Correlation of Geological Time Lines by Reducing Uncertainties to Regions - A Global Seismic Interpretation Workflow*

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Abstract

Global seismic interpretation solutions are changing trends in seismic interpretation because they allow auto-tracking of hundreds of seismic reflectors. A method for generating these horizons that utilizes an algorithm based on dip- and azimuth data is presented. Previously, interpreter input to the workflow was limited but with evolving technology, interpreters are now able to correlate polygonal regions bounded by horizons and faults, channels or mounds, manually. The result is more robust and minimizes uncertainties. A regional 2D line was selected to demonstrate the workflow and results. The line is located offshore Tanzania, which has seen increased interest in exploration activities in recent years. The setting is a combination of complex structural and stratigraphic elements and includes several channelized sections at different stratigraphic levels. These features make it ideal to demonstrate the workflow. By utilizing thousands of auto-picked events and adding constraints in an iterative manner, we were able to produce more reliable Wheeler (flattened) diagrams. The structural and Wheeler domains were then used to pick boundaries for packages where changes in stacking patterns or amplitude character were observed. "Regions" were then correlated manually to obtain time-equivalent RGT (Relative Geologic Time) lines, or iso-time lines, across the regional 2D line.

Correlation of Geological Time Lines by Reducing Uncertainties to Regions — A Global Seismic Interpretation Workflow

Kristoffer Rimaila
06/02/2015

Data courtesy of: ion

Presenter's notes: Welcome everyone. In this talk I am going to present to you a global seismic interpretation workflow that includes automatic tracking of hundreds or thousands of horizons, what we call events. This workflow will also present the concept of regions that maximizes interpreter input and thus makes the workflow more robust. Finally we will look at a case study where we have utilized this method in a frontier area in order to pinpoint interesting areas, highlight possible reservoir presence and delineate stratal packages based on stacking patterns.

Overview

- Introduction
  - – Global Seismic Interpretation Methods
  - – What Regions..?
- Workflow
- Case Study
- Conclusions

Presenter's notes: I will first give you an overview of the methodology followed by the workflow. As mentioned, a 'real world' case study will also be presented followed by conclusions before we open up for the Q&A session.

Overview

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Introduction

Global Seismic Interpretation Methods

- Global Seismic Interpretation Methods
  - Auto-tracked horizons or packages
  - A new starting point in the interpretation effort
- Dip field is used to propagate a closely spaced set of auto- tracked horizons
- Data set: Regional 2D lines from the BasinSPAN data-set offshore Tanzania and Mozambique

Presenter's notes: Global seismic interpretation methods have become widespread in recent years and we would like to think of them as a new starting point in the interpretation workflow. With a dense set of auto tracked horizons, we can conduct seismic sequence stratigraphic analysis by looking, for example, at stacking patterns and depositional shifts in a Wheeler diagram that is automatically created using all the auto-tracked events. Further, these events could be used to create low frequency models, propagate information from wells across the whole seismic survey or for stratal slicing. The benefit of using horizons, or in this case these events that follow the seismic grain is obviously superior to using simple time or depth slices. The density of the events also allow us to sample on a sub-seismic scale where each sample is interpolated from the two closest samples.

In this instance the events have been propagated using the dip-field. This allows for extraction of continuous horizons, instead of horizon patches that often result from amplitude based tracking. The data-set utilized in the case study consists of regional 2D lines from the ION BasinSPAN survey offshore Tanzania and Mozambique. This frontier, deepwater area consists of complex structures, thus allowing us to prove the robustness of the workflow.

Introduction

What Regions..?

- Constrained by faults and horizons
- The interpreter correlates each region manually
- End product is a merged set of horizons across the whole regional line

- Benefits include increased robustness due to increased interpreter input, multi-seed horizon picks

Presenter's notes: What then are these regions???
A region is bounded by two horizons and faults. It is then up to the interpreter to correlate the regions manually using an interactive horizon, or event slider. The end product is a merged set of these auto tracked events that correctly jump from one fault block to the other and so forth. The correlation of the regions can be done as many times as the interpreter wants so it could be viewed as an iterative process. Another new feature that adds to the robustness is the fact that if bounding horizons for the regions are picked within the software, the dip-tracker is now multi-seed.

