Structural Framework Workflows for Petrel 2018

Module 4: Boundary definition and model construction

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Structural framework with Petrel 2018 – Modeling line

- **Introduction to subsurface modeling**
  - Overview of reservoir modeling
  - Petrel modeling workflows and grids
  - Structural model complexity
- **Structural framework and the concept of VBM**
  - Structural framework overview
  - Volume-based modeling theory
- **Fault modeling**
  - Fault complexity examples
  - Fault framework modeling overview
  - Fault framework modeling interface
  - Quality control and fault framework optimization
- **Boundary definition and model construction**
  - Model boundary workflow
  - Model construction
  - Common input data issues
  - Quality control and model optimization
  - Horizon attributes
- **Enhanced quality checks and modeling**
  - 2D seismic restoration
  - Advanced options in the VBM method
- **Model refinement and Depospace calculation**
  - Model refinement: Create the zone model
  - Depospace
- **Structural gridding for stair-stepped grids**
  - Stair-stepped structural gridding
- **Structural gridding for depogrids**
  - Characteristics and workflows of depogrids
  - Quality control on depogrids
  - Reservoir compartments in a depogrid
  - Advantages and disadvantages of stair-stepped and Depogrid structural grids

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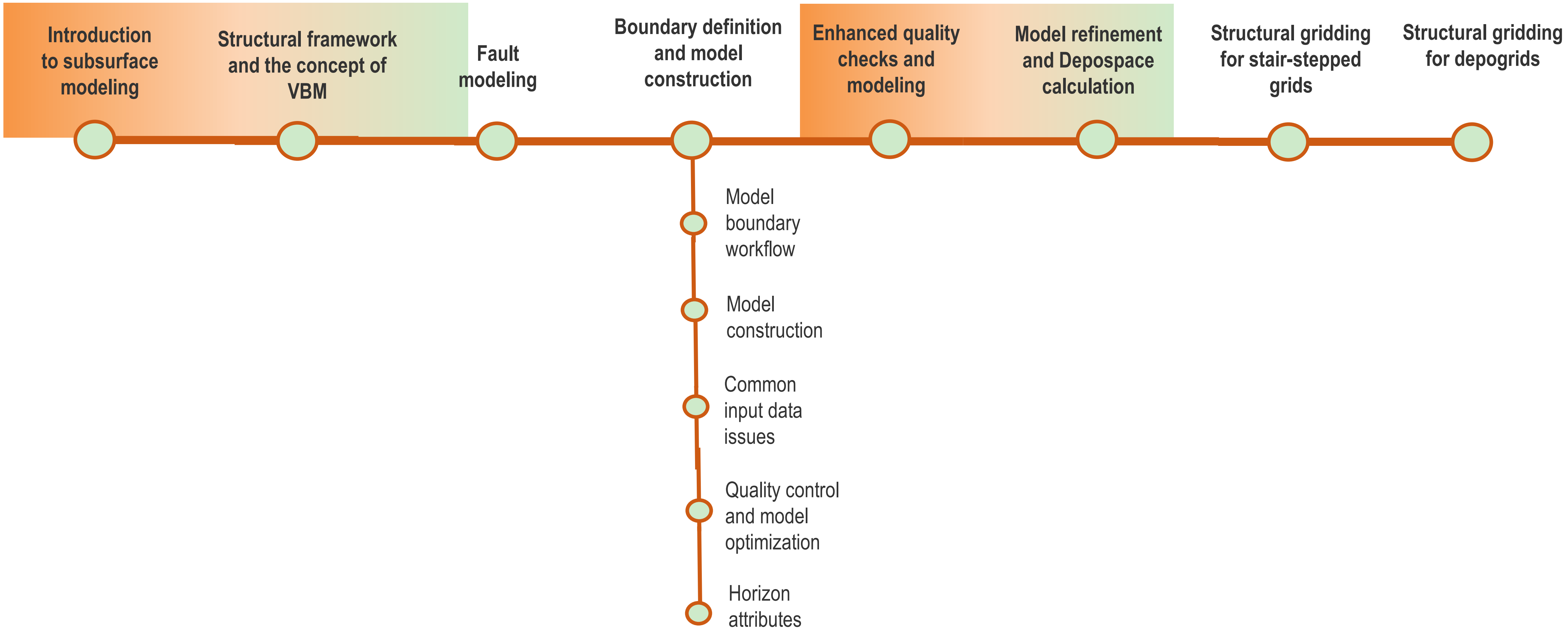
Agenda
Structural framework – Day 2

9.00-12.00	12.00-12.30	12.30-14.30	14.30-16.45	16.45-17.00
Boundary definition and model construction	Lunch	Enhanced quality checks and modeling	Model refinement and Depospace calculation	Review

KEYWORDS

- Model construction
- Boundary
- Depospace
- Quality control
- 2D seismic reconstruction
- Depospace
- Zone model
- Model refinement

Module 4: Boundary definition and model construction



Learning objectives

When you complete this module, you will know:

- how to create a volume of interest of your structural framework
- the Model construction workflow
- common input data issues and how to address them
- how to create and use the Horizon filtering attribute in the Model construction process
- important structural operation tools to quality check your model

Boundary definition and model construction

- Model boundary workflow (Demo)
- Model construction
- Common input data issues
- Quality control and model optimization
- Horizon attributes

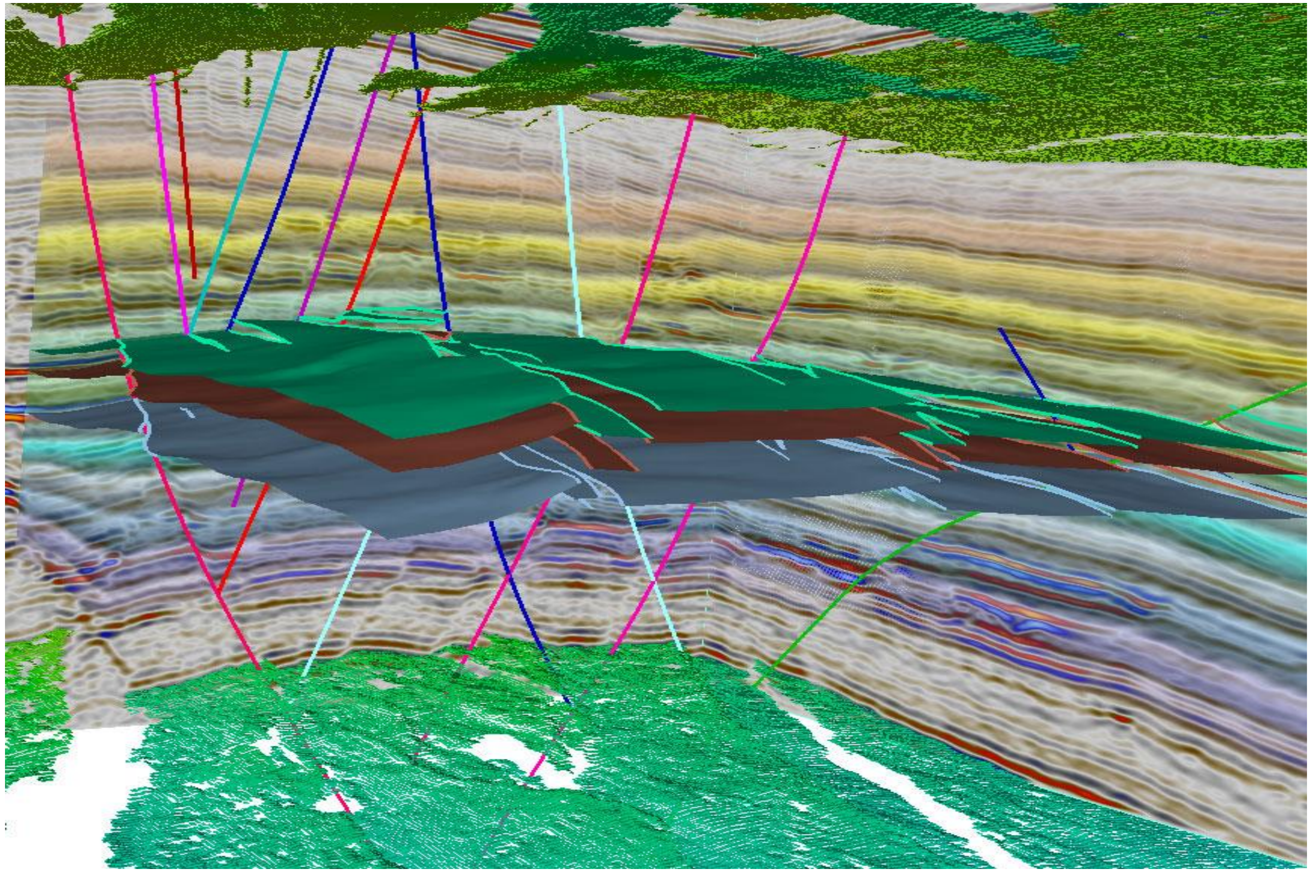
Boundary definition and model construction

- Model boundary workflow (Demo)
- Model construction
  - Input data type
  - **Stratigraphy** tab (Demo)
  - Horizon type
  - Well tops input data
  - Isochore input data
  - **Fault activity** tab (Demo)
- Common input data issues
- Quality control and model optimization
- Horizon attributes

Model construction (1)

Seismic horizons and fault interpretations are extracted from the stratigraphic function and then you generate unrefined horizons.

