POST-EARLY TRIASSIC FORMATIONS OF NORTHEASTERN ALASKA AND THEIR PETROLEUM RESERVOIR AND SOURCE-ROCK POTENTIAL

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METRIC CONVERSION FACTORS

To convert feet to meters, multiply by 0.3048. To convert inches to centimeters, multiply by 2.54.

POST-EARLY TRIASSIC FORMATIONS OF NORTHEASTERN ALASKA AND THEIR PETROLEUM RESERVOIR AND SOURCE-ROCK POTENTIAL

by W.M. Lyle,[1] I.F. Palmer, Jr.,[2] J.G. Bolm,[2] and L.R. Maxey[2]

ABSTRACT

During the 1979 State-Federal North Slope field project, more than 5,000 feet of stratigraphic section and 10,000 feet of traverse along strike were measured and 306 samples were collected and analyzed. Significant new paleontological age determinations and data concerning petroleum reservoir- and source-rock potentials, depositional environments, diagenesis, and organic geochemistry were obtained.

Data collected indicate that the regional Mesozoic-Tertiary stratigraphic pile consists of interbedded good to excellent quality mature source rocks and extensive tabular or linear sand bodies in which good to very good secondary porosity has been observed at the surface and may be inferred to exist in favorable subsurface locations. We conclude that the basins of the Arctic Coastal Plain in northeastern Alaska and adjacent offshore areas which are filled with these sediments have excellent potential for discovery of commercial hydrocarbons.

INTRODUCTION

Stratigraphic field studies were made within and adjacent to the William O. Douglas Arctic Wildlife Range during a 2-week period in mid-July 1979 by the U.S. Geological Survey (USGS) and the State of Alaska, Division of Geological and Geophysical Surveys (DGGS) (fig. 1). The project was similar in scope to previous cooperative State-Federal field projects completed in 1975 in the Gulf of Alaska Tertiary Province; in 1976 in the uplands near lower Cook Inlet and Kodiak Island; in 1977 on the Alaska Peninsula; and in 1978 in Western Alaska from Norton Sound to the Kilbuk Mountains.

Both State and Federal agencies are responsible for the evaluation of petroleum potential of all submerged lands under their jurisdictions. Collaboration of State and Federal geologists results in uniformity in collecting and processing geological data, provides for a common data base, melds ideas affecting extrapolation offshore, and eliminates (or greatly reduces) duplication of effort. Data are extrapolated into the adjacent submerged areas and facilitate evaluation of areas that may be offered in future lease sales.

The commercial facilities at Deadhorse near Prudhoe Bay served as base of operations. The crew was transported to and from Prudhoe Bay by commercial airliner. A Bell 206B Jet Ranger II was the primary means of on-the-job field-crew transport, and helicopter fuel caches were established at Barter Island and Kavik airstrip by means of fixed-wing charter aircraft. In addition a small inflatable boat was used for transport on Canning River.

FIELD METHODS AND SAMPLING

Stratigraphic sections were measured and sampled using 100-foot tapes, Brunton compasses, and in some places Jacob's staffs. Samples were taken for determination of porosity and permeability, hydrocarbon content, age,

[1]Alaska Division of Geological and Geophysical Surveys.
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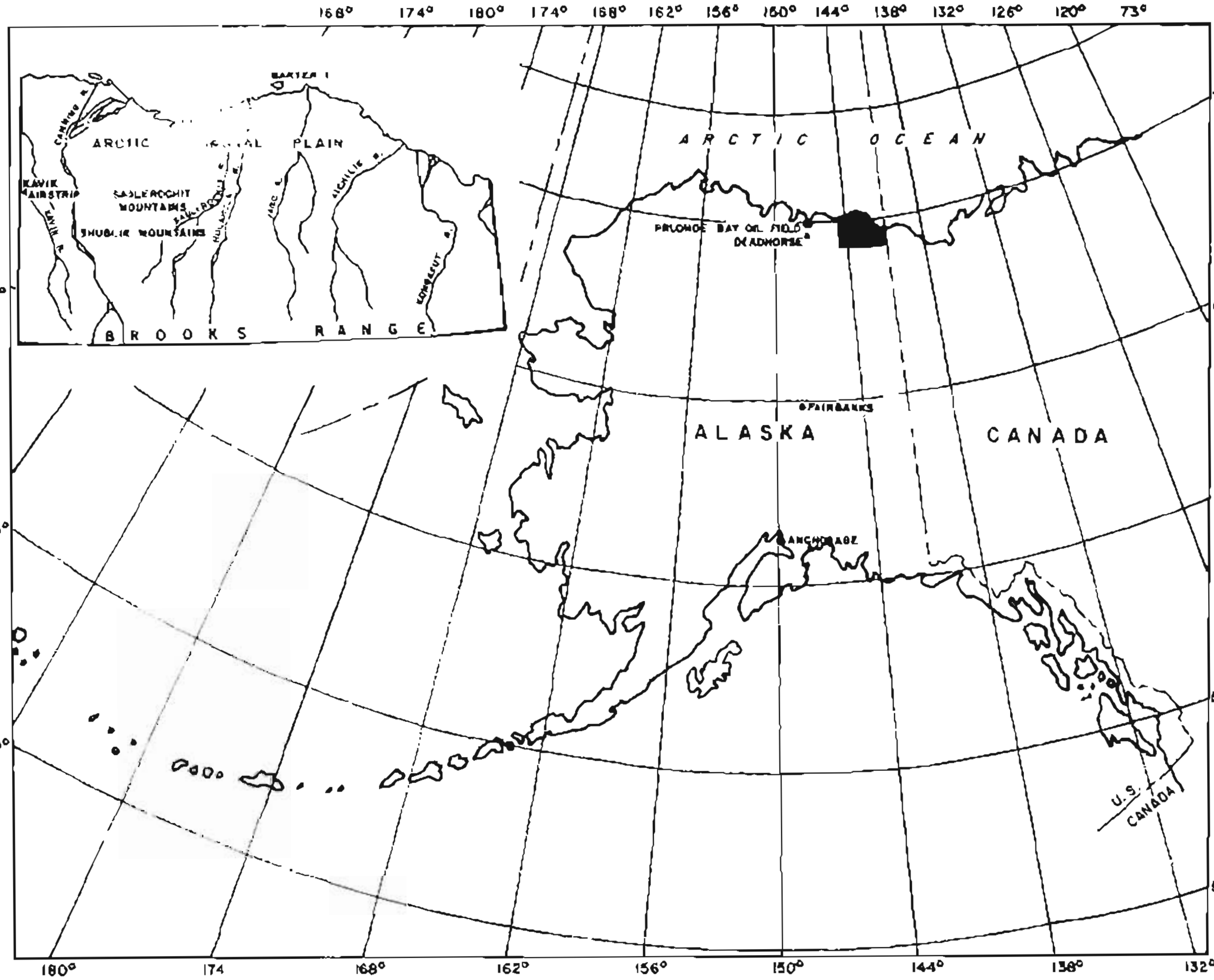

Figure 1. Index map.

and basin maturity. All samples were identified with a sample number, collector's initials, and last 2 digits of the year (e.g., 1-IP-79). All samples are cross-referenced to a map location (see Table I, Plates 1 and 2). A generalized stratigraphic section (fig. 2) depicts relative stratigraphic positions of measured sections and traverses.

STRATIGRAPHY

The fieldwork was directed toward testing reservoir and source-bed potentials of rock units stratigraphically above the Permian and Triassic Sadlerochit Group. With the exception of the Moose Channel Formation, the following descriptions are based on comprehensive stratigraphic work done in the area by Detterman and others (1975).

SHUBLIK FORMATION

The Shublik Formation crops out in narrow belts along mountain fronts, where structural complications lead to duplication or absence of beds locally and

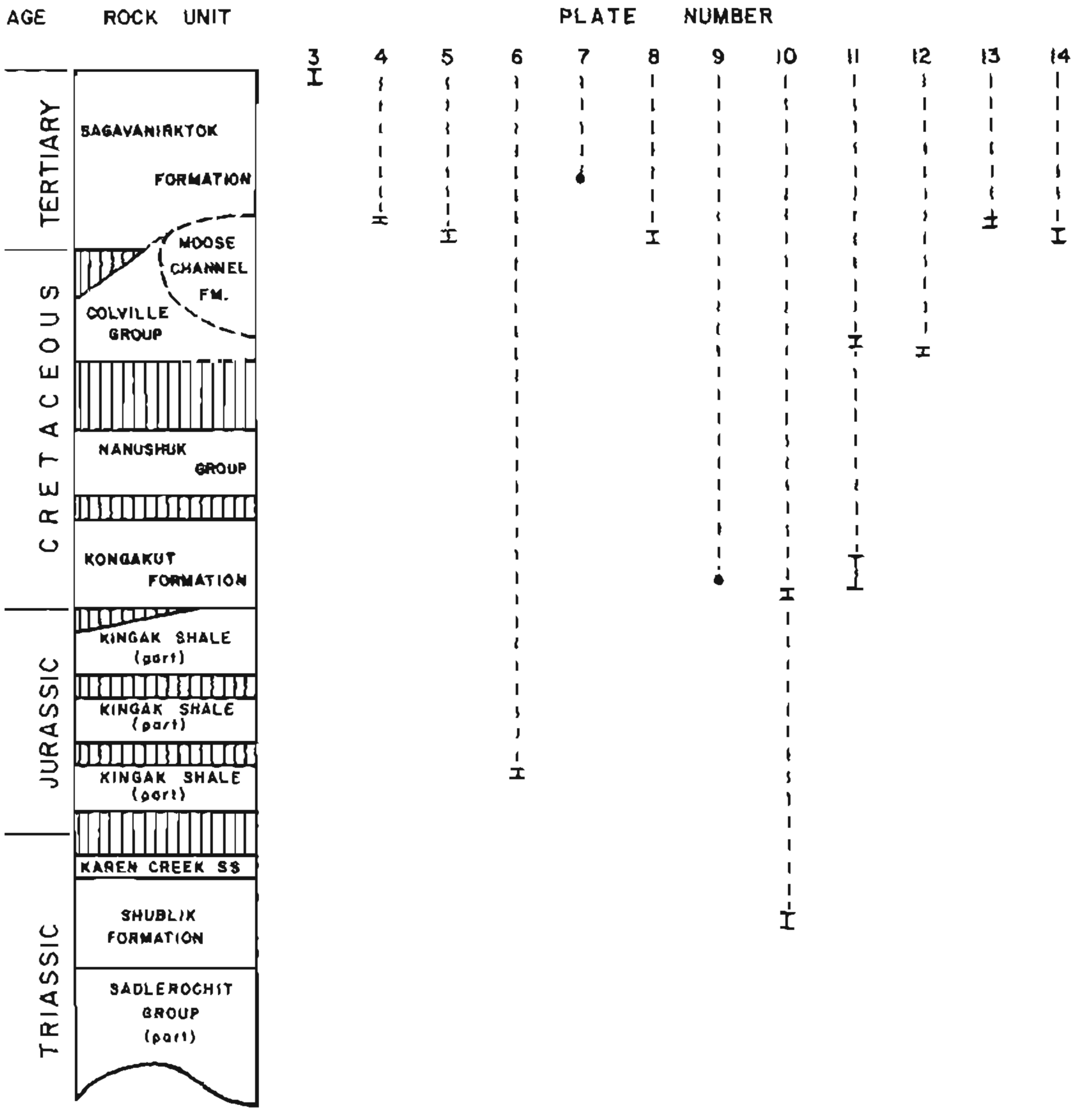

Figure 2. Generalized stratigraphic column of Triassic to Tertiary rocks in area showing relative stratigraphic positions of measured sections and traverses. The Nanushuk Group comprises the Tuktu and Chandler Formations, and the Colville Group comprises the Seabee, Prince Creek, and Schrader Bluff Formations.

thereby produce apparent thicknesses greater than the general range of 300 to 450 ft. The incompetent character of the formation restricts good exposures to canyon walls.

Upward from its base the Shublik Formation consists of siltstone, carbonate, and clay shale informally termed members. The basal siltstone member is composed predominantly of quartz with minor plagioclase and sericite; calcite cement is common. The middle carbonate member consists mainly of thin-bedded to massive layers of flattened pelecypod fragments, which are commonly somewhat phosphatized and dolomitized. Some layers contain as much as 20 percent silt, and shale is commonly interbedded with thin-bedded carbonate layers. The upper clay shale is very soft and contains a few silty very fine calcareous sandstone beds and calcareous concretions near the top.

Abundant monotid and halobiid pelecypods and locally abundant ammonites indicate that the Shublik Formation ranges in age from the Anisian to the Norian (Middle and Late Triassic). The Shublik is conformable with overlying and underlying formations wherever contacts have been observed in the area.

KAREN CREEK SANDSTONE

The Karen Creek Sandstone is exposed in Ignek Valley and on the north side of Kikiktat Mountain. The formation consists of massive fine quartzose sandstone which is colored by a dark organic stain. Secondary calcite is commonly present and generally becomes more abundant northward in the formation; locally calcite has altered to dolomite or siderite. Large phosphate nodules are common throughout the formation.

The thickness of the Karen Creek Sandstone ranges from 10 to 125 ft; the formation tends to be thinner in the west and north than in the east and south. Fossil pelecypods from near the base of the northernmost exposures indicate a Norian (latest Triassic) age, but the age of the formation may extend into Jurassic time.

KINGAK SHALE

The Kingak Shale consists of incompetent dark-gray to black shales with associated siltstones, claystones, and clay ironstones that crop out in belts of lowlands around mountains. Structural complications and poor exposure preclude accurate thickness determinations; the formation appears to change thickness rapidly and may be as much as 3,000 ft thick in places.

Although not all Jurassic ages are represented by fossil assemblages in the Kingak, the formation appears to represent all parts of the Jurassic when consideration is given nonfossiliferous lithologic intervals. Fossils are not uniformly abundant in the formation, but locally abundant ammonite and pelecypod fauna permit the recognition of numerous diastems and show the formation to be bounded by disconformities at top and bottom.

KONGAKUT FORMATION

The Kongakut Formation crops out in Ignek Valley and along the northeastern flank of the Sadlerochit Mountains. The formation is bounded by unconformities top and bottom and contains many local internal unconformities; its thickness in the project area is much less than the reported 2,090 ft at the type section near Bathtub Ridge in the southern part of the Demarcation Point quadrangle (pl. 2).

The formation is divided into three informal and one named member, in ascending order the clay shale member, the Kemik Sandstone Member, the pebble shale member, and the siltstone member. The clay shale member consists of soft, dark-gray, fissile shale in which clay ironstone nodules are common; the member also contains several thin arenaceous limestone beds. The Kemik Sandstone Member is a resistant fine sandstone which grades from feldspathic wacke with stringers of pebble conglomerate near the base to subfeldspathic quartz arenite near the top; tripolitic chert and limonite stain are common throughout. The pebble shale member consists of soft shale with flattened, highly polished chert pebbles; clay ironstone nodules are common except in a more resistant, black, manganiferous zone in the middle of the member. The siltstone member consists of siltstone beds with a few interbedded ledge-forming sandstone beds.

A sparse marine megafauna in the lower part of the Kongakut Formation indicates Neocomian (Early Cretaceous) age. The upper part of the formation is not fossiliferous, but the occurrence of strata as old as middle Albian immediately above the Kongakut Formation indicates that the upper part of the formation can be no younger than Albian.

NANUSHUK GROUP

The Nanushuk Group crops out west of the Kavik River, south of the Sadlerochit Mountains, and east of the Sadlerochit Mountains to the Okerokovik River. Both the lower and upper contacts of the Nanushuk are unconformities.

The lower of the two formations in the Nanushuk Group in the report area is the Tuktu Formation, which consists of interbedded greenish-yellow fine calcareous sandstones, dark siltstones, and shales as much as 1,700 ft thick. Inoceramus prisms are abundant locally in the sandstones, and in some areas sandstones are crossbedded and contain pebble conglomerate stringers.

The Chandler Formation, which conformably overlies the Tuktu Formation, is present only near Sabbath Creek. This formation consists of 4,775 ft of cyclic polymictic conglomerate, sandstone, siltstone, and shale. The shale contains abundant fossil plant debris, and cut-and-fill channels and point-bar-type crossbedding are common features of conglomerates and sandstones.

A sparse molluscan fauna and other fossil evidence indicate middle Albian age for the Tuktu. No identifiable fossil material is reported from the Chandler, but the formation is believed to be of middle to late Albian age.

COLVILLE GROUP

Rocks of the Colville Group crop out in the southern, hilly part of the Arctic Coastal Plain and in Ignek Valley. The Colville comprises three conformable formations which are everywhere unconformable to underlying rocks. Although younger rocks overlie the Colville Group conformably over large areas of its exposure, the upper contact of the group is unconformable at least locally.

Lowest of the three formations in the Colville Group is the Seabee Formation, which consists of dark, thinly bedded bentonitic shales overlain by gray, green,

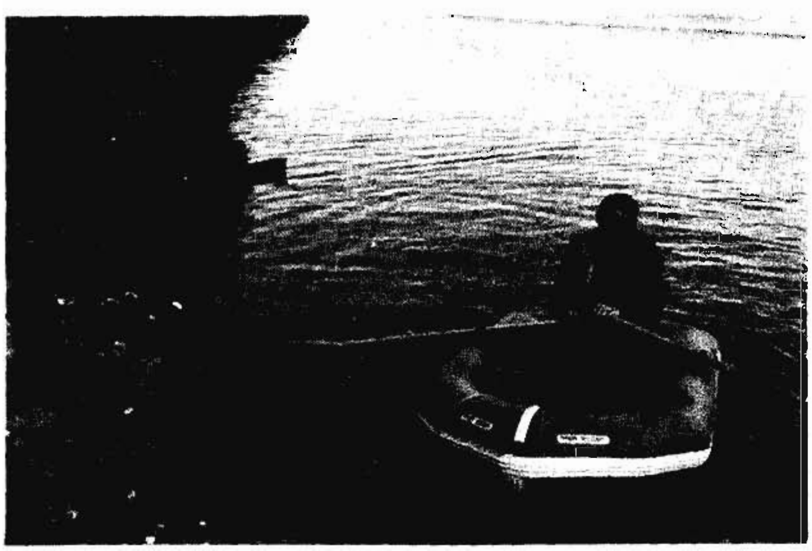

Figure 3. Inflatable boat used to measure the Canning River stratigraphic section. The boat provided quiet access to outcrop areas along the river without disturbing nesting birds.

and pink bedded devitrified tuffs and capped by interbedded orange-weathering shales, siltstones, and argillaceous fine sandstones. A preserved thickness of approximately 850 ft along Ignek Creek is probably the maximum preserved thickness of the Seabee Formation in the area.

Overlying the Seabee are the intertonguing nonmarine Prince Creek and marine Schrader Bluff Formations. The Prince Creek Formation consists of poorly consolidated sandstone, conglomerate, siltstone, shale, and coal which is probably as much as 1,150 ft thick in the area. Sandstones are subfeldspathic lithic arenites, and siltstones and shales are dark in the Prince Creek Formation. The uppermost unit in the formation is an extensively exposed, dark-brown, odorous, petroleum-stained sandstone.

The Schrader Bluff Formation is at least 1,100 ft thick in the area. The basal Rogers Creek Member of the formation consists of bentonitic shale with interbedded very fine sandstone and siltstone. The middle Barrow Trail Member consists of feldspathic wacke with a few siltstone and shale interbeds; rocks from this member are generally tuffaceous and commonly contain at least minor bentonite. Thin-bedded light-gray to tan tuffaceous siltstones and silty shales constitute the uppermost Sentinel Hill Member in the Schrader Bluff Formation.

An ammonite and pelecypod fauna indicative of middle to late Turonian age is known from the Seabee Formation, and a few radiolaria of Turonian to Santonian age have been reported from the formation. No fossils have been reported from the Prince Creek Formation, but pelecypods indicative of Santonian and Campanian age have been collected from the Schrader Bluff Formation, which intertongues with the Prince Creek Formation. For these reasons, Detterman, Reiser, Brosgé, and Dutro (1975) assigned a Late Cretaceous age to the Colville. Analyses (tables V and VI) of paleontological samples collected for this report from the Prince Creek and Schrader Bluff Formations in the Canning River and Katakturuk River stratigraphic sections indicate Paleogene age according to Anderson, Warren & Associates, Inc., and thus indicate that the formations may transgress the Mesozoic-Cenozoic boundary at least locally.

MOOSE CHANNEL FORMATION

Detterman, Reiser, Brosgé, and Dutro (1975) correlated interbedded sandstone, mudstone, and conglomerate that is exposed discontinuously between the Okpilak and Okerokovik Rivers with the Bathtub Graywacke of Early Cretaceous age. Diagnostic fossils were not known from these exposures, and correlation was based primarily on lithologic similarity. Subsequent work, including that reported here, has recovered fossil material indicative of Paleocene age from these exposures, and Detterman (oral communication, 1979) has recorrelated these rocks with the Moose Channel Formation of the western Canadian Arctic coast.

The Moose Channel Formation was designated by Mountjoy (1967) to include fine- to coarse-grained greenish- to grayish-brown feldspathic sandstone interbedded with brownish-gray silty shale and lensy conglomerate that crop out along the Arctic coast west of the Mackenzie Delta. The type section contains some coal seams and a fossil flora of possible Late Cretaceous to early Tertiary, but most likely Paleocene, age.

SAGAVANIRKTOK FORMATION

The Sagavanirktok Formation is present throughout almost all the northern part of the Arctic Coastal Plain, where its contacts are generally unconformable. A minimum thickness of 3,780 ft has been suggested for the formation in northeastern Alaska; the maximum thickness may be as much as 6,000 ft in this area.

Three named members compose the Sagavanirktok Formation. The basal Sagwon Member consists of interbedded dark-gray to brown bentonitic shale and siltstone with clay ironstone nodules, lignite beds, carbonaceous shale with poorly consolidated, massive sandstone and conglomerate in the upper part.

The overlying Franklin Bluffs Member consists of repeated cycles of thinly interlaminated gray to brown clay and silt with some chert pebbles and mud lumps along bedding planes overlain by massive beds of pink, tan, orange, or yellow unconsolidated sand and gravel and interbedded volcanic ash locally. Sand and gravel beds display large-scale crossbedding locally, and in some places zones several inches thick in the sand and gravel have been cemented with limonite.

The uppermost Nuwok Member consists of crossbedded sand overlain by pebble conglomerate which in turn is overlain by pebbly mudstones and siltstones with some silty limestone interbeds capped by crossbedded pebbly sand, which is generally unconsolidated but is locally cemented by limonite.

A fossil flora representative of Paleocene and Eocene age has been collected from the Sagwon Member, and a molluscan fauna representative of late Miocene (?) and early Pliocene age is known from the Nuwok Member; rich foraminifera and ostracod faunas in the Nuwok may be as young as late Pliocene or early Pleistocene. The Franklin Bluffs is thought to range from Oligocene (?) to Miocene (?) age. The Sagavanirktok Formation spans most if not all Tertiary time and may extend into the Pleistocene.

GUBIK FORMATION

The youngest named stratigraphic unit in the area is the Gubik Formation of Pleistocene age. This formation consists of beds of unconsolidated marine sand and gravel which are locally crossbedded and separated by thin beds of dark bluish-gray laminated silt and clay. In this area the formation is at least 35 ft thick, but its maximum thickness may be several times that amount. The basal contact of the Gubik Formation is unconformable wherever it has been observed; locally glacial outwash has been observed to overlie the formation unconformably.

STRATIGRAPHIC SECTIONS

CARTER CREEK (LOCALITY 1)

The Carter Creek section (pl. 3) is in sec. 21, T. 7 N., R. 30 E., where part of the Nuwok Member of the Sagavanirktok Formation crops out in the head and east side of a draw in the bluff on the right bank of Carter Creek (figs. 4 and 5) in the north flank of Marsh Creek anticline.

Mudstone is the principal rock type; sandstone and unconsolidated sand and gravel are present only in the upper fifth of the exposure, where they predominate. Fossil material, especially pelecypod fragments, is locally abundant, and some woody material was observed. Foraminiferal analyses of 6 samples indicate deposition in marginal marine to middle neritic environments during Neogene (probably Miocene) time. Palynological analyses of 5 samples support but are less definite than the depositional environment and age determined by foraminiferal analyses.

Poor induration prevented sampling the sandstone section for determination of porosity and permeability. Organic carbon in 6 samples ranged from 1.00 to 2.02 percent; thermal alteration indices of visual kerogen from the same samples ranged from 1+ to 2.

SOUTHEAST CARTER CREEK (LOCALITY 2)

This stratigraphic section (pl. 4) is in sec. 27, T. 7 N., R. 30 E., where part of the Sagwon Member of the Sagavanirktok Formation is exposed in the bluff along the left bank of an unnamed tributary to Carter Creek.

Figure 4. Nuwok Member of Sagavanirktok Formation on northeast flank of Marsh Creek anticline, Carter Creek stratigraphic section. View to north.

The section consists of interbedded thin layers of sandstone and mudstone with three thin pebble conglomerate beds near the top. Foraminiferal analysis of 1 sample was indeterminate of age or depositional environment, but palynological analysis of another sample indicates deposition in a marine environment during Eocene time.

KATAKTURUK RIVER (LOCALITY 8)

This stratigraphic section (pl. 5) is in sec. 11, T. 4 N., R. 27 E., where part

Figure 5. Upper part of Nuwok Member, Sagavanirktok Formation, at Carter Creek section. Grooves were cut into relatively unconsolidated sediments to enable study of depositional features.

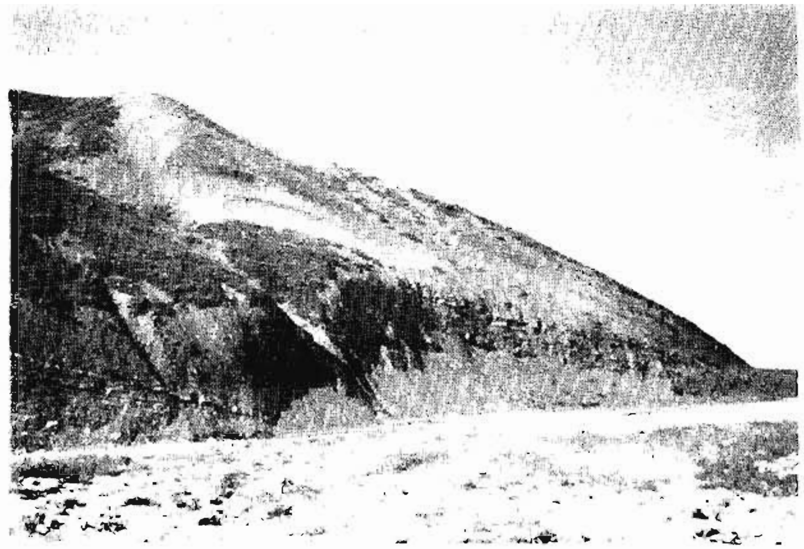

Figure 6. Sentinel Hill Member of Schrader Bluff Formation in upper part of Katakturuk River stratigraphic section. Hill along skyline is also visible in fig. 7. View to west.

of the Sentinel Hill Member of the Schrader Bluff Formation is exposed in a cliff along the left bank of Katakturuk River (figs. 6 and 7).

The outcrop consists of olive-gray mudstone and gray fine to very fine sandstone in beds which range in thickness from 1/2 inch to 124 feet. Both lithologies are laminated or locally ripple laminated, and carbonaceous debris is locally abundant. One mudstone unit contains calcareous concretions, and several mudstone beds contain siltstone

Figure 7. Sentinel Hill Member of Schrader Bluff Formation in lower part of Katakturuk River stratigraphic section. Hill along skyline is also visible in fig. 6. View to west.

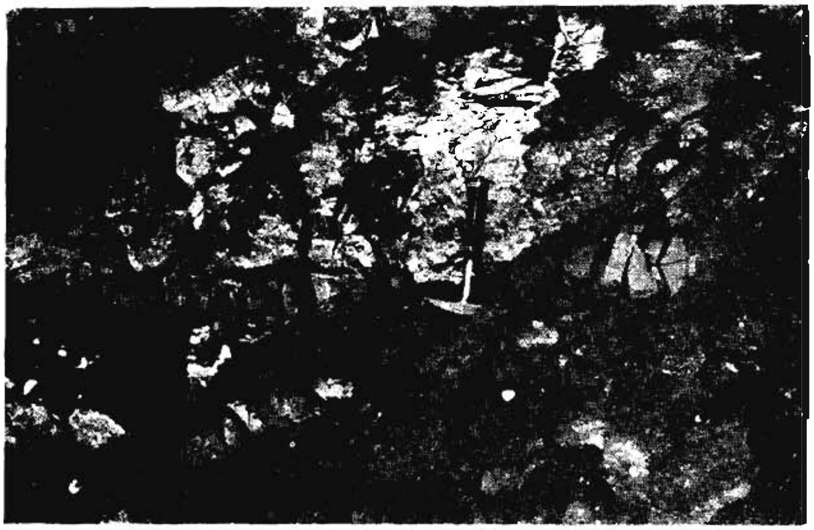

Figure 8. Siltstone boudins in topmost interbedded mudstone and siltstone unit of Kingak Shale in Itkilyariak Creek stratigraphic section.

lenses and pods. Foraminiferal analyses of 9 samples indicate deposition in marginal marine to neritic or possibly upper bathyal environments, probably during Paleogene time. Palynological analyses of 10 samples indicate deposition during Tertiary time in a nonmarine to marginal-marine environment.

Organic carbon ranged from 0.98 to 2.10 percent in 10 mudstone samples; thermal alteration indices of visual kerogen from the same samples ranged from 2- to 2. Five sandstone samples tested 0.4 to 9.4 percent porosity and from less than 0.01 to 0.06 millidarcy permeability.

