DEPARTMENT OF THE INTERIOR
MINERALS MANAGEMENT SERVICE

PRELEASE INVESTIGATION MAPS OF THE NORTH ALEUTIAN SHELF OUTER CONTINENTAL SHELF BERING SEA ALASKA 1984

by
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and
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MMS MAP SERIES 84-0002
SHEET 1 OF 5

DEPARTMENT OF THE INTERIOR
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GEOLOGY

The bathymetric map was constructed by hand-digitizing and contouring seismic profiles collected in 1981 by Marine Technical Services (MTS), Inc. Data used in this interpretation were collected using a 40-kHz fathometer with a 2.5° beam width which was calibrated periodically using a bar check. Water depths were calculated using an acoustic velocity of 1,450 m/s. This velocity was computed using salinity and temperature measurements from a Nansen cast performed at lat 55°02' N., long 164°59' W. (Carl Fefe, National Ocean Survey, written commun., 1981). Corrections for instrument tow depth were applied. Tidal corrections were not applied and the vertical datum is mean sea level. Mean and diurnal tide ranges at Amak Island are 1.6 and 2.4 m, respectively (U.S. National Ocean Survey, 1981).

The estimated error in digitizing depths from fathometer records is 0.4 m. The consistency of the data set was checked by comparing the computed depths at track line intersections. At 218 line intersections, the average depth discrepancy is 0.7 m with a standard deviation of 0.6 m. Closed contours are annotated with either H or L to indicate bathymetric highs or lows.

In the western part of the study area, 48 km north of Otter Point, is a 1- to 2-m deep east-west-trending sea-floor sag. This sag is the manifestation of a major growth fault which is part of the North Amak fault zone (sheet 3). Along the northern boundary of the study area, 76 km north of Cape Leontovich, is a group of four prominent linear ridges. These features trend 52° which is parallel to the northwesterly current direction interpreted from contemporary bed forms (sheet 5) and from direct measurements (Hebard, 1959, 1961). These ridges rise as much as 12 m above the sea floor and were deposited during the Holocene (sheet 4). Twenty-four km north of Amak Island is a series of three east-west-trending sediment swells. These features were deposited during the Holocene and probably formed as a result of the deflection of the northwesterly current as it flowed around Amak Island. Near the eastern end of the study area are numerous small, narrow-crested ridges. These ridges rise 2 to 8 m above the sea floor and are randomly oriented. Possible explanations of their origin are moraine deposits, isolated sand waves, or volcanic dikes.

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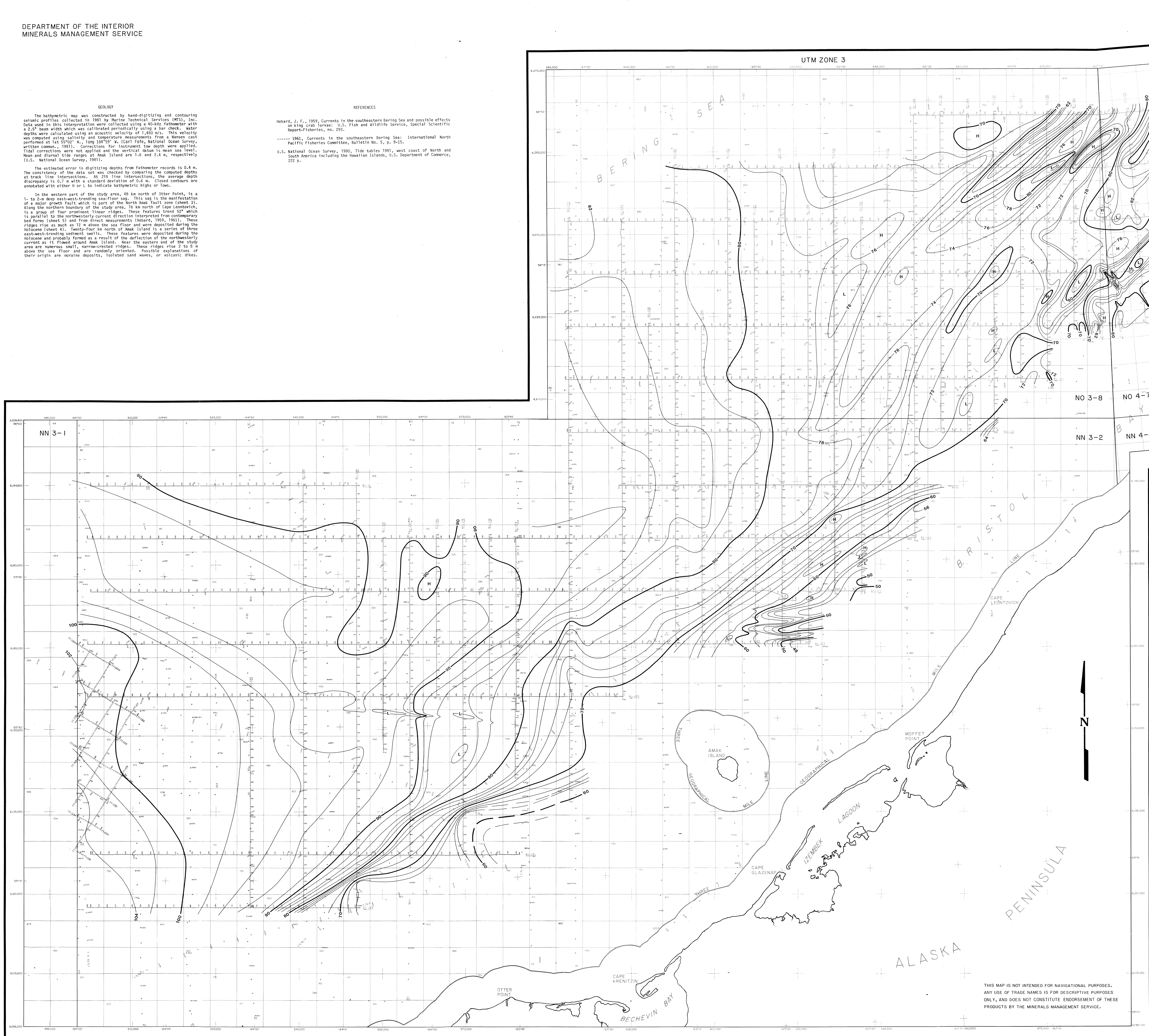
U.S. National Ocean Survey, 1980, Tide tables 1981, west coast of North and South America including the Hawaiian Islands, U.S. Department of Commerce, 222 p.



