DecisionSpace® Geosciences:

Integrated Interpretation and Mapping using Dynamic Frameworks to Fill Release 5000.10.0

Volume 1

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Halliburton | Landmark Software & Services
2107 City W Blvd, Building 2, Houston, Texas 77042-3051, USA
P.O. Box 42806, Houston, Texas 77242, USA
Phone:713-839-2000
FAX: 713-839-2015
Internet: www.halliburton.com/landmark

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Preface

This class will demonstrate the value of DecisionSpace Geosciences' interpretation tools and our next generation mapping system, Dynamic Frameworks to Fill. As you proceed through the course, you will see the workflow-oriented design of the DecisionSpace system.

Rather than using a series of independent tools to create a series of maps, you will learn how to use this tightly integrated interpretation and mapping system to create your maps. This integrated system enables geologists and geophysicists to construct and automatically update multi-surface structural frameworks (i.e., structure maps) and property maps in a straightforward manner.

This class will benefit geoscience interpreters and model-building specialists alike. We believe you will see that our workflow-based approach automates much of the complex model-building process, and brings advanced structure mapping into the mainstream.

Overview

DecisionSpace Geosciences and Dynamic Frameworks to Fill

The DecisionSpace Geosciences platform possesses several particularly powerful strengths:

- It is a unified workspace, wherein geoscientists and engineers can leverage their skills in a collaborative environment to discover and evaluate assets.
- Within this collaboration space, you can access and manage geoscientific and engineering data by leveraging database connectivity and multi-user interpretation tools across the DecisionSpace platform (i.e., OpenWorks, EDM, and corporate data stores).
- Well-tie and velocity modeling tools enable on-the-fly conversion of time to depth (and vice versa), ensuring that all data can be interpreted and used in a common domain.
- The co-location of seismic data, interpreted horizons and faults, well tops, well faults, and well logs accelerates cross-domain interpretation. Cross-domain data integration provides essential cross-validation of the overall interpretation, mapped surfaces, and property maps.

Close integration between geological and geophysical interpretation tools—tied directly to dynamically updated framework-based mapping tools—provides an order-of-magnitude increase in core exploration and development workflows.

Our goal in this course is to develop your skills through hands-on training to a level that will give you sufficient experience, that, with supporting materials, you will be able to achieve substantial productivity gains.

You will achieve breakthrough changes in efficiency and accuracy through cross-domain data visualization and new paradigms in integrated interpretation and mapping capabilities. This new approach to integrated interpretation and mapping is referred to as Dynamic Frameworks to Fill (DFF).

Dynamic Frameworks to Fill

Dynamic Frameworks to Fill has many advantages and benefits.

1. Integrated geologic and geophysical interpretation tools that leverage framework surfaces in their respective workflows. For example you will have the ability to pick and edit well faults from 'predicted' seismic faults in correlation view, which then triggers update of DFF.

2. An advanced topology engine that properly grids surface data in the context of fault blocks (with an associated ability to automate the construction of fault polygons) and unconformity-bounded regions.

3. Conformance technology that models well-top surfaces, guided by seismic horizons.

4. An advanced topology engine that properly extracts zone properties for wells with incomplete penetrations and multiple traversals of the same zone for horizontal wells.

5. Multi-surface framework and property map updates tied to changes in data or edits to existing interpretation. This is enabled by the ability to:

   - Associate or blend multiple data sources (e.g., tops, seismic horizons, pointsets for structural surfaces, raw and calculated log curve data for property maps) with a given surface or property map.

   - Update all surfaces and property maps when input data are changed by data import (i.e., new wells are drilled and additional top and well log data are available) or interpretations are changed (e.g., horizon or top data for surfaces, and raw or calculated log curves for log-derived property maps).

   - Update all dependent surfaces when primary surfaces (e.g., parent surfaces in conformance relationships, or fault planes cutting multiple surfaces) are altered in a multi-surface framework.

Design Background of Dynamic Frameworks to Fill

The direct tie between data, interpretations, and mapping is the key theme in the design of DecisionSpace and DFF. The DecisionSpace Geosciences environment facilitated the design of DFF as an integrated interpretation and mapping system tied directly to a next generation, framework-based mapping system. As a result, DFF workflows tie directly back to raw interpretive data such as horizons, tops, and well logs.

By contrast, other framework or earth model construction systems emphasize the use of static grids (and point sets) as their starting point for model building. This reflects an increasingly outmoded manner of thinking about framework construction, which assumes that interpretation is the realm of interpreters and framework building is the realm of (earth) model builders. Given the historical bias toward separating interpretation and framework (model) construction, many competitive products designed their framework building tools with a strong emphasis on the use of static grids and point sets, two input types that possess no ability to tie back to the original data that the interpretation was based upon. Many model builders who use these competitive products accept the fact that interpreters will supply interpretations in the form of point sets or static grids. Consequently, these products have tools to manipulate static grids to make the model look correct. In other words, they have tools to locally warp grids to make indentations or bumps. The grids only update where they are pushed or pulled. There is no way to update the entire trend of a surface based on changes to source data.

Dynamic Frameworks to Fill supports the proposition that the industry would prefer that edits to a framework model are based on changes to the original interpretation. The key point is that DFF takes a data centered approach to the framework construction process that fully involves the professional interpreter. The benefit of this approach is that the framework QC process can compare framework surface geometries directly to original seismic, horizon, and top data to verify its accuracy.

Summary of Chapters

This section provides a high-level summary of the chapters and exercises that comprise the course.

You must be familiar with core DecisionSpace functionality to derive maximum benefit from this course. You should be comfortable working with DecisionSpace and general seismic and geologic interpretation workflows. You will use the DecisionSpace Geosciences user interface, data selection methods, display control tools, and underlying system management conventions in all exercises that follow, though little introductory level guidance is included. A fundamental understanding of these aspects of the DecisionSpace software is necessary before you embark on the interpretation and mapping workflows in the following chapters.

Class Structure

The class is organized as a series of workflows that cumulatively allow you to create high quality structure and property maps on a series of reservoir levels. Finally, you will generate gross rock volume and STOOIP calculations for the field.

Chapter 1: Seismic Interpretation and Mapping using Dynamic Frameworks to Fill

You will begin this chapter with an overview of the workflow roadmap to create the best possible set of structure and property maps over the studied field. The chapter includes work in initial fault interpretation, well-tie workflow to bring time and depth together, initial horizon interpretation, dynamic frameworks, velocity modeling, and depth conversion. All this in the context of optimum structural mapping.

Chapter 2: Geologic Interpretation and Mapping using Dynamic Frameworks to Fill

This chapter presents geologic workflows, including building cross sections, correlating logs, deriving basic maps, and editing maps using GeoShapers. You will also use your time seismic structural interpretation in the geologic correlation process and to improve well top surface mapping. Geological and Geophysical integration will be highlighted with a subsurface fault interpretation workflow, which allows fault picks to directly impact seismic fault plane modeling.

Chapter 3: Advanced Framework Construction

You already know that default parameters have their place and their limitations. Thus far, your framework relies on horizons, tops, and faults, with fairly automatic mapping. You will learn how to optimize parameters for your data and apply editing tools to produce the best possible set of maps within your framework. The chapter focuses on the theory and practical application of Framework parameterization and editing, based on original geophysical and geological interpretations.

Chapter 4: Dynamic Property Mapping and Volumetrics

In this chapter, you will 'Fill' your framework with reservoir properties and calculate hydrocarbon volumes. You will learn how to create log-derived property maps and display them in standard map views, as well as show them as 'fill' in section view between intervals defined by the structural framework. The chapter uses mapping tools to define multiple top-base intervals with multiple log-derived attributes per interval. Changes to inputs of the property maps will trigger an automatic (dynamic) update of all affected maps.

Organization and Conventions

This manual comprises several chapters that discuss key workflows within DecisionSpace Geosciences.

General Organization

Each chapter generally conforms to the following organizational structure. This format allows you to use the topic introduction as a quick reference.

- **Introduction:** The focus and learning goals are defined and exercise topics are introduced. Sometimes a diagram is presented that describes the workflow you will encounter; at other times a few sentences of description suffice.

- **Overview:** Most of the chapters contain an overview section that calls attention to theory and functionality related to the chapter's topic. Though some of the dialogs are displayed, these overview sections are not written as step-by-step exercises. Your instructor may demonstrate the overview items, or may simply ask you to use DSG to explore the overview topics yourself.

- **Exercises:** These are the core of the manual. Indeed, most of this manual comprises detailed steps that are necessary to achieve tutorial learning goals. You will find diagrams and screen captures in abundance, to help guide your learning. The exercises may include current topic descriptions of varying length, with accompanying notes.

- **Review:** Each chapter concludes with a short list of the main learning goals that you should have achieved.

Exercises that contain **bold** font require your interaction (with keyboard and mouse). Overviews are for reading.

Note on Exercises

Each exercise comprises a series of steps that build a workflow, help you select parameters, execute the flow, or analyze the results. Many of the steps provide detailed explanations of how to correctly pick parameters or make good use of the functionality of interactive processes.

The numbered bodies of text will guide you through the command path. As you proceed through the exercises, note the options you will find on the dialogs, but stay near the prescribed path. This will enable you to complete the exercise in the allotted time and produce results similar to those shown in the accompanying figures.

This sophisticated application, with its user-friendly interface, offers many ways to accomplish interpretation tasks. When you work with DecisionSpace Geosciences you will sometimes note multiple paths. For the sake of clarity and to keep you moving through the course, only one method is described in each exercise. The authors hope that after this class, you will return to your workplace and explore the solution paths that are easiest and most intuitive for you. To enable you to effectively cover course material we ask that you follow the instructions in the manual and use the solution paths described herein.

As you progress through the exercises, familiar parameters and obvious instructions may not be shown in workflow steps. For instance, in many workflows the instruction to click the **OK** button after parameter selection is sometimes implied by the context. In these cases we often omit that instruction, to avoid monotony.

The screen captures you will see throughout this manual are chosen to best illustrate the point at hand. Because of variations in path and session state during the writing and following of the exercises, screen captures may not always precisely match the image on your monitor. Variables such as window size, display scale, colorbar content and limits, object visibility, data display characteristics, perspective, and other factors can produce variations between images. Header text in the main viewer can vary, as the manual uses a few incremental releases of the application.

Personalized Outputs

In this course you may need to personalize and identify some of your work. We refer to certain output data, perhaps a horizon that you initiate, a volume that you save, or a state file, as having your initials as filename. For example, if your name is Aaron Buster Chapman, you might save some of your data by naming it ABC. We don’t know your name, so we use the letters “YOU” to refer to your initials. When you see the letters “YOU,” use your initials.

By using your initials you make your saved sessions easy to identify. In addition, your horizons, faults, picks, and other interpretations will be easy to find among the other files saved in this project.

The saved state files are very helpful if you go astray in one of the exercises or encounter a hardware or software problem. When that happens you can restart at the previous saved point.

Manual Conventions

The manual uses the following conventions in explaining how to access and use various features of DecisionSpace Geosciences. You are probably familiar with most of them.

Windows, dialogs, and boxes	DecisionSpace Geosciences has user interfaces that appear as windows on your workstation. The terms ‘window’ and ‘dialog’ are often used interchangeably, but the term dialog is usually reserved for windows that require user interaction in the form of parameter selection or information input. ‘Box’ is usually a smaller window, such as a warning box or message box. ‘Box’ can also be an area inside a window that is defined by a rectangular line.
Dialog Names	The titles of windows, dialogs, some tabs, and occasional boxes are *italicized* when they appear in text. Typically, dialog names appear in a bar at the top of a window (this is also known as the window title).
Mouse Buttons **MB1**, **MB2**, **MB3**	The manual does not instruct you to press mouse buttons. Instead, you will see instructions to press or use MB1, MB2, or MB3. Mouse buttons are numbered from left to right. **MB1** means click the left mouse button, **MB2** means click the middle mouse button, **MB3** means click the right mouse button. If your computer is set up for a left-handed mouse, the mouse buttons are reversed in direction. Mouse buttons may not work properly if Caps Lock or Num Lock are on. **MB1** is used for most selections.
Menu Options	Menu options and push-button names are bolded when they appear in a step (an instruction for an action). For example, when you see the instruction “**Close** the dialog,” it is an instruction to click the Close button.

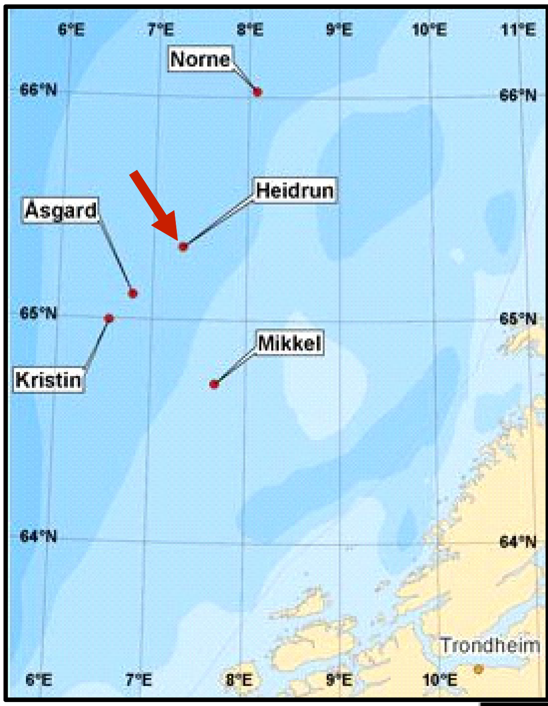
Type or enter	Type all terms that appear in quotes and bolded. For example, when you see the expression, *Enter "***2300***" in XYZ field,* you should type 2300 in the prescribed place. Context will often suggest that you need to change an instruction. For example, when you read "**YOURINITIALS**" or "**YOU**", you are expected to type your initials.
<**key**>	Press the indicated key on the keyboard. For example, <**Enter**> is an instruction to press the Enter key.
Select, Click, or Highlight	Move the cursor to the specified option or object and press, then release, the mouse button. Unless otherwise specified, use **MB1**.
Click and drag	Press the mouse button and hold it down while moving the cursor. Then release the button. This is also called press and drag, or **MB1-drag**.
Shift and drag	Hold the shift key while pressing the mouse button. Hold the mouse button down while moving the cursor around the option you want, then release the button.
Double-click	Click the button twice, rapidly, without moving the mouse. The first click highlights the option or object beneath the cursor; the second click is equivalent to pressing the **OK** button to accept the selection.
Conditions for bold font	We use bold font to make the exercises easier to follow. Bolded text means the text is an instruction that requires user action, such as an instruction to click a button or an icon, enter text, or highlight listed items. Often the instruction has the subject-verb-object structure, such as "You can click the **Open** button to display the dialog." In this situation *You* is the subject, *click* is the verb, and ***Open*** is the object. Sometimes the sentence has an imperative structure, such as "Click **Open**." In this case, the subject is implied. In general, we bold the ***object*** in these action sentences both to draw attention to the need for student action and to provide a quick visual aid in clearly distinguishing what the action should be directed to. On a few occasions an instruction requires that the verb be bolded, though we do this reluctantly, because excessive use of bolding creates visual confusion.

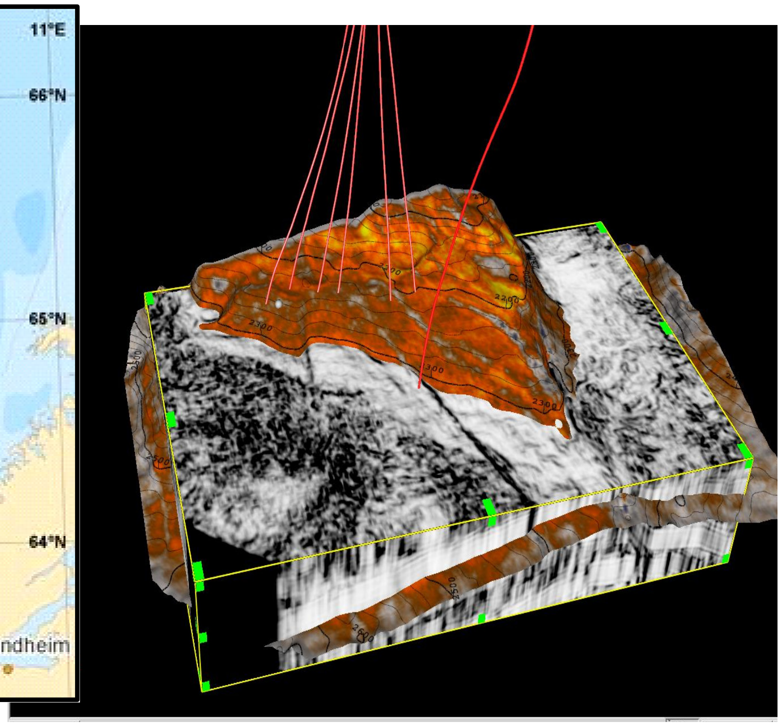
Note

This manual follows the popular usage of "data" as singular or plural. You will see both "data is" and "data are".

Class Dataset: Heidrun Field

Heidrun in the Norwegian Sea (map below) has been producing oil and gas since October 1995.





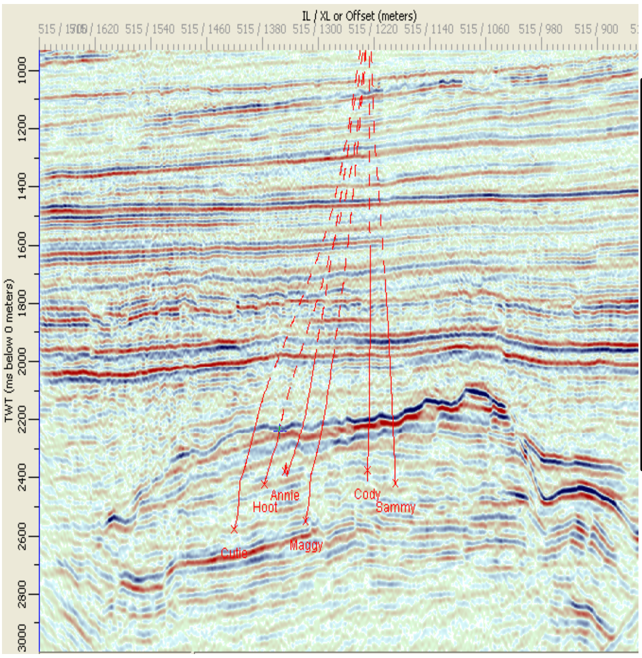
The Heidrun field is located on Haltenbanken in the Norwegian Sea. The sea depth is about 350 meters. The field was developed with a floating concrete tension-leg platform, installed over a subsea template with 56 well slots. The northern part of the field is developed with subsea facilities. The reservoir comprises Lower and Middle Jurassic sandstones and the structure is a fault block that is heavily faulted. The recovery strategy for the field is pressure maintenance using water injection and injection of excess gas.

The Heidrun field has yielded some 660 million barrels of oil since it came on stream, and is currently flowing about 150,000 barrels per day. At it’s peak, it produced over 300,000 barrels per day from the Fangst group.

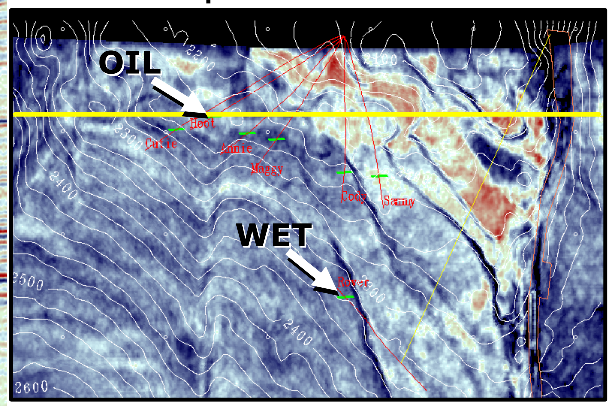
Annual gas output totals roughly 1.3 billion cubic metres. Purposeful efforts to improve oil recovery have helped to boost estimated oil reserves in the field to about 1,130 million barrels.

Original discovery was on a high-amplitude-gas bright spot. But most of the production is from non-bright seismic signatures of the oil leg, which makes up about 80% of the total production.

Seismic stack signature does not change much from oil pay to non-pay, as seen in the amplitude map on the pay horizon (below).



Amplitude on Reservoir Horizon



Shows location of gas cap, but not oil pay

Red = high amplitude
Blue = low amplitude

Chapter 1

Using Dynamic Frameworks to Fill in Seismic Interpretation and Mapping

In this chapter you will perform core seismic interpretation workflows, including fault interpretation, well tie, velocity modeling, horizon interpretation, and depth conversion.

You will focus on new ways to improve these established workflows and results.

Topics Covered in this Chapter

The following topics are covered in this chapter:

- Interpreting faults
- Creating synthetics from well logs
- Tying synthetics to seismic
- Interpreting horizons
- Introducing the velocity model
- Converting depths

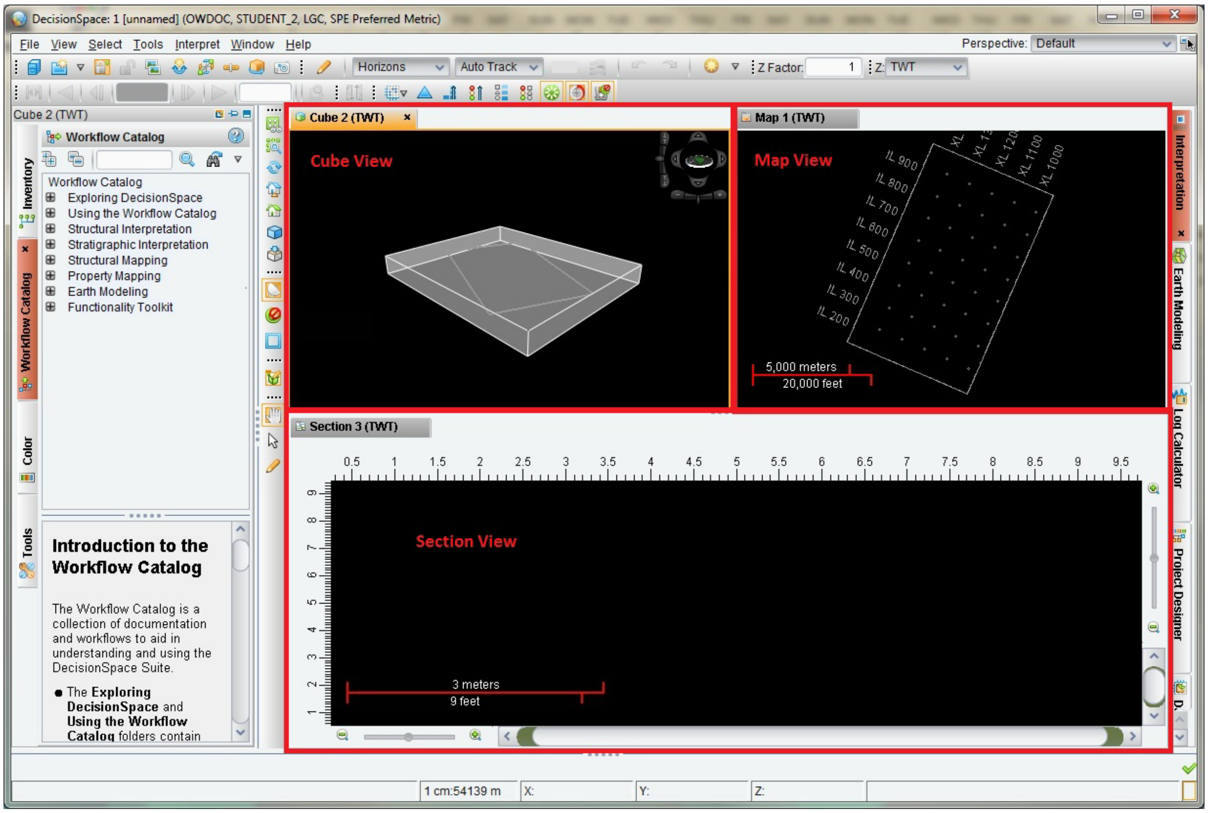
This chapter initiates your core interpretation tasks, using DecisionSpace in the context of the *Dynamic Frameworks to Fill* workflow. You will learn more detail in the second and third Overviews.

The following Overview offers a refresher on a few key DecisionSpace user interface concepts.

Overview: DecisionSpace Layout and Organization

Using the Active View

By default, DecisionSpace opens a single window with three views. *Cube* view is the default active view. The active view tab is orange.



Most of the controls—including Zoom, Domain, Step Increment, Data Visibility, and actions performed from the *Interpretation* task pane—apply to the active view. A view becomes the active view when you click the view tab.

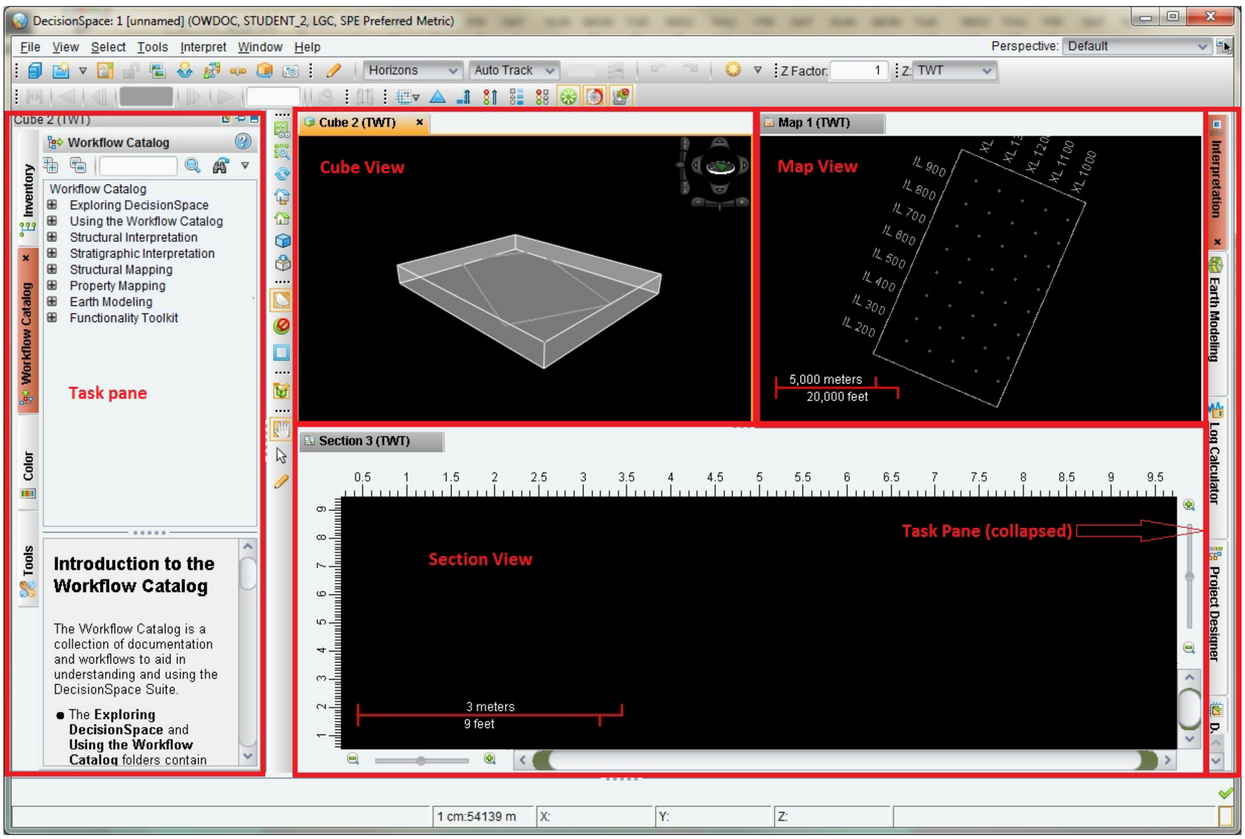
You will run DecisionSpace with multiple windows. Each window can have an active view and a separate set of controls for managing the views and performing interpretation tasks.

Managing Tabs

Use the **Tab Manager** to Arrange, Redistribute, Resize, Move, and Rename tabbed views in DecisionSpace. You can access the **Tab Manager** by **MB3** on a view tab or by clicking **Alt+M** anywhere within DecisionSpace.

Managing Task Panes

DecisionSpace workspace windows have two sets of task panes. One set is on the left side of the window and the other set is on the right side. Each task pane extends vertically. The placement and order of the tabs in each task pane is configurable from an MB3 pop-up menu on a task pane tab. As with the Active view, the selected task pane tab is red.

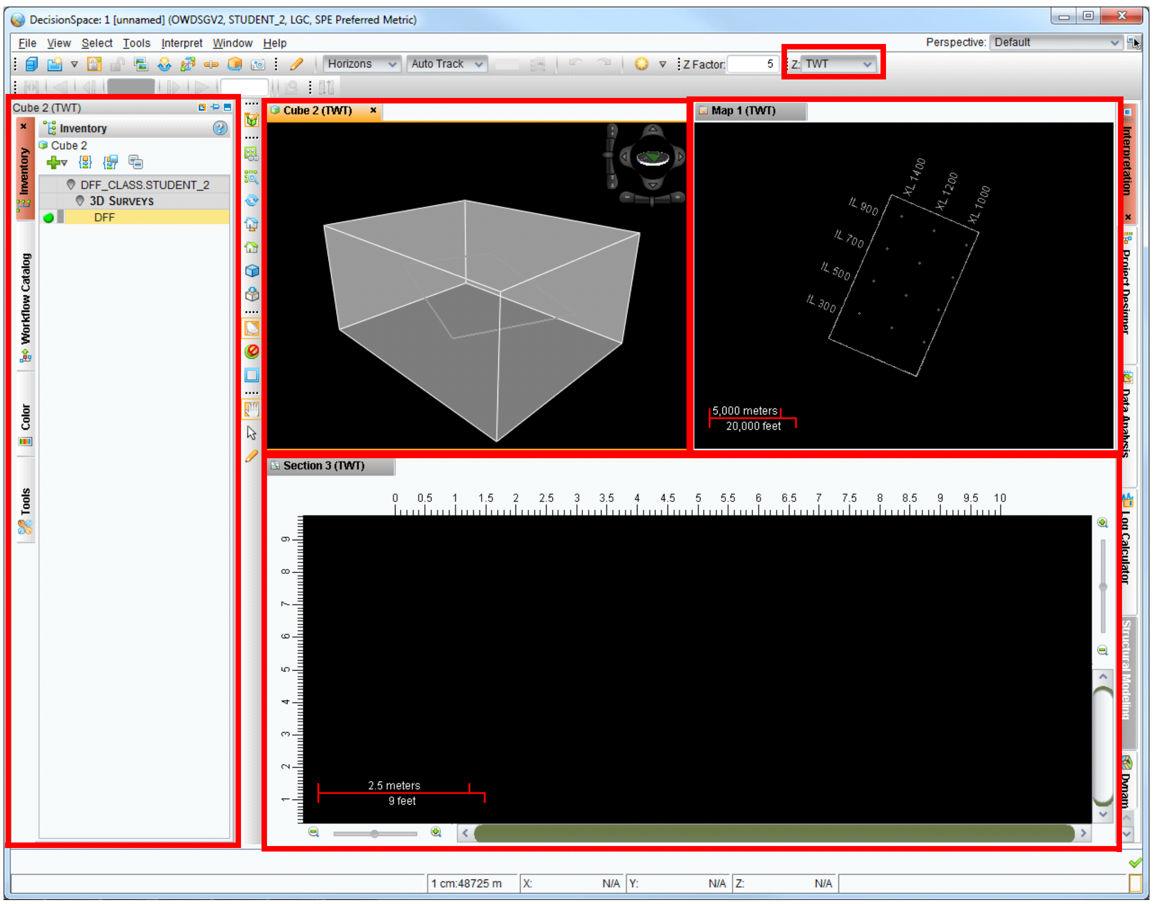


Click an active task pane tab to expand or collapse the task pane.

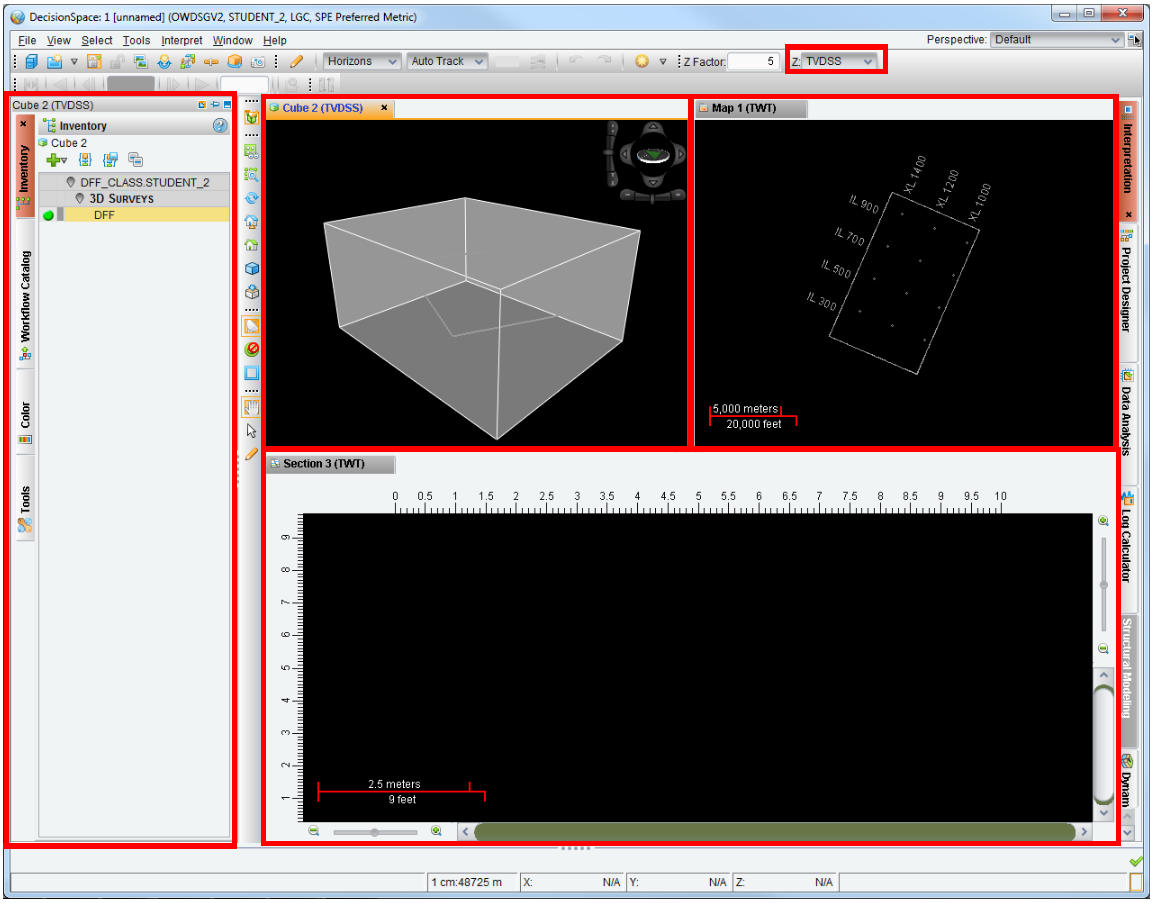
Using Domain Indicators

When you launch an existing or new DecisionSpace session from the *Session Manager* dialog box, the Domain setting (*Session Parameters* tab) determines the default domain for new windows and views. Setting Domain to Depth in the *Session Manager* results in all views opening with the domain set to TVDSS. Setting the Domain to Time will result in all views opening with the domain set to TWT. You can change the domain setting for any view at any time after starting the session.

You should be aware of the current domain for your session and views. Notations indicating time domain (TWT) are pictured below.



You will use time and depth domain DecisionSpace sessions in the following chapters. You will also convert between the two domains. Notations indicating depth domain (TVDSS) are shown below.



Note

Images in this manual will not always precisely match what you see on your monitors. Expect minor variations in background color, interface color, window configuration, and view appearance. Occasionally the data names or data content may be different than what you see on your screen.

In particular, gray background is used in this manual to improve image quality on the printed page. Certain grays are the default color for a few data objects, such as 2D/3D Project outline. A gray object on a gray background can be invisible. Therefore, either avoid gray backgrounds during the class or change the color of the gray objects.

Another obvious difference may be interface color, light or dark. This manual uses light interface for print quality. Interface color is set from a DecisionSpace window primary menu bar, Window > Interface.

Overview: Interpretation and Dynamic Frameworks to Fill

This chapter addresses the problem of updating fault polygons after you change your interpretation or add more data. Because the fault polygon exercise is detailed and lengthy, interpreters tend to put this off until all faults and horizons are tied. The resulting mis-ties early in the interpretation magnify the amount of rework needed later in the mapping workflow.

In this workflow, you will apply Dynamic Frameworks to Fill mapping as you interpret faults and horizons to find and fix problems before a significant amount of interpretation is built on top of those mis-ties.

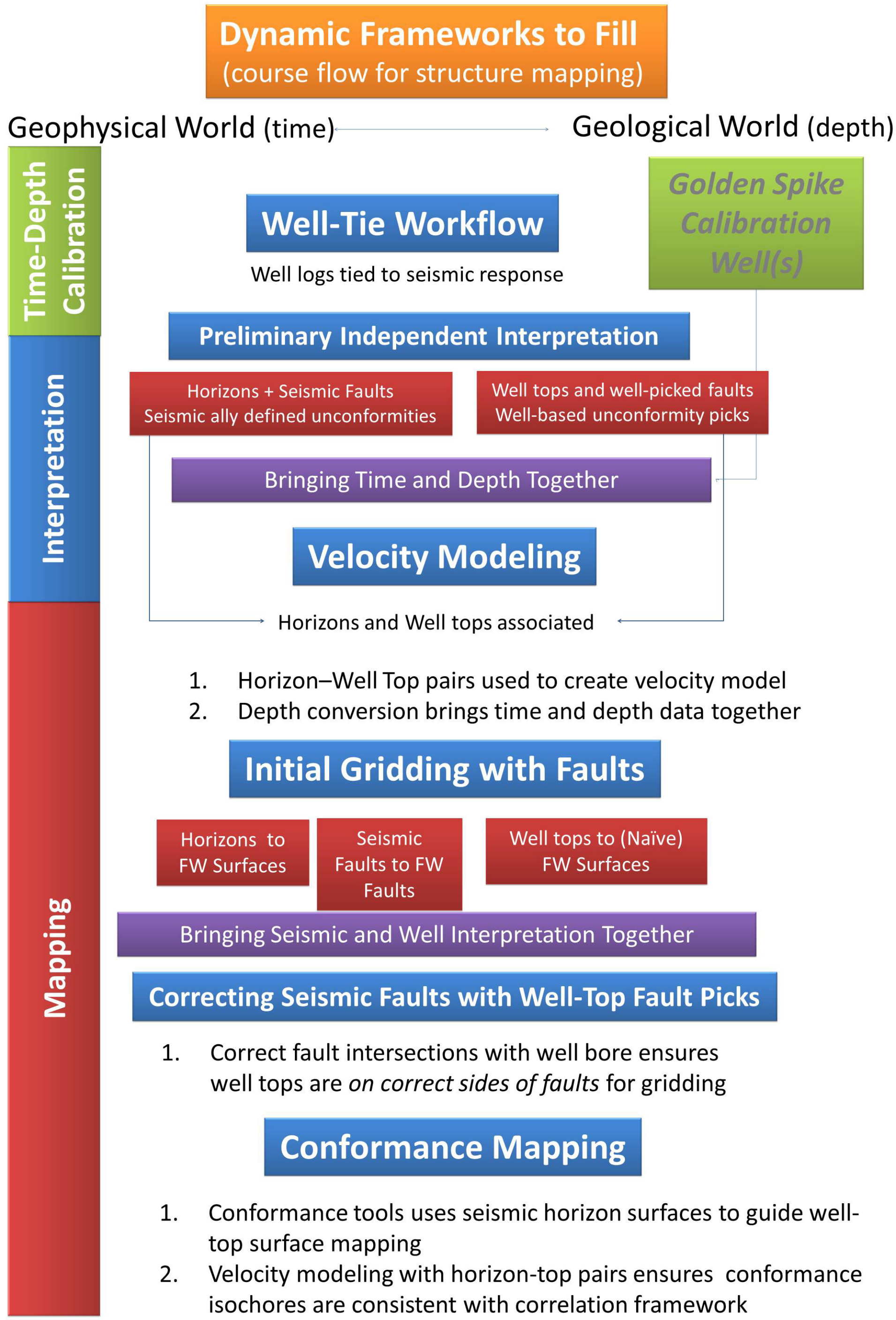
Geologists will also learn the tools to adjust seismic interpretation as they work through the geological workflow. The result is a better well correlation and map.

In later chapters geologists and geophysicists will use geologic data to solve two other problems that often challenge geophysicists:

- Interpreting at geologic intervals that are not well imaged by seismic data
- Integrating seismic faults with geologic faults to ensure that the fault trace (polygon) map honors well points

The following figure presents an overview of the workflow you will follow to create the best possible set of structure and property maps over the studied field. This chapter covers initial seismic interpretation, well tie, depth calibration, and structural mapping. The structural mapping integrates seismic horizon and subsurface controls to build the best possible maps.

The figure demonstrates that this course is about the best practices for creating structure and property maps.



An important part of the course is your review of the mapping technology contained in Dynamic Frameworks to Fill. You will see how Landmark interpretation tools are linked tightly with those mapping tools, and that, as the interpretation changes or evolves, the resulting multi-surface structural framework updates concurrently.

The key goal in the first exercise will be to define best practices for interpreting faults by use of semblance attribute volumes and the leveraging of Dynamic Frameworks to Fill technologies. You will model fault planes to assist in projecting interpretations across the project area.

You will work with the new DecisionSpace velocity modeling tool, which uses framework geometries in velocity interpolation.

Later, you will review best practices for horizon interpretation and create framework surfaces from these horizons. These horizons integrate with your initial fault interpretation through Landmark's Dynamic Frameworks to Fill technology. The topology engine within Dynamic Frameworks to Fill allows you to grid surface data in the context of individual fault blocks, thus automating the creation of fault polygons as part of the mapping process. The dynamic part of this process is related to the linking of source data (e.g., horizons, fault sticks, and so forth) with the framework surfaces in such a way that as source data changes (i.e., new or revised interpretation) the framework surfaces (with all dependencies) update as well.

Finally, you will use your well tie and velocity model workflows and apply the velocity model to an on-the-fly depth conversion in DecisionSpace.

Overview: Interpreting Faults

This chapter starts with faults, because well-defined fault networks can yield both structural and productivity improvements in horizon interpretation. You can use faults to map polygons as you interpret, and in unfaulting and unfolding workflows. Horizon auto-tracking can honor the faults, resulting in more accurate interpretations.

You will discover fault interpretation workflows that benefit from Dynamic Frameworks to Fill. You will focus on the strengths the *Cube* view brings when added to the section and map interpretation workflows, to build a better fault network faster. You will also see comments in this chapter that indicate when named faults work best and when the unassigned fault workflow (complex fault patterns) in *Cube* view can improve productivity.

Using Keypad Commands for Interpretation

- M – Resets the center of interest for rotation and pan. Place the cursor over an object where you want to reset the center and press the M key.
- F12 – Turns Interpretation mode on and off. You can also click the **pencil** icon on the interpretation tool bar or the navigation bar to move in and out of Interpretation mode. When you leave Interpretation mode, you return to the mode you were in before you entered Interpretation mode.
- Alt – Holding the Alt key down temporarily allows you to go to Pan/Zoom/Rotate mode (from Interpretation mode). Press and hold the Alt key to rotate, zoom, or pan without fully leaving Interpretation mode. Release the Alt key to return to Interpretation mode.
- z – Pressing and holding z enables Select/Drag mode from either Pan/Zoom/Rotate mode or Interpretation mode.
- Tab – Pressing Tab toggles from Interpretation mode to Select/Drag mode; pressing again toggles between Select/Drag and Pan/Zoom/Rotate modes.
- Shift – **Shift+MB1+drag** moves a probe face. You can do this from any mode.

Click **MB1** to add a fault node. Click **MB2** to end the segment.

Click **MB2** on a fault node to delete it. Click **MB2** on a segment (after ending a segment) to delete that segment.

You can extend or shorten fault segments without seismic, but the segments will follow that trend of the last two nodes.

Exercise 1.1: Interpreting Faults on Probes

In this exercise, you will see how to interpret faults in DecisionSpace. DecisionSpace has many controls and features to facilitate seismic data interpretation.

As noted above, a typical workflow begins with fault and fault framework interpretation. This allows horizon interpretation to be more consistent with the faults, which means less time spent editing when you make changes in your interpretation.

Launching DecisionSpace Geosciences

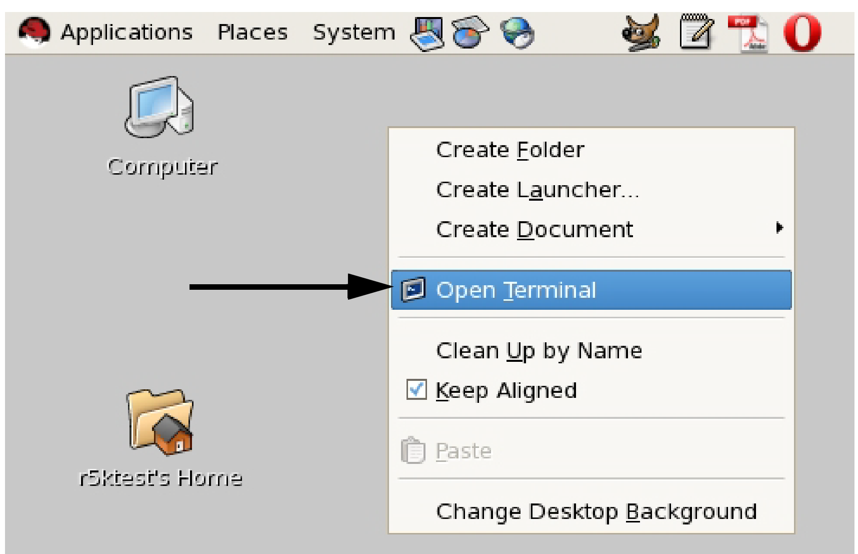
Starting DecisionSpace Geosciences on Windows

1. Click the **Start** icon and then select **All Programs** > **Landmark** > **DecisionSpace 5000.10.0**. Skip to step 6 to bypass the Linux launch and continue with selection of a saved session.

Starting DecisionSpace Geosciences on Linux

2. If your *OpenWorks Command Menu* dialog box is open, skip to step 6.

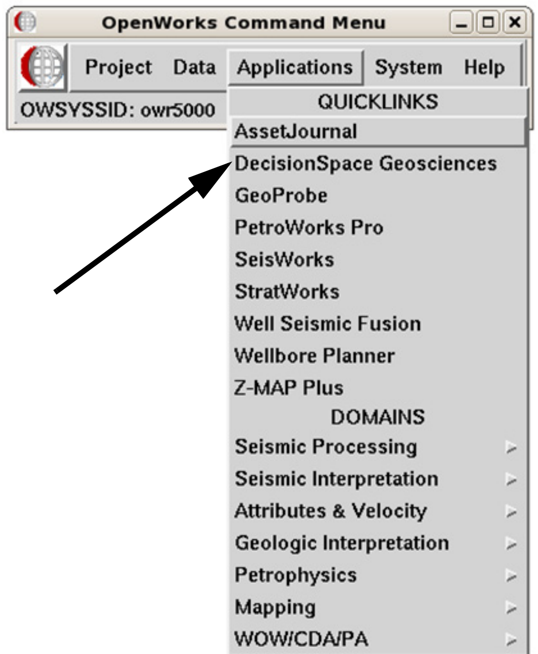
3. On the desktop, **MB3** and select **Open Terminal**.



4. Type "**startow**" in the *Terminal* window to start OpenWorks. The *OpenWorks Command Menu* dialog box will appear.

   Your *Applications* drop-down menu may differ slightly from the image below.

5. From the **OpenWorks Command Menu**, select **Applications > DecisionSpace Geosciences** to launch the program.



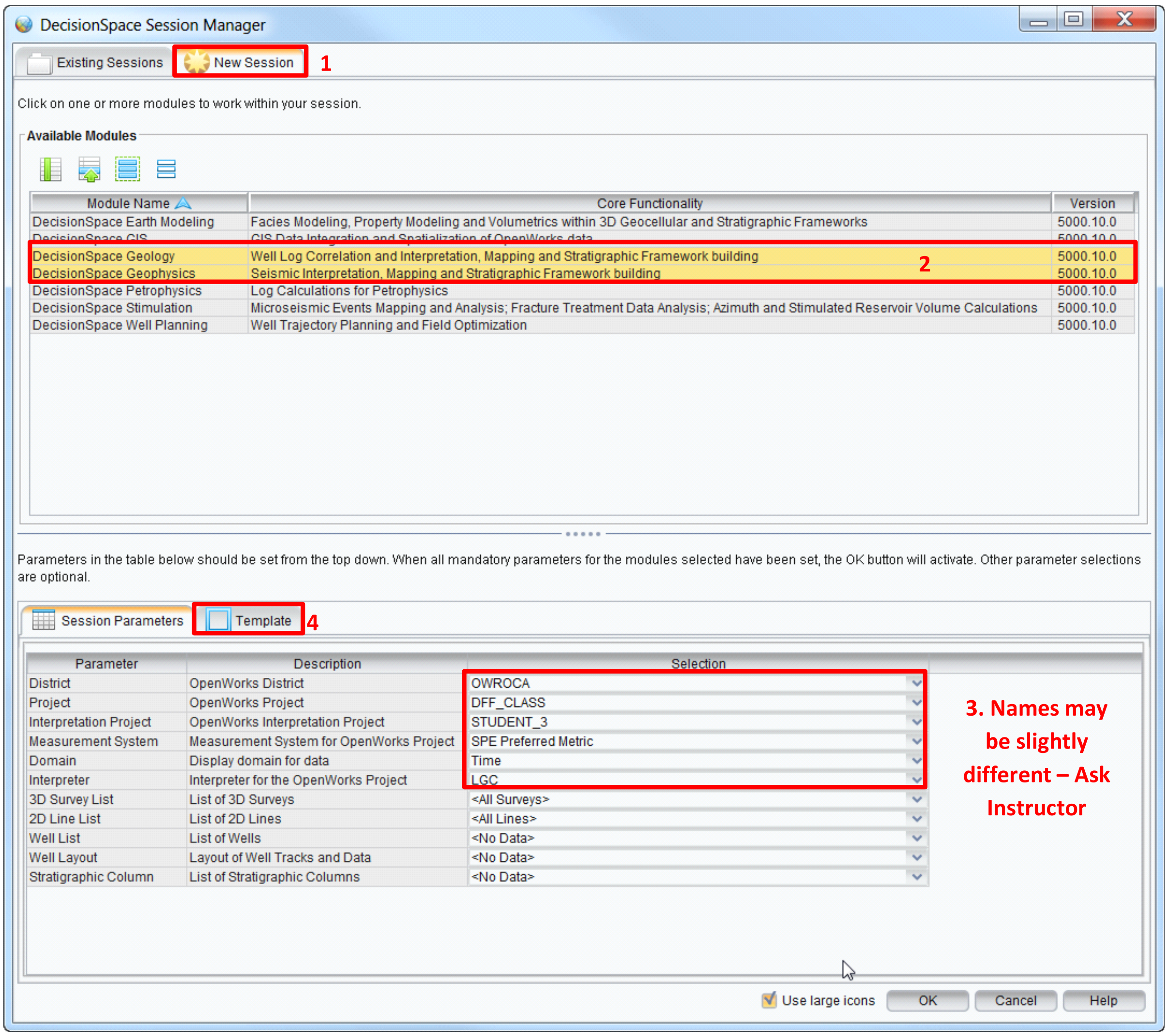
The *DecisionSpace Session Manager* dialog box opens with the *Existing Sessions* tab active (by default). Previously saved sessions are listed in the *Available Sessions* section. Loading an available session launches DecisionSpace with all of the data and views present at the time the session was saved.

You will load a previously saved session to start this exercise. If this session is unavailable, you will start a new session and load well, horizon, and fault data from an Interpretation Set (ISet).

Loading a Pre-existing Session or Loading from an Interpretation Set

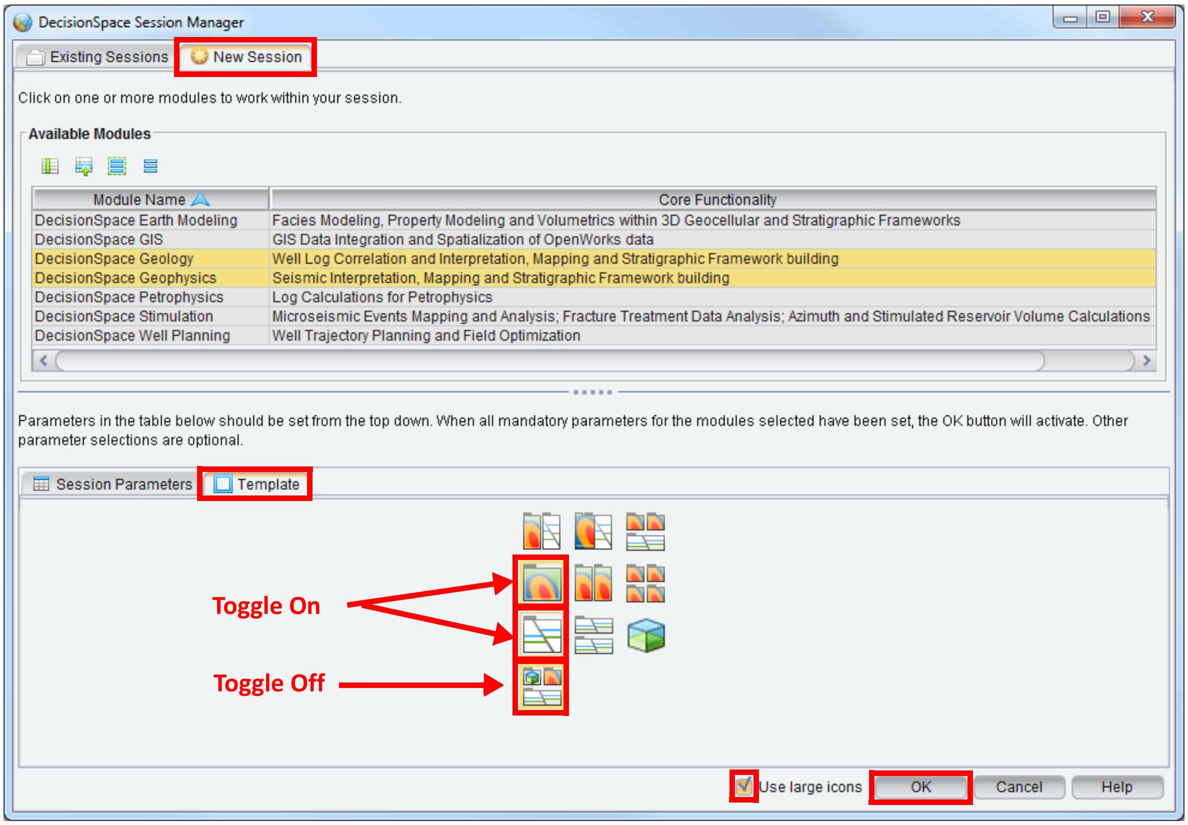
6. In the *DecisionSpace Session Manager*, load session **Chapter1_FaultInterpretation**. If this session loads successfully, skip to Step 12.

7. If you have trouble loading the session named above, initiate a ***New Session*** in **Time,** as shown below.



Your settings for the top three entries may differ. Select your interpreter name.

8. Click the *Template* tab in the lower half of the *Session Manager*. Turn off the **default template** with the three views, and then click the **Map-** and **Section- Single Window** icons. Select the **Use large icons** check box**,** if you wish, and then click **OK**.

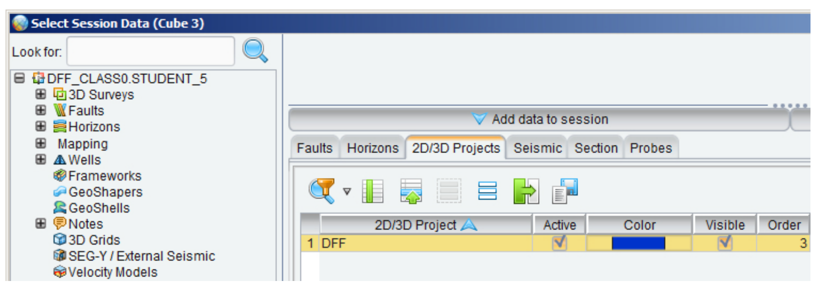


Two DecisionSpace windows should appear.

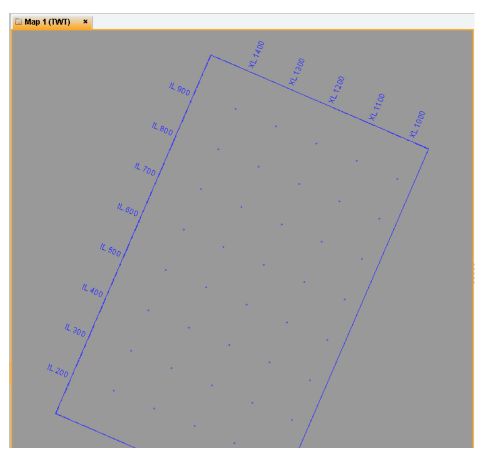
Note

If you used the session file or your *Map* view lacks survey annotation, you should adjust the color for 2D/3D Project. Alternatively, you could adjust the background color. There is no inline or crossline annotation apparent in the view below.

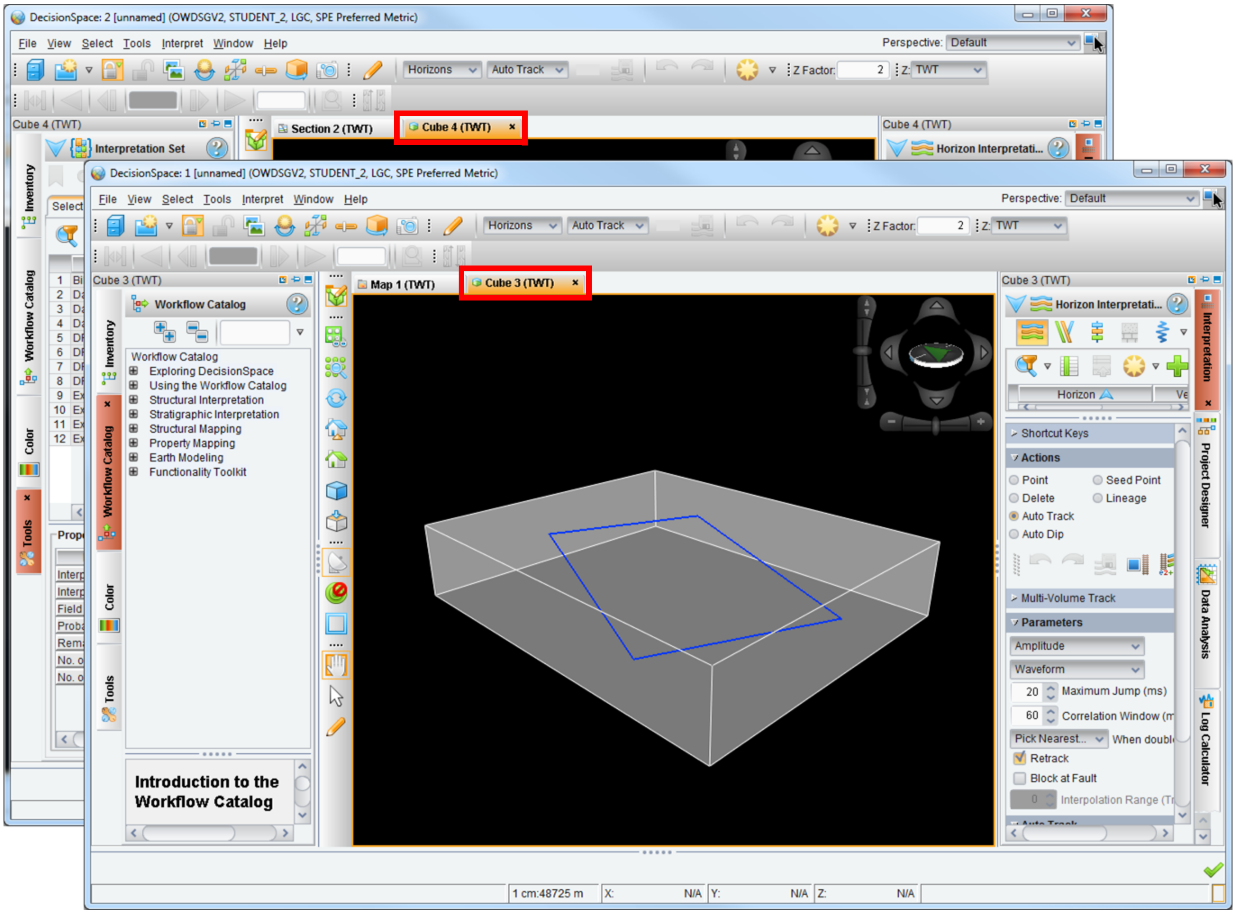
On the *Select Session Data* () dialog box, adjust the Color for the DFF survey on the *2D/3D Projects* tab.



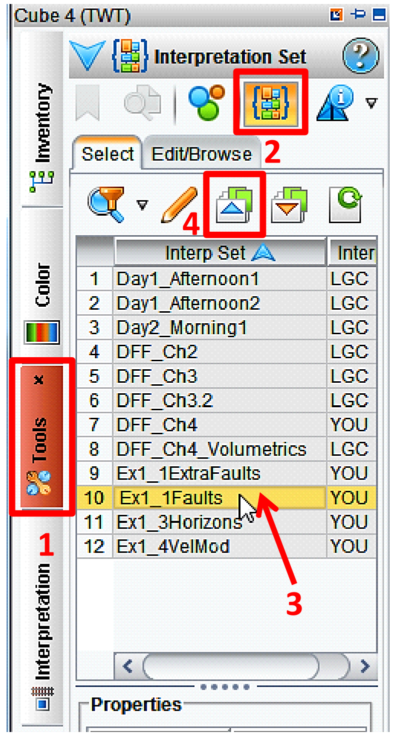
This Color setting also affects survey annotation in both *Cube* and *Section* views.



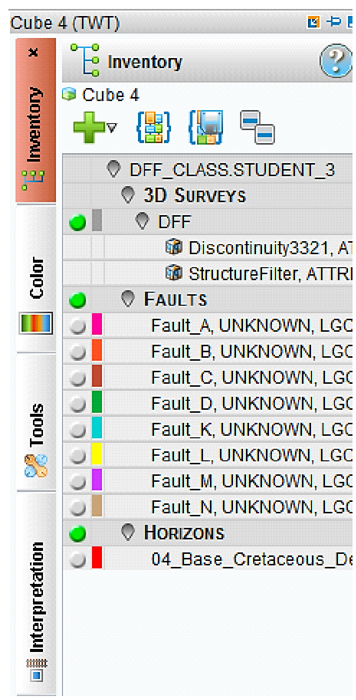
9. Add a new *Cube* view to each DecisionSpace window. Your background, bounding box, and volume colors may differ. (Hint: **File > New Tab > Cube**)



10. From the *Tools* task pane, click the **Interpretation Set** icon, and then load the **Ex1_1Faults** ISet to your session. Follow the sequence in the picture below.

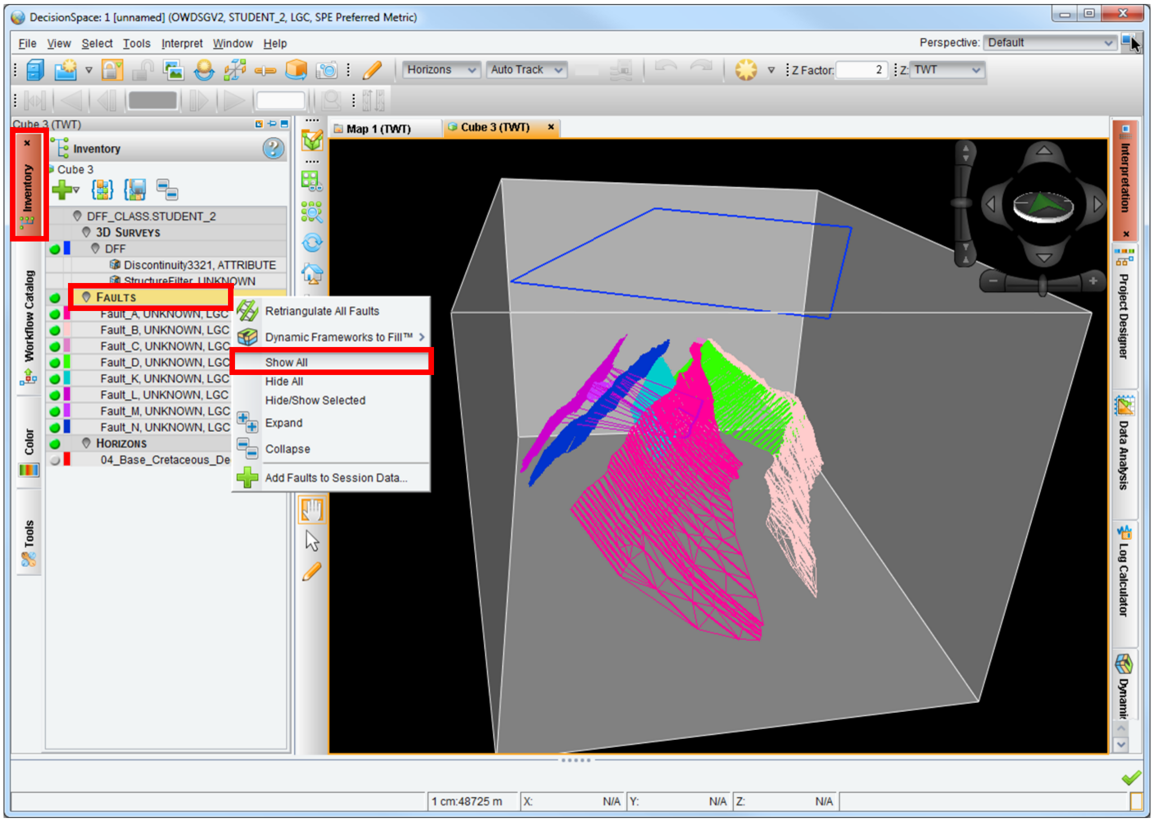


11. Go back to the *Inventory* task pane and make sure you have the same seismic surveys, faults, and horizons as shown below:

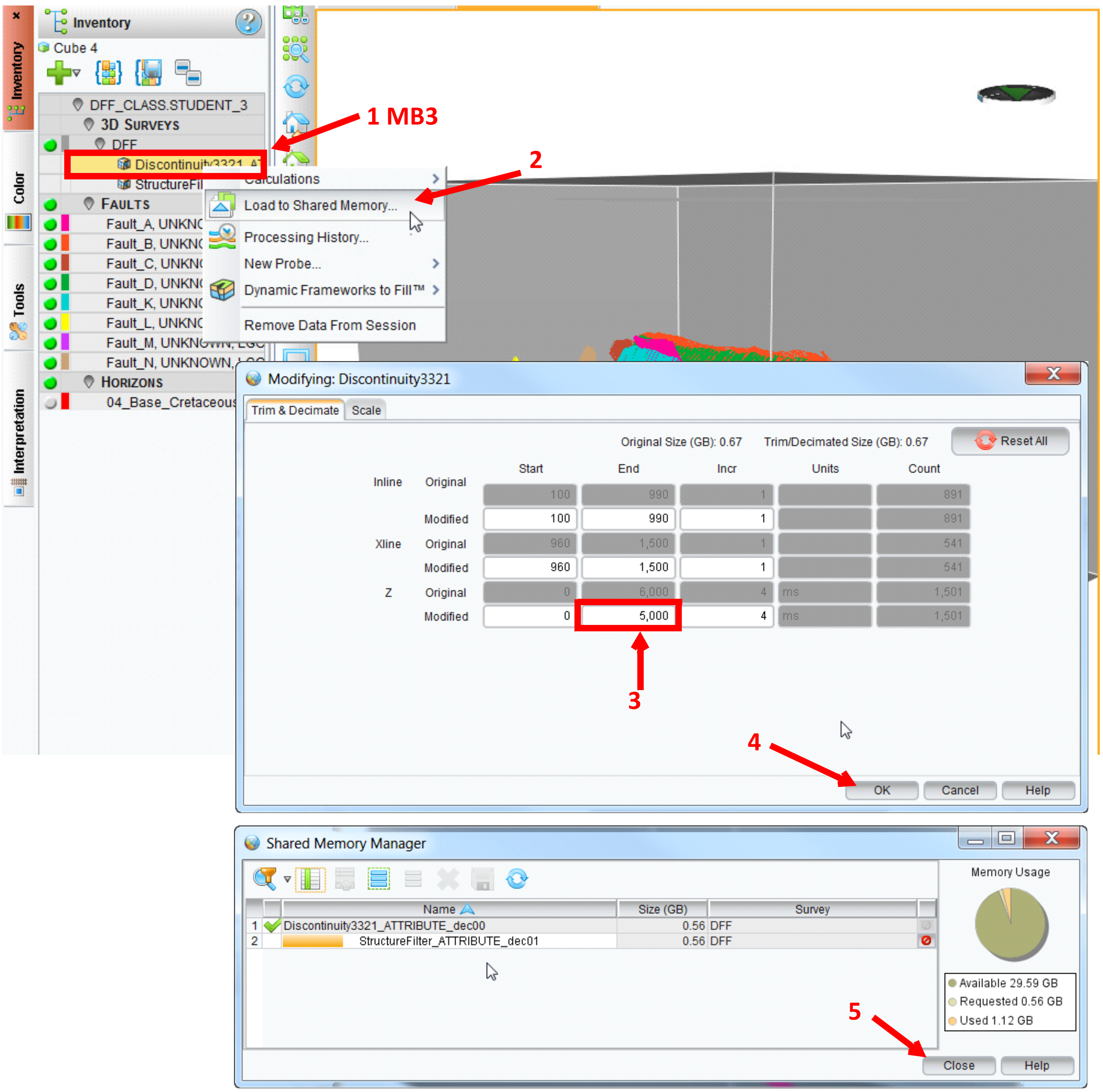


Because this class has limited time, you will interpret three faults. Other faults are already loaded (see ISet contents listing above).

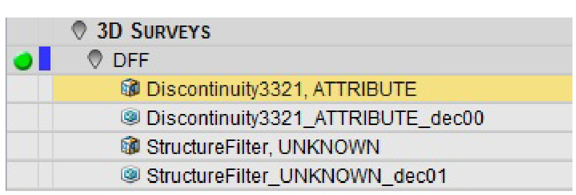
12. In the window containing the *Map* and *Cube* views, display all faults in *Cube* view.



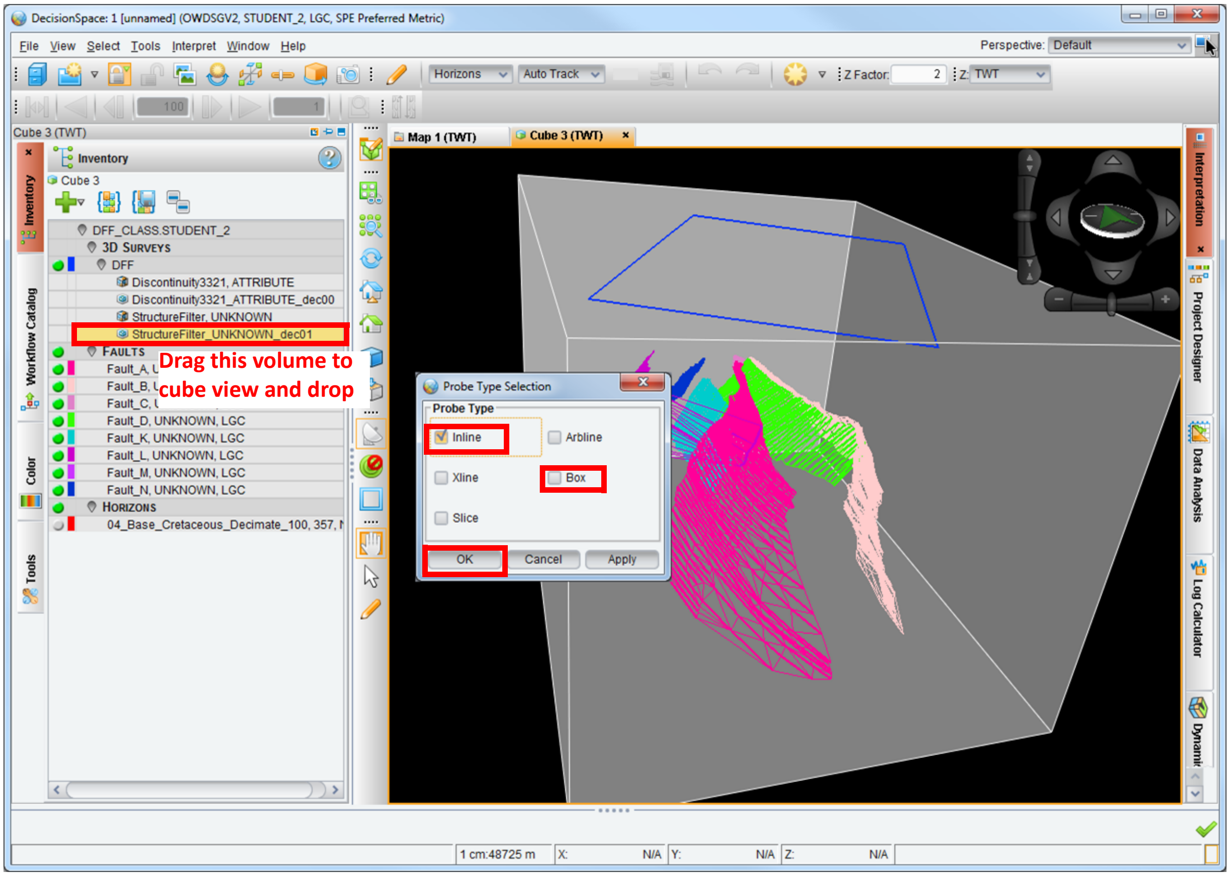
13. Load the **Discontinuity3321** and **StructureFilter** volumes to the shared memory. In the *Modifying* dialog box, change the Z End value of both volumes to **5000**.



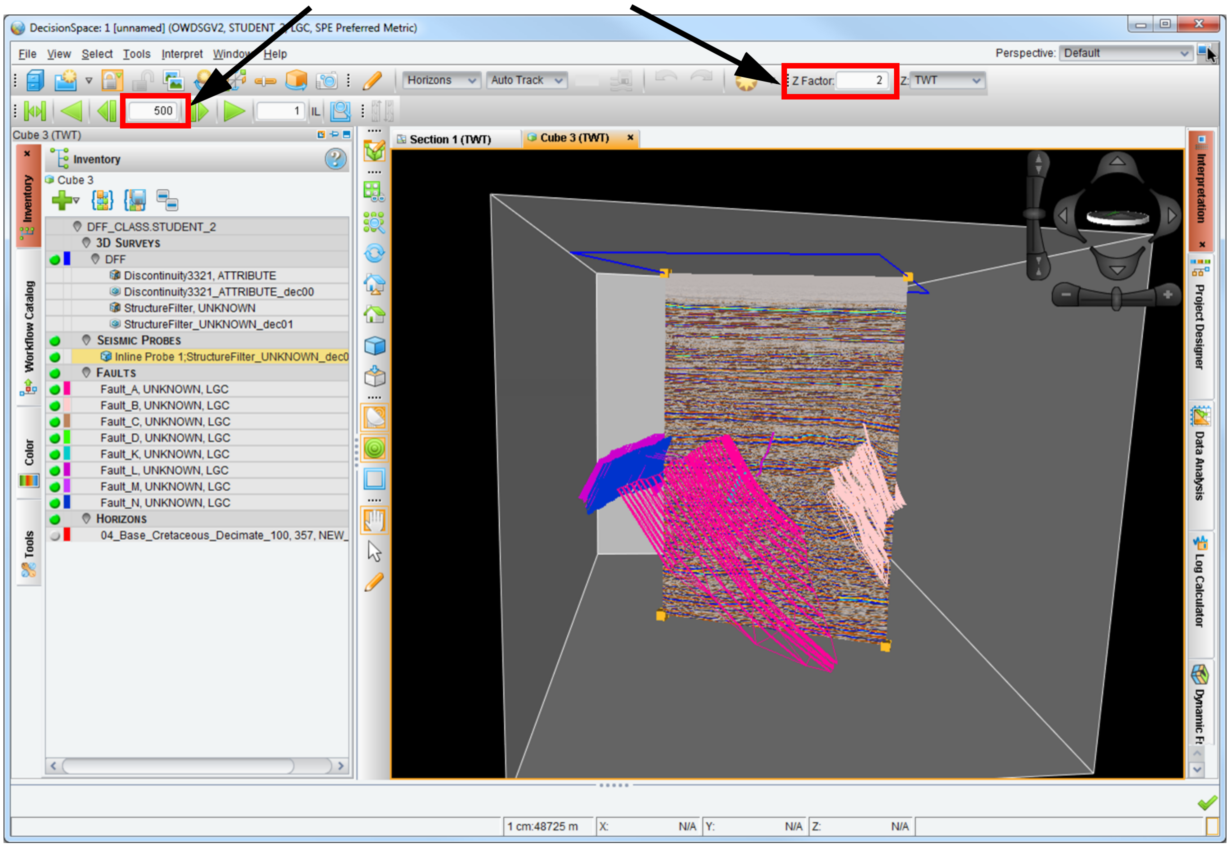
The volumes are now listed twice, once for the data loaded in the traditional Landmark formats ( ) icon and the second time for the data loaded into shared memory ( ) icon.



14. In the window containing the *Map* and *Cube* views, drag and drop the **StructureFilter** shared memory volume from the *Inventory* task pane to the *Cube* view. In the *Probe Type Selection* dialog box, turn off **Box** and turn on **Inline**. Click **OK**.



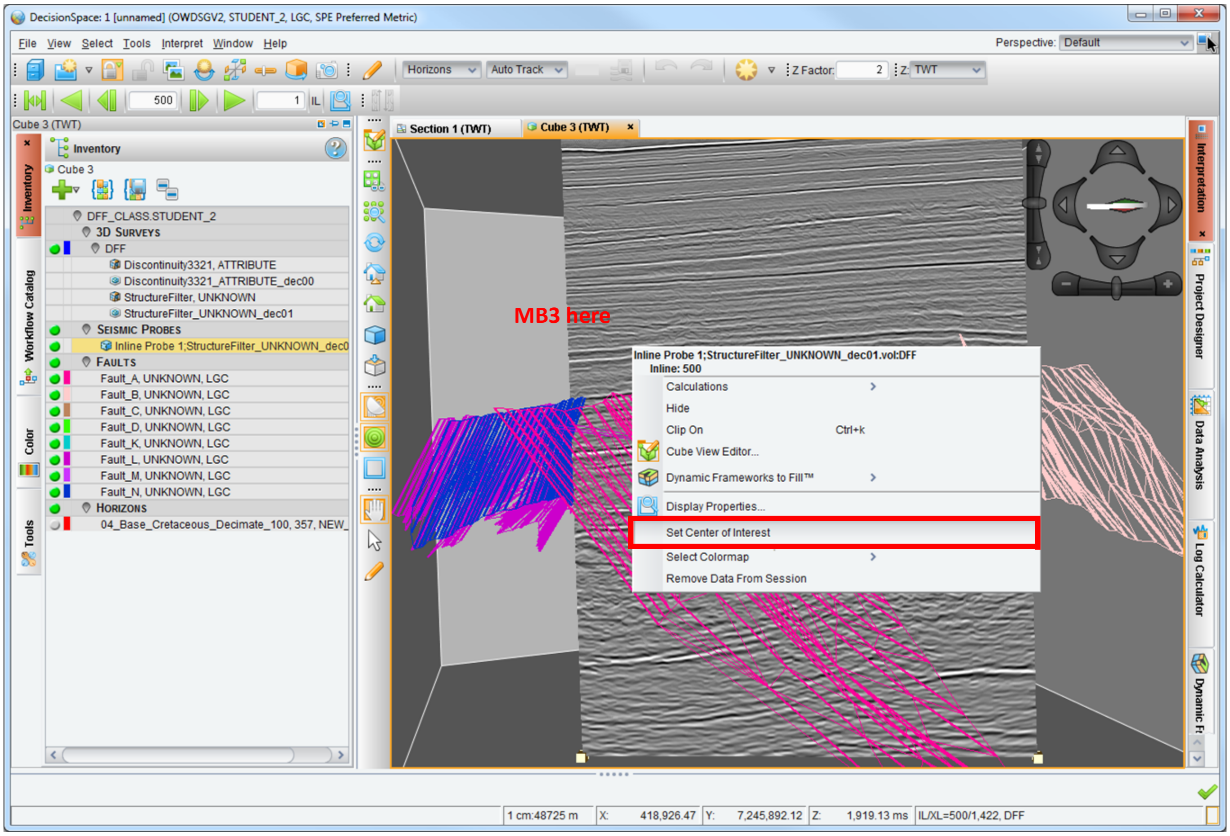
15. From the icon bar at the top of the *Map/Cube* window, change the inline number to **500** and the Z factor to **2**.



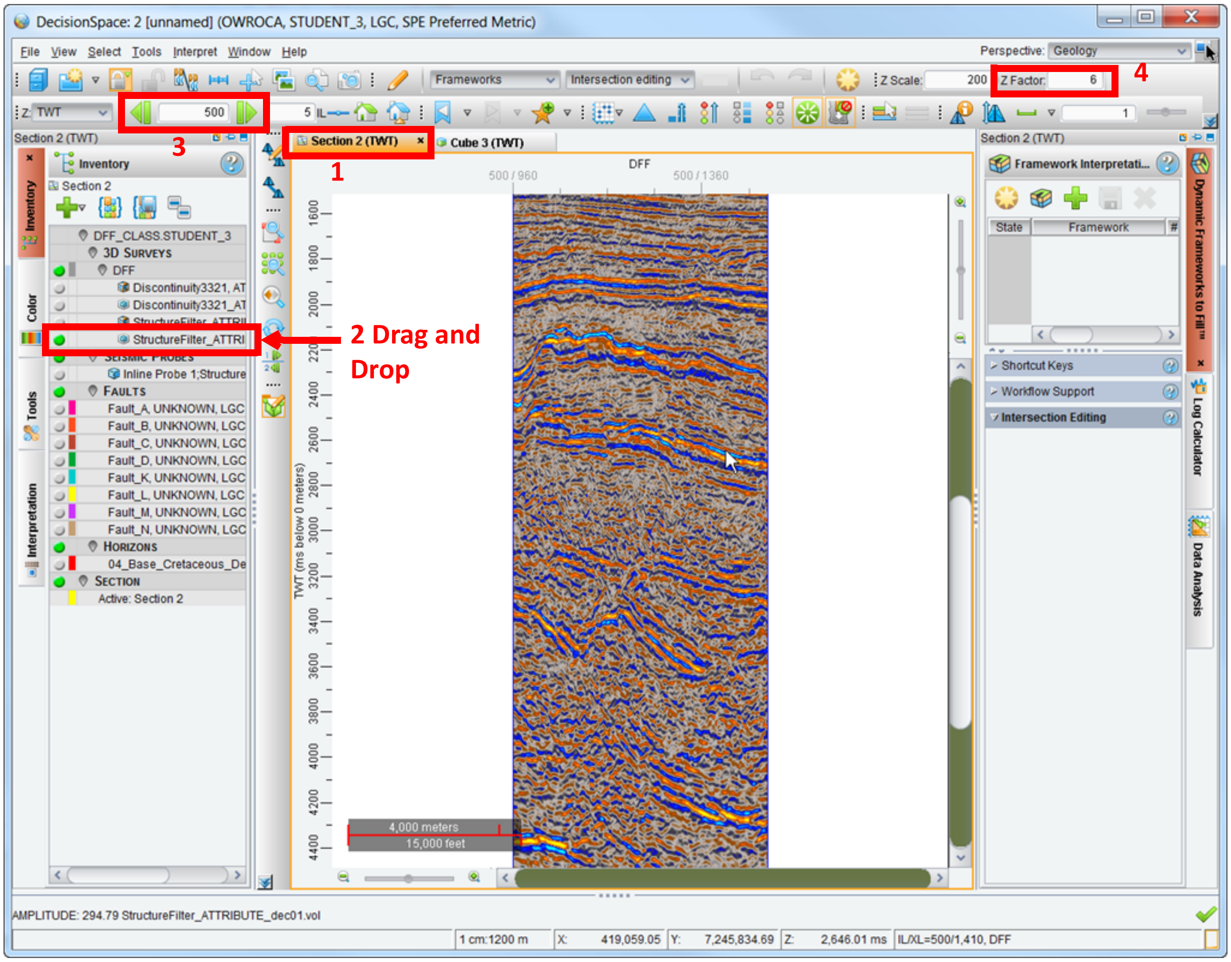
16. If you wish to change the color scale: **MB3** on the probe, and then select **Color Map > System > 3_Magic**.

> **Note**
>
> In many of the following figures, the authors use a Grayscale because it shows up well on the printed page and the color faults are more visible. The 3_Magic or the Amplitude_Pk color scale are usually a better choice for delineating subtle breaks in reflectors caused by faults.

17. Set your center of rotation between **Fault_A** and **Fault_B** by **MB3** and selecting **Set Center of Interest**. **Zoom** in until your *Cube* view looks something like the image below.



18. In the *Section/Cube* window, click the *Section* tab. Display inline **500** of the StructureFilter shared memory volume (**Select > Section from List...**). Alternatively, you can drag and drop **StructureFilter (share memory volume)** into *Section* view, type **500**, and set Z factor to **6** as shown in the picture.

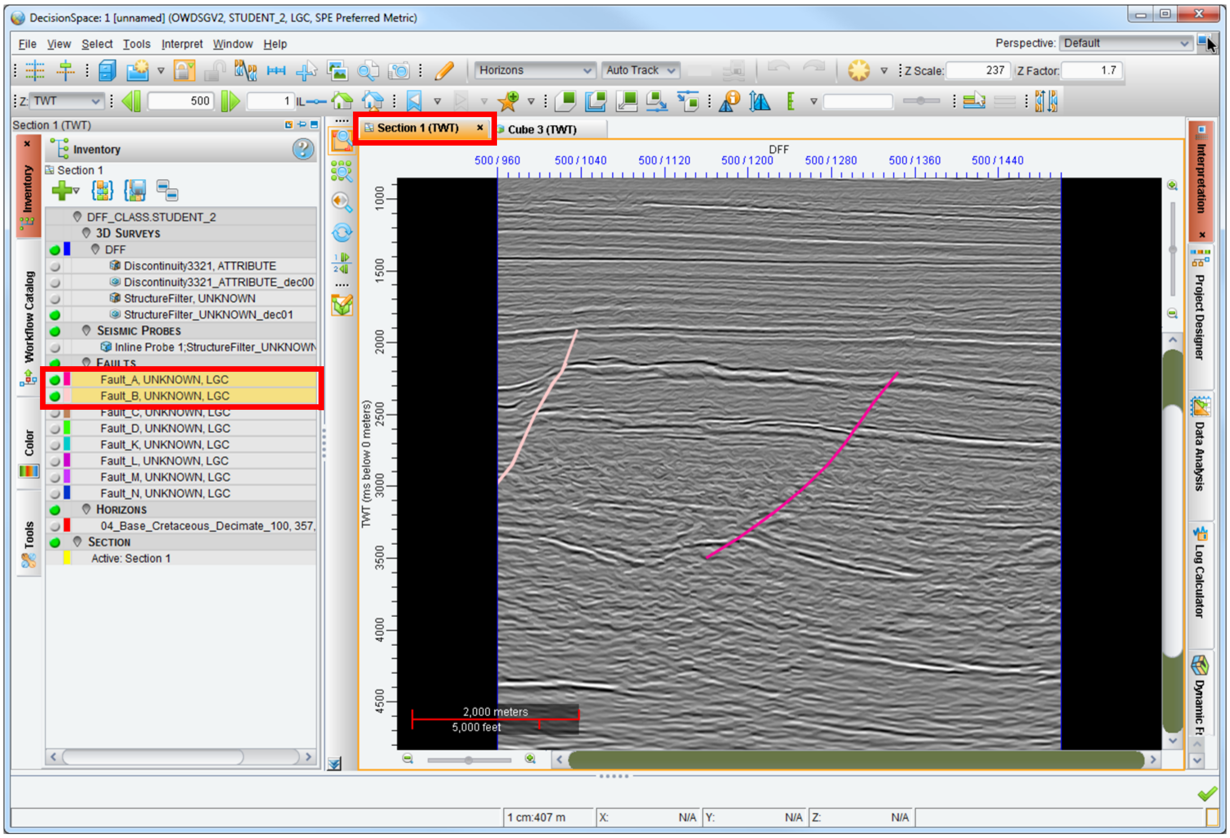


Note that the section has the east on the left and the west on the right. This matches the view from the north in your *Cube* view.

Note

To reverse the orientation of a section in *Section* view, press the hotkey <**v**>.

19. Zoom in on the section between approximately **1700** and **3600** msec. In the *Inventory* task pane, turn on **Fault_A** and **Fault_B**. If necessary, reverse your section to match the illustration below.



You will interpret smaller faults between these two major faults, but before that, save your session.

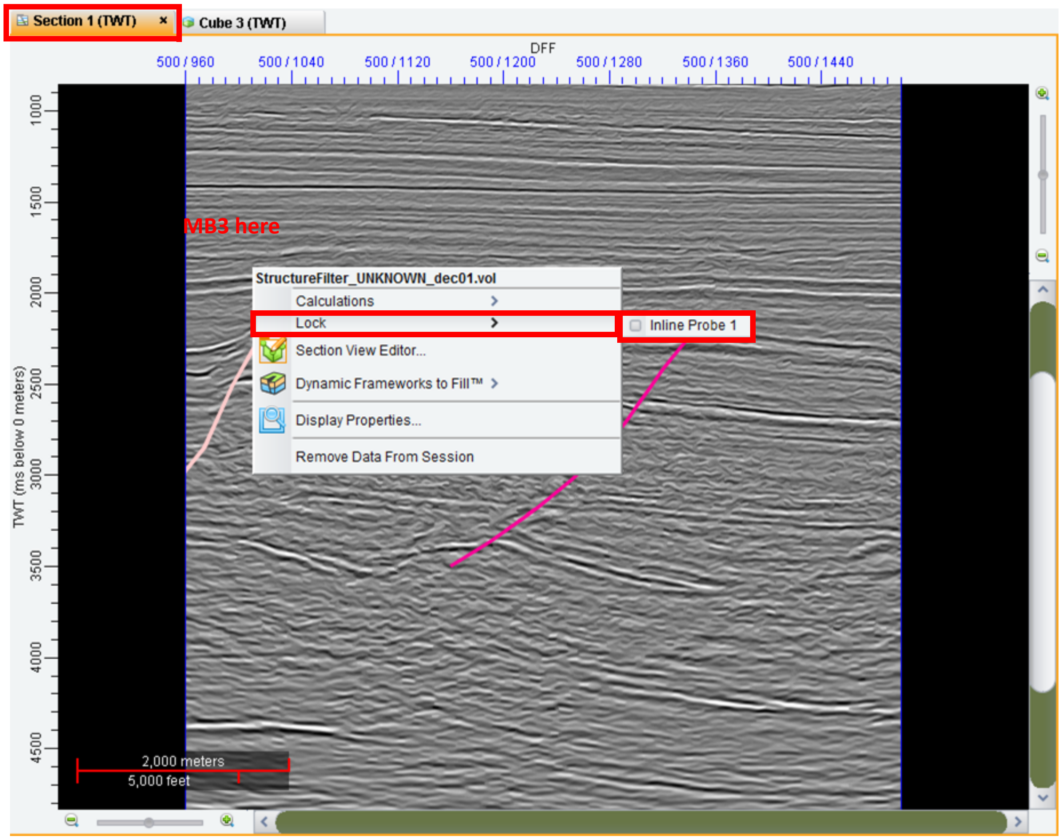
20. From the top menu bar on either of the DecisionSpace windows, select **File > Save Session as...**. In the *Save Session As* dialog box, enter a unique session name, such as “**YOU_Ex1.1**.”

Creating and Interpreting Faults in Section View

You will interpret several faults in this exercise, to learn the workflow and important fault interpretation tools within DecisionSpace. Your goal is not to definitively pick the faults. Work rapidly through the exercise.

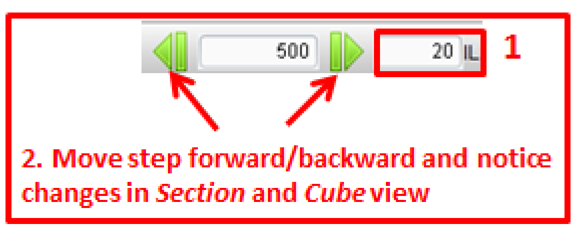
You should have one DecisionSpace window showing an inline probe of line **500** and the other DecisionSpace window showing a *Section* view of the same line. You can synchronize the inline views of the two windows.

21. In the *Section* view, **MB3** on the seismic data and then select **Lock > Inline Probe 1**.



Now, when you change the line in one view, the other view will also change.

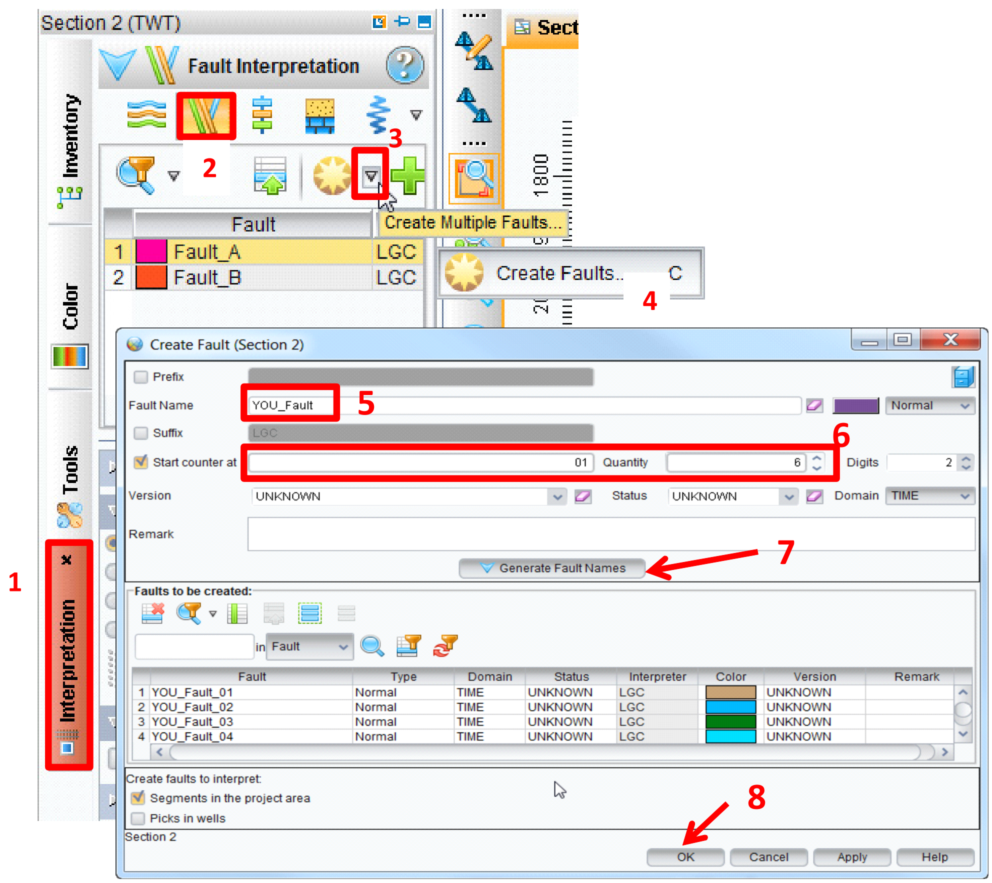
22. Still in *Section* view, set the step interval to **20**. Click the **Step Forward** and **Step Backward** icons to confirm inline display change in both windows.



23. With *Section* view active, create six new faults named:

- **YOU_Fault_01**
- **YOU_Fault_02**
- **YOU_Fault_03**
- **YOU_Fault_04**
- **YOU_Fault_05**
- **YOU_Fault_06**

From the *Interpretation* task pane, click the **Fault Interpretation** icon and then the **Create Multiple Faults** icon (gray down arrow). The *Create Fault (Section N)* dialog box appears. Create the six faults as shown in the picture below.

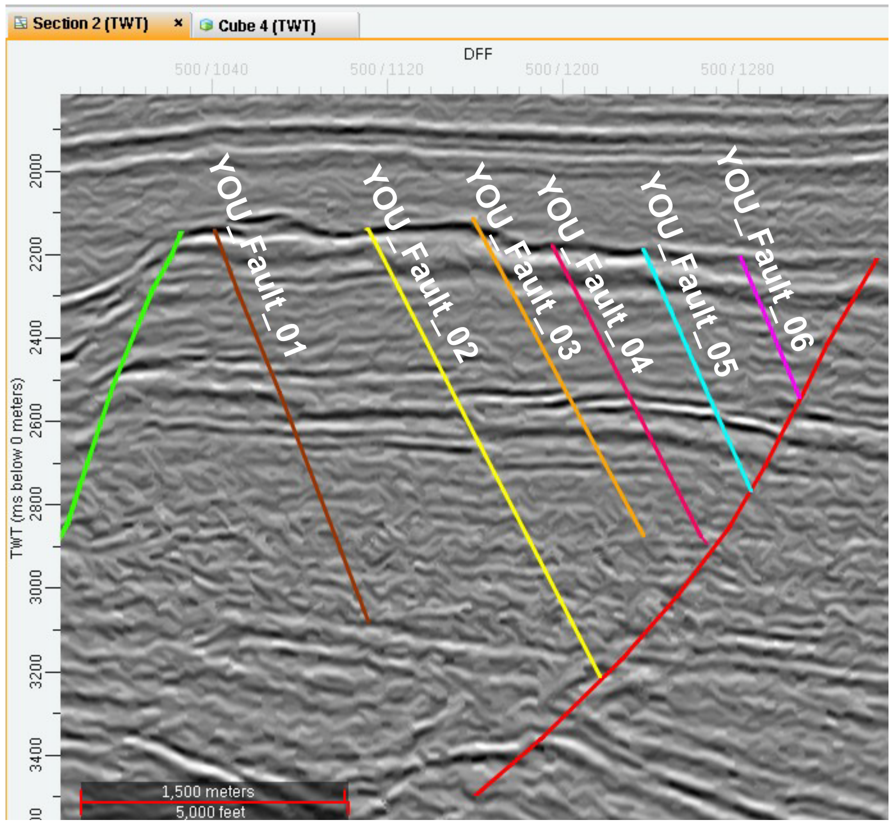


You should see your six newly created faults shown in the Faults section of the *Inventory* task pane and in the Fault Interpretation list. You have created six faults, but because of time constraints, you will pick only three faults (unless your instructor asks you to interpret fewer or more faults).

> **Note**
>
> This review of (mouse button) fault interpretation fundamentals may be useful:
>
> Click **MB1** to add a fault node.
>
> Click **MB2** to end the segment.
>
> Click **MB2** on a fault node to delete the node.
>
> Click **MB2** on a segment (after ending a segment) to delete the segment.

Traditionally, one interprets faults on inlines or crosslines in *Section* view. You will start with that approach, but move to interpretation in *Cube* view, where you can add the power of probes and 3D visualization. You will also use the fault QC Display to refine your faults.

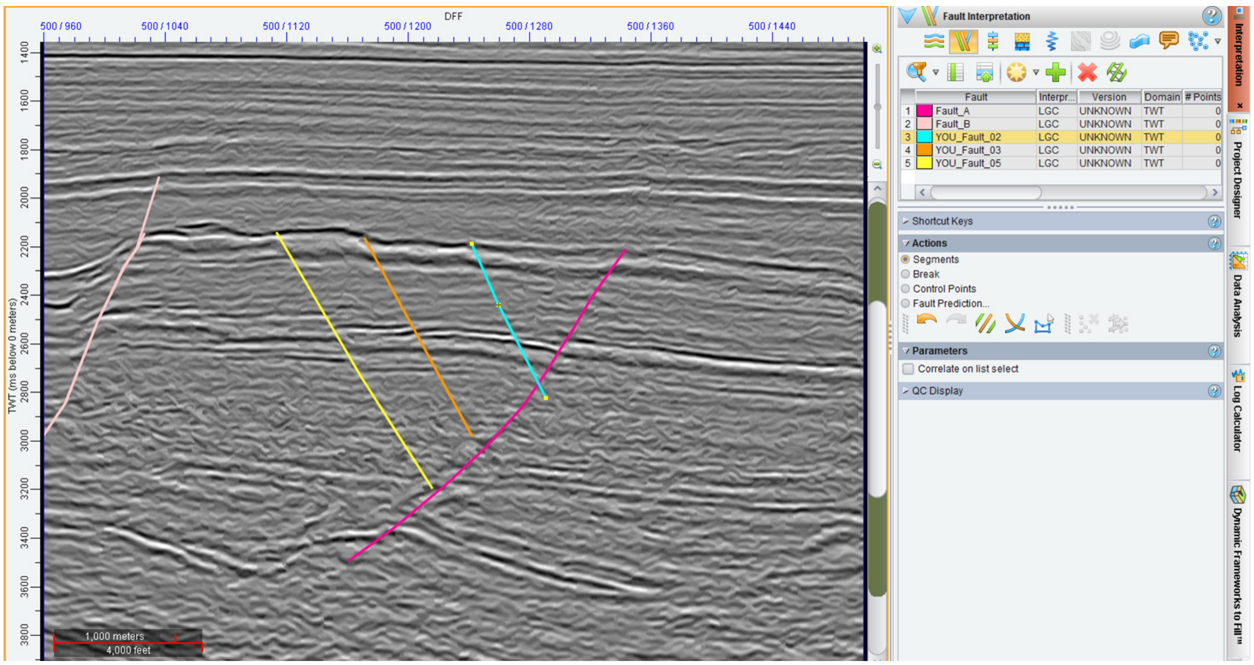
For your reference, the location of the faults you have created are shown below on inline section **500**. Remember the section is being viewed from the north with the west on the right and the east on the left.



The faults are most strongly expressed as discontinuities in the reflectors between 2400 and 2700 msec.

24. In *Section* view, display inline **500**. You will interpret only **YOU_Fault_02**, **YOU_Fault_03**, and **YOU_Fault_05** (see picture above). If time permits you can interpret the other faults later (ask instructor). Don't worry about terminating the fault segments exactly at **Fault_A**. The framework will do that for you.

When the interpretation is completed the interpreted fault segments should look something like the cross section below.



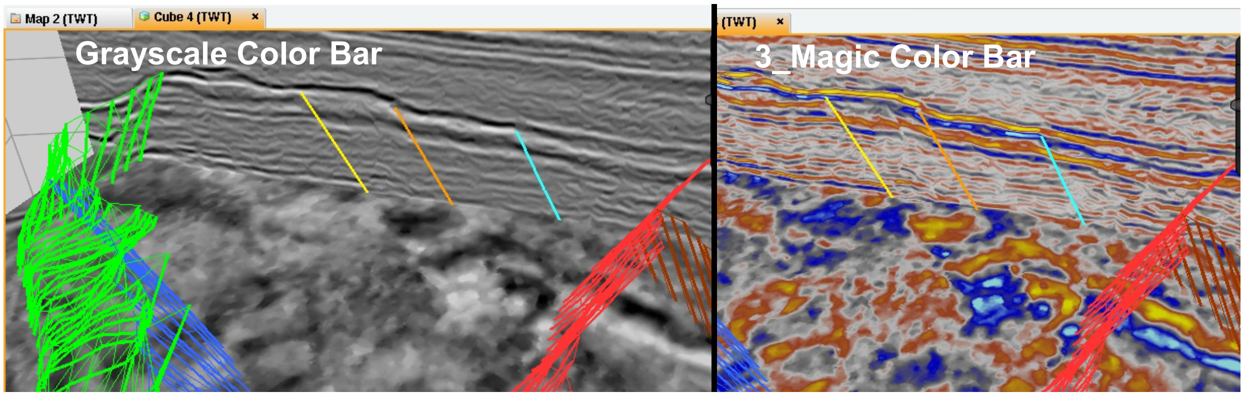
Instead of continuing interpretation on inline sections, you will now move to the *Cube* view, where you can get a 3D perspective of the volume and use time slices to see trends in the faults.

Using Probes to Interpret Faults in Cube View

25. With *Section* view still displayed, select *Cube* view in the other window (the window with *Map* and *Cube* views). Check that all faults are turned on. If necessary turn on **YOU_Fault 2**, **YOU_Fault 3**, and **YOU_Fault 5**. The *Section* view should be locked to the inline probe so they display the same section. You should see your newly interpreted faults on the section.

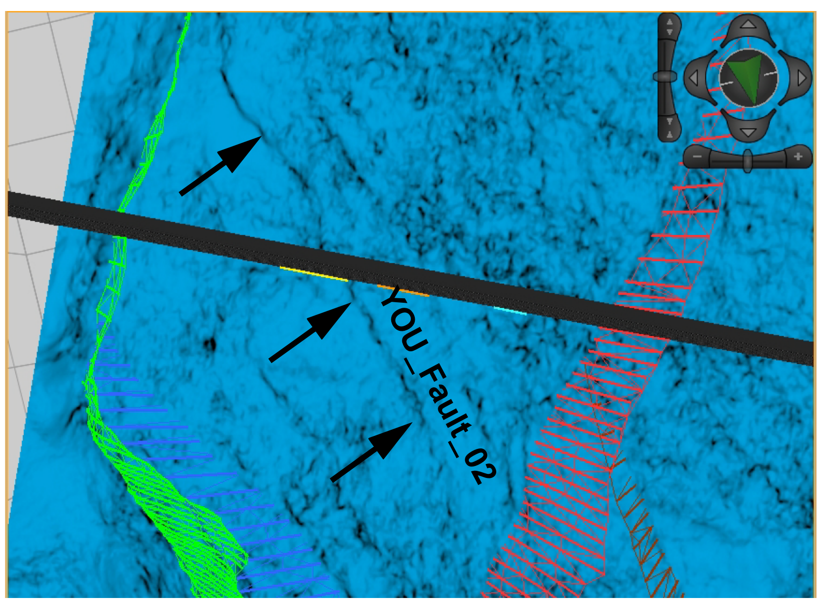
26. Create a **Slice probe** from the StructureFilter shared memory volume and **move** the slice up and down to see how the faults are expressed.

Although most images here are in grayscale for printing clarity, the **3_Magic** color bar defines the discontinuities better, as shown below.



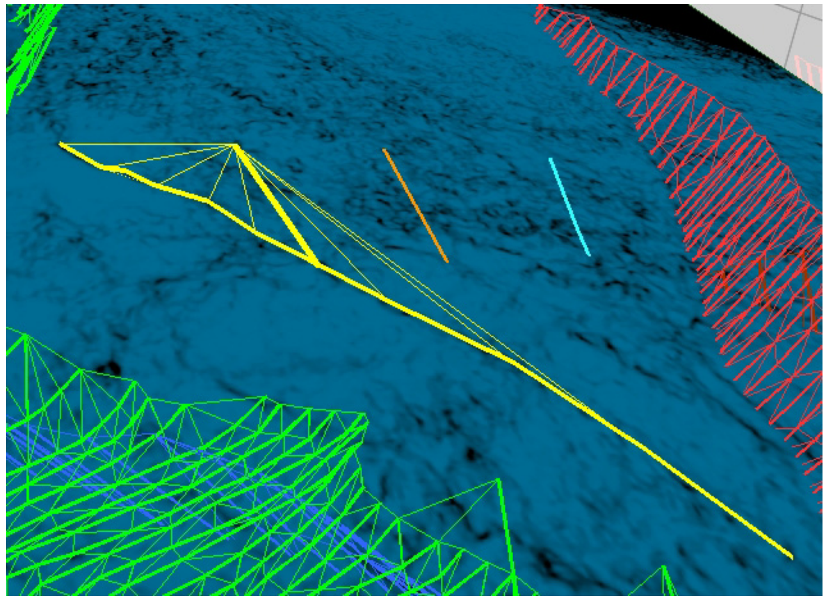
On these slices, you can see discontinuities associated with some of your interpreted faults, but they are not distinct. The discontinuity volume shows a better display. You will now add a slice probe of the discontinuity volume to the *Cube* view.

27. Turn off the Slice Probe from the StructureFilter and create a Slice probe from the **Discontinuity3321** shared memory volume. Move the probe up and down to see how the discontinuity attribute better delineates the faults. Leave the slice at about **2500** msec, where you can follow fault **YOU_Fault_02**.

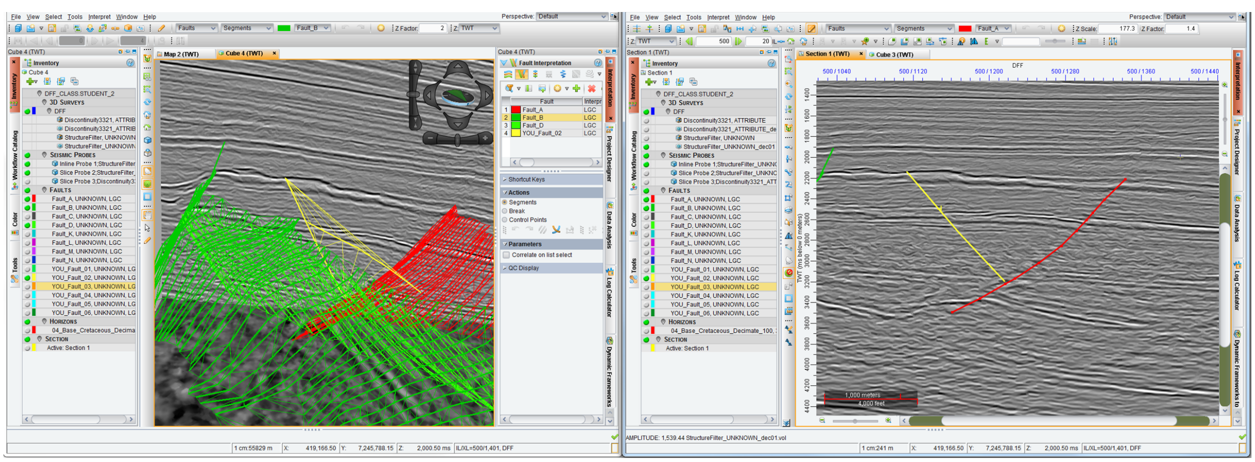


28. Interpret fault **YOU_Fault_02** on the discontinuity slice in *Cube* view. Make sure **Interpretation Mode** is on and the fault is selected.

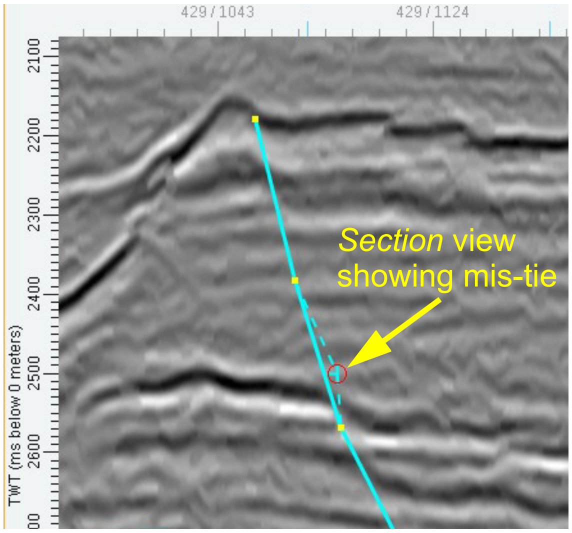
29. **Hide** the inline probe and continue interpreting the fault on the slice until it nears Fault B (green in the image below).

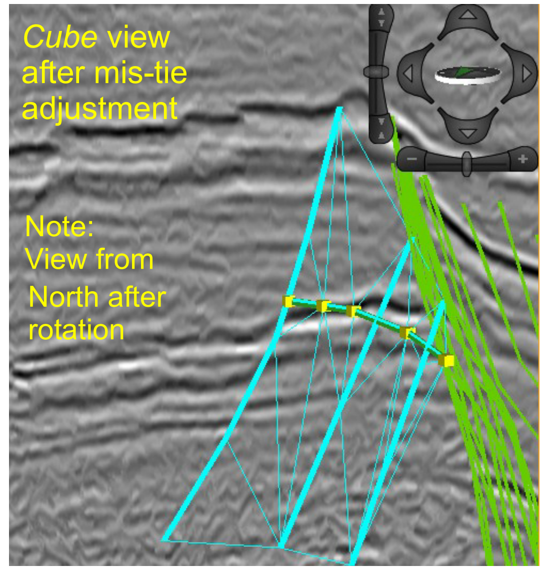


30. **Show** the inline probe and **hide** the discontinuity slice probe. Continue your fault interpretation in *Cube* view until you have interpreted the entire fault. If necessary, hide some other faults so you can have a better visualization of **YOU_Fault 2** in *Cube* view. Remember that *Section* view and *Cube* view are synchronized, so you can check your interpretation in *Section* view.

