NATIONAL PETROLEUM RESERVE IN ALASKA

GEOLOGICAL REPORT

TUNALIK TEST WELL NO. 1

HUSKY OIL NPR OPERATIONS, INC.
Prepared by: Harry Haywood
Edited by: Gordon W. Legg

For the

U. S. GEOLOGICAL SURVEY
Office of the National Petroleum Reserve in Alaska
Department of the Interior
AUGUST 1983

TABLE OF CONTENTS

Page

GEOLOGIC SUMMARY

Introduction 1
Pre-Drilling Prognosis 1
Post-Drilling Summary 1
Location Map (Figure 1) 3
Surveyor's Plat (Figure 2) 4
Structure Map - Top of Carboniferous (Figure 3) 5

WELLSITE GEOLOGIST'S REPORT

Introduction 6
Stratigraphy
Wireline Tops 7
Cretaceous
Nanushuk Group
Corwin-Grandstand (Undifferentiated)
Interval 106-2650' 7
Interval 2650-3540' 8
Interval 3540-5030' 9
Interval 5030-5935' 9
Torok Formation
Interval 5935-8300' 10
Interval 8300-10,632' 11
"Pebble Shale"
Interval 10,632-10,902' 11
Interval 10,902-11,460' 12
Interval 11,460-12,270' 12
Interval 12,270-12,606' 13
Interval 12,606-13,378' 13
Jurassic
Kingak Formation - 13,378-14,263' 14
Triassic
Sag River Sandstone - 14,263-14,520' 14
Shublik Formation - 14,520-14,819' 15
Triassic-Permian
Sadlerochit Group
Ivishak Formation - 14,819-15,560' 15
Kavik Shale Member - 15,560-16,890' . . 16
Echooka Formation - 16,890-17,100' 16
Permian-Pennsylvanian
Lisburne Group
Interval 17,100-17,570' 16
Volcanics - 17,570-18,353' 16
Interval 18,353-20,335' 17
Conclusions 18

LIST OF FIGURES

Figure 1 - Location Map 3
Figure 2 - Surveyor's Plat 4
Figure 3 - Carboniferous Structure Contour Map 5

PERTINENT DATA AND APPENDICES

Appendix		Page
A.	Summary Pertinent Data, Operations and Analysis	A-1-4
B.	Drill Cuttings and Core Descriptions	B-1-57
C.	Log Analysis	
	Report of February 3, 1979	C-1-2
	Report of June 6, 1979	C-3
	Report of August 6, 1979	C-4
	Report of November 13, 1979	C-5
	Report of January 3, 1980	C-6
D.	Logging Reports	
	Report of January 24, 25, 26, 27, 1979	D-1
	Report of May 31, June 1, 1979	D-2
	Report of July 25-31, 1979	D-3
	Report of November 3-7, 1979	D-4
	Report of December 22-27, 1979	D-5
E.	Core Analysis	
	Interval 5558-5561'	E-1
F.	Listing of Other Available Data	F-1
	Micropaleontology Report	
	Drilling History	
	Source of Other Geological and Well Data	

COMPOSITE LITHOLOGY LOG (In Pocket)

GEOLOGIC SUMMARY

INTRODUCTION

The Tunalik Test Well No. 1 is located in the SE 1/4, protracted Section 20, T10N, R36W, Umiat Meridian, approximately 40 miles southwest of Wainwright, Alaska (Figures 1 and 2). Drilling of the well commenced on November 10, 1978. The well reached a total depth of 20,335 feet on December 22, 1979. Considerable well control and hole problems related to overpressuring were encountered in low porosity sandstones of the Torok Formation and underlying sediments to a depth of approximately 12,550 feet. The well was plugged and abandoned and the rig released on January 7, 1980.

PRE-DRILLING PROGNOSIS

The Tunalik well was drilled as a deep stratigraphic test primarily of pre-Cretaceous rocks in the western portion of NPRA. The location was centered on a small seismically interpreted closure which had been identified in the Triassic-Permian and underlying horizons. Figure 3 illustrates the interpreted closure at the Carboniferous horizon.

Primary objectives were possible sandstones in the "Pebble Shale"; sandstones of the Sadlerochit Group; and carbonates of the Lisburne Group. The well was forecasted to penetrate the "argillite" basement at 19,950 feet.

Definition of exact potential reservoir horizons could not be made due to the paucity of subsurface control; however, potential reservoirs were expected to occur in the lower Cretaceous ("Pebble Shale") through Triassic-Permain clastics (Sadlerochit Group) and in anticipated shallow water carbonates of the Lisburne Group.

POST-DRILLING SUMMARY

The well bottomed in Lisburne Group limestones (Late to Middle Pennsylvanian) at a subsea depth of -20,226 feet. The primary objectives were found to be generally composed of low porosity, and low permeability, rocks. A thick sandstone (approximately 550 feet) of Neocomian age, with very poor porosity (average of approximately 6%) was encountered from 10,905' to 11,672' within the "Pebble Shale" unit. Anderson, Warren & Associates, Inc. have assigned an age of Early Cretaceous, Neocomian (F-12 to F-13) to sediments from 10,620-12,620', and Neocomian (F-13 to F-14) from 12,620-13,380', so that the sandstone would lie well within the Neocomian and, thus, would not be equivalent to the "Kugrua Sandstone" of Jurassic age.

The Triassic-Permian Sadlerochit Group penetrated by the well is composed principally of shales and nonpermeable siltstones with very minor amounts of fine grained dirty sandstones. No potential reservoir rocks were noted from the interval.

7

The Lisburne Group in the well is composed of deep water limestones, chert beds, and thin interbedded siltstones. No apparent reservoir intervals were noted from the interval. Within the Lisburne Group were approximately 800 feet of volcanic rocks determined to be amygdaloidal

of gas were noted within the lower part of the marine
up at approximately 5,000 feet to 6,000 feet and within thin
oot net) sandstones of the Torok Formation. These shows
d to represent slightly overpressured, very low volume

ows were also noted in sandstones within lower portions of
age rocks. The most significant gas show in this interval
an interbedded sandstone and shale sequence between 12,550
0 feet. A maximum of 1,250 units of ditch gas was recorded
before the well was shut-in. Considerable time was spent
the overpressured conditions within this zone before drilling
umed. As a result of the well control procedures,
nounts of barite were lost from the drilling fluids into the
erval, making accurate porosity determination from logs
cult (see discussion in Appendix C). A total of nine (9)
were attempted in the interval. No definitive pressure was
the attempted tests nor were any fluid samples collected due
to obtain a packer seal with the formation. Because of the
formation damage in the interval 12,520 feet to 12,600 feet,
ests of these sandstones were attempted. No other intervals
d significant enough to warrant additional evaluation.

Minor shows
Nanushuk Grou
(less than 5 f
are considere
reservoirs.

Several gas sh
the Neocomian
occurred from
feet and 12,60
(100% methane)
in controlling
could be res
considerable a
sandstone int
extremely diffi
wireline tests
obtained from
to the inability
high degree o
no additional t
were considere

8.

6

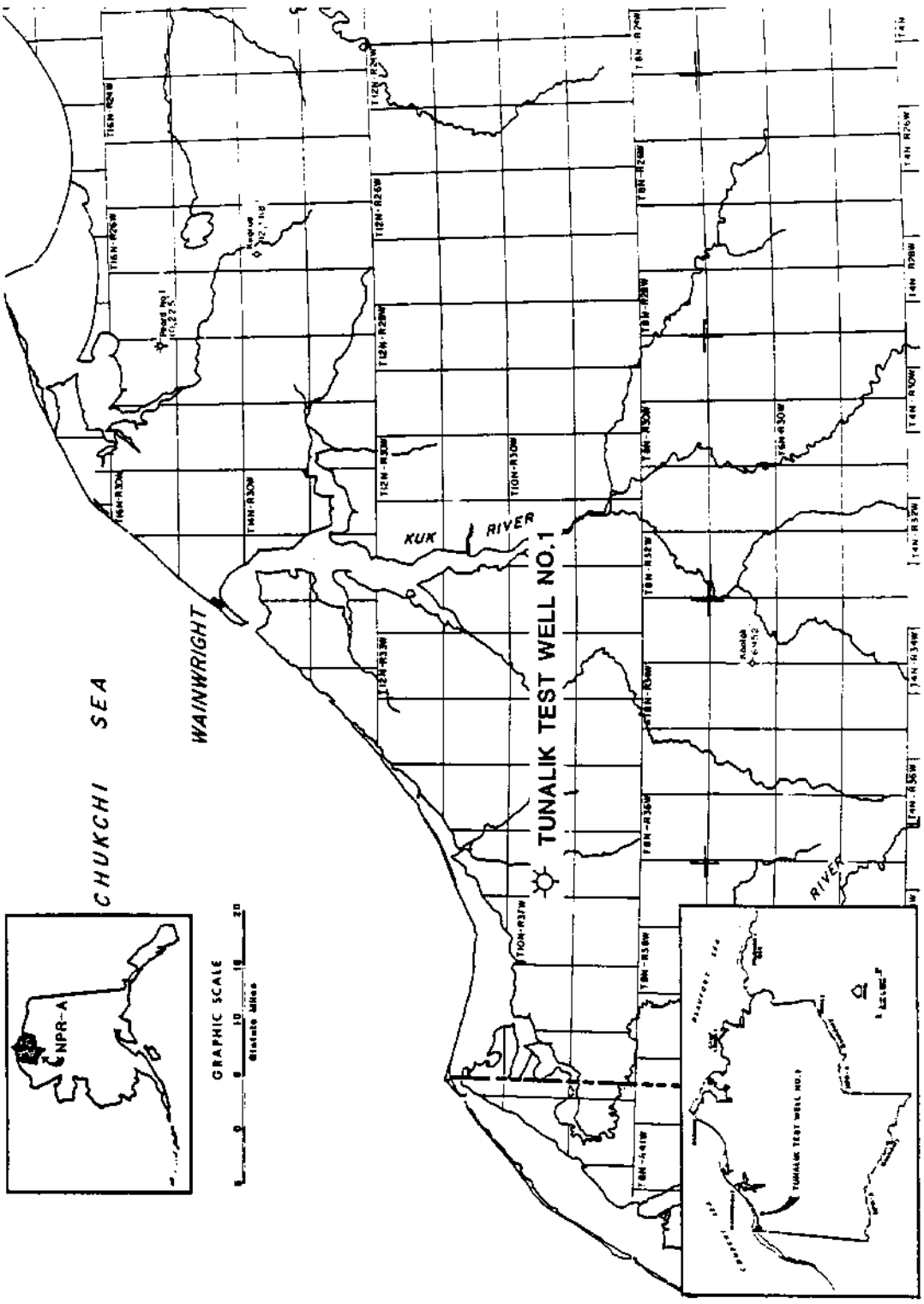
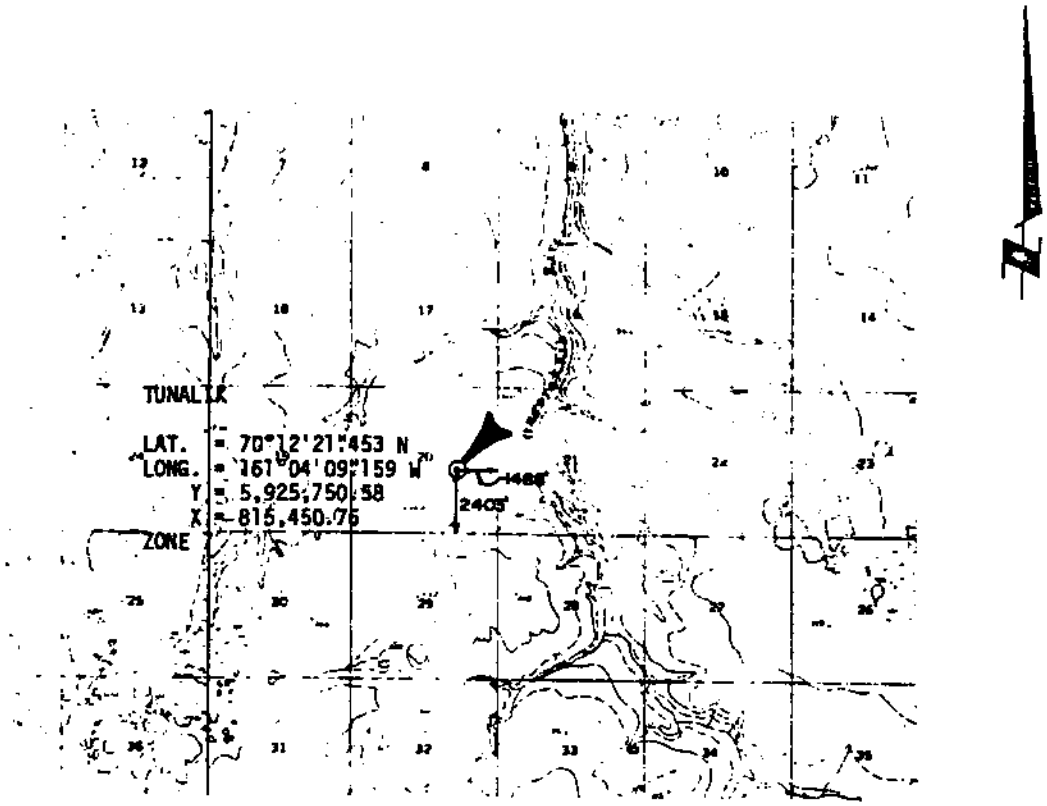


FIGURE 1 - LOCATION MAP - TUNALIK TEST WELL NO. 1



CERTIFICATE OF SURVEYOR

I hereby certify that I am properly registered and licensed to practice land surveying in the State of Alaska and that this plat represents a location survey made by me or under my supervision, and that all dimensions and other details are correct.

August 17, 1977

0 1/2 1 2
SCALE IN MILES

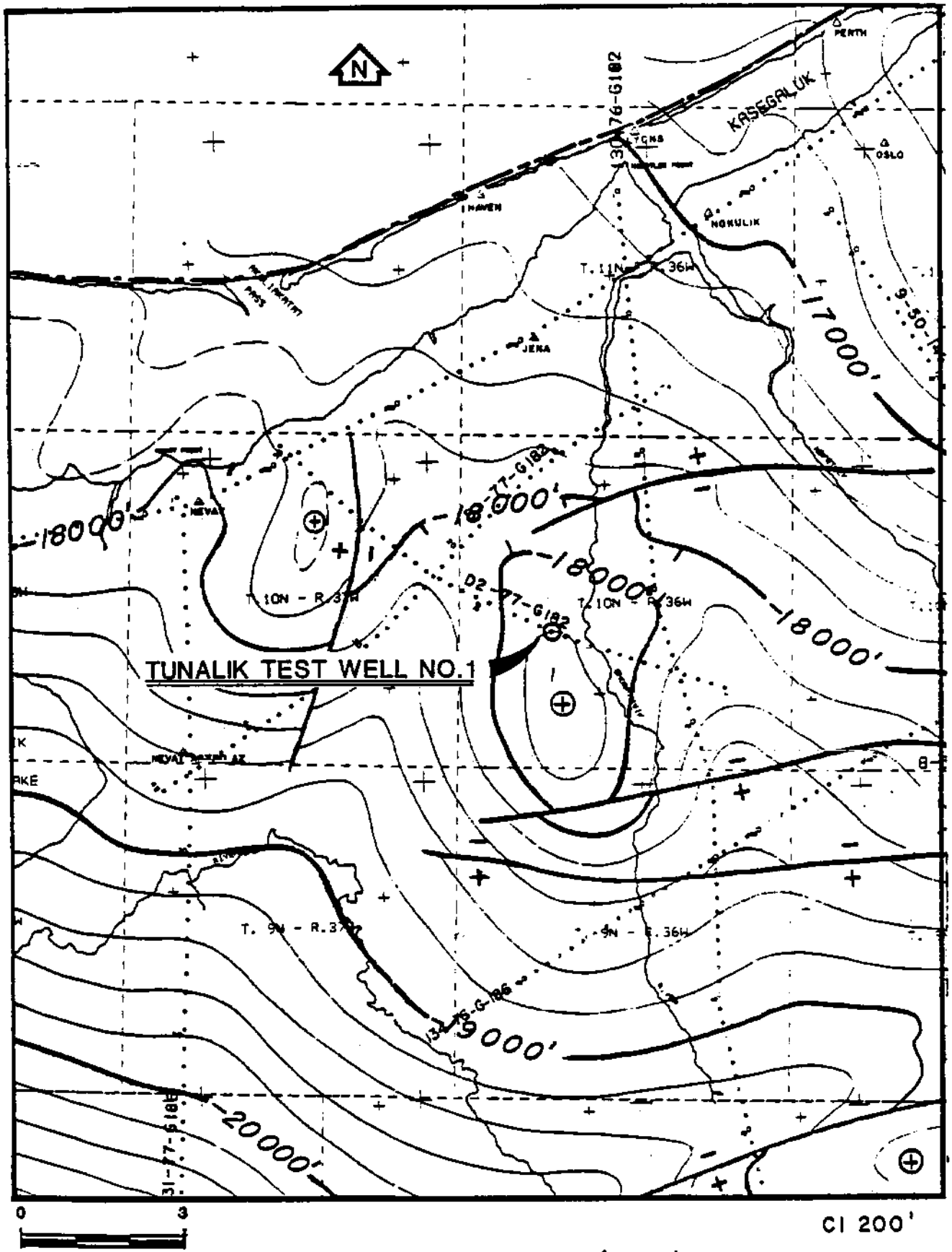
AS STAKED
TUNALIK
LOCATED IN
[illegible] PROTRACTED SEC. 29 T10 N, R30 W. [illegible]

Surveyed for
HUSKY OIL
N.P.R. OPERATIONS INC.

Surveyed by
Bell, Herring and Associates
ENGINEERS AND LAND SURVEYORS
801 West Fireweed, Suite 102
ANCHORAGE, ALASKA 99503

FIGURE 2
Surveyor's Plat
Tunalik Test Well No. 1

11.



CARBONIFEROUS (D-I)

FIGURE 3 - STRUCTURE MAP, TOP OF CARBONIFEROUS (LISBURNE CARBONATES) C.I. = 200'
From Tetra Tech Drawing No. 104-4200, entitled "Composite Structure Map"

WELLSITE GEOLOGIST'S REPORT
BY: WM. D. FENEX
EDITED BY: GORDON W. LEGG

INTRODUCTION

The Tunalik Test Well No. 1 is located 2403' FSL, 1488' FEL, SE 1/4 of protracted Section 20, T10N, R36W, Umiat Meridian, North Slope Borough, Alaska (Figures 1 & 2). The location is 40 miles southwest of the village of Wainwright and is just five miles south of the coastline of the Chukchi Sea. Surrounding the location is flat-lying, marshy terrain near the mouth of the Tunalik River.

The test well, which is situated in an area of very sparse subsurface control, was drilled on a small, seismically interpreted closure on the Triassic-Permian and underlying horizons. Additionally, the well was drilled in order to obtain lithologic and stratigraphic control in this essentially unknown area of the National Petroleum Reserve in Alaska.

Minor gas shows were logged in the Nanushuk Group (5000-6000') and within several thin sandstones of the Torok Formation. These were associated with over-pressured conditions. Several over-pressured gas shows were noted in lower portions of Neocomian age rocks. One significant show in this interval occurred in an interbedded sandstone and shale unit between 12,550 feet and 12,600 feet. A maximum of 1,250 units of gas was recorded, when the sand "kicked", forcing the operator to shut-in the well for an extended period of time in order to combat a narrow range of conditions which caused the well to "kick" when the mud weight was reduced slightly and to lose circulation with the subsequent raising of the mud weight. Considerable amounts of barite were lost from the drilling fluid to the formation, rendering log calculations for porosity very difficult. A total of nine wireline test attempts failed to yield any definitive pressure data on the formation because of difficulties in obtaining a seal between the sandstone and the pad of the tool. No additional tests of this zone were attempted because of the formation damage, the thin, interbedded nature of the sandstone and, finally, because sample analysis failed to reveal adequate porosity or shows, conditions which would be necessary for the sandstone to be considered a potential reservoir. The gas was again associated with over-pressured conditions.

The primary objectives in the "Pebble Shale", Sadlerochit Group and the Lisburne Group all exhibited very low porosities and were not considered to be worthy of further evaluation. Of particular interest was a section of volcanics contained within the Lisburne Group of carbonates. The volcanics were determined to be amygdaloidal basalts and were 783 feet thick.

Wireline log tops, originally reported from the wellsite, have been revised to conform with paleontological determinations and are listed below.

STRATIGRAPHY

WIRELINE TOPS

	MEASURED DEPTH BELOW KB	SUBSEA DEPTH
CRETACEOUS		
Nanushuk Group		
Corwin-Grandstand (Undifferentiated)	Surface	±80'
Torok Formation	5,935'	(-5,826')
"Pebble Shale"	10,632'	(-10,523')
JURASSIC		
Kingak Formation	13,378'	(-13,269')
Upper Kingak	13,378'	(-13,269')
Lower Kingak	14,040'	(-13,931')
TRIASSIC		
Sag River Sandstone	14,263'	(-14,154')
Shublik Formation	14,520'	(-14,411')
TRIASSIC-PERMIAN		
Sadlerochit Group		
Ivishak Formation	14,819'	(-14,710')
Kavik Shale Member	15,560'	(-15,451')
Echooka Formation	16,890'	(-16,781')
PERMIAN-PENNSYLVANIAN		
Lisburne Group	17,100'	(-16,991')
Volcanics	17,570'	(-17,461')
Base of Volcanics	18,353'	(-18,244')
Lisburne Group (lower section below volcanics)	18,353'	(-18,244')
TOTAL DEPTH	20,335'	(-20,226')

CRETACEOUS

Nanushuk Group

Corwin-Grandstand (Undifferentiated): Surface-5935' (Albian)

Interval 106-2650'

Samples were first collected and examined below 106' at the base of the 42" conductor pipe. From 106' to approximately 2650' were sediments of the Nanushuk Group of Cretaceous Albian age. Lithologies in this interval consisted of sandstones, limestones, dolomites(?) and coals, with only occasional mudstones and claystones.

