

PS Detecting Lateral Continuity of Taranaki Basin Reservoir Sand Based on Sequence Stratigraphy and Seismic Attribute Analysis*

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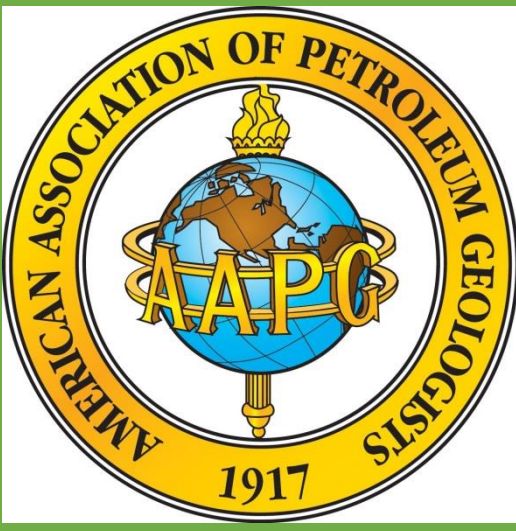
Abstract

Delineating lateral continuity of a reservoir sand with few wells is one of the challenging parts in any interpretation and one of the main factors that controls the reservoir volumetric estimation. When seismic encounters thinner sediments ($< \frac{1}{4}$ length of the wavelength), the wavelets used to tune to be an unresolved reflections which cannot be seen under a broadband seismic dataset. However, thicker sediments on the other hand show resolved reflections, which can be seen on the seismic data. The main purpose of this study is to show how spectral decomposition (SD) attributes is used to delineate reservoir sand and to come out with the dominant frequency of a specific geobody. These includes on how seismic attributes helps is sequence stratigraphy analysis in recognizing reservoir continuity as well as the responses towards the subtle features of the basin. In accordance to seismic attributes, sequence stratigraphy method was used to delineate the targeted reservoir by analysing the seismic termination features, paleo environment and with log correlation analysis. The result was presented in a facies map marked by the seismic termination surfaces with information on the sediment migration.

Detecting lateral continuity of Taranaki basin reservoir sand based on sequence stratigraphy and seismic attribute analysis



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Introduction

Delineating lateral continuity of a reservoir sand with few wells is one of the challenging part in any interpretation and also one of the main factors that controls the reservoir volumetric estimation. When seismic encounters thinner sediments ($< \frac{1}{4}$ length of the wavelength), the wavelets used to tune to be an unresolved reflections which is not able to be seen under a broadband seismic dataset. However, thicker sediments on the other hand shows resolved reflections which can be seen on the seismic data. The main purpose of this study is to show how spectral decomposition(SD) attributes is used to delineate reservoir sand and to come out with the dominant frequency of a specific geobody. These includes on how seismic attributes helps in sequence stratigraphy analysis in recognizing reservoir continuity as well as the responses towards the subtle features of the basin. In accordance to seismic attributes, sequence stratigraphy method was used to delineate the targeted reservoir by analysing the seismic termination features, paleo environment and with log correlation analysis. The final result was presented in a facies map marked by the seismic termination surfaces with information on the sediment migration.

Methods

Spectral Decomposition, Coherency, phase and envelope volume created to investigate the seismic volume.

Spectral decomposition- Seismic data decomposed into 10 different frequency bands with spectral volume that ranges from 8 to 10 Hz. The dominant frequency at depth was chosen which shows most of the feature

Seismic reflection termination mapping, sequence boundary identification and seismic internal configuration

Integrate well logs with seismic stratigraphy and verify the sequences.

facies mapping by projecting the seismic termination reflectivity on map. Close spaced inline and crosslines was used to create the 3D representative of the entire volume.

