PETROLEUM EXPLORATION OF NPRA, 1974-1981

Final Report

VOLUME 3

PETROLEUM EXPLORATION

OF NPRA, 1974-1981

FINAL REPORT

VOLUME 3

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Tetra Tech Report No. 8200

March 31, 1982

Prepared for:
Husky Oil NPR Operations, Inc.
2525 "C" Street
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Prepared by:
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FIGURE 85

FIGURE 85

ISOPACH MAP, NANUSHUK GROUP

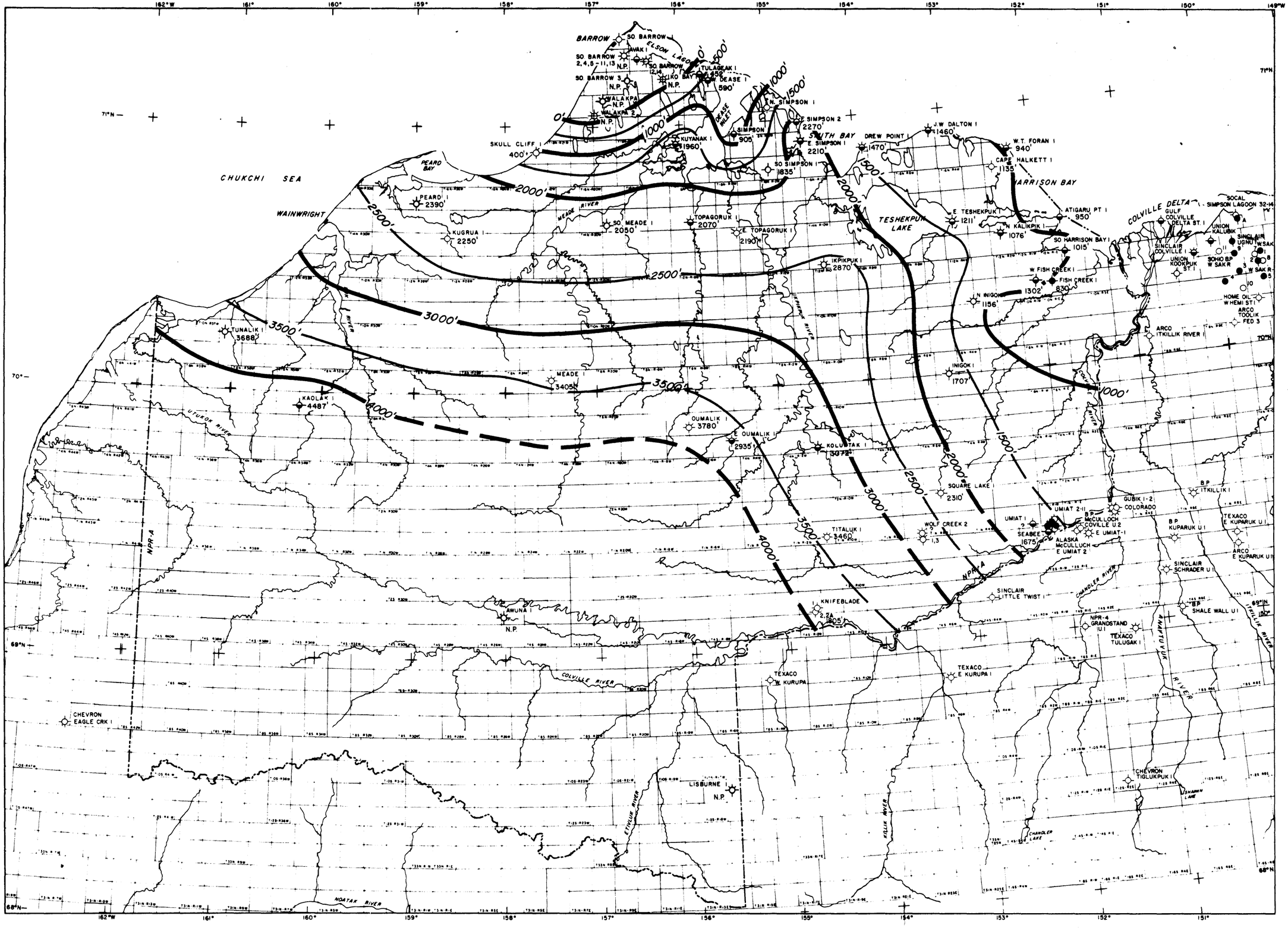
Well	Thickness Feet	Meters
Atigaru Point 1	950	290
Cape Halkett 1	1,135	346
J. W. Dalton 1	1,460	445
West Dease 1	590	180
Drew Point 1	1,470	448
Fish Creek 1	830	253
West Fish Creek 1	1,302	397
W. T. Foran 1	940	286
South Harrison Bay	1,015	309
Ikpikpuk 1	2,870	875
Inigok 1	1,707	518
North Inigok 1	1,156	352
North Kalikpik 1	1,076	328
Kaolak 1	4,487	1,368
*Knifeblade 1	1,805+	550
Koluktak 1	3,072	936
Kugrua 1	2,250	686
Kuyanak 1	1,960	597
*Meade 1	3,405+	1,038
South Meade 1	2,050	625
Oumalik 1	3,780	1,152
East Oumalik 1	2,935+	895
Peard 1	2,390	728
Seabee 1	1,675	510
*Skull Cliff	440+	135
Simpson 1	905	276
East Simpson 1	2,210	674
East Simpson 2	2,270	692
South Simpson 1	1,835	559
*Square Lake 1	2,310	704
East Teshekpuk 1	1,211	369
*Titaluk 1	3,460	1,055
Topagoruk 1	2,070	631
East Topagoruk 1	2,190+	668
Tunalik 1	3,688	1,124

*Taken from Molenaar (1981)

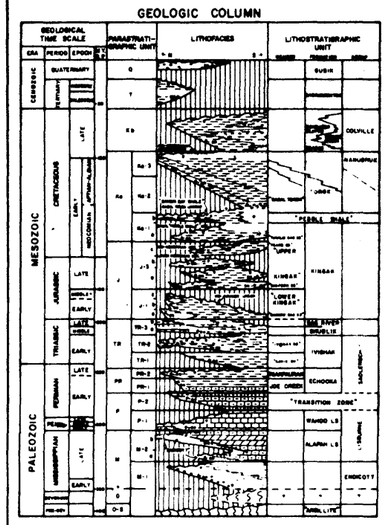
The Nanushuk Group is present at the surface in the southern NPRA at Awuna 1, Koluktak 1, and Seabee 1. In all other wells, where present, the Nanushuk Group is separated from the overlying Kb (Colville Group) unit by the mid-Cenomanian unconformity or lies directly below Quaternary surface beds.

Three criteria were used to determine the top of the Nanushuk Group: a lithologic boundary between the Nanushuk and overlying deposits, indicated by the presence of a distinct shoulder on electric, gamma-ray, and sonic logs; seismic horizon 0390, corresponding to the top of the Nanushuk, which was tied into the wells and related to log character; and the F-8 faunal zone, which, when present, corresponds to the upper part of the Nanushuk.

The base of the Nanushuk Group was delimited primarily on lithology and log character. The lower Nanushuk, a predominantly marine facies, is generally characterized on gamma-ray and sonic logs and to a lesser degree on electric logs by a series of stacked, serrated, funnel-shaped, coarsening upwards, log expressions. The base of the Nanushuk was placed at the base of the lowest of these log characters, thus marking the contact between the more sand-rich sediments of the marine Nanushuk facies and the more shale-rich sediments of the deeper marine facies of the Torok Formation.



GEOLOGIC COLUMN

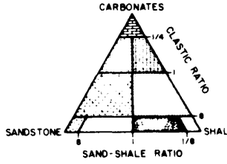


0 10 20 30 40 50
KILOMETERS
0 10 20 30
MILES

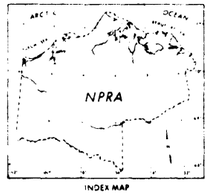
EXPLANATION

ALASKA I
25' THICKNESS (ISOPACH)
N.R NOT REACHED
N.P NOT PRESENT

CARBONATES



O LOCATION
ABANDONED WELL
ABANDONED WELL (GAS SHOW)
ABANDONED WELL (OIL SHOW)
GAS WELL
OIL WELL
ABANDONED OIL WELL



INDEX MAP

TETRA TECH, INC.
HOUSTON TEXAS — ENERGY MANAGEMENT DIVISION — PASADENA CALIFORNIA

PETROLEUM EXPLORATION OF NPRA 1974-1981 (FINAL REPORT)

ISOPACH MAP
NANUSHUK GROUP

NPR — ALASKA

FOR
ONPRA
HUSKY OIL NPR OPERATIONS INC

PROJECT MANAGER: J.W BRUYNZEEL		PROJECT NO. TC-7174	
INTERPRETATION BY: H. BAIK		REV. NO. / DATE	INITIAL
DATE: FEB. 1982	DATUM:		
CONTOUR INT: 500'	SCALE:	DWG NO.	

TETRA TECH REPORT NO 8200

FIGURE 85

FIGURE 86

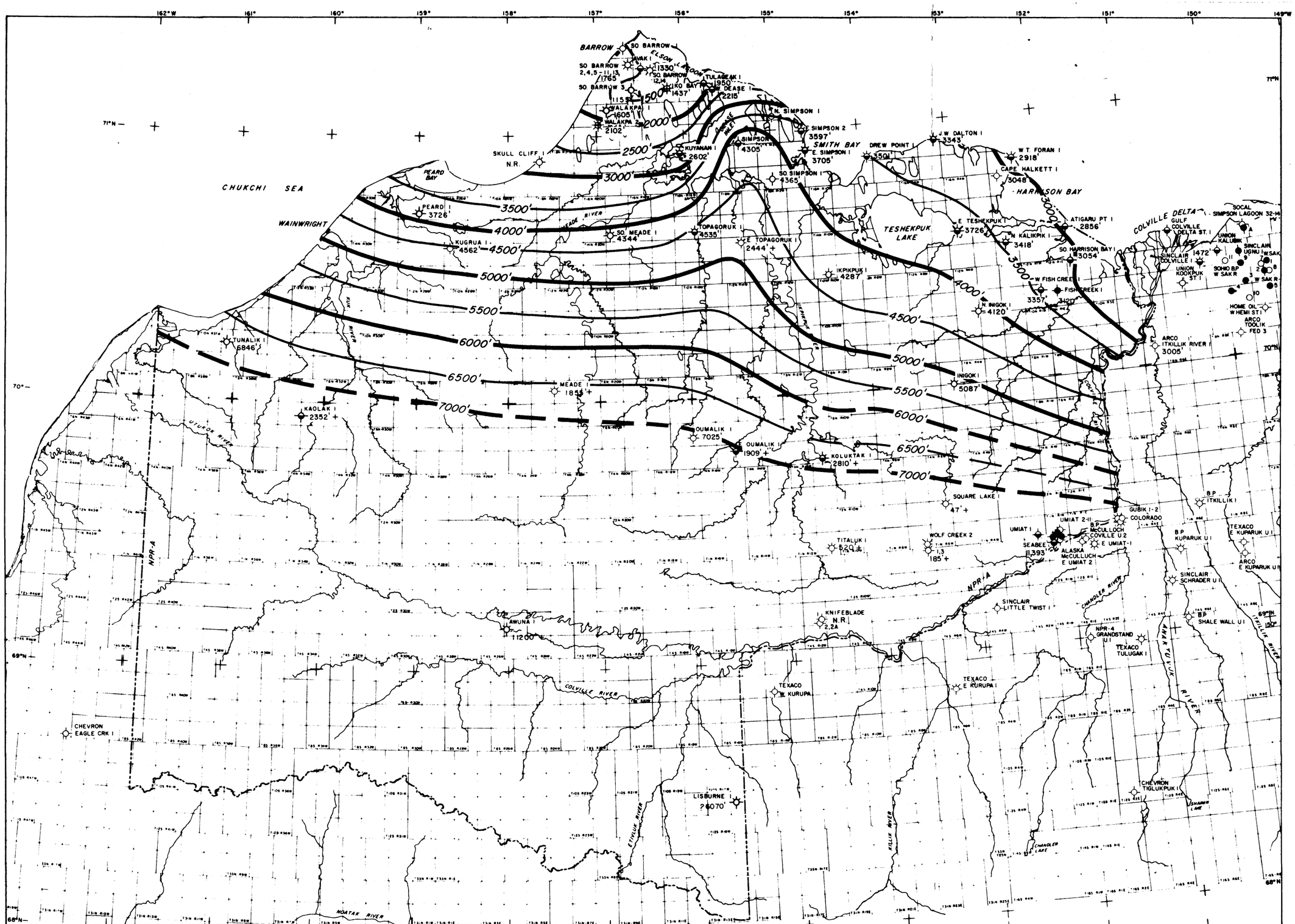
ISOPACH MAP, TOROK FORMATION

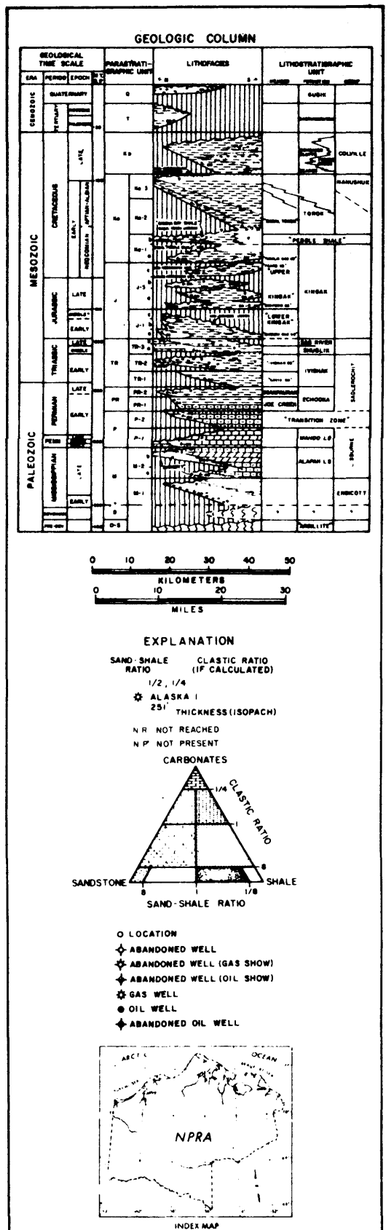
Well	Thickness	
	Feet	Thickness
Atigaru Point 1	2,856	809
Awuna 1	11,200+	3,104
South Barrow 3	1,155	352
South Barrow 13	1,765	538
Cape Halkett 1	3,048	928
West Dease 1	2,215	675
J. W. Dalton 1	3,343	1,019
Drew Point 1	3,501	1,067
Fish Creek 1	3,120	951
West Fish Creek 1	3,357	1,023
W. T. Foran 1	2,918	889
South Harrison Bay 1	3,054	931
Iko Bay 1	1,437	438
Ikpikpuk 1	4,287	1,307
Inigok 1	5,087	1,551
North Inigok 1	4,120	1,256
North Kalikpik 1	3,418	1,041
Kaolak 1	2,352	717
Koluktak 1	2,810	856
Kugrua 1	4,562	1,390
Kuyanak 1	2,602+	793
Lisburne 1	6,070(?)	1,850
Meade 1	1,855	565
South Meade 1	4,344	1,324
Oumalik 1	7,025	2,141
East Oumalik 1	1,909+	582
Peard 1	3,726+	1,136
Seabee 1	11,393	3,473
Simpson 1	4,305	1,312
Square Lake 1	47+	14
East Simpson 1	3,705	1,129
East Simpson 2	3,597	1,096
South Simpson 1	4,365	1,330
East Teshekpuk 1	3,726	1,136
Titaluk 1	520+	158
Topagoruk 1	4,535	1,382
East Topagoruk 1	2,444+	745
Tulageak 1	1,950	594
Tunalik 1	6,846	2,026
Walakpa 1	1,605	3,048
Walakpa 2	2,102	641
Wolf Creek 1	185+	56
Sinclair Colville 1	1,472	449
Arco Itkillik River 1	3,005	916

At Awuna 1 and Lisburne 1, the Torok Formation is on the surface. However, because of the structural complexity in that part of the NPRA, the Awuna 1 and Lisburne 1 areas were not contoured.

The Torok Formation is very thick in the southwestern part of the NPRA, but thins northward toward the Barrow High and eastward.

The lithology is predominantly shale with a few thin silt members. In the northeastern NPRA, a number of oil shows were noted in the silt members.





TETRA TECH, INC

HOUSTON TEXAS — ENERGY MANAGEMENT DIVISION — PASADENA CALIFORNIA

PETROLEUM EXPLORATION OF NPRA 1974-1981 (FINAL REPORT)

ISOPACH MAP
TOROK FORMATION

NPR — ALASKA

FOR

ONPRA

HUSKY OIL NPR OPERATIONS INC

PROJECT MANAGER: J.W. BRUYNZEEL	PROJECT NO. TC 7174
INTERPRETATION BY: H.Y. BAIK	REVISED: DATE / INITIAL
DATE: FEB. 1982 DATUM:	
CONTOUR INT: 500' SCALE:	DWG NO.
TETRA TECH REPORT NO. 7000	

FIGURE 86

TGE-0170

FIGURE 87

LITHOFACIES CROSS SECTION OF THE TOROK-NANUSHUK GROUP

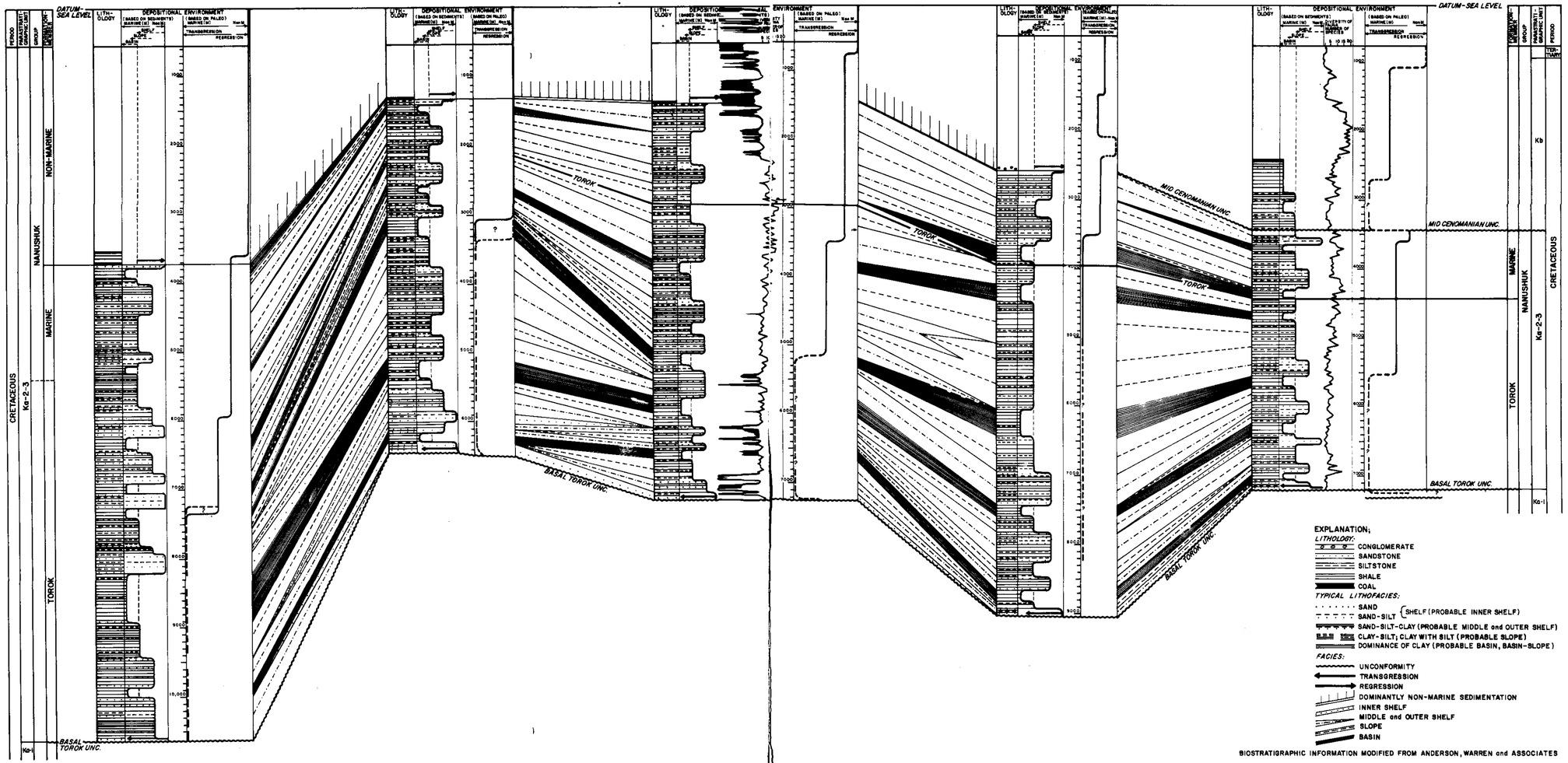
This figure shows the distribution of lithofacies in the Torok Formation and marine Nanushuk Group at Tunalik 1, South Meade 1, Ikpikpuk 1, Inigok 1, and Atigaru Point 1. The lithofacies are time-transgressive and become younger from the west to the east. Time lines cut diagonally downward from the left side of the section to the right side. These facies are in the Ka-2 and Ka-3 parastratigraphic units. Features of interest in this section are:

1. Geologic time units, parastratigraphic labels, and conventional lithostratigraphic names are shown on the right and left of the figure. For each well, the dominant lithology is in the left-hand column. The next column shows the interpreted depositional environment based on sediments. A middle column for Ikpikpuk 1 and Atigaru Point 1 shows a faunal diversity plot modified from biostratigraphic reports of Anderson, Warren, and Associates. The right-hand column for each well shows the depositional environment based on those biostratigraphic reports.

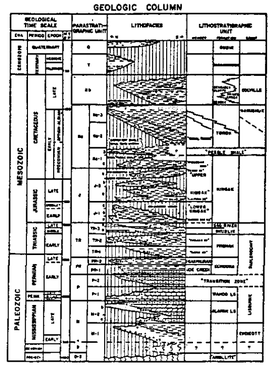
2. The Torok Formation unconformably overlies unit Ka-1 and in turn is overlain by marine facies of the Nanushuk Group. The "basal Torok" unconformity at the base of Ka-2 or Ka-3 is traced over the region. A boundary between marine and nonmarine deposits of the Nanushuk is at the bottom of the cross-beds.

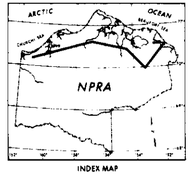
3. The Early Cretaceous Torok-Nanushuk depositional cycle began after a hiatus at the end of the deposition of the Ka-1 unit. Ka-2 and Ka-3 were deposited in a series of depositional pulses that do not seem to be marked by major hiatuses. Each pulse started with a transgression, followed by a stage of stable sedimentation at the end of the deposition of the Torok Formation lithofacies. The completion of each pulse was marked by regression and the deposition of the nonmarine Nanushuk lithofacies.

4. The generalized lithological subdivisions were correlated with their lithofacies equivalents. An assumption was made that changes in lithofacies from the predominantly sand and silt-sand to clay directly reflected paleogeographic areas of sedimentation from the shelf to basin part of the Early Cretaceous sea. All these facies are shown on the lithofacies cross section.



GEOLOGIC COLUMN





INDEX MAP

TETRA TECH, INC.
HOUSTON, TEXAS — ENERGY MANAGEMENT DIVISION — PASADENA, CALIFORNIA

PETROLEUM EXPLORATION OF NPRA 1974-1981 (FINAL REPORT)

LITHOFACIES CROSS SECTION OF THE TOROK-NANUSHUK GROUP

NPR — ALASKA

FOR
ONPRA
HUSKY OIL NPR OPERATIONS INC.

PROJECT MANAGER: J.W. BRUYNZEEL		PROJECT NO. TC-7174	
INTERPRETATION BY: M.B. ORLOVSKY		REVISED	
		DATE	INITIAL
DATE: SEPT. 1981	DATUM: SEA LEVEL		
CONTOUR INT:	SCALE:	DWG NO.	

TETRA TECH REPORT NO. 8200

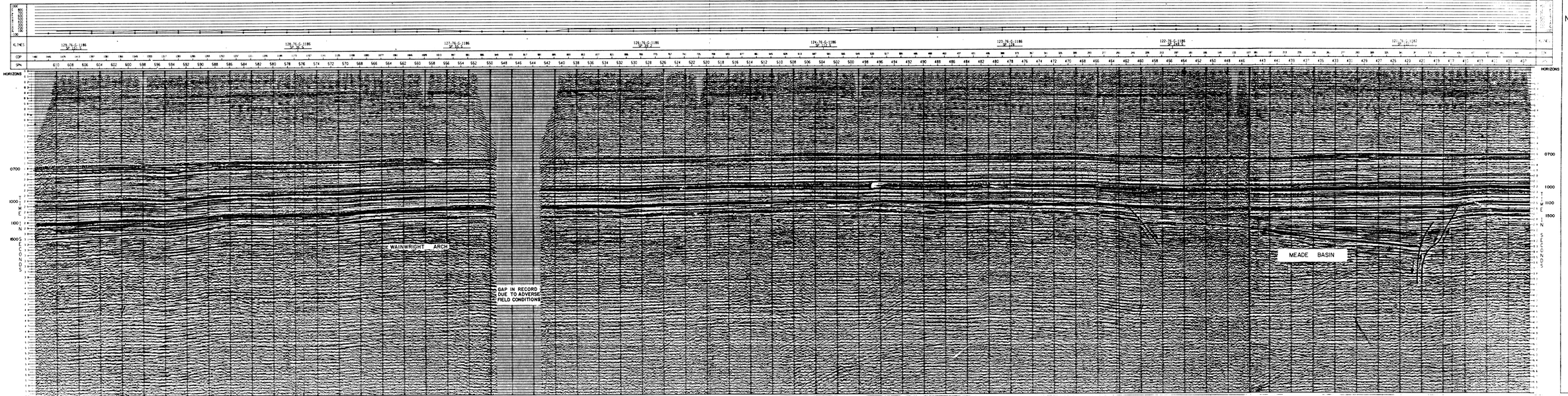
TGE-0170 FIGURE 87

FIGURE 88

LINE 30-76-G-1186, SHOTPOINTS 407-610,
SCALED FINAL STACK

Line 30-76, oriented east-west, crosses the Wainwright Arch and Meade Basin. These are broad features trending in a north-south direction. Slight thinning of the deeper section is observed over the Wainwright Arch with thickening of the horizon 1100 to 1500 interval in the Meade Basin. Major interest lies in the high-angle faults that dot the peripheries of these features. A large normal fault is obvious in the deep portion of the section near the eastern edge of the Meade Basin (shotpoint 420).

