

# **PS Seismic Attributes for Differential Compaction Features in Fluvial Channel Complex and Reef Carbonate Buildups: Case Study from Malaysia Basins\***

**Nasaruddin B Ahmad<sup>2</sup>, Abdul Jailani B Che Johari<sup>2</sup>, Megat Iskandar B Megat Ismail<sup>2</sup>, Satyabrata Nayak Parsuram<sup>2</sup>, and Nur Bakti B M Makhatar<sup>1</sup>**

Search and Discovery Article #11030 (2017)\*\*

Posted December 18, 2017

\*Adapted from extended abstract prepared in conjunction with poster presentation given at AAPG/SEG 2017 International Conference and Exhibition, London, England, October 15-18, 2017

\*\*Datapages © 2017 Serial rights given by author. For all other rights contact author directly.

<sup>1</sup>Exploration Malaysia, PETRONAS Carigali Sdn Bhd, Kuala Lumpur, Malaysia ([bakti\\_makhatar@petronas.com.my](mailto:bakti_makhatar@petronas.com.my))

<sup>2</sup>Exploration Malaysia, PETRONAS Carigali Sdn Bhd, Kuala Lumpur, Malaysia

## **Abstract**

‘Differential Compaction’ features have been reported from various basins around the world and are found to give notable seismic expression. These features form as the different sediments (shale or sand or limestone) are compacted differently as per their mineralogical constituents and therefore produce a subtle irregular topography. Differential compaction on seismic can be used to define features of interest, such as identifying subtle carbonate buildups in a shale matrix and to define channel fill, point bars sand in complex channel belt surrounded by shale matrix flooding plain. The constituent of shale is mainly clay minerals (i.e. kaolinite and illite) known as phyllosilicates meanwhile sand constitute silicate. These sheeted phyllosilicate minerals tend to be compacted more than silica by overburden stress thus will give the seismic expression of differential in compaction. In this paper we will discuss some of the striking differential compaction features from two examples of (1) negative relief, shale-filled channel features with excellent positive relief of sandy point bar build up with a shale matrix (flood plain) in the Malay Basin, and (2) carbonate reefal buildups in a shale matrix in the Central Luconia Carbonate Province. Using this thorough and “creative” approaches of seismic interpretation together with detailed analysis of various seismic attributes and different color blendings, the ‘unseen’ potential that was left behind can be opened. Besides reefal carbonate and channel belt complex, this method also can be applied at other geological setting with differential elements such as distal sand of turbidite and slope deposit.

## **Discussion**

Malaysia’s offshore Tertiary basins have yielded billions of barrels of hydrocarbon since Miri-1 in 1910 and are considered as matured basins. The remaining exploration targets are often in the form of stratigraphic traps and subtle structures. New and novel approaches in exploration thinking and methods are currently needed to achieve commercial success.

Here, we present a new trap style that has recently been proven in the Malay Basin and Central Luconia Province in the form of differential compaction traps. These traps are formed by differential compaction process involving less compactable lithologies such as sandstones or carbonates surrounded by more compactable lithologies such as shales. The shales tend to compact more than sands and carbonates because shales comprise flat minerals that could be aligned during burial; this could create subtle traps. (from Maher 2012). In this work, we will show examples of these traps in 3-D seismic involving channel-related ([Figure 1](#)) and carbonate reef build-up play types ([Figure 3](#), [Figure 4](#), and [Figure 5](#)).

The best example of differential compaction traps is found in the channel-related play types in the Malay Basin. The best proven analogue for this play type so far is the Angsi Field, located on the western hinge of the Malay Basin. The Angsi Field is an anticlinal structural feature that also comprises of channel-related stratigraphic trap components at some reservoir levels, in which point bar sand reservoirs are being enclosed by shale-filled channels and floodplains. Although proven, exploration of these play types in the eastern hinge had not been seriously undertaken.

In 2015, one of these point-bar features was drilled in the eastern hinge area ([Figure 2](#)). 3D seismic data shows a subtle positive relief at the interpreted point-bar feature within a channel belt and the channel features show negative relief. The well penetrated good sandy formation with oil and gas discovery. This discovery is a play-type opener in the eastern hinge and is easily monetized as it is located near a producing field.