Results

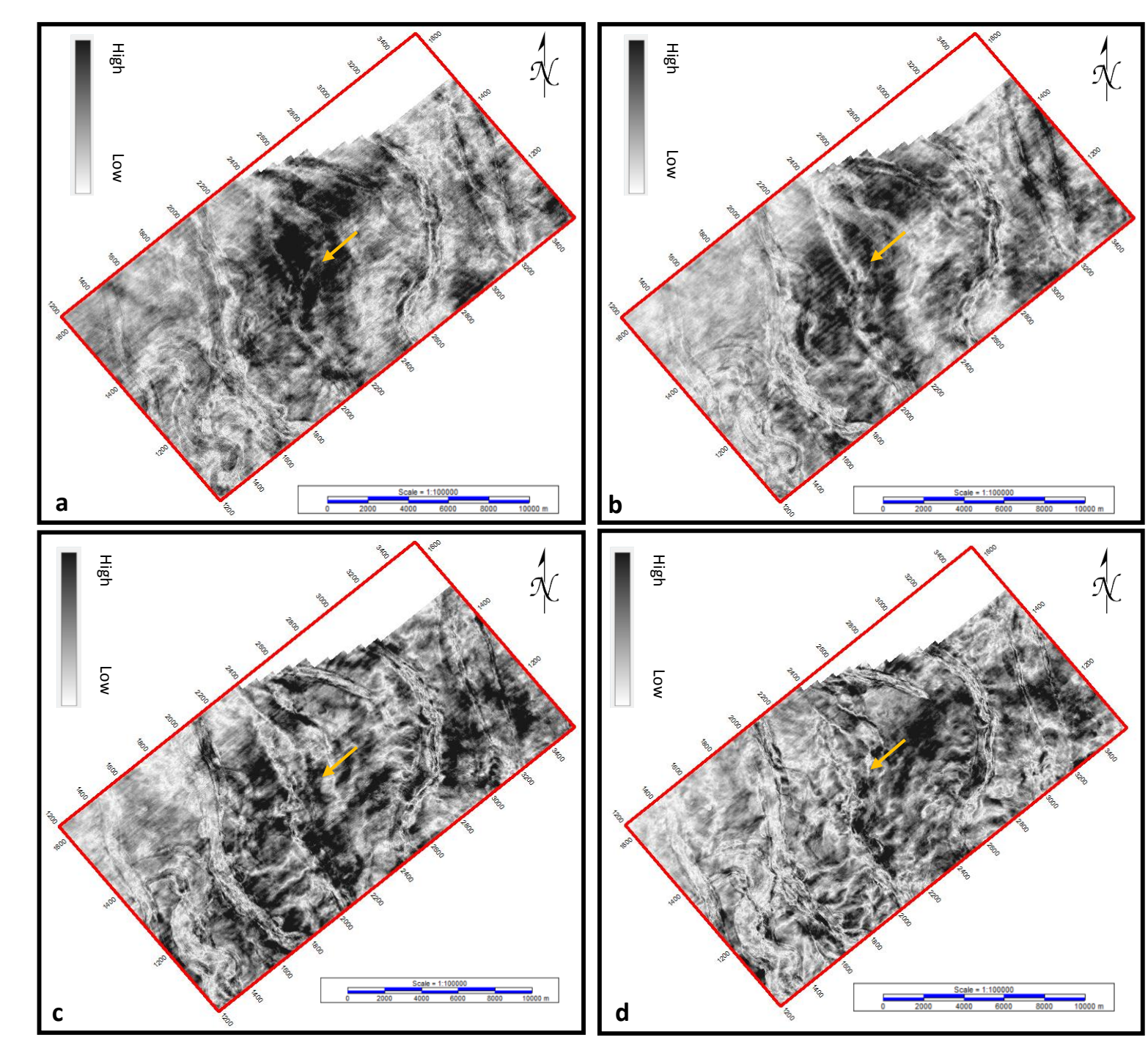


Figure 1. Showing time slices of spectral decomposition starts from 8.0 hz, 10.30 hz, 13.3 hz and 17.2 hz (a-d). More noise appears to be accumulating when frequency starts to increase.

The purpose of this spectral decomposition is to check on the best frequency that depicts the continuation of a specific feature. We are looking at the channel that pointed out by the arrow and the visibility became poorer when it comes to an higher frequency.

