G033

Diffractor Scan (DSCAN) for Attenuating Scattered Energy

N. Gulunay* (CGG Americas Inc.), M. Magesan (CGG Americas Inc.) & J. Connor (CGG Americas Inc.)

SUMMARY

We present a method of attenuating diffracted noise in marine seismic surveys. Such noise originates from heterogeneities near shallow sea beds. We locate position of such obstructions using semblance scan analysis, and then extract the noise from the traces at the calculated travel times for each diffraction trajectory.

Introduction

3D marine surveys occasionally suffer from scattering of source energy from sharp discontinuities at, or around, the sea bottom. Reflected energy from deep strata is weak and such scattered noise is much stronger than reflections since it travels only in water.

As this strong energy can interfere with many prestack processes, such as deconvolution, surface related multiple prediction and prestack migration, the position of the scattering points may need to be detected and the energy associated with them attenuated.

Industry solution to this problem has been (see, for example, Fookes et al., 2003) to: a)-determine the position of a diffractor from travel times, b)-flatten the record using those travel times, c)-filter the flat event using f-k or Radon filter, for example, d)-restore travel times e)-repeat steps a) through d) for each significant diffractor.

As there could be many diffractors to work with our motivation is to detect and remove diffracted energy without picking arrival times. For this we use semblance scans. The use of semblance scans for diffractors was first made by Landa et al. (1987) to detect the location of buried diffractors under land surveys. Last year, Gulunay et al. (2005) proposed an automatic method for the detection of shallow water diffractors in marine surveys and for building the corresponding noise model from the records for later subtraction. Here we summarize that method and show its application to a 3D marine data as well as to a 2D marine survey. In its use of the travel time equations (double square root) our method resembles Nemeth et al.'s (2000) technique called "migration filtering" that is used to attenuate low velocity diffractors but we don't solve for a linear system of equations in determining noise and signal components.

Diffractor position scan (DSCAN) method

The energy of the diffracted noise travels from the source to the diffractor. The diffractor then scatters the energy back. The energy arrives at the receivers at a time which is the sum of the time from the source to the diffractor plus the time from the diffractor to the receiver:

$$T = \frac{1}{V}\sqrt{(x_s - x_d)^2 + (y_s - y_d)^2 + z_d^2} + \frac{1}{V}\sqrt{(x_r - x_d)^2 + (y_r - y_d)^2 + z_d^2}$$

where V is the velocity of propagation. Given a diffractor point $D=(x_d,y_d,z_d)$, in an area (x and y range), the amplitudes of data at time T calculated as above for all traces (i.e. source $S=(x_s , y_s)$ and receiver $R=(x_r, , y_r)$ pairs), can be used to provide useful information on the coherency of the diffraction generated by that diffractor location. Stack amplitudes, or stack power, could be used to estimate how strong this diffractor is. One could also use other coherency measures as well. Semblance is known to be the most useful coherency measure. We use the best estimate of the water velocity for V and generally assume $z_d=0$ for shallow water cases. Note that given the finite record length (typically from 5 to 14 seconds) and for a given shot record there is a finite area that one needs to scan to find the diffractor locations that are affecting that shot. Once semblance scan in the x and y range is completed then most coherent points (diffractors) can be automatically selected and for each such point the travel times to a receiver-shot pair (trace) can be calculated. A short wavelet around this time can be extracted from that trace to obtain the contribution of this diffractor to the noise model at that trace which will later be subtracted from the input record to obtain the noise attenuated record.

Field Data examples

We have tested this method on a number of marine surveys. Here we would like to present two of them: the first one is a sailline of a 3D survey with 3 streamers per shot, and the second one is a 2D survey with one cable. A typical noisy shot from the 3D survey is shown in Figure 1a. Close inspection of the shot record suggests that there are a few diffractors but it is not easy to predict how many or which event belongs to which diffractor.

The semblance scan of this shot and another one next to it, using a scan area of 11km by 12 km are shown in Figure 2. We used V=1538 m/s in the scans. Red indicates semblance values above 0.08. Highest semblance value found in the search was 0.53. The holes in the middle of the semblance distributions shown in Figure 2 are due to the fact that first second of data was not included in the diffractor scans. The missing parts from the semblance scan on the broadside are due to the fact that cyclic (low frequency) reflectors may look like broadside diffractors, especially when the number of cables per shot is small, and such points may need to be eliminated from the analysis to protect against reflector damage. Note the consistency of diffractors between two shots. Diffractor selection can be made using local maxima criteria with thresholding.