EXPLANATION

— 30 — BATHYMETRIC CONTOUR dashed where inferred
H – BATHYMETRIC HIGH
L – BATHYMETRIC LOW

SURVEYS

1981 M.T.S.
1980 Fugro (R/V Discoverer)
1976 U.S.G.S. (R/V S.P. Lee)
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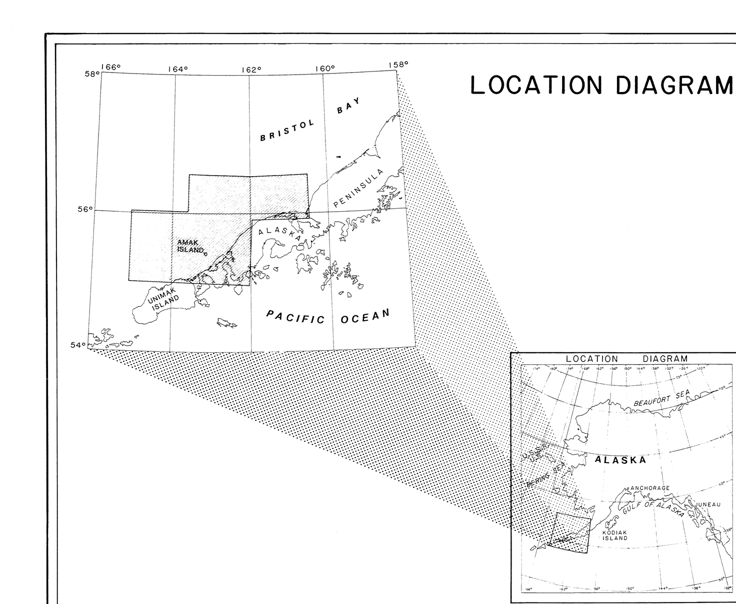

SOURCE OF SHORELINE FROM BUREAU OF LAND MANAGEMENT PROTRACTION DIAGRAMS NN 3-2, NN 4-1, AND NO 4-7. PUBLISHED IN 1976.

SCALE 1:250,000

5 0 5 10 15 20 STATUTE MILES
5 0 5 10 15 20 25 30 KILOMETERS
5 0 5 10 NAUTICAL MILES

BATHYMETRIC CONTOUR INTERVAL 2 METERS (INDEX C.I. 10 METERS)

MAP PROJECTION UTM, CLARKE 1866 SPHEROID, ZONES 3 AND 4.

BATHYMETRIC MAP OF NORTH ALEUTIAN SHELF, BERING SEA, ALASKA

PETER J. HOOSE AND LYNN D. LYBECK

1984

DEPARTMENT OF THE INTERIOR
MINERALS MANAGEMENT SERVICE

GEOLOGY

This map shows the distribution and thickness of Holocene sediment. The base of the Holocene sedimentary unit was identified from seismic profiler data and piston core samples as a thin layer of well-sorted fine sand (D. R. Askren, 1972, Holocene stratigraphic framework, southern Bering Sea continental shelf, University of Washington, unpublished thesis, 104 p.). On 3.5 kHz, minisparker, and analog water-gun profiles, this horizon is manifested as a distinct, easily traceable reflector. Using Askren's seismic lines, this horizon was extended from his piston core control sites at lat 58°22' N., long 168°56' W. and lat 56°40' N., long 164°26' W. to the North Aleutian Shelf study area.

Askren's grain-size analysis of piston core samples and the discontinuous nature of subbottom reflectors in his data lead him to conclude that in much of the Bering Sea the Holocene unit was deposited on a surface that had been subaerially eroded. In the North Aleutian Shelf study area, Askren's conclusion is corroborated by the presence of an angular unconformity containing buried channels at the base of the Holocene unit. On the basis of paleontological, radiocarbon, and grain-size analyses, Askren estimates the sea level minimum associated with the subaerial erosion occurred 13,000 to 14,000 years BP. Based on this chronology, he estimates a Holocene sedimentation rate on the inner shelf of 9 cm/1000 yr. Radiocarbon dates from another study determined that the ages of intact shells from depths of 7 cm and 10 cm were 12,390 + 250 yr BP and 11,720 ± 245 yr BP, respectively (B. Molnia, written commun., 1982). This apparent contradiction can be explained by considerable sediment reworking.

Holocene sediment consists primarily of olive-gray and gray-green sand. The average composition of seventy-six surface sediment samples is 91 percent sand and 6 percent silt. Silt becomes more abundant away from shore and some near-shore samples contain as much as 55 percent gravel. In piston cores, mean grain size generally increases toward the bottom.

The Holocene layer is thinnest (< 4 m) in the distal part of the southwestern half of the study area and thickest (> 48 m) in the proximal part of the northeastern half. The thick wedge of Holocene sediment near the northeastern end of the study area suggests proximity to a sediment source. Several elongate ridges near the northern edge of the study area trend parallel to the prevailing current direction (sheet 5; Hebard, 1959, 1961) suggesting current-controlled deposition.

The thickness of the Holocene unit was measured by hand-digitizing 3.5 kHz piezoelectric profiler, minisparker, and analog water-gun data collected in 1981 by Marine Technical Services, Inc. Time measurements were converted to thickness by applying a sound velocity of 1660 m/s for sandy deposits derived from Hamilton (1974).

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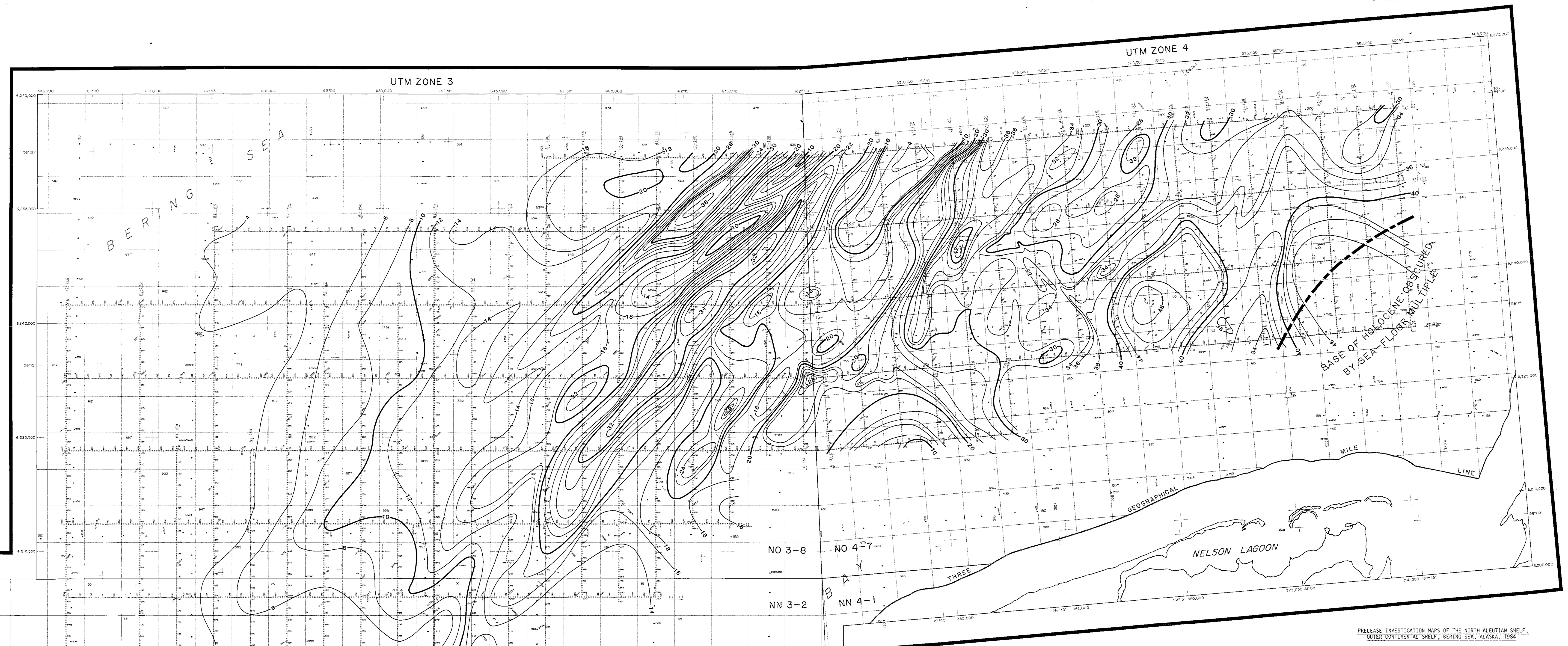

