Nelson

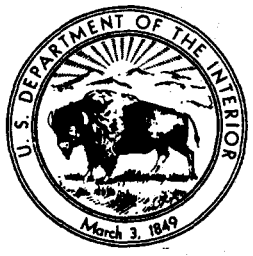
Test Wells, Gubik Area Alaska

EXPLORATION OF NAVAL PETROLEUM RESERVE NO 4 AND ADJACENT AREAS, NORTHERN ALASKA, 1944–53

PART 5, SUBSURFACE GEOLOGY AND ENGINEERING DATA

GEOLOGICAL SURVEY PROFESSIONAL PAPER 305–C

Prepared and published at the request of and in cooperation with the U. S. Department of the Navy, Office of Naval Petroleum and Oil Shale Reserves



Test Wells, Gubik Area Alaska

By FLORENCE M. ROBINSON

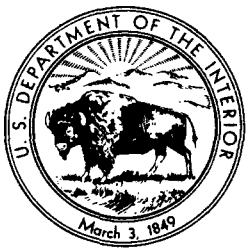
With Micropaleontologic Study of the Gubik Test Wells, Northern Alaska
By HARLAN R. BERGQUIST

EXPLORATION OF NAVAL PETROLEUM RESERVE NO. 4 AND ADJACENT AREAS, NORTHERN ALASKA, 1944–53

PART 5, SUBSURFACE GEOLOGY AND ENGINEERING DATA

GEOLOGICAL SURVEY PROFESSIONAL PAPER 305-C

Prepared and published at the request of and in cooperation with the U. S. Department of the Navy, Office of Naval Petroleum and Oil Shale Reserves



UNITED STATES GOVERNMENT PRINTING OFFICE, WASHINGTON : 1958

UNITED STATES DEPARTMENT OF THE INTERIOR

FRED A. SEATON, *Secretary*

GEOLOGICAL SURVEY

Thomas B. Nolan, *Director*

For sale by the Superintendent of Documents, U. S. Government Printing Office
Washington 25, D. C.

CONTENTS

ILLUSTRATIONS

[Plates 13, 15, 16 are in pocket]

EXPLORATION OF NAVAL PETROLEUM RESERVE NO. 4 AND ADJACENT AREAS, NORTHERN ALASKA, 1944–53

TEST WELLS, GUBIK AREA, ALASKA

By FLORENCE M. ROBINSON

ABSTRACT

From 1944 to 1953 the U. S. Navy, through its contractor and assisting Government agencies, explored the petroleum possibilities of Naval Petroleum Reserve No. 4 and adjoining areas in northern Alaska. In the course of this exploration, seismic, magnetic, and gravimetric geophysical surveys and field geologic surveys were made, and a test-well drilling program was undertaken.

Two tests were drilled on the Gubik anticline, which is about 180 miles southeast of Point Barrow. The two wells were little more than a mile apart, and the same Upper and Lower Cretaceous rocks were penetrated. Gas was discovered at two horizons: in the Tuluvak tongue of the Prince Creek formation, and in the Chandler and Ninuluk formations undifferentiated. Gubik test well 1 was drilled to 6,000 feet then plugged and abandoned; Gubik test well 2 was drilled to 4,620 feet; it then blew out, caught fire, and was subsequently abandoned.

INTRODUCTION

In the course of the exploration of Naval Petroleum Reserve No. 4, northern Alaska (Robinson, 1956, p. 1–3), two test wells were drilled on the Gubik anticline, 180 miles southeast of Barrow and approximately 16 miles northeast of Umiat near latitude 69°26′ N. and longitude 151°28′ W. (See fig. 11.) The Gubik anticline extends eastward between the Anaktuvuk and Colville Rivers across the mouth of the Chandler River. The presence of the anticline was reported in 1945 by a reconnaissance geologic field party, and its structural features were later defined by geologic mapping and reflection seismograph work. The name "Gubik" is a variant of the Eskimo word for "Big River," the native name applied to the lower Colville River.

The test wells are on a low gravel terrace 10–12 feet above the normal river level on the west side of the Chandler River a short distance above its mouth. (See pl. 13.) In general, the area near the confluence of the Colville, Chandler, and Anaktuvuk Rivers is one of low rolling hills at the northern edge of the northern foothills of the Brooks Range. Close to its mouth, the Anaktuvuk River flows through a broad valley with low bluffs. The valley of the Chandler is narrower and has steeper walls, which are 50 to several hundred feet high.

The test wells were drilled into Upper and Lower Cretaceous strata. Gas in commercial quantities was found in two separate sandstone beds 1,500 feet apart stratigraphically. A detailed description of the rocks examined and the logistic, engineering, drilling, and production data are assembled in this paper.

ACKNOWLEDGMENTS

Engineering information presented here is taken largely from the weekly, completion, and final reports made to the U. S. Navy by Arctic Contractors. United Geophysical Co. did most of the geophysical work, and the Schlumberger Well Surveying Corp. recorded all but one of the electric log runs. Gas analyses were made by the U. S. Bureau of Mines at Bartlesville, Okla., and some core analyses were made by Core Laboratories, Inc., of Dallas, Tex. The help of persons connected with these organizations is gratefully acknowledged.

Lithologic descriptions and other core analyses were made by the author in the Fairbanks laboratory of the U. S. Geological Survey. Members of the Geological Survey whose work is included are Harlan R. Bergquist, who identified the microfossils; Ralph W. Imlay, who identified the Lower Cretaceous megafossils, and George Gryc, who identified the Upper Cretaceous megafossils; Robert H. Morris, who established heavy-mineral zones; and Roland W. Brown, who identified plant fossils. The stratigraphic distribution of microfossils in the test wells of northern Alaska will be presented by H. R. Bergquist in another chapter of this series.

STRUCTURE

The Gubik anticline was first noted by a Geological Survey reconnaissance field party descending the

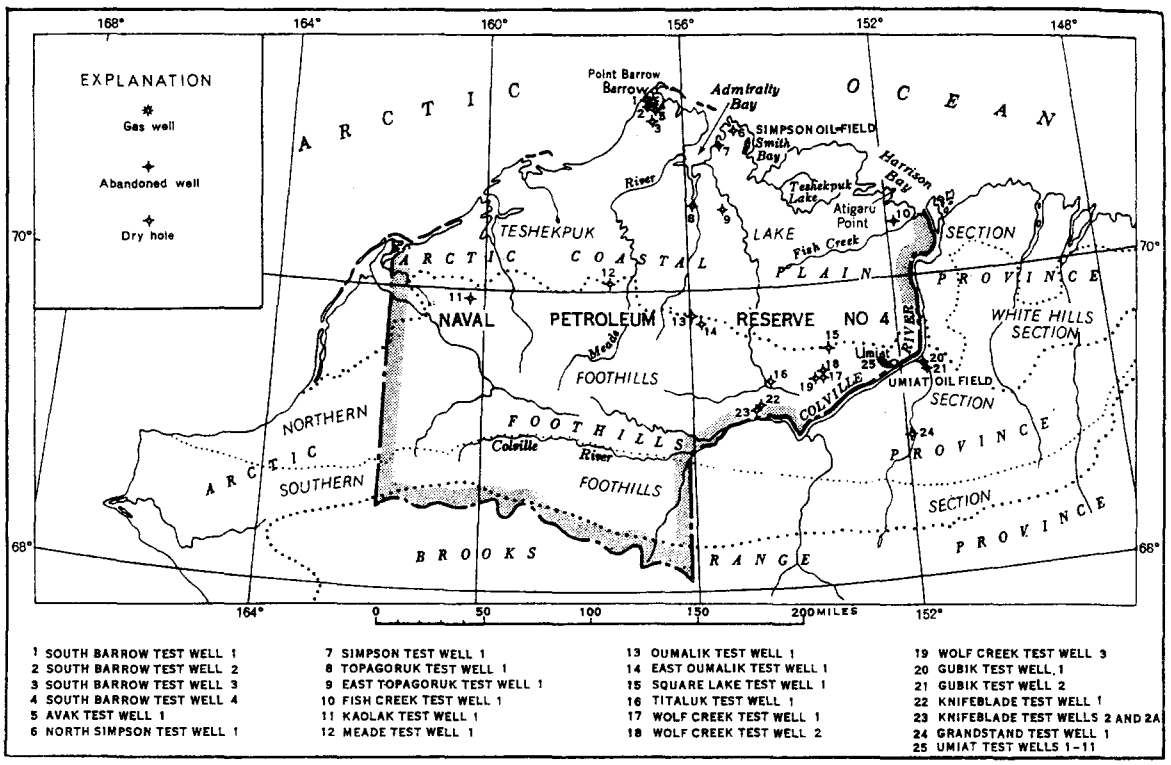


FIGURE 11.—Index map of northern Alaska, showing location of test wells and oil fields.

Anaktuvuk River in 1945. In 1947 another Geological Survey party found that the anticline plunges west near the Colville River. In 1945 and 1946 an airborne magnetometer survey was made of part of the Reserve and adjoining areas by the Geological Survey in a joint effort with the U. S. Navy. This survey included the area around the Gubik anticline. The Gubik test wells are at the northwestern end of an elongate magnetic high, which parallels the much larger high associated with the Umiat anticline to the southwest.

As a followup of the surface geologic mapping, a seismograph crew in 1950 shot two lines on the west end of the Gubik anticline. East closure was mapped during the same summer by a Survey party, and a detailed seismic survey to completely delineate the Gubik structure was made the following year. No gravity work was done in the Gubik area.

The area of closure on seismic horizon "A," a phantom horizon in the Grandstand formation of Cretaceous age, extends eastward; it is about 12 miles long and has a minimum width of a little over 2½ miles. (See pl. 13.) Closure is at least 400 or 500 feet and average dip on the flanks is about 3°. Seismic reflections were good on the flanks of the anticline, but poor on the crest. Below a depth of 4,000 feet, no satisfactory reflections were obtained; apparently most of the section is shale. No seismic evidence of faulting was noted.

PURPOSE OF TESTS

Gubik test well 1 was drilled near the apex of the Gubik anticline to test the oil and gas possibilities between the surface and the bottom of the sands that are productive on the nearby Umiat anticline (Collins, 1958). Gas in commercial quantities was found at a depth of 890 to 1,750 feet in the sandstones of the Tuluvak tongue in the Prince Creek formation (Upper Cretaceous) and at a depth of 3,350–3,700 feet in the sandstones of the Chandler and Ninuluk formations undifferentiated.

The producing strata at Umiat, the upper and lower sandstone beds of the Grandstand formation, apparently become finer grained eastward and in Gubik test well 1 are represented only by siltstone with a few thin beds of sandstone. Surprisingly good cuts were obtained from the silty clays in cores 42–44 and in core 50 of Gubik test well 1, considering the "tight" nature of these rocks.

Gubik test well 2 was drilled on the south flank of the anticline to test for oil in sands which were gas bearing or showed reservoir properties in Gubik test well 1, to determine the extent of the gas deposit in each gas-bearing sand, and to determine the depths of any gas-oil, gas-water, or oil-water contacts that might be penetrated. Both gas and oil shows were found. A discussion of these shows by C. L. Mohr, chief of

exploration, Arctic Contractors, can be found on page 254. Unfortunately, the well blew out and was abandoned before the testing was completed.

STRATIGRAPHY

The Gubik test wells are about 6,000 feet apart, and there is little difference in the sections penetrated. Each well was drilled through a thin mantle of unconsolidated surficial sediments into the Schrader Bluff formation of Late Cretaceous age. Below this, the drills penetrated the Tuluvak tongue of the Prince Creek formation, the Seabee formation, the Chandler and Ninuluk formations undifferentiated, the Grandstand formation, and finally the Topagoruk formation of Early Cretaceous age. (See fig. 12.)

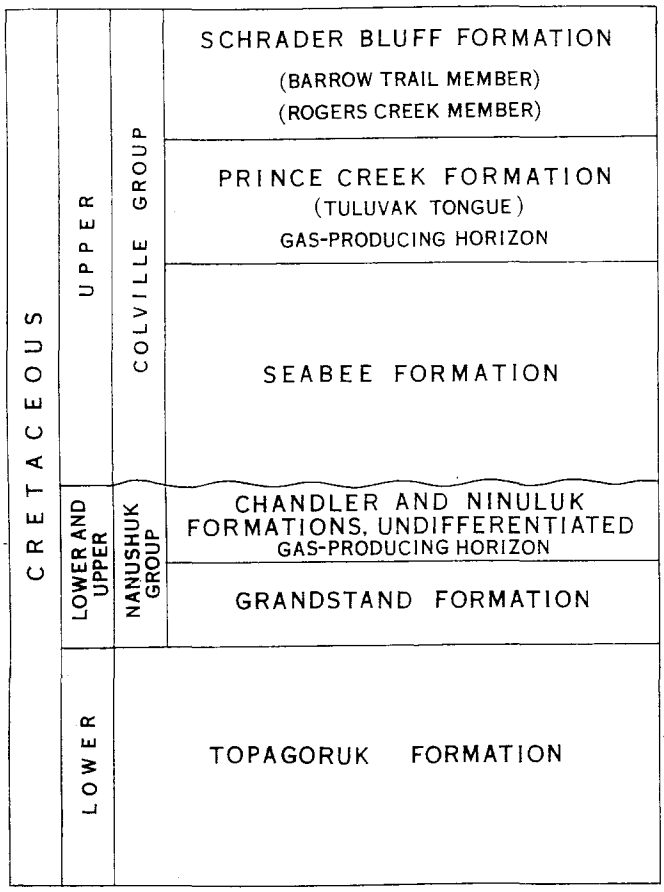


FIGURE 12.—Cretaceous section penetrated on the Gubik anticline.

QUATERNARY DEPOSITS

ALLUVIUM

The first samples received in the Fairbanks laboratory were from the 75-foot depth of Gubik test well 1 and from the 160-foot depth of Gubik test well 2. From the well geologist's description of test well 1, it is assumed that the top 67 feet in that well represents relatively unconsolidated river deposits of sand, gravel, and clay of Recent or possibly of Pleistocene age. Examination of samples received in Fairbanks indicate that the near-surface sands are made up of coarse grains of subangular yellow quartz, white and clear quartz, red chert, dark-gray and black chert, and also rare grains of green chert. The well geologist did not report on the first 160 feet of Gubik test well 2.

CRETACEOUS ROCKS

COLVILLE GROUP (UPPER CRETACEOUS)

SCHRADER BLUFF FORMATION

The Barrow Trail and Rogers Creek members of the Schrader Bluff formation (Late Cretaceous age) are present in the Gubik wells. The Sentinel Hill member, youngest part of the formation, does not occur here.

The Barrow Trail and Rogers Creek members are similar lithologically except that the former has a larger proportion of sandstone. They are distinguished in outcrops largely by topographic expression, because the sandier Barrow Trail member is more resistant to erosion. The total thickness of the two members in the test wells is 823 feet (Barrow Trail, 228 feet thick, at the top of the section, and Rogers Creek, 595 feet thick, at the bottom).

The Schrader Bluff formation consists primarily of soft medium-light-gray clay shale and a total of about 240 feet of siltstone and sandstone. The sandstone beds are very light to light gray and medium hard, with very fine to fine angular to subangular grains, about 85 percent white and clear quartz. Coal particles, dark chert, some biotite, pyrite, and as much as 10 percent opaque white volcanic glass shards make up the remainder of the grains. The matrix is characteristically bentonitic and argillaceous. This reduces permeability although porosity may be relatively high. Structures in the sandstone suggesting worm or mollusk burrows are relatively common in the cores. The sandstones are noncalcareous.

At 336 feet in Gubik test well 2, there is 3 inches of conglomerate made up of rounded black chert granules and pebbles as much as an inch in diameter. Quartz granules are rare. Also present are pelecypod fragments. The pebbles and shell fragments are in a light-gray bentonitic clay matrix.

Seven inches of medium-gray rather hard argillaceous limestone was found near 384 feet in Gubik test well 1. The limestone breaks parallel to the bedding and contains white crystalline calcite in fractures and veins.

Bentonite and tuff are abundant in the section. The tuff is white, very light gray, greenish gray, and pinkish gray. It is hard and contains particles of carbonaceous material, biotite plates, and rare sand grains. Traces and beds of bentonite are fairly common.

The Schrader Bluff formation has a few microfossils and is probably marginal marine. A thick-shelled *Inoceramus*, possibly *I. lundbreckensis* McLearn, is present.

PRINCE CREEK FORMATION

The Tuluvak tongue of the Prince Creek formation underlies the Schrader Bluff formation in the Gubik area. It is 870 feet thick and is made up mostly of sandstone with some conglomerate, clay shale, coal beds, and bentonite.

The sandstone is light gray to medium light gray, soft and friable to moderately hard, and thin bedded to massive. Sandstone in the Tuluvak tongue is coarser grained than any of the older sandstones drilled in the Reserve. The grains are subangular to subrounded and range in size from very fine to very coarse, with a preponderance of the coarser material, including granules and pebbles. Generally, the larger sizes are better rounded. Fifty to eighty-five percent of the sand grains is white and clear quartz, and as much as 40 percent of the total is dark-gray and black chert. The coarser-grained sandstones have the larger proportion of dark chert and consequently have a salt-and-pepper appearance in the hand specimen. Biotite, coal, ironstone, and white feldspar (?) particles, rare yellow quartz (?), pyrite, and rock fragments are the other constituents of the sandstone. The matrix ranges from argillaceous and sideritic to very calcareous. In a few beds the sandstone grades to siltstone. Rare tiny worm burrows similar to those in the Schrader Bluff formation are in the uppermost 50 feet of these beds. The effective porosity of the sandstone in the Tuluvak ranges from 4.4 to 25.4 percent, averaging about 15 percent, and the permeability, from impermeable to 3,780 millidarcys. Gas is present in the Tuluvak tongue.

Conglomeratic layers in the Tuluvak tongue are not common nor very thick. The conglomerate consists of rounded granules and pebbles of black chert and white quartz in a coarse sand matrix.

Twelve percent of the tongue is clay shale which is medium light gray to medium gray and ranges from soft to hard. Most of the clay shale has good cleavage except in the lower part of the section where some claystone is found. Bentonite is common throughout in beds as much as 2 feet thick and is also finely disseminated in the clay shale. This bentonite is soft, white, very light gray, light gray, greenish gray, and bluish gray. The bentonitic shales are softer and of lighter color than the nonbentonitic clay shale. Bentonite is rarely found in the matrix of the sandstones in contrast to the sandstone in the Schrader Bluff formation above, but is, in many places, closely associated with coaly or carbonaceous layers. Carbonaceous laminae, partings, and plant fragments are common in both the clay shale and the sandstone. Coal, mostly in thin beds, is also common. It is shiny to dull and black and is rather brittle. Small amounts of clear yellow amber occur in the coal beds. The clay shale is much darker where associated with carbonaceous material. Thin hard medium-gray limestone layers are very rare. Calcite and aragonite in tiny veinlets in the limestone and clay shale were noted. Clay ironstone nodules and lenses are common in the formation. The Tuluvak section is mostly nonmarine as suggested by the abundance of carbonaceous material, coal, and plant fossils. However, some pelecypods (including *Inoceramus*) Foraminifera, and Radiolaria were found.

SEABEE FORMATION

In the Gubik test wells, 1,545 feet of marine clay shale and a small amount of silty sandstone make up the Seabee formation. In the subsurface the lithologic break between the Prince Creek and the Seabee formations is placed at the base of the major sandstone group and above a distinctive microfauna. (See p. 261.) In the type section (Detterman, *in* Gryc and others, 1956), the Ayiyak member, 360 feet of marine siltstone and sandstone, is described at the top of the Seabee formation. In the Gubik test wells the upper part of the section assigned to the Seabee formation is also partly sandy and probably represents the Ayiyak member. However, regional correlations in the subsurface suggest that there may be a small unconformity at the top of the Seabee formation, and because the boundaries of this member cannot be clearly defined lithologically in the subsurface at Gubik, the term "Ayiyak member" is not used here.

The 100 feet or so of sandy beds in the uppermost part of the Seabee formation contains marine pelecypods and some microfossils. The sandstone is light to medium light gray, rather hard, and silty to fine grained and shows fair porosity but very low permeability; some has very calcareous cement. The sandstone contains 80 percent of white and clear quartz, and 20 percent of dark chert, rock fragments, coal particles and mica. The sandstone grades downward into silty and argillaceous beds.

Below this clastic unit is 900 feet of clay shale with scattered thin beds of siltstone. In the upper third of the Seabee formation the clay shale is medium light gray but becomes medium gray lower in the section; on the whole the shale is darker than the shale of other Upper Cretaceous formations. Slightly silty beds are common. White bentonite and light-colored bentonitic shale are also found.

In certain parts of the 900-foot shaly Seabee formation, the clay shale is medium dark gray, breaks easily

parallel to the bedding, and characteristically is associated with thin beds and partings of light-colored bentonite, laminae of limestone and aragonite, thin-shelled *Inoceramus labiatus?* fragments and prisms, and fishbone fragments. These beds are probably correlative with the dark "paper shales" that crop out in the Umiat area and are lithologically distinctive in the Cretaceous section. The section between 3,040 and 3,100 feet in Gubik test well 2 is a good example of these beds.

Silty clay shale, siltstone, and sandstone make up the lowest 500 feet of the Seabee formation. The lower sandstone beds of this formation are light gray, hard, massive, and very fine to medium grained. The grains are subangular to subround, and 70–95 percent are white and clear quartz. Other constituents are chert, coal particles, rock fragments, and mica. Over a wide area these beds rest unconformably upon the Nanushuk group and closely resemble the sandstone of that group; they may represent reworked material from the older rocks. They can be differentiated from the sandstones of the Nanushuk group by the abundance of biotite plates, rock particles, and generally a very "dirty" matrix. A large part of the sandstone is silty and grades into siltstone. Argillaceous beds are the same as those described above in the 900-foot shaly part of the Seabee. Bentonite and limestone beds and fish fragments are rare. *Inoceramus* prisms and fragments are common in both the core and cuttings. Mollusklike borings appear in the siltstone. "Swirly" beds present are the result of slump or deformation at the time of deposition. In one core a broken *Inoceramus* shell is embedded vertically in the distorted beds. The beds are noncalcareous to moderately calcareous, and porosity is fair, but permeability is very low. They are not good reservoir rocks and have very few shows of gas or oil.

NANUSHUK GROUP (LOWER AND UPPER CRETACEOUS)

CHANDLER AND NINULUK FORMATIONS UNDIFFERENTIATED

Below the Seabee formation is 440 feet designated as the Chandler and Ninuluk formations undifferentiated. The marine Ninuluk formation is the time equivalent of the upper part of the nonmarine Chandler formation (Robinson, 1956, fig. 3). The upper 60 feet is definitely marine and could be assigned to the Ninuluk formation as both marine megafossils and microfossils typical of the Ninuluk formation were found. However, in the rest of the section the proportion of marine to nonmarine rocks cannot be determined; so the entire 440 feet has not been divided.

The sandstones of the Nanushuk group are similar to those of the Seabee formation above; sandstones of the Nanushuk, however, contain a smaller amount of argillaceous material in the matrix and are less calcareous. The grain size is also slightly coarser than that in the Seabee formation. Carbonaceous material and clay ironstone are more common. The break between the Colville and Nanushuk groups is picked on the basis of lithologic evidence, as well as on a major change in microfauna and a change in heavy-mineral zones.

The Chandler and Ninuluk section, the lower of the two gas-producing beds in the Gubik anticline, is 86 percent of sandstone and siltstone and 14 percent of clay shale. The sandstone is light gray to medium light gray, hard, and mostly massive with irregular fracture. The grains range from silt to medium sand and are composed of 75–90 percent of white and clear quartz and varying amounts of dark-colored chert, coaly particles, mica, and rock fragments. Chalky white-weathered chert or feldspar particles, pyrite, and garnet are rare. The matrix is argillaceous and locally calcareous. At 3,603 feet in Gubik test well 1, the carbonate content is 38.3 percent by weight, but this high percentage is unusual.

The effective porosity of the sandstone beds ranges from 1.6 to 15.1 percent, and the permeability, from impermeable to 265 millidarcys. The sandstone at about 3,500 feet in Gubik test well 1 and at about 3,800 feet in Gubik test well 2 has the best porosity stone and permeability.

The siltstone is similar in composition to the sandstone but is medium light gray and more regularly bedded. Crossbedding, ripple marks, and "swirly" bedding were noted. Carbonaceous partings and very rare thin shiny black coal beds are present. Nodules and laminae of olive-gray and yellowish-gray clay ironstone are typical of the section.

The clay shale is medium to medium dark gray and moderately hard, has good cleavage, is finely micaceous, and has micaceous and carbonaceous partings. A small amount of the shale could be called claystone as it has poor or no cleavage.

A foot of hard medium-gray limestone occurs at 3,890 feet in Gubik test well 2. This limestone contains a thin vein of white calcite. The only occurrence of bentonite (very light gray) is in the well cuttings at about 3,655 feet in Gubik test well 1. A 3-inch bed containing abundant white oolites was found in Gubik test well 2 at 3,734 feet. The matrix and some of the oolites are very calcareous; other oolites appear to be composed of weathered chert and still others are coated with pyrite.

GRANDSTAND FORMATION

The transition from Chandler and Ninuluk formations undifferentiated to the Grandstand formation is gradational. The top of the predominantly marine

429370—58——2

Grandstand formation is marked approximately by the first appearance of the microfossils and megafossils of the *Verneuilinoides borealis* faunal zone.

The Grandstand formation is 580 feet thick and composed of clay shale with about 30 percent of siltstone and sandstone. The clay shale is medium to medium dark gray and moderately hard and has fairly good cleavage. A small proportion of it has poor cleavage. It is finely micaceous and has rare micaceous-carbonaceous partings as in the formation above. It is interbedded and gradational with siltstone beds.

The remaining beds are silty clay shale, siltstone, and silty sandstone. The color ranges from light to medium gray, depending on the amount of sand; the more sand the lighter the color. The sand grains range from very fine to fine. Eighty-five percent or more is composed of subangular to subrounded white and clear quartz grains. The sandy, silty beds range from noncalcareous to calcareous. All beds tested were impermeable or had a permeability of less than 1 millidarcy. Effective porosity ranges from 3.9 to 11.1 percent. Good oil cuts were obtained from the more clastic beds. The sandstone of the Grandstand formation can be correlated with the producing beds at Umiat (Collins, 1958), but reservoir conditions, where tested on the Gubik anticline, are much poorer. The sandstones become finer grained northeast from Umiat.

There is a trace of bentonite or bentonitic clay shale in the upper part of the Grandstand formation. Thirty percent of a ditch sample at 4,130 feet in Gubik test well 2 is light-bluish-gray bentonite containing numerous plates of biotite and scattered subangular grains of quartz. Clay ironstone is very rare in the section, and carbonaceous or coaly partings are uncommon.

TOPAGORUK FORMATION

The oldest rocks reached by the Gubik test wells are in the Topagoruk formation. Gubik test well 1 was drilled through 1,685 feet, which was almost entirely clay shale; the bottom of the formation was not reached. Much of the clay shale is silty, but less than 75 feet is siltstone. Sandstone beds are very rare. The contact between the Topagoruk and Grandstand formations is arbitrarily drawn where a much higher percentage of siltstone and sandstone is noticeable. There is no sharp break between the two formations.

The clay shale of the Topagoruk formation is mostly medium to medium dark gray, although lighter gray beds containing bentonite are present. The shale is moderately hard and has fair to excellent cleavage. It is silty and interbedded with numerous thin beds and partings of medium-light-gray siltstone. The proportion of silt in the clay shale decreases with depth, and in the lowest part of the formation penetrated, silt is essentially absent. The few massive siltstone beds found are medium light gray and resemble those of the Grandstand formation.

White bentonite and bentonitic clay shale are quite common in the upper half of the formation drilled. Traces of coal also occur in this formation. Except for a calcareous matrix in a few silty beds, a trace of aragonite, and a trace of clay ironstone, carbonates are lacking in the Topagoruk formation.

A slight show of oil and gas was obtained from silty beds in this formation in core 50 at 5,441 feet of Gubik test well 1. Megafossils and microfossils of the *Verneuilinoides borealis* faunal zone are present and the formation is marine in origin.

HEAVY-MINERAL STUDIES

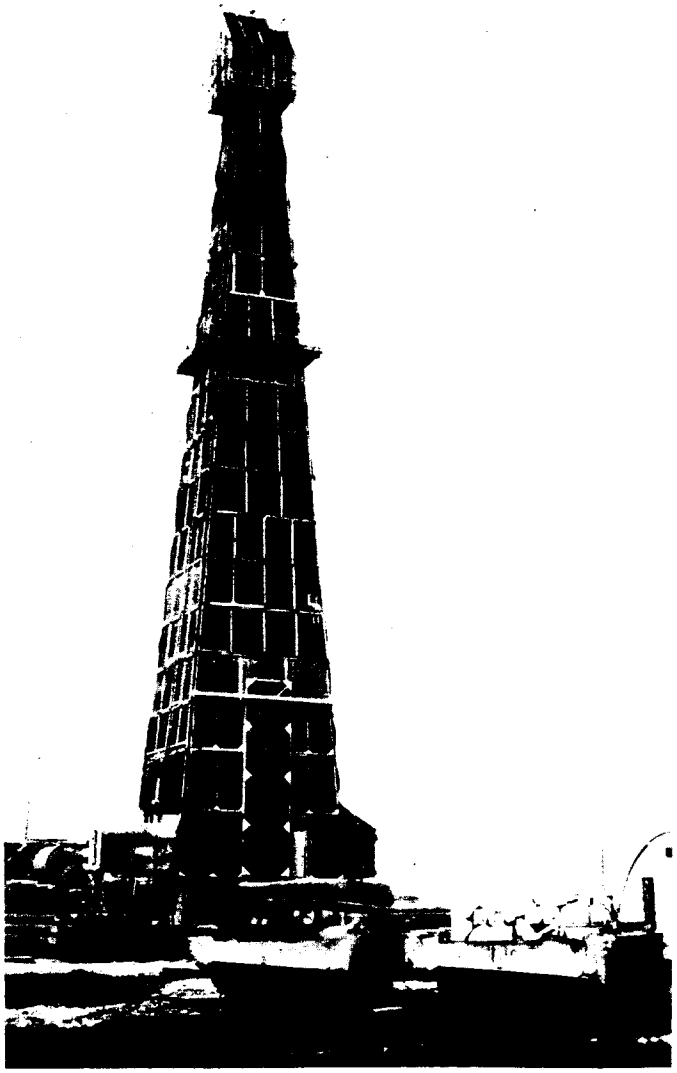
Sixty-two heavy-mineral samples were taken from the two Gubik test wells and were analyzed by R. H. Morris as a part of his study of the heavy minerals of Naval Petroleum Reserve No. 4. He concludes that biotite and hornblende heavy-mineral zones are represented in the holes. The method of preparing samples and a short description of the various heavy-mineral zones (written before the Gubik wells were drilled) may be found in Morris and Lathram (1951). In Gubik well 1 the biotite zone ranges from 360 to 3,280 feet, and the hornblende zone, from 3,340 to 3,600 feet. In Gubik well 2 the biotite zone ranges from 320 to 3,540 feet, and the hornblende zone, from 3,620 to 4,080 feet. The biotite zone coincides with the Colville group, and the hornblende zone, with the upper part of the Nanushuk group. Figure 13 shows the range and abundance of biotite and hornblende and the other heavy minerals which were used to define the zones.

