UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

PRELIMINARY RESULTS OF GEOPHYSICAL AND GEOLOGICAL STUDIES OF THE BERING SEA SHELF DURING 1982

BY

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U.S. Geological Survey
OPEN FILE REPORT
83-322

During July 1982, approximately 2,900 nautical miles of geophysical data as well as rocks from 14 dredge stations were collected aboard the R/V S.P. LEE from the Bering Sea shelf (fig. 1). The first phase of the cruise (L9-82-BS) was a government-industry cooperative project (GICORP) with the Center for Marine Crustal Studies of the Gulf Oil Corporation; the objectives were to collect data on deep crustal structure from seismic refraction profiles and to use these data for designing a future two-ship multifold seismic-reflection/refraction survey of the shelf. During this phase, 52 sonobuoys and approximately 1,500 nm of multichannel seismic-reflection, gravity, magnetic, and bathymetric data were collected. The second phase included dredging the outer edge of the continental shelf and collecting geophysical data between dredge stations.

Phase 1 - Deep crustal refraction studies

Unreversed seismic refraction profiles were recorded to offsets of 35-45 km using U.S Navy and commercial sonobuoys. A large volume (1,300-2,250 cu in) airgun array, fired at 50-m intervals, provided the seismic source. Preliminary analysis of the sonobuoy data has been done by the slope-intercept technique has provided crustal velocity-versus-depth information to depths of 12-14 km (fig. 2). The technique assumes that discrete layers of uniform velocity are present, an assumption that is not valid over long distances in areas of complex geology. Because only straight segments of the refraction arrivals have been used, the velocities and thicknesses of crustal layers close to the sonobuoy location are probably reliable. Future processing of the refraction data with intercept-ray parameter and ray-tracing methods will give better definition of the variations of velocity with depth and with horizontal distance along the transect.

Several preliminary observations and conclusions can be made from two transects shown in figure 2:

1. Crustal layers with high velocities (6.7-7.6 km/sec) are found at shallow depths (5-9 km) beneath large areas of the inner Bering shelf. High-velocity igneous and metamorphic rocks, such as layered gabbros, ultramafic rocks, schists, and amphibolites, occur near Hagemeister Island (transect 4-5; Hoare and Coonrad,1977). These or similar rocks may underlie the inner shelf near St. Matthew Island (transect 6-9) and be part of the igneous-metamorphic belt that is believed to extend across the shelf from Alaska to Siberia (Marlow and others, 1976)

2. Large crustal depressions are associated with Bristol and Navarin basins, and these depressions may be filled with as much as 6 km and 13 km, respectively, of Cenozoic and Mesozoic strata.

3. The northern part of Bristol Basin is underlain by rocks with velocities (6.0-6.2 km/sec) similar to those for granitic rocks; these rocks may be a continuation of the granitic-plutonic belt in the Alaska Peninsula.

4. An abrupt change in magnetic and gravity anomalies occurs along transect 6-9 on the eastern side of Navarin Basin; the change is seen in other profiles across the region and may mark the fault-controlled juxtaposition of two distinct terranes: a predominantly igneous-metamorphic terrane beneath the inner shelf (Nunivak arch) and a predominantly sedimentary terrane beneath Navarin Basin.

5. Kuskokwim Bay is underlain by a crustal depression that is filled with at least 5 km of rocks that have velocities (4.1-5.5 km/sec) similar to those for Mesozoic volcanic and sedimentary rocks sampled in the onshore Bethel well, 150 km to the northeast. The offshore section may be a continuation of the onshore Kuskokwim Basin. Other small depressions, between Nunivak and St. Matthew Island, are suggested by undulations in the gravity data and by shallow high-velocity refractors; these depressions may also contain Mesozoic sedimentary and volcanic rocks.

6. Large magnetic anomalies of the inner shelf fall into two general categories: those of very high-amplitude, high-frequency (St. Matthew Island), and those of lesser amplitude and broader wavelength (Kuskokwim Bay). The first category may be caused by near-seafloor intrusive and volcanic rocks (Hagemeister Island area), as well as volcanic flows (St. Matthew Island); the second category probably results from more deeply buried volcanic piles (Kuskokwim Bay) and intra-basement structures.

7. The extensive volcanic flows that make up Nunivak Island appear to be confined to the island, because large magnetic anomalies are not present in the adjacent offshore areas.

