SBGf28499

AVO Attribute Mapping: A Case Study

Ana Zélia N. de Barros, André L. Romanelli Rosa, Aristides P. Francês

PETROBRAS S/A, Brazil

ABSTRACT

Amplitude Versus Offset (AVO) attributes are well known hydrocarbon indicators. The importance of its application increases with advances in processing and a better understanding of the expected kind of play. AVO analysis on 3-D seismic data introduces more confidence on the process, resulting in a better understanding of the distribution of both the hydrocarbon and the reservoir distribution. This technique was successfully applied in an area with an oil-bearing sandstone reservoir. The seismic response at the target level, which is sometimes misleading in migrated sections, proved to be highly useful when analyzed in map form.

INTRODUCTION

AVO attributes are a well known kind of Direct Hydrocarbon Indicator (DHI). They are based on the fact that the introduction of hydrocarbon in a water saturated reservoir changes not only its acoustic impedance, but also its Poisson's ratio (Ostrander, 1984). Consequently, the behavior of the reflection coefficient and the corresponding amplitude are changed not only for normal incidence but also for incidence angles, or offsets, greater than zero.

Successful 2-D applications of the AVO technique have been widely reported in the geophysical literature. However, many other papers report important pitfalls, a great part of them related to inadequate migration of the seismic data. Other pitfalls are due to poor stacking velocity estimation, which leads to residual NMO. And, finally, an important reason for numerous unsuccessful applications of the technique is the excessive focalization of the analysis. It may be proven that, with proper treatment, 3-D data provide the means to reduce the importance of these pitfalls, bringing even more important economical benefits to the application of the technique.

METHODOLOGY

It is a well known fact that amplitude treatment is a key step in AVO analysis because only the relative amplitude variation related to the earth reflectivity must remain in the final data. In the technique used in this paper, the phase treatment is also important, because of the use of the elastic impedance concept (Rosa e Santos, 1999). Further improvement may be achieved with 3-D pre-stack migration even if just in its time version (Rosa and others, 1999).

At the end of the processing, at least three volumes of 3-D data are made available for the interpreter. These are: (1) near offset migrated stack; (2) far offset migrated stack; and (3) conventional migrated stack. The interpreter extracts amplitudes for one given horizon from the different volumes of data. This task results in maps that can be manipulated in order to generate different AVO attributes. This method insures proper extraction of the amplitudes, avoiding the need for residual NMO corrections. In terms of interpretation, it also provides the means for a more consistent areal analysis.

EXAMPLE

The example described in this paper was extracted from a 3-D survey recorded in Campos basin. One of the reservoirs in the area is a deep water system of sandstones, characterized by pinch-outs in different directions and partial truncation by an erosion (Figure 1). In the seismic data, the top of the reservoir is normally associated with an important negative amplitude, specially strong in the presence of hydrocarbon. However, in most of the area, the sandstone bodies are superposed by a limestone layer whose seismic response may interfere with the reflection at the top of the reservoir. As a consequence, it is not difficult to misinterpret the meaning of the amplitude anomalies.

The complex stratigraphic characteristics of the reservoirs in the area justified the acquisition of a large 3-D survey, just after the first discovery was made. Lately, after AVO has proven to be useful in the area, a careful data reprocessing of the data was carried out, with emphasis on amplitude and phase preservation. It is interesting to highlight the importance of the corrections for the source phase and geometrical spreading. Another important step was the application of trace integration, needed for the generation of relative elastic impedance data.

The interpretation of the final data lead to interesting results. In first place, the hydrocarbon bearing sandstone layer is better defined in the far offset volume, as compared to the near offset volume. There is a clear increase in absolute amplitude with offset, as opposed to the decrease in absolute amplitude at the surrounding events. As a consequence, the stacked volume has a greater contribution of the far offsets at the target level, as compared with the other levels. This behavior characterizes a class 3 AVO response (following Rutherford and Williams classification, 1989).

Another important result was the possibility of better understanding the reservoir distribution by using the AVO attribute maps. An example may be seen in Figure 2, which is the reproduction of the AVO Product map at the target level (Intercept times Gradient). The effect of the overlying limestone layer, an important problem in conventional amplitude maps, is almost unseen. The distribution of the hydrocarbon bearing sandstone is clearly visible (red to yellow in the figure), as compared with the areas with brine or shale. The wells drilled in the area validate these results.

CONCLUSIONS

Properly processed 3-D seismic data volumes increase the confidence on the results of AVO analysis. The most important benefit comes from the possibility of the generation of AVO attributes in map form, including the fluid effect (Smith and Gidlow, 1987). Another obvious benefit comes from the 3-D migration of the data. In the Campos basin example, a more reliable description of an oil-bearing sandstone was achieved, when compared with conventional 3-D interpretation. Value was added to the process by applying the elastic impedance concept.

REFERENCES

Ostrander, W. J., 1984, Plane-wave reflection coefficient coefficients for gas sands at nonnormal angles of incidence: Geophysics, v. 49, p. 1637-1648.

Rutherford, S.R., and Williams, R.H., 1989, Amplitude versus-offset variations in gas sands: Geophysics, v. 54, no. 6, p. 680-688.

Rosa, A. L. R., Cunha, C., Pedrosa, I., Panetta, J., Sinedino, S. and Braga, V., 1999: Two-pass 3-D pre-stack time migration: SBGF Meeting, Rio de Janeiro.

