Appendix G: Source rock data, in Fehlmann, R.H., and Amoco Oil Co., Data compilation 1970 Amoco field party, western and central Brooks Range, Alaska

Fehlmann, R.H., and Amoco Oil Co.

GMC DATA REPORT 463G

This GMC data report from the Amoco Heritage collection has been made available through funding from the FY2018 USGS National Geological and Geophysical Data Preservation Program, Grant Number G18AP00054. This project report is presented in its original format and has not been reviewed for technical content or for conformity to the editorial standards of DGGS. It should not be used or cited as reviewed data.

2019
State of Alaska
Department of Natural Resources
Division of Geological & Geophysical Surveys
GEOLOGIC MATERIALS CENTER

APPENDIX G

RECOMMENDATIONS

All objectives of the field program as set forth for the 1969 summer program could not be attained. The primary reasons for this are: (1) an early snowfall prevented two weeks of scheduled work; (2) the poor quality of existing geologic literature did not permit sufficient understanding of the geology as rapidly as anticipated; therefore, much additional time was spent determining the stratigraphy; (3) an additional control section, Skimo Creek, was made the responsibility of the eastern party.

It is recommended that during the 1970 field season, the objectives of the 1969 program be completed with emphasis on stratigraphic sections in the Sadlerochit Mountains, Aichilik River, Kikiktak Mountain, Kongakut River, Joe Creek, and Mount Greenough areas where it is anticipated to measure approximately 28,000 feet, collect 165 paleontology samples, and 400 lithology samples. The sections represent rocks from Devonian through Early Cretaceous and results from the field program of 1969 and 1970 will complete the stratigraphic control of the eastern Brooks Range from Skimo Creek to the Canadian border. A detailed field program proposal will be submitted at a later date.

SOURCE AND RESERVOIR ROCKS

The presence of large oil reserves at Prudhoe Bay has been proven by recent drilling. The possibilities of finding additonal extensive petroleum production from structural and stratigraphic traps beneath the Arctic coastal plain and the foothill belts of the Brooks Range are strongly supported by unusually thick sequences of rocks with source and/or reservoir characteristics. These rocks, extensively exposed on the flanks of the eastern Brooks Range, attain a cumulative thickness of nearly 10,000 feet (see Table 2). The known stratigraphic relationship of source rocks to reservoir rocks, the possibilities of lateral migration of petroleum into reservoir rocks via routes controlled by sedimentary facies changes, and the probability of source rocks being juxtaposed to reservoir rocks at unconformities and by faulting, all make the subsurface Paleozoic and Mesozoic section northeast of the Brooks Range one of highest petroleum potential.

Highly carbonaceous shales, mudstones, siltstones, and limestones, as well as extensive phosphoritic rocks, are found in the Kayak Shale, the Lisburne Formation, the Siksikpuk Formation, the Shublik Formation, Kingak Formation, and the Okpikruak Formation. Many rock sequences are heavily stained and yield marked petroliferous odor on fresh break. Samples from the Lisburne, Siksikpuk, Shublik, and Okpikruak formations have been sent to Dr. Gerould Smith, Union Oil Research Center, for geochemical and petroleum analyses.

Reservoir rocks with notable permeability are the Mt. Weller Dolomite, dolomite sequences in the Lisburne Formation, remarkably clean, thick quartz arenites of the Sadlerochit Formation, and the basal sandstone of the Kingak Formation. Samples of these will be analyzed for reservoir capabilities.

Table 2 lists the more noteworthy source and reservoir zones of the eastern Brooks Range.

SOURCE AND RESERVOIR ZONES, EASTERN BROOKS RANGE

Source Rocks	Thickness
Okpikruak Formation Dark carbonaceous shales, sandstones and calcisiltites.	>1,700'
Kingak Formation Black, carbonaceous and sooty shales.	>100'
Shublik Formation Sooty limestones, phosphatic units, fissile, carbonaceous shales.	1,040'
Siksikpuk Formation Dark calcisiltites and shales.	478'
Lisburne Formation (in part) Sooty limestone and phosphatic units (thick algal and coralline sequences may be additional source zones in the subsurface).	~250'
Kayak Shale Black, fissile, carbonaceous shale.	763'
TOTAL THICKNESS	4,331' +

Reservoir Rocks	Thickness
Kingak Shale (in part) Basal sandstone.	67'
Sadlerochit Formation Clean quartzose sandstones.	436'
Lisburne Formation (in part) Bedded limestones, porous dolomites and bioherms.	>2,858'
Mt. Weller Dolomite Porous, vuggy dolomite and dolomitized oolites.	>1,685'
	5,046' +

Union Oil Company of California
Union Research Center, P[illegible], California 92621
Telephone (714) 528-7201

E&PE-69-345

UNION

November 26, 1969

Mr. Fred C. Hankinson
Union Oil Company of California
628 East 5th Avenue
Anchorage, Alaska 99501

NO. SLOPE OUTCROP SAMPLES AND KOOKPUK NO. 1 CUTTINGS - GEOCHEMICAL ASSAY

Dear Fred,

I received a request through Dave Abrahamson to obtain an assay on the balance of the samples from Union's eastern No. Slope 1969 field party. The data are summarized in the attached TABLE 1. As you can note, two samples contained large quantities of elemental sulfur so the value for oily extractable organic matter would actually be 0.0019% and 0.0033% for samples FCH-200 and FCH-354G, respectively. The amount of oily extract from 20 lbs of rock was too small to process in detail for these two samples. Additional detailed analysis will be made on the other four samples for Union Oil Company confidential use.

The Kookpuk No. 1 cuttings have been assayed and are quite rich. The results, summarized in TABLE 2, show these cuttings to have nearly ten fold the extractable organic matter obtained from the field party outcrop samples. Note also that the earthy Seabee and Topogoruck shales contained a comparable amount of extract to the hard black shales from deeper horizons.

All of these cuttings were unwashed and many were still wet. The Seabee and Topogoruck shales could not be washed because they disintegrated during washing. Perhaps most of the mud can be at least rinsed away when taken directly from the shaker screen. It would make the results more reliable. A second problem related to the use of unwashed cuttings is the presence of oil in the mud from shows or from the addition of diesel to the mud. Cuttings for geochemical purposes should be washed as thoroughly as possible when taken. Further, at least a quart mud sample should be taken whenever a geochemical cutting sample is taken. Also, a quart sample of any diesel or other oil added to the mud should be taken for geochemical testing.

In view of the high values for the extractable organic matter in the Kookpuk shales, a twenty-five pound bag of washed cuttings should be ample. However, under any circumstances, cuttings are not as satisfactory as cores. Therefore, any shale cores that are taken should be saved and used for geochemical work rather than cuttings whenever possible, as they minimize contamination and loss of organic matter of interest.

If cans or additional sacks for sampling are needed, please advise us.

Very truly yours,

Gerould H. Smith

Gerould H. Smith
Research Associate

GHS:ms

CC: R. A. Saunders
C. H. Glidden
J. R. Fox
E. C. Copelin
Dave Abrahamson
Charles Barker

Sec. 31 & 35

TABLE 1

ASSAY FOR EXTRACTABLE ORGANIC MATTER FROM NORTH SLOPE 1969 EASTERN FIELD PARTY ROCKS

Field No.	Location	Formation	Extractable Organic Matter (EOM), %	Oils, % in EOM	Elemental Sulfur, % in EOM	Asphaltenes in EOM
DNA-170	E-2 Skimo Creek	Lisburne	0.0156 4.2	83.4 3.5	Trace	16.6
FCH-146	E-2 Skimo Creek	Siksikpuk	0.0177 4.8	82.8 4.0	--	17.2
FCH-176	E-3 Tiglukpuk Creek	Okpikruak	0.0065 1.8	82.8 1.5	--	17.7
DNA-244	E-6 Sadlerochit Mtn's.	Shublick	0.0028 0.7	92.4 0.6	3.4	4.2
FCH-200	Peregrine Creek	Shublick (?)	0.0031 0.5	49.5 0.4	39.1	11.4
FCH-354G	E-13 Kavik River	Shublick	0.0113 0.9	26.5 0.8	71.0	2.5
FCH-204	Peregrine Creek	Shublick (?)	(a)	--	--	--

(a) Black bituminous-appearing material insoluble in solvents.

Source > .01%

TABLE 2

ASSAY OF KOOKPUK NO. 1 CUTTINGS FOR EXTRACTABLE ORGANIC MATTER

Depth, ft.	Formation	Extractable Organic Matter, %	BBL/ACRE-FT	Oils, % in EOM	Tons/Acre-Ft	Asphaltenes in EOM, % *
5080-5280	Seabee Shale [a] U.K.	0.090	24.3	65.6	15.9	34.4
5720-5820	Topogoruck Shale [a] L.K.	0.135	36.5	65.1	23.8	34.9
6240-6580	Kingak "Pebble" Shale J	0.122	32.0	34.5	11.0	65.5
7610-7810	Kingak Shale J	0.135	36.5	56.0	20.4	44.0
9710-9780	Kayak Shale [b] Miss.	0.080	21.6	58.8	12.7	41.2

Extractable Hydrocarbons % of Extractable C.M.

a Could not wash out mud so results contain any oil that might have been in mud from previous or nearby oil shows.

b Cut after addition of diesel oil to the mud.

* NOT THE TRUE ASPHALTENES, BUT INCLUDES EVERYTHING NOT ELUTED FROM CHROMATOGRAPHIC COLUMN DURING SEPARATION OF "OILS" (EXTRACTABLE HYDROCARBONS).

Geochem 1968
W. Brooks Range - Union

Geochemical

An attempt was made to sample some of the rich oil shales described by Tourtelot and Tailleur (1965) in their open file report. This was not a primary objective of the field crew; one foggy afternoon was spent searching for the U.S.G.S. localities. None of the U.S.G.S. localities were located with confidence. U.S.G.S. localities 15, 17, and 18 were sampled; the letter that follows gives the negative results.

During a personal interview, A. K. Armstrong of the U.S.G.S. mentioned the occurrence of waxy oil shales in the Mississippian clastics that crop out on a feature named "Figure 4" on the Lisburne Peninsula. The negative results of this endeavor are listed in a separate letter that follows.

Union Oil Company of California
Union Research Center, Brea, California 92621
Telephone (714) 528-7201

UNION

E&PE-70-214

July 15, 1970

Mr. Jean Paul Chauvel
Union Oil Company of California
628 East 5th Avenue
Anchorage, Alaska 99501

SAMPLES FROM UNION'S NORTH SLOPE
WEST PARTY - 1969

The three samples sent to us from the above field party were assayed for total extractable organic matter. The values were as follows:

#15 USGS Cula Creek Shale	less than 50 ppm
#17 USGS Cula Creek Shale	about 200 ppm
#18 USGS Ipnar KR Shale	less than 50 ppm

The two samples with less than 50 ppm are too small to separate enough organic matter to process. The sample shown as #17 USGS Cula Creek is probably large enough to process further. This sample is not nearly as rich in extractable organic matter as some shales we have tested, which contain up to 2000-3000 ppm extractable matter. A value of 100 ppm is about as low as we can successfully process using a 25 pound sample.

