Submission code: 5K4R5Z4MK7

See this and other abstracts on our website: https://home.sbgf.org.br/Pages/resumos.php

Evaluation of internal multiple on 1.5D sonic log model from Paraná Basin

Renan Sales (Tecgraf Institute/PUC-Rio), FRANCISCO SILVA (PUC-RIO), Carlos Rodriguez (Tecgraf Institute/PUC-Rio), Deane Roehl (Tecgraf Institute/PUC-Rio)

Evaluation of internal multiple on 1.5D sonic log model from Paraná Basin

Summary

The basalt stratification can provoke severe internal multiple events, which damage the sub-basalt imaging. This work investigates the destructive interference of those internal multiples in the events of interest and uses synthetic models built from real sonic-log data of the Paraná Basin. The results indicate that multiple harms can lead to a misinterpretation of the sub-basalt events.

Introduction

Seismic interpretation and imaging are critical to understanding geological structures and identifying reservoir location. The high contrast and heterogeneity of the layered basalt (massive layers vertically alternating with vesicular and fractured zones) give rise to several strong internal multiples that can significantly impact the seismic interpretation of the main events associated with sub-basalt layers.

Several studies highlighted the basalt attenuation and proposed strategies focusing in the removal of high-amplitude internal multiples (Alá'i & Verschuur, 2003; Jia et al., 2021) and using the low-frequency (Spitzer & White, 2005; Ziolkowski et al., 2003)

This work consists of an analysis of the interference of the basalt internal multiples at Serra Geral Gr, in synthetic scenarios based on real well-log data from Paraná Basin. Additionally, measure the destructive effect of those multiples on the sub-basalt events.

Method

To separate the sub-basalt events from the basalt internal multiples, and also to analyze the destructive interference of those multiples, we proceed with the following methodology:

1. We build two 1.5D compressional wave velocity models using the well-log information: one considering the whole information of the model and one considering only the volcanic layer (Serra Geral Gr).
2. Calculate the synthetic seismograms for both models by solving the 2D acoustic wave equation through finite difference method. From these results, we separate the sub-basalt events by taking the difference between the two seismograms.
3. Sort the seismogram data in the common midpoint domain.
4. Semblance analysis (Geldart & Sheriff, 2004) focusing in identifying the velocity of the main reflections.
5. Apply a normal moveout correction (NMO) using the velocity table built from semblance analysis in the previous step.
6. Assessment of the basalt internal multiples interference in the sub-basalt events in NMO stack

Examples

In this numerical test, we evaluate the basalt internal multiples in the compressional wave velocity model built from the sonic log of well 1-BB-1-PR (edited from ANP/REATE, 2021). The velocity models consist of 1.5D model with horizontal, homogeneous, and isotropic layer with 15 km extension. Figure 1 depicts the models with all reflectors and with only the basalt layers. The idea is to separate the sub-basalt events and analyze how the basalt internal multiples are destructively interfering in those events. The model has a grid size of 6440x2043 with spacing of 2.5 m. The density is constant with a value of 1.0 g/cc. The perfectly match layer is employed as the absorption layer for all model boundaries.

The acquisition geometry consists of one single located at $(x_{src}, z_{src}) = (0,0)\, m$, and 601 receivers equally distributed along 15 km at model surface. To total time propagation is 4.0 s. The pulse is a volume injection of Ricker wavelet with dominant frequency of 20 Hz.

