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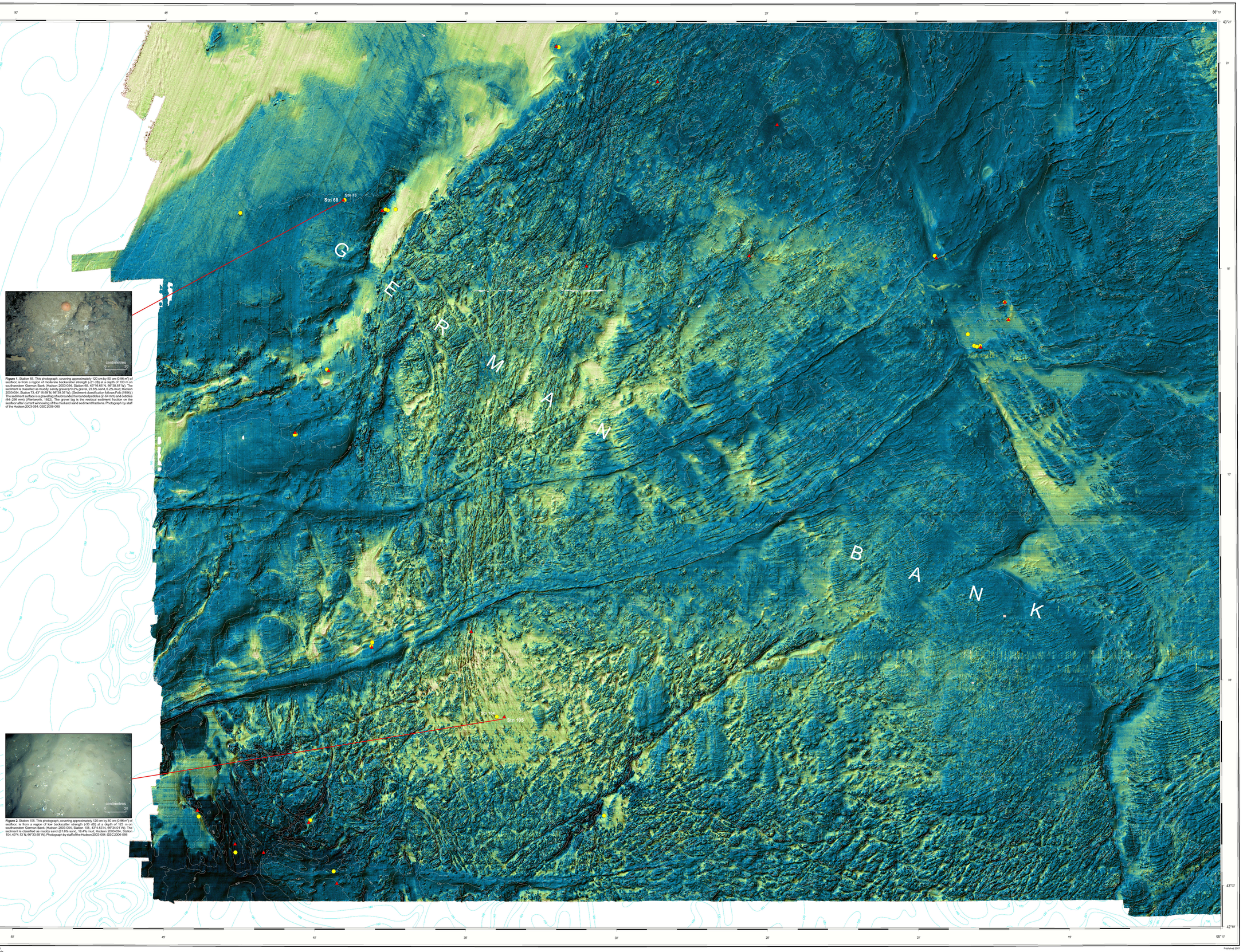

Figure 1. Station 68. This photograph, covering approximately 120 cm by 80 cm (0.96 m^2) of seafloor, is from a region of moderate backscatter strength (-21 dB) at a depth of 100 m on southwestern German Bank (Hudson 2003-054, Station 68, 43°16.65 N, 66°38.81 W). The sediment is classified as muddy, sandy gravel (70.2% gravel, 23.6% sand, 6.2% mud; Hudson 2003-054, Station 73, 43°16.69 N, 66°39.05 W). (Sediment classification follows Folk (1954).) The sediment surface is a gravel lag of subrounded to rounded pebbles (2–64 mm) and cobbles (64–256 mm) (Wentworth, 1922). The gravel lag is the residual sediment fraction on the seafloor after current winnowing of the mud and sand sediment fractions. Photograph by staff of the Hudson 2003-054, GSC 2006-095

Figure 2. Station 105. This photograph, covering approximately 120 cm by 80 cm (0.96 m^2) of seafloor, is from a region of low backscatter strength (-33 dB) at a depth of 123 m on southwestern German Bank (Hudson 2003-054, Station 105, 43°4.53 N, 66°34.01 W). The sediment is classified as muddy sand (81.6% sand, 18.4% mud; Hudson 2003-054, Station 104, 43°4.13 N, 66°33.58 W). Photograph by staff of the Hudson 2003-054, GSC 2006-095

DESCRIPTIVE NOTES

INTRODUCTION

This map is part of a four-map series of German Bank, located on the Scotian Shelf off southern Nova Scotia. This map is the product of a 1997–2003 survey that used a multibeam sonar system to map 1929 km^2 of the seafloor. Other surveys collected geological and biological data for scientific interpretation. This map shows the seafloor topography of German Bank (southwest area) in shaded-relief view and backscatter strength (coded by colour) at a scale of 1:50 000.