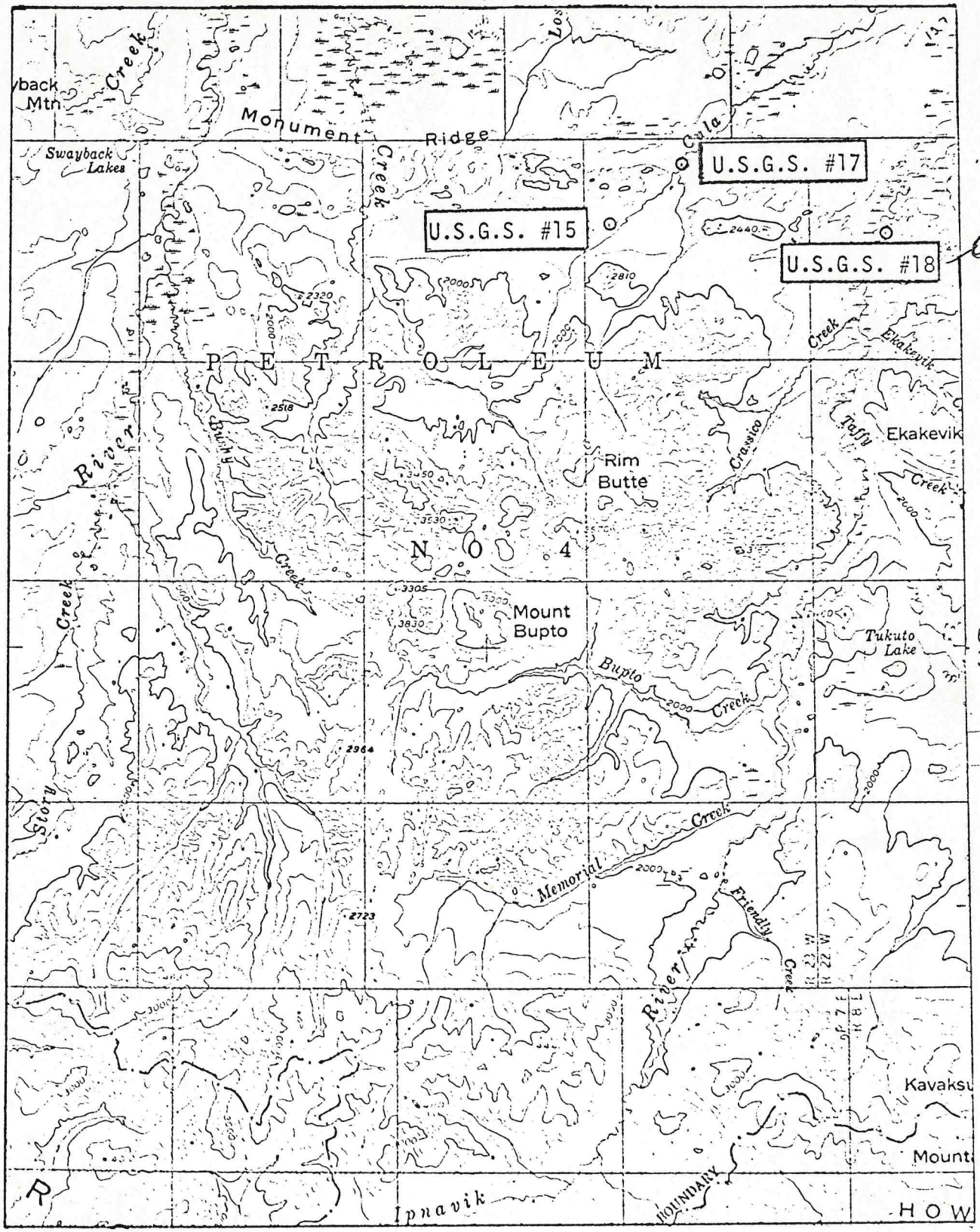
Very truly yours,

Gerould H. Smith

Gerould H. Smith
Research Associate

GHS:ms

~~150° 30'~~ 150° 30'



Location of Oil Shale Samples
Refer: Tourtelot, N.J. & Tailleur, I.L. (1965)

HOWARD PASS, ALASKA 1956

SCALE 1 250,000

5 0 5 10 15 MILES

Union Oil Company of California

Union Research Center, Brea, California 92621
Telephone (714) 528-7201

UNION

E&PE-70-243

August 4, 1970

Mr. Jean Paul Chauvel
Union Oil Company of California
628 East 5th Avenue
Anchorage, Alaska 99501

GULF NO. 4 SHALE
WESTERN FIELD PROGRAM

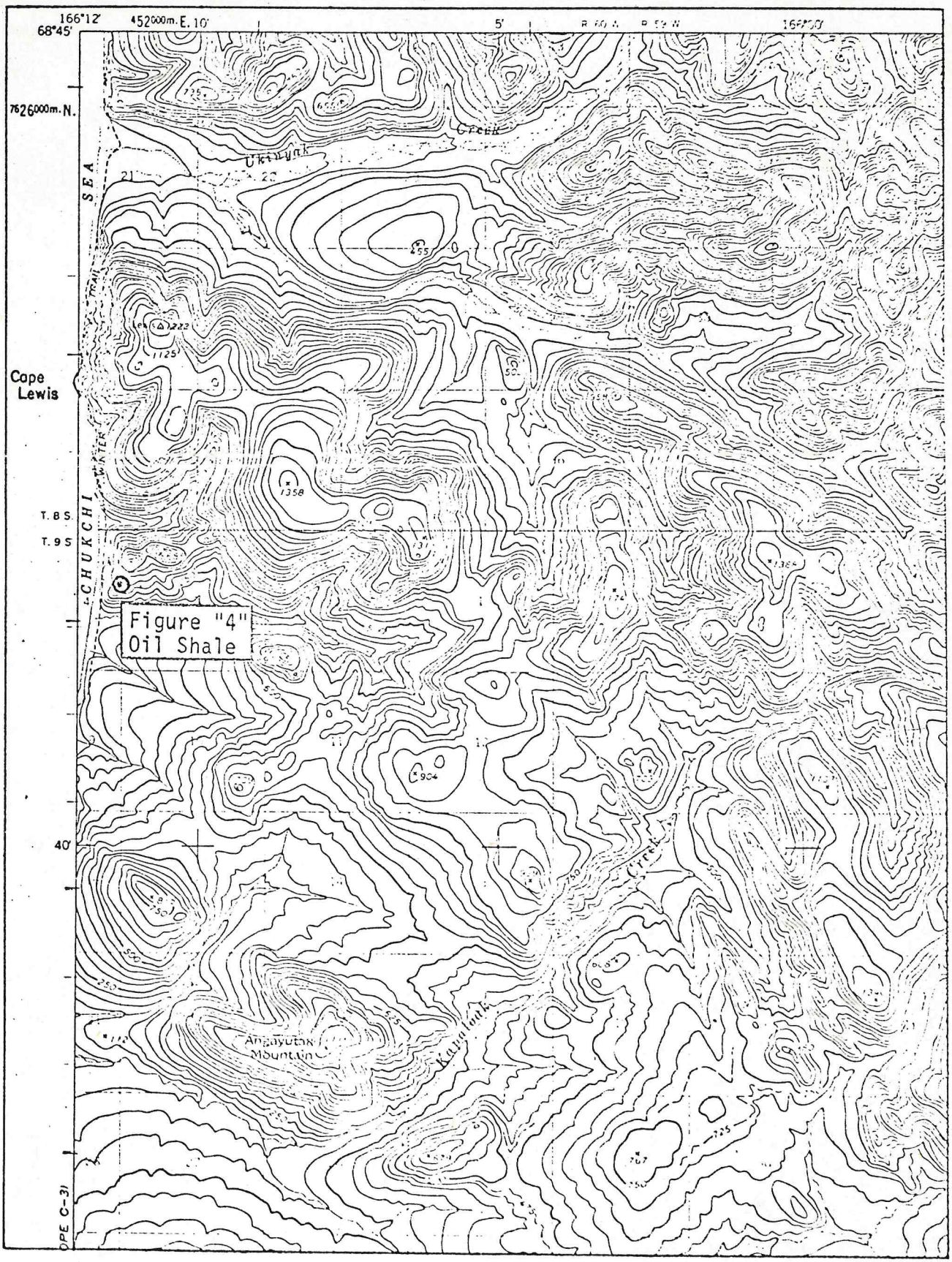
This sample of shale was received from Francis Blake at the Paleo Laboratory in Santa Fe Springs. As I recall in our last telephone conversation, you wanted to have this tested for comparison with those from USGS sites, collected by Union's 1969 North Slope West party. I have assayed it for extractable organic matter and found it to be very low. It is no better than the two shale samples from Cula Creek and Ipnar KR listed as less than 50 ppm in my letter to you, E&PE-70-214, on July 15, 1970. I will not plan any further work unless you request it.

Very truly yours,

Gerould H. Smith

Gerould H. Smith

GHS:ms



Location of Oil Shale Samples

POINT HOPE (C-2), ALASKA

0 1 2 MILES

Union Source Rock data
No. Y. Slope

ABSTRACT

The North Slope eastern field party was operational from June 14 to August 11; 38 days were spent describing 30,676 feet of section and collecting 763 samples from 15 stratigraphic sections representing rocks ranging in age from Devonian to Early Cretaceous.

Devonian rocks include the Mt. Weller Dolomite, a good potential reservoir rock, and the Kanayut Conglomerate; the stratigraphic interrelationship between these two formations is unclear. The Carboniferous Kayak Shale, a potential source rock, and the Lisburne Limestone, a source and reservoir rock, are transgressive deposits on an areally extensive carbonate shelf.

The Permo-Triassic Siksikpuk and Sadlerochit Formations are potentially excellent source and reservoir rocks respectively. The name "Sadlerochit Formation", heretofore comprised of the Ivishak and Echooka Members, is reserved for the sandstone of the Echooka Member, while the carbonate and shale beds of this member are more correctly Siksikpuk equivalents. (Thus the Siksikpuk Formation is more widespread than originally thought.) The upper Ivishak Member is raised to formational status to include the thick sequence of siltstone which disconformably overlies the Sadlerochit Sandstone.

The Sadlerochit Sandstone thins to the south and was deposited in a southerly direction on a south dipping paleoslope. The Ivishak Formation thins to the north and was deposited in a southerly direction.

