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Near Surface Scattering Noise: General Characteristics

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Near Surface Seismic Scattering Noise: General Characteristics

Summary

Near surface scattering is a seismic event present in most onshore basins, mainly those with shallow high velocities rocks, as Paraná Basin. Knowing the characteristics of this type of noise is important to attenuate it with the least possible signal loss. In this research two characteristics will be investigated: a) the waves generated at a diffracting point in acoustic media, and b) the relationship between the velocities of the asymptotes in the shot domain and in the stacked section. It will be shown that four different waves emerge from the scattering point and that the velocity in the stacked data is twice as large as the velocity in the shot domain.

Introduction

Near surface scattering is a seismic event present in most onshore basins, and has very specific characteristics. Larner *et al* (1983) report some characteristics of this noise, such as the velocity in the shot, receiver and CMP domains, its almost hyperbolic and almost linear shape, and its cross shape, as well as its high amplitude in relation to the signal in the stacked data. It is important to have a detailed and deep understanding of noise to design attenuation filters with the least possible damage. Such analysis is also fundamental to assigning acquisition parameters.

Characteristics of near surface scattering noise

The seismic quality of land basins generally presents some loss in image quality due to the presence of near surface scattering noise. The basins where this loss is most significant are those with the presence of high velocity rocks and diffracting points in shallow depths. Larner *et a*l (1983) showed, using marine data, the laws of formation of this type of noise, and approaches to attenuate them. They also listed a series of characteristics that are extremely useful in its characterization, like:

- the cross shape in which it appears in seismograms and stacked data;
- the quasi-linear or quasi-hyperbolic shape of its transit time curve in shots, receivers, CMPs, and stacked data;
- their apparent velocities in shots as well as in CMPs, and
- the low signal to noise ratio in the stacked data, particularly for the deeper reflectors.

This last characteristic is directly associated with signal loss due to energy partition at the interfaces, which does not happen for noise. In this paper, two other features will be presented to further aid noise identification: velocities relation and waves generated by scattering points.

The relationship between asymptotes velocities in shot domain and stacked section

The transit time curve of the near surface scattering noise changes the shape when it moves from the seismogram to the stacked section. Therefore, their velocities are also different in each domain. In Larner *et al* (1983), velocities in shot and CMP domains was addressed. This work discusses the relationship between asymptote velocities in shot and stacked data domains.

Figure 1 shows a simple model, with only two layers and a diffracting point. In this figure, it also can be seen the synthetic data corresponding to this model (shot gather and stacked section). In these two images, two direct readings of the asymptote's approximate velocities of the respective transit time curves were made. It can be assumed, due to the approximations, that the asymptote velocity in the seismogram is twice the asymptote velocity in the stacked data. In the equations below, the analytical proof of this statement was developed:

$$\lim_{x\to\infty}\frac{dx}{dT} = ??, \text{ where } \mathrm{T}^2 = \mathrm{T}_0^2 + \left(\frac{\mathrm{x}}{\mathrm{v}}\right)^2, \text{ then } \lim_{\mathrm{x}\to\infty}\frac{\mathrm{dx}}{\mathrm{dT}} = \mathrm{v}$$

for the diffraction transit time in the shot. Here $\frac{dx}{dT}$ is the apparent velocity for large offsets; *x* is the offset, T the transit time, T_0 is the double vertical time from surface until the second layer, and v is the first layer velocity.

