# Contributions of 4D data for Revitalizations Projects in Campos Basin: Marlim Field Case - Priority Area

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## Abstract

The Marlim Field is a massive oil field located in the Campos Basin. The discovery was made in 1985, and production began in 1991. After 30 years of activity, the field has reached a mature phase, making a revitalization project necessary to sustain and continue production. This undertaking includes platform upgrades and the drilling of new wells. Because mechanisms of recovery such as water injection can cause breakthrough, it is crucial to implement measures to control this, leading to the adoption of technologies such as 4D seismic as a tool for optimizing well positioning.

The Marlim Field has undergone two cycles of 4D seismic analysis (in 2005/1997 and 2010/1997) which yielded positive results in several cases (Oliveira et al. 2007). In order to support the field's revitalization project, a third cycle (2020/2010) was planned, with a focus on a priority area located in the southern part of the field. The analysis concentrated on four locations that were to be drilled in the project. The 4D survey was conducted in 2020 and was processed promptly, providing sufficient time to support the well drillings and adjust the locations to avoid areas with high water saturation values. This paper will detail the workflow used to achieve these recent results

## Introduction

The Marlim Field is located off the eastern coast of Brazil at water depths ranging from 600 to 1200m (see Figure 1). The reservoir is comprised of unconsolidated sandstone turbidite that is associated with the regressive mega sequence of the Brazilian eastern continental margin (Oliveira et al. 2007). The reservoir has an average porosity of 29% and an average permeability of 2350 mD. The oil gravity ranges from 18° to 24° API, while the viscosity in the reservoir is between 4 and 8 cp. The original pressure of the reservoir is 287 kgf/cm2, while the saturation pressure is 265 kgf/cm2. The field currently has 9 platforms, but these will be replaced by 2 new platforms as part of the revitalization project. Additionally, approximately 60 wells (producers/injectors) will be reused, and 14 new wells will be drilled.

During its production history, the Marlim Field has undergone multiple acquisitions, including 5-streamers and 1 OBC-Ocean Bottom Cable. These acquisitions have provided valuable 4D data from 1997, 2005, 2010, and 2020. This paper will specifically focus on the 2020/2010 surveys to visualize the most recent 4D events. The study will also make comparisons with the 2010/1997 datasets.

### Acquisition Characteristics

The new seismic acquisition of the Marlim Field covers a large area of the Campos Basin, which also includes the Voador and Albacora Fields (Figure 2). A priority area was selected to initiate the acquisition and processing, focusing on the first four well locations of the revitalization project. The survey parameters remained the same as the 2010 streamer, with an azimuth of 122o (Figure 3).

### Quality Controls

The NRMS map for the area covered in the 2020/2010 cycle shows good repeatability with dominant values ranging between 10-15, which is typical of high-quality streamers datasets (refer to Figure 4). However, certain regions show poor repeatability, mainly around the platforms. Fortunately, the NRMS map indicates that the four well locations selected for analysis are located in a good repeatability area, giving us confidence in the 4D analysis. To ensure data quality, we compared the old and new datasets with the injector well history. For instance, during the 2010/1997 cycle, we observed hardening around the I-1 injector well in the difference amplitude section (refer to Figure 5). However, in the new 2020-2010 survey, the hardening is observed farther away from the well (refer to Figure 6), indicating better fluid substitution and reservoir sweep progress.

### Interpretation Workflow

To integrate with geologic and simulation models, the stacked dataset was properly analyzed and quality controls were made. The 4D acoustic impedance was then performed, and the cube of impedance change was calculated to identify anomalies. Time-depth conversion was carried out, and adjustments were made to the simulation model grid to incorporate the impedance changes (Figure 7). This step facilitated interpretation with other properties such as water saturation and helped ensure that the asset team had a unified perspective.