The black shale of the Triassic Shublik Formation is a potential source rock. The Jurassic Kingak Formation contains a basal sandstone of good reservoir quality and an upper shale which can be a source rock. The Early Cretaceous Okpikruak, a monotonous and thick sequence of shale, sandstone, mudstone and limestone, also is a probable good source rock; unidirectional current flow structures show an eastward-inclined paleoslope. The source and reservoir rocks studied by the eastern field party attain a cumulative thickness of 10,000 feet.

A general structural analysis together with paleocurrent data and thickening and thinning of clastic units indicates a south dipping basement high to the north and west of the Sadlerochit Mountains. Sample analyses presently in progress include petrographic, porosity and permeability, heavy mineral, macro and micro paleontologic, palynological, carbonate environmental and geochemical studies, and results of sample analyses are being integrated to build the geologic framework of the Umiat Basin.

Pan Am 1969
Surface SR Anal

PAN AMERICAN PETROLEUM CORPORATION

SOURCE ROCK EVALUATION

Western Brooks Range

Alaska

Geochemistry Group
J. A. Williams
W. G. Dow

Distribution: R. W. Craig, Attn Bill Dalness
R. K. Taylor
NW Operations District Source Rock File
W. R. Walton
J. A. Momper

TS 7732CR
Denver NW Operations District
May 4, 1970

J. A. Momper

OFFICE Denver, Colorado AREA NW Explor. District

AUTHORIZED BY R. W. Craig DATE 1-19-70

TECHNICAL SERVICE NUMBER 7732 CR

PAN AMERICAN PETROLEUM CORPORATION
RESEARCH CENTER
SOURCE ROCK EVALUATIONS

STATE (PROVINCE) Alaska COUNTY WELL LOCATION Western Brooks Range

SAMPLE NUMBER	SAMPLE TYPE	SAMPLE QUALITY	Age and Location	LITHOLOGY	Field No.	INSOLUBLE RESIDUE	ORGANIC CARBON WT. %	ORGANIC CARBON RATING	EXTRACTABLE ORGANIC Bbl/ACRE FT.	EXTRACTABLE ORGANIC RATING	EXTRACT. HYDROCARBON Bbl/ACRE FT.	EXTRACT. HYDROCARBON RATING	EXTRACT. ORGANIC / TOTAL ORGANIC
WBR-1	Out-crop	Good	Mississippian Cape Lewis	ls	69-3-LE-10	24.0	0.12	Non-source	0.5	-	0.2	-	.02
WBR-2	"	"	Permian Agate Rock	sh	69-3-LE-51	88.6	2.45	Very Good	5.3	Expended	4.0	Migrated oil	.008
WBR-3	"	"	Devonian? Bastille Mt.	sh	69-2-WD-104	80.6	0.59	Poor	2.7	"	2.3		.02
WBR-4	"	"	Mississippian Nunaviksak Cr.	sh	69-2-WD-200	79.0	0.29	Non-source	0.7	-	0.6	-	.01
WBR-5	"	"	L. Mississippian Utukok R.	ls	69-2-PD-74	68.4	0.40	Poor	1.9	Expended	1.1		.02
WBR-6	"	"	Mississippian Tupik Mt.	ls	69-2-UG-58	8.2	0.11	Non-source	1.6	-	0.8	-	.05
WBR-7	"	"	Mississippian Nunaviksak Cr.	ls	69-2-UG-173	11.0	0.06	Non-source	1.8	-	1.0	-	.12
WBR-8	"	"	"	ls	69-2-UG-175	6.6	0.08	Non-source	0.9	-	0.8	-	.05

Elemental analysis of insoluble organic matter
(analysis and interpretation made by R. E. LaPlante).

	%C	%H	%O	%N	H/C
WBR-2	78.14	2.38	16.96*	2.52	0.37
-3	86.99	3.45	8.30	8.30	0.48
-5	83.91	4.10	10.11	10.11	0.58

*Sample WBR-2 appears to have undergone appreciable oxidation, possibly bacterial, as indicated by its high oxygen content.

REMARKS: (See attached sheet)

cc: R. W. Craig, Attn Bill Dalness
R. K. Taylor
NW Explor. District Source Rock File
W. R. Walton
J. A. Momper

ANALYST J. [illegible] W. B. Dow DATE 5-4-70

TABLE 4a

Western Brooks Range
Alaska
Denver NW Exploration Dist.
T.S. 7732 CR

REMARKS

Although sample WBR-2 has a high organic content, it does not appear to be in an active oil generating stage. The amount of extractable organic matter is quite low for the quantity of organic matter present. Elemental analysis indicates that it is expended and in a relatively advanced stage of diagenesis. Heavy hydrocarbon distribution data and the high proportion of hydrocarbon in the extract suggest that most of the extractable organic matter now present in WBR-2 is migrated oil. From carbon isotope and heavy hydrocarbon data this oil appears similar to Prudhoe Bay oil (see Table 4b). All the other samples were quite low in organic content, being rated either as non-source or poor. Samples 3 and 5, like sample 2, were indicated by elemental analysis to be in an advanced stage of diagenesis. The amount of extractable organic matter is generally very low, and that which is present in most of the samples appears to be non-indigenous. However, the quantities of oil present in samples 7 and 8 are too small to account for the "staining" that was reported. The staining in samples 7 and 8 is apparently not organic material, as evidenced by the very low organic carbon values, and is therefore not petroleum-related. The "oil-like" odor described from samples 4 and 6 can not be attributed to the presence of hydrocarbons or oil, both of which are present in very small quantities.

PAN AMERICAN PETROLEUM CORPORATION
RESEARCH CENTER
CORRELATION ANALYSES

OFFICE Denver AREA NW Opr.

AUTHORIZED BY R. W. Craig DATE 1-19-70

TECHNICAL SERVICE NUMBER 7732 CR

OIL ☐ ROCK ☒

STATE (~~PROVINCE~~) Alaska, Western Brooks Range

SAMPLE	SAMPLE NO.	COUNTY	AGE AND LOCATION	PAY SAMPLE INTERVAL	CARBON ISOTOPE δC^{13} ‰ ~~ALIPHATIC~~ EXTRACT	CARBON ISOTOPE δC^{13} ‰ WHOLE OIL TOTAL ORG.	SULFUR ISOTOPE δS^{34} ‰	OPTICAL ROTATION, DEGREES [1]	INFRARED SPECTRUM TYPE	~~ASSOCIATION VALUE~~ ISOMER DISTRIB.	~~ASSOCIATION VALUE~~ HEAVY HC DISTRIB.	OIL TYPE
WBR-2	69-3-LE-51		Permian, Agate Rock		-29.6				*	**	Fig. 4	

REMARKS:

[1] POSITIVE UNLESS OTHERWISE INDICATED; NOT RUN ON ROCK EXTRACTS

*Insufficient aromatics for infrared spectrum.

**Insufficient light ends for ID analysis.

ANALYST J. Gehman M. D. Dow DATE 5-4-70

TABLE 4b

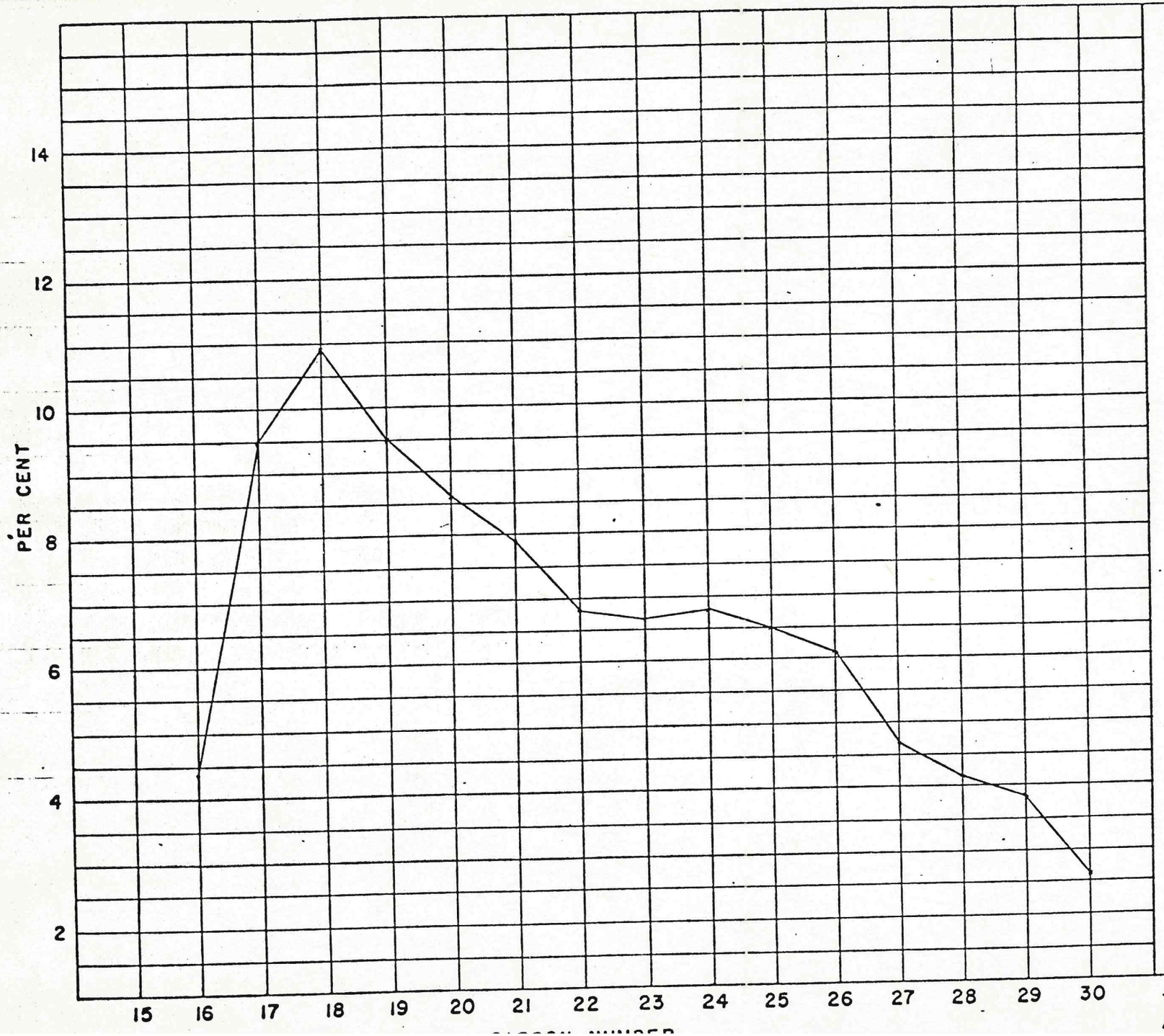
PAN AMERICAN PETROLEUM CORPORATION
RESEARCH CENTER

OIL ☐ ROCK EXTRACT ☒

HEAVY HYDROCARBON DISTRIBUTION

WESTERN BROOKS RANGE
ALASKA

Sample WBR-2



TECHNICAL SERVICE 7732 CR
AREA Denver NW Explor. District

FIGURE 4

Surface
Tri. – Tert,

AMOCO PRODUCTION COMPANY
RESEARCH CENTER

SOURCE ROCK EVALUATION

- North Slope outcrop sections -

Geochemistry Group

R. L. Ames
J. A. Williams

Distribution: B. F. Baldwin
R. K. Taylor
B. G. Newton
W. R. Walton
J. A. Momper

Technical Service 7969CR
Denver Division, North Operations

James A Momper
3-19-91

T.S. 7969CR
Denver, North Operations
North Slope outcrop sections

DISCUSSION

Thirty-one shales and siltstones, ranging in age from Tertiary to Triassic, were analyzed for source rock quality (Table 1). Seventeen of the above samples were selected for elemental analysis of the residual organic matter (kerogen) to determine their state of diagenesis and the type of hydrocarbon expected to be generated during diagenesis (Table 2).

