U.S. DEPARTMENT OF THE INTERIOR
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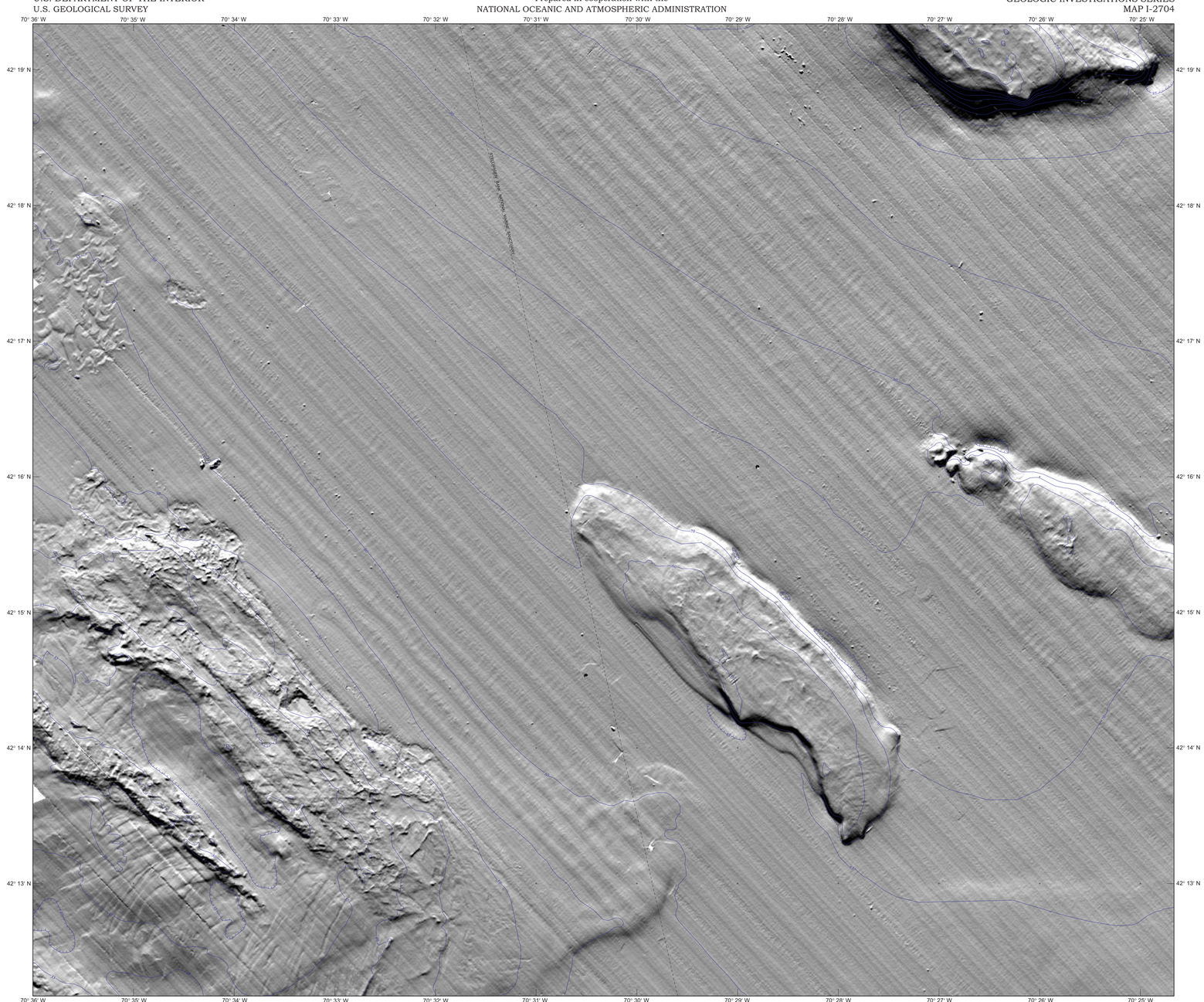
GEOLOGIC INVESTIGATIONS SERIES
MAP I-2704



Mercator projection
Geodetic Reference System 1980; North American Datum 1983
Longitude of central meridian 70° 19' W; latitude of true scale 41° 39' N
False easting 0 m; false northing 0 m
This map is not intended for navigational purposes.