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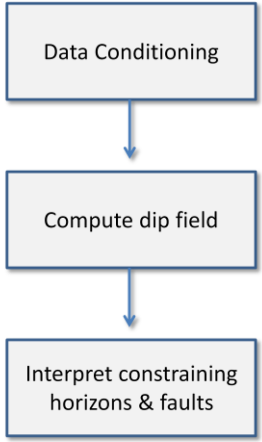
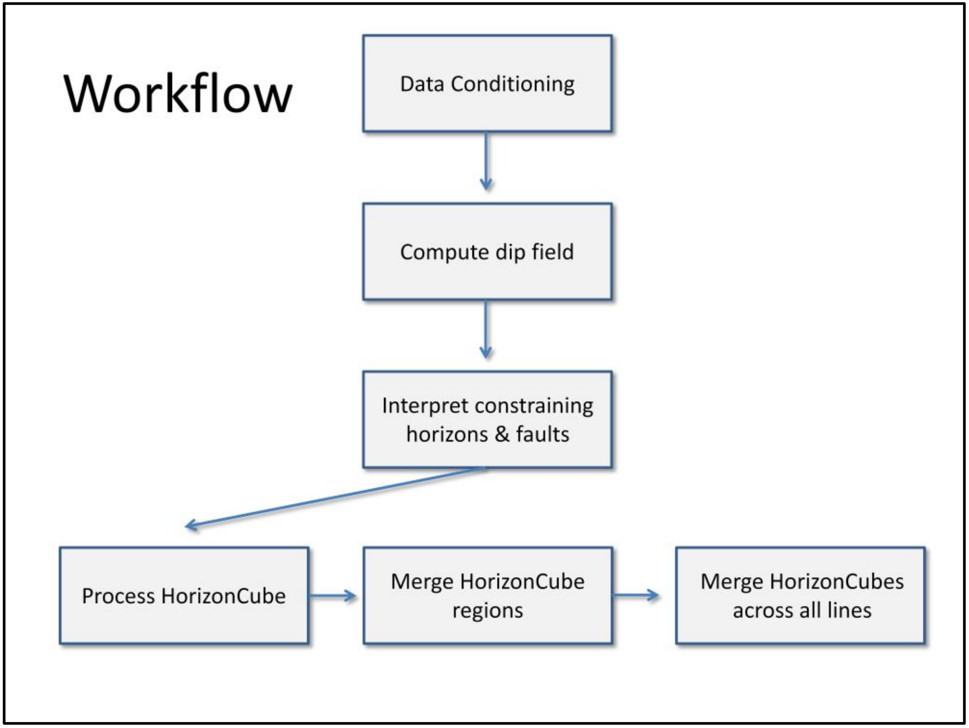
Presenter's notes: Let's have a look at the workflow then more closely.

Workflow



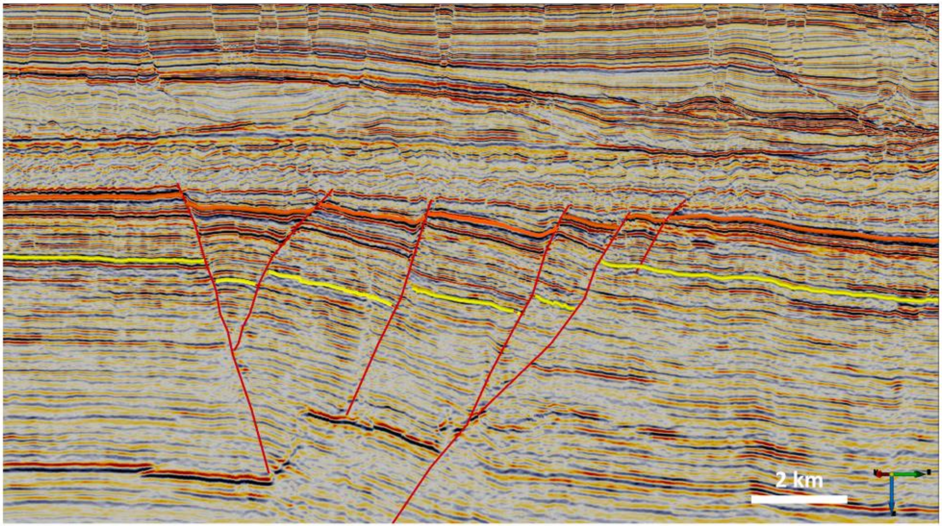
Presenter's notes: We start by conditioning the data and this step is quite important as we all know the quality of the end result often depends on the inputs. We compute the dip-field, or in this case apparent dip, as we are dealing with 2D data. Horizons can be picked either using an amplitude tracker or an integrated dip-tracker or imported from elsewhere, most importantly a top and a base horizon is needed to delineate where the auto-tracked events will be created. Faults are optional.



Presenter's notes: Next we process and extract the events, what we call a HorizonCube. Next the interpreter correlates all regions manually, per package. After some initial QC the final end product can be processed, meaning we will merge all regions in order to have one single set of horizons that span the whole 2D line.

Workflow

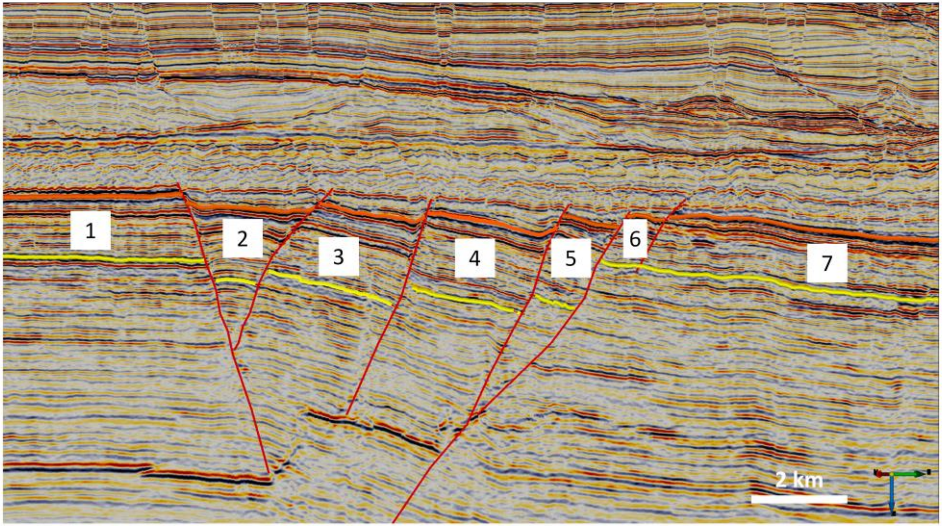
Australia, NW Shelf



Presenter's notes: Let's have a look at how this works on an actual 2D line. On this line you can see that we have a top and base horizon as well as faults interpreted.

