[PS]A Combination of Genetic Inversion and Seismic Frequency Attributes to Delineate Reservoir Targets in Offshore Northern Orange Basin, South Africa*

Chris A. Samakinde[1], Jan van Bever Donker[2], and Silvia Lanes[2]

Search and Discovery Article #51398 (2017)**
Posted July 17, 2017

*Adapted from poster presentation given at AAPG 2017 Annual Convention and Exhibition, Houston, Texas, April 2-5, 2017

[1]Department of Earth Sciences, University of the Western Cape, Capetown, Western Cape, South Africa (chrissamakinde@gmail.com)
[2]Department of Earth Sciences, University of the Western Cape, Capetown, Western Cape, South Africa

Abstract

A combination of genetic inversion (Seismic Impedance and Porosity) and seismic attributes (Instantaneous Frequency and Iso-Frequency) are used to characterize Albian and Cenomanian clastic reservoir targets in offshore, northern Orange Basin. The reservoirs are mapped from the well Af-1 position throughout the seismic volume after initial seismic-well tie and consequently, Time-Depth relationship established. Frequency filtering was performed as a form of post stack seismic processing technique to remove passive noise and enhance geological features. Seismic acoustic impedance inversion calibrated with porosity inversion reveals the presence of fluvial channels and associated point bars deposit within meandering channels within the Cenomanian and Albian sequence. The identified channels expectedly show high porosity along its geometry compared to its surrounding lithology. Iso –Frequency (Frequency decomposition) using the Cosine Correlative Transform (CCT) was applied to identify the sweet spots. Iso- frequency of 45 Hz, 12 Hz, and 8Hz windows were captured to isolate hydrocarbon charged reservoirs within the Albian and Cenomanian sequence. The CCT method shows that 8Hz window resolved stratigraphic features present within the seismic volume but unable to resolve the presence of hydrocarbon charged reservoirs. However, the application of Instantaneous Frequency (IF) attribute reveals the presence of hydrocarbon charged Cenomanian reservoirs in close proximity to a fault judging by the attenuation of frequency observed. This was achieved by using Thirty-three seismic traces as an input in the Hilbert transform window, subsequently, trace envelope and instantaneous phase were transformed into instantaneous frequency. This study demonstrates the effectiveness of integrating different seismic attributes as a non-invasive approach in characterizing clastic reservoirs.

Selected References

Castagna, J., S. Sun, and R. Siegfried, 2003, Instantaneous Spectral Analysis: Detection of Low-Frequency Shadows Associated with Hydrocarbons: The Leading Edge, v. 22, p. 120-127.

Chen, G., G. Matteucci, B. Fahmi, and C. Finn, 2008, Spectral-Decomposition Response to Reservoir Fluids from a Deepwater West Africa Reservoir: Journal of Geophysics, v. 73, p. 23-30.

Chopra, S., and K.J. Marfurt, 2007, Seismic Attributes for Prospect Identification and Reservoir Characterization: SEG CE Course, Society for Exploration Geophysicists. Tulsa, OK, USA, 456 p.

Chopra, S., and K.J. Marfurt, 2007, Curvature Attribute Applications to 3D Surface Seismic Data: The Leading Edge, v. 26, p. 404-414.

Chopra, S., and K.J. Marfurt, 2006, Seismic Attributes - A Promising Aid for Geologic Prediction: Canadian Society Exploration Geophysics Recorder: v. 31, p. 110-120.

Farfour, M., W.J. Yoon, and J. Kim, 2015, Seismic Attributes and Acoustic Impedance Inversion in Interpretation of Complex Hydrocarbon Reservoirs: Geophysics, v. 114, p. 68-80.

Hirsch, K.K., K. Bauer, and M. Scheck-Wenderoth, 2009, Deep Structure of the Western South African Passive Margin - Results of a Combined Approach of Seismic, Gravity and Isostatic Investigations: Tectonophysics, v. 470/1-2, p. 57-70.

A Combination of Genetic Inversion and Seismic Frequency Attributes to Delineate Reservoir Targets in Offshore northern Orange Basin, South Africa.

Chris Samakinde, Jan van Bever Donker, Silvia Lanes

Department of Earth sciences, University of the Western Cape, Capetown, South Africa.