12

16.

The presence of significant thicknesses of limestones and dolomites within this interval is somewhat surprising in view of their relative scarcity in rocks of the same approximate age in other areas on the North Slope. The high percentages of carbonates logged in samples from the interval may be related to the unconsolidated nature of enclosing sediments resulting in over-estimating the true carbonate percentages on sample logs. Since coals are persistent and well developed through the interval, an environment of deltaic, estuary and marginal marine sediments is inferred, hardly an ideal environment for widespread deposition of limestone and dolomite. The occurrence of both limestones (typically dolomitic) and dolomites, together with predominantly calcareous cement in the sandstone, leads to the presumption that the sediment source was rich in calcium and magnesium minerals (probably feldspars) and the depositional conditions probably were cyclical leading to restricted circulation and resulting in the chemical precipitation of limestones and dolomites. It is noteworthy that no fossils were observed in the limestones at the wellsites and very sparse assemblages of forams were observed by the paleontologists of Anderson, Warren & Associates, Inc. and no mention was made on which sediments contained what few forams were present.

None of the sandstones or carbonates within this interval were noteworthy for either their porosity or their uninterrupted thickness. The sandstones generally were very fine grained to fine grained with occasional medium grained constituents. The quartz grains of the sandstones tended to be subangular to subrounded with only fair sorting. Cementing materials were typically clay and calcite with frequent white clay in the matrix, which is probably from the decomposition of feldspars. The limestones and dolomites were essentially nonporous.

Abundant coal beds were developed throughout this section, but were generally rather thin, ranging from 2' to 10' in thickness. The grade of the coal was extremely variable, ranging from earthy, impure lignitic coals to vitreous, hard, subbituminous coals.

The minor claystones and mudstones were often completely dispersed by the drilling mud and probably constituted a somewhat higher percentage of the sediments than the samples descriptions would indicate.

Interval 2650-3540'

The sequence of rocks 2650' to 3540' are similar in both composition and probable depositional origin to those above (106-2650'), but shales, siltstones, and sandstones predominate with much less coal and only occasional limestones and dolomites. The age of this sequence is probably Albian, but the depositional environment is more marginal marine than the previous interval.

Probably the most outstanding characteristic of the interval 2650-3540' is the introduction of finer clastics in the form of shales and siltstones, and the silty nature of most of the sandstones. The cementing material for the sandstones is now typically clay, and specifically, abundant matrix material of white clay, with lesser amounts of calcareous cement. The sandstone

porosities are generally less than above, due to the abundance of "fines". Thicknesses of individual sand bodies never exceed 30', and are generally 15' or less.

The coals of this sequence do not appear to be significantly different than those above, as far as grade is concerned, but they are less persistent, form a smaller overall percentage of the section, and individual beds are somewhat thinner.

Shales, claystones and mudstones in this sequence are generally gradational with the sandstones and siltstones, and differ from those in the interval 106-2650' by being somewhat more indurated, especially in the case of the shales.

No oil or gas shows (except for methane from the coals) were observed in this section.

Interval 3540-5030'

Rocks in this sequence of sediments are probably Albian age and vary from the previously encountered sediments only by the fact that coals have now become very rare, as have limestones and dolomites, by the fact that the finer clastics now predominate (shales and claystones) and that the sandstones are now relatively thin and are gradational with the siltstones, shales and claystones.

Sandstones are typically carbonaceous, silty, and have abundant clay in the matrix. Porosity is generally poor and thicknesses rarely exceed 15' except for one sandstone that extends from 3740' to 3780'.

There were two very poor residual oil shows:

(1) Sandstone, 4108-4126', very slight trace of fluorescence (2 pieces) yielding a very faint cut. The porosity of the sandstone ranged from poor to fair, with the residual show being confined to the poorer porosity.

(2) Siltstone, 4607-4612', soft and mushy (clayey), with a slight dull yellow fluorescence and a slight cut.

Interval 5030-5935'

Middle to Late Albian (Nanushuk) sediments in this interval are much the same as those in the interval 3540' to 5030' except that the rocks appear to be completely gradational between the shales, claystones, siltstones, and sandstones, and are characterized by being thin bedded, alternating sequences, and perhaps reflect a more marine environment than overlying sediments.

The sandstones of this sequence are generally 3' to 10' thick, with the thickest being about 12'. Porosities are typically poor due to the "dirty" nature of the sandstones, which contain a high percentage of clay and silt-size particles.

14

16

Numerous shows were present in this interval with most of the sandstones having a small percentage of the cuttings with fluorescence ranging from very dull yellow to occasionally bright yellow, and cuts generally yielded only after crushing, but with occasional bright yellow streaming cuts. Most or all of these shows are judged to be residual and of no economic importance, especially in view of the low porosities and the lack of thicker sand bodies.

Torok Formation: 5935-10,632' (Aptian)

The top of the Early Cretaceous-Aptian Torok Formation is selected at 5935'. This top is supported by paleontological data, which indicates that the top of Aptian (F-10) sediments occurs at about 5950'.

Interval 5935-8300'

The interval from 5935' to 6880' consists of marginal marine cyclical sequences of shale, siltstone, and sandstone beds of which sandstone is the dominant lithology. The beds grade vertically from one rock to the other. These sediments appear to have been deposited in a delta-front environment.

The sandstones are light gray, and are composed of fine to medium quartz grains with common black, ferromagnesian minerals and rare feldspar grains in a largely calcitic matrix. White kaolinitic clay filling occurs in some sands in the lower portion of this interval. Numerous carbonaceous (almost coaly) laminations and inclusions occur throughout the sands. Individual sandstone beds generally are thin and usually do not exceed 10' to 15' in thickness. Porosity is very low except in occasional sandstones, where porosities as high as 15% have been calculated from wireline logs. These sands all carry minor amounts of gas, probably of the high-pressure, low-volume type.

The interbedded shale beds throughout this interval are typically dark gray-brown in color, with finely disseminated mica and occasional carbonaceous and pyrite inclusions. The shales become silty and grade to siltstone in part.

From 6880 to 7910', the Torok rocks grade to a deeper marine sequence of predominantly shale and siltstone, which is lithologically similar to those in the previous interval. Only very thin stringers of sandstone occur within this section.

The interval from 7910' to 8300' represents a return to a marginal marine delta front facies, which is composed predominantly of light gray sandstones, with interbedded shale and siltstone. Porosities, except in rare cases, are generally very low and thickness of individual sandstone beds does not exceed 10'. An increase in white kaolinitic clay filling occurs in sandstones within this interval, which additionally inhibits the already poor porosity and permeability. Gas shows of the high-pressure, low-volume type occur throughout this interval. These scattered zones proved so troublesome that it became necessary to run casing.

The thin sandstone beds that are present in the upper portion of the Torok contain minor amounts of gas. The sand from 6090-6115' had a total gas measurement of 1,300 units. Chromatograph measurements were 260,000 ppm C_1, 5,000 ppm C_2, and 3,500 ppm C_3. A 25 barrel "kick" occurred from this sand, which was circulated out on the choke and controlled by raising the mud weight.

Gas readings in the zone from 7910' to 8300' reached as high as 3,000 units total gas, and was accompanied by chromatograph readings of 600,000 ppm C_1, 28,000 ppm C_2, 10,000 ppm C_3, and 8,000 units C_4.

Interval 8300-10,632'

This sequence of rocks was dated by AWA as being of Lower Cretaceous (Aptian) Age and is characterized by the predominance of shales, which are typically bentonitic. The rocks in this interval are again gradational and thinly bedded, ranging from shales to siltstones and sandstones.

The outstanding characteristic of this interval is the presence of thin beds of "over-pressured" siltstones and sandstones, which infers a delta-front environment and especially suggests a limited areal extent for sandstone and siltstone bodies resulting in "under-compaction" due to the inability of these bodies to expel water with compaction, thus giving rise to pockets of high-pressure, low-volume gas.

Sandstones in this interval are usually quite argillaceous (especially with the white kaolinitic clay) and are very fine grained to silt size, only occasionally becoming fine grained. The clay in the matrix is frequently bentonitic and swells rapidly when contacted by fresh water (NOTE: the well was drilled using an inhibiting KCL base mud which was designed to reduce clay swelling and sloughing). Porosities are poor to very poor, and thicknesses are generally less than 10', with only two or three exceptions.

One of the exceptions was a nicely developed sandstone approximately 80' thick. Unfortunately, this sandstone is very silty and argillaceous with abundant clay matrix and calcareous cement. Porosity is low due to clay and calcite in the matrix, and secondarily, to probable silica cement, as well, in the bottom 30'.

Only high-pressure, low-volume gas shows, associated with this type of "geo-pressured" sediments, were encountered, and are of no interest from an economical standpoint.

"Pebble Shale": 10,632-13,378' (Neocomian)

The "Pebble Shale" of Lower Cretaceous Neocomian (AWA F-12 and F-13) was encountered at 10,632' and persists to 13,378', where Jurassic age sediments were encountered.

Interval 10,632-10,902'

The "Pebble Shale" is predominantly black to charcoal gray, and contains a great deal of organic "trash" including fish remains. The name "Pebble Shale" is derived from the presence of quartz and chert "pebbles" floating within the shale. In this respect, the section from 10,632' to 10,902' is typical "Pebble Shale", containing fine grained, polished and rounded quartz grains and occasional chert fragments. The section appears to be normally pressured.

Interval 10,902-11,460'

At 10,902', a sandstone was penetrated which has no apparent equivalent (at least with respect to age-dating) with other "Pebble Shale" sections on the National Petroleum Reserve in Alaska. In fact, the sandstone from 10,902-11,460' was at first believed to be equivalent to the basal Cretaceous unconformity sandstone, but subsequent paleontological dating has indicated that the sandstone is unrelated to any unconformity and is, in fact, of a younger Neocomian age. If the paleontological dating is correct, a distinct depositional change has occurred within the "Pebble Shale" in the vicinity of the Tunalik well.

The sandstone zone which occurs at 10,902' and continues to 11,460' consists predominantly of light gray sandstone having very fine to medium quartz grains with common altered feldspar grains, rare green glauconite pellets, mica flakes and black ferromagnesian minerals. The sands are tightly cemented with silica, and porosity is generally very low. Numerous carbonaceous laminations and inclusions occur within these sands. Abundant mica (Muscovite) flakes occur within these laminae.

Interbedded with these sands are thin, well indurated, dark gray-brown to black bentonitic shales, which contain abundant minute mica flakes and pyrite nodules. These shales grade vertically into siltstone, and thence to sandstone. Numerous light gray-brown laminations and lenses occur throughout the shales. An increase in the number of shale beds occurs towards the base. The lower part of the section is transitional toward the base and grades into a lower unit of the "Pebble Shale" (AWA F-13 and F-14).

Only minor gas shows were recorded on the gas analyzer through this interval. Log analysis indicates porosities are very low, generally less than 10%.

Interval 11,460-12,270'

A gradual return to deeper marine conditions typifies this interval, resulting in a transition to cyclical sequences of predominantly dark gray-brown to black shale similar to those described above and continuing sandstone laminations and lenses. Thin interbeds of sandstone and siltstone are scattered throughout this interval. The various lithologies are gradational between the sands, silts and shales. Abundant carbonaceous material occurs throughout this interval in the form of laminae and inclusions.

Only minor amounts of methane gas were recorded on the gas analyzer through this interval.

Interval 12,270-12,606'

A gradual increase in sandstone content occurs in this interval which probably represents a "stillstand" or minor regression. These sands, which are interbedded with shales similar to those described above, are tan to light gray-brown in color, argillaceous in part, becoming cleaner toward the base. The sand is composed of very fine to fine quartz grains with rare ferromagnesian minerals, which are tightly cemented with silica except in the lowermost 8 feet. From 12,549-12,557', the sand becomes loosely cemented and exhibits fair to poor intergranular porosity with finely disseminated, black, tarry residue within the pore space. No fluorescence or cut was observed from this residual oil. Only minor amounts of gas were recorded on the gas analyzer in the tight section of this zone; however, upon circulating out the drilling break associated with the porous sand, total gas increased from a background of 350 units to 1,250 units. This gas was not allowed to peak because the well began to flow, which necessitated closing the Hydril before "bottoms up" was attained. Only methane was measured on the chromatograph.

Considerable time was spent in attempting to kill the gas "kick" from this sand, which was eventually depleted or damaged to the extent that it was not capable of further production. Barite invasion into the pore space during the "kill" operation is indicated from the density log where anamolous bulk densities were measured ranging from 2.70 to 3.10 gr/cc (Barite density = 4.5) within the zone 12,510-12,560'. The gradual diminishing of the gas and the presence of the bulk density anomaly both indicate that depletion of the reservoir and/or formation damage has occurred within the gas sandstone. Total thickness of the porous gas sand is 22 feet with porosity averaging from 10% to 20%. A maximum of 24% porosity in the top portion of the sandstone was calculated from the sonic log.

Interval 12,606-13,378'

A transgressive sequence of medium to dark gray-brown, fissile, silty shale deposited in a middle to outer neritic marine environment occurs at 12,606'. This shale prevails to 12,775' where it grades into a transitional sequence of interbedded siltstone, shale and sandstone which continues to 12,958'. The sandstone within this interval is brown to dark gray, very argillaceous to silty, very fine grained, well indurated, very slightly calcareous, generally siliceous cement, and with nil to very poor intergranular porosity. These sands are extremely thin, do not exceed 7' in thickness, and grade into siltstone, which is dark gray-brown, very argillaceous to sandy, siliceous, and well indurated. The siltstone grades into shale similar to the overlying shale. Total gas measured throughout the sandy portion of this interval ranged from 150 to 600 units of methane.

Paleontologic data collected from this interval indicates a Neocomian (AWA F-13 to F-14) age.

JURASSIC

Kingak Formation: 13,378-14,263'

The Kingak Formation was deposited in a bathyal to outer neritic environment. The Kingak from 13,378' to 13,672' consists of dark gray to black, organic shale, fissile to platy, micromicaceous, pyritic, silty, with thin zones of siltstone scattered throughout. From 13,672' to 13,953', siltstone content within the Kingak decreases markedly. Numerous ironstone concretions occur throughout the lower interval.

From 13,672' to 13,953', a gradual increase in background gas ranging from 20 units to 120 units occurs, which is probably attributable to over-pressuring.

Paleo data from AWA indicates the age of the above interval to be Late Jurassic undifferentiated.

The part of the Kingak Formation below 13,953' is very similar lithologically to the above interval and was deposited in a bathyal environment. Lithology within the section is dark gray to black organic shale, which is fissile to splintery, micromicaceous, pyritic, contains ironstone concretions, and is silty with thin beds of siltstone, which is dark brown and very argillaceous. Paleo data from this interval indicates a probable age of Late Jurassic (AWA F-16) from 13,590-14,040' and probable Early Jurassic (AWA F-18) from 14,040' to 14,250'.

A marked increase in background gas, which varied from 200 to 450 units at the top of this zone continued to 14,351'. The mud weight was increased at that point from 16.6 lb./gal. to 17.0 lb./gal., which resulted in attenuation of the gas in the mud. The increase in background gas is probably the result of overpressuring within this shale interval.

TRIASSIC

Sag River Sandstone: 14,263-14,520'

The top of the Sag River Sandstone was chosen from the electric log to approximate the top of the Triassic as determined by paleontological analysis (paleo top about 14,250'), although actual sandstone development was not encountered before 14,350'. Samples obtained while drilling the Sag River sequence were extremely poor due to the large volume of "sloughing" overpressured Kingak shale directly overlying the Sag River; however, traces were noted of siltstone, which was brown, very argillaceous and pyritic, with large pellets of glauconite. The siltstone was interbedded with very dark gray shale, well indurated and brittle, silty in part, with common pyritized fossil casts and inclusions, and containing rare microfossils. These siltstones and shales are thought to represent the Sag River in the Tunalik area. The deposition of these finer clastics within this portion of the basin indicates a deeper open marine environment.

No shows of oil or gas were encountered in the Sag River sand.

Paleo dating from this interval indicates an age of Triassic (AWA F-19).

Shublik Formation: 14,520-14,819'

The Shublik Formation, which was deposited in a middle neritic to open marine environment, underlies the Sag River. The Shublik consists predominantly of shale, very dark gray, silty, pyritic, micromicaceous, very calcareous, with thin interbedded limestone, medium to dark gray, calcilutitic, argillaceous, chalky, silty, well indurated, finely laminated, with numerous shell fragments.

The shale zones within the Shublik in the interval from 14,630' to 14,819' are overpressured. A marked increase in gas occurs at 14,630', where background gas increased from an average of 100 units to 600 units. Connection gas increased from 110 units to a high of 2,520 units at 14,720'. Mud weight was increased from 17.4 lb./gal. to 18.0 lb./gal. to attenuate the gas in the mud. At this point, the decision was made to set casing. Seven and five-eighths inch casing was set at 14,719'.

Additional overpressured Shublik shale and limestone zones similar to the above were drilled from the casing shoe to the top of the Sadlerochit Group at a depth of 14,819'.

Paleo dating from this interval indicates an age of Triassic (AWA F-19).

TRIASSIC-PERMIAN

Sadlerochit Group: 14,819-17,100'

Ivishak Formation: 14,819-15,560'

The Ivishak Formation of the Sadlerochit Group, which occurs as a prodelta deposit in a marginal marine environment, underlies the Shublik. The Ivishak is composed of a sequence of very fine, to medium, to coarse grained, slightly calcareous sandstone, with finely disseminated pyrite and mica. Interbedded with this sandstone are thin beds of gray siltstone and dark gray to black, silty shale, which contains finely disseminated mica and pyrite nodules. This pro-delta sequence prevails to 15,160'. From 15,160' to 15,470', the section is composed predominantly of siltstone, which is medium gray, sandy, finely micaceous, argillaceous, calcareous, finely pyritic, with interbedded black, micaceous, silty shale. The interval from 15,470' to 15,560' is composed of a near-shore marine sandstone, gray, very fine-grained to silty, calcareous, micaceous, glauconitic, with interbedded black shale as in the previous interval.

The sandstones within the Ivishak interval exhibit generally very poor porosity and are not of reservoir quality.

No shows of oil or gas were noted in the Ivishak and background gas of only 20 to 30 units was recorded on the gas detector.

Kavik Shale Member: 15,560-16,890'

The near-shore marine Kavik Shale Member of the Ivishak Formation consists of an interbedded sequence of siltstone: light gray, sandy in part, calcareous, finely laminated, and shale: black, platy, firm, with common, finely disseminated mica. This lithology continues to 16,780' where thin sandstones occur interbedded with siltstones and shales. These thin sandstones are light to mottled dark gray, very fine grained to silty, and quartzitic with quartz overgrowths, finely disseminated pyrite and mica, rare pale green glauconite, and nil porosity.

No oil and gas shows were noted in the Kavik interval.

Echooka Formation: 16,890-17,100'

The Echooka Formation was encountered at 16,890'. The sequence of rocks representing the Echooka was probably deposited in a marginal marine environment. Lithology from the top of the Echooka to 17,100' is predominantly siltstone: dark gray, sandy, glauconitic, micromicaceous, with thin beds of dark gray shale and quartzitic siltstones near the base of the unit. Reservoir quality rocks are not present in the Echooka and no oil and gas shows were observed.

Sparse faunal data from the Echooka indicates that this zone is Permian in age.

PERMIAN-PENNSYLVANIAN

Lisburne Group: 17,100-20,335' (Gross)

Interval 17,100-17,570' ("Upper Lisburne")

The top of the Lisburne Group is marked by a lithologic change from clastics to a mottled tan to gray limestone. The limestone is finely crystalline, very siliceous, fossiliferous, with common chert inclusions and interbedded siltstone as in the overlying Echooka. No potential reservoir rocks were noted from the interval.

The interval has been dated by Anderson, Warren & Associates, Inc. as Early Permian.

Volcanics: 17,570-18,353'

A thick (783') interval of extrusive volcanic rocks was encountered at 17,570'. This zone is indicated to be amygdaloidal basalt from mineral composition. This basalt interval is medium to dark gray-green and is composed of very fine to fine-grained feldspar, which is in places altered to kaolin; rounded blebs of chlorite, which are altered to pale green clay in part. Rounded gas vesicles are filled with calcite. Traces of red hematite occur throughout this interval. Thin zones of volcanic tuff occur toward the base which is pale blue-gray, very fine grained to

sublithographic, very hard and brittle, and with inclusions of minute glass shards. Overall, these volcanics have been subjected to intense weathering, which is characterized by the alteration of the feldspar and chlorite into clay.

No oil or gas shows were observed in this volcanic interval.

Paleontological data is totally lacking in this zone and age dating is derived from stratigraphic position only.

Interval 18,353-20,335' ("Lower Lisburne")

Underlying the thick section of volcanic rocks are the shallow marine, shelf carbonates of the Lisburne group. This lower portion of the Lisburne occurs at 18,353' and continues to the total depth of 20,335'. The lithology of the Lisburne is largely limestone composed of allochemical and biogenic constituents such as crinoids, bryozoans, oolites, pellets and intraclasts which are cemented with spar calcite or calcilutitic cement.

From the top at 18,353' to 18,596', the Lisburne is composed of tan to mottled brown limestone, intrabiocalcarenitic (composed of crinoids, sponge spicules, bryozoans, forams), cemented with spar calcite and calcilutitic cement, and containing sporadic gray chert inclusions and rare calcite fracture filling. This rock becomes argillaceous and dark gray in color, in part. Interbedded with this calcarenitic limestone are zones of silty, argillaceous calcilutite, dark brown to black in color, siliceous, sublithographic, flaky, vitreous, hard and brittle, with abundant minute black phosphate pellets, and grading to tan, chalky calcilutite in part.

