In the early Tertiary, possibly in response to the extension of Atlantic rifting into the Arctic basin, a new stress field developed that produced subsidence and basin formation. Neogene subsidence allowed the sea to invade progressively linked subshelf basins, creating the first sinuous shallow water connection between the Pacific and Arctic Oceans late in Miocene time. This seaway was severed about 5 m.y. ago, probably in response to uplift of the Bering Strait horst. Subsidence resumed, and the Bering and Chukchi Seas assumed their present form about 3.5 m.y. ago during the late Pliocene Beringian transgression.

Local basin formation combined with general subsidence of the Bering shelf continues to the present. However, movement along the western submerged extensions of the major transcurrent faults of Alaska appears to be slow or absent.

HOWITT, FRANK, BP Alaska Inc., Anchorage, Alaska, and MICHAEL W. CLEGG, British Petroleum Co., London, England

Permafrost in Prudhoe Bay Field: Geology and Physical Characteristics

In the recently discovered Prudhoe Bay field on the North Slope of Alaska the upper part of the production wells penetrates a massive permafrost zone. The base of this zone gets deeper as the distance from the existing seashore increases, the greatest depth so far found being about 2,000 ft. The extent of the permafrost zones may be seen quite clearly on logs run in the hole prior to casing, provided the hole diameter is not too large. The best definition can be obtained from the sonic, resistivity, and caliper logs. In addition, temperature surveys run in the completed wells several months after completion show clearly the base of the permafrost, and the different thermal conductivity of the frozen and unfrozen material.

Soils and geologic data have been obtained from a continuous core of the permafrost zone in the Prudhoe Bay area in the interval from 500 to 1,850 ft, and from several cores taken in parts of the upper 500 ft. A wide range of measurements has been made including densities and relative densities, porosities, ice saturations, and soil and ice classifications. From the results of these and other studies some comments and speculation on the deposition of the permafrost and the general geology of the surface deposits can be made.

HUNT, A. D., and H. W. WOODWARD, Dept. Indian Affairs and Northern Development, Ottawa, Ont.

Logistics' Costs Associated with Oil and Gas Exploration and Exploitation in Far North of Canada

Realization of the oil and gas wealth in Canada's North has been, and will continue to be limited by difficult logistic problems and attendant costs.

During the past decade, however, there has been a continuous improvement in the northern infrastructure, including community development, communications and, most notably, in transportation, which have served to reduce greatly the cost of logistic requirements. Roads suitable for year-round use are complemented by roads suitable in the winter. Barge transportation on the Mackenzie River has greatly expanded, as has commercial sea-lift to the Arctic Islands in the summer months. Cargo aircraft, both fixed and rotating wing, carry bulky and heavy loads and land and take off on water, or on improvised airstrips on land and ice on river or sea, adding a surprising degree of flexibility in transportation. Large diameter pipelines may be built on the permafrost of the Arctic region for cheap transport of crude oil and gas to Canada's Arctic or Pacific seacoast, or to southern interior markets.

IMLAY, RALPH W., U.S. Geol. Survey, Washington, D. C.

Jurassic Paleogeography of Alaska

During the Jurassic, marginal seas occupied considerable areas in southern and northern Alaska and in the western part of the Kuskokwim region of southwestern Alaska. They appear to have been less extensive during Bathonian and Tithonian times and absent during late Callovian time. They appear to have been absent from large areas in the interior of Alaska. Connection of the northern with the southern seas may have occurred through Siberia, through Yukon territory or, possibly, through westernmost or central Alaska.

The ammonite succession in Alaska is similar in general to that in central and northern Europe; in the Lower Jurassic, it is essentially identical. In Bajocian and in Callovian to Kimeridgian beds, the ammonite succession in Alaska differs mainly by the presence of some genera that have been found only in areas bordering the Pacific Ocean. In contrast, the Bathonian rocks of Alaska contain ammonites, such as *Arcticoceras, Arctocephalites,* and *Cranocephalites* that are widespread in the Arctic region but are unknown in central Europe. Comparisons with the Tithonian of Europe are not possible because ammonites of that age are not yet known from Alaska. The presence of Tithonian strata, however, is shown by the occurrences of *Buchia piochii* (Gabb) at a few places.

ION, DANIEL C., British Petroleum Co., London, England

Arctic Oil and the World—One Perspective

The Arctic is the latest accretion to the prospective petroliferous areas of the world which historically has grown in steps as new areas have come within reach through technical and economic breakthroughs.

The production of Arctic oil will depend on the effort expended. Historically, though total world oil supply and demand have increased smoothly and exponentially, individual country productions and demand have moved in steps as the effort expended has varied with the presence or absence of restrictions, self or externally imposed.

Resulting world oil supply patterns over the past 30 years have also shown some marked changes, some short, some longer lived.

North American Arctic oil, on presently indicated reserves, will be used in the United States. But what would the world supply pattern be in 1985 if the North American Arctic had proved to be equal to the Middle East in size of reserves?

IVANOVA, E. F., Inst. Geol. Geophys., Siberian Branch, Acad. Sci. USSR, Novosibirsk, USSR

Importance of Foraminifera for Zoogeographical Division of Arctic Seas in Late Jurassic and Early Cretaceous Times

The discovery of abundant and varied benthonic Foraminifera in marine deposits of the Pechora basin and in western and middle Siberia has made it possible to distinguish separate water bodies in this region. The following principles and criteria are the bases of constructing zoogeographical divisions into smaller subdivisions or districts: (1) the degree and the rank of endemism; (2) endemism of species; (3) the areal extents of species, genera, and families; and (4) the coefficient of the community (K_c = the ratio of the quantity of species, genera, and families characteristic of a district, to the total number of species, genera, and families).