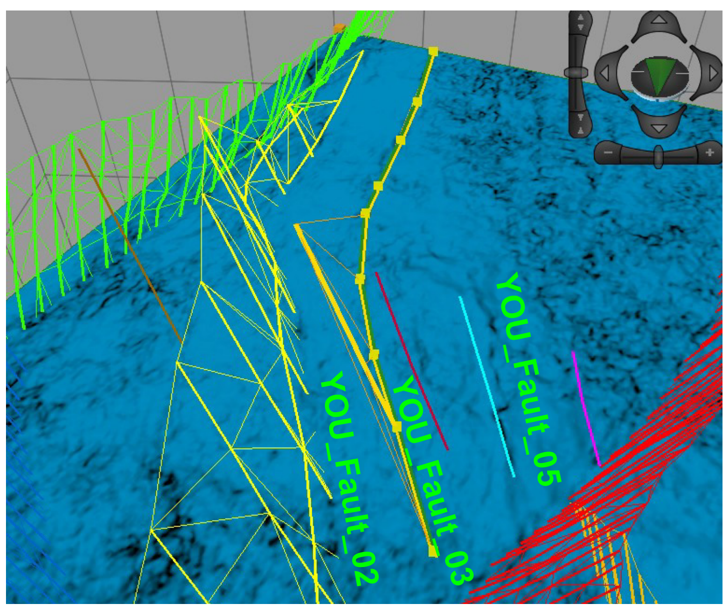


31. If your original interpretation on the discontinuity slice probe was incorrect, you may see a mis-tie on your *Section* view (see below). If so, turn the discontinuity slice back on and make an adjustment.



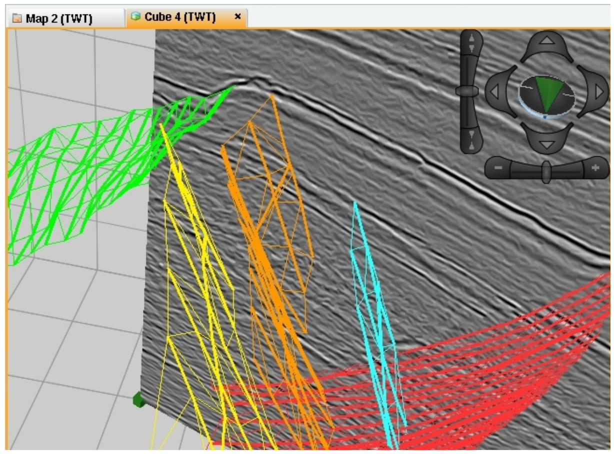


32. **Hide** the inline probe and **show** the discontinuity probe at about **2608** msec. Interpret fault **YOU_Fault_03**.



33. Move the discontinuity slice and interpret **YOU_Fault _05** (about 2628 ms).

34. **Hide** the discontinuity slice probe and **show** the inline probe. Interpret **YOU_Fault_3** and **YOU_Fault_5** on this probe as you did for **YOU_Fault_2**. Leave some seismic lines without the interpretation of **YOU_FAULT_5**, you will finish interpreting this fault in the next steps.

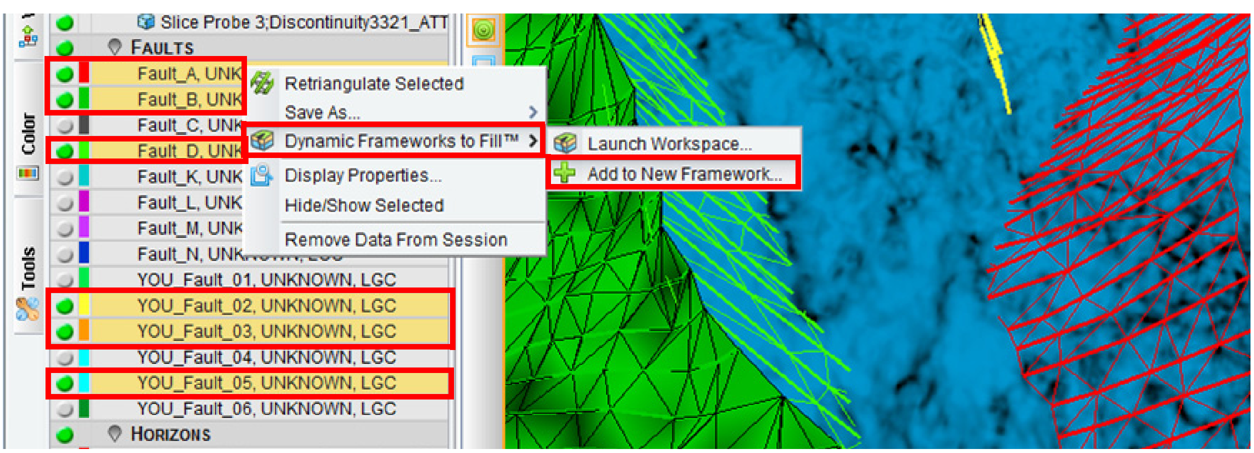


When you finish interpreting, make sure to turn **Interpretation Mode** off.

You should have three interpreted faults. In the next steps you will use a framework to refine all the faults.

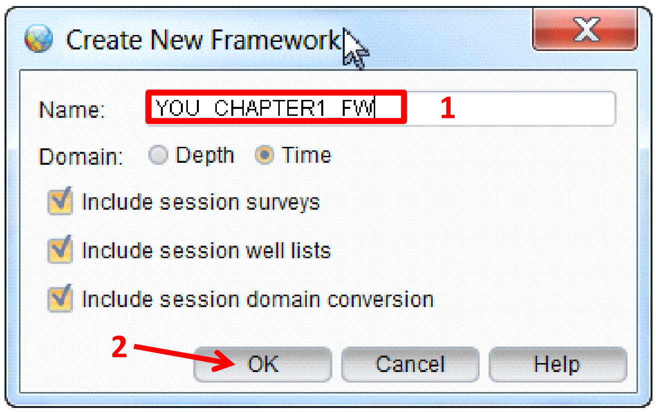
Adding Faults to Framework

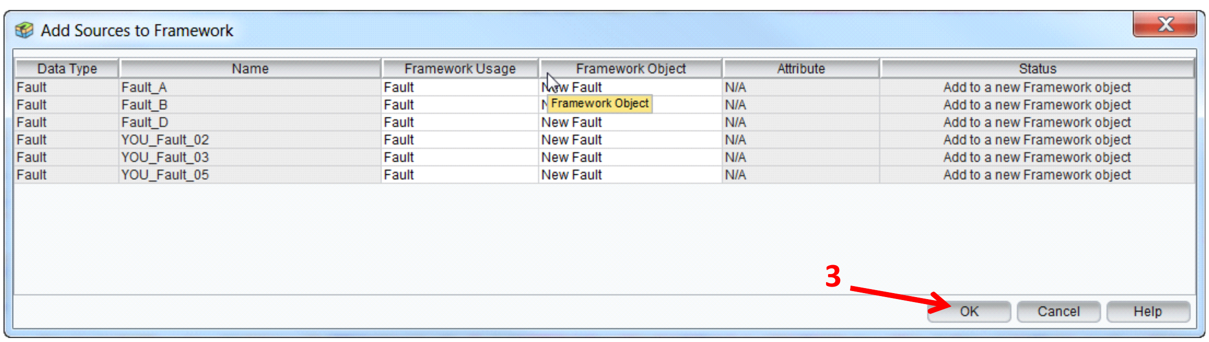
35. From the *Inventory* task pane, highlight **your three interpreted faults**, **Fault_A**, **Fault_B**, and **Fault_D**. On one of the highlighted faults, **MB3** and then select **Dynamic Frameworks to Fill > Add to New Framework**.



The seismic faults are interpolated to create separate framework faults that are displayed as a solid color. Seismic faults are still displayed as a mesh.

The *Create New Framework* dialog box appears, rename the framework to “**YOU_CHAPTER1_FW**,” accept the others defaults, and then click **OK**. A new window, *Add Sources to Framework* appears indicating that all the faults will be added as new objects in the Framework. Click **OK**.



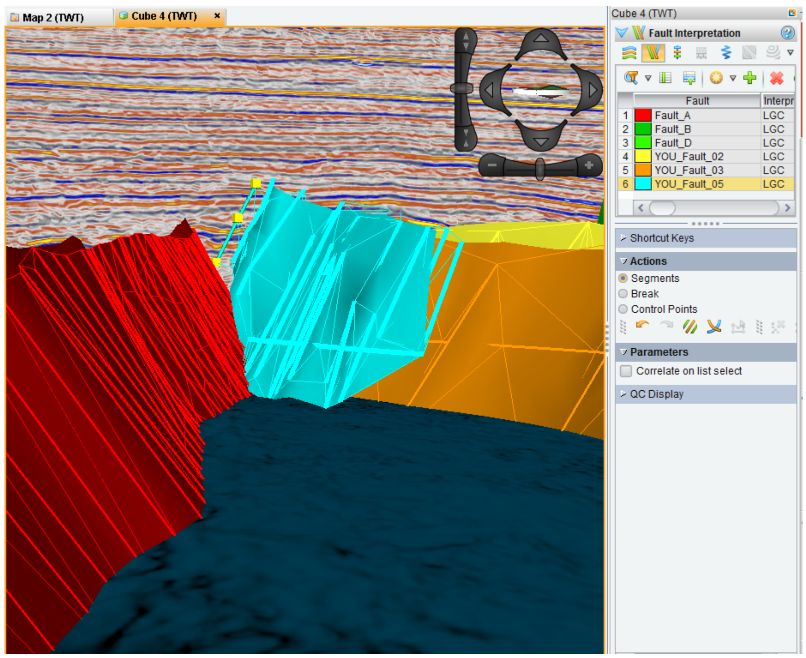


Note

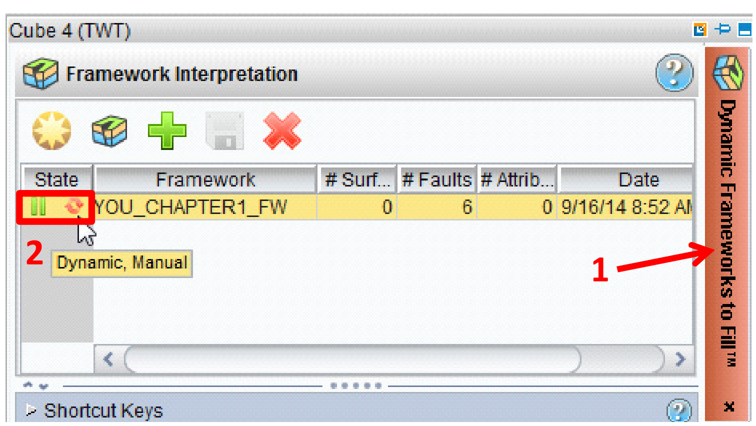
The *Add Sources to Framework* window controls if you are creating a new object in the framework, adding the object as a secondary source for an existing object, adding polygons (to be used either as areas of interest to delimit the boundaries of your framework or to exclude data from modeling), and adding the objects as attributes or structural maps. You will work with these other options in detail further in this manual.

The seismic faults are interpolated to create separate framework faults that are displayed as a solid color. Seismic faults are still displayed as a mesh. The framework faults should appear automatically in the *Cube* view where you were interpreting since it was the active window. However, if you don't see your framework faults in *Cube* view, turn them on manually from the *Inventory* task pane.

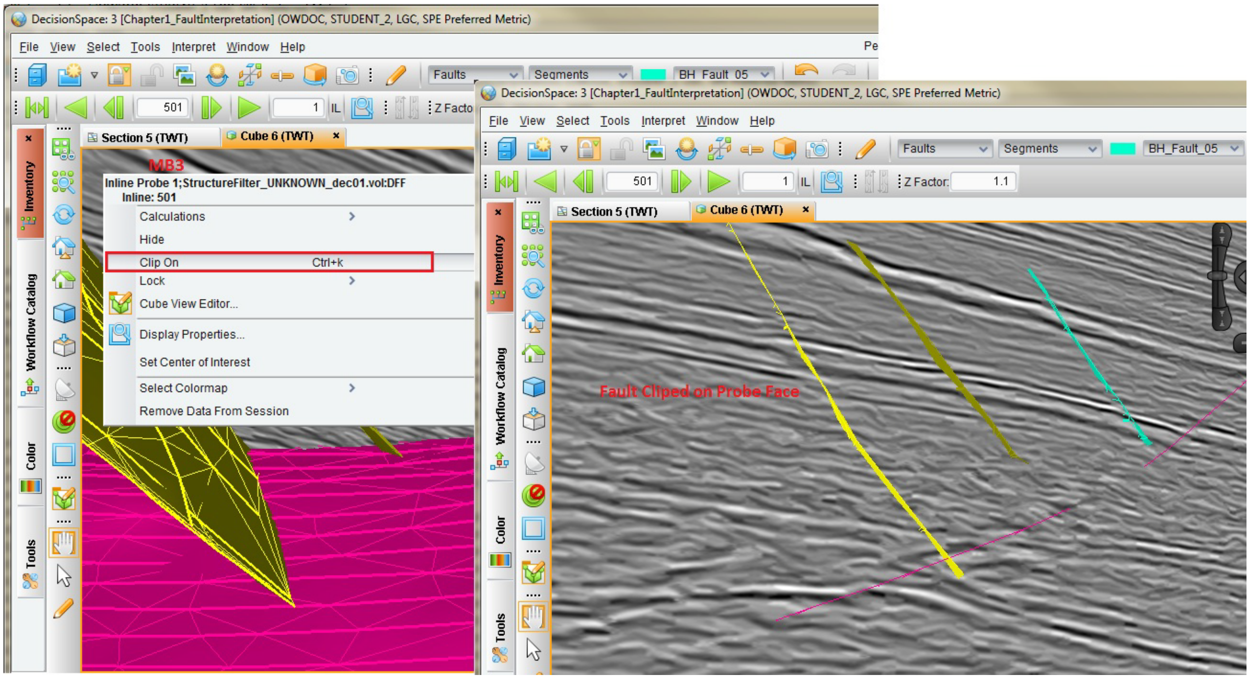
36. Move the inline probe and interpret several more segments of **YOU_Fault_05**. In the figure below (a view from the south), more segments were interpreted and some extended on **YOU_Fault_05**.



37. In the *Dynamic Frameworks to Fill* task pane, click the Refresh ( ) icon under the **State** column to update the **YOU_CHAPTER1_FW** framework. The new segments will be included in the framework.



38. To show faults only near the probe surface, **MB3** on the probe face, and select **Clip On**.



39. Move the inline probe slowly. When you see the framework fault not honoring the seismic, add a segment on the probe to correct the problem. Refresh your framework.

40. In the window with your *Section* view, click the *Cube* tab. In the *Inventory* task pane under **FRAMEWORKS**, **MB3** on **FAULTS_FW**, and select **Show All**.

41. Arrange your *Cube* views so that you can see the framework faults in one *Cube* view, while the other shows the clipped view of the framework and the interpreted fault segments.

42. If needed, add or modify a few fault segments, and then update the framework. **MB3** on any object of **YOU_CHAPTER1_FW** in the *Inventory* task pane, and select **Dynamic Frameworks to Fill > Refresh Framework**.

The new or modified segments will be included in the framework. Note how the framework faults were modified where you made changes.

You have now seen the power of working with *Cube* view, and especially the value of having several views showing different aspects of the fault. Now you will use another powerful tool, the Fault QC Tool, to continue your interpretations.

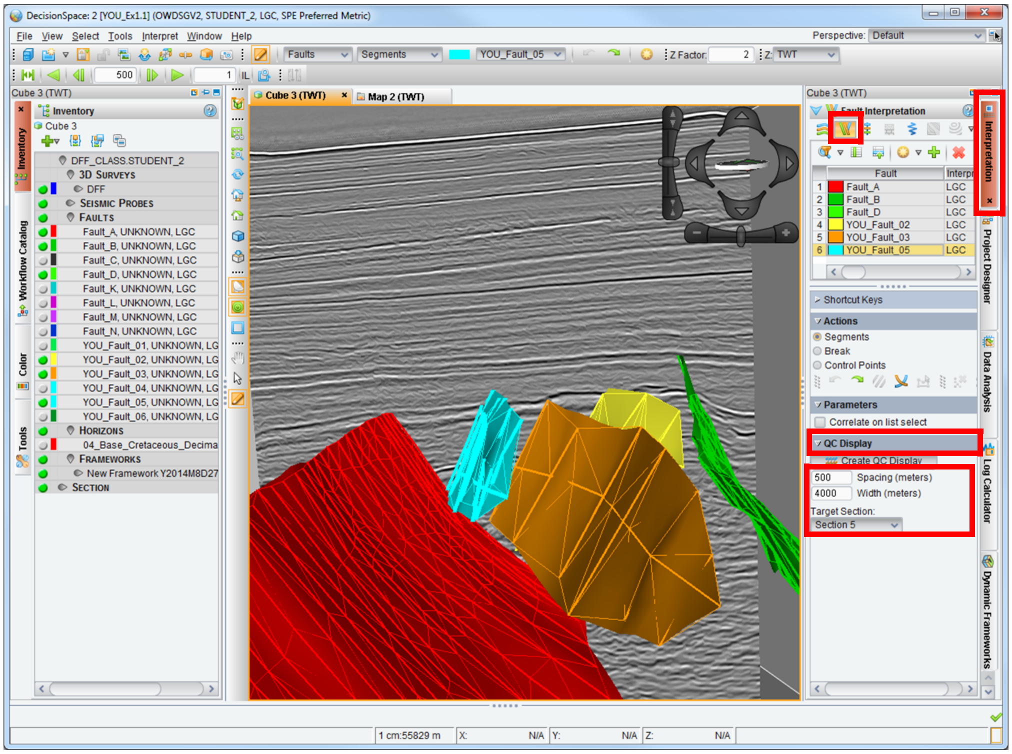
Using Fault QC Display to Interpret Faults

Interpreting faults is most accurate on fault dip sections—faults that are perpendicular to the strike. You have been interpreting on inlines that are sub-parallel to the optimum fault-dip sections. Faults can curve; therefore, these fault-dip sections can change direction along the fault. You can use DecisionSpace's **Fault QC Display** function to make a set of fault-dip sections and rapidly evaluate and interpret along the length of one fault. This will enhance your previous interpretation, which was made on inlines that are sub-parallel to the faults.

43. In the DecisionSpace window containing the *Section* view, click the *Section* view tab to make it active.

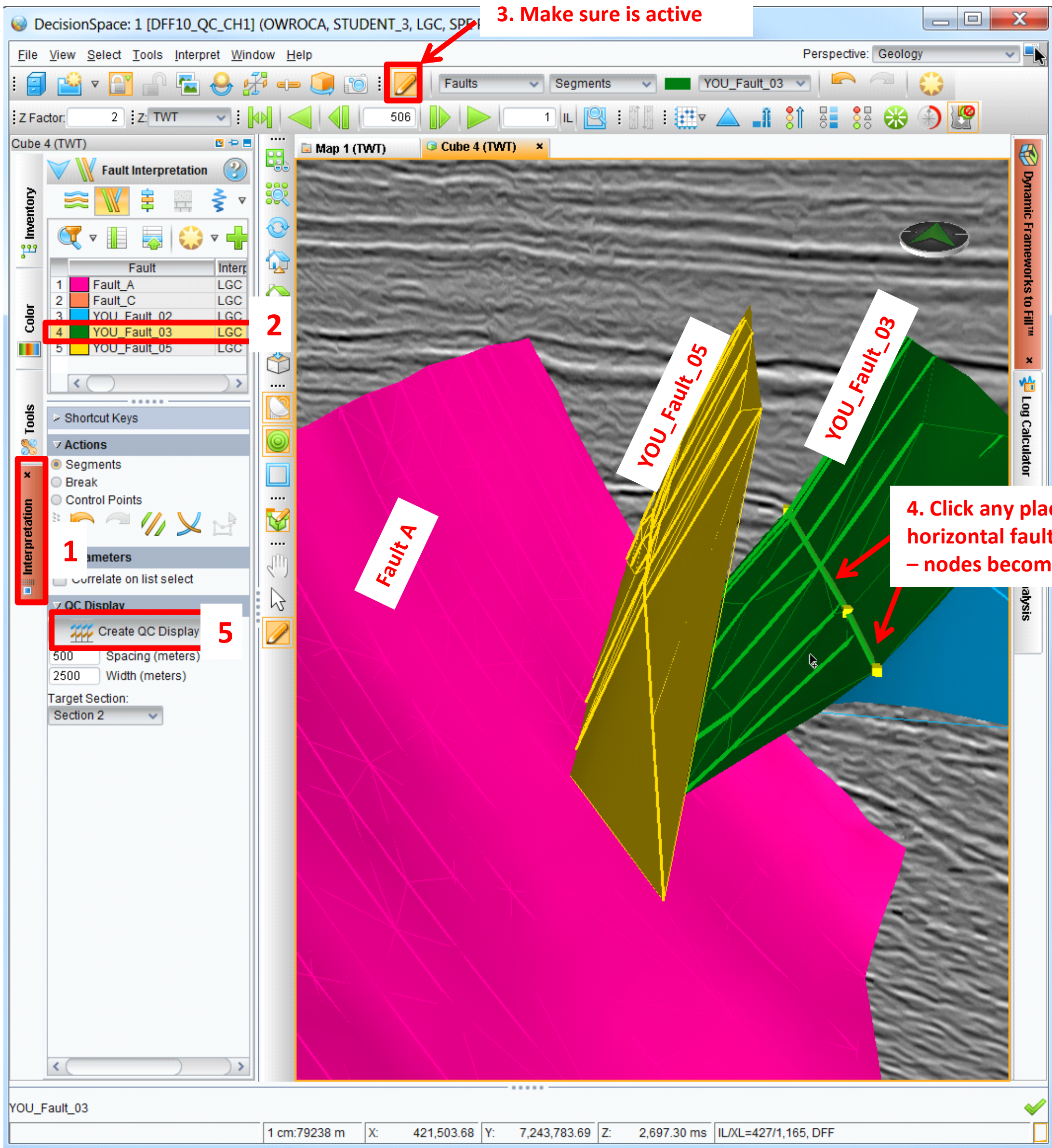
44. In the window containing both *Map* and *Cube* views, select *Cube* view. In the *QC Display* sub-panel of the *Fault Interpretation* task pane, enter these parameters:
    - Spacing (meters) = "**500**"
      Will create a strike line every 500 meters along the fault.
    - Width (meters) = "**4000**"
      Will make each strike line 4000 meters long.

- Target Section: **Section N**
  Will replace the data in *Section N* with the QC panel display.



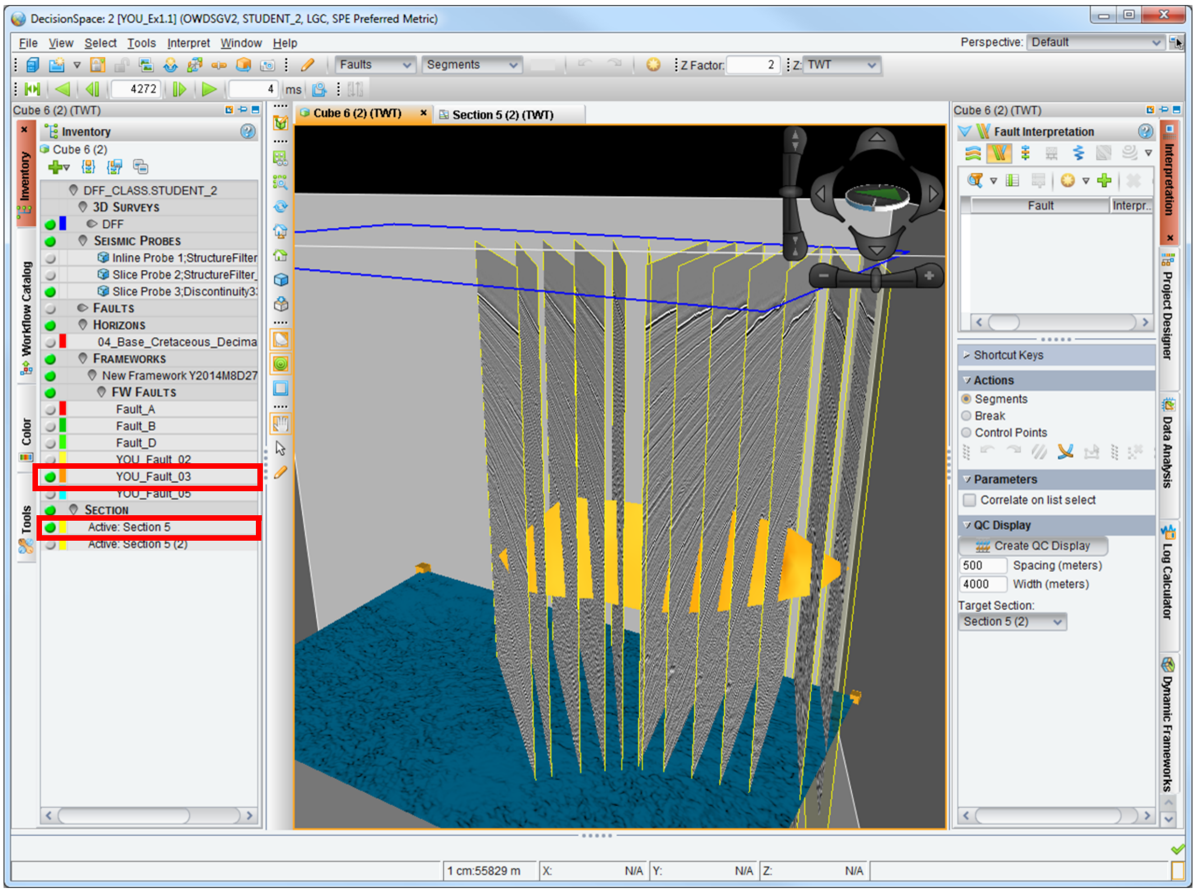
In this and subsequent figures, all six YOU_Faults are shown as interpreted. You will only have three.

45. In *Cube* view, select **YOU_Fault_03** from the *Fault Interpretation* task pane. Activate **Interpretation mode** on. Click a horizontal **fault segment** that was interpreted on a time slice. Click the **Create QC Display** button.

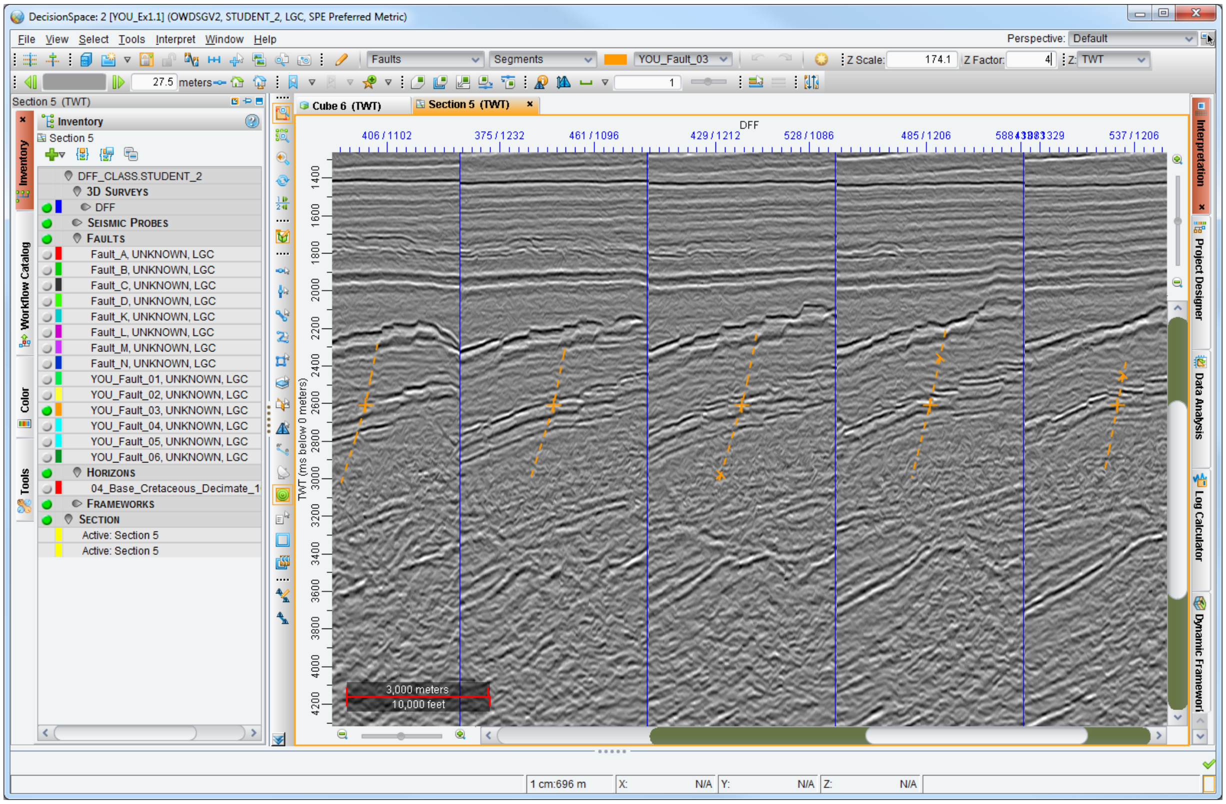


46. **Hide** all faults (Seismic faults and Framework faults) except **YOU_Fault_03** under **FAULTS_FW**. In *Cube* view, turn on the **Active: Section N** (near the bottom of the *Inventory* task pane).

The sections will appear in *Cube* view, as shown below. These are the sections that are perpendicular to the fault segment.



The *Section* view contains the same series of cross sections that are perpendicular to your fault.

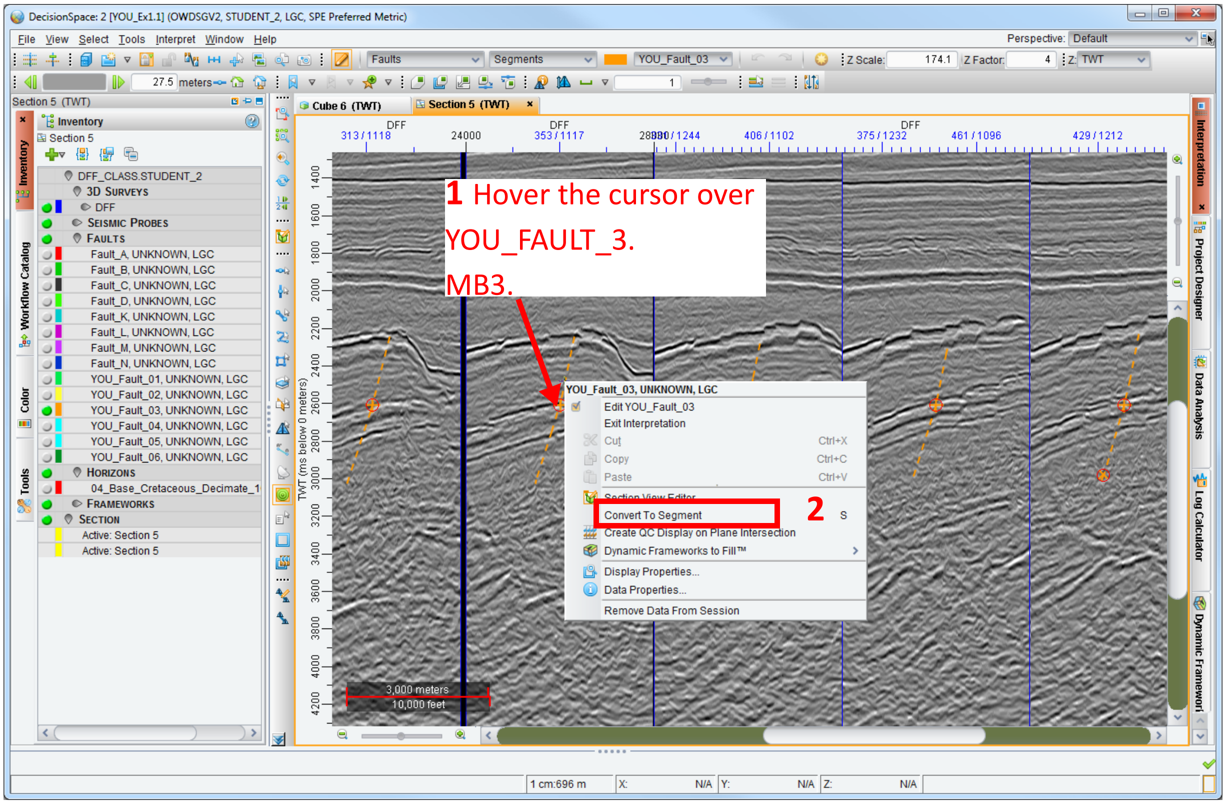


47. In *Section* view, move your cursor over the QC Display and see the linked cursor moving on the *Cube* view sections. When you understand the geometry, in *Cube* view **hide** the **Active: Section N** and **show** all the **FAULTS_FW**.

48. In *Section* view, turn off all the **FAULTS_FW** and turn on all the seismic faults. The faults should show as dashed lines created from triangulation of segments you previously interpreted.

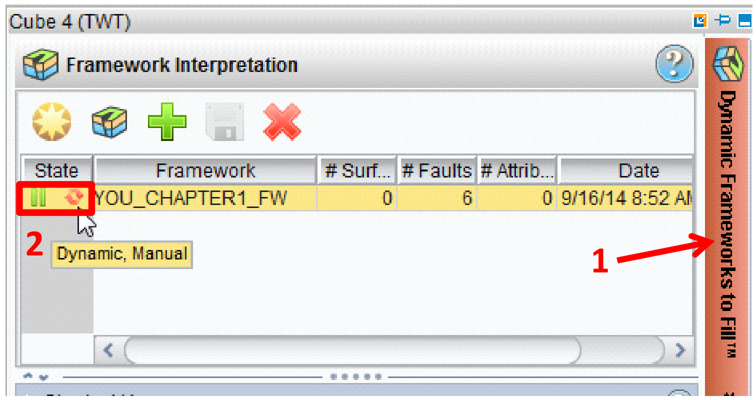
49. Scroll to the far left section in the display. Interpret the fault **YOU_FAULT_03**.

50. For triangulated planes that are close to the correct position, convert the triangulation to a segment. Interpret some more fault segments of **YOU_FAULT_3** in *Section* view, either converting the triangulated planes into a segment or using the previous learned fault interpretation methods.



51. In any *Inventory* task pane, refresh your **framework**. In the *Section* view with the QC display, turn on all framework faults. Compare these interpolated framework faults to your seismic fault interpretation.

52. In the *Dynamic Frameworks to Fill* task pane, click the refresh symbol of **Dynamic/Manual state** () to update your framework. In the *Section* view with the QC display, turn on all framework faults. Compare these interpolated framework faults to your seismic fault interpretation.

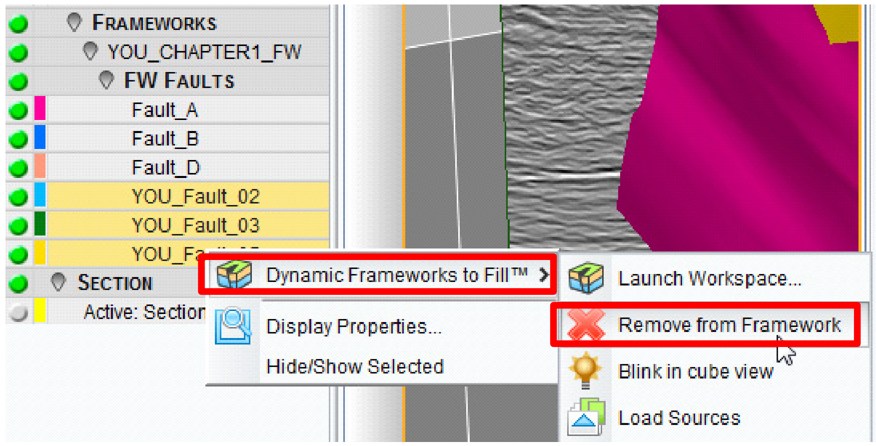


Creating Auto-Networked Framework Faults

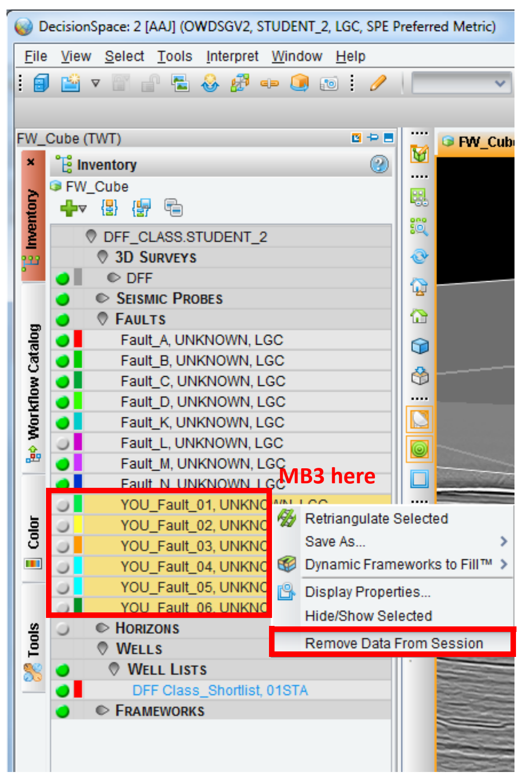
In this section of the exercise, you will build a fault framework establishing hierarchical fault relationships. This operation sutures together faults by truncating faults where they overlap and by extending faults that nearly intersect. In later chapters you will learn how to control and refine the fault network.

Because of the limited time you have had to pick the faults, your work is an initial interpretation. Your faults may not match the rest of the more mature faults. To make the last part of this exercise consistent and have repeatable results, you will unload your faults and use pre-picked faults. Your faults remain in the database and you can return to do this fault network exercise with your faults, if you have time.

53. In any *Inventory* task pane under **FW_Faults**, highlight **YOU_Fault_02**, **YOU_Fault_03**, and **YOU_Fault_05**. **MB3** on any of the selected faults and select **Dynamic Frameworks to Fill > Remove from Framework**.



54. Similarly, under **FAULTS**, highlight your faults (**YOU_Fault_01** to **YOU_Fault_06**). **MB3** on one of these faults, and select **Remove Data From Session**.

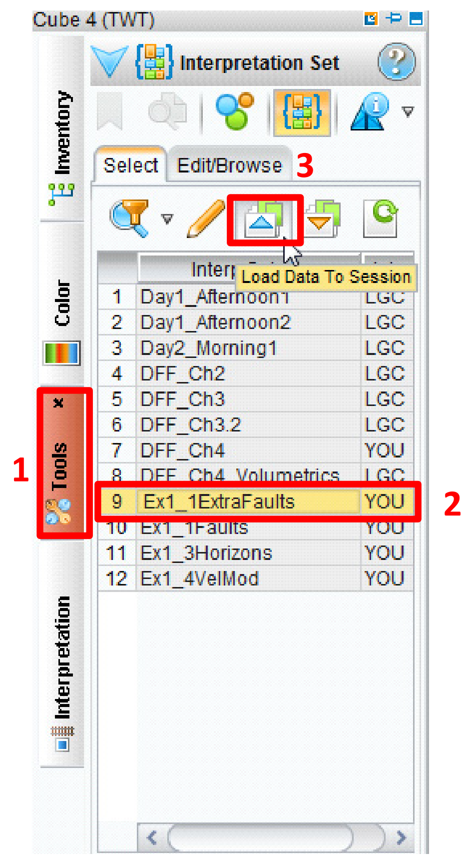


Remove all faults you created from the session.

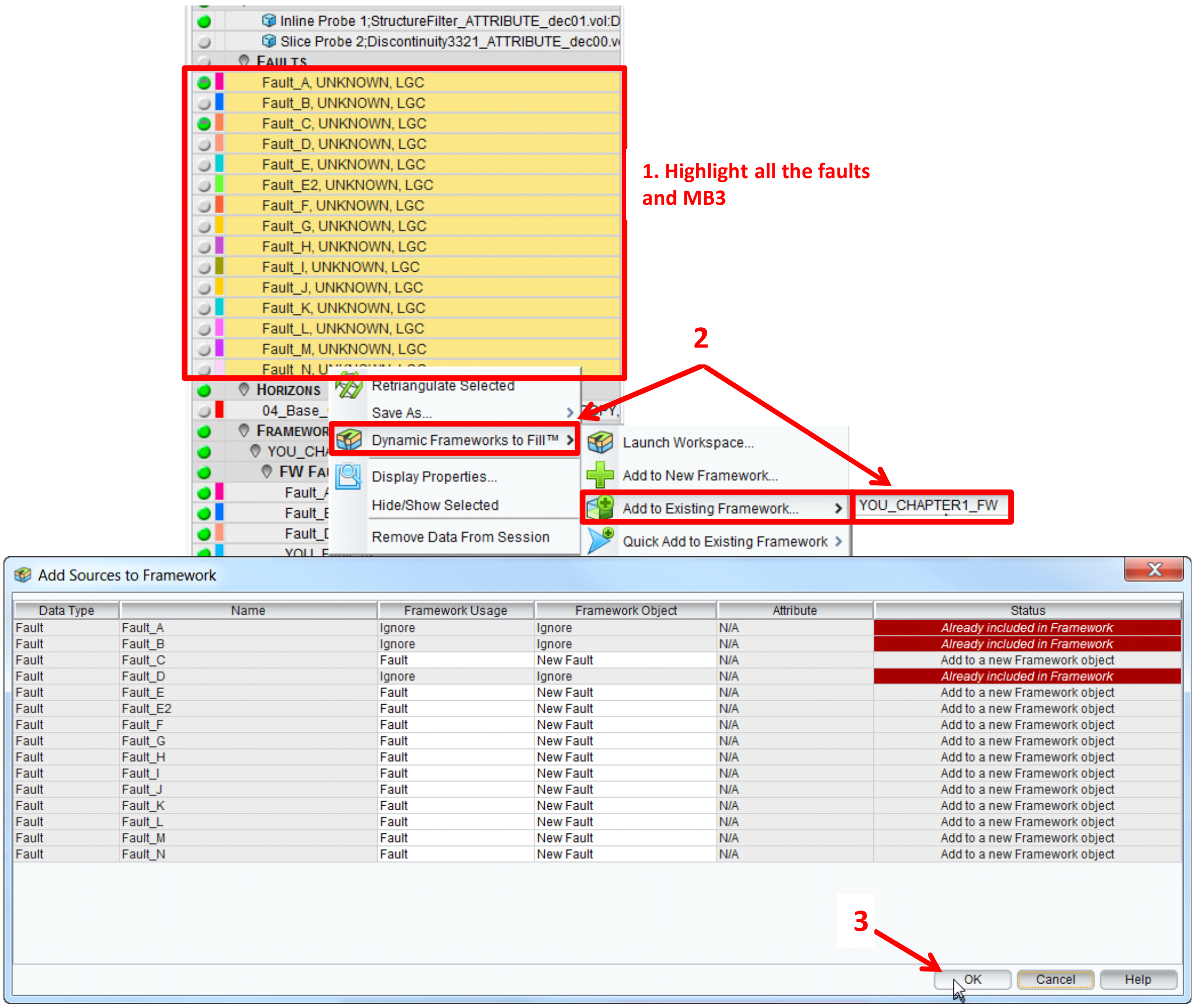
The following are the equivalents between **YOU_Faults** and pre-picked Lettered Faults that you will load in the next step:

- **YOU_Fault_01** = **Fault_E**
- **YOU_Fault_02** = **Fault_F**
- **YOU_Fault_03** = **Fault_G**
- **YOU_Fault_04** = **Fault_H**
- **YOU_Fault_05** = **Fault_I**
- **YOU_Fault_06** = **Fault_J**

55. Load the **Ex1_1ExtraFaults** ISet to your session. Follow the sequence in the picture below.

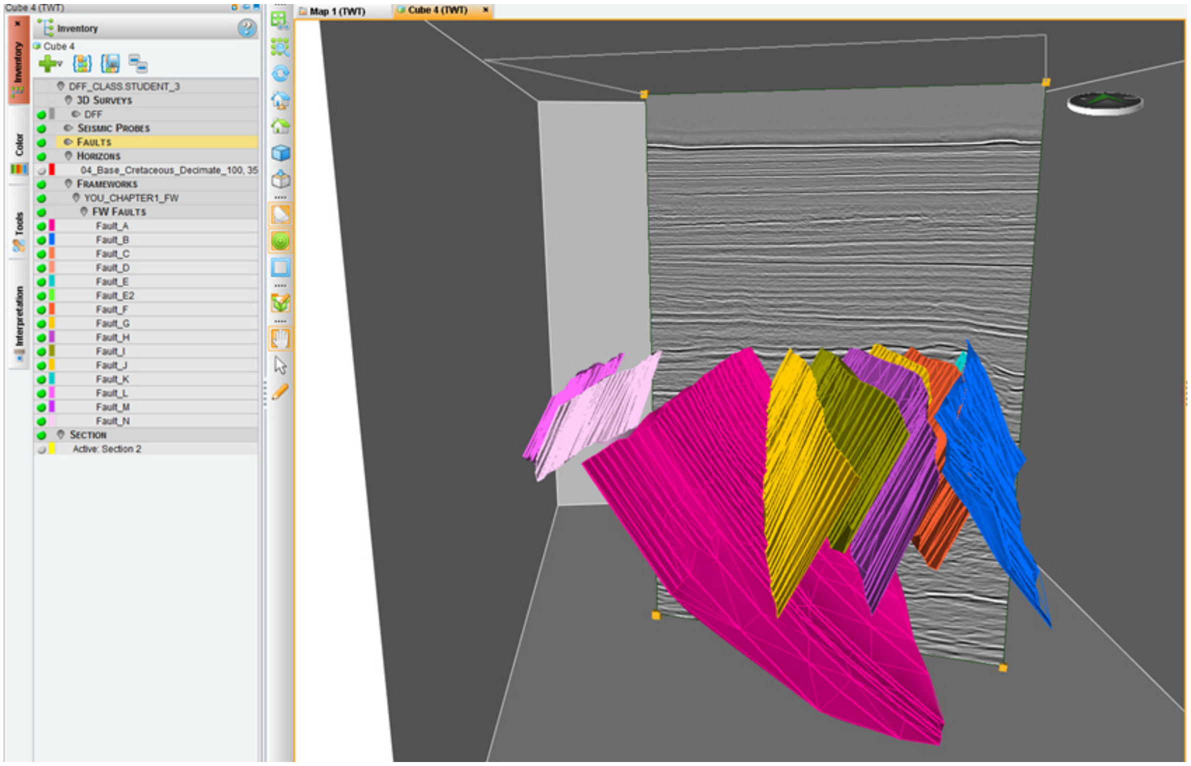


56. Highlight all seismic faults and then add them to the **YOU_CHAPTER1_FW** framework.



Notice that **Faults A**, **B** and **D** are already in the framework, this is the reason why they are being ignored in the *Add Sources to Framework* window. After adding the new faults to the framework, refresh **YOU_CHAPTER1_FW** using any of the methods explained before.

Your display should look similar to the picture below.

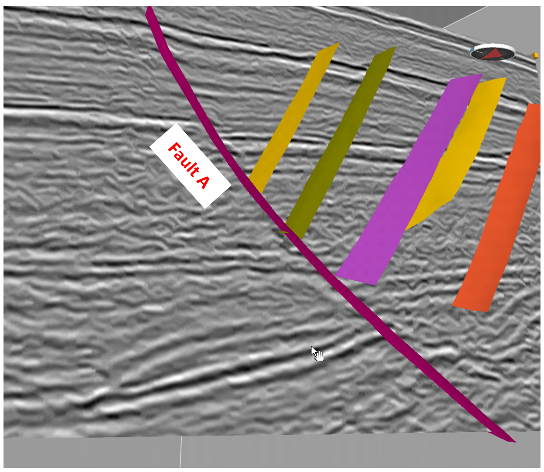


57. Clean up your *Cube* view to visualize only your Framework faults.

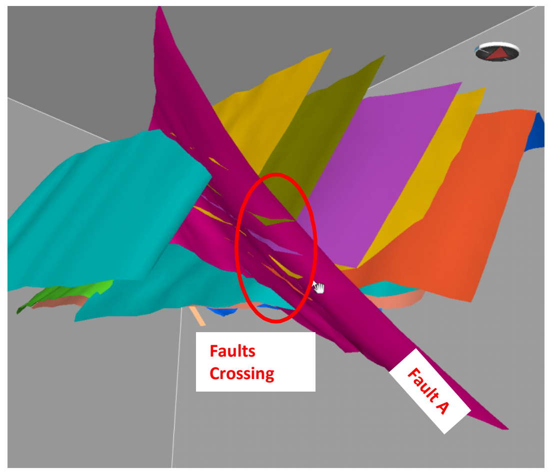
58. Create a box probe of the **StructureFilter**. **MB3** on the box probe and select **Clip On**.

59. To QC the faults, find a location where the faults cross. (Hint: **SHIFT + drag MB1** on any of the box probe faces). Below is an example of one of these locations (circled in the figures). **Hide** the probe to see the overlaps inside the probe.

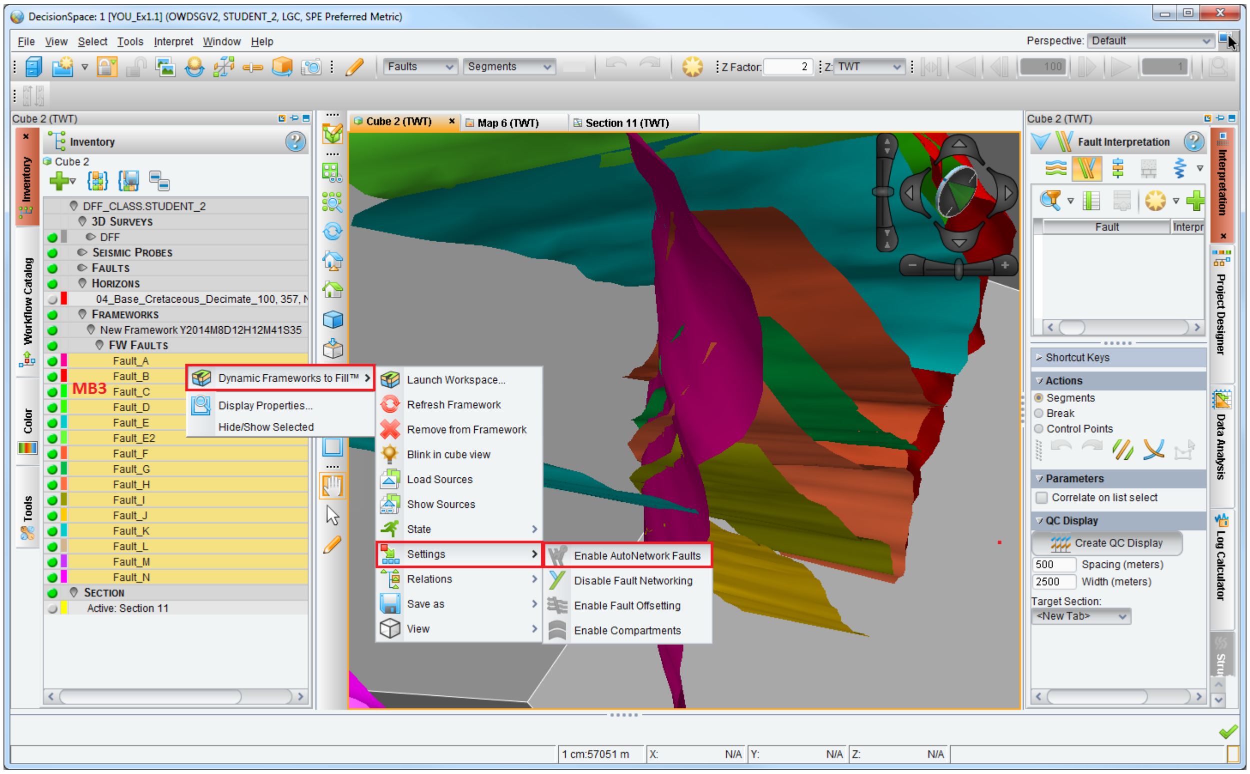
> **Note**
>
> You can reduce or increase the amount of fault clipping by using the hot keys (- / +). (+): Increases fault exposure over the clipped probe. (-): Reduces fault exposure over the clipped probe.



After hide probe

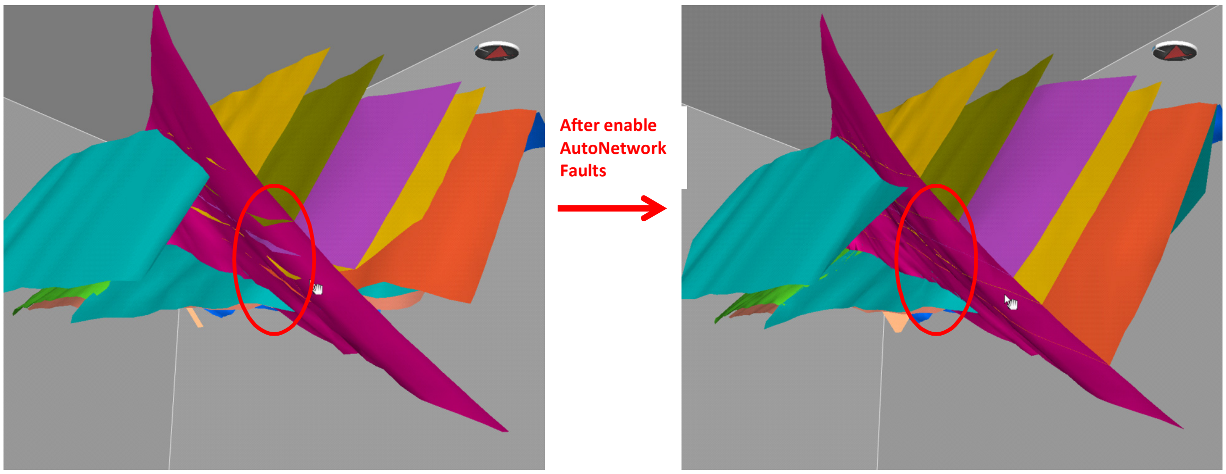


60. In the same *Cube* view, highlight all the frameworks **FAULTS_FW** in the *Inventory* task pane (multi-select). **MB3** on one of the highlighted faults and select **Dynamic Frameworks to Fill > Settings > Enable AutoNetwork Faults**.

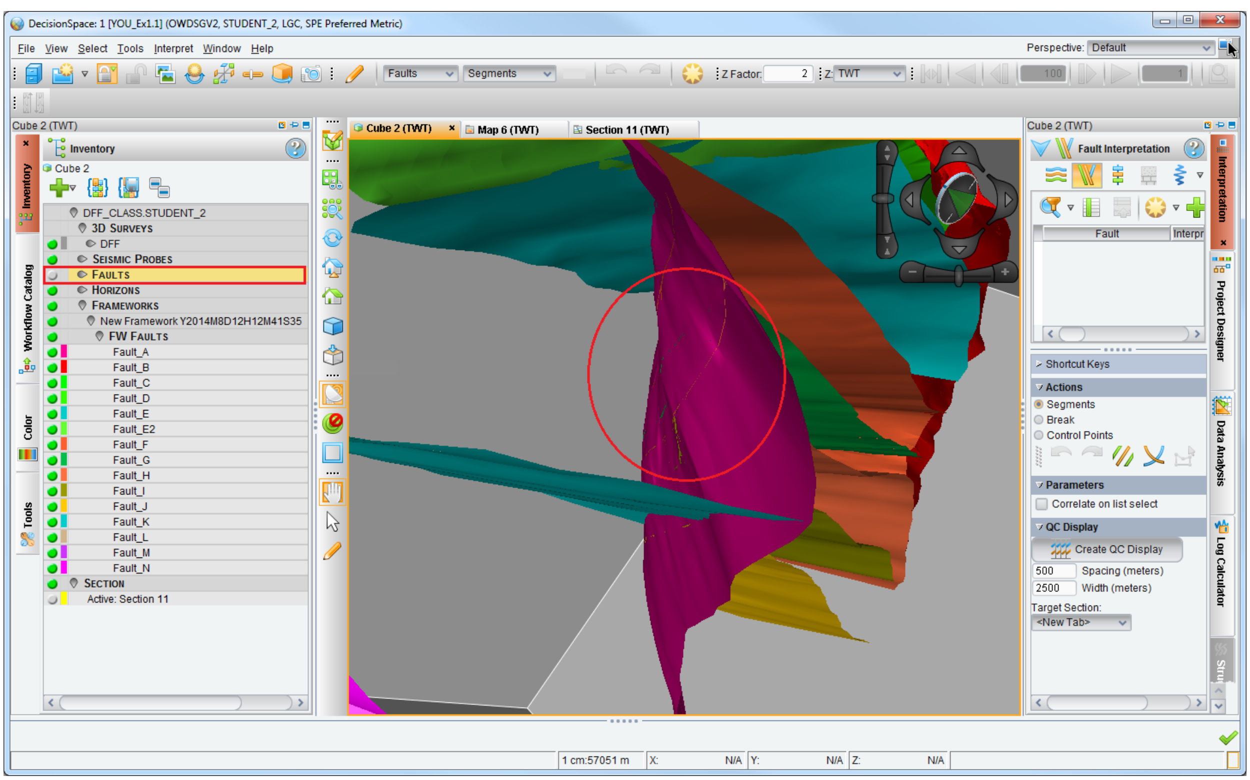


This process will determine the parent-child relationship between the faults and truncate the child faults against the parent fault.

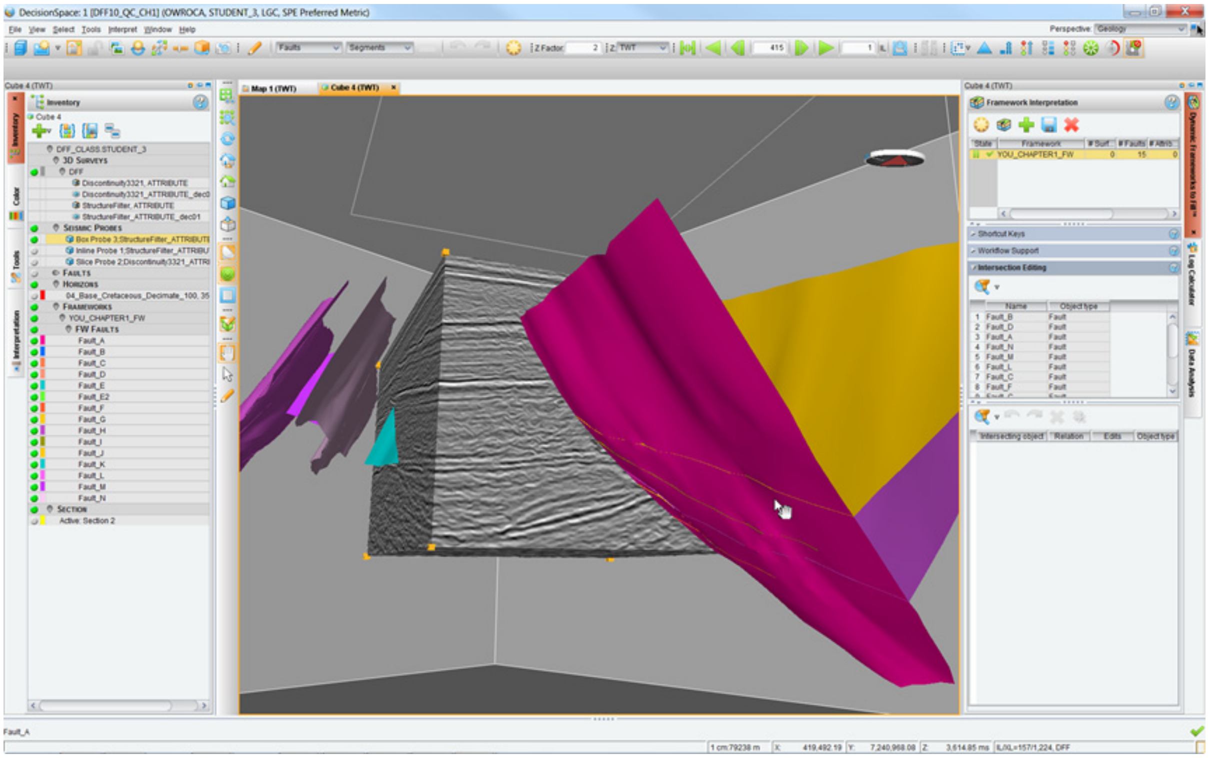
61. Refresh the framework (**MB3** and then select **Dynamic Frameworks to Fill > Refresh Framework**). Note that the framework faults are truncated and sutured. Notice also that some faults are crossing the main fault (Fault A). This is because the area crossing the fault corresponds to more than 25% of the total fault area. 25% is the default the software uses to determine if a fault is either truncated or crossing. In Chapter 3 you will learn more about the algorithm and also how to modify the fault relationships.



62. If you wish, rotate your *Cube* view to visualize better the truncated and crossing faults.



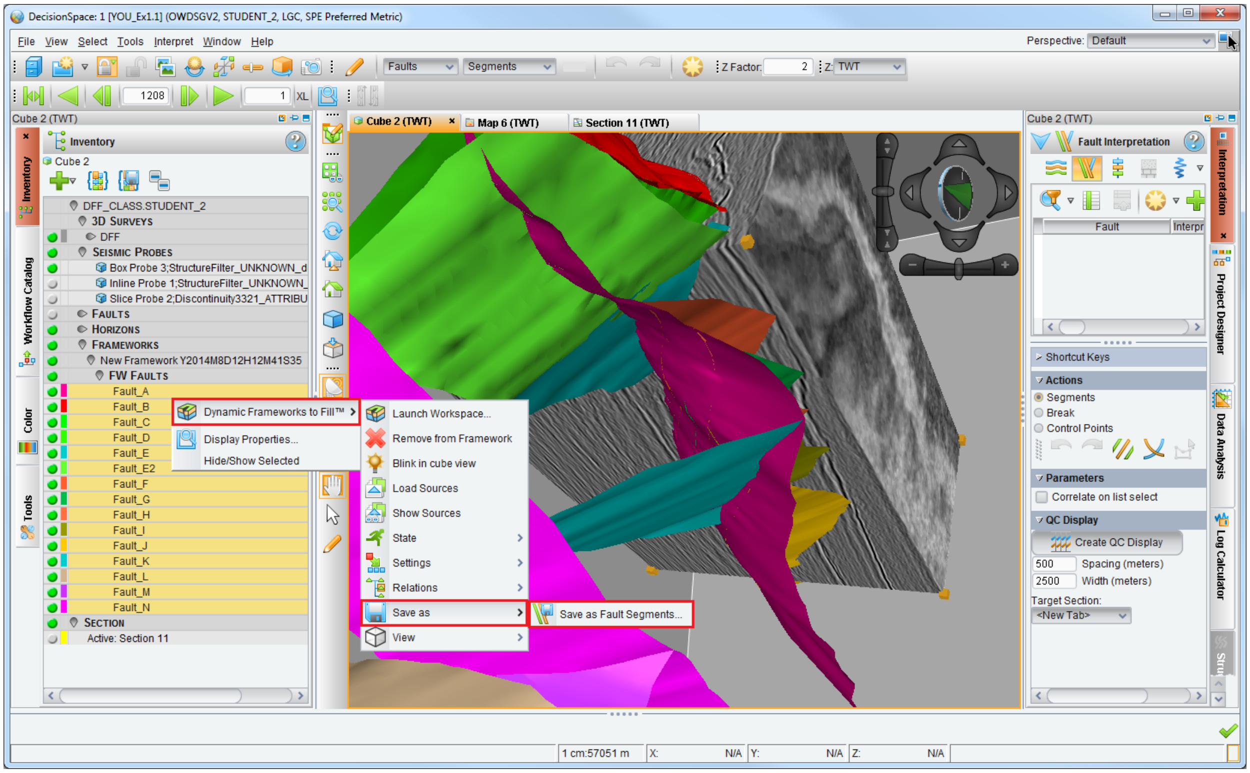
63. **Show** the box probe. Turn the clipping off. Now you can see the entire framework. Investigate which faults are truncated.



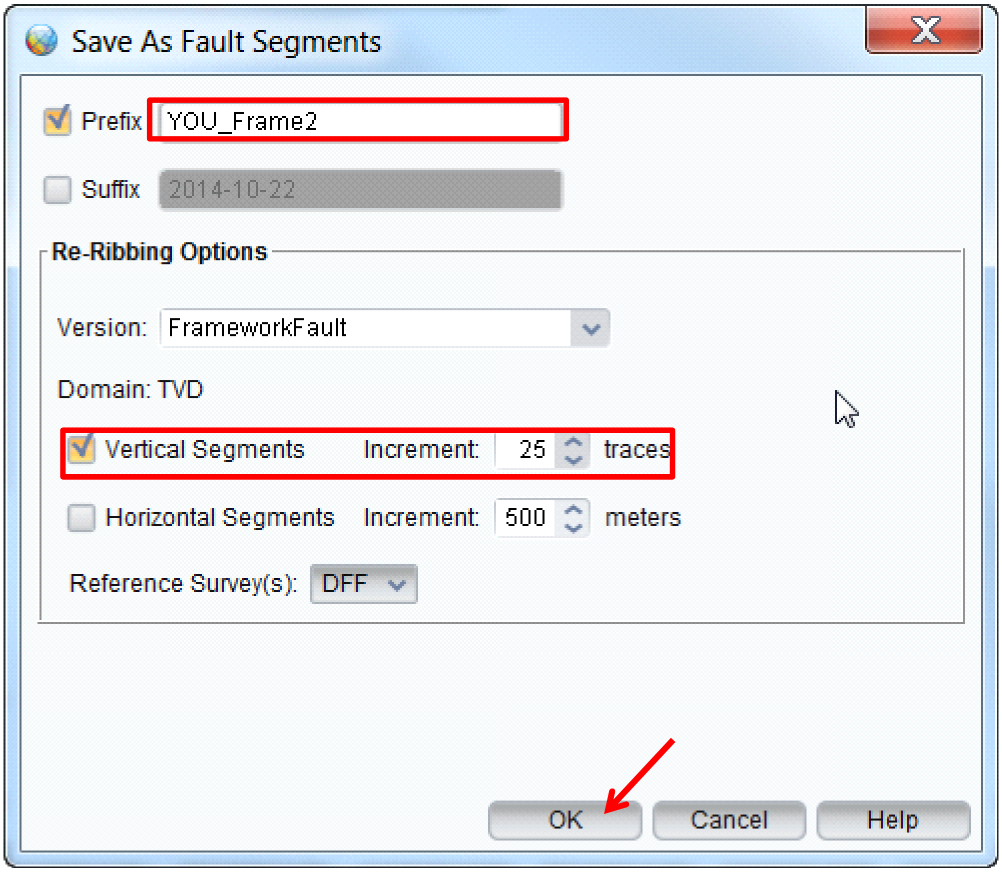
The parent-child relationship between the faults was automatically determined, based primarily on fault sizes. The right task pane now shows the *Frameworks to Fill* tab active. Listed there are the intersecting faults. You will learn how to edit these relationships in Chapter 3. Now you will accept the current fault hierarchy.

You will now re-rib your framework faults at a constant increment and save them as seismic faults. They can then be used for unfaulting and auto-tracking workflows in horizon interpretation.

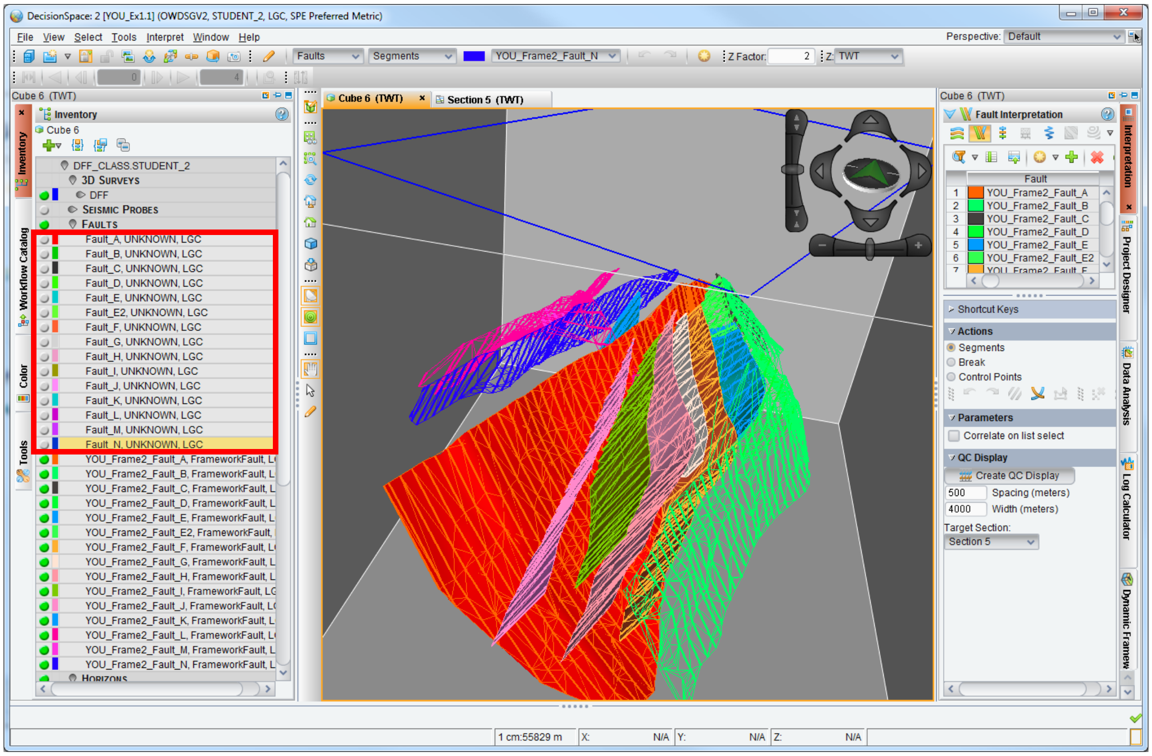
64. In the *Inventory* task pane under **FAULTS_FW**, highlight all faults, **MB3**, and then select **Dynamic Frameworks to Fill > Save as > Save as Fault Segments...**.



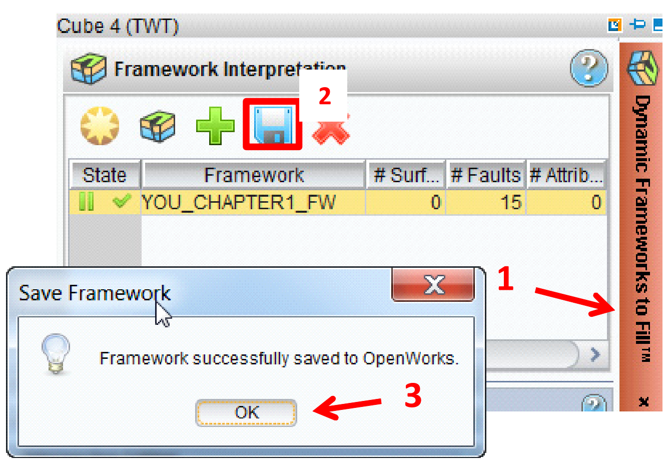
65. On the *Save As Fault Segments* dialog box in the Prefix field, enter the name "**YOU_Frame2**." Set the Vertical Segments Increment to **25**, and then click **OK**.



66. In the *Inventory* task pane, **hide** the framework faults (**FAULTS_FW**) and view the re-ribbed versions of the faults that you will use in later exercises.



67. In the *Dynamic Frameworks to Fill* task pane, click the **Save Framework** icon to save your Framework to OpenWorks.



In this exercise you employed the many tools and workflows you can use to interpret faults. In the next exercise you will investigate well ties.

Overview: Well Tie Workflow

The well tie workflow is a crucial step in true geological and geophysical integration. When the seismic interpreter and geologist know how seismic reflectors relate to the geologic section in their project area, a ground truth is added to the maps around the wells.

In addition to being certain you are interpreting correct reservoir intervals, you need time-to-depth relationships, so you can eventually depth-convert maps, calculate volumetrics, and plan accurate wells.

DecisionSpace has an integrated well tie workflow wizard that guides you through the key steps to generate both the synthetic and the well tie. The synthetic helps you understand the character of the seismic repose (reflections) that the layers of rocks in the well should produce. It also allows you to match synthetic to seismic data. This match provides a time-depth relationship that you will use to display well picks and later build a robust velocity model.

Explaining Background Theory

Understanding Acoustic Impedance and Reflection Coefficients

This review of geophysics theory is a reminder of what DecisionSpace is doing to create the synthetic.

Remember that a reflection is produced at interfaces of layers of rock with different velocities (V) or different densities (ρ). The magnitude of the reflection at the interface is given by the following formula:

$$\text{reflection coefficient} = \frac{(\rho_2 V_2 - \rho_1 V_1)}{(\rho_2 V_2 + \rho_1 V_1)}$$

where V = p-wave velocity and ρ = density

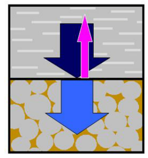
To simplify the formula, the term acoustic impedance is defined as follows:

acoustic impedance = density * velocity, or $I = \rho V$

acoustic impedance is typically shown as I.

Therefore,

reflection coefficient = $(I_2 - I_1) / (I_2 + I_1)$

A two-layer model:  layer with ρ_1 and V_1

layer with ρ_2 and V_2

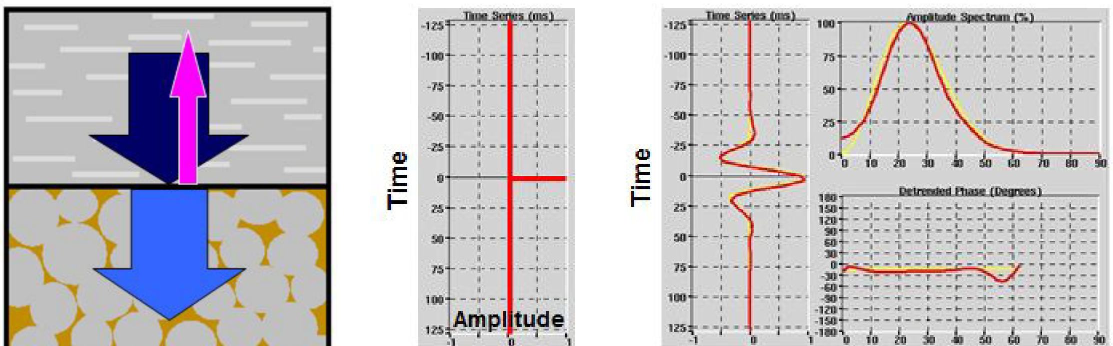
This model shows an arrow that represents the down-going seismic energy striking the interface. The (thin) up-going arrow represents the reflected energy. Most of the energy continues downward, as shown by the slightly smaller, down-going arrow.

The reflection coefficient specified above is for sound striking the interface at 90 degrees (perpendicular). If the sound energy reflects at some other angle, you will need the much more complicated Zoeppritz equations to calculate the reflection amplitude. This amplitude variation with angle of incidence is the basis of AVO analysis.

If you have sonic and density logs of wells in your project area you can calculate acoustic impedance changes in depth. As noted above, where there is a change in acoustic impedance there is a reflection.

Understanding Reflections, Wavelets, and Convolution

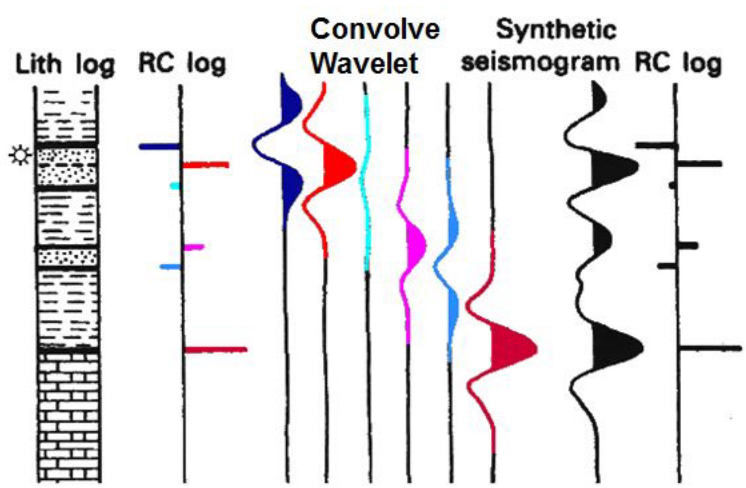
Reflection occurs at interfaces of differing density or differing velocity. Your seismic data is a record that shows the resulting (seismic) reflected energy. If you could produce, transmit, and record all frequencies, those reflections would be a spike at the two-way time required to travel down to the reflector and back to the energy source (and the recording device). In the figure below you see the interface and the reflection spike at the reflection time. But seismic data is limited in frequency typically ranging from greater than 4 Hertz to less than 80 Hertz (higher frequencies are possible in shallow surveys). Therefore, the seismic reflections are not spikes, but band-limited wavelets, as shown below.



Reflection Spike (all frequencies)

Red: Extracted wavelet from seismic
Yellow: Ricker 23 Hz wavelet, phase= -16

The figure below starts with a lithologic log, wherein each layer has constant velocity and density. The reflection coefficients are shown at each interface (RC log). Each spike is replaced by a wavelet (a process called convolution). The wavelets are then summed to produce the synthetic, which represents the seismic response expected from those particular layers of rock.



This type of convolution is performed by DecisionSpace to create your synthetic. But instead of a lithologic log, DecisionSpace uses the acoustic impedance changes calculated from your sonic and density logs.

Seismic data is created by interface properties, not by reservoir or layer properties. Therefore, in order to see a geologic top or base, there has to be enough change in the velocity and density at that boundary to generate a reflection that can be detected over background noise.

The synthetic that you generate from the sonic and density logs can be compared to your seismic data. They should match—the peaks and troughs in the synthetic matching similar characteristics in the seismic data. This is called a seismic tie because it ties a depth in the well (from the well log) to a time in the seismic data.

This well tie correlates the geology to the seismic at well locations. Tracking the seismic changes can indicate how the geology changes away from well locations.

From the well tie you obtain depth and time. Therefore, you have the velocity between well depth and seismic time at the well location. You will use these velocities when you create your velocity model.

Exercise 1.2: Well Tie Workflow

To create synthetic seismograms, DecisionSpace uses a *Well Tie Workflow* window that is based on Landmark's Well Seismic Fusion program. The workflow uses an easy-to-follow wizard that simplifies the rather complicated process of synthetic generation and well tie correlation. But it stays true to the high science underlying the process. In this exercise, you will investigate this wizard and generate your own synthetic seismogram.

Inputting Data and Creating Synthetics

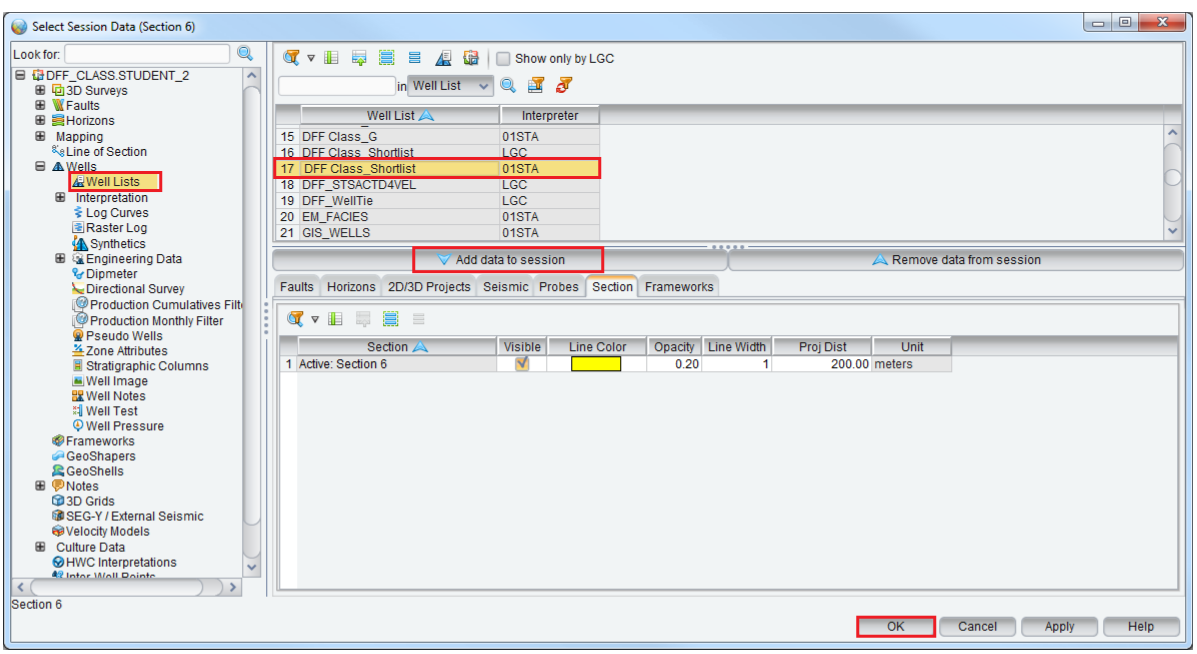
1. Click the *Section* tab and the *Map* tab in the two DecisionSpace windows, if not already active.

Continuing from Exercise 1.1, you will need to do a little cleaning up.

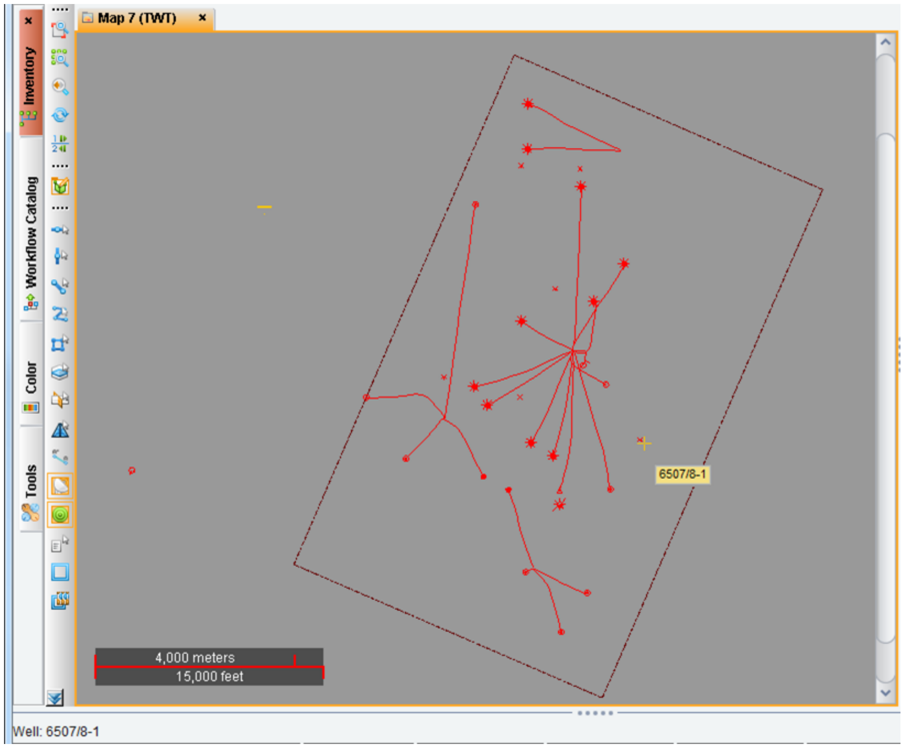
2. Display inline **505** in *Section* view. (Hint: With *Section* view active: **Select > Section from list > Inline tab > 505**.) **Hide** all faults.

You will add wells and look at their locations on a map with one of the reservoir horizons.

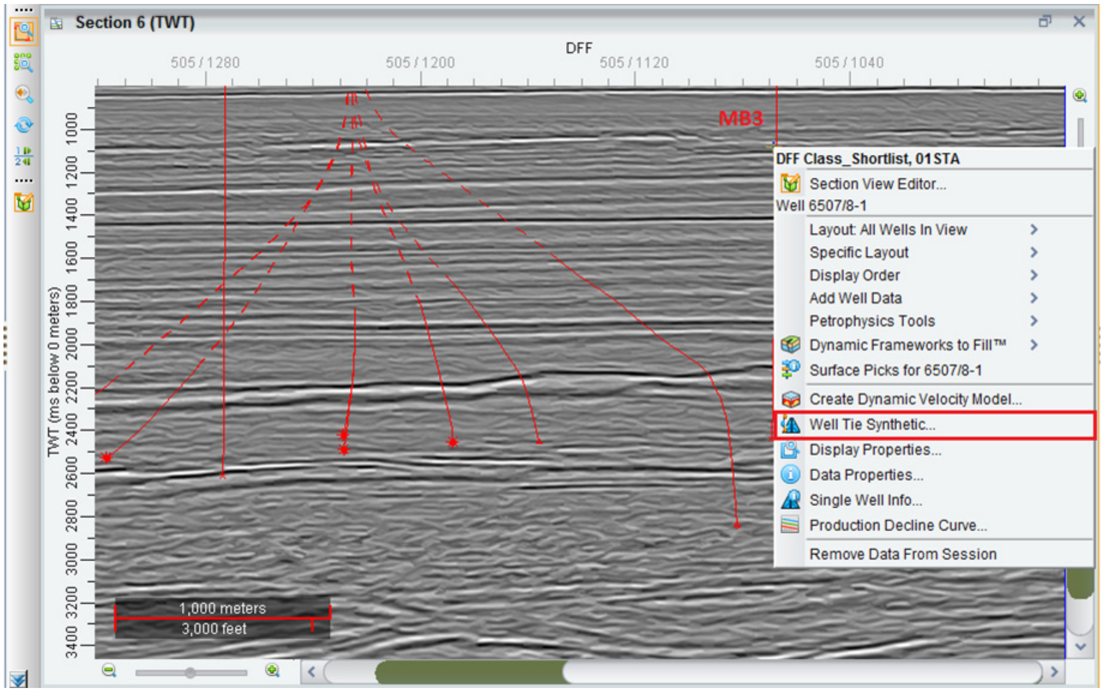
3. Add the **DFF_Class_Shortlist** (01STA) well list to your session. Click **OK**.

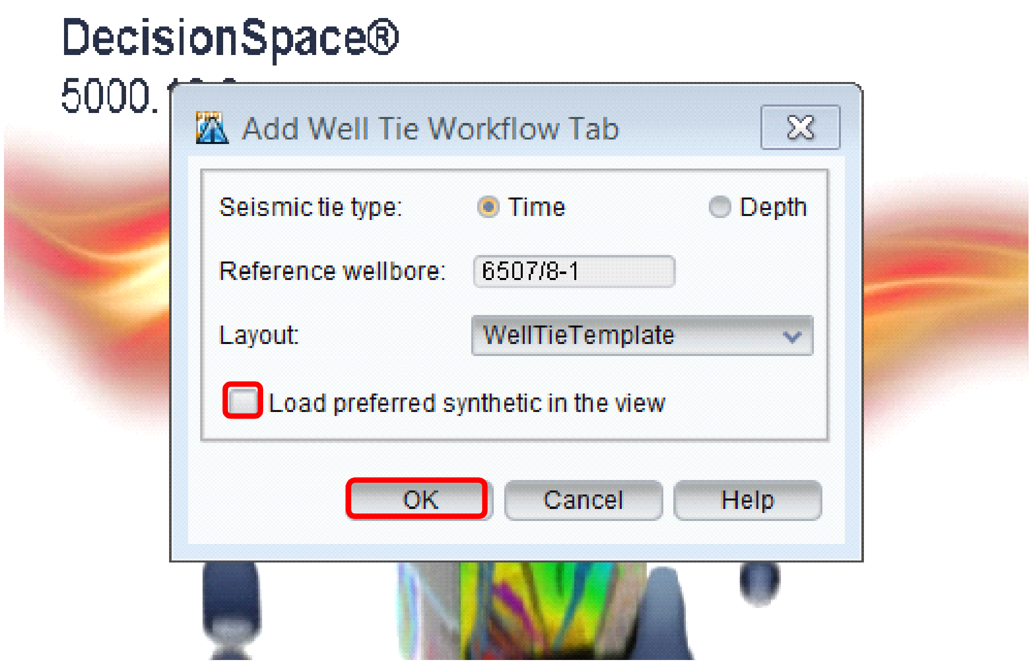


4. In *Map* view, turn on the **DFF_Class_Shortlist** well list. Mouse over (hover the cursor over) the well symbol at approximately IL 505 and XL 1070. The status bar at the lower left corner identifies the well as **6507/8-1**.



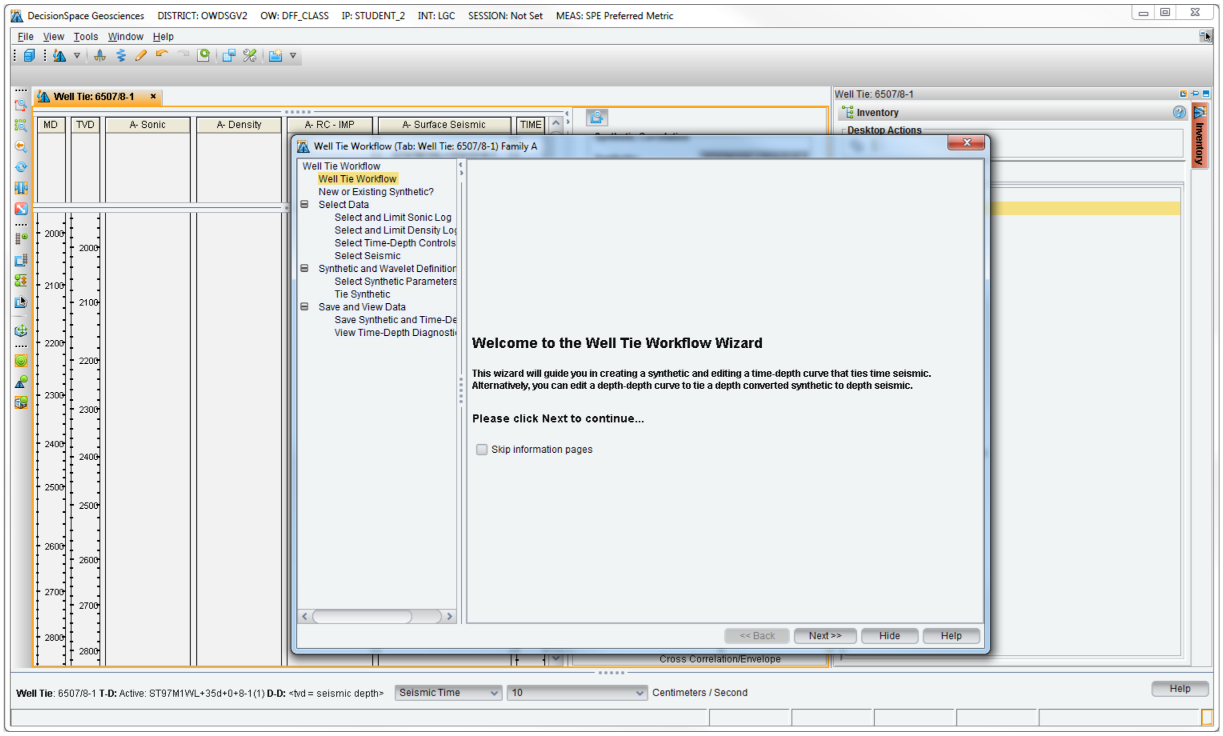
5. In the *Section* view showing inline 505, turn on the **DFF Class_Shortlist** well list. **MB3** on the **8-1** well and select **Well Tie Synthetic...**. In the *Add Well Tie Workflow* dialog box, uncheck the **Load preferred synthetic in the view** option, and then click **OK**.





A new window appears, containing a *Well Tie* view tab. The welcome screen for the *Well Tie Workflow* window also appears.

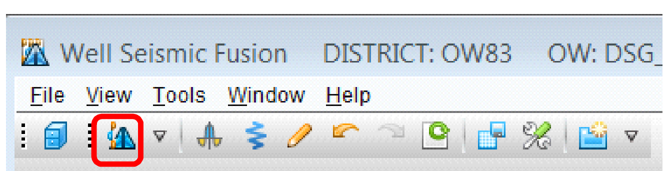
6. Move the *Well Tie Workflow* window aside so you can see both windows easily. Click **Next**.



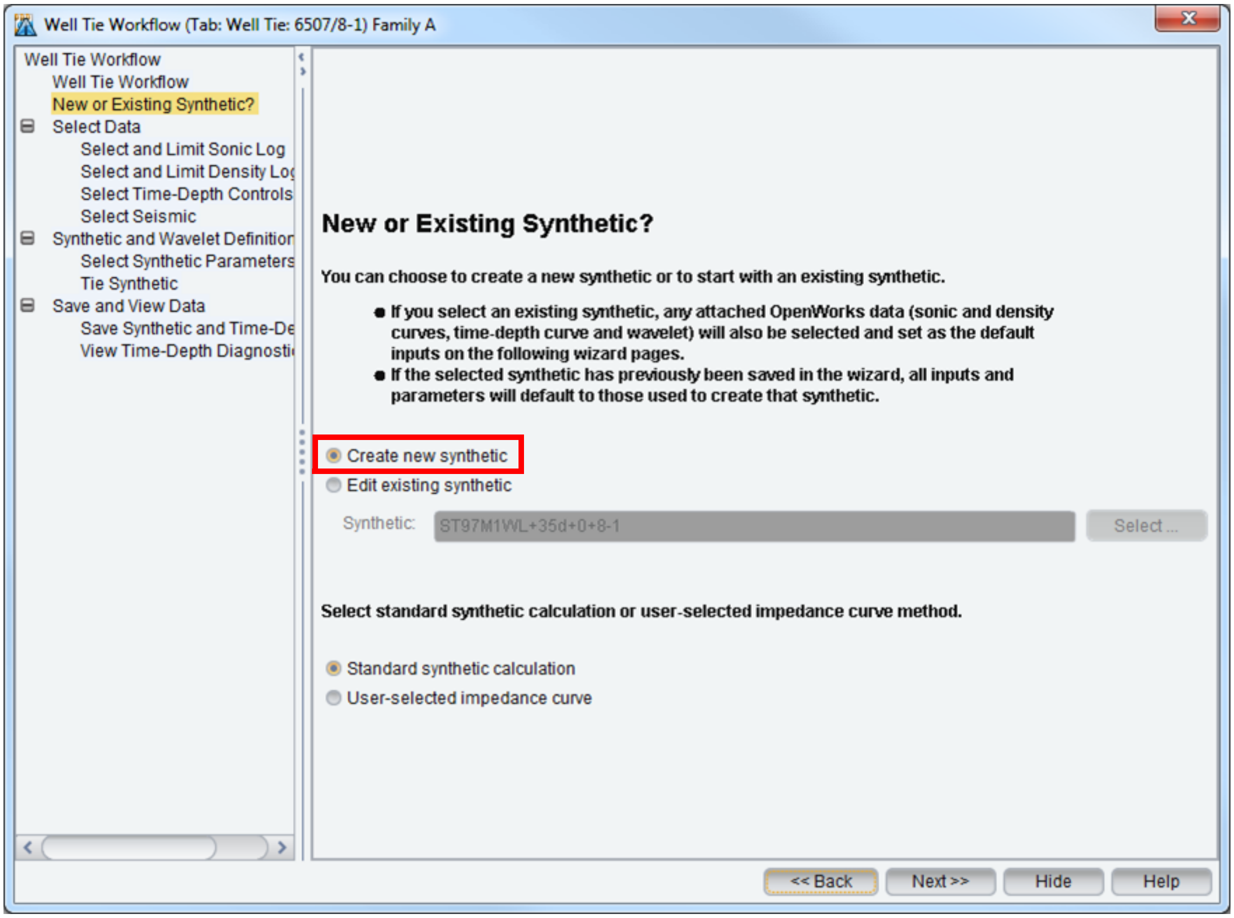
Note

The *Well Tie Workflow* wizard contains useful information pages. You can turn on the Skip information pages box after you become familiar with the wizard.

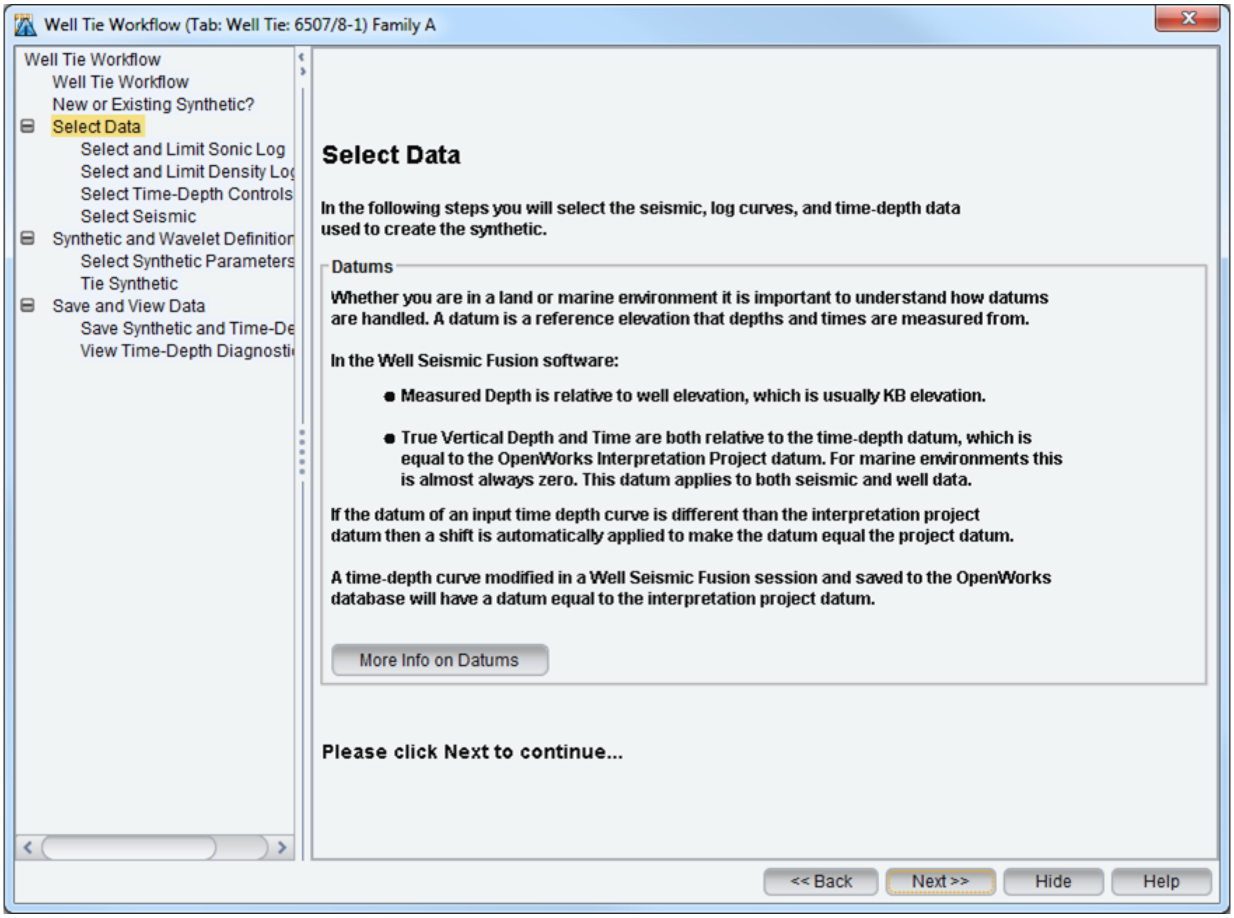
You can hide the Well Tie Workflow window by clicking Hide; you can reopen it by clicking the Well Tie Workflow wizard icon on the tool bar.



7. In the first wizard page, *New or Existing Synthetic?*, select **Create new synthetic**. Click **Next**.

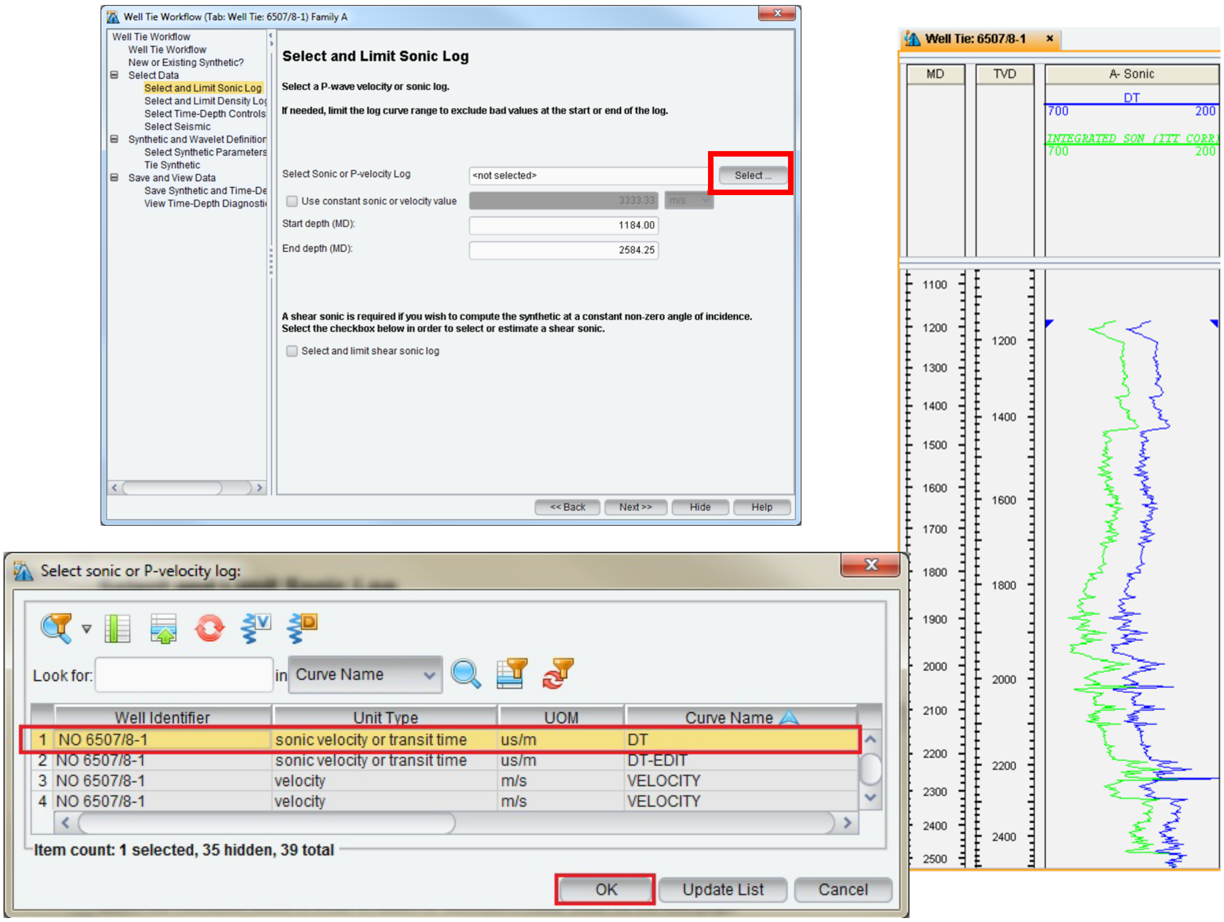


8. **Read** the information page about selecting data and datum, then click **Next**.

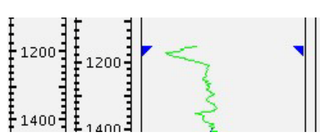


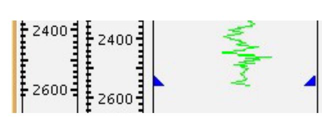
To create the synthetic, you need to specify which sonic and density logs will be used as input data.

9. From the *Select and Limit Sonic Log* page, click the **Select...** button. In the *Select sonic or P-velocity log* dialog box, select the **DT** curve (highlight and then click **OK**). Verify that the DT log and its integrated equivalent appear in the *Sonic* panel of the *Well Tie* view. Click **Next**.

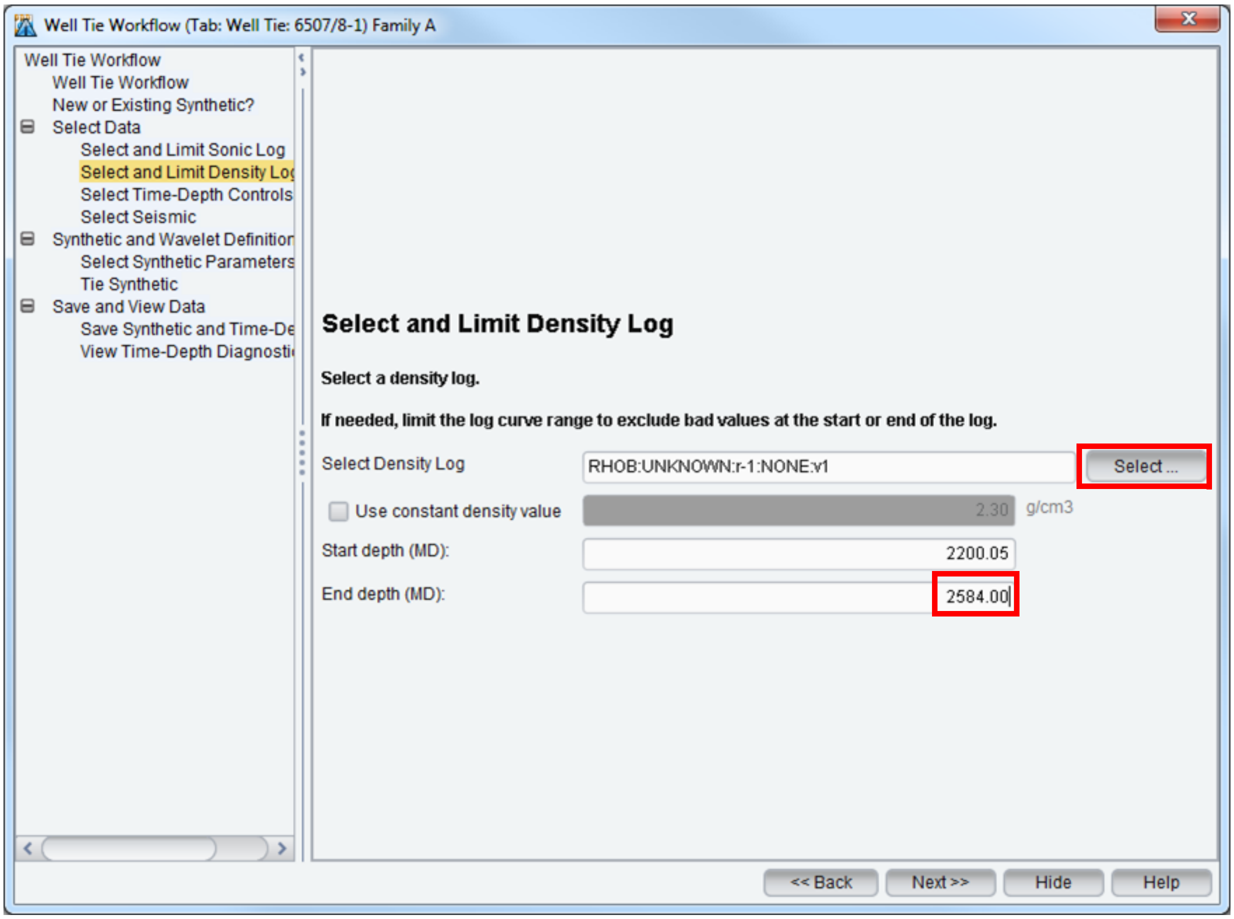


By default, the whole well log is used to calculate the synthetic. The extent of the log can be limited by changing the Start or End depths in the *Select and Limit Sonic Log* dialog box, or by interactively dragging the triangle icons at the top and bottom of the log in the *Sonic* panel.

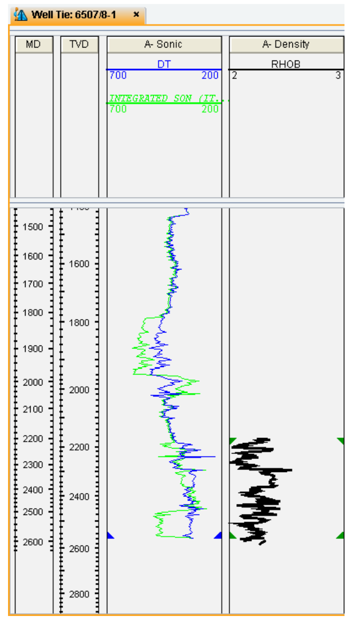




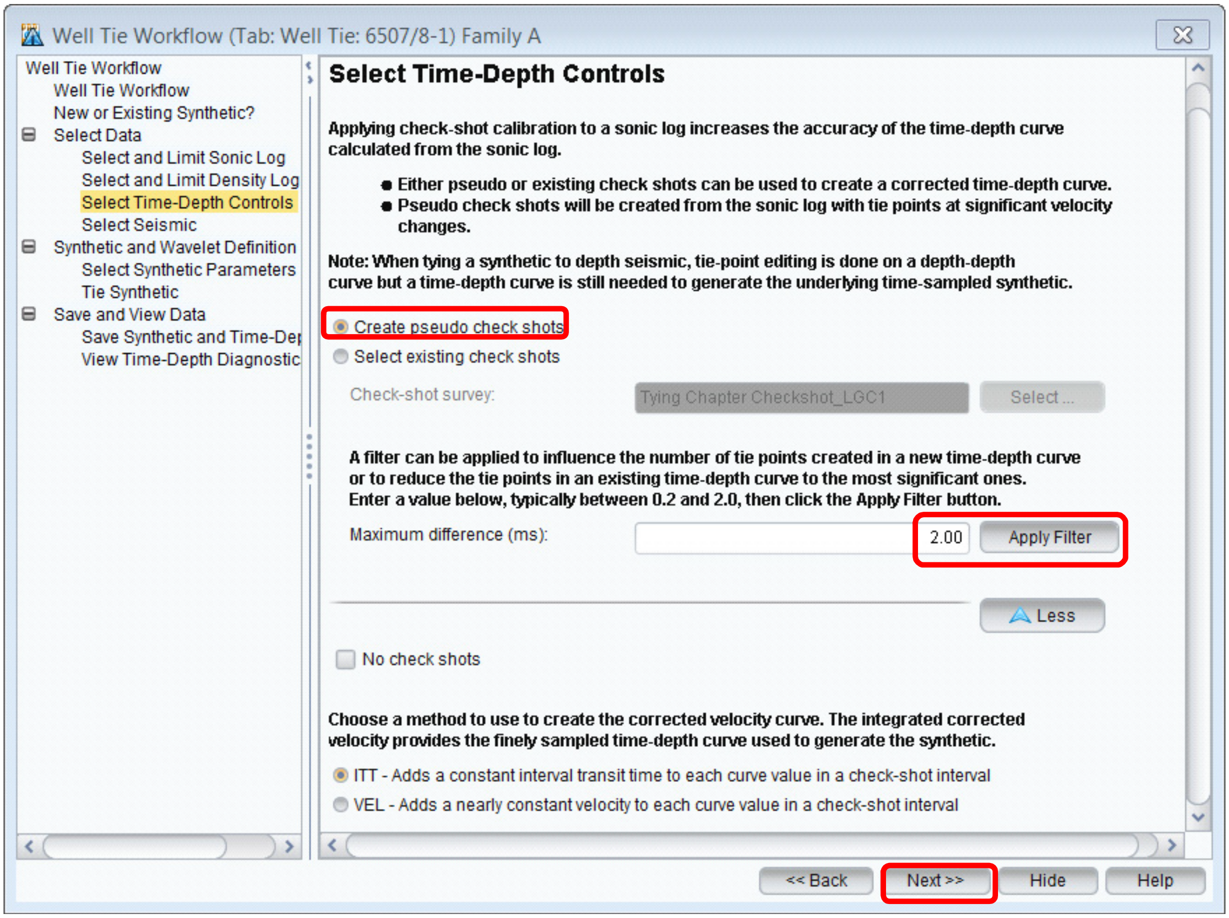
10. In the *Select and Limit Density Log* wizard page, click the **Select...** button and then double-click the **RHOB** log to select it. Change the End depth of the log to "**2584**," to match the DT log and to remove some noise from the bottom of the log. Select **Next**.



Since you have loaded the two components that are needed to calculate acoustic impedance, the Acoustic Impedance and Reflection Coefficient curves are now shown in the Well Tie view. A red trace shows the raw synthetic.



11. In the *Select Time-Depth Controls* wizard page, turn on **Create pseudo checkshots**. This option identifies time points at significant changes in the velocity log. Change the Maximum difference to **2.00**, as in the following illustration, and then click **Apply Filter**. Click **Next**.