Input data type: Seismic horizon interpretation



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Model construction (2)

Start simple

- Major seismic-defined horizons
- Low resolution mesh

QC and iterate

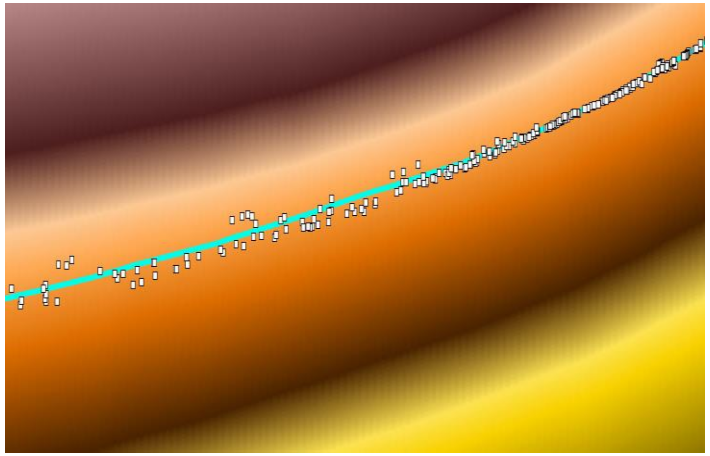
- Clean and filter input
- Adjust settings
- Add well top horizons
- Increase resolution if required

Full model

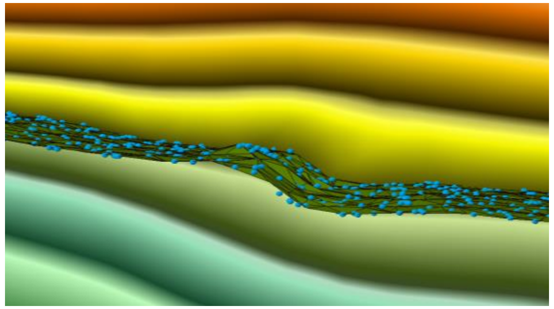
Ready for model refinement

Model construction (3)

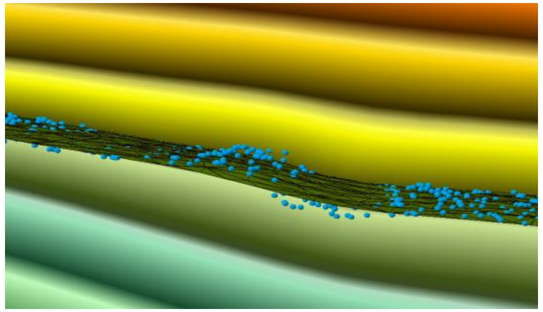
- Stratigraphic function fits well tops*
- Stratigraphic function does not attempt to fit non-well top data perfectly.
  (Model refinement does attempt to fit perfectly.)
- Smoothness parameter controls degree of fit.
- One smoothness value per conformable sequence.



*except when you select *Dense well top regularization*.



Low smoothness



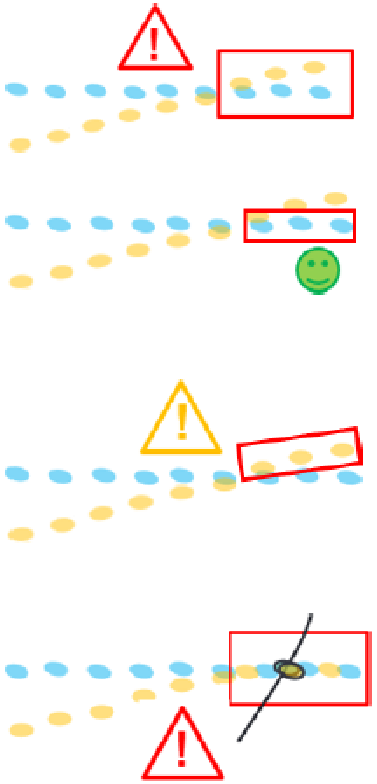
High smoothness

Input data type

The horizons modeling algorithm accepts most data objects that are used to delineate stratigraphic intervals in a reservoir.

- Seismic horizon interpretation
- Points
- Polylines
- Triangular surfaces
- Gridded surfaces
- Well tops

Input data constraints



Conformable horizons cannot cross

Conformable - Base
Conformable - Erosion

Ground interpretation

Conformable - Base
Base - Discontinuous

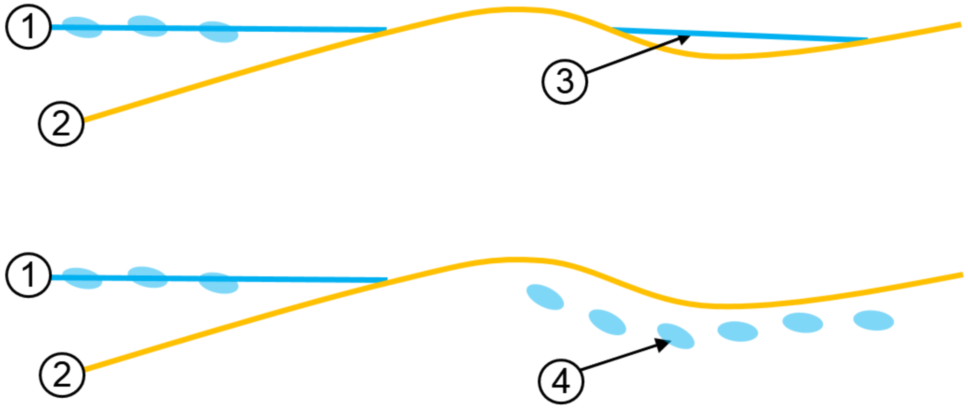
Air interpretation

Erosion
Conformable – Erosion - Discontinuous

Collapsed well markers

=

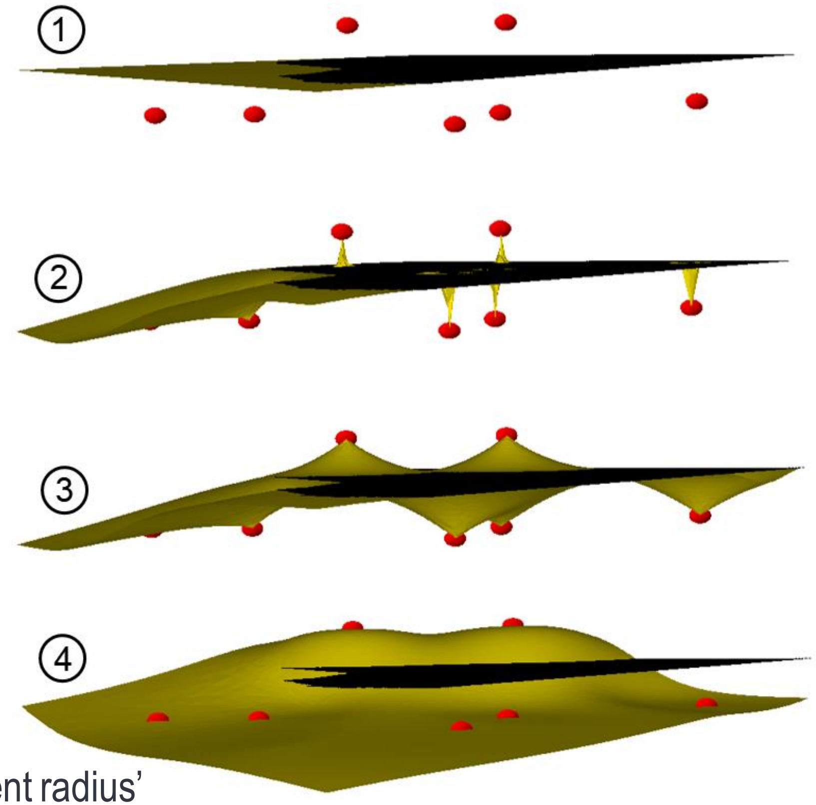
A ground interpretation is helpful to control conformable horizons above a base horizon that undulates across the model.