Bathymetric contours (in metres) and the names of geographic features are shown on the colour-coded backscatter strength at a depth interval of 20 m. Bathymetric contours (in blue) outside the multibeam survey area, presented at a depth interval of 10 m, are from the Natural Resource Map series (Canadian Hydrographic Service, 1967, 1972). Map 2107A (Todd, 2007) shows colour-coded seafloor topography in shaded-relief view. Map 2108A (Todd, in press) shows seafloor topography in shaded-relief view with colour-coded surficial geological units. Map 2109A (Todd and Kostylev, in press) shows seafloor topography in shaded-relief view with colour-coded benthic habitat zonation.

The map includes two adjoining map areas at a scale of 1:50 000: sheet 1 and sheet 3. The three map areas (sheets 1, 2, and 3) cover the entire survey area. A multibeam sonar system. In total, twelve map sheets constitute the German Bank map suite (three map sheets on four themes: topography, backscatter strength, surficial geology, and benthic habitat).

BACKSCATTER STRENGTH

Multibeam bathymetric data were collected by the Canadian Hydrographic Service using the Canadian Coast Guard ship (CCGS) *F. C. Creed*, a SWATH (small waterplane area twin hull) vessel. The ship was equipped with a Simrad Subsea EM1000 multibeam bathymetric survey system (95 kHz) with the transducer mounted in the starboard pontoon. This system produces 60 beams arrayed over an arc of 150° and operates by ensonifying a narrow strip of seafloor across track and detecting the seafloor echo. The width of seafloor imaged on each survey line was five to six times the water depth. Line spacing was about three to four times water depth to provide ensonification overlap between adjacent lines. The Differential Global Positioning System was used for navigation, providing positional accuracy of ±3 m. Survey speed averaged 14 knots, resulting in an average data collection rate of about 0.5 km^2/h in water depths of 25–70 m. The sound velocity in the ocean was measured during multibeam data collection and processing to correct for refraction effects of the sonar beams. Spurious bathymetric and backscatter data and erroneous values were removed. The data were adjusted for tidal variation using tidal predictions from the Canadian Hydrographic Service.

Backscatter strengths ranging from 0 to -128 dB were logged by the Simrad Subsea EM1000 system simultaneously with the bathymetric data. To reduce the dynamic range of the recorded data, the system applied a partial correction to the backscatter strength values for the varying angle of incidence by using Lambert's law for the variation with angle and assuming a flat seafloor. Backscatter strengths were computed using calibration values for the electronics and transducers at the time of instrument manufacture.

Some features in the backscatter data are artifacts of data collection, environmental conditions during the survey periods, and data processing. The orientation of the survey track lines can, in some instances, be revealed by faint parallel stripes in the image. Those stripes are particularly evident on northwest German Bank near 43°20' N, 66°41' W. Because these artifacts are usually regular and geometric in appearance on the map, the human eye can disregard them and distinguish real patterns of backscatter strength distribution.

Courtney and Shaw (2000) summarized the relationship of backscatter strength to seafloor sediment. Multibeam systems record the mean backscattered signal strength, or mean amplitude, in each returned beam. The amount of acoustic energy returned in each beam depends upon the interaction of the incident energy in the downgoing ray with the physical characteristics of the seabed and the shallow subsurface, and is strongly dependent on the angle of incidence of the beam to the seabed. Multibeam sonar systems typically operate at 0° for the vertical beam and increase to as much as 80° for the outermost beams and as high as 75° for the outermost beams. For angles of incidence less than approximately 20°, the signal returned from the seabed is within the specular cone where a reflection from the seabed is recorded from objects larger than the acoustic wavelength (~1.6 cm). The amount of energy returned from a specular reflection increases with the acoustic impedance contrast across the water-seabed boundary (acoustic impedance is the product of density and acoustic velocity). At wide beam angles, the signal returned from the seabed arises from constructive interference with roughness on the seabed and this scattered energy increases with increasing surface roughness. At these angles, there can also be an added contribution to the backscatter energy from volume heterogeneity within the subsurface material. For example, acoustic energy penetrates into soft, fine-grained material (mud) and is scattered from buried objects or layers into hard, coarse-grained material (gravel). Subsurface coarse-grained material will contribute to backscattered energy.