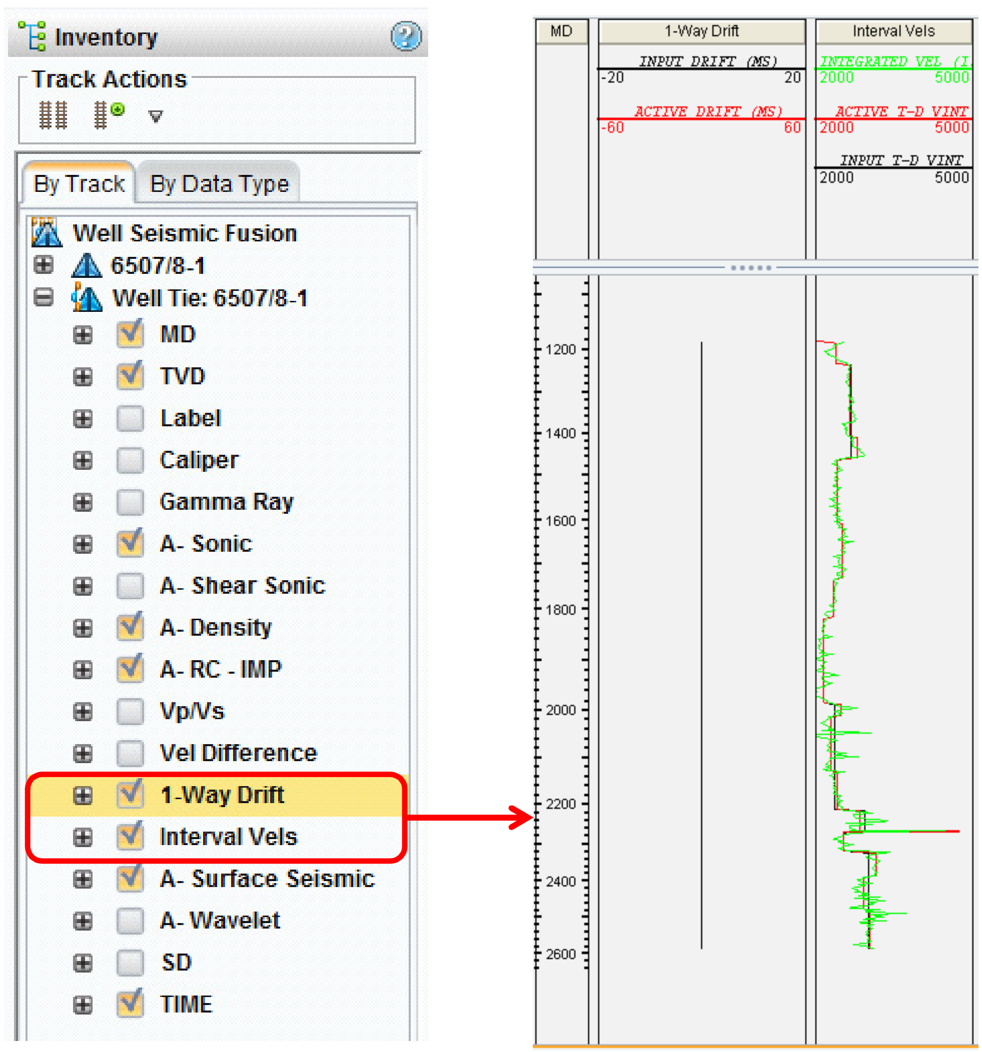
The larger you set the Maximum difference, the fewer tie points will be created. Fewer points will usually make the editing easier.

Checkshot surveys and VSPs use surface sources and downhole geophones to acquire a set of travel times. Input checkshot or VSP information will be used as “guide” corrections to the time/depth curve so that synthetic traces created from the sonic log will match the seismic data more accurately.

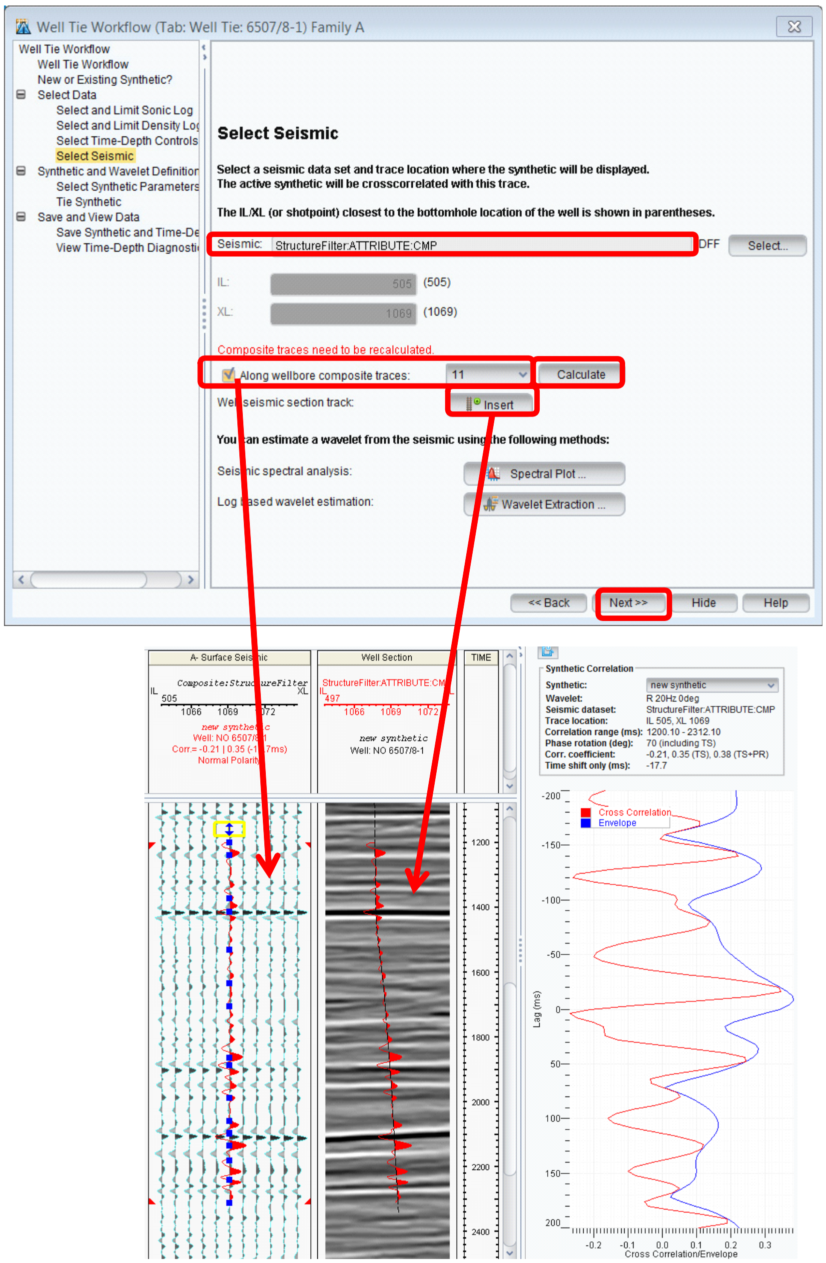
The two options for checkshots:

- Create pseudo check shots - Select this option if you want to add more time-depth pairs at significant velocity changes on the sonic log curve.
- Select existing check shots - Select this option if you want to re-calibrate the time-depth curve generated from the selected sonic log by using check-shot survey data.

12. Before continuing in the wizard, make a change in the *Well Tie* view. In the *Inventory* task pane, scroll down and turn on the **1-Way Drift** and **Interval Vels** to display a new panel showing the drift curve and interval velocity curve.



13. Return to *Well Tie Workflow* window, in the pane titled *Select Seismic*, click the **Select...** button, double-click the **StructureFilter** (pick any format) volume, toggle on **Along wellbore composite traces**, change the trace number to **11**, click **Calculate**, and then click **Insert** to add a well seismic section track. Click **Next**.



Note

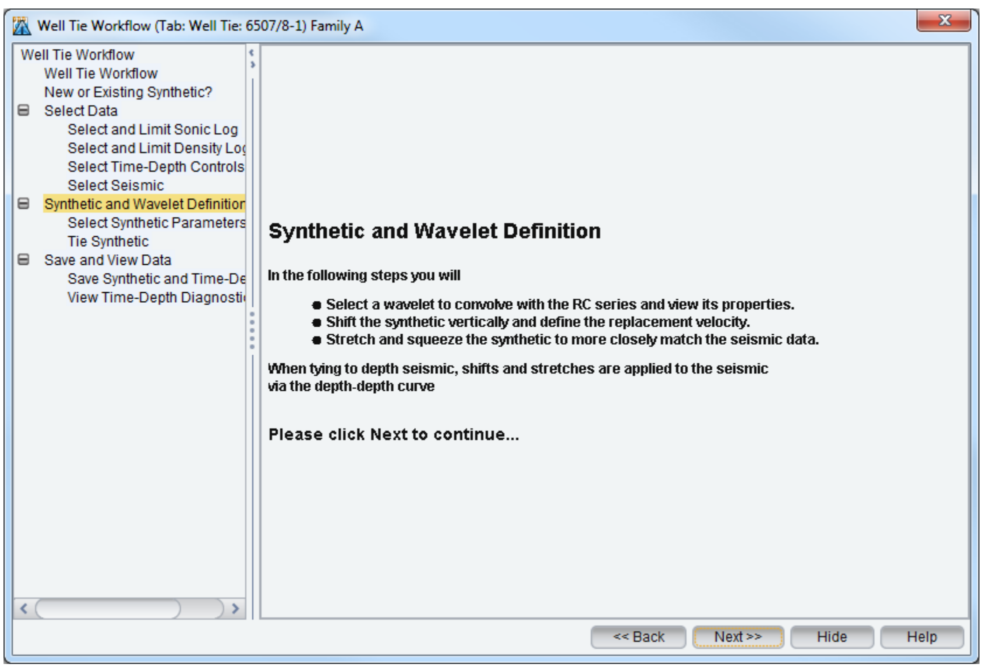
In the case of having a deviated wells, the best practice is to generate a pseudo seismic volume along the wellbore by toggling on the **Along wellbore composite traces** option.

The output composite volume is centered at the inline/xline location nearest to the bottom hole location of the well. The number of output traces is limited from 3 to 11, and, because this is a volume output, this means there will be 3 to 11 in lines and 3 to 11 cross lines calculated.

Tying the Synthetic to Seismic

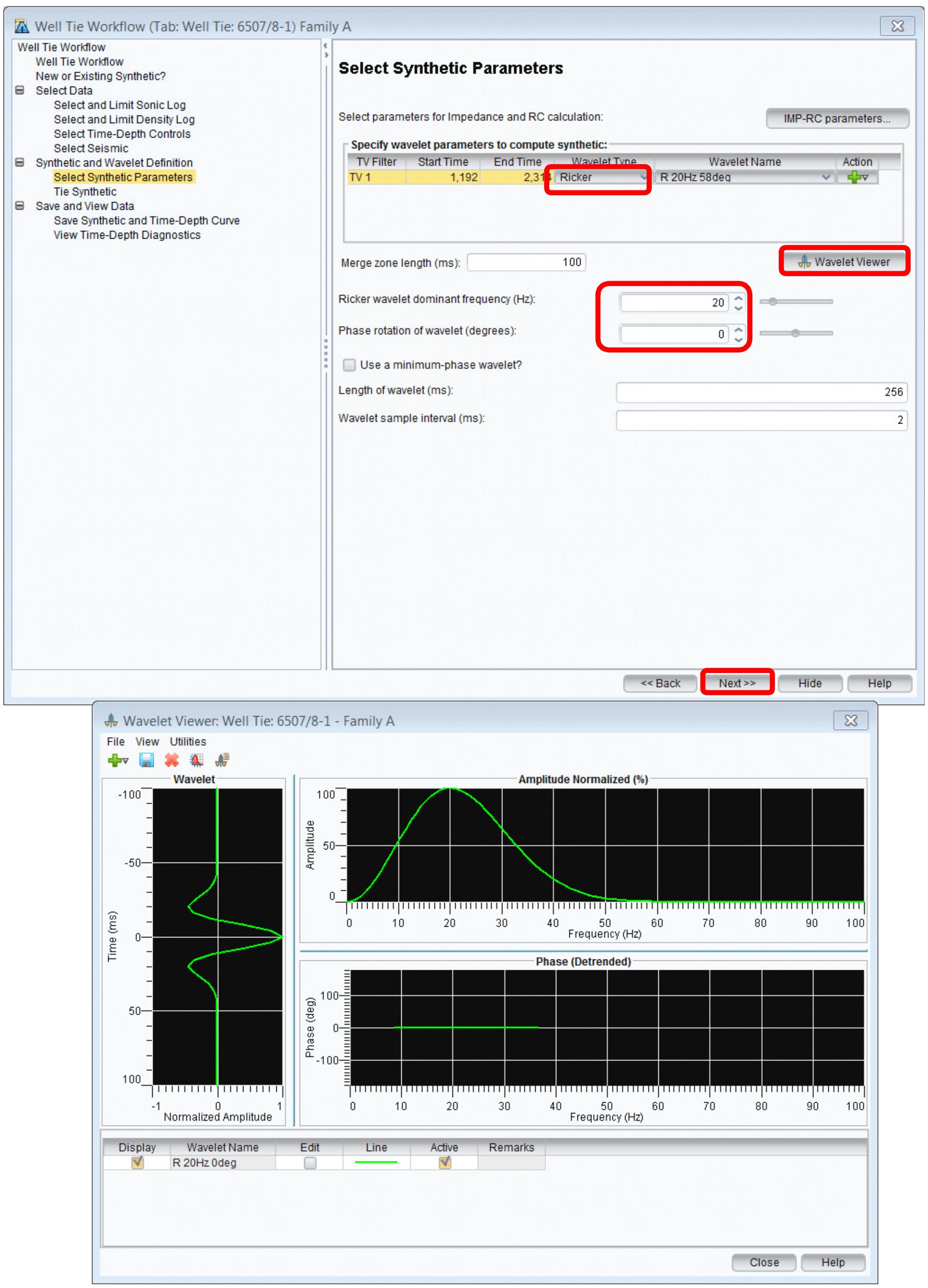
The next part of the *Well Tie* workflow contains three steps, as described in the informational *Synthetic and Wavelet Definition* page.

14. Read the steps in the *Synthetic and Wavelet Definition* page, and then click **Next**.

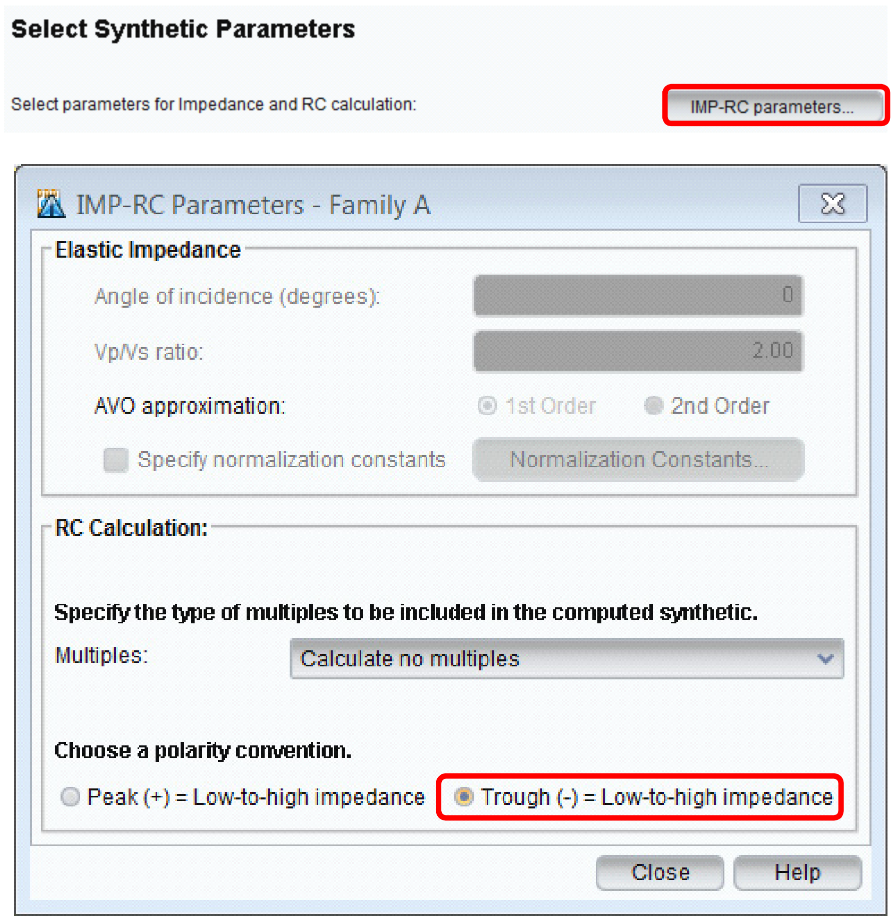


15. In the *Select Synthetic Parameters* panel, change wavelet to a **Ricker** wavelet, if needed, modify the dominant frequency to **20 Hz** and set the phase to **0** degrees. Click the **Wavelet Viewer** button. The *Wavelet Viewer* appears.

    Most seismic data, including this class dataset, is processed to zero phase. Therefore, you need to confirm that the option **Using a minimum-phase wavelet?** is unchecked.



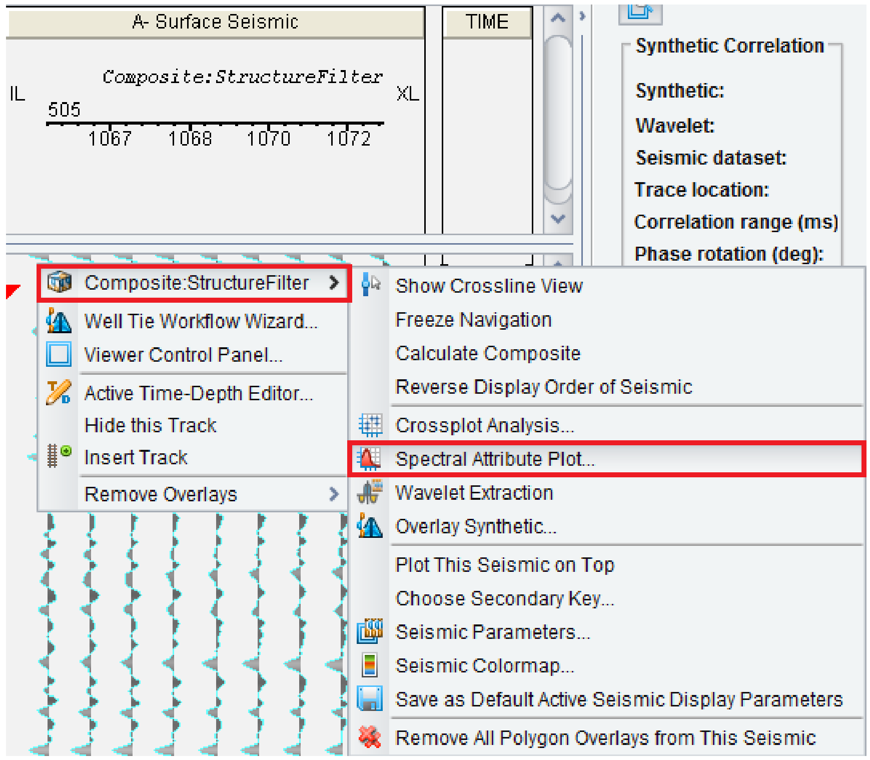
16. Since this is a Norway dataset, the polarity should follow the European convention which means a trough represents the low-to-high impedance. To change the polarity for your synthetic, open the *IMP-RC Parameters* window, change the convention to **Trough (-)**, and then click **Close**.



Choose a polarity convention for the synthetic from the following options:

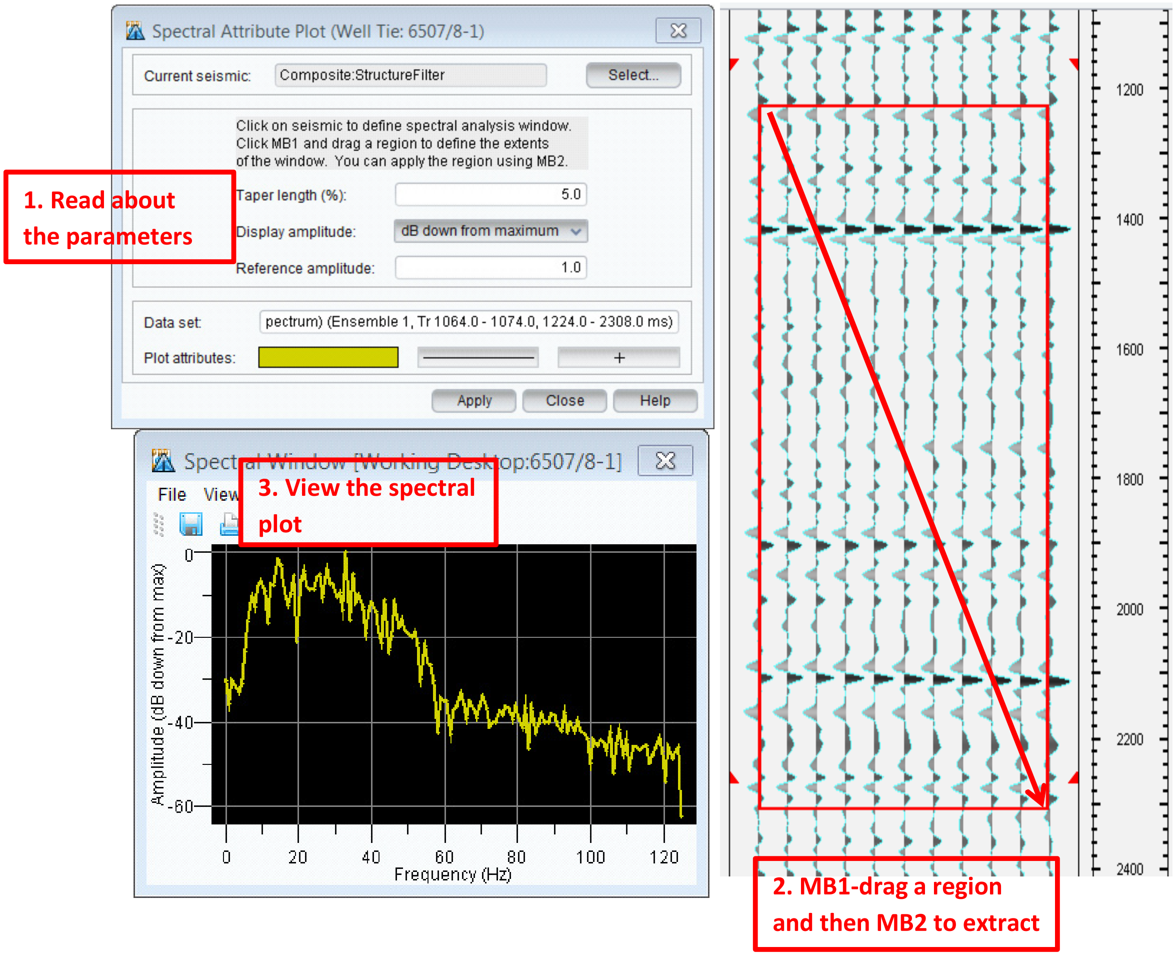
- **Peak (+)**—low-to-high impedance is indicated by a peak
- **Trough (-)**—low-to-high impedance is indicated by a trough

17. Next, you will extract wavelet from the seismic. **MB3** on the **A-Surface Seismic** track and select **CompositeStructureFilter > Spectral Attribute Plot...**.

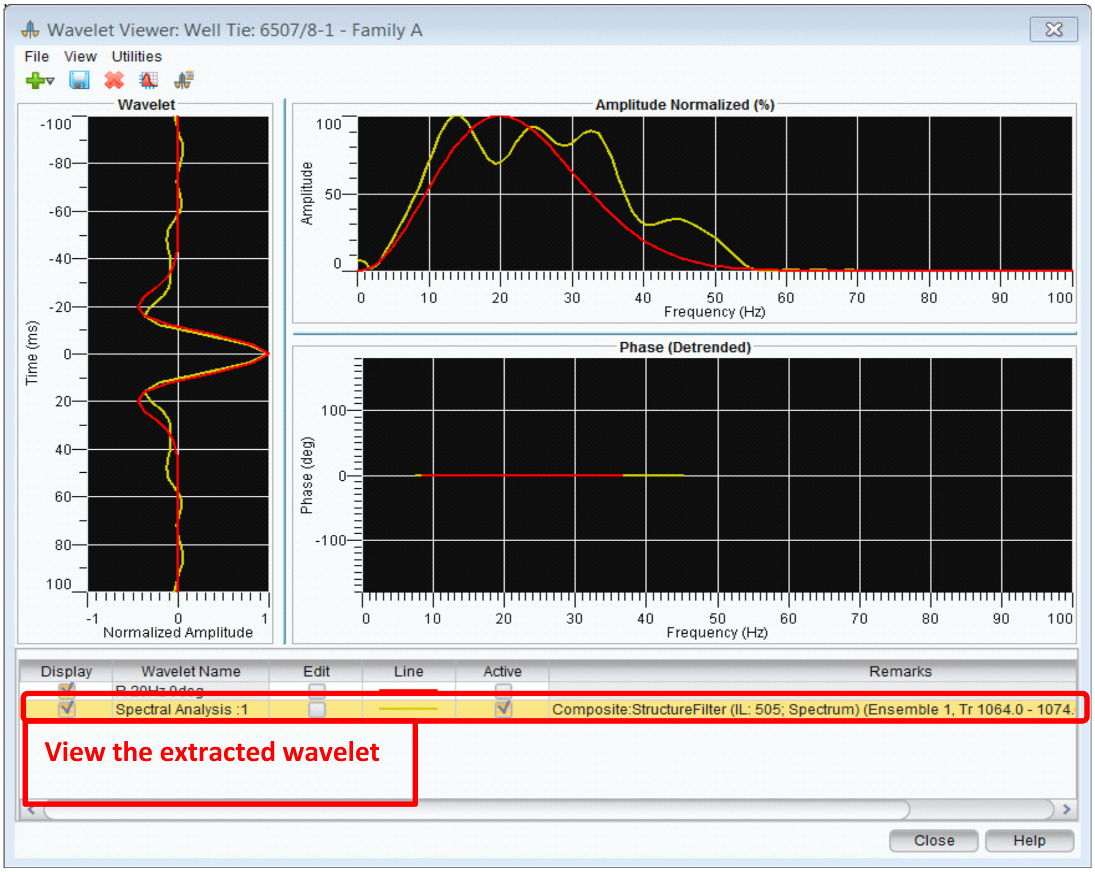


18. Read the message in *Spectral Attribute Plot* window, in the A-Surface Seismic track, click and hold **MB1** and drag a region to define the wavelet extraction window as shown in the picture below and then click **MB2** to apply. The *Wavelet Viewer* pops out, the extracted wavelet is shown as *Spectral Analysis: 1*. (In this way, the wavelet is generated based on the frequency of your seismic data.)

    The *Wavelet Viewer* should be displaying the Ricker wavelet (**R 20Hz 0 deg**) (from previous exercise) and the extracted **Spectral Analysis: 1** wavelet; compare both of them. (If necessary, toggle on both wavelets under the *Display* column.) Experiment by changing the active wavelet (by checking the box under Active column) and notice the changes in your synthetic trace. After comparing both wavelets, leave the R20Hz 0 deg wavelet active, this will be used to correlate synthetics with seismic.

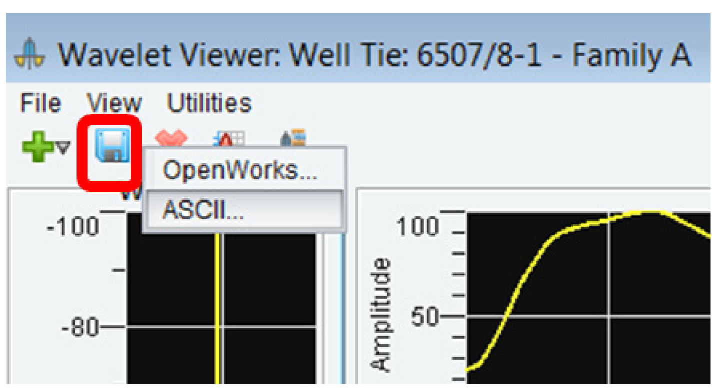


Spectral Attribute Plot (Well Tie: 6507/8-1)
Current seismic:
Composite:StructureFilter
Select...
Click on seismic to define spectral analysis window.
Click MB1 and drag a region to define the extents
of the window. You can apply the region using MB2.
Taper length (%):
5.0
Display amplitude:
dB down from maximum
Reference amplitude:
1.0
Data set:
pectrum) (Ensemble 1, Tr 1064.0 - 1074.0, 1224.0 - 2308.0 ms)
Plot attributes:
Apply
Close
Help
1. Read about the parameters
File
View
3. View the spectral plot
Amplitude (dB down from max)
Frequency (Hz)
2. MB1-drag a region and then MB2 to extract



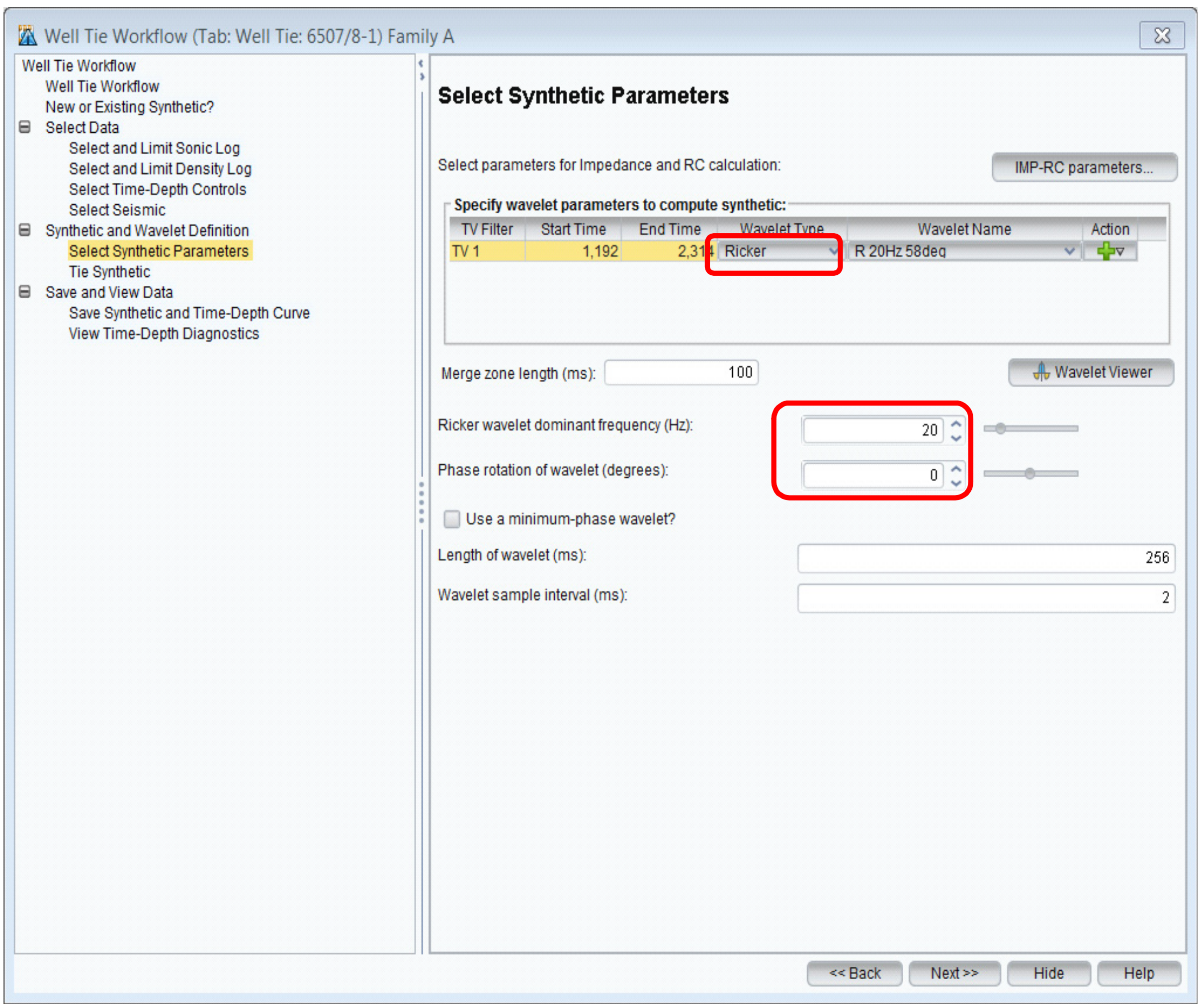
Note

To save a wavelet, in *Wavelet Viewer*, **MB1** select any of the extracted wavelet, click the **Save Wavelet** icon ( ), select **OpenWorks…** or **ASCII…**, define the path where you want to save the Wavelet (e.g. Desktop), and then click **Save** in the *Save* dialog box.

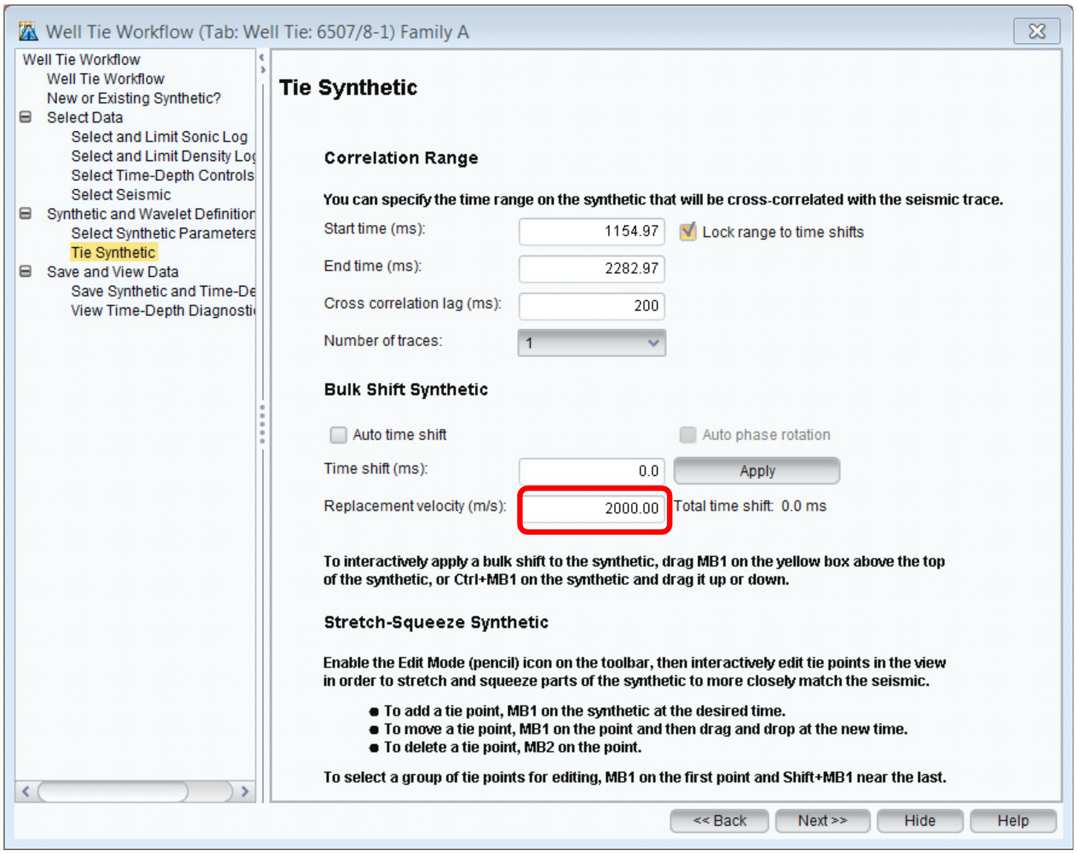


19. Close the *Wavelet Viewer*, *Spectral Window*, and *Spectral Attribute Plot* windows, return to the *Well Tie Workflow* wizard (if it is closed, click **well tie workflow** icon ( ), navigate to the *Select Synthetic Parameters* dialog box, make sure the **Ricker** wavelet is active here (in this case, Ricker wavelet is an ideal approximation of the real wavelet, if the extracted wavelet is contaminated by noise, it is safer to use the Ricker wavelet instead).

20. To get a rough estimation of the dominant frequency of your seismic data, simply count the number of peaks or troughs within 1 second (1200 ms—2200 ms). You would probably get a number from 20 to 25 (20 Hz is used in this example). You could experiment with other dominant frequencies to find the maximum correlation. Set Phase rotation of wavelet (degrees) to **0**.
Click **Next**.



21. The *Tie Synthetic* dialog box allows you to set the correlation range, bulk shift the synthetic, and stretch and squeeze the synthetic. Note that under *Bulk Shift Synthetic*, the replacement velocity may be a number close to 1974 m/s or some other value from a previous running of the program. For consistency with the manual and the following exercise, make sure Time shift (ms) is set to **0** and set the Replacement velocity (m/s) to **2000**, and then press <**ENTER**>.

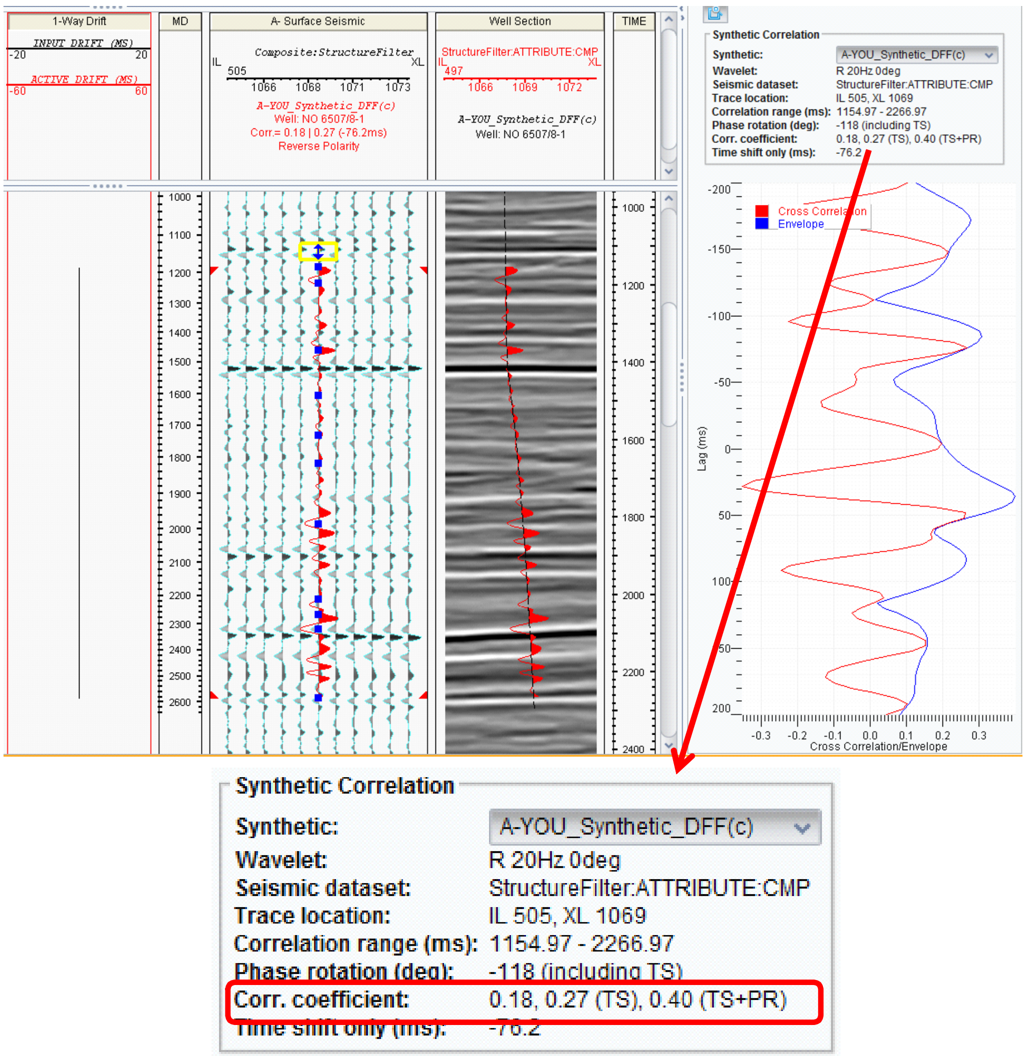


Note

Replacement velocity displays the replacement velocity used to start the synthetic at the displayed time (or depth). Enter a value and press the Tab keyboard key to change the replacement velocity. Entering a faster replacement velocity moves the synthetic upward; a slower replacement velocity shifts the synthetic downward. It may be the default 2000 m/s or a value left from a previous synthetic calculation.

Correlation Range is an important parameter for synthetic tie. By default, it is set to the entire length of the computed synthetic. You can change it to cover the target interval for seismic interpretation, but the interval should be greater than 500 ms to get a valid statistical correlation.

22. Go back to the *Well Tie* main window, find the *Synthetic Correlation* panel and record the correlation coefficients.



You will find three types of Correlation Coefficients:

- Correlation Coefficient
- Correlation Coefficient with Time Shift (TS)
- Correlation Coefficient with Time Shift and Phase Rotation (TS+PR)

The first number is the current correlation coefficient. The additional two numbers show what the correlation would be with the time shift specified (TS) and what it would be with time shift and phase rotation (TS+PR).

Before you start, record the first Corr. coefficient number: _______.

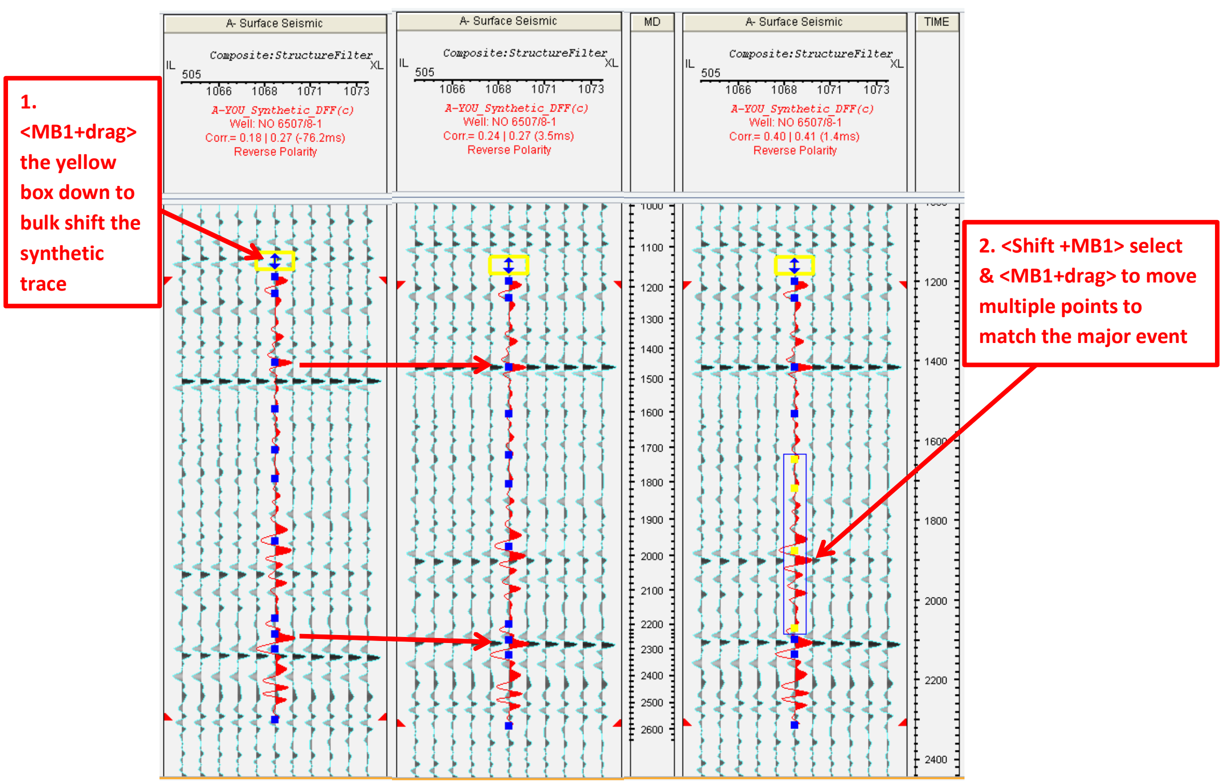
Find this value near the bottom of the Synthetic Correlation box. Your numbers may be slightly different from those shown in the previous screenshot.

The current correlation coefficient is small because the synthetic has not been tied.

23. At the top of the synthetic trace is a yellow box that allows you to move the whole synthetic up and down.

    Click the **Edit tie point mode** icon ( ), **MB1-drag** the yellow box to bulk shift the entire trace until the most prominent peaks in upper and lower part of synthetic (as indicated in the screenshot below) match the corresponding seismic peaks (at around 1420 and 2110ms TIME). See step one in picture below.

24. Press <**shift**> and click on a range of points in the middle part of the synthetic trace, notice that those tie points are now in a group, **MB1-drag** the group down to match another major seismic event as shown in the screenshots below. See step two in picture below.

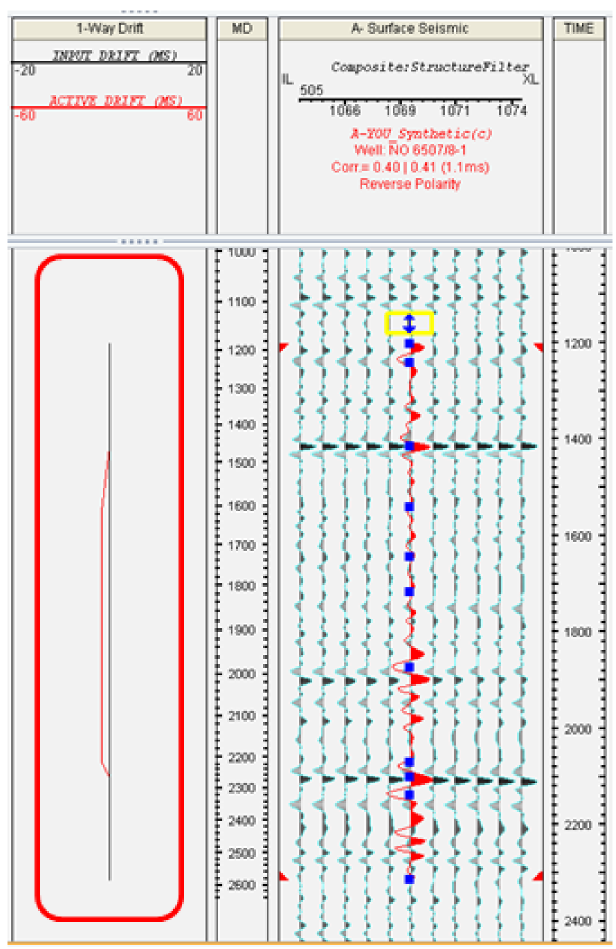


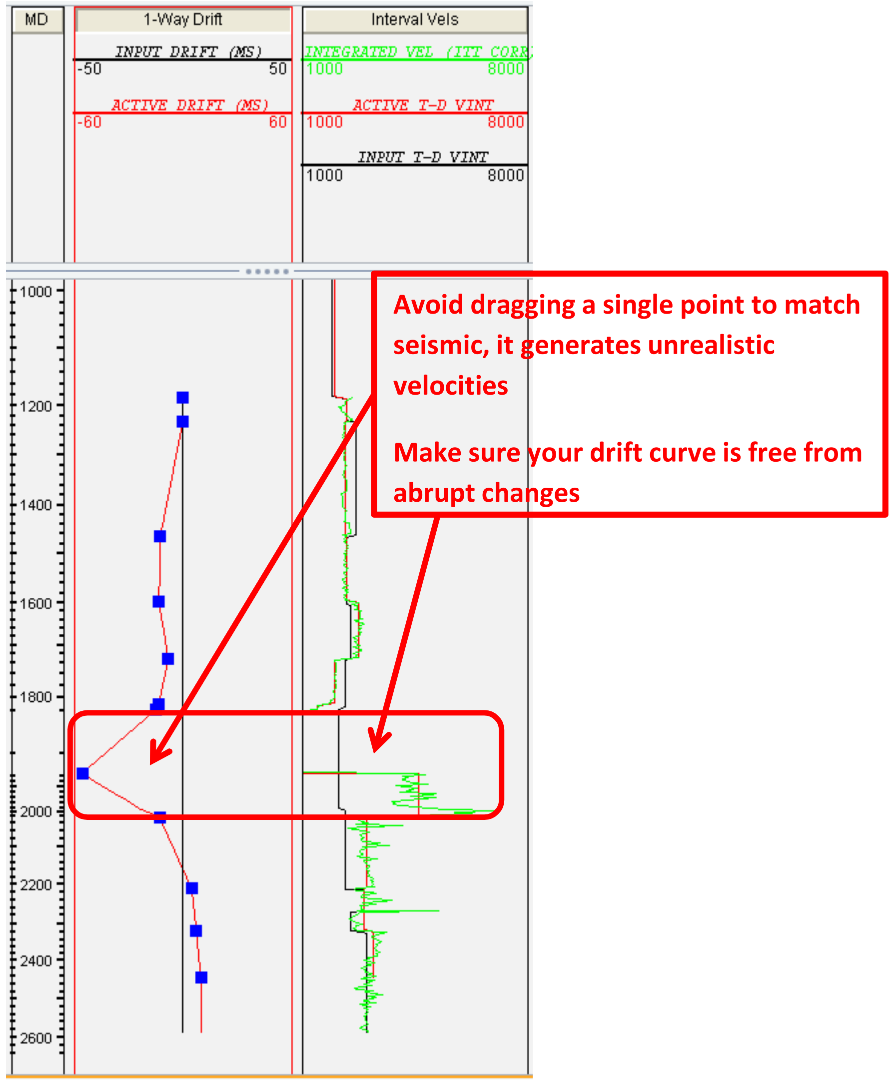
Note

Stretching and squeezing synthetic traces to fit seismic need your extra attention, especially when you are using an accurate time-depth control, it is a good practice to do it as gentle as possible and as less as possible.

Undo the point modification by clicking the **Undo tie point edit** ( ) icon, or <Ctrl+Z>.

25. Check your drift curve; make sure it is free from abrupt changes, meaning it is geologically reasonable. Usually, you can get a smooth drift curve by shifting a certain range of tie points instead of editing each single point.



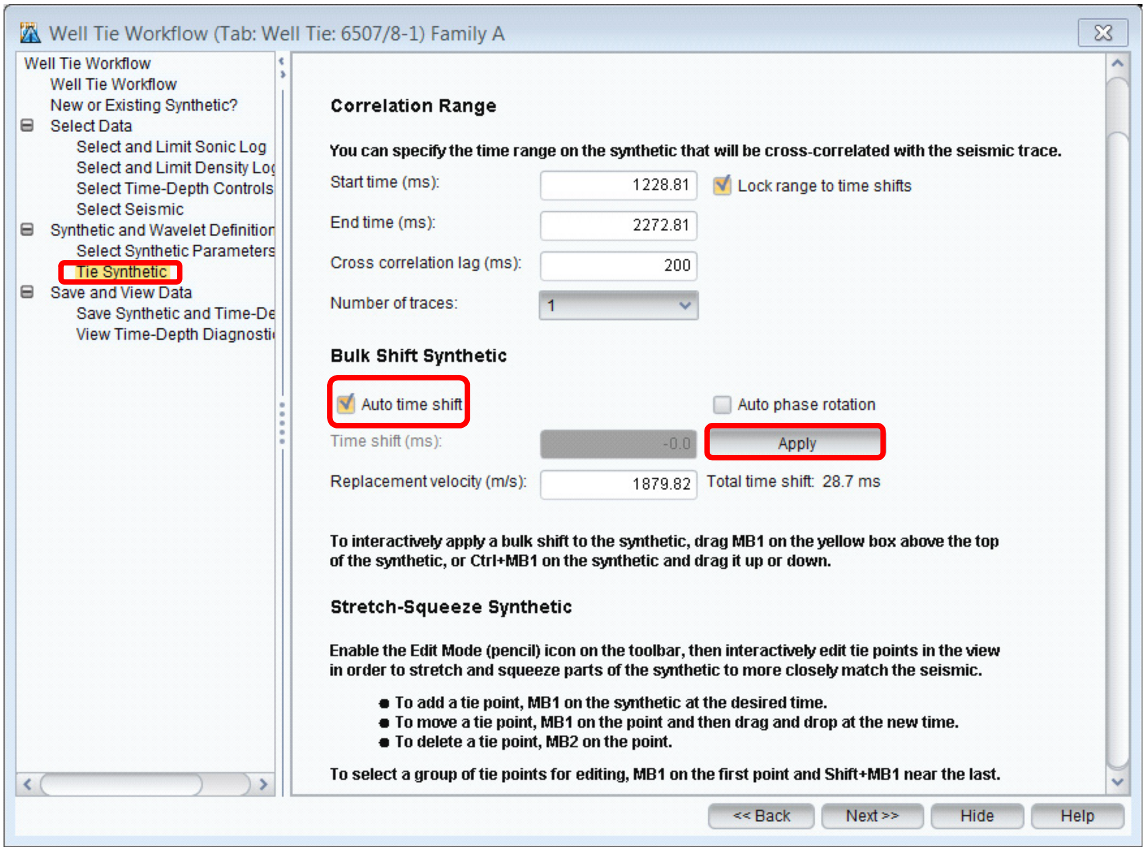


You can improve the overall synthetic correlation by repositioning the T-D points. However, you need to consider the velocity changes by observing separation between original Sonic and Integrated Sonic, and by viewing the **1-Way Drift** active curve. Always ask yourself if the changed velocities seem geologically reasonable, and know the velocities for typical rocks in your area.

Notice that in the synthetic correlation, a modification of the T-D point position can change the phase-shift suggested value.

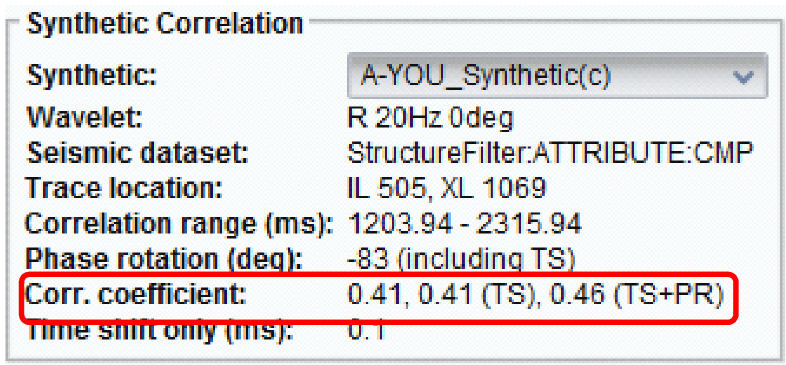
> **Note**
>
> To obtain a conclusive statement about seismic phase content, you need to compare analysis results from multiple wells and correlate with a Vertical Seismic Profile (VSP).

26. Return to the *Well Tie Workflow* wizard, in the *Tie Synthetic* dialog box, turn on **Auto time shift** and then click **Apply**.

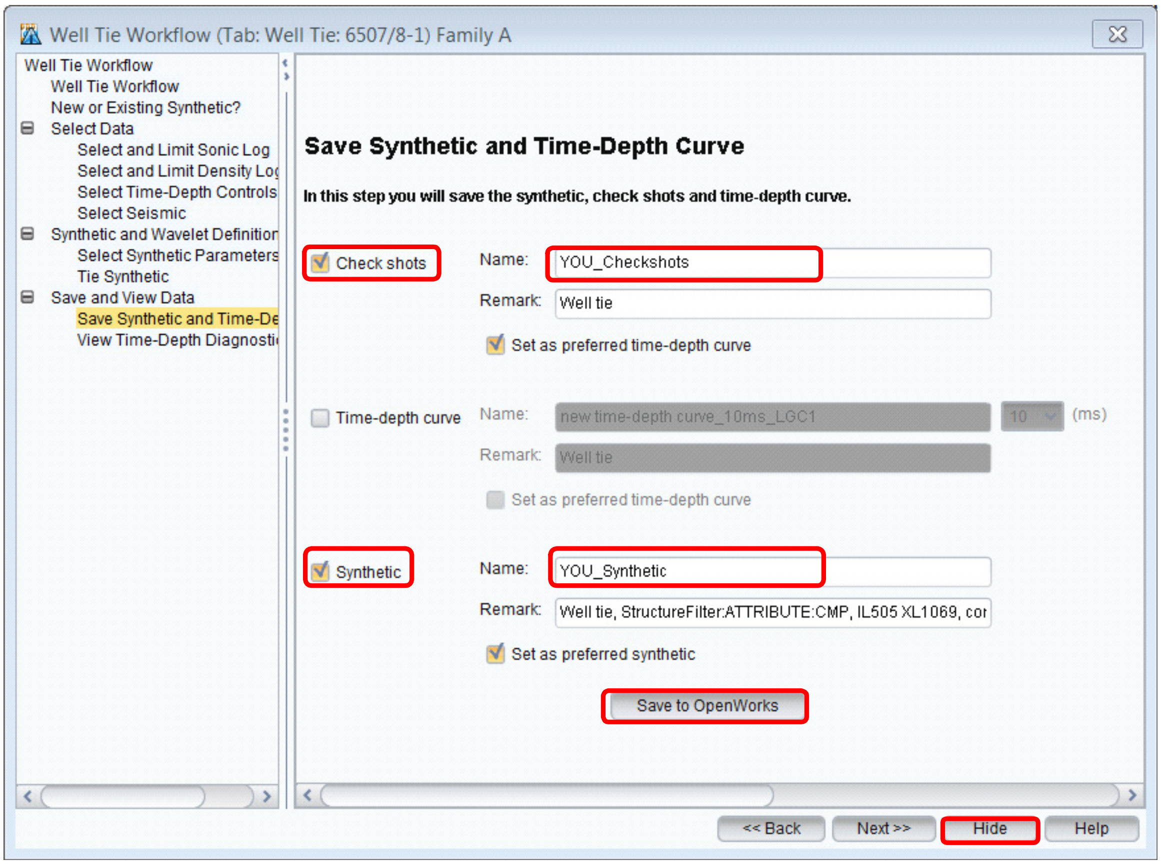


27. After applying auto time shift, record your new Corr. Coefficient: ________. Is it better? You could experiment with extracted wavelet or other dominant frequencies to find the maximum correlation, but to save time, continue to next step.

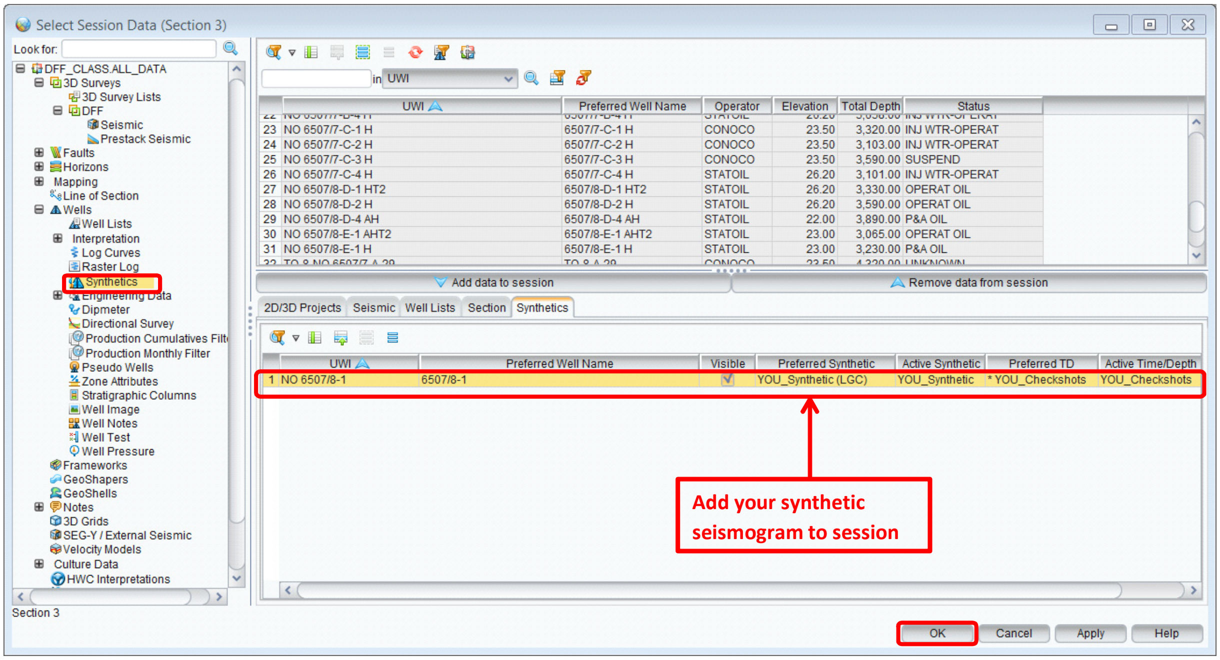
Typically when the peak of the cross correlation lines up with the peak of the envelope, it means that the phase of the wavelet is correct. A symmetrical cross correlation and envelope is also an indication of a good tie. After the synthetic is in good shape, with the best correlation near a zero Lag, you can further tune the TD relationship by adjusting the Correlation Range parameters on the Tie Synthetic panel. For example, change the Cross correlation lag length to 100 ms. If you are interested in just tying a certain event, then you can set the Start time and End time of the Correlation Range around the event of interest.



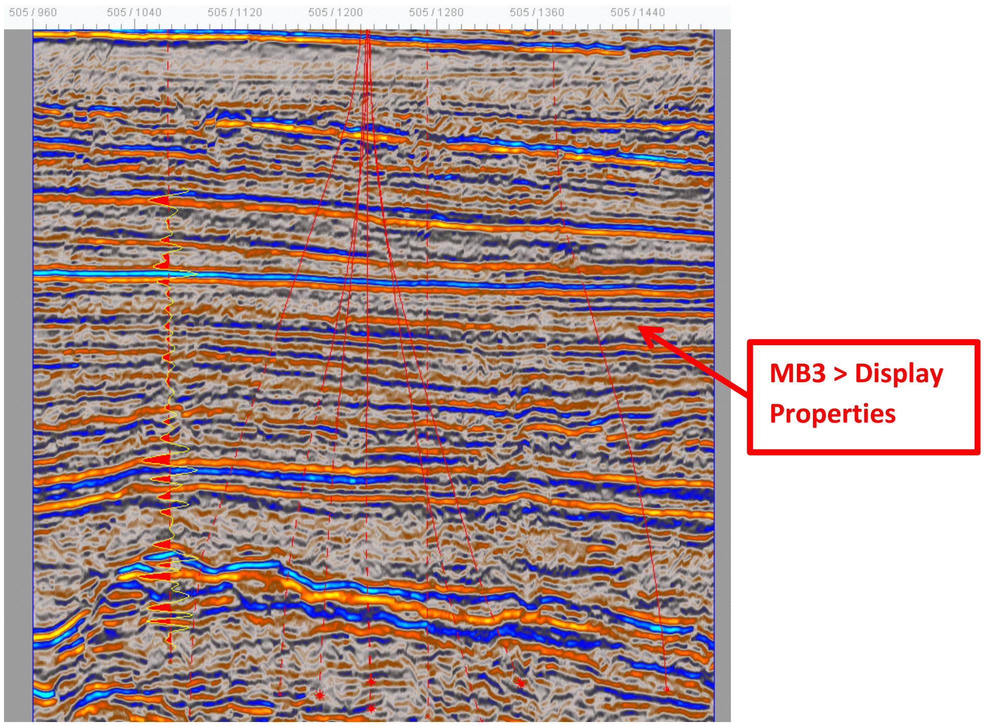
28. Open the *Well Tie Workflow* wizard by clicking well tie workflow icon ( ) and click the *Save Synthetic and Time-Depth Curve* panel. You can choose to save check shots, time-depth curve and synthetic for future use. Toggle on **Check shots** and **Synthetic**. Enter their names as “**YOU_Checkshots**” and “**YOU_Synthetic**.” Click **Save to OpenWorks**. Hide the *Well Tie Workflow* dialog box by clicking **Hide**.

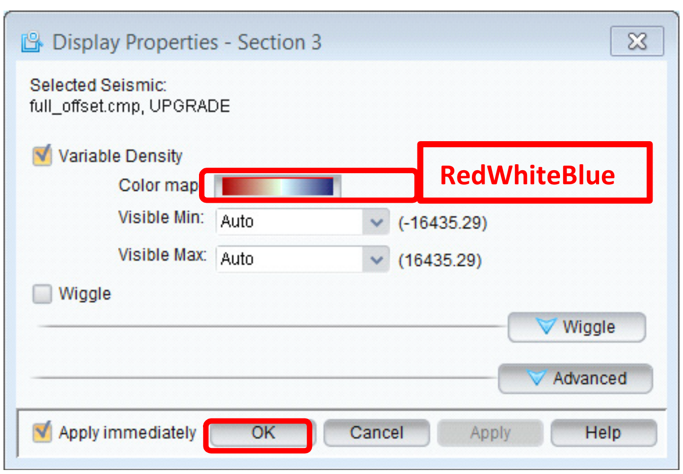


29. Go to DecisionSpace, double-click the *Section View* window to enlarge it (make sure the seismic and well are toggled on in your inventory and the Inline number is 505), click the **Select Session Data** icon ( ), find and select Well **6507/8-1** under *Synthetics*, click **Add data to session**, and make sure the preferred and active synthetic is **YOU_Synthetic**. Click **OK**.

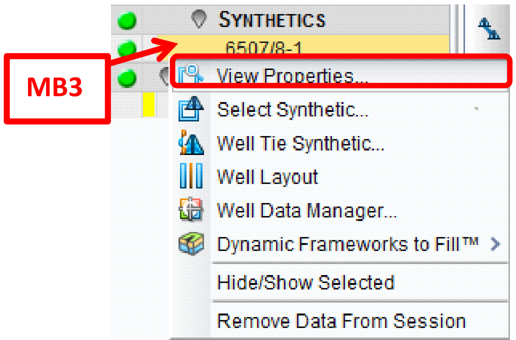


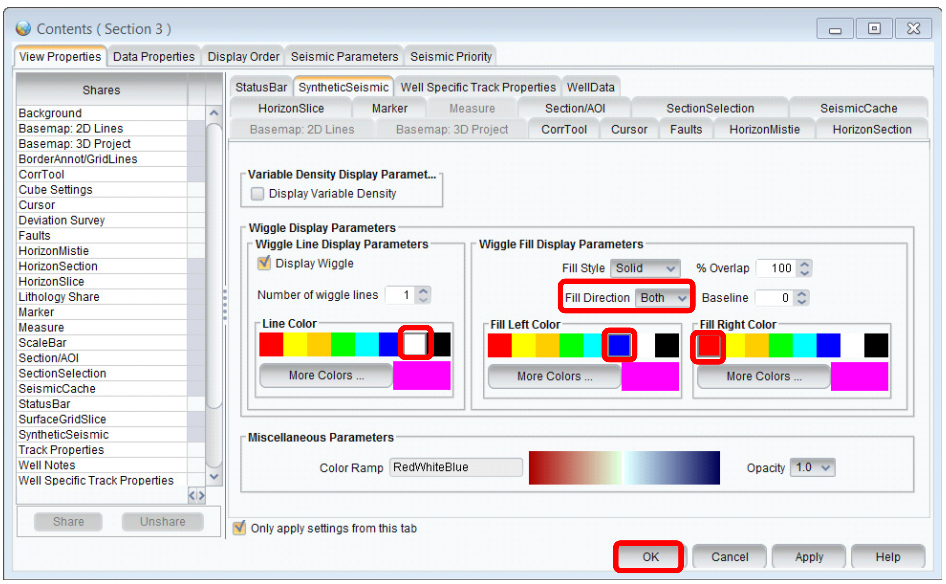
30. The Section view now shows the synthetic you just added for 8-1. Verify that your synthetic is used: **MB3** on the seismic section, select **Display Properties…**, and then change the Color map to **RedWhiteBlue**. Click **OK**.



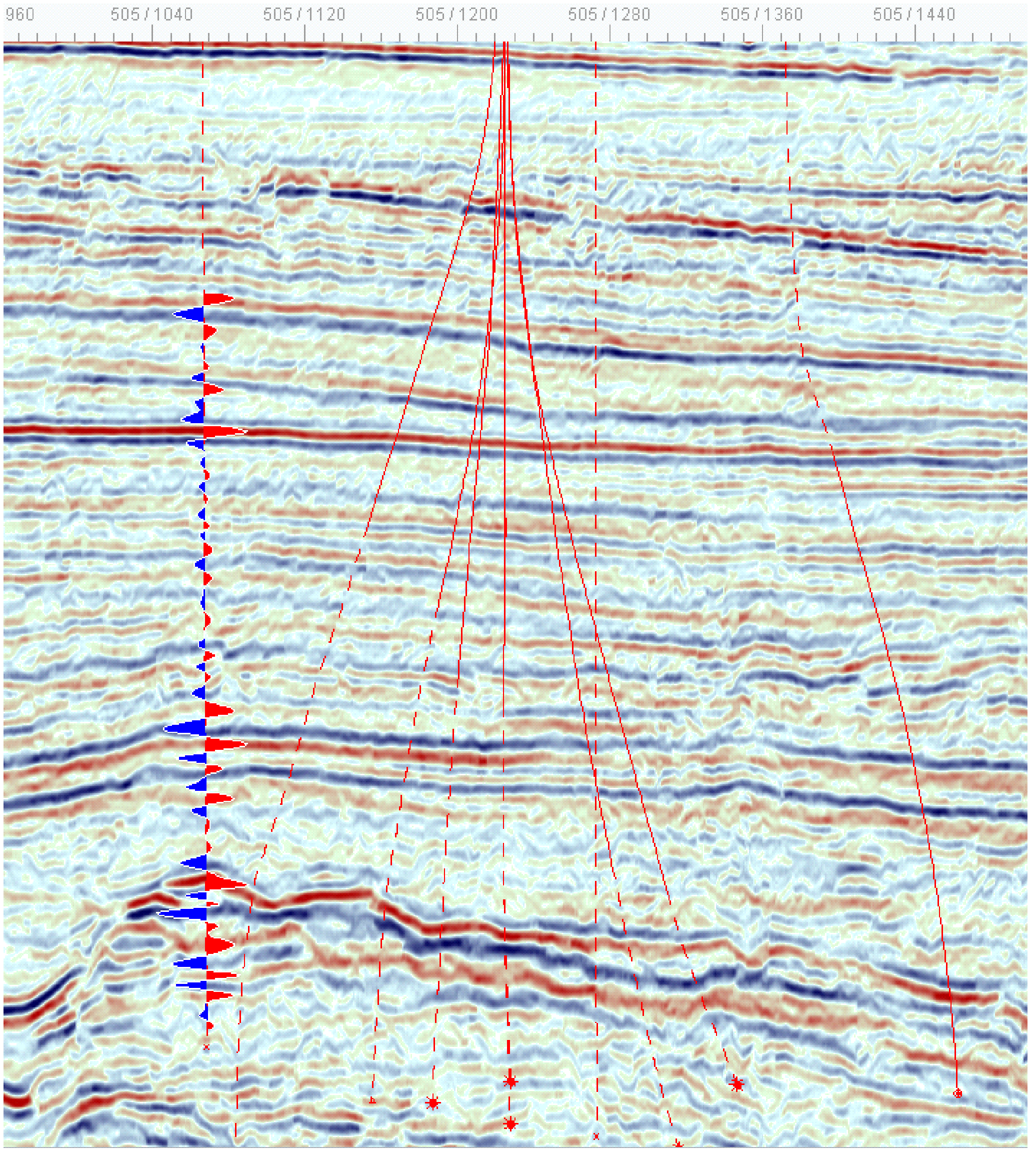


31. Find the SYNTHETICS in the *Inventory* task pane, **MB3** on **6507/8-1** and select **View Properties…**. In the *Contents* window, change Fill Direction to **Both**, set Line Color to **White**, Fill Left Color to **Blue**, and Fill Right Color to **Red**. Click **OK**.





32. Return to your *Section* view. Focus on some major reflectors to examine how your synthetic is tied to the seismic.



Overview: Interpreting Horizons

In this section you will learn how to:

- Unfault and unfold a fault network
- Create new horizons
- Interpret horizons on seismic probes
- AutoTrack and paintbrush edit
- PolygonTrack and polygon delete
- Convert a horizon to a framework surface

Interpreting Horizons Using a Fault Network

In exercise 1.1 you created a fault network. You will now use the fault network to accurately generate interpreted surfaces across fault throws.

You will unfault the seismic data to interpret fault blocks in areas with no well control. By blocking at faults you will have more control to auto-track horizons using both Area Track! and ezTracker Plus. Then you will use ribbed faults as polygon boundaries, which eliminates one of the most time consuming parts of the interpretation workflow.

You will use Dynamic Frameworks to Fill to build seismic-based maps at the top and base of the target section in real time. This workflow will show areas that need additional interpretation, have mis-ties, or where the final framework matches the interpretation. Your framework will be depth converted later in this chapter.

Tracking Parameters

You can pick horizons on three attribute types: amplitude, value, or phase.

Tracking Amplitudes

You perform Tracking on the amplitudes of the trace. Peaks, troughs, and zero crossings are designated onset types. The onset types are minimum, zero, maximum jump, zero (+/-), and zero (-/+).

Tracking Modes Available with Amplitude

- **Waveform** – This is the default mode. As your interpretation progresses, it uses the original trace instead of the newly tracked trace as input for the next tracking attempt. When you select the Waveform option, the **Correlation window (ms)** text field becomes active. The default is 60 ms.
- **Peak to Peak** – The data are selected on peaks of amplitude.
- **Cross Correlation** – This is a classic method for statistically comparing data to determine if there is a match. The correlation process looks at a user-specified range of data above and below the seed point and scans within a search window on nearby traces to see if it can identify a similar set of data. If it finds a match, it will track the horizon to those traces.
  Cross correlation normalizes the correlation coefficient to a range of 1 to 100. When you select Cross Correlation from the drop-down window in the *Parameters* panel, the **Correlation window** text field becomes active. The default is 60 ms.

Using Maximum Jump

Use Maximum Jump to specify the maximum value for jumps between traces in an auto-tracked horizon. For time horizons, the value is set in milliseconds. For depth horizons, the value is set in feet or meters. The Maximum Jump default setting is 24. For example, when working with time data, a value of 10 means that no adjacent traces vary by more than 10 ms above or below the seed point, for a total tracking range of 20 ms.

Encountering Doublets

DecisionSpace Geosciences allows you to choose how to handle doublets. The default selection is Pick Largest, but you may also make other selections from the menu in the *Parameters* pane. The doublets option applies only to amplitude tracking. The drop-down menu choices are:

- Pick nearest event
- Pick upper event
- Pick lower event
- Pick largest event

The Pick Nearest Event option improves stability for interactive auto-tracking on the designated onset.

Tracking Horizons Accurately with the Block at Fault Option

The Block at Fault option provides accurate horizon tracking near a fault plane. The option prevents the auto tracker from tracking consecutive traces that are separated by a fault plane. The appearance of a gap at the fault depends on the steepness of fault-plane dip and the magnitude of the fault heave. The default setting for the Block at Fault option is off.

Tracking Data by the Value Tracker

The Value Tracker tracks any type of data stored in a vertical seismic file. Like the phase tracker, the value tracker allows you to track events that do not coincide with minimums, maximums, or zero crossings. In contrast to the phase tracker, the value tracker does not anticipate any particular type of waveform.

Use the value tracker with:

- Conventional seismic data
- Seismic data that has been converted to depth data
- Petrophysical data that has been processed to populate a vertical file
- Velocity data

Data Values

Specify any of the following:

- Constant Value changes the constant value. The default is 0. Double-click the text field or use the up and down arrows.
- High to Low replaces Constant Value with Minimum Change (ms).
- Low to High replaces Constant Value with Minimum Change (ms).
- Maximum Change replaces Constant Value with Minimum Change (ms).

Tracking Phase Data

The Phase Tracker tracks phase data that has been stored in a vertical file. Tracking is performed on the phase angle of instantaneous phase wavelets. The data values range from -180° to +180°, forming a sawtooth-shaped signal. The only data value for Phase is Data Values Constant Value. Angle specifies the phase angle you want the phase tracking software to pick.

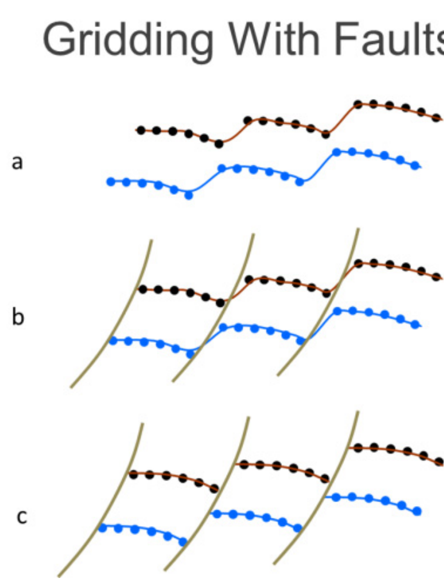
Note

Phase Tracking cannot accurately track amplitude data.

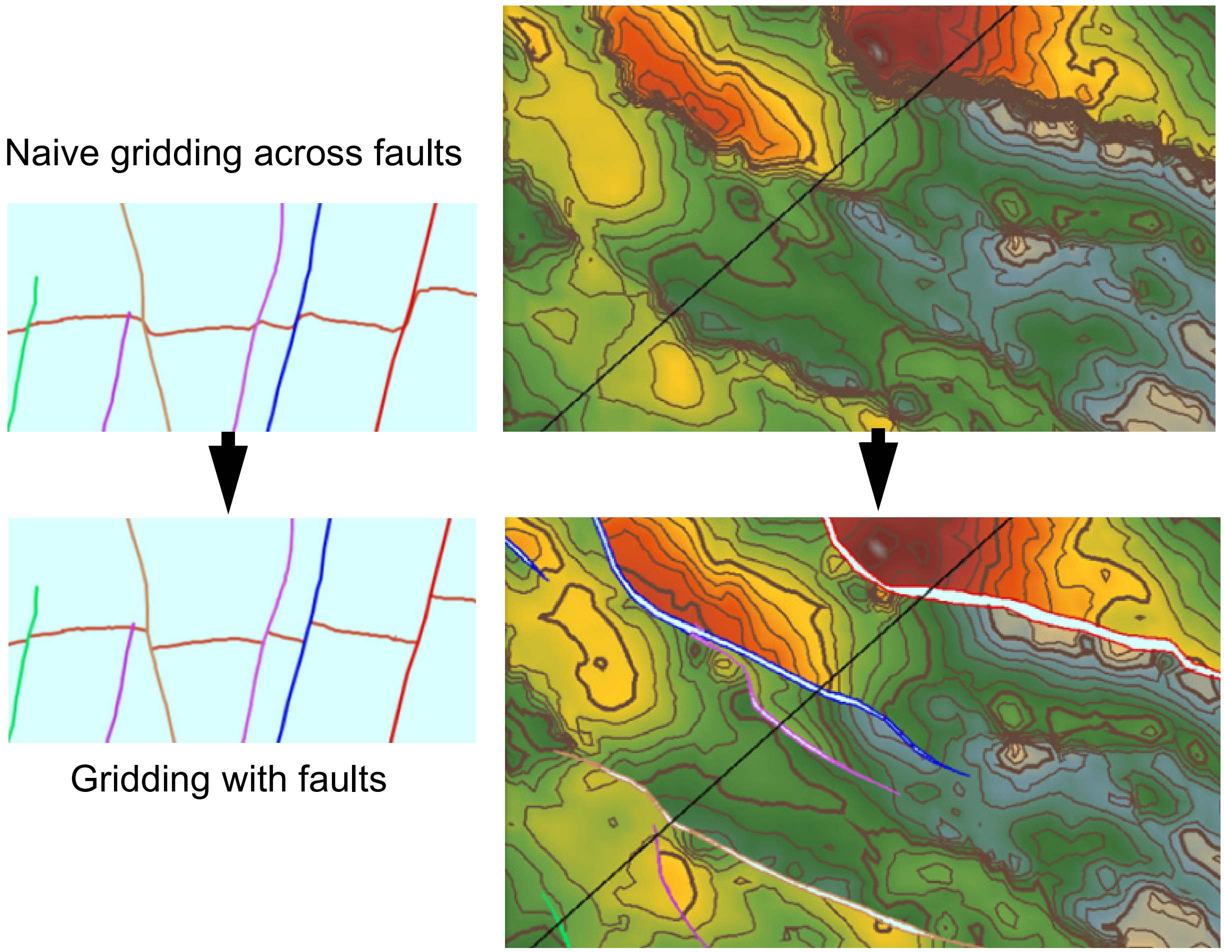
Representing Faults in Frameworks

Framework mapping algorithms can grid surface data that bisect fault planes. This differs from traditional mapping algorithms that use fault centerlines or hand-drawn fault polygons to denote the location of faults in gridding algorithms. Dynamic Frameworks to Fill uses fault plane data to segregate surface data, and then grids the data on a fault-block by fault-block basis.

In the figure below, you can see horizon surface data gridded initially without a fault interpretation (a). In (b), faults have been added, and in (c), you can see the results of incorporating the fault planes in the gridding process. Effectively, the fault planes segregate and grid the surface data by fault block, and then project the surfaces into the fault-block bounding faults where they are truncated.



The figures below show the results of naive gridding, without considering the faults, and of gridding by fault block. The latter creates fault polygons as the natural intersection of fault planes with truncated structural surfaces. In this exercise, you will pick several lines of your horizons, then refresh your framework. The surfaces will immediately be updated and you can watch as your fault polygons develop in *Map* view.



Exercise 1.3: Interpreting Horizons

In this exercise you will learn several methods of picking and editing horizons. You will see how the Dynamic Frameworks will enhance the speed and accuracy of the interpretation.

First, you will interpret a horizon on one inline, and then interpret on intersecting lines to give a widely spaced mesh. Then you will use the auto track feature to fill in the interpretation.

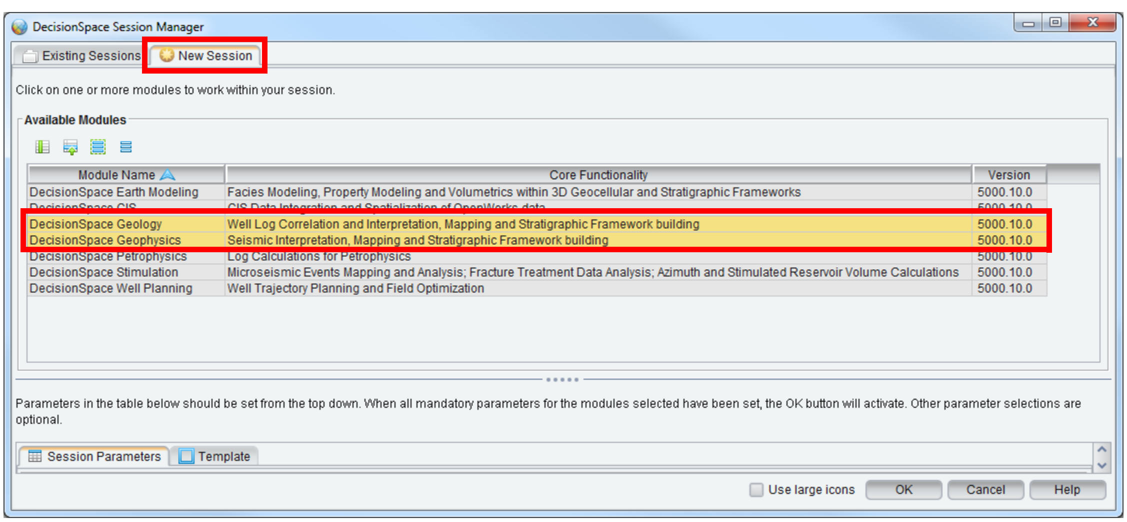
Starting DecisionSpace

You will restart DecisionSpace and load an existing session. This will unify the class at the same place and with similar inputs. After you go through the workflow with the class dataset, and if there is time, you can rerun the exercise using the faults and framework that you built in the previous exercise.

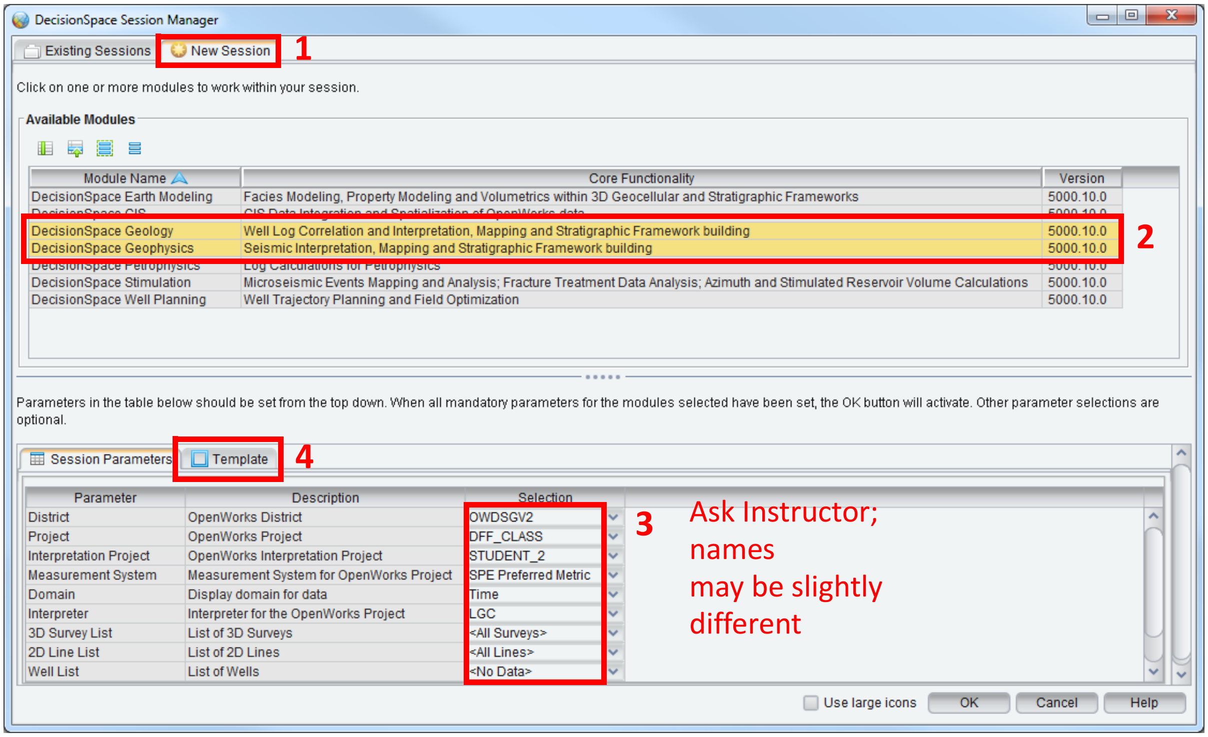
Loading a Pre-existing Session or Loading from an Interpretation Set

1. Launch DecisionSpace as you did in Exercise 1.1. In the *DecisionSpace Session Manager*, load session **Chapter1_HorizonInterpretation**. If this session loads successfully, skip to Step 8.

2. If you have trouble loading the session named above, initiate a ***New Session*** with the Geophysics and Geology modules selected.



3. Specify the Session Parameters as shown below. This will be a **Time** domain session.

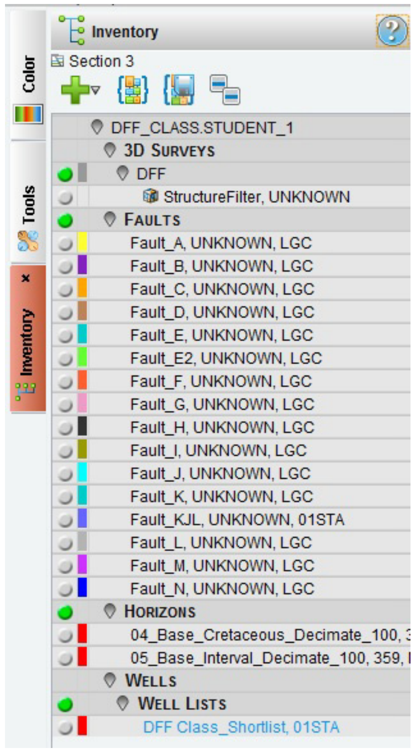


4. From the *Template* tab, click the **Map-** and **Section-Single-Window** icons, and then click **OK**.

5. Add a *Cube* view to both of the DecisionSpace windows.

6. From the *Tools* tab, load the **Ex1_3Horizons** ISet into your session.

Your *Inventory* task pane should look like the image shown below.



7. Load the **StructureFilter** seismic volume to shared memory.

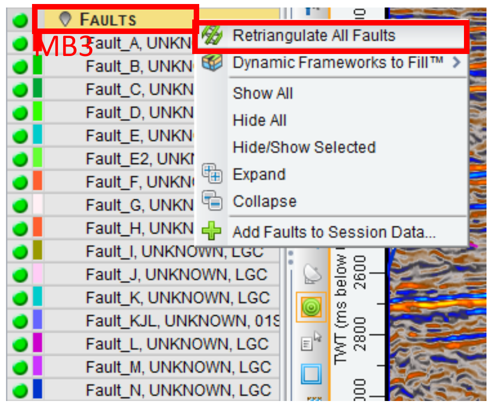
8. Set up your two DecisionSpace windows with the *Section* view selected on one window and the *Cube* view active on the other.

9. In the *Cube* window, create an inline and arbline probe from the **StructureFilter Share memory** volume.

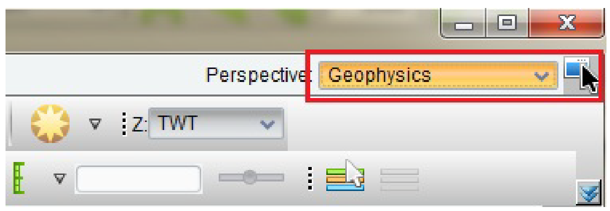
10. In the *Cube* view in the upper icon bar, enter “**2**” in the Z Factor field.

11. In the other window, in the active *Section* view, turn on the **StructureFilter** shared memory seismic. Display inline **500**.

12. **Zoom** the section to approximately 1800 to 3600 msec. Turn on all faults. **MB3** in **FAULTS** and select **Retriangulate All faults** to ensure that the faults are updated.



13. In the upper right corner of both DecisionSpace windows, click the **Perspective** drop-down menu and then select **Geophysics**. Note that the tabs of some unneeded tools no longer appear in the task panes.



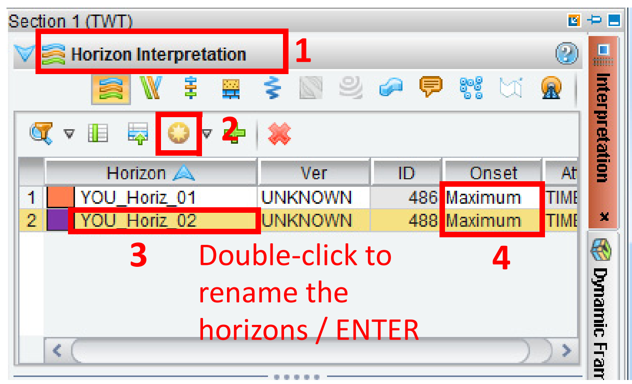
Interpreting Horizons Across Faults

You will begin interpreting horizons across faults. You may wish to review the section preceding this exercise, entitled "Overview: Horizon Interpretation." It contains background information on tracking modes. You will start by creating a new horizon.

Creating Horizons

14. From the *Horizon Interpretation* panel, create a new horizon and name it "**YOU_horiz_01**." Change the onset to **Maximum**.

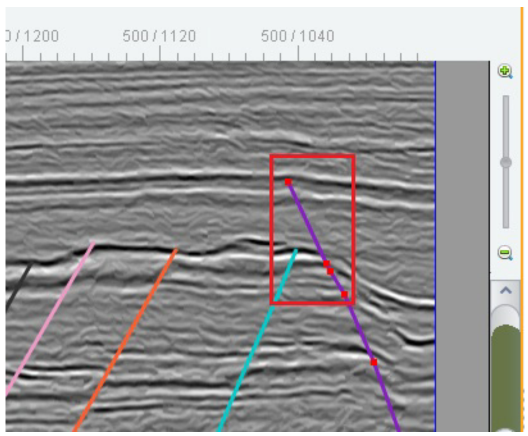
15. Create a second horizon named "**YOU_horiz_02**." Set Onset to **Maximum**.



Using ezValidator to Unfault Section

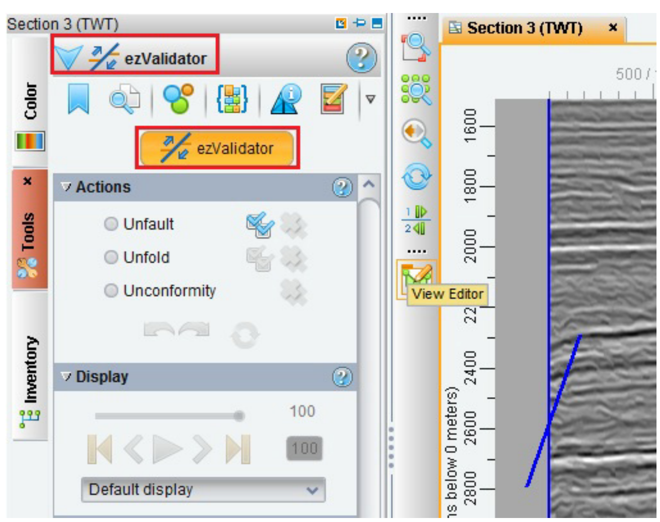
The ezValidator module allows you to adjust (stretch or squeeze) the seismic on either side of a fault to match the character and stratigraphy. You will use ezValidator to improve the picking of your horizons.

16. In *Section* view, turn on all the **Faults** (seismic faults) if they are not already on. Extend the interpretation of Fault_B (on right) up to about **2000** msec. (This *Section* view has an orientation W-E; if necessary use the hot key “**V**” to match the orientation of the picture below).

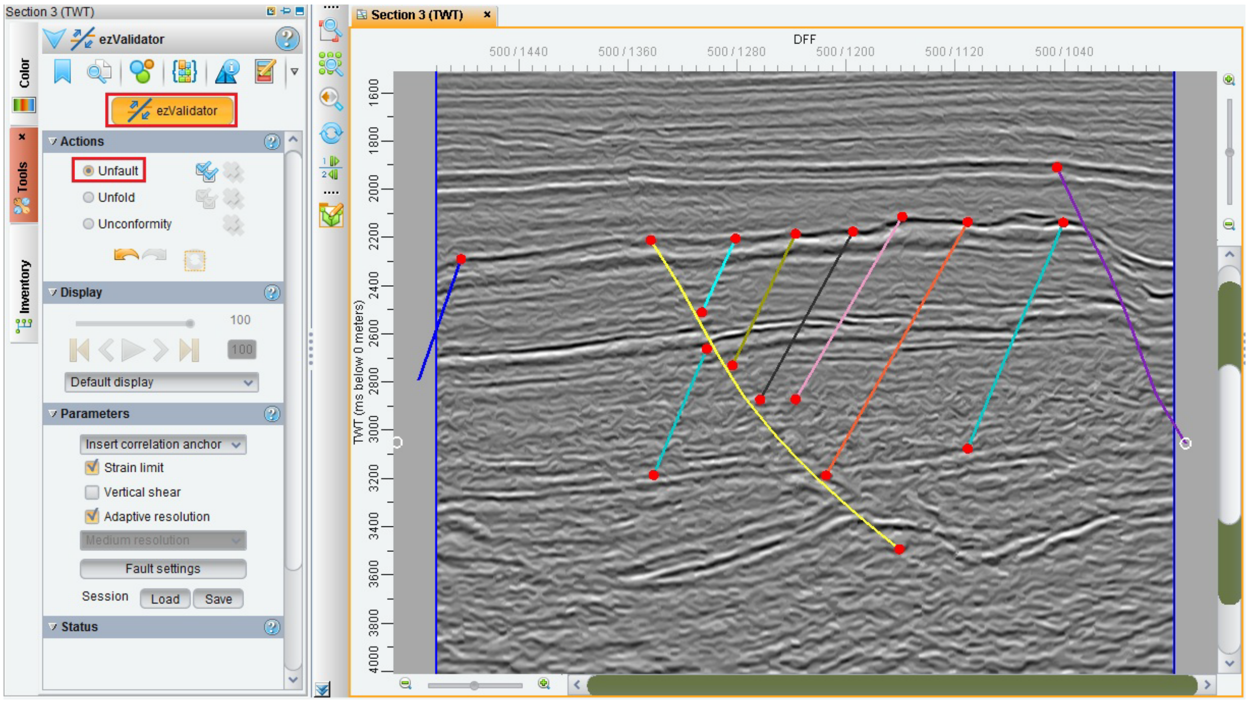


17. Click the *Tools* tab. From the icon bar at the top of the pane, click the **ezValidator** icon. If the icon is hidden, you may need to click the down arrow at the end of the bar to see it.

18. Click the **ezValidator** button to enter ezValidator mode.



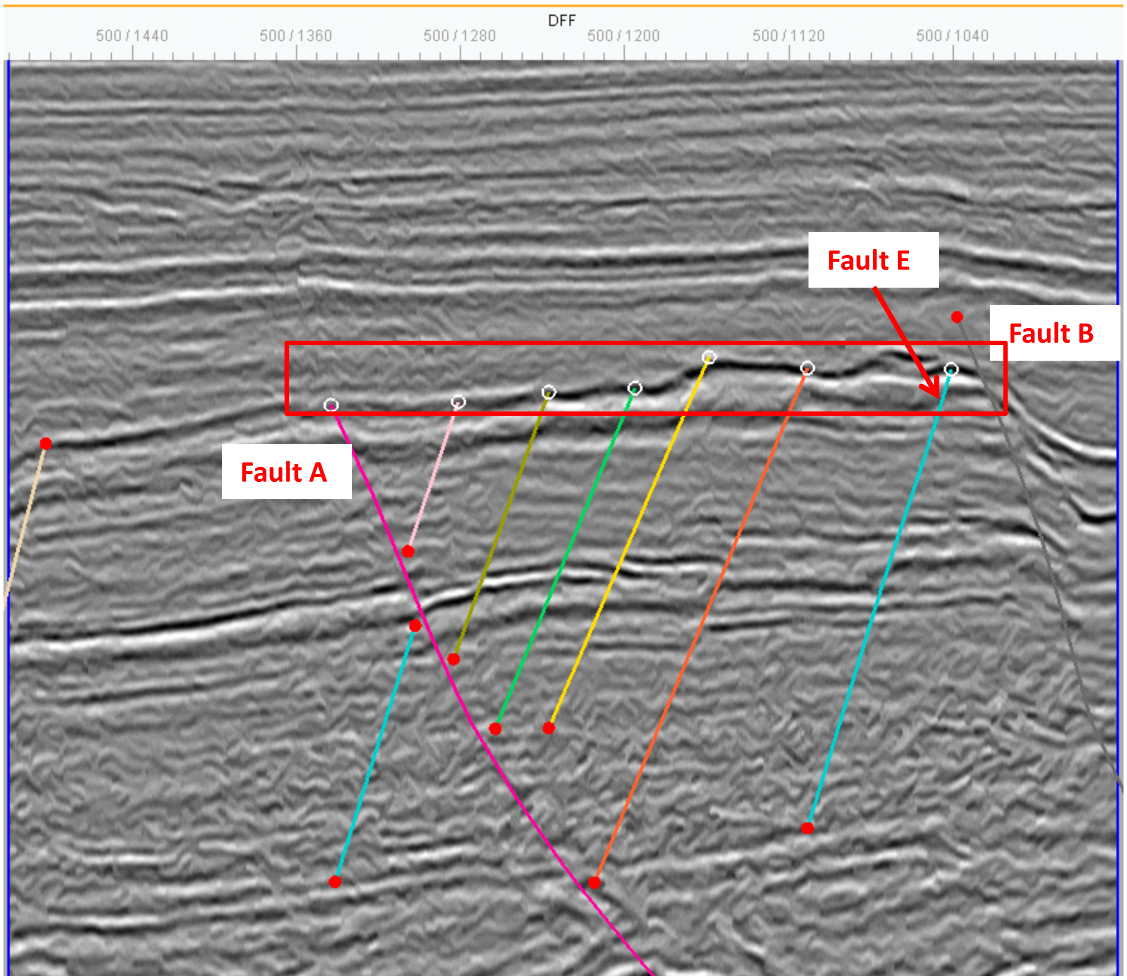
19. Click the **Unfault** option in the *Actions* pane. By default, all the faults will appear with red circles at the fault tips.



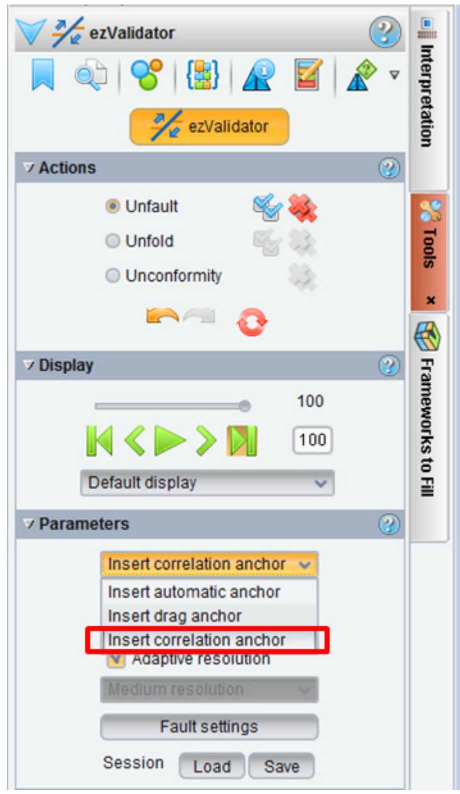
You can set the fault tip anchor to active (filled red circle), above which there is no relative movement of the seismic. You can make the fault tip anchor inactive (white circle with no fill), which allows the fault adjustment to continue higher in the section. You will use the inactive anchor at an unconformity (04_Base_Cretaceous) where, before erosion, throw did extend above the unconformity surface. By allowing throw at the top of the fault, the throw below is handled correctly. For now, you will focus your interpretation below the unconformity and ignore the faulted data above the unconformity.

In the next steps, you will inactivate the fault tip anchors on some faults and then unfault the section.

20. Put your cursor over **Fault_A** (parent fault on left) to highlight the fault. Its color changes to yellow. Click **MB2** on the **red circle** at the top of the fault to change the anchor. The tip will become a white circle, indicating that the fault anchor is inactive. Repeat this operation for the six faults to the right, but not the large Fault_B at the right side of the section. The section should appear as in the image below.

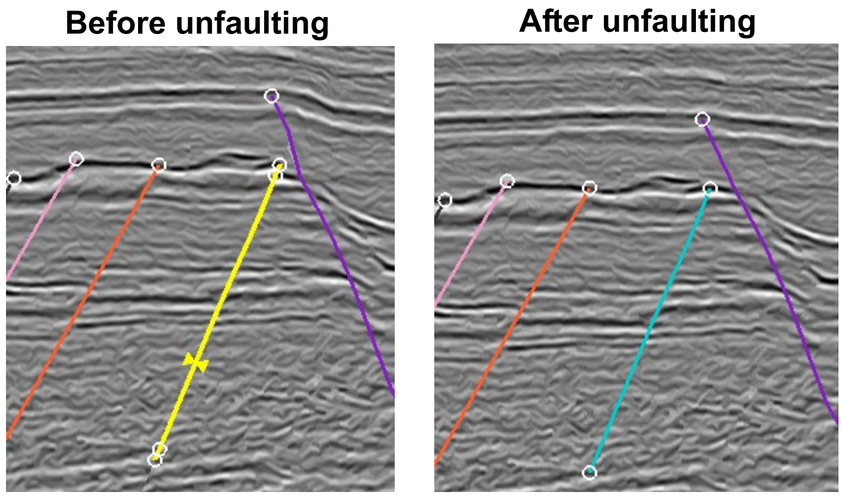


21. In the *Parameters* sub-panel (within the *ezValidator* task pane), click the drop-down and select the **Insert Correlation anchor** option. Place your cursor over **Fault_E.** It will become outlined in yellow, and the section will be ready for adjustment.



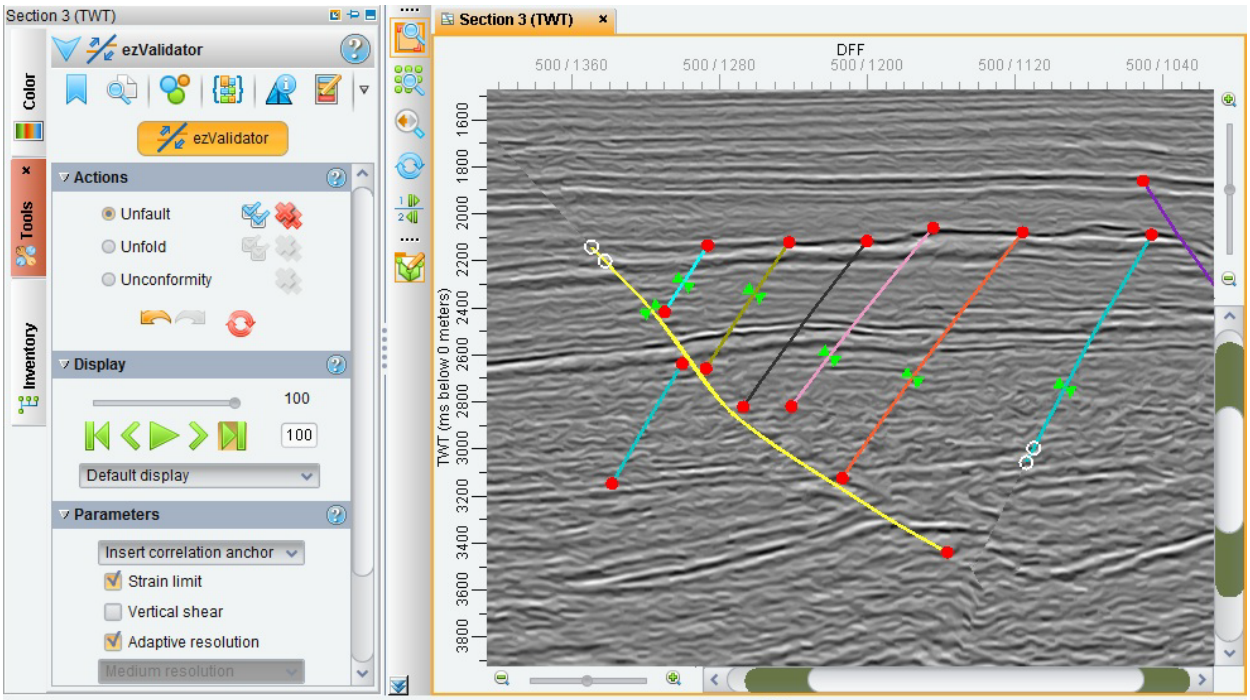
You will enter the throw on the fault, and the seismic will be adjusted to remove the throw.

22. Click a **reflector** on one side of the fault and a yellow arrow will appear to mark the spot. Click the same **reflector** on the other side of the fault. The seismic will be unfaulted to eliminate the fault offset.

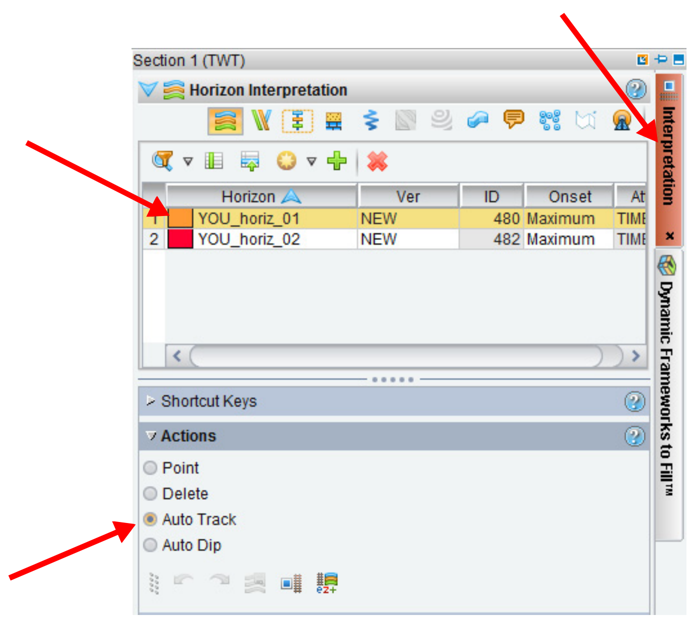


23. A small green triangle appears on each side of the fault. On one of the triangles, click **MB1** and drag to **slide it** up or down to find the best correlation. You can add more **correlation anchors** to stretch and squeeze the interval. Because the base of the fault has a solid red fault-tip anchor, there will be no offset. Therefore the region from the lowest correlation anchor to this deep anchor will be stretched or squeezed.

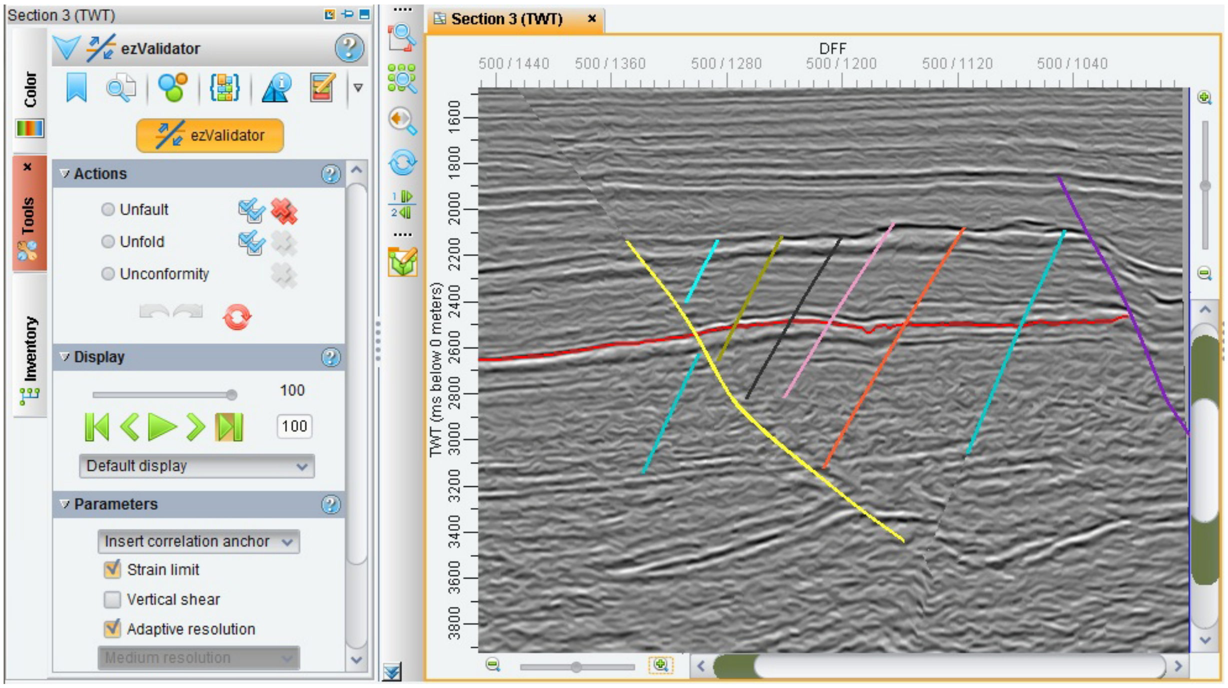
24. **Unfault** the entire section by repeating the procedure explained for **Fault_E** in **Fault_F**, **Fault_G**, **Fault_H**, **Fault_I**, **Fault_J**, and **Fault_A**. The image below shows one possible interpretation.