### Impacts on Revitalization Project

Figure 8 depicts the acoustic impedance change map from the 2010/1997 cycle, where hardening anomalies are marked in blue, and the producers' well locations are defined. According to this map, the P27, P25, P8, and S6 locations are in favorable positions. However, after analyzing the map for the 2020/2010 cycle (Figure 9), it was observed that P27 and P25 were located in an area of significant hardening, indicating high water saturation. On the other hand, P8 and S2 were still in good positions. After discussions with the asset team, the locations were adjusted for better positioning (Figure 9). These observations were also evident in the section grid of acoustic impedance change. The P8 well location was found to be suitable in both 4D surveys analyzed (2010/1997 and 2020/2010) (Figure 10). The S6 well location showed a minor hardening anomaly at the bottom of the reservoir in both 4D cycles (Figure 11). A look at the section grid for P27 well location revealed that it was properly situated in the old 4D cycle (2010/1997) (Figure 12). However, the new 4D cycle (2020/2010) showed a hardening anomaly covering almost the entire reservoir, indicating that it was completely flooded. When compared with the water saturation property from the simulation model, the 4D data presented a more pessimistic scenario (Figure 13), resulting in a decision to move to a new location (see Figure 8). Along the P25 section grid of acoustic impedance change in 4D (2010/1997), the well location was appropriate. However, upon analyzing the new time-lapse (2020/2010) (Figure 14), it was observed that there was a high probability of crossing zones with high water saturation at the beginning and end of the well trajectory (Figure 14). Therefore, the well location was moved, and the trajectory was rotated to avoid hardening anomalies, as in the case of P27.

### Conclusions

New 4D data covers close to 50% of Marlim Field. The data has a good repeatability and confident results. Data interpretation shows portions of hardening in two locations and have showed changes in positions were performed. Despite the short time available to processing and data interpretation, was possible give important contributions on decisions of revitalization project. The studies will continue with elastic properties evaluations, time-shifts/time-strains analysis in the full area.

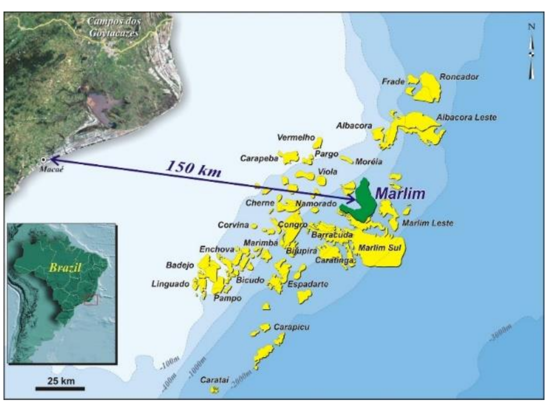


Figure 1- Location Map of Marlim Field.

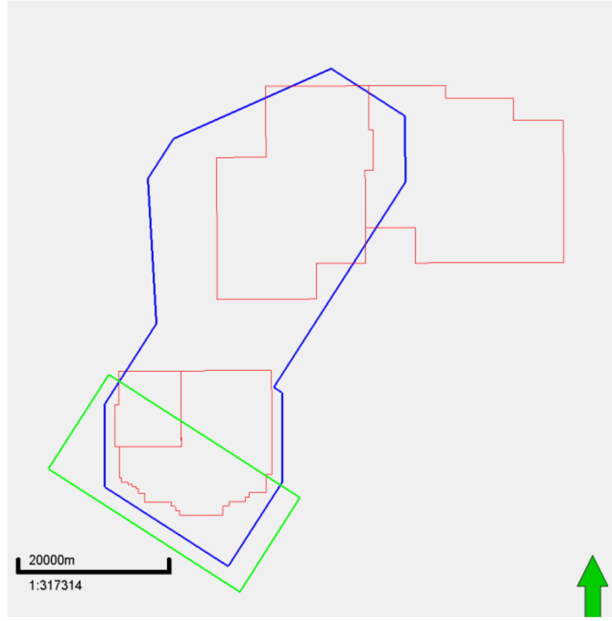


Figure 2: Polygonal of Marlim, Voador e Albacora Fields - red ones, with boundaries of new acquisition (blue) and priority area (green).

| Parameters | 122,7° | |
|---|---|---|
| Area | South area | North area |
| Fields | MRL + VD | AB + Forno |
| target | 4D | 3D |
| # cables | 12 | |
| # cables Pre-plot | 9 | 12 |
| ILT | 225 m | 300 m |
| IPT | 18,75 m | |
| Cables strength | 6000 m / 3200 m | 8000 m |
| Cable depth * | 7 m | |
| Source depth | 6 m | |
| Source geometry | Dual source | |
| Recording time | 7,0 s | |

Figure 3- Survey parameters from 2020 acquisition.

