New Processing and Seismic Interpretation for the Northern São Francisco Basin, Brazil

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Abstract

Aiming to investigate the stratigraphy in the northern São Francisco Basin, ANP (Agência Nacional de Petróleo) acquired eleven 2D seismic lines and drilled one stratigraphic well, 2-ANP-3-BA. However, despite the original seismic data suggested a region with deep basement, the 2-ANP-3-BA well sampled crystalline rocks at 840 meters, much shallower than expected.

After this inconsistency, ANP requested seismic reprocessing to PETROBRAS (Petróleo Brasileiro S.A.), in order to correct the seismic data and to clarify the reasons behind the mistakes in the original data. This way, we applied a new processing flow, including a model to reproduce the real conditions and to support testing of distinct hypotheses.

As a result, studies indicated that the false events were made up by S-waves, peg-legs and refraction reverberations. Furthermore, the new data permitted reinterpretation of seismic reflectors, updating the structural maps, and helped to understand the paleogeography and the limits of the Bambuí carbonate platform (Cryogenian to Upper Ediacaran) in this region.

Introduction

The São Francisco Basin is located in part of Minas Gerais (MG), Bahia (BA), Goiás (GO) and Tocantins (TO) states. This onshore basin consists of distinct tectono-sedimentary sequences that record a complex and long-term evolution (Martins-Neto et al., 2001; Zalán & Silva, 2007). The oldest one is a Paleo-Mesoproterozoic Rift Supersequence that comprises the Espinhaço and Araí groups. The Neoproterozoic Macaúbas and Paranoá groups (*Tonian-Cryogenian*) is composed by limestones, marine and aeolian sandstones, conglomerates and glacial diamictites. A third sequence (*Cryogenian-Ediacaran*) is composed by deposits that record the evolution of intracratonic synecIises related to the foreland stage; this sequence involves the Bambuí Group, which is composed by carbonates and shales. A Paleozoic sequence (Santa Fé Group) may occur in the southern portion of the basin. The upper unit is represented by Cretaceous sandstones (mainly the Urucuia Group).

From the first, original seismic data, it was interpreted a thick pack of sediment overlying a strong basement reflector around 700-1000 ms (Figure 2); this section was then correlated with the Bambuí Group. However, the drilled stratigraphic well found a relatively thin column (840 m) of Cretaceous sandstones (the Urucuia Group) on the Precambrian basement (Figure 3).

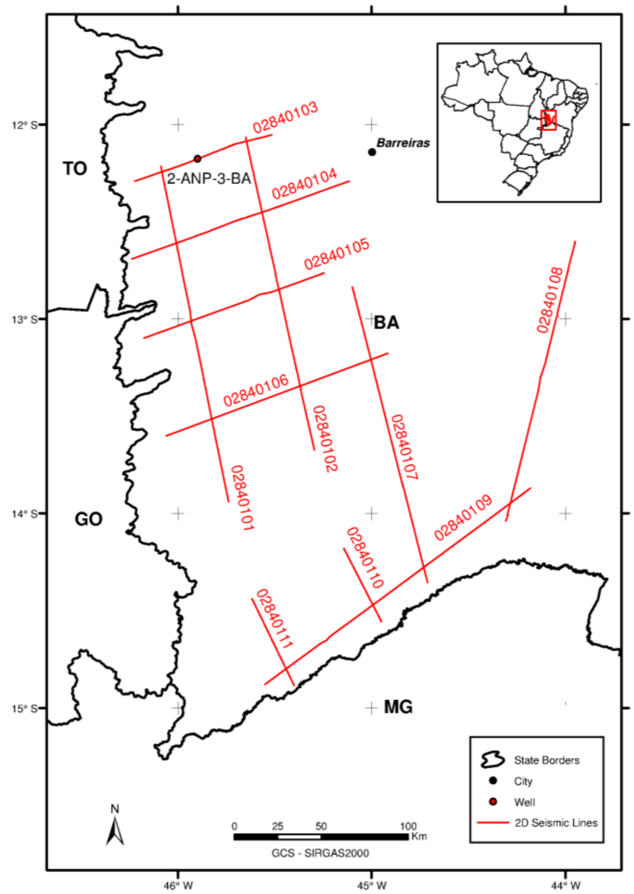

Figure 1. Localization of 2D seismic lines and the 2-ANP-3-BA well.

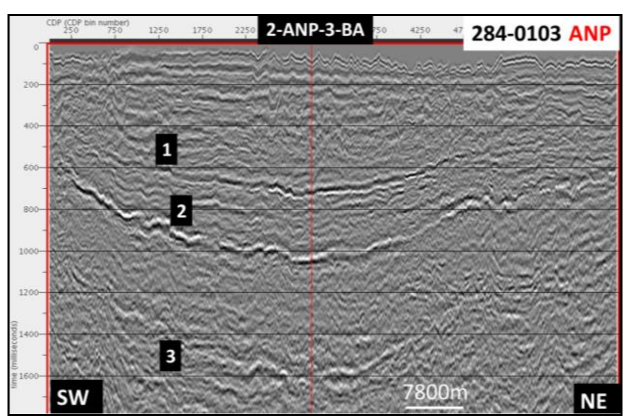

Figure 2. Original seismic data (ANP) showing three strong reflectors.

