suitable for forming reservoir rock during the time that deep circulation has been an important process in the western North Atlantic. This process is thought to have begun about 50 m.y.B.P. There would be deposition only of fine-grained, relatively impermeable, potential source beds.

It is concluded that Cenozoic sediments of the continental rise, at least off the east coast of North America, may not be a likely source for future hydrocarbon recovery. A few deep holes into the continental rise (preceded by complete seismic surveys) are needed to assess the potential of the underlying, deeply buried Paleozoic section.

HOLMES, MARK L., U.S. Geol. Survey, Seattle, Wash., and M. A. FISHER, U.S. Geol. Survey, Menlo Park, Calif.

Sonobuoy Refraction Measurements from Norton Basin, Northern Bering Sea

Recent discovery of thermogenic gaseous hydrocarbons seeping from the seafloor 45 km south of Nome, Alaska, suggests that the underlying Norton basin may be an important future petroleum province. The results of 38 sonobuoy refraction profiles obtained in 1977 and 1978 show that Norton Sound and Chirikov basin are underlain by a single sedimentary trough approximately 130 km wide and 350 km long; the basin axis trends west-northwest and extends from Stuart Island to a point 100 km west-southwest of King Island. Although average depth to basement is only 2.5 km, two deeper areas, containing up to 5.5 km of sedimentary section, were discovered 75 to 90 km northwest of the Yukon River delta.

Norton basin is floored by an acoustic basement whose compressional velocity is 5.5 to 6.5 km/sec. The basin fill consists of three major units distinguishable on the basis of their compressional velocities; unconformities probably separate each of these units. The basal unit, with a velocity of 4.9 km/sec, is present only in the deeper parts of the basin. A thick (2 to 3 km) section has velocities ranging from 2.3 to 3.7 km/sec and lies on this lower unit and on acoustic basement. Compressional velocities in the 1.2 km-thick upper unit range from 1.6 to 2.1 km/sec. The lower two units are probably Cretaceous and lower to middle Tertiary marine and nonmarine rocks lying on a basement complex of Paleozoic and Mesozoic igneous, metamorphic, and sedimentary rocks similar to those mapped on Seward Peninsula and St. Lawrence Island. The upper unit probably consists of upper Tertiary and Quaternary sedimentary rocks and sediment.

HORODYSKI, ROBERT J., Tulane Univ., New Orleans, La.

Microfossils, Macrofossils, and Stromatolites from Middle Proterozoic Belt Supergroup, Montana

Essentially unmetamorphosed strata exposed in the eastern part of the Beltian basin contain a wide variety of middle Proterozoic fossils and stromatolites.

Organically preserved microfossils are abundant in shales of the Chamberlain Shale and Newland Limestone (ca. 1,400 m.y.) in the Little Belt Mountains. This assemblage includes tubular filaments which appear to represent mainly the preserved sheaths of *Lyngbya*-like oscillatoriacean cyanophytes and sphaeromorphs which might in turn represent the preserved outer sheaths of colonial coccoid cyanophytes or possibly the encystment stages of eukaryotic algae. The sphaeromorphs include forms (e.g., *Kildinella* sp.) which are potentially useful for intercontinental biostratigraphic correlation.

Tabular microstructures defined by hematite particles and probably representing outlines of sheaths of oscillatoriacean cyanophytes in calcareous stromatolites of the Snowslip Formation (ca. 1,100 m.y.) in Glacier National Park represent one of the few occurrences of Proterozoic microfossils preserved within wholly calcareous rocks. Microfossils also occur in association with syngenetic sulfides in shales of the Appekunny Argillite (ca. 1,300 m.y.) in Glacier National Park.

Macroscopic carbonaceous compressions occur in shales of the Newland Limestone (ca. 1,400 m.y.) in the Little Belt Mountains and probably represent macroscopic, and possibly eukaryotic, algae.

Stromatolites are particularly abundant, diverse, and well exposed in strata ranging from 1,400 to 1,100 m.y. old in Glacier National Park. In addition to having paleoenvironmental significance, inclined conical stromatolites provide paleocurrent information useful in basin analysis, and branched columnar forms are potentially useful time-stratigraphic indicators.

HORVITZ, L., Horvitz Research Lab., Houston, Tex.

Pool Depletion and Geochemical Signal Decay

No abstract available.

HORVITZ, LEO, Horvitz Research Lab., Inc., Houston, Tex.

Effect of Depletion on Near-Surface Hydrocarbon Anomalies

Early in the history of geochemical prospecting, it was recognized that more intense soil-hydrocarbon anomalies occur in the near-surface soil over newly discovered petroleum accumulations than over those that are depleted or nearing depletion. The first convincing confirmation of this effect was obtained in 1968 after resurveying the Hastings oil field, Brazoria County, Texas, which previously was sampled in 1946. The outstanding soil hydrocarbon anomaly of the earlier survey did not reappear in the 1968 study.

Surveys conducted in 1970-71 over new and old oil and gas producing areas in Jackson County, Texas, furnished additional support to the thesis that removal of hydrocarbons from subsurface reservoirs affects near-surface soil hydrocarbon anomalies.

HOWARD, JAMES D., Univ. Georgia Marine Inst. and Skidaway Inst. Oceanog., Savannah, Ga., and HANS-ERICH REINECK, Inst. Meeresgeologie und Meeresbiologie "Senckenberg," Wilhelmshaven, Germany

Sedimentary Structures of "High-Energy" Beach-to-Offshore Sequence, Ventura–Port Hueneme Area, California

An examination of the continental shelf in the Ventura–Port Hueneme, California, area included the collection of can cores, box cores, and vibrocores to determine the primary physical and biogenic sedimentary structure to establish a depositional-facies model.

