distribution of the minor lateral channels gives them most of the drainage.

The inlet flow issues with appreciable velocity scouring the trough and hole and forming a local maximum of current energy in its flow direction. The trough typically has two major branches at each end separated by shoals but narrowly and sub-centrally confined. If unobstructed and unbranched, the issuing channel flares like a horizontal jet, which ideally flares at 12°. Whether single or branched, the issuing current is a *tidal jet*.

Thus, at the ends of the inlet, both the flood and ebb tides are drains on the high side and jets on the low side of the barrier, in both cases being there local maxima of hydraulic energy.

The mouths of shallow estuaries, but not those of deep straits, show the type of channel pattern characteristic of the tidal inlet.

PUSEY, WALTER, Department of Geology, Rice University, Houston, Texas

RECENT CARBONATE SHOAL COMPLEXES IN NORTHERN BRITISH HONDURAS

In two separate areas on the continental shelf of British Honduras, the accumulation of Recent carbonate mud results in a series of mud shoals, herein termed mud shoal complexes. These shoal complexes range in depth from 1–5 feet and are dissected by tidal channels 6–10 feet deep. The tidal channels have slopes approximating 15° and divide each of the mud complexes into many individual mud mounds. The long axes of these mud mounds are essentially at right angles to the long axis of each mud shoal complex.

Both mud shoal complexes are represented by 7–9 feet of silt- and clay-size carbonate overlying a Pleistocene erosion surface. However, the mineralogical and biological characteristics of the two mud shoal complexes differ. With respect to mineralogy, one mud shoal complex, the Bulkhead, contains a lower percentage of aragonite and a higher percentage of low-magnesium carbonate in both the muds and adjacent sandy sediments than the Ambergris-Cangrejo mud shoal complex. With respect to biota, the Bulkhead shoal is characterized by a relative paucity of turtle grass, whereas the opposite is true for the other mud shoal complex. In the former case, mud deposition apparently results from the confluence of currents, the deposited mud being stabilized rapidly by the mucilagenous products of diatoms and other algae and less rapidly by the production of mucous-bound fecal pellets of worms. On the Ambergris-Cangrejo shoal, mud deposition and stabilization may be a product of the current-baffling and sediment-stabilizing attributes of the dense covering of turtle grass.

The mineralogical and biological differences between these two mud shoal complexes are not likely to be preserved in the geologic record. Inversion of aragonite and high-magnesium calcite to low-magnesium calcite, decay of plants, and possible dissolution of the opal tests of diatoms will undoubtedly occur during diagensis. Thus the tendency of diagenesis may be to reduce the lithologic and biologic distinctiveness of mud mounds of dissimilar origin. Consequently, the origin of similar-appearing ancient mud mounds may not be identical, and any theory of origin of any particular mud mound should be evaluated with respect to the source of the mud, the cause of local mud accumulation and stabilization, and the possible relation of the mound to a mud shoal complex.

RAINWATER, E. H., Shell Development Company, Exploration and Production Research Division, Houston, Texas

TRANSGRESSIONS AND REGRESSIONS IN THE GULF COAST TERTIARY

In the central and western Gulf Coast the Tertiary, whose maximum thickness at any one place is probably about 30,000 feet, consists almost entirely of alternating marine and non-marine fine-grained terrigenous clastics. Some of the marine formations extend to the outcrop, but many others are now deeply buried and are represented in the outcrop by non-marine deposits. All formations grade eastward into shallow marine carbonates.

Numerous local and many regional transgressive and regressive sequences of sediment are present. The local fluctuations in the strandline were caused by delta building and abandonment; the regional shifts are believed to have been caused by variation in the rate of subsidence of the basin or to variation in the amount of sediment transported to the area. It appears that sedimentation was faster during the regressive periods than during transgressions. However, the progradation was in most cases slower than the movement inland (transgression) of the sea.

The generalized sedimentation history of the Tertiary in the central and western Gulf Coast is explained. The only rhythmic or cyclic sedimentation patterns in this thick section are a result of shifting strandlines which may have no relation to eustatic changes in sea-level.

