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BATHYMETRIC MAP OF THE CONTINENTAL SHELF, SLOPE, AND RISE OF THE BEAUFORT SEA NORTH OF ALASKA

By Jonathan Greenberg, Patrick E. Hart, and Arthur Grantz

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DATA SOURCES

The "Bathymetric map of the continental shelf, slope, and rise of the Beaufort Sea north of Alaska" is based primarily on new bathymetric data acquired during the course of seismic reflection surveys conducted by the U.S. Geological Survey in 1972–74 and 1977–78 and by the Geophysical Corporation of Alaska in 1973 (figs. 1 and 2). The primary data sets provide regional coverage of the shelf, slope, and parts of the continental rise north of Alaska with good position control by satellite or integrated satellite (satellite plug doppler sound) navigation. These data were supplemented in the western half of the map by soundings from the continental slope and rise furnished by R. L. Fisher of the Scripps Institution of Oceanography (in part published in Fisher and others, 1958), near the coast by data published by the National Ocean Survey, and on the lower slope and rise by both published and unpublished soundings from the U.S. Naval Oceanographic Office. Numerous spot soundings obtained during the course of gravity surveys north of Alaska were contributed by Peter Dehlinger of the University of Connecticut, and a dense network of soundings obtained in the course of gravity surveys north of Canada was contributed by J. R. Tanner of the Earth Physics Branch, Department of Energy, Mines and Resources, Canada. The supplemental data sets were positioned mainly by radar and celestial navigation. Except for the data of the Earth Physics Branch, which were positioned by a shore-based Lambda-Decca navigation system, and the nearshore data of the National Ocean Survey, the supplemental data sets provide coverage that is generally less systematic and less closely positioned than the primary sets.

ACKNOWLEDGMENTS

We thank R. L. Fisher, Peter Dehlinger, and J. R. Tanner for the data that they contributed to this map. J. B. Chandler, R. W. Harpe, and John Lanier of the Defense Mapping Agency also furnished many valuable unpublished soundings. Wer are indebted to the U.S. Coast Guard for providing the icebreakers USCGC *Burton Island* in 1972–74 and USCGC *Glacier* in 1976 as platforms for our surveys, and to Captain R. G. Moore and George Schmidt of *Burton Island* and Captain J. J. Dirschel of *Glacier* for their support of the Geological Survey field parties aboard their ships. The Naval Arctic Research Laboratory, Barrow, Alaska, provided valuable logistic support. The 1977 and 1978 U.S. Geological Survey data were obtained from the U.S. Geological Survey Research Vessel *S. P. Lee*. We are grateful to Captain W. T. Ruff of the *S. P. Lee* for his efforts on behalf of our surveys.

USES OF THIS MAP

The bathymetric map was prepared as a base for displaying physiographic and geological data being developed by the U.S. Geological Survey on the continental shelf, slope, and rise north of Alaska. It was not designed to serve as a chart for navigation. The bathymetry shown has also been released as a set of six maps at a scale of 1:250,000 (Greenberg and others, 1979) to aid users requiring a map at a larger scale. A preliminary analysis of the physiography of the Beaufort Sea can be found in Grantz and Eittreim (1979).

DATUM AND SOURCES OF ERROR

The bathymetry is plotted on a computer generated polar stereographic projection with a scale of 1:500,000 at lat 72°00′N. Inherent inaccuracies in the computer-controlled plotter that was used to generate the map produced nonsystematic errors, estimated to be as large as 1 km, in the position of both the grid points and the bathymetry. Datum for the National Ocean Survey charts, our primary data source nearshore, is mean lower low water. Mean range of the periodic tide along the coast in the map area is only about 10 to 20 cm (U.S. National Ocean Survey, 1976), and hence none of the other data sets was adjusted for tide. Variations in sea level related to changes in water temperature and salinity (steric variations), wind, and excursions of barometric pressure can be larger. Beal (1968) reports that steric and barometric variations cause an annual winter-to-summer fluctuation of sea level at Barrow of 30 to 40 cm, and Hume and Schalk (1967) report that exceptional storm surges raise sea level at Barrow by 3 to 4 m, although the effect is presumably less offshore. No corrections for these effects were attempted. Other sources of bathymetric error are electronic noise and water-column inhomogeneities, commonly estimated to produce random errors of about 1 or 2 percent, and nonvertical echos. In the Beaufort Sea north of Alaska the inclination of the continental slope averages 4° to 12°, with local steep pitches of 16°. Bathymetric profiles that trend directly down uniform slopes indicate depths that are too shallow by about 0.3 percent where the slope is 4°, by about 2.2 percent where the slope is 12°, and by about 4 percent where the slope is 16°.

