NATIONAL PETROLEUM RESERVE IN ALASKA

GEOLOGICAL REPORT

SOUTH BARROW WELL NO. 19

HUSKY OIL NPR OPERATIONS, INC.
Prepared by: R. G. Brockway

For the

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

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GEOLOGIC SUMMARY

INTRODUCTION

The South Barrow Well No. 19, 1320' FEL and 1320' FSL, protracted Section 23, T22N, R17W, Umiat Meridian (Figures 1 & 2), was drilled to define the northern limits of the East Barrow Gas Field. Drilling began below conductor casing at 80' (driller's depth) on April 18, 1978. Rocks of Cretaceous through Triassic age were penetrated. The drilling was terminated at a total depth of 2,300 feet on May 6 in argillite of indeterminate age, and the rig was released on May 16, 1978.

In each of the South Barrow wells drilled after South Barrow No. 13, an inhibitive mud system, containing calcium-chloride, was used after intermediate casing (commonly 9-5/8" to approximately 1,500 feet). This was done in order to minimize damage to potential reservoirs caused by swelling clays, which are present in the Barrow sandstones and the Sag River Sandstone (determined by water susceptibility tests on cores from South Barrow Nos. 12 and 13 wells). The high concentrations of calcium-chloride used in the section below the intermediate casing, necessitated running a dual laterolog, as the high calcium and chloride ion concentration in the drilling mud adversely affects the measurement of conductivity by the dual induction log. The dual induction log was run in the upper part of each well where fresh-water-mud was used.

Five conventional cores were cut and 75 sidewall cores were shot with a recovery of 66. One drill-stem test and one production test were undertaken.

The well was completed as a suspended gas well.

PRE-DRILLING PROGNOSIS

The primary objective of the well was the Lower Barrow sandstone, with the Sag River Sandstone, thin sandstones in the lower "Pebble Shale", and possibly the Upper Barrow sandstone, as secondary objectives.

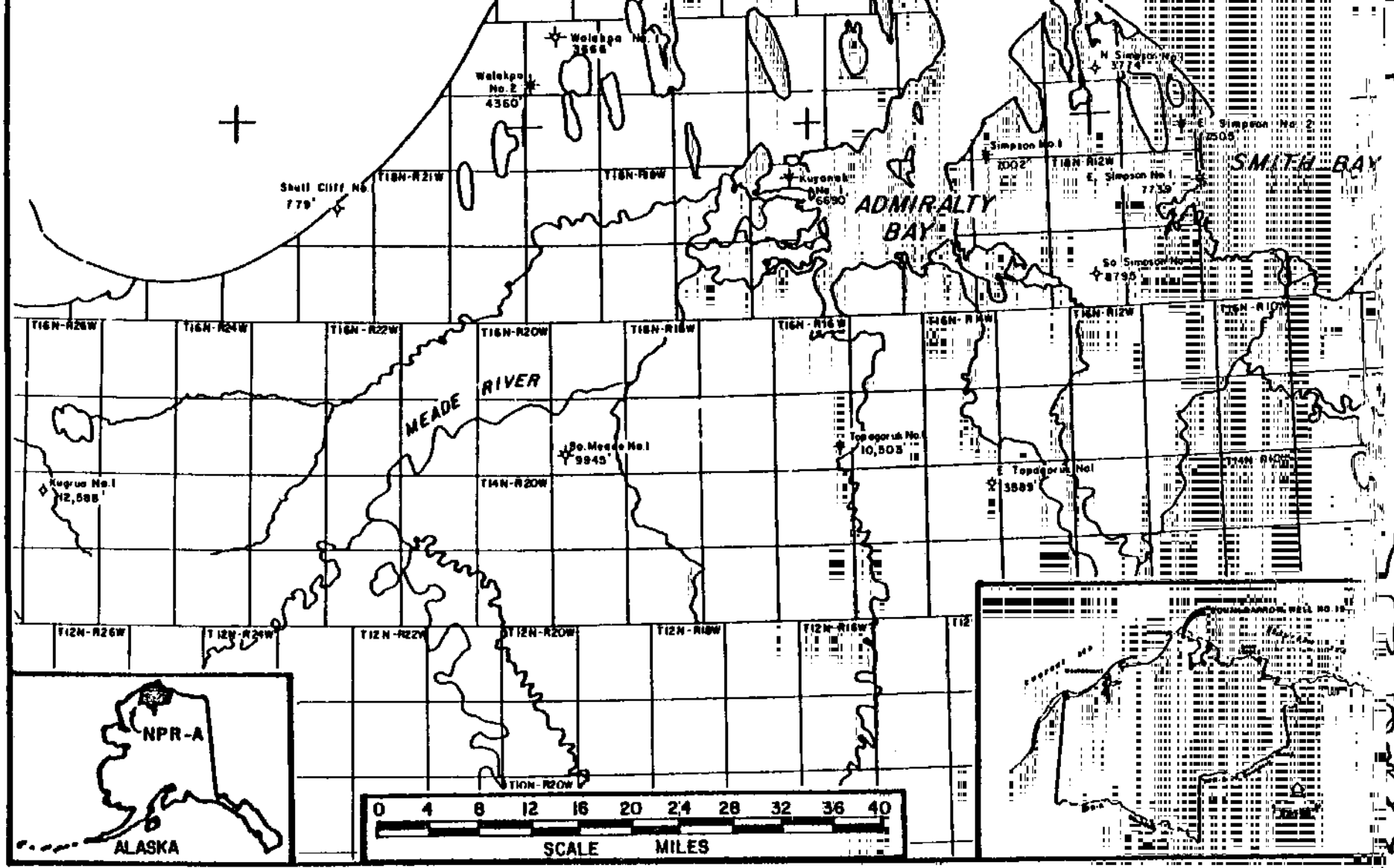
POST-DRILLING SUMMARY

Drilling of Well No. 19 confirmed a northward extension of the East Barrow field and established that it was higher on structure than either of the two correlating wells, South Barrow Wells Nos. 12 and 17. At the top of the Lower Barrow sandstone, Well No. 19 was 17 feet higher than No. 12 and 81 feet higher than No. 17 (Figure 3).

The Lower Barrow sandstone had 17 net feet of porous sandstone with porosities averaging 22% and a water saturation of 40% (Appendix C). This zone was production tested with a calculated absolute open flow of 7.22 MMCFGPD (Appendix H). This establishes this well as the best in the field.

A drill-stem test of the Sag River Sandstone recovered an estimated 800,000 CFGPD and 7 gallons of gassy oil-cut mud from the interval 2161-2245' (Appendix E). Analysis of Core No. 5 (2230-2245') shows porosities of 9.1 to 22.1 and poor to fair permeabilities.

Other secondary objectives ("Pebble Shale" and Upper Barrow) contained hydrocarbon shows, but because of thin bedding, low permeabilities and argillaceous content, they were not deemed worthy of testing.



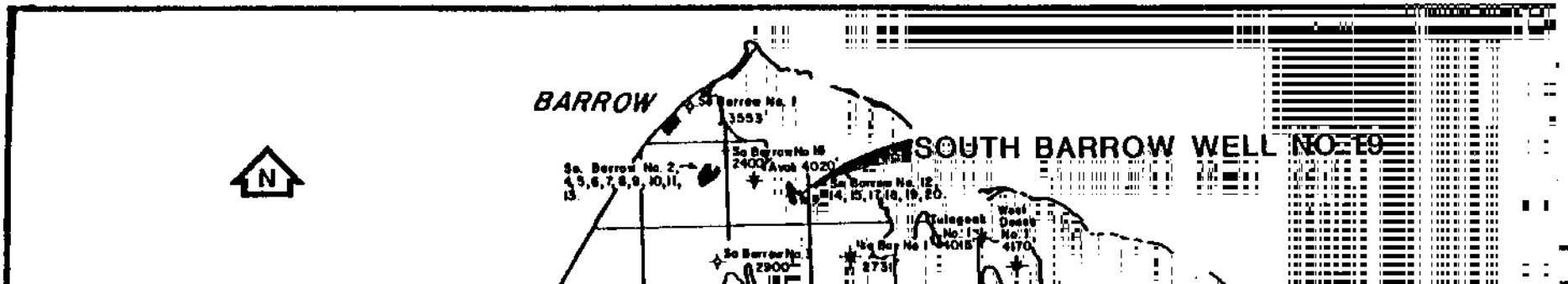
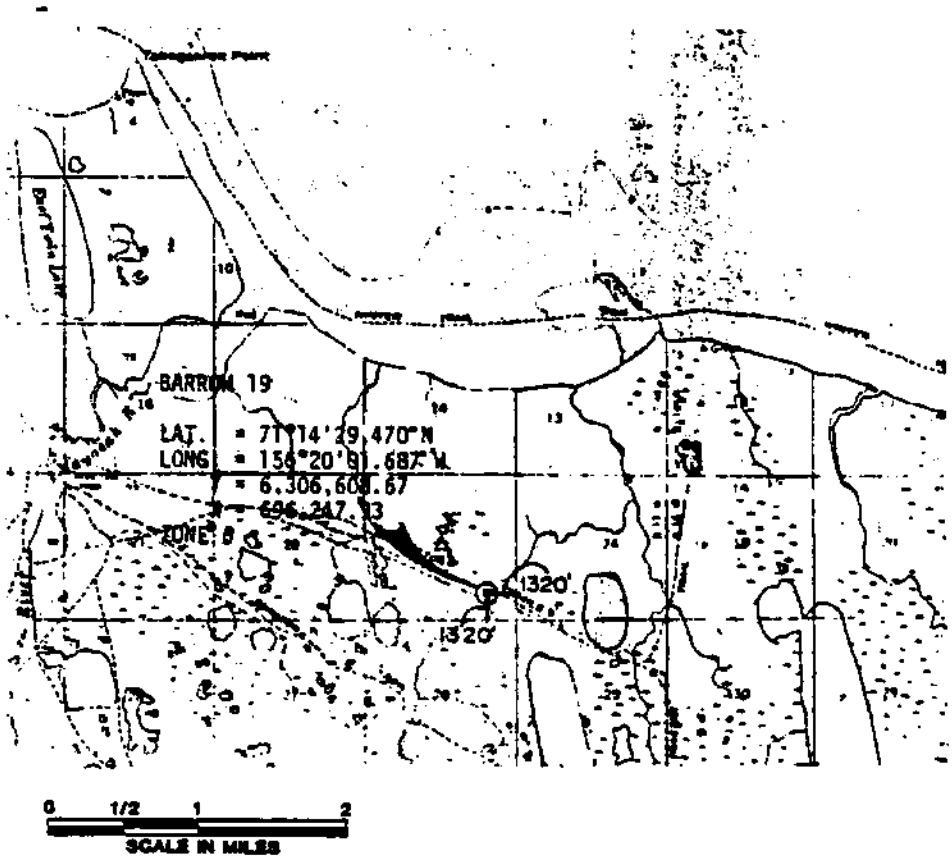


FIGURE 1 - LOCATION MAP - SOUTH BARROW WELL NO. 19



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 24, 1977

STATE OF ALASKA 49TH JOHN H. HERRING No. 953-S REGISTERED PROFESSIONAL LAND SURVEYOR

AS STAKED

BARROW 19

LOCATED IN

SE 1/4 PROTRACTED SEC. 23 T22 N, R17W UMIAT MERIDIAN, AK

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 - CERTIFICATE OF SURVEYOR - SOUTH BARROW WELL NO. 19

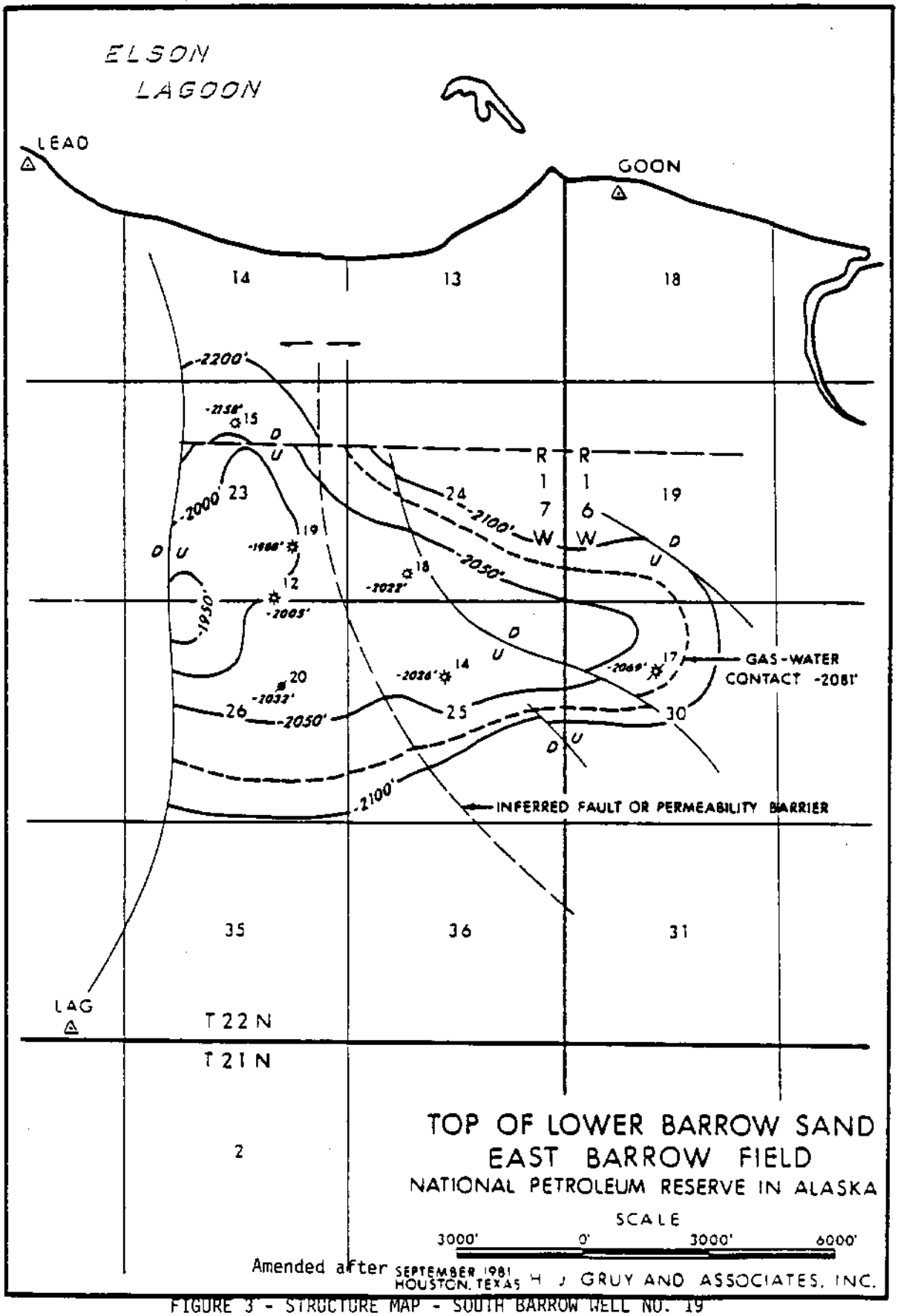


FIGURE 3 - STRUCTURE MAP - SOUTH BARROW WELL NO. 19

WELLSITE GEOLOGIST'S REPORT
BY: D. YOUNG
REVISED BY: R. G. BROCKWAY

INTRODUCTION

The South Barrow Well No. 19 was drilled as a step-out well to help delineate the northern limit of the East Barrow Gas Field. The Lower Barrow sandstone was the primary objective. Additional objectives were the Sag River Sandstone and the thin persistent sands of the "Pebble Shale". The well was drilled to a total depth of 2,300 feet, penetrating rocks of Cretaceous to Triassic age and terminated in the argillite of indeterminate age. The Lower Barrow sandstone included 17' of net porous sand; it was production tested at a rate of 7.22 MMCFGPD calculated absolute open flow. The "Pebble Shale" sandstone stringers were poorly developed and were not tested. The Sag River Sandstone, with a gross thickness of 54' of shaly sands, was drill-stem tested at an estimated rate of 800 MCFGPD. Gas- and very slightly oil-cut mud were recovered from the test tools. The well was completed as a suspended gas well from the Lower Barrow sandstone.

