Geological Velocity Approach in Order to Obtain a Detailed Velocity Model for the Evaporitic Section – Santos Basin

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Abstract

Several exploration areas in Santos Basin, Brazil, focusing the Pre-Salt Section lack a refined velocity model for migration purposes.

There are many different techniques to build better velocity models trying to fit as good as it is possible the needed geology for those models. These alternatives are to bring information from old processing efforts, include interpreted horizons, well information, etc.

In order to build an optimum velocity model for the migration process, in that case recommended to be the RTM (Reverse Time Migration) at least the recommended approach would be to use more than salt flooding, constant velocity or tomography. In our suggested technique, real geological information is needed in order to build this model.

In this work we present a way to build this velocity model using a legacy amplitude data to better find the portions of the data (using 3D analysis) to locate the places where we must have the velocity anomaly to allow for the best image construction.

The obtained results will allow us to migrate once again the data as well as to generate input data to perform uncertainty analysis regarding volumetric calculations, geomechanical studies, etc.

Introduction

After the expressive exploration results of the Pre-salt section in Santos Basin, Brazil, inside complex and deep geological environments special attention is given to seismic data in order to achieve the best information to support the reservoir studies.

The referred complex environment is a sum of several aspects related on salt-tectonics and high magnitude igneous intrusions and extrusions as described in Oreiro (2006).

The interval seismic velocity in these complex environments must reflect the geology in order to represent the vertical and horizontal event positioning

after any migration process, mainly for the PSDM migration.

Jardim *et al.* (2014), Maul *et al*. (2015), Meneguim *et al*. (2015) and Oliveira *et al.* (2015) have shown the importance in consider the stratification inside the salt-section as a key point for any velocity model purpose such as: time-depth conversion, uncertainty analysis, inversion studies, geomechanical analysis, illumination studies, migration processes. Jardim *et al.* (*op cit*) & Maul *et al*. (*op cit*) also emphasized the lack of the complex velocity model as the main cause of seismic image distortion. Therefore we assume the velocity model construction is a crucial step for all the mentioned purposes.

In this paper we will present the obtained results using this purposed methodology regarding the stratification incorporation inside the salt-section through the velocity model.

Method

The purposed method used in this work was first suggested by Maul & Falcão, 2014 (Petrobras Internal Information) when they intended to identify and also to quantify the difference between the forecast and the obtained results regarding depth forecast for the Pre-Salt reservoir in Santos Basin.

The mentioned authors verified the velocity models used for the salt section were: constant or not constant but with no geological criteria for the variation. They also observed the tomographic models (known as the improved ones) have the mentioned variation as purposed by the method itself but has only a good mathematical response. That mathematical response in average, concerning only the vertical response, is true for the migration process but it did not fit any geology.

Therefore they suggested a way to modify any interval velocity using the amplitude response as a mask and built the models with real positioning of the velocity variations (3D approach). To modify the velocity information was used the observed background obtained from well information such as the sonic information, the measured depth (MD) for each logged information and the top and the depth of the salt section as well as the cutting sample summary describing the geological observations during the drilling time.

Results

According to the sample cutting description (well site description) and the instantaneous velocity sonic analysis in this studied area was possible to discriminate several rock velocities inside the salt-section: halite, anhydrite, igneous rock and low velocity rocks (Figure1). Using this methodology would be possible also to compute the percentage of each studied rock per well (Figure 2).

