

Pseudo sidescan images from backscatter amplitude data of the Hydrosweep multibeam sonar system

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Using the rms (root mean square) backscatter amplitude values, a procedure was evolved to generate pseudo sidescan images. A comparison of the pseudo sidescan image with actual Hydrosweep sidescan image, from an area covering a pear shaped seamount in the southeast Pacific Ocean is presented. The two sidescan images are perfectly comparable. This result will enhance the utility of the Hydrosweep multibeam system so that, even in the absence of sidescan option, the offline pseudo sidescan images can be obtained using only the rms backscatter amplitude values.

Introduction

Principally, the bathymetric systems provide information only about the water depths, whereas the sidescan images can provide information on the structure, roughness and composition of the seafloor. Typical sidescan sonar systems transmit narrow beams of sound perpendicular to the ships track to both the starboard and the port side of a towed transducer. Acoustic returns are displayed as a function of time or ground range¹. The sidescan images generally assume a flat bottom as no depth information is available throughout the fan of survey. If correctly located imagery is needed, a detailed bathymetric survey will have to be carried out in conjunction with the traditional sidescan survey in order to combine the bathymetric data with sidescan imagery. It is therefore desirable to have a hull-mounted system which can achieve the dual objectives of collecting high-resolution bathymetry as well as high quality sidescan imagery. The major advantages² of such a facility are

- (a) accurate determination of sensor position and altitude
- (b) increased survey speed, resulting in greater cost effectiveness
- (c) increased accuracy and

(d) no chance of losing the sensor.

There have been several attempts in the recent past to obtain bathymetric data and simultaneous sidescan images from multibeam systems,^{3,4} but these attempts failed to obtain the expected accuracy. Because multibeam sonars transmit a narrow fan-like beam similar to sidescan sonars, attempts to preserve the acoustic backscattered returns and to produce sidescan-like images yielded encouraging results.^{5,6} A significant breakthrough has been the recent improved multibeam echosounders such as Sea Beam 2000⁶ and Atlas Hydrosweep DS-2 which have the capability of generating real-time bathymetrically corrected sidescan images in addition to the bathymetric data. The Hydrosweep DS system on the *Polar Research Vessel POLARSTERN* (Alfred Wegener Institute for Polar and Marine Research) was upgraded to increase the swath width from 90° to 120°, and to record backscatter amplitude values. Later in 1994, hardware and software were added to the system to sample the signal amplitudes in each preformed beam, summing the data from each beam and generating 1024 amplitude samples across the swath to generate online sidescan images. In this paper, we present a comparison of the sidescan images (1024 amplitude values) with the pseudo-sidescan images

generated using the rms backscatter amplitude value for each beam (59 values). A good correlation between the two images will enhance the utility of the backscatter amplitude values to produce sidescan like images in the absence of the costly hardware and software modifications to the older multibeam Hydrosweep system.

Data and results

Hydrosweep is a deep-sea multibeam echosounder providing coverage equal to twice the water depth (for versions with 90° fan width) and operating at frequency of 15.5 kHz. Survey profiles are insonified at right angles to the direction of travel and the result is output as 59 depth values. (For technical details, see⁷). The transmit and receive geometry of the Hydrosweep DS-2 can be used not only for measuring directional travel times (ie. water depths) but also for extraction of signal information on the nature and form of the insonified area. As only electrical quantities are measured in the Hydrosweep, the reflected signal parameters have to be converted to acoustic variables. Electrically measured signal amplitudes can be inversely used for estimation of seafloor scattering properties. The parameters provided by the Hydrosweep amplitude record are principally the output amplitude (echo rms voltage) and echo duration for the 59 beams.