CONVERSION OF REFLECTION TIME TO WATER DEPTH

Most of the depth values used to construct the bathymetric map were not corrected for the increase in velocity of sound with depth in the water column. Instead, a constant velocity was used to convert the transit time of echo-sounder signals to depth. The U.S. Geological Survey soundings were converted using a constant velocity of 1,464 m/s (meters per second), and the Geophysical Corporation of Alaska soundings a constant velocity of 1,448 m/s, a good approximation for the shelf areas where most of their profiles are located. The different assumed velocities on the shelf yield depth differences ranging from 0.1 to 2 m. All other data sets were computed using an assumed velocity of 1,463 m/s (4,800 ft/s) except for the Canadian Earth Physics Branch data along the eastern margin of the map, which were corrected by a velocity function that increases with depth. For water depths exceeding 2,200 m, where slopes become gentle and the depth correction is significant, we removed the correction from the Canadian soundings to make them consistent with the other data sets.

The departure of the isobaths based on an assumed constant velocity of sound in the Beaufort Sea of 1,464 m/s from water depths based on a model in which sound velocity increases with depth is shown in figure 3. Curve A shows the variation of sound velocity with depth calculated from the variation of temperature and salinity with depth in the Beaufort Sea given by Coachman and Aagaard (1974, fig. 4, p. 7) using tables in U.S. Naval Oceanographic Office Special Publication SP–58 (1962). As temperature and salinity are nearly constant, and pressure has the principal effect on velocity below 1,000 m, the curve was extrapolated to 4,000 m from the deepest readings (1,800 m) given by Coachman and Aagaard. A constant slope of 0.01725 m/s/m (curve B) approximates the increases in velocity of sound with depth in the Beaufort Sea. This approximation is poorest in the upper 100–200 m of the water column in summer, when local variations in temperature and salinity produced by shifting of the ice pack, currents, and local plumes of river discharge can create velocity variations as large as 2 or 3 percent. Depths determined from the 0.01725 m/s/m approximation vary by a maximum of 0.8 percent (at 80 m) from depths determined from the actual velocity-depth plot (curve A, fig. 3), but at most depths the difference is not significant. The isobaths, which are mostly based on an assumed constant water-column velocity of 1,463 or 1,464 m/s (curve C, fig. 3), can be converted to depths based on the constantly increasing velocity model (curve B, fig. 3) by means of a correction factor (fig. 4). The maximum correction at the deepest isobath (3,800 m) is +1.1 percent. In waters of the Beaufort Sea deeper than 200 m, this curve may be generally useful for approximating true depths from calculated depth values.

CONTOURING METHOD

The data sets shown in figures 1 and 2 were digitized and plotted by computer on a polar stereographic grid. Initial contouring was done on the basis of the digitized data alone. The data were then recontoured using continuous bathymetric and seismic reflection profiles as interpretive guides. Where data sets of comparable quality conflicted, the contours were generalized rather than arbitrarily shifted to fit one data set or the other.