Another example of differential compaction traps could be found in the Central Luconia Carbonate Province. Here, Cycle V and Cycle IV Carbonates plays are quite extensively explored, but reefal build-up play type of Cycle III Carbonates are relatively underexplored due to its subtle structural feature and lack of 3D data. The new interpretation approach of differential compaction features using frequency-based attributes in 3D seismic data leads to finding new prospectivity over a small block on the western part of Central Luconia. Carbonate build-ups buried in shale appear as subtle structural high. The total carbonates thickness is estimated around 100 m to 150 m.

In early 90s, an exploration well that was targeting older Cycle II Carbonates drilled through one of these Cycle III reefal features. The well electric logs show 50 m of gas column with good porosity and permeability. This Cycle III interval was not tested because the extent of the carbonate body could not be defined as the well was drilled on 2D data. Cycle III Carbonates prospectivity over this area is quite promising as the biggest identified feature is estimated around 32 sq. km.

Using seismic attributes to recognize differential compaction features/traps could open ‘unseen’ potential that was left behind due to lack of technology i.e. 3D seismic coverage and advanced software. Apart from reefal carbonates and channel complexes, this method also can be applied to other geological settings with potential differential compaction features such as turbidites and slope deposits (from Chopra and Marfurt 2013).

### **References Cited**

- Chopra, S., and Marfurt, K., 2013, Seismic Attribute Expression of Differential Compaction: AAPG Annual Convention and Exhibition, Pittsburgh, Pennsylvania, May 19-22, 2013, [Search and Discovery Article #41265 \(2014\)](#). Website accessed December 2017.
- Maher, H.D. Jr., 2012, Surface, Neotectonic and Compaction Structures: Department of Geography and Geology, University of Nebraska at Omaha, Omaha, Nebraska.