After that, following ANP requirement, a new processing flow was developed at Petrobras in order to investigate why those false reflectors have been stacked during original seismic processing.

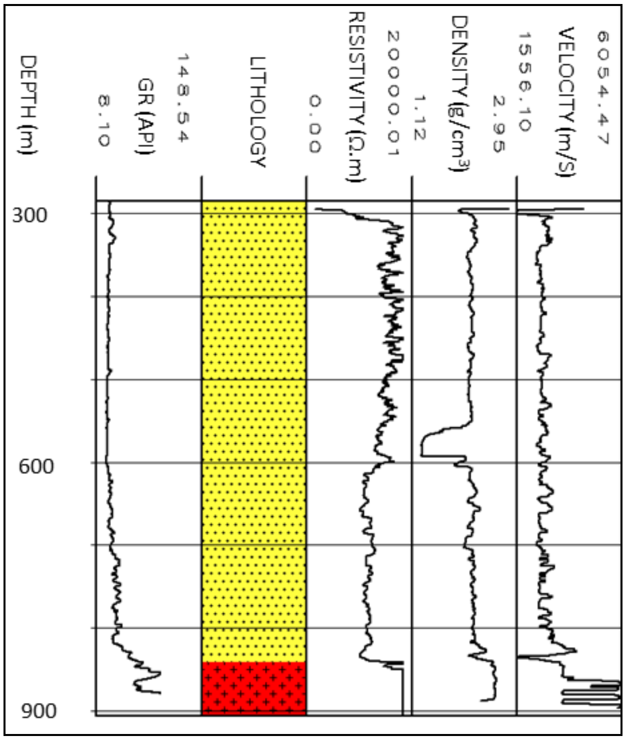

Figure 3. Results of 2-ANP-3-BA well: sandstone from the Urucuia Group (2671 m/s, standard deviation 183 m/s) above basement (6000 m/s; information comes from other well because the sonic tool in this well has a large standard deviation).

Method

Due to coherent noise present in the data, a number of seismic events with different velocities were stacked in several time positions, during the initial velocity analysis. As an example, Figure 4 shows results for applying a velocity of 2800 m/s to the whole 284-0103 line.

To understand these events, we performed an acoustic seismic modeling, calibrated with well information. As a result, the same characteristics were found between real and synthetic data (Figure 5). Notice in the synthetic data (red ellipse in Figure 5.3) that there are other possible velocities for stacking.

After modeling, the following hypotheses were tested:

(1) The first hypothesis assumed that the second and the third reflectors in Figure 2 represent an older stratigraphic sequence, and, in that case, it is expected that the velocity should increase as basin deeps. Nonetheless, in the velocity table provided by ANP for this seismic line, it is observed the opposite: there is a velocity inversion (Table 1). So, this hypothesis was rejected.

Time (ms)	Stack Velocity (m/s)
648	2426
724	2522
868	2353
1084	2156

Table 1. Inversion velocity for the reflector two, CMP 3000, next to the 2-ANP-3-BA well.

(2) The second hypothesis tested if the event could be a multiple primary related to the free surface, but it was also rejected because the second reflection (figure 2) does not have: reversed polarity, multiple period, and the same velocity as the primary reflection.

(3) Internal multiple was the third hypothesis, albeit the well sampled one quite homogenous bed, the sandstones of the Urucuia Group (Figure 3). Even so, it could be an internal multiple between the base of the Cretaceous layer and the base of the Low Velocity Zone (LVZ). However, it was rejected because the second reflector in Figure 2 does not display: reversed polarity, the expected period and similar velocity.

(4) The fourth hypothesis consists of a probable event stacking S-waves. In this case, its velocity would be slower than the velocity of P-wave and would represent just one event in Figure 6. However, it does not explain the sequence of events shown by the decreasing velocities trend (Figure 6).

(5) The fifth hypothesis deals with peg-legs, considering that the capture of energy occurs within the LVZ. Comparing the semblance panel of the real data (Figure 6) with the semblance panel of synthetic data (Figure 5.3), we observe a decreasing velocities trend. However, the very long period observed in the semblance panel in real data is not in agreement with the period inside the LVZ. We surmise that the process of building and destructing of peg-legs would be able to define only some reflectors in time and so this hypothesis remains valid.

