Seismic Pre-Stack Igneous Reservoir Characterization:
Guanaco Field Study Case, Neuquina Basin, Argentina*

Hernán De Simone[1], Mario Sigismondi[1], and Marcelo Barrionuevo[1]

[1]YPF S.A., Buenos Aires, Argentina (hernan.desimone@ypf.com)

Abstract

The basement of the Neuquina basin consists of plutonic, volcanic and epiclastic rocks of Choiyoi Formation. This type of reservoir shows strong heterogeneity, and the post-stack inversion cannot identify efficiently reservoirs. Pre-stack seismic inversion techniques can improve reservoir analysis by understand physical and fluid properties in fractured and altered intervals. Elastic properties from logs cross plot, SNR of the seismic data, and fractured intervals in these igneous rocks in a tectonic structural high helped to understand zones with possibility to storage gas. The Guanaco field is located in Neuquén province, west Argentina (Figure 1). 23 wells crossed the reservoir totally or partially, many of them have density and full wavelet sonic well logs, there is a very good quality 3D PSTM seismic registered in 2013 with favorable near and far offsets, nominal fold, bandwidth and specially oriented to illuminate these deep goals. These conditions are more than favorable for making seismic inversion in the pre-stack domain. The workflow applied consist in conditioning of gathers, as well as the evaluation of synthetic and real gathers in six key-wells, log´s cross plots such as Zp, Zs, LMR, YM and PR. These well-logs perform the low frequency model to run the final elastic volumes. The relationship between the behavior of the elastic properties and rocks mechanics, allow us to predict the fractured reservoir zones most hypothetically to find best prospects, leading to lower the risk in future drilling campaigns.

Introduction

Huincul High scope and Guanaco Field in special are structurally complex with different tectonic stages and in the ambit of an oblique convergence, referred to this there are several contributions that discourse it in detail; Silvestro and Zubiri (2008), Giunta et al (2018) between others. Productive units extend in almost entirety lithologic column. The structural evolution of Huincul Dorsal, southern Neuquina Basin, Argentina, is related with a main transpressional forces (Late Jurassic). As a result, a NE-N trending extensive struct, with several episodes of reactivation. The deformation uplift of Huincul Dorsal give the deformation of Basement along dominating North dip high angle thrust faults, that in zone of interest vertical offset near 2000 meters. The Huincul Dorsal structure zone (DHSZ) is essential a cortical boundary between the

Patagonia at south and the accreted terrain at North. The main object is to identify basement intervals most likely to be fractured, which is due to rock geomechanical properties and to the efforts they have been somite.

Method

3D seismic survey geometry in 234 km^2 area was designed to maximize attributes, such as offset (reaching 5600 m); wide azimuth and fold (182) to improve SNR and imaging deep goals as basement for a best interpretation. The performed sequence begins from feasibility of well logs elastic properties, preserving amplitude gather conditioning (Figure 2) and finally simultaneous inversion and results interpretation. The processing of gathers can have critical impact of the inversion analysis (Sigismondi, 2017). For gather conditioning, synthetic at well scale were generated using Elastic wave equations and evaluating the influence of phase changes and conditioning parameters. According to this, the conditioning stages of real gathers with modeled gather could be compared. A critical issue in all seismic inversion workflow is the account for missing frequency below the bandwidth. We need the wider bandwidth; therefore, we use the key well control in six locations.

To perform angle conversion, four possible velocities were tested: Well, PSTM processing, generated with multi attribute neural networks and generated with velocity modelling. The last one was selected for presenting better regionality and representativeness. At moment of perform Low frequency model, techniques of improvement are tested with using multiattributes regression to generate modeled filtered Impedances volumes (Kumar and Chopra 2016; Colwell, 2016), the results compared to the conventional technique were superior To run inversion, six wells were used, and three key wells were utilized for blind test. Wavelet combinations were tested, both vertically and by angle, finding the better combination. With Zp and Zs volumes was possible to calculate Lammé parameters $\lambda\rho$ and $\mu\rho$ (Goodway, el al; 1997) as illustrated in Figure 3, and other attributes to capture geobodies of interest at a seismic scale.

