SBGf14699

Feasibility Study for Seismic Monitoring of Deep Water Campos *Basin* Fields: Albacora and Marlim

Aggio A. and Dillon L.

PETROBRAS/CENPES, BRAZIL

Abstract

Feasibility studies are the first steps to be considered in a Time Lapse Seismic Monitoring (TLSM). The feasibility study evaluates if a reservoir is seismic visible for TLSM or not. We performed feasibility studies for two turbidites fields in Campos Basin: Marlim and Albacora. For this purpose, massive core and elastic logs analysis have been carried out. Those analysis were used as a calibration input in order to better evaluate invasion and dispersion for acoustic (monopole) log effects, generating therefore a more accurate basis for the fluid substitution exercise. 2D simple elastic models for Marlim and Albacora have been generated. A seismic amplitude response was studied for those models with oil/gas and oil/water substitution. A scale of random noise levels was added to the seismic response to evaluate the sensitivity of the seismic amplitude to the fluid substitution. Comparative analysis was performed as well.

INTRODUCTION

The management of the reservoir has long being known as an integrated field of experts: engineers, geologists and geophysicists. In recent years, the seismic method is participating more effectively in the reservoir management. The TLSM (Time Lapse Seismic Monitoring) intends to give more information about fluid movements for the reservoir management. This information results from the difference in the seismic response due to the fluid substitution when two or more seismic acquisitions in the same area were performed at different times of the production history. Previously, such information were based on conceptual geological models, reservoir simulation and well data set. Now, the goal of the TLSM technique (4D seismic) is to generate more confidence and accuracy for the whole process, which is decisive for a reservoir management optimization.

In order to check the improvement of applying TLSM techniques in some areas of Campos Basin, a feasibility study for the Marlim and Albacora fields to evaluate the seismic visibility concerning the fluid substitution was started by PETROBRAS. In order to improve the quality of the rock/log/seismic calibration, which is the basis for a better reservoir characterization and also for the feasibility studies applied to TLSM, a careful rock physics test was carried out.

GEOLOGICAL MODELS AND 4D SPREADSHEET

Figures 1 and 2 show the geological section models of Albacora and Marlim used in this feasibility study. Albacora is more complex than Marlim. Marlim is a thicker reservoir than Albacora. Both fields are tubidites offshore deep-water fields in the Campos Basin.

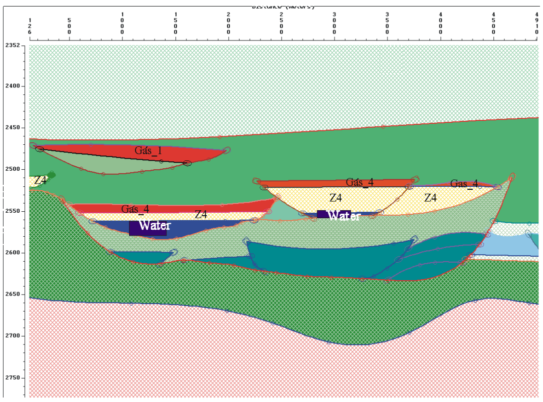

Figure 1 Albacora Geological Model

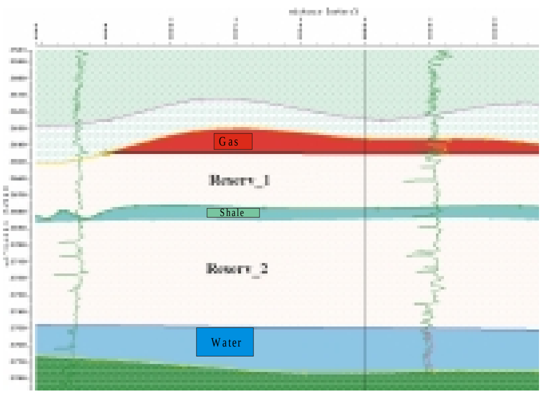

Figure 2 Marlim Geological Model

These depositional architecture features play positively in favor of Marlim. These features are more important for the seismic interpretation than to TLSM itself. The factors that play more effectively in the feasibility fluid analysis can be summarized in Table 1 which may be called 4D Fact Sheet (1), where the ranks show the weights of all the main factors. These scores show that Marlim is seismically better visible than Albacora, which will be shown below.

The maximum value for the score rank is 25 in this table, since the dry density was not considered; the minimum total value acceptable would be around score 15.

For the o/g fluid substitution, both fields yield a higher than minimum rank, but for the o/w, fluid substitution in Albacora is closer to the minimum.

The main difference in this analysis is related to a higher value for the dry bulk modulus and a lower percentage of fluid saturation change in o/w for the Albacora field, that plays negatively in the total score in table 1.