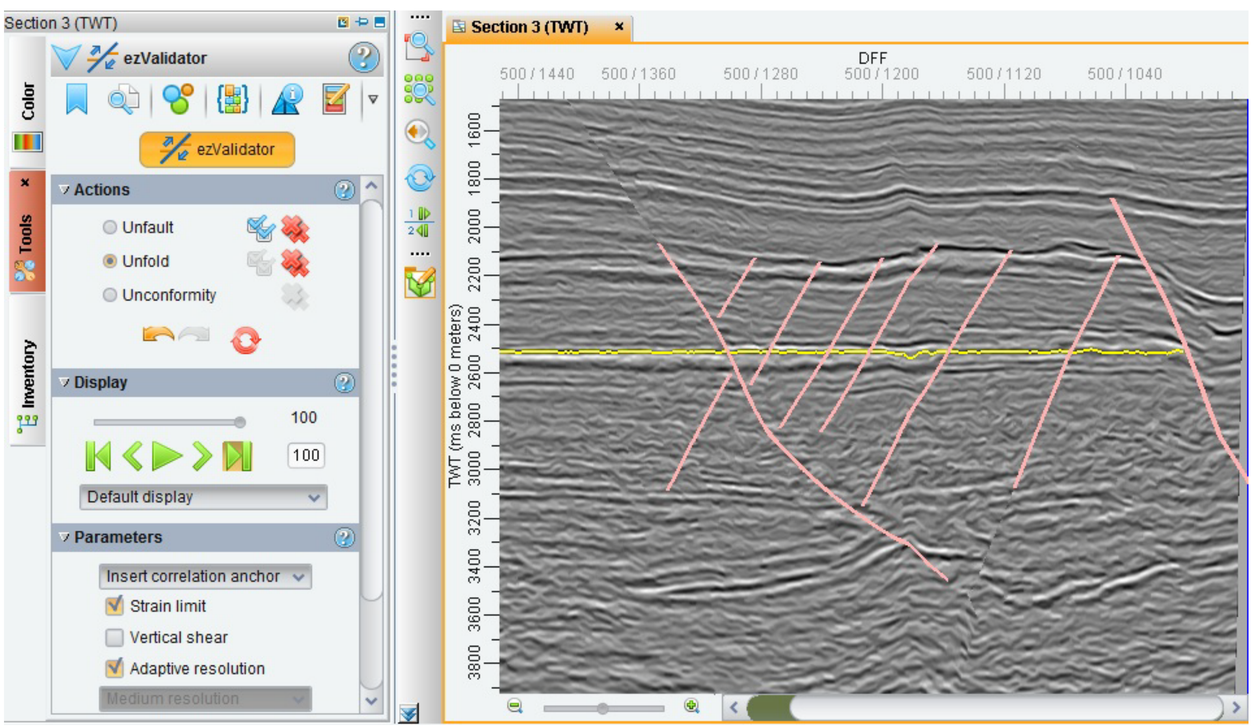
25. Do not exit **ezValidator**. Press <**h**> to open *Horizon Interpretation* view, and then select the Horizon **YOU_horiz_01**. In the *Actions* sub-panel select **Auto Track**.



26. Interpret the horizon that runs between **2500–2700** msec. Interpret on both sides of the fault as you interpret across the section.



27. Go back to the *ezValidator* task pane, and in the *Actions* section, select **Unfold**. Click the **horizon** that you just interpreted and you will see the section that is unfaulted and unfolded.

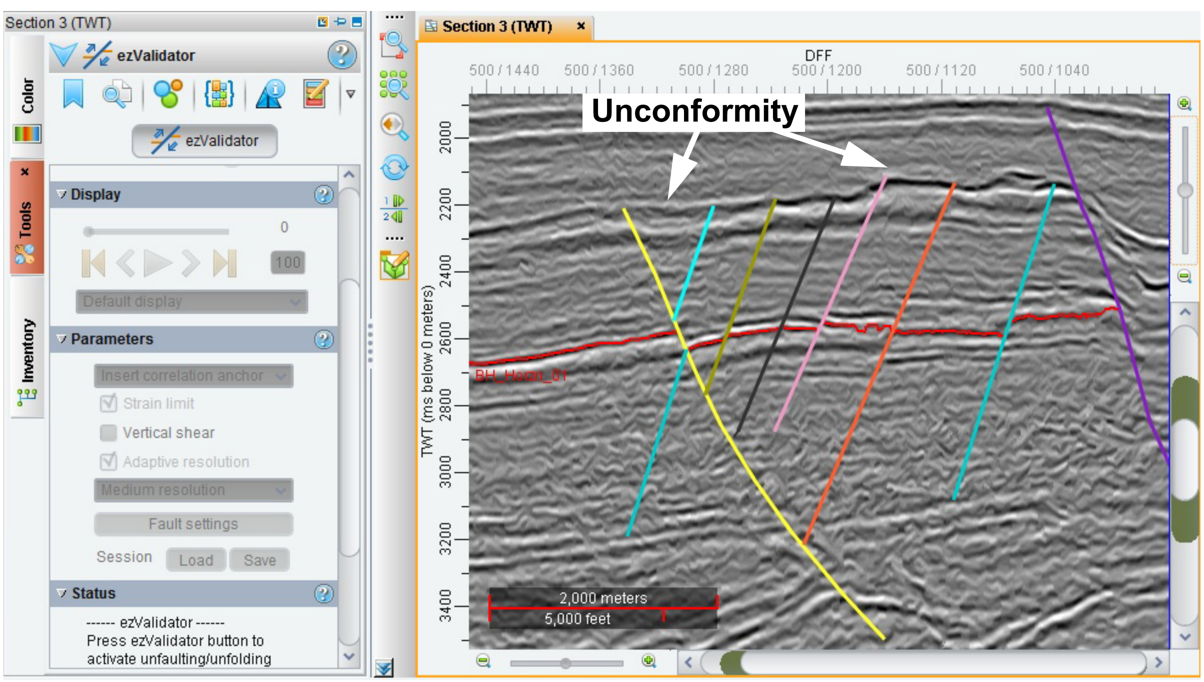


> **Note**
>
> While you are using this for a structural interpretation, you can see that Unfold can show you the stratigraphic changes across the structure. You can also observe how this is superior to the flattening workflow, because it doesn't create strange artifacts at the faults where gaps exist in the horizons.

28. To reset the Unfold, click the () icon in *ezValidator*. Then you can adjust your unfaulting, or interpret on another horizon and unfold it by activating the **Unfault** and/or **Unfold** radio buttons.

29. Click the **ezValidator** button to exit ezValidator mode. The section will return to normal and you will see your faulted interpretation.

30. In the *Section* view on inline 500, pick **YOU_horiz_02** on the unconformity, as shown in the figure below.

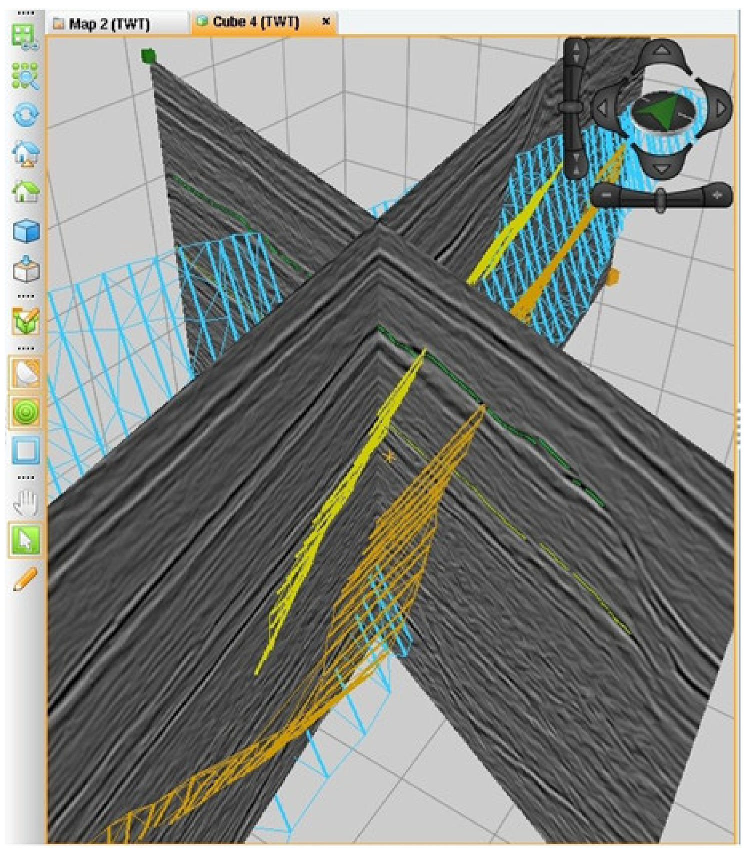


Extending the Interpretation on Arbitrary Lines

The next logical step is to expand the interpretation from that line by picking the horizon on intersecting cross sections. A good approach is to stay within fault blocks where the horizon should be more consistent. An arbitrary line can be used in cases (like this one) where fault blocks do not align with inline or crossline directions.

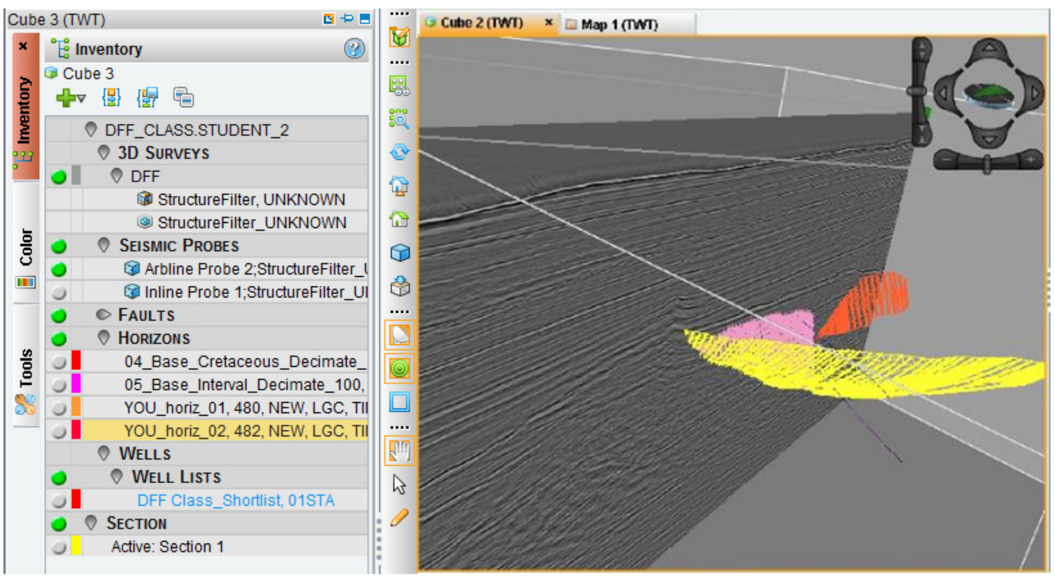
Because of limited time in this course, you will only pick on one arbitrary line. In a usual interpretation you may pick quite a few lines or even a course grid before using auto-picking to fill in the interpretation.

31. On the window containing the *Map* view, activate the *Cube* tab. Ensure that the inline and arbline probes are turned on. Move the inline to **500** and display your two interpreted horizons. Turn off **all faults** except faults **A**, **F**, and **G**. Using the probe handles, crop both probes vertically to the extent of the faults (1800-3500 msec). Your *Cube* view should look something like shown below.

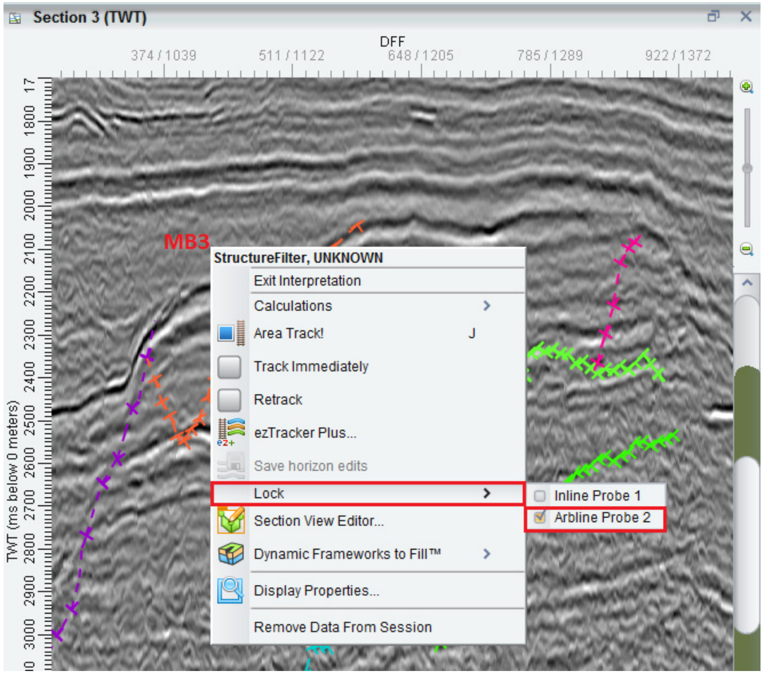


> **Note**
>
> To crop the probes, you need to activate **Select/Drag mode** in *Cube* View ( ). Then you can drag the probe handles to the desired position. Turn back on **Pan/Zoom/Rotate mode** ( ) when finished. You can also switch between the two modes by double clicking on an empty space in *Cube* view.

32. Rotate the arbline (using **Shift+MB2**) until it is parallel with the elongate fault block between **Fault_F** and **Fault_G**. Then use the **Step Forward** and **Step Backward** icons in the upper icon bar to move the arbline probe to be centered in the fault block as shown below.

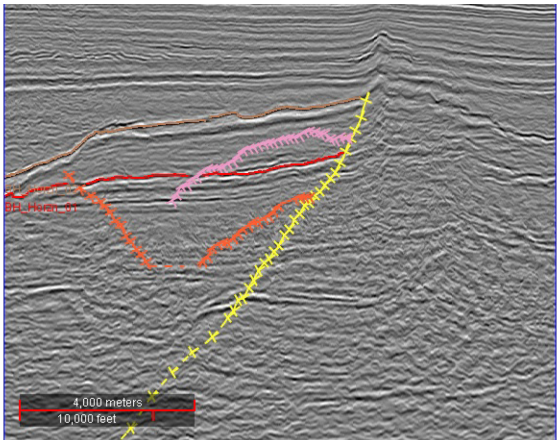


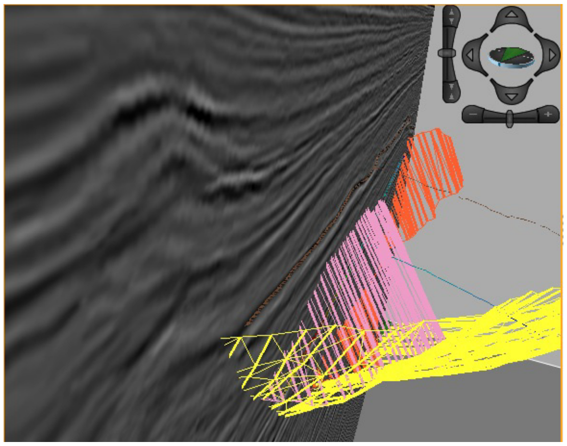
33. In the other DecisionSpace window in *Section* view, lock the section to the arbitrary probe (**MB3** on a section and select **Lock > Arbline Probe 2**).



34. On this arbline section, pick the **YOU_horiz_01** horizon in the fault block.

35. On this same arbitrary line, pick **YOU_horiz_02** on the unconformity above **Fault_G**.





36. Move the arbitrary probe using the **Step** icons or **Shift + MB1** so they are centered in a different fault block. Pick both of your horizons on this section. Continue on other fault blocks. Check your progress on the *Map* view.

Now that you have interpreted several lines, you can use the power of automatic tracking to fill in the interpretation, with the faults acting as boundaries.

Interpreting with Area Track!

In this exercise you have interpreted in *Section* view (both inline and arbline). In the next part of the exercise you will learn the advantages of interpretation on both the section and seismic probes, and the speed of automatic picking.

Using Area Track! to Extend Interpretation

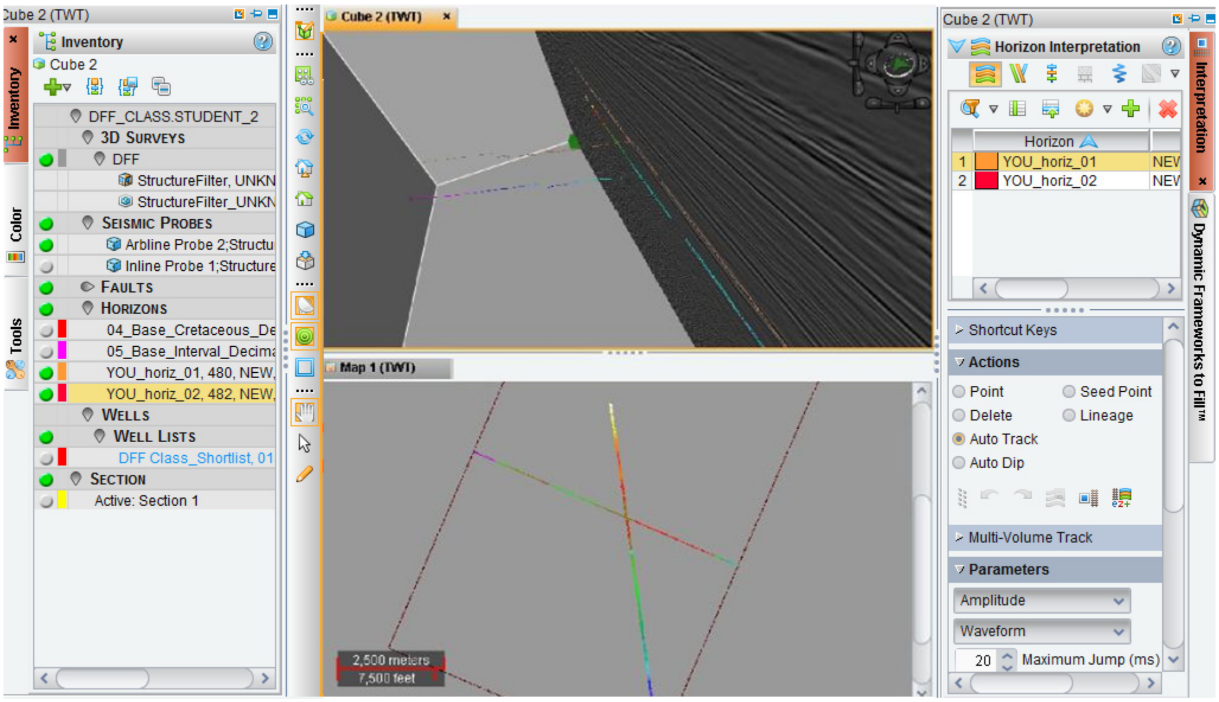
By using Area Track! you can automatically extend your interpretation of an active horizon for a specified area. The basic workflow is to interpret on a line. Area Track! follows the horizon perpendicularly from that line a specified number of lines. You then review the output in *Map* view, step to the edge of the tracked area, and track again. Once initialized, you can press <j> to track until you want to change settings.

If there is a problem with the tracked horizon (for instance, there is no data in a new fault block, or tracking has jumped up or down a reflector), you can re-interpret the section, then re-track using the corrected interpretation as input.

You can initiate the Area Track! option by putting your cursor on the seismic data in *Section* view or on the probe in *Cube* view, **MB3** and then selecting **Area Track!**. To have the Area Track! option available in the MB3 menu, ensure that you are in horizon interpretation mode and that the **pencil** icon is selected.

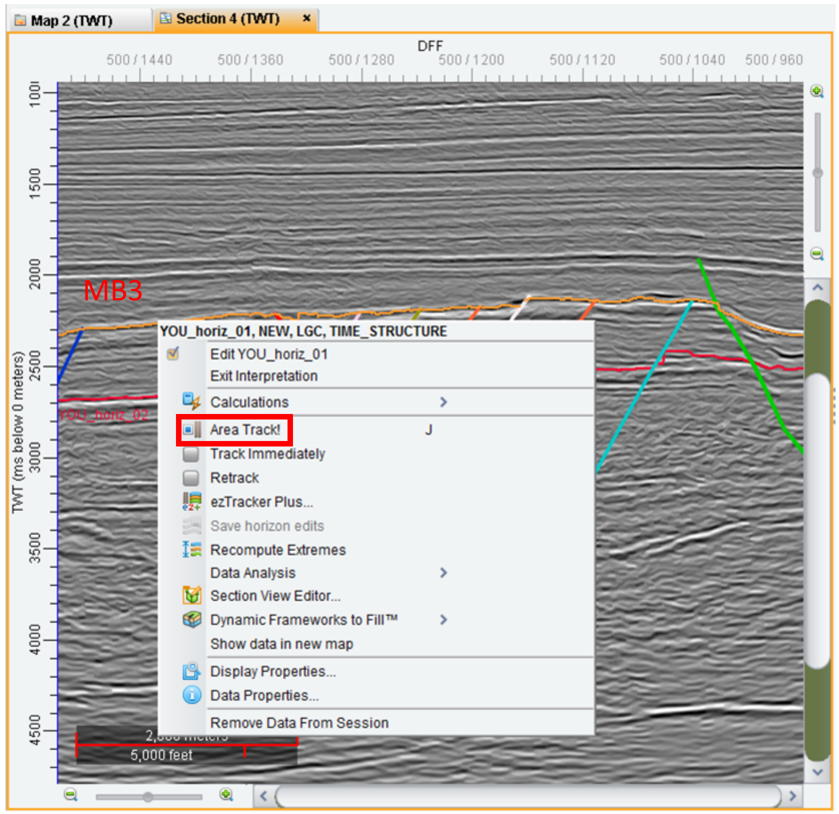
37. In the *Cube*/*Map* window, arrange your *Cube* and *Map* views so that they are on top of one another.

38. In *Cube* view, display only the inline probe and horizons **YOU_horiz_01** and **YOU_horiz_02**. Click the *Map* view tab and turn on **YOU_horiz_02**.

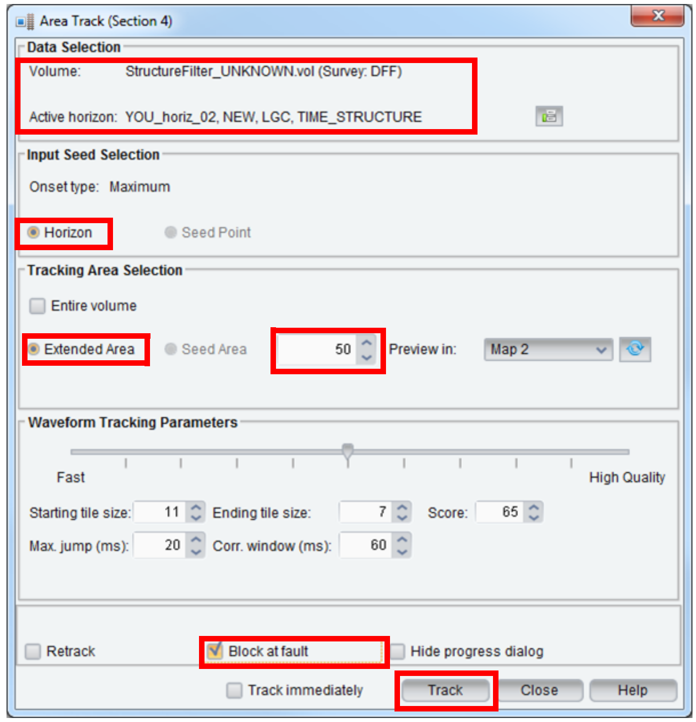


39. Lock your section display with the inline probe that is displayed in the *Cube* view. Move the *Section* view to inline **500** and set the Increment to **50**.

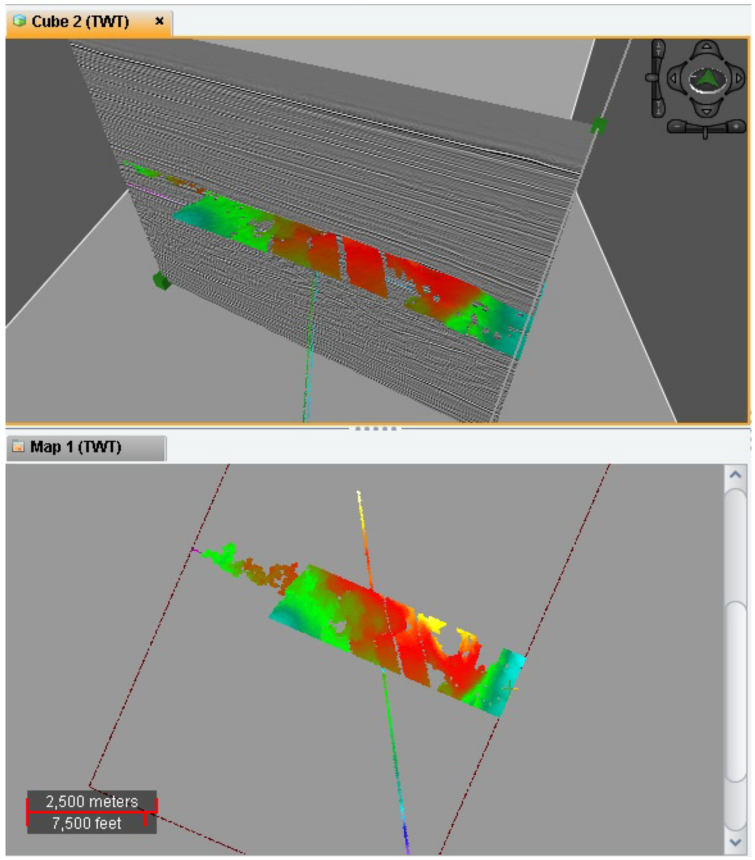
40. In *Section* view, ensure that you are in Interpretation mode, **MB3** and then select **Area Track!**.



41. In the *Area Track* dialog box, set the parameters as shown below, and then click **Track**. Notice that the active horizon should be **YOU_horiz_02**.

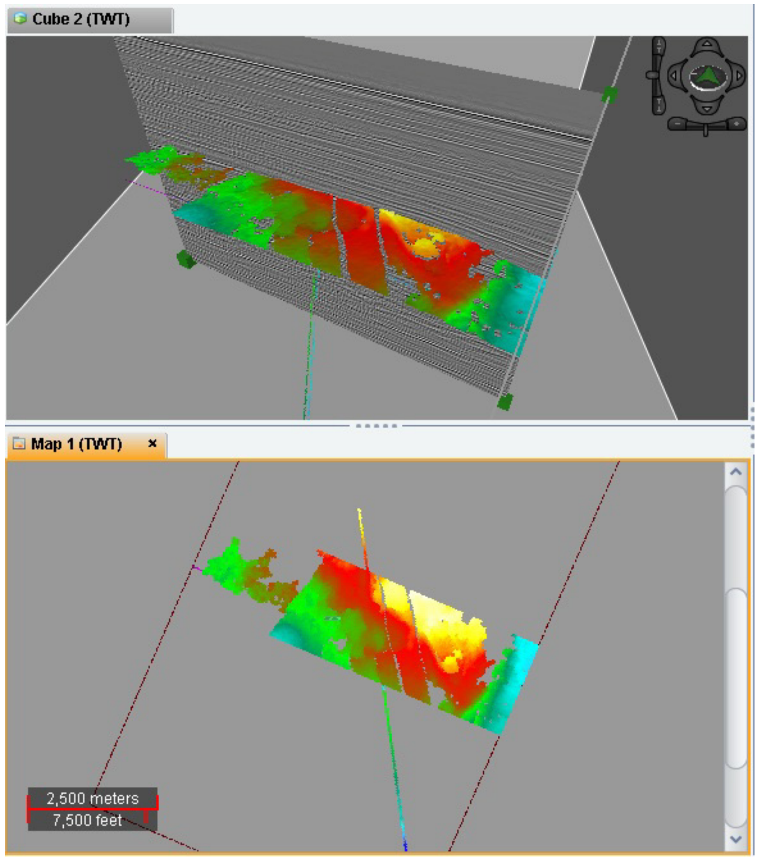


42. In the *Cube* and *Map* views, observe the tracked area.

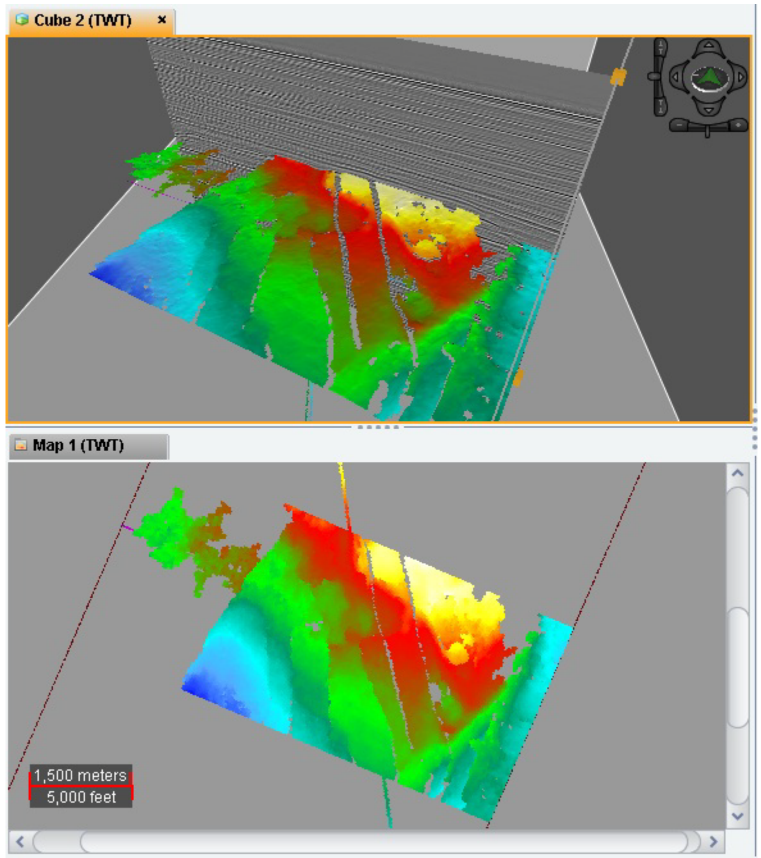


43. In *Section* view, move to **inline 550**. Using auto track, touch up the horizon. The interpretation should have some picks in every fault block.

44. Press hotkey **<j>**. The Area Track! will be extended to cover 50 more lines to inline 600. View the results in the *Cube* and *Map* views. Note how your edits allowed for some filling in of the previous Area Track! results.



45. Repeat the above procedure for inlines 450 and 400. Your results should look similar to those shown below.



46. Repeat the horizon interpretation workflow, to interpret the **YOU_horiz_01** horizon in the *Section* and *Cube* views.

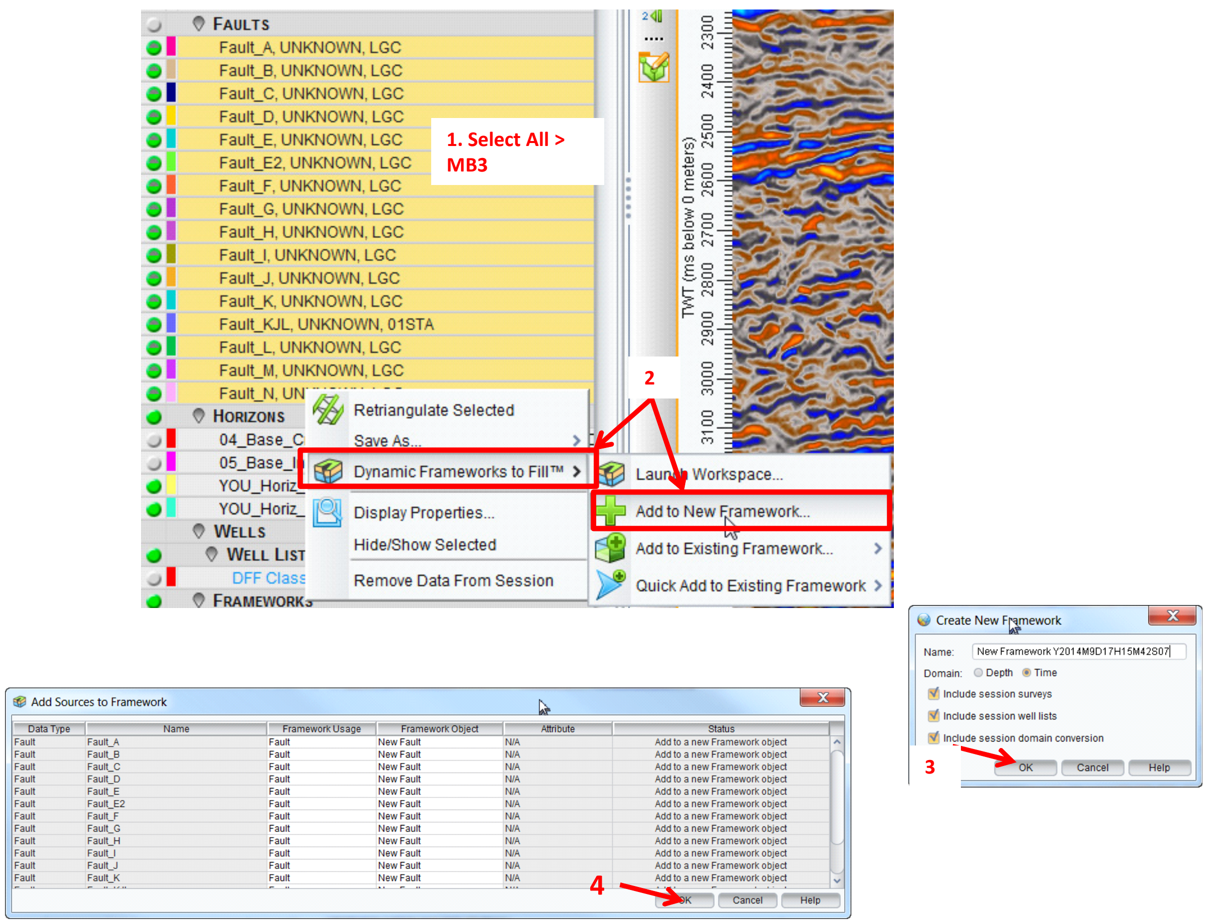
47. When you finish, close all the *Auto Track* related windows.

Interpreting with Frameworks

You will now create a framework with your just-picked horizons and the faults. Then you will use the frameworks to quickly interpret the horizons in more of your area.

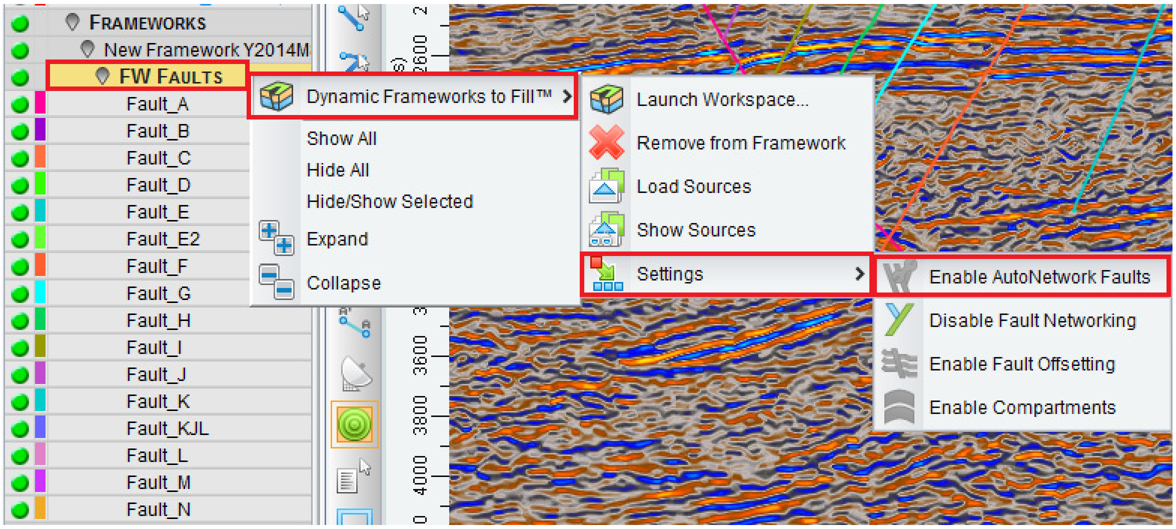
48. In *Section* view, display inline **550**. Hide all faults.

49. From the *Inventory* task pane, select all faults and add them to a new framework. Accept all the defaults and click **OK** in the *Create New Framework* and *Add Sources to Framework* windows.

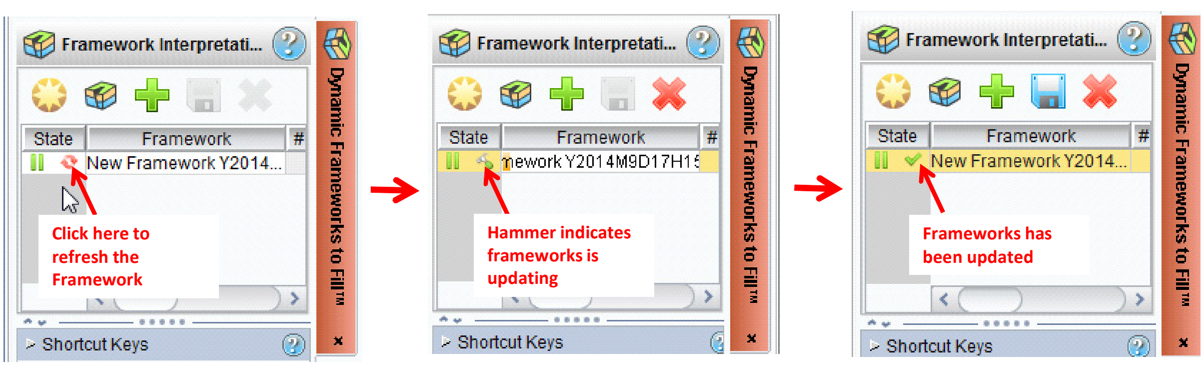


The seismic faults are now framework faults and visible on the section. The right task pane of the *Frameworks to Fill* tab is now active.

50. **MB3** on **FW_FAULTS**, and then select **Dynamic Frameworks to Fill > Settings > Enable AutoNetwork Faults**.



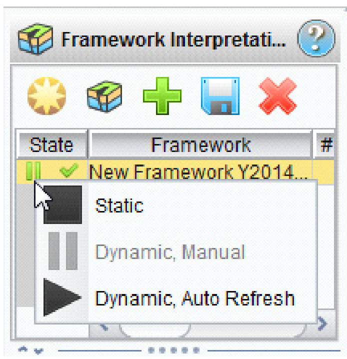
51. Refresh your framework by going to the *Dynamic Frameworks to Fill* task pane. Notice that under the State column there is a Refresh () symbol. Click it to refresh your framework. See the picture below for additional explanation.



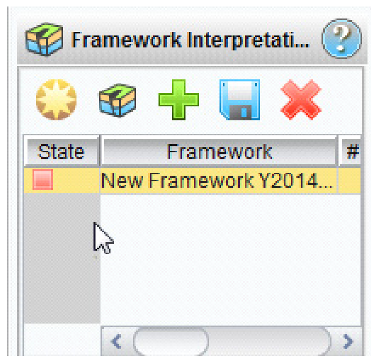
Note

When you create a Framework, the default is to be in **Dynamic, Manual** mode. This means that the framework is listening all the changes in the database and source interpretation; however, in this mode the framework won't update until you manually refresh the framework by clicking on the refresh symbol ( ) as it was explained in the previous step. Other mode is **Static**, here the framework is not listening any changes in the database or source interpretation. Finally, there is the **Dynamic, Auto Refresh** mode, with this option, the framework will update dynamically as soon as there are changes in source data or interpretation. In this mode it is not necessary that you refresh your framework, it will happen automatically.

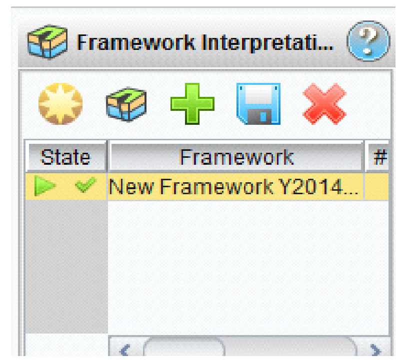
To switch between the different modes you need to click the Pause symbol ( ) to access the other modes and select the desired one.



1. Dynamic, Manual mode. **MB1** on **pause** symbol to access other modes



2. Static mode.

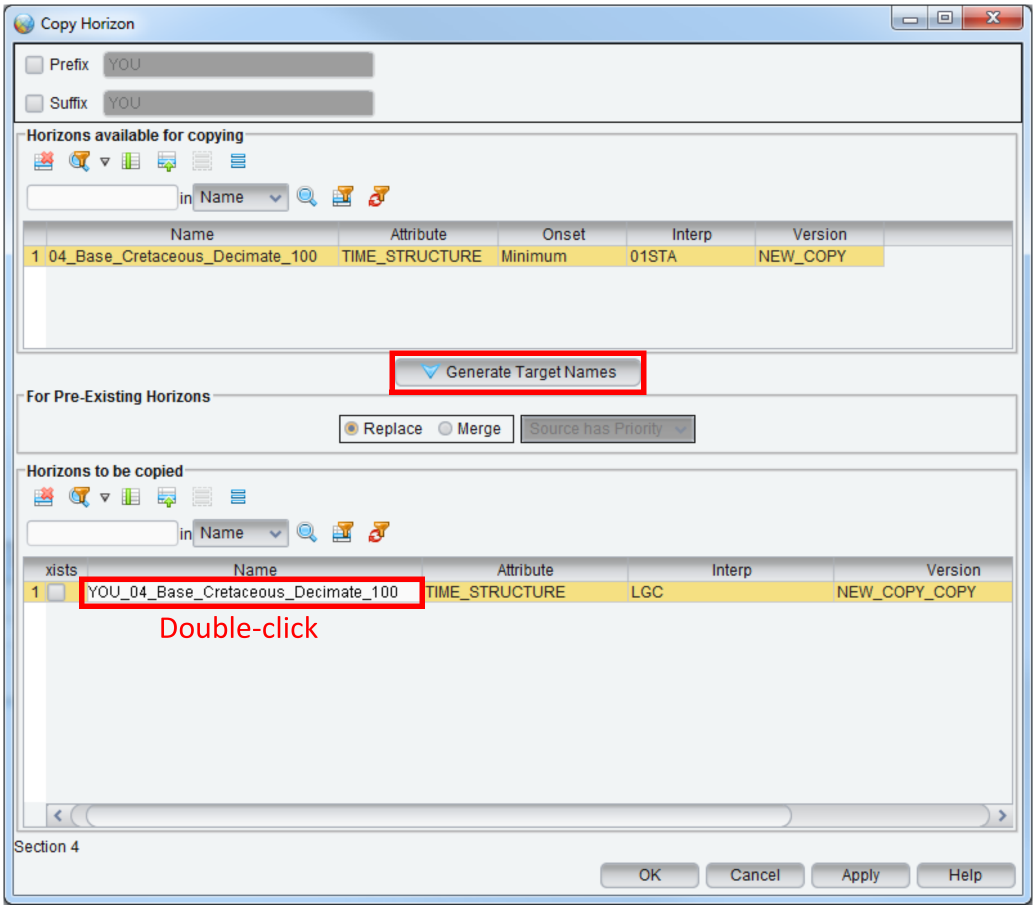


3. Dynamic, Auto Refresh mode.

52. In the window with the *Map* and *Cube* views, drag the *Cube* tab down over the *Map* to create one pane showing the *Cube* view.

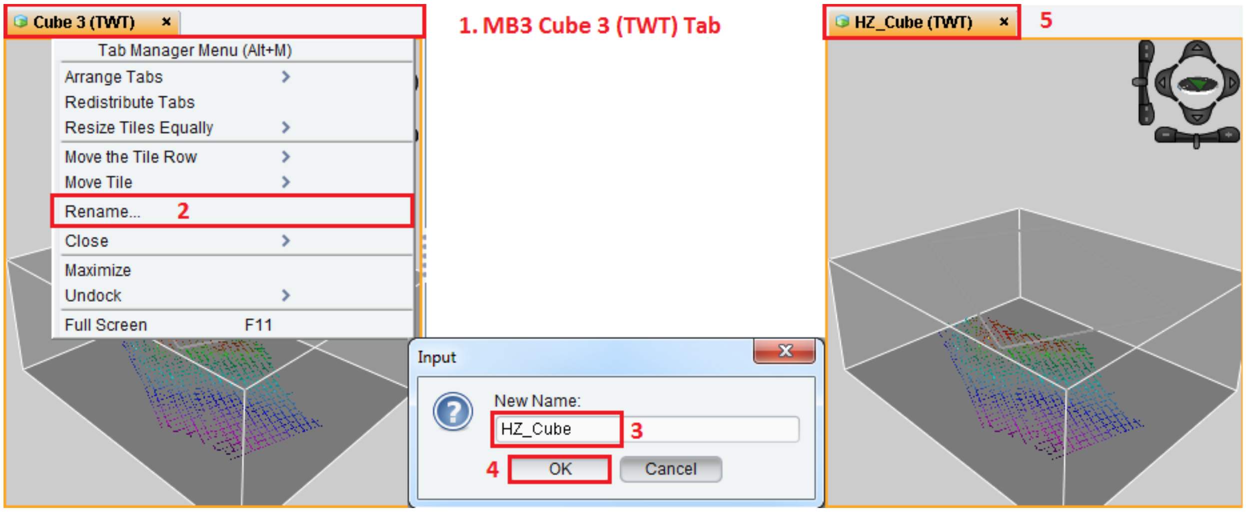
Your picking of **YOU_horiz_02** was quick and incomplete. A more mature interpretation of this unconformity is **04_Base_Cretaceous**. To save time in this short class, you will use this pre-picked horizon. First you will copy this horizon so you do not change the original.

53. Add the **04_Base Cretaceous_Decimate_100** horizon to your session if it is not already there. Make a copy of that horizon (in the *Inventory* task pane, **MB3** on the horizon and then select **Save As > Copy**). Add the prefix **YOU** to differentiate it from the original.

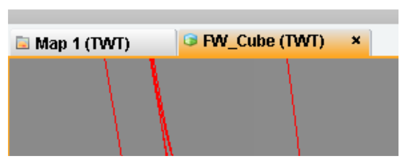


You will now set up *Cube* views on both DecisionSpace windows. The window with the *Section* and *Cube* views is now designated the Horizon *Cube*. After a little set-up, you will interpret in that window. The window with the *Map* and *Cube* views is now designated the Framework *Cube*. There you will see the model update, based on your interpretation changes.

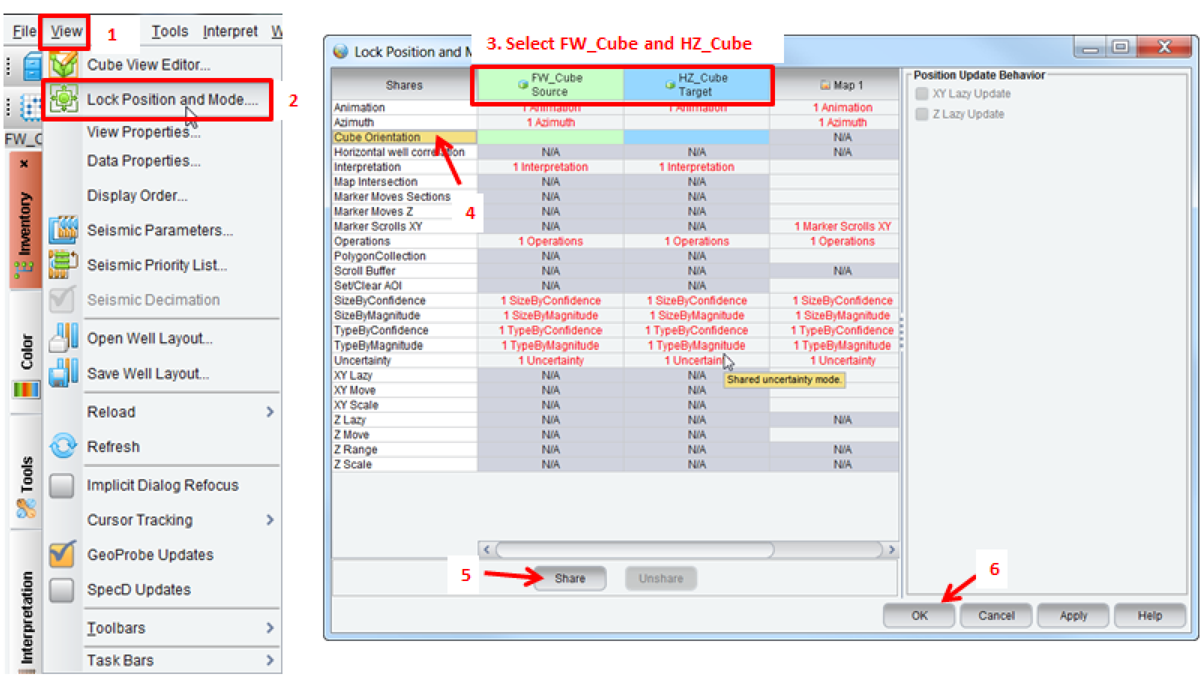
54. Rename the *Cube* view tab in the window with the *Section* and *Cube* views to “**HZ_Cube**.”



55. In the same way, rename the *Cube* view tab in the window with the *Map* and *Cube* views to “**FW_Cube**.*”*



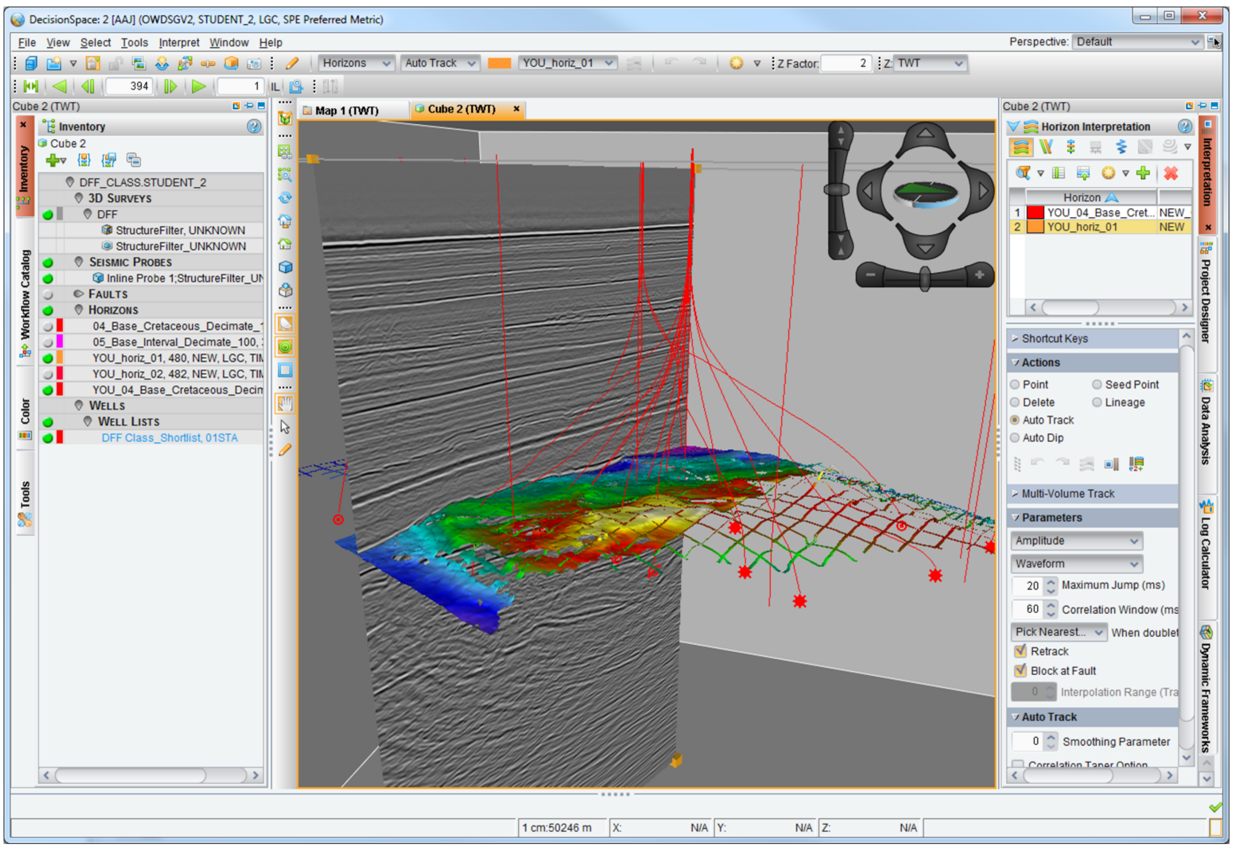
56. Share the orientation of *HZ_Cube* view and *FW_Cube* view. (**View > Lock Position and Mode**).



Working in the Horizon *Cube*

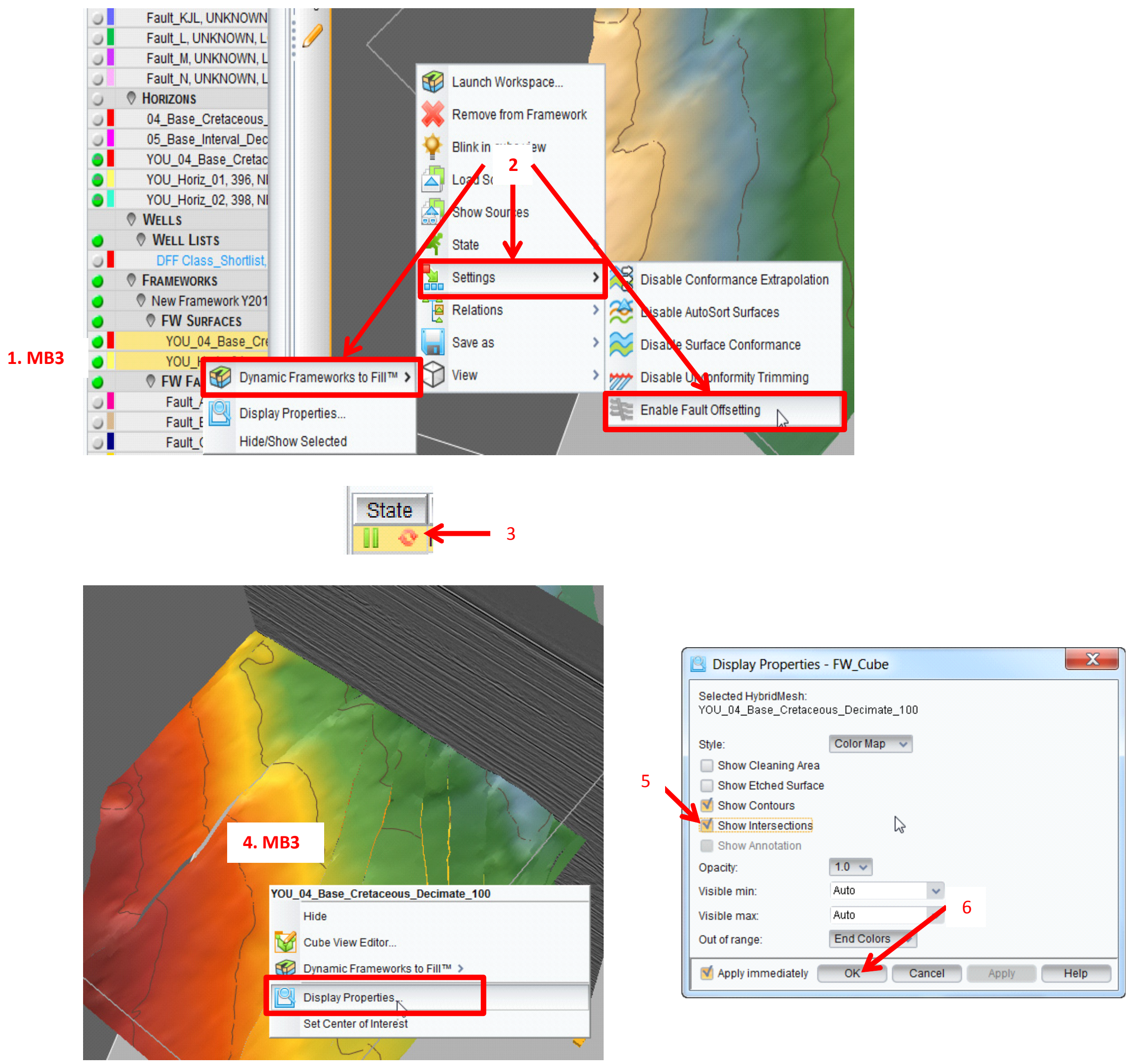
57. In the window containing the *HZ_Cube* tab, display only the arbline probe (turn off all other probes) and the **YOU_04_Base_Cretaceous** and **YOU_horiz_01** horizons. Add these horizons to the active framework as new objects (default), and then refresh the framework ( ). The framework surfaces may appear in the active *HZ_Cube* view; if that is the case, turn the framework surfaces off. We will visualize the framework surfaces in the Framework cube in the following steps (*FW_Cube* tab).

    Turn on the well list **DFF_Class_Shortlist**. In the *Color* tab, for the **StructureFilter_ATTRIBUTES** volume select **Color Map > System > 3_Magic**.

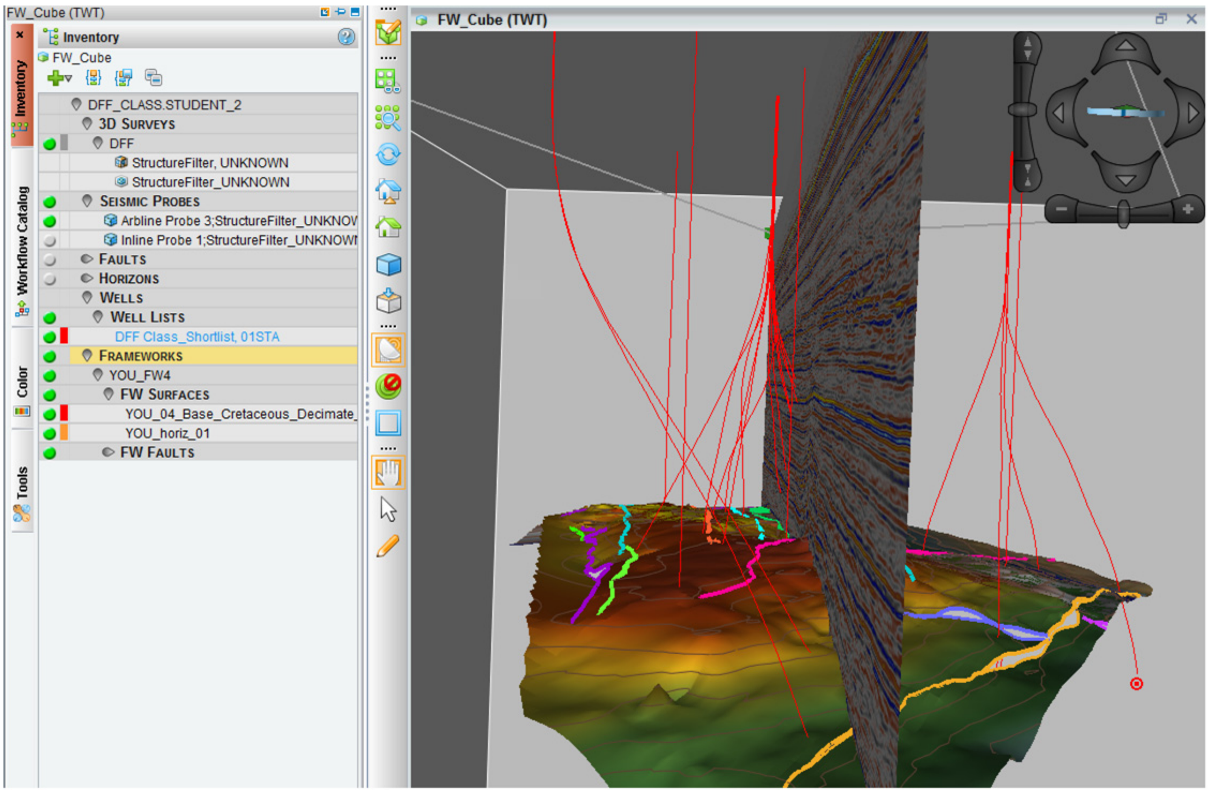


Working in the Framework *Cube*

58. In the window containing the *FW_Cube* tab, turn off the **HORIZONS** and turn on the **SURFACES_FW**. The framework surfaces will be displayed with contours. To display the fault polygons over the horizons, you need to enable fault offsetting and intersections. From the *Inventory* task pane, **MB3** on any of the framework objects, then select **Dynamic Frameworks to Fill > Settings > Enable Fault Offsetting**. Refresh your Framework. Once your framework is updated, **MB3** over the surface, select **Display Properties**, and then activate **Show Intersections**. Follow the sequence in the picture below.



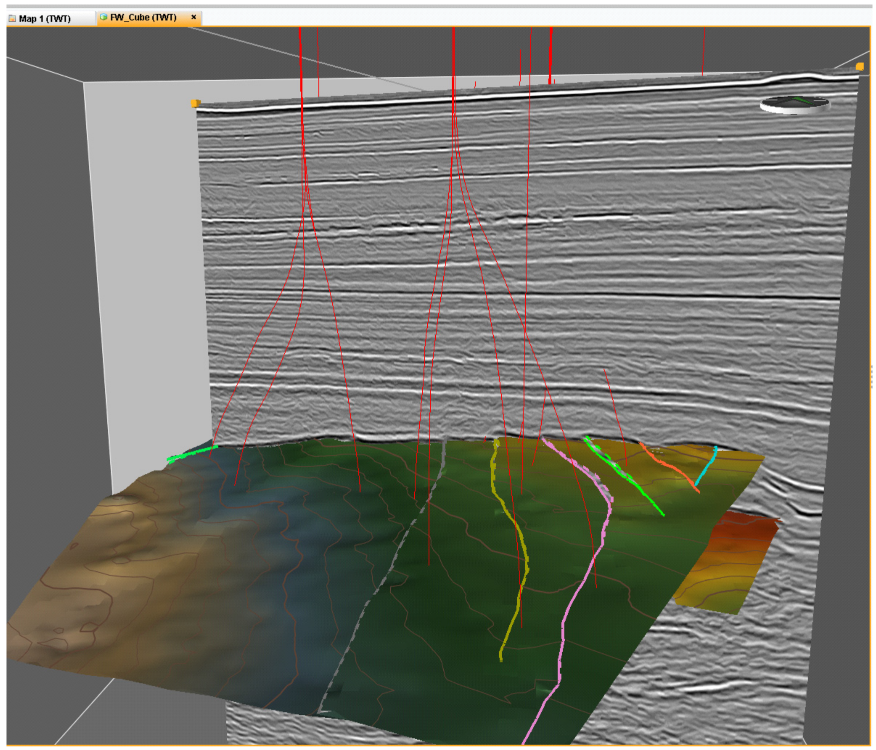
59. Again, turn on the well list **DFF_Class_Shortlist**. In the *Color* tab, for the **StructureFilter_ATTRIBUTES** volume, select **Color Map > System > 3_Magic**. Display only the arbline probe; turn off all other probes.



In the Framework *Cube*, you should see two preliminary maps covering the area interpreted so far: a complete interpretation for the **YOU_04_Base_Cretaceous** and a partial interpretation on **YOU_horiz_01**. The fault traces were created and displayed because you already loaded faults to the framework.

60. In the *FW_Cube* view, **MB3** on the arbline probe, and then select **Lock > Active: Section N**.

61. Test the linkage by moving the arbline with **Shift+MB1**. Then try rotating it with **Shift+MB2**. Try to align the arbitrary line so it lies mostly in one fault block (see the figure below). This should allow a continuous interpretation for that block.



You will do the interpretation in the Horizon *Cube* and check the results (after a framework update) in the Framework *Cube*. Remember, your framework is in **Dynamic, Manual** mode.

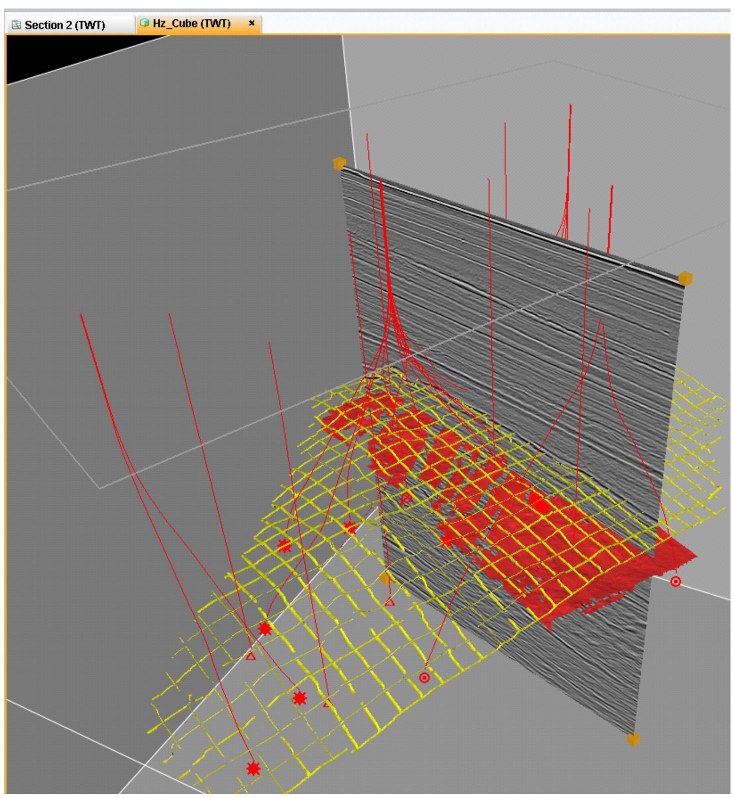
Reviewing Hotkeys for Cube View Interpretation

Before you perform more interpretation, review the following list of hotkeys. These hotkeys can be important in making your interpretation faster and easier.

- **M** – Resets the center of interest for rotation and pan. Place the cursor over an object at the point you want to re-center and press the M key.
- **F12** – Turns Interpretation mode on and off. You can also turn Interpretation mode on and off by clicking the orange **pencil** icon on the interpretation toolbar or on the navigation toolbar. When you leave Interpretation mode, you are back in the mode (hand or pointer) that you were in when you entered Interpretation mode.

- **Alt** (hold down) – Allows you to go to hand mode while still interpreting. Use this mode to rotate, zoom, or pan without leaving Interpretation mode. Release the alt key to return to Interpretation mode.
- **Shift+MB1** – Moves a probe face. You can implement this command from any mode.
- **Shift+MB2** – Rotates an arbitrary probe. You can implement this command from any mode.
- **D** – To enter the delete mode.
- **T** – To enter the auto-track mode.
- **J** – Runs Area Track!
- Double-click any blank space — Toggles between hand and pointer mode.

62. In the *HZ_Cube* view, change the color of both horizons to any solid color. (**MB3** on horizons, and select **Display Properties**. In *Display Properties*, change to a solid color.)



DecisionSpace allows you to use other available *Cube* views to interpret a different horizon or to use a different probe to interpret the same horizon. For example, you could:

- Interpret the **YOU_horiz_1** on one *Cube* view and the **YOU_horiz_2** on the other.
- Interpret on inlines on one *Cube* view and cross lines on the other; or make your arbline perpendicular to the main faults, then parallel to the fault blocks.
- Interpret with faults in one *Cube* view and horizons in another *Cube* view.

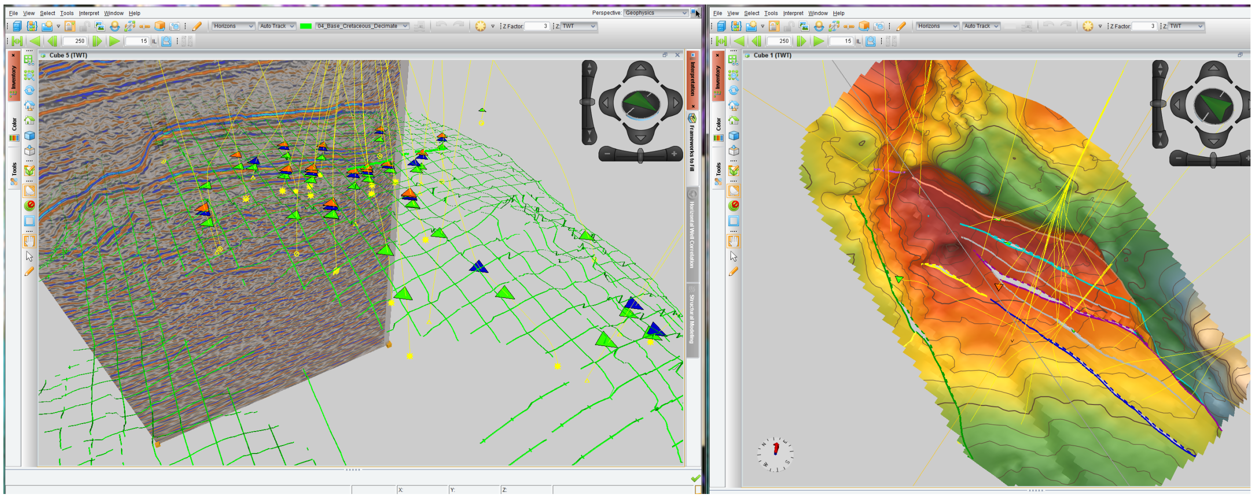
You may want to review the Overview preceding this exercise, which explains how the framework mapping algorithms grid surface data that bisect fault planes. In effect, the software will generate fault-polygons around fault planes and grid the surface by fault block. Surfaces are projected into the fault-block bounding faults, were they are subsequently truncated. As you refresh your framework, watch your fault polygons develop, as shown in the figure below.

63. Spend a few minutes interpreting **YOU_horiz_01** in the *HZ_Cube* view. After interpreting every few lines, with your cursor in the framework, **MB3** and select **Dynamic Frameworks to Fill > Refresh Framework** to update it. To see how the **YOU_horiz_01** framework surface is updating in the *FW_Cube* view, you may need to hide the framework surface **YOU_04_Base_Cretaceous**.

64. Look closely at the **YOU_horiz_01** framework surface. If the interpreted lines are far apart, ascertain if there are any holes within the framework surface. If holes exist, move the probe to that area and interpret more.

65. Turning on the clipping on the probe surface can be helpful. This limits the wells, horizons, and faults to be visible only near the probe surface. You may wish to turn on the **FAULTS_FW** and **Wells**.

66. After every few lines of interpretation, go to the *FW_Cube* view and refresh it to see how well the interpretation is filling in. Note that horizon detail is increasing. Fix any mis-ties by overlaying the horizon and then editing or deleting sections and re-interpreting. Note the fault polygons being refined as you fill in the framework.



Overview: Velocity Modeling

Introduction

The DecisionSpace Velocity Modeling tool is a powerful means for creating and editing 3D velocity models. With the Velocity Modeling software you can quickly build geologically constrained velocity models for time-depth domain conversion or seismic depth migration. Velocity Modeling handles complex models that incorporate faulted frameworks to define a structural framework. It also allows multi-Z salt bodies with the input of multiple top and base horizons. For simpler layered structures, Velocity Modeling uses horizons from the DecisionSpace software to build an erosional model that can include salt intrusions, if necessary. The background velocities can be constant velocities, analytic functions, velocity volumes, or velocities calculated from well information.

You can specify many geologic parameters to ensure that a model has accurate behavior between the wells. For example, velocities within particular structural compartments may be conformably constrained to a minimum or maximum value, or its resolution can be specified. This ensures that velocities are geologically reasonable when they are updated to tie your well picks or time-depth functions.

The basic format of the velocity model is a multi-resolution, non-artifact object with the following attributes:

- Corrects problems associated with gridded and triangulated models
- Handles multi-Z salt and other geobody shapes
- Handles faulted frameworks
- Handles both time and depth horizon input
- Handles basin scale models at high resolution
- Handles horizontal wells and inter-well hard points
- Has direct connection to the SeisSpace processing system

Input Data Types

The Velocity Modeling module guides you through a series of workflow steps that require input data from DecisionSpace or the OpenWorks database. You can use the following data types for the models structural framework:

- Time and depth horizons
- Time and depth faults
- Time and depth geobodies including multi-Z salt bodies
- Structural frameworks created in the Frameworks workflow

The structural elements are filled with velocities (or general attributes) that can be provided as:

- Constant values
- ASCII file values
- V_0+ k*Z analytical functions
- OpenWorks seismic formatted volumes
- OpenWorks velocity models
  (TDQ, DepthTeam Express, or DecisionSpace hybrid format)

You can use the following input to calibrate the velocity model to geologic markers:

- OpenWorks well picks
- OpenWorks time-depth “TD” functions

You can also use geologic layer parameters to constrain the velocity model:

- Min/Max velocity
- Interpolation type
- Horizontal and vertical grid resolution

By including so much interpretation information, the Velocity Modeling tool creates a geologically plausible model. The model will vary conformably with horizons, which are tied to the proper surface picks. Lithotype is used by assigning values to specific layers in a layer-based model, with surface picks assigned to those layer interfaces. The Velocity Modeling tool also has the ability to combine well time-depth curve data with salt bodies and faulted frameworks to make a robust imaging/depth conversion velocity model for complex, deep-water imaging.

Output Data Types

A volume in Hybrid Model format is the main output data type of the Velocity Modeling tool. The Hybrid Model format is a new technology that combines the advantages of densely sampled grids and sealed topological frameworks. It is a volume data format that is ideally suited for large-scale projects with embedded complex structures. You can display the Hybrid Model volumes and use them for domain conversion in DecisionSpace. Output Velocity Models are also used within the suite of SeisSpace processing tools. Note that a single Hybrid Model can store more than velocity values; it can also include multiple complementary attributes (such as porosity, density, and anisotropy parameters), each at its own resolution within distinct structural compartments.

Velocity Modeling also can generate SEG Y, shared memory, and OpenWorks brick volumes. As with brick volumes, Hybrid Models are stored within the OpenWorks database.

Apart from depth conversion and integrated geological and geophysical (G&G) interpretation, the velocity model has other uses:

- Seismic imaging (wave-equation-based pre-stack imaging)
- Seismic inversion
- Reservoir modeling
- Pore pressure prediction
- AVO, 4D, and fracture analysis

How the Hybrid Velocity Model is Calibrated

The following steps describe how the models are actually constructed and calibrated.

1. Define the resolution/grid and the conformance of each layer or framework compartment.

> **Note**
>
> Any layers that share the same formation will have continuous velocities across the layer boundaries, while still using the internal boundaries for guiding the interpolation.

2. Grid the seismic and/or analytic background velocities.

   All remaining calculations are performed on residual errors relative to this background model.

3. Break the TD curves into delta velocity bins filled from the deepest to shallowest TD point, including delta velocity at all pick locations.

4. Compute the delta velocity from the shallowest TD receiver to the surface.

5. Iterate to update the delta velocity to tie each well pick.

6. Interpolate the delta velocities to all bin locations and apply the deltas to the background seismic or analytic velocity.

   Note

   All interpolation/extrapolation is conformal using Shepard's reciprocal distance-squared weighting. Think of this conformal grid as many thin layers, each of which follows a conformal depth. The thickness of these thin layers is the vertical bin thickness. The spatial interpolation is continuous and shows no visible bin edges.

7. Optionally, you can further update the model with least-squares fitting.

   Least squares fitting will add no new features between wells, but will better distribute any errors between contradictory data. Least-squares fitting may be useful for frameworks such as faults, salt, and horizontal wells.

Exercise 1.4: Creating a Preliminary Velocity Model

This exercise introduces the Velocity Modeling tool. Your goal is to launch the module and initiate a velocity model with a few of the data input types previously described. Though velocity modeling is a key component of a successful framework process, do not consider this exercise a thorough exploration of DecisionSpace Velocity Modeling. Our overall focus in this course is the Dynamic Frameworks to Fill mapping method.

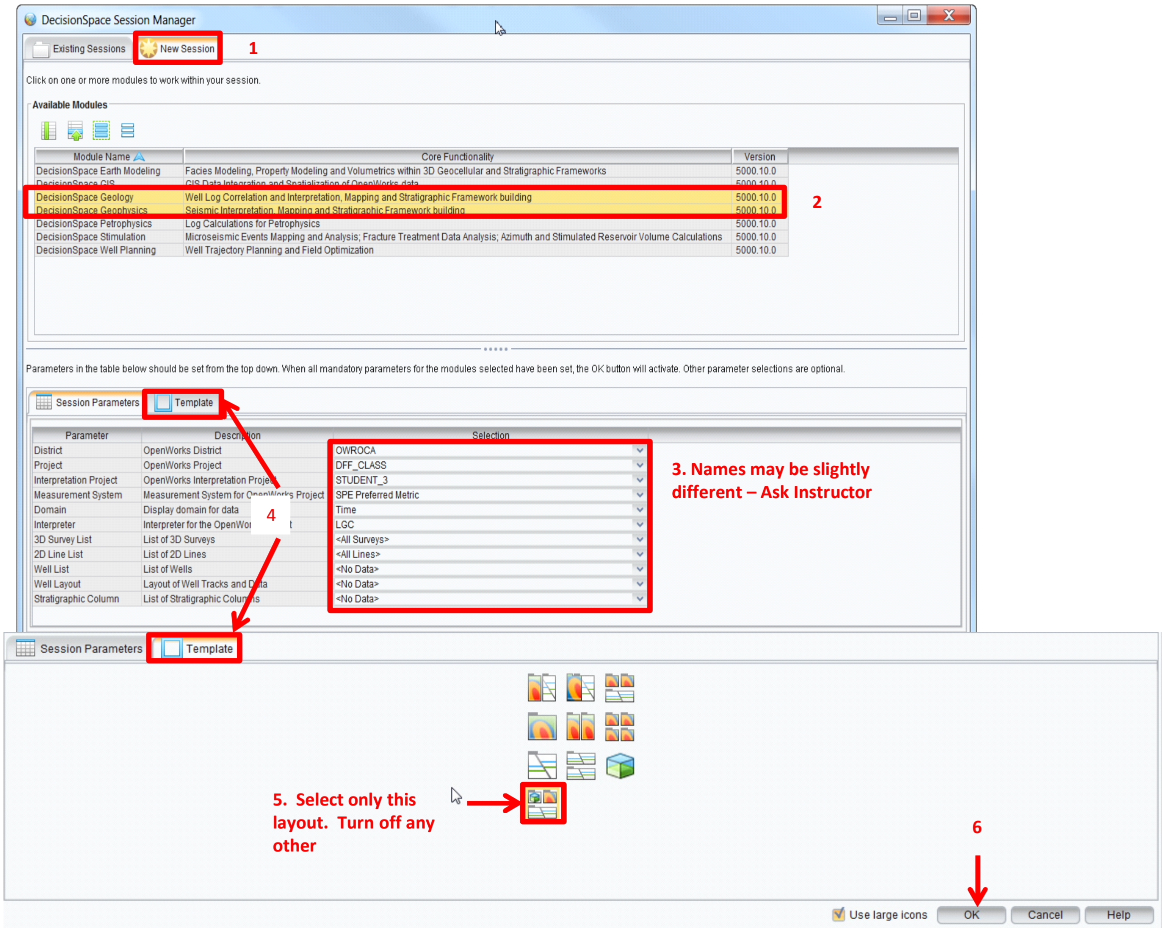
Your final model from this exercise will include TD functions, framework structure, and depth picks.

Initialize the Session

The only step in this section is to load the data that will be used for the velocity modeling exercise.

1. If DSG is open, close it. It is not necessary to save your previous work, we will start a brand new session for the Velocity Model workflow.

2. Create a new time domain session, selecting **DS Geology** and **DS Geophysics** licenses in the *New Session* tab. In the *Template* tab, select only the **Map/Section/Cube Triple Tile**.



3. Once DSG is open, select the following data objects for your session:

Seismic:	StructureFilter (amplitude) cmp
	(**3D Survey List** > **DFF** > **Seismic**)
Faults:	Faults: A, B, C, D, E, F, G, H, I, J, K, L, M, N
	(**Faults** > **Faults**)
Horizons:	01_Seabed_Decimate
	04_Base_Cretaceous_Decimate
	05_Base_Interval_Decimate
	(**Horizons** > **Horizons**)

Well List:	DFF Class_Shortlist (**Wells > Well Lists**)
Surface Picks:	FANGST GP. HD Top SM_12 (**Wells > Interpretation > Surface Picks**)

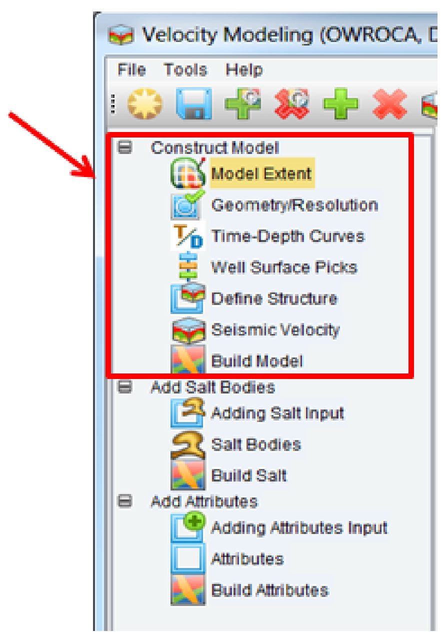
Add data to your session, if necessary, using the **Select Session Data** () icon and the *Select Session Data* dialog box. The data resides in the branch of the data tree specified above, within parentheses.

Create and QC a TD Function-Based Model

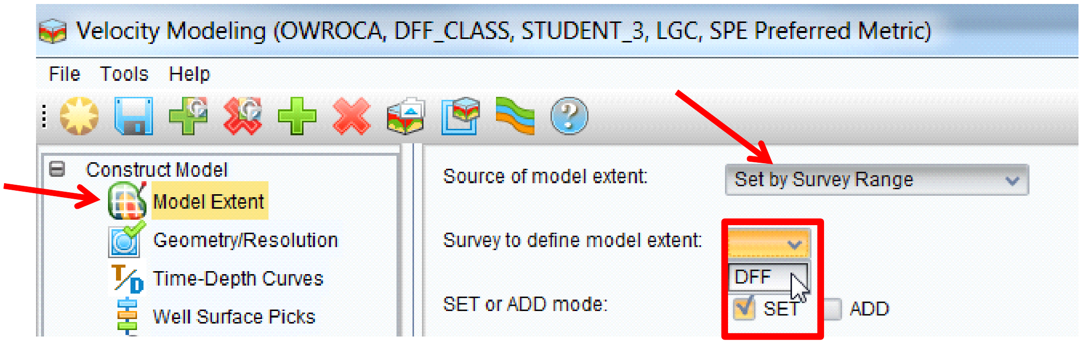
1. In the DecisionSpace main window top menu bar, select **Tools > Velocity Modeling...**.

2. In the *Velocity Modeling* dialog box, click **Create Model**.

   The Velocity Modeling program can include complex structures such as multi-Z salt bodies and attributes. This exercise is confined to the processes found under the *Construct Model* level in the left sub-panel of the *Velocity Modeling* dialog box. In general, your modeling efforts will flow down the list from *Model Extent* to *Geometry/Resolution* to *Define Structure*, and so forth. The flow is not strictly wizard-guided; you can vary the process sequence.



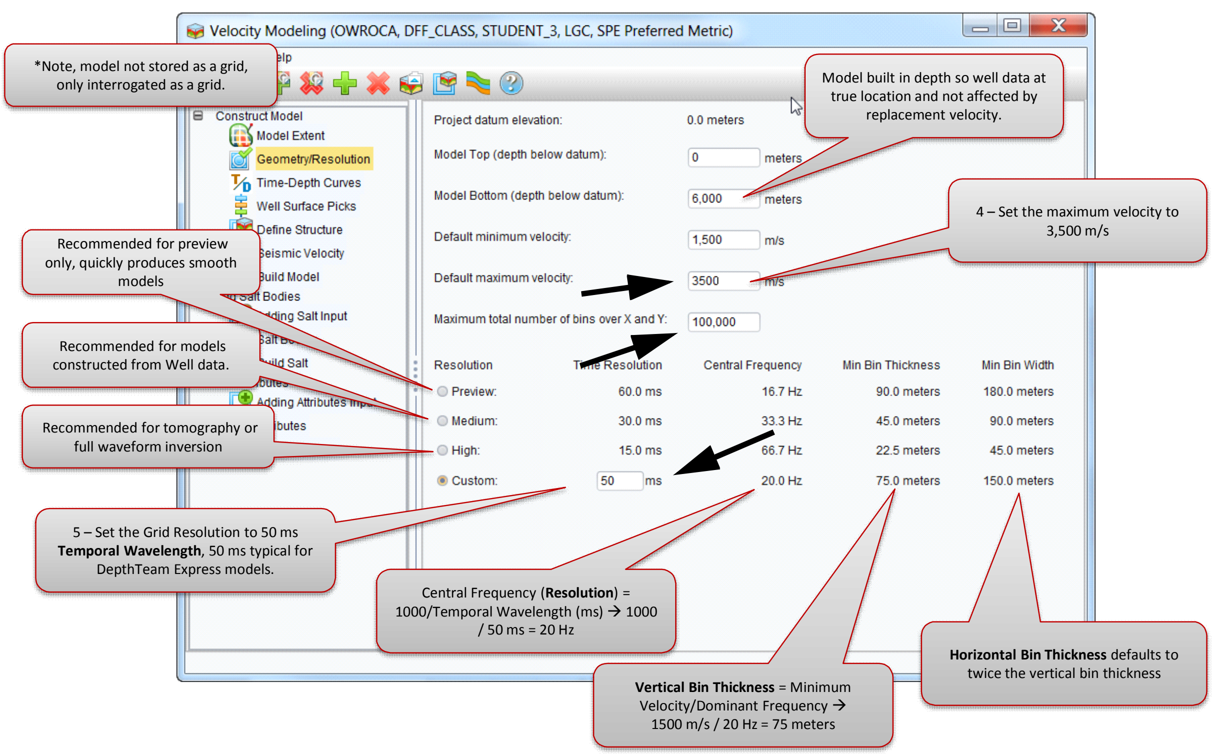
3. With *Model Extent* active in the left sub-panel (or click the **Continue** icon in the lower right corner of the *Velocity Modeling* dialog box), set the Source of model extent to **Set by Survey Range**, and set Survey to define model extent to **DFF**.



The dialog box updates to show the model extents, based on the survey specification. This model should be around 136 square kilometers.

4. Click **Geometry/Resolution** in the left sub-panel of the *Velocity Modeling* dialog box and change the Resolution to **Custom 50 ms**.

5. Also change the min and max velocities as shown below.

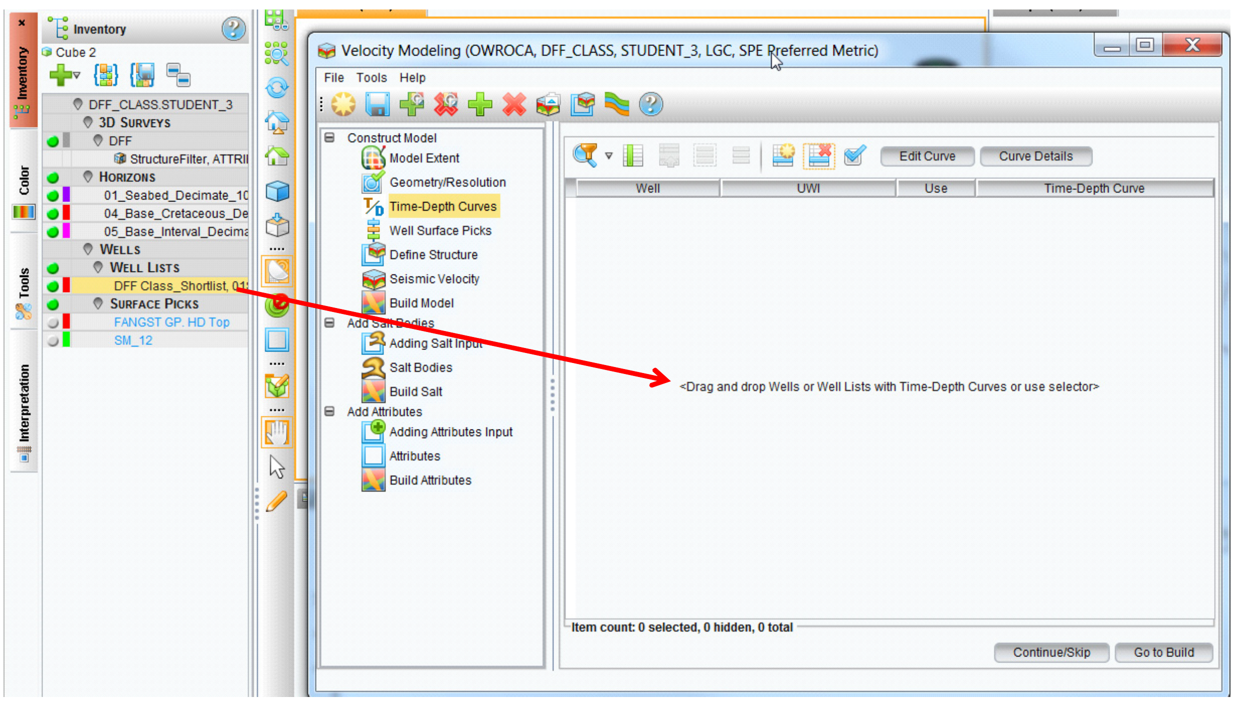


The information in this dialog box is used for setting default values for the model construction. Any of these values can be overridden on a per-layer basis.

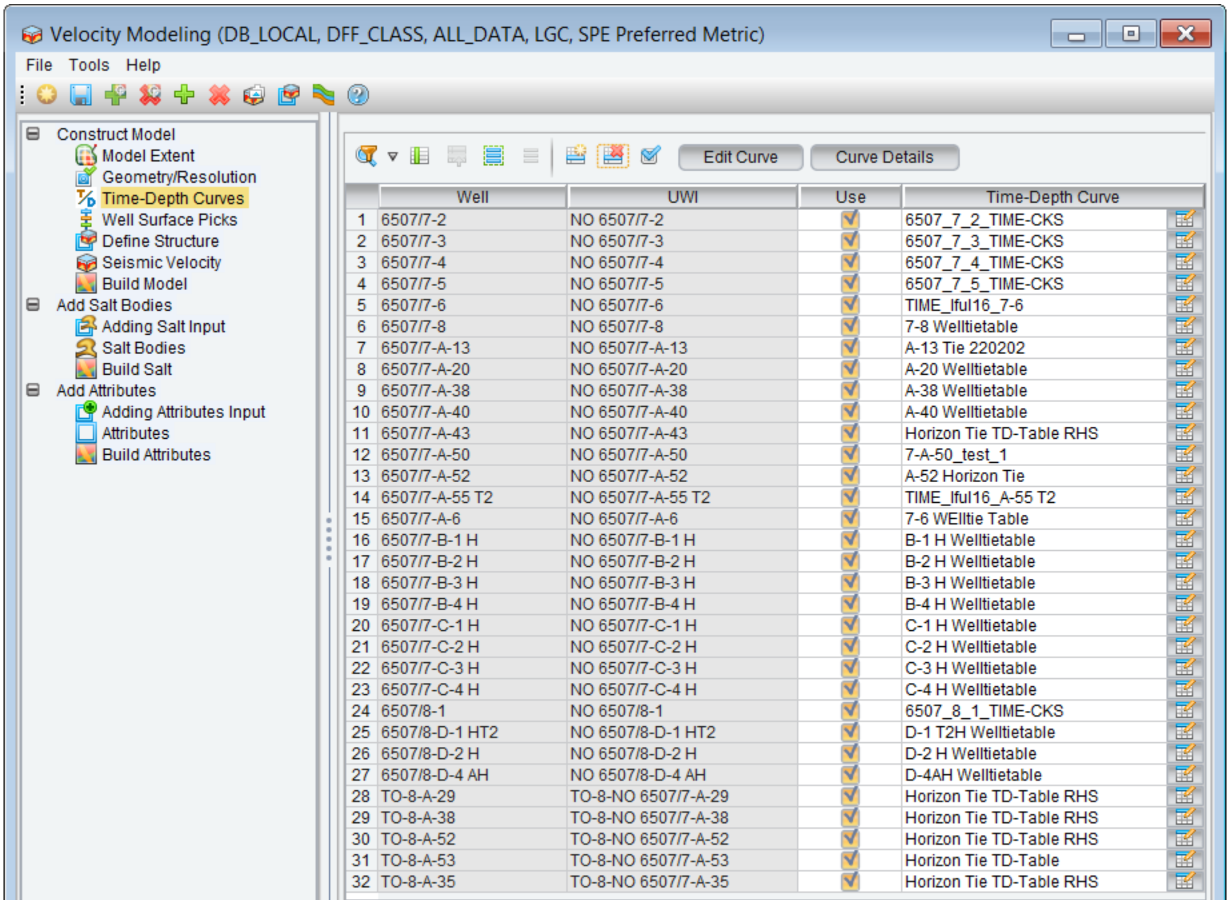
> **Note**
>
> The bin size determines how rapidly a velocity can change within a formation. The bin size is not the precision of the values within the bin (think of focus versus megapixels, as a 10 megapixel camera cannot provide a high resolution picture without a nice lens with which to precisely focus the image). Also be aware that the model is not stored as a grid, it is only evaluated/interrogated as a conformal grid.

6. Click **Continue** to proceed to the *Time-Depth Curves* tab.

7. From one of your DecisionSpace Geosciences *Inventory* task panes, drag and drop the well list **DFF_Class_Shortlist** into the *Velocity Modeling* dialog box, where indicated.

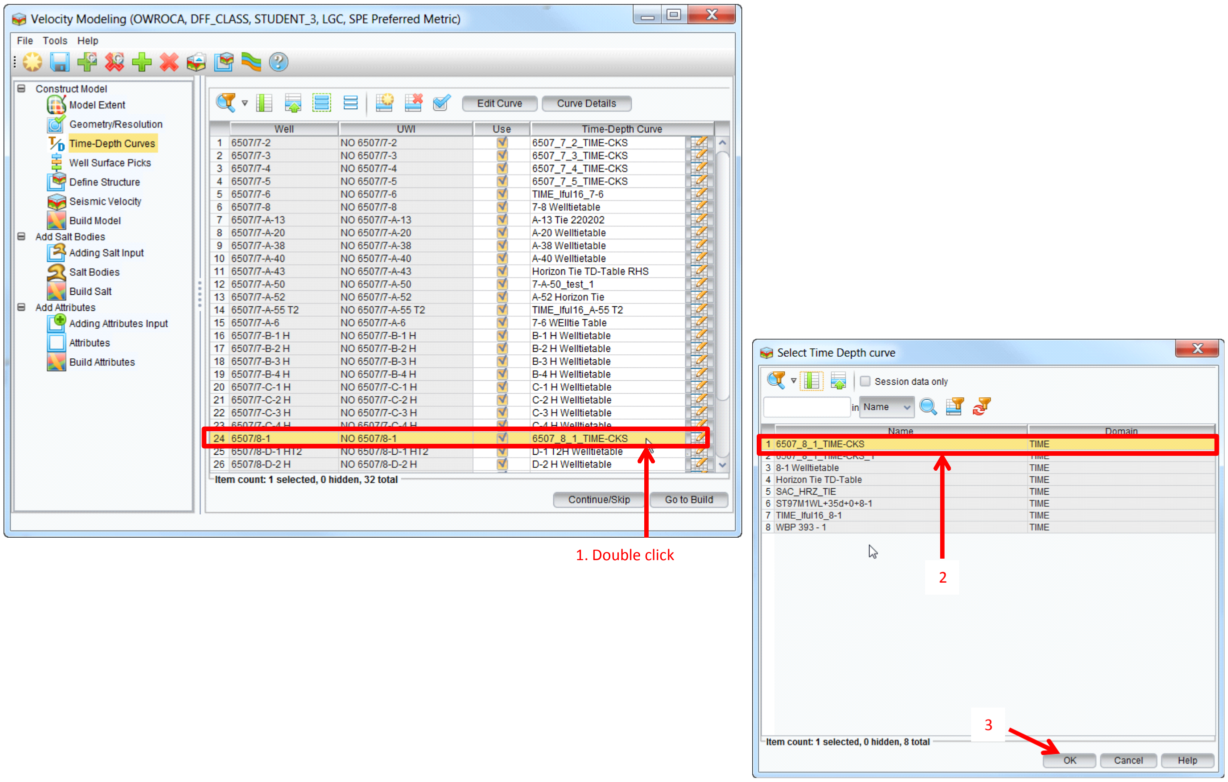


As you have no stacking velocity information at the moment, the TD curves will be the primary velocity input. In the *Velocity Modeling* dialog box, the main panel changes to show a table of wells and their preferred TD curves.



You can select alternative TD curves for a well in two ways. In the *Velocity Modeling* dialog box, double-click the **Time-Depth Curve** cell for a particular well and then select a new curve, or you can change the Preferred TD for any well in the *Well Details* dialog box from the main DecisionSpace GUI.

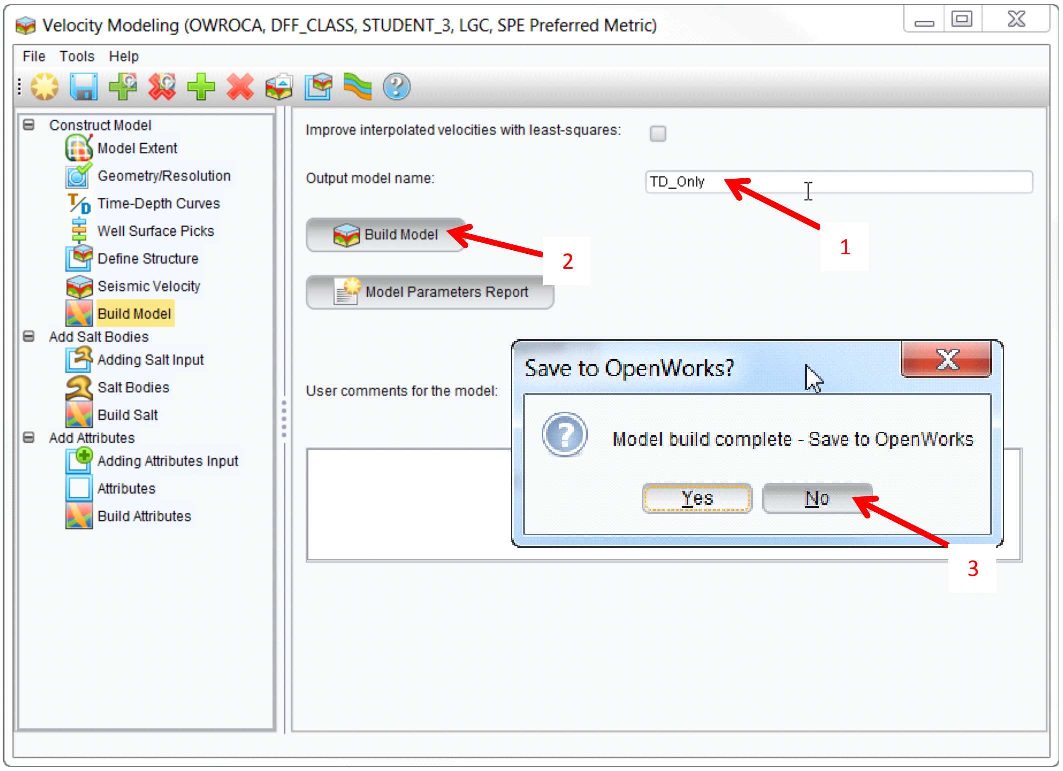
8. Highlight well **6507/8-1**, double-click in its Time-Depth curve and select **6507_8_1_TIME-CKS** if is not already selected.



9. Click the **Go to Build** button, name the model "**TD_Only**," and then click **Build Model** as shown in the next picture.

A progress indicator will open.

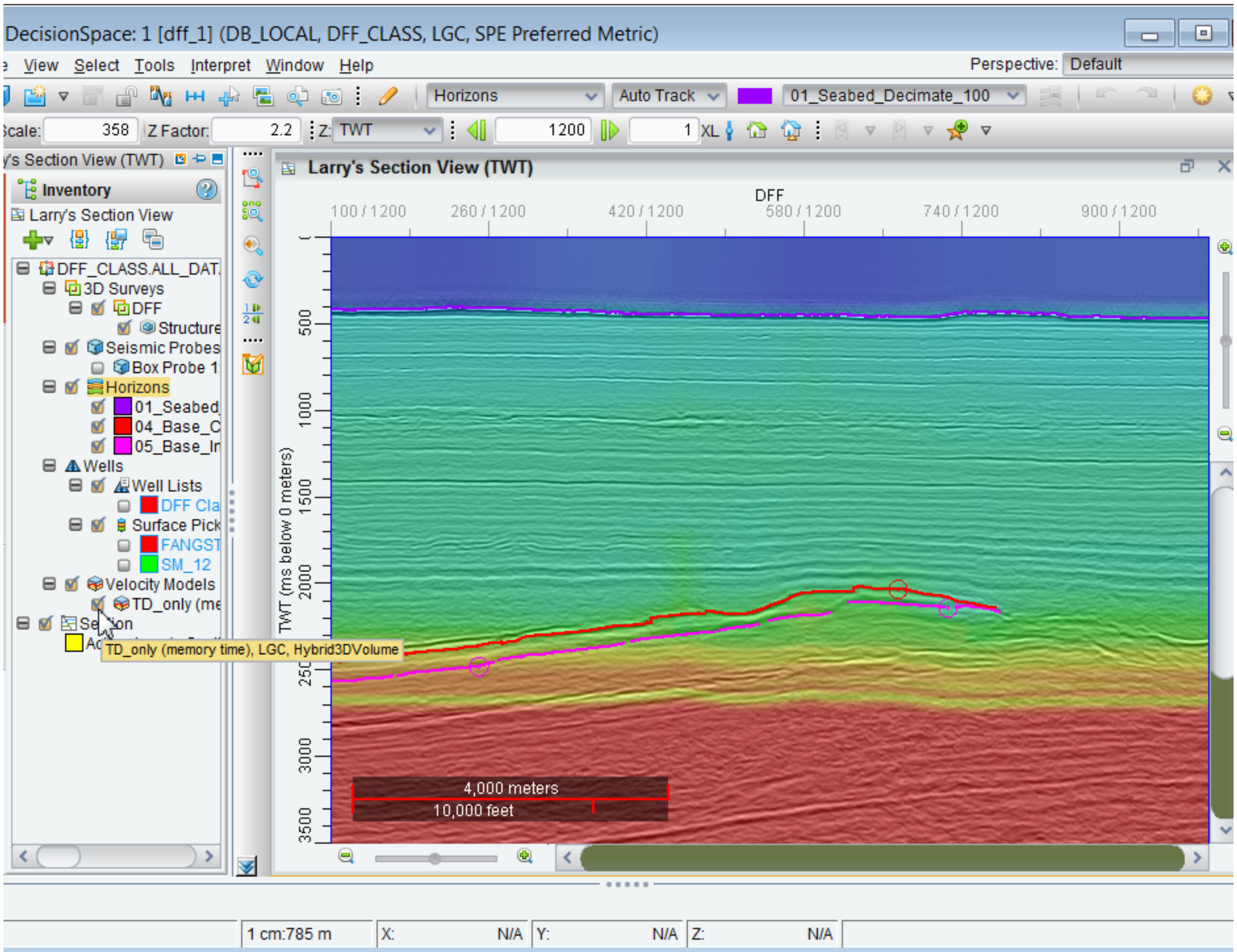
10. When the build is complete, click **No** to the *Save to OpenWorks* message box.



Be aware that if you have a time tab active, then your velocity model is loaded as a time object (black font) and if you have a depth tab active, then the velocity model is loaded as a depth object (blue font).

As velocity modeling is an iterative process involving some trial and error evaluation of inputs and parameterization. Therefore, trial models are not automatically saved to the OpenWorks database. The completed model is left in memory and listed in your DecisionSpace *Inventory* task pane. You will always have a chance to save the model to disk when you exit DecisionSpace.

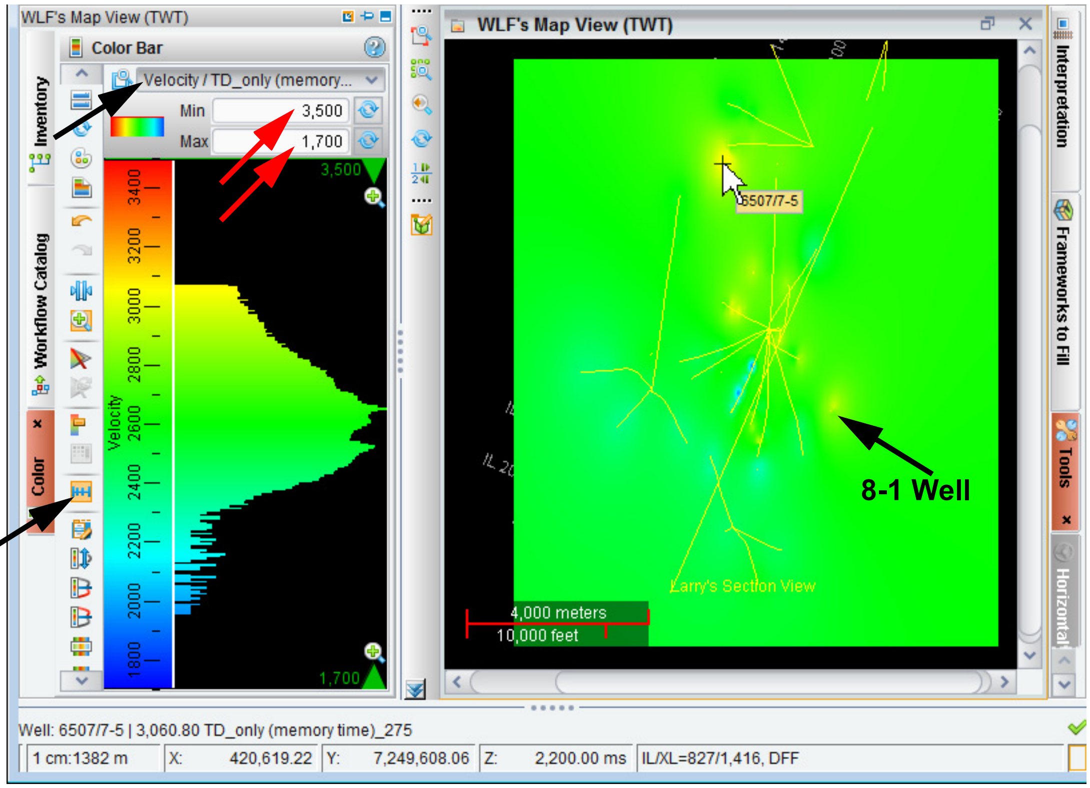
11. With the *Section* view active on crossline **1200 (Select > Section From list > Crossline > 1200)**, turn on the newly created velocity model.



This view shows the velocities laterally changing between the well controls. The view also shows that the velocities are not following the geologic structure. You will add the structural component later in this exercise.

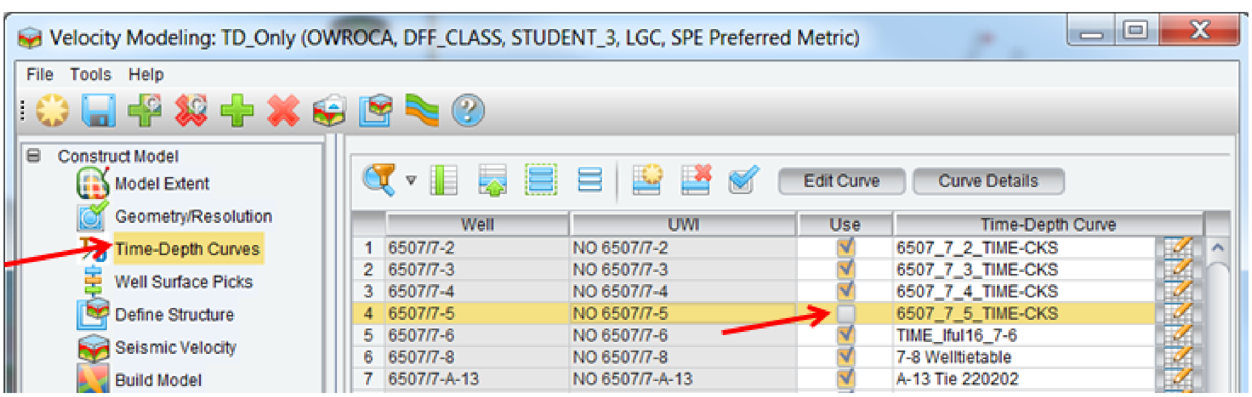
12. For another quick QC, turn on a velocity time slice at **2200** ms in the *Map* view. Also turn on the well list **DFF Class_shortlist** in *Map* view.

13. To highlight the contributions of each well, adjust the color bar in the *Map* view as shown below.

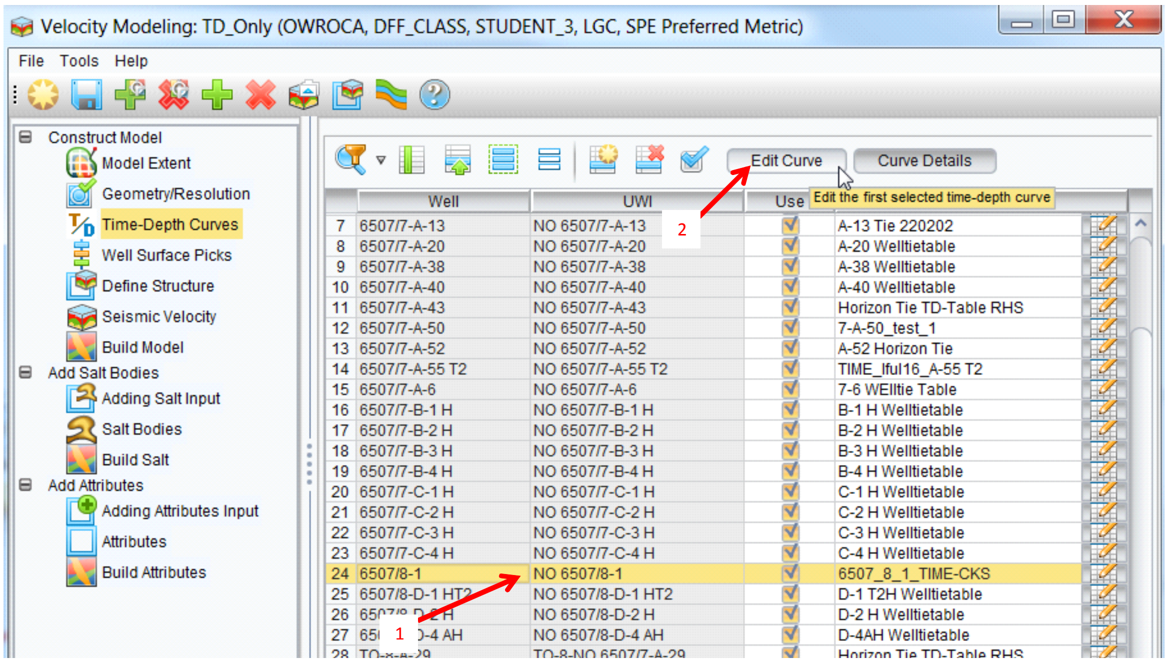


This view shows some TD anomalies at a few wells (in particular look at the **7-5** and the **8-1** wells).

14. One way to get rid of the anomalies is just to remove the wells from the model. For example, you can turn off *Use* for well **6507/7-5**.

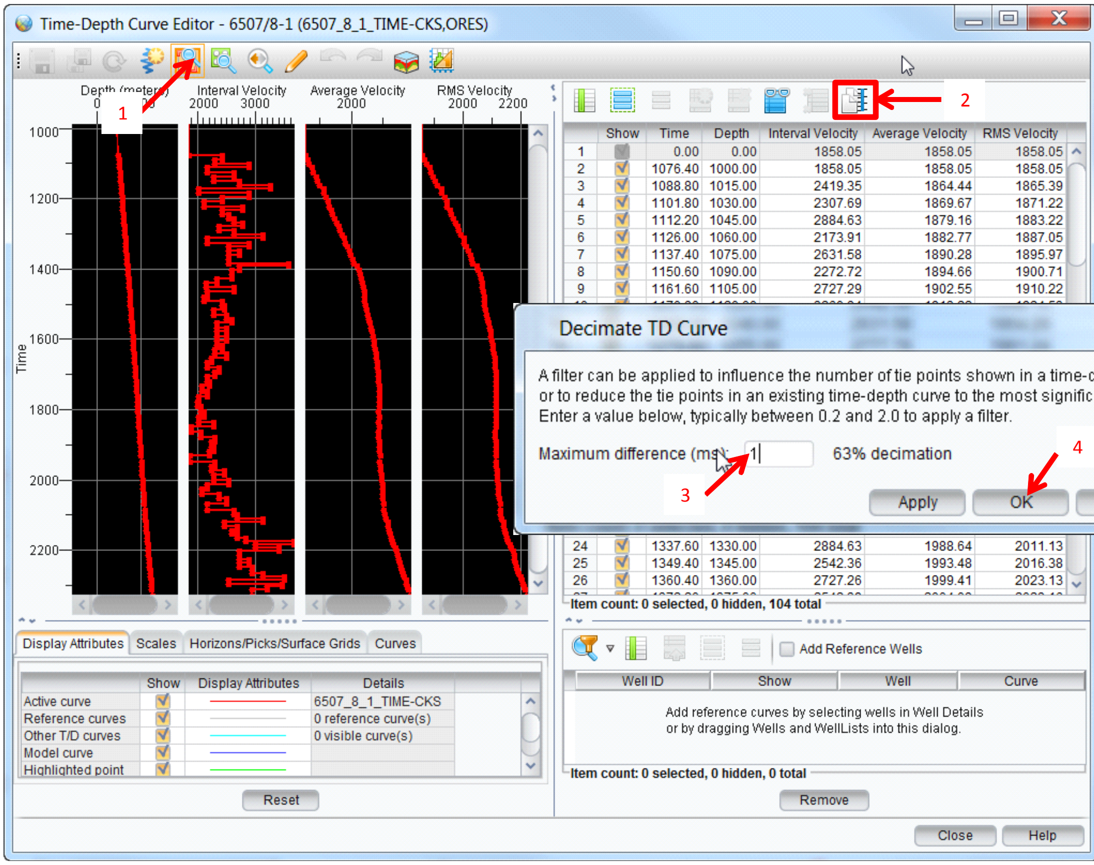


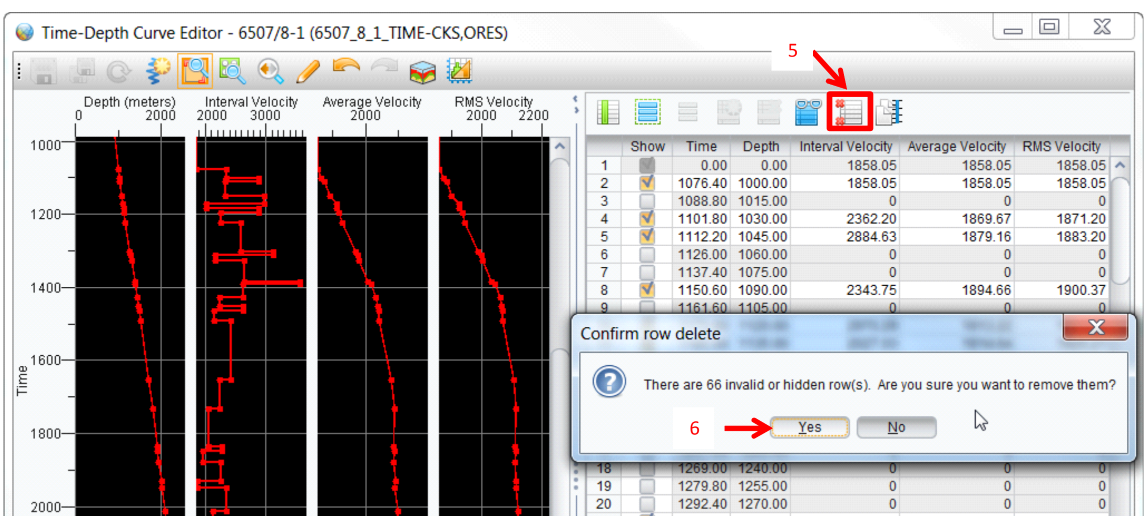
15. You can also edit anomalous TD curves. For example, highlight the **8-1** well, and then click **Edit Curve**.