Several relationships between elastic properties and facies were tested in five wells geographically distributed, obtaining better discrimination with lambda-rho and-mu rho cross plots logs filtered at seismic scale. Because of this it is possible to separate six seismic facies families linked to rocks rheological behavior.

Results

As observed both in cross plots of elastic and geomechanical properties at well and seismic inversion scale (Figure 4), the best identification and capture occurs with attributes $\lambda\rho$ and $\mu\rho$, combining them with the calculation of brittleness (Kumar and Chopra 2015), where in the axis of $\mu\rho$ the discrimination is almost direct in all the scales evaluated, obtaining a consistent facies capture and classification. According to that, it is possible to use the tree properties in the capture. These properties are directly related to the physical characteristics of the reservoirs evaluated. Once the results were obtained it was possible to prove the geological model integrating them with rock data, petrophysics and seismic interpretation (horizons, faults and post stack attributes) helping to achieve a consistent static model.

Discussion

The effect of AVO and application of seismic inversion methods on sandstones with hydrocarbons has been proven on many occasions and by several authors: Ostrander 1984, Shuey 1985, Smith and Gidlow 1987, Rutherford and Williams 1989, Castagna and Swan 1997, Aki and

Richards 2002. Hampson, et al 2005, Chopra and Castagna 2014, among others. In this paper we propose the use of these techniques with some modifications resulting from recent research to solve rocks that diverge from the classic theory, conforming an unusual antecedent in the industry.

Conclusions

We perform gathers conditioning and compare with well synthetics, getting an acceptable correlation. Conditioned gathers quality es quite good (above 40°), which allows confidence at the time of obtaining attributes. Inversion analysis test were performed with different parameters, searching for better results. With inversion attributes (Zp, Zs y VpVs ratio) we could obtain elastic and geomechanics properties: LMR, Young modulus, Poisson ratio and Brittleness. By scaling elastic properties, is possible to capture facies geobodies identified in well logs. The relationship between elastic properties allow us to predict the fractured reservoir zones most hypothetically to find best prospects and increasing the chance of success of future drilling campaigns.

Acknowledgments

References Cited

Aki, K., and P.G. Richards, 2002, Quantitative Seismology, 2nd Edition: W.H. Freeman and Company.

Castagna, J.P., and H.W. Swan, 1997, Principles of AVO Cross Plotting: The Leading Edge, v. 6/4, p. 337-344.

Chopra, S., and J.P. Castagna, 2014, AVO, SEG Investigations in Geophysics Series No. 16, http://dx.doi.org/10.1190/1.9781560803201

Colwell, T., 2016, Low frequency velocity Model Building by combining Seismic and well velocity: CGG Geo consulting. 24 p.

Giunta, D., L. Fernández, J. Poblet, and J. Massaferro, 2018< Evolución tectosedimentaria del Grupo Cuyo en el ámbito occidental de la Dorsal de Huincul, Cuenca Neuquina, Argentina. 10° Congreso de Exploración y Desarrollo de Hidrocarburos, ConExplo 2018.

Goodway, W., T. Chen, and J. Downton, 1997, Improved AVO fluid Detection and Lithology Discrimination Using Lame Petrophysical Parameters: Extended Abstracts, Soc. Expl. Geophysics, 67th Annual International Meeting, Denver.

Hampson, D.P., B.H. Russell, and B. Bankhead, 2005, Simultaneous inversion of pre-stack seismic data: Ann. Mtg. Abstracts", SEG, p. 1633-1637.

Ostrander, W.J., 1984, Plane-wave reflection coefficients for gas sands at non-normal incidence: Geophysics, v. 49, p. 1637-1648.

Ray, A.K., and S. Chopra, 2016, Building more robust low-frequency models for seismic impedance inversion: First Break, v. 34/5, p. 29-34.

Rutherford, S.R., and R.H. Williams, 1989, Amplitude-versus-offset variations in gas sands: Geophysics, v. 54, p. 680-688.

Schiuma, M., and E.J. Llambías, 2008, New ages and chemical analysis on Lower Jurassic volcanism close to the Huincul High, Neuquén: Revista de la Asociación Geológica Argentina, v. 63, p. 644-652.

Sharma, R.K., and S. Chopra, 2015, Determination of lithology and brittleness of rocks with a new attribute: The Leading Edge, v. 34/5, p. 936-941.