Workflow

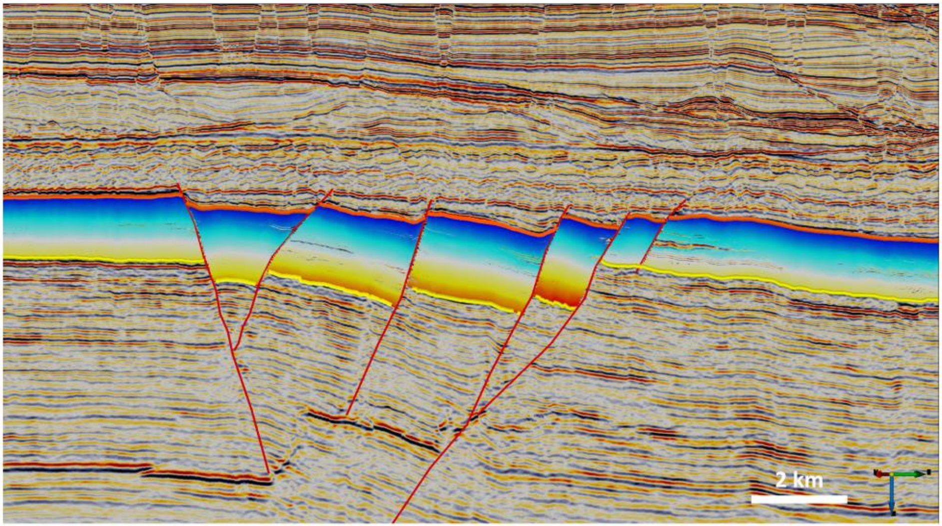
Australia, NW Shelf



Presenter's notes: In this case we will then have 7 regions as you see here.

Workflow

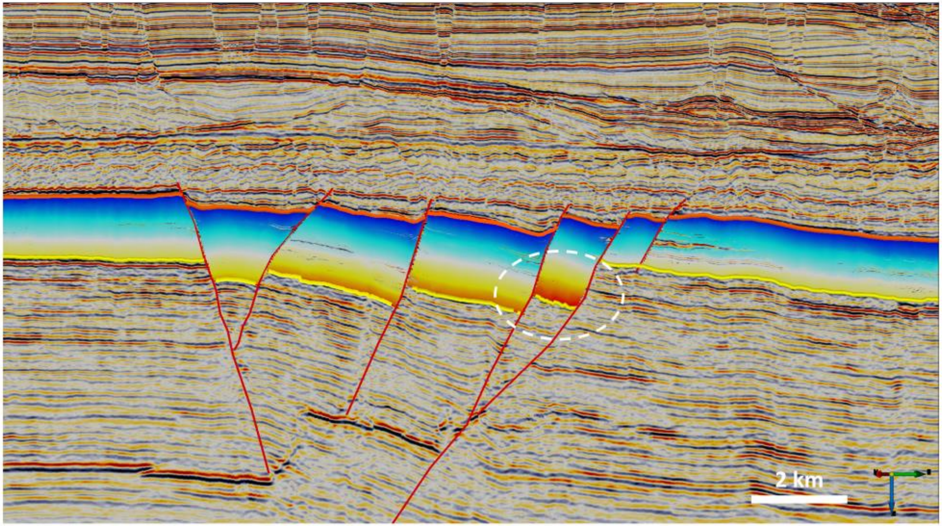
Australia, NW Shelf



Presenter's notes: After processing the HorizonCube this is what we get, you could think of it as 7 individual sets of auto-tracked events. Keep in mind we have not correlated them yet.

Workflow

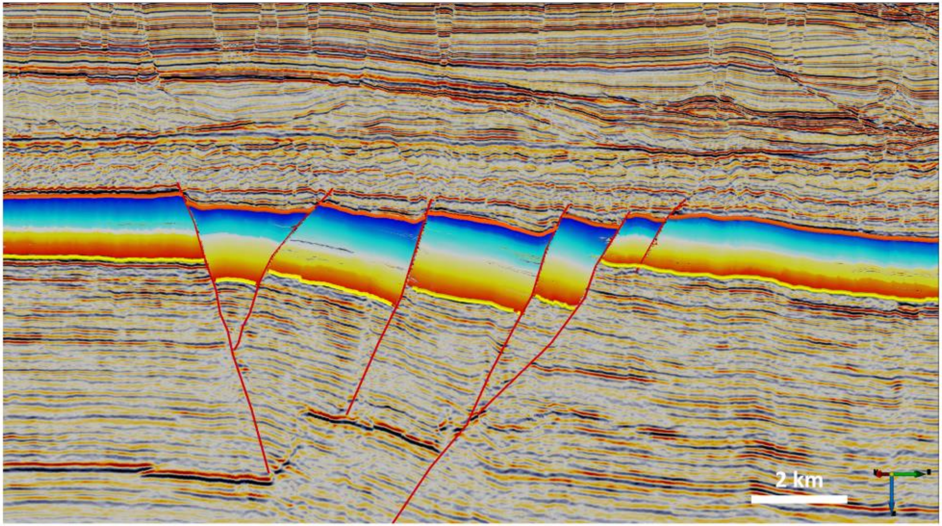
Australia, NW Shelf



Presenter's notes: Particularly here, you see that our colors across the fault blocks do not match. This will lead to mismatches when we start looking at relative geologic age. The colors across all fault blocks should range from dark orange at the base toward blue at the top, with the right-most package having the thinnest blue package as it has been subject to erosion.

