Geophysical Research Abstracts, Vol. 5, 05372, 2003

SEAFLOOR CHARACTERISATION OF THE GAKKEL RIDGE USING MULTIBEAM SONAR, BACKSCATTER AND SIDESCAN DATA

J. Hatzky, H.W. Schenke

Alfred Wegener Institute for Polar and Marine Research, 27568 Bremerhaven, Germany
E-Mail: jhatzky@awi-bremerhaven.de Fax: +49-471-4831-1149

The Gakkel Ridge in the Arctic Ocean was the object of the Arctic Mid-Ocean Ridge Expedition (AMORE) which was carried out by the research icebreakers R/V "Polarstern" (Germany) and USCGC "Healy" (USA) in the boreal summer 2001. This largely unexplored mid-ocean ridge (MOR) is of particular scientific interest due to its volcanic activity and tectonic structure. With spreading rates of 13mm/a in the western and 6 mm/a in the eastern part Gakkel Ridge is the slowest spreading MOR on earth (Michael et al., 2001). The surveyed area which is situated between 82°N / 8°W and 87°N / 75°E has a length of 1100 km and a varying width from 18 to 46 km. The range of measured depths reaches from 566 m on the top of a huge seamount to 5673 m in the central rift valley. Prominent underwater features of remarkable morphologic diversity (e.g. small volcanoes embedded in massive ridge flanks) were discovered in this region.

One of the most important goals of the expedition was the compilation of a high resolution grid which serves as basis for a three dimensional digital terrain model (DTM), the derivation of contour lines and the production of bathymetric maps. Accordingly, two hull-mounted multibeam sonars were used for the depth data acquisition: the "Hydrosweep DS-2" system onboard "Polarstern" and the "Seabeam 2112" system onboard "Healy". In order to calculate a combined grid out of two independent data sets different technical specifications of both sonar systems (e.g. frequency, opening angle, number of beams, accuracy) had to be taken into account. Dense sea ice cover made the sonar measurements difficult. Thick floes caused hydroacoustic disturbances that heavily debased the data quality. Outliers and blunders of depths and navigation data had to be corrected in a drawn-out post-processing by appropriate software tools.

Both echo sounding systems recorded backscatter information and sidescan data during the entire cruise. Onboard "Polarstern" the sub-bottom profiling system "Parasound" was operated additionally in order to explore sediment layers on the seabed. The analysis of the collected sonar data in combination with topographic information derived from the compiled DTM (e.g. elevation difference, slope) facilitates a characterisation of the seafloor. An attempt to subdivide the seabed into classes of different ground types (peridotite, basalt, gabbro and sediment) is primary based on backscatter information and will show preliminary results for selected test areas. The outcome of this classification can be verified with the aid of ground truth since "Polarstern" and "Healy" accomplished more than 200 geologic sampling stations (box/gravity corer, pipe/frame dredge, TV grab) along the ridge system.

Seafloor Characterisation of the Gakkel Ridge using Multibeam Sonar, Backscatter and Sidescan Data

J. Hatzky[1] & H. W. Schenke[1]

Alfred Wegener Institute for Polar and Marine Research

[1] Alfred Wegener Institute for Polar and Marine Research
Columbusstraße, 27568 Bremerhaven, Germany
E-Mail: jhatzky@awi-bremerhaven.de
Fon: + 49 - 471 - 4831 - 1227
Fax: + 49 - 471 - 4831 - 1149

Poster Board Number P0480
European Geophysical Society
Ocean Sciences Programme, Session OS4
"Ice Covered and High Latitude Oceans"