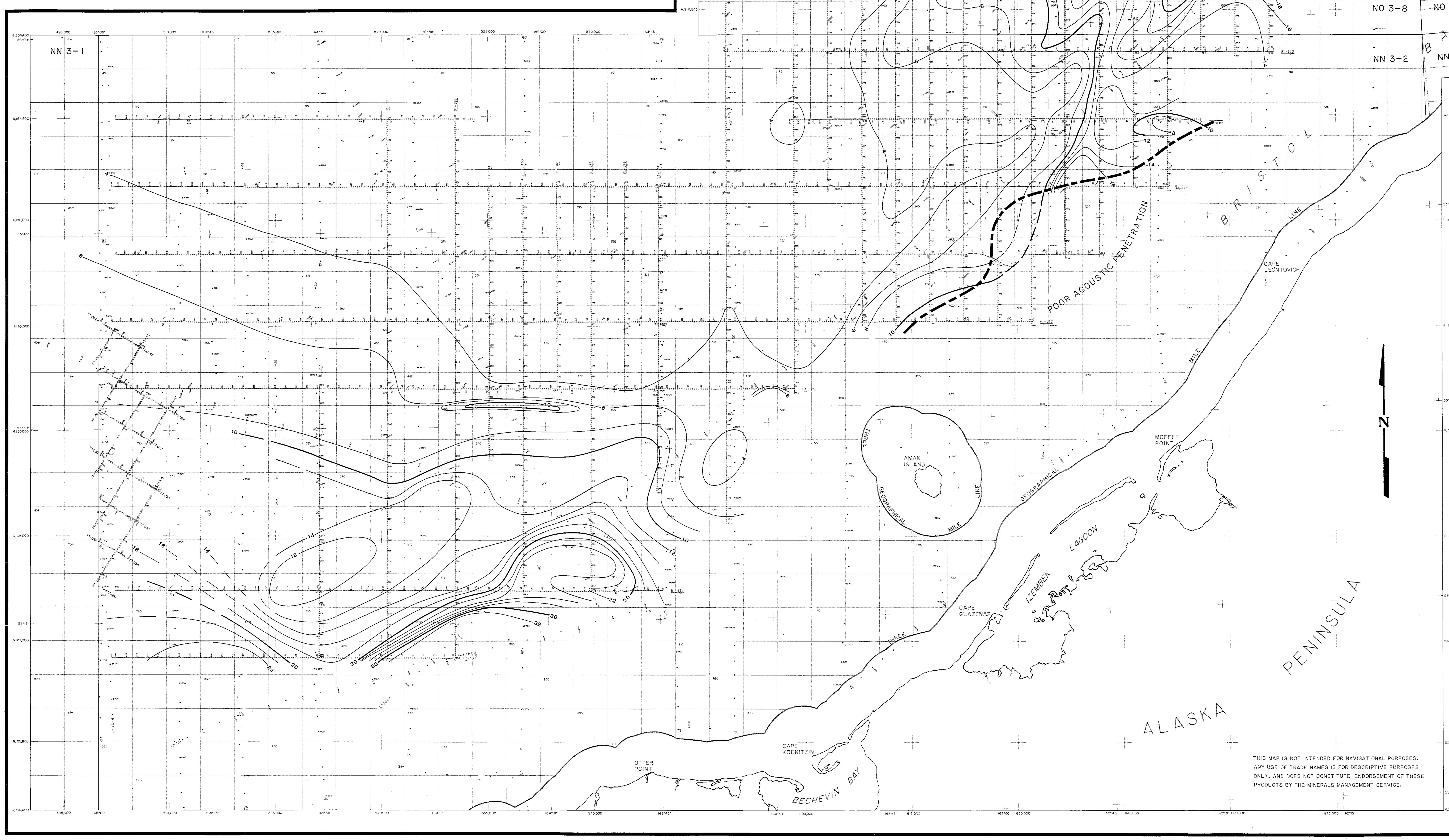

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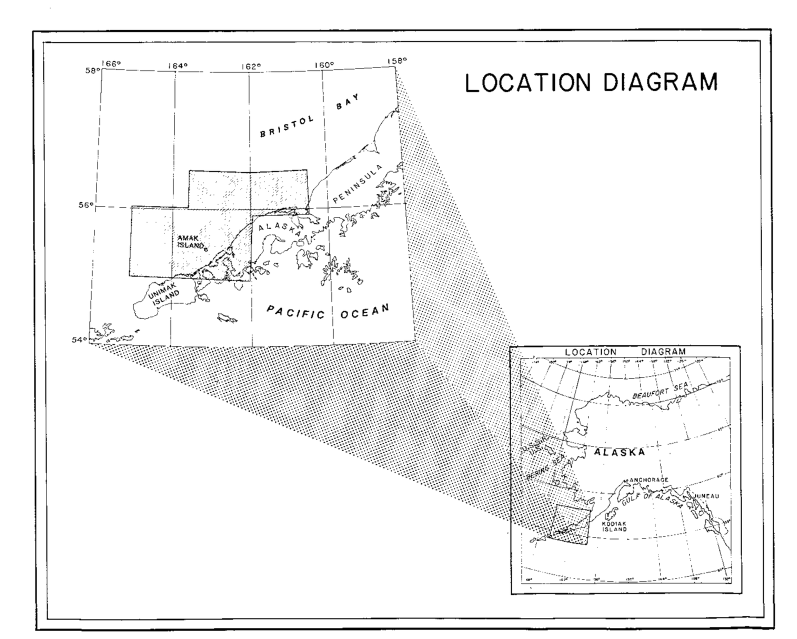

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PETER J. HOOSE, LYNN D. LYBECK, AND MARY J. HOUSE

1984

DEPARTMENT OF THE INTERIOR
MINERALS MANAGEMENT SERVICE

GEOLOGY

This map shows faults and probable gas-related acoustic anomalies that may be hazardous to hydrocarbon exploration and production. From north to south, the regional structural features of the North Aleutian Shelf study area are Bristol Bay basin, North Amak fault zone, Black Hills ridge, and Amak basin (fig. 1) (Marlow and Cooper, 1980; Marlow and others, 1980). Of these structural features, the only one that is evident on the 1-s seismic records is the North Amak fault zone, an eastward extension of the St. George graben system. This feature is indicated by numerous faults within a 30-km-wide east-west-trending zone in the southwestern part of the study area.