Generally, the samples were average in source quality, but except for three samples, the amount of extractable organic matter is very low. The results of elemental analyses together with the low extractable values suggest that gas rather than oil was the primary type of hydrocarbon generated in the sampled shales.

Elemental analysis also demonstrates that the percent carbon in the kerogen (degree of carbonization) increases with stratigraphic age of the samples at a given outcrop section as shown in Figure 1. The degree of carbonization also varies significantly from one section to another and probably reflects varying thermal histories of the outcropping intervals. Rough, relative figures for the previous depth of burial can be calculated from carbon percentages using nomographs from the coal literature, assuming an average geothermal gradient of 15°F/1000' during the geologic past and estimating an exposure time. Several calculated approximate depth of burial figures are shown in Figure 1. The exposure time can be approximated by subtracting 30 million years from the geologic age to compensate for the time required for burial to maximum depth and uplift to the surface.

Since the samples were collected from scattered geographic locations, they will be discussed by outcrop section. For each outcrop section, the samples in Tables 1 and 2 are listed from youngest to oldest.

Carter Creek Section

The Miocene-Pliocene shale has good source rock quality based on organic carbon content. Elemental analysis indicates that the organic matter is in a very early stage of diagenesis and that significant hydrocarbon generation has not been realized, so this interval would be rated as a potential source. The irregular heavy hydrocarbon pattern (Figure 2) also indicates an early stage of hydrocarbon maturity.

Franklin Bluff Section

The Tertiary Sagavanirktok shale has insufficient organic carbon to generate commercial quantities of hydrocarbons (nonsource rating). As above, the heavy hydrocarbon patterns reflect early generation of immature oils (Figure 2).

Schrader Bluff Section

This Upper Cretaceous section showed source rock quality ranging from poor to good. The low hydrogen content of the kerogen indicates that gas would be the primary hydrocarbon type generated in these shales. Elemental analyses indicate that at the time of deepest burial the upper part of this section was in an early stage of hydrocarbon generation whereas the lower part of the section was near peak generation. The Tuluvak Formation would have had to be buried to at least 8000 feet for 40 million years in order to achieve the measured degree of carbonization. A shorter exposure time would require deeper burial, or higher thermal environment, to achieve the same stage of diagenesis.

It is interesting that USGS Professional Paper 303-E, page 280, reports the smell of oil in tight, Tuluvak sands at Schrader Bluff outcrop. Since the Tuluvak shales were near peak generation, the reported oil could be indigenous to the section. This would suggest that there are effective oil source beds in the Schrader Bluff area (refer to definition of effective and expended source, Research Department Report F70-G-4).

Shale Wall Bluff Section — Different type than Prudhoe Bay

Although the Upper Cretaceous Shale Wall siltstone is not of source quality, the large amount of extract and the high ratio of extractable hydrocarbons/extractable organic matter indicate that migrated oil is present. The relatively smooth slope of the heavy hydrocarbon pattern (Figure 3) indicates that the oil is mature and unaffected by bacterial alteration at the outcrop.

migrated oil

East Fork Tuluga River Section

The Upper Cretaceous Ayiyak shale has little merit as an oil source rock, as evidenced by its marginal organic carbon and very low extractable organic matter value. It may represent an effective source for gas in areas where peak generation has been attained.

Corwin Bluff Section

The Lower Cretaceous Corwin shale has good source capability and appears to have passed peak hydrocarbon generation stage in this area, but its low hydrogen content and low extractable values suggest gas rather than oil generating potential.

Barbara Syncline Section

Both the Lower Cretaceous Corwin and Grandstand shales have fair to good source rock quality and elemental analysis indicates a peak or past peak hydrocarbon generation stage of diagenesis. Low hydrogen content of the kerogen suggests gas was the primary hydrocarbon generated. The large amount of extractable organic matter in the Grandstand siltstone (sample ANS-31) is probably a microshow of oil. The heavy hydrocarbon pattern (Figure 3) and the carbon isotope value differ from those noted previously for the show in the Shale Wall siltstone. These data suggest at least two types of oil are present in the area of sampling. The oil in the Grandstand sample is quite similar to the Prudhoe Bay oil reported in T.S. 7789CR, 5-4-70.

There is a marked increase in carbonization (80 to 87 percent carbon) from upper to lower parts of the section, as was noted for the Schrader Bluff section. Here the youngest sample is at or near peak generation and the oldest sample is well past the peak stage. Both the low hydrogen content and the advanced stage of diagenesis in ANS-32 (Grandstand shale) suggest that the oil in ANS-31 (Grandstand siltstone) was not generated locally.

Archimedes Ridge Section

The Lower Cretaceous Torok shales have sufficient organic carbon to qualify as fair to good sources for hydrocarbons. The data suggest this interval was probably an effective source primarily for gas.

Kasegaluk Syncline Section

Lower Cretaceous Corwin and Grandstand shales from this section have abundant organic carbon but low amounts of extractable organic matter. As in the Archimedes Ridge section these rocks are effective sources for primarily gaseous hydrocarbons. In contrast to the Barbara syncline section, these samples show a small range of carbonization, suggesting that the samples represent a narrow stratigraphic interval.

Tuktu Bluff, Chandler River, Kekiktuk Sections

The Lower Cretaceous Torok and Upper Cretaceous U. Ignek contain enough organic matter to be rated as fair sources of oil, but it was not established whether they have been effective. A possible oil show is indicated in the Kekiktuk sample. The heavy hydrocarbon pattern and carbon isotope values are similar to those obtained for the Shale Wall and Teglukpuk samples.

Canning River, Dodo Creek Sections

The shales from both sections have fair to good quality and are far past the peak stage of generation. The hydrogen content of the organic matter in the Jurassic and Triassic shales is significantly lower than that in the Cretaceous shales. The low hydrogen percentage is likely due to low initial content (probable gas source), but because of the well-advanced diagenetic stage, the possibility that they originally contained enough hydrogen to be oil sources cannot be ruled out.

Tiglukpuk Creek Section

Migrated (Jurassic)

A microshow of migrated oil in sample ANS-50 is indicated by the anomalous amount of extractable organic matter (relative to the other samples) and by the high ratio of extractable hydrocarbons/extractable organic. The heavy hydrocarbon pattern (Figure 3) is intermediate between that for the oil in the Shale Wall and Grandstand siltstones. Isotopically the Shale Wall, Tiglukpuk, and Kekiktuk oils are similar.

SUMMARY

1. None of the sampled beds were indicated to be effective sources for oil, but most pre-Tertiary sections were indicated to be favorable for gas. This contrasts with the favorable Cretaceous oil source beds previously reported in the Shell Lake 79 well (T.S. 7877CR, 9/28/70) and in the Mobil-Phillips Kadler State No. 1 (T.S. 7678CR, 5/4/70).

2. Two types of migrated oil were found, one similar to the Prudhoe Bay oil and the other isotopically heavier. The presence of migrated oil suggests that there may be effective oil sources in the area that were not sampled.

Roger Cimea

AMOCO PRODUCTION COMPANY
~~PAN AMERICAN PETROLEUM CORPORATION~~
RESEARCH CENTER

SOURCE ROCK EVALUATIONS

OFFICE Denver, North Operations AREA North Slope
AUTHORIZED BY R. W. Craig DATE 11-10-70
TECHNICAL SERVICE NUMBER 7969CR
STATE (PROVINCE) Alaska COUNTY WELL LOCATION North Slope outcrop sections

SAMPLE NUMBER	TYPE	DIV. #	FORMATION	LITHOLOGY	OUTCROP SECTION	INSOLUBLE RESIDUE %	ORGANIC CARBON WT. %	EXTRACTABLE ORGANIC Bbl/ACRE FT.	EXTRACT. HYDROCARBON Bbl/ACRE FT.	EXTRACT. ORG. / TOTAL ORG.	RATING	$\delta C^{13}/C^{12}$ EXTRACT HCB
ANS-24		CC-10	Mio-Pliocene	gry, silty sh	Carter Ck	90	1.38	2.3	1.1	< 0.01	good	-28.1
23		FB-4	Tertiary Sagavanirktok Fm	gry sh	Franklin Bluff	91	0.19	0.9	0.5	0.02	nonsource	
27		SB-11	U. Cretaceous Sentenel Hill	gry sh	Schrader Bluff	90	1.13	0.8	0.3	< 0.01	good	
26		SB-10	U. Cretaceous Barrow Trail	brn sh	"	87	1.11	0.8	0.2	< 0.01	good	
25		SB-7	U. Cretaceous Rogers Ck	gry siltst	"	84	0.57	0.7	0.2	< 0.01	poor	
43		SB-3	U. Cretaceous Tuluvak Fm	gry siltst	"	66	0.83	0.7	0.2	< 0.01	fair	
41		SWB-6	U. Cretaceous Shale Wall	lt gry siltst	Shale Wall Bluff	88	0.30	migrated oil 8.7	7.5	0.11	nonsource	-26.4
42		EFTR	U. Cretaceous Aviyak Fm	silty sh	E. Fork Tuluga R.	92	0.53	0.9	0.3	< 0.01	poor	
28		CB-7	L. Cretaceous Corwin Fm	gry sh	Corwin Bluff	84	1.13	1.5	0.6	< 0.01	good	-27.8
46		BS-62	L. Cretaceous Corwin Fm	gry siltst	Barbara Syncline	94	1.24	1.9	0.6	< 0.01	good	-27.7
45		BS-46	"	brn siltst	"	70	0.61	1.2	0.3	< 0.01	fair	
44		BS-35	"	"	"	90	0.75	1.1	0.3	< 0.01	fair	
33		BS-28	"	brn sh	"	86	1.42	1.5	0.5	< 0.01	good	-28.8
32		BS-14	L. Cretaceous Grandstand Fm	silty sh	"	87	1.22	1.2	0.4	< 0.01	good	
31		BS-2	"	gry siltst	"	90	0.77	not local gen. 14.0	7.8	0.07	fair	-29.5

