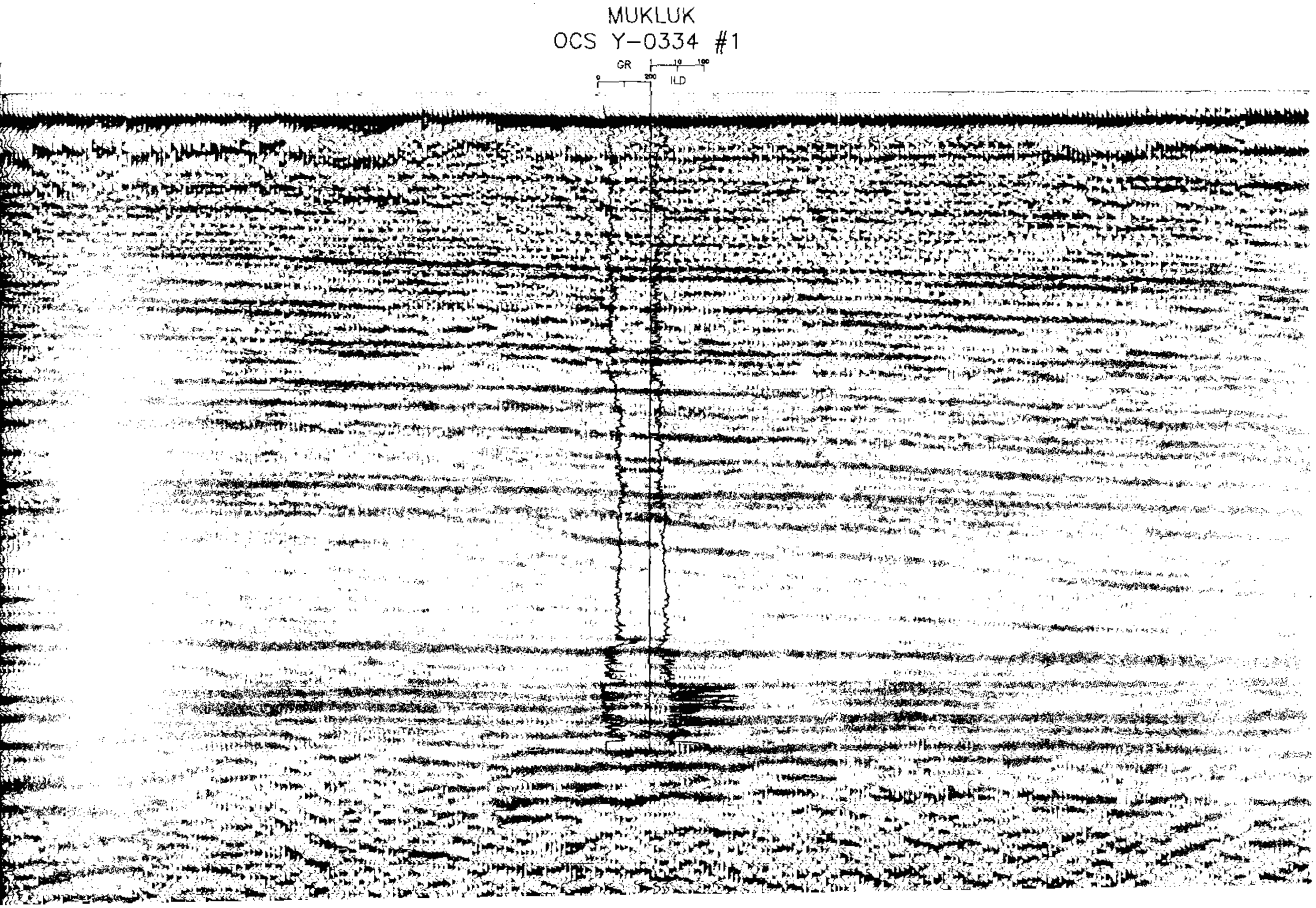
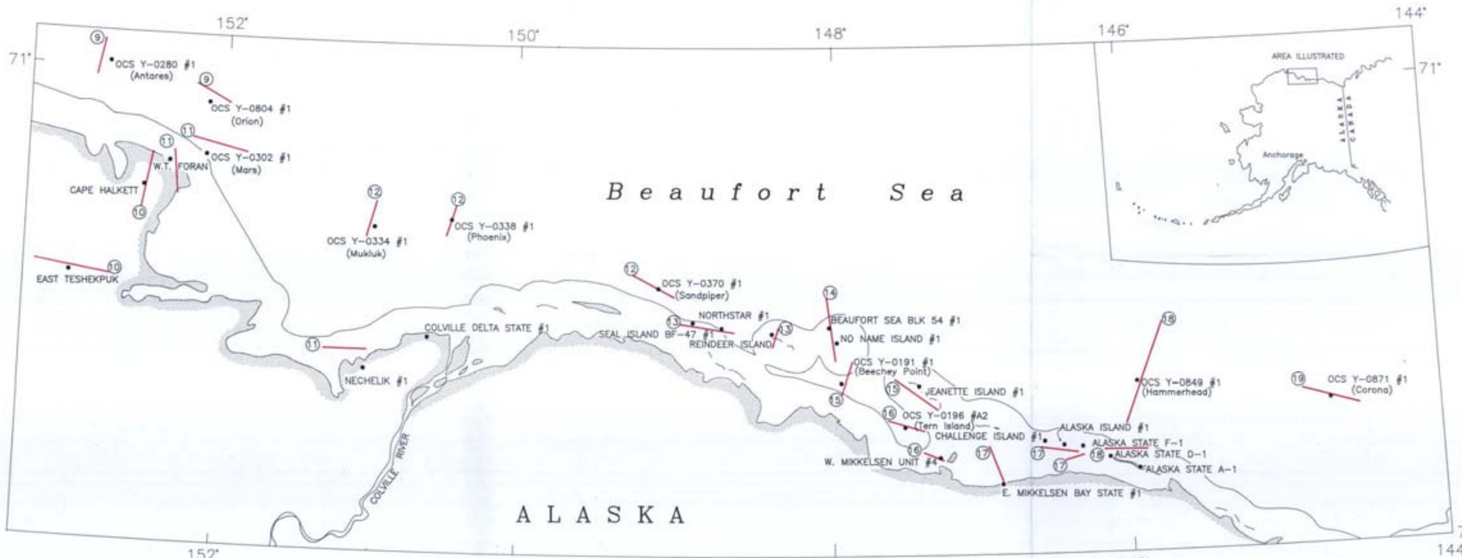
OCS Report
MMS 91-0076

Correlation Study of Selected Exploration Wells from the North Slope and Beaufort Sea, Alaska





EXPLANATION

14 SEISMIC LINE AND PLATE NUMBER

3-MILE LIMIT

WELL LOCATION

10 0 10 20 30 MILES

10 0 10 20 30 KILOMETERS

CORRELATION STUDY OF SELECTED EXPLORATION WELLS FROM THE NORTH SLOPE AND BEAUFORT SEA, ALASKA

INDEX MAP OF WELLS AND SEISMIC LINES

U.S. GOVERNMENT PRINTING OFFICE

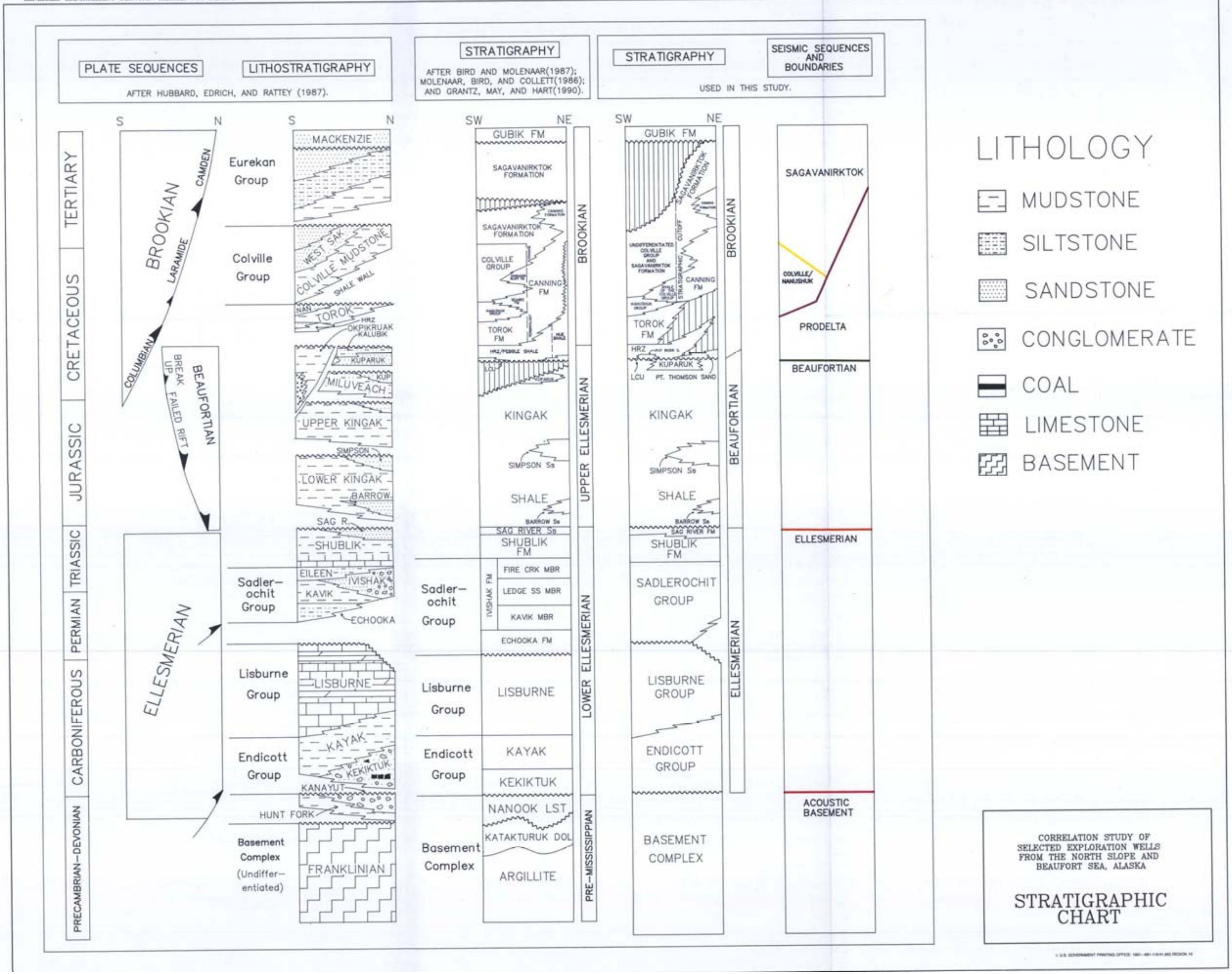
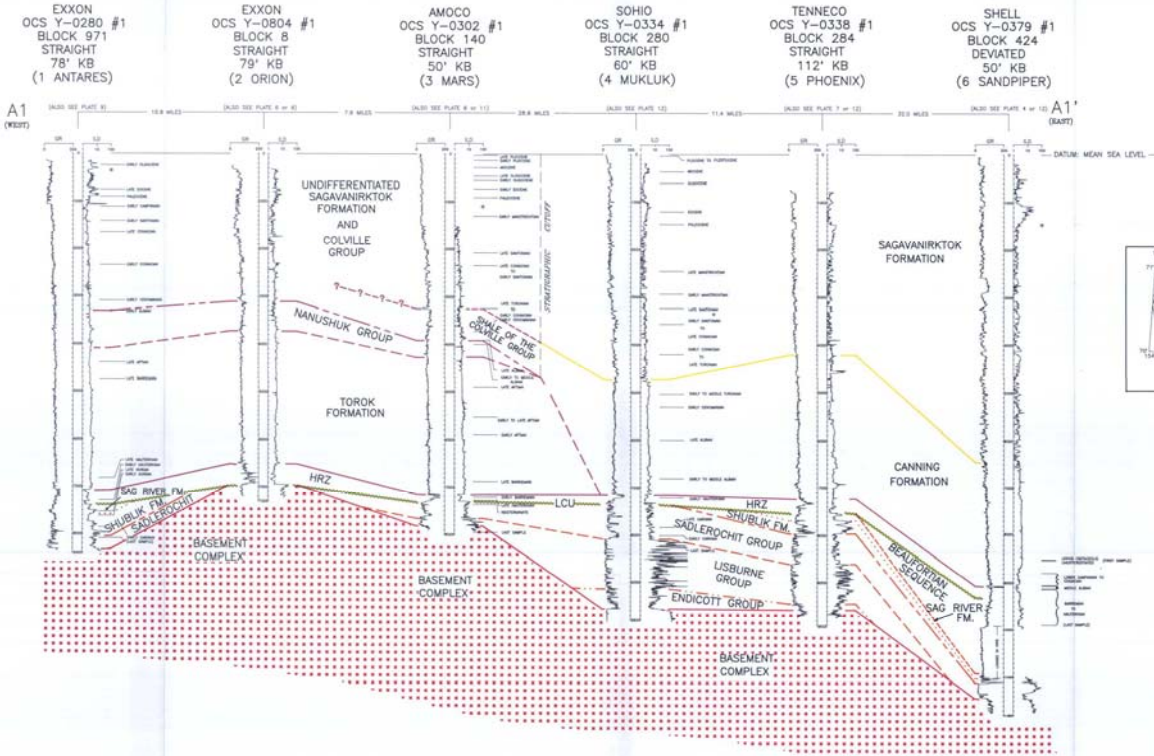
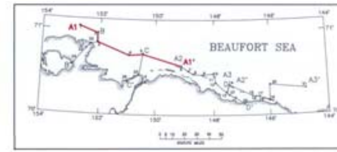


PLATE SEQUENCES
LITHOSTRATIGRAPHY
AFTER HUBBARD, EDRICH, AND RATTEY (1987).
STRATIGRAPHY
AFTER BIRD AND MOLENAAR(1987); MOLENAAR, BIRD, AND COLLETT(1986); AND GRANTZ, MAY, AND HART(1990).
STRATIGRAPHY
SEISMIC SEQUENCES AND BOUNDARIES
USED IN THIS STUDY.
TERTIARY
CRETACEOUS
JURASSIC
TRIASSIC
PERMIAN
CARBONIFEROUS
PRECAMBRIAN-DEVONIAN
S
N
BROOKIAN
CAMDEN
LARAMIDE
COLUMBIAN
BEAUFORTIAN
BREAK UP
FAILED RIFT
ELLESMERIAN
Eurekan Group
Colville Group
Sadlerochit Group
Lisburne Group
Endicott Group
Basement Complex (Undifferentiated)
MACKENZIE
WEST SAK
COLVILLE MUDSTONE
SHALE WALL
NAN
TOROK
HRZ
OKPIKRUAK
KALUBIK
KUPARUK
KUP
MILUVEACH
UPPER KINGAK
SIMPSON
LOWER KINGAK
BARROW
SAG R.
SHUBLIK
EILEEN
IVISHAK
KAVIK
ECHOOKA
LISBURNE
KAYAK
KEKIKTUK
KANAYUT
HUNT FORK
FRANKLINIAN
SW
NE
GUBIK FM
SAGAVANIRKTOK FORMATION
SAGAVANIRKTOK FORMATION
COLVILLE GROUP
CANNING FM
TOROK FM
HRZ/PEBBLE SHALE
LCU
KINGAK
SIMPSON Ss
SHALE
BARROW Ss
SAG RIVER Ss
SHUBLIK FM
IVISHAK FM
FIRE CRK MBR
LEDGE SS MBR
KAVIK MBR
ECHOOKA FM
LISBURNE
KAYAK
KEKIKTUK
NANOOK LST
KATAKTURUK DOL
ARGILLITE
BROOKIAN
UPPER ELLESMERIAN
LOWER ELLESMERIAN
PRE-MISSISSIPPIAN
GUBIK FM
SAGAVANIRKTOK FORMATION
UNDIFFERENTIATED COLVILLE GROUP AND SAGAVANIRKTOK FORMATION
STRATIGRAPHIC CUTOFF
CANNING FM
TOROK FM
HRZ
KUPARUK
LCU
PT. THOMSON SAND
KINGAK
SIMPSON Ss
SHALE
BARROW Ss
SAG RIVER FM
SHUBLIK FM
SADLEROCHIT GROUP
LISBURNE GROUP
ENDICOTT GROUP
BASEMENT COMPLEX
BROOKIAN
BEAUFORTIAN
ELLESMERIAN
SAGAVANIRKTOK
COLVILLE/ NANUSHUK
PRODELTA
BEAUFORTIAN
ELLESMERIAN
ACOUSTIC BASEMENT
LITHOLOGY
MUDSTONE
SILTSTONE
SANDSTONE
CONGLOMERATE
COAL
LIMESTONE
BASEMENT
CORRELATION STUDY OF SELECTED EXPLORATION WELLS FROM THE NORTH SLOPE AND BEAUFORT SEA, ALASKA
STRATIGRAPHIC CHART



