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

trough cross-bedded and ripple-bedded top. The lower sandstone unit is interbedded with black to dark-gray, carbonaceous shale and siltstone, whereas the upper sandstone unit is recognized by associated basal conglomerate or interbedded lenticular conglomeratic beds, and poorly bedded, plant-disturbed sandstones. The boulder beds between the sandstone units are composed of novaculite, limestone, sandstone, and conglomerate, and are interstratified with black, carbonaceous shale and gray siltstone. The boulders are considered to be of tectonic origin, probably derived as a result of faulting and/or uplift of the source area.

The environment of deposition of this facies is shown by features associated with the sandstone units. The erosion channels, occurrence of conglomeratic beds with the sandstones, poorly bedded and plant-disturbed sandstones, interstratification with carbonaceous shale, lack of marine fossils, and development of large-scale cross-bedded sandstones in general suggest a very restricted shallow-water to transitional deep-water depositional environment for these strata.

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DANIAN PLANKTONIC FORAMINIFERA FROM CANNONBALL FORMATION, NORTH DAKOTA

Seven species of planktonic Foraminifera occur sporadically through 395 ft of the Cannonball Formation at Garrison Dam, North Dakota. Samples were obtained from a damsite core drilled by the U.S. Army Corps of Engineers. The species are: *Globigerina edita* Subbotina, *Globorotalia pseudobulloides* (Plummer), *Globoconusa daubjergensis* (Brönnimann), *Subbotina triloculinoides* (Plummer), *Subbotina varianta* (Subbotina), *Chiloguembelina midwayensis* (Cushman), and *Chiloguembelina morsei* (Kline).

This assemblage is indicative of the *Globigerina edita* Zone of Hollebrandt, 1965 (=*Globorotalia pseudobulloides* Zone of Bolli, 1966), and it generally is recognized as representing the lower parts of the Danian Stage (below the *Globorotalia trinidadensis* Zone). This precise correlation of the Cannonball with the lower Danian indicates a similar age for the nonmarine equivalents of the Cannonball (Ludlow and Tullock) on the west. The Ludlow in western North and South Dakota has been dated as Paleocene by plants, spores, and pollen. The Tullock has been dated previously as Paleocene on plant evidence and more recently as Puercan (early Paleocene) on the basis of mammals from eastern Montana. Therefore, the evidence presented here suggests that the Puercan is equivalent to the early Danian.

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CARBONATE SEDIMENTS IN CLASTIC ENVIRONMENT: REEFS OF VERACRUZ, MEXICO

Lying on an extremely narrow continental shelf in the southwest Gulf of Mexico are two groups of living patch reefs in the vicinity of Veracruz and Antón Lizardo, Mexico. Extending from the shoreline to water depths of 50 m, these are the only major reef buildups in the clastic province of the Gulf of Mexico west of the Yucatán and Florida carbonate provinces. Terrigenous clastic sediments are the major sediments in the interreef areas, and are primarily mud and silt brought in by high-gradient rivers which drain a narrow coastal basin and high mountains within 150 km of the coast. Some sand may be left from the last Pleistocene low sea level. The clastic sediments also contain 1–2% carbonate material from planktonic and benthonic fauna. Reef-derived carbonate sediments are present only in a narrow zone around each reef patch. The carbonate percentage ranges from 100 in the living coral areas to less than 5 within 100 m, although traces of reef-carbonate material extend considerably farther. Several areas of dead reefs are also present. If these results are applied to ancient deposits, the location of reefs by sampling from either outcrops or well cuttings would be difficult, although the presence of reefs could be inferred as being in an upcurrent direction.

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FACIES VARIATIONS IN ORDOVICIAN SEDIMENTS OF SOUTHEAST IRELAND AND THEIR PALEOGEOGRAPHIC SIGNIFICANCE

A continuous section through the Ordovician belt in southeast Ireland is exposed in southwestern County Wexford. There an unconformity separates Lower Ordovician (mainly Arenigian) sediments from an Upper Ordovician (Caradocian) sequence.

The thick Lower Ordovician sequence contains four facies, of which the most important is alternating siltstone and shale. Interfingered as minor facies are thick shale beds, paraconglomerate, and interbedded sandstone and shale. The siltstone and sandstone are interpreted as deposits from axial turbidity currents, with associated bottom-current activity, in an otherwise low-energy environment. Paleoslope data indicate that deposition was near the southeast flank (the "Irish Sea landmass") of a northeast-trending basin. Only the paraconglomerates were derived from this border area; the dispersal pattern and petrology indicate a northeastern source for the other detrital sediments.

Volcanic rocks (laterally equivalent to the more westerly Tramore limestones) are at the base of the Caradocian. An initial nearshore environment, progressively deepening, is probable for this sequence. The overlying sediments contain three facies; quantitatively, the most important is interbedded siltstone (turbidite) and shale. Paleocurrent directions indicate a southwestern source and deposition in a northeast-aligned basin. A close mineralogical similarity with the Arenigian sediments suggests that the Arenigian composed much of the source area. This facies shows an upward increase in shale, and is overlain by two facies of less importance—a pyritic siltstone and silty mudstone facies, and a black shale facies. This upward change implies diminishing supply of terrigenous material and a change in basin geometry to quiet, restricted, shallow depositional areas. These probably were near shore, because overlying rhyolite flows were extruded subaerially.

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SEDIMENT DISTRIBUTION, DIFFERENTIAL SEDIMENTARY CYCLING, and GEOCHEMICAL "UNIFORMITARIANISM"

Sediments have been deposited and destroyed continuously throughout geologic time. The writers constructed simplified models of world sediment distribution as a function of time and compared these models