Debubble and Deghost application in a vintage seismic section in Rio Grande Cone - Pelotas Basin

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Abstract

New seismic processing technologies have been improving signal response and seismic imaging in vintage data, providing an opportunity to review the interpretation of the data, and hopefully to get additional information. This case study is part of an ongoing project, that encompasses the reprocessing of a 2D marine seismic line from Pelotas Basin (Southern Atlantic Margin - Brazil), acquired in 1990. So far, we applied some up-to-date seismic processing tools implemented to filter the source signature (bubble effect, ghost reflections), in order to observe possible seismic signal improvements. The applied workflow properly recovered the complex structural pattern observed in the vintage data, and improved noise attenuation.

Introduction

Seismic reprocessing is a low cost and fast option to search for additional information in seismic data already available. Indeed, the possibility to extract more information from vintage seismic data with advances in computational technology and in seismic processing algorithms have been already reported (Heinonen, 2013; Beccaletto, 2011; Bracatelli, 2021). This approach has been applied in order to squeeze all the information from the available data, and to define the need and the scope of new acquisition efforts, particularly in exploration frontier areas.

The Pelotas Basin is an untapped hydrocarbon province with already reported gas hydrate reserves in the Rio Grande Cone area, and with some potential active petroleum systems (Conti, 2017; Miller et al., 2015; Zalan, 2005). In this work we reprocessed a 2D marine seismic line from the public dataset of the Brazilian Petroleum Agency (ANP), acquired in 1990, in Pelotas Basin. It's a regional, 700 km long, dip line, roughly orthogonal to the coast (figure 1). The line runs from very shallow to ultra-deep water, imaging the whole Pelotas Basin shelf, the slope, and the distal Rio Grande Cone sedimentary wedge. The main objective of this work was to evaluate the application of new filter techniques to the source signature deconvolution of the vintage seismic data, in order to obtain better signal resolution and to improve the signal to noise ratio. As the Pelotas Basin is mostly covered with old 2D seismic programs, the tested algorithms could hopefully be useful for further exploration efforts in the basin. The results will be discussed with focus on the distal part of the line, in the Rio Grande Cone area (figure 1).

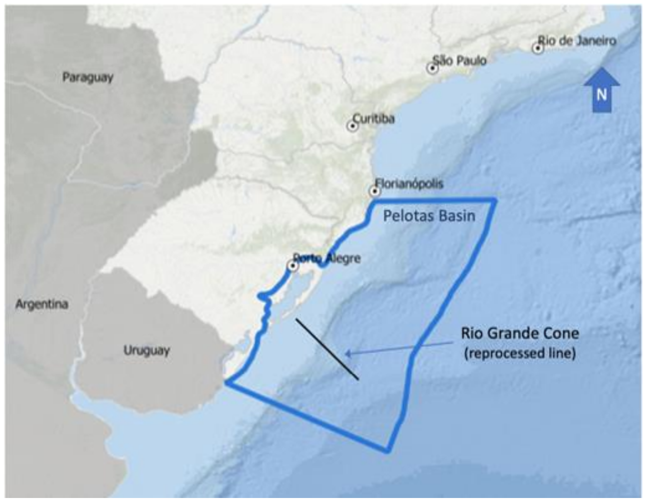

Figure 1- *Pelotas Basin.*

Geologic Setting

The Pelotas Basin is the southernmost offshore basin along the South Atlantic coast of Brazil, and it extends far to the South, along the coast of Uruguay. The Rio Grande Cone, where is located the part of the seismic line focused in this work, is a progradational sedimentary wedge generated by the fast inflow of fine sediments deposited in the distal domain of the Pelotas Basin, beyond the shelf edge and slope, from the Miocene to the Recent (Zalan, 2005; Bueno, 2004).

The Rio Grande Cone (figure 2) is characterized by active deformation, with proximal normal faults, and a distal fold and thrust system (López, 2014; Zalan, 2005). It also encompasses a world class gas hydrate accumulation, with a typical bottom simulating reflector - BSR (Miller et al., 2015).