1 Conformable - Base
2 Base – Discontinuous
3 Conformable horizon reappears
4 Ground interpretation

Well adjustment option:
Use well tops for seismic-based horizons

- Well-based horizons:
  - Defined by well tops only
  - Well tops always used
- Seismic-based horizons:
  - Defined by other data
  - May include well tops which can be used in different ways



1 Option not selected
2 Option used with 'No adjustment'
3 Option used with 'Local adjustment radius'
4 Option used with 'Global adjustment'

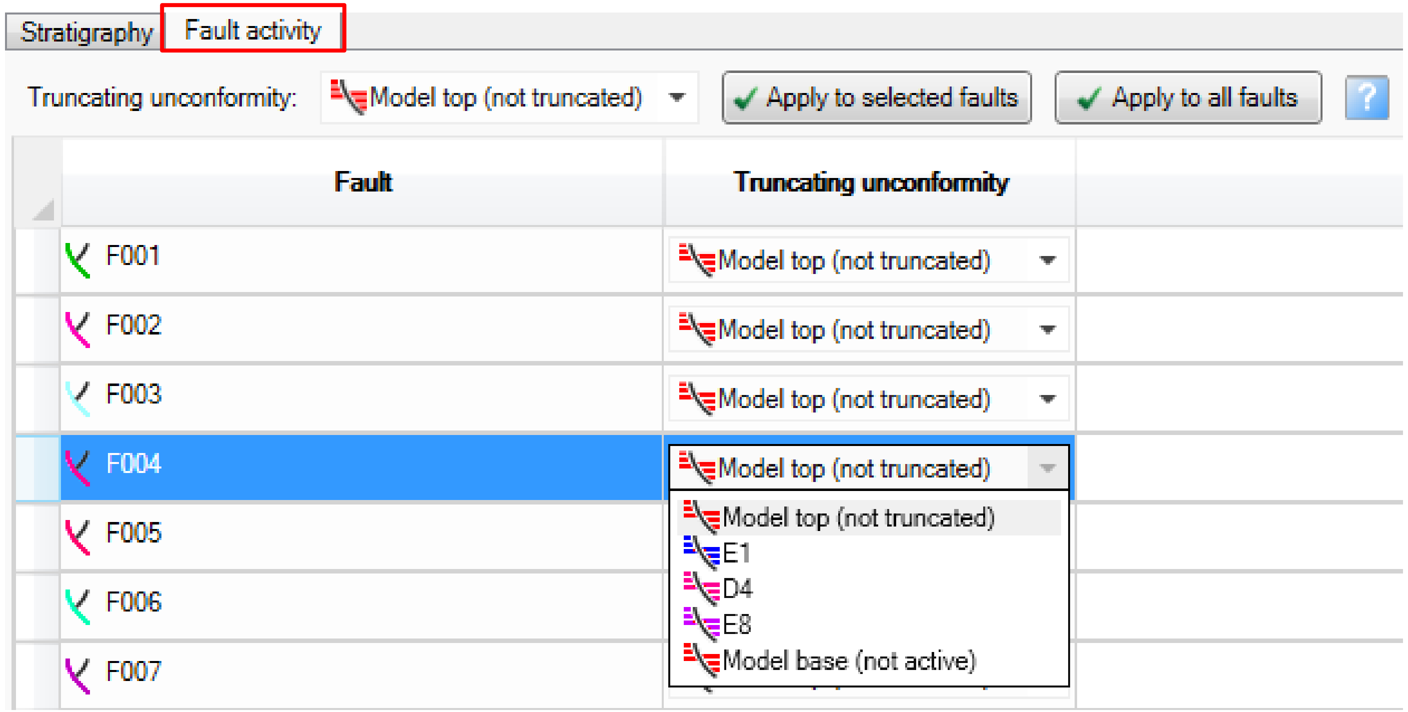
Isochore input data

If you use isochores, you must enter the isochore surface and the reference surface.

	Horizon	Color	Horizon type	Isochore	Reference	Input #1
1	H1		Conformable		None	H1
2	H2_1		Conformable	isoH2_1	H1	
3	H2_2		Conformable	isoH2_2	H2_1	
4	H2		Conformable		None	H2
5	H3_1		Conformable	isoH3_1	H4	
6	H4		Conformable		None	H4

Fault activity

The **Fault activity** tab controls the stratigraphic (vertical) extent of faults.



Boundary definition and model construction

- Model boundary workflow (Demo)
- Model construction
- Common input data issues
  - Wrong sided data
  - Reduced fault extension
  - Incorrect sequence identification
- Quality control and model optimization
- Horizon attributes

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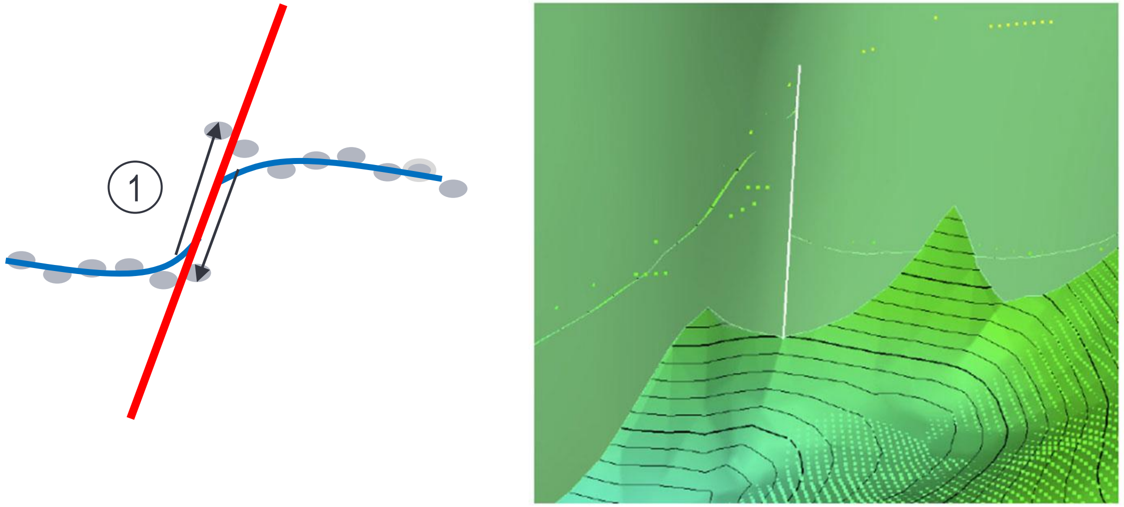
Common input data issues

Frequently, the fault interpretation and the horizon interpretation have problems.

- There can be subtle features in the seismic data.
- Seismic horizon auto-trackers picked an incorrect wavelet on one or both sides of a fault.
- Interpreters are not working with the same vintage data.
- Data from the hanging wall or footwall can push through the fault interpretation.

