DEPARTMENT OF THE INTERIOR

U.S. GEOLOGICAL SURVEY

Cruise Report for EEZ-SCAN 86 Cruise F3-86 Zhemchug Canyon and Central Aleutian Basin, Bering Sea August 6 through September 1, 1986

by

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This report is preliminary and has not been reviewed for conformity with U.S. Geological Survey editorial standards and stratigraphic nomenclature.

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INTRODUCTION

From August 6 through September 1, 1986, a joint USGS/IOS geophysical survey of the central Aleutian Basin and Beringian margin was conducted using the GLORIA III system (Somers et al., 1978; Swinbanks, 1986), two-channel digitally recorded 160^3-in airgun seismic-reflection, 3.5 kHz high-resolution seismic reflection, 10 kHz bathymetry, gravity, and gradiometer magnetic profiling systems. The cruise, the second of three EEZ-SCAN cruises in 1986 in the Bering Sea, covered 8509 line kilometers and insonified approximately 200,000 km^2. Seventeen hours of transit were required from Dutch Harbor, AK before the survey began and 42 hours of transit were necessary from the point where the cruise terminated to return to Dutch Harbor. The GLORIA system was down only 5 hours out of the 564 hours (0.9%) of the entire survey.

Leg 3 was designed to continue the survey of the central Aleutian Basin and Beringian margin that was begun by the previous leg (Carlson et al., 1986). The courses for the survey were parallel to those established during cruise F2-86 and were generally 130^0 and 310^0. Tracklines were spaced approximately 2-km apart over the steep continental slope of the Beringian margin and approximately 30-km apart over the Aleutian Basin (Figure 1). All of the seismic systems and the gradiometer were deployed when we commenced the first GLORIA survey line and all systems were recovered when we completed the last GLORIA survey line. This scheme allowed the maximum time to be spent in the survey area and for transit to and from the survey area to be at relatively fast speed.

The survey began northeast of Pribilof Canyon and continued toward the northwest over the upper continental slope. The trackline orientations over the continental slope must be parallel to the contours so that the swath widths do not change along the trackline. We chose to survey the continental slope first because the weather and sea state were so good that trackline orientation was no problem. We completed the entire continental slope area without mishap and then expanded our trackline spacings to the maximum 30 km that would provide about 5 km of overlap as we surveyed the deep waters of Aleutian Basin. The survey progressed southwestward toward the Aleutian Arc and was terminated because of time just northeast of Bowers Ridge.

The weather and sea states were good throughout the cruise and only one line had to be altered because of adverse seas. All of the equipment performed well and only one line had to be interrupted because of equipment failure.

Table 1 is a list of the scientific personel that sailed on cruise F3-86-BS.

TABLE 1

Gardner, J.V. (USGS)	Chief Scientist
Huggett, Q. (IOS)	Chief Scientist
Karl, H.A. (USGS)	Chief Scientist
Beney, M. (IOS)	Navigator
Dean, W.E. (USGS)	Geologist
Grey, A. (IOS)	Airgun Engineer
Harris, M. (IOS)	Sr. GLORIA Engineer
Kooker, L. (USGS)	Electronics Technician
O'Brian, T. (USGS)	Electronics Engineer
Rothwell, G. (IOS)	Photographer
Torresan, M. (USGS)	Geologist
Walker, R. (IOS)	GLORIA Engineer
Wittle, S. (IOS)	Airgun Technician

EQUIPMENT REPORT

GLORIA III LONG-RANGE SIDE-SCAN SONAR

GLORIA performed well throughout the entire survey. Leg 2 (F2-86-BS) experienced problems with beam steering that were diagnosed as being due to cross-wired electronics. wired. The beam steering electronics were checked out prior to our departure and then tested in Dutch Harbor harbor by steering the ship in several different courses with GLORIA in the gantry on deck and observing the digital compass. The beam steering was working correctly before we departed.

