Hydrocarbon Identification through Acoustic Impedance and Elastic Impedance Cross-Correlation using Constrained Sparse Spike Inversion Method

Putu Ayu Saraswati[1], Adi Susilo [1], WawanSatriawan[2], Farid Hosni[3]
1) Physics Department, Mathematics and Natural Science Faculty, Brawijaya University
2) Premier Oil Indonesia
3) Jason, CGG
Email: p.a.saraswati@mail.com

Abstract

Among other interpretation methods used in oil and gas industries, seismic inversion has become a method widely practiced to get better understanding on the subsurface condition. By combining seismic and well log data and applying certain workflow, information regarding hydrocarbon distribution presented in the form of impedance section. Using constrained sparse spike inversion, a generated low frequency model was use as input for inversion process to obtain acoustic impedance and elastic impedance variation based on seismic and low frequency data from well log data. To enhance the difference between sand and shale presence, the gamma ray distribution between acoustic impedance (AI) and elastic impedance (EI) generated from the inversion process are cross-correlated. Based on the cross plot, gas sand bodies detected in the area was mapped.

Keywords: inversion, acoustic impedance, elastic impedance

Introduction

Seismic inversion is one of the approaches to subsurface geological modeling that convert seismic reflection amplitudes into volumes or sections of acoustic (or elastic) impedance. While there have been great advances in seismic inversions technology, the quantitative inversion of seismic data for lithofacies and fluids still come as a challenge[1]. Acoustic impedance inversion has become a standard procedure to describe the detailed physical properties of seismic data. However, in some case it is quite difficult to distinguish the sand and shale present in the area using only acoustic impedance inversion.Therefore in order to improve the confidence level of reservoir prediction, it has become a significant important to improves the seismic inversion method over the years. By combining acoustic impedance (AI) and elastic impedance (EI), information regarding a reservoir character can be generated with a relatively higher certainty level [2]. As a result of seismic inversion technique, the prospect zone that possess a certain character to be classified as reservoir can be identified from its' impedance and the porosity level in and around the well area [3].

Methods

The data used in this study are well data, formation marker, checkshot and 3D post stack seismic data that contain the base map of the focused area. The seismic and well data are used to identify the target zone and later on doing the inversion analysis.

Seismic data used in this study is 3D near and far stack seismic data. The loaded data consisted of 206 inline started from inline 1130 until inline 1335 and 716 crossline which begin in crossline 11475 and ends in crossline 12190 with the area coverage of 5.2 km x 9 km. 3D seismic data provide detailed information about fault distribution and subsurface structures compared to 2D seismic data.

To be able to estimate an appropriate wavelet for the current project, the well tied to the seismic data with correlation value as close to one as possible. In this study, a checkshot table is used to create the TD relationship between seismic data and well data. The final wavelet form is then applied to the well-to-seismic tie to achieve a better level of correlation between the synthetic and seismic data[4].

The elastic and acoustic inversion process requires wavelet data, initial model and the seismic data that has been checked and processed thoroughly [5]. The inversion is only applied to the area between marked horizons to maximize the result. By using the Constraint Sparse Spike Inversion (CSSI), the seismic amplitude data inverted into acoustic impedance. The output of the inversion is the inverted impedance. The inversion result interpretation combined to isolate and map the reservoir zone.

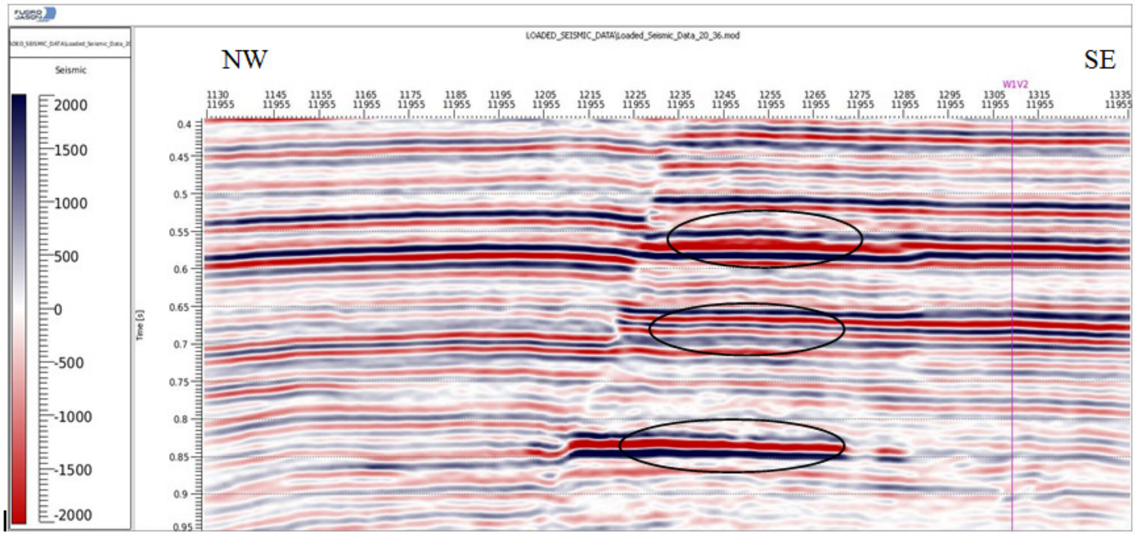

Figure1. The bright spots phenomena indicated by the circle in one of thecrossline section.