During the ANTIXII/4 cruise of *PRV POLARSTERN*, continuous multibeam bathymetry (Hydrosweep) data along with sidescan and backscatter amplitude data was collected in the southeastern Pacific Ocean. The Polarstern uses the Global Positioning System (GPS) for navigation. Offsets and positioning errors were subsequently corrected to provide accurate position. Data from small seamount between latitudes 53° 51' S 53° 21' S and longitudes 89° 51' W 89° 21' W are presented here. The total area covered by 3 north-south track lines, spaced 5 nautical miles apart is 1550 km². The average depth of the seafloor surrounding the seamount is 4300 m. Traditional sidescan sonars generate online images and adjacent tracks are overlain to form a mosaic, the area chosen here is from 3 tracks, with slight overlap.

The Hydrosweep bathymetry data were processed using the MB-System software (developed by LDEO) and the GMT software (SOEST and

LDEO). The depth contour map of the area (100m contour interval) is presented in Fig. 1. The main feature seen in the depth contour map, is the seamount at 53° 30' S, 89° 30' W. In addition to this seamount, the area includes several smaller elevated areas that are probably lava flows and small volcanoes buried by sediments. The seamount has a pear shape, is 9 km long and 7 km wide and has a height of 1000 m. The northern side of the seamount is slightly elongated and has gentler slopes. The area exhibits average slope angles of 13° with a maximum of 40°.

The sidescan sonar images are generated online by the Hydrosweep system. The data consist of the amplitude of the backscattered energy for each ping. The waveforms from the 59 beamformers are combined and resampled to yield 1024 amplitude values across the swath. This provides a measurement of the strength of the acoustic signal reflected back by the seafloor. Although some of the variation in the reflected signal is caused by

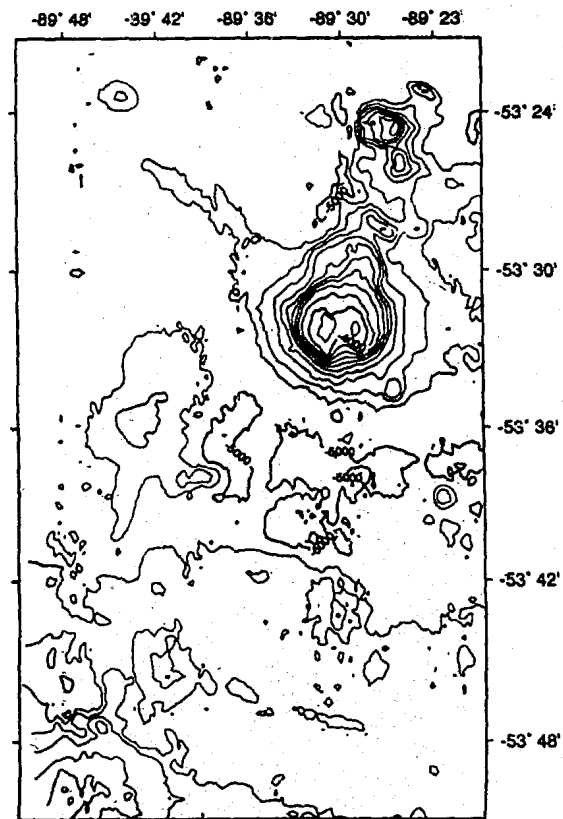


Fig. 1—Depth contour map of the study area (contour interval, 100 m).

large-scale bathymetric features, the signal also provides important information about the small-scale seafloor roughness that cannot be obtained from the bathymetric information alone. These roughness variations can be caused by fine-scale sedimentary structures such as sediment waves, or by different seafloor materials. Many small features are thus revealed that would not otherwise be observed. The digital sidescan amplitude data are stored and were later processed using the WHIPS (Woods Hole Image Processing System) and the GMT software. The sidescan sonar image from this region is presented in Fig. 2. Many small features not revealed by the depth contour map are brought out clearly in the sidescan image. Although the smaller elevations are covered by sediment, the rough-surfaced, steeper slopes have higher backscattering strength and appear brighter on the image. In contrast, the low-lying flat areas covered by smooth sediment reflect little

backscattered energy and appear dark in the figure. Some of the smaller circular features seen in the sidescan data may be volcanic craters.