1. Abstract

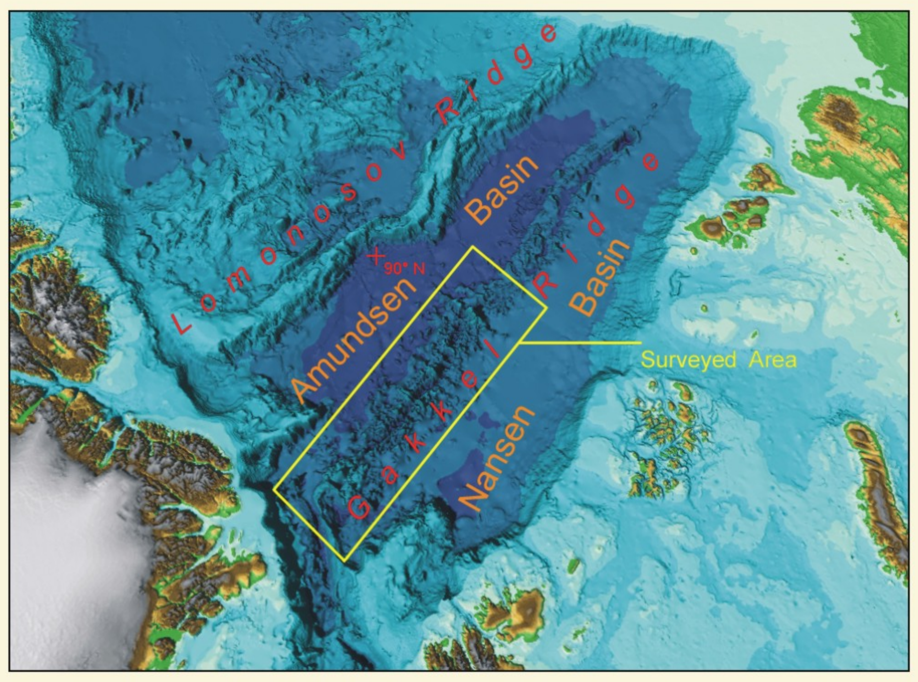
The Gakkel Ridge in the Arctic Ocean was the object of the Arctic Mid-Ocean Ridge Expedition (AMORE) which was carried out by the research icebreakers R/V "Polarstern" (Germany) and USCGC "Healy" (USA) in the boreal summer 2001. This largely unexplored mid-ocean ridge (MOR) is of particular scientific interest due to its volcanic activity and tectonic structure. With spreading rates of 13 mm/a in the western and 6 mm/a in the eastern part Gakkel Ridge is the slowest spreading MOR on earth ([5] Michael, P. et al., 2001).

The surveyed area is situated between 82°N / 8°W and 87°N / 75°E, has a length of 8890 km and a varying width from 18 to 46 km. The range of measured depths reaches from 566 m on the top of a huge seamount to 5673 m in the central rift valley. Prominent underwater features of remarkable morphologic diversity, for example small volcanoes embedded in massive ridge flanks, were discovered in this region.

One of the most important goals of the expedition was the compilation of a high resolution grid which serves as basis for a three dimensional digital terrain model (DTM), the derivation of contour lines and the production of bathymetric maps. Accordingly, two hull-mounted multibeam sonars were used for the depth data acquisition: the "Hydrosweep DS-2" system onboard "Polarstern" and the "Seabeam 2112" system onboard "Healy". In order to calculate a combined grid out of two independent data sets different technical specifications of both sonar systems (e.g. frequency, opening angle, number of beams, accuracy) had to be taken into account. ([3] Gauger, S. et al., 2001). Dense sea ice cover made the sonar measurements difficult. Thick floes caused hydroacoustic disturbances that heavily debased the data quality. Outliers and blunders of depths and navigation data had to be corrected in a drawn-out post-processing by appropriate software tools.