GUBIK TEST WELL 1

Location: Lat 69°26′46″ N., long 151°28′06″ W.
Elevation: Ground, 144 feet; kelly bushing, 156 feet.
Spudded: May 20, 1951.
Completed: August 11, 1951, plugged and abandoned.
Total depth: 6,000 feet.

Gubik test well 1 was drilled on the west side of the Chandler River (see pl. 14) a little more than a mile above its junction with the Colville River. The latitude and longitude given for this well and for Gubik test well 2 are subject to correction, because detailed topographic surveys had not been made of the area at the time the holes were located.

A. WELL AND CAMP BESIDE CHANDLER RIVER



B. DRILLING RIG

GUBIK TEST WELL 1

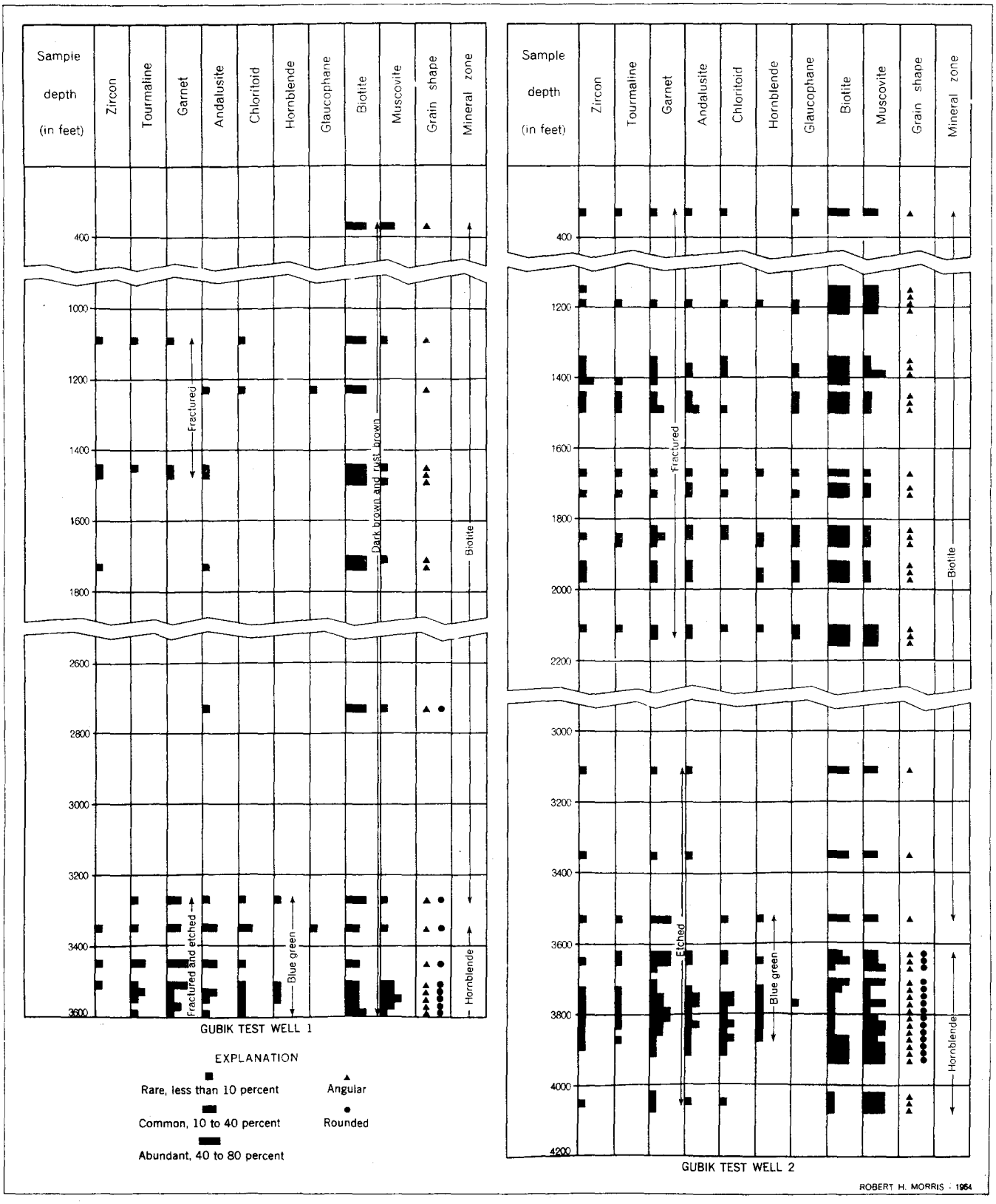


FIGURE 13.—Relative abundance of heavy minerals in the Gubik test wells.

The formations in this well are given in the following table:

Formations present in Gubik test well 1

Formation	Depth (feet below kelly bushing)
Gubik	12–67
Schrader Bluff:	
Barrow Trail member	67–295
Rogers Creek member	295–890
Prince Creek, Tuluvak tongue	890–1, 760
Seabee	1, 760–3, 305
Chandler and Ninuluk undifferentiated.	3, 305–3, 735
Grandstand	3, 735–4, 315
Topagoruk	4, 315–6, 000 (total depth)

As could be expected near the crest of an anticline, the dip of the beds, as determined by cores from the Barrow Trail member of the Schrader Bluff formation down through the Grandstand formation, averages less than 2°. Many of the beds are flat lying. One notable exception is near 1,717 feet, where dips of 25°–30° are associated with slickensides. Another exception is the dip of 43° recorded at 2,513 feet, where steep slickensides were also noted.

Dips in the Topagoruk formation are much steeper, averaging 10° or more. The rocks at 5,107 feet were fractured and have polished slickensided surfaces and steep dips. A few poorly developed slickensides were noted at 5,446 and 5,448 feet. Dip and hole deviations are recorded on plate 1.

DESCRIPTION OF CORES AND CUTTINGS

All depths are measured from the top of the rotary drive bushing, which was 12 feet above the surface of the ground. The material in this test and in Gubik test well 2 was described dry; colors were determined by comparison with the Rock Color Chart distributed by the National Research Council (Goddard and others, 1948). The term "trace" as used here means less than 3 percent and in most places less than 1 percent. Clay ironstone is a dense and rather hard sideritic mudstone that generally effervesces very slowly in cold dilute hydrochloric acid.

The abundance of microfossil specimens listed at the beginning of each core description is defined as follows: 1–4 very rare, 5–11 rare, 12–25 common, 26–50 abundant, and over 50 very abundant.

Well cuttings above 75 feet were not received by the Fairbanks laboratory, but contamination of the highest samples received indicate that near-surface sands are made up of coarse grains of subangular yellow quartz, white and clear quartz, red chert, dark-gray and black chert, and rare green chert. The well geologist reported the following rock depths:

	Depth (feet below kelly bushing)
Rotary drive bushing above ground	0–12
Sand and gravel	12–52
Clay	52–55
Coarse sand	55–67
Shale—The contact between the Gubik formation and the Barrow Trail member of the Schrader Bluff formation is placed at 67 feet	67–75

The following well log description was made by the author in the Fairbanks laboratory:

Lithologic description

[Where no core is listed, description is based on cutting samples]

Core	Depth (feet)	Description
----	75–95	Clay shale, medium-light-gray, with traces of light-gray siltstone and white bentonite; rare *Inoceramus* prisms.
----	95–125	Sandstone, very light-gray, dirty, very fine-grained to silty; subangular grains; contains 75 percent (estimated) white and clear quartz, 10 percent opaque white volcanic glass shards, also dark rock fragments, chert, biotite and scattered yellow quartz, argillaceous bentonitic cement.
----	125–135	Siltstone and some very fine-grained sandstone, very light-gray, rather hard; coaly particles in sand and coaly partings; trace bentonite.
----	135–165	Silty clay shale or argillaceous siltstone, light- to medium-light-gray, rather hard; with biotite, coal particles, trace bentonite.
----	165–195	Clay shale, medium-light to medium-dark-gray; trace siltstone at top of unit.
----	195–235	Sandstone, very light- to light-gray, fine-grained, soft; subangular grains, 85 percent white and clear quartz; also dark chert, coal particles, biotite, rare volcanic shards; argillaceous bentonitic matrix. *Inoceramus* fragment at 205-215 ft.
----	235–265	Clay shale, medium-dark-gray, particularly at base of unit, plus sandstone as above. *Inoceramus* at 245–255 ft.
----	265–295	Siltstone, light- to medium-light-gray, soft; black carbonaceous partings; *Inoceramus* prisms at 275–295 ft.
----	295–345	Clay shale, medium-light- to medium-gray, trace siltstone at 295–325 ft and 335–345 ft plus 40 percent very light- to light-gray siltstone at 325–335 ft. Top of Rogers Creek member of Schrader Bluff formation placed at 295 ft.

Lithologic description—Continued

Core	Depth (feet)	Description
----	345–355	Tuff, light-greenish-gray, hard, dense; speckled with tiny particles of black carbonaceous material.
----	355–365	Sandstone, light-gray, fine-grained; 90 percent quartz; some dark chert; carbonaceous particles.
1	365–385	Recovered 17 ft: Microfossils very rare. 7 ft 9 in., sandstone, very light- to light-gray, fine-grained, medium-hard, massive; mostly subangular grains, 85 percent white and clear quartz, also coal particles, dark chert, and a very small amount of pyrite and fluted opaque white volcanic glass shards. Matrix made up of soft light-colored bentonitic clay containing abundant brown biotite plates. Very slightly calcareous; dip undetermined; no shows. At 371 ft effective porosity 14.88 percent parallel to bedding and 14.93 percent normal to bedding. Samples impermeable. 7 ft 9 in., interbeded sandstone, 85 percent, and clay shale. Sandstone same as described above. Clay shale is medium light to medium gray and medium hard; contains numerous particles of carbonaceous material and biotite plates, and occurs as laminae a few inches thick in the sandstone; laminae are irregular, lenticular, and have erratic dips with a slight tendency toward swirly bedding in spots. A small piece of a thick-shelled *Inoceramus* cf. *I. lundbreckensis* McLearn found at 381 ft; dip 7° (?); noncalcareous; no shows. 11 in., clay shale, medium-light-gray, slightly silty; medium-soft, fair cleavage; part of the shale contains multiple, small, elongated (flat and parallel to bedding) fragments of medium-gray clay; very rare carbonaceous partings. 7 in., limestone, medium-gray, argillaceous and medium hard; fractures parallel to bedding; contains white crystalline calcite in a vein or fracture plane.
----	385–395	Sandstone, light-gray, and medium-gray clay shale.
----	395–545	Clay shale, medium-light to medium-gray; trace siltstone at 395–415 and 435–445 ft; trace white aragonite at 515–525 ft; mollusk shell fragment at 415–425 ft; chunk of thick *Inoceramus* prisms at 445–455 ft.
----	545–555	Sandstone, very light-gray, very fine-grained; subangular grains, 90 percent white and clear quartz, also rock fragments, dark chert, some volcanic shards; argillaceous bentonitic matrix.
----	555–565	Siltstone, light-gray, bentonitic matrix.
----	565–575	Siltstone, light-gray, and medium-light-gray clay shale.
----	575–585	Siltstone, light-gray, bentonitic matrix.
----	585–595	Clay shale, very light-to light-gray, silty.
----	595–605	Siltstone and very fine-grained sandstone; considerable amount of biotite, bentonitic matrix.
----	605–655	Clay shale, medium-light-gray.
----	655–665	Clay shale, medium-light-gray, and very light-gray siltstone, with bentonitic matrix.
----	665–731	Clay shale- medium- to medium-dark-gray; trace pyrite at 665–695 ft; trace light-gray siltstone at 705–715 and 725–735 ft; thick-shelled *Inoceramus* at 675–685 ft.
2	731–751	Recovered 20 ft: Microfossils abundant. 10 ft 9 in., claystone, medium-gray, slightly silty, hard; no cleavage but fractures roughly parallel to bedding; very rare light-gray bentonitic partings, but texture and color mostly uniform; rare vermicular pyritic streaks; noncalcareous; dip 1°. 7 in., bentonite, very light-gray, medium-soft when dry, irregular fracture. 2 ft 11 in., claystone, as above. 2 in., bentonite, light-gray with slight greenish cast. 5 in., claystone as above. 10 in., bentonite, light-greenish-gray; medium-soft when dry; fractures easily. 4 ft 4 in., claystone, as in first part of this core.
----	751–845	Clay shale, medium-light- to medium-gray; trace of light-gray siltstone at 785–795 and 815–825 ft.
----	845–890	Clay shale, medium-light- to medium-gray; rare round black-chert granules noted at 845 ft; trace siltstone at 865–875 ft.
----	890–920	Sandstone, light-gray, fine-grained, rather soft; 95 percent white and clear quartz; rare rock fragments, chert; pyrite fairly common, slightly calcareous; matrix argillaceous but not bentonitic. Rare medium sand grains, and rare subrounded black-chert granules; 10 percent clay shale at base of sandstone. Top of the Tuluvak tongue of Prince Creek formation placed at 890 ft.
----	920–940	Clay shale, medium-gray; also fairly large amount of very fine- to fine-grained light-gray sandstone, slightly to moderately calcareous.
----	940–950	Sandstone, light-gray, fine-grained; subangular grains, 90 percent white and

Lithologic description—Continued

Core	Depth (feet)	Description
		clear quartz; also dark chert and rock fragments; exceedingly rare very coarse rounded dark-chert grains; pyrite very common; argillaceous matrix, slightly calcareous.
----	950–960	Siltstone and very fine-grained sandstone, medium-light-gray
----	960–1, 060	Clay shale, medium-gray and rare medium-light-gray; trace siltstone at 970–980 ft.
----	1, 060–1, 070	Coal, dull to subvitreous, black; platy cleavage.
----	1, 070–1, 086	Clay shale, medium-gray; trace of medium-light-gray siltstone; about 10 ft of coal.
3	1, 086–1, 106	Recovered 20 ft: Microfossils absent. 19 ft, sandstone, light-gray with very light-gray streaks, medium-grained, hard, partly massive; 85 percent white and clear quartz; also some dark-gray chert, rare coal grains; grains subangular; slightly to very calcareous cement. Very light-gray streaks represent laminae in which the calcareous material is concentrated; very rare, thin partings of black carbonaceous material. Slickensides of 17° and 30° noted at 1,100–1,101 ft. Beds dip as much as 15° in the vicinity of these slickensides; dips elsewhere are variable, averaging about 6°. Faint odor, very pale cut and pale-yellow residue from 1,087 and 1,096 ft. At 1,087 ft, effective porosity 21.1 percent; air permeability 166 millidarcys, and carbonate content, 9.3 percent by weight. At 1,096 ft the determinations parallel to bedding are as follows: 7.93 percent, impermeable, and 22.04 percent by weight. At 1,096 ft, normal to bedding, they are 7.88 percent and impermeable. 1 ft, conglomerate with matrix of sandstone of same type as described above. Pebbles and granules consist entirely of black chert and white quartz with a slightly larger proportion of the former. They are well-rounded, and range from ⅛ to ½ in. in diameter. Constituents of this conglomerate are well sorted, primarily medium-sized sand grains and pebbles of the size mentioned above, with very little of intermediate grades. Cemented by calcareous material.
----	1, 106–1, 155	Conglomerate and sandstone, light-gray, medium-grained; pebbles and some granules of black chert and white quartz, rounded; some of the sandy matrix is coarse grained.

Lithologic description—Continued

Core	Depth (feet)	Description
4	1, 155–1, 163	Recovered 8 ft: Microfossils absent. 8 in., coal, shiny to dull black, platy cleavage. 2 ft 7 in., clay shale, light-gray, medium soft, very bentonitic; fair cleavage. At about 1,157 ft., 2 in. of shale impregnated with prismatic crystals of white calcite or aragonite in laminae parallel to bedding plane. Rest of the clay shale is noncalcareous and grades down into bentonite. 2 ft 9 in., bentonite, light-gray, argillaceous; similar to clay shale immediately above; contains minute brown-biotite plates. 2 ft, sandstone, medium-light-gray, very fine- to fine-grained, very hard and tight; probably has siliceous rather than calcareous cement; mostly quartz; a few dark minerals including a little biotite; noncalcareous; dip 1°.
5	1, 163–1, 175	Recovered 12 ft: Microfossils absent. 8 in., bentonite, very light-gray with slight greenish cast; soft and crumbly when dry; swells to unctuous mass when moistened with water; contains numerous biotite plates. 4 ft 10 in., sandstone, medium-light-gray, similar to sandstone of core 4 but softer, very bentonitic, and contains more biotite; grades into clay shale in places; dip 5°. 2 ft, clay shale, medium-light-gray, fair cleavage, medium-soft; contains streak of light-gray bentonite; noncalcareous; dip 3°. 1 ft 9 in., bentonite or very bentonitic clay, very light-gray, poor cleavage, with subconchoidal fracture; biotite plates abundant. 2 ft 9 in., clay shale, medium- to medium-dark gray, noncalcareous, slightly bentonitic; fair cleavage.
----	1, 175–1, 185	Clay shale, medium- to medium-dark-gray; trace sandstone and clay ironstone.
----	1, 185–1, 195	Bentonite, white, and very light-gray; very bentonitic clay shale; also medium-light-gray clay shale; trace yellowish-gray-clay ironstone.
----	1, 195–1, 205	Clay shale, light-olive-gray, about a quarter of sample is subvitreous black coal; trace light-gray bentonite.
----	1, 205–1, 218	Sandstone, medium-light-gray, medium-grained, rather soft and friable; salt-and-pepper, noncalcareous; 80 percent white and clear quartz; rest dark chert and rock fragments, coal particles, white chalky material, rare biotite. Also trace coal and medium-dark-gray clay shale.

Lithologic description—Continued

Core	Depth (feet)	Description
6	1, 218–1, 238	Recovered 20 ft: Microfossils absent. Sandstone, light-gray, fine- to medium-grained, moderately soft to very soft and friable; subangular grains, 80 percent white and clear quartz; remainder mostly dark-gray chert and some white chert (?), and scattered partings and thin laminae of abundant black coal particles; slightly to moderately calcareous. Fleeting oil odor and slight yellow greasy stain in evaporating dish from sample at 1,224 ft. At 1,232 ft effective porosity 20.5 percent; no permeability test was run because sample plug was too irregular. Other samples at same depth had permeability of 407 millidarcys parallel the bedding and 357 millidarcys normal to the bedding. Carbonate content at 1,232 ft is 7.49 percent.
----	1, 238–1, 248	Sandstone as above.
----	1, 248–1, 278	Clay shale, medium-olive-gray; up to 20 percent sand.
----	1, 278–1, 288	Clay shale, medium-light-olive-gray to medium-olive-gray and light-gray fine- to medium-grained, soft, salt-and-pepper sandstone; trace of coal and very light-gray bentonite.
----	1, 288–1, 308	Sandstone, light-olive-gray, very fine- to fine-grained; and conglomerate with rounded black, dark-gray, and red-chert granules. Sandstone slightly to moderately calcareous with sideritic matrix; trace bentonitic-clay shale and trace coal.
----	1, 308–1, 328	Siltstone, medium-light-olive-gray, noncalcareous; trace very fine sandstone and of ironstone.
----	1, 328–1, 338	Conglomerate, very fine-grained sandstone and medium-dark-olive-gray clay shale; chert granules; trace coal.
----	1, 338–1, 348	Clay shale, medium-light-olive-gray.
----	1, 348–1, 358	Bentonite, very light-gray with slight greenish tinge; also medium-light-olive-gray clay shale.
----	1, 358–1, 398	Clay shale, medium-light-gray and medium-olive-gray; trace bentonite at 1, 358–1, 378 ft; trace coal at 1,378–1,388 ft; trace medium-grained sandstone at 1,388–1398 ft.
----	1, 398–1, 418	Clay shale, medium-olive-gray and medium-dark-gray; also considerable amount of light-gray to pale-yellowish-brown sandstone with sideritic matrix, salt-and-pepper, fine- to medium-grained, 80 percent quartz.
----	1, 418–1, 444	Clay shale, medium-light-olive-gray; trace coal.

Lithologic description—Continued

Core	Depth (feet)	Description
7	1, 444–1, 457	Recovered 11 ft: Microfossils absent. 5 ft, sandstone, light-gray, rather soft and friable, very fine- to coarse-grained; grain size gradually becomes coarser with depth; salt-and-pepper, particularly in larger size range with white and clear quartz and dark-gray chert; some argillaceous material; scattered black plant impressions; noncalcareous. 6 ft, conglomerate, medium-light-gray; very coarse sand and granules plus a few small pebbles; size increases with depth; rather soft and friable; consists almost entirely of 50 percent light quartz and 50 percent dark subrounded chert granules; argillaceous to very slightly calcareous cement. This core is an excellent example of graded bedding from coarse at base to fine at top. Faint odor, very pale cut and very pale-yellow residue from 1,450 ft. At 1,447 ft effective porosity, 22 percent; air permeability 376 millidarcys; and carbonate content 5.34 percent by weight. At 1,450 ft porosity 24.4 percent; sample too soft to determine permeability and was noncalcareous.
8	1, 457–1, 469	Recovered 3 ft: Microfossils absent. Sandstone, light- to medium-light-gray, medium-hard; grains coarse to granule size, subrounded to subangular; 50 percent white and clear quartz, 50 percent dark-gray chert, very calcareous cement in part; dip 4°. Faint to fair odor; very pale cut and very pale-yellow residue from 1,458 ft. At 1,458 ft, effective porosity is 7.77 percent, parallel to bedding, and 6.48 percent, normal to bedding. Both samples were impermeable; the carbonate content was 25.6 percent by weight. *Inoceramus* prisms (in microfossil cut).
9	1, 469–1, 475	Recovered 3 ft: Microfossils absent. 2 ft 9 in., sandstone as above, coarse- to very coarse-grained, rare granules; noncalcareous cement. Faint to fair odor, pale-straw-colored cut, yellow residue from 1,471 ft. At 1,471 ft, effective porosity 20 percent parallel to bedding, and air permeability 988 millidarcys; normal to bedding readings were 20.1 percent and 570 millidarcys. Carbonate content at this depth 7.05 percent by weight. 3 in., coal, shiny-black with platy fracture.

Lithologic description—Continued

Core	Depth (feet)	Description
10	1,475–1,495	Recovered 20 ft: Microfossils absent. 5 ft, clay shale, medium-gray to dark-gray, medium-hard; poor cleavage; scattered lighter colored silty streaks; dark color of some portions is due to abundance of finely disseminated carbonaceous material and a few black plant impressions. 2 ft, sandstone, light-gray, as described in lowest segment of this core; rare plant impressions. Slight petroliferous odor. 3 ft 4 in., clay shale as in first part of this core. The plant *Credneria elegans* Hollick found at 1,484 ft. 9 ft 8 in., sandstone, light-gray, medium-grained, hard, massive, irregular fracture; salt-and-pepper with light quartz and dark chert; other minerals rare; slightly calcareous cement; dip undetermined. Faint to fair odor, pale-straw-colored cut and pale-yellow residue from 1,491 ft. At 1,491 ft effective porosity 16.37 percent and air permeability 19 millidarcys parallel to bedding. Normal to bedding readings are 14.85 percent and 13 millidarcys. Carbonate content 13.9 percent by weight.
----	1,495–1,525	Sandstone, light- to medium-light-gray, fine-grained, very porous, noncalcareous; mostly white and clear quartz grains with rare chert granules; conglomeratic from 1,505–1,515 ft with very coarse sand, and subangular to rounded granules of black chert, yellow chert, and white quartz.
----	1,525–1,535	Clay shale, very light-gray, bentonitic, and white bentonite.
----	1,535–1,545	Sandstone, light-gray, fine-grained; 90 percent white and clear quartz grains; slightly calcareous; 5 percent of this sample is coal.
----	1,545–1,555	Clay shale, dark-gray and 20 percent coal.
----	1,555–1,585	Coal, dull to subvitreous, black, flaky, some dark-gray siltstone, and trace medium-grained dark-gray sandstone at 1,555–1,565 ft; trace light-gray fine-grained sandstone and medium-dark-gray clay shale at 1,575–1,585 ft.
----	1,585–1,645	Sandstone, light-gray, very fine- to very coarse-grained; 60 percent white and clear quartz grains, 30 percent dark-gray chert and coal particles; the grains subangular to subrounded, largest are roundest; noncalcareous, very soft, friable and porous. Trace coal at 1,605–1,615 and 1,625–1,635 ft.
----	1,645–1,655	Sandstone as above, 20 percent dull to subvitreous black coal and 15 percent white bentonite; trace medium-gray clay shale.
----	1,655–1,665	Clay shale, medium-dark-gray; trace sandstone.
----	1,665–1,711	Sandstone, light-gray, fine- to very coarse-grained; fine grains mostly white quartz, as much as 50 percent dark chert in sample at 1,685–1,695 ft.
11	1,711–1,718	Recovered 7 ft: Microfossils absent. 1 ft 3 in., sandstone, light-gray, conglomerate, medium-soft and friable. The sand grains are medium-sized and subangular; 80 percent white and clear quartz grains; some mica, coal particles, and dark chert; sandstone contains angular fragments of shiny-black coal as much as 2 in. in diameter, rare rounded black-chert pebbles and angular medium-gray clay fragments; argillaceous cement; noncalcareous. At 1,712 ft, effective porosity 29 percent, but sample was too soft for permeability tests. Kerosenelike odor, yellow cut, and brownish-yellow residue from 1,712 ft. 4 ft 11 in., clay shale, dark-gray, medium-hard; good cleavage; dark color apparently due to finely disseminated carbonaceous material; also minute flakes of mica, some pyrite; vertical fracture; contains rare thin laminae of pale-yellowish-brown clay ironstone and very rare fishbone fragments; noncalcareous. Slickensides at base; dip of beds just above slickensides 25°; dip at top of 8°. 10 in., sandstone, light-gray; similar to first unit of this core, with scattered pebbles of black chert only; noncalcareous; dip 30°; petroliferous odor. *Inoceramus* prisms in microfossil cut.
----	1,711–1,723	Sandstone, fine- to coarse-grained, also 20 percent coal.
12	1,723–1,738	Recovered 11 ft: Microfossils absent. Sandstone, light-gray, fine- to rarely medium-grained, hard, massive; grains subrounded to angular, 95 percent white and clear quartz; some mica, coal, and dark chert; rock has slight yellowish stain in spots; noncalcareous; dip 1°. At 1,730 ft parallel to bedding, effective porosity 19.55 percent, and air permeability 39 millidarcys. It is 18.7 percent and 8 millidarcys normal to bedding. Kerosenelike odor, yellow cut, and brownish-yellow residue from 1,730 ft. *Inoceramus* prisms in microfossil cut.

Lithologic description—Continued

Core	Depth (feet)	Description
----	1,738–1,760	Sandstone, medium-light-gray, fine- to coarse-grained, very soft; 95 percent white and clear quartz grains, with biotite and coal particles; noncalcareous. Trace coal and dark-gray clay shale.
----	1,760–1,770	Siltstone, medium-light-gray, and light-gray sandstone; contains biotite; moderately to very calcareous. Top of Seabee formation placed at 1,760 ft.
----	1,770–1,790	No sample.
----	1,790–1,830	Clay shale, medium-light-gray; trace sandstone at 1,800–1,810 ft; trace coal at 1,810–1,820 ft.
----	1,830–1,840	Clay shale, medium-light-gray, and approximately 40 percent very calcareous sandstone.
----	1,840–1,856	Sandstone, medium-light-gray, fine-grained, porous, very soft; grains subrounded to subangular, mostly white and clear quartz, some chert and biotite; slightly calcareous.
13	1,856–1,877	Recovered 10 ft: Microfossils absent. 3 ft, sandstone, light-gray, fine-grained, slightly calcareous, medium-soft; excellent cleavage parallel to bedding; subangular grains composed of 70 percent white and clear quartz; biotite and chlorite common; dark chert and rock fragments also present; dip 1° or less. 7 ft, sandstone and siltstone, light-gray, medium-soft; of same composition as above; no cleavage. This part of recovery is broken into pieces averaging about 2 in. in diameter. Slightly calcareous.
14	1,877–1,897	Recovered 10 ft: Microfossils absent. Siltstone and sandstone, light-gray with fairly good cleavage in part; sandstone very fine-grained and 50 percent quartz. Biotite and other mica minerals extremely abundant; coal particles also present; some dark-carbonaceous partings; slightly calcareous; dip 1°.
----	1,897–1,970	Clay shale, medium-light-gray, micaceous; contains traces of sandstone and siltstone throughout.
----	1,970–1,980	Sandstone, medium-light-gray, fine- to medium-grained; angular to subangular grains, 85 percent white and clear quartz, 15 percent dark-gray to black chert (salt-and-pepper), very small amount of yellow quartz; trace medium-gray clay shale.
----	1,980–2,040	Clay shale, medium-light-gray trace very fine-grained sandstone and siltstone at 2,000–2,040 ft; sandstone slightly to moderately calcareous at 2,010–2,020 ft.

Lithologic description—Continued

Core	Depth (feet)	Description
----	2,040–2,050	Clay shale, medium-light to medium-gray about 40 percent light-gray very fine- to fine-grained sandstone; contains scattered biotite and coal particles and is slightly calcareous; trace very light-gray bentonite with biotite plates.
----	2,050–2,185	Clay shale, medium-gray. Trace sandstone at 2,130–2,150 ft and 2,160–2,180 ft. Trace siltstone at 2,060–2,070 ft, 2,080–2,130 ft (moderately calcareous at 2,110–2,130 ft), and 2,150–2,160 ft. Trace to 10 percent bentonite or bentonitic clay, light gray at 2,080–2,090 ft, 2,110–2,120 ft and 2,150–2,160 ft. Trace coal at 2,070–2,080 ft.
15	2,185–2,200	Recovered 10 ft: Microfossils absent. Clay shale, medium-gray, noncalcareous, medium-hard, fair to good cleavage with subconchoidal fracture; lighter colored silty laminae which show small scale crossbedding; very rare scattered brown fish fragments noted; dip 0.5°.
----	2,200–2,250	Clay shale, medium-gray. Trace siltstone and very fine-grained sandstone at 2,200–2,220 ft and 2,230–2,240 ft.
----	2,250–2,400	Clay shale, medium- to medium-dark-gray; chunk *Inoceramus* prisms at 2,290–2,300 ft; trace very fine-grained sandstone at 2,300–2,310, 2,340–2,350, and 2,360–2,370 ft; 5 percent slightly calcareous siltstone, contains biotite, at 2,320–2,330 ft, trace siltstone at 2,330–2,350 ft, trace light-gray clay shale at 2,390–2,400 ft.
----	2,400–2,420	Silty clay shale, medium-light- to medium-gray.
----	2,420–2,450	Siltstone, medium-light-gray, noncalcareous; also medium-gray clay shale.
----	2,450–2,480	Clay shale, medium-gray; trace siltstone.
----	2,480–2,499	Clay shale, medium- to medium-dark-gray.
16	2,499–2,519	Recovered 20 ft: Microfossils absent. Clay shale, medium-gray, medium-hard, with good cleavage, thin-bedded with light-colored silty laminae. Pelecypod fragments at 2,506, 2,510, 2,511, and 2,515 ft. Three of these are a thin-shelled *Inoceramus*, cf. *I. labiatus* Schlotheim of the Seabee formation. Brown fishbone fragments rare; noncalcareous; dip 1½° in upper part of core, uniformly increasing to 43° at 2,513 ft where steep slickensides were noted, decreases to 9° at base.
----	2,519–2,610	Clay shale, medium-gray; 10 percent medium-light-gray siltstone, moderately calcareous; chunk *Inoceramus* prisms at at 2,520–2,530 ft. Trace very calcareous siltstone at 2,540–2,550 ft; also trace aragonite and trace coal at 2,600–2,610 ft.

