Analysis of Lobes and Channels in Turbidities using Seismic attributes in Canterbury Basin New Zealand

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Abstract

Seismic attributes are used to observe geologic structures that may be unnoticed in a conventional seismic amplitude volume for interpretation. In this work we present some basic concepts of seismic attributes and we apply a combination of two well-known seismic attributes (variance and envelope) in order to analyze different aspects of seismic response such as energy, geometry and limits of the deep water environment in the Canterbury basin, New Zealand. We used the Waka-3D seismic data that is public for use in research and education. We have successfully enhanced some features that couldn’t be seen before.

Introduction

The rapid uplift and erosion of the Southern Alps in the last 5 million years increased the amount of sediments that resulted in the formation of a thick and extension layers of sediment in the Canterbury basin, New Zealand. We used that prior information to help us interpret the lobes and channels presented in the seismic data as in the model of Figure1.

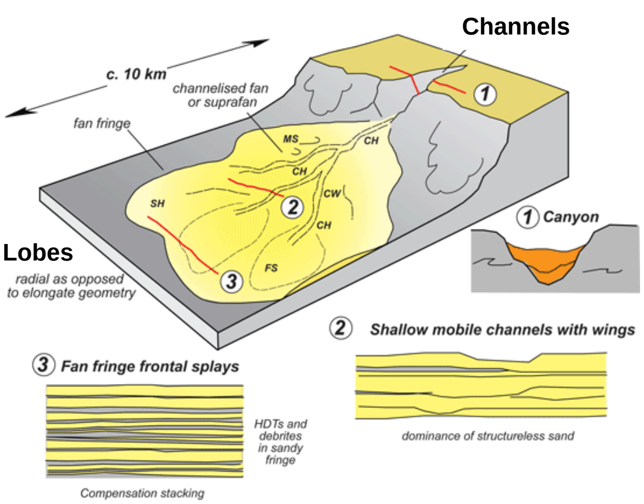

Figure 1: Model of turbidities with lobes and channels highlighted by the red lines (from SEMP STRATA)

Seismic attributes are quantifications extracted from seismic data that enhances the information difficult to be seen for a human eye and they help us to interpret better the data (Chopra & Marfurt, 2007). There are some attributes that are related to amplitude of the seismic data such as envelope amplitude, average energy, RMS amplitude, variance, etc. Some attributes give us a better vision of the characteristics in time such as coherence, azimuth, curvature and variance. In this work we use a combination of variance and envelope trying to highlight architectural features of the channels and lobes presented in basin. The attributes are combined because those two are mathematically well designed and independent to return an intuitive geologic and geophysical meaning (Banes, 2007).

Method-Data Description

The data quality is good even though we have some problems with migration in the deeper parts of this inline (**A-A’**). We can see some diffractions present on top of the strongest reflector (most likely to be the basement). The section is crossing the lobes and some channels. Look the cursor tracking showing the features (Figure 2). The high amplitude on the seismic data is due to the presence of compacted lobes (Figure 3).

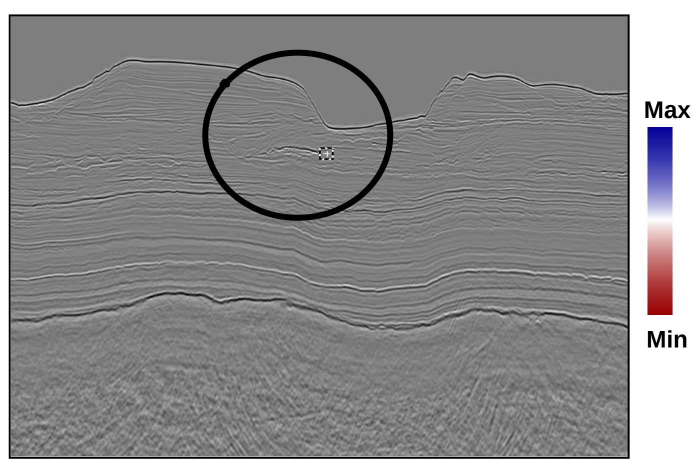

Figure 2: Inline crossing the lobe feature and seismic amplitude data. Note the eye feature presented in this

section that may indicate a plane with more lobes and possible channels.