Within the study area, the North Amak fault zone consists of many parallel and subparallel normal faults that generally can be traced for 16 km or less. In some places, faults occur in pairs and produce narrow grabens traceable 12 km or less. The structural style of the fault zone changes near the western end of the study area where a distinct central graben is contained within marginal faults. This change in structural style occurs approximately where the North Amak fault zone-St. George graben system changes trend from east-west to northwest-southeast.

Two types of normal faults are indicated on the map. Faults that extend up to the sea floor are called surface faults, and those that terminate below the sea floor are called subsurface faults. All surface faults are growth faults whereas only some of the subsurface faults are of this type. At the sea floor, surface faults are not manifested by abrupt scarps but rather by sags. This is because of the unconsolidated nature of the Holocene sediment and the vigorous, contemporary, sea-floor erosion taking place on the shelf (sheet 5). Subsurface faults terminate at depths ranging from 30 to 290 m below the sea floor. All faults in the study area have greater than 5 m of offset. On the 24-channel CDP data collected by the U.S. Geological Survey in 1976, some faults extend into basement offsets (Marlow and Cooper, 1980). Gardner and Vallier (1981) also described and classified faults in the southern Bering Sea region.

From 1957 through 1978, 38 shallow-focus (< 75 km) earthquakes with magnitudes up to 5.7 were detected in the St. George Basin-North Aleutian Shelf region (Davies, 1981). Most events whicn occurred in the study area were located within the North Amak fault zone. Although it is not usually possible to correlate individual seismic events with a specific fault, the location of one 1963 event of 5.5 magnitude coincides with a prominent surface fault. Recent seismicity and sea-floor expression indicate that certain faults in this region are active.

Acoustic anomalies, which may represent gas-charged sediment, are present in all parts of the study area. Most anomalies occur within 7 to 25 m of the sea floor but some occur as deep as 60 m. Elsewhere in the Bering Sea, occurrences of gas within the first 4 m of sediment have been documented (Kvenvolden and others, 1980). On the 12-fold CDP profiles, these anomalies are characterized by disrupted, incoherent reflectors which often contain point source diffractions. In the survey area devoid of acoustic anomalies, the interval occupied by the turbid zone is acoustically transparent. On both CDP and analog profiles, the disrupted and incoherent reflectors often produce wipeout of the underlying reflectors. On CDP profiles, pulldown of reflectors is often present at the margins of the wipeout zone and indicates that low-velocity material, such as gas-charged sediment, is causing the acoustic anomaly. The largest acoustic anomalies in the study area occur near the northern limit of the survey where they are centered over depressions in the pre-Holocene surface (sheet 4). During the low sea-level stillstand at the end of the Pleistocene, this area was characterized by fluvial processes and tundra vegetation (sheet 2; Hopkins, 1967). At that time, these depressions were probably filled with peaty mud. Gas generated by microbial decay of organic material within this peaty mud, followed by its subsequent migration into the overlying porous Holocene sand, is the likely cause of these anomalies. This scenario implies that either a seal exists within the overlying sand or else decay of organic material is continually generating gas to replace what has leaked out. Elsewhere in the study area some acoustic anomalies are located near faults. It is not clear whether these anomalies are caused by biogenic gas that originated in situ or by thermogenic gas that migrated upwards along faults.

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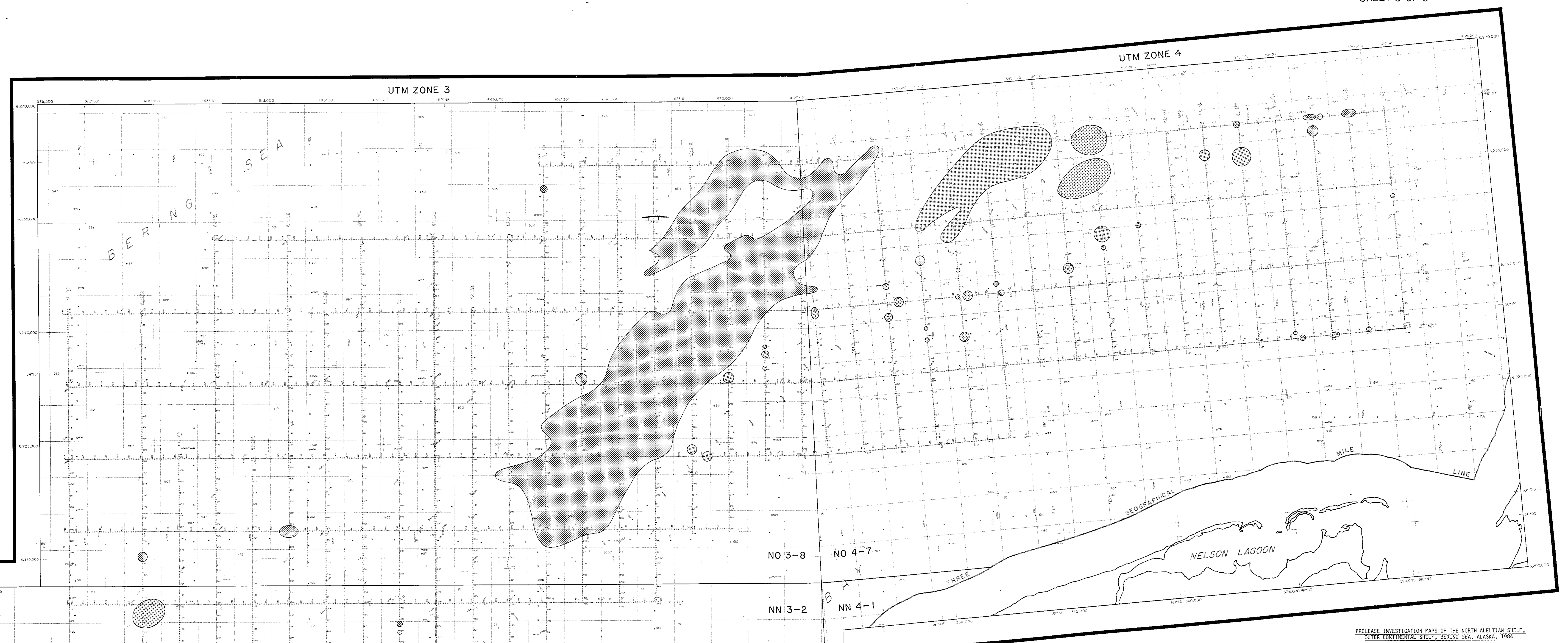

