many paleocurrent data. In simple cases, trough-sets yield bimodal histograms bisected by trough axes (which must be distinguished from other bimodal causes). Asymmetry of troughs or predominance of readings from trough ends produce more complex histograms, which commonly are statistically random (*e.g.*, St. Peter Sandstone; certain Cambrian sandstones, Wisconsin; Meridian Sandstone, Mississippi). Trough-axis plunge azimuths provide a superior paleocurrent indicator; Hamblin's Franconian data and new data from Wisconsin show dispersions half as great as published results for cross-sets only. But oppositely plunging troughs associated in single outcrops and even doubly plunging single troughs discovered in Wisconsin may becloud trough-axis distributions. Double plunges probably reflect both oscillatory (wave?) flow and unidirectional current flow, which produced complex, coalescing, elongate dune forms between which doubly-plunging troughs formed.

Trough cross-stratification has no environmental significance. Long-standing eolian interpretations reflect early recognition of only 1 possible modern analogue, whereas subaqueous dunes with amplitudes up to 65 ft have been known for a century. Cambrian sandstones with complex trough cross-stratification probably reflect submarine dunes affected both by current and oscillatory flow like those of Georges Banks. Paleoslope has little if any influence on orientations of eolian and most shallow-marine cross-stratification; records of "rare" storms may mask "average" conditions. Therefore, independent dispersal indicators (*e.g.*, pebble or mineral trains) should be sought.

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PENNSYLVANIAN FUSULINIDS FROM SOUTHEASTERN ALASKA[1]

Fusulinids of Middle Pennsylvanian age were obtained from 4 sections measured in the west-central part of Prince of Wales Island in southeastern Alaska. Three assemblages can be recognized in ascending order: (1) *Millerella, Nankinella,* and *Pseudostaffella;* (2) *Nankinella* and *Fusulinella;* and (3) *Nankinella?, Fusulinella,* and *Fusulina.* Other Foraminifera including *Bradyina* and *Climacammina* are present in several of the samples. The species present show some affinities with forms from Japan and a close relation with the faunas from the Fort St. James area in north-central British Columbia.

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GEOLOGY AND OIL POTENTIAL OF CANADIAN ARCTIC ISLANDS

The Canadian Arctic Islands sedimentary basin covers an area of approximately 530,000 sq mi, has a land area of 306,000 sq mi, and contains an estimated 900,000 cu mi of sediment. Ultimate recoverable oil reserves are estimated to be 40 billion bbl.

The area consists of 4 major structural provinces: (1) shield-bordering Precambrian shield areas with structural arches extending into the basin, (2) Central Stable region, (3) Innuitian region, and (4) the Arctic coastal plain.

The Central Stable region includes several basins containing relatively flat-lying shelf carbonates of Ordovician-Silurian age, with thicknesses generally 5,000 ft within the basin areas thickening northward to a maximum of 15,000 ft.

The Innuitian region is a mobile belt, characterized by thick sedimentation, that was tectonically active from the Paleozoic to the Tertiary. It is comprised of (a) the Franklinian fold belt, a gently folded early Paleozoic geosyncline, approximately 1,500 mi long, containing up to 16,000 ft of Ordovician and Silurian carbonate, evaporite, and shale; up to 6,000 ft of Lower Devonian clastics; and 16,000 ft of Middle and Upper Devonian strata ranging upward from marine carbonates and clastics to nonmarine clastics; and (b) Sverdrup basin, a NE-SW-trending basin, approximately 600 by 200 mi, containing up to 40,000 ft of post-Devonian to Tertiary strata. Permo-Pennsylvanian rocks are dominantly carbonate and evaporite. The Mesozoic to early Tertiary was dominated by heavy and continuous terrigenous clastic deposition, generally characterized by basinal marine-shale facies and marginal-sandstone facies. The axis of the basin is characterized by numerous evaporite diapirs.

The Arctic coastal plain contains late Tertiary and Pleistocene strata, along the northwest edge of the Arctic Islands, bordering the Arctic Ocean in the position of the present-day continental shelf.

The Arctic Islands sedimentary basin has all the necessary geologic elements conducive to the entrapment of hydrocarbons in prolific quantities. There is a very thick, lithologically varied, stratigraphic succession representing every geologic period, adequate source beds, and abundant potential rocks. There is an abundance of diversified traps—large anticlines, reefs, evaporite domes, faulted homoclines, unconformities, and facies changes. A wide range of hydrocarbon shows, including oil sands, seeps, stain, and bitumen, are present in a large area. The Arctic Islands is an area of outstanding potential for the discovery of large oil fields.

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KEYSTONE VUGS IN CARBONATE BEACH DEPOSITS

Voids that are considerably larger than interstices and therefore termed "vugs" are present in ancient grainstone, in modern beachrock, and in loose carbonate beach sand. They are as large as 10 grains in diameter and are roughly spherical or lens shaped. The roof of the vug resembles a crude keystone arch. Similar vugs can be made in the laboratory by alternately draining and flooding loose carbonate sand in the manner characterizing the swash zone. During the flooding stage, bubbles of trapped air lift grains into the form of a keystone arch, which is stable after the bubble is gone. Keystone vugs in ancient rocks probably will prove to be useful indicators of beach deposition.