Sigismondi, M.E., 2017, The impact of near traces conditioning on pre-stack characterization: SEG International Exposition and 87th Annual Meeting. http://dx.doi.org/10.1190/1.1451331.

Silvestro, J., and M. Zubiri, 2008, Convergencia Oblicua: Modelo estructural alternativo para la Dorsal Neuquina (39°S)-Neuquén: RAGA, v. 63, p. 49-64.

Shuey, R.T., 1985, A simplification of the Zoeppritz equations: Geophysics, v.50, p. 609-614.

Smith, G.C., and P.M. Gidlow, 1987, Weighted stacking for rock property estimation and detection of gas: Geophysical Prospecting, v. 35, p. 993-1014.
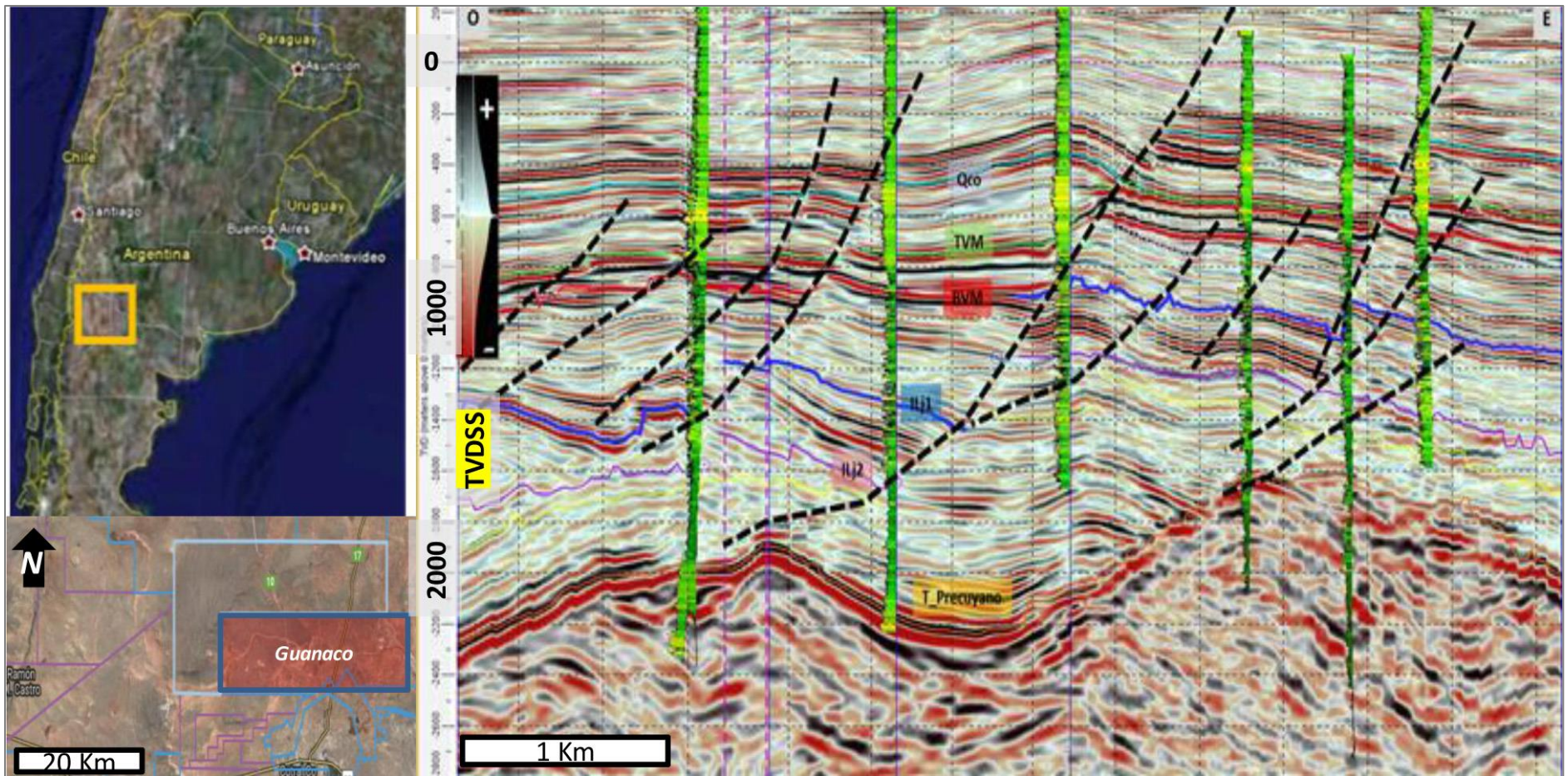
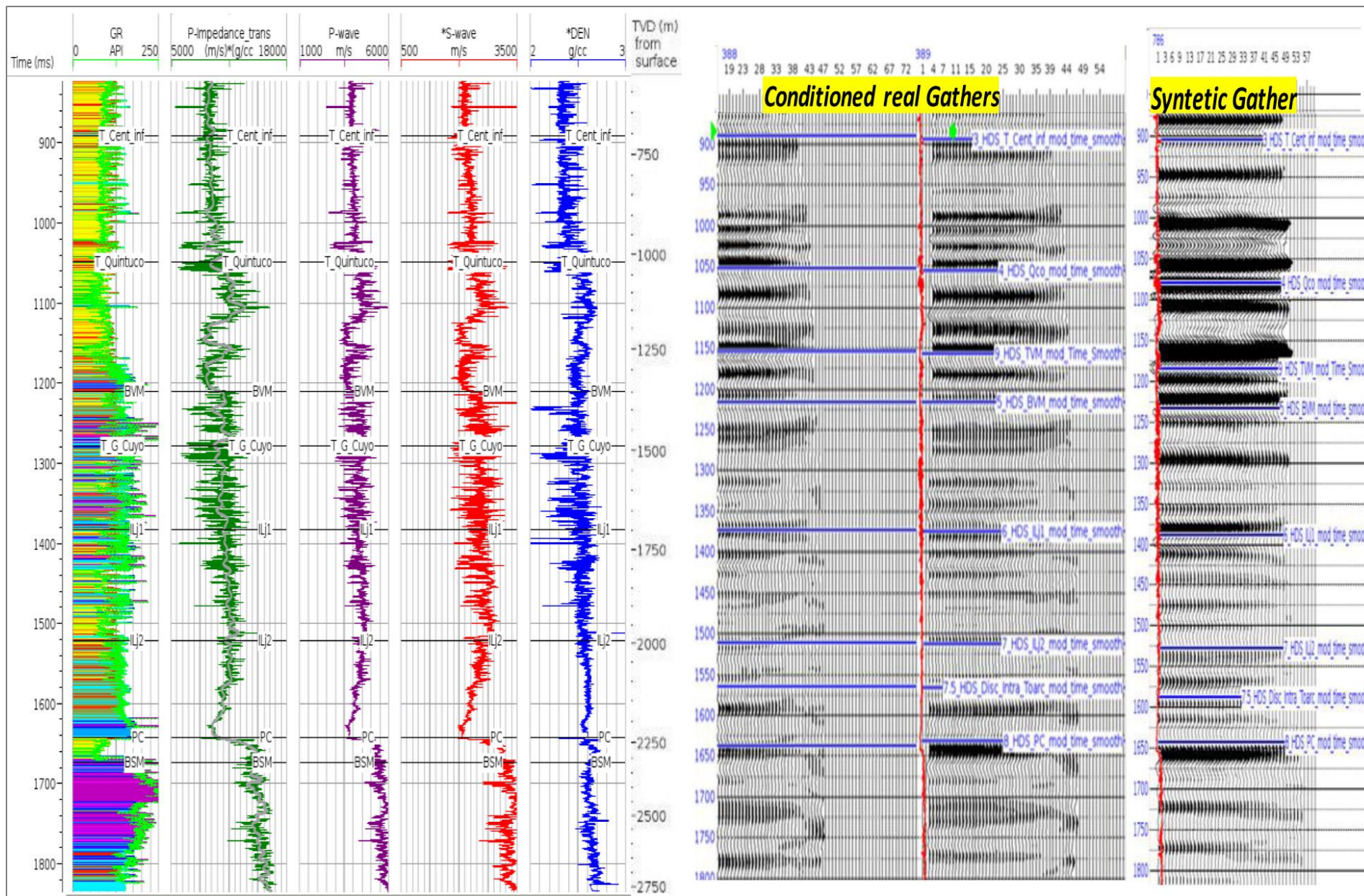Figure 1. Guanaco Field location map and TVDSS seismic regional W-E section.

