

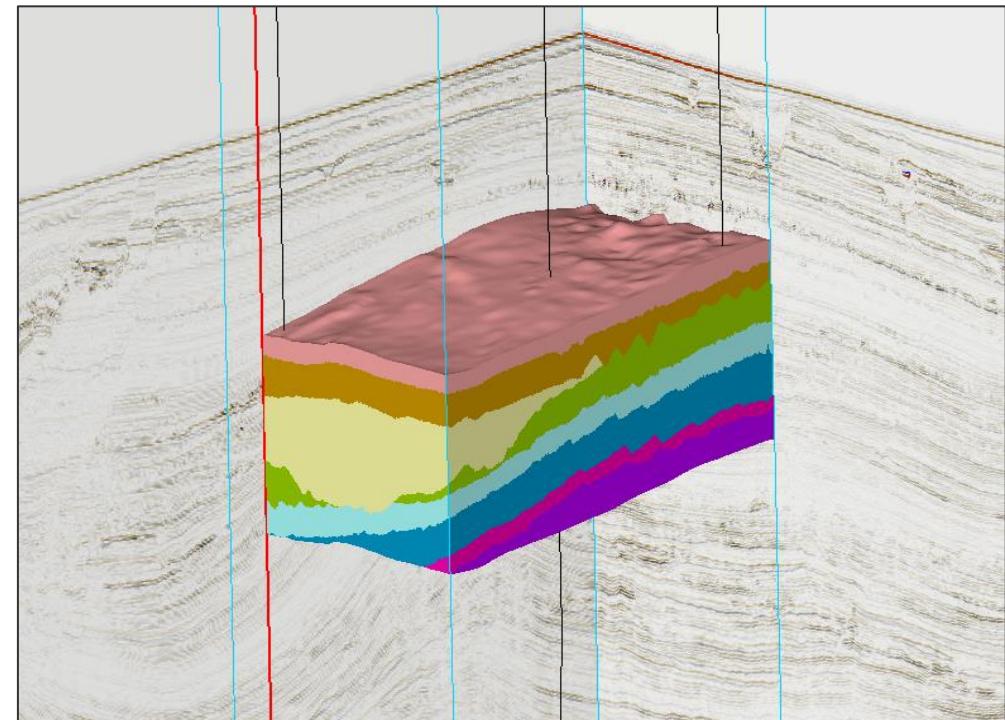
Master in Petroleum Engineering

Integration of seismic interpretation in to geostatistical
acoustic impedance
Results presentation and discussion

SERGIO CRUZ BARDERA

Summary

- Motivation
- Methodology
 - Traditional Geostatistical seismic inversion “GSI”
 - GSI divided by zones
- Comparison of results
- Conclusion
- References



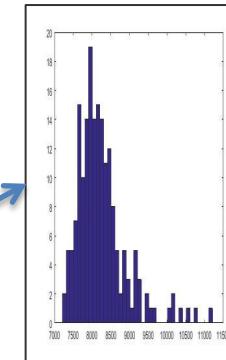
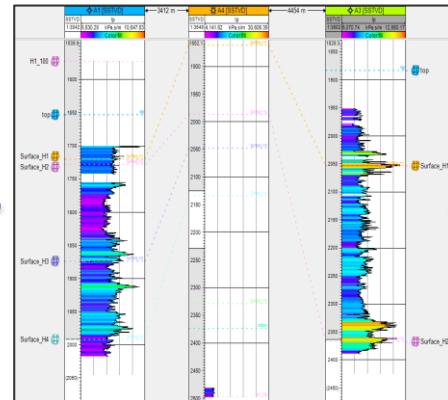
Motivation

**Traditional
GSI**

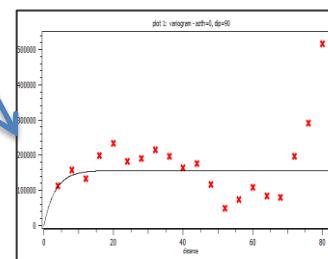
It's based on:

- **1 distribution function**
- **1 variogram model**

Wells log data

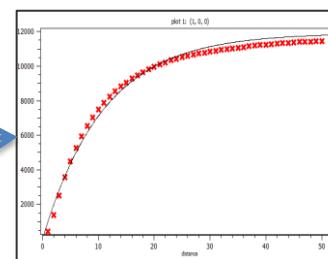
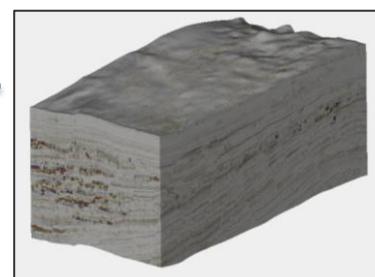


Distribution function of entire
Ip dataset



Vertical variogram

Fullstack



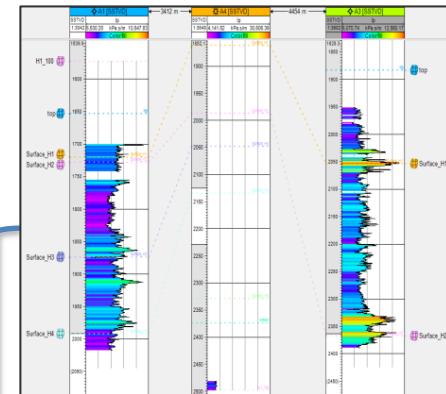
Horizontal variogram

Motivation

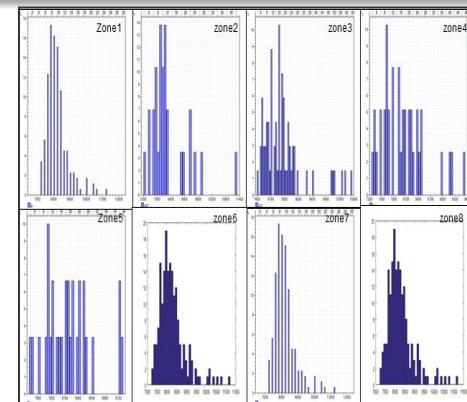
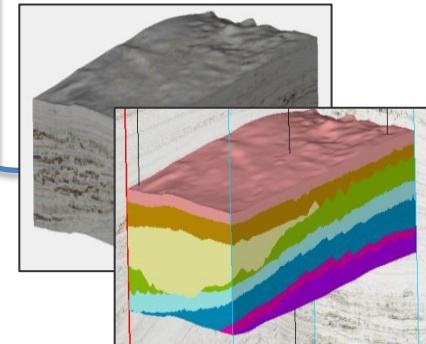
**GSI
by zones**

- It's based on:
- 1 distribution function by zone
- 1 variogram model by zone

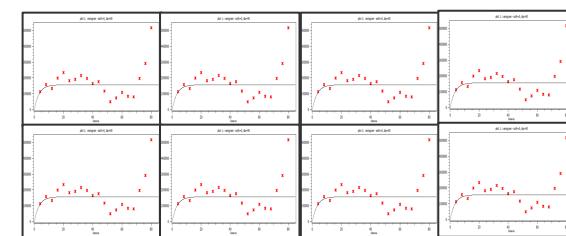
Wells log data



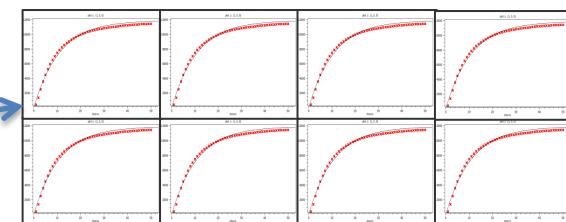
Fullstack in zones



Distribution function
by zones

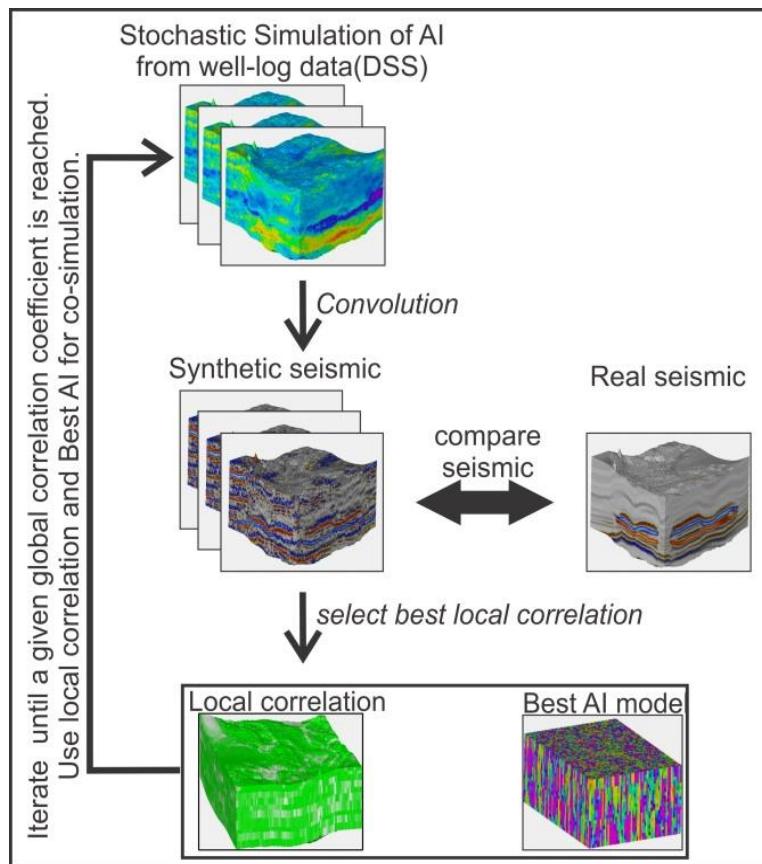


Set of vertical
variograms by
zones



Set of
horizontal
variograms by
zones

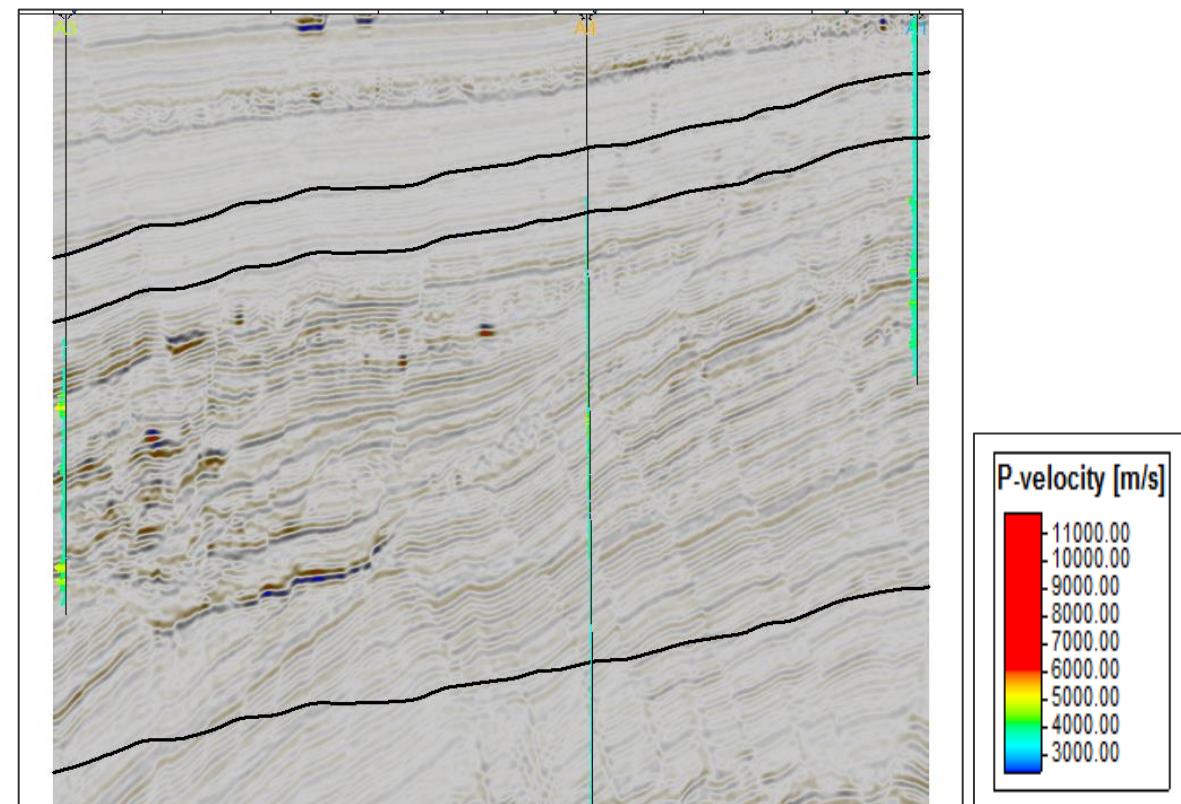
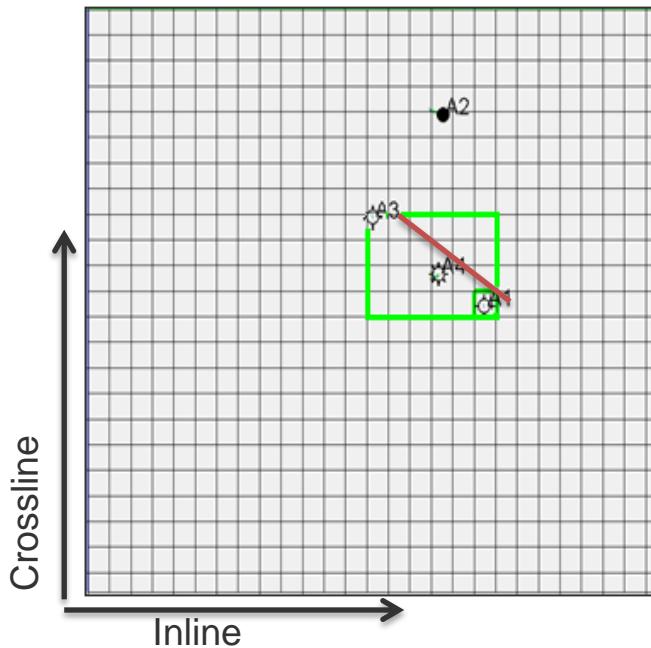
Methodology