Email: chrissamakinde@gmail.com, jvanbeverdonker@uwc.ac.za,

Introduction

A combination of genetic inversion and seismic attributes are commonly applied synchronously as a concept to delineate potential hydrocarbon reservoirs in sedimentary basins . These two procedures can be applied independently, however, their integration have been more utilized recently to reduce possible uncertainties associated with delineating complex and heterogeneous reservoirs in sedimentary basins. Different authors (Farfour et al., 2015; Chopra and Marfurt, 2007; Castagna, 2003; Chen et al., 2008 and Han et al., 2011) have documented the successful application of these concepts in identifying potential reservoir targets and hydrocarbon bearing reservoirs. In this study, these concepts are applied within an exploration block located in the northern Orange Basin, South Africa, to identify potential reservoirs and hydrocarbon charged reservoirs . A 3D seismic volume acquired in 2009 and well logs from a well drilled within the grid of the seismic volume are used for the study.

Study Location And Geology

Study location is within in an exploration block in the northern Orange Basin, South Africa.

Figure1: Location of Study Area, 3D seismic volume in green grid acquired offshore West Coast, South Africa.

The Orange Basin is situated along the passive South Atlantic continental margin that straddles the borders of Namibia and South Africa (Hirsch et al., 2009). The architecture of the basin is defined by the Walvis Ridge in the north and Agulhas-Columbine arch in the south. Margin evolution was initiated by extensional forces that started in the early Mesozoic and culminated in rifting and drifting apart of the South American and African continents, in the late Jurassic and early Cretaceous.

The pre-rift basement rocks are overlain by a succession of Pre-Barremian, syn-rift basic lavas within the central rift sequence and coarse continental clastic, fluvial and lacustrine sediments, along with volcanic deposits within the marginal rift. These are in turn overlain by a Barremian to Post-rift succession of alternating fluvial and marine rocks that are deposited as a result of transgression and regression of sea level.

Methods

Coherency filtering

Frequency filtering was performed to enhance resolution and remove incoherent noises from the data, dip-steering coherency which improve data interpretation, smooth data along reflection dips and still preserve faults and reflection discontinuity is applied here. Figure 2 below shows data before coherency is applied (A) and after which it is applied (B).

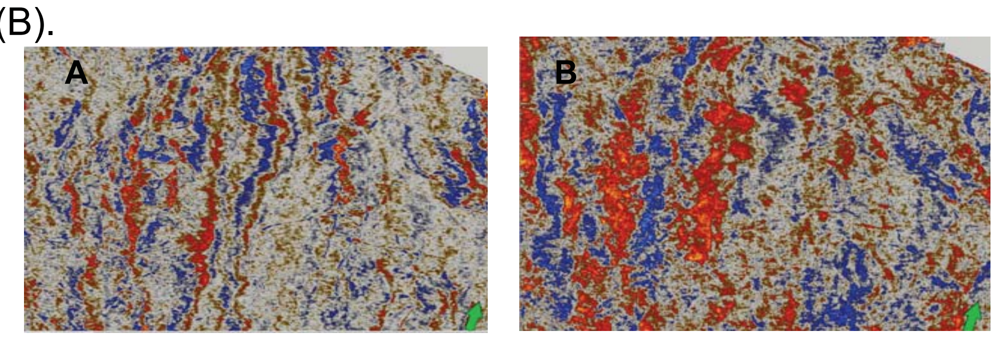


Figure 2 A and B : Without (A) and with (B) Coherency filtering application, respectively at 968ms.

Seismic-Well Tie

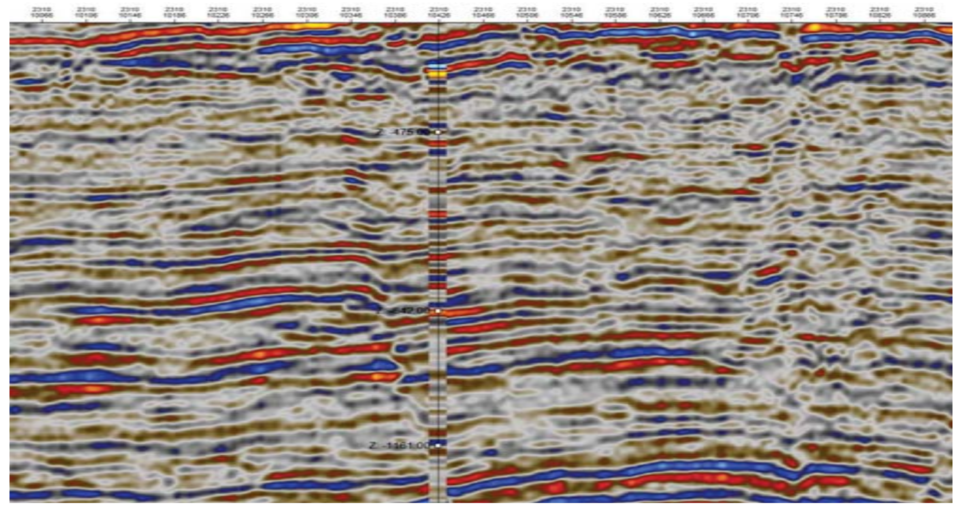


Figure 3: Well tie with seismic volume to balance amplitude and position formation tops to map reservoir units

