Earth models for early exploration stages

Ângela Pereira
PhD student
angela.pereira@tecnico.ulisboa.pt

Outline

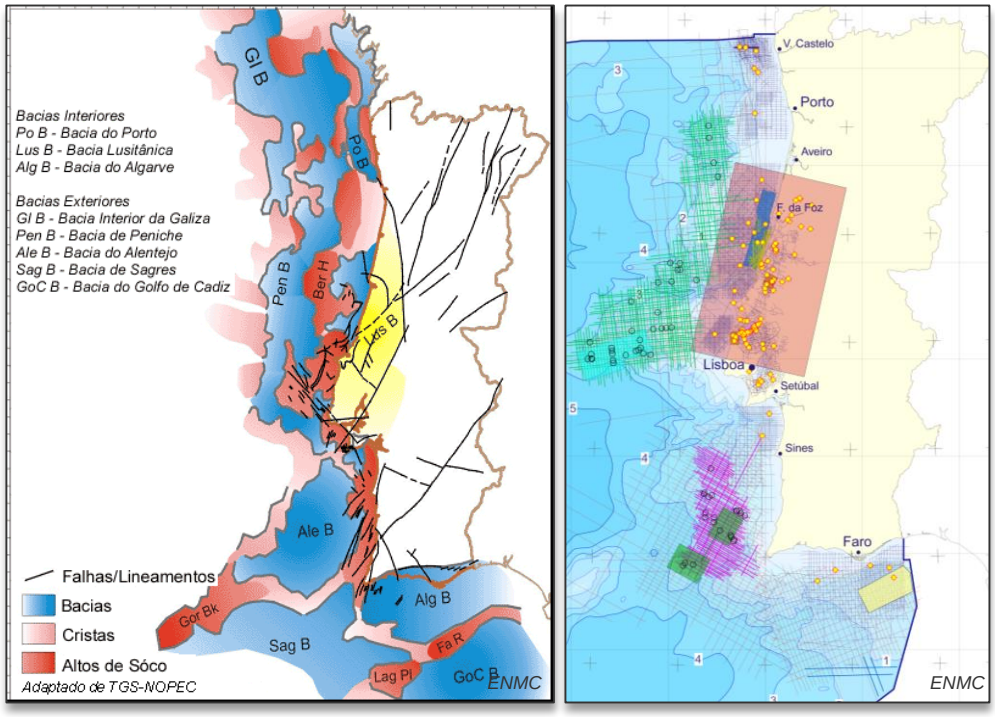
- Motivation
- Methodology
- Case Study
- Seismic inversion results
- Conclusions

Motivation

Prospect characterization and uncertainty assessment of unexplored areas or in early stages of exploration.

How?

Combination of information from Geological analogs and Geophysical data in a geoestatistical seismic inversion procedure.

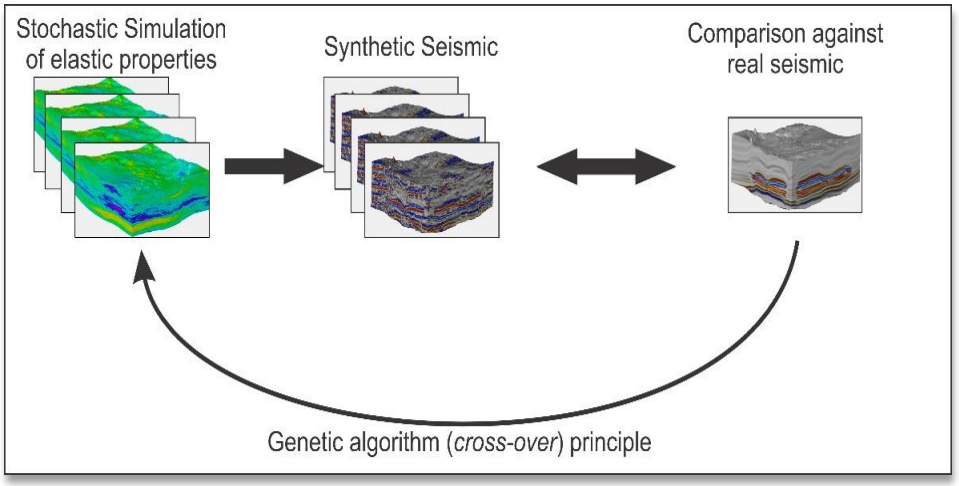


Methodology

- Geostatistical Seismic Inversion algorithm - GSI (Soares et al. 2007; Caetano, 2009)).
- Use of **geological analogs** for extraction of a priori distributions of Acoustic Impedance (AI) (e.g. well-logs from nearby wells).
- Use of a **geological conceptual model** based on seismic interpretation.

Geostatistical Seismic Inversion - GSI

Global approaches (Soares et al., 2007; Caetano, 2009)

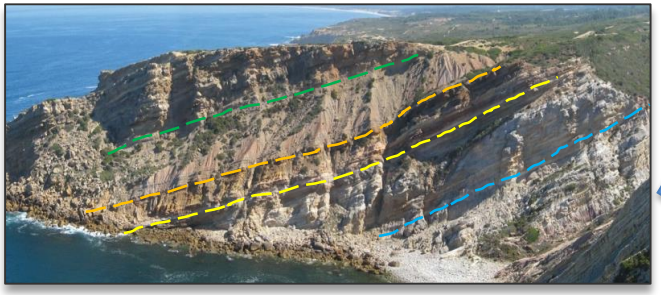


i. **Generation and perturbation of entire cube of parameters (acoustic properties) .**