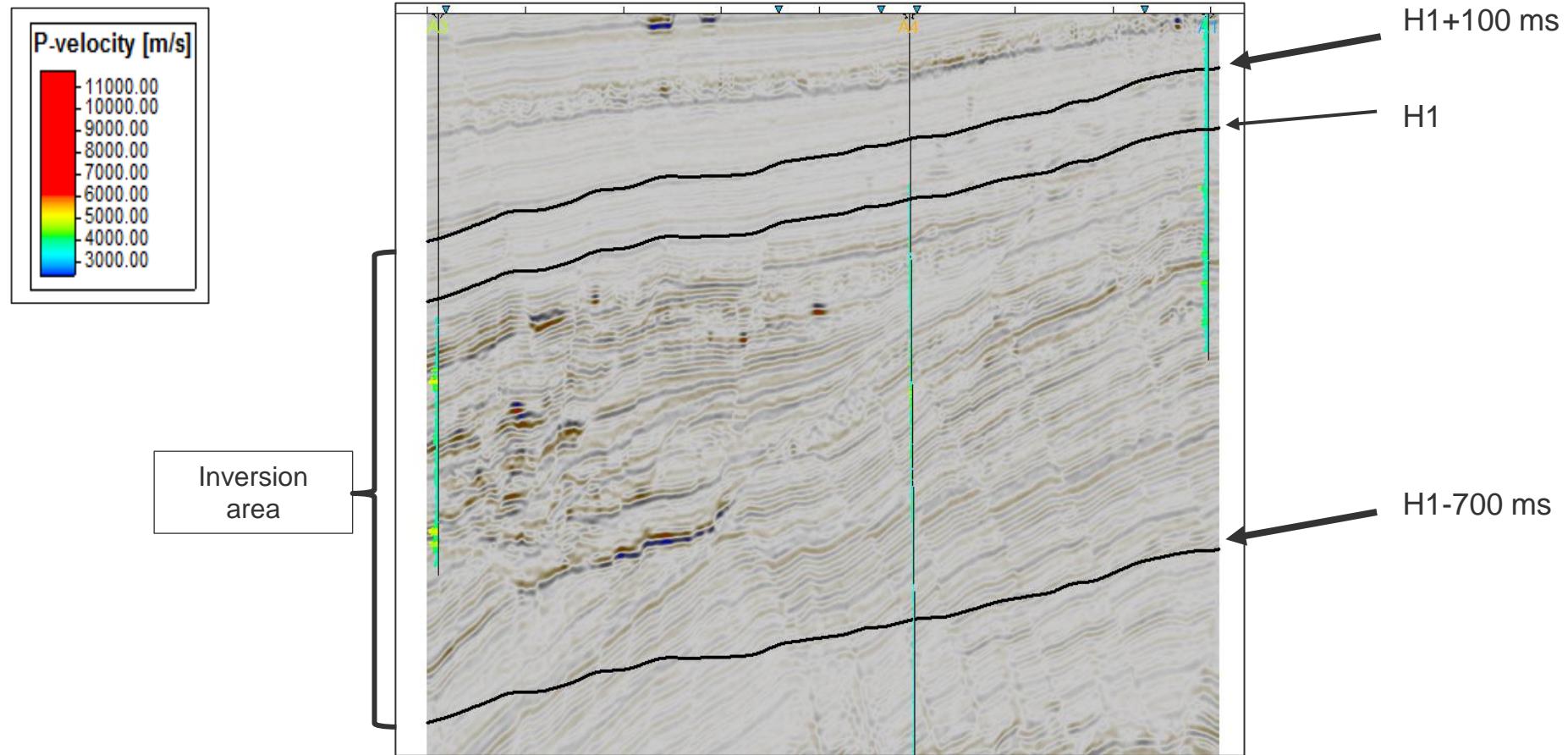
- The traditional methodology GSI (Geostatistical seismic inversion) allow the inversion of post-stack reflection data, directly for AI models.
- And uses a global optimizer based on a cross-over genetic algorithm to converge the simulated earth model, toward an objective function, that consist on the correlation coefficient between the real seismic and the synthetic seismic volume.

Dataset description

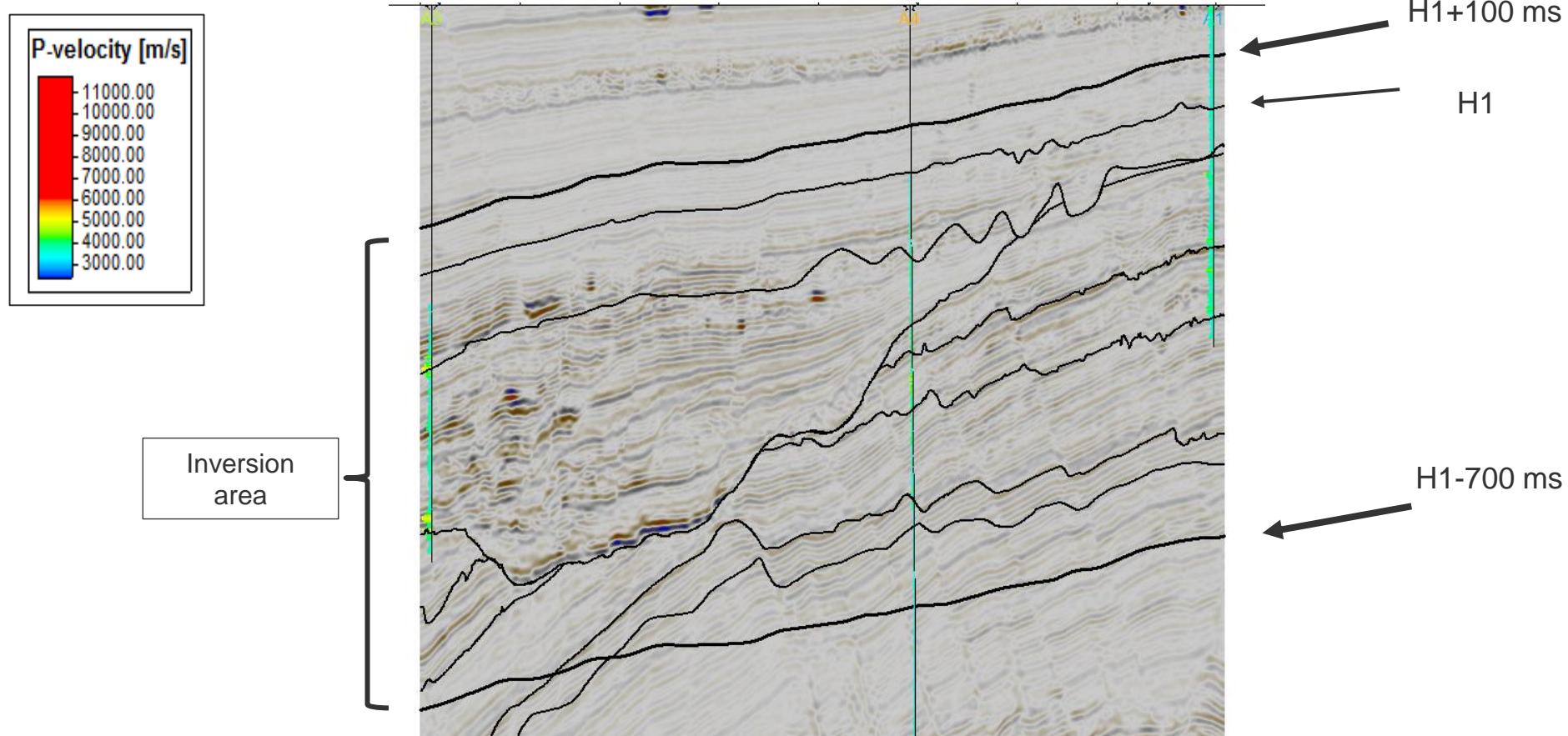
- Grid size: 398 x 598 x 200.
- Seismic volume of 794 inline by 1194 crossline
- sample rate of 4ms
- 4 wells with Ip and Is, 3 wells assessed (A1,A3,A4)



Model Definition for the traditional GSI



Model Definition for the GSI by zones



Inversion Parameterization

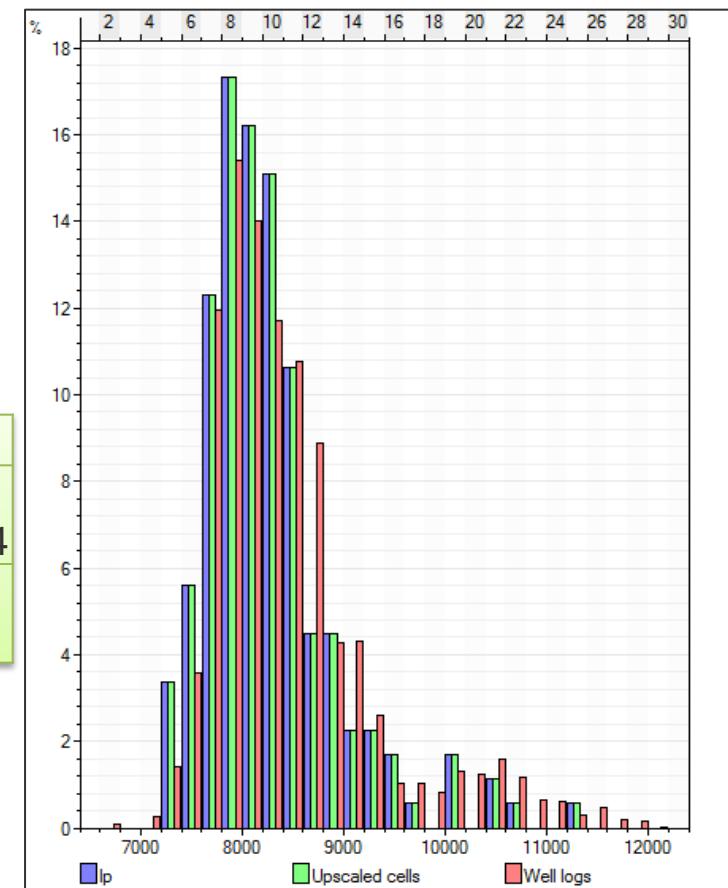
- 6 iterations between layers
- 32 models of l_p simulated at each iteration
- 3 well were used as conditioning data (A1, A3, A4)
- Spatial continuity pattern expressed by a variogram model with 2 structures
 - *Vertical variogram from well-log data*
 - *Horizontal variogram from seismic*
- Cell thickness in $k = 4$ ms

Traditional GSI

Inversion Parameterization:

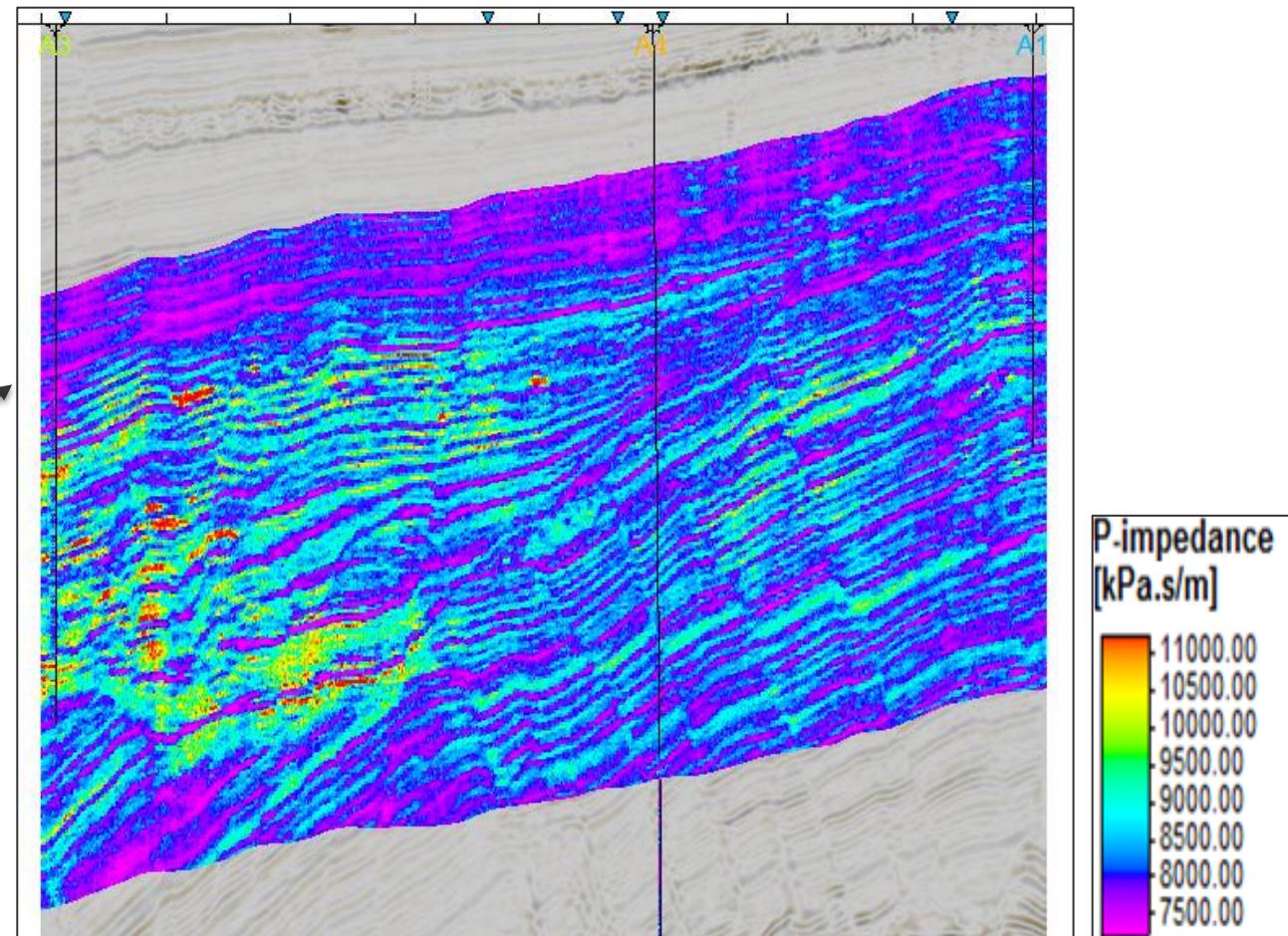
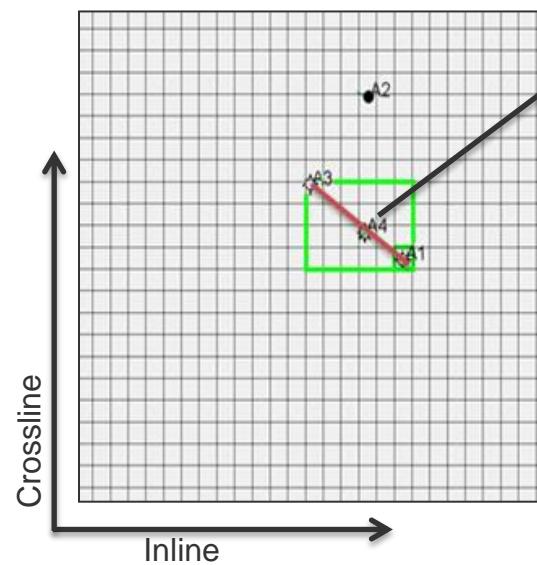
Acoustic impedance values from the wells