FIGURE 88



DEPARTMENT OF THE NAVY

NAVAL PETRO. RESERVE-4
WESTERN SECTOR

30-76-G-1186

SHOTPOINTS 407-610

SCALED FINAL STACK

FIGURE 88

0 1.0 2.0
MILES

TGZ-0170

TETRA TECH REPORT NO. 8200

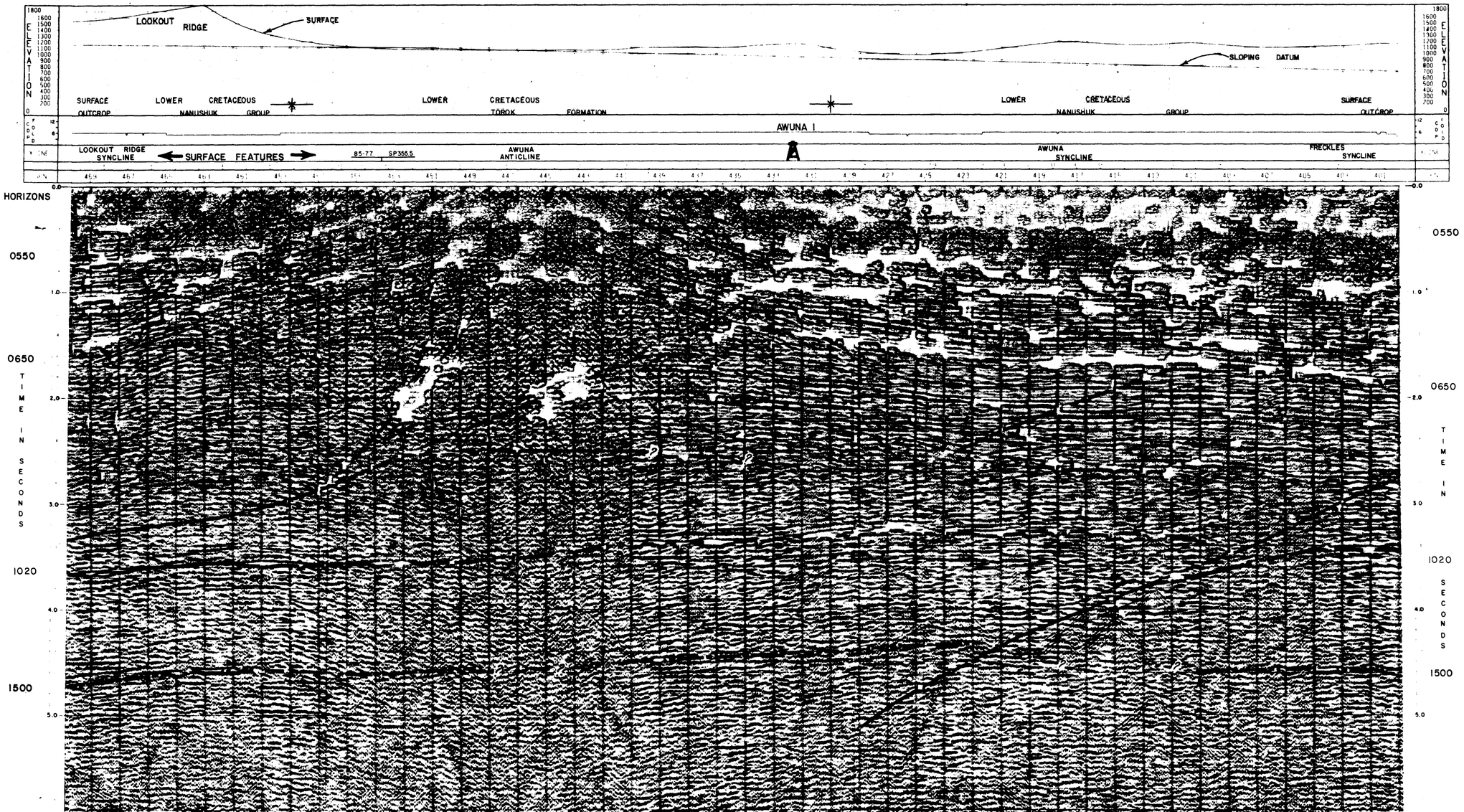
FIGURE 89

LINE 89X-78-G-1184, SHOTPOINTS 470-400,
SCALED FINAL STACK

Seismic line 89X-78, located in the Lookout Ridge Quadrangle, intersects the Carbon Trend at a right angle across the Awuna anticline. Thrust faulting with relative movement from south to north is interpreted along the axis of the Carbon Trend down to and including horizon 0650. The Awuna anticline is located on the northern flank of this thrust zone and appears to be an allochthanous block. At horizon 0650, closure extends approximately 106 miles in length and 6 to 8 miles in width. The closure is defined by thrust faulting to the south and structural dip in all other directions. North dip of horizons 0650 and 0550 is evident on line 89X-78.

The Awuna anticline is breached with the Nanushuk-Torok section outcropping along the trend axis just south of Awuna 1. Possible trapping mechanisms in this area include localized faulting or stratigraphic changes, especially within the "basal Torok."

FIGURE 89



USGS ONPRA

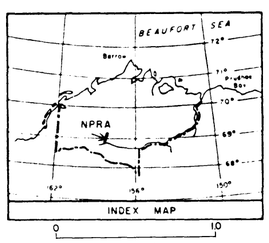
HUSKY OIL NPR OPRS INC
NATIONAL PETROLEUM RESERVE ALASKA
SOUTHERN FOOTHILLS AREA

89X-78-G-1184

SHOTPOINTS 470-400

SCALED FINAL STACK

FIGURE 89



TETRA TECH REPORT NO 8200

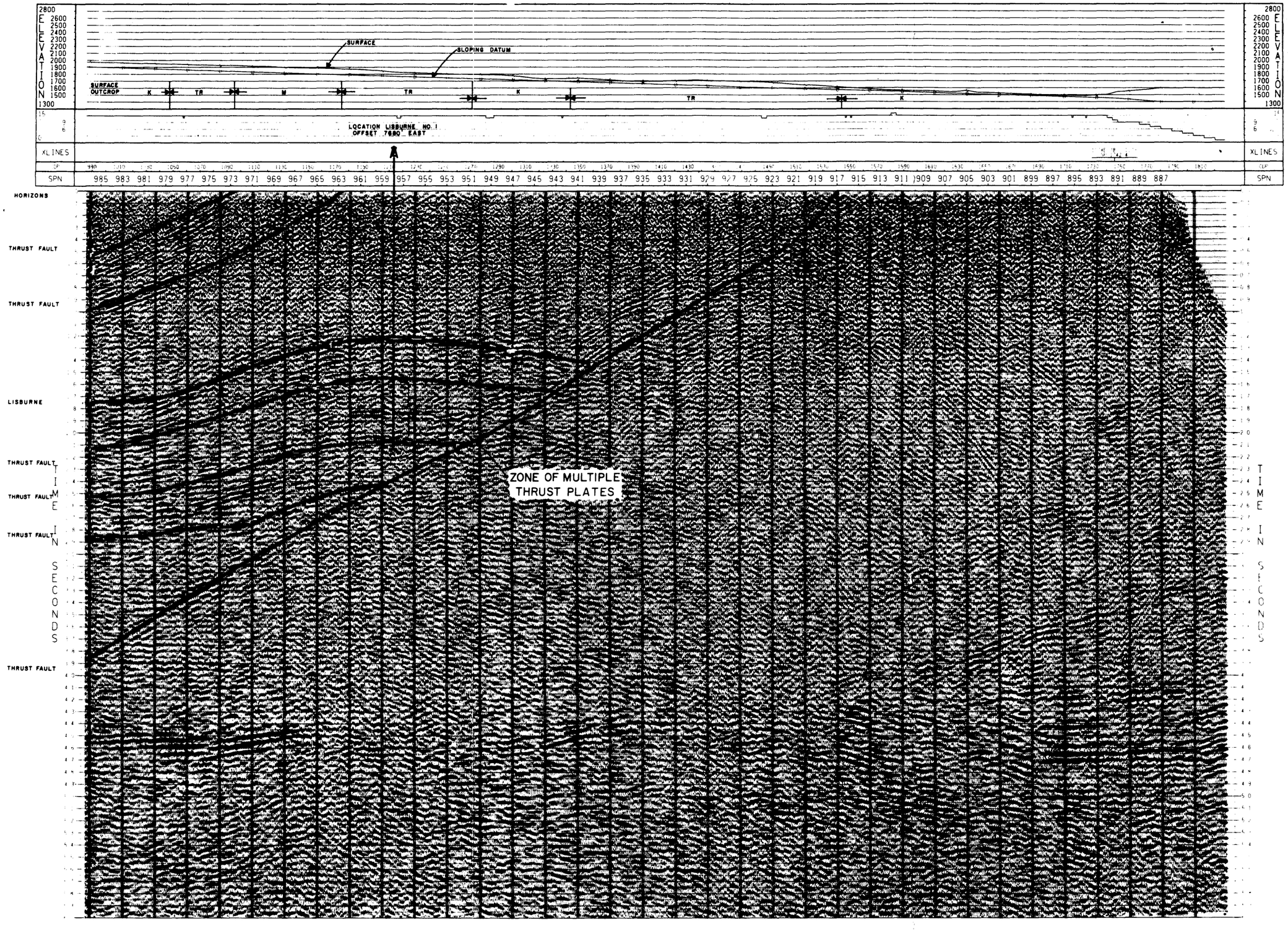
TGZ-0170

FIGURE 90

LINE 732-80-1182, SHOTPOINTS 134-198,
SCALED FINAL STACK

Line 732-80 shows structural closure at horizon 0500 extending down through the Nanushuk Group. Laterally offset from this closure, a large structural closure is shown at the horizon 0650 level, extending downward through the "basal Torok" and including horizon 0700. This local structure is part of the Carbon Trend, a large decollement faulting trend extending across the southern NPRA. Along the axis of this trend, running from the Colville River northwest to the Utukok River, thrust faulting is evident with relative movement from south to north. Deformation from this faulting is shallow and generally extends only through the "basal Torok." Line 732-80 is situated in the Utukok Quadrangle, and extends northeasterly across the Carbon Trend. The local structure shown is centered at T2N-R36W.

FIGURE 90



USGS ONPRA

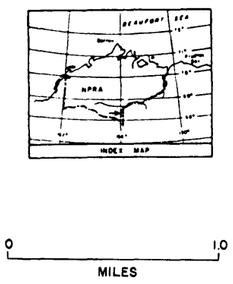
NATIONAL PETROLEUM RESERVE ALASKA
HUSKY OIL NPR OPRS. INC
SOUTHERN FOOTHILLS AREA

37X-78-G-1173

SHOTPOINTS **986-887**

SCALED FINAL STACK

FIGURE 91



TETRA TECH REPORT NO. 8200

TGZ-0170

FIGURE 92

LINE 46XS-79-G-1184, SHOTPOINTS 2040-1601, SCALED FINAL STACK

Line 46XS-79, oriented north-south, displays the multiple allochthanous blocks caused by thrust faulting. Relative movement of these blocks was from south to north. Lisburne 1, east of this line, is the only well in the area. Based on information from this well, the shallow horizon shown was correlated with the Okpikruak Formation of the Lower Cretaceous. A number of potential structural traps occur at this horizon due to the combination of southwest-dipping strata and southeast-trending thrust faults.

The intermediate horizon also shows similar southwest dip and southeast-trending thrust faults, resulting in large structural closures at this level.

The deep horizon may correlate with the deepest Lisburne carbonates reached by Lisburne 1. This horizon shows less decollement deformation but still exhibits large structural closures. There is fairly good correlation along seismic lines for these three horizons, except across major faults where the correlation becomes questionable because of large amounts of horizontal and vertical displacement.

NORTH

USGS ONPRA

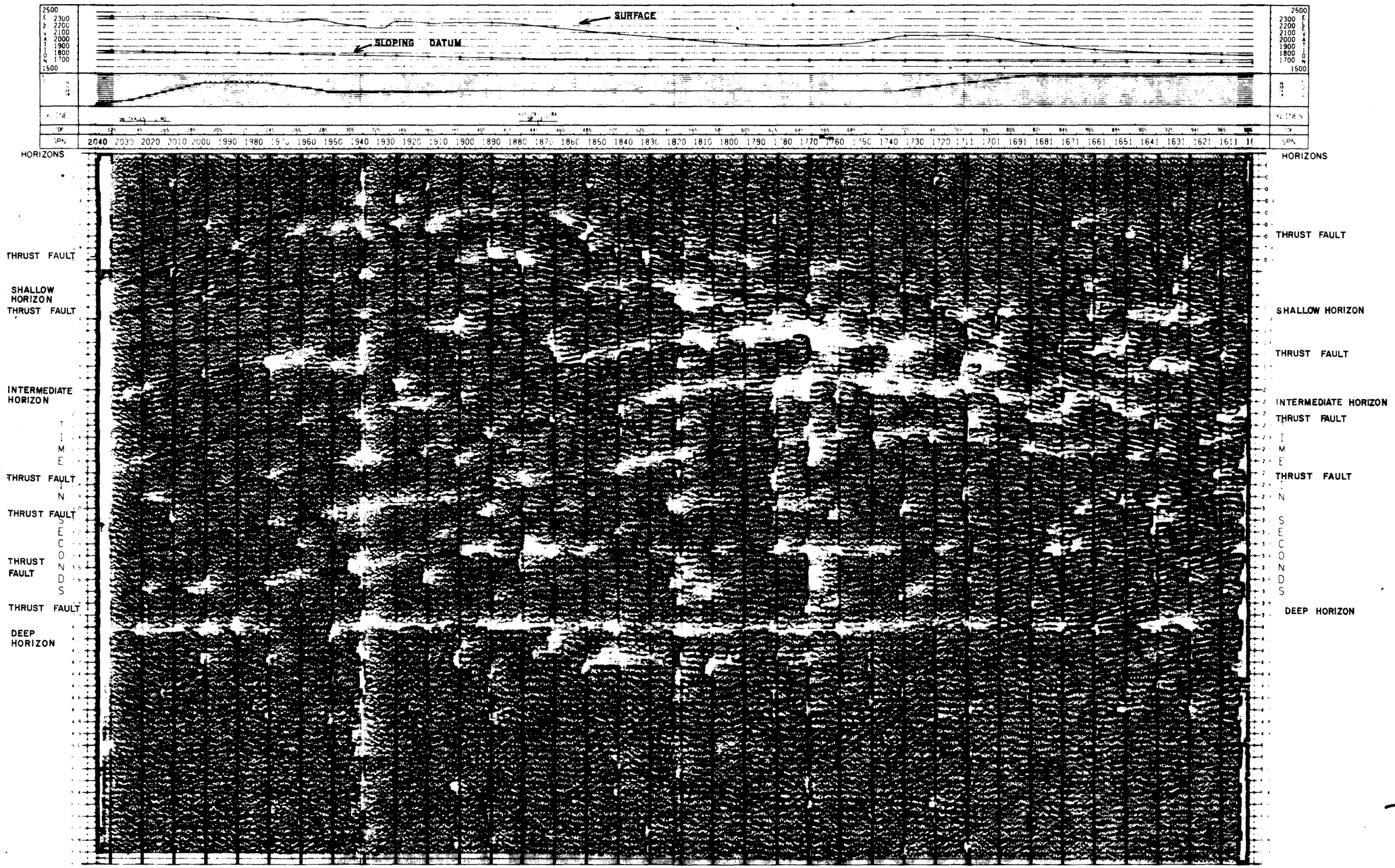
HUSKY OIL NPR OPRS. INC.
NATIONAL PETROLEUM RESERVE ALASKA
SOUTHERN FOOTHILLS AREA

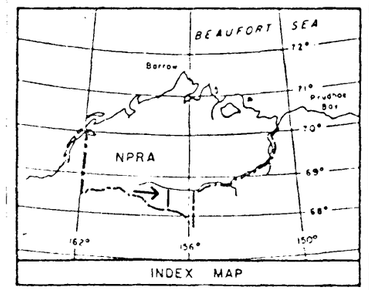
46XS-79-G-1184

SHOTPOINTS 2040 - 1601

SCALED FINAL STACK

FIGURE 92





0 0.5 1.0
MILES

TGZ-0170
TETRA TECH REPORT NO 8200

FIGURE 93

STRUCTURAL FORM LINE MAP (SHALLOW HORIZON)

The structural form line map (shallow horizon) represents the general structure in the shallow rocks of the northern part of the Brooks Range Orogen. The region is so complexly faulted that few seismic horizons can be traced more than a few miles. It is not possible to correlate seismic events across these faults with any certainty.

FIGURE 93

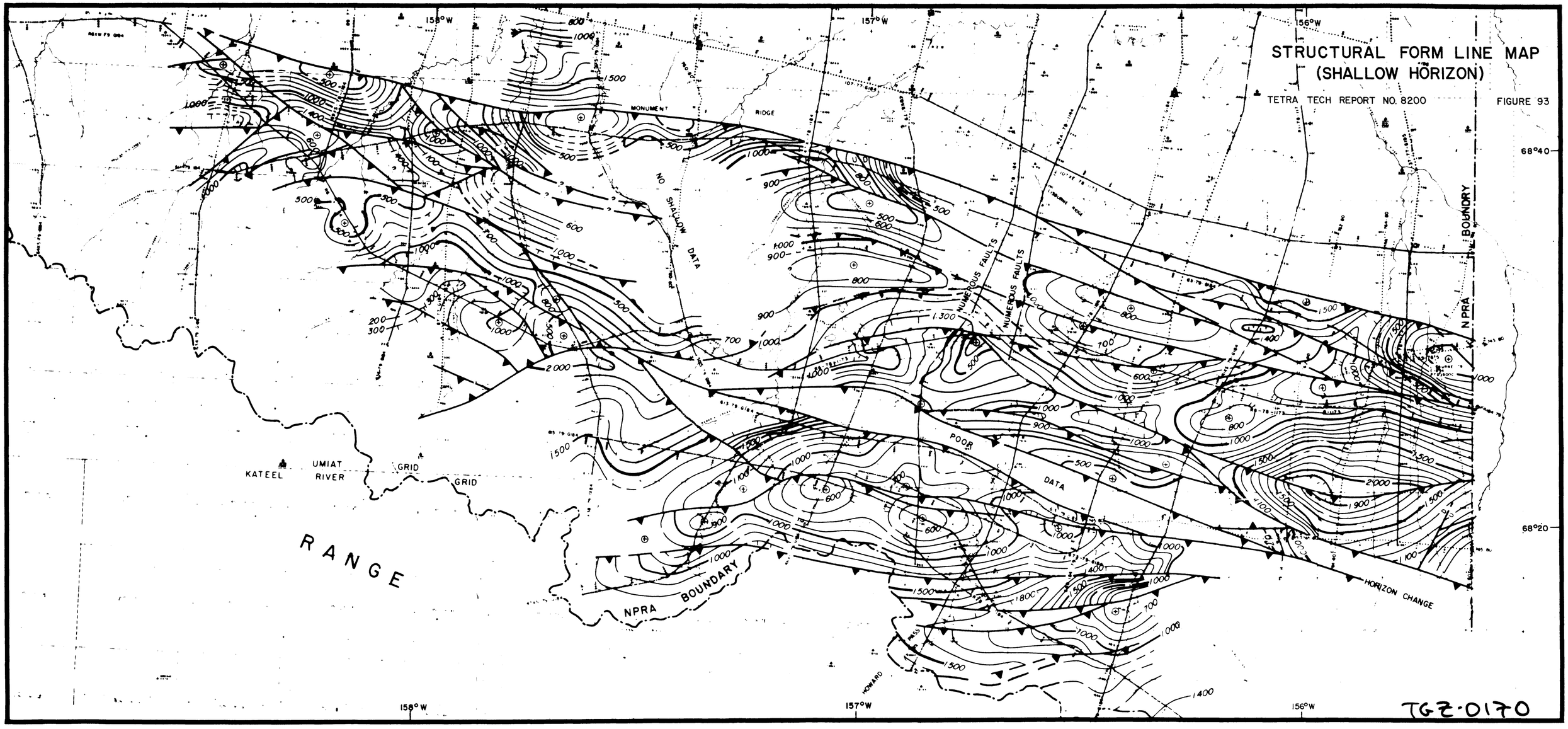
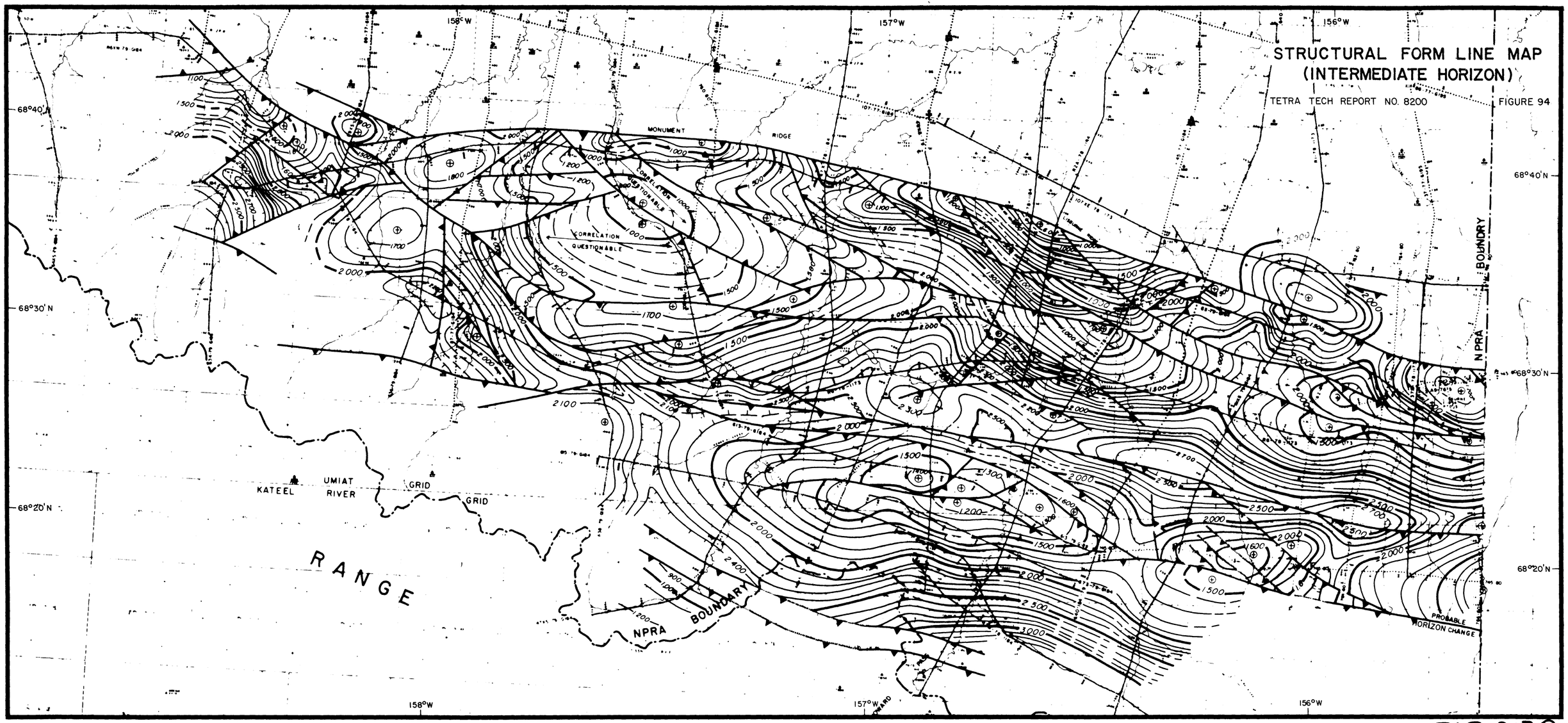

STRUCTURAL FORM LINE MAP
(SHALLOW HORIZON)
TETRA TECH REPORT NO. 8200
FIGURE 93
158°W
157°W
156°W
68°40
68°20
MONUMENT
RIDGE
NO SHALLOW DATA
NUMEROUS FAULTS
NUMEROUS FAULTS
POOR DATA
N PRA BOUNDARY
HORIZON CHANGE
KATEEL
UMIAT
RIVER
GRID
GRID
RANGE
NPRA BOUNDARY
HOWARD
PASS
TGZ-0170

FIGURE 94

STRUCTURAL FORM LINE MAP
(INTERMEDIATE HORIZON)

The structural form line map (intermediate horizon) represents the general structure of the intermediate rocks in the northern part of the Brooks Range Orogen. The region is so complexly faulted that few seismic horizons can be traced more than a few miles. It is not possible to correlate seismic events across these faults with any certainty.

FIGURE 94


STRUCTURAL FORM LINE MAP
(INTERMEDIATE HORIZON)
TETRA TECH REPORT NO. 8200
FIGURE 94
158°W
157°W
156°W
68°40'N
68°30'N
68°20'N
MONUMENT
RIDGE
CORRELATION QUESTIONABLE
KATEEL
UMIAT
RIVER
GRID
GRID
RANGE
NPRA BOUNDARY
N PRA BOUNDRY
PROBABLE HORIZON CHANGE

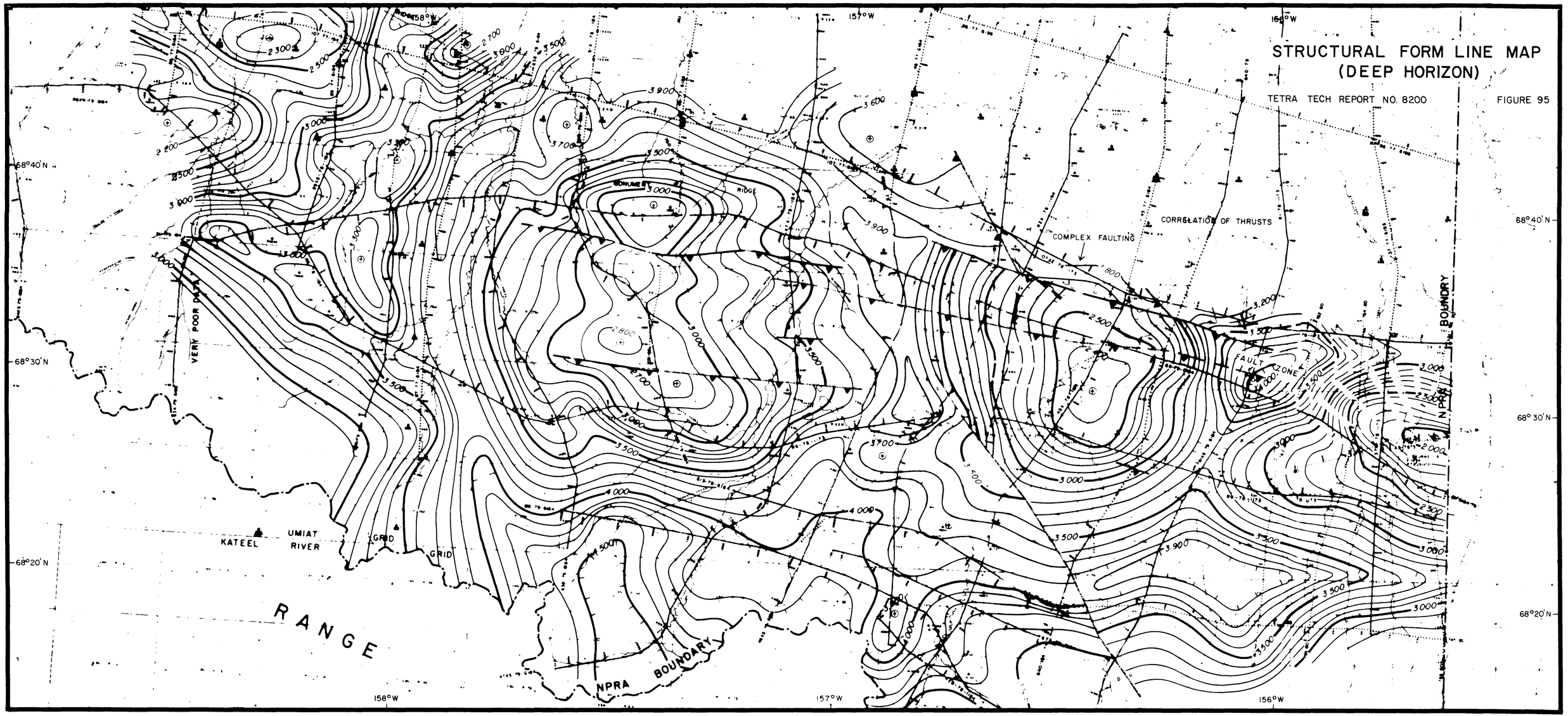
TGZ-0170

FIGURE 95

STRUCTURAL FORM LINE MAP
(DEEP HORIZON)

The structural form line map (deep horizon) represents the general structure of the deep rocks in the northern part of the Brooks Range Orogen. The region is so complexly faulted that few seismic horizons can be traced more than a few miles. It is not possible to correlate seismic events across these faults with any certainty.

FIGURE 95


STRUCTURAL FORM LINE MAP
(DEEP HORIZON)
TETRA TECH REPORT NO. 8200
FIGURE 95
158°W
157°W
156°W
68°40'N
68°30'N
68°20'N
VERY POOR DATA
BONNIE RIDGE
COMPLEX FAULTING
CORRELATION OF THRUSTS
FAULT ZONE
NPRA BOUNDARY
KATEEL
UMIAT RIVER
GRID
RANGE
NPRA BOUNDARY

TGZ-0170

FIGURE 96

HISTORICAL CROSS SECTION B-B'

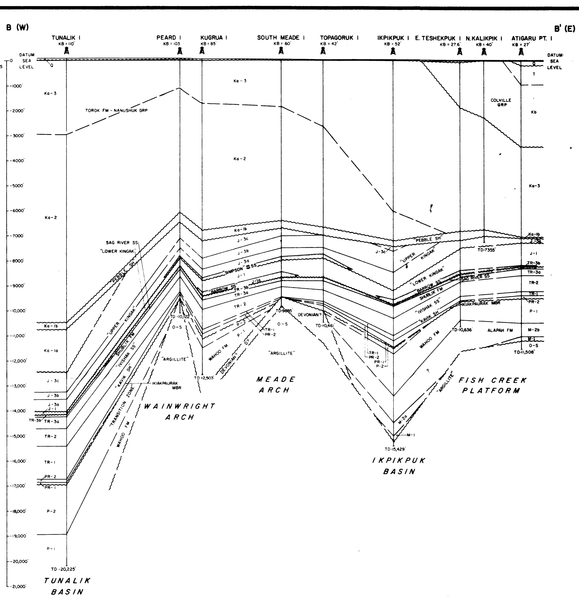
Historical reconstruction of the NPRA, using successively younger datums, shows contemporaneous tectonic episodes for an interval of geologic time. Development of the basins and arches also is shown. Historical cross section B-B' starts in the west (left) at Tunalik 1 and ends in the east (right) at Atigaru Point 1. The cross section also includes Peard 1, Kugrua 1, South Meade 1, Topagoruk 1, Ikpikpuk 1, East Teshekpuk 1, and North Kalikpik 1. Datums used in the historical reconstruction are the tops of parastratigraphic units M-1, M-2b, P-2, TR-3b, J-1, Ka-1b, and Ka-3, and sea level. The main tectonic episodes and features are:

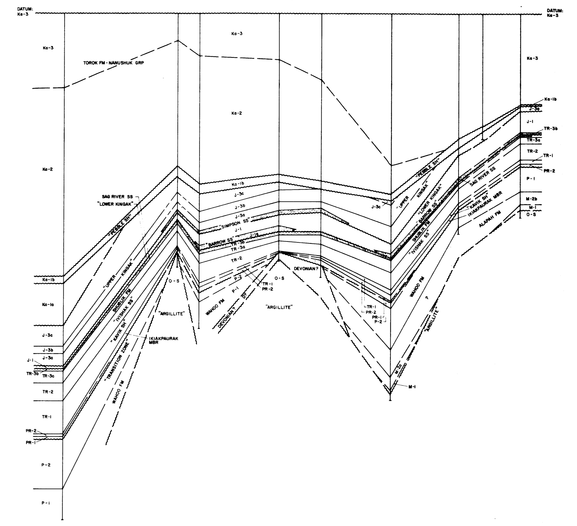
1. The initial development of the Ikpikpuk Basin took place in Late Mississippian (late Meramecian to early Chesterian) time and continued through Late Cretaceous (Cenomanian) time. The greatest basin growth occurred in Albian time.