Core analysis permits recognition of three principal zones: (1) nearshore facies (backshore to 9 m water depth), made up primarily of parallel-laminated, ripple-laminated, and cross-bedded, clean sand; bioturbation is only locally significant; (2) transition facies (9 to 18 m water depth), zone of fine sand and silty sand, characterized by an increase in biogenic over physical sedimentary structures; wave-ripple bedding and parallel lamination are important structures in this facies; (3) offshore facies (>18 m water depth), sandy silt is the primary texture, and bioturbation is the dominant sedimentary structure; remnant parallel lamination is the only physical sedimentary structure present.

Comparison of the results of this study with a previous description of "low-energy" beach-to-offshore facies at Sapelo Island, Georgia, indicates that the two areas do not differ greatly in overall vertical sequence of sedimentary structures. The principal difference is in the thickness of the three facies: the California facies are significantly thicker than their Georgia counterparts. It is concluded that this difference is in direct response to the role of higher wave energy on the California coast.

HOWARD, JAMES J., State Univ. New York, Binghamton, N.Y.

Mixed-Layer Clays in Eocene Interlaminated Shales and Sandstones

Kaolinite, illite, and mixed-layer montmorillonite-illite are present in interlaminated sandstones and shales from the Eocene Wilcox Formation of the Texas Gulf Coast at depths of 2,000 to 4,000 m. Ratios of kaolinite to discrete illite are higher in the sandstones than in the interlaminated shales. Mixed-layer clays in the sandstones are 5 to 20% more expansible and less ordered than those in interlaminated shales. These mineralogic differences are interpreted to reflect a significant difference in the solution chemistry of pore waters in the sandstones from that of pore waters in the interlaminated shales. At the relatively shallow depth of 2,000 m, mixed-layer montmorillonite-illite from the shales is roughly 30% expansible; this figure is significantly less than the 75% expansibility reported by J. Hower et al for Miocene age mixed-layer clays at similar depths. Assuming similar source and geothermal gradient for the two sets of samples, two explanations may account for these differences. The most plausible explanation is that the expansibility of the mixed-layer clay is controlled by the montmorillonite-to-illite transformation rate. Because the Eocene sediments have had an additional 25 m.y. to react, the montmorillonite-to-illite transformation is more complete in these samples. An alternative explanation is that the chemistry of pore waters in the Wilcox Formation is significantly different from that of pore waters in sediments studied by Hower.

HOWE, HERBERT J., Purdue Univ., West Lafayette, Ind.

Carbonate Rocks of Montoya Group (Middle and Upper Ordovician) of Trans-Pecos Texas

In the petroliferous Permian basin of west Texas the subsurface Montoya Formation consists of a monotonous sequence of dolomitic limestones. However, 100 to 200 mi (160 to 320 km) west in the Franklin and Hueco Mountains of Texas and the Cooks Range and Sacramento Mountains of New Mexico, the Montoya is divided into three distinctive carbonate formations (in ascending order): the Upham Limestone, the Aleman Limestone, and the Cutter Limestone.

Study of microscopic sections shows several carbonate lithologies including: (1) crinoidal calcarenite with calcareous mud matrix (biomicrite); (2) crinoidal calcarenite with clear calcite cement (biosparite); (3) micrites with abundant cherty nodules and layers of interbedded chert; (4) laminated micrites without chert; (5) shelly limestones (mainly brachiopodal biomicrites); (6) autochthonous reef rock (coralline biolithite); and (7) partly or completely dolomitized equivalents of any of the former.

Crinoidal calcarenites with a calcareous mud matrix characterize the Upham Limestone except for the uppermost beds. There, shallow-water, high-energy conditions apparently winnowed out the calcareous mud, which is replaced by clear calcite cement. Cherty and chert-free micrites and biomicrites form the dominant lithologies of the overlying Aleman and Cutter Limestones.

At some localities, especially near faults, dolomitization is massive, cutting across all facies and rock layers. Dolomitization progresses from sporadic small crystals embedded in the original matrix to total replacement where original features are obscured or destroyed. Layered dolomites are most common in the Cutter Formation.

Montoya deposition is cratonic, averaging only 320 ft (96 m) over about 10 m.y. Individual rock units representing specific shallow-water epineritic environments may be traced widely (in some places more than 100 mi; 160 km).

HRISKEVICH, M. E., J. M. FABER, and J. R. LANGTON, Aquitaine Co. Canada, Calgary, Alta.

Strachan-Ricinus Gas Field, Alberta

Exploration for reef reservoirs in the "Deep Basin" of Alberta during the mid-60s resulted in the discovery of 1.9 Tcf of sales gas, 50 million bbl of condensate, and 24.5 million LT of sulfur in two reefs of Late Devonian age, at Strachan and Ricinus. The reefs were discovered in 1967 and 1969, respectively, by adapting the seismic CDP techniques of data acquisition and processing that were then being developed (particularly in the Rainbow area, in the shallower part of the Western Canada sedimentary basin).

The key well for these discoveries was the Gulf-Strachan well in Lsd. 12-31-37-9 W5M, which was drilled in 1955. This well encountered a partial buildup of Upper Devonian reef which yielded some gas and salt water