As discussed in the earlier paragraphs, the backscatter amplitudes were also recorded as rms values for each beam in this area. Basically, amplitude values can be used to calculate the backscatter strength and ultimately the bottom type⁸. In order to classify the seabed material, the interaction effect of bottom relief on the acoustic signal must be known^{9,10}. Stanton & Clay¹¹ and Dunsiger *et al*⁵, tried to identify the bottom type from reflection and scattering characteristics. However, here we attempt to use these amplitude data in a qualitative way to produce sidescan sonar like images. A program was written to reformat the amplitude record to comply with the format used by the MB-software. Peak amplitude and the beamformer basic gain of each beam are converted as follows in the amplitude values. (a similar approach was used by de Moustier & Alexandrou¹²

$$\text{factor} = 100 * 10 \text{ to the power } (-0.005 * 6 * \text{basic gain})$$

$$\text{new amplitude} = \text{factor} * \text{peak amplitude.}$$

AntXII/4 Hydrosweep Sidescan

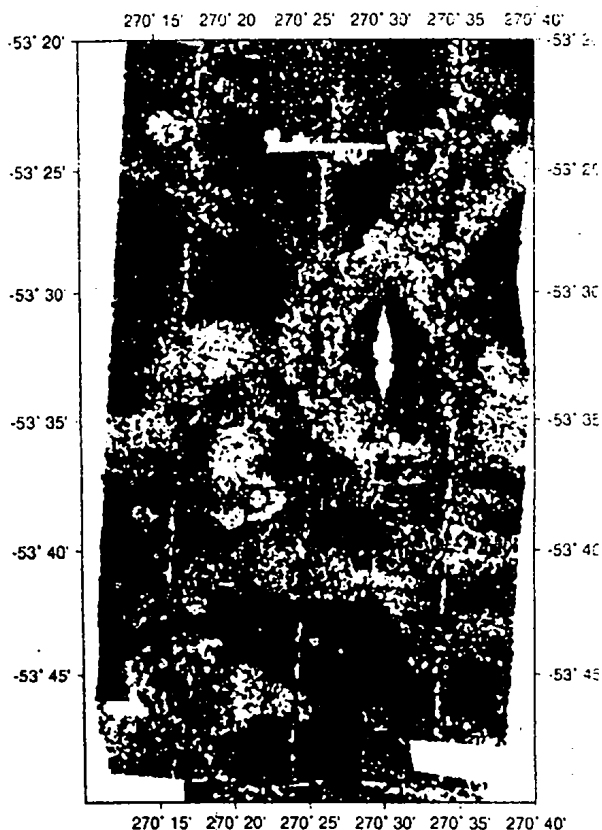


Fig. 2—Sidescan sonar image generated from 1024 amplitude values.

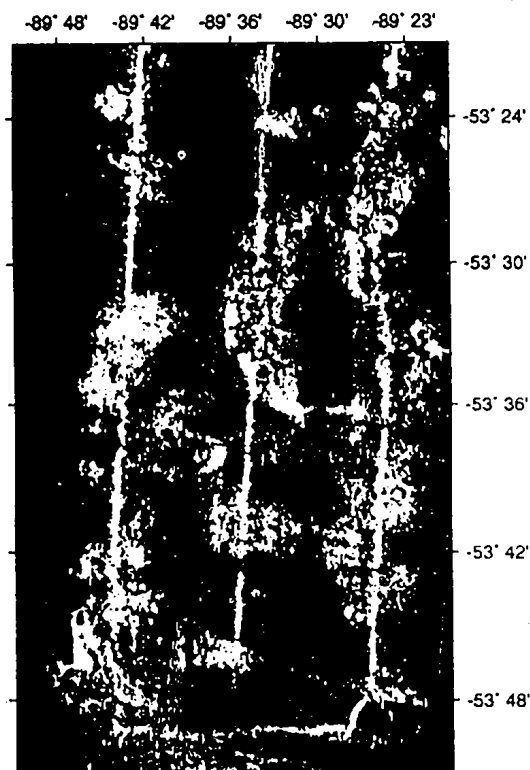


Fig. 3—Sidescan sonar image generated using 59 backscatter amplitude values.