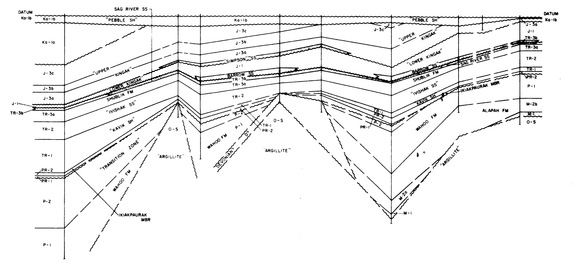
2. Initial uplift of the Fish Creek Platform also took place in late Meramecian to early Chesterian time. The platform remained a positive tectonic feature through Late Triassic time. Lowering of the Fish Creek Platform and a relative rise in sea level allowed unit J-1 to be deposited in Early Jurassic (Hettangian) time. Renewed uplift of the Fish Creek Platform and subsidence of the Tunalik Basin caused a regional tilt of strata to the southwest in Late Jurassic time. Uplift of the Fish Creek Platform continued after the Late Jurassic, reaching a maximum in Late Albian time. At that time, the Fish Creek Platform was higher structurally than the Meade and Wainwright Arches. Subsidence of the Fish Creek Platform took place in early Cenomanian through Tertiary time.

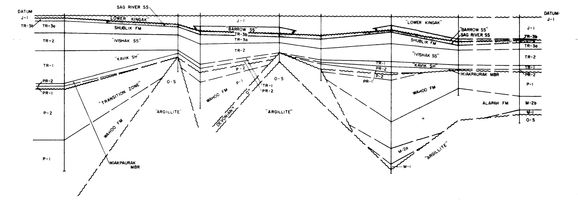
3. Development of the Meade and Wainwright Arches probably occurred in Late Mississippian (late Chesterian) to Early Pennsylvanian (Morrowan) time and possibly earlier in Meramecian time. The Arches continued to be positive tectonic features through Late Cretaceous time. The Wainwright Arch was uplifted higher than the Meade Arch in Early Cretaceous (Barremian) time and existed through Tertiary time and to the present.

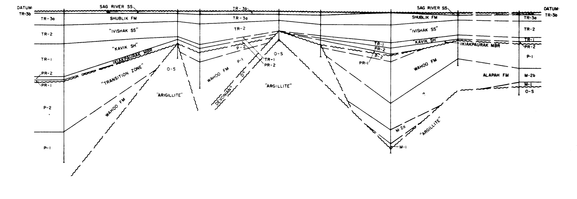
4. Initial development of the Tunalik Basin probably occurred in late Chesterian to Morrowan time and possibly earlier in late Meramecian time. Further development of the basin continued through Late Triassic time, followed by a dormant period in Early Jurassic (early Hettangian to late Callovian) time. Renewed subsidence took place in Late Jurassic (Oxfordian) time and continued through Early Cretaceous (late Albian) time. Greatest basin growth occurred in early Aptian to late Albian time.

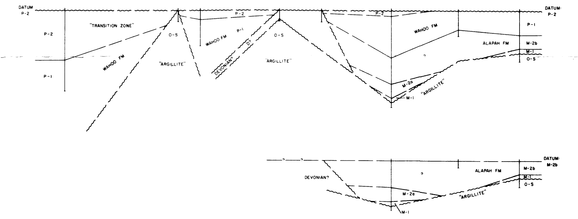


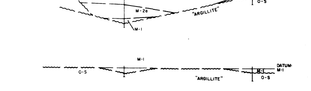


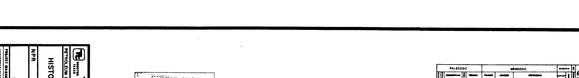


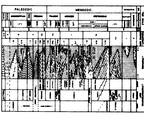












TETRA TECH, INC.
TERRAN RESOURCE MANAGEMENT DIVISION
PROJECT DEVELOPMENT & ENVIRONMENTAL SERVICES

HISTORICAL CROSS SECTION B-B'

NPR

ALASKA

PREPARED FOR
ARCO ALASKA, INC.
ANCHORAGE, ALASKA

PREPARED BY: T. A. BOLLES
REVIEWED BY: T. A. BOLLES
DRAWN BY: M. BEUTER
DATE: 1-8-85
TETRA TECH PROJECT NO. 8-0600

FIGURE 36

TG2-0170

FIGURE 97

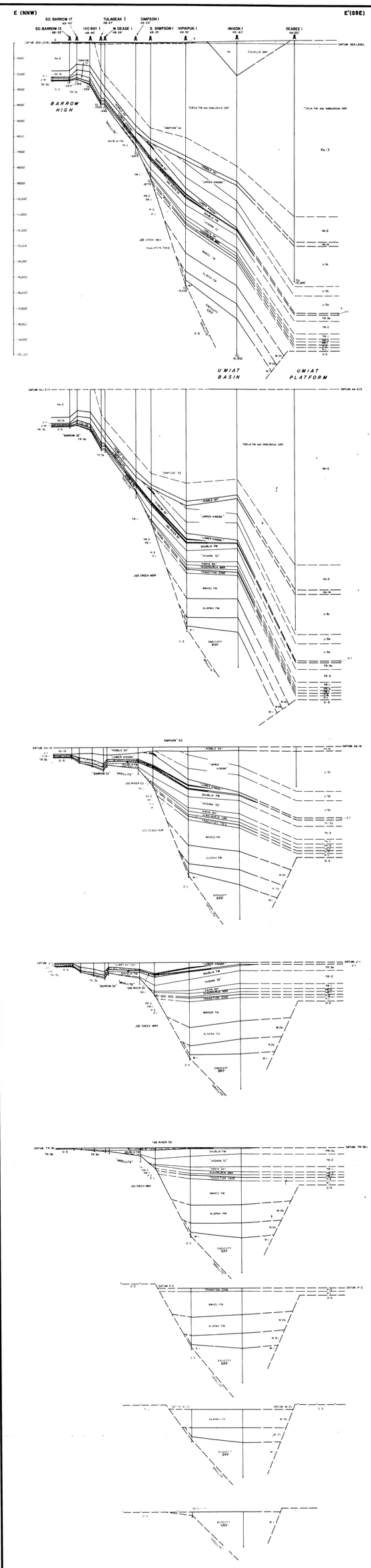
HISTORICAL CROSS SECTION E-E'

Historical cross section E-E' runs generally northwestward, starting in the north (left) at South Barrow 13 and ending in the southeast (right) at Seabee 1. The section also includes South Barrow 17, Iko Bay 1, Tulageak 1, West Dease 1, Simpson 1, South Simpson 1, Ikpikpuk 1, and Inigok 1. Datums used in the historical reconstruction are the tops of parastratigraphic units M-1, M-2b, P-2, TR-3b, J-1, Ka-1b, Ka-2, and Ka-3, and sea level. The main tectonic episodes and features are:

1. The Barrow High existed as a positive feature in the early geologic history of the NPRA (pre-Mississippian). Uplift continued through Late Jurassic time. Paleozoic to Triassic rocks lap out on the Barrow High. Subsidence of the Fish Creek Platform and the Barrow High and a relative rise in sea level allowed unit J-1 to be deposited in an east-to-west direction in Early Jurassic (Hettangian) time. Rocks of Hauterivian age (Ka-1b) were deposited completely across the High, indicating a pause in uplift and a relative rise in sea level. Greatest uplift of the Barrow High took place after the deposition of the Ka-1b unit over the Barrow High in late Barremian to early Aptian time. The Barrow High limited the northward deposition of Ka-2 and Ka-3 in Aptian to late Albian time. Renewed uplift of the Barrow High probably occurred in Late Cretaceous time, which is indicated by the erosion of parts of Ka-2 and Ka-3, and the absence of Kb on the Barrow High.

2. Initial development of the Umiat Basin began in Early Mississippian (late Osagian) to Late Mississippian (early Meramecian) time and continued through Middle Triassic (Anisian-Ladinian) time. Relatively little basin growth took place in Late Triassic (Karnian-Norian-Rhaetian) to Early Jurassic (Hettangian) time. Subsidence once again took place in Late Jurassic (Oxfordian) time and lasted throughout Late Cretaceous.

3. The Umiat Platform existed as a positive tectonic feature through Late Mississippian (Chesterian) time. Seismic-stratigraphic evidence indicates that the Umiat Platform was overlapped by the P-1 unit in Early Pennsylvanian (Morrowan) time, and deposition of strata over the platform continued through Early Cretaceous (Albian) time. Lowering of the Umiat Platform, uplift of the Barrow High, and further subsidence of the Umiat Basin caused a regional tilt of strata to the south in Cretaceous time.



TETRA TECH, INC.
ENGINEERS CONSULTANTS SCIENTISTS
PROGRAM MANAGEMENT DIVISION
ANCHORAGE, ALASKA

HISTORICAL CROSS SECTION E-E'

NPR

ONPRA

NORTH PORCUPINE RIVER BASIN, ALASKA

PROJECT GEOLOGIST: J. W. SCHMOLL
DRAWN BY: J. W. SCHMOLL
DATE: JAN. '80
SCALE: 1:1000
TETRA TECH PROJECT NO. 1000

FIGURE 97

TG2-0170

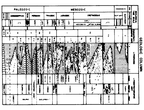


FIGURE 98

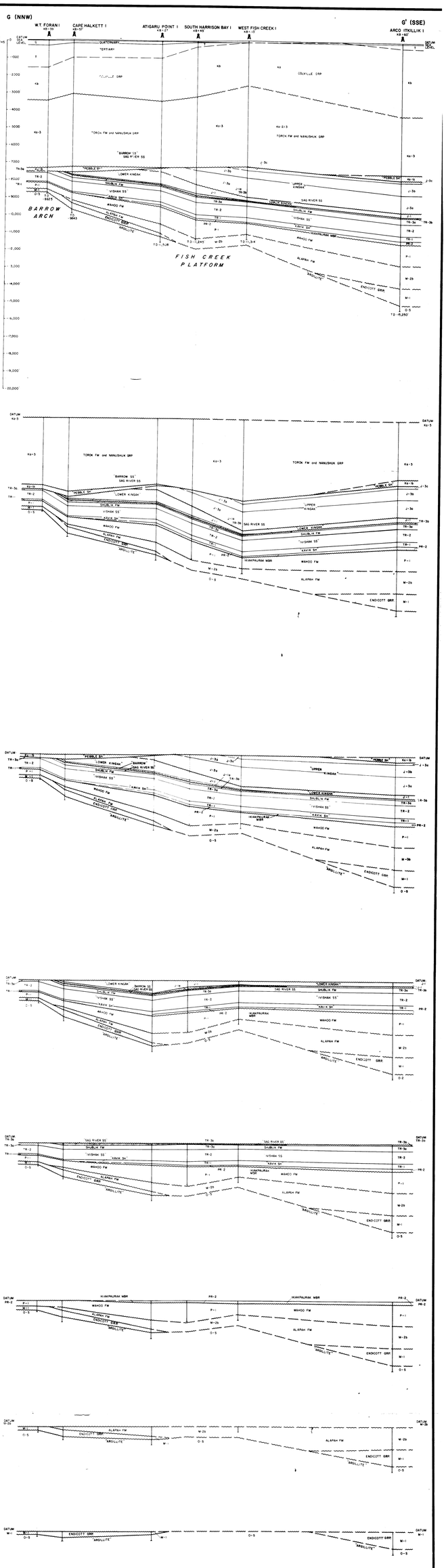
HISTORICAL CROSS SECTION G-G'

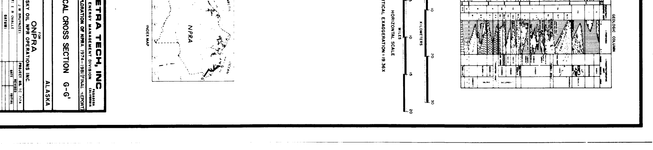
Historical reconstruction of the NPRA, using successively younger datums, shows contemporaneous tectonic episodes for an interval of geologic time. The development of the basins is also shown. Historical cross section G-G' starts at W. T. Foran 1 in the northwest (left) and ends in the southeast (right) at Arco Itkillik River 1. W. T. Foran 1 is on the south flank of the Barrow Arch. The section, which crosses the Fish Creek Platform and the eastern edge of the Ikpikpuk Basin, also includes Cape Halkett 1, Atigaru Point 1, South Harrison Bay 1, and West Fish Creek 1. Datums used in the historical reconstruction are the tops of parastratigraphic units M-1, M-2b, PR-2, TR-3b, J-1, Ka-1b, and Ka-3, and sea level. The main tectonic episodes and features are:

1. The Barrow Arch existed as a positive tectonic feature early in the geologic history of the NPRA (pre-Mississippian) and influenced deposition of sediments until Late Cretaceous time. Rocks of late Hauterivian age (Ka-1b) were deposited completely across the Barrow Arch, indicating a relative rise in sea level. After deposition of unit Ka-1b over the Barrow Arch in late Barremian to early Aptian time, the Barrow Arch was uplifted again and remained as a positive tectonic feature throughout late Albian time. The Barrow Arch was lowered in Tertiary time, but remained structurally higher than the Fish Creek Platform.

2. The Fish Creek Platform existed as a positive tectonic feature from Late Mississippian (late Meramecian to early Chesterian) time through Late Triassic time. Lowering of the Fish Creek Platform and the area between it and the Barrow Arch allowed deposition of unit J-1 in Early Jurassic (Hettangian) time. Uplift of the Fish Creek Platform and the Barrow Arch and a lowering of the Tunalik Basin caused a regional tilt of strata to the southwest in Late Jurassic time. Uplift of the Fish Creek Platform continued until late Albian time when uplift was greatest. Subsidence of the Fish Creek Platform occurred in Late Cretaceous (early Cenomanian) through Tertiary time.

FIGURE 98





VERTICAL EXAGGERATION IN MILES

TERRA-TECH, INC.
TERRA-TECH, INC.
ALASKA EXPLORATION OF NPR-A, 1974-1978 FINAL REPORT

NPR

HISTORICAL CROSS SECTION G-G'

ALASKA

PREPARED BY: ONPRA
TERRA-TECH, INC.
TERRA-TECH, INC.
DATE: 1 MAY 1978
SCALE: 1" = 1 MILE
DRAWN BY: DAVID P. MOSS
FIGURE 98

TG2-0170

FIGURE 99

J-1a FACIES PROFILES, B-B'

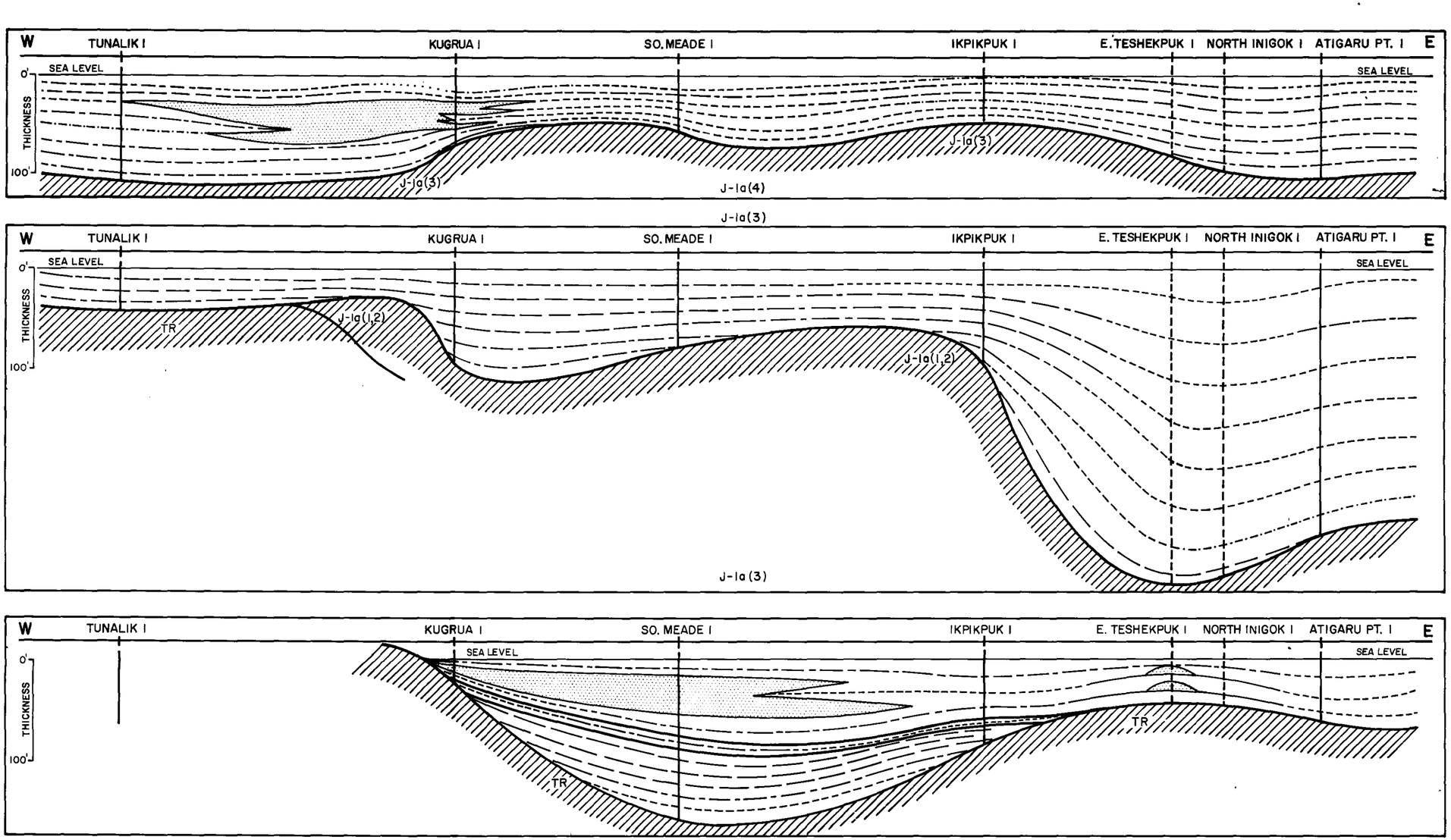
Unit J-1a is at the base of the Jurassic Kingak Formation. The unit is subdivided into four smaller units: J-1a(1), J-1a(2), J-1a(3), and J-1a(4).

J-1a(1), composed of siltstone and shale, apparently occupies depressions on the eroded Triassic surface. The bottom cross section in this figure shows that J-1a(1) is present at South Meade 1 and Ikpikpuk 1, but is absent at Kugrua 1 and wells to the east of Ikpikpuk 1.

J-1a(2) contains siltstone and shale, as well as barlike sandstones that collectively make up the "Barrow sandstone." This unit, shown in the bottom section, is present in all of the wells east of Tunalik 1.

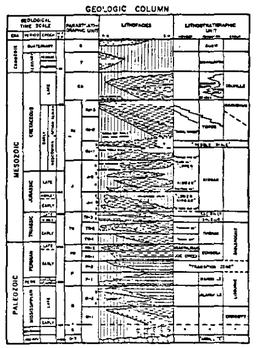
The middle cross section shows that J-1a(3) is composed mainly of siltstone and shale. The unit overlies J-1a(2), except at Tunalik 1 where it lies directly on Triassic section.

The upper cross section shows that unit J-1a(4) contains siltstones and shales as well as barlike sandstones. J-1a(4) lies directly over unit J-1a(3) in each well on profile B-B'.



EXPLANATION

- UNDERLYING ROCKS
- CLAY
- SILTY CLAY
- SILT
- SILTY SAND
- SAND
- BAR SAND



TETRA TECH, INC

HOUSTON, TEXAS — ENERGY MANAGEMENT DIVISION — PASADENA, CALIFORNIA

PETROLEUM EXPLORATION OF NPRA 1974-1981 (FINAL REPORT)

J-Ia FACIES PROFILES B-B'

NPR — ALASKA

FOR ONPRA
HUSKY OIL NPR OPERATIONS INC.

PROJECT MANAGER: J. W. BRUYNZEEL		PROJECT NO. TC-7174
INTERPRETATION BY: M. R. ORLOVSKY		REVISED: DATE / INITIAL
DATE: MAY 1981	DATUM:	
CONTOUR INT:	SCALE:	DWG NO.

TETRA TECH REPORT NO. 8200

TGZ-0170

FIGURE 99

FIGURE 100

J-1a FACIES PROFILES, E-E'

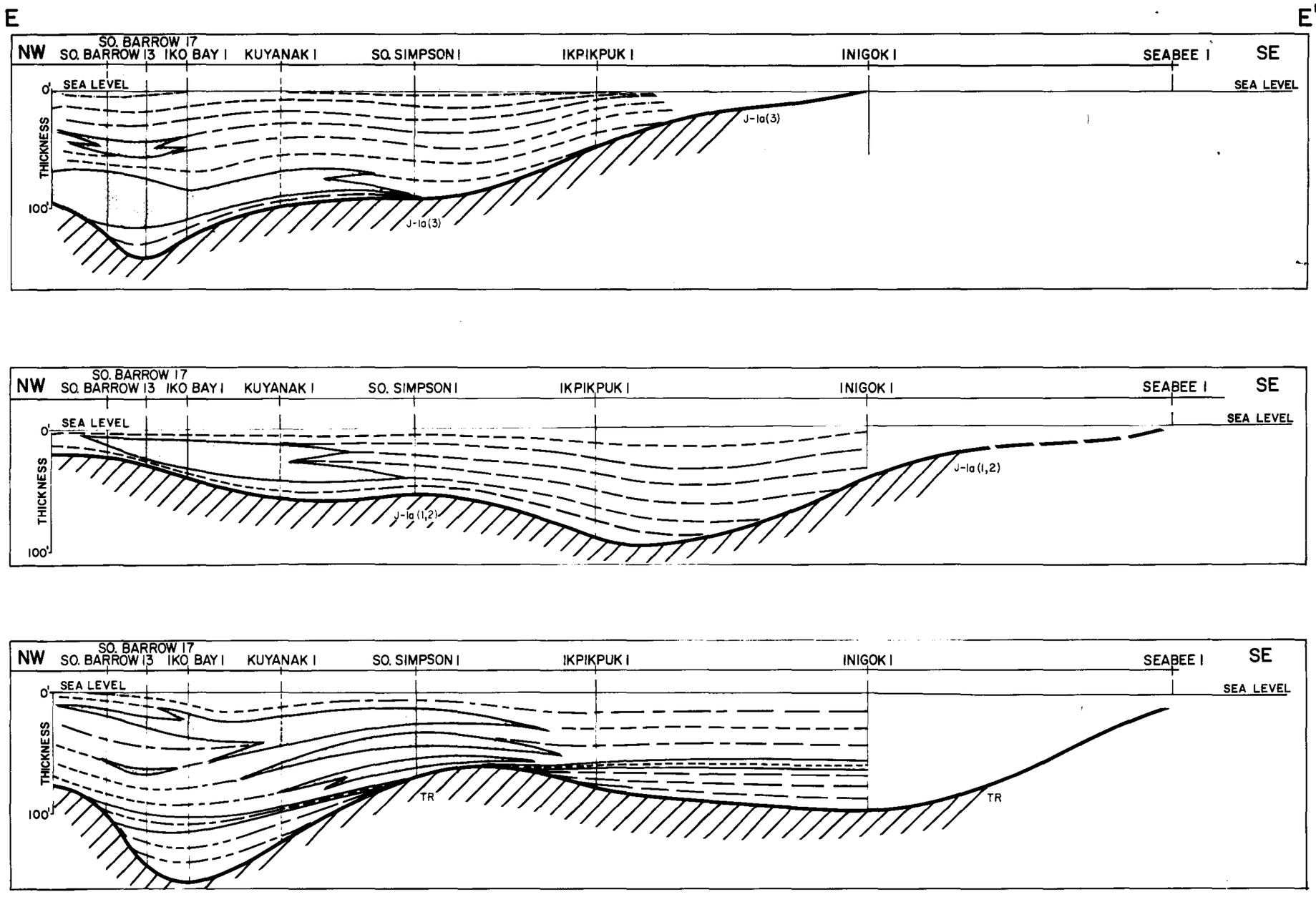
Figure 100 shows facies profiles for four subunits of unit J-1a at South Barrow 13, South Barrow 17, Iko Bay 1, Kuyanak 1, South Simpson 1, Ikpikpuk 1, Inigok 1, and Seabee 1 (cross section E-E').

J-1a(1) occupies depressions in the eroded Triassic surface. The unit is absent in South Simpson 1 and on the Barrow Arch to the northwest.

Unit J-1a(2), shown in the lower facies profile, overlies J-1a(1), except at South Simpson 1 where it overlies Triassic section. J-1a(2) is composed of siltstones and shales with interbedded barlike sandstones. These sandstones are collectively called the "Barrow sandstone."

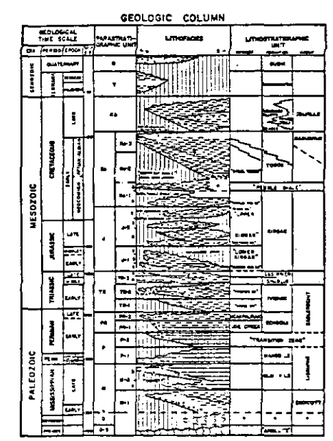
Unit J-1a(3) also is composed of siltstones and shales with interbedded barlike sandstones. The middle profile shows that these sandstones are present to the northwest in the Barrow area. This unit thins considerably as it approaches the Barrow High.

Unit J-1a(4) has essentially the same lithologic composition as unit J-1a(3), but is much thicker in the Barrow area. The unit thins to the southeast, and the barlike sandstones are absent at South Simpson 1 and Ikpikpuk 1.



EXPLANATION

- UNDERLYING ROCKS
- CLAY
- SILTY CLAY
- SILT
- SILTY SAND
- SAND
- BAR SAND



TETRA TECH, INC
HOUSTON, TEXAS — ENERGY MANAGEMENT DIVISION — PASADENA, CALIFORNIA

PETROLEUM EXPLORATION OF NPRA 1974-1981 (FINAL REPORT)

J-Ia FACIES PROFILES E-E'

NPR — ALASKA

FOR
ONPRA
HUSKY OIL NPR OPERATIONS INC.

PROJECT MANAGER: J. W. BRUYNZEEL		PROJECT NO. TC 7174
INTERPRETATION BY: M.B. ORLOVSKY		REVISED: DATE / INITIAL
DATE: MAY 1981	DATUM:	
CONTOUR INT:	SCALE:	DWG NO.