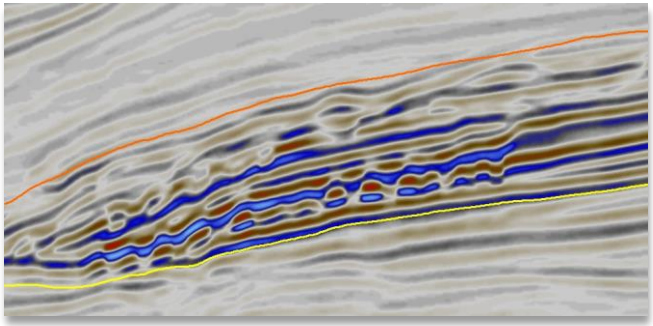
ii. **Optimization method (genetic algorithms) to assure the convergence of the iterative procedure.**

Geological analogs

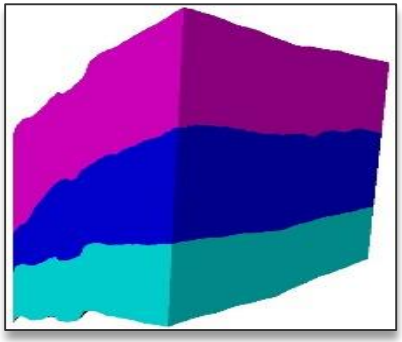
Regional Geology



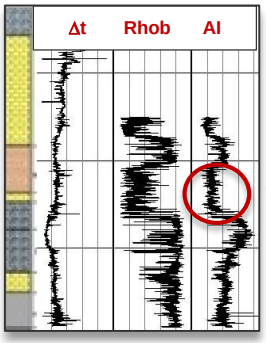
Seismic Interpretation



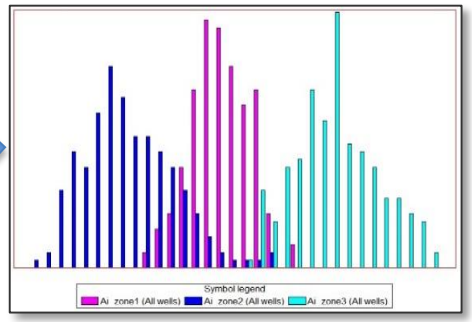
GEOLOGICAL MODEL



Geological Analogs
(wells-logs from nearby wells)

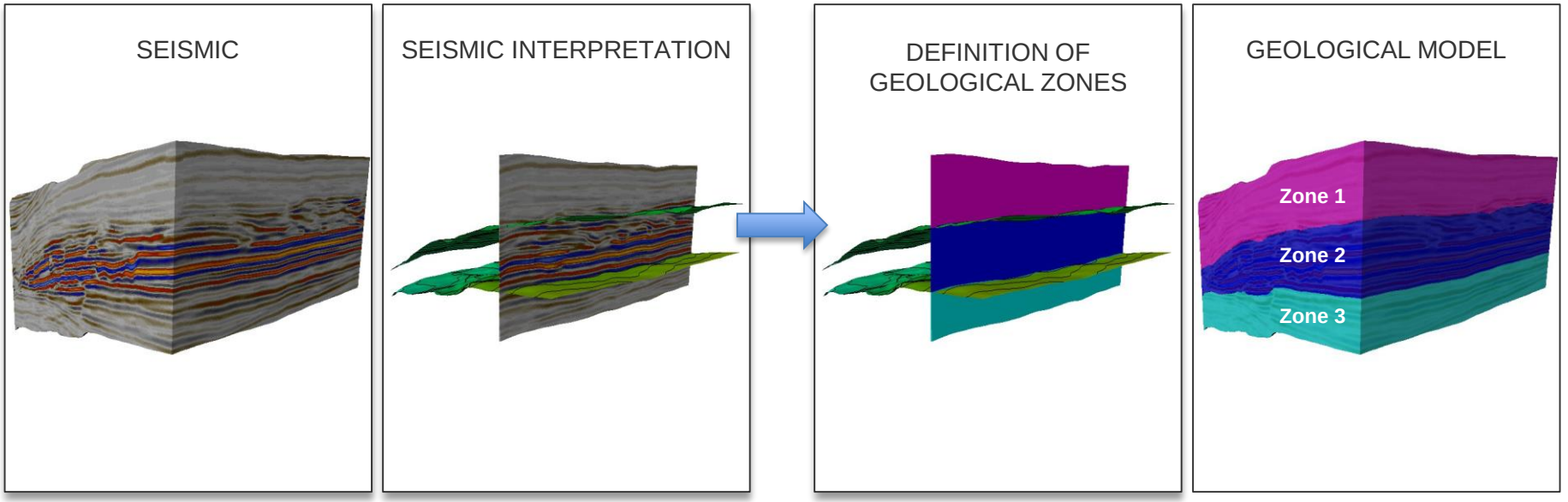


Acoustic Impedance distributions
extracted from geological analogs



- The distributions of AI should be representative of the expected lithofacies and also of the relation between the different litho-stratigraphic units.