REMARKS:

REFERENCES: T.S. 7877CR, 8-19-70
T.S. 7678CR, 5-4-70
T.S. 7679CR, 5-4-70
T.S. 7680CR, 5-4-70
T.S. 7732CR, 5-4-70
T.S. 7789CR, 5-4-70

ANALYST [signature] DATE MAR 19 1971
TABLE 1a

AMOCO PRODUCTION COMPANY

~~PAN AMERICAN PETROLEUM CORPORATION~~

RESEARCH CENTER

SOURCE ROCK EVALUATIONS

OFFICE Denver, North Operations AREA North Slope

AUTHORIZED BY R. W. Craig DATE 11-10-70

TECHNICAL SERVICE NUMBER 7969CR

STATE (PROVINCE) Alaska COUNTY WELL LOCATION North Slope outcrop sections

SAMPLE NUMBER	SAMPLE TYPE	SAMPLE DIV. #	FORMATION	LITHOLOGY	OUTCROP SECTION	INSOLUBLE RESIDUE %	ORGANIC CARBON WT. %	EXTRACTABLE ORGANIC Bbl/ACRE FT.	EXTRACT. HYDROCARBON Bbl/ACRE FT.	EXTRACT. ORG. / TOTAL ORG.	RATING	$\delta C^{13}/C^{12}$ EXTRACT HCB
ANS-34	✓	AR-7	L. Cretaceous Torok Fm	brn, silty sh	Archimedes Ridge	81	0.48	1.1	0.7	< 0.01	poor	-27.4
35	✓	AR-10	"	gry siltst	"	92	0.69	1.7	0.2	0.01	fair	
36	✓	AR-14	"	gry silty sh	"	88	1.11	1.8	0.3	< 0.01	good	
37	✓	AR-28	"	gry sh	"	89	1.30	1.5	0.4	< 0.01	good	
38		KS-20	L. Cretaceous Corwin Fm	brn sh	Kasegaluk Syncline	87	1.54	3.5	1.6	< 0.01	v. good	-27.0
47		KS-26	L. Cretaceous Grandstand Fm	gry sh	"	80	1.27	2.3	0.7	< 0.01	good	-28.5
48		KS-32	"	gry sh	"	93	1.37	3.1	1.2	< 0.01	good	
30		TB-5	L. Cretaceous Tuktu Fm	gry sh	Tuktu Bluff	84	0.75	0.9	0.2	< 0.01	fair	
29		TT-3	L. Cretaceous Torok Fm	gry sh	Chandler R.	85	0.83	1.2	0.3	< 0.01	fair	
39		KR-3	Cretaceous	blk sh	Kekiktuk	88	0.67	4.0	3.3	0.02	fair	-26.8
40		CR-12	U. Cretaceous Up. Ignek Fm	gry silty sh	Canning R.	85	0.83	3.0	1.5	0.01	fair	-28.8
52		CR-4	Triassic Shublik Fm	fissile, blk sh	"	77	1.33	1.0	0.3	< 0.01	good	
50		TC-3	Jurassic Tiglukpuk Fm	gry sh	Tiglukpuk Ck	80	0.79	migrated oil 8.5	7.0	0.04	fair	-26.9
51		WC-2	"	blk sh	Welcome Ck	85	0.65	1.2	0.4	< 0.01	fair	
49		DC-8	Jurassic Kingak Fm	fissile, blk sh	Dodo Ck	92	1.20	3.2	1.8	0.01	good	-28.6

REMARKS:

ANALYST J. Gehman DATE MAR 19 1971

TABLE 1b

AMOCO PRODUCTION COMPANY
~~PAN AMERICAN PETROLEUM CORPORATION~~
RESEARCH CENTER
SOURCE ROCK EVALUATIONS

OFFICE Denver, North Operations AREA North Slope
AUTHORIZED BY R. W. Craig DATE 11-10-70
TECHNICAL SERVICE NUMBER 7969CR
STATE (PROVINCE) Alaska COUNTY WELL LOCATION North Slope outcrop sections

SAMPLE NUMBER	SAMPLE TYPE	SAMPLE DTV. #	FORMATION	LITHOLOGY	OUTCROP SECTION	INSOLUBLE RESIDUE %	ORGANIC CARBON WT. %	EXTRACTABLE ORGANIC Bbl/ACRE FT.	EXTRACT. HYDROCARBON Bbl/ACRE FT.	EXTRACT. ORG. / TOTAL ORG.	RATING	
ANS-53	out-crop	DC-4	Triassic Shublek Fm	fissile, blk sh	Dodo Crk	68	2.91	0.7	0.3	< 0.01	v. good	

REMARKS:

ANALYST J. Gallegos DATE MAR 19 1971
TABLE 1c

AMOCO PRODUCTION COMPANY
~~PAN AMERICAN PETROLEUM CORPORATION~~
RESEARCH CENTER
ORGANIC DIAGENESIS DATA

OFFICE Denver, North Operations AREA North Slope
AUTHORIZED BY R. W. Craig DATE 11-10-70
TECHNICAL SERVICE NUMBER 7969CR
STATE (PROVINCE) Alaska COUNTY WELL LOCATION North Slope outcrop sections

SAMPLE			FORMATION	LITHOLOGY	OUTCROP SECTION	ELEMENTAL ANALYSIS, PERCENT				RATIO H/C	STATE OF DIAGENESIS	HYDROCARBON TYPE BY	
NUMBER	TYPE	DIV. #				CARBON	HYDROGEN	OXYGEN	NITROGEN			% HYDROGEN	PYROLYSIS
ANS-24		CC-10	Mio-Pliocene	gry, silty sh	Carter Crk	70.47	4.50	23.54	1.49	0.77	pre-generation	gas	
27		SB-11	U. Cretaceous Sentinel Hill	gry sh	Schrader Bluff	74.30	4.27	19.66	1.77	0.69	"	"	
26		SB-10	U. Cretaceous Barrow Trail	brn sh	"	76.45	4.27	17.34	1.94	0.67	early generation	"	
43		SB-3	U. Cretaceous Tuluvak Fm	gry siltst	"	77.25	4.73	16.08	1.95	0.73	"	"	
28		CB-7	L. Cretaceous Corwin Fm	gry sh	Corwin Bluff	83.71	4.75	9.21	2.33	0.68	past peak generation	"	
46		BS-62	"	gry siltst	Barbara Syncline	79.88	4.58	14.09	1.45	0.69	peak generation	"	
33		BS-28	"	brn sh	"	83.74	4.93	8.74	2.59	0.71	past peak generation	"	
32		BS-14	L. Cretaceous Grandstand Fm	silty sh	"	87.43	4.35	5.99	2.23	0.60	"	"	
36		AR-14	L. Cretaceous Torok Fm	gry silty sh	Archimedes Ridge	69.50*	5.16	23.30*	2.03	0.89	*		
37		AR-28	"	gry sh	"	88.12	4.67	5.47	1.73	0.64	past peak generation	gas	
38		KS-20	L. Cretaceous Corwin Fm	brn sh	Kasegaluk Syncline	85.21	4.76	8.05	1.98	0.67	"	"	
47		KS-26	L. Cretaceous Grandstand Fm	gry sh	"	86.03	4.81	7.14	2.02	0.67	"	"	
48		KS-32	"	gry sh	"	85.02	4.57	8.66	1.75	0.65	"	"	
40		CR-12	U. Cretaceous Up. Ignek Fm	gry silty sh	Canning R.	87.21	4.78	6.15	1.86	0.66	"	"	
52		CR-4	Triassic Shublik Fm	blk, fissile sh	"	89.26	2.63	6.99	1.12	0.35	"	"	

REMARKS:

* state of diagenesis is obscured by oxidation

ANALYST Roque E. LaPlante DATE 3/18/71
TABLE 2a

AMOCO PRODUCTION COMPANY
~~PAN AMERICAN PETROLEUM CORPORATION~~
RESEARCH CENTER
ORGANIC DIAGENESIS DATA

OFFICE Denver, North Operations AREA North Slope
AUTHORIZED BY R. W. Craig DATE 11-10-70
TECHNICAL SERVICE NUMBER 7969CR
STATE (PROVINCE) Alaska COUNTY WELL LOCATION North Slope outcrop sections

SAMPLE			FORMATION	LITHOLOGY	OUTCROP SECTION	ELEMENTAL ANALYSIS, PERCENT				RATIO H/C	STATE OF DIAGENESIS	HYDROCARBON TYPE BY	
NUMBER	TYPE	DIV. #				CARBON	HYDROGEN	OXYGEN	NITROGEN			% HYDROGEN	PYROLYSIS
ANS-49		DC-8	Jurassic Kingak Fm	fissile, blk sh	Dodo Ck	89.12	2.98	6.65	1.25	0.40	past peak generation	gas	
53		DC-4	Triassic Shublik Fm	"	"	88.65	2.49	7.34	1.52	0.34	"	"	

REMARKS:

