Swath-bathymetric mapping

Steffen Gauger, Gerhard Kuhn, Thomas Feigl, Polina Lemenkova

XX. SWATH-BATHYMETRIC MAPPING

(S. Gauger, G. Kuhn, T. Feigl, P. Lemenkova)

Objectives

The main objective of the bathymetric working group was to perform high resolution multibeam surveys during the entire cruise for geomorphological interpretation, to locate geological sampling sites, to interpret magnetic and gravimetric measurements and to expand the world database for oceanic mapping.

Precise depth measurements are the basis for creating high resolution models of the sea surface. The morphology of the seabed, interpreted from bathymetric models, gives information about the geological processes on the earth surface.

Methods and equipment

The main characteristic of the deep water sounding system Atlas Hydrosweep DS-2 is a coverage angle of up to 120°, which results in a depth profile with a length of 3.4 times the water depth perpendicular to the ship's long axis. Most of the time a coverage angle of 100° was applied. The acoustic signal, generated by the hull mounted transducer, has a frequency of 15.5 kHz and allows measurement up to full ocean depth. Based on the acoustic pulse 240 depth measurements with individual opening angles of about 2.3° (in deep water operation) and an accuracy of approximately 1 % of water depth were derived. In addition, the echo amplitudes were converted to multibeam sidescan (4094 pixels per swath) and angular backscatter data (59 values per swath).

For the slant range corrections of the outer sonar beams, CTD (conductivity, temperature, density) profiles, collected on this expedition or on former expeditions of other vessels, were mostly used. Where there was no information about the water properties, the automatic crossfan calibration, which generates a swath in the direction of the ship's long axis and adjusts the vertical position of the outer beams by overlaying with the previous central beams, was used to calculate the mean sound velocity in the water column.

To assign the depth measurement to a geographic position, the GPS navigation and the ship's motion data, received from the Trimble MS750 GPS system and the MINS ringlaser gyro respectively, were applied.

To prevent the disturbance of marine mammals, the multibeam sonar system was switched off during periods, when there was no scientific necessity for surveying the sea floor and if marine mammals were close to the ship (nearer than 100 m). After updating the multibeam system with the HDBE (High Definition Bearing Estimation) soft beam modus, the source level can be adjusted, so that the acoustic energy transmitted into the water is not higher then needed to obtain high quality measurements. The multibeam sonar was exclusively operated in the source level mode "Maximum Level", where the maximum source level is reduced manually to a minimum, depending on the water depth and hydroacoustic conditions.

Besides operating and observing the multibeam sonar system, the data processing was the main part of the work on board. Erroneous depth measurements, caused by hydroacoustic disturbances i.e. because of sea ice, waves or interferences with other sounding systems, need to be cleaned. The depth editing, as well as the cleaning of navigation spikes, was done using the Caris Hips software. Furthermore, data processing includes integration of the ship's navigation into the ESRI database BatGIS, containing most multibeam survey lines of the AWI. The preparation of meta data describing each data set allows data exchange and

archiving. The data preparation for terrain modelling includes the projection of geographic coordinates into metric coordinates and the recomputing of depths. In order to make depth data compatible to previous and subsequent measurements, a sound velocity of 1500 ms^{-1} has been applied.

For the interpretation of the sea bottom topography, digital elevation models (DTM's) were calculated out of the edited data and presented in preliminary bathymetric maps, using the Generic Mapping Tool (GMT) and ESRI ArcGIS software. Based on the DTM's (grid spacing up to 50 m in medium water depths), contour line maps with color-coded depth ranges (scales up to 1 : 100000) and additional information like coastlines and surface elevation, sea ice coverage or sampling stations were produced. Using the ArcGIS module ArcScene, virtual flights above the sea floor were prepared in regions of specific interest. These three-dimensional visualisations faciliate the interpretation of morphology and support interdisciplinary work.

Results

Peter I. Island

A systematic bathymetric survey of ~ 32 hours was added to the existing data at Peter I. Island (69° S / 90° 30' W). The data set (with an area of approx. 4500 km^2 and a depth range of 100 m to 4200 m), representing the sea floor topography of the volcanic island, is a compilation of data sets collected on four scientific cruises by the vessels RV "Akademik B. Petrov" in 1998 and RV "Polarstern" in 1994, 2001 and 2006.