TETRA TECH REPORT NO. 8200

TGZ-0170

FIGURE 100

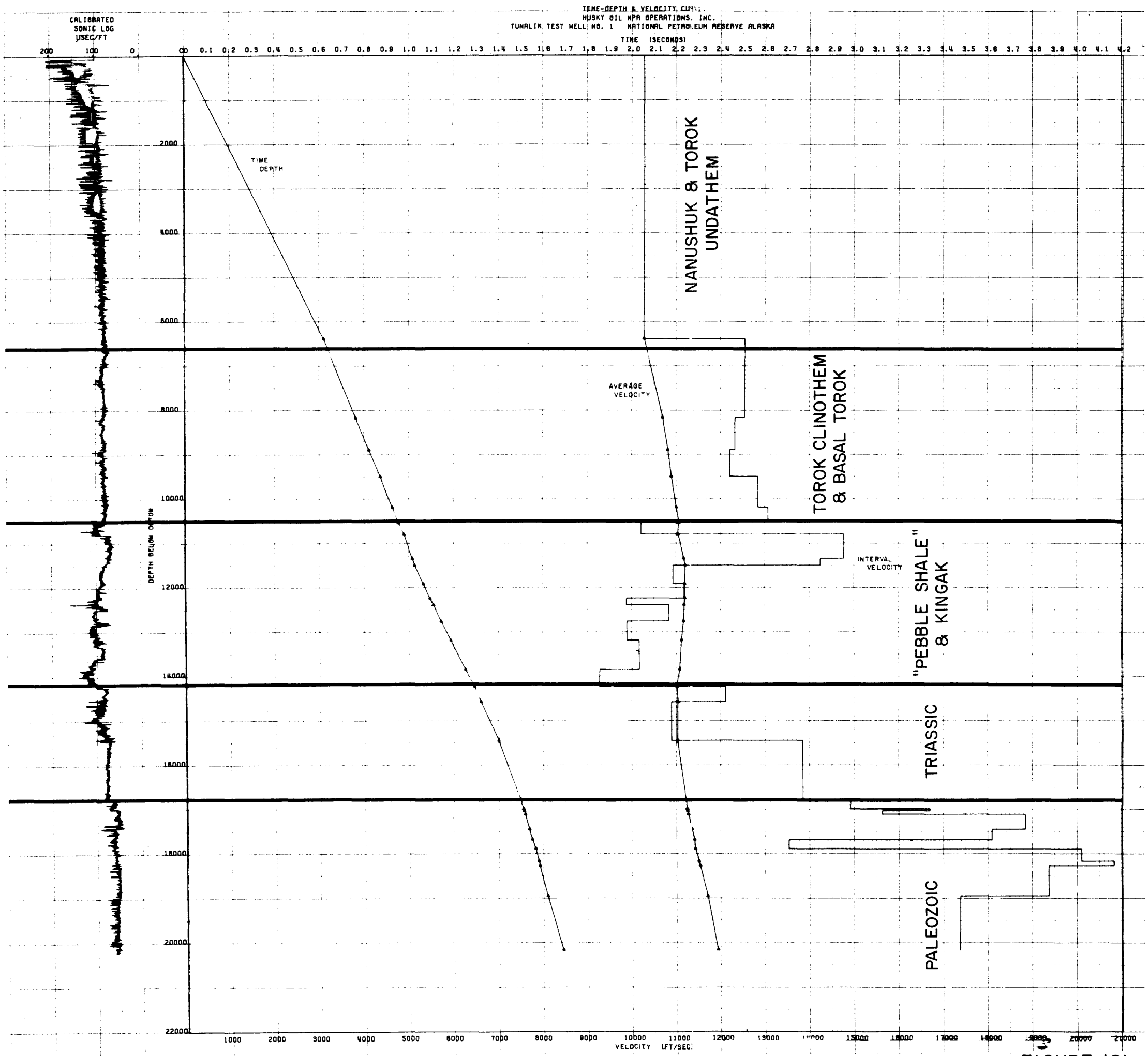
FIGURE 101

TIME-DEPTH AND VELOCITY CURVES,
TUNALIK 1

This velocity display shows a calibrated sonic log as well as a time-depth curve, interval velocities, and average velocity functions. The velocity functions are derived from check-shot survey data.

The five major velocity groups shown in figure 101 correlate well with Inigok 1 data, especially the interval velocity function.

FIGURE 101



TR-7-0120

FIGURE 101

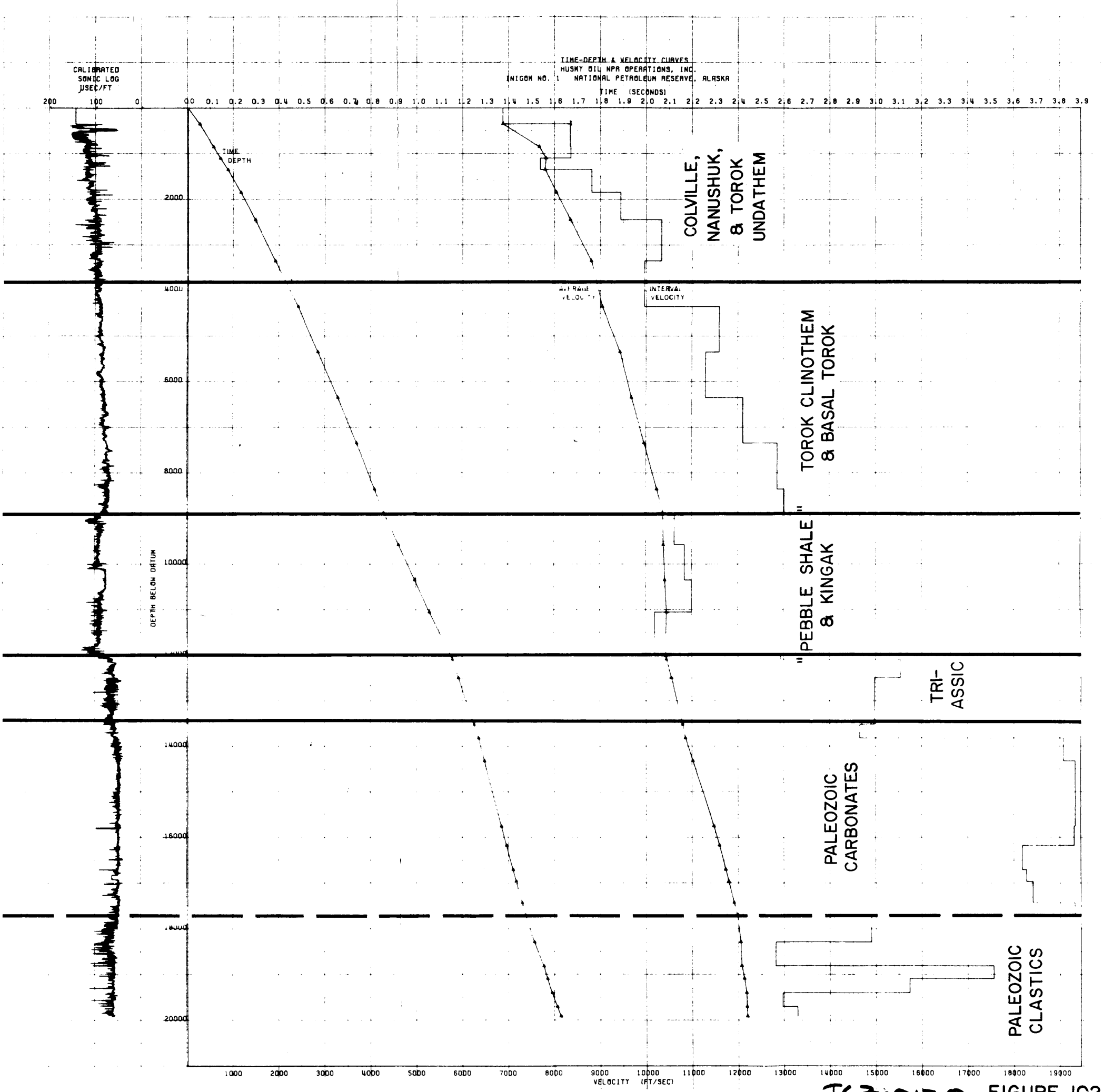
FIGURE 102

TIME-DEPTH AND VELOCITY CURVES,
INIGOK 1

This velocity display shows a calibrated sonic log as well as a time-depth curve, interval velocities, and average velocity functions. The velocity functions are derived from check-shot survey data.

The five major velocity groups shown in figure 102 correlate well with Tunalik 1 data, especially the interval velocity function.

FIGURE 102



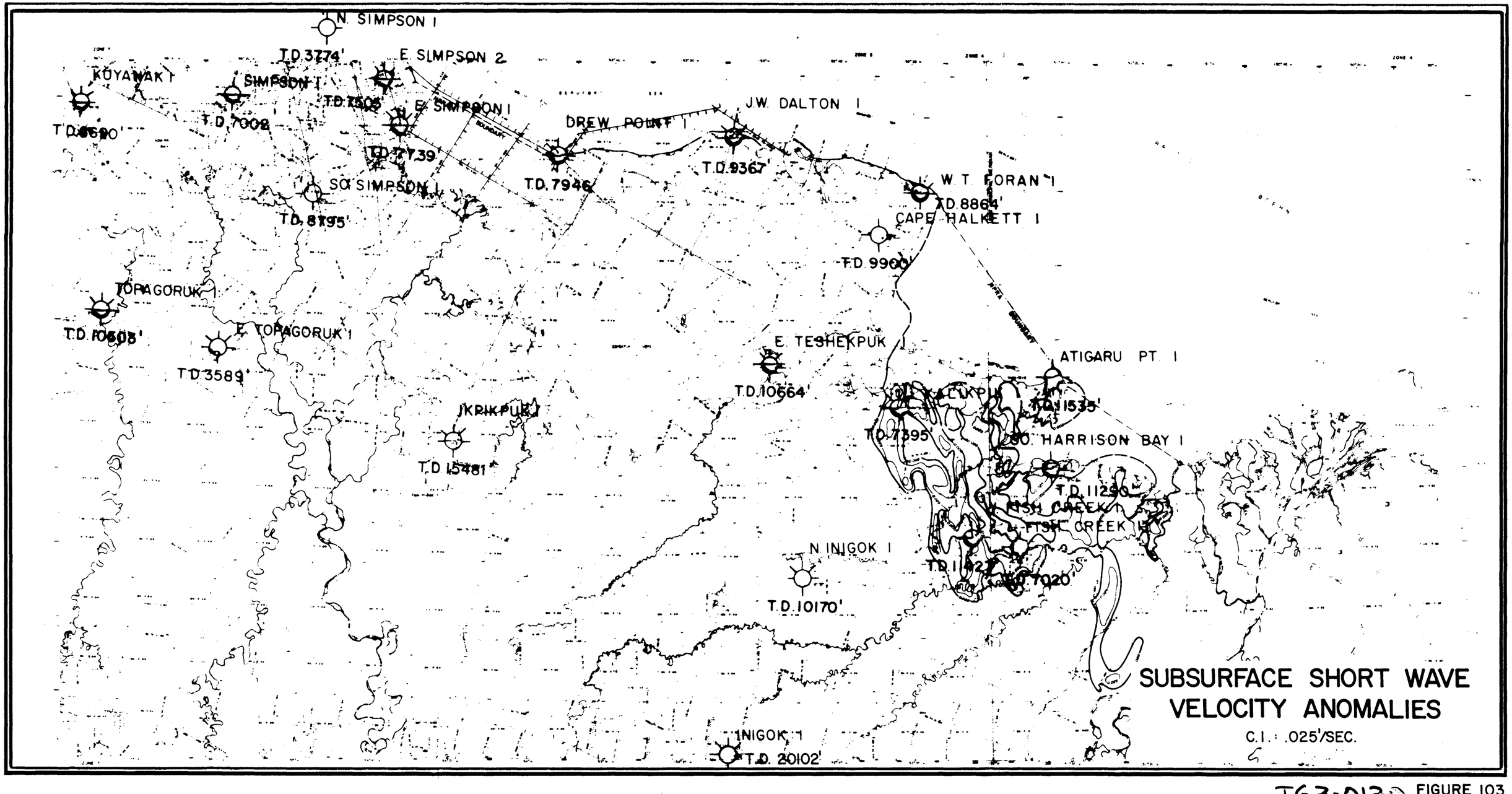
TGZ-0170 FIGURE 102

FIGURE 103

SUBSURFACE SHORT-WAVE VELOCITY ANOMALIES

This figure shows the distribution of subsurface short-wave velocity anomalies in the Fish Creek Platform area. These anomalies result from rapid variations in the thickness of the "Pebble Shale" unit. The absence of the low-velocity "Gamma Ray Shale," "Pebble Shale," and some basal Torok sediments, due to erosion, contributes to the subsurface anomalies. These anomalies manifest themselves as "pull-ups" of underlying pre-Cretaceous reflectors on the seismic sections.

FIGURE 103



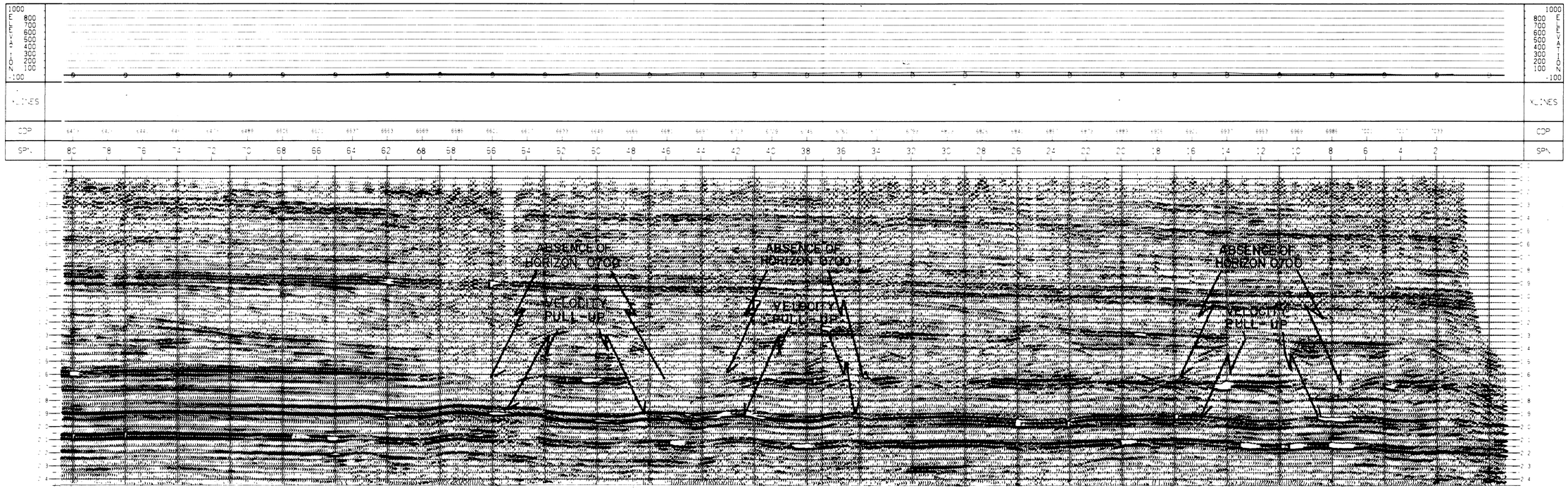
TGZ-0170 FIGURE 103

FIGURE 104

LINE 75-75-G-1182, SHOTPOINTS 1-80, FINAL STACK

This northwest-southeast seismic line across the Fish Creek area illustrates the result of the subsurface short-wave velocity anomalies discussed in figure 103. Where horizon 0700 is absent, part of the "Pebble Shale" was removed by erosion. The underlying reflectors clearly are "pulled-up" as a result of these anomalies.

FIGURE 104



DEPARTMENT OF THE NAVY

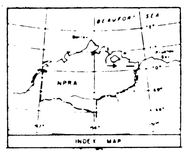
NAVAL PETRO. RESERVE-4
COASTAL ZONE

75-75-G-1182

80

FINAL STACK

FIGURE 104



MILES
0 10 20

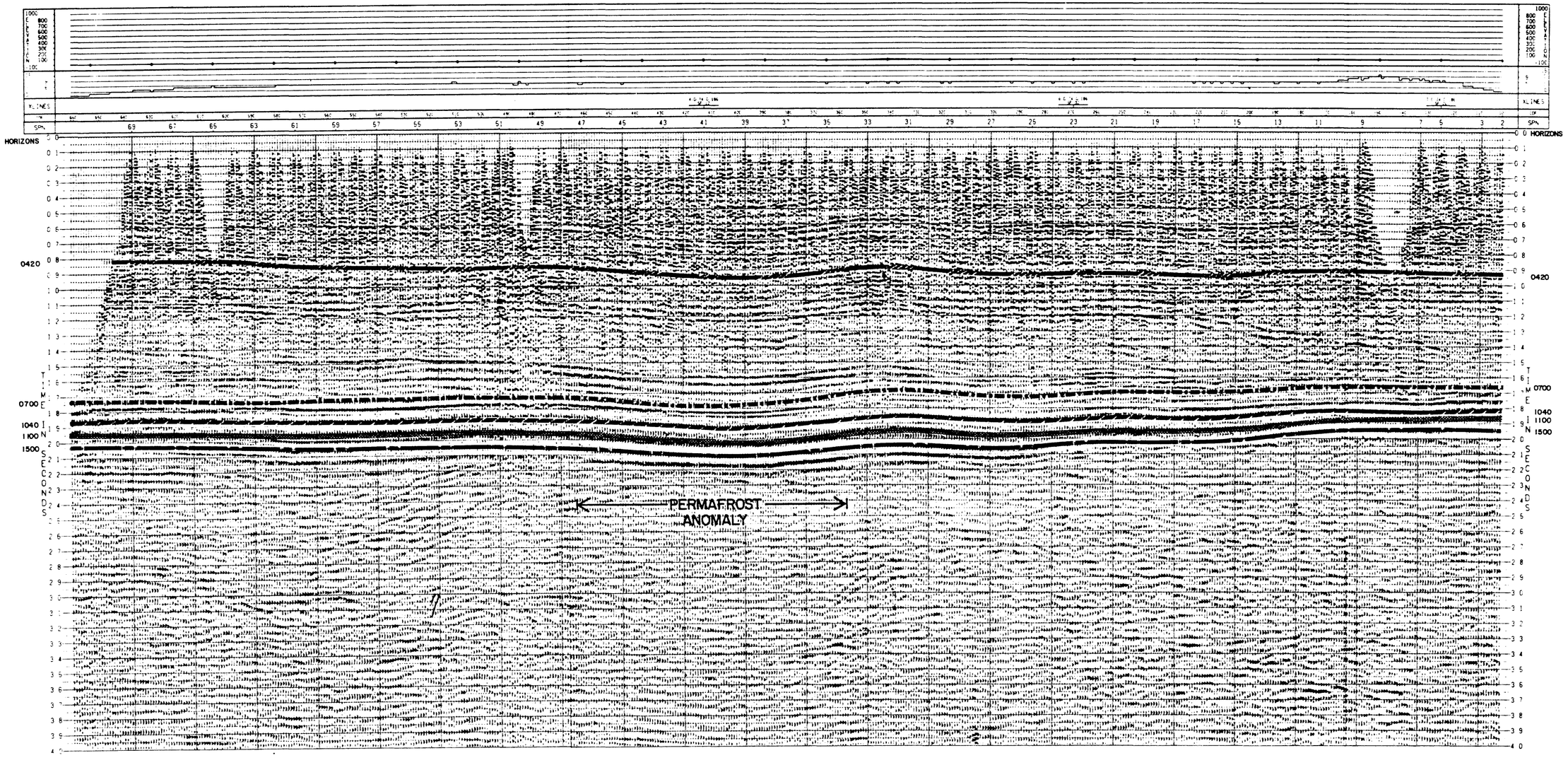
TGZ-0170

FIGURE 105

LINE 3D-74-G-186, SHOTPOINTS 2-69,
SCALED FINAL STACK

All reflections on line 3D-74 exhibit a pronounced sag between shotpoints 35 and 45. When all seismic reflections exhibit the same amount of sag, a surface or near-surface anomaly usually exists. In the NPRA, this type of anomaly is explained by inconsistencies in the thickness or velocity of the high-velocity permafrost layer. In certain areas, especially near active lakes and streams, the permafrost layer is abnormally thin. This lack of high-velocity surface material causes the pulldowns or sags seen on seismic sections.

FIGURE 105



USGS
ONPRA

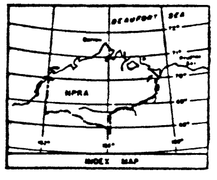
HUSKY OIL NPR OPRS. INC
NATIONAL PETROLEUM RESERVE ALASKA
ZONE A

3-D-74-G-186

SHOTPOINTS 2-69

SCALED FINAL STACK

FIGURE 105



0 1.0 2.0
MILES

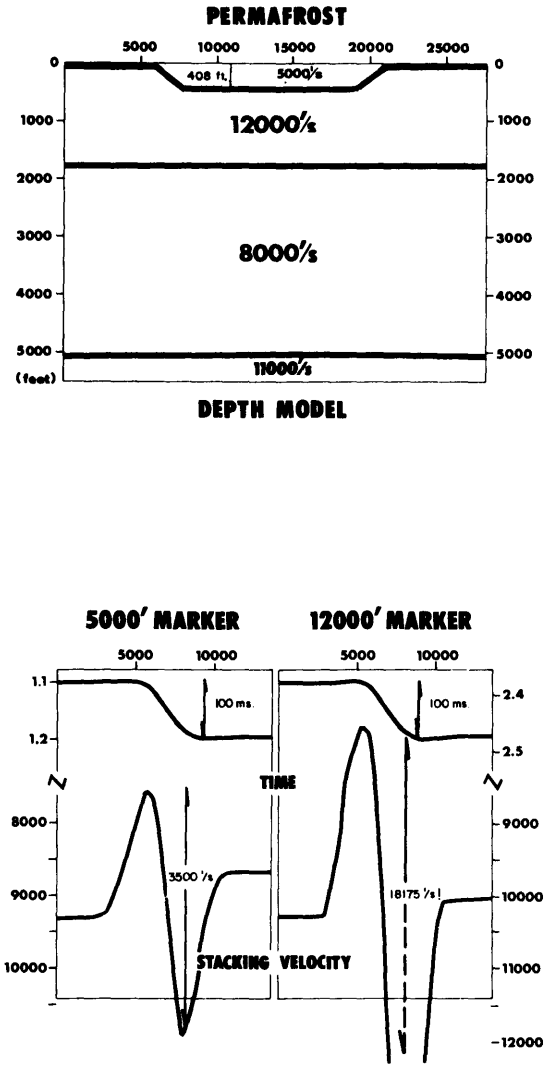
TETRA TECH REPORT NO.8200

TGZ-0170

FIGURE 106

MODEL OF A PERMAFROST VELOCITY ANOMALY

Figure 106 illustrates a simple model with a short-wave, permafrost-type, low-velocity anomaly at the surface. The figure shows the effects of this anomaly on the reflection time and stacking velocity of two horizontal markers at 5,000 ft and 12,000 ft, with stacking velocity fluctuations of 3,500 ft/s and 18,175 ft/s, respectively, across the edge of the anomaly. The average velocity grades smoothly from about 9,300 ft/s to 8,700 ft/s for the shallow marker, and from about 10,300 ft/s to 10,000 ft/s for the deep marker (MacCallum and Card, 1978, p. 55-65).



(MacCALLUM AND CARD, 1978)

FIGURE 106. MODEL OF A PERMAFROST VELOCITY ANOMALY

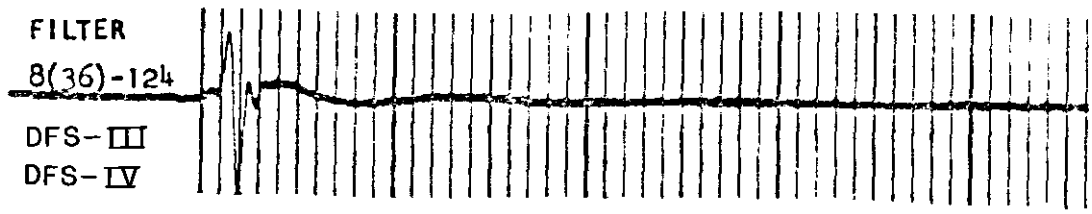
TGZ-0170

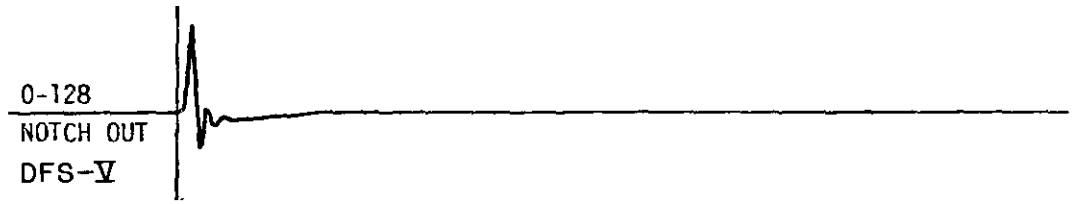
FIGURE 107

IMPULSE RESPONSE OF DFS-III, DFS-IV, AND DFS-V RECORDING SYSTEMS

Figure 107 shows the impulse response of various field recording filters used with DFS (Digital Field System)-III, DFS-IV, and DFS-V recording systems. These types of systems with broad-band filters were used to record all NPRA seismic data in 1972 through 1981.

FIGURE 107





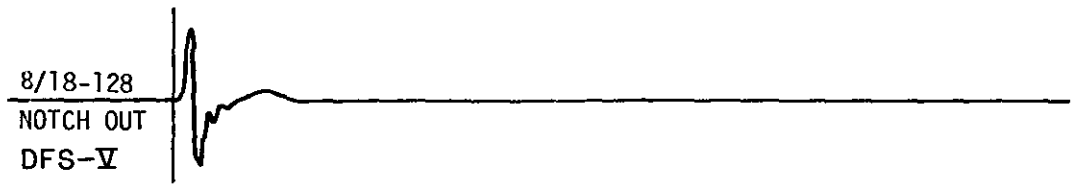


FIGURE 107. IMPULSE RESPONSE OF DFS – III, DFS – IV, AND DFS – V RECORDING SYSTEMS

TGZ-0170

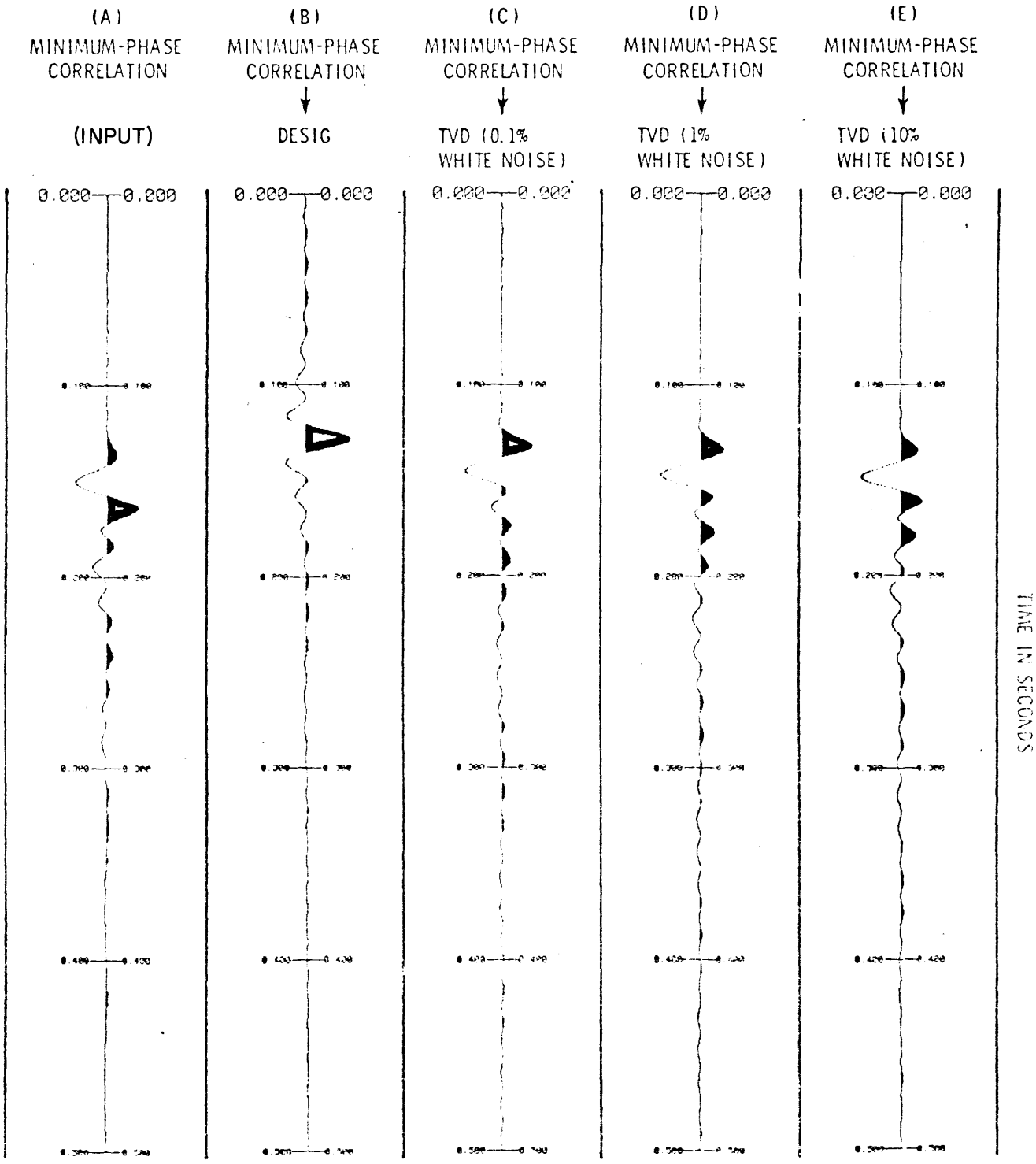
FIGURE 108

OUTPUT FROM VARIOUS DECONVOLUTION OPERATORS

Figure 108 illustrates the effects of various deconvolution operators on a wavelet resulting from minimum phase correlation of Vibroseis data obtained from a test impulse. The information presented is directly applicable to data acquired using dynamite as the energy source.