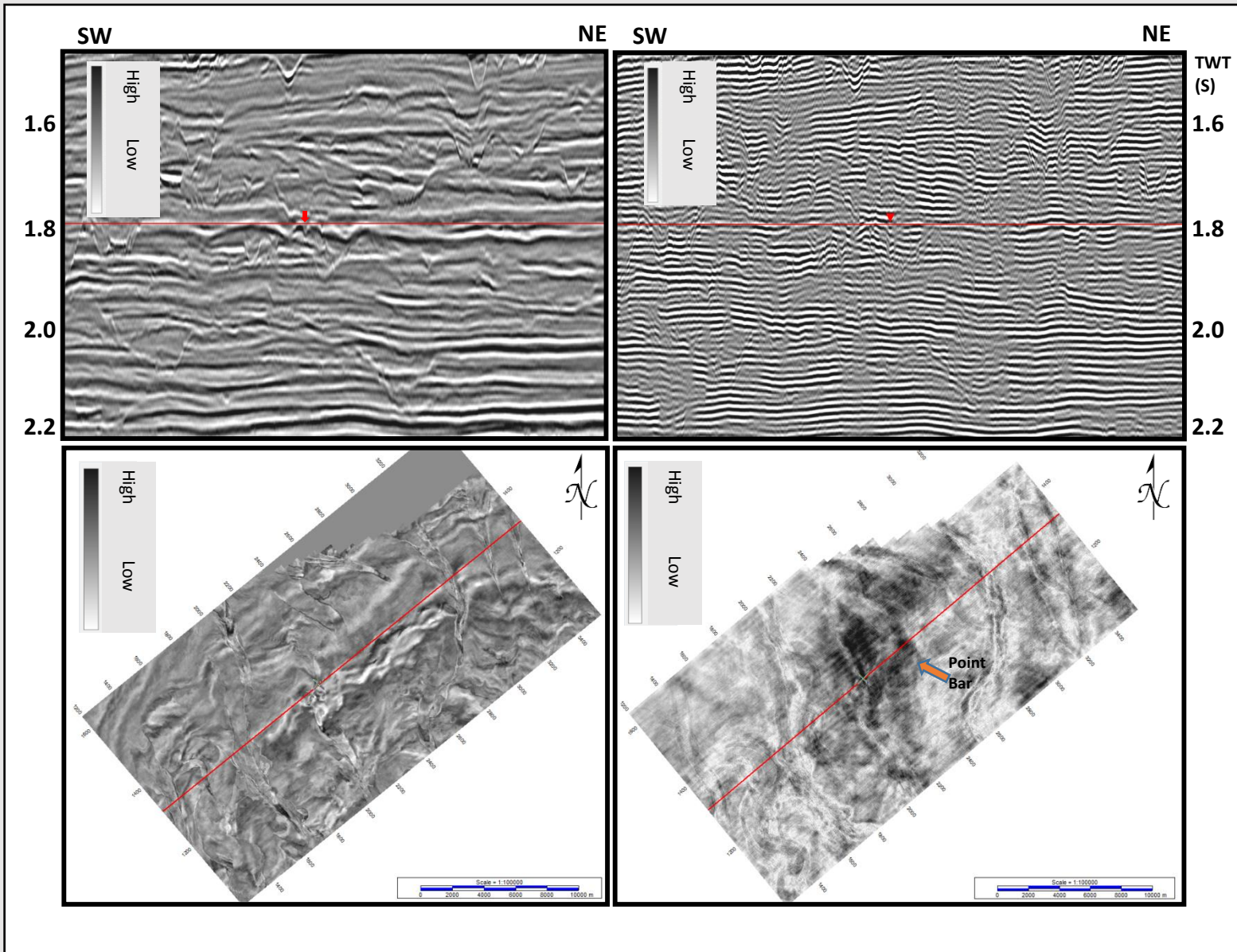


Figure 2. showing comparison between amplitude and spectral decomposition on vertical seismic section and on map view.

- Strong amplitude reading in the center of the map indicates the presence of the thicker channel captured under 10.3 Hz SD. The N-S trending channel was not clearly seen in the amplitude (conventional seismic trace) data compare to SD.
- Low frequency SD has less noise and able to bring up the continuous features of the channels and the lateral migration. This is also could be that the channels might have tuned at the tuning thickness more than 17.2 Hz.
- SD also shows detail features of the sinuosity including point bar and channels that stand out against the background.