Name	Min	Max	Mean	Std	Var
Property	7214.42	11213.21	8266.45	659.52	434970.4
Well logs	6611.53	12019.38	8460.36	835.2	697563



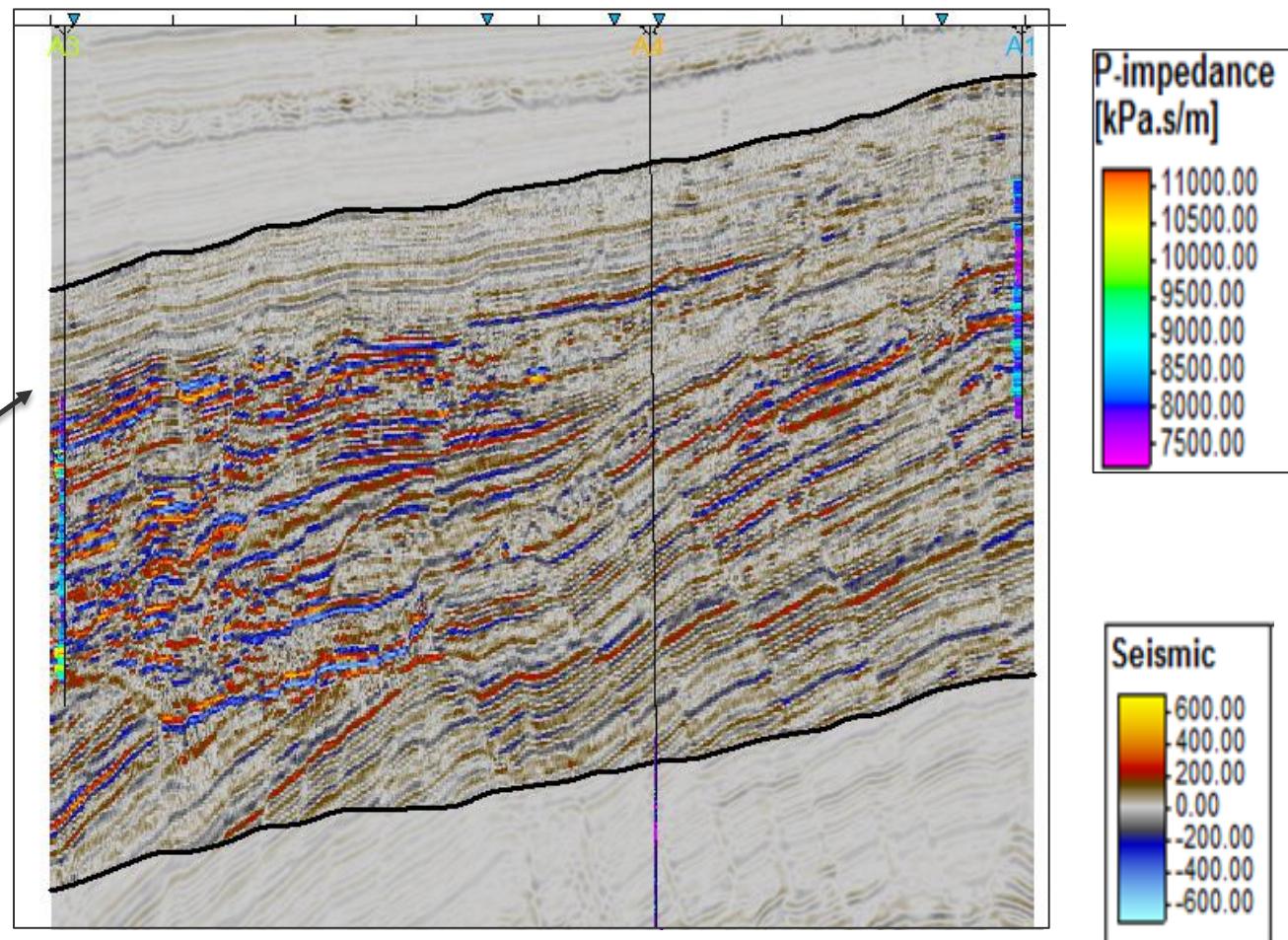
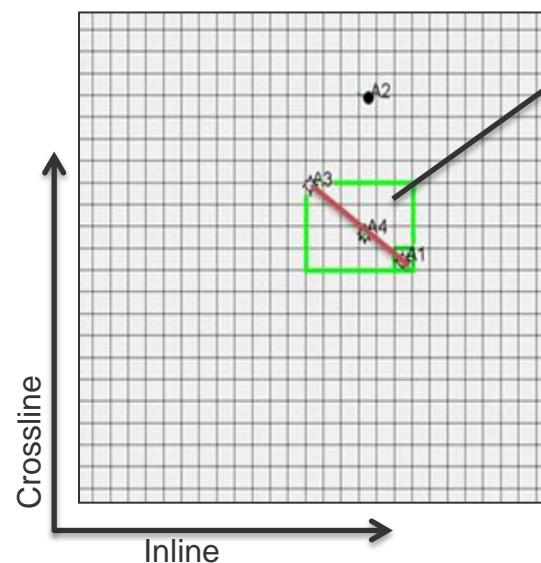
Traditional GSI

Results: best AI model from last iteration 6



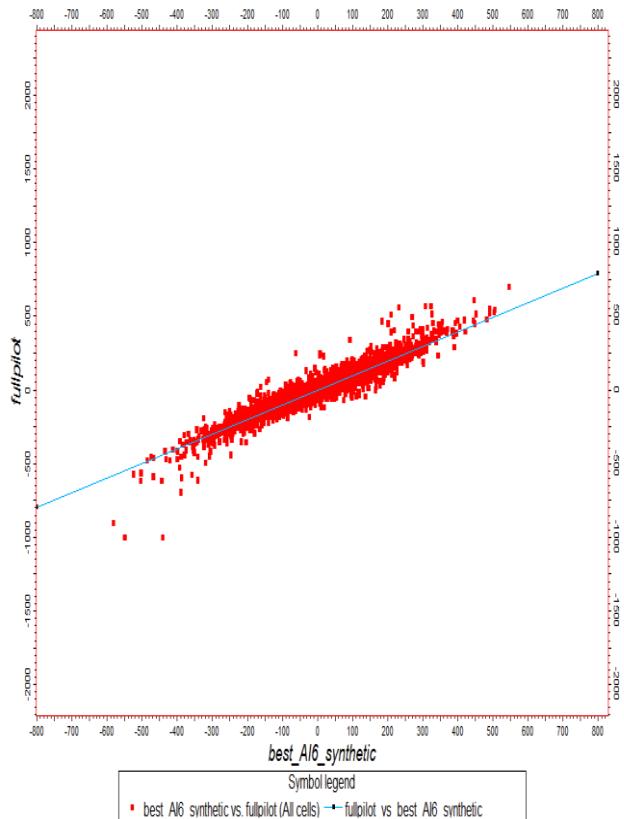
Traditional GSI

Results: Synthetic seismic from the best AI model



Traditional GSI

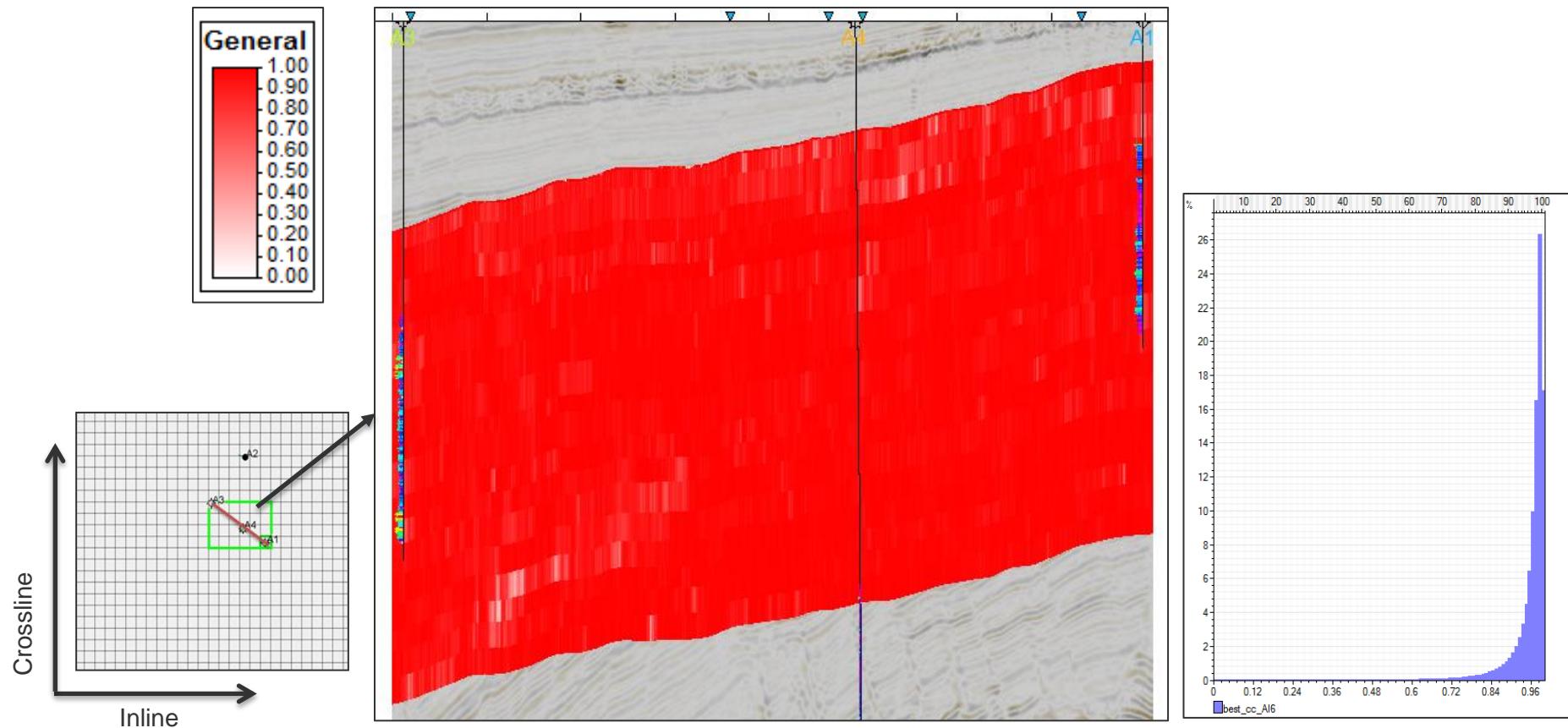
Results: correlation between synthetic and real seismic



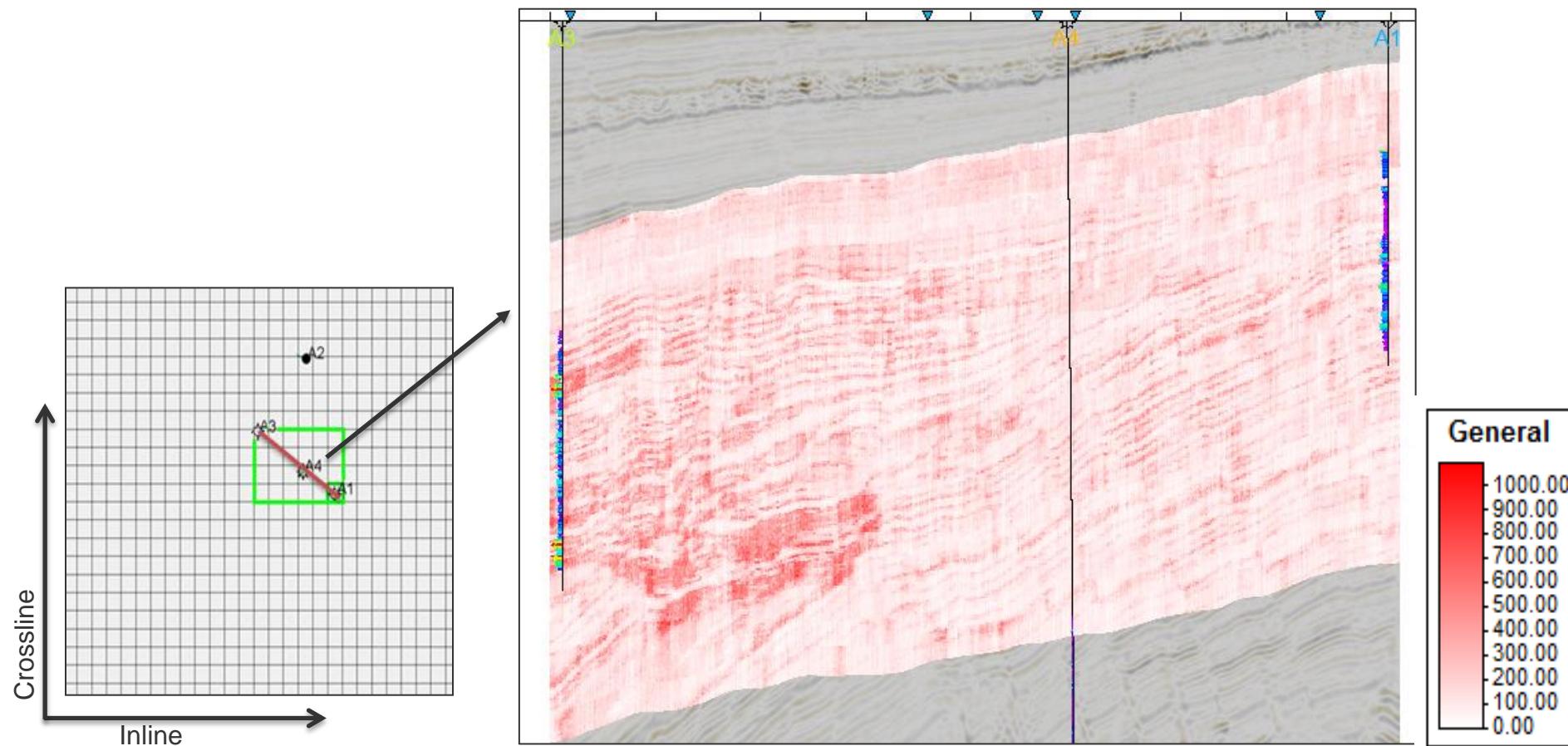
Global correlation coefficient between synthetic computed from the best model of the last iteration and real seismic ~0.951

