ASEG-PESA 2015
Geophysics and Geology together for Discovery
24th International Geophysical Conference and Exhibition
15–18 February 2015 Perth, Western Australia

Seismic waveform classification: renewing the interest in Barrolka field, SW Queensland, Cooper Basin

Yahya Villareal Basman II
Santos Limited
60 Flinders Street, Adelaide SA 5000
yahya.basman@santos.com

SUMMARY

Seismic wave form classification techniques have been used to significantly improve the efficiency of the interpretation of the Barrolka field 3D seismic survey. Pattern recognition of seismic shape based on a neutral network has proven to be powerful approach in reducing risk associated with characterising and predicting the extent of the Barrolka field's historically elusive PC30 reservoir. This technique resulted in recent drilling success with development wells intersecting predicted reservoir and resulting in exceptional initial gas rates, a contrast to the field complex's 30 years low drilling success. This study has rejuvenated interest to convert the field's large contingent resource to reserves.

Key words: seismic waveform classification, seismic facies, sand prediction, neural network.

INTRODUCTION

Discovered in 1976, the Barrolka field is located in the northern area of southwest Queensland. It is a subculmination of a much larger Barrolka structural complex which holds a substantial volume of gas. For over three decades, this area has been a testing ground for various new technology trials to improve the low recovery of Barrolka field. Nineteen (19) wells had been drilled to end 2012, of which only 4 wells were on production. Despite some successes, the high failure rate tainted the field's reputation and hampered further development.

A revisit in 2013 confirmed the large volume and highlighted the issues contributing to the failures. Failures are attributed both to mechanical and geologic factors. This paper will present the success of the 2013/14 development drilling program which has been attributed largely to a better understanding of sand development trend established through seismic waveform classification.

The primary producers are the Permian fluvial channel sands, PC35 and PC30. Reservoir failure is predominantly attributed to the lack of productivity due to variable reservoir quality of intersected sands. Although thick blocky PC35 sands were commonly intersected, it is the shallower and thinner PC30 sands that are giving the better productivity. However, PC30 sands are by nature more limited in distribution and hence more difficult to predict. It is below the seismic resolution and the presence of coal further discouraged the use of conventional seismic attribute mapping.

The distinct soft acoustic properties of coal can give clues to the general lateral distribution of areas that are predominantly coal bedded from non-coals. Coaly facies typically exhibit high amplitude with very continuous seismic reflectivity. In contrast, there are variabilities in seismic characters observed in non-coaly areas by which better PC30 sands are typically associated with wavy and discontinous seismic characters. When mapped using a tool based on seismic waveform classification, the lateral distribution reflects the overall sand-shale facies in Barrolka field. Sand prone seismic facies which display reasonable conformance to the paleo-topography of the Barrolka structure added weight into the geologic context of its pattern of distribution.

Following the waveform classification model, three development wells were drilled in 2013/14. All wells encountered the elusive PC30 sands as predicted and two of these wells flowed at initial rates rarely observed in Barrolka structural complex. The success of the recent development drilling program has rejuvenated the interest in Barrolka field to convert the remaining large proportion of contingent resources to additional reserves.

METHOD AND RESULTS

One part of a sedimentary sequence or unit can be distinguished from others according to the general seismic appearance. Seismic wave shape is a resultant effect of all relevant geophysical information such as amplitude, frequency and phase. Changes in wave shapes are generally related, among other factors to changes in lithology, bed thicknesses and fluid content. In Barrolka, the abrupt total lateral lithological changes (i.e. limited channel complexes in a predominantly shale or coal background) compensated for the constraints due to vertical resolution. Classifying the actual trace shapes in the 3D survey to a set of specified number of model traces (neurons) captured patterns within a specified interval which may directly or indirectly be associated to the overall geology.

