neath the Mendeleyev plain suggest a strong bottom circulation in the past. A zone of bottom erosion along the Mendeleyev Ridge flank may reflect a circulation of water through the Cooperation Gap, a trough which appears to cross the ridge. Two buried channels extending to subbottom depths of 700 m were observed between the Mendeleyev fracture zone and the Mendeleyev plain.

HAMILTON, WARREN, U.S. Geol. Survey, Denver, Colo.

Continental Drift in Arctic

Cretaceous and Cenozoic spreading of the northern Atlantic basins steps via transform faults to the Arctic Ocean, where simple spreading of the Eurasia basin appears highly probable, and more complex opening of the polar half of the Amerasia basin by spreading of Alpha and Mendeleyev Ridges appears likely. The Alaskan half of Amerasia basin may have opened behind counterclockwise-rotating Alaska, as proposed by S. W. Carey; this accounts for many features, including the provenance and northern source of clastic upper Paleozoic and lower Mesozoic sediments of northern Alaska.

As no young subduction zones are evident around the Arctic Ocean, these spreading motions must be matched by continental deformation and transform faults in Alaska and northeastern Siberia. A transform fault from the Eurasia basin may cross the East Siberian shelf, displacing the New Siberian Islands from Taimyr and separating Wrangel Island and northeastern Chukotka from mainland Siberia. Further deformation is absorbed by clockwise oroclinal rotation of the Verkhoyansk geosyncline south of this fault.

Reversing these motions indicates that the late Paleozoic and early Mesozoic Verkhoyansk, Wrangel, and Brooks geosynclinal terranes were parts of a continuous continental shelf, facing the open Pacific Ocean. The Laurasian continent fringed by this shelf was an aggregate of North American, European, and Siberian plates that had collided in Paleozoic time as Caledonian and Uralian oceanic plates vanished beneath them.

The stability of the Verkhoyansk-Brooks shelf ended when Jurassic subduction inaugurated conveyor-belt accretion at the Pacific continental margin, and magmatism above Benioff zones. Lena River and northern Alaska foreland basins, superimposed on the old continental shelf, received sediments from the new Pacific mountain systems concurrently with thin-skinned overthrusting. In middle Cretaceous time, the Verkhoyansk belt was wrapped into a compound orocline. Later Cretaceous and Cenozoic subduction produced successively the Okhotsk-Chukotsk, Kamchatka-Koryak, and Kuril-Aleutian systems. Central and southern Alaska may consist largely of debris (including continental fragments and island arcs) swept in since Triassic time on oceanic plates, and of successor-basin deposits and Benioff-zone magmatic rocks.

HARLAND, W. B., Dept. Geol., Univ. Cambridge, Sedgwick Museum, Cambridge, England

Mesozoic Geology of Svalbard

Mesozoic rocks are known from most of the major islands of Svalbard, namely Spitsbergen, Nordaustlandet, Barentsøya, Edgeøya, Kong Karls Land, Hopen, and Bjørnøya.

Sedimentary rocks range in age from Triassic (early Scythian) through Early Cretaceous (Albian), with facies mostly drab shale, siltstone, and sandstone—generally marine shale and continental sandstone—and comprise 2 lithostratigraphical units: Sassendalen Group (Griesbachian to Toarcian) and Adventdalen Group (Bathonian to mid-Albian). These units contrast markedly with the underlying Permian cherty carbonates, and not so obviously with the resistant overlying Tertiary coal measures. The marine strata are characterized by ammonites, bivalves, and saurians; the continental strata have plant beds, thin coal seams, some bivalves, and vertebrates. The succession and facies are very similar to those of Arctic Canada.

The most conspicuous rocks in the older part of the sequence are the cliff-forming basic igneous sills and flows of latest Jurassic and/or Early Cretaceous age.