A total of five conventional cores were cut. Core No. 1 was cut for stratigraphic purposes to help define the Torok-"Pebble Shale" boundary. Cores Nos. 2, 3, 4, and 5 were taken for reservoir purposes. In addition to the conventional cores, 75 sidewall cores were shot with 66 recovered. Drill-bit cuttings were continuously collected from spud to total depth. Sample increments of 30' were used from spud to 1500' and 10' from 1500' to total depth.

STRATIGRAPHY

WIRELINE TOPS

	DRILLED DEPTH (FEET BELOW KELLY BUSHING)	SUBSEA
CRETACEOUS		
Torok Formation	100' samples start	-70'
"Pebble Shale"	1352'	-1322'
JURASSIC		
Kingak Formation	1744'	-1714'
Upper Barrow sandstone	1952'	-1922'
Lower Barrow sandstone	2018'	-1988'
TRIASSIC		
Undifferentiated	2153'	-2123'
Sag River Sandstone	2194'	-2164'

INDETERMINATE		
Argillite	2264'	-2234'
TOTAL DEPTH	2300'	-2270'

CRETACEOUS

Torok Formation: 100-1352'

Lithology of the Torok consists of interbedded sandstones, siltstones and claystones. The sandstones, most prominent in the upper 370' and lower 150' of the formation, are light gray, fine grained, hard, carbonaceous, argillaceous, calcareous and in part pyritic. A few small gas shows were recorded below 1190'. Siltstones are dark gray, hard and calcareous. The claystones are medium to light gray, soft, sticky, and silty in part. Scattered fossil fragments are present.

The first paleontological age determinations by Anderson, Warren & Associates, Inc. indicate an age of Early Cretaceous, Aptian to Albian, to a depth of 1330'. Faunal diversity and abundance suggest a middle neritic environment of deposition for the interval from 100' to 820'. With species diminishing in diversity and abundance from 820' to 1330', only some type of marine conditions is suggested. No identifiable log correlations exist within the Torok, although faunal correlation points at 160' and 430' appear to be recognizable with South Barrow Wells Nos. 12, 14 and 17.

Bulk lithology for the Torok is approximately 80% claystone, 17% siltstone, and 3% sandstone.

"Pebble Shale": 1352-1744'

It appears from the electric logs that the zone 1712-1744' may be a transition zone above the lower Cretaceous unconformity. Sidewall cores at 1732' and 1737' recovered black shale with medium to coarse grained and pebble-size quartz and chert. Ditch samples indicate brown shales, dark gray siltstone, and 20-30% loose chert, quartz, and argillite pebbles. A 320-unit gas reading was present from 1740-1745', and it may be that a remnant of the basal "Pebble Shale" conglomerate is present from 1740-1744'. The E-logs indicate a "dirty" sand, conglomerate or siltstone in this interval.

Age of the interval 1680-1740' is determined by Anderson, Warren & Associates, Inc. (Final Micropaleontological Report, July 25, 1978) as Early Cretaceous to Late Jurassic (Neocomian). They note that "this assemblage contains forms suggestive of Late Jurassic but could conceivably still be in Early Creataceous". Possibly the Jurassic forms are reworked from pre-existing Jurassic rocks cut by the lower Cretaceous unconformity.

The environment of deposition for the "Pebble Shale" is thought to have been neritic to middle bathyal with turbid conditions.

Bulk volume is approximately 77% claystone, 15% siltstone and 8% sandstone.

JURASSIC

Kingak Formation: 1744-2153'

The top of the Kingak Formation, which contains the Upper and Lower Barrow sandstones, has been placed at 1744', the base of the transition zone. From 1744' to 1952', the rocks are composed of brownish-gray shales and brown claystones with interbedded light and dark gray siltstones and some thin light gray, fine to very fine grained sandstones.

Upper Barrow sandstone: 1952-2006'

Sandstones of the Upper Barrow are light gray, very fine grained, glauconitic and argillaceous. Fossil wood and lignite are common. Interbedded with the sandstones are thin siltstones and shales. Poor hydrocarbon shows were observed in the sandstones. Environment of deposition is thought to be shallow marine off bar facies.

The base of the Upper Barrow has been picked at 2006', the base of a thin resistive zone on the DIL or DLL logs and a shale break on the gamma-ray logs that can be correlated throughout the field.

Separating the Upper Barrow from the Lower Barrow is a sandstone and shale sequence. The sandstones are similar to those of the Upper Barrow and have some hydrocarbon shows. At the base of this interval and capping the Lower Barrow sandstone is a thin 1-2' shale that is readily recognized and used as a marker bed on the gamma-ray logs throughout the field.

Lower Barrow sandstone: 2018-2037'

At 2018', a 19' section of porous Lower Barrow sandstone was entered. The sands of the Lower Barrow are interpreted to be central bar facies. The quartz sand is tan to light gray, very fine grained, clean to slightly argillaceous, friable, glauconitic, with occasional lignite and fossil wood fragments. Some swelling clay in the matrix is indicated by swelling and disintegration of samples in fresh water. Sidewall cores indicate claystone pods and partings with poorly preserved crossbedding at 2032'. Large soft, clayey, dark green glauconite grains were noted in a sidewall core at 2036'. Good hydrocarbon shows were observed and the zone 2018-2044' was production tested at a calculated AOF rate of 7.22 MMCFGPD.

The Kingak Formation below the Lower Barrow from 2037' to 2153', consists of light gray, very fine grained, argillaceous quartz sandstone interbedded with dark gray siltstones and light gray silty claystone.

Core No. 2 (2039-2069') is interbedded light gray, very fine grained, argillaceous sandstone and medium to dark gray siltstone, with common lignite and fossil wood. Swelling clays are indicated by fresh-water tests. A thin bed of pelecypods (species unknown) occurred at 2048'. No dips were apparent from the core and it is thought that bioturbation has removed all evidence of bedding in these strata.

The strata of the Kingak Formation have been assigned an Early to Middle Jurassic age (AWA Zones F-17 to F-18).

Environment of deposition below 2153' to 2250' is thought to have been inner to middle neritic.

TRIASSIC

Undifferentiated: 2153-2194'

A 41' interval of Triassic rocks, identified by paleontology, is present above the Sag River Sandstone. It is composed of thin interbedded tan to light gray, fine to coarse grained sandstones, medium gray siltstones and light gray claystones. The faunal top of the Triassic (AWA Zone F-19 which extends to 2250') was picked at 2153'. No hiatus is apparent in the samples.

Sag River Sandstone: 2194-2264'

The Sag River top was picked on the basis of samples and electric log responses and is marked by a thin bed of limestone that is tan, hard, sandy, and slightly glauconitic. This bed was also noted in South Barrow Well No. 17. The top of the sandstone is thought to be at 2200'. Cores Nos. 3, 4, and 5 (2209-2245') were cut in the Sag River. Lithology of the cores was very fine grained quartz sandstone. The sandstone is brown, well sorted, well rounded, argillaceous, calcareous, with common shell fragments and glauconite. Thin biocalcarenite shell pods (probably echinoid plates and pelecypods) occur at 2219' and 2230-2233'. The limestone is white to tan with viscous oil in intergranular porosity. Thin

stringers of soft amorphous glauconite and dark gray-brown shale also occur. At 2222', bedding planes of 45° were noted. These are interpreted as probably foreset beds. Minor fracturing was noted at this depth also, being parallel to and at right angles to the bedding planes. Good oil stain is present throughout the Sag River. A much higher percentage of sandstone was noted in the Sag River in this well than in South Barrow No. 17 where sandy biocalcarenite is the predominant lithology.

Drill-Stem Test No. 1 (2161-2245') recovered an estimated 800 MCFGD and 7 gallons of gas- and slightly oil-cut mud.

Lithology from 2245' to the top of the argillite at 2264' consists of light gray, argillaceous, calcareous sandstone with interbedded medium gray, soft claystone.

Environment of deposition for the Sag River is suggested to be inner to middle neritic.

Bulk lithology of the Sag River is approximately 14% shale, 16% limestone, and 70% sandstone.

PRE-MISSISSIPPIAN

Argillite: 2264-2300' (Total Depth)

The argillite was entered at 2264' with a change in lithology to dark gray-black, firm to hard, slightly graphitic, pyritic argillite. Finely disseminated pyrite, thin quartz lenses, and free quartz are common in the ditch cuttings.

STRUCTURE

Core No. 1, 1330-1360', which included the Torok-"Pebble Shale" contact had poorly developed partings in the shale and claystone indicating horizontal bedding with no apparent unconformity.

A Schlumberger 4-arm dipmeter was run over the interval 1500' to 2174' to aid in structural interpretation. Low dip angles ranging from 2° to 4°, trending generally north-northwest, occur from 1550' to 1740'. At the top of the Kingak Formation (1744'), which is considered to be a surface of unconformity, dip increased to a maximum of 8°, averaging 4°, with direction changing from north-northwest to north-northeast.

From 1800' to 2039', dips range from 2° to 5°, averaging 3°, with direction to the north and northeast. A sidewall core at 2032', with poorly preserved crossbedding, indicated low angle bedding on shale partings.

From 2039' to 2080', dip continues at a 3° average with direction changing from north-northeast to south-southwest. No dip information was detectable from Core No. 2, 2039-2069'. Bioturbation probably has removed all evidence of bedding in this interval.

From 2080' to 2170', dips range from 4° to 6°, averaging 5°, with orientation to the west.

A dipmeter was not run in the bottom-hole section of the well due to small hole size. Cores Nos. 3, 4, and 5 were cut over the interval 2209' to 2245'. Low angle dips of approximately 5° are present on shale partings. At 2222', poorly developed 45° foreset bedding was noted.

OIL AND GAS INDICATIONS

Torok Formation

Very slight indications of methane gas were noted from the start of logging at 100'. Total gas increased from 2 units at 845', to an average of 40 units to 900' (maximum 80 units) and contained the first occurrence of ethane. Small gas peaks were noted at 1190', 1240', 1290', and 1315' from thin sandstone stringers. These sandstones are generally light gray, fine grained, argillaceous, and hard.

No potential reservoir rock was present in the Torok Formation.

"Pebble Shale"

A gas reading of 576 units was logged at 1475' to 1480' on the mud log and appears to be associated with a thin limestone which was present in the 1470-1480' samples. Possibly some sandstone is present but was not detected in the samples. The S.P. log indicates a slight amount of porosity at 1476'. Components of the gas were: methane, 10,500 ppm; ethane, 300 ppm; and a trace of propane. A sidewall core cut at 1476' recovered claystone.

From 1587' to 1594', a light gray, fine grained sandstone stringer was cut giving a gas peak of 296 units. Dull yellow-gold sample fluorescence, giving a slow, streaming, yellow cut fluorescence, was observed. Analysis of a sidewall core at 1587' indicated an effective porosity of 23.4% and a permeability of 26 millidarcies.

At 1640' to 1643', another sandstone stringer was penetrated. A gas reading of 960 units was noted with components of 60,000 ppm methane and traces of ethane. The sandstone, light gray and very fine grained, had bright yellow sample fluorescence and an immediate yellow cut fluorescence.

Other thin sands occur at 1660' to 1662'; 1695' to 1697'; and 1710' to 1715'. These sands gave minor gas readings; however, they were more argillaceous than the preceding sands.

Kingak Formation

Gas peaks of 280 to 390 units occurred at 1940' and 1950', respectively, from thin argillaceous sandstone beds.

The Upper Barrow sandstone was entered at 1952', and below this depth, fairly continuous sandstones occur. Fourteen sidewall cores were recovered from 1952' to 2018'. Lithology of the sidewall cores was predominantly sandstone, generally light gray, very fine grained, argillaceous, poorly consolidated with silt and clay in the matrix. Tests indicate the presence of swelling clays. There was a poor gas odor, and rare dull gold fluorescence with a slight crush cut from chloroethane. Measured porosities from sidewall cores range from 18.8% at 1996' to 26.4% at 1972', with the average being 20.9%. Horizontal permeability ranging from 9.4 millidarcies at 1996' to 273 millidarcies at 1972' were noted. Water saturations are all in excess of 50%. A gas peak of 270 units was noted within this interval.

The Lower Barrow sandstone was picked by log and samples at 2018'. The sandstones become cleaner with less clay and silt content than those above, and have higher effective porosities, lower water saturations, and higher horizontal permeabilities. Porosities range from 17.4% at 2020' to 26.1% at 2034', as measured from sidewall cores. Log-derived porosity averages 21%, with water saturation calculated at 40%. Gross thickness of the pay sand is 19' with 17' of net pay.

At 2020', gas rose from a background of 100 units to a peak of 1,500 units. Gas readings remained at 1,000 units to a depth of 2039', where mud weight was raised from 10.7 ppg to 11.7 ppg prior to coring. The component breakdown of the gas was 92,000 ppm methane, 20,000 ppm ethane, with a trace of propane. Good gas odor, stain, and yellow fluorescence were present in the samples.

The interval directly beneath the porous Lower Barrow sandstone was cored from 2039' to 2069' (Core No. 2). This interval had sample fluorescence, good gas odor, and yellow cut fluorescence. Below 2069' and down to the top of the Sag River Sandstone, no hydrocarbon shows were observed.

The Lower Barrow sandstone was production tested at a calculated absolute open flow rate of 7.22 MMCFGPD. Actual gauging on 29/64" choke was 3.687 MMCFGPD. Additional test information is available in Appendix H.

Sag River Sandstone

The Sag River was encountered at 2194'. A very slight increase in gas was noted from 10 units to 20 units. Maximum gas of 200 units was recorded at 2250' in the basal portion of the Sag River. The gas was composed entirely of methane.

Cores Nos. 3, 4, and 5 (2209-2245') were generally bleeding oil and gas with good gas odor. Fractures, with good oil staining on the faces, were present in Core No. 4. Good to spotty gold fluorescence and light brown chloroethane cuts were present throughout the Sag River. At 2230' to 2233', dark brown tarry oil was present in interparticle porosity in a biocalcarenite sequence.