Figure 1b shows the noise model built from first 22 strong diffractors chosen from the scans like Figures 2. This model can later be subtracted from the record either by straight subtraction (Figure 1c) or by least squares subtraction, if desired.

Figure 3a, 3b and 3c show, respectively, the stack of the raw record, the stack of the noise model generated by DSCAN in 35-375 Hz range, and the stack of the noise reduced records, for a different survey, a 2D shallow marine high resolution survey (Nyquist frequency=500Hz). The diffractors on this line were mostly broadside diffractors and are therefore undesirable for a 2D survey. These diffractions are so strong that they indeed leak into the stack as seen in Figure 3a. The stack of the noise attenuated records (Figure 3c) show that most of the diffracted energy is attenuated by our method. Remaining noise has lower frequency content (0-35Hz) and is due to its exclusion of this range for reflection protection during noise model building.

Discussions and Conclusions

We have presented an automated method for attenuating diffracted energy from shallow water inhomegeneities that are harmful to marine surveys. The method uses the double square root travel time equation and in essence is a migration/demigration type process except that it uses semblance instead of stacking amplitudes at constant depth (e.g. z_d=0) and applies signal processing methods to build the noise model instead of a demigration process. When diffractions are tangent to the reflections on the input record there is a possibility of damaging reflections. Having multiple cables per shot and building diffraction model from all the cables help discriminate between reflections and diffractions. Also ignoring broadside diffractors that arrive at the shot records at near offsets (as reflectors do) and using mutes and/or low cut filtered version of the data during model building help reduce this damage.

Acknowledgments

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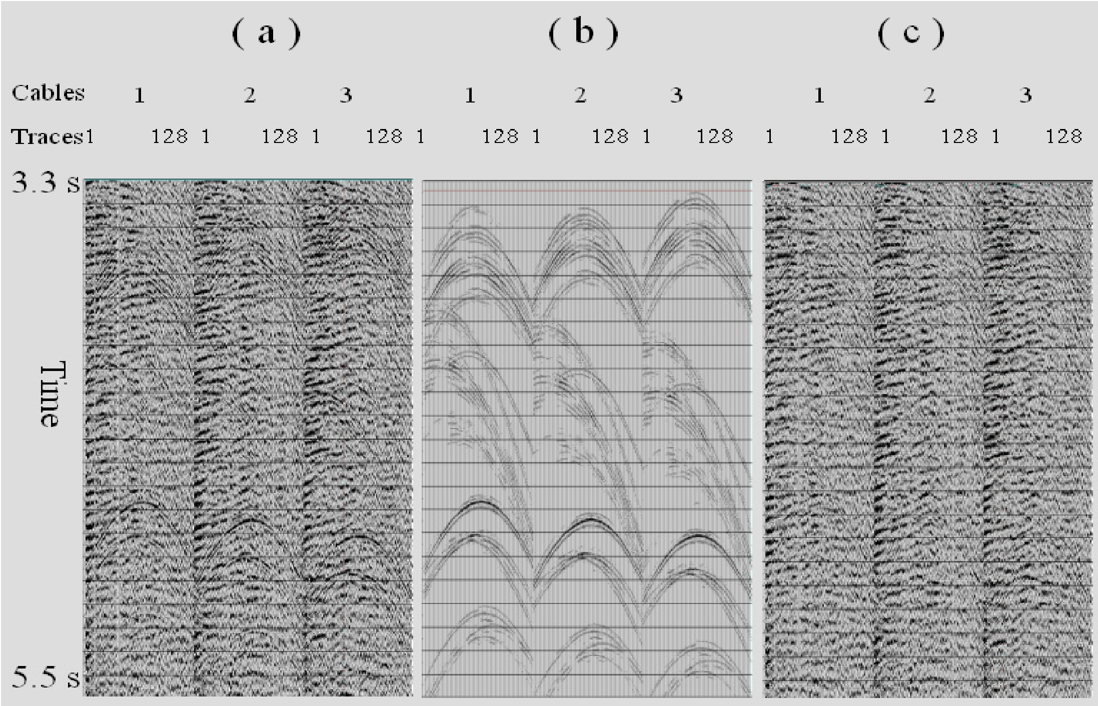

Figure 1. a) An input shot with three cables (each cable with 128 traces) contaminated with diffracted noise, b)- diffraction model built, and c)- shot after subtraction of noise model from the input.