Unnamed Ridge

With three survey lines approx. 240 km north of Peter I Island (66°50' S / 91° W) a small ridge was mapped. This was discovered on a pre-existing seismic profile and its morphology is unknown until now. The north-south orientated ridge is approx. 31 km long and 2 - 5 km wide. It has a height of ~ 950 m above the surrounding seafloor with a depth of approx. 4600 m. The ridge with slope angles of up to 40°, is characterised by three tops, the southernmost being the highest.

De Gerlache Seamounts

At the western De Gerlache Seamount (65° S / 93° W) two multibeam profiles were added to the existing bathymetric data set, which was collected during the RV Polarstern cruise ANT-XII/4 (1995). The two new profiles crossing the top of the seamount in northwestern and northeastern directions are approx. 60 km long and show depths from 4700 m at the surrounding seafloor to 300 m on the flat top of the seamount.

Bathymetric Survey in the Amundsen Sea Embayment

In the Amundsen Sea Embayment two major systematic bathymetric surveys were carried out, in addition to the bathymetric measurements during seismic surveys, station work or transits. Some more smaller systematic surveys were carried out in the Amundsen Sea Embayment, i. e. east of Bear Peninsula (74°30' S / 110° W), where parts of the trough offshore from the Crosson Ice Shelf with depths of more than 1300 m were mapped. New bathymetric data was added to the existing data set of Pine Island Bay, mostly based on the surveys of RV "Palmer" in 1999 and 2000.

Glacial Lineation west of Abbot Ice Shelf

At the entrance to the embayment, west of the Abbot Ice Shelf (71°50' S / 104°20' W, Figure 1), a 800 km^2 wide survey shows megascale glacial lineations, the traces of grounded ice movements on the seabed. In depths between 550 m and 750 m four prominent individual

lineations with directions varing between 2°, 10°, 25° and 35°, a maximum length of 24 km, depths of approx. 25 m and a width of approx. 600 m leaving there mark on the floor, but there are many more less dominant lineations similar aligned. Based on the morphology of the intersection points of the lineations a relative age of the lineations can be obtained: with turning of the direction of the lineations to north-east, the age becomes junger. While in the deeper areas no scours of icebergs are visible, they are more abundant at shallower depths (< 650 m).

Trough offshore from Getz Ice Shelf

The trough offshore from the central Getz Ice Shelf (74° S / 118° W, Figure 2), a nearly 3000 km^2 wide area, was mapped during approx. 36 hours of systematic multibeam survey, in addition to one survey line of the RV "Palmer" in 2000. The investigated area is connected to the survey area of the RV "James Clark Ross" of the British Antarctic Survey in 2006. Based on the morphology the trough can be roughly devided into 2 parts, where the seabed was formed by grounded ice scratching the seafloor and melt water. The first part, directly in front of the current ice shelf, is characterised by a very rough morphology with depths variing between 700 m and 1600 m. The second part in the north-east of the trough is characterised by megascale glacial lineations, oriented in north-eastern direction, and depths of approx. 1100 m to 800 m.

Marie Byrd Seamounts

In the area of the southern Marie Byrd Seamounts, where a huge seamount was shown in the Smith-Sandwell bathymetric dataset (71° S / 122°30' W), compiled from marine gravimety anomaly from satellites together with ships sonar data, the multibeam survey shows flat seafloor. The further survey mapped a north-west to south-east aligned ridge at 70°40' S / 122°30' W with two overlapping profiles.

The south-eastern part of a seamount at 69°45' S / 126°20' W (Figure 3), which was never mapped before, was surveyed within approx. 16 hours. The north-west to south-east aligned seamount with a length of approx. 40 nm and a width of approx. 15 nm shows a flat top in a depth of 1200 m, steep flanks reaching the surrounding ocean floor at 3400 m water depth and lots of volcanic cones with heights of approx. 200 m.

The seamount at 69°35' S / 124°45' W, which was partly mapped before by RV "Palmer" in 1996, was crossed on a line north of the existing survey profile to create connected bathymetry data sets. The seamount at 69°05' S / 123°30' W, which was completely mapped before by RV "Palmer" in 1996, was crossed on a line at the southern slope. The Hubert Miller Seamount at 69°15' S / 121°30' W, which was partly mapped before by RV "Polarstern" in 2001, was crossed on a line at the southern slope, which added new bathymetry information to the existing data set. The seamount at 69°12' S / 117°30' W, which was discovered befove by RV "Polarstern" in 2001, was crossed with one line.