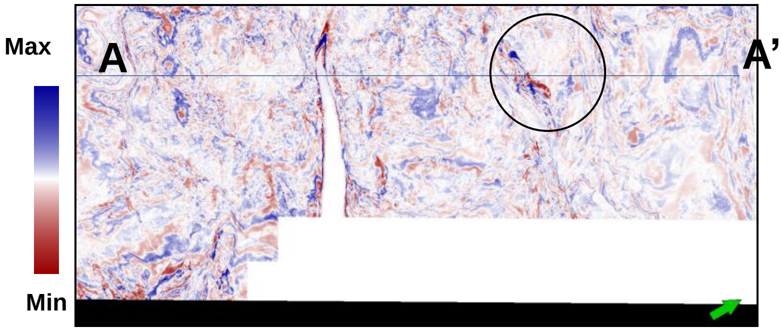

Figure 3. Time slice 1,864s. High amplitude on the lobe feature. Note that this is the only possible lobe presented in the volume since we cannot see others. The goal of this work is actually show that are more lobes and the presence of channels too.The high amplitude on the seismic data is due to the presence of compacted lobes. The green arrow indicates north direction.

Method-Geological Setting Description

The evolution of the Canterbury basin can be divided in four main intervals: from Permian to Jurassic it was a convergent margin. In the middle Cretaceous it was rifting. From late Cretaceous to Oligocene it was a passive margin. From Miocene to Recent it has been in a transcurrent tectonics. During the last 5 million years, rapid uplift and erosion of the Southern Alps (Figure 4) has greatly increased the supply of coarse clastic sediment which resulted in the turbidities with its lobes and some channels that we will see in this paper. We examine a turbidite system imaged in the Waka-3D seismic survey acquired over the Canterbury Basin,

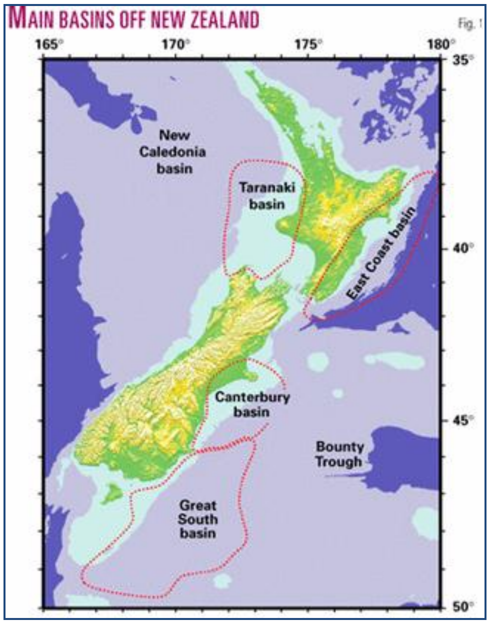

Figure 4: Main basis offshore New Zealand (Haskell & Wylie, 1997)

The study area is on the transition zone of continental slope and rise with an abundance of paleocanyons and turbidite deposits of Cretaceous and Tertiary ages. These sediments were deposited in a single, tectonically driven transgressive-regressive cycle (Uruski, 2010). Possible source rocks in the Canterbury Basin are from the Late Jurassic coaly sediments, Late Cretaceous coaly sediments, and Paleocene marine shales. Reservoir rocks are fluvial, estuarine, and marine sandstones of Cretaceous and Tertiary (Sutherland and Browne, 2003). The channels and canyons presented in the Figure 5 are very similar to those expected in this trasition zone. We can very easily associate this place to the model of Figure 1. The Waka-3D seismic survey is seen in black in the Figure 5.

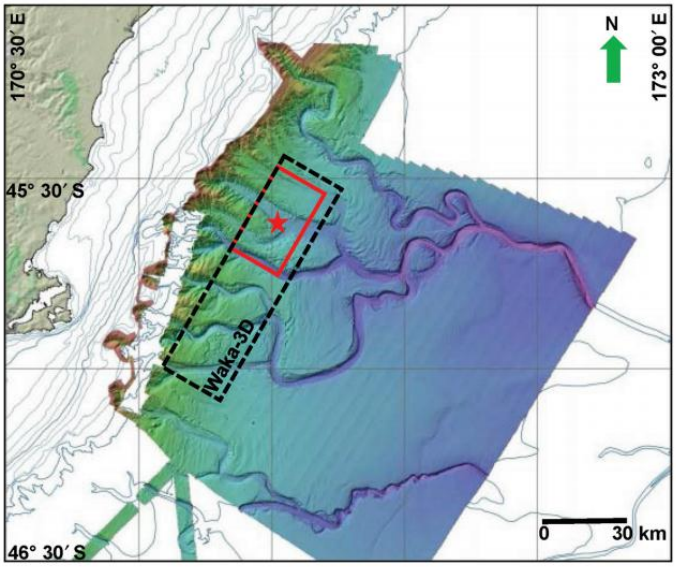

Figure 5: Map of the location of the 3D seismic survey acquired over the Canterbury Basin, offshore New Zealand. The black rectangle denotes the limits of the Waka-3D survey. (modified from Mitchell, 2009).

Since this region is a very new underexplored region, we try to bring some information from this basin. We show few time slices and it is not necessaraly represents the overall region, but we still can obtain good results from the location.