Traditional GSI

Results: local correlation coefficients from last iteration

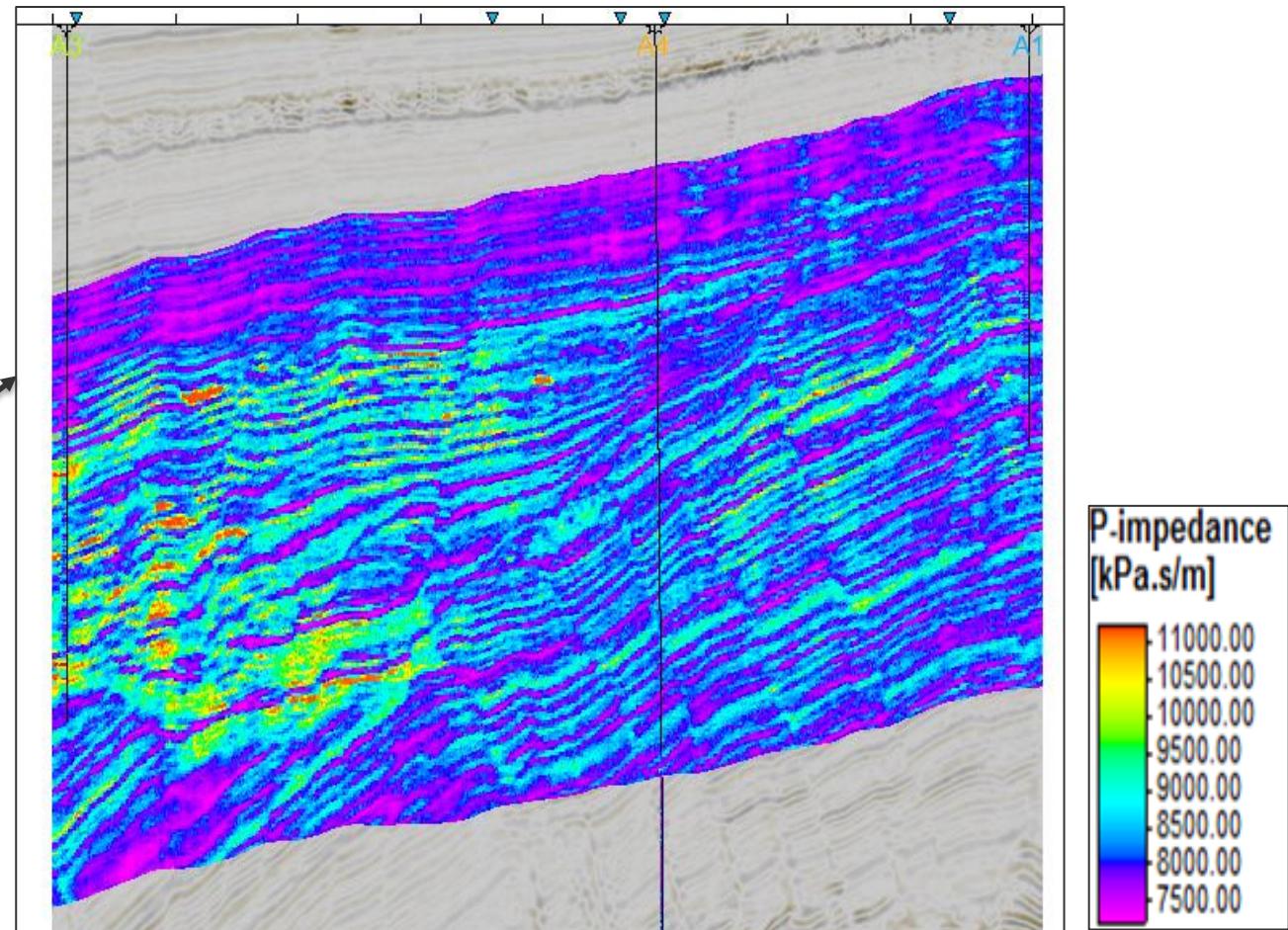
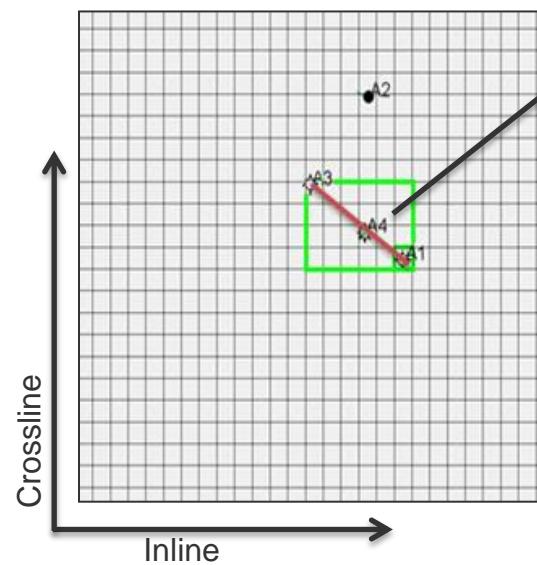


Traditional GSI

Results: *standard deviation*

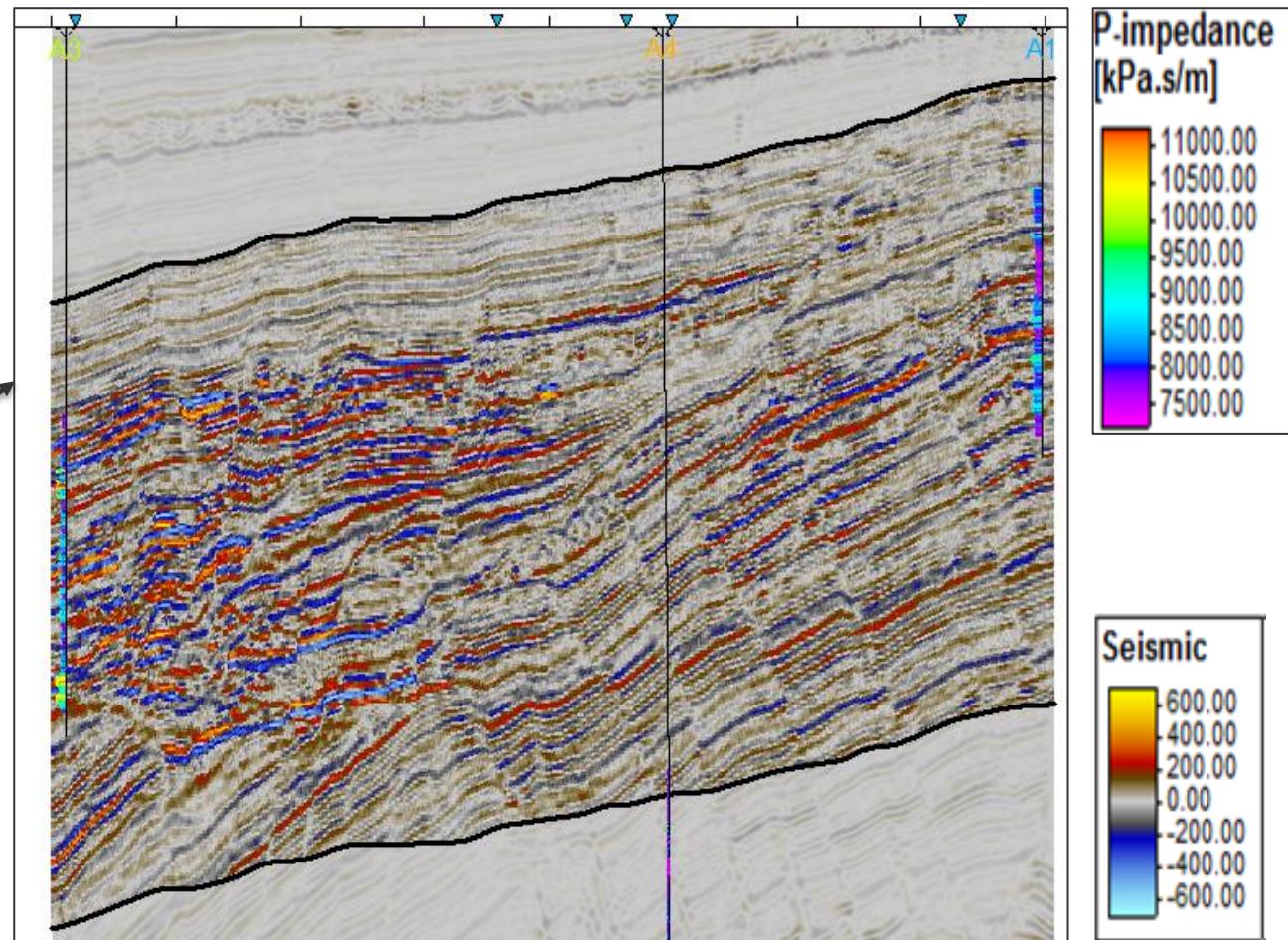
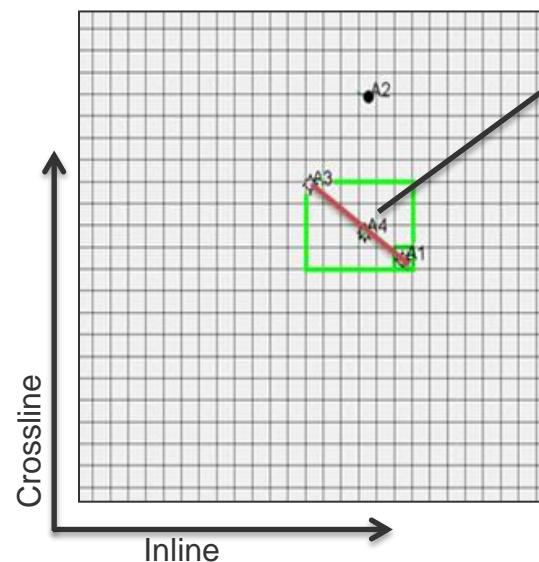
Traditional GSI

Results: mean AI
model from last
iteration



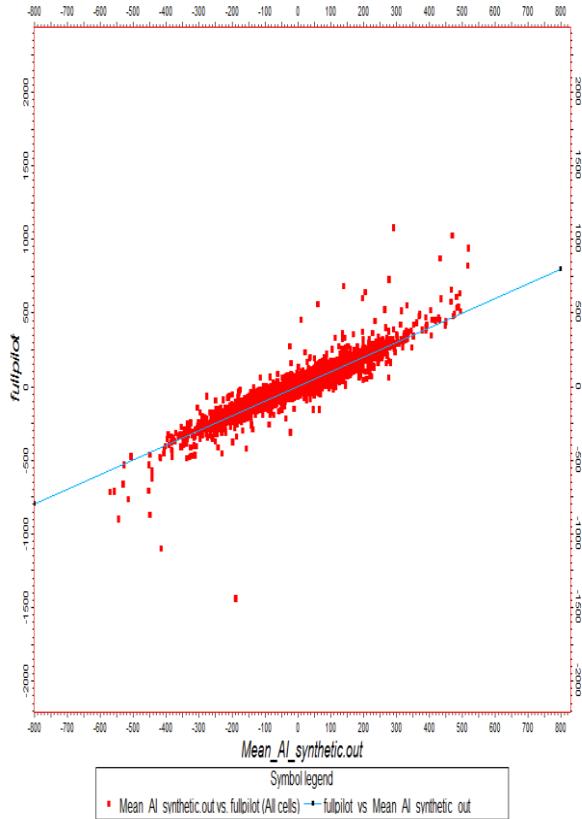
Traditional GSI

Results: Synthetic seismic from mean AI model from last iteration



Traditional GSI

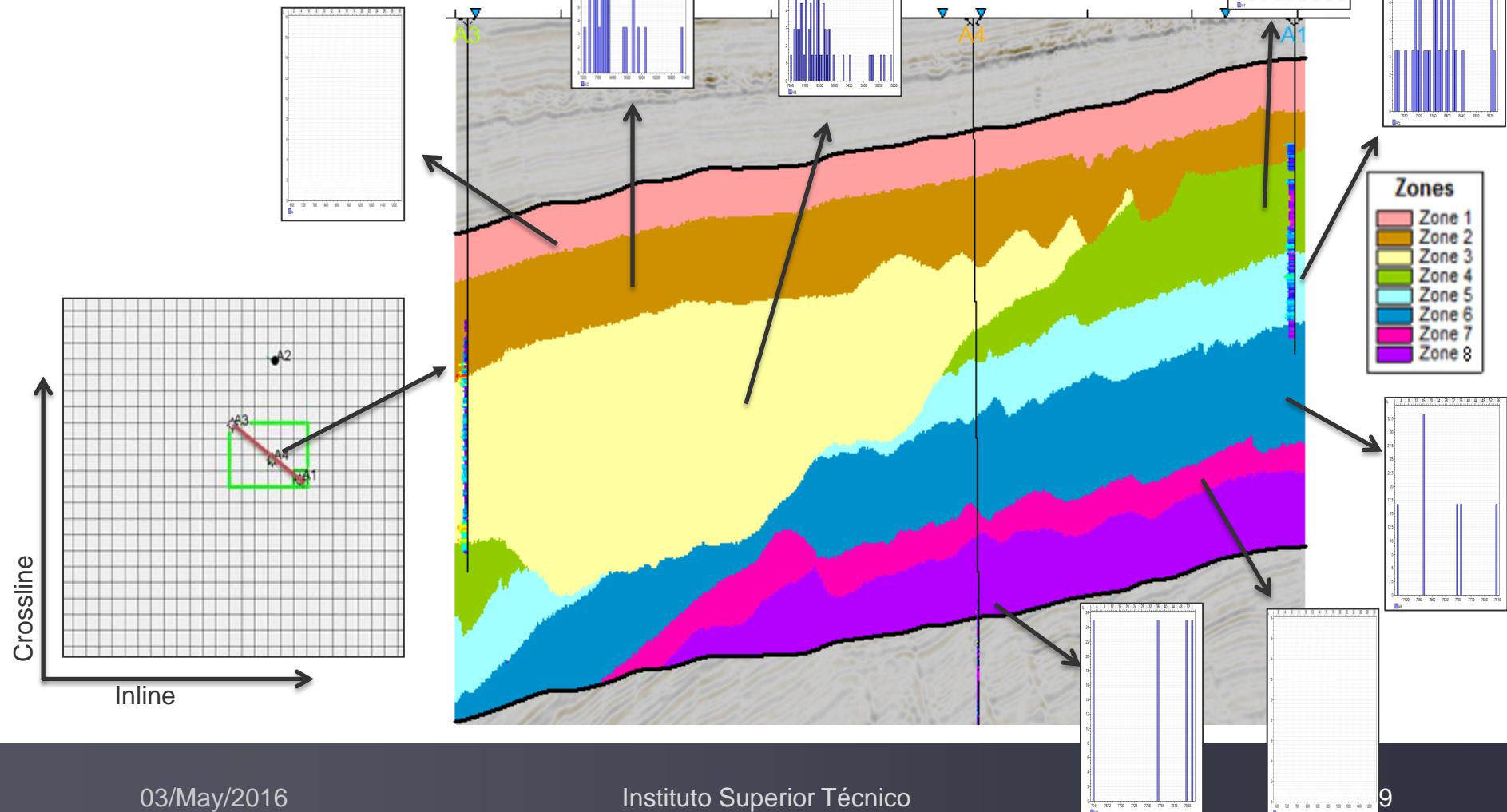
Results: correlation between synthetic and real seismic