The Mesozoic tectonic pattern followed a relatively stable late Paleozoic history with a marked change of facies but conformable strata. The maximum known thickness of Meozoic strata is about 3 km. The first distinguishable disturbance (warping and faulting) accompanied basic igneous activity but with little change of sedimentary facies. The principal unconformity represents a hiatus which took place in late Albian to early? Paleocene time. There is local overstep of Tertiary rocks onto lowermost Triassic, but generally only the uppermost Albian members are missing. These minor distrubances may be related to movements that culminated in the West Spitsbergen Orogeny in early to mid-Tertiary time, and to the mainly Tertiary Arctic Ocean spreading. Svalbard was probably moved from subtropical to temperate latitudes in Mesozoic time, only subsequently achieving arctic latitudes.

Petroleum prospects in the Arctic must take Mesozoic rocks into account as providing source, cap, and reservoir rocks.

HARLAND, W. B., Dept. Geol., Univ. Cambridge, Sedgwick Museum, Cambridge, England

Tectonic Evolution of Barents Shelf and Related Plates

In this paper an attempt has been made to reconstruct successively earlier configurations of lithosphere plates and their constituent parts, as related to the Barents Shelf. This involved a brief investigation of some possible past relations between Spitsbergen and the northwestern Eurasian plates, Greenland, the Canadian Arctic Islands, and the intervening seas and ocean basins. The restoration of observed crustal strains from structural and geophysical evidence were tested in each case for stratigraphical consistency of the implied reconstructions.

Working backward in time the study begins by reversing the late Phanerozoic spreading of the Norwegian and Greenland Sea basins of the Atlantic Ocean and the Eurasian basin of the Arctic Ocean. This leads to familiar reconstructions of Triassic/Permian paleogeology, with Spitsbergen adjacent to North Greenland and Ellesmere Island. There are some alternative reconstructions which have been rejected.

The restoration of Paleozoic displacements depend mainly on different interpretations of the Caledonides (especially the amount of closing and the amount of sinistral transcurrence involved). Relations between these structures, the North Greenland and Innuitian fold belts, the Lomonsov Ridge, and the Uralides, for instance, are critical.

There are more speculative possibilities for unraveling late Precambrian movements. The development of the North Atlantic geosyncline, in relation both to alternative models for a proto-Atlantic Ocean basin, and to late pre-Cambrian diastrophism as variously inferred has been considered.

HEMSTOCK, R. A., Imperial Oil Ltd., Calgary, Alta.

ENGINEERING GEOLOGY AND PETROLEUM EXPLORATION IN ARCTIC

"Geotechnique" is a new term incorporating the idea of engineering and geology as applied to soil materials. It is particularly appropriate in the Arctic where many of the soils are frozen and their physical behavior can be deduced only by properly understanding the geologic history and the present engineering properties.

Perennially frozen ground (permafrost) results in geomorphologic features which are unique to the Arctic. These include patterned ground, solifluction, ice mounds, pingoes, ice wedges, and masses. Permafrost may be continuous or discontinuous. An important engineering factor is the overlying active layer which seasonally freezes and thaws.

The chief factor that concerns the engineer regarding the soil (terrain) is the quantity of ice that may be in it. Permafrost as a term says nothing about this, but simply indicates that the ground remains frozen. Some workers have used the terms "detrimental" and "nondetrimental" permafrost, but these, too, are meaningless.

To the explorationist, permafrost thickness may be the most important factor. Depth seems to be influenced by the geologic history of the area, the present mean annual temperature, terrain type, and the proximity of heat sources such as lakes and rivers.

In many areas the upper layer of permafrost is protected from thawing by the organic cover. Destruction of this insulating mantle will result in thawing and slumping where ice is present. This is perhaps the greatest concern to those interested in Arctic development with minimum environmental disturbance.

HENAO-LONDOÑO, DIEGO, Panarctic Oils Ltd., Calgary, Alta.