Drill-Stem Test No. 1 was run from the 7" casing shoe at 2161' down to 2245' in the Sag River. A 540 psi nitrogen cushion was used. One flow period of 225 minutes was used with gas to the surface in 23 minutes. Flow rate stabilized at 800 MCFGPD (estimated) through 3/4" choke. Fluid recovery consisted of gas- and very slightly (less than 1%) oil-cut emulsified drilling mud. Pressure charts indicate a low productivity depleting reservoir.

Pressure Data - Bottom Bomb at 2216'

IHP	1,270 psi
IFP	331 psi
FFP	204 psi
ISIP	1,017 psi
FHP	1,220 psi
Temperature	55°F

Argillite

The argillite was entered at 2264'. No hydrocarbon indications were noted from the argillite down to total depth of 2300'.

CONCLUSIONS

1. The complete sedimentary section was penetrated and evaluated at this location.

2. The "Pebble Shale" sandstone stringers appear to be gas bearing; however, clay and silt in the matrix combined with the thinness and probable discontinuity of the beds make significant production unlikely.

3. The well extended the East Barrow Gas Field one location to the north and proved up an additional 17' of structural advantage to the South Barrow No. 12 well.

4. The oil shows in the Sag River are concluded to be noncommercial residual oil. While gas was tested from the Sag River at the rate of 800 MCFGPD, the pressure charts appear to indicate a depleting low productivity reservoir.

5. No hydrocarbon shows were indicated in the argillite.

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Appendix

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- Report of May 18, 1978 . . . . . F-7
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- Report of February 27, 1979 . . . . . F-9
- Report of February 27, 1979 . . . . . F-10
- Report of January 17, 1980 . . . . . F-11

G. Crude Oil Analysis Report G-1-2

H. Production Test No. 1 . . . . . H-1-16

SUMMARY OF PERTINENT DATA *

WELL NAME:	South Barrow Well No. 19
API NO.:	50-023-20012
OPERATOR:	Husky Oil NPR Operations, Inc.
LOCATION:	1320' FEL, 1320' FSL protracted Section 23, T22N, R17W, Umiat Meridian, Alaska
COORDINATES:	Latitude: 71°14'29.470"N Longitude: 156°20'01.687"W X = 696,247.93 Y = 6,306,608.67 Zone 6
ELEVATION:	7' Ground, 12' Pad, 30' Kelly Bushing
DATE SPUDDED:	April 18, 1978
TOTAL DEPTH:	2,300 feet 2,100 feet - plug-back depth

DATE REACHED: May 6, 1978

TOTAL DEPTH:

RIG RELEASED: May 16, 1978

STATUS: Gas Well (Suspended)

CASING: 13-3/8" @ 80' (driller)
9-5/8" @ 1491'
7" @ 2161'

LOGGING RECORD:

	99-1495'	DIL/SP
r	1491-2173'	DLL/SP/Calipe
	2161-2284	DLL/SP
/Caliper	100-1497'	BHCS/GR/TTI
	1490-2170'	
	2161-2296'	
Caliper	1490-2176'	FDC/CNL/GR/
	2062-2294'	
aliper	1490-2176'	FDC/GR/RR/C
	2062-2294'	
	2110-2299'	MLL
	1450-2081'	CBL/VDL/GR
	80-2300'	Mudlog

LOGGING RECORD: (Continued)

Computed Logs:

Dipmeter Arrow Plot	1501-2167'
Saraband	1500-2260'

SIDEWALL CORES: Run 1, Shot 30, Recovered 29
Run 2, Shot 45, Recovered 37

CONVENTIONAL CORES:

No.	Depth	Recovery	Formation
1	1330-1360'	30'	Torok & "Pebble Shale"
2	2039-2069'	30'	Lower Barrow
3	2209-2217'	4'	Sag River Sandstone
4	2217-2230'	9'	Sag River Sandstone
5	2230-2245'	15'	Sag River Sandstone

TESTS:

DST No. 1	2161-2245'	800 MCFGPD (estimated) and 7 gallons gas- and very slightly oil-cut emulsified mud.
Production Test No. 1	perf. 2018-2044'	Calculated AOF 7.22 MMCFGPD.

ANALYSIS REPORTS:

Crude Oil: Chemical & Geological Laboratories of Alaska, Inc.
Gas Analysis: U. S. Bureau of Mines
Gas Analysis: Chemical & Geological Laboratories of Alaska, Inc.

WELLSITE GEOLOGIST: D. Young

WELL LOG ANALYST: Armour Kane

CONTRACTOR: Brinkerhoff Signal, Inc.

MUD LOGGERS: Borst & Giddens Well Logging Service, Inc.

BIOSTRATIGRAPHIC ANALYSIS: Anderson, Warren & Associates, Inc.

* Copies and/or reproducibles of all geological data are available from:

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

SOUTH BARROW WELL NO. 19
DRILL CUTTINGS AND CORE DESCRIPTIONS
BY: D. YOUNG

DRILLED DEPTH (FEET BELOW KELLY BUSHING)	
0- 100	No recovery.
100- 220	Sandstone: light gray, fine grained, medium hard, silty, carbonaceous, calcareous, argillaceous, interbedded with Siltstone: medium gray, hard, carbonaceous, calcareous, a few pelecypod fragments.
220- 370	Sandstone: fine grained, light to medium gray, hard, calcareous, carbonaceous in part, argillaceous, a few pyritic inclusions.
370- 460	Claystone: gray, soft, sticky.
460- 490	Siltstone: light gray, argillaceous, firm, calcareous.
490- 760	Claystone: medium gray, soft, sticky, slightly silty, with interbedded siltstone and minor sandstone.
760- 820	Siltstone: dark gray, hard, calcareous.
820- 880	Claystone: as above.
880- 940	Claystone: medium gray, soft, sticky, interbedded with Sandstone: fine grained, light gray, hard, calcareous, pyritic.
940-1000	Claystone: medium gray, soft, sticky, interbedded with Siltstone: dark gray, hard, calcareous, pyritic and Sandstone: very fine grained, light gray, hard, calcareous, trace of kaolinite, trace of pelecypods.
1000-1120	Claystone: medium gray, soft, sticky, interbedded with Siltstone: dark gray, calcareous, hard, occasional pyrite, trace of kaolinite.
1120-1180	No sample returns.
1180-1210	Claystone: gray, brown, soft, lumpy, interbedded with Siltstone: dark gray, firm, pyritic, calcareous.
1210-1300	Sandstone: fine grained, hard, light gray, argillaceous, calcareous, pyritic, interbedded with siltstone and Claystone: as above.
1300-1330	Claystone: light gray, soft, sticky.

1330-1360	Core No. 1 - Cut 30', Recovered 30'	
	1330.0-1335.0' (5.0')	Claystone: medium gray, silty, firm, blocky, faint gassy odor.
	1335.0-1338.0' (3.0')	Claystone: medium gray, silty, firm, as above.
	1338.0-1340.0' (2.0')	Claystone: medium gray, silty, firm, slightly pyritic, poor gassy odor.
	1340.0-1344.0' (4.0')	Claystone: medium to dark gray, firm, slightly silty.
	1344.0-1348.0' (4.0')	Claystone: medium to dark gray, firm, hard, slightly silty, becomes fissile, noncalcareous.
	1348.0-1350.0' (2.0')	Claystone: grading to dark gray Shale: fissile, noncalcareous, poor horizontal partings.
	1350.0-1353.0' (3.0')	Shale: dark gray, hard, fissile, pyritic inclusions, rare Gastropod imprint, probable spines.
	1353.0-1356.0' (3.0')	Shale: dark gray, fissile, hard, pyritic inclusions, slickensides common, horizontal partings.
	1356.0-1359.0' (3.0')	Shale: dark gray, hard, fissile, as above.
	1359.0-1360.0' (1.0')	Shale: as above, few pyritic inclusions, horizontal partings.
1360-1390	Shale: as above, trace of calcite, trace of coal.	
1390-1450	Shale: dark gray, fissile, as above, and dark green, glauconitic, interbedded with Limestone: tan to brown, green, pyritic, hard, tight, common frosted quartz grains.	
1450-1500	Shale: brown, soft, slightly fissile, calcareous, interbedded with Limestone: tan to brown, pyritic, in part silicified, large pyritohedrons, common loose frosted quartz grains.	
1500-1570	Shale: dark brown-gray, soft, silty, occasional pyrite inclusions, and wood fragments, a few loose medium quartz grains.	

1570-1590	Sandstone: fine grained, light gray, argillaceous, silty, clear, white, brown, green, pyritic, dull yellow-gold fluorescence with slow streaming cut, yellow cut fluorescence, interbedded with Shale: as above.
1590-1640	Shale: dark brown, soft, silty, slightly pyritic, becoming micromicaceous with a few loose quartz grains.
1640-1650	Sandstone: fine grained, light gray, argillaceous, silty matrix, poorly sorted, subangular, subrounded, clear quartz, 10% dark mafics, dull gold fluorescence, immediate streaming cut, yellow cut fluorescence.
1650-1660	Shale: dark brown-gray, silty, soft, micaceous, few rounded frosted quartz grains, trace of pyrite.
1660-1670	Sandstone: fine grained, light gray, slightly argillaceous, silty matrix, clear quartz, yellow-gold fluorescence, slight cut.
1670-1680	Shale: brown-gray, soft, silty, micaceous, common free frosted quartz grains.
1680-1690	Sandstone: as above.
1690-1700	Shale: brown, soft, silty.
1700-1710	Conglomerate: pebbles of chert, quartz, and argillite, free, subrounded to well rounded, interbedded with Sandstone: fine grained, light gray, tight, hard, argillaceous, poorly sorted, and Siltstone: dark gray, argillaceous, firm.
1710-1720	Limestone: brown, argillaceous, hard, tight, abundant siderite(?), orange to clear, partly euhedral, with gold fluorescence, interbedded with common coarse grained to pebble sized free quartz, chert and argillite, well rounded.
1720-1740	Shale: brown, soft, highly sandy, abundant loose, fine to medium grained quartz, chert and argillite.
1740-1780	Siltstone: dark gray, highly argillaceous, firm with thin beds of Sandstone: fine grained, light gray, friable, argillaceous, glauconitic, calcite common, pebbles, as above.
1780-1850	Shale: brown-gray, soft, silty, in part slightly fissile, gradational with claystone.

1850-1890	Siltstone: light gray, argillaceous, soft, gradational with Claystone: soft, silty, micromicaceous.
1890-1910	Claystone: brown, soft, micaceous.
1910-1920	Claystone: as above, interbedded with Siltstone: gray, argillaceous, firm.
1920-1930	Siltstone: dark gray, firm, pyrite inclusions with Limestone stringers: brown, hard, dense.
1930-1940	Claystone: gray, soft, silty.
1940-1950	Siltstone: light gray, soft, highly argillaceous, grading to very fine grained, highly argillaceous sandstone.
1950-1970	Sandstone: very fine grained, light gray-tan, glauconitic, hard, argillaceous, pyritic, fossil wood with interbedded Siltstone: brown, soft, highly argillaceous, highly sandy, slightly calcareous.
1970-1980	Sandstone: very fine grained, light gray, tan, friable, silty matrix, micaceous, slightly argillaceous, glauconitic, no odor, stain, or fluorescence.
1980-1990	Sandstone: very fine grained, light gray, tan, silty, argillaceous, friable, clay matrix, common fossil wood and lignite, glauconite, clear, white, green quartz, a few orange pebbles.
1990-2000	Sandstone: as above, very slight gas odor, poor yellow crush cut, yellow cut fluorescence.
2000-2020	Sandstone: very fine grained, light gray, silty matrix, slightly argillaceous, fossilized wood, slight odor of gas, dull gold fluorescence, slight crushed cut, yellow cut fluorescence, in part tan, hard, slightly calcareous.
2020-2030	Sandstone: very fine to fine grained, clean, clear, very friable, loose grained, subrounded to rounded, well sorted, quartzose, clear, white, 5% dark green, gold fluorescence, 100% yellow cut fluorescence.
2030-2039	Sandstone: very fine grained, light gray, tan, friable, clean, clear, trace of light green quartz, large dark green glauconite, abundant loose sand grains, gold fluorescence, slight stain, slight yellow cut, in part clay filled matrix.

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2039-2069 Core No. 2 - Cut 30', Recovered 30'

2039.0-2042.0' (3.0')	Sandstone: fine grained, tan, firm, friable, slightly silty, clay in matrix, swells on test with fresh water, clear quartz, well sorted, subrounded to rounded, bright yellow, mottled fluorescence, immediate yellow cut, yellow cut fluorescence.
2042.0-2045.0' (3.0')	Sandstone: fine grained, tan, silty, swelling clay in matrix, friable, glauconite, as above, lignite, pelecypod, megafossils.
2045.0-2047.0' (2.0')	Sandstone: fine grained, tan to light gray, silty clay in matrix, calcareous.
2047.0-2047.2' (0.2')	Sandstone: fine grained, tan to light gray, argillaceous, clear, hard; Siltstone: argillaceous, hard, sandy, calcareous, yellow fluorescence, good cut.
2047.2-2048.0' (0.8')	Siltstone: argillaceous, hard, sandy, calcareous, yellow fluorescence, good cut.
2048.0-2049.0' (1.0')	Siltstone: firm, medium gray, highly argillaceous, shell bed, small pelecypod, lignite.
2049.0-2051.5' (2.5')	Siltstone: dark gray, firm, sandy, pyritic, bioturbation.
2051.5-2054.0' (2.5')	Sandstone: very fine grained, tan to gray, argillaceous, silty, firm, poorly friable, spotty fluorescence, yellow cut.
2054.0-2056.0' (2.0')	Sandtone: very fine, gray, tan, light gray, silty, argillaceous, calcareous, pyritic.
2056.0-2058.1' (2.1')	Siltstone: dark gray, sandy, calcareous, yellow spotty fluorescence, good odor, fair yellow cut fluorescence, large fossil wood fragment, 5" x 2".

2058.1-2059.0' (0.9')	Sandstone: very fine grained, highly argillaceous, silty, clay pods.
2059.0-2060.0' (1.0')	Sandstone: as above.
2060.0-2061.0' (1.0')	Sandstone: as above, highly argillaceous, silty, good odor.
2061.0-2062.0' (1.0')	Sandstone: light gray, very hard, siliceous, pyritized fossil wood.
2062.0-2063.0' (1.0')	Sandstone: very fine grained, light gray, partly clean and fine grained, good odor, yellow fluorescence, yellow cut fluorescence.
2063.0-2066.0' (3.0')	Sandstone: light gray, very fine grained, hard, argillaceous, calcareous.
2066.0-2069.0' (3.0')	Sandstone: light gray to brown, very fine grained, hard, argillaceous, silty, slightly friable, spotty yellow fluorescence, good gassy odor.
2069-2080	Sandstone: light gray, very fine grained, slightly argillaceous, few pyritic inclusions, clay matrix swells, with thin beds of dark gray, firm, slightly sandy shale.
2080-2110	Siltstone: dark gray, firm, sandy, interbedded with Sandstone: light gray to tan, hard, tight, highly calcareous, and Shale: gray, slightly fissile, firm.
2110-2140	Siltstone: dark gray, firm, slightly sandy, micaceous, slightly calcareous, with thin stringers of Sandstone: fine grained, tan, hard, partly friable, clear, subrounded, quartzose.
2140-2170	Claystone: light gray, soft, highly sandy.
2170-2175	Sandstone: tan to light gray, fine grained, hard, subrounded to rounded, clear, white quartz, glauconitic, interbedded with Claystone: as above.
2175-2180	Siltstone: medium gray, firm, calcareous, slightly carbonaceous, micromicaceous.