Global correlation coefficient between synthetic
computed from mean model and real seismic
~0.946

GSI by zones

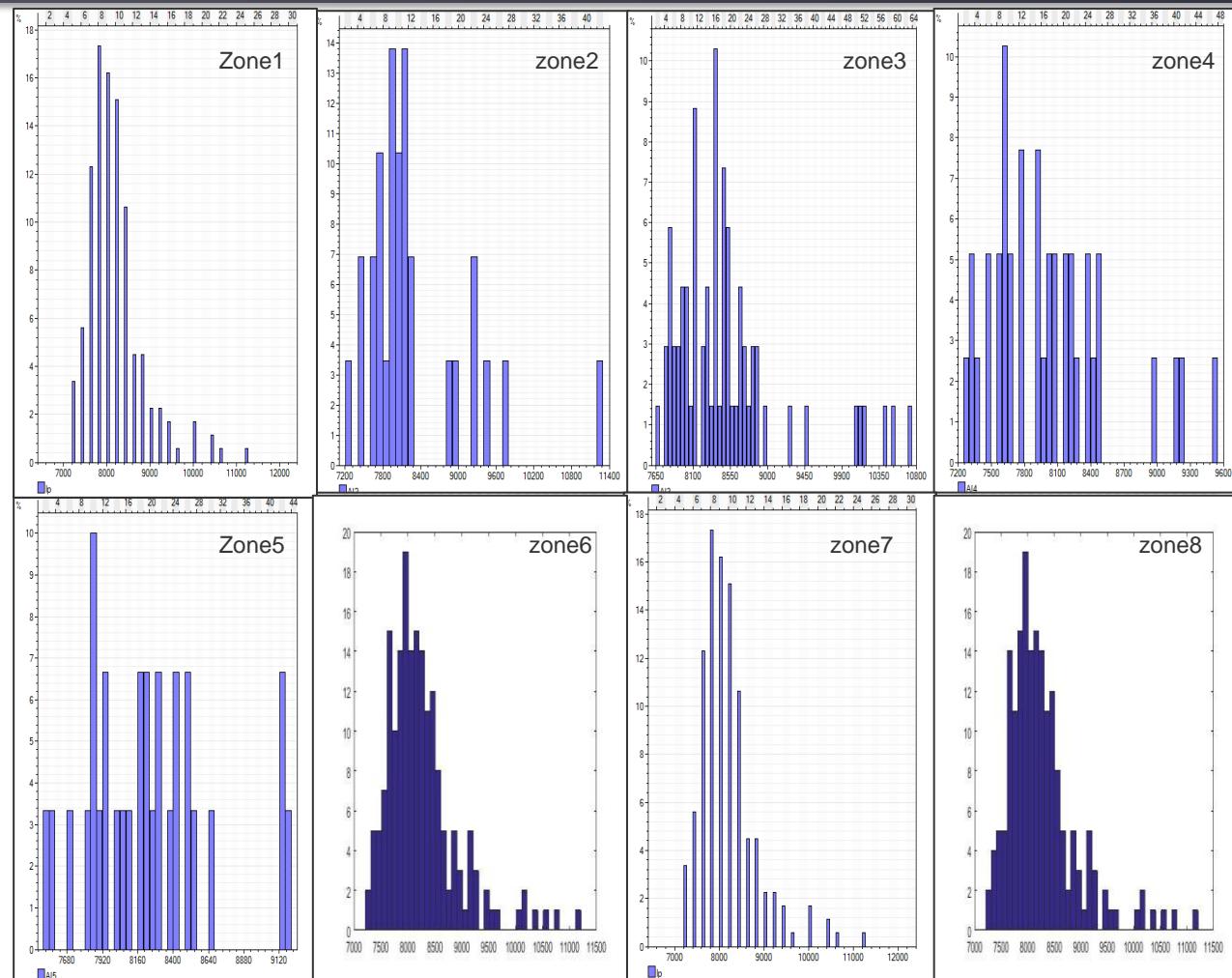
Division by zones



GSI by zones

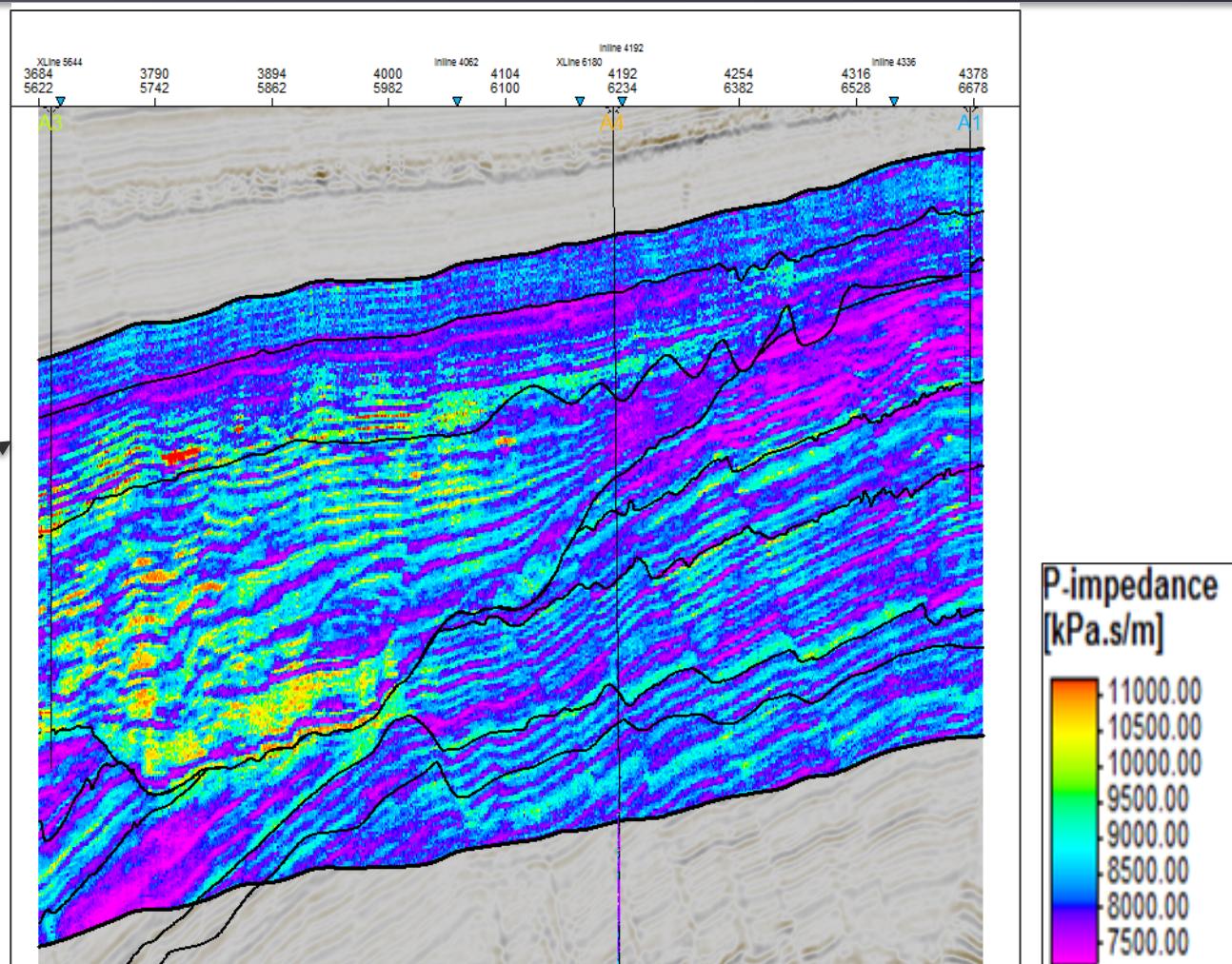
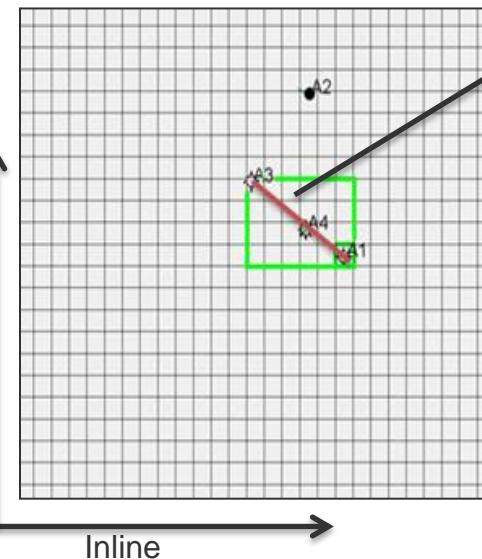
Inversion Parameterization:

- Histograms of Ip dataset of all zones 1-8.
- Zones 1 and 7 have the same dataset with the entire Ip data but with coordinates far away from the study area because they had not any data.
- In zones 6 and 8 have been included all dataset of Ip as well, because their dataset were not enough to simulate the methodology



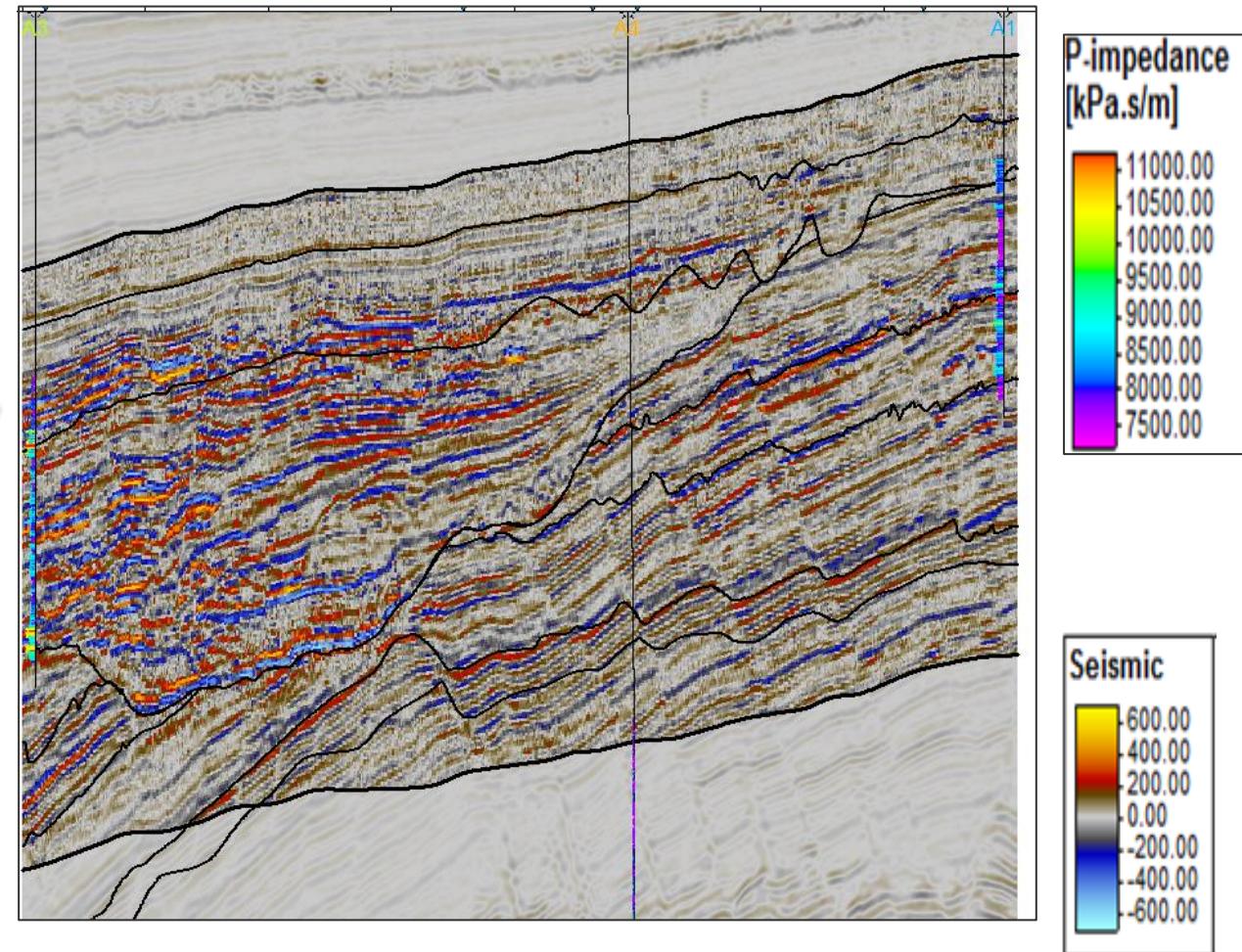
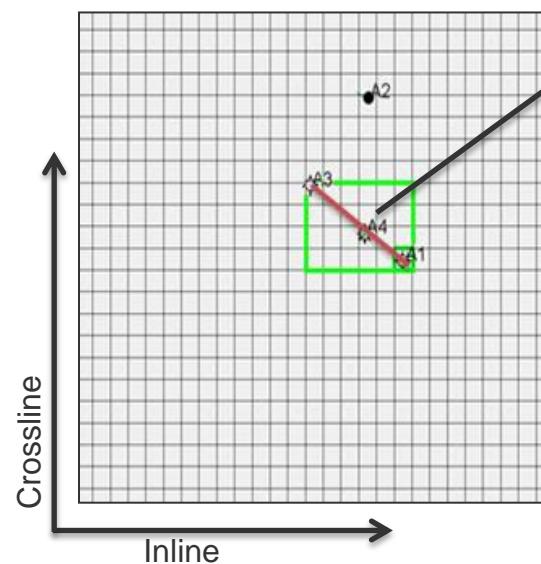
GSI by zones