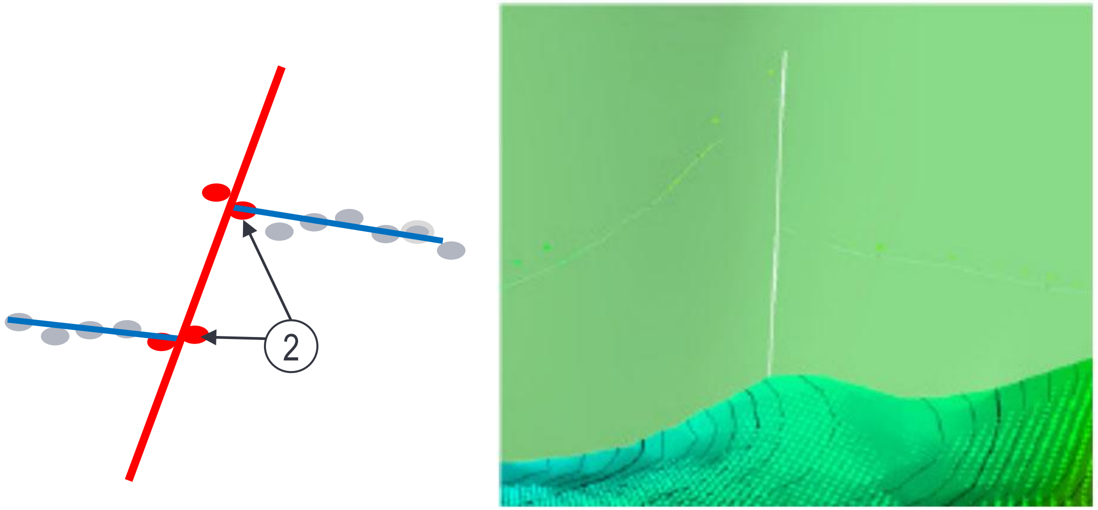
Wrong sided data

Wrong sided data can distort the stratigraphic function because the algorithm attempts to fit it to the data. The result is that horizons often are pulled up/down close to the fault.



Impact of wrong sided data to a modeled horizon

1 Model horizon attracted by wrong sided input points horizon

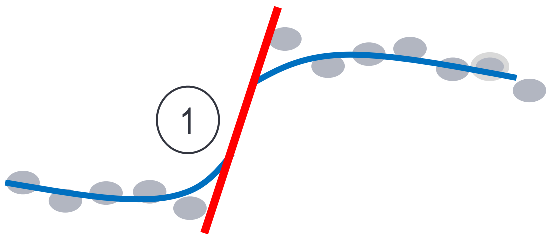


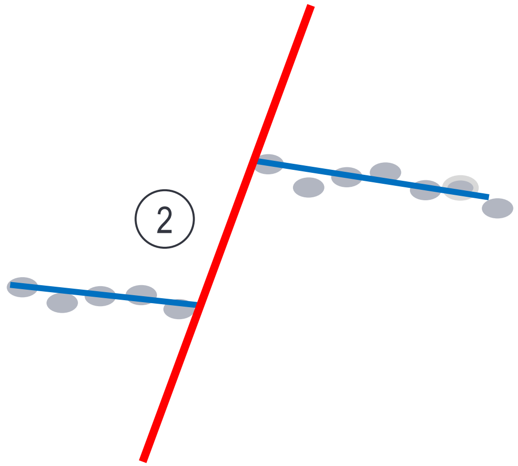
Correct behavior

2 Input points filtered around the fault to correct the model

Reduced fault extension

The stratigraphic function tries to match the throw across a fault that is implied by input data.





Impact of inconsistent fault vertical extent compared to throw

1 Horizon throw in input data not consistent to fault extent

Correct behavior

2 Horizon throw in input data consistent to fault extent

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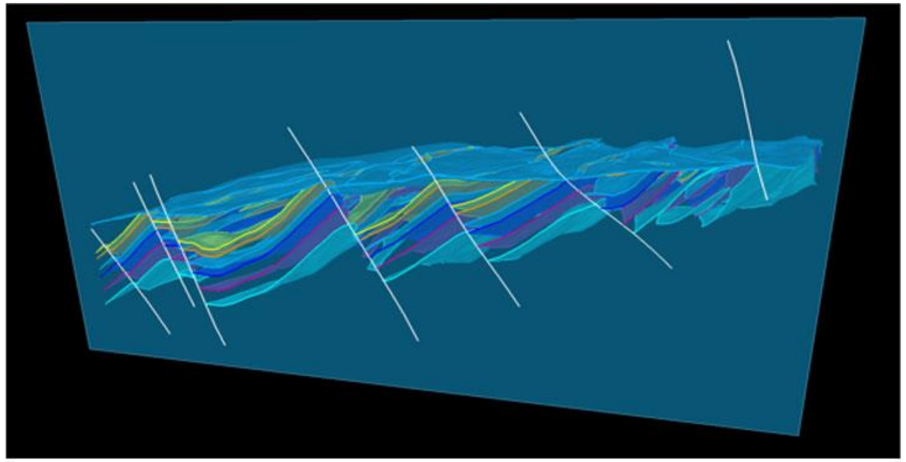
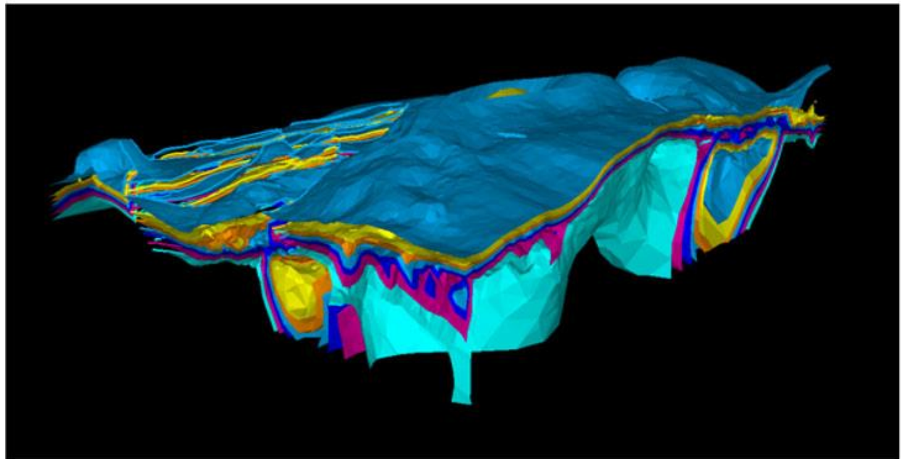
Incorrect sequence identification

Horizons form an angular relationship with the top horizon.



Incorrect result if the top (erosional) horizon is not set as a sequence boundary.



Boundary definition and model construction

- Model boundary workflow (Demo)
- Model construction
- Common input data issues
- Quality control and model optimization
  - Horizon clean-up
  - Horizon filtering attribute (Demo)
  - Cross-fault thickness change
  - Fault throw
  - Fault displacement
  - Fault heave
  - Throw consistency
- Horizon attributes