2180-2185	Sandstone: medium to coarse grained, angular quartz, light gray, argillaceous, calcareous, slightly carbonaceous, Siltstone: as above.
2185-2190	Siltstone, as at 2175', trace of brown oil stain with gold fluorescence.
2190-2195	Limestone: tan, hard, sandy, slightly glauconitic, orange, gold fluorescence, very slight cut.
2195-2205	Sandstone: fine grained, brown to tan, argillaceous, calcareous, a few coarse grained pebbles, rounded quartz grains as floaters with thin bed of Claystone: light gray, firm, abundant gilsonite.
2205-2209	Sandstone: fine grained, tan to brown, light gray, slightly argillaceous, hard, tight, common glauconite, subrounded, clear quartz, a few quartz pebbles, 10% gold fluorescence, gold cut fluorescence.
2209-2217	Core No. 3 - Cut 8', Recovered 4'
2209.0-2209.7' (0.7')	Shale: dark gray, very hard, carbonaceous, slightly silty.
2209.7-2211.0' (1.3')	Sandstone: very fine to fine grained, brown, firm to slightly friable, highly glauconitic, subrounded to well rounded quartz, good brown oil stain, tea cut, 100% gold fluorescence, shell fragments of pelecypod and echinoid.
2211.0-2212.0' (1.0')	Sandstone: very fine grained, brown, very friable, glauconite, quartz, as above, poorly consolidated, silty matrix, good brown oil stain, fluorescence cut, bleeding oil, in part good visible porosity.
2212.0-2213.0' (1.0')	Sandstone: very fine grained, brown to gray, friable, glauconite, highly argillaceous, clay in matrix.
2213.0-2217.0' (4.0')	No recovery.
2217-2230	Core No. 4 - Cut 13', Recovered 9'
2217.0-2219.3' (2.3')	Sandstone: very fine grained, brown, clean, highly glauconitic,

		thin beds, well sorted, well rounded quartz, few pelecypod shell fragments, slightly calcareous.
	2219.3-2220.2' (0.9')	Limestone: brown to tan, firm, biocalcarenitic, sandy, highly glauconitic beds, calcareous.
	2220.2-2222.0' (1.8')	Sandstone: brown, very fine grained, firm, glauconitic.
	2222.0-2223.0' (1.0')	Sandstone: very fine grained, brown, poorly consolidated, very friable, argillaceous, clear, well rounded, well sorted quartz, glauconitic, heavy oil stain, 45° bedding planes, vertical fractures and fractures at right angles to bedding planes possibly induced, closed to slightly open good stain on faces, no mineralization.
	2223.0-2225.0' (2.0')	Sandstone: as above at 2220.2', highly calcareous, increase in fossils with pelecypod and echinoid plates.
	2225.0-2226.0' (1.0')	Sandstone: very fine grained, brown, friable, highly calcareous, highly glauconitic, pelecypods and echinoids, clean, clear, well rounded quartz.
	2226.0-2230.0' (4.0')	No recovery.
2230-2245	<u>Core No. 5 - Cut 15', Recovered 15'</u>	
	2230.0-2231.2' (1.2')	Limestone: white, tan-brown, hard, fossils, glauconitic, sandy, spotty oil stain, gold fluorescence 100%, scattered, dense, black tar blebs, pelecypod and echinoid fragments, thin shale and sandstone partings; Shale: dark gray-brown, hard, gold spores, Sandstone: stringers, very fine grained, friable, firm, brown, glauconitic, heavy oil stain, tea cut.
	2231.2-2232.8' (1.6')	Limestone: biocalcarenite, white, clear, tan, green, large shell fragments, common pelecypod,

		echinoid plates, large glauconitic pellets, soft amorphous, few small argillaceous pebbles, dark brown, high visible crude in pockets of	
ity, good odor, spotty sta			poro
stone: very fine grained, n, calcareous, hard, good odor oil stain, slightly friable, tered shell fragments, bleeding nd gas.		2232.8-2236.0' (3.2')	Sand brow and scatt oil a
stone: as above, very hard, eous, good fluorescence, poor .		2236.0-2238.0' (2.0')	Sand silic stai
stone: very fine grained, rn, calcareous, hard, low sity, poor permeability, 100% fluorescence, tea cut, cypod, brachiopod, scattered s.		2238.0-2240.0' (2.0')	Sand brow poro gold pele shel
lstone: very fine grained, rn, well sorted, well rounded, tly friable, calcareous, shell ments, rare glauconite, slightly llaceous, good odor, stain cut rescence, bleeding oil and gas.		2240.0-2243.0' (3.0')	Sand brow sligh frag argi fluo
lstone: as above, increasingly llaceous.		2243.0-2245.0' (2.0')	Sand argi
e grained, light gray, firm, s.	2245-2250	Sandstone: very fi calcareous, argillaceou	
gray, soft, bedded with	2250-2260	Claystone: medium Sandstone: as above.	
o black, firm, slightly graphitic,	2260-2280	Argillite: dark gray t flaky.	
dark gray, firm, graphitic, , broken quartz, probably as ings.	2280-2290	Argillite: medium t pyritic, common clea lenses and fracture fill	
firm, graphitic, poorly foliated, gray, quartzose, common free no odor, stain, cut, or	2290-2300	Argillite: dark gray, in part mottled, light Quartz: as above; fluorescence observed.	
	2,300 feet Total Depth		

Log Analysis

ARMOUR KANE

Formation Evaluation

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

May 12, 1978

Mr. Gordon W. Legg
Husky Oil/NPR Operations, Inc.
2525 C Street, Suite 400
Anchorage, Alaska 99503

Dear Mr. Legg:

Logging operations on South Barrow #19 were begun by Schlumberger at 1300 hours April 30, 1978 and completed at 0400 hours May 1. Logs run were Dual Laterolog, Neutron-Density, Sonic, Dipmeter and sidewall cores. The DLL had to be run twice due to SP trouble, the Neutron-Density had to be run twice due to "spikes" on the neutron curve, the caliper was inoperative on the sonic log and their sepia print paper was too old to print. In my opinion, these problems and those on other wells show a disturbing lack of preventative maintenance on Schlumberger's part.

Log tops were: Kingak, 1714; Upper Barrow Sand, 1965; Lower Barrow Sand, 2018. The Upper Barrow appears quite shaly and of low permeability while the Lower Barrow indicates an average porosity of 22%, an average water saturation of 40% and invasion diameter of 30-35 inches. It should produce gas with some water cut.

The final logging run was commenced at 1300 hours May 6 and was completed at about 2300 hours May 7, 1978. Trouble was encountered with the DLL resulting in some 6 hours of lost rig time, the Neutron-Density and Sonic logs were run successfully, one more try with the DLL was a failure and the Microlaterolog failed to reach bottom. A cleanout run was made and after replacement equipment was flown in the DLL was completed. However, the field printer broke down so field prints of the DLL and MLL could not be obtained. Again, a maintenance problem.

The Sag River Sand was topped at 2194 and Argillite at 2264. Sag River porosity averaged 15% and water saturation 48%. Here, again, Rw values were 0.12 to 0.13, or about 50,000 ppm as in Barrow #17 compared to measured values of produced water in #17 of .45 to .49. A check of Barrow #12, drilled with fresh mud, resulted in a computed Rw of 0.5 and average porosity of 23% and water saturation of 48%, which compares favorably with the figures from Barrow #17 and #19. True resistivity in #12 was from 30 to 38 ohm-meters and in #19 from 13 to 20 ohms. This is a problem difficult to resolve but it would appear that log interpretation can be relied upon as borne out by well performance in #17.

Very truly yours,

Armour Kane

Armour Kane

Log Analysis

COMPANY: HUSKY OIL/NPR OPERATIONS, INC. | WELL: SOUTH BARROW #19

FIELD: SOUTH BARROW | COUNTY: NORTH SLOPE | STATE: ALASKA

DEPTH	R_T	ϕ_D	ϕ_N	ΔT	ϕ_s	ϕ_{sc}*	ϕ_c	S_w	D_i	REMARKS
2018-20	13	21	24	100	30	21	21	46	30"	
2020-22	13	27	21	105	33	23.1	25	38	30"	
2022-26	18	27	21	108	36	25.2	25	33	32"	
2026-30	20	15	27	102	32	22.4	15	52	33"	
2030-34	18	26	23	108	36	25.2	25	33	33"	
2034-36	18	22	25	110	37	25.9	22	37	35"	
					Av. ϕ = 22%					
						Av. S_w = 40%				

R_{MF} = .012 @ 61° BHT EST = 70° R_{MF} @ 70° F .063

R_{MFe} = .034 SP @ 2030 = 25 MV

$\frac{R_{MFe}}{R_{we}}$ = .42 R_{we} = .085 R_w = 0.12 = 6000 ppm

* ϕ_s CORRECTED FOR GAS EFFECT BY "RULE OF THUMB" FIGURE OF 0.7

Log Analysis

COMPANY: HUSKY OIL/NPR OPERATIONS, INC. | WELL: So. BARROW #19

FIELD: So. BARROW | COUNTY: NORTH SLOPE | STATE: ALASKA

DEPTH	R_T	ϕ_D	ϕ_N	ΔT	ϕ_S	S_w			S_w *				REMARKS
2198	20	18	29	100	30	45			83				
2202-10	26	16	27	90	24	44			82				
2210-16	23	16	31	98	29	47			87				
2223-26	25	17	31	93	25	42			79				
2226-30	40	10	26	87	22	57			106				
2234-44	25	15	27	85	20	48			89				
2248-52	25	13	27	85	20	55			103				

Av. ϕ = 15% Av. S_w = 48%

* IF THE MEASURED VALUE OF R_w OF 0.45 FROM BARROW 19 IS USED.

R_{mf} = .08 @ 75° SP = +18 MV @ 2244

R_{mfe} = .06

$\frac{R_{mfe}}{R_{we}}$ = .55

R_{we} = 0.11 R_w = 0.13

Log Analysis

COMPANY	WELL
HUSKY OIL/NPR OPERATIONS, INC.	SOUTH BARROW #19

FIELD	COUNTY	STATE
SOUTH BARROW	NORTH SLOPE	ALASKA

DEPTH	R_T	ϕ_D	ϕ_N	C 4T /10 ΔT	ϕ_s	ϕ_{sc}	ϕ_c	S_w		$\phi \times FT$	$S_w \times FT.$		REMARKS
2018-20	13	21	24	100	30	21	21	46		42	92		
2020-22	13	27	21	105	33	23.1	25	38		50	76		
2022-26	18	27	21	108	36	25.2	25	33		100	132		
2026-30	20	15	27	102	32	22.4	15	52		60	208		
2030-34	18	26	23	108	36	25.2	25	33		100	132		
2034-36	18	22	25	110	37	25.9	22	37		44	74		
										396	714		
									Av ϕ =	22	40%		

ϕ_s CORRECTED FOR GAS EFFECT BY "RULE OF THUMB" FIGURE OF 0.7

R_{MF} = .072 @ 61° ESTIMATED BHT = 70°
R_{MF} @ 70° = .063 R_{MF_e} = .036 SP @ 2030 = + 25 MV.
$\frac{R_{MF_e}}{R_{W_e}}$ = .42 R_{W_e} = .085 R_W = .12 = 60,000 ppm

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CHEMICAL & GEOLOGICAL LABORATORIES OF ALASKA, INC.
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ANCHORAGE, ALASKA 99509

CORE ANALYSIS REPORT

Company Husky Oil Company Date May 3, 1978 Lab. No. 7818
Well No. South Barrow No. 19 Location
Field NPR No. 4 Formation
County Depths Core No. 2 (2039-2069)
State Alaska Drilling Fluid

LEGEND
C—Crack, P—Fracture, H—Horizontal, O—Open
NF—No Fracture
IS—Insufficient Sample
S—Slight, St—Stale, V—Vertical, Vu—Vuge

SAMPLE NO.	LEGEND	DEPTH, FEET	EFFECTIVE POROSITY PERCENT	PERMEABILITY MILLIDARCIES HORIZONTAL	PERMEABILITY MILLIDARCIES VERTICAL	SATURATIONS % PORE SPACE RESIDUAL OIL	SATURATIONS % PORE SPACE TOTAL WATER	CONNATE WATER	SOLUBILITY MUD ACID	SOLUBILITY 15 % ACID
1.		2039-40	14.1	3.35	2.13	Trace	69.4			
2.		2040-41	18.9	61	6.88	5.6	68.2			
3.		2041-42	22.2	83	67	5.4	58.0			
4.		2042-43	2.0	5.75	4.40	1.9	80.2			
5.	HF	2043-44	8.6	91	7.11	2.1	81.7			
6.		2044-45	13.9	14	8.55	7.1	50.0			
7.		2045-46	16.9	8.91	10	Trace	57.9			
8.		2046-47	14.3	24	20	Trace	60.6			
9.		2047-48	14.3	2.30	0.84	Trace	57.4			
10.		2048-49	13.7	2.06	2.00	Trace	69.7			
11.		2049-50	14.8	1.27	0.63	Trace	58.6			
12.		2050-51	13.6	2.12	1.07	Trace	62.1			
13.		2051-52	17.7	5.56	2.26	1.4	62.8			
14.		2052-53	19.9	12	1.37	1.2	53.6			
15.		2053-54	24.9	4.67	1.55	2.0	56.4			
16.		2054-55	16.4	3.43	1.60	4.5	66.4			
17.		2055-56	18.4	9.91	1.69	2.7	58.3			
18.		2056-57	20.0	11	4.19	2.5	58.9			
19.		2057-58	12.6	5.64	3.03	3.1	71.1			
20.		2058-59	11.6	9.38	4.12	Trace	76.0			
21.		2059-60	18.0	15	10	1.3	62.9			
22.		2060-61	20.8	11	1.94	2.4	51.3			
23.		2061-62	11.1	9.59	0.36	Trace	60.4			
24.		2062-63	17.1	4.40	2.49	Trace	59.8			
25.	HF	2063-64	14.1	40	0.51	Trace	60.1			
26.		2064-65	15.0	6.34	0.42	4.9	59.3			
27.		2065-66	12.6	3.52	1.18	Trace	62.8			
28.		2066-67	14.1	5.96	0.51	5.1	67.7			
29.		2067-68	16.6	1.91	1.19	5.9	61.5			
30.		2068-69	16.0	6.69	3.23	6.1	59.6			

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ANCHORAGE, ALASKA 99509

CORE ANALYSIS REPORT

Company Husky Oil Company Date May 8, 1978 Lab. No. 7856
Well No. South Barrow No. 19 Location
Field NPR #4 Formation
County Depths
State Alaska Drilling Fluid

LEGEND
C—Crack, F—Fracture, H—Horizontal, O—Open
NF—No Fracture
IS—Insufficient Sample
S—Slight, St—Stala, V—Vertical, Vg—Vugs

SAMPLE NO.	LEGEND	DEPTH, FEET	EFFECTIVE POROSITY PERCENT	PERMEABILITY MILLIDARCIES HORIZONTAL	PERMEABILITY MILLIDARCIES VERTICAL	SATURATIONS % PORE SPACE RESIDUAL OIL	SATURATIONS % PORE SPACE TOTAL WATER	CONNATE WATER	SOLUBILITY MUD ACID	SOLUBILITY 15 % ACID
				SIDEWALL CORES						
1.		1587	23.4	26		---	---			
2.		1636	----	--		Trace	63.6			
3.		1960	20.5	33		---	---			
4.		1964	----	--		Trace	55.3			
5.		1972	26.4	273		---	---			
6.		1976	----	--		1.1	54.6			
7.		1980	19.2	18		---	---			
8.		1984	----	--		1.3	58.8			
9.		1988	21.3	20		---	---			
10.		1992	----	--		Trace	60.1			
11.		1996	18.8	9.44		---	---			
12.		2000	----	--		Trace	55.6			
13.		2004	20.6	28		---	---			
14.		2014	----	--		Trace	52.1			
15.		2016	19.3	17		---	---			
16.		2018	----	--		1.6	40.9			
17.		2020	17.4	14		---	---			
18.		2022	----	--		1.0	42.2			
19.		2024	25.6	58		---	---			
20.		2026	----	--		Trace	40.3			
21.		2028	23.0	43		---	---			
22.		2032	----	--		Trace	41.7			
23.		2034	26.1	26		---	---			
24.		2036	----	--		Trace	48.3			

NOTES: AVERAGE POROSITY OF FOOTAGE ABOVE AND BELOW USED FOR FLUID SATURATIONS.