Deep Sea Channel in the Amundsen Sea

In addition to the bathymetric survey by RV "Polarstern" in 1994, a deep sea channel system was completely mapped. The channel system consists of three channels in a water depth of approx. 3000 m south of a seamount with a height of 500 m, where the biggest channel has a length of 28 km, a depth of 50 m and a width of up to 2.5 km. All channels leading in north-eastern direction and disembogue in a common basin.

King Georg Island

In addition to former surveys by RV "Polarstern" the Maxwell Bay and the Potter Cove was mapped during approx. 1 day of systematic surveying and station work. The mapped area of approx. 50 km^2 shows depths between 50 m and 500 m.

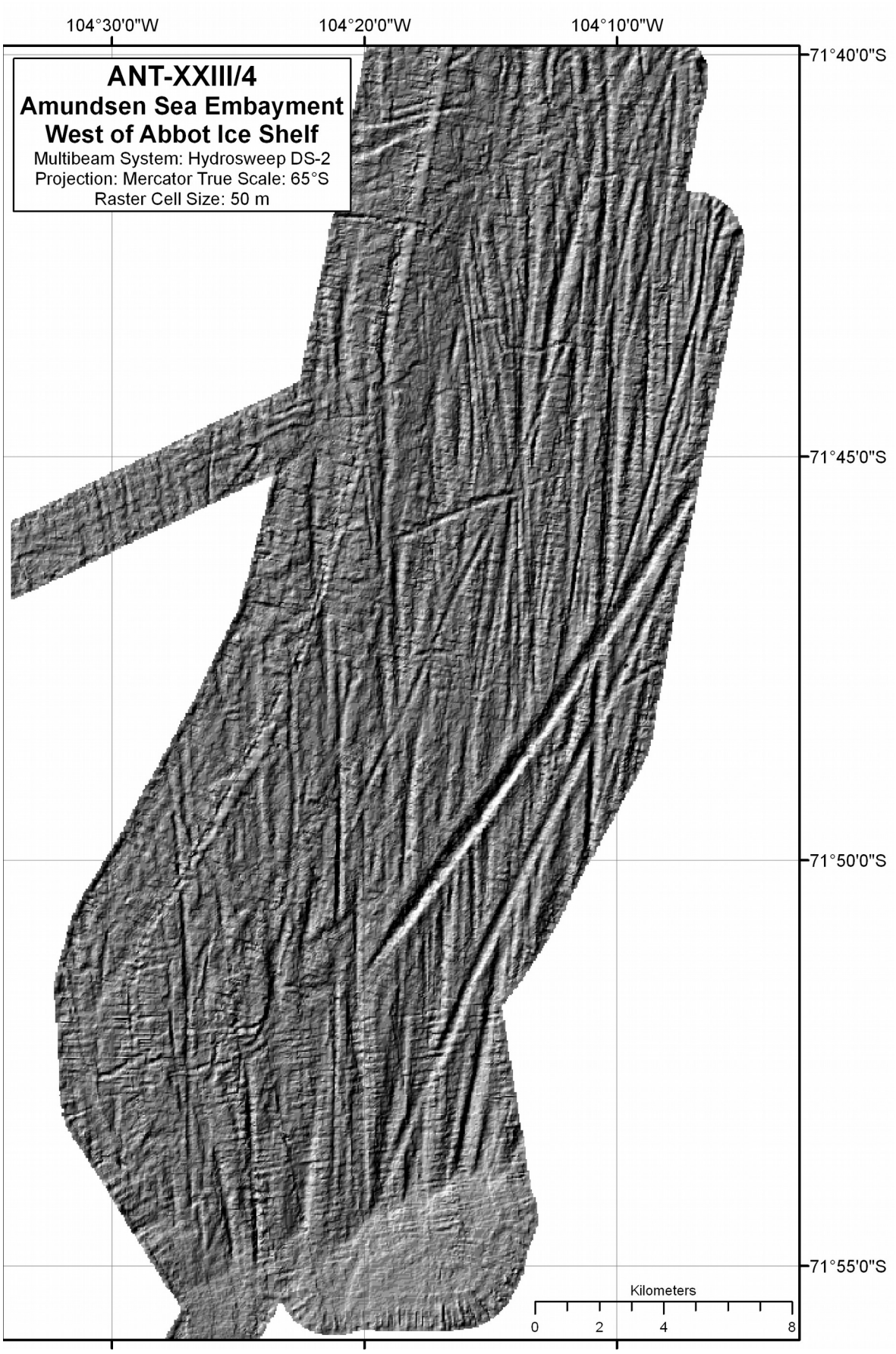

Fig. 1: Hillshade of the survey area west of the Abbot Ice Shelf

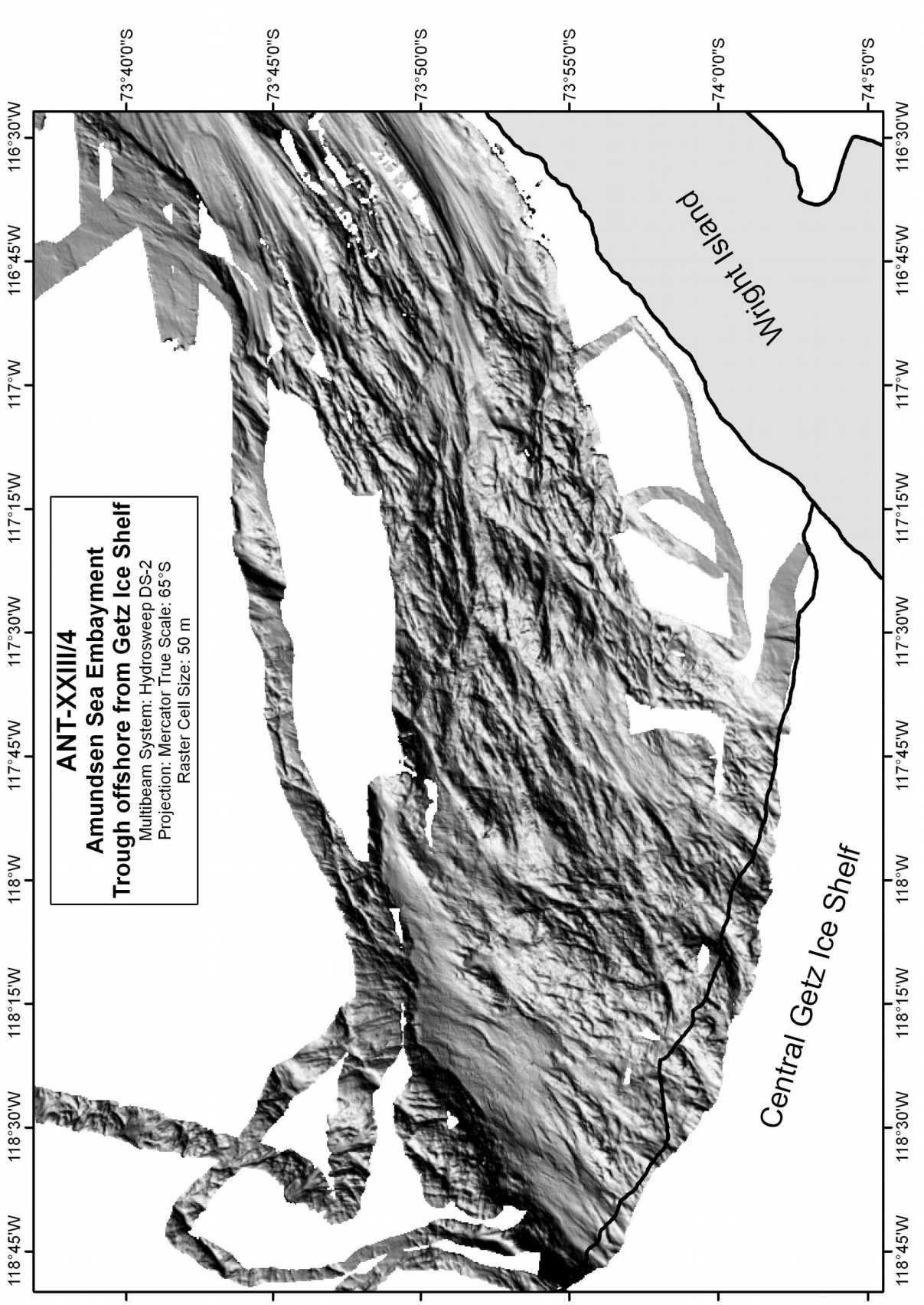

Fig. 2: Hillshade of the trough offshore from the Getz Ice Shelf

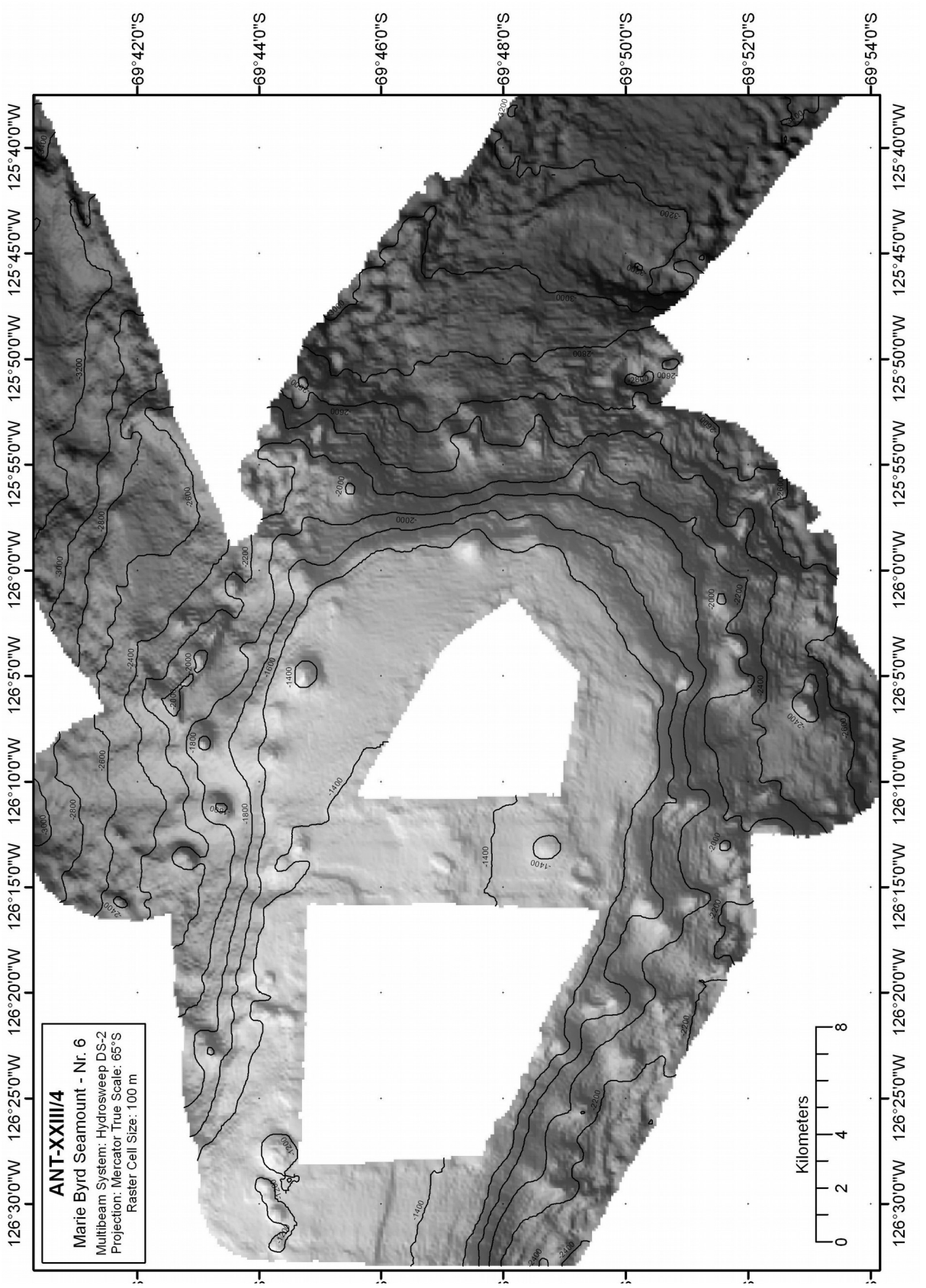

Fig. 3: Bathymetry of Seamount Nr. 6 of the Marie Byrd Seamounts