"offshore" trace fossil assemblage; (5) coarsening-upward sequence of lithologies; and (6) position with respect to the strandline facies. Scarce evidence, such as coal partings and plant fragments, from irregular-shaped fields seems to be inconsistent with deposition offshore. All evidence, however, along with the shingling of the sediment sheets can be explained by retrogradational shelf sedimentation. Modern sediments of the New Jersey shelf are analogous.

BEAUMONT, E. A., J. P. HOBSON, JR., and M. L. FOWLER, Cities Service Co., Tulsa, OK

Depositional Facies, Geometry, and Genesis of Upper Cretaceous Mid-Shelf Sand Complex—Sussex Sandstone at House Creek Field, Powder River Basin, Wyoming

At House Creek, cores of the producing Sussex zone reveal a coarsening-upward marine sequence beginning with silty shale and ending with a conglomeratic sandstone. Producing sandstone, 36 mi (58 km) in length, rarely exceeds 1 mi (1.6 km) in width and has an outward "shoestring" appearance. However, distribution of producing and nonproducing sand shows that the thickest part of the complex is immediately southwest of the producing trend and that the sand complex is geometrically asymmetrical—about 17 mi (27 km) across.

The sand zone appears asymmetrical also with respect to sand facies. On the steeper northeast side, the sand complex maintains a sanding-upward profile. In contrast, on the gentler sloping side the facies sequence merges into a single widespread facies. This asymmetry has made possible development of an E-log model for the sand zone.

Deposition of Sussex sand in the House Creek area may have been 50 to 100 mi (80 to 161 km) from the general shoreline in water depths of 50 ft (15 m) or greater. The Sussex zone forms the marine "topsets" of a major basin-filling wedge of fine clastic sediments which prograded from the northwest.

We have difficulty in explaining how sands and gravels in this depositional setting were transported great distances offshore by shelf processes alone. A suggested analog, the Atlantic shelf ridges formed during post-Pleistocene transgression by shoreface erosion and being restructured by the shelf hydrologic regime, is unacceptable because regression and shoreface retreat cannot be documented for the Sussex at House Creek. A model proposed here combines up-coast regression, shoreline retreat, and along-shelf transport. The model emphasizes wave-generated unidirectional currents transporting sediment southerly along or oblique to shelf isobaths.

BELKNAP, DANIEL F., and JOHN C. KRAFT, Univ. Delaware, Newark, DE

Fractional Preservation of Transgressive Coastal Lithosomes on Atlantic Continental Shelf

Migration of coastal environmental lithosomes across the continental shelf is a response to the latest Quaternary rise of the sea. Preservation of fractions of the transgressive sequence is dependent on depth of erosion, which is a function of impinging wave energy, sediment supply, resistance to erosion, and rate of relative sea-level change. Materials deeper in the column have a greater potential for preservation. The relative sea-level curve for Delaware, based on C^{14}-dated basal peats, rises smoothly from 25 m below present from 10,000 years B.P. to the present at a decreasing rate with time. Shells and peats 9,000 to 10,000 years old on the shelf are 40 m deeper, suggesting an east-southeast shelf tilt, tectonically or hydro-isostatically induced. Sea-level rise results in rates of coastal retreat of 10^2 m/year for 10, 000 years B.P., 10^1 m/year for 5,000 years B.P., and 10^0 m/year at present. In a model of constant volume of net erosion per unit length of coast, a much smaller depth of erosion applies early in the transgression, allowing a greater preservation potential. Changes in wave climate, sediment supply, and downwarping across the shelf also apply. Recovered sediments, seismic profiles, and recognized morphic features indicate better preservation of shoreline elements on the outer shelf, and more planing off and reworking on the inner shelf. Similar analysis of Delaware Bay indicates that it too follows such a model, in changing from a dendritic fluvial system to a broad estuary.

BENCH, BERNARD M., U.S. Bur. Mines, Denver, CO

Drilling for Methane Gas in Fishers Peak Area, Las Animas County, Colorado

In July and August 1978, two holes were drilled in the Raton basin 12 mi (19 km) southeast of Trinidad, Colorado, for measuring methane gas in coal beds. The sites are near the Morley mine, where the presence of abundant methane gas had been reported during mining operations.

The principal objective was the Morley coal, located just above the Trinidad Sandstone. The geology, drilling procedures, coal beds encountered, tests for gas, and experience gained are described. The amount of methane, although lower than expected, is consistent with the correlation of coal rank to gas yield. The coal is classed as high volatile A; the ratio of fixed carbon to volatile matter is 1.69.

Strong shows of methane are known in other parts of the basin where thicker, more consistent coal sections of higher rank occur. Such localities will most likely prove the importance of the region for methane gas production by future exploration and drilling.

BERESKIN, S. R., and S. A. FRY, California State Univ., Fresno, CA

Devonian Reefs Exposed Along Central Cantabric Coast, Northern Spain

In sea cliffs along the central zone of the Cantabric coast, near Cabo de Peñas, Asturias, the Peran Member of the Candas Limestone (Middle and Upper Devonian) appears in two stratigraphic sections situated near the towns of Peran and Luanco respectively. Faunal assemblages consist of alternations of compact biostromes with units of diversely populated marls. These interbedded deposits reveal that different organisms and morphologies have specific roles in one or more of the following phases of reef development: (stage 1) mud trapping; (stage 2) substrate stabilization; and (stage 3) reef building. Important parameters that probably influenced this succession were intensity and periodicity of sedimentation, energy as a function of depth, light availability, and substrate characteristics.