The initial GLORIA sonographs were striped perpendicular to the ship track. The problem was tracked to the ship's autopilot, which was set to correct the course with a recovery time of about 80 sec rather than about 10 seconds. Consequently, the ship was steering a wiggle course and GLORIA was yawing through its receive/transmit cycle, at times more than the maximum 8 degrees that can be compensated by the beam steering. The autopilot was reset to correct for any deviation away from the course greater than 1.5 degrees and the records immediately improved.

The digital compass on the GLORIA fish failed after about a week of surveying. This was considered serious enough to suspend the survey to repair it. Because the compass is located in the tail section of the fish, it took only 5 hours from suspension of the line until the resumption of operations to repair the compass. The depth sensor and temperature thermosister, which also failed about one week into the survey, would have required too much time to repair and were deamed not critical to the survey so were left inoperative.

The northwestern part of the F3-86-BS survey encountered the acoustic interference on the GLORIA imagery similar to that which vexed the F2-86-BS survey. The interference may be a Lloyd mirror effect (Urick, 1983).

Airgun Seismic-reflection profiling system

We reconfigured the Masscomp/seismic-reflection profiling system into a data-logging system so that the seismic system is not affected when the Masscomp crashes. We installed the DAFE programs on the Masscomp and placed all DAFE work in background with the NICE option. We found that the Masscomp was unaffected by DAFE data entry but would crash from time to time if the DAFE data were edited with the VI editor. We chose to continue using the DAFE but left the editing for post-cruise processing.

When we got aboard the ship all of the seismic systems electronics were checked out. We found that the trigger-pulse voltage was not matched at the LSR recorder and the bandpass filters were not properly wired. The mismatched trigger-pulse voltage was causing the recorder to not print the scans correctly because the time = 0 pulse was not strong enough to trip the print circuit. The improperly wired bandpass filters would have not given us the frequency band that we thought we were recording. These problems were corrected before departure and did not give us any trouble throughout the cruise.

We shot the seismic system at 10-second intervals and recorded for 6-seconds using 4 sec/scan, 120 lines/inch with 70/15 hz bandpass filters. The water-column delay worked flawlessly.

We experienced broken airgun shuttles twice during the cruise. This is an unusual failure and caused some debate as to the problem. We decided it was fatigued shuttles brought about by extended use rather than cold water or improper assembly.

3.5 kHz system

The 3.5 kHz system worked but the recorder did give us some problems. A bad IC board in the programmer of the LSR was diagnosed but we had no spares. We lost several hours of data over the continental slope while the recorder was rebuilt. Once rebuilt, the system gave no further trouble.

10 kHz system

The 10 kHz system worked without fault through the entire survey.

Gradiometer

The gradiometer was recovered at the end of F2-86-BS with the slave jug missing. We had to change out the entire gradiometer cable prior to departure from Dutch Harbor. There were no spares aboard to repair the damaged cable so it was simply stored below deck.

Once deployed, we found that the gradiometer chart recorder had been wired incorrectly and the recorder was not monitoring gradient. However, because both master and slave values were being recorded separately on magnetic tape, we determined it not prudent to shut the system down for a day to effect repairs on it.

The slave jug got very noisy but we had no spares to correct the problem so we had no recourse but to continue to collect noisy data.

Gravimeter

We did not have a land meter to make a land tie in Dutch Harbor. We did record the dock location, ship's position at the dock, and the spring tension and gravity values from the ship's meter prior to departure. During the cruise the strip chart recorder behaved erratically producing spikes in both spring tension and gravity values. The recorder was rebuilt and the system settled down. Three days before the termination of the cruise the gravimeter failed because an amplifer had burned out. Because it was 1730 hr on a Friday prior to a three day weekend back in Menlo Park, and hence nothing could be done to help out, we simply secured the system.

XBT-GOES system

The system worked without failure during the cruise. We recorded steep thermoclines throughout the survey area. We attributed this to the mild weather conditions that prevailed through the cruise. No problems were encountered launching the XBTs over the starboard rail.