No apparent porosity or permeability occurs in the rocks through this section.

From 18,596' to 19,745', the Lisburne section becomes predominantly calcilutite similar to that encountered in the above section. Common chert inclusions and varying amounts of silt, grading to siltstone, occur throughout this interval. Abundant calcite-filled fractures are also present throughout. An increase in thin zones of biocalcarenitic limestone, as previously described, occurs at 19,046' and prevails to 19,745'. No porosity was observed in this portion of the Lisburne.

Lithology from 19,745' to total depth of 20,335' is predominantly limestone, calcarenitic, mottled tan to gray-brown, composed of fossil debris (fauna similar to that described above) in a spar calcite matrix, rare black phosphate pellets, chert and pyrite inclusions, moderately well indurated. Zones of calcilutite similar to the above occurs interbedded with the calcarenite.

No observed porosity occurred through this part of the Lisburne section. No oil or gas shows were observed in the Lisburne interval.

Paleontological data indicates that the lower Lisburne in the Tunalik area is Early Permian to 19,050' and Middle to Late Pennsylvanian from 19,050' to 20,335' (Total Depth).

CONCLUSIONS

The Tunalik Test Well No. 1 was completely evaluated as far as potentially productive zones were concerned, with one exception. That exception was the sandstone at 12,508' to 12,603', which caused the well to "kick" from over-pressured gas. The primary reason why this sandstone was not satisfactorily evaluated was because of the inability to obtain either reliable log analysis (see "barite plugging" explanation in Appendix C by Armour Kane) or drill-stem test/wireline test pressure or fluid recovery data. This sandstone, which was only 40 feet in net thickness, and was interrupted by shale beds, would hardly be commercial at this depth, regardless of porosity or fluid content.

Probably, the most promising development to have come from drilling Tunalik was the presence of a thick sandstone within the "Pebble" Shale" (approximately 550'). This sandstone, although very tight with very poor porosity and permeability, and with only a minor gas show at the top, was, nevertheless, a promising potential reservoir because of its relatively clean nature (the low porosity was due mostly to secondary calcareous and siliceous cement) and its gross thickness. Perhaps this sandstone could be investigated at another location where conditions could be predicted to be more favorable for porosity development.

Of interest, in an academic sense, was the volcanic section encountered within the Lisburne carbonates. Volcanic activity, probably contributed to the silification, and subsequent porosity decrease, in the Lisburne carbonates.

PERTINENT DATA AND APPENDICES

Appendix		Page
A.	Summary Pertinent Data, Operations and Analysis	A-1-4
B.	Drill Cuttings and Core Descriptions	B-1-57
C.	Log Analysis	
	Report of February 3, 1979	C-1-2
	Report of June 6, 1979	C-3
	Report of August 6, 1979	C-4
	Report of November 13, 1979	C-5
	Report of January 3, 1980	C-6
D.	Logging Reports	
	Report of January 24, 25, 26, 27, 1979	D-1
	Report of May 31, June 1, 1979	D-2
	Report of July 25-31, 1979	D-3
	Report of November 3-7, 1979	D-4
	Report of December 22-27, 1979	D-5
E.	Core Analysis	
	Interval 5558-5561'	E-1
F.	Listing of Other Available Data	F-1
	Micropaleontology Report	
	Drilling History	
	Source of Other Geological & Well Data	

SUMMARY PERTINENT DATA, OPERATIONS AND ANALYSIS

WELL NAME:	Tunalik Test Well No. 1
API NO.:	50-301-20001
OPERATOR:	Husky Oil NPR Operations, Inc.
LOCATION:	2403' FSL; 1488' FEL, protracted Section 20, T10N, R36W, Umiat Meridian North Slope Borough, Alaska
COORDINATES:	Latitude: 70°12'21.453" North Longitude: 161°04'09.159" West X = 815,450.76 Y = 5,925,750.58 Zone 7
ELEVATION:	109' KB; 85' Ground (Pad)
DATE SPUDDED:	November 10, 1978
TOTAL DEPTH:	20,335' Driller 20,329' Wireline (BHC)
DATE TOTAL DEPTH REACHED:	December 22, 1979
FORMATION AT TOTAL DEPTH:	Lisburne Group
DATE RIG RELEASED:	January 7, 1980
STATUS:	Plugged and abandoned
CASING:	42" Conductor @ 106' 30" Conductor @ 516' 20" Conductor @ 2,584' 13-3/8" @ 8,298' 9-5/8" @ 12,385' 7-5/8" Liner @ 12,029-14,719'

HYDROCARBON SHOWS:

5,032- 5,422'	Nanushuk: trace to 2,090 units bright yellow speckled fluorescence, yellow crushed cut fluorescence. Lithology: very fine grained tight sandstone interbedded with shales.
6,096- 6,110'	Nanushuk 700 units gas in sandstone; fair porosity, no sample show.

7,966- 7,971'	Torok Sandstone, 4' net, 15% porosity, 57% S_w (gas and water).
8,106- 8,110'	Torok Sandstone, 4' net, 15% porosity, 42% S_w (gas).
8,110- 8,113'	Torok Sandstone, 3' net, 9% porosity, 74% S_w (gas and water).
11,440-11,450'	Sandstone, 10% porosity, S_w 50-55%, NOSCF, possible gas zone.
11,517-11,519'	Sandstone, 12% porosity, S_w 50-55% possible gas zone.
12,549-12,557'	Sandstone, poor to fair porosity with scattered black tarry residue, had gas kick, 1,250 units gas before closing Hydril, all methane.

OPERATIONS AND ANALYSIS PERFORMED:

Logging Record:		
Open hole	DIL/DLL/GR/SP	111-20,303'
	BHCS/GR/TTI	111-20,323'
	FDC/GR/CAL/RR	2,583-18,278'
	CNL/FDC/CAI/GR0	2,583-18,278'
	HDT-Dipmeter	2,584-18,271'
	HRT-Temperature Log	
	Run No. 1	100-15,485'
	Run No. 2	75-14,772'
	Velocity Survey	172-20,332'
	Mud Log	100-20,335'
	Temperature Log (Mud)	100-20,335'
	Dc Exponent	100-20,335'
	Pressure Evaluation	100-20,335'
	IDEL Log	100-20,335'
	$CaC0_3$ Log	14,250-20,300'
Cased Hole	CBL/VDL/CCL/GR	5,200-14,633'
Computed Logs	CYBERLOOK	12,390-14,630'
	SARABAND	2,600-12,370'
	Geogram Survey	Surface-20,211'
	Stratigraphic Dipmeter	10,699-11,552'
Other Wireline Logs	RFT (Repeat Formation Tester)	12,600'*

* See Test Data Listing

SIDEWALL CORES:

Run No. 1	3319-8112', 45 shot*, 43 recovered.
Run No. 2	8450-12,364', 45 shot*, 13 recovered.

* Some depths were double shot to sample for Paleo, Lithology and/or reservoir analysis.

CONVENTIONAL CORES:

No.	Interval	Recovery	Formation/Unit
1	3,280- 3,308'	26.0'	Nanushuk
2	3,820- 3,830'	9.0'	Nanushuk
3	5,552- 5,562'	9.5'	Nanushuk
4	6,504- 6,514'	7.25'	Torok
5	7,870- 7,880'	10.0'	Torok
6	8,782- 8,810	28.0'	Torok
7	10,472-10,502'	30.0'	Torok
8	10,671-10,702'	31.0'	"Pebble Shale"
9	10,910-10,940'	30.0'	"Pebble Shale" sandstone
10	11,672-11,694.5'	22.5'	"Pebble Shale"
11	12,567-12,597'	30.0'	"Pebble Shale"
12	14,846-14,856'	9.0'	Ivishak
13	15,408-15,438'	30.0'	Ivishak
14	16,236-16,261'	25.0'	Kavik
15	16,929-16,959'	21.0'	Echooka
16	17,134-17,149'	11.5'	Lisburne
17	17,255-17,286'	28.0'	Lisburne
18	17,858-17,888'	30.0'	Volcanics

CORE ANALYSIS:

Date	Interval	Core No.	Sample No.
6-6-79	5558-5561 (Nanushuk)	3	1-4

TESTS:

Interval	Description
12,522-12,585'	Total nine (9) wireline tests (RFT) attempted in a sandstone interval within the "Pebble Shale". All tests were misruns. No seal obtained, no bottom hole pressures recorded, no fluid samples collected.

FLUID ANALYSIS: None

WELLSITE GEOLOGISTS: G. Legg
D. Fenex
R. Nelson

WELL LOG ANALYST:	Armour Kane
DRILLING CONTRACTOR:	Parker Drilling Company, Rig 95
MUDLOGGERS:	Borst & Giddens Logging Services, Inc. (The Analysts)
BIOSTRATIGRAPHIC ANALYSIS:	Anderson, Warren & Associates, Inc.
SPECIAL STUDIES & ANALYSIS:	None

TUNALIK NO. 1
DRILL CUTTINGS AND CORE DESCRIPTIONS
BY

G. LEGG	-	106- 5,680'
		8,301-10,940'
		12,557-14,290'
		16,959-17,560'
		18,680-20,030'
D. FENEX	-	5,680- 8,301'
		10,940-12,557'
		14,726-16,959'
		17,560-18,680'
		20,030-20,335'
R. NELSON	-	14,290-14,726'

DEPTH DRILLED (FEET BELOW KELLY BUSHING)	
0 - 106	No samples recovered.
106 - 120	Coal: subbituminous, very impure with abundant argillaceous material, occasional intraclasts of brown impure chert and with soluble clay.
120 - 150	Predominantly soluble clay with Mudstone: tan, moderately indurated, and minor Sandstone: mottled "salt and pepper" from medium grained clasts of coal and carbonaceous material, fine to medium grained, very argillaceous, poorly indurated, poor to nil porosity.
150 - 180	Clay: soft, soluble, and Claystone: tan to brown, with Dolomite: gray, argillaceous, microcrystalline, dense, blocky.
180 - 210	Clay and Mudstone: as above, with Coal: argillaceous, impure, and minor Dolomite: as above.
210 - 240	Dolomite: tan to brown, blocky, dense, with clay, and Claystone: as above, and with minor Coal: as above.
240 - 270	Sandstone: mostly loose grains, fine grained with some medium grained, subangular to subrounded, frosted quartz, weakly cemented with clay, with Dolomite: becoming very calcareous, grading to Limestone: tan to brown, dense, hard, blocky, with Clay and Coal: as above.

270 -	300	Limestone: dolomitic, tan to brown, blocky, dense, microcrystalline, silty and argillaceous, nil porosity, with Clay and minor Coal: as above.
300 -	330	Coal: mostly impure with high content of argillaceous material, with Clay: as above, and with minor Limestone: as above.
330 -	360	Limestone: mostly as above, but becoming very argillaceous, less blocky, grading to marl, with Coal and Clay: as above.
360 -	390	Coal: black, subbituminous, vitreous, higher grade, no longer impure, with minor Clay: as above.
390 -	450	Coal, Clay and Limestone: as above, with Sandstone: gray, occasionally tan, very fine grained, very calcareous, hard, nil visible porosity.
450 -	480	Limestone: dolomitic, tan to brown and red-brown, some appears to be sideritic (red-brown), blocky, dense, hard, occasionally angular and splintery, microcrystalline, frequent calcite crystals along vug or fracture faces, nil visible porosity.
480 -	520	Limestone, Coal and Clay: as above, with minor Sandstone: gray, very fine grained, very argillaceous and silty.
520 -	540	No samples (cement).
540 -	560	Coal: as above, with minor Limestone: dolomitic, gray to brown, microcrystalline, dense, slightly argillaceous, nil porosity.
560 -	650	Coal and Limestone: as above, with trace of sandstone, loose, frosted quartz grains, medium grained, subangular to subrounded.
650 -	690	Limestone: dolomitic, tan, blocky, silty, slightly lithographic in part, nil porosity, with Coal: as above, and with minor Sandstone: white to gray, very silty, grading to Siltstone: very fine grained calcareous, occasional specks of carbonaceous material, poor to nil porosity, no show.
690 -	710	Coal: becoming slightly earthy and impure.
710 -	770	Coal: as above, with Limestone: tan to gray to brown, argillaceous, silty, occasional thin laminae of carbonaceous material, nil porosity, with Sandstone

	grading to Siltstone: white to gray to brown, very fine grained to silt, calcareous, occasional "salt and pepper" appearance, with carbonaceous material, hard, nil visible porosity.
770 - 860	Sandstone: white to gray to tan, grading in part to Siltstone, very fine grained to fine grained, carbonaceous in part, argillaceous in part, poor intergranular porosity, with minor Coal and Limestone: as above.
860 - 890	Coal: as above, but much more impure, argillaceous, with Limestone: mostly as above, but very argillaceous and silty, and with Sandstone: mostly as above, but becoming more argillaceous and silty, very carbonaceous, grading in part to coal.
890 - 1040	Coal and Sandstone: as above, with Limestone: as above, grading to siltstone and sandstone, and with minor Clay: pale gray, soft.
1040 - 1100	Coal: black, vitreous, higher grade than above, interbedded with limestone, and minor Sandstone: as above.
1100 - 1130	Coal: as above, with Sandstone: as above, but more argillaceous and silty, essentially siltstone, with Limestone: as above, but very silty, grading to calcareous siltstone in part, marly.
1130 - 1160	Coal: becoming earthy in part.
1160 - 1190	Sandstone: as above, and Sandstone: loose grains, clear to frosted, fine grained to medium grained, subrounded, interbedded with coal, and with Limestone: as above.
1190 - 1250	Sandstone: as above, with Sandstone: gray to off-white, "salt and pepper" with specks of Coal: very fine grained to medium grained, poorly sorted, grades to Siltstone: gray-brown, calcareous, silty in part, with Limestone: dolomitic, mostly tan, microcrystalline.
1250 - 1280	Sandstone: as above, with Limestone: as above, but very dolomitic and argillaceous, inhibiting acid reaction initially.
1280 - 1310	Coal: black, vitreous, higher grade than above.

1310 - 1430	Sandstone: light tan to off-white, very fine grained, subangular to subrounded, very calcareous, occasional secondary quartz overgrowths on grains, some interstitial white clay, rarely carbonaceous, poor intergranular porosity.
1430 - 1460	Coal: mostly as above, but some very argillaceous and silty, grading to organic shale to siltstone, with Siltstone: very carbonaceous and argillaceous, grading to coal.
1460 - 1550	Sandstone: tan to off-white, very fine grained to fine grained, occasionally medium grained, poorly sorted, subangular to subrounded, abundant interstitial clay, poor to fair intergranular porosity, no show.
1550 - 1610	Sandstone: as above, but becoming poor to moderately indurated, poor to nil porosity, interbedded with Limestone and Coal: as above.
1610 - 1640	Sandstone: mostly as above, but some becoming carbonaceous, well indurated with Limestone: marly to very argillaceous.
1640 - 1670	Sandstone: off-white to gray, occasionally buff, very fine grained to fine grained, rare loose medium grained, poorly sorted, abundant carbonaceous material, fair intergranular porosity, no show.
1670 - 1700	Sandstone: as above, but abundant loose grains and small aggregates, very friable, fair to good porosity, no show.
1700 - 1730	Sandstone: as above, interbedded with Limestone and Coal: as above.
1730 - 1820	Sandstone: becoming more fine grained, moderately indurated, less friable, poor porosity, interbedded with Limestone and Coal: as above.
1820 - 1850	Coal: black, vitreous, hard, splintery in part.
1850 - 1910	Dolomite: very calcareous, grading to very dolomitic Limestone: tan to brown, hard, dense, microcrystalline, nil porosity, with Sandstone: gray to off-white, very fine grained, silty, subangular to subrounded, slightly "salt and pepper" with carbonaceous material, well indurated, poor to nil porosity, no show.
1910 - 1970	Sandstone: mostly as above, but becoming more silty and argillaceous, some white clay in matrix.

1970 - 2060	Dolomite: tan to buff, brown and gray, typically calcareous, often earthy, microcrystalline, with Sandstone and Coal: as above.
2060 - 2090	Sandstone: clear to off-white to tan, very fine grained to fine grained, often loose, very friable, slightly carbonaceous, subangular to subrounded, fair intergranular porosity, no show, with interbedded Dolomite and Coal: as above.
2090 - 2150	Sandstone: as above, but slightly more indurated, interbedded with Dolomite and Coal: as above.
2150 - 2180	Dolomite: gradational to very calcareous sandstone and siltstone, with sandstone, gradational to siltstone and dolomite.
2180 - 2210	Sandstone: tan to very pale gray, very fine grained to fine grained, carbonaceous inclusions, friable, white clay matrix, fair intergranular porosity, no show.
2210 - 2270	Coal: as above, but becoming impure and earthy in part, with Sandstone and Dolomite: as above.
2270 - 2360	Sandstone: as above, but better cemented, more well indurated, interbedded with Dolomite and Coal: as above.
2360 - 2390	Dolomite: mostly as above, but some appears to be siliceous, very well indurated.
2390 - 2420	Sandstone: as above, and abundant Sandstone: loose grains, frosted, fine grained, some medium grained, subangular to subrounded, friable, calcareous and clay cement, poor to fair intergranular porosity, no show.
2420 - 2450	Dolomite: tan to brown, microcrystalline, hard, dense, partly siliceous, with Sandstone: as above, but fine grained to medium grained, very well cemented, hard, calcareous, becoming siltstone in part.
2450 - 2510	Dolomite: as above, siliceous for most part, some becoming very calcareous, grading to limestone, with Sandstone: as above.
2510 - 2540	Coal: black, vitreous, splintery, appears to be less dense than previous coals, interbedded with Dolomite and Sandstone: as above.
2540 - 2600	Claystone: gray, soft in part, very finely micaceous, silty, grading to siltstone with Coal, Dolomite and Sandstone: as above.

2600 - 2620	Limestone: very dolomitic, grading to Dolomite: tan to brown, siliceous, microcrystalline, nil porosity.
2620 - 2630	Sandstone: gray to off-white, occasionally buff, subangular to subrounded, silty, argillaceous, carbonaceous, occasional inclusions of white clay in matrix, calcareous cement, poor to nil porosity, no show.
2630 - 2640	Sandstone and Siltstone: gray to brown, very fine grained to silt, argillaceous, occasional "salt and pepper" from carbonaceous particles, well indurated, poor to nil porosity, no show, with Limestone: tan, microcrystalline, earthy, nil porosity.
2640 - 2670	Lithology as above, except sandstone becomes mostly siltstone.
2670 - 2700	Shale and claystone grading to siltstone, with siltstone grading to claystone and shale, and with Coal: black, vitreous, subconchoidal to conchoidal fracture.
2700 - 2730	Shale and Claystone: light to medium gray, lumpy to subfissile, micromicaceous with Siltstone: gray to brown, argillaceous, with some free frosted quartz grains, medium grained to coarse grained.
2730 - 2760	Shale: becoming mostly medium to dark gray, silty, carbonaceous, micromicaceous, with Siltstone and some Sandstone: light gray, very fine grained, silty, argillaceous, with coal, becoming earthy and impure, argillaceous.
2760 - 2790	Siltstone grading to sandstone in part.
2790 - 2850	Sandstone: white to light gray, very fine grained to fine grained, silty and argillaceous, calcareous, feldspars, recrystallized quartz faces on grains, apparently siliceous, very well indurated, poor to nil porosity, grades to siltstone in part.
2850 - 2880	Sandstone: white to light gray, very silty, grading to Siltstone: very fine grained to silt, tight, abundant interstitial white clay, poor to nil porosity, no show.
2880 - 2910	Sandstone: becoming more fine grained, slightly friable, "salt and pepper" in part, abundant white clay filling, fair intergranular porosity, no show.
2910 - 2940	Claystone and shale, grading to siltstone and minor sandstone.

2940 - 3030	Siltstone: gray, occasionally sandy, with claystone, and some Shale: gray, subfissile in part, silty.
3030 - 3060	Shale: light gray to gray, silty, grades to claystone, with Sandstone: very fine grained to fine grained, clay filled matrix, occasional "salt and pepper", poor to nil porosity, with a trace of Dolomite: tan, microcrystalline, appears to be siliceous, calcareous in part, grades to limestone, nil porosity.
3060 - 3120	Shale and Claystone: medium gray, calcareous.
3120 - 3150	Sandstone, siltstone, shale and claystone appear to be gradational, becoming very calcareous.
3150 - 3210	Siltstone: sandy with minor sandstone, gradational with shale and dolomite, and with Shale: very calcareous and silty, and with dolomite, becoming very argillaceous, marly grading to shale.
3210 - 3240	Siltstone and Sandstone: as above, but with sandstone minor.
3240 - 3280	Shale: mostly very silty, lumpy, occasionally subfissile, grades to Siltstone: gray, very argillaceous, grades to shale, with only trace of Sandstone: white, very fine grained to fine grained, white clay filling, poor to nil porosity.
3280 - 3308	Core No. 1, Cut 28', Recovered 26'

3280.0-3306.0' (26.0')	Interbedded Shale: medium gray to dark gray, depending on organic and carbonaceous content, frequent plant and stem impressions, sometimes coaly with two feet of coal, and with Sandstone: gray, very fine grained to silt, subangular to subrounded, grading to Siltstone: very argillaceous, very slightly calcareous, occasional "salt and pepper" from carbonaceous inclusions, some crossbedding 3289.5-3292' (15-20°), bedding essentially horizontal.
3306.0-3308.0' (2.0')	No recovery.

3308 - 3340 Shale: [illegible] with mostly siltstone and only occasional sandstone.