A nearly minimum phase wavelet similar to the one displayed under "A" in the figure would result from a positive reflection coefficient if SEG standard recording polarity is used. The NPRA seismic data processed with time variant deconvolution (TVD) had 5 to 10 percent white noise added, thus "E" in the figure is the appropriate display of the output after TVD. The resulting complex wavelet most closely approximates zero phase, and a positive reflection coefficient produces a trough. The output after designature deconvolution (DESIG), shown under "B" in the figure, is virtually zero phase, with a positive reflection coefficient producing a peak. The maximum amplitude of the DESIG output occurs at an earlier time than the TVD output. The relative phase angle between DESIG and TVD output is about 180°, nearly equivalent to reversing the polarity.

OUTPUT FROM VARIOUS DECONVOLUTION OPERATORS



TETRA TECH REPORT NO.8200

FIGURE 108

TGZ-0170

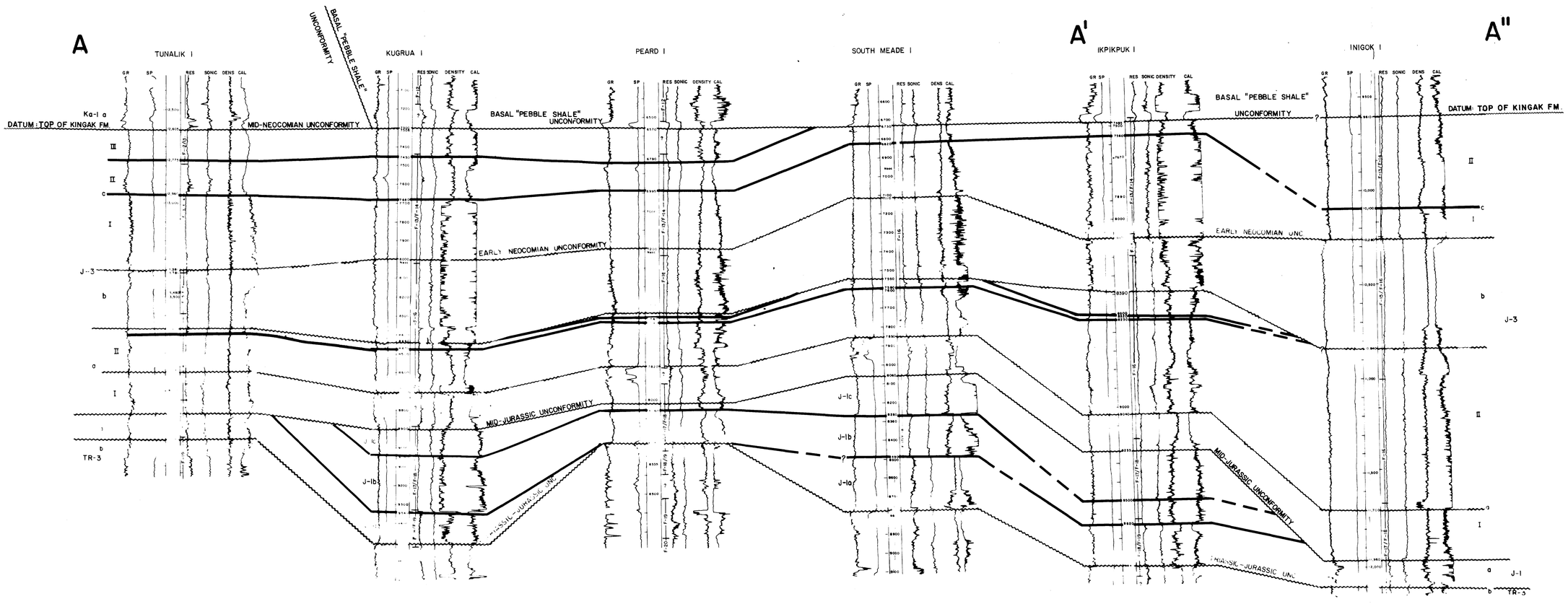
FIGURE 109

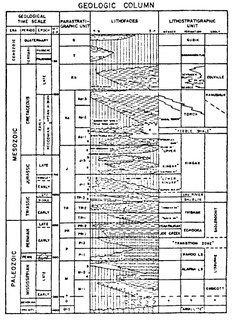
CORRELATION CROSS SECTION A-A'-A", *TUNALIK 1 TO INIGOK 1*

The datum of cross section A-A'-A" is the top of the Kingak Formation. The cross section shows the major J-1 subdivisions and all of the J-3 subdivisions, which are the J-3aI and J-3aII subunits of J-3a; J-3b; and the J-3cI, J-3cII, and J-3cIII subunits of J-3c.

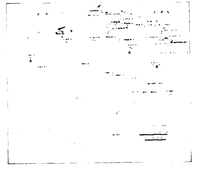
An unconformity between the Triassic and Jurassic separates unit J-1 from the underlying TR-3 unit. The mid-Jurassic unconformity separates unit J-1 from the overlying J-3 unit, and an early Neocomian unconformity separates units J-3b and J-3c. The basal "Pebble Shale" unconformity defines the top of the Kingak Formation, except at Tunalik 1 where the mid-Neocomian unconformity separates units J-3c and Ka-1a.

The AWA foraminifera zonules are displayed to show their relationship to the lithologic subdivisions.





NO HORIZONTAL SCALE



TETRA TECH, INC

CORRELATION CROSS SECTION A A' A''
TUNALIK - INIGOK

NPR ALASKA

ONPRA
HUSKY OIL NPR OPERATIONS INC

TETRA TECH REPORT NO.8200

TGZ-0170

FIGURE 109

FIGURE 110

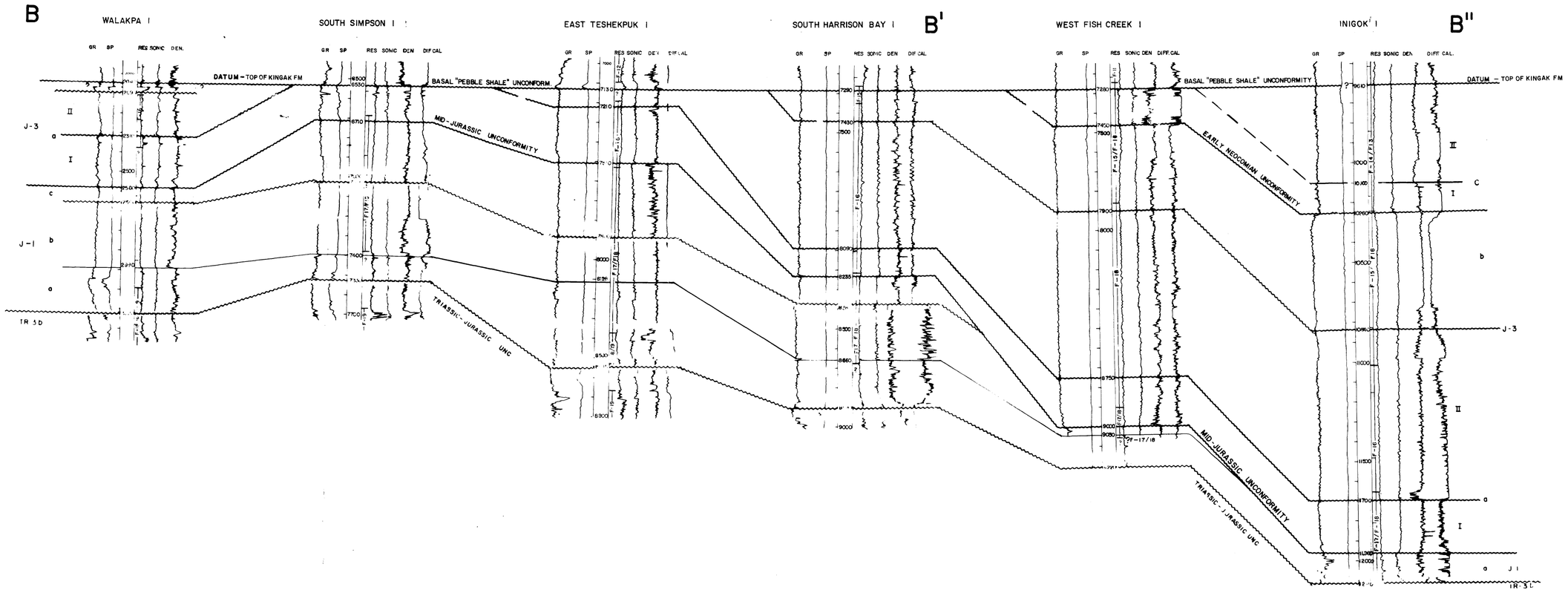
CORRELATION CROSS SECTION B-B'-B",
WALAKPA 1 TO INIGOK 1

The datum for cross section B-B'-B" is the top of the Kingak Formation. As in figure 109, this section shows unit J-1 unconformably overlying Triassic rocks and unit J-3 unconformably overlying unit J-1.

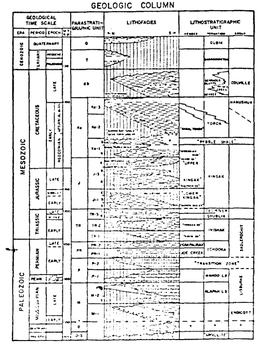
Across the area represented by this cross section, the basal "Pebble Shale" unconformity defines the top of the Kingak Formation. At Walakpa 1, South Simpson 1, and East Teshekpuk 1, units J-3b, J-3c, and parts of unit J-3a were eroded, leaving a relatively thinner "Upper Kingak" section.

The AWA foraminifera zonules shown for each well indicate their relationship to the lithologic subdivisions.

FIGURE 110



GEOLOGIC COLUMN



NO HORIZONTAL SCALE

TETRA TECH, INC.

CORRELATION CROSS SECTION B-B'-B''

WALAKPA - INIGOK I

NPR ALASKA

ONPRA

HUSKY OIL NPR OPERATIONS INC.

TETRA TECH REPORT NO. 8200

FIGURE 110

TGZ-0170

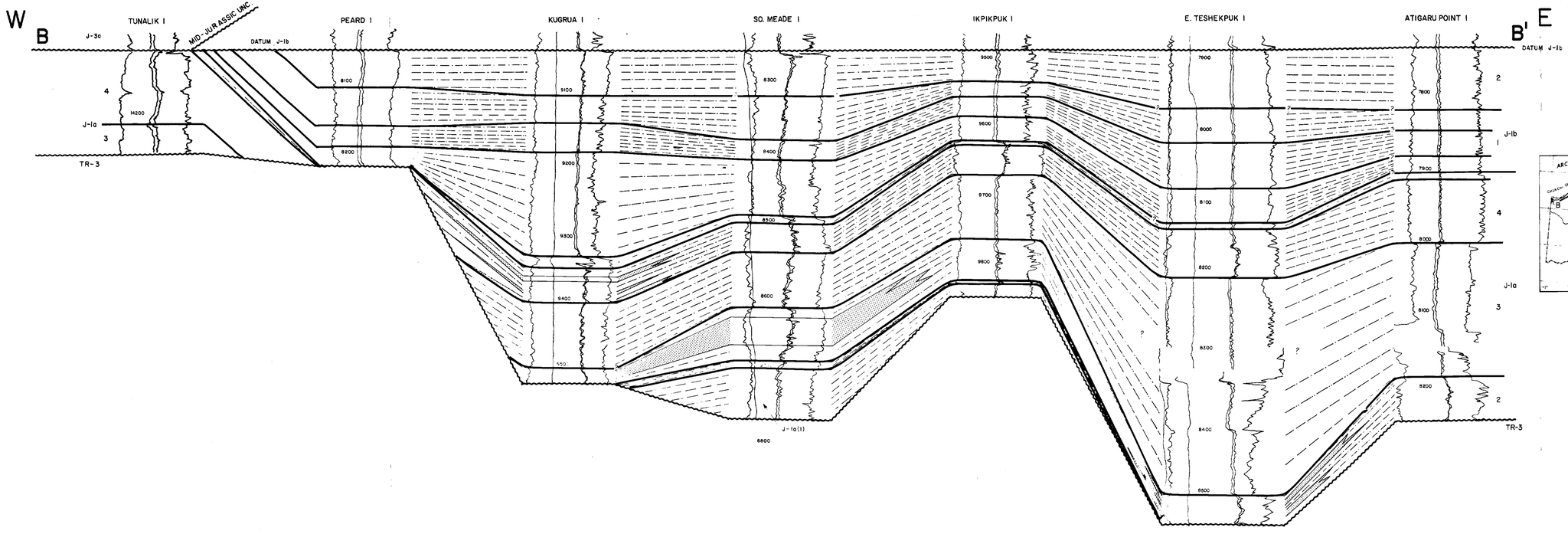
FIGURE 111

CORRELATION CROSS SECTION B-B',
TUNALIK 1 TO ATIGARU POINT 1

This section shows detailed facies correlations within units J-1a and J-1b ("Lower Kingak"). The datum for the section is the top of unit J-1b, which in this area is a local unconformity. The rest of the "Lower Kingak" is unit J-1c, as shown on figures 113 and 114. The unconformity at the top of unit TR-3 is at the bottom of the section.

Unit J-1a has four subunits: J-1a(1), J-1a(2), J-1a(3), and J-1a(4). Unit J-1b has two subunits: J-1b(1) and J-1b(2). On this section, subunit J-1a(1) is present only in South Meade 1 and Ikpikpuk 1. In Tunalik 1, only J-1a(4) and the upper part of J-1a(3) are present. In Peard 1, J-1a is absent and J-1b(1) directly overlies TR-3.

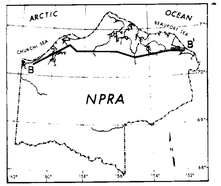
FIGURE 111



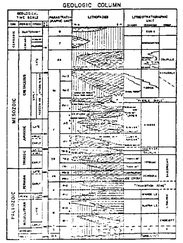
EXPLANATION

- SHALE
- SILTY SHALE
- SILTSTONE
- SILTY SANDSTONE
- SANDSTONE
- BAR SANDSTONE
- UNCONFORMITY

NO HORIZONTAL SCALE



INDEX MAP



TETRA TECH, INC

HOUSTON, TEXAS — ENERGY MANAGEMENT DIVISION — PASADENA, CALIFORNIA

PETROLEUM EXPLORATION OF NPRA -74-1981 (FINAL REPORT)

CORRELATION CROSS SECTION B-B'
TUNALIK 1 - ATIGARU POINT 1

NPR — ALASKA

FOR:

ONPRA

HUSKY OIL NPR OPERATIONS INC.

PROJECT MANAGER: J.W. BRUYNZEEL		PROJECT NO. TC-7174	
INTERPRETATION BY: M.B. ORLOVSKY		REVISED	
		DATE	INITIAL
DATE: MAY, 1981	DATUM: J-1b		
CONTOUR INT:	SCALE:	DWG NO.	

TETRA TECH REPORT NO. 6200 — TG2-0170 — FIGURE 111

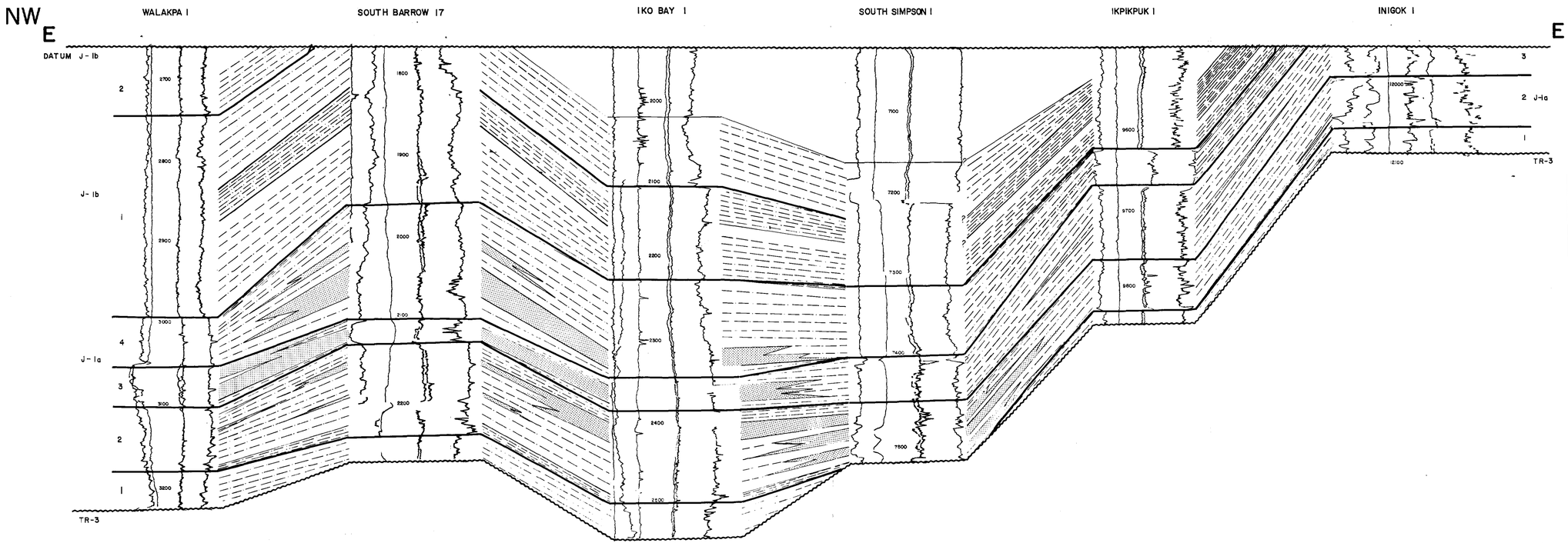
FIGURE 112

CORRELATION CROSS SECTION E-E',
WALAKPA 1 TO INIGOK 1

This section shows detailed facies correlations within units J-1a and J-1b ("Lower Kingak"). The datum for the section is the top of unit J-1b, which in this area is a local unconformity. The rest of the "Lower Kingak" is unit J-1c, as shown on figures 113 and 114. The unconformity at the top of unit TR-3 is at the bottom of the section.

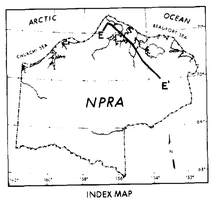
Unit J-1a has four subunits: J-1a(1), J-1a(2), J-1a(3), and J-1a(4). Unit J-1b has two subunits: J-1b(1) and J-1b(2). Subunit J-1a(1) is absent at South Simpson 1. Subunit J-1b(2) is present only at Walakpa 1. At Inigok 1, the upper part of J-1a(3) and all of J-1a(4) and J-1b are absent.

FIGURE 112

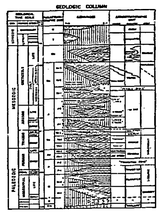


EXPLANATION

- SHALE
- SILTY SHALE
- SILTSTONE
- SILTY SANDSTONE
- SANDSTONE
- BAR SANDSTONE
- UNCONFORMITY



INDEX MAP



NO HORIZONTAL SCALE

TETRA TECH, INC.
HOUSTON TEXAS — ENERGY MANAGEMENT DIVISION — PASADENA, CALIFORNIA

PETROLEUM EXPLORATION OF NPRA 1974-1981 (FINAL REPORT)

CORRELATION CROSS SECTION E-E'
WALAKPA I - INIGOK I

NPR — ALASKA

FOR
ONPRA
HUSKY OIL NPR OPERATIONS INC.

PROJECT MANAGER: J. W. BRUYNZEEL		PROJECT NO. TC-7174	
INTERPRETATION BY: M. B. ORLOVSKY		REVISED DATE	INITIAL
DATE: MAY 1981	DATUM: J-1b		
CONTOUR INT:	SCALE: 1.5" = 100'	DWG NO.	

TETRA TECH REPORT NO. 6200 — TGZ-0170

FIGURE 112

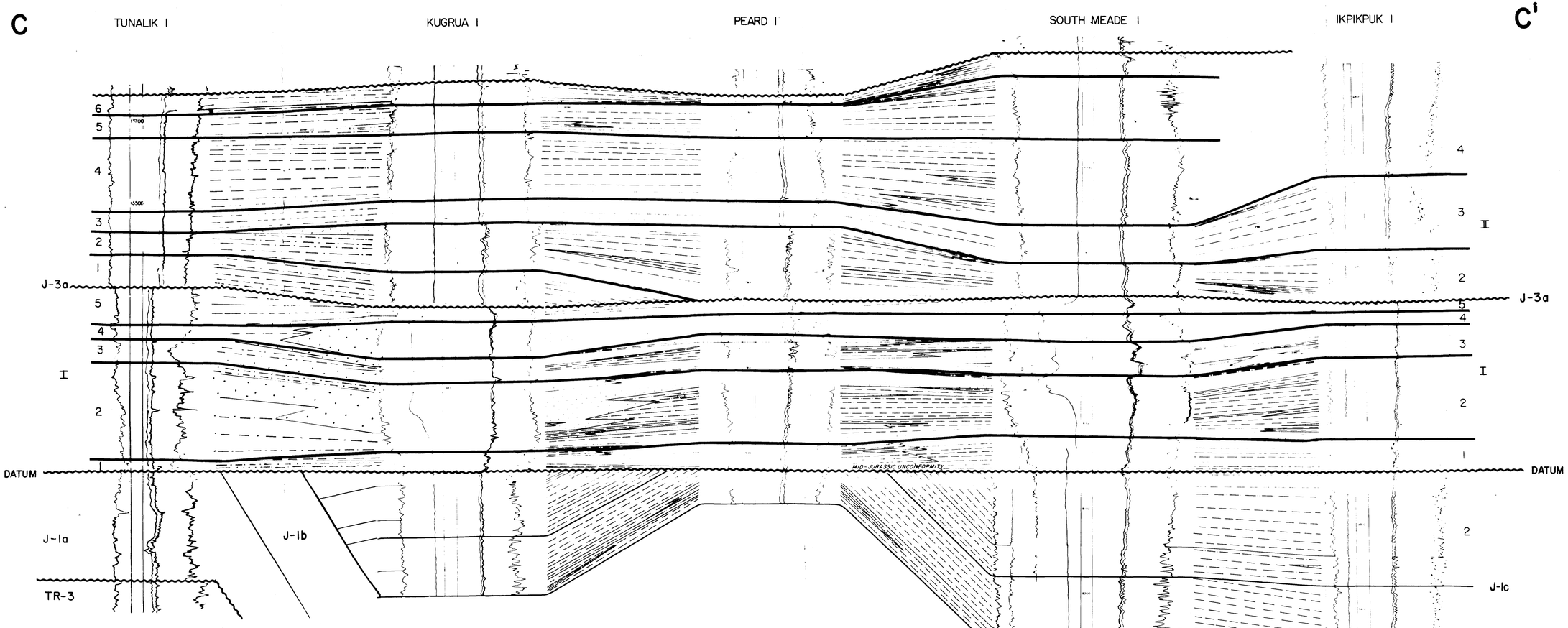
FIGURE 113

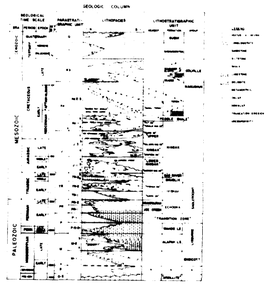
CORRELATION CROSS SECTION C-C',
TUNALIK 1 TO IKPIKPUK 1

This section shows detailed facies correlations within the subunits J-1c(1) and J-1c(2) (uppermost "Lower Kingak") and unit J-3a (lowermost "Upper Kingak"). Unit J-1a is present in Tunalik 1, where units J-1b and J-1c are absent. The datum for the section is the mid-Jurassic unconformity. The top of unit J-3a is a local unconformity.

Above the mid-Jurassic unconformity, subunits J-3aI and J-3aII were finely subdivided for more detailed study. J-3aI, which contains the "Simpson sandstone," is divided into five subunits. The best developed sands on this cross section appear in subunit J-3aI(4) at Kugrua 1, Peard 1, and South Meade 1.

Unit J-3aII is divided into six subunits. Subunit J-3aII(1) is present only in Tunalik 1 and Kugrua 1. Units J-3aII(5) and J-3aII(6) are not recognizable in Ikpikpuk 1.





NO HORIZONTAL SCALE

TETRA TECH, INC.
ENERGY MANAGEMENT DIVISION PASADENA, CALIFORNIA
JURASSIC STRATIGRAPHIC STUDY
CORRELATION CROSS SECTION C-C'
TUNALIK I - IKPIKPUK I
NPR ALASKA
ONPRA
HUSKY OIL NPR OPERATIONS INC
PROJECT MANAGER: J. M. MELVILLE
INTERPRETATION BY: M. M. DALLAHAY
DATE: AUGUST 1983
DRAFTSMAN BY: MICHAEL A. LEED
PROJECT NO. 17-1-158
SCALE: NONE
DATE: 8/83
TETRA TECH REPORT NO. 6200

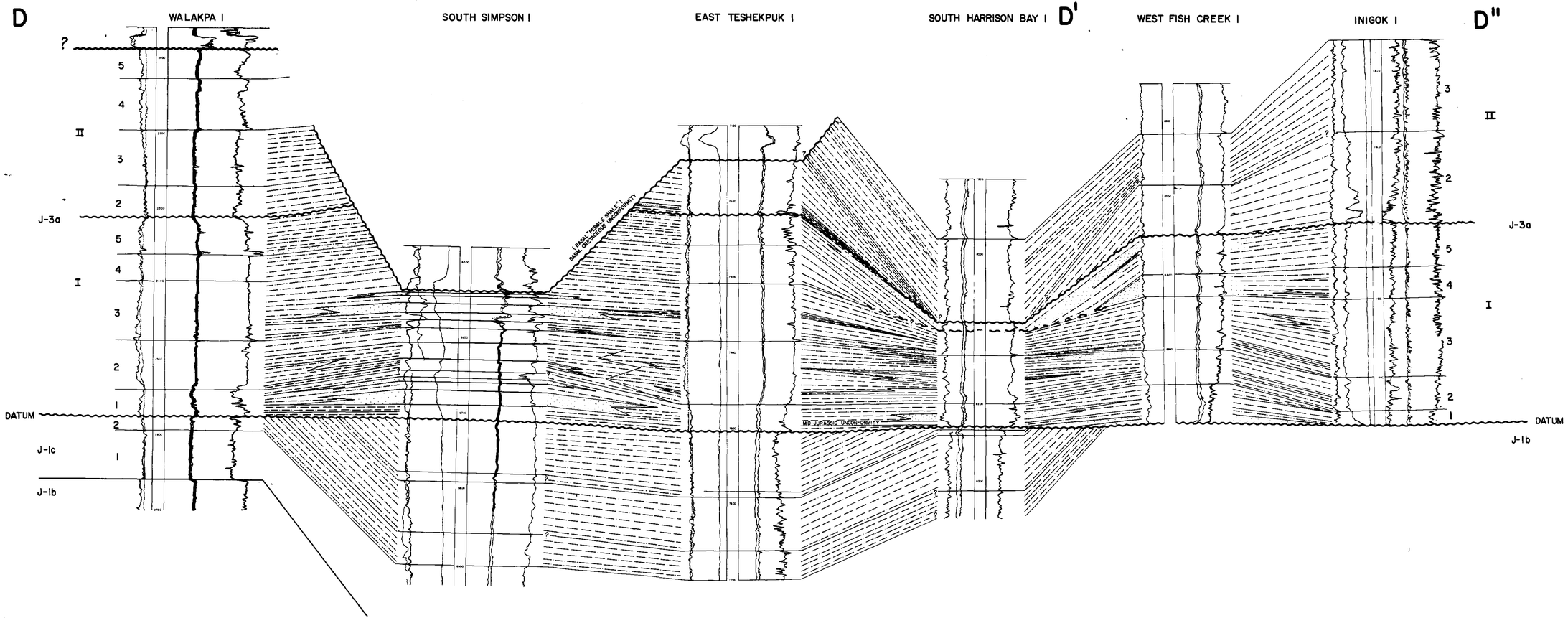
TGZ-0170 FIGURE 113

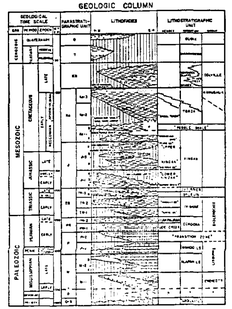
FIGURE 114

CORRELATION CROSS SECTION D-D'-D", WALAKPA 1 TO INIGOK 1

This section shows detailed facies correlations for subunit J-1c(2) (uppermost "Lower Kingak") and subdivisions of unit J-3a (lowermost "Upper Kingak"). All of unit J-1c is absent in West Fish Creek 1 and Inigok 1. The datum is the mid-Jurassic unconformity. The top of J-3a is a local unconformity in this area.