ITKILYARIAK CREEK (LOCALITY 9)

This stratigraphic section (pl. 6) is in Sec. 28, T. 4 N., R. 31 E., where part of the Kingak Shale is exposed in a cliff along the right bank of an unnamed tributary to Itkilyariak Creek (fig. 8).

Foraminiferal analyses of 5 samples of interbedded dark-gray siltstone and brownish-black mudstone indicate deposition in a neritic environment during Early to Middle Jurassic time. Palynological analyses of 5 samples of the same lithologies indicate deposition in nonmarine or marginal-marine environments during Permian or Mesozoic time. Similar disagreement between foraminiferal and palynological depositional environment and age indications are known from Lower and Middle Jurassic subsurface samples from the North Slope; the depositional environment and age indicated by the foraminiferal analyses are presumed to be correct.

Four siltstone samples tested from 1.2 to 5.6 percent porosity and from less than 0.01 to 0.02 millidarcy permeability. Organic carbon ranged from 0.43 to 1.00 percent in 5 mudstone samples, and thermal alteration indices of visual kerogen from the same samples ranged from 3- to 3+.

CANNING RIVER (LOCALITY 13)

This stratigraphic section (pl. 8) is in Sec. 30, T. 3 N., R. 24 E., where intertonguing beds of the Prince Creek and Schrader Bluff Formations are exposed in a cliff along the left bank of Canning River.

Predominant lithologies are gray and brown mudstone, siltstone, and sandstone which commonly contain carbonaceous debris. Sandstone is commonly gravelly, and some sandstone units are crossbedded. Palynological analyses of 5 samples and foraminiferal analyses of 6 samples indicate that the rocks are of Paleocene age and were deposited in nonmarine and marginal-marine to inner-neritic environments.

Organic carbon content of 10 samples ranged from 1.00 to 1.37 percent, and thermal alteration indices of visual kerogen from the same samples ranged from 2- to 2+. In 8 sandstone samples porosity ranged from 2.1 to 10.9 percent and permeability from less than 0.01 to 1.29 millidarcies.

SADLEROCHIT RIVER (LOCALITY 18)

This stratigraphic section (pl. 10) is located in Sec. 11, T. 3 N., R. 31 E., where parts of the Shublik and Kongakut Formations are exposed in the flank of Sadlerochit Mountains along the left bank of Sadlerochit River.

The Shublik Formation consists mainly of siltstone and mudstone with lesser amounts of limestone. Foraminiferal analyses of 6 samples and palynological analyses of 6 samples indicate deposition in a marine environment; palynological analyses are indeterminate of age, but foraminiferal analyses indicate a probable Triassic age.

The unconformably overlying Kongakut comprises shale, mudstone, and siltstone. Foraminiferal analyses of 5 samples indicate deposition in middle-neritic to middle-bathyal environments during Neocomian time. Palynological analyses of 5 samples also indicate deposition during Neocomian time but indicate less specifically only a marine depositional environment.

Two siltstone samples from the Shublik tested 0.6 and 2.1 percent porosity and less than 0.01 millidarcy permeability. Organic carbon ranged from 0.42 to 2.33 percent in 7 samples from the Shublik, and thermal alteration indices of visual kerogen from the same samples ranged from 2- to 3+. In 5 samples from the Kongakut organic carbon ranged from 0.56 to 1.31 percent; thermal alteration indices of visual kerogen from the same samples ranged from 3 to 4-. We can offer no explanation why samples from the younger, stratigraphically higher Kongakut Formation have higher thermal alteration indices than samples from the older, stratigraphically lower Shublik Formation.

IGNEK VALLEY (LOCALITY 21)

In Sec. 3, T. 2 N., R. 27 E., parts of the Kongakut and Seabee Formations (pl. 11) are exposed on an interfluvial ridge in Ignek Valley.

At the base of this section the very fine to fine-grained Kemik Sandstone Member of the Kongakut Formation forms a cliff along the left bank of Katakturuk River. Above the Kemik is dark mudstone of the pebble shale member, which contains siltstone pods in its lower part. The section is capped by red rubblecrop of bentonitic clay, shale, and siltstone of the Seabee Formation. Foraminifera from one sample near the base of the pebble shale member indicate deposition in an outer-neritic to middle-bathyal environment in Neocomian time; analysis of a single foraminiferal sample from near the top of the member indicates a probable marine depositional environment, but is indeterminate of age. Neither depositional environment nor age could be determined from analyses of 2 palynological samples from the member. No paleontological samples were collected from the Kemik or the Seabee.

A single sample of the Kemik Sandstone Member tested 3.0 percent porosity and 0.01 millidarcy permeability. Organic carbon contents of two samples of the pebble shale member are 0.93 and 1.46 percent; thermal alteration indices of visual kerogen from these same samples are 2+ and 3.

JAGO RIVER (LOCALITY 23)

At the Jago River section (pl. 12), sec. 4, T. 6 N., R. 35 E., part of the Seabee Formation is exposed in a cliff along the left bank of Jago River (fig. 9).

The predominant lithology is olive-black paper shale with scattered thin beds of bentonitic clay, carbonate beds and lenses, and calcareous mudstone concretions. Sulfur dust and gypsum crystals are common in shale fissility planes, and the outcrop has a fetid odor. Numerous soft-sediment folds are visible. Palynological analyses of 3 samples indicate deposition in a marine environment during Late Cretaceous time. No environmental or age determinations could be made from most of the 5 foraminiferal samples collected in this section, but one sample which contained Inoceramus prisms was determined to be of Jurassic or Cretaceous age and to have been deposited in a marine environment.

Organic carbon content of 5 samples ranged from 2.84 to 12.41 percent, and thermal alteration indices of visual kerogen from the same samples ranged from 1+ to 2-.

SABBATH CREEK NO. 1 (LOCALITY 24)

This stratigraphic section (pl. 13) is in sec. 27, T. 4 N., R. 35 E., where part of the Moose Channel Formation is exposed in the bluff along the right bank of Sabbath Creek.

About a quarter of this section consists of beds of poorly sorted dark-gray sandstone and conglomerate, some of which are cross-laminated. The remainder is composed of beds of cross-laminated olive-black mudstone in which carbonaceous debris is common. Foraminiferal analyses of 5 samples were indeterminate of age or depositional environment, but palynological analyses of 5 samples indicate deposition in a nonmarine environment during Tertiary (probably Paleocene) time.

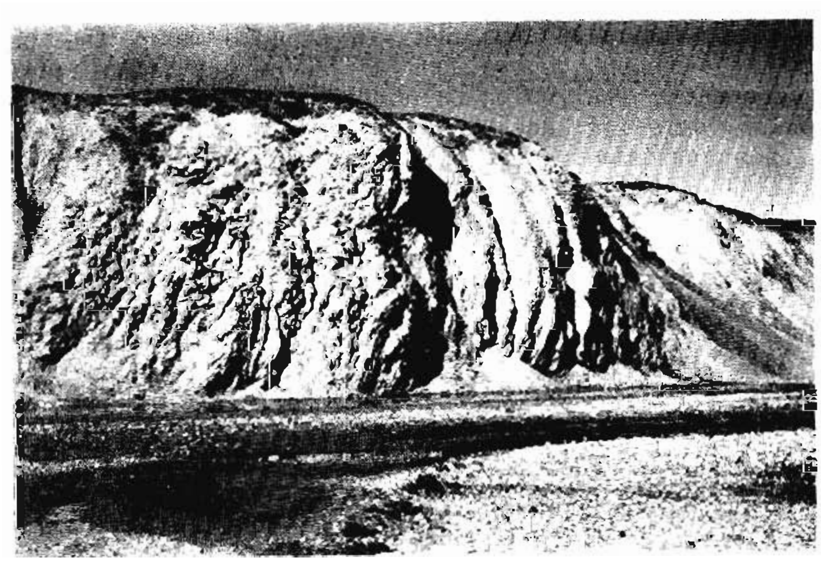

Figure 9 Seabee Formation in 60-ft cliff at Jago River stratigraphic section. Soft-sediment folds are visible at left (stratigraphically higher) part of exposure. View to west.

Three sandstone samples tested from 3.2 to 4.4 percent porosity and from 0.04 to 2.29 millidarcies permeability. Organic carbon in 5 samples ranged from 0.83 to 2.82 percent; thermal alteration indices of visual kerogen from the same samples ranged from 1+ to 2.

SABBATH CREEK NO. 2 (LOCALITY 25)

This stratigraphic section (pl. 14) is in sec. 33, T. 4 N., R. 35 E., and sec. 4, T. 3 N., R. 35 E., where part of the Moose Channel Formation is exposed in the bluff along the right bank of Sabbath Creek. Large covered intervals in this section may be related to faulting or outcrop of incompetent rock types, and stratigraphic continuity is not certain across these intervals.

Sandstone and conglomerate predominate. Only a minor amount of mudstone was measured, but mudstone undoubtedly underlies much of the covered portion of the section and so is probably much more abundant than measurement of exposed beds has indicated. If all of the covered intervals in this section are underlain by mudstone, the sand-shale ratio is approximately the same as that observed in the Sabbath Creek No. 1 stratigraphic section (pl. 13). Foraminiferal analyses of 6 samples from this section were indeterminate of age and depositional environment, but palynological analyses of 6 samples indicate deposition in a nonmarine environment during Paleocene time.

Eleven sandstone and conglomerate samples tested 1.0 to 5.6 percent porosity and less than 0.01 to 1.18 millidarcies permeability. Organic carbon in 5 samples ranged from 0.92 to 4.02 percent, and thermal alteration indices of visual kerogen from the same samples ranged from 2- to 2+.

TRAVERSES

Potential reservoir sandbodies were examined and sampled laterally in an assessment of reservoir characteristics including porosity, permeability, diagenetic history, geometry, size, and depositional environment.

IGNEK VALLEY (LOCALITY 16)

This traverse (pl. 9) was measured in secs. 25 and 26, T. 3 N., R. 26 E., where the Kemik Sandstone Member of the Kongakut Formation crops out along a conspicuous hogback in Ignek Valley. The sandstone was sampled for porosity and permeability determinations at intervals of 175 to 625 ft. The sandstone is a subgraywacke typically very fine to fine-grained, medium- to dark-gray weathering gray to reddish-brown, well indurated, noncalcareous, and has a massive, blocky-weathering habit (fig. 10).

The length of the exposure is approximately 6,620 ft. Other similar sandbodies present nearby appear to be parallel and offset, suggesting en echelon marine-strandline upper-shoreface deposits or barrier bars.

Analyses of 13 samples indicated a range of porosity from 5.0 to 11.9 percent and of permeability from 0.01 to 20 millidarcies.

Paleontologic determinations from samples of mudstone above and below the sandbody (locs. 15 and 17) indicate that the unit is Early Cretaceous (Neocomian) in age.

KAVIK (LOCALITY 10)

This 4,875-ft traverse (pl. 7) is within an apparently continuous sandstone unit of the Sagavanirktok Formation in sec. 30, T. 3 N., R. 21 E. This sandstone is fine-grained with lenses of poorly sorted pebble and cobble conglomerate. High-angle crossbeds are common (figs. 11 and 12). Cobbles consist of metamorphic rocks, gray chert, and quartz. Locally the unit contains carbonized reeds, and one tree limb was observed (fig. 13).

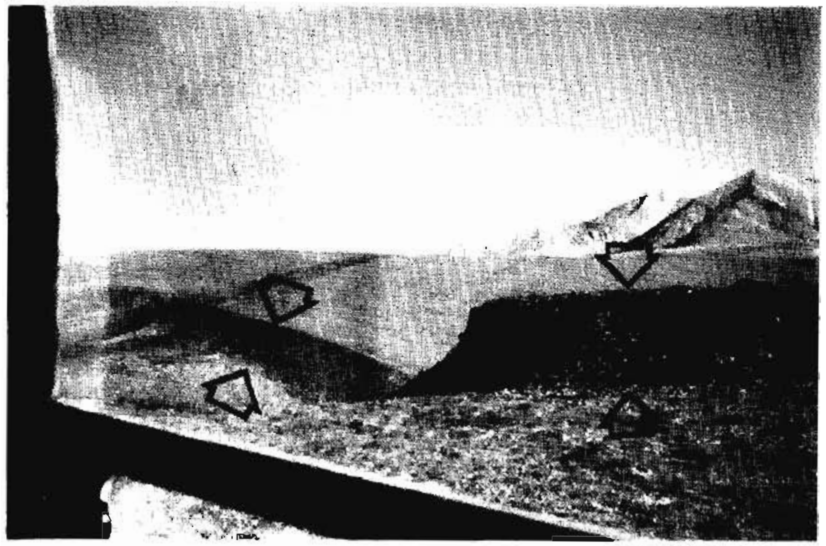

Figure 10. Kemik Sandstone Member (between arrows) of Kongakut Formation in Ignek Valley. View to east.

In 14 samples analyzed, porosity ranged from 15.2 to 20.8 percent and permeability from 2.80 to 3200 millidarcies.

SPOT SAMPLES

Samples were collected from several spot localities where measuring stratigraphic sections was impractical owing to poor exposure or time limitations. Laboratory determinations

Figure 11. Sagavanirktok Formation at station 7 in Kavik traverse. Hammer rests on crossbedded zone. View to north.

Figure 12. Sagavanirktok Formation at station 8 in Kavik traverse. Two cross-bedded zones (A and C) are separated by a parallel bedded zone (B). Cross-bedding indicates northward-flowing paleocurrents.

from these samples supplement data derived from stratigraphic sections and traverses. Localities are shown on plates 1 and 2.

LOCALITY 3

A single sample was collected in sec. 17, T. 6 N., R. 28 E., from an isolated exposure of sandstone from the Sagavanirktok Formation in the bluff along

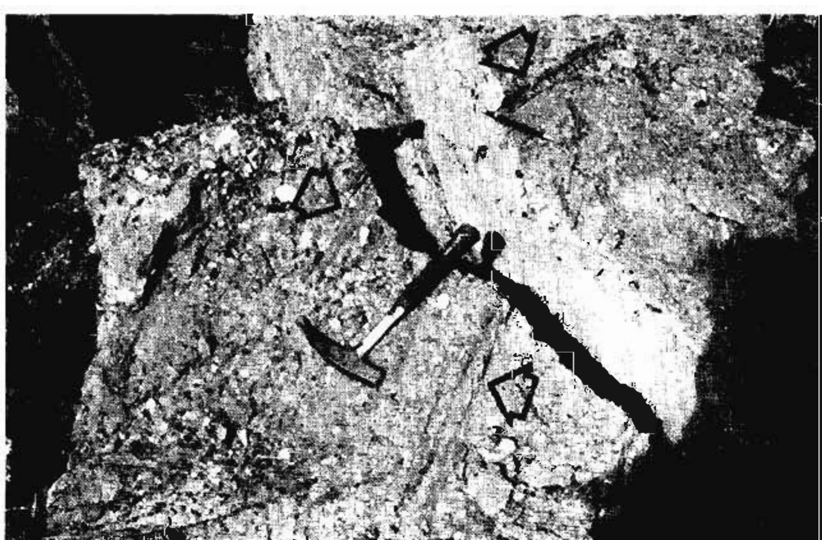

Figure 13. Tree limb and reed imprints in Sagavanirktok Formation at station 9 in Kavik traverse. This coarse-grained conglomeratic sandstone, which exhibits channel cut-and-fill and high concentration of terrestrial organic materials, suggests a high-energy, nearshore depositional environment.

the right bank of Katakturuk River. This sandstone is laminated, pebbly, and very fine to coarse-grained and contains coal fragments, carbonaceous debris, and cobble-sized shale rip-up clasts. It is moderate-brown (5YR3/4) on fresh surfaces and weathers to light-gray (N7). A thermal alteration index of 2- was obtained on visual kerogen which consisted largely of algal and amorphous-sapropel material with some herbaceous and woody or coaly material. The sample tested 22.8 percent porosity and 683 millidarcies permeability.

LOCALITIES 4, 5, AND 6

Samples were collected from three exposures of the Franklin Bluffs Member of the Sagavanirktok Formation in the bluffs along the right banks of two unnamed creeks tributary to Tamayariak River in secs. 24 and 36, T. 4 N., R. 26 E. These exposures consist of interbedded sandstone, shale, and minor siltstone (fig. 14). Sandstone ranges from very fine to medium grained and is medium-gray (N5) or dark-yellowish-brown (10YR4/2), calcareous, and cross-laminated. Sandstone, in beds from 2 to 6 inches thick, grades upward to shale, which is olive-gray (5Y4/1) and in 1- to 6-inch beds. Siltstone is dark-gray (N3) and is present in 1-inch beds. Organic carbon in 8 samples ranged from 1.08 to 1.60 percent. Thermal alteration indices of 1+ to 2+ were obtained from the same 8 samples on visual kerogen, which consisted of abundant herbaceous material with common woody and some coaly materials. Two sandstone samples from location 4 had porosities of 0.4 and 3.1 percent and permeabilities of <0.01 and 0.04 millidarcy. Foraminiferal study of 8 samples was indeterminate of age or depositional environment, but palynological examination of 8 samples indicated deposition in a nonmarine environment during Tertiary time.

LOCALITY 7

Three samples were collected from the Schrader Bluff Formation on the right bank of Katakturuk River in sec. 26, T. 4 N., R. 27 E. The rock exposed here is laminated olive-black (5Y2/1) shale which has a fetid odor. Sulfur dust is present along laminae and on the surface of the outcrop. A sample subjected to geochemical analysis contained 3.9 percent organic carbon with a thermal alteration index of 3 to 3+ on visual kerogen, which was predominantly amorphous with common herbaceous and some woody material. A sample submitted for foraminiferal study was barren, but palynological examination of another sample indicated deposition in a marine environment during Campanian time.

LOCALITIES 11 AND 12

Samples were collected from the Franklin Bluffs Member of the Sagavanirktok Formation from 2 exposures in the bluff along the left bank of Kavik River in secs. 17 and 20, T. 3 N., R. 22 E. Exposed are dark-gray (N3) carbonaceous mudstones and light-brownish-gray (5YR6/1) conglomeratic fine to medium sandstones. Two mudstone samples contained 6.50 and 6.68 percent organic carbon; thermal alteration indices were 2- to 2 on visual kerogen, which was largely herbaceous with some woody and coaly material. In 3 sandstone samples porosity ranged from 11.6 to 16.2 percent and permeability from 2.07 to 162.00 millidarcies. Two foraminiferal samples were barren, but palynological examination of 2 other samples indicated deposition in a probable nonmarine environment during Tertiary time.

LOCALITY 14

Samples were collected from an exposure of the Seabee Formation along the right bank of Ignek Creek in the south side of Red Hill in sec. 24, T. 3 N., R. 24 E. About 10 percent of the exposed rock is laminated, slightly calcareous,

Figure 14. Franklin Bluffs Member of Sagavanirktok Formation at locality 4. View to southeast.

light-gray (N7), very fine sandstone; the remaining 90 percent of exposed rock is hackly, olive-black (5Y2/1), calcareous mudstone. A mudstone sample tested geochemically contained 0.96 percent organic carbon; the thermal alteration index of visual kerogen, which was largely amorphous with some herbaceous material, was 2- to 2. A single sandstone sample tested 6.6 percent porosity and 0.26 millidarcy permeability. Foraminiferal examination of 1 sample indicated deposition in a marginal-marine to inner-neritic environment, probably during Cretaceous time, whereas palynological investigation of another sample indicated deposition in a marine environment during Campanian time.

LOCALITY 17

Samples were collected from the pebble shale member of the Kongakut Formation in sec. 26, T. 3 N., R. 26 E., 200 ft south of station 7 in the Ignek Valley traverse. Here the pebble shale is grayish-black (N2), noncalcareous, crumbly mudstone. Analysis of foraminifera in 1 sample indicates deposition in a middle-neritic to upper-bathyal environment during Neocomian time; a single palynological sample was barren of playnomorphs. One geochemical sample contained 4.77 percent organic carbon with a thermal alteration index of 2+ to 3- on visual kerogen that was largely amorphous with some herbaceous and minor woody material.

LOCALITY 19

Samples were collected from outcrops of the Tuktu Formation near the crest of Kingak Hill in sec. 30, T. 3 N., R. 32 E. Observed at this locality were dark-gray (N3) siltstone and shale that weather to a rust color and dark-gray (N3) very fine to fine sandstone. One sample contained 0.42 percent organic carbon had a thermal alteration index of 3 to 3+ on visual kerogen, which was largely herbaceous with some amorphous and minor woody material. Two sandstone samples tested 3.5 and 4.0 percent porosity and 0.01 and 0.02 millidarcy permeability. A paleontological sample was barren.

LOCALITY 20

Samples were collected from an exposure of the Kongakut Formation in a cliff along the left bank of Canning River in sec. 31, T. 2 N., R. 24 E. (fig. 15). The predominant lithology in this exposure is massive, noncalcareous, dark- to medium-gray (N3 to N5), very fine sandstone which is locally pebbly or cobbly; much less abundant is dark-gray (N3) to olive-gray (5Y3/2) noncalcareous silty shale with flattened dark-gray (N3) calcareous pods in layers. Two shale samples contained 1.31 and 2.90 percent organic carbon and had thermal alteration indices of 2 to 2+ on visual kerogen that was largely amorphous or herbaceous. Three sandstone samples tested 0.7 to 3.2 percent porosity and <0.01 to 0.02 millidarcy permeability. Foraminiferal study of 2 samples indicates deposition in a middle-neritic to upper-bathyal environment during Neocomian time, and palynological examination of 1 sample indicates marine deposition in Early Cretaceous time.

LOCALITY 22

Samples were collected from a small exposure of mudstone of the Sagavanirktok Formation in the bluff along the left bank of Jago River in sec. 27, T. 7 N., R. 35 E. The mudstone is dusty yellowish-brown (10YR2/2), laminated, poorly indurated, and hackly. Two samples contained 2.24 and 2.30 percent organic carbon and had thermal alteration indices on visual kerogen, which was largely amorphous and woody material, of 1+ to 2-. Two foraminiferal samples were barren, but 2 palynological samples indicated deposition in a marine environment during Eocene time.

PETROGRAPHY

All 76 samples collected for porosity and permeability testing were examined petrographically. Their stratigraphic distribution was as follows: 2 from the Shublik Formation, 4 from the Kingak Shale, 20 from the Kongakut Formation, 2 from the Tuktu Formation, 14 from the Moose Channel Formation, 1 from the Seabee Formation, 8 from the Prince Creek and Schrader Bluff Formations undifferentiated, 5 from the Schrader Bluff Formation, and 20 from the Sagavanirktok Formation.

Both samples from the Shublik Formation are silty to very fine sandy limestone in which silt and sand are

Figure 15. Massive sandstone of Kongakut Formation exposed at locality 20. View to northwest.

predominantly quartz and carbonate is variably micritic and microsparry or pseudosparry. Silicate clasts tend to be abundant in sparry areas and much rarer in micritic areas; this suggests that the sediment was bioturbated prior to lithification. A few fish bones and echinoid plates were observed in these samples.

The 4 samples from the Kingak Shale consist of bioturbated mixtures of siltstone and dark-brown mudstone. Silt grains are mainly quartz. Fine-grained carbonate cement is common in the siltstones, and the mudstones are at least locally micritic.

The remaining 70 samples from the Kongakut, Tuktu, Prince Creek, Schrader Bluff, Moose Channel, and Sagavanirktok Formations are all lithic sandstone in which quartz and rock fragments are the principal framework components. Small amounts of feldspar and minor mica are also present in most of these samples. Clasts range from very fine to very coarse sand grade, but individual samples are generally well sorted. Roundness ranges from subangular to rounded with no obvious relationship to clast type.

Quartz clasts are predominantly monocrystalline. Smaller quartz clasts show straight to slightly undulatory extinction, whereas larger quartz clasts (some of which display mosaic structure or Boehm lamellae) commonly show moderate to marked undulatory extinction. A few schistose polycrystalline quartz clasts were observed in some samples, and chert is common in many samples.

Rock fragments are predominantly microgranular and are most commonly melanocratic, but leucocratic grains that would be taken for chert except for the presence of microphenocrysts are common in many samples. Recognizable volcanic and sedimentary rock fragments are not uncommon in these samples, but metamorphic rock fragments are rare.

Plagioclase is more common than K-feldspar in the samples, and total feldspar does not exceed 10 percent in any of the samples. A few feldspar clasts have been slightly to moderately kaolinitized or slightly sericitized, but most feldspar is fresh.

Muscovite is the principal mica in most samples. Brown biotite is also common in the samples and is more abundant than muscovite in some samples. Detrital chlorite was observed in small amounts in a few samples. Total mica does not exceed 3 percent in any of the samples.

All these rocks have been tightly compacted; micas are commonly crinkled, and rock fragments have commonly been ductilly deformed. Some ductile grain deformation has proceeded so far as to produce pseudomatrix, which is abundant in some of the samples. Whatever intergranular space may have remained after compaction was filled with cements, and present intergranular porosity is of secondary origin. Authigenic clay, quartz, iron oxide, and carbonate are the principal intergranular cements in these samples, and minor amounts of pyrite, authigenic kaolinite, and zeolite are present as cements in a few samples. Quartz cement is present as syntaxial overgrowths on quartz clasts, and overgrowths have commonly produced a mosaic of interlocking quartz grains wherever several quartz clasts are in contact. Formation of authigenic clay and quartz cement seems to have occurred penecontemporaneously and prior to any carbonate cementation. Authigenic kaolinite, which occurs in vermicular stacks, and zeolite are present only as fills in secondary pores and so are the youngest cements observed in any sample.

Intergranular porosity was observed in 17 of the 70 sandstone samples; porosity is much better developed in coarser than in finer samples. The maximum intergranular porosity observed was 16 percent in a sample from the Schrader Bluff Formation. Inhomogeneity of packing, commonness of elongate pores or oversized pores with "floating" grains, evident partial dissolution and honeycombing of cements, and broken and corroded clasts in porous samples indicate that porosity is secondary and formed by dissolution of cement, especially carbonate, while the rocks were buried at considerable depth. It is likely, then, that these sandstones contain significant porosity at least locally in the subsurface and have good potential as petroleum reservoirs.

RESERVOIR CHARACTERISTICS

RESERVOIR GEOMETRY AND SIZE

Potential reservoirs in this area will probably be mainly tabular bodies deposited as beaches, upper and middle shoreface deposits, and offshore bars that result from clastic deposition along linear shorelines (Selley, 1976). In such tabular bodies the width commonly is 50 to 1,000 times the thickness (Krynine, 1957).

Exposed large tabular sandbodies in Marsh Creek anticline suggest that similar sandbodies exist in the subsurface. Individual sandbodies which extend for thousands of feet parallel to the axis of the fold can be observed in Marsh Creek anticline. These largely unconsolidated deposits are probably Pliocene to Pleistocene in age; however, they probably reflect the orientation, size, and geometry of Miocene sandbodies in the subsurface. In pre-Miocene rocks prisms or shoestring sandbodies may occur where streams entered the marine environment, but these types should decrease in number as extrapolations are carried northward, farther and farther from the source terrane.

RESERVOIR QUALITY

Seventy-six samples were analyzed for porosity and permeability (see Table IV). The porosities ranged from 0.4 to 22.8 percent. The samples can be divided into two groups: (1) samples collected near the Sadlerochit Mountains have consistently low porosity and permeability (average porosity 4.7 percent and average permeability 12.4 millidarcies); (2) samples collected about 15 miles west of the uplift had higher values (16.78 percent average porosity and 438.99 millidarcies average permeability).

HYDROCARBON SOURCE ROCKS

A total of 81 samples were processed for C_{15}+ soxhlet extraction and deasphaltening, visual kerogen assessment, thermal alteration index, and gas chromatographic analysis. Table II presents organic carbon contents and visual kerogen data, and Table III presents the results of C_{15}+ extraction. Many of the samples contain more than 300 parts per million (ppm) hydrocarbons, the generally accepted threshold level for a petroleum source rock. Total extracts ranged from 102 to 21,144 ppm and averaged 1,783 ppm. Total hydrocarbons ranged from 0 to 10,965 ppm and averaged 602 ppm. Analysis of the hydrocarbons shows about an even split between paraffin-naphthene and aromatic constituents. Organic carbon ranged from 0.42 to 12.41 percent and averaged 3.07 percent. The extracts and total organic carbon content averages are impressive source-rock values and compare favorably with some of the major oil-producing basins in the world.

The excellent mix of predominant and secondary kerogen constituents present in the samples supports the concept that these source rocks have the ability to generate both liquid and gaseous hydrocarbons. Amorphous-sapropel and herbaceous types (liquid hydrocarbon precursors) are especially abundant in the Seabee Formation in the Jago River stratigraphic section, but they are also present at several other widely separated locations and at different stratigraphic positions. Thermal alteration index (TAI) levels range from immature (1) in the Nuwok Member of the Sagavanirktok Formation in the Carter Creek stratigraphic section to slightly over mature (4-) in the Kongakut Formation in the Sadlerochit River stratigraphic section; however, most samples range from 2 to 3 and are, therefore, within the generally accepted mature range for hydrocarbon generation.

Gas chromatograms of saturate (paraffin-naphthene) hydrocarbon fractions follow Table III. The chromatograms show corroborative evidence of a generally mature suite of source rocks as suggested by the thermal alteration index values. Samples from the Nuwok Member of the Sagavanirktok Formation show the definite odd-carbon predominance that is a primary criterion of immaturity, but most samples do not show such odd-carbon predominance and are thereby shown to be mature.

The data show conclusively that good to excellent quality mature source rocks exist in the William O. Douglas Arctic Wildlife Range. Furthermore, it is highly probable that the same source rock formations or their equivalents could have generated hydrocarbons in the offshore area north of the Range or that hydrocarbons generated within the Range could have migrated to high structural positions both onshore and offshore.

