and folding the upper sediments during the WR thrust deformation through latest Cretaceous and Paleocene time.

LYONS, PAUL C., ROBERT B. FINKELMAN, ORRIN G. OFTENDAHL, et al, U.S. Geol. Survey, Reston, VA

Resin Rods and Woody Rod-Like Structures in Pennsylvanian Coal Beds of Appalachian and Illinois Basins

Coalified rod-like structures of plant origin have been discovered in fusain bands within bituminous coal beds of the Appalachian and Illinois basins. The rods have been found in the Allegheny, Conemaugh, and Monongahela Formations and Dunkard Group of southwestern Pennsylvania and central and northern West Virginia in coal beds ranging from the upper Freeport coal (uppermost part of the Allegheny) to the Washington coal (lower part of the Dunkard). In the Illinois basin, similar structures are found in the Springfield (No. 5) coal bed of Indiana and in the correlative No. 9 coal bed of western Kentucky in the Carbondale Formation. In 1914 Charles David White discovered similar oriented and disoriented rods in fusain partings in the No. 2 (Colchester) coal bed of Colchester and Exeter in western Illinois at the base of the Carbondale Formation. In the Illinois basin, the needle-like bodies are associated with coalified wood, cuticles, seed coats, and megaspores.

Under the scanning electron microscope, some of the needle-like structures found in West Virginia are noncellular and appear to be the remains of resin. Others are woody, cellular in cross section, and have cell walls with pits or pores 1 to 2 μ in diameter in longitudinal section. In polished cross sections of coal, the cellular rods would be described petrographically as sclerotinites. These rods have the appearance of minute match sticks in longitudinal section.

The preliminary work on the biostratigraphic distribution of the rods in coals indicates that they range from Middle to Late Pennsylvanian or younger in age. The association of the rods and highly resistant megaspores, seed coats, cuticles, and coalified wood in fusain bands indicates that they were separated from woody tissue during a period of oxidation of surficial plant matter or peat. *Cordaites* (a gymnosperm) and tree ferns, which are commonly associated in the partings of the coals, are probable sources of the resin rods.

MACQUOWN, WILLIAM C., Univ. Kentucky, Lexington, KY, and J. HUNT PERKINS, Petroleum Exploration Corp. of Texas, Lexington, KY

Comparison of Shallow-Marine Shelf Carbonate Mounds of Fort Payne Formation (Lower Mississippian) of Tennessee with Waulsortian Mounds of Western Europe

Although Fort Payne and Waulsortian carbonate mounds are similar, differences in sedimentary and diagenetic environments account for the development of porosity, permeability, and emplacement of petroleum in producing Fort Payne mounds. Waulsortian-type mounds, including the Fort Payne mounds, are characterized by: (1) similar mound morphology and alignment of mound trends, (2) distinctive microfacies and limited faunal diversity, and (3) limited stratigraphic and widespread geographic occurrence.

European Waulsortian mounds, exposed on the surface, range up to 300 m thick, are not generally porous, and contain little evidence of hydrocarbons. They occur on relatively rapidly subsiding shelf margins, at intermediate water depths, and were not subaerially exposed during buildup.

Fort Payne limestone mounds are low relief features (30 m thick) with initial dips less than 1°, containing primary and secondary porosity in bryozoan grainstones in multiple zones within dominant mud-supported microfacies. Mounds formed on a shallow slowly subsiding shelf (ramp) during transgression. Variation in rate of subsidence or eustatic sea-level changes are recorded either by minor zones bearing normal marine fauna or by zones bearing shallow-marine dolomite and evaporites. Periodic subaerial exposure and descending, dissolving, meteoric water probably enhanced secondary porosity development. Minor, but complex, synsedimentary solution collapse, fracturing, and brecciation during mound compaction occurred above evacuated evaporites, solution seams, and stromatactis cavities. After burial by Warsaw Formation clastics, subsurface (mesogenetic) diagenesis is documented by postlithification compaction features including stylolites, microstylolites, and multiple-fractured breccias. Pore-fill spar occlusion of some porosity, and emplacement of petroleum in permeable reservoirs were late mesogenetic events.

MAGATHAN, ESTHER R., Consulting Geologist, Denver, CO

Conveyer-Belt Tectonics and Geologic Evolution of Alaska's Eastern Interior

From the Coleen-Old Crow highlands south to the Yukon River, Alaska's eastern interior is a geologic collage of northeast-trending slivers which have been displaced in conveyer-belt fashion since the Jurassic along a trans-Arctic shear system which extends to the eastern end of the Arctic archipelago. Rock sequences of the region have remarkable affinities with the North Slope and Arctic island assemblages, suggesting a common origin in the Arctic Ocean region.

Pre-Cretaceous rocks can be attributed to four successive paleotectonic phases: (1) Cambrian through Lower Devonian carbonate rocks and shales are shelf-slope-basin sequences recording passive subsidence of an Atlantic-type shelf margin; (2) Middle through Upper Devonian siliceous black shales and turbidites document trench development and associated folding, uplift, and reworking of deep-sea sediments, a dramatic change ascribed to oceanic plate subduction; (3) Upper Paleozoic rocks are extremely varied and include acid intrusives and metamorphic rocks, as well as a spectrum of sedimentary deposits ranging from deep marine to fluvial. Collectively, they are attributed to a major period of orogenic uplift; and (4) early Mesozoic rocks are dominantly post-orogenic molassoid clastics.