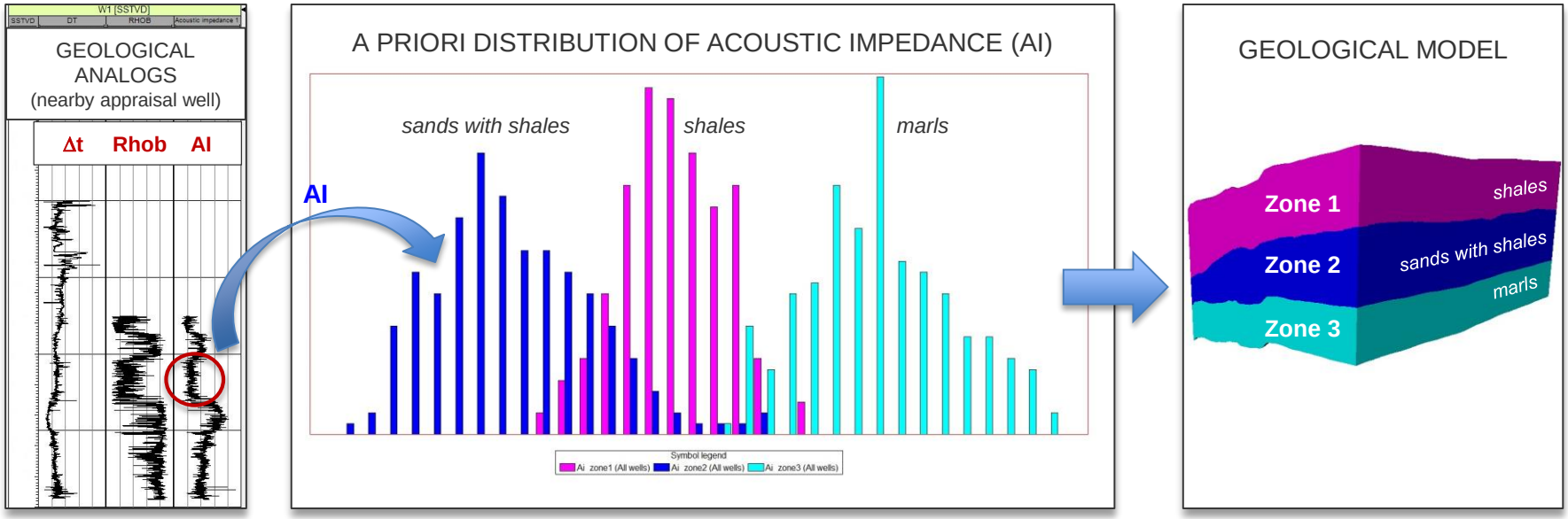
Geological model



- **Geological model with 3 different lithofacies based on seismic interpretation**
- Grid size: 198 x 279 x 190

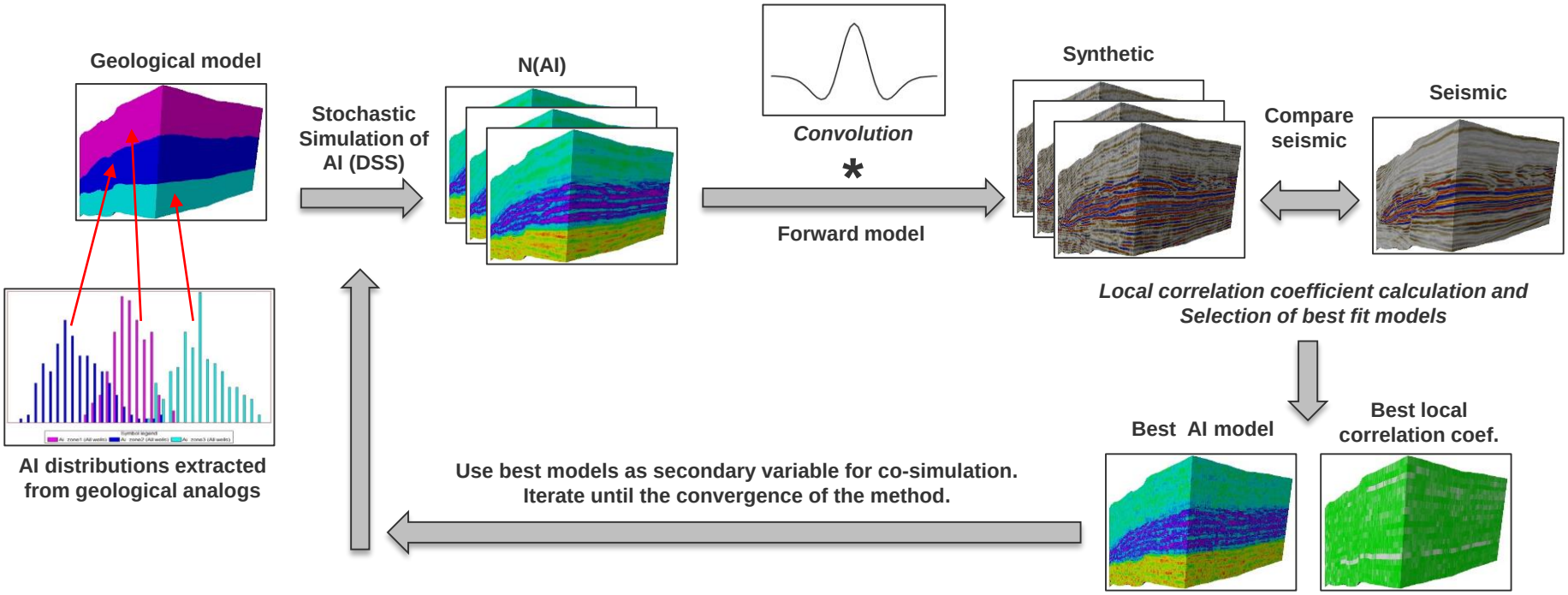
Geological analogs
Acoustic Impedance - AI

Each a priori **AI distribution**, for the different geological zones **were extracted directly from geological analogs** (well-logs from nearby wells). **They correspond to the expected lithofacies for each zone**.