Workflow

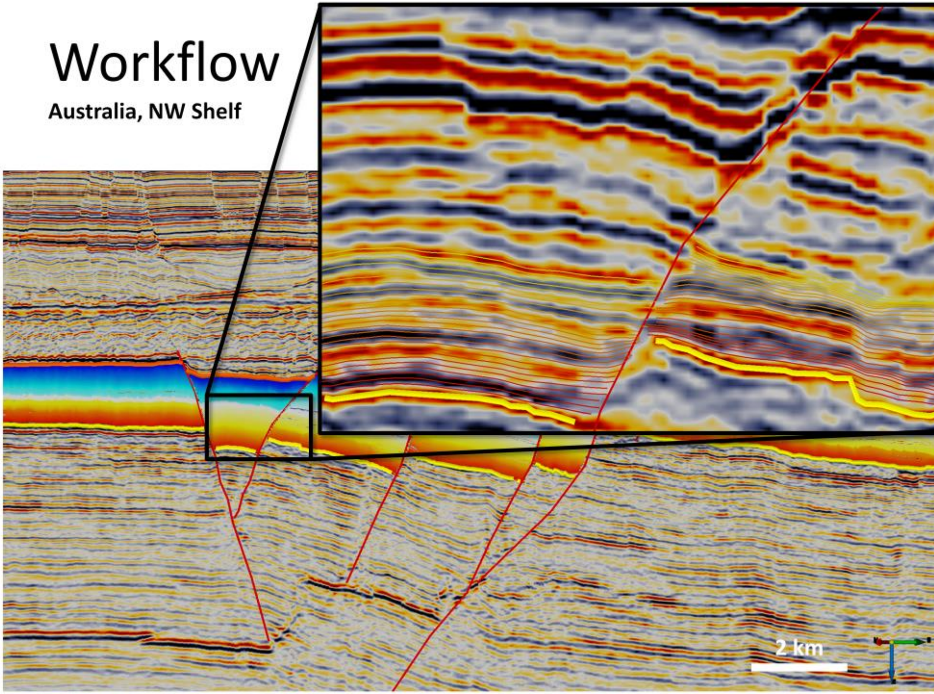
Australia, NW Shelf



Presenter's notes: Like so. This is what it looks like after correlation. The colors match much better now.