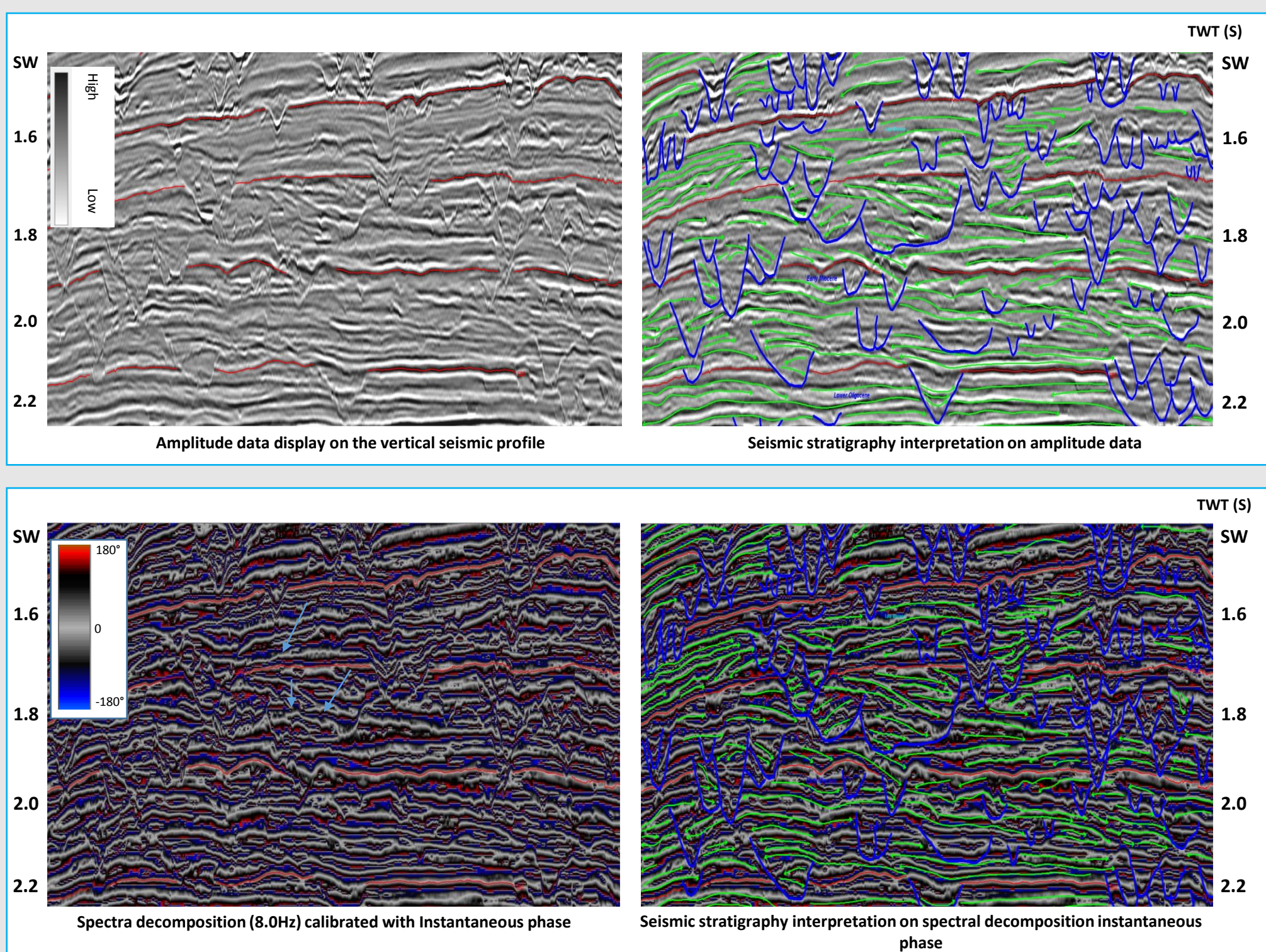


Figure 3. showing comparison between amplitude and SD Instantaneous phase at 10.3Hz. Downlap and onlap marked in green arrows, channels are in blue lines and erosional surfaces/SB marked in red lines.

- Phase is one of the attribute that not very much in use compared to frequency, however phase can be a remarkable tool when associated with other attributes to get a better results. The above result proves that SD instantaneous phase can be useful in detecting the sequence boundaries and help in to visualize the bedding configurations into more details.
- The SD attributes shows that most of the standing reflections are from zero phase where the energy at this period are the maximum. Cross checking the SD attribute with amplitude shows more clear configuration and seismic termination patterns can be recognized though this attribute..
- The bottom of the channel can be easily seen together with the reflection termination surfaces such as, onlapping and downlapping surfaces. This helps in identifying the sequence boundary effectively as well.
- The parasequence setting in this are ranges from aggradation to progradation stacking patterns. Aggradation pattern tells that the accommodation and sediment supply are at balance and progradation parasequence set tells the sedimentation is towards basinwards with low relative sea level. Another way of looking at this situation is base on the high sedimentation rate with less accommodation space. Such environment can create more deeper channels and higher erosions. It is possible that the deposition took place or in the HST or FSST.