EXPLANATION

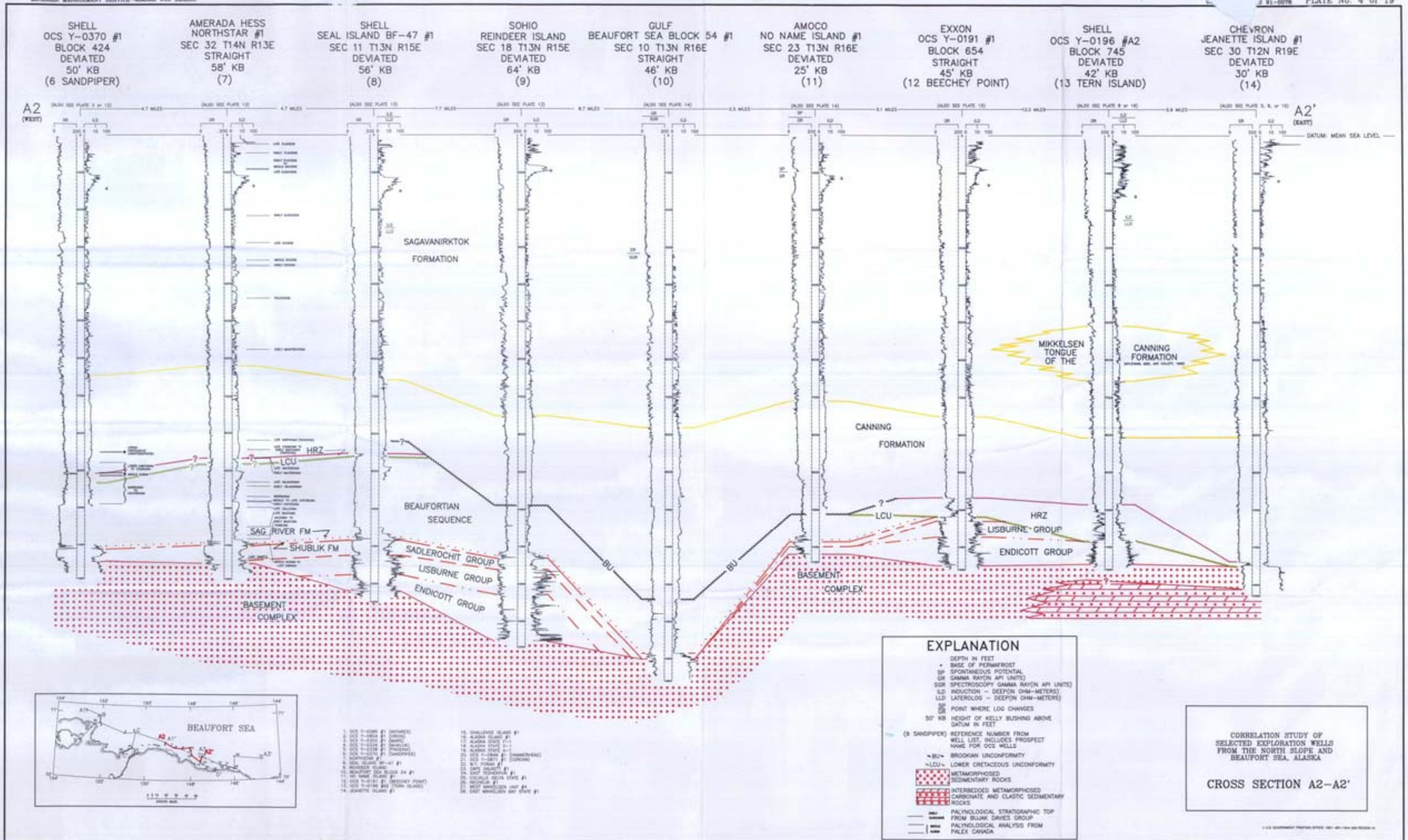
- DEPTH IN FEET
- * BASE OF PERMAFROST
- GR GAMMA RAY(IN API UNITS)
- ILD INDUCTION – DEEP(IN OHM – METERS)
- 60' KB HEIGHT OF KELLY BUSHING ABOVE DATUM (IN FEET)
- (4 MUKLUK) REFERENCE NUMBER FROM WELL LIST, INCLUDES PROSPECT NAME FOR OCS WELLS
- LCU LOWER CRETACEOUS UNCONFORMITY
- METAMORPHOSED SEDIMENTARY ROCKS
- PALYNOLOGICAL STRATIGRAPHIC TOP FROM BUJAK DAVIES GROUP
- PALYNOLOGICAL ANALYSIS FROM PALEX CANADA

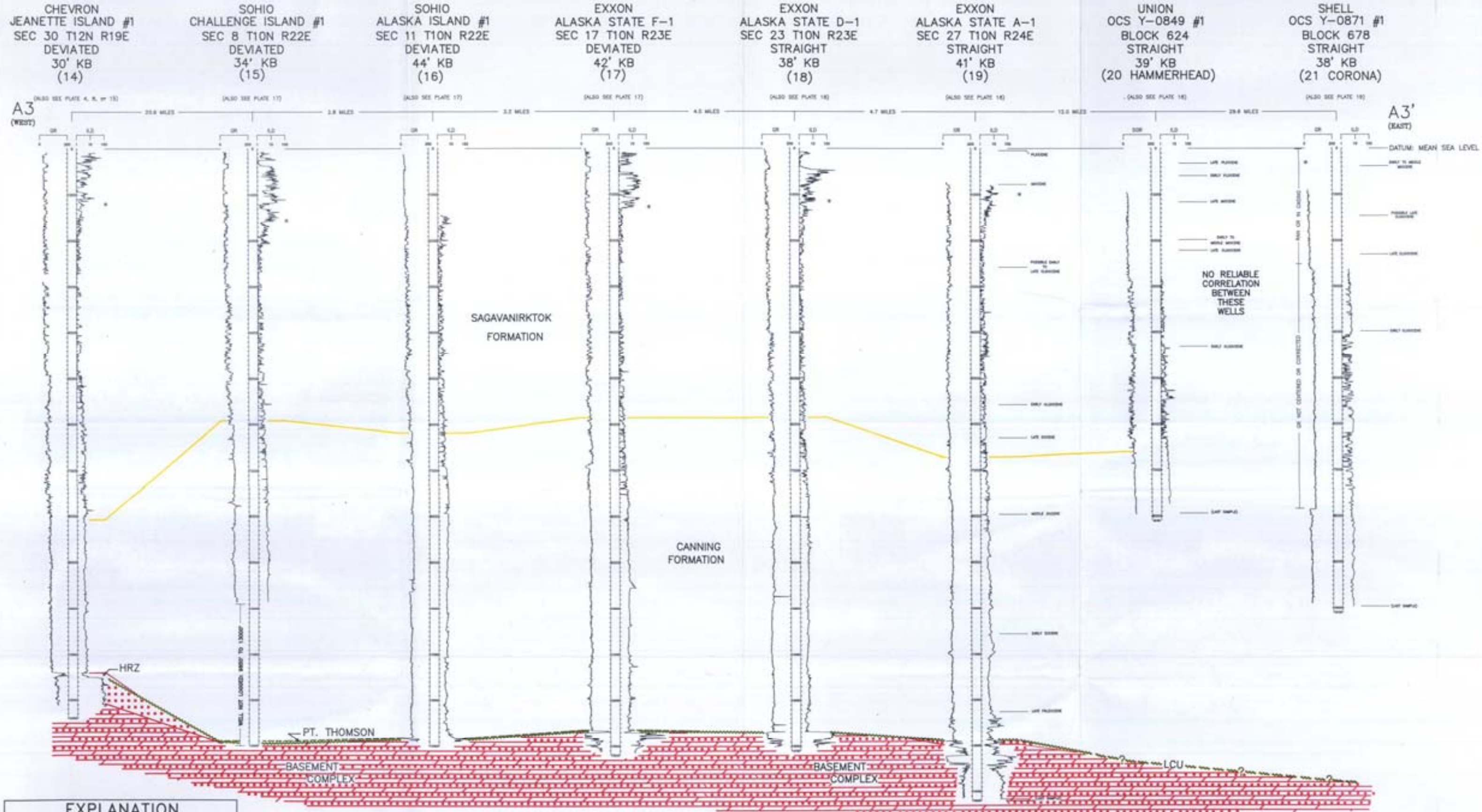


1. OCS Y-0280 #1 (ANTARES)
2. OCS Y-0804 #1 (ORION)
3. OCS Y-0302 #1 (MARS)
4. OCS Y-0334 #1 (MUKLUK)
5. OCS Y-0338 #1 (PHOENIX)
6. OCS Y-0370 #1 (SANDPIPER)
7. NORTHSTAR #1
8. SEAL ISLAND BF-47 #1
9. REINDEER ISLAND
10. BEAUFORT SEA BLOCK 54 #1
11. NO NAME ISLAND #1
12. OCS Y-0191 #1 (BEECHEY POINT)
13. OCS Y-0196 #A2 (TERN ISLAND)
14. JEANETTE ISLAND #1
15. CHALLENGE ISLAND #1
16. ALASKA ISLAND #1
17. ALASKA STATE F-1
18. ALASKA STATE D-1
19. ALASKA STATE A-1
20. OCS Y-0849 #1 (HAMMERHEAD)
21. OCS Y-0871 #1 (CORONA)
22. W.T. FORAN #1
23. CAPE HALKETT #1
24. EAST TESHEKPUK #1
25. COLVILLE DELTA STATE #1
26. NECHELIK #1
27. WEST MIKKELSEN UNIT #4
28. EAST MIKKELSEN BAY STATE #1

CORRELATION STUDY OF SELECTED EXPLORATION WELLS FROM THE NORTH SLOPE AND BEAUFORT SEA, ALASKA

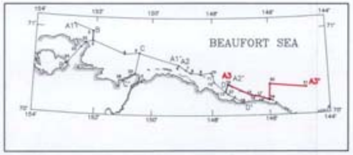
CROSS SECTION A1–A1'


SHELL
OCS Y-0370 #1
BLOCK 424
DEVIATED
50' KB
(6 SANDPIPER)
AMERADA HESS
NORTHSTAR #1
SEC 32 T14N R13E
STRAIGHT
58' KB
(7)
SHELL
SEAL ISLAND BF-47 #1
SEC 11 T13N R15E
DEVIATED
56' KB
(8)
SOHIO
REINDEER ISLAND
SEC 18 T13N R15E
DEVIATED
64' KB
(9)
GULF
BEAUFORT SEA BLOCK 54 #1
SEC 10 T13N R16E
STRAIGHT
46' KB
(10)
AMOCO
NO NAME ISLAND #1
SEC 23 T13N R16E
DEVIATED
25' KB
(11)
EXXON
OCS Y-0191 #1
BLOCK 654
STRAIGHT
45' KB
(12 BEECHEY POINT)
SHELL
OCS Y-0196 #A2
BLOCK 745
DEVIATED
42' KB
(13 TERN ISLAND)
CHEVRON
JEANETTE ISLAND #1
SEC 30 T12N R19E
DEVIATED
30' KB
(14)
A2
(WEST)
A2'
(EAST)
DATUM: MEAN SEA LEVEL
SAGAVANIRKTOK
FORMATION
MIKKELSEN
TONGUE
OF THE
CANNING
FORMATION
CANNING
FORMATION
HRZ
LCU
BEAUFORTIAN
SEQUENCE
SAG RIVER FM
SHUBLIK FM
SADLEROCHIT GROUP
LISBURNE GROUP
ENDICOTT GROUP
BASEMENT
COMPLEX
BU
LISBURNE GROUP
ENDICOTT GROUP
BEAUFORT SEA
EXPLANATION
DEPTH IN FEET
• BASE OF PERMAFROST
SP SPONTANEOUS POTENTIAL
GR GAMMA RAY(IN API UNITS)
SGR SPECTROSCOPY GAMMA RAY(IN API UNITS)
ILD INDUCTION - DEEP(IN OHM-METERS)
LLD LATEROLOG - DEEP(IN OHM-METERS)
POINT WHERE LOG CHANGES
50' KB HEIGHT OF KELLY BUSHING ABOVE DATUM IN FEET
(6 SANDPIPER) REFERENCE NUMBER FROM WELL LIST, INCLUDES PROSPECT NAME FOR OCS WELLS
BU BROOKIAN UNCONFORMITY
LCU LOWER CRETACEOUS UNCONFORMITY
METAMORPHOSED SEDIMENTARY ROCKS
INTERBEDDED METAMORPHOSED CARBONATE AND CLASTIC SEDIMENTARY ROCKS
PALYNOLOGICAL STRATIGRAPHIC TOP FROM BUJAK DAVIES GROUP
PALYNOLOGICAL ANALYSIS FROM PALEX CANADA
CORRELATION STUDY OF SELECTED EXPLORATION WELLS FROM THE NORTH SLOPE AND BEAUFORT SEA, ALASKA
CROSS SECTION A2-A2'



EXPLANATION

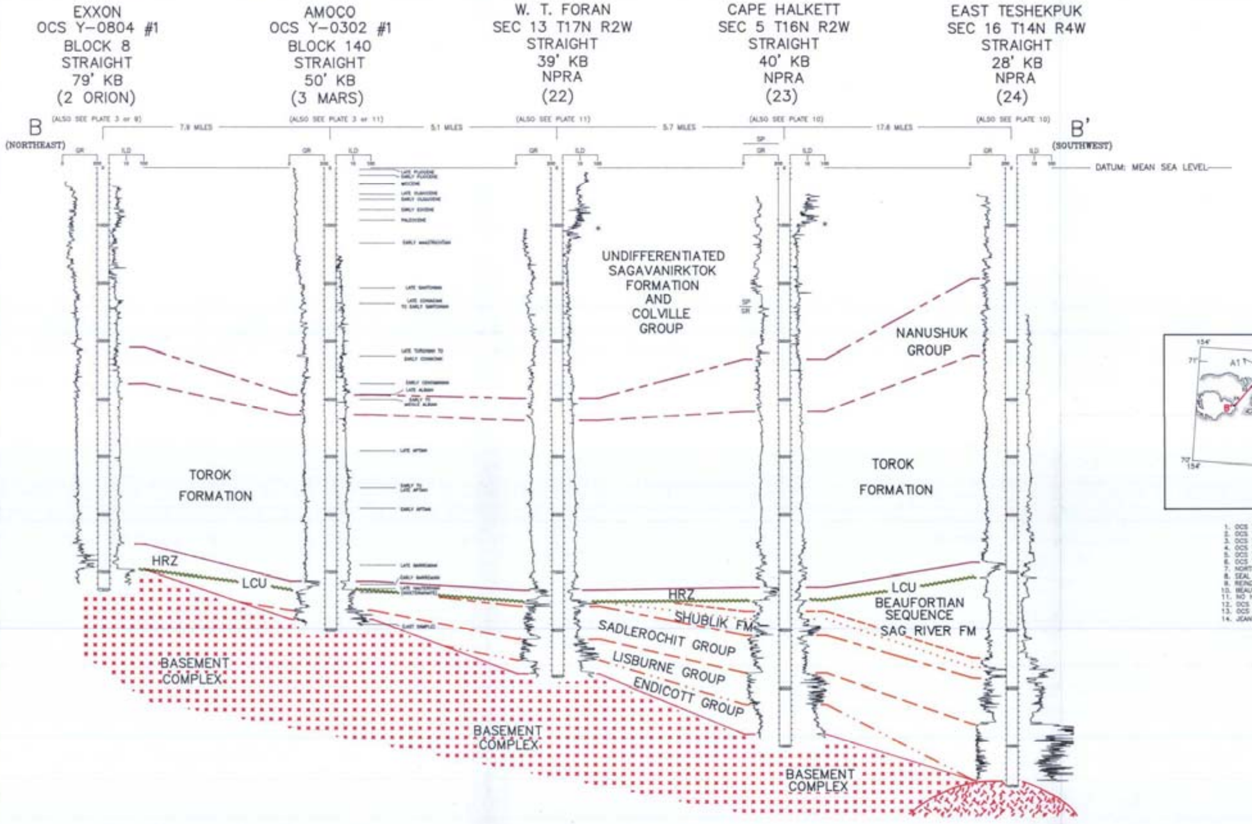
- DEPTH IN FEET
- * BASE OF PERMAFROST
- SGR SPECTROSCOPY GAMMA RAY(IN API UNITS)
- GR GAMMA RAY(IN API UNITS)
- ILD INDUCTION – DEEP(IN OHM–METERS)
- 39' KB HEIGHT OF KELLY BUSHING ABOVE DATUM(IN FEET)
- (20 HAMMERHEAD) REFERENCE NUMBER FROM WELL LIST, INCLUDES PROSPECT NAME FOR OCS WELLS
- ~LCU~ LOWER CRETACEOUS UNCONFORMITY
- METAMORPHOSED SEDIMENTARY ROCKS
- INTERBEDDED METAMORPHOSED CARBONATE AND CLASTIC SEDIMENTARY ROCKS
- PALYNOLOGICAL STRATIGRAPHIC TOP FROM BUJAK DAVIES GROUP



1. OCS Y-0280 #1 (ANTARES)
2. OCS Y-0804 #1 (ORION)
3. OCS Y-0302 #1 (MARS)
4. OCS Y-0334 #1 (MUKLUK)
5. OCS Y-0338 #1 (PHOENIX)
6. OCS Y-0370 #1 (SANDPIPER)
7. NORTHSTAR #1
8. SEAL ISLAND BF-47 #1
9. REINDEER ISLAND
10. BEAUFORT SEA BLOCK 54 #1
11. NO NAME ISLAND #1
12. OCS Y-0191 #1 (BEECHEY POINT)
13. OCS Y-0196 #2 (TERN ISLAND)
14. JEANETTE ISLAND #1
15. CHALLENGE ISLAND #1
16. ALASKA ISLAND #1
17. ALASKA STATE F-1
18. ALASKA STATE D-1
19. ALASKA STATE A-1
20. OCS Y-0849 #1 (HAMMERHEAD)
21. OCS Y-0871 #1 (CORONA)
22. W.T. FORAN #1
23. CAPE HALKETT #1
24. EAST TESHEKPUK #1
25. COLVILLE DELTA STATE #1
26. NECHELIK #1
27. WEST MIKKELSEN UNIT #4
28. EAST MIKKELSEN BAY STATE #1

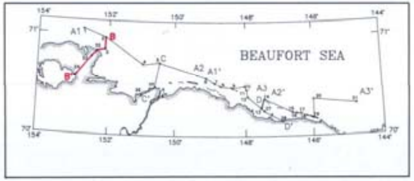
CORRELATION STUDY OF SELECTED EXPLORATION WELLS FROM THE NORTH SLOPE AND BEAUFORT SEA, ALASKA

CROSS SECTION A3–A3'