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CORE ANALYSIS REPORT

Company Husky Oil Company Date May 10, 1978 Lab. No. 7882
Well No. South Barrow No. 19 Location
Field NPR #4 Formation
County Depths 2230-2245 (Core No. 5)
State Alaska Drilling Fluid

LEGEND
C—Crack, F—Fracture, H—Horizontal, O—Open
NF—No Fracture
IS—Insufficient Sample
S—Slight, St—Stale, V—Vertical, Vg—Vugs

SAMPLE NO.	LEGEND	DEPTH, FEET	EFFECTIVE POROSITY PERCENT	PERMEABILITY MILLIDARCIES HORIZONTAL	PERMEABILITY MILLIDARCIES VERTICAL	SATURATIONS % PORE SPACE RESIDUAL OIL	SATURATIONS % PORE SPACE TOTAL WATER	CONNATE WATER	SOLUBILITY MUD ACID	SOLUBILITY 15 % ACID
1.		2230-31	9.1	9.31	0.62	Trace	44.0			
2.		2231-32	16.9	977	712	8.6	52.9			
3.		2232-33	11.7	17.3	2.40	Trace	50.9			
4.		2233-34	15.0	9.13	38.4	Trace	50.0			
5.		2234-35	18.6	19.7	7.28	Trace	55.5			
6.		2235-36	14.7	9.13	7.77	1.8	50.2			
7.		2236-37	13.7	7.18	8.68	3.8	48.7			
8.		2237-38	15.9	15.6	8.31	Trace	47.9			
9.		2238-39	16.3	7.35	4.16	Trace	54.1			
10.		2239-40	13.3	4.38	0.13	3.9	58.4			
11.		2240-41	17.1	38.0	11.8	3.0	53.4			
12.		2241-42	15.1	16.5	12.7	0.9	55.6			
13.		2242-43	17.4	16.4	9.04	Trace	50.5			
14.		2243-44	22.1	82.8	24.8	1.2	48.1			
15.		2244-45	20.2	29.2	13.8	1.3	47.5			

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

DRILL STEM TEST REPORT FORM

WELL NAME SOUTH BARROW No. 19

Test Number 1 — Hole Size 5 5/8" rathole 7" casing

Date 5/5/78 — Drill Pipe (Size & Lgth) —

Test Interval 2161-2245' Sag River / Top Sag River (2200) — Drill Collars (Size & Lgth) —

Total Depth 2245' — Type of Cushion Fluid Nitrogen gas

Amount of Cushion 540 psi Nitrogen cushion

TEST DATA

1. Tool open at 0607 hours.
2. Initial open period 223 mins.
3. Initial shut-in period 367 mins.
4. Final flow period not run mins.
5. Final shut-in period not run mins.
6. Description of blow on initial open period Open tool- bled nitrogen cushion 540 psi decr. to 0 psi 0611 ; mod. blow incr to strong ; drlg mud to surf. 0618 20 psi
7. Description of blow during test GTS 0630 57 psi; 0800 67 psi stabilized on 20/64 choke; 0843 64 psi stab. on 1/2" chk.; 0950 39 psi stab. on 3/4" chk.
8. G.T.S. 23 mins; 20 O.T.S. ____ mins; Bottom hole choke size 3/4"
   Surface choke size variable 20/64, 1/2 3/4
9. Flow Rate: Gas 800 M (estd) C.F.P.D. Oil ____ B.P.H. G.O.R. ____
10. Gravity of Gas ____ Gravity of Oil ____
11. Total fluid recovery: 7 gal. from collar below circulating valve and 1 pint from sealed sub below tester valve gas and V. slightly oil cut emulsified mud
12. Resistivity of H_2O ____ Chlorides of H_2O rat hole mud 70,000 ppm P.P.M.
13. Depth of top press bomb 2111 Bottom Bomb 2216

Depth packer 2129'

PRESSURE DATE

Top Bomb: No. 7581 24 hour clock		Bottom Bomb: 7582 24 hour clock	
I.H.P.	1224	I.H.P.	1270
I.S.I.P.	995	I.S.I.P.	1017
I.F.P.	333	I.F.P.	331
F.F.P.	179	F.F.P.	204
F.S.I.P.		F.S.I.P.	
F.H.H.	1199	F.H.H.	1220
Temp.	55	Temp.	55

SAMPLE CHAMBER DATA

1. Gas ____ C.F.
2. Oil ____ C.C.
3. H_2O ____ C.C.
4. Mud ____ C.C.
5. B.O.R. ____ % S. & W. ____ %

REMARKS:

4 gas pressure bottles were filled two at 1 hour into test and two at 3 hours 20 min.

4 1 qt. plastic sample containers and 2 1 gal. paint cans were filled with fluid recovery.

DST chart shows a mechanically successful test . Chart interpretation indicates a tight low productivity reservoir based primarily on flow curve analysis.

The sealed sub contained primarily gas at 1000 psi, approx. 1 pint of gas and v. sli. oil cut mud was also recovered.

D. B. Young

Prepared By

CHEMICAL & GEOLOGICAL LABORATORIES OF ALASKA, INC.

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GAS ANALYSIS REPORT

Company Husky Oil Company Date May 15, 1978 Lab. No. 7868-1
Well No. South Barrow No. 19 Location
Field Formation Sag River
County Depth DST No. 1 (2161-2245)
State Alaska Sampling point Choke Manifold
Line pressure ___ psig; Sample pressure 65 psig; Temperature --- ° F; Container number
Remarks Sample No. 1. One hour sample in part drilling mud, 5-5-78.

Component	Mole % or Volume %	Gallons per MCF
Oxygen	0	
Nitrogen	6.25	
Carbon dioxide	0.20	
Hydrogen sulfide	---	
Methane	91.47	
Ethane	1.64	
Propane	0.20	0.055
Iso-butane	0.03	0.010
N-butane	0.08	0.025
Iso-pentane	0.03	0.011
N-pentane	0.03	0.011
Hexanes	0.04	0.016
Heptanes & higher	0.03	0.014
Total	100.00	0.142

GPM of pentanes & higher fraction 0.052

Gross btu cu. ft. @60° F. & 14.7 psia (dry basis) 967
Specific gravity (calculated from analysis) 0.596
Specific gravity (measured) 0.598

Remarks:

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GAS ANALYSIS REPORT

Company Husky Oil Company Date May 15, 1978 Lab. No. 7868-2
Well No. South Barrow No. 19 Location
Field NPR #4 Formation Sag River
County Depth DST No. 1 (2161-2245)
State Alaska Sampling point Choke Manifold
Line pressure psig; Sample pressure 39 psig; Temperature ° F; Container number
Remarks Sample No. 2, 3 hour 20 min. sample, 5-5-78

Component	Mole % or Volume %	Gallons per MCF
Oxygen	0	
Nitrogen	6.20	
Carbon dioxide	0.17	
Hydrogen sulfide	---	
Methane	91.44	
Ethane	1.58	0.063
Propane	0.23	0.013
Iso-butane	0.04	0.041
N-butane	0.13	0.015
Iso-pentane	0.04	0.029
N-pentane	0.08	0.021
Hexanes	0.05	0.018
Heptanes & higher	0.04	
Total	100.00	0.200

GPM of pentanes & higher fraction 0.065

Gross btu cu. ft. @60° F. & 14.7 psia (dry basis) 972
Specific gravity (calculated from analysis) 0.598
Specific gravity (measured) 0.600

Remarks:

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ANCHORAGE, ALASKA 99509

GAS ANALYSIS REPORT

Company Husky Oil Company Date May 15, 1978 Lab. No. 7863-3
Well No. South Barrow No. 19 Location
Field NPR #4 Formation Sag River
County Depth DST No. 1 (2161-2245)
State Alaska Sampling point Choke Manifold
Line pressure psig; Sample pressure 39 psig; Temperature ° F; Container number
Remarks Sample No. 3, 3 hour 20 min. sample, 5-5-78

Component	Mole % or Volume %	Gallons per MCF
Oxygen	0	
Nitrogen	6.23	
Carbon dioxide	0.18	
Hydrogen sulfide	---	
Methane	91.45	
Ethane	1.52	0.060
Propane	0.22	0.013
Iso-butane	0.04	0.041
N-butane	0.13	0.018
Iso-pentane	0.05	0.029
N-pentane	0.08	0.021
Hexanes	0.05	0.023
Heptanes & higher	0.05	
Total	100.00	0.205

GPM of pentanes & higher fraction 0.091

Gross btu cu. ft. @60° F. & 14.7 psia (dry basis) 972
Specific gravity (calculated from analysis) 0.599
Specific gravity (measured) 0.600

Remarks:

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GAS ANALYSIS REPORT

Company Husky Oil Company Date May 18, 1978 Lab. No. 7936-1
Well No. South Barrow No. 19 Location
Field NPR #4 Formation Barrow Sand
County Depth 2018-44
State Alaska Sampling point Separator
Line pressure ____ psig; Sample pressure 260 psig; Temperature 84 ° F; Container number
Remarks Sample No. 1 taken 5-12-78

Component	Mole % or Volume %	Gallons per MCF
Oxygen	0	
Nitrogen	11.65	
Carbon dioxide	0.06	
Hydrogen sulfide	---	
Methane	87.67	
Ethane	0.35	
Propane	0.08	0.022
Iso-butane	0.01	0.003
N-butane	0.11	0.035
Iso-pentane	0.06	0.022
N-pentane	0.01	0.004
Hexanes & Higher	Trace	---
Total	100.00	0.086

GPM of pentanes & higher fraction 0.026

Gross btu cu. ft. @60° F. & 14.7 psia (dry basis) 900
Specific gravity (calculated from analysis) 0.608
Specific gravity (measured) 0.610

Remarks:

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GAS ANALYSIS REPORT

Company Husky Oil Company Date May 18, 1978 Lab. No. 7936-2
Well No. South Barrow No. 19 Location
Field NPR #4 Formation Barrow Sand
County Depth 2018-44
State Alaska Sampling point Separator
Line pressure psig Sample pressure 260 psig Temperature 84 °F Container number
Remarks: Sample No. 2 taken 5-12-78

Component	Mole % or Volume %	Gallons per MCF
Oxygen	0	
Nitrogen	11.60	
Carbon dioxide	0.06	
Hydrogen sulfide	---	
Methane	87.76	
Ethane	0.33	
Propane	0.07	0.019
Iso-butane	0.01	0.003
N-butane	0.10	0.031
Iso-pentane	0.06	0.022
N-pentane	0.01	0.004
Hexanes & Higher	Trace	---
Total	100.00	0.079

GPM of pentanes & higher fraction 0.026

Gross btu cu. ft. @60° F. & 14.7 psia (dry basis) 900
Specific gravity (calculated from analysis) 0.607
Specific gravity (measured) 0.608

Remarks:

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GAS ANALYSIS REPORT

Company Husky Oil Company Date May 18, 1978 Lab. No. 7936-3
Well No. South Barrow No. 19 Location
Field NPR #4 Formation Barrow Sand
County Depth 2018-44
State Alaska Sampling point Separator (Fourth Rate)
Line pressure psig; Sample pressure 270 psig; Temperature 75 ° F; Container number
Remarks Sample No. 3 taken 5-13-78

Component	Mole % or Volume %	Gallons per MCF
Oxygen	0	
Nitrogen	12.35	
Carbon dioxide	0.09	
Hydrogen sulfide	---	
Methane	86.95	
Ethane	0.39	
Propane	0.05	0.014
Iso-butane	0.02	0.007
N-butane	0.09	0.028
Iso-pentane	0.05	0.018
N-pentane	0.01	0.004
Hexanes & Higher	Trace	---
Total	100.00	0.071

GPM of pentanes & higher fraction 0.022

Gross btu cu. ft. @60° F. & 14.7 psia (dry basis) 892
Specific gravity (calculated from analysis) 0.611
Specific gravity (measured) 0.611

Remarks:

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GAS ANALYSIS REPORT

Company Husky Oil Company Date May 18, 1978 Lab. No. 7936-4
Well No. South Barrow No. 19 Location
Field NPR #4 Formation Barrow Sand
County Depth 2018-44
State Alaska Sampling point Separator (Fourth Rate)
Line pressure psig; Sample pressure 270 psig; Temperature 75 ° F; Container number
Remarks Sample No. 4 taken 5-13-78

Component	Mole % or Volume %	Gallons per MCF
Oxygen	0	
Nitrogen	12.39	
Carbon dioxide	0.09	
Hydrogen sulfide	---	
Methane	86.88	
Ethane	0.41	
Propane	0.05	0.014
Iso-butane	0.02	0.007
N-butane	0.10	0.031
Iso-pentane	0.05	0.018
N-pentane	0.01	0.004
Hexanes & Higher	Trace	---
Total	100.00	0.074

GPM of pentanes & higher fraction 0.022

Gross btu cu. ft. @60° F. & 14.7 psia (dry basis) 892
Specific gravity (calculated from analysis) 0.611
Specific gravity (measured) 0.613

Remarks:

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ANCHORAGE INDUSTRIAL CENTER
5633 B Street

GAS ANALYSIS REPORT

Company: Husky Oil Company — Date: February 27, 1979 — Lab. No. 9787-1
Well No.: South Barrow No. 19 — Location:
Field: South Barrow — Formation: Lower Barrow Sand
County: — Depth: 2044 Feet
State: Alaska — Sampling point: Choke
Line pressure: ____ psig; Sample pressure: 820 psig; Temperature: 18 ° F; Container number:
Remarks: Sample No. 1. Sample taken February 14, 1979

Component	Mole % or Volume %	Gallons per MCF
Oxygen	0	
Nitrogen	4.32	
Carbon dioxide	Trace	
Hydrogen sulfide	---	
Methane	95.65	
Ethane	0.03	
Propane & Higher	Trace	Trace
Total	100.00	Trace

GPM of pentanes & higher fraction: ---

Gross btu cu. ft. @60° F. & 14.7 psia (dry basis): 967
Specific gravity (calculated from analysis): 0.572
Specific gravity (measured): 0.570

Remarks:

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CHEMICAL & GEOLOGICAL LABORATORIES OF ALASKA, INC.

