times connected) depocenters of the miogeosyncline.

Ely Limestone (Pennsylvanian) exhibits rhythmic arrangement of skeletal to bioclastic, calcarenitic, matrix, and micritic limestones with some interbedded calcareous sandstones. The sedimentary cyclic pattern occurs in stratigraphic sections totaling 1,000 to 1,500 feet, particularly in the Burbank Hills, Confusion Range, and Leppy Range of western Utah, and in the Cherry Creek Mountains, Butte Mountains, Pequop Mountains, Diamond Range, and Pancake Range of Nevada.

Ferguson Mountain Formation (Wolfcampian) of northeastern Nevada and part of adjacent Utah is approximately 2,000 feet of alternating reefoid, bioclastic matrix, and micritic limestones arranged in a remarkable pattern in which this tetrad is repeated numerous times by patterned sedimentation. Farther south in east-central Nevada and west-central Utah the Riepe Spring Limestone and restricted Arcturus Formation (both Wolfcampian) aggregate 1,000 to 2,000 feet of cyclically arranged reefoid, bioclastic-lithoclastic, matrix, and micritic limestones with which occur interbedded calcareous quartzose sandstones.

The Leonardian-age Pequop Formation crops out in a large area of eastern Nevada and western Utah; essentially all sections studied display patterned or rhythmic sedimentation of bioclastic, skeletal, matrix, and micritic limestones. Butte Mountains and Pequop Mountains of Nevada contain finest stratigraphic sections; the one at Moorman Ranch near U.S. Highway 50 about 35 miles northwest of Ely is a remarkable arrangement of about 2,500 feet of criquinites, fusulinid coquinites, sandy matrix limestones, and micrites. A normal triad of criquinites with fusulinids, sandy matrix limestones, and micritic limestones typifies the section in rhythmic succession.

Marine strata of Guadalupian age in western Utah and eastern Nevada include, in ascending order, the Loray Formation, Kaibab Limestone, Plympton Formation, Indian Canyon Formation, and Gerster Formation. The Loray contains shale, siltstone, dolosiltites, evaporitic dolomites, and petroliferous limestones arranged in cyclic manner; this succession evidently formed in marine to non-marine environments under transgressive-regressive conditions. The overlying Kaibab, Plympton, and Indian Canyon do not display marked pattern sedimentation. Gerster Formation normally is less than 1,000 feet thick, but where more than 4,000 feet thick in south-central Elko County, Nevada, it consists of cyclically arranged tetrads of skeletal, matrix, and micritic limestones, and arenaceous criquinites.

Evidence suggests that periodicity of diastrophism of marginal and intra-basin landmasses substantially controlled the pattern of sedimentation in depocenters of the Late Paleozoic miogeosyncline. Marine oscillations and concomitant transgressive-regressive sedimentation across the broad shelves, banks, basin, troughs, and evaporite pans established a pattern of carbonate deposition. Rhythmic activity of the Antler-Sonoma orogenic belt, Northeast Nevada Highland, West-Central Utah Highland, Ely Uplift, and others provided detritus and otherwise initiated and controlled patterned sedimentation.

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SEDIMENTARY FACIES MODEL OF TURBIDITES

Deposits of turbidity currents are characterized by alternating layers of sandstone and shale, in which a unit layer is defined as the sandstone together with its overlying shale.

Studies of turbidites of different ages, and from many different localities in Europe, make it clear that turbidites are characterized by *one* sedimentary facies model, which is composed of five specific intervals in a fixed succession. In a complete layer the intervals from bottom to top are: graded interval (20–500 cm), lower interval of parallel lamination (10–200 cm), interval of current ripple lamination (4–100 cm), upper interval of parallel lamination (2–50 cm), and pelitic interval (1–40 cm).

Each turbidite layer in the areas studied shows part or all of this sequence, and everywhere the succession is the same. The completeness of the sequence generally increases with increase in thickness of the unit layer. Incomplete sequences normally are caused by truncation of the upper intervals or omission of the lower intervals. Large differences in grain size between successive turbidite layers occur where the base of a layer is formed by one of the three lower intervals. The lower bedding planes of such layers are most readily exposed by weathering and are more likely to contain sole markings than layers in which the lower three intervals are missing.

An understanding of the origin of each of the five intervals and the reason for their definite succession in turbidite layers is essential to understand the mechanism of deposition by turbidity currents.

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WEST BASTIAN BAY FIELD, SOUTH LOUISIANA

The large, domal structure at West Bastian Bay field, central Plaquemines Parish, Louisiana, is interpreted as a deep-seated salt dome. A large, east-west striking, south-dipping, contemporaneous normal fault traverses the dome and controls accumulation of oil and gas in multiple upper Miocene sands. At the time of maximum growth along the Bastian Bay fault, sediment was deposited approximately three times as fast in the downthrown block, where most of the hydrocarbon accumulation occurs. The relative thickness of sediments shows that domal uplift, deposition of upper Miocene and younger beds, and movement along Bastian Bay fault were contemporaneous. Reliable electric log correlations together with paleontological data from well samples in the field area, afford excellent data for a detailed study of contemporaneous normal faulting, a type of faulting common to Miocene sediments of the Gulf Coast and important to exploration for oil and gas.

Microfaunal and lithologic data from conventional cores through productive intervals show that the "R" and "S" sands were deposited predominantly in nonmarine environments. These sands in turn are separated by dense homogenous gray-black shales, deposited in marine environments equivalent to those existing on the modern continental shelf.

Production has been established in 20 sands ranging in depth from 8,677 to 15,305 feet.