Both the "Seabeam 2112" and the "Hydrosweep DS-2" echosounder recorded backscatter and sidescan data during the entire cruise. Onboard "Polarstern" the sub-bottom profiling system "Parasound" was operated additionally in order to explore sediment layers on the seabed (compare area PS). The analysis of the collected sonar data in combination with topographic information derived from the compiled DTM (height difference, slope) facilitates a characterisation of the seafloor. The subdivision of the seabed into classes of different ground types (Peridotite, Basalt, Gabbro, Mud and Sediment) is primary based on backscatter information and shows preliminary results for the test areas B1, P1, G1 (hard rock), M1, M2 (Mud) and S1, S2 (Sediment). The outcome of this classification is verified with the aid of ground truth since "Polarstern" and "Healy" accomplished more than 200 geological sampling stations (box/gravity corer, pipe/frame dredge, TV grab) along the western part of the ridge system.

2. Geographical situation



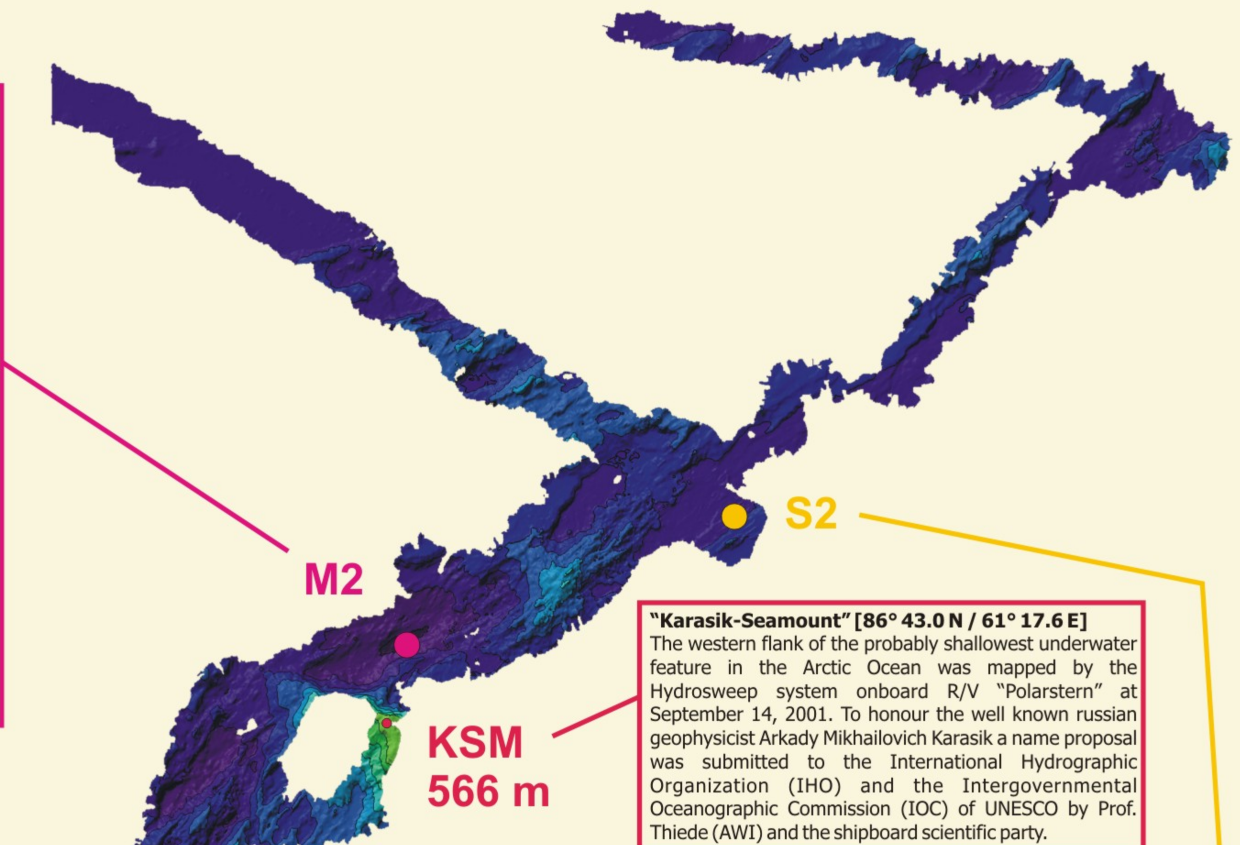
The ultra-slow spreading Gakkel Ridge forms the boundary of the north-american and eurasian plate and subdivides the cenozoic Eurasian Basin into the Amundsen and Nansen Basin ([1] Cochran, J. et al., 2003). The yellow box illustrates the surveyed area which extends from 82°N / 8°W to 87°N / 75°E (map source: International Bathymetric Chart of the Arctic Ocean (IBCAO), Vol. 1.0, 2001)