Workflow

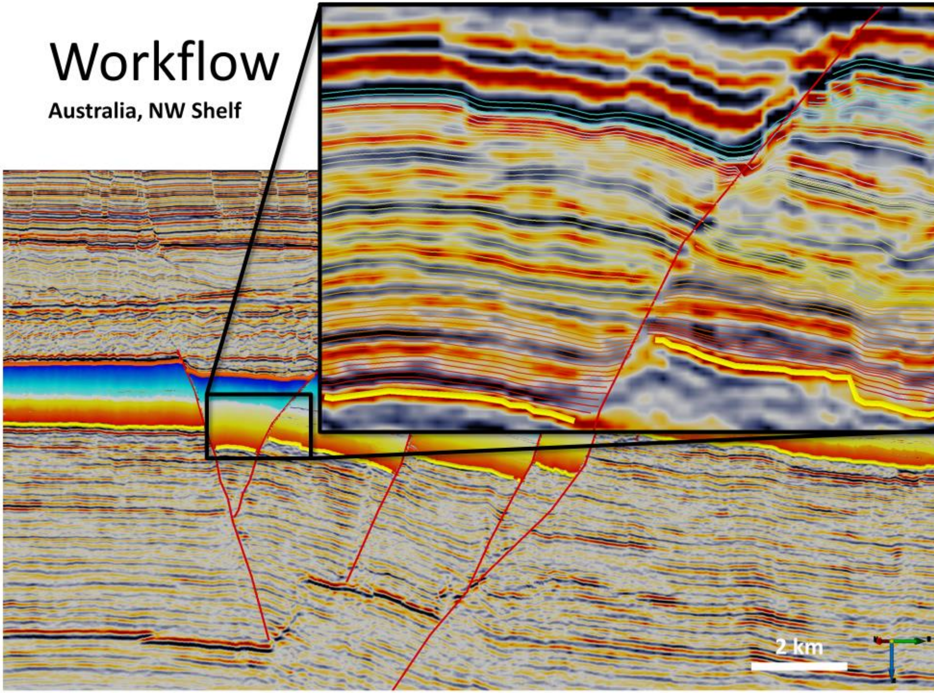
Australia, NW Shelf

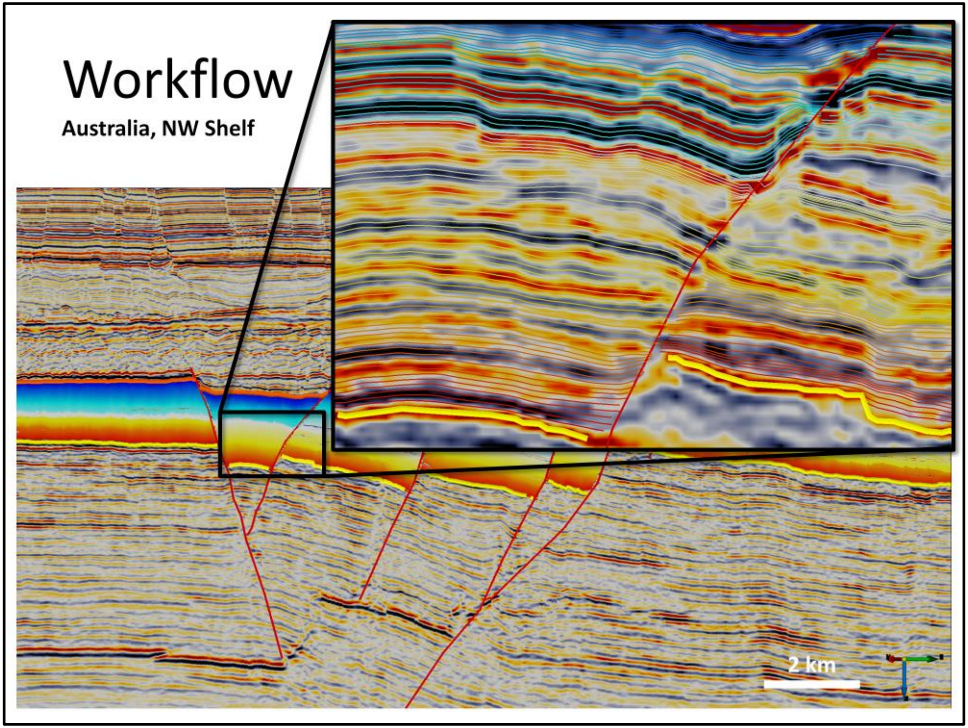


Presenter's notes: We can have a zoomed in view here in order to QC the jump across this fault.

Workflow

Australia, NW Shelf





Presenter's notes: And finally so. The events are crossing the fault with the correct throw now. Now we can start interpreting seismic sequence stratigraphy.

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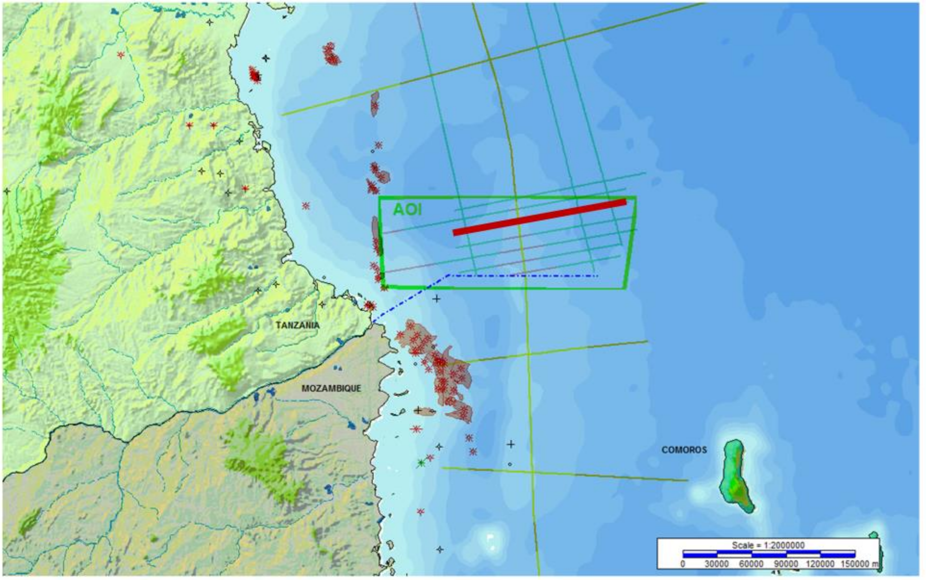
Presenter's notes: Next we will move to the actual case study of this talk.