Navigation

We had GPS, hyperbolic Loran C, NNSS satellite, and Omega systems available to us. The Northstar Loran C unit gave poor signal-to-noise ratios relative the two MNS Loran C units on the bridge. About two weeks into the cruise it was found that the Northstar Loran C interface box had been improperly installed. The instructions state that the interface box can be no greater than 6 feet away from the computer; it was installed 120 feet from the unit. The interface box was moved and the Northstar Loran C signal-to-noise strength improved considerably.

Ship's 110 VAC electrical supply

There continued to be a lot of problems with the 110 VAC power to the geophysics lab during the early phase of the cruise. Eventually the power spikes were isolated to a cyclic 20 amp load on the system by the Cannon copier. The copier was put on its own transformer and no further problems were encountered with the electrical system.

PRELIMINARY SCIENTIFIC RESULTS

The organization of the cruise allowed us to construct and interpret a shipboard mosaic of shipboard-processed GLORIA images, compile structure contour and total sediment thickness maps from the seismic data, compile detailed bathymetry, and compile a magnetic anomaly map from the data collected. From these compilations we have deduced the following preliminary observations.

The entire margin, including Zhemchug Canyon (Figure 2), appears to be collapsing through mass wasting. Hundreds of small feeder canyons, most with only first-order tributaries, are organized into a few major channels at the base of the slope. The major channels are are extremely sinuous and levees are ubiquitous. Basement highs are only seen on the upper slope; all relief from the mid-slope and deeper is sediment highs, presumably levees or large blocks of margin that have collapsed and been transported downslope. Gullying is pronounced throughout the slope. Gullying of the levees has, in many cases, produced tributaries that approach the main channel with a trend normal to the channel. The floors of the main channels typically are tilted from bank to bank. Often a thalweg can be seen on the 3.5 kHz data, and several of the channels have terraces, suggesting stages of down-cutting. The main channels can be followed in the subsurface on the airgun records and numerous buried channels can be seen.

The origin and development of Zhemchug Canyon appears to be as follows: Up until sometime in the Pliocene the Beringian margin in the area of Zhemchug Canyon was straight with numerous, small-scale canyons and gullies. Sometime in the Pliocene (in mid-Pliocene if we correlate our data to DSDP Site 190), a large olistostrome (about 100 x 100 km) broke away from the margin and slid intact out onto the abyssal plain. Headward erosion in the scarp left by the olistostrome eventually worked its way northward until the southernmost of the two parallel faults that parallel the margin were intersected. Headward erosion followed the fault, as well as continued toward the northern fault. Erosion along the faults caused the "winged" topography of Zhemchug Canyon. Additional olistostromes slid down the margin intact, clogged the sediment transport paths, and formed a complex pattern of channels. Eventually, the channels in the proximal region organized into a few dominant channels. South of the initial olistostrome block the channel has small levees that die out within about 30 km of the block. The olistostromes have been heavily gullied and may well be a major source of sediment to the channels. The volume of sediment transported to the abyssal plain from Zhemchug Canyon appears insignificant compared to that funnelled down Bering Channel.

The airgun records show a pronounced, relatively flat-lying reflector upon which all the relief has been built. This reflector can be mapped throughout the lower slope and it has many similarities to the upper one second of reflectors on the abyssal plain. Apparently, the reflector is the surface that marks the transition from pelagic or at least distal hemipelagic sedimentation to predominantly hemipelagic deposition. The increased hemipelagic sedimentation was a result of the increased terrigenous flux provided to the basin during the beginning stages of the collapse of the margin front.

