# DISPLAY ENHANCEMENT FOR SEISMIC INTERPRETATION

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## ABSTRACT

To aid in the interpretation of seismic data received from a marine sub-bottom profiler a number of digital signal processing techniques are applied. A quadrature bandpass with a Gaussian response is used to obtain a display representative of the reflected energy in selected windows within the source pulse spectrum. This type of filtering reveals frequency-dependent features of the sediment without introducing artificial layering because of a ripple-free response. Subsequent processing, differentiation or peak detection, further enhance the image for the human interpreter. The use of colour display to simultaneously compare seismic data in selected frequency windows is described.

## RÉSUMÉ

Des données provenant d'un profilomètre de sous-sol marin sont soumises à diverses techniques de traitement numérique de signaux afin de faciliter leur interprétation. Un filtre passe-bande de quadrature à réponse gaussienne permet de visualiser d'une façon sélective l'énergie réfléchie par des portions du spectre des impulsions incidentes. Ce type de filtrage met en relief des caractéristiques des couches sédimentaires dépendantes de la fréquence sans générer des stratifications artificielles grâce à une réponse libre d'ondulation. Un traitement subséquent, dérivation ou extraction de crêtes, permet d'améliorer l'image pour faciliter l'interprétation humaine. On décrit enfin l'utilisation d'images pseudo-chromatiques pour l'affichage simultané de trois bandes de fréquences adjacentes.

This paper describes the application of some digital signal processing techniques to seismic data obtained from broadband subbottom profiler. The data were acquired with the Huntec Deep Tow Seismic System (DTS), a primary survey tool in a program to demonstrate the feasibility of remote identification of the sediments of the ocean floor.

The purpose of this study is to obtain a display representative of the reflected energy in selected frequency windows within the source pulse spectrum. Frequency dependent features of the sediment would assist an interpreter in the classification of the subbottom type. Furthermore, whereas conventional displays exhibit the amplitude of the reflected signal, complex trace analysis is used here to obtain a display of the amplitude of the envelope which is representative of the desired reflected energy. Since the received signal is ideally a series of impulses, replicas of the acoustic source pulse, the response of a filter with a Gaussian characteristic is found to be a compromise between sharp cutoff in the frequency domain and no ringing output impulse response. This filter is referred to here as a quadrature digital bandpass filter (QBPF) and comprises two parts:

(1) a recursive bandpass filter with a Gaussian response obtained by applying the bilinear transformation to a lowpass Gaussian analog filter and

(2) a quadrature filter that generates the envelope of the response by taking the magnitude of the complex output of a Hilbert transformer.

The results of processing the seismic records through the QBPF are presented in the form of an image. The X and Y axes of the image represent the direction of travel of the profiler over the ocean floor and the depth into subbottom sediments, respectively. The reflected signal is displayed as a grey scale intensity.

A measure of the expected performance of the filter is demonstrated by the impulse response for bandwidths 1-3, 3-5, and 1-10 kHz, Figure 1. These responses are asymmetrical due to the group delay in the system. However extensive testing showed that for the application with the profiler data the effect caused no noticeable degradation in the image presentation. Thus the allpass group delay equalizer designed and tested with these data

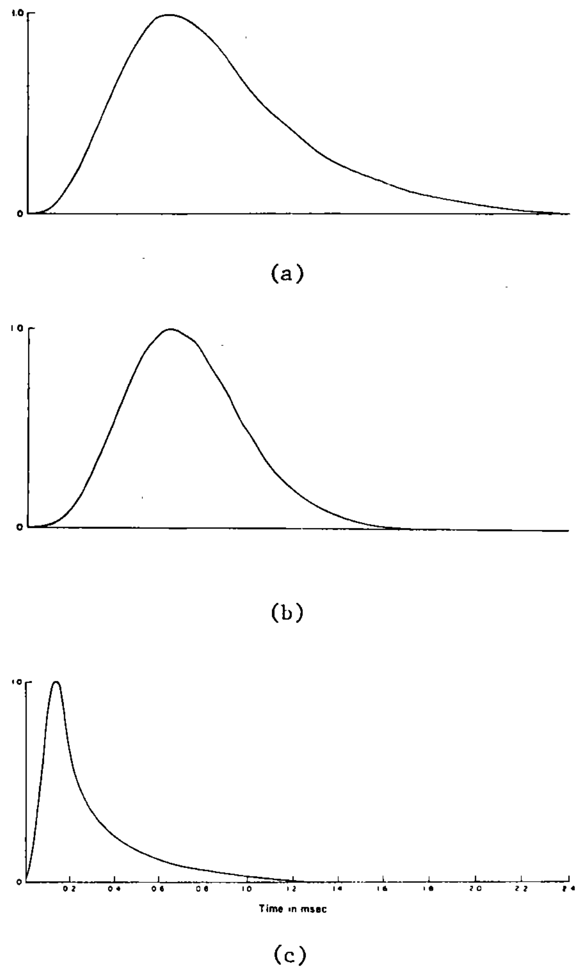



Fig. 1. QBPF's impulse responses
(a) 1-3 kHz, (b) 3-5 kHz, and
(c) 1-10 kHz bandwidths.

was unnecessary. Furthermore the addition of such an equalizer to the QBPF is not recommended for this application since it has the unfortunate effect of adding ripples on the skirts of the impulse response. These ripples appear as artificial layers on either or both sides of a strong reflector.