	Ideal value	MARLIM value	score	ALBAC. value	score
Rocks					
dry bulk modulus (GPa)	low	5.3	4	7.1	3
dry density (g/cc)	low	1.9		1.9	
porosity (%)	high	.28	4	.27	4
4-D Fluids		o/g o/w	o/g o/w	o/g o/w	o/g o/w
fluid saturation change (%)	high	75 50	5 5	75 40	5 4
fluid compression contrast (%)	high	100 60	3 2	100 60	3 2
Seismic Contrast					
		o/g o/w	o/g o/w	o/g o/w	o/g o/w
predicted impedance change (%)	> 4	16 7	5 3	10 7	4 3
TOTAL			o/g o/w		o/g o/w
Reservoir Total			21 18		19 16

Table 1 - 4D Spreadsheet for Albacora and Marlim

SONIC LOGS AND FLUID SUBSTITUTION

Aiming at the modeling of fluid substitution, 210 samples related to seven wells in Marlim field were tested. It was observed that the results of dry sand lab measurements (Vp and Vs), modeled for the seismic frequency using Gassmann equation and in situ fluid properties, show a systematic drift of about 300 m/s on the average if the Vp acoustic logs response (2) are compared. There is a certainty about the mechanical integrity of the samples and, on the other hand, the resistive and density logs analysis shows no significant mud filtrate invasions. The conclusion is that this kind of Vp shift can be explained only as a dispersion effect. In this context, two models were generated for Marlim: a standard reference (original well logs) and a second reference where the acoustic logs have been corrected for those dispersion effects. Figure 3 shows the fluid substitution from oil to gas, considering both references. For this case, it can be seen that the correction for the dispersion effects improves the compressional (p) impedance contrasts. In other words, the percentage change in impedance due to the o/g substitution at the 15-m highest portion of the reservoir reaches 20% if considered the correction for the dispersion effects. If the correction were not considered, the o/g p impedance contrast would be around 12%. The same kind of effect can also be seen for the o/w fluid substitution. However, the p impedance changes for o/w substitution are much lower than o/g as expected. The p impedance contrast for o/w substitution at Marlim field would be about 10%, if the logs were corrected for the dispersion effects and 7% if based on the original sonic log.

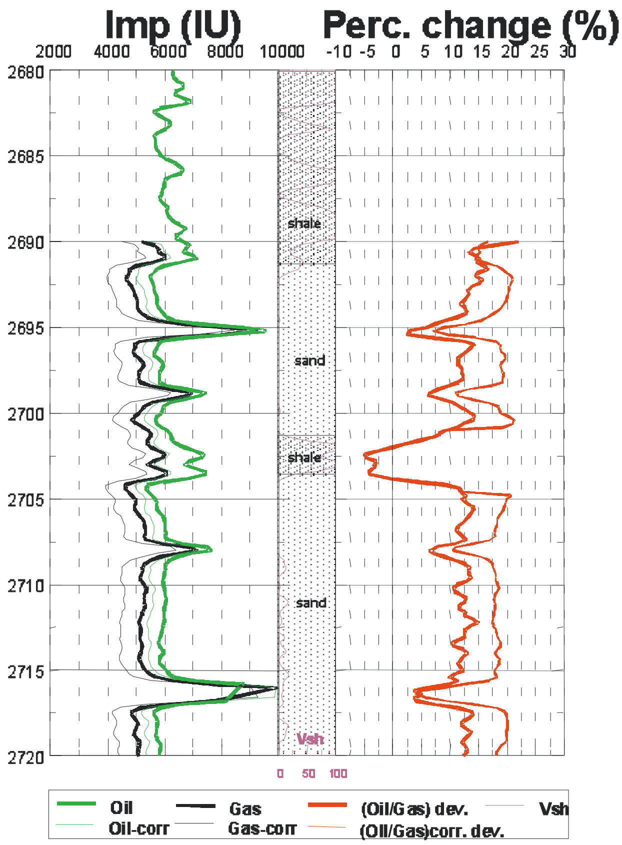

Figure 3 Fluid substitution (oil/gas) for Marlim Field shows the dispersion effects

Albacora field does not show the dispersion effect observed in Marlim field. The study for the fluid substitution in Albacora field was supported on tests effected on around 60 samples from 4 wells. The percentage change for both o/g and o/w is lower than changes observed for the Marlim field. The modeling of the fluid substitution is about 9% and 5% for the o/g and o/w respectively on the average for the Albacora field. From those values, it can be inferred that Marlim should have better seismic visibility for TLSM than Albacora.

It should be noted that two models were generated for Marlim (corrected and not corrected for dispersions effects). However, for both references it was hypothesized that the fluid substitutions were at first oil and afterwards, as can be seen on the geological model represented in figure 2, 5 m of gas in the top of the reservoir and 20 m of water in the reservoir bottom. For Albacora field only one model was generated for fluid substitution. Such model was designed with 5 m of gas in the top of zone 4 and 10 m of water at the bottom of zone 4 as represented on the geological model of Figure 1.

SEISMIC RESPONSE

The zero-offset ray method was used to evaluate the seismic amplitude response to the effect of fluid substitution in the Marlim and Albacora fields. The level of amplitudes was evaluated using many levels of random noise added to the seismic trace, as a portion of the level of RMS of the trace. Figure 4 shows the difference section for Marlim field for fluid substitution 5 m of o/g at the top of the reservoir and 20 m of o/w at the reservoir bottom. In item (a) of Figure 4 the presence of gas is visible around the 2300 ms of the difference seismic section, and at the 2400 ms the water substitution effect appears. Observe around 2500 ms the effect of pull down in a reflector below the reservoir. All these effects are present in item (b) of Figure 4, but the amplitude level is less than item (a). Item (a) shows the dispersion correction model and item (b) shows the results with original logs. The random noise level is –40db/RMS of the trace. This starting level of noise was used to compare with the Albacora seismic response.