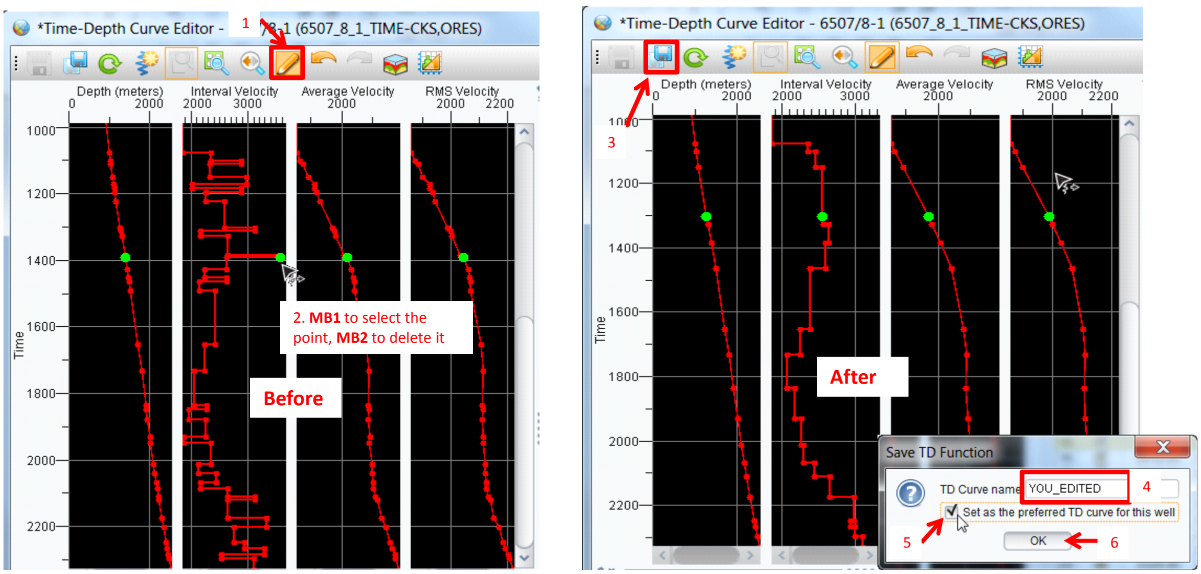
There seem to be several anomalous TD points in this well.

16. Before editing the anomalous points, zoom in between 1000 ms and 2300 ms and click the **Decimate Curve** icon, follow the sequence described in the picture below, and then click the **Delete all hidden rows** icon.

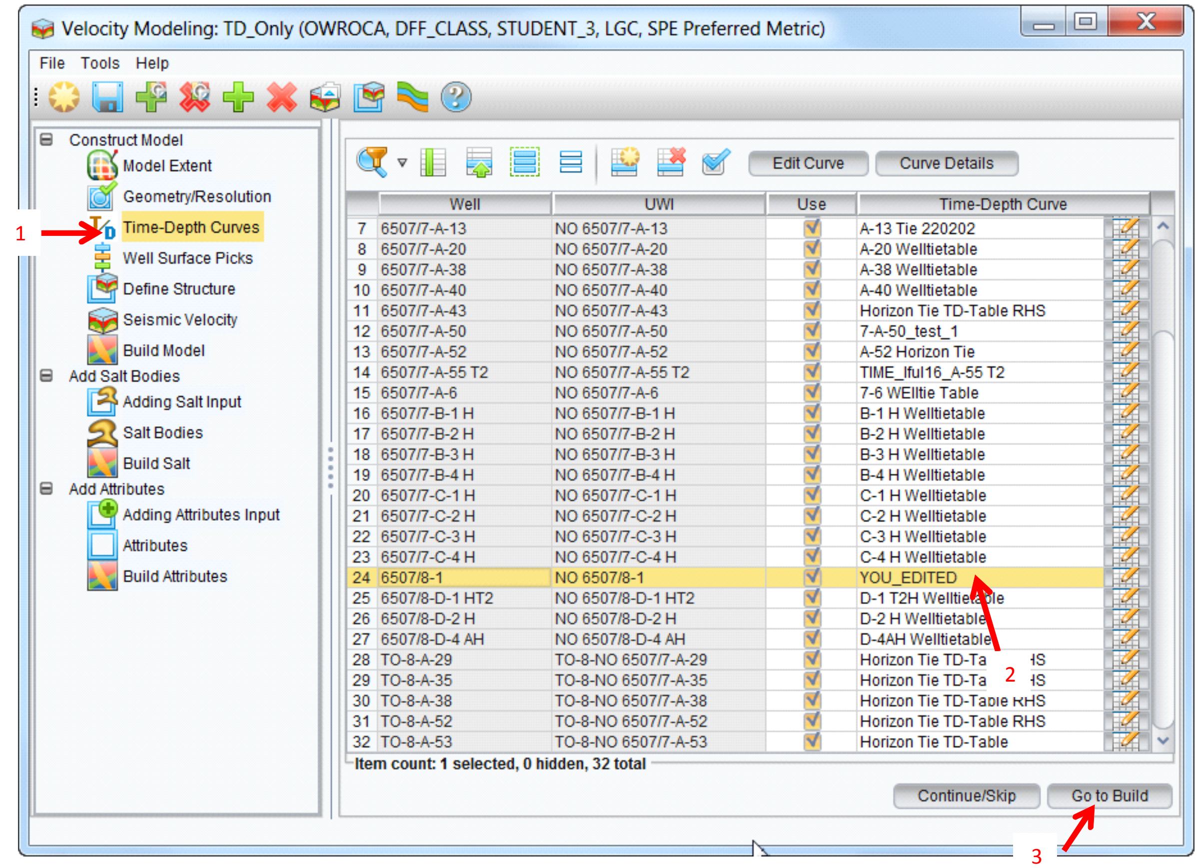




17. Click the **pencil** icon and graphically delete some of the anomalous points. Select the point to delete with **MB1**, then delete it by clicking **MB2**. Delete points until you have a smooth curve. Use the picture below as a reference. Save the edited curved and name it “**YOU_EDITED**.” Also set this curve as preferred.



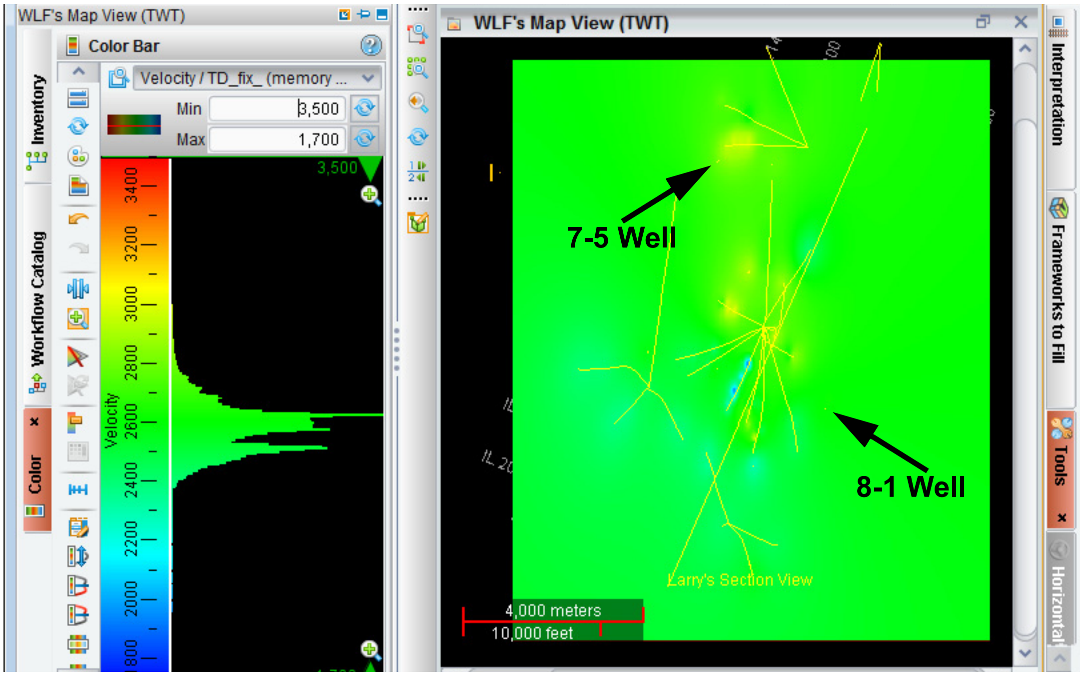
18. Back in the *Velocity Modeling* dialog box in the *Time-Depth Curves* section, select your newly edited TD curve for the **8-1** well and proceed to the *Go to Build* dialog box.



19. Name the model "**TD_Fix**," and then click **Build Model**.

20. When the build is complete, select **No** in the *Save to OpenWorks* message box.

21. QC the time slice. As done before, change the color bar scale values (min: **3500**, max:**1700**).

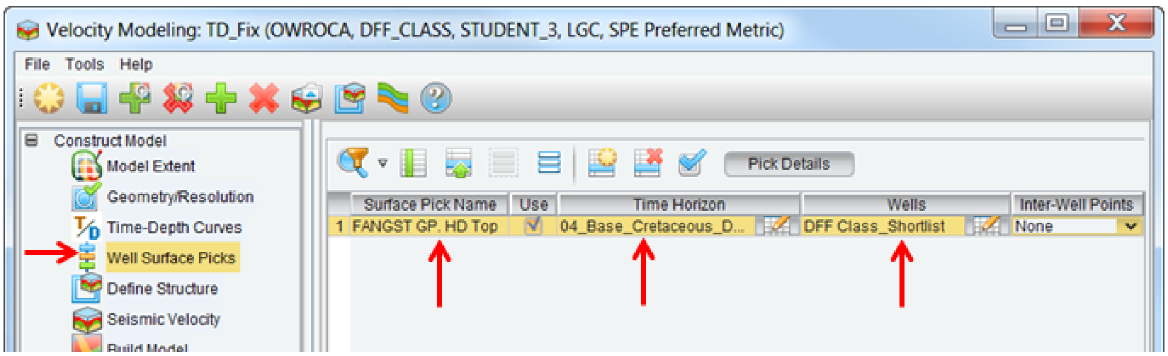


Notice that the **7-5** and **8-1** anomalies have disappeared. There is more cleanup and QC you could do, such as looking at the *Curve Details* or graphically observing the TD curves launched from the *Well Details* dialog box, but for now let's move on and ensure that the TD curves are tied to the well picks.

Add Well Picks to the Model

Typically the most reliable source of velocity data are the well picks. DecisionSpace Velocity calibrates to the well picks as close as possible within the resolution of the model.

1. In the *Velocity Modeling* dialog box, click **Well Surface Picks** and set the parameters as shown below.

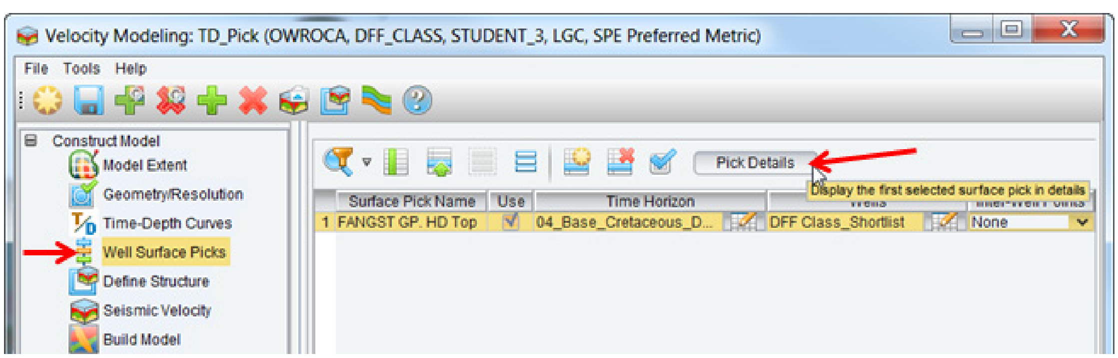


2. Go to the *Build Model* dialog box, name the new model "**TD_Pick**," and then click **Build Model**.

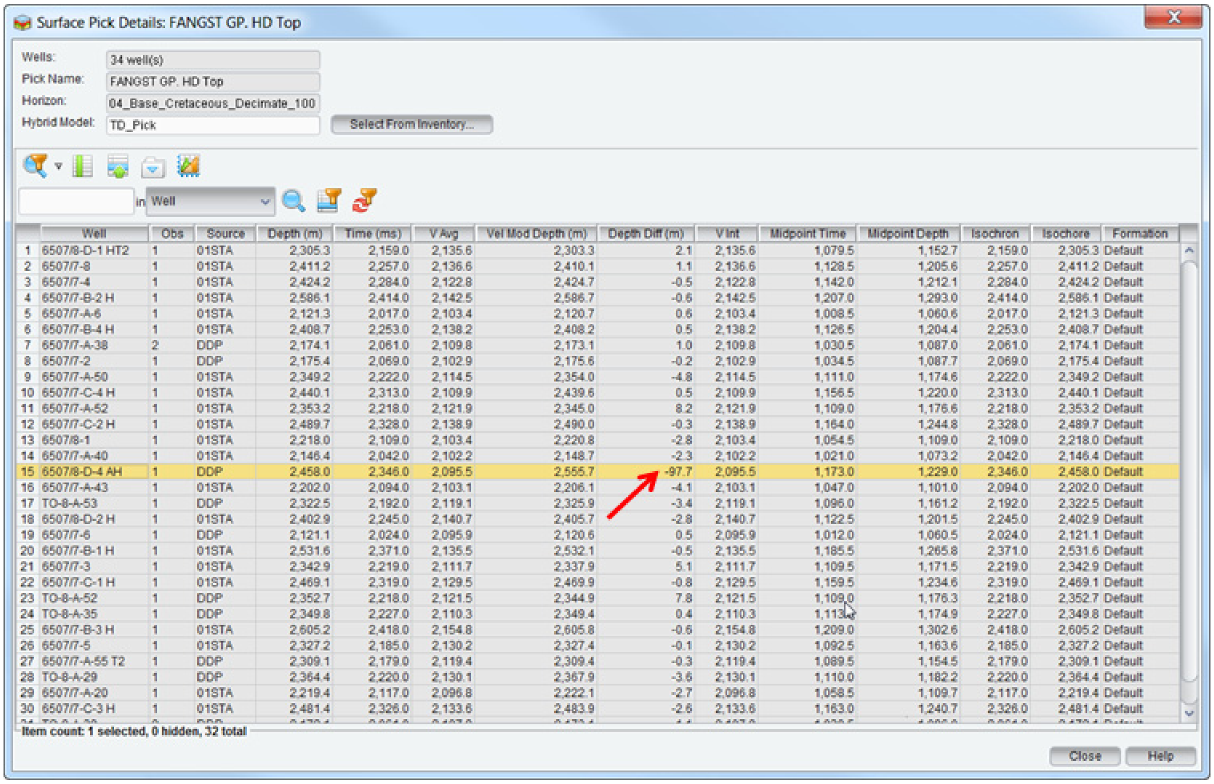
3. When the build is complete, select **No** at the *Save to OpenWorks* message box.

4. QC the time slice as before.

5. Return to the *Well Surface Picks* dialog box, and click the **Pick Details** button.



The *Surface Pick Details* dialog box is an excellent QC report.



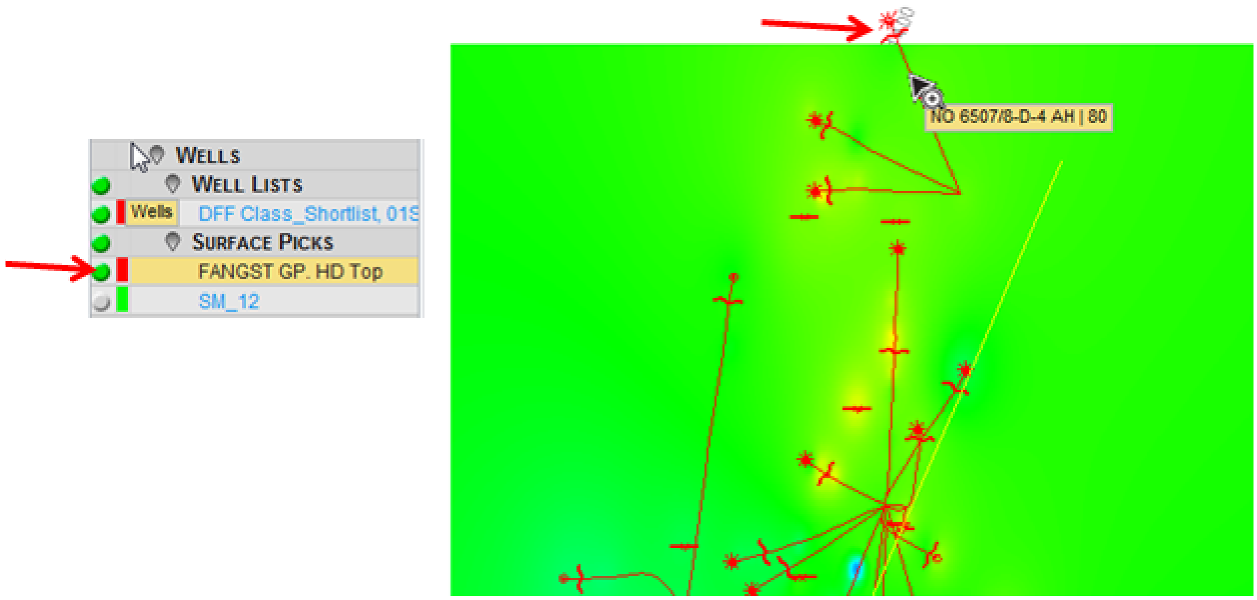
	Well	Obs	Source	Depth (m)	Time (ms)	V Avg	Vel Mod Depth (m)	Depth Diff (m)	V Int	Midpoint Time	Midpoint Depth	Isochron	Isochore	Formation
1	6507/8-D-1 HT2	1	01STA	2,305.3	2,159.0	2,135.6	2,303.3	2.1	2,135.6	1,079.5	1,152.7	2,159.0	2,305.3	Default
2	6507/7-8	1	01STA	2,411.2	2,257.0	2,136.6	2,410.1	1.1	2,136.6	1,128.5	1,205.6	2,257.0	2,411.2	Default
3	6507/7-4	1	01STA	2,424.2	2,284.0	2,122.8	2,424.7	-0.5	2,122.8	1,142.0	1,212.1	2,284.0	2,424.2	Default
4	6507/7-B-2 H	1	01STA	2,586.1	2,414.0	2,142.5	2,586.7	-0.6	2,142.5	1,207.0	1,293.0	2,414.0	2,586.1	Default
5	6507/7-A-6	1	01STA	2,121.3	2,017.0	2,103.4	2,120.7	0.6	2,103.4	1,008.5	1,060.6	2,017.0	2,121.3	Default
6	6507/7-B-4 H	1	01STA	2,408.7	2,253.0	2,138.2	2,408.2	0.5	2,138.2	1,126.5	1,204.4	2,253.0	2,408.7	Default
7	6507/7-A-38	2	DDP	2,174.1	2,061.0	2,109.8	2,173.1	1.0	2,109.8	1,030.5	1,087.0	2,061.0	2,174.1	Default
8	6507/7-2	1	DDP	2,175.4	2,069.0	2,102.9	2,175.6	-0.2	2,102.9	1,034.5	1,087.7	2,069.0	2,175.4	Default
9	6507/7-A-50	1	01STA	2,349.2	2,222.0	2,114.5	2,354.0	-4.8	2,114.5	1,111.0	1,174.6	2,222.0	2,349.2	Default
10	6507/7-C-4 H	1	01STA	2,440.1	2,313.0	2,109.9	2,439.6	0.5	2,109.9	1,156.5	1,220.0	2,313.0	2,440.1	Default
11	6507/7-A-52	1	01STA	2,353.2	2,218.0	2,121.9	2,345.0	8.2	2,121.9	1,109.0	1,176.6	2,218.0	2,353.2	Default
12	6507/7-C-2 H	1	01STA	2,489.7	2,328.0	2,138.9	2,490.0	-0.3	2,138.9	1,164.0	1,244.8	2,328.0	2,489.7	Default
13	6507/8-1	1	01STA	2,218.0	2,109.0	2,103.4	2,220.8	-2.8	2,103.4	1,054.5	1,109.0	2,109.0	2,218.0	Default
14	6507/7-A-40	1	01STA	2,146.4	2,042.0	2,102.2	2,148.7	-2.3	2,102.2	1,021.0	1,073.2	2,042.0	2,146.4	Default
15	6507/8-D-4 AH	1	DDP	2,458.0	2,346.0	2,095.5	2,555.7	-97.7	2,095.5	1,173.0	1,229.0	2,346.0	2,458.0	Default
16	6507/7-A-43	1	01STA	2,202.0	2,094.0	2,103.1	2,206.1	-4.1	2,103.1	1,047.0	1,101.0	2,094.0	2,202.0	Default
17	TO-8-A-53	1	DDP	2,322.5	2,192.0	2,119.1	2,325.9	-3.4	2,119.1	1,096.0	1,161.2	2,192.0	2,322.5	Default
18	6507/8-D-2 H	1	01STA	2,402.9	2,245.0	2,140.7	2,405.7	-2.8	2,140.7	1,122.5	1,201.5	2,245.0	2,402.9	Default
19	6507/7-6	1	DDP	2,121.1	2,024.0	2,095.9	2,120.6	0.5	2,095.9	1,012.0	1,060.5	2,024.0	2,121.1	Default
20	6507/7-B-1 H	1	01STA	2,531.6	2,371.0	2,135.5	2,532.1	-0.5	2,135.5	1,185.5	1,265.8	2,371.0	2,531.6	Default
21	6507/7-3	1	01STA	2,342.9	2,219.0	2,111.7	2,337.9	5.1	2,111.7	1,109.5	1,171.5	2,219.0	2,342.9	Default
22	6507/7-C-1 H	1	01STA	2,469.1	2,319.0	2,129.5	2,469.9	-0.8	2,129.5	1,159.5	1,234.6	2,319.0	2,469.1	Default
23	TO-8-A-52	1	DDP	2,352.7	2,218.0	2,121.5	2,344.9	7.8	2,121.5	1,109.0	1,176.3	2,218.0	2,352.7	Default
24	TO-8-A-35	1	DDP	2,349.8	2,227.0	2,110.3	2,349.4	0.4	2,110.3	1,113.[illegible]	1,174.9	2,227.0	2,349.8	Default
25	6507/7-B-3 H	1	01STA	2,605.2	2,418.0	2,154.8	2,605.8	-0.6	2,154.8	1,209.0	1,302.6	2,418.0	2,605.2	Default
26	6507/7-5	1	01STA	2,327.2	2,185.0	2,130.2	2,327.4	-0.1	2,130.2	1,092.5	1,163.6	2,185.0	2,327.2	Default
27	6507/7-A-55 T2	1	DDP	2,309.1	2,179.0	2,119.4	2,309.4	-0.3	2,119.4	1,089.5	1,154.5	2,179.0	2,309.1	Default
28	TO-8-A-29	1	DDP	2,364.4	2,220.0	2,130.1	2,367.9	-3.6	2,130.1	1,110.0	1,182.2	2,220.0	2,364.4	Default
29	6507/7-A-20	1	01STA	2,219.4	2,117.0	2,096.8	2,222.1	-2.7	2,096.8	1,058.5	1,109.7	2,117.0	2,219.4	Default
30	6507/7-C-3 H	1	01STA	2,481.4	2,326.0	2,133.6	2,483.9	-2.6	2,133.6	1,163.0	1,240.7	2,326.0	2,481.4	Default

Note the anomalous *Depth Diff* at well **6507/8-D-4 AH**.

6. **Close** the *Surface Pick Details* dialog box.

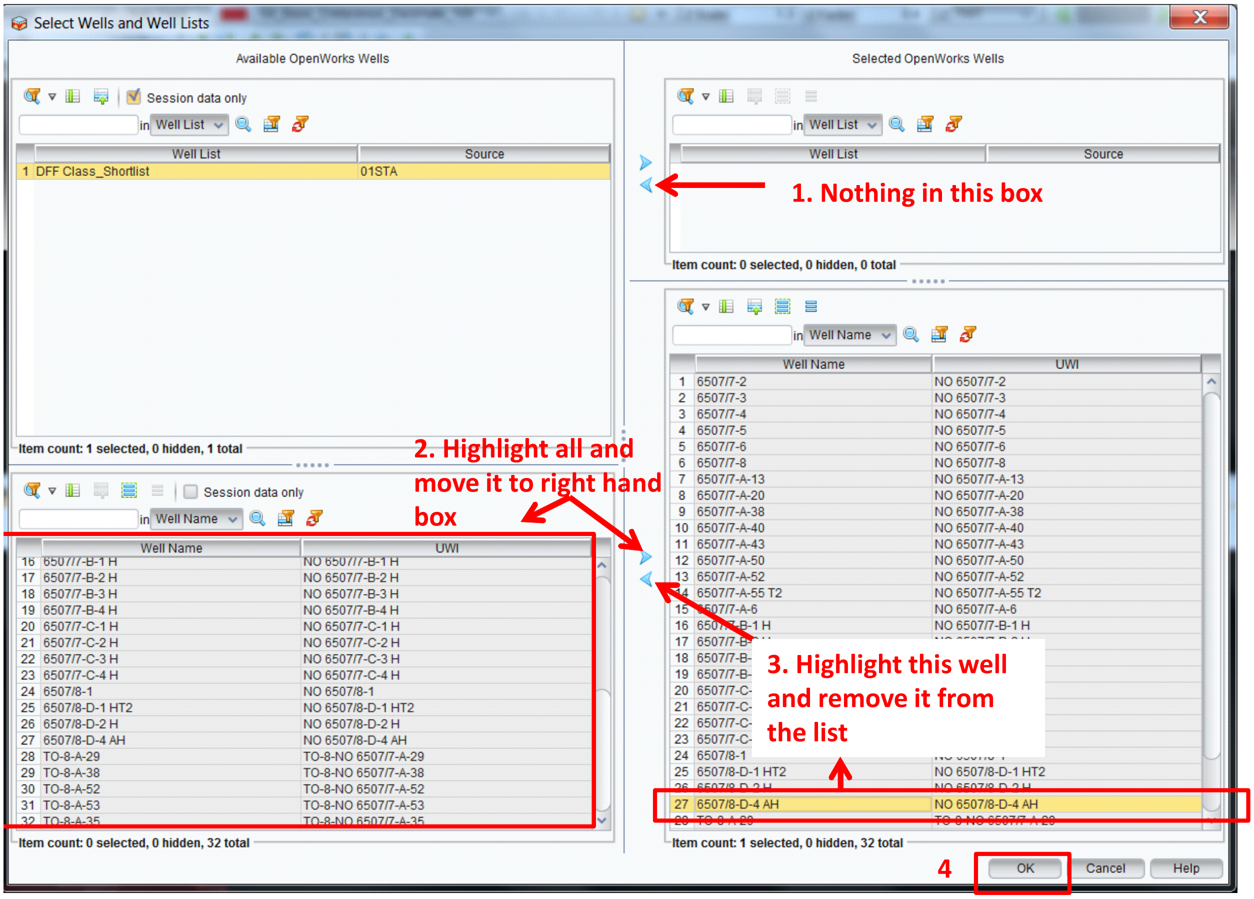
   The best procedure is to revisit the time (horizon) and depth (surface pick) interpretations at that well.

7. Turn on the **FANGST GP. HD Top** in the *Map* view and notice that the **D-4** well pick is outside of the input horizon area.



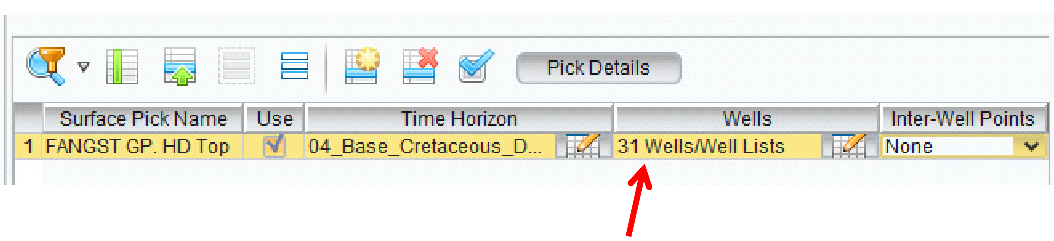
In this case, you need to re-generate the velocity model excluding the **D-4** well.

8. Double-click the **Wells list** icon and set the parameters as shown below. Be sure and remove the **D-4** well from the Selected OpenWorks Wells column.



9. After removing the **D-4** well from the selection, click **OK** to close the *Select Wells and Well Lists* dialog box.

   The dialog box should indicate that only 31 well picks are being used.



10. Rebuild the model, naming it "**TD_Pick_Fix**."

11. When the build is complete, select **No** in the *Save to OpenWorks* message box.

12. Review the *Surface Pick Details* dialog box.

    Notice that the Depth Difference range is on the order of -10 to +10 meters. This is the difference between the calibrated velocity model and the depth pick. A +/-10 meter error is very good for a seismic velocity model.

    At this point, you have only applied quick fixes to the velocity model by excluding bad data. You have not addressed all the underlying issue of the input data responsible for the velocity model anomalies. Often a re-examination of the interpretation and TD curves at each suspect well is required.

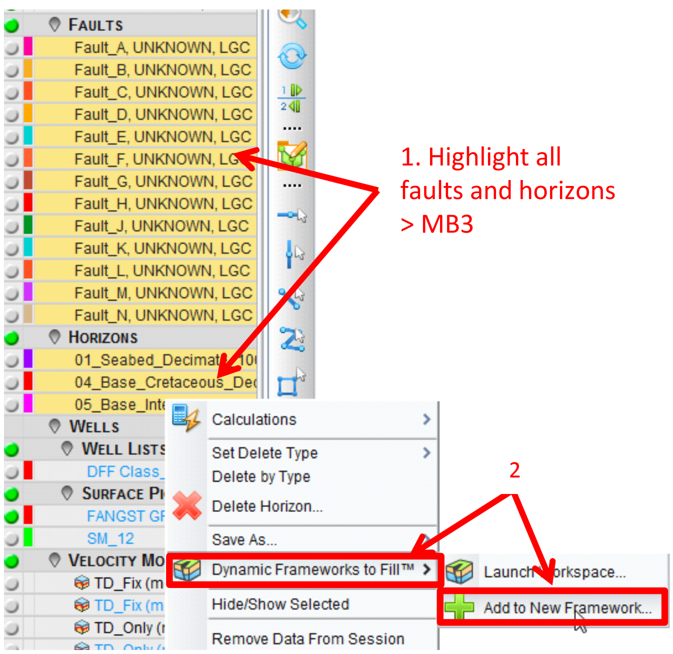
    As you refine time-depth relationships for your wells, we recommend that you create a well list containing your best velocity wells. Wells in this list would have the most reliable Time-Depth curves and (time) horizon to (depth) pick correlations. Maintaining your velocity well list is preemptive velocity model QC.

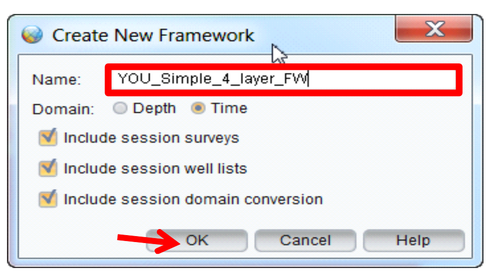
    In any case, now that you are comfortable with the input velocity data, you are ready to improve the velocity model by interpolating the velocities along structure.

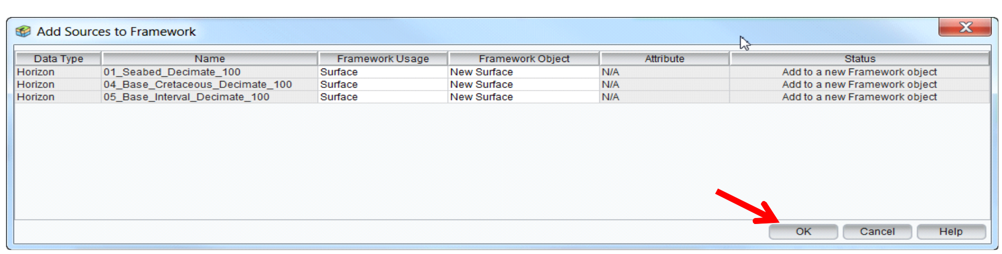
Add Structural and Layer Controls to the Model

The velocity model interpolation can use structural control provided by horizons or a framework. In this exercise, you will build a simple framework using three horizons and 13 faults. The resulting framework will become an integral part of your velocity model.

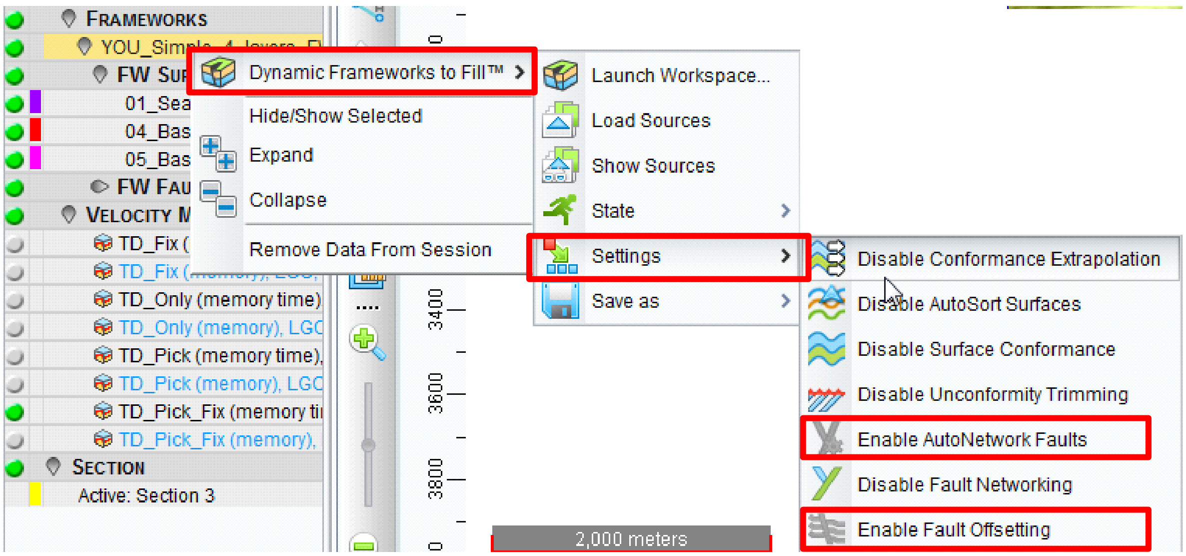
1. In the *Inventory* task pane, highlight all three structural horizons, all faults, **MB3** and then select **Dynamic Frameworks to Fill** > **Add to New Framework**. Name the framework "**YOU_Simple_4_layers_FW**." Accept the defaults in the *Add Sources to Framework* window.



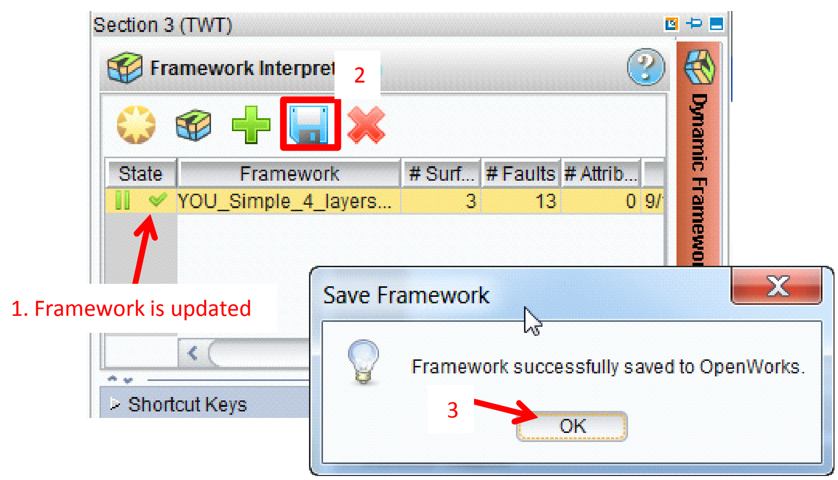




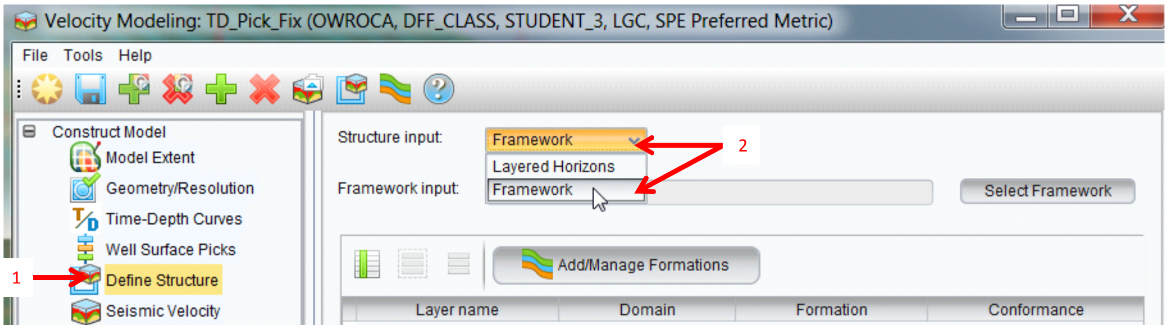
2. In the *Inventory* task pane, **MB3** on the framework **YOU_Simple_4_Layer_FW**, and then select **Dynamic Frameworks to Fill > Settings > Enable AutoNetwork Faults**. Repeat the same process to **Enable Fault Offsetting**.



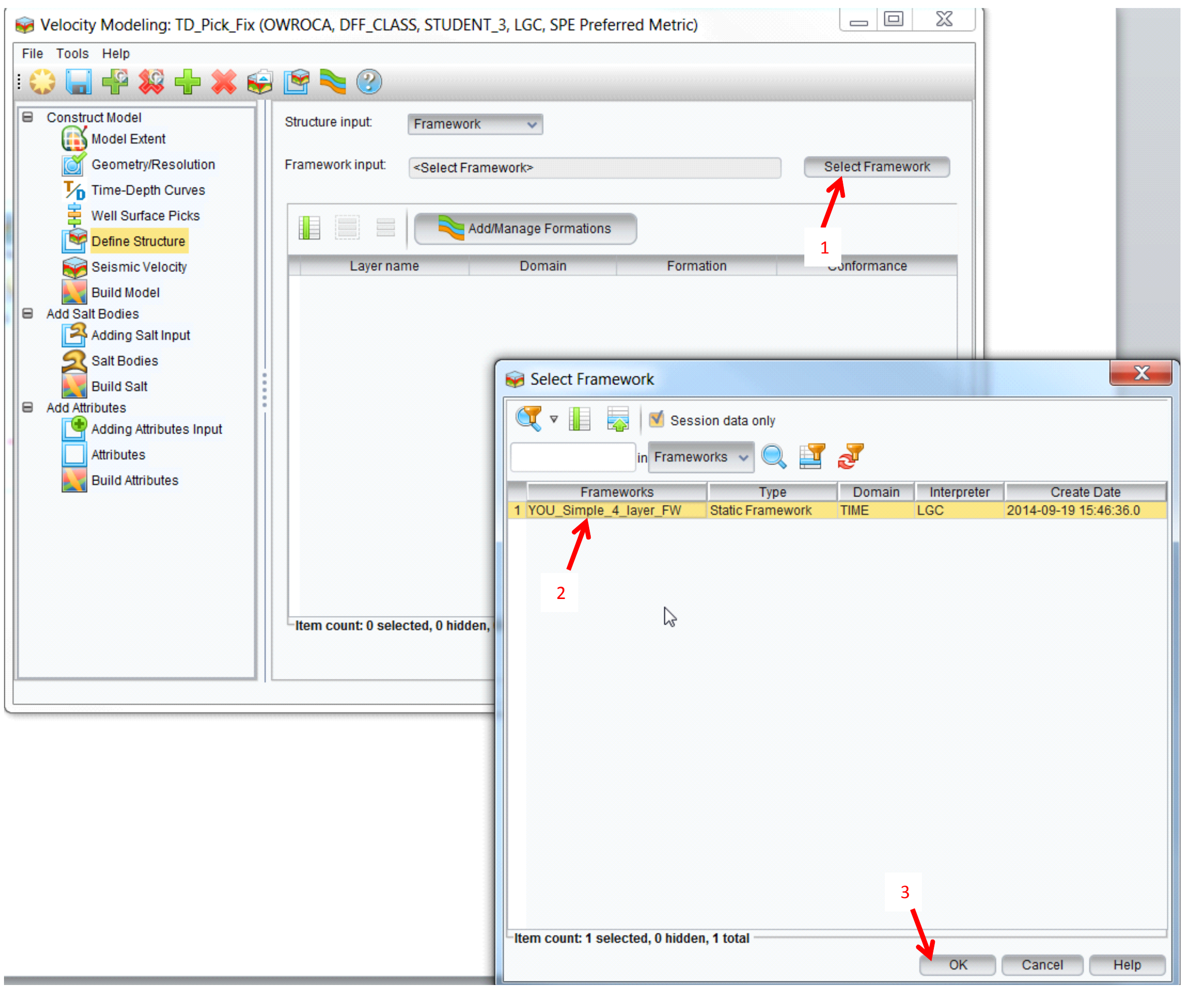
3. In the *Dynamic Frameworks to Fill* task pane, refresh your framework, then click the **Save** icon to save your framework into OpenWorks.



4. Back in the *Velocity Modeling* dialog box, navigate to the *Define Structure* tab and switch Structure input to **Framework**.



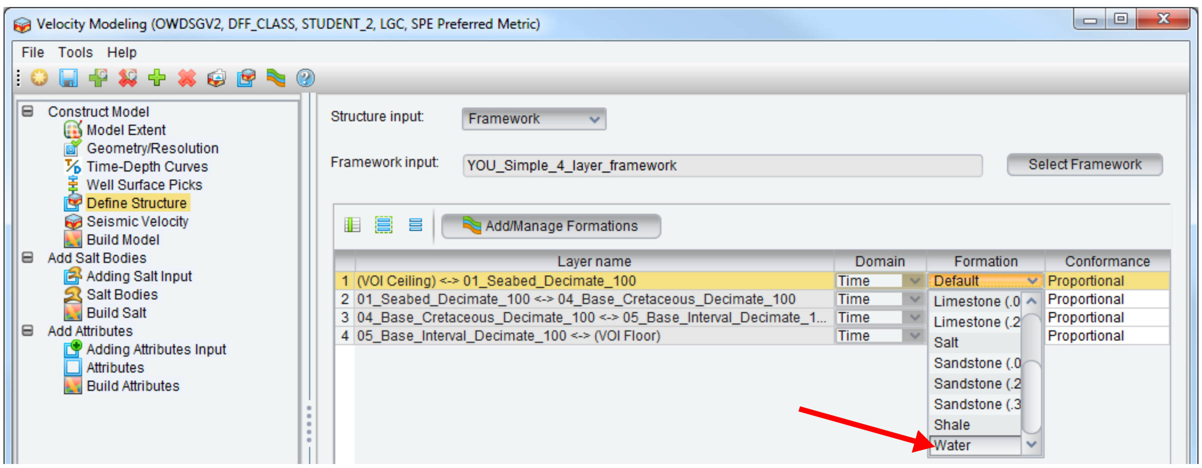
5. Click **Select Framework**, and then select the **YOU_Simple_4_layer_FW** framework you just saved.



The framework contains layers/compartments for the model to use. In this case, four regions (or compartments) are formed by your three framework horizons and the top and bottom of the model. You can define different parameters for each region/compartment, by assigning a unique “Formation” to each region.

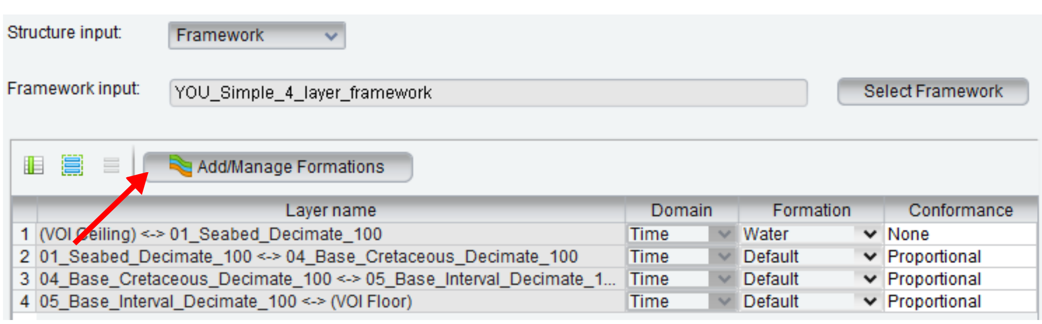
Be aware that *Formation management is a key to success in the use of this velocity tool*. With formation management, you define important physical properties for the layers, including velocity range, conformance behavior, smoothness parameters, and various attributes. Up to now, you have been using the default formation parameters for your entire model.

6. Set the Formation definition to **Water** for the first layer [*(VOI Ceiling) <-> 01_Seabed*].



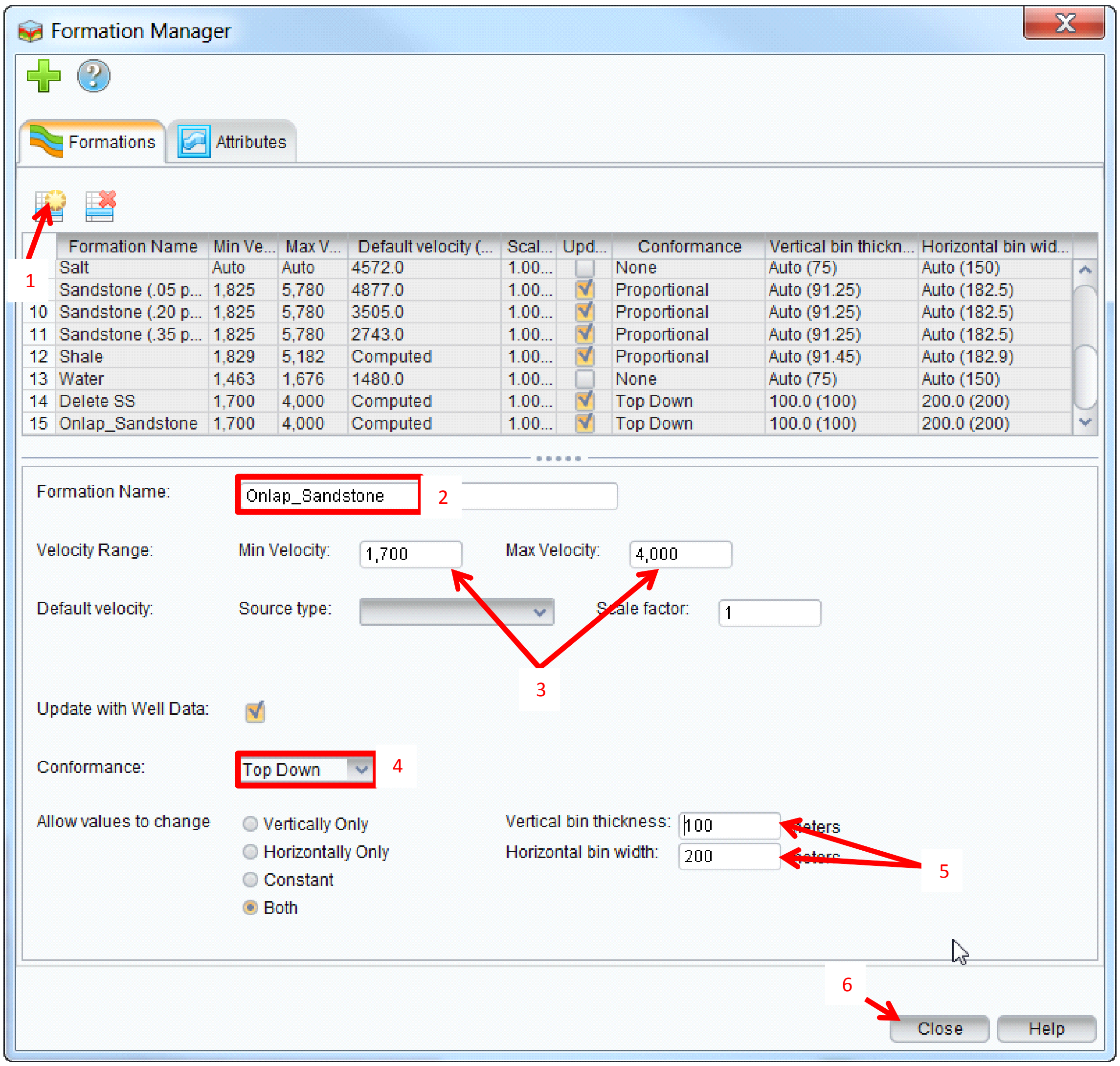
Specifying a formation overrides the default parameters for how the velocities are populated between the wells.

7. Click the **Add/Manage Formations** button.



Review the *Formation Manager* dialog box and the default settings for various provided formations.

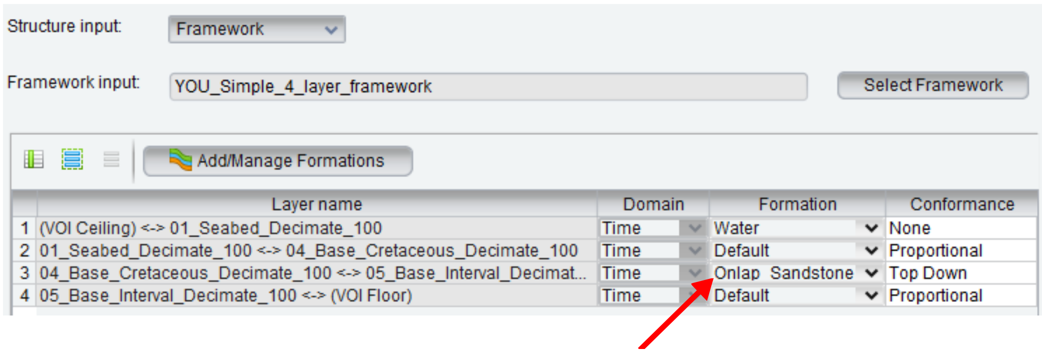
8. In the *Formation Manager* dialog box, create a new formation called “**Onlap_Sandstone**” with the parameters shown below. Follow the sequence provided.



Note that the *Formation Manager* also allows for analytic velocity functions and importing of external velocities per formation. This allows for the creation of very complex models for “what-if” type scenario testing.

9. Click **Close** on the *Formation Manager* dialog box.

10. Change the **Base_Cretaceous** reservoir layer's formation to **Onlap_Sandstone**.

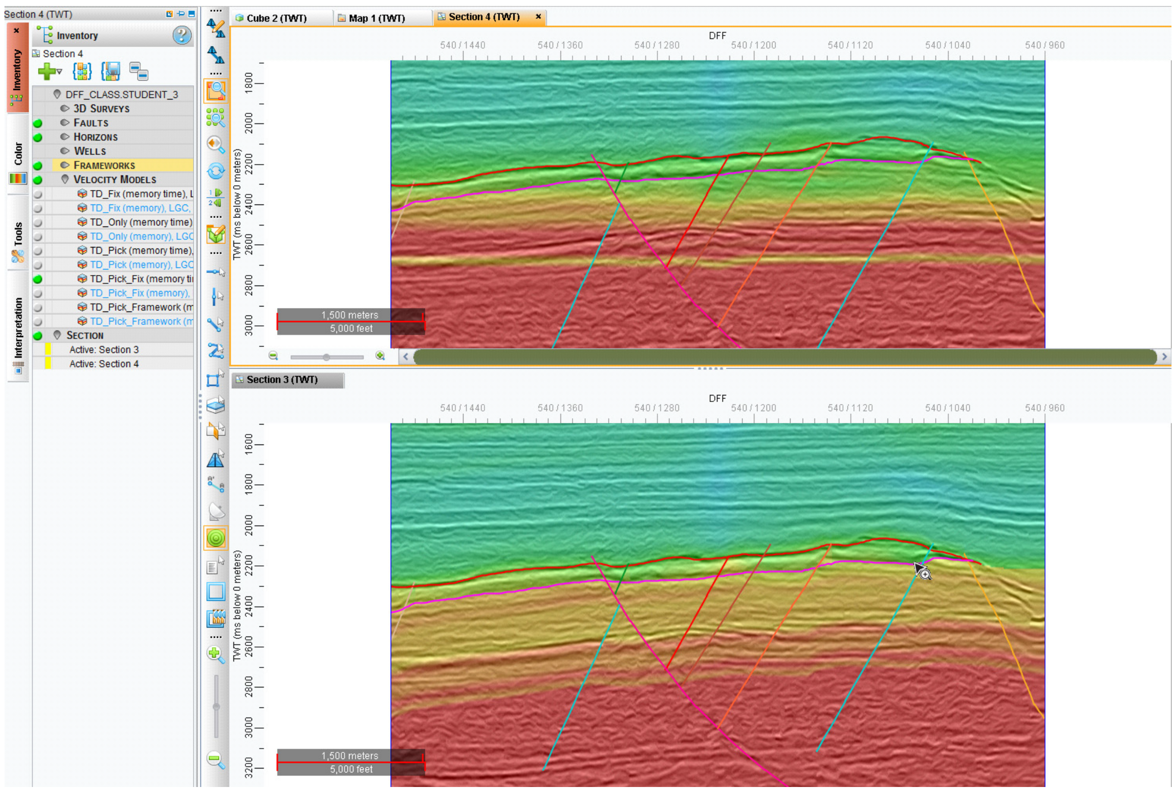


11. Now build another new model named "**TD_Pick_Framework**."

    Note that this model will take significantly longer to build than the previous models. On the writer's laptop, it takes around one and a half minutes to build.

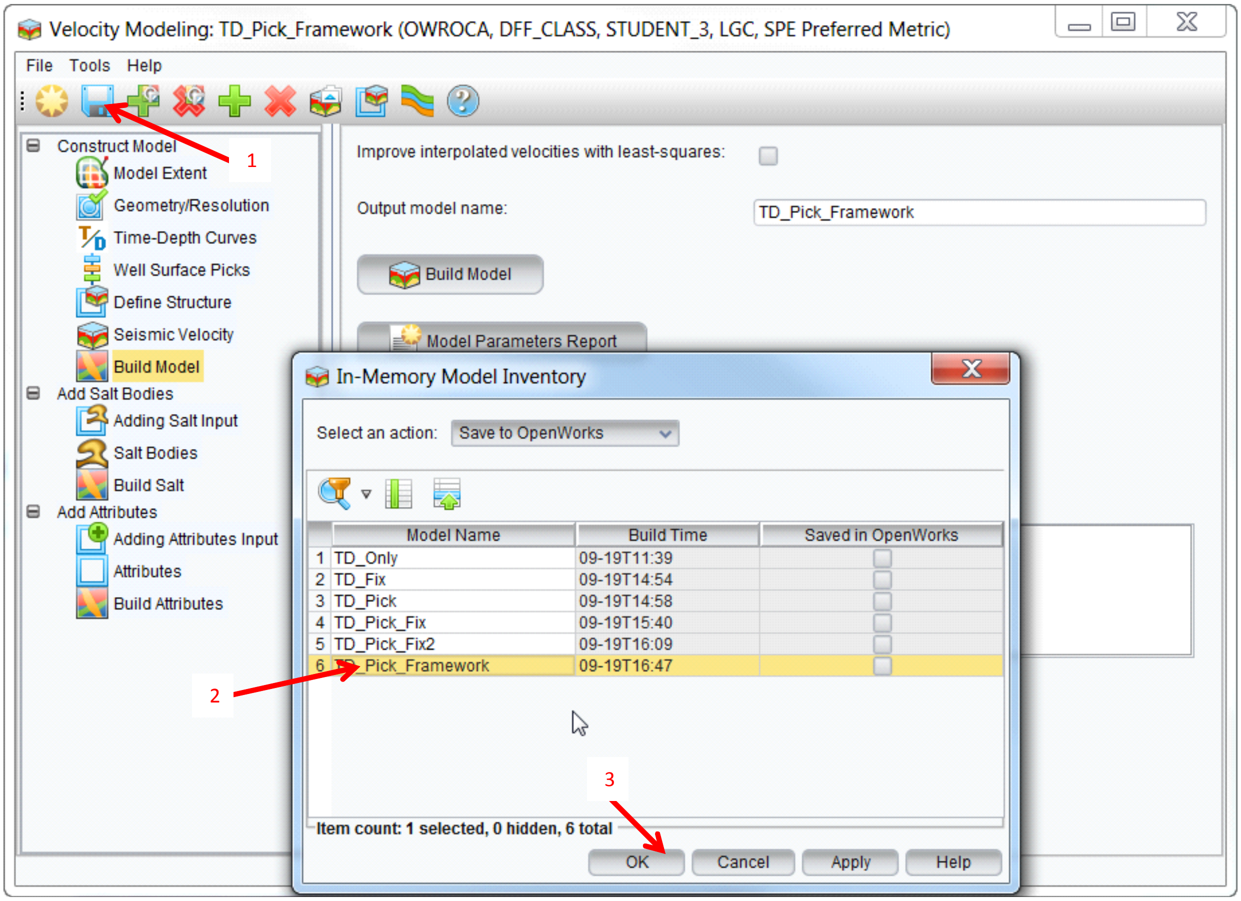
    Do not save the model in OpenWorks.

12. Open a new *Section* view as follow: with the current *Section* view active, select **File > New Tab > Section**. A *Section* tab showing the same seismic section and velocity model will appear. In one of the *Section* views, turn on the new velocity model. Compare the new model with the previous model by arranging the displays as shown below.



Note that both models shown above tie the wells with exactly the same resolution, but which model do you think is more accurate between the wells? Notice that the framework-based model has the velocities following structure in a geologically realistic manner. Clearly, having the velocities conform to structure is a superior solution.

13. Save the final structural model to OpenWorks.



14. Click **Yes** and then click **OK** in save the model messages.

At this point, your structurally well-tied model is ready for anyone on your project team to use.

This concludes the basic introduction to the Velocity Modeling tool. Advanced topics include:

- Using faulted frameworks
- Using multi-Z salt bodies
- Using seismic velocities
- Using analytic velocity functions
- Using horizontal wells and inter well hard points
- Using depth and time horizon input
- Directly connecting with the processing system
- Interacting with DepthTeam Express

Overview: Converting Domains

One of the fundamental problems in geological and geophysical interpretation is creating a collaborative workspace that accommodates time and depth domains. This is especially challenging because geologic interpretations are generally associated with depth domain data, while geophysical interpretations are generally associated with time domain data. To accommodate this disparity, DecisionSpace has several dynamic time-to-depth features that leverage capabilities in OpenWorks to track whether the data or interpretations are in time or depth domains. You can use your velocity model to make on-the-fly conversions of data from time to depth and vice versa. This means you can perform necessary data conversions quickly and efficiently, and without the need to jump between applications.

This provides an integrated workspace to geologists and geophysicists, wherein both can interpret in their domains of interest while sharing their interpretations with one another. This particularly helps geophysicists because they can interpret legacy time-seismic data with new depth-migrated versions of the seismic data. For teams working with seismic depth and well depth, a depth-depth capability is also available to ensure that well picks and seismic can be reconciled.

Key Capabilities of Domain Conversions

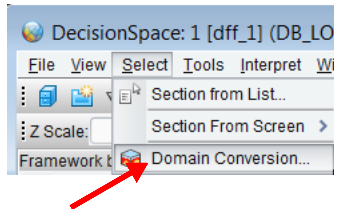
- Well data such as logs and picks are displayed in time or depth, using a well time-depth curve or a velocity model.
- All other data types are displayed using a velocity model that is selected for the session.
- The velocity model can be created in DecisionSpace Velocity Modeling, DepthTeam Express, TDQ or a third-party software package with the results converted to one the aforementioned types.
- Using the velocity model selected for the session, horizons, grids, seismic and faults can be saved as domain converted.

Note

To maintain performance, seismic probes in *Cube* view are the only data type not dynamically domain converted. The seismic must be depth converted first, and then a probe created from that volume can be used in the *Cube* view.

Choosing Domain Conversion Options

Domain conversion options are set from **Select > Domain Conversion** from the main DecisionSpace dialog box.

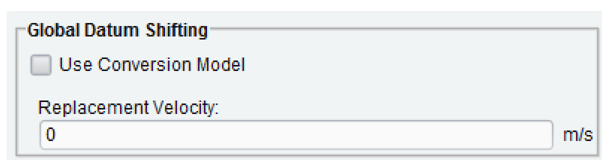


Key dynamic domain conversion options are described below.

Shifting Global Datum

The *Global Data Shifting* panel offers two options:

- **Use Conversion Model** – This enables all data to use the same datum conversion method. In addition, the velocity for this option will likely vary laterally across the project.
- **Replacement Velocity** – Velocity is constant. This value is dimmed when you select **Use Conversion Model**.

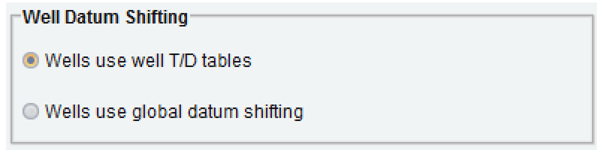


Shifting Well Datum

Two options are available in the *Well Datum Shifting* panel:

- **Wells use well T/D tables** – This is the default option. It shifts well datums according to individual time-depth tables. By keeping this default, DecisionSpace uses the same mechanism as the SeisWorks® software for data-shifting wells.
- **Wells use global datum shifting** – If you change the display datums for other data items, the well display would not adjust

accordingly, unless you selected **Wells use global datum shifting settings**.



Using Well Time-Depth Conversions

The *Well Time-Depth Conversion* panel has three options:

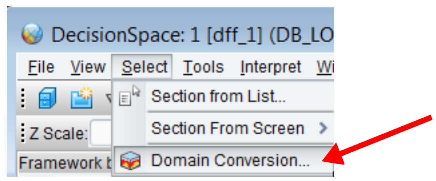
- **Wells always use active TD table** – Wells would not use the Active Model selected above, but instead would use their active time-depth table. See *Well Details* for more information.
- **Wells always use TD model** – Wells would use the Active Model selected above.
- **Wells use preferred by well**–The default is **Wells always use active TD table**.

Exercise 1.5: Converting Domains

In this exercise you will walk through the basics of how DecisionSpace handles on-the-fly and more permanent domain conversions.

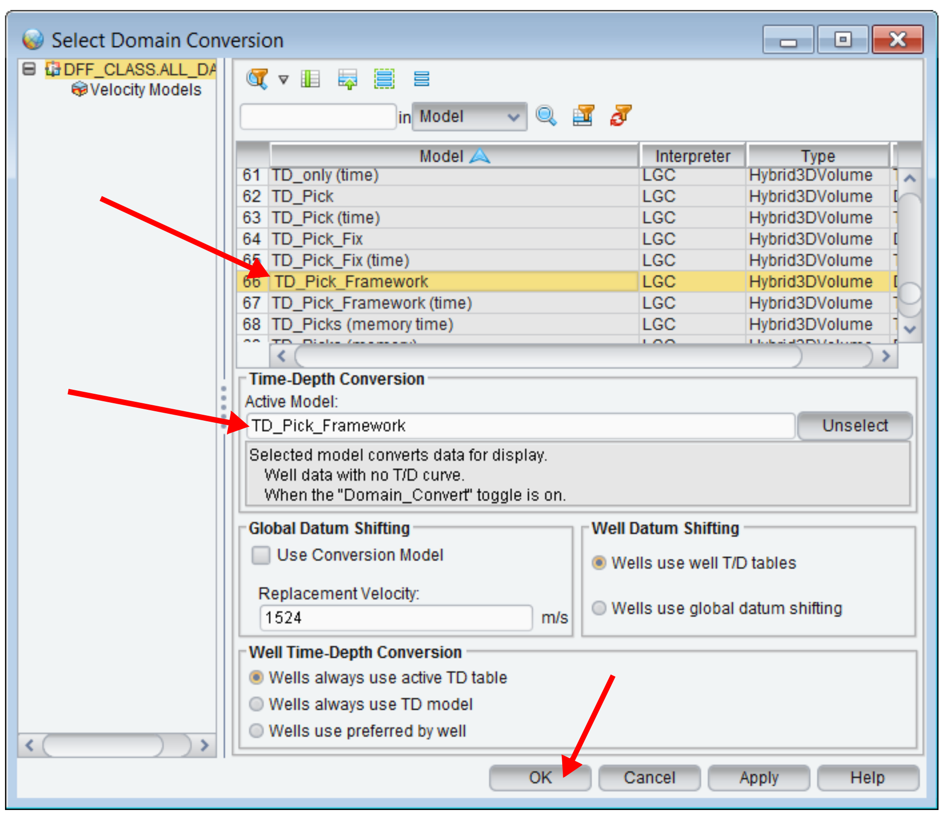
Dynamic Domain Conversion

1. In the *Cube* view showing the framework, click **Select > Domain Conversion** on the main menu bar.



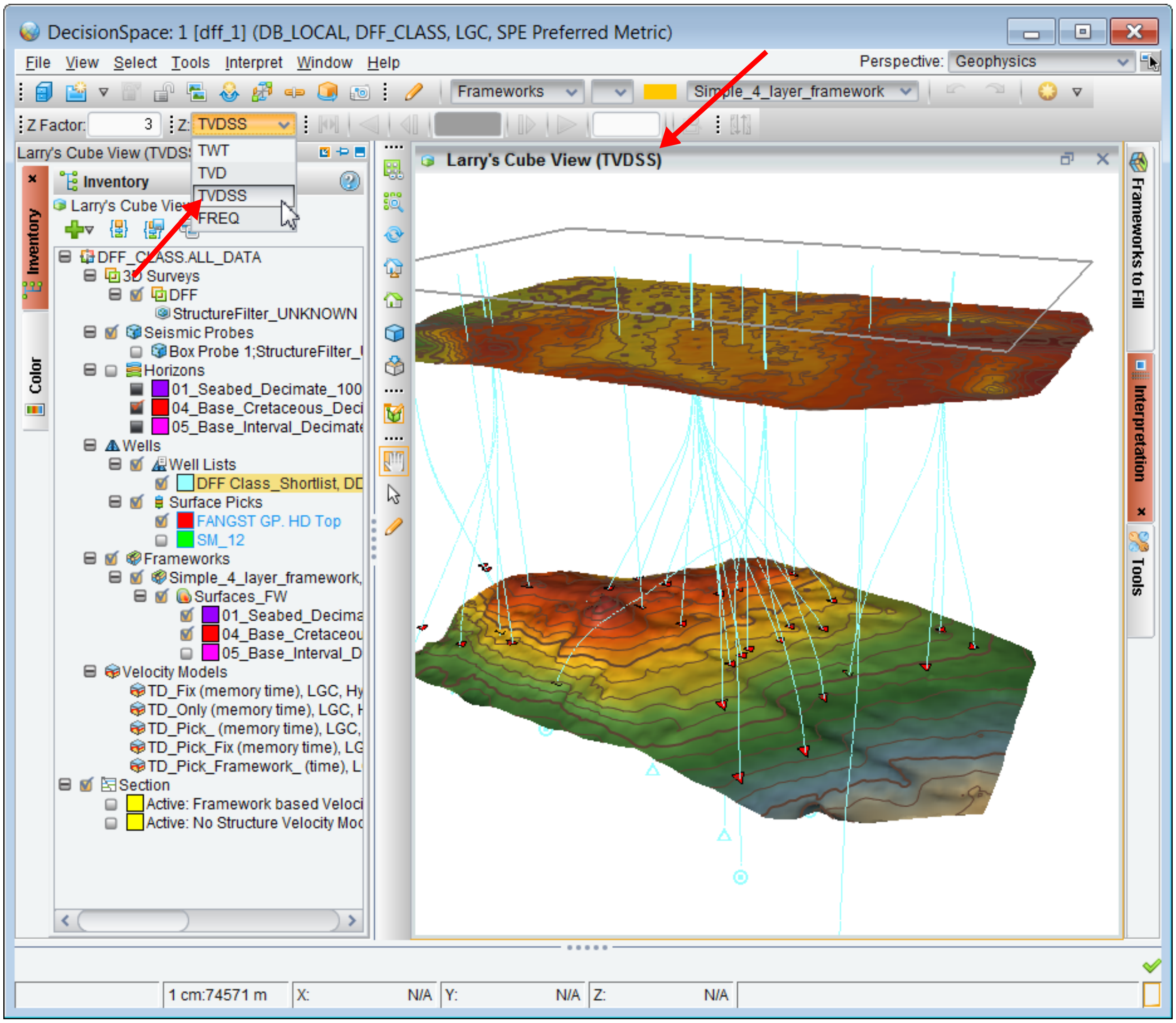
The *Select Domain Conversion* dialog box displays.

2. In the *Select Domain Conversion* dialog box, make the Active Model **TD_Pick_Framework**, and then click **OK**.



3. Select **Yes** if asked about resetting the framework velocity model.

4. Display the framework and wells in the *Cube* view and then toggle the **Z** domain to **TVDSS**. When you do this, the frameworks and other time data will by dynamically converted from time to depth.

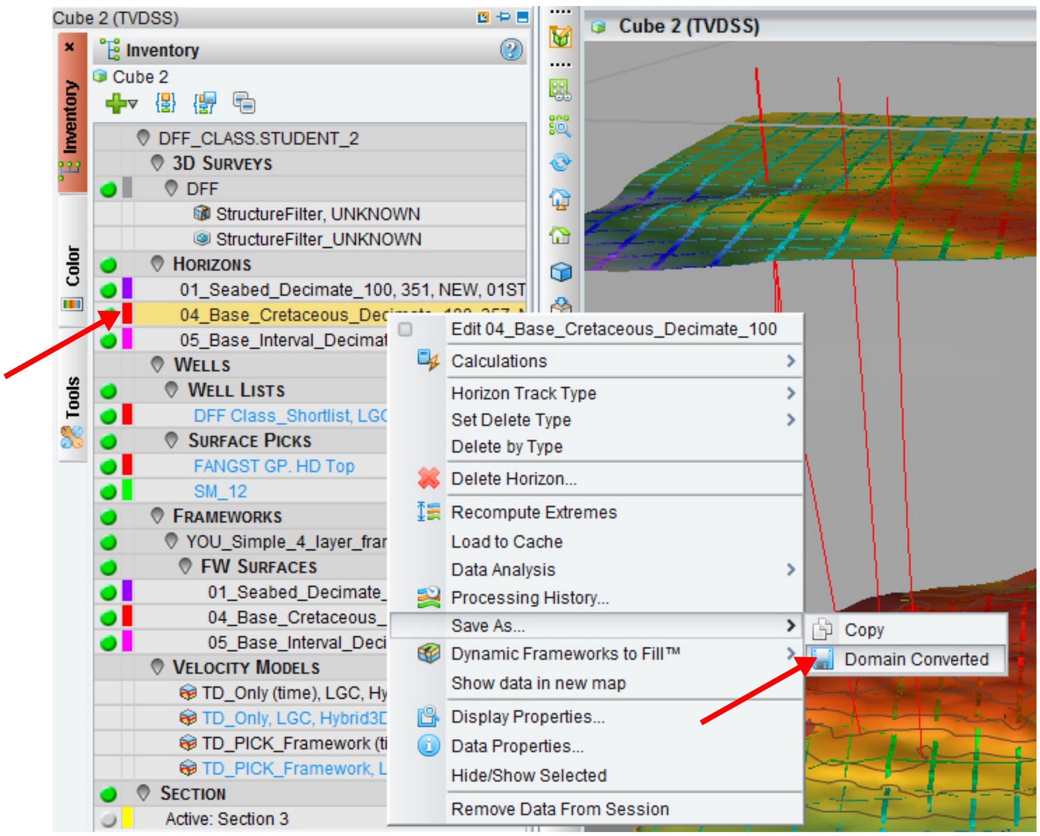


If you did not have a model selected for domain conversion, then all the time objects would have disappeared from the TVDSS view because there would be no velocity model to convert from time to depth.

Static Domain Conversion

In the previous exercise, you performed a dynamic depth conversion, which allowed different types of time and depth data to be interpreted together. This generated on-the-fly conversions. You can also save permanent conversions as static files.

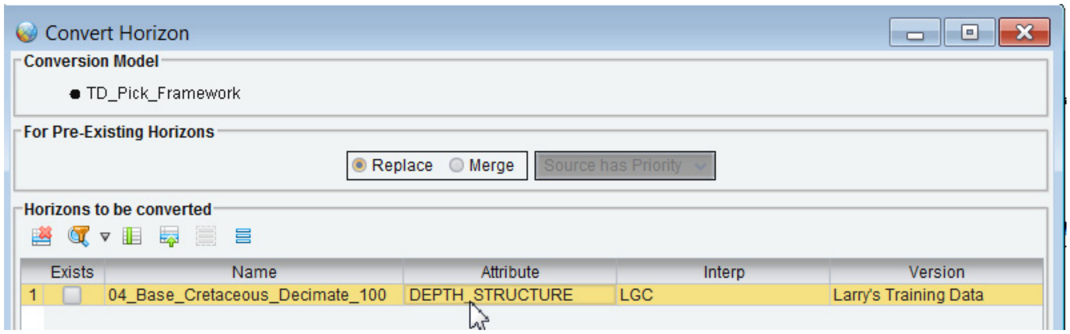
1. In the *Inventory* task pane, highlight the **04_Base_Cretaceous** horizon, **MB3**, and then select **Save As... > Domain Converted**.



The *Convert Horizon* dialog box appears.

Note that the **Save As...** option is enabled only when an Active Model is defined in the *Select Domain Conversion* dialog box.

2. Take the default name (which is the same as the input) and notice that the Attribute type of **DEPTH_STRUCTURE** makes name unique in the database.



3. Click **OK** to perform the static conversion.

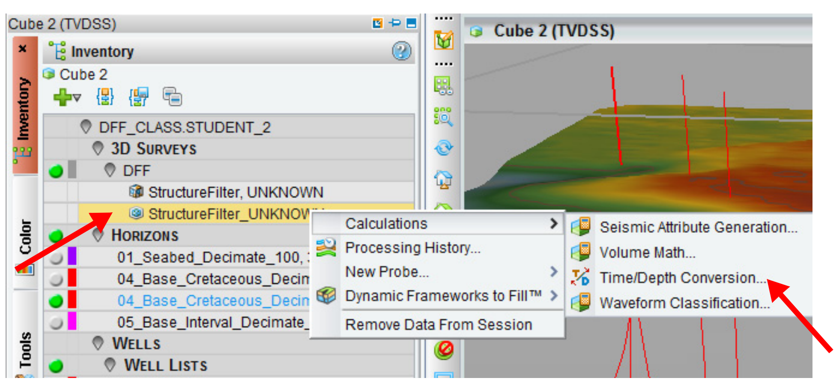
   When the conversion is complete, you will see the depth horizon appearing (in blue) in the *Inventory* task pane. Blue text denotes depth domain, while black text denotes time domain.

4. You can use the same procedure to convert Faults and Grids.

   Note that you can multi-select to domain convert many objects at a time.

   Using a velocity model, you can also convert seismic files, in much the same way that you convert domains of horizons, grids and faults. This eliminates the need use other applications to convert the domains.

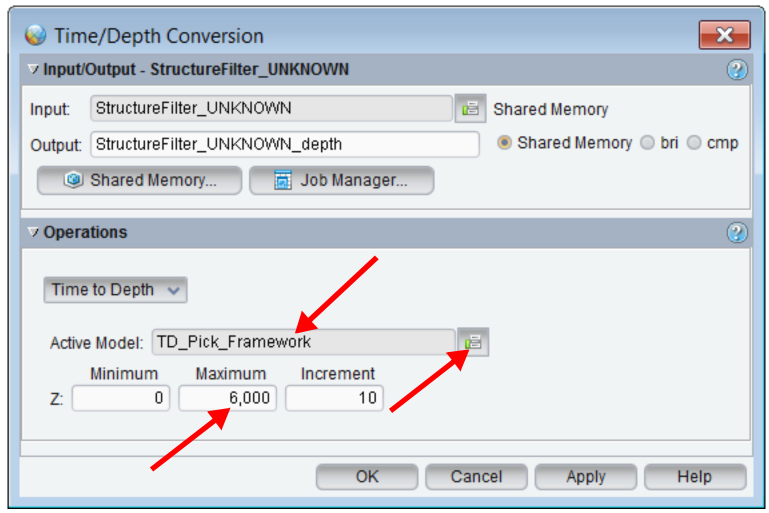
5. In the *Inventory* task pane, **MB3** on the **StructureFilter** shared memory volume, and select **Calculations > Time/Depth Conversion...**.



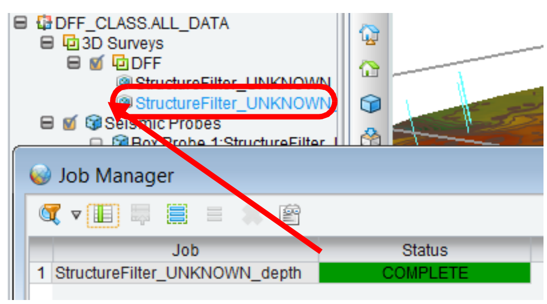
6. Accept the defaults in the *Input/Output* dialog box.

7. In the *Operations* pane, click the icon to set the Active Model to **TD_Pick_Framework**.

8. Drop the maximum depth down to **6,000** meters, and then click **OK**.



9. After the calculation is complete, you will see your newly created depth volume in the *Inventory* task pane.



This volume can be dropped in the cube view for fast dynamic analysis in the depth domain. You also have the option of saving the volume to the OpenWorks database, which will make it viewable in the depth domain by other interpreters in your Interpretation Project.

This concludes the domain conversion exercises.

Review

In this chapter you followed some of the core seismic interpretation workflows in DecisionSpace. DecisionSpace has many tools for the common tasks of fault interpretation, well tie, velocity modeling, horizon interpretation, and depth conversion. These tools are enhanced and extended by the use of Dynamic Frameworks to Fill methodology.

Activities in this chapter included:

- Working with fault interpretation in *Section* and *Cube* views
- Improving fault interpretation with Fault QC Display
- Generating a fault network in Dynamic Frameworks to Fill
- Creating synthetics from well logs
- Using the *Well Tie* workflow to tie synthetics to seismic
- Interpreting horizons within a fault network, including ezValidator
- Using Area Track!
- Interpreting horizons using Dynamic Frameworks to Fill
- Setting-up the velocity model
- Deriving and comparing velocity models
- Using the Domain Conversion within DecisionSpace
- Converting data between time and depth domains

Now that you have covered the core interpretation tasks, the rest of the class will concentrate on the details of the DecisionSpace *Dynamic Frameworks to Fill* workflow.

Chapter 2
Geologic Interpretation

In this chapter you will review the following basic geologic workflows:

- Searching for wells
- Building cross sections
- Correlating logs
- Building basic maps

You will also use interpreted and mapped seismic horizon data to assist in the correlation process and to guide well-top surface mapping.

With DecisionSpace Geoscience and Dynamic Frameworks to Fill, interpretation and mapping go hand in hand. As a result, interpreted tops and horizons are shown in several views:

- *Map* view—conventional contour maps
- *Cube* view—surfaces in perspective
- *Section* view—surfaces that show true structure varying between wells
- *Well Correlation* view—predicted tops, where surfaces intersect well bores (also referred to as *Correlation* view)

Topics Covered in this Chapter

- Building cross sections in *Well Correlation* and *Section* view, and the strengths of each
- Applying existing well layouts and modifying well layouts to use in cross section displays
- Displaying mapped horizon surfaces in *Well Correlation* view
- Correlating logs: techniques and guidelines
- Integrating seismic framework faults and subsurface fault interpretations
- Mapping while interpreting
- Guiding well-top surfaces, and using horizon surfaces and conformance technology
- Editing contours

For more information on these topics, see “Chapter 6: Best Practices in Well Log Correlation” and “Chapter 1: Best Practices for Dynamic Frameworks to Fill Framework Construction”. The Decision Space Geosciences: Software Best Practices book is distributed with this manual.

Overview: Building Cross Sections

In this section, you will review fundamental cross section construction techniques that you will employ in the well correlation exercises. Two types of cross sections are available in DecisionSpace Geosciences: *Section* view and *Well Correlation* view.

In this manual, *Well Correlation* view and *Correlation* view are equivalent.

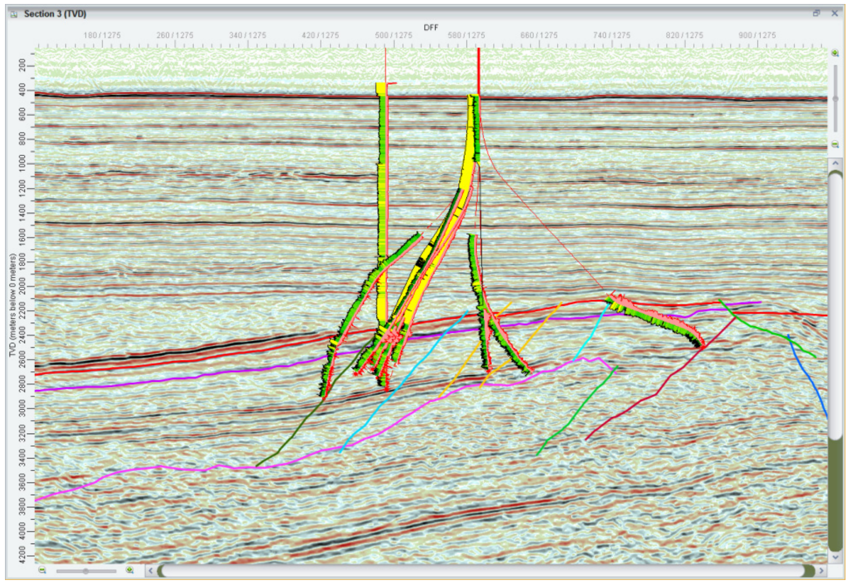
Defining Section View

Section view is a two-dimensional vertical slice through a study area.

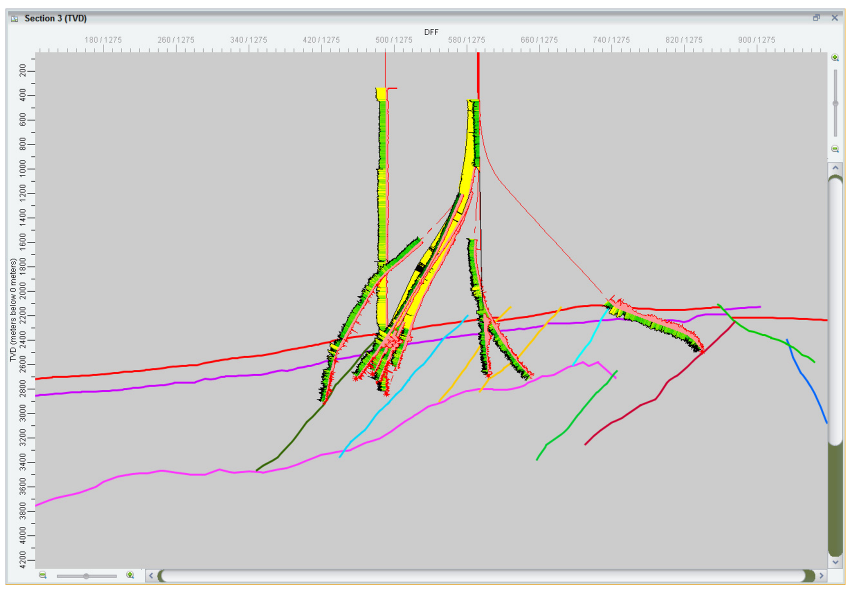
In *Section* view, you can:

- View data from multiple domains
- Share data by all DecisionSpace modules (Geophysics, Geology, Earth Modeling, and so forth)
- Vary vertical and horizontal scales independently, while data (wells, seismic, and so forth) remain in the correct proportional position relative to real-world coordinates
- Perform well-to-well surface pick correlation, wherein surface picks are connected when modeled within a framework as they intersect the line of section
- Have simultaneous access to cross-domain data visualization and interpretation, which allows horizon interpretations and subsurface correlations to be co-visualized, providing a powerful means for cross validation

The following image is an example of a *Section* view, with seismic display turned on.



Below, in the same image, the seismic is turned off.



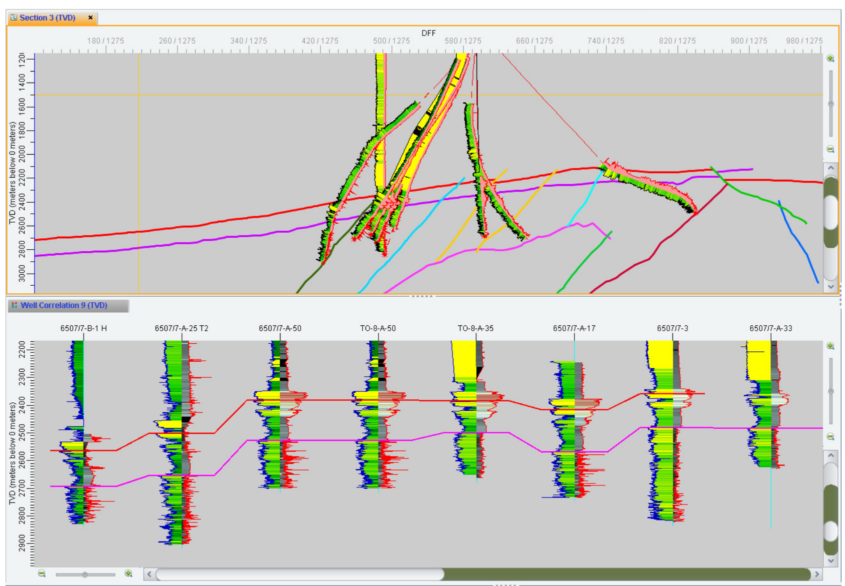
Defining Correlation View

Correlation view is a fit-for-purpose window that places wells, with a well layout, side-by-side to enhance visualization and interpretation of well-data.

In *Correlation* view, you can:

- Hold well spacing constant between wells (show none of the real-world coordinate distance, as is the case with *Section* views)
- Show deviated wells as straight, vertical well bores in TVD, TVDSS, TST, or MD modes
- Connect surface-pick correlations by straight-line segments between wells

Inter-well geology cannot be shown in *Correlation* view. However, the intersection of a framework surface or fault with the well bore can be displayed as a predicted top in the *Correlation* view. The image below combines *Correlation* and *Section* views.

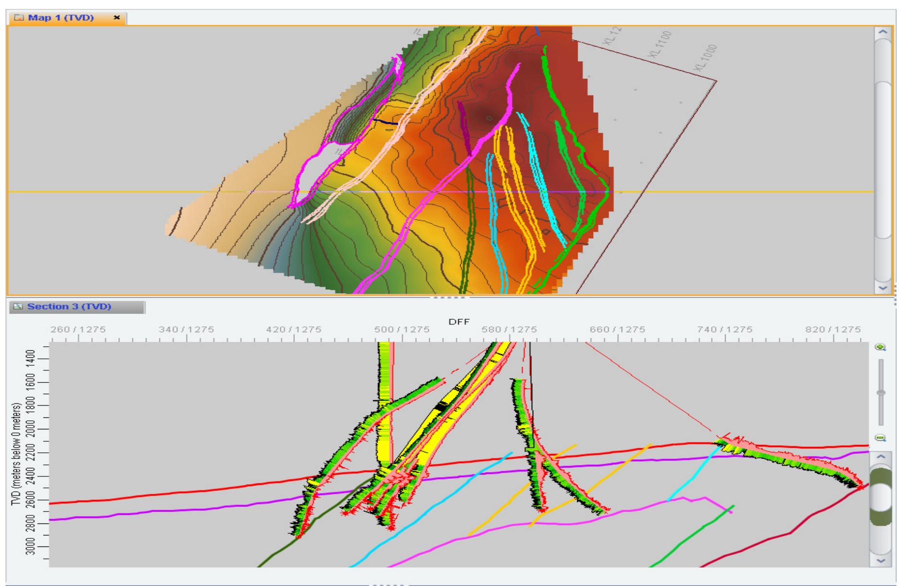


Using Section View and Correlation View Together

Section view and *Correlation* view can be regarded as complimentary views of the same set of well data along a line of section. For example, many geologists prefer the side-by-side well presentation in *Correlation* view for log correlation and a well-data-only summary of subsurface information. *Section* view—which can be presented at the same time as *Correlation* view—provides a view of seismic data (if present along a line of section) and the structural context (surfaces and faults) between the wells. In effect, horizon interpretations in *Section* view can be used to validate subsurface correlations, and vice versa. The previous image, showing *Section* and *Correlation* views for the same set of wells along a line of section, is a recommended best practice use of the two cross section tools within DecisionSpace Geosciences.

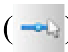
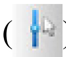
Summarizing Cross Section Tools

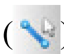
The composite *Map* view and *Section* view in the image below is an example of the numerous ways you can build cross sections with both *Section* and *Correlation* views.



First, build a series (or network) of *Section* view cross sections that traverse your study area (e.g., strike, dip, and all-well-zig-zag sections).

As you build these sections you have the option of building them as projected sections, in which wells within some specified projection distance are displayed on the line of section. You can build projected sections in at least four ways.

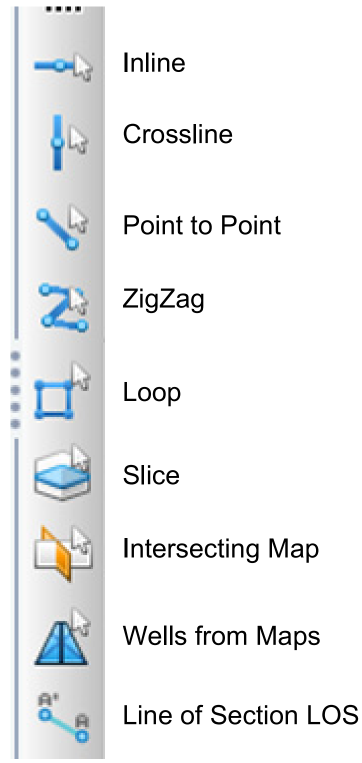
- You can click the **Inline** () or **Crossline** () icons and then select *Map* view on the respective Inline and Crosslines from the 3D seismic survey.

- You can click the **Select Point to Point** () icon, and then click **MB1** on a series of anchor points to define your line of section, terminating the line of section by clicking **MB2**.

- You can **Ctrl**+click the **Select Point to Point** () icon, and then click **MB1** to select wells. This creates a projected section, in which the line of section exactly follows the well path of selected wells and includes any additional wells within the projection distance. When you finish the selection, click **MB2** to terminate the section and send it to the existing (highlighted) *Section* view.

- You can click the **Create Line of Section LOS** () icon, and then select the anchoring mode from the dialog box, or from **MB3** in the *Map* view. Click **MB1** on a series of anchor points to define your line of section, terminating the line of section by clicking **MB2**. Using **Ctrl+MB1** you can override the current Anchor Mode option and snap the Line of Section along the wellbore.

The following figure shows the tool bar positions of the different selecting options: **Inline**, **Crossline**, **Point to Point**, **ZigZag**, **Loop**, **Slice**, **Intersecting Map**, **Wells from Maps**, and **Line of Section LOS** icons.

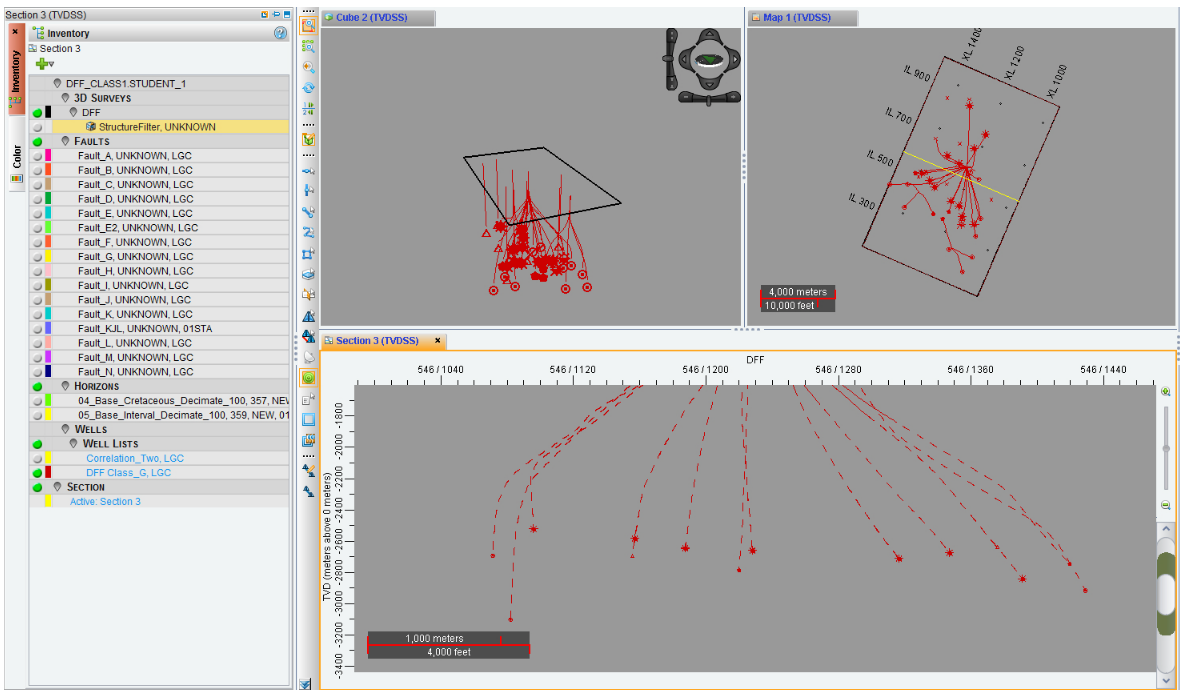


Exercise 2.1: Creating a Session and Loading Data

You will launch a new session, load data, and assemble cross sections in this exercise.

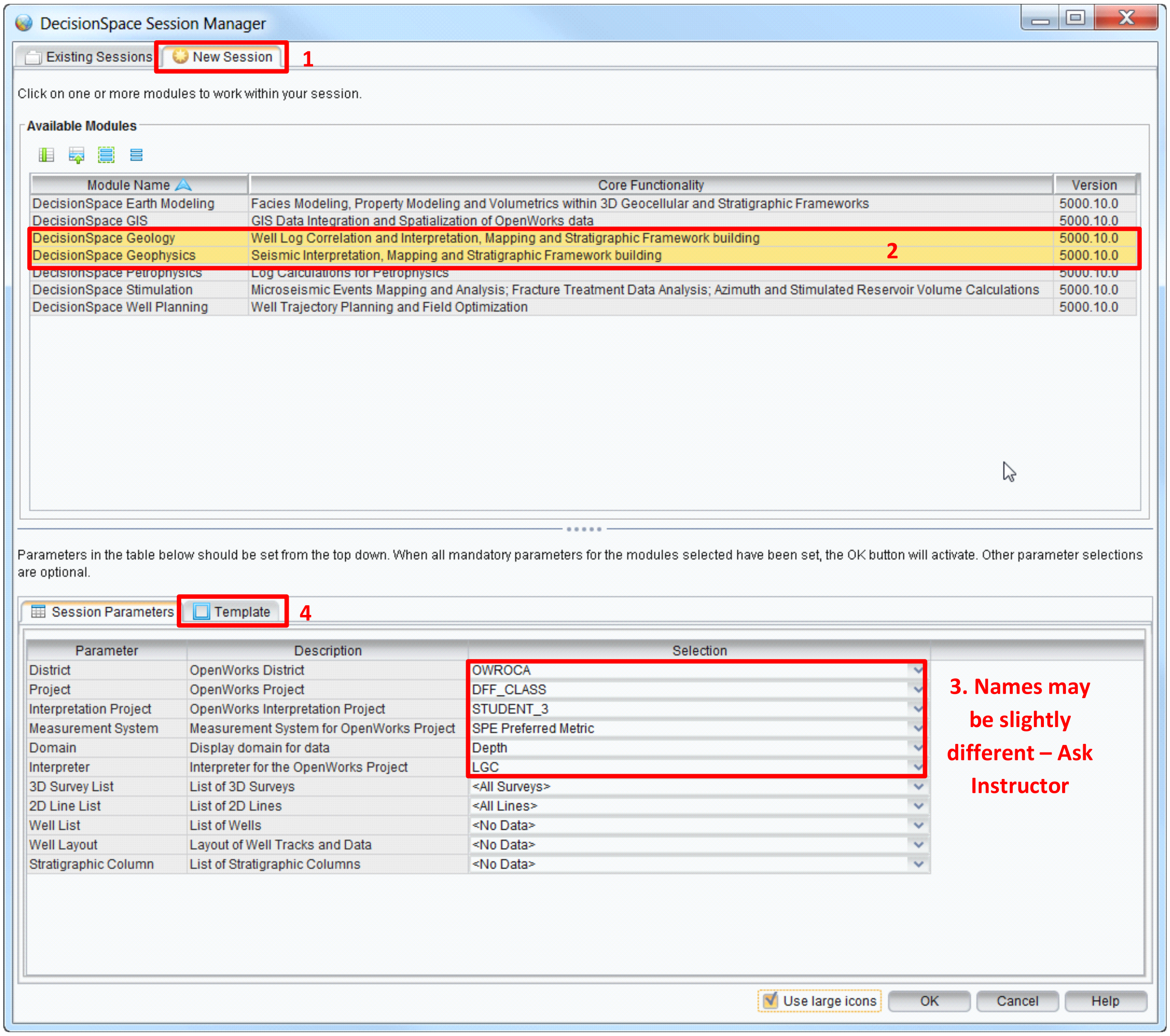
1. Launch DecisionSpace.

2. Load session **Chapter2_GeologicInterpretation**. If your session looks similar to the image below, go to Step 11.

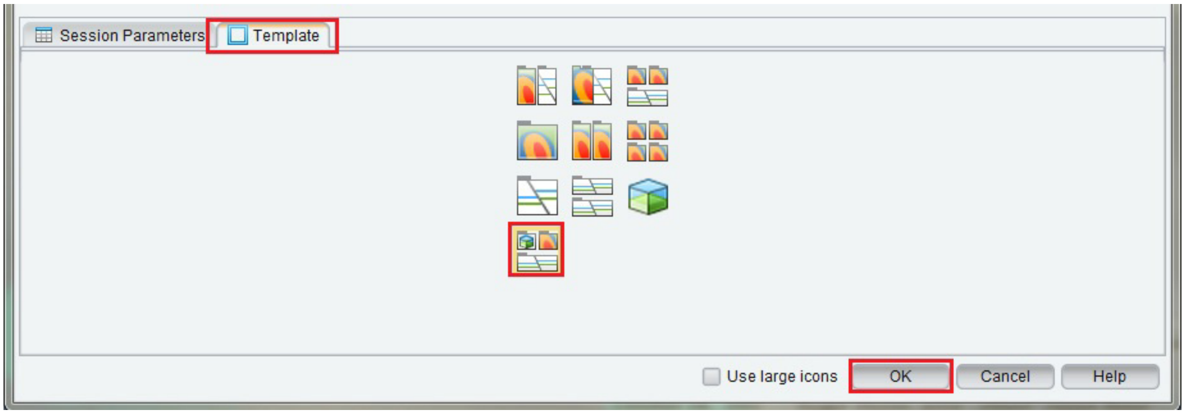


3. If you have trouble loading the above session, select the **New Session** tab (New Session).

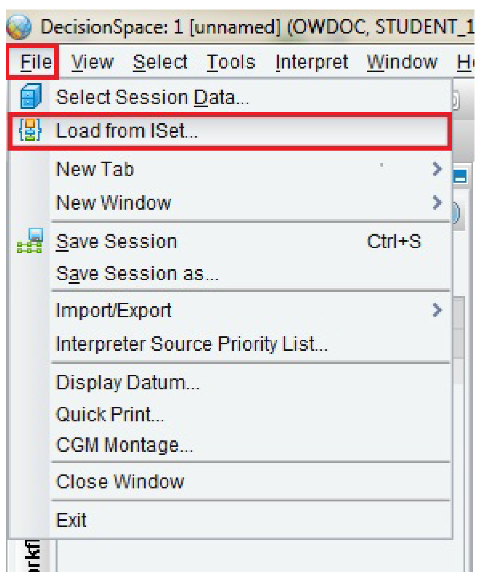
4. Select the **DecisionSpace Geology** and **DecisionSpace Geophysics** modules. Configure the *Session Parameters* tab to match the details shown below. Select **Depth** as the Domain and **LGC** for the Interpreter.



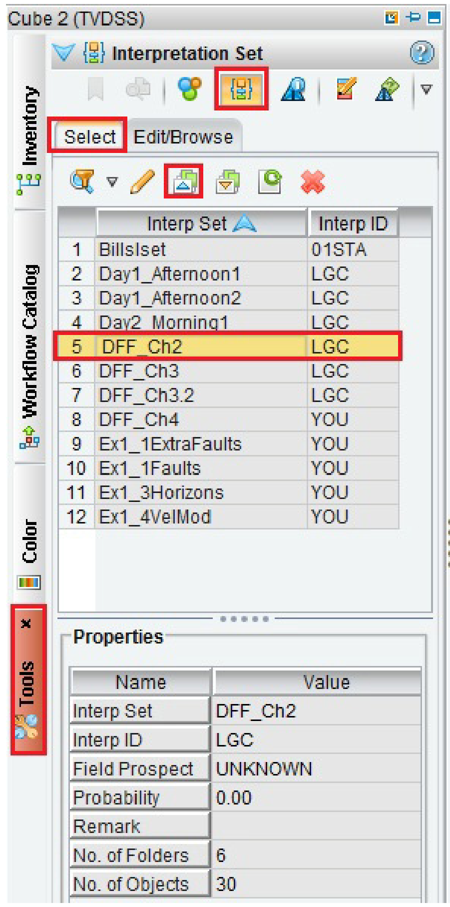
5. Select the **Template** tab of the *Session Manager* dialog box, and then select the **Map/Section/Cube - Triple Tile** icon. Make sure none of the other templates are selected, and then click **OK** to launch the session. If you wish, check **Use large icons**.



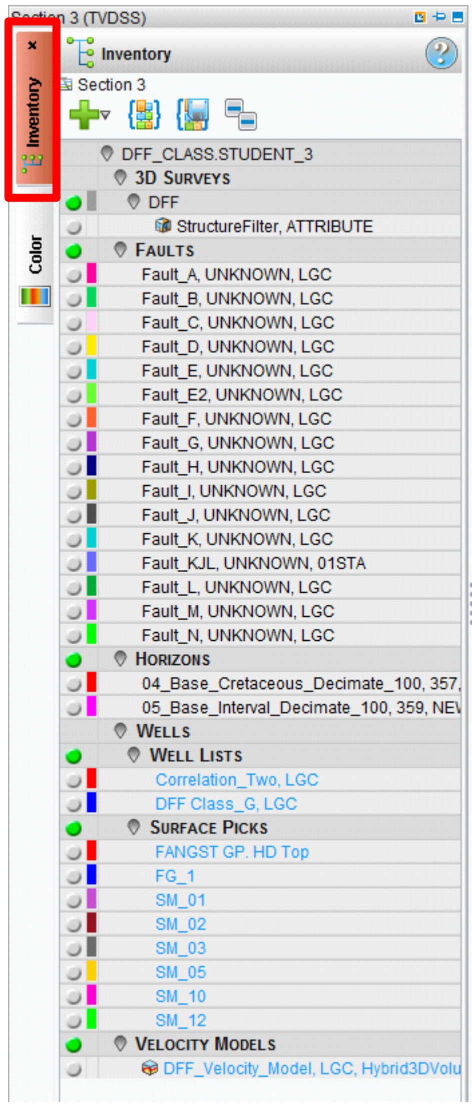
6. Once Decision Space opens, select **File > Load from ISet...** to load the assembled data for this chapter.



7. On the *Tools* task pane, confirm that **Interpretation Set** is listed at the top. Select the **DFF_CH2** ISet, and then click the **Load Data to Session** ( ) icon.



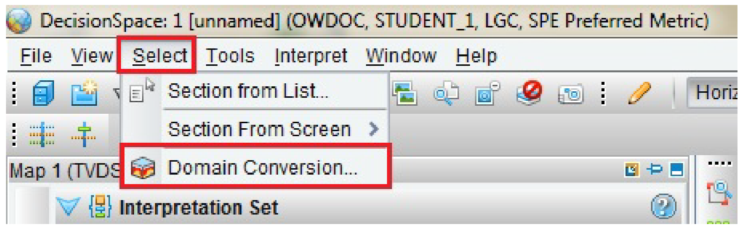
The ISet should contain the data shown in the image below.



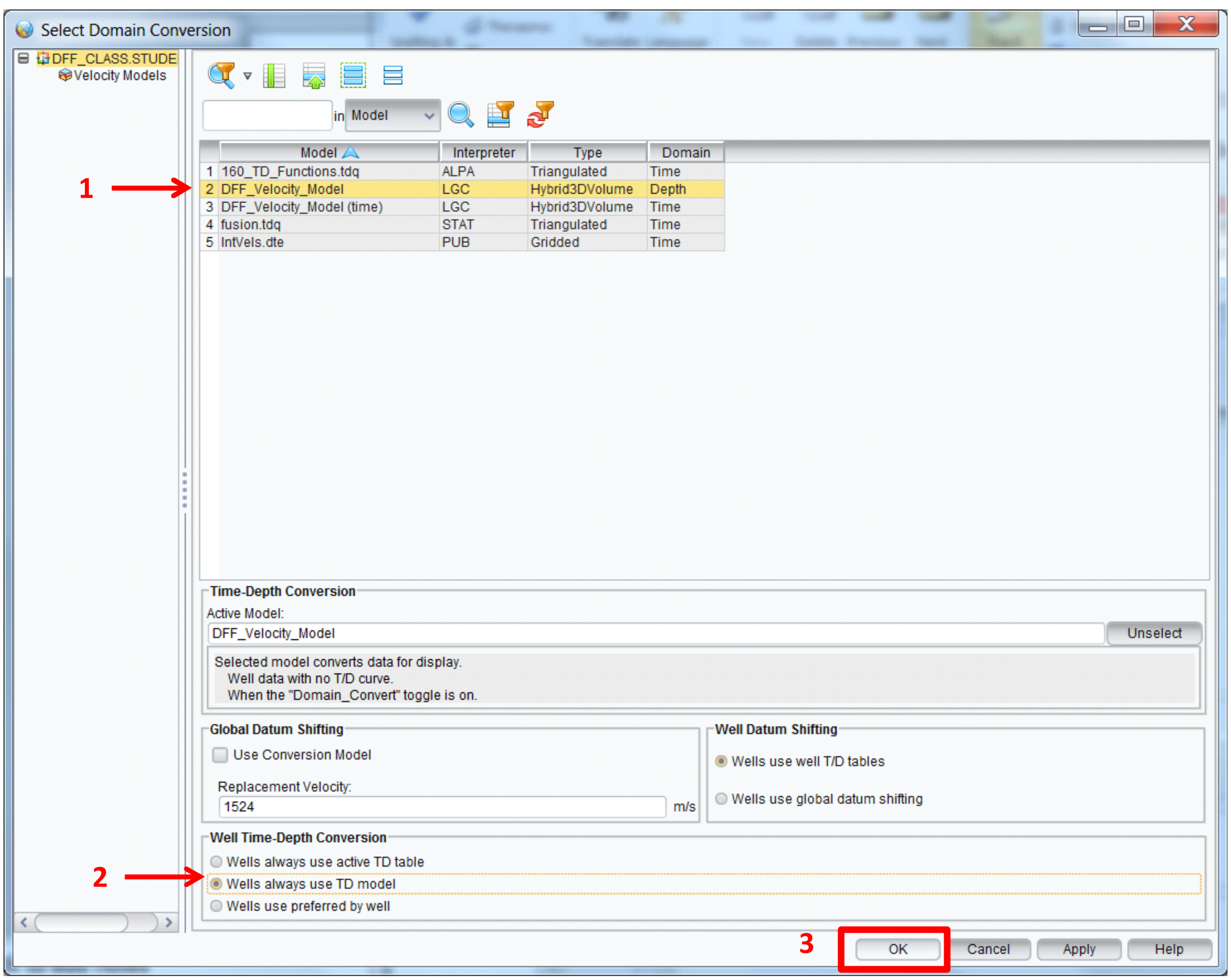
8. If any data is missing, add it manually from the *Select Session Data* dialog box.

The session initiated with depth domain, but some of the data is time domain. You must select a velocity model to view and work with all of the data.

9. From the main menu bar, select **Select > Domain Conversion...**.

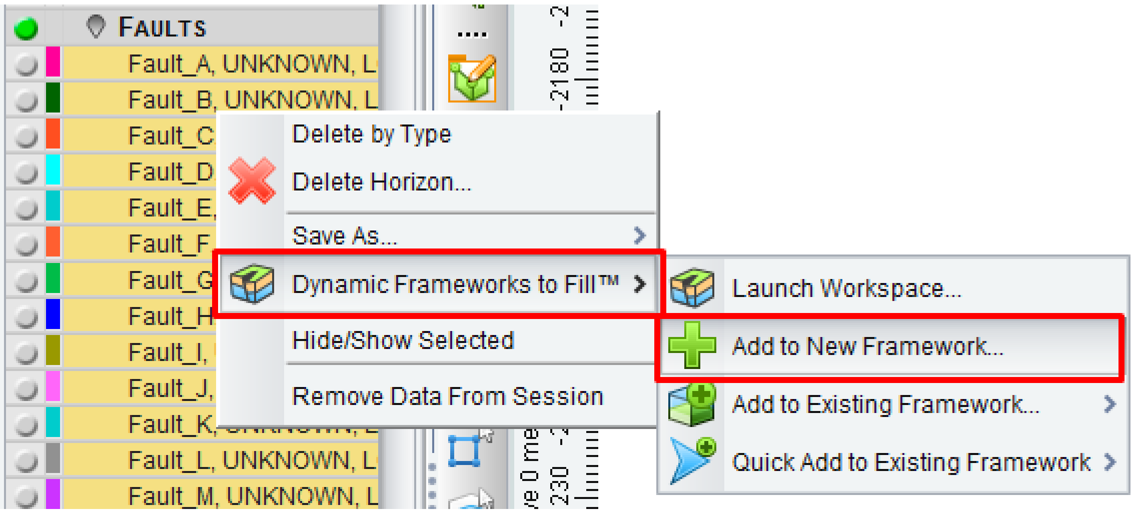


10. In the *Select Domain Conversion* dialog box, highlight **DFF_Velocity_Model (depth domain)** the velocity model. The velocity model displays in the Active Model field. In the *Well Time-Depth Conversion* sub-panel, select **Wells always use TD Model**. Click **OK**.