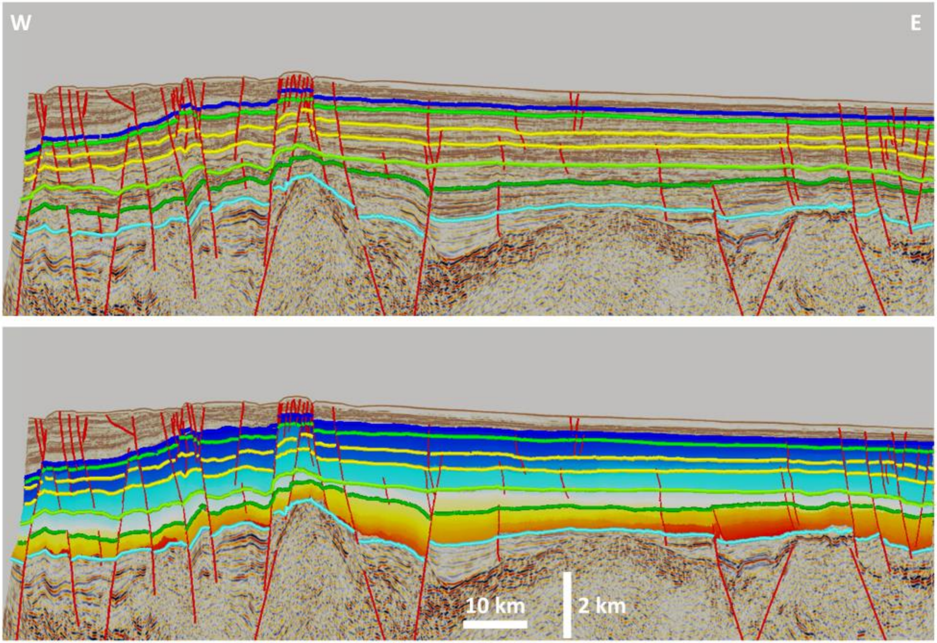
Case Study

Survey Location – Offshore Tanzania

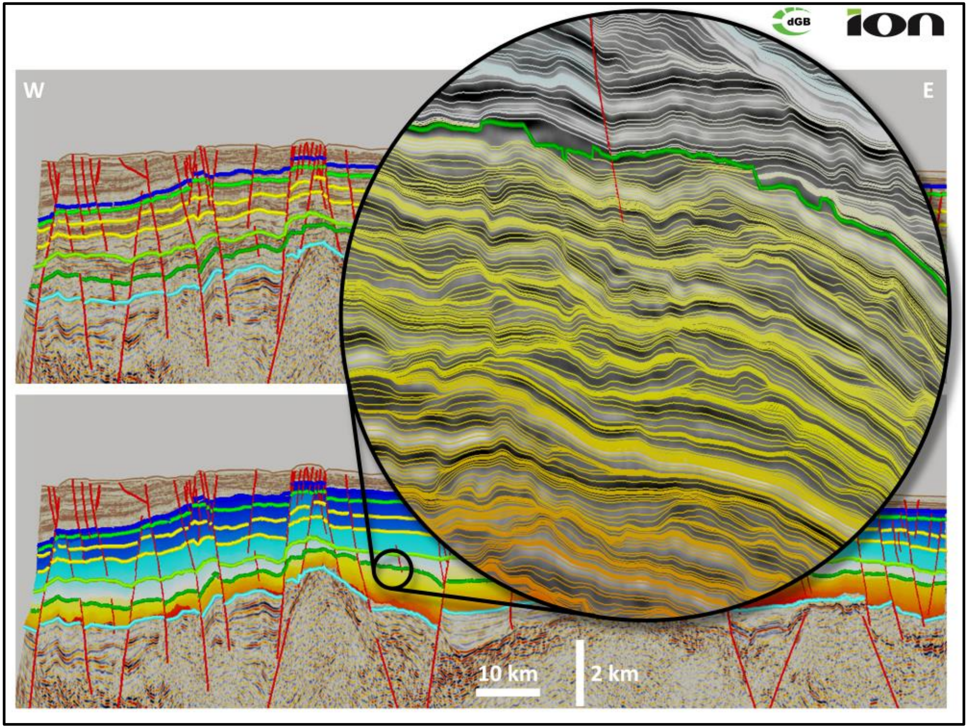


Presenter's notes: The lines used are part of the ION BasinSPAN data-set in deep water offshore Tanzania and Mozambique. This is a frontier area with no proven hydrocarbons in the deepwater portions although several large discoveries have been made recently up toward the shelf as seen in this map. The age of the studied interval is an Upper Cretaceous through Early Miocene deep water fan play that is age equivalent to some of the up dip-dip discoveries made in recent years.

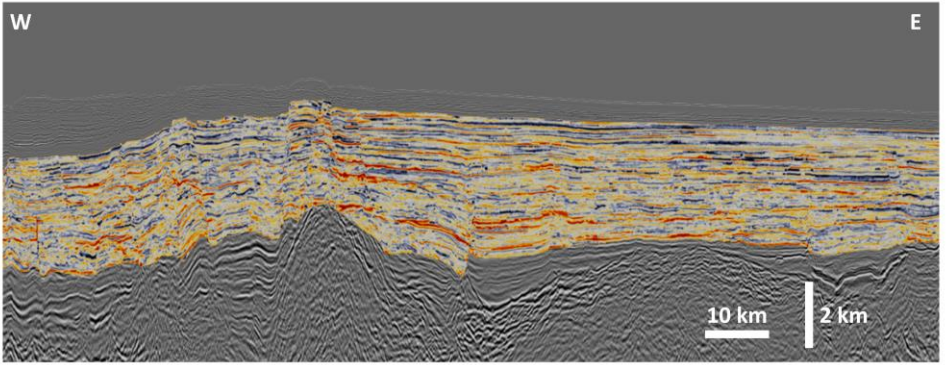
In this talk I am going to use this East-West line, highlighted in RED here.. The polygon called AOI is the area of interest we were given while conducting the study.



Presenter's notes: At the top you can see the seismic line along with our inputs, meaning previously interpreted horizons and faults. In the image below you can see the same line with the auto-tracked events overlain.