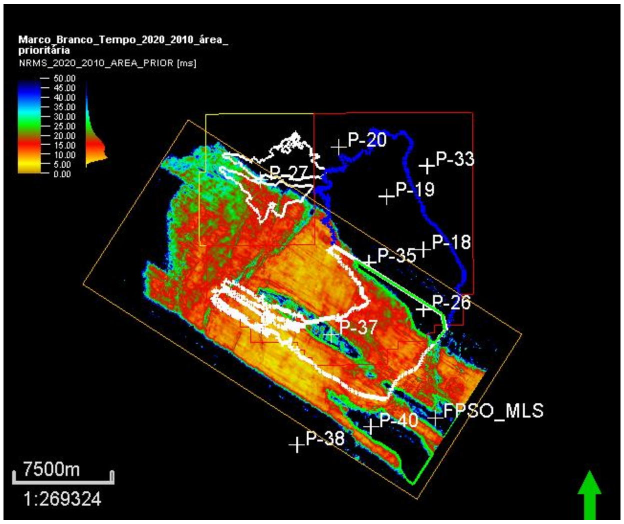


Figure 4-NRMS map of new 4D dataset (2020/2010) in the priority area, showing good quality of the data e area of bad repeatability due to platforms.

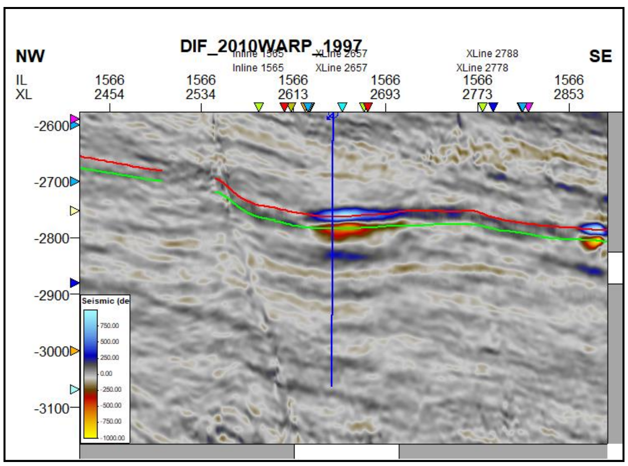


Figure 5- Amplitude difference section of 2010/1997 in the well I-1, showing the hardening effect in the well position.

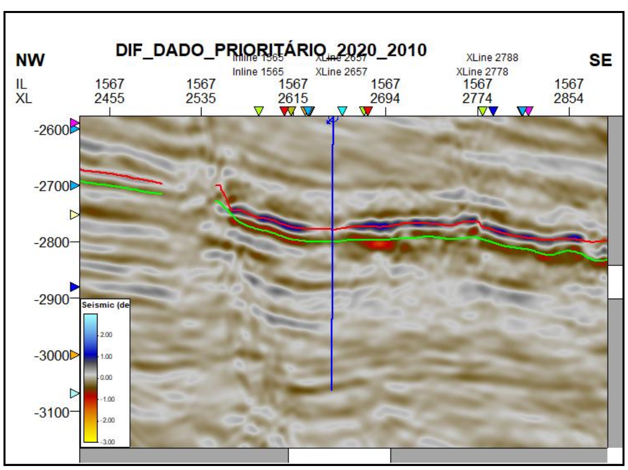


Figure 6- Amplitude difference section of 2020/2010 in the well I-1, showing the hardening effect away from the well.