429370—58——3

Lithologic description—Continued

Core	Depth (feet)	Description
----	2, 610–2, 620	Siltstone, light-gray, also about 40 percent clay shale, trace coal.
17	2, 620–2, 639	Recovered 10 ft: Microfossils absent. Clay shale, medium-gray, medium-hard, noncalcareous, with good cleavage; approximately 10 percent medium-light-gray siltstone in very thin laminae and lenses in shale. *Inoceramus* shell fragment noted at 2,638 ft. Fish fragments very rare; dip less than 1°.
18	2, 639–2, 659	Recovered 19 ft: Microfossils absent. Clay shale as above but with approximately 15 percent siltstone; some subconchoidal fracture; poor to good cleavage; parts of lowest 8 ft of core have good poker-chip cleavage and are slightly softer than rest of core. *Inoceramus* found at 2,649 and 2,655 ft; shale noncalcareous; dip less than 1°.
----	2, 659–2, 670	Clay shale, medium-gray; trace siltstone, chunks of *Inoceramus* prisms.
----	2, 670–2, 680	Clay shale, medium- to medium-dark-gray; trace light-gray clay shale; trace siltstone.
----	2, 680–2, 690	Clay shale, medium-gray; 20 percent of sample light-gray moderately calcareous siltstone.
----	2, 690–2, 700	Clay shale, medium-gray; trace fine-grained slightly calcareous sandstone; trace ironstone.
----	2, 700–2, 723	Clay shale, medium-gray and dark-gray; 25 percent light-gray dirty micaceous slightly calcareous sandstone.
19	2, 723–2, 743	Recovered 19 ft: Microfossils absent. Interbedded sandstone, 92 percent, and clay shale, 8 percent. Sandstone light gray, hard, very fine to medium grained; moderately to very calcareous; subangular grains, 85 percent white and clear quartz. Ten percent dark chert and rock fragments and approximately 5 percent fairly large biotite plates speckled throughout. Clay shale is medium to medium dark gray, hard, and interbedded in thin laminae with sandstone. In part of core sand and clay show well graded beds, each cycle about 2 in. thick. Carbonate content at 2,739 ft 15.4 percent by weight. Dip 1½°. No shows. All samples in following table impermeable to air.

Lithologic description—Continued

Core	Depth (feet)	Description

Depth (feet)	Effective porosity (percent)	Carbonate content (percent by weight)
2,725 parallel	10.31	7.6
2,725 normal	9.53	----
2,739 parallel	10.70	15.4
2,739 normal	9.62	----

Core	Depth (feet)	Description
----	2, 743–2, 760	Sandstone, light-gray, fine-grained with some medium grains; grains subangular, 60 percent white and clear quarts, remainder mostly dark chert, coal fragments, and biotite; moderately to very calcareous. Also some clay shale, medium-dark-gray.
----	2, 760–2, 770	Clay shale, medium to medium-dark-gray, and 15 percent sandstone as above.
----	2, 770–2, 780	Clay shale, medium-gray; approximately 30 percent of sample is light-gray fine-grained and silty only very slightly calcareous sandstone.
----	2, 780–2, 810	Clay shale, medium- to medium-dark-gray; slightly silty at 2,790–2,800 ft.
----	2, 810–2, 820	Bentonite, white, and medium-dark-gray clay shale.
----	2, 820–2, 830	Clay shale, medium-gray, very small amount of white aragonite.
----	2, 830–2, 840	Clay shale, medium-dark-gray; trace white bentonite.
20	2, 840–2, 860	Recovered 7 ft: Microfossils absent. Clay shale, medium-gray, hard, fair to good cleavage; scattered very light-gray bentonitic partings; 2 in. bentonite at very top of core is light gray and rather hard when dry and contains numerous plates of brown biotite. About 1½ ft from bottom is 6 in. of light-bluish-gray bentonite, laced throughout with veins of white prismatic aragonite or calcite; dip 2°.
----	2, 860–2, 910	Siltstone, medium-light-gray; small amount of white-vein calcite or aragonite. Trace very light-gray bentonitic clay, 2,890–2,900 ft. Rare *Inoceramus* prisms 2,870–2,880 and 2,900–2,910 ft.
----	2, 910–2, 930	Clay shale, medium-gray and some siltstone.
----	2, 930–2, 940	Sandstone, light-gray, fine-grained; grains subangular to subrounded, 85 percent white and clear quartz, also dark chert; very calcareous.
----	2, 940–2, 954	Clay shale, 40 percent, medium-dark-

Lithologic description—Continued

Core	Depth (feet)	Description
		gray, and 40 percent medium-light-gray siltstone, rest light-gray very calcareous sandstone with trace bluish-gray clay shale.
21	2, 954–2, 974	Recovered 15 ft: Microfossils rare. 5 ft, siltstone, 90 percent, very argillaceous, and silty clay shale. Color varies from light to medium gray. The central part shows an excellent pattern of slump or swirly bedding. Impression of a small pelecypod at very top of unit. Siltstone slightly calcareous. 10 ft, clay shale, medium-gray, hard, with fair cleavage; interbedded with approximately 6 percent irregular laminae and lenses of medium-light-gray siltstone. Carbonaceous fragments rare; beds very nearly flat lying; a small unidentified pelecypod at 2,962 ft. *Inoceramus* prisms in microfossil cut.
----	2, 974–3, 000	Sandstone, medium-light-gray, very fine-grained, and siltstone; noncalcareous, also some medium-gray clay shale. *Inoceramus* fragments and prisms at 2,970–2,980 and 2,990–3,000 ft.
----	3, 000–3, 040	Siltstone, medium-light-olive-gray, and as much as 50 percent silty clay shale.
----	3, 040–3, 051	Clay shale, medium-gray, silty, and small amount of siltstone.
22	3, 051–3, 070	Recovered 5 ft: Microfossils rare. Siltstone and claystone, all gradations between these two types but predominantly medium-light- to medium-gray hard siltstone with irregular fracture; micaceous; scattered dark carbonaceous fragments; fractured *Inoceramus* embedded vertically throughout bottom foot of recovery. Noncalcareous; beds approximately flat lying.
----	3, 070–3, 090	Sandstone, light-gray, fine-grained, rather soft, noncalcareous; subangular to subrounded grains, 90 percent white and clear quartz; remainder mostly dark chert; biotite fairly common; very rare *Inoceramus* prisms. Trace medium-gray clay shale.
----	3, 090–3, 100	Sandstone and siltstone.
----	3, 100–3, 120	No sample.
----	3, 120–3, 130	Siltstone, medium-light-gray; trace medium-dark-gray silty limestone.
----	3, 130–3, 150	Sandstone, light-gray, fine-grained, very slightly calcareous; 90 percent white and clear quartz grains, also dark chert, rock and coal particles, fairly common biotite; very rare *Inoceramus* prisms.

Lithologic description—Continued

Core	Depth (feet)	Description
----	3, 150–3, 169	Siltstone, medium-light-gray, noncalcareous. Trace medium-gray clay shale.
23	3, 169–3, 186	No recovery.
----	3, 186–3, 200	Sandstone, light-gray, very fine-grained, silty, noncalcareous. Trace silty clay shale; *Inoceramus* prisms fairly common at 3,186–3,190 ft.
----	3, 200–3, 220	Siltstone, medium-light-gray; biotite very common.
----	3, 220–3, 230	Sandstone, light-gray, noncalcareous, soft; grains subangular to subrounded, 90 percent white and clear quartz; rest dark chert and coal particles; biotite not so common.
----	3, 230–3, 240	Clay shale, medium-dark gray; 40 percent medium-light-gray siltstone.
----	3, 240–3, 261	Sandstone and siltstone; sandstone moderately calcareous; some clay shale; one chunk of *Inoceramus* prisms 3,250–3,260 ft.
24	3, 261–3, 281	Recovered 19 ft: Microfossils absent. 7 ft. 6 in., interbedded sandstone, 60 percent, siltstone, 25 percent, and clay shale, 15 percent. Sandstone is light gray, fine to medium grained, hard; 60 percent white and clear quartz; rest mostly dark chert and coal particles; chloritoid and glaucophane noted; very calcareous cement. Siltstone similar to sandstone but medium light gray. Clay shale is medium dark gray, hard, good cleavage. Sandstone and siltstone contain rare gray ironstone nodules; certain sections contain rare small fragments of clay shale parallel to bedding; coaly, carbonaceous partings present; moderately to very calcareous; dip low but some indication of cross bedding with dips in the siltstone as much as 27°; faint petroliferous odor, very pale cut and yellowish greasy stain in evaporating dish at 3,266 ft. At 3,266 ft effective porosity 7.96 percent parallel to bedding, and 9.8 percent normal to bedding. Both sample plugs impermeable. 11 ft 6 in., clay shale, siltstone, and all gradations, very thin beds. Clay shale is medium gray, and siltstone is medium light gray. Fair cleavage; moderately hard; moderately to very calcareous; dip ½°.
----	3, 281–3, 342	Clay shale, medium-dark-gray; one chunk *Inoceramus* prisms 3,290–3,300 ft. Trace to 10 percent siltstone at 3,310–3,340 ft. Top of Chandler and Ninuluk formations undifferentiated placed at 3,305 ft.

Lithologic description—Continued

Core	Depth (feet)	Description
25	3, 342–3, 362	Recovered 19 ft: Microfossils abundant. 3 ft, clay shale, medium-dark-gray, very slightly micaceous, medium-hard, with rare carbonaceous fragments; fair cleavage, and some subconchoidal fracture. 5 ft 10 in., siltstone and silty clay shale, medium-light-gray, hard, with rare slightly sandy streaks. Part of the siltstone occurs as lenses in silty clay shale; rare carbonaceous partings; beds approximately flat lying. A 6-in. segment between siltstone and underlying sandstone marked by rare small rounded black-chert pebbles. 10 ft 2 in., sandstone, light-gray, fine-grained, silty, noncalcareous, tight, massive, hard; grains subrounded to subangular; 90 percent white and clear quartz; rest mostly dark chert and rare coal particles plus mica. Unidentified pelecypods (two types) as much as 1 in. in diameter preserved as brownish-coated casts at 3,356 and 3,362 ft. A pelecypod found at 3,360 ft is *Arctica* sp. Faint odor, no cut, greasy stain in evaporating dish at 3,361 ft. At 3,361 ft effective porosity 10.75 percent parallel to bedding and 10.54 percent normal to bedding. Both samples impermeable.
----	3, 362–3, 370	Sandstone, light-gray, fine-grained; subangular to subrounded grains, 85 percent white and clear quartz; rest dark chert, carbonaceous particles, and common biotite.
----	3, 370–3, 380	No sample.
----	3, 380–3, 390	Clay shale, medium-light-gray, very rare chips of coal.
----	3, 390–3, 400	Sandstone, light-gray, and siltstone; 20 percent medium-light-gray clay shale.
----	3, 400–3, 410	Siltstone, medium-light-gray, very slightly calcareous. Trace very fine-grained sandstone and clay shale.
----	3, 410–3, 420	No sample.
----	3, 420–3, 435	Siltstone and trace of silty clay shale.
26	3, 435–3, 455	Recovered 20 ft: Microfossils absent. Siltstone, medium-light-gray, hard, with fair cleavage parallel to bedding; scattered streaks of medium-dark-gray clay shale and very fine-grained sandstone, carbonaceous partings; rare light-yellowish-gray clay ironstone nodules; slightly calcareous to noncalcareous; dip 1°, irregularities of some beds suggest small-scale local deformation at time of deposition by slumping and (or) current action. No shows.

Lithologic description—Continued

Core	Depth (feet)	Description
27	3, 455–3, 466	Recovered 11 ft: Microfossils absent. 7 ft., siltstone as described in core immediately above; rare laminae of medium-dark-gray slightly carbonaceous clay shale. Siltstone grades downward into sandstone. 3 ft. 9 in., sandstone, light-gray, very fine- to fine-grained, massive, hard; irregular fracture: grains 85 percent white and clear quartz; rest dark chert, mica, and coaly particles. Carbonate content at 3,464 ft 8.64 percent by weight; dip 2°; no irregular bedding. Fair petroliferous odor, very pale cut and yellowish greasy stain in evaporating dish at 3,464 ft. At 3,464 ft effective porosity 10.24 percent parallel to bedding and 10.46 percent normal to bedding. Both samples impermeable; carbonate content at that depth 8.24 percent by weight. 3 in., clay shale, medium-dark-gray, hard, with fair cleavage and numerous carbonaceous and micaceous particles.
----	3, 466–3, 485	Sandstone, light-gray, fine-grained, noncalcareous; grains subangular to subrounded, 85 percent white and clear quartz; rest dark chert, coal particles, and mica; probably has carbonaceous partings. Trace ironstone at 3,480–3,485 ft.
28	3, 485–3, 502	Recovered 17 ft: Microfossils absent. Sandstone, light- to medium-light-gray, fine-grained, silty, massive, hard, tight, subangular to subrounded grains 85 percent white and clear quartz; remainder coal particles and dark chert; mica rarely common; argillaceous matrix, very rare brownish-gray clay-ironstone nodules in lowest 3 ft core. Beds approximately flat lying; faint odor, very pale cut, and greasy stain from 3,489 ft and very faint odor, no cut, and greasy stain from 3,500 ft. Following porosity and permeability determinations were made:

Depth (feet)	Effective porosity (percent)	Air permeability (millidarcys)	Carbonate content (percent by weight)
3,489 parallel	9.56	0	8.18
3,489 normal	9.44	0	----
3,500 parallel	11.52	0	4.34
3,500 normal	10.02	<1	----

Lithologic description—Continued

Core	Depth (feet)	Description
29	3, 502–3, 519	Recovered 17 ft: Microfossils absent. Sandstone, light-gray, fine- to medium-grained, medium-hard, breaks parallel to bedding; subangular to subrounded grains (mostly subangular); 85 percent white and clear quartz; rest mostly black-coal particles and dark-gray chert. Sandstone is slightly softer and more porous than that above; bedding poorly defined but probably approximately flat lying, fair to good sour crude-oil odor, straw-colored cut and yellow residue from 3,503 and 3,518 ft. Following porosity and permeabilities were determined:

Depth (feet)	Effective porosity (percent)	Air permeability (millidarcys)	Carbonate content (percent by weight)
3,503 parallel	15.14	265	1.86
3,503 normal	15.15	70	
3,518 parallel	13.74	43	5.77
3,518 normal	13.35	35	

Core	Depth (feet)	Description
30	3, 519–3, 535	Recovered 16 ft: Microfossils absent. Sandstone, light-gray; essentially same as that in core 29 but very fine to fine grained and slightly harder and tighter particularly toward base. Carbonate content 6.57 percent by weight at 3,522 ft and 6.12 percent at 3,532 ft; beds approximately flat lying; no odor or cut but yellowish greasy stain in evaporating dish at 3,523 and 3,532 ft. Porosity and permeability determined as follows:

Depth (feet)	Effective porosity (percent)	Air permeability (millidarcys)	Carbonate content (percent by weight)
3,522 parallel	11.05	15.0	6.57
3,522 normal	12.94	15.0	
3,532 parallel	12.20	3.1	6.12
3,532 normal	11.94	.5	

Core	Depth (feet)	Description
31	3, 535–3, 555	Recovered 20 ft: Microfossils absent. Sandstone, light-gray, fine-grained, hard, massive; has irregular fracture approximately at right angles to side of core; subangular to subrounded grains, 90 percent white and clear quartz; rest dark chert, coal particles, rare mica, and rare chalky white weathered chert particles; a few laminae have a larger proportion of dark minerals. Bedding obscure but beds probably flat lying.

Lithologic description—Continued

Core	Depth (feet)	Description
		No odor or cut but a greasy film as residue in evaporating dish at 3,542 and 3,548 ft. Porosity and permeability determinations made at same depths:

Depth (feet)	Effective porosity (percent)	Air permeability (millidarcys)	Carbonate content (percent by weight)
3,542 parallel	13.11	29.0	5.67
3,542 normal	13.34	20.0	
3,548 parallel	14.10	27.0	6.14
3,548 normal	13.10	18.5	

Core	Depth (feet)	Description
32	3, 555–3, 567	Recovered 12 ft: Microfossils absent. Sandstone, light- to medium-light-gray, very fine- to fine-grained, hard, massive; tighter than in core above; grains subangular to subrounded; most constituents as in core above. Quartz, 85 percent; rare dark carbonaceous-micaceous partings; very rare slightly yellowish-gray ironstone concretions; a few thin medium-gray clay shale laminae in last 1½ ft of core; essentially noncalcareous. Beds flat lying; no odor or cut, but a greasy film residue in evaporating dish, at 3,559 ft. At 3,559 ft effective porosity 13.65 percent parallel to bedding and 13.32 percent normal to bedding; air permeability 32 and 24 millidarcys respectively, and carbonate content 7.5 percent by weight.
33	3, 567–3, 586	Recovered 19 ft: Microfossils absent. 3 ft, sandstone, light-gray, massive, hard, same constituents as above but more argillaceous material; noncalcareous; beds flat lying. 16 ft, sandstone, light-gray, fine- to medium-grained, noncalcareous to slightly calcareous, medium-hard; has tendency to fracture roughly parallel to bedding giving a pseudo poker-chip effect; 75 percent white and clear quartz grains; rock fragments and dark chert, 15 percent (salt-and-pepper) in part); rest is white weathered chert, mica, garnet, and a small amount of other minerals; very rare coaly partings; beds approximately flat lying. Faint odor, no cut, greasy film from 3,571 ft and faint odor, very pale cut, and greasy film from 3,580 ft. Following porosity and permeability determinations made:

Lithologic description—Continued

Core	Depth (feet)	Description

Depth (feet)	Effective porosity (percent)	Air permeability (millidarcys)	Carbonate content (percent by weight)
3,571 parallel	11.90	8.5	7.41
3,571 normal	11.38	<1	
3,580	12.30	Sample unsuitable.	11.60

Core	Depth (feet)	Description
34	3, 586–3, 602	Recovered 15 ft: Microfossils absent. Sandstone, light-gray, fine-grained, slightly calcareous to noncalcareous, hard, massive; not as soft and does not have the distinctive fracture as in core above; grains subangular to subrounded, 85 percent white and clear quartz; rest is dark chert, rock fragments, weathered white chert, biotite (quite common), and very rare carbonaceous partings. Becomes finer grained toward the base: dip 1°. Fair to good kerosenelike odor, pale-straw-colored cut and yellow residue from 3,594 and 3,598 ft. All samples in the following table were impermeable to air.

Depth (feet)	Effective porosity (percent)	Carbonate content (percent by weight)
3,594 parallel	11.10	18.45
3,594 normal	10.75	
3,598 parallel	10.20	15.10
3,598 normal	10.45	

Core	Depth (feet)	Description
35	3, 602–3, 608	Recovered 4 ft: Microfossils absent. Sandstone, medium-light-gray, very fine- to fine-grained, very calcareous, very hard; irregular fracture; constituents similar to above; biotite quite common; nearly a sandy limestone. Dip 1°; no shows. Carbonate content at 3,603 ft 38.3 percent.
----	3, 608–3, 623	Sandstone, light-gray, very fine- to fine-grained; 85 percent white and clear quartz; grains subangular to subrounded; also dark-gray chert, coal particles, and biotite. Very calcareous but softer and noncalcareous in bottom 10 ft. Trace medium-dark-gray clay shale.
----	3, 623–3, 633	Siltstone, medium-light-gray, and slightly calcareous sandstone.
----	3, 633–3, 643	Clay shale, medium- to medium-dark-gray; 20 percent siltstone; trace subvitreous black coal.
----	3, 643–3, 653	Siltstone, medium-light-gray, argillaceous, slightly calcareous, and medium-gray clay shale; trace coal.

Lithologic description—Continued

Core	Depth (feet)	Description
----	3, 653–3, 663	Siltstone, medium-light-gray, argillaceous; rare pebbles, granules and very coarse grains of rounded black chert. Also 30 percent very light-gray bentonite.
----	3, 663–3, 680	Siltstone, medium-light-gray, noncalcareous, and trace to 10 percent light-gray fine-grained very calcareous sandstone.
----	3, 680–3, 685	Sandstone, very fine-grained, and siltstone.
----	3, 685–3, 702	Siltstone, medium-light-gray, argillaceous, and some soft light-gray clay 3,790–3,795 ft. (nonbentonitic).
36	3, 702–3, 707	Recovered 1 ft: Microfossils absent. Clay shale, medium-light-gray, noncalcareous, medium-hard, with good cleavage; very thin silty laminae; medium-gray slightly micaceous-carbonaceous partings; dip 2°.
----	3, 707–3, 735	Clay shale, medium-gray; trace of siltstone 3,710–3,715 ft and 3,730–3,735 ft; trace coal at 3,710–3,715 ft.
----	3, 735–3, 762	Siltstone, medium-gray- very fine-grained; sand streaks toward base; as much as 40 percent medium- to medium-dark-gray clay shale. Top of Grandstand formation placed at 3,735 ft.
37	3, 762–3, 782	Recovered 20 ft: Microfossils absent. 14 ft, claystone, medium-light- to medium-gray, hard, incipient or no cleavage; contains much micaceous and some carbonaceous material; silty toward base. Suggestion of swirly bedding at 3,770 ft, slickensides of 50° at 3,770½ ft; slightly calcareous; dips reach a maximum of 6°. 6 ft, clay shale and siltstone, medium-light- to medium-gray, very silty; essentially as in upper part of this core, but with slightly better cleavage and with better defined alternation of silty and clayey beds. Silty layers slightly calcareous.
38	3, 782–3, 783	Recovered 1 ft: Microfossils absent. Siltstone, medium-light- to medium-gray, hard, has poor cleavage; micaceous-argillaceous partings and laminae; slightly calcareous. Maximum dips of 10° suggest crossbedding. No shows.
----	3, 783–3, 795	Siltstone, medium-light-gray, sandy, and 20 percent medium- to medium-dark-gray clay shale.
----	3, 795–3, 810	Silty clay shale, medium-gray; trace coal and trace white vein aragonite or calcite.
----	3, 810–3, 820	Sandstone, light-gray, fine-grained, rather soft; grains subangular to subrounded; 85 percent white and clear quartz; rest is dark chert, rare coal particles, and some pyrite; also siltstone and some clay shale, with very rare *Inoceramus* prisms.

Lithologic description—Continued

Core	Depth (feet)	Description
----	3, 820–3, 840	Siltstone, slightly sandy; as much as 60 percent medium- to medium-dark-gray clay shale.
----	3, 840–3, 900	Clay shale, medium- to medium-dark-gray, partly silty; trace dull to subvitreous black coal 3,840–3,845, 3,850–3,860, and 3,885–3,895 ft; worm tube, *Ditrupa* sp; and a chunk of *Inoceramus* prisms at 3,840–3,845 ft.
39	3, 900–3, 920	Recovered 20 ft: Microfossils very abundant. Clay shale, medium-dark-gray, calcareous, micaceous, medium-soft; poor to fair cleavage; some subconchoidal fracture; rare small dark carbonaceous fragments; dip 1½°.
----	3, 920–3, 935	Clay shale, medium- to medium-dark-gray, slightly silty.
----	3, 935–3, 940	Clay shale, medium-gray, plus about 40 percent light-gray flaky very bentonitic clay shale.
----	3, 940–3, 955	Clay shale, medium-gray, very silty, with trace medium-light-gray slightly calcareous siltstone.
----	3, 955–3, 965	Sandstone, light-gray, very fine-grained, slightly calcareous; subangular to subrounded grains, 90 percent white and clear quartz; rest is dark-colored chert, very rare pyrite.
----	3, 965–3, 975	Clay shale, medium-gray, 10 percent sandstone and siltstone.
----	3, 975–3, 990	Siltstone, light- to medium-light-gray, sandy, and as much as 50 percent medium-gray clay shale.
----	3, 990–4, 020	Clay shale, medium- to medium-dark-gray; trace siltstone at 3,995–4,000 ft.
40	4, 020–4, 034	Recovered 11 ft: Microfossils rare. 8 ft, clay shale, medium-dark-gray, moderately calcareous, finely micaceous, with fair cleavage; contains scattered thin lenses and laminae of medium-light-gray siltstone; moderately calcareous; dip 3°. 3 ft, claystone, medium-dark-gray, similar to upper part of core but lacks cleavage and silty laminae. Irregular fracture; minor slickensides at base of core.
----	4, 034–4, 110	Clay shale, medium-gray, silty to very silty, and 50 percent of argillaceous medium-light-gray siltstone at 4,050–4,060 ft.
----	4, 110–4, 130	Clay shale, medium-gray.
41	4, 130–4, 143	Recovered 11 ft: Microfossils absent. Clay shale, medium- to medium-dark-gray, noncalcareous, medium-hard; excellent pokerchip cleavage; very rare very thin silty laminae; dip 2°–4°.

Lithologic description—Continued

Core	Depth (feet)	Description
----	4, 143–4, 210	Clay shale, medium- to medium-dark-gray; trace siltstone at 4,150–4,160 and 4,200–4,210 ft; trace calcareous medium-light-gray clay shale at 4,200–4,210 ft.
----	4, 210–4, 230	Siltstone, medium-light-gray, slightly to very calcareous, also some medium-gray clay shale.
----	4, 230–4, 250	Clay shale, silty, and argillaceous siltstone.
----	4, 250–4, 261	Clay shale, medium-gray; trace coal.
42	4, 261–4, 281	Recovered 17 ft: Microfossils very rare. Claystone, medium- to medium-dark-gray, noncalcareous, hard, micaceous; silt disseminated throughout: very rare lighter colored silty laminae; no cleavage, irregular fracture; low dip; good fleeting odor on fresh fracture; pale-straw-colored cut and pale-yellow residue from 4,279 ft. Pelecypod, *Entolium* sp., found at 4,277 ft.
43	4, 281–4, 290	Recovered 9 ft: Microfossils absent. Claystone, silty, and argillaceous siltstone, medium-light- to medium-gray, gradational; siltier laminae lighter colored, hard, micaceous; noncalcareous; poor or no cleavage; dip 0°–2°; good kerosenelike odor; pale-straw-colored cut and pale residue from 4,283 ft.
44	4, 290–4, 305	Recovered 15 ft: Microfossils absent. Claystone, silty, and argillaceous siltstone as in core above; some slity clay shale with poor cleavage; *Ditrupa* sp. and *Nucula* cf. *N. dowlingi* McLearn found at 4,302 ft, a fragment of an unidentified pelecypod at 4,292 ft, and *Entolium?* at 4,294 ft; noncalcareous; beds flat lying; fair kerosenelike odor, pale-straw-colored cut and yellow residue from 4,292 and 4,301 ft.
----	4, 305–4, 352	Clay shale, medium-gray and medium-light-gray; silty streaks throughout; slightly micaceous. Top of Topagoruk formation placed at 4,315 ft.
45	4, 352–4, 372	Recovered 10 ft: Microfossils very abundant. Clay shale, medium-gray, noncalcareous, mostly medium-soft; fair to good cleavage; very rare slightly harder slightly silty streaks; the pelecypod *Pleuromya* sp. found at about 4,360 ft; beds flat lying.
----	4, 372–4, 410	Clay shale, medium-gray, slightly silty; much pyrite at 4,400–4,410 ft.
----	4, 410–4, 450	Clay shale, medium-gray.
----	4, 450–4, 460	Clay shale, medium-gray; much pyrite; trace of siltstone.

Lithologic description—Continued

Core	Depth (feet)	Description
----	4, 460–4, 480	Clay shale, medium-light-gray, silty, and some light-gray fine-grained sandstone; 80 percent white and clear quartz, also dark chert, some biotite.
----	4, 480–4, 510	Clay shale, medium- to medium-dark-gray; trace of medium-light-gray siltstone also trace light-gray clay with biotite (nonbentonitic) 4,490–4,510 ft.
----	4, 510–4, 543	Clay shale, medium-gray.
46	4, 543–4, 563	Recovered 20 ft: Microfossils absent. Clay shale, silty, and some argillaceous siltstone, medium-gray, medium-hard, slightly micaceous, with fair to poor cleavage; *Modiolus?* sp. found at 4,546 ft, and a small pelecypod at 4,559 ft is identified as *Nemodon* cf. *N. mcconnelli* McLaren; noncalcareous; local dips as much as 10° but beds almost flat lying (?).
----	4, 563–4, 610	Clay shale, medium- to medium-dark-gray; trace to 5 percent medium-light-gray siltstone at 4,590–4,600 ft.
----	4, 610–4, 640	Clay shale, medium-gray; trace to 10 percent medium-light-gray noncalcareous siltstone; also trace very light-gray bentonite; a few flakes of brown biotite; trace coal at 4,620–4,640 ft.
----	4, 640–4, 650	Clay shale, medium- to medium-dark-gray, with varying amounts of silt; trace siltsone and sandstone.
----	4, 650–4, 670	Clay shale, medium-gray, also some light-gray and some dark-gray; fish scale present. Trace very light-gray bentonite.
----	4, 670–4, 680	Clay shale, medium- to medium-dark gray, also some light-gray clay shale with bluish cast.
----	4, 680–4, 700	Clay shale, medium-gray; trace siltstone.
----	4, 700–4, 735	Clay shale, medium-gray, plus trace to 40 percent medium-light-gray siltstone; trace fine-grained sandstone; noncalcareous; trace bentonite.
47	4, 735–4, 746	Recovered 8 ft: Microfossils absent. Clay shale, medium-dark-gray, silty, medium-hard; good to excellent cleavage; very rare thin siltstone laminae; noncalcareous; dip 10°–11°.
48	4, 746–4, 756	No recovery.
----	4, 756–4, 920	Clay shale, medium-gray, some siltstone or silty clay at 4,770–4,780, 4,860–4,870, 4,880–4,890, and 4,910–4,920 ft. Five percent coal 4,800–4,810 ft and trace of coal 4,870–4,890 ft; 5 percent white bentonite or bentonitic clay shale 4,780–4,790, 4,820–4,830, and 4,870–4,880 ft plus numerous other traces of bentonite

Lithologic description—Continued

Core	Depth (feet)	Description
----	4, 920–5, 100	Clay shale, medium- to medium-dark-gray; trace very calcareous siltstone, 4,980–5,000, 5,020–5,040, and 5,050–5,060 ft. Five to ten percent white bentonite 5,030–5,040, 5,050–5,060, and 5,090–5,100 ft plus several other traces of bentonite. Trace shiny black coal at 4,950–4,960 ft.
49	5, 100–5, 115	Recovered 10 ft: Microfossils abundant. Clay shale, medium-dark-dray, noncalcareous, medium-hard, with poor to fair cleavage; rare slightly silty partings; bottom half of core broken into pieces many of which have polished slickensided surfaces; dip of slickensides 30° to nearly vertical; dip of beds 25°–35° throughout core.
----	5, 115–5, 160	Clay shale, medium- to medium-dark-gray; 5 percent grayish-brown clay ironstone at 5,120–5,130 ft; 5 percent aragonite at 5,140–5,150 ft; trace coal at 5,115–5,120 ft; some bentonitic clay.
----	5, 160–5, 200	Clay shale, medium- to dark-gray, plus trace soft light-olive-gray siltstone throughout; trace aragonite at 5,160–5,170 ft; trace light-bluish-gray bentonitic clay shale, and trace white bentonite at 5,190–5,200 ft.
----	5, 200–5, 210	Bentonite, white, with few brown biotite plates, approximately 40 percent of sample; also 30 percent bentonitic light-bluish-gray clay shale with brown biotite plates; 30 percent medium-dark-gray clay shale.
----	5, 210–5, 441	Clay shale, medium-dark-gray, 5 percent white bentonite, and (or) very light-gray bentonitic shale 5,210–5,220 and 5,290–5,300 ft; several traces of bentonite above 5,370 ft. Trace aragonite at 5,220–5,230 ft; trace coal and pyrite at 5,360–5,370 ft; trace siltstone at 5,410–5,420 ft.
50	5, 441–5, 458	Recovered 9 ft: Microfossils very rare. Clay shale, medium-dark- to (rarely) dark-gray, medium-hard, with good cleavage; numerous thin laminae and partings of medium-gray siltstone, rare slightly micaceous partings. About a foot of swirly bedding; poorly developed slickensides at approximately 5,446 and 5,448 ft; straw-colored cut and pale-yellow residue from 5,441 ft. Noncalcareous; dip 10°.