Phase 2 - Geological studies

Prior to this study, dredge sampling along the northern Bering Sea shelf edge (Marlow and others, 1979) recovered upper Jurassic and upper Cretaceous limestone and sandstone as well as lower Tertiary basalt, limestone, and mudstone from the acoustic basement; these rocks are overlain by Cenozoic mudstone, sandstone, limestone, and tuff. During the 1982 cruise, dredge samples were collected at fourteen nearby localities along the outer shelf edge(fig. 1). Rocks from beneath and above the prominent unconformity at the top of the acoustic basement surface were collected and analyzed.

Preliminary examination of the rock samples obtained during the 1982 cruise show that:

1. Limestone recovered at most dredge stations and throughout the sedimentary section is of secondary origin and was not deposited originally as carbonate sediment.

2. A pinnacle of fresh basaltic rocks, discovered on the shelf in shallow water, cross-cuts and overlies the flat-lying sedimentary section at the shelf edge. These rocks may be syngenetic with Quaternary volcanic flows on Nunivak and the Pribilof Islands.

3. Rocks with opaline silica(opal-CT) and quartz were recovered from the lower parts of the sedimentary section and may be the result of diagenesis of the overlying diatomaceous (opal-A) mudstone and siltstone.

4. Conglomerate, found at several sites and presumed to be from the unconformity directly above basement, may be of Oligocene age, based on its similarity to a sample recovered nearby in 1970 (Marlow and others, 1976).

5. Volcanic and meta-igneous rocks, recovered from the basement in an area where a sample of Eocene (minimum age) basaltic andesite was obtained in 1978, do not appear to be widespread beneath the slope, based on magnetic and sample data; however, they may be more common beneath the shelf where refraction data indicate rocks having similar velocities (5.5-6.0 km/sec) are present.

6. Correlation of refraction and geologic data at the shelf edge (fig. 3) indicates a sequence of presumably Neogene diatomaceous mudstone, sandstone, and limestone (1.6-4.5 km/sec) overlying an unconformity marked by conglomerate (4.9 km/sec) and underlain by other more highly indurated sedimentary and volcanic basement rocks (4.9-5.8 km/sec).

BIBLIOGRAPHY

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FIGURE CAPTIONS

Figure 1: Index map showing location of geophysical tracklines and geological sampling site for cruise L9-82-BS. Water depth in meters.

Figure 2: Interpretation of two geophysical transects across the Bering Sea shelf that show preliminary velocities (km/sec) and thicknesses for crustal layers, based on sonobuoy refraction profiles located on figure 1.

Figure 3: Seismic-reflection profile showing rock types dredged along the profile and refraction velocities (km/sec) measured at a sonobuoy station 5 km from the end of the profile. See figure 1 for location.