45.

3340 - 3420	Shale: as above, but some becoming darker, more carbonaceous, with Siltstone and Sandstone: white to gray, abundant clay filling, very fine grained, subangular to subrounded, well indurated, "salt and pepper", poor intergranular porosity, no show.
3420 - 3480	Sandstone: white to off-white, some clear, fine grained, subangular to subrounded, friable, some loose grains, some white clay filling, fair porosity, no show, with trace of Dolomite: tan to brown, microcrystalline, dense, hard, and with Shale: as above.
3480 - 3500	Shale: as above, but becoming very silty, grading to siltstone.
3500 - 3540	Dolomite: as above, probably from concretions, with Coal: as above with some becoming impure, earthy.
3540 - 3560	Shale: becoming more dark gray, organic, carbonaceous, grading to coal.
3560 - 3580	Shale: as above, with Siltstone: very argillaceous, grading to shale.
3580 - 3600	Shale: as above, but much less organic with Siltstone and some Sandstone: white to off-white to light gray, very fine grained, well indurated, siliceous in part, argillaceous, poor to nil porosity, no show.
3600 - 3660	Shale: becoming light to medium gray, silty in part, lumpy to subfissile.
3660 - 3700	Sandstone: becoming slightly friable, very fine grained to silt, poor to fair porosity, no show, with Shale: as above.
3700 - 3720	Sandstone: becoming mostly siltstone, with Shale: as above.
3720 - 3740	Sandstone: white to off-white, very fine grained to fine grained, "salt and pepper" from carbonaceous particles, white clay matrix, slightly friable, fair intergranular porosity, no show, with Shale: as above, but becoming slightly bentonitic in part.
3740 - 3760	Sandstone: mostly as above, but becoming silty in part.
3760 - 3780	Sandstone: now becoming essentially kaolinitic clay in part, with floating sand grains, very fine grained to fine grained, nil porosity with sandstone, and Shale: as above.

3780 - 3800	Dolomite: brown, microcrystalline, dense, hard, with Sandstone and Shale: as above.
3800 - 3820	Sandstone: becoming very silty, grading to siltstone, tight, with Shale: as above.
3820 - 3830	Core No. 2, Cut 10', Recovered 9'
	3820.0-3829.0' (9.0') Shale: light gray to medium gray, very finely micaceous, subfissile to fissile, slightly calcareous, moderately indurated, becoming slightly silty in part, alternating from micaceous to nonmicaceous and from slightly silty to non-silty.
	3829.0-3830.0' (1.0') No recovery.
3830 - 3880	Sandstone: becoming more silty, essentially siltstone, with Shale: as above.
3880 - 3940	Shale: medium to dark gray, becoming slightly organic in part.
3940 - 3980	Sandstone: white with some clear grains, very fine grained to fine grained, white clay matrix, friable, poor to fair porosity, no show, with Shale: as above.
3980 - 4000	Shale: as above with claystone, slightly bentonitic, swells and spalls.
4000 - 4020	Sandstone: white with some clear grains, occasionally carbonaceous and with shale inclusions, fine grained to very fine grained, subangular to subrounded, moderate sorting, white clay matrix, but less than above, friable to occasionally loose, fair intergranular porosity, no show.
4020 - 4040	Shale: as above, but some very silty, grading to siltstone, becoming slightly carbonaceous in part, with Sandstone: as above, with some Siltstone: gray, very shaly, essentially shale.
4040 - 4060	Shale: as above, but less carbonaceous, more clayey with siltstone, and rare Sandstone: as above.
4060 - 4100	Shale now becoming claystone, readily loses shape and dissolves in water.

4100 - 4120	Sandstone: white to off-white, slight dark mottling, very fine grained to fine grained, subangular to subrounded, very calcareous with some matrix of white clay and some chalky limestone, very friable, poor to fair intergranular porosity, restricted by chalk and clay, very slight trace of fluorescence (2 pieces), very faint cut.
4120 - 4140	Sandstone: mostly as above, but becoming slightly silty, with trace of Siderite: mottled brown to black, resinous.
4140 - 4160	Sandstone: mostly as above, but becoming very silty, with Shale: as above.
4160 - 4180	Sandstone: white to gray, very fine grained, occasional carbonaceous laminae, silty, white clay matrix, slightly calcareous, poor porosity, no show.
4180 - 4220	Shale: as above, but becoming mostly carbonaceous.
4220 - 4240	Sandstone: as above with abundant fine grained coal particles, some apparent feldspar, poor to fair porosity, no show, with Shale: as above.
4240 - 4320	Sandstone: becoming silty, grading to siltstone, with Shale: as above.
4320 - 4340	Shale again becoming clayey, grading to claystone, spalls and slumps in water.
4340 - 4400	Shale: as above, but less clayey, slightly more silty.
4400 - 4420	Shale: as above, very slightly organic in part.
4420 - 4440	Sandstone: mostly clear, very fine grained, very friable, fair intergranular porosity, no show.
4440 - 4480	Sandstone: gray, mottled black with carbonaceous inclusions, occasional pink to orange from probable feldspar, fine grained, subrounded to subangular, heavy clay matrix, very heavy calcareous cement, poor intergranular porosity, no show, with Shale: as above.
4480 - 4500	Sandstone: clear with white matrix, inclusions of gray shale, black carbonaceous material and rust colored hematitic material, probably altered feldspar, calcareous cement, fine grained to very fine grained, very friable, fair intergranular porosity, no show.

4500 - 4520	Sandstone: as above, with abundant feldspar, becoming more silty to shaly, less porosity, with Shale: as above.
4520 - 4540	Sandstone, grading in part to siltstone.
4540 - 4590	Sandstone: becoming very dirty, shaly, poor porosity, no show, with Shale: as above.
4590 - 4610	Shale: as above, but becoming very carbonaceous to coaly in part, with Coal: black, earthy, silty in part.
4610 - 4630	Siltstone: tan, very calcareous, soft and mushy, slight dull yellow fluorescence, slight cut.
4630 - 4730	Sandstone: white, gray and with occasional clear grains in white matrix, very heavy white clay and calcareous matrix, very fine grained to fine grained, friable, subangular to subrounded, poor to fair intergranular porosity, some dull yellow fluorescence, nil stain or cut, probably mineral fluorescence from calcite in matrix, with Shale: as above.
4730 - 4740	Sandstone: clear to white with occasional rust red spots, fine grained to very fine grained, silty in part, calcareous, poor intergranular porosity, no show, with Shale: as above.
4740 - 4760	Sandstone: mostly as above, but becoming more silty to shaly, with Shale: as above.
4760 - 4780	Shale: as above, with trace of pyrite along bedding planes, with trace of Dolomite: tan to brown, microcrystalline, hard, dense.
4780 - 4820	Sandstone: as above, but slightly more well indurated, with Shale: as above.
4820 - 4830	Siltstone and Sandstone: very argillaceous, grading to silty shale.
4830 - 4840	Shale: becoming soft, clayey in part.
4840 - 4880	Shale: becoming very silty, grading in part to siltstone.
4880 - 4920	Sandstone: white to gray, very fine grained, silty, argillaceous, moderate to well indurated, calcareous cement, poor to nil porosity, no show, with trace of Dolomite: tan to brown, dense, hard, microcrystalline, and with Shale: as above.

eous, concnoidal fracture	4020 - 4020	Trace of Coal: black, vit high grade.
nse, microcrystalline, with	4930 - 4950	Dolomite: brown, hard, de Shale: as above.
th Siltstone: dark gray, to Shale: carbonaceous)	4950 - 4960	Sandstone: as above, wi very argillaceous, grading well indurated.
some thin carbonaceous and becoming slightly more coaly and carbonaceous	4960 - 4990	Siltstone: as above, with coaly laminae with shale carbonaceous) occasional laminae.
becoming gray to off-white nd, calcareous matrix, poon h Shale: as above.	4990 - 5010	Siltstone and Sandstone: to white, very heavy, clay to nil porosity, no show, wit
r Siltstone: becoming fine , with Shale: as above.	5010 - 5030	Increase in sandstone ove grained to very fine grained
white, very fine grained, abundant white clay and naceous shale inclusions, ntly friable in part, poor bright yellow fluorescence, g, with orange-rust colored y more friable, no show, ray to tan to brown, hard,	5030 - 5060	Sandstone: gray to off-w subangular to subrounded, calcareous matrix, carbo moderately indurated, slig intergranular porosity, 20% yellow cut only on crushing inclusions at 5040', slightl trace of Dolomite: light g dense, microcrystalline.
th trace of bright yellow y-yellow cut.	5060 - 5070	Sandstone: as above, wi fluorescence, very slow milk
10-20% having medium to very slight, very slow : as above, with some t.	5070 - 5080	Sandstone: as above with bright yellow fluorescence crushed cut, with Shale becoming soft, clayey in par
with very poor porosity, fluorescence, very slight above.	5080 - 5090	Sandstone: as above, but trace of medium yellow crushed cut, with Shale: as
trace of show as above,	5090 - 5100	Sandstone: as above with with Shale: as above.
becoming fine grained with well indurated, tight, very trace of fluorescence, with	5100 - 5110	Sandstone: as above, but some medium grained, more poor porosity, very slight Shale: as above.

50.

43

5110 - 5120	Sandstone: as above, but with no show.
5120 - 5130	Sandstone: becoming silty and argillaceous, no show, with Siltstone: light gray to gray to dark gray, carbonaceous, sandy, argillaceous, with Shale: as above.
5130 - 5140	Sandstone: becoming slightly more fine grained to medium grained, less silty, slightly friable, trace of bright yellow fluorescence, slight streaming bright yellow cut, good bright yellow residue, with Shale: as above, with a trace of pyrite.
5140 - 5160	Sandstone: as above, but only very slight trace of fluorescence, very slight crushed cut, with Shale: mostly as above, but some soft, soluble, clayey in part.
5160 - 5170	Sandstone: white to off-white, some clear grains, abundant feldspar and altered feldspar to clay, "salt and pepper" from carbonaceous and shale particles, fine to medium grained, subangular to subrounded, moderate to well indurated, poor porosity, trace of fluorescence, no cut, with Shale: as above.
5170 - 5180	Sandstone: white to clear with white matrix, black, carbonaceous and shale inclusions, fine grained to very fine grained, subangular to subrounded, friable, occasionally loose, poor to fair intergranular porosity, no show, with Shale: as above.
5180 - 5200	Sandstone: as above, but less friable, more well indurated, slightly less porous, no show, with Shale: as above.
5200 - 5220	Sandstone: becoming more silty to argillaceous, more well indurated, very slight trace of dull yellow fluorescence, very weak crushed cut, with Shale: as above.
5220 - 5270	Sandstone: mostly as above, with trace of medium yellow fluorescence, slight streaming cut, light yellow residue, with Shale: as above.
5270 - 5300	Sandstone: white to clear, mottled black with carbonaceous specks and shale particles, moderate white clay matrix, friable, occasionally loose, fair intergranular porosity, no show, with Shale: as above.

5300 - 5330	Sandstone: as above, with trace of bright yellow fluorescence, slight streaming milky yellow cut, bright yellow residue, with Shale: as above.
5330 - 5370	Shale: as above, but very silty in part, grading to siltstone.
5370 - 5380	Sandstone: grading to siltstone in part, trace of dull yellow fluorescence, slight crushed cut, with Shale: as above.
5380 - 5390	Sandstone: becoming even more silty, no show, with Shale: as above.
5390 - 5410	Shale: becoming gray to dark gray, silty, fissile to splintery, more well indurated.
5410 - 5450	Sandstone and siltstone, with siltstone becoming very hard, appears siliceous in part, with Shale: as above.
5450 - 5460	Sandstone: as above, with trace of dull yellow fluorescence, very weak cut, with Shale: as above.
5460 - 5480	Sandstone: as above, with trace of medium yellow fluorescence, very slight crushed cut, with Shale: as above.
5480 - 5520	Sandstone and siltstone, with Sandstone: light gray to dark gray, very fine grained to silt, argillaceous, "salt and pepper", very well indurated, appears siliceous, poor to nil porosity, no show, with Shale: as above, but mostly very silty, with trace of Dolomite: tan to brown, hard, dense, microcrystalline.
5520 - 5530	Sandstone: as above, but grading to siltstone, with Shale: as above.
5530 - 5552	Siltstone with trace of sandstone, Siltstone: gray to brown, sandy, grading to Sandstone: very argillaceous, with Shale: as above.
5552 - 5562	<u>Core No. 3, Cut 10', Recovered 9.5'</u>

5552.0-5553.0' (1.0')	Shale: dark gray, fissile, very finely micaceous, very slightly calcareous, slightly silty.
5553.0-5557.5' (4.5')	Shale: medium gray, subfissile, micromicaceous to non-micaceous, no longer silty, approaching claystone.

5557.5-5560.0' (2.5')	Sandstone: gray to very light tan, fine grained to very fine grained, moderately sorted, subangular to subrounded, abundant feldspar, rare green mineral, probably chlorite alteration, not glauconite, "salt and pepper" from carbonaceous partings, very heavy matrix of calcareous material and white clay, acid reaction reduces sandstone to grains and aggregates, well indurated with very poor intergranular porosity, no show.
5560.0-5561.5' (1.5')	Sandstone: as above, but becoming more fine grained, silty and argillaceous with some indication of dead oil stain along breakage planes, no cut or fluorescence, grades in final 1/2' to less argillaceous and silty with no dead oil stain.
5561.5-5562.0' (0.5')	No recovery.
5562 - 5600	Siltstone: dark gray to gray-brown, very argillaceous, grading to shale, with Shale and Sandstone: as above.
5600 - 5630	Sandstone and siltstone gradational with silty, argillaceous sandstone and sandy siltstone, with Shale: as above.
5630 - 5640	Sandstone now becoming mostly siltstone, with Shale: as above.
5640 - 5660	Sandstone and Siltstone: as above, with some sandstone becoming blocky, very hard, siliceous, with Shale: as above.
5660 - 5670	Sandstone and Siltstone: as above, with increase in sandstone, becoming more clay filled, poor porosity, no show, with Shale: as above.
5670 - 5680	Sandstone: becoming white with some clear grains, "salt and pepper", becoming friable in part, poor to fair intergranular porosity, no show, with Shale: as above.
5680 - 5750	Siltstone: gray, "salt and pepper", blocky in part, hard and brittle, grades to sandstone in part, interbedded with Shale: gray, as above, becomes very dark gray, carbonaceous, subfissile, blocky, slightly calcareous, silty in part, trace pyrite.

5750 - 5820	Sandstone: gray with some pink feldspar grains, "salt and pepper", very fine to fine grained, occasional medium grained, poor to fair sorting, subangular to subrounded, well cemented with calcite, some white clay fill, occasional carbonaceous laminations, moderately indurated, some friable, nil to very poor visible porosity, no show, with interbedded Shale: as above.
5820 - 5885	Siltstone: gray, as above, some feldspar grains, blocky, hard, brittle, some carbonaceous laminations, with interbedded Shale: as above.
5885 - 5930	Sandstone: gray, with pink feldspar grains, "salt and pepper", fine grained to very fine grained, subangular to subrounded, fair sorting, occasional carbonaceous laminations, moderately friable, some white clay filling, nil to very poor intergranular porosity, no show, with some interbedded Siltstone: as above.
5930 - 6015	Shale: dark gray, platy to blocky, smooth, some silty, firm, with interbedded Siltstone and Sandstone: as above.
6015 - 6092	Siltstone: gray to brown, "salt and pepper", blocky, very well indurated, becomes sandy in part, carbonaceous laminations and inclusions, grades to Sandstone: gray, with pink feldspar grains, "salt and pepper", very fine to fine grained, moderate to well indurated, nil to very poor intergranular porosity, no show, with some interbedded Shale: as above.
6092 - 6115	Sandstone: light gray to brown, "salt and pepper", fine to medium grained, fair sorting, subangular to subrounded, friable to unconsolidated in part, fair to good intergranular porosity, no show; carbonaceous (coal) inclusions and laminations; maximum 1,300 units of gas; 25 barrel increase in pit volume.
6115 - 6137	Siltstone: dark gray-brown, argillaceous, "salt and pepper", fine carbonaceous inclusions; grades to shale, silty, micromicaceous.
6137 - 6248	Thinly interbedded Sandstone: as above, and Shale and Siltstone: as above, sandstone contains abundant carbonaceous inclusions and laminations and exhibits fair to good intergranular porosity, no show.
6248 - 6370	Predominantly interbedded Siltstone and Shale: as above, with occasional thin Sandstone: as above.

6370 - 6435	Sandstone: light gray, "salt and pepper", fine grained, moderately well sorted, subrounded to subangular, moderately friable, arkosic, some carbonaceous inclusions and laminations, poor intergranular porosity, no show, with thin beds of Shale and Siltstone: as above.
6435 - 6452	Shale: dark gray, platy to splintery, smooth, firm, silty in part.
6452 - 6478	Sandstone: as above, with interbedded Shale: as above, becomes very silty, grades to siltstone.
6478 - 6504	Interbedded Siltstone and Shale: as above.
6504 - 6514	Core No. 4, Cut 10', Recovered 7.25'

6504.0-6505.25' (1.25')	Shale: dark gray, silty, micromicaceous, finely disseminated carbonaceous inclusions, well to moderately indurated, with thin horizontally bedded, irregular laminations of Siltstone: sandy, light gray, "salt and pepper", slightly calcareous, well indurated.
6505.25-6507.7' (2.45')	Siltstone: light gray, sandy, salt and pepper, fair sorting, subangular to subrounded, rare mica, slightly calcareous, hard, brittle, nil intergranular porosity, no show, with thin Shale laminations: as above.
6507.7-6509.5' (1.8')	Shale: as above, with thin Siltstone laminations: as above.
6509.5-6510.6' (1.1')	Siltstone: light gray, sandy, as above, with thin Shale laminations: as above.
6510.6-6511.25' (0.65')	Shale: as above, with thin Siltstone laminations: as above.
6511.25-6514.0' (2.75')	No recovery.

6514 - 6525	Shale and Siltstone: as above.
6525 - 6545	Sandstone: light gray, "salt and pepper", very fine to fine grained, fair sorting, subangular to subrounded, moderately friable to some unconsolidated, carbonaceous inclusions and laminations, poor intergranular porosity, no show, grades to siltstone towards base, some interbedded Shale: as above.

6545 - 6572	Interbedded Shale and Siltstone: as above.
6572 - 6602	Sandstone: light gray, "salt and pepper", some pink grains, fine to medium grained, fair sorting, subangular to subrounded, moderately friable to unconsolidated in part, nil to fair intergranular porosity, no show, becomes silty towards base, some carbonaceous inclusions.
6602 - 6675	Interbedded Shale: dark gray, silty, micromicaceous, blocky to platy, firm, some finely disseminated carbonaceous inclusions, and Siltstone: as above, some thin Sandstone beds: as above.
6675 - 6695	Sandstone: light gray, "salt and pepper", poor to fair sorting, subangular to subrounded, very fine to medium grained, abundant coarse carbonaceous inclusions and laminations, moderately friable, fair to good intergranular porosity, becomes unconsolidated in part, some feldspar and glauconite(?) grains, no show, 600 units of gas.
6695 - 6707	Shale: as above.
6707 - 6730	Sandstone: as above, arkosic in part, good intergranular porosity, no show, 300 units of gas.
6730 - 6770	Interbedded Shale: dark gray, platy to blocky, silty in part, essentially as above, with Sandstone: as above, becomes very fine grained, moderately well indurated, nil intergranular porosity, no show.
6770 - 6818	Sandstone: light gray, "salt and pepper", fair sorting, subangular to subrounded, fine to medium grained, arkosic, rare dull green glauconite(?), some carbonaceous laminations and inclusions, poor to good intergranular porosity, no show.
6818 - 6855	Interbedded Shale: dark gray, platy to blocky, smooth, firm, micromicaceous, some carbonaceous inclusions, and Siltstone: dark gray to medium gray, sandy, grades to Sandstone: gray, "salt and pepper", carbonaceous inclusions, very fine grained, nil visible porosity, no show.
6855 - 6885	Interbedded Shale, Siltstone and Sandstone: as above.
6885 - 6908	Siltstone: dark gray to brown, argillaceous, carbonaceous inclusions, firm, becomes medium gray, sandy, grades to Sandstone: light gray, "salt and pepper", very fine grained, hard and brittle at base.

4/9

56

6908 - 6928	Shale: dark gray to brown, micromicaceous, as above.
6928 - 6948	Siltstone: light gray, sandy, grades to Sandstone: light gray, very fine grained, "salt and pepper", carbonaceous inclusions and laminations, hard, nil to very poor intergranular porosity, no show.
6948 - 6978	Interbedded Shale: as above, and Siltstone: dark gray to brown, argillaceous in part, grades to light gray, carbonaceous inclusions, sandy, as above.
6978 - 6988	Sandstone: as above, very poor intergranular porosity, no show.
6988 - 7050	Interbedded Shale and Siltstone: as above.
7050 - 7110	Shale and Siltstone: as above, with thin beds of Sandstone: as above.
7110 - 7250	Interbedded siltstone and shale; Siltstone: dark gray-brown, argillaceous, carbonaceous inclusions, Shale: dark gray, platy, blocky, micromicaceous, silty in part.
7250 - 7260	Sandstone: gray-brown, "salt and pepper", very fine grained, silty, fair sorting, subangular to subrounded, very well indurated, nil visible porosity, no odor, stain, cut, or fluorescence.
7260 - 7370	Interbedded Siltstone and Shale: as at 7110'.
7370 - 7722	Shale: dark gray to black, smooth, micaceous, blocky to splintery, firm, with trace to occasional Siltstone: as above.
7722 - 7728	Sandstone: dark gray, argillaceous, "salt and pepper", very fine grained to silty, carbonaceous, nil visible porosity, no odor, stain, cut, or fluorescence.
7728 - 7740	Shale: as above at 7370-7722'.
7740 - 7803	Interbedded Shale: dark gray to black, blocky to occasionally splintery, with Siltstone: gray to brown, argillaceous, calcareous, blocky, well indurated.
7803 - 7808	Sandstone: dark gray to gray-brown, "salt and pepper", argillaceous, very fine grained to silty, poorly sorted, subangular to subrounded, calcareous, nil intergranular porosity, no odor, stain, cut or fluorescence.
7808 - 7838	Interbedded Shale and Siltstone: as at 7740-7803'.