Rosa, A. L. R., Santos, P. R., and Campos, R. J., 1999, AVO analysis with the elastic impedance concept: SBGF Meeting, Rio de Janeiro.

Smith, G. C. and Gidlow, P. M., 1987, Weighted stacking for rock property estimation and detection of gas: Geophysical Prospecting, v. 35, p. 993-1014.

ACKNOWLEDGMENTS

We would like to thank PETROBRAS S.A. for permission to publish this work. We are also grateful to the colleagues who collaborated during the course of this work.

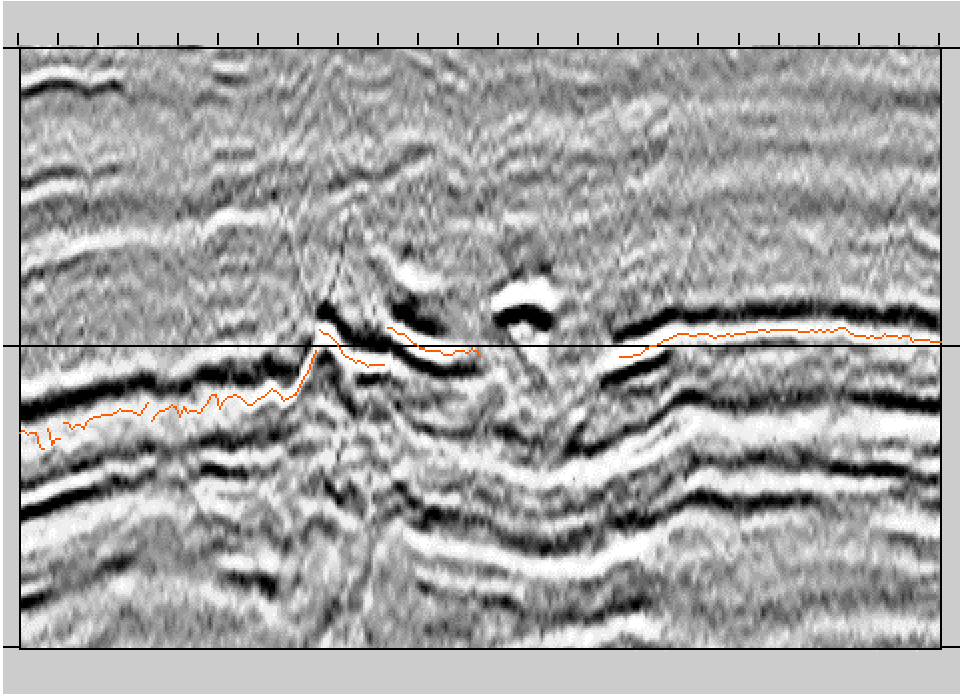

Figure 1 : Seismic section SW-NE in the central part of the map. The orange horizon corresponds to the reservoir level.

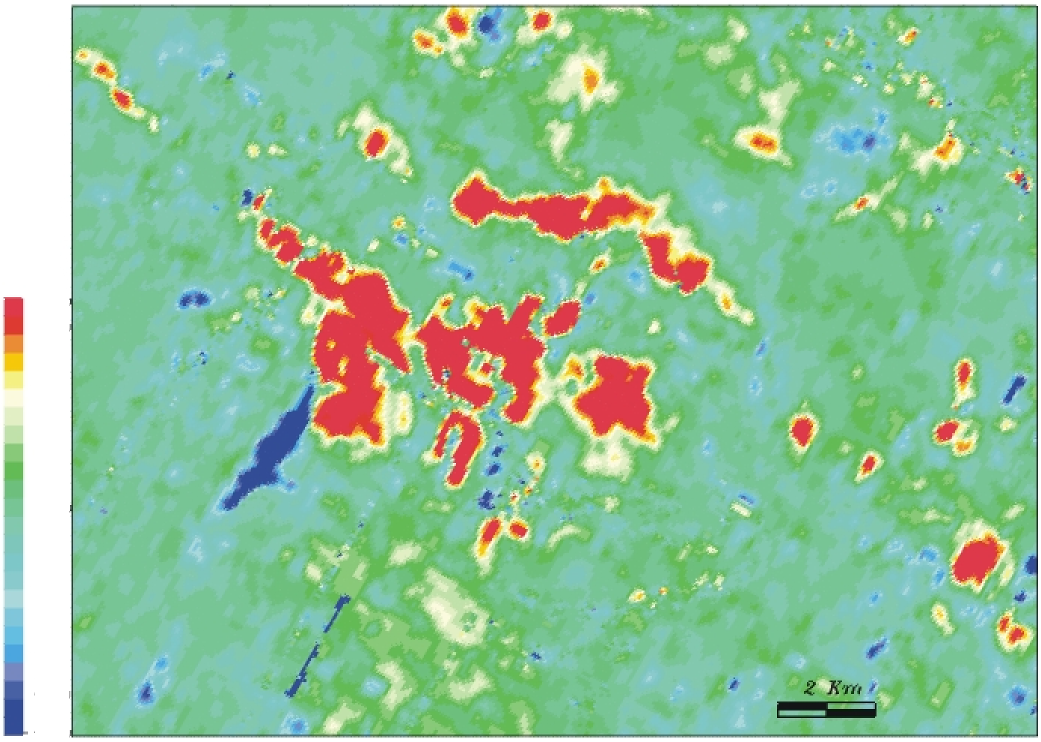

Figure 2: AVO Product map showing the distribution of the hydrocarbon reservoir.