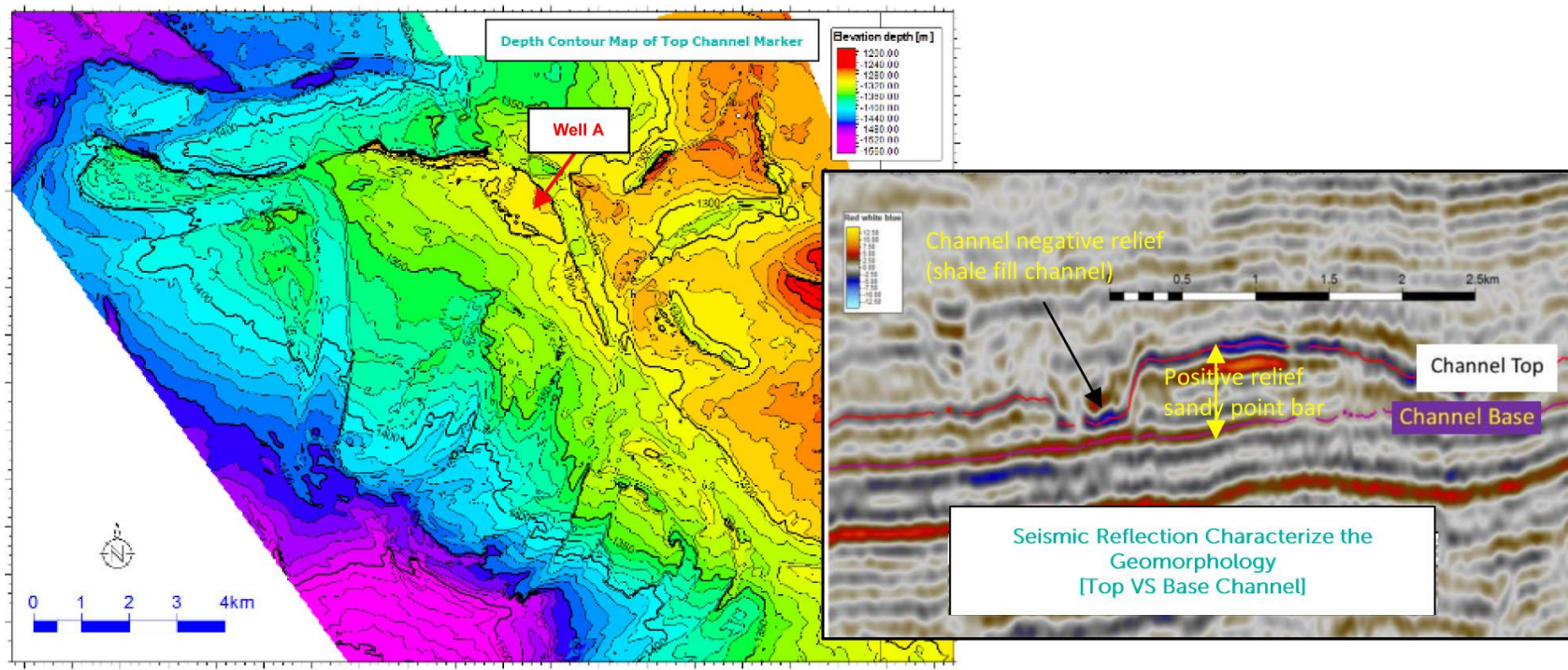


Figure 1. Map showing the geomorphology of the channel complex; note the different in elevation on the depth structure map that cause the point bar to pop up. The difference in elevation create sedimentary non-tectonic subtle structure for possible hydrocarbon trapping.

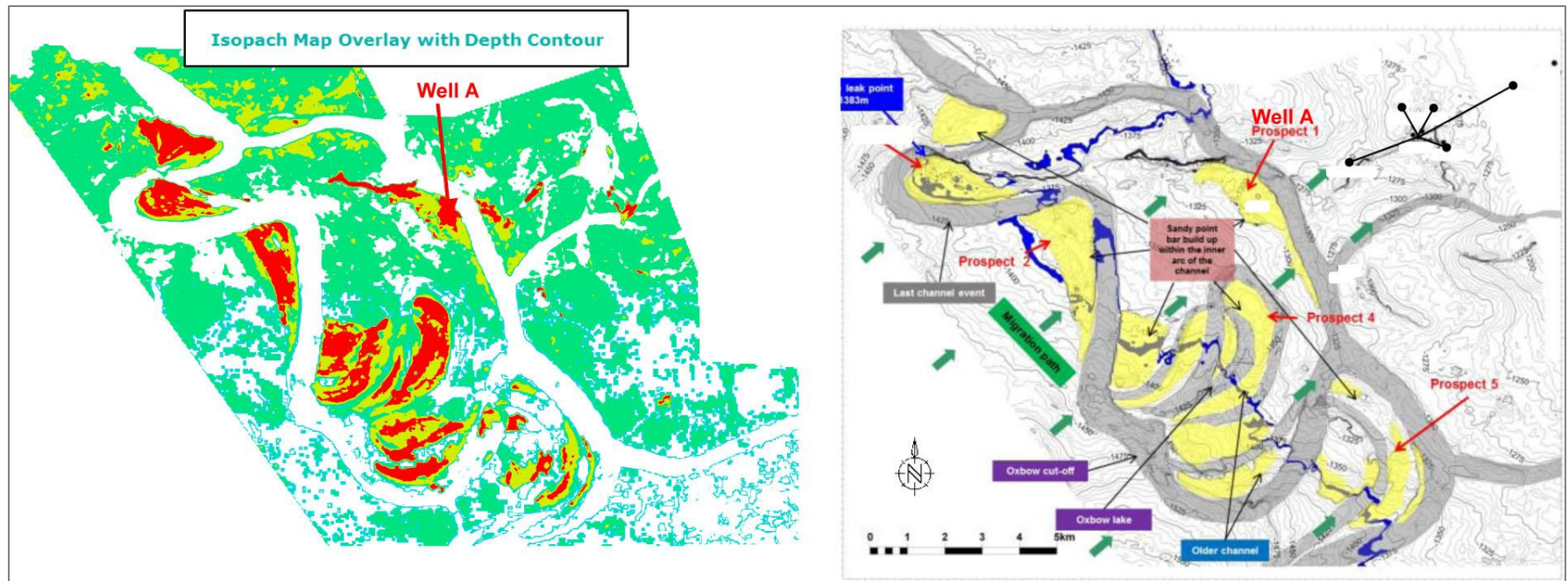


Figure 2. From depth structure contour overlay with isopach, a geological model was constructed. Note the proximity of the facilities. Less than 3 km.