CONCLUSION

The juxtaposition of laterally extensive potential reservoir sandstone units with organic-rich, mature source rocks indicates excellent potential for commercial hydrocarbon discovery in the basins of the Arctic Coastal Plain in northeastern Alaska and adjacent offshore areas.

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Table I.--SAMPLE NUMBERS CROSS REFERENCED TO MAP LOCALITY AND STRATIGRAPHIC UNIT

Map localities 1-21 shown on plate 1; localities 22-25 shown on plate 2.

Letters designate sample collector: GB, Bolm; IP, Palmer; WL, Lyle

Locality No.	Sample Nos.	Stratigraphic Unit: Formation	Stratigraphic Unit: Member
1 ---	78- to 96-WL-79	Sagavanirktok	Nuwok
2 ---	97- to 99-WL-79	do.	Sagwon
3 ---	48-GB-79	do.	---
4 ---	129- to 142-GB-79	do.	Franklin Bluffs
5 ---	143- to 148-GB-79	do.	do.
6 ---	149- to 154-GB-79	do.	do.
7 ---	155- to 157-GB-79	Schrader Bluff	---
8 ---	23- to 47-GB-79	do.	Sentinel Hill
	53- to 61-GB-79	do.	do.
9 ---	62- to 80-GB-79	Kingak	---
10 ---	11- to 25-WL-79	Sagavanirktok	---
11 ---	7- to 10-WL-79	do.	Franklin Bluffs
12 ---	1- to 6-WL-79	do.	do.
13 ---	5- to 15-IP-79	Prince Creek/ Schrader Bluff	---
	5- to 22-GB-79	do.	---
14 ---	49- to 52-GB-79	Seabee	---
15 ---	16- to 18-IP-79	Kongakut	Kemik
	19- to 21-IP-79	do.	Clay shale
	26- to 28-WL-79	do.	do.
16 ---	22- to 25-IP-79	do.	Kemik
	68A, 69A, 70- to 77-WL-79	do.	do.
17 ---	26- to 28-IP-79	do.	Pebble shale
18 ---	33- to 54-WL-79	Shublik	---
	55- to 69-WL-79	Kongakut	---
19 ---	29- to 32-WL-79	Tuktu	---
20 ---	1- to 4-GB-79	Kongakut	Kemik
	1- to 4-IP-79	do.	do.
21 ---	122-GB-79	do.	do.
	123- to 128-GB-79	do.	Pebble shale
22 ---	97- to 102-GB-79	Sagavanirktok	---
23 ---	81- to 96-GB-79	Seabee	---
24 ---	103- to 121-GB-79	Moose Channel	---
25 ---	30- to 59-IP-79	Moose Channel	---

Table II

SUMMARY OF ORGANIC CARBON CONTENT AND VISUAL KEROGEN DATA

[Determinations by Geochem Laboratories, Inc., Houston, Texas. TAI: scale from 1 (unaltered) to 4 (severely altered); underlined number indicates dominant rank of alteration. Kerogens listed in order of decreasing abundance: predominant (60-100%); secondary (20-40%); tract (1-20%). Al, algal; Am, amorphous-sapropel; C, coal; H, herbaceous-spore/cuticle; H*, degraded herbaceous; W, woody; U, unidentified material. A hyphen between kerogen types indicates subequal abundance. Kerogen types enclosed in parentheses following Am are recognizable degraded constituents of the amorphous population. Minor constituents of the trace population are indicated in parentheses following the code for the more abundant trace kerogen types.]

Loc. No.	Sample No.	Organic carbon (percent)	Thermal alteration index (TAI)	Visual kerogen data--Type of organic matter: Indigenous kerogen	Reworked kerogen	Total kerogen
			SAGAVANIRKTOK FORMATION			
3	48-GB-79	2.65	2-	Am(Al);-;H(W)	C;-;-	Am(Al);-;H(W-C)
22	97-GB-79	2.24	1+ to 2-	W;Am-H;-	W-C;-;-	W;Am-H;C
	100-GB-79	2.30	1+ to 2-	Am-H-W;-;-	W-C;-;-	Am-H-W;-;-
			Nuwok Member			
1	78-WL-79	1.00	1+ to 2-	H;W;-	C;H;W	H;C;W
	82-WL-79	2.02	1+ to 2-	H-W;-;-	C;H;W;-	H-W;-;C
	85-WL-79	1.79	1+ to 2-	H-W;-;-	W-C;-;-	H-W;C;-
	88-WL-79	1.40	1+ to 2-	H-W;-;-	H-C;W;-	H-W;C;-
	91-WL-79	1.22; 1.25	2- to 2	H;W;C	H-C;-;-	H;W;C
	94-WL-79	1.41	1+ to 2-	H;W;Am	H-C;-;-	H;W;Am(C)

Table II.--SUMMARY OF ORGANIC CARBON CONTENT AND VISUAL KEROGEN DATA--continued

Loc. No.	Sample No.	Organic carbon (percent)	Thermal alteration index (TAI)	Visual kerogen data--Type of organic matter: Indigenous kerogen	Reworked kerogen	Total kerogen
				Franklin Bluffs member		
4	129-GB-79	1.20	1+ to 2-	H;W;-	W-C;-;	H;W;C
	133-GB-79	1.08	2 to 2+	H;W;Am	C;W;-	H;W;C(Am)
	137-GB-79	1.11	2 to 2+	H;W;-	C;H-W;-	H;W;C
	140-GB-79	1.21	2 to 2+	H;W;-	C;W;	H;W;C
5	143-GB-79	1.60	2 to 2+	H-W;-;Am-C	C;-;-	H-W;C;Am
	146-GB-79	1.31; 1.28	2 to 2+	H-W;-;-	C;-;-	H-W;C;-
6	149-GB-79	1.20	2 to 2+	H-W;C;-	C;-;H-W	H-W;C;-
	152-GB-79	1.17	2+	H;W;C	W-C;-;-	H;W;C
11	9-WL-79	6.68	2- to 2	H;W;C	C;W;-	H;W-C;-
12	3-WL-79	6.50	2- to 2	H;W;-	C;W;-	H-W;C;-
				MOOSE CHANNEL FORMATION		
24	103-GB-79	0.94; 0.95	1+ to 2-	W;-;H	W-C;-;-	W-C;-;H
	107-GB-79	1.30	1+ to 2-	H-W;-;-	W-C;-;H*	H-W;C;-
	111-GB-79	2.45	2-	W;H;-	C;-;-	W;H;C
	115-GB-79	0.83	2- to 2	W;H;-	W-C;-;-	W;H;C
	119-GB-79	2.82	1+ to 2-	W;H;Am	W-C;-;-	W;H;Am(C)
25	31-IP-79	1.12	2 to 2+	H;W;C	C;W;-	H;W-C;-
	35-IP-79	0.95; 0.92	2- to 2	H;W;C	W-C;-;-	H;W-C;-
	40-IP-79	1.02	2- to 2	H;W;-	W-C;-;-	H;W-C;-
	48-IP-79	0.97	2 to 2+	H;W;C	W-C;-;-	H;W;C
	56-IP-79	4.02	2 to 2+	H;W-C;-	W-C;H;-	H-W;C;-

Table 11.--SUMMARY OF ORGANIC CARBON CONTENT AND VISUAL KEROGEN DATA--continued

			Undifferentiated PRINCE CREEK and SCHRADER BLUFF FORMATIONS			
13	6-GB-79	1.37	2 to 2+	H;W;Am	W-C;-;-	H-W;C;Am
	9-GB-79	1.16	2 to 2+	H-W;-;-	W-C;-;-	W;H-C;-
	11-GB-79	1.15	2- to 2	H-W;-;Al	W-C;-;-	W;H-C;Al
	13-GB-79	1.25; 1.23	2- to 2	Am-H;-;W	C;W;-	Am-H;-;W-C
	16-GB-79	1.25	2- to 2	H-W;-;-	W-C;-;-	W;H-C;-
	18-GB-79	1.35	2- to 2	H;W;-	W-C;-;-	H;W;C
	20-GB-79	1.00	2- to 2	H;W;-	W-C;-;-	H-W;C;-
	6-IP-79	1.35	2 to 2+	H;W;Am	W-C;-;-	H;W;C(Am)
	9-IP-79	1.32	2 to 2+	H;W;Am	C;H-W;-	H;W-C;Am
	11-IP-79	1.00	2 to 2+	H-W;-;C	W-C;-;H	W;H-C;-
			SCHRADER BLUFF FORMATION			
7	155-GB-79	3.95	3 to 3+	Am;H;W	W-C;-;-	Am;H;W(C)
			Sentinel Hill Member			
8	24-GB-79	2.10	2- to 2	H-W;-;-	W-C;-;-	H-W;C;-
	27-GB-79	1.14	2- to 2	H-W;-;-	W-C;-;-	W;H-C;-
	30-GB-79	1.29	2- to 2	H;W;-	W-C;-;-	H-W;C;-
	35-GB-79	1.10	2- to 2	H;W;-	W-C;-;-	H-W;C;-
	38-GB-79	1.12	2- to 2	H;W;-	W-C;-;-	H-W;C;-
	42-GB-79	1.30	2- to 2	W;H;-	W-C;-;-	W;H-C;-
	46-GB-79	1.01	2- to 2	H-W;-;-	W-C;-;-	H-W;-;C
	53-GB-79	1.29	2- to 2	H;W;-	W-C;-;-	H;W;C
	56-GB-79	0.98	2- to 2	H;W;-	W-C;-;-	H;W;C
	59-GB-79	1.01	2- to 2	W;H;-	W-C;-;-	W;H;C

Table II.--SUMMARY OF ORGANIC CARBON CONTENT AND VISUAL KEROGEN DATA--continued

Loc. No.	Sample No.	Organic carbon (percent)	Thermal alteration index (TAI)	Visual kerogen data--Type of organic matter: Indigenous kerogen	Reworked kerogen	Total kerogen
			SEABEE FORMATION			
14	50-GB-79	0.96	2- to 2	H;W;-	W-C;-;-	W-C;H;-
23	81-GB-79	2.84	1+	Am(Al);-;H	H-W-C;-;-	Am(Al);-;H(W-C)
	84-GB-79	4.84	1+	Am(Al);-;H	W;C;-	Am(Al);-;H-W(C)
	88-GB-79	9.82	1+ to 2-	Am(Al);H;W	W-C;-;-	Am(Al);H;W(C)
	91-GB-79	12.41	1+ to 2-	Am(Al);H;-	W-C;-;-	Am(Al);H;W-C
	94-GB-79	10.01	1+ to 2-	Am(Al);-;H	W-C;-;-	Am(Al);-;H-W-C
			TUKTU FORMATION			
19	30-WL-79	0.42	3 to 3+	H;Am-W;C		H;Am-W;-
			KONGAKUT FORMATION			
18	55-WL-79	0.56	3+ to 4-	H-C;W;-	-;-;H	H-C;W;-
	58-WL-79	1.11	3 to 3+	W-C;H;Am	-;-;H	W-C;H;Am
	61-WL-79	0.99	3+ to 4-	W-C;H;-	-;-;H	W-C;H;-
	64-WL-79	1.09	3 to 3+	W-C;H;-	-;H;-	W-C;H;-
	67-WL-79	1.31	3 to 3+	H-C;W;-	-;H-W;-	H-C;W;-
			Pebble shale member			
21	123-GB-79	0.93	2+ to 3-	H;W;Am	W-C;-;H*	W-C;H;Am
	126-GB-79	1.46	3	W;H;Am	W-C;-;-	W;H-C;Am

Table II.--SUMMARY OF ORGANIC CARBON CONTENT AND VISUAL KEROGEN DATA--continued

Loc. No.	Sample No.	Organic carbon (percent)	Thermal alteration index (TAI)	Visual kerogen data--Type of organic matter: Indigenous kerogen	Reworked kerogen	Total kerogen
			Kemik Sandstone Member			
17	26-IP-79	4.77	2+ to 3-	Am;H;W		Am;H;W
20	2-GB-79	2.90	2 to 2+	Am;H;W	W-C;-;-	Am;H-W;C
	2-IP-79	1.31	2 to 2+	H;W;Am	W-C;-;-	H;W;Am-C
			Clay shale member			
15	19-IP-79	1.25	3 to 3+	W-C;H;Am	W-C;-;-	W-C;H;Am
	26-WL-79	3.65; 3.61	3 to 3+	Am;H;-		Am;H;-
			KINGAK SHALE			
9	62-GB-79	0.62	3	H;W;-	W-C;H;-	W-C;H;-
	66-GB-79	0.70; 0.70	3 to 3+	H;W;-	W-C;-;-	W-C;H;-
	69-GB-79	0.43	3- to 3	H-W;-;-	W-C;-;H*	W-C;H;-
	73-GB-79	1.00	3- to 3	H;-;W	W-C;-;H*	W-C;-;H
	77-GB-79	0.96	3	H;W;-	W-C;-;-	H;W;C

Table II.--SUMMARY OF ORGANIC CARBON CONTENT AND VISUAL KEROGEN DATA--continued

Loc. No.	Sample No.	Organic carbon (percent)	Thermal alteration index (TAI)	Visual kerogen data--Type of organic matter		
				Indigenous kerogen	Reworked kerogen	Total kerogen
			SHUBLIK FORMATION			
18	34-WL-79	0.49	3 to 3+	H-C;Am;W		H-C;Am;W
	38-WL-79	0.42	3+	W-C;H;-	C;W;-	W-C;H;-
	41-WL-79	2.33	3 to 3+	Am;H;C		Am;H;C
	44-WL-79	1.13	3	Am;H;W-C		Am;H;W-C
	48-WL-79	0.64	3- to 3	Am;-;H	W-C;-;-	Am;W-C;H
	51-WL-79	1.95; 1.94	3 to 3+	H;Am;-		H;Am;-
	53-WL-79	1.70	2- to 2	H;W;C	C;H;W	H;W-C;-

Table III.--GEOCHEMICAL ANALYSES OF C_{15+} EXTRACTED MATERIAL IN ROCK

[All values in parts per million. NSO's nitrogrn-sulfur-oxygen derivatives. Determinations by Geochem Laboratories, Inc., Houston, Texas. Localities 1-19 shown on plate 1; localities 20-23 shown on plate 2. Gas chromatograms of these samples follow table VI]

Loc. No.	Sample No.	Total extract (H+N)	Hydrocarbons (H): Paraffin-naphthene	Hydrocarbons (H): Aro-matic	Hydrocarbons (H): Total	Nonhydrocarbons (N): Sul-fur	Nonhydrocarbons (N): Preciptd. asphaltene	Nonhydrocarbons (N): Eluted NSO's	Nonhydrocarbons (N): Noneluted NSO's	Nonhydrocarbons (N): Total
				SAGAVANIRKTOK FORMATION						
3	48-GB-79	21144	839	4079	4918	-	13638	2588	0	16226
22	97-GB-79	14999	2788	7418	10206	-	1057	1789	1947	4793
	100-GB-79	17314	3494	7471	10965	-	1833	2688	1828	6349
				Nuwok Member						
1	78-WL-79	862	22	56	78	-	630	76	79	784
	82-WL-79	757	26	74	100	2	357	200	98	657
	85-WL-79	744	30	39	69	-	401	135	139	676
	88-WL-79	1044	72	119	191	233	322	234	64	853
	91-WL-79	832	50	79	129	128	275	192	107	702
	94-WL-79	579	26	55	81	60	239	122	77	498
				Franklin Bluffs Member						
4	129-GB-79	504	34	90	124	-	246	82	52	380
	133-GB-79	575	34	87	121	-	322	81	51	454
	137-GB-79	841	50	122	172	3	462	146	57	668
	140-GB-79	750	39	136	175	-	392	137	46	575
5	143-GB-79	535	48	107	155	-	252	69	59	380
	146-GB-79	560	39	83	122	5	353	49	31	438

Table III.--GEOCHEMICAL ANALYSES OF C_{15+} EXTRACTED MATERIAL IN ROCK--continued

Loc. No.	Sample No.	Total extract (H+N)	Hydrocarbons (H) Paraffin-naphthene	Hydrocarbons (H) Aro-matic	Hydrocarbons (H) Total	Nonhydrocarbons (N) Sul-fur	Nonhydrocarbons (N) Preciptd. asphaltene	Nonhydrocarbons (N) Eluted NSO's	Nonhydrocarbons (N) Noneluted NSO's	Nonhydrocarbons (N) Total
			Franklin Bluffs Member--continued							
6	149-GB-79	820	32	101	133	5	584	73	26	688
	152-GB-79	290	22	62	83	6	137	47	16	207
11	9-WL-79	3104	198	624	822	-	1340	579	363	2282
12	3-WL-79	1824	56	59	116	18	707	338	645	1708
			MOOSE CHANNEL FORMATION							
24	103-GB-79	205	--	--	--	-	110	--	--	--
	107-GB-79	239	27	18	45	-	122	40	32	194
	111-GB-79	246	21	18	39	-	129	38	40	207
	115-GB-79	218	--	--	--	-	132	--	--	--
	119-GB-79	424	28	35	63	-	197	82	82	361
25	31-IP-79	610	30	60	90	-	404	71	45	520
	35-IP-79	274	19	51	70	-	145	46	13	204
	40-IP-79	207	20	41	61	-	91	40	15	146
	48-IP-79	496	22	43	65	5	327	64	34	431
	56-IP-79	677	55	61	116	-	299	138	124	561
			Undifferentiated PRINCE CREEK and SCHRADER BLUFF FORMATIONS							
13	6-GB-79	581	67	140	207	-	248	88	38	374
	9-GB-79	709	71	119	190	-	385	94	40	519
	11-GB-79	572	43	115	158	2	287	109	16	414
	13-GB-79	715	58	77	135	1	389	76	114	580
	16-GB-79	723	58	141	199	24	390	77	33	524

Table III.--GEOCHEMICAL ANALYSES OF C_{15+} EXTRACTED MATERIAL IN ROCK--continued

Loc. No.	Sample No.	Total extract (H+N)	Hydrocarbons (H) Paraffin-naphthene	Aro-matic	Total	Nonhydrocarbons (N) Sul-fur	Preciptd. asphaltene	Eluted NSO's	Noneluted NSO's	Total
	Undifferentiated PRINCE CREEK and SCHRADER BLUFF FORMATIONS--continued									
	18-GB-79	454	51	118	169	-	178	64	43	285
	20-GB-79	390	39	90	129	-	191	43	27	261
	6-IP-79	373	17	55	72	7	248	33	12	301
	9-IP-79	433	32	80	112	1	234	58	28	321
	11-IP-79	446	41	69	110	2	289	43	2	336
	SCHRADER BLUFF FORMATION									
7	155-GB-79	1807	296	328	624	233	759	130	60	1183
	Sentinel Hill Member									
8	24-GB-79	1293	118	345	463	-	651	160	19	830
	27-GB-79	483	49	103	152	-	236	59	36	331
	30-GB-79	874	79	214	293	-	461	110	10	581
	35-GB-79	705	43	147	190	-	426	62	27	515
	38-GB-79	768	65	149	214	-	448	84	22	554
	42-GB-79	980	62	230	291	-	555	126	8	688
	46-GB-79	737	58	133	191	-	435	84	27	546
	53-GB-79	1084	95	215	310	-	589	162	23	774
	56-GB-79	746	70	136	206	-	403	104	33	540
	59-GB-79	595	52	118	170	5	293	82	45	425
	SEABEE FORMATION									
14	50-GB-79	444	96	126	222	7	147	35	33	222

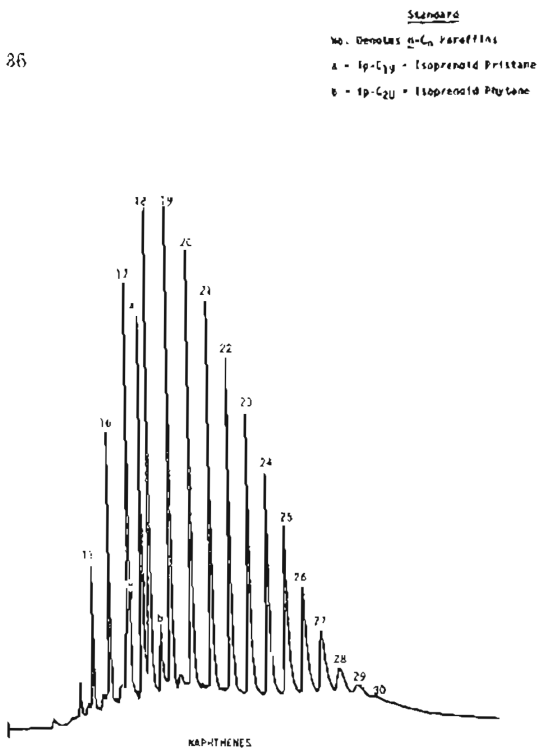
Table III.--GEOCHEMICAL ANALYSES OF C_{15+} EXTRACTED MATERIAL IN ROCK--continued

Loc. No.	Sample No.	Total extract (H+N)	Hydrocarbons (H) Paraffin-naphthene	Aro-matic	Total	Nonhydrocarbons (N) Sul-fur	Preciptd. asphaltene	Eluted NSO's	Noneluted NSO's	Total
					SEABEE FORMATION--continued					
23	81-GB-79	6055	666	2151	2817	95	1259	971	914	3238
	84-GB-79	6996	768	2176	2944	-	2003	961	588	4052
	88-GB-79	13442	659	3203	3862	-	4880	1706	2994	9580
	91-GB-79	9673	475	1654	2129	-	4465	1724	1355	7544
	94-GB-79	6696	282	879	1161	482	2350	1227	1476	5535
					TUKTU FORMATION					
19	30-WL-79	102	--	--	--	-	64	--	--	--
					KONGAKUT FORMATION					
18	55-WL-79	207	--	--	--	-	177	--	--	--
	58-WL-79	153	--	--	--	-	81	--	--	--
	61-WL-79	406	--	--	--	-	393	--	--	--
	64-WL-79	318	9	7	16	-	181	47	74	302
	67-WL-79	314	4	11	15	117	101	38	43	299
					Pebble shale member					
17	26-IP-79	792	23	215	238	-	357	134	63	554
21	123-GB-79	160	--	--	--	-	113	--	--	--
	126-GB-79	286	--	--	--	-	191	--	--	--

Table III.--GEOCHEMICAL ANALYSES OF C_{15+} EXTRACTED MATERIAL IN ROCK--continued

Loc. No.	Sample No.	Total extract (H+N)	Hydrocarbons (H) Paraffin-naphthene	Aro-matic	Total	Nonhydrocarbons (N) Sul-fur	Preciptd. asphaltene	Eluted NSO's	Noneluted NSO's	Total
				Kemik Sandstone Member						
20	2-GB-79	1152	134	405	539	173	284	143	13	613
	2-IP-79	1277	184	205	389	244	289	145	210	888
				Clay shale member						
15	19-IP-79	577	29	22	51	95	279	54	98	526
	26-WL-79	1654	287	170	457	175	700	132	190	1197
				KINGAK SHALE						
9	62-GB-79	132	--	--	--	-	68	--	--	--
	66-GB-79	163	--	--	--	-	76	--	--	--
	69-GB-79	167	--	--	--	-	79	--	--	--
	73-GB-79	299	6	12	18	122	78	43	38	281
	77-GB-79	395	3	6	9	140	87	40	119	386
				SHUBLIK FORMATION						
18	34-WL-79	477	--	--	--	-	406	--	--	--
	38-WL-79	137	--	--	--	-	73	--	--	--
	41-WL-79	134	--	--	--	-	59	--	--	--
	44-WL-79	167	--	--	--	-	131	--	--	--
	48-WL-79	123	--	--	--	-	96	--	--	--
	51-WL-79	237	--	--	--	-	154	--	--	--
	53-WL-79	188	--	--	--	-	116	--	--	--