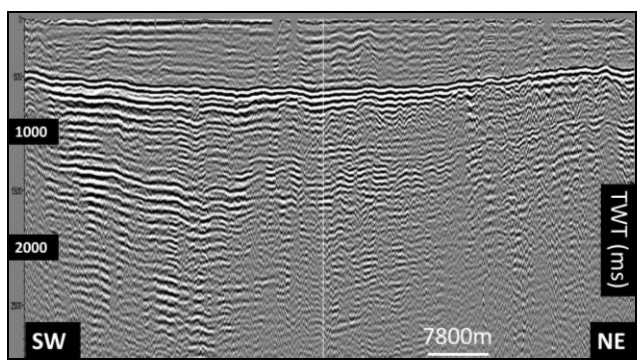

Figure 4. Stacked section using 2800m/s for velocity analysis in real data (284-0103 seismic line).

(6) Finally, the sixth hypothesis considers that there are stacking reverberations of refractions from the crystalline basement and the top of the Urucuia Group (see shot 8980, line 284-0103, in Figure 7).

In short, the analysis, processing and data modeling permitted to infer that the false reflectors (Figure

2) are a composition of S-waves, peg-legs and reverberations of refractions.

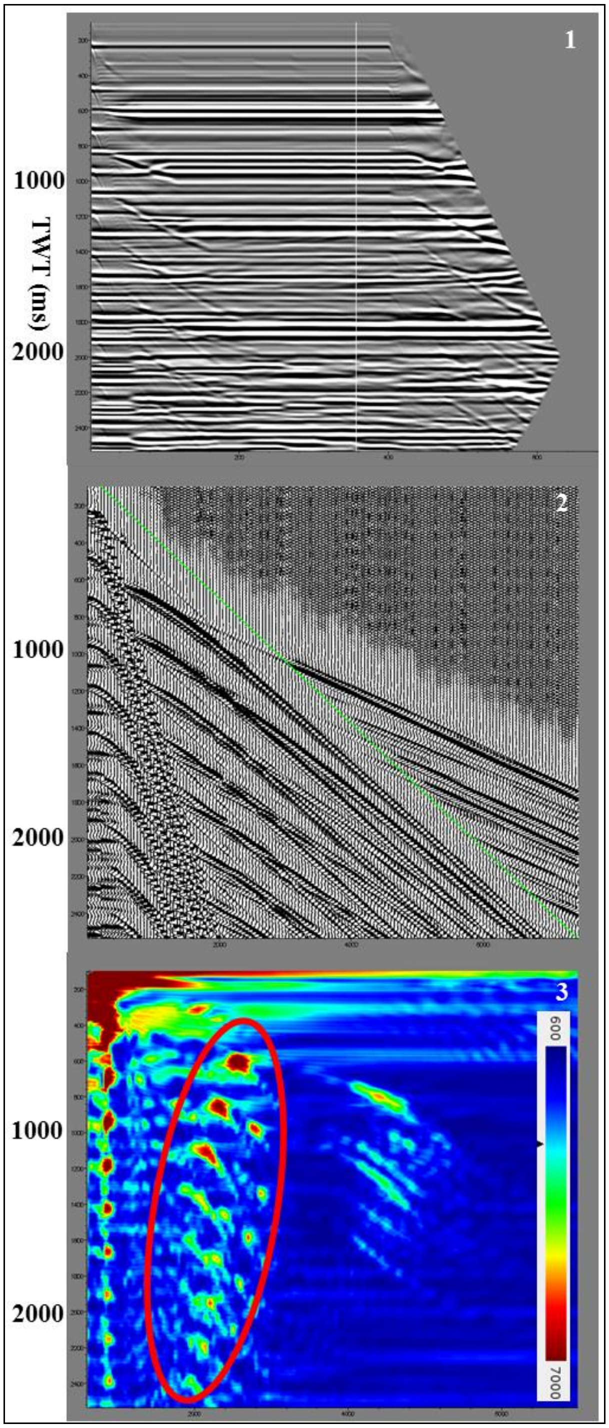

Figure 5. Velocity panel of modeling data, showing the stacked section with constant velocity of 2600 m/s (1), open CMP (2) and semblance (3).

Results and Conclusions

The application of a tailored, distinct processing flow and the interpretation of new migrated seismic lines permitted: (1) to update the data with well information; (2) to reprocess and produce a more reliable 2D seismic dataset (Figure 8); (3) to build maps of this portion of basin (Figure 9); (4) to improve the understanding of regional paleogeography; (5) and to better constrain the occurrence of the Bambuí carbonate platform (Cryogenian to Upper Ediacaran) in subsurface.