No simple relationship exists between backscatter strength and surficial sediment type, however, for incidence angles beyond the specular range, there is a correspondence between backscatter strength and surficial sediment roughness. This correspondence can be utilized for preliminary sediment identification and rudimentary mapping (Mitchell and Hughes Clark, 1994; Shaw et al., 1997; Todd et al., 1999). Cobbles and boulders (>64 mm) constitute a locally rough seabed, return high-amplitude backscatter signals (typically -10 to -30 dB), and are shown as blue on this map. Silt and sand (< 2 mm) are smooth at the scale of centimetre-scale roughness and return low-amplitude signals (-30 to -60 dB) and are shown as light green to white on this map. Because backscatter is a function of a suite of acoustical variables, it is prudent to interpret backscatter images in conjunction with other geophysical data (seismic-reflection profiles and sidescan-sonar sonograms), geological samples of seafloor materials, and seafloor photographs. This groundtruth surveying and accompanying interpretation is an essential component in the production of German Bank surficial geology and benthic habitat maps (Todd, in press; Todd and Kostylev, in press).

BACKSCATTER DISTRIBUTION

The distribution of backscatter strength on German Bank provides insight into ocean circulation and related modern seafloor sediment transport processes not apparent in the bathymetric image. Ocean circulation in the region of German Bank has been studied using moored current meters, drifting buoys and finite-element modelling (Smith, 1983; Page and Smith, 1989; Lynch and Naimie, 1993; Hannah et al., 2000). Tidal currents flow around the bank and interact to produce a residual counterclockwise flow toward the Gulf of Maine. The winnowing and transport of fine-grained sediment under the influence of currents results in remnant coarse-grained deposits with moderate backscatter strength as illustrated in seafloor photograph Station 68 (Fig. 1). Sand is deposited in bedforms characterized by low backscatter strength (Station 105, Fig. 2). Mixed sediment, e.g. sandy gravel, has a backscatter value between sand and a gravel lag.

ACKNOWLEDGMENTS

G. Costello of the Canadian Hydrographic Service (CHS) organized the multibeam bathymetric survey of German Bank and oversaw data processing. Canadian Hydrographic Service provided the data to the Geological Survey of Canada (GSC) for further processing and interpretation. K. DesRoches processed the backscatter strength using software developed by R.C. Courtney (GSC). The authors thank the master and crew of the CCGS *Frederick G. Creed* for their efforts at sea. R.A. Pickrill (GSC), G. Costello, and M. Lamplugh (CHS) supported the development of the German Bank maps. Geographical Information Systems and cartographic support was provided by S. Hayward, W.A. Rainey, S. Hynes, and P. O'Regan. The authors thank V. Barrie and A. Bobco for scientific review of the map.

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in press: Surficial geology and sun-illuminated seafloor topography, German Bank, Scotian Shelf, offshore Nova Scotia; Geological Survey of Canada, Map 2108A, scale 1:50 000.

Todd, B.J. and Kostylev, V.E.
in press: Benthic habitat and sun-illuminated seafloor topography, German Bank, Scotian Shelf, offshore Nova Scotia; Geological Survey of Canada, Map 2109A, scale 1:50 000.

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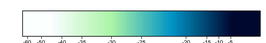
SYMBOLS

Grab sample . . . . . Stn 73

Seafloor photograph . . . . . Stn 68



Location map shows extent of map sheet in red. The pink shadowing shows the extent of the multibeam sonar coverage. Five-digit numbers refer to Mapsheet Square System used for Natural Resource Map series at 1:250 000 scale. Blue line shows 200 m isobath.

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Author: B.J. Todd

Multibeam bathymetric data collected by Canadian Hydrographic Service, 1997, 1998, 2000, 2002, and 2003

Multibeam backscatter data compiled by Geological Survey of Canada, 2004

Digital cartography by P. O'Regan, Data Dissemination Division (DDD) and S. Hayward, GSC (Atlantic)

MAP 2106A

BACKSCATTER STRENGTH AND SUN-ILLUMINATED SEAFLOOR TOPOGRAPHY

GERMAN BANK

SCOTIAN SHELF
OFFSHORE NOVA SCOTIA

Scale 1:50 000/Échelle 1/50 000

kilometres 1 0 1 2 3 4 kilometres

Universal Transverse Mercator Projection
North American Datum 1983

Projection transverse universelle de Mercator
Système de référence géodésique nord-américain, 1983

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This map is not to be used for navigational purposes

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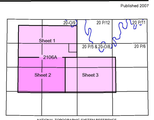
Cette carte ne doit pas être utilisée aux fins de navigation

Any revisions or additional information known to the user would be welcomed by the Geological Survey of Canada

Digital bathymetric contours in metres supplied by the Canadian Hydrographic Service and GSC (Atlantic)

Magnetic declination 2007, 17°27'W, decreasing 5.9' annually

Depth in metres below mean sea level



Sheet 2 of 3, backscatter strength and sun-illuminated seafloor topography (southwest area)

Recommended citation:
Todd, B.J.
2007: Backscatter strength and sun-illuminated seafloor topography, German Bank, Scotian Shelf, offshore Nova Scotia; Geological Survey of Canada, Map 2106A, scale 1:50 000.