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PROGRESS IN RESEARCH ON ORIGIN AND MIGRATION OF OIL

Analyses of petroleum and sedimentary hydrocarbons have provided a number of clues to the origin and primary migration of petroleum from source sediments and can reasonably be expected to continue to be a fruitful

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field of investigation. A review of recent contributions in identification of hydrocarbon structures in petroleum supports and reaffirms earlier evidence that some of the hydrocarbons in petroleum have been derived from the residues of biological materials.

The hydrocarbons distributed in sediments are observed to be more petroleum-like after burial and compaction. There is no systematic change with depth or age. Large variations may occur between different formations and different facies of the same formation. Mild metamorphism can change the kind, and reduce the amount, of liquid and solid hydrocarbons in rock.

A number of mechanisms have been suggested for the primary migration and collection of the finely disseminated oil from the presumed source rocks. These modes of migration, however, should explain observed differences between reservoir and sediment hydrocarbons, including the larger percentages of alkanes in the heavy saturated hydrocarbons of crude oils.

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Geology of Mount Gran Area, Antarctica

The Mount Gran area, encompassing Mount Gran and the ice-free Gran Valley (unofficial name) adjoining on the north, is located 77°S and 161°E in the rugged, glaciated mountains of South Victoria Land, Antarctica.

Most of the area is underlain by sedimentary rocks, intruded by, and sandwiched between, thick diabase sills. However, a basement complex of metamorphic and igneous rocks crops out in a small, isolated exposure at the northwest corner of Gran Valley. This complex consists of granitic rocks and gneisses which are cut by acid and basic dikes. The gneisses show foliation striking northwest with a nearly vertical dip. The age of the gneisses may be Precambrian or possibly Early Paleozoic.

The sedimentary rocks, all referred to the Beacon Sandstone Group, which ranges from Silurian to Jurassic in age, crop out on the southeast face of Mount Gran and in a thick belt rimming most of the 8-mile long, northeasterly trending Gran Valley. Dips are 3°–8° northwestward. In Gran Valley, the dominant lithologic type consists of light gray to white, well sorted, fine- to medium-grained, cross-bedded, quartzose sandstone between 1,000 and 1,300 feet in thickness. The lower half of this section includes ferruginous concretions as much as one foot in diameter. A few thin beds of green silicified siltstone occur in the upper half of the section.

At Mount Gran 130 feet of the quartzose sandstone is overlain by 470 feet of a nearly cyclic sequence of carbonaceous shale, coal, conglomerate, arkosic sandstone with interbedded shaly siltstone, and sandstone. Correlation between the quartzose sandstone at Mount Gran and Gran Valley is not clear because of lack of diagnostic fossils and discontinuity of exposures, but it is believed that the coal-bearing section stratigraphically overlies the Gran Valley section.

The youngest formation, the Ferrar Dolerite, probably of Jurassic or Cretaceous age, occupies the largest part of the Mount Gran area. Two large sills are present in Gran Valley. One, which probably overlies the basement complex and generally underlies the Beacon Group, forms the floor of the valley. The second overlies the Beacon Group in Gran Valley, forming the escarpment and skyline of the Mount Gran area. To the south, at Mount Gran, the two sills join, leaving only a remnant of Beacon sandstone which is dissected by diabase sills and dikes.

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Detrital Heavy Minerals of Upper Triassic Sandstones of West Texas

Heavy-mineral analysis of 53 outcrop samples from the Upper Triassic Dockum Group in West Texas and northeastern New Mexico showed a stable heavy-mineral association of zircon, tourmaline, garnet, leucoxene, magnetite-ilmenite, and rutile. An adjacent sedimentary source terrane was suggested by these results.

Previous studies of cross-bedded Dockum sandstones indicated a source for the Upper Triassic at the southeast. Fifteen outcrop samples were therefore examined from sandstones of Pennsylvanian and Permian age in central Texas, the assumed source area. Both heavy minerals and quartz varieties in these rocks were virtually the same in most details as those of the Dockum Group. Comparisons of mineral varieties and their roundness characteristics also indicated close similarities.

It is concluded that: (1) mineralogical comparisons corroborate cross-bedding results of a major source of detritus for the Upper Triassic at the southeast, (2) this source area was the sedimentary terrane consisting of clastics of Pennsylvanian and Permian age in central Texas, (3) more than one sedimentary cycle was involved, and (4) the probable ultimate source was a granitic terrane with minor basic igneous and metamorphic contributions.

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Role of Bryozoa in Cenozoic Paleoecology

Distribution and abundance of fossil organisms still furnish the major basis for ecological interpretation of sedimentary rocks because organisms respond to, and therefore record, the whole complex of their surroundings, animate and inanimate. The task of the paleoecologist, resolution of this response into meaningful components, depends on knowledge of the requirements and tolerances of the organisms involved.

Bryozoa are a numerically important element of faunas enclosed in Cenozoic limestones, marls, and calcareous clays. They comprise more than 500 marine, mostly stenohaline genera that collectively are widely distributed in all of the main faunal provinces. Individually these genera tend to be stenothermal and therefore reliable paleoclimatological guides to the position and shifts of the provinces during Cenozoic time.

As part of the sedentary epifauna, bryozoans are especially sensitive to movement of water and consistency of substrate, physical determinants which are themselves consonant with water depth. This sensitivity provided the basis for investigation of two paleobathymetric problems in the Gulf Cenozoic.

1. The depth of accumulation of Quaternary mudlumps at the mouth of South Pass of the Mississippi River was determined by a taxonomic method. The mudlump faunules include 34 species whose present depth ranges are known from published accounts. Analysis of these ranges and comparison with individual Recent faunules yielded a depth of accumulation of 20–50 fathoms, 40 fathoms being the single most probable value.