GAS CHROMATOGRAMS OF SATURATE HYDROCARBON
FRACTIONS PRESENTED IN TABLE III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b = Ip-C20 = Isoprenoid Phytane
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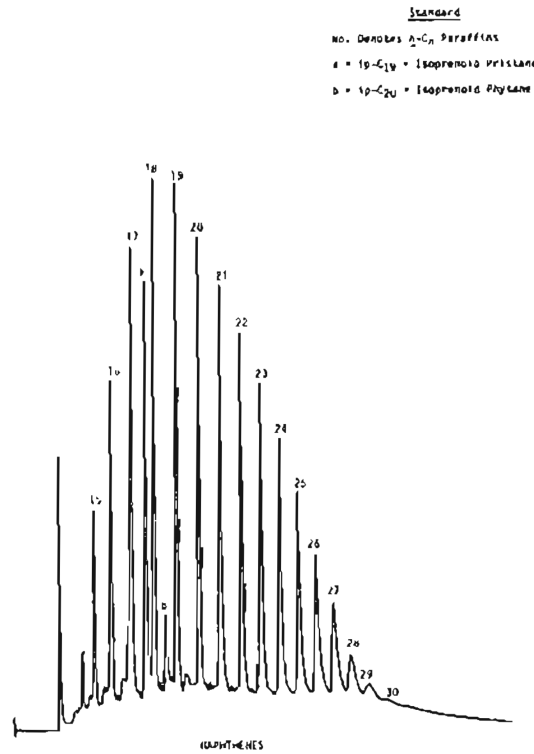
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b = Ip-C20 = Isoprenoid Phytane
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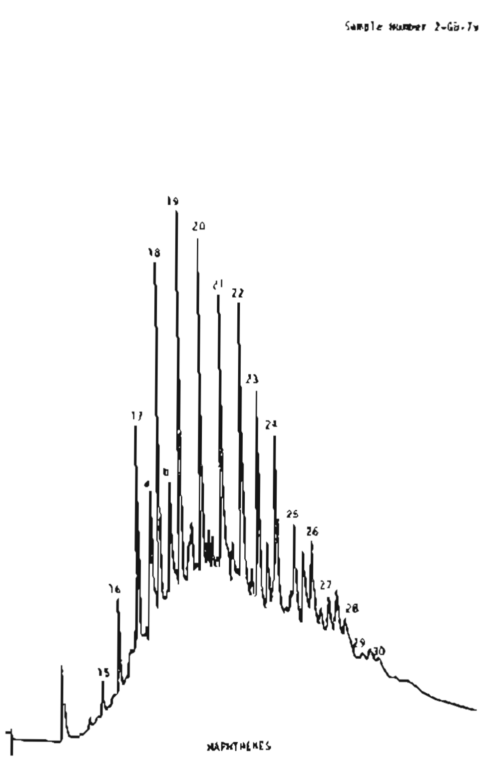
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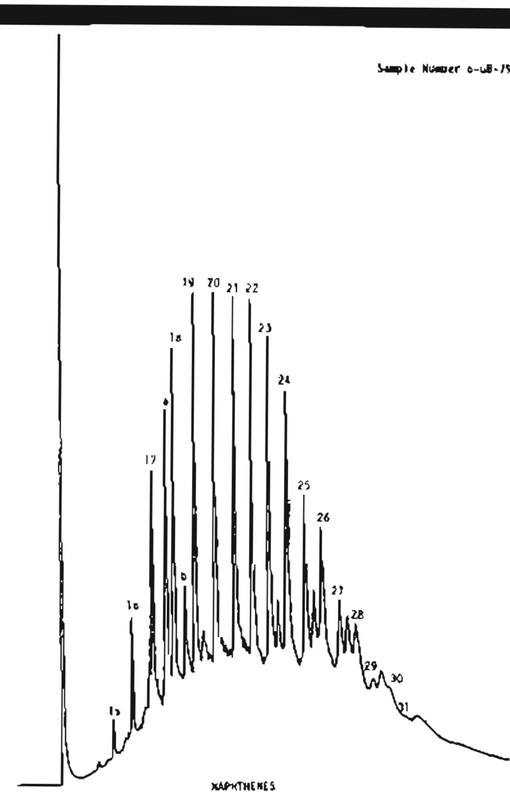
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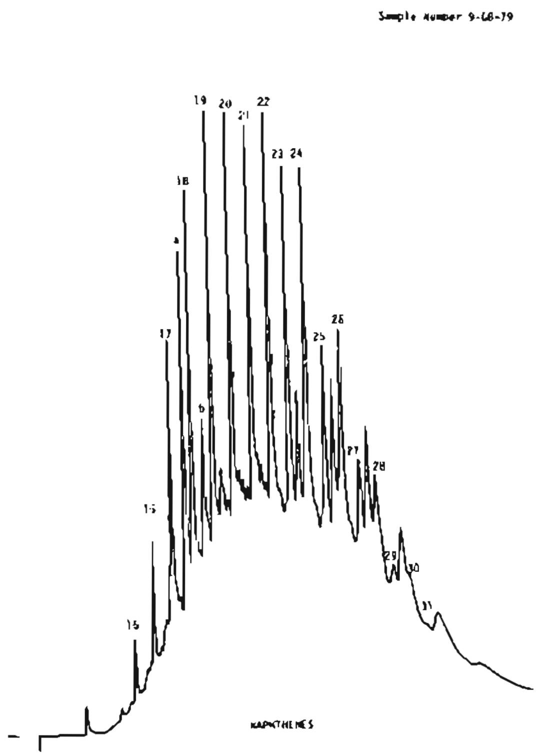
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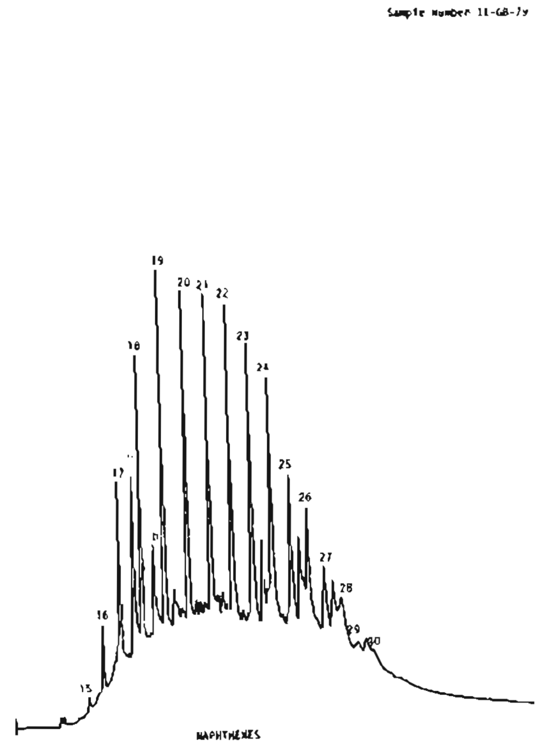
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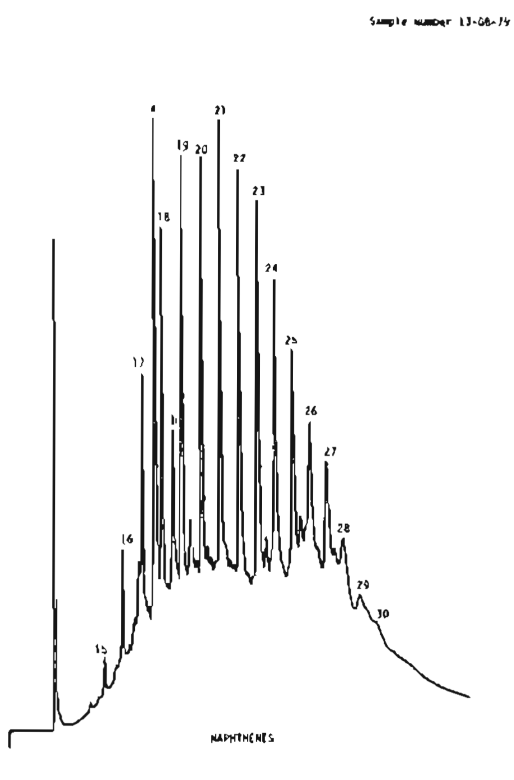
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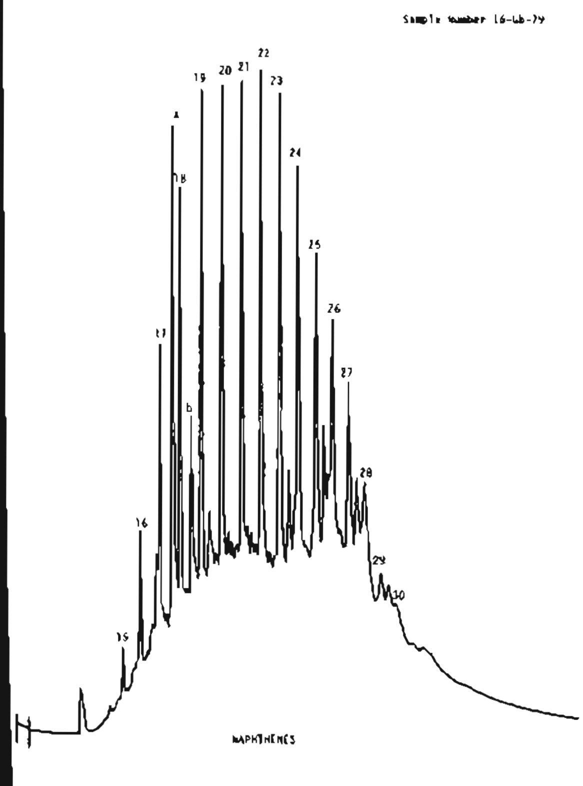
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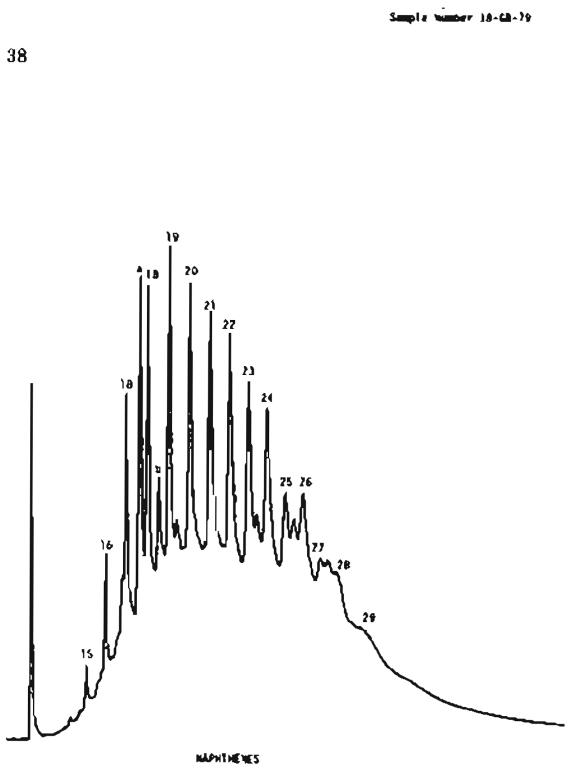
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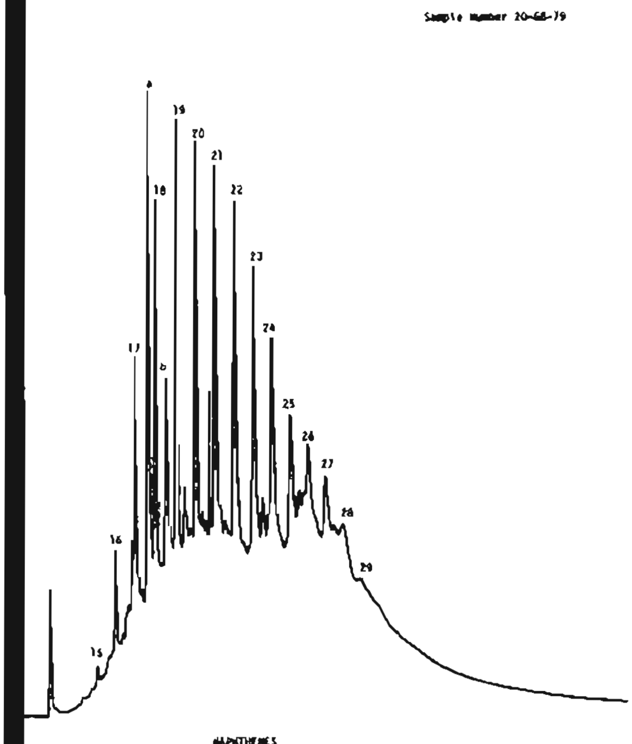
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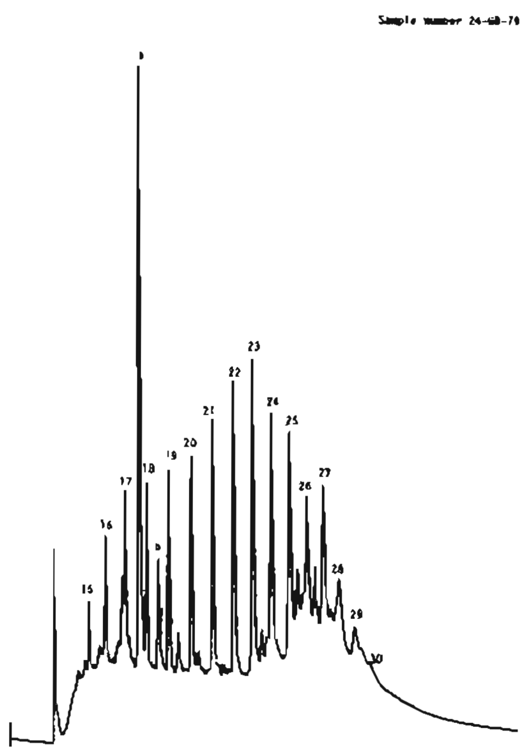
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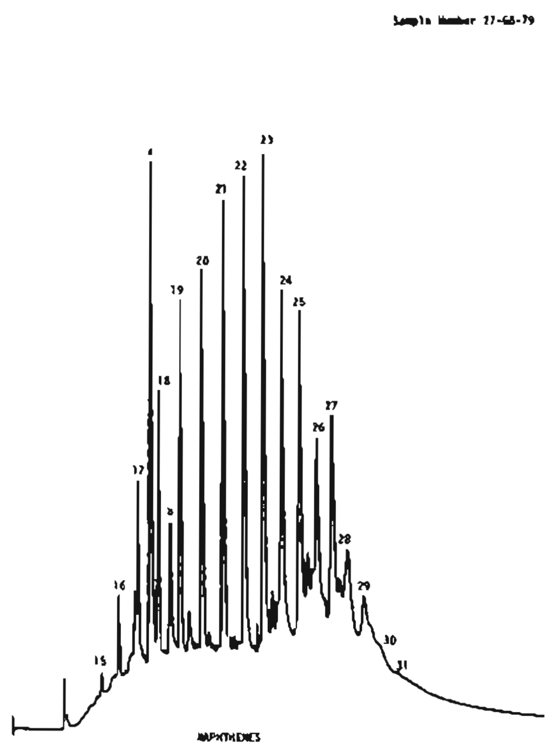
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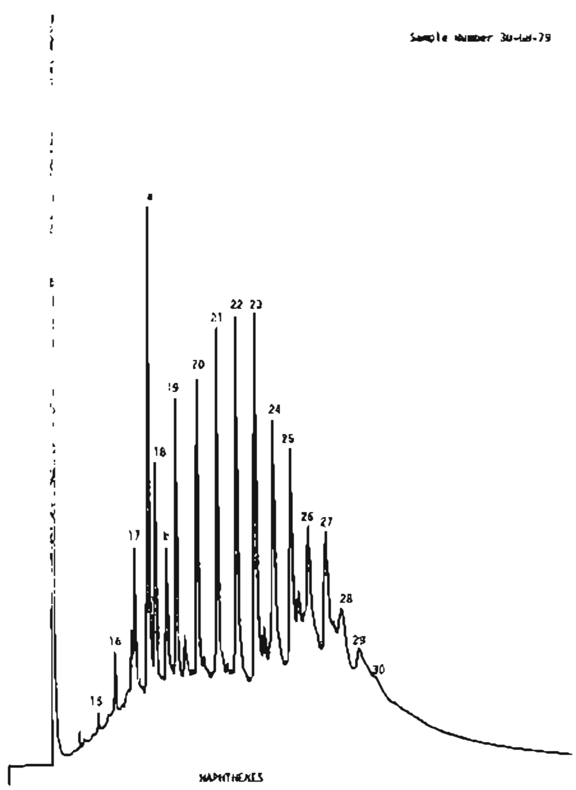
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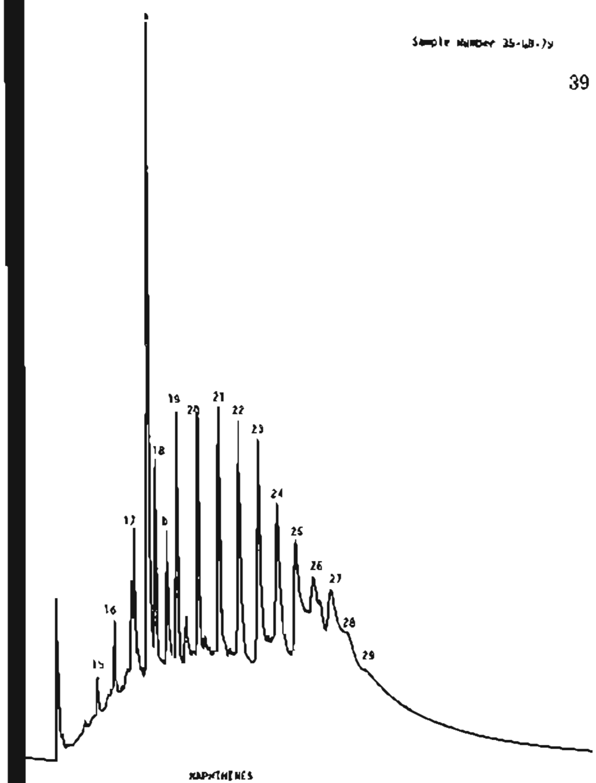
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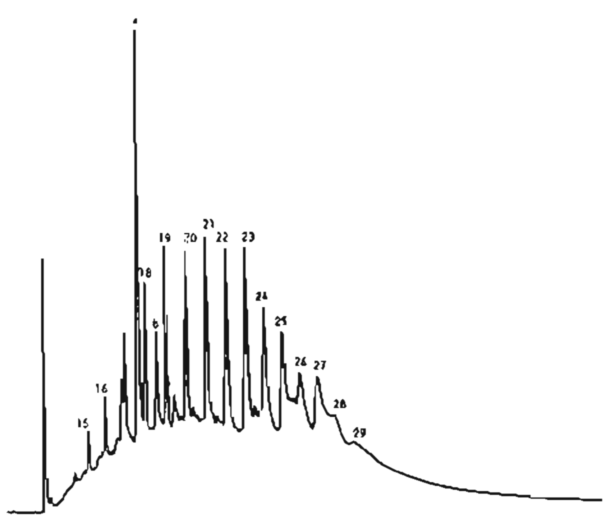
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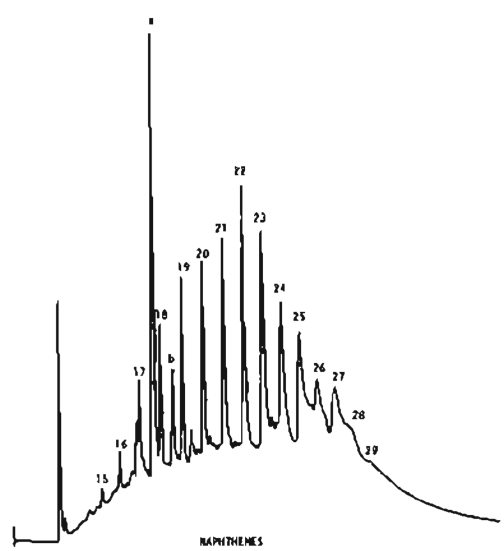
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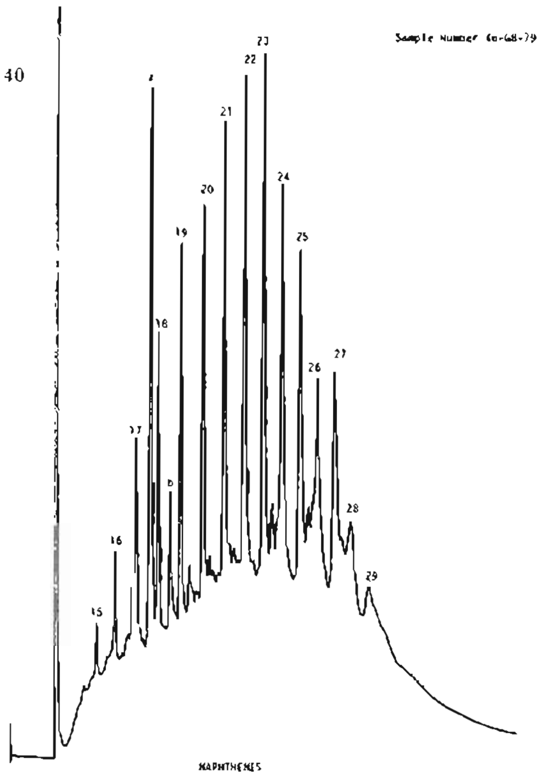
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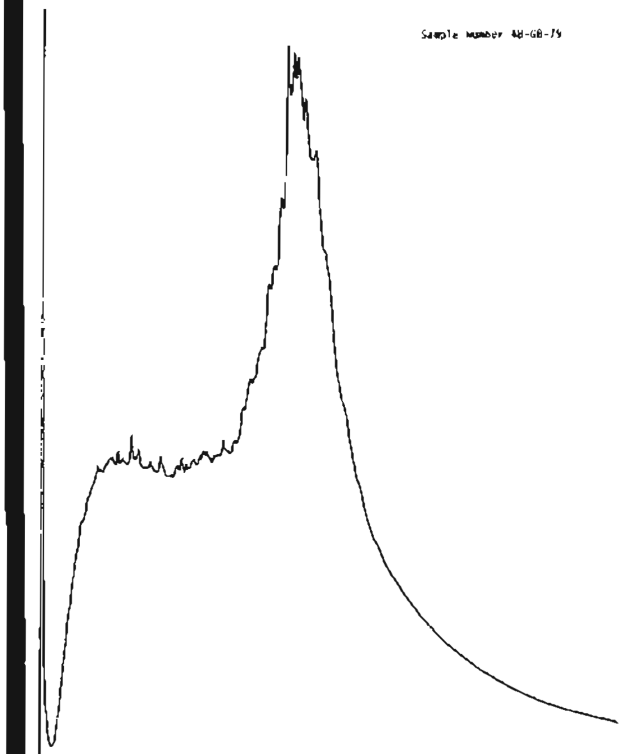
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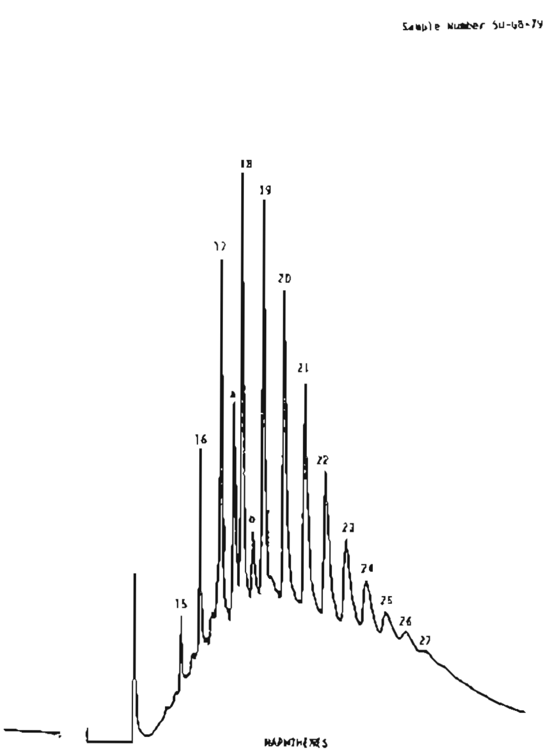
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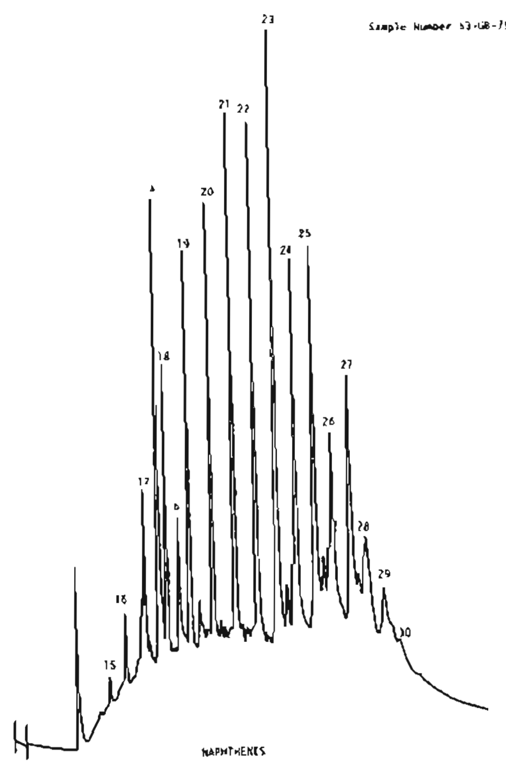
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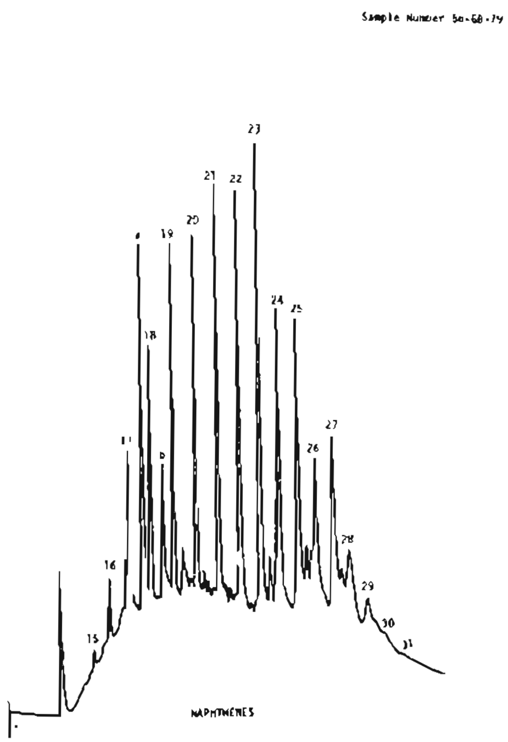
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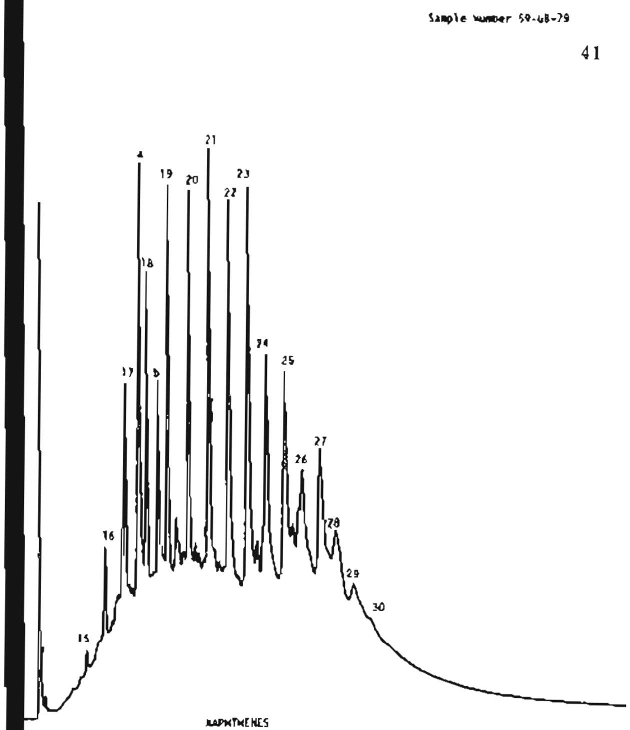
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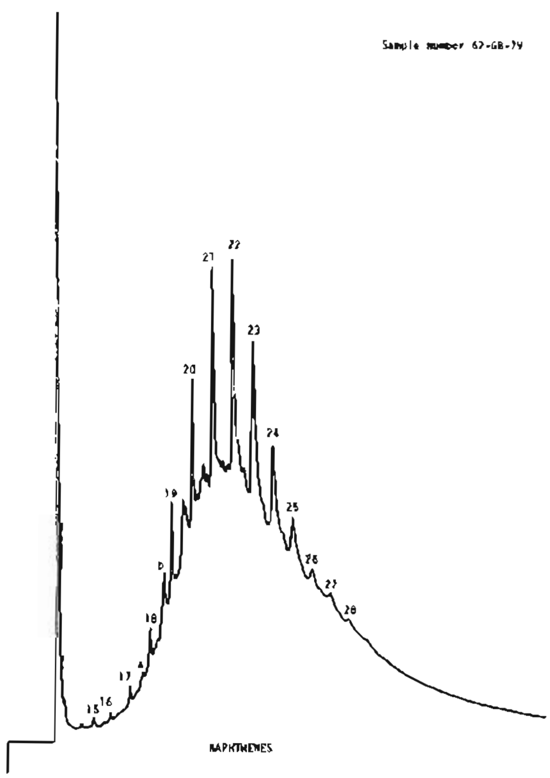
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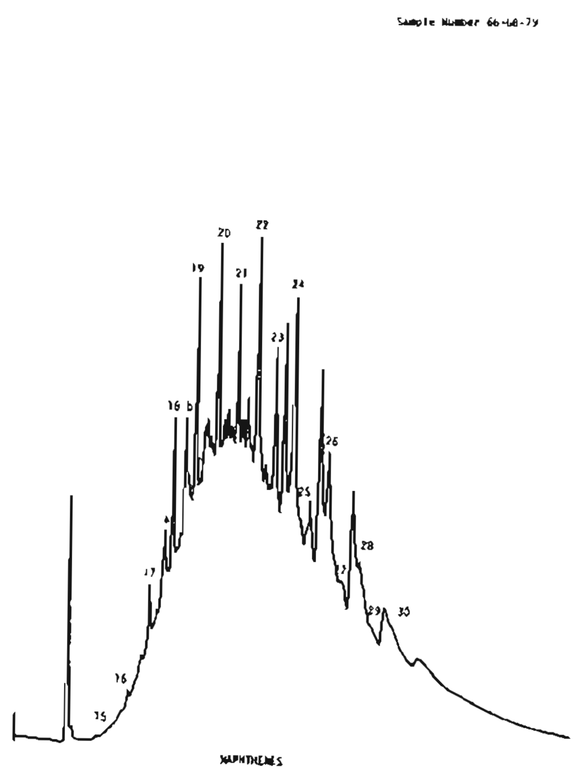
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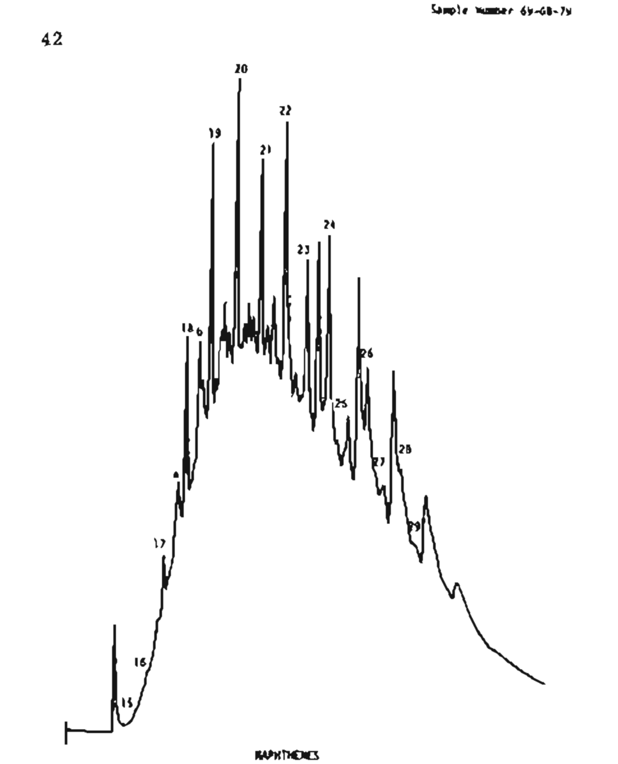
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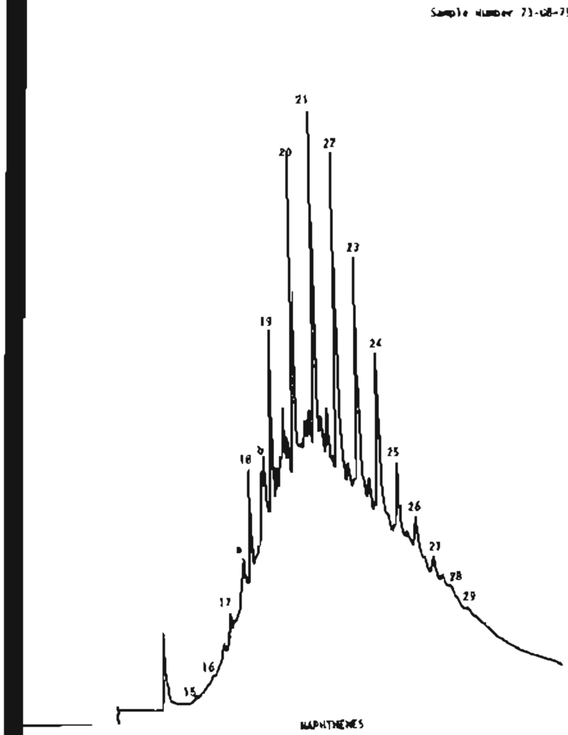
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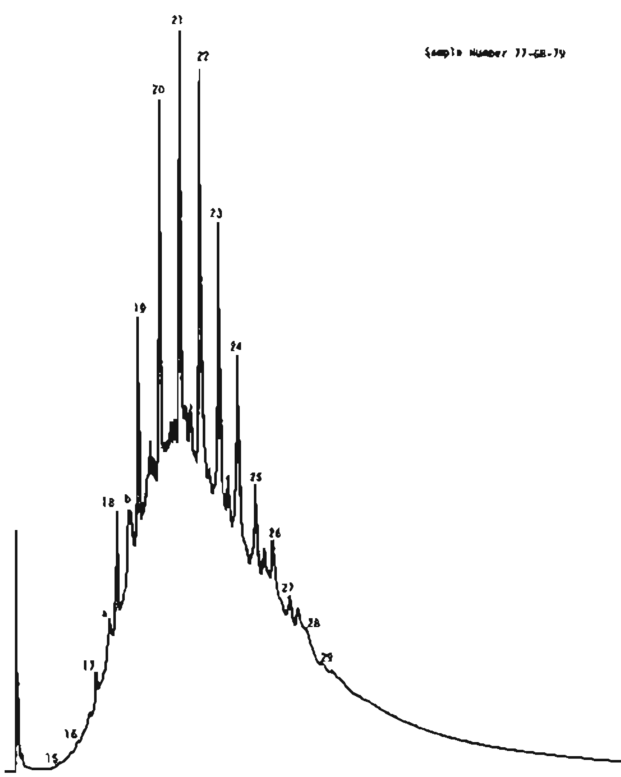
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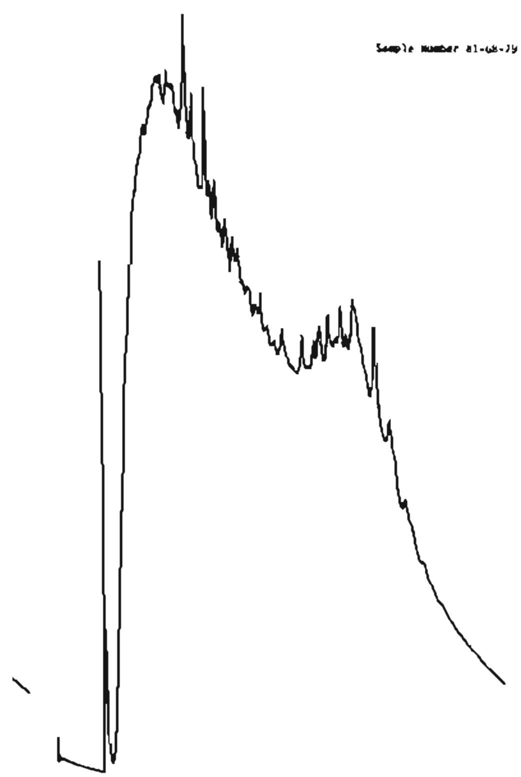
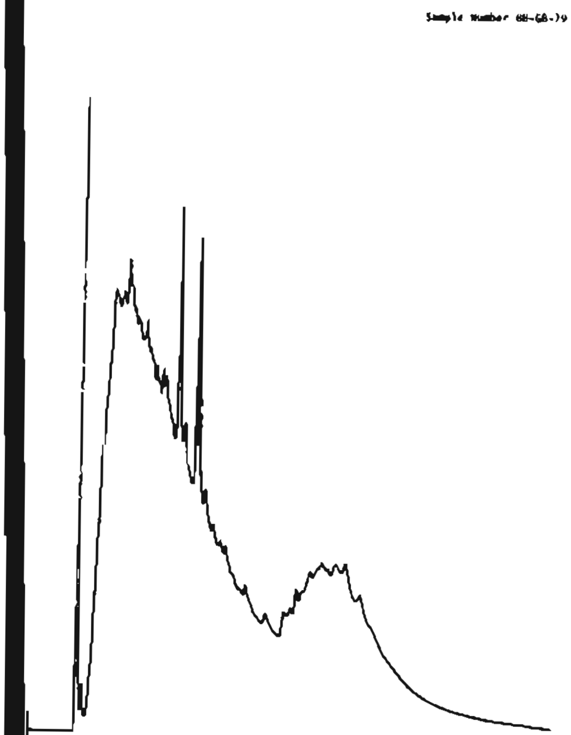
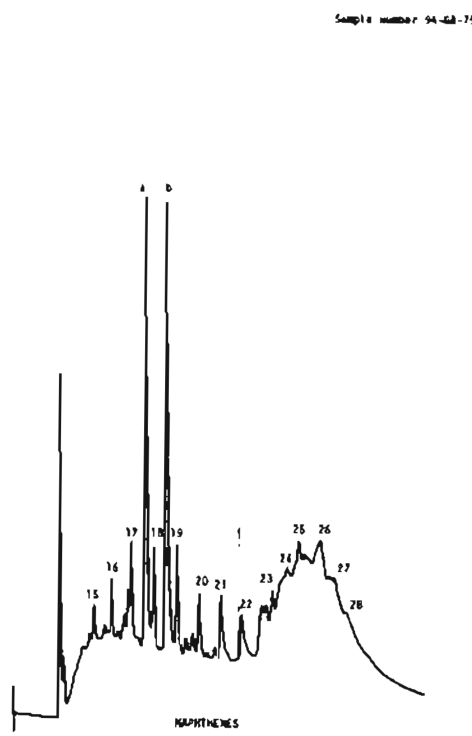

