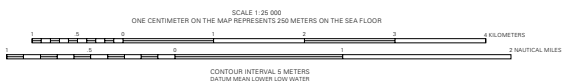


Map projection:
Geographic Reference System 1980, North American Datum 1983
Longitude of central meridian 70°19' W; latitude of true scale 41°39' N
False easting 0 m; false northing 0 m
This map is not intended for navigational purposes.



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 Service. The multibeam echo sounder 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 semi-transparent shaded relief view at a scale of 1:25,000, with topographic contours overlaid in blue. The map shows here uses a sea elevation angle of 45 degrees above the horizon from an altitude of 2500 meters and a vertical exaggeration of four times. In effect, topographic relief is enhanced by having 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 they include small high and low and non-streak-like 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 of all 18 quadrangles in the map series are available as a CD-ROM in EPS, PS, Arc export, and PDF file formats (Valentine and others, 1998). Blank areas represent places where no data exist.

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 glacial history that developed in several stages. Ice containing rock debris moved across the region, sculpting its surface and depositing sediment to form the large banks, basins, ridges, and valleys. Many other features observed here represent the later stages of deglaciation. They are the result of processes at work when much of the area was covered by stationary retreating 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 included the region formerly occupied by ice, and seabed features were partly eroded and some new sedimentary deposits formed. Today, the sea floor is modified mainly by strong

southward-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 and gravel remains; and the western flanks of the banks, as well as adjacent basins, are built up by deposits of mud and sand.

Quadrangle 9 features

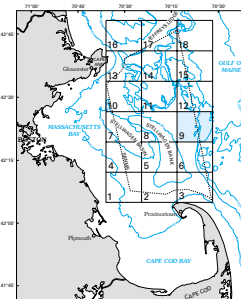
This quadrangle covers the northeastern flank of Stellwagen Bank. The bank surface slopes gently northward through water depths of 45 to 100 m and is covered with sand and gravel. In the central and eastern parts of the quadrangle, the gravelly sea floor is very rough due to the presence of boulder piles and ridges and large depressions. Many of the boulder ridges resemble valleys (sand and gravel deposited by running water within stationary glacial ice; see example at 42°24' N, 70°06.6' W). Other prominent boulder ridges are located along the upper margins of small valleys (for example, the ridge at 42°23.1' N, 70°04.5' W, which lies along the northern edge of a shallow, northeast-trending valley). They appear to be lateral moraines (remnants of rock debris piled up at the edge of moving ice) formed by small valley glaciers. The boulder ridges commonly are constructed of boulders and cobbles that now are separated by voids from which sand and small gravel presumably were eroded during advance of the sea after the glacial ice melted. The depressions (for example, at 42°20.5' N, 70°08.5' W) possibly outline the former locations of large masses of melting glacial ice.

Several large coarse-grained sand deposits are present in this quadrangle. In the northeastern part, the sea floor is dominated by a northeast-trending sand bank that lies at 70 m water depth and that is interrupted with northeast-trending gullies and bedforms. In the east-central part of the quadrangle, a series of northeast-trending sand ridges (interrupted by a deep narrow valley between 42°22' and 42°24' N) is present at depths of 75 to 90 m; these features are part of a larger system of sand banks that extends southwestward into Quadrangle 6 (Valentine and others, 1999). In the southeast corner of Quadrangle 9, the edge of Stellwagen Bank forms a sharp corner that is capped at 85 m by sand banks below which sediment becomes finer grained and muddy with increasing water depth. Homocyclic topography in the southeast corner of the quadrangle in water depths of 130 to 180 m represents buried rock debris and the eroded western flank of a 90-meter-deep bank whose summit lies 900 m southeast of the quadrangle corner. The bank margin west of the

homocyclic area displays multiple narrow ridges that parallel topography and that are interpreted to be lateral moraines. The moraines, now covered with muddy sand, were piled up at the edge of moving ice that flowed northward down a valley that begins in Quadrangle 6 to the south (Valentine and others, 1999). Another lateral moraine, partly buried by sand, is present along the eastern edge of the large sand bank in the northeast corner of Quadrangle 9. The seabed of muddy sand to the east of this feature displays northeast-trending grooves caused by the gouging action of icebergs that grounded here during the late stages of the last glaciation. The grooves are approximately 5 m deep and up to 100 m wide. The floor of a shallow valley extending about 1.5 km southwest from 42°24' N, on the eastern edge of the quadrangle displays low, gently rising ridges whose distinctive meander-like patterns resemble that of cross-bed fill (bedforms deposited in large cracks in glacial ice). A similar pattern is present near the northern edge of the quadrangle between 70°09' and 70°10' W, and in the adjacent Quadrangle 12 to the north (Valentine and others, 2000). Short, dark angled lines located along 42°20' N are not sea floor features but are artifacts in the sear records that mark the ends of survey lines.

REFERENCES CITED

Valentine, P.C., Baker, J.L., Unger, T.S., and Roworth, E.T., 1997, Sea floor topography of Quadrangle 9 in the Stellwagen Bank National Marine Sanctuary of Boston, Massachusetts: U.S. Geological Survey Open-File Report 97-482, scale 1:25,000.
Valentine, P.C., Baker, J.L., Unger, T.S., and Pullen, 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., Unger, T.S., and Baker, J.L., 1999, Sea-illuminated sea floor topography of Quadrangle 6 in the Stellwagen Bank National Marine Sanctuary of Boston, Massachusetts: U.S. Geological Survey Geologic Investigations Series Map I-2706, scale 1:25,000.
—, 2000, Sea-illuminated sea floor topography of Quadrangle 12 in the Stellwagen Bank National Marine Sanctuary off Boston, Massachusetts: U.S. Geological Survey Geologic Investigations Series Map I-2712, scale 1:25,000.



Location map outlining the 18 quadrangles in this series. Quadrangle 9 shown in blue. Stellwagen Bank National Marine Sanctuary (SBNSM) boundary indicated by dashed line. Bathymetric contours in meters.

SUN-ILLUMINATED SEA FLOOR TOPOGRAPHY OF QUADRANGLE 9 IN THE STELLWAGEN BANK NATIONAL MARINE SANCTUARY OFF BOSTON, MASSACHUSETTS

By
Page C. Valentine, Jessica L. Baker, and Tanya S. Unger
2000

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For sale by the U.S. Geological Survey, Information Services, Box 25286, Federal Center, Denver, CO 80225.
For more information contact:
Page Valentine, U.S. Geological Survey,
380 Woods Hole Road, Woods Hole, MA 02543

