Construction of velocity model from cokriging between wells and seismic

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Abstract

This paper presents the methodology used for the construction of the model of velocities in time through wells and seismic cokriging. A small portion was chosen with wells in the Foz do Amazonas Basin (Figure 1).

The following data were used for the construction of the velocity model in the Foz do Amazonas Basin: 7 horizons, two wells and one PSTM seismic.

Introduction

The main objective of this work is the construction of a model of velocities in time that accompanies in a more reliable way the geological structures present in the PSTM seismic for time-depth conversion. However, this methodology is restricted to geological models with little lateral velocity variation and moderate structural complexity.

Through the cokriging of the wells with the seismic it is possible to spread a property that accompanies the variation of amplitude, generating a model of velocities with a greater detail.

This paper will present the methodology used to construct the velocity model from the use of wells and seismic and the results presented through the time-depth conversion of the horizons and the seismic.

Method

Construction of the velocity model through well cokriging and seismic

The following methodology was used to construct the velocity model of the studied area:

a) The interval velocity property of the regional velocity model calibrated with the tables was transferred to the wells (Figures 2a).

B) An arithmetic average filter was used to smooth the amplitude of the PSTM seismic and to reduce the noises present (Figures 3a).

c) A stratigraphic grid was created with the horizons and the same size of the PSTM seismic. The **horizontal** resolution used was 100mx100m and the vertical resolution used was 25m (Figures 3b).

d) The interval velocity of the wells and the PSTM seismic were transferred to the stratigraphic grid.

e) Finally, an interval velocity in time expansion of the wells (primary variable) was carried out, starting from a cokriging with the seismic amplitude (secondary variable), using the following variogram configuration for the model created in the Foz do Amazonas Basin: Major axis: 30km, minor axis: 20km and vertical axis: 1km following the coastline and direction of the wells (Figure 4).

The key point of this methodology is the last step, in which the geostatistical method of cokrigation is used, which aims to improve the estimation of the sub-sampled primary variable (in this case the interval velocity of the wells) through correlation with the more densely sampled secondary variable (In this work represented by the amplitude of the PSTM seismic) and that has better continuity. Cokriging is considered a multivariate analysis of estimates (Yamamoto et. Al., 2013), in which the model is constructed with two or more variables in the same random field.

Results

It can be observed in the inline section presented, that the interval velocity model (Figure 5a) accompanies the impedance or amplitude contrast of the PSTM seismic (Figure 5c). This means that the higher the impedance or amplitude contrast, the greater the velocity value and, in the opposite case, the velocity value will be smaller, indicating a directly proportional relationship between velocity and amplitude.

The time-depth conversion by vertical radius of the PSTM seismic (Figures 5d) and the horizons (Figure 6b) using the velocity model created in the Foz do Amazonas and Espírito Santo Basin regions presented satisfactory results. The creation of artifacts in seismic was not observed and the horizons coherently followed the seismic reflections. The velocity model was also converted to depth through the vertical radius method (figure 5b) and the formation of very discrepant structures was not verified, since the model presents low structural complexity.

Conclusions

The methodology used to build the velocity model with well data and seismic data was effective, since the velocity followed the seismic in a cohesive way and the time-depth conversion by vertical radius of the seismic and the horizons did not generate new divergent structures. In addition, the cokriging between two variables can be applied to interpolate in a controlled way any property coming from well profiles such as density, porosity, Ip, Is, besides the velocity itself.

Acknowledgments

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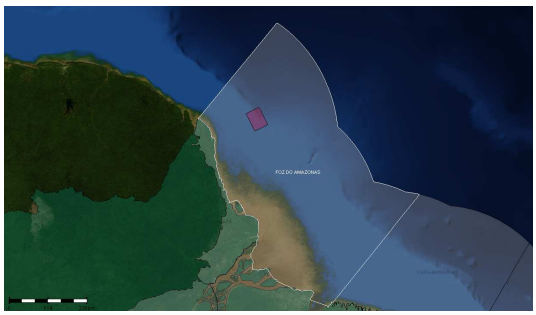

Figure 1: The purple rectangle represents the region of the Foz da Amazonas Basin where the velocity model was constructed.