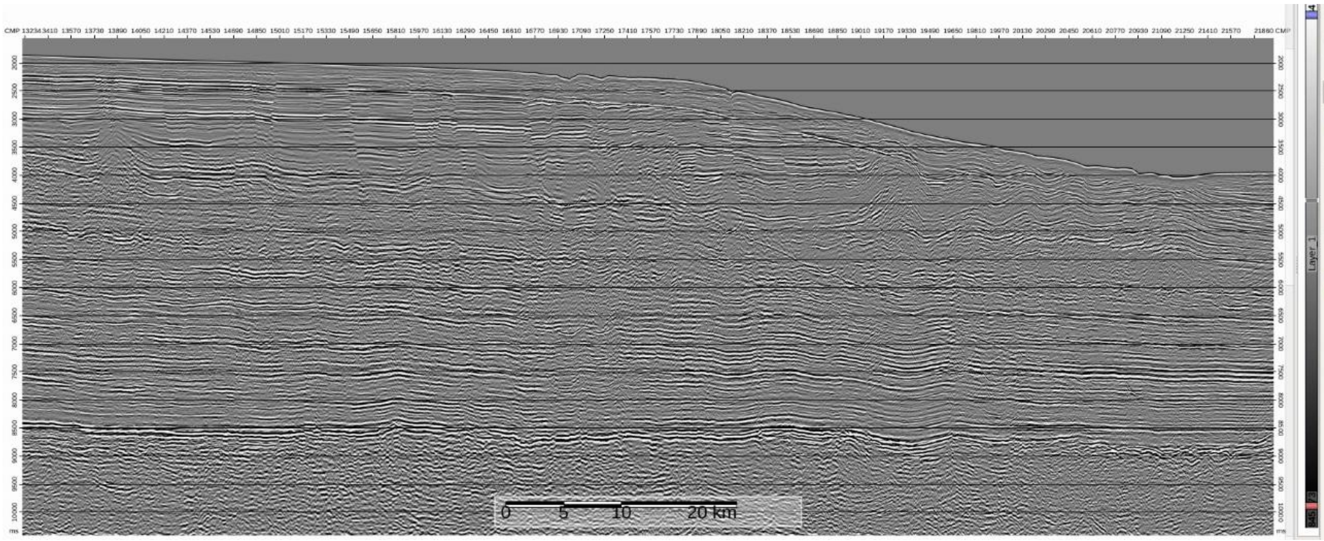

Figure 2 – *Dip seismic line reprocessed in the Rio Grande Cone área.*

Method

The vintage seismic data was reprocessed using the Echos package (the software and all the referred tools are property of Emerson Paradigm), following the workflow indicated in Figure 3. The SEGY input of the field data was followed by definition of the acquisition geometry using the UKOOA P1-90 coordinate file, and the metadata from the Observer Report file, as usual. Before quality control and trace edition procedures, it was applied a 0-2Hz Low-cut filter.

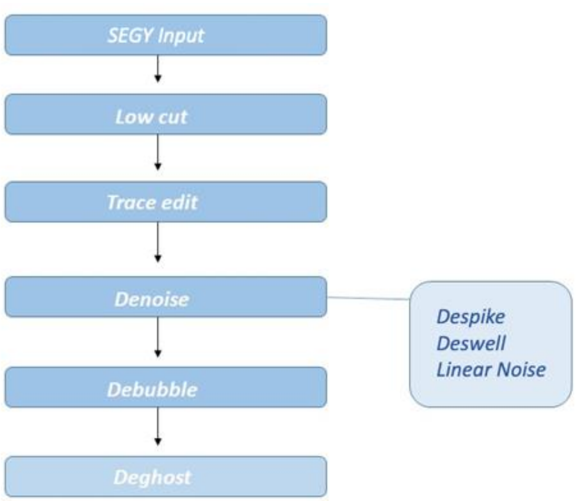

Figure 3 *– Seismic Processing workflow.*

The next step was noise attenuation. The tool REMSPK from the Despike tool kit was used to remove spikes, based on a threshold ratio of the median absolute amplitude in a moving time window. We then applied the tool AMPSCAL from the Deswell tool kit. AMPSCAL analyses across overlapping spatial and temporal windows, comparing the window amplitude with the amplitude of neighboring windows, in order to scale windows with remaining anomalous amplitudes. Finally, we applied an F-K filter to attenuate the linear noise observed on the F-K spectrum analysis.

As it's well known, the bubble oscillations of the air gun shots generate a characteristic reverberating noise in marine seismic data (bubble effect). To attenuate this noise, we applied a filter tool called Debubble. The main challenge of this step was the lack of a source Far-field Signature, which had to be estimated using near-trace information. The source wavelet was extracted from the sea-bottom reflector in traces corrected with NMO based on water velocity, and with autocorrelation statics (STATIC tool). We then computed a matching filter to deconvolve the bubble effect from the estimated source wavelet, and the filter was applied to the data.