Unit J-3a is the interval that contains the "Simpson sandstone"; the best development of this sandstone on this section is at South Simpson 1. Subunits J-3aI and J-3aII were subdivided further for more detailed study. All of subunit J-3aI(4) and most of the basal part of J-3aI(5) are missing at South Harrison Bay 1 where these subunits appear to lap onto a minor, local unconformity. At South Harrison Bay 1, subunit J-3aII(2) is interpreted to lap onto J-3aI(5). The upper part of J-3aI and all of J-3aII are truncated by the basal "Pebble Shale" unconformity, which also truncates the upper part of J-3aII(3) at East Teshekpuk 1. At Walakpa 1, the "Walakpa sandstone" is interpreted to overlie the basal "Pebble Shale" unconformity at the top of subunit J-3aII(5).





NO HORIZONTAL SCALE

TETRA TECH, INC.
ENERGY MANAGEMENT DIVISION
DENVER, COLORADO
CORRELATION CROSS SECTION D-D-D''
WALAKPA - NICOL
NPR ALASKA
ONPRA
HUSKY OIL NPR OPERATIONS INC.
TETRA TECH REPORT NO. 8200

TGZ-0170

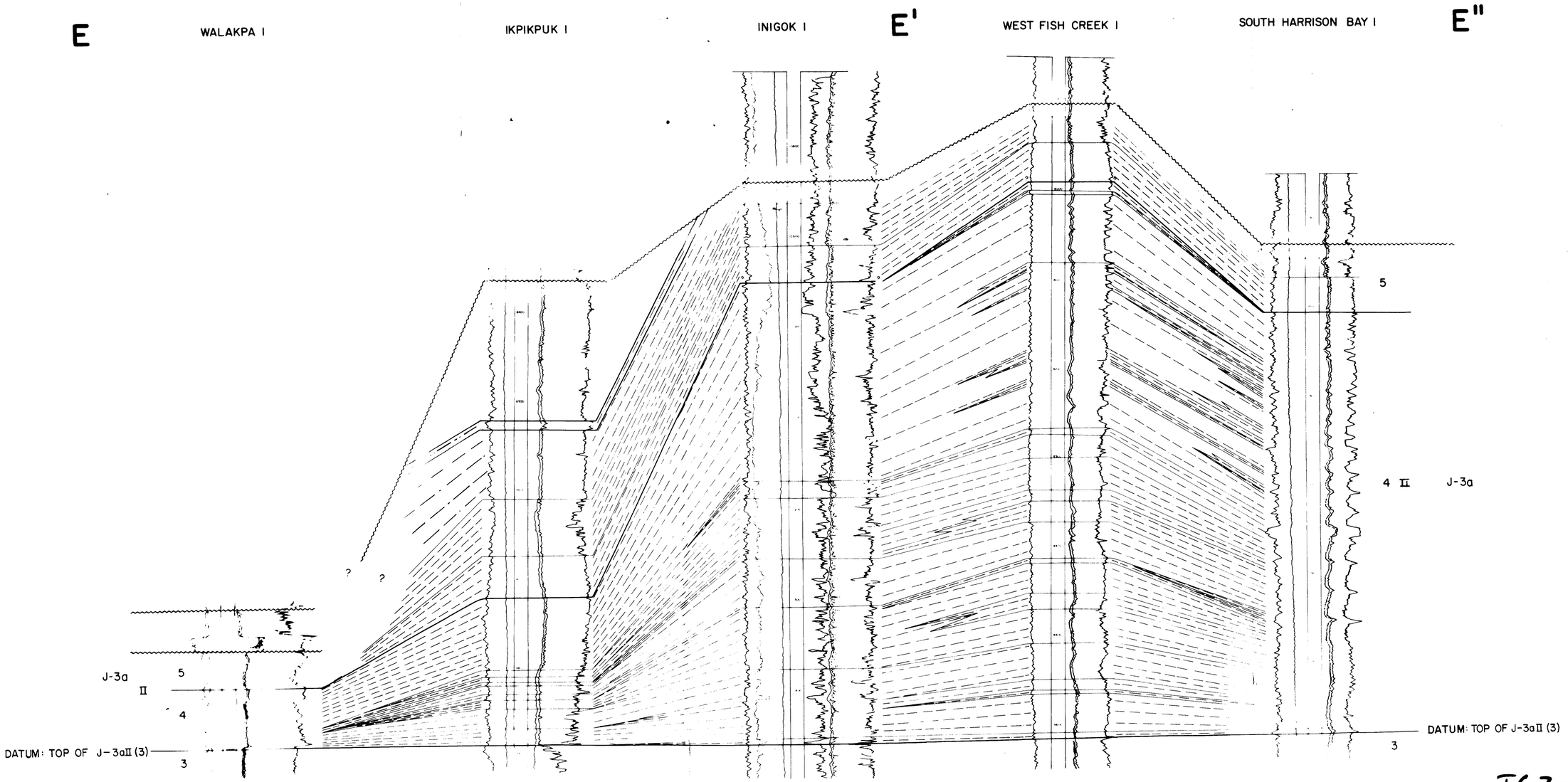
FIGURE 114

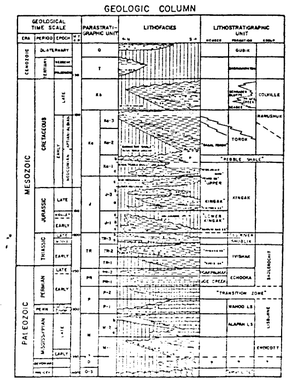
FIGURE 115

CORRELATION CROSS SECTION E-E'-E",
WALAKPA 1 TO SOUTH HARRISON BAY 1

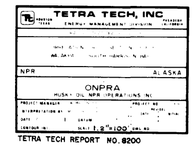
This section shows detailed facies correlations for subunits J-3aII(4) and J-3aII(5). The datum is the top of subunit J-3aII(3). The top of the section from Ikpikpuk 1 eastward is the base of unit J-3b.

At Walakpa 1, the top of subunit J-3aII(5) is the basal "Pebble Shale" unconformity, but the relationship of this part of the stratigraphic section at Walakpa 1 to that in other wells is uncertain. The section shows great thickening of J-3aII(4) from Walakpa 1 toward West Fish Creek 1, and thickening of J-3aII(5) from Walakpa 1 to Ikpikpuk 1.





NO HORIZONTAL SCALE



TGZ-0170

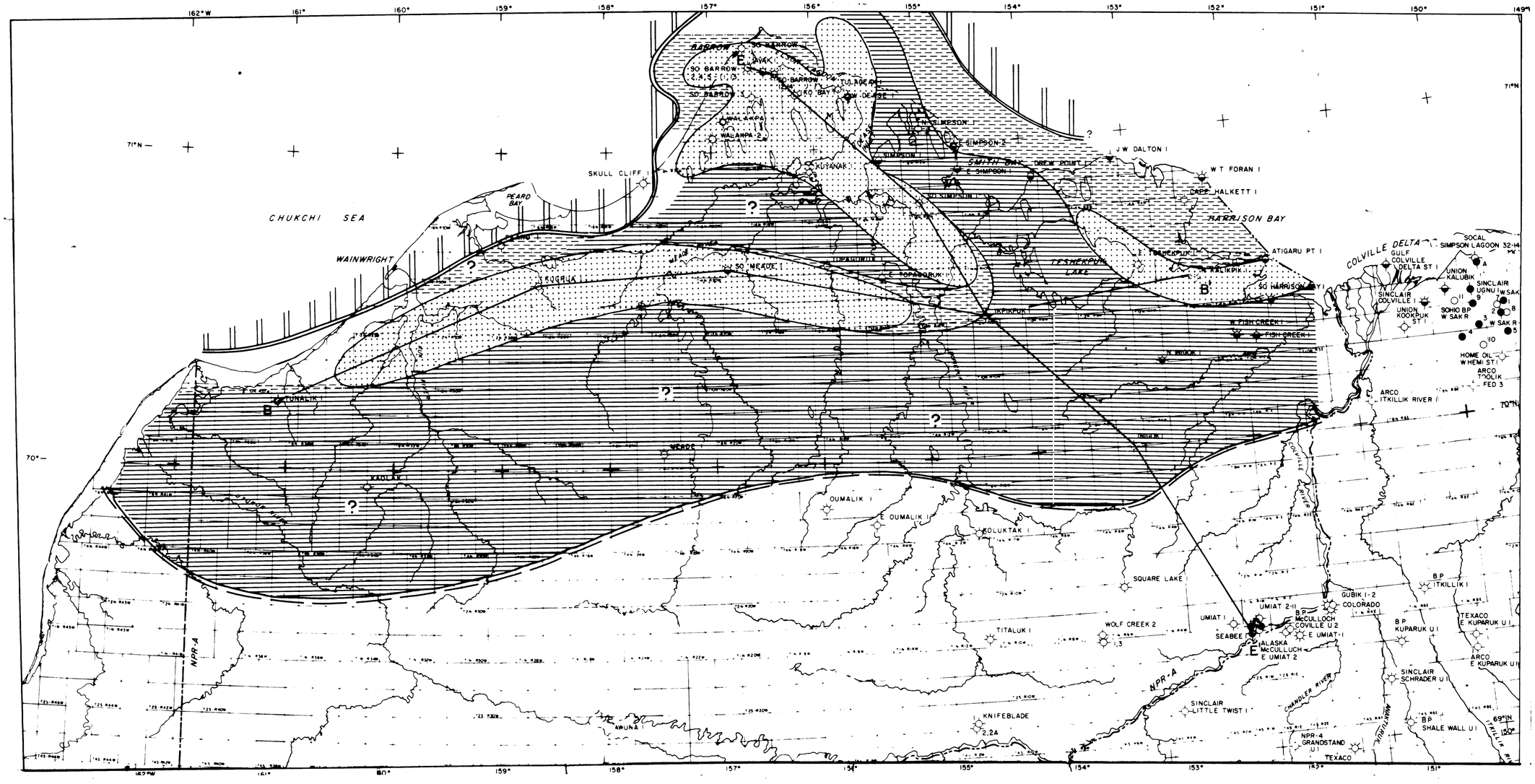
FIGURE 115

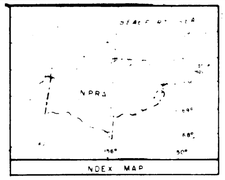
FIGURE 116

FACIES MAP OF EARLY JURASSIC SEDIMENTATION (J-1a)

Figure 116 shows the facies distribution of Early Jurassic (J-1a) strata in the NPRA. The linear distribution of sands indicates probable deposition as strand bars. The presence of adjacent clays creates possible hydrocarbon environments because of the close proximity of potential sources to potential reservoirs.

FIGURE 116





EXPLANATION

- LOCATION
- ABANDONED WELL
- ABANDONED WELL GAS SHOW
- ABANDONED WELL OIL SHOW
- GAS
- OIL
- ABANDONED OIL

EXPLANATION

- CLAY
- SILT
- SAND
- BAR
- PROBABLY NON-MARINE SEDIMENTATION
- APPROXIMATE J-1a LIMIT
- A — A' FACIES PROFILES

TETRA TECH, INC.
HOUSTON TEXAS — ENERGY MANAGEMENT DIVISION — PASADENA CALIFORNIA

PETROLEUM EXPLORATION OF NPRA 1974-1981 (FINAL REPORT)

FACIES MAP OF EARLY JURASSIC SEDIMENTATION (J-1a)

NPR — ALASKA

ONPRA
HUSKY OIL NPR OPERATIONS INC

PROJECT MANAGER J. W. BRUYNZEEL	PROJECT NO
ORIGINAL INTERPRETATION BY M. B. ORLOVSKY	REVISED INTERPRETATION
DATE JUNE 1, 1981	DATUM
CONTOUR INT	SCALE

TETRA TECH REPORT NO. 8200

FIGURE 116

TG2-0170

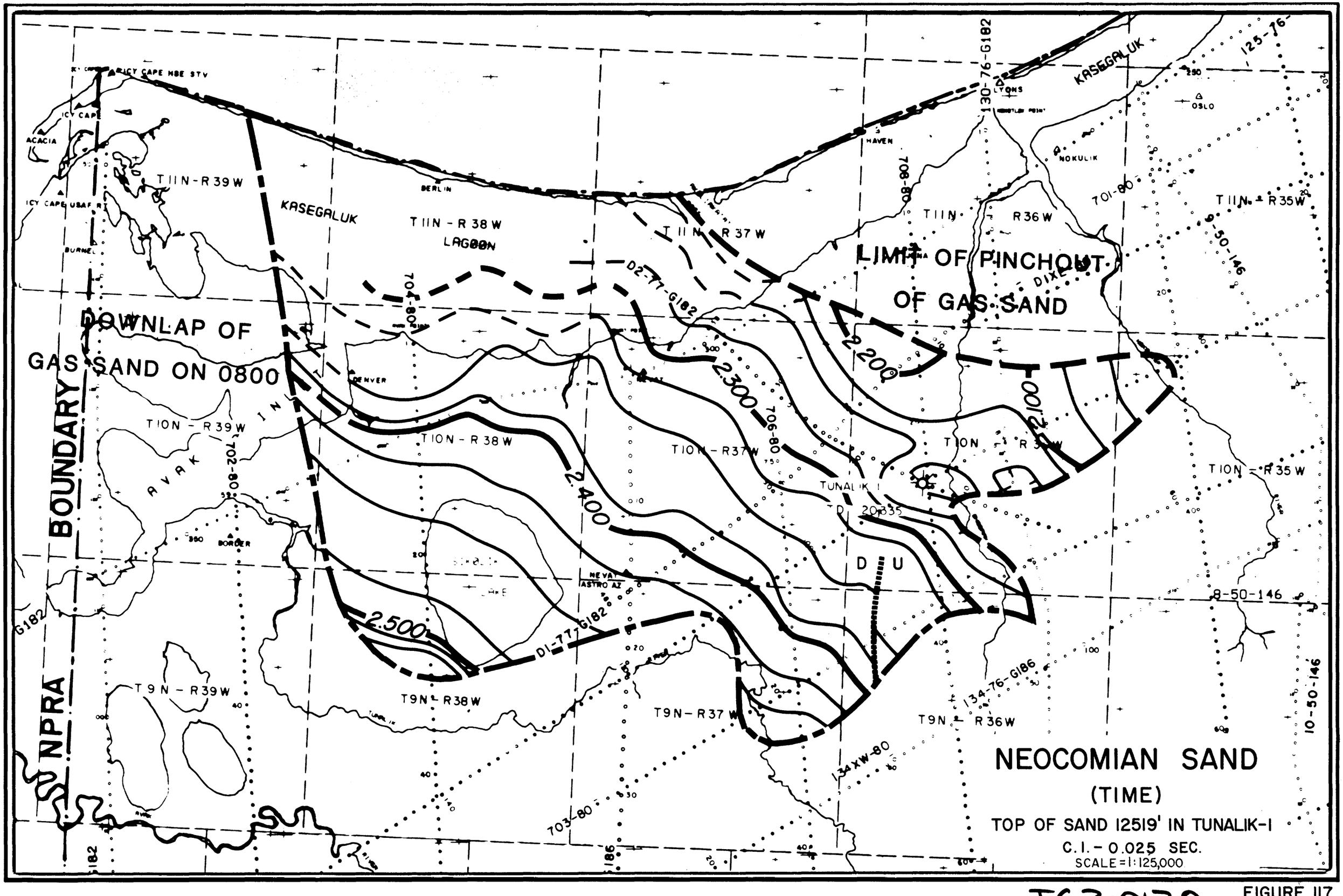
FIGURE 117

NEOCOMIAN SAND, TIME, TOP OF
SAND IN TUNALIK 1

The Neocomian sand represented by this time map is interpreted as lying immediately above seismic horizon 0800. To the west and south, the sands appear to downlap onto the horizon on the seismic sections; the northwestern limit is not as well defined seismically. The Neocomian sand terminates due to either truncation by a local unconformity or lateral facies change to the northwest.

Contours are represented by dashes in the northwestern part of the map due to a lack of seismic data.

FIGURE 117



TG2-0170

FIGURE 117

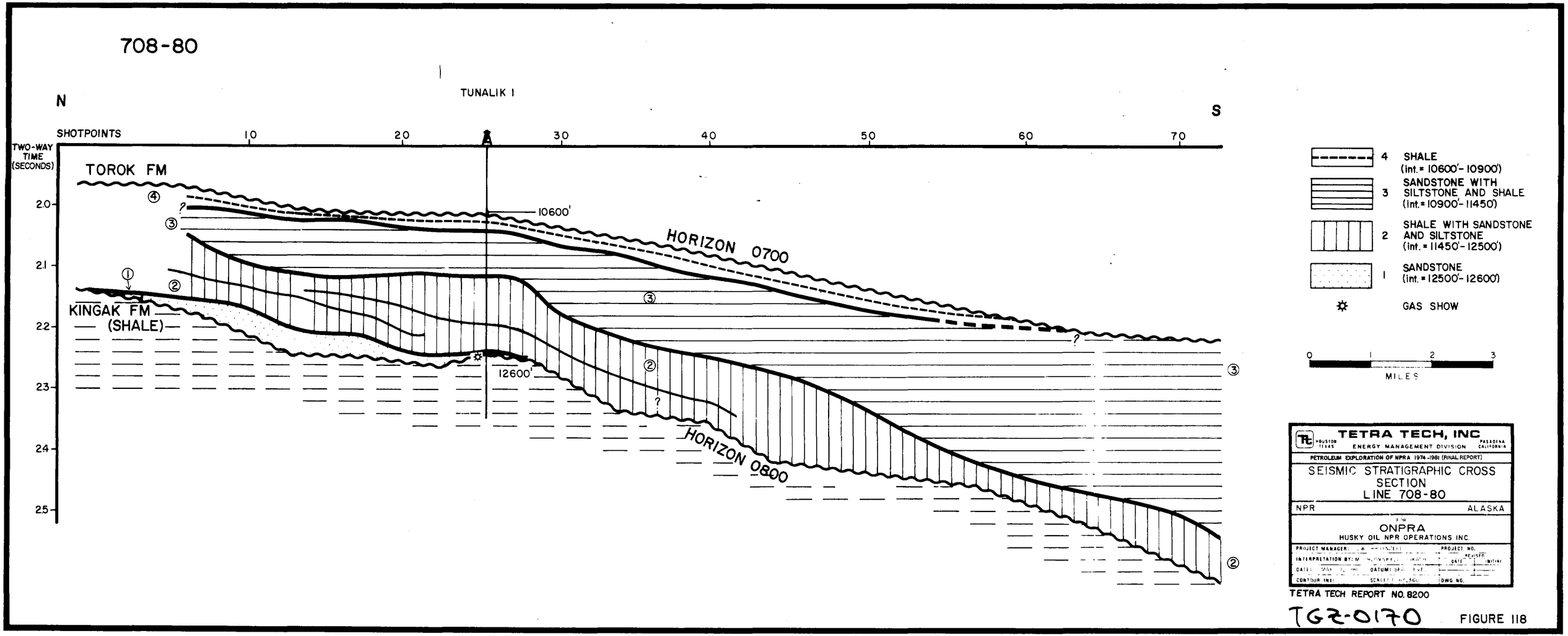
FIGURE 118

SEISMIC-STRATIGRAPHIC CROSS SECTION, LINE 708-80

This cross section illustrates the stratigraphic relationship between the uppermost Kingak Formation and the overlying "Pebble Shale" unit and Torok Formation. The "Pebble Shale" unit is denoted by ④ on figure 118. Numbers ①, ②, and ③ represent the interval containing the Neocomian sands at Tunalik 1; this interval is equivalent to the Ka-la parastratigraphic unit and was identified only in Tunalik 1.

The Neocomian sand with significant gas shows in the interval from 12,510 to 12,565 ft (3,814 to 3,831 m) is the sand unit represented as ①.

FIGURE 118



TETRA TECH REPORT NO. 8200

TGZ-0170

FIGURE 118

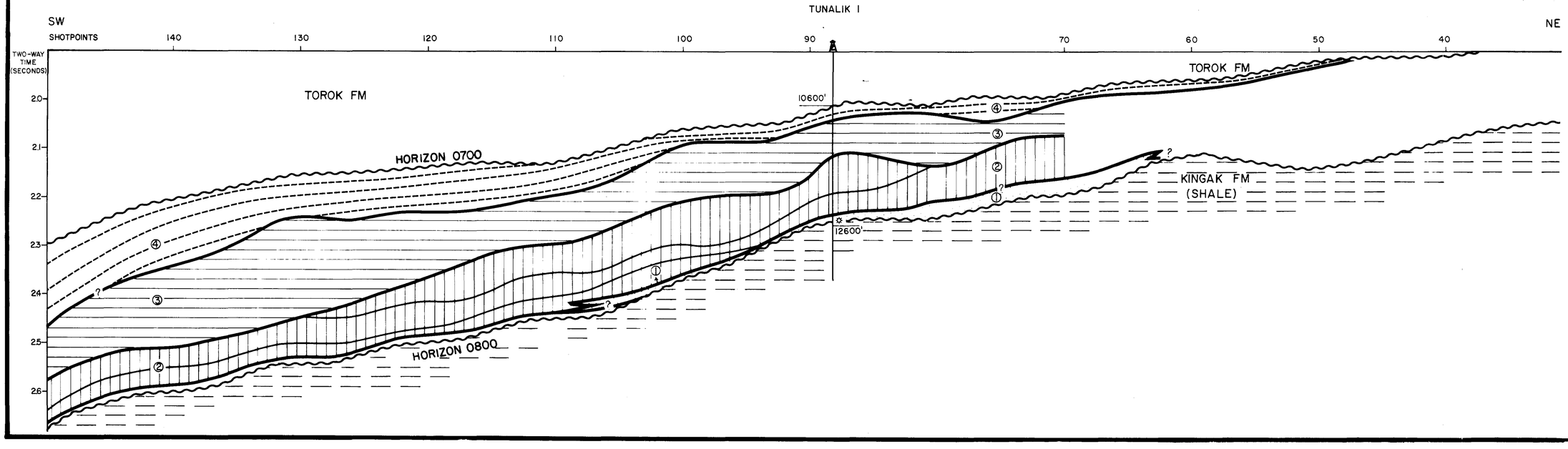
FIGURE 119

SEISMIC-STRATIGRAPHIC CROSS SECTION, LINE D5XW-80

This cross section illustrates the stratigraphic relationship between the uppermost Kingak Formation and the overlying "Pebble Shale" unit and Torok Formation. The "Pebble Shale" unit is denoted by ④ on figure 119. Numbers ①, ②, and ③ represent the interval containing the Neocomian sands at Tunalik 1 that contain gas. This interval is equivalent to the Ka-1a parastratigraphic unit and was identified only in Tunalik 1.

FIGURE 119

D5XW-80



4 SHALE (int.= 10600'- 10900')

3 SANDSTONE WITH SILTSTONE AND SHALE (int.= 10900'- 11450')

2 SHALE WITH SANDSTONE AND SILTSTONE (int.= 11450'- 12500')

1 SANDSTONE (int.= 12500'- 12600')

GAS SHOW

0 1 2 3
MILES

TETRA TECH, INC.
HOUSTON TEXAS — ENERGY MANAGEMENT DIVISION — PASADENA CALIFORNIA

PETROLEUM EXPLORATION OF NPRA 1974-1981 (FINAL REPORT)

SEISMIC STRATIGRAPHIC CROSS SECTION
LINE D5XW-80

NPR — ALASKA

FOR
ONPRA
HUSKY OIL NPR OPERATIONS INC

PROJECT MANAGER: A. [illegible]
INTERPRETATION BY: M. [illegible]
DATE: [illegible] DATUM: SEA LEVEL
CONTOUR INT: SCALE: 1:1,760

PROJECT NO.
REVISED
DATE | INITIALS
DWG NO.

TETRA TECH REPORT 8200

TGZ-0170

FIGURE 119

FIGURE 120

COMPARISON OF REGIONAL CYCLE CHART OF NPRA WITH GLOBAL CYCLE CHART

Figure 120 compares paleoenvironmental sequences of selected NPRA wells and global cycles during Devonian to Tertiary time. The extreme left- and right-hand scales show geologic time in millions of years. On the left side of the chart are first-, second-, and third-order global cycles outlined by Vail and others (1977, p. 83-97). The first-order cycle and Devonian through Late Jurassic parts of the second- and third-order cycles are expanded horizontally to compare more clearly the paleoenvironmental sequences of the NPRA to the global sea-level curves.

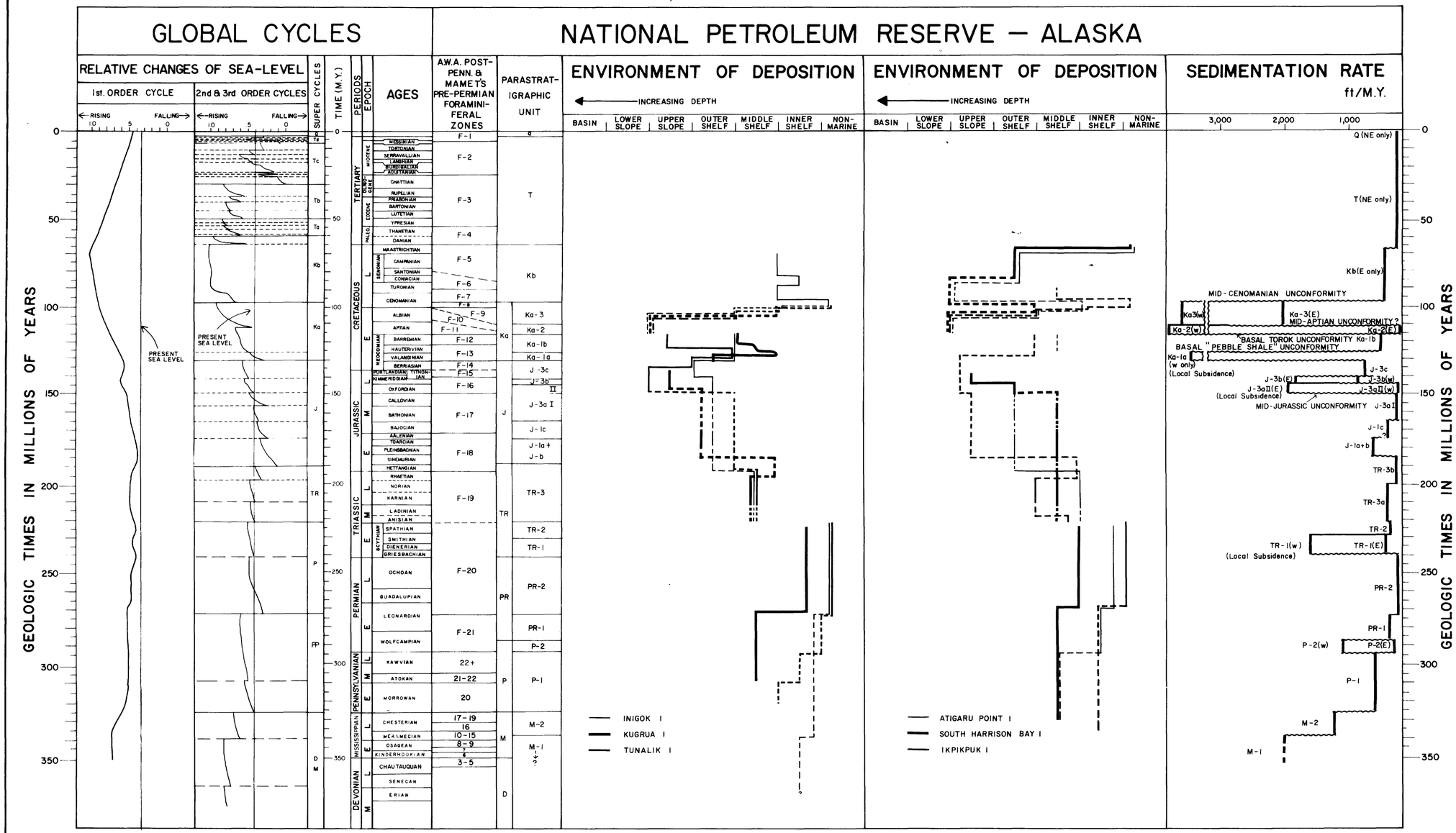
The standard geological time scale, including eras, periods, and epochs, is plotted to the right of the sea-level curves. To the right of the geological time scale, the AWA foraminiferal zones (Anderson, Warren, and Associates, 1974-1979) and parastratigraphic units are given. The figure also shows paleoenvironmental sequences for six selected NPRA wells and average sedimentation rates for the main parastratigraphic units.