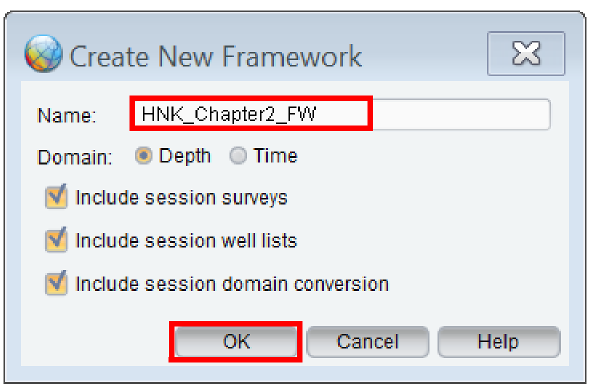


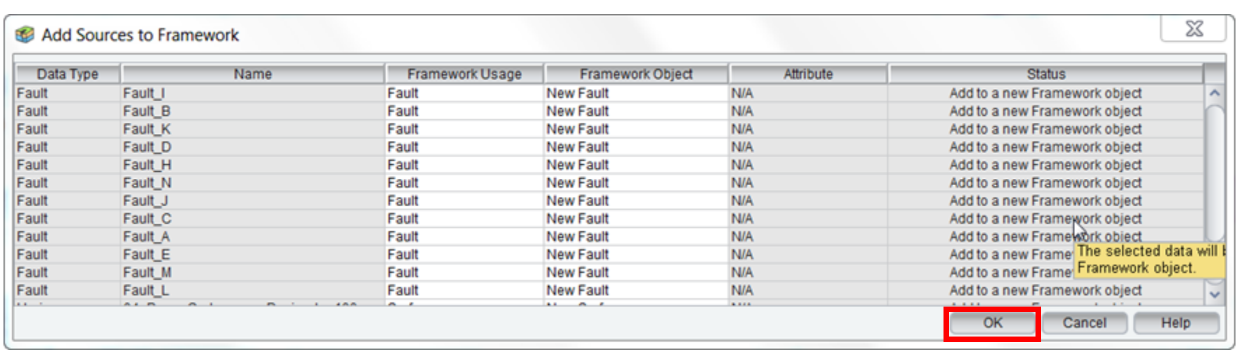
11. You will now create a new framework. Select both of the horizons in your session and all of the faults, excluding Fault_E2 and Fault_KJL.

12. **MB3** on any of those surfaces and select **Dynamic Frameworks to Fill > Add to New Framework**.



13. The *Create New Framework* dialog box displays. Name the new framework **YOU_Chapter2_FW**. Accept all the other defaults and click **OK**.





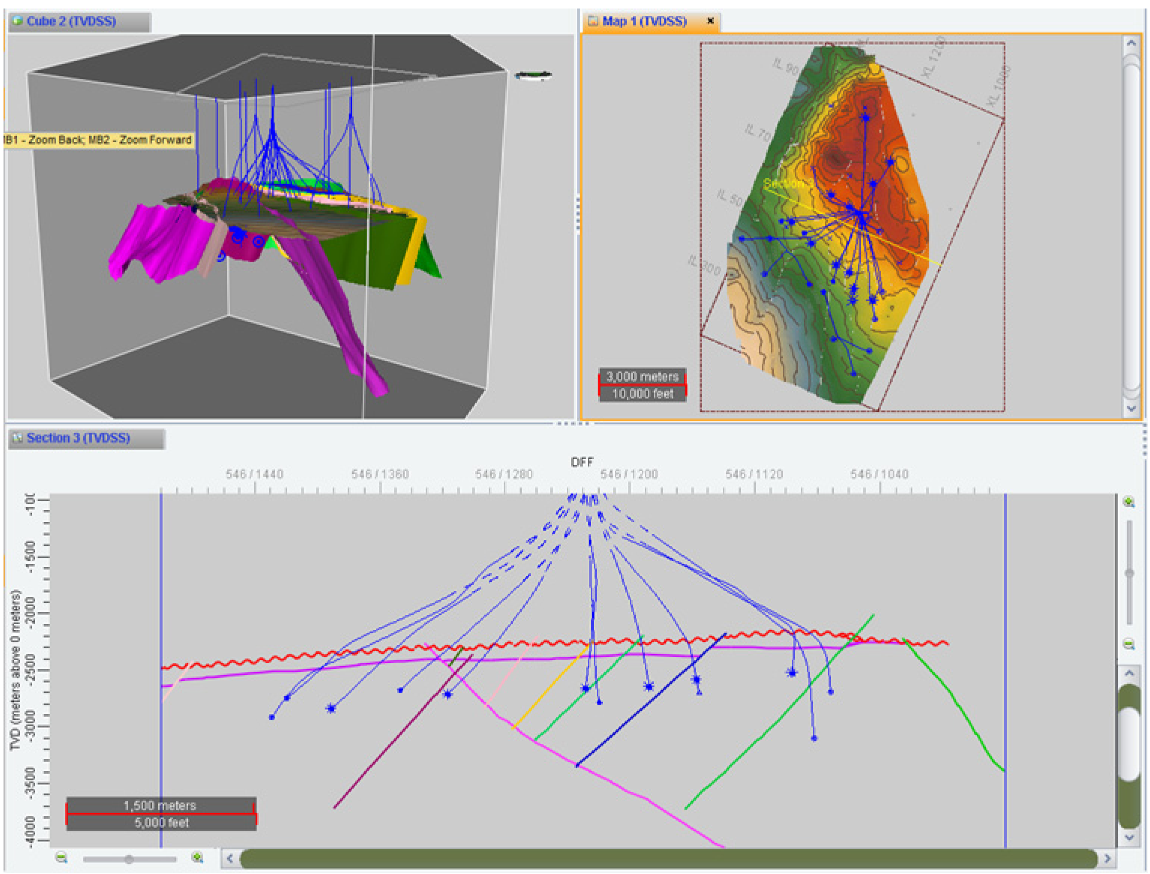
14. Arrange your displays so they look similar to the ones below.

    - The *Cube* view shows the **04_Base_Cretaceous** framework surface, **DFF CLASS_G, LGC** well list, and all the **FW Faults**.

    - The *Map* view shows only the framework surface **04_Base_Cretaceous** and the **DFF CLASS_G, LGC** well list.

    - The *Section* view shows both **FW surfaces**, all **FW faults**, and the well list.

    To visualize these frameworks objects in *Section* view, you need to drag and drop the seismic volume **StructureFilter, ATTRIBUTE**. You can turn off the seismic volume once the objects are displaying. This step is necessary for *Section* view to have spatial reference.



Now that you have had a quick overview of the data within your framework, you will be looking at the 3D structure in 2D by constructing a series of cross sections.

Exercise 2.2: Building Cross Sections

Two types of cross section area available in DecisionSpace Geosciences: *Section* view and *Correlation* view. Geologists typically use *Correlation* views to interpret geological tops since they can control parameters like distance between wells, structural or stratigraphic datum, deviated wells can be represented straight, etc.

Using *Section* view while interpreting and mapping geological tops with framework approach methodology is extremely important, as it helps to understand the geological model. S*ection* view makes it possible for the interpreters to visualize the 3D framework in 2D space along inlines, crosslines, or arbitrary lines. All the data displayed in *Section* view (wells, seismic, faults, etc.) is always placed in the correct proportional position relative to real-world coordinates. Similarly in *Section* view you control where in the wells you want to intersect your cross section: at the well header, TD, any specific surface top or well path; but if the section is not directly crossing any well, the user has the option to project the wells accordingly at any desired angle.

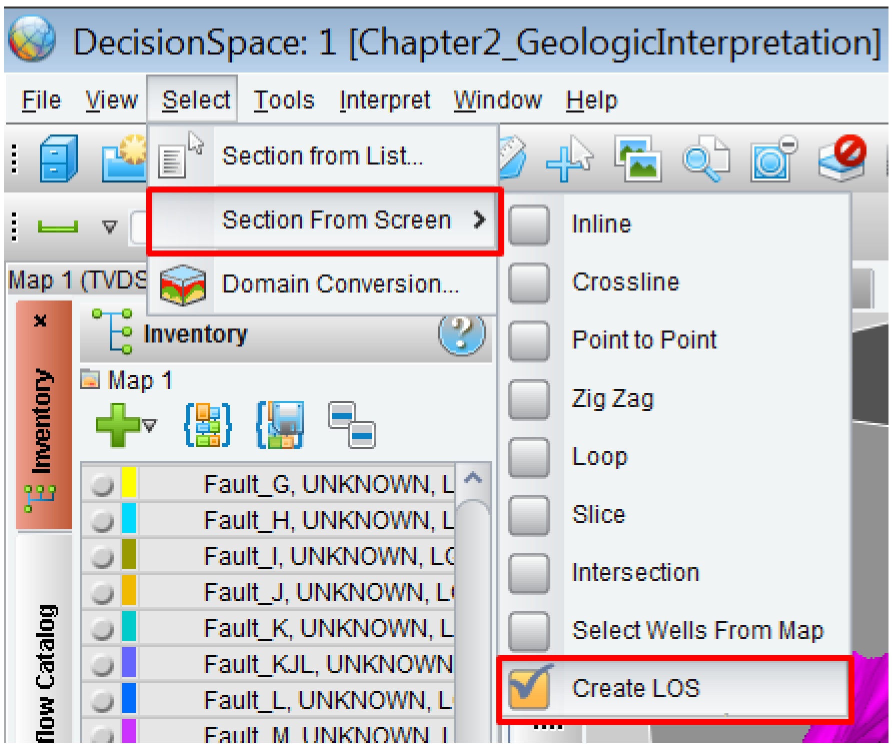
It is a best practice to use both views while you are correlating tops. In the next section, you will explore the options available to create *Section* view to visualize your framework and, ultimately, start using *Correlation* view to interpret tops.

Creating a Line of Section

You will now visualize your 3D structure in 2D by constructing a Line of Section (LOS).

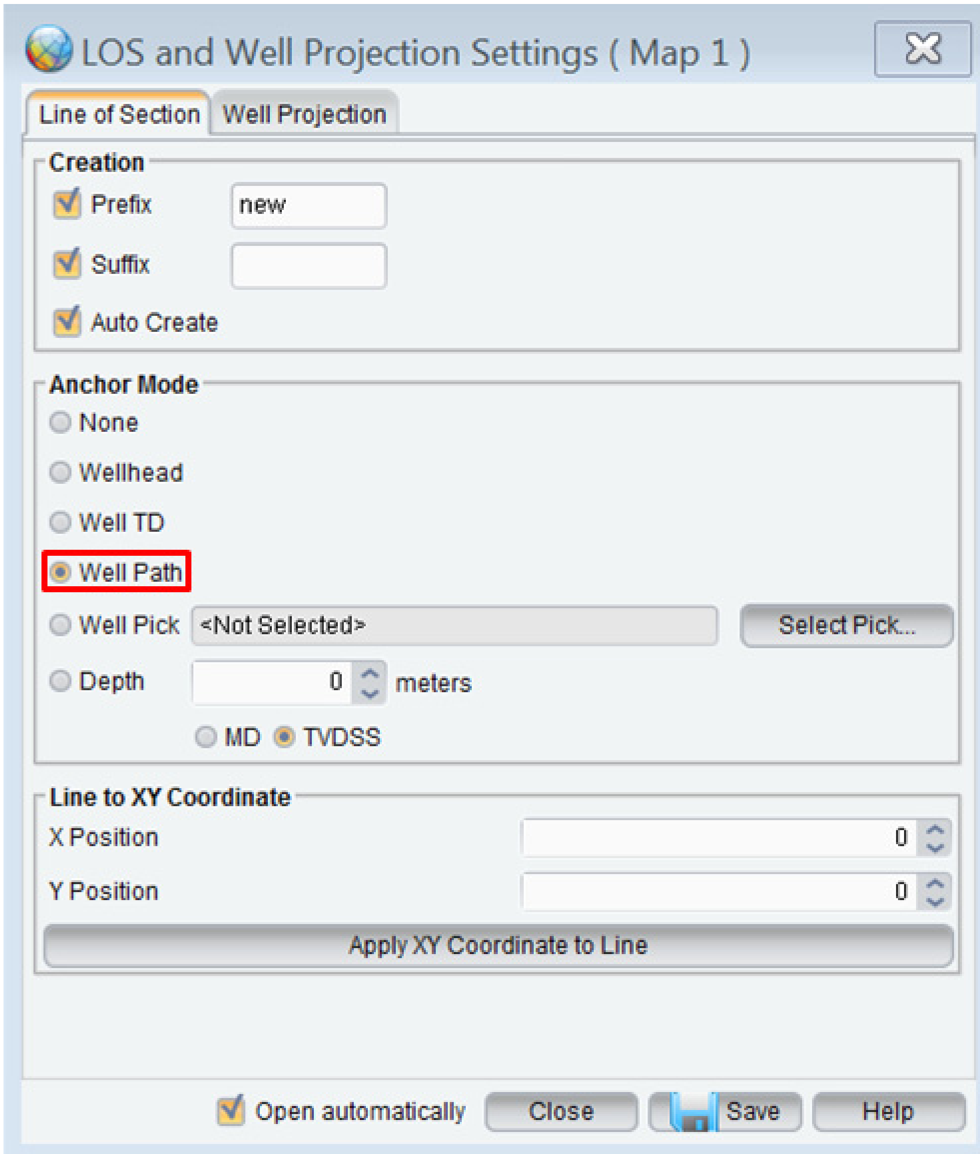
1. Click the *Map* view to make it active. If you wish, turn off the FW Surface for the best view of the wells.

2. Click the **Create Line of Section** icon ( ), or select **Select > Section From Screen > Create LOS**.

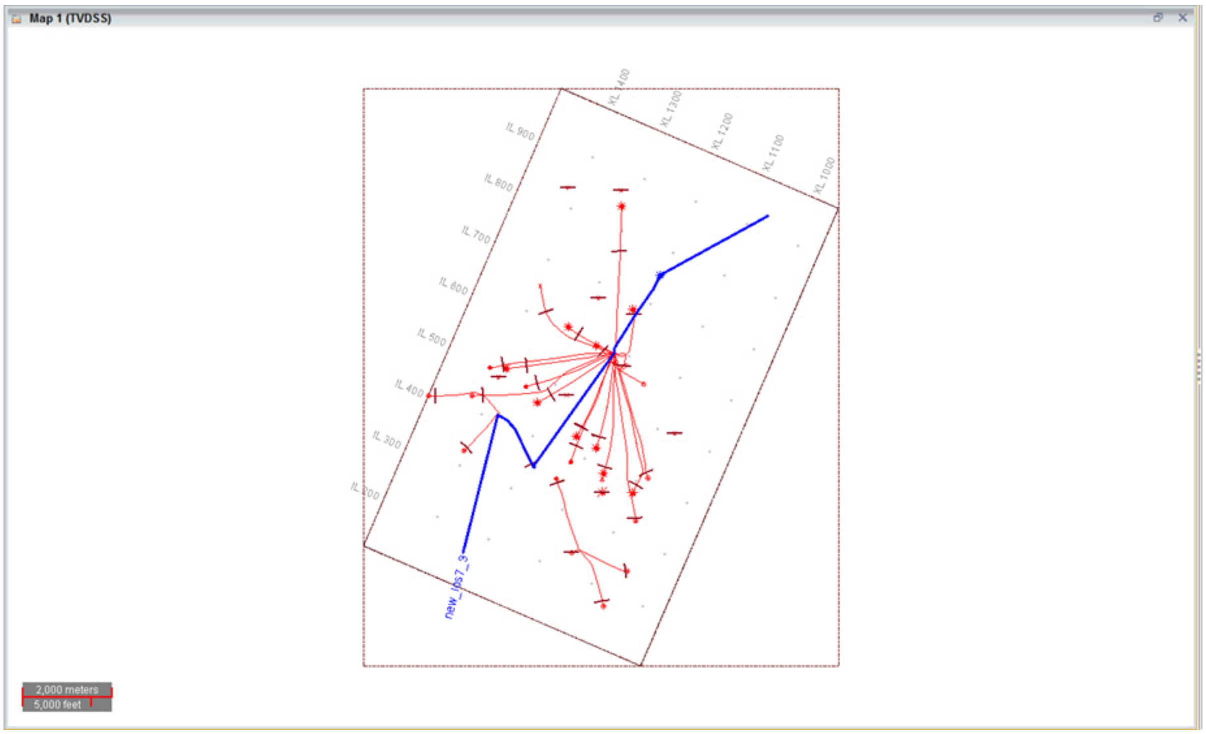


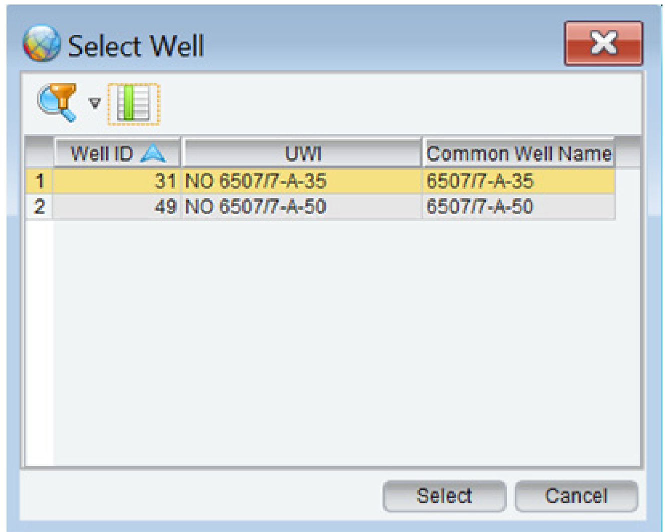
Line of Section along Well Path

3. Select the **Well Path** option to select the entire wellbore of the well to be included within the LOS (this should be the default option). Leave the *LOS and Well Projection Settings* window open.

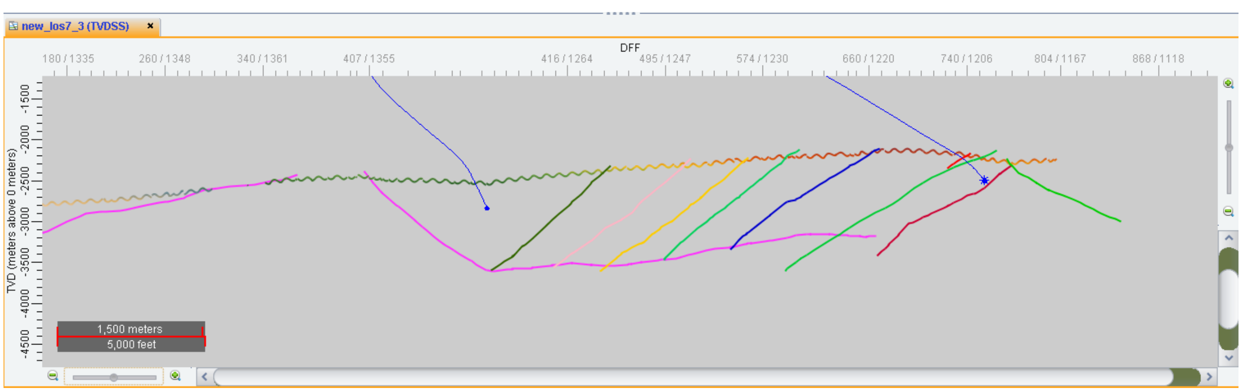


4. **MB1** in *Map* view off of the wells to place your first anchor point. Hover over the wells that you want included in your LOS, and **MB1** (select any wells, you don't necessarily have to match the picture below, the idea is that you become familiar creating LOS, later in the exercise you will be guide to open a common LOS before start interpreting). The entire wellbore for that well will be highlighted. **MB2** to finish the line and send the LOS to a *Section* view.



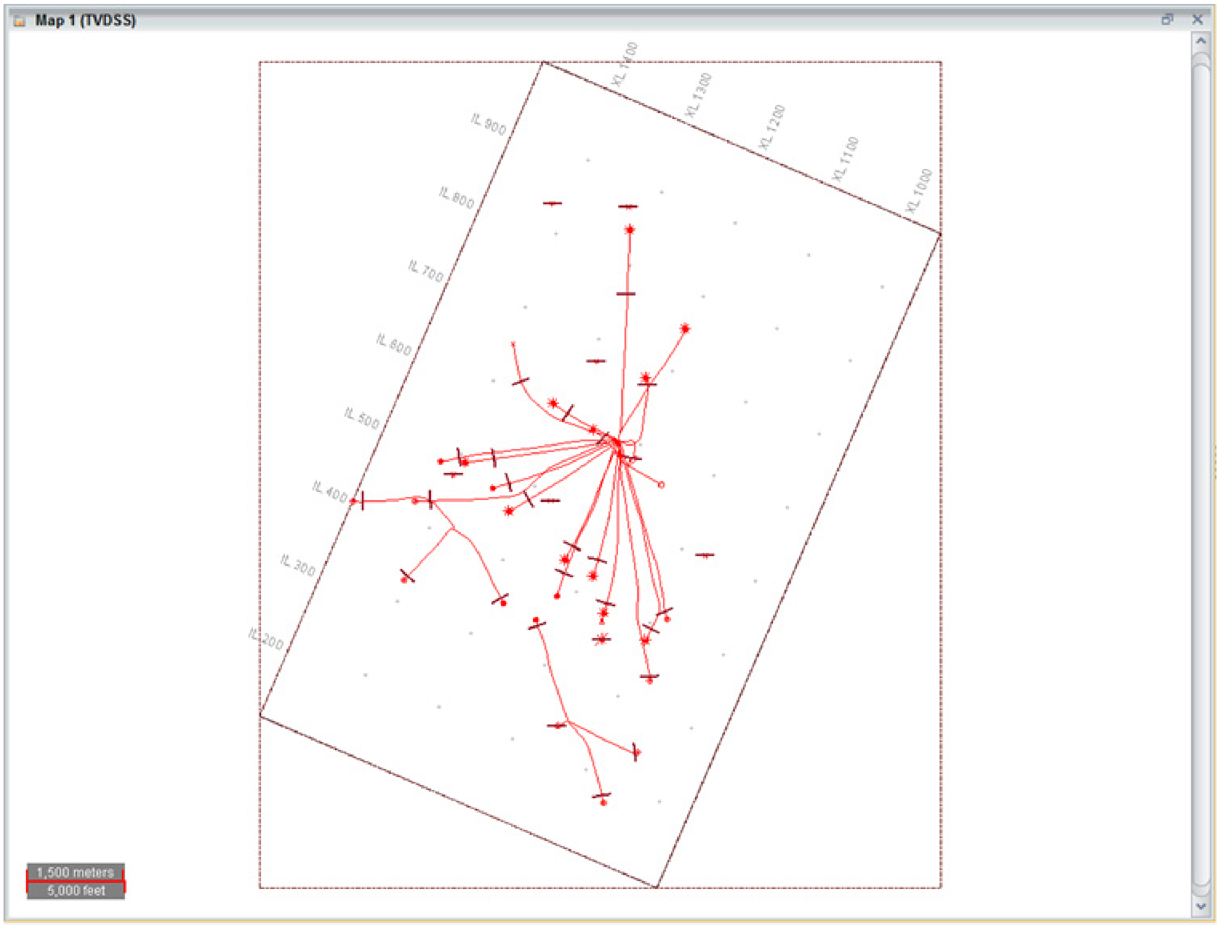
> **Note**
>
> When you **MB1** on a spot with multiple wells a dialog box displays asking you which well you would like to use.
>
> 
>

Your *Section* view should look similar to the one below.

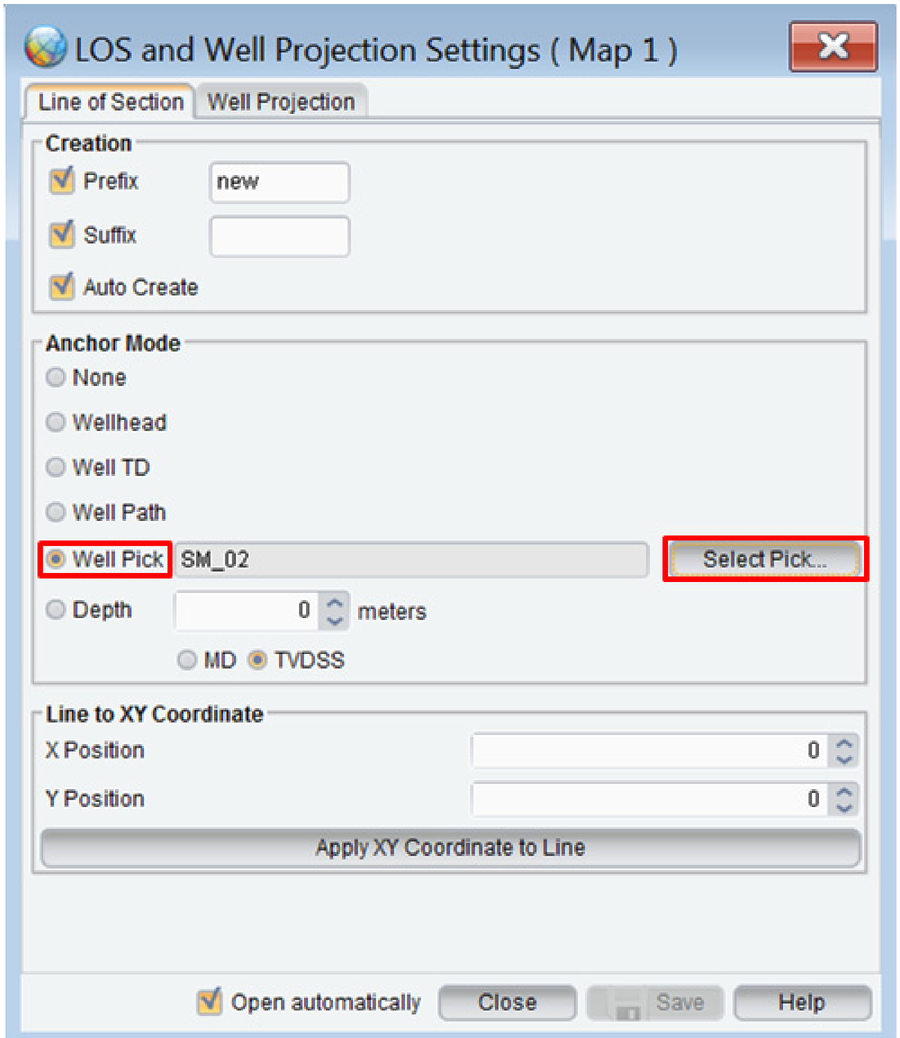


Line of Section along Well Picks

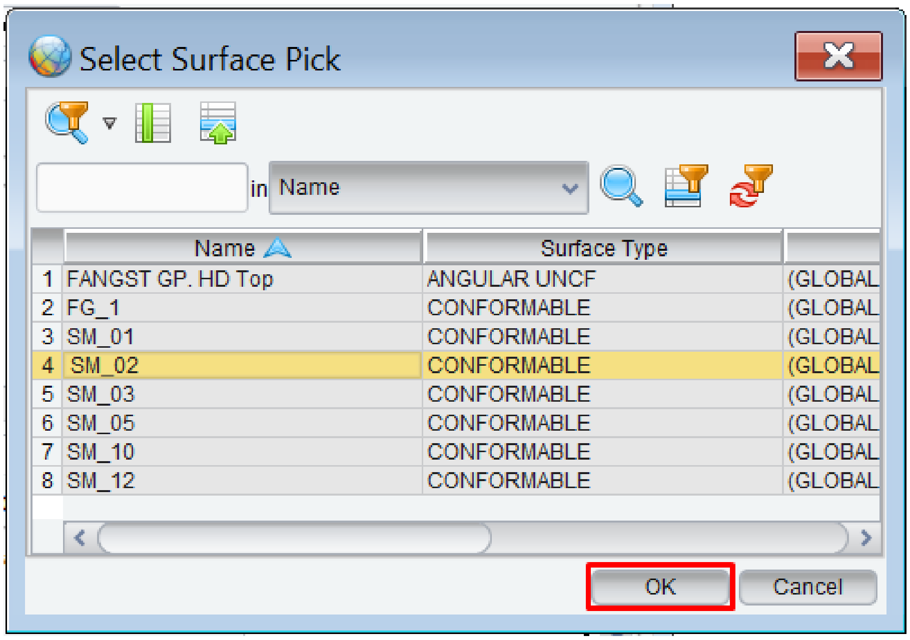
5. In *Map* view, turn off the previous LOS that was just created, so you can clearly see your wells, and turn on the **SM_02** surface pick. (You may also want to turn off the Section projection in *Map* view.)



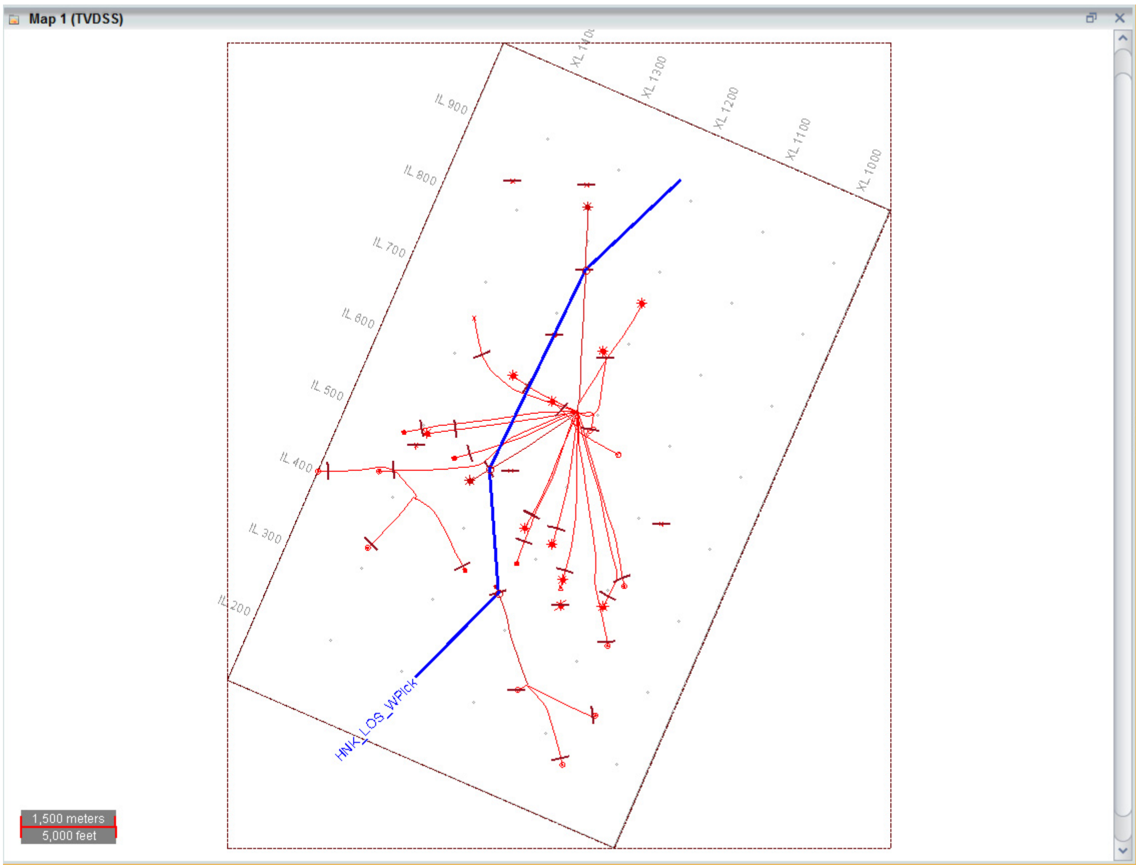
6. Within the *LOS and Well Projection Settings* dialog box select the **Well Pick** option.



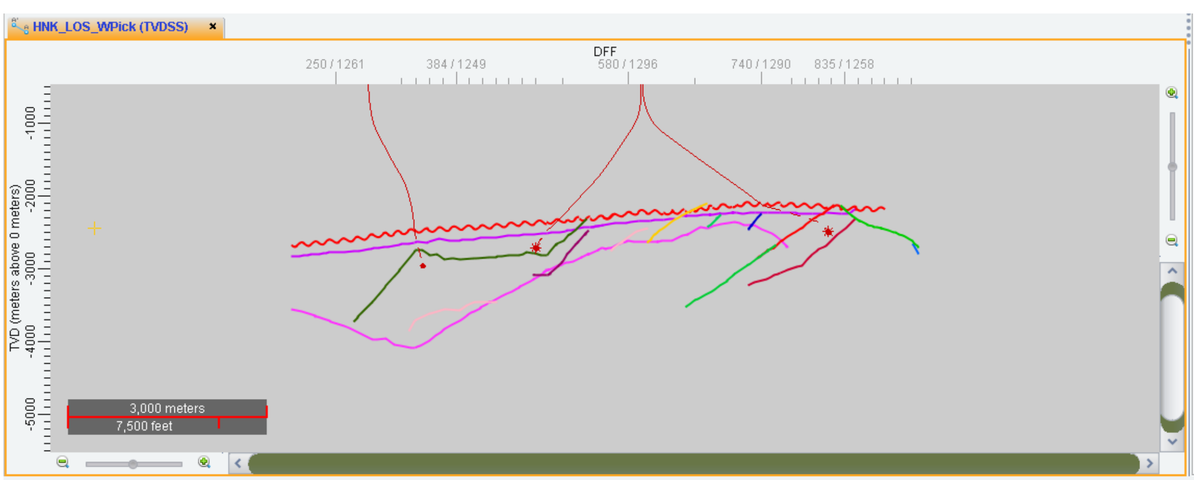
7. Click the **Select Pick** button to the side of the Well Pick name box. A dialog box displays with a list of all the surface picks you can snap to. Select the **SM_02** surface pick. Click **OK**.



8. **MB1** in the *Map* view off of the wells to place your first anchor point. Hover over the wells that contain the surface picks you want the LOS to go through. **MB1** anywhere on the well and the line will snap to the pick you designated. **MB2** to finish the LOS and send it to *Section* view.



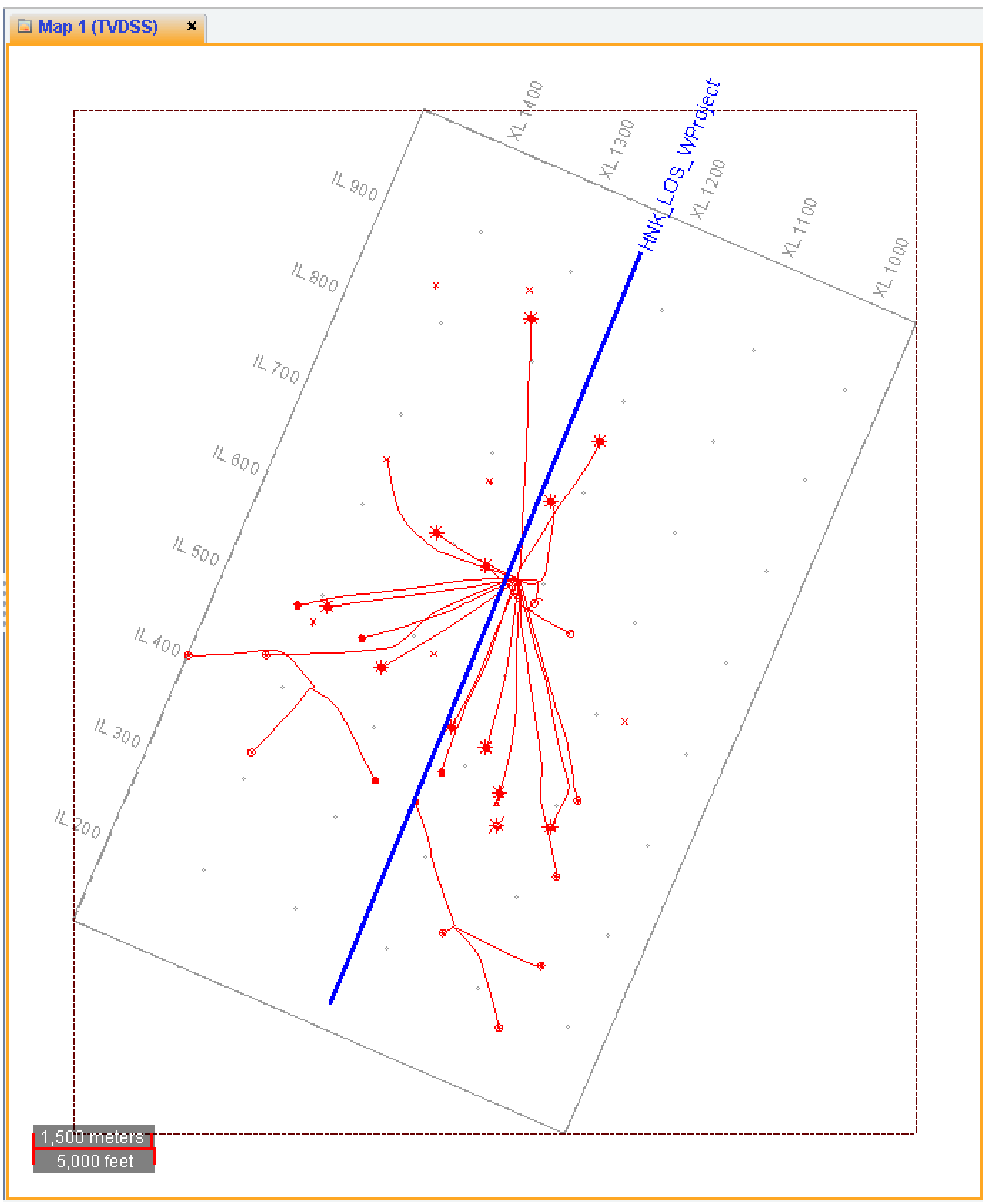
Your *Section* view should look similar to the one below.



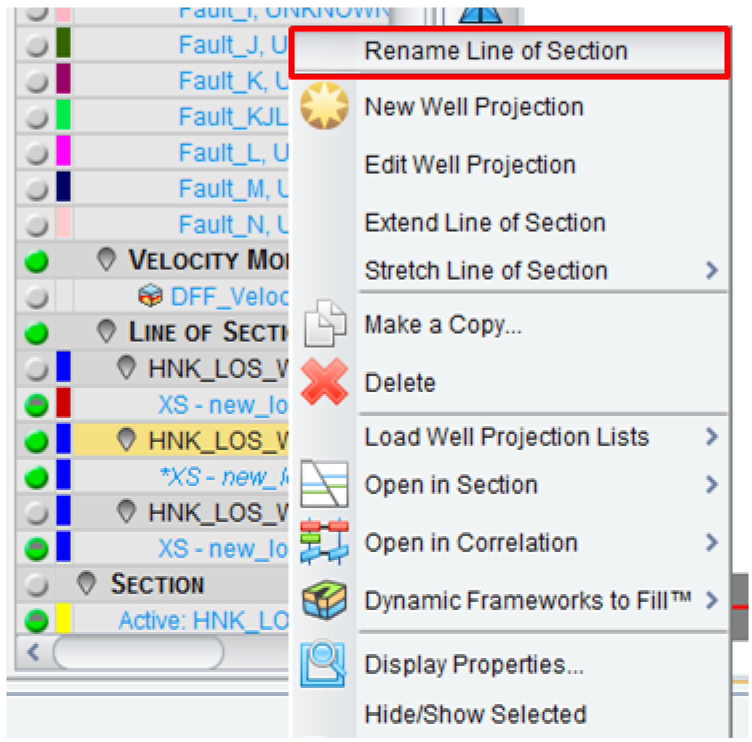
Projected Wells along LOS

9. In *Map* view, turn off the previous LOS you just created, so you can see your wells clearly.

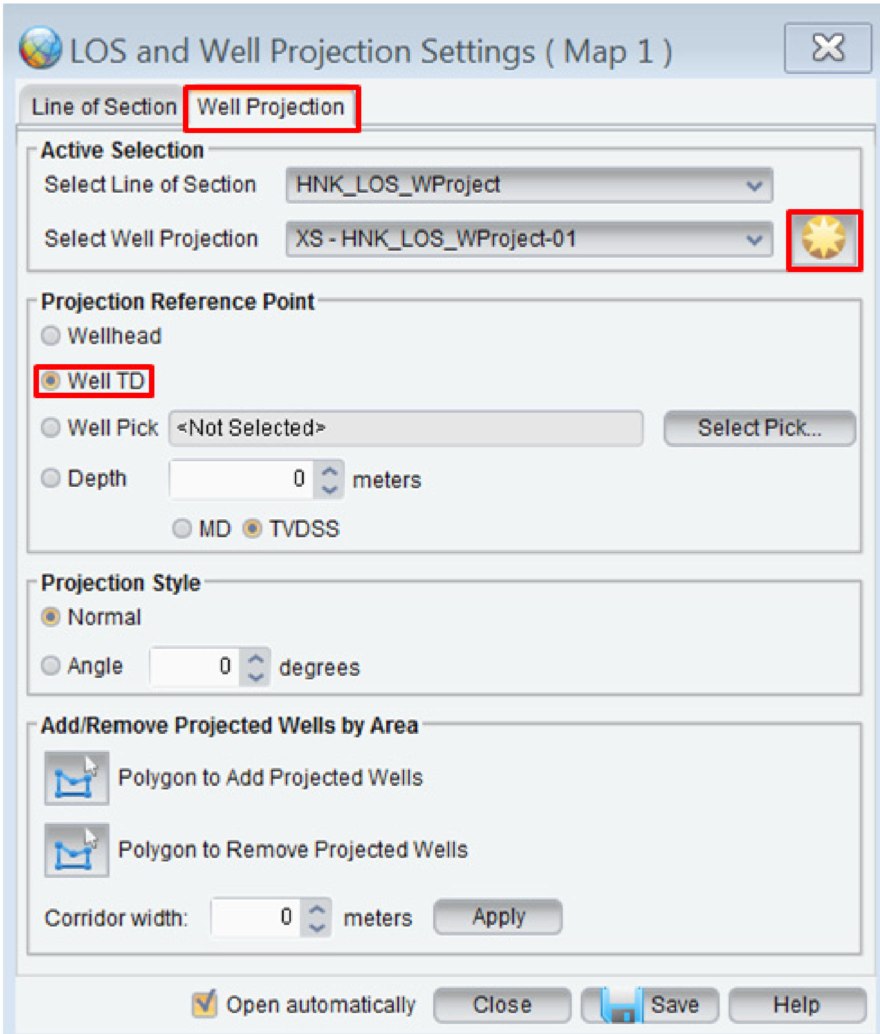
10. Check that the *LOS and Well Projection Settings* window is still open, if not, click the **Line of Section** icon again. In *Map* view, draw a straight line down the middle of the mapping area. This will be used for your well projection. **MB1** to set the two points of your line and **MB2** to finish it. The new LOS is listed in your *Inventory* as well as projected in *Section* view.



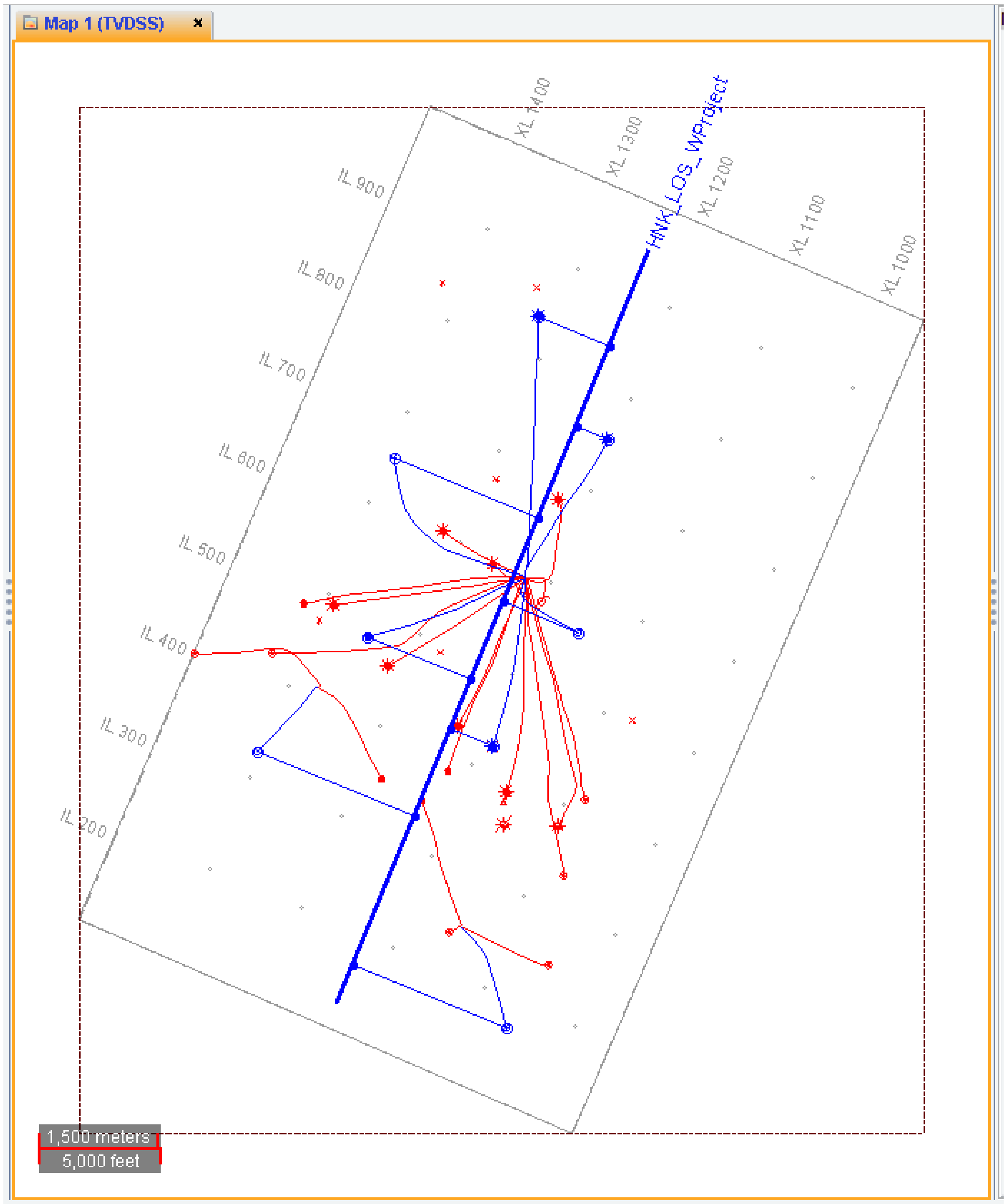
11. Now you can start projecting the wells along the LOS. However, before doing that you will learn how to rename a LOS from the *Inventory* task pane. Sometimes is extremely useful to rename a LOS to avoid confusion. In the *Inventory* task pane, **MB3** on the section you just created and rename the LOS to **YOU_LOS_WProject**. (Lines of Sections are automatically named in sequential order. So far you have created three LOS including this one.)



12. In the *LOS and Well Projection Settings* dialog box select the **Well Projection** tab. Click the **Create New Well Projection List** icon. Select the **Well TD** option if it is not already selected (see picture below).



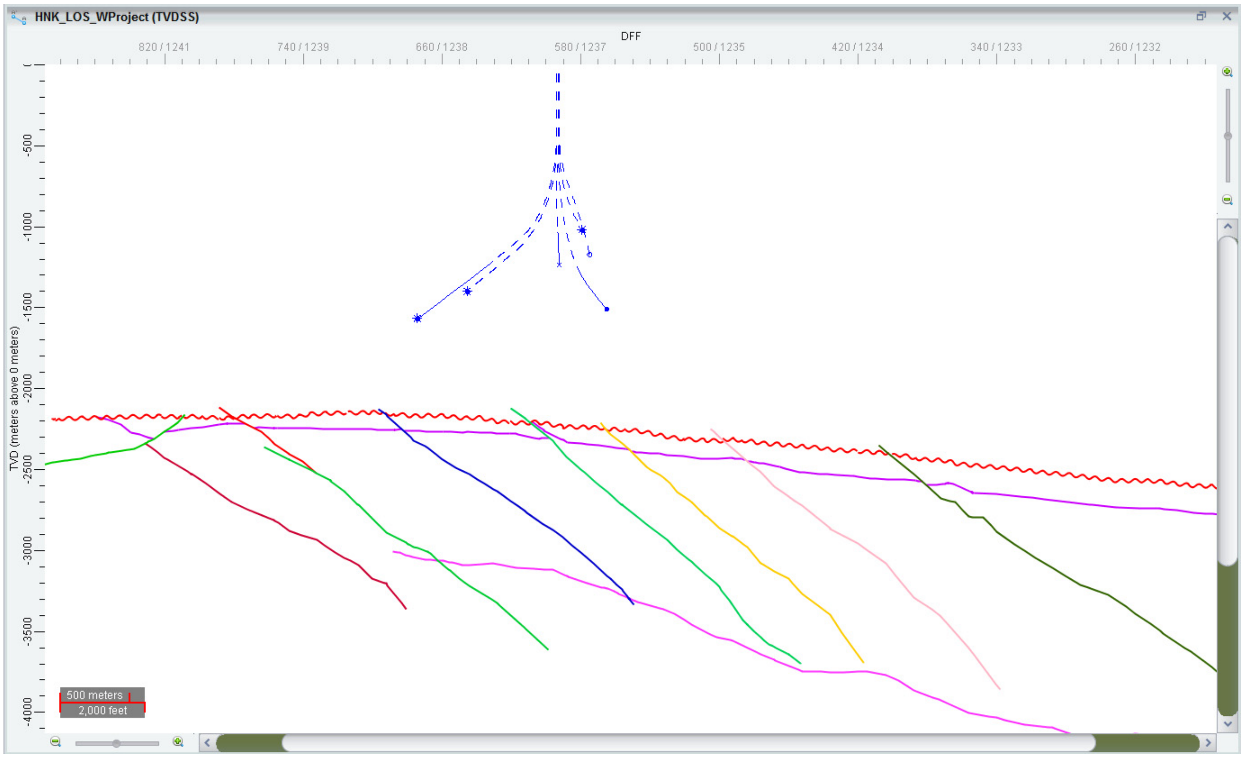
13. In *Map* view, **MB1** on the wells that you wish to include in your projection. The LOS will snap to the TD of the wells, and a projection line will be created. **MB2** to finish the LOS and send it to a new *Section* view.



Note

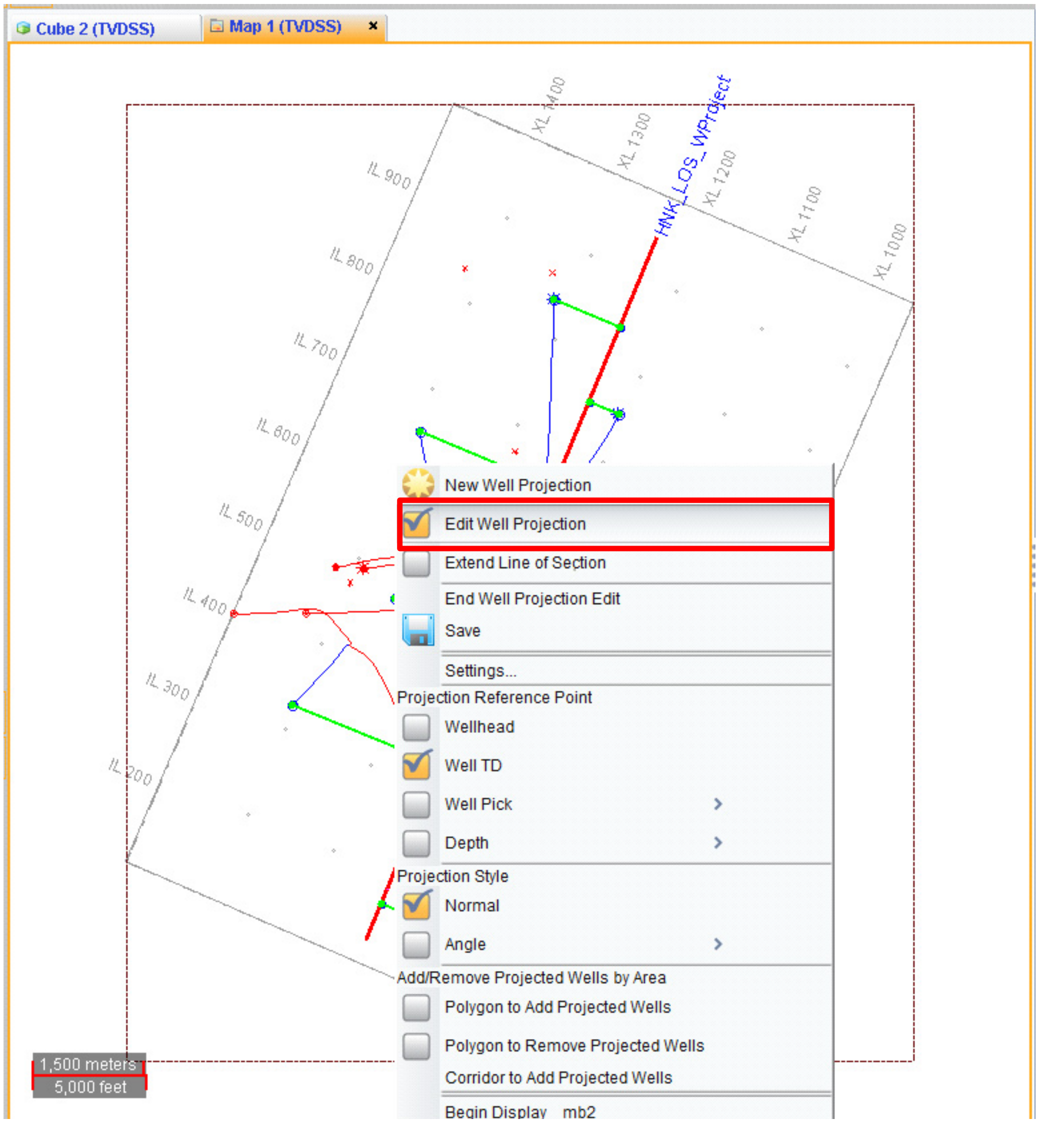
When projecting wells in LOS, **MB2** off of the wells will finish the LOS and send it to *Section* view. **MB2** over a well will remove that well from the projection.

Your *Section* view should look similar to the one below.



14. Arrange your screen to view both a *Map* view and *Section* view at the same time, to see the changes of projection reflected in the *Section* view.

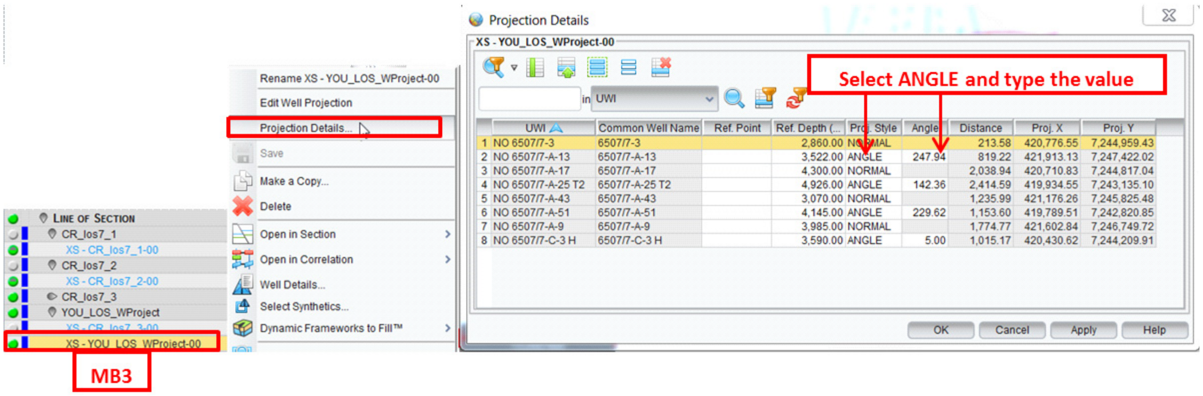
15. In *Map* view, **MB3** on the LOS and select **Edit Well Projection**. The LOS will be highlighted.



16. **MB1** on the node of any well that you wish to change the projection angle. **MB2** to finish editing the line. Both views will be updated to reflect the changes. Close the *LOS and Well Projection Settings* window when finished editing projections.

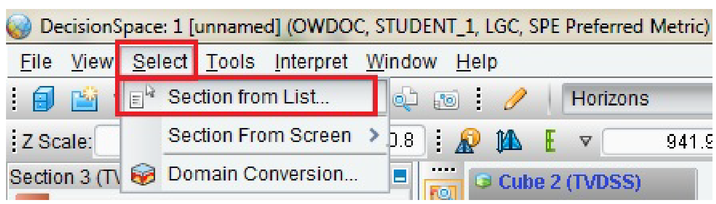
Note

The previous step shows how to graphically modify the well projection angle, however you can also modify the projections manually, by **MB3** on the **<LOS name>** from the *Inventory* task pane and selecting **Projection Details**. Here you can change the projection style and type the angle. By default all the projections are normal.

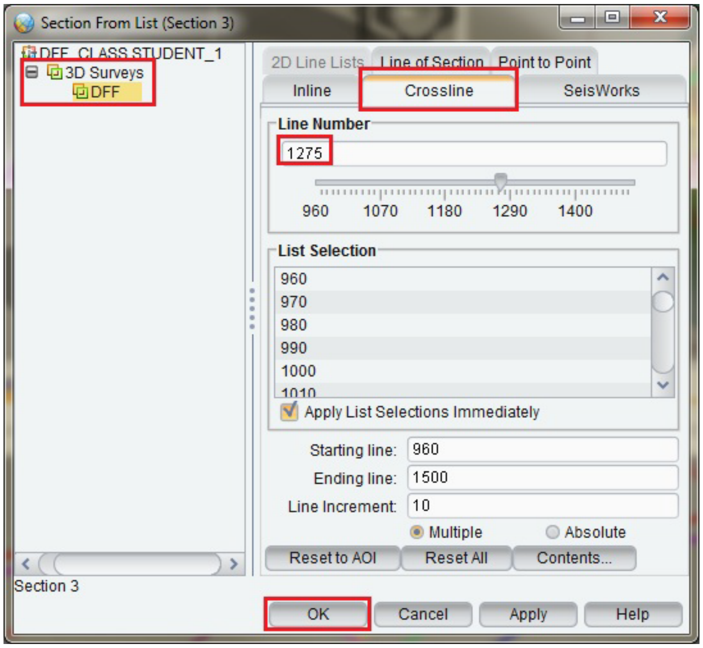


Section from List

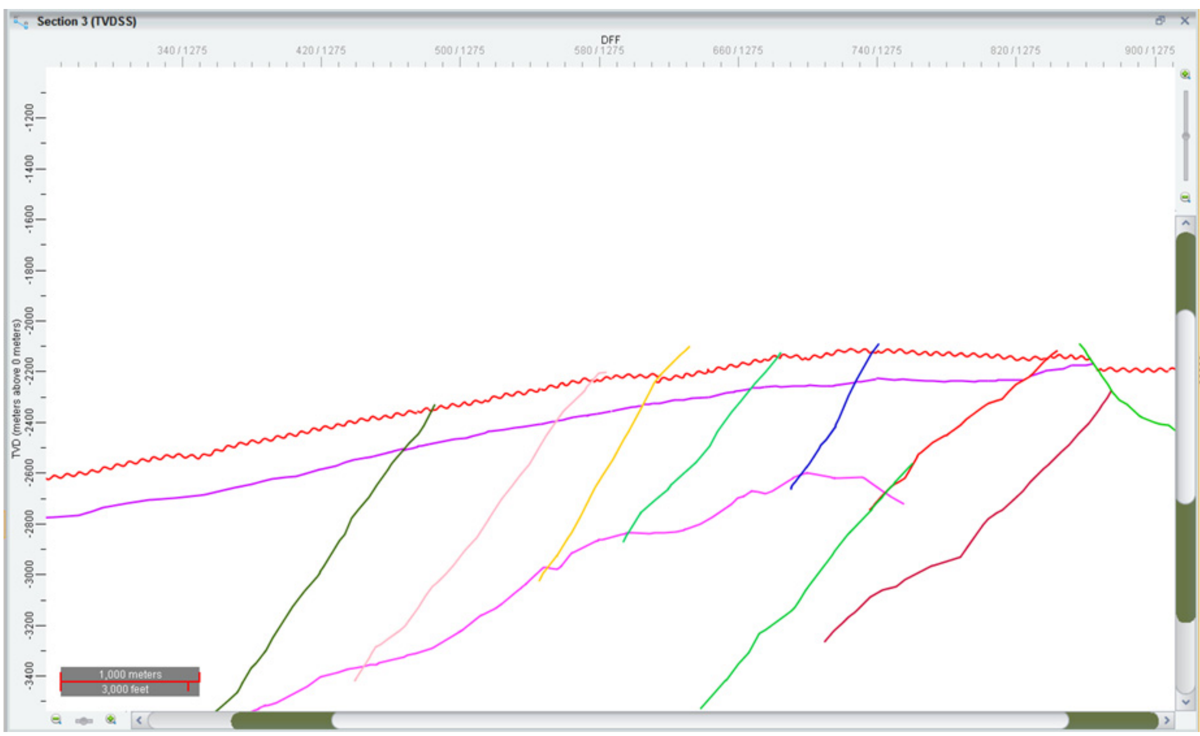
17. To open a Section from List, select **Select > Section from List...**.



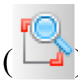
18. In the *Section from List* dialog box, select the **DFF** survey, and then select the **Crossline** tab. Enter “**1275**” in the Line Number field. Click **OK**.



Crossline 1275 is displayed, as well as two framework surfaces. Several framework faults are also shown.



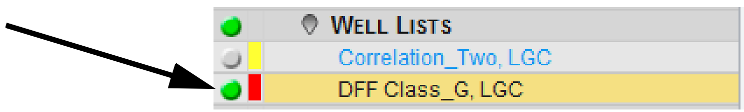
Zooming

19. Click the **Area Zoom** () icon, click **MB1** and drag to define the zoom area with a stretchy box. Zoom into the section until the surface data fills the view.

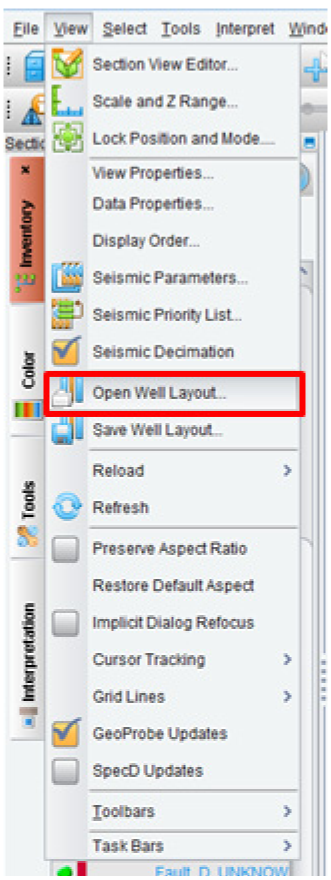
> **Note**
>
> Many zoom tools are available in *Section* view. Your instructor will provide an overview of these tools:
>
> - Area zoom (button)
> - Isotropic (proportional) zoom (on the bottom of the vertical tool bar)
> - Vertical stretch and squeeze controls (in the upper right side of the view)
> - Horizontal stretch and squeeze controls (on the lower left side)

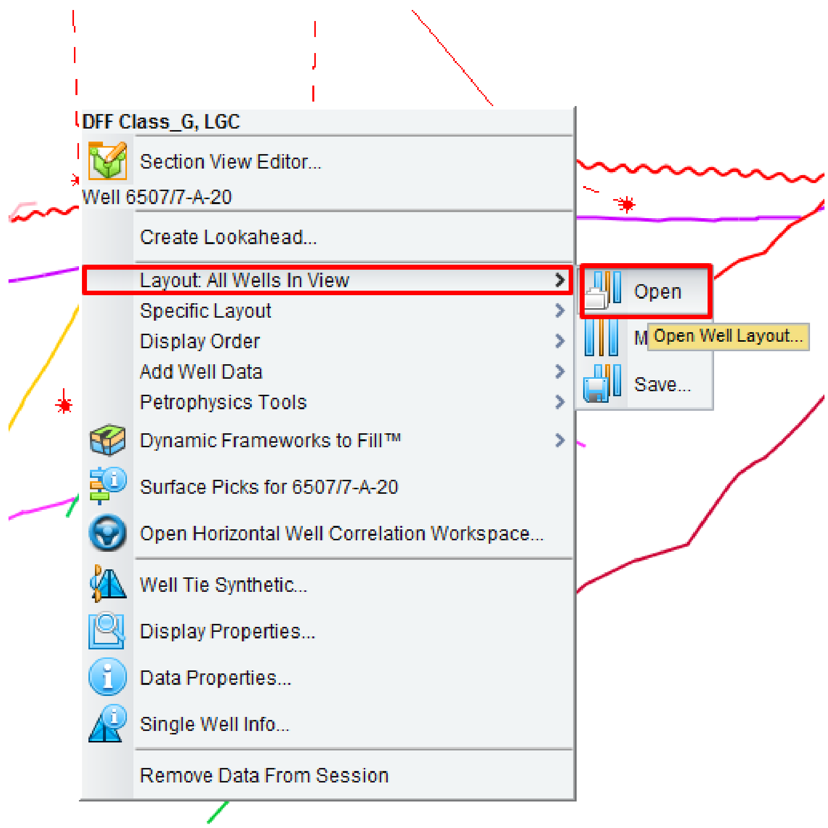
Applying Well Layouts

20. Turn on (show) the **DFF Class_G** well list.



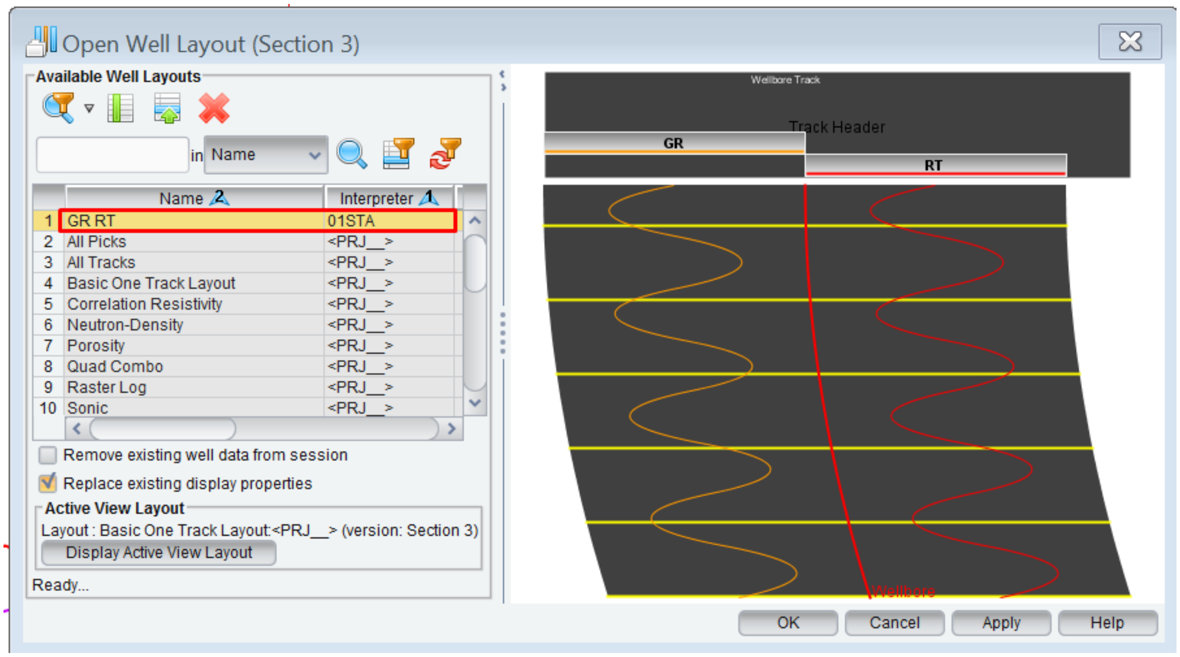
21. Select **View > Open Well Layout...** to display log data on the well bores or **MB3** on any of the wells displayed within your *Section* view and select **Layout: All Wells In View > Open**.



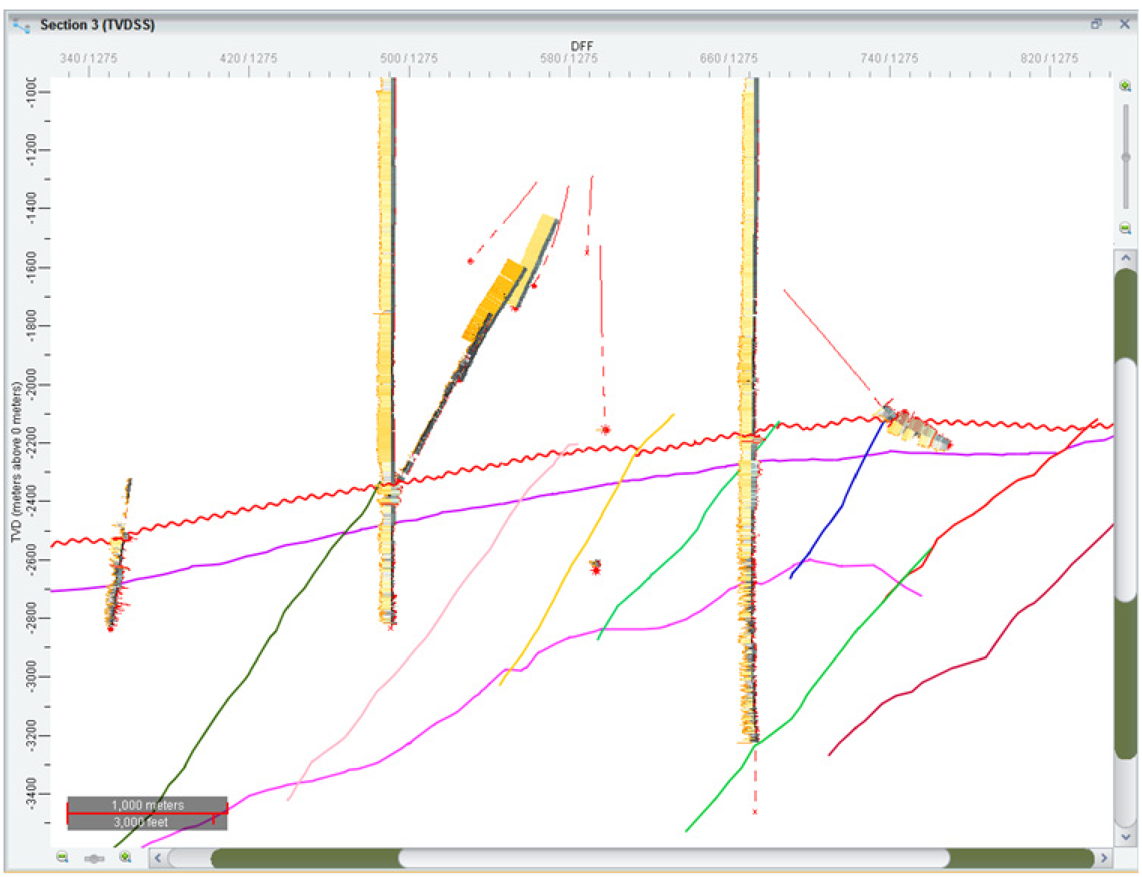


The *Open Well Layout* dialog box shows a list of well layouts displayed with a preview of the track and the log curves defined for that layout.

22. Locate the **GR RT** well layout. Click **OK**.



The *Section* view should look similar to the one below.

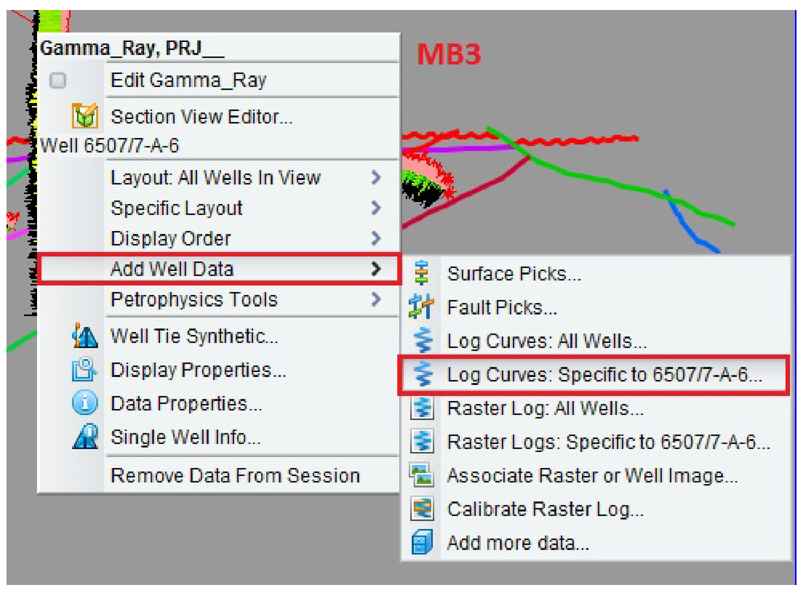


Note

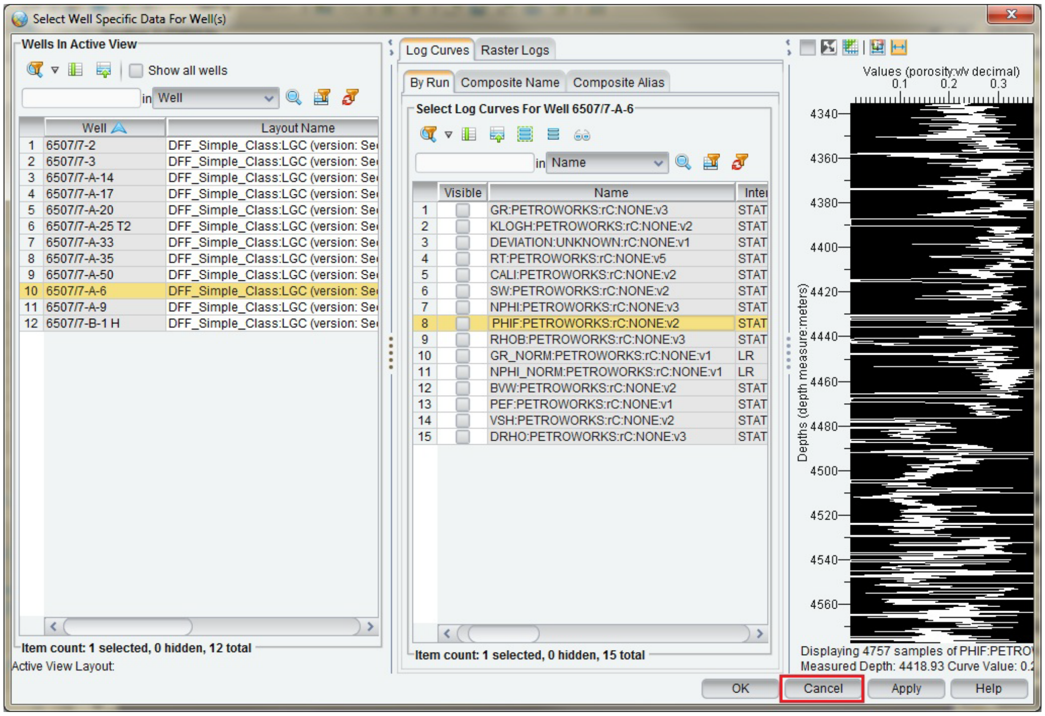
If a layout is applied, but not every well contains log curves defined in the Well Layout or *Inventory*, it is probably because:

- Wells are missing the requested log curve. (This can be determined by looking at the Log Curves Specific option discussed in the following steps).
- The equivalent log curve of the well has a non-standard curve name that has not been entered in the log curve alias list. The curve alias list is found in the Curve Data Manager tool. You can put your cursor on a log curve in your *Inventory* tree, **MB3** and select **Curve Dictionary** to launch the Curve Data Manager tool.
- Alternatively, you can access the OpenWorks database directly through DecisionSpace, to browse for available log curves that may need to be added to a well-specific layout.

23. In some cases, interpreters need to explore what curves are available for any specific well. You will explore this option; however, you won't add any new data. On a well or a displayed log curve, **MB3** and then select **Add Well Data > Log Curves: Specific to <well name>...**.



The *Select Well Specific Data for Well(s)* dialog box shows all of the log data (curves and rasters) available for that well, with a preview panel for selected data. Any curve that you select and apply will be added and displayed in a well-specific layout.



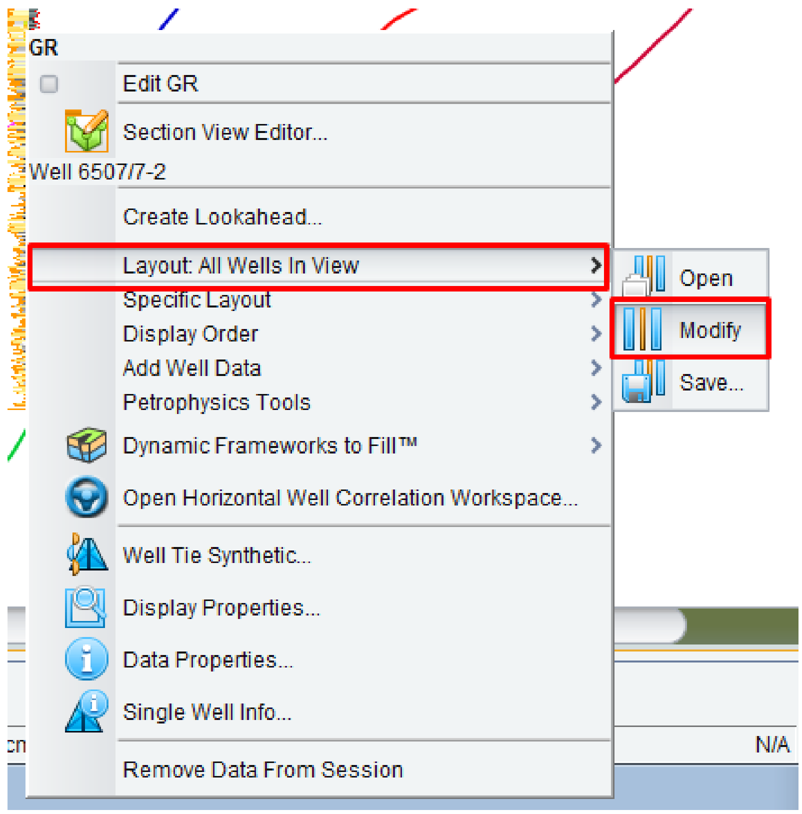
24. Click the **Cancel** button on the *Select Well Specific Data for Well(s)* dialog box.

> **Note**
>
> All available wells can be viewed in this window.

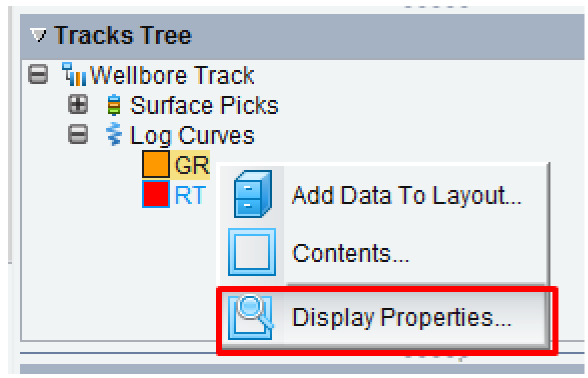
Modifying Well Layouts

Many times, before interpreting tops, it is handy to modify layouts in a way that the geoscientists can infer types of depositional environments. In the following steps you will create a mirror layout using the Gamma Ray curve, with this type of visualization geoscientists usually identify if the sequences are coursing upwards or downwards, which, in fact, is giving information such as regressions or transgressions of sea level.

25. **MB3** on any of the wells within your view. Select **Layout: All Wells In View > Modify**.



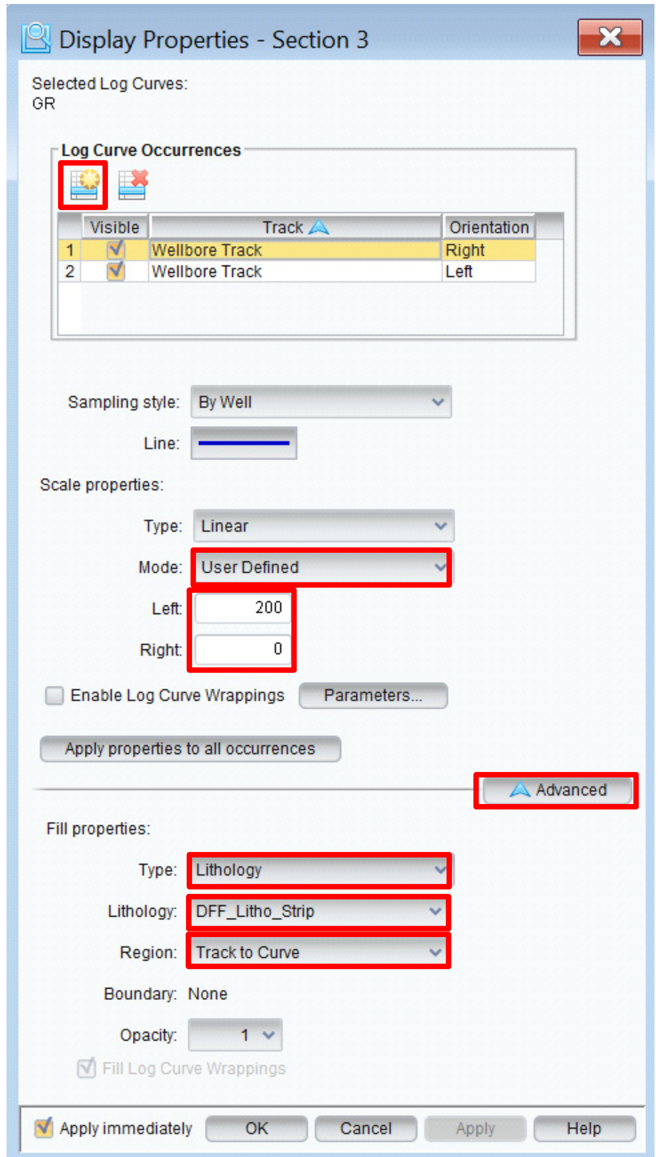
26. The *Tools* task pane opens with the Edit Well Layout button activated. Turn off the **Single Well Layout Mode** icon ( ). Within the *Tracks Tree* sub-panel expand the **Wellbore Track** and then the **Log Curves** nodes. **MB3** on **GR**, and then select **Display Properties...**.



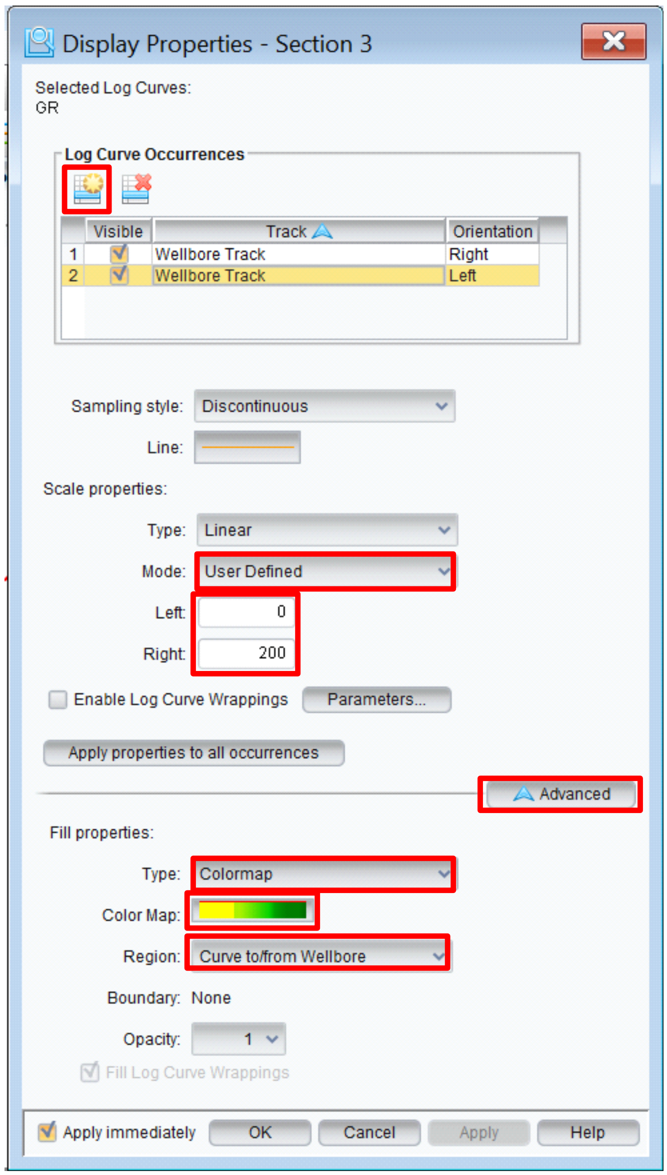
27. The *Display Properties* dialog box displays. Click the **Add an occurrence of the log curve** ( ) icon. This allows you to display the GR twice within the same track, with different properties.

28. Select the **Right** occurrence of the curve. For Mode, choose **User Defined**, and the Left and Right values should be "**200**" and "**0**" respectively.

29. Expand the *Advanced* pane to define the *Fill properties*. For Type, select **Lithology** and for Lithology, select **DFF_Litho_Strip**. For Region, select **Track to Curve**.

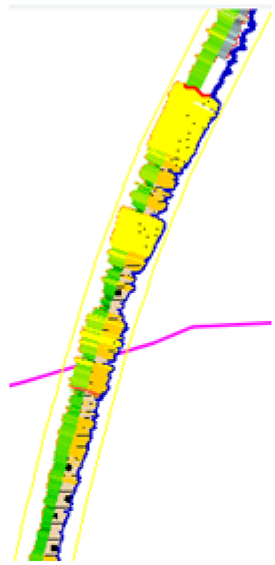


30. Select the **Left** occurrence of the curve, and change the specifications to match the display below. Left scale is set to **0**, right scale is set to **200**, Fill properties type is set to **colormap**, the Color Map palette selected is **Geology>Gamma Ray**, and Region is set to **Curve to/from Wellbore**. Notice that in this example you are using two types of fills, one is based in a previous lithological interpretation and other is based on curve values interpolation.



31. Click **OK** to close *Display Properties* dialog box.

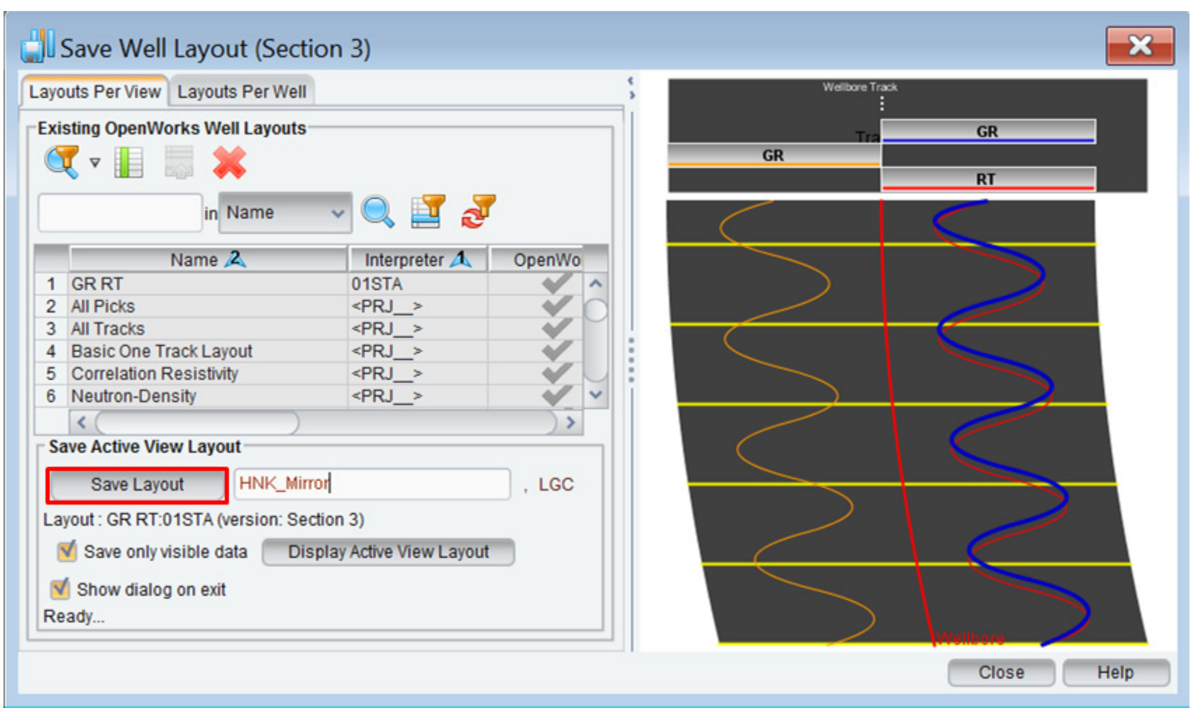
The well layout should look similar to the one below.



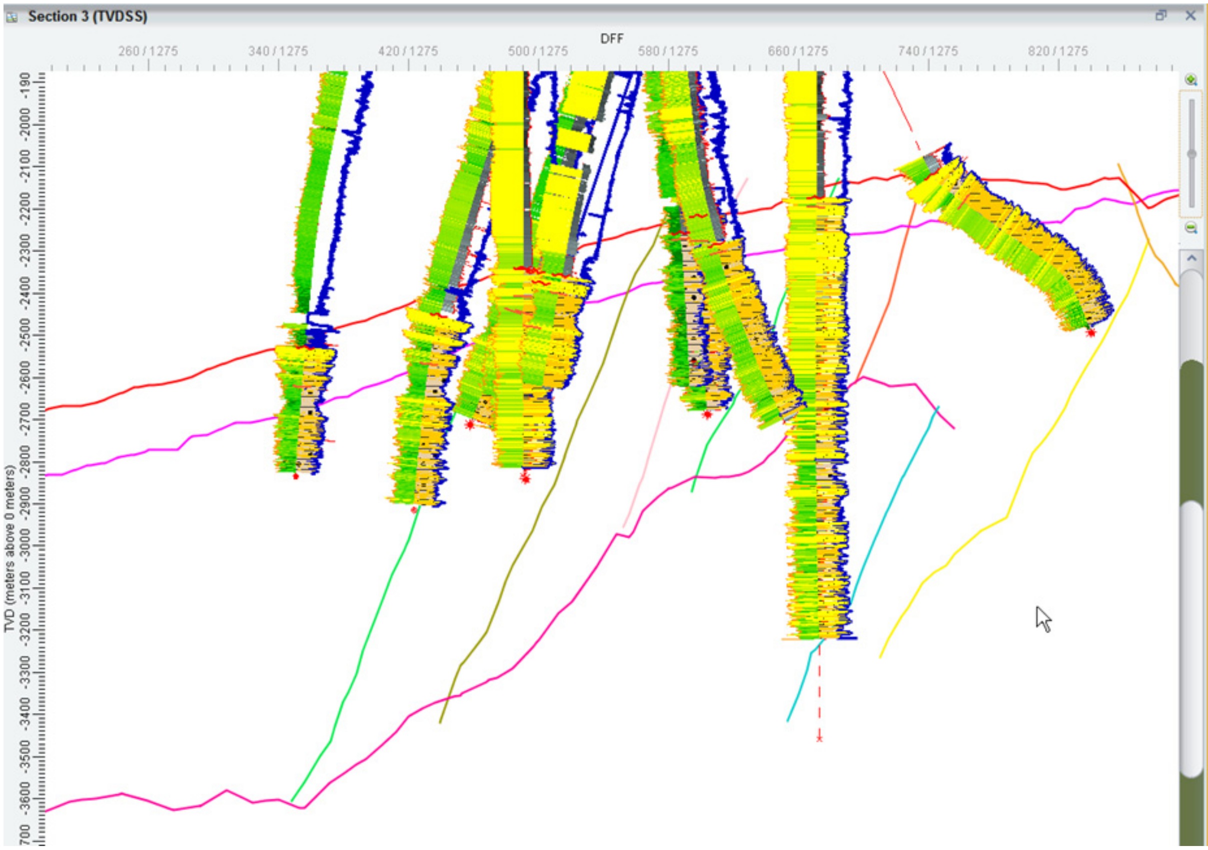
32. Click the **Exit Well Layout** () button.

33. **MB3** on any of the wells within the view and select **Layout: All Wells In View > Save…**.

34. The *Save Well Layout* dialog box displays. Rename the well layout "**YOU_Mirror**." Click **Save Layout**. Once saved, the new well layout should appear in the list. Click **Close**.



Your *Section* view should look similar to the one below.

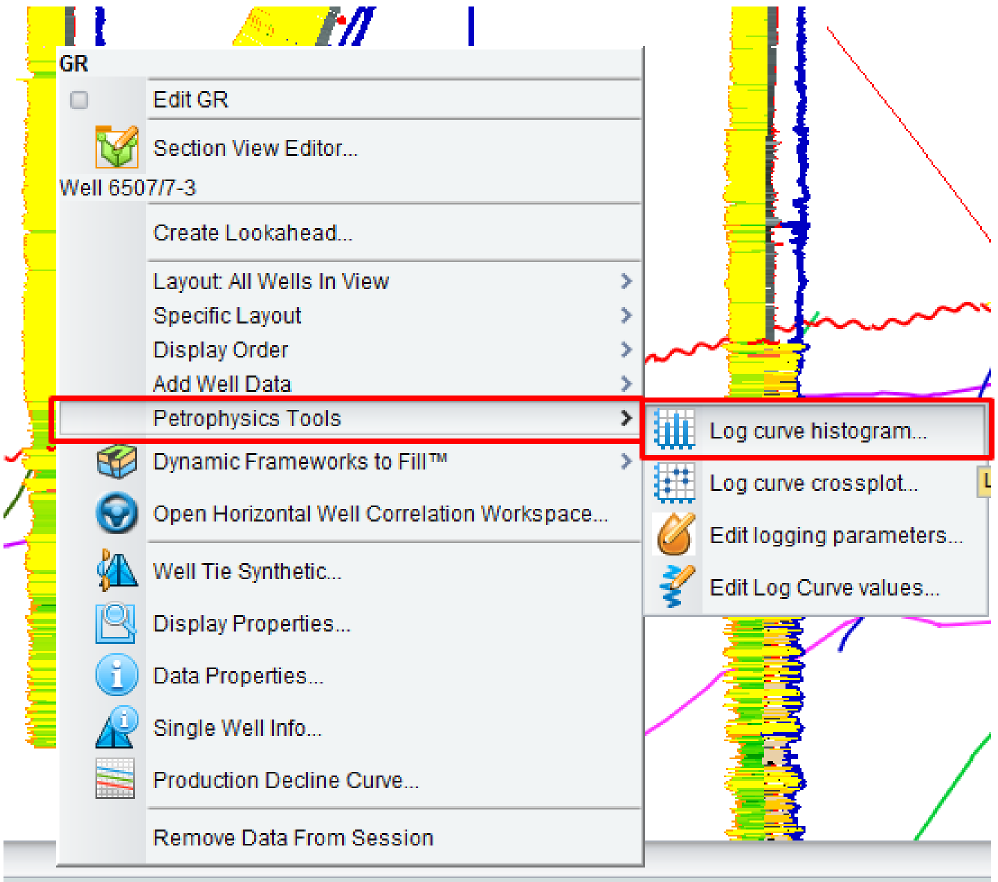


> **Note**
>
> You can change the well layout for any specific well by **MB3** on the well you want changed and then selecting **Specific Layout > Assign Layout**. The list of well layouts will come up and you can specify which specific layout you want from there.

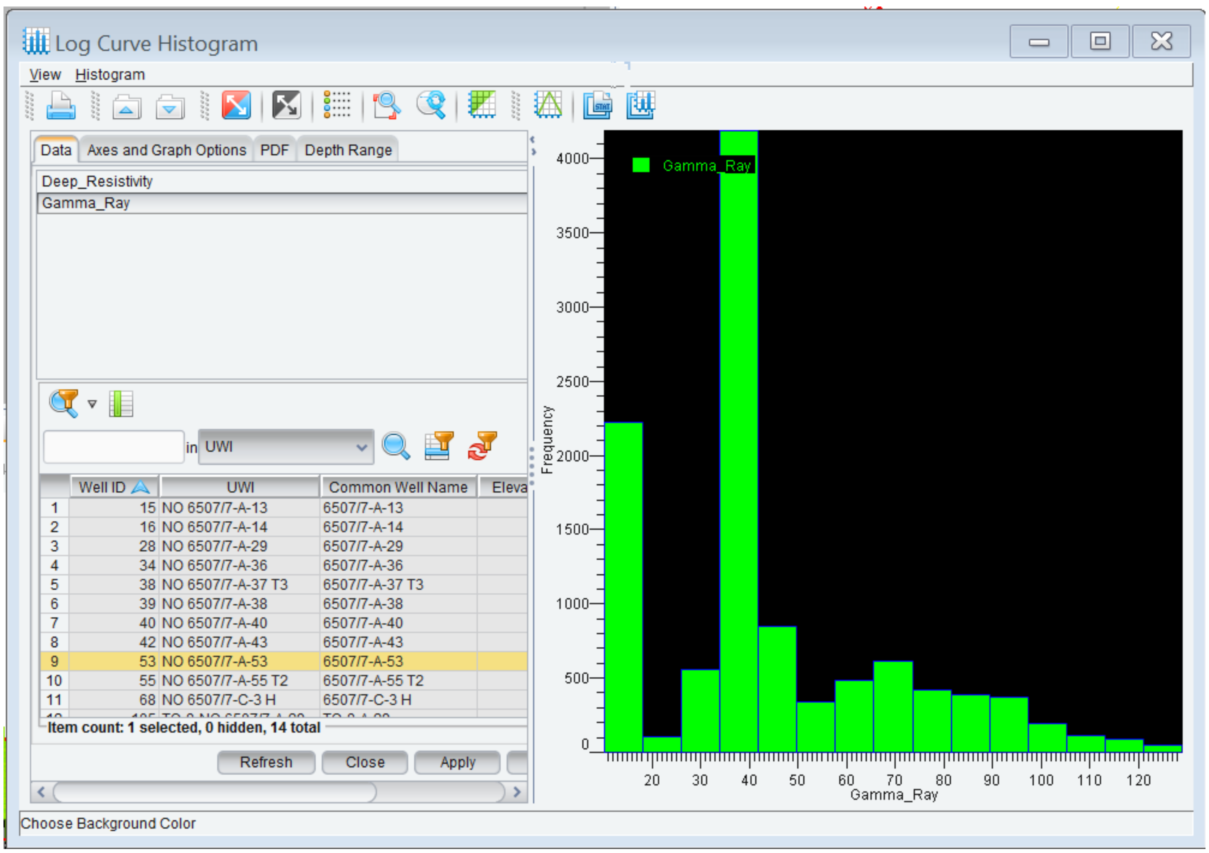
Petrophysics Tools

If curves in any particular well are not displaying as you expected, you can see the values of the curve that are potentially causing the unexpected results in the petrophysics tools located within the MB3 menu options.

35. **MB3** on any curve of the well you wish to see. Select **Petrophysics Tools > Log curve histogram…**.

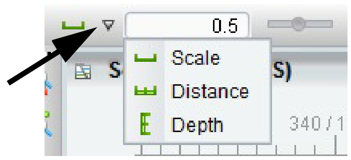


36. A histogram displays showing the values of the curve you specifically selected. You can change to other wells from this dialog box, and you can limit your display range to only see values from certain depths within your well. Explore the different tabs in this window. For instance, select the **Gamma_ray** curve for any well, modify the **Depth Range** between **FANGSST GP. HD Top** and **SM_12** (this is the reservoir interval), turn on different statistical distributions from **PDF** tabs, etc. Remember to click **Apply** each time you introduce any change in the histogram. Close the *Log Curve Histogram* dialog box once you finished exploring it.



Adjusting Layout Width

You can adjust the width of the well layout through the Well Width Options toolbar, which is at the top of the main *DecisionSpace* window. You can use a slider bar or enter a numerical value to increase the width of the well layouts (move to the right) or decrease the width of the well layouts (move to the left). Three well width options are available.

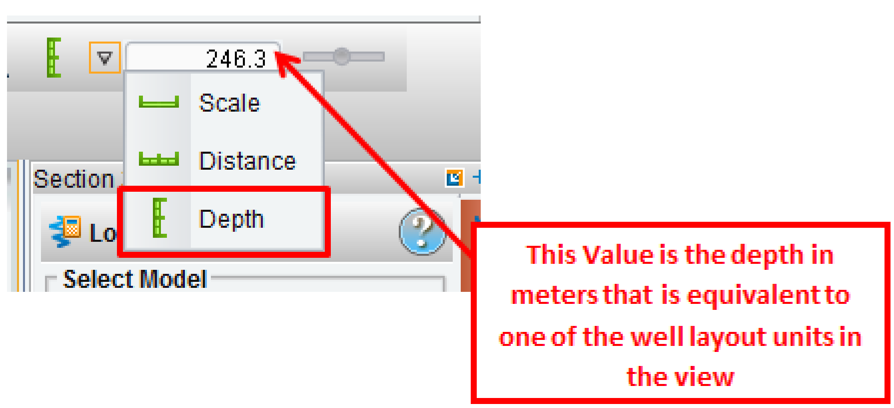


- **Depth**—Depth is the default setting. Depth adjusts the vertical scale in the view. It calculates the vertical distance in the view and adjusts the scale factor to allow the track widths to change proportionally with the amount of vertical zoom.

- **Scale**—For the tracks displayed along a wellbore, Scale multiplies the track width entered in the Track Details Table by the value for the scale factor displayed in the toolbar. For example, the 0.50 track width in the Track Details Table represents 1/2 inch in the project. If the scale factor value in the text field is two, the view displays well widths as one inch.

- **Distance**—Distance adjusts the horizontal scale in the view. It calculates the horizontal distance in the view and adjusts the scale factor to allow the track widths to change proportionally with the amount of horizontal zoom.

37. Click the **down arrow** (), and then click **Depth** to confirm you are using the default well width option. Drag the slider bar to the left and to the right to observe the changes in your well layout width.

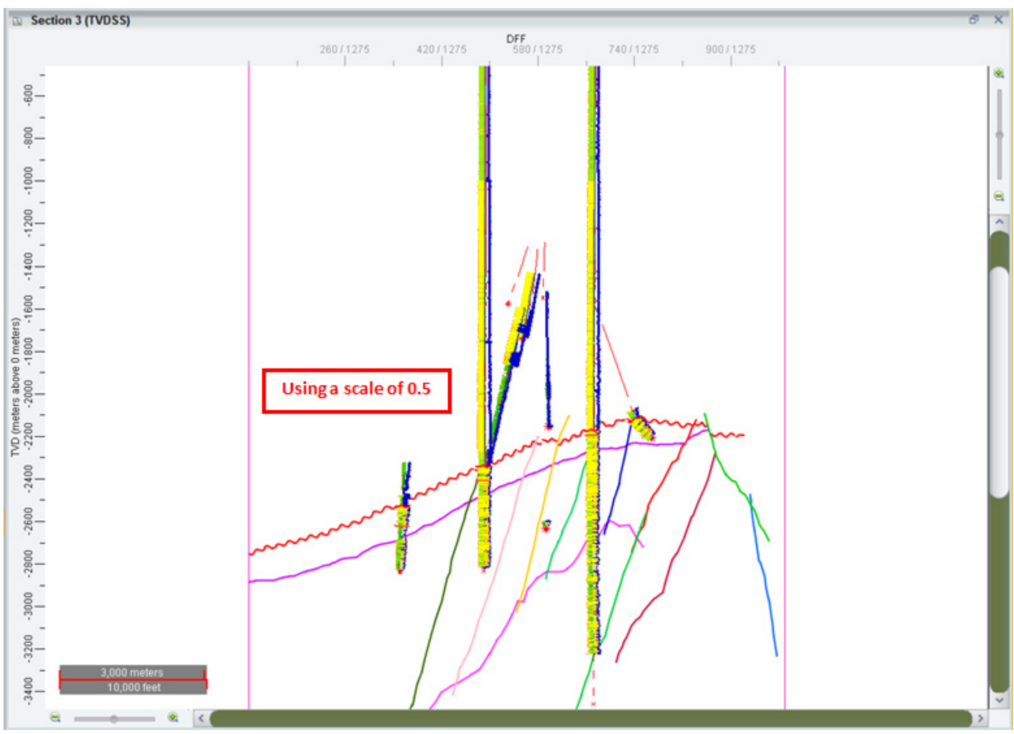


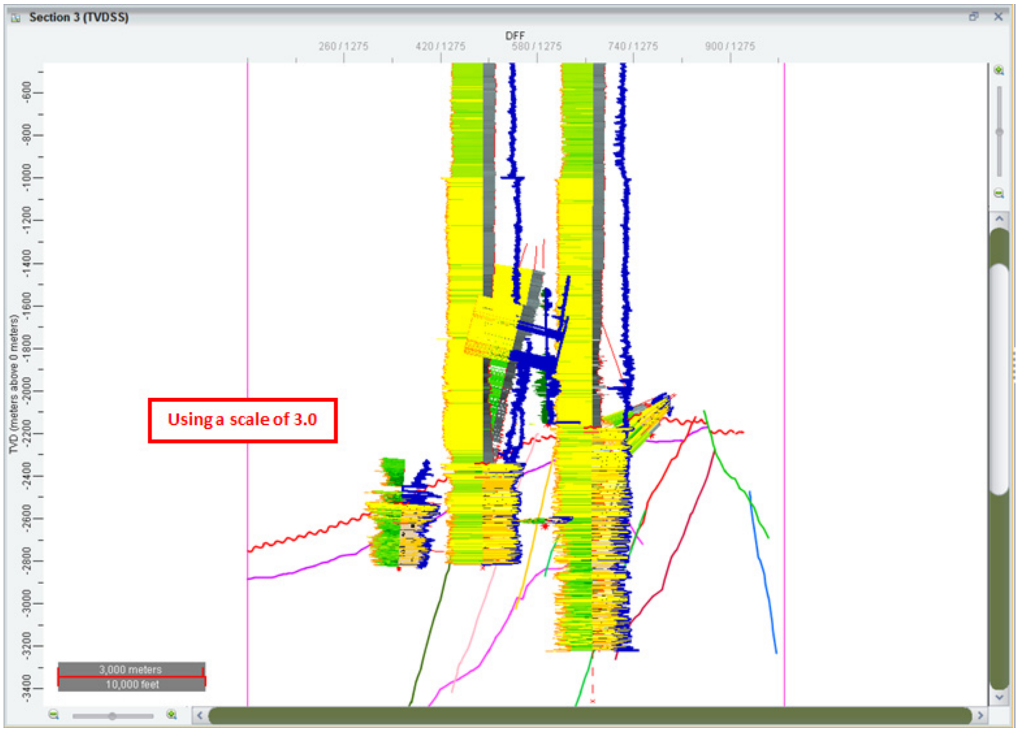
38. Click the **down arrow** (▿), and then select the **Scale** option. Drag the **slider bar** to the left and to the right. Notice that as you increase or decrease the scale value, the well layout width is scaled by that amount.

39. Experiment with the **Distance** option noting the changes. When you are finished, return to the **Depth** option.

The Problem with Disproportionate Zooming

Disproportionate zooming can cause significant problems—especially for geologists—with respect to the aesthetics of cross section displays. The problems relate to the aspect ratio of a well layout as the geologist or geophysicist disproportionately zooms in and out of the section. When the vertical stretch/squeeze function is used (upper right in the *Section* view window) in any of the other well width tools besides Depth, the well layouts are disproportionately stretched as well. This leads to skinny or fat logs like the logs in the two images of crossline 1275 (below).





The *Section* view updates while you zoom in and out. Well track widths increase or decrease. This behavior is embedded in the Depth option to solve the disproportional zooming problem. On the other hand, as noted above, when you select the Scale or Distance option, your display will show skinny and fat logs as you zoom in and out, because your well layout aspect ratio is not preserved in these options. This behavior can become a problem when you are dealing with raster logs, because raster logs are scanned at a native scale and look distorted when displayed in non-native aspect ratios. That is, rasters do not have enough resolution to be distorted and still look good, whereas resolution is not a problem with vector logs.

Because the Depth option maintains the aspect ratio of well layouts as the view is disproportionately zoomed, you can change the vertical exaggeration of the section, while holding the aspect ratio constant.

Note

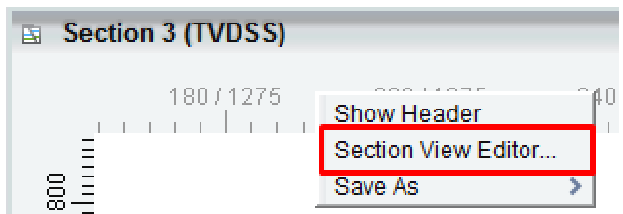
The well width option controls are relevant only when Preserve Aspect Ratio is turned off.

For more information about setting up sections and controlling scaling parameters, see "Chapter 5: Best Practices for Section Construction" in the Landmark manual, *DecisionSpace Geosciences Software Best Practices*.

Controlling the Vertical Range of Well Layouts

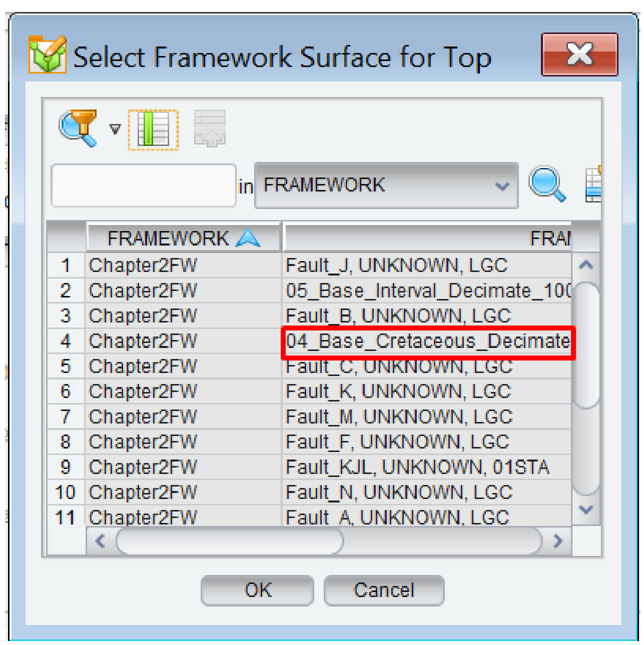
You can adjust the displayed vertical range of your wells.

40. In your *Section* view, on the header area, **MB3** and then select **Section View Editor...**, or click the **Section View Editor** ( ) icon.



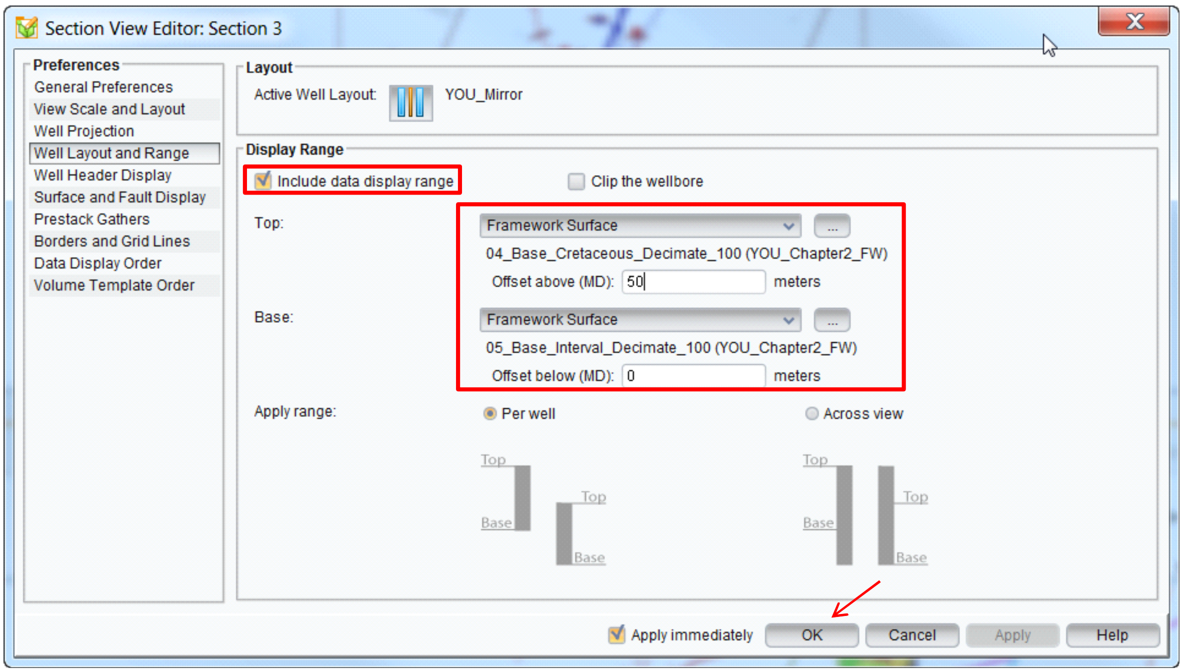
41. The *Section View Editor* dialog box displays. In the *Well Layout and Range* tab enable the **Include data display range** option.