The transcurrent movements which transported these sequences into Alaska and contiguous Yukon probably began in the Cretaceous as a result of southwesterly Arctic plate motion. Simultaneously, however, northwesterly translation of cordilleran elements interfered with this movement, causing complex dovetailing of geologic blocks and the evolution of a curious, but systematic pattern of orogenic uplifts. Thermal activity associated with these uplifts has locally reduced the originally high petroleum potential of the region.

MAGOON, LESLIE B., U.S. Geol. Survey, Menlo Park, CA, and GEORGE E. CLAYPOOL, U.S. Geol. Survey, Denver, CO

Two Oil Types on North Slope of Alaska—Implications for Future Exploration

The North Slope of Alaska is a proved petroleum province containing numerous seeps, many small undeveloped oil fields, and the largest oil field on the North American continent, Prudhoe Bay. Genetic relations among oils in the NPRA (National Petroleum Reserve in Alaska), the Prudhoe Bay area, and the Arctic Wildlife Range have important implications for future exploration.

Forty-two oil samples from across the North Slope analyzed by the U.S. Bureau of Mines and the U.S. Geological Survey suggest two separate oil types, even though some oils are biodegraded. The first, the Barrow-Prudhoe oil type, is present in reservoir rocks of Carboniferous to Tertiary age and includes oils from South Barrow gas field, Prudhoe Bay oil field, and the Fish Creek 1 test well. Physical properties of Barrow-Prudhoe oils are variable, but in general the oils are medium-gravity, high-sulfur, with a slight even-numbered n-alkane predominance and pristane-to-phytane ratio of less than 1.5. The second type, the Simpson-Umiat oil type, is present in reservoir rocks of Cretaceous to Quaternary age and includes oils from seeps in the Skull Cliff, Cape Simpson, Manning Point, and Ungoon Point areas, the Wolf Creek 3 test well, and the Umiat oil field. These are higher gravity, low-sulfur oils with no or slight odd-numbered n-alkane predominance and pristane-to-phytane ratios greater than 1.5.

The two types probably originate from different sources, the Barrow-Prudhoe type from a carbonate or other iron-deficient source rock, and the Simpson-Umiat type from a siliciclastic source rock. Distribution of the two oil types indicates at least two exploration fairways. The fairway for the Barrow-Prudhoe type is along the Barrow arch, and the fairway for the Simpson-Umiat type coincides with the area of best reservoir development of the Nanushuk Group.

NORTH SLOPE OIL TYPES

	Barrow-Prudhoe	Simpson-Umiat
API gravity	25	35
Sulfur, percent	0.9	0.1
CPI	<1	≥1
Pristane/phytane	<1.5	>1.5
$\delta^{34}S$, permil	<-4	>-3
$\delta^{13}C_{sat}$, permil	-30	-29
$\delta^{13}C_{arom}$, permil	-29.5	-28
$\delta^{13}C_{whole\ oil}$, permil	-30	-28.5

MAHAN, THOMAS K., and WILLIAM B. HARRISON, III, Western Michigan Univ., Kalamazoo, MI

Depositional Environment of Lower Cincinnatian Kope Formation and Some Paleoecologic Implications

The lower Cincinnatian Kope Formation in southwestern Ohio and northern Kentucky has been previously studied from the standpoint of paleontology, lithology, and stratigraphy. This study, however, deals with the environment within which the Kope Formation was deposited with some paleoecologic implications.

The Kope Formation is defined as comprising at least 75 to 85% shale and siltstones with thin (5 to 10 cm), laterally discontinuous lenses of predominantly biogenic limestone and biomicrite. Shales are usually fissile while the coarser grained siltstones are more blocky and occasionally rippled or cross-stratified.

The bioclasts in the limestones were measured as discrete grains in an attempt to analyze flow regimes. Degree of sorting and grain roundness varied somewhat but consistently indicated that transport distance and length of time were kept to a minimum. Several of the limestone lenses are megaripple-bedded indicating a higher flow regime.

Faunal diversity is low, generally limited to three or four numerically abundant species. The morphology of the organisms suggests that they were adapted to a soft substrate and probably served as pioneer communities. Burrowing traces were present in the limestones although not as abundantly as in the shale and siltstones.

The environment of the Kope Formation was one of shallow, quiet water in a marine setting where sedimentation was slow and consisted of silt and clay. This setting was periodically interrupted by storm events and changing current patterns which disrupted the isolated communities of organisms and spread their remains laterally, producing carbonate shoals and migrating bioclastic ripples. These events probably represent occasional "instants" of geologic time while the more typical deposition was clay and silt in calmer water.

MALEK-ASLANI, M., Tenneco Oil Co., Houston, TX

Environmental and Diagenetic Controls of Carbonate Source Rocks

The preservation and evolution of organic matter in carbonate rocks are controlled by the depositional environments, eogenesis, mesogenesis, and telogenesis. Tidal flat, restricted lagoon, and basinal environments