Endemic families and genera are absent. High values of K_c are found at the family level. Thus the very great similarity of the Late Jurassic middle Volzhian fossil complexes of the Pechora basin, and western and middle Siberia (K_c = 0.70–0.77), and the endemism of species (22–48%) indicate that these districts belong to the North Boreal subregion of the Boreal region. Values of K_c, and the areal distribution and endemism of species made it possible to recognize the Pechora–West Ural (Pechora basin, West Siberian basin) and North Siberian (Ust'-Yenisey district, middle Siberia) provinces in middle and early Volzhian times. In late Volzhian time a climatic change took place. The ensuing temperature decrease of the marine water caused a narrowing of the distribution of almost all species in middle Siberia and an increase in agglutinated Foraminifera (Ammodiscidae, Ataxophragmiidae, Trochamminidae). The basins of the Pechora, western Siberia, and middle Siberia districts were part of the Boreal region, the boundary of which shifted southwestward. In Berriasian (Early Cretaceous) time, the water area of the Soviet Arctic zone was included in the Boreal region with the western and northern Siberia provinces.

IVANOV, V. V., USSR

OIL AND GAS PROBLEMS OF NORTHEASTERN ASIA AND ADJOINING SHELF

1. Northeastern Asia and vast areas of the adjoining shelf attract the attention of petroleum geologists, particularly after the discovery of many large oil and gas fields in structurally similar areas nearby, and in Alaska.

2. There are 18 possible oil-gas bearing basins in the northeast of USSR (excluding Kamchatka).

3. *Geosynclinal basins* (Khatyrka, Olyutorka, Korfovskiy) are linked with young depressions within the Olyutorka-Kamchatka system of the Cenozoides. These basins are characterized by the presence of orthogeosynclinal lithologic sequences, complex folding, and numerous oil and gas seeps that also are known on the adjoining shelf areas.

4. *Proto-orogenic basins* are confined to various intermontane areas. Their positions are defined by the geotectonic setting and the structure of the underlying late geosynclinal and postgeosynclinal rocks. Primary exploration objectives are in molasse complexes. Examples include: Momskiy, Indigirka-Zyryanka, Yamsk-Tauy, Kresty Bay, Anadyr, Penzhino, Parapol' and Pustoretsk basins. In the Anadyr basin, gas flows and definite oil shows were recovered in the wells which have been drilled.

5. *Deutero-orogenic basins* (Ulyogan, North Kolyma) in the area are found entirely within old middle Mesozoides massifs, and are characterized by the presence of two facies: The subplatform and molasse complexes.

6. *Platform-type basins* are confined to an extensive area of epi-Mesozoic depressions on the Arctic and Okhotsk shelves. These depressions are partly exposed on land. The Arctic group of basins is in depressions formed during the waning stages of the Mesozoides. It is possible that in the Arctic shelf conditions similar to those of Prudhoe Bay field in northern Alaska will be found.

7. On the basis of a comparative geologic-economic analysis, the most prospective and immediate objectives are the Anady basin, Indigirka-Zyryanka basin, the inland part of the Laptiyev-Yanskiy basin, and the inner zone of the Novobirsk basins. The large reserves for the future are on the shelves.

JELETZKY, J. A., Geol. Survey Canada, Ottawa, Ont.

CRETACEOUS PALEOGEOGRAPHY OF ARCTIC CANADA

In Early Cretaceous time Berriasian-Valanginian boreal seas covered North Yukon and Sverdrup basins and were connected at the site of the present Beaufort Sea. Dawson City strait connected the North Yukon sea with the North Pacific sea of the Saint Elias trough across the present Klondike plateau. The remainder of Arctic Canada was dry land.

In latest Valanginian time, uplift excluded the Hauterivian-Barremian seas from Sverdrup basin but North Yukon basin and Dawson City strait remained flooded after partial, early Hauterivian regression.

An Aptian boreal transgression flooded the Sverdrup basin and restored direct connection with the North Yukon sea which subsequently spread eastward into Darnley Bay and lower Peel River areas. Aptian orogeny closed the Dawson City strait and separated permanently the Canadian Boreal and North Pacific seas.

The early and middle Albian boreal seas covered Sverdrup and North Yukon basins and most of Mackenzie Lowlands and Mountains but late Albian and Cenomanian seas were restricted to a residual seaway east of Mackenzie River that connected the Mowry sea with that of Sverdrup basin.

An early Turonian transgression flooded the present regions of northern Yukon, Mackenzie Mountains, and, possibly, the Sverdrup basin; its total extent is still obscure. In the late Turonian the sea left the Mackenzie Mountains region but the North Yukon and Sverdrup basins remained flooded and were connected with a residual seaway east of Mackenzie River. A new seaway, connecting Sverdrup basin with the West Greenland sea across Ellesmere Island and Baffin Bay, opened in the late Turonian.

The most extensive flooding of Arctic Canada was caused by the Coniacian to mid-Santonian transgression which covered the areas of the Mackenzie Mountains, North Yukon basin, and Sverdrup basin, and extended east as far as Coppermine River.

Strong late Santonian uplifts on the west side of the Mackenzie Lowlands were followed by a series of increasingly intense uplifts that caused progressive eastward retreat of the Campanian-Maestrichtian seas. A residual seaway connecting the Bearpaw sea with that of West Greenland across the Canadian Arctic Archipelago and Baffin Bay continued to exist east of Mackenzie River until late Maestrichtian time. All of Arctic Canada became dry land in late Maestrichtian or early Paleocene time.

JOHNSON, G. LEONARD, and PETER R. VOGT, U.S. Naval Oceanographic Office, Washington, D.C.

MARINE GEOLOGY OF ATLANTIC NORTH OF ARCTIC CIRCLE