**Results: best AI
model from last
iteration 6**



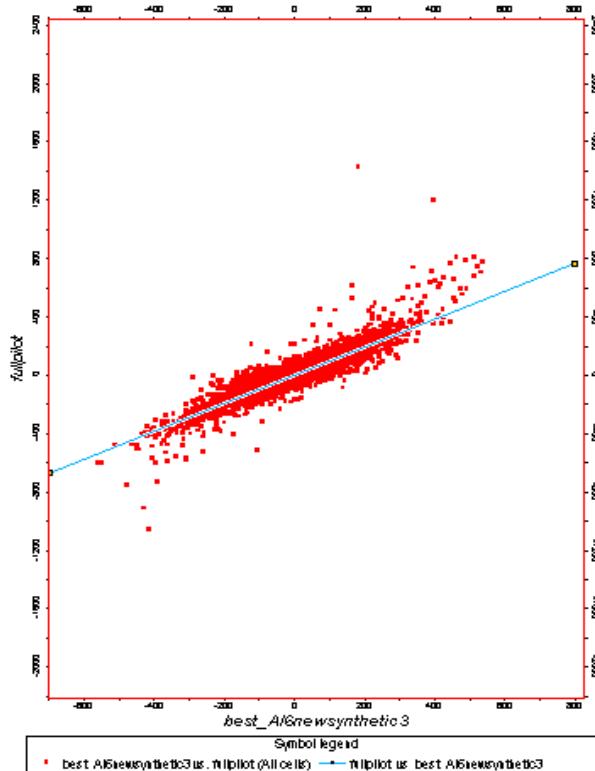
GSI by zones

Results: Synthetic seismic from the best AI model



GSI by zones

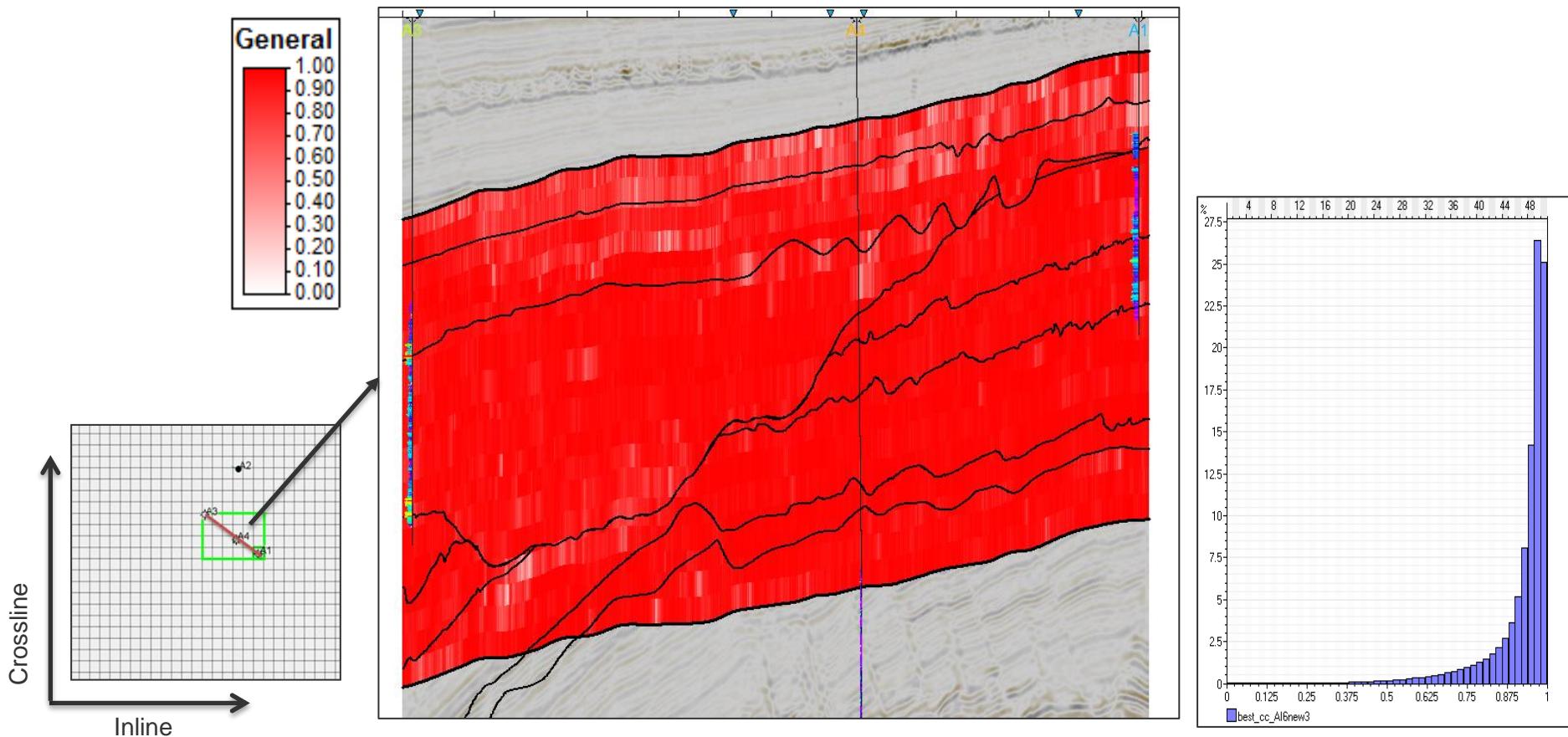
Results: correlation between synthetic and real seismic



Global correlation coefficient between synthetic computed from the best model of the last iteration and real seismic ~0.926

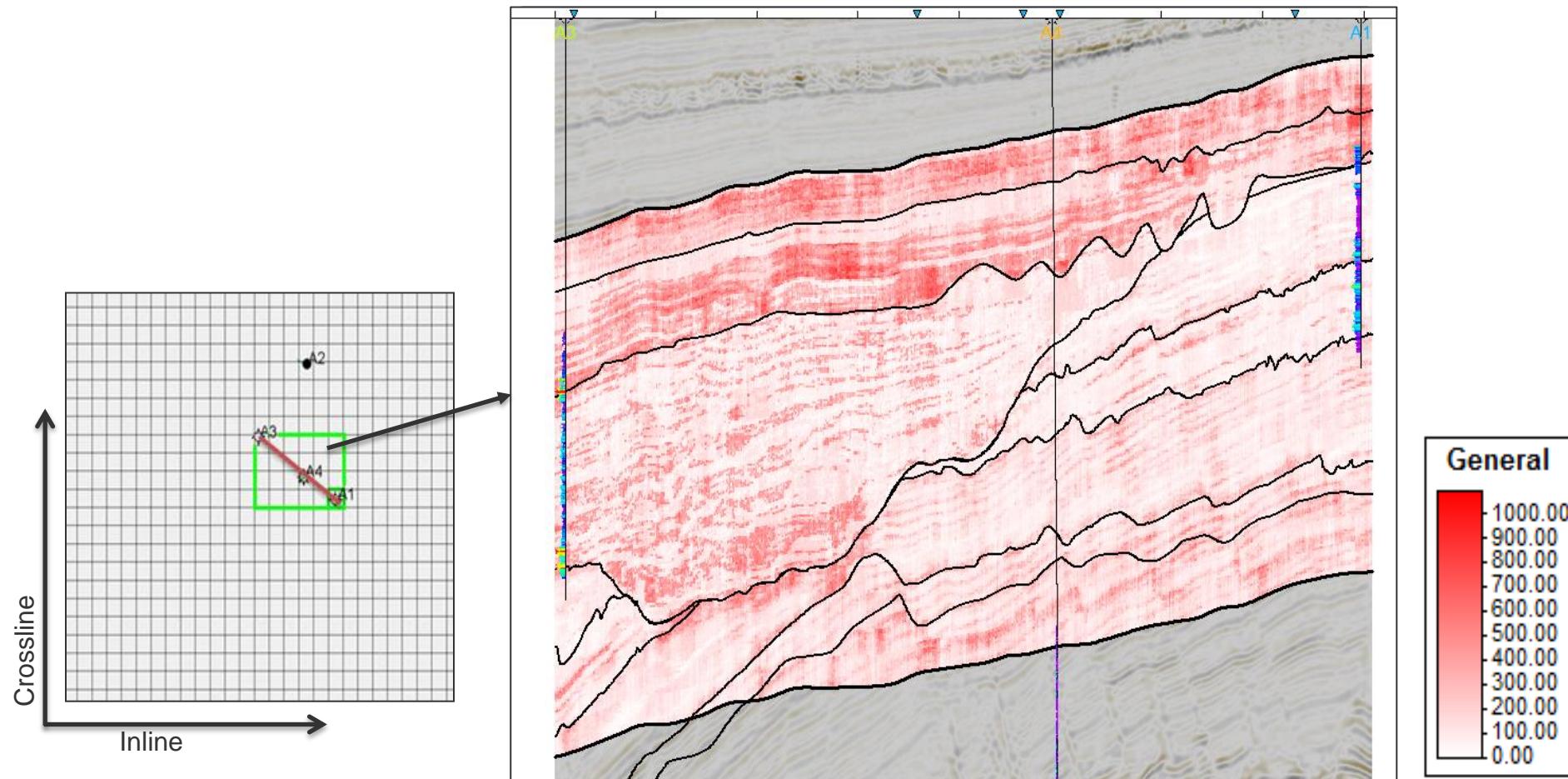
GSI by zones

Results: local correlation coefficients from last iteration



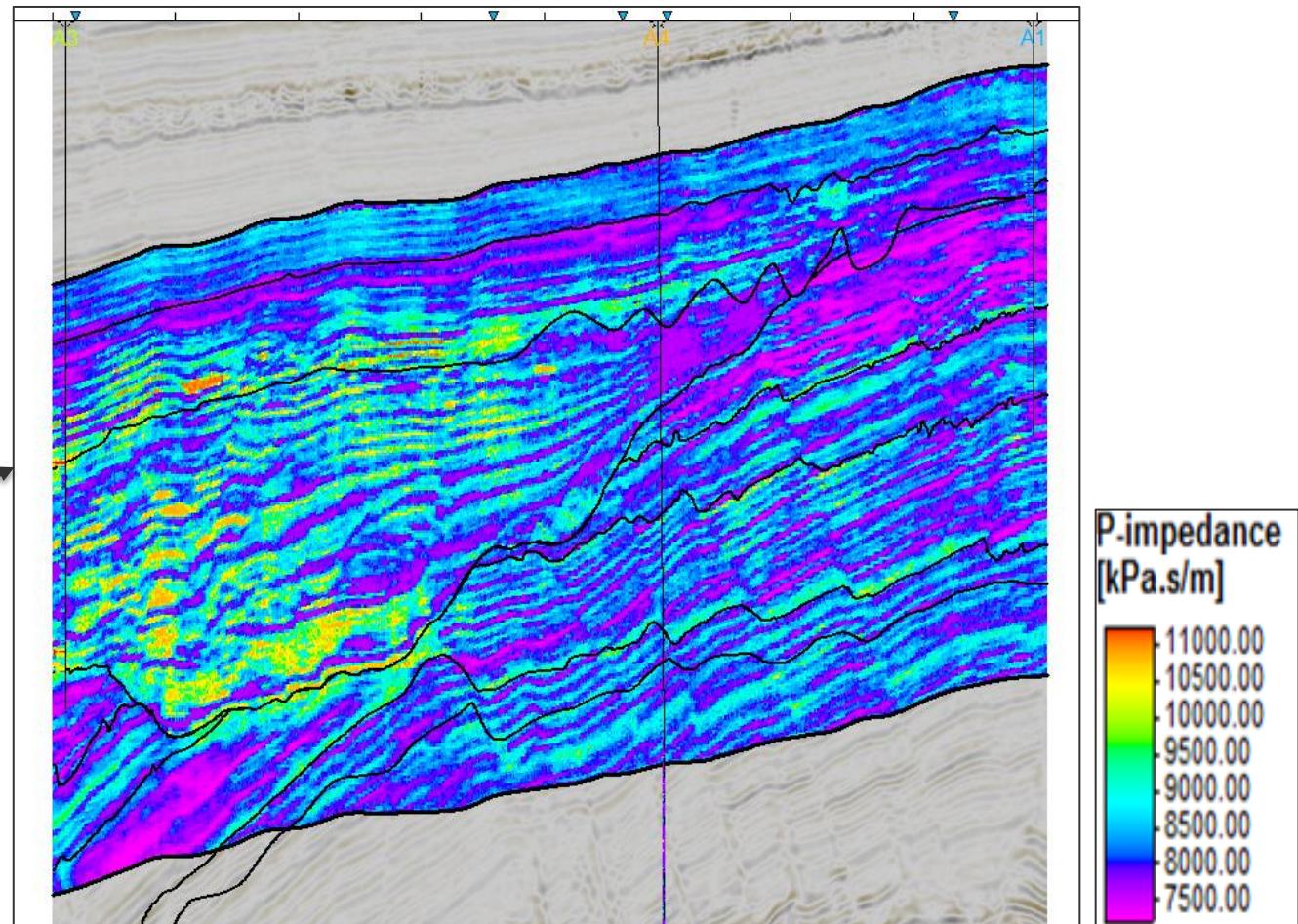
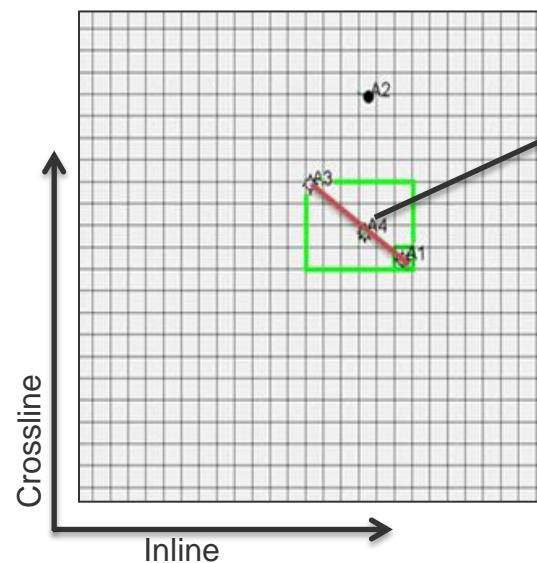
GSI by zones