ANALYST Roque E. LaPlante DATE 3/18/71
TABLE 2b

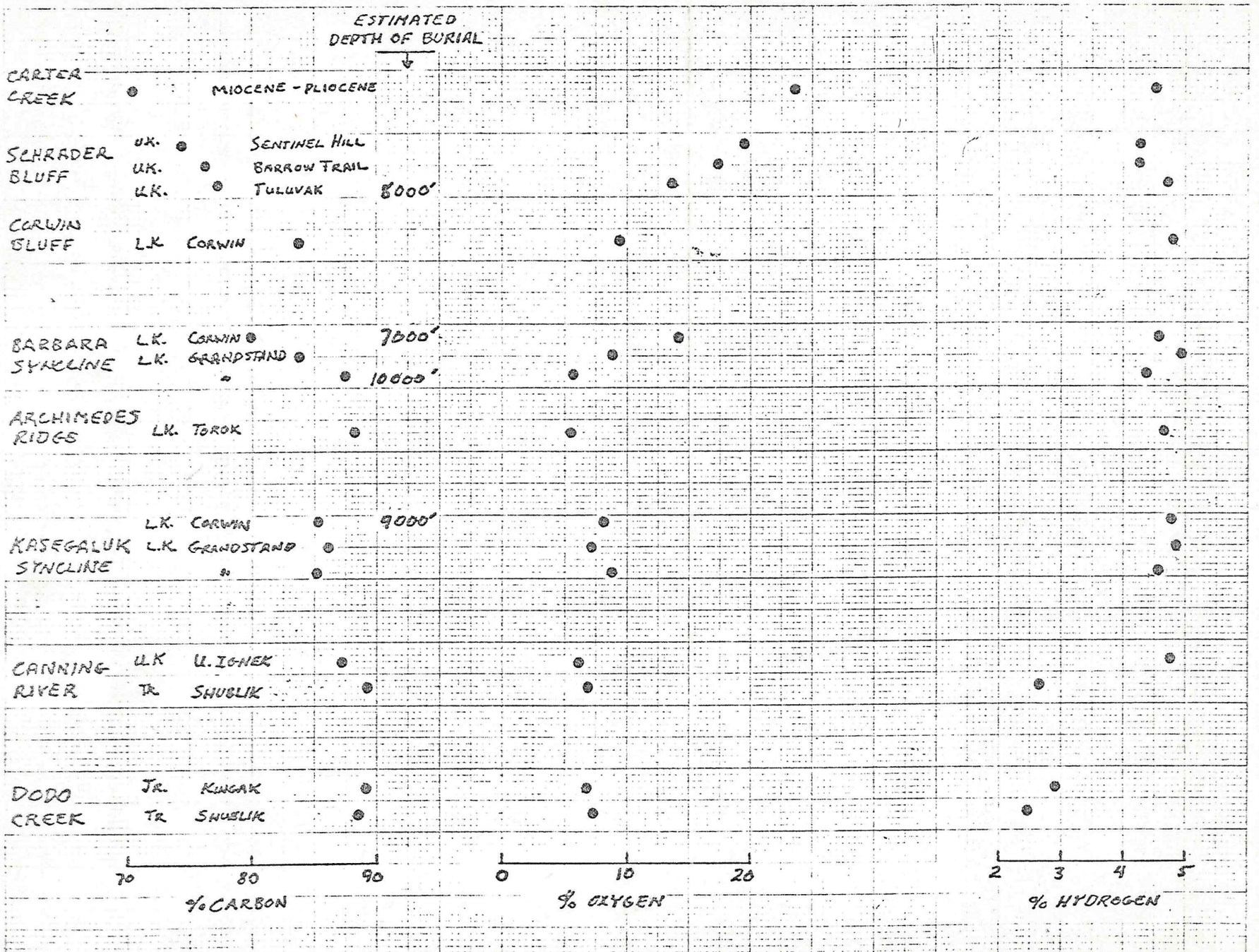


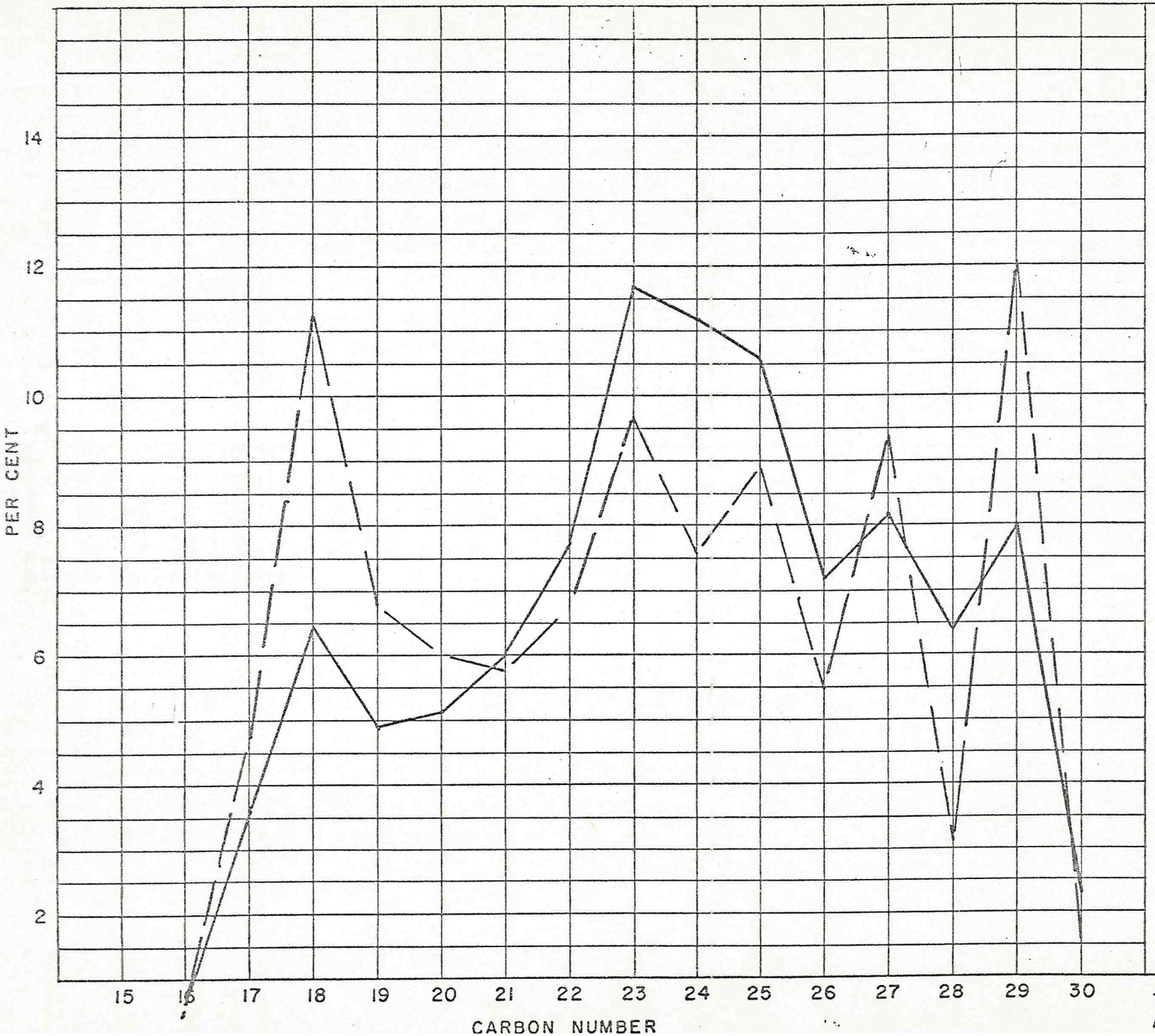
FIGURE 1. ELEMENTAL COMPOSITION OF RESIDUAL ORGANIC MATTER

T.S. 7969CR

OIL ☐ ROCK EXTRACT ☒

HEAVY HYDROCARBON DISTRIBUTION

NORTH SLOPE OUTCROP SECTIONS



——— ANS-23 Sagavanirktok Fm, Tertiary, Franklin Bluff section

— — — ANS-24 Miocene-Pliocene, Carter Creek section

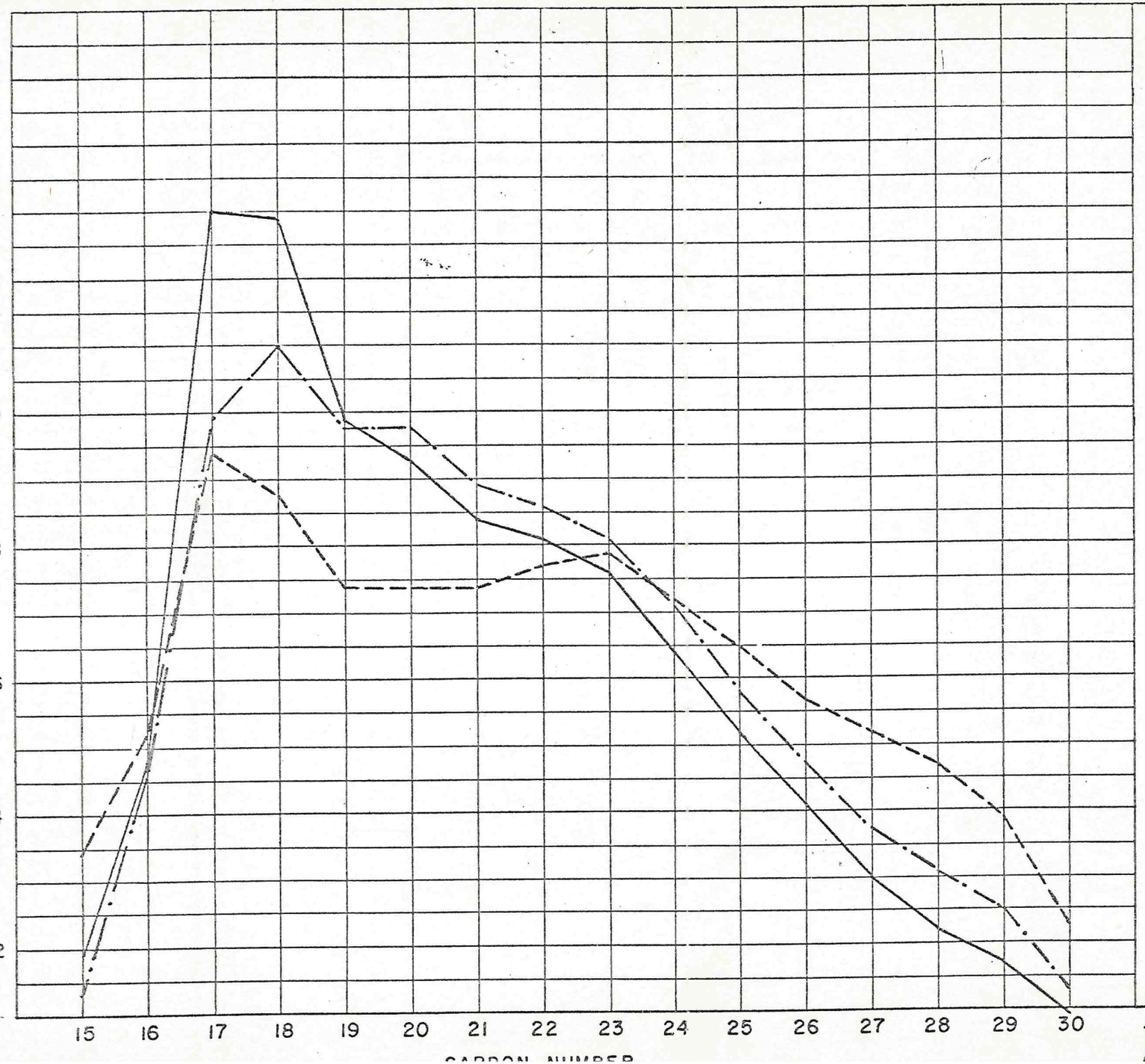
TECHNICAL SERVICE 7969CR
AREA North Slope

AMOCO PRODUCTION COMPANY

PAN AMERICAN PETROLEUM CORPORATION
RESEARCH CENTER

OIL ☐ ROCK EXTRACT ☒

HEAVY HYDROCARBON DISTRIBUTION



NORTH SLOPE OUTCROP SECTION

———	ANS-41	Shale Wall Fm., U. Cret., Shale Wall Bluff section
– – – –	ANS-31	Grandstand Fm., L. Cret., Barbara Syncline section
——·——	ANS-50	Tiglukpuk Fm., Jurassic, Tiglukpuk Creek section

TECHNICAL SERVICE 7969CR
AREA North Slope

AMOCO PRODUCTION COMPANY
RESEARCH CENTER

SOURCE ROCK EVALUATION

- North Slope outcrop sections and Pan Am Kavik #1 -

Geochemistry Group

R. L. Ames
J. A. Williams

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7-27-71

DISCUSSION

Source rock evaluations have been completed for 13 outcrop samples from the North Slope area of Alaska and for 4 cuttings samples from the Pan American Kavik #1 well. Both groups of samples supplement previous source rock studies (see references, Table 1). The new samples from the Shale Wall Bluff, Barbara Syncline, and Tiglukpuk Creek sections help to further evaluate the occurrences of migrated oil reported previously, whereas the samples from the Archimedes Ridge and Canning River sections are intended to clarify the stage of organic diagenesis. The Kavik samples evaluate shales younger than those previously studied from the same well. It should be noted that some previously reported data on both outcrop and Kavik well samples are included in the tables for clarity and completeness.