Lithologic description—Continued

Core	Depth (feet)	Description
51	5, 458–5, 463	Recovered 4 ft: Microfossils rare. Claystone and clay shale, medium-dark-gray, noncalcareous, hard; some medium-gray silty laminae; poor cleavage; very small amount of irregular bedding; dips range between 3° and 20°.
----	5, 463–5, 480	Clay shale, medium-dark-gray; trace medium-gray siltstone.
----	5, 480–5, 510	Clay shale, medium-dark-gray; 30–50 percent medium-gray siltstone; noncalcareous.
----	5, 510–5, 530	Clay shale, medium-dark-gray; 40 percent medium-light-gray noncalcareous to very calcareous sandy siltstone.
----	5, 530–5, 610	Clay shale, medium-dark-gray; 20 percent medium-gray moderately calcareous siltstone at 5,550–5,560 ft; traces of medium-light-gray noncalcareous siltstone throughout; trace coal at 5,560–5,570 ft.
----	5, 610–5, 748	Clay shale, medium-dark-gray; trace medium-gray noncalcareous siltstone at 5,650–5,660 ft.
52	5, 748–5, 768	Recovered 19 ft: Microfossils common. Clay shale, medium-dark-gray, noncalcareous, medium-hard, slightly micaceous; silt essentially absent; fair to good cleavage; dip 13°–16°.
----	5, 768–5, 982	Clay shale, medium-dark-gray; trace medium-light-gray siltstone at 5,790–5,810 and 5,910–5,920 ft; 5–10 percent white bentonite or very light-gray bentonitic clay shale, and coal at 5,850–5,860 and 5,960–5,970 ft.
53	5, 982–6, 000	Recovered 14 ft: Microfossils rare. Clay shale, medium- to medium-dark-gray, nonsilty, noncalcareous, moderately hard; excellent poker-chip cleavage; dip 9°–15°.

CORE ANALYSES

Core analyses were run on sandstone cores to determine effective porosity, air permeability, and carbonate content. (See following table.) The Barnes (vacuum) method was used to measure porosity. A permeameter, the general requirements of which are detailed in API Code No. 27, second edition, April 1942, was used to determine the permeability.

Analyses of core samples, Gubik test well 1

Core	Depth (feet)	Effective porosity (percent)	Air permeability (millidarcys)	Carbonate content (percent by weight)
1	371P [1]	14.88	0	Not tested
	371N [2]	14.93	0	Not tested
3	1,087	21.1	166	9.3
	1,096P	7.93	0	22.04
	1,096N	7.88	0	----
6	1,232	20.5	[3]	7.49
	1,232P	[3]	407	----
	1,232N	[3]	357	----
7	1,447	22.0	376	5.34
	1,450	24.4	[3]	Trace
8	1,458P	7.77	0	25.6
	1,458N	6.48	0	----
9	1,471P	20.0	988	7.05
	1,471N	20.1	570	----
10	1,491P	16.37	19	13.9
	1,491N	14.85	13	----
11	1,712	29.0	[3]	Trace
12	1,730P	19.55	39	Trace
	1,730N	18.7	8	Trace
19	2,725P	10.31	0	7.6
	2,725N	9.53	0	----
	2,739P	10.70	0	15.4
	2,739N	9.62	0	----
24	3,266P	7.96	0	Not tested
	3,266N	9.80	0	----
25	3,361P	10.75	0	Not tested
	3,361N	10.54	0	----
27	3,464P	10.24	0	8.24
	3,464N	10.46	0	----
28	3,489P	9.56	0	8.18
	3,489N	9.44	0	----
	3,500P	11.52	0	4.34
	3,500N	10.02	<1	----
29	3,503P	15.14	265	1.86
	3,503N	15.15	70	----
	3,518P	13.74	43	5.77
	3,518N	13.35	35	----
30	3,522P	11.05	15	6.57
	3,522N	12.94	15	----
	3,532P	12.20	3.1	6.12
	3,532N	11.94	.5	----
31	3,542P	13.11	29	5.67
	3,542N	13.34	20	----
	3,548P	14.10	27	6.14
	3,548N	13.10	18.5	----
32	3,559P	13.65	32	7.50
	3,559N	13.32	24	----
33	3,571P	11.90	8.5	7.41
	3,571N	11.38	<1	----
	3,580	12.30	[3]	11.6
34	3,594P	11.10	0	18.45
	3,594N	10.75	0	----
	3,598P	10.20	0	15.10
	3,598N	10.45	0	----
35	3,603	Not tested	Not tested	33.8

[1] P—parallel to bedding.
[2] N—normal to bedding.
[3] Sample unsuitable.

OIL AND GAS

OIL AND GAS SHOWS

The following table presents the oil and gas shows as logged by the contractor's well geologist, C. A. Everett, at the time the hole was drilled.

Oil and gas shows, Gubik test well 1

Depth (feet)	Showing	Remarks [1]
1,215	Gas in ditch	
1,438–1,495	Gas odor and very slight fluorescence in cores.	Formation tests 1 and 2, 1,438–1,495 ft.
1,585–1,738	Slight to good fluorescence	Formation test 3, 1,681–1,738 ft.
1,840–1,897	Slight show of gas	
3,435–3,455	Slight show of oil and very slight show of gas.	Formation tests 4 and 5, 3,435–3,519 ft.
3,502	Pale cut in ether	Formation test 6, 3,488–3,519 ft.
3,519–3,702	Odors of gas from cores	Formation tests 7 and 8, 3,491–3,608 ft.
4,261–4,543	Shaly cores bled traces of gas and oil from fractures.	

[1] See list of formation tests in following column for additional information.

The cuts listed in following table were made with carbon tetrachloride in the Fairbanks laboratory after the cores had been shipped from Naval Petroleum Reserve No. 4.

Test for oil stain in CCl_4, Gubik test well 1

Core	Depth (feet)	Cut	Residue
3	1,087	Very pale straw colored	Pale yellow.
	1,096	do	Do.
6	1,224	None	Slight yellow greasy stain.
7	1,450	Extremely faint	Very pale yellow.
8	1,458	do	Do.
9	1,471	Pale straw colored	Yellow.
10	1,491	do	Pale yellow.
11	1,712	Yellow	Brownish yellow.
12	1,730	do	Do.
24	3,266	Very pale straw colored	Yellowish greasy stain.
25	3,361	None	Greasy stain.
27	3,464	Very pale straw colored	Yellowish greasy stain.
28	3,489	do	Greasy stain.
	3,500	None	Do.
29	3,503	Straw colored	Yellow.
	3,518	do	Do.
30	3,522	None	Yellowish greasy stain.
	3,532	do	Do.
31	3,542	do	Greasy stain.
	3,548	do	Do.
32	3,559	do	Do.
33	3,571	do	Do.
	3,580	Very pale straw colored	Do.
34	3,594	Pale straw colored	Yellow.
	3,598	do	Do.
42	4,279	do	Pale yellow.
43	4,283	do	Do.
44	4,292	do	Do.
	4,301	do	Yellow.
50	5,441	Straw colored	Pale yellow.

One oil-saturation test was made: a sample from core 3 at a depth of 1,096 feet contained a trace of petroleum, and 15.7 percent of basal sediment and water by volume. A chloride test with silver nitrate was positive.

FORMATION TESTS

Test 1, 1,438–1,495 feet—A Johnston formation tester was run with a ⅛-inch bean, 57 feet of tailpipe, and a 9⅝-inch packer set at 1,438 feet. There was no blow in one-half hour. The tester was closed for 15 minutes and then pulled. The fluid rose 100 feet. The pressure chart showed that the retaining valve did not open and was leaking. No test was obtained.

Test 2, 1,438–1,495 feet—The bean was removed and test 2 was run with the packer, as above. Gas reached the surface in 13 minutes, and there was a fair flow for 17 minutes. The tester was closed 30 minutes. Recovery consisted of 120 feet of drilling fluid, and the closed-in pressure was 740 psi at 80°F.

Test 3, 1,681–1,738 feet—The formation tester was run with 57 feet of tailpipe, two pressure recorders, and a ¾-inch opening (no bean). The 9⅝-inch packer was set at 1,681 feet. The valve was opened, and gas came to the surface in a few seconds. The tester was open for 112 minutes and closed for 25 minutes. One sample of gas was taken for analysis. The gas volume was calculated to be 2,060,000 cubic feet per day. The valve seat leaked, and a reliable buttom-hole pressure was not obtained. The closed-in pressure was 450 psi.

Test 4, 3,435–3,519 feet—A tester was run in with a 9⅝-inch packer, 84 feet of tailpipe, and two pressure recorders. The packer failed to hold at 3,435 feet.

Test 5, 3,440–3,519 feet—A tester was run in with a 9⅝-inch packer and 79 feet of tailpipe. The packer failed to hold at 3,440 feet.

Test 6, 3,488–3,519 feet—A 5¾-inch packer was set at 3,488 feet with a 5/16-inch bean, 31 feet of tailpipe, and two pressure recorders on the bottom. The flow rates by critical flow provers were:

½-in. orifice, 2,046,000 cu ft per day at 347 psig and 65°F.
¾-in. orifice, 2,444,000 cu ft per day at 178 psig and 64.5°F.
1-in. orifice, 2,561,000 cu ft per day at 100 psig and 63°F.

Test 7, 3,491–3,608 feet—The tester was run with a 5¾-inch packer set at 3,491 feet, 117 feet of tailpipe and two pressure recorders. The packer did not hold.

Test 8, 3,521–3,608 feet—A packer was set at 3,521 feet and a tester run with a ¾-inch bean, 86½ feet of tailpipe, and two pressure recorders on the bottom. The gas flow rates were:

¼-in. orifice, 388,700 cu ft per day at 271.4 psig and 46.5°F.
½-in. orifice, 798,100 cu ft per day at 125 psig and 52.5°F.
¾-in. orifice, 823,200 cu ft per day at 50 psig and 52°F.

GAS ANALYSES

The gas analyses in the following table were made by the U. S. Bureau of Mines at Bartlesville, Okla.

Gas analyses, Gubik test well 1

Depth (feet)	1,495	1,738 [1]	3,519
Methane	97.05	97.05	94.7
Ethane	1.25	[2] 2.95	[2] 4.5
Propane plus	1.57		
Nitrogen	.13		
Noncondensables			.8
	100.00	100.00	100.00

[1] Insufficient sample for complete analysis.
[2] Ethane plus.

Arctic Contractors (written communication, 1953) report that—

Drill stem tests at 1,681 to 1,738 ft. and 3,488 to 3,519 ft. gave volumes of gas in excess of 2 million cubic feet per day from sands of sufficient thickness, porosity, and areal extent to be considered commercial provided a pipe line and market were to be made available.

LOGISTICS

TRANSPORTATION

Gubik test well 1 was drilled with a rig which was moved from the site of Fish Creek test well 1 (fig. 11). Early in 1951 two thousand tons of equipment was moved by tractor train to Gubik. During drilling operations an airstrip was maintained near the well site, but no heavy hauling was done by air.

HOUSING

Two quonsets, sixteen jamesway huts and six wanigans were used. The quonsets housed the galley and messhall and the warehouse and storeroom. The other buildings were for sleeping quarters, recreation, geology-engineering office, utility, latrine, machine shop, water storage, boiler, and cement and chemical storage and were a few hundred feet southeast of the rig site.

PERSONNEL

A drilling foreman, a petroleum engineer, and a geologist made up the supervisory personnel. The rig crew consisted of 2 drillers, 2 derrickmen, 6 rotary-equipment helpers, 2 firemen, 2 heavy-duty-equipment mechanics, and an oiler. Other permanent employees were 2 cooks, a kitchen helper, a bull cook, a laborer, a tractor operator, an electrician, and a warehouseman-timekeeper. Rig builders, carpenters, a cementer, a Schlumberger engineer, and a stoveman were brought in from Umiat or Barrow as the occasion demanded.

VEHICLES AND DRILLING EQUIPMENT

During drilling operations 2 weasels, 1 TD–9 crane (cherrypicker), 1 D8 Caterpillar tractor with dozer blade, and 1 Northwest crane were employed. The major items of drilling equipment used by Arctic Contractors were:

1 122-ft Ideco derrick with racking platform and finger.
1 Emsco type NC–36–4 traveling block.
1 Ideco type CB–200 crown block.
1 Ideal National 50 drawworks with Parkersburg hydromatic brake.
3 Caterpillar D–13,000 diesel engines.
1 Ideal type D swivel.
1 Ideal FE–17 ½-in. rotary table.
1 Ideal C–250 7¼ x 15-in. circulating pump.
1 General Motors quad 6 diesel engine.
1 Gardner-Denver 7¼ x 10-in. circulating pump.
1 Marlow, model 445 with 5 hp electric motor cellar pump.
2 Mud tanks, 140-bbl capacity.
1 Kewanee 35 hp boiler.
1 Shaffer blowout preventer.

FUEL, WATER, AND LUBRICANT CONSUMPTION

The materials used while drilling the test were as follows: 602,900 gallons of water, 63,759 gallons of diesel fuel, 1,322 gallons of 72-octane gasoline, 813 gallons of lubricating oil, 445 gallons of thread lubricant, and 160 pounds of grease.

DRILLING OPERATIONS

RIG FOUNDATION

The derrick and drawworks were mounted on pilings driven into the permafrost. After about 2 months of drilling, the substructure supporting the rotary table sank approximately three-fourth inch due to the weight of the drill column. Steel shims were made, inserted under the points of bearing, and rigidity was restored.

While drilling, some difficulty was experienced in keeping the rotary table alined with the drive chain, causing excessive wear of the latter.

DRILLING NOTES

The following table is composed of selected notes from the drilling records.

Notes from drill records

Depth (feet)	Remarks
0	Well spudded in May 20, 1951.
70	Casing set; 68 ft of 16-in. welded casing with guide shoe; 22.9 ft of casing jacketed to 23 in. Cemented with 70 sacks of Cal-Seal.
675	A 4-in. pump hose to standpipe parted; replaced hose with 4-in. steel pipe.

Notes from drill records—Continued

Remarks

890— Casing set; 890 ft of 11¾-in. 47 lb, grade J–55, range 2, seamless 8-round thread-coupled casing. Displaced mud with 34 bbl of diesel fuel and 10 bbl salt-water solution followed by a neat slurry of 210 sacks Hi-Early cement. Top 43 ft of casing was cemented with 25 sacks of Cal-Seal through 1-in. pipe between muck string and 11¾-in. casing. Cement was displaced through guide shoe and float collar.

5,982— Main clutch bearing burned out. Shut down 2 days for repairs.

6,000— Completed drilling Aug. 7, 1951. Suspended operations Aug. 11, 1951. Completion status: all casing was left in hole. Pumped cement into hole at 3,625, 1,650, 900, 870, and 800 ft. Tested top plug at 800 psi with no measurable drop in pressure in 15 min. The well head hook-up was left as follows: 11¾ in casing about 12 in. above cellar floor; a steel plate welded on top of 11¾-in. casing with 2-in. nipple 9 in. long welded on top; capped with a 2-in. Nordstrom plug valve. The hole was left full of thin mud above the plug.

One small mishap occurred while the well was being drilled—the aircraft-warning light on the crown block shorted and caused a minor fire in the canvas covering of the rig. The maximum outdoor temperature was 79° on July 26th, and the minimum was 22° on May 24th.

DRILL AND CORE BITS

To the total depth of 6,000 feet, 50 drill bits (three 15-in. and forty-seven 10⅝-in.) were used to drill 5,135 feet (including 35-ft rathole) and 812 feet was reamed. Fifteen percent (900 ft) of the total depth of the hole was cored, employing 50 core bits. Total recovery was 715.4 feet or 79.6 percent. See graphic log (pl. 15) for further information on drill and core bits.

DRILLING MUD

The Contractor's petroleum engineer (written communication, 1951) states:

A water base mud was used to drill to the total depth. A 75 pound per cubic foot water-Aquagel drilling fluid was mixed initially. The shale formations drilled dispersed sufficiently to maintain the required quantity as drilling progressed. Small amounts of Aquagel were added to maintain desirable wall building properties. Baroid was used to increase mud weight as gas bearing sands were encountered.

Formations drilled contained high percentages of bentonite. The viscosity-increasing characteristics of bentonite required the use of considerable quantities of chemical thinners to keep viscosities at workable values. Anticipated short drilling time indicated the use of dehydrated phosphates for thinning agents and acid pyrophosphate and pyrophosphate were used. Quebracho and Driscose were used to reduce water loss.

No difficulties were encountered on the mud control. The hole drilled clean and at no time was any difficulty experienced in running in or out. Tests show the native clays produce a good filter cake of medium permeability. Gas flow during the tests did not increase appreciably with time indicating no serious mudding off of the permeable formations.

The mud-treating materials used were:

Aquagel	115 sacks.
Baroid	627 sacks.
Quebracho	3,085 lb.
Sodium acid pyrophosphate	735 lb.
Tetrasodium pyrophosphate	3,740 lb.
Driscose	160 lb.
Caustic soda	370 lb.

The following table gives the approximate amounts of materials used at the various depths.

Drilling-mud characteristics and additives, Gubik test well 1

Depth (feet)	Weight (lb/cu ft)	Viscosity (seconds API)	Filtration loss (cc/30 min)	Drilling fluid temperature (°F)	Remarks
15	----------	48	----------	----------	
75	81	40	----------	45	
105	81.5	----------	----------	46	Added 280 lb tetrasodium pyrophosphate, 200 lb quebracho, 100 sacks Aquagel, and 30 sacks Baroid.
365	72	45	----------	58	
650	77	48	5.5	59	
755	78	47	3.5	62	
835	78	47	2.5	70	
890	77	45	5.5	80	
1,090	75	42	6	72	Added 530 lb tetrasodium pyrophosphate, 250 lb quebracho, 9 sacks Aquagel, and 192 sacks Baroid.
1,245	79	45	5.5	70	
1,460	79	47	3.5	64	
1,500	87	45	4	62	
1,655	95	56	3.5	68	
1,735	95	59	4	62	Added 675 lb tetrasodium pyrophosphate, 200 lb quebracho, and 90 sacks Baroid.
1,855	95	60	3.5	78	
2,095	95	59	2.5	72	
2,225	95	60	3	72	
2,445	95	60	3.5	80	
2,550	95	60	3	80	
2,660	95	60	3	75	
2,705	95	56	3	84	
2,770	94	58	3	79	Added 225 lb tetrasodium pyrophosphate.
2,840	94	55	3	79	
2,930	94	57	3.5	82	
2,950	93	50	3	84	
3,050	93	59	3	80	
3,105	93	60	3.5	----------	
3,185	94	57	----------	84	Added 345 lb tetrasodium pyrophosphate and 140 lb quebracho.
3,285	94	53	3	85	
3,345	94	54	3.5	84	
3,430	94	55	3	85	
3,480	93.5	59	3.5	88	
3,520	94	60	3.5	80	
3,560	94.5	60	3.5	70	Added 245 lb tetrasodium pyrophosphate and 110 lb quebracho.
3,585	94.5	56	2.5	70	
3,610	94.5	56	3	70	
3,665	94.5	57	3.5	71	
3,710	95	57	3	70	
3,765	91	48	3	80	
3,800	95	50	3	82	Added 825 lb tetrasodium pyrophosphate, 295 lb quebracho, and 174 sacks Baroid.
3,895	93.5	60	4.5	82	
3,985	95	55	3	84	
4,085	95	60	3.5	84	
4,170	91	60	3.5	89	
4,260	94	60	5.5	80	
4,280	93	53	----------	80	
4,330	93	57	5	88	
4,395	94	56	5	89	Added 100 lb tetrasodium pyrophosphate, 380 lb sodium acid pyrophosphate, 330 lb quebracho, 160 lb Driscose, 20 lb caustic soda, and 71 sacks Baroid.
4,505	94	56	5.5	----------	
4,575	94	55	5.5	86	
4,655	95	56	5	86	
4,740	94	56	5	85	
4,775	94	57	4	85	
4,835	93	49	4.5	92	
4,930	94	54	4.5	98	

Drilling-mud chracteristics and additives, Gubik test well 1—Con.

Depth (feet)	Weight (lb/cu ft)	Viscosity (seconds API)	Filtration loss (cc/30 min)	Drilling fluid temperature (°F)	Remarks
5,040	93	56	5	98	Added 120 lb sodium acid pyrophosphate, 560 lb quebracho, 135 lb caustic soda, and 10 sacks Baroid.
5,100	93	58	5	98	
5,150	94	56	5	95	
5,205	94	59	5.5	96	
5,300	94	54	5.5	98	
5,360	94	58	5	96	
5,410	93	59	5	98	Added 135 lb sodium acid pyrophosphate, 500 lb quebracho, and 150 lb caustic soda.
5,465	94	59	6	98	
5,515	94.5	59	6	98	
5,580	93.5	58	5.5	97	
5,645	93	62	5	98	
5,720	93	59	5	98	Added 365 lb tetrasodium pyrophosphate, 100 lb sodium acid pyrophosphate, 150 lb quebracho, and 15 lb caustic soda.
5,770	93	57	5	96	
5,845	93	69	5.5	100	
5,905	97	59	6	98	
5,970	94	62	6	98	
5,980	94	63	6	90	
6,000	93.5	58	5.5	98	Added 150 lb tetrasodium pyrophosphate, 350 lb quebracho, 50 lb caustic soda, and 60 sacks Baroid.

HOLE-DEVIATION RECORD

No hole-deviation check was made above 2,675 feet (see pl. 15), but from that depth to 2,800 feet the deviation was 1° or more. From 2,800 to 3,900 feet the deviation was less than 1° with one notable exception at 3,009 feet where 2°15′ was recorded. From 3,900 to 5,690 feet the deviation was 1° to 2°, and below that depth it was less than 1°.

ELECTRIC LOGGING

The first electric log run (see following table) from 830 feet was made with a Widco (Well Instrument Developing Co.) Logger. This instrument did not provide a long normal curve. The rest of the surveys were made by the Schlumberger Well Surveying Corp.

Electric-log runs, Gubik test well 1

Run	Date 1951	Depth (feet)
1	May 27	70–830
2	July 20	890–5, 100
3	Aug. 8	5, 100–6, 000

GUBIK TEST WELL 2

Location: Lat 69°25′10″ N., long 151°27′26″ W.
Elevation: Ground, 151 feet; kelly bushing, 163 feet.
Spudded: September 10, 1951.
Completed: December 14.1941; junked and abandoned.
Total depth: 4,620 feet.

Gubik test well 2 also was drilled on the west bank of the Chandler River 4,469 feet east and 3,458 feet south of Gubik test well 1. It is on the south flank of the Gubik anticline, 240 to 270 feet structurally lower than Gubik test well 1. The stratigraphic section drilled is identical with that in Gubik test well 1 except for an additional 250 feet of younger Cretaceous rocks (Barrow Trail member of the Schrader Bluff formation) at the top.

The formations drilled in Gubik test well 2 are as follows:

Formation	Depth (feet) below kelly bushing
Gubik	?
Schrader Bluff:	
Barrow Trail member	160?–555
Rogers Creek member	555–1,135
Prince Creek:	
Tuluvak tongue	1,135–2,010
Seabee	2,010–3,585
Chandler and Ninuluk undifferentiated.	3,585–4,025
Grandstand	4,025–4,395
Topagoruk	4,395–4,620 (total depth)

The average dip of the beds from the top of the hole to the bottom of the Seabee formation is 6°–7°. In the Chandler and Ninuluk formations undifferentiated the dip is 3°. This lower dip may be only apparent, due to the excessive hole deviation of 4° (see pl. 16) recorded at 3,825 feet. Dip in the Grandstand formation averages 4°, but may be affected by the normal fault described below. Although only 200 feet of the Topagoruk formation was penetrated in Gubik test well 2, the lowest two cores show an increase in dip to 13° similar to that of the Topagoruk formation in Gubik test well 1.

Excessively high dips are not present in Gubik test well 2. Slickensides were noted at 1,916, 4,252, and 4,415 feet. Approximately 200 feet of section in the middle of the Grandstand formation present in Gubik test well 1 is missing in Gubik test well 2. In Gubik test well 2 the section may have been cut out by a normal fault at 4,270 feet; another possibility is that the missing section represents an unconformity. Regionally, however, there is no evidence for an unconformity within the Grandstand formation.

DESCRIPTION OF CORES AND CUTTINGS

No samples were received from the first 160 feet of the hole. The quality of the well cuttings was good. The following description of the cores and well cuttings was made after the material was dried.

Lithologic description

[Where no core is listed, description is based on cutting samples]

Core	Depth (feet)	Description
----	0–12	Elevation, rotary drive bushing.
----	12–160	No samples received.
----	160–180	Clay shale, medium-gray, slightly mottled with medium light gray. Yellow and black chert (probably contamination from surface materials), very coarse grains. The first sample received was from 160 ft and represented the Barrow Trail member of the Schrader Bluff formation.
----	180–200	Sandstone, very light-gray, very fine-grained, "tight"; grains subangular to subrounded; 85 percent white and clear quartz; rest dark chert, rare coal particles, mica; white argillaceous, slightly bentonitic matrix. Noncalcareous. Chunk *Inoceramus* prisms imbedded in sandstone.
----	200–240	Siltstone, light-gray, slightly bentonitic; trace to 30 percent medium-gray clay shale.
----	240–250	No sample.
----	250–310	Clay shale, medium-gray; trace to 40 percent light-gray siltstone.
----	310–320	Sandstone, light-gray, very fine- to fine-grained, noncalcareous; grains subangular; 85 percent white and clear quartz; rest dark chert, rock fragments, mica, very rare volcanic glass shards; bentonitic, argillaceous matrix. One chip of sandstone with medium sized grains, noncalcareous.
1	320–340	Recovered 18 ft: Microfossils absent. Sandstone and siltstone 80 percent of core, very light- to light-gray, medium-hard; cleaves parallel to bedding; sandstone is fine to (rare) medium grained but very "dirty" with much silty and argillaceous material; grains angular to subangular, approximately 75 percent white and clear quartz, 15 percent dark chert, coal, and rock fragments, 3 percent opaque white volcanic glass shards, and 3 percent mica; matrix argillaceous and bentonitic. Partings, flakes, and tiny particles of black coal are relatively common. Sandstone and siltstone closely interbedded with medium-light- to medium-gray clay shale with fair cleavage. Certain sections of core show broken laminae suggesting reworking at time of deposition. Three or four cylinders about a half inch in diameter cut vertically or at various angles through the bedding, suggesting mollusk or worm burrows which were later filled with sediment. Large parts of the core are mottled with rounded masses of dark clay surrounded by lighter silt. The masses are 1/16–1/8 inch wide and seldom longer than one-half inch in one plane. These blotches or specks in general have a random orientation but tend to be elongate parallel to the bedding. The origin of these structures is obscure but could be small worm burrows, organic remains, reworked sediments, or the result of chemical action around a foreign nucleus. About 3 in. of conglomerate at 336 ft is made up of rounded black chert granules and pebbles as much as an inch in diameter; quartz granules rare, included also are numerous fragments of an unidentified mollusk plus one piece of a thick-shelled *Inoceramus*, all pebbles and shells are in a light-gray bentonitic clay matrix; sand and silt are slightly to moderately calcareous; dip ranges from 3° to 8°, probably nearer the latter; no shows.
----	340–350	Siltstone, medium-light-gray, 50 percent; sandstone, as above but very fine-grained, 30 percent; and medium-gray clay shale, 20 percent.
----	350–380	Sandstone as in interval 310–320 above, very fine- to fine-grained, very slightly bentonitic, rather hard.
----	380–400	Siltstone, light- to medium-light-gray.
----	400–450	Clay shale, medium-light-gray, silty; as much as 10 percent very light-gray bentonitic siltstone.
----	450–500	Sandstone, very light- to light-gray, very fine- to fine-grained, noncalcareous; grains subangular, 75–85 percent white and clear quartz; rest dark chert, mica, rock fragments, coal particles; white argillaceous, very slightly bentonitic matrix. Thick-shelled *Inoceramus* chunks at 470–480 ft; trace to 10 percent clay shale near base.
----	500–510	Siltstone, medium-light-gray, also 15 percent light-gray sandstone.
----	510–520	Sandstone, light-gray, fine-grained, slightly calcareous; trace medium-gray clay shale.
----	520–530	Clay shale, medium-gray, 50 percent; and light-gray siltstone.
----	530–560	Siltstone, light- to medium-light-gray; as much as 40 percent medium-gray clay shale; some sandstone; rare carbonaceous partings at 530–540 ft; very slightly bentonitic at 550–560 ft. Top of the Rogers Creek member of Schrader Bluff formation placed at 555 ft.