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DEEP-SEA DRILLING PROJECT—FUTURE PROGRAM

The Deep-Sea Drilling Project is now engaged in a 30-month program extension which will take the drilling vessel *Glomar Challenger* to the Atlantic, Pacific, and Indian Oceans. Drilling sites have been selected by advisory panels established by JOIDES (Joint Oceanographic Institution Deep Earth Sampling). During the first 18 months of operation the program directed its effort to testing the hypotheses of sea-floor spreading

[1] Publication authorized by the Director, U.S. Geol. Survey.

and continental drift, sampling old sediments, and recovering a complete sedimentary section for paleontologic reference. Drilling on the mid-ocean ridge system in relatively young (Tertiary) sediments was extremely successful. Every site drilled with the intention of testing sea-floor spreading has substantiated the hypothesis. Almost complete Cenozoic sedimentary sections have been recovered in both the Atlantic and Pacific Oceans. Attempts to recover the oldest sediments in the oceans have been thwarted by the inability to penetrate chert layers that appear to be ubiquitous in the deep basins. Drilling throughout the first 18-month program was undertaken without the ability to withdraw the drill string and reenter the same hole. The capability to reenter the hole is anticipated early in the program extension and will be instrumental in the success of the proposed future drilling program. The emphasis of the new program has shifted from the mid-ocean ridge system to the deep basins where the oldest sediments may be sampled and to the continental margin to investigate the interaction of the mobile sea floor and the continental masses.

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UPPER DEVONIAN BIOSTROMES AND BIOHERMS ON NORTHEASTERN BANKS ISLAND, NORTHWEST TERRITORIES

The Mercy Bay Member (Frasnian) is a 200-ft thick limestone unit that is present in the 4,000-ft sequence of terrigenous clastic rocks of the Upper Devonian, Griper Bay Formation of northeastern Banks Island, Northwest Territories. The limestone crops out as extensive steep cliffs and thus affords the detailed study of vertical and lateral facies variations.

In the western part of the outcrop area, the Mercy Bay Member is an areally extensive biostrome which within itself consists of bioherms, penecontemporaneous interbiohermal strata, and biostromal beds. The bioherms consist of a lower zone of corals and tabular stromatoporoids in a carbonate-mud matrix and an upper zone almost entirely of massive stromatoporoids. These 2 facies form a massive core. Bedded deposits of coral and stromatoporoid rubble form the flanks of the bioherms. Interbiohermal strata are finely bedded, unfossiliferous, argillaceous micrite. Areally extensive, thick beds, composed almost entirely of massive stromatoporoid colonies, normally overlie the biohermal masses.

A vertical sequence of environmental development can be interpreted: the lower coral zone represents a stage of biogenetic mud mounds which formed in the subturbulent zone; the massive stromatoporoid zone represents development of true organic reefs in turbulent water; the massive stromatoporoid biostrome represents a table reef which developed in turbulent water in response to a reduced rate of subsidence.

In the east the member consists of isolated bioherms with younger, coarse, terrigenous clastic rocks in the interbiohermal areas. This fact implies that a shelf-to-basin transition occurs from west to east; biostromal deposits characterize the slowly subsiding shelf; bioherms characterize the more rapidly subsiding basin.

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BIOFACIES RELATIONS IN BUDA LIMESTONE (COMANCHE SERIES, CRETACEOUS) OF WEST AND TRANS-PECOS TEXAS: PALEOGEOGRAPHIC AND PALEOBATHYMETRIC IMPLICATIONS

Biofacies relations in the Cenomanian Buda Limestone have been studied by reference to fossil and rock collections made at more than 40 surface sections and shallow cores in a 55,000 sq mi area of west and Trans-Pecos Texas.

Three east-west trending biofacies bands are distinguished. These facies approximately parallel the Cretaceous shoreline on the north and the axis of the Mexican geosyncline on the south-southwest. The northernmost biofacies is dominated generally by miliolids, *Cuneolina*, and calcareous algae, and locally by rudists, corals, and stromatoporoids. The southernmost biofacies is characterized by globigerinids, *Höglundina*, calcispheres, and siliceous sponges; calcareous algae, rudists, and serpulid worms are abundant locally. The northern and southern biofacies are separated by a transitional biofacies dominated by mollusks and echinoids with microfaunal elements of the adjacent biofacies locally common.

The northern biofacies is coincident with a carbonate grainstone and packstone lithofacies and records very shallow-water (0–30 ft) nearshore environments. Stromatoporoid, coral, and rudist patch reefs are distributed sparsely through the area. The siliceous sponge-globigerinid biofacies is coextensive with a carbonate mudstone and wackestone lithofacies and records a relatively quiet, deep-water (100–300 ft) environment. Algal, rudist, and serpulid assemblages in this biofacies are associated with structurally high areas and mark offshore islands and reefs present during Buda deposition. The transitional biofacies and its coincident wackestone and packstone lithofacies reflect shallow-water (20–100 ft) open-shelf environments.

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DETERMINATION OF BULK PROPERTIES OF SATURATED SEDIMENTS THROUGH SPECTRAL ANALYSIS

Spectral analysis is a technique that uses both the incident and reflected acoustic signals of a low-frequency subbottom profiling system. The differences in spectral quality are converted into time-frequency-energy plots which can be contoured within the dynamic range of 42 db.

Analysis of the resulting energy contour map shows that certain "topographic highs" appear to be related to certain sediment types existing under differing degrees of *in-situ* moisture content and bulk (wet) densities. The resulting energy contours define these conditions and identify the stratal characteristics as if they were "sedimentary fingerprints."

Data presently available from known areas of Fishers Island and Long Island Sound off the coast of southeastern Connecticut, and the Gulf of Mexico, show good correlation between the spectral energies and the sediment bulk properties to maximum depths of 200 ft.

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GASMAP—A METHOD OF GEOCHEMICAL PROSPECTING

Geochemical prospecting is, theoretically, the most direct approach to oil and gas exploration. Migration