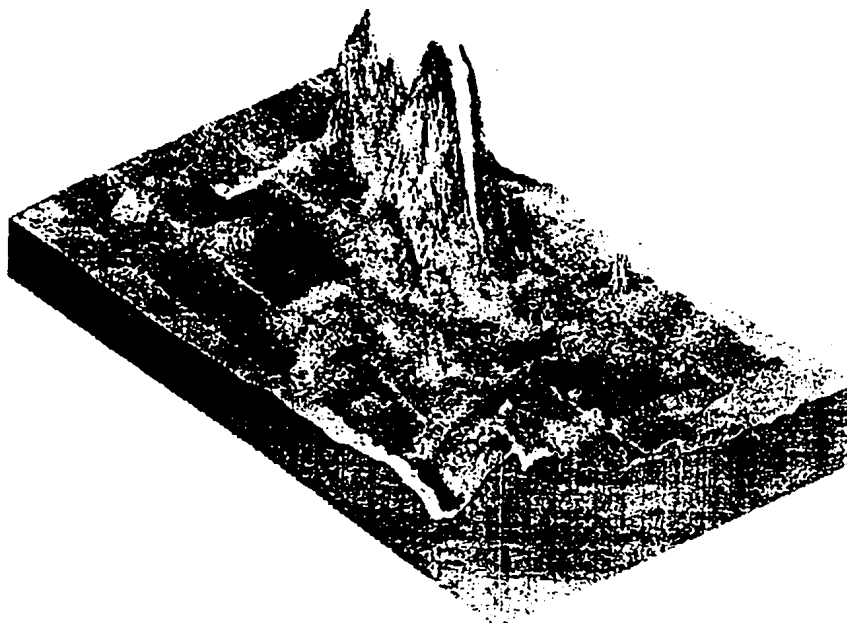


Fig. 4—3D overlay of the depth data and the sidescan image.

These values were used to create an amplitude grid and the resultant pseudo sidescan image is presented in Fig.3. The gridding was done at a very fine scale (32 m × 53 m). This way, the backscatter amplitude data is resampled to a fine scale and different gray shades are attributed different ranges of amplitude values. An attempt is thus made to produce a sidescan like image using the amplitude values. The amplitude values generated using the above program were processed using the MB and GMT software packages to grid and later to produce a gray shaded grid image (Fig.3). The grey scale used for this figure is similar to that used for Fig. 2. The darker tones indicate areas of little backscatter energy (flat and sediment filled) and the lighter tones represent the rough surfaced steeper areas with high backscatter energy. It is observed that, Figs. 2 and 3 are very similar. The sidescan images (Figs. 2 and 3) also show light tones in places where the seamount and other rough terrains are observed in the depth contour map. Additionally, the light tones (indicating higher backscattered strength) are observed in locations not associated with topography, highlighting the utility of the sidescan images. Beyond the base of the seamount on the south and eastern slopes, clear bright backscatter amplitude patches are observed which do not correspond to the depth contours. Also, a few

circular crater-like features are clearly visible in the sidescan images and are not observed in the depth contour map. Figure 4 presents a 3D—view of the area wherein the sidescan image data is superimposed on the depth data. The combined image of sidescan and depth data will help explain the presence of certain bright or dark areas as being due to the angle of insonification or due to real lithological variations. Integration of sidescan and bathymetric data leads to improvement of seafloor model visualization, data interpretation and data quality^{1,2}.

In the above approach, we have not considered the amplitude values as a function of the grazing angle. However, using the MB-software it was possible to generate a table of average amplitude values as function of grazing angle which can be used to correct the amplitude values for variation with grazing angle. We tried this method and the resultant pseudo-sidescan image from the amplitude values didn't show any appreciable change from the one presented in Fig.3. Hence, this study shows that the beam rms amplitude values from the multibeam system Hydrosweep can effectively be used for generating pseudo-sidescan images and will provide additional information on the nature and lithology of the seafloor.

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