EXPLANATION

DEPTH IN FEET
* BASE OF PERMAFROST
GR GAMMA RAY(IN API UNITS)
ILD INDUCTION – DEEP(IN OHM-METERS)
SP SPONTANEOUS POTENTIAL
SP/GR POINT WHERE LOG CHANGES
40' KB HEIGHT OF KELLY BUSHING ABOVE DATUM(IN FEET)
(2 ORION) REFERENCE NUMBER FROM WELL LIST, INCLUDES PROSPECT NAME FOR OCS WELLS
NPRA NATIONAL PETROLEUM RESERVE–ALASKA
–LCU– LOWER CRETACEOUS UNCONFORMITY
METAMORPHOSED SEDIMENTARY ROCKS
GRANITIC ROCKS
PALYNOLOGICAL STRATIGRAPHIC TOP FROM BUJAK DAVIES GROUP

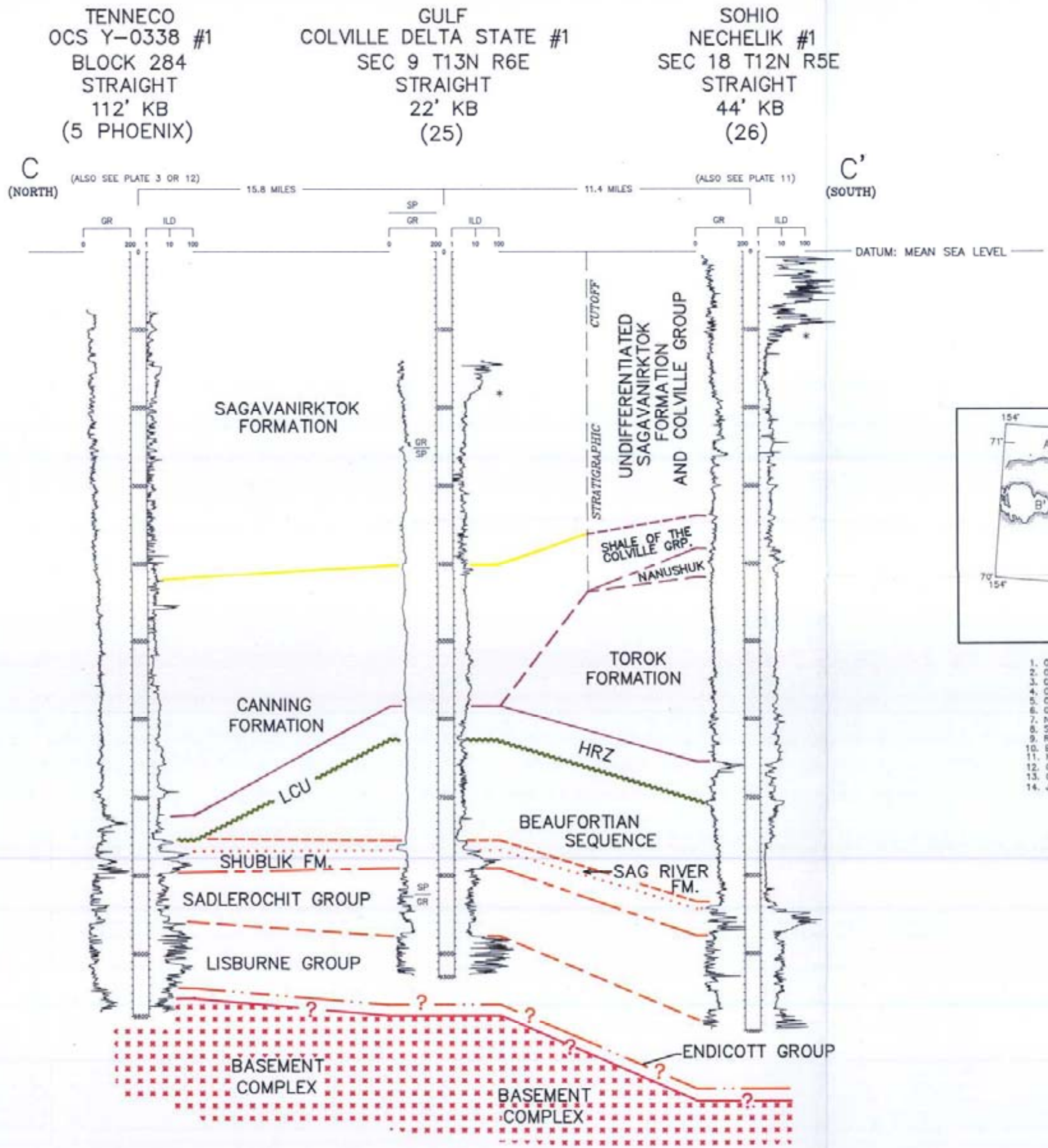


1. OCS Y-0280 #1 (ANTARES)
2. OCS Y-0804 #1 (ORION)
3. OCS Y-0302 #1 (MARS)
4. OCS Y-0334 #1 (MUKLUK)
5. OCS Y-0338 #1 (PHOENIX)
6. OCS Y-0370 #1 (SANDPIPER)
7. NORTHSTAR #1
8. SEAL ISLAND BF-47 #1
9. REINDEER ISLAND
10. BEAUFORT SEA BLOCK 54 #1
11. NO NAME ISLAND #1
12. OCS Y-0181 #1 (BEECHEY POINT)
13. OCS Y-0196 #A2 (TERN ISLAND)
14. JEANETTE ISLAND #1
15. CHALLENGE ISLAND #1
16. ALASKA ISLAND #1
17. ALASKA STATE F-1
18. ALASKA STATE D-1
19. ALASKA STATE A-1
20. OCS Y-0849 #1 (HAMMERHEAD)
21. OCS Y-0871 #1 (CORONA)
22. W.T. FORAN #1
23. CAPE HALKETT #1
24. EAST TESHEKPUK #1
25. COLVILLE DELTA STATE #1
26. NECHELIK #1
27. WEST MIKKELSEN UNIT #4
28. EAST MIKKELSEN BAY STATE #1

CORRELATION STUDY OF SELECTED EXPLORATION WELLS FROM THE NORTH SLOPE AND BEAUFORT SEA, ALASKA

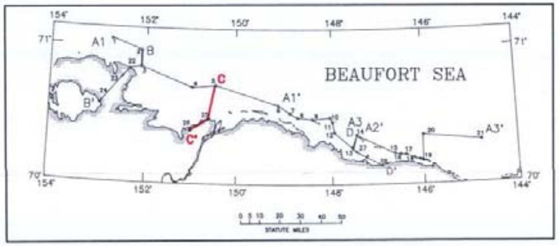
CROSS SECTION B–B'

U.S. GOVERNMENT PRINTING OFFICE: 1991—491-118/41,805 REGION 10



EXPLANATION

	DEPTH IN FEET
*	BASE OF PERMAFROST
GR	GAMMA RAY(IN API UNITS)
ILD	INDUCTION – DEEP(IN OHM-METERS)
SP	SPONTANEOUS POTENTIAL
SP/GR	POINT WHERE LOG CHANGES
112' KB	HEIGHT OF KELLY BUSHING ABOVE DATUM(IN FEET)
(5 PHOENIX)	REFERENCE NUMBER FROM WELL LIST, INCLUDES PROSPECT NAME FOR OCS WELLS
LCU	LOWER CRETACEOUS UNCONFORMITY
	METAMORPHOSED SEDIMENTARY ROCKS

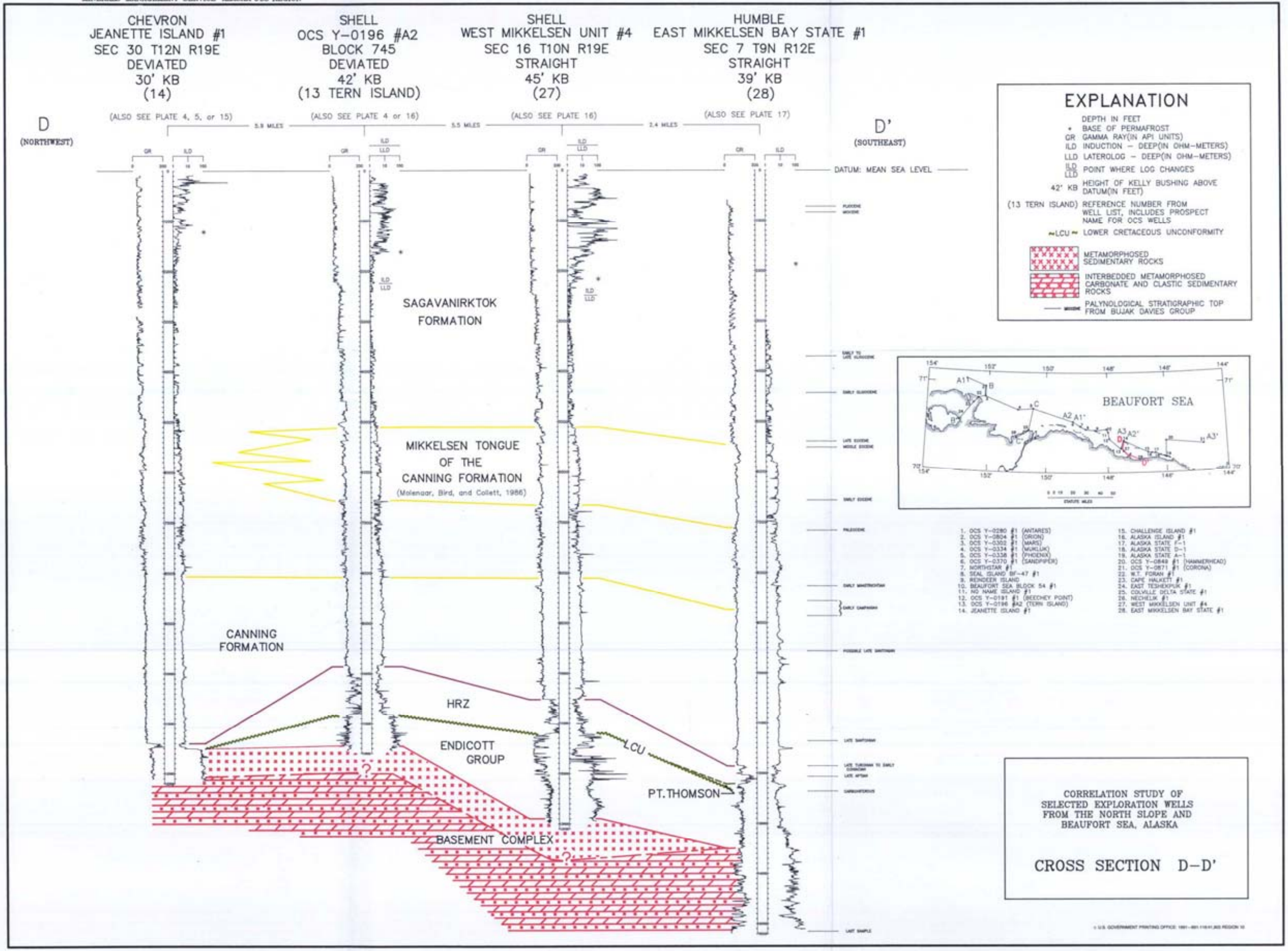


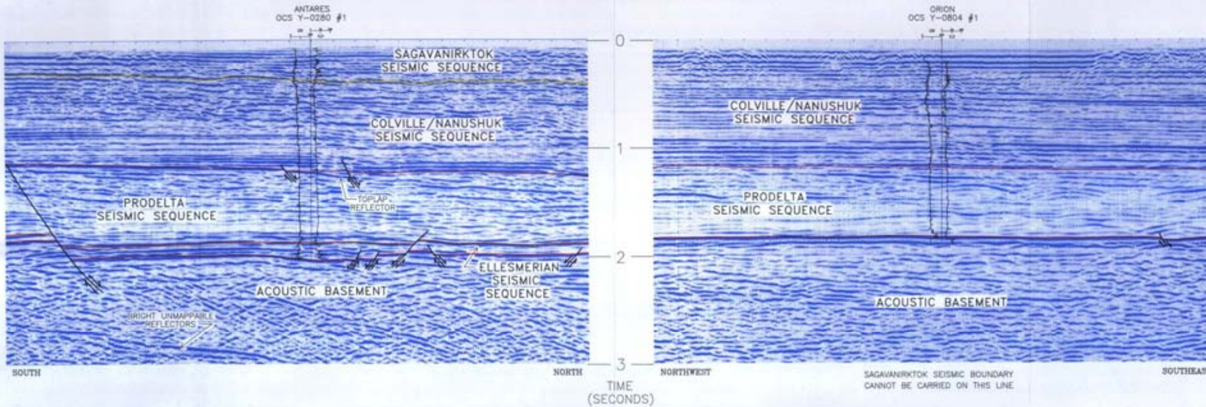
1. OCS Y-0280 #1 (ANTARES)
2. OCS Y-0804 #1 (ORION)
3. OCS Y-0302 #1 (MARS)
4. OCS Y-0334 #1 (MUKLUK)
5. OCS Y-0338 #1 (PHOENIX)
6. OCS Y-0370 #1 (SANDPIPER)
7. NORTHSTAR #1
8. SEAL ISLAND BF-47 #1
9. REINDEER ISLAND
10. BEAUFORT SEA BLOCK 54 #1
11. NO NAME ISLAND #1
12. OCS Y-0191 #1 (BEECHEY POINT)
13. OCS Y-0196 #A2 (TERN ISLAND)
14. JEANETTE ISLAND #1
15. CHALLENGE ISLAND #1
16. ALASKA ISLAND #1
17. ALASKA STATE F-1
18. ALASKA STATE D-1
19. ALASKA STATE A-1
20. OCS Y-0849 #1 (HAMMERHEAD)
21. OCS Y-0871 #1 (CORONA)
22. W.T. FORAN #1
23. CAPE HALKETT #1
24. EAST TESHEKPUK #1
25. COLVILLE DELTA STATE #1
26. NECHELIK #1
27. WEST MIKKELSEN UNIT #4
28. EAST MIKKELSEN BAY STATE #1

CORRELATION STUDY OF SELECTED EXPLORATION WELLS FROM THE NORTH SLOPE AND BEAUFORT SEA, ALASKA

CROSS SECTION C–C'

U.S. GOVERNMENT PRINTING OFFICE: 1991-491-116/41,803 REGION 10


CHEVRON
JEANETTE ISLAND #1
SEC 30 T12N R19E
DEVIATED
30' KB
(14)
(ALSO SEE PLATE 4, 5, or 15)
SHELL
OCS Y-0196 #A2
BLOCK 745
DEVIATED
42' KB
(13 TERN ISLAND)
(ALSO SEE PLATE 4 or 16)
SHELL
WEST MIKKELSEN UNIT #4
SEC 16 T10N R19E
STRAIGHT
45' KB
(27)
(ALSO SEE PLATE 16)
HUMBLE
EAST MIKKELSEN BAY STATE #1
SEC 7 T9N R12E
STRAIGHT
39' KB
(28)
(ALSO SEE PLATE 17)
D
(NORTHWEST)
D'
(SOUTHEAST)
DATUM: MEAN SEA LEVEL
SAGAVANIRKTOK FORMATION
MIKKELSEN TONGUE OF THE CANNING FORMATION
(Molenaar, Bird, and Collett, 1986)
CANNING FORMATION
HRZ
ENDICOTT GROUP
LCU
PT. THOMSON
BASEMENT COMPLEX
EXPLANATION
DEPTH IN FEET
BASE OF PERMAFROST
GR GAMMA RAY(IN API UNITS)
ILD INDUCTION – DEEP(IN OHM-METERS)
LLD LATEROLOG – DEEP(IN OHM-METERS)
ILD/LLD POINT WHERE LOG CHANGES
42' KB HEIGHT OF KELLY BUSHING ABOVE DATUM(IN FEET)
(13 TERN ISLAND) REFERENCE NUMBER FROM WELL LIST, INCLUDES PROSPECT NAME FOR OCS WELLS
LCU LOWER CRETACEOUS UNCONFORMITY
METAMORPHOSED SEDIMENTARY ROCKS
INTERBEDDED METAMORPHOSED CARBONATE AND CLASTIC SEDIMENTARY ROCKS
PALYNOLOGICAL STRATIGRAPHIC TOP FROM BUJAK DAVIES GROUP
BEAUFORT SEA
1. OCS Y-0280 #1 (ANTARES)
2. OCS Y-0804 #1 (ORION)
3. OCS Y-0302 #1 (MARS)
4. OCS Y-0334 #1 (MUKLUK)
5. OCS Y-0338 #1 (PHOENIX)
6. OCS Y-0370 #1 (SANDPIPER)
7. NORTHSTAR #1
8. SEAL ISLAND BF-47 #1
9. REINDEER ISLAND
10. BEAUFORT SEA BLOCK 54 #1
11. NO NAME ISLAND #1
12. OCS Y-0191 #1 (BEECHEY POINT)
13. OCS Y-0196 #A2 (TERN ISLAND)
14. JEANETTE ISLAND #1
15. CHALLENGE ISLAND #1
16. ALASKA ISLAND #1
17. ALASKA STATE F-1
18. ALASKA STATE D-1
19. ALASKA STATE A-1
20. OCS Y-0849 #1 (HAMMERHEAD)
21. OCS Y-0871 #1 (CORONA)
22. W.T. FORAN #1
23. CAPE HALKETT #1
24. EAST TESHEKPUK #1
25. COLVILLE DELTA STATE #1
26. NECHELIK #1
27. WEST MIKKELSEN UNIT #4
28. EAST MIKKELSEN BAY STATE #1
CORRELATION STUDY OF SELECTED EXPLORATION WELLS FROM THE NORTH SLOPE AND BEAUFORT SEA, ALASKA
CROSS SECTION D–D'



Horizontal Scale
0 1 2
feet (thousands)