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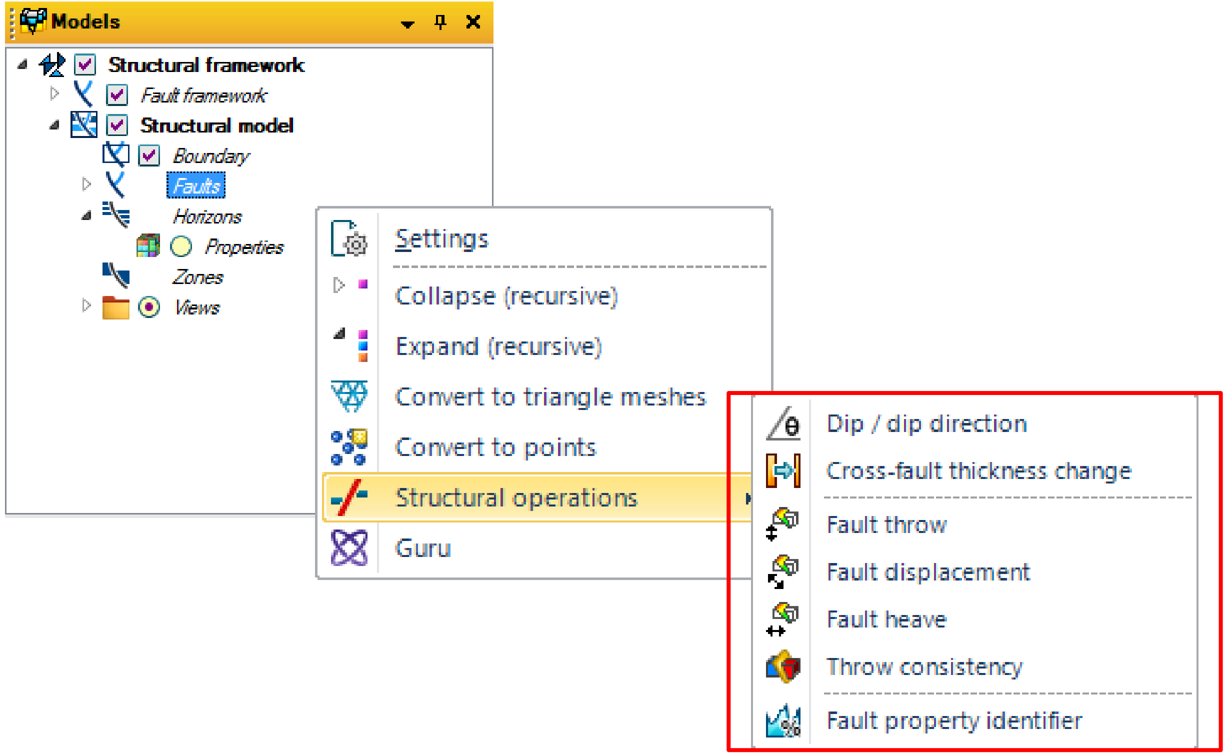
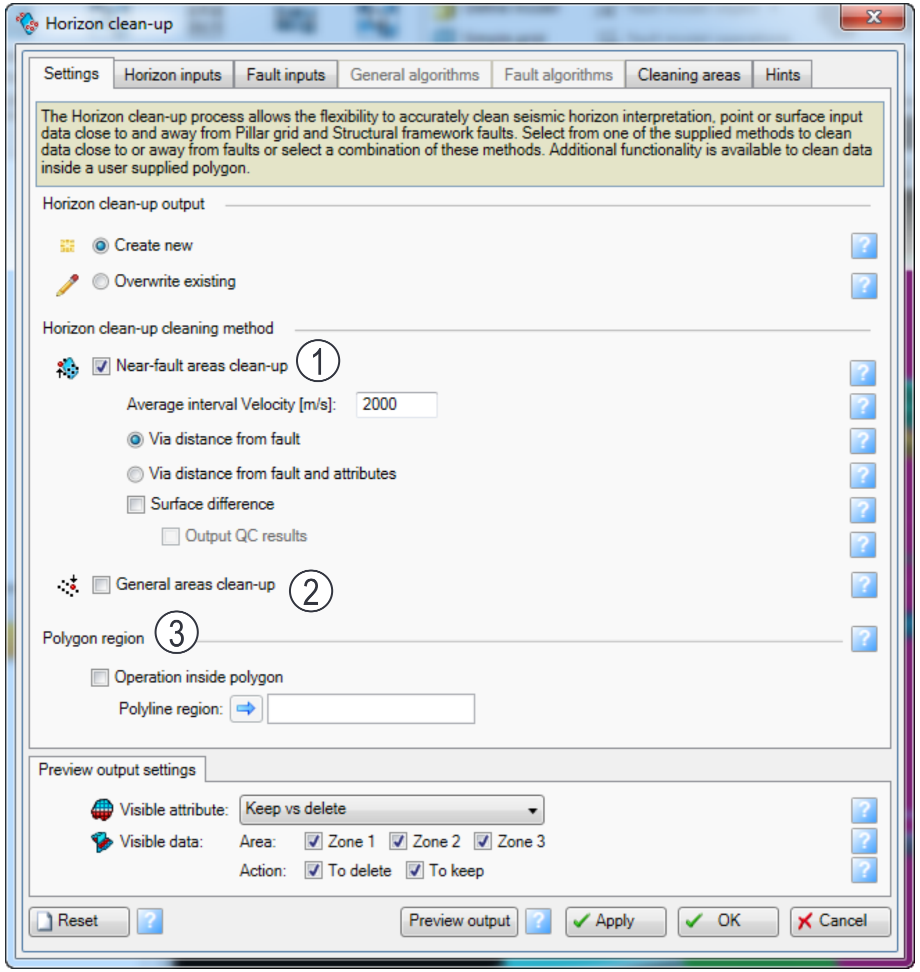
Quality control and model optimization

For QC, you also can use functions from the Structural and fault analysis toolkit.



Horizon clean-up

This simple and powerful tool allows you to accurately and rapidly clean up a seismic horizon interpretation that is close to faults or away from them.



1 Near-fault areas clean-up: Select *Via distance from fault* or *Via distance from fault and attributes*. You can combine a method with the Surface difference option.

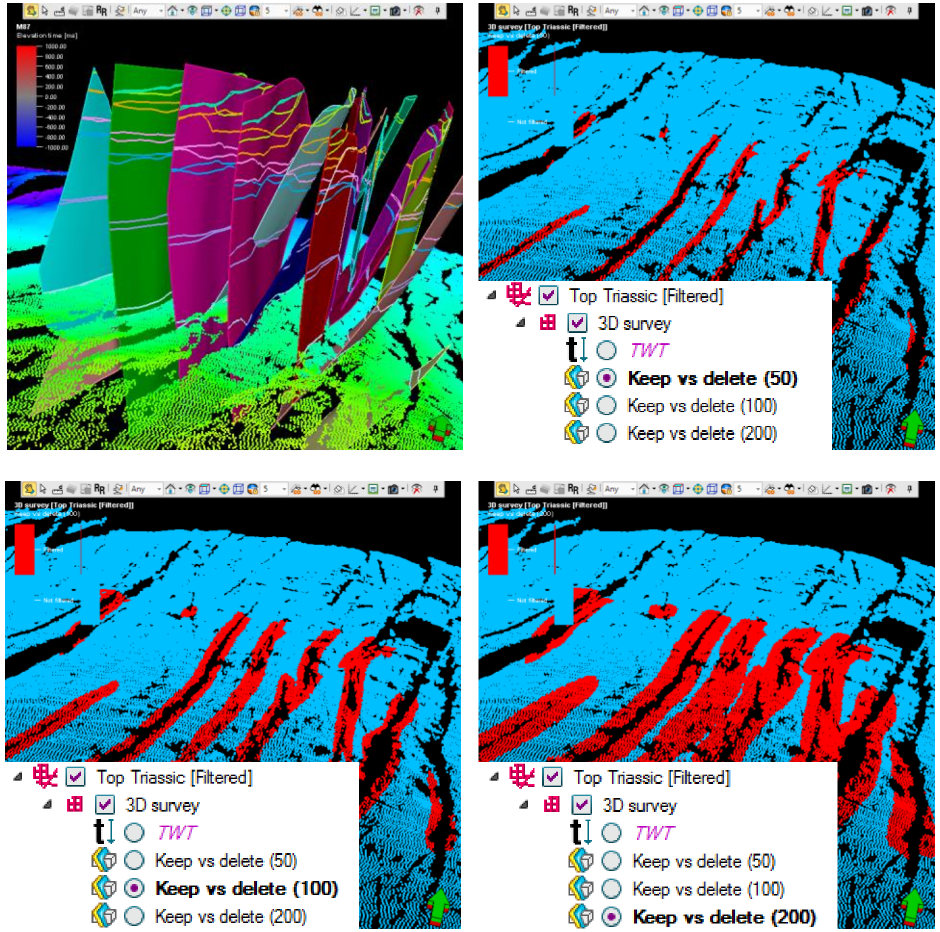
2 General areas clean-up: Do not consider the location of faults.

3 Polygon region: Enter a region to compute a method inside a specified polygon.

Horizon filtering attribute (1)

- Use this option with the Model construction process to disregard filtered data points without deleting them from the original interpretation.
- You can generate different amounts of filtering distances around faults.

Note: The HFA can be created only on seismic horizon interpretation objects. It cannot be created for other inputs, such as point sets, surfaces, and polylines.