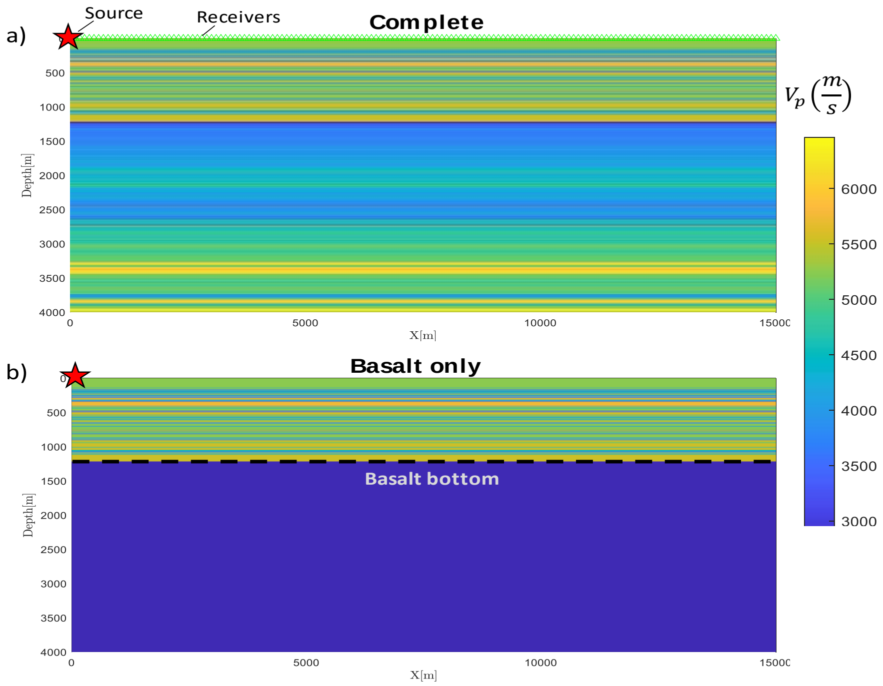

Figure 1: 1.5D compressional wave velocity models built from well 1-BB-1-PR sonic log (edited from ANP/REATE, 2021), using whole log (top) and basalt (Serra Geral Gr.) interval only (bottom).

Results

Figure 2 depicts synthetic seismograms of the model considering the whole log and volcanic interval only. By differencing these two seismograms, we isolate the sub-basalt events. Since the primary events and internal multiples become indistinguishable for long offset, we proceed with a semblance analysis followed by a NMO correction to separate them. Figure 3 shows the results of the NMO correction for the seismogram with all events, basalt-only events, and difference between them. We note that the main reflections are well-corrected but, on the other hand, the basalt internal multiples are, as expected, overcorrected.

By stacking the NMO corrected data, we observe that the interference of the basalt internal multiples on the sub-basalt events mainly occurs at the time window between 0.5 s and 1.0 s, as shown in Figure 4. Below 1.0s the amplitude of those multiples is weak, but still can harm reflections from potential reservoirs at Rio Bonito and Campo Mourão Fm.

It is worth mentioning that even though we considered an offset of 15 km in the NMO correction, only the information up to 7.5 km is useful. This may indicate that we can adopt a shorter offset without a significant information loss in our analysis.