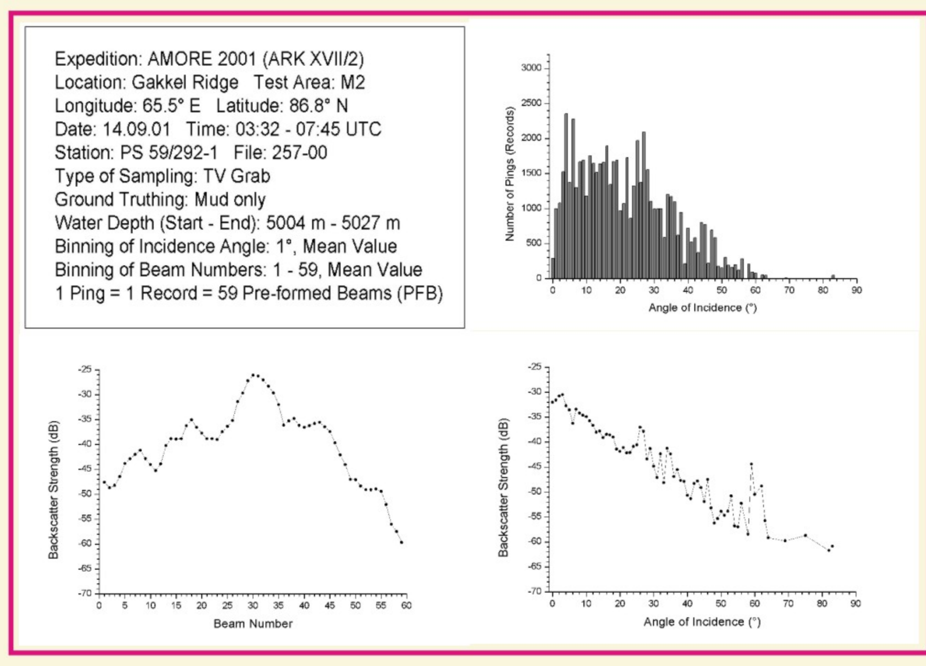
3. High resolution bathymetry

The digital terrain model (DTM) presented on this poster was compiled with the 3D-visualisation program *Fledermaus*. It is based on a grid of 100 m cell size which was calculated with an inverse distance weighting (IDW) algorithm using the geo-information system *ArcGIS* and converted to the netCDF format using the *Generic Mapping Tools (GMT)* software.