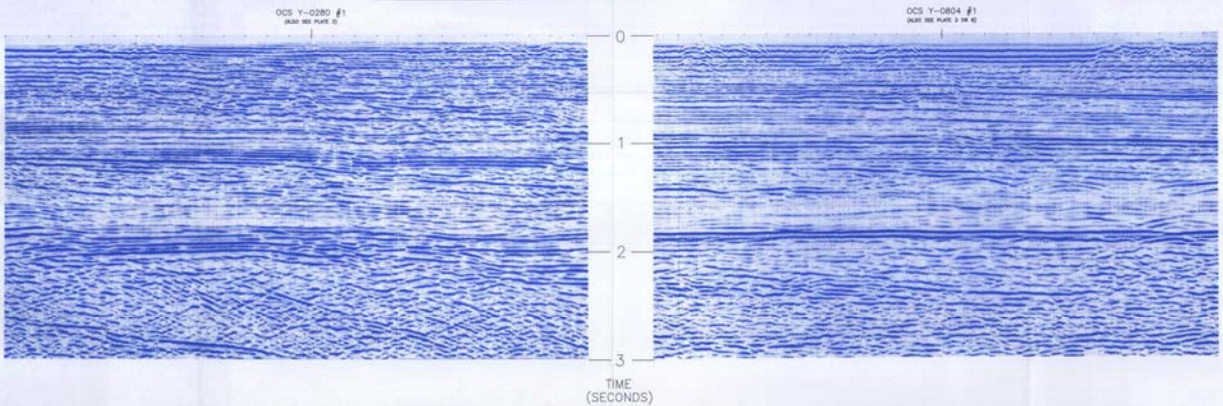
CORRELATION STUDY OF SELECTED EXPLORATION WELLS FROM THE NORTH SLOPE AND BEAUFORT SEA, ALASKA

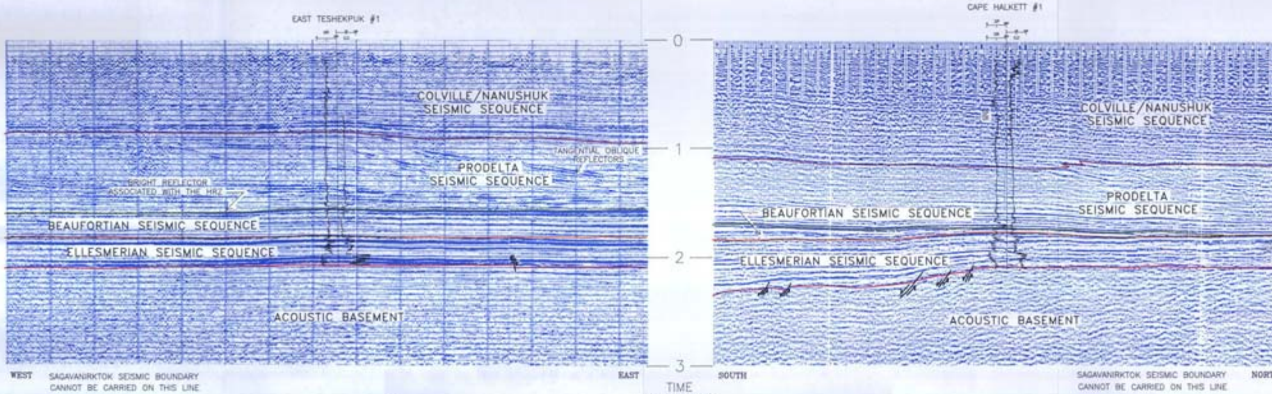
Y-0280 No. 1 AND Y-0804 No. 1 CORRELATED TO SEISMIC DATA

SEISMIC SEQUENCE BOUNDARY

- TOP OF COLVILLE/NANUSHUK
- TOP OF PRODELTA
- TOP OF ELLESMERIAN
- TOP OF ACOUSTIC BASEMENT

Horizontal Scale
0 1 2
feet (thousands)





Horizontal Scale
0 1 2 3 4
feet (thousands)

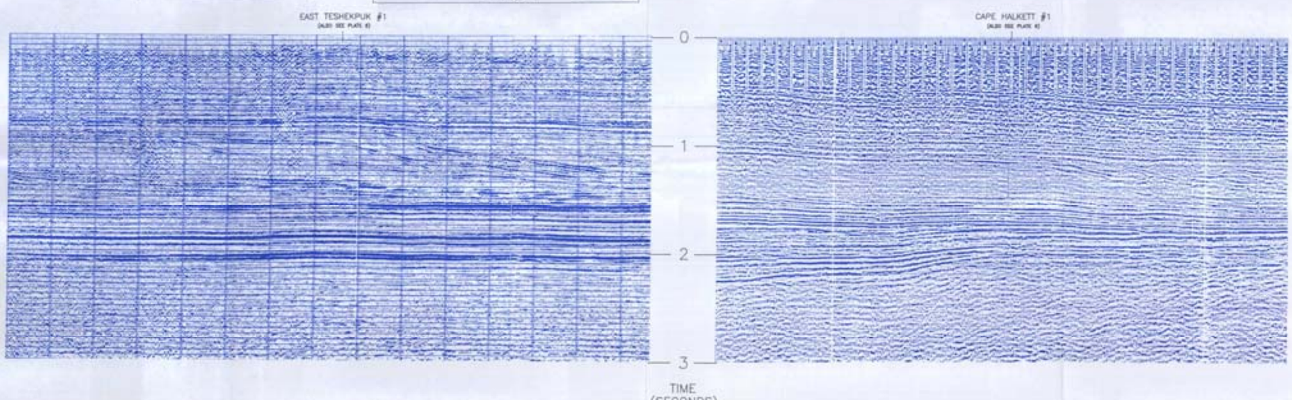
CORRELATION STUDY OF SELECTED EXPLORATION WELLS FROM THE NORTH SLOPE AND BEAUFORT SEA, ALASKA

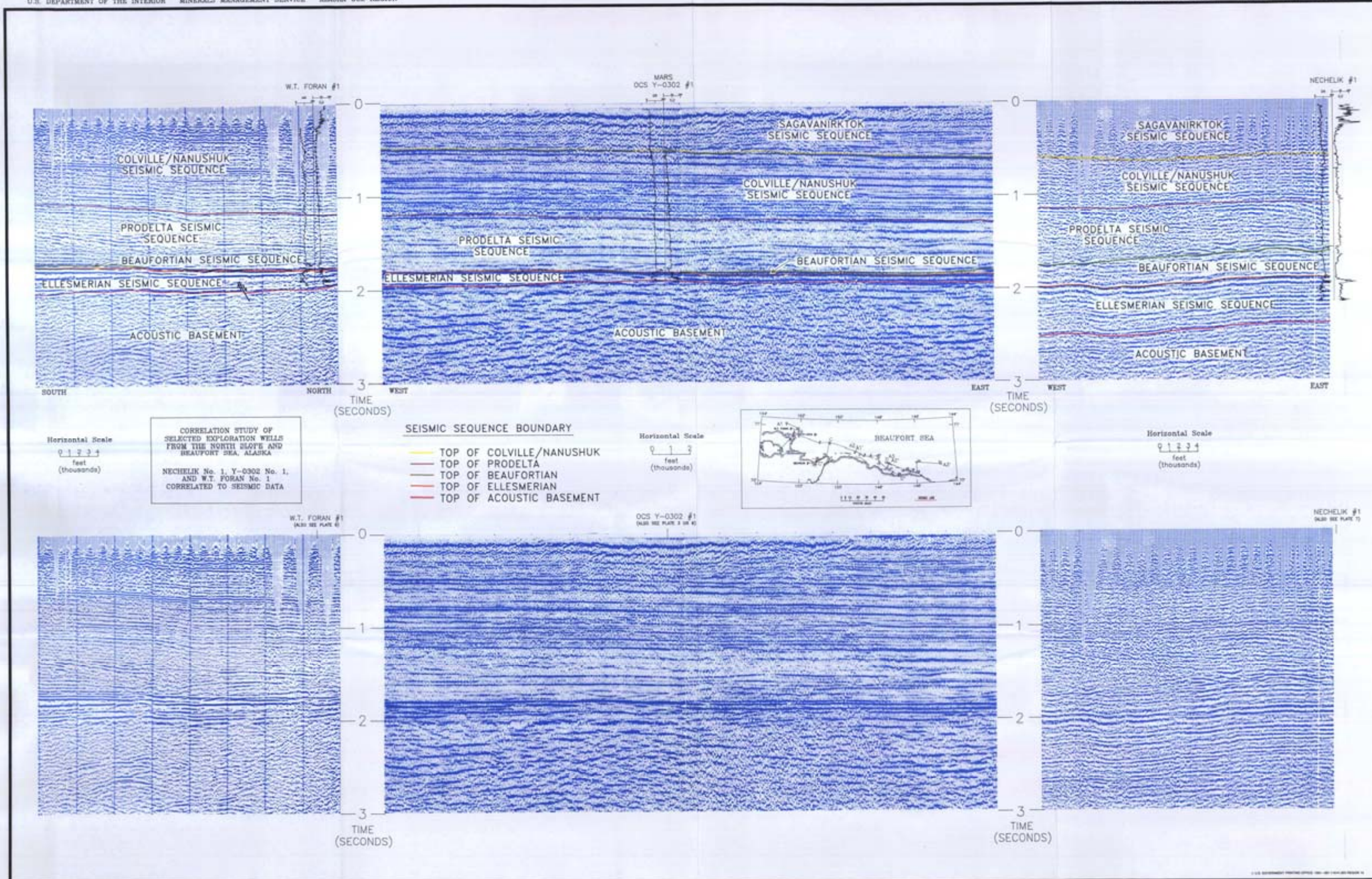
CAPE HALKETT No. 1 AND EAST TESHEKPUK No. 1 CORRELATED TO SEISMIC DATA

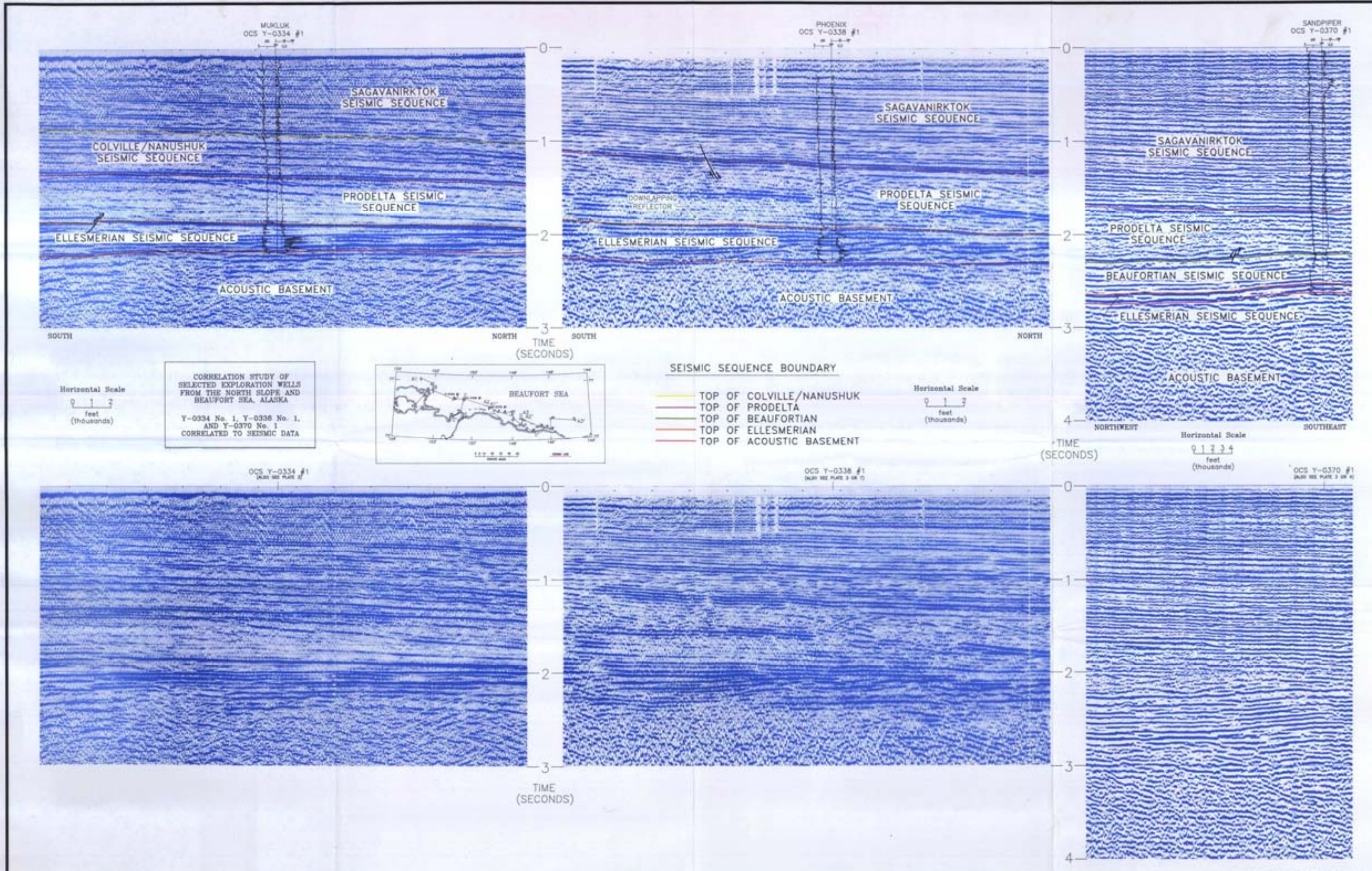
SEISMIC SEQUENCE BOUNDARY

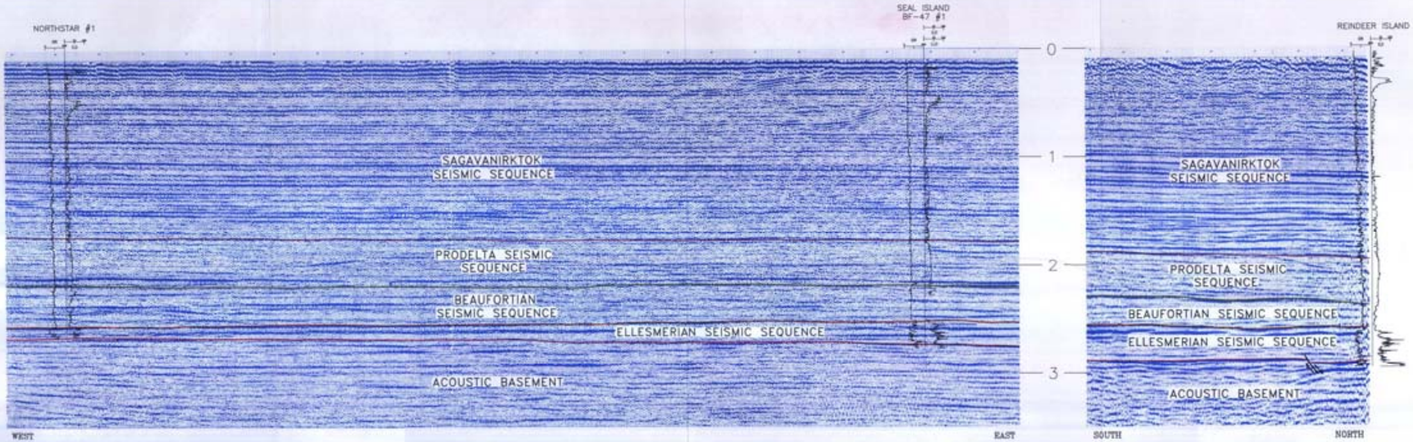
- TOP OF PRODELTA
- TOP OF BEAUFORTIAN
- TOP OF ELLESMERIAN
- TOP OF ACOUSTIC BASEMENT

Horizontal Scale
0 1 2 3 4
feet (thousands)



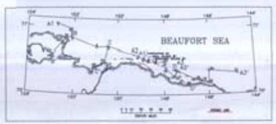

W.T. FORAN #1
MARS
OCS Y-0302 #1
NECHELIK #1
SAGAVANIRKTOK SEISMIC SEQUENCE
COLVILLE/NANUSHUK SEISMIC SEQUENCE
PRODELTA SEISMIC SEQUENCE
BEAUFORTIAN SEISMIC SEQUENCE
ELLESMERIAN SEISMIC SEQUENCE
ACOUSTIC BASEMENT
SOUTH
NORTH
WEST
EAST
0
1
2
3
TIME (SECONDS)
Horizontal Scale
0 1 2 3 4
feet (thousands)
CORRELATION STUDY OF SELECTED EXPLORATION WELLS FROM THE NORTH SLOPE AND BEAUFORT SEA, ALASKA
NECHELIK No. 1, Y-0302 No. 1, AND W.T. FORAN No. 1 CORRELATED TO SEISMIC DATA
SEISMIC SEQUENCE BOUNDARY
TOP OF COLVILLE/NANUSHUK
TOP OF PRODELTA
TOP OF BEAUFORTIAN
TOP OF ELLESMERIAN
TOP OF ACOUSTIC BASEMENT
BEAUFORT SEA


MUKLUK
OCS Y-0334 #1
SAGAVANIRKTOK SEISMIC SEQUENCE
COLVILLE/NANUSHUK SEISMIC SEQUENCE
PRODELTA SEISMIC SEQUENCE
ELLESMERIAN SEISMIC SEQUENCE
ACOUSTIC BASEMENT
SOUTH
NORTH
PHOENIX
OCS Y-0338 #1
SAGAVANIRKTOK SEISMIC SEQUENCE
DOWNLAPPING REFLECTOR
PRODELTA SEISMIC SEQUENCE
ELLESMERIAN SEISMIC SEQUENCE
ACOUSTIC BASEMENT
SOUTH
NORTH
SANDPIPER
OCS Y-0370 #1
SAGAVANIRKTOK SEISMIC SEQUENCE
PRODELTA SEISMIC SEQUENCE
BEAUFORTIAN SEISMIC SEQUENCE
ELLESMERIAN SEISMIC SEQUENCE
ACOUSTIC BASEMENT
NORTHWEST
SOUTHEAST
0
1
2
3
4
TIME (SECONDS)
Horizontal Scale
0 1 2
feet (thousands)
CORRELATION STUDY OF SELECTED EXPLORATION WELLS FROM THE NORTH SLOPE AND BEAUFORT SEA, ALASKA
Y-0334 No. 1, Y-0338 No. 1, AND Y-0370 No. 1 CORRELATED TO SEISMIC DATA
BEAUFORT SEA
SEISMIC SEQUENCE BOUNDARY
TOP OF COLVILLE/NANUSHUK
TOP OF PRODELTA
TOP OF BEAUFORTIAN
TOP OF ELLESMERIAN
TOP OF ACOUSTIC BASEMENT
Horizontal Scale
0 1 2
feet (thousands)
Horizontal Scale
0 1 2 3 4
feet (thousands)
OCS Y-0334 #1
OCS Y-0338 #1
OCS Y-0370 #1