42. Click the Top: pull-down menu and then select **Framework Surface**. On the *Select Framework Surface for Top* dialog box, select **04_Base_Cretaceous_Decimate_100**, and then click **OK**. In the *Section View Editor*, for *Offset above (MD)*: enter **50** meters.



43. Click the Base: pull-down menu and then select **Framework Surface**. On the *Select Framework Surface for Base* dialog box, select **05_Base_Interval_Decimate_100**, and then click **OK**.

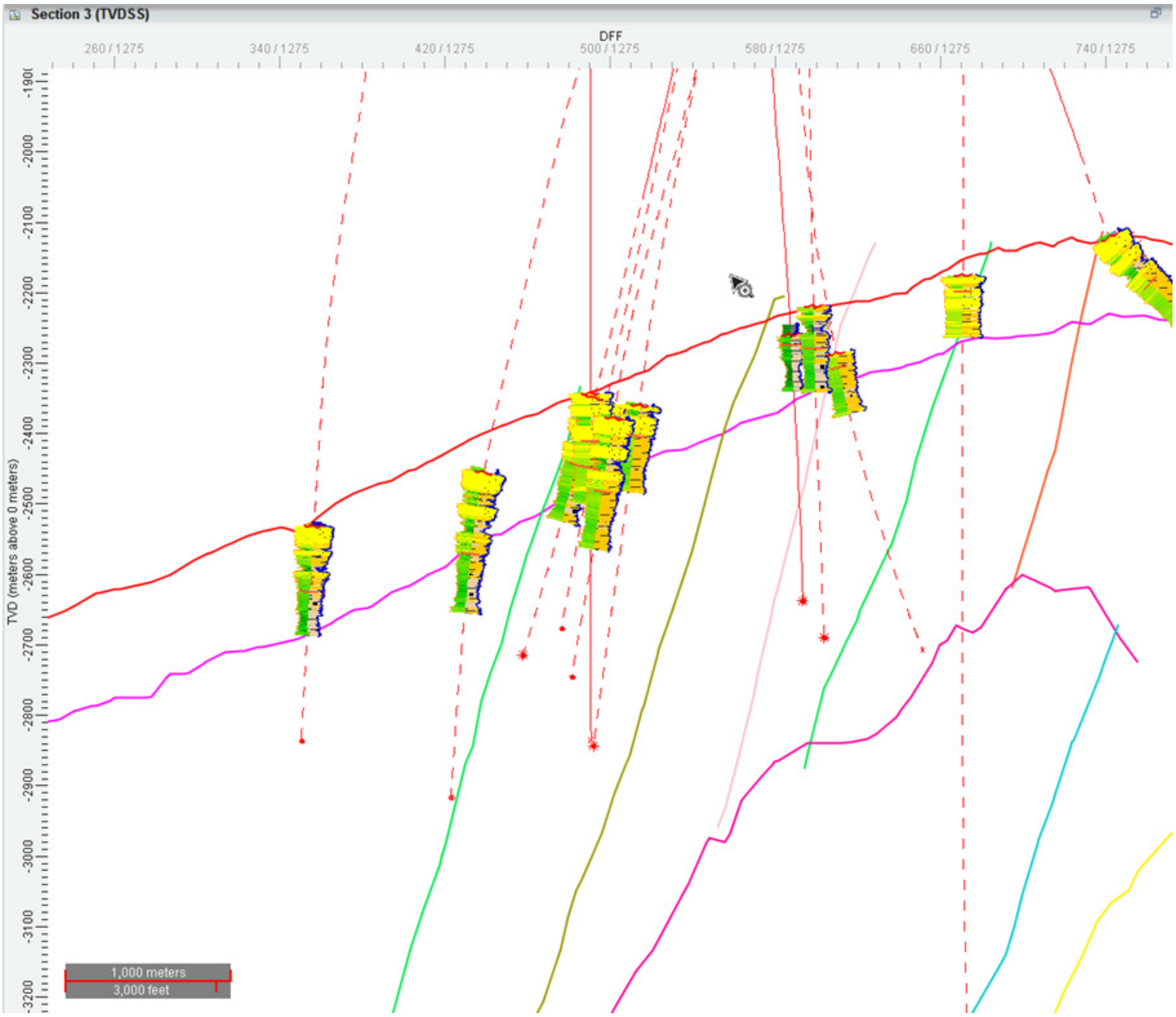
    The *Display Range* sub-panel on your *Section View Editor* dialog box should look like the one below.



44. Click **OK** to close *Section View Editor*.

Note
You can also change the well layout from *Section View Editor* as well.

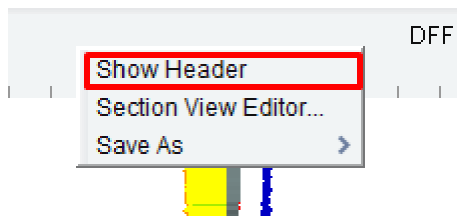
Your *Section* view should look like the image below.



Displaying Log Curves and Well Headers

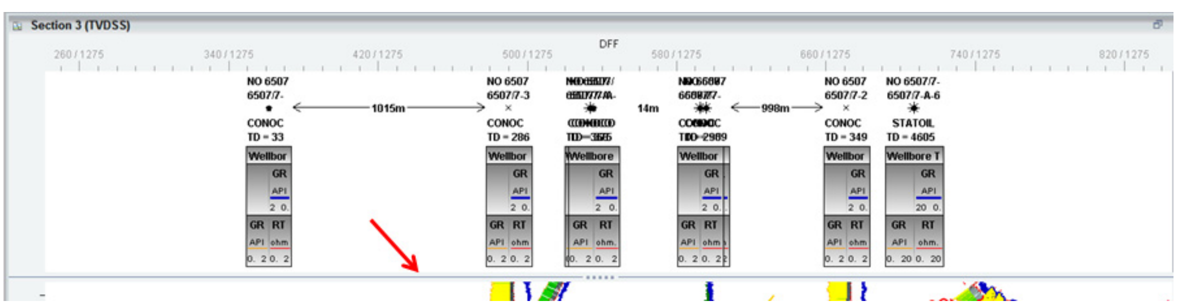
Along with changing the display range and well layout from *Section View Editor*, you can also control other aspects of the *Section* view and the way your wells are viewed. This includes seeing well headers, as well as the distance from the LOS a well can be located and still be displayed.

45. In your *Section* view, **MB3** on the header area, and then select **Show Header** to turn on headers.



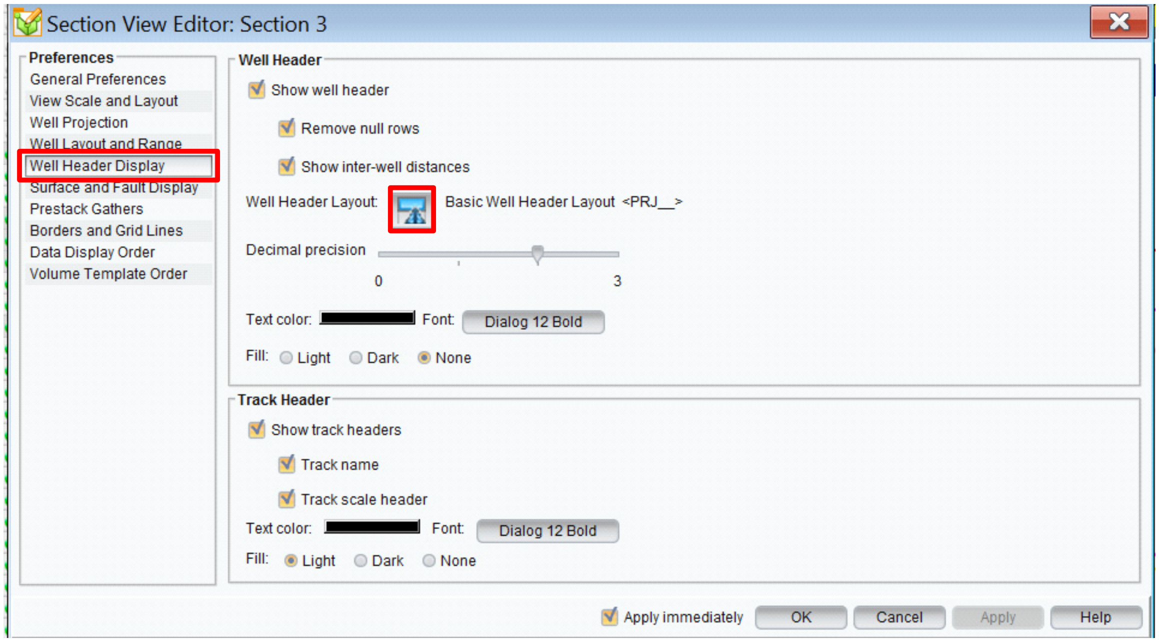
This enables display of a header area at the top of the *Section* view. You can adjust the height of the header.

46. Drag the sash (separator) between the header and cross section areas. Notice all the information related to the wells like TD, displayed curves, scales, etc.

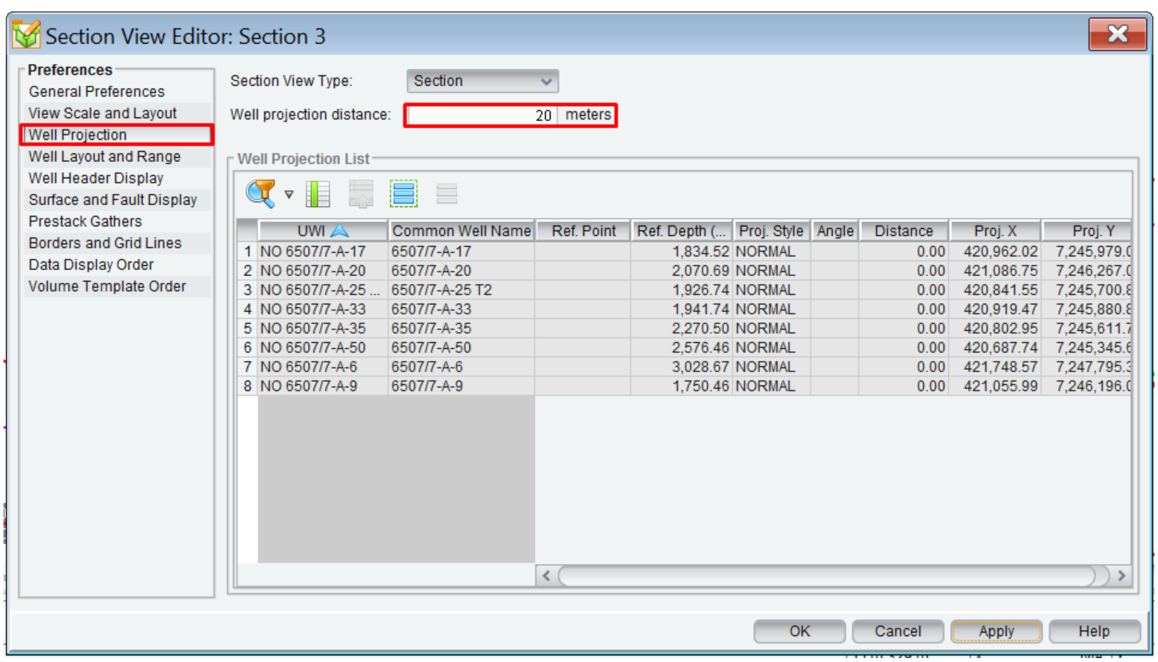


47. Go back to the *Section View Editor* dialog box and navigate to the *Well Header Display* section. Here you can control whether you want to see the well header and/or track header, and what you want included within them.

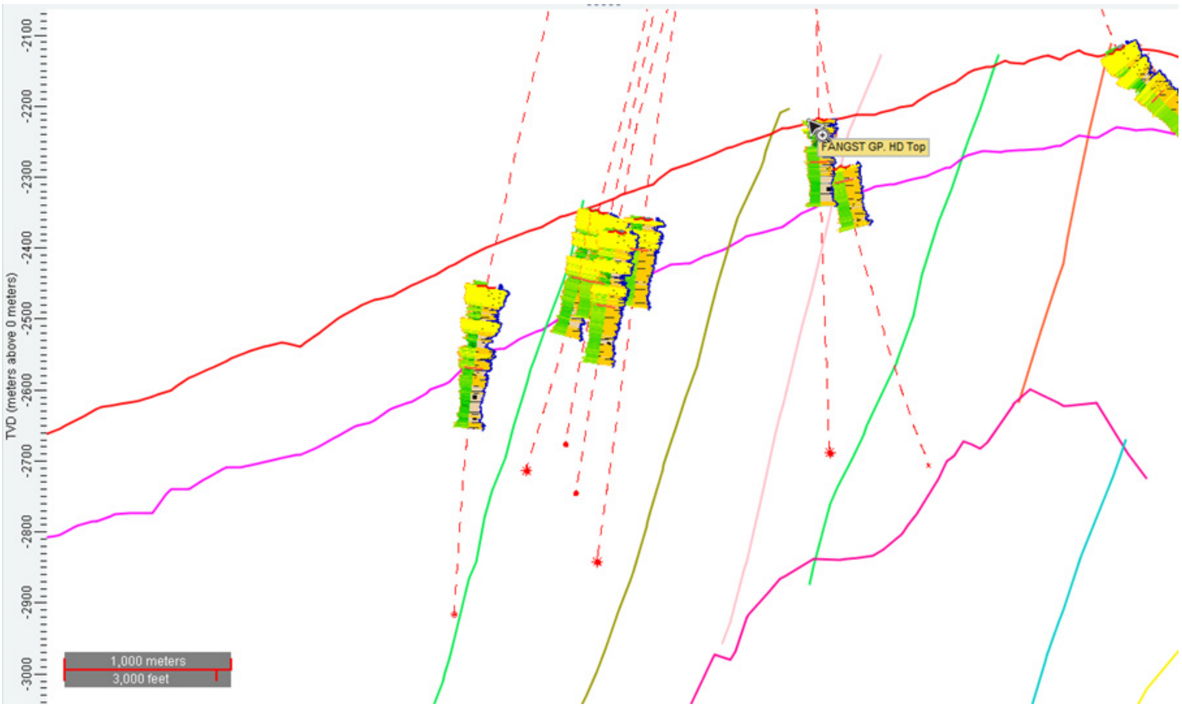
48. Click the **Well Header Layout** icon ( ) to add or remove any details you wish to remove from the well header. For instance, remove TD from Header view.



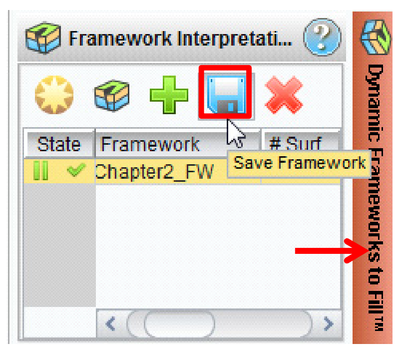
49. You will now change the Well Projection distance to reduce the number of wells in *Section* view. In the *Section View Editor* dialog box, go to *Well Projection* and change Well projection distance to **20**. Click **Apply** and notice that some wells are removed from both, well projection list and *Section* view. Click **OK** to close *Section View Editor*.



Your *Section* view should look similar to the picture below.



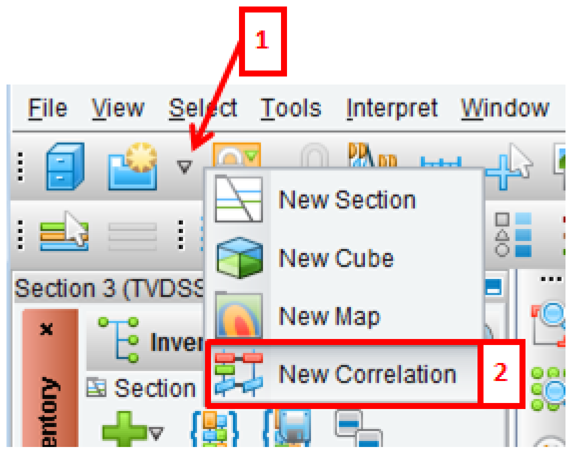
50. Before continuing with the next exercise, save your framework and session. In the *Dynamic Frameworks to Fill* task pane, click the **Save Framework** icon. Then, go to **File > Save Session as…** and name your session “**YOU_CHAPTER_2**.” It is always good practice to save your session periodically.



Exercise 2.3: Surface Picks and Log Correlation

In this section, you will see how to set up and begin correlating well tops (surface picks) within the *Correlation* view. A set of pre-existing correlations is provided to give context to the exercise, but the focus will be on creating new surface picks and using them in correlation.

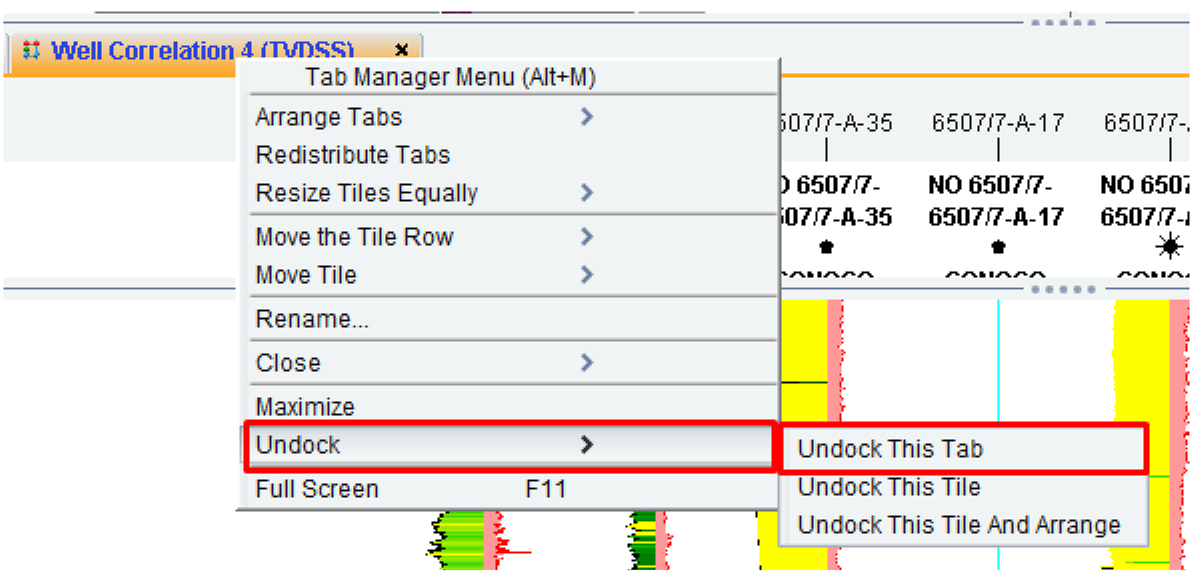
1. With the *Section* view from the previous exercise active, go to **File > New Tab > Correlation**, or locate the down arrow next to the **New Tab** icon and select **New Correlation** ().



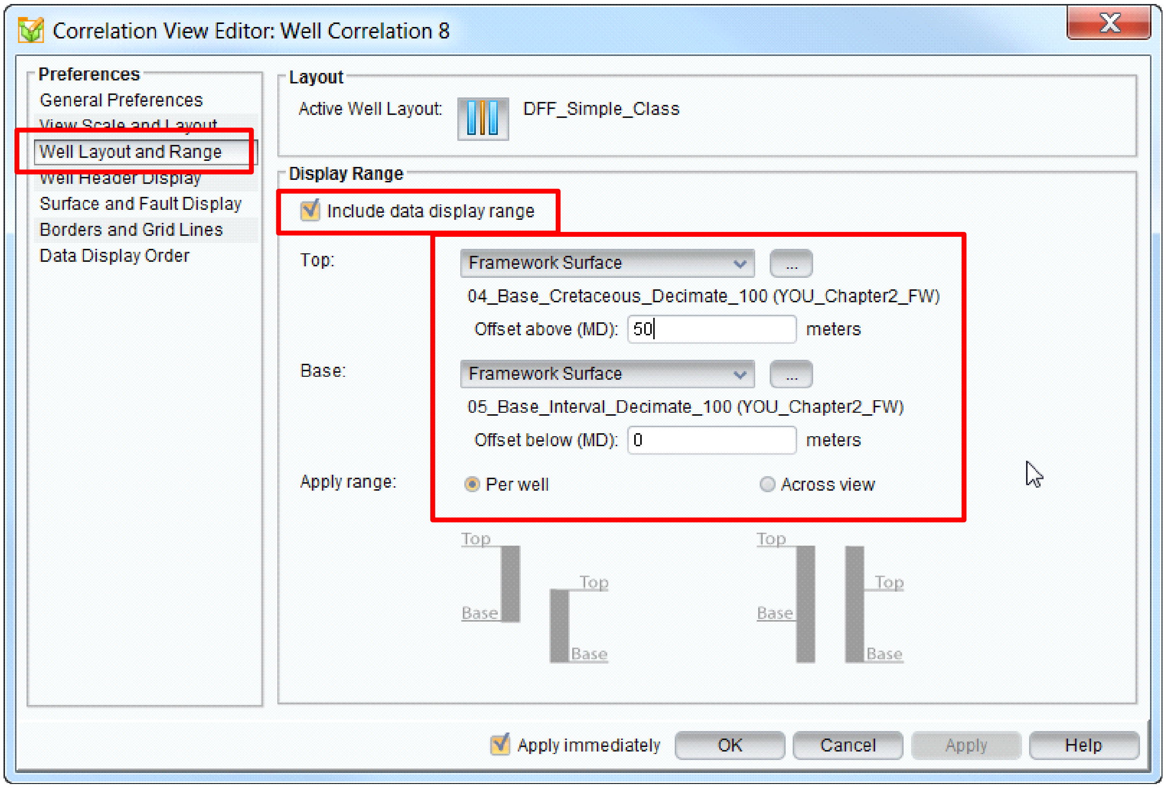
2. **MB3** on one of the wells in the *Correlation* view, and select **Layout: All Wells In View > Open**. Select the **DFF_Simple_Class** well layout from the list. (You may stay with the **YOU_Mirror** layout if you wish to correlate with that one as well. If you decide to use **YOU_Mirror** layout, you will need to turn on all the other surface picks from the *Inventory* task pane.)

3. Activate the new *Correlation* view from the previous section, and then drag-and-drop the *Correlation* tab outside the main *DecisionSpace* window. This undocks it from the other views.

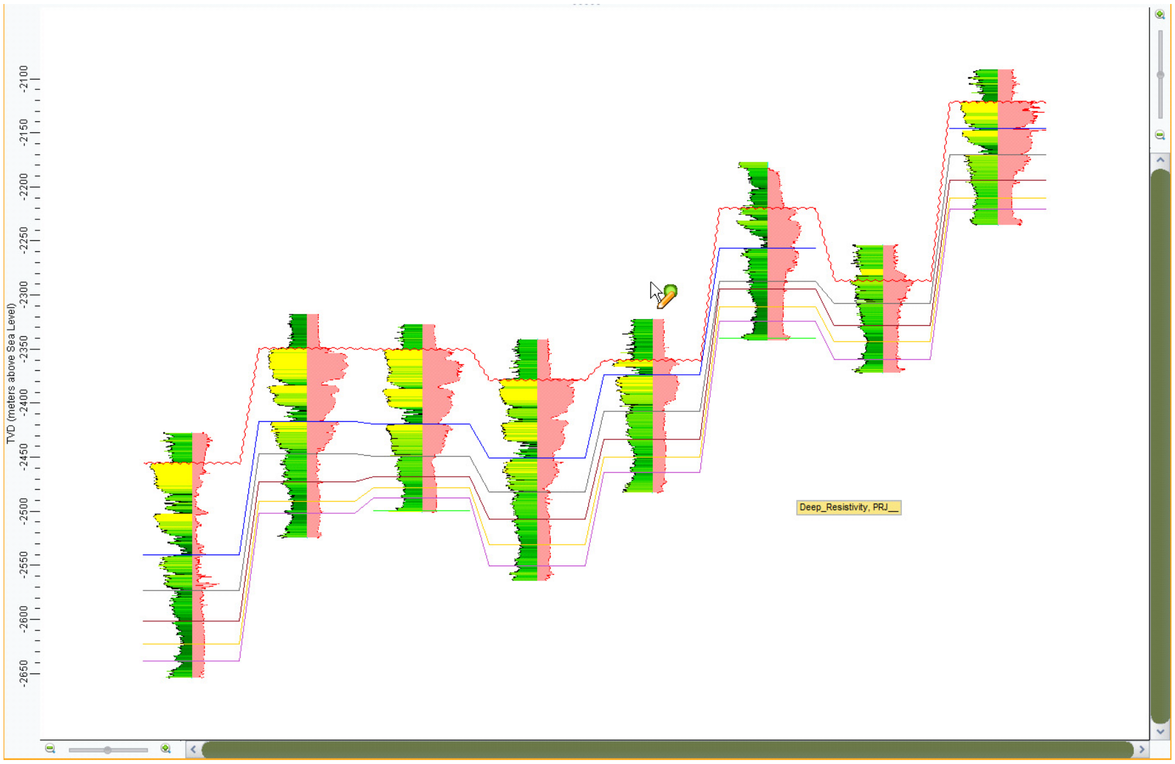
   Alternatively, on the *Well Correlation* view tab, **MB3** and then select **Undock > Undock This Tab**.

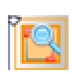


If necessary, adjust the display range by **MB3** within *Correlation* view and select **Correlation View Editor > Well Layout and Range** section and make sure the **Display Range** is set as shown below.



4. Your *Well Correlation* view of crossline 1275 should look similar to the one below. Adjust the zoom as necessary until you get a good view of the reservoir area.

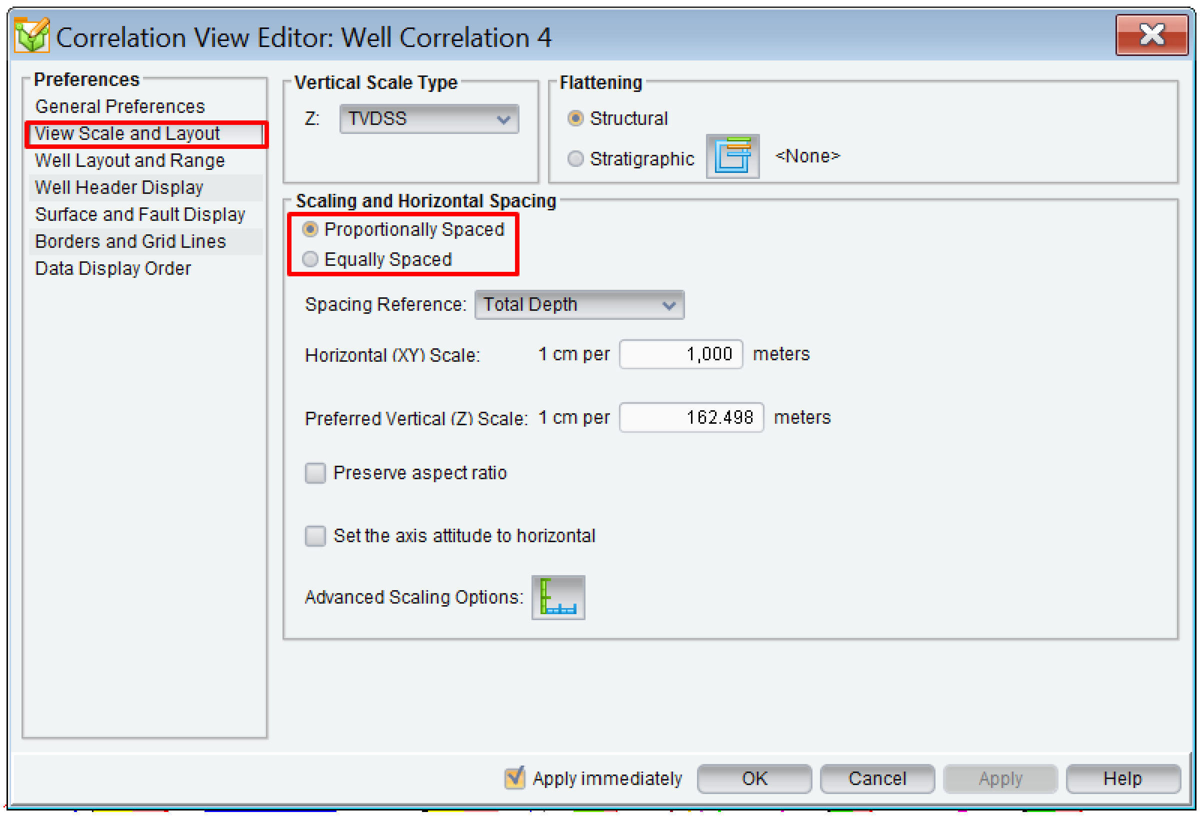


Note
Remember to turn the Zoom off when it is no longer needed.
 Zoom on
 Zoom off

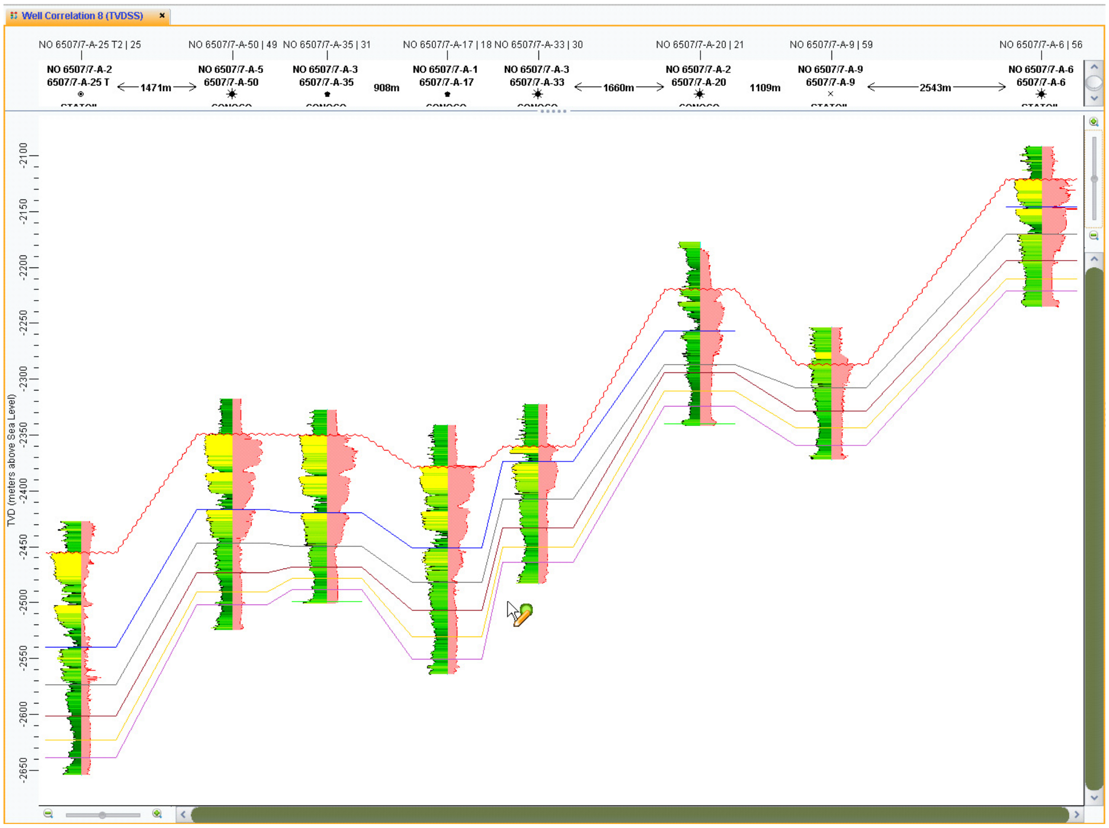
Proportional vs. Equally Spaced Wells

You can decide if you would like to see the wells in your *Correlation* view equally spaced from each other (the default) or proportionally spaced, which reflects the distances that they are truly away from each other.

5. Click the **Correlation View Editor** ( ) icon or **MB3** on the *Correlation* view and select **Correlation View Editor**, navigate to the *View Scale and Layout* section, and then select **Proportionally Spaced**. Click **OK** to close the *Correlation View Editor*.



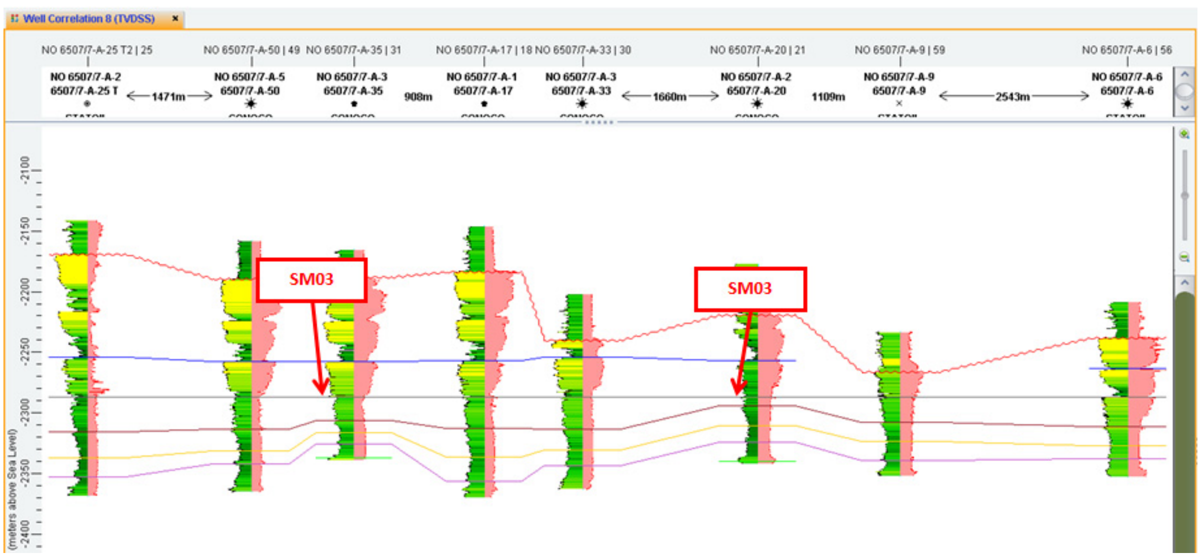
Your *Correlation* view should look similar to the one below.



Comparing Stratigraphic and Structural Datums

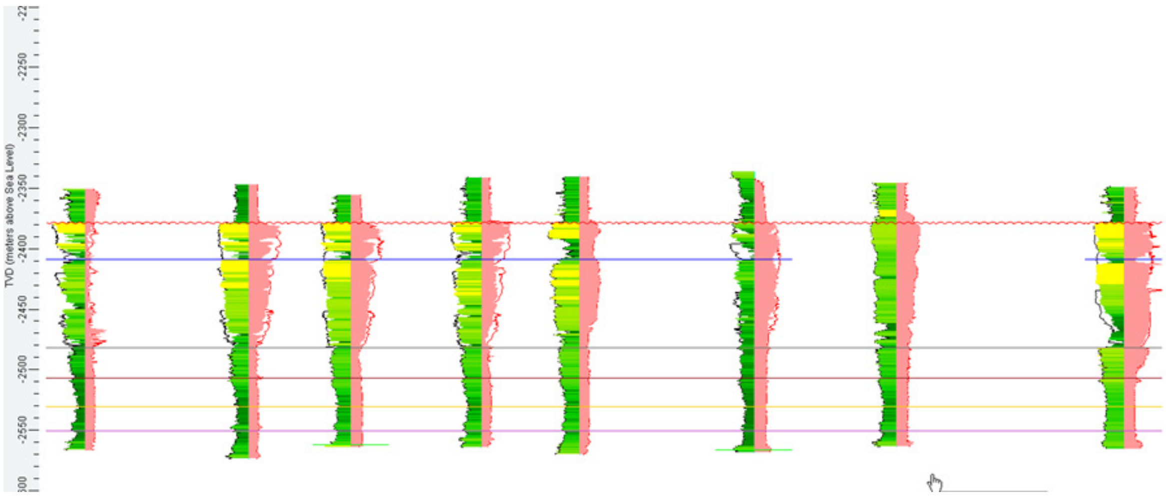
You will flatten the *Correlation* view from an existing surface pick.

6. Click the **Select Pick for Flattening** ( ) icon, on the upper toolbar. The cursor shape will change to white hand symbol ( ). Click a surface pick to flatten across all instances of that surface. The example below flattens the **SM_03** surface pick. (This is the third surface from top to bottom; in the picture below is represented in grey).



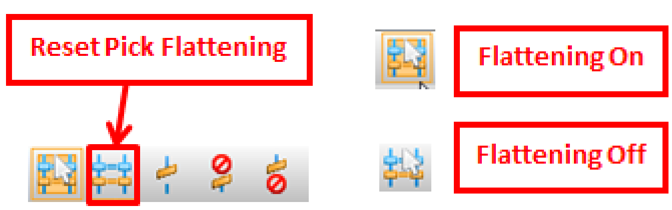
7. You can also flatten on multiple picks within the view. **Ctrl+MB1** on any of the other surfaces within the view.

The following picture has been flattened on the **FANGST GP. HD Top** and all surfaces below.



> **Note**
>
> You can also choose a surface to flatten on from the *View Scale and Layout* section in the *Correlation View Editor*. You can only pick one stratigraphic surface to flatten on within that area, and if you would like multiple you have to **Ctrl+MB1** in *Correlation* view as previously mentioned.

8. To unflatten the picks, click the **Reset Pick Flattening** icon. Turn off **Flattening**.

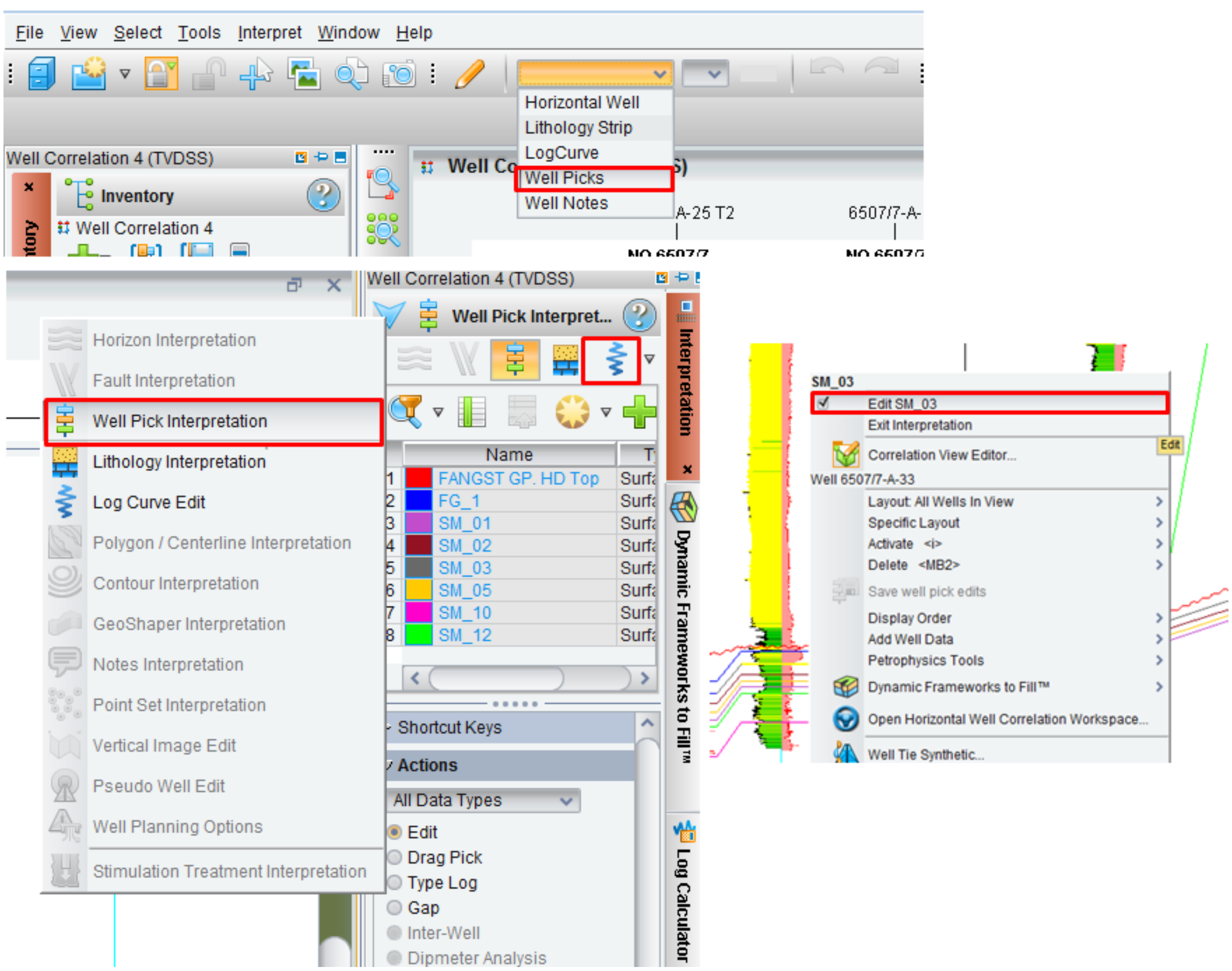


Overview: Editing Surface Picks

Well Pick Interpretation Mode

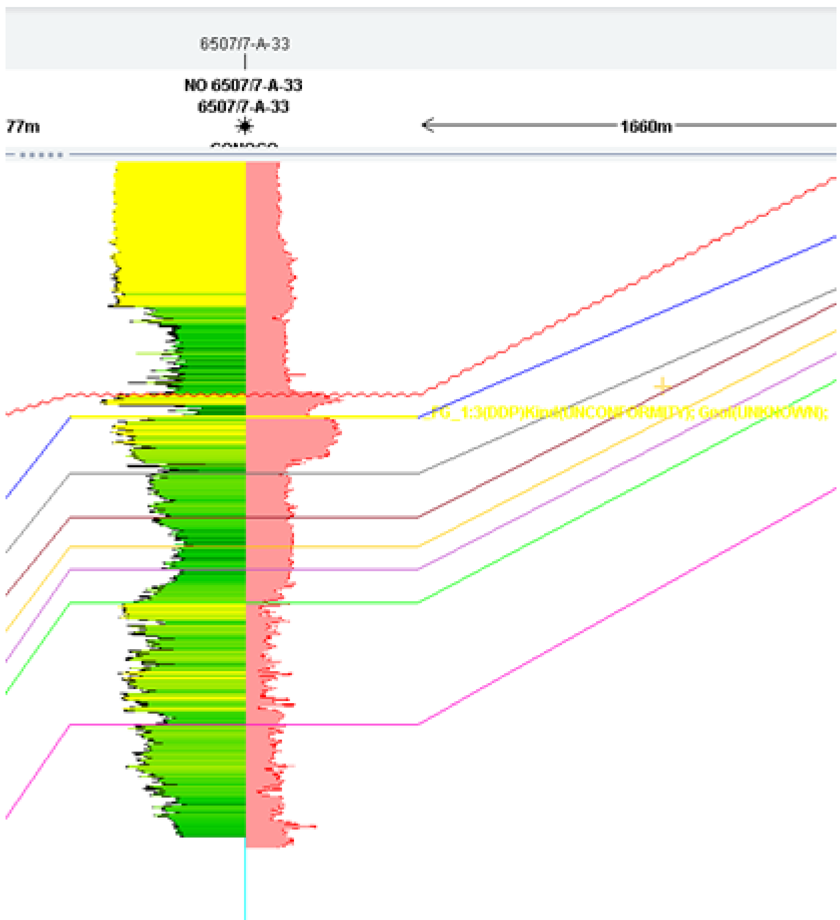
Existing, selected picks can be edited by entering Well Pick Interpretation mode. You are familiar with Interpretation mode, in general, from working with faults and horizons. You can access Well Pick Interpretation mode in several ways illustrated below.

- Interpretation tool bar
- Interpretation task pane
- MB3 on a pick
- Double-click on a pick



Regardless of how you initiate Interpretation mode, you must confirm that Interpretation mode is active (on) before you start editing. The image below shows the appearance of the **Interpretation Mode** icon when it is activated (orange background) and deactivated (grey background).

When you are in Interpretation mode, the selected pick will become highlighted to indicate it is ready to be edited.



Well Pick Interpretation mode supports several actions with surface picks.

- Edit—The default mode allows you to add or move picks along well bores.

  — To add a pick, click the well bore. Cursor shape is .

  — To move a pick, click **MB1** and drag the pick to a new location on the well bore. The cursor shape is  .

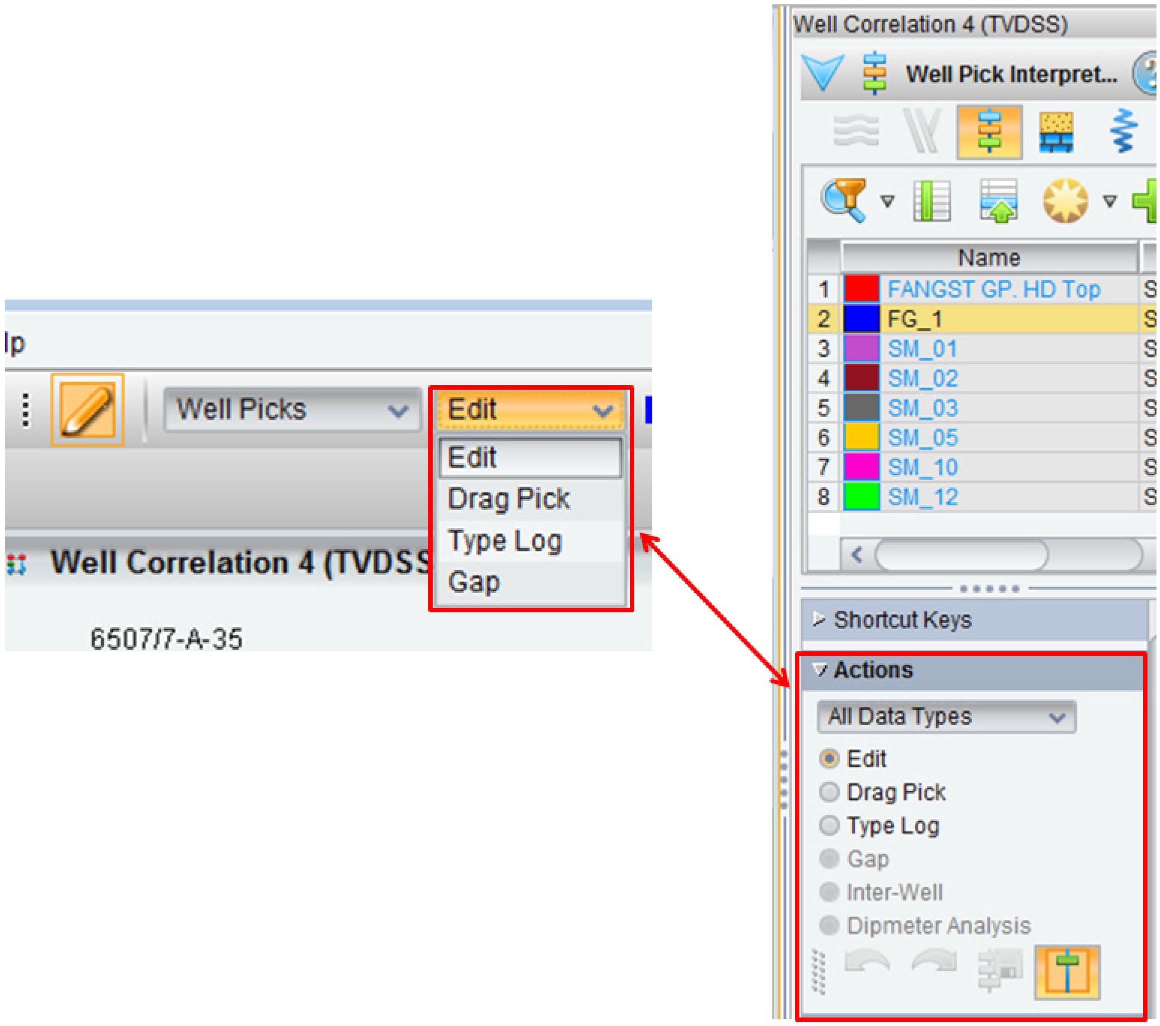
  — Click **MB2** to delete a pick.

- Drag Picks—You can move a ghost copy of a well bore with picks or log curves to compare it with other well bores, using it to make your picks.

  To start the ghost, **MB1** on the pick name that you wish to interpret, and then in another well **MB1** on the place you would like to place the interpretation of that pick.

- Type Log—Allows you to compare a ghost curve, like Drag Picks, but no interpretation can be done in this mode.

- Gap



> **Note**
>
> When there is a change made to a pick the **Save well pick change to database** icon is activated in the *Interpretation* task pane.

Exercise 2.4: Creating and Interpreting Surface Picks

Geology Background

The upper Jurassic Fangst group is the main reservoir sandstone in the Heidrun field. It comprises three shallowing-upwards, siliclastic, parasequences. An early cretaceous uplift event caused significant erosion on the top of the Heidrun field structure. The newly created pick used in this exercise has been eroded from several of the wells in the *Correlation* view.

We will create a new pick **my_pick_YOU**, which corresponds to the next Sandstone under the base cretaceous unconformity. The erosion event has removed the pick from these wells.

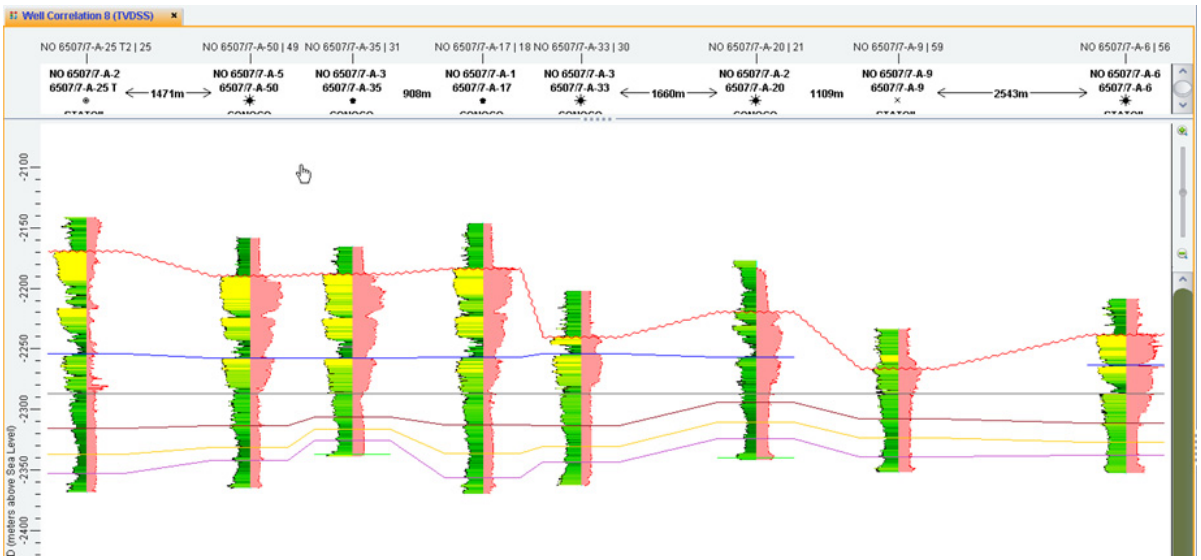
- 7-A-33
- TO-8-A-33
- TO-8-A-14
- 7-A-14
- 7-A-9
- 7-2
- 7-A-6

In this exercise, see how surface picks are created and interpreted in the *Correlation* view.

1. In the active *Correlation* view created from crossline 1275, confirm that all surface picks are turned on.

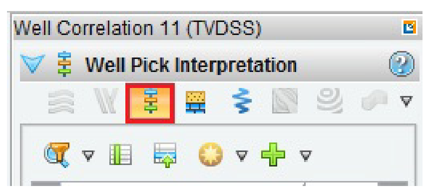
2. If you are using the *Correlation* view from the previous exercise, reset your pick flattening, and flatten only on the **SM_03** pick.

Flattening on the **SM_03** surface pick enables you to see the full structure.

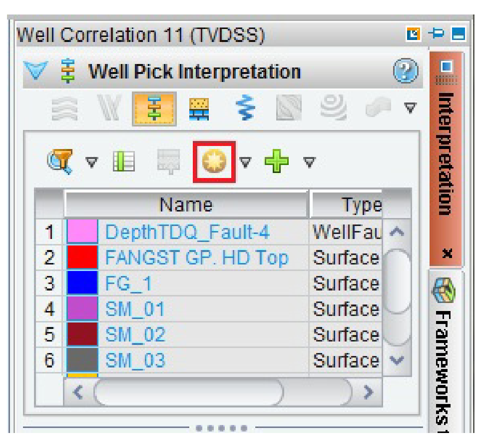


Creating a New Pick

3. In the *Interpretation* task pane, select **Well Pick Interpretation**.

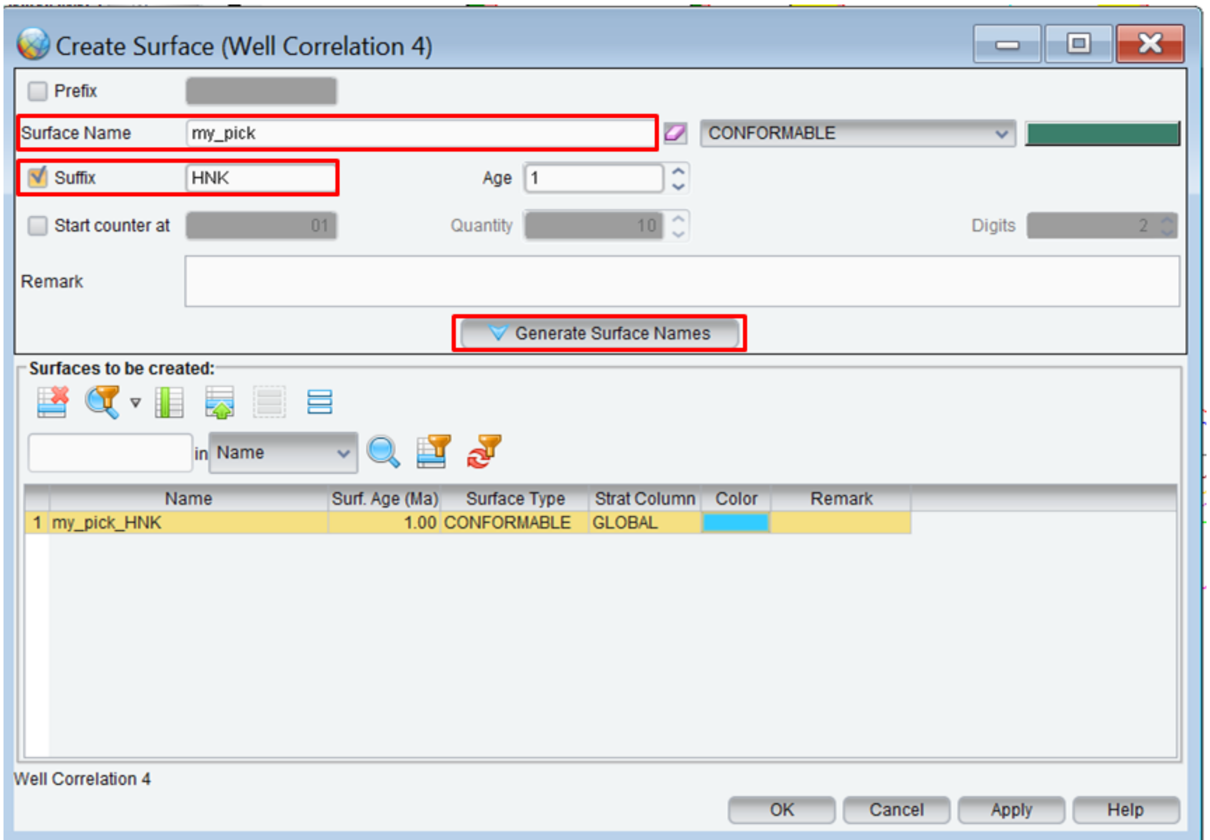


4. Click the **Launch Create Surfaces dialog box (** **)** icon on the task pane menu to open the *Create Surfaces* dialog box.



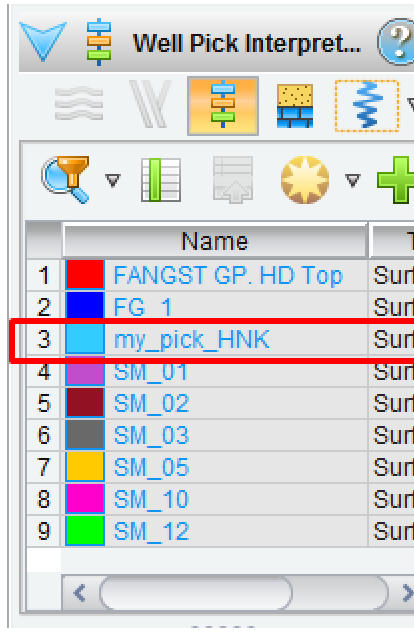
5. Configure the *Create Surface* dialog box as follows.

   - Surface Name: **my_pick**
   - Suffix (turned on): **YOU**
   - Color: **Light Blue** (Click the **Generate Surface Names** button to enable color selection.)



6. Click **OK** on the *Create Surface* dialog box to proceed with this pick name.

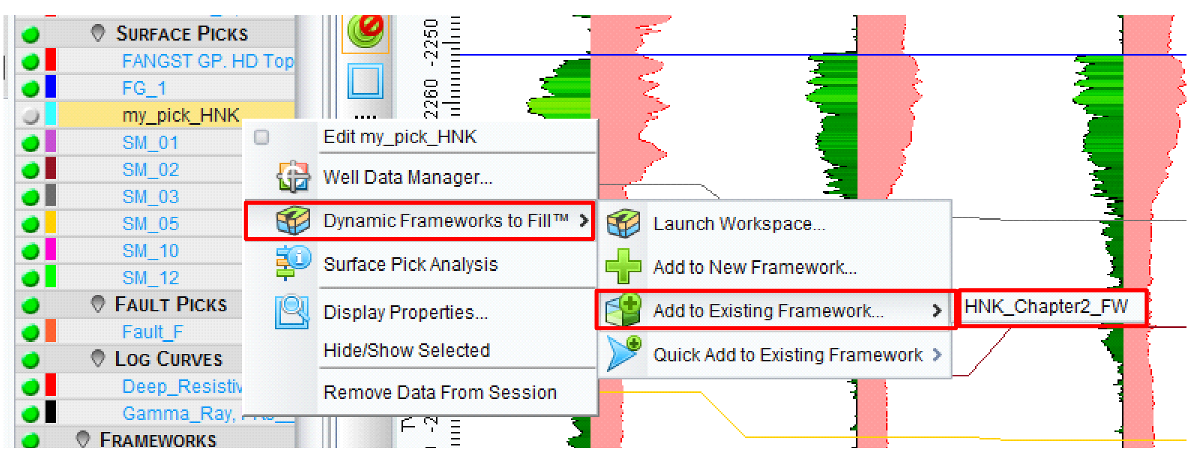
7. Confirm that **my_pick_YOU** is shown in both the *Correlation* and *Section* views. Use the visibility toggle in the *Inventory* task pane.



Adding Surface Pick to Framework

You can add the **my_pick_YOU** surface picks to the **YOU_Chapter2_FW** framework.

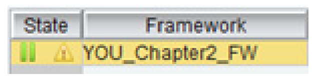
8. In the *Inventory* task pane under SURFACE PICK, **MB3** on **my_pick_YOU** that was just created. Select **Dynamic Frameworks to Fill > Add to Existing Framework > YOU_Chapter2_FW**. The *Add Sources to Framework* dialog box displays, showing that it is going to add your pick to the Framework. Click **OK**.



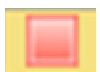
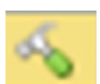
9. Refresh your framework by either clicking on the refresh icon ( ) within the *Dynamic Frameworks to Fill* task pane, or **MB3** on the **YOU_Chapter2_FW** framework in the *Inventory* task pane, and select **Dynamic Frameworks to Fill > Refresh Framework**. The **my_pick_YOU** will show up as a surface within the **FW Surfaces**.

Note

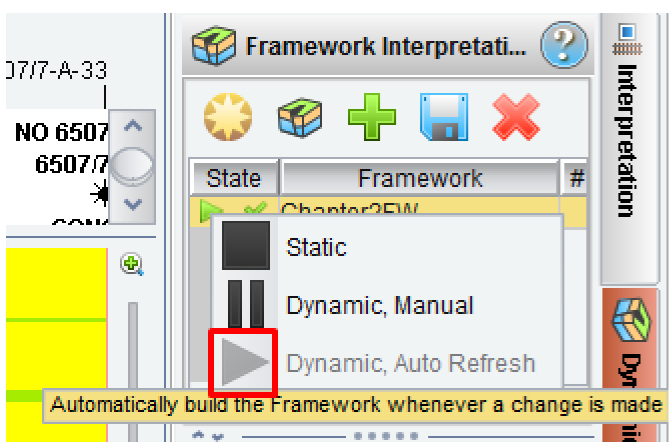
You may have a warning symbol in the state of your framework, this is because the new surface you just added to the framework does not have any data yet since you haven't started the interpretation. After you interpret in a couple of wells and refresh your framework, the warning symbol will disappear.



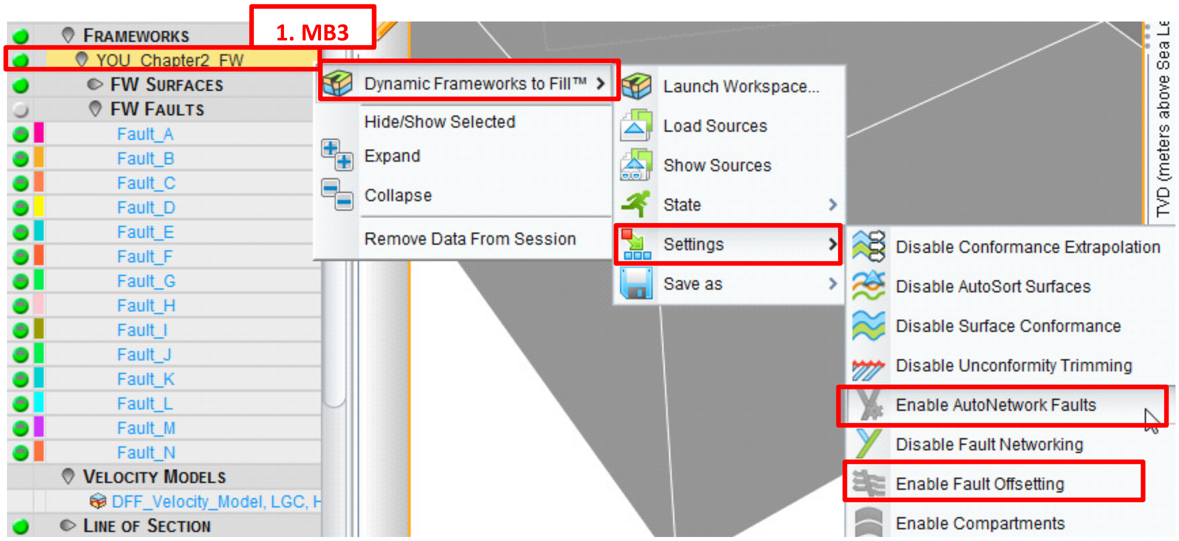
There are multiple symbols in the *Dynamic Frameworks to Fill* task pane next to the framework that show what is going on with the framework.

Icon	Purpose
	Dynamic, Manual: indicates the framework will not update automatically as data is added or removed.
	Dynamic, Auto Refresh: indicates the framework will update automatically as data is added or removed.
	Static: changes to data will not be reflected within the framework, and nothing will be added.
	Refresh: displays only when a framework is in Manual and changes have been made to it. Click the Refresh icon to update the framework.
	Checkmark: displayed when the framework is updated.
	Hammer: indicates the framework is in the process of updating. This will be shown when changes to the data are made (Dynamic, Auto Refresh) or if the framework has been updated by means of the Refresh icon (in Dynamic, Manual).

10. In the *Dynamic Frameworks to Fill* task pane, change **YOU_Chapter2_FW** to **Dynamic, Auto Refresh**. This will automatically update any changes made to the framework.

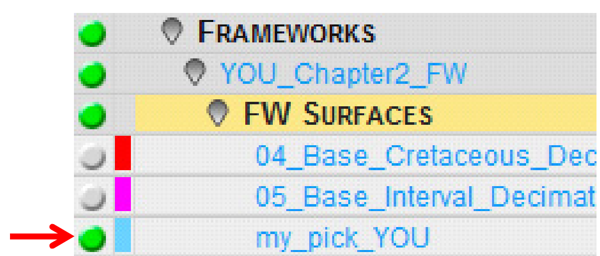


11. Enable **AutoNetwork Faults** and **Fault Offsetting** by going to the *Inventory* task pane, **MB3** on **YOU_Chapter2_FW** and then select **Dynamic Frameworks to Fill > Settings > Enable AutoNetwork Faults**. Repeat this step to **Enable Fault Offsetting**. Your framework should update automatically.

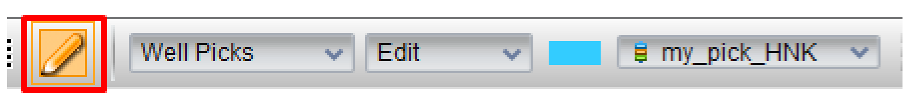


12. Open a *Cube* view and split the screen between it and the *Correlation* view. Doing this will allow you to see the framework updating itself as you interpret the **my_pick_YOU**.

13. In *Cube* view, turn off all the frameworks objects except for the framework surface **my_pick_YOU**.



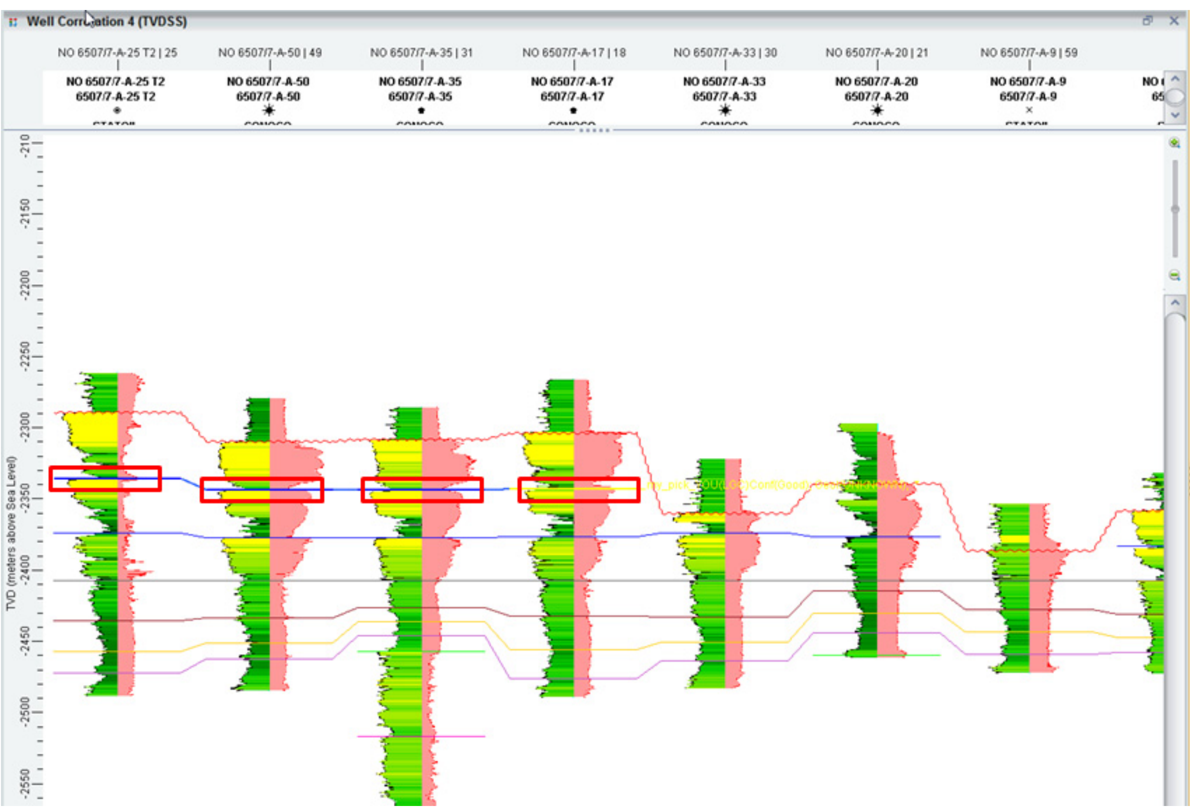
14. In the *Correlation* view, select **my_pick_YOU** in the *Well Pick Interpretation* list. To enter Interpretation mode, turn on the Pencil icon on the toolbar.



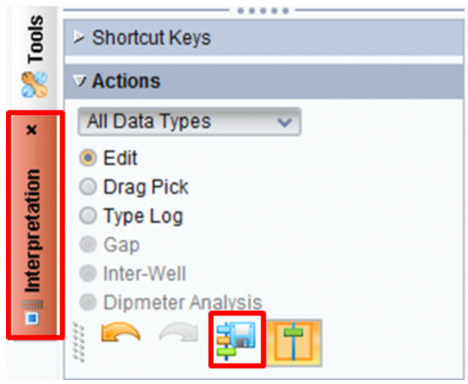
> **Note**
>
> You can also select which pick you wish to interpret from the drop-down menu on the toolbar.

15. Begin your interpretation on the **6507/7-A-25 T2** wellbore at approximately **-2340** meters (TVD Scale at the left of *Correlation* view). Click **MB1** there for **my_pick_YOU** and continue picking the surface on the adjacent wellbores (red boxes below). Interpret until well **6507/7-A-17**.

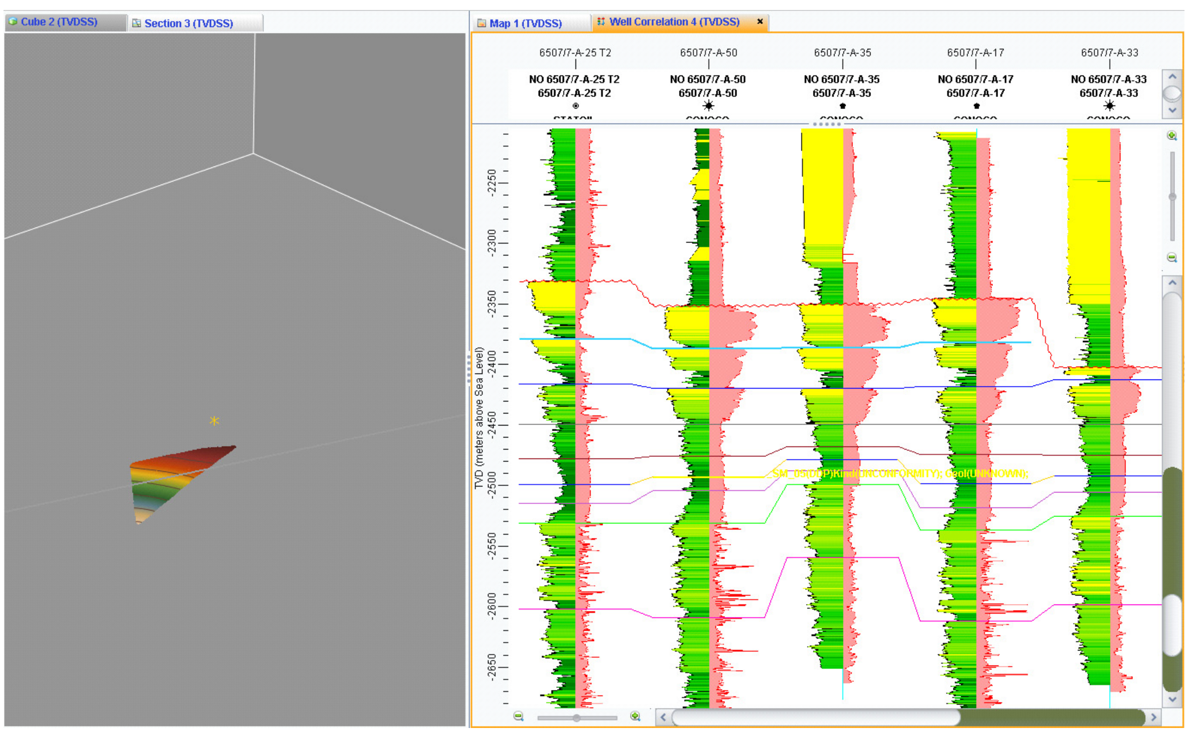
> **Note**
>
> **my_pick_YOU** does not appear in well **6507/7-A-33**, the pick in this well has been eroded by the early cretaceous uplift event.



16. In the *Interpretation* task pane, click the **Save well pick changes to the database** ( ) icon, and after a couple of seconds observe how the frameworks surface displays in *Cube* view (your framework should be automatically updating from previous steps).



After the framework updates, the *Correlation* and *Cube* views will look similar to the image below.



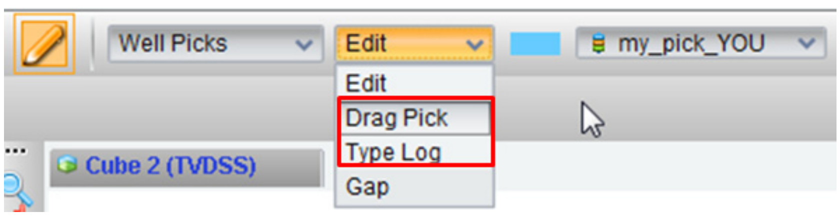
In the following steps you will continue the interpretation of **my_pick_YOU** in other wells using ghost curve.

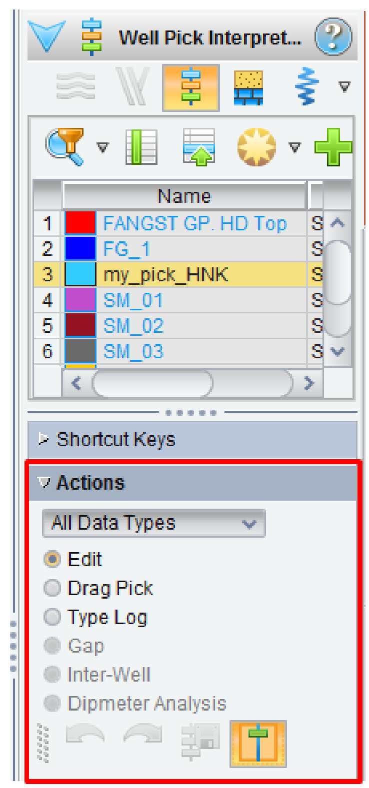
Initiating a Ghost Curve

There are two ways to use Ghost Curve in the *Correlation* view of DecisionSpace Geosciences.

One, the **Type Log** option, is just to visualize and compare two or more wells. In this option you can drag the ghost curve over other wells and no additional well picks will be created in the adjacent wells. The second way, **Drag Pick**, uses the ghost curve to interpret new picks in the adjacent wells.

These options can be found in multiple places: the *Interpretation* toolbar, and the *Actions* panel of the *Interpretation* task pane.

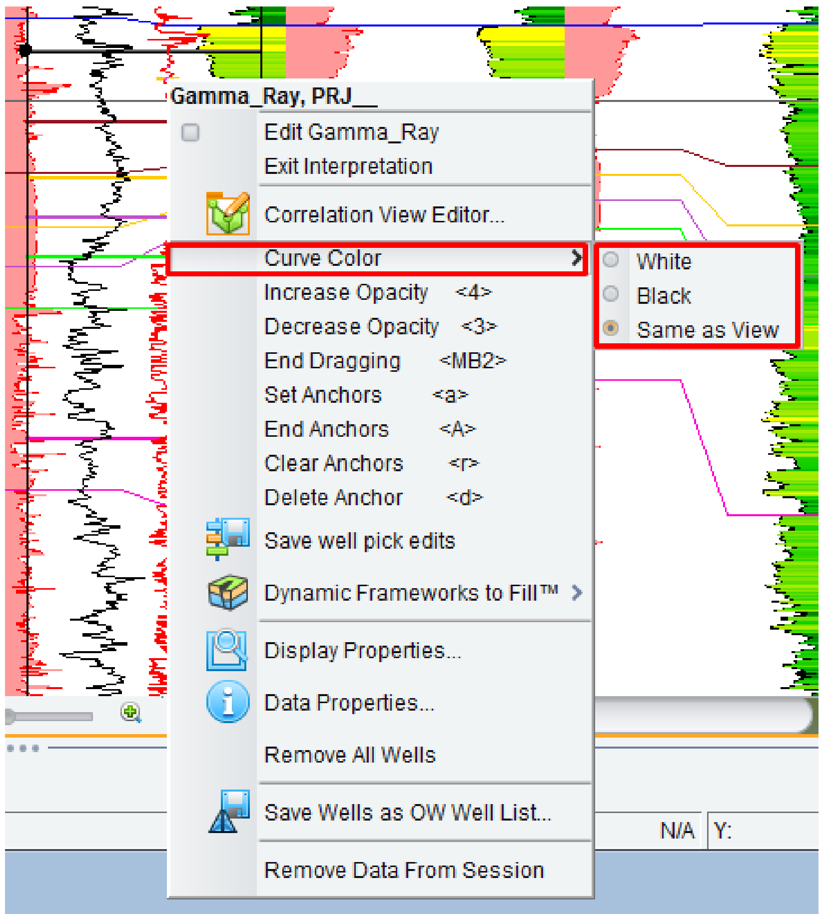


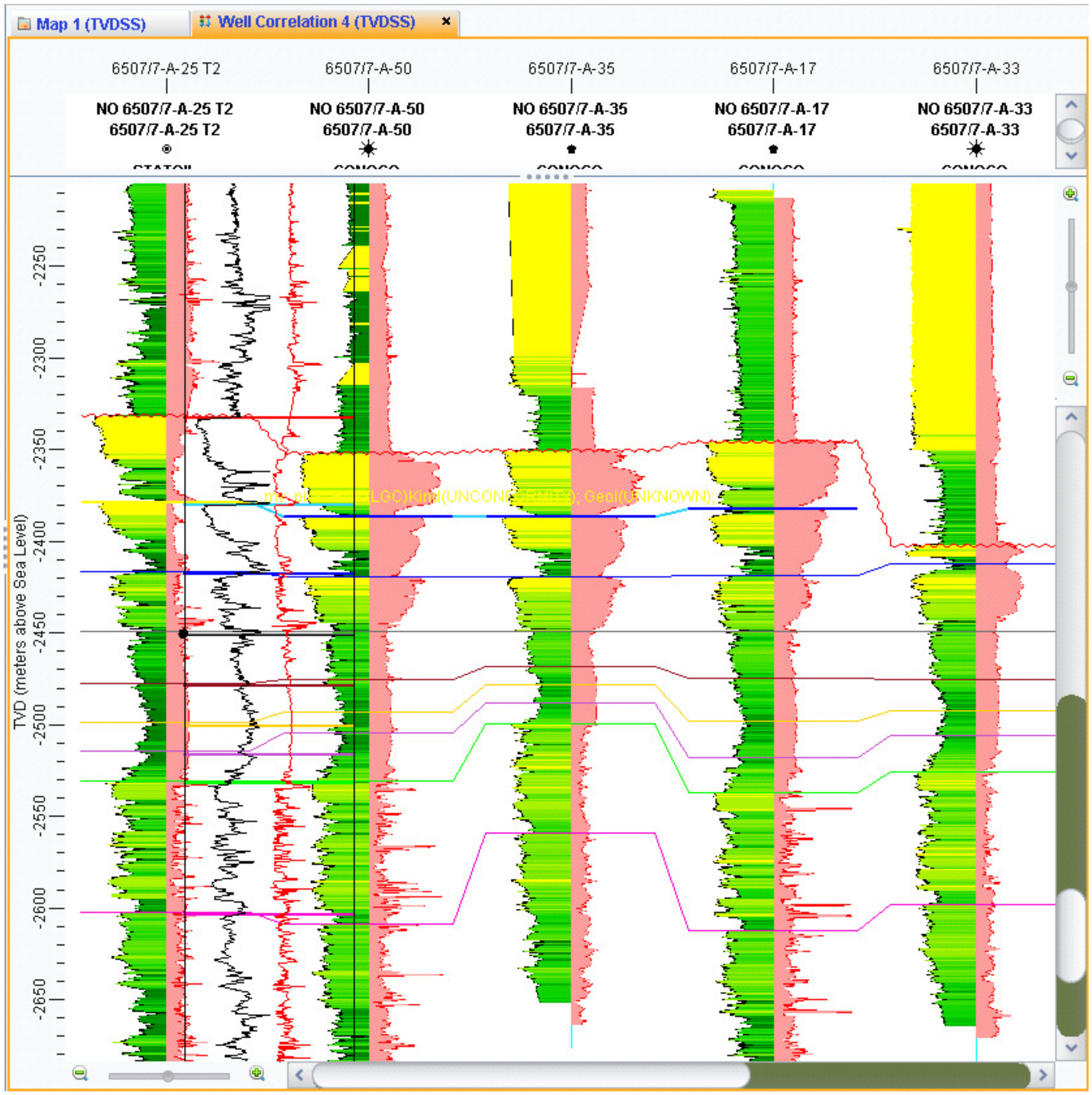


Using Ghost Curves for Visualization and Comparison Only

Once you are in **Type Log** mode, to create a Ghost Curve just for comparison with no pick interpretation involved, **MB1** on the well that from which you want to create the Ghost Curve.

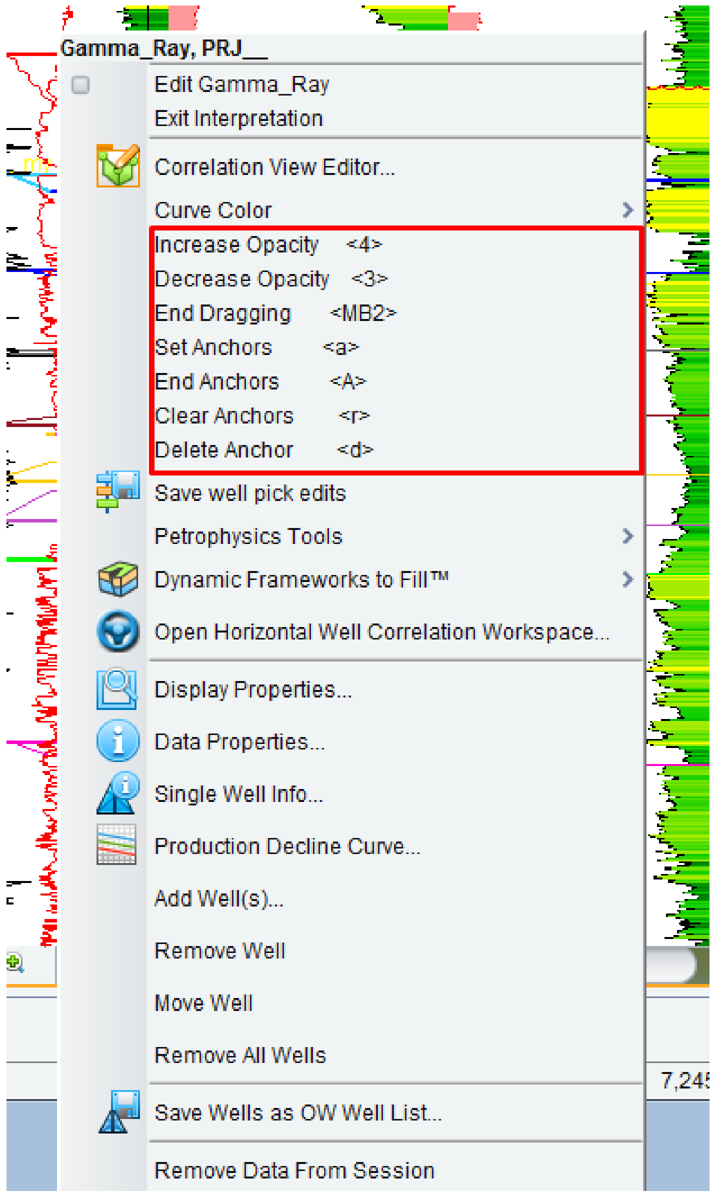
Once you have created a ghost curve you can change it to several different colors. **MB3** on the ghost curve select **Curve Color > Same as View** (or the black/white options).





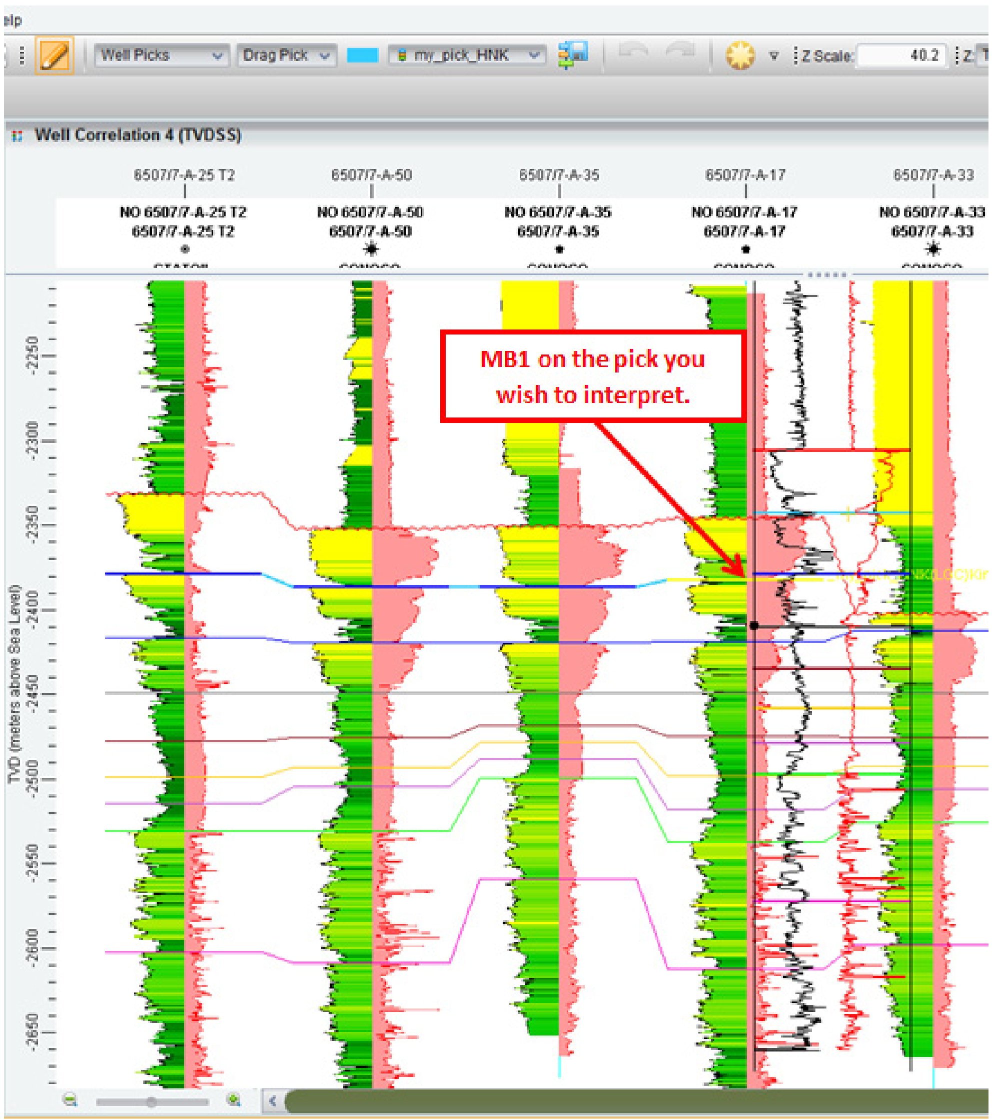
Map 1 (TVDSS)
Well Correlation 4 (TVDSS)
6507/7-A-25 T2
6507/7-A-50
6507/7-A-35
6507/7-A-17
6507/7-A-33
NO 6507/7-A-25 T2
6507/7-A-25 T2
NO 6507/7-A-50
6507/7-A-50
NO 6507/7-A-35
6507/7-A-35
NO 6507/7-A-17
6507/7-A-17
NO 6507/7-A-33
6507/7-A-33
TVD (meters above Sea Level)
-2250
-2300
-2350
-2400
-2450
-2500
-2550
-2600
-2650

In this mode, additional options, like **Set Anchors**, are available with MB3. The anchors are created to stretch or squeeze the Ghost Curve to better match and find correlations in other wells. It is a good way to find changes in thickness and stratigraphy.



Using Ghost Curves to Pick in Other Wells

If you want to use the Ghost Curve to interpret picks in adjacent wells do the following: with **Drag Pick** mode active, click in the well you want to create the Ghost Curve from, directly on the surface pick you want to correlate.



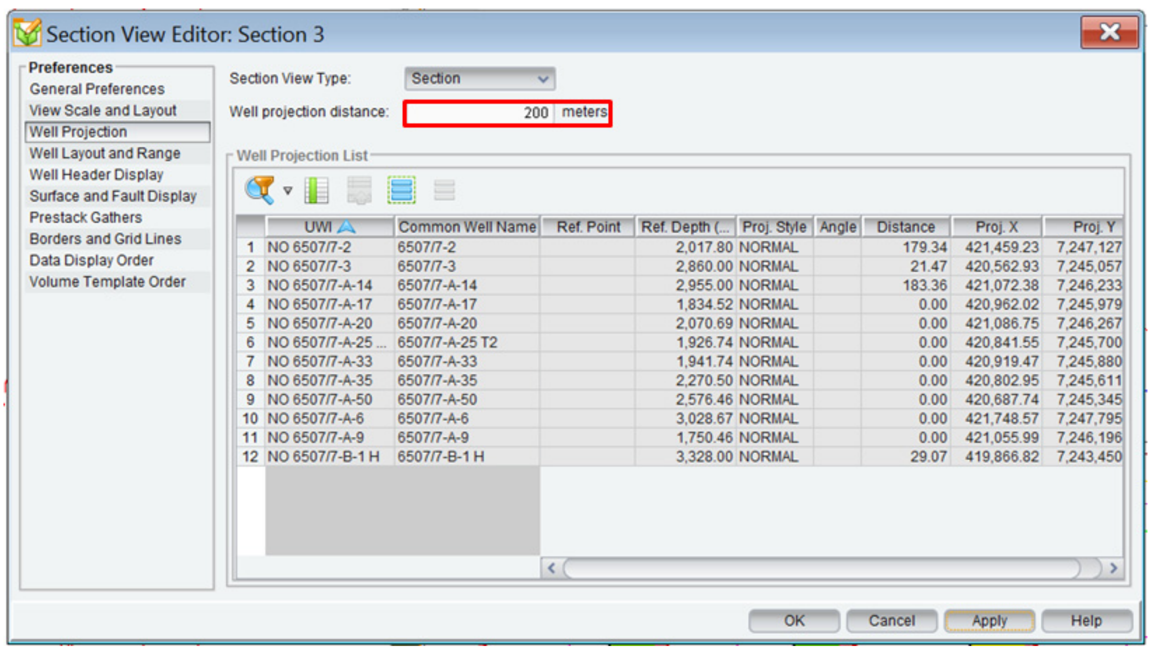
> **Note**
>
> The ghost curve will snap to the mouse. Also, if you have one pick selected to interpret, but you click on a different pick within *Correlation* view while in **Drag Pick** mode it will switch to interpret that pick.

A box with an outline of the log curves and surface picks displays over the wellbore. The box is the ghost of the selected well. In this mode, options like Set Anchors are disabled.

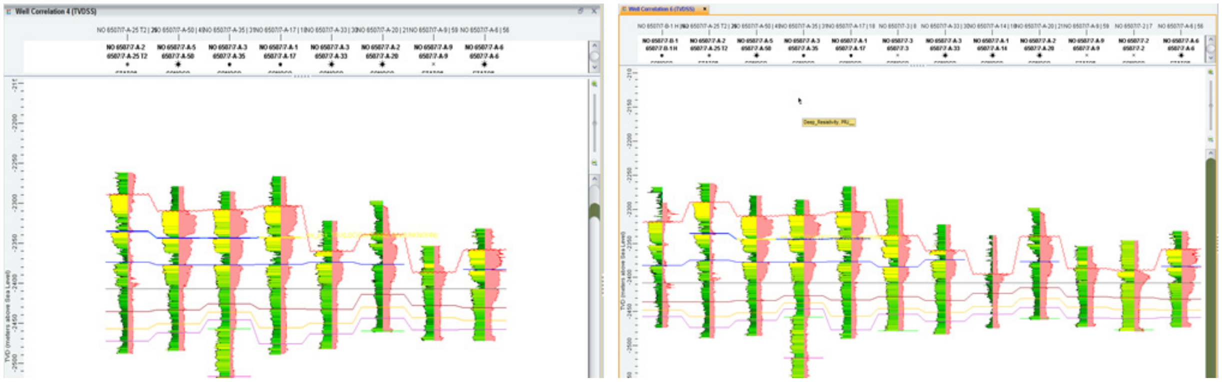
Hold the ghost curve over the next well you want to interpret, and **MB1** to make the interpretation.

Interpreting with a Ghost Curve

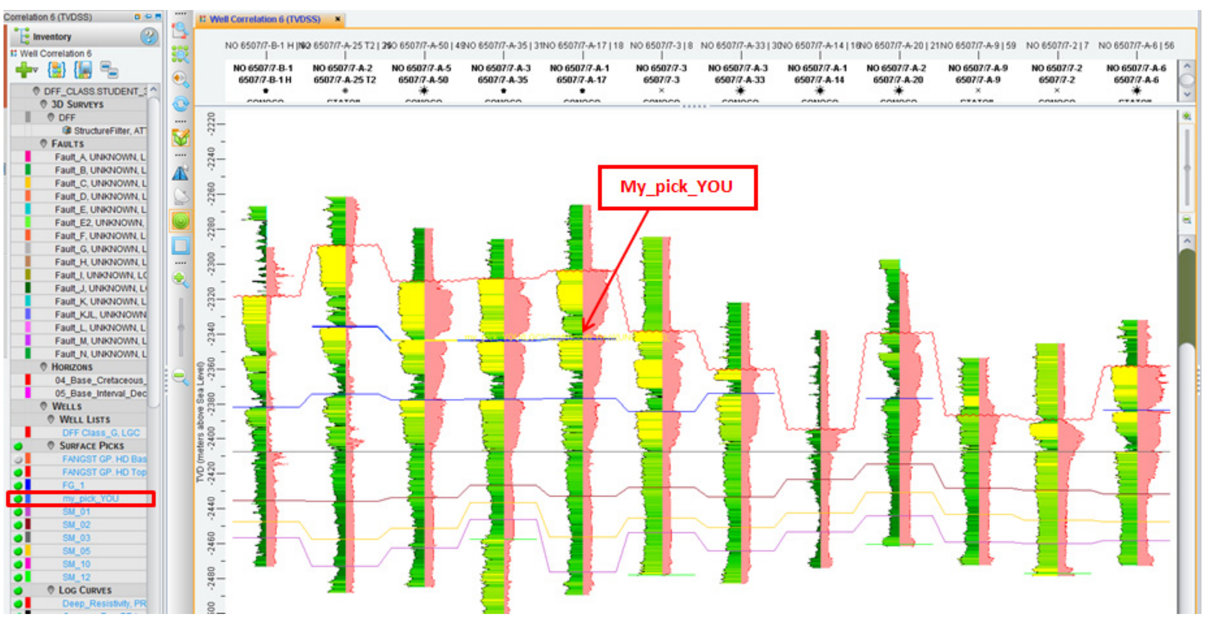
17. Go back to *Section* view, **MB3** over the Section Header and select **Section View Editor**. Within the *Well Projection* section of the *Section View Editor*, change the well projection distance to **200** m. Click **Apply**. The list of wells within the projection will change to reflect what is seen in *Section* view. Click **OK** to close *Section View Editor*.



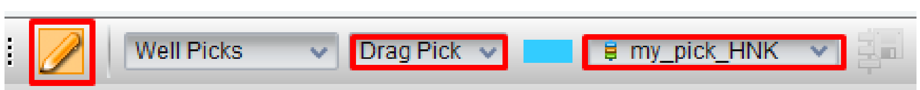
18. With *Section* view active, create a second *Correlation* window, notice that this one will have more wells than the first one, since the well projection distance is bigger. **File** > **New Window** > **Correlation**.



19. In the new *Correlation* tab, adjust the scale and if necessary flatten the cross section on the surface **SM_03** to match the picture below. Make sure that all the surfaces, including **my_Pick_YOU** are on.



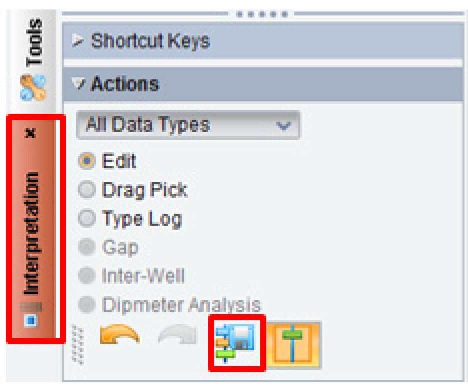
20. In the *Interpretation* tool bar, make sure that the **Interpretation** icon is on, **my_pick_YOU** is active, and select **Drag Pick** from the drop-down.



21. On the well **6507/7-A-17**, **MB1** directly on the surface **my_pick_YOU**. A box with an outline of the log curves and surface picks displays over the wellbore. The box is the ghost of the selected well. At this point you are ready to move the ghost box over the other wells to continue the interpretation of **my_pick_YOU**. Move the ghost over the very first well in your correlation **6507/7-B-1 H**. Align the ghost curve until the inflection of **my_pick_YOU** matches with the log response of the well and **MB1** to create the surface **my_pick_YOU** on that well.

22. Similarly, move the ghost curve over well **6507/7-3**, **MB1** on the corresponding inflection. Once you finish picking in this well, click **MB2** to remove the Ghost Curve.

23. In the *Interpretation* task pane, click the **Save well pick changes to the database** ( )icon, and after a couple of seconds observe how the frameworks surface will update in *Cube* view (your framework should be automatically updating from previous steps).

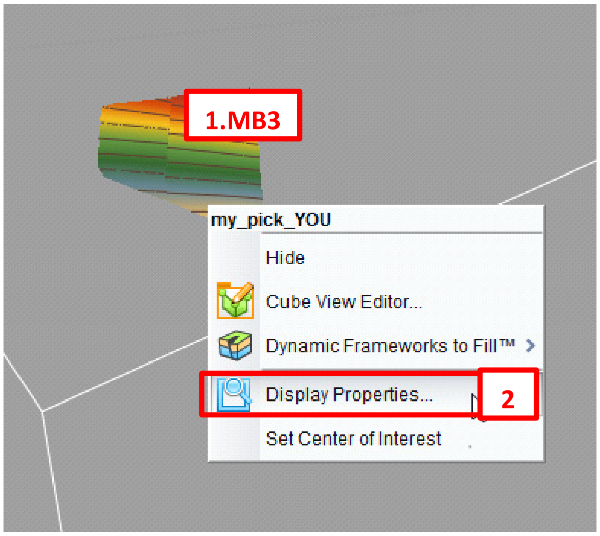


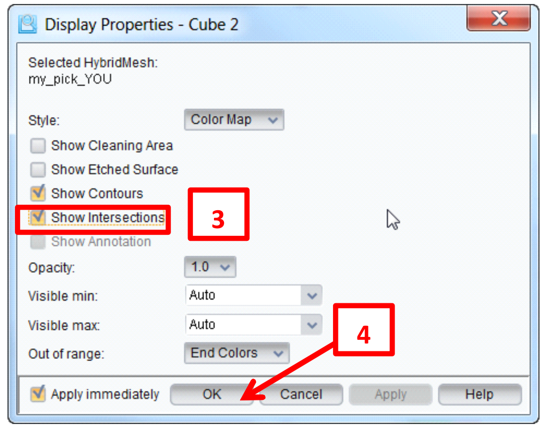
24. Your *Correlation* and *Cube* views should now look similar to the picture below. Notice that as the geological surface is being interpreted, the fault features are starting to appear in the surface. This is because fault offsetting is currently active in your framework. This means that the faults planes are interacting with the surfaces to build the fault polygons in real time.

Note
Clicking MB2 while you are in Drag Pick mode makes the Ghost Curve disappear. Clicking MB2 in Edit mode will delete the pick. Remember you can use the Undo icon under the *Actions* sub-panel, or on the toolbar, if you make any mistake.

The previous picture shows **my_pick_YOU** is eroded away on the **6507/7-A-33** well and does not reappear until the **6507/7-A-20** well. You will create a new ghost curve of the **6507/7-3** well and manipulate it using anchors to pick **my_pick_YOU** surface on the **6507/7-A-20** well.

25. To visualize the fault polygons on the framework surface **my_pick_YOU**, activate *Cube* view, **MB3** on the surface, select **Display properties**, and then check on **Show Intersections**.

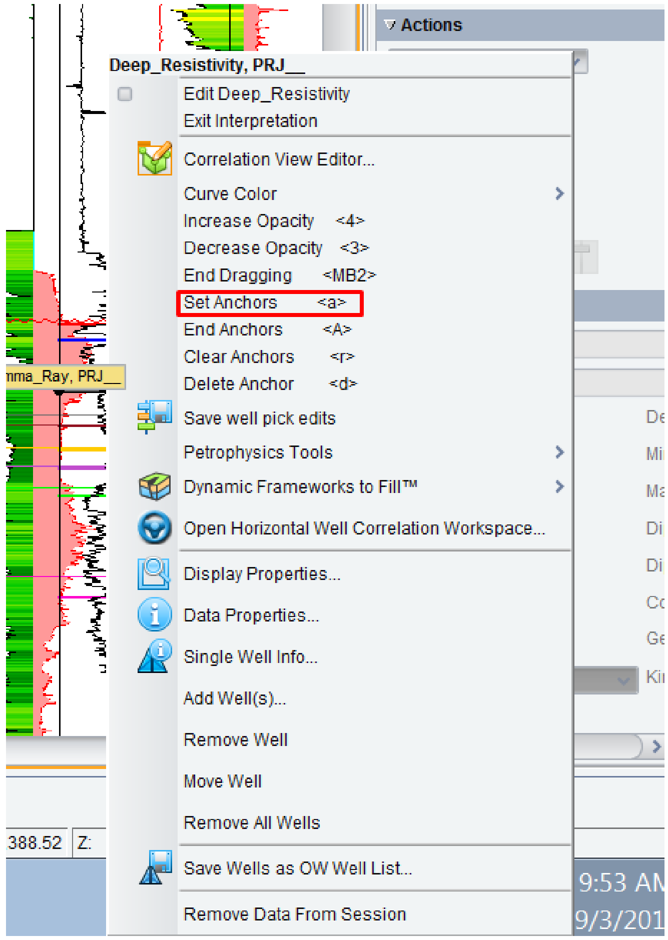




26. Back in *Correlation* view, activate **Type Log** mode to create a Ghost Curve of the **6507/7-3** well.

    This Ghost Curve can be stretched and squeezed to get a closer match with another well log curve. You will set anchor points on two or three surface picks.

27. With your cursor on the Ghost Curve, **MB3** and select **Set Anchors**.

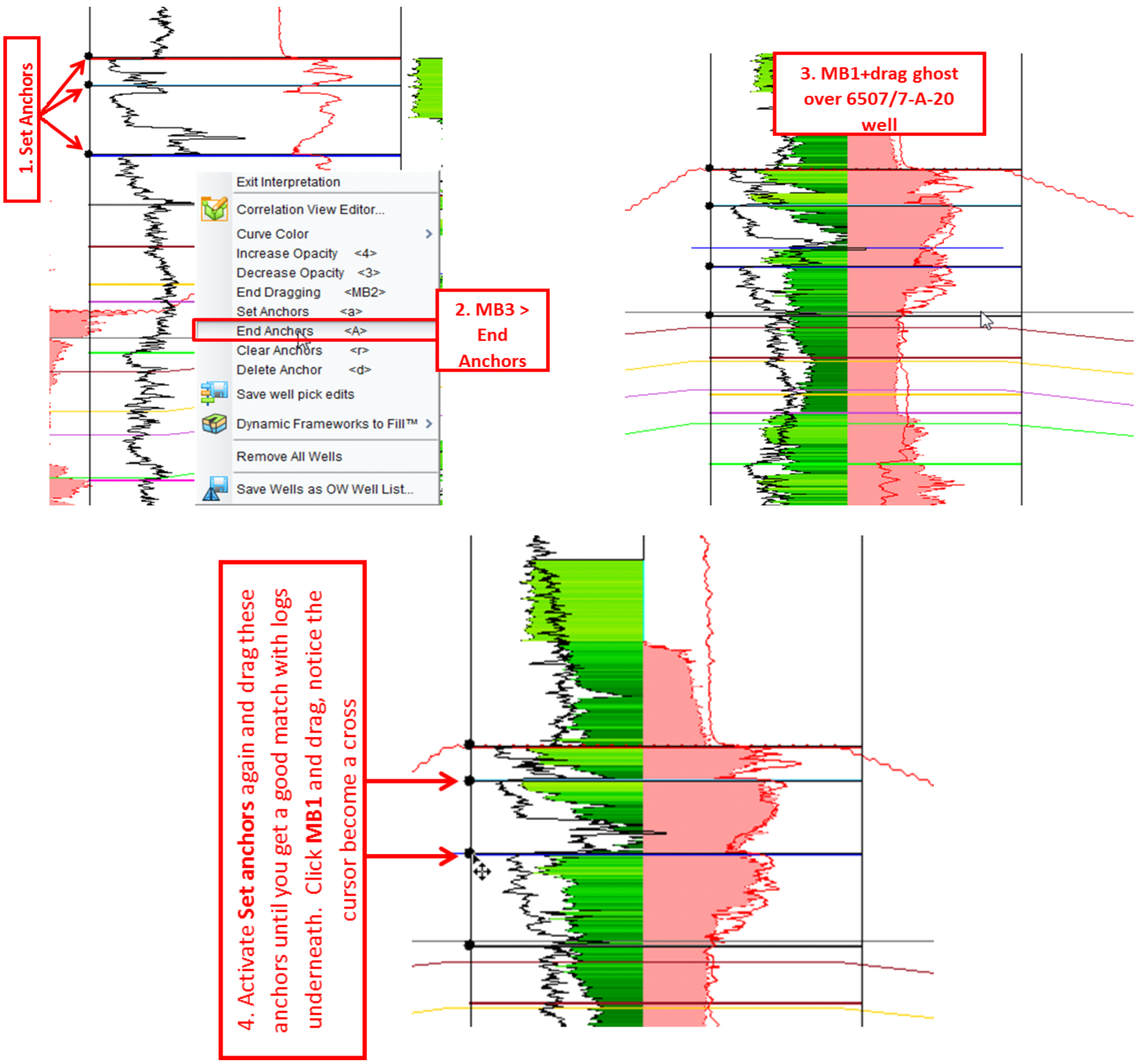


28. While Set Anchors is enabled, click within the ghost curve to set a series of anchor points over the first three surface picks: **FANGST GP. HD Top**, **my_pick_YOU**, and **FG_1**.

29. **MB3** and then select **End Anchors**. Drag the ghost curve with the anchors over the **6507/7-A-20** well. (In **Type Log** you drag the ghost curve by holding MB1). You can align the first anchor point corresponding to **FANGST GP. HD Top** in both wells.

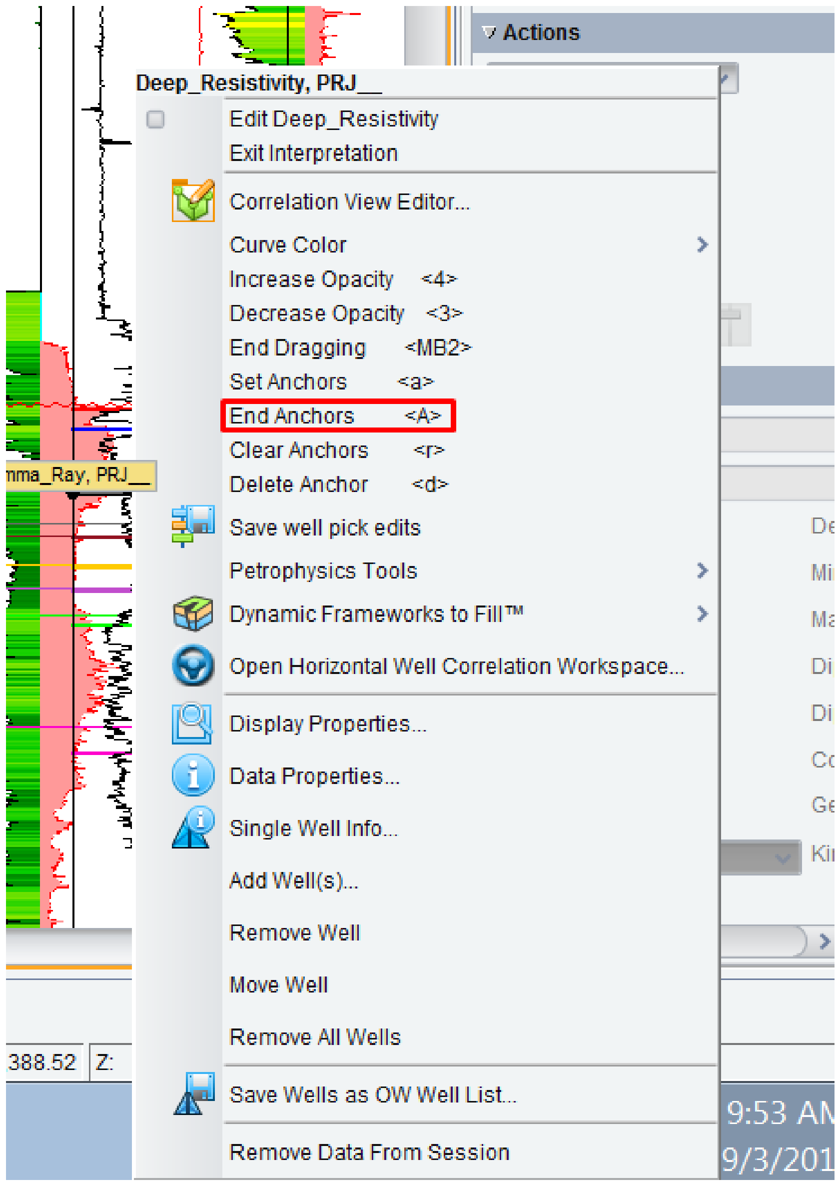
30. Activate **Set Anchors** again, **MB1** and drag the anchor points corresponding to **my_pick_YOU** and **FG_1** up or down until the ghosted curve becomes a closer match to the curve beneath it. These steps are illustrated in the picture below.

> **Note**
>
> The hot keys for setting anchors <**a**> and ending anchors <**A**> are very helpful when trying to compare the curves. You cannot move the ghost curve while you have enabled the setting anchors option.



> **Note**
>
> The cursor shape changes to a four-pointed arrow ( ) when you hover the cursor over an anchor point. Click MB1 and drag.

31. **MB3** and select **End Anchors**.

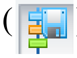


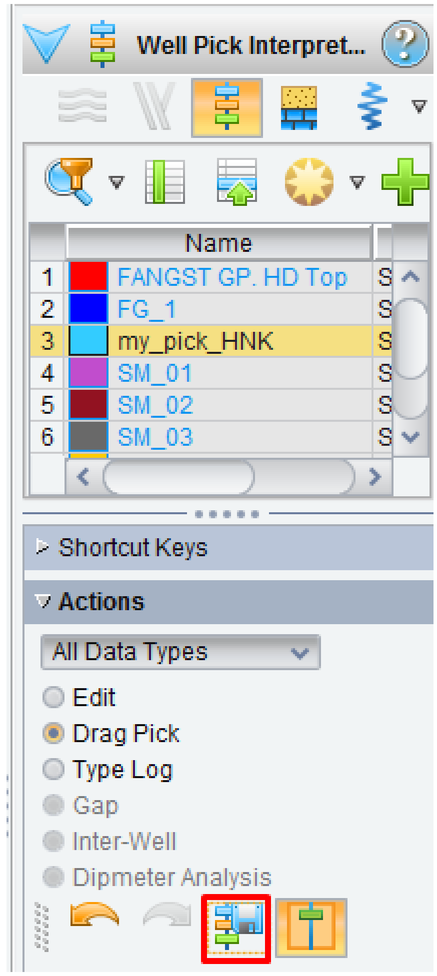
Note the other anchor-related options on the menu.

32. Correlate the **my_pick_YOU** surface on the **6507/7-A-20** well. As this Ghost Curve does not have pick interpretation capability, you have to switch to **Edit** mode to interpret the top.