Results: standard deviation



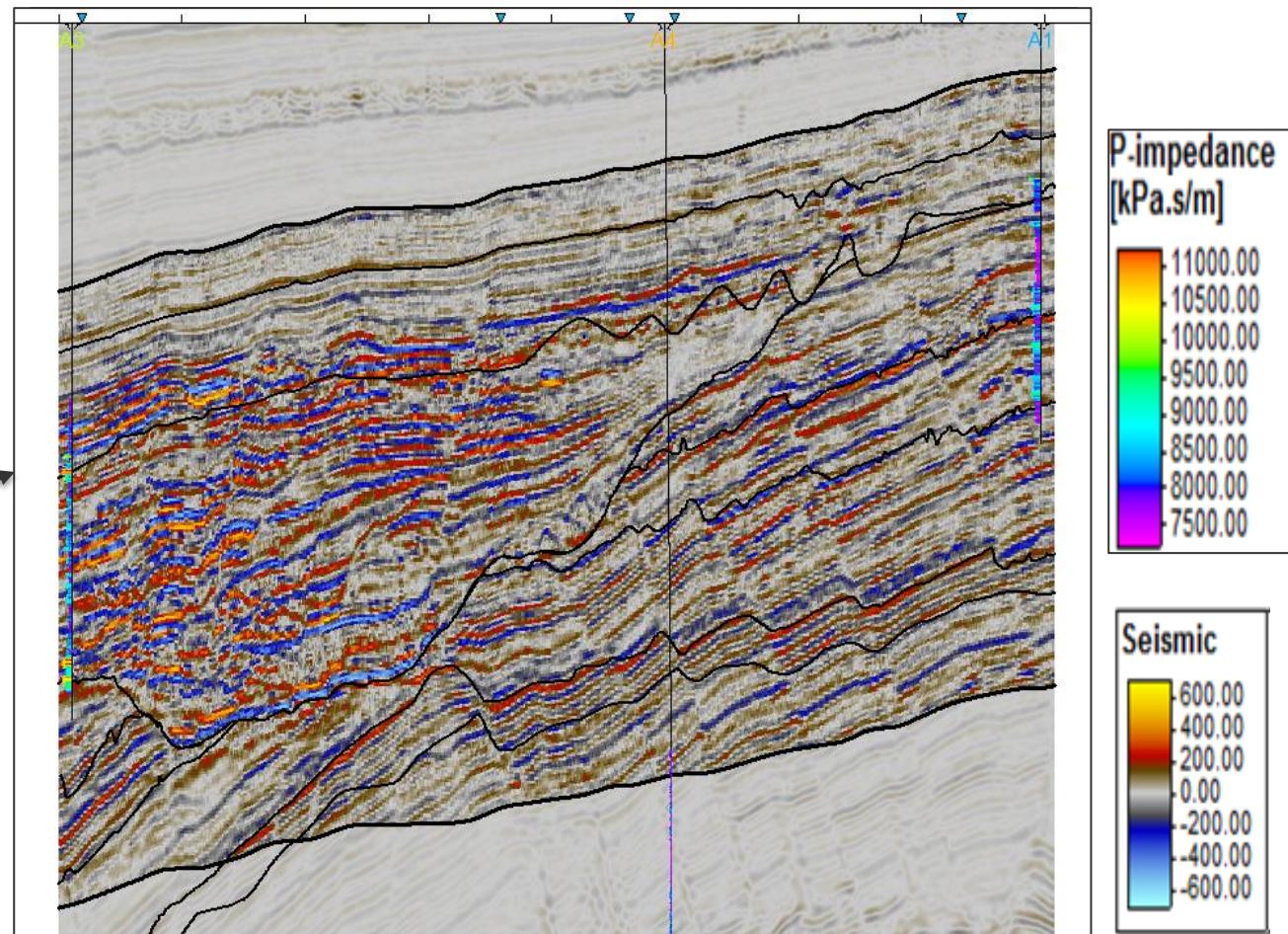
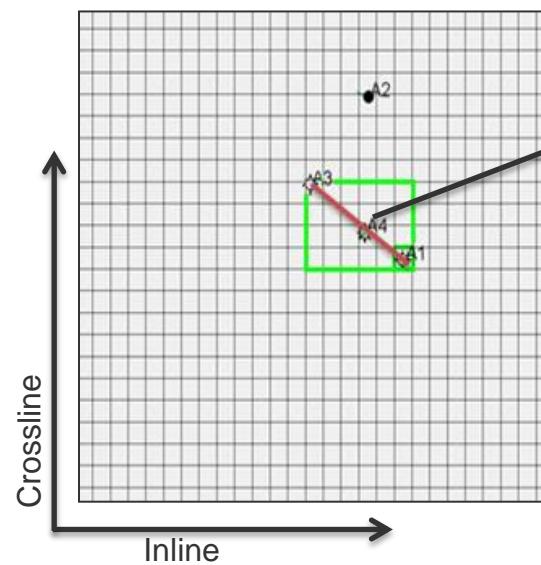
GSI by zones

**Results: mean AI
model from last
iteration**



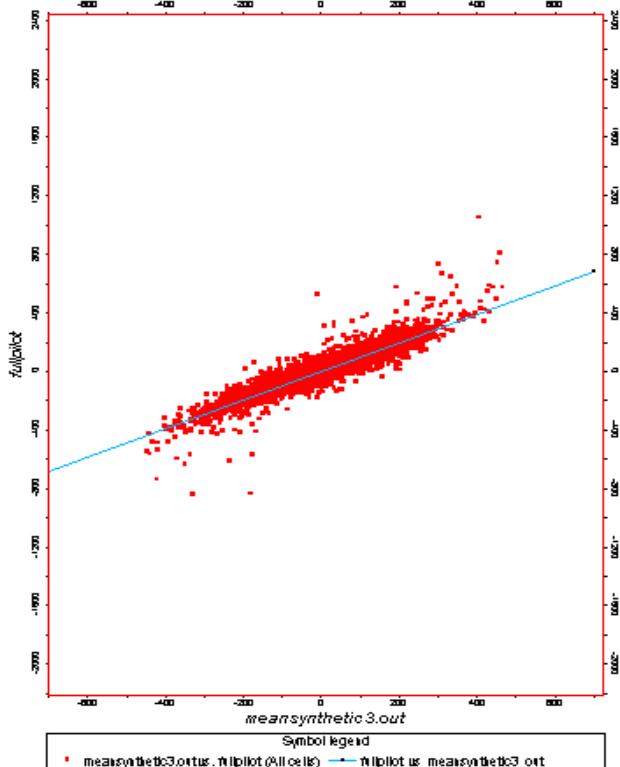
GSI by zones

Results: Synthetic seismic from mean AI model from last iteration



GSI by zones

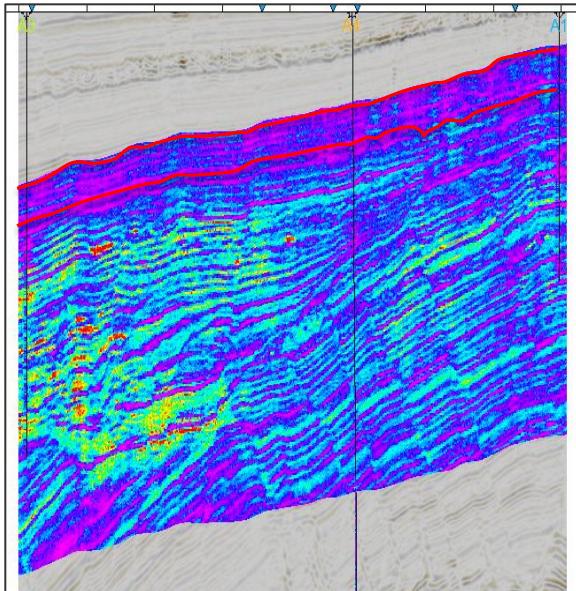
Results: correlation between synthetic and real seismic



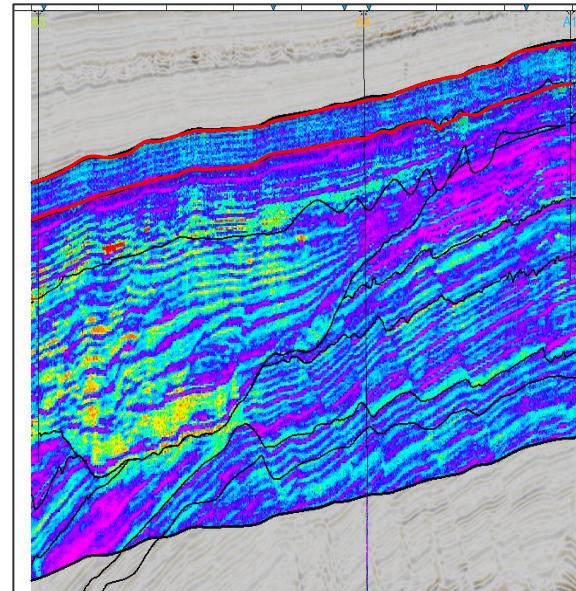
Global correlation coefficient between synthetic
computed from mean model and real seismic
~0.922