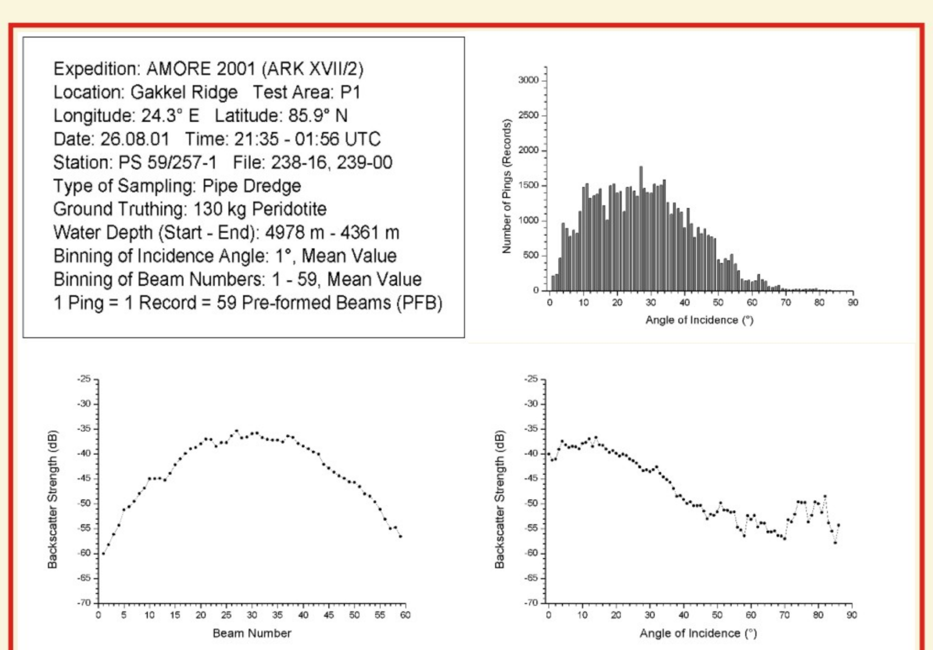
Due to the strong ice coverage in the operation area, ice-ramming and unstable ship's courses the collected multibeam and navigation data of "Polarstern" and "Healy" had to be corrected in a drawn-out post-processing. Outliers and blunders were removed by appropriate statistical methods like spike detection and surface cleaning which are implemented in the software package CARIS HIPS. Finally the entire grid was subdivided into slope classes and smoothed with various slope-dependent filter matrices ([2] Gauger, S., 2002):

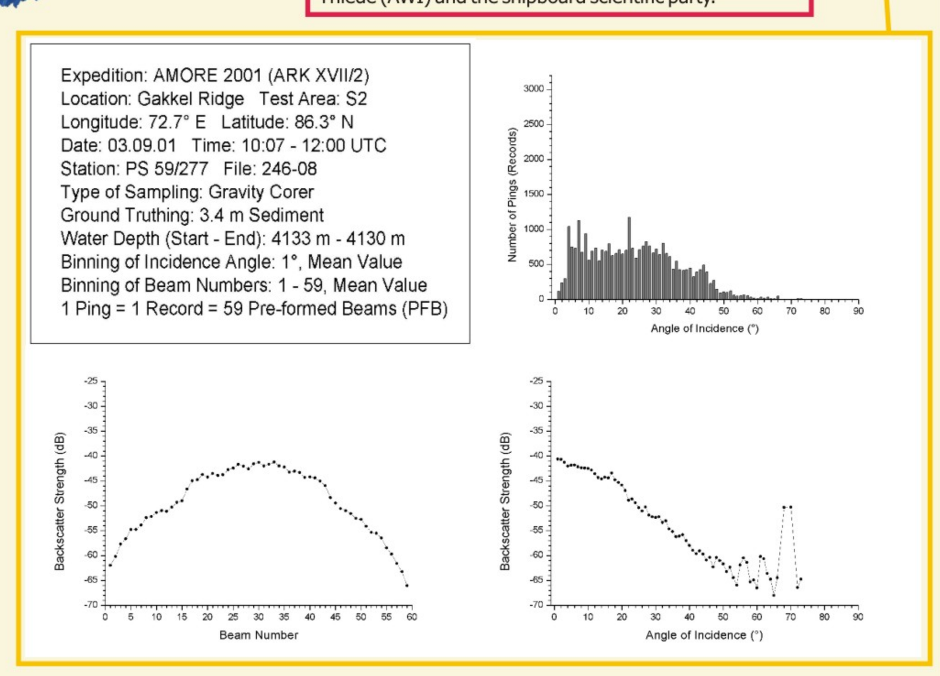
Class	Slope	Filter matrix
1	> 35°	3x3 binomial
2	20° - 35°	3x3 mean value
3	10° - 20°	5x5 binomial
4	5° - 10°	7x7 binomial
5	< 5°	9x9 binomial