Recognition of the Canterbury basin as part of the continental Great South basin Gondwana sequence changes the basin's economic geology considerably and positively. It provides additional mature source-rock potential where structures were previously considered to be remote from source of any type, it opens the possibility of a new trap style at and below the several rift to break-up unconformities and the probability of Hoiho Group reservoir sequences based on Great South basin.

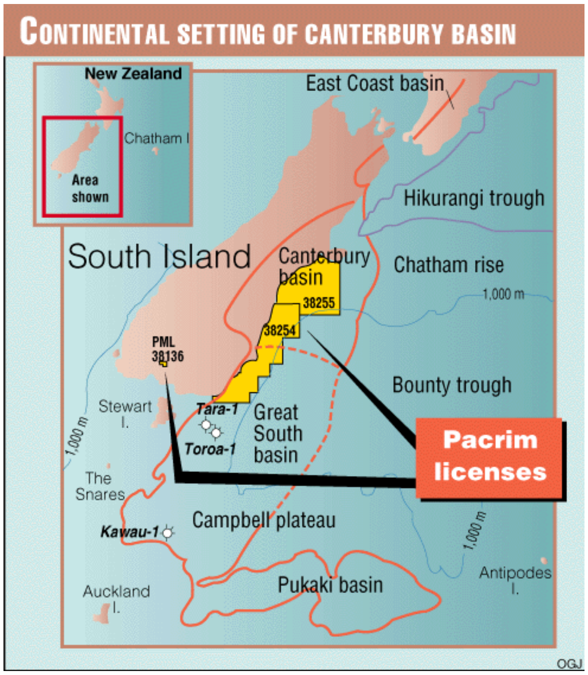

Figure 5. The onshore basin is well known compared to the offshore region (Haskell, 2009)

Results

We start the interpretation by looking in the inline A-A' on Figure 6. Pay attention on the eye feature indicated by arrow 1. It seems to be a cut through the middle of a thick lobe. We observe in a different display (Figure 7) and the first impression is that compared to Figure 6 the Figure 7 is a better vision of the seismic feature.

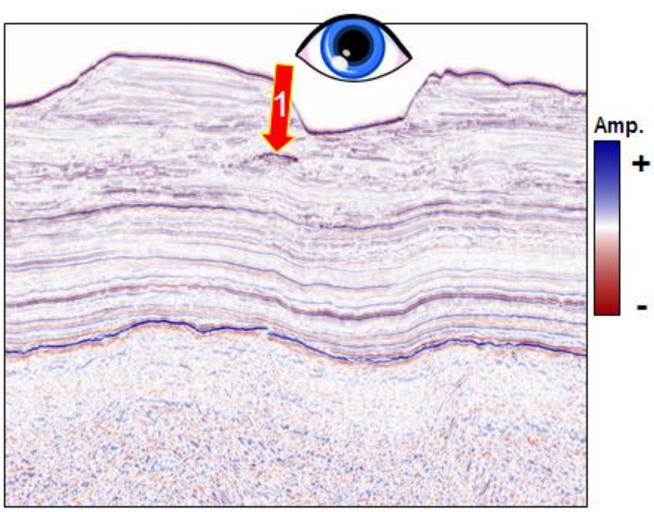

Figure 6. Inline A-A' that is crossing the biggest lobe in this area. We notice the higher amplitude on top of the "eye ball" (1) feature.

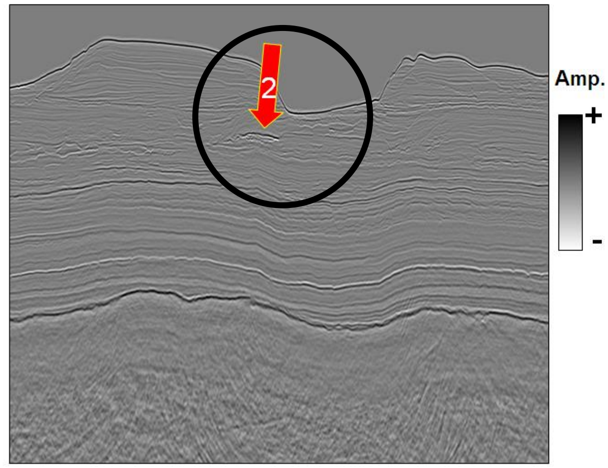

Figure 7. Inline A-A' that is crossing the biggest lobe in this area. We can see around the "eye" that there are other mini lobes (arrow 2) and they make "stairs" amalgamated layers below and above of the structure. This means we are having an increasing in sediment supply and it is affecting the thickness and position of the layers over time. This observation was essential for choosing the envelope and variance attributes because they will reveal high amplitude for compacted sand deposits.