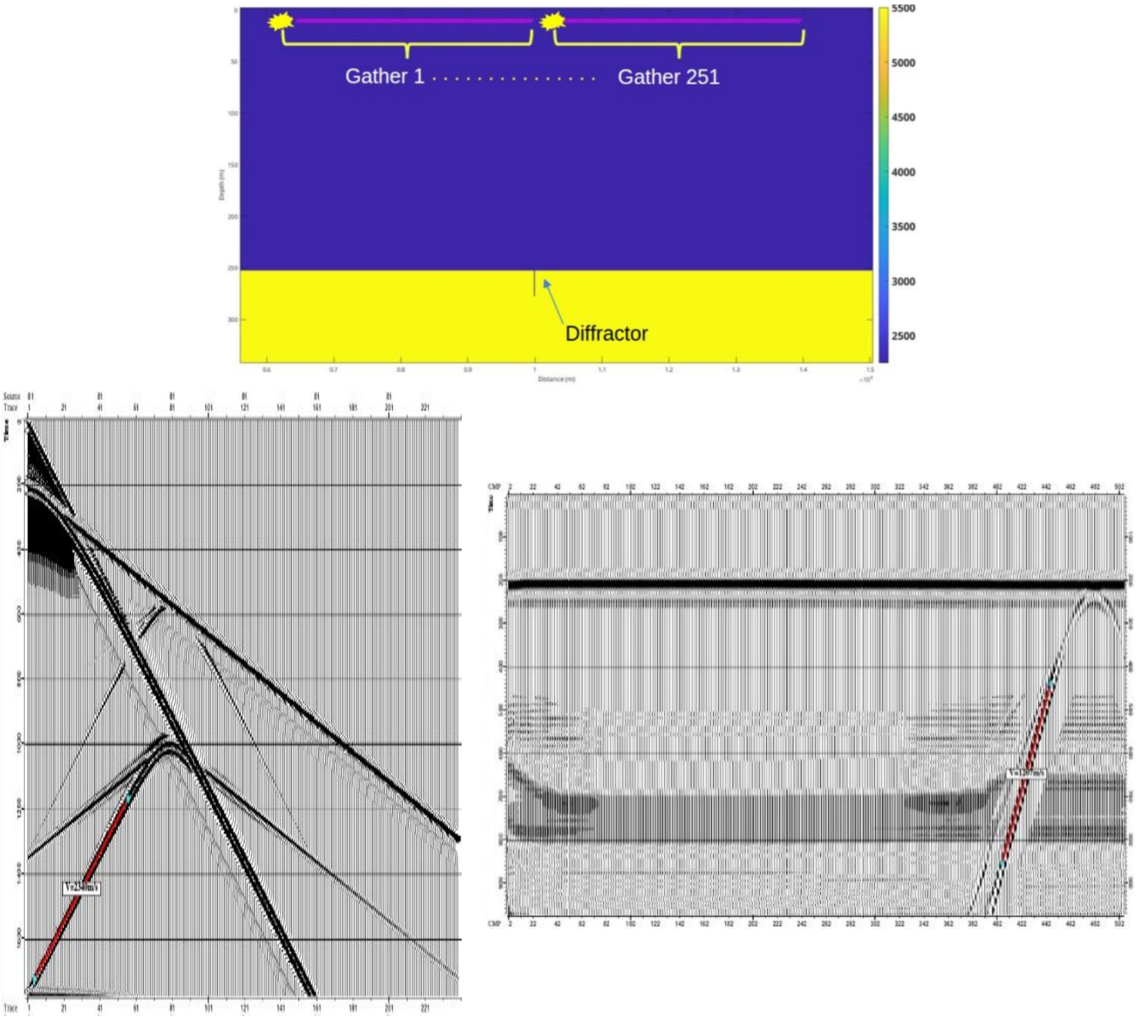

Figure 1: On top, geological model with two layers. The blue arrow indicates the diffraction point position. Bottom left shows a seismogram related with this model, and bottom right the final stacked section from all shots (seismograms). In red are apparent velocities for long distance, being 2340 m/s for the seismogram (left) and 1207 m/s for stacked section (right).

and,

$$\lim_{\mathrm{x}\to\infty}\frac{\mathrm{dx}}{\mathrm{dT_d}} = ??, \text{ where } \mathrm{T_d^2} = 2^2\left(\frac{\mathrm{x^2+h^2}}{\mathrm{v^2}}\right), \text{ then } \lim_{\mathrm{x}\to\infty}\frac{\mathrm{dx}}{\mathrm{dT_d}} = \frac{\mathrm{v}}{2}$$

for the diffraction transit time in the stacked data. Here $\frac{dx}{dT}$ is the apparent velocity for large offsets; x is the offset; T_d the transit time; h is the distance from surface until the second layer and v is the first layer velocity.

The waves generated at the diffracting point

Larner *et a*l (1983) showed two different waves emerging from the diffracting point, located at the interface of a model with only two layers. The first wave travels directly from the source to the diffracting point and scatters, while the second refracts at the interface and reaches the diffracting point, and then scatter.

However, two additional waves are generated at the diffracting point. To show this, the same model of Figure 1 will be used, with the velocity of bottom layer higher than velocity of upper layer. We call these waves W1, W2, W3 and W4.

Figure 2 shows these four waves in shot and CMP domains. The first wave (W1) goes directly from source to diffracting point, and then returns to receivers.