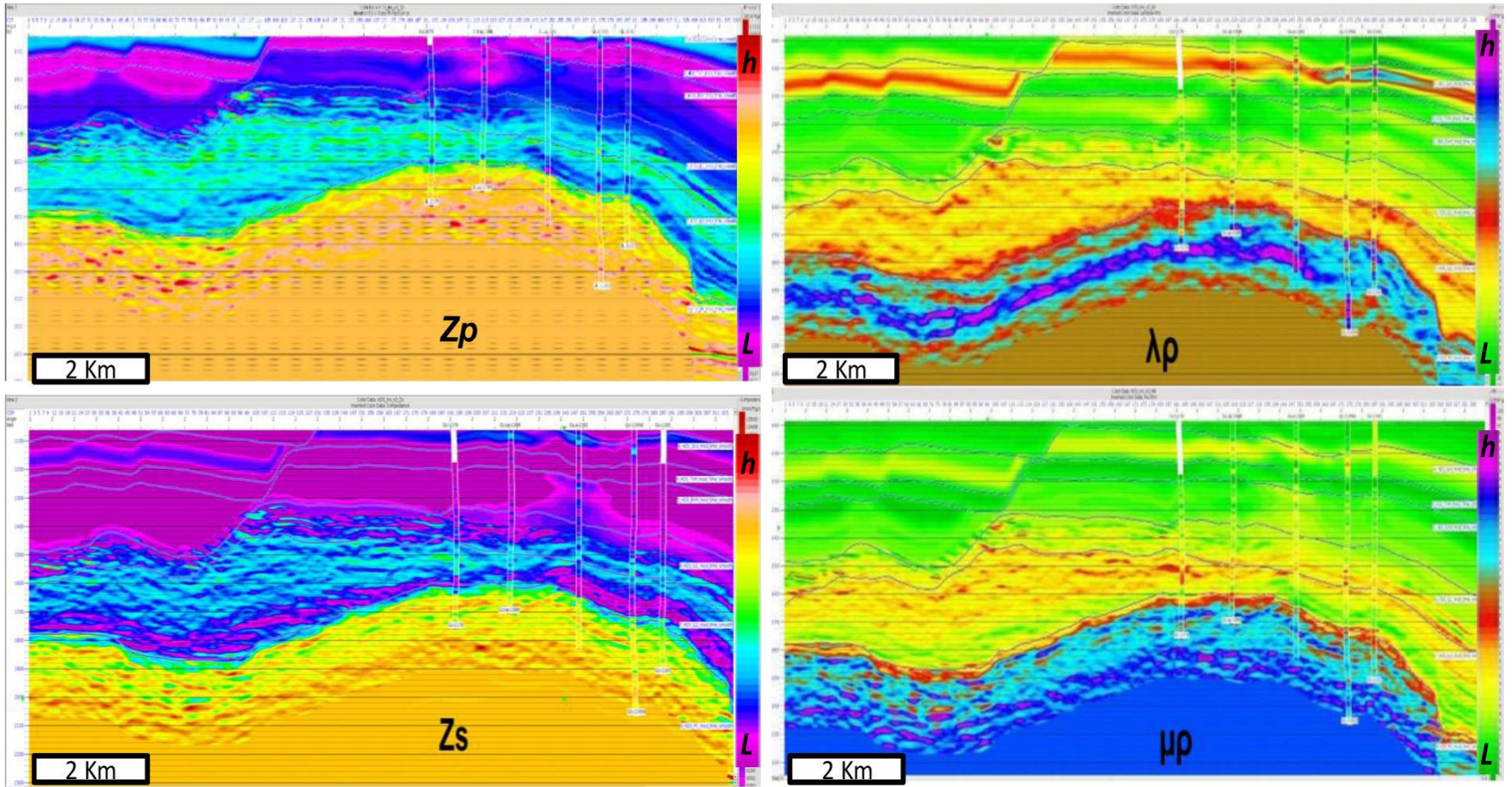Figure 2. Well logs, conditioned synthetic and real gather.