Lithologic description—Continued

Core	Depth (feet)	Description
----	560–590	Clay shale, medium-gray and, where silty, medium-light-gray.
----	590–610	Tuff, light-gray with slight greenish cast and very light-gray, rather hard; contains particles of carbonaceous material and biotite; a few sand grains at 600–610 ft.
----	610–620	Clay shale, medium-gray.
----	620–630	Sandstone, medium-light-gray, fine-grained; subangular to subrounded grains, 80 percent white and clear quartz; rest dark chert, rock and coal particles, small amount of mica, also 15 percent medium-gray clay shale, *Inoceramus* prisms.
----	630–640	Clay shale, medium-gray.
----	640–650	Sandstone, light-gray, fine-grained, noncalcareous; like sandstone at 620–630 ft; 20 percent medium-gray clay shale; trace tuff.
----	650–800	Clay shale, medium-light- to medium-gray; silty at 650–670 and 730–760 ft, sandy at 760–770 ft.
2	800–820	Recovered 17 ft: Microfossils common. Clay shale and siltstone, gradations from one to the other but the whole is very silty; mostly light gray with some medium gray and medium dark gray laminae, medium hard; poor to fair cleavage. Siltstone contains finely disseminated carbonaceous material, mica, and pyrite; bentonitic matrix. Blotches of the type described in core 1 are rare; noncalcareous to slightly calcareous in the siltier streaks; dip 4°–10°.
----	820–850	Siltstone, medium-light-gray, bentonitic matrix; trace sandstone.
----	850–860	Clay shale 80 percent and siltstone 20 percent.
----	860–870	Siltstone, light-gray, sandy.
----	870–880	Tuff, very light- to light-gray, hard; contains biotite plates.
----	880–900	Clay shale, medium-light- to medium-gray; and 10–30 percent very light-gray tuff; much biotite.
----	900–910	Tuff, white to very light-gray, rather hard; trace medium-gray clay shale.
----	910–970	Clay shale, medium-light- to medium-gray; 5 percent white tuff; some bentonitic material at 940–950 ft.
----	970–980	Clay shale, very light- to medium-gray; trace bentonitic siltstone.
----	980–990	Clay shale, medium-light-gray; 5 percent very light-gray tuff.
----	990–1,000	Clay shale, medium-gray.
----	1,000–1,020	Clay shale, medium-gray, 50 percent, and 50 percent pinkish-white tuff; rather soft and porous.
----	1,020–1,040	Clay shale, medium-gray; 5 percent light-gray tuffaceous clay.
----	1,040–1,050	Clay shale, medium-gray; 40 percent white tuff.
----	1,050–1,060	Tuff, white, hard; a few biotite plates; as much as 60 percent soft white bentonite; some medium-gray clay shale.
----	1,060–1,070	Clay shale, medium- to medium-dark-gray, silty; 10 percent tuff.
----	1,070–1,080	Sandstone, light-gray, very fine-grained, silty; largely white and clear quartz grains, some dark chert, coal particles; biotite common; bentonitic matrix; 15 percent medium-gray clay shale.
----	1,080–1,100	Siltstone and clay shale, medium-light-gray, bentonitic.
----	1,100–1,110	Clay shale, medium-gray (some medium-light-gray), silty; biotite present in tiny flakes; 5 percent white tuff.
----	1,110–1,120	Siltstone, light-gray, slightly sandy; carbonaceous particles; fairly large amount of biotite; nonbentonitic; also a fairly large amount of clay shale.
----	1,120–1,140	Clay shale, medium-gray; biotite plates; trace siltstone. Top of the Tuluvak tongue of Prince Creek formation is placed at 1,135 ft.
----	1,140–1,142	Sandstone, light gray.
3	1,142–1,149	Recovered 1 ft 6 in.: Microfossils absent. Sandstone, light-gray, fine-grained, slightly to very calcareous, very hard; 80 percent white and clear quartz grains; rest dark-gray and black chert, rock fragments, and rare coaly particles; biotite surrounded by a brownish material, fairly common; irregular thin streaks of black coal extend nearly vertically through the core; dip not determined; no shows.
4	1,149–1,153	Recovered 4 ft: Microfossils absent. 1 ft 9 in., sandstone, light- to medium-light-gray, very fine-grained, noncalcareous; cleaves parallel to bedding; constituents as in core above; argillaceous cement; dip 5°–9°; no shows. At 1,150 ft effective porosity 20.6 percent, and air permeability, 18 millidarcys parallel to bedding. 2 ft 3 in., clay shale, 50 percent, interbedded with sandstone and siltstone. Sandstone as above. Clay shale is medium gray, medium hard, slightly micaceous and has fair cleavage; tiny blotches (worm burrows?) as described in core 1 are common; noncalcareous.
5	1,153–1,161	Recovered 6 ft 6 in.: Microfossils absent. 1 ft 4 in., clay shale interbedded with siltstone and sandstone as above.

Lithologic description—Continued

Core	Depth (feet)	Description
		5 ft 2 in., sandstone, light-gray, very fine-grained, noncalcareous, medium-hard; good cleavage parallel to bedding; grains subangular, 90 percent white and clear quartz; rest is biotite, dark chert, and scattered ironstone particles; brownish-sideritic cement in lowest 3 inches; dip 4°–8°; no shows. At 1,158 ft effective porosity 23.9 percent, and air permeability, 150 millidarcys parallel to bedding.
6	1, 161–1, 171	Recovered 10 ft: Microfossils absent.
		Sandstone as above, very fine-grained, silty, noncalcareous; good cleavage parallel to bedding in upper half of core but becomes less distinct with depth; argillaceous cement. A small white mollusk fragment plus a few *Inoceramus* prisms at 1,161 ft; dip 8°–12°; no shows. Effective porosity and air permeability parallel to bedding at 1,162 ft are 19.9 percent and 7.5 millidarcys, respectively.
7	1, 171–1, 181	Recovered 10 ft: Microfossils rare.
		Clay shale, 60 percent, sandstone, 30 percent, and siltstone, 10 percent. Clay shale is medium gray, medium soft, and thin bedded; has good cleavage; alternates with slightly micaceous siltstone, containing rare worm burrow "masses"; sandstone is light-gray, silty, noncalcareous; dip 4°–10°.
8	1, 181–1, 191	Recovered 10 ft: Microfossils very rare.
		Sandstone, light-gray, moderately soft, noncalcareous to moderately calcareous; good cleavage parallel to bedding; mostly very fine-grained but with some larger sizes; grains subangular, 85 percent white and clear quartz; rest is dark-colored chert and mica; rare black carbonaceous partings and scattered laminae of medium-gray clay shale; very rare tiny "worm burrows"; dip 5°–10°; no shows. At 1,189 ft effective porosity 12.2 percent, and air permeability, 25 millidarcys parallel to bedding; carbonate content 17.55 percent by weight.
9	1, 191–1, 201	Recovered 10 ft: Microfossils absent.
		Sandstone light-gray, fine-grained, medium-hard; fair to no cleavage; fractures irregularly; contains ironstone particles; rare thin laminae and irregular lenses of medium-gray clay shale. Two or three rounded nodules as much as 2 in. in diameter of medium-light-gray clay ironstone at 1,197 ft. Dip 5°–10°, dips as much as 30° probably represent crossbedding. At 1,197 ft effective porosity 6.8 percent parallel to bedding. Sample plug is impermeable, and carbonate content 28.2 percent by weight. Well geologist reports of cores 3–9 "some gas breaking mud sheath." No shows noted in laboratory.
10	1, 201–1, 211	Recovered 10 ft: Microfossils absent.
		8 ft 4 in., sandstone, light-gray, very fine-grained, silty, calcareous, medium-soft; good cleavage, mostly parallel to bedding; grains subangular, 85 percent white and clear quartz; rest is dark chert, and carbonaceous particles; pyrite common; dip 5°; cross-bedding dips as much as 55°; well geologist reports slight odor, none when core arrived in laboratory.
		8 in., limestone, medium-gray, argillaceous, hard; irregular fracture; contains a few thin white calcite veinlets; some evidence of fracturing; small slickensided surfaces.
		1 ft, siltstone, medium-gray, hard, very calcareous; fair cleavage parallel to bedding; micaceous-carbonaceous partings. At 1,207 ft effective porosity 20 percent, and air permeability 10.5 millidarcys parallel to bedding. Carbonate content 20 percent by weight.
11	1, 211–1, 218	Recovered 5 ft: Microfossils very rare.
		Siltstone, 60 percent, and clay shale, 40 percent. Siltstone is medium-light-gray, slightly calcareous, and argillaceous; has good cleavage and rare dark carbonaceous partings; grades down into medium-gray medium-soft clay shale with fair cleavage; noncalcareous; dip 3°–5°.
12	1, 218–1, 236	Recovered 18 ft: Microfossils absent.
		4 ft 6 in., clay shale, medium- to medium-dark-gray, silty, noncalcareous; poor cleavage contains scattered small dark carbonaceous plant fragments and several medium-light-gray silt laminae.
		2 ft 8 in., sandstone, medium-light-gray, very fine-grained, silty, hard; irregular fracture, subangular grains, 85 percent white and clear quartz, also dark chert, mica and a small amount of pyrite; sandstone becomes light gray and very calcareous in lower 3 in.
		10 ft 10 in., clay shale, medium-gray, silty, medium-hard; poor cleavage; numerous siltstone laminae; clay shale is noncalcareous, and siltstone is slightly calcareous; dip 3°–5°.

Lithologic description—Continued

Core	Depth (feet)	Description
13	1, 236–1, 256	Recovered 5 ft: Microfossils absent. Clay shale, medium-gray; fair cleavage; scattered black carbonaceous or coaly fragments; rare slightly lighter colored silty laminae; clay shale is noncalcareous, but silty laminae are very calcareous; dip 6°–7°.
----	1, 256–1, 305	Clay shale, medium-light- to medium-gray, very silty; 15 percent pinkish-white vein calcite 1,300–1,305 ft.
14	1, 305–1, 315	Recovered 6 ft 6 in.: Microfossils rare. 3 ft 7 in., clay shale, medium-gray, medium-hard, very slightly silty, noncalcareous; fair cleavage; dip 5°–6°. 1 ft 11 in., sandstone, light-gray, fine- to medium-grained; hard; irregular fracture; subangular grains, 90 percent white and clear quartz; rest nearly all dark chert plus some pyrite; argillaceous cement; noncalcareous. 1 ft, coal, dull, black, soft, brittle; badly broken.
15	1, 315–1, 320	No recovery.
16	1, 320–1, 340	Recovered 20 ft: Microfossils absent. 7 ft, interbedded sandstone, 50 percent and clay shale, 50 percent. Sandstone as described below in this core. Medium-gray hard clay shale; fair cleavage; very finely micaceous. 13 ft, sandstone, light- to medium-light-gray, very fine-grained, noncalcareous to very calcareous, hard; massive in part; 75–90 percent white and clear quartz; rest is mostly dark-gray chert, some coal particles and pyrite, and some clay shale laminae at 1,336 ft; dip 7°; no shows. At 1,329 ft effective porosity 13.8 percent, and air permeability 8.5 millidarcys. Sample essentially noncalcareous. At 1,335 ft porosity is 5.81 percent, and sample was impermeable, with a carbonate content of 30.35 percent by weight. The sample plugs tested were parallel to bedding.
17	1, 340–1, 351	Recovered 10 ft: Microfossils very abundant. 4 ft, sandstone, light- to medium-light-gray; mostly fine-grained but some laminae with coarse grains; fine grains subangular; coarse grains subrounded to subangular; fine grains mostly white and clear quartz, but coarser streaks are a salt-and-pepper sand with as much as 50 percent dark-colored chert; at 1,341 ft are very rare rounded black-chert and white-quartz pebbles as much as one-fourth inch in diameter, also one flat ironstone nodule 1 in. wide; noncalcareous; dip 5°–7°; exceedingly faint and fleeting odor, very pale cut and very pale-yellow residue from 1,342 ft. At 1,342 ft effective porosity 21.6 percent, and air permeability 215 millidarcys parallel to bedding. 6 ft, clay shale, medium-dark-gray, medium-hard; rare black coaly or carbonaceous flecks. Plant *Credneria* sp. found.
----	1, 351–1, 353	No sample.
18	1, 353–1, 373	Recovered 20 ft: Microfossils absent. 6 in, clay shale, medium-light- to medium-dark-gray, sandy and silty lenses; rather soft; core broken. 1 ft, coal, shiny to dull, black, platy, brittle. 18 ft 6 in., sandstone, light-gray, fine- to medium-grained, noncalcareous, medium-hard, slightly friable; grains subangular, 80 percent white and clear quartz; rest mostly dark chert, coal particles, rare rock fragments, and some biotite. Fairly abundant partings and thin laminae of coal; some yellow resinous material found in one of these coaly laminae at 1,372 ft; dip 9°, with dips of 22° probably representing crossbedding; faint to fair odor, yellow cut and brown residue at 1,359 and 1,367 ft. At 1,359 ft effective porosity 22.7 percent, and air permeability 51 millidarcys; at 1,367 ft porosity 21.3 percent, and permeability 117 millidarcys. All sample plugs were taken parallel to bedding.
19	1, 373–1, 392	Recovered 19 ft: Microfossils absent. Sandstone color and composition as above, grain size varies approximately as follows: 1,373–1,378 ft, medium grained, with coaly partings containing resinous material as in core above; 1,378–1,383 ft, sandstone is very fine grained and silty with core bleeding oil through a 6-in. segment at about 1,381 ft; 1,383–1,388 ft, fine to medium grained, massive, faint oil stain at about 1,384 ft; 1,388–1,392 ft, sandstone is very fine grained and silty, about 1½ ft of medium-gray clay shale, very rare very thin laminae of yellowish-gray clay ironstone; noncalcareous; dip 3°–12°; fair odor, olive stain, amber cut, and brown residue from 1,381 ft and 1,384 ft. At 1,381 ft effective porosity 19.35 percent, and air permeability 4.5 millidarcys. At 1,384 ft porosity 19.4 percent, and permeability 160 millidarcys. Both

Lithologic description—Continued

Core	Depth (feet)	Description
		sample plugs tested were parallel to bedding.
20	1, 392–1, 402	Recovered 10 ft: Microfossils absent. 1 ft 1 in., sandstone, light-gray, very fine-grained and silty, noncalcareous, hard; mostly white and clear quartz grains, with rare partings containing medium-sized dark chert grains. 2 ft 1 in., coal, dull to shiny, black, brittle, flaky. 4 ft, clay shale, light-gray, bentonitic, medium-soft; very silty and sandy toward base; biotite plates very common; a few plant fragments at top; about 4 in. of clay shale at 1,397 ft impregnated along bedding planes with white crystalline aragonite; grades into sandstone below. 2 ft 10 in., sandstone, light-gray, fine- to medium-grained, medium-hard, massive; angular to subangular grains; 75 percent white and clear quartz; 10–20 percent biotite; rest mostly coal particles and dark chert; cement partly argillaceous or calcareous; dip 5°–7°; no shows. At 1,400 ft effective porosity is 5.6 percent parallel to bedding; impermeable; carbonate content 14.6 percent by weight.
----	1, 402–1, 420	Sandstone, light-gray, fine- to medium-grained, noncalcareous; composition as above but less biotite; also some medium-light- to medium-gray clay shale; trace bentonite, coal, and light-olive-gray clay ironstone.
----	1, 420–1, 430	Clay shale, medium-light- to medium-gray; trace to 5 percent coal; moderate-yellowish-brown clay ironstone.
21	1, 430–1, 445	Recovered 13 ft: Microfossils absent. 2 in., bentonite, light-bluish and greenish-gray, medium-soft when dry; swells tremendously when moistened. 1 ft 10 in., clay shale and claystone, medium-gray, medium-hard; poor cleavage; subconchoidal to irregular fracture. 7 in., bentonite, light-gray, rather soft, argillaceous, also slightly sandy; contains much biotite. 7 ft, clay shale, light- to dark-gray, soft and crumbly, ranges from carbonaceous and coaly to very bentonitic. 3 ft 5 in., sandstone, light-gray, medium-grained, noncalcareous, medium-hard to soft and friable; subangular grains, 75 percent white and clear quartz; rest mostly dark chert and coal particles, biotite common; dip 4°–8°; no shows. At 1,440 ft parallel to bedding, effective porosity 18.26 percent, and air permeability 88 millidarcys.

Lithologic description—Continued

Core	Depth (feet)	Description
22	1, 445–1, 462	Recovered 11 ft: Microfossils absent. Sandstone, light- to medium-light-gray, medium-grained, noncalcareous to very slightly calcareous, medium-hard to rather soft and friable; tends to break parallel to bedding; grains subangular, 75 percent white and clear quartz; rest dark chert, rock fragments, coal particles, scattered white chert (?) particles, and some biotite; argillaceous cement; rare carbonaceous partings; no shows. Effective porosity 19 percent, and air permeability 105 millidarcys parallel to bedding at 1,446 ft.
23	1, 462–1, 482	Recovered 20 ft: Microfossils absent. Sandstone, light- to medium-light-gray, medium-grained, medium-hard, slightly friable, massive; composition as in core immediately above; noncalcareous to very calcareous cement; no shows; dip undetermined. At 1,463 ft effective porosity 18.56 percent, and air permeability 32 millidarcys parallel to bedding.
24	1, 482–1, 502	Recovered 17 ft; Microfossils abundant. 3 ft 7 in., sandstone as above. 2 ft 2 in., clay shale, medium-dark- to grayish-black, hard; poor to good cleavage; becomes fissile and very coaly toward base; rare pyrite nodules; slickensided surface dipping 50° near top of segment. 2 in., bentonite, grayish-green, flaky. 5 in., coal, grayish-black to black, shiny to dull, thin sand interbeds. 10 ft 8 in., sandstone, light- to medium-light-gray, fine- to medium-grained, noncalcareous to very calcareous, hard, slightly friable; grains subangular, 75 percent white and clear quartz; rest dark chert, rock fragments, and chalky-white particles which may be weathered chert; scattered dark carbonaceous partings; lighter-colored streaks of sandstone with very calcareous matrix; dip 7°; no shows. At 1,493 ft effective porosity 14.63 percent, and air permeability <1 millidarcy; at 1,495 ft porosity 20.66 percent, and permeability 430 millidarcys; all readings were made on sample plugs cut parallel to bedding.
25	1, 502–1, 512	Recovered 9 ft: Microfossils absent. 1 ft, clay shale, medium-gray, medium-hard, slightly micaceous; fair cleavage. 8 ft, sandstone, light-gray, very fine- to fine-grained, slightly to very calcareous, medium-hard; cleaves parallel to bedding; grains subangular, 75–90 percent white and clear quartz;

Lithologic description—Continued

Core	Depth (feet)	Description
		rest dark chert, rock fragments, and some biotite; argillaceous and calcareous cement; dark carbonaceous partings common; rare clay shale laminae; dip 3°–7°; no shows. At 1,508 ft effective porosity is 8.65 percent; sample was impermeable; carbonate content not tested. At 1,509 ft porosity 18.5 percent; sample unsuitable for permeability test, carbonate content 22.65 percent by weight.
26	1, 512–1, 522	Recovered 10 ft; Microfossils absent. Interbedded clay shale, 40 percent, siltstone, 30 percent, and sandstone, 30 percent. Clay shale is medium gray and medium hard; good cleavage. Sandstone is medium light gray, very fine grained, medium soft and friable; good cleavage parallel to bedding; vertical fracture; 85 percent white and clear quartz grains, some with yellowish tinge; rest is dark chert, coal, rock particles, and mica; grades into siltstone; rare carbonaceous partings, suggestion of swirly bedding at 1,513 ft, very rare dark plant impressions near top; noncalcareous; dip 4°–7°; no shows. Effective porosity 21.62 percent, and air permeability, 43.5 millidarcys (sample cracked) parallel to bedding.
27	1, 522–1, 532	Recovered 5 ft: Microfossils absent. Interbedded clay shale, 80 percent and siltstone, 20 percent. Clay shale is medium gray, medium hard, and slightly micaceous; fair cleavage. Siltstone is medium light gray and medium hard; has fair cleavage; grades from clay to silt; very thin laminae of shiny black coal at bottom of core; very slightly sideritic streaks; no shows.
28	1, 532–1, 542	Recovered 1 ft 6 in.: Microfossils absent. Siltstone, light-gray, sandy, noncalcareous, soft to hard; bentonite in streaks; fair cleavage; also laminae of soft medium-gray clay shale and light-bluish-gray bentonite; dip undetermined; no shows.
29	1, 542–1, 552	Recovered 8 ft: Microfossils absent. Sandstone, medium-light-gray, very fine-grained, silty, medium-soft and friable to medium-hard; tends to cleave parallel to bedding; vertical fracture; grains subangular, 80 percent white and clear quartz; rest coal particles, rock fragments, and common chert and mica; slightly bentonitic partings at 1,544 ft, light-olive-gray flat ironstone nodules as much as 1½ in. in diameter at 1,546–1, 547 ft; mostly noncalcareous but very calcareous at 1,547 ft; dip 9°; no shows.
30	1, 552–1, 554	Recovered 2 ft: Microfossils absent. Sandstone, very fine-grained, silty (as above), noncalcareous, micaceous, one-half in. medium-gray hard limestone at bottom of core; dip 7–19°; no shows. At 1,553 ft, effective porosity 11.87 percent parallel to bedding, and sample plug is impermeable.
31	1, 554–1, 558	Recovered 3 ft: Microfossils absent. 4 in., limestone, medium-gray, hard, vertical fracture. 2 ft 8 in., sandstone, medium-light-gray, very fine-grained and silty, noncalcareous, medium-hard; grains subangular, largely white and clear quartz; good cleavage parallel to bedding; carbonaceous-micaceous partings; dip 9°; no shows. At 1,557 ft effective porosity 11.12 percent, and sample plug is impermeable.
32	1, 558–1, 568	Recovered 10 ft: Microfossils absent. Sandstone and siltstone, as in core 31 above, very fine-grained, noncalcareous, medium-hard; good to excellent cleavage; carbonaceous-micaceous partings; yellowish-gray ironstone laminae as much as 2 in. thick at 1,561 and 1,565 ft; scattered medium-gray clay shale laminae; dip 4°–9°; no shows. At 1,560 ft effective porosity 16.71 percent, and air permeability 6.96 millidarcys parallel to bedding.
33	1, 568–1, 578	Recovered 10 ft: Microfossils absent. Interbedded siltstone, 80 percent and clay shale, 20 percent. Siltstone is medium light gray, hard, slightly sandy, also argillaceous; tends to cleave parallel to bedding; grains almost entirely white and clear quartz; small amount of crossbedding. Clay shale is medium gray, noncalcareous, and moderately hard; fair cleavage; closely interbedded with the siltstone; finely micaceous, exceedingly rare bentonitic partings; yellowish-gray ironstone nodules at 1,570 ft and 1,577 ft; dip 6°; no shows. At 1,574 ft effective porosity 14.90 percent, and sample plug is impermeable.
34	1, 578–1, 580	Recovered 2 ft.: Microfossils common. Interbedded clay shale, 70 percent, and 30 percent finely micaceous siltstone; crossbedding on a small scale; 2 inches of yellowish ironstone in about the middle of the core; noncalcareous except for sideritic concretion; dip 6°. At 1,580 ft effective porosity 12.15 percent and sample plug impermeable.

Lithologic description—Continued

Core	Depth (feet)	Description
----	1, 580–1, 600	Sandstone, light- to medium-light-gray, very fine-grained, silty.
----	1, 600–1, 630	Clay shale, medium-light-gray with some medium-gray, slightly to very silty; trace sandstone; trace bentonite and bentonitic greenish-gray shale; trace light-olive-gray ironstone.
----	1, 630–1, 640	Siltstone, light-gray, slightly sandy, argillaceous, noncalcareous; biotite common.
----	1, 640–1, 650	Clay shale, silty, and argillaceous siltstone; micaceous.
----	1, 650–1, 669	Clay shale, medium-light to medium-gray; trace bentonitic siltstone 1,645–1,655 ft; trace to 5 percent ironstone at 1,660–1,669 ft; trace coal; dark-gray carbonaceous shale and bentonitic shale at 1,660–1,669 ft; trace to 5 percent white bentonite 1,665–1,670 ft.
35	1, 669–1, 676	Recovered 7 ft. Microfossils absent. Interbedded sandstone, 40 percent, siltstone, 30 percent, and clay shale, 30 percent. Sandstone is light to medium light gray, hard, medium grained; subangular grains 80 percent white and clear quartz grains; rest almost all dark-gray and black chert plus fairly abundant pyrite; grades into medium-light-gray siltstone and medium-gray moderately hard finely micaceous clay shale with good cleavage; siltstone and clay shale noncalcareous; dip 6°; no shows. At 1,673 ft effective porosity 15.7 percent; sample unsuitable for permeability test.
36	1, 676–1, 686	Recovered 4 ft 6 in.: Microfossils absent. Clay shale, 60 percent and siltstone, 40 percent, very closely interbedded in thin varvelike beds. Siltstone is medium light gray with sandy streaks. Clay shale is medium to medium dark gray and noncalcareous; an inch of dark-gray argillaceous coal 6 in. from top of core; one piece of clear yellow resinous material embedded in shale near coal; carbonaceous and micaceous partings; dip 3°–7°.
37	1, 686–1, 696	No recovery.
38	1, 696–1, 700	No recovery. A few chunks of core taken from bit at 1,700 ft consisted of hard medium-gray siltstone laced with black coaly plant impressions; also some medium-gray clay shale.
39	1, 700–1, 706	Recovered 6 ft: Microfossils absent. Sandstone, light-gray, salt-and-pepper, fine- to medium-grained (mostly the latter), also rare coarse grains; hard, massive; angular to subangular grains, 65 percent white and clear quartz, 20 percent dark-gray and black chert, also some opaque white material (weathered chert or possibly feldspar) some yellow quartz, rare brown ironstone particles, some mica; calcareous cement; one medium-dark-gray subrounded chert pebble one-half inch in diameter at 1,704 ft. Dip undetermined. Very faint odor, straw-colored cut and pale-yellow residue from 1,702 ft. At 1,702 ft effective porosity parallel to bedding 16.61 percent, and air permeability 13 millidarcys; carbonate content 17.55 percent by weight.
40	1, 706–1, 722	Recovered 16 ft: Microfossils absent. Sandstone, composition as above, medium-grained with scattered coarse-grained streaks; grain size decreases to fine toward base of core. On parting of clay shale and one of coal near top of core; light-colored very calcareous cement in upper 2 ft; rest of core noncalcareous; dip 5°; very faint odor, pale-straw-colored cut and pale-yellow residue at 1,710 ft. The following porosity and permeability determinations were made:

Depth (feet)	Effective porosity (percent)	Air permeability (millidarcys)	Carbonate content (percent by weight)
1,710 parallel	14.65	9.5	Trace.
1,715 parallel	15.4	6	Do.
1,719 parallel	9.82	0	Do.

Core	Depth (feet)	Description
41	1, 722–1, 731	Recovered 8 ft: Microfossils absent: Sandstone, medium-light-gray, very fine-grained, hard; cleaves parallel to bedding; grains subangular, 85 percent white and clear quartz; rest rock fragments, dark chert, carbonaceous particles, and common biotite; argillaceous cement. About 10 percent of the recovery is medium-gray hard finely micaceous clay shale, with fair cleavage; noncalcareous to slightly calcareous in upper few feet of core where there is some sideritic cement; dip 4°; no shows. At 1,725 ft effective porosity 7.62 percent; sample plug is impermeable, and carbonate content 28.4 percent by weight.
42	1, 731–1, 737	Recovered 3 ft 6 in.: Microfossils common. Interbedded siltstone, 60 percent, and clay shale, 40 percent. Siltstone is medium light gray, hard; interbedded with and gradational with medium-

Lithologic description—Continued

Core	Depth (feet)	Description
		gray hard finely micaceous clay shale with fairly good cleavage; noncalcareous; dip 5°; no shows. At 1,730 ft effective porosity 4.89 percent, and sample plug impermeable.
----	1, 737–1, 745	Clay shale, 60 percent, medium-light-gray; 30 percent light-gray siltstone; and 10 percent light-gray medium-grained sandstone; trace very light-gray bentonitic clay shale; coal and ironstone.
----	1, 745–1, 750	Sandstone, light-gray, very fine-grained, noncalcareous, hard; subrounded to subangular grains, 85 percent white and clear quartz, also black carbonaceous fragments, dark chert, and mica; 5 percent medium-gray clay shale.
----	1, 750–1, 765	Bentonite, white; also medium-dark-gray clay shale; trace grayish-black carbonaceous shale and coal; trace slightly calcareous very fine- to fine-grained sandstone.
----	1, 765–1, 770	Clay shale, medium-light-gray; trace sandstone, bentonite, and coal.
----	1, 770–1, 780	Sandstone, light-gray, medium-grained; subangular to (rarely) subrounded grains, 85 percent white and clear quartz; rest mostly dark-gray and black chert, some coal particles; trace clay shale and coal.
----	1, 780–1, 795	Clay shale, medium-light-gray; trace carbonaceous shale, bentonite, and ironstone; 15 percent sandstone at 1,790–1,795 ft.
----	1, 795–1, 806	Sandstone, light-gray, salt-and-pepper, very fine- to very coarse-grained, noncalcareous, soft; 65 percent white and clear quartz, 30 percent dark-gray and black chert, some coal particles and mica, rare rounded black chert granules; trace to 10 percent medium-light-gray clay shale; 10 percent shiny black coal at 1,800–1,805 ft; trace very light-gray bentonitic clay shale at 1,805–1,810 ft.
43	1, 806–1, 813	No recovery.
44	1, 813–1, 820	Recovered 7 ft: Microfossils absent. 1 ft 6 in., interbedded siltstone, 90 percent, and clay shale; medium-light-gray and medium-gray, noncalcareous, hard, sandy, with fair cleavage; dip 9°. 5 ft 6 in., sandstone, light-gray, medium- to coarse-grained, noncalcareous, medium-hard but slightly friable; good, nearly poker-chip cleavage; grains subangular; salt-and-pepper sandstone; 55 percent white and clear quartz grains, 40 percent rock fragments and dark-gray, brownish, and black chert; other minerals rare; argillaceous cement; numerous coaly partings; quite coaly in the lowest 6 in. of recovery;

Lithologic description—Continued

Core	Depth (feet)	Description
		rare clay shale laminae; drop test indicates moderate porosity; dip 9°; no shows.
45	1, 820–1, 826	Recovered 6 ft: Microfossils absent. Sandstone, light-gray, clean, coarse-grained, soft to nearly unconsolidated; friable although upper 2 ft of recovery was hard; cleaves approximately parallel to bedding; subangular, salt-and-pepper sandstone, 50 percent white and clear quartz grains, 45 percent dark-gray and brown chert, rock fragments, and coaly particles; mica and other minerals rare; loosely cemented with argillaceous material and in some places with calcite. Rare carbonaceous partings in upper foot of recovery; very calcareous in upper 2 ft and noncalcareous below; dip 10°; no shows.
46	1, 826–1, 836	Recovered 6 ft 6 in.: Microfossils absent. Sandstone, color and composition as above, soft, coarse, rarely very coarse, noncalcareous; dip undetermined.
47	1, 836–1, 841	Recovered 4 ft.: Microfossils absent. Sandstone, color and composition as above, nearly unconsolidated, coarse- to very coarse-grained, noncalcareous; 55 percent dark minerals and rock fragments, 45 percent light-colored quartz; dip undetermined; no shows.
48	1, 841–1, 848	Recovered 7 ft: Microfossils absent. Sandstone, light-gray, coarse- to very coarse-grained, noncalcareous, salt-and-pepper, soft, friable, clean, poker-chip cleavage; subangular to subrounded grains, 55 percent dark-gray, brown, and black chert, dark-colored rock fragments and coaly particles, 45 percent white and clear quartz, very rare rounded black chert granules and pebbles; also brown flat pebbles or nodules of clay ironstone as much as 2 in. in diameter particularly at 1,847 ft; one 2-in. medium-gray clay shale pebble at 1,845 ft; argillaceous cement; dip 9°; faint odor, straw-colored cut, yellow residue from 1,843 ft; faint odor, pale-straw-colored cut, and yellow residue from 1,846 ft. At 1,843 ft effective porosity 25.2 percent, and air permeability 3,780 millidarcys parallel to bedding.
49	1, 848–1, 868	Recovered 20 ft: Microfossils absent. Sandstone as above, but slightly more consolidated; cleavage not developed quite as well; brown ironstone nodules as much as 1-in. thick at 1,848, 1,849, 1,850, 1,858, 1,861, 1,862, and 1,865 ft. Black carbonaceous plant frag-

Lithologic description—Continued

Core	Depth (feet)	Description
		ments and black coaly laminae at 1,855, 1,861, and 1,864 ft; clear yellow resinous material in the coal; very calcareous in upper foot of core and rarely in other spots, noncalcareous elsewhere; dip 8°; faint odor, pale-straw-colored cut, yellow residue from 1,852 ft; faint odor, pale-yellow cut, brownish-yellow residue from 1,856 ft; faint odor, yellow cut and yellow-brown residue from 1,861 and 1,865 ft. Following porosity and permeability determinations were made.

Depth (feet)	Effective porosity (percent)	Air permeability (millidarcys)	Carbonate content
1,852 parallel	25.4	Not suitable	Trace.
1,861 parallel	18.35	61	Do.
1,865 parallel	19.5	95	Do.