Ideal succession of stages is better developed in the eastern Peran section. Detrital matrix of these reefs is generally grain-supported, whereas interreefal deposits consist of fossiliferous marls. Organic banks of the western Luanco section contain a muddy matrix, and true reef development (stage 3) is rarely attained. Interbank deposits include gray bioturbated mud which contains tentaculitids, trilobites, and clearly transported elements. These observations suggest that the Peran section was formed under very shallow-water conditions on the shelf edge, facing deeper waters toward the west. This shelf edge thins eastward toward a major topographic high in the present-day vicinity of the Picos de Europa. Such a paleogeographic picture is decidedly reversed to that of the now famous Devonian reefs of Belgium and Germany.

BERG, R. R., Texas A&M Univ., College Station, TX, G. M. LARBERG, Shell Oil Co., New Orleans, LA, J. T. LIN, Phillips Petroleum Co., Bartlesville, OK, et al

Hydrodynamic Flow in Lower Cretaceous Muddy Formation, Northeast Powder River Basin, Wyoming and Montana

Hydrodynamic flow in the Muddy aquifer is generally downdip to the west with an average gradient of 25 ft/mi (5 m/km). Flow patterns are controlled by the distribution of porous sandstone so that the regional patterns of flow reflect the total thickness of the Muddy aquifer. Local potentiometric highs appear to represent isolated areas of high pressure and downward flow from Mowry Shale (source rock) to the Muddy aquifer.

Lenticular Muddy sandstones form stratigraphic oil traps, but oil columns are determined largely by hydrodynamic flow. Calculations suggest that hydrodynamic flow accounts for 130 ft (40 m) of the total 150 ft (46 m) of the oil column at Recluse field; for 230 ft (70 m) of the total 250 ft (76 m) at Gas Draw field; and for 100 ft (30 m) of the total 150 ft (46 m) at Bell Creek field. Larger oil columns are the result of vertical flow. A potentiometric high of 6,000 ft (1,830 m) occurs at Kitty field, about 4,000 ft (1,220 m) in excess of the expected hydrostatic head, and the vertical pressure gradient probably accounts for a large part of the total 850 ft (259 m) of oil column. Vertical flow results in updip gradients and reduction of total oil column as at LX Bar field.

Potentiometric surface maps show that the Muddy aquifer is a dynamic system of both downdip and vertical, cross-formational flow. Observed oil columns are in equilibrium with present flow. Migration of oil downward from Mowry source rock has taken place in relatively recent time and is still occurring; it may result from montmorillonite dehydration at temperatures in excess of 200°F (94°C). The early history of fluid migration is obscured by present flow but may have been updip, eastward toward the basin flank. Flow of compaction waters may have been great enough to have prevented early oil accumulation. Exposure of the Muddy aquifer was post-Laramide and resulted in recharge by meteoric waters. Therefore Muddy oil fields are late accumulations as suggested by their present equilibrium with basinward flow.

BERGSTRÖM, STIG M., Ohio State Univ., Columbus, OH

Early Paleozoic Conodont Biostratigraphy, Biogeography, and Paleoecology

Extensive work, particularly during the last 25 years, has led to the recognition of several hundred species and more than 100 genera of Cambrian, Ordovician, and Silurian conodonts. Wide distribution, short vertical range, and abundant occurrence have made conodonts some of the best early Paleozoic index fossils known. Most detailed conodont work has been done in North America and Europe but significant data are available from South America, Asia, and Australia. Cambrian conodonts, still poorly known and apparently not greatly varied taxonomically, are less useful biostratigraphically than Ordovician and Silurian conodonts. No Cambrian conodont zone succession has been proposed but some conodonts have considerable stratigraphic potential in the Late Cambrian. Ordovician conodonts are characterized by explosive taxonomic diversification and striking provincial differentiation. Two sequences of 15 to 20 conodont zonal units are in common use, one in each main province. Conodonts permit, in many places, a greater stratigraphic resolution than is achieved using any other fossils. Silurian conodonts are less diversified taxonomically (about 15 genera) and less differentiated provincially than those of the Ordovician. They form the basis of a succession of about 15 standard zones. Both Ordovician and Silurian conodonts have been tied into graptolite biostratigraphy producing a detailed and regionally useful framework.

Apart from various aspects of biostratigraphy, biogeography, and taxonomy, current early Paleozoic conodont research includes paleoecology which has resulted in a greatly improved understanding of the environmental significance of these enigmatic fossils.

BEUS, STANLEY S., Northern Arizona Univ., Flagstaff, AZ

Devonian Paleogeography and Paleoenvironments in Northern Arizona

Devonian strata in the northern half of Arizona are mostly early Upper Devonian (Frasnian) carbonate rocks up to 160 m thick but include some terrigenous clastics of latest Middle Devonian (Givetian) and Frasnian age. Devonian sediments were deposited on a shallow-marine cratonic platform bordered by the Defiance lowland area to the east and by the continental shelf adjacent to the Cordilleran geosynclinal belt to the west.

The Beckers Butte Member of the Martin Formation accumulated as fluvial to subtidal sands in a small em-