SEISMIC SEQUENCE BOUNDARY

- TOP OF PRODELTA
- TOP OF BEAUFORTIAN
- TOP OF ELLESMERIAN
- TOP OF ACOUSTIC BASEMENT

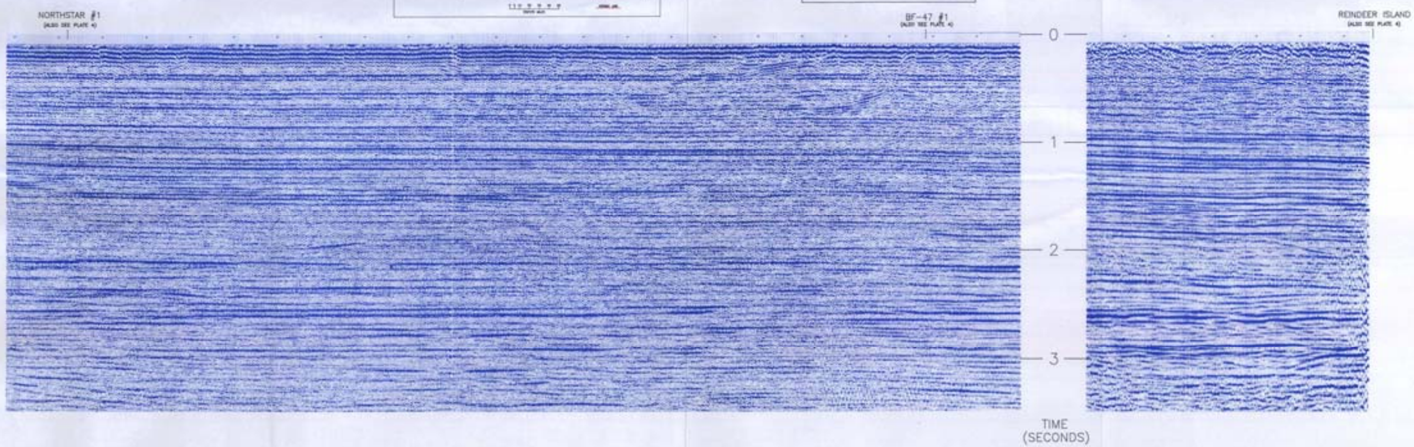


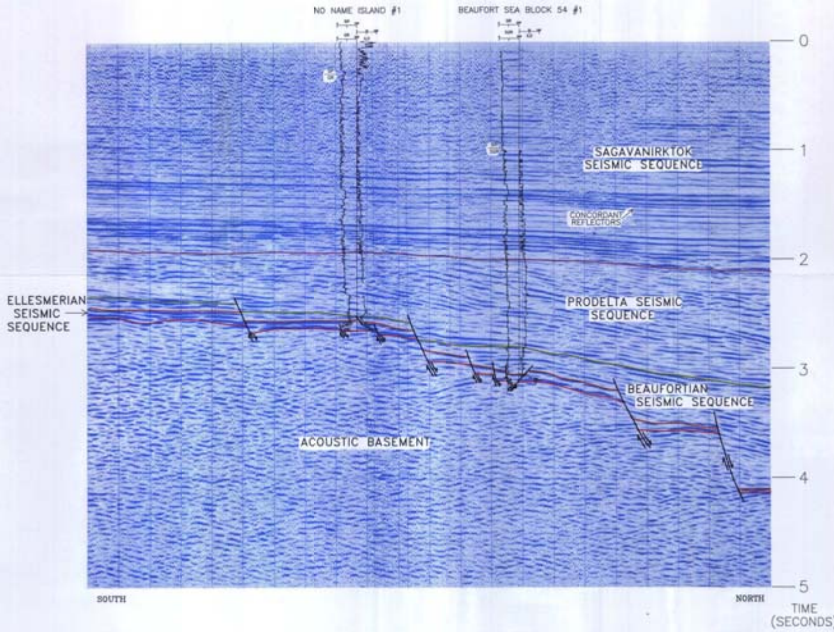
Horizontal Scale
0 1 2 3 4
feet
(thousands)

CORRELATION STUDY OF SELECTED EXPLORATION WELLS FROM THE NORTH SLOPE AND BEAUFORT SEA, ALASKA

NORTHSTAR No. 1, REINDEER ISLAND, AND SEAL ISLAND BF-47 No. 1 CORRELATED TO SEISMIC DATA

Horizontal Scale
0 1 2
feet
(thousands)





CORRELATION STUDY OF SELECTED EXPLORATION WELLS FROM THE NORTH SLOPE AND BEAUFORT SEA, ALASKA

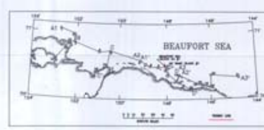
BEAUFORT SEA BLOCK 54 No. 1 AND NO NAME ISLAND No. 1 CORRELATED TO SEISMIC DATA

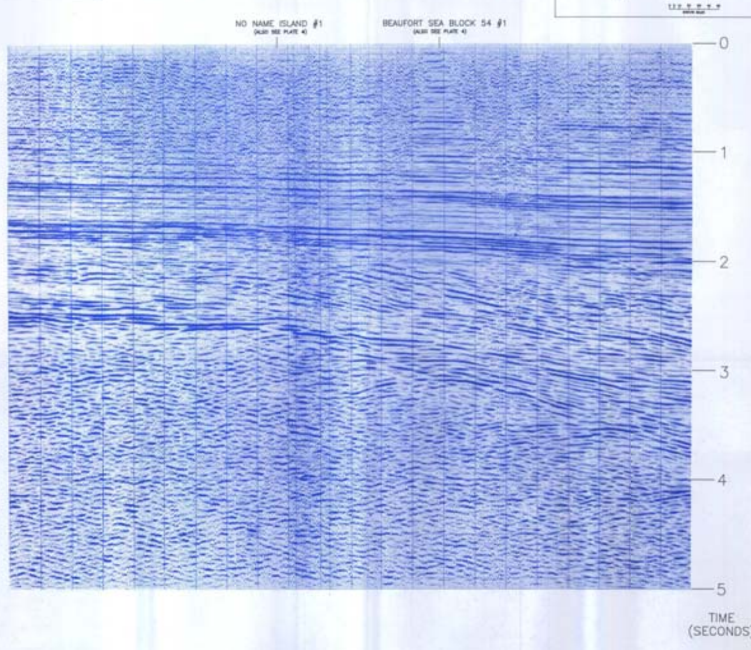
SEISMIC SEQUENCE BOUNDARY

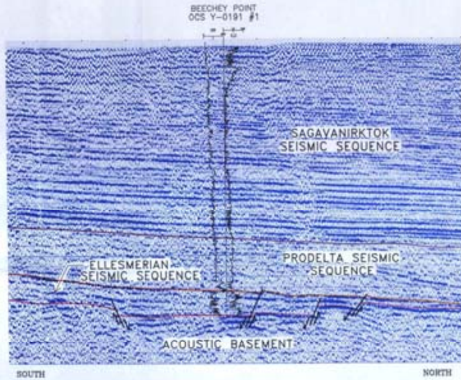
- TOP OF PRODELTA
- TOP OF BEAUFORTIAN
- TOP OF ELLESMERIAN
- TOP OF ACOUSTIC BASEMENT

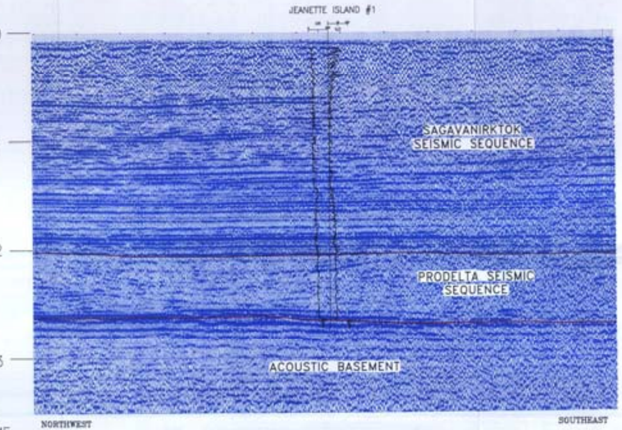
Horizontal Scale

0 1 2
feet (thousands)



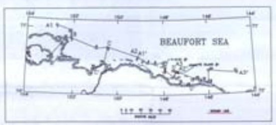






0
1
2
3

TIME
(SECONDS)



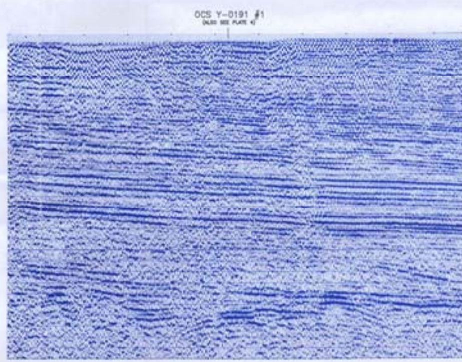
Horizontal Scale
0 1 2
feet
(thousands)

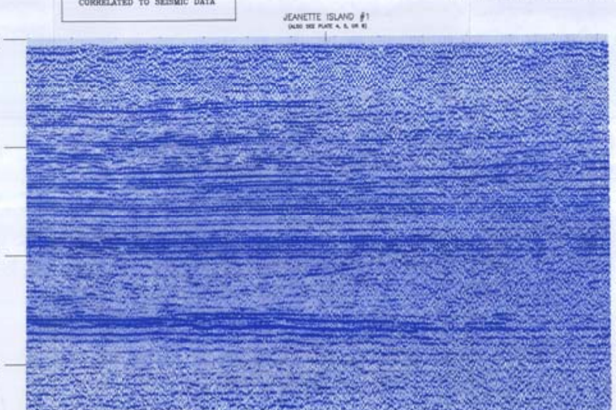
CORRELATION STUDY OF
SELECTED EXPLORATION WELLS
FROM THE NORTH SLOPE AND
BEAUFORT SEA, ALASKA

JEANETTE ISLAND No. 1
AND Y-0191 No. 1
CORRELATED TO SEISMIC DATA

Horizontal Scale
0 1 2
feet
(thousands)

SEISMIC SEQUENCE BOUNDARY
- TOP OF PRODELTA
- TOP OF ELLESMERIAN
- TOP OF ACOUSTIC BASEMENT



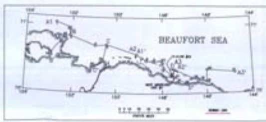


0
1
2
3

TIME
(SECONDS)

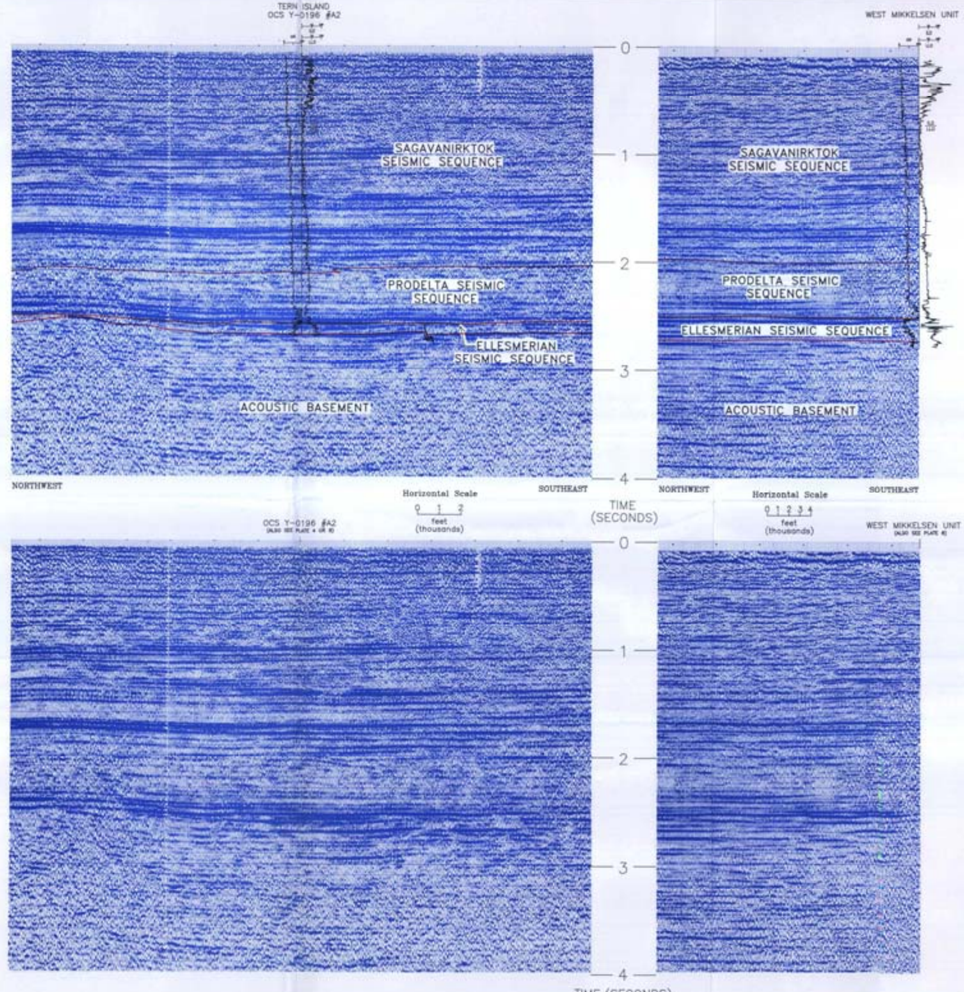
SEISMIC SEQUENCE BOUNDARY

- TOP OF PRODELTA
- TOP OF ELLESMERIAN
- TOP OF ACOUSTIC BASEMENT



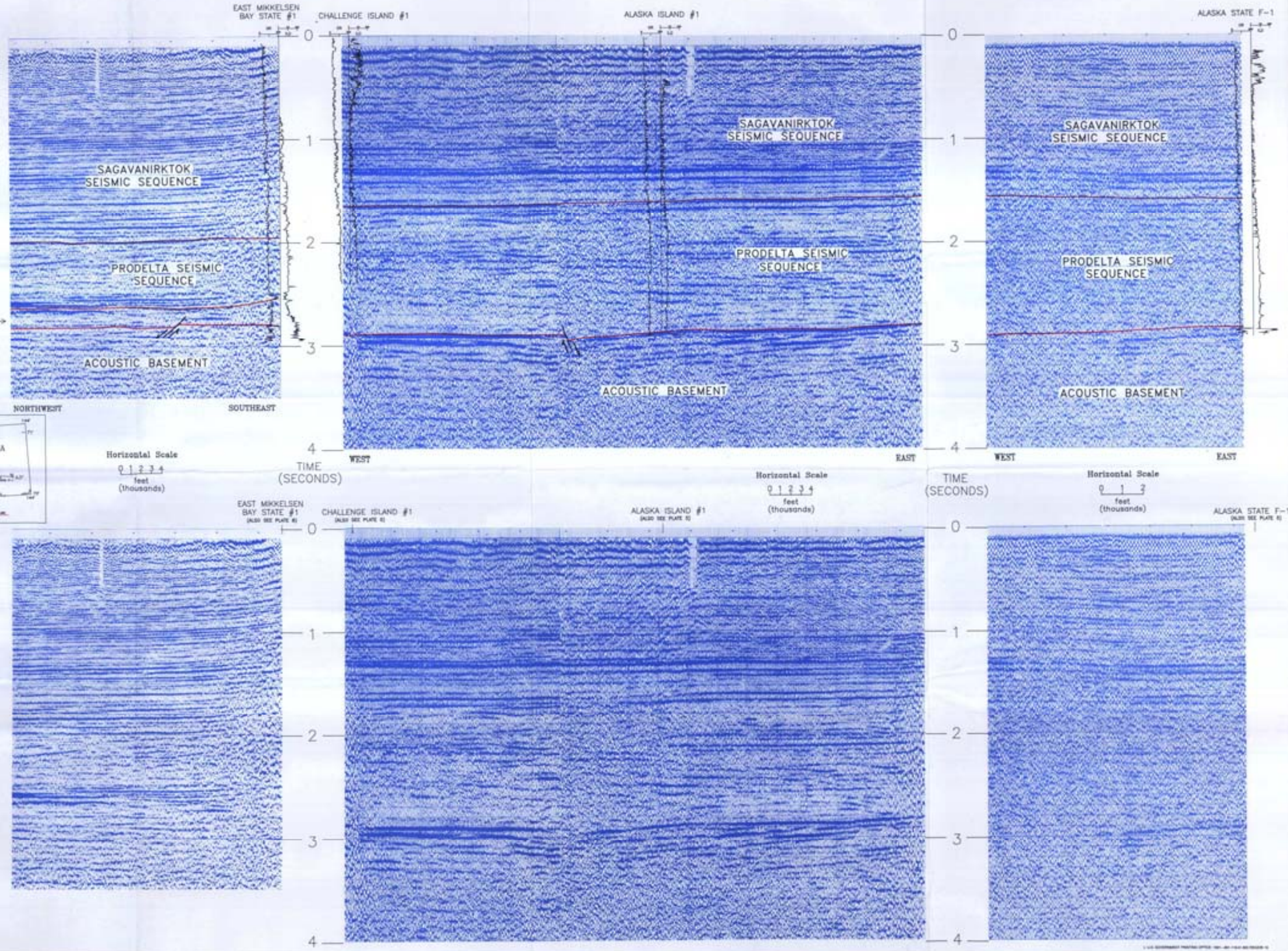
CORRELATION STUDY OF SELECTED EXPLORATION WELLS FROM THE NORTH SLOPE AND BEAUFORT SEA, ALASKA

