabulated. Natural levee deposits contained abundant current ripple bedding, unidirectional cross-laminations, parallel and wavy laminations, distorted layers and burrowed oxidized silty sands, whereas channel fill deposits consisted of alternating beds of clay and silt containing trough cross-laminations, scour and fill structures, and distorted layers. The distributary mouth bar, composed predominantly of silt and sand, is characterized by a variety of small-scale multi-directional cross-laminations and air-heave structures. Three types of interdistributary bay deposits were recognized; highly burrowed interbedded silt and clay, homogeneous clay with scattered brackish-water fauna, and a predominantly clay section with thin parallel and lenticular laminations and ripple marks. The structures within these three types are a reflection of availability of coarse detritus. Marsh deposits are characterized by the abundance of peat, carbonaceous clays, calcareous nodules, and root disturbances.

Each environment is characterized by a distinct assemblage of structures. These assemblages can be used to interpret paleoenvironments in ancient sedimentary rocks.

COOK, THEODORE D., Shell Oil Company, Houston, Texas

### Deep Lower Cretaceous Exploration on the Western Gulf Coastal Plain

Hydrocarbon exploration in Lower Cretaceous rocks of the western Gulf Coastal Plain dates from the 1920's when such shallow fields as Luling, Darst Creek, and Salt Flat were discovered. Deeper exploration for objectives in the Lower Cretaceous increased sharply following the 1954 discovery of Stuart City field, LaSalle County, Texas.

The rock column under consideration, dates from Neocomian to upper Albian including, in ascending order, the following stratal units: Trinity, Fredericksburg, and Washita. While the deep Lower Cretaceous activity is often referred to as "the Edward reef play," objective horizons actually fall within the Edwards, Glen Rose, and Sligo limestones.

The middle Trinity Pearsall shale and middle to late Washita Del Rio shale are widely distributed, easily mapped units. Limestones between these key beds are composed of three generalized lithofacies grading from north-northwest to south-southeast as follows: (1) Carbonate rocks of shallow-water origin characterized by mudstones, wackestones, and packstones in which miliolid and larger foraminifers, oölites, and algal structures are common. Evaporites are locally abundant and dolomite is widely developed; (2) Wackestones, boundstones, and grainstones of shallow-water origin in which the dominant faunal elements are rudistids, corals, algae, and stromatoporids; (3) Carbonate mudstone of somewhat deeper-water and more open-sea origin bearing pelagic foraminifers and calcispheres.

Lithofacies 1 and 3 have widespread distribution whereas the rudistid-bearing rocks are limited to a rather narrow band along platform margins, and have thus become known as "the Edwards reef."

These Lower Cretaceous rocks produce from fault closures in the Edwards and Glen Rose where dolomitization and dissolution have greatly improved the reservoir 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.

CRAM, IRA H., Continental Oil Company, New York, N. Y.

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.

CRITZ, JAMES S., Superior Oil Company, Houston, Texas

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.

CRONEIS, CAREY, Rice University, Houston, Texas

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 shortsighted 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.

DAVIS, MORGAN J., Humble Oil & Refining Company, Houston, Texas

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