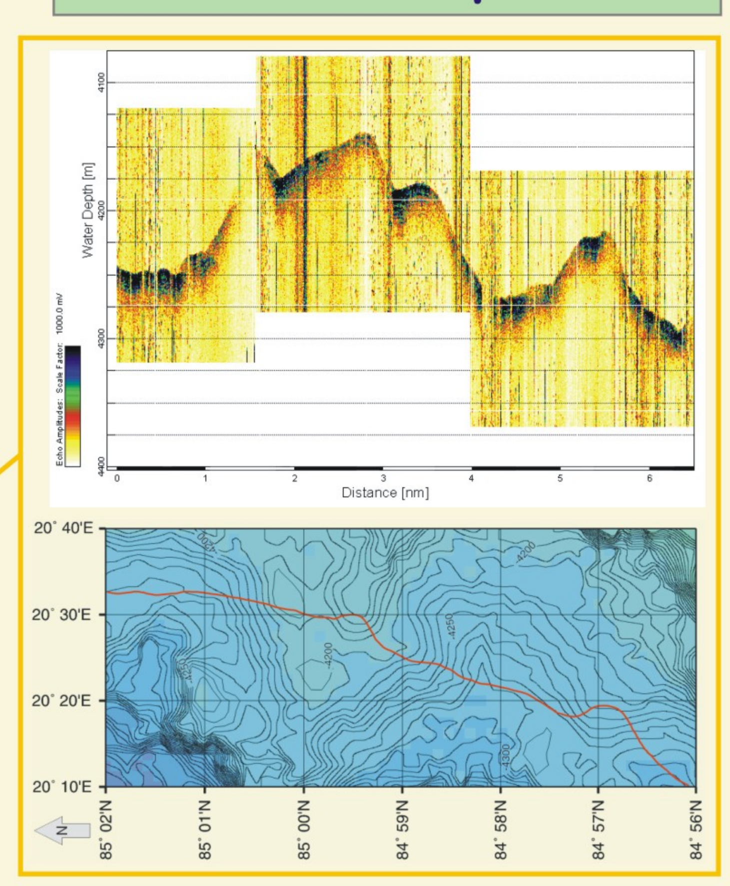


"Karasik-Seamount" [86° 43.0 N / 61° 17.6 E]
The western flank of the probably shallowest underwater feature in the Arctic Ocean was mapped by the Hydrosweep system onboard R/V "Polarstern" at September 14, 2001. To honour the well known russian geophysicist Arkady Mikhailovich Karasik a name proposal was submitted to the International Hydrographic Organization (IHO) and the Intergovernmental Oceanographic Commission (IOC) of UNESCO by Prof. Thiede (AWI) and the shipboard scientific party.