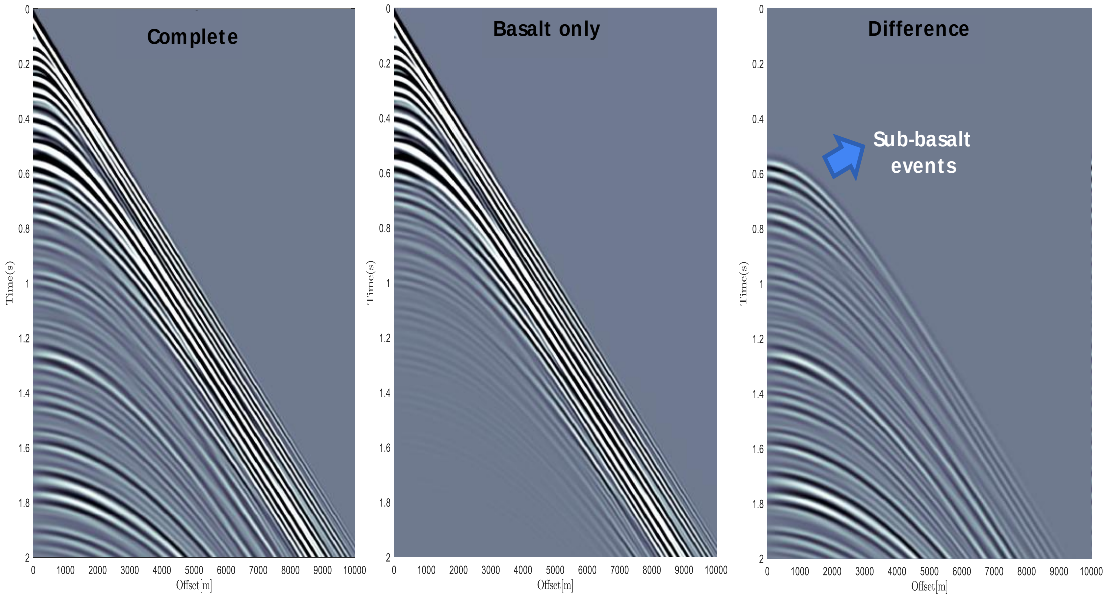

Figure 2: Synthetic seismogram of the models using the complete (left) and basalt only information (center) of well log. The difference between the two seismogram is also shown on right, indicates only the sub-basalt events.

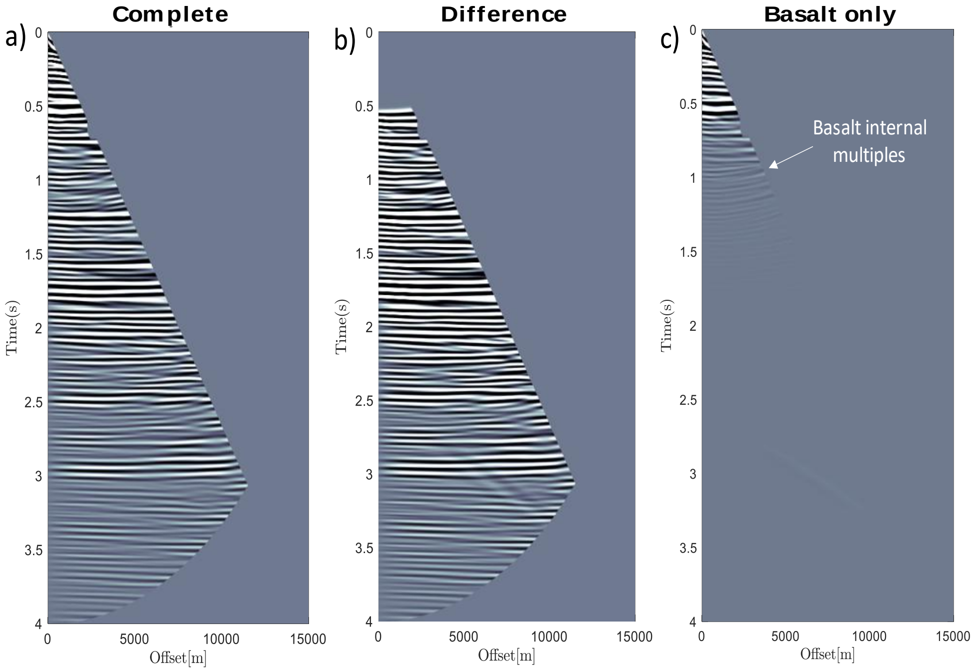

Figure 3: NMO correction (a) complete and (c) basalt-only models, and for the (b) difference between them. A manual mute was applied to cancel stretch effects.