7838 - 7845 Sandstone: as above at 7803-7808'.

7845 - 7870 Interbedded Shale and Siltstone: as at 7740'.

7870 - 7880 Core No. 5, Cut 10', Recovered 10'

7870.0-7880.0' (10.0') Shale: dark gray to brown, silty, fissile to platy, micromicaceous, with rare fine to medium carbonaceous inclusions, moderately indurated with occasional thin irregular laminations and blebs of gray siltstone.

7880 - 7910 Interbedded Shale and Siltstone: as above.

7910 - 8043 Sandstone: gray to brown, "salt and pepper", very fine grained to silty, poorly sorted, subangular to subrounded, well indurated, some carbonaceous inclusions, nil intergranular porosity, no odor, stain, cut or fluorescence, grades to fine grained 7945-7783', with poor to fair porosity and 1,280 units ditch grains (C_1-C_5), interbedded with Shale and Siltstone: as above.

8043 - 8075 Predominantly Siltstone: dark brownish-gray, "salt and pepper", sandy, very argillaceous, well indurated.

8075 - 8120 Sandstone: tan and "salt and pepper", very fine to medium grained, occasionally coarse grained, with some feldspar grains, white clay matrix, slightly calcareous, nil porosity (grades to poor porosity below 8093'), carbonaceous inclusions, no odor, stain, cut or fluorescence.

8120 - 8170 Interbedded Siltstone: dark brown, argillaceous, and Shale: dark gray to brown, silty, micromicaceous, blocky.

8170 - 8230 Sandstone: light gray to brown, "salt and pepper", very fine to fine grained, poorly sorted, subangular to subrounded, firm, carbonaceous inclusions, slightly calcareous, nil intergranular porosity, no odor, stain, cut, or fluorescence, with Shale and Siltstone interbeds: as above.

8230 - 8245 Siltstone: dark gray-brown to "salt and pepper".

8245 - 8260 Shale: as above with trace of Inoceramus prisms.

8260 - 8288 Siltstone: grading to Sandstone: medium gray to brown, "salt and pepper", grades from silty to very fine grained, poorly sorted, subangular to subrounded, well indurated, nil visible porosity, no odor, stain, cut, or fluorescence.

8288 - 8301	Shale: as above at 8245-8260'; ran 13-3/8" casing shoe at 8298'.
8301 - 8350	Shale: gray to dark gray, micromicaceous in part, lumpy, splintery, silty in part, grading to siltstone (samples extremely poor, very contaminated with cement).
8350 - 8390	Clay Shale: light gray, lumpy to slightly soluble, sticky and gummy, very calcareous.
8390 - 8400	Clay Shale: light gray, lumpy, soft and sticky, partly soluble.
8400 - 8430	Clay Shale: as above, with occasional pieces becoming carbonaceous, more well indurated
8430 - 8460	Shale: as above, but becoming slightly firmer in part.
8460 - 8490	Shale: as above, but becoming more silty in part, with Siltstone: dark gray, very argillaceous, calcareous, sandy in part, well indurated.
8490 - 8500	Shale: as above, but more soluble, fluffy in part, probably bentonitic.
8500 - 8530	Shale: as above with some Shale: dark gray, platy to splintery.
8530 - 8540	Shale: as above, but becoming silty in part, with Siltstone to Sandstone: mottled gray to gray-black, occasional very fine grained sand, carbonaceous, calcareous, very argillaceous, grading from sandstone to siltstone to shale.
8540 - 8550	Shale: as above, but becoming more silty.
8550 - 8570	Shale: as above, with Shale: dark gray, splintery, carbonaceous.
8570 - 8620	Shale: as above, occasionally silty to sandy.
8620 - 8680	Shale: as above, with occasional silty laminae, with trace of Siltstone: light to dark gray, very argillaceous, calcareous.
8680 - 8700	Shale: as above, but some becoming dark gray, slightly more indurated, slightly carbonaceous.
8700 - 8710	Shale: as above, with Sandstone: white to gray, very argillaceous, silty, abundant white clay matrix, well indurated, poor to nil porosity, no show.

8710 - 8750 Shale: as above, with Sandstone: now becoming mostly Siltstone: very argillaceous and sandy, grading from shale, siltstone and sandstone.

8750 - 8760 Shale: as above, with Sandstone: off-white to gray, very silty, grading to siltstone, well indurated, poor to nil porosity, no show.

8760 - 8782 Shale: as above, with sandstone becoming more argillaceous and silty, grading to siltstone, well indurated, poor to nil porosity, no show.

8782 - 8810 Core No. 6, Cut 28', Recovered 28'

8782.0-8810.0' (28.0') Shale: varies from medium gray to dark gray, micromicaceous, very slightly calcareous, brittle, subfissile, slightly splintery with occasional irregular turbidite structures of very fine grained sandstone, grading to Siltstone: light gray, very fine grained to silt, moderately calcareous, tightly cemented with calcite, clay and probable silica, abundant recrystallization of quartz grains forming distinct crystal faces, bedding horizontal as evidenced from breakage, appears to be non-fossiliferous except for plant and wood remains at 8805-8808'.

8810 - 8840 Shale: as in Core No. 6, with trace of Gilsonite: black, vitreous, conchoidal fracture.

8840 - 8850 Shale: as above, becoming very slightly bentonitic, with Sandstone: off-white to light gray, mottled dark gray, very fine grained to silt, very argillaceous, with clay and white clay matrix, grading to silty, sandy claystone, poor to nil porosity, no show.

8850 - 8870 Shale: as above, with Sandstone: as above, but becoming very dirty, very tight.

8870 - 8880 Shale: as above, with Sandstone: mostly as above, grading to siltstone and shale, but with some becoming friable, poor to fair porosity, no show.

8880 - 8900 Shale: as above, with Sandstone: as above, but becoming tighter.

8900 - 8940 Shale: as above, silty, with Sandstone: mostly as above, but grading more to siltstone and shale.

8940 - 8950	Shale: as above, with Siltstone: gray to brown, very argillaceous, grading to shale, with some sandstone, very friable to loose aggregates, clay matrix, poor to fair porosity, no show.
8950 - 8990	Shale: as above, with siltstone now becoming mostly sandstone.
8990 - 9030	Shale: as above, with Sandstone: very silty and argillaceous, very poor porosity.
9030 - 9070	Shale: becoming bentonitic, readily swells in fresh water, with Sandstone and Siltstone: as above. with trace of gilsonite.
9070 - 9120	Shale: as above, sample very poor, mostly lost circulation material.
9120 - 9190	Shale: as above, with Sandstone: dark gray to brown, fine grained to very fine grained to silt, very argillaceous, abundant carbonaceous material, moderately indurated, very poor to nil porosity, no show.
9190 - 9300	Shale: as above, but becoming silty in part.
9300 - 9380	Shale: gray to dark gray, very slightly calcareous, occasionally slightly splintery, mostly lumpy, with Sandstone and Siltstone: as above.
9380 - 9410	Shale: as above, mostly silty.
9410 - 9420	Shale: becoming very silty, micromicaceous in part, grading to Siltstone: dark gray to brown, very argillaceous, grading to shale.
9420 - 9520	Shale: as above, with Sandstone and Siltstone: dark gray.
9520 - 9560	Shale: silty for most part (sample quality extremely poor).
9560 - 9590	Shale: as above, with Shale: dark gray, splintery, subfissile, very slightly calcareous, moderate to well indurated.
9590 - 9620	Mostly siltstone and silty sandstone.
9620 - 9680	Shale: as above, with minor Sandstone: gray-brown, mottled black with grains of Shale: fine grained to very fine grained, argillaceous, moderately indurated, poor porosity, no show.

9680 - 9720	Shale: appears to become more competent and indurated, less soft and sticky.
9720 - 9740	Shale: as above, with Shale: dark gray to black, carbonaceous, slight submetallic luster, micromicaceous, slightly splintery.
9740 - 9800	Shale: as above, with Shale: dark gray to black, with Sandstone: gray-brown, very fine grained to fine grained, subangular to subrounded, mottled black with shale particles, very calcareous, argillaceous, poor porosity, no show.
9800 - 9840	Shale: as above, with trace of Gilsonite: black, vitreous, subconchoidal fracture.
9840 - 9900	Shale: as above, with some dark gray to black carbonaceous shale.
9900 - 9920	Shale: as above, with trace of Sandstone: gray to brown, very fine grained to silt, very argillaceous, moderately indurated, poor to nil porosity, no show.
9920 - 9930	Shale: as above, becoming very bentonitic.
9930 -10,010	Shale: as above, but becoming silty, less bentonitic.
10,010-10,020	Shale: becoming more silty, grading in part to siltstone.
10,020-10,030	Shale: as above, with Sandstone: white to gray to brown, very fine grained to fine grained, very argillaceous and silty, very heavy white clay matrix, calcareous, poor to nil porosity, no show.

080 Shale: as above, with Siltstone: off-white to light gray, very argillaceous, abundant white clay, occasionally grading to very fine grained sandstone. 10,030-10,

090 Shale: very silty, grading to siltstone, with Siltstone: 10,080-10,
illaceous, grading to shale: very arg

gray-brown, very argillaceous, grading to
e at one extreme and shale at the other. 10,090-10,100 Siltstone:
sandston

grading more to sandstone, with Sandstone: 10,100-10,120 Siltstone:
very argillaceous, calcareous, very fine brown,
to silt, carbonaceous, slightly friable, but grained
sity due to clay and calcite matrix, no show. poor por

carbonaceous; 10,120-10,130 Sandstone: as above, or more

10,130-10,180 Sandstone: becoming less friable, more very fine grained to fine grained, more well indurated, siliceous appearance in part, poor to nil porosity, no show.

10,180-10,210 Sandstone: as above, but becoming slightly more indurated, with Shale: as above.

10,210-10,300 Sandstone, Siltstone and Shale: gradational from silty carbonaceous shale to very argillaceous siltstone and silty sandstone.

10,300-10,420 Predominantly Shale: gray to light gray, soft and sticky, with Shale: dark gray, splintery, fissile to subfissile, very fine mica, interbedded with Siltstone: gray, very argillaceous, sandy, grading to Sandstone: gray-brown, very silty, grading to siltstone, with carbonaceous and shale particles, very argillaceous, calcareous, poor visible porosity, no odor, stain, cut of fluorescence.

10,420-10,470 Shale: as above, interbedded with sandstone, Shale: dark gray, splintery, subfissile to fissile, very fine mica. Sandstone: white to light gray, very fine to fine grained, very argillaceous, abundant white clay matrix in part, friable, poor to fair visible porosity, no odor, stain, cut or fluorescence, shale increasing downward, sandstone decreasing downward.

10,470-10,472 No samples recovered.

10,472-10,502 Core No. 7, Cut 30', Recovered 30'

10,472.0-10,502.0' (30.0') Shale: medium gray, submetallic luster, micro to very finely micaceous, noncalcareous to very slightly calcareous, subfissile, breaks into splintery fragments at random angles, hard, brittle, rare irregular patches and pods of sandy and silty shale, no fossils, no visible bedding.

10,502-10,550 Shale: as in Core No. 7, with Shale: light gray, soft, sticky, and minor Sandstone: dirty gray, very argillaceous and silty, very fine grained to silty, poor visible porosity, no odor, stain, cut or fluorescence.

10,550-10,560 No sample returns.

10,560-10,580 Shale and Sandstone: as above at 10,502'.

10,580-10,590 No sample returns.

10,590-10,600	No samples.
10,600-10,630	Predominantly Shale: light gray, sticky, and Shale: dark gray, splintery, very fine mica, and with minor to trace of Sandstone: gray, very silty and argillaceous grading to Siltstone.
10,630-10,650	Shale: medium gray, organic, greasy appearance, subfissile, mostly blocky to slightly blocky, slightly calcareous with some fine grained, clear, polished, rounded free quartz grains.
10,650-10,660	Shale: as above, with some free pyrites, some smoky to clear, rounded quartz grains.
10,660-10,671	Shale: as above, but becoming slightly silty.
10,671-10,702	Core No. 8, Cut 31', Recovered 31'

10,671.0-10,702.0' (31.0')	Shale: medium to charcoal-gray, moderately fissile, very finely micaceous with occasional flakes up to 1 mm, occasionally breaks with conchoidal fracture, very slightly calcareous, greasy appearance when damp, organic, rare nodules of pyrite, typically less than 1 mm, occasionally up to 2 mm, becoming more abundant and with veinlets of pyrite below 10,678', very rare, scattered, random, very fine grained to medium grained, polished and clear, subrounded and rounded quartz grains, 45° fracture at 10,682-10,683', with very smooth grooved surface, possibly slickensides, two parallel sets of 45° fractures at 10,687-10,688', pyritized worm borings or trace fossils at 15° to bedding 10,693-10,694', and 10,696-10,697', bedding essentially horizontal.

10,702-10,720	Shale: as above, with traces of rounded sandstone grains and with Pyrite: as above and with a trace of smoky chert.
10,720-10,750	Shale: as above, with Shale: light gray, very earthy, bentonitic, nonfissile to fissile.

10,750-10,770	Shale: as above, with increase in charcoal-gray shale and increase in chert fragments and quartz grains.
10,770-10,780	Shale: as above, with some gray-black, splintery shale.
10,780-10,800	Shale: becoming gray-black with very long splintery fragments, noncalcareous.
10,800-10,840	Shale: as above, with loose sand grains becoming more abundant, trace to 10%.
10,840-10,905	Shale: as above, with trace of Sandstone: brown, fine grained, subangular to subrounded, "salt and pepper" from shale inclusions, hard, siliceous, very slightly calcareous, poor to nil porosity, no show.
10,905-10,910	Sandstone: pale gray, very fine grained with some fine grained, occasional specks of shale, very calcareous with heavy calcareous cement, abundant

-kaolinite. Clay: hard, some with
nce, poor intergranular porosity, no
zones of white
siliceous appeara
show.

30", Recovered 30"

10,910-10,940 Core No. 9, Cut

Sandstone: light gray, very fine grained, slightly silty and argillaceous, moderately calcareous, tightly cemented with silica and calcite, very hard and dense, fragments of gray to white mineral, probably altered feldspar, some secondary recrystallization of quartz grains, occasional muscovite flakes, subangular to subrounded, moderately sorted, poor to very poor intergranular porosity, no show, occasional weak hairline 75° fractures, no mineralization on fracture planes.

10,910.0-10,914.0
(4.0')

Sandstone: mostly as above, but somewhat more shaly with occasional specks of green mineral, probably glauconite, some veinlets, small pods and laminae of dark gray, argillaceous, carbonaceous material, very poor intergranular porosity, no show, fractured as above, two approximately 1/2"

10,914.0-10,931.0
(17.0')

27

B-

shaly sandstone partings 10,920-10,921' and 10,924-10,925', decrease in glauconite toward bottom of interval.

10,931.0-10,932.0' (1.0') Sandstone: as above, but becoming slightly cleaner, no shaly, carbonaceous veinlets and pods, very poor porosity, no show.

10,932.0-10,935.0' (3.0') Sandstone: as in 17' interval above, but with increase in glauconite, very poor porosity, no show.

10,935.0-10,938.0' (3.0') Sandstone: becoming poorly sorted, with grains ranging from very fine grained to medium grained, and with occasional subrounded to rounded coarse grained quartz, (increase in grain size and amount of very soft waxy mineral, glauconite(?) downward), poor porosity, no show.

10,938.0-10,940.0' (2.0') Sandstone: becoming cleaner, mostly fine grained, well sorted with decrease in glauconite, very hard and dense, slightly more calcareous, some small fragments of white to gray mineral becoming more abundant, probably altered feldspar, poor intergranular porosity, no show.

Note: Entire core very weakly fractured with hairline fractures nearly vertical (75°, no apparent bedding; breaks at all angles).

10,940-10,965 Sandstone: light gray, very fine grained to fine grained, rare pale green glauconite pellets, rare mica, very well indurated, nil to very poor intergranular porosity, no show, with interbedded Shale: black, smooth, pyrite nodules, firm.

10,965-10,982 Shale: black, as above.

10,982-11,032 Sandstone: essentially as above, very fine to fine grained, subrounded to subangular, well sorted, very well indurated, rare mica and green glauconite pellets, nil to very poor porosity, no show.

11,032-11,042	Shale: black, as above.
11,042-11,122	Sandstone: as above, occasional black ferromagnesian minerals, grades to argillaceous, with carbonaceous laminations and inclusions towards base, some shale interbeds.
11,122-11,145	Predominantly Shale: as above, with thin sandstone streaks, as above.
11,145-11,195	Sandstone: as above, grades to medium grained, subrounded to subangular, clean, well sorted, moderately friable, decrease in carbonaceous laminations, nil to very poor intergranular porosity, no show.
11,195-11,218	Shale: as above, with thin Sandstone: as above.
11,218-11,302	Sandstone: light gray to tan, very fine to fine grained, subrounded to subangular, well sorted, rare pale green glauconite pellets, some white clay filling, nil to very poor intergranular porosity, no show, thin beds of Shale: as above, smooth, blocky to platy.
11,302-11,312	Shale: black, as above, with sandstone laminations.
11,312-11,392	Sandstone: light gray to clear, very fine to medium grained, quartzitic, recemented with silica, subrounded to subangular, some pink feldspar grains, grades to coarse grained in part, very well indurated, nil intergranular porosity, no show, with some interbedded Shale: as above, occasional carbonaceous laminations towards base.
11,392-11,402	Siltstone: brown, argillaceous, very well indurated, some carbonaceous laminations, grades to Shale: black, as above, with sandstone laminations.
11,402-11,458	Sandstone: clear, as above, becomes very argillaceous in part, some white clay, some carbonaceous laminations, nil intergranular porosity, no show.
11,458-11,512	Siltstone: brown, very argillaceous, grades to Sandstone: as above, medium to coarse grained, some carbonaceous laminations, sandstone occurs from 11,462-11,467' and 11,482-11,488'.
11,512-11,528	Predominantly Siltstone: brown, very argillaceous, occasional "salt and pepper", carbonaceous laminations, grades to very fine grained Sandstone: clear, well indurated, nil intergranular porosity, with interbedded Shale: black, smooth to silty, micaceous, pyritic nodules, fissile to platy.

11,528-11,600	Sandstone: clear, as above, becomes well indurated with nil porosity, and interbedded Sandstone: brown, argillaceous, as above, with common carbonaceous laminations.
11,600-11,625	Sandstone: brown to tan, very fine grained, subangular to subrounded, poorly sorted, argillaceous, with well indurated carbonaceous laminations, nil visible porosity, no odor, stain, cut or fluorescence, with streaks of Shale: as above.
11,625-11,649	Sandstone: clear, medium to coarse grained, occasional "salt and pepper", but generally clean, subrounded to subangular, well sorted, moderately friable, grades to well indurated, poor to fair intergranular porosity, no show, grades to Siltstone: brown, argillaceous, with carbonaceous laminations, as above, thence to Shale: as above.
11,649-11,672	Sandstone: tan, very fine to fine grained, slightly argillaceous, well indurated, nil to very poor intergranular porosity, no show, grades to Siltstone: as above, with carbonaceous laminations.
11,672-11,694.5	<u>Core No. 10, Cut 22.5', Recovered 22.5'</u>

11,672.0-11,681.0' (9.0')	Shale: dark gray-brown to black, silty, micromicaceous, carbonaceous partings with submetallic luster, well indurated, platy to fissile, with lenses and very thinly bedded (1/8-1/2") zones of Sandstone: clear to light gray, brown, medium to coarse grained, common coarse ferromagnesian minerals, subrounded to subangular, fair sorting, argillaceous in part, poor intergranular porosity, no show, occasionally micaceous; sandstone and shale are in approximate equal amounts.
11,681.0-11,686.0' (5.0')	Predominantly Shale: as above, with decrease in number of sandstone laminae and lenses.
11,686.0-11,688.0' (2.0')	Alternating thin bands of Shale: as above, and Sandstone: as above in equal amounts.

11,688.0-11,692.5' (4.5')	Predominantly Shale: black to dark gray-brown, as above, with decrease in lenses and partings of Sandstone: as above.
11,692.5-11,694.5' (2.0')	Alternating equal bands of Shale: as above, and Sandstone: as above.

Note: Core is badly broken and weakly fractured in bottom 1.5'. Fracture is nearly vertical (75°). Bedding planes horizontal. Rare worm burrows occur throughout.

11,694.5-11,735	Shale: dark gray-brown to black, as above, with thin beds of Sandstone: light gray-brown, as above.
11,735-11,860	Predominantly Shale: as above, with thin streaks of Sandstone: as above, grades to siltstone in part.
11,860-11,927	Alternating thin beds of Sandstone: gray-brown, fine grained to silty, subrounded to subangular, fair sorting, "salt and pepper", argillaceous in part, well indurated, nil intergranular porosity, no show, and Shale: as above.
11,927-11,995	Shale: as above, with thin beds of Sandstone: as above, grades to Siltstone: brown, very argillaceous, well to moderately indurated.
11,995-12,010	Sandstone: as above, fine to very fine grained, well indurated, nil intergranular porosity, no show.
12,010-12,030	Shale: as above.
12,030-12,052	Predominantly Siltstone: brown, argillaceous, as above, grades to sandstone in part, with thin shale streaks, as above.
12,052-12,092	Shale: dark gray-brown, silty, micromicaceous, pyrite nodules, well indurated, platy to some fissile.
12,092-12,137	Predominantly Sandstone: gray-brown, fine to very fine grained, subangular to subrounded, fair sorting, occasional "salt and pepper", well indurated, nil intergranular porosity, no show, with thin shale streaks, as above.
12,137-12,178	Predominantly Shale: as above.
12,178-12,215	Predominantly Sandstone: gray-brown, argillaceous in part, carbonaceous laminations, nil intergranular porosity, no show, with interbedded Shale: as above.