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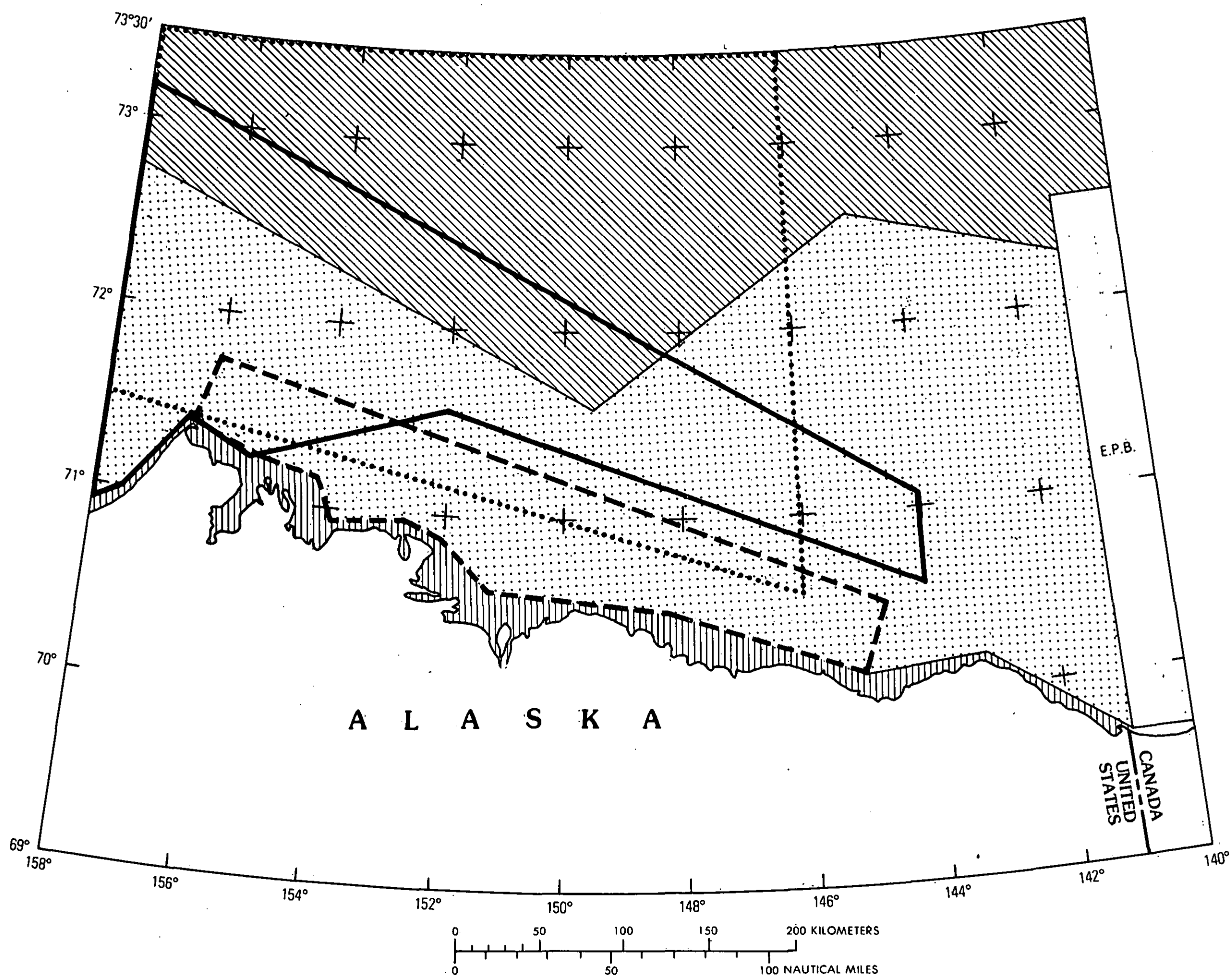

SYMBOL	YEAR SURVEYED	ORGANIZATION	FORMAT OF DATA USED IN COMPILATION	NAVIGATION
	1977, 1978	U.S. Geological Survey	Continuous bathymetric profiles	Integrated satellite
	1972, 1973, 1974, 1976	U.S. Geological Survey	Continuous bathymetric profiles	Satellite
	1973	Geophysical Corporation of Alaska	Continuous bathymetric profiles	Integrated satellite
Not shown	1972	University of Connecticut	Spot soundings	Satellite
E. P. B.	1969, 1970, 1971	Earth Physics Branch, Department of Energy, Mines and Resources, Canada	Spot soundings	Lambda Decca shorebased
	Compiled from government, military, and private sources	U.S. Naval Oceanographic Office and Defense Mapping Agency	Hydrographic Charts: NO 16002 (HO 6782), NO 15026 (HO 6785), HO 6783, and unpublished spot soundings	Mostly celestial some radar
	1951, 1952	Scripps Institution of Oceanography, Naval Electronics Laboratory	Unpublished charts	Radar and celestial
	1951	National Ocean Survey	NOS charts: 16041–46, 16061–67, 16081–83	Visual methods (sextant) supplemented by Shoran

FIGURE 1. Index map showing location of bathymetric data sets.