In marine seismic data, source and receiver ghost events are related to short-delayed seismic energy that reverberates at the air-water surface, replicating primary events. Ghost secondary reflections overlap the primary wavefield, producing notches on the spectrum. We applied the Deghost tool kit to attenuate the ghost effect, by means of an inverse filter computed with a least squares algorithm that estimates source and receiver ghost times, and the reflection coefficients at the air-water interface.

So far, the data was stacked with an analytical velocity model, with constant velocities for the water layer and for the basement, with a linear gradient in between. The results will be analyzed comparing this preliminary stack with the vintage section. It's important to keep in mind that the results can be further improved with proper velocity modeling and seismic imaging.

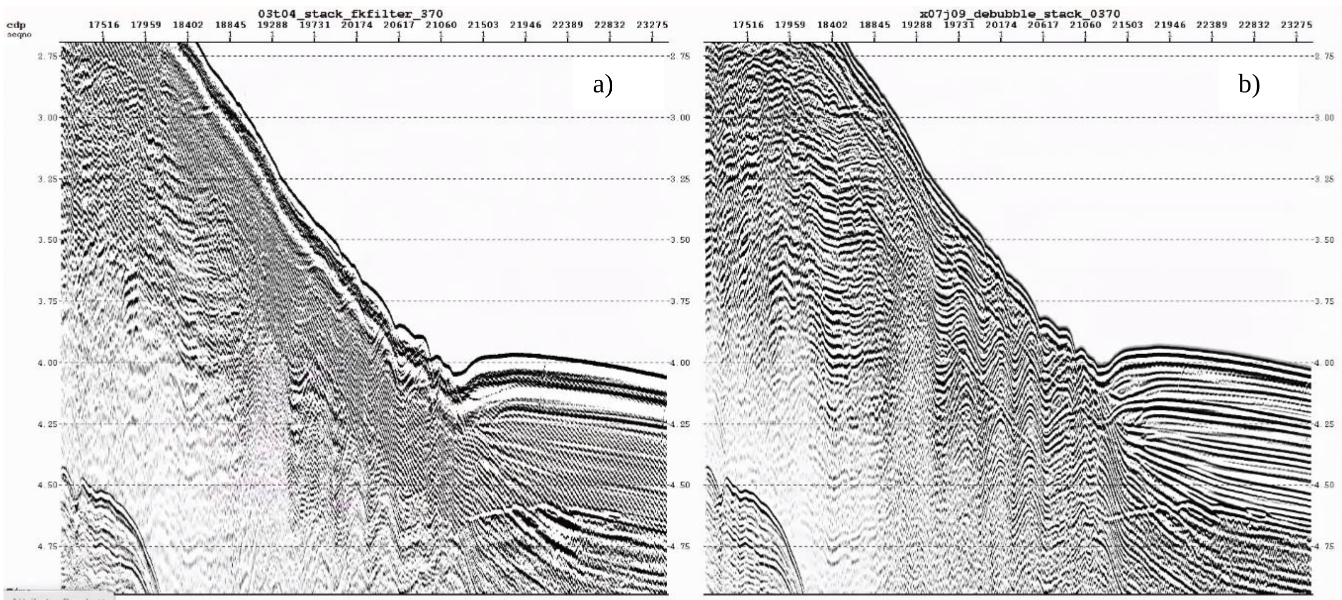

Figure 4 - *Comparison between FK filter output (a), and Debubble output (b).*

Results and Discussion

The filter used to attenuate the bubble effect from the source signature brought significant improvement to signal deconvolution. Observe in Figure 4 the brut stack before (Figure 4a), and after (Figure 4b) the application of the Debubble filter. The strong attenuation of the source signature noise allowed to get a better picture of the complex structural pattern, and of the reflector at the base of the gas hydrate layer (BSR) in the distal part of the Rio Grande Cone.

As a whole, the signal processing workflow applied in this work allowed to clean the primary wavefield response, improving the overall signal to noise ratio (Figure 5). The brut stack with a lower noise level obtained in the present work recovered properly the complex structural pattern of the Rio Grande Cone, with a distal fold and thrust belt (Figure 5a-b), a proximal normal fault system (Figure 5c-d), and the reflector at the base of the gas hydrate layer (BSR; Figure 5). Most of the improvement in the signal to noise ratio is credited to the updated algorithms used to deconvolve the source signature.