Methodology

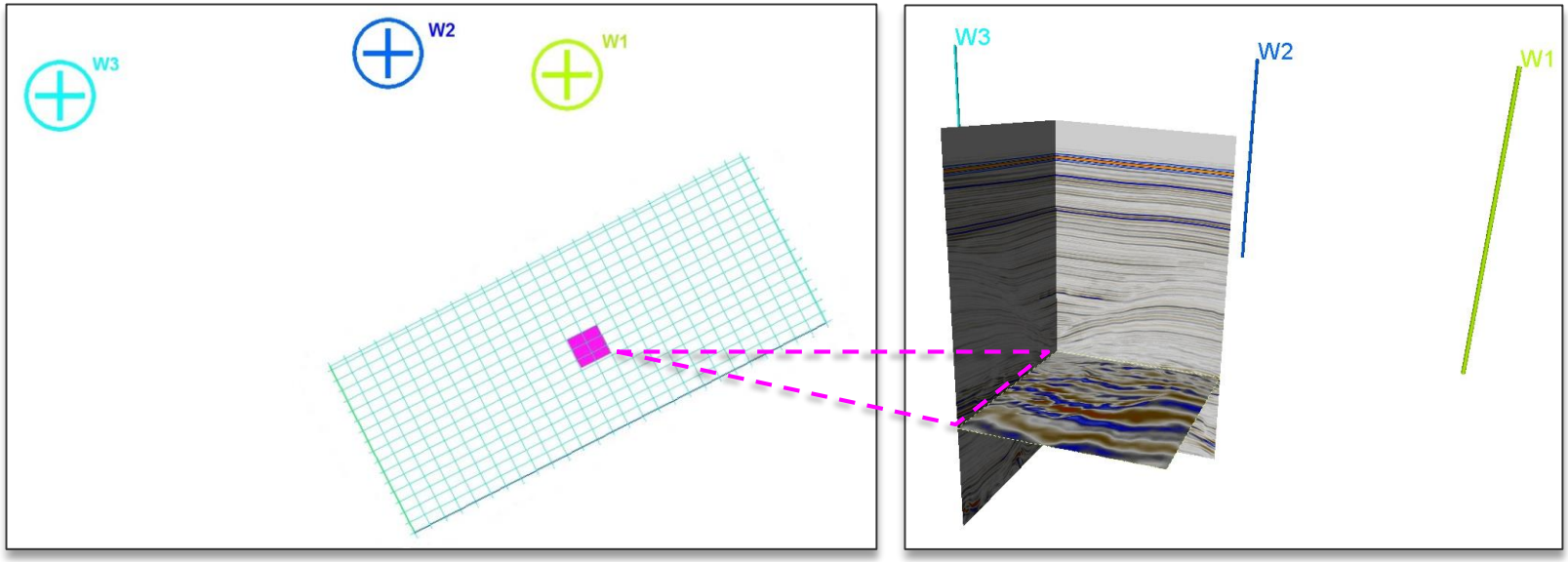
Workflow



Case study

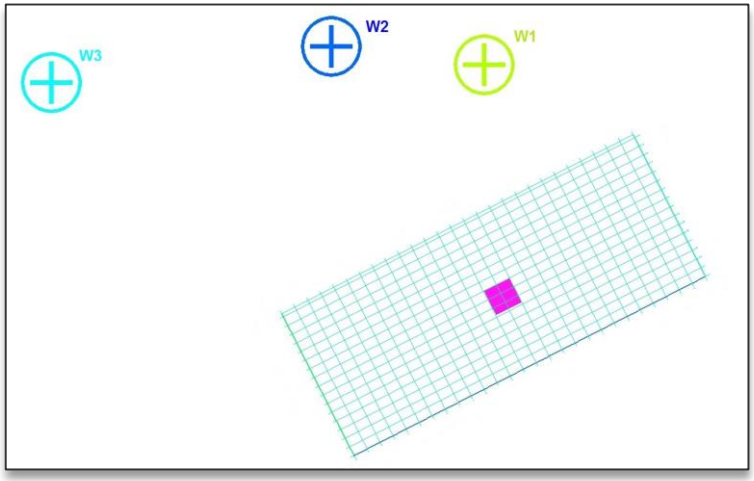
The methodology proposed was applied to an unexplored area, where the potential reservoir is expected to be in a turbidite system.

- 3D post-stack seismic volume, with sampling interval 2ms
- 3 appraisal wells outside the area used as analogs (w1, w2, w3)

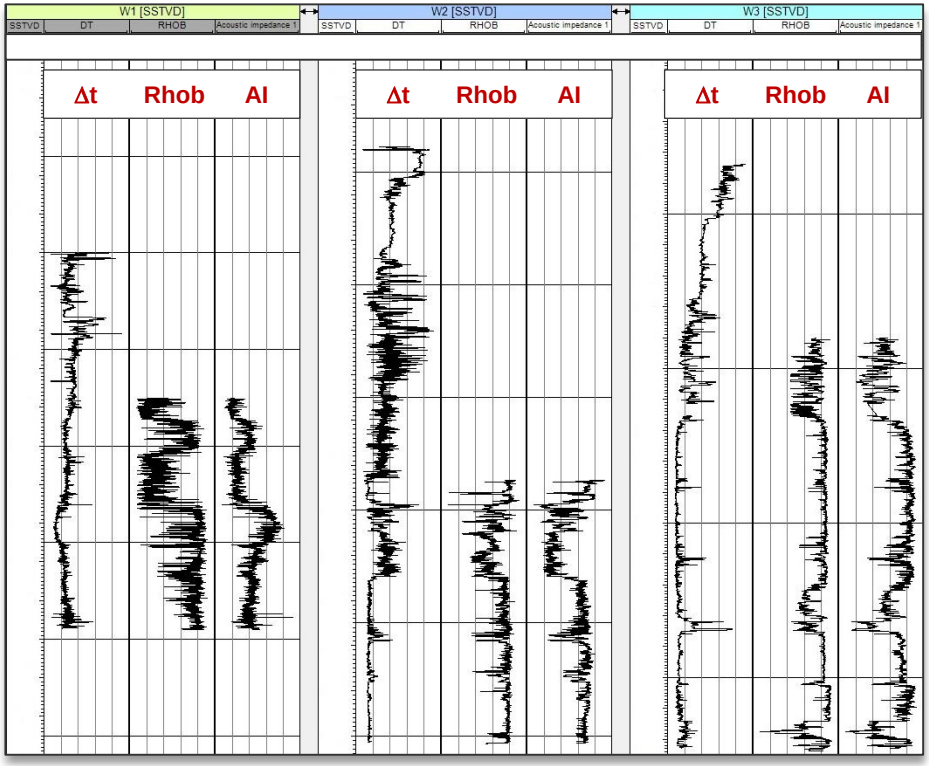


Case study

Well-logs available: Sonic, Density, Acoustic Impedance (computed from Sonic and Density logs)