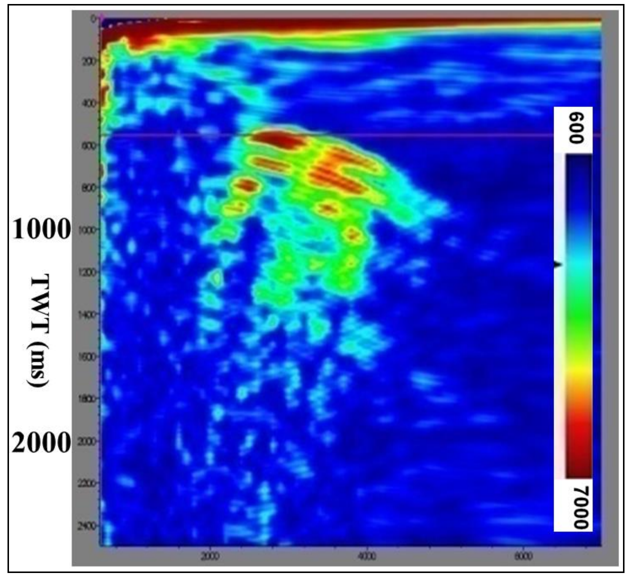

Figure 6. Semblance panel to the velocity analysis in real data. This panel uses a fixed velocity of 2800 m/s to stack the section in Figure 4.

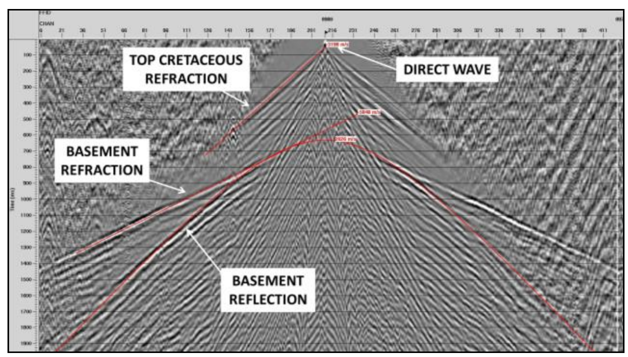

Figure 7. Shot 8980, line 284-0103. Notice major events: basement reflection, top of Cretaceous refraction, and basement refraction.

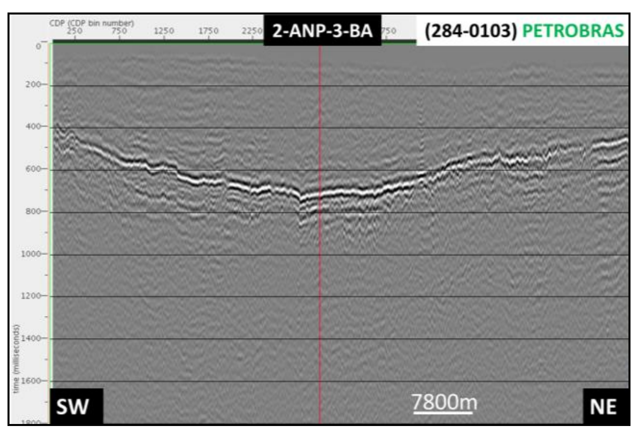

Figure 8. Stack section in time, ms, (284-0103), final data, after reprocessing PETROBRAS.

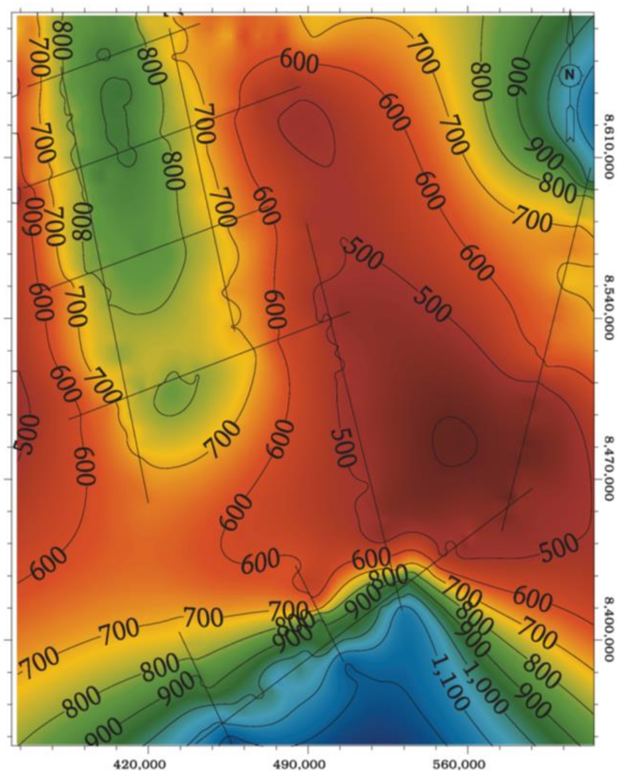

Figure 9. Time structural map of the basement, in milliseconds. UTM, 45°W, SIRGAS 2000.

Acknowledgments

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anp Agência Nacional do Petróleo

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