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GAS ANALYSIS REPORT

Company Husky Oil Company Date February 27, 1979 Lab. No. 9787-2
Well No. South Barrow No. 19 Location
Field South Barrow Formation South Barrow Sand
County Depth 2044 Feet
State Alaska Sampling point Choke
Line pressure ___ psig; Sample pressure 880 psig; Temperature 17 ° F; Container number
Remarks Sample No. 2. Sample taken February 14, 1979.

Component	Mole % or Volume %	Gallons per MCF
Oxygen	0	
Nitrogen	4.54	
Carbon dioxide	Trace	
Hydrogen sulfide	---	
Methane	95.40	
Ethane	0.04	0.005
Propane	0.02	Trace
Iso-butane & Higher	Trace	
Total	100.00	0.005

GPM of pentanes & higher fraction ---

Gross btu cu. ft. @60° F. & 14.7 psia (dry basis) 965
Specific gravity (calculated from analysis) 0.573
Specific gravity (measured) 0.570

Remarks:

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5633 B Street

GAS ANALYSIS REPORT

Company: Husky Oil Company — Date: February 27, 1979 — Lab. No. 9787-3
Well No.: South Barrow No. 19 — Location:
Field: South Barrow — Formation: Lower Barrow Sand
County: — Depth: 2044 Feet
State: Alaska — Sampling point: Choke
Line pressure: ___ psig; Sample pressure: 890 psig; Temperature: 18 ° F; Container number:
Remarks: Sample No. 3. Sample taken February 14, 1979

Component	Mole % or Volume %	Gallons per MCF
Oxygen	0	
Nitrogen	4.50	
Carbon dioxide	Trace	
Hydrogen sulfide	---	
Methane	95.42	
Ethane	0.04	
Propane	0.04	0.011
Iso-butane & Higher	Trace	Trace
Total	100.00	0.011

GPM of pentanes & higher fraction: ---

Gross btu cu. ft. @60° F. & 14.7 psia (dry basis): 965
Specific gravity (calculated from analysis): 0.573
Specific gravity (measured): 0.570

Remarks:

E Barrow #19

HA - 1 (2/2/68)

REPORT OF ANALYSIS

F. S. - 15889 M.S.N-67890 ,H 1.11 OBS. PRES. 60.9 CAL. PRES. 65.6

STATE- ALASKA COUNTY- NORTHWESTERN

FIELD-BARROW E WELL NAME- WELL NO. 19

LOCATION- NOT GIVEN 1320'FEL, 1320 FSL Sec. 23, T22N, R.17W OWNER- HUSKY OIL NPR OPERATIONS INC

DATE COMPLETED- NOT GIVEN 16 MAY, 1978 DATE SAMPLED- 01/17/80

SAMPLED BY- NICHOLLS & CRANE

NAME OF PRODUCING FORMATION- NOT GIVEN BARROW SAND

DEPTH IN FEET-NOT GIVEN ±2050 THICKNESS IN FEET- NOT GIVEN 20'

SHUT IN WELLHEAD PRES., PSIG- 1000 OPEN FLOW, MCF/D- NOT GIVEN 1,220 MCFPD

CHECK OF DATA-
THE WELL DATA ARE ACCURATE, (_____) WITHOUT CORRECTION,(_____) AS CORRECTED ABOVE.

REMARKS-

ANALYSIS-

METHANE	86.1	%	NORMAL PENTANE	TRACE	%	OXYGEN	0.0	%
ETHANE	0.5	%	ISOPENTANE	0.1	%	ARGON	TRACE	%
PROPANE	TRACE	%	CYCLOPENTANE	TRACE	%	HYDROGEN	0.0	%
NORMAL BUTANE	0.1	%	HEXANES PLUS	TRACE	%	H2S *	0.0	%
ISOBUTANE	0.0	%	NITROGEN	11.8	%	CO2	0.1	%
SPECIFIC GRAV 0.604						HELIUM	1.22	%
						TOTAL	99.90	%

CALCULATED GROSS BTU/CU. FT., DRY AT 60 DEG. F AND 30 IN. MERCURY- 889

* DUE TO THE ABSORPTION OF H2S DURING SAMPLING, THE REPORTED RESULTS MAY NOT BE RELIABLE

PERMISSION FOR RELEASE:

Permission is hereby granted for the Bureau of Mines to release the above data, together with similar data released by other operators as public information and as parts of a series of papers on analyses of gases from various fields, states, or regions.

COMPANY U.S. Geological Survey

BY Robert J. Lang

TITLE Geologist

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CRUDE OIL ANALYSIS REPORT

Company: Husky Oil Company
Well No.: South Barrow No. 19
Field: NPR #4
County:
State: Alaska

Date: May 17, 1978 Lab. No.: 7870
Location:
Formation:
Depth: DST No. 1
Analyzed by: JP

GENERAL CHARACTERISTICS

Specific gravity @ 60/60 °F	0.9154
A.P.I. gravity @ 60 °F	23.1
Saybolt Universal Viscosity @ 70°F., seconds	458
Saybolt Universal Viscosity @ 100°F., seconds	216
B. s. and water, % by volume	92
Pour point, °F.	13
Total sulphur, % by weight	1.33

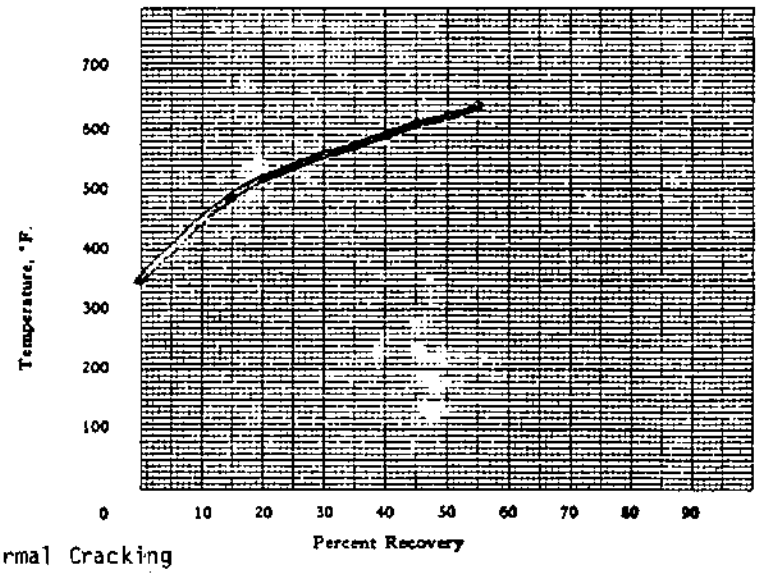
REMARKS:

ENGLER DISTILLATION

Recovery, %	Temperature, °F.
IBP	350
5	398
10	450
15	490
20	518
25	540
30	560
35	576
40	592
45	610
50	624
55	638
60	
65	
70	
75	
80	
85	
90	
95	
E.P.	638-Thermal Cracking

Recovery, %: 58.0
Residue, %: 42.0
Loss, %: 0

DISTILLATION GRAPH



Approximate Recovery

300 EP gasoline, %	0
392 EP gasoline, %	4.0
500 EP distillate, %	13.0

4.7

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WATER ANALYSIS REPORT

OPERATOR Husky Oil Company DATE May 17,1978 LAB NO. 7870

WELL NO. South Barrow No. 19 LOCATION

FIELD NPR #4 FORMATION

COUNTY INTERVAL DST No. 1

STATE Alaska SAMPLE FROM

REMARKS & CONCLUSIONS:

Cations	mg/l	meq/l	Anions	mg/l	meq/l
Sodium	1771	77.07	Sulfate	250	5.20
Potassium	1100	28.16	Chloride	72500	2044.50
Calcium	39000	1946.10	Carbonate	0	---
Magnesium	40	3.29	Bicarbonate	300	4.92
Iron			Hydroxide	-	---
Total Cations		2054.62	Total Anions		2054.62

Total dissolved solids, mg/l 114809

NaCl equivalent, mg/l 112707

Observed pH 7.6

Specific resistance @ 68 °F.:

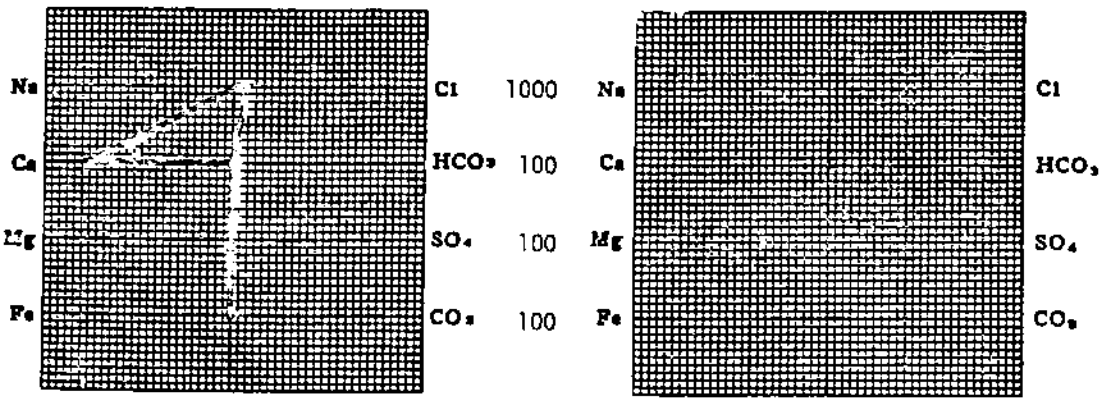
Observed 0.08 ohm-meters

Calculated 0.08 ohm-meters

WATER ANALYSIS PATTERN

Sample above described

Scale MEQ per Unit



(No value in above graphs includes Na, K, and Li)

NOTE: Mg/l = Milligrams per liter Meq/l = Milligram equivalents per liter

Sodium chloride equivalent by Dunlap & Hawthorne calculation from components

ENGINEERING MEMORANDA

SOUTH BARROW WELL NO. 19

PRODUCTION TEST NO. I

May 11-14, 1978

This memoranda is a presentation of the reservoir data gathered and reservoir calculations from the production test of the Barrow Sand in the South Barrow Well No. 19. Table I presents basic well and formation data. Table II is a listing of primary analysis results. These are original gas in place, back-pressure analysis, drawdown analysis, pressure buildup analysis, and pressure gradient test analysis. Presented next is a discussion of each analysis. Conclusions and recommendations are followed by data, graphs, and example calculations.

TABLE I - WELL AND FORMATION DATA

1.	Barrow Sandstone, early-middle Jurassic	
2.	Perforations 2018 to 2044 feet at 4 spf	
3.	Gross sand thickness	l = 26 feet
4.	Net pay thickness	h = 16 feet
5.	Bulk porosity in net pay	$\emptyset_B$ = 24.2%
6.	Effective porosity in net pay	$\emptyset_e$ = 20.8%
7.	Average water saturation in net pay	S_w = 48.2
8.	Gas gravity	ϱ_g = 0.611
9.	Critical temperature	T_c = 336.1°R
10.	Critical pressure	P_c = 650.9 psia
11.	Reservoir temperature	T_i = 527°R
12.	Initial reservoir pressure	P_i = 984.0
13.	Initial gas compressibility	z_i = 0.88

TABLE II - LISTING OF TEST RESULTS

A. Volumetric Reserves:

Original gas in place = 353.466 McF/AcFt

B. Backpressure Analysis:

Absolute open flow = AOF = 7.22 MMcF/D
Back pressure slope = n = 0.844
Back pressure constant = C = .000064062 $\frac{MMcF/D}{PSI^2}$

C. Pressure Buildup Analysis:

Initial reservoir pressure	P_i = 984 psia
Flow Capacity	kh = 542.19 md ft

Permeability	k = 33.89 md
Skin	S = 1.348
Skin pressure drop	ΔP_s = 42.22 psi
Productivity index (actual)	J_a = 14.13 $\frac{\text{McF/d}}{\text{psi}}$
Productivity index (ideal)	J_i = 16.87 $\frac{\text{McF/d}}{\text{psi}}$
Flow efficiency	Ef = .837
Gas mobility	M = 2854.6 md/cp
Effective wellbore radius	r_w' = 1.104 inch
Approximate radius of investigation	r_{inv} = 462 ft

D. Wellbore Pressure Gradient Survey:

BHP at 2037 ft	= 980.9
Fluid level	= 1767
WHP	= 793.0
Fluid gradient	= .515 psi/ft

DISCUSSION OF DATA, ANALYSIS TECHNIQUE, AND RESULTS

Original Gas in Place

The porosity, water saturation, and reservoir temperature used in the calculation of Original Gas in Place were derived from log analysis and are representative of the 16 feet of net pay selected between 2023 and 2040 feet. The initial reservoir pressure was derived from the buildup analysis, with both the initial and final buildup curves indicating 984.0 psia. The pressure readings were taken from the Sperry Sun Tool No. 311 at 2037 feet.

The calculated value of Original Gas in Place is 353.466 McF/Ac ft. This is 18.5% higher than the assumed value of 298.2 McF/Ac ft in use for the South Barrow field. The primary cause of this difference is the porosity of 20.8% as opposed to the 16.0% in use as an average field porosity.

Four Point Backpressure Analysis

The pressure-flow history obtained during the four point flow test was very smooth and provided excellent alignment of points in the plot of $P_c^2 - P_t^2$ vs Q. The indicated absolute open flow was 7.22 MMcF/d. The backpressure slope was 0.844.

Reservoir Parameter Analysis

Two types of reservoir parameter analysis were performed. The first drawdown of the four point flow was analyzed as was the final buildup. Table III compares the results of these two analyses.

The drawdown analysis technique was based on the semilog plot of Pwf vs log Tp and the pressure equation:

$$Pwf = P_i - \frac{28984\ q\ \mu g B g}{kh}\left[\log Tp + \log \frac{k}{\phi \mu g C_t r_w^2} - 3.2275 + 0.86859\ S\right]$$

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The final buildup was analyzed using a multiple flow rate technique with the plot of P_{ws} vs $\sum_{j=1}^{n} q_j/q_n \log\left(\frac{Tn - T_{j-1} + \Delta T}{Tn - T_j + \Delta T}\right)$

and the equation of the straight line being

$$P_{ws} = P_j - \frac{28984\ q\ \mu g\ Bg}{kh} \sum_{j=1}^{n} q_j/q_n \log\left(\frac{T_n - T_{j-1} + \Delta T}{T_n - T_j + \Delta T}\right)$$

This analysis was chosen as the most representative of the reservoir as the flow and buildup times were the longest and the shut in pressure at the start of the flow period was nearest to the projected initial reservoir pressures. Table III shows that the values of kh are in close agreement. The kh in use in the South Barrow field is 154.5 md ft. The calculated kh for Wells No. 14 and No. 17 were 346.28 md ft and 493.80 md ft respectively. The values of Skin, ΔP_s and r_w' show considerable divergence. This can be explained, however, by the rate dependent nature of these parameters. The most significant fact about the Skin and Flow Efficiency parameters is that they show a considerably larger amount of formation damage than was indicated by the tests of Well No. 17 and Well No. 14.