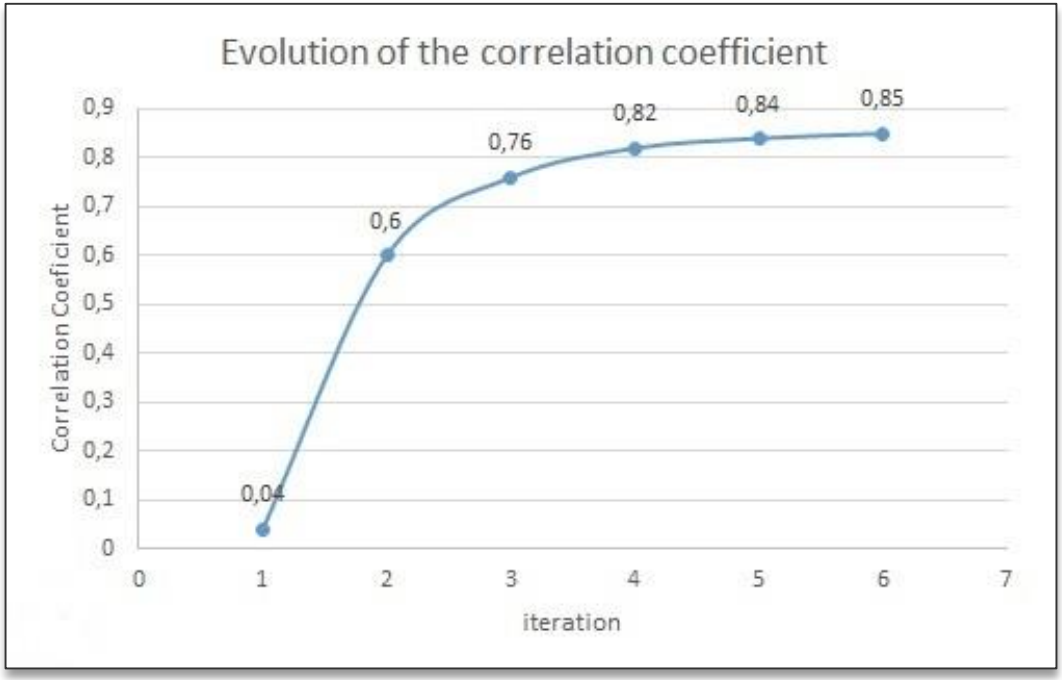
Well-logs used as analogs



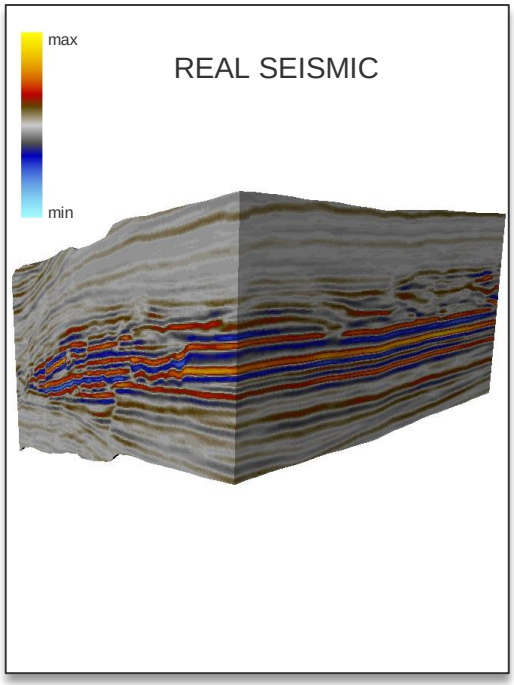
Seismic Inversion Parameterization

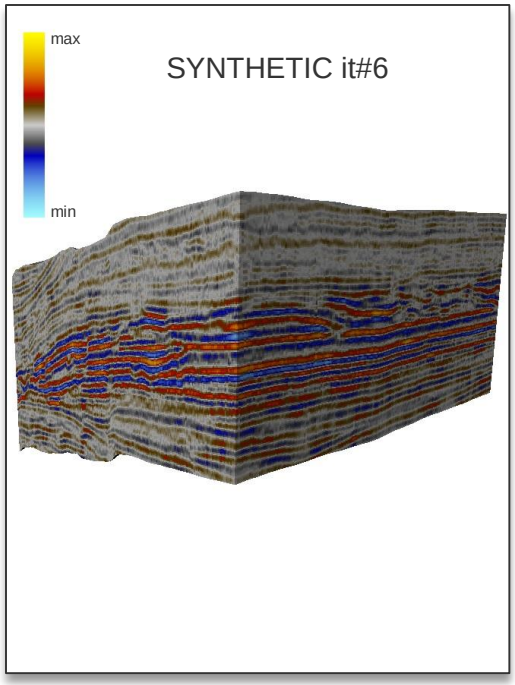
- **Geological model** with 3 lithofacies zones
- Tree different a priori **Acoustic Impedance (AI) distributions extracted from the geological analogs**.
- Spatial continuity pattern expressed by a **variogram model** obtained from seismic data.
- **Statistical wavelet** extracted from seismic data.
- The algorithm was run with 6 iterations in each one were generated 32 models of Acoustic Impedance.