Based on correlation, neurons are created, assigned to and subsequently modified according to actual traces to classify set of traces in the 3D dataset. The method uses neural network classification technology which has the ability to analyse and classify shapes using a discriminating process. The purpose of any seismic mapping project primarily drives the decision on input parameters such as, number of neurons and window of interval (i.e. lesser neurons for regional objectives). Seismic to well tie and the quality of horizon mapping are crucial to identify the interval window.

Initial rounds of preliminary classification mapping were carried out to test the sensitivity of the data and to get the minimum working window that can still properly model the variations observed in the seismic data (Figure 1).

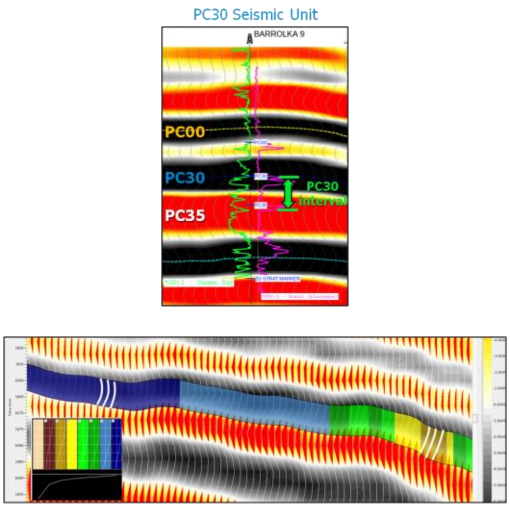

Figure 1. PC30 target window interval. The vertical extent is approximately ½ wavelength. Similar wave shapes are color-coded according to their assigned neurons.

It is an iterative process to decide on the most appropriate parameters to use in the final classification. Correlation and discrimination maps that are generated with each process were used to check the quality of each model. Each model is then visually cross examined in few arbitrary type seismic section lines. A proper model was able to pick up the most obvious seismic variations (Figure 2).

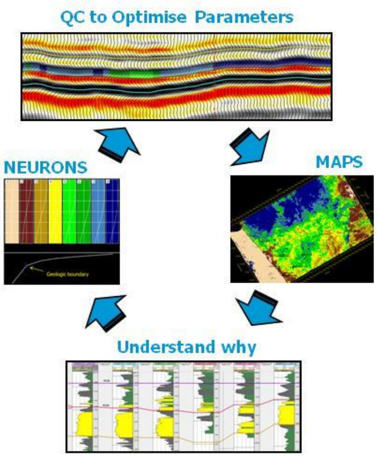

Figure 2. Seismic waveform classification workflow.

There are a number of wells in Barrolka showing extreme ends of lithologies in the area, from non-reservoir coal-shale interbed facies to a better developed PC30 sands producing in Barrolka-9 well. An arbitrary section line along few wells representing both ends of lithology also consistently displayed extreme sets of modelled neurons. It gave initial clues that the changes observed in lithology facies causes the variations in seismic wave shapes. Hence, sharp lateral boundaries between two extreme neurons are most likely related to geology (i.e. a different fault block).

Additional information like seismic terminations, isochron maps and possible geologic features using horizon slices aided the final interpretation of the waveform classification map to delineate sectors with low risk sands (Figure 3).

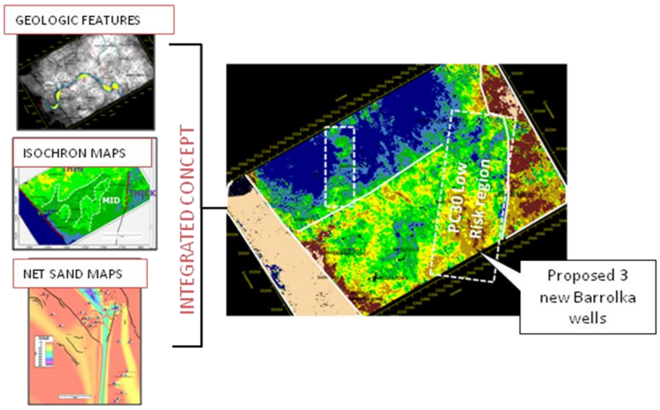

Figure 3. Seismic waveform classification map integrated with other subsurface information.. New wells are proposed in sand prone area of the final PC30 facies map.