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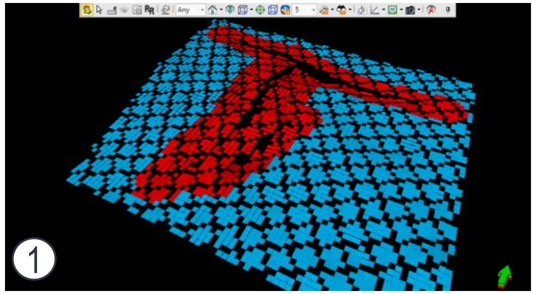
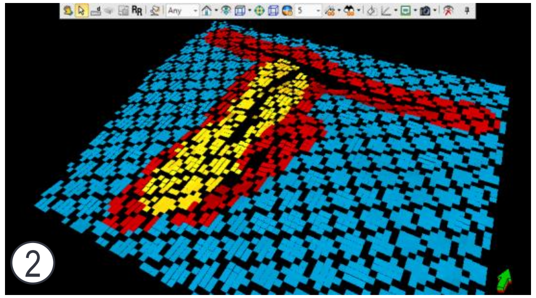
Horizon filtering attribute (2)

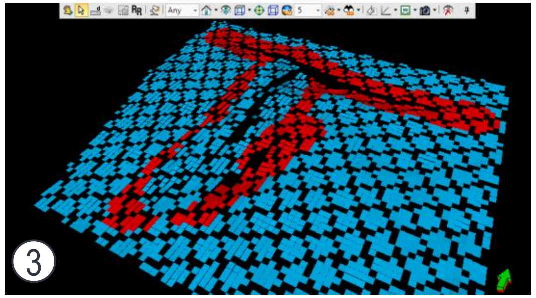
1 Data between two closely spaced faults (red) is set to be filtered out.
It is not included in the Model construction process.



2 With the *Selection paintbrush* tool, paint the areas you do not want to filter.
Selected points appear in yellow.



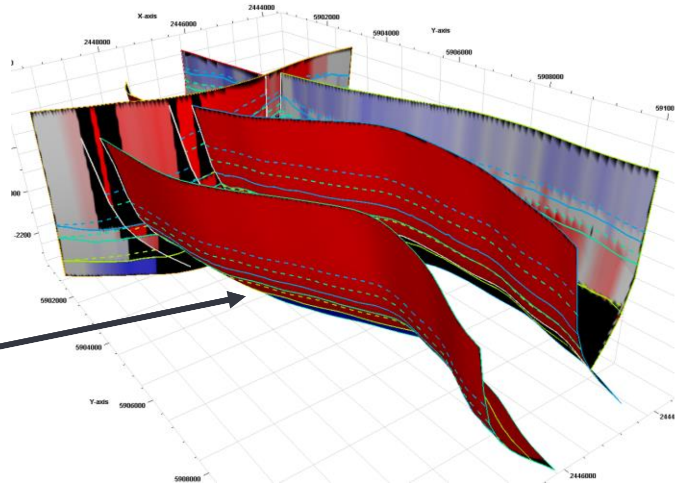
3 When you click anywhere outside of the display, the picked points change to unfiltered data and appear in blue. Now, the points are included in Model construction process.



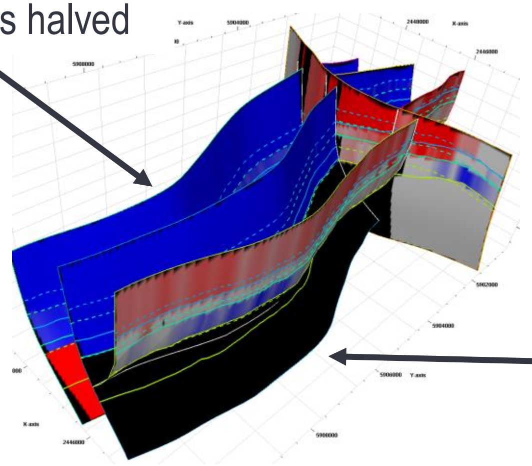
Cross-fault thickness change

Identify where rapid changes in stratigraphic thickness are present across faults.

- Do the thickness changes make geological sense?
- Syn-depositional faulting?
- Do horizons need to be fixed?



+1 = thickness doubled
–1 = thickness halved



No calculation or estimate

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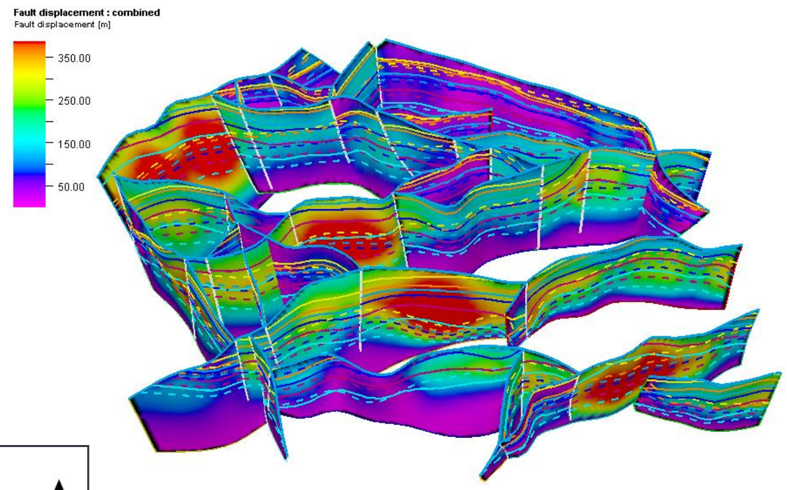
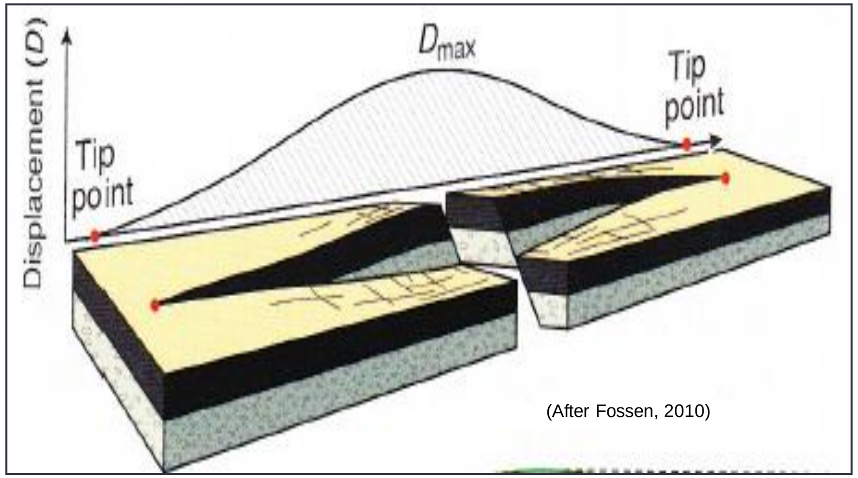
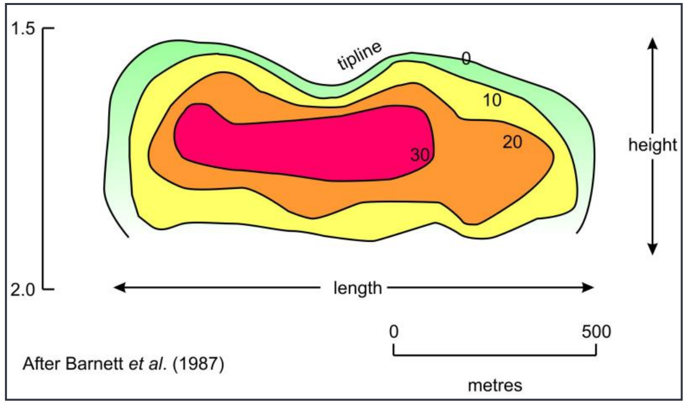
Fault throw/displacement/heave

- Is variation across fault consistent with theory?
- Is displacement size consistent with fault size?
- Insight into fault tip location.