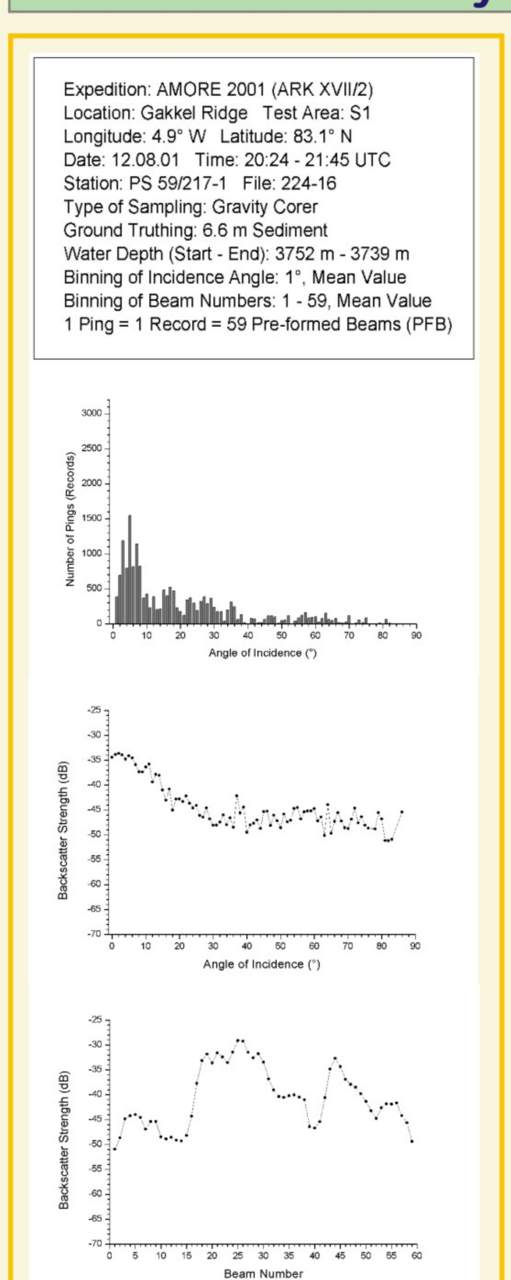
4. Sub-bottom profiles



The sub-bottom profiling system *Parasound* onboard R/V "Polarstern" is designed for the exploration of sediment layers on the seabed and works in water depths between 10 m and 15000 m. The acoustic waves can be transmitted with varying impulse frequencies from 2.5 to 5 kHz, the opening angle depends on the frequency and is 4° at 4 kHz. The waves penetrate the seafloor in a range from 10 m to 200 m and insonify an area (footprint) of approximately 7% of the water depth ([4] Kuhn, G., Weber, M. 1993).

The data were captured using the software *Paradigma* ([6] Spieß, V. 1993), later burned on CDs and visualised with the program *SeNT*. Location PS at 85.0° N / 20.5° E shows an area with quickly changing seafloor topography and a thin layer of sediments upon the oceanic crust. The red line in the picture below illustrates the track of R/V "Polarstern".