ROSS, CHARLES A., Illinois State Geological Survey, Urbana, Illinois

EVOLUTION AND DISPERSAL OF THE EARLY PERMIAN FUSULINID GENERA *Pseudoschwagerina* AND *Paraschwagerina*

Two genera of fusulinids, *Pseudoschwagerina* and *Paraschwagerina*, long recognized as stratigraphic guides to Lower Permian beds, contain more than 100 species which can be grouped according to their morphological similarities and differences into twelve phylogenetic lineages. The primitive species complexes that initiated these lineages began near the beginning of the Permian in the Western Hemisphere. Their widespread migration and subsequent restriction led to the evolution of more advanced lineages of which several had times of widespread, but commonly brief, distribution.

The most primitive pseudo-schwagerinid complex, the *Pseudoschwagerina beedei* complex, arose from inflated *Triticites* ancestors probably in the Andean geosyncline. This complex gave rise to the *P. uddeni* complex, which attained both Eurasian and Western Hemisphere distribution, and the *P. d'orbignyi* complex which is known from South America and southern Europe. The *P. heritschi*, *P. carniolica*, and *P. miharanoensis* complexes are largely restricted to Eurasia or to small areas of the Eurasian fusulinid province. The ancestors of each of these three complexes are poorly known but they apparently arose from advanced species in the *P. uddeni* lineage. Both the *P. yabei* and *P. stanislavi* lineages appeared very late in the evolution of the genus. The *P. yabei* complex ranges into strata of Leonardian age in southern Europe and Asia and the *P. stanislavi* complex occurs in strata of Leonardian age in Eurasia and North America.

The most primitive paraschwagerinid species complex, the *Paraschwagerina gigantea* complex, is apparently related to the genus *Schwagerina* but its ancestry is not well known and species of *Schwagerina* that would form typical ancestors for *Paraschwagerina* did not evolve until *Paraschwagerina* itself was nearly extinct. Of the younger and more advanced complexes, the *P. plena* complex is restricted to western North America and the *P. roveloi* and *P. endoi* complexes are known from both North America and Asia.

ROSS, JUNE PHILLIPS, Illinois State Geological Survey, Urbana, Illinois

LOWER PERMIAN BRYOZOA, CARNARVON BASIN, WESTERN AUSTRALIA

The early Permian (Asselian-Sakmarian) Lyons Group consisting of tillite, greywacke, sandstone, siltstone, and conglomerate rests unconformably on the Precambrian basement and is conformably overlain by the Permian (Artinskian) Callytharra Formation. Bryozoa occur in thin, local, calcareous lenses in the Lyons Group, 4,600 feet thick in its type section, whereas they form rich bryozoan calcarenites and bryozoan calcirudites in the overlying Callytharra Formation, 765 feet thick. The stenoporid species in the Lyons Group display similarities to certain Eastern Australian forms from the early Permian, and a well distributed fenestellid species of *Polypora* has close affinities with species from the Lower Permian in Eastern Australia and from the Bitauni Beds (equivalent to the Asselian Series of Russia) from Timor. These species of *Polypora* appear to be primitive members of a well-defined phylogenetic group of species including *P. tuberculifera*, *P. punctata*, *P. subovaticellata*, and *P. nadinae* from the upper part of the Sakmarian Series of the Ural Mountains. The geographic and stratigraphic distributions of such early Permian bryozoan lineages appear useful tools in the correlation of different stratigraphic units.

The generic and specific composition of the bryozoans in the overlying Callytharra Formation is vastly different and the bryozoan faunal break between these two stratigraphic units is very distinctive. Genera such as *Hexagonella*, *Evactinopora*, *Protoretepora*, *Ramipora*, *Streblotrypa*, *Rhombocladia*, and *Streblocladia* which are prominent in the Callytharra bryozoan faunas are not found in the Lyons Group.