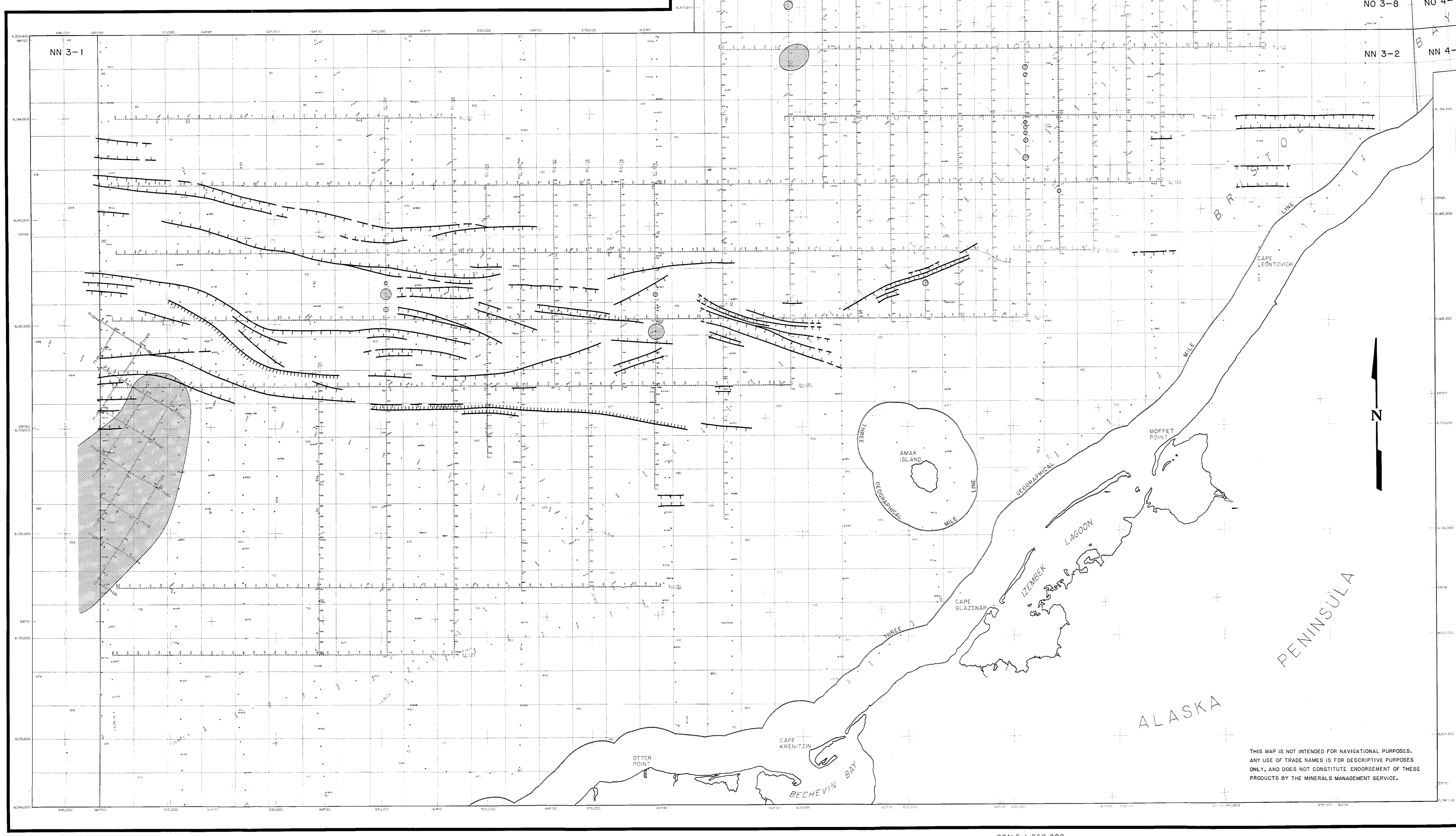

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PRELEASE INVESTIGATION MAPS OF THE NORTH ALEUTIAN SHELF, OUTER CONTINENTAL SHELF, BERING SEA, ALASKA, 1984

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Map showing contemporary sea-floor bed forms, North Aleutian Shelf, Bering Sea, Alaska, by P. J. Hoose and K. H. Ashenfelter. Sheet 5.

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EXPLANATION

SUBSURFACE FAULT; bars on downthrown side; dashed where inferred

SURFACE FAULT; bars on downthrown side

ACOUSTIC ANOMALY

SURVEYS

1981 M.T.S.

1980 Fugro (R/V Discoverer)

1976 U.S.G.S. (R/V S.P. Lee)

1976 Petty Ray Geophysical

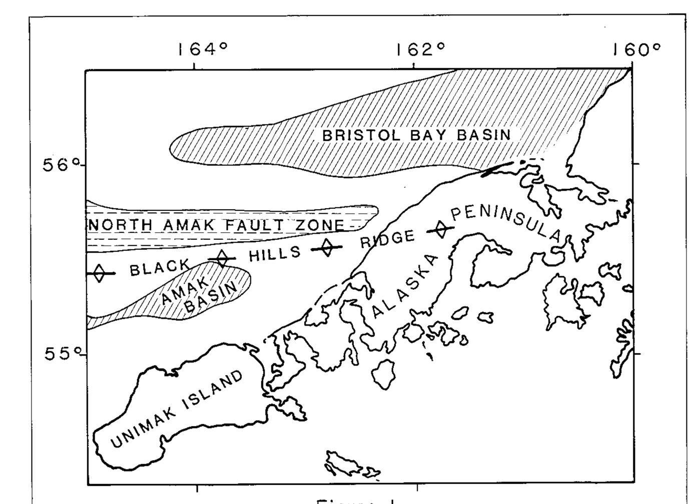
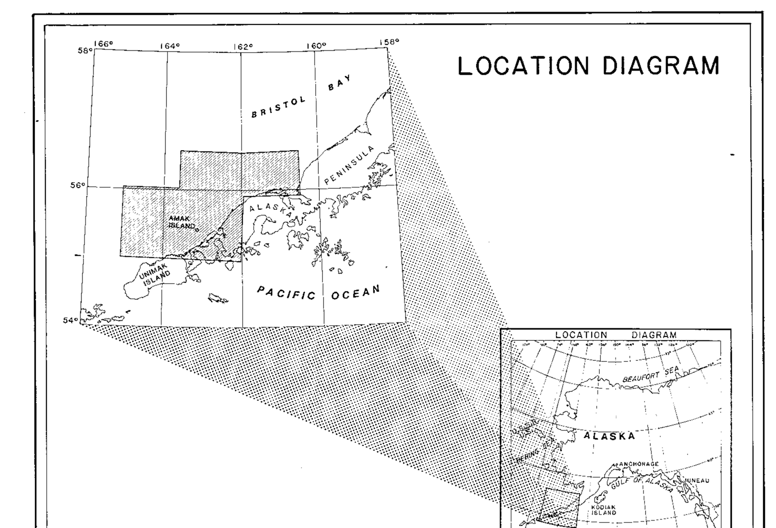


Figure 1



SOURCE OF SHORELINE FROM BUREAU OF LAND MANAGEMENT PROTRACTION DIAGRAMS NN 3-2, NN 4-1, AND NO 4-7. PUBLISHED IN 1976.