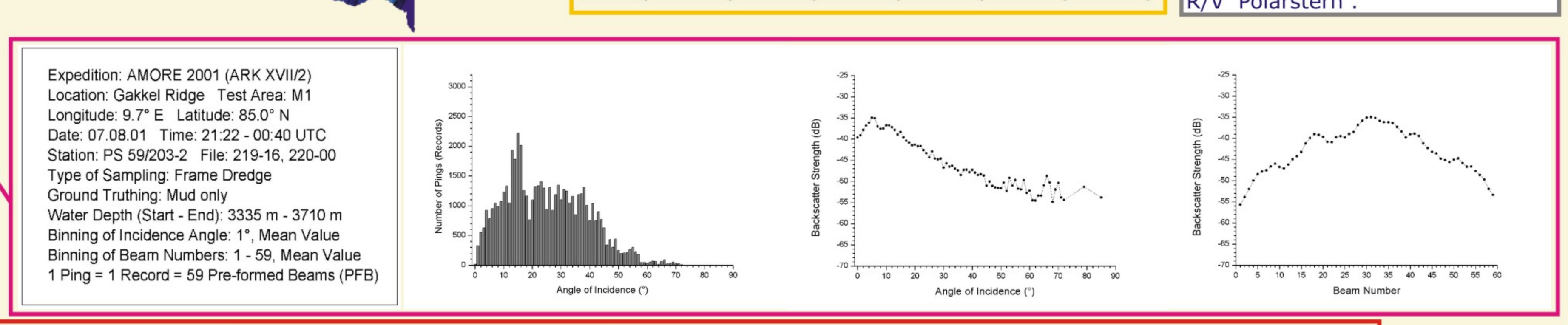
5. Backscatter Analyses

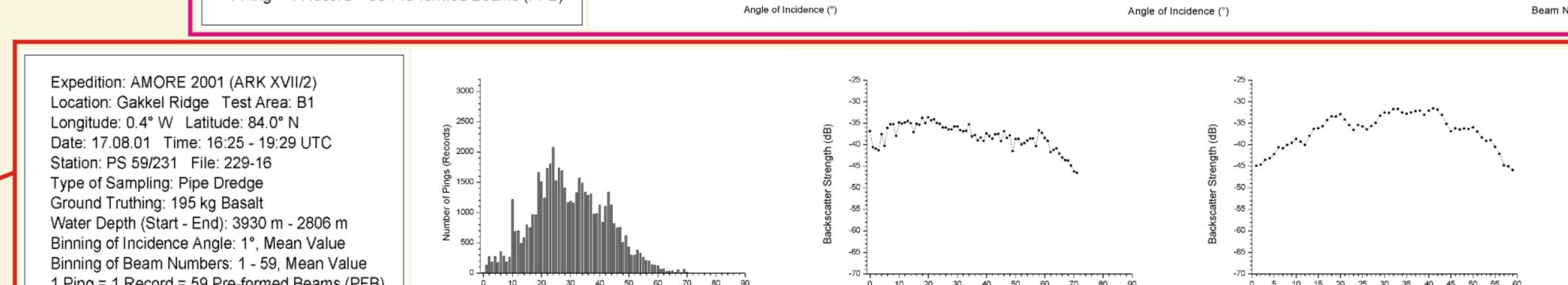


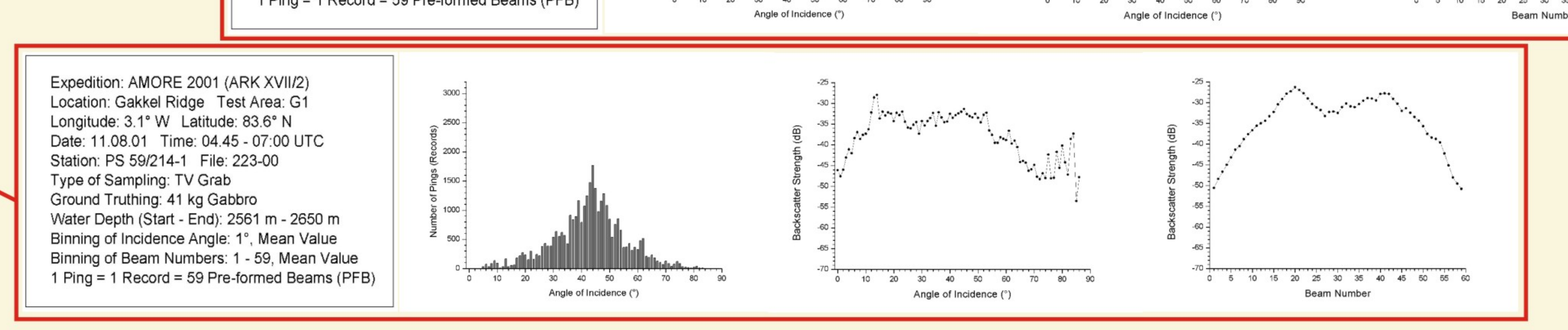
The "Hydrosweep" backscatter data were processed using a modified code of the *XMBScat* software (Atlas Electronics, Germany) which uses an xyz-grid to model the insonified area of the seabed.

The *backscatter strength* [dB] indicates the relation between backscattered and transmitted acoustic energy and depends on the *incidence angle* of the sound wave. For each of the 59 pre-formed beams (PFB) backscatter strength values were calculated and binned in 1° intervals due to better visualisation.

The diagrams for test area S2, M2, P1, M1, B1, G1 and S1 (in geographical order from NO to SW) show preliminary results which will be utilised for a classification of the ridge into areas of a) hard rock [peridotite, gabbro, basalt], b) mud and c) sediment.







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