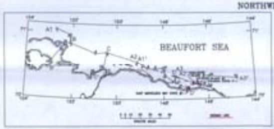
WEST MIKKELSEN UNIT No. 4 AND Y-0196 No. A2 CORRELATED TO SEISMIC DATA



SEISMIC SEQUENCE BOUNDARY

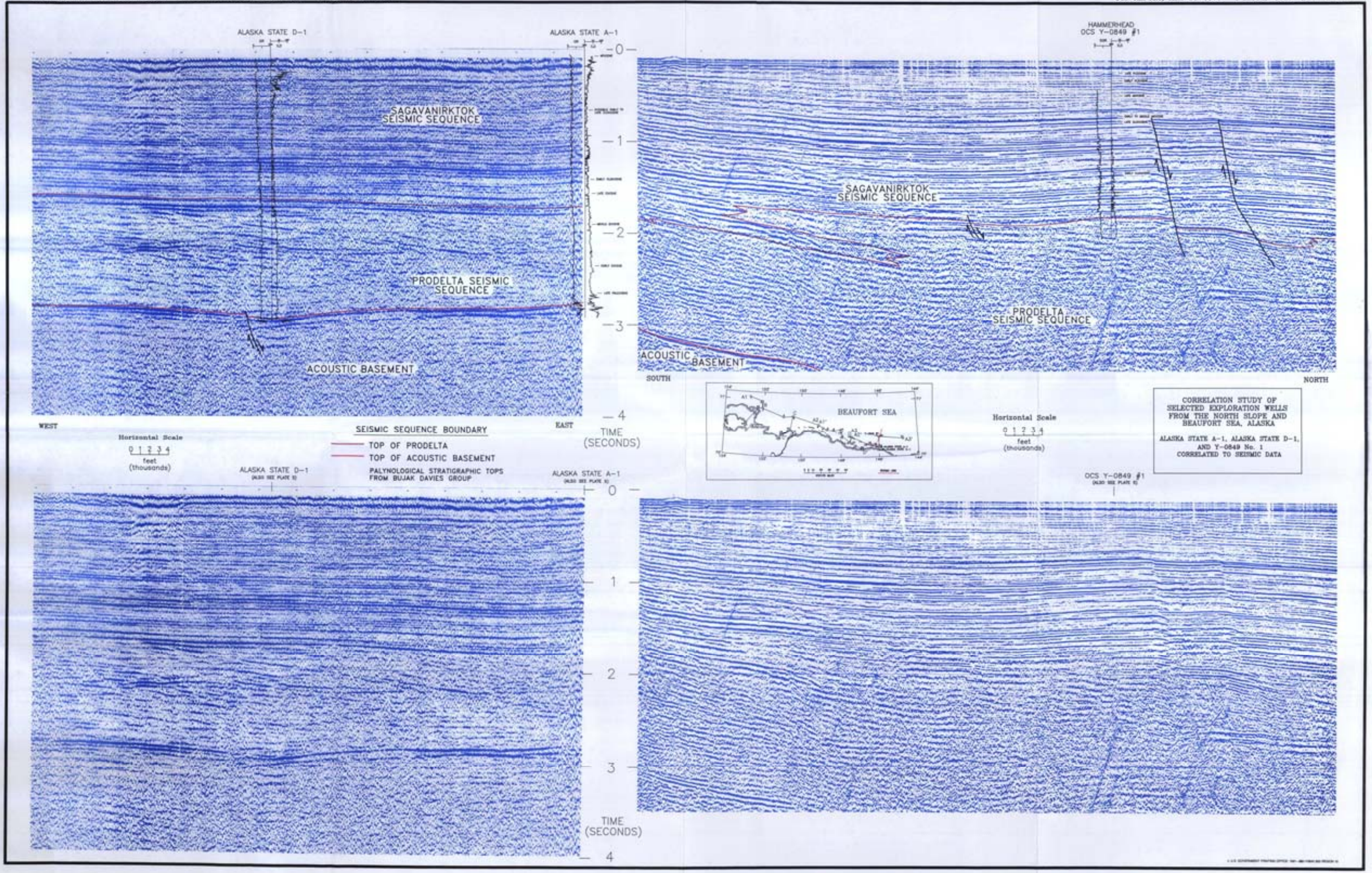
- TOP OF PRODELTA
- TOP OF ELLESMERIAN
- TOP OF ACOUSTIC BASEMENT

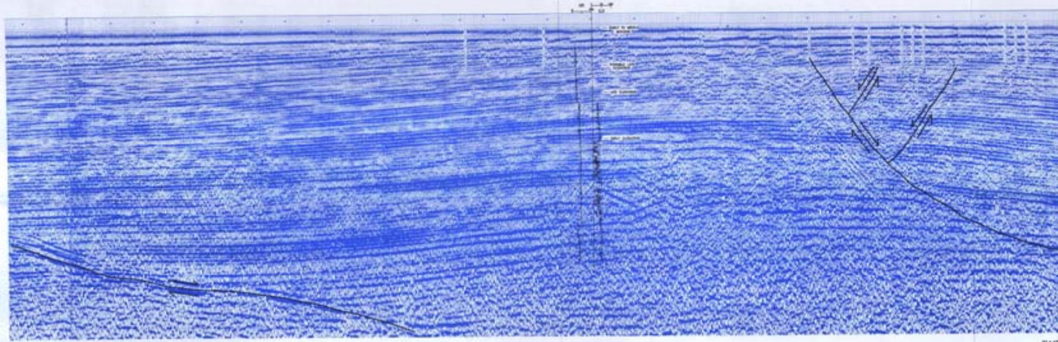




CORRELATION STUDY OF SELECTED EXPLORATION WELLS FROM THE NORTH SLOPE AND BEAUFORT SEA, ALASKA

ALASKA ISLAND No. 1, ALASKA STATE F-1, CHALLENGE ISLAND No. 1, AND EAST MIKKELSEN BAY STATE No. 1 CORRELATED TO SEISMIC DATA


ALASKA STATE D-1
ALASKA STATE A-1
SAGAVANIRKTOK SEISMIC SEQUENCE
PRODELTA SEISMIC SEQUENCE
ACOUSTIC BASEMENT
WEST
EAST
Horizontal Scale
0 1 2 3 4
feet (thousands)
SEISMIC SEQUENCE BOUNDARY
TOP OF PRODELTA
TOP OF ACOUSTIC BASEMENT
PALYNOLOGICAL STRATIGRAPHIC TOPS FROM BUJAK DAVIES GROUP
TIME (SECONDS)
0
1
2
3
4
HAMMERHEAD OCS Y-0849 #1
SOUTH
NORTH
BEAUFORT SEA
CORRELATION STUDY OF SELECTED EXPLORATION WELLS FROM THE NORTH SLOPE AND BEAUFORT SEA, ALASKA
ALASKA STATE A-1, ALASKA STATE D-1, AND Y-0849 No. 1 CORRELATED TO SEISMIC DATA
OCS Y-0849 #1



Horizontal Scale

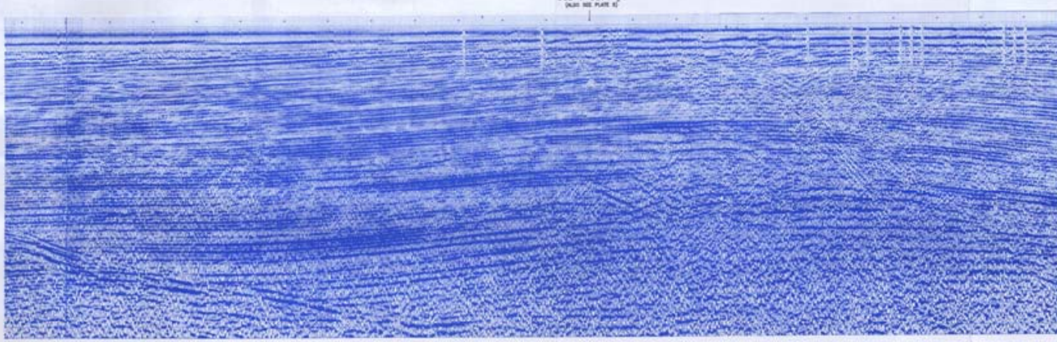
0 1 2
feet
(thousands)

NEITHER THE PRODELTA SEISMIC SEQUENCE BOUNDARY NOR THE ACOUSTIC BASEMENT BOUNDARY CAN BE SEISMICALLY CORRELATED BETWEEN PLATE 18 AND PLATE 19.

PALYNOLOGICAL STRATIGRAPHIC TOPS FROM BUJAK DAVIES GROUP

CORRELATION STUDY OF SELECTED EXPLORATION WELLS FROM THE NORTH SLOPE AND BEAUFORT SEA, ALASKA

Y-0871 No. 1
CORRELATED TO SEISMIC DATA



COVER

The Y-0334 Mukluk No. 1 well tested a large, Prudhoe Bay-type structure in Harrison Bay. In early 1984, Sohio and its drilling partners announced that the Mukluk well was a dry hole after spending over $140 million on drilling. Various oil companies paid $1.207 billion for leases on just seven of the tracts over the Mukluk structure.

OCS Report
MMS 91-0076

Correlation Study of Selected Exploration Wells from the North Slope and Beaufort Sea, Alaska

By James Scherr, Susan M. Banet, and Barbara J. Bascle

ACKNOWLEDGMENTS

The authors wish to thank various staff members: Don Nelson and Devon Peterson for their excellent work on the graphics, Irene Reeder for the fine job she did on the text, and our esteemed editor Jody Lindemann. We appreciate the many helpful suggestions and comments received from technical reviewers Arthur Banet, Kirk Sherwood, and James Craig.

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ABSTRACT

Previous correlation studies of North Slope geology mainly use outcrop data and onshore well data. This study uses data from 10 wells located in Federal Outer Continental Shelf (OCS) Beaufort Sea waters and 18 coastal wells to extend the geologic correlations to the offshore Beaufort Sea. Six geologic cross sections illustrate the stratigraphic correlations of the 28 wells. Paleontological age data for nine of these wells also appear on the cross sections. Seismic lines are tied to borehole logs from 27 of the 28 wells to illustrate the structural and stratigraphic complexity of the offshore Beaufort Shelf.

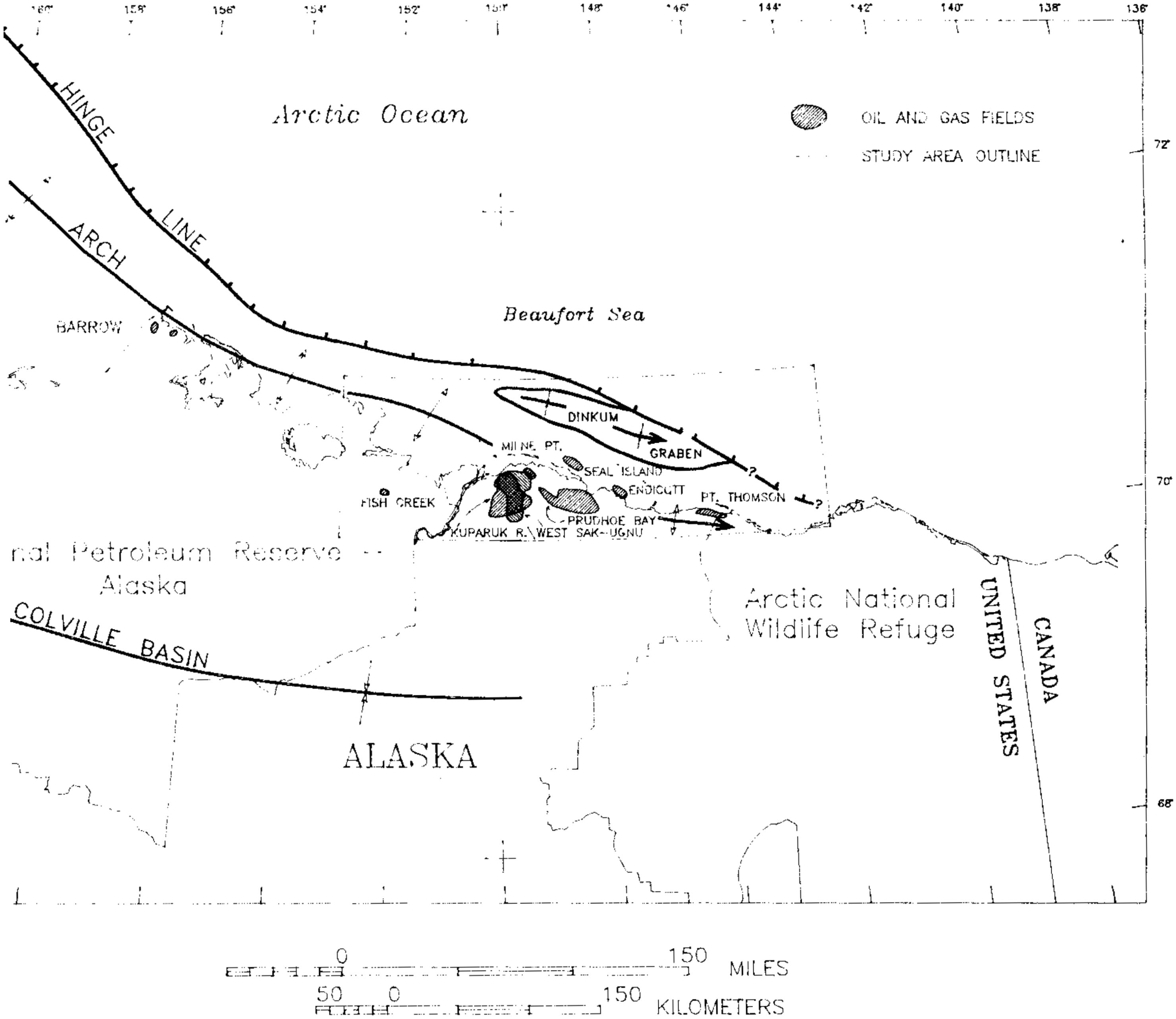
We divide the stratigraphy of the North Slope into four different tectonic sequences—basement complex, Ellesmerian, Beaufortian, and Brookian. The basement complex rocks, Devonian in age and older, represent the acoustic and economic basement throughout the area. The Ellesmerian sequence includes the northerly derived clastic sediments and carbonates of Late Devonian to Triassic age deposited on the stable Arctic Platform. The Beaufortian sequence records the transition from a northern to southern sediment source which occurred during rifting of the continental margin from Early Jurassic to middle Cretaceous time. The southerly derived sediments deposited from the Early Cretaceous to the present make up the Brookian sequence.

We recognize six seismic stratigraphic sequences—acoustic basement, Ellesmerian, Beaufortian, Prodelta, Colville/Nanushuk, and Sagavanirktok. The acoustic basement seismic sequence corresponds to the basement complex. The Ellesmerian and Beaufortian seismic sequences relate directly to the tectonic sequences of the same names. The Brookian sequence contains three distinct seismic units—Prodelta, Colville/Nanushuk, and Sagavanirktok.

INTRODUCTION

This study presents an integrated geological and geophysical interpretation of the North Slope of Alaska and adjoining Beaufort Sea. The study area covers a 155 mile-long strip along the coast of the North Slope, Alaska, from longitude 144° 45' W. to 153° 00' W. (Figure 1). Various correlation studies exist for the onshore and nearshore areas of the North Slope (Molenaar, Bird, and Collett, 1986; Bird and Molenaar, 1987; and the Alaska Geological Society, 1971, 1973, 1977, and 1981). We correlate data from selected wells used in these previous publications with unpublished, publicly released State of Alaska and Federal well data. In addition, seismic sequences identified offshore are integrated with the general stratigraphy of the onshore North Slope area.

Publicly available well logs, in addition to selected common-depth-point (CDP) seismic lines, illustrate the interpretation. The borehole logs are from wells drilled in the National Petroleum Reserve in Alaska (NPRA), the State of Alaska's waters and lands, and the Federal Outer Continental Shelf (OCS). The seismic data come from several geophysical contractors who granted us permission to publish these CDP seismic lines. Plate 1 shows the location of wells and seismic data used.



Arctic Ocean
OIL AND GAS FIELDS
STUDY AREA OUTLINE
HINGE LINE
ARCH
Beaufort Sea
BARROW
DINKUM GRABEN
MILNE PT.
SEAL ISLAND
ENDICOTT
PT. THOMSON
FISH CREEK
PRUDHOE BAY
KUPARUK R.
WEST SAK--UGNU
nal Petroleum Reserve
Alaska
COLVILLE BASIN
ALASKA
Arctic National
Wildlife Refuge
UNITED STATES
CANADA
72°
70°
68°
0 150 MILES
50 0 150 KILOMETERS

1. DATABASE

Ten of the 28 wells used in the study are in Federal OCS Beaufort Sea waters. These 10 wells represent the locations drilled and completed in the Beaufort Federal OCS prior to January 1987. Three wells are located in NPRA. The remaining 15 wells were drilled in areas regulated by the State of Alaska. Table 1 is a list of the 28 wells.

The principle factors used to select the non-OCS wells include the existence of geophysical borehole logs which start near the surface and preferably end in basement; the use of the well in a published correlation study; and the availability of seismic lines connecting the well with OCS wells.

The Minerals Management Service (MMS) possesses a large database of proprietary seismic CDP data for the North Slope and the Beaufort Sea. To illustrate the seismic stratigraphy from onshore to offshore, we selected approximately 142 line-miles of this data to tie to 27 of the wells. The seismic data are unmigrated and gathered at different stacking folds.

The selection of the seismic lines was based on four factors: (1) nearness of the seismic line to the well being tied, (2) orientation of the seismic line along the structural dip of the strata, (3) location of more than one well near the line, and (4) permission from the contractor to publish the line.