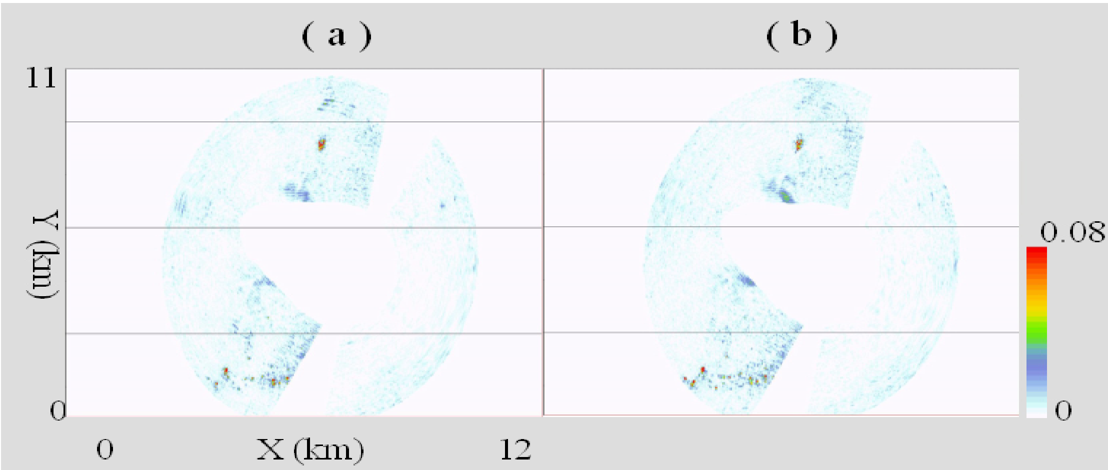

Figure 2. Diffractor semblance scans for two consecutive shots (a and b). Scan covers an area of 11 km by 12 km.

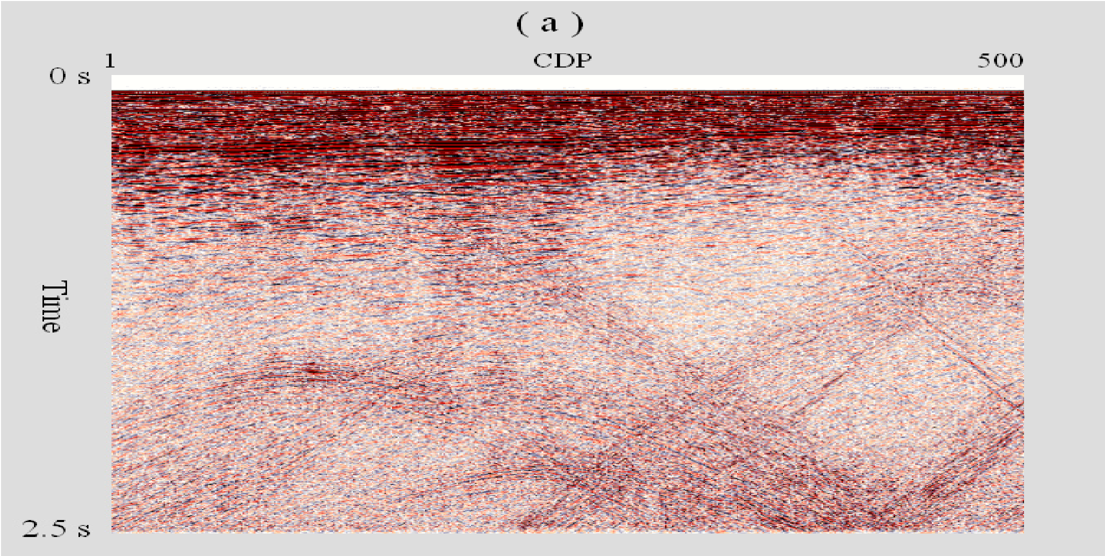

Figure 3a) Stack of raw shot records from a 2D line.