Sample Number 81-GB-79


Sample Number 84-GB-79


Sample Number 88-GB-79


Sample Number 91-GB-79


Sample number 94-GB-79
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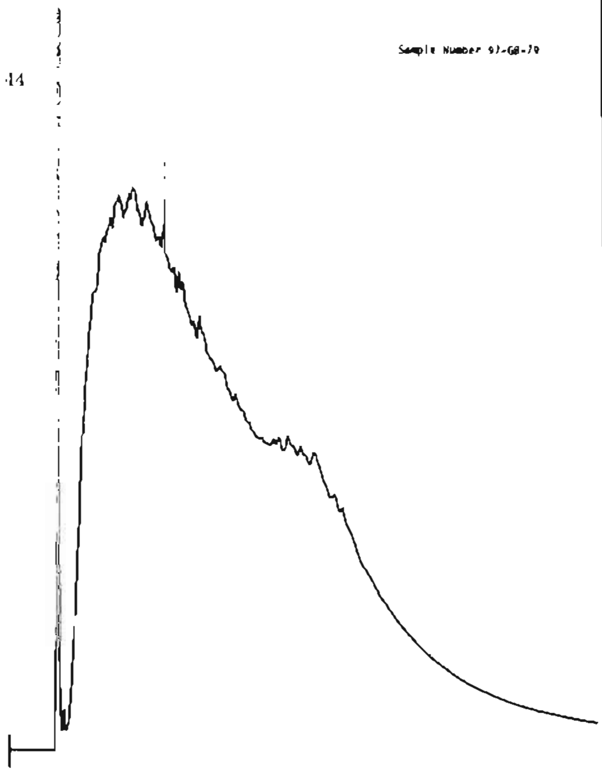
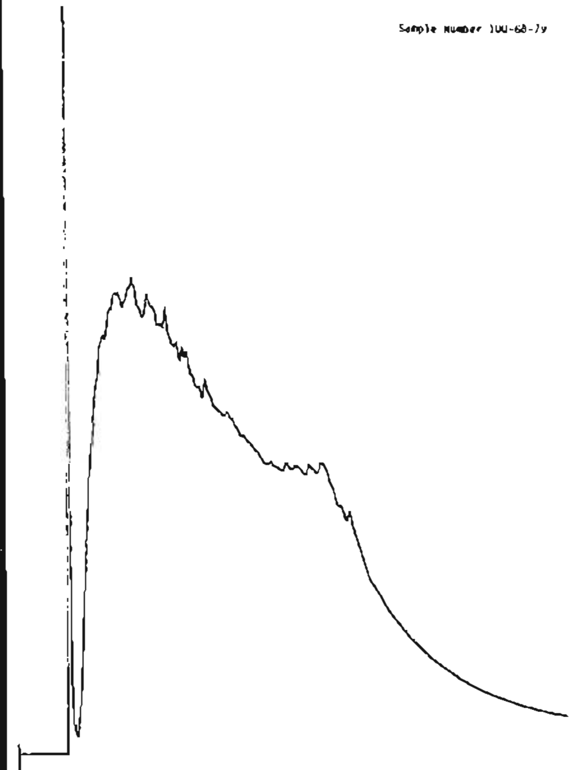
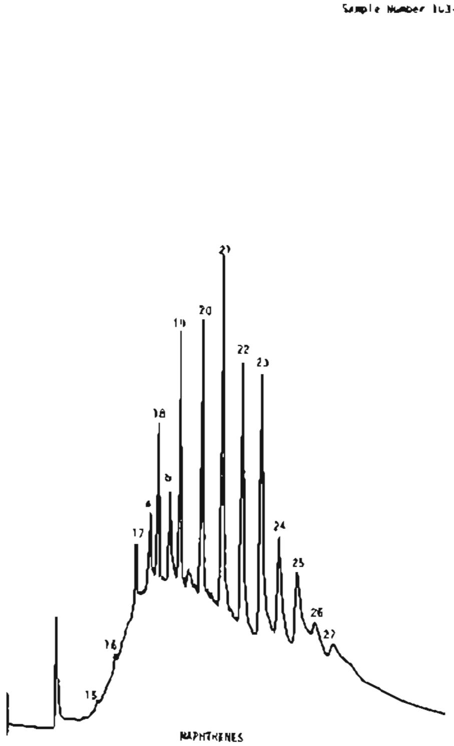
NAPHTHENES


Sample Number 97-GB-79


Sample Number 100-GB-79


Sample Number 103-GB-79
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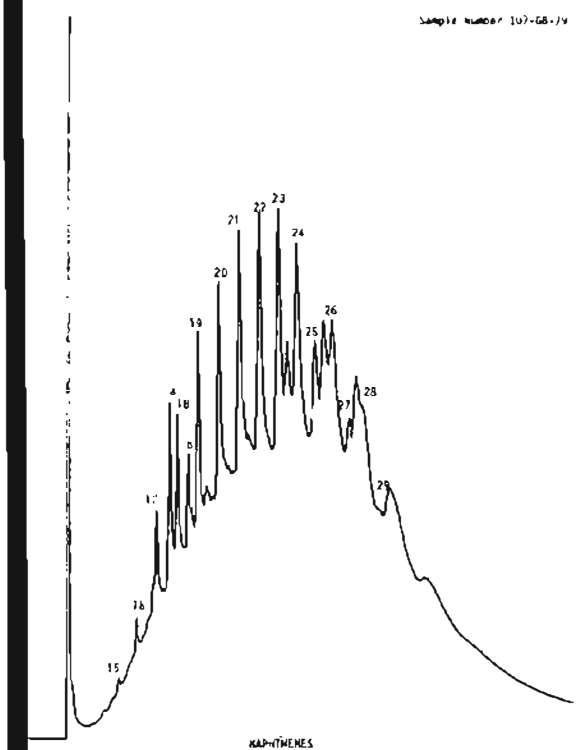
NAPHTHENES


Sample Number 107-GB-79
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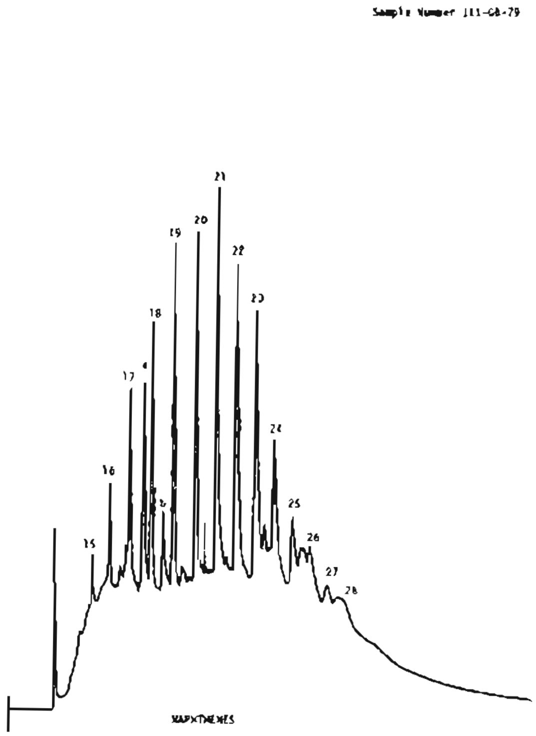
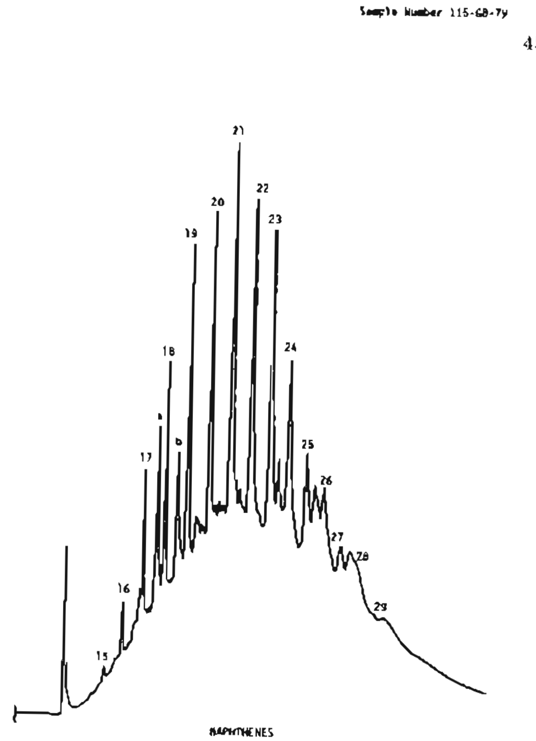
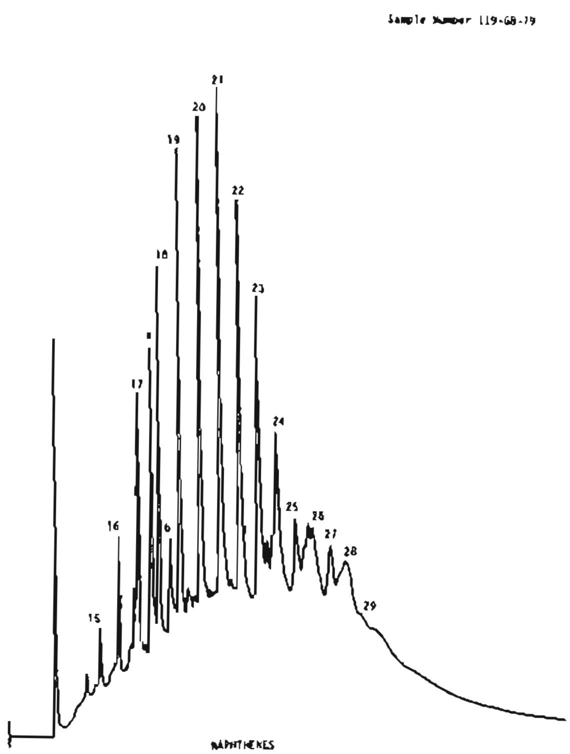
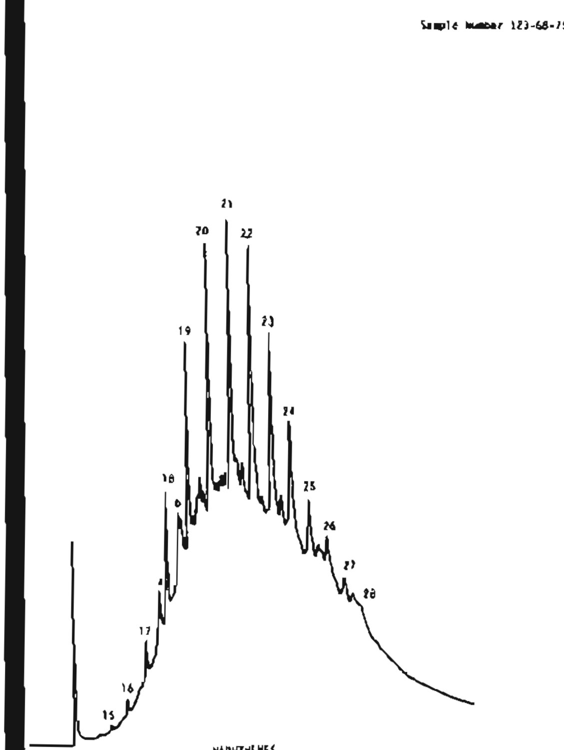
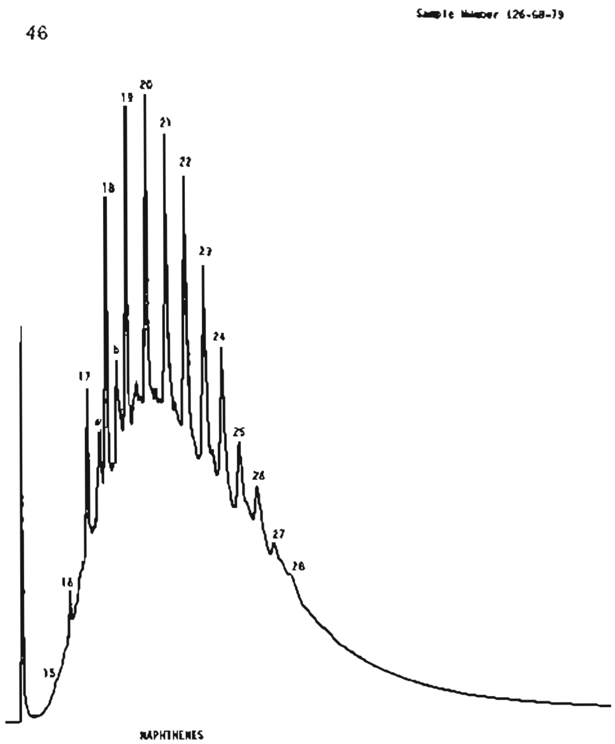
NAPHTHENES


Sample Number 111-GB-79
NAPHTHENES


Sample Number 115-GB-79
NAPHTHENES


Sample Number 119-GB-79
NAPHTHENES


Sample Number 123-GB-79
NAPHTHENES



Sample Number 126-68-79
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b
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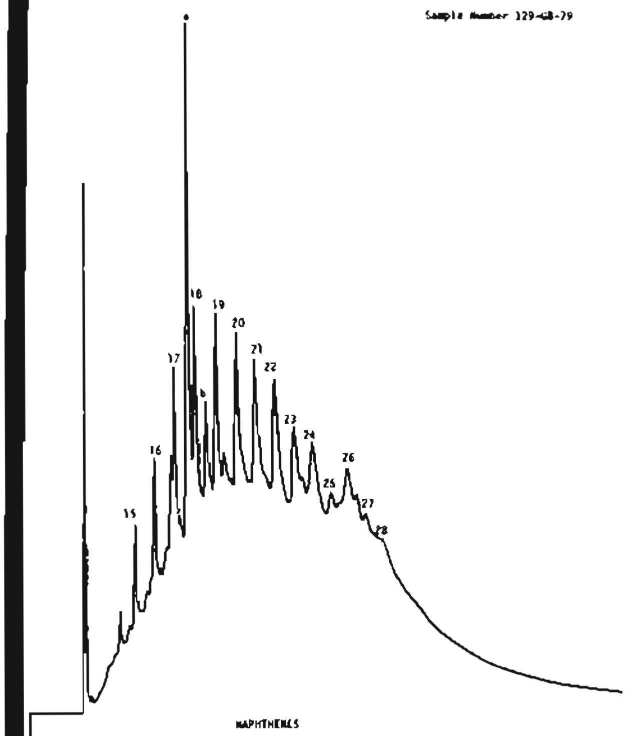
NAPHTHENES



Sample Number 129-68-79
a
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17
22
b
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16
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15
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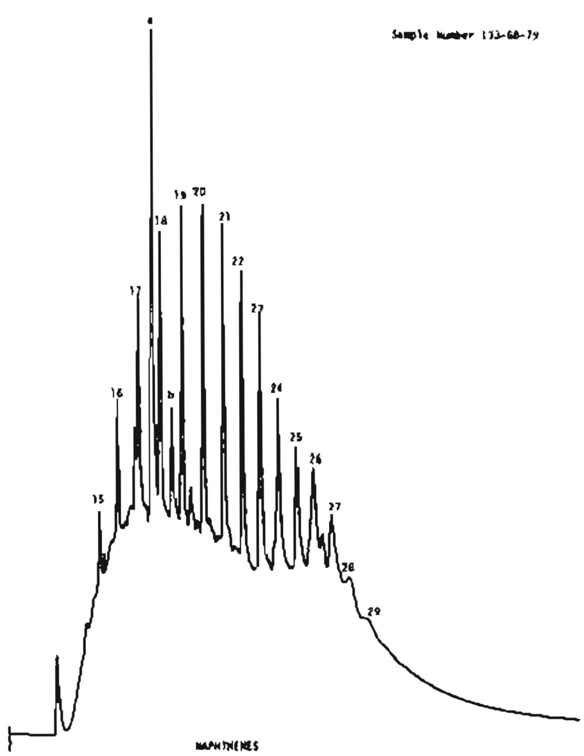
NAPHTHENES



Sample Number 133-68-79
a
19
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b
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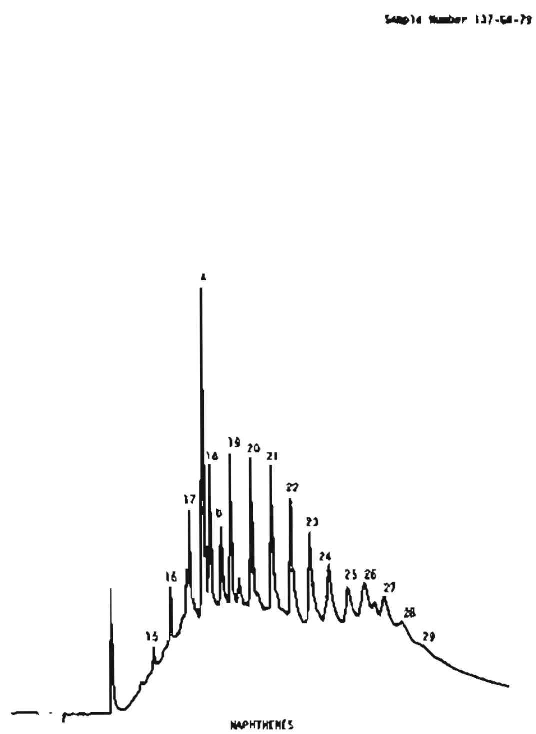
NAPHTHENES



Sample Number 137-68-79
a
19
20
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b
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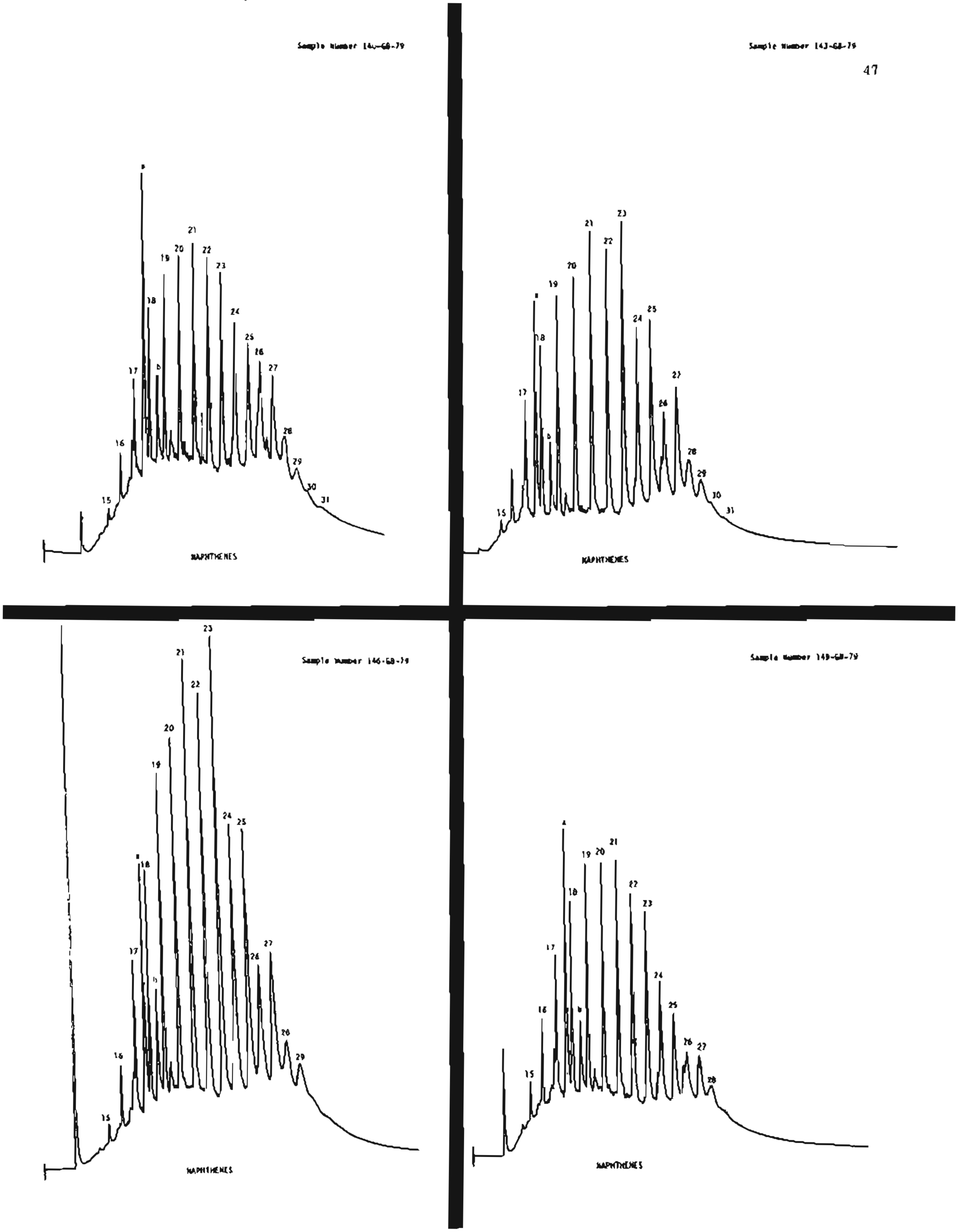
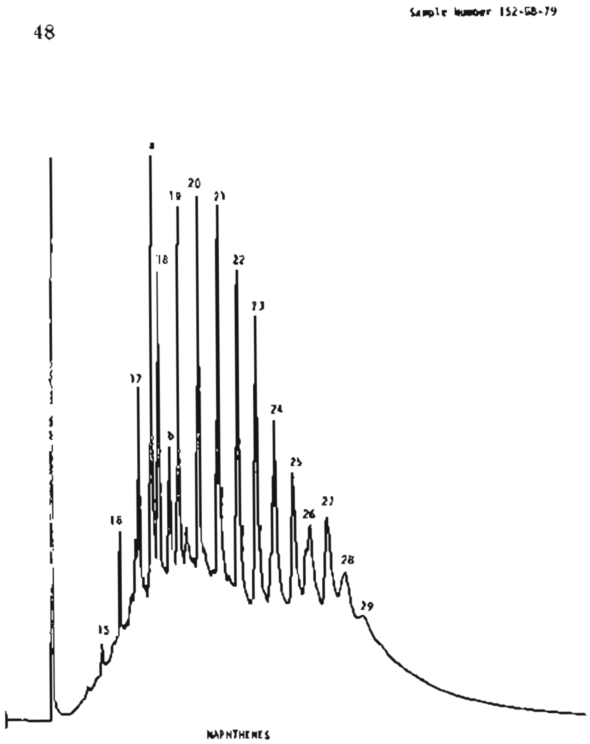
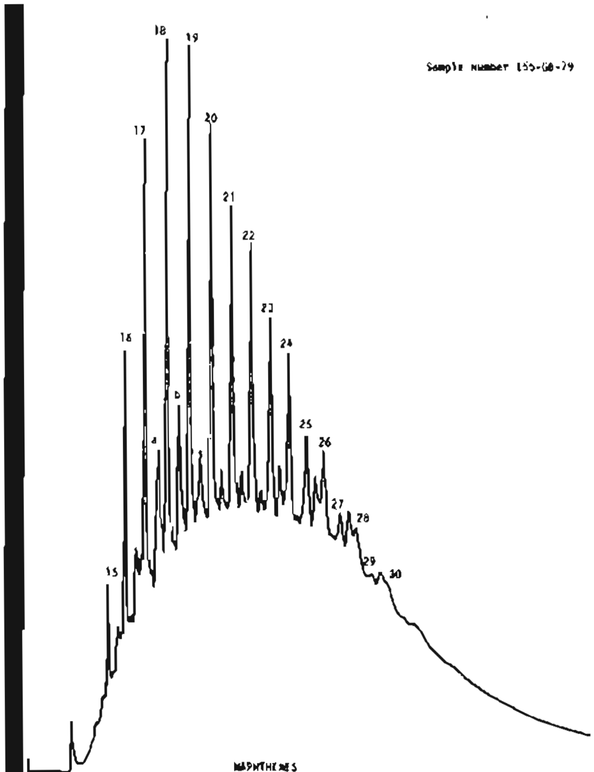
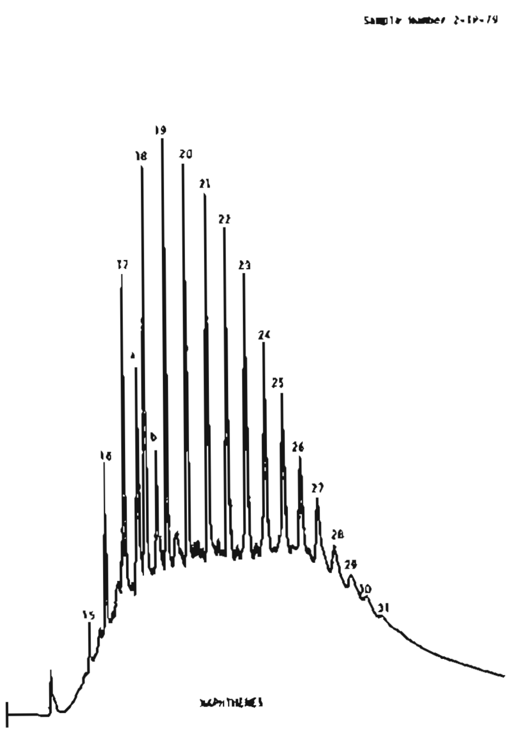
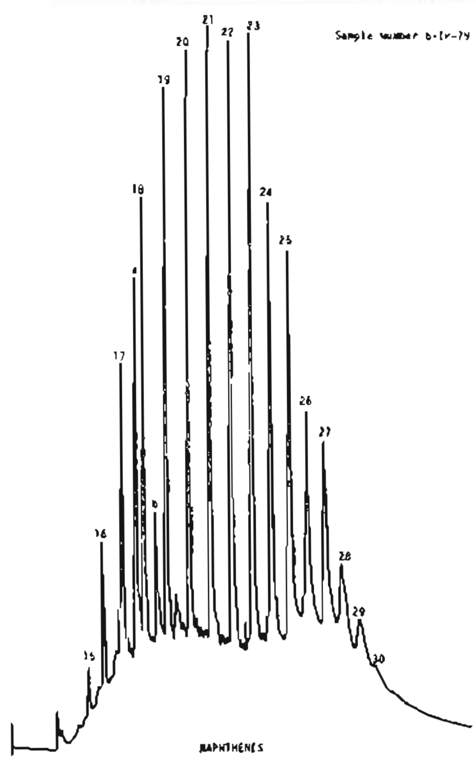
NAPHTHENES