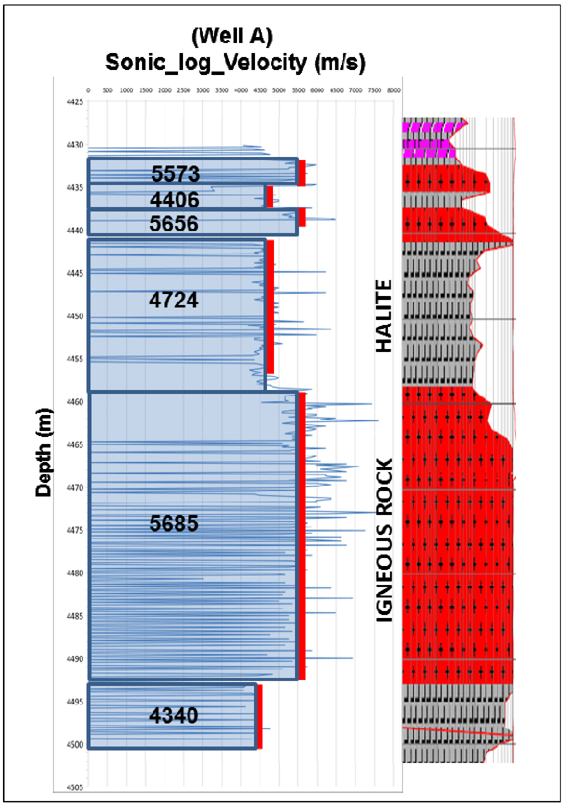

Figure 1: Sample cuttings description, sonic velocity information and the average interval velocity for each described rock.

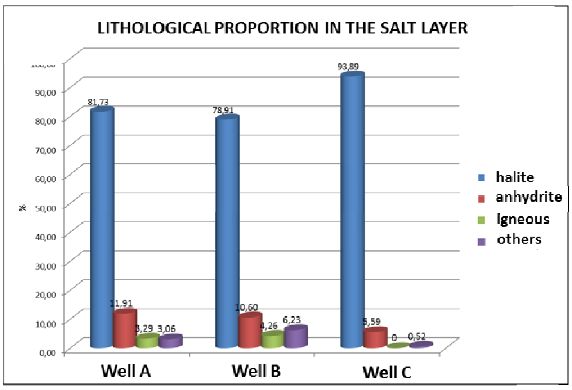

Figure 2: The percentage analysis for each studied well.

As per Bunting (2014) those heterogeneities inside the salt-section is not mandatory when building the velocity model for the migration process. Therefore this author defends the homogenous and/or smoothed velocity models for this use.

However, there are several methods such as RTM (Reverse Time Migration) or FWI (Full Waveform Inversion) that request interval velocity models with as much complexity as possible once these methods need to reflect the detailed geology through the velocity model.

The analyzed wells in this study indicated there is a high level of heterogeneity inside the salt-section and these could be caused by the salt stratification inside this section. As per Maul & Falcão (2014) method we used the amplitude response as a guide to discriminate these heterogeneities inside this section (Figure 3).

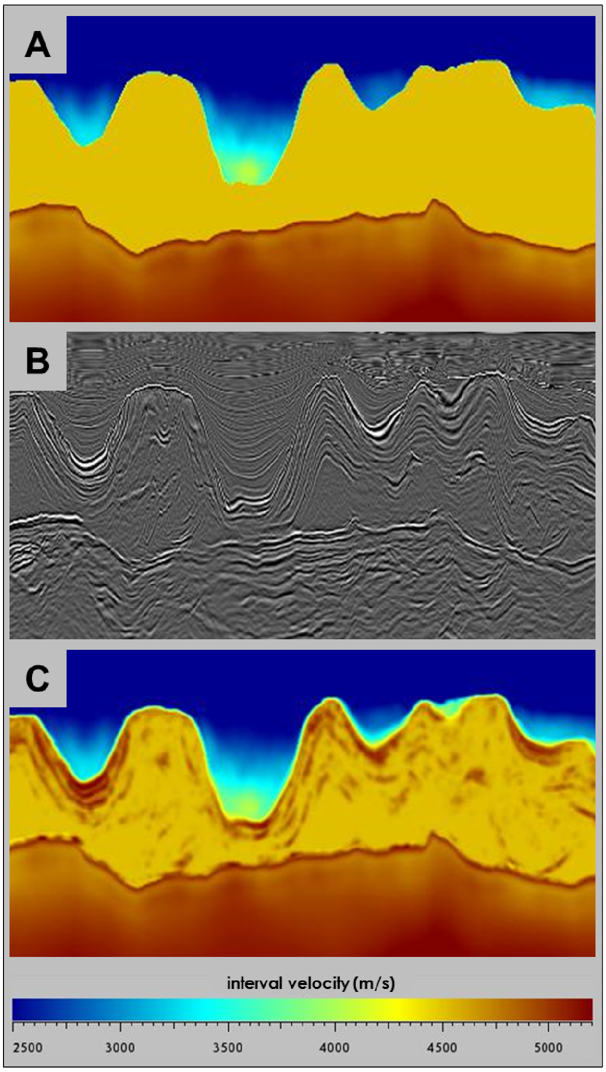

Figure 3: Results of velocity models for the studied area. A) The original velocity model obtained from the migration process; B) The amplitude response used to conditioning

the velocity modeling; and C) The modeled velocity using this purposed methodology.