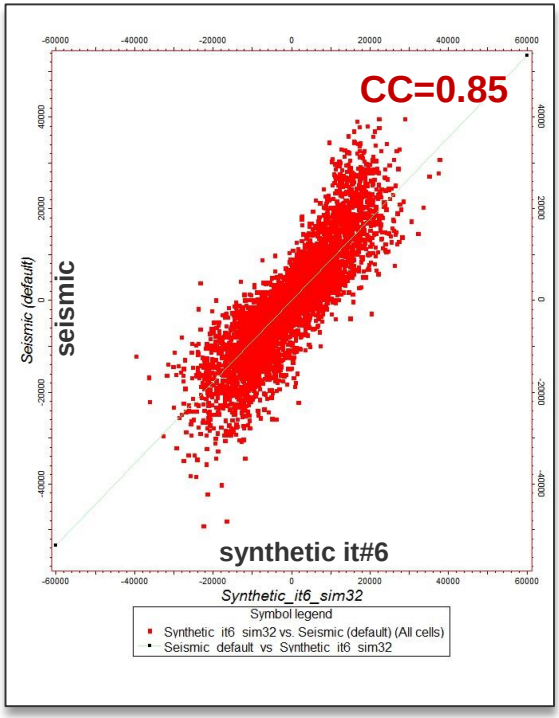
Evolution of Global Correlation Coefficient