MESOZOIC TRANSGRESSIONS IN SVERDRUP BASIN

Three major Mesozoic transgressions have been recognized in the Sverdrup basin. The first started in earliest Triassic and culminated during Late Triassic (Norian). A sequence of sands, silts, and clay, with a maximum known thickness of 17,800 ft was deposited during this time. The second transgression started in Early Jurassic (Sinemurian) and ended in Early Cretaceous (Neocomian), leaving a sandstone-shale sequence with maximum known thickness of 5,000 ft. The last marine transgression began during Early Cretaceous (Valanginian?) culminating in Albian time; the regressive phase ended in Late Cretaceous (early Senonian) when the seas retreated entirely from the basin. Maximum inferred thickness of the sandstone-shale sequence deposited is of the order of 8,000 ft. At the close of Cretaceous, rejuvenation of the source areas resulted in the deposition of a thick sequence of continental clastics. This, the last major sedimentary cycle recorded in the basin, came to an end during the early Tertiary.

Clastic distribution indicates southern and eastern sources for the Triassic sediments, with suggested open marine conditions on the north and northwest. Similar conditions may be inferred for the Jurassic and Cretaceous sediments in the eastern part of the basin. However, in the central and western areas the clastic distribution presents some problems. Apparently this distribution was controlled by some epeirogenic events of intra-Jurassic age which affected mainly the northwestern parts of the basin. These events appear to have caused temporary interruptions of the sedimentary processes during the second transgressive cycle.

HENRIKSEN, NIELS, Geol. Survey Greenland, Copenhagen, Denmark

CALEDONIAN GEOLOGY OF SCORESBY SUND REGION, CENTRAL EAST GREENLAND

The Geological Survey of Greenland has completed the first 3 years of a 5-year mapping campaign in the Scoresby Sund region which includes the southernmost Caledonian fold belt of East Greenland.

The preliminary results show that it is possible to distinguish 4 main geologic units in the Caledonian fold belt. (1) A Precambrian crystalline basement with a cover of Precambrian metasediments and metavolcanics. These rocks are reworked by Caledonian folding to a varying degree. (2) A metamorphosed but nonmigmatized supracrustal complex composed of psammitic and pelitic rocks with occasional bands of calcareous rocks and totaling several kilometers in thickness. These rocks represent Caledonian geosynclinal deposits of miogeosynclinal aspect and are probably of very late Precambrian age. (3) A Caledonian infracrustal complex of mainly gneisses, migmatites and synkinematic granites. This unit is formed by migmatization of Caledonian geosynclinal deposits. (4) Late- to post-Caledonian intrusions, mainly of granitic type.

Westward directed thrust-sheets with a displacement of several tens of kilometers are present along the western rim of the fold belt. They comprise largely Caledonian supracrustal rocks, but in places basement rocks are incorporated in the thrust sheets. The central part of the N-S directed fold belt is characterized by infracrustal rocks which exhibit simple low-dipping macroscopic structures, which in parts of the area can be shown to be the limbs of major recumbent folds.

The Caledonian supracrustal rocks in the western part of the region were metamorphosed under high-pressure facies conditions and are characterized by kyanite-bearing rocks, whereas the central migmatitic part of the region was formed under low-pressure conditions and is characterized by cordierite-bearing assemblages.

HERMAN, YVONNE, Dept. Geol., Washington State Univ., Pullman, Wash.

LATE CENOZOIC BIOSTRATIGRAPHIC AND PALEOECOLOGIC STUDIES OF ARCTIC OCEAN DEEP-SEA CORES

Deep-sea cores from the central Arctic basin, collected by Lamont Doherty Geological Observatory and the U.S. Geological Survey, yield significant faunal and lithologic evidence of alternating cold and milder periods during late Pliocene and Pleistocene times. Biostratigraphic and lithologic correlations between cores, some with established paleomagnetic stratigraphy, supplemented by radiometric dating and $O^{18/16}$ determinations, were used to estimate ages and sedimentation rates as well as to reconstruct the climatic and oceanographic history of the Arctic. The time interval represented by the longest core (T3-67-12) is thought to exceed 3 m.y.

Ice-rafted debris throughout the cores indicates that