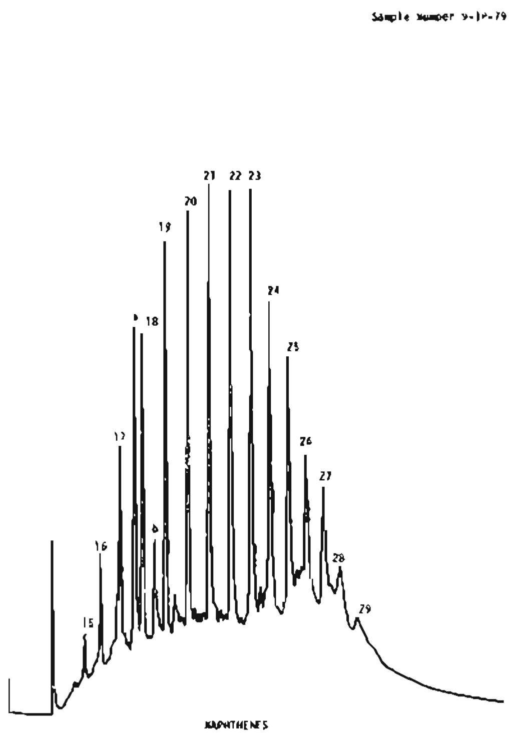

Sample Number 144-GB-79
NAPHTHENES
Sample Number 143-GB-79
NAPHTHENES
Sample Number 146-GB-79
NAPHTHENES
Sample Number 149-GB-79
NAPHTHENES

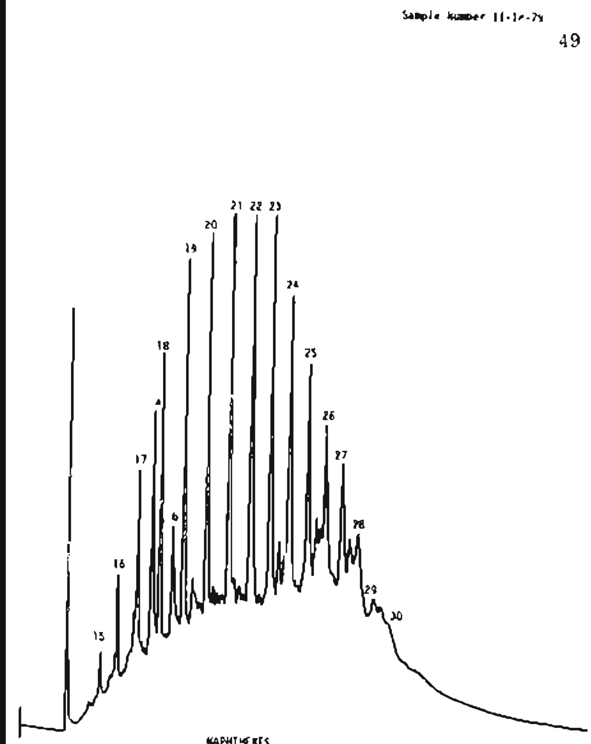

Sample number 152-GB-79
NAPHTHENES

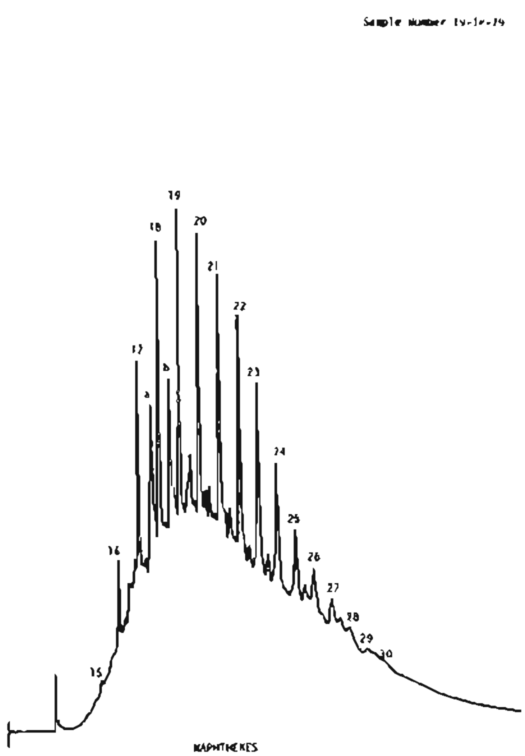

Sample number 155-GB-79
NAPHTHENES

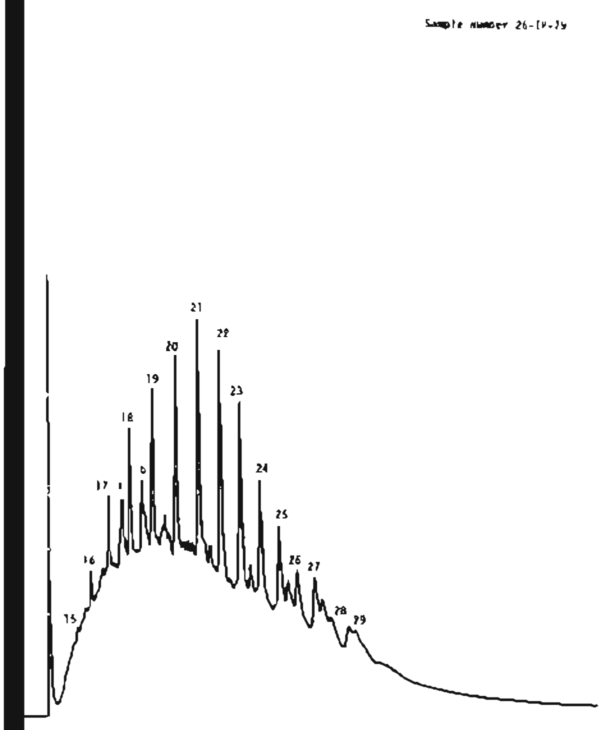

Sample number 2-IV-79
NAPHTHENES

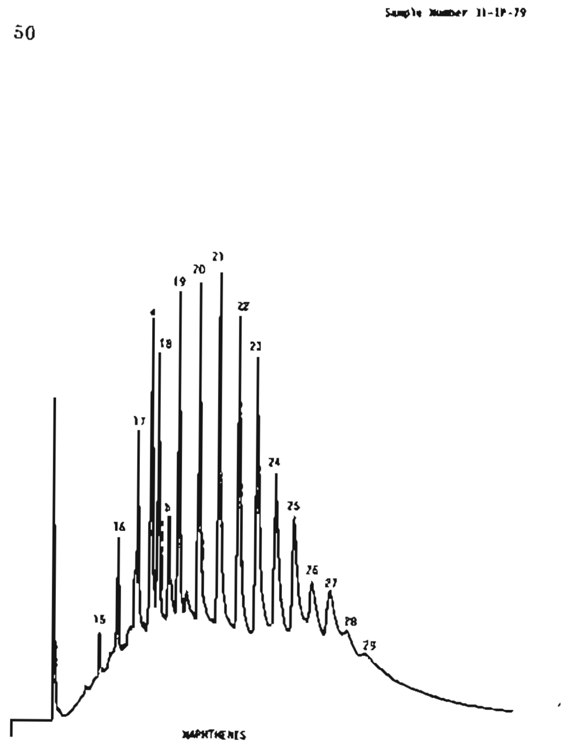

Sample number 6-IV-79
NAPHTHENES

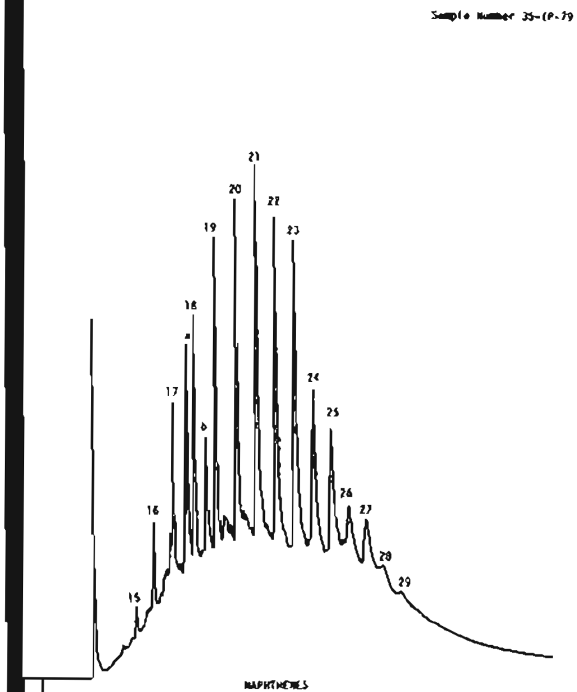

Sample number 9-IP-79
15 16 17 a 18 b 19 20 21 22 23 24 25 26 27 28 29
NAPHTHENES

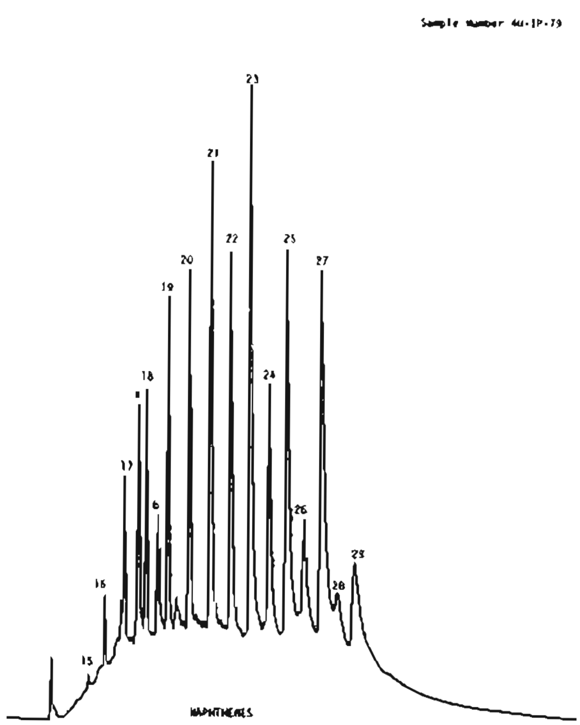

Sample number 11-IP-79
15 16 17 a b 18 19 20 21 22 23 24 25 26 27 28 29 30
NAPHTHENES

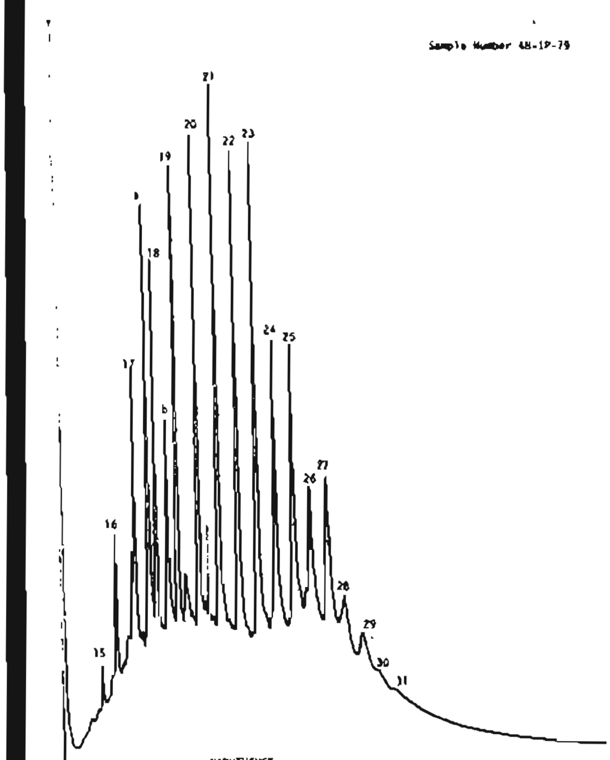

Sample number 19-IP-79
15 16 17 a b 18 19 20 21 22 23 24 25 26 27 28 29 30
NAPHTHENES

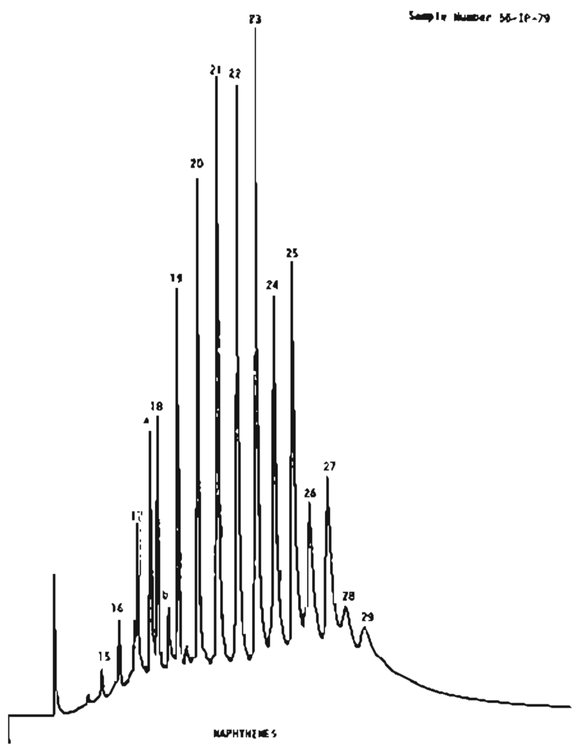

Sample number 26-IP-79
15 16 17 a b 18 19 20 21 22 23 24 25 26 27 28 29
NAPHTHENES


Sample Number 31-IP-79
NAPHTHENES


Sample Number 35-IP-79
NAPHTHENES


Sample Number
NAPHTHENES


Sample Number
NAPHTHENES


Sample Number 56-IP-79
23
21 22
20
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18
a
17
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16
b
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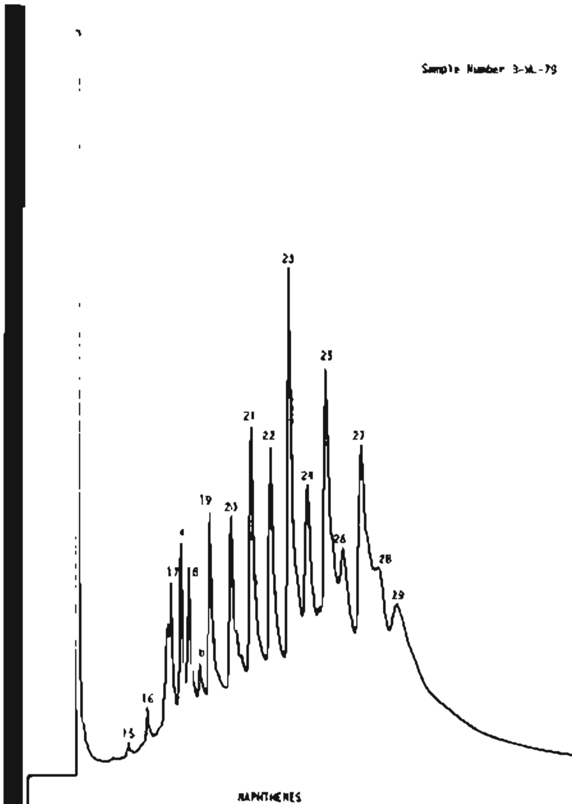
NAPHTHENES


Sample Number 3-WL-79
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25
21
22
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20
a
17
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28
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b
16
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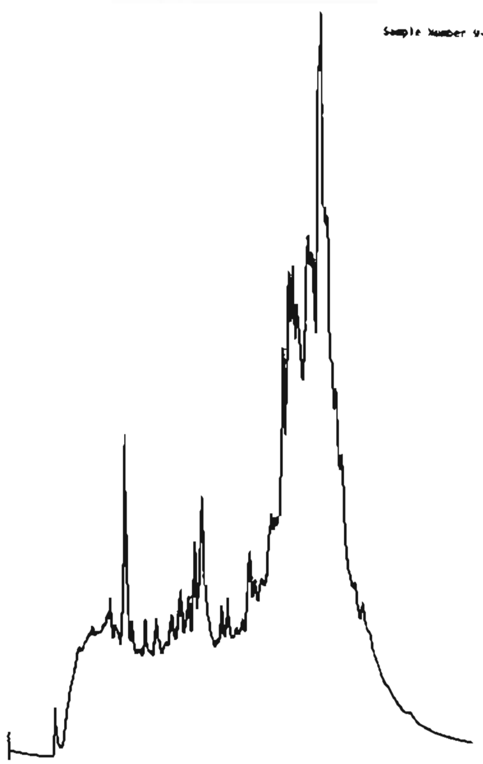
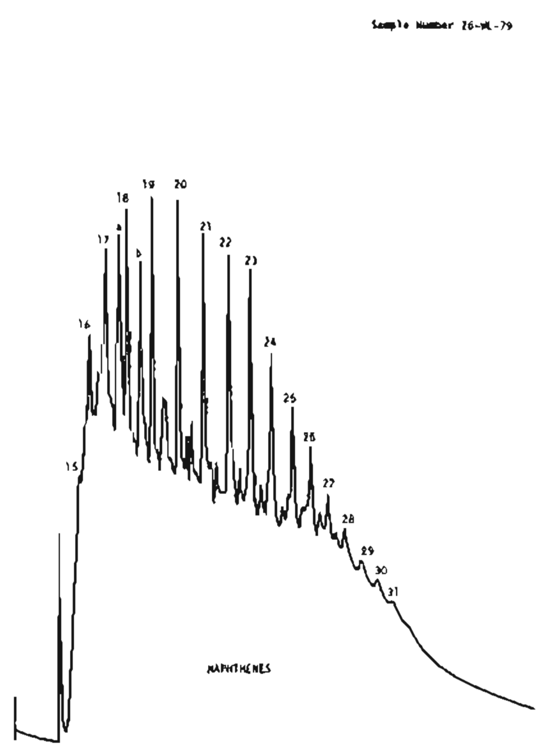
NAPHTHENES


Sample Number 9-WL-79


Sample Number 26-WL-79
19
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17
a
b
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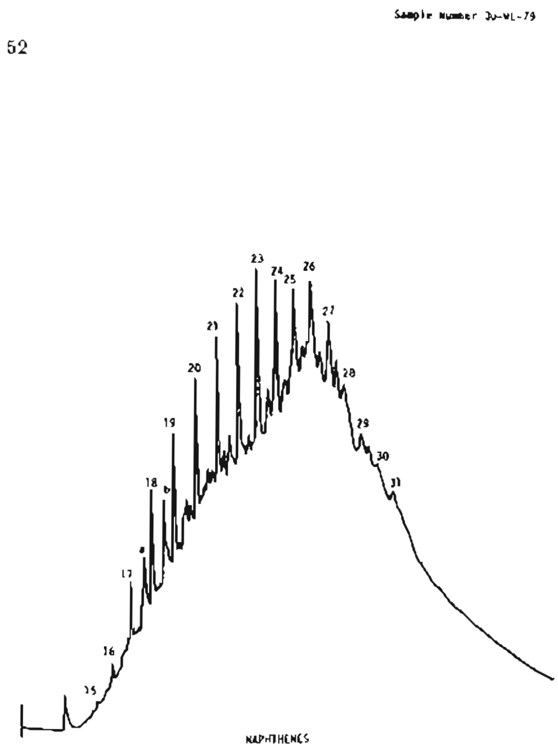
NAPHTHENES


Sample Number 30-WL-79
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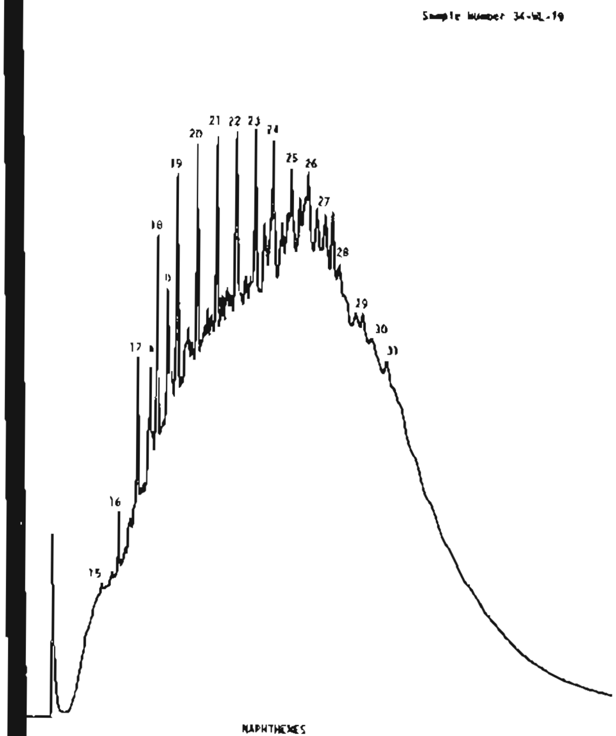
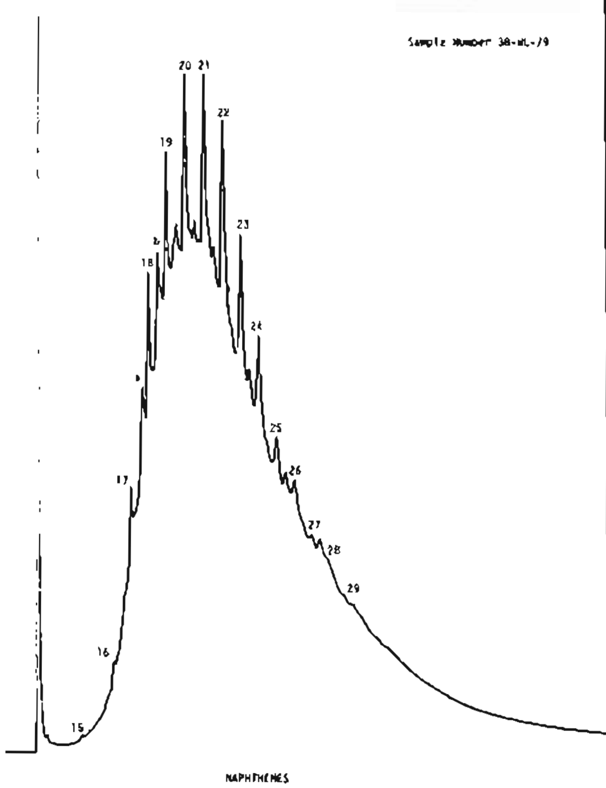
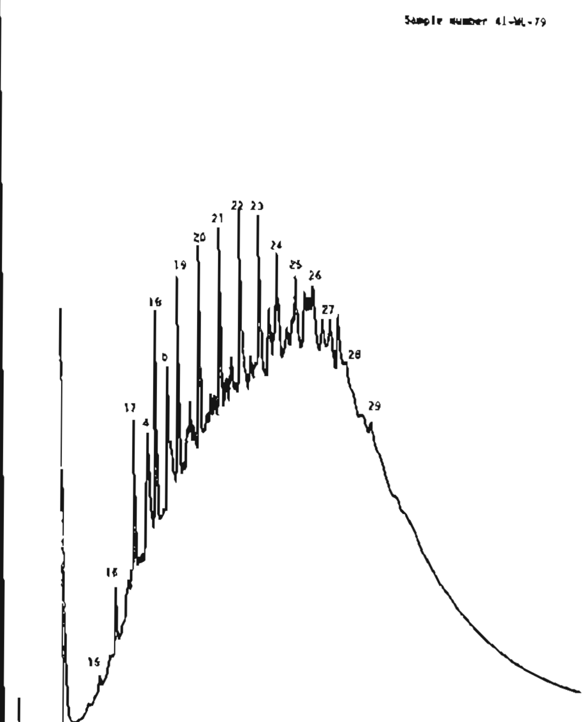
NAPHTHENES


Sample Number 34-WL-79
15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
NAPHTHENES


Sample Number 38-WL-79
15 16 17 18 19 20 21 22 23 24 25 26 27 28 29
NAPHTHENES


Sample Number 41-WL-79
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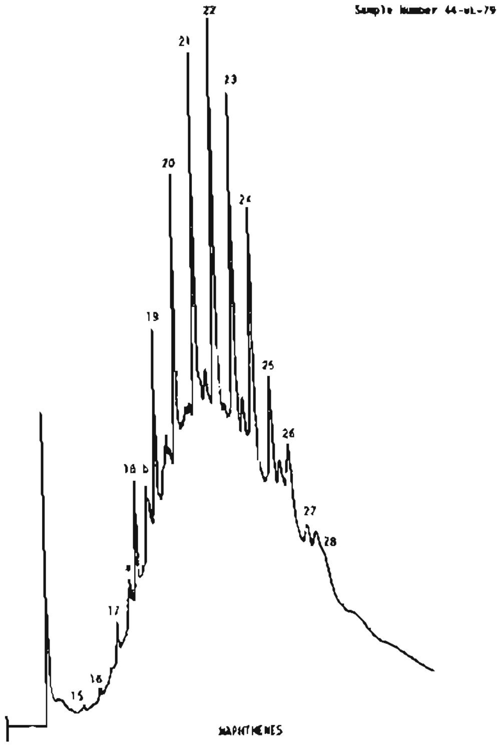
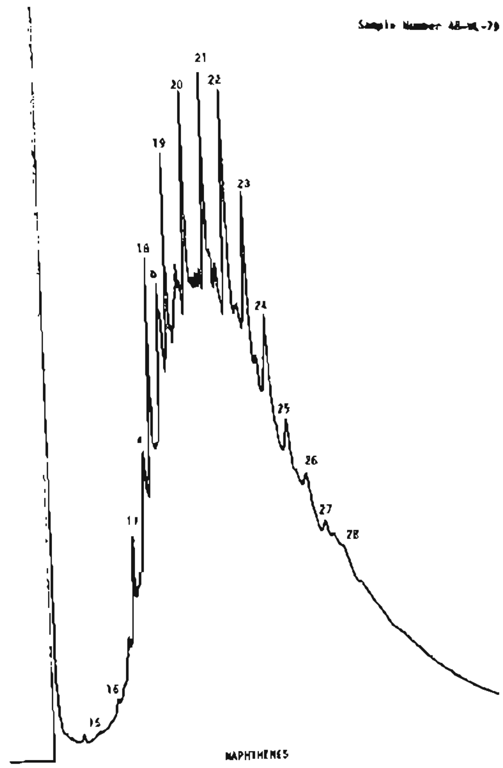
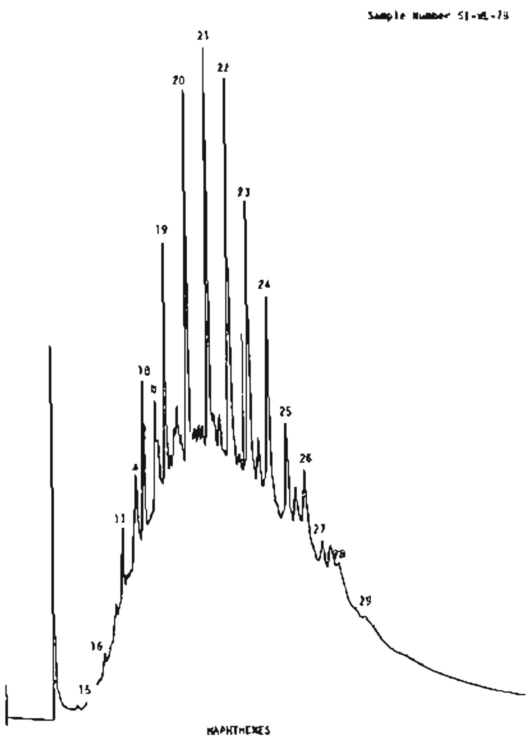
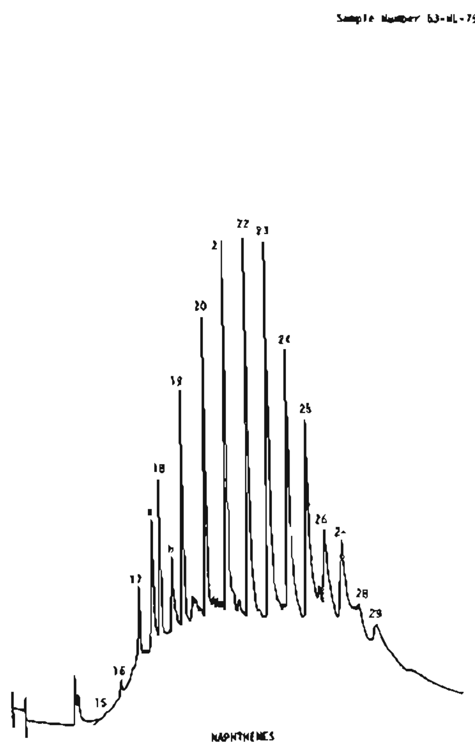
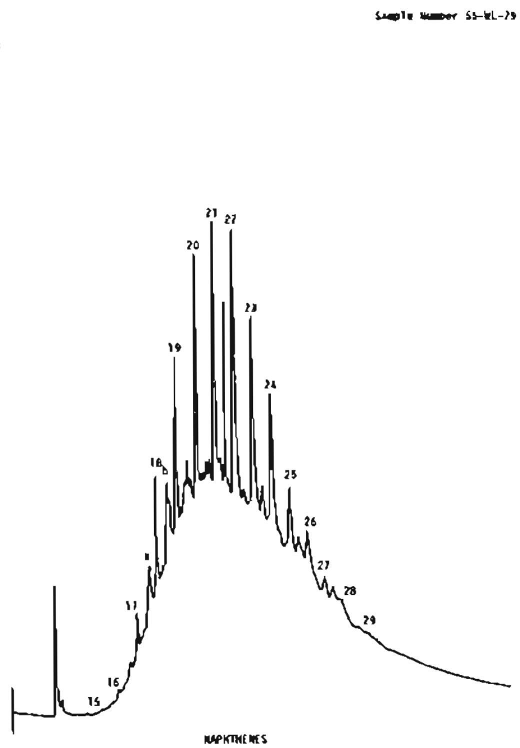