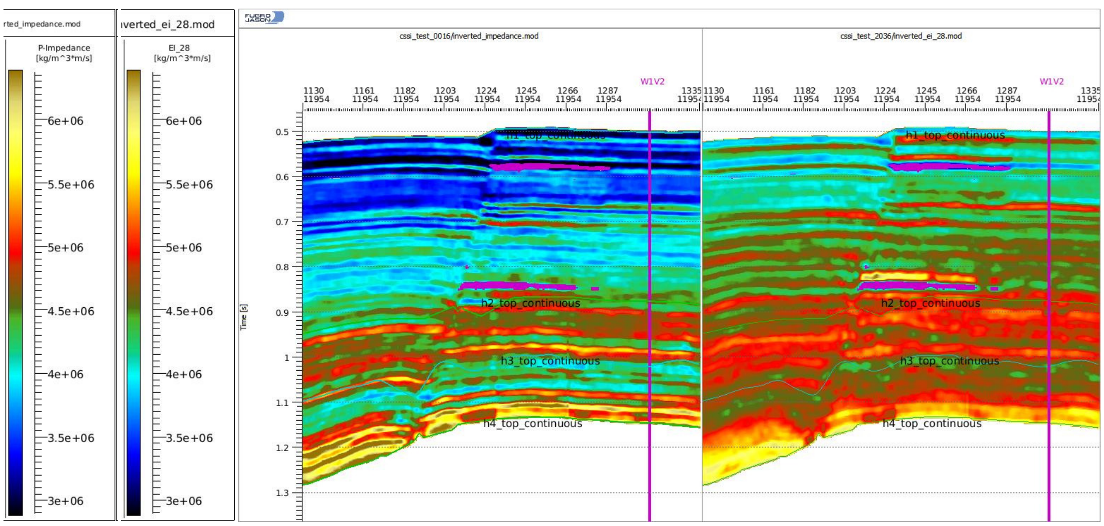

Figure2. The side by side comparison of the inverted acoustic impedance (left) and the inverted elastic impedance (right).

Results and Discussion

The geology structures presence in the area established through the horizons interpolation result. According to the section view from one of the seismic data, there appear to be two major faults presence and numbers of much smaller faults as well. With the aid of the established geology structures, the formation evaluation done by converts the amplitude into impedance. Resulting in information of the subsurface condition in the predetermine depth. Based on the bright spots presence (Figure 1), the focused area is then restricted between time range 0.5 seconds and 1.15 seconds. The well tie and seismic inversion are focused inside those time range as well.

Sparse spike inversion is done by reducing the noise in the seismic data by classifying the small spikes as noise and the large spikes as data. Resulting in inverted acoustic and elastic impedance used to create inverted elastic impedance versus inverted acoustic impedance cross-plot. Based on this cross-plot, the exact spot of gas-sand presence can be identified more precisely in the seismic section (Figure2). According to the section, w1v2 well was drilled in the down-dip part of the area while the hydrocarbon accumulation located in the up-dip part of the area. This is the reason why the w1v2 well turned up filled with water and no show of hydrocarbon.

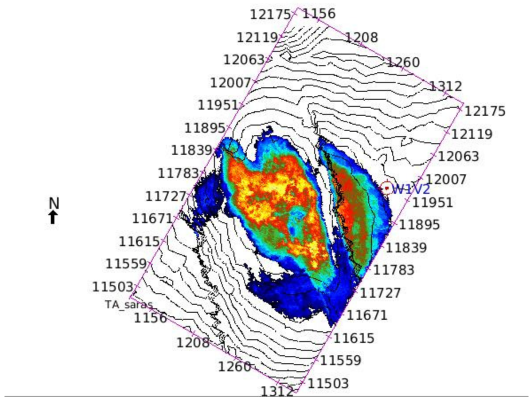

Figure 3. The gas-sand thickness contour of the studied area.

A 3D model derived from the polygon created on the cross plot is created to see the lateral and vertical distribution of the gas-sand.From the 3D model, a thickness contour map is generated. Based on the contour map, the gas-sand bodies' thickness estimated ranging from around 0.06 s up to 0.01 s, with the thickest area between crossline 11671 and 11895. It can also be seen that instead of two major faults, there appears to be three faults affecting the studied area.

Conclusion

Based on the study completed using all the available data, it can be concluded that:

1. An early hydrocarbon prediction made based on the reflectivities on the seismic section indicates possible hydrocarbon accumulation in between 0.5 s and 1.0 s deep.
2. Low impedance in the cross plot between inverted AI and EI show several gas-sand bodies presence in the studied area located between 1400 ft and 3600 ft deep below the sea level.
3. According to the thickness contour derived from the 3D model, the gas-sand with thickness varies between 0.005-0.04 s.

Acknowledgements

We thank Premier Oil for providing the data and Jason for providing the software used throughout the study.

References

[1] Filippova, K., A. Kozhenkov and A. Alabushin. 2011. Seismic Inversion Techniques: Choice and Benefits. First Break. May: 103-114.
[2] Satinder, C. and R.K. Sharma. 2012. An Elastic Impedance Approach. AAPG Explorer. October.
[3] Tabah, F.R. and H. Danusaputro. 2010. Inversi Model Based untukGambaranLitologiBawahPermukaan. JurnalSains&Matematika. Juli: 88-93.
[4] Ewing, T.E. 1997. Synthetic Seismograms: Preparation, Calibration, and Associated Issues. AAPG Explorer. July: 14-17.
[5] Fugro-Jason. 2003. Jason Geoscience Workbench. Fugro-Jason.