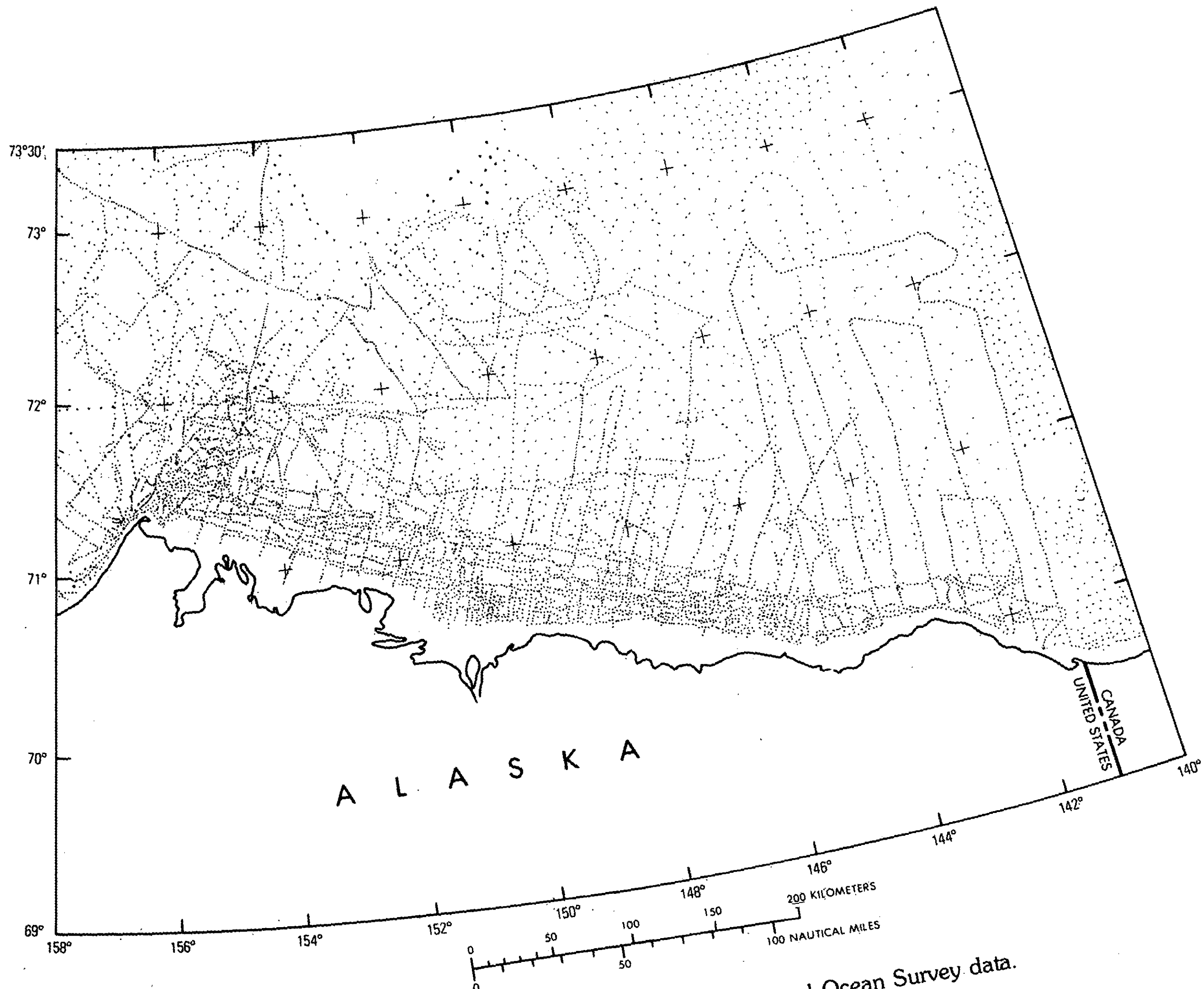

FIGURE 2. Density of soundings exclusive of National Ocean Survey data.