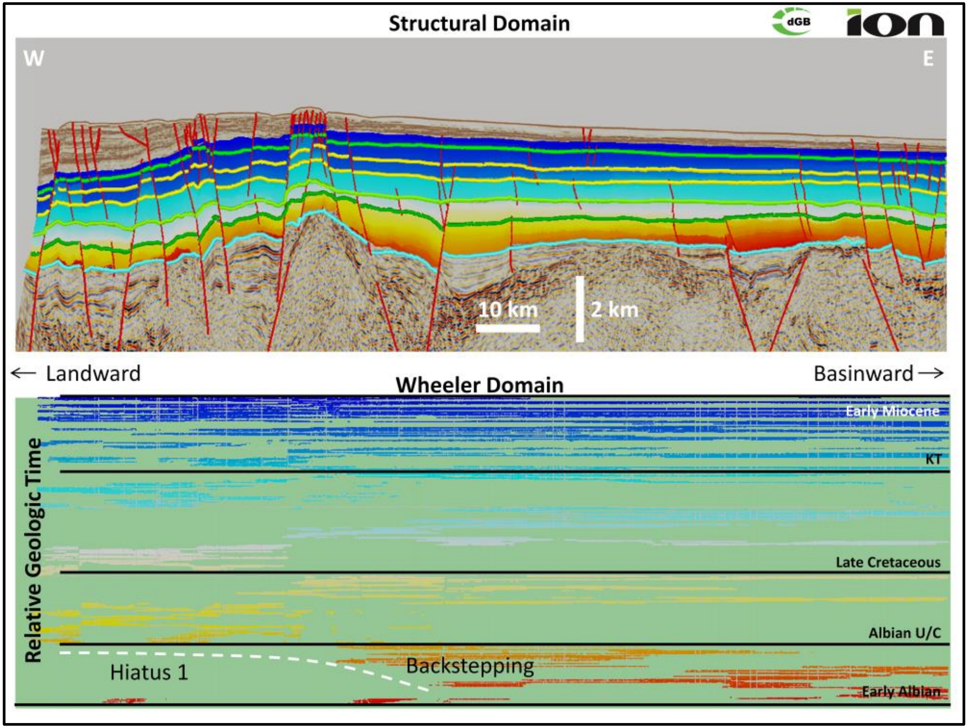


Presenter’s notes: This zoomed in view shows you the HorizonCube density of the events. That is, how many events there are in a user selected vertical window. Already here convergence and divergence become apparent, but we will return to this in a bit.

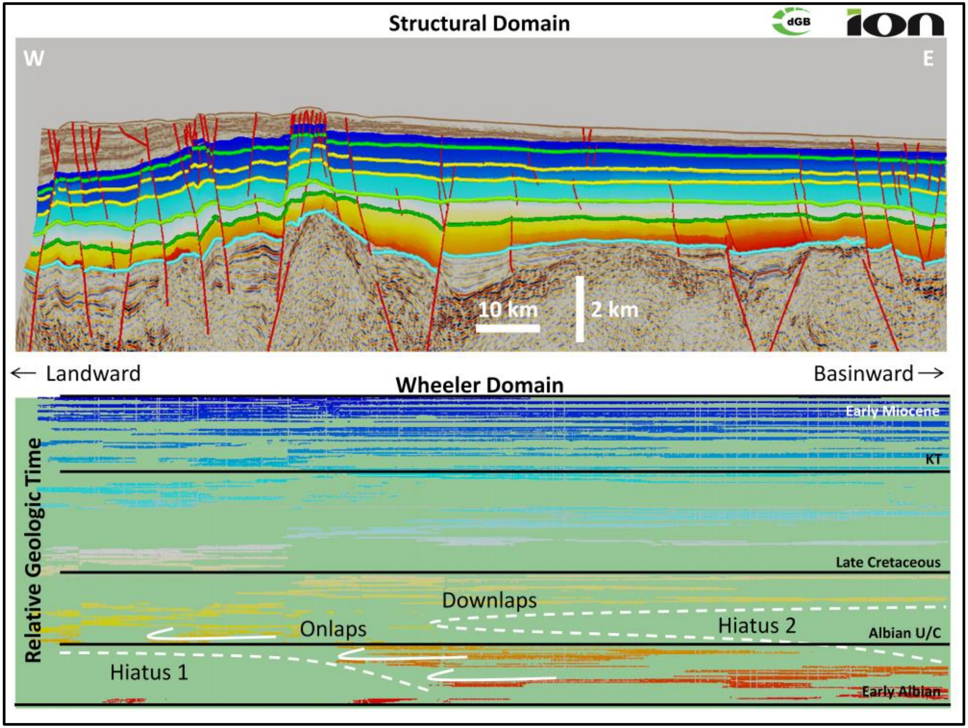


Event density attribute, vertical gate -20 to 20 m

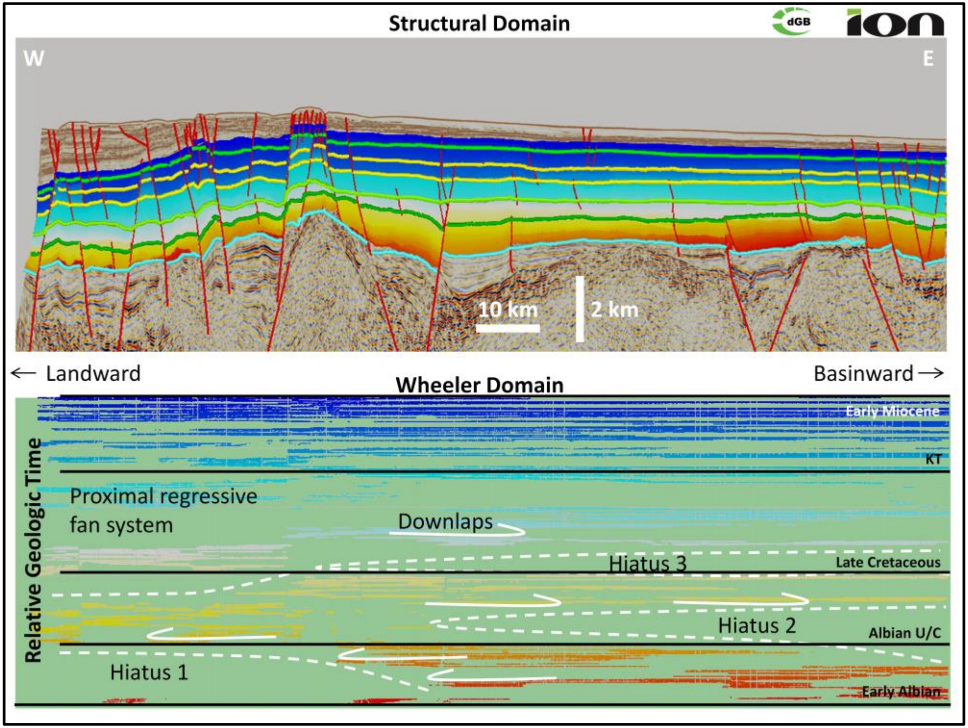
Low sedimentation rate **High sedimentation rate**