SCALE 1:250,000

5 0 5 10 15 20 STATUTE MILES
5 0 5 10 15 20 25 30 KILOMETERS
5 0 5 10 NAUTICAL MILES

MAP PROJECTION UTM, CLARKE 1866 SPHEROID, ZONES 3 AND 4.

MAP SHOWING ACOUSTIC ANOMALIES AND FAULTS, NORTH ALEUTIAN SHELF, BERING SEA, ALASKA

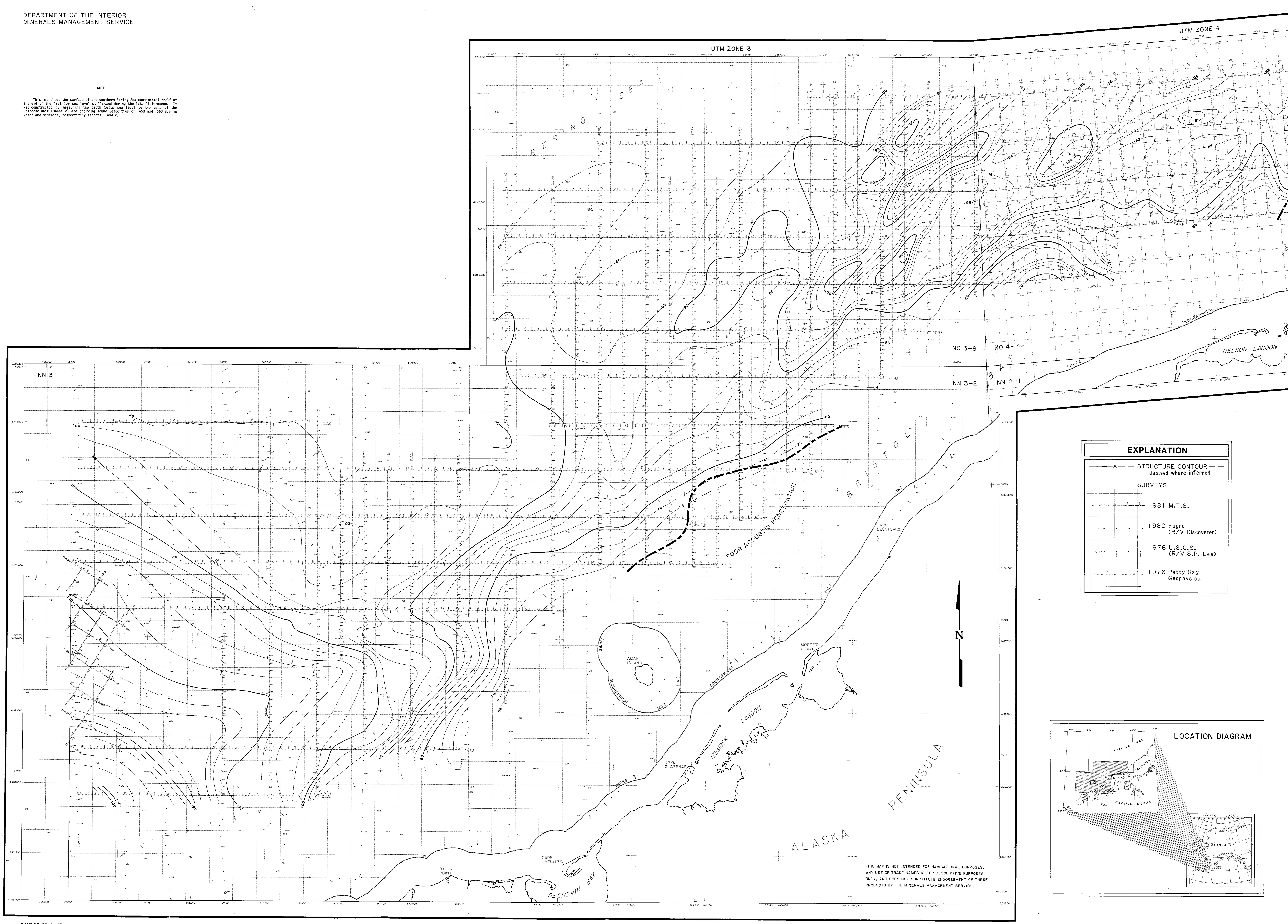
PETER J. HOOSE AND KATHERINE H. ASHENFELTER

1984

DEPARTMENT OF THE INTERIOR
MINERALS MANAGEMENT SERVICE

NOTE

This map shows the surface of the southern Bering Sea continental shelf at the end of the last low sea level stillstand during the late Pleistocene. It was constructed by measuring the depth below sea level to the base of the Holocene unit (sheet 2) and applying sound velocities of 1450 and 1660 m/s in water and sediment, respectively (sheets 1 and 2).



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CONTOUR INTERVAL 2 METERS (INDEX C.I. 10 METERS)

MAP PROJECTION UTM, CLARKE 1866 SPHEROID, ZONES 3 AND 4.

STRUCTURE-CONTOUR MAP OF THE PRE-HOLOCENE SURFACE, NORTH ALEUTIAN SHELF, BERING SEA, ALASKA

KATHERINE H. ASHENFELTER AND PETER J. HOOSE

1984

DEPARTMENT OF THE INTERIOR
MINERALS MANAGEMENT SERVICE

GEOLOGY

The nearshore part of the North Aleutian Shelf study area contains considerable evidence of sediment erosion and transport. Four types of current-generated bed forms are visible on sonograph records. These are scour depressions, small ripple marks, megaripples, and sediment waves.

The scour depressions appear on 3.5-kHz piezoelectric profiler records as flat-floored troughs recessed as much as 2 m below the sea floor and bounded by steep walls. This morphology is similar to the scour depressions in Norton Sound described by Larsen and others (1979). The seismic character of echoes from the bottoms of these depressions is fuzzy and prolonged in contrast to the crisp echo off the adjacent sea floor. The boundaries between these areas of contrasting echo characteristics are abrupt and coincide with the edges of the scour depressions. A similar contrast between the echo character of the scour depressions and the surrounding sea floor is apparent on side-scan sonographs. On these records, the scour depressions show up as dark (highly reflective) linear stripes across a light (poorly reflective) sea floor. The difference in echo character is caused by scattering off the rough surface of a coarse lag deposit that covers the bottoms of the scour depressions. This conclusion is supported by 76 surface sediment samples collected from the study area. These samples reveal that sediment from scoured sea floor (31 samples) contains an average of 6.9 percent gravel, 92.1 percent sand, and 0.7 percent silt compared with sediment from sea floor without bed forms (45 samples) which contains an average of 0.4 percent gravel, 98.6 percent sand, and 0.9 percent silt. Current measurements and television observations made on a September 1981 cruise aboard the R/V S. P. Lee indicate that scouring and sediment transport are both actively occurring (D. McInia, oral commun., 1983). Similar highly reflective features have been identified in other areas. Kenyon and Belderson (1973) recognized similar linear features on side-scan sonographs from the Gulf of Cadiz, which they attributed to a lag deposit formed beneath a tongue of Mediterranean outflow. McKinney and others (1974) identified very reflective linear patterns on side-scan sonographs from the New Jersey shelf, which were caused by troughs filled with gravel and coarse sand.