Correlation between real and synthetic seismic

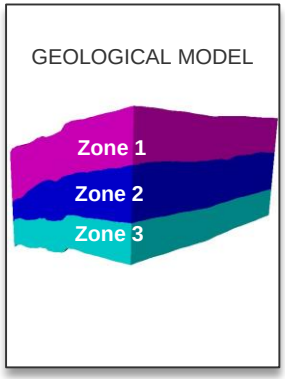


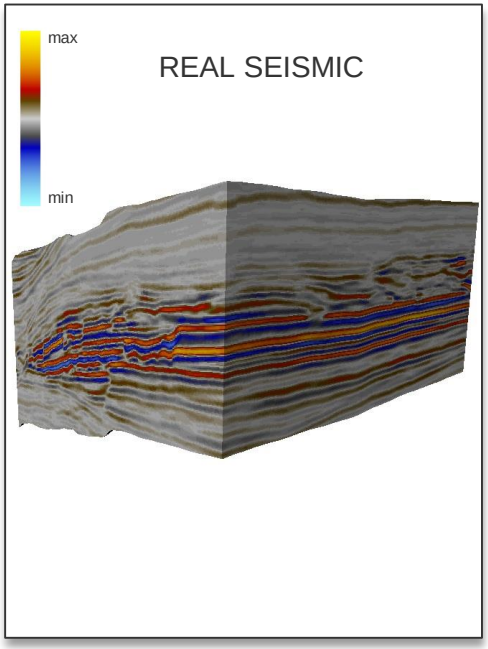


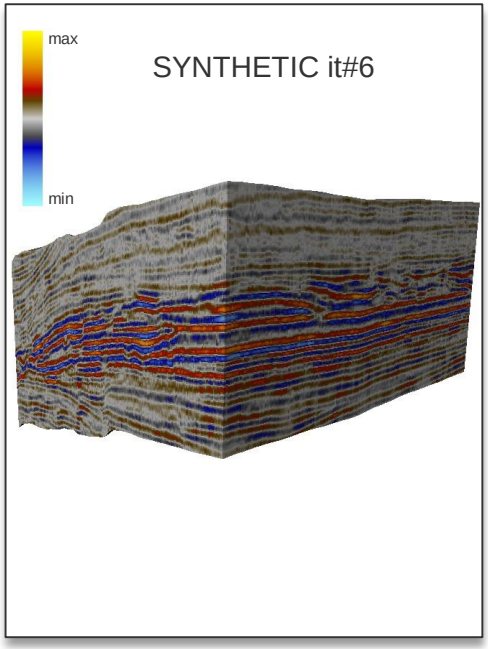


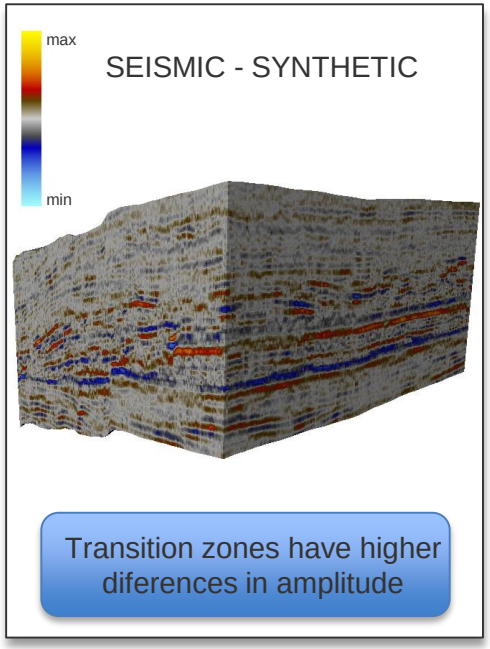
Seismic amplitude

Difference in amplitude between real and synthetic seismic

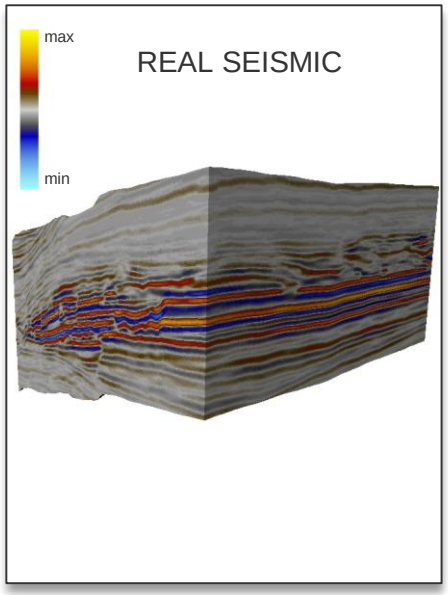


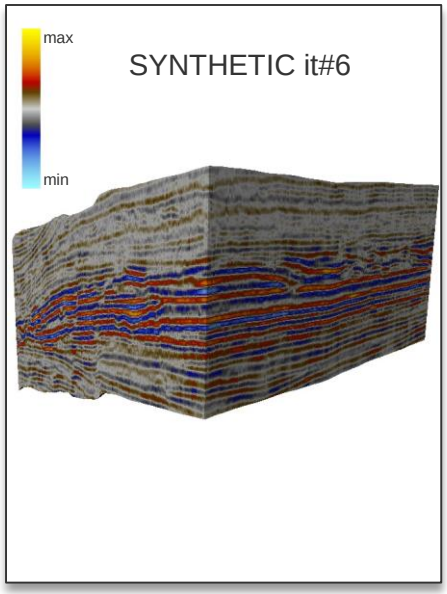


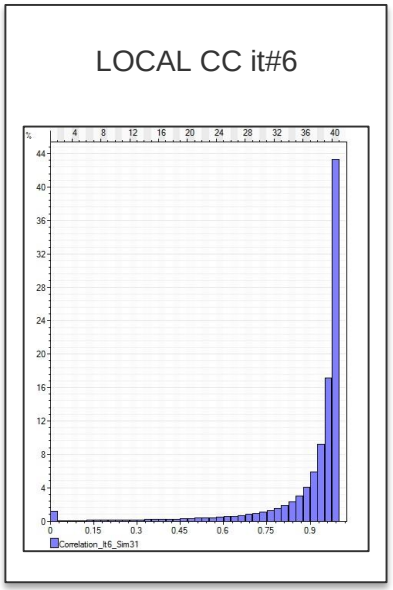


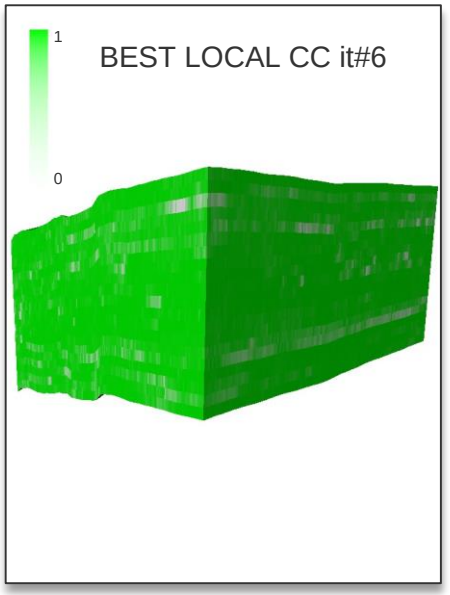


Local Correlation Coefficient - CC



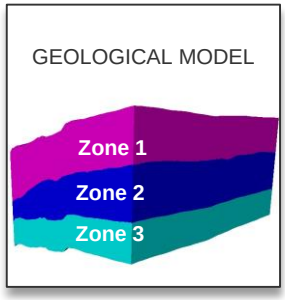


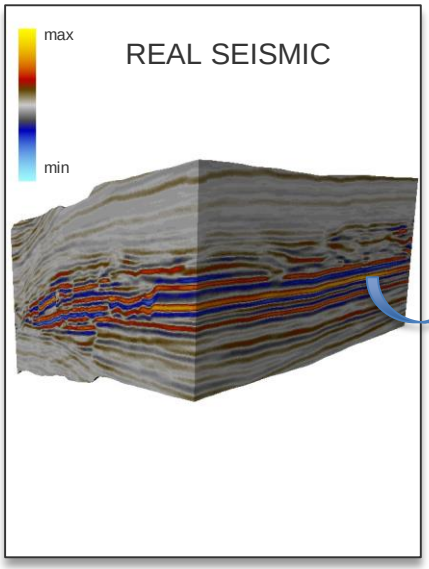


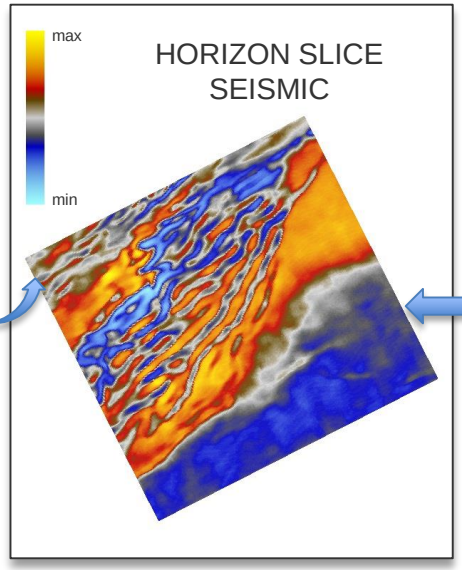


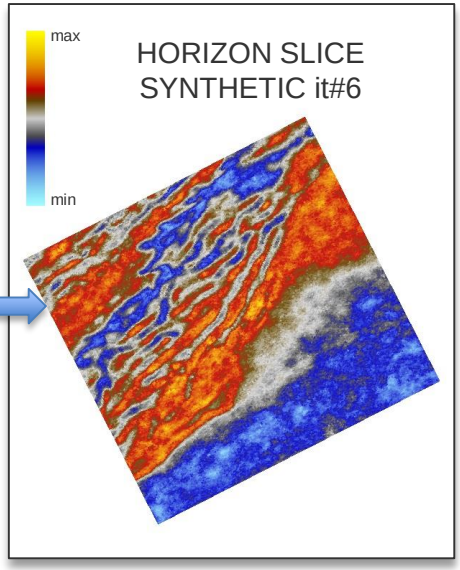
Correlation between real and synthetic seismic

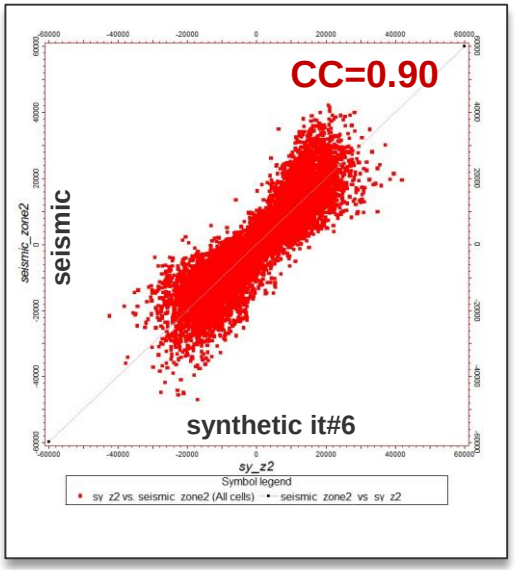
Zone 2
Potential reservoir – turbidite system