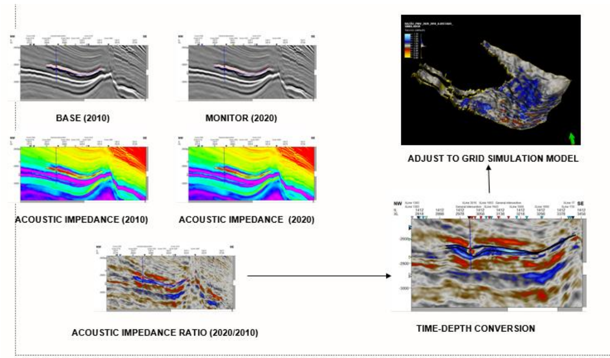


Figure 7- Interpretation workflow to adjust the 4D dataset to integration analysis.

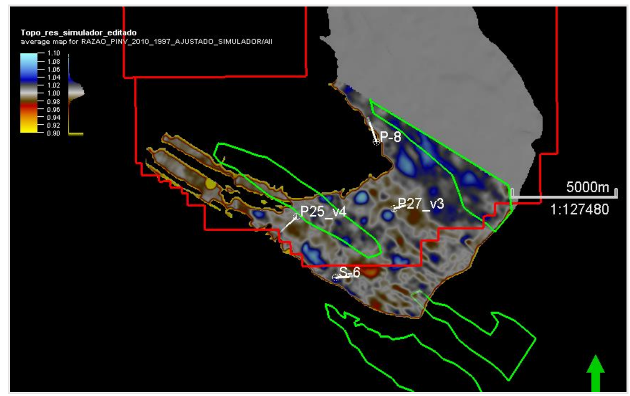


Figure 8- Hardening anomalies map (>1) from 2010/1997 survey with well locations (white color).

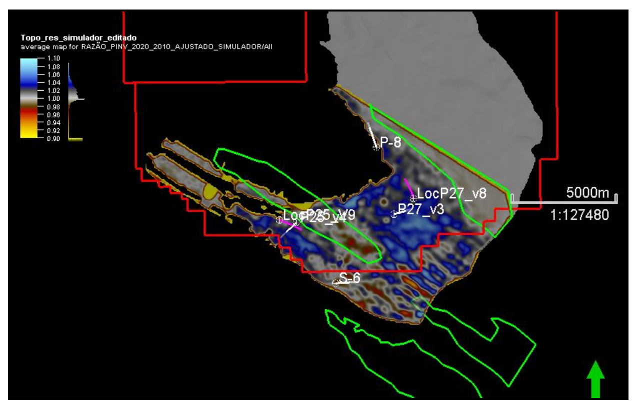


Figure 9- Hardening anomalies map (>1) from 2020/2010 survey with P8 and S6 well locations still in a good positioning, but P25 and P27 have been moved due to be in hardening anomaly area.

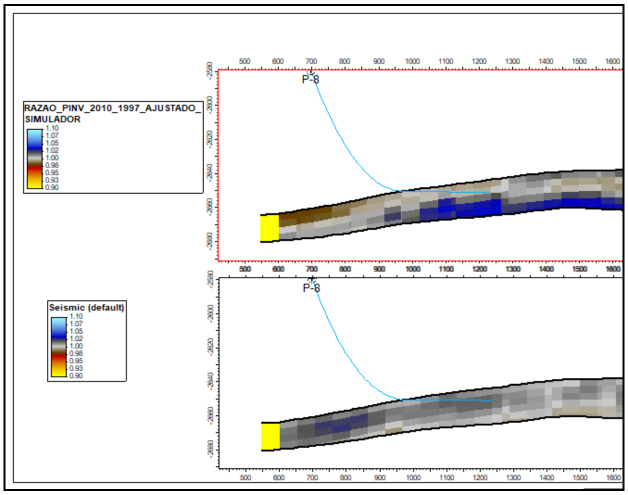


Figure 10- Sections grid of acoustic impedance change of P8 well location. It looks in good position in both 4D survey analyzed (2010/1997-above) and 2020/2010-below)