(After Fossen, 2010)



After Barnett *et al.* (1987)

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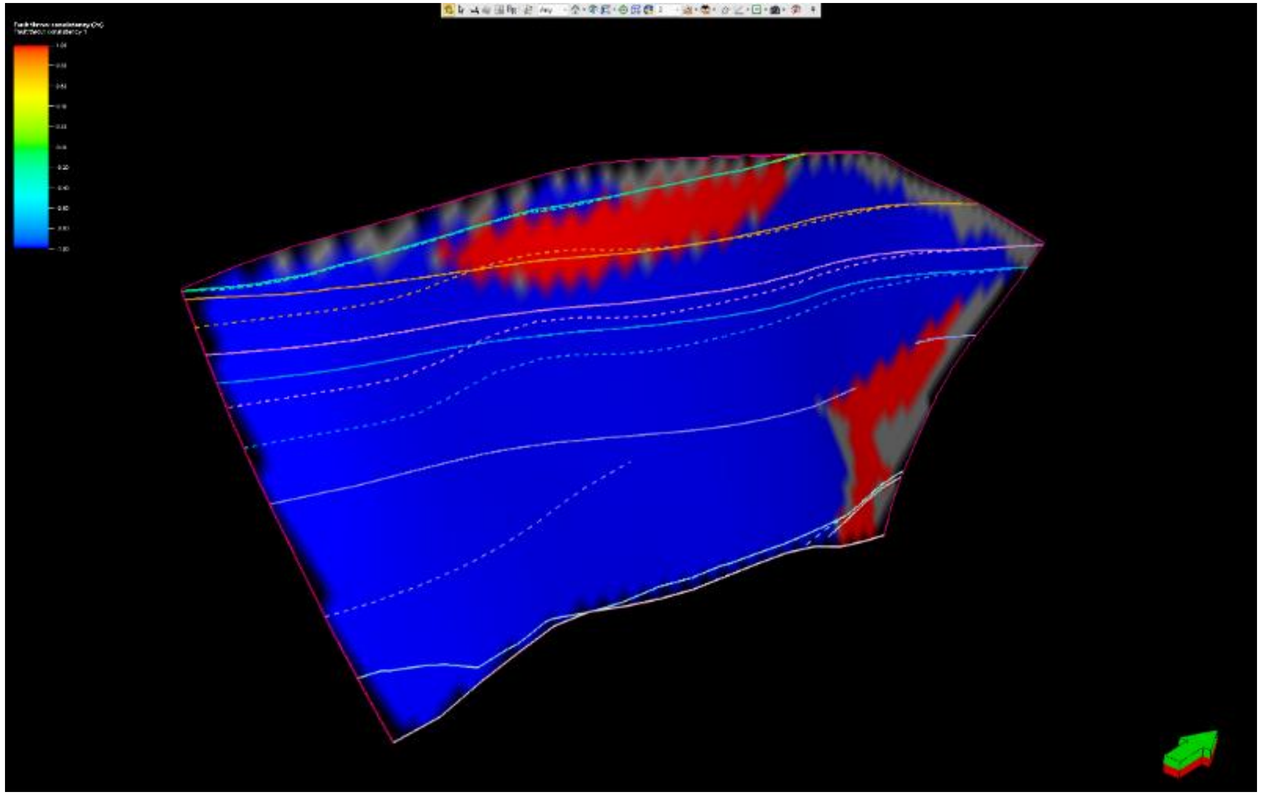
Throw consistency

- Identify areas of the faults where the throw sense changes.
- Throws in the specified tolerance appear in a gray color.
- A useful tool for rapid QC of large models.



Boundary definition and model construction

- Model boundary workflow (Demo)
- Model construction
- Common input data issues
- Quality control and model optimization
- Horizon attributes
  - Edge detection
  - Anomaly identifier
  - Confidence classification

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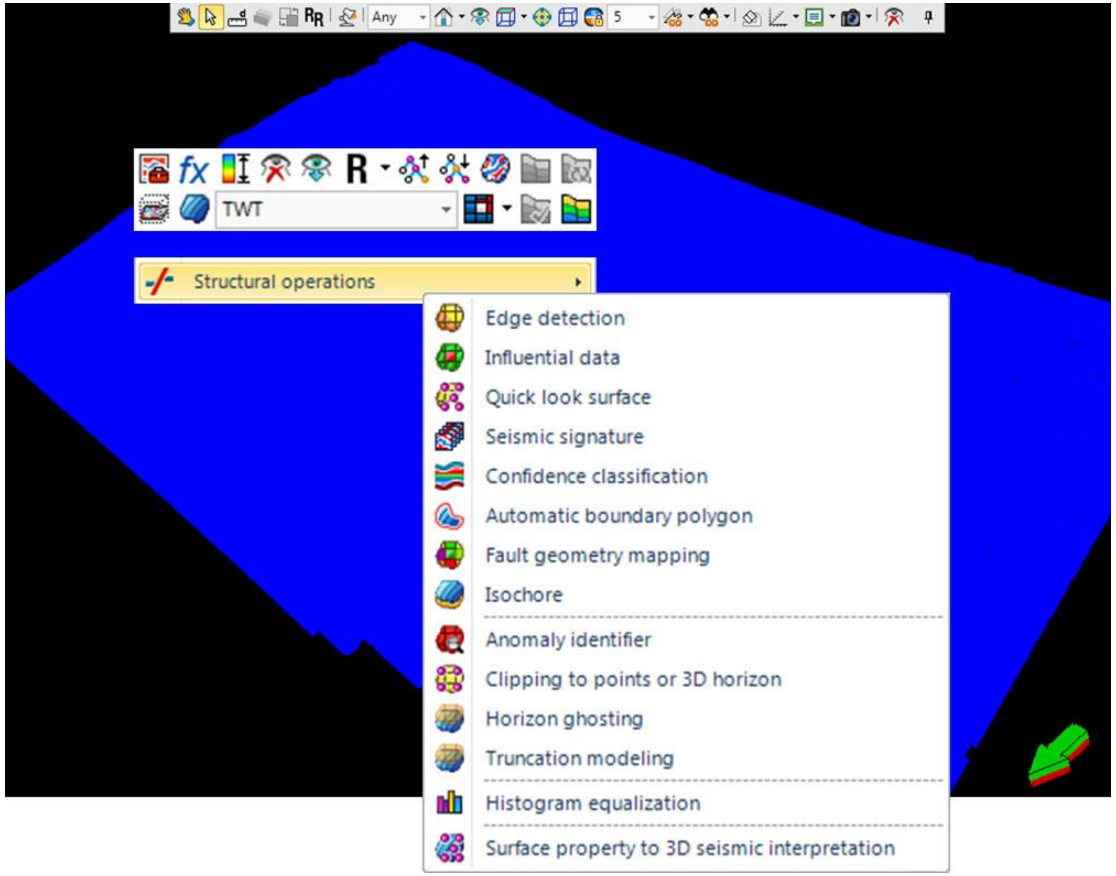
Horizon attributes

Several useful attributes are available for seismic interpretations that help you identify inconsistencies during interpretation.



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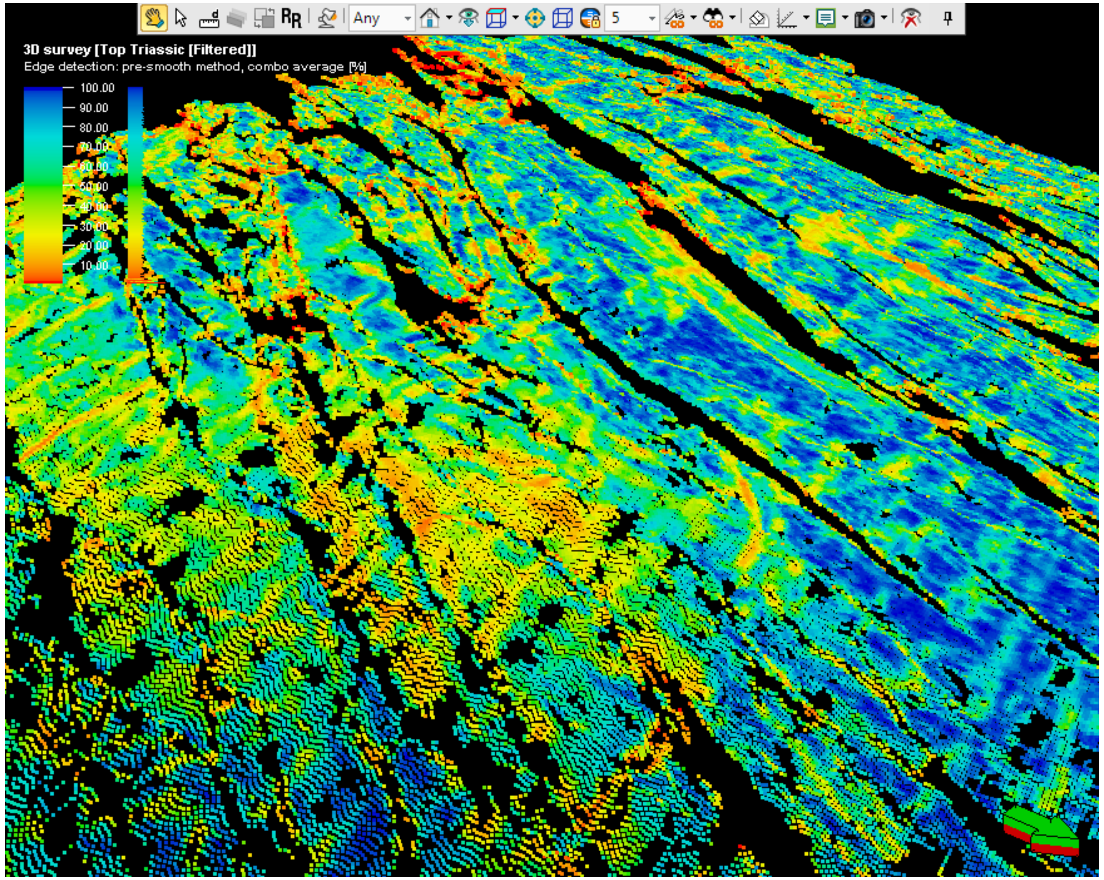
Edge detection

- Highlights lateral extent of the fault network.
- Identifies potential low throw structures not discernible in seismic sections.
- Strong red colors identify edges in the data that correspond to know locations of mapped faults.