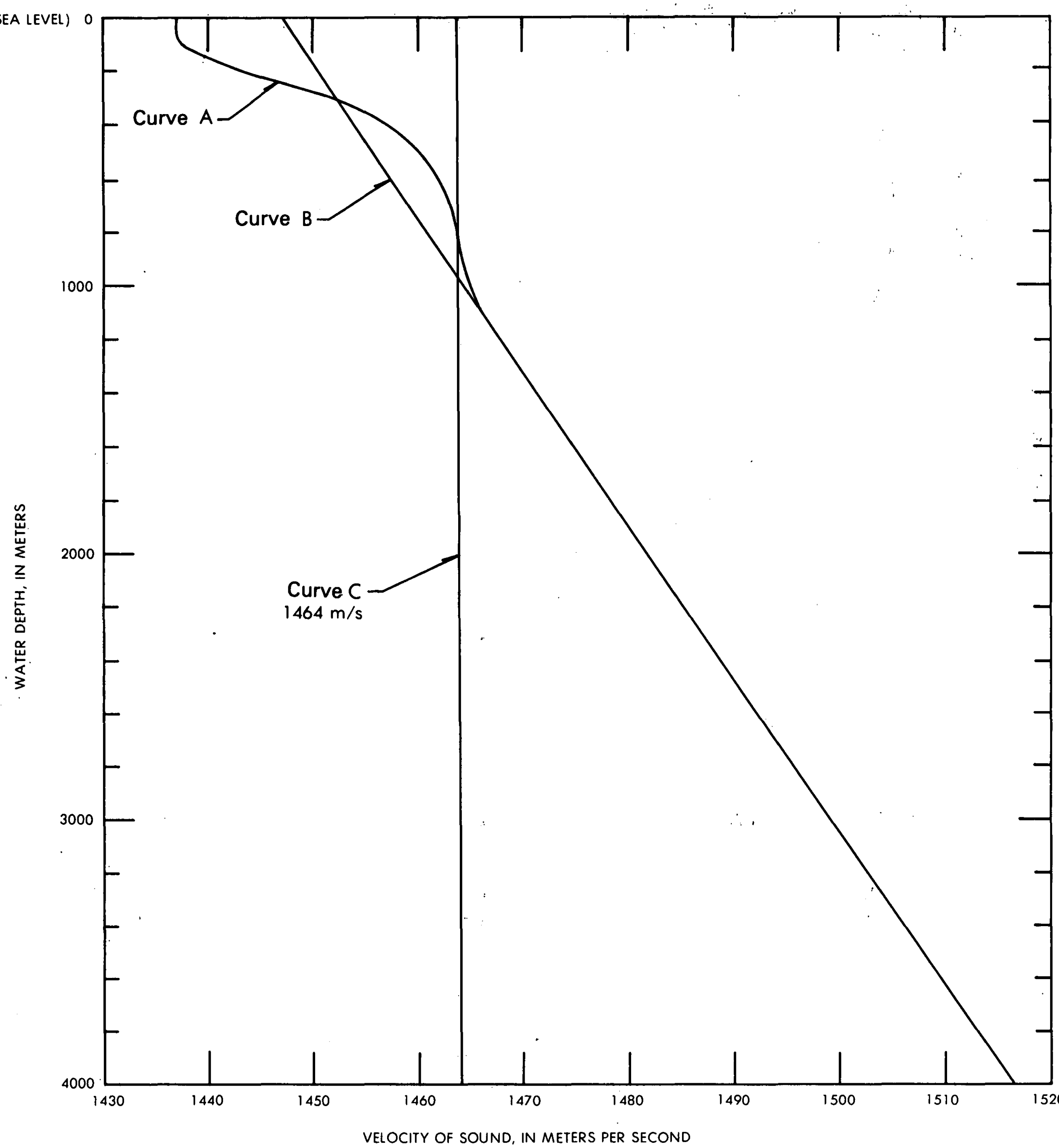

FIGURE 3. Curve A, general variation of velocity of sound with depth in the Beaufort Sea constructed according to tables in U.S. Naval Oceanographic Office (1962) from plots of variation of temperature and salinity with depth in Coachman and Aagaard (1974, p. 7). Curve B, linear approximation of curve A used to compute corrections shown in figure 4. Curve C, average velocity of sound in the Beaufort Sea used to convert echo-sounder transit times to depths in most of the bathymetric data sets (see text).