Scour depressions rarely occur as individual features. Usually they occur in small zones comprised of three or more scour depressions or in extensive scour zones which contain many individual scours and cover up to 600 km². The width of individual scour depressions varies within the study area and ranges from 6 to 200 m. Within a small scour zone, individual scour depressions will be approximately the same width and tend to run parallel to each other. In large scour zones, scour depressions are also parallel but width and spacing often change laterally across the zone.

Larsen and others (1979) propose that erosion by turbulent eddies formed the lobate-shaped scour depressions in Norton Sound. They invoke a scenario in which a bottom current, which has already been accelerated by flowing over or around a sea-floor obstruction, encounters small-scale sea-floor irregularities. These irregularities disrupt the flow, which causes current separation and eddy formation downstream. Although in some instances scour zones in the North Aleutian Shelf study area are associated with sea-floor obstructions ranging in height from 2 to 14 m, this scenario is not fully satisfactory because it fails to explain the characteristically linear, evenly spaced, and parallel morphology of the depressions. Alternatively, these features may have been formed by secondary helical circulation within a turbulent boundary layer. This explanation has been previously proposed for the origin of similar bed forms in a variety of other oceanic settings (Allen, 1969; McKinney and others, 1974; Flood, 1978; Embley and others, 1980). In the North Aleutian Shelf study area there appears to be no relationship between the width and spacing between individual scour depressions and the water depth. This suggests that these features are generated by secondary helical flow within a turbulent boundary layer and the diameter of these helical cells is unrelated to water depth.

On side-scan sonographs, scour depressions extend to the limit of the insonified sea floor and are probably continuous between track lines. The trends of scour depressions are displayed in a rose diagram in figure 1. Scour-depression azimuths were compiled by measuring the average trend for all scour depressions within five shot points (1500-m) intervals. The predominant trend of the scour depressions (63°) follows the regional isobaths. Deviations from this regional trend directly reflect the influence of local sea-floor topography. This trend is also parallel to the prevailing current which is part of a weak counterclockwise gyre that Hebard (1959, 1961) derived from direct current measurements. Maximum tidal and nontidal current velocities measured by Hebard were 35 cm/s and 9 cm/s, respectively.

Two types of ripple marks appear on side-scan sonographs from the study area and are distinguished by their wavelength and location. The first type, small ripple marks, have straight crests, wavelengths of approximately 1 m, and are found exclusively in the coarse sediment on the floors of scour depressions. Larsen and others (1979) also saw small ripple marks on the bottoms of scour depressions in Norton Sound. The second type, megaripples, have wavelengths of 9 to 25 m and occur on the sea floor outside of scour depressions. Ripple height cannot be resolved on profiles recorded by the hull-mounted fathometer owing to the heave of the survey vessel. In some areas, fields of megaripples coincide with scour zones and the megaripples are observed only on the sea floor between individual scour depressions. As water depth increases, the crests of megaripples become sinuous and some grade into strongly undulatory and lunate megaripples. The strikes of straight-crested megaripples were compiled using the technique described by Potter and Pettijohn (1963) and the statistical method used for scour zones described above. The results of this compilation are displayed in figure 2. The dominant trend of megaripple strike is 150°, approximately orthogonal to the scour-depression trend.

Sediment waves occur in only one locality in the survey area. These are relatively large features with crest-to-trough heights as much as 3.7 m. From the data coverage, it is not possible to determine their strike or wavelength. They occur at the crest and down current from a 14-m rise in sea-floor topography suggesting that they may be formed by a stationary internal wave on the lee side of the rise. This conclusion is similar to that of Flood (1978) for the origin of sediment waves on the Blake-Bahama Outer Ridge in the western North Atlantic.

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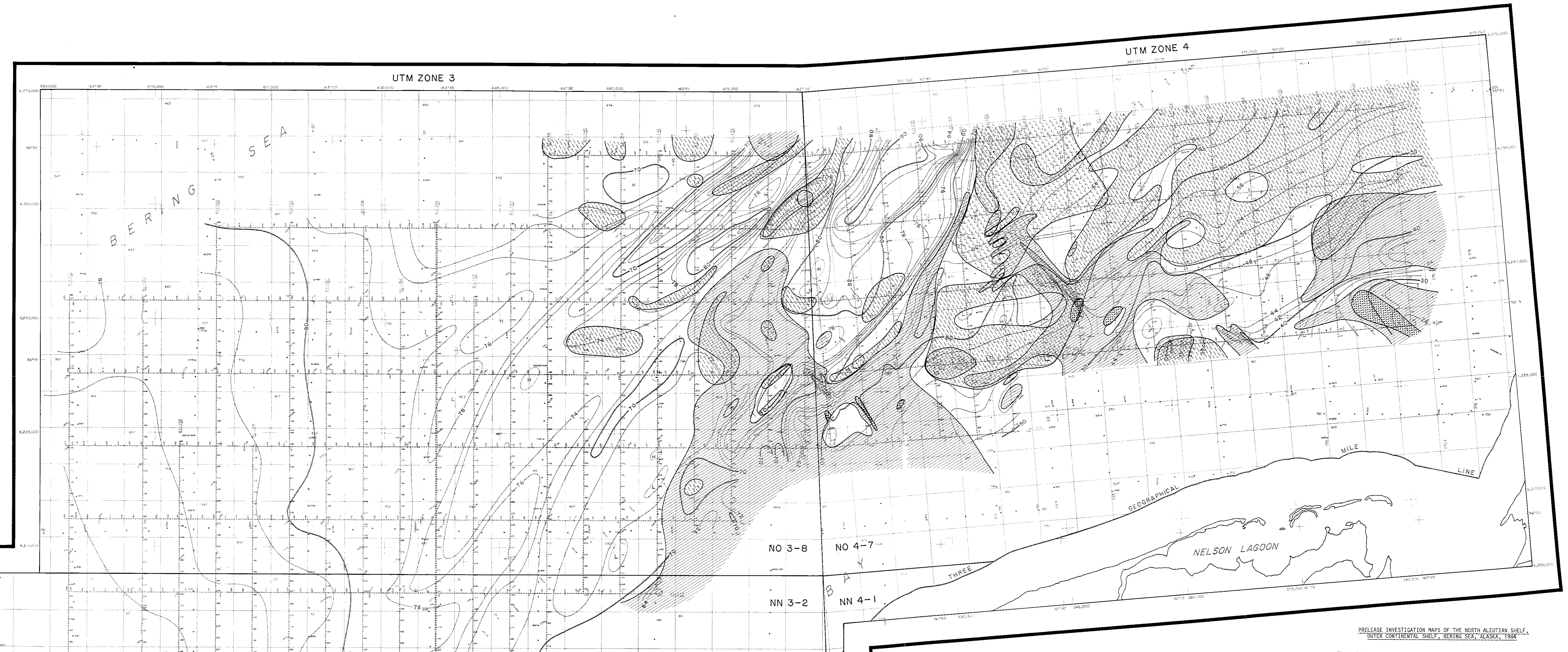