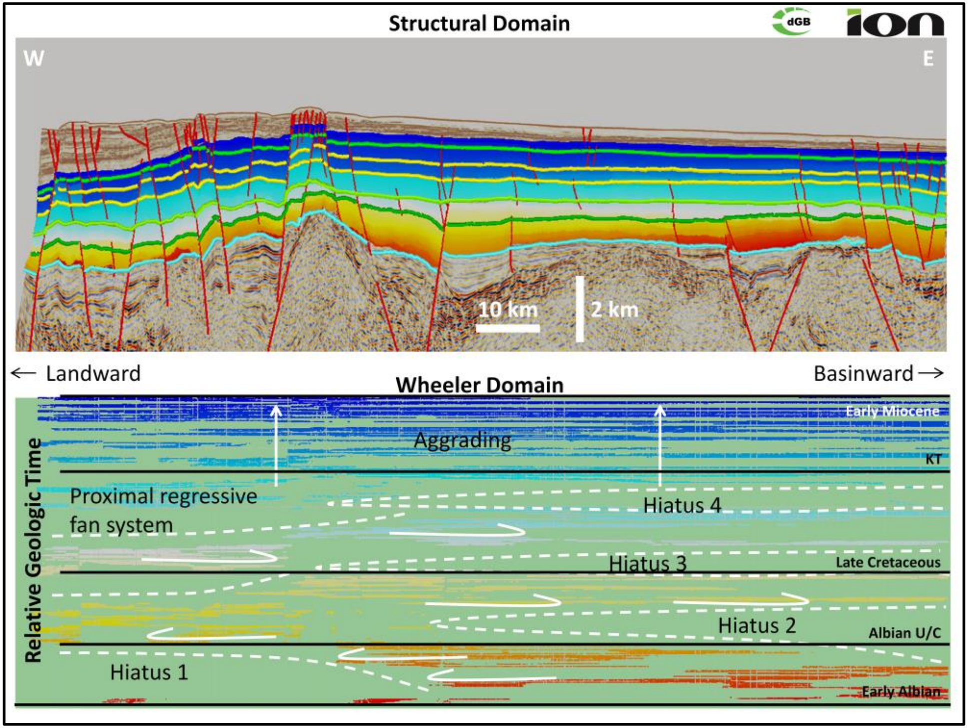
Presenter's notes: By using all of these events for flattening we can create a Wheeler diagram. The Wheeler diagram allows us to visualize a number of things. In this case study the whole interval was divided into 9 stratal packages based on stacking patterns and shifts in depo-centers.



Structural Domain
dGB
ion
W
E
10 km
2 km
← Landward
Basinward →
Wheeler Domain
Relative Geologic Time
Early Miocene
KT
Late Cretaceous
Downlaps
Onlaps
Hiatus 2
Albian U/C
Hiatus 1
Early Albian

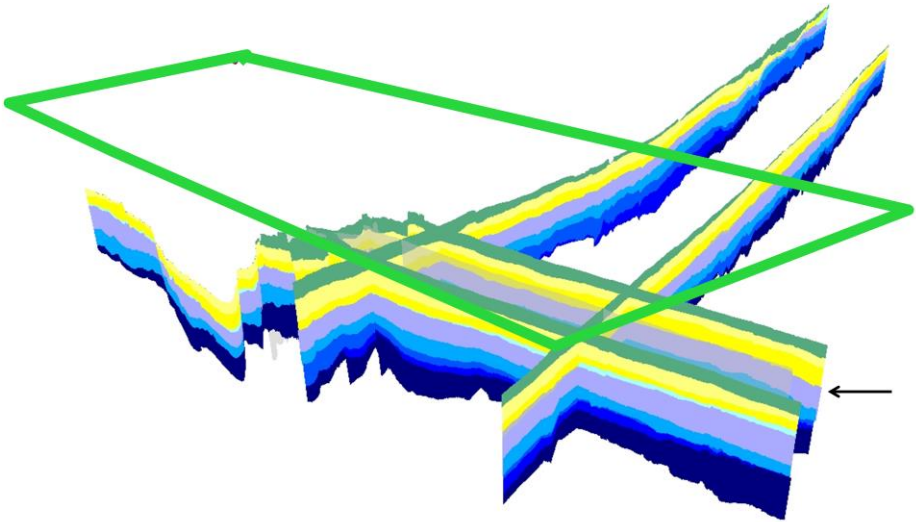


Structural Domain
dGB
ion
W
E
10 km
2 km
← Landward
Basinward →
Wheeler Domain
Relative Geologic Time
Early Miocene
KT
Proximal regressive fan system
Downlaps
Hiatus 3
Late Cretaceous
Hiatus 2
Albian U/C
Hiatus 1
Early Albian



Structural Domain
W
E
10 km
2 km
← Landward
Basinward →
Wheeler Domain
Relative Geologic Time
Early Miocene
Aggrading
KT
Proximal regressive fan system
Hiatus 4
Hiatus 3
Late Cretaceous
Hiatus 2
Albian U/C
Hiatus 1
Early Albian

Fence Diagram with picked stratal packages



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Conclusions

- Global interpretation methods useful in frontier areas
  - Delineate AOIs, pinpoint targets within AOI
- Robust workflow, increased interpreter input
- Regions – interpreter is in a key role, iterative process

Conclusions

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