especially within a marine-to-terrestrial facies transition. Otherwise, an interpretation of frequently shifting sites of supratidal sedimentation along a mainland is favored.

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FORAMINIFERAL TRENDS WITHIN INNER SUBLITTORAL ZONE OFF COAST OF WASHINGTON

Foraminiferal and diatom distributional trends within the inner sublittoral zone have been studied along 170 km of the coast of Washington from Grays Harbor to Cape Flattery. The samples are from water depths of 7–59 m.

Trends in the concentration of foraminiferal tests and diatom frustules in bottom sediments appear to be closely related to wave-induced turbulence at the sediment surface. Concentrations of tests markedly increase seaward at 20-m water depth, apparently the deepest limit of intense turbulence. Frustules, because of their very slow settling velocity, are prevented from settling at depths less than about 50 m except in certain microenvironments. These trends are not correlated with trends in sediment grain size, a fact which suggests that little modern sediment is accumulating in this area.

One trend is related to increasing depth and distance from shore; *Elphidium* spp. decrease markedly seaward of 30 m as *Eggerella advena* increases. Comparison with other studies in nearby areas indicates that this trend is heterobathyal. Off Oregon it occurs at about 100 m and off Washington south of Grays Harbor, if the *Elphidium* fauna is present at all, it occurs at depths less than 20 m.

Other foraminiferal trends are related primarily to substrate. Rocky substrates near the coastline have a characteristic *Cibicides lobatulus-Glabratella ornatissima* fauna. Relict coarse sand substrates offshore have faunas with abundant *Trochammina charlottensis, Cribrostomoides jeffreysii,* and *Elphidiella hannai.*

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HOLOCENE OCEANOGRAPHY OF CHUKCHI SEA

Piston cores from the southeastern Chukchi Sea have permitted differentiation of modern from Holocene sediments deposited when sea level stood about 20 m lower. Because microfossil distributions in modern sediments are associated closely with ice-free oceanographic conditions, the following trends appear to be related to Holocene oceanographic conditions. *Eggerella advena,* indicative of warm, dilute Alaskan coastal water, is as abundant in Holocene as in modern sediments, but *Reophax arctica,* indicative of central shelf water, and *Spiroplectammina biformis,* indicative of cold bottom water in the northern Chukchi Sea, are much less abundant in Holocene sediments. Frustules of the planktonic diatom *Coscinodiscus,* presently displaced northward by the Bering Strait current from regions of maximum phytoplankton concentrations in the overlying water, are more abundant in Holocene than in modern sediments in cores directly north of Bering Strait.

The northward-flowing Bering Strait current controls conditions in the southeastern Chukchi Sea. This flow was reduced during the Holocene because the cross-section area of the strait was smaller; apparently, however, the flow was reduced at the expense of central shelf water as Alaskan coastal water filled the southeastern Chukchi Sea. Although currents were slight in the central part of the southeastern Chukchi Sea, waters still piled up against the coast near the present settlement of Kivalina and produced a high-velocity northwest current. As evidence of this, Holocene sediments northwest of Point Hope contain more plant fragments and sand than nearby areas, and these presumably were deposited from the current.

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FRINGING REEF OR ALLOCHTHONOUS BLOCKS?

Many Permo-Pennsylvanian reef complexes of the Permian basin, Texas, have flanking carbonate mounds or "reefs." Faunal evidence indicates that these are topographically low relative to equivalent-age sediments in the reef proper. The shallow-water carbonate rocks were deposited either at times of lowered sea level, or they flowed or slid down the slope *en masse.* It is a real challenge to the subsurface geologist to identify their mode of deposition, particularly in the absence of cores.

Lloyd C. Pray and colleagues, using geopetal fabrics, showed that the so-called Bone Spring "patch reefs" in the Guadalupe Mountains were emplaced by gravity. In Howard and Glasscock Counties, Texas, large reef-dolomite blocks are embedded in a cherty forereef limestone facies of the Wolfcampian Wichita-Albany, and there is no question that they are allochthonous.

On the flanks of the Pennsylvanian and Wolfcampian "Horseshoe atoll" in Howard, Scurry, and Kent Counties, Texas, the problem is less simple. The greatly leached and porous atoll was raised intermittently above sea level, and fringing reefs should have formed on the flanks of islands. However, this does not preclude the other methods of emplacement of shallow-water limestone. Very careful study is required to differentiate the various types of deposits. Differentiation of each type is critical to the exploration geologist because the fringing reefs appear to make prolific petroleum reservoirs whereas the allochthonous or turbidite carbonates commonly host noncommercial accumulations.

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VIBRO-BOX SAMPLER: NEW TOOL FOR STUDY OF SEDIMENTARY STRUCTURES IN NEARSHORE SANDS

Increased exploration for stratigraphic traps in ancient shallow-marine sandstone and the resulting problems in environmental reconstruction have emphasized once again the lack of information on the characteristics of modern counterparts. The vibro-box sampler is designed to provide data on sedimentary structures of sand from the important zone between low tide and the 10-fm line. The sampler is a combination of the box sampler of Klovan, as modified by Imbrie, and the vibro-corer of Sanders.

The sampler is made of stainless steel (to resist corrosion) and can recover a 20 by 19 in., vertical, undisturbed "slice" from the bottom. A compressed-air vibrator is used, first, to drive the sampler into the bottom and, second, to activate a diagonal plate which seals in the sample. Additional vibration is necessary to free the sampler from the bottom. Surprisingly, the

vibration disturbs only the boundary layer of the sample where it contacts the box directly. The vibro-box sampler and its accompanying compressor are relatively inexpensive and may be operated from a small boat. Divers orient the sampler and handle the operation, but with a more sophisticated system this could be accomplished from the surface.