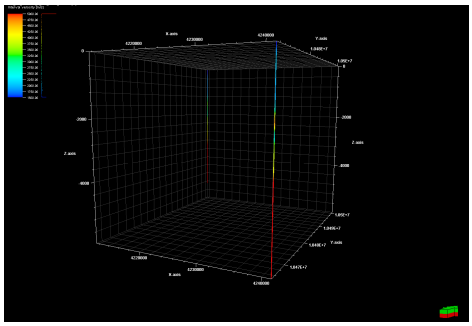

Figure 2: Interval velocity calibrated in the wells used in the velocity model area of the Foz do Amazonas Basin.

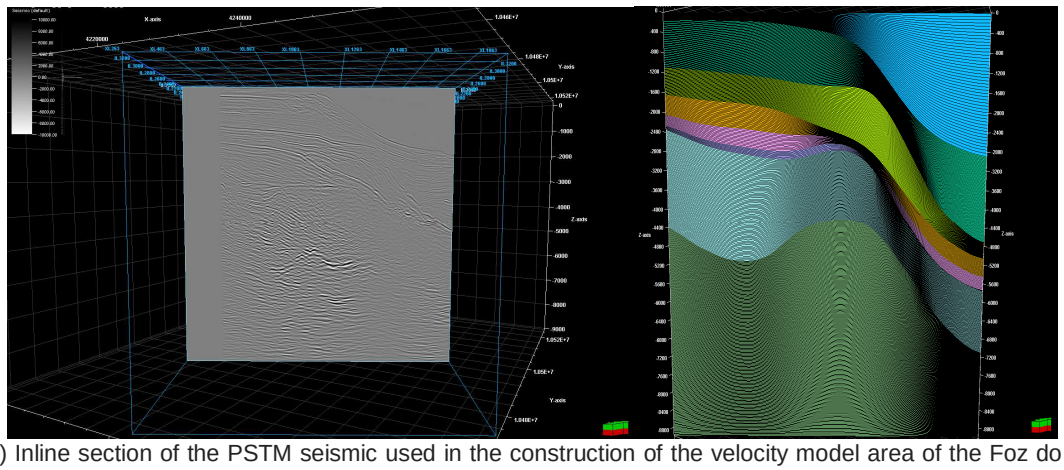

Figure 3: a) Inline section of the PSTM seismic used in the construction of the velocity model area of the Foz do Amazonas Basin. B) Stratigraphic grid used in the creation of the velocity model in the area of the Foz do Amazonas Basin.

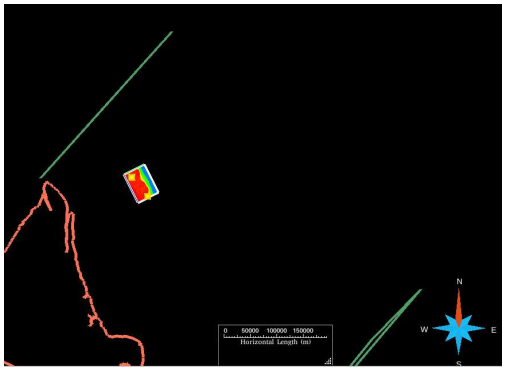

Figure 4: Region with the slice of the interval velocity model created from cokriging between wells and seismic and the two wells highlighted in yellow.