TABLE III - COMPARISON OF TEST ANALYSES

Derived Parameter	Drawdown Value	Buildup Value
Flow Capacity	kh = 567.90 md/ft	kh = 542.19 md/ft
Permeability	k = 35.49 md	k = 33.89 md
Skin	S = .786	S = 1.348
Skin Pressure Drop	ΔP_s = 6.77 psi	ΔP_s = 42.22 psi
Actual Productivity Index	J_a = 19.57	J_a = 14.13
Ideal Productivity Index	J_i = 22.06	J_i = 16.87
Flow Efficiency	E_f = 88.71	E_f = 83.7
Gas Mobility	M = 2936.9 $\frac{md}{cp}$	M = 2854.6 $\frac{md}{cp}$
Effective Wellbore Radius	r_w' = 1.936 inch	r_w' = 1.104 inch
Radius of Investigation	r_{inv} = 222 ft	r_{inv} = 462.6 ft

Pressure Gradient Survey

The pressure gradient survey was run with stops at 25, 50, 100, 500, 1000, and 1500 feet of bottom. The survey results are presented in Table II.

CONCLUSIONS AND RECOMMENDATIONS

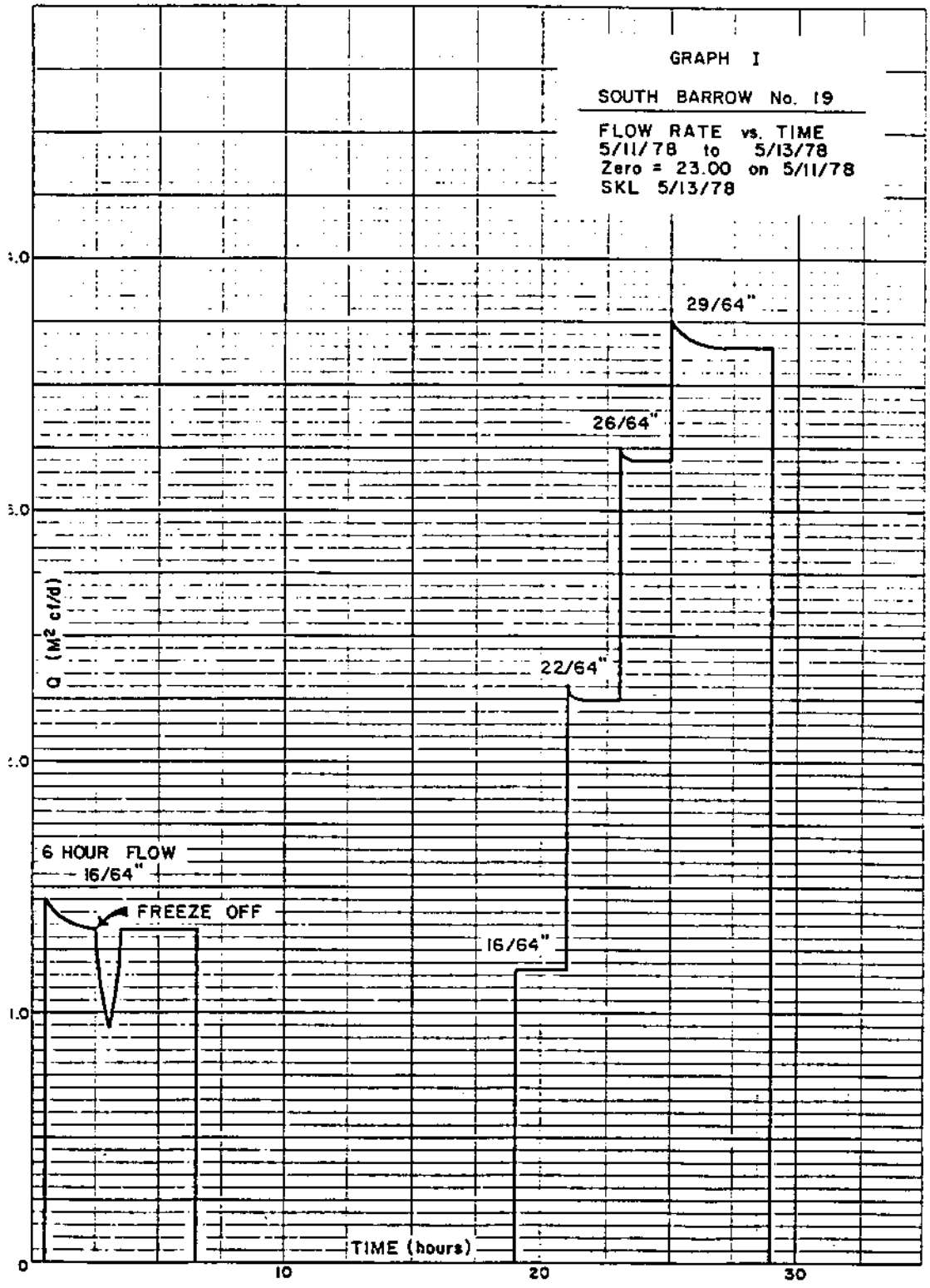
The production testing of South Barrow No. 19 was exceptionally smooth operationally and yielded excellent pressure and flow data. Minor problems were experienced with the test tree and one flow line freeze off was successfully countered with alcohol injection.

The somewhat higher (as compared to South Barrow Wells No. 14 and 17) skin damage may be due to the 232 psi overbalance being carried when the well was perforated. It would appear that 100 psi overbalance might be a better operation parameter from a reservoir viewpoint. Also of interest is the total absence of produced water during the flow period. This is probably due to the structurally high position of the well. As compared to the water production experienced in Well No. 17, the dry nature of Well No. 19 confirms the importance of staying high on the structure in future wells and exercising caution in selecting the perforation interval in any wells which may be drilled lower on the structure.

DATA AND EXAMPLE CALCULATIONS

Attached are data displays and calculations as listed below.

1.	Graph I	Flow Rate vs Time
2.	Example Calculation I	Original Gas in Place
3.	Graph II	$P_c^2 - P_t^2$ vs Q
4.	Example Calculation II	Backpressure Data
5.	Graph III	P_t vs Log T_p
6.	Example Calculation III	Drawdown Analysis
7.	Graph IV	P_{ws} vs $\sum_{j=1}^{n} q_j / q_n \log\left(\frac{Tn - T_{j-1} + \Delta T}{Tn - T_j + \Delta T}\right)$
8.	Example Calculation IV	Buildup Analysis
9.	Graph V	P_{ws} vs Depth
10.	Example Calculation V	Gradient Analysis


GRAPH I
SOUTH BARROW No. 19
FLOW RATE vs. TIME
5/11/78 to 5/13/78
Zero = 23.00 on 5/11/78
SKL 5/13/78
29/64"
26/64"
22/64"
16/64"
6 HOUR FLOW
16/64"
FREEZE OFF
Q (M² cf/d)
TIME (hours)
0
1.0
10
20
30

EXAMPLE CALCULATION I

Volumetric Reserve Calculation

Original Gas in Place - McF/AcFt

43560 Ft^2/Ac

$\emptyset_e$ = 20.8%

Sw = 48.2%

P_i = 984.0 psia

T_i = 67°F

Z_i = .880

T_{sc} = 520°R

P_{sc} = 14.65 psia

$$OGIP = A \emptyset Sg \frac{P_i}{P_{sc}} \frac{T_{sc}}{T_i} \frac{1}{Z_i}$$

$$= 43560 \times .208 \times .518 \times \frac{984}{14.65} \times \frac{520}{527} \times \frac{1}{.87}$$

= 353.466 McF/Ac Ft

ATTACHMENT 2

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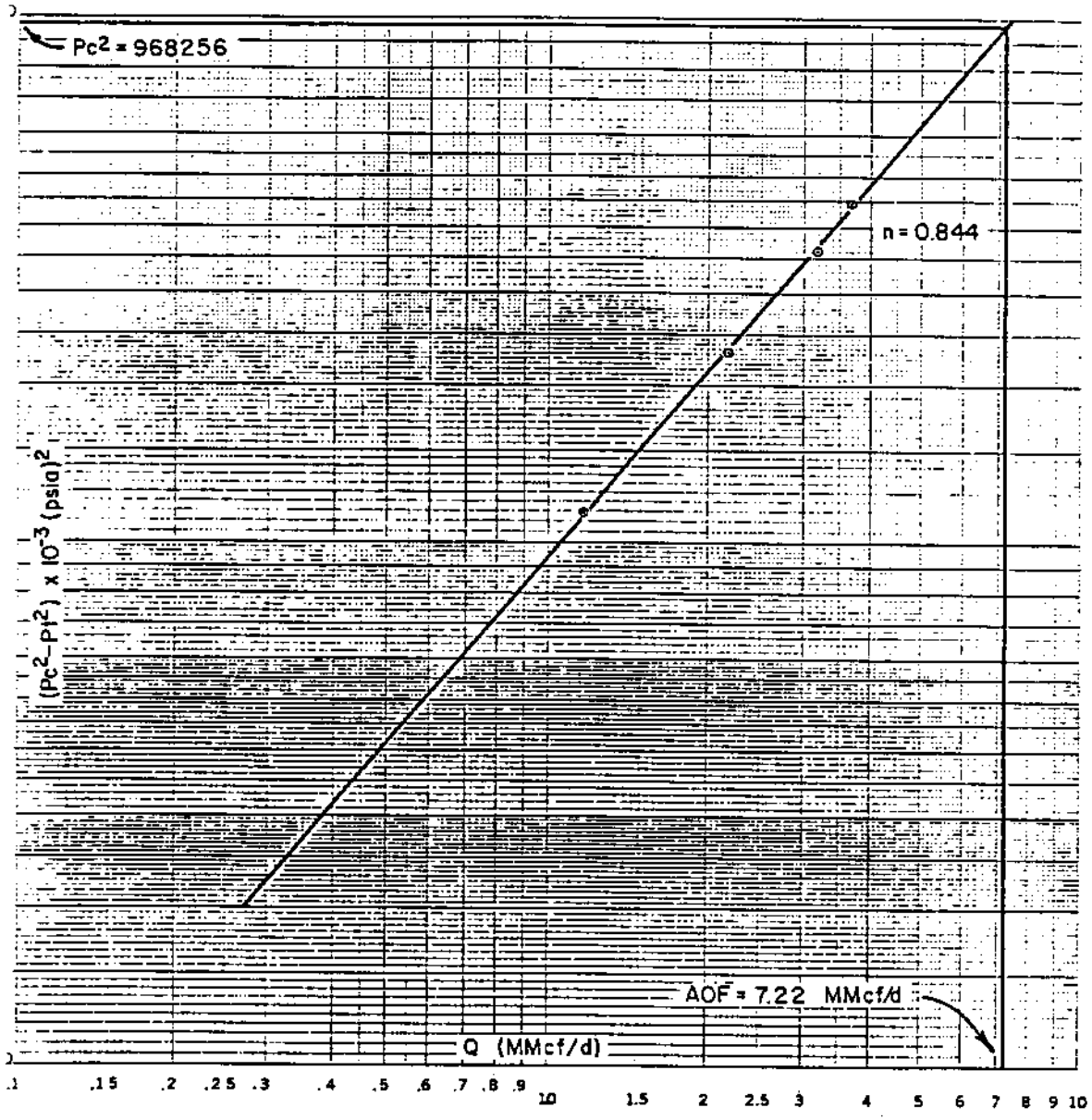


GRAPH II

SOUTH BARROW No. 19

Q vs Pc^2-Pt^2
Sperry Sun Tool No. 311
at 2037'
SKL 5/13/78

EXAMPLE CALCULATION II

Four Point Flow Test - 5/12/78

Initial Reservoir Pressure = 984 psia

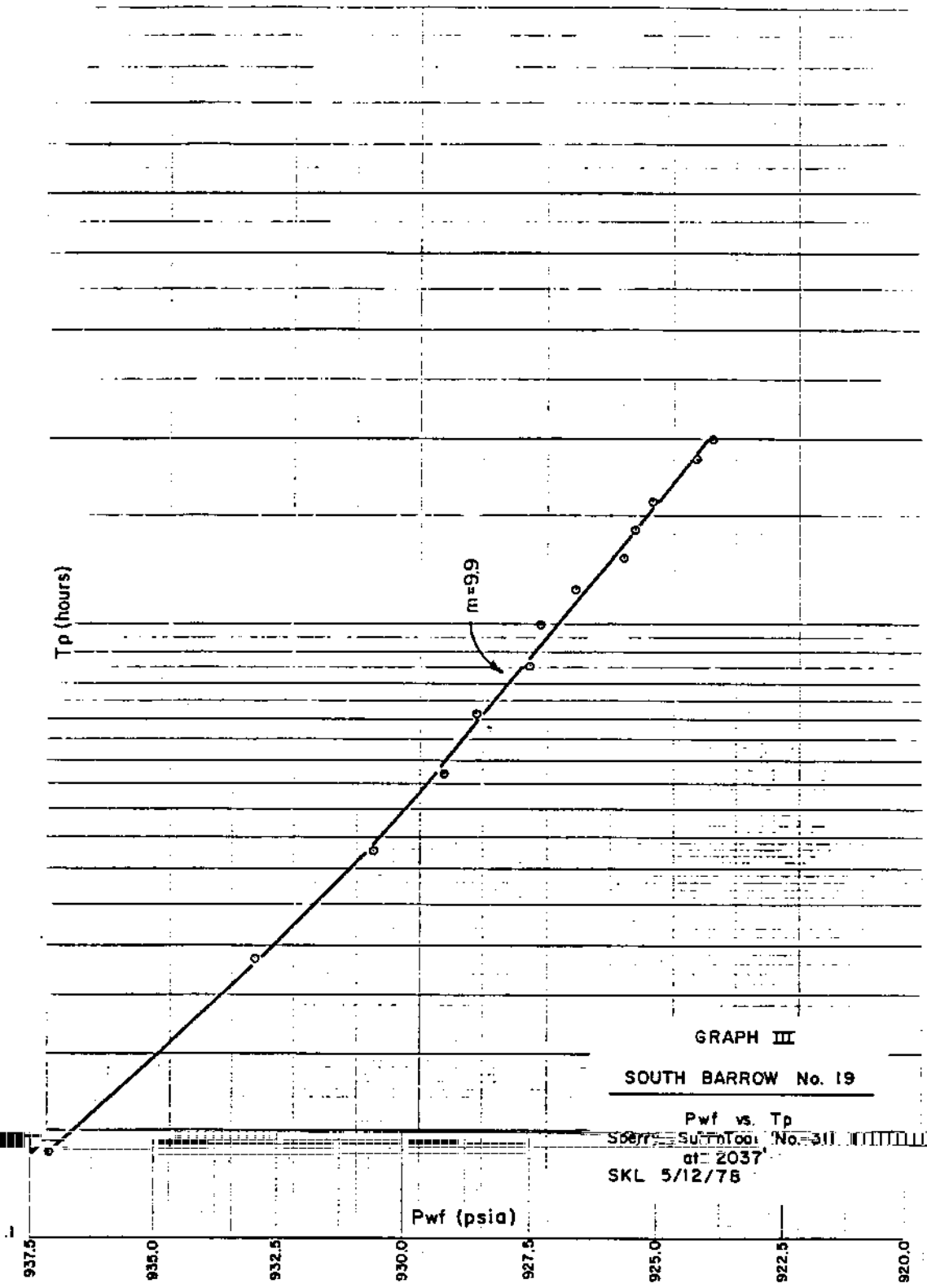
Rate	Choke	Pressure	Flow Rate	ΔP^2
1	16/64	924.2 psia	1.170 M^2cF/d	114077
2	22/64	858.5 psia	2.188 M^2cF/d	231233
3	26/64	779.4 psia	3.191 M^2cF/d	360826
4	29/64	724.5 psia	3.687 M^2cF/d	445165