Three development wells were drilled inside and proximal to sectors with low risk for sand presence. Target locations were optimized based on the final waveform classification model, benchmarked to the neuron representing Barrolka-9. The results from these new wells were then cross plotted to gross sands, net sands, porosity, Kh etc (Figure 4). The cross plot suggested that reservoir facies are sitting on neuron classes 3 &4. These models are strongly related to gross and net sands. It is a powerful tool to predict sand presence, although not necessarily the reservoir quality (Figure 5).

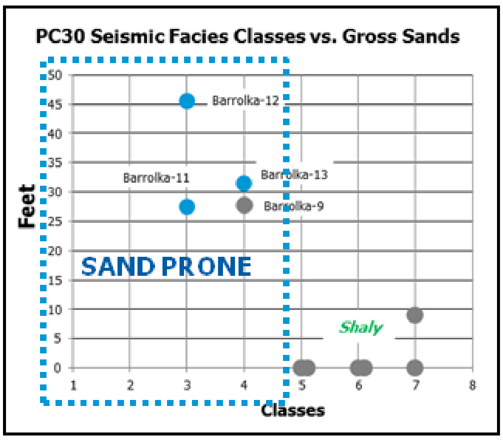

Figure 4. Crossplot of the 3 new development wells (blue) confirms that the waveform classification model is a good tool to predict gross sands in Barrolka field.

CONCLUSIONS

Seismic waveform classification technique significantly improves the efficiency of seismic interpretation. It can be used for sector wise stratigraphic analysis of areas within a 3D seismic survey to highlight regions of reservoir and non-reservoir facies.

In interpreting, one must account for the fact that seismic response is smeared across overlying and underlying sequences. Therefore, window selection is critical.

The method assumes that any wave shape variations caused during seismic acquisition parameters or processing are taken care of during processing. Under normal pressure conditions, wave shape change is related to change in geologic facies.

It can be interpreted either directly or indirectly and its geologic meaning can only be contextualized after integrating additional subsurface information.

This study supports the conclusion that pattern recognition of seismic wave shape based on neural network is a very powerful approach to characterize sectors prone to reservoir facies, interpret boundaries and predict areal distribution of reservoir quality for planning and drilling wells with an acceptable degree of confidence.

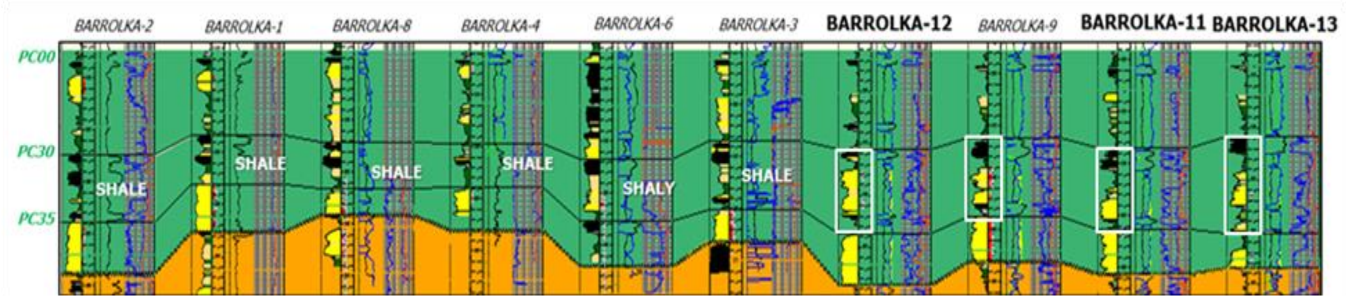

Figure 5. Stratigraphic correlation showing the new wells intersecting the productive PC30 sands found in Barrolka-9.