Once we realized the presence of this eye feature we than observed through the time slices until we get the time slice showed in Figure 8 (time slice 1,864 s). We applied the variance attribute in other to enhance the contrast between the edges. Figure 8 shows us the presence of lobes in the arrow 3 and reveals new submarine channels.

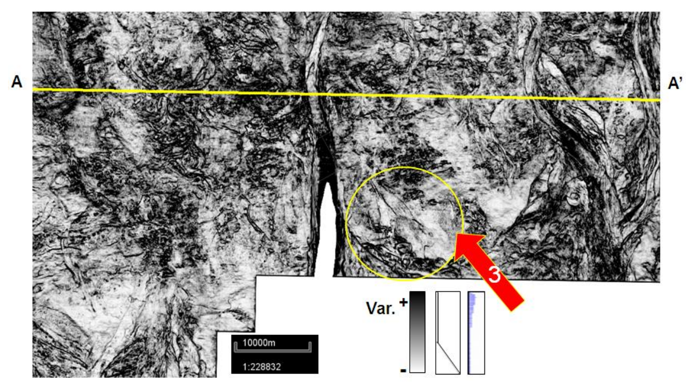

Figure 8. Time slice 1,864s showing the lobes close to the canyon a little far away from the A-A' inline. We can see that there are two main lobes surrounded by the cycle (3) and submarine channels. Trying to highlight that, we used the seismic attribute envelope as the next Figure 9 shows.

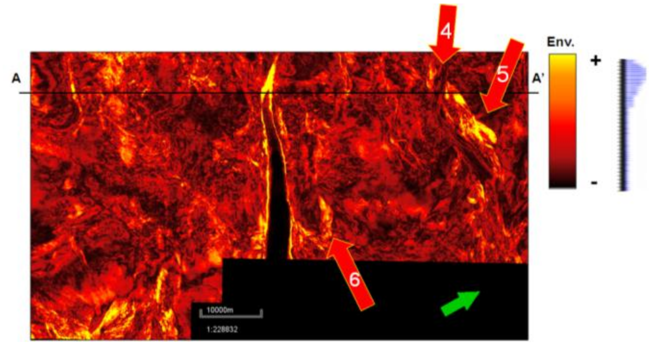

Figure 9. Time slice 1,864s through the volume. In the arrows 5 and 6 we can really see very clear the lobes that are around two kilometers in size. However we still needed sharp the edges and we coherended with variance using the opacity besides the color bar. Arrows 5 and 6 show high amplitude features that indicate sand deposities highly homogeneous. In arrow 4 we probably have a channel cutting through the lobe indicated by arrow 5. The scale bar and the histogram is indicated in the side.

The Figure 9 is showing us a possible mudfilled channel indicated by arrow 4 by just using the envelope because its low value of envelope. Indicating a not well compacted feature. To better visualize the edges of the architectural elements we cohered with variance using the opacity besides the color bar in Figure 10.

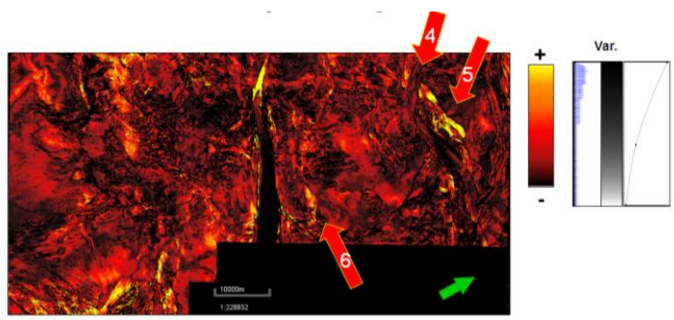

Figure 10. Time slice 1,864s using variance and envelope to identify channels (4) and the main lobe (5). Also the other lobe (6) could be delineated.

If we compare the first image (Figure 2) in the begging of this work with the Figure 10 we can really see the power of seismic attributes to enhance features such as the degree of complexity and information from the data after its processing. Look the yellow lobe indicating a possible sand deposit. Using just two attributes (envelope and variance) we delineated possible channels and lobes in a submarine environment. When we do not have continuous reflectors to pick those attributes can enhance features as seen in the figures above. This type of structural information is decisive when we want to take strategical decisions, for example locate reservoirs and drill a well.

Conclusions

The data has a good quality and was possible to use seismic attributes to highlight features related to structural elements such as lobes and channels in the Canterbury Basin, New Zealand. Using the seismic attributes variance and envelope we could make a better interpretation of the data if compared with conventional seismic amplitude. We highlight that seismic attributes are decisive tools when making strategical decisions such a location of a potential reservoir.

Acknowledgments

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