The Aleutian Basin southwest of Zhemchug Canyon, beyond the large olistostromes, has a cresent-shape zone of bedforms that may be the toe of the olistostrome front. A major deep-sea channel enters into the survey area from Bering Canyon (Figure 2). The channel is not entrenched, but rather a shallow, gently sloping feature with a well-developed levee on the north side. The front of the levee is gullied whereas the back side (lee side) is ornamented with large bedforms, similar to those seen on Monterey Fan. We cannot define any submarine fan, *senso stricto*, but rather a flat, continuous depositional surface. The large "Bering deep-sea channel" has crevasse splays to the south and braided features similar to the patterns found proximal deep-sea basins west of California (EEZ-SCAN 84 Scientific Staff). Bering deep-sea channel is the most prominent of three channels that can be followed onto the Aleutian Basin, and this suggests to us that it has been the principal conduit for sediment transport into Aleutian Basin. The channel cannot be followed in the subsurface on airgun record, which suggests to us that sheet flow has been the dominant process. The continental margin from just north of Pribilof Canyon (Figure 2) extending to the north end of Zhemchug Canyon apparently has not provided much sediment to Aleutian Basin, other than to the immediate proximal areas of the lower slope. There is no appreciable continental rise, but rather the abyssal plain abuts rather abruptly into the slope. This is additional evidence that the continental margin has not been a major source of sediment to the Aleutian Basin.

The Bering Channel and Fan system evolves from a distributary system into what could be called a sheet-flow fan system. Pronounced backscatter patterns of high and low intensity cannot be correlated easily with any reflectivity patterns on the 3.5 kHz. Features on the images interpreted to be debris flows transported from the east, presumably coming off Umnak Plateau (Figure 2), onlap the sheet-flow deposits of Bering Fan. However, the 3.5 kHz records show that the debris flows and the sheet flows are both blanketed by about 10 meters of conformable (presumably pelagic) sediment. Consequently, the sedimentation in the eastern sector of the survey area appears to have been more active in the pre-Holocene. The distributaries and sheet-flow deposits of Bering Fan that veer to the southwest appear to be younger than those to the east; however, they also may not be presently active.

An increasing influence from debris flows from Bowers Ridge (Figure 2) is seen in the southwest and northward onto Bering Fan. Here again, the acoustic backscatter is uncorrelated with 3.5 kHz reflectivity.

Small canyons and gullies are carved in the flank of Bowers Ridge, but there are no indications of sediment aprons at the base of the ridge. The 3.5 kHz record shows >70 m of penetration, and the sediment looks pelagic, with no hard surface reflector. The airgun data show a reflector rising from depth and merging with another reflector so that the upper acoustically stratified unit is composed of two distinct subunits. The GLORIA and airgun data from the base of Bowers Ridge suggest that Bering Fan sediment has veered to the northwest because of the bathymetric barrier of Bowers Ridge. Bowers Ridge apparently is a very minor sediment source to the basin, based on the lack of any debris aprons or even any topographic expression of sediment accumulations.

The detailed bathymetry that we have collected suggests that the deepest area of Aleutian Basin is to the west of our survey area, and the abyssal plain gently slopes from E to W toward the deep. However, Bering Channel, which enters our survey area trending SE, makes a series of gentle bends to the south so that by about 200 km into our survey area the channel is trending almost due south. The channel proper is a subtle feature on seismic data but a distinct low-backscatter feature on GLORIA. Numerous crevasse splays occur on both sides of the channel and a small levee persists on the N side. As the levee was built, the channel flowed toward the south, transverse to the regional bathymetric gradient. The cause of this deflection is unknown. The channel-levee complex covers an area greater than 35,000 km^2. The channel traverses about 300 km in our area and then breaks up into distributary system. The only evidence of sediment transport from Zhemchug Canyon onto the abyssal plain is lobate bedforms at the mouth of the canyon described earlier in this cruise report.

We can continuously map oceanic basement, even at depths of 3.5 sec, and can see that basement does not control the channel-levee complex. There are no indications of buried channels or levees beneath the channel-levee complex and the acoustic stratigraphy tracks uninterrupted beneath it and beyond. The levee has strange whispy backscatter patterns on its surface that can not be correlated with any acoustic signature on the 3.5 or 10 kHz.