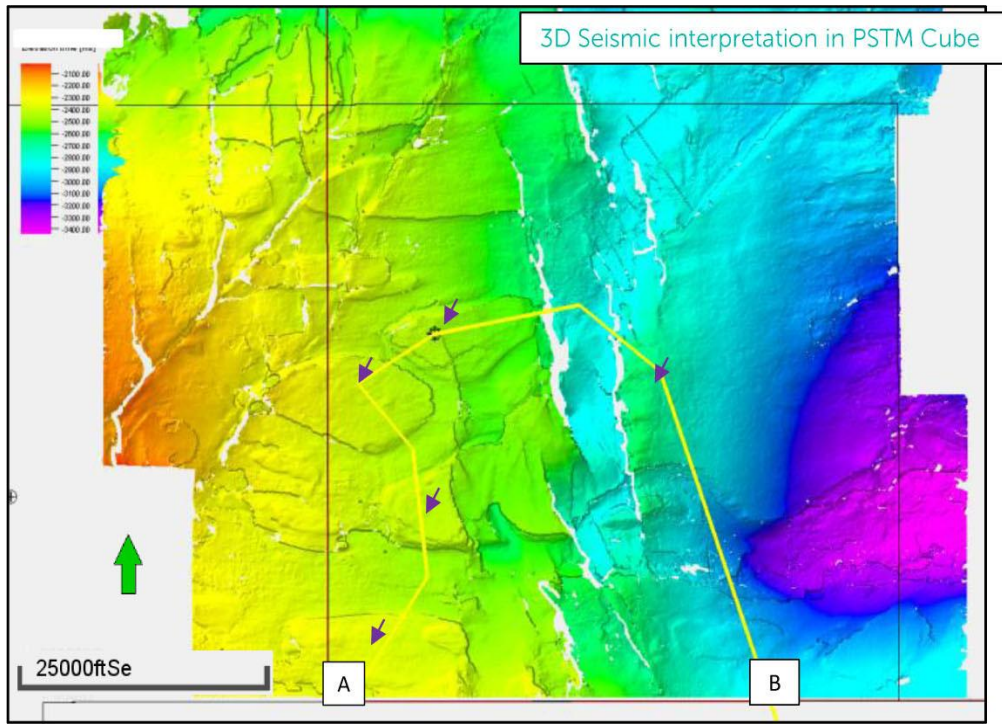


Figure 3. Depth structure map shows the morphology of carbonate reef as the interpretation approach by differential compaction.