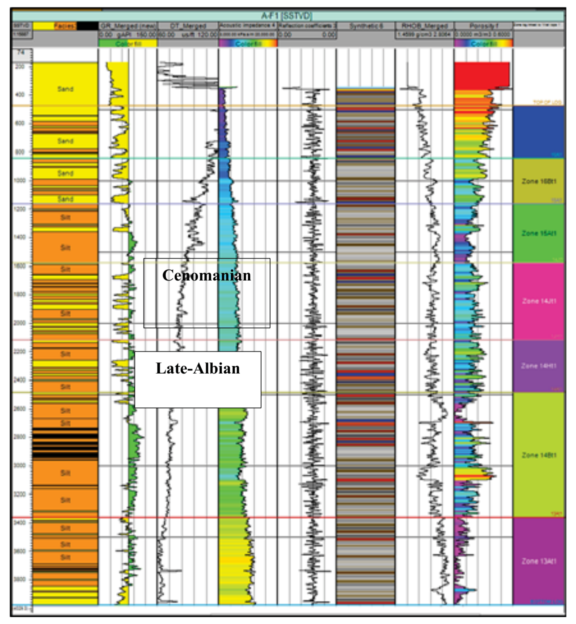
Genetic Acoustic Impedance inversion

3D seismic amplitude calibrated with acoustic impedance log was used to generate the AI inversion and integrated with porosity to confirm observation because of the empirical relationship between the two properties.

RMS Amplitude, Instantaneous Frequency, and Iso-Frequency Attributes.

RMS amplitude of a periodic waveform is the average value of one-half cycle of sine wave in time. This was done in Petrel 2014. Instantaneous frequency was applied by computing 33 seismic trace and phase in the Hilbert filter window on Petrel 2014 into frequency domain. Iso-Frequency component attribute was equally used at varying frequency values and varying periodic cycles. In this study F=1/t , 45Hz and 8Hz are the frequency values used while period cycle was increased from 1.5 to 3.0s

Results



Well Logs: Figure 4 below shows the Cenomanian and Late Albian reservoirs as encountered in this well. Gamma ray log signature suggest the presence of channel-filled sandstones within the Late Albian and Cenomanian sequences .

Figure 4: Depth track, Facies , Gamma ray, sonic, Acoustic impedance, Reflection Coefficient, synthetic seismogram, Density, Porosity logs and formation zones of the well used in the study respectively.

Acoustic Impedance and Porosity

Figure 5 below shows the acoustic impedance inversion on the left and porosity calibration on the right. Results show two parallel Cenomanian-aged low impedance fluvial channels at time slice 968Ms. The fluvial channels shows high porosity along its geometry. Channels are averagely estimated to be 378m in width.