50	1, 868–1, 880	Recovered 12 ft: Microfossils absent. 5 ft 6 in., sandstone, light-gray, medium- to (rare) coarse-grained, medium-soft; cleaves parallel to bedding; subangular grains, 60 percent white and clear quartz; rest mostly brown and gray chert; other minerals rare; argillaceous cement except for 6 in. with light-colored very calcareous cement at 1,873 ft; scattered dark carbonaceous partings; dip 9°; faint odor, yellow cut and yellowish-brown residue at 1,872 ft. At 1,871 ft effective porosity 19.64 percent, and air permeability 270 millidarcys (plug cracked); essentially noncalcareous. At 1,873 ft porosity 5.45 percent, and sample plug impermeable; carbonate content 24.8 percent by weight. Abrupt change to unit below. 5 ft, siltstone, medium-light-gray, medium-hard; excellent cleavage in part; much finely disseminated carbonaceous material and scattered partings with black broken plant fragments; rare irregular sandy lenses; dip 4°–7°; grades into unit below. 1 ft 6 in., clay shale, medium-light-gray, noncalcareous, rather hard and brittle, thin-bedded; uniform in color and texture; fair cleavage; ½-in. layer of yellowish-gray clay ironstone and ½-in. layer light-gray soft bentonitic shale near base.
51	1, 880–1, 885	Recovered 5 ft: Microfossils absent. Clay shale, medium-light- to medium-gray, noncalcareous, medium-soft to medium-hard; poor to fair hackly cleavage; possibly slightly bentonitic; medium-light-gray siltstone laminae as much as 2 in. thick also present; dip 7°.
----	1, 885–1, 900	Clay shale, medium-light- to medium-gray; trace siltstone and ironstone; also trace very calcareous medium- to coarse-grained sandstone as below.
----	1, 900–1, 910	Sandstone, light-gray, salt-and-pepper, fine- to coarse-grained granule; grains subangular to subrounded; granules rounded; quartz and chert grains; very calcareous cement in part, loose sand grains in part; 10 percent medium-light-gray clay shale and 5 percent clay ironstone.
----	1, 910–1, 915	Clay shale, medium-light- to dark-gray.
52	1, 915–1, 935	Recovered 20 ft: Microfossils absent. 2 ft, claystone, medium-dark-gray, noncalcareous, hard, dense; hackly or no cleavage; subconchoidal fracture; almost vertical slickensides at 1,916 ft; excellent small black leaf impressions throughout the core. These leaves identified by Roland W. Brown, U. S. Geological Survey, as *Trapa? microphylla* Lesquereux, which ranges in age from Late Cretaceous to Paleocene; grades down into unit below. 8 ft, interbedded siltstone, 70 percent, and very fine-grained sandstone; light- to medium-light-gray, hard, argillaceous; some small scale crossbedding; impression of large leaf at 1,923 ft, shiny black coal fragments 2 in. long embedded in the sandstone at 1,924 ft; sandstone very slightly calcareous; dips variable, average about 7°; grades into unit below. 10 ft, sandstone, light-gray, medium- to (very rare) coarse-grained, medium-hard, massive; irregular fracture; subangular to subrounded grains, 50 percent white and clear quartz; rest is dark-gray, brown, and black chert, rock fragments, and scattered coaly particles; very rare ironstone nodules; dip undetermined; no odor, no cut, very pale-yellow residue from 1,932 ft.

Depth (feet)	Effective porosity (percent)	Air permeability (millidarcys)	Carbonate content (percent by weight)
1,924 parallel	12.24	3	Trace.
1,928 parallel	18.7	222	13.5.
1,932 parallel	5.5	0	30.5.

Lithologic description—Continued

Core	Depth (feet)	Description
53	1, 935–1, 955	Recovered 20 ft: Microfossils absent. Sandstone color and composition as above, grain size variable, very fine- to fine-grained in the upper 6 ft; also numerous partings with broken black leaf impressions. Rest of core medium grained; no odor, no cut, greasy film in evaporating dish, from 1,948 ft.

Depth (feet)	Effective porosity (percent)	Air permeability (millidarcys)	Carbonate content (percent by weight)
1,939 parallel	4. 44	0	53.8.
1,944 parallel	14. 8	12. 5	Trace.
1,948 parallel	15. 0	14	Do.

54	1, 955–1, 960	Recovered 5 ft: Microfossils absent. 4 ft, sandstone, light-gray, fine- to (rare) coarse-grained, hard; irregular fracture; subangular grains; constituents as above but with 75 percent white and clear quartz; very rare silty laminae; noncalcareous to very calcareous in thin light-colored streaks; dips as much as 15° probably indicate cross-bedding; no shows. At 1,957 ft effective porosity 16.8 percent, and air permeability 12.5 millidarcys parallel to bedding. 1 ft, coal, shiny to dull, black, blocky fracture, a few inches of carbonaceous sandstone at base.
55	1, 960–1, 980	Recovered 20 ft: Microfossils absent. Sandstone, light-gray, hard, fine- to medium-grained; massive in upper half of core, subangular to subrounded grains, 75 percent white and clear quartz, 20 percent dark-gray and black chert, dark-colored rock fragments, and coal particles; some dark carbonaceous coaly partings particularly in lower half of core, some clear resinous material with the coal; two small rounded black-chert pebbles (three-fourths inch in diameter) at 1,972 ft. Six inches of paper-thin laminae of clay shale topping at 1,973 ft, medium-light-greenish-gray, contains abundant black carbonaceous particles, also much biotite and large (one-sixteenth inch) plates of white mica; matrix resembles bentonite but does not swell when moistened; noncalcareous to very calcareous cement; dip 5°–7°; no shows. Porosity and permeability determinations were made as follows:

Depth (feet)	Effective porosity (percent)	Air permeability (millidarcys)	Carbonate content (percent by weight)
1,964 parallel	16. 7	50	8. 24
1,972 parallel	4. 8	0	30. 35
1, 977 parallel	18. 6	22. 5	17. 71

56	1, 980–1, 984	Recovered 4 ft: Microfossils absent. Sandstone, light-gray, fine-grained, noncalcareous, hard; breaks parallel to bedding; some very fine-grained and silty layers; 85 percent white and clear quartz grains; rest is mostly dark chert, carbonaceous particles, and some mica; rare thin laminae of light-gray clay shale; dip 3°; no shows.
----	1, 984–1, 995	Sandstone, light-gray, very fine-grained, soft, noncalcareous; 95 percent white and clear quartz grains, rare dark chert and biotite.
----	1, 995–2, 000	Clay shale, 70 percent, medium-light-gray, and sandstone as above.
----	2, 000–2, 030	Sandstone, light-gray, salt-and-pepper; fine- to medium-grained, 75 percent white and clear quartz grains; white, very calcareous matrix at 2,020–2,030 ft. The top of the Seabee formation is placed at 2,010 ft.
----	2, 030–2, 069	Clay shale, 50–80 percent, medium-light-gray and light-gray, fine- to medium-grained sandstone; trace brownish-gray clay ironstone at 2,050–2,060 ft.
57	2, 069–2, 079	Recovered 10 ft: Microfossils absent. 4 ft, claystone, medium-gray, hard, dense; irregular fracture; finely disseminated mica gives a sheen to the fracture surfaces. 6 ft, interbedded clay shale, 85 percent, and siltstone, 15 percent. Clay shale is medium gray; alternates with very thin beds of medium-light-gray hard siltstone, with good cleavage, and rare carbonaceous flecks; yellowish-gray ironstone concretions fairly common; noncalcareous; dip 7°.
58	2, 079–2, 089	Recovered 10 ft: Microfossils rare. Interbedded clay shale as above, 65 percent, and siltstone, as above, 35 percent, contacts between the two mostly quite sharp; small amount of gradation; rare carbonaceous partings; ironstone lenses and laminae present; noncalcareous; dip 5°–7°.

Lithologic description—Continued

Core	Depth (feet)	Description
59	2, 089–2, 109	Recovered 20 ft: Microfossils common. 10 ft 6 in., interbedded siltstone, as above, 75 percent and clay shale as above; 6 inches of light-gray medium-grained sandstone at 2,090 ft; yellowish-gray ironstone nodule at 2,093 ft; a few very small white pelecypods and gastropods at 2,095 ft; some pyrite stringers; noncalcareous; dip 5°–7°. 9 ft 6 in., sandstone, light-gray, fine-grained, hard, massive; subangular grains, 80 percent white and clear quartz, some with yellowish tinge; rest is dark chert, rock fragments, coal particles and mica; some calcareous cement; no shows. At 2,100 ft effective porosity 14.32 percent, air permeability 3.5 millidarcys and carbonate content 12.85 percent by weight. At 2,107 ft porosity 15.4 percent, permeability 6.1 millidarcys, and carbonate content 16.51 percent.
60	2, 109–2, 129	Recovered 17 ft: Microfossils absent. Sandstone, light- to medium-gray, very fine- to fine-grained, silty, hard to very hard; irregular fracture; composition as in core above; upper 6 ft of core extremely calcareous, nearly a silty limestone; at 2,113 ft a 116-in.-thick white-calcite vein extends at an angle of 70° through the core; one small poorly preserved pelecypod at 2,127 ft; dip 5°; no shows. At 2,110 ft effective porosity 0.75 percent, sample impermeable, and carbonate content 49.6 percent by weight. At 2,125 ft porosity 15.2 percent, permeability 4.5 millidarcys, and carbonate content 21.05 percent.
61	2, 129–2, 145	Recovered 16 ft: Microfossils rare. Siltstone and very fine-grained sandstone, light- to medium-light gray, medium-hard; excellent cleavage; numerous partings containing black carbonaceous plant particles; 5–10 percent thin medium-gray laminae of clay shale; noncalcareous; dip 6°; no shows. At 2,132 ft effective porosity 11.39 percent, and at 2,140 ft 7.3 percent. Both samples impermeable.
62	2, 145–2, 146	Recovered 1 ft: Microfossils rare. Siltstone with clay shale streaks as above; dip 5°.
----	2, 146–2, 155	Clay shale, 80 percent, medium-light-gray; and light-gray fine- to medium-grained sandstone.
----	2, 155–2, 170	Siltstone and very fine-grained sandstone, light- to medium-light-gray, noncalcareous; trace to 10 percent medium-light-gray clay shale.
63	2, 170–2, 180	Recovered 7 ft: Microfossils abundant. Interbedded siltstone, 60 percent, and clay shale, 40 percent, medium-light- and medium-gray, noncalcareous, medium-hard; excellent cleavage; micaceous-carbonaceous partings; dip 6°.
64	2, 180–2, 190	Recovered 9 ft: Microfossils very abundant. Interbedded siltstone as above, 50 percent, and clay shale, as above, 50 percent; dip 5°.
65	2, 190–2, 200	Recovered 10 ft: Microfossils abundant. Clay shale, medium-dark-gray, medium-hard, good cleavage; about 25 percent medium-light-gray thin siltstone laminae; carbonaceous and micaceous partings; fragment of unidentified dicotyledonous leaf; noncalcareous; dip 6°.
66	2, 200–2, 210	Recovered 8 ft: Microfossils abundant. 4 ft, clay shale, medium-dark-gray, noncalcareous, hard; 5 percent silty laminae; one tiny white mollusk fragment at top of core; poor to fair cleavage. 1 ft 3 in., limestone, medium-light- to medium-gray, hard, argillaceous; irregular fracture. 2 ft 9 in., clay shale as in upper part of core; carbonaceous and micaceous partings; dip 6°.
67	2, 210–2, 218	Recovered 2 ft: Microfossils abundant. Clay shale as immediately above.
----	2, 218–2, 370	Clay shale, medium-light- to medium-dark-gray, primarily medium-gray; as much as 10 percent medium-light-gray calcite at 2,315–2,325 ft.
----	2, 370–2, 400	Clay shale, medium-light- to medium-dark-gray, micaceous; trace siltstone.
----	2, 400–2, 470	Clay shale, medium-light- to medium-gray; trace siltstone at 2,420–2,460 ft.
----	2, 470–2, 510	Clay shale, medium-light- to medium-gray; trace to 5 percent siltstone, one-third is medium light to light gray at 2,490–2,510 ft; 30 percent bentonitic light-gray shale 2,470–2,480 ft; trace of medium-light-gray limestone and aragonite at 2,470–2,480 ft; trace of bentonitic clay shale; and 5 percent very calcareous siltstone at 2,480–2,490 ft.
----	2, 510–2, 520	Siltstone, 90 percent, light-gray, slightly calcareous; and medium-gray clay shale.
----	2, 520–2, 680	Clay shale, medium-light- to medium-gray; 10 percent shiny to dull black coal at 2,520–2,530 ft; 10 percent medium-light-gray siltstone; some medium-dark-gray shale; clump of *Inoceramus* prisms at 2,540–2,550 ft; pieces of *Inoceramus* shell and fish fragments at 2,670–2,680 ft.
----	2, 680–2, 690	Siltstone, medium-light-gray, argillaceous, noncalcareous, and medium-gray clay shale; clump of *Inoceramus* prisms.

Lithologic description—Continued

Core	Depth (feet)	Description
----	2, 690–2, 700	Clay shale, medium- to medium-dark-gray; one piece of *Inoceramus* shell; trace siltstone and trace light-gray bentonite containing biotite plates.
----	2, 700–2, 760	Clay shale, medium-light- to medium-gray, silty; trace coal at 2,740–2,750 ft; chunks of *Inoceramus* prisms at 2,700–2,710 and 2,740–2,750 ft; some medium-dark-gray clay shale and fish fragments at 2,750–2,760 ft.
----	2, 760–2, 770	Clay shale, medium-light-gray; trace light-gray bentonitic clay shale; trace coal, *Inoceramus* chunks.
----	2, 770–2, 780	Clay shale, medium-gray; trace brownish-gray limestone.
----	2, 780–2, 790	Clay shale, medium-gray; trace white bentonite and shiny black coal; *Inoceramus* chunk.
----	2, 790–2, 800	Clay shale, medium-gray; some medium-light-gray siltstone; slightly calcareous; trace medium-dark-gray limestone; small calcite vein; trace white bentonite; *Inoceramus* chunks.
----	2, 800–2, 810	Siltstone, 70 percent, medium-light- to medium-gray, very calcareous; medium-dark-gray limestone and clay shale as much as 30 percent; trace very light-gray bentonitic clay shale and white bentonite; trace shiny black coal.
----	2, 810–2, 840	Clay shale, medium-gray, silty; trace white aragonite and bentonitic clay; *Inoceramus* prisms at 2,810–2,820 ft.
----	2, 840–2, 870	Clay shale, medium-gray, and as much as 30 percent medium-light-gray siltstone; trace sandstone at 2,860–2,870 ft.
----	2, 870–2, 900	Clay shale, medium- to medium-dark-gray; trace coal; trace very light- and greenish-gray clay shale; trace limestone and white calcite crystals at 2,890–2,900 ft; *Inoceramus* chunks.
----	2, 900–2, 930	Clay shale, medium- to medium-dark-gray; trace coal at 2,900–2,920 ft; trace very fine-grained sandstone at 2,910–2,920 ft., contains biotite.
----	2, 930–2, 940	Sandstone, light- to medium-light-gray, soft, very fine- to (rarely) medium-grained; 85 percent white and clear quartz grains; rest dark-colored chert, rock fragments, and some biotite; harder chips of sandstone very slightly calcareous; trace medium-gray clay shale.
----	2, 940–2, 950	Clay shale, medium-gray; 30 percent sandstone as above.
----	2, 950–3, 040	Clay shale, light- to medium-dark-gray, mostly medium-gray; trace siltstone at 2,980–2,985 ft and 3,010–3,020 ft; *Inoceramus* prisms at 2,970–2,975 ft and 2,985–2,990 ft.

Lithologic description—Continued

Core	Depth (feet)	Description
----	3, 040–3, 100	Clay shale, medium-dark-gray; trace to 15 percent very light-gray to white bentonite or bentonitic shale; bentonite contains brown biotite plates. Trace white aragonite at 3,090–3,095 ft; *Inoceramus* prisms, fish fragments, and Radiolaria also present. This may be compared to the black fissile shale of Umiat area.
68	3, 100–3, 110	Recovered 10 ft: Microfossils abundant. 4 ft 6 in., clay shale, medium-dark-gray, moderately hard; fair cleavage; biotite common; 2 in. light-gray bentonitic shale at 3,102 ft and 1 in. at 3,104 ft. Shale includes much white aragonite extending 5 in. along the bedding planes and terminating upward at 3,103½ ft; also a few thin vertical veins of aragonite. Clay shale grades into unit below. 5 ft 6 in., sandstone, light-gray, very fine-grained (grading to siltstone), slightly to moderately calcareous, massive, hard; irregular fracture; grains subangular, 75 percent white and clear quartz; rest is rock fragments, dark chert, biotite, and carbonaceous particles; dip undetermined; no shows in laboratory, but well geologist reported core bled slight amount of gas. At 3,106 ft effective porosity 11.31 percent, sample plug impermeable, and carbonate content 8.63 percent by weight.
69	3, 110–3, 120	Recovered 10 ft: Microfossils absent. Sandstone, very silty, noncalcareous to slightly calcareous; 90 percent white and clear quartz; dips as high as 15° probably indicate crossbedding; regular dip about 4° (?); no shows. At 3,112 ft effective porosity 10.6 percent, sample impermeable, and carbonate content 9.79 percent by weight.
70	3, 120–3, 126	Recovered 6 ft: Microfossils absent. 5 ft 6 in., very fine-grained sandstone, as above, and siltstone; a few inches of medium-light-gray clay shale at 3,120 ft. Clay shale contains very light-gray silty slightly bentonitic partings; dip undetermined, probably low; noncalcareous; no shows. 6 in., limestone, medium-gray, silty, argillaceous, medium-hard.
----	3, 126–3, 155	Clay shale, medium-light- to medium-dark-gray, silty; trace bentonite.
----	3, 155–3, 160	Siltstone 60 percent, medium-light-gray, argillaceous, and medium-gray clay shale.

Lithologic description—Continued

Core	Depth (feet)	Description
----	3, 160–3, 175	Clay shale, medium- to medium-dark-gray, silty; trace to 15 percent bluish-gray bentonite; trace aragonite; chunk of *Inoceramus* prisms.
----	3, 175–3, 185	Clay shale, medium- to medium-dark-gray; 10 percent white and very light-gray bentonite with biotite plates; trace shiny black coal, pyrite, and fish fragments; *Inoceramus* prisms.
----	3, 185–3, 200	Clay shale, medium-light- to medium-gray; trace medium-light-gray siltstone.
----	3, 200–3, 220	Sandstone, light-gray, fine-grained, noncalcareous; grains subangular and subrounded, 85 percent white and clear quartz; rest mostly dark chert, rock fragments, and biotite; also 40 percent medium-light-gray clay shale.
----	3, 220–3, 225	Siltstone, 80 percent, medium-light-gray; and medium-gray noncalcareous clay shale.
----	3, 225–3, 240	Clay shale, medium-gray, silty, and as much as 30 percent siltstone.
----	3, 240–3, 245	Siltstone, light- to medium-light-gray, very argillaceous; trace medium-gray clay shale.
----	3, 245–3, 250	Clay shale, medium-light- to medium-gray, and 30 percent of medium-light-gray siltstone.
----	3, 250–3, 260	Sandstone, light-gray, very fine-grained, and 5 percent medium-dark-gray siltstone.
----	3, 260–3, 285	Clay shale, medium-light- to medium-dark-gray; trace to 5 percent white bentonite and bentonitic shale; as much as 50 percent siltstone; trace very fine-grained sandstone; trace white aragonite at 3,275–3,280 ft; 20 percent light-greenish-gray bentonitic shale at 3,280–3,285 ft; chunk of *Inoceramus* prisms and fish fragments at 3,265–3,270 ft.
----	3, 285–3, 300	Sandstone and siltstone. Sandstone is light gray, very fine grained, noncalcareous; grains subangular to subrounded, 95 percent white and clear quartz; trace to 5 percent medium-gray-clay shale; chunk of *Inoceramus* prisms at 3,290–3,295 ft.
----	3, 300–3, 320	Siltstone, medium-light-gray, and 10–50 percent medium-gray clay shale; trace coal and bentonite at 3,310–3,315 ft, trace of very fine-grained sandstone at 3,315–3,320 ft. *Inoceramus* chunks and prisms at 3,310–3,320 ft.
----	3, 320–3, 324	Sandstone, light-gray, noncalcareous; 90 percent white and clear quartz grains, some biotite; also siltstone and clay shale.
71	3, 324–3, 333	Recovered 3 ft. Microfossils absent. Clay shale, medium-light- to medium-gray, noncalcareous, medium-hard; fair cleavage; *Inoceramus* shell fragments firmly embedded in the shale; some thin laminae of siltstone; pyrite nodules; dips as much as 10°.
72	3, 333–3, 343	Recovered 10 ft: Microfossils absent. Siltstone, medium-light-gray, sandy, medium-hard; nearly poker-chip cleavage in upper 7 ft of recovery; lower 3 ft somewhat harder siltstone with no cleavage; slightly micaceous; noncalcareous except lower siltstone which is slightly calcareous. *Inoceramus* prisms in microfossil cut.
73	3, 343–3, 353	Recovered 8 ft. Microfossils absent. 3 ft, siltstone, medium-light-gray, noncalcareous, medium-hard; near poker-chip cleavage. 5 ft, siltstone, medium-light-gray, noncalcareous to moderately calcareous, hard, massive, and some very fine-grained micaceous sandstone, composed almost entirely of white and clear quartz grains; dip approximately 5°; no shows.
74	3, 353–3, 363	Recovered 10 ft. Microfossils absent. Siltstone, medium-light-gray, argillaceous; poor to fair cleavage; micaceous (biotite) partings. Bladelike inclusions of silty medium-dark-gray clay are 1 in. wide, ⅛–¼ in. thick, and generally several inches long with variable orientation; possible mollusk borings; noncalcareous to moderately calcareous; dip 5°.
75	3, 363–3, 368	Recovered 4 ft. Microfossils rare. Claystone, medium-gray, silty, micaceous, noncalcareous, moderately-hard; irregular fracture approximately parallel to bedding; dip undetermined. *Inoceramus* prisms in microfossil cut.
76	3, 368–3, 380	Recovered 12 ft: Microfossils common. Siltstone, medium-light-gray, argillaceous; and medium-gray silty clay shale, interbedded and grading from one to the other; upper half of core generally more argillaceous and lower part more silty and micaceous (not biotite); poorly preserved small pelecypod impression at 3,372 ft; lower half of core has "borings" as described in core 74 above—some as much as 2 in. wide; noncalcareous; dips as much as 12°; average about 5°. *Inoceramus* prisms in microfossil cut.
77	3, 380–3, 400	Recovered 20 ft: Microfossils absent. 15 ft, siltstone, medium-light-gray and some medium-gray clay shale laminae; noncalcareous to moderately calcareous; essentially as in cores above; "borings" present; some irregular bedding suggests local disturbance prob-

Lithologic description—Continued

Core	Depth (feet)	Description
		ably close to time of deposition; broken *Inoceramus* shells distributed irregularly in swirly beds at 3,379 ft; dips as much as 15°; general dip probably 3°–5°; sandier toward base and grades into sandstone below.
		5 ft, sandstone, light-gray, very fine-grained, silty, noncalcareous to very slightly calcareous, hard, massive; subangular to subrounded grains, 95 percent white and clear quartz; rest carbonaceous particles and mica; dip undetermined; no shows. At 3,395 ft effective porosity 9.45 percent, and sample plug impermeable.
----	3, 400–3, 425	Sandstone, light gray, very fine- to fine-grained, slightly to very calcareous; contains biotite plates and trace of siltstone; 20 percent of light-olive-gray clay ironstone at 3,410–3,415 ft; trace greenish-gray bentonite with biotite plates at 3,415–3,425 ft.
----	3, 425–3, 435	Siltstone and very fine-grained sandstone containing biotite, very slightly calcareous; trace medium-gray clay shale.
----	3, 435–3, 445	Clay shale, 60 percent, medium-gray; and medium-light-gray siltstone, with biotite; 5 percent white bentonite, and trace of white aragonite at 3,440 ft.
----	3, 445–3, 460	Siltstone, medium-light- to medium-gray, very argillaceous, noncalcareous; trace medium-gray clay shale and fish fragments at 3,445–3,460 ft.
----	3, 460–3, 475	Sandstone, light-gray, fine-grained, noncalcareous; grains subangular to subrounded, 90 percent white and clear quartz, also dark chert and carbonaceous particles, some biotite and white mica.
----	3, 475–3, 480	Siltstone, medium-light-gray, and 15 percent white bentonite.
78	3, 480–3, 490	Recovered 10 ft: Microfossils absent. Interbedded clay shale, 75 percent, and siltstone. Clay shale is medium dark gray to dark gray, medium soft, micaceous (not biotite); good cleavage; numerous laminae and lenses as much as 3 in. thick of medium-light-gray siltstone; very rarely slightly sandy; noncalcareous; dip 3°–7°.
79	3, 490–3, 500	Recovered 9 ft: Microfossils absent. Sandstone, medium-light-gray, very fine-grained, silty, noncalcareous, hard; tends to cleave normal to sides of core; subangular grains, 85 percent white and clear quartz; rest dark chert, rock fragments, and rare carbonaceous and chalky white particles; rare medium-gray clay shale partings; small amount of irregular bedding; dip 3°; no shows.
80	3, 500–3, 510	Recovered 3 ft: Microfossils absent. Interbedded siltstone, 80 percent, and clay shale, 20 percent. Siltstone is medium light gray, medium hard, and slightly micaceous; has good cleavage; contains many laminae and partings of medium-gray clay shale; noncalcareous; dips range from 3°–10°. *Inoceramus* prisms in microfossil cut.
81	3, 510–3, 518	Recovered 4 ft: Microfossils absent. Interbedded clay shale, as above, 75 percent, and siltstone, as above, 25 percent; gradation from one to the other; undulatory surfaces on siltstone suggest ripple marks; slightly micaceous; noncalcareous; dip 7°. *Inoceramus* prisms in microfossil cut.
82	3, 518–3, 528	Recovered 10 ft: Microfossils absent. Sandstone, light-gray, medium-hard, fine-grained; excellent, nearly poker chip cleavage; subangular salt-and-pepper grains; 65 percent white and clear quartz, nearly 35 percent black chert, rock fragments, and coaly particles, some chalky white particles; other minerals rare; rare medium-gray clay shale laminae and very rare clay chips in the sandstone; slightly to moderately calcareous; dip 8°; no shows; well geologist reported slight odor. Effective porosity at 3,526 ft 12.62 percent, at 3,527 ft 13.11 percent. In both samples air permeability <1 millidarcy. Carbonate content at 3,526 ft 18.64 percent by weight; other sample not tested.
83	3, 528–3, 537	Recovered 9 ft: Microfossils absent. Sandstone, as above, very rare medium grains; poker chip cleavage; 5 in. of medium-dark-gray claystone at very bottom of core; slightly to moderately calcareous; dip 4° (?); no shows; well geologist reported slight odor. At 3,529 ft effective porosity 13.46 percent, air permeability 2.3 millidarcys; carbonate content not tested. At 3,530 ft porosity 13.28 percent, permeability <1 millidarcy, and carbonate content 16.62 percent by weight.
84	3, 537–3, 540	Recovered 2 ft 6 in.: Microfossils absent. Interbedded clay shale 70 percent, medium-gray; and light-gray, hard, slightly micaceous sandstone with fair cleavage; rare dark carbonaceous partings in the sandstone; irregular bedding at top; sandstone has very calcareous cement, and shale is moderately calcareous; dip 9°; no shows.

Lithologic description—Continued

Core	Depth (feet)	Description
----	3, 540–3, 575	Clay shale, medium-gray, rarely medium-dark-gray, moderately calcareous; trace siltstone and sandstone; 10 percent light-gray bentonitic shale at 3,550–3,555 ft; chunk of *Inoceramus* prisms 3,565–3,570 ft.
----	3, 575–3, 620	Clay shale, medium- to medium-dark-gray. Top of Chandler and Ninuluk formations undifferentiated placed at 3,585 ft.
85	3, 620–3, 640	Recovered 19 ft 6 in.: Microfossils abundant. 11 ft, clay shale, medium-dark- to dark-gray, micaceous; medium-hard; good cleavage; some medium-light-gray silty partings; light-olive-gray clay ironstone nodule at 3,625 ft; noncalcareous; dip 4°–6°. 8 ft 6 in., sandstone, medium-light- to medium-gray, silty and fine-grained, hard; cleaves parallel to bedding; subangular to subrounded grains, 80 percent white and clear quartz; rest dark-colored rock fragments and chert, also pyrite, garnet, and other rare minerals; some mica and soft white particles; argillaceous cement; rare carbonaceous and coaly partings, also rare finely micaceous medium-gray clay shale laminae as much as 2 in. thick, very thin light-olive-gray ironstone laminae at 3,636 ft; noncalcareous; dip 4°–7°; fleeting odor, no cut, slight greasy stain in evaporating dish at 3,632 ft. At 3,632 ft effective porosity 9.45 percent, and sample impermeable.
86	3, 640–3, 660	Recovered 18 ft: Microfossils absent. 10 ft, sandstone, light-gray, very fine- to fine-grained, hard, massive; composition as in core above; 2 feet of medium-grained, salt-and-pepper sandstone at 3,644 ft is slightly softer, with a slightly higher proportion of dark grains than the rest of core; rare small medium-gray clay chips embedded in sandstone at 3,651 ft with flat axes parallel to bedding. Numerous brownish-coated pelecypod casts found at 3,643 ft. These casts similar in type and preservation to those at approximately 3,360 ft in Gubik test well 1; noncalcareous to slightly calcareous; dip 3°; very fleeting odor, very slight cut and greasy stain in evaporating dish at 3,645 ft. At 3,645 ft effective porosity 10.36 percent, and sample impermeable to air. 8 ft, interbedded, hard, very fine-grained sandstone as above, 50 percent, and medium-dark-gray, finely micaceous hard clay shale; sandstone has some crossbedding; some laminae and lenses of silt in clay shale; noncalcareous to moderately calcareous; dip 4°; crossbedding dips 2°–16°; fleeting odor, pale straw colored cut and very pale yellow residue from 3,651 ft. At 3,651 ft effective porosity 7.19 percent, sample impermeable, and carbonate content 17.06 percent by weight.
87	3, 660–3, 669	Recovered 7 ft: Microfossils absent. Claystone and clay shale, medium-gray, medium-soft to medium-hard; cleavage poor where present subconchoidal fracture; some medium-light-gray siltstone laminae and lenses as much as 6 in. thick; first 6 in. of clay shale is soft and laced with white veins of aragonite; siltstone is moderately to very calcareous; part of claystone is slightly calcareous; dip 2°–20°, average probably nearer 2°.
----	3, 669–3, 672	Siltstone and sandstone, light- to medium-light-gray.
88	3, 672–3, 682	Recovered 9 ft: Microfossils absent. Siltstone and sandstone with a little clay shale, grading into clay shale with a little siltstone in lower 5 ft of core. Siltstone and sandstone are light to medium light gray, medium hard; have fair to good cleavages. Sandstone is very fine grained and silty; composed mostly of white and clear quartz, but also contains quite a few coal particles and abundant mica. Clay shale is medium gray, finely micaceous; siltstone is in thin laminae or lenticles in the clay shale; noncalcareous to slightly calcareous; dip 2°; good gasolinelike odor, pale-straw-colored cut and yellow residue from 3,674 ft. At 3,674 ft effective porosity 11.5 percent, and sample impermeable.
89	3, 682–3, 684	Recovered 2 ft: Microfossils absent. Interbedded clay shale, as above, 60 percent, and siltstone, as above; siltstone is slightly calcareous; dip 3°–6°; no shows.
90	3, 684–3, 692	Recovered 8 ft: Microfossils absent. Clay shale, medium- to medium-dark-gray, moderately hard, finely micaceous; good cleavage; some carbonaceous and micaceous partings; as much as 30 percent medium-light-gray siltstone in laminae and lenses; some small-scale crossbedding indicated in the siltstone; siltstone is moderately calcareous; clay shale is noncalcareous; dip 4°–7°; no shows.