The results for the OUTCROP SECTIONS are as follows:

1. Organic carbon and extractable matter values for the recently obtained Cretaceous and Jurassic samples are generally similar to those obtained previously. No oil was observed in the new samples, suggesting that the previously reported occurrences are somewhat limited stratigraphically. The slightly higher extractable values, e.g. the Archimedes Ridge and Canning River sections, probably reflect more efficient extraction procedures now in use, rather than migrated oil.

2. The organic matter in all the samples has attained an advanced state of diagenesis which indicates that peak hydrocarbon generation has occurred. However, the severe thermal conditions required to reach this advanced diagenesis would have converted most of the indigenous oil to gas. This implies that oil found in these intervals may have migrated from less severely altered rocks.

3. The hydrogen content of the kerogen is within the coal range which suggests that gas would have been the dominant type of hydrocarbon formed throughout the generation cycle. The new data confirm the interpretation reported in T.S. 7969CR, 3-19-71.

Because these samples are now at the outcrop, it is not likely that the hydrocarbons they expelled still remain in traps. Thus they would be considered as "expended" rather than "effective" sources according to the definitions given in Research Department Report F70-G-4. However, hydrocarbons

expelled from the same sections downdip may remain trapped, in which case the source would be considered "effective".

It was stated in T.S. 7969CR that the anomalously low hydrogen content (2.49-2.98% H, Table 3) in the Triassic Shublik and Jurassic Kingak shales at the Canning River and Dodo Creek sections indicated that these shales were gas source beds. Evidence from recent studies in several areas, e.g. the Permian in the Delaware Basin of West Texas, suggests that the organic matter in oil source rocks tends to lose hydrogen more readily during peak generation than that in gas source beds. As a result, oil source beds in a stage of diagenesis just past peak hydrocarbon generation (approximately 86 to 90% carbon) will have low hydrogen values in the range of about 2 to 3.5%. In light of these new findings, the original interpretations on the Kingak shales at Canning River and Dodo Creek should be changed. These rocks are now considered to be oil source beds at an advanced stage of diagenesis.

The results of the KAVIK WELL samples are:

1. Cretaceous Shrader Bluff and Jurassic Kingak shale samples have good or very good source rock quality based on the organic content.

2. The organic matter shows increasing carbonization with depth. The Upper Cretaceous Shrader Bluff shales have only reached the early stages of hydrocarbon generation, whereas the Jurassic and Triassic shales have progressed to near the peak stage of generation. Therefore, the Lower Jurassic and Triassic shales may have expelled some hydrocarbons, but the Cretaceous shales should not have generated and expelled commercial quantities of hydrocarbons.

3. The low hydrogen content of the kerogen indicates that dry gas would be the principal type of hydrocarbon formed.

4. The data indicate migrated oil to be present in the Upper Cretaceous Shrader Bluff sample, ANS-67. The main evidence for migrated oil is the relatively large amount of extractable organic matter for its stage of diagenesis and the mature character (fairly smooth slope) of the heavy hydrocarbon pattern (Figure 1). Furthermore, as noted above, the low hydrogen content suggests that gas, not oil, would be generated during maturation.

The carbon isotope ratio for the extract from ANS-67 is quite close to that for Prudhoe Bay oil (-29.6), but its heavy hydrocarbon distribution curve (Figure 1) does not show much similarity to Prudhoe Bay oil (T.S. 7789CR).

Summary

None of the new outcrop samples were indicated to be sources for oil, but all have probably been gas source beds. Reinterpretation of previous data suggests that the Shublik and Kingak shales at Canning River and Dodo Creek are expended oil source beds (note discussion above regarding "expended" and "effective" source beds).

Migrated oil was found in one Shrader Bluff sample in the Kavik well. The hydrogen content of the kerogen indicates that the shale intervals studied would generate mostly dry gas.

Roger L Kirsch

Amoco Production Company

RESEARCH CENTER
SOURCE ROCK EVALUATIONS

OFFICE Denver, North Operations AREA North Slope
AUTHORIZED BY B. F. Baldwin DATE 4-15-71
TECHNICAL SERVICE NUMBER 8149CR
STATE (PROVINCE) COUNTY WELL LOCATION Outcrop Sections

SAMPLE NUMBER		DIV. #	FORMATION	LITHOLOGY	Footage from base of section	INSOLUBLE RESIDUE %	ORGANIC CARBON WT. %	EXTRACTABLE ORGANIC Bbl/ACRE FT.	EXTRACT. HYDROCARBON Bbl/ACRE FT.	EXTRACT. ORG. / TOTAL ORG.	RATING	
			ARCHIMEDES RIDGE SECTION									
AMS-36	*	AR-14	Lower Cret. Torok fm.	gry silty sh.	2500'	88.0	1.11	1.8	0.3	< 0.01	good	expended? **
AMS-54		AR-23	"	sh.	850'	86.3	1.16	4.7	1.2	0.02	"	"
AMS-55		AR-24	"	sh.	750'	81.7	1.06	4.0	1.6	0.01	"	"
AMS-37	*	AR-28	"	gry sh.	200'	89.0	1.30	1.5	0.4	< 0.01	"	"
			BARBARA SYNCLINE SECTION									
AMS-31	*	BS-2	Lower Cret. Grandstand fm.	gry siltst.	500'	90.0	0.77	14.0	7.8	0.07	fair	"
AMS-56		BS-8	"	sh.	1000'	88.7	1.37	4.5	1.7	0.01	good	"
AMS-32	*	BS-14	"	silty sh.	1400'	87.0	1.22	1.2	0.4	< 0.01	"	"
			CANNING RIVER SECTION									
AMS-40	*	CR-12	Upper Cret. Ninuluk fm.	gry silty sh.	170	85.0	0.83	3.0	1.5	0.01	fair	"
AMS-57		CR-14	"	sh.	210	83.3	0.73	5.2	2.9	0.03	"	"
AMS-58		CR-15	"	sh.	230	86.3	0.75	7.3	4.3	0.04	"	"
AMS-59		CR-16	"	sh.	280	87.1	0.52	5.2	2.9	0.04	"	"

REMARKS: *Previous study

**See attached remarks

REFERENCES: T.S. 7679CR, 5-4-70
T.S. 7789CR, 5-4-70
T.S. 7969CR, 3-19-71

ANALYST J. A. Williams DATE JUL 27 1971

TABLE 1

Amoco Production Company

RESEARCH CENTER
SOURCE ROCK EVALUATIONS

OFFICE Denver, North Operations AREA North Slope

AUTHORIZED BY B. F. Baldwin DATE 4-15-71

TECHNICAL SERVICE NUMBER 8140CR

STATE (PROVINCE) COUNTY WELL LOCATION Outcrop Sections

SAMPLE NUMBER	SAMPLE TYPE	SAMPLE Div. #	FORMATION	LITHOLOGY	Footage from base of section	INSOLUBLE RESIDUE %	ORGANIC CARBON WT. %	EXTRACTABLE ORGANIC Bbl/ACRE FT.	EXTRACT. HYDROCARBON Bbl/ACRE FT.	EXTRACT. ORG. / TOTAL ORG.	RATING	
			- SHALE WALL BLUFF SECTION									
ANS-41	*	SWB-6	Upper Cret. Shale Wall fm.	gry siltst.	110'	88.0	0.30	8.7	7.5	0.11	nonsource	
ANS-60		SWB-8	"	sh.	130'	80.4	0.40	1.0	0.7	0.01	poor	
ANS-61		SWB-9	"	sh.	200'	82.0	0.41	1.0	0.7	0.01	poor	
ANS-62		SWB-10	"	sh.	230'	89.3	0.30	1.0	0.5	0.01	nonsource	
ANS-63		SWB-11	"	sh.	240'	81.5	0.16	0.7	0.4	0.02	"	
	*		- TIGLUKPUK CREEK SECTION									
ANS-64		TC-2	Upper Jurassic Tiglukpuk fm.	sh.	10'	80.5	0.63	3.3	1.4	0.02	fair	expended? **
ANS-50	*	TC-3	"	gry sh.	30'	80.0	0.79	8.5	7.0	0.04	"	"
ANS-65		TC-4	"	sh.	60'	75.3	0.76	2.8	1.3	0.01	"	"
ANS-66		TC-5	"	sh.	90'	82.5	0.46	2.1	1.2	0.02	poor	"

REMARKS:

*Previous study

**See attached remarks

ANALYST J. A. Baldwin DATE JUL 27 1971

TABLE 1 (contd)

Amoco Production Company

RESEARCH CENTER
SOURCE ROCK EVALUATIONS

OFFICE Denver, North Operations AREA North Slope
AUTHORIZED BY B. F. Baldwin DATE 4-15-71
TECHNICAL SERVICE NUMBER 8149CR
STATE (PROVINCE) COUNTY WELL LOCATION Pan Am Kavik #1

SAMPLE NUMBER	SAMPLE TYPE		FORMATION	LITHOLOGY	DEPTH	INSOLUBLE RESIDUE %	ORGANIC CARBON WT. %	EXTRACTABLE ORGANIC Bbl/ACRE FT.	EXTRACT. HYDROCARBON Bbl/ACRE FT.	EXTRACT. ORG. / TOTAL ORG.	RATING	$\delta C^{13}/C^{12}$
ANS-67	Cuttings		Upper Cret. Shrader Bluff fm.	lt-dk brn siltst. & sh.	2360-2500'	87.6	1.14	11.8*	7.1*	0.04	good potential	-23.2
ANS-68	"		"	dk brn-gry sh.	2900-3100'	84.6	2.79	4.6	1.7	< 0.01	v. good potential	
ANS-69	"		Upper Jurassic Kingak fm	brn siltst. & sh.	3200-3400'	85.6	2.54	7.1	2.9	0.01	v. good ** effective(?)	
ANS-70	"		"	"	3500-3700'	86.2	1.44	2.8	1.5	0.01	good ** effective(?)	