AOF = 7.220 M^2cF/d

n = .844

c = .000064062 $\frac{M^2cF/d}{ps^2}$

ATTACHMENT 4


Tp (hours)
m=9.9
Pwf (psia)
937.5
935.0
932.5
930.0
927.5
925.0
922.5
920.0
GRAPH III
SOUTH BARROW No. 19
Pwf vs. Tp
Sperry-Sun Tool No. 311
at 2037'
SKL 5/12/75

EXAMPLE CALCULATION III

First Drawdown - Sperry Sun Tool 311 at 2037'

I. $B_g = Z \frac{T}{T_{sc}} \frac{P_{sc}}{\frac{Pi-Pwf}{2}}$ $\quad T_c = 336.1^\circ R$ $\quad P_c = 650.9$ $\quad T_R = 1.568$ $\quad P_R = \frac{954.1}{650.9} = 1.466$

$Z = .882$

$B_g = .882 \frac{527}{520} \frac{14.65}{954.1} = .01372$

II. $\mu g = \mu g/\mu i * 0.0106 * X 1.14 = .012084$

III. $C_t = SgCg + SwCw + CF = (.518 \times .00115225) + (.482 \times 3.3 \times 10^{-6}) + (3.3 \times 10^{-6}) = C_t = .0006017561$

IV. $kh = \frac{28984\ q\ \mu g B g}{m}$ $\quad q = 1170$ McF/d, $m = 9.9$, $h = 16$, $P1hr = 927.3$ psia, $Pi = 984$ psia, $r_w = 4.25"$, $\phi = .208$

$= 567.9$ mdft

$k = 35.49$ md

V. $S = 1.1513 \left(\left(\frac{Pi - P1hr}{m} \right) - \log \left(\frac{k}{\phi \mu C t r_w^2} \right) + 3.2275 \right)$

$S = .786117$

VI. $\Delta P_s = m \times .87(S) = 9.9 \times .87\ (.786117)$
$= 6.77$ psi

VII. Productivity Index = J

$J_a = \frac{q}{P_i - P_{wf}} = \frac{1170}{984.0 - 924.2} = 19.57 \frac{McF/d}{psi}$

$J_i = \frac{q}{(P_i - P_{wf}) - \Delta P_s} = \frac{1170}{984 - 924.2 - 6.77} = 22.06 \frac{McF/d}{psi}$

Flow Efficiency $= \frac{J_a}{J_i} = \frac{19.57}{22.06} = .8871$

ATTACHMENT 6

VIII. Average Gas Mobility = M

$$M = \frac{k_g}{\mu_g} = \frac{35.49}{.012084} = 2936.94 \text{ md/CP}$$

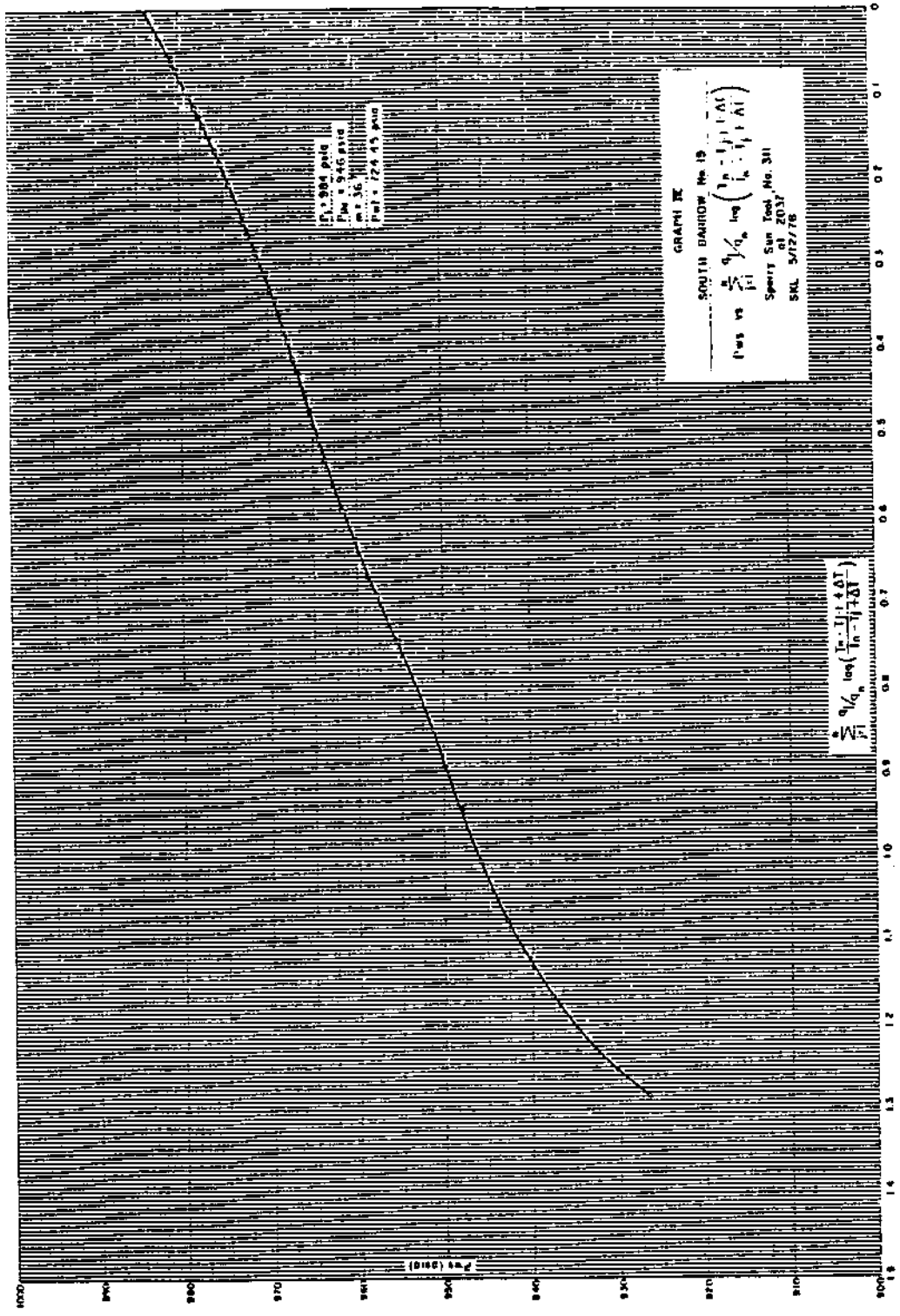
IX. Effective Wellbore Radius = r_w'

$$r_w' = r^w e^{-s} = 1.936 \text{ inches}$$

X. Approximate Radius of Investigation = r_{inv}

$$r_{inv} = \sqrt{\frac{0.00105\ k\ T_p'}{\phi\ \mu\ C_t}} = 222 \text{ ft}$$

ATTACHMENT 6
Page 2


GRAPH IX
SOUTH BARROW No. 19
Sperry Sun Tool No. 311
at 2037
SKL 5/12/78

EXAMPLE CALCULATION IV

Final Buildup - Sperry Sun Tool 311 at 2037'

I. $B_g = Z \frac{T}{T_{sc}} \frac{P_{sc}}{\frac{Pi-Pwf}{2}}$ $T_c = 336.1^\circ R$ $P_c = 650.9$ $T_R = 1.568$ $P_R = \frac{854.225}{650.9} = 1.312$

$Z = .890$

$B_g = .890 \ \frac{527}{520} \ \frac{14.65}{854.225} = .015469$

II. $\mu g = \mu i \times \mu g/\mu i = .0106 \times 1.12 = .011872$

III. $C_t = SgCg + SwCw + CF = (.518 \times .00129052) + (.482 \times 3.3 \times 10^{-6}) + (3.3 \times 10^{-6}) = C_t = .0005606721$

IV. $kh = \frac{28984 \ q \ \mu g B g}{m}$

$q = 3667$ McF/d
$m = 36$
$h = 16$
$P1hr = 946$
$Pwf = 724.45$
$rw = 4.25"$
$\emptyset = .208$

V. $S = 1.1513 \left(\left(\frac{P1hr - Pwf}{m} \right) - \log \left(\frac{k}{\emptyset \mu C t r_w^2} \right) + 3.2275 \right)$

$S = 1.348$

VI. $\Delta P_s = m \times .87(S) = 36 \times .87 \ (1.348)$
$= 42.22$ psi

VII. Productivity Index = J

$J_a = \frac{q}{P_i - P_{wf}} = \frac{3667}{984 - 724.45} = 14.128 \ \frac{McF/d}{psi}$

$J_i = \frac{q}{P_i - P_{wf} - \Delta P_s} = \frac{3667}{(984 - 724.45) - 42.22} = 16.873 \ \frac{McF/d}{psi}$

Flow Efficiency $= \frac{J_a}{J_i} = \frac{14.128}{16.873} = 0.837$

ATTACHMENT 8

VIII. Average Gas Mobility = M

$$M = \frac{k_g}{\mu_g} = \frac{33.89}{.011872} = 2854.6 \text{ md/CP}$$

IX. Effective Wellbore Radius = r_w'

$$r_w' = r^w e^{-s} = 1.104 \text{ inches}$$

X. Approximate Radius of Investigation = r_{inv}

$$r_{inv} = \sqrt{\frac{0.00105\ k\ T_p}{\phi\ \mu\ C_t}} = 463 \text{ ft}$$

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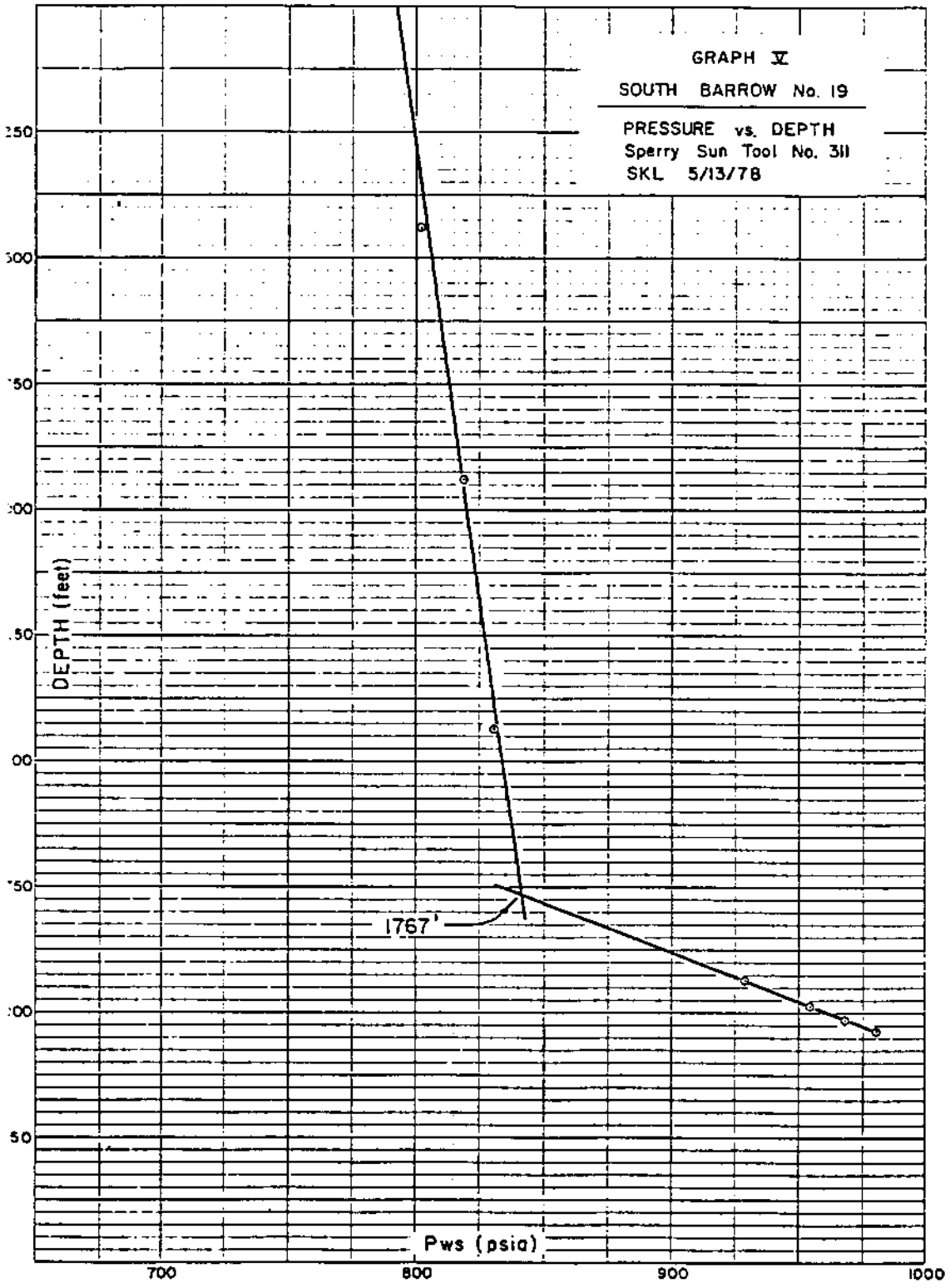
GRAPH V
SOUTH BARROW No. 19
PRESSURE vs. DEPTH
Sperry Sun Tool No. 311
SKL 5/13/78
DEPTH (feet)
1767'
Pws (psia)
700
800
900
1000

EXAMPLE CALCULATION V

Pressure Gradient Test - 5/13/78

D	L	P	ΔP	Gradient
2037	0	980.9	0	-
2012	25	968.1	12.8	.512 psi/ft
1987	25	954.7	13.4	.536 psi/ft
1937	50	929.4	25.3	.506 psi/ft
1437	500	831.0	98.4	.197 psi/ft
937	500	819.7	11.3	.023 psi/ft
437	500	802.2	17.5	.035 psi/ft
0	437	793.0*	9.2	.021 psi/ft*

*Extrapolated from plot of P vs D

ATTACHMENT 10