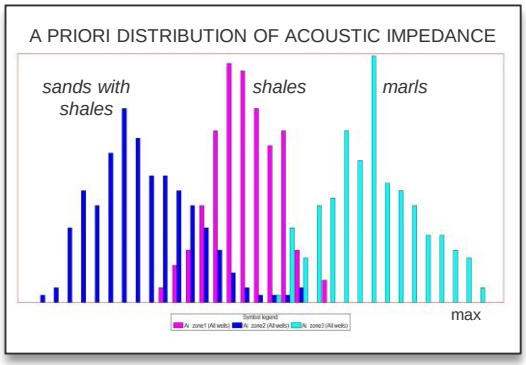




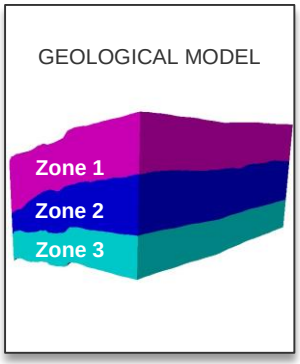


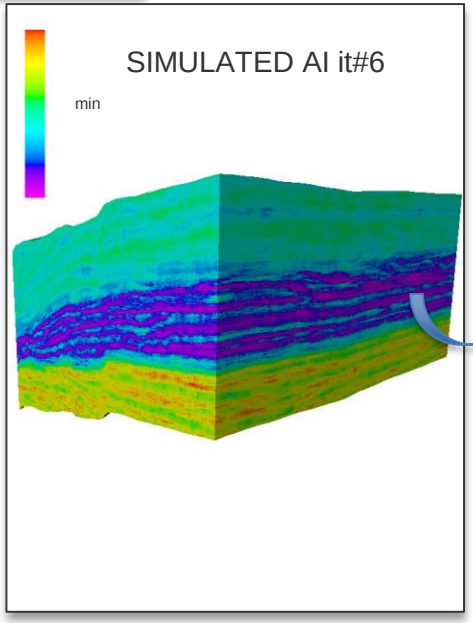


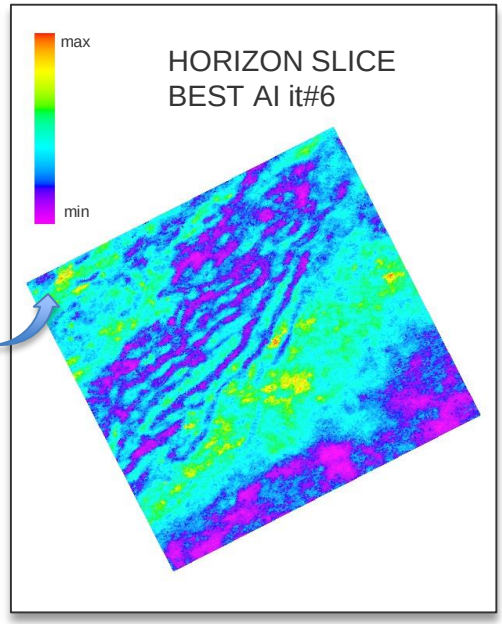
Acoustic Impedance model

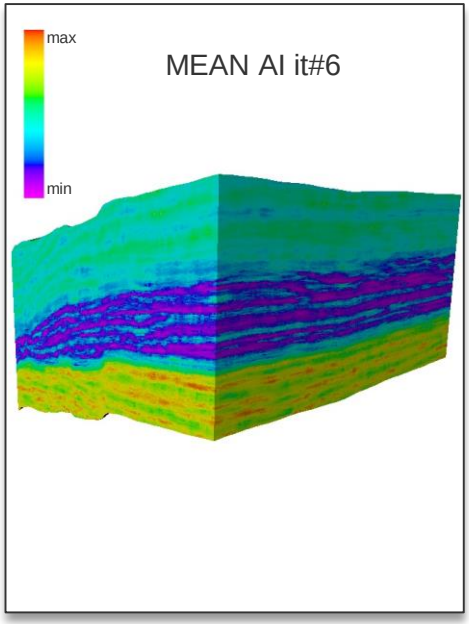


- Low acoustic impedance values correspond to high porosity areas









Conclusions

- It is important that the acoustic impedance distributions extracted from geological analogs should be representative of the expected lithofacies and also of the relation between the different litho-stratigraphic units.

- The Geostatistical Seismic Inversion methodology using geological analogs proved to be a valuable tool to be applied on unexplored areas or in early stage of exploration for prediction of the subsurface geology and for prospect characterization.

Acknowledgements

- Partex Oil and Gas and Repsol for allowing the use of the data and give permission to show the results.
- Schlumberger for the academic licenses of Petrel®
- CGG for the academic licenses of Hampson-Russel software.

Thank you

References

- Caetano, H. [2009] Integration of Seismic Information in Reservoir Models: Global Stochastic Inversion, PhD thesis, Instituto Superior Técnico, University of Lisbon.
- Pereira A., Nunes R., Azevedo L., Guerreiro L. & Soares A. [2016] Seismic inversion using analogs for reservoir characterization and uncertainty assessment in early stages of exploration. Search and Discovery, *Proccedings* of International Conference and Exhibition AAPG/SEG 2016 (*Accepted*).
- Pereira A., Nunes R., Azevedo L., Guerreiro L. & Pereira M.J. [2015] Global Stochastic Inversion Using "Analogs-wells" and Zonal Distributions - Application to an Unexplored Area. *Proceedings* of EAGE 2015 Conference - Petroleum Geostatistics.
- Soares, A., Diet, J.D. & Guerreiro, L. [2007] Stochastic Inversion with a Global Perturbation Method, *EAGE Conference on Petroleum Geostatistics*, Extended Abstracts.