12,215-12,230	Shale: as above.
12,230-12,237	Sandstone: as above.
12,237-12,267	Shale: as above.
12,267-12,273	Sandstone: tan to gray-brown, fine to occasional medium grained, subrounded to subangular, fair to well sorted, moderately friable, poor intergranular porosity, no show.
12,273-12,298	Shale: as above.
12,298-12,308	Sandstone: as above, poor intergranular porosity, no show.
12,308-12,328	Shale: as above, becomes very silty in part.
12,328-12,350	Predominantly Sandstone: as above, with thin Shale: as above.
12,350-12,398	Shale: as above, black, platy to fissile, smooth, rare mica, firm, silty in part.
12,398-12,404	Sandstone: as above, 430 units of gas.
12,404-12,430	Shale: as above.
12,430-12,451	Sandstone: tan to gray-brown, mottled, "salt and pepper", very argillaceous in part, very fine to fine grained, well indurated, but grades to moderately friable in part, some finely disseminated pyrite nodules, nil to very poor intergranular porosity, no show.
12,451-12,469	Shale: as above, micromicaceous, silty in part, pyritic.
12,469-12,520	Predominantly Sandstone: as above, becomes blocky, quartzitic, (gradual increase in background gas), becomes shaly at base.
12,520-12,549	Sandstone: tan to clear, fine grained clear quartz grains, subrounded to subangular, well sorted, moderately friable to well indurated, some white clay (loose), nil to very poor intergranular porosity, blocky and quartzitic in part.
12,549-12,557	Sandstone: tan to clear, fine clear quartz grains, subangular to subrounded, well sorted, moderately friable to moderately indurated, generally fair to very poor intergranular porosity, some finely disseminated

70. 67

black tarry residue within pores, no fluorescence or cut. (Check for flow at 12,552', very slight flow. Proceeded to circulate out; gas increased to 1,250 units, did not peak because of well flow, which necessitated closing Hydril before bottoms up.)

12,557-12,567 Sandstone: tan to clear, fine grained, well cemented with silica, poor intergranular porosity, no show, with Shale: dark gray to black, subfissile, organic.

12,567-12,597 Core No. 11, Cut 30', Recovered 30'

12,567.0-12,576.5' (9.5') Shale: dark gray to black, very finely micaceous and slightly silty along lenses and bedding planes, subfissile, organic, noncalcareous, moderate to well indurated, irregular wavy lenses and pods of very fine grained sandstone and siltstone, occasionally assuming near vertical apparent bedding, probably slump structures, bedding becoming nearly 45° at 12,572-12,573' and 12,575-12,576', occasional bleeding zones, no gas odor, one observed pelecypod shell at 12,571'.

12,576.5-12,591.0' (14.5') Predominantly Sandstone: medium gray, very fine grained, moderately sorted, slightly argillaceous, very slightly calcareous, well cemented with silica, subangular to subrounded, very quartzitic in part with some approaching orthoquartzite, breaking across grains, very well indurated, very poor to nil porosity, occasional lenses with poor porosity, no show, occasional bleeding of both shales and sandstones, mostly appears along bedding planes, interbedded and interlaminated with Shale: as above, occasional small vugs up to 2 cm long and 3-4 mm wide, some bleeding gas(?), no odor or shows.

12,591.0-12,597.0' (6.0') Predominantly Shale: as above, with interbedded and interlaminated pods and lenses of quartzitic Sandstone: as above.

12,597-12,610	Shale: as above, with Sandstone: light gray, very fine grained, some clear grains, generally translucent.
12,610-12,710	Shale: dark gray to black, as above, with Sandstone: as above, but becoming very silty, grading to siltstone.
12,710-12,720	Shale: as above, but becoming slightly more silty.
12,720-12,730	Shale: becoming darker, now mostly black, fissile, splintery.
12,730-12,750	Shale: becoming more dark gray, less splintery, more subfissile, slightly silty, organic.
12,750-12,790	Shale: as above, with Sandstone: mostly loose grains, fine grained, clear to frosted, subangular to subrounded.
12,790-12,810	Shale: as above, with Sandstone: becoming very fine grained, clear to white, very quartzitic, well indurated, nil porosity.
12,810-12,830	Shale: as above, with abundant free pyrite.
12,830-12,840	Siltstone: gray to pale brown, sandy, grading to Sandstone: very calcareous, very argillaceous, with white clay, and with Shale: as above.
12,840-12,850	Siltstone: becoming gray to dark gray, very argillaceous.
12,850-12,860	Shale: as above, with Siltstone: becoming more sandy and siliceous.
12,860-12,870	Siltstone: dark gray to brown, very argillaceous, sandy, grading in part to Sandstone: siliceous, well indurated, with Shale: as above.
12,870-12,880	Sandstone: brown, very fine grained, argillaceous, silty, well indurated, very slightly calcareous, silica cement, poor to nil porosity, no show.
12,880-12,890	Sandstone: brown to dark gray, more silty, argillaceous, grading back to siltstone.
12,890-12,910	Siltstone: grading from sandstone.
12,910-13,000	Siltstone: as above, but with some off-white to pale gray siltstone, with heavy white chalky clay matrix, with Shale: as above.

13,000-13,040	Shale: as above, with a trace of Dolomite: dark gray to brown, microcrystalline, dense, silty, with occasional grains of orange to brown chert.
13,040-13,100	Shale: as above, with Dolomite: dark gray to brown, very argillaceous and carbonaceous, microcrystalline, dense, silty, occasional hairline microfractures filled with carbonaceous material.
13,100-13,140	Shale: becoming micromicaceous, abundant pyrite replacement of worm borings.
13,140-13,190	Shale: as above, with Dolomite: gray to brown, microcrystalline, dense, nil visible porosity.
13,190-13,210	Shale: as above, with abundant pyrite.
13,210-13,220	Shale: as above, with some floating, frosted rounded medium grained quartz grains.
13,220-13,230	Shale: as above, with floating, rounded quartz grains becoming more abundant.
13,230-13,240	Shale: as above, with some Shale: light gray, waxy, occasionally soft and partly soluble, subfissile, noncalcareous, no quartz grains.
13,240-13,250	Dolomite: tan to gray, slightly calcareous, slightly argillaceous, and with occasional carbonaceous streaks, microcrystalline, hard, dense, subconchoidal fracture, nil porosity.
13,250-13,270	Shale: as above, with large increase in light gray, waxy shale, and with clear to frosted, subrounded to rounded, quartz grains.
13,270-13,280	Shale: as above, with floating quartz grains and with waxy, talc-like mineral with inclusions of biotite flakes.
13,280-13,285	Dolomite: gray, microcrystalline, dense, hard, slightly silty in part, some milky calcareous veins and occasional well developed crystals of quartz indicating some open vugs or fractures, some bleeding, with Shale: as above.
13,285-13,330	Shale: as above.
13,330-13,340	Dolomite: dark gray to brown, very silty, grading to Siltstone: very argillaceous, dense, blocky, nil visible porosity, no show, with Shale: as above.

13,340-13,350	Shale: light gray to dark gray, organic, fissile, with some medium grained, rounded, floating, polished quartz grains.
13,350-13,360	Shale: as above, with trace of siltstone, with abundant pellets and fragments of glauconite in groundmass of silt, clay, and siderite.
13,360-13,370	Shale: as above, with glauconite, siderite, and with Siltstone: as above.
13,370-13,420	Shale: as above, with a trace of Shale: pale gray, soft, waxy.
13,420-13,430	Shale: dark gray to black, organic, fissile to subfissile, with occasional shale, gray, very silty, soft.
13,430-13,440	Shale: as above, with increase in silty shale, and with abundant pyrite.
13,440-13,450	Shale: as above, but grading to siltstone in part.
13,450-13,510	Siltstone: dirty gray-brown, very argillaceous, grading to Shale: slightly calcareous, moderately indurated to soft.
13,510-13,540	Siltstone: becoming more dirty, calcareous, slightly softer, slight greasy appearance when damp, very organic.
13,540-13,620	Shale: dark gray to black, silty in part, subfissile to blocky, occasionally fissile, organic, with Siltstone: as above.
13,620-13,630	Siltstone: now becoming very finely micaceous.
13,630-13,650	Siltstone: very argillaceous, grading to very silty shale.
13,650-13,670	Shale: dark gray, very finely micaceous, fissile to subfissile, silty in part.
13,670-13,710	Limestone: dark brown, very silty, grading to Siltstone: moderate to well indurated, occasional milky calcite from veins or vugs, poor to nil porosity, no show, abundant pyrite, with Shale: as above.
13,710-13,720	Shale: as above, with Limestone: dark brown, hard, dense, silty, nil visible porosity.
13,720-13,760	Shale: gray to black, shiny, fissile, very finely micaceous, rarely silty, abundant pyrite.

13,760-13,810	Shale: as above, with Shale: light gray, soft, lumpy, silty.
13,810-13,820	Shale: as above, with abundant pyrite.
13,820-13,830	Shale: as above, with Limestone: tan to dark brown, very argillaceous, silty, dense, hard.
13,830-13,900	Shale: as above, with Shale: light gray, waxy, soft, tuffaceous(?)
13,900-13,920	Shale: as above, becoming slightly silty in part.
13,920-13,940	Shale: as above, with Shale: medium gray, blocky to lumpy, very calcareous, grading to limestone, with occasional microlaminae and inclusions of carbonaceous material.
13,940-13,960	Shale: as above, but becoming slightly silty in part.
13,960-13,970	Shale: as above, with increase in light gray, very calcareous shale.
13,970-14,010	Shale: as above, with Limestone: light brown, microcrystalline, slightly argillaceous, dense, hard, nil porosity.
14,010-14,035	Sample mostly all lost circulation material, presumed to be 100% shale.
14,035-14,040	Shale: as above, with trace of Limestone: brown, microcrystalline, hard, dense, with a trace of Siltstone: dark brown, very argillaceous, hard, nil porosity, and with abundant pyrite.
14,040-14,090	Shale: as above, but some with coaly appearance.
14,090-14,150	Shale: as above, with occasional free pyrite.
14,150-14,160	Shale: as above, with a trace of Limestone: tan to brown, microcrystalline, hard, dense.
14,160-14,170	Shale: becoming slightly silty in part, becoming more calcareous, grading to limestone in part.
14,170-14,200	Shale: grading to siltstone in part, very argillaceous, with a trace of Siltstone: dark gray, very argillaceous, soft to moderately indurated.
14,200-14,220	Shale: as above, with some shale having tarry appearance when damp.
14,220-14,260	Shale: gray to black, very finely micaceous, some with submetallic luster, calcareous, fissile to splintery.

14,260-14,270	Shale: as above, with a trace of Shale: pale gray, waxy, soft, tuffaceous(?), abundant free pyrite.
14,270-14,280	Shale: as above, but becoming slightly silty in part, with minor Siltstone: dark gray, very argillaceous, grading to Shale: calcareous, moderately indurated, abundant pyrite, some as fossil replacement.
14,280-14,290	Shale: as above, but less silty.
14,290-14,350	Shale: dark to very dark gray, firm to hard and brittle, slightly calcareous, occasionally silty, pyrite common, often as fossil replacement, with traces of light gray, firm, waxy, tuffaceous(?) or bentonitic(?) material, traces of brown, moderately hard, calcareous, argillaceous siltstone.
14,350-14,370	Shale: dark to very dark gray, slightly calcareous, pyritic, moderately hard, silty, micaceous, with interbedded Siltstone: medium to dark gray and brown, very argillaceous, moderately calcareous, hard, micaceous.
14,370-14,520	Shale: very dark gray, slightly calcareous, occasionally silty, fractures papery to blocky, firm to hard, with very fine mica, pyrite and pyritized fossil fragments common, occasional microfossils, occasional concentrations of fine, light green glauconitic pellets, traces of ironstone and light gray tuffaceous(?) material.
14,520-14,530	Sand: medium grained quartz; light gray, loose grains, subangular to subrounded, possibly conglomeratic, probably as a very thin bed (about 2-4") in dark Shale: as described above.
14,530-14,570	Shale: very dark gray, firm to hard, silty, pyritic, calcareous (possibly more calcareous than above).
14,570-14,600	Shale: as above, with minor limestone and siltstone, Limestone: medium to dark gray, lime mudstone with shell fragments (possibly phosphatic), hard, argillaceous, with Siltstone: medium gray, hard, argillaceous, very calcareous, with fine to medium sized, well rounded quartz grains and occasional glauconite pellets.
14,600-14,630	Shale: as above, with interbeds of Limestone: light gray, chalky, porous, lime mudstone with calcareous pelecypod shell fragments and medium to dark gray, Lime Mudstone: hard, tight, argillaceous, with abundant dark gray shell fragments (possibly phosphatic), occasional zones of shale with concentrations of fine, light green glauconitic pellets.

14,630-14,690	Shale: very dark gray, hard, silty, moderately calcareous, very fine mica is common, pyrite abundant, traces show a mixing (possibly biological) of dark shale and light gray, chalky lime mud.
14,690-14,700	Shale: dark gray, hard, slightly calcareous, silty, with Siltstone: very dark gray, very argillaceous, moderately to very calcareous, trace of light gray, chalky, lime mudstone and trace of medium to dark gray, hard, dense, lime mudstone.
14,700-14,726	Limestone: light gray, chalky, silt size and finer crystals, probably as thin beds, with shale and siltstones, as seen above; parts show a pelletal nature and a mixing (possibly biological) of lime mud, which is light gray and very dark gray argillaceous material; set 7-5/8" liner at 14,719'.
14,726-14,748	Limestone: light to dark gray, mottled, very finely laminated, argillaceous, moderately indurated, grades to limestone, which is very shaly, lumpy, soft, silty in part.
14,748-14,768	Shale: dark gray, calcareous, silty, very finely disseminated mica, platy to lumpy, moderately indurated, trace pyrite.
14,768-14,820	Limestone: as above, with interbedded Shale: as above, at 14,820'.
14,820-14,846	Sandstone: clear, frosted and pink grains, very fine grained, "salt and pepper" (common black ferromagnesian minerals), subangular to subrounded, some finely disseminated pyrite, friable to largely unconsolidated, probable fair intergranular porosity, no show.
14,846-14,856	Core No. 12, Cut 10', Recovered 9'
14,846.0-14,855.0' (9.0')	Shale: black, silty, well indurated, fissile to platy, slightly to moderately calcareous, finely disseminated mica, isolated inclusions of pyrite.
14,855.0-14,856.0' (1.0')	No recovery.
14,856-14,898	Interbedded Sandstone and Shale: as above. (Lithology determined by drilling time, nil to very little sand grains in sample.)

14,898-14,958	Sandstone: unconsolidated, very fine grained to silty, composed of frosted, clear to pink quartz grains, subangular to subrounded (only trace in sample), grades to medium grained, angular to subangular, towards base.
14,958-14,980	Siltstone: light gray, sandy, "salt and pepper", argillaceous, well indurated, blocky.
14,980-15,050	Sandstone: unconsolidated, medium to coarse pink, frosted, clear quartz grains, angular to subangular, poor to fair sorting, pyrite nodules, probably fair porosity, with Shale: black, silty, platy, blocky, finely disseminated mica.
15,050-15,140	Shale: black, silty, blocky to platy, finely disseminated mica, as above, grades to siltstone in part from 15,078-15,084' and 15,105-15,117', Sandstone: unconsolidated, fine to medium grained, subrounded to subangular, some poorly cemented with calcite, fair sorting, poor intergranular porosity, no show.
15,140-15,150	Sandstone: unconsolidated, as above, coarse grained, predominantly angular to subangular, with subrounded black ferromagnesian minerals.
15,150-15,210	Sandstone: light gray, very fine grained to silty, fair sorting, subangular to subrounded, moderately indurated, calcite cement, poor intergranular porosity, grades to fine to medium grained, unconsolidated in part, interbedded with Shale: as above.
15,210-15,282	Predominantly Siltstone: medium gray, sandy, very finely micaceous, argillaceous, very calcareous to limy, finely disseminated pyrite, moderately indurated, with Shale: as above.
15,282-15,408	Interbedded Sandstone: unconsolidated, coarse pink, frosted, clear quartz and black ferromagnesian grains, subangular to occasionally subrounded, fair sorting, pyritic, probable fair porosity, with Shale: as above.
15,408-15,438	<u>Core No. 13, Cut 30', Recovered 30'</u>
15,408.0-15,415.0' (7.0')	Shale: black, subfissile to platy, well indurated, noncalcareous, finely disseminated mica, rare, black, minute carbonaceous inclusions.

	15,415.0-15,417.5' (2.5')	Shale: as above, becomes very silty, thinly laminated, very fossiliferous (1/4" bivalves), grades to siltstone, essentially flat dip.
	15,417.5-15,430.5' (13.0')	Shale: black, as above, rare fossils.
	15,430.5-15,434.0' (3.5')	Shale: as above, becomes very silty, fossiliferous (1/4" bivalves), minute carbonaceous inclusions.
	15,434.0-15,438.0' (4.0')	Shale: as above,
15,438-15,548		Siltstone: light gray, "salt and pepper", sandy, moderately indurated, siliceous to calcareous cement, blocky, micaceous, rare glauconite pellets, grades to Sandstone: very fine grained, interbedded with Shale: black, slightly silty, platy, finely disseminated mica, moderately indurated.
15,548-15,610		Predominantly Siltstone: as above, becomes very argillaceous, well indurated, with interbedded Shale: as above.
15,610-15,620		Siltstone: as above, grades to Sandstone: light gray, very fine grained.
15,620-15,720		Interbedded Siltstone: argillaceous, as above, and Shale: as above.
15,720-15,845		Siltstone: light gray, sandy, "salt and pepper", slightly calcareous, finely laminated, blocky, well indurated, with interbedded Shale: black, platy, smooth to silty, finely disseminated Mica: as above.
15,845-16,010		Siltstone: medium gray, very argillaceous, very finely laminated, finely disseminated mica, grades to shale in part.
16,010-16,030		Predominantly Shale: black, platy, firm, finely disseminated mica, well indurated, silty in part.
16,030-16,236		Predominantly Siltstone: medium gray, very argillaceous, finely disseminated mica, finely laminated, blocky, well indurated, grades to Shale: black, silty, finely disseminated Mica: as above.

16,236-16,261 Core No. 14, Cut 25', Recovered 25'

16,236.0-16,261.0' (25.0') Siltstone: medium dark gray, very argillaceous, finely disseminated mica, very well indurated, siliceous, blocky, thinly laminated (1/8-1/2"), with Shale: black, silty to smooth, platy to subfissile, rare pyrite nodules, finely disseminated mica, well indurated, noncalcareous, (density of rock exceeds 2.6 gm/cc) bedding planes exhibit about 8° dip.

16,261-16,385 Siltstone: as in Core No. 14, interbedded with Shale: as above.

16,385-16,420 Siltstone: light gray, sandy, "salt and pepper", finely disseminated mica, siliceous, very well indurated, grades to sandstone towards base.

16,420-16,465 Siltstone: medium dark gray, argillaceous, as above, with interbedded Shale: as above.

16,465-16,500 Siltstone: as above, grades to shale.

16,500-16,778 Predominantly alternating beds of Siltstone: light gray, sandy, as above, and Siltstone: medium dark gray, argillaceous, as above.

16,778-16,929 Interbedded Sandstone: light gray, as above, and Siltstone: dark gray to black, argillaceous, blocky, very well indurated, common pale green glauconite pellets, finely disseminated mica, pyrite nodules, nil porosity.

16,929-16,959 Core No. 15, Cut 30', Recovered 21'

16,929.0-16,950.0' (21.0') Siltstone: dark gray to black, sandy, very argillaceous, common, coarse, pale green (altered?) glauconite pellets, finely disseminated mica, common, coarse, black, shiny biotite minerals, finely disseminated pyrite and pyrite nodules, noncalcareous, occasional convoluted slump structures, extremely hard and brittle, quartzitic, exhibits 25° dip.

16,950.0-16,959.0' (9.0') No recovery.

16,959-16,980 Siltstone: becoming slightly sandy, with occasional sandy lenses and streaks, some quartz grains with glassy appearance, with Shale: as above, gray to dark gray, shiny, micromicaceous.

16,980-17,020 Siltstone: very sandy, grading to sandstone, abundant white altered fledspar or tripolitic chert.

17,020-17,030 Siltstone: as above, but becoming very shaly, grading to Shale: brown, earthy, very silty, grading to siltstone, occasionally banded.

17,030-17,040 Shale: brown, as above, and dark gray, very silty, grading to siltstone, with Siltstone: as above.

17,040-17,050 Siltstone: becoming more sandy, more altered feldspar or chert.

17,050-17,080 Siltstone: grading in part to sandstone.

17,080-17,100 Shale: as above, with Siltstone: as above, but becoming more shaly with a trace of Limestone: light brown, very earthy with some carbonaceous partings, appears to be veinlets along bedding planes.

17,100-17,120 Shale and Siltstone: as above, with a trace of Limestone: dolomitic, gray to dark gray, very argillaceous, very silty, tabular pieces, probably vein material.

17,120-17,134 Limestone: mottled tan and gray, slightly chalky in part, argillaceous, moderate to well indurated, calcite replaced microfossils, no observed porosity, no show.