RUMMERFIELD, BEN F., GeoData Corporation, Tulsa, Oklahoma
MORRISEY, NORMAN S., Consultant, Tulsa, Oklahoma

HOW TO EVALUATE EXPLORATION PROSPECTS

The problems of exploration evaluation are occupying an ever-increasing importance in the petroleum industry. Recent developments in exploration trends and in the field of data handling stress the need and desire to minimize risk in business decisions.

Geologic-geographic preference has long been an excellent criterion to determine where to concentrate exploration efforts. This becomes very obvious when the exploration efforts and results in areas such as the Gulf Coast and West Texas are carefully analyzed and compared with other areas. Exploring for oil in certain foreign countries, too, has paid off munificently, particularly when the oil finding costs are compared in dollars per barrel with similar costs in the United States.

All exploration programs have one common goal: To find and exploit oil and gas reserves at a profit. However, economic factors are playing an ever-increasingly important role. The problem of arriving at what appears to be the optimum route to follow in petroleum exploration can be facilitated by a statistical approach, particularly with the recent advent and utilization of data processing techniques. This approach is not a substitute for intelligence or judgment but it is a new advance in the solution of problems of all kinds. The theories of probability provide a method of measuring uncertainty that may lead to better exploration decisions.

Innumerable factors affect exploration decisions but these can be placed in four broad categories—geophysical, geological, economic and engineering aspects. Since the primary goal of any exploration problem is to find and exploit reserves efficiently, a realistic approach for exploration decisions is needed. The various factors must be considered and an attempt made to translate them into a desired return on investment. The resultant solution can be accepted or rejected, depending on good judgment and the particular company's criteria and policies.

Analytical evaluations bring oil exploration from the realm of educated guessing to a quantitative approach that fits into modern businesses' techniques. Management and explorationists can thus appraise the merits of a prospect or exploration program and expect to derive optimum results with minimum risk.

RUSNAK, GENE A., Institute of Marine Science, University of Miami, Florida
NESTEROFF, W. D., Laboratoire de Geologie Dynamique, Paris, France

MODERN TURBIDITES: TERRIGENOUS ABYSSAL PLAIN VERSUS BIOCLASTIC BASIN*

Many of the fundamental characteristics of abyssal plain turbidites may be traced in the modern calcareous turbidites of the Tongue of the Ocean. However, less broad areas of coverage and greater diversity of the constituents are evident from the Tongue of the Ocean than would be expected in abyssal plain deposits. This difference reflects a narrower depositional basin and several localized sources, each with its own materials.

The abyssal plain deposits are laterally transported cyclic-graded beds of terrigenous sand, silt, and clay alternating with possibly minor layers of true pelagic sediment consisting of the vertically (particle by particle) settled clay components characteristic of red clays. The cyclic units are monotonously similar, with no outstanding distinctions between them except for thickness and maximum grain size, and are of broad areal extent.

The Tongue of the Ocean deposits are also cyclic, but the turbidites consist of bioclastics, pteropods, foraminiferal sands, and calcareous silts and clays; the pelagic beds between are homogeneous calcareous clayey silts (calcilutites) with varying amounts of Foraminifera and pteropods. The sediments are primarily calcareous silts in contrast to the terrigenous clays of the abyssal plain. Cyclic units vary in composition and are only locally distributed.

RYAN, ROBERT, Central Illinois Light Company, Peoria, Illinois
BUSCHBACH, T. C., Illinois State Geological Survey, Urbana, Illinois

TECTONIC HISTORY OF THE GLASFORD CRYPTOEXPLOSION STRUCTURE

Exploration sponsored by the Central Illinois Light Company has delineated a structural high, 12 miles southwest of Peoria, near the village of Glasford, Illinois. The structure is nearly circular and consists of a normal sequence of Paleozoic strata down to the Ordovician Maquoketa Shale. The Maquoketa is abnormally thick over the dome, and the underlying 1,500 feet of rocks are faulted and severely brecciated. The structure appears

* Contribution from the Marine Laboratory, University of Miami.