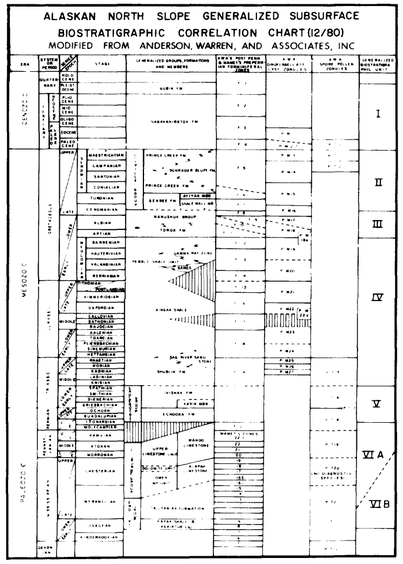
The depositional environments represented in the selected NPRA wells range from nonmarine to open marine equivalent to modern continental slope and basin. Most of the rocks of Middle Triassic through Early Cretaceous age were deposited in marine shelf and slope environments. However, rocks of Mississippian through Lower Triassic age and rocks of Late Cretaceous age are mainly nonmarine to marginal-marine deposits. The interpretations of paleoenvironmental sequences are based mainly on micropaleontologic analysis by Anderson, Warren, and Associates. Interpretations of the data presented here are preliminary, and modifications can be expected as further analyses are made.

The paleoenvironmental sequences in the six NPRA wells can be correlated with the second-order cycle of the global sea-level chart. Several major drops in the global sea-level chart (Vail and others, 1977, p. 85) coincide with the gaps in the paleoenvironmental sequences that were found in the NPRA wells. These gaps probably represent major regressions of the sea. After major drops are correlated, each marked sequence can be tied with the parastratigraphic units and seismic horizons.

GLOBAL CYCLES

NATIONAL PETROLEUM RESERVE — ALASKA





TETRA TECH, INC
HOUSTON, TEXAS — ENERGY MANAGEMENT DIVISION — PASADENA, CALIFORNIA

PETROLEUM EXPLORATION OF NPRA 1974-1981 (FINAL REPORT)

COMPARISON OF REGIONAL CYCLE CHART OF NPR A WITH GLOBAL CYCLE CHART

NPR — ALASKA

FOR
ONPRA
HUSKY OIL NPR OPERATIONS INC.

PROJECT MANAGER: J. W. BRUYNZEEL		PROJECT NO. TC-7174
INTERPRETATION BY: H. Y. BAIK		REVISED: DATE / INITIAL
DATE: JULY 1981	DATUM:	
CONTOUR INT:	SCALE:	DWG NO.

TETRA TECH REPORT NO. 8200

FIGURE 120

TG-0170

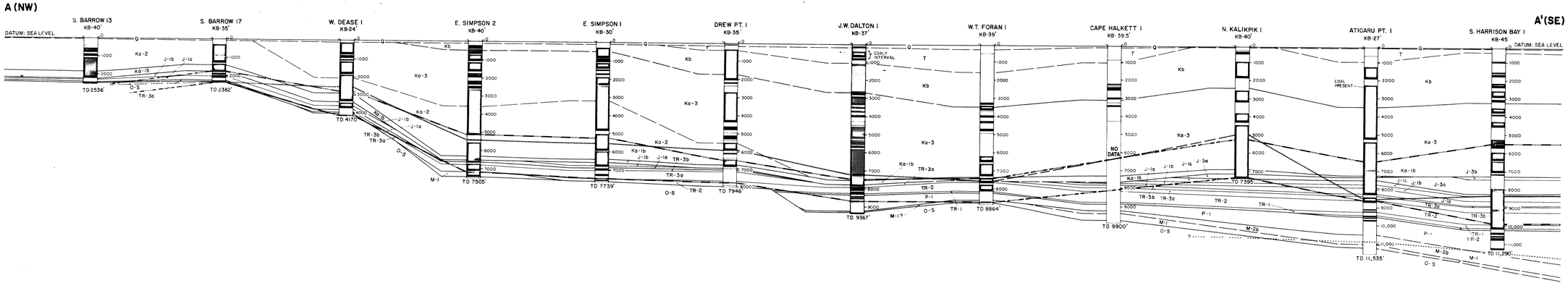
FIGURE 121

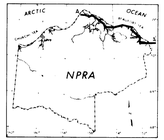
CROSS SECTION A-A', SOURCE ROCK POTENTIAL/THERMAL MATURATION

Vitrinite reflectance of 1.2 percent was not reached in any well northwest of Atigaru Point 1. At South Barrow 13, mature section was not penetrated.

Geochemical data for Cape Halkett 1 ends at 4,900 ft (1,494 m). Dashed lines indicate projected vitrinite reflectance and gas-wetness values.

FIGURE 121





INDEX MAP

EXPLANATION

MATURITY INDICATORS

0.6% VITRINITE REFLECTANCE

C_1-C_5 GAS WETNESS EXCEEDS 50%

1.2% VITRINITE REFLECTANCE

SOURCE ROCK POTENTIAL (TOTAL ORGANIC CARBON)

GOOD - >2% T.O.C.

FAIR - 1-2% T.O.C.

POOR - <1% T.O.C.

NO HORIZONTAL SCALE

TETRA TECH, INC.

HOUSTON TEXAS — ENERGY MANAGEMENT DIVISION — PASADENA CALIFORNIA

PETROLEUM EXPLORATION OF NPRA 1974-1981 (FINAL REPORT)

CROSS SECTION A-A'

SOURCE ROCK POTENTIAL / THERMAL MATURATION

NPR — ALASKA

FOR:

ONPRA

HUSKY OIL NPR OPERATIONS INC.

PROJECT MANAGER: J.W. BRYNZEEL		PROJECT NO. TC-7174	
INTERPRETATION BY: A. HULLSTEIN		REVISED: DATE	INITIAL
DATE: AUGUST, 1981	DATUM: SEA LEVEL		
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TGZ-0170

FIGURE 121

FIGURE 122

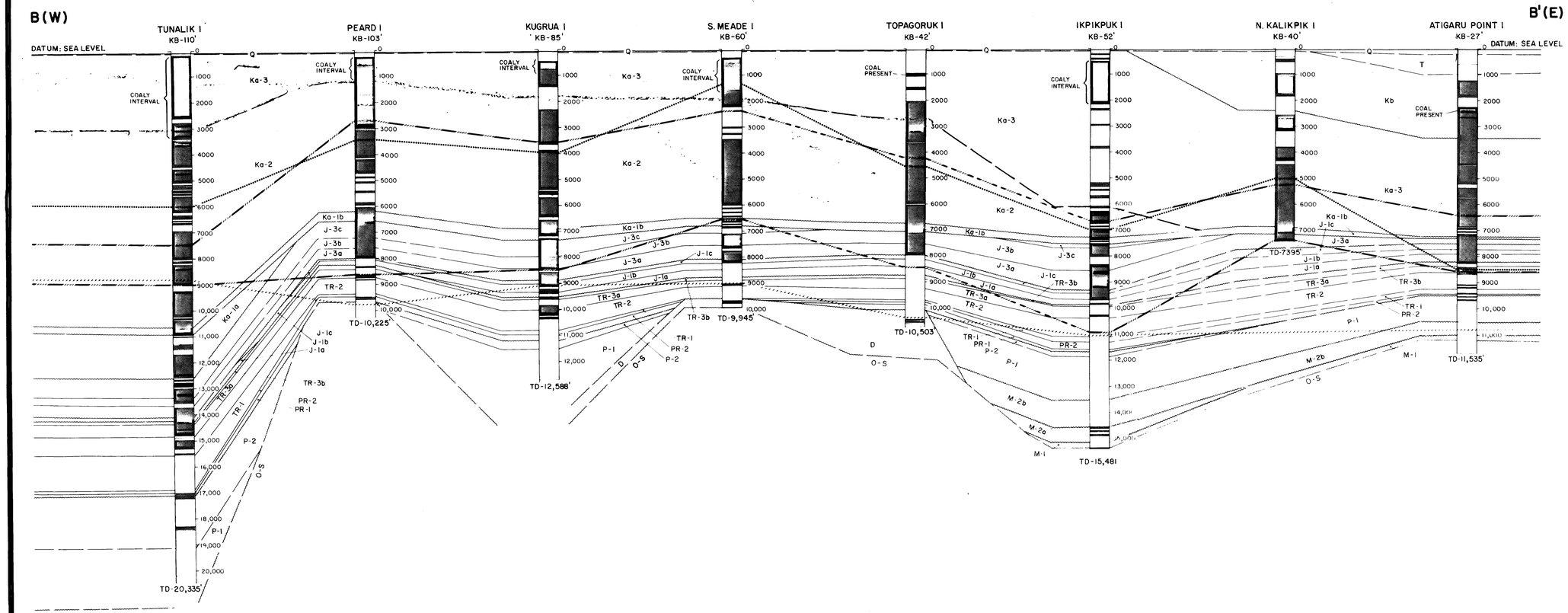
CROSS SECTION B-B', SOURCE ROCK POTENTIAL/THERMAL MATURATION

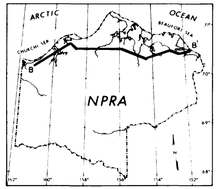
On cross section B-B', vitrinite reflectance of 1.2 percent was reached at all wells except North Kalikpik 1.

An anomalous, shallow maturity level present at South Meade 1 could reflect localized uplift.

The dashed gas-wetness line at Topagoruk 1 is a projection, because no gas data are available.

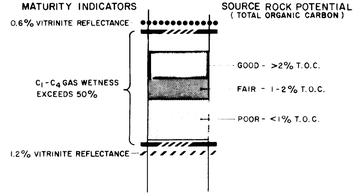
FIGURE 122





INDEX MAP

EXPLANATION



NO HORIZONTAL SCALE

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PETROLEUM EXPLORATION OF NPRA 1974-1981 (FINAL REPORT)

CROSS SECTION B-B'
SOURCE ROCK POTENTIAL / THERMAL MATURATION

NPR — ALASKA

FOR
ONPRA
HUSKY OIL NPR OPERATIONS INC.

PROJECT MANAGER: J. W. BRUYNZEEL		PROJECT NO. TC-7174
INTERPRETATION BY: A. GOLDSTEIN		REVISED: DATE / INITIAL
DATE: AUGUST, 1981	DATUM: SEA LEVEL	
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TG2-0170

FIGURE 122

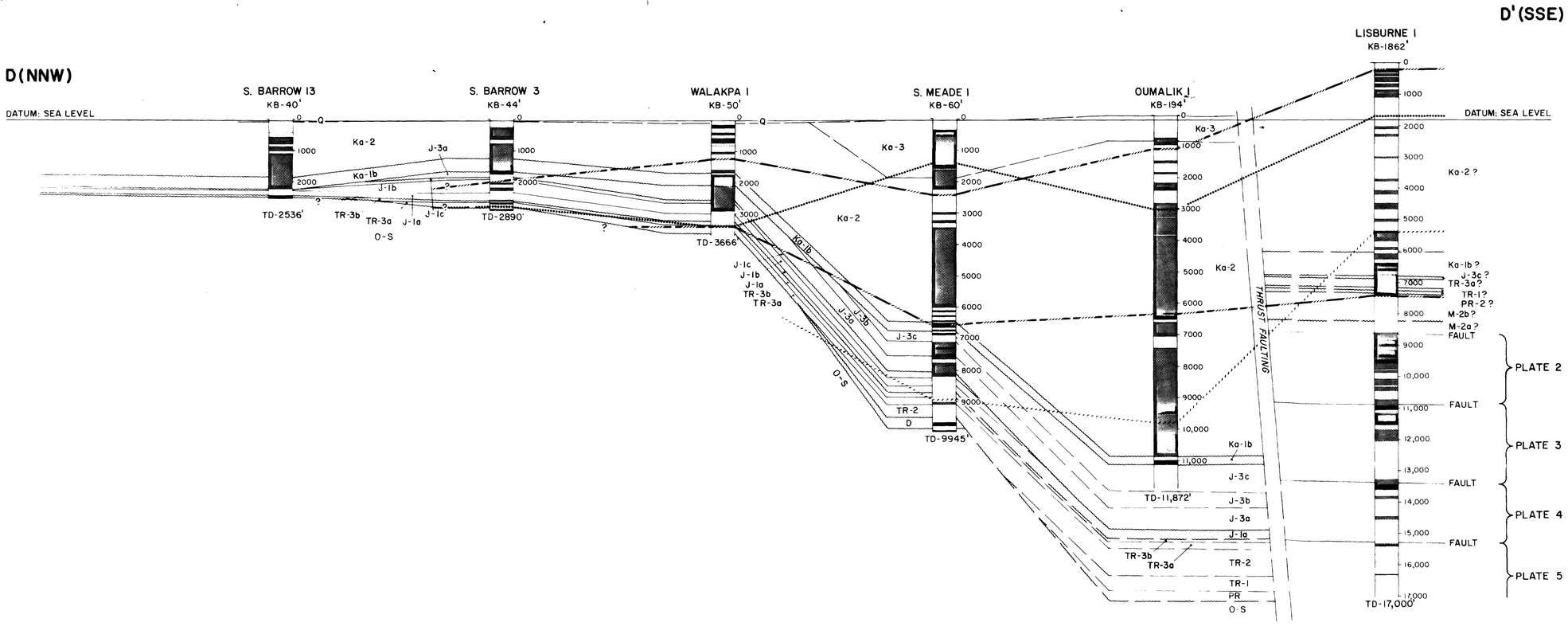
FIGURE 123

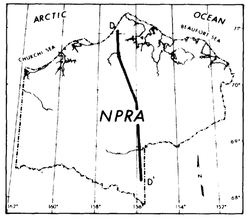
CROSS SECTION D-D', SOURCE ROCK POTENTIAL/THERMAL MATURATION

Vitrinite reflectance values of 1.2 percent were reached at all wells on cross section D-D' except for Walakpa 1, South Barrow 13, and South Barrow 17. At South Barrow 13, mature section was not penetrated. Abnormally shallow maturity and post-maturity levels at Lisburne 1 are in agreement with thrusting determined by several other methods.

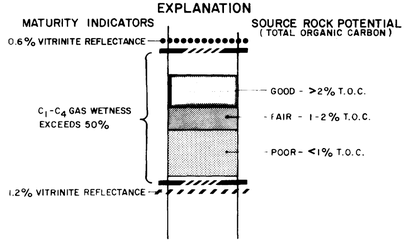
Gas-wetness data are not available for South Barrow 3 and Oumalik 1.

FIGURE 123





INDEX MAP



NO HORIZONTAL SCALE

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PETROLEUM EXPLORATION OF NPRA 1974-1981 (FINAL REPORT)

CROSS SECTION D-D'
SOURCE ROCK POTENTIAL/ THERMAL MATURATION

NPR — ALASKA

FOR
ONPRA
HUSKY OIL NPR OPERATIONS INC.

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INTERPRETATION BY: A. GOLDSTEIN		REVISED — DATE / INITIAL
DATE: AUGUST, 1981	DATUM: SEA LEVEL	
CONTOUR INT:	SCALE:	DWG NO.

TETRA TECH REPORT NO.8200
TGZ-0170

FIGURE 123

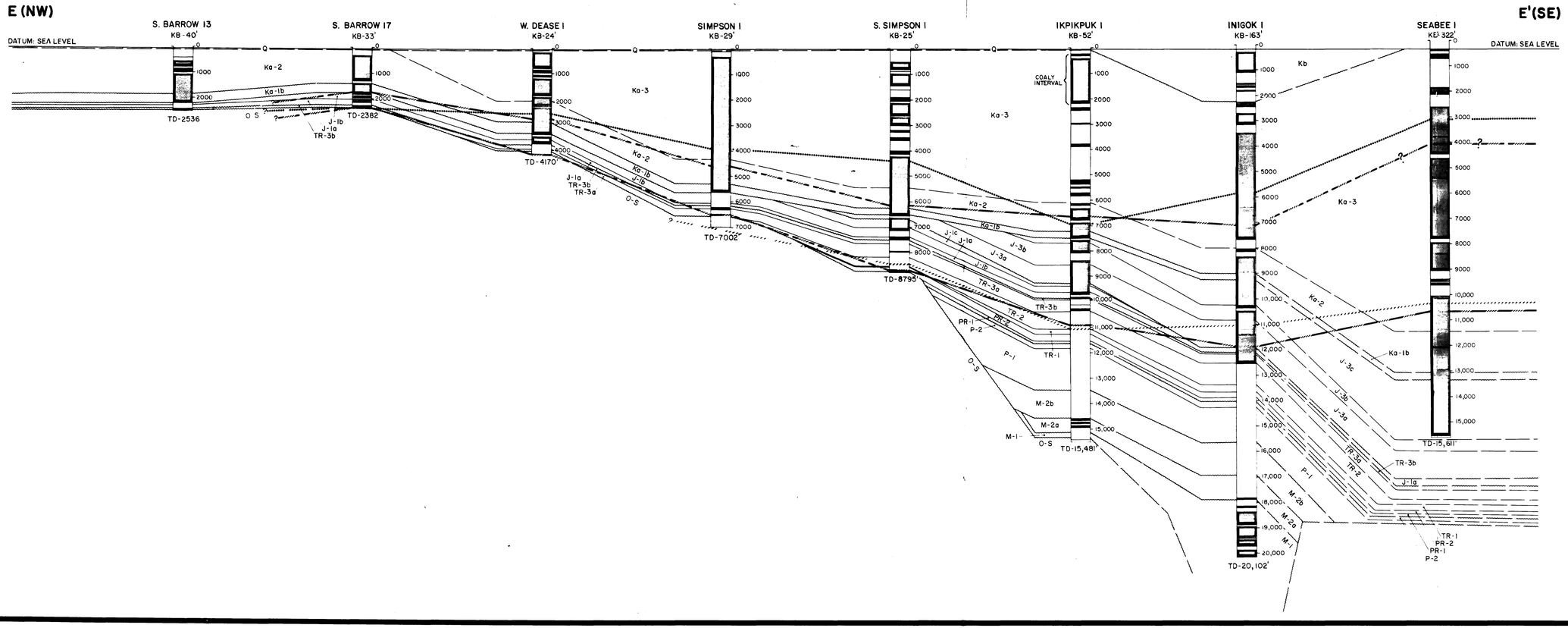
FIGURE 124

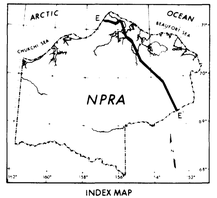
CROSS SECTION E-E', SOURCE ROCK POTENTIAL/THERMAL MATURATION

On cross section E-E', no vitrinite reflectance values of 1.2 percent were reached northwest of South Simpson 1. At South Barrow 13, no mature section was penetrated.

Gas-wetness data are not available for Simpson 1, and depths are projected. In Seabee 1, the top of the 50 percent gas-wetness interval is questionable.

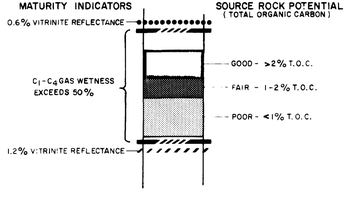
FIGURE 124





INDEX MAP

EXPLANATION



NO HORIZONTAL SCALE

TETRA TECH, INC

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PETROLEUM EXPLORATION OF NPRA 1974-1981 (FINAL REPORT)

CROSS SECTION E-E'

SOURCE ROCK POTENTIAL / THERMAL MATURATION

NPR — ALASKA

FOR

ONPRA

HUSKY OIL NPR OPERATIONS INC.

PROJECT MANAGER: J.W. BRUYNZEEL		PROJECT NO. TC-7174	
INTERPRETATION BY: A. GOLDSTEIN		REVISED DATE	INITIAL
DATE: AUGUST, 1981	DATUM: SEA LEVEL		
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FIGURE 12

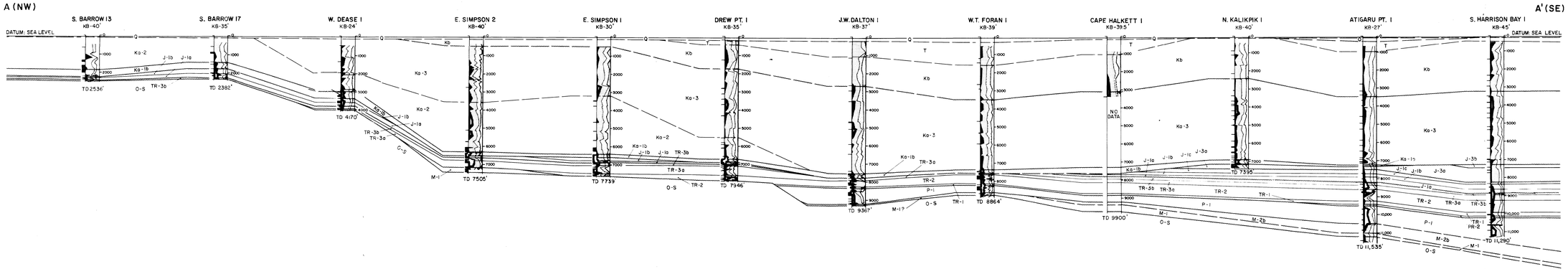
FIGURE 125

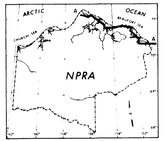
CROSS SECTION A-A', VISUAL KEROGEN COMPOSITION AND PHC/OC SOURCE TYPE INDICATORS

Visual kerogen data are shown for all wells on cross section A-A', but at Cape Halkett 1 visual kerogen data stop at 3,390 ft (1,033 m). The short horizontal lines on the left side of the well column represent oil-prone sources indicated by PHC/OC values. The longer lines represent gas-prone sources.

Four kerogen types, identified by optical analyses, are shown in their relative abundance. These types are amorphous, herbaceous, woody, and inertinite kerogen. Amorphous kerogen, which is considered oil-prone, is lipid-rich material found in marine or lacustrine sediments. Herbaceous kerogen may be either oil- or gas-prone and is lipid-rich material derived from terrestrial plants. Woody kerogen is a gas source derived from woody structural plant material. Inertinite, which is composed of charred wood and "dead" oxidized carbon, is not a hydrocarbon source.

FIGURE 125



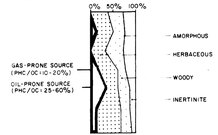


INDEX MAP

EXPLANATION

PHC/OC SOURCE TYPES

VISUAL KEROGEN TYPES



NO HORIZONTAL SCALE

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PETROLEUM EXPLORATION OF NPRA 1974-1981 (FINAL REPORT)

CROSS SECTION A-A'
VISUAL KEROGEN COMPOSITION and PHC/OC SOURCE TYPE INDICATORS

NPR — ALASKA

FOR

ONPRA

HUSKY OIL NPR OPERATIONS INC.

PROJECT MANAGER: J.W. BRUYNZEEL		PROJECT NO. TC-7174
INTERPRETATION BY: A. GOLDSTEIN		REVISED: DATE / INITIAL
DATE: SEPT. 1981	DATUM: SEA LEVEL	
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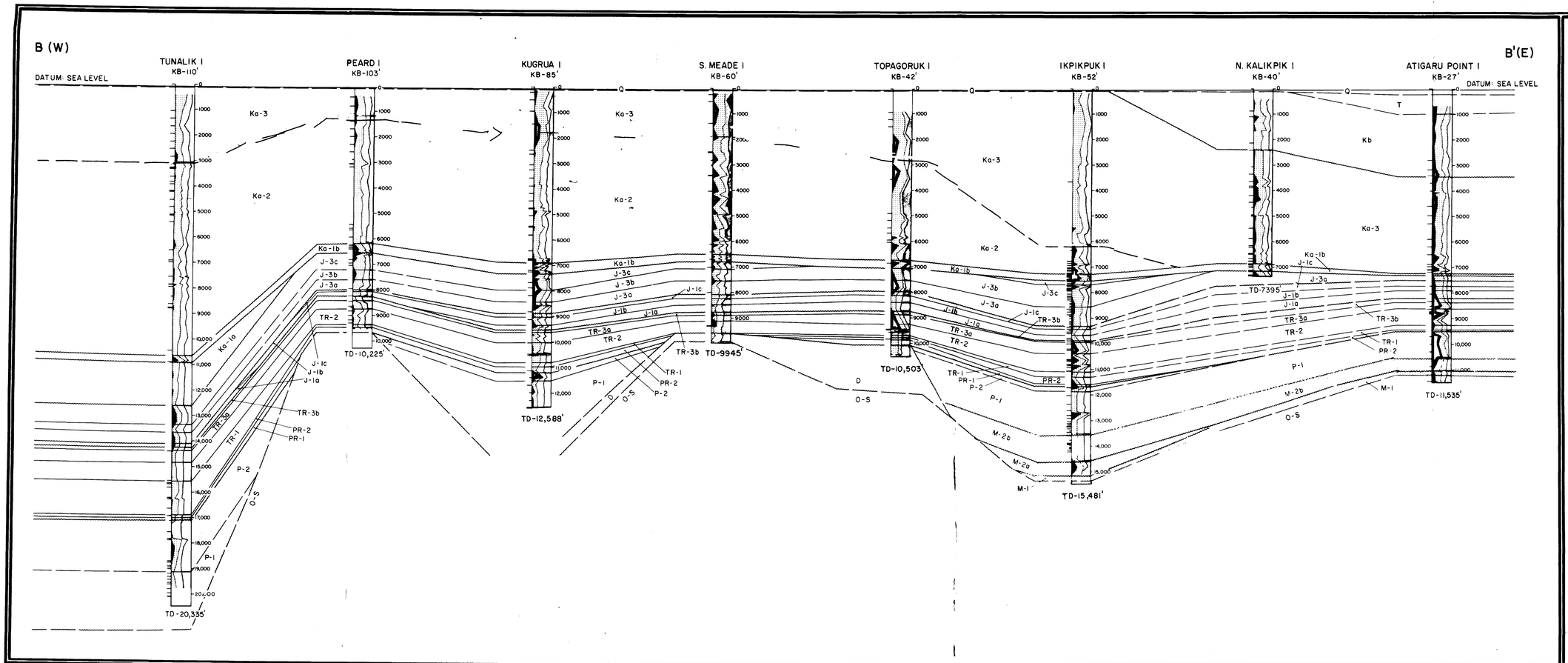
FIGURE 125

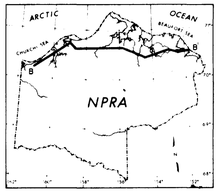
FIGURE 126

CROSS SECTION B-B', VISUAL KEROGEN COMPOSITION AND PHC/OC SOURCE TYPE INDICATORS

In cross section B-B', the short horizontal lines on the left side of the well columns represent oil-prone sources indicated by PHC/OC values. The longer lines represent gas-prone sources.

Four kerogen types, identified by optical analyses, are shown in their relative abundance. These types are amorphous, herbaceous, woody, and inertinite kerogen. Amorphous kerogen, which is considered oil-prone, is lipid-rich material found in marine or lacustrine sediments. Herbaceous kerogen may be either oil- or gas-prone and is lipid-rich material derived from terrestrial plants. Woody kerogen is a gas source derived from woody structural plant material. Inertinite, which is composed of charred wood and "dead" oxidized carbon, is not a hydrocarbon source.



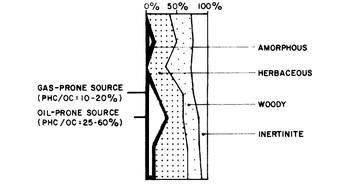


INDEX MAP

EXPLANATION

PHC/OC SOURCE TYPES

VISUAL KEROGEN TYPES



NO HORIZONTAL SCALE

TETRA TECH, INC

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PETROLEUM EXPLORATION OF NPRA 1974-1981 (FINAL REPORT)

CROSS SECTION B-B'
VISUAL KEROGEN COMPOSITION and PHC/OC SOURCE TYPE INDICATORS

NPR — ALASKA

FOR

ONPRA

HUSKY OIL NPR OPERATIONS INC.