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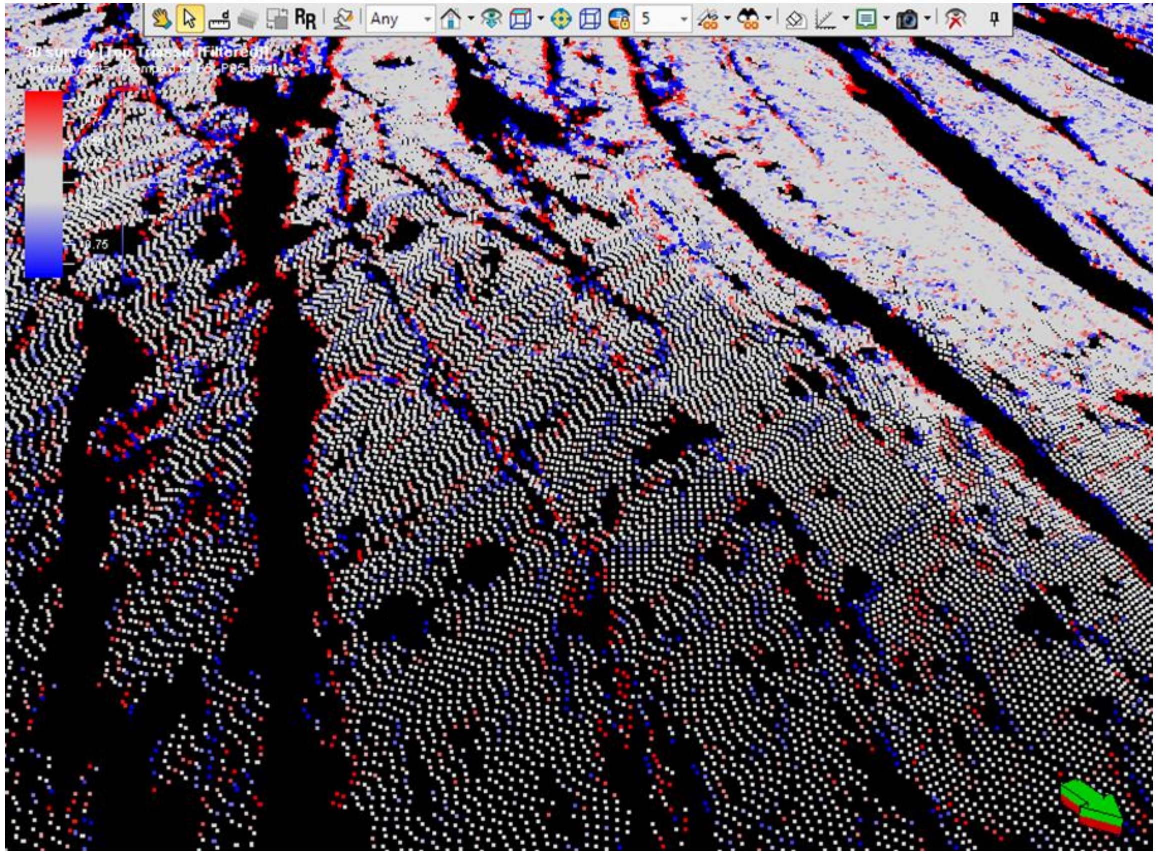
Anomaly identifier

- Assess the degree of geometrically anomalous data (mis-picks).
- Assess the high degree of variability in the seismic wavelets (noise).
- Filter the result to remove geometric or noise anomalies without manually edit original interpretation.



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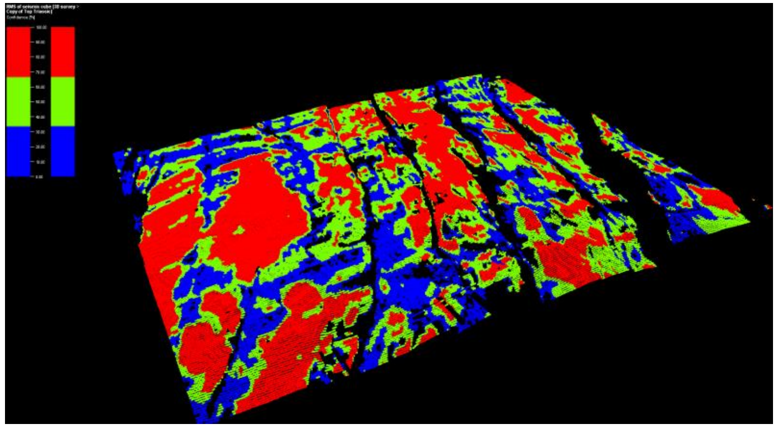
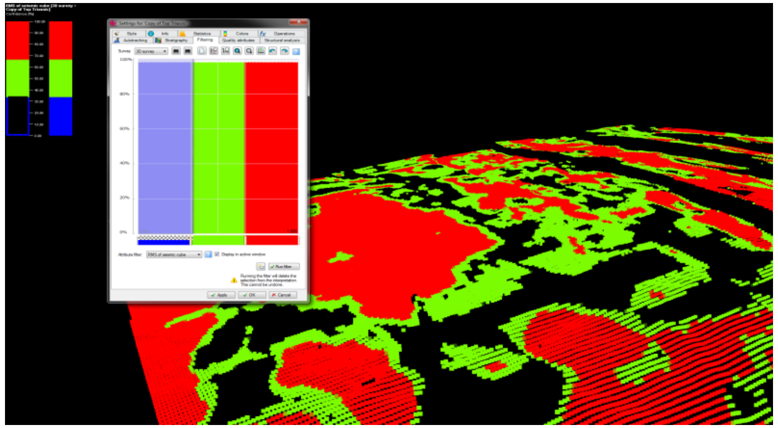
Confidence classification

- Create a combined confidence map with areas of high, mid-range and low stability.

- Omit low confidence data and generate a new interpretation object containing only high and mid-range confidence results.





High stability

Mid-range stability

Low stability

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Exercises and workflow example videos:

- Exercise: Define the boundary for the structural model
- Exercise: Build structural model horizons
- Exercise: Apply smoothness control
- Exercise: Generate the horizon filtering attribute
- Workflow example video: Generate and edit the horizon filtering attribute
- Exercise: Edit and consume the horizon filtering attribute
- Workflow example video: Consume the horizon filtering attribute
- Exercise: Use horizon attributes to quality control input data

Summary

In this module, you learned about:

- volume-based modeling used for horizon modeling in the structural framework
- common input data issues and how to address them
- important structural operation tools to quality check your model
- create a volume of interest of your structural framework
- create and use the horizon filtering attribute for model construction

Learning game: Boundary definition and model construction (1)

Instructions:
There are several questions. Select the correct answers.

Learning game: Boundary definition and model construction (2)

Name three methods you can use to define a structural model boundary.

a. By using a polygon

b. From data object with geometric extent

c. Manually in the dialog box

d. All the answers above are correct

e. Both a. and b. are correct

Learning game: Boundary definition and model construction (3)

What type of data objects can you use to define the structural model horizons?

a. Seismic interpretations and surfaces
b. Point sets, fault tops and isochores
c. Well tops and polylines
d. $\boxed{\text{All the answers above are correct}}$
e. Both a. and c. are correct

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Learning game: Boundary definition and model construction (4)

Where do you generate the horizon filtering attribute?

a. In the **Horizon filtering attribute** dialog box

b. In the **Horizon clean-up** dialog box

c. In the **Model construction** dialog box