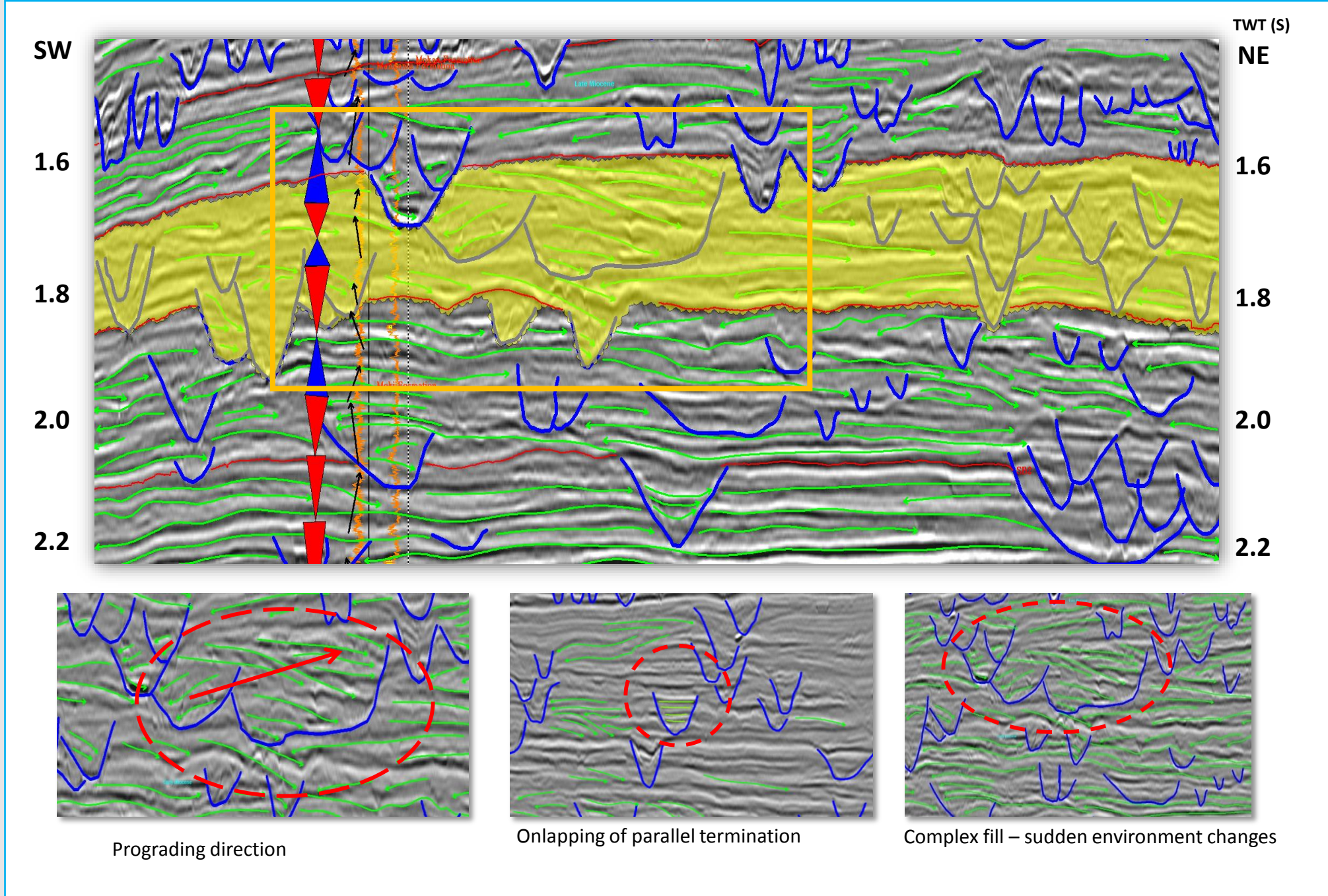


Figure 4. showing internal configuration that can be seen on the seismic which used to determined facies changes.

- Seismic reflection in this area shows parallel to subparallel patterns indicates the depositional environment at this stage is quite stable and not much influenced by the tectonic events. Some part of the seismic below 2.5 second shows chaotic and hummocky clinoforms.
- The highlighted section (yellow) is an area of interest where interesting features such as stacking channels, deep cutting channels and presence of complex internal configurations. We have tried to mapped the area based on the seismic stratigraphy in order to see the correlation of the lateral migration.
- Sequence boundary identified based on the erosional surface MFS.
- The depositional environment recognized as fluvial to shore zone.
- Internal seismic (Onlapping and downlapping) configuration used to make confirmation of the depositional direction.
- The area shows stacking channels and incised valleys with the width ranges from 1-2km (calculated from basemap/timeslice).
- The area might have gone through sudden changes in the depositional environment with change in depositional directions. This is also involve sudden changes in sea level which affect the accommodation space for the sedimentation to occur.
- Classified as SQ type 2 as the deposition setting and fluctuation of the relative sea level did not shows the sea level drop below the shelf-slope break.