Figure 5 shows the seismic response to the fluid substitution for the Albacora field. The level of the random noise was varied from –40db/RMS in item (a), –50db/RMS in item (b), until –60db/RMS in item (c). For the same level (–40db/RMS) of random noise (as used for the Marlim case), the seismic amplitude response for the fluid substitution is not visible in Albacora field.

The seismic response of the Albacora field is visible only when the level of noise is below –50db/RMS of the trace. This is shown in Figure 5 items (b) and (c).

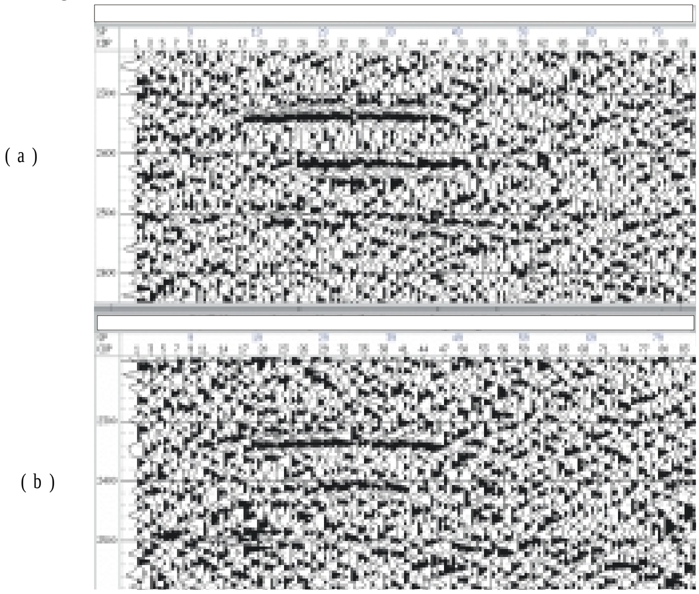

Figure 4 Difference of seismic section of fluids substitution (o/g and o/w) for Marlim field with random noise of –40db/RMS of trace: (a) corrected for dispersion effects and (b) without correction

CONCLUSIONS

Experimental and theoretical rock physics analysis has been carried out as part of an effort for the 4D Time Lapse Seismic Monitoring (TLSM) feasibility studies for Marlim and Albacora Fields. The rock/log calibration techniques showed dispersion problems related to the acoustic logs in the Marlim field case. Mostly due to the o/g fluid change, the 2D seismic forward modeling helps to visualize the results of the 1D fluid substitution petrophysical analysis that indicates Marlim rather than Albacora as a better reservoir to apply the TLSM techniques. If the dispersion corrections were taken into account, the seismic contrasts forecast for Marlim would be even higher.

REFERENCES:

1 Lumley D. E. at all, 1997, Assessing the technical risk of a 4-D Seismic project, TLE, VL 16,n°9, 1287-1291.

2 Dillon L. at all, 1998, Dispersion effects and their impact on reservoir geophysics: A Brazilian turbidite field example, 69th Annual Meeting of the SEG, Rock Physics 1.

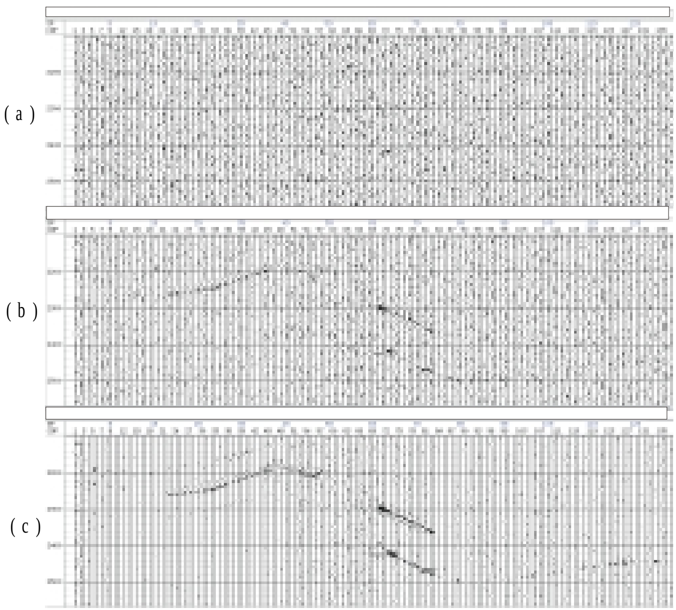

Figure 5 Difference of seismic section of fluid substitution (o/g and o/w) for Albacora: with random noise (a) –40db/RMS, (b) –50db/RMS, –60db/RMS

ACKNOWLEDGMENTS

We would like to acknowledge Petrobras for the permission to this publication, and the support and information of many experts of Petrobras in these two Campos Base fields.