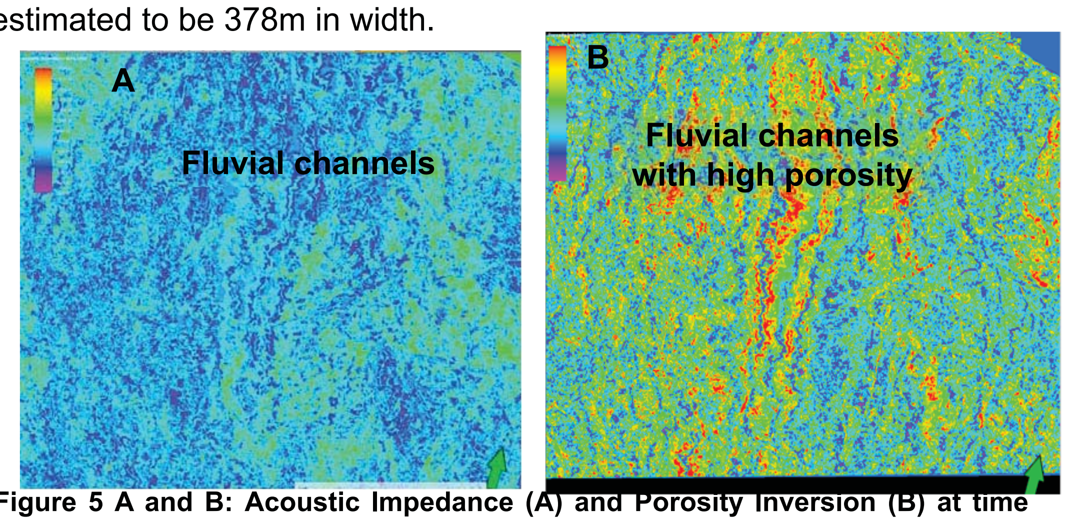


Figure 5 A and B: Acoustic Impedance (A) and Porosity Inversion (B) at time slice at 968Ms

RMS Amplitude.

Figure 6 below shows a low amplitude meandering channel of Mid-Albian-age isolated by RMS amplitude at time-slice 200Ms. Figure 6A is the un-interpreted section while 6B is the interpreted section.

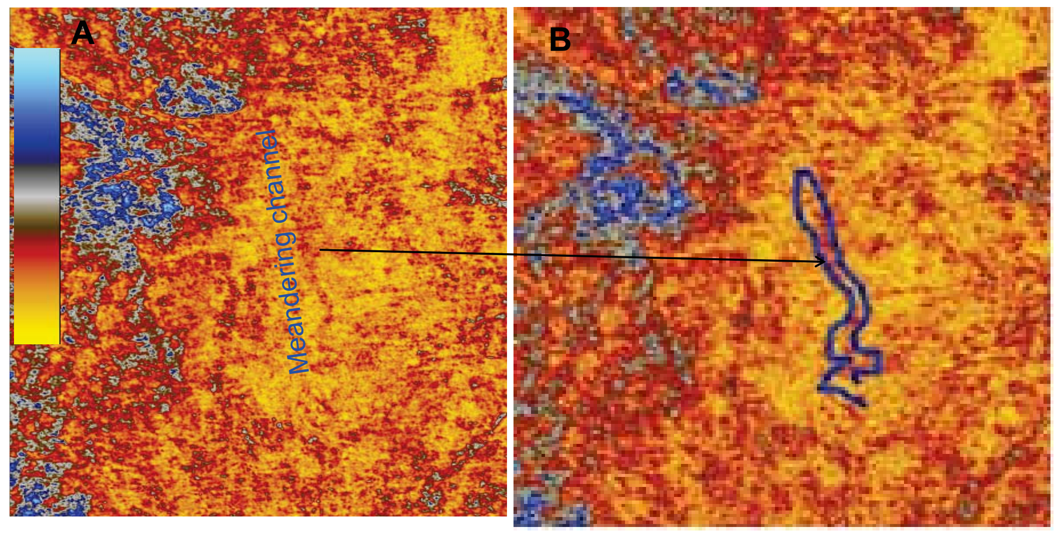


Figure 6 A and B: Show un-interpreted section and interpreted section showing low amplitude meandering channel.

Instantaneous Frequency

Figure 7A below shows a bright spot anomaly on both side of a listric fault. An instantaneous frequency was performed to investigate possible frequency attenuation due to suspected gas-charged sediments as occasioned by the bright spot in the Cenomanian sequence. Figure 7B shows an instantaneous frequency time-slice which indicates frequency attenuation on both side of the fault, suggesting gas charged sediments.