Fig 1

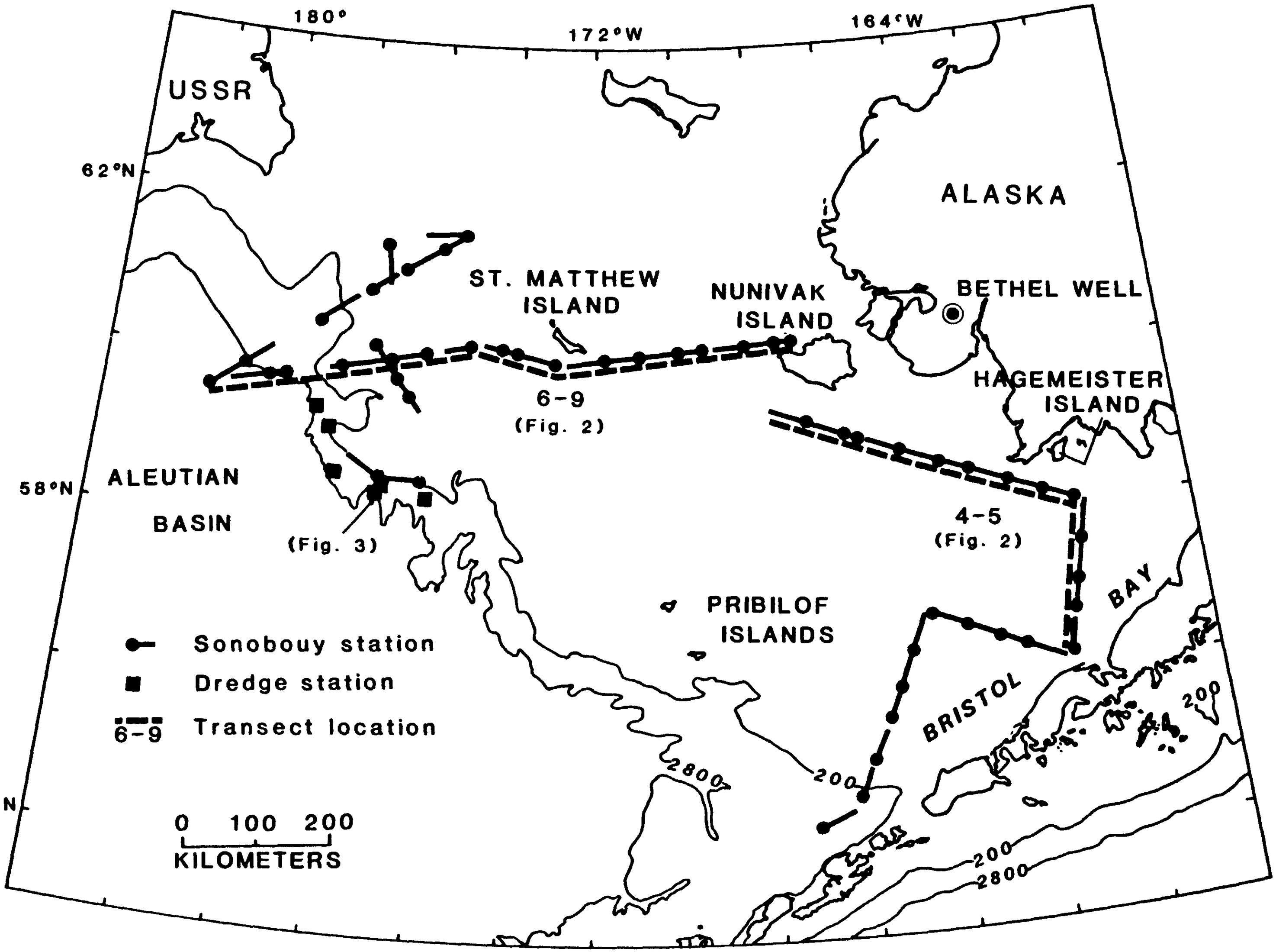
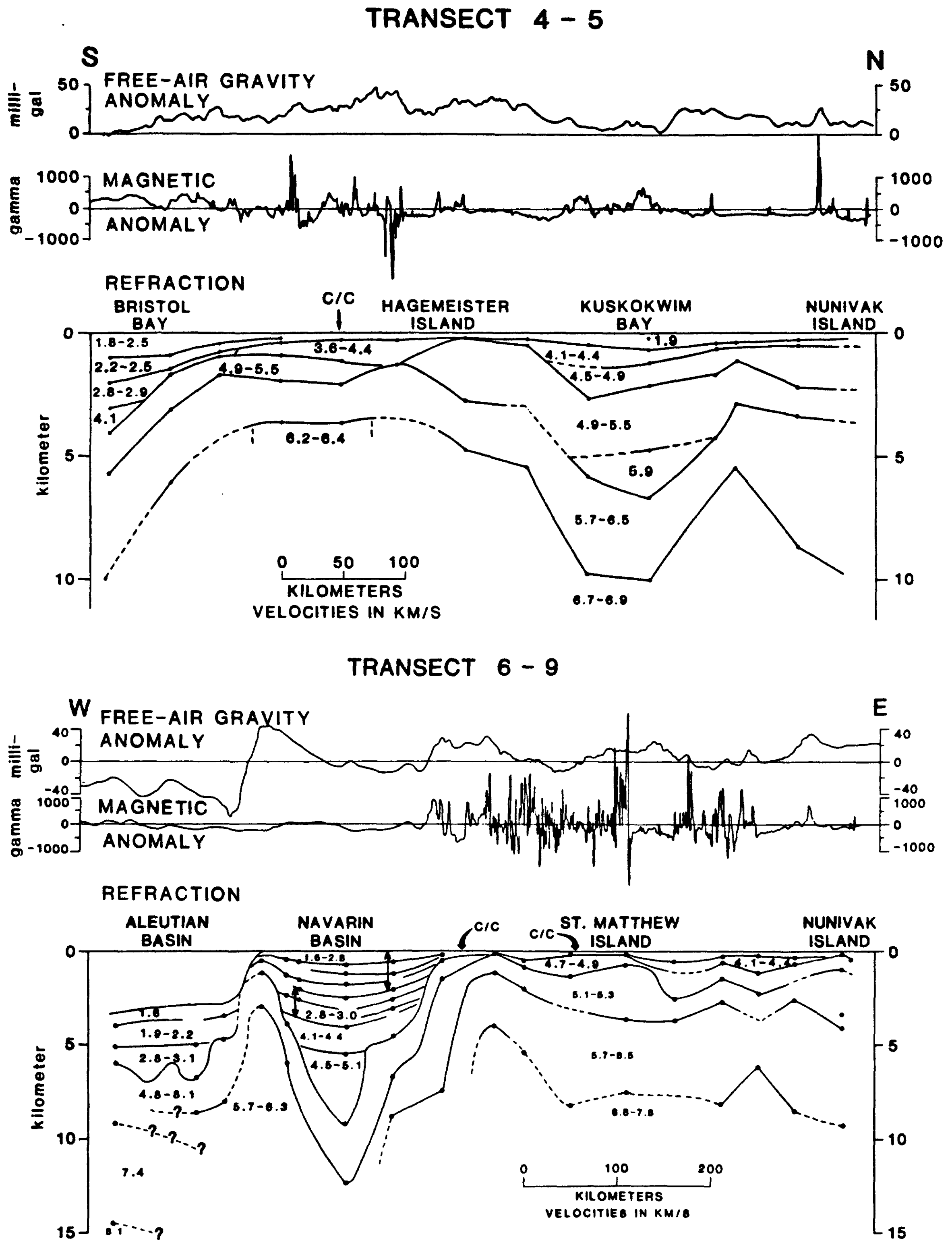