The full spectum display of the seismic data used in this study is shown in Figure 2. We are here dealing with two distinct problems. One is filtering the data in narrow windows without introducing artificial layering, and this is accomplished by the use of the QBPF as illustrated in Figures 3(a) to 5(a). The second problem is the display of this data in a suitable, familiar manner, one in which the

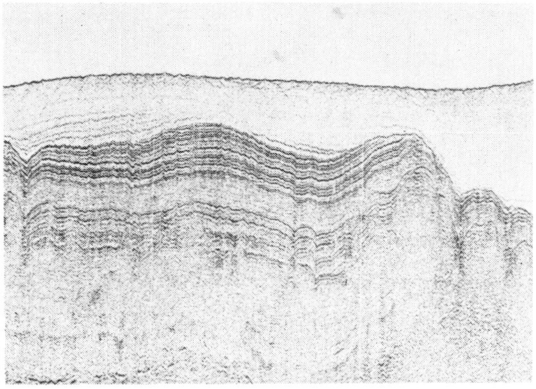


Fig.2. Huntec'70 seismic subbottom profiler echoes

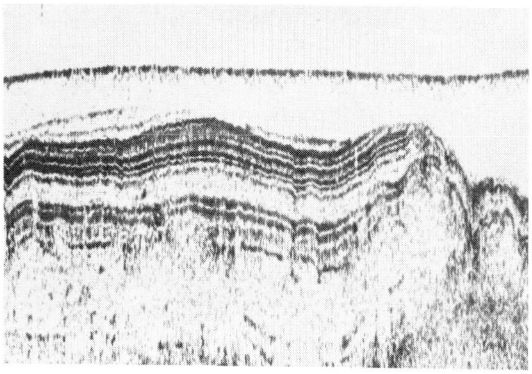
layers of the sediments are a dominant feature. Contrast enhancement through histogram modification techniques were not successful. But when differentiation or peak detection was applied to the filtered data, the displays shown in Figures 3(b,c) to 5(b,c) resulted. It is noticed that the sharp layering existing in the original display reappears giving a display familiar to the interpreter.

The differentiating filter was obtained using the Stirling formula. Only the positive values of the differentiated data were kept. As a result a narrower response is obtained.

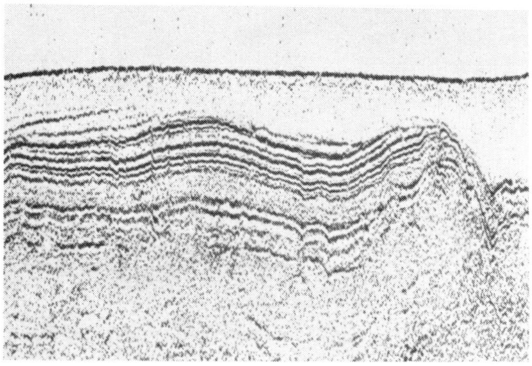
The peak detection, in an approach similar to a difference differentiation method, searches through the data for a change in slope and thus locates a peak. This method displays the values of the peaks and a small number of points around them and results in a narrower and near symmetrical representation of the response.

A detailed description of this study is given in NRC reports ERB-926 and ERB-927.

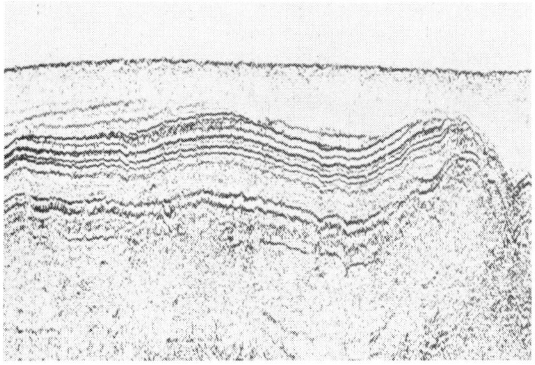
It is now feasible through the use of colour to display simultaneously all the information in three grey scale images. This colour image displays the reflected energy in three selected narrow windows with the information in each window presented by the intensity of a primary colour. Additional processing is required to normalize the displayed intensities to the source pulse spectrum and to compensate for the time delay in the response of each filter. Such a display may provide a new aid in the analysis of the subbottom sediments.