17,134-17,149 <u>Core No. 16, Cut 15', Recovered 11.5'</u>

17,134.0-17,137.0' (3.0') Limestone: gray, mottled with translucent sparry calcite, very fine crystalline to fine crystalline, moderately fossiliferous with numerous pelecypod and one observed brachiopod, all replaced by calcite, moderately argillaceous, very well indurated, dense, siliceous in part with partial chert-like matrix, nil visible porosity, occasional shaly partings 1/2-2", with approximate 20° dip.

	17,137.0-17,141.0' (4.0')	Limestone: dark gray, very argillaceous, grading to calcareous shale, microcrystalline to very fine crystalline, hard and dense, less siliceous than above, moderately fossiliferous with brachiopods and pelecypods replaced by calcite, nil porosity, bedding, as evidenced by partings, approximately 20°.
	17,141.0-17,145.5' (4.5')	Limestone: gray, occasionally mottled with translucent sparry calcite, moderately argillaceous, occasionally very argillaceous, very fine crystalline to fine crystalline, occasionally medium crystalline, slight to moderately fossiliferous, as above, with fossils replaced by calcite, hard and dense, slightly more siliceous than above, nil porosity, occasional shaly partings, as above.
	17,145.5-17,149.0' (3.5')	No recovery.
17,149-17,160		Chert or silica replaced Limestone: gray, microcrystalline to very fine crystalline, slightly argillaceous, very siliceous, occasionally with blocky fracture, nil porosity, no show.
17,160-17,190		Limestone: tan to gray, very fine crystalline, slightly argillaceous, siliceous, becoming slightly fossiliferous with occasional pelecypods, and with chert or silica replaced limestone.
17,190-17,200		Limestone: much less siliceous than above, with Chert: as above.
17,200-17,210		Limestone: dark gray-brown, very argillaceous, grading to calcareous shale, typically siliceous to very siliceous, with Shale: dark gray, occasionally micromicaceous, very calcareous, grading to limestone, with chert or silica replaced limestone, typically argillaceous.
17,210-17,230		Limestone: dark gray to brown, slight to moderately argillaceous, very slightly siliceous, very fine crystalline to fine crystalline, moderate to well indurated, nil porosity, no show, with Chert: as above.

17,230-17,240 Limestone: as above, but slightly more siliceous, with Chert: as above.

17,240-17,255 Limestone: becoming still more siliceous, with Chert: as above.

17,255-17,286 Core No. 17, Cut 31', Recovered 28'

17,255.0-17,269.0' (14.0')	Shale: light gray, silty, grading to siltstone, generally very siliceous, noncalcareous, subfissile, apparently nonmicaceous, quartzitic in part with some very fine grained to silt-size quartz grains, breaks across grains.
17,269.0-17,277.0' (8.0')	Shale: light gray to dark gray, silty, as above, but very slightly calcareous in part, more siliceous, becoming essentially quartzite bottom 3' with some pinpoint calcite pods.
17,277.0-17,281.0' (4.0')	Shale: light gray to dark gray, silty, as above, but noncalcareous, less quartzitic than above, some rough subfissility, no apparent micas.
17,281.0-17,283.0' (2.0')	Shale: becoming very quartzitic, breaks with subconchodial fracture, breaks across silty quartz grains.
17,283.0-17,286.0' (3.0')	No recovery.

17,286-17,290 Siltstone: very argillaceous, very siliceous, grading to quartzite, gray and gray-brown, some off-white to light gray, very well indurated with some altered chert or weathered feldspar.

17,290-17,300 Siltstone: as above, but less siliceous.

17,300-17,330 Siltstone: as above, but increase in chalky matrix, probably altered feldspar or tripolitic chert.

17,330-17,350 Sandstone: dark gray to black, mottled white and pale milky-blue with probable feldspar, very fine grained to silt, argillaceous, heavy silica matrix, very well indurated, with Siltstone: as above, but becoming carbonaceous in part, with Shale: charcoal-gray, shiny, micromicaceous.

17,350-17,370	Siltstone: grading to quartzite, very slightly calcareous, with chert, grading to quartzitic siltstone.
17,370-17,380	Chert: gray, translucent in part, conchoidal fracture, some silt and sand inclusions, very slightly calcareous in part, with Siltstone: as above.
17,380-17,390	Chert: as above, with Siltstone: very siliceous, grading to chert, with minor Limestone: light gray, very silty, grading to Siltstone: siliceous, chalky matrix, nil porosity.
17,390-17,400	Chert: as above, with silicified siltstone, approaching quartzite, with a trace of quartz grains, very pale amber to milky-gray.
17,400-17,420	Siltstone: as above, but slightly less siliceous.
17,420-17,430	Siltstone: very silicified, essentially quartzite, very slightly calcareous in part, glassy appearance, blocky to subconchoidal fracture.
17,430-17,440	Siltstone: light gray to dark gray, very calcareous, grading in part to Limestone: sandy, occasional microfossils replaced by chert (fusulinids?), moderately siliceous, nil porosity, with Limestone: light gray, chalky, silty, with Chert: as above.
17,440-17,450	Limestone: dark gray, silty, argillaceous, slight to moderately siliceous, occasionally very siliceous, occasionally chalky, organic, H_2S released when HCL added, some calcite mineralization along vugs or fractures, no crystal faces.
17,450-17,480	Limestone: as above, but becoming more siliceous, with Chert: impure, silty, slightly calcareous (H_2S detected on crushing limestone).
17,480-17,510	Limestone: mostly as above, but becoming slightly more chalky and less siliceous, with Chert: as above.
17,510-17,520	Limestone: as above, but slightly more siliceous, with Chert: as above.
17,520-17,540	Limestone: becoming slightly silty and carbonaceous.
17,540-17,550	Siltstone: dark gray to black, grading to quartzite at one extreme and limestone at other, mottled pale blue-green with possible glauconite, very well indurated, nil porosity, with Limestone: as above.
17,550-17,560	Siltstone, replaced with silica, approaching quartzite, calcite in seams and pods with chert, impure, silty, occasionally slightly calcareous.

17,560-17,583 Siltstone: as above, becoming dark gray, argillaceous, very siliceous, calcareous, occasional glauconite, with trace of Limestone: as above.

17,583-17,645 Volcanic Basalt: gray-green, composed of very fine grained feldspar with lath structure in part, grades to kaolin in part, with large dark green chlorite blebs, subangular to subrounded, tan calcite vein filling and large blebs of coarse crystals, rare pyrite inclusions, well indurated, with some red hematite.

17,645-17,728 Volcanic Basalt: light gray-green, predominantly feldspar, kaolinitic, fine to medium grained, abundant tan calcite blebs and veins, decrease in large angular, dark green chlorite, grades downward to very weathered and kaolinitic, chlorite grades to pale green clay, increase in hematite towards base, abundant tan calcite blebs and veins, some milk-white mineral occurring as blebs, pyrite.

17,728-17,815 Volcanic Basalt: as above, grades to dark maroon in part, very fine grained, very hematitic in part, feldspar laths grade to kaolinite, rare pyrite, common to abundant dark green chlorite blebs, subrounded to rounded (oolite looking), abundant tan calcite blebs.

17,815-17,858 Volcanic Basalt: as above, with increase in calcite and chlorite.

17,858-17,888 <u>Core No. 18, Cut 30', Recovered 30'</u>

17,858.0-17,888.0' (30.0') Volcanics, probable basaltic flow, very pale gray-green with groundmass of very fine crystalline bladed irregular white-green mineral (feldspar?) with green microcrystalline silica and subrounded to irregular pods of dark green to black mineral, soft and waxy (probable chlorite, possible talc), some radiating crystal structure in chlorite(?) with occasional pods (amygdules) lined with chlorite with an aureole of calcite and rarely with calcite having an aureole of chlorite and with rare specks of pyrite, pods of pale brown translucent medium crystalline calcite 17,863-17,864' and abundant pods of white medium crystalline calcite at 17,866-17,867', becoming coarse

crystalline to very coarse crystalline at 17,871-17,872', calcite pods decrease below 17,872', some apparent hairline fractures, near vertical, at 17,875-17,876' and filled with white fine crystalline to medium crystalline calcite, rare pods and fractures, with calcite 17,876-17,887', abundant pods and lenses of mostly clear to white coarse crystalline to very coarse crystalline calcite at 17,887-17,888'. NOTE: all calcite and chlorite minerals are obviously secondary in what appears to have been gas vesicles (amygdules).

17,888-17,925 Volcanic Basalt: gray-green, feldspar laths grading to kaolin, trace of hematite, abundant rounded chlorite pellets (oolite appearing) and large angular blebs, generally fine grained matrix, abundant tan calcite blebs.

17,925-17,962 Volcanic Basalt: medium to dark gray-green, increase in chlorite blebs, feldspar grades to kaolinite, very fine grained matrix, large angular and rounded blebs of chlorite, abundant tan calcite blebs, abundant volcanic Tuff: pale blue-gray, smooth texture, very well indurated, subconchoidal fracture, some minute glass shards, trace of hematite.

17,962-18,005 Volcanic Basalt: light gray-green, feldspar laths grading to kaolinite, essentially as above, increase in dark green chlorite blebs and oolite appearing pellets toward base.

18,005-18,090 Volcanic Basalt: light to medium gray-green, very fine grained matrix, highly weathered in part, feldspar grades to kaolinite, and chlorite to pale green clay, some large, angular to oval, chlorite blebs, abundant calcite blebs, with Tuff: pale blue-gray, as above, increase in tuff from 18,058-18,068'.

18,090-18,107 Volcanic Basalt: medium gray-green, increase in chlorite, (large, dark green, rounded pellets), less weathered than above, with large pyrite inclusions.

18,107-18,145 Volcanic Tuff: pale blue-gray, very fine grained to sublithographic, hard, brittle, flaky, with minute glass shards, grades to medium dark green in color, smooth texture, subconchoidal fracture, blocky to flaky, some minute glass shards, with Basalt: as above.

79

86.

18,145-18,170 Volcanic Basalt: light gray-green, feldspar laths in part grading to kaolin, calcite blebs, large, angular to rounded, chlorite, very pyritic towards base, with Tuff: as above.

18,170-18,290 Predominantly Volcanic Basalt: as above. NOTE: Samples from this interval are extremely poor. Composed primarily of Shale: dark brown to black, micromicaceous, subfissile. Appears to be slough.

18,290-18,328 Volcanic Basalt: light gray-green, feldspar laths grading to kaolin, very weathered, moderately indurated, with large, dark green chlorite, abundant tan calcite blebs, pyrite inclusions, trace of tuff. Ran Schlumberger at 18,295'.

18,328-18,350 Shale: dark gray-brown, silty, grades to siltstone in part, blocky, well indurated, micromicaceous, becomes subfissile.

18,350-18,398 Limestone: intrabiocalcarenite, calcilutitic, tan to dark gray-brown, argillaceous in part, coarse grained with very finely crystalline calcilutite and clear spar calcite cement, moderately indurated, dark green specks (glauconite?) with crinoid stems, sponge spicules, some microfossils, rare calcite veins, occasional bryozoa, grades to calcilutite in part.

18,398-18,422 Limestone: as above, becomes primarily calcilutite, very argillaceous, silty to sandy with fine grained rounded quartz; well indurated.

18,422-18,445 Limestone: intrabiocalcarenite, calcilutitic, as above, with trace of Chert: gray.

18,445-18,452 Limestone: dark gray-brown to black, lithographic, vitreous luster, argillaceous, smooth, flaky, hard, brittle.

18,452-18,470 Limestone: intrabiocalcarenite, as above.

18,470-18,492 Limestone: dark brown to black, lithographic, as above.

18,492-18,518 Probably Limestone: intrabiocalcarenite, as above, but logged samples contain only Calcilutite: black, lithographic, as above, and Calcilutite: tan, very finely crystalline, as above.

18,518-18,550 Interbedded Calcilutite: black, lithographic, as above, and Calcilutite: tan, as above.

87

18,550-18,582	Limestone: intrabiocalcarenite, as above, grades to calcilutite in part, with crinoids, bryozoa.
18,582-18,612	Limestone: calcilutitic, dark brown, argillaceous, silty, finely crystalline, hard, blocky.
18,612-18,680	Predominantly Limestone: calcilutitic, dark brown to black, lithographic, vitreous luster, hard, brittle, flaky, conchoidal fracture, argillaceous, grades to Calcilutite: medium gray-brown to tan, very fine crystalline, chalky in part, rare fossil debris, lumpy, moderately indurated, some calcite veins.
18,680-18,700	Limestone: dark gray to black, organic and carbonaceous, occasionally tan in part, seams and veins of calcite, blocky to splintery fracture, dense, siliceous, nil visible porosity.
18,700-18,710	Limestone: becoming gray to dark gray with some gray-black, less organic and carbonaceous than above, with trace of Chert: gray, translucent, smoky.
18,710-18,730	Limestone: mixed gray, dark gray and gray-black, partly organic and carbonaceous, becoming very silty in part, siliceous, dense.
18,730-18,740	Limestone: as above, but less carbonaceous and siliceous.
18,740-18,750	Limestone: becoming more silty, grading to very calcareous siltstone.
18,750-18,770	Limestone: as above, but slightly less silty.
18,770-18,790	Limestone: becoming slightly more dark gray to black, carbonaceous.
18,790-18,810	Limestone: as above, but slightly more siliceous, fragments very splintery to subconchoidal.
18,810-18,820	Limestone: as above, with some free calcite crystals and occasional pieces with drusy calcite crystals from fracture faces or vug linings.
18,820-18,830	Limestone: mostly as above, but becoming slightly more silty.
18,830-18,840	Limestone: as above, with trace of Chert: dark brown to black, blocky.
18,840-18,850	Limestone: as above, becoming more siliceous, grading to impure chert in part, with chert, impure, grading to limestone.

18,850-18,860	Limestone: becoming silty.
18,860-18,870	Limestone: very cherty and siliceous.
18,870-18,880	Limestone: gray and gray-brown, silty, argillaceous, frequently siliceous to cherty, moderate to well indurated, abundant crystalline calcite from vugs or fractures.
18,880-18,900	Limestone: as above, with some finely disseminated pyrite.
18,900-18,920	Limestone: as above, but with frequent subconchoidal fracture.
18,920-18,930	Limestone: as above, with some becoming light gray, very silty.
18,930-18,940	Limestone: as above, with increase in light gray silty limestone, with trace of Shale: charcoal-gray to black, fissile, submetallic luster.
18,940-18,970	Limestone: as above, but becoming slightly more argillaceous, partly carbonaceous, occasional free pyrite.
18,970-18,980	Limestone: silty, as above, with Limestone: gray, microcrystalline, lithographic, some argillaceous and chalky in part, one piece with volcanics on one face, with Volcanic: green, chloritic, probably a flow.
18,980-19,000	Limestone: becoming medium crystalline, some coarse crystalline, abundant chalky pieces, some calcite replacement of fossils.
19,000-19,010	Limestone: gray, very silty to sandy, grading to Siltstone, microcrystalline, dense, occasional specks of pyrite, nil porosity.
19,010-19,040	Limestone: becoming dark gray, carbonaceous, argillaceous, still silty, with trace of Volcanics: red and green.
19,040-19,050	Limestone: as above, with abundant fine grains of pyrite and occasional fine grained, angular, clear quartz.
19,050-19,060	Limestone: as above, very argillaceous and silty and organic, grading to siltstone, pyrite and occasional Quartz, as above.

19,060-19,080	Limestone: as above, but some pieces with very glassy appearance, very minute glassy inclusions, possibly volcanic glass.
19,080-19,090	Limestone: as above, silty, argillaceous.
19,090-19,100	Limestone: as above, but some with dark black asphaltic appearance.
19,100-19,110	Limestone: tan to off-white to light gray, fine crystalline to medium crystalline, abundant spar calcite, inclusions of gray shale, rare pyrite, occasional crystalline calcite as vein material, moderately indurated to dense, nil visible porosity, with trace of Shale: dark charcoal-gray, micromicaceous, submetallic luster.
19,110-19,120	Limestone: as above, with increase in dark gray, argillaceous limestone, increase in pyrite, with trace of Shale: as above.
19,120-19,130	Limestone: dark gray, argillaceous, silty, organic,

19,220-19,230	Limestone: less silty, more fine crystalline to medium crystalline, partly lithographic, with Siltstone: as above.
19,230-19,250	Limestone and Siltstone: as above, with Shale: charcoal-gray, micromicaceous, finely pyritic, submetallic luster, blocky fracture.
19,250-19,260	Limestone: as above, with Siltstone: as above, but becoming very siliceous.
19,260-19,270	Limestone: as above, with Siltstone: very calcareous and siliceous, grading to limestone.
19,270-19,290	Limestone: dark gray, very silty and argillaceous, with Siltstone: as above.
19,290-19,310	Limestone: becoming even more silty to sandy, essentially calcareous siltstone, with Siltstone: generally slightly less calcareous.
19,310-19,320	Limestone: light tan, microcrystalline, chalky to earthy, moderately indurated, nil visible porosity, with decreasing Siltstone: as above.
19,320-19,330	Limestone: as above, but slightly fossiliferous with some pelecypods and one observed fish scale.
19,330-19,360	Limestone: as above, with Limestone: gray, fine crystalline to medium crystalline, abundant pyrite mineralization and occasional pale blue mineral, appears to be altered Chert: siliceous, well indurated.
19,360-19,370	Limestone: dark gray, very argillaceous, very silty, grading in part to very argillaceous Siltstone: organic to carbonaceous, moderate to well indurated, with Shale: dark gray, splintery, calcareous, organic, micromicaceous.
19,370-19,380	Limestone: as above, with some Limestone: tan to gray, mottled darker gray, occasionally fossiliferous with pelecypod and fossil hash, rare, rounded, smoky, very fine grained quartz.
19,380-19,400	Limestone: as above, with floating, very fine grained to silt, subangular quartz grains; all limestone dissolves in acid leaving grains.
19,400-19,410	Limestone: becoming even more silty with heavy silt to very fine grained sand grains in matrix, grading to very calcareous sandstone (some quartz grains could be glass).

19,410-19,430	Limestone and siltstone to very fine grained silty sandstone - completely gradational from very calcareous siltstone to very silty limestone.
19,430-19,440	Limestone: as above, with Siltstone: gray, very argillaceous, very calcareous, grading to limestone.
19,440-19,460	Limestone: as above, with Limestone: cream to off-white, very coarse crystalline rhombs, good rhombic cleavage, small crystals 5 mm or larger.
19,460-19,470	Limestone: as above with Limestone: gray-brown, fine crystalline to medium crystalline, occasional calcite replacement of fossil hash, moderately indurated.
19,470-19,490	Limestone: as above, but becoming slightly silty and argillaceous, some spar calcite in matrix.
19,490-19,510	Limestone: as above, becoming moderately fossiliferous with fossils replaced by calcite.
19,510-19,520	Limestone: becoming dark gray to black, very argillaceous, siliceous, appears to be slightly carbonaceous, no longer fossiliferous.
19,520-19,550	Limestone: as above, but slightly less carbonaceous and argillaceous, more silty.
19,550-19,560	Limestone: as above, with 10% calcite, cream to off-white, rhombic crystals.
19,560-19,570	Limestone: as above, with abundant inclusions of spar calcite, both crystalline and some which appear to be replacement of detrital fossil hash, with trace of chert.
19,570-19,590	Limestone: as above, with abundant calcite, some as small veins through cuttings.
19,590-19,620	Limestone: as above, becoming slightly silty and argillaceous.
19,620-19,630	No sample, 100% walnut hulls.
19,630-19,650	Limestone: light gray to dark gray, siliceous, very silty in part, grading to siltstone, abundant calcite veining.
19,650-19,660	Limestone: becoming very silty and argillaceous, gradational to siltstone, with Siltstone: light gray to dark gray, siliceous, very calcareous, argillaceous, grading to limestone.

19,660-19,670 Limestone: tan to gray, fine crystalline to medium crystalline, abundant spar calcite in matrix, rare broken fossils, mostly replaced by calcite, moderately indurated.

19,670-19,690 Limestone: as above, with some Limestone: dark gray to black, carbonaceous, argillaceous, silty, moderate to well indurated.

19,690-19,700 Limestone: as above, with Limestone: gray, microcrystalline, siliceous, with flint-like appearance, subconchoidal fracture, pyritic in part, very well indurated.

19,700-19,720 Limestone: as above, with increase in fine crystalline to medium crystalline limestone, decrease in microcrystalline, siliceous limestone.

19,720-19,750 Limestone: becoming gray to dark gray, very silty, grading to siltstone, with Siltstone: light gray to gray, argillaceous, very calcareous, grading to limestone.

19,750-19,790 Limestone: as above, but becoming fine crystalline to medium crystalline, abundant spar calcite in matrix, occasional scattered fossil detritus.

19,790-19,800 Limestone: becoming fine crystalline to medium crystalline to coarse crystalline, with increase in calcite replaced fossils, some with recrystallized appearance.

19,800-19,820 Interbedded microcrystalline, lithographic limestone with fine crystalline to medium crystalline, slightly fossiliferous limestone.

19,820-19,850 Limestone: as above, with abundant altered fossils, appears to be brecciated, but probably altered detrital fossil hash, some small rounded inclusions, possible oolites.

19,850-19,890 Limestone: now mostly light tan to tan, fine crystalline to medium crystalline, occasionally chalky to earthy, abundant spar calcite crystals in matrix, moderately fossiliferous with broken altered pieces.

19,890-19,900 Limestone: becoming generally very siliceous, very well indurated.

19,900-19,910 Limestone: tan to brown, fine crystalline to medium crystalline, some coarse crystalline, chalky in part, siliceous in part, with Shale: dark gray, silty, organic, micromicaceous, poor to moderately indurated.