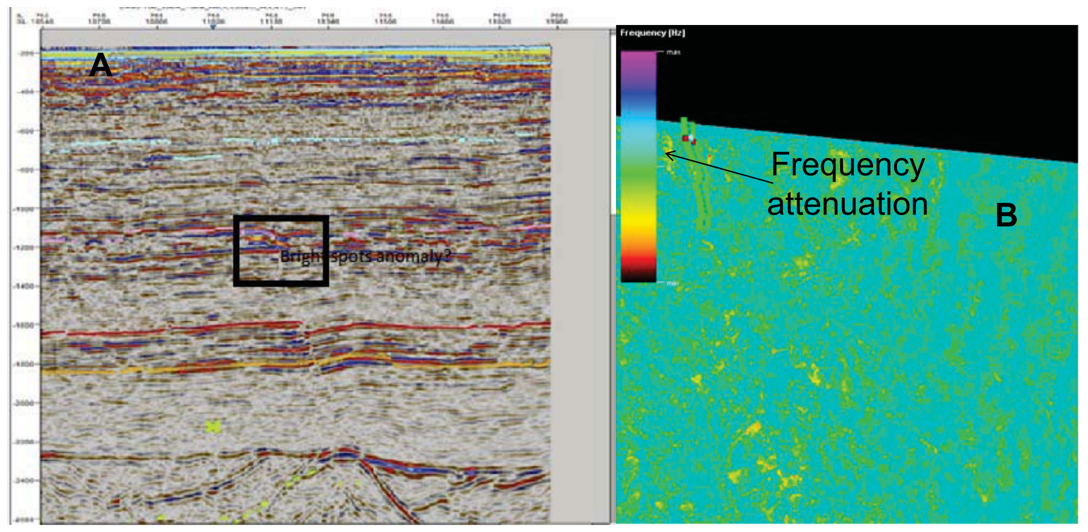


Figure 7A and B: Seismic section at inline 756 showing bright spot anomaly(A) and instantaneous frequency attenuation (red spots) around the fault at time slice 1160ms (B).

Iso-Frequency Attribute.

Iso-frequency attribute was performed at varying frequency band to observe the frequency range suitable to delineate possible hydrocarbon -charged reservoirs. Because of varying frequency of seismic data, decomposition of seismic trace at various frequency is valuable in detecting hydrocarbon –charged sediments and stratigraphic features. Figure 8A and B shows 756 time slice section at 45Hz and 8Hz respectively. 8Hz shows attenuation of frequency around the fault, which could point to possible gas charged sediments.

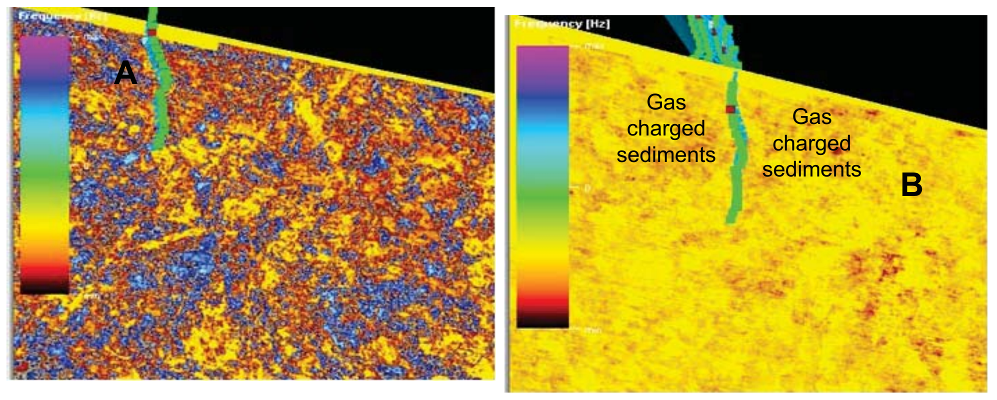


Figure 8A and B: Iso-Frequency attribute at 45Hz (A) and 8Hz(B); Time slice 1160Ms. Frequency attenuation is more visible at 8Hz and the low frequency features (red spots) could suggest likely gas charged sediments. 8Hz frequency is more suitable for this data to the identify likely hydrocarbon -charged sediments.

Conclusions

A combination of seismic attributes and genetic acoustic impedance inversion revealed that acoustic impedance delineated a couple of cenomanian-aged parallel channels which shows high porosity along its geometry. The channels have low to medium acoustic impedance. RMS amplitude resolves the presence of low –amplitude Albian aged meandering channel, judging by the loop observed. Finally, instantaneous and Iso-frequency resolved bright spot anomaly seen on the seismic section around a fault . The frequency attenuation observed on either side of the fault plane could point to gas-charged sediments.

References

Chen, G., Matteucci, G., Fahmi, B. and Finn, Ch., 2008. Spectral-Decomposition response to reservoir fluids from a deepwater West Africa reservoir. Journal of Geophysics 73, 23-30.

Chopra, S. and Marfurt, K. 2006. Seismic Attributes–a promising aid for geologic prediction. Canadian Society Exploration Geophysics Recorder. 31, 110-120.

Farfour, M., Yoon, W.J. and Kim, J. 2015. Seismic attributes and acoustic impedance inversion in interpretation of complex hydrocarbon reservoirs. Geophysics, 114, 68-80.