REMARKS:

*Probably migrated oil

**Samples ANS-69 and -70 would be rated as marginally effective sources for mostly gas.

ANALYST J. A. Williams DATE JUL 27 1971

TABLE 1 (contd)

Amoco Production Company

RESEARCH CENTER
ORGANIC DIAGENESIS DATA

OFFICE Denver, North Operations AREA North Slope

AUTHORIZED BY B. F. Baldwin DATE 4-15-71

TECHNICAL SERVICE NUMBER 8149CR

STATE (PROVINCE) COUNTY WELL LOCATION Outcrop Sections

SAMPLE NUMBER	SAMPLE TYPE	SAMPLE Div. #	FORMATION	LITHOLOGY	Footage from base of section	ELEMENTAL ANALYSIS, PERCENT CARBON	HYDROGEN	OXYGEN	NITROGEN	RATIO H/C	STATE OF DIAGENESIS	HYDROCARBON TYPE BY % HYDROGEN	PYROLYSIS
			- ARCHIMEDES RIDGE SECTION										
ANS-36	*	AR-14	Lower Cret. Torok fm.	gry silty sh.	2500'	69.50	5.16	23.30	2.03	0.89	**	**	
ANS-54		AR-23	"	sh.	850'	87.42	3.71	7.14	1.74	0.40	past peak hydro-carbon generation	gas	
ANS-55		AR-24	"	sh.	750'	89.20	3.94	5.15	1.71	0.53	"	"	
ANS-37	*	AR-28	"	gry sh.	200'	88.12	4.67	5.47	1.73	0.64	"	"	
			- BARBARA SYNCLINE SECTION										
ANS-56		BS-8	Lower Cret. Grandstand fm.	sh.	1000'	87.06	4.72	6.35	1.87	0.65	"	"	
ANS-32	*	BS-14	"	silty sh.	1400'	87.43	4.35	5.99	2.23	0.60	"	"	
			- CANNING RIVER SECTION										
ANS-40	*	CR-12	Upper Cret. Ninuluk fm.	gry silty sh.	170'	87.21	4.78	6.15	1.86	0.66	"	"	
ANS-57		CR-14	"	sh.	210'	87.94	4.05	8.08	1.93	0.57	"	"	
ANS-58		CR-15	"	sh.	230'	86.03	4.92	7.15	1.90	0.69	"	"	
ANS-59		CR-16	"	sh.	280'	88.14	4.24	6.00	1.62	0.58	"	"	

REMARKS:

*Previous study

**Indeterminate, due to oxidation of the organic matter

ANALYST J. Sackett DATE JUL 27 1971

TABLE 2

Amoco Production Company

RESEARCH CENTER
ORGANIC DIAGENESIS DATA

OFFICE Denver, North Operations AREA North Slope

AUTHORIZED BY B. F. Baldwin DATE 4-15-71

TECHNICAL SERVICE NUMBER 8149CR

STATE (PROVINCE) COUNTY WELL LOCATION

SAMPLE NUMBER	SAMPLE TYPE	SAMPLE Div. #	FORMATION	LITHOLOGY	Footage from base of section	ELEMENTAL ANALYSIS, PERCENT CARBON	HYDROGEN	OXYGEN	NITROGEN	RATIO H/C	STATE OF DIAGENESIS	HYDROCARBON TYPE BY % HYDROGEN	PYROLYSIS
			- TIGLUKPUK CREEK SECTION										
ANS-64		TC-2	Upper Jurassic-Tiglukpuk fm.	sh.	10'	89.92	3.85	5.62	1.50	0.52	past peak hydrocarbon generation	gas	
ANS-65		TC-4	"	sh.	60'	87.49	4.53	6.49	1.49	0.62	"	"	
ANS-66		TC-5	"	sh.	90'	87.47	3.79	7.35	1.39	0.53	"	"	
			- PAN AM KAVIK #1		Depth								
ANS-67			Upper Cret. Shrader Bluff fm.	brn siltst. & sh.	2360-2500'	78.83	4.26	15.40	1.51	0.65	early hydrocarbon generation	"	
ANS-68			"	brn-gry sh.	2900-3100'	78.22	3.64	15.89	2.25	0.56	"	"	
ANS-69			Upper Jurassic Kingak sh.	brn siltst. & sh.	3200-3400'	81.94	4.95	11.36	1.75	0.72	near peak hydrocarbon generation	"	
ANS-70			"	"	3500-3700'	80.92	4.06	13.61	1.41	0.60	"	"	
ANS-4	*		Lower Jurassic Kingak	sh.	4000-4270'	83.50	4.20	10.04	1.69	0.60	peak hydrocarbon generation	"	
ANS-5	*		Triassic Shublik & Sadlerochit	sh. + carb.	4270-4730'	82.40	3.61	12.30	1.76	0.53	"	"	

REMARKS:

*Previous study

ANALYST J. A. Williams DATE JUL 27 1971

TABLE 2 (cont'd)

Amoco Production Company

RESEARCH CENTER
ORGANIC DIAGENESIS DATA

OFFICE Denver, North Operations AREA North Slope
AUTHORIZED BY R. F. Baldwin DATE 4-15-71
TECHNICAL SERVICE NUMBER 8149CR
STATE (PROVINCE) COUNTY WELL LOCATION

SAMPLE			FORMATION	LITHOLOGY	~~DEPTH~~	ELEMENTAL ANALYSIS, PERCENT				RATIO H/C	STATE OF DIAGENESIS	HYDROCARBON TYPE BY	
NUMBER	TYPE	QUALITY				CARBON	HYDROGEN	OXYGEN	NITROGEN			% HYDROGEN	PYROLYSIS
ANS-52	Out-crop		Triassic Shublik fm.	blk fissile sh.	Canning R. Section	89.26	2.63	6.99	1.12	0.35	past peak generation	oil*	
ANS-49	"		Triassic Kingak fm.	"	Dodo Ck. Section	89.12	2.98	6.65	1.25	0.40	"	"	
ANS-53	"		Triassic Shublik fm.	"	"	88.65	2.49	7.34	1.52	0.34	"	"	

REMARKS: *These data were reported previously in T.S. 7969CR. In light of recently obtained diagenesis data from several areas, the original interpretation that these rocks generated primarily gas has been changed. They are now considered to be a source for mostly oil (see attached discussion).

ANALYST J. A. Williams DATE JUL 27 1971
TABLE 3

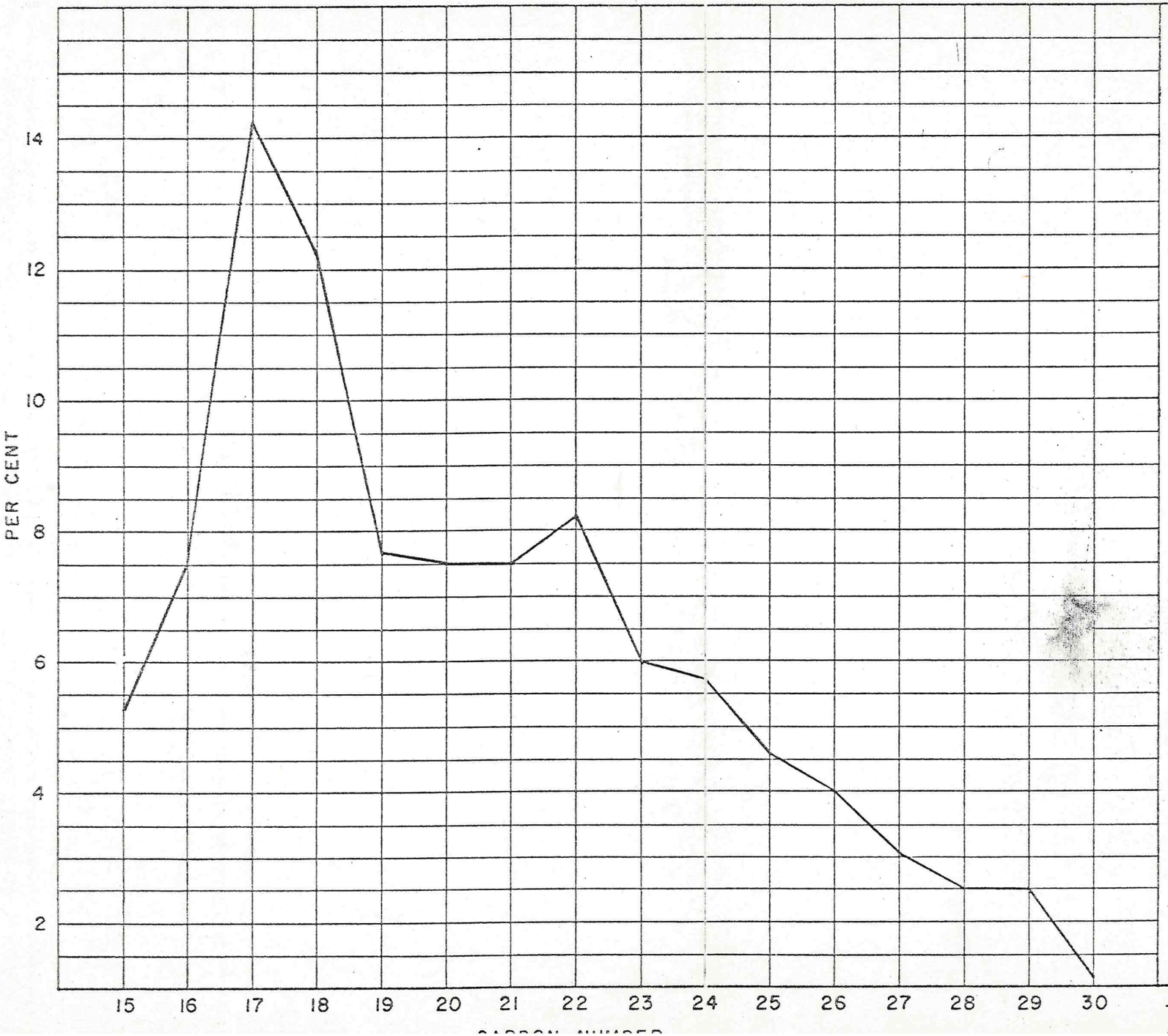
PAN AMERICAN PETROLEUM CORPORATION
RESEARCH CENTER

OIL ☐ ROCK EXTRACT ☒

HEAVY HYDROCARBON DISTRIBUTION

PAN AM KAVIK #1

ANS-67 Shrader Bluff fm., Upper Cret., 2360'-2500'



TECHNICAL SERVICE 8149CR

AREA North Slope, Alaska