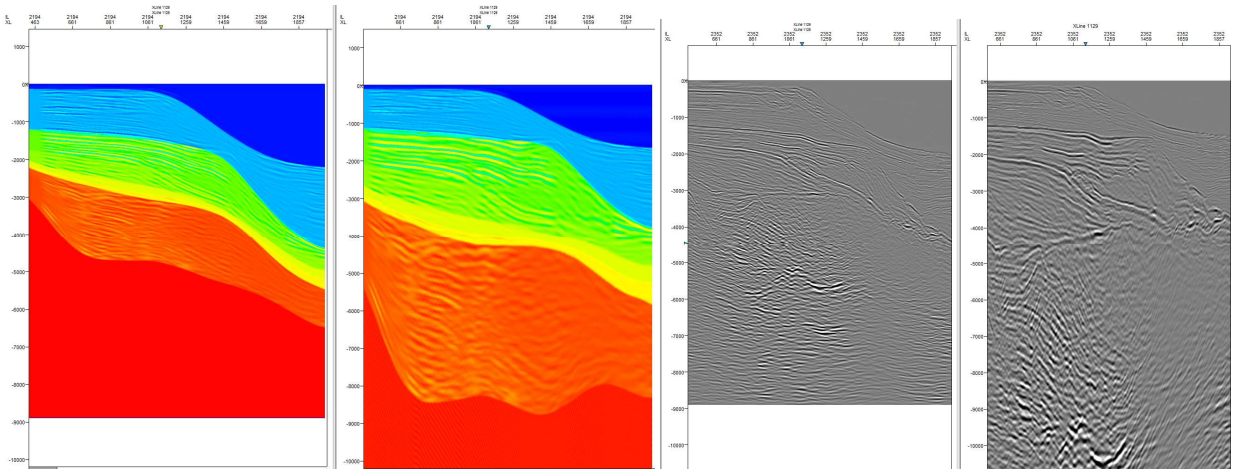

Figure 5: a) Time velocities model, created by cokriging the interval velocity of the wells with seismic in the region of the Foz do Amazonas Basin. B) Velocity model converted to depth by vertical radius c) Seismic PSTM in time. D) PSTM seismic converted to depth by vertical radius.

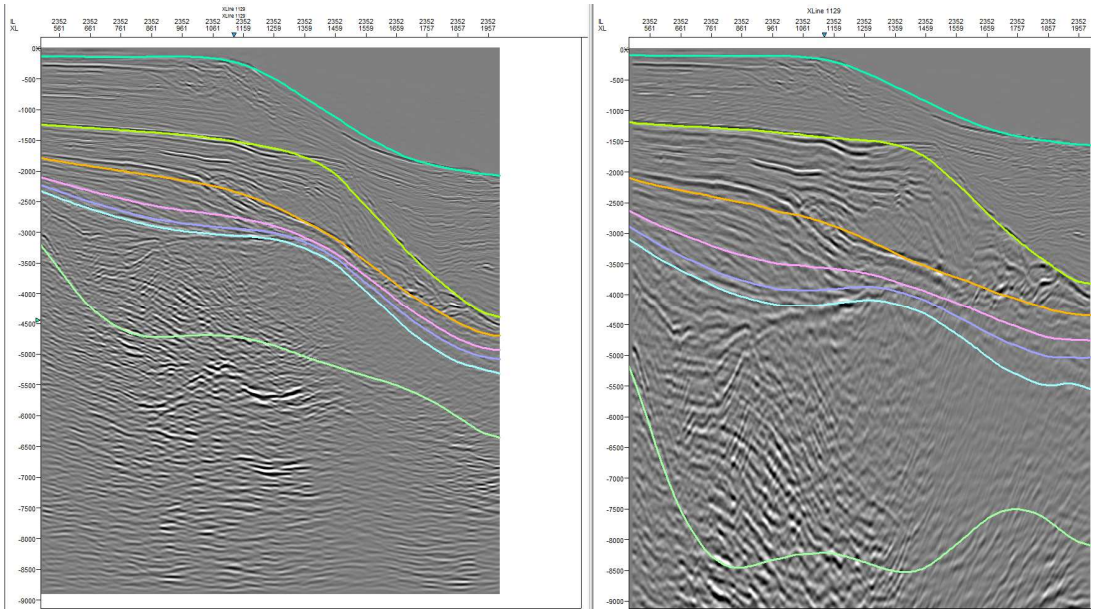

Figure 6: a) Horizons in time and b) horizons converted to depth by vertical radius with the velocity model created by cokriging the interval velocity of the wells with the seismic in the region of the Foz do Amazonas Basin.