19,910-19,920	Limestone: as above, with Limestone: gray to dark gray, very silty, slightly sandy, argillaceous, grading to siltstone, with shale, very silty, grading to siltstone.
19,920-19,940	Limestone: as above, with Siltstone: dark gray to black, very argillaceous, very calcareous, grading to limestone.
19,940-19,950	Limestone: gray and dark gray, generally argillaceous and silty, some gray to brown, fine crystalline to medium crystalline.
19,950-19,990	Limestone: tan to brown, fine to medium crystalline, some coarse crystalline, abundant inclusions of calcareous detrital material, some fossils, possible crinoid stems.
19,990-20,000	Limestone: becoming gray to dark gray in part, silty, argillaceous, silty to cherty in part, with Shale: dark gray to black, organic, subfissile to fissile, silty, noncalcareous.
20,000-20,020	Limestone: as above, with occasional very coarse crystalline spar crystals.
20,020-20,030	Limestone: as above, with minor Shale: dark gray to black, as above.
20,030-20,102	Limestone: calcarenitic, mottled light gray-brown, composed of fossil detritus (crinoid stems) in spar calcite cement, coarse grained, rare black phosphate pellets, moderately well indurated, nil porosity, grades to Limestone: black to dark brown, silty, argillaceous, carbonaceous, crypto to very finely crystalline, with rare coarse fossil and calcite fragments, dense, well indurated, with chert inclusions, smoky gray to black, some finely disseminated pyrite.
20,102-20,120	Predominantly Limestone: calcilutitic, black, silty, argillaceous, as above, some rare calcite filled seams, trace of pyrite and chert, very siliceous, well indurated, with thin zones of Calcarenite: as above.
20,120-20,218	Interbedded Limestone: calcarenitic, light, mottled gray-brown, as above, and Limestone: black-brown, as above; calcarenite grades to Calcilutite: tan, chalky in part, pyrite and chert inclusions.
20,218-20,227	Limestone: black, silty, as above.

20,227-20,250	Limestone: calcarenitic, tan, as above, rare pyrite, phosphate pellets, calcilutitic in part.
20,250-20,258	Limestone: black, as above, grades to calcilutite, smooth, cryptocrystalline, very siliceous, very well indurated, with calcite filled seams, inclusions of Chert: smoky gray to black.
20,258-20,335	Interbedded Limestone: calcarenitic, tan, as above, grades to Calcilutite: tan, chalky in part, and Limestone: calcilutitic, black, as above.
20,335 Feet	Total depth.

Log Analysis

ARMOUR KANE
Well Log Analyst
18360-6 Cantara St.
Reseda, Ca. 91335
(213) 993-0586

Formation

February 3, 1979

Mr. S. L. Hewitt
Husky Oil/ NPR Operations, Inc.
2525 C Street
Anchorage, AK 99503

Dear Mr. Hewitt:

Schlumberger began logging operations at Tunalik River #1 at 2015 hours on January 24, 1979 and finally finished DLL-MSFL, CNL/FDC, BHC, dipmeter and sidewall cores at 0730 on January 27, 1979. The elapsed time includes 24 hours for a round trip to condition gassy mud. Approximately 10 hours of lost rig-time were caused by tool failure. The logs as obtained are of acceptable quality and 43 of 45 sidewall cores were recovered.

The only formation top was the Torok which was tentatively put at 6015 and was identified from examination of ditch samples. Log responses indicate the possible presence of numerous coal streaks from the casing to about 3500 feet. Five zones totalling 24 feet of sand appear to contain gas although the water saturations are high (55% to 75%), except for one interval 8106-8110 in which Sw is 42%. These quantitative values were computed using an Rw of 0.1 calculated from the positive SP in the shallow (5600) sand and assuming Rw=Rmf=0

zones. This assumption is based on the fact that [illegible] in the deeper
ght line through the sand intervals and is our only means [illegible] SP is a strai
Rw. [illegible] of estimating

on this job were Andy Chaffy and Tom Bruckman who did [illegible] Engineer
ob locating and overcoming their several equipment [illegible] a creditable
ere most cooperative in keeping us informed of their [illegible] failures and
problems.

Very truly yours,

Armour Kane

Mr. Armour Kane

AK/ pab

C-1

Log Analysis

COMPANY: HUSKY OIL/NPR OPERATIONS, INC.
WELL: TUNALIK RIVER NS 1
FIELD: NORTH SLOPE
COUNTY:
STATE: ALASKA

DEPTH	RT	ϕ_D	ϕ_N	ΔT	ϕ_S	Sw				REMARKS
5666-74	9	14	22	75	15	75	R_w	0.1		
7966-71	11	15	27	77	16	57	R_w	0.08		
7974-75	18	12	27	75	15	55	"	"		
8106-10	20	15	20	70	11	42	"	"		
8110-13	18	9	21	71	12	74	"	"		

91

98

Log Analysis

ARMOUR KANE
Well Log Analyst
18360-8 Cantara St.
Reseda, Ca. 91335
(213) 993-0586

Formation

June 6, 1979

Mr. S. L. Hewitt
Husky Oil/NPR Operations, Inc.
2525 C Street
Anchorage, Ak 99503

Dear Mr. Hewitt:

Schlumberger began logging operations on Tunalik Test Well No. 1 on May 31, 1979, at 0230 hours and finished DLL, CNL/FDC, BHC, HRD, Birdwell Velocity Survey and sidewall cores at 0930, June 1, 1979, a total of 31 hours. All logs were of good quality but about two hours of lost rig time were incurred by the failure of an electronic component in the BHC. The engineer recognized the trouble immediately, pulled out of the hole, changed tools and ran a good log. 45 sidewall cores were selected but only 13 were recovered due to the gun being completely covered and packed with lost circulation material from the mud column. Since there was no way of overcoming the problem it was decided not to run another gun.

Correlations with Kugrua, Peard Bay and South Meade wells were very good with the Pebble Shale found in Tunalik at 10,632, Kuparuk River Sand at 10,902 and Kingak at 11,160.

In two intervals, 11,140-50 and 11,517-19, the CNL/FDC response indicated the presence of some gas. Cross-plot porosity in the upper zone is about 10% and Rt averaged at 60 ohm-meters; in the lower zone Rt is 30 ohm-meters and ϕ about 12%. In making quantitative computations Rw was assumed to be the same as R_{mf} (0.15) since the SP is practically a straight line. Based on this assumption, which may or may not be valid but is the only way to approximate Rw, water saturation in both zones is in the 50-55% range. While the sonic response is not the classic "reversal" for a gas sand, it does confirm the porosity values from the CNL/FDC. No other zones of interest were encountered.

Engineers Tom Bruckman and Dave Barnes are to be commended for a very efficient job and highly cooperative attitude.

Very truly yours,

A. Kane

99.

Log Analysis

ARMOUR KANE
Well Log Analyst
18360-6 Cantara St.
Reseda, Ca. 91335
(213) 993-0586

Formation

August 6, 1979

Mr. S. L. Hewitt
Husky Oil/NPR Operations, Inc.
2525 C Street
Anchorage, Ak. 99503

Dear Mr. Hewitt:

Logging operations at Tunalik Test Well No. 1 were begun at 2000 hours on July 26, 1979, and were not completed until 0400 hours on July 31. This total time of 104 hours includes 72 hours of clean-out runs incurred by the extremely rugose and washed out bore hole and the 18.3 pound mud which caused Schlumberger trouble in getting to bottom and which frequently stuck their tools for short periods of time. Finally, DIL, CNL/FDC, BHC, HRD and Velocity Surveys were completed, and, considering the hole conditions, all logs were of good quality except for a few non-critical cycle skips on the BHC. The Schlumberger crews, engineers Bond and Chaffey, are to be commended for their persistent and successful efforts to get to bottom and back out again.

Top of the Tunalik was found at 11,360 and correlated well with the Kugrua #1.

No potentially productive zones were seen on the logs. The sands from 12,500 to 12,600 which apparently caused the gas problem have been deeply invaded and obviously contain large amounts of barite within the pore space. I understand that when circulation was lost in this interval, a few hours later the hole would start making mud, but the returning mud was some two pounds lighter than the original. This would indicate that the barite had been "strained" out and left behind which is confirmed by the very high bulk density values of 2.85 to 3.1 g/cc. The bulk density of barite is 4.5 g/cc. An approximation of porosity can be made by substituting the barite density for fluid density in the porosity equation. This assumes the pore space is completely filled with barite which, of course, is not a valid assumption since some fluid must remain in the pores. However, the computations do result in a porosity "index" which is of some value. Attached is a porosity curve calculated using the bulk density of barite in the equation.

Very truly yours,

A. Kane

A. Kane

101.

Log Analysis

ARMOUR KANE
Well Log Analyst
18360-6 Cantara St.
Reseda, Ca. 91335
(213) 993-0586

Formation Evaluati

November 13, 1979

Mr. S. L. Hewitt
Husky Oil/NPR Operations, Inc.
2525 C Street
Anchorage, Ak 99503

Dear Mr. Hewitt:

Schlumberger began logging operations on Tunalik Test Well No. 1 at 1700 hours on November 3, 1979, and finished DIL at 2030 hours of the same day. Log quality was very good. They began CNL/FDC at 2100 hours and logged up to 15,560 feet when the weak point in the head parted and the tool was dropped at 2300 hours. The first fishing trip failed and on the second attempt the tool was pushed to bottom and engaged in the overshot surfacing at 2230 hours on November 4. The remainder of the CNL/FDC was begun at 2300 hours November 4 and was completed with the BHC at 0630 hours November 5. Log quality of the CNL/FDC was satisfactory except for a peculiar anomaly on the density log from 14,980-15,150 where bulk density was 2.2 g/cc and the correction curve read -0.20. The BHC was very noisy with many "spikes" and skips possibly due to the sonde dragging on the ha rd, rough, deviated bore hole wall. Numerous tight spots and hard pulls were encountered on the run.

A wiper run was begun at 0730 hours November 5 and was completed at 0330 hours November 6 after which the first temperature log began at 0430 hours November 6. An "O" ring failure was experienced at the casing shoe, was replaced and the survey was continued but the tool stopped at 15,485 and the attempt was finished at 1215 November 6. The HRD was begun at 1300 hours and went to bottom all right but the hole was very bad, grabbing the tool some 25 times. Hole deviation went from 8° to 18° in a few hundred feet. The second temperature survey was then attempted but the tool stopped at 14,772. Birdwell's velocity survey was then begun at 2300 hours November 6 and finished at 0900 hours November 7 after having shorting problems on their tools.

No zones of interest were found and the Sadlerochit was at 14,820, Kavik at 15,560, Echooka at 16,890, Lisburne at 17,100 and volcanics at 17,563. Correlations were good with the Kugrua well.

Very truly yours,

A. Kane

Armour Kane

Log Analysis

ARMOUR KANE

Formation Evaluation

Well Log Analyst
18360-6 Cantara St.
Reseda, Ca. 91335
(213) 993-0586

January 3, 1980

Mr. S. L. Hewitt
Husky Oil/NPR Operations, Inc.
2525 C Street
Anchorage, Ak 99503

Dear Mr. Hewitt:

Logging operations were begun at Tunalik Test Well No. 1 by Schlumberger at 1400 hours on December 22, 1979, with the sonic log but a bridge was encountered at 15,200 feet. While trying to get through the bridge the weak point broke, just as it did on the previous run in November, and the tools were left in the hole. Waited for fishing tools from Dead Horse and began the fishing run at 2400 hours, December 22, but the driller lost count of the number of stands and had to pull out and re-strap. The fish was engaged in the early morning hours of December 24 and was recovered at 0500 on December 25. A clean-out and mud conditioning run was begun at 0830 hours and was finished at 2200 hours on December 26.

Schlumberger re-entered the hole with the DIL at 2300 hours, December 26 and finished at 0300 on December 27. The log was of poor quality due partly to a bad hole, high temperature and some engineer error. The heat, which reached 371° during the DIL run, burned out first the IL_D, then the IL_m and the gamma ray. The BHC was run next at about 0500 hours and completed at 1000 hours December 27. Again, the log was of poor quality due to the temperature which had reached 405° and burned out another gamma ray. The log was quite valid for the most part but was very hashy in a number of intervals but repeated the hashiness encountered in the previous run in November. Travel times were extremely fast ranging from 47-60 microseconds per foot indicating very hard formation. Birdwell's velocity survey was successfully completed but on the way out of the hole their tool stuck below 15,000 feet, the cable was pulled off, the fishing attempt was unsuccessful and the tool was left in the hole.

No zones of interest were seen and the base of the volcanics appeared to be at 18,278 feet. Incidentally, the bottom hole temperature on the Birdwell run was still at 405°.

Very truly yours,

Armour Kane

Armour Kane

HUSKY OIL NPR OPERATIONS, INC.
U.S. GEOLOGICAL SURVEY/ONPRA

LOGGING REPORT

WELL NAME TUNALIK RIVER #1

Date January 24, 25, 26, 27, 1979 Driller Depth 8301'

Elevation 109' K.B. Logger Depth 8302'

Logs Ran and Intervals

SP/GR/DLL/MSFL	2584-8301'
GR/BHC	2584-8294'
GR/CAL/FDC/CNL	2582-8300'
HRD-Dipmeter	2584-8300'
CST-Sidewall Sampler	3319-8112'

Additional Logs to Run

None

Zones of Interest

pth	Gross Thickness	Net Feet of Porosity	Lith	Porosity	Sw	Probable Fluid Content
6674'	8'	8'	Sandstone	14	75	Gas & Water
7971'	5'	5'	Sandstone	15	57	Gas & Water
7978'	4'	4'	Sandstone	12	55	Gas & Water
8110'	4'	4'	Sandstone	15	42	Gas
8112'	3'	3'	Sandstone	9	74	Gas & Water

on:

quantitative values obtained using Rw = 0.1 at 566' calculated from SP
w = .08 for lower zones assuming Rw = Rmf since SP is a straight line.

s & Correlations:

rok 6015' (Tentative from ditch samples)

al Evaluation Plans:

DAVE FENEX
Wellsite Geologist

ARMOUR KANE
Log Analyst

D-1

12/77

107

HUSKY

HUSKY OIL NPR OPERATIONS, INC.
U.S. GEOLOGICAL SURVEY/ONPRA

LOGGING REPORT

WELL NAME TUNALIK #1

Date May 31, June 1, 1979 Driller Depth 12,386'

Elevation 109' KB Logger Depth 12,388'

Logs Ran and Intervals

GR/SP/DLL	8298-12,374'
GR/CAL/CNL/FDC	8298-12,387'
GR/BHC	8298-12,384'
HRD-Dipmeter	8298-12,387'
Birdwell Velocity Survey	6500-12,355'
CST-Sidewall Samples	8450-12,374'

Additional Logs to Run

Zones of Interest

Depth	Gross Thickness	Net Feet of Porosity	Lith	Porosity	Probable Fluid Content
11,440-50'	10	10	Sandstone	10%	GAS - Sw 55% ±
11,517-19'	2	2	Sandstone	12%	GAS-Sw 53% ±

Discussion:

The above Sw values are based on Rw = 0.15 assuming Rw = Rmf since the SP is a straight line. This may or may not be a valid assumption. Sonic response is not characteristic of gas but confirms the 10% porosity.

Log Tops & Correlations:

	TUNALIK	PEARD	KUGRUA	S. MEADE
PEBBLE SHALE	10,632'	6195'	6890'	6475'
* KUPARUK RIVER SAND	10,902'	6530'	7201'	6716'
* KINGAK	11,460'	6590'	7304'	6730'

Additional Evaluation Plans:

* Tops were furnished from the field and are now incorrect in the light of paleo dating.

GORDON LEGG
Wellsite Geologist

ARMOUR KANE
Log Analyst

12/77

HUSKY

HUSKY OIL NPR OPERATIONS, INC.
U.S. GEOLOGICAL SURVEY/ONPRA

LOGGING REPORT

WELL NAME TUNALIK #1

Date JULY 25-31, 1979 Driller Depth 14,726'

Elevation 109' KB Logger Depth 14,735'

Logs Ran and Intervals

GR/SP/DIL	12,385-14,729'
GR/CAL/CNL/FDC	12,385-14,718'
GR/BHC	12,385-14,710'
HRD	12,382-14,650'
Velocity Survey	Top shot 12,505'; bottom shot TD (14,700')

Additional Logs to Run

None

CST not attempted because of adverse hole conditions.

Zones of Interest

Depth	Gross Thickness	Net Feet of Porosity	Lith	Porosity	Probable Fluid Content
Sand stringers from 12,870-12,960' are all of low porosity, 3-8%. *See below.					

Discussion:

*The sand between 12,500' and 12,600', which apparently caused the gas problem, shows no evidence of gas on the porosity logs. This is probably because of barite left within the pore space during lost circulation and invasion. Bulk densities from 12,510-12,560' range from 2.70 to 3.0 g/cc. Barite bulk density = 4.5.

Log Tops & Correlations:

	Tunalik
* Kingak	13,670'
Sag River	14,350'
Shublik	14,493' (?)

Additional Evaluation Plans:

NONE.

* Field top - incorrect

R.V. NELSON/H. HAYWOOD
Wellsite Geologist

ARMOUR KANE
Log Analyst

12/77

III.

HUSKY OIL NPR OPERATIONS, INC.
U.S. GEOLOGICAL SURVEY/ONPRA

LOGGING REPORT

WELL NAME TUNALIK #1

Date Nov. 3 - 7, 1979 Driller Depth 18,295'

Elevation 109' KB Logger Depth 18,282'

Logs Ran and Intervals

GR/SP/DIL	14,722-18,276'
GR/CAL/CNL/FDC	14,723-18,278'
GR/BHC	14,722-18,273'
Temperature (2)	1) 100-15,485'; 2) 75-14,772'
Birdwell Velocity Survey	14,690-TD (12 levels)
HRD-Dipmeter	14,705-18,271'

Additional Logs to Run

None

Zones of Interest

Depth	Gross Thickness	Net Feet of Porosity	Lith	Porosity	Probable Fluid Content
NO ZONES OF INTEREST					

Discussion:

BHC very noisy due to rugose; deviated borehole with numerous tight spots; "M" "N" calculations plot mainly in the Dolomite region through the Volcanics interval.

Log Tops & Correlations:

	TUNALIK	KUGRUA
Sadlerochit	14,820'	9,989'
Kavik	15,560'	10,828'
Echooka	16,890'	10,988'
Lisburne	17,100'	11,160'
Volcanics	17,563'	

Additional Evaluation Plans:

DAVE FENEX
Wellsite Geologist

ARMOUR KANE
Log Analyst

12/77

HUSKY OIL NPR OPERATIONS, INC.
U.S. GEOLOGICAL SURVEY/ONPRA

LOGGING REPORT

WELL NAME TUNALIK #1

Date December 22-27, 1979 Driller Depth 20,335'

Elevation 109' KB Logger Depth 20,328'

Logs Ran and Intervals

GR/SP/DIL 18,000-20,322' *

GR/BHC 18,000-20,329'

Birdwell Velocity Survey Top: 17,563 - Bottom: 20,300'

HRD, CNL/FDC and CST cancelled due to adverse hole conditions.

Additional Logs to Run

NONE

Zones of Interest

Depth	Gross Thickness	Net Feet of Porosity	Lith	Porosity	Probable Fluid Content
	NO ZONES OF INTEREST				

Discussion:

Borehole very rough and hot - burned out 2 GR tools and one DIL.

* DIL was recorded 19' shallow. Depths shown above have been corrected.

Log Tops & Correlations:

No identifiable formation tops.

Base Volcanics 18,278'

Additional Evaluation Plans:

DAVE FENEX
Wellsite Geologist

ARMOUR KANE
Log Analyst

12/77

15.

CORE LABORATORIES, INC.
Petroleum Reservoir Engineering
DALLAS, TEXAS

Company USGS/HUSKY OIL COMPANY, OPR Formation _____ Page 1 of _____
Well TUNALIK #1 Cores DIAMOND File BP-3-530
Field WILDCAT Drilling Fluid WBM Date Report JUNE 6,1979
County NORTH SLOPE State ALASKA Elevation _____ Analysts WSP
Location _____ Remarks PERM & BOYLES LAW POROSITY

CORE ANALYSIS RESULTS

(Figures in parentheses refer to footnote remarks)

SAMPLE NUMBER	DEPTH FEET	PERMEABILITY MILLIDARCYS			POROSITY PERCENT	GRAIN DENSITY	RESIDUAL SATURATION		REMARKS
		Horizontal Maximum	Horizontal 90°	Vertical			Oil % Pore	Total Water % Pore	
1	5558	0.0			7.2	2.70			ss,vfg,v calc
2	5559	0.0			5.2	2.69			same
3	5560	0.1			10.8	2.69			same
4	5561	0.3			10.8	2.69			same

These analyses, opinions or interpretations are based on observations and materials supplied by the client to whom, and for whose exclusive and confidential use, this report is made. The interpretations or opinions expressed represent the best judgment of Core Laboratories, Inc. (all errors and omissions excepted); but Core Laboratories, Inc., and its officers and employees, assume no responsibility and make no warranty or representations, as to the productivity, proper operation, or profitableness of any oil, gas or other mineral well or sand in connection with which such report is used or relied upon.

LISTING OF OTHER AVAILABLE DATA

A. Micropaleontology Reports by Anderson, Warren & Associates, Inc.

1. Foraminifera Report, dated 1-17-80
2. Palynology Report, dated 1-17-80

B. Drilling History of Tunalik Test Well No. 1 by Husky Oil.

SOURCE OF OTHER GEOLOGICAL AND WELL DATA

Copies and some reproducibles of information referenced in this report which was generated as part of the USGS/NPRA exploration effort, can be obtained by contacting:

National Oceanic and Atmospheric Administration
EDIS/NGSDC (D62)
325 Broadway
Boulder, CO 80303