Lithologic description—Continued

Core	Depth (feet)	Description
91	3, 692–3, 702	Recovered 2 ft: Microfossils absent. Clay shale, medium-dark-gray, finely micaceous, medium-hard; fair to good cleavage; some medium- to medium-light-gray silty laminae and lenses; one small unidentified pelecypod noted in middle of recovery; silty streaks are slightly calcareous; dip 6°–9°.
92	3, 702–3, 708	Recovered 1 ft: Microfossils absent. Clay shale, as above; rare carbonaceous plant impressions; noncalcareous; dip 3°.
93	3, 708–3, 714	Recovered 2 ft: Microfossils absent. Clay shale, silty, and argillaceous siltstone grade from one to the other, medium-light to medium-gray, hard, finely micaceous; poor to fair cleavage; noncalcareous; dip 5°.
94	3, 714–3, 734	Recovered 18 ft: Microfossils absent. 6 ft, sandstone, medium-light-gray, very fine-grained, silty, noncalcareous, hard, subangular grains, 90 percent white and clear quartz, also rock fragments, dark chert, carbonaceous particles, and mica; dip undetermined; no shows. At 3,718 ft effective porosity 2.91 percent, and sample impermeable to air. 12 ft, interbedded siltstone, 80 percent, and clay shale, 20 percent, gradations of each. Siltstone is medium light gray and clay shale is medium gray; some lenticular and irregular bedding, crossbedding, and ripple marks (?); scattered very fine-sandy streaks, finely micaceous; ⅛-in.-thick, shiny coal lenses at 3,733 ft. Last 1½ in. of core is light olive gray and filled with white oolites. The matrix and some of the oolites are very calcareous. Other oolites appear to be partially replaced with rather soft (tripolitic?) white chert. Many of the oolites are coated with pyrite. Slickensides noted in core at 3,732 ft, 3,733 ft, and 3,734 ft; noncalcareous; dip 0°–3°.
95	3, 734–3, 748	Recovered 2 ft: Microfossils absent. Sandstone (and some siltstone), light- to medium-light-gray, fine-grained, silty, slightly calcareous, hard; first inch of recovery is oolitic as in core immediately above; subangular grains, 85 percent white and clear quartz; rest dark chert, rock fragments, and coal particles; numerous dark-colored partings containing micaceous and coaly particles; dip 3°; no shows. At 3,735 ft effective porosity 6.37 percent, and sample impermeable.

Lithologic description—Continued

Core	Depth (feet)	Description
96	3, 748–3, 768	Recovered 20 ft. Microfossils absent. Interbedded sandstone, 85 percent, and clay shale, mostly with sharp breaks between the two. Sandstone is light gray, hard, very fine to fine grained; grades to siltstone in places; composition similar to core above; rare carbonaceous-micaceous partings; some very small-scale crossbedding in silty layers. Clay shale is medium dark gray to dark gray, medium hard, finely micaceous, has good cleavage; sandstone is noncalcareous to slightly calcareous; clay shale is noncalcareous; dip 3°; exceedingly faint fleeting odor; no cut and greasy film in evaporating dish from 3,750 and 3,759 ft. At 3,750 ft effective porosity 11.75 percent and at 3,759 ft 12.5 percent. Both samples impermeable and essentially noncalcareous.
97	3, 768–3, 777	Recovered 9 ft. Microfossils absent. Sandstone, light-gray, fine-grained (with rare medium grains), noncalcareous, hard, massive; grains subangular to (rarely) subrounded, 80 percent white and clear quartz; rest dark-colored chert, rock fragments, and carbonaceous particles, chalky-white particles and other rare minerals; siliceous or argillaceous cement; dip undetermined; exceedingly faint odor, no cut, greasy stain from 3,771 ft. At 3,771 ft effective porosity 11.30 percent, and sample impermeable.
98	3, 777–3, 787	Recovered 1 ft: Microfossils absent. Sandstone, light-gray, fine-grained (or slightly smaller), noncalcareous, hard, massive; subangular to (rarely) subrounded grains, 90 percent white and clear quartz; rest dark-colored rock fragments, chert, and rare carbonaceous particles; dip undetermined but probably low; no shows. Sample from 3,777–3,787 ft has an effective porosity of 5.28 percent and is impermeable.
99	3, 787–3, 796	No recovery.
100	3, 796–3, 809	Recovered 12 ft 6 in. Microfossils absent. Sandstone, light-gray, fine-grained (with rare medium grains), noncalcareous, hard, massive, slightly friable; subangular to rare subrounded grains, 85 percent white and clear quartz; rest dark chert, carbonaceous particles, and rock fragments; trace garnet; rare soft chalky-white particles (tripolitic chert or feldspar?); dip 0°–3°; no shows. At 3,798 ft effective porosity

Lithologic description—Continued

Core	Depth (feet)	Description
		14.41 percent, and air permeability 60 millidarcys; at 3,803 ft they are 14.15 percent and 49 millidarcys, respectively. Both samples essentially noncalcareous.
101	3, 809–3, 829	Recovered 20 ft: Microfossils absent. Sandstone, light-gray, fine- to (rare) medium-grained, noncalcareous, hard, massive; composition as in core above; thin irregular dark-yellowish-brown clay ironstone laminae at approximately 3,814 and 3,818 ft. One lens of hard shiny black coal one-third inch thick at 3,823 ft; a few irregular clayey partings in bottom half of recovery; dip as much as 10°; very fleeting odor, no cut, and no residue from 3,818 ft. At 3,818 ft effective porosity 14.03 percent, and air permeability 11.5 millidarcys; at 3,822 ft they are 14.07 percent and 22 millidarcys, respectively. Both samples essentially noncalcareous.
102	3, 829–3, 848	Recovered 19 ft. Microfossils absent. Interbedded sandstone and siltstone, 90 percent, and clay shale, 10 percent. Sandstone and siltstone are light to medium light gray, very fine to medium grained, silty; composition approximately as in cores above; some yellowish-gray particles of ironstone present. Clay shale is medium dark gray, micaceous, medium hard; fair cleavage; shale in laminae as much as 3 in. thick but mostly as partings in the sandstone. Rare laminae of yellowish-gray clay ironstone, also carbonaceous-micaceous partings; noncalcareous; dip 3°; no shows. At 3,835 ft, parallel to bedding effective porosity 9.06 percent; at 3,839 ft, normal to bedding, 11.06 percent. Both samples impermeable and essentially noncalcareous.
103	3, 848–3, 858	No recovery.
104	3, 858–3, 872	Recovered 14 ft: Microfossils absent. Interbedded sandstone and siltstone, 95 percent, and clay shale as in core 102 above; lowest 5 ft of core has no clay, some irregular bedding; rare carbonaceous and coaly partings; clay ironstone nodules; noncalcareous; dip 1°–3°; faint to fair fleeting odor, no cut, pale-yellow residue from 3,860 and 3,871 ft. At 3,860 ft, normal to bedding effective porosity 13.17 percent, and at 3,871 ft, parallel to bedding, 12.14 percent. Both samples impermeable and essentially noncalcareous.
105	3, 872–3, 892	Recovered 20 ft: Microfossils absent. Sandstone, light-gray, very fine- to fine-grained, moderately to very calcareous, hard, massive; subangular to (rare) subrounded grains, 85 percent white and clear quartz; rest dark-colored chert, rock fragments, coaly particles, and mica; grades into about a foot of hard medium-gray silty limestone topping at 3,890 ft; thin vein of white calcite in the limestone; dip 3°; fair odor, pale-straw-colored cut, yellow residue from 3,874 ft; faint fleeting odor, no cut, pale-yellow residue from 3, 892 ft. See page 253 for a quantitative test for petroleum at 3,883 ft. At 3,874 ft effective porosity 8.97 percent, and carbonate content 18.74 percent by weight. At 3,892 ft they are 11.22 percent and 16.31 percent, respectively. Both samples impermeable and parallel to bedding.
106	3, 892–3, 912	Recovered 20 ft: Microfossils absent. Sandstone as above; common carbonaceous and micaceous partings; some medium-gray clay shale streaks in the lowest 1½ feet of recovery; slightly to noncalcareous; dip 2°; no shows. At 3,895 ft effective porosity 6.04 percent, and carbonate content 13.42 percent by weight. At 3,903 ft porosity 11.9 percent, and carbonate content 14.4 percent by weight. Both samples impermeable.
107–108	3, 912–3, 933	Recovered 16 ft: Microfossils absent. Siltstone, sandstone, and clay shale, with gradations of each; primarily silty; color varies with sand content from light-gray sandstone to medium-dark-gray clay shale. Siltstone is massive; clay shale is bedded; sandstone has silty carbonaceous partings and crossbedding dips as much as 15°; sandier layers moderately to very calcareous; general dip very low; no shows. Effective porosity at 3,915 ft 5.89 percent, and carbonate content 21.91 percent by weight. At 3,927 ft determinations are 1.65 percent and 19.61 percent, respectively.
----	3, 933–3, 950	Siltstone, medium-light-gray, and medium- to medium-dark-gray clay shale; trace sandstone; 5 percent shiny black coal.
----	3, 950–3, 960	Clay shale, medium- to medium-dark-gray; 10 percent medium-light-gray siltstone; noncalcareous.
----	3, 960–3, 967	Siltstone and very fine-grained sandstone, light- to medium-light-gray; 5 percent medium-gray clay shale.

Lithologic description—Continued

Core	Depth (feet)	Description
109	3, 967–3, 987	Recovered 5 ft: Microfossils absent. Siltstone, medium-light-gray, noncalcareous, hard, with fair cleavage; made up mostly of white quartz grains; contains numerous partings and laminae of medium-dark-gray clay shale; small amount of crossbedding; dip 5°; no shows.
110	3, 987–3, 995	Recovered 7 ft: Microfossils absent. Siltstone with abundant clay shale partings, as in core above, also carbonaceous and micaceous partings.
----	3, 995–4, 000	Siltstone and very fine-grained sandstone; 10 percent medium-gray clay shale.
----	4, 000–4, 010	Siltstone and clay shale.
----	4, 010–4, 031	Clay shale, medium-gray, very silty; trace brownish-gray ironstone at 4,010-4,015 ft; sandstone at 4,031 ft as in core below. Top of Grandstand formation placed at 4,025 ft.
111	4, 031–4, 048	Recovered 16 ft: Microfossils very rare. Interbedded sandstone and siltstone, 80 percent, and clay shale, 20 percent. Sandstone and siltstone are light to medium light gray, hard; has fair cleavage parallel to bedding; sandstone is very fine grained; grains subangular to (rarely) subrounded, 90 percent white and clear quartz; rest is rock fragments, dark chert, and rare carbonaceous particles; mica rare; some crossbedding. Clay shale is medium dark gray, medium hard, and finely micaceous, in beds as much as 5 inches thick; has fairly good cleavage; rare unidentified pelecypods at 4,031½ and 4,037 ft; noncalcareous; dip 3°-15°; fair to good oil odor, pale-straw-colored cut and yellow residue from 4,036 ft, fair oil odor, pale-straw-colored cut and very pale-yellow residue from 4,047 ft. At 4,036 ft effective porosity 8.19 percent, and air permeability 1 millidarcy; at 4,047 ft porosity 8.66 percent, and sample impermeable.
112	4, 048–4, 058	Recovered 1 ft: Microfossils absent. Sandstone, light-gray, very fine-grained, noncalcareous, hard; composition as above; dip 7°; fair oil odor; trace of a cut and very pale-yellow residue from middle of recovered core. At 4,048 ft effective porosity 8.96 percent, and sample impermeable.
113	4, 058–4, 059	Recovered 1 ft: Microfossils absent. Siltstone and sandstone, medium-light-gray, silty and fine-grained, slightly calcareous, hard; irregular fracture; subangular to subrounded grains 90 percent or more white and clear quartz; rest dark-colored minerals; dip undetermined; no cut, yellowish greasy stain from 4,058 ft.
114	4, 059–4, 060	Recovered 1 ft: Microfossils absent. Siltstone, medium-light- to medium-gray, noncalcareous medium-hard; excellent cleavage; numerous carbonaceous-micaceous partings; very small amount of cross-bedding; dip 5°. crossbeds dip as much as 10°; no shows. *Ditrupa* sp. in microfossil cut.
115	4, 060–4, 075	Recovered 10 ft: Microfossils abundant. Interbedded sandy siltstone, 85 percent, and clay shale. Siltstone is medium light gray, hard, with poor to fair cleavage; shows small amount of small-scale crossbedding; some lenticular beds in the clay shale; rare carbonaceous and micaceous partings; one coaly parting contains a small yellowish-amber aggregate, and scattered plant impressions. Clay shale is medium dark gray, moderately hard, micaceous and has fair cleavage; noncalcareous to slightly calcareous; dip 2°; no shows. At 4,063 ft effective porosity 3.96 percent, sample impermeable, and carbonate content 19.2 percent by weight.
----	4, 075–4, 110	Siltstone, medium-light-gray; as much as 20 percent very fine-grained sandstone; trace clay shale toward base.
----	4, 110–4, 115	Clay shale, medium-light to medium-gray, silty; trace medium-dark-gray shale.
----	4, 115–4, 125	Siltstone, clay shale, and some sandstone.
----	4, 125–4, 130	Sandstone, 50 percent, medium-light-gray, very fine-grained, noncalcareous; grains subangular; 80 percent white and clear quartz; rest dark chert, rock fragments, and rare mica; silty argillaceous material in matrix; also siltstone and clay shale.
----	4, 130–4, 135	Bentonite, 30 percent, light-bluish-gray; contains numerous plates of biotite and scattered subangular grains of quartz; also clay shale and siltstone; *Inoceramus* prisms.
----	4, 135–4, 230	Clay shale, medium-light- to medium-dark-gray, as much as 30 percent siltstone and sandstone in upper 30 ft; trace siltstone at 4,170–4,190 ft; trace bentonite at 4,200–4,205 ft; trace light-olive-gray ironstone at 4,150–4,160 ft.
116	4, 230–4, 243	Recovered 10 ft: Microfossils abundant. Sandstone, 85 percent, and clay shale, 15 percent. Sandstone is light to medium light gray, fine grained, hard; grains subangular to subrounded, 85 percent white and clear quartz; rest mostly dark-gray chert, rock particles,

Lithologic description—Continued

Core	Depth (feet)	Description
		and mica; rare carbonaceous or coaly partings. Clay shale is medium to medium dark gray, moderately hard, fair cleavage; noncalcareous; dip 3°; good to excellent oil odor throughout core, yellow cut and brownish-yellow residue from 4,232 ft. Following samples were impermeable to air and had only a trace of carbonate.
		Depth (feet) / Effective porosity (percent): 4,230 parallel 10.72; 4,232 parallel 9.26; 4,235 parallel 9.76; 4,237 parallel 9.74
117	4, 243–4, 261	Recovered 15 ft: Microfossils absent. 11 ft, sandstone, light- to medium-light-gray, as above; but becomes very fine grained and silty at base, rare argillaceous laminae and lenses. 4 ft, clay shale or claystone, medium-dark-gray, noncalcareous, finely micaceous, moderately hard; has partly fair cleavage; rare dark carbonaceous plant fragments, *Solecurtus* n. sp. found at 4,255 ft; several slickensided surfaces between 4,252 and 4,255 ft; dip 2°–4°; good odor, yellow cut, brownish-yellow residue from 4,243 ft. Following samples were impermeable to air and had only trace of carbonate.
		Depth (feet) / Effective porosity (percent): 4,243 parallel 10.35; 4,245 parallel 8.92; 4,249 parallel 2.52
----	4, 261–4, 275	Clay shale, 60 percent, medium-gray, and light-gray very fine- to fine-grained noncalcareous sandstone.
----	4, 275–4, 280	Siltstone, medium-light-gray, and 10 percent clay chale.
----	4, 280–4, 300	Clay shale, 70 percent, medium-gray, and siltstone and sandstone.
----	4, 300–4, 303	Sandstone, 70 percent, light gray, 20 percent siltstone and 10 percent clay shale.
118	4, 303–4, 323	Recovered 18 ft: Microfossils absent. Interbedded siltstone, 45 percent, sandstone, 40 percent, and clay shale. Siltstone and sandstone are light to medium light gray, hard, dirty, silty, very fine grained with rare fine grains; subangular to subrounded grains; 85

Lithologic description—Continued

Core	Depth (feet)	Description
		percent white and clear quartz; rest rock fragments and dark-gray chert, scattered carbonaceous or coaly particles, and mica. Clay shale is medium to medium dark gray, finely micaceous; rare micaceous and carbonaceous partings; some gradation from siltstone to clay shale; about 3 ft of swirly bedding in the lowest part of core; essentially noncalcareous; dip 5°; no shows. At 4,305 ft effective porosity 9.10 percent, at 4,318 ft 9.65 percent. Samples impermeable.
119	4, 323–4, 336	Recovered 11 ft: Microfossils absent. Sandstone, medium-light-gray, silty, very fine- to fine-grained, hard; constituents as in core above; massive except for a few irregular thin laminae of clay shale in upper 2 ft of recovery; noncalcareous to moderately calcareous at base of core; dip 6°; fairly good but fleeting gasoline odor, very pale-straw-colored cut, very pale-yellow residue from 4,330 ft. At 4,330 ft effective porosity 11.1 percent, sample impermeable, and carbonate content 17.94 percent by weight.
120	4, 336–4, 350	Recovered 15 ft: Microfossils absent. Sandstone, very fine- to fine-grained, hard, tight; massive as in core above; composition as above; a few laminae of clay shale in lower foot of recovery; cement calcareous; dip 1½°; fair fleeting odor, very pale-straw cut, very pale-yellow residue from 4,337 ft, fair fleeting odor, trace of a cut, and yellowish greasy stain from 4,342 ft. At 4,337 ft effective porosity 9.15 percent, and carbonate content 19.30 percent by weight. At 4,342 ft porosity 9.50 percent, and carbonate content 20.06 percent. Both samples impermeable.
121	4, 350–4, 370	Recovered 18 ft: Microfossils rare. Interbedded clay shale, 40 percent, siltstone, 40 percent, and sandstone, 20 percent. Sandstone, light- to medium-light-gray, very fine-grained, hard; primarily white and clear quartz grains, with quite a few yellowish siderite or calcareous grains. Siltstone is medium light gray similar to sandstone; has rare micaceous and carbonaceous partings. Clay shale is medium gray, moderately hard; small amount is gradational with siltstone but most is in well-defined laminae; bedding is rather irregular and in some places the silt appears lenticular in the clay shale; dip 1°; no shows. At

Lithologic description—Continued

Core	Depth (feet)	Description
		4,351 ft effective porosity 9.1 percent, and carbonate content 26.01 percent by weight. Sample impermeable.
122	4, 370–4, 383	Recovered 12 ft: Microfossils very rare. Interbedded siltstone, 50 percent, and clay shale, 50 percent, mostly sharp contacts; medium-light- to medium-dark-gray, moderately hard; lenses of siltstone in the clay shale; some ripple marks (?); finely micaceous; siltstone is slightly calcareous; dip 5°; no shows.
----	4, 383–4, 399	Siltstone and clay shale; trace very fine-grained sandstone. Top of Topagoruk formation placed at 4,395 ft.
123	4, 399–4, 418	Recovered 19 ft: Microfossils rare. Clay shale, medium-dark-gray, finely micaceous, moderately hard; contains as much as 5 percent very thin beds and partings of medium-light-gray siltstone; lower 10 ft of recovery has numerous shiny slickensided surfaces with dips in all directions; small displacement of beds as much as one-half in. was noted; siltstone is slightly calcareous; dip 3°–7°.
----	4, 418–4, 430	Clay shale, medium-dark-gray, and 40 percent sandstone and siltstone.
----	4, 430–4, 460	Clay shale, medium-light- to medium-dark-gray; some siltstone.
----	4, 460–4, 480	Siltstone, medium-light- to medium-gray, argillaceous; 5–50 percent medium-gray clay shale.
----	4, 480–4, 502	Clay shale, medium-gray; as much as 40 percent siltstone; trace light- to very light-gray bentonite.
124	4, 502–4, 522	Recovered 20 ft: Microfossils absent. Clay shale, medium-gray, medium-hard, with good to excellent cleavage; numerous medium-light-gray silty partings; finely micaceous; dip 13°.
----	4, 522–4, 535	Clay shale, medium-light- to dark-gray; some siltstone.
----	4, 535–4, 540	Clay shale, medium- to medium-dark-gray; trace of siltstone; trace very light-gray bentonite.
----	4, 540–4, 560	Clay shale, medium-gray; 10–25 percent siltstone and sandstone, medium-light-gray, very slightly calcareous.
----	4, 560–4, 590	Clay shale, medium-light- to medium-dark-gray; trace very light-gray, white, and greenish-gray bentonite; trace siltstone and very rare bentonitic siltstone.
----	4, 590–4, 600	Clay shale, medium-light- to medium-gray, 50 percent; very fine-grained sandstone and siltstone, medium-gray, moderately calcareous, 50 percent.

Lithologic description—Continued

Core	Depth (feet)	Description
125	4, 600–4, 620	Recovered 17 ft: Microfossils absent. Clay shale with silty partings, as in core 124; some gradations between silt and clay; excellent cleavage parallel to bedding; dip 12°–14°.

CORE ANALYSES

Porosity and permeability were determined by the same methods as were used for samples from Gubik test well 1. (See page 227.) All samples in following table were cut parallel to the bedding planes of the rock except two, which were cut normal to the bedding and are indicated by "N."

Analyses of core samples, Gubik test well 2

Core	Depth (feet)	Effective porosity (percent)	Air permeability (millidarcys)	Carbonate content (percent by weight)
4	1,150	20.64	18	Trace.
5	1,158	23.90	150	Do.
6	1,162	19.90	7.5	Do.
8	1,189	22.24	25	17.5.
9	1,197	6.84	0	28.2.
10	1,207	20.00	10.5	20.0.
16	1,329	13.8	8.5	Trace.
16	1,335	5.81	0	30.3.
17	1,343	21.60	215	Trace.
18	1,359	22.70	51	Do.
18	1,367	21.35	117	Do.
19	1,381	19.35	4.5	Do.
19	1,384	19.40	160	Do.
20	1,400	5.60	0	14.6.
21	1,440	18.26	88	Trace.
22	1,446	19.08	105	Do.
23	1,463	18.56	32	Do.
24	1,493	14.63	<1	Do.
24	1,495	20.66	430	Do.
25	1,508	8.65	0	Trace.
25	1,509	18.50	(1)	22.6.
26	1,520	21.62	43.5 (cracked)	Do.
28	1,533	17.75	5.67	Do.
30	1,553	11.87	0	Do.
31	1,557	11.12	0	Do.
32	1,560	16.71	6.96	Do.
33	1,574	14.90	0	Do.
34	1,580	12.15	0	Do.
35	1,673	15.7	(1)	Do.
39	1,702	16.61	13	17.5.
40	1,710	14.65	9.5	Trace.
40	1,715	15.4	6	Do.
40	1,719	9.28	0	Do.
41	1,725	7.62	0	28.4.
42	1,730	4.89	0	Trace.
48	1,843	25.2	3,780	Do.
49	1,852	25.4	(1)	Do.
49	1,861	18.35	61	Do.
49	1,865	19.5	95	Do.

See footnotes at end of table.

Analyses of core samples, Gubik test well 2—Continued

Core	Depth (feet)	Effective porosity (percent)	Air permeability (millidarcys)	Carbonate content (percent by weight)
50	1,871	19.64	270 (slightly cracked)	Trace.
50	1,873	5.45	0	24.8.
52	1,924	12.24	3	Trace.
52	1,928	18.7	222	13.5.
52	1,932	5.5	0	30.5.
53	1,939	4.44	0	53.8.
53	1,944	14.8	12.5	Trace.
53	1,948	15.00	14	Do.
53	1,951	6.84	<1	25.0.
53	1,953	16.1	9	12.5.
54	1,957	16.8	12.5	Trace.
55	1,964	16.7	50	8.2.
55	1,972	4.8	0	30.3.
55	1,977	18.6	22.5	17.7.
59	2,100	14.32	3.5	12.8.
59	2,107	15.4	6.1	16.5.
60	2,110	0.75	0	49.6.
60	2,125	15.2	4.5	21.0.
61	2,132	11.39	0	Trace.
61	2,140	7.3	0	Do.
68	3,106	11.31	0	8.6.
69	3,112	10.6	0	9.8.
77	3,395	13.6	0	8.3.
82	3,526	12.62	<1	18.6.
82	3,527	13.11	<1	Not tested.
83	3,529	13.46	2.3	Not tested.
83	3,530	13.28	<1	16.6.
85	3,632	9.45	0	Trace.
86	3,645	10.36	0	Do.
86	3,651	7.19	0	17.
88	3,674	11.50	0	Trace.
94	3,718	2.91	0	Do.
95	3,735	6.37	0	Do.
96	3,750	11.75	0	Do.
96	3,759	12.50	0	Do.
97	3,771	11.30	0	Do.
98	3,777–3,787	5.28	0	Do.
100	3,798	14.41	60	Do.
100	3,803	14.15	49	Do.
101	3,818	14.03	11.5	Do.
101	3,822	14.07	22.0	Do.
102	3,835	9.06	0	Do.
102	3,839N [2]	11.06	0	Do.
104	3,860N	13.17	0	Do.
104	3,871	12.14	0	Do.
105	3,874	8.97	0	18.7.
105	3,892	11.22	0	16.3.
106	3,895	6.04	0	13.4.
106	3,903	11.90	0	14.4.
107–108	3,915	5.89	0	21.9.
107–108	3,927	1.66	0	19.6.
111	4,036	8.19	<1	Trace.
111	4,047	8.66	0	Do.
112	4,048	8.96	0	Do.
115	4,063	3.96	0	19.2.
116	4,230	10.72	0	Trace.
116	4,232	9.26	0	Do.
116	4,235	9.76	0	Do.
116	4,237	9.74	0	Do.
117	4,243	10.35	0	Trace.
117	4,245	8.92	0	Do.
117	4,249	2.54	0	Do.
118	4,305	9.10	0	Do.
118	4,318	9.65	0	Do.
119	4,330	11.10	0	17.9.
120	4,337	9.15	0	19.3.
120	4,342	9.50	0	20.1.
121	4,351	9.10	0	26.01.

[1] Sample unsuitable. [2] Cut normal to bedding.

Several samples were sent by Arctic Contractors to Core Laboratories, Inc., for analysis. The following table presents their determinations.

Core and saturation analyses, Gubik test well 2

[Core Laboratories, Inc.]

Depth (feet) [1]	Porosity (percent)	Permeability (millidarcys)	Saturation (percent pore)	Total water (percent pore)	Sodium chloride (ppm)
4,035a	11.5	0.1	10.4	37.4	10,050
4,035b	13.1	.2	19.2	31.3	10,200
4,238a	11.7	.1	21.4	34.1	11,060
4,238b	12.7	.1	18.9	26.1	12,750
4,238c	14.0	.1	24.3	15.7	12,570

[1] Letters in column distinguish samples taken at the same depth.

OIL AND GAS

OIL AND GAS SHOWS

The following table is a list of the oil and gas shows as recorded by the Contractor's well geologists C. A. Everett and C. W. Fleming at the time the hole was being drilled. Ether was used in making these determinations.

Oil and gas shows, Gubik test well 2

Depth (feet)	Showing	Formation test number [1]
1,142–1,149	Very slight flow gas	1
1,152–1,218	Very faint odor, very slight fluorescence	1
1,353–1,392	Good cut and fluorescence	3
1,669–1,676	Pale cut, slight fluorescence	6
1,700–1,737	Bled slight amount of gas; slight fluorescence	6
1,813–1,841	Bled slight amount of gas; slight fluorescence	7
1,841–1,880	Cores bled oil and gas	8, 9
1,915–1,987	Bled slight amount of gas; oil cut	10
3,620–3,660	Slight odor	
3,672–3,682	Bled small amount of gas	
3,840–3,848	Rare specks of fluorescence; fleeting odor	
3,872–3,886	Oil odor, slight fluorescence	15
4,031–4,058	Cores bled oil and gas	19
4,230–4,248	Strong fluorescence; slight amount of gas	20, 21, 22
4,248–4,261	Oil stain; spotty fluorescence	20, 21, 22
4,290–4,303	Slight fluorescence and odor	
4,303–4,323	Core bled gas; fluorescent streaks	
4,323–4,336	Slight oil odor	
4,336–4,383	Cores bled gas; rare free oil on parting faces	
4,395–4,418	Slight fluorescence and odor; bled gas	

[1] See list of formation tests, page 253, for additional information.

The oil cuts from Gubik test well 2, made after the cores were shipped to the Fairbanks laboratory, were generally similar to those obtained from Gubik test well 1. The best odors and cuts came from the thin siltstone and sandstone beds below the thickest sandstone beds in the Nanushuk group. Carbon tetrachloride was used instead of ether in processing the porosity-permeability plugs and in making cuts because it reduced the fire hazard. The cuts are described in the following table.

Test for oil stain in CCl_4, Gubik test well 2

Core	Depth (feet)	Cut	Residue
17	1,342	Very pale	Very pale yellow.
18	1,359	Yellow	Brown.
18	1,367	do	Do.
19	1,381	Amber	Do.
19	1,384	do	Do.
39	1,702	Straw colored	Pale yellow.
40	1,710	Pale straw colored	Do.
48	1,843	Straw colored	Yellow.
48	1,846	Pale straw colored	Do.
49	1,852	do	Do.
49	1,856	Pale yellow	Brownish yellow.
49	1,861	Yellow	Yellowish brown.
49	1,865	do	Do.
50	1,872	do	Do.
52	1,932	None	Very pale yellow.
53	1,948	do	Pale yellowish greasy film.
85	3,632	do	Slight greasy stain.
86	3,645	Trace	Greasy stain.
86	3,651	Pale straw colored	Very pale yellow.
88	3,674	do	Yellow.
96	3,750	None	Greasy stain.
96	3,759	do	Do.
97	3,771	do	Do.
101	3,818	do	None.
104	3,860	do	Pale yellow.
104	3,871	do	Do.
105	3,874	Pale straw colored	Yellow.
105	3,892	None	Pale yellow.
111	4,036	Pale straw colored	Yellow.
111	4,047	do	Very pale yellow.
112	4,048–4,058	Trace	Do.
113	4,058	None	Yellowish greasy stain.
116	4,232	Yellow	Brownish yellow.
117	4,243	do	Do.
119	4,330	Trace	Very pale yellow.
120	4,337	Very pale straw colored	Do.
120	4,342	Trace	Yellowish greasy stain.

One sample sealed in paraffin at the well was tested in the laboratory for oil saturation in a Ruska still, but the results were negative. A sample, from core 105 at 3,883 feet, contained no petroleum and contained 5.74 percent basal sediment and water by volume.

No samples of gas were taken in either of the two tests made on the only sandstone in Gubik test well 2 in which sufficient gas was present to reach the surface.