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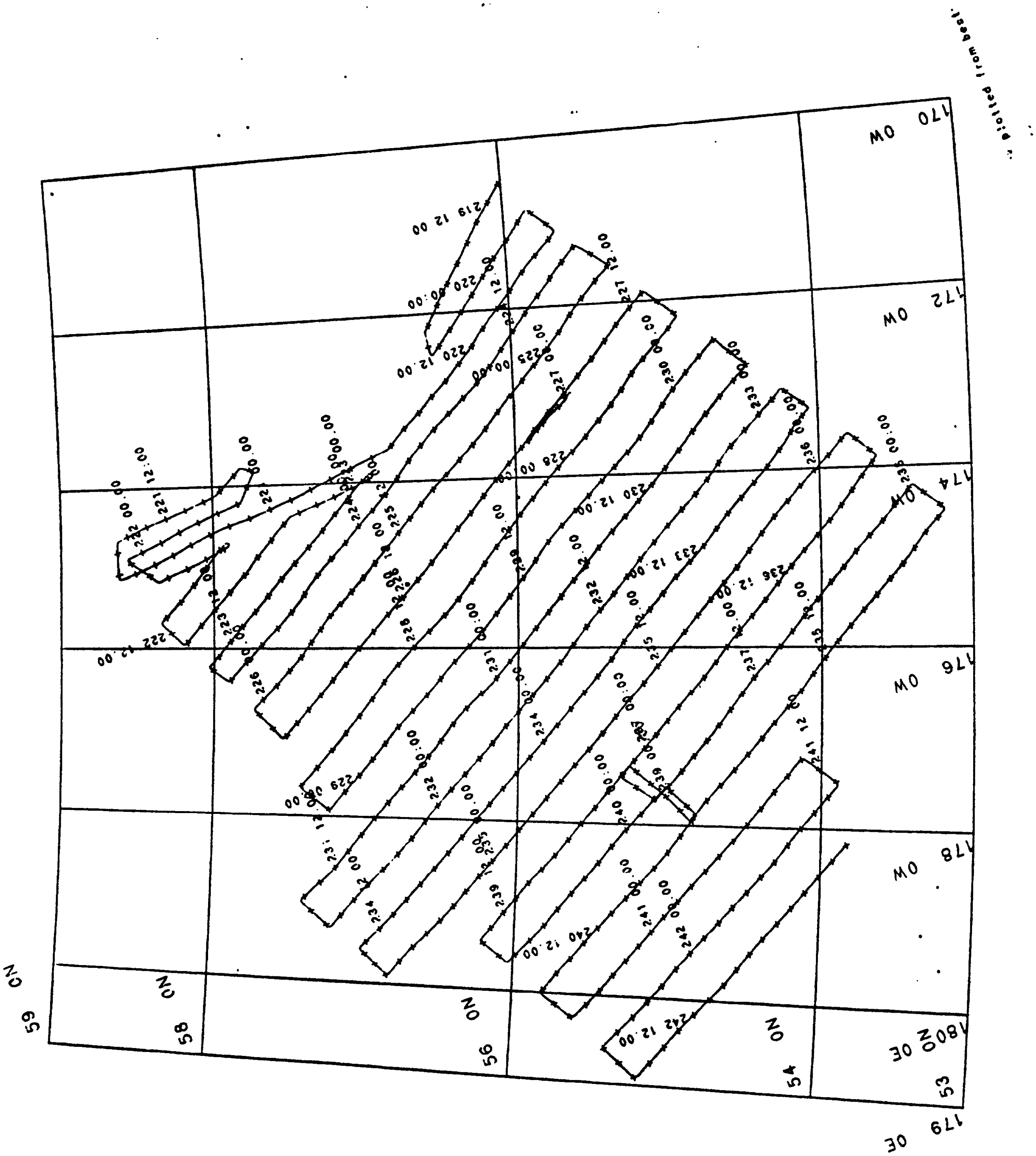