(a)

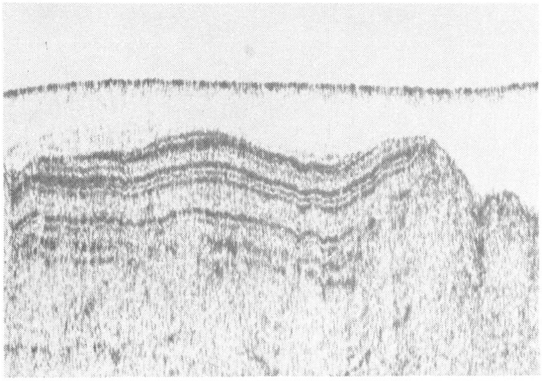


(b)

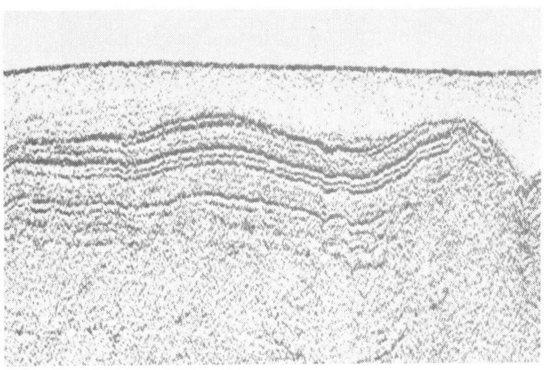


(c)

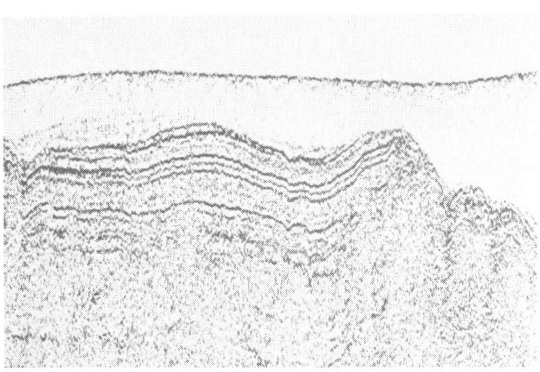
Fig.3. (a) Real data processed through a 1-3 kHz QBPF.
(b) Differentiation of data in a, and
(c) Peak detection of data in a.



(a)

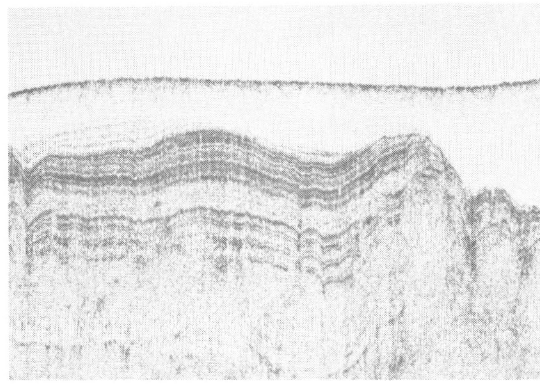


(b)

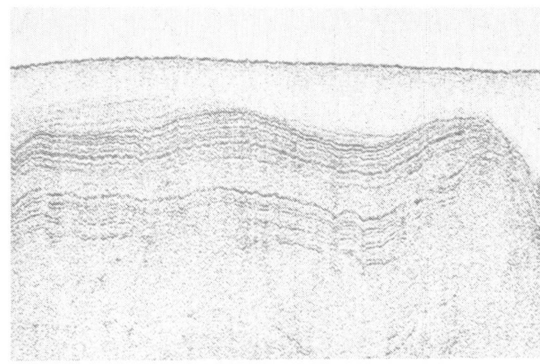


(c)

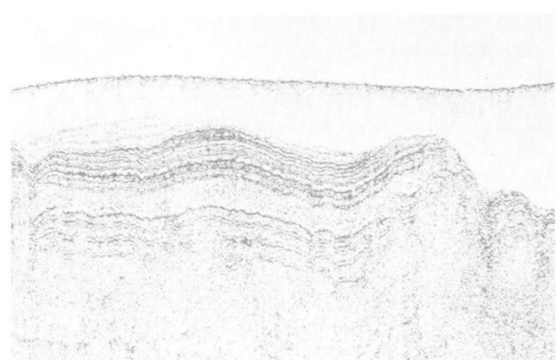
Fig.4. (a) Real data processed through a 3-5 kHz QBPF
(b) Differentiation of data in a, and
(c) Peak detection of data in a.



(a)



(b)



(c)

Fig.5. (a) Real data processed through a 1-10 kHz QBPF,
(b) Differentiation of data in a, and
(c) Peak detection of data in a.