Conclusions

The application of a seismic reprocessing workflow with updated techniques for signal deconvolution allowed to improve noise attenuation in vintage seismic data from the Rio Grande Cone area in the Pelotas Basin. A reprocessed brut stack produced in this work recovered properly the complex geology of the area, with a better signal to noise ratio. Further improvements are expected with the use of updated workflows and algorithms for velocity modeling and seismic imaging. The preliminary results obtained in this work suggest that it’s possible to improve the quality of the vintage seismic data available in the Pelotas Basin by means of reprocessing with up-to-date algorithms, at least for the main exploration objectives at the Rio Grande Cone area. Further acquisition efforts in the area should be probably directed to fill the gaps of the existing 2D data, or to get 3D seismic data

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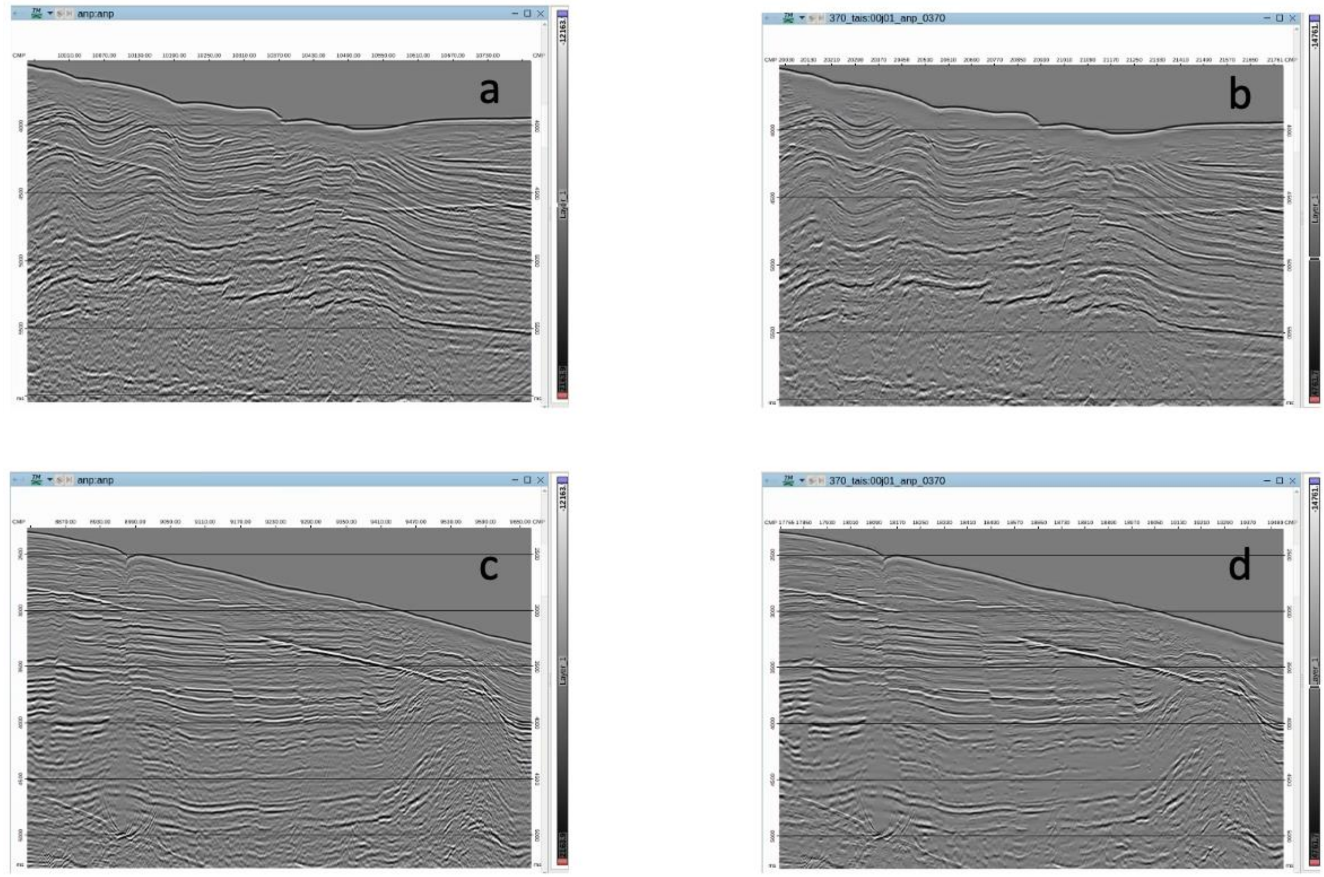

Figure 5 *- Comparison between the available final section (left; a-c) and the brut stack obtained in this work after signal processing (right; b-d). The reprocessed brut stack propely recoverd all the geologic information observed in the vintage final section, with a better noise attenuation. Further improvements can be obtained with updated velocity modeling and imaging techniques.*

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