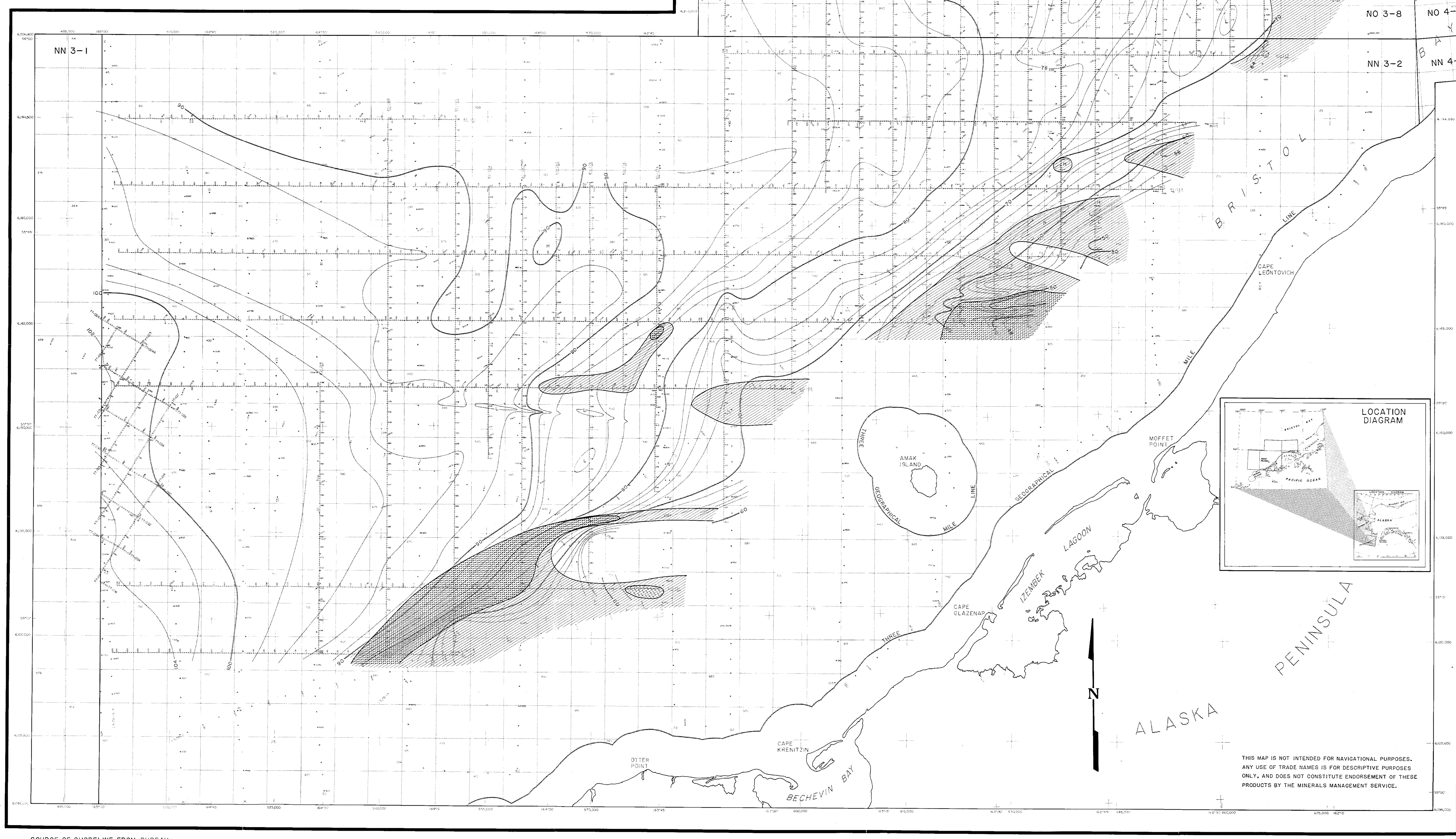

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EXPLANATION

- SCOUR ZONES
- SMALL RIPPLE MARKS
- MEGARIPPLES
- SEDIMENT WAVES
- BATHYMETRIC HIGH
- BATHYMETRIC LOW

SURVEYS

- 1981 M.T.S.
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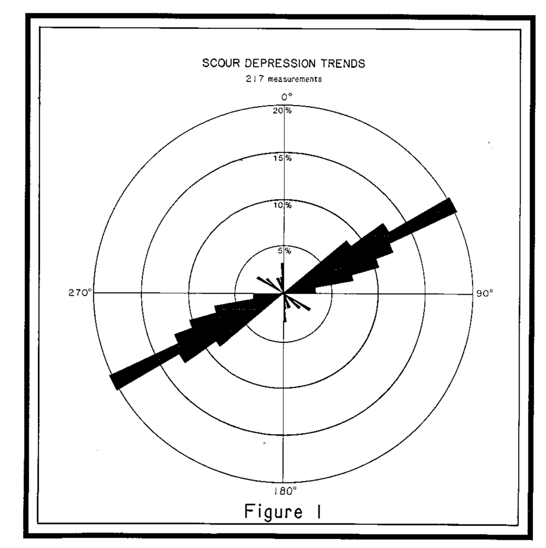

Figure 1

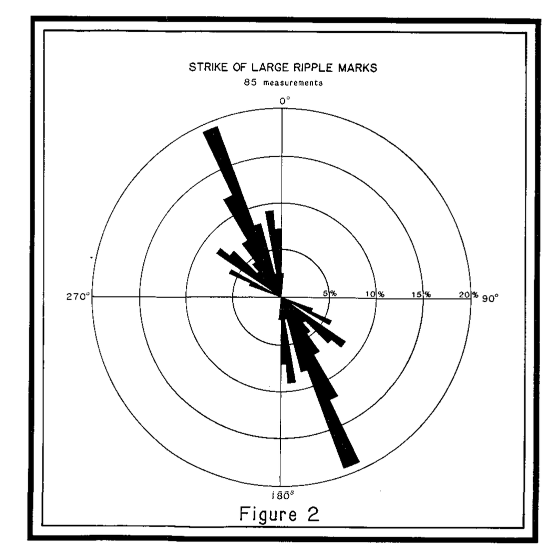

Figure 2

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MAP SHOWING CONTEMPORARY SEA-FLOOR BED FORMS, NORTH ALEUTIAN SHELF, BERING SEA, ALASKA

PETER J. HOOSE AND KATHERINE H. ASHENFELTER

1984