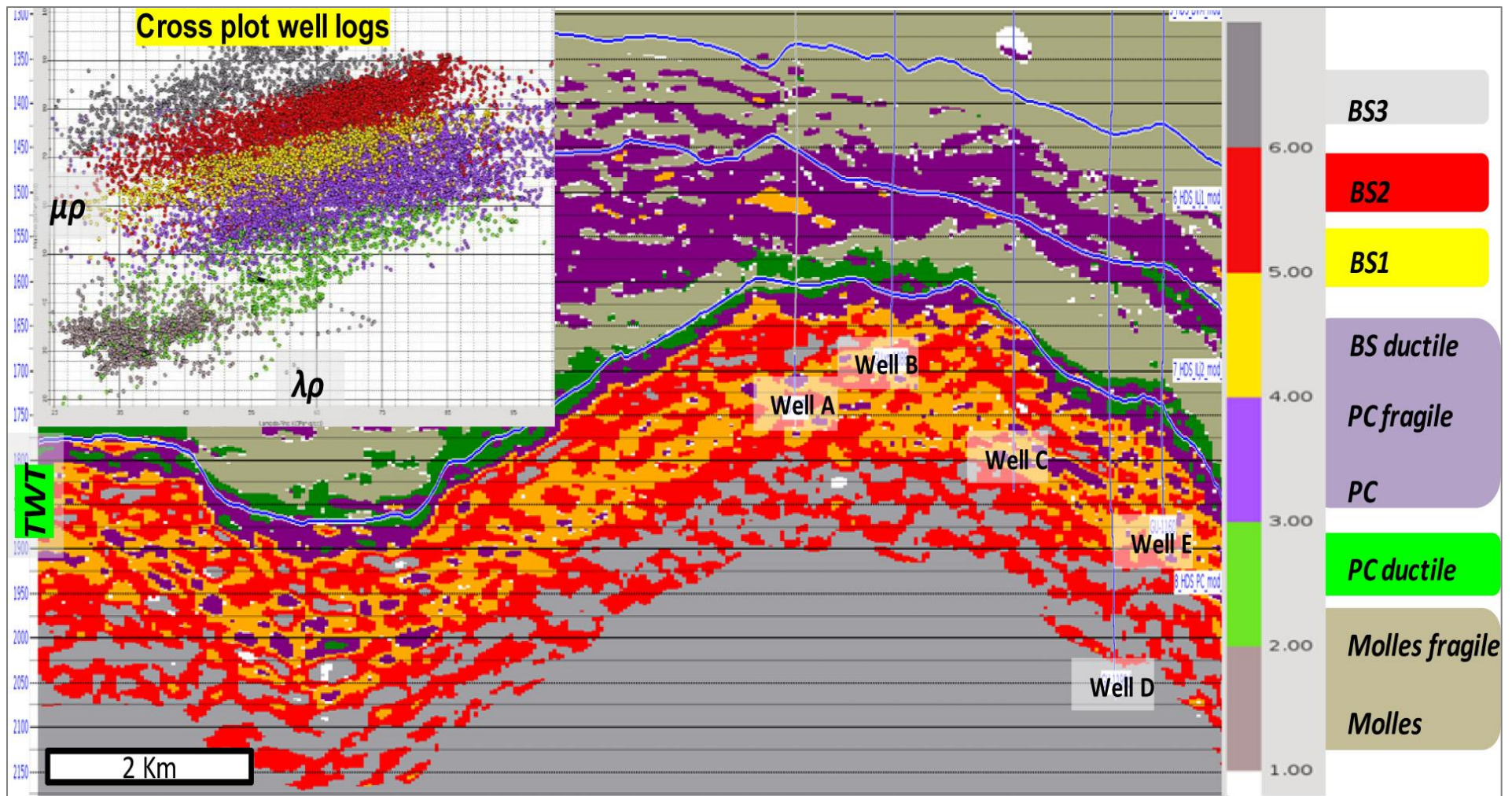Figure 3. Pre-stack inversion results in W-E arbitrary section Zp, Zs, λρ and μρ.

Figure 4. Cross plots well logs (upscaled) and geobody capture section.