SCALE 1: 25 000

ONE CENTIMETER ON THE MAP REPRESENTS 250 METERS ON THE SEA FLOOR

1 0 1 2 3 4 5 KILOMETERS

CONTOUR INTERVAL 5 METERS
DATUM MEAN LOWER LOW WATER

INTERIOR - U.S. GEOLOGICAL SURVEY, RESTON, VIRGINIA - 1999

SUN-ILLUMINATED SEA FLOOR TOPOGRAPHY OF QUADRANGLE 4 IN THE STELLWAGEN BANK NATIONAL MARINE SANCTUARY OFF BOSTON, MASSACHUSETTS

By

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DISCUSSION

Introduction - The Stellwagen Bank National Marine Sanctuary Mapping Project is a cooperative effort of the U.S. Geological Survey and the National Oceanic and Atmospheric Administration, with support from the University of New Brunswick and the Canadian Hydrographic Survey. The multibeam echosounder survey was conducted on four cruises over a two-year period from the fall of 1994 to the fall of 1996. This map shows one of a series of 18 quadrangles (see location map) in which sea floor depth information is depicted in sun-illuminated (or shaded relief) view at a scale of 1:25,000, with topographic contours overprinted in blue. The image shown here uses a sun elevation angle of 45 degrees above the horizon from an azimuth of 350 degrees and a vertical exaggeration of four times. In effect, topographic relief is enhanced by having the sun illuminate the sea floor from a position 10 degrees west of north so that shadows are cast on the southern flanks of seabed features. Some features in the images are artifacts of data collection. They are especially noticeable where the seabed is smooth and include small highs and lows and unnatural-looking features and patterns that are oriented parallel or perpendicular to survey tracklines. For a depiction of the topographic contours alone, and for an explanation of survey and topographic data processing methods, see the companion map by Valentine and others (1997). Topographic contour maps for all 18 quadrangles of the map series are available on a CD-ROM in EPS, PS, Arc export, and PDF file formats (Valentine and others, 1998). Blank areas represent places where no data exists.

Regional seabed features - The major topographic features depicted in the map series were formed by glacial processes. In broad terms, these features are interpreted here to represent a geologic history that developed in several stages. Ice containing rock debris moved across the region, sculpting its surface and depositing sediment to form the large basins, banks, ridges, and valleys. Many other features observed here represent the latter stages of deglaciation. They are the result of processes at work when much of the area was covered by stationary rotting ice, and when at the same time small valley glaciers and ice falls were active in and near areas of high topographic relief. The sea invaded the region formerly occupied by ice, and seabed features were partly eroded and some new sedimentary deposits were formed. Today, the sea floor mainly is modified by strong southwestward-flowing bottom currents caused by storm winds from the northeast. These currents erode sediments from the shallow banks and transport them into the basins. With time, the banks affected by these currents become coarser, as sand and mud are removed but gravel remains; and the western flanks of the banks, and adjacent basins, are built up by deposits of mud and sand.