In addition to well and seismic data, nonproprietary, stratigraphic age data are available for nine of the wells. These data come from palynology and micropaleontology studies done by two companies for MMS. The Bujak Davies Group provided the geologic ages shown on

TABLE 1 List of wells used in study

WELL NAME STATE WELLS	OPERATOR	TVSS' DEPTH IN FEET	LATITUDE	LONGITUDE	CROSS SECTION PLATES	SEISMIC PLATES
ALASKA ISLAND No. 1	SOHIO	13,049	70°13'47"	146°29'57"	5	17
ALASKA STATE A-1	EXXON	14,165	70°11'21"	146°00'42"	5	18
ALASKA STATE D-1	EXXON	13,012	70°12'09"	146°12'26"	5	18
ALASKA STATE F-1	EXXON	13,131	70°13'38"	146°21'34"	5	17
BEAUFORT SEA BLOCK 54 No. 1	GULF	14,492	70°29'31"	147°58'54"	4	14
CHALLENGE ISLAND No. 1	SOHIO	13,060	70°14'09"	146°37'01"	5	17
COLVILLE DELTA STATE No. 1	GULF	9,277	70°29'41"	150°35'12"	7	
EAST MIKKELSEN BAY STATE No. 1	HUMBLE OIL	15,192	70°09'07"	146°54'10"	8	17
JEANETTE ISLAND No. 1	CHEVRON	12,306	70°21'47"	147°25'04"	4,5,8	15
NECHELIK No. 1	SOHIO	9,974	70°23'36"	150°58'44"	7	11
NO NAME ISLAND No. 1	AMOCO	11,320	70°27'39"	147°56'09"	4	14
NORTHSTAR No. 1	AMERADA HESS	11,762	70°31'42"	148°51'21"	4	13
REINDEER ISLAND	SOHIO	13,617	70°29'05"	148°21'34"	4	13
SEAL ISLAND BF-47 No. 1	SHELL	12,405	70°29'31"	148°41'34"	4	13
WEST MIKKELSEN UNIT No. 4	SHELL	13,014	70°13'04"	147°20'45"	8	16
OCS FEDERAL WELLS						
Y-0191 BEECHEY POINT No. 1	EXXON	11,593	70°23'12"	147°53'28"	4	15
Y-0196 TERN ISLAND No. A2	SHELL	11,872	70°16'47"	147°29'45"	4,8	16
Y-0280 ANTARES No. 1	EXXON	8,372	71°02'10"	152°43'25"	3	9
Y-0302 MARS No. 1	AMOCO	7,932	70°50'35"	152°04'18"	3,6	11
Y-0334 MUKLUK No. 1	SOHIO	9,800	70°41'00"	150°55'10"	3	12
Y-0338 PHOENIX No. 1	TENNECO	9,755	70°43'01"	150°25'40"	3,7	12
Y-0370 SANDPIPER No. 1	SHELL	11,759	70°35'05"	149°05'48"	3,4	12
Y-0804 ORION No. 1	EXXON	7,221	70°57'22"	152°03'46"	3,6	9
Y-0849 HAMMERHEAD No. 1	UNION	7,995	70°21'53"	146°01'27"	5	18
Y-0871 CORONA No. 1	SHELL	9,962	70°18'53"	144°45'32"	5	19
NPRA WELLS						

- Alaska State A-1 (Plate 5)
- Y-0280 Antares No. 1 (Plate 3)
- Y-0871 Corona No. 1 (Plate 5)
- East Mikkelsen Bay State No. 1 (Plate 8)
- Y-0849 Hammerhead No. 1 (Plate 5)
- Y-0302 Mars No. 1 (Plates 3 and 6)
- Y-0334 Mukluk No. 1 (Plate 3)
- Northstar No. 1 (Plate 4)

Palynological data interpreted by Palnex Canada provide the geologic ages for the interval from 8,500 to 9,900 feet in the Y-0370 Sandpiper No. 1 well (Plates 3 and 4).

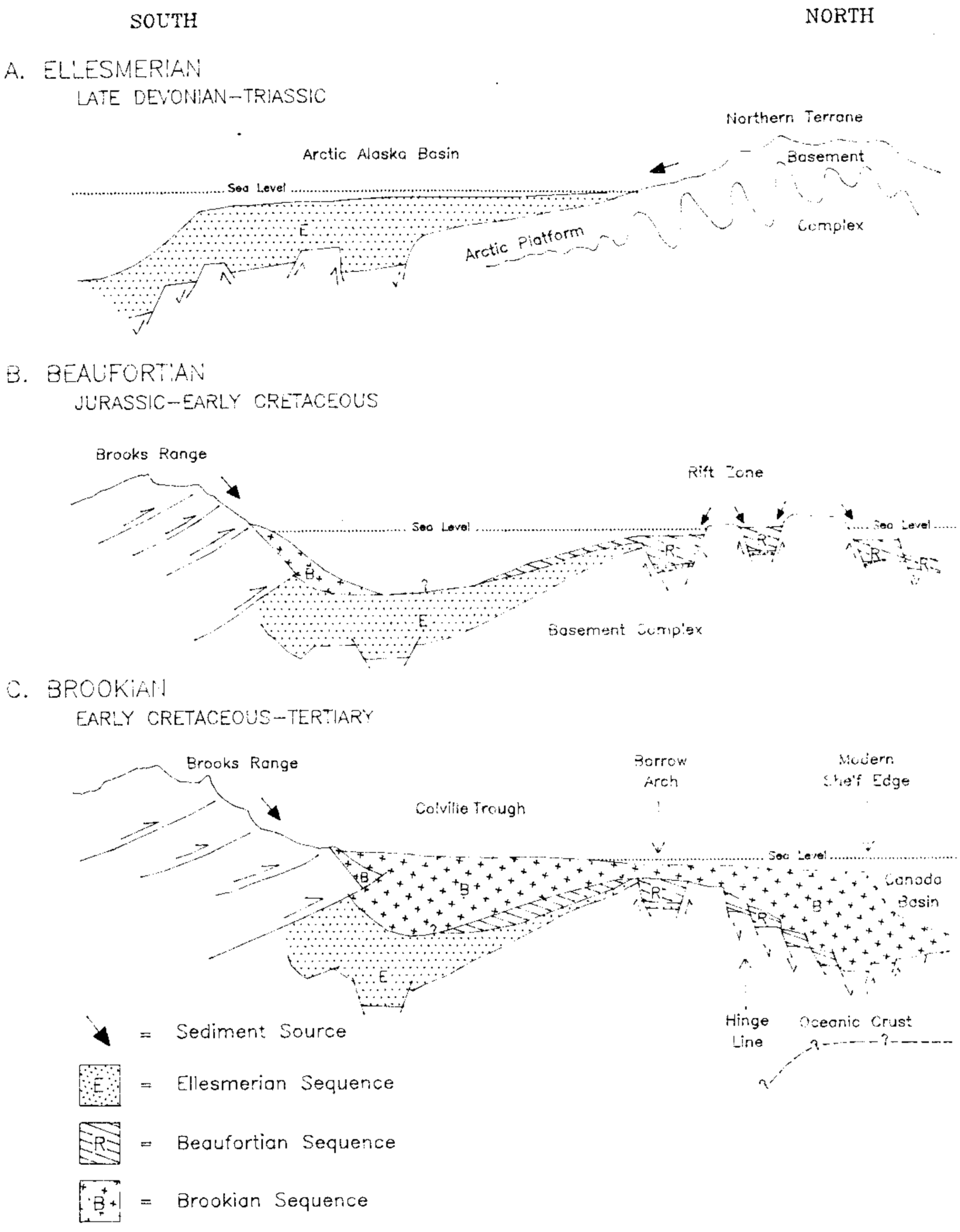
2. BASIN DEVELOPMENT

The Ellesmerian orogeny of Late Silurian to Early Mississippian time deformed and mildly metamorphosed Precambrian and early Paleozoic sedimentary rocks that compose the present-day basement complex (Grantz, May, and Hart, 1990). Carbonates and northerly sourced clastics were deposited during Early Mississippian through Triassic time across a southward-sloping stable shelf, known today as the Arctic Platform. These shelf sediments lie unconformably on the basement complex rocks (Figure 2, part A).

During Jurassic time, two major tectonic events occurred that affect North Slope geology (Figure 2, part B). Rifting of the northern part of the Arctic Platform began in Early Jurassic time (Grantz and May, 1983). In Late Jurassic time, uplift and deformation in the region of the present central southern Brooks Range began as a result of the initial stages of subduction of the North American plate beneath the intraoceanic Koyukuk arc (Box and Patton, 1987).

The present continental margin of northern Alaska formed as an extensional feature similar to an Atlantic-type, or passive, margin (Grantz and May, 1983). Extensional structures resembling those associated with Atlantic-type margins occur beneath the Alaskan Beaufort Shelf.

Grantz and May (1983) compare the Beaufort Shelf with typical rifted margins as defined by Falvey (1974). Falvey postulates two cycles of uplift, erosion, and subsidence in his model. Formation of a rift-valley system culminates the first cycle of uplift. The Dinkum Graben (Figure 1) formed as a rift valley during this first cycle of uplift and extension.


SOUTH
NORTH
A. ELLESMERIAN
LATE DEVONIAN–TRIASSIC
Northern Terrane
Arctic Alaska Basin
Basement
Sea Level
Complex
Arctic Platform
E
B. BEAUFORTIAN
JURASSIC–EARLY CRETACEOUS
Brooks Range
Rift Zone
Sea Level
Sea Level
R
B
E
Basement Complex
C. BROOKIAN
EARLY CRETACEOUS–TERTIARY
Brooks Range
Barrow Arch
Modern Shelf Edge
Colville Trough
Sea Level
Canada Basin
B
R
E
Hinge Line
Oceanic Crust
= Sediment Source
E = Ellesmerian Sequence
R = Beaufortian Sequence
B = Brookian Sequence

Uplift and erosion during the rifting cycles occurred in pulses at different locations over time. Sediments eroded from these uplifted areas collected in adjacent low areas, such as downdropped fault blocks or grabens. The sediments filling much of the Dinkum Graben are probably pre-Hauterivian and mainly northerly sourced (Grantz and May, 1983).

Rifting and onset of the Brookian orogeny formed at least three major tectonic features of the North Slope: the Hinge Line, the Barrow Arch, and the Colville Basin (Figure 1 and Figure 2, part C). The Hinge Line marks the point at which the seaward slope of the basement surface increases markedly into the Canada Basin (Grantz and May, 1983). The Hinge Line often appears on seismic data as a zone of down-to-the-north normal faults (Plate 14).

The Barrow Arch is a broad structural high trending along the Arctic coast of Alaska (Figure 1). A combination of various geologic events, rather than a single episode of upwarping or folding, created the arch during Jurassic and Cretaceous time (Grantz, May, and Hart, 1990). The northern flank of the arch formed from postrift subsidence of the northern part of the Arctic Platform in middle Cretaceous time. The southerly dipping Arctic Platform forms the south flank of the arch.

Tectonic loading by Late Jurassic and Cretaceous sediments and nappes in the ancestral Brooks Range on the southern Arctic Platform tilted the Platform southward, creating the Colville Basin (Figures 1 and 2). Clastic sediments eroded from the Brooks Range filled the Colville Basin and overtopped the Barrow Arch by middle Albian time (Grantz and May, 1983). The Brookian clastic wedge prograded northward and eastward from Late Cretaceous through Tertiary time, filling the basins formed by postrift subsidence on the north side of the Barrow Arch (Figure 2, part C).

3. STRATIGRAPHY

The basement complex is an informal and simplistic term used for all subsurface rocks older than the Endicott Group (Bird, 1988). The basement complex ranges in age from Precambrian to Devonian. Some authors (e.g., Lerand, 1973; Hubbard, Edrich, and Rattey, 1987) refer to the basement complex as the Franklinian. The basement complex rocks represent the acoustic and economic basement throughout the North Slope.

Bird and Molenaar (1987) describe the basement complex as including at least 40 different rock units. The rock units vary from slightly metamorphosed sedimentary rocks to metamorphic rocks, to local volcanic and intrusive igneous rocks. On Plates 3 through 8, the basement complex is divided into two general lithologic groups. The lithology of the first group, metamorphosed sedimentary rocks, includes:

- argillite
- schist
- phyllite
- volcanogenic sediments
- quartzites
- graptolitic shales
- cherts

The second group—interbedded, metamorphosed carbonate and clastic sedimentary rocks—includes the following lithologies (Banet, 1990):

- limestone
- dolostone
- argillite
- shale

The East Teshekpuk No. 1 well encountered granite below the Mississippian rocks (Plate 6). The granite yields radiometric ages of 332 Ma from K-feldspar and 243 Ma from biotite (Bird et al., 1978). The 332 Ma is considered a minimal age from the slightly altered feldspar. Banet (1990) suggests that the age is closer to the age of the granites in the Brooks Range in the Arctic National Wildlife Refuge (maximum age of 430 Ma).

Hubbard, Edrich, and Rattey (1987) separate the sediments above the basement complex of northern Alaska into three tectonic sequences—Ellesmerian, Beaufortian, and Brookian. Each sequence represents a complete cycle of basin development. This study uses a modified version of these sequences for correlation purposes (Plate 2).

The base of the Endicott Group and the disconformity at the top of the Sag River Formation define the bottom and top of the Ellesmerian sequence, respectively. The sequence includes the carbonates and clastics deposited on the southward-sloping, stable Arctic Platform prior to the onset of rifting in the Early Jurassic.

Endicott strata (Lower to middle Mississippian) represent a regressive-transgressive cycle. Deposition began with swamp, braided-stream, floodplain and fluvial environment sediments, grading upward into intertidal and shallow marine sediments (Woidneck et al., 1987). The transgressive cycle culminates with deposition of the shallow marine carbonates in the Lisburne Group (Mississippian to Early Permian) along with minor amounts of shale and sand.

Uplift and partial erosion of the Lisburne Group followed in Early Permian time. Deposits of the Sadlerochit Group include shallow marine, fluvial, floodplain, alluvial fan, and point-bar sediments. This transgressive-regressive cycle occurred from middle Permian to Late Triassic time (Hubbard, Edrich, and Rattey, 1987).

The Shublik and Sag River Formations (Triassic) record a final Ellesmerian transgressive-regressive cycle. The rocks of the Shublik are shallow marine carbonates and shales, commonly rich in organic matter. The Sag River Formation is a glauconitic, commonly bioturbated sandstone deposited in a nearshore environment (Hubbard, Edrich, and Rattey, 1987).

between the Beaufortian and Brookian sequences. The LCU is usually discernible on both well logs and seismic data throughout the study area. When locally sourced sandstones, such as the Point Thomson Sandstone, Put River Sandstones, and their equivalents, lie on top of the LCU, we place the top of the Beaufortian sequence at the top of these sandstones (Plate 2).

The Beaufortian sequence records the transition from a northern to southern sediment source which occurred from Early Jurassic to middle Cretaceous time. The northerly derived Kingak Shale and Miluveach Formation consist largely of silts and shales deposited across a marine shelf (Hubbard, Edrich, and Rattey, 1987). Local regressive cycles are represented by the Barrow and Simpson Sands.

Deposition of the upper Beaufortian sequence was strongly controlled by rifting. Erosion of Ellesmerian and some of the basement complex rocks occurred along the rift margin uplift. Coarse-grained sediments, such as the marine Kuparuk Sandstone and the fluvial Put River and Point Thomson Sandstones (Hubbard, Edrich, and Rattey, 1987), accumulated in nearby topographic lows.

The Brookian sequence includes the series of southerly derived, deltaic sediments deposited from Early Cretaceous to the present time. The depocenter for each delta shifted from west to east through time. Paleontological data on Plates 3, 4, and 5 illustrate the decreasing age of the Brookian to the east. The formalized Brookian terminology, developed mainly from outcrop data (Lerand, 1973), does not apply well to the offshore Brookian strata. The onshore Brookian strata are mostly nonmarine to shallow-marine facies in the southern and western North Slope. Along the coast and offshore, distal delta facies make up a greater part of the Brookian strata in the subsurface. Thus, existing stratigraphic nomenclature needs to be redefined for the offshore strata. Our solutions to problems we encountered with Brookian terminology are explained below.

Usage of the term Pebble Shale is the first problem we encountered. Previous reports refer to part or all of this informally named unit as follows:

- the Hue Shale (Bird and Molenaar, 1987; Molenaar, Bird, and Kirk, 1987; Molenaar, Bird, and Collett, 1986)
- the Highly Radioactive Zone (HRZ) (Hubbard, Edrich, and Rattey,

- the Pebble Shale (Craig, Sherwood, and Johnson, 1985; Hubbard, Edrich, and Rattey, 1987; Molenaar, 1981, 1983; Molenaar, Bird, and Kirk, 1987; Bird and Molenaar, 1987; Carman and Hardwick, 1983; Bird, 1985; Noonan, 1987)

Definitions for these various unit names seem to depend on the area studied and the authors' view of the lithology and the source of sedimentation.

We chose to use the HRZ because it allows consistent correlations to be made in the wells examined. The definition for the HRZ as used in this study is the first prominent increase in gamma-ray log values above the LCU. We do not use the Pebble Shale or Hue Shale (as defined in the references listed above) for correlation purposes in this report because neither of them appear different from younger Brookian or older Beaufortian shales on the borehole logs or on the seismic lines.

The HRZ consists of relatively thin sections of organic-rich, radioactive shales that range in age from Hauterivian to early Coniacian (Plates 3 and 4). These shales represent a series of condensed-section, distal facies that accumulated during different cycles of deposition (Carman and Hardwick, 1983; Hubbard, Edrich, and Rattey, 1987; Mickey and Haga, 1987; Molenaar, Bird, and Kirk, 1987; Grantz, May, and Hart, 1990). Portions of the HRZ that are older than Aptian age probably represent deposition in a starved basin (low sedimentation rates) prior to the influx of Brookian deltaic sediments from the Colville Basin. The transgressive age of the HRZ from west to east corresponds to the progradation of the Brookian deltaic lobes. Therefore, the HRZ of Aptian to Coniacian age consists of distal basin facies associated with the prograding prodelta shale facies.