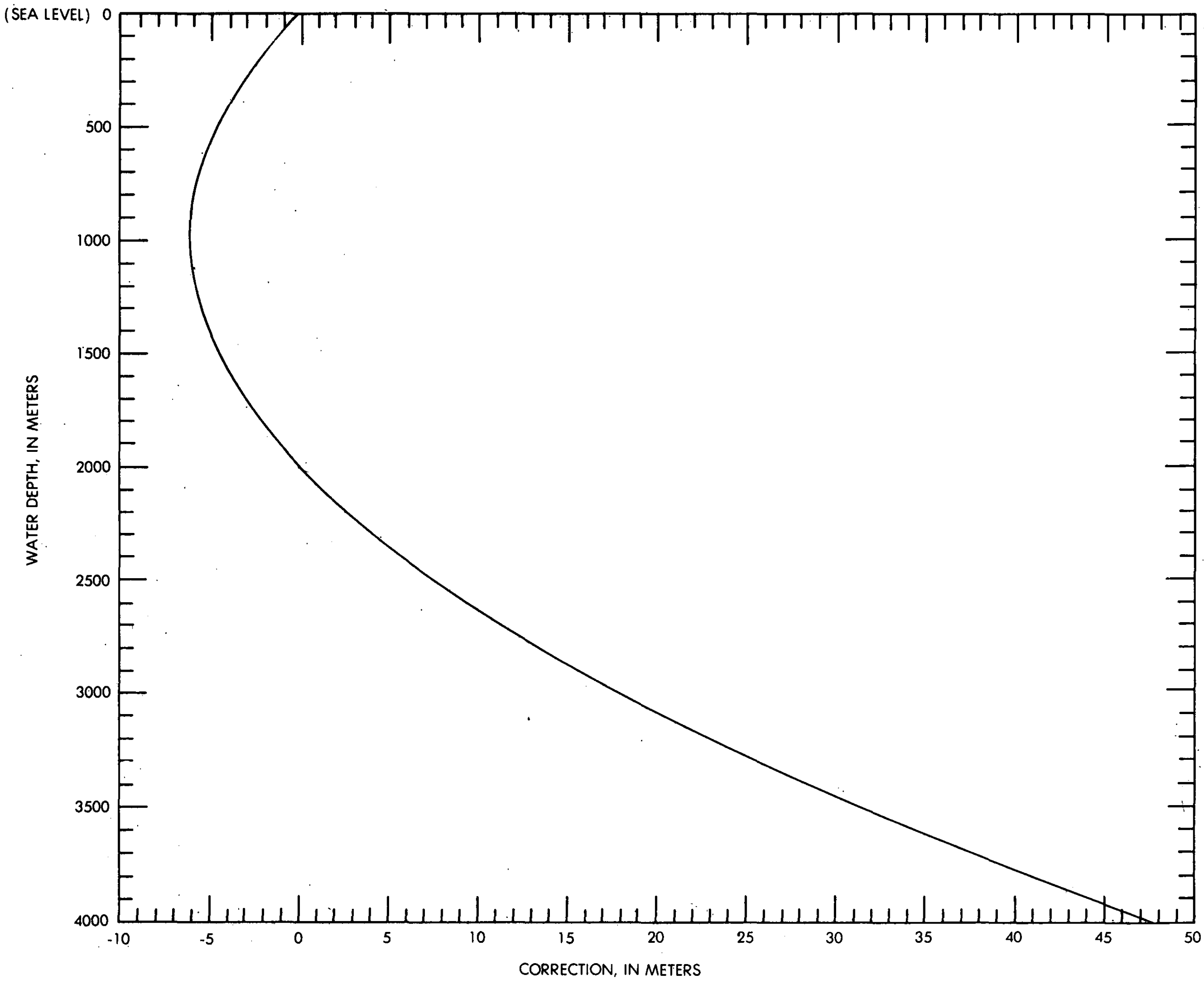

FIGURE 4. Correction factors to be added to the isobaths of the bathymetric map to obtain water depths according to the constantly increasing water velocity model of curve B, figure 3.