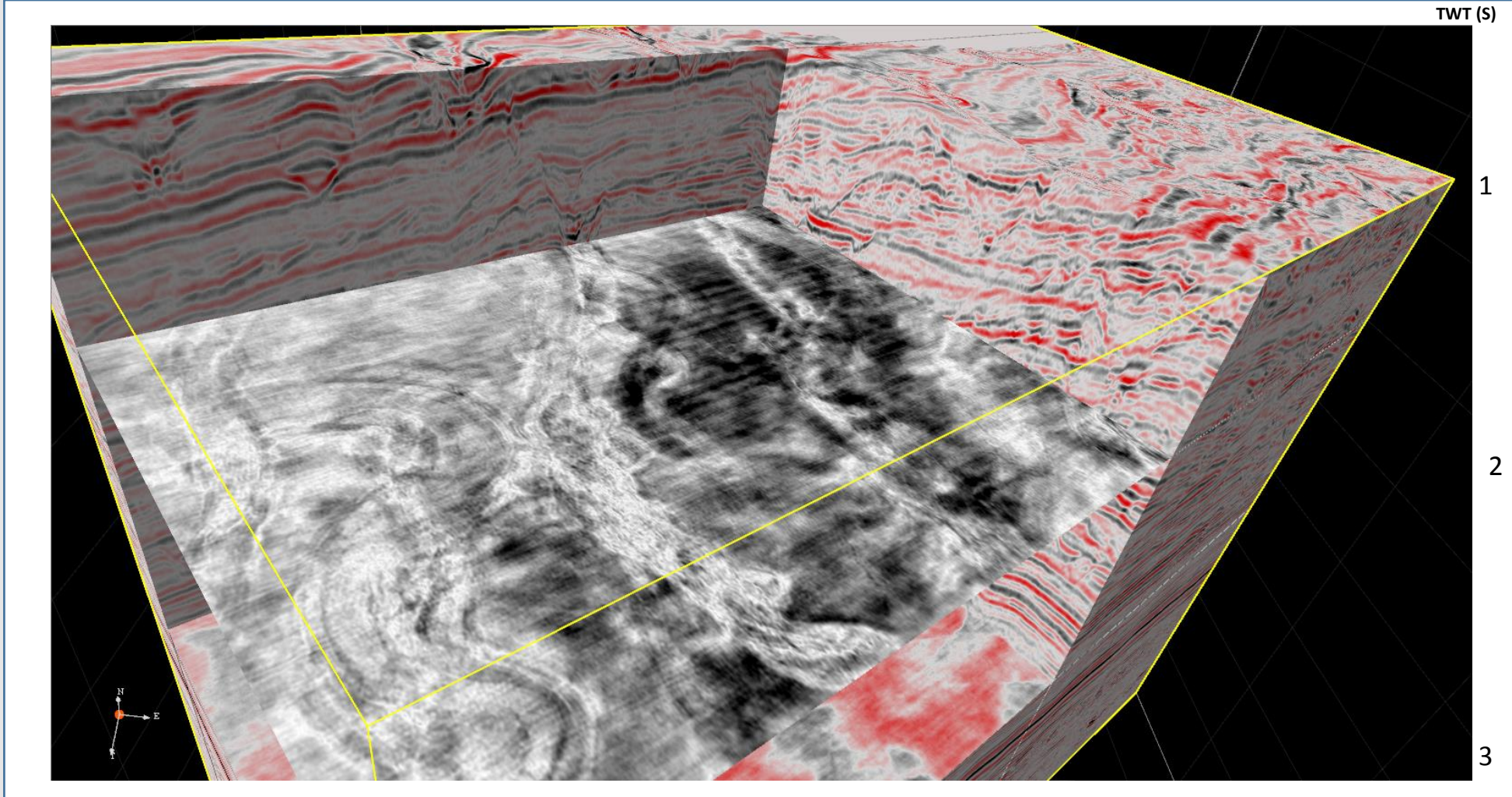


Figure 5. Showing 3D chair-cut 3D visual of Amplitude cube with vertical seismic slice of SD 10.3hz.

Time slice though seismic volume used to detect the migration of channels and the depositional sequences. Panning through the seismic volume reveals that the orientation of the channels are from N-S and NW-SE. However, looking only at the vertical seismic section probably will result in different channel orientations. There might be a major fault that might cause an uplifting at southern block that looks like the channels are flowing the opposite directions. Uplifting block at the Eastern part of the survey which occurred during Middle Miocene can be one of the possible clue that indicates the Western Block quite stable compared to the Eastern block.