Another important obtained result through this study was to couple the salt thickness map and the average interval velocity map for the same section. Thus it was possible to identify the mini-basins velocity response which is important for many purposes, such as when performing geomechanical analysis in order to prevent any incident regarding the risk of formation failure or salt creeping (Figure 4).

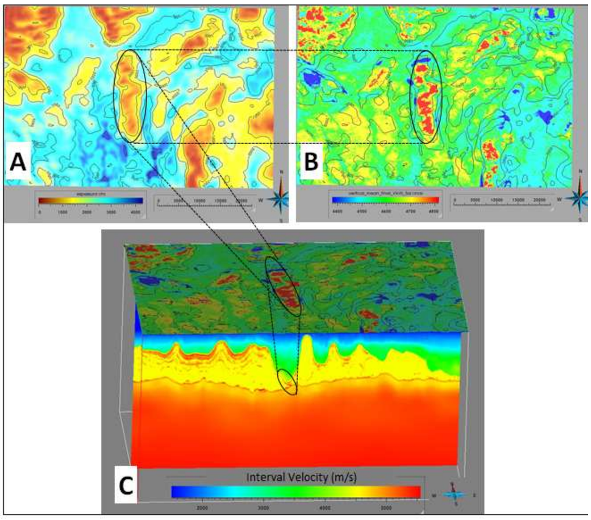

Figure 4: Inputs for geomechanical analysis: A) Thickness map for the salt section; B) Average interval velocity map for the salt section and C) 3D information view showing the coupling of thickness and the average interval velocity.

The result of the average interval velocities maps using both the original and modeled models showed that the average interval velocity was maintained within a certain observation window. It suggests that this velocity model would not cause positioning impacts in migration process (Figure 5).

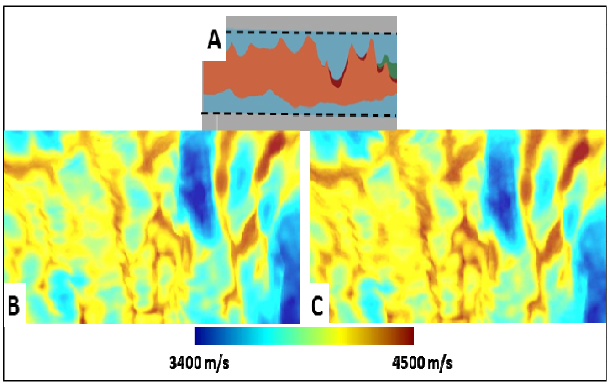

Figure 5: Input for migration process: A) Analyzed section; B) Original average interval velocity map for the section represented in "A" and C) Modeled average interval velocity map for the section represented in "A". It is important to emphasize the maps are almost equals as the main assumption suggests.

Conclusions

The use of amplitude information as a conditioning factor for any heterogeneity study regarding velocity modeling is still is a new research area.

The well analysis emphasized that the used velocity information inside the salt-section (constant) is under estimated as expected. However the analysis revealed that there are no reasons to be assuming a constant value for the mentioned section as we described several different rocks within it: halite, anhydrite, igneous rock, etc.

The positive high seismic reflections show good match with the anhydrite and/or igneous rock presence and could be used as the guide to map them. In the other hand the negative high seismic reflection could also indicate the portion where we could find low velocity rocks. However the negative values could be interpreted also as a lateral lobe of the positive amplitude response.

The interval velocity model using geological approach seems to be the best way to build models for many purposes such as uncertainty analysis, geomechanics, seismic reprocessing, inversion and illumination studies.

In general lines, the incorporation of geological features in the velocity models is a difficult task. The majority of the analyzed velocity models consider the evaporitic (salt) section as a homogenous layer.

Acknowledgments

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