Quadrangle 4 features - Much of Quadrangle 4 lies in the southeastern part of Stellwagen Basin where the sea floor is relatively smooth mud that slopes northeastward through water depths of 45 to 95 m. Three large elongated banks are present in the basin. They are 4.5 to 6.2 km in length, their tops lie in water depths of 55 to 65 m, and they have a relief of 15 to 30 m. The surfaces of the banks are sand and gravel, including boulder piles and ridges, and a thin veneer of mud. The internal composition of the banks is unknown. Their northwest-southeast elongated shape suggests formation by glacial processes that eroded surrounding less-resistant sediment and rock during ice movement to the southeast and that further modified the banks during later melting of the ice. The bank in the northeast corner of the quadrangle (42° 19.2'N, 70° 26.5'W) also lies partly in the adjacent Quadrangle 7 to the north (Valentine and others, 1999a). It has a subelliptical shape and a relatively flat surface. Another bank is located in the south central part of the quadrangle (42° 15'N, 70° 29'W). It is long and narrow, and its western flank has been eroded into two arcuate embayments. The third bank lies along the eastern edge of the quadrangle (42° 15'N) and is more eroded than the other two; it extends southeastward into the adjacent Quadrangle 5 (Valentine and others, 1999b). A small, low hill, located near the northwestern edge of the quadrangle (42° 17.9'N, 70° 35.4'W), has a relief of only a few meters and possibly is the eroded remnant of a bank. Its surface, at 55 m water depth, is covered with gravel and a veneer of sandy mud. West and south of this feature, along the western edge of the quadrangle (42° 16.8' to 42° 18.3'N) at 50 to 55 m, there are scattered exposures of coarse-grained sand that are partly covered with deposits of fine-grained sand. The edges of the fine layer, where they bound the coarse sand exposures, are curved and sharply defined, as if formed by bottom currents. It is possible that the coarse deposits have been exposed by bottom currents that have eroded the overlying fine layer. Similar features are present in the adjacent Quadrangle 1 to the south (Valentine and others, 1999c). The southwestern part of the quadrangle is a complex of long, southeastward-trending gravel banks that are separated by elongate basins covered with sand and muddy sand. The orientation of these features parallels the movement of glacial ice. Similar features are present in Quadrangle 1. The banks lie at 30 to 35 m water depth and have a relief of 5 to 10 m. Their surfaces are gravel, including elongate boulder piles and ridges that have a relief of less than 5 m. These features resemble eskers (sand and gravel deposited by running water within stationary glacial ice) and end moraines (deposits of rock debris piled up at the forward edges of moving ice). Eskers are present on the bank tops and flanks (42° 15.3'N, 70° 34.7'W) and probable end moraines are located on the southeastern ends of the banks and are oriented northeastward, across the regional grain (42° 13.3'N, 70° 32.1'W; 42° 12.2'N, 70° 32.7'W). These gravel features are, in places, partly covered by a thin veneer of sand. Shallow, irregularly-shaped depressions in the sea floor outline the former locations of large masses of melting glacial ice (42° 14.3'N, 70° 33.3'W). The basins that lie between the gravel banks are covered with sand and gravelly sand. The sand deposits that cover the southwestern flanks of two ridges (42° 12.6'N, 70° 33.1'W; 42° 13.0'N, 70° 35.0'W) display southwest-trending grooves that are interpreted to have been caused by the gouging of icebergs that drifted southwestward from ice located on the banks. The grooves are up to 50 m wide and 1.5 km long and are less than 5 m deep. They do not appear at water depths greater than 35 to 40m. A large lobe of sediment (42° 13'N, 70° 30'W) extends eastward into the basin. This feature has a relief of several meters along its southern margin, and its surface varies from muddy sand in the west to sandy mud with increasing water depth to the east. In one area of the basin, the smooth, almost flat mud floor is interrupted by a shallow depression that is irregular in outline and surrounds small mounds (42° 17.3'N, 70° 34.5'W). The depression is 600 m long. Observations in Quadrangles 7 and 8 (Valentine and others 1999a, d) have shown similar mounds to be patches of gravel, including boulders, that are frequented by groundfish. Some boulders and smaller gravel are exposed in the bottom of pits in the mud in which fish are present. The depressions are interpreted to have formed by the scouring actions of groundfish that have exposed the gravel habitat and prevent its burial by basin mud.

REFERENCES CITED

Valentine, P.C., Unger, T.S., Baker, J.L., and Roworth, E.T., 1997, Sea floor topography of Quadrangle 4 in the Stellwagen Bank National Marine Sanctuary off Boston, Massachusetts: U.S. Geological Survey Open-File Report 97-505, scale 1:25,000.

Valentine, P.C., Baker, J.L., Unger, T.S., and Polloni, C., 1998, Sea floor topographic map and perspective view imagery of Quadrangles 1-18, Stellwagen Bank National Marine Sanctuary off Boston, Massachusetts: U.S. Geological Survey Open-File Report 98-138, 1 CD-ROM.

Valentine, P.C., Baker, J.L., and Unger, T.S., 1999a, Sun-illuminated sea floor topography of Quadrangle 7 in the Stellwagen Bank National Marine Sanctuary off Boston, Massachusetts: U.S. Geological Survey Geologic Investigations Series Map I-2707, scale 1:25,000.

Valentine, P.C., Baker, J.L., and Unger, T.S., 1999b, Sun-illuminated sea floor topography of Quadrangle 5 in the Stellwagen Bank National Marine Sanctuary off Boston, Massachusetts: U.S. Geological Survey Geologic Investigations Series Map I-2705, scale 1:25,000.

Valentine, P.C., Baker, J.L., and Unger, T.S., 1999c, Sun-illuminated sea floor topography of Quadrangle 1 in the Stellwagen Bank National Marine Sanctuary off Boston, Massachusetts: U.S. Geological Survey Geologic Investigations Series Map I-2701, scale 1:25,000.

Valentine, P.C., Unger, T.S., and Baker, J.L., 1999d, Sun-illuminated sea floor topography of Quadrangle 8 in the Stellwagen Bank National Marine Sanctuary off Boston, Massachusetts: U.S. Geological Survey Geologic Investigations Series Map I-2708, scale 1:25,000.

Location map - Shows mapped quadrangle outlined. Stellwagen Bank National Marine Sanctuary (SBNMS) boundary shown as dashed line. Bathymetric contours in meters.