Figure 1

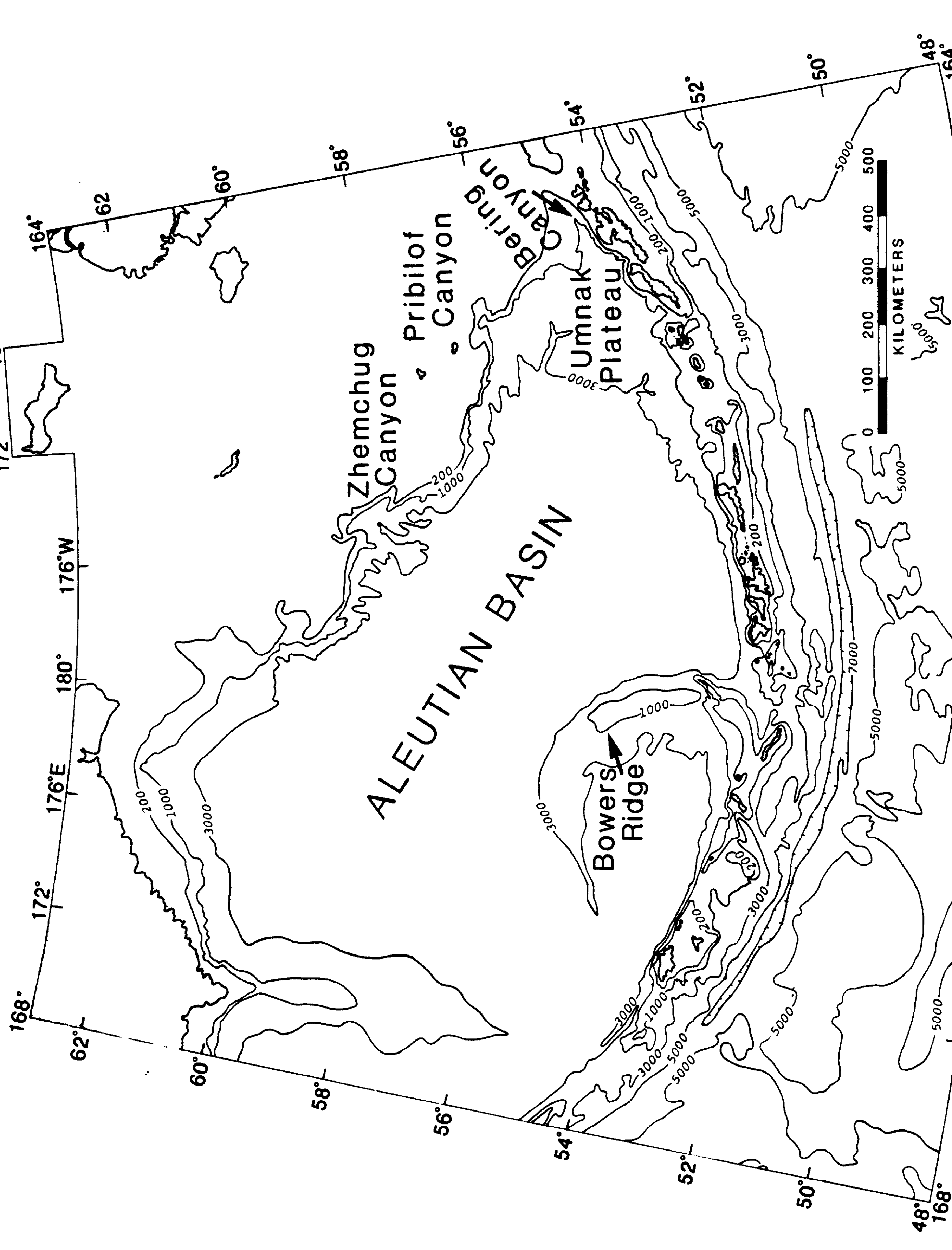
ALEUTIAN BASIN
Zhemchug Canyon
Pribilof Canyon
Bering Canyon
Umnak Plateau
Bowers Ridge
KILOMETERS
0 100 200 300 400 500
176°W
180°
176°E
172°
168°
164°
62°
60°
58°
56°
54°
52°
50°
48°

Figure 2