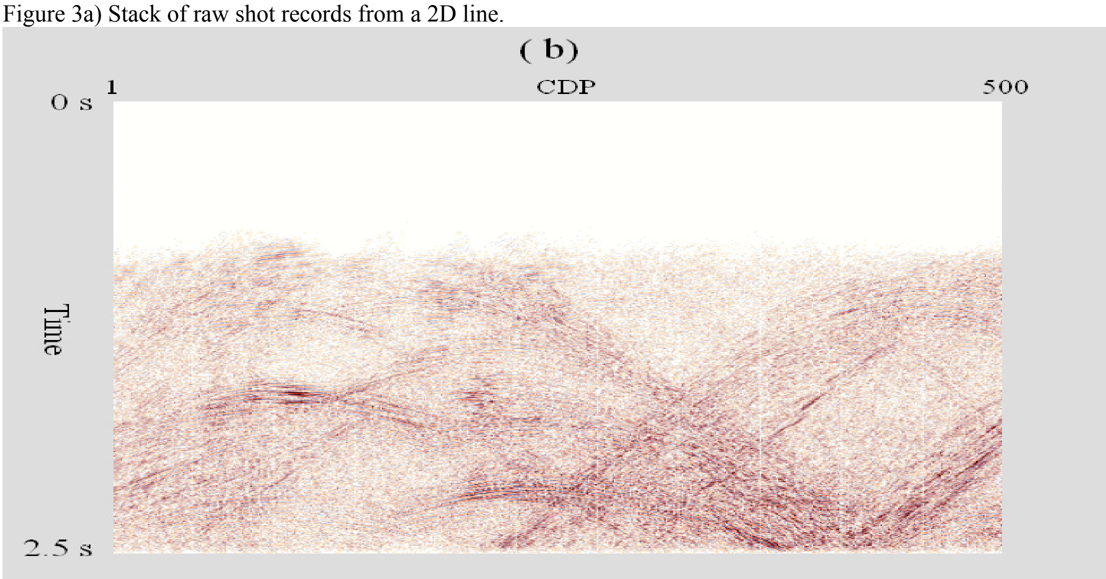

Figure 3b) Stack of noise model traces of the 2D line.

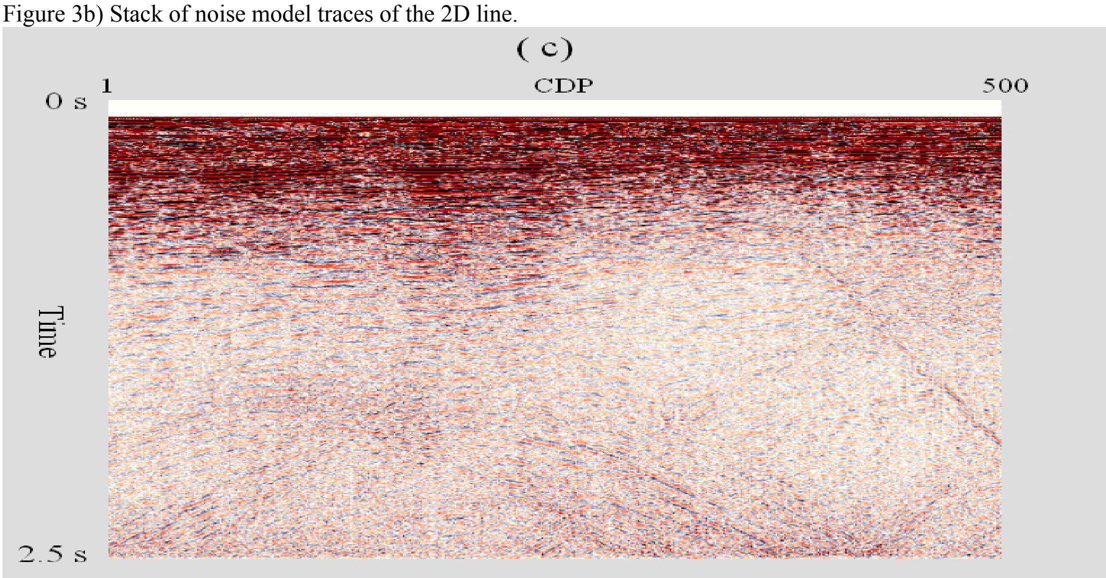

Figure 3c)-Stack of noise reduced shots of the 2D line.