Sample Number 44-WL-79
NAPHTHENES


Sample Number 48-WL-79
NAPHTHENES


Sample Number 51-WL-79
NAPHTHENES


Sample Number 63-WL-79
NAPHTHENES


Sample Number 55-WL-79
15
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a
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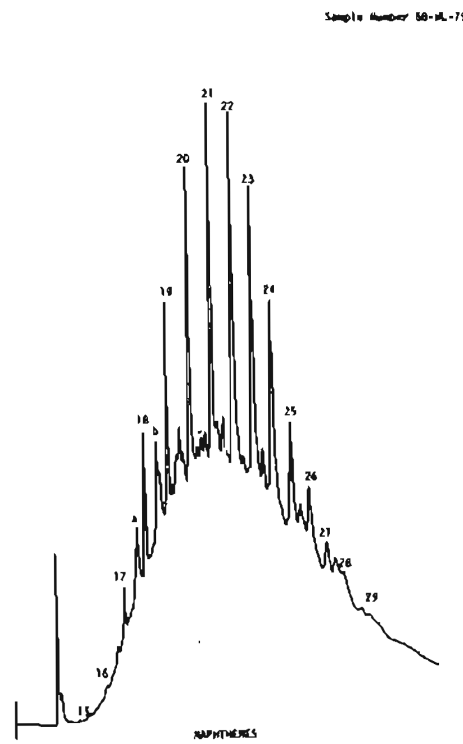
NAPHTHENES


Sample Number 58-WL-79
15
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a
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b
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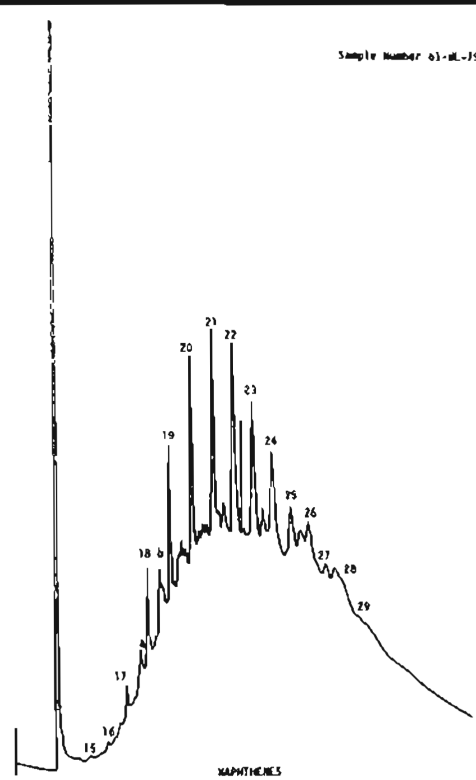
NAPHTHENES


Sample Number 61-WL-79
15
16
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18
b
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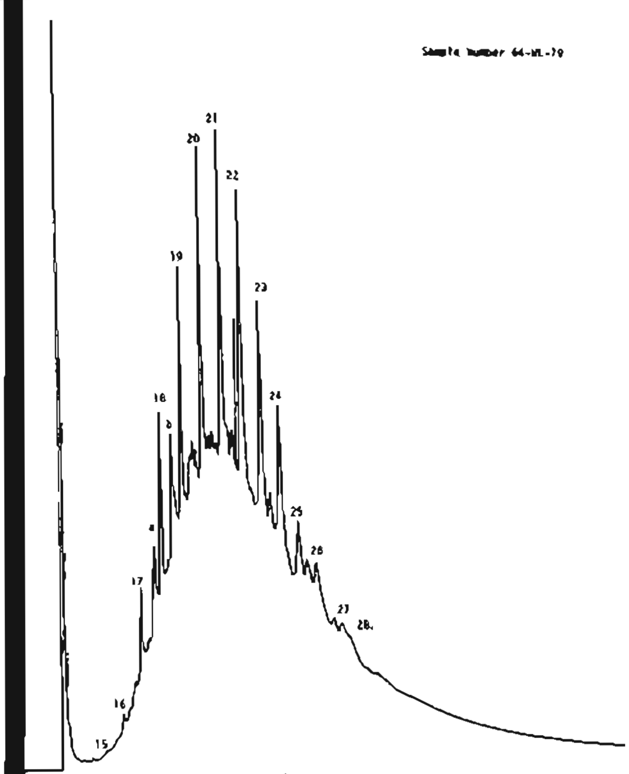
NAPHTHENES


Sample Number 64-WL-79
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17
a
18
b
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27
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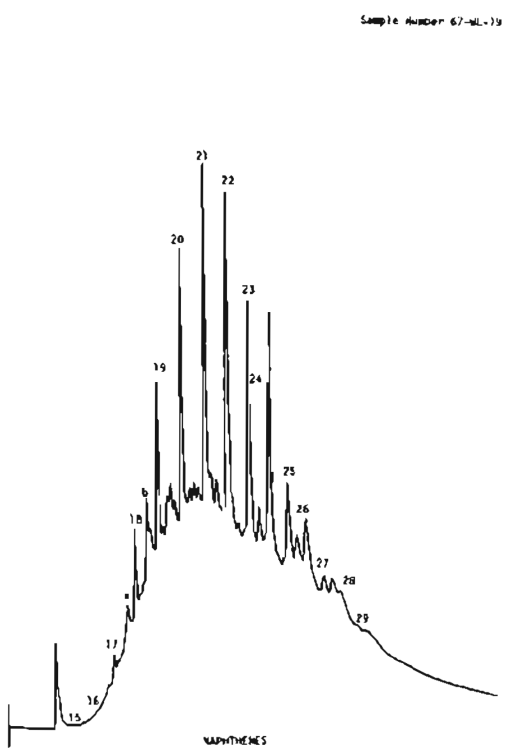
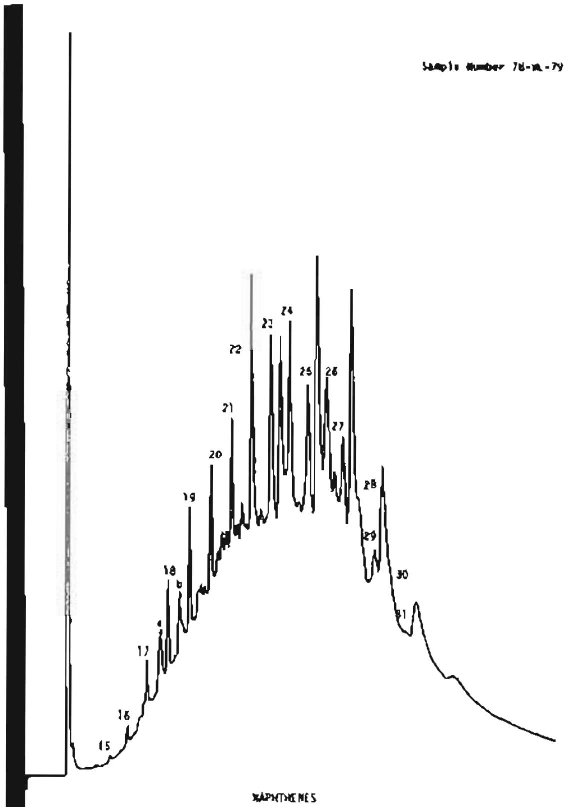
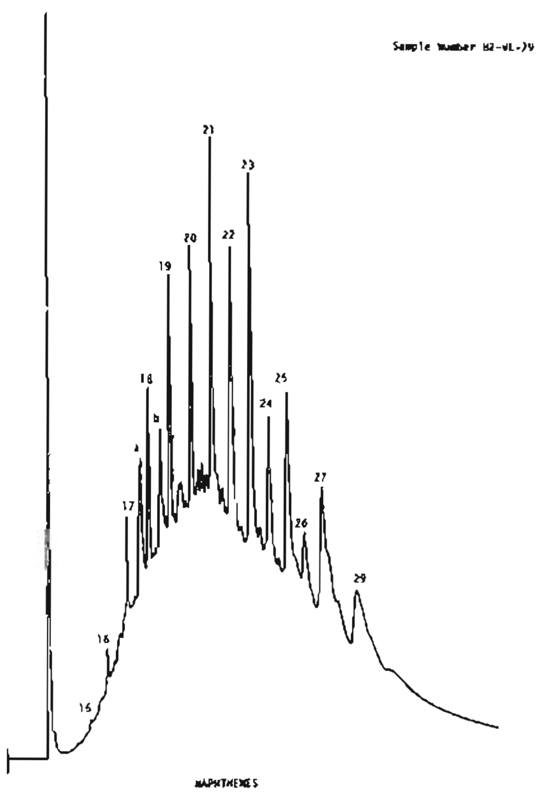
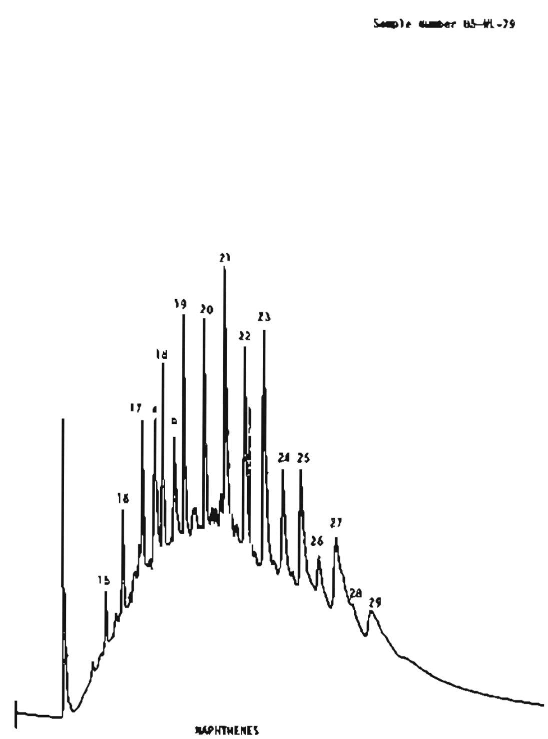
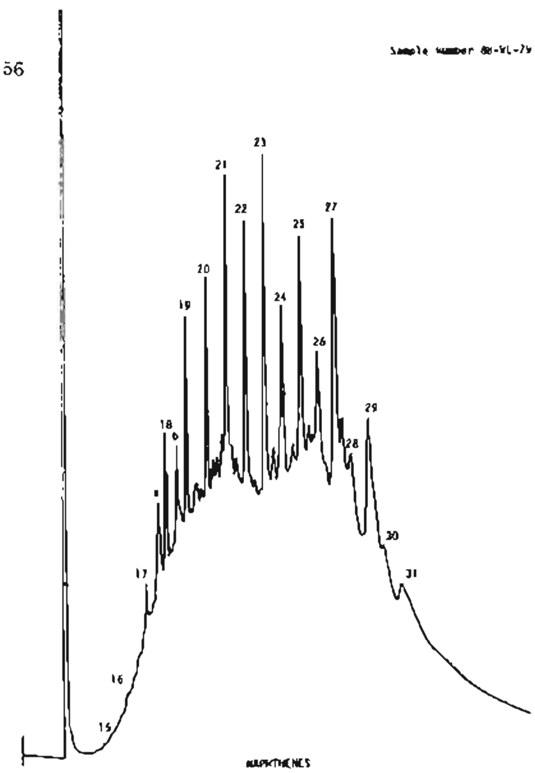
NAPHTHENES

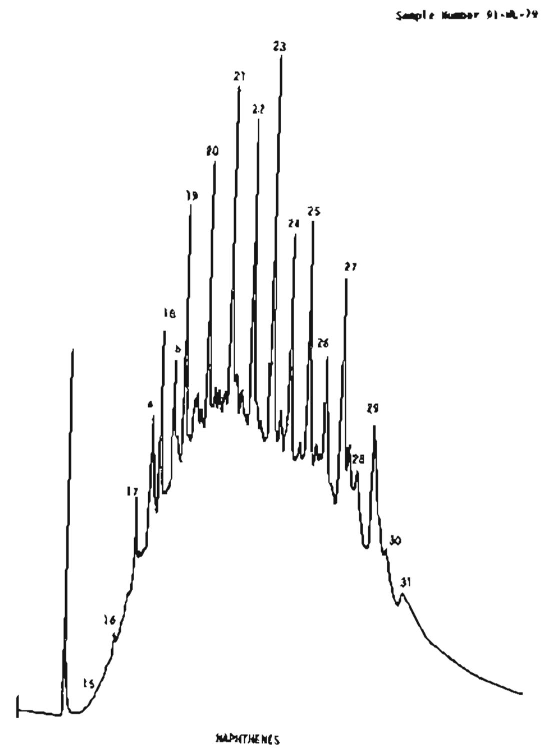

Sample Number 67-WL-79
NAPHTHENES


Sample Number 78-WL-79
NAPHTHENES


Sample Number 82-WL-79
NAPHTHENES


Sample Number 85-WL-79
NAPHTHENES


Sample Number 88-WL-79
15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
NAPHTHENES


Sample Number 91-WL-79
15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
NAPHTHENES

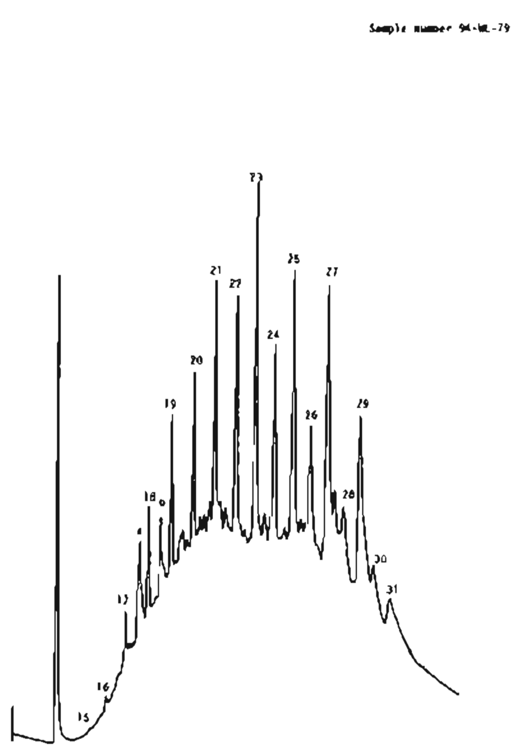

Sample number 94-WL-79
15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
NAPHTHENES

Table IV.--PORUSITY AND PERMEABILITY

[Determinations by Chemical & Geological Laboratories of Alaska, Inc. Localities 1-19 shown on plate 1; localities 19-23 shown on plate 2]

Locality No.	Plate No.	Sample No.	Effective porosity (percent)	Horizontal permeability (milli-darcies)
		SAGAVANIRKTOK FORMATION		
3	--	48-GB-79	22.8	683.00
10	7	11-WL-79	16.2	43.00
		12-WL-79	15.2	34.00
		13-WL-79	17.6	56.00
		14-WL-79	16.0	114.00
		15-WL-79	17.3	39.00
		16-WL-79	16.4	38.00
		17-WL-79	16.3	38.00
		18-WL-79	18.1	306.00
		20-WL-79	18.5	339.00
		21-WL-79	18.6	267.00
		22-WL-79	16.9	2.80
		23-WL-79	17.3	80.00
		24-WL-79	20.8	2731.00
		25-WL-79	16.8	3200.00
		Franklin Bluffs member		
4	--	132-GB-79	0.4	< .01
		136-GB-79	3.1	.04
11	--	10-WL-79	15.5	11.00
12	--	2-WL-79	11.6	2.07
		5-WL-79	16.2	162.00
		MOOSE CHANNEL FORMATION		
24	13	106-GB-79	3.4	2.29
		110-GB-79	3.2	.26
		118-GB-79	4.4	.04
25	14	30-IP-79	3.6	.04
		34-IP-79	3.0	.04
		38-IP-79	3.1	.11
		39-IP-79	4.0	.09
		43-IP-79	2.6	.09
		44-IP-79	4.5	1.18
		45-IP-79	5.1	.08

Table IV.--POROSITY AND PERMEABILITY--continued

Locality No.	Plate No.	Sample No.	Effective porosity (percent)	Horizontal permeability (millidarcies)
MOOSE CHANNEL FORMATION--continued				
25	14	46-IP-79	5.6	.15
		47-IP-79	3.0	.08
		51-IP-79	1.0	< .01
		59-IP-79	4.2	.12
Undifferentiated PRINCE CREEK and SCHRADER BLUFF FORMATIONS				
13	8	5-GB-79	6.8	.17
		8-GB-79	3.8	.01
		15-GB-79	3.1	< .01
		22-GB-79	4.8	.02
		5-IP-79	6.4	.11
		10-IP-79	3.2	.03
		14-IP-79	2.1	.01
		15-IP-79	10.9	1.29
SCHRADER BLUFF FORMATION Sentinel Hill Member				
8	5	23-GB-79	9.4	.06
		33-GB-79	5.5	.05
		34-GB-79	3.6	.03
		41-GB-79	.7	< .01
		45-GB-79	.4	< .01
SEABEE FORMATION				
14	--	49-GB-79	6.6	.26
TUKTU FORMATION				
19	--	29-WL-79	4.0	.02
		32-WL-79	3.5	.01

Table IV.--POROSITY AND PERMEABILITY--continued

Locality No.	Plate No.	Sample No.	Effective porosity (percent)	Horizontal permeability (millidarcies)
		KONGAKUT FORMATION Kemik Sandstone Member		
15	--	16-IP-79	5.0	.01
		17-IP-79	6.2	.02
		18-IP-79	4.1	< .01
16	9	22-IP-79	8.0	.04
		23-IP-79	4.4	< .01
		24-IP-79	7.1	.02
		25-IP-79	4.4	.01
		68A-WL-79	6.9	.08
		69A-WL-79	6.8	.08
		70-WL-79	3.0	.01
		71-WL-79	7.5	.03
		72-WL-79	11.9	20.00
		73-WL-79	5.5	.08
		74-WL-79	6.0	.20
		75-WL-79	3.5	< .01
		76-WL-79	3.8	< .01
20	--	1-GB-79	0.7	< .01
		4-GB-79	2.8	< .01
		1-IP-79	3.2	.02
21	11	122-GB-79	3.0	.01
		KINGAK SHALE		
9	6	65-GB-79	1.2	< .01
		72-GB-79	5.1	< .01
		76-GB-79	5.6	.02
		80-GB-79	5.2	.01
		SHUBLIK FORMATION		
18	10	33-WL-79	2.1	< .01
		37-WL-79	0.6	< .01

Table V

SUMMARY OF FORAMINIFERAL AGE AND ENVIRONMENT DATA

[Determinations by Anderson, Warren & Associates, Inc., San Diego, Calif. Frequency symbols used in fossil assemblages: R, rare; F, frequent; C, common; A, abundant; FL, flood]

SAGAVANIRKTOK FORMATION

Locality 22

98-GB-79: No foraminifera found. Coal (F), megaspores (R). Brownish-gray muddy fine-grained sandstone.

AGE: Indeterminate
ENVIRONMENT: Indeterminate

101-GB-79: No foraminifera found. Pyrite (R), coal (R), calcispheres? (R). Light-brownish-gray medium- to coarse-grained sandstone.

AGE: Indeterminate
ENVIRONMENT: Indeterminate

Nuwok Member

Locality 1

79-WL-79: No foraminifera found. Calcisphaera? sp. (R). Gray fine- to medium-grained cherty sandstone.

AGE: Indeterminate
ENVIRONMENT: Indeterminate

Nuwok Member--continued

Locality 1--continued

83-WL-79: Elphidium? ustulatum (R), pyrite (C), coal (F), fecal pellets (F), plant debris (F). Brownish-gray very fine grained sandstone or siltstone.

AGE:	Probable Neogene
ENVIRONMENT:	Marginal marine to inner neritic

86-WL-79: Buliminella curta (F), Elphidiella? brunnescens (F), Elphidium? ustulatum (F), Globulina inaequalis (R), Nonion planatum (R), Nonionella sp. (R), Quinqueloculina sp. (F), pyrite spheres (A), pyrite (F), coal (R). Dark-gray very fine grained pyritic sandstone.

AGE:	Neogene (probable Miocene)
ENVIRONMENT:	Inner to middle neritic

89-WL-79: Buliminella curta (F), Cibicides fletcheri (R), C. perlucidus (R), Elphidiella? brunnescens (F), Elphidium? ustulatum (R), Globulina inaequalis (R), Nonion planatum (R), Quinqueloculina sp. (R), pyrite (R), coal (F). Gray very fine grained sandstone.

AGE:	Neogene (probable Miocene)
ENVIRONMENT:	Inner to middle neritic

92-WL-79: Angulogerina fluens (F), Cibicides perlucidus (F), Elphidiella? brunnescens (C), Elphidium? ustulatum (F), Globulina inaequalis (R), Gyroidina cf. girardana (R), pyrite (C), coal (F), pyrite sticks (C), calcisphaera? (R). Gray fine- to medium-grained cherty sandstone.

AGE:	Neogene (probable Miocene)
ENVIRONMENT:	Inner to middle neritic

Nuwok Member--continued

Locality 1--continued

95-WL-79: Angulogerina fluens (A), Buliminela curta (F), Cibicides lobatulus (F), C. perlucidus (F), C. fletcheri (R), Dentalina soluta (R), Elphidiella? brunnescens (C), Elphidium? ustulatum (F), Gyroidina girardana (R), Lagena saccata (R), Nonion planatum (F), Quinqueloculina akneriana (R), Q. cf. sphaera (F), pyrite (C), pyrite sticks (C). Dark brown pyritic fine-grained muddy sandstone.

AGE: Neogene (probable Miocene)
ENVIRONMENT: Inner to middle neritic

Franklin Bluffs Member

Locality 4

130-GB-79: No foraminifera found. Megaspores (F). Brownish-gray fine- to medium-grained sandstone.

AGE: Indeterminate
ENVIRONMENT: Indeterminate

134-GB-79: No foraminifera found. Coal (F), plant debris (F), megaspores (R). Brown siltstone.

AGE: Indeterminate
ENVIRONMENT: Indeterminate

Locality 4--continued

138-GB-79: No foraminifera found. Megaspores (R), plant debris (C), vein calcite (A). Brown fine-grained sandstone.

AGE: Indeterminate
ENVIRONMENT: Indeterminate

141-GB-79: No foraminifera found. Light-brownish-gray sandy dolomite?

AGE: Indeterminate
ENVIRONMENT: Indeterminate

Locality 5

144-GB-79: No foraminifera found. Cenosphaera sp. (R). Dark-brown fine-grained sandstone.

AGE: Indeterminate
ENVIRONMENT: Possible marine

147-GB-79: No foraminifera found. Pyrite (A), pyrite spheres (C). Dark-brown pyritic fine- to medium-grained sandstone.

AGE: Indeterminate
ENVIRONMENT: Indeterminate

Locality 6

150-GB-79: No foraminifera found. Fecal pellets (C). Dark-brown muddy fine-grained sandstone.

AGE: Indeterminate
ENVIRONMENT: Indeterminate

153-GB-79: No foraminifera found. Fecal pellets (F). Brown sandy siltstone or shale.

AGE: Indeterminate
ENVIRONMENT: Indeterminate

Locality 11

8-WL-79: No foraminifera found. Coal (C). Yellow-brown iron-stained fine-grained coaly sandstone.

AGE: Indeterminate
ENVIRONMENT: Indeterminate

Locality 12

1-WL-79: No foraminifera found. Coal (F), fecal pellets (F). Dark-gray to black shale.

AGE: Indeterminate
ENVIRONMENT: Indeterminate

Sagwon Member

Locality 2

98-WL-79: No foraminifera found. Coal (F). Orange-brown sandy shale.

AGE: Indeterminate
ENVIRONMENT Indeterminate

MOOSE CHANNEL FORMATION

Locality 24

104-GB-79: No foraminifera found. Fecal pellets (A). Dark-brown iron-stained silty shale.

AGE: Indeterminate
ENVIRONMENT: Indeterminate

108-GB-79: No foraminifera found. Calcispheres? (R). Dark-brown iron-stained muddy very fine grained sandstone.

AGE: Indeterminate
ENVIRONMENT: Indeterminate

112-GB-79: No foraminifera found. Coal (A), fecal pellets (F). Black carbonaceous shale.

AGE: Indeterminate
ENVIRONMENT: Indeterminate

Locality 24--continued

116-GB-79: No foraminifera found. Dark-brown to black medium-grained cherty muddy sandstone.

AGE: Indeterminate
ENVIRONMENT: Indeterminate

120-GB-79: No foraminifera found. Coal (R), fecal pellets (C). Dark-brown iron-stained shale.

AGE: Indeterminate
ENVIRONMENT: Indeterminate

Locality 25

32-IP-79: No foraminifera found. Vein calcite (A), fecal pellets (R). Dark-brown siltstone.

AGE: Indeterminate
ENVIRONMENT: Indeterminate

36-IP-79: No foraminifera found. Pyrite (R), coal (R), vein calcite (F). Dark-brown siltstone.

AGE: Indeterminate
ENVIRONMENT: Indeterminate

41-IP-79: No foraminifera found. Fecal pellets (R). Dark-brown to black fine-grained muddy sandstone.

AGE: Indeterminate
ENVIRONMENT: Indeterminate

MOOSE CHANNEL FORMATION--continued

Locality 25--continued

49-IP-79: Hyperammina sp. (R), Haplophragmoides sp. (R), fecal pellets (C). Dark-brown sandy siltstone.

AGE:	Indeterminate
ENVIRONMENT:	Possible marginal marine to inner neritic

54-IP-79: No foraminifera found. Dark-orange-brown iron-stained fine- to medium-grained sandstone.

AGE:	Indeterminate
ENVIRONMENT:	Indeterminate

57-IP-79: No foraminifera found. Fecal pellets (F), black chert? pebble breccia (R). Black iron-stained shale.

AGE:	Indeterminate
ENVIRONMENT:	Indeterminate

Undifferentiated PRINCE CREEK and SCHRADER BLUFF FORMATIONS

Locality 13

7-GB-79: Arenaceous sp. (R), fecal pellets (R). Dark-brown silty shale.

AGE:	Indeterminate
ENVIRONMENT:	Possible marine

Locality 13--continued

17-GB-79: No foraminifera found. Brownish-gray very fine grained sandstone or siltstone.

AGE: Indeterminate
ENVIRONMENT: Indeterminate

19-GB-79: No foraminifera found. Fecal pellets (F). Brownish-gray iron-stained very fine grained sandstone or siltstone.

AGE: Indeterminate
ENVIRONMENT: Indeterminate

21-GB-79: Bathysiphon vitta (R), Hippocrepina sp. (R), coal (R). Brown sandy siltstone.

AGE: Indeterminate
ENVIRONMENT: Marginal marine to inner neritic

7-IP-79: No foraminifera found. Brown sandy shale.

AGE: Indeterminate
ENVIRONMENT: Indeterminate

12-IP-79: Arenaceous spp. (R). Brown iron-stained muddy sandstone.

AGE: Indeterminate
ENVIRONMENT: Possible marine

SCHRADER BLUFF FORMATION

Locality 7

156-GB-79: No foraminifera found. Pyrite (F). Mottled dark-gray iron-stained bentonitic shale.

AGE: Indeterminate
ENVIRONMENT: Indeterminate

Sentinel Hill Member

Locality 8

25-GB-79: No foraminifera found. Brown sandy siltstone.

AGE: Indeterminate
ENVIRONMENT: Indeterminate

28-GB-79: Arenaceous sp. (R), Cyclammina ? (R), Haplophragmoides cf. excavatus (F), fecal pellets (C). Brown iron-stained shale.

AGE: Probable Paleogene
ENVIRONMENT: Inner neritic

31-GB-79: Haplophragmoides cf. excavatus (R), coal (F). Brownish-gray sandy shale.

AGE: Indeterminate
ENVIRONMENT: Marginal marine

36-GB-79: No foraminifera found. Fecal pellets (F). Brown siltstone.

AGE: Indeterminate
ENVIRONMENT: Indeterminate

Locality 8-continued

39-GB-79: Bathysiphon sp. (R), Haplophragmoides cf. excavatus (R), fecal pellets (F). Brownish-gray muddy fine-grained sandstone.

AGE: Indeterminate
ENVIRONMENT: Marginal marine

43-GB-79: Bathysiphon sp. (R), coal (R). Brown muddy fine-grained sandstone.

AGE: Indeterminate
ENVIRONMENT: Probable marginal marine

54-GB-79: Arenaceous spp. (R), Cyclammina 7 (F), Haplophragmoides cf. excavatus (R), coal (F). Brown iron-stained sandy shale.

AGE: Probable Paleogene (Paleocene)
ENVIRONMENT: Middle neritic

57-GB-79: Cyclammina 71 (R), C. 7 (C), Haplophragmoides cf. excavatus (F), Cenosphaera sp. (R), coal (R), fecal pellets (F). Brown sandy shale.

AGE: Probable Paleogene (Paleocene)
ENVIRONMENT: Middle neritic to upper bathyal

60-GB-79: Cyclammina 71 (R), C. 7 (A), Haplophragmoides cf. excavatus (F), pyrite (R), coal (R), fecal pellets (F). Orange-brown iron-stained siltstone.

AGE: Probable Paleogene (Paleocene)
ENVIRONMENT: Middle neritic to upper bathyal

SEABEE FORMATION

Locality 14

51-GB-79: Arenaceous spp. (A), Bathysiphon vitta (F), Haplophragmoides excavatus (F), H. spp. (F), pyrite (R), fecal pellets (R). Brown siltstone.

AGE: Probable Cretaceous
ENVIRONMENT: Marginal marine to inner neritic

Locality 23

82-GB-79: No foraminifera found. Inoceramus prisms (C), gypsum (A). Buff tan sandstone.