FORMATION TESTS

Test 1, 1,145–1,201 feet.—A Johnston formation tester was run with a 7¼-inch open-hole packer set at 1,145 feet with a ¾-inch bean and two pressure recorders on the bottom. The tester was open 30 minutes with no measurable gas flow. Two hundred feet of uncut drilling fluid was recovered. No bottom-hole pressure was recorded. Bottom-hole temperature was 78°F.

Test 2, 1,308–1,351 feet.—A tester was run with a 7¼-inch open-hole packer set at 1,308 feet, a 9/16-inch bean, and two pressure recorders on the bottom. The tester was open 33 minutes with no measurable gas flow. The recovery consisted of 175 feet of gas- and water-cut drilling fluid. No bottom-hole pressure was recorded. The salinity of the recovered fluid was 300 ppm.

Test 3, 1,355–1,402 feet.—A tester was run with a 5¾-inch open-hole packer set at 1,355 feet and with a 9/16-inch bean. There was one pressure recorder on the bottom. The tester was open 59 minutes with no measurable gas flow. The recovery consisted of 497 feet of slightly gas-cut water. No bottom-hole pressure was recorded. The salinity of the recovered fluid was 275 ppm.

Test 4, 1,431–1,502 feet.—A tester was run with a 5¾-inch open-hole packer set at 1,431 feet and a ½-inch bean. Two pressure recorders were set on the bottom. The tester was open 58 minutes with no measurable flow of gas. Five hundred feet of uncut water was recovered. The salinity of the recovered fluid was 290 ppm. The bottom-hole pressure recorded was 300 psi.

Test 5, 1,504–1,554 feet.—A 7⅛-inch open-hole packer was set at 1,504 feet with a ½-inch bean and two pressure recorders on the bottom. The tester was open 27 minutes with no measurable gas flow. The recovery consisted of 115 feet of uncut drilling fluid. The salinity of the recovered fluid was 300 ppm. The bottom-hole pressure recorded was 500 psi, and the bottom-hole temperature was 75°F.

Test 6, 1,674–1,737 feet.—A 7¼-inch open-hole packer was set at 1,674 feet with a ½-inch bean and two pressure recorders on the bottom. The tester was open 31 minutes and recovered 113 feet of uncut drilling fluid. No bottom-hole pressure was recorded. The salinity of the recovered fluid was 285 ppm, the same as the salinity of the circulated drilling fluid.

Test 7, 1,792–1,841 feet.—A 9⅝-inch open-hole packer was set at 1,792 feet with a ½-inch bean and two pressure recorders on the bottom. The tester was open 42 minutes. There was a very strong blow of gas estimated in excess of 8,000,000 cubic feet per day. Frozen connecting lines of the critical flow prover prevented accurate measurement of the volume. The tester was closed 11 minutes, and a bottom-hole pressure of 1,050 psi was recorded with a bottom-hole temperature of 80°F.

Test 8, 1,844–1,885 feet.—A 5¾-inch open-hole packer was set at 1,844 feet with a ½-inch bean and two pressure recorders on the bottom. The tester was open 58 minutes. There was an initial blow of 400 psi behind a 1-inch orifice in a 4-inch critical flow prover. Frozen connecting flow prover lines prevented an accurate gas-volume determination. No bottom-hole pressure was recorded. The flowing pressure was 950 psi.

Test 9, 1,876–1,885 feet.—A 5-¾inch open-hole packer was set at 1,876 feet with a ½-inch bean and two

pressure recorders on the bottom. The tester was open 69 minutes and there was a weak flow of gas of insufficient volume for a critical flow-prover measurement. The recorded bottom-hole pressure was 825 psi. The recovery consisted of 7 gallons of gas, oil, and water cut mud. This test was made because oil appeared in cores of this segment.

Test 10, 1,928–1,984 feet.—A 5¾-inch open-hole packer was set at 1,928 feet with a ½-inch bean and two pressure recorders on the bottom. The tester was open 110 minutes with no detectable flow of gas. Four hundred feet of gas, oil, and water-cut mud was recovered. The salinity of the circulated mud was 400 ppm. The salinity of the recovered fluid was 2,475 ppm. No bottom-hole pressure was recorded; bottom-hole temperature was 75° F.

Test 11, 2,096–2,146 feet.—A 5¾-inch open-hole packer was set at 2,096 feet with a ½-inch bean and two pressure recorders on the bottom. The packer failed to hold.

Test 12, 2,103–2,146 feet.—A 5¾-inch open-hole packer was set at 2,103 feet with a ½-inch bean and two pressure recorders on the bottom. The packer failed to hold.

Test 13, 3,496–3,450 feet.—A 7¼-inch open-hole packer was set at 3,496 feet with a ½-inch bean and two pressure recorders on the bottom. The tester was open 60 minutes with no detectable flow of gas. The recovery consisted of 195 feet of water-cut mud. The salinity of the circulated mud was 540 ppm. The salinity of the recovered fluid was 7,000 ppm. No bottom-hole pressure was recorded; bottom-hole temperature was 83° F.

Test 14, 3,781–3,809 feet.—A 7⅛-inch open-hole packer was set at 3,781 feet with a ½-inch bean and two pressure recorders on the bottom. The tester was open 119 minutes with no gas coming to the surface. Then the tester was closed 15 minutes. The recovery consisted of 1,910 feet of water. The salinity of the circulated mud was 218 ppm. The salinity of the recovered fluid was 7,755 ppm. The bottom-hole pressure recorded was 1,400 psi.

Test 15, 3,872–3,892 feet.—A 5¾-inch open-hole packer was set at 3,872 feet with a ½-inch bean and two pressure recorders on the bottom. The tester was open 152 minutes with no gas coming to the surface. Recovered 10 feet of water-cut mud. The salinity of the circulated mud was 236 ppm, and the salinity of the recovered fluid was 1,031 ppm. No bottom-hole pressure was recorded; bottom-hole temperature was 81°F.

Test 16, 4,034–4,060 feet.—A 5¾-inch open-hole packer was set at 4,034 feet with a ½-inch bean and two pressure recorders on the bottom. The packer failed.

Test 17, 4,038–4,060 feet.—A 5¾-inch open-hole packer was set at 4,038 feet with a ½-inch bean and two pressure recorders on the bottom. The packer failed.

Test 18, 4,033–4,060 feet.—A 7⅛-inch open-hole packer was set at 4,033 feet with a ½-inch bean and two pressure recorders on the bottom. The packer failed.

Test 19, 4,039–4,060 feet.—A 7⅛-inch open-hole packer was set at 4,039 feet with a ½-inch bean and two pressure recorders on the bottom. The tester was open 180 minutes and 12 feet of water-cut mud was recovered. The salinity of the circulated mud was 214 ppm. The salinity of the recovered fluid was 330 ppm. No bottom-hole pressure was recorded; the bottom-hole temperature was 82°F.

Test 20, 4,233–4,261 feet.—A 5¾-inch open-hole packer was set at 4,233 feet with a ½-inch bean and two pressure recorders on the bottom. The packer failed.

Test 21, 4,233–4,261 feet.—A 7⅛-inch open-hole packer was set at 4,233 feet with a ½-inch bean and two pressure recorders on the bottom. The packer failed.

Test 22, 4,232–4,261 feet.—A 7⅛-inch open-hole packer was set at 4,232 feet with a ½-inch bean and two pressure recorders at the bottom. The tester was open 165 minutes. Sixty feet of oil-cut mud was recovered. The salinity of the circulated mud was 338 ppm, and the salinity of the recovered fluid was 392 ppm. No bottom-hole pressure was recorded. Bottom-hole temperature was 84°F.

SIGNIFICANCE OF OIL AND GAS SHOWS AND TESTS

The following evaluation of the shows and tests of Gubik test well 2 was made by C. L. Mohr, chief of exploration for Arctic Contractors (written communication, 1952):

Gas deposits discovered in 6 sands between 1,066 and 1,875 feet in the Gubik 1 were found to extend down the structural dip to some undetermined points beyond Gubik 2. Assuming that gas extends down the dip to a uniform sea-level elevation on all parts of the anticline in each of these sands. the areal extent of the gas deposits would exceed 7,000 acres A seventh gas sand of "the Tuluvak tongue" in Gubik 1 does not carry gas as far down the structure as well 2, where it is found to be water bearing. An eighth gas sand, at 1,905 feet to 1 945 feet in Gubik 1. becomes impervious and nonproductive somewhere between 1 and 2.

A tight sand, which might yield some gas if further tested, was topped at 3,242 feet in 1 and 3,513 feet in 2.

An important gas sand at 3,460 to 3,615 feet in 1 is water bearing in 2 at 3,781 to 3,903 feet. An untested belt, or zone, of this sand extending from 1 to 2 and covering 4,800 acres of the structure, might yield gas, water, or oil over an extensive area of the anticline; but a third well about halfway down the dip between 1 and 2 would be required to test the fluid content in this belt. The fact that good oil saturation was found within a few hundred feet below this sand in the 2 well is a strong suggestion that this sand might carry an oil deposit between 1 and 2.

The oil saturation found in the 2 well at 4,031 to 4,060 feet, and 4,233 to 4,254 feet, also signifies the possibility that these sands might be better developed and capable of oil production at some

other location on the Gubik anticline. Their stratigraphic position corresponds roughly to that of the Umiat pay sands.

A significant feature of the basal part of the gas sand at 1,810 to 1,880 feet in Gubik 2 is the presence of true oil saturation and some free oil below the highly porous and permeable, gas-bearing part of the sand. If this represents a true gas-oil contact, as seems to be the case, then by drilling somewhat farther down the dip, the highly porous and permeable part of the sand should be found at the level of the oil and should yield prolific oil production.

LOGISTICS

A large working force was used to move the drilling rig about 1½ miles southeast from Gubik test well 1 to the site of Gubik test well 2. The rig was not unitized, and the season was bad for moving. However, Gubik test well 2 was ready to spud within a month after the completion of 1. One thousand and eight hundred tons of material, hauled by cat train, was used in drilling Gubik test well 2; 200 tons was flown in using the large airstrip at Gubik test well 1. An additional strip for bush planes was constructed near Gubik test well 2.

The camp setup was similar to that of the first well—2 quonset huts, 10 jamesway huts on sled runners, and 6 wanigans were used. The personnel, vehicles, and drilling equipment remained the same.

The following materials were consumed during the drilling of Gubik test well 2: 564,000 gallons of water, 89,821 gallons of diesel fuel, 7,517 gallons of 72-octane gasoline, 960 gallons of lubricating oil, 295 gallons of thread lubricant, and 358 pounds of grease.

DRILLING OPERATIONS

RIG FOUNDATION

The derrick and drawworks were mounted on piling. The remainder of the equipment such as tanks, and pumps were mounted on timbers laid on the river gravel.

DRILLING NOTES

The following table is composed of selected notes from the drilling records.

Notes from drill records

Depth (feet)	
0	Well spudded in on Sept. 11, 1951.
120	Ran 101 ft of 16½-in. 47 lb slip-joint welded casing. Top 40 ft jacketed with 23-in. casing. Cemented casing to surface with 100 sacks Cal-Seal.
810	Ran 810 ft of 6 joints, range 3, and 28 joints, range 1, 11¾-in. 47 lb, 8-round thread-coupled casing. Cemented casing with 8 bbl 15 percent by weight salt brine, 40 bbl diesel oil, and 200 sacks Hi-Early cement.
4,620	Hole plugged with cement from 2,300 to 2,260 ft and 2,260 to 2,200 ft, approximately. Started out of hole intending to run in with 10⅝-in. bit and clean out to approximately 2,200 ft. Well started to flow mud and immediately went out of control with three stands in the slips. Closed blowout preventers around drill pipe in attempt to control well. After estimated 5 min of gas blow, the well ignited and burned for approximately 4 days, resulting in the destruction of the rig. Hole bridged itself near 1,800 ft and was filled with water above the bridge and allowed to freeze. Owing to the circumstances it was impossible to set plugs between the various gas sands above 1,800 ft; therefore, there is nothing but a bridge of sand or cavings to prevent the movement of high-pressure gas from the 1,800-ft sand upward to any of the various shallower permeable sands beginning at 1,134 ft. Completion status: at the cellar floor there are an 11¾-in. landing base, 11¾-in. landing spool, 12-in. series 900, 10¾-in. to 3-in. sewage, and 3-in. Hamer plug valve, 6,000-lb test.

Notes from drill records—Continued

BLOWOUT

After the first cement plug was placed at 2,260 feet, a second plug of 40 sacks was placed at 2,251 feet. After the second plug was in place, the drill pipe was pulled above the estimated top of the cement, and the circulation system was run for about 3 hours to clean up the mud. While pulling pipe to change bit, preparatory to running in to feel for top of plug, mud started to blow out when all but three stands were out of the hole. Efforts to close rams around drill pipe failed as mud and gas were blowing out at such a rate that it was impossible to see results. After the well sanded up it was found that the drill pipe had been lifted enough to free the slips and had dropped down the hole. The well blew wild and ignited in about 5 minutes. In only 3 or 4 minutes the rig collapsed. The well sanded up in a few hours, but enough gas from an upper sand was escaping from the casing to flame about 4–6 feet high.

Two days after the original blowout, the well again blew out with volume and force about the same as the first time, but it again sanded up within a few hours and continued to burn with a flame about 4 or 5 feet high. Wreckage was cut away with a torch before extinguishing the blaze, in order to remove the Shaffer gates which were still usable. After the blaze was extinguished with carbon dioxide, the hole was filled with water. The 204 barrels of water required to fill the hole indicated that the top of the bridge was approximately at 1,800 feet.

The only zone in this well which showed by formation test to have high-pressure, large volume gas was between 1,810 and 1,858 feet. This zone was also the only one on the electric log about which there could be no question of the content being oil or gas. The long normal and lateral resistivities were a great deal higher than the short normal.

The volume of fluid required to fill up the hole after it had bridged over following the blowout was the amount required to fill it from 1,802 feet to the surface.

There can be little doubt that the gas blowout came from the sand between 1,810 feet and 1,858 feet.

DRILL AND CORE BITS

A total of 1,445 feet was cored (see pl. 16) using 68 bits, with 82.1 percent core recovery. Thirty-five drill bits were used, three 15-inch bits, thirty-one 10⅝-inch bits, and one 7⅞-inch bit, with an average of 90.5 feet drilled per bit.

DRILLING MUD

Arctic Contractor's petroleum engineer (written communication 1952) states that—

A water-base mud was used to drill to total depth. A 75 pound-per-cubic-foot water-Aquagel drilling fluid was mixed initially; Baroid was used as the mud-weighting agent. Sodium tannate was used to maintain viscosity at a desirable value; sodium bicarbonate to combat cement contamination; and carboxymethyl cellulose to control water loss and stabilize the drilling fluid.

A total drilling time of 86 days was required to complete the well. This treatment maintained an excellent drilling fluid throughout the period. The mud and tanks were cleaned while the well was standing cemented at 810 ft, and only the mud remaining in the tanks at this time was dumped.

In treating the mud, 945 sacks of Baroid, 118 sacks of Aquagel, 1,510 pounds of quebracho, 190 pounds of sodium bicarbonate, 430 pounds of Driscose, and 150 pounds of tetrasodium pyrophosphate were used. Following table shows the approximate amounts used, by depth.

Drilling-mud characteristics and additives, Gubik test well 2

Depth (feet)	Weight (lb/cu ft)	Viscosity (seconds API)	Filtration loss (cc/30 min)	Drilling fluid temperature (°F)	Remarks
120	78	40	8.0	----------	Added 100 lb quebracho, 15 lb caustic soda, 56 sacks Aquagel, 50 lb tetrasodium pyrophosphate, and 70 lb Driscose
160	78	40	8.0	45	
320	78	55	8.0	54	
410	76	51	8.0	82	
620	75	55	6.3	82	
700	76	55	6.2	82	Added 215 lb quebracho, 15 lb caustic soda, 41 sacks Aquagel, 192 sacks Baroid, and 350 lb sodium bicarbonate.
800	76	55	6.1	82	
945	76	55	5.8	82	
1,095	80	60	7.0	88	
1,180	86	59	6.7	86	
1,200	90	52	5.6	80	
1,280	87	47	5.0	80	Added 95 lb quebracho, 6 sacks Aquagel, 30 lb Driscose, and 120 sacks Baroid.
1,350	88	56	5.0	80	
1,400	88	55	4.8	74	
1,480	88	58	4.4	68	
1,505	88	55	4.6	66	
1,550	88	53	4.4	70	Added 90 lb quebracho, 5 lb caustic soda, 5 sacks Aquagel 50 lb tetrasodium pyrophosphate, 20 lb Driscose, and 141 sacks Baroid.
1,670	88	57	4.6	76	
1,725	88	50	4.8	86	
1,750	87	55	4.2	78	
1,840	90	56	4.6	87	
1,870	----------	57	4.4	74	
1,975	95	55	4.0	80	Added 75 lb quebracho, 5 lb caustic soda, 30 lb Driscose, and 93 sacks Baroid.
2,010	92	56	4.2	74	
2,070	93	55	4.0	80	
2,145	91	57	4.0	84	
2,170	92	55	4.0	86	
2,220	92	60	3.8	80	
2,360	91	57	4.0	88	

Drilling-mud characteristics and additives, Gubik test well 2—Con.

Depth (feet)	Weight (lb/cu ft)	Viscosity (seconds API)	Filtration loss (cc/30 min)	Drilling fluid temperature (° F)	Remarks
2,495	90	56	4.4	90	
2,590	89	56	----------	----------	
2,630	90	57	4.0	96	Added 25 lb quebracho, and 50 lb Driscose.
2,810	90	60	4.0	96	
2,910	90	55	4.2	96	
2,980	89	55	4.2	100	
3,095	90	54	4.2	102	
3,125	89	58	5.4	92	
3,180	92	58	4.4	88	
3,250	93	58	4.4	94	Added 240 lb quebracho, 5 lb caustic soda, 50 lb Driscose, and 180 sacks Baroid.
3,310	92	56	4.4	94	
3,350	92	58	4.4	94	
3,395	90	56	4.4	88	
3,430	87	58	4.7	90	
3,500	87	58	4.7	85	
3,540	91	57	----------	88	Added 125 lb quebracho, 15 lb caustic soda, 100 lb Driscose, and 60 sacks Baroid.
3,560	91	58	4.2	----------	
3,605	91	58	4.6	84	
3,640	91	56	4.4	84	
3,670	91	58	----------	80	
3,695	90	56	5.0	80	Added 65 lb quebracho, 20 lb caustic soda, 10 sacks Aquagel, 80 lb Driscose, and 93 sacks Baroid.
3,710	90	56	4.5	80	
3,750	90	58	4.5	80	
3,805	89	54	5.5	80	
3,830	89	58	5.0	80	
3,860	89	58	5.4	80	Added 35 lb quebracho, 10 lb caustic soda, and 21 sacks Baroid.
3,890	89	55	5.0	74	
3,920	89	55	5.2	74	
3,930	89	56	4.8	----------	
3,975	89	55	6.2	82	
4,000	88	56	5.8	80	
4,040	88	55	6.0	84	
4,060	87	56	5.8	76	
4,100	88	55	5.8	76	Added 145 lb quebracho, 60 lb caustic soda, and 12 sacks Baroid.
4,185	88	58	6.0	----------	
4,245	89	55	6.1	86	
4,265	88	57	6.0	76	
4,295	90	52	6.2	76	
4,320	----------	55	6.0	82	
4,370	----------	----------	5.8	77	Added 200 lb quebracho, 50 lb tetrasodium pyrophosphate, 40 lb caustic soda, 33 sacks Baroid, and 50 lb sodium bicarbonate. Later added, 100 lb quebracho, and 50 lb sodium bicarbonate
4,380	----------	----------	6.2	77	
4,420	90	55	6.0	84	
4,500	89	55	6.2	86	
4,530	90	58	6.0	84	
4,600	89	54	6.3	84	

HOLE-DEVIATION RECORD

The deviation for the first 1,200 feet was less than 1½°, but at 1,300 feet it was 2°. This straightened to 0°50′ at 1,355 feet. From 1,480 to 3,272 feet the deviation was close to 2° and dropped gradually to 1°30′ at 3,560 feet. However, at 3,825 feet the deviation was 4° and was reduced to 2° at 4,400 feet. (See pl. 16 for complete record.)

ELECTRIC LOGGING

The following table gives the electric log runs made by Schlumberger Well Surveying Corp.

Electric-log runs Gubik test well 2

Run	Date	Depth (feet)
	1951	
1	Sept. 19	116–800
2	Oct. 17	810–2, 260
3	Nov. 2	2, 260–3, 620
4	Dec. 4	3, 620–4, 598

LITERATURE CITED

Detterman, Robert L., 1956, New and redefined nomenclature of Nanushuk group, *in* Gryc, George, and others, 1956, Mesozoic sequence in Colville River region, northern Alaska: Am. Assoc. Petroleum Geologists Bull., v. 40, no. 2, p. 209–254.

Goddard, E. N., and others, 1948, Rock color chart: Natl. Research Council, Washington, D. C.

Morris, Robert H., and Lathram, Ernest H., 1951, Heavy-mineral studies, *in* Payne, Thomas G., and others, 1951, Geology of the Arctic Slope of Alaska: U. S. Geol. Survey Oil and Gas Invs., Map OM 126.

Robinson, Florence M., 1956, Introduction *to* Subsurface geology and engineering data, pt. 5 *of* Exploration of Naval Petroleum Reserve No. 4 and adjacent areas, northern Alaska, 1944–53: U. S. Geol. Survey Prof. Paper 305–A p. 1–3.

Collins, Florence Rucker, 1958, Test wells, Umiat area, Alaska: U. S. Geol. Survey Prof. Paper 305–B.

Whittington, Charles L., 1956, Revised stratigraphic nomenclature of Colville group, *in* Gryc, George, and others, 1956, Mesozoic sequence in Colville River region, northern Alaska: Am. Assoc. Petroleum Geologists Bull., v. 40, no. 2, p. 209–254.

species of Radiolaria were common in a sample from 525–535 feet, and a few Radiolaria occurred in samples from 815–885 feet. Two or three species of Foraminifera were found in the lower beds. In the core from 731–741 feet, *Verneuilinoides fischeri* Tappan was abundant, and *Trochammina diagonsis?* (Carsey) was common. A few tests of *Nonionella austinana* Cushman and *Praebulimina venusae* (Nauss) occurred in ditch samples.

TULUVAK TONGUE OF THE PRINCE CREEK FORMATION (890–1,760 FEET)

The cores were unfossiliferous except for *Inoceramus* prisms found in three. Scattered Foraminifera and a few Radiolaria were found in some ditch samples. None of the fossils were diagnostic, for the species range throughout the Colville group of sedimentary rocks.

SEABEE FORMATION (1,760–3,305 FEET)

Most of the cores were barren except for *Inoceramus* prisms. The only ditch samples having any degree of abundance of Foraminifera were from 1,910–2,000 feet; *Haplophragmoides rota* Nauss was common in two samples.

NINULUK FORMATION AND KILLIK TONGUE OF THE CHANDLER FORMATION (3,305–3,735 FEET)

Fossils were found in only 1 sample, a core from 3,342–3,352 feet, in which were 4 species of Foraminifera and 1 species of Radiolaria; *Saccammina* sp. and *Gaudryina canadensis* Cushman were common.

VERNEUILINOIDES BOREALIS FAUNAL ZONE (3,735 FEET TO TOTAL DEPTH)

Specimens of the *Verneuilinoides borealis* fauna were relatively abundant throughout much of the interval from 3,805–4,100 feet. *Verneuilinoides borealis* Tappan, the species for which the fauna is named, occurred most frequently and was common in several samples. A core from 3,900–3,920 feet was very fossiliferous, having common to abundant specimens of *V. borealis*, *Saccammina* sp., *Miliammina ischnia* Tappan, *Trochammina rutherfordi* Stelck and Wall, *Trochammina umiatensis* Tappan, *Reophax* sp., *Valvulineria loetterlei* Tappan, and *Zonodiscus* sp., plus a few specimens of a half dozen other species. The fauna is sparse in samples from 4,100–4,190 feet, and the lower beds are barren except for 2 or 3 occurrences of *Inoceramus* prisms in ditch samples and a fragment of *Ditrupa* sp.[1] in a core from 4,295–4,305 feet.

Occurrences of Foraminifera below 4,000 feet were scattered through beds to a depth of 5,100 feet, and in only 2 or 3 samples were specimens of 1 species common. *Haplophragmoides topagorukensis* Tappan was very abundant in a core from 4,352–4,372 feet. This species and specimens of *Trochammina rutherfordi* Stelck and Wall were common in a ditch sample from 4,410–4,415 feet. *T. rutherfordi* was also the most frequently occurring species in many of the ditch samples, but there were very few specimens in each one. A core from 5,100–5,115 feet had common specimens of *Haplophragmoides topagorukensis* and *Verneuilinoides borealis* and 1 or more specimens each of 10 other species; 8 specimens of *Gaudryinella irregularis* Tappan were foremost of this secondary group.

Only a few Foraminifera, generally *V. borealis* and *T. rutherfordi*, occurred in most of the samples throughout the underlying beds from 5,115 feet to the bottom of the hole. Very few specimens were found in the lower cores. *Haplophragmoides topagorukensis* was common, and *V. borealis* very abundant in a ditch sample from 5,270–5,280 feet, and *T. rutherfordi* was very abundant in a sample from 5,510–5,520 feet. Of the few calcareous Foraminifera, *Nanushukella umiatensis* Tappan and *Globorotalites alaskensis* Tappan each occurred in five samples. A core sample from 5,758–5,768 feet had common specimens of *Theocampe?* sp. and a few other specimens of Radiolaria, but only four specimens of Foraminifera were found in it. In a bottom core a few specimens of *T. rutherfordi* and *Nanushukella umiatensis* were identified, and a few others were questionably referred to three species.

GUBIK TEST WELL 2

SCHRADER BLUFF FORMATION (160–1,135 FEET)

No microfossil samples were received for the upper 160 feet of section. Scattered *Inoceramus* prisms, a few specimens of *Haplophragmoides rota* and *Verneuilinoides fischeri*, and a very few specimens of *Anomalinoides pinguis* (Jennings) constitute the fauna found in the upper 700 feet of section in this well. In the lower beds of the Schrader Bluff formation, *V. fischeri* was found in several samples and was common in a core from 810–820 feet. Tests of *Nonionella austinana* Cushman and *Praebulimina venusae* (Nauss) occurred in samples below 720 feet. Radiolaria were common in several samples. In a sample from 780 feet, *Cenosphaera* sp. and *Spongodiscus* sp. were common; in samples from 1,000 feet through 1,060 feet, the same species were common, plus a few other Radiolaria.

TULUVAK TONGUE OF THE PRINCE CREEK FORMATION (1,135–2,010 FEET)

Most of the cores were unfossiliferous, but in some of the continuously cored intervals rare occurrences of fossils are conspicuous. The fauna of the Tuluvak is slightly different from that of the overlying Schrade

[1] Curved tubular shells from the Cretaceous beds of northern Alaska were formerly referred to *Laevidentalium* sp. or *Dentalium* sp. Determinations by Ralph W. Imlay show that these shells are not scaphopods but are worm tubes of the genus *Ditrupa*.

Bluff formation. Specimens of *Trochammina ribstonensis* Wickenden and *Gaudryina irenensis* Stelck and Wall were scattered through samples from the section. Both of these species and *Verneuilinoides fischeri* Tappan were common in a core from 1,340–1,351 feet. In a core sample from 1,482–1,502 feet, *T. ribstonensis* was common to abundant. A few Foraminifera of the same species occurred in a core from 1,578–1,580 feet. In a core from 1,731–1,737 feet, *Saccammina* sp. and *Trochammina whittingtoni?* Tappan were both common. The continuously cored section from 1,813 feet through 1,984 feet was unfossiliferous except for some plant imprints at 1,915 feet.

SEABEE FORMATION (2,010–3,585 FEET)

In the upper part of the Seabee formation from 2,129 feet to 2,218 feet is a conspicuous fauna in which *Haplophragmoides rota* is abundant and *Pseudoclavulina hastata* (Cushman) and *Arenobulimina torula* Tappan occur. Because regional studies seemingly indicate that these two species are limited to the upper part of the Seabee formation, I have designated that part of the section as the *Pseudoclavulina-Arenobulimina* faunal zone. A few specimens of *Praebulimina seabeensis* Tappan and a few Radiolaria were associated with the fauna in this well. In one sample (2,180–2,190 feet) *Zonodiscus* sp. was common.

Throughout most of the rest of the Seabee formation below the *Pseudoclavulina-Arenobulimina* zone, species of Foraminifera and Radiolaria are rare, and only a few specimens were found—exceptions to this follow. A ditch sample from 3,030–3,040 feet in which there were no Foraminifera but *Spongurus* sp. was common. A core sample from 3,100–3,110 feet had common specimens of *Gaudryina irenensis?* and an abundance of *Trochammina diagonis?*. *Zonodiscus* sp. was common in a ditch sample from 3,150–3,155 feet, and *Inoceramus* prisms were found in several core and ditch samples low in the section. In a core sample from 3,368–3,380 feet, *Gümbelitria cretacea albertensis* Stelck and Wall was common.

NINULUK FORMATION AND KILLIK TONGUE OF THE CHANDLER FORMATION UNDIFFERENTIATED (3,585–4,025 FEET)

The section was unfossiliferous excepting a core sample near the top from 3,620–3,630 feet, which had common specimens of *Saccammina* sp. and *Trochammina rutherfordi*, abundant specimens of *Gaudryina canadensis*, and a few specimens of *Miliammina ischnia* and *Zonodiscus* sp.

VERNEUILINOIDES BOREALIS FAUNAL ZONE (4,025 FEET TO TOTAL DEPTH)

The top of the *Verneuilinoides borealis* fauna occurs in a sample from 4,025–4,030 feet. Only a few Foraminifera were present in the sample, but in a core sample from 4,060–4,075 feet, *Haplophragmoides topagorukensis* Tappan was common. *Ditrupa* sp. occurred in a core from 4,058–4,060 feet. *Verneuilinoides borealis* was common in a sample from 4,150 feet, and a few specimens of *Ammobaculites fragmentarius* Cushman were found in a sample from 4,210 feet. Specimens of *Trochammina umiatensis* were common in samples from 4,180, 4,210, and 4,225–4,230 feet. Few Foraminifera occurred in the samples from lower beds in the test well, and several of the cores were barren.

BIBLIOGRAPHY OF THE MICROPALEONTOLOGIC STUDY

Nauss, A. W., 1947, Cretaceous fossils of Alberta; Jour. Paleontology, v. 21, no. 4, p. 329–434.

Stelck, C. R., and Wall, J. H., 1954, Kaskapau Foraminifera from Peace River area of western Canada: Prov. of Alberta, Res. Council Rept. no. 68.

Stelck, C. R., and Wall, J. H., 1955, Foraminifera of the Cenomanian *Dunveganoceras* zone from Peace River area of western Canada: Prov. of Alberta, Res. Council Rept. no. 70.

Tappan, Helen, 1951, Northern Alaska Index Foraminifera, Contrib. Cushman Foundation Foram. Research, v. 2, pt. 1, p. 1–8, pl. 1.

Tappan, Helen, 1957, New Cretaceous Foraminifera from northern Alaska: U. S. Natl. Mus. Bull. 215.

Wickenden, R. T. D., 1932, New species of Foraminifera from the Upper Cretaceous of the Prairie Provinces: Royal Soc. Canada. Proc. and Trans. 3d ser., v. 26, sec. 4, p. 85–92, pl. 1.

INDEX