blage in the Ensenada de la Broa; (2) a transitional miliolid-*Elphidium* facies over much of the inner bay area; (3) an *Archaias* high-energy biofacies in the eastern part of the bay associated with coarse sediment, relatively stable salinity values, and a rather high oxygen content; (4) a *Discorbis-Vertebralina* low-energy biofacies in the western part of the bay in areas of mostly mud matrix; and (5) a reef-front facies composed of *Amphistegina lessonii, Asterigerina carinata,* and *Rotorbinella rosea* which are associated with coarse well-sorted sediments, strong currents, and a high oxygen content. Planktonic Foraminifera do not occur in the platform biofacies.

Deep-water cores off the Batabano platform show high percentages of displaced platform Foraminifera within the benthic faunas, more than 80 per cent planktonic Foraminifera in deeper-water cores, foraminiferal numbers of several thousand, and rare reworked Miocene Foraminifera.

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VELA UNIFORM AS OF EARLY 1963

For the past three years, VELA UNIFORM has been underway as a major national effort directed toward achieving a reliable system for detecting, locating, and identifying nuclear explosions underground. A brief review is made of the more interesting technical developments of importance to the practicing earth scientist. Such developments include improved knowledge of variations in the earth's crust and upper mantle, distribution of seismic noise near and below the earth's surface, ocean-bottom seismometry, advanced seismic array processing, and on-site inspection techniques, both aerial and surface. A brief film of some of the major physical facilities sponsored by VELA UNIFORM is also shown.

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RECENT MEANDER BELT DEPOSITS OF THE BRAZOS RIVER: AN ALLUVIAL "SAND" MODEL

Point bar deposits of the Brazos River near Richmond, Texas, appear to be typical of an alluvial meandering stream of this size. They are the principal meander belt deposits and consist of a sequence of silt and fine sand grading downward to coarse sand and gravel. A typical section may be subdivided into four generalized zones, each characterized by a particular class of sedimentary structure: (1) small ripple (or small scale) cross-bedding, (2) horizontal lamination, (3) giant ripple (or medium scale) cross-bedding, and (4) poor bedding. The section is an offlap sequence deposited within the channel or the depositional (convex) bank area as the stream meandered laterally toward the erosional or caving (concave) bank. The average thickness of the total section is 55 feet, which is equal to the average maximum depths of the river during flood stages.

Natural levee sediments deposited along the flood stage bank are 5 feet or less in thickness and are difficult to distinguish from the uppermost point bar sediments.

As the stream meanders within its belt, it produces a suite of deposits, consisting of sediments characteristic of point bars, natural levees, and fills of abandoned channels and oxbow lakes. The widths of the belts and related deposits, which are approximately 1.5 miles and 18–20 times the width of the stream, appear to be controlled primarily by the radius of curvature (600–2,400 feet) of the meanders.

Abandoned channel fills consist principally of laminated and bedded clay and silt. They are tortuous or arcuate in ground plan, a few hundred feet wide, and their cross sections are roughly U-shape. The deposits range from a few feet to approximately 40 feet thick and usually occupy positions within the upper two-thirds of the compounded point bar sections.

Flood basins within the alluvial plain of the Brazos are adjacent to the meander belts and are topographically lower, approximately 5 feet, than the uppermost point bar and natural levee sediments. The flood basin deposits are laminated and poorly stratified sandy clay and silt containing numerous soil zones and calcareous and ferruginous nodules.

During the Late Recent standing sea-level stage, approximately the past 3,500–5,000 years, the Brazos has developed and abandoned several meander belts within its alluvial plain, which is approximately 7 miles wide near Richmond. Most belt trends are approximately at right angles to the regional depositional strike. Cross-bedding directions and grain orientation conform with various river current directions, and most are aligned closely with the trends of the depositional banks of the individual point bar deposits.

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INTRODUCTION: WHY A SYMPOSIUM ON CONTINENTAL SHELVES AND SLOPES?

Criticism of two kinds often is leveled at research symposia held in conjunction with annual meetings—lack of timeliness and lack of substance. Our premise in organizing this Research Symposium has been that its topic should be of current interest and be concerned with fundamental geologic problems; likewise, new data should be presented and interpreted.

An informal summary of fourteen alternative topics for this Research Symposium was circulated among a large number of geologists with a representative range of practical to theoretical interests. The topic being discussed was favored by the majority in a ratio of two to one. Every effort has been made to locate and invite the participation of all those workers who currently are investigating facets of these problems. All of the speakers are from the various oceanographic institutes. The absence of representatives from the petroleum industry as participants in this Symposium is not due to any lack of invitations.

Off-shore petroleum exploration is one of the most important and competitive spheres of petroleum exploration today. The importance of such marine exploration promises to become even greater in the future. The major part of this exploration will be confined to continental shelves and slopes. Likewise, the major part of land-based petroleum exploration occurs within sediments that were deposited in so-called shelf or slope environments. Any better understanding of the entire geologic framework of continental shelves and slopes will assist materially in petroleum exploration.

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PATTERNED SEDIMENTATION OF PENNSYLVANIAN AND PERMIAN MARINE STRATA IN PART OF THE CORDILLERAN AREA

Repetitive to cyclic sedimentary patterns characterize many sequences of marine rocks of Pennsylvanian and Permian age in parts of eastern Nevada and western Utah. The assemblages accumulated in different (at

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 non-marine 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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