PROJECT MANAGER: J. W. BRUYNZEEL		PROJECT NO. TC-7174
INTERPRETATION BY: A. GOLDSTEIN		REVISED: DATE / INITIAL
DATE: SEPT. 1981	DATUM: SEA LEVEL	
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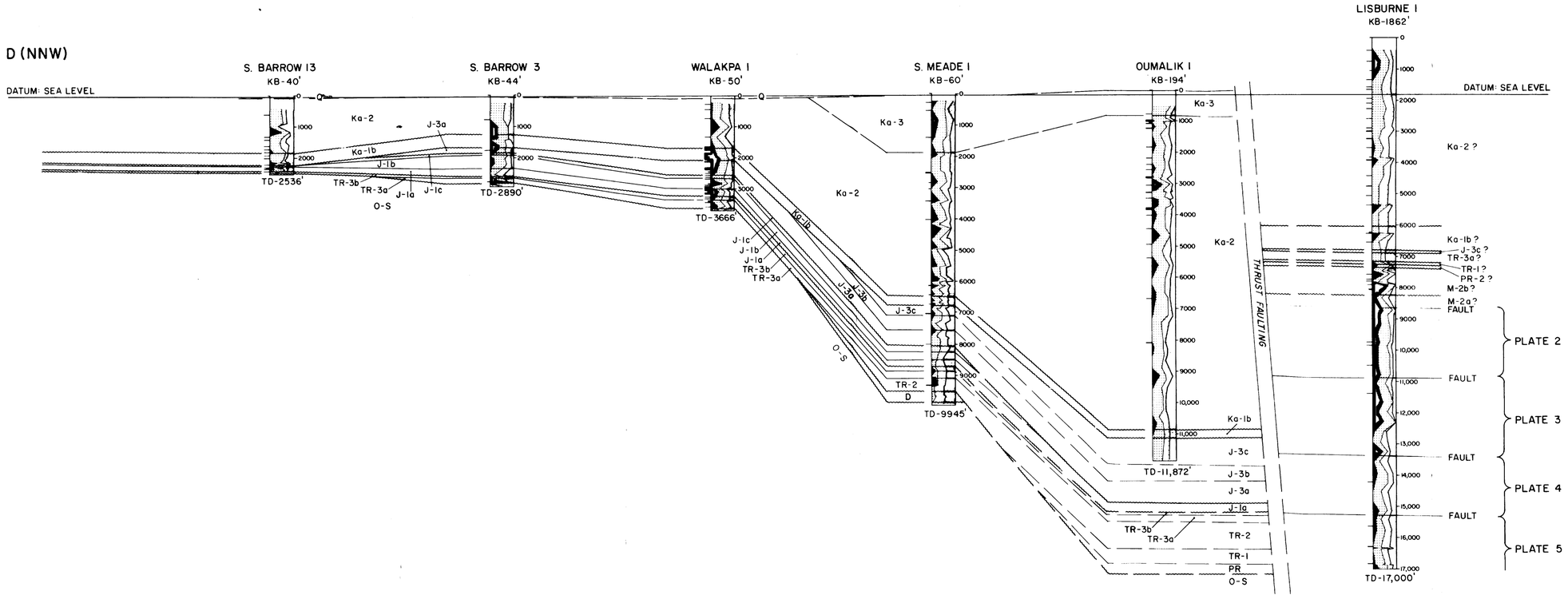
FIGURE 126

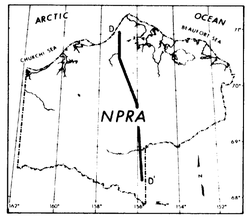
FIGURE 127

CROSS SECTION D-D', VISUAL KEROGEN COMPOSITION AND PHC/OC SOURCE TYPE INDICATORS

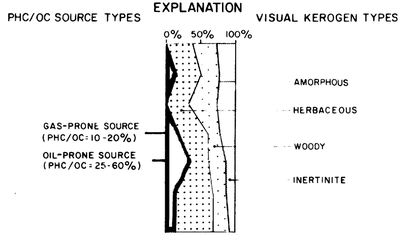
In cross section D-D', the short horizontal lines on the left side of the well columns represent oil-prone sources indicated by PHC/OC values. The longer lines represent gas-prone sources.

Four kerogen types, identified by optical analyses, are shown in their relative abundance. These types are amorphous, herbaceous, woody, and inertinite kerogen. Amorphous kerogen, which is considered oil-prone, is lipid-rich material found in marine or lacustrine sediments. Herbaceous kerogen may be either oil- or gas-prone and is lipid-rich material derived from terrestrial plants. Woody kerogen is a gas source derived from woody structural plant material. Inertinite, which is composed of charred wood and "dead" oxidized carbon, is not a hydrocarbon source.





INDEX MAP



NO HORIZONTAL SCALE

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PETROLEUM EXPLORATION OF NPRA 1974-1981 (FINAL REPORT)

CROSS SECTION D-D'
VISUAL KEROGEN COMPOSITION and PHC/OC SOURCE TYPE INDICATORS

NPR — ALASKA

FOR

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HUSKY OIL NPR OPERATIONS INC.

PROJECT MANAGER: J. W. BRUYNZEEL		PROJECT NO. TC-7174
INTERPRETATION BY: A. GOLDSTEIN		REVISED: DATE / INITIAL
DATE: SEPT. 1981	DATUM: SEA LEVEL	
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FIGURE 127

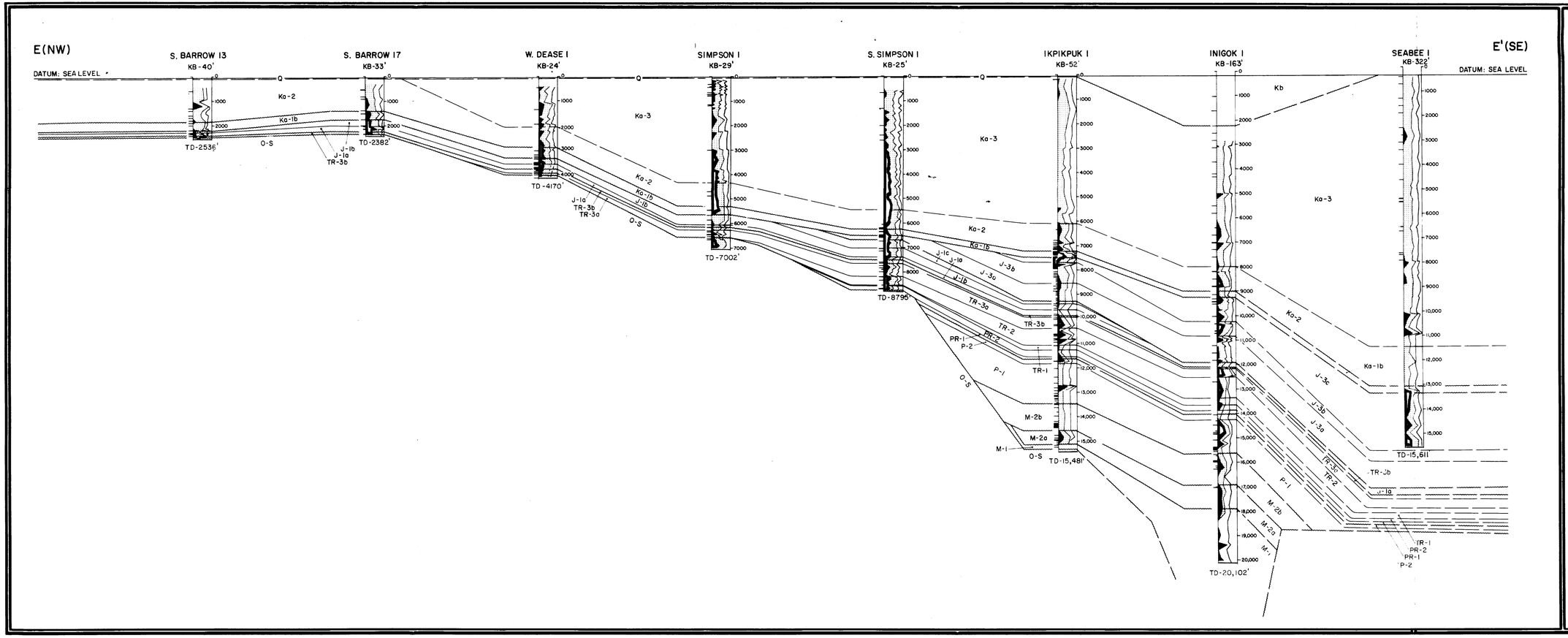
FIGURE 128

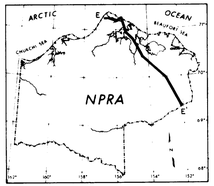
CROSS SECTION E-E', VISUAL KEROGEN COMPOSITION AND PHC/OC SOURCE TYPE INDICATORS

In cross section E-E', the short horizontal lines to the left of the well columns represent oil-prone sources indicated by PHC/OC values. The longer lines represent gas-prone sources.

Four kerogen types, identified by optical analyses, are shown in their relative abundance. These types are amorphous, herbaceous, woody, and inertinite kerogen. Amorphous kerogen, which is considered oil-prone, is lipid-rich material found in marine or lacustrine sediments. Herbaceous kerogen may be either oil- or gas-prone and is lipid-rich material derived from terrestrial plants. Woody kerogen is a gas source derived from woody structural plant material. Inertinite, which is composed of charred wood and "dead" oxidized carbon, is not a hydrocarbon source.

FIGURE 128



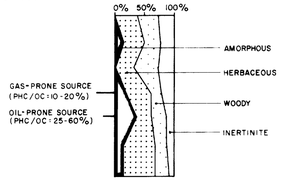


INDEX MAP

EXPLANATION

PHC/OC SOURCE TYPES

VISUAL KEROGEN TYPES



NO HORIZONTAL SCALE

TETRA TECH, INC

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PETROLEUM EXPLORATION OF NPRA 1974-1981 (FINAL REPORT)

CROSS SECTION E-E'
VISUAL KEROGEN COMPOSITION and PHC/OC SOURCE TYPE INDICATORS

NPR — ALASKA

FOR

ONPRA

HUSKY OIL NPR OPERATIONS INC.

PROJECT MANAGER: J. W. BRUYNZEEL	PROJECT NO. TC-7174	
INTERPRETATION BY: A. GOLDSTEIN	REVISED: DATE	INITIAL
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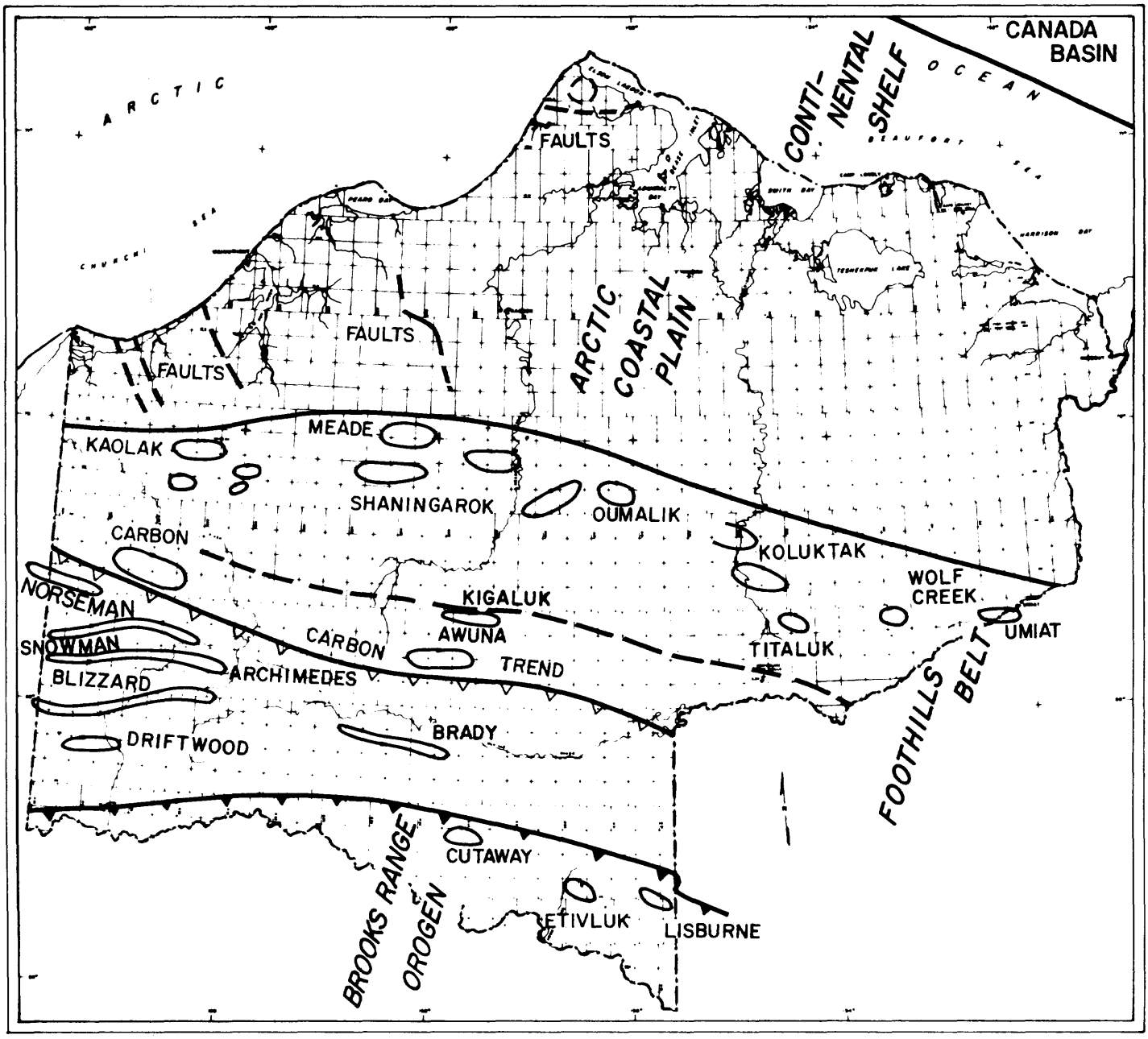
FIGURE 128

FIGURE 129

TECTONIC REGIONS MAP, NPRA

The three main tectonic regions in the NPRA are the Arctic Coastal Plain, Foothills Belt, and Brooks Range Orogen. Potential hydrocarbon traps on the Arctic Coastal Plain are mainly stratigraphic. In the Foothills Belt, there are large anticlinal trends both north and south of the Carbon Trend. Thrust faulting in the Brooks Range Orogen may provide hydrocarbon traps somewhat similar to those in the Rocky Mountain Overthrust Belt.

FIGURE 129



TECTONIC REGIONS MAP, NPRA

TGZ-0170

FIGURE 129

FIGURE 130

CORRELATION CROSS SECTION C-C',
TUNALIK 1 TO LISBURNE 1

Cross section C-C' includes Tunalik 1, Kaolak 1, Awuna 1, and Lisburne 1. Datum is sea level. The main geologic features are:

1. Of the four wells, only Tunalik 1 and Lisburne 1 penetrated pre-Cretaceous rocks. None of the wells reached basement. The deepest well was Tunalik 1, which reached unit P-1 (Wahoo Limestone). At Kaolak 1 and Awuna 1, all units below Ka-2 (Torok-Nanushuk) are projected; the stratigraphic relationships shown are based on seismic-stratigraphic interpretation.

2. Unit J-1 ("Lower Kingak") is deeply truncated by the mid-Jurassic unconformity. At Tunalik 1, only 140 ft (43 m) of J-1a remain. Unit J-1 is absent at Lisburne 1.

3. The mid-Neocomian unconformity truncates unit J-3 ("Upper Kingak").

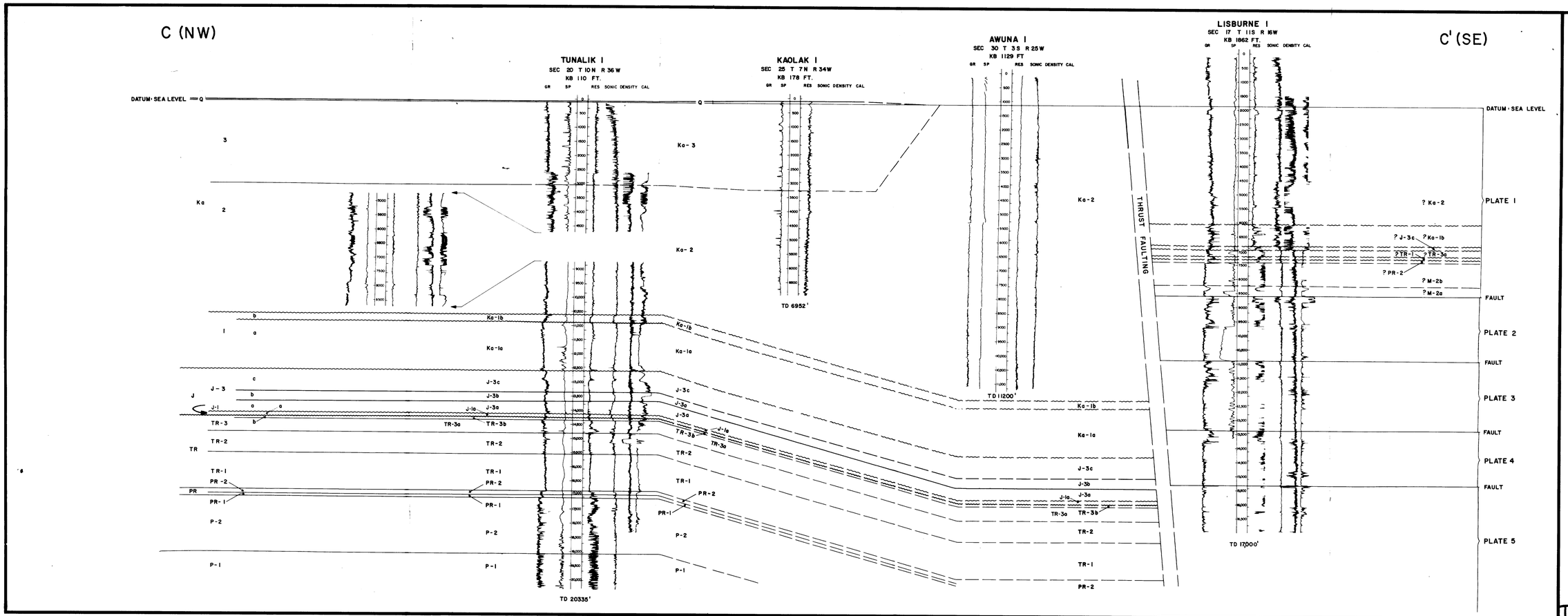
4. The basal "Pebble Shale" unconformity truncates the Ka-1a unit. At Tunalik 1, Ka-1a consists of 1,705 ft (520 m) of interbedded silty sandstones and siltstones that are Neocomian. The silty sandstones may be turbidites.

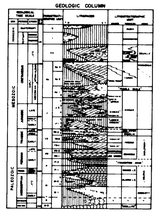
5. Torok fondothem (bottomset) beds within the time-transgressive Ka-2 unit are present above the Ka-1b ("Pebble Shale") unit at Tunalik 1. At Awuna 1, the Torok fondothem beds within Ka-2 were the deepest rocks reached. The Torok undathem (topset) beds within Ka-2 are the deepest strata penetrated at Kaolak 1.

6. The time-transgressive Ka-3 unit (Torok-Nanushuk) is present just below Quaternary beds at Tunalik 1 and Kaolak 1. At Tunalik 1, Ka-3 contains Nanushuk marine and nonmarine beds. At Kaolak 1, Ka-3 is composed of Nanushuk nonmarine rocks.

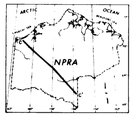
7. At Awuna 1, Torok clinothem (foreset) beds within Ka-2 are at the surface; at Lisburne 1, Torok fondothem (bottomset) beds within Ka-2 are at the surface.

8. Just north of Lisburne 1 is a zone of thrust faulting, which precludes direct correlation with wells to the north. Five fault-separated repeat sequences were found at Lisburne 1; tops for the plates are given in figure 69. Numerous high gamma-ray curve deflections in the TR-3a (Shublik) to Ka-1b interval may indicate several unconformities and slow deposition in this area. All pre-Cretaceous rocks thin at Lisburne 1.





NO HORIZONTAL SCALE



INDEX MAP

TETRA TECH, INC
WESTON TEXAS — ENERGY MANAGEMENT DIVISION — PASADENA CALIFORNIA

PETROLEUM EXPLORATION OF NPR-A 1974-1981 FINAL REPORTS

CORRELATION CROSS SECTION C-C'
TUNALIK I - LISBURNE I

NPR — ALASKA

FOR
ONPRA
HUSKY OIL, NPR OPERATIONS INC.

PROJECT MANAGER: J. W. BALLIGETT — PROJECT NO. TC-7174
INTERPRETATION BY: V. BERGER, D. HIGGS — REVISED DATE / BY / REVISED
DATE: JUNE, 1981 — DATUM: SEA LEVEL
DRAFTING BY: — SCALE: — DWG NO.

T62-0170 FIGURE 130

FIGURE 131

PARASTRATIGRAPHIC CROSS SECTION C-C', TUNALIK 1 TO LISBURNE 1

Because of the inadequate quality of the seismic data over most of the length of cross section C-C', a compressed seismic cross section was not compiled. This parastratigraphic cross section was assembled by plotting seismic horizon times where seismic lines intersect the line of section. (Seismic line numbers are shown along the datum line.) The points were then compared to interpreted conventional seismic sections and projected accordingly. Features of interest on the northwest (left) portion of the figure include:

1. The southeastward lapout of P-1 onto a minor, positive basement feature, northwest of Kaolak 1, is apparent. This basement feature is probably a saddle along the Wainwright Arch-Utukok High trend.

2. Units TR-1 and TR-2 are very thick. This sequence probably consists of shale and siltstone.

3. The Jurassic (J-1, J-3a, J-3b, and J-3c) part of the Kingak Formation is relatively thin. Units TR-3 and J-1 are combined southeast of Kaolak 1, because it is difficult to separate horizon 1000 (top of TR-3b) from horizon 0900 (mid-Jurassic unconformity) beyond that point.

4. The Ka-1a part of the Kingak Formation is relatively thicker than the Jurassic part. At Tunalik 1, several turbidite(?) silty sandstones and a 604-ft (185-m) silty sandstone occur within this unit.

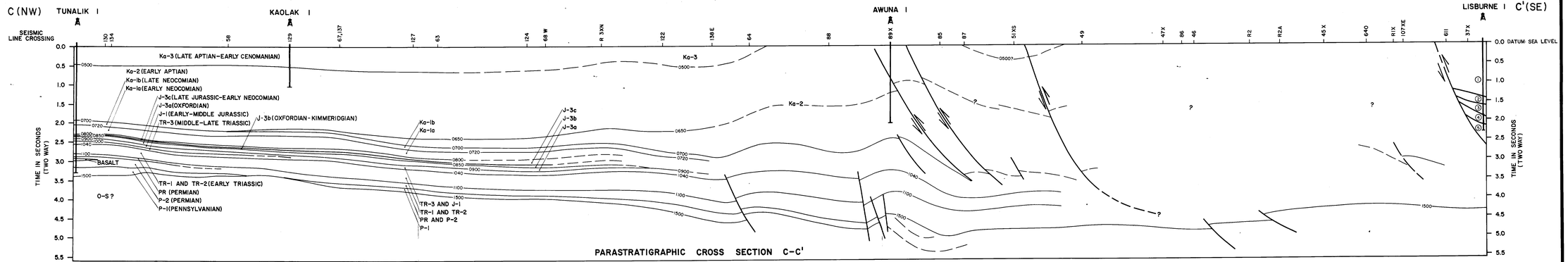
5. Ka consists mainly of unit Ka-2, which is progressively older to the southeast. Horizon 0650 may bound strata that are earliest Aptian to latest Neocomian in age.

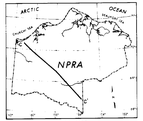
Farther to the southeast, it is more difficult to trace seismic horizons due to poor data quality. Features of interest include:

1. At Awuna 1, there are anticlines and thrust faults comprising the prominent Carbon Trend, which is the largest surface structure of potential economic interest within the Foothills Belt.

2. In the complexly thrust-faulted area around Lisburne 1, six thrust plates are identifiable in seismic sections. Five of these plates were drilled at Lisburne 1.

Between seismic lines 49 and 107XE, there is a large area of virtually uninterpretable data.





INDEX MAP

TETRA TECH, INC

HOUSTON, TEXAS — ENERGY MANAGEMENT DIVISION — PASADENA, CALIFORNIA

PETROLEUM EXPLORATION OF NPR-A 1974-1975 (FINAL REPORT)

PARASTRATIGRAPHIC CROSS SECTION C-C'

TUNALIK I - LISBURNE I

NPR — ALASKA

FOR

ONPRA

HUSKY OIL NPR OPERATIONS INC.

PROJECT MANAGER: J. H. BRUYNZEEL		PROJECT NO. TC-7174	
INTERPRETATION BY: C. GULDENZOPF		REVISED DATE	INITIAL
DATE: JUNE, 1981	DATUM: SEA LEVEL		
CONTOUR INT:	SCALE:	DWG NO.	

TGZ-0170

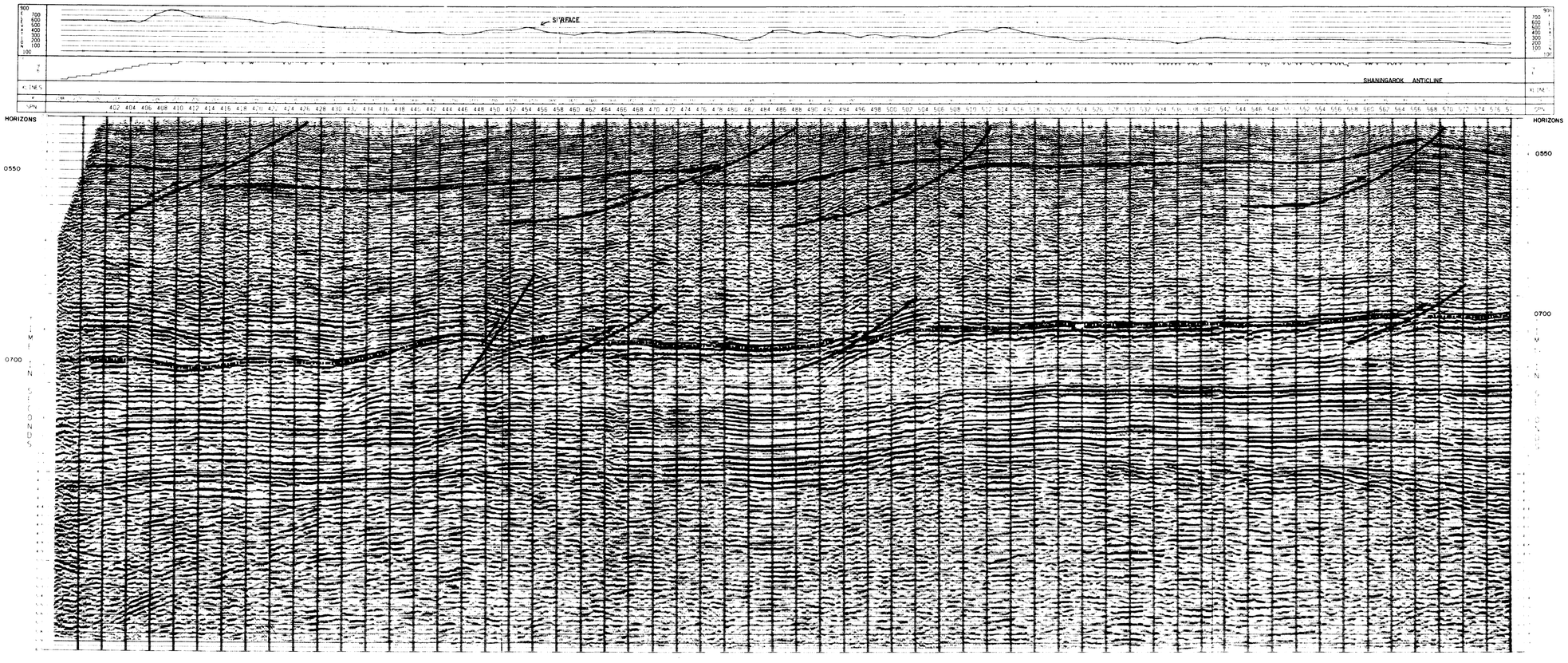
FIGURE 131

FIGURE 132

LINE R7XN-79-G-1186, SHOTPOINTS 578-401,
SCALED FINAL STACK

Line R7XN-79, oriented in a north-south direction in the northwest portion of the Lookout Ridge Quadrangle, crosses the east-west trending Shaningarok anticline. This feature exhibits closure extending approximately 26 mi (42 km) in length and 5 to 7 mi (8 to 11) in width. The shallow section within this area also is cut by shallow thrust faulting.

FIGURE 132



USGS
ONPRA

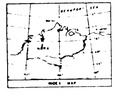
HUSKY OIL NPR OPRS. INC.
NATIONAL PETROLEUM RESERVE ALASKA
DRIFTWOOD AREA

R7XN-79-G-1186

SHOTPOINTS 578-401

SCALED FINAL STACK

FIGURE 132



0 1.0 2.0
MILES

TETRA TECH REPORT NO 8200

TGZ-0170