180°
172°W
164°W
62°N
58°N
54°N
USSR
ALASKA
BETHEL WELL
HAGEMEISTER ISLAND
ST. MATTHEW ISLAND
NUNIVAK ISLAND
6-9
(Fig. 2)
4-5
(Fig. 2)
ALEUTIAN BASIN
(Fig. 3)
PRIBILOF ISLANDS
BAY
BRISTOL
200
2800
200
2800
200
2800
Sonobouy station
Dredge station
6-9 Transect location
0 100 200
KILOMETERS

FIG 2

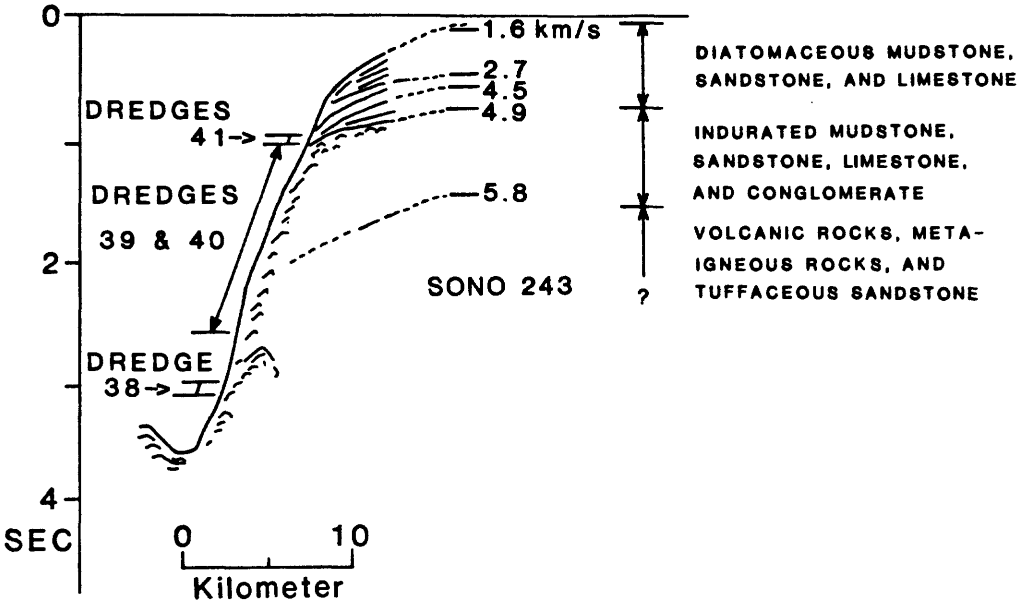


TRANSECT 4 - 5

TRANSECT 6 - 9

7

Fig 3


0
2
4
SEC
DREDGES
41->
DREDGES
39 & 40
DREDGE
38->
0
10
Kilometer
1.6 km/s
2.7
4.5
4.9
5.8
SONO 243
?
DIATOMACEOUS MUDSTONE, SANDSTONE, AND LIMESTONE
INDURATED MUDSTONE, SANDSTONE, LIMESTONE, AND CONGLOMERATE
VOLCANIC ROCKS, META-IGNEOUS ROCKS, AND TUFFACEOUS SANDSTONE