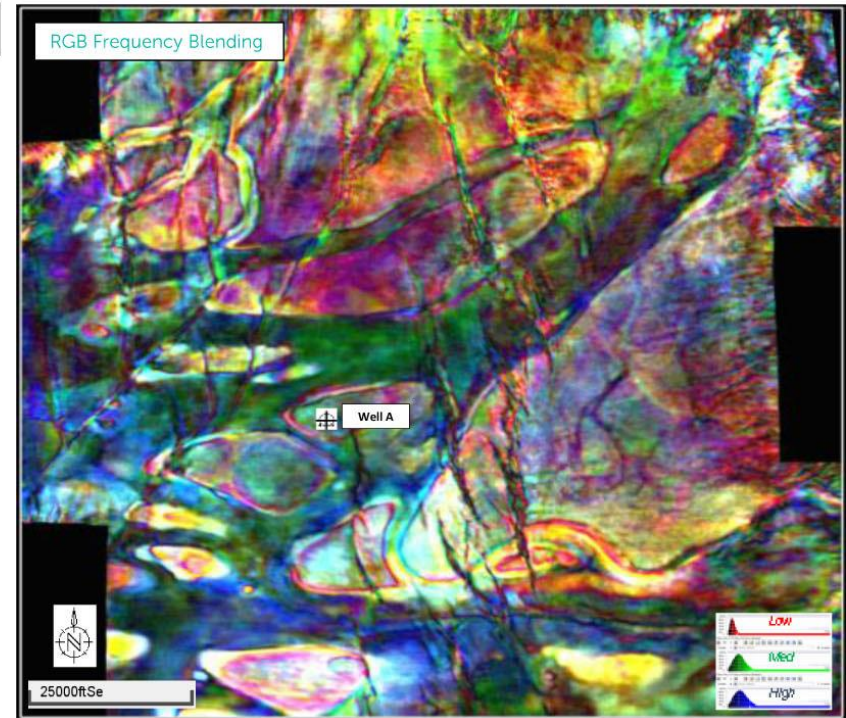


Figure 4. RGB Blending of Frequency map shows the distribution of carbonate reefs. A well was drilled into the carbonate reef and well logs shows accumulation of gas (at least 50 m), but unfortunately not tested.

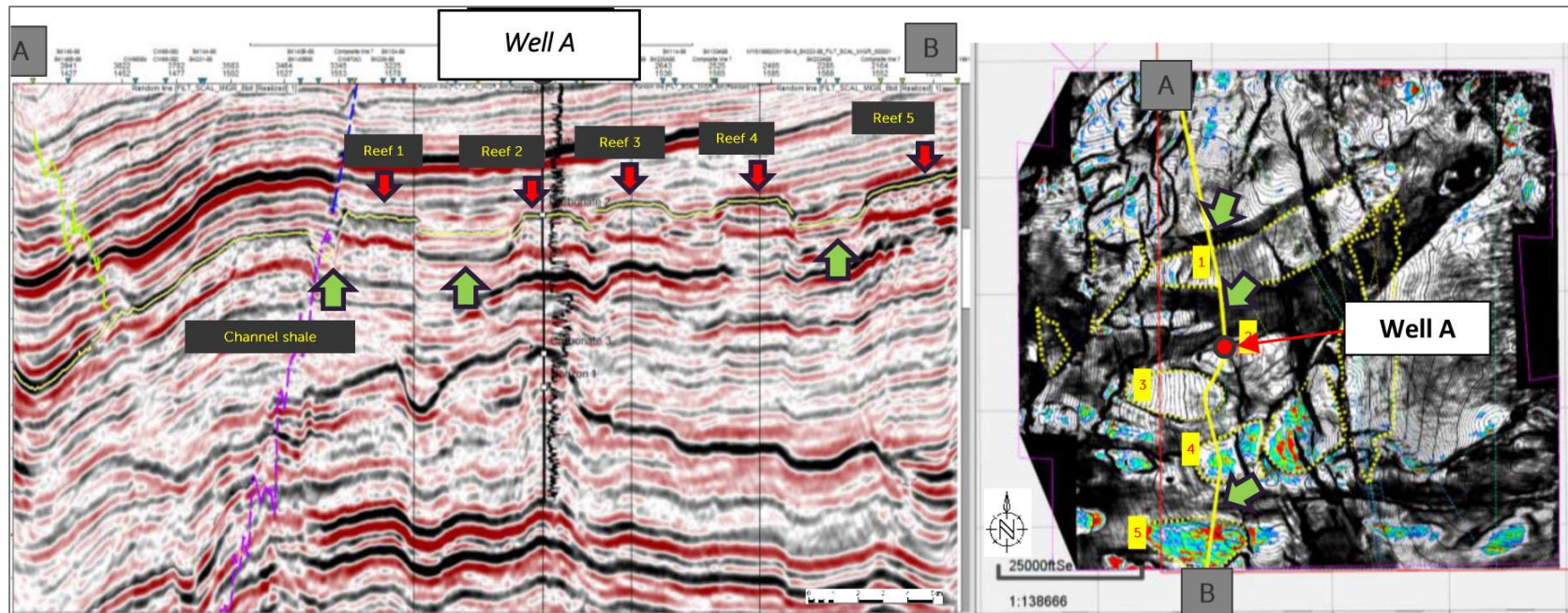


Figure 5. Seismic cross section showing subtle reefal carbonates growth (Carbonate number provided for cross reference). Amplitude extraction (Extract Amplitude +20ms blw) shows the map view of the distribution of isolated carbonated reefal bodies. Noted larger reefal carbonate growth