After the sample is collected, sand is removed with a trowel or small shovel until a smooth vertical face is exposed. The sample is dried for about 24 hours and then partly impregnated with polyester resin. The relief surface formed by differential penetration of the plastic shows sedimentary structures in great detail.

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ECONOMIC POTENTIAL OF CONTINENTAL RISE AND SLOPE

Little investigation of the continental slope and rise with respect to their oil potential has been made, mainly because their depths are much greater than presently is practicable for oil and gas exploitation, and partly because national jurisdictions have not been established. The continental slope overlies the general seaward limit of continental-crustal rocks, but these rocks are covered with sedimentary strata that have prograded beyond the original position of the continental slope. The sedimentary strata are chiefly Cenozoic and Mesozoic in age; they have a seaward dip, and they include few sandstone layers suitable for accumulation of oil and gas.

Sediments of the continental rise lap against the continental slope and contain many good acoustic reflecting horizons that are believed to be the surfaces of sand bodies deposited by turbidity currents. The strata between the reflectors are silt and clay that were deposited slowly from suspension; many of them have slumped from the continental slope where they were deposited originally beneath oxygen-poor water that permitted the accumulation of relatively high concentrations of organic matter. The interbedded position of organic-rich silt and clay (source beds) and of turbidite sand bodies (reservoir beds), which pinchout and are structurally deformed near the heads of the continental rises of the world, may constitute a geologic environment in which large oil and gas accumulations have developed. Exploratory drilling is needed before possible exploitation can be considered.

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EOCENE PLANKTONIC FORAMINIFERAL ZONATION OF NEW JERSEY ATLANTIC COASTAL PLAIN

Six planktonic foraminiferal zones, which can be correlated with Trinidad, are identified from the New Jersey Eocene. Modification of Bolli's zonation was necessitated by the presence of interpreted mid-latitude elements.

1. *Globorotalia subbotina-G. aequa* Assemblage Zone. Diagnostic species are *G. elongata G. pseudoscitula, Acarinina quetra,* and *Pseudohastigerina wilcoxensis.*

2. *Globorotalia formosa formosa* Assemblage Zone. This zone contains the most fully developed fauna and is characterized by *G. formosa gracilis* and transitional forms to *G. formosa formosa,* with advanced forms of *A. quetra* and *Globigerina prolata. Truncorotaloides rohri guaracaraensis* (non *Globigerninoides pseudodubia*) also appears in this zone.

3. *Subbotina inaequispira* Range Zone (approximately coeval with Bolli's *Globorotalia aragonensis* zone). *Pseudohastigerina sharkriverensis* and *Acarinina bullbrooki* first appear in the upper part.

4. *Pseudohastigerina sharkriverensis* Assemblage Zone is coeval with Bolli's *"Globorotalia" palmerae* zone.

5. *Subbotina frontosa* Assemblage Zone. The lowest appearance of the zone species identifies the base of the zone and the base of the middle Eocene. Also present are *Hantkenina aragonensis, H. dumblei, Globorotalia lehneri,* and *Truncorotaloides rohri rohri.*

6. *Turborotalia centralis* Assemblage Zone. The zone species and *Truncorotaloides topilensis* range through this zone to the top of the section studied.

High percentages of the genus *Acarinina* and low percentages of species of keeled *Globorotalia,* together with mid-latitude species, indicate that the seas off New Jersey were temperate during the Eocene. Similar faunal elements have been found in Spain, Austria, and the Caucasus. Seemingly these faunas characterize the temperate-subtropical boundary, and corresponds closely to the paleobotanical evidence.

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DEEP-WATER DRILLING: ATLANTIC BASIN

The Atlantic deep-water drilling campaign of *Glomar Challenger* has been an outstanding success. The extensive seismic reflector Horizon A has been sampled. It consists of a sequence of hard radiolarian cherts of late Mesozoic to early Cenozoic age; the presence of these beds supports the suggestion that an opening connected the Pacific with the Caribbean when extensive Eocene chert beds were formed in the Caribbean. Turbidites form an important part of the Atlantic basin deposits and lead to uncertainty in determining accumulation rates to unsampled sections. Where igneous rocks have been reached beneath sediments on the Mid-Atlantic Ridge, the ages of the oldest sediments are in general agreement with those predicted on the basis of correlation with magnetic anomaly patterns and the hypothesis of sea-floor spreading.

The Tithonian sediments from a site east of the Bahamas are underlain by a considerable unsampled sedimentary section, suggesting that deep-water, open-ocean conditions have existed here since at least Early Jurassic time.

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SHALLOW-WATER FACIES OF UPPER PENNSYLVANIAN HAYMOND FORMATION IN MARATHON BASIN, TEXAS

The Upper Pennsylvanian Haymond Formation crops out along the southeast, east, and northeast parts of the Marathon basin, Texas, and consists of two major units of thin- to thick-bedded, fine- to medium-grained sandstone separated by boulder beds. These rock types overlie and grade into the underlying deep-water turbidite sequence which is composed of interbedded fine- and very fine-grained sandstone and dark-gray shale.

The sandstones occur as *en échelon,* lenticular bodies which have partly erosional bases, and laterally interfingering, gradational upper boundaries. The sandstone beds are massive at the base, grading upward into a