Comparison of results

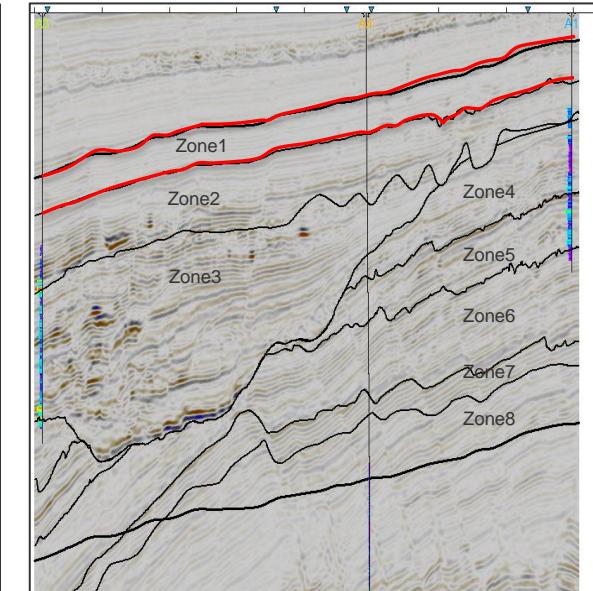
Best model without zones



Best model by zones

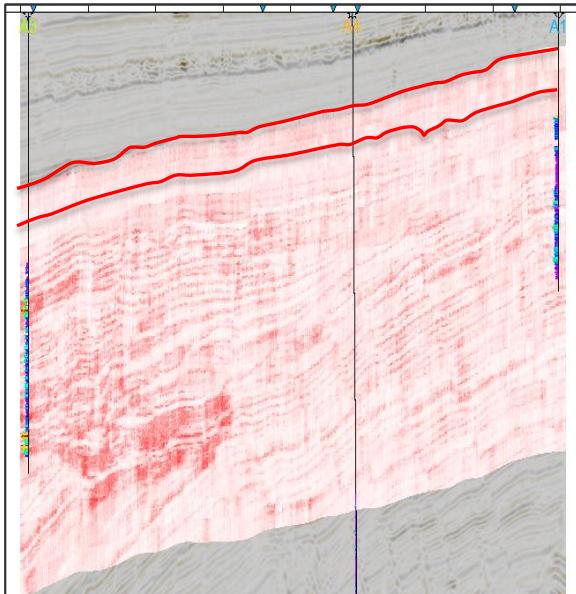


Fullstack seismic

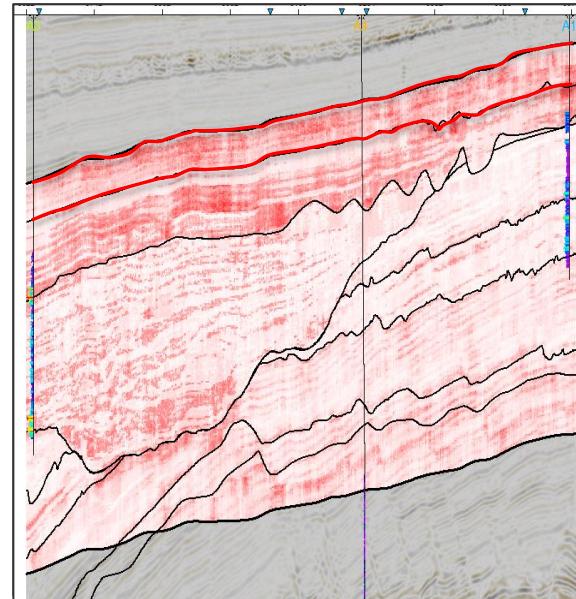


Comparison of results

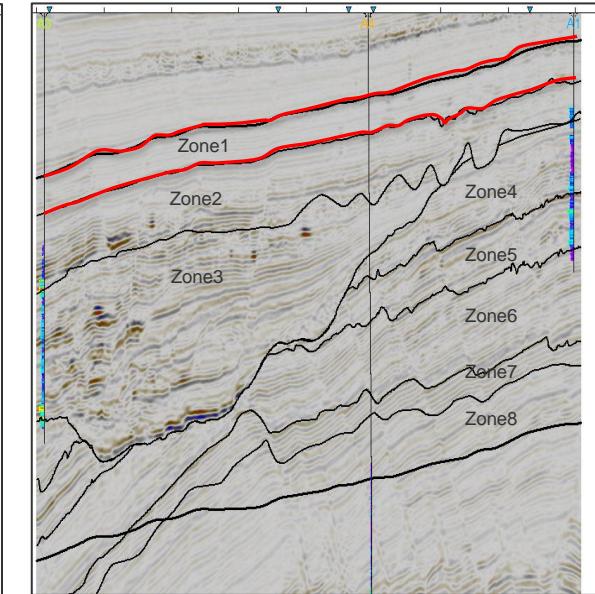
Std desviation without zones



Std desviation by zones

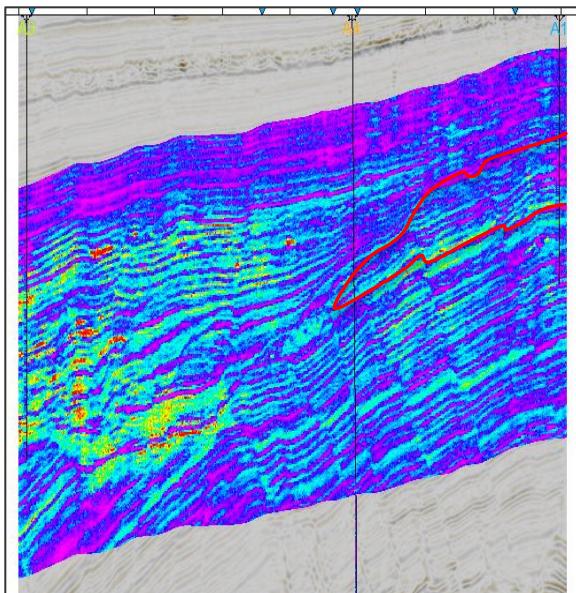


Fullstack seismic

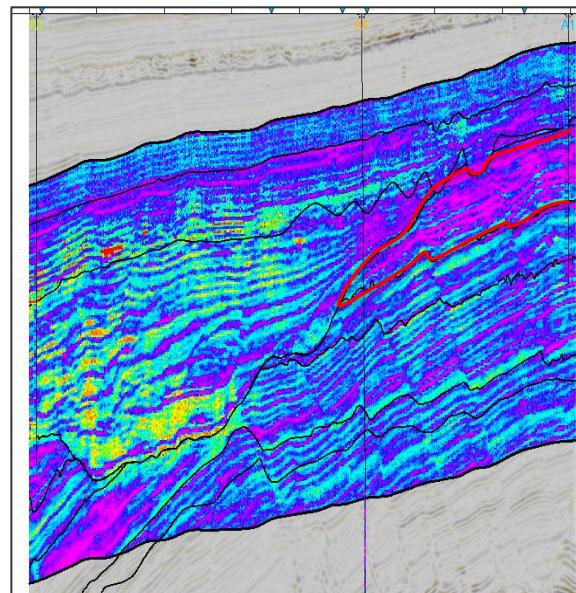


Comparison of results

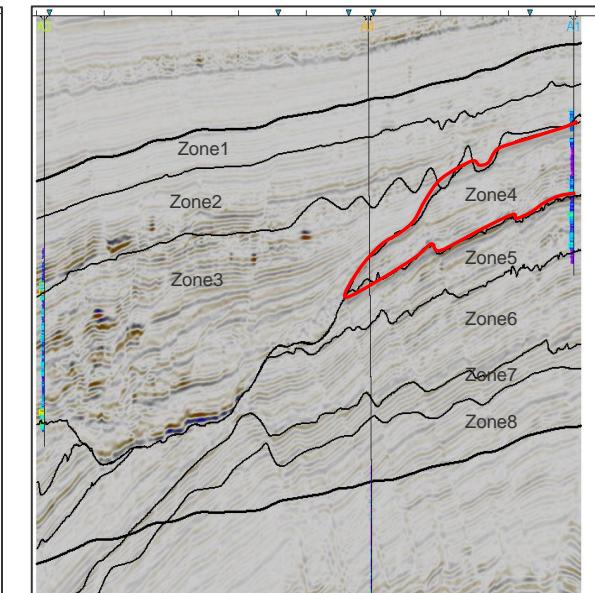
Best model without zones



Best model by zones

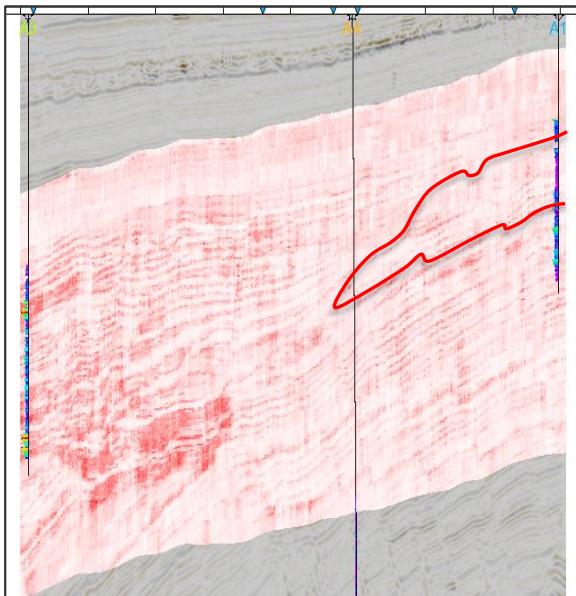


Fullstack seismic

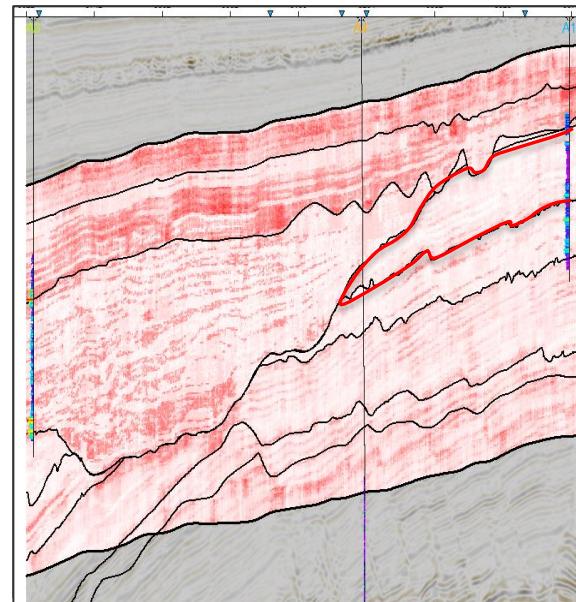


Comparison of results

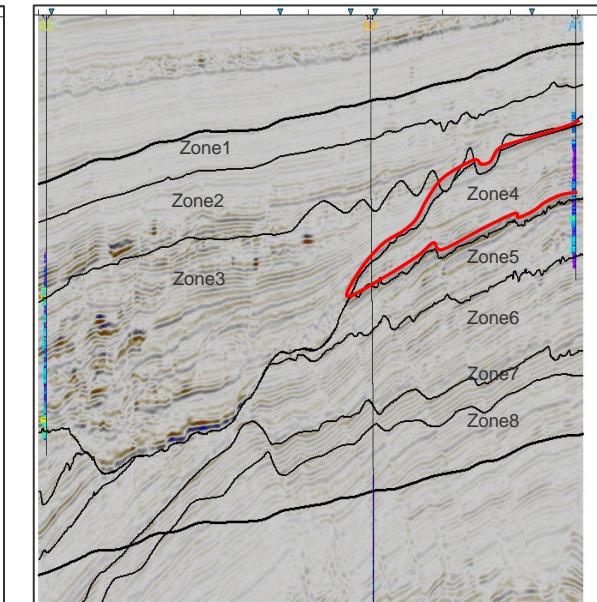
Std desviation without zones



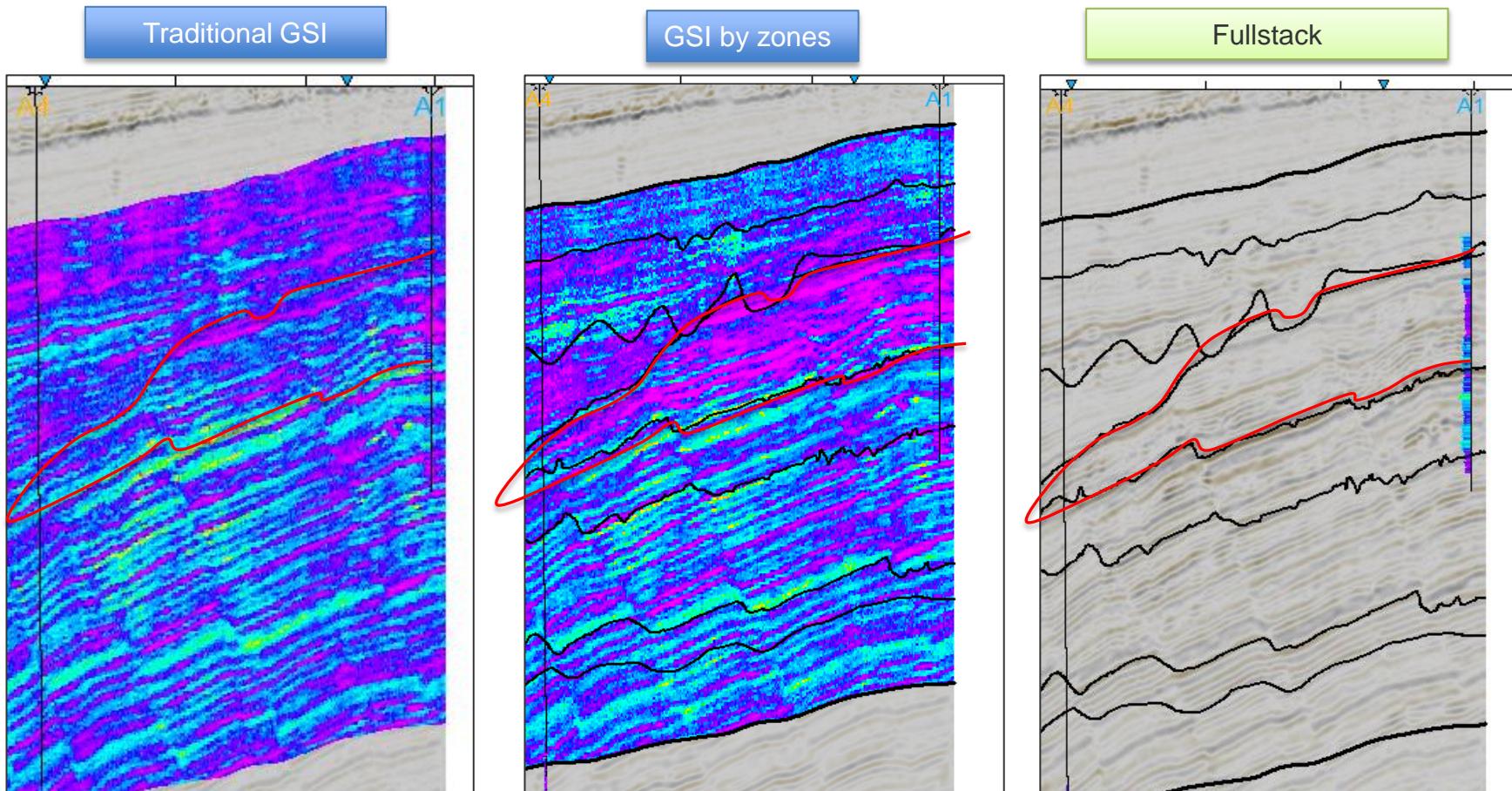
Std desviation by zones



Fullstack seismic



Comparison of results in zone 4, more in detail



Conclusion

- ❖ The ability to integrate data from others wells or taking the entire data values of some property to incorporated in the different zones is an advantage of the proposed methodology, since the values used to populate the conditioning distribution are assigned to each seismic unit individually.
- ❖ The methodology is very flexible allowing complex spatial regionalization to be reproduce and simple enough to use, and allowing high numbers of scenarios to be tested.
- ❖ At the end, the retrieve inverse models are more geologically realistic since incorporated the knowledge of the subsurface geology.

- Thanks to Partex and CERENA/CMRP for supporting my research work and for providing me the necessary datasets to test and to implement the new algorithms presented in this work.
- Thanks Schlumberger for the academic donation of Petrel® license.

References

- Avseth, Per, Tapan Mukerji, and Gary Mavko. 2005. *Quantitative Seismic Interpretation*. Cambridge University Press
- Azevedo,L. 2013 Thesis “Geostatistical methods for integrating seismic reflection data into subsurface Earth models”
- Azevedo,L., R.Nunes, A.Soares, C.Mundin.Evaldo, and N.Guenther Schwedersky, Integration of well data into geostatistical seismic amplitude variation with angle inversion for facies estimation:Geophysic,80,no 6. Doi: 10.1190/GEO2015-0104.1
- Barclay,F., A.Bruun, J.Camara, A. Cooke, D.Cooke, F.Gonzalez..."Inversion sísmica: Lectura entre lineas" Publication Schlumberger, Oilfield Review Summer 2008, vol 20, issue 1.
- Dvorkin, Gutierrez and Grana. 2014 “Seismic Reflections of Rock Properties”. Cambridge University.
- Horta, A., & Soares, A. (2010). Direct Sequential Co-simulation with Joint Probability Distributions. *Math Geosci*, pp. 262-292.
- Rutherford and Williams 1989; Avseth, Mukerji, and Mavko 2005; J. Castagna and Backus 1993
- Michael E. Brownfield and Ronald R. Charpentier: Geology and Total Petroleum Systems of the West-Central Coastal Province (7203), West Africa, U.S.G.S Bulletin 2207-B. June 2006.
- Nunes. R, Soares. A, Azevedo. L and Pereira.P, : Geostatistical seismic inversion with direct sequential simulation and co-simulation with multi-local distribution functions, CERENA. 2016.
- Schoellkopf, N. B., and B. A. Patterson, 2000, Petroleum systems of offshore, Cabinda, Angola, in M. R. Mello and B. J. Katz, eds., Petroleum systems of South Atlantic margins: AAPG Memoir 73, p. 361–376
- Shuey, R.T. 1985. “A Simplification of the Zoeppritz Equations.” *Geophysic* 50 (4)(April): 609-614. doi: 10.1190/1.1441936.
- Soares, A. (2000). *Geoestatística para Ciências da Terra e do Ambiente*, 1^a Edição. Lisboa: IST Press.
- Soares, Amilcar.2001. “Direct sequential Simulation and Cosimulation.” *Mathematical Geology* 33(8): 911-926
- Soares, Amilcar, JD Diet, and Luis Guerreiro. 2007. “Stochastic Inversion with a Global Perturbation Method.” *Petroleum Geostistics*, EAGE, Cascais, Portugal (September 2007): 10-14.
- Tarantola, Albert. 2005. *Inverse Problem Theory*. SIAM



GRACIAS DANKSCHEEN
SPASSIBO SNACHALUJA
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MAKE SUKSAMA
MAKKE EKHMET
KOMAPSUMANIDA MEHRBANI
HERASEREMY GOZAIMASHITA
EFCHARISTO KAVYDE
FAKAUE Paldies
THANK YOU TINGKI
NATRI S BİYAN
EXAM SHUKRIA
SRIDAO HAYKIN
BOLZİN MERCI MENDONCHAR