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.

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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

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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.

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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 are favorable sites for generation and accumulation of organic biomass.

The prolonged exposure to the freshwater diagenesis in regressive phases of depositional megacycles results in destruction of organic matter in tidal-flat and lagoonal environments. The transgressive phase of depositional megacycles provides for short-lived exposures to the freshwater diagenesis. Consequently, tidal-flat and astricted lagoonal deposits of transgressive phase can be considered as petroleum source rocks.

Bitumens and hydrocarbons, which evolve from the thermal degradation of kerogens, migrate to the nearest available microporosities such as recrystallized patches of limestones, calcite cements, and dolomitic mosaics. Thus, early and late diagenesis helps to bring about a continuous segregation of bitumens and hydrocarbons from kerogens in carbonate source rocks. Tectonic fracturing can provide avenues for secondary migration from source to reservoir facies.

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Recent Activities in United States Tar Sand

The known tar sand resources of the United States consist of about 550 occurrences located in 22 states. Total oil-in-place in 39 of these occurrences, which have been submitted to some reservoir evaluation, is estimated between 23.7 billion and 32.7 billion bbl. At least 90% of this resource is located in Utah, where six deposits each contain from 1 to 16 billion bbl of oil. Other significant deposits occur in Texas, New Mexico, California, and Kentucky.

Current efforts to develop the United States tar sand resource include: reservoir characterization and evaluation work by industry, states, and the U.S. Department of Energy (D.O.E.); oil recovery and related research by industry, academia, and D.O.E.; and a few field minitests and pilots by industry and D.O.E.

The future supply role of the United States tar sand resource is necessarily vague because of the relatively small magnitude of the known resource, when compared to other potential synthetic fuels such as coal or oil shale, the lack of demonstrated applicable oil recovery technologies, and a resultant lack of recoverable reserve estimates.

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Hydrocarbon Prospects of Bering Sea Shelf South of St. Lawrence Island, Alaska

Hydrocarbon prospects of the Bering Sea shelf are encouraging because of the presence of numerous, large sediment-filled basins, a variety of structural and stratigraphic traps, and potential reservoir beds. The large shelf area south of St. Lawrence Island is underlain by at least 13 sediment-filled basins. One of these basins, Bristol Bay basin, extends offshore from the Alaska Peninsula and contains more than 3 km of section. Nearby on the northwest is St. George basin, a graben approximately 300 km long and 50 km wide that includes a section about 10 km thick. The northwestern region of the shelf near Siberia is underlain by the large Navarin basin province (40,000 sq km), which comprises three subshelf basins that contain sections as much as 15 km thick.

Structural traps for hydrocarbons occur as folds associated with growth faults flanking the basins, strata draped over basement blocks, regional dip divergence in the upper sedimentary basin sequence, and thinning of beds against the basement flanks of the basins. Diapirlike folds as well as large anticlinal structures occur in the Navarin basin province.

Rocks dredged from the Beringian continental slope include volcanic sandstone of Late Jurassic age, mudstone of Late Cretaceous age, and less consolidated deposits of early Tertiary age. Pyrolytic analyses of these rocks indicate that none are good source beds for petroleum; however, the samples are generally sandy units that may not be representative of finer grained possible source beds that may be present along the margin or within the subshelf basins. Tertiary samples are generally porous—probably because of abundant diatom frustules. The permeability of these rocks is variable. Tertiary outcrops can be traced as seismic reflectors to the subshelf basins, where, if the beds remain diatomaceous, potential reservoir beds may be present.

SOURCE ROCK & RESERVOIR CHARACTERISTICS
BERING SHELF DREDGE SAMPLES

Sample number	Lith.	Age	Org. Carb. (Wt.%)	Pyrol. HC (Wt.%)	Vitr Refl. (%)	Por. (%) perm.(md)
96-77-BS						
DRI-20	Vol. Ss.	Late Jur.	—	—	0.38	— —
DRI-26	Vol. Ss.	Late Jur.	—	—	1.14	— —
TT-1-021						
001	Mudst.	Late Cret.	0.62	0.11	0.40	— —
L5-78-BS						
5-5	Ss.	Late Jur.	0.27	0.02	0.63	— —
2-3	Mudst.	E. Tert.	0.33	0.02	0.41	— —
16-9	Mudst.	M. Eo.	0.83	0.04	0.31	— —
2-4	Mudst.	L. Olig.	—	—	—	68.3/5.46
2-11	Sltst.	L. Olig.	—	—	—	45.1/1.25
5-10	Tuff	L. Olig.	—	—	—	50.7/19.0
7-3	Mudst.	M. Mio.	—	—	—	57.4/1.67

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Development of Conceptual Model to Characterize Uncertainty in Coal Resource Estimates

Published coal reserve estimates for the United States have traditionally differed by wide margins, e.g., Electric Power Research Institute estimating 135 billion tons and U.S. Geological Survey estimating 212 billion tons. These differences in reserve estimates possibly result from mechanically following the USGS/USBM resource classification system, without appreciation of lateral variability in seam thickness and seam discontinuity. Variability and discontinuity are dependent in part upon depositional history. For example, coals accumulated on an ancient alluvial plain or in a back barrier setting are more variable and, thus, more difficult to characterize as to resources than are those that accumulated on a delta plain.

A statistical model for characterizing uncertainty in