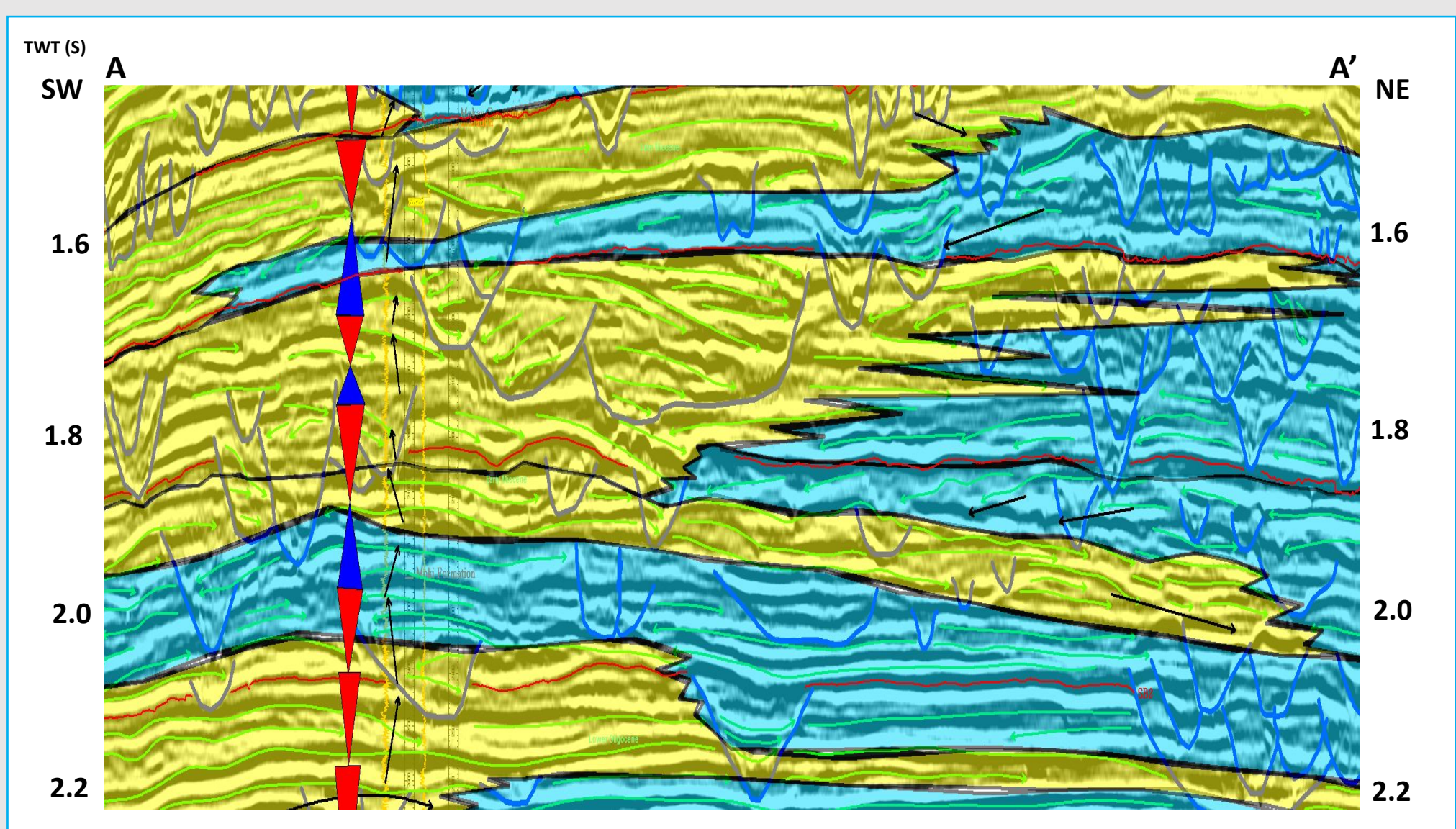


Figure 6. showing mapping of facies changes based on reflection terminations. The yellow zone represents the downlapping features and the blue zone indicaes mostly on the onlapping features.

- Lateral changes of the facies identified though seismic reflection patterns (reflection termination), sea level changes and tectonic events. Lateral migration of the facies is towards basinward, with downlapping patterns.
- Frequent change in the facies also indicates the area might gone though sudden changes in relative sea level that can verified from the sea level curve. Also sudden drop in realtive sea level forces the base level to be in equilibrium and this phenomena might results in deeper channels that cuts through the previous sediments.
- The overall GR reading at this survey showing coarsening upward and the corresponding age which is from Early Miocene also show a lower sea level. However at the same time, subsidence curve from the well indicates the lowest in the chart. Due this condition more hinterland sediment expected to be deposited around the area and more channels must have been created.
- As the sediments from hinterland are more coarser and it is expected that more coarser sediment deposited at the NW part of the area compared to SE as the sediments expected to become finer. Also the sediment that brought from SE should be finer as these are onlapping of basinal sediments.