Conclusions

The basalt internal multiples from Serra Geral Gr. at Paraná Basin can significantly affect the sub-basalt events, causing some misinterpretation of important reflections. We also see that sub-

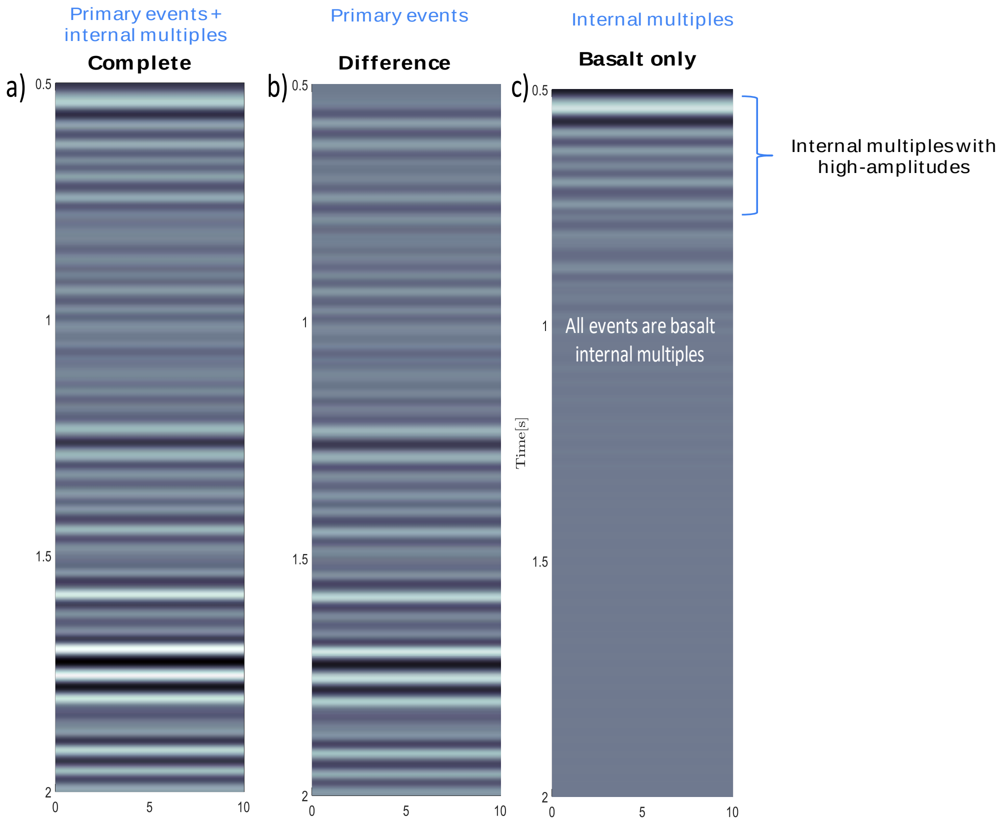

Figure 4: Stack of NMO corrected seismogram with single trace repeated ten times. (a) complete and (c) basalt-only models and the (b) difference between them.

basalt events are more affected in a time window 0.5s down from basalt bottom reflection. The semblance analysis, followed by the NMO correction, is a helpful tool for identifying the internal multiples and main reflection in the synthetic seismograms.

Acknowledgments

The authors would like to thank the Brazilian National Agency for Petroleum, Natural Gas and Biofuels (ANP) and CNPC Brasil for subsidizing this research project through the R&D Clause.

References

ANP/REATE (2021). Public Land Data Free Access. https://reate.cprm.gov.br/anp/TERRESTRE

Alá'i, R., & Verschuur, E. (2003). Aiming towards imaging beneath basalt : multiple suppression offshore Faroe Islands. 8th International Congress of the Brazilian Geophysical Society, 4.

Geldart, L. P., & Sheriff, R. E. (2004). Problems in Exploration Seismology and their Solutions. Society of Exploration Geophysicists.

Jia, X., Baumstein, A., Jing, C., Neumann, E., & Snieder, R. (2021). Subbasalt Marchenko imaging with offshore Brazil field data. Geophysics, 86(5), WC31–WC40.

Spitzer, R., & White, R. S. (2005). Advances in seismic imaging through basalts: A case study from the Faroe-Shetland Basin. Petroleum Geoscience, 11(2), 147–156.

Ziolkowski, A., Hanssen, P., Gatliff, R., Li, X. Y., & Jakubowicz, H. (2003). The use of low frequencies for sub-basalt imaging. Geophysical Prospecting, 51, 169–182.