The second wave (W2) is generated from the same direct ray from source to the diffracting point, which when spreading generates the energy that travels at the interface between the layers, with the velocity of lower medium – so, it is a refraction.

The third wave (W3) is generated from the refracted ray that spreads at the diffracting point and returns directly to the geophones.

The fourth wave (W4) is generated by the refraction spread at the diffracting point, and that travels at the interface between the mediums with velocity of bottom medium – so, it is a refraction of a refraction.

The differences among these waves can be observed in amplitude and velocities. The amplitude of W1 is greater than W2, which in turn is greater than W3, and finally W3 being greater than W4. Reasons for this amplitude difference are being evaluated.

Another important feature is the differences between velocities in shot and CMP domains. In CMP domain, W1 (which has been analyzed by Larner *et al* (1983)), is the one that should stack better, as W2 and W4 are linear events, and W3 has negative velocity.

One important aspect is all analysis presented considered acoustic medium/propagation. An elastic analysis, being currently performed and to be shown at the Conference, would present shear and Rayleigh waves. As for the acoustic scenario, these waves would reach the diffracting point, generating two upgoing scattered waves: one traveling directly from diffracting point to receivers, and another traveling at the two layers interface, as a refracted wave.

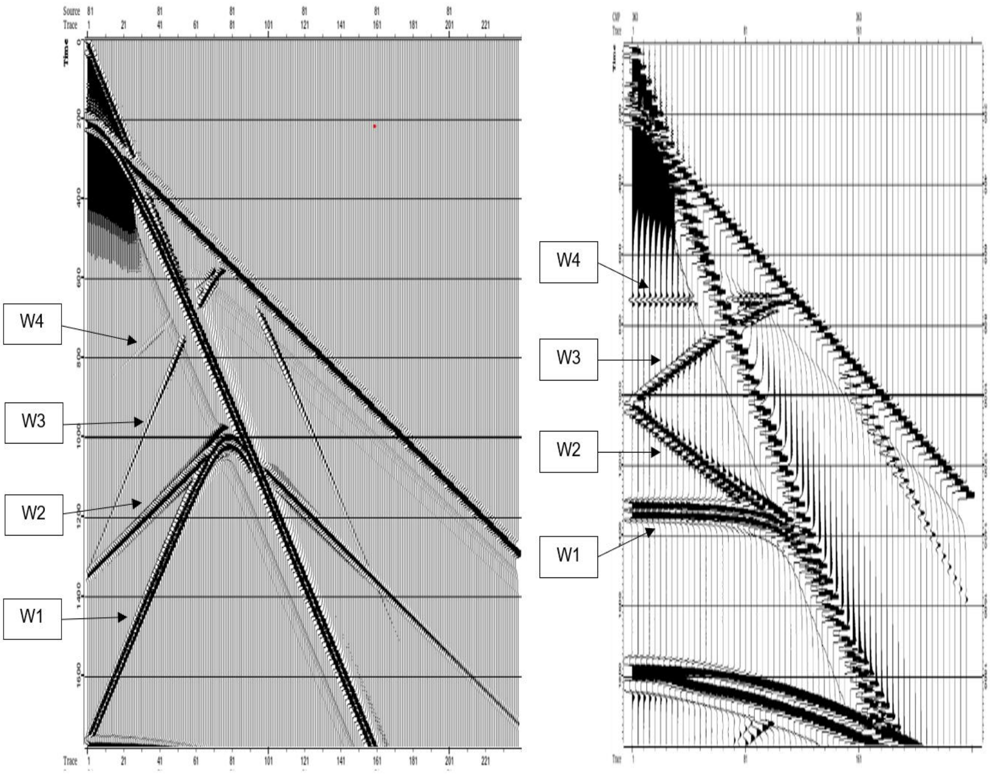

Figure 2: Shot (left) and CMP (right) gathers indicating four waves (W1 to W4) related to diffraction point at an interface. Black arrows indicate diffraction transit time.

Conclusions

In this research, several characteristics of near-surface scattering noise were presented. All of them are relevant to identifying this noise. This identification makes it possible to better adjust parameters for noise attenuation, as well as adjust field parameters during acquisition.

Two new features were introduced. The first showed that the apparent velocity at long offset in the shooting domain is twice the same velocity in the stacked data. And the second showed that, in an acoustic media, there are four different waves generated at a diffracting point.

Acknowledgments

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References

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