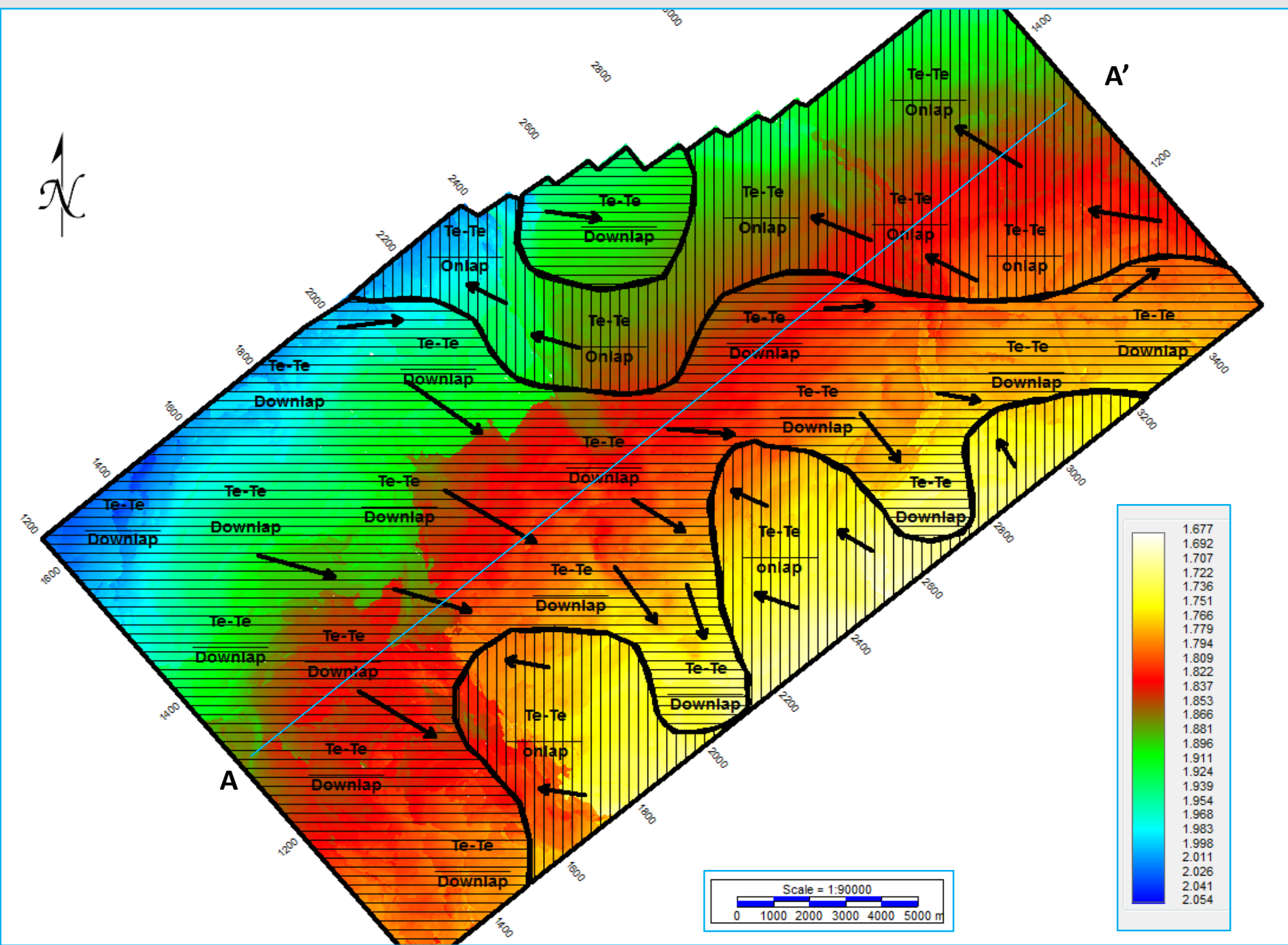


Figure 7. Illustrating different areal configuration modified based on the seismic facies code system which was introduced by Ramsayer (1979). The sequence boundary top and base identified with the their type of truncation and then correlate them with type of seismic internal configurations. Te = erosional truncation, → flow direction.

- The code system identified as A-B/C, where A is the Upper boundary, B is the lower boundary and C is the internal configuration. Instead of identifying the internal configuration as patterns, we have chosen to identify the internal configuration based on the reflection terminations.
- Inline (5 km) and Crossline (2.5 km) intervals marked with the seismic facies code as to detect facies changes around the area. The intersecting lines extended to create boundary between the onlapping and downlapping reflection terminations.
- Seismic in this area charcterized as continuous and discontinuous parallel reflections.
- The complete study on the seismic facies comes up with three dimensional seismic stratigraphy map that can be used in detecting the lateral changes in a reservoir.
- Most of the sediment in this sequence deposited as downlapping with NW-SE orientation.
- Chronostratigraphy chart has been created for the basin to analyze depositional sequences. The stratigraphy intervals is from Late Pliocene to early Miocene which was penetrated by two wells. These sequence is overlain by Late Miocene sediments that form an onlapping surface on top of the Sequence boundary.
- The result shows the source of sediment supply might come from Western part of the survey that fill up the channels that trending N-S and NW-SE. The mapped area contain vast areal extend of sediments compared to other sequence in this basin. This was identified based on the seismic termination that reflecting the most downlaps surround the area.

Summary and Conclusions

Use of Spectral Decomposition verifies the amplitude that decomposed at 10.3Hz shows clear N-S trending channels compared to the one at higher frequency. Higher frequency domain seems to have lower signal to noise ratio compare to the lower frequency. Identifying channels from its domain frequency help in identifying the thickness from the tuning thickness value. This helps in reconfirming the depositional environment and the Paleo currents which associate to the sediment thickness. Sediment information best to incorporate with sequence stratigraphy to enhance the depositional environment model. However, subsurface geology is not as easy as we might expect and that is why we need collaborate different approaches in seismic attributes and more confirmation from modern and paleo analogues to come up with reliable reservoir models.

Defining every seismic sequence termination brings the interpretation near to its depositional environment. Internal seismic configuration and seismic structural features stand out more with spectral decomposition attribute and with the phase depending frequencies. It is not viable to conclude the sedimentation and depositional environment of this area as there are changes in

Work In Progress

- Quantitative analysis will be conducted on the targeted reservoirs. Porosity and facies mapping based on velocity-Porosity analysis will used to classify the reservoir into various fluids. Creating model with velocity-porosity relationship is another option to create resourceful porosity and facies maps.
- Considering to use seismic inversion to assist further in the rock physics methods.
- There are other seismic termination patterns been recognized in this area which can give more idea of the depositional environment.
- More research on the paleo current need to address to this research to get the most possible depositional environment setting.