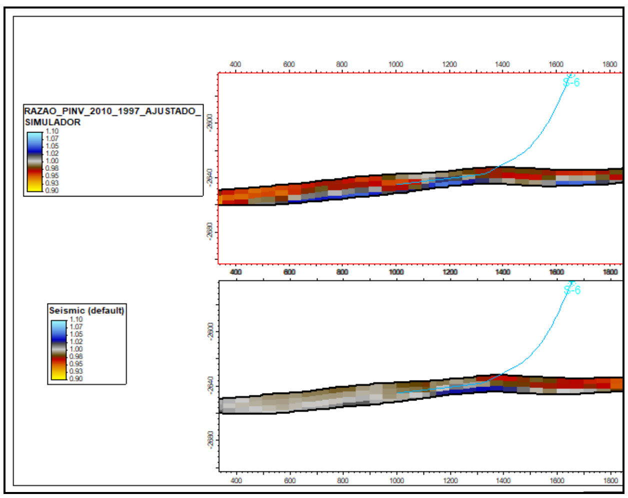


Figure 11- . S6 well location acoustic impedance changes showed a bit hardening anomaly on the bottom of reservoir in both 4D cycles, with trajectory on the top.

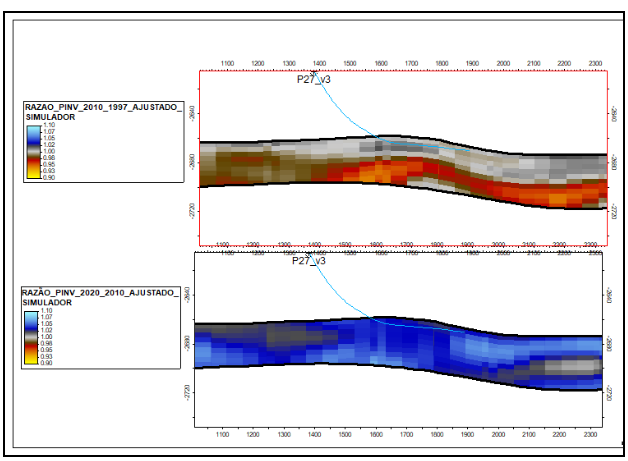


Figure 12- P27 well location Acoustic impedance change section showing good position without anomalies (4D 2010/1997-above), in contrast with hardening anomalies (4D 2020/2010-below), indicating water saturation increase.

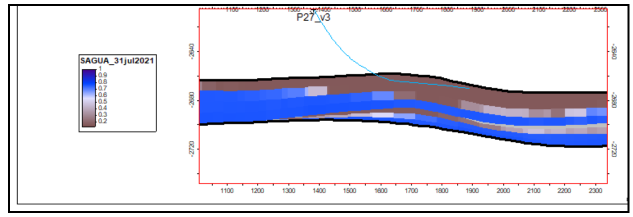


Figure 13- Water Saturation property section along P27 well location show high values to the bottom of reservoir.

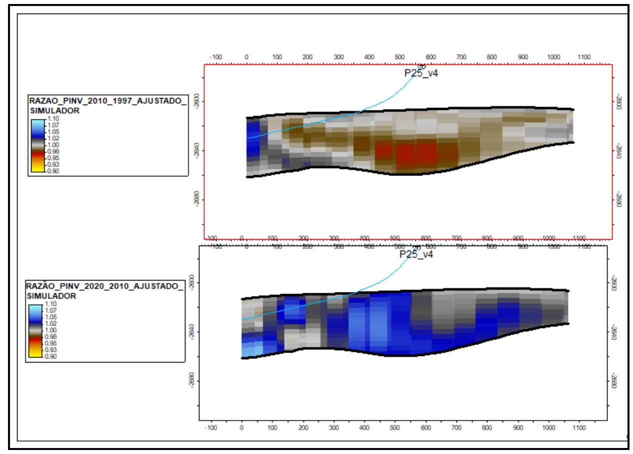


Figure 14- P25 well location Acoustic impedance change section showing good position without anomalies (4D 2010/1997-above), in contrast with hardening anomalies (4D 2020/2010-below) close to the top of reservoir and in the end of well trajectory.

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