The next terminology problem is defining the different prodelta shales. The Torok Formation is lithologically recognizable only west of the Colville River delta where it lies between the HRZ and the sands of the Nanushuk. When the Nanushuk sands lap out near the Colville River delta, the Torok Formation can no longer be lithologically distinguished from the shale of the Colville Group or the Canning Formation. However, paleontological age data on Plate 3 clearly show the age difference between the older Torok Formation shales in the Y-0302 No. 1 well and the middle Cretaceous prodelta shales in the Y-0334

For the other prodelta shales we propose a stratigraphic cutoff, following guidelines proposed by Krumbein and Sloss (1963, p. 350), at the Nanushuk Group pinch-out. At the cutoff, the shale of the Colville Group changes to the Canning Formation (Plates 2, 3, and 7).

No clear lithologic break separates the Colville Group and the Sagavanirktok Formation in many of the wells. Molenaar (1983) suggests the two sequences may be part of the same deltaic sequence and, therefore, not divisible into distinct formations. For these reasons, we extend the stratigraphic cutoff to the surface near the Colville River delta. West of the cutoff is the undifferentiated Sagavanirktok Formation and Colville Group; east of the cutoff is the Sagavanirktok Formation (Plates 2, 3, and 7).

The Gubik Formation, a deposit of unconsolidated sediments only a few hundred feet thick (Bird, 1982), is the surface formation along most of the coast. However, it cannot be distinguished on either the borehole logs or the seismic lines. Therefore, we combine the Gubik Formation with the Sagavanirktok Formation. We define the top of the Sagavanirktok Formation as either the ground level or the seafloor on borehole logs or seismic lines.

4. WELL LOG CORRELATION CROSS SECTIONS

The wells shown on the cross sections (Plates 3 through 8) tie with wells used in previous correlation studies. Wells correlated by Molenaar, Bird, and Collett (1986) include:

- Alaska State A-1
- Alaska State D-1
- Colville Delta State No. 1
- East Mikkelsen Bay State No. 1
- East Teshekpuk No. 1
- Nechelik No. 1

The wells correlated by Tailleur and Weimer (1987) include:

- Alaska State A-1
- Alaska State D-1
- East Mikkelsen Bay State No. 1

Each geologic formation or group shown on the cross sections has distinctive characteristics allowing correlation across the North Slope. The correlations were determined by examining borehole geophysical logs, core reports, mud logs, paleontological reports, and CDP seismic lines. Plate 2 shows the stratigraphic relationships of the correlations.

Basement Complex

The basement complex is composed of pre-Mississippian rocks (Plate 2) of varying depositional environments and lithologies. The top of basement is an unconformity of varying age. The ages of three of these erosional events are pre-Mississippian, Permian, and Lower Cretaceous. The basement complex is characterized by:

- lithologies varying from

- one of the above lithologies on the mud logs but no consistent response on the geophysical logs
- locally steep dips

Ellesmerian Sequence

The Ellesmerian sequence consists of Upper Mississippian to Triassic age sediments deposited from a northerly source. The lithology varies from carbonates of the Lisburne Group and Shublik Formation to the sandstones and shales of the Endicott Group, Sadlerochit Group, and Sag River Formation (Plate 2). The thickness of the Ellesmerian deposits was affected by several erosional events and depositional hiatuses. Ellesmerian rock is missing in the wells located either on the crest of the Barrow Arch or northeast of the arch (Plates 3, 4, 5, 6, and 8).

Endicott Group

The Endicott Group is the basal unit of the Ellesmerian sequence along the Barrow Arch. It is composed of nonmarine sediments and coals overlain by a marine shale (Bird and Molenaar, 1987). The Endicott Group is characterized by:

- interbedded conglomerates, sandstones, thin coals, and shales
- a wide range of response on borehole logs (Plate 4) due to the varied lithology
- a thickness ranging from 130 to 1,600 feet where present (Plate 8)

Lisburne Group

The Lisburne Group represents a period of marine transgression when a diverse assortment of transgressive and platform carbonate facies were deposited (Armstrong and Bird, 1976). The Lisburne Group is characterized by:

- a regionally continuous, massive limestone with some dolomite and minor amounts of sand and shale
- low gamma-ray values and high resistivity values on the borehole logs (Plate 6)

Sadlerochit Group

The Sadlerochit Group grades upward from marine sands to marine shales to an alluvial fan–delta deposit. The fluvial sands of the fan–delta complex (Ivishak Formation) constitute the primary hydrocarbon reservoir on the North Slope. The Sadlerochit Group is characterized by:

- an unconformity at the base of the Sadlerochit (Atkinson, Trumbly, and Kremer, 1988)
- fine-grained sands grading upward into a shale which is overlain by a coarsening-upward complex of silts, sands, and conglomerates
- a sharp break on the borehole logs at the top of the group where it passes into the overlying Shublik Formation or the LCU
- a serrated pattern on the gamma-ray log in the lower shaly section and a blocky pattern on the gamma-ray log in the upper alluvial fan–delta clastic section
- a thickness ranging from 116 to 1,080 feet where present (Plate 7)

Shublik Formation

The transgressive marine sediments of the Shublik Formation were deposited in a shelf or shelf–slope environment (Parrish, 1987). These deposits include fossiliferous limestone, mudstone, and calcareous siltstone. The Shublik Formation is characterized by:

- moderately high gamma-ray values and a prominent kick on the resistivity logs, indicative of carbonate-rich sediments (Plate 4)
- a sharp break on the well logs at the base of the formation where it passes into the underlying Sadlerochit Group
- a thickness ranging from 58 to 457 feet (Plate 3)

Sag River Formation

The Sag River Formation, the youngest rock in the Ellesmerian sequence, is a fine-grained, shaly, bioturbated, glauconitic sandstone that was deposited in a low-energy marine environment (Barnes, 1987). On the borehole logs, the Sag River Formation shows the following characteristics (Plate 6):

- a gamma-ray signature typical of shaly sandstones

Beaufortian Sequence

The Beaufortian sequence consists of thick marine shales, such as the Kingak and Miluveach Formations, and relatively thin sands, such as the Simpson and Barrow Sand members of the Kingak, the Kuparuk Formation, and the Point Thomson and Put River Sandstones (Plate 2). The Point Thomson Sandstone, a member of the Beaufortian sequence, is described separately on the cross sections. The Beaufortian sequence appears on the borehole logs as:

- relatively featureless on both the gamma-ray and resistivity logs owing to the predominance of shale
- ranging in thickness from 15 to 2,050 feet where present (Plate 4)

Point Thomson Sandstone

The Point Thomson Sandstone is a marine sand eroded from nearby uplands during the LCU erosional event. It is rich in carbonate lithic fragments locally derived from rocks of the basement complex. This sandstone may be correlative to the Put River Sandstone (Gautier, 1987). The Point Thomson Sandstone is characterized by:

- low gamma-ray values and high resistivity measurements on the well logs
- a thickness ranging from 0 to 47 feet in this study, but much thicker onshore (Plate 5)

Brookian Sequence

The lower part of the Brookian sequence consists of the condensed shales of the HRZ and the thick, prodelta shales of the Torok Formation, the shale of the Colville Group, and the Canning Formation. These shales grade southward and upward into age-equivalent, deltaic sandstones—the Nanushuk Group, the Colville Group, and Sagavanirktok Formation, respectively (Plate 2). These sediments span the time from the Lower Cretaceous to the Pliocene.

Highly Radioactive Zone (HRZ)

Jeanette Island No. 1, the HRZ is missing because of either nondeposition or erosion (Plate 5). The shale has a distinctive high gamma-ray-log reading, except in the Sandpiper and Northstar No. 1 wells (Plate 4), where palynology tops help confirm the gamma-ray-log pick. The HRZ has the following characteristics:

- high gamma-ray-log reading due to uranium and thorium concentrated in the organics (Carman and Hardwick, 1983)
- a thickness ranging from 30 to 990 feet where present (Plate 4)

Torok Formation

The Torok Formation is a thick, prodelta shale which grades into the overlying Nanushuk Group. The Torok laps out near the Colville River delta (Plate 3). The Torok Formation is characterized by:

- a relatively featureless response on the gamma-ray and resistivity logs
- a thickness ranging from 0 to 3,600 feet (Plate 6)

Nanushuk Group

The Nanushuk Group is a shallow marine to nonmarine deltaic sequence of sandstone and siltstone which grades into the underlying Torok Formation (Molenaar, 1983). The Nanushuk pinches out in the Colville River delta area (Plate 3). The Nanushuk Group is characterized by:

- interbedded sands and thin shales which form a serrated pattern on the gamma-ray log
- a thickness ranging from 0 to 1,300 feet (Plate 6)

Colville Group

The Colville Group represents a major regressive sequence above the Nanushuk Group. The Colville Group consists of prodelta shales grading upward into marine sandstones. The top of the Colville Group is not readily distinguishable lithologically from the base of the Sagavanirktok Formation. Therefore, west of the Colville River delta, we refer to the

- in the lower section, a featureless gamma-ray signal representing prodelta shales when present
- in the upper section, a serrated pattern on the gamma-ray and resistivity logs representing interbedded sandstones and shales (Plates 6 and 7)
- for the Undifferentiated Colville and Sagavanirktok, a thickness ranging from 1,912 to 3,971 feet

Canning Formation

The Canning Formation consists of prodelta shales which grade upward into the Sagavanirktok Formation. We use a stratigraphic cutoff based on the pinch-out of the Nanushuk to differentiate between the shale of the Colville Group and the Canning Formation (Plates 2, 3, and 7). The Canning Formation is characterized by:

- featureless gamma-ray and resistivity curves
- a thickness ranging from 1,800 to 7,000 feet (Plate 5)

Sagavanirktok Formation

The Sagavanirktok Formation is a shallow marine to nonmarine sequence of interbedded sandstones and shales (Plate 2). In this study we have included the younger, unconsolidated Gubik Formation in the Sagavanirktok because the Gubik is not recognizable on either the well logs or the seismic data. The Sagavanirktok is characterized by:

- a serrated pattern on both the gamma-ray and resistivity logs
- a thickness ranging from 4,720 to 8,058 feet east of the Colville River delta (Plate 4)

Permafrost

The borehole logs for some of the wells on Plates 3 through 8 show evidence of permafrost. In other wells, either logs were not run in the section where the permafrost might occur or the permafrost is absent. Plate 8 shows the permafrost thinning markedly seaward. Using the borehole log responses described in Scott et al. (1986), permafrost in the study area is characterized by:

- a high resistivity on the resistivity logs (Plate 4)

5. SEISMIC CORRELATIONS

Twenty-four CDP seismic reflection lines are presented in Plates 9 through 19. These lines are tied to 27 of the 28 wells shown in the geologic cross sections (Plates 3 to 8) in order to illustrate structural and stratigraphic relations near the wells. (Plate 1 shows the seismic line and well locations.)

Tying geophysical borehole logs to seismic lines involves a number of steps. A time-depth function is calculated for each well using the sonic logs and borehole velocity surveys. This function then is used to scale the borehole log to match the time scale on the seismic line. Synthetic seismograms are made for each well from the edited sonic log. The character of the synthetic seismogram, regional seismic correlations, and the borehole log correlations help specify each seismic boundary.

Using proprietary CDP data, the seismic lines are correlated between each well, though the intervening seismic lines used for these correlations are not shown in this report. The seismic sequence boundaries in this study, from deepest to shallowest, are:

- top of acoustic basement
- top of Ellesmerian
- top of Beaufortian
- top of Prodelta
- top of Colville/Nanushuk
- surface of seafloor/top of Sagavanirktok

These boundaries are used to define the seismic sequences described below. The stratigraphic chart, Plate 2, shows the relation of the seismic sequences to the geologic formations on the cross sections. The seismic stratigraphy terminology used follows Mitchum (1977)

Acoustic Basement

The top–of–acoustic–basement seismic boundary is coincident with the top of the basement complex and is delineated by unconformities of different ages. Bright reflectors can be seen below the top of acoustic basement (Plate 9) but cannot be mapped regionally. The top-of-acoustic-basement seismic boundary is:

- the deepest regional seismic reflector
- a bright reflector below which no regionally continuous reflectors occur
- downdropped to the north by normal faults (Plate 14)
- locally, a demonstrable angular unconformity (Plate 17)

Ellesmerian Seismic Sequence

The Ellesmerian seismic sequence consists of rocks of the Endicott, Lisburne, and Sadlerochit Groups and the Shublik and Sag River Formations (Plate 2). The Ellesmerian seismic sequence has:

- the bright, acoustic-basement seismic boundary at the base
- either a low-angle angular unconformity or a bright coherent reflector at the top
- concordant, bright internal reflectors representing the major geologic groups and formations within the sequence
- up to 0.5 seconds (3,200 feet) of section

Examples of these features are shown on Plates 10, 11, 12, and 13.

Beaufortian Seismic Sequence

The Beaufortian seismic sequence consists of the marine shales and minor sands of the Kingak and Miluveach Formations and the sands of the Kuparuk Formation. Characteristics of the Beaufortian seismic sequence include:

- at the base, either an angular unconformity (Plate 13), the bright coherent reflector of the Ellesmerian seismic boundary, or the acoustic-basement seismic boundary
- at the top, a bright regional reflector usually representing the HRZ (Plate 12) or a low-angle angular unconformity that is usually the LCU (Plate 10)

Prodelta Seismic Sequence

The Prodelta seismic sequence represents three time-transgressive prodelta shales—the Torok Formation, the shale of the Colville Group, and the Canning Formation.

The palynological ages on Plates 5, 18, and 19 suggest that rocks of similar age as those in the Prodelta seismic sequence probably extend at least as far east as Corona No. 1, but structural complexities prevent a confident seismic correlation between Hammerhead No. 1 and Corona No. 1.

The seismic stratigraphy of this sequence is characterized by:

- downlapping reflectors at the base (Plate 12)
- toplap reflectors against the overlying Colville/Nanushuk or Sagavanirktok seismic sequence (Plate 9), or the boundary between the discontinuous, indistinct seismic signature of the prodelta shales and the bright, continuous reflectors of the deltaic sands
- discordant and tangential oblique internal reflectors (Plate 10)
- up to 1.35 seconds (7,200 feet) of section (Plate 17)

Colville/Nanushuk Seismic Sequence

The Colville/Nanushuk seismic sequence consists of prograding deltaic sands and shales. The Colville/Nanushuk sequence pinches out eastward at its distal facies near the Colville River delta. On some seismic lines, the top of the Colville/Nanushuk seismic sequence boundary cannot be confidently interpreted because it is near the top of the seismic section (Plate 10). Age data must be used in some areas to help define the top of this seismic sequence because the sands and shales of the Colville Group and the Sagavanirktok Formation are indistinguishable on seismic data.

The Colville/Nanushuk seismic sequence has the following characteristics:

- the Prodelta seismic boundary at the base
- toplapping reflectors of the Colville/Nanushuk seismic sequence (Plate 11) and/or the Tertiary–Cretaceous boundary

Sagavanirktok Seismic Sequence

The Sagavanirktok seismic sequence consists of prograding deltaic sands and shales. As mentioned previously, in some areas age data from wells must be used to help define the boundary between the Colville/Nanushuk sequence and the Sagavanirktok seismic sequence (Table 2). The palynological tops on Plates 5, 18, and 19 suggest that rocks of similar age to those in the Sagavanirktok seismic sequence probably extend eastward to the Corona No. 1 well, but structural complexities prevent a confident seismic correlation between Hammerhead No. 1 and Corona No. 1.

The characteristics of the Sagavanirktok seismic sequence include:

- at the base, the Colville/Nanushuk seismic boundary west of the Colville delta and the Prodelta seismic boundary east of the Colville delta (Plate 12)
- at the top, the seafloor or land surface (Plate 11)
- bright, internally concordant reflectors (Plate 14)
- up to 2.1 seconds (8,400 feet) of section (Plate 16)

TABLE 2 TERTIARY-CRETACEOUS BOUNDARY
Based on palynological analysis from the Bujak Davies Group, Calgary, Alberta, Canada

WELL NAME and OCS NUMBER	DEPTH (FEET) (TVSS)[1]
Antares No. 1 Y-0280	1,100
Mars No. 1 Y-0302	1,300
Mukluk No. 1 Y-0334	2,450

[1]TVSS - True vertical

SUMMARY

The combination of well log data and seismic CDP data used in this study provides a graphic illustration of an extension of North Slope geology into the outer continental shelf. The report also demonstrates some of the attendant problems of nomenclature currently faced by workers in this area.

Our interpretation depicts four major tectonic sequences in northern Alaska—the basement complex with varied lithologies, the south-facing trailing-margin Ellesmerian, the rift-associated Beaufortian, and the northerly prograding Brookian. Each sequence represents different, internally complex, cycles of basin development and depositional geometries.

The first stratigraphic-nomenclature problem encountered in the study area is the delineation of the basal Brookian shales, a problem compounded by the Pebble Shale/HRZ/Hue Shale nomenclatural morass. A consistent correlation can be made in the wells by picking the top of the Pebble Shale/HRZ unit at the first prominent increase in gamma-ray log values above the LCU. We called the unit the HRZ. It is composed of a time-transgressive, condensed, distal-basin facies.

Several correlation problems exist in the Brookian sequence between the onshore and offshore stratigraphy. The onshore Brookian sequence, where the stratigraphic nomenclature was developed, consists mostly of nonmarine to shallow marine facies, interbedded with marine facies. This nomenclature does not apply well to the distal-delta facies encountered along the coast and offshore.

The main correlation problem is the identification or separation of the different prodelta shales. Paleontological age data are used to define the termination of the Torok Formation near the Colville River delta. However, we must use a stratigraphic cutoff, based on the pinch-out of the Nanushuk Group, to differentiate between the shale of the Colville

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