AGE: Mesozoic (Jurassic to Cretaceous)
ENVIRONMENT: Marginal marine to inner neritic

85-GB-79: No foraminifera found. Jarosite (C). Mottled dark-gray paper shale.

AGE: Possible Late Cretaceous (based on lithology only)
ENVIRONMENT: Indeterminate

89-GB-79: No foraminifera found. Cenosphaera sp. (R), gypsum (A). Dark-gray mottled paper shale.

AGE: Possible Late Cretaceous (based on lithology only)
ENVIRONMENT: Possible marine

92-GB-79: No foraminifera found. Light- and dark-gray mottled bentonitic shale.

AGE: Possible Late Cretaceous (based on lithology only)
ENVIRONMENT: Indeterminate

SEABEE FORMATION--continued

Locality 23--continued

95-GB-79: No foraminifera found. Gypsum (R). Dark-gray bentonitic shale.

AGE: Possible Late Cretaceous (based on lithology only)
ENVIRONMENT: Indeterminate

TUKTU FORMATION

Locality 19

31-WL-79: No foraminifera found. Limonite (C). Orange-brown limonitic siltstone.

AGE: Indeterminate
ENVIRONMENT: Indeterminate

KONGAKUT FORMATION

Locality 18

56-WL-79: Arenaceous spp. (large, coarse) (F), Gaudryina tailleuri (R), Glomospirella sp. (R), G. S (R), Haplophragmoides canui (R), H. duoflatis (R), H. coronis (R), H. inflatigrandis (F), rounded frosted quartz floaters (F). Brownish-gray sandy siltstone.

AGE: Early Cretaceous (Neocomian)
ENVIRONMENT: Outer neritic to middle bathyal

Locality 18--continued

59-WL-79: Ammobaculites reophacoides (F), Arenaceous spp. (large, coarse) (C), Bathysiphon scintillata (R), Gaudryina milleri (R), Glomospirella S (R), Haplophragmoides goodenoughensis (F), H. duoflatis (C), H. inflatigrandis (C), H. canui (R), rounded frosted quartz floaters (A), fecal pellets (C). Dark-brown pebble shale.

AGE: Early Cretaceous (Neocomian)
ENVIRONMENT: Outer neritic to middle bathyal

62-WL-79: No foraminifera found. Vein calcite (F), fecal pellets (F). Black siltstone.

AGE: Indeterminate
ENVIRONMENT: Indeterminate

65-WL-79: Ammobaculites reophacoides (R), Gaudryina tailleuri (R), Haplophragmoides coronis (R), H. duoflatis (R), fecal pellets (C), limonite (F). Dark-gray to black shale.

AGE: Early Cretaceous (Neocomian)
ENVIRONMENT: Middle to outer neritic

68-WL-79: Ammobaculites reophacoides (R), Gaudryina tailleuri (R), Haplophragmoides coronis (R), rounded frosted quartz floaters (R). Black shale.

AGE: Early Cretaceous (Neocomian)
ENVIRONMENT: Middle to outer neritic

Pebble shale member

Locality 17

27-IP-79: Ammobaculites reophacoides (R), Ammodiscus mackenziensis (R), Conorboides cf. hofkeri (C), Gaudryina tailleuri (R), G. Tappanae (F), Haplophragmoides coronis (F), H. canui (R), rounded frosted quartz floaters (C), oil staining (F). Black sandy shale.

AGE: Early Cretaceous (Neocomian)
ENVIRONMENT: Middle neritic to upper bathyal

Locality 21

124-GB-79: Ammobaculites reophacoides (R), Ammodiscus rotalarius (R), Arenaceous spp. (large, coarse) (C), A. spp. (F), Gaudryina milleri (R), G. Tailleuri (R), Glomospira corona (R), Glomospirella arctica (R), Haplophragmoides inflatigrandis (F), H. duoflatis (C), H. goodenoughensis (R), Saccamina lathrami (R), rounded frosted quartz floaters (F), pyrite (R), fecal pellets (C). Dark-gray sandy shale.

AGE: Early Cretaceous (Neocomian)
ENVIRONMENT: Outer neritic to middle bathyal

127-GB-79: No foraminifera found. Inoceramus prisms (R), limonite (C). Black weathered shale.

AGE: Indeterminate
ENVIRONMENT: Probable marine

Kemik Sandstone Member

Locality 20

3-GB-79: Ammobaculites fragmentarius (R), Arenaceous spp. (F), Gaudryina tappanae (R), Haplophragmoides coronis (F), H. duoflatis (C), H. inflatigrandis (R), Miliammina ischnia (R), Trochammina squamata (R), round frosted quartz floaters (R), pyrite (F), pyrite sticks (F), fecal pellets (F). Dark-gray sandy bentonitic shale.

AGE: Early Cretaceous (Neocomian)
ENVIRONMENT: Middle neritic to upper bathyal (turbid)

3-IP-79: Haplophragmoides coronis (R), rounded frosted quartz floaters (R), fecal pellets (F). Black shale.

AGE: Possible Early Cretaceous (Neocomian)
ENVIRONMENT: Probable marine

Clay shale member

Locality 15

20-IP-79: Ammobaculites reophacoides (R), Arenaceous spp. (R), Gaudryina tailleuri (R), Haplophragmoides coronis (R), fecal pellets (F). Dark orange-brown iron-stained shale.

AGE: Early Cretaceous (Neocomian)
ENVIRONMENT: Probable neritic

27-WL-79: No foraminifera found. Jarosite? (F). Dark-gray shale.

AGE: Indeterminate
ENVIRONMENT: Indeterminate

KINGAK SHALE

Locality 9

63-GB-79: Ammobaculites alaskensis (F), A. cf. vetusta (R), Ammodiscus cheradospirus (R), Arenaceous spp. (F), Bathysiphon sp. (R), Haplophragmoides spp. (F), Recurvoides sp. (R). Dark-brown siltstone.

AGE: Probable Early to Middle Jurassic
ENVIRONMENT: Probable inner to middle neritic

67-GB-79: Ammobaculites alaskensis (F), A. barrowensis (R), Ammodiscus cheradospirus (C), Arenaceous spp. (F), Bathysiphon anomalocoelia (F), Haplophragmoides spp. (R), pyrite (R). Brown very fine grained sandstone.

AGE: Probable Early to Middle Jurassic
ENVIRONMENT: Probable inner to middle neritic

70-GB-79: Ammobaculites alaskensis (R), Ammodiscus cheradospirus (R), Haplophragmoides spp. (F), fecal pellets (F). Brown iron-stained very fine grained sandstone.

AGE: Probable Early to Middle Jurassic
ENVIRONMENT: Inner to middle neritic

74-GB-79: Ammobaculites alaskensis (F), Ammodiscus cheradospirus (F), Arenaceous spp. (F), Gaudryina cf. milleri (R), Gaudryina dyscrita (R), Haplophragmoides spp. (C), fecal pellets (C). Dark-reddish-brown iron-stained siltstone.

AGE: Early to Middle Jurassic
ENVIRONMENT: Middle to outer neritic

KINGAK SHALE--continued

Locality 9--continued

78-GB-79: Ammobaculites alaskensis (F), Arenaceous spp. (F), Bathysiphon anomalocoelia (R), Gaudryina topagorukensis (R), G. dyscrita (R), Haplophragmoides spp. (F), fecal pellets (C). Dark-brown to black siltstone.

AGE: Early to Middle Jurassic
ENVIRONMENT: Middle to outer neritic

SHUBLIK FORMATION

Locality 18

35-WL-79: No foraminifera found. Limonite (F). Dark-gray limonitic quartzitic siltstone.

AGE: Indeterminate
ENVIRONMENT: Indeterminate

39-WL-79: No foraminifera found. Fecal pellets (F). Reddish-brown silty shale.

AGE: Indeterminate
ENVIRONMENT: Indeterminate

42-WL-79: No foraminifera found. Black chert? pebbles (FL). Black chert? pebble breccia.

AGE: Indeterminate (possible Triassic suggested by lithology only)
ENVIRONMENT: Indeterminate

SHUBLIK FORMATION--continued

Locality 18--continued

45-WL-79: No foraminifera found. Monotis/Halobia fragments (C), ostracodes (medium-large) (R), black chert? pebbles (F). Black shelly calcareous shale.

AGE: Probable Triassic
ENVIRONMENT: Marine

49-WL-79: No foraminifera found. Echinoid spines (R). Dark-gray silty shale.

AGE: Indeterminate
ENVIRONMENT: Possible marine

52-WL-79: No foraminifera found. Monotis/Halobia fragments (FL), coal (R), gypsum (F). Dark-gray shell hash.

AGE: Probable Triassic
ENVIRONMENT: Marine

TABLE VI

SUMMARY OF PALYNOLOGICAL AGE AND ENVIRONMENT DATA

[Determinations by Anderson, Warren & Associates, Inc., San Diego, Calif. Frequency symbols used in fossil assemblages: R, rare; F, frequent; C, common; A, abundant]

SAGAVANIRKTOK FORMATION

Locality 22

99-GB-79: Undifferentiated bisaccates (A), Vitreisporites pallidus (single, reworked), Laevigatosporites sp. (F), Lycopodiumsporites sp. (R), Osmundacidites sp. (F), Sphagnum sp. (F), Taxodiaceae (C), Alnus (F), Betulaceae (R), Carya (R), Juglans (R), Tilia (F), Ulmus (R).

Cyclonephelium exuberans (R), Paralecaniella indentata (F), Odontochitina operculata (single, reworked), Oligosphaeridium complex (single, reworked), Gardodinium trabeculosum (single, reworked).

AGE: Paleogene (Eocene) with reworked Cretaceous
ENVIRONMENT: Marine

102-GB-79: Undifferentiated bisaccates (F), Lycopodiumsporites sp. (R), Sphagnum (R), Taxodiaceae (F), Juglans (R), Tilia (R).

Cyclonephelium distinctum (single, reworked), Deflandrea wetzelii (A), Pterospermopsis sp. (R).

AGE: Paleogene (Eocene) with reworked Cretaceous
ENVIRONMENT: Marine

Nuwok Member

Locality 1

80-WL-79: Undifferentiated bisaccates (A), Tsuga (F), Laevigatosporites sp. (F), Osmundacidites sp. (F), Betulaceae (C), Juglans (R).

Spiniferites mirabilis (single).

AGE: Neogene-Quaternary(?)
ENVIRONMENT: Marginal marine

84-WL-79: Undifferentiated bisaccates (C), Tsuga (F), Laevigatosporites sp. (R), Lycopodiumsporites sp. (R), Sphagnum (R).

AGE: Tertiary-Quaternary(?)
ENVIRONMENT: Nonmarine?

90-WL-79: Undifferentiated bisaccates (A), Tsuga (R), Laevigatosporites sp. (R).

AGE: Tertiary-Quaternary(?)
ENVIRONMENT: Nonmarine?

93-WL-79: Undifferentiated bisaccates (F), Tsuga (R), Sphagum (R).

?Lejeunia sp. (single).

AGE: Tertiary-Quaternary(?)
ENVIRONMENT: Marginal marine

Nuwok Member--continued

Locality 1--continued

96-WL-79: Undifferentiated bisaccates (C), Tsuga (F), Laevigatosporites sp. (R), Betulaceae (R), ?Aquilapollenites sp. (single, reworked).

AGE: Tertiary-Quaternary(?)
ENVIRONMENT: Nonmarine?

Franklin Bluffs Member

Locality 4

131-GB-79: Undifferentiated bisaccates (F).

Spiniferites sp. (single), Chatangiella sp. (single, reworked).

AGE: Possible Tertiary with reworked Late Cretaceous
ENVIRONMENT: Nonmarine?

135-GB-79: Undifferentiated bisaccates (C). Poor preservation.

Veryhachium sp. (R), Oligosphaeridium complex (R), Odontochitina operculata (single, reworked?).

AGE: Possible Tertiary with reworked Cretaceous
ENVIRONMENT: Nonmarine?

Locality 4--continued

139-GB-79: Alnus (R), ?Betulaceae (R), Hystricosporites sp. (single, reworked), Cicatricosisporites australiense (R, reworked).

Oligosphaeridium complex (R, reworked), Odontochitina operculata (single, reworked).

AGE:	Probable Tertiary with reworked Cretaceous and Devonian
ENVIRONMENT:	Nonmarine?

142-GB-79: Betulaceae (R).

Oligosphaeridium complex (single, reworked?).

AGE:	Tertiary
ENVIRONMENT:	Nonmarine?

Locality 5

145-GB-79: Undifferentiated bisaccates (A), Alnus (R), Betulaceae (R), Aquilapollenites trialatus (R, reworked), A. senonicus (single, reworked).

Oligosphaeridium complex (single, reworked), Chatangiella decorosa (single, reworked).

AGE:	Probable Tertiary with reworked Late Cretaceous
ENVIRONMENT:	Nonmarine?

Locality 5--continued

148-GB-79: Undifferentiated bisaccates (A), Lycopodiumsporites sp. (R), Osmundacidites sp. (R), Alnus (R), Betulaceae (R), Aquilapollenites magnus (single, reworked), A. sp. (single, reworked), Juglans (R).

Oligosphaeridium complex (single, reworked).

AGE: Tertiary with reworked Late Cretaceous
ENVIRONMENT: Nonmarine

Locality 6

151-GB-79: Undifferentiated bisaccates (C), Alnus (R), Aquilapollenites trialatus (single, reworked).

AGE: Tertiary with reworked Late Cretaceous
ENVIRONMENT: Nonmarine

154-GB-79: Undifferentiated bissaccates (A), Alnus (R), Aquilapolenites sp. (single, reworked), ?Paraalnipollenites confusus (single).

AGE: Probable Paleogene (Paleocene) with reworked Late Cretaceous
ENVIRONMENT: Nonmarine?

Franklin Bluffs Member--continued

Locality 11

7-WL-79: Undifferentiated bisaccates (R), Cicatricosisporites sp. (single), Expressipollis accuratus (single, reworked).

Cyclonephelium distinctum (single, reworked).

AGE: Probable Tertiary with reworked Late Cretaceous
ENVIRONMENT: Nonmarine?

Locality 12

4-WL-79: Undifferentiated bisaccates (C), Deltoidospora sp. (C), Alnus (R), ?Ulmus sp. (R).

Odontochitina operculata (single, reworked).

AGE: Tertiary with reworked Cretaceous
ENVIROMENT: Nonmarine?

Sagwon Member

Locality 2

99-WL-79: Undifferentiated bisaccates (A), Tsuga (R), Laevigatosporites sp. (F), Taxodiaceae (R), Alnus (F), Juglans (R), Tilia (R).

Cyclonephelium exuberans (R), Deflandrea wetzelii (F).p

AGE: Paleogene (Eocene)

ENVIRONMENT: Marine

Locality 24

105-GB-79: ?Alnus (R), Spinozonotriletes sp. (single, reworked). Very poor preservation.

Oligosphaeridium complex (single fragment, reworked?). Very poor preservation.

AGE: Probable Tertiary with reworked Cretaceous
ENVIRONMENT: Nonmarine?

109-GB-79: Undifferentiated bisaccates (R), Betulaceae (F), ?Ulmus (R). Poor preservation.

AGE: Tertiary
ENVIRONMENT: Nonmarine

113-GB-79: Laevigatosporites sp. (R), Alnus (F), Betulaceae (C), Juglans (R), ?Paraalnipollenites confusus (single), ?Ulmus (R). Poor preservation.

AGE: Probable Paleogene (Paleocene)
ENVIRONMENT: Nonmarine

117-GB-79: Undifferentiated bisaccates (R), Lycopodiumsporites sp. (R), Betulaceae (F), ?Paraalnipollenites confusus (single). Poor preservation.

AGE: Probable Paleogene (Paleocene)
ENVIRONMENT: Nonmarine

Locality 24--continued

121-GB-79: Undifferentiated bisaccates (F), Laevigatosporites sp. (F), Alnus (F), Betulaceae (C), ?Ulmus (F).

AGE: Tertiary
ENVIRONMENT: Nonmarine

Locality 25

33-IP-79: Undifferentiated bisaccates (F), Lycopodiumsporites sp. (R), Betulaceae (R), Paraalnipollenites confusus (single).

?Odontochitina operculata (single, reworked), Oligosphaeridium complex (R, reworked).

AGE: Paleogene (Paleocene) with reworked Cretaceous
ENVIRONMENT: Nonmarine

37-IP-79: Undifferentiated bisaccates (F), Lycopodiumsporites sp. (R), Taxodiaceae (R), Alnus (R), Hymenozonotriletes lepidophytus (single, reworked).

Odontochitina operculata (R, reworked), Oligosphaeridium complex (thick-wall) (R, reworked).

AGE: Tertiary with reworked Cretaceous and Devonian
ENVIRONMENT: Nonmarine

Locality 25--continued

42-IP-79: Undifferentiated bisaccates (R), Alnus (R).

Isabelidinium cooksoniae (single, reworked), Odontochitina operculata (single, reworked).

AGE: Tertiary with reworked Late Cretaceous
ENVIRONMENT: Nonmarine?

50-IP-79: Undifferentiated bisaccates (C), Taxodiaceae (R), Betulaceae (R), Paraalnipollenites confusus (R).

Odontochitina operculata (R. reworked), Oligosphaeridium complex (R, reworked), Palaeoperidinium cretaceum (R, reworked).

AGE: Paleogene (Paleocene) with reworked Cretaceous
ENVIRONMENT: Nonmarine

55-IP-79: Lycopodiumsporites sp. (R), Alnus (R), ?Paraalnipollenites confusus (single, poor preservation).

AGE: Tertiary (possible Paleocene?)
ENVIRONMENT: Nonmarine

58-IP-79: Undifferentiated bisaccates (F), Alnus (R), Betulaceae (F), Ulmus (F).

Gardodinium trabeculosum (single, reworked).

AGE: Tertiary (probable Paleogene) with reworked Early Cretaceous
ENVIRONMENT: Nonmarine

Undifferentiated PRINCE CREEK and SCHRADER BLUFF FORMATIONS

Locality 13

10-GB-79: Undifferentiated bisaccates (A), Aquilapollenites sp. (R), Expressipollis accuratus (R), Gleicheniidites senonicus (R), Taxodiaceae (F).

Chatangiella sp. (single), Cleistosphaeridium sp. (single), ?Odontochitina operculata (R, fragments), Oligosphaeridium complex (thick-wall) (single).

AGE: Probable Late Cretaceous (Campanian Maestrichtian)
All forms presumed indigenous
ENVIRONMENT: Marginal marine

12-GB-79: Undifferentiated bisaccates (A), Betulaceae (R), Aequitriradites spinulosus (single, reworked), Paraalnipollenites confusus (single).

Odontochitina operculata (single, reworked), Oligosphaeridium complex (thick-wall) (single, reworked).

AGE: Paleogene (Paleocene) with reworked Cretaceous
ENVIRONMENT: Nonmarine

14-GB-79: Undifferentiated bisaccates (F), ?Betulaceae (R). Poor preservation.

Tasmanaceae (single).

AGE: Tertiary
ENVIRONMENT: Nonmarine?

Locality 13--continued

8-IP-79: Undifferentiated bisaccates (C), Lycopodiumsporites sp. (R), Taxodiaceae (R), ?Betulaceae (single), Aquilapollenites trialatus (single, reworked?). Poor preservation.

Cyclonephelium distinctum (single, reworked?), Baltisphaeridium sp. (single), ?Gonyaulacysta sp. (single, reworked), Odontochitina operculata (single), reworked?), Oligosphaeridium complex (single, reworked?).

AGE: Possible Tertiary with reworked Cretaceous
ENVIRONMENT: Nonmarine?

13-IP-79: Undifferentiated bisaccates (C), indeterminate spores (F). Poor preservation.

AGE: Indeterminate
ENVIRONMENT: Nonmarine?

SCHRADER BLUFF FORMATION

Locality 7

157-GB-79: Undifferentiated bisaccates (R).

Chatangiella coronata (C), C. spp. (F), ?Diconodinium arcticum (F), Oligosphaeridium complex (R). Poor preservation.

AGE: Late Cretaceous (Campanian)
ENVIRONMENT: Marine

Sentinel Hill Member

Locality 8

26-GB-79: Undifferentiated bisaccates (R), Taxodiaceae (R).

AGE: Tertiary?
ENVIRONMENT: Nonmarine?

29-GB-79: Undifferentiated bisaccates (F), Lycopodiumsporites sp. (R), Sphagnum (R), Taxodiaceae (R), Alnus (R), Betulaceae (R).

AGE: Tertiary
ENVIRONMENT: Nonmarine

32-GB-79: Undifferentiated bisaccates (F), Betulaceae (R). Poor preservation.

AGE: Tertiary
ENVIRONMENT: Nonmarine?

37-GB-79: Undifferentiated bisaccates (F), Lycopodiumsporites sp. (R), Alnus (R), Betulaceae (R).

Chatangiella sp. complex (single, reworked), Odontochitina operculata (R, reworked).

AGE: Tertiary, with reworked Cretaceous
ENVIRONMENT: Nonmarine?

Locality 8--continued

40-GB-79: Undifferentiated bisaccates (F), Taxodiaceae (R), Alnus (R), Betulaceae (R).

Oligosphaeridium complex (single, reworked).

AGE: Tertiary
ENVIRONMENT: Nonmarine?

44-GB-79: Undifferentiated bisaccates (F), Lycopodiumsporites sp. (R), Aquilapollenites trialatus (single, reworked).

Odontochitina operculata (single, reworked), Oligosphaeridium complex (single, reworked), Cyclonephelium distinctum (single, reworked), Gardodinium trabeculosum (single, reworked).

AGE: Probable Tertiary with reworked Cretaceous
ENVIRONMENT: Nonmarine?

47-GB-79: Undifferentiated bisaccates (C), Lycopodiumsporites sp. (R), Betulaceae (R), Densosporites sp. (single, reworked).

Oligosphaeridium complex (R, reworked), Cyclonephelium distinctum (R, reworked), Muderongia sp. (single, reworked).

AGE: Tertiary with reworked Cretaceous
ENVIRONMENT: Nonmarine?

Locality 8--continued

55-GB-79: Undifferentiated bisaccates (F), Aquilapollenites senonicus (single, reworked), A. trialatus (single, reworked), ?Ulmus (single).

AGE:	Possible Tertiary with reworked Late Cretaceous
ENVIRONMENT:	Nonmarine?

58-GB-79: Undifferentiated bisaccates (F), Vitreisporites pallidus (R, reworked), Lycopodiumsporites sp. (R), Sphagnum (F), Alnus (F), Betulaceae (R).

Micrhystridium sp. (R), Pterospermopsis sp. (R), Odontochitina operculata (single, reworked), Oligosphaeridium complex (single, reworked).

AGE:	Tertiary with reworked Cretaceous
ENVIRONMENT:	Marginal marine

61-GB-79: Undifferentiated bisaccates (F), Lycopodiumsporites sp. (R), Taxodiaceae (R), Alnus (R), Betulaceae (R). Poor preservation.

AGE:	Tertiary
ENVIRONMENT:	Nonmarine

SEABEE FORMATION

Locality 14

52-GB-79: Chantangiella cf. coronata (F), C. spp. (C), Isabelidinium cookoniae (C.). Poor preservation.

AGE: Late Cretaceous (Campanian)
ENVIRONMENT: Marine

Locality 23

83-GB-79: Undifferentiated bisaccates (R), Osmundacidites sp. (R), Taxodiaceae (C).

Spiniferites ramosus (R), ?S. cingulatus (R).

AGE: Possible Late Cretaceous
ENVIRONMENT: Marine

86-GB-79: Undifferentiated bisaccates (R), Taxodiaceae (C).

Deflandrea sp. (single), Hystrichosphaeridium stellatum (R), Isabelidinium acuminatum (R), Odontochitina operculata (R), Wallodinium lunum (R), Pterospermopsis sp. (F).

AGE: Late Cretaceous
ENVIRONMENT: Marine

Locality 23--continued

90-GB-79: Undifferentiated bisaccates (R), Taxodiaceae (F).

Hystrichodinium cf. Voigti (single), Isabelidinium acuminatum (R), Pterospermopsis sp. (F), Odontochitina operculata (F), Oligosphaeridium complex (R), Palaeoperidinium basilium (R).

AGE:	Late Cretaceous
ENVIRONMENT:	Marine

93-GB-79: Undifferentiated bisaccates (F), Taxodiaceae (C).

Chatangiella biapertura (single), Chlamydophorella nyei (R), Isabelidinium cooksoniae (R), I. acuminatum (F), Pterospermopsis sp. (F), indeterminate yellow cysts (C), Odontochitina operculata (R), Oligosphaeridium complex (F).

AGE:	Late Cretaceous
ENVIRONMENT:	Marine

96-GB-79: Undifferentiated bisaccates (R), Taxodiaceae (C).

Isabelidinium cooksoniae (R), I. acuminatum (R), indeterminate yellow cysts (F), Oligosphaeridium complex (R).

AGE:	Late Cretaceous
ENVIRONMENT:	Marine

KONGAKUT FORMATION

Locality 18

57-WL-79: ?Classopollis classoides (R), Densosporites (R, reworked), Lycospora sp. (R, reworked). Brown organics.

?Tenua sp. (R).

AGE: Possible Cretaceous
ENVIRONMENT: Marginal marine

60-WL-79: Indeterminate spore (R, poor preservation). Brown organics.

AGE: Indeterminate
ENVIRONMENT: Marine

63-WL-79: Indeterminate spore (R). Brown organics. Poor preservation.

?Oligosphaeridium complex (thick-wall) (R, fragments).

AGE: Possible Early Cretaceous
ENVIRONMENT: Marine

66-WL-79: Undifferentiated bisaccates (R), Classopollis classoides (F). Poorly preserved. Brown-dark brown organics.

?Cyclonephelium distinctum (F), Oligosphaeridium complex (thick-wall) (R), ?Tenua sp. (R).

AGE: Probable Early Cretaceous (Neocomian)
ENVIRONMENT: Marine

KONGAKUT FORMATION--continued

Locality 18--continued

69-WL-79: Undifferentiated bisaccates (R), Vitreisporites pallidus (R). Poor preservation.

Batioladinium jaegeri (R), Cribroperidinium edwardsi (R), Cyclonephelium distinctum (A), Gardodinium trabeculosum (F), Oligosphaeridium complex (C), O. complex (thick-wall) (C), ?Pseudoceratium nudum (single).

AGE: Early Cretaceous. Probable Neocomian (Hauterivian-Barremian)

ENVIRONMENT: Marine

Pebble shale member

Locality 17

28-IP-79: Barren of palynomorphs.

AGE: Indeterminate

ENVIRONMENT: Indeterminate

Locality 21

125-GB-79: Undifferentiated bisaccates (R), Alnus (R), Betulaceae (R), Densospore (R, reworked).

AGE: Indeterminate with Quaternary contamination

ENVIRONMENT: Indeterminate

Pebble shale member--continued

Locality 21--continued

128-GB-79: Betulaceae (single, recent contaminant), Compositae Artemisia-type (single, recent contaminant).

AGE: Indeterminate with Quaternary contamination
ENVIRONMENT: Indeterminate

Kemik Sandstone Member

Locality 20

4-IP-79: Cyclonephelium distinctum (single), Gardodinium trabeculosum (single).

AGE: Early Cretaceous
ENVIRONMENT: Marine

Clay shale member

Locality 15

21-IP-79: ?Classopollis classoides (R, poor preservation), rare indeterminate spore fragments, poor preservation.

AGE: Mesozoic
ENVIRONMENT: No marine evidence

Clay shale member--continued

Locality 15--continued

28-WL-79: Rare, unidentifiable dinocysts(?), very poor preservation. Organics brown-dark brown.

AGE: Indeterminate
ENVIRONMENT: Indeterminate

KINGAK SHALE

Locality 9

64-GB-79: Classopollis classoides (R), Rogalskaisporites cicatricosus (R), Taeniaesporites sp. (R).

AGE: Possible Triassic
ENVIRONMENT: Nonmarine?

68-GB-79: Micrhystridium sp. (R), Gnetaceapollenites sp. (R), Striatites richteri (R), Taeniaesporites sp. (R).

AGE: Possible Permian-Triassic
ENVIRONMENT: Marginal marine

71-GB-79: Taeniaesporites sp. (R).

AGE: Possible Permian-Triassic
ENVIRONMENT: Nonmarine?

KINGAK SHALE--continued

Locality 9--continued

75-GB-79: Classopollis classoides (single), Taeniaesporites sp. (single).

AGE: Possible Triassic
ENVIRONMENT: Nonmarine?

Note: Samples 64-, 68-, 71-, and 75-GB-79 yielded only Permian-Triassic palynomorphs. In some North Slope subsurface core samples, foraminiferal recoveries indicate an Early to Middle Jurassic age while the palynomorphs indicate Triassic ages. In these instances, the foraminiferal Jurassic ages are presumably the valid age assignments.

79-GB-79: Classopollis classoides (single), indeterminate spore (single).

AGE: Mesozoic
ENVIRONMENT: Nonmarine?

SHUBLIK FORMATION

Locality 18

36-WL-79: Barren of palynomorphs. Brown organics.

AGE: Indeterminate
ENVIRONMENT: Indeterminate

40-WL-79: Undifferentiated bisaccates (R).

AGE: Indeterminate
ENVIRONMENT: Nonmarine?

Locality 18--continued

43-WL-79: Micrnystridium sp. (F). Brown organics, poor preservation.

AGE: Indeterminate
ENVIRONMENT: Marginal marine

46-WL-79: Essentially barren of palynomorphs. Organics brown.

AGE: Indeterminate
ENVIRONMENT: Indeterminate

50-WL-79: Indeterminate spore (R, poorly preserved). Brown organics.

AGE: Indeterminate
ENVIRONMENT: Nonmarine?

53-WL-79: Indeterminate spore (single, poor preservation). Brown, poorly preserved organics.

AGE: Indeterminate
ENVIRONMENT: Nonmarine?