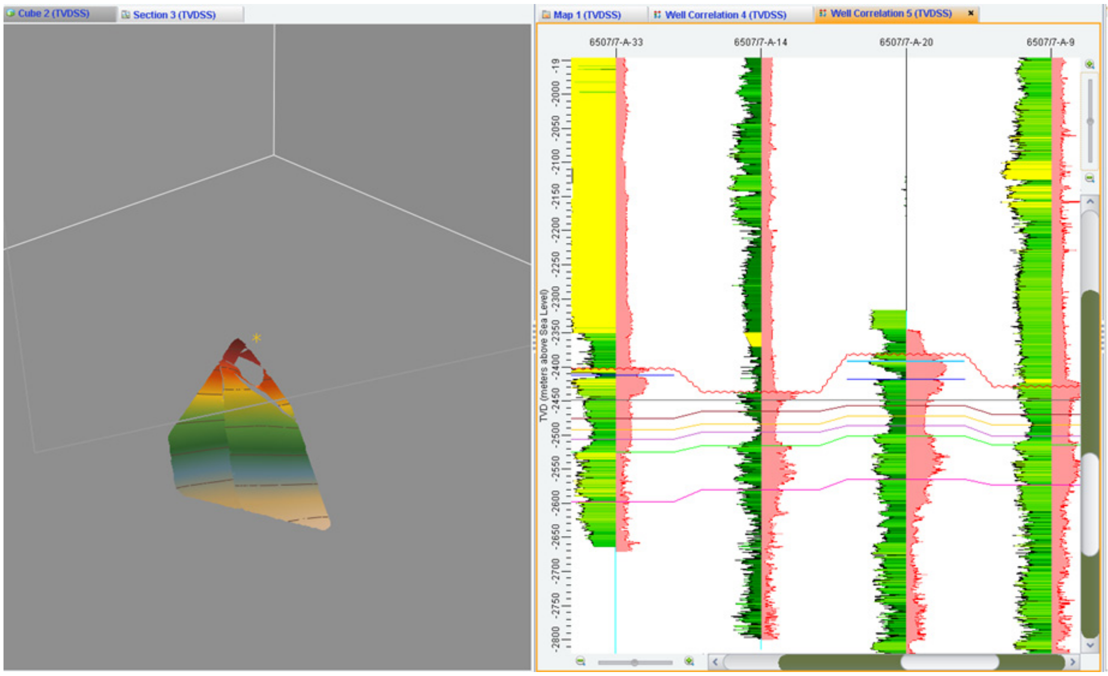
> **Note**
>
> If you switch to Drag Pick mode from Type Log mode the ghost curve that you edited with anchors will disappear. If you switch to Edit then the ghost curve will stay in the view, in order to remove the ghost curve you have to switch back to Type Log mode and MB2.

The unconformity truncates **my_pick_YOU** in the next two wells in the correlation, and it appears again in the right-most well in the *Correlation* view, the **6507/7-A-6**. This well has a different log signature than the previous wells (**6507/7-A-20**), so you cannot use a ghost curve from that well, but perhaps the ghost curve from the **6507/ 7-3** well will suffice.

33. In the *Actions* sub-panel (of the *Interpretation* task pane), click the **Save Pick to Database** () icon.



Your framework will update upon saving your surface picks. Notice the change in the surface **my_pick_YOU** displayed in your *Cube* view.



34. Save your framework and your session.

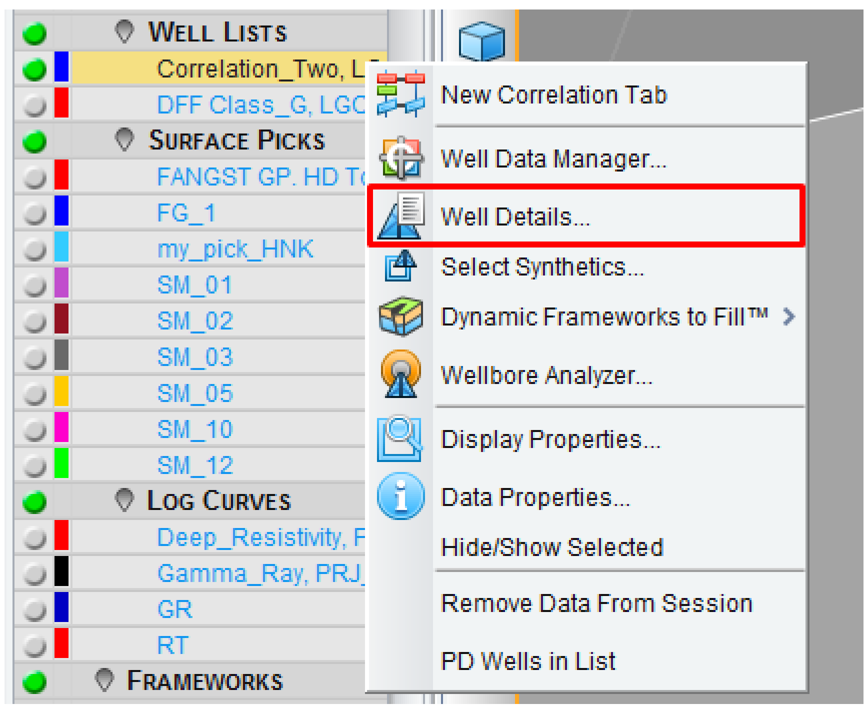
Exercise 2.5: Mapping Workflows in Dynamic Frameworks to Fill

In this exercise, you will continue to interpret the surface you created in the previous exercises, and see the improvements in your framework surface due to your interpretation. Also, you will finalize your *Correlation* view display, by filling the Auto-ties between wells with a lithology fill. This feature allows for viewers to be able to quickly identify significant areas, without having to interpret the logs themselves.

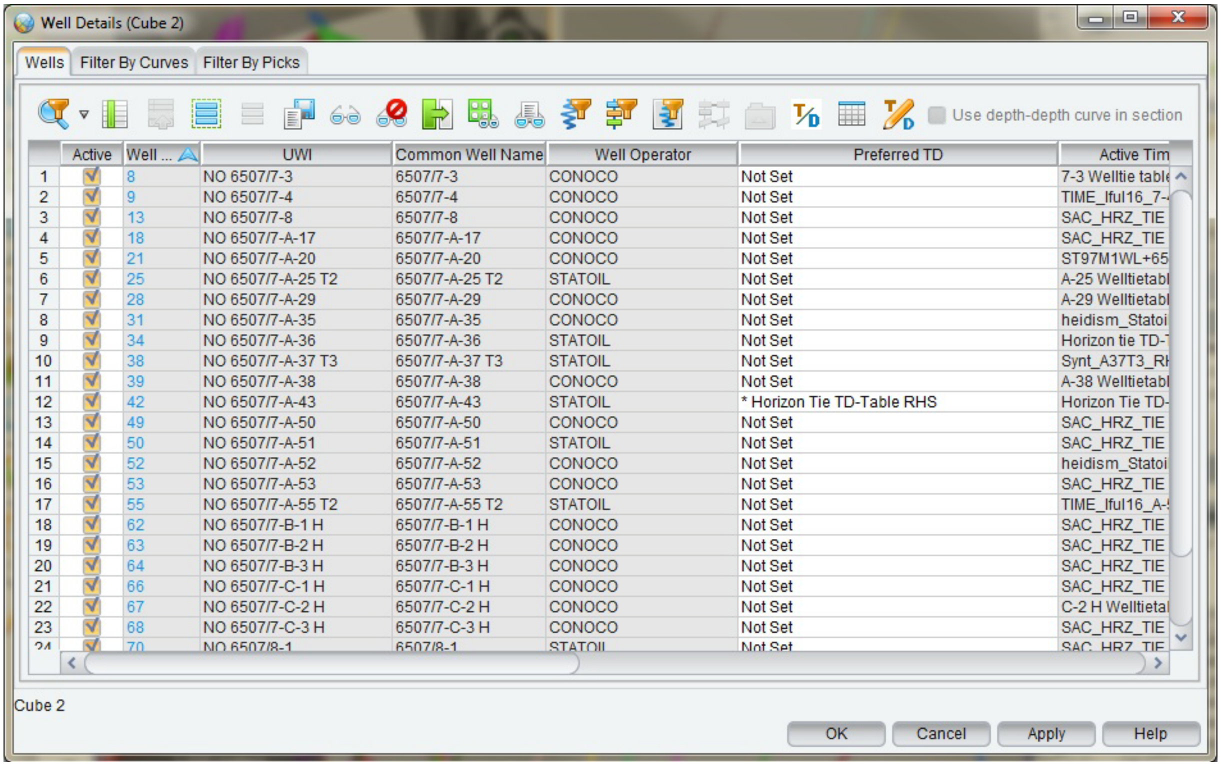
Building a Correlation View of Wells from Well Details

1. Click **Select Session Data** () to add the **Correlation_Two** well list into the current session, it if is not already present.

2. In the *Inventory* tree, on well list **Correlation_Two**, **MB3** and select **Well Details**.



The *Well Details* dialog box allows you to select and edit TD tables, make wells visible or invisible, and create *Correlation* views for selected wells.

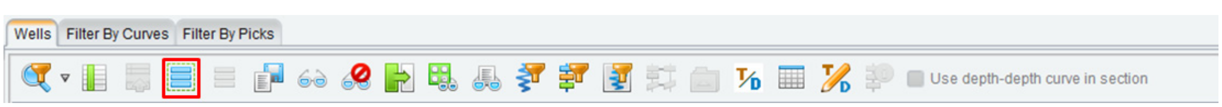


Note

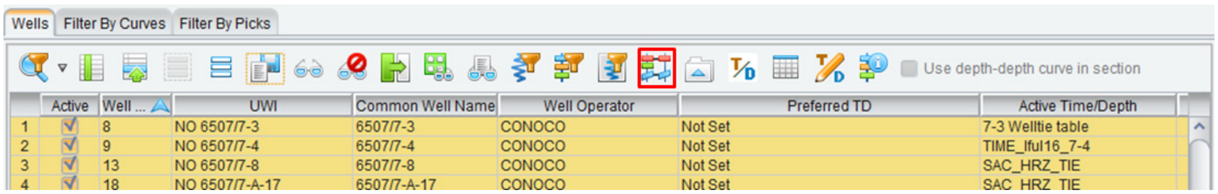
You can use the *Wells Details* dialog box to create filtered lists of wells based on log curves and surface picks.

In this exercise, you need a *Correlation* view containing all available wells.

3. Click the **Select All** () icon on the tool bar.

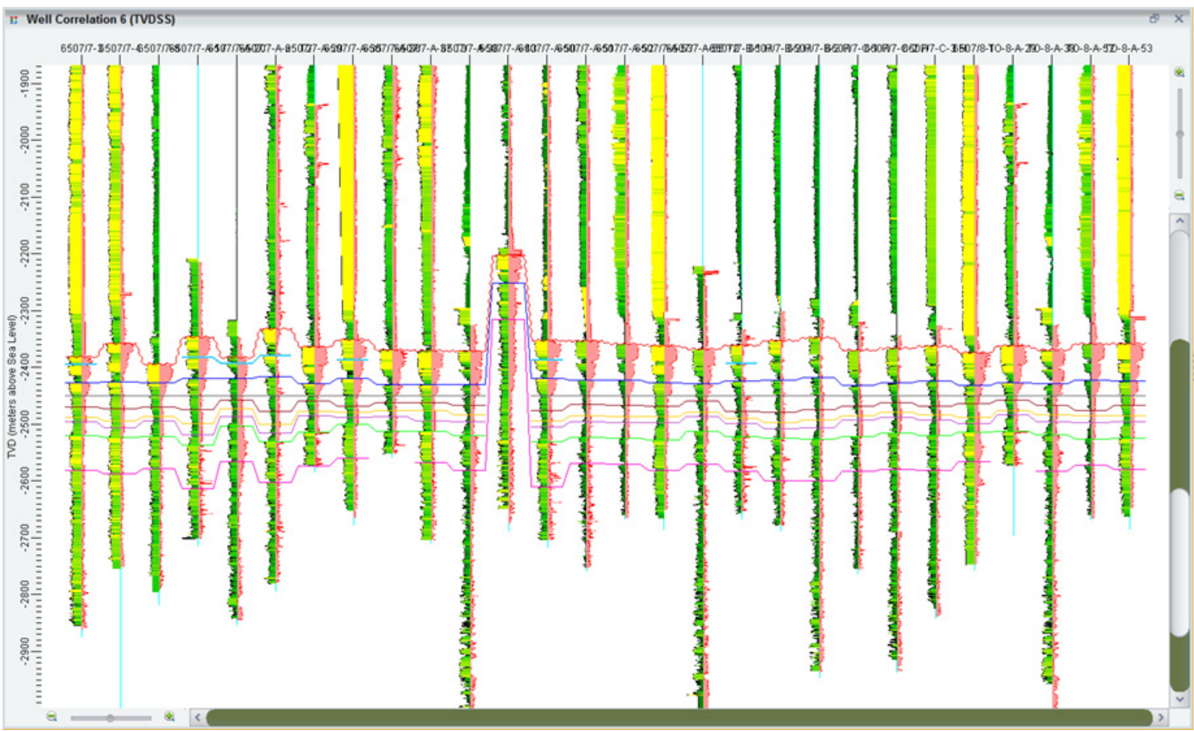


4. Click the **Display Selected Wells in New Correlation View** ( ) icon to launch a new *Correlation* view. Minimize the previous *Correlation* view.



5. Click **Cancel** to close the *Well Details* dialog box.

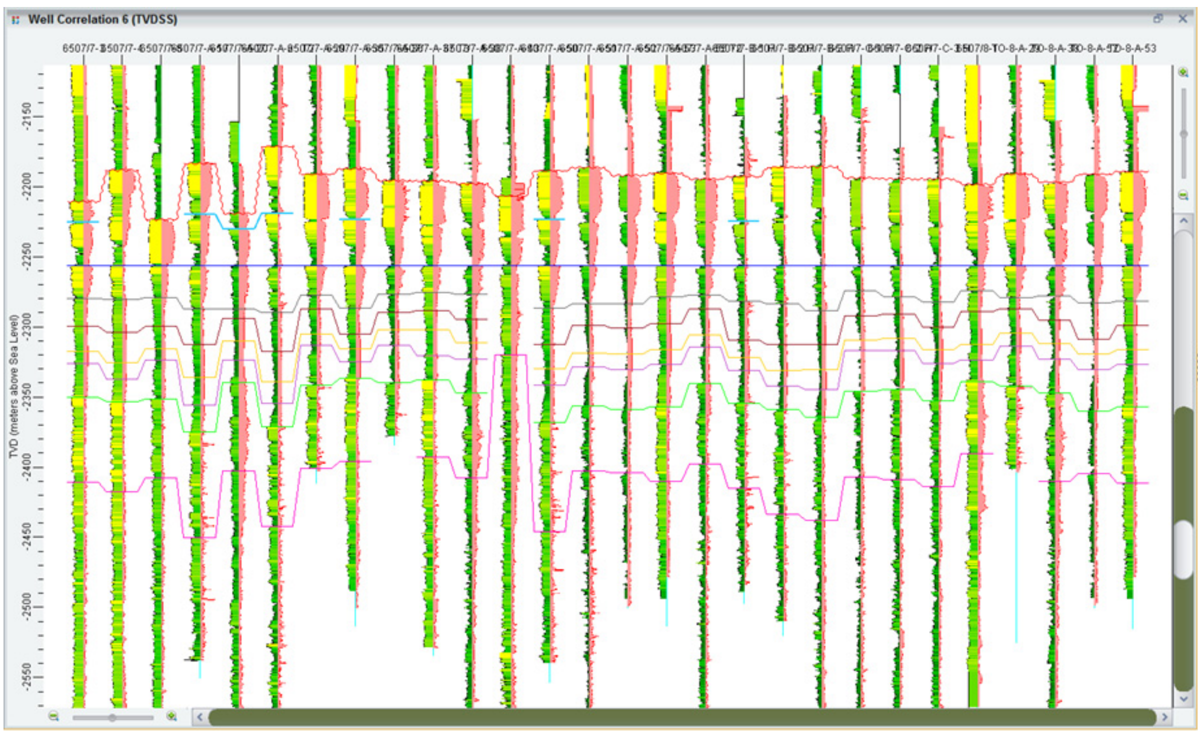
   The new *Correlation* view should look like the following image.



Continuing Surface Pick Interpretation

You will continue to pick the **my_pick_YOU** surface on this new *Correlation* view. As you can see, this *Correlation* view contains some of the wells used in the previous correlation exercise. This will give you a good reference for where the **my_pick_YOU** is and will serve as a guide in correlating.

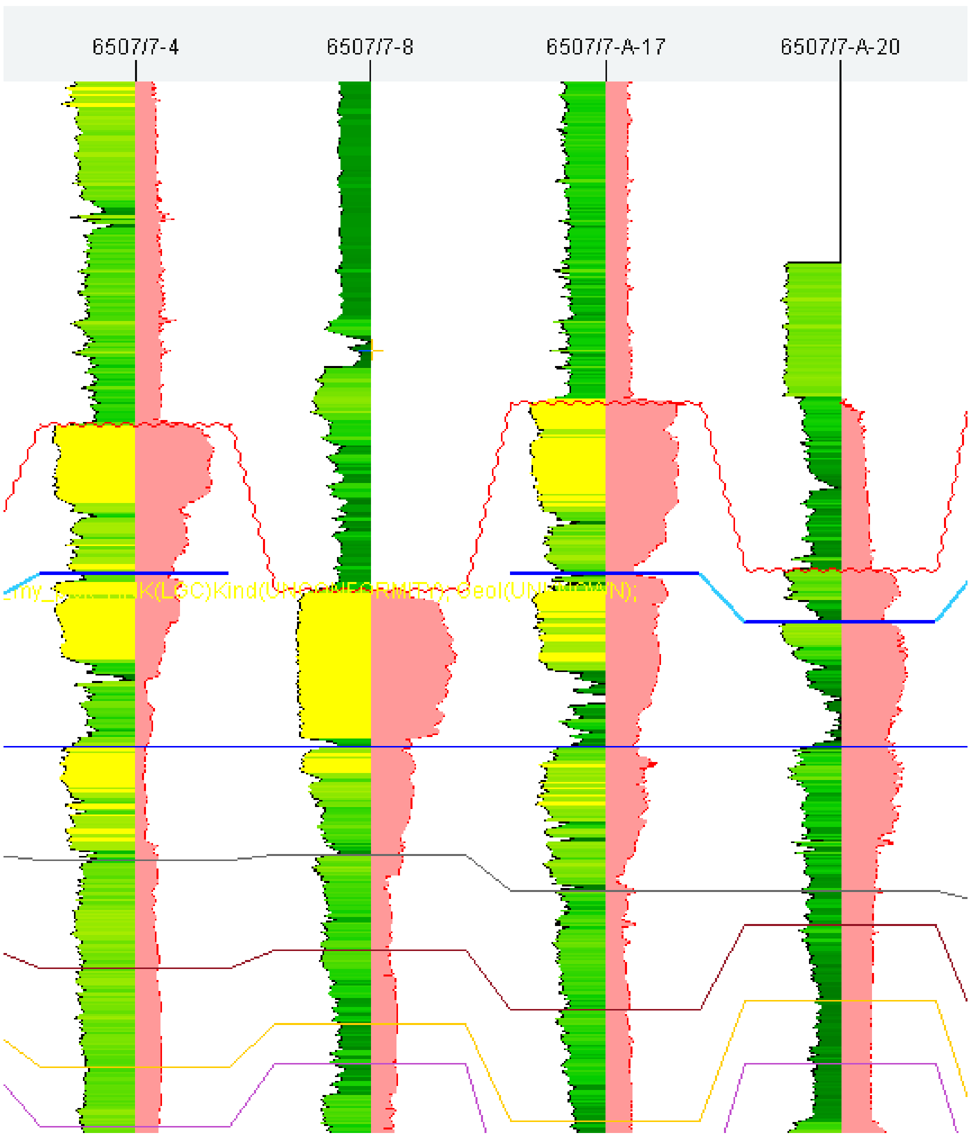
6. Zoom in to the area between the base cretaceous unconformity (**FANGST GP. HD Top**) and the last pick in your *Well Correlation* view, click the **Pick Flattening** icon ( ) to hang on the **FG_1** surface.



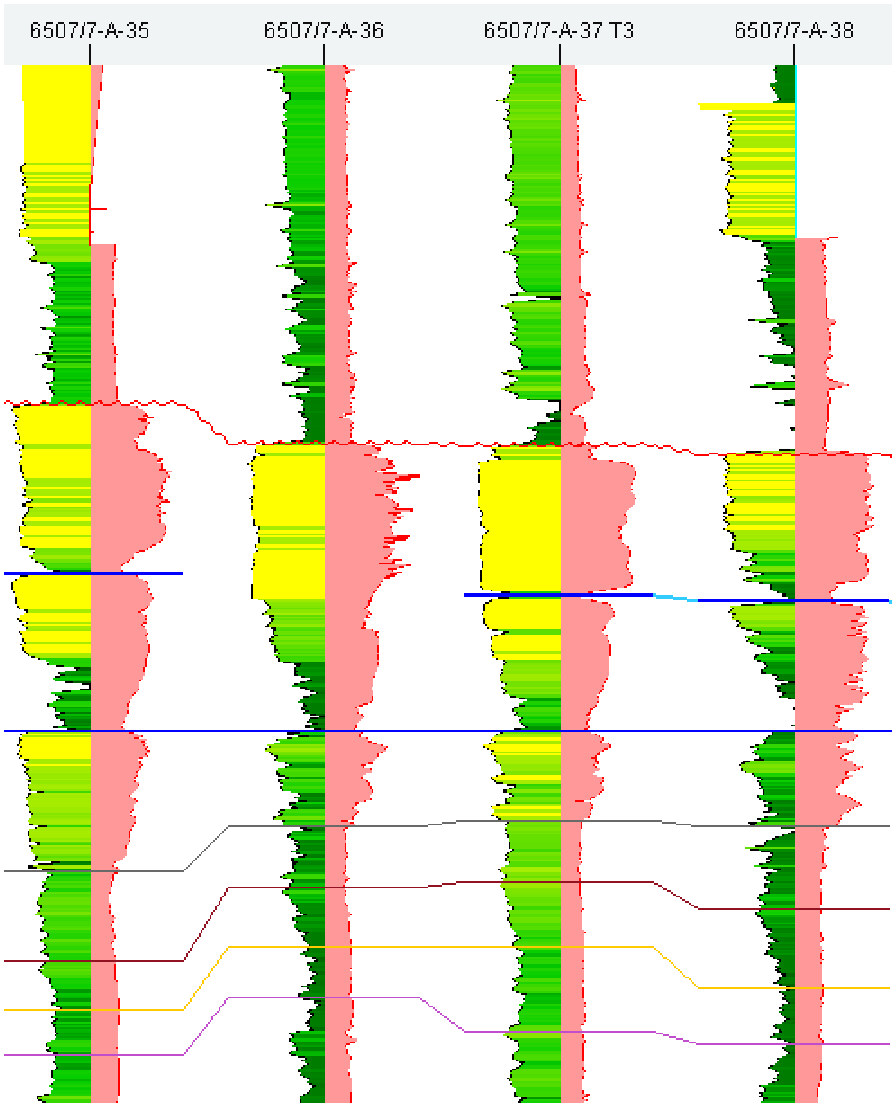
7. Confirm the framework is set to **Dynamic, Auto Refresh** ( ).

8. Interpret the **my_pick_YOU** surface on the displayed wells. Start with a well already showing **my_pick_YOU** and continue from there. You can work in either direction to complete the interpretation (where the pick is clear) throughout the *Correlation* view.

   In some cases, the **my_pick_YOU** surface can be cut out, as on well **6507/7-8** in the image below.



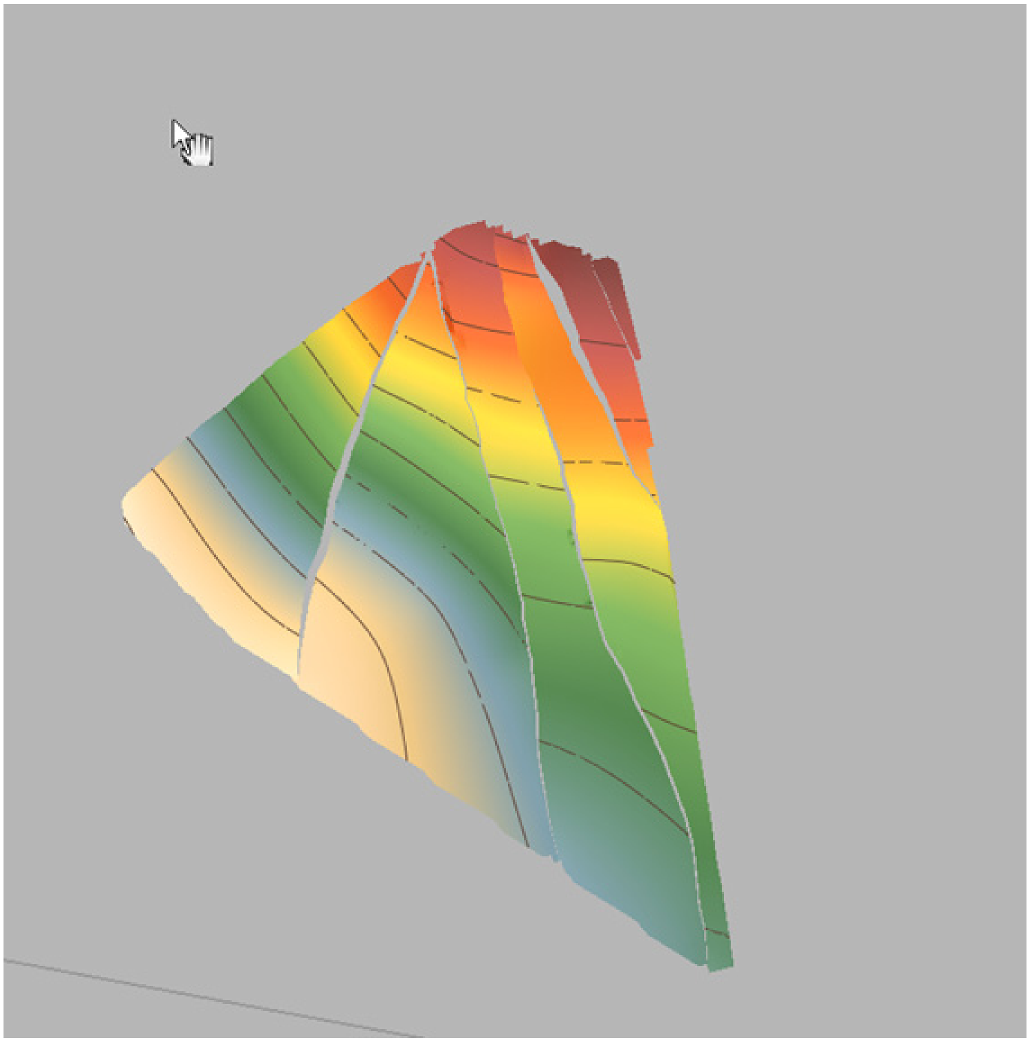
Elsewhere, wells may be harder to correlate than others. For example, it is not clear where the pick belongs on the **6507/8-1** well, so it is best to not interpret it. Similarly, the **6507/7-A-36** pick may not be straightforward. You can decide whether to make the pick, or not.



9. Click the **Save Pick to Database** ( ) icon under the *Actions* sub-panel (*Interpretation* task pane).

> **Note**
>
> The icon will grey-out to indicate the pick is saved to the database.

10. Pay attention to *Cube* view to see the updates of your **my_pick_YOU** framework surface as you interpret.

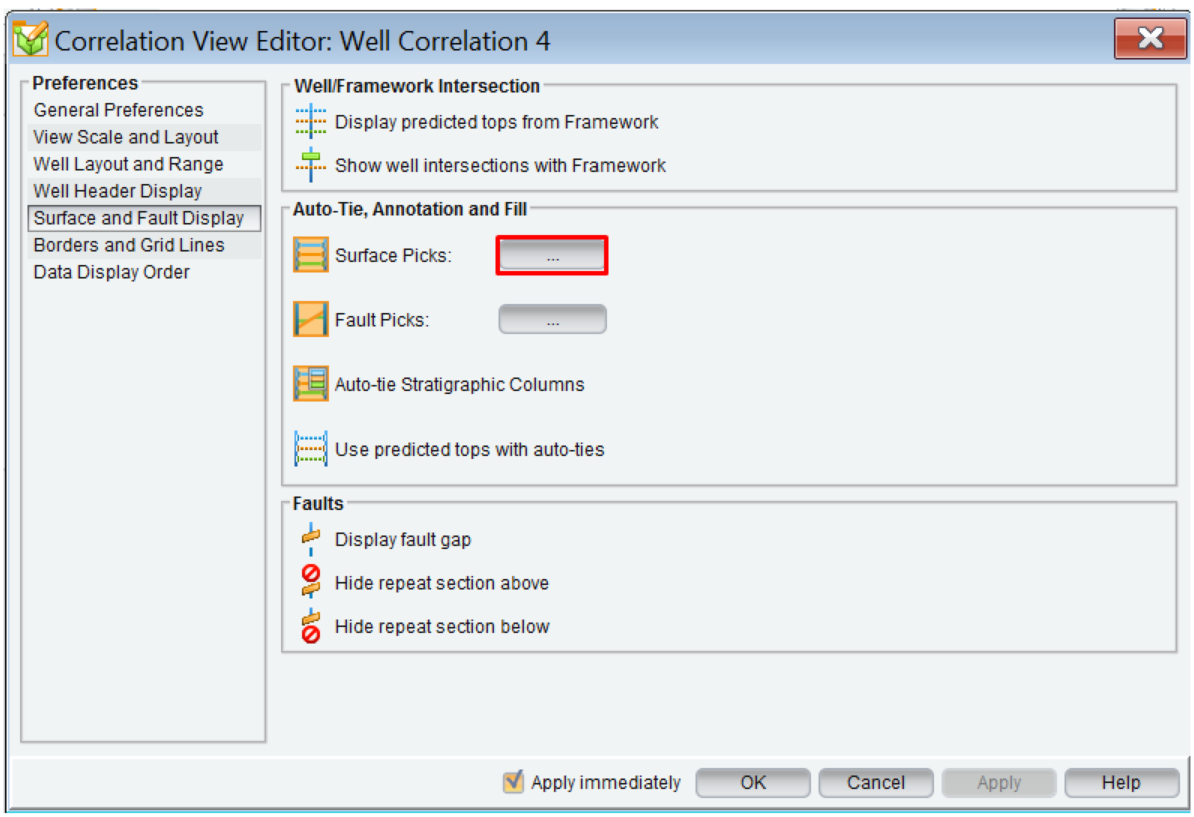


Adding Fill Between Wells

Now that you are done with the interpretation of **my_pick_YOU**, you will finalize the display of your *Correlation* view to make it presentation ready. This feature is important when showing your interpretations to people who are not familiar with the geology in the area, because they do not have to look at the logs and make the interpretation themselves.

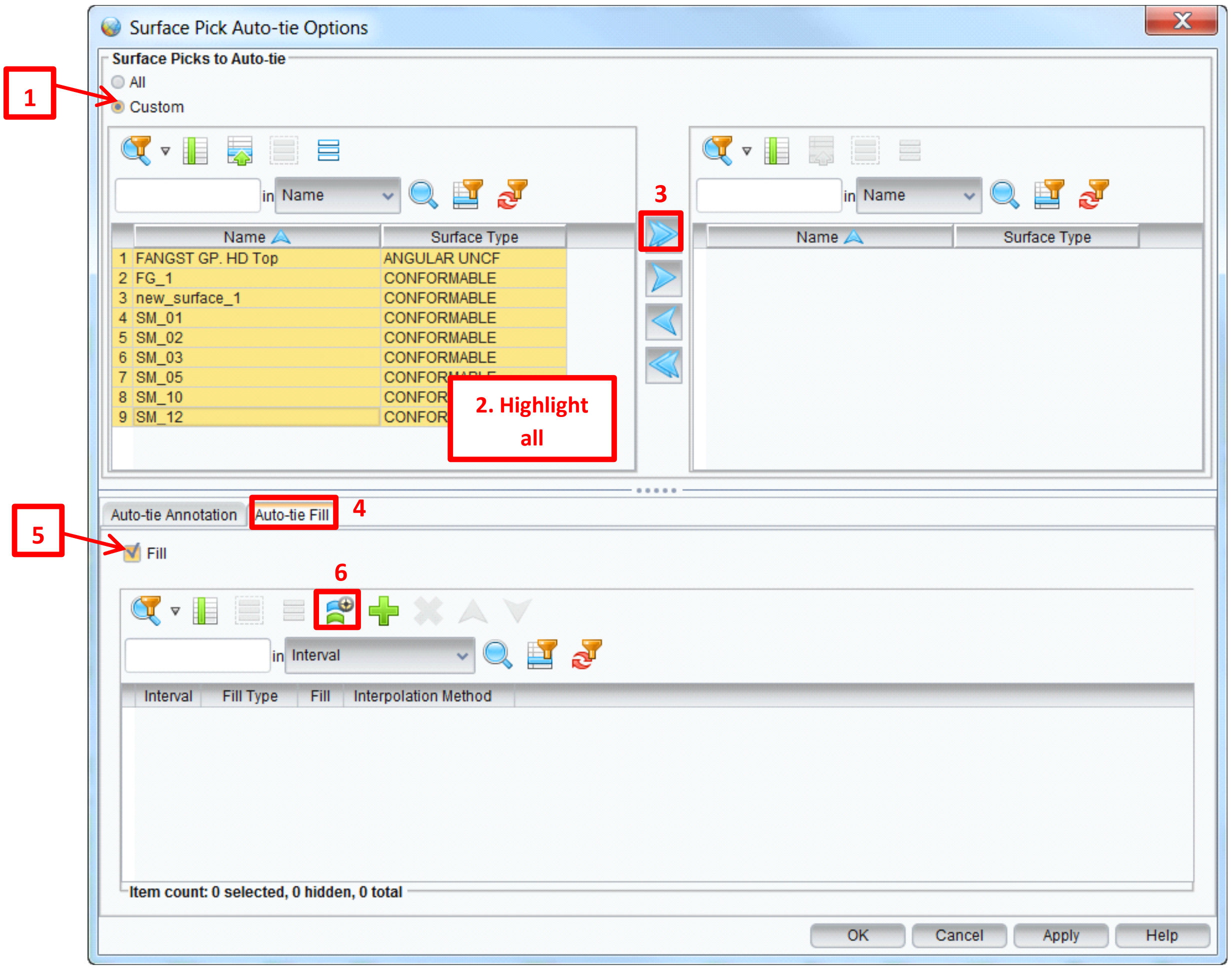
11. Click on the **Correlation View Editor** ( ) icon.

12. Within the *Correlation View Editor* dialog box, select **Surface and Fault Display**. In the *Auto-Tie, Annotation Fill* section, click the browse button for **Surface Picks**.

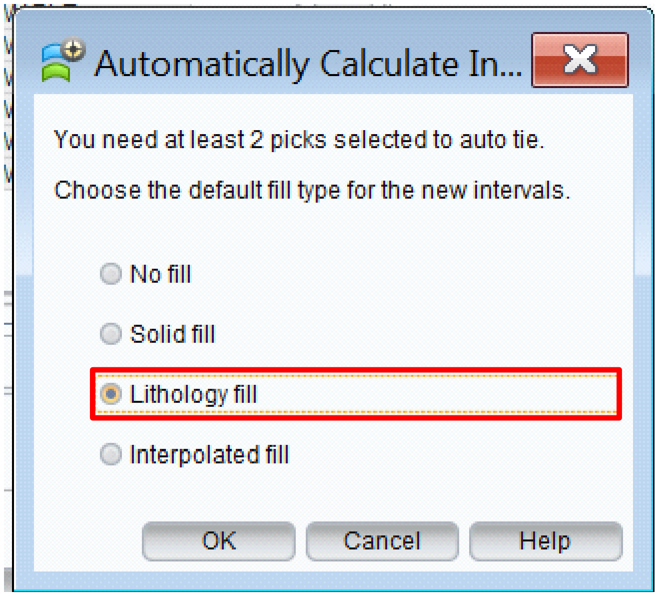


13. The *Surface Pick Auto-tie Options* dialog box displays. To enable the *Auto-Tie Fill* tab, you need to check the box next to **Custom** under *Surface Picks to Auto-tie* section. Click the **Add all entries to the section table** ( ) icon to send all of the surfaces over to be considered when making intervals.

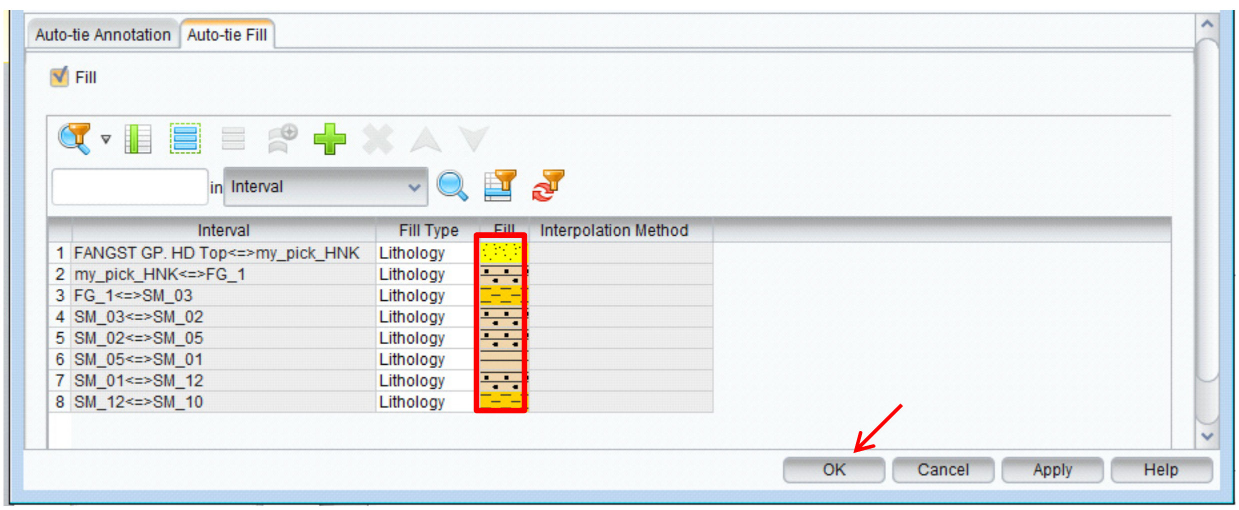
14. The *Auto-tie Fill* tab should be now active. Check the box for **Fill** and then click the **Automatically populate table with calculated intervals** () icon. This will create an interval between each surface in your list in order of increasing depth.



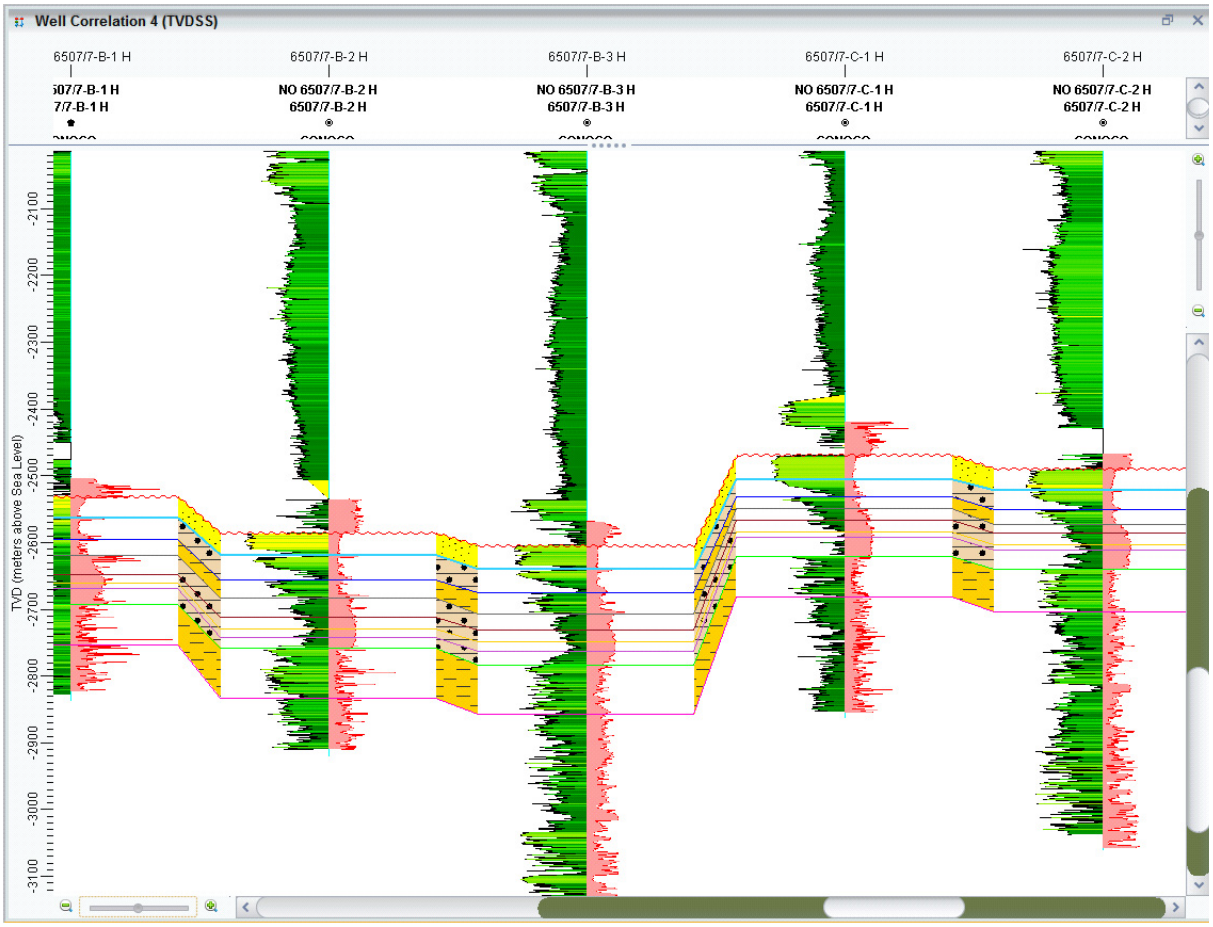
15. A dialog box displays asking you which type of fill to use for each interval. Select **Lithology fill** and click **OK**.



16. **MB1** on the Fill cell for each interval and designate a lithology. This is a clastic coursing upward sequence, for the purpose of this exercise select lithologies varying from sandstones to claystones. Click **OK** in both the *Surface Pick Auto-tie Options* dialog box and the *Correlation View Editor* to close them.

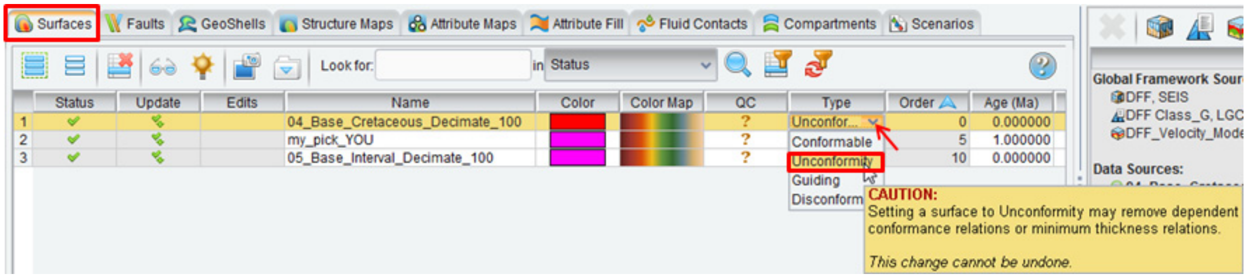


Your *Correlation* view should look similar to the one below.

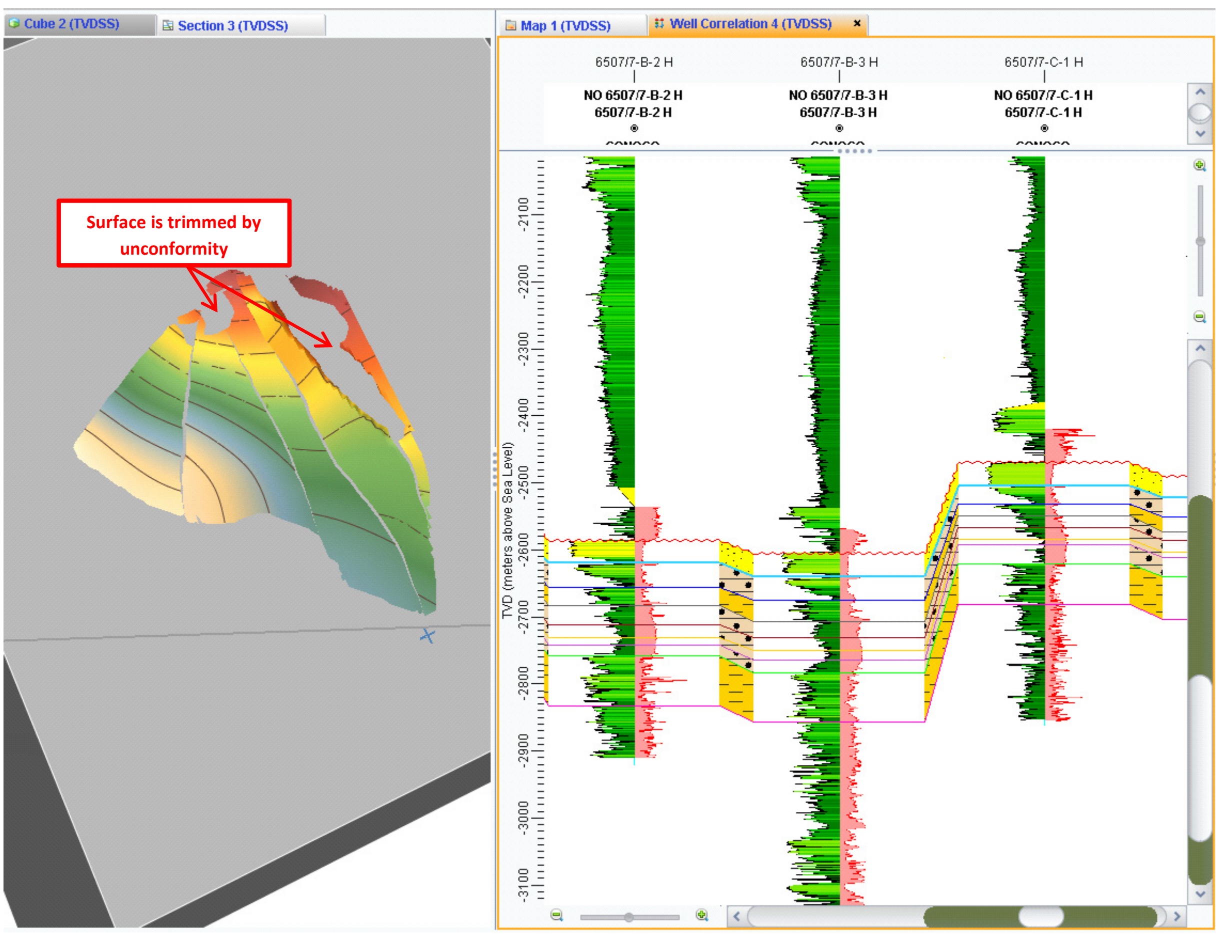


After interpreting the **my_pick_YOU** geological surface, you noticed that the top was removed from several wells (i.e: **6507/7-8**, **6507/8-1**, **6507/7-A-9**, etc.). The framework surface generated from the seismic horizon **04_Base_Cretaceous** is equivalent to the geological top **FANGST GP. HD Top**, which is the unconformity. Next you will define this surface as an unconformity in the *Dynamic Frameworks to Fill Workspace*.

17. Open the *Dynamic Frameworks to Fill Workspace* ( ). Go to the **Surfaces** tab. For the surface **04_Base_Cretaceous_decimate_100**, change its Type column to **Unconformity**. The framework will automatically update to trim **my_pick_YOU**.



Your final *Correlation* and *Cube* views should look similar to the following image.



18. Save your framework and your session.

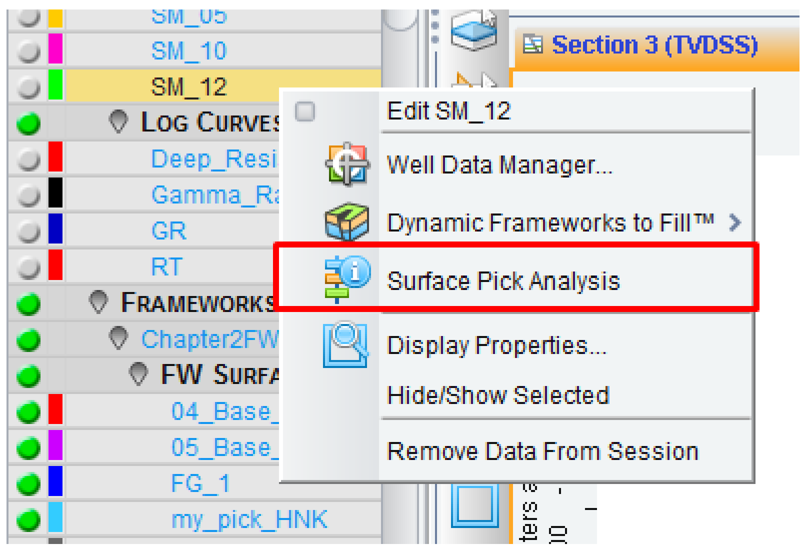
Exercise 2.6: Integrating Geological and Geophysical Interpretation

In this section you will learn how to add multiple picks to a framework, and how to establish conformance relationships between the surfaces.

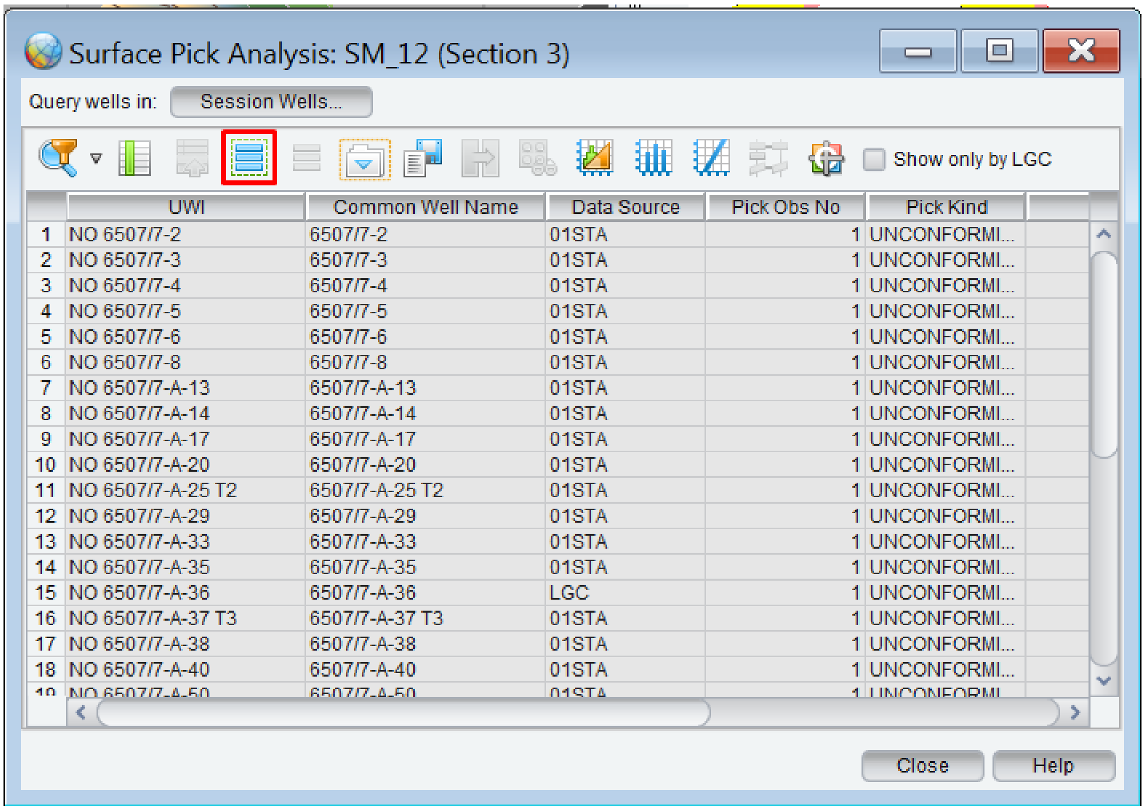
Surface Pick Analysis

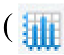
Before adding new geological tops to the framework, it is important to perform some quality control on the surfaces that have been interpreted. With Surface Pick Analysis you can look at your data in multiple ways to make sure that everything makes geological sense.

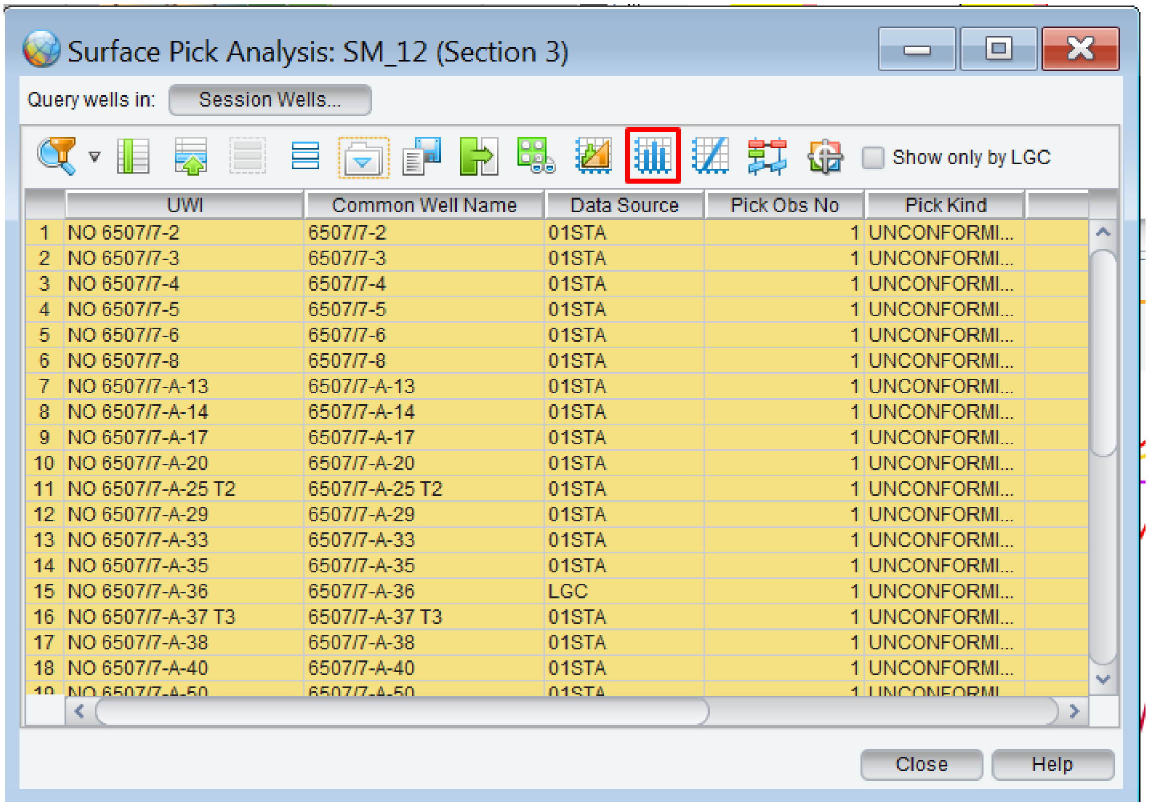
1. From the *Inventory* task pane, **MB3** on the **SM_12** surface pick and select **Surface Pick Analysis**.



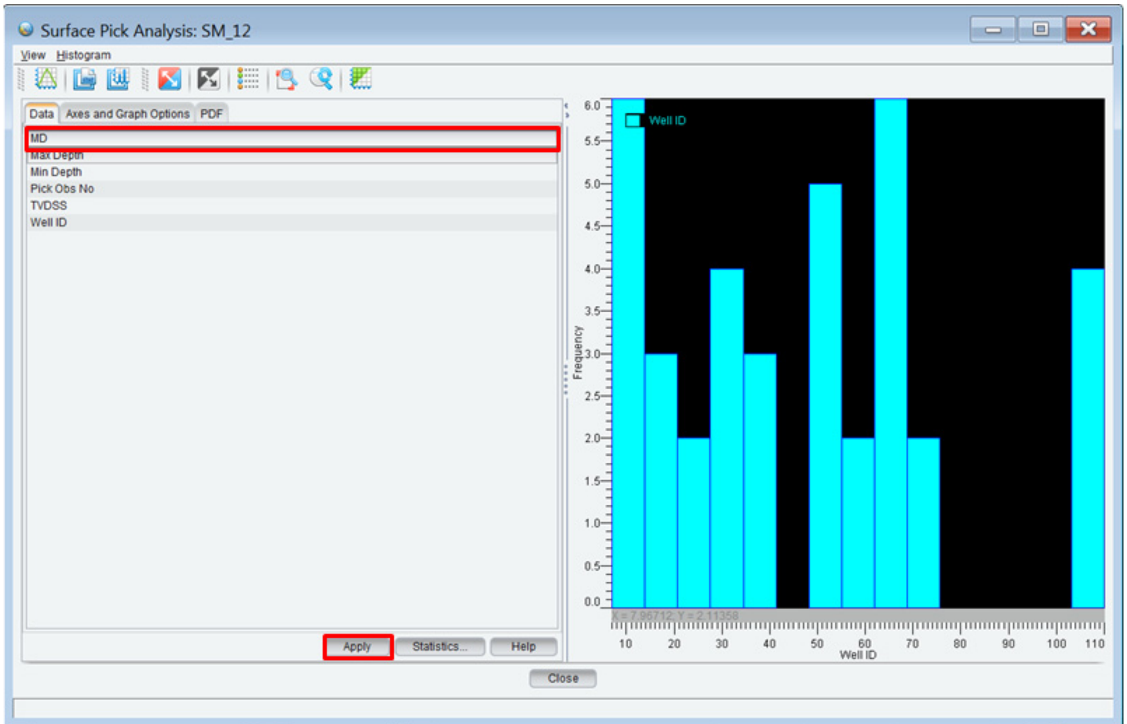
2. The *Surface Pick Analysis* dialog box for SM_12 displays. Click the **Select All** () icon.



3. With all the wells selected, click the **Histogram** () icon.

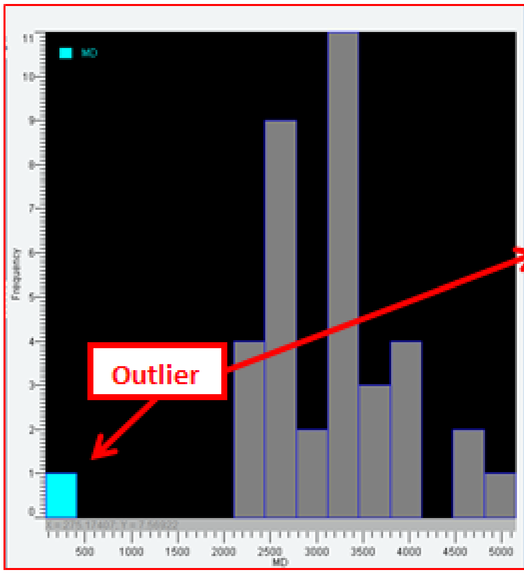


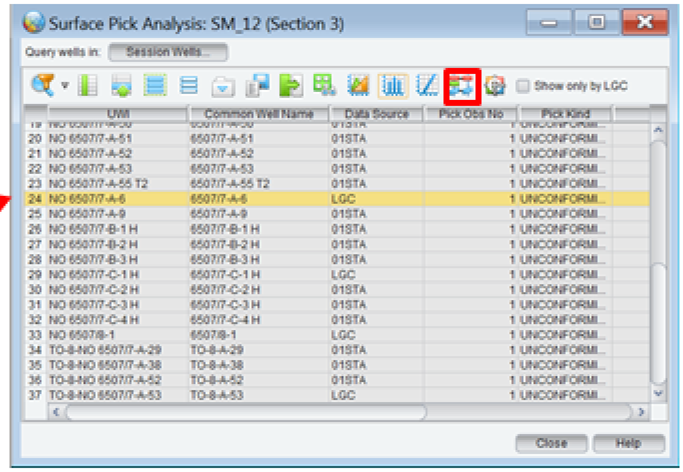
4. A new *Surface Pick Analysis* dialog box displays with the histogram displayed. Select **MD** as the data to display in the graph, and click **Apply**.



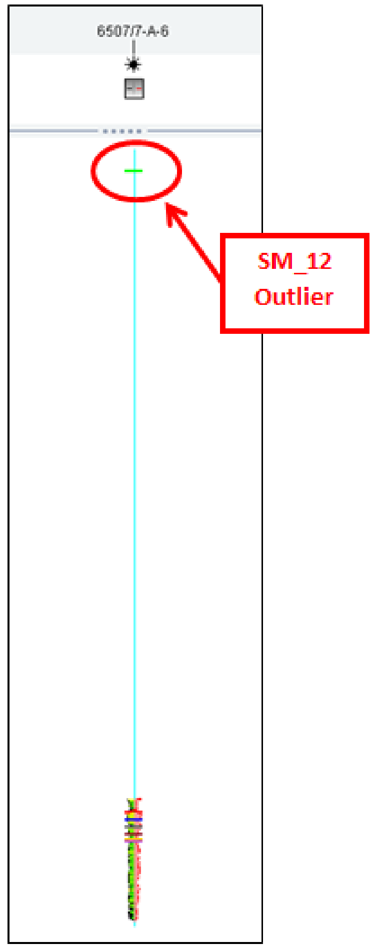
5. A new graph displays with the x-axis being MD of the **SM_12** picks, and the y-axis being the frequency in which a pick is interpreted in that range of MD. **MB1** on the outlier in the far left, and that value will be highlighted.

6. **MB3** anywhere within the histogram. The value you selected will remain the original color of the graph, while the other values are greyed out. This process also highlights the well(s) that are within that value range on the *Surface Pick Analysis* table.





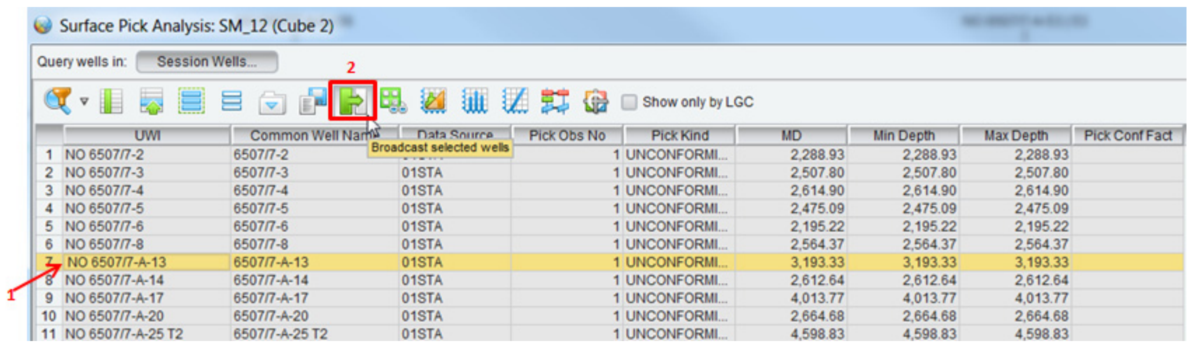
7. Within the *Surface Pick Analysis* table click the **Display Selected Wells in New Correlation View** () icon. This will allow you to see where in the well(s) the outlying picks are located. To see the entire well, **MB3** inside *Correlation* view, select **Correlation View Editor > Well Layout and Range**, and then uncheck the **Include data display range** box.



The above picture shows the well logs for well **6507/7 A-6** where the **SM_12** pick has clearly been placed in the wrong spot.

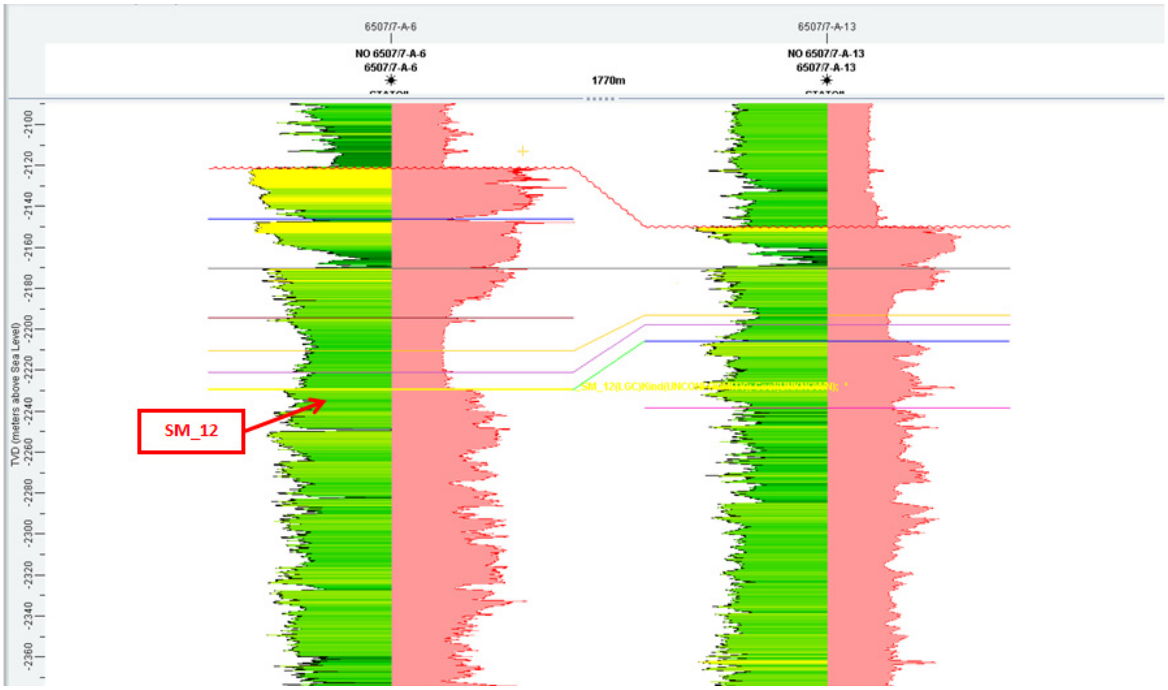
8. Add a second well to your *Correlation* view, by going back to the *Surface Pick Analysis* window, highlight the well **6507/7-A-13** from the list and broadcast ( ) the well to the *Correlation* view. This will help to determine the correct placement of **SM_12** in well **6507/7 A-6**.

> **Note**
>
> You can also add wells to active *Correlation* view clicking the Select Wells From Map ( ) icon, or from opening the *Well Details* window and using the broadcast option.



9. Activate *Interpretation* mode ( ), and select the **SM_12** surface pick to interpret.

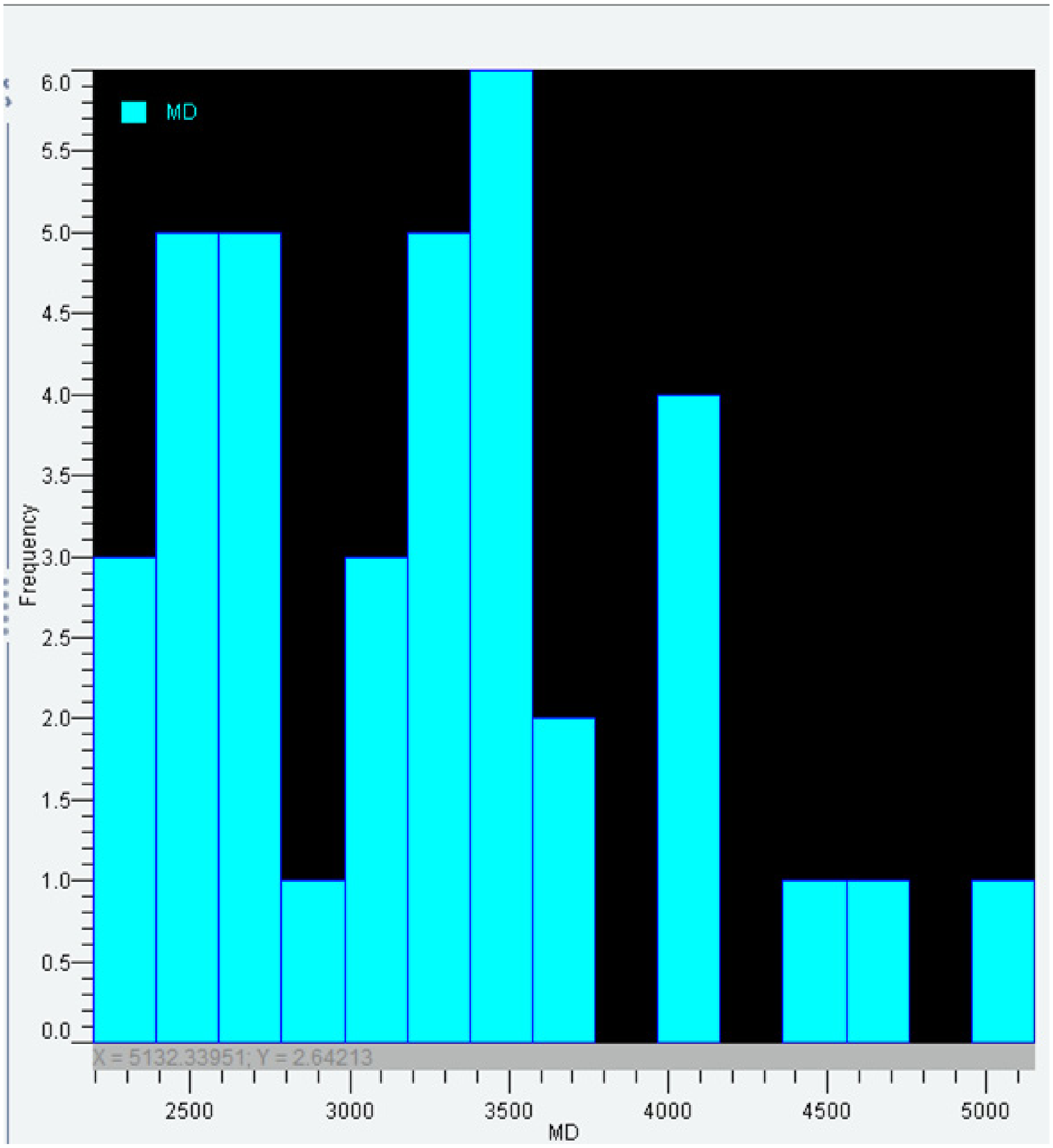
10. With either **Edit** mode or **Drag Pick** mode, interpret the **SM_12** pick in **6507/7 A-6**. Place the pick at about **3763** MD (-**2240** TVD on left scale).



11. Click the **Save well pick changes to the database** () icon, in the *Actions* sub-panel, to save your picks to the database and update the new interpretation.

12. From the *Inventory* task pane, **MB3** on the **SM_12** surface pick and select **Surface Pick Analysis**, to open a new *Surface Pick Analysis* table.

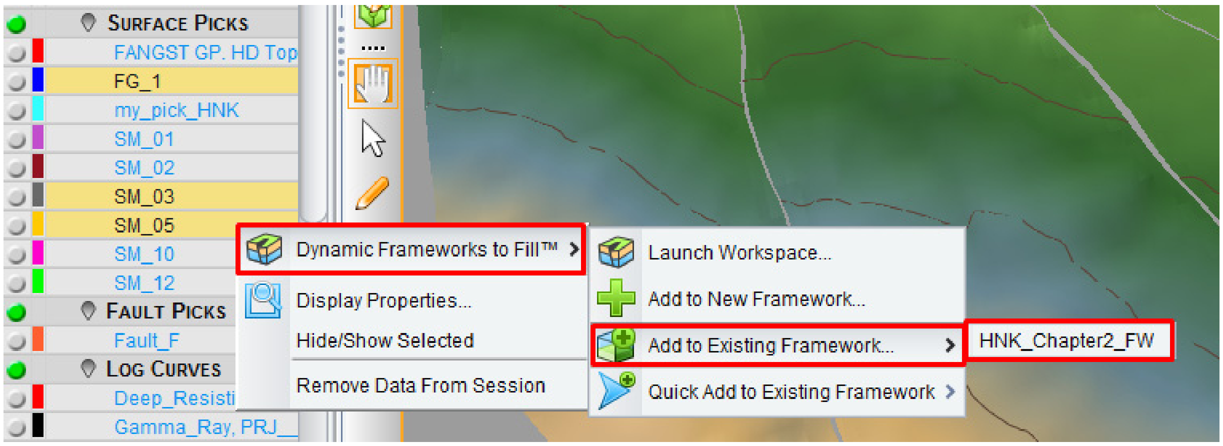
13. Select all of the wells, and create a new histogram with **MD** as the x-axis.



The new histogram shows that there are no significant outliers within the picks made for **SM_12**. You can do this for all of the other surfaces as well. For the purpose of this class, all the other picks are correct; however if you have time, check the other picks. Close all the open histograms and *Surface Pick Analysis* dialog boxes.

Now that you have checked to make sure all of your surfaces have interpretations that make sense, you can add them to your existing framework.

14. In the *Inventory* tree, multi-select the **FG_1**, **SM_03**, and **SM_05** surface picks. On one of the selected surface picks, **MB3** and then select **Dynamic Frameworks to Fill > Add to existing Framework > YOU_Chapter2_FW**. Refresh the framework, if necessary. (You will add **SM_12** to the framework later on in other exercise as a secondary source of an existing surface, for now it is not necessary to add this surface.)



15. Activate *Section* view, it should be displaying crossline 1275 from previous exercises, if not, display that crossline. Note the appearance of these surfaces in the *Section* view. (You may need to show the new framework surfaces.) The image below shows frameworks surfaces before conformance relationships have been applied. If necessary, turn off seismic and well list so you can better see the framework surfaces and faults.

Showing Zig Zag Line of Section

Before setting up and applying conformance instructions with these new well tops (next exercise), you will open the **Zig_Zag_Section1** LOS. After conformance is applied this will give you a better appreciation of the three-dimensional aspects of the multi-surface, high resolution framework you are constructing.

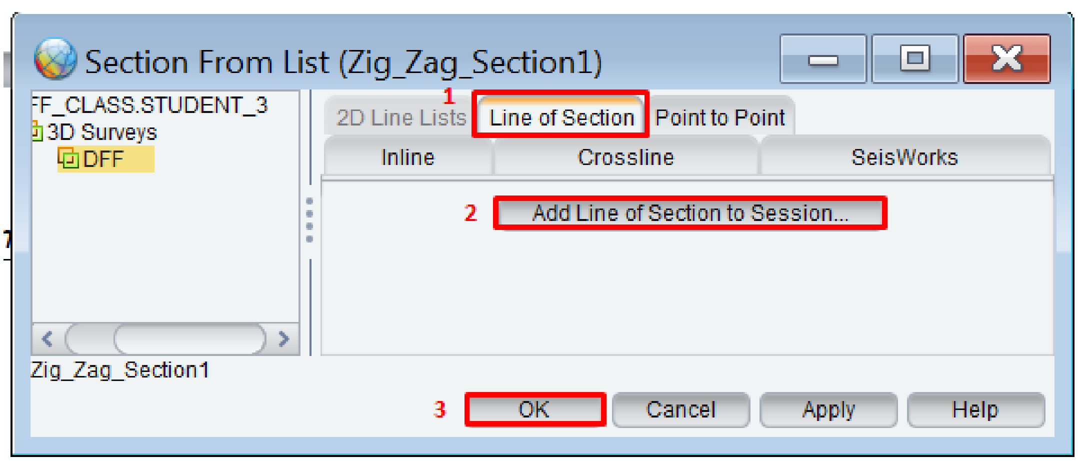
When conformance is finished, you will note the complexity of the multi-surface model as it showcases the fault offsetting of all conformed surfaces and the erosional truncation of the upper two well-top surfaces toward the top of the structure.

16. Close any open *Correlation* views. Click **OK** to the *Window selection* warning message asking to dock the views to other windows. **DO NOT** dock the views to other windows.

17. Activate *Section* view, and then click the **Section from List** () icon. In the *Section from List* dialog box, select the **Line of Section** tab.

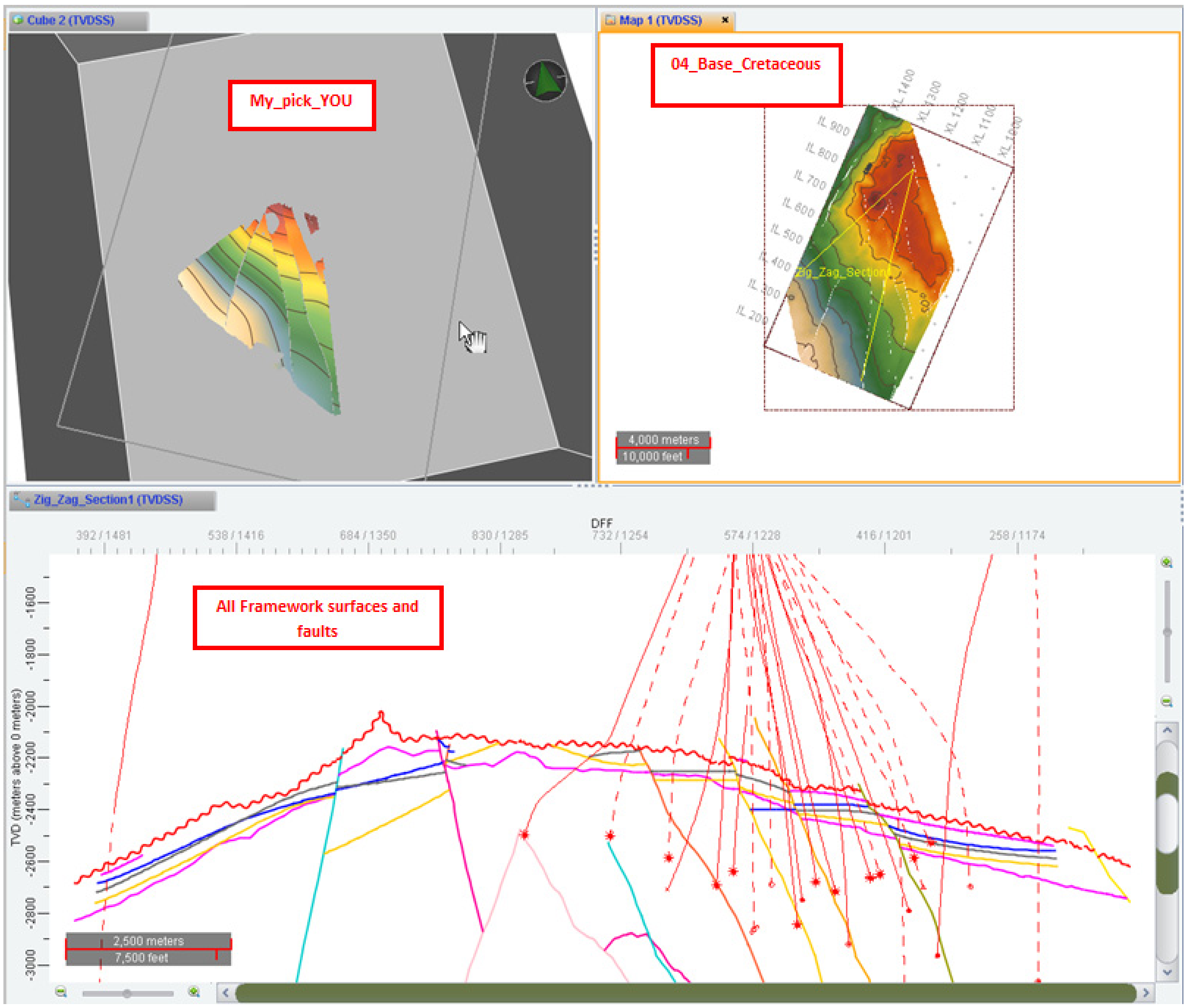
18. Click the **Add Line of Section to Session…** button. A *Select Session Data* dialog box for Lines of Sections displays. Choose the **Zig_Zag_Section1** section. Click **OK** and the section will be added to the session, and become active.

19. Click **OK** in the *Section From List* dialog box to close it.



20. **Turn on** all framework surfaces and faults in *Section* view. In *Cube* view, make sure you are displaying the framework surface **my_pick_YOU**. In *Map* view, display the framework surface **04_Base_Cretaceous_decimate_100**. If necessary, **turn off** all of the surface picks and log curves in *Section* view to see the structure as best as possible.

    Your views should look similar to the picture below.



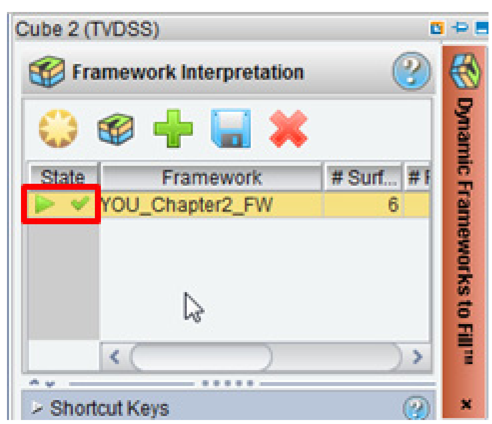
Applying Conformance

Because **my_pick_YOU**, **FG_1**, **SM_03**, and **SM_05** are framework surfaces created from geological tops, the resultant surfaces are naïve and they don't exhibit the horizontal resolution of a framework surface created from a seismic horizon. (Compare **my_pick_YOU** framework surface in *Cube* view with **04_Base_Cretaceos_Decimate_100** framework surface in *Map* view). In the following steps you will apply conformance technology to improve the resolution of the surfaces coming from geological tops. In this way, you will have your interpretation with high vertical resolution from your wells and high horizontal resolution from your seismic. Remember you previously created and QC a velocity model to integrate the time domain and depth domain properly. In this exercise, you will see how to apply, from the *Inventory* tree, conformance instructions and rules on framework surfaces through MB3 menu options.

The top of the reservoir is an unconformity (Base of the cretaceous), so it cannot be used as a reference surface in conformance mapping of the internal reservoir units. Instead, you will use the base of the reservoir, **05_Base_Interval_Decimate_100**, to conform up the geological surfaces.

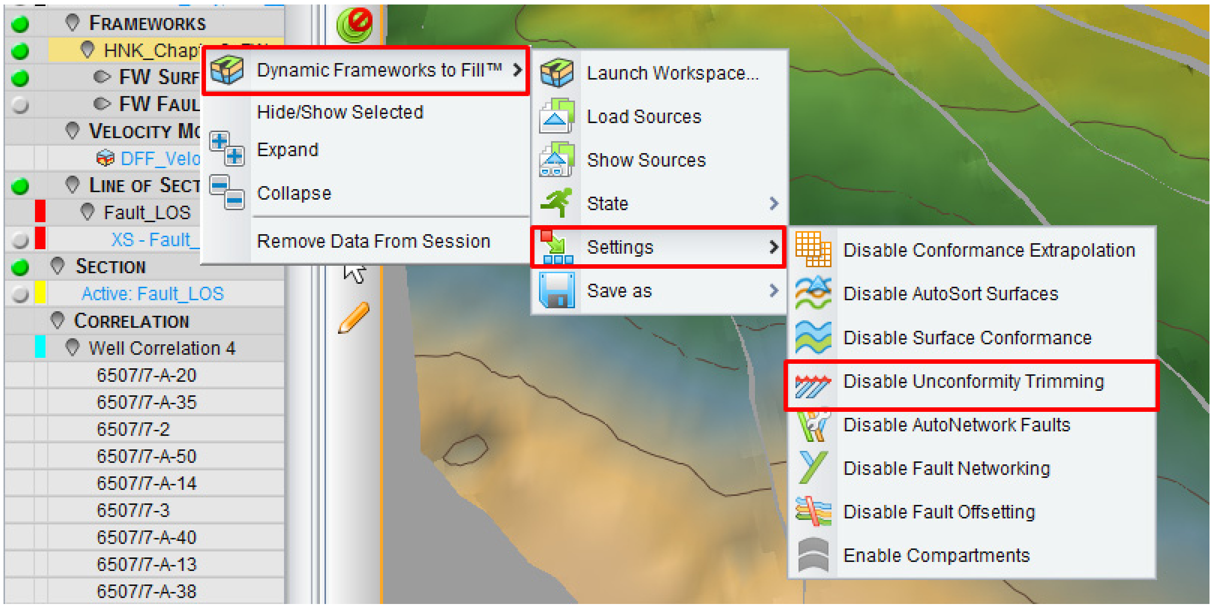
Continuing from the previous exercise, you should still have the LOS **Zig_Zag_Section1** in your active *Section* view.

21. In the *Dynamic Frameworks to Fill* task pane, ensure that the **YOU_Chapter2_FW** framework is set to **Dynamic, Auto Refresh**.

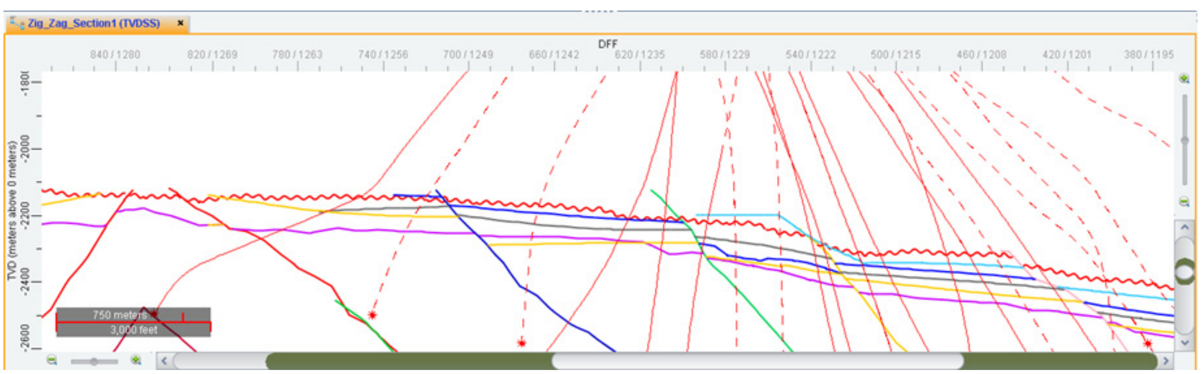


22. In the *Inventory* tree, with the *Section* view active, **MB3** on the **YOU_Chapter2_FW** framework and then select **Dynamic Frameworks to Fill** > **Settings** > **Disable Unconformity Trimming**.

This turns the unconformity trimming tool off.

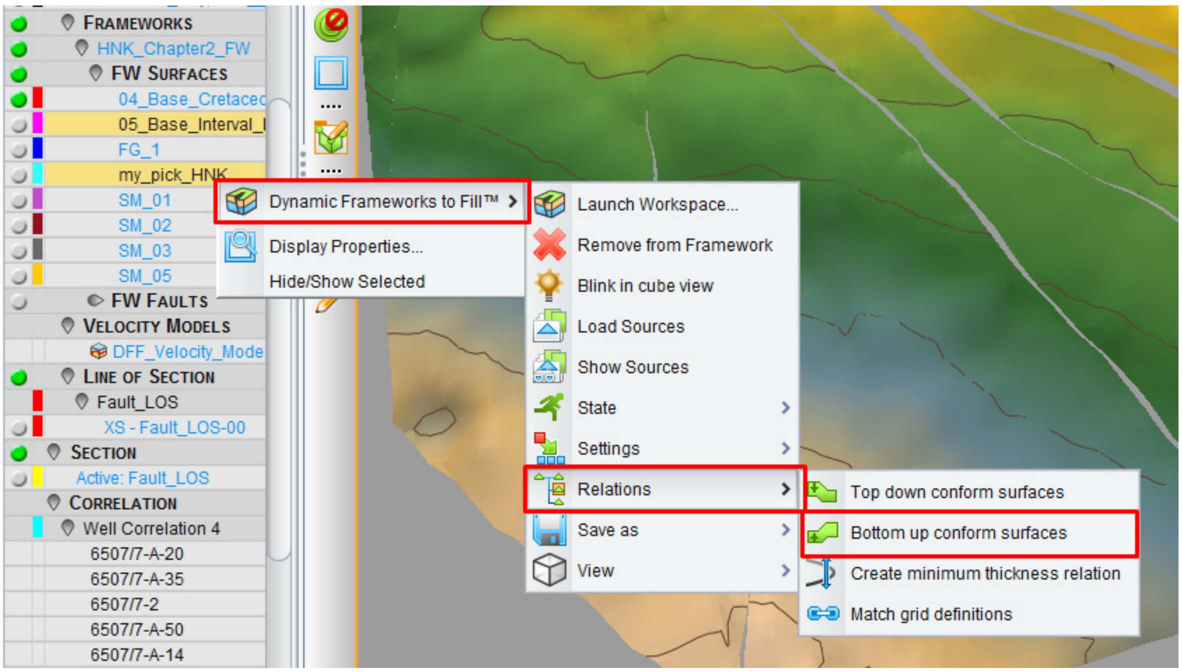


Note the update to the **my_pick_YOU** framework surface in *Section* view. It is now crossing the unconformity.

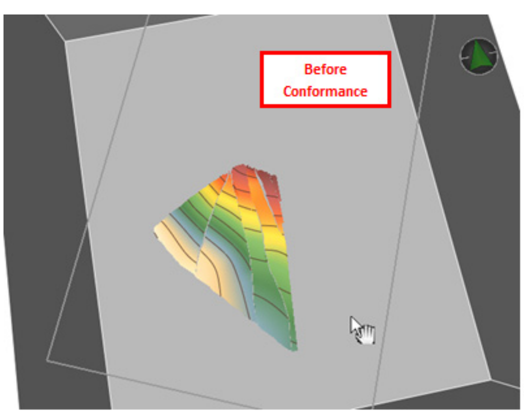


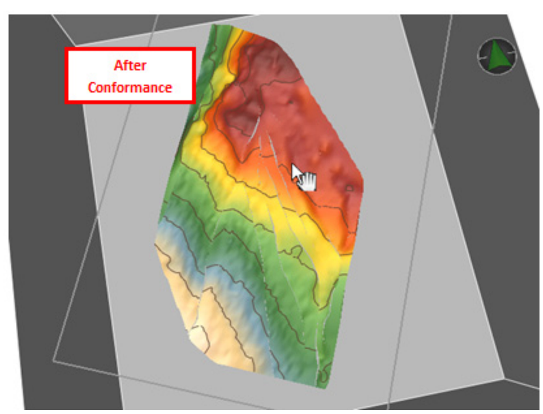
Bottom Up Conform

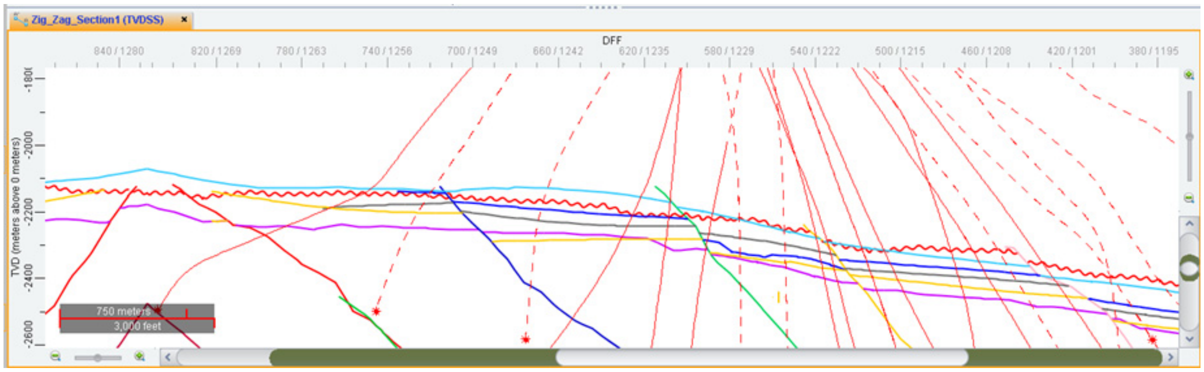
23. In the *Inventory* tree, multi-select the framework surfaces **05_Base_Interval_Decimated_100** and **my_pick_YOU**. On one of the two selected surfaces, **MB3** and select **Dynamic Frameworks to Fill** > **Relations** > **Bottom up conform surfaces**.



This operation will model the **my_pick_YOU** surface by applying bottom-up conformance based on the lower surface. This conformance operation allows the surface pick to inherit the same structural geometry as the parent surface. Notice how in *Cube* view and *Section* view the **my_pick_YOU** framework surface is updated, reflecting a much higher lateral resolution.

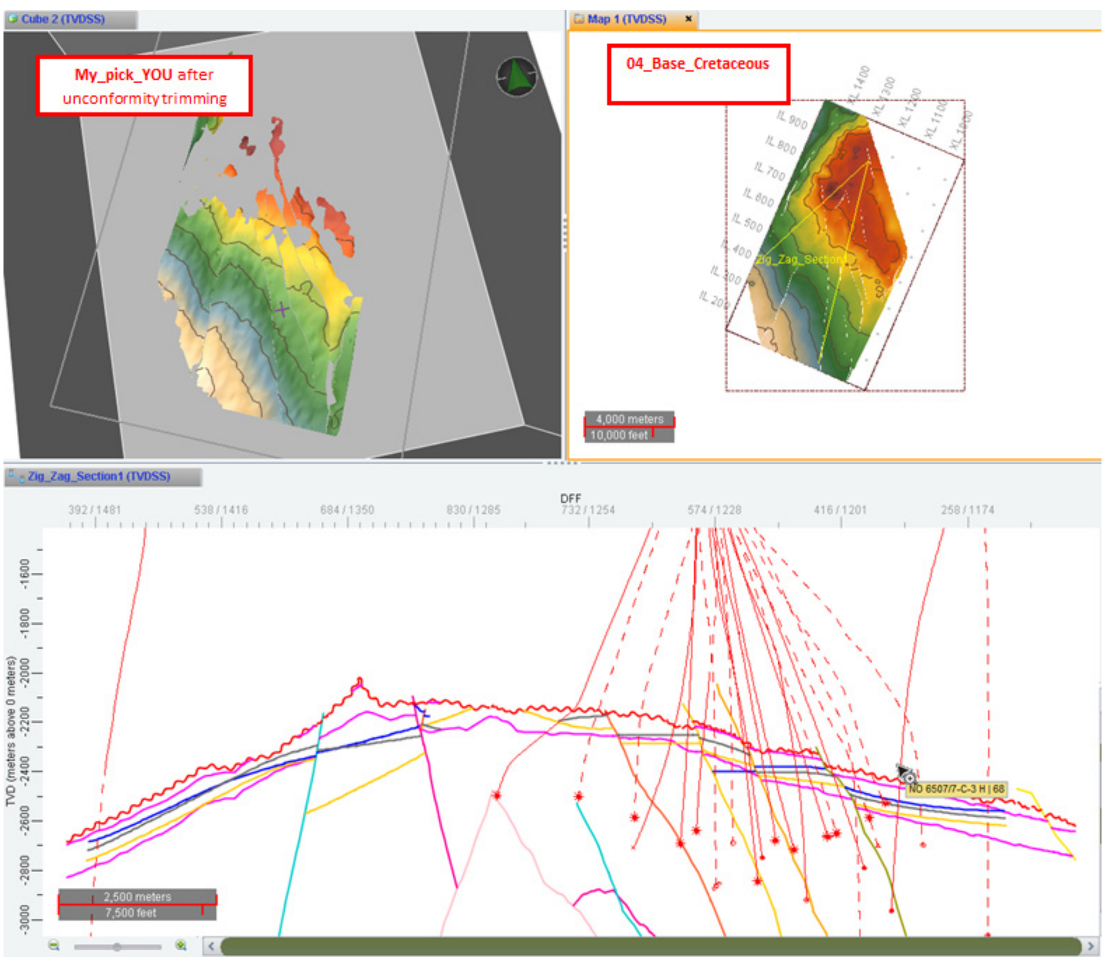






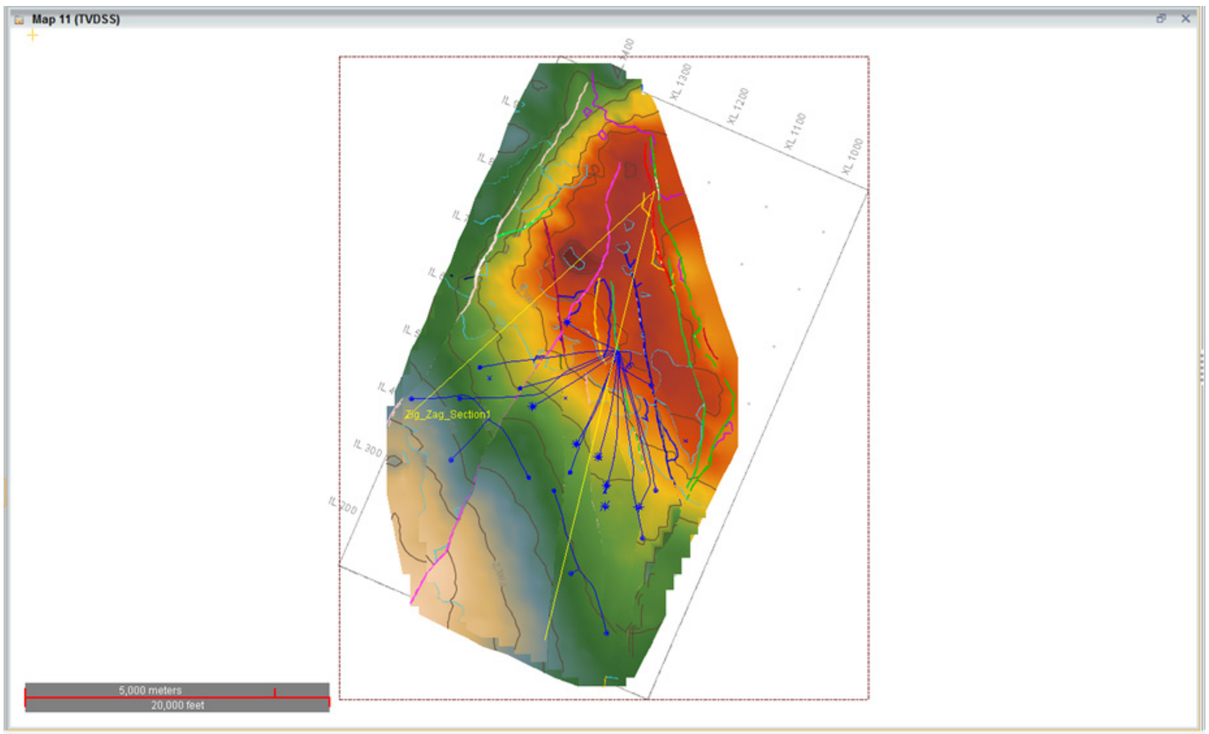
Unconformity Trim

24. Turn Unconformity Trim back on. (Hint: *Inventory* tree, **MB3** on **YOU_Chapter2_FW** and select **Dynamic Frameworks to Fill > Settings > Enable Unconformity Trimming**.) Notice how the **my_pick_YOU** framework surface is now truncated against the unconformity in *Section* and *Cube* views.



25. In *Map* view, show the **04_Base_Cretaceous** framework surface. With Unconformity Trim on, the unconformity subcrops of the eroded **my_pick_YOU** surface are outlined.

> **Note**
>
> For outline **MB3** and then select **Display Properties > Show Intersections**, on the **04_Base_Cretaceous** FW Surface.



Setting Conformance Relationships

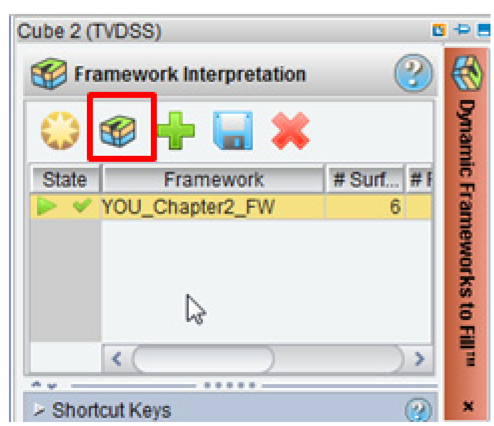
Use the conformance tools to set the relationships between the frameworks surfaces. You can drag-and-drop one surface onto another, or you can multi-select surfaces and then click the appropriate icon to relate them.

Perform link or unlink operations on selected surfaces using the icons shown below:

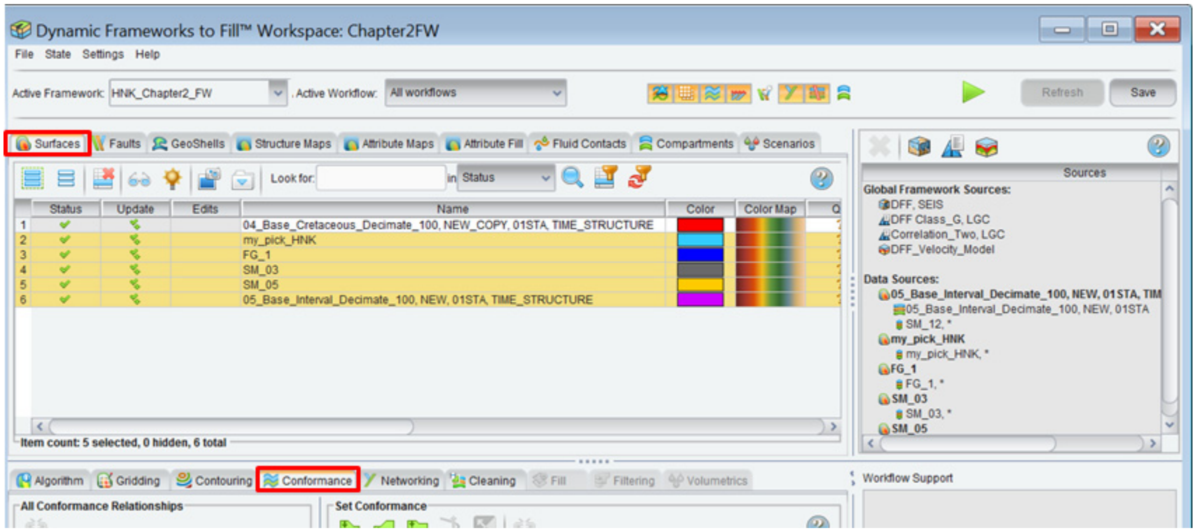
Icon	Name
	Top Down Conformance
	Bottom Up Conformance
	Proportional Conformance
	Unlink Conformance Relations
	Unlink All Conformance Relations

To set up conformance relationships, you must launch the *Dynamic Frameworks to Fill Workspace* window.

26. Activate the *Dynamic Frameworks to Fill* task pane. Click the **Launch Framework Workspace Window** () icon.

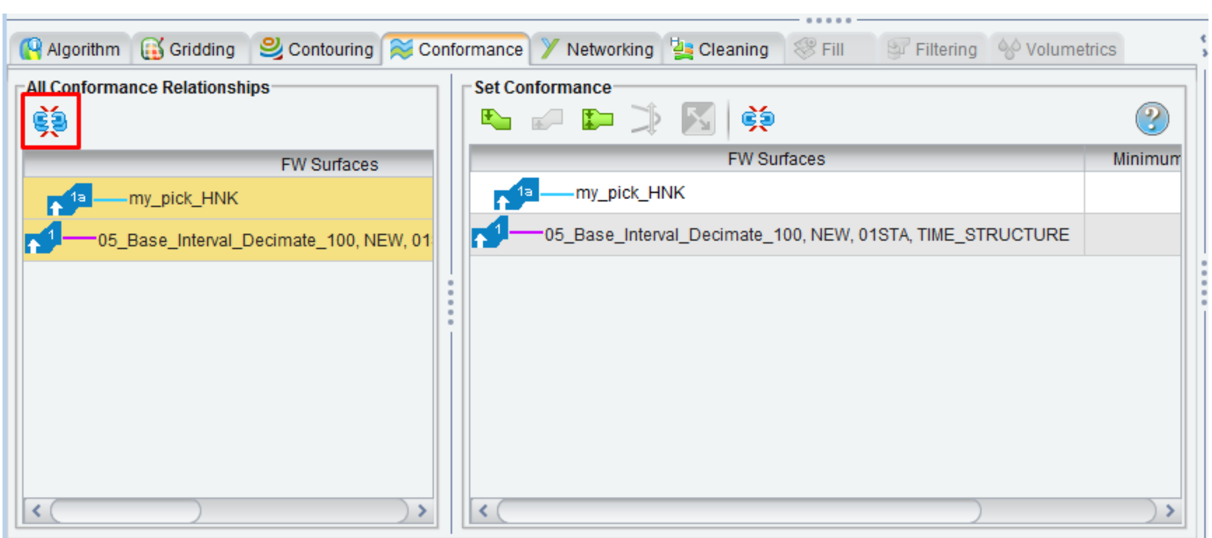


27. When the *Surface* tab of the *Dynamic Frameworks to Fill Workspace* dialog box is active, the *Conformance* action tab at the bottom of the dialog box is accessible. Open the *Conformance* action tab.



28. In the *All Conformance Relationships* sub-panel, click the **Unlink All Shown Relationships for this Framework** ( ) icon to unlink any previous linked relationships and allow you to easily set up conformance.

> **Note**
>
> Clicking this option is not reversible.



29. In the *Surfaces* tab, set the conformance so the surfaces (except **04_Base_Cretaceous**) conform to the **05_Base Interval_Decimate_100** surface from the bottom up:

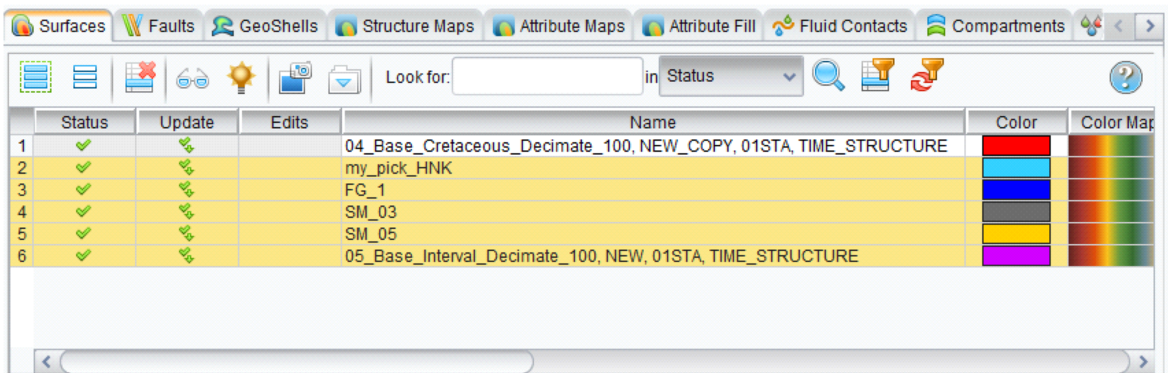
my_pick

FG_1

SM_03

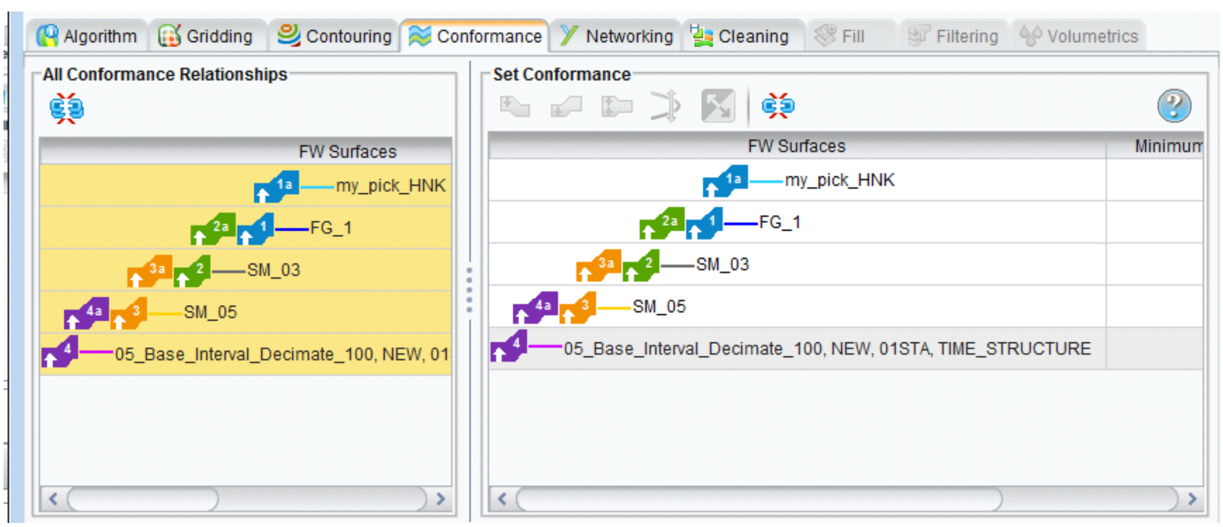
SM_05

05_Base_Interval_Decimate_100



30. In the *Surfaces* tab, select all the surfaces except the **04_Base_Cretaceous**. In the *Conformance* action tab, click the **Conform Surfaces Bottom Up** ( ) icon.

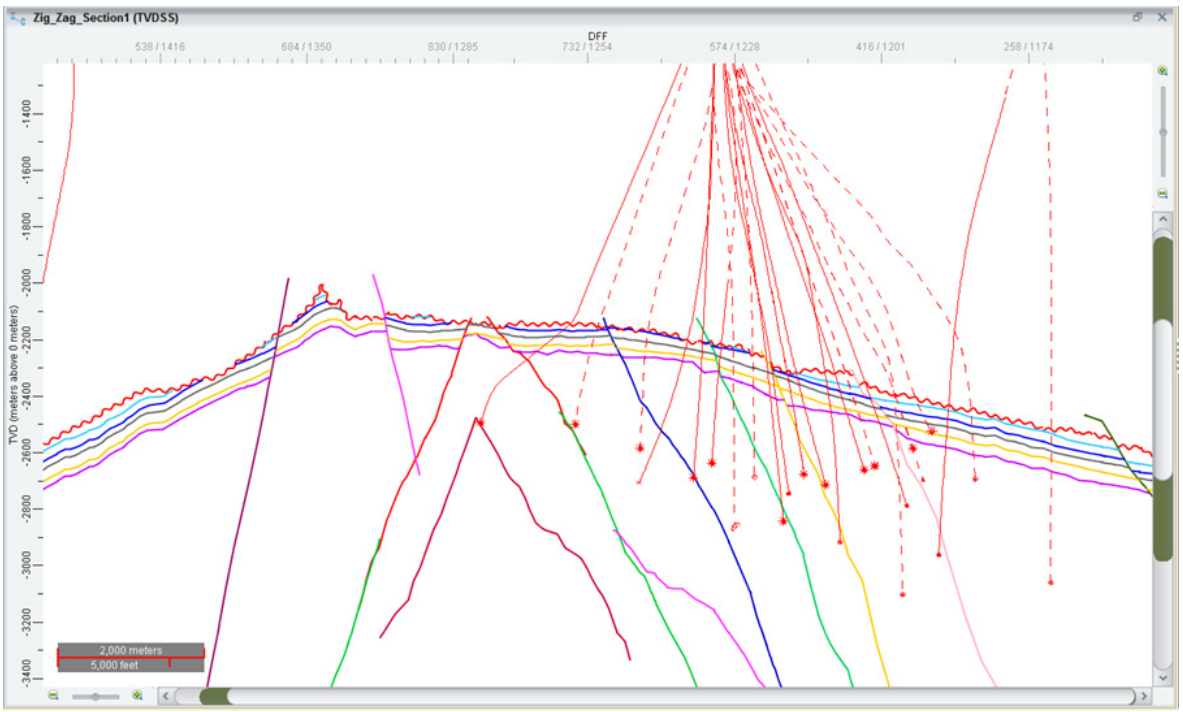
The conformance relationships should match those shown below.



31. After the conformance relationships are set, confirm that Conformance is **enabled** (on) at the top of the *Dynamic Frameworks to Fill Workspace*. Close the framework workspace.

32. Return to a *Section* view and examine the results of applying conformance to the framework.

    Your *Section* view should look similar to the one below, with your framework surfaces changed after applying conformance.



33. Save your framework and your session.

Note

Conformance technology is based on the following assumptions:

- **The well logs are correlated in a time-stratigraphic manner**. That is, the correlations are made on geologic time-synchronous surfaces that should be parallel (conformable) to seismic reflections from geologic time-synchronous events. When well log correlations are not correlated in a time-stratigraphic manner, conformance mapping tools may not operate properly.
- **Seismic horizons have been properly converted to depth**. If the velocity model applied at each well location is not calibrated with horizon-well top pairs, the intersection of seismic horizons with the well bore may vary significantly from well to well. This can cause the calculated interval thicknesses between well tops and horizon intersections at the well bores to vary so much that the conformance tool will operate in a sub-optimal manner. This is particularly true when modeling one or more well-top surfaces in close vertical proximity to the parent seismic surface. The closer the well top is, vertically, to the parent or guiding seismic surface, the more sensitive the conformance process is to a poor velocity model across the project area.
- **Faults have been picked between intervals targeted for conformance mapping**. Unpicked faults cause apparent thinning on wells which cause conformance isochores to be inaccurate. It is best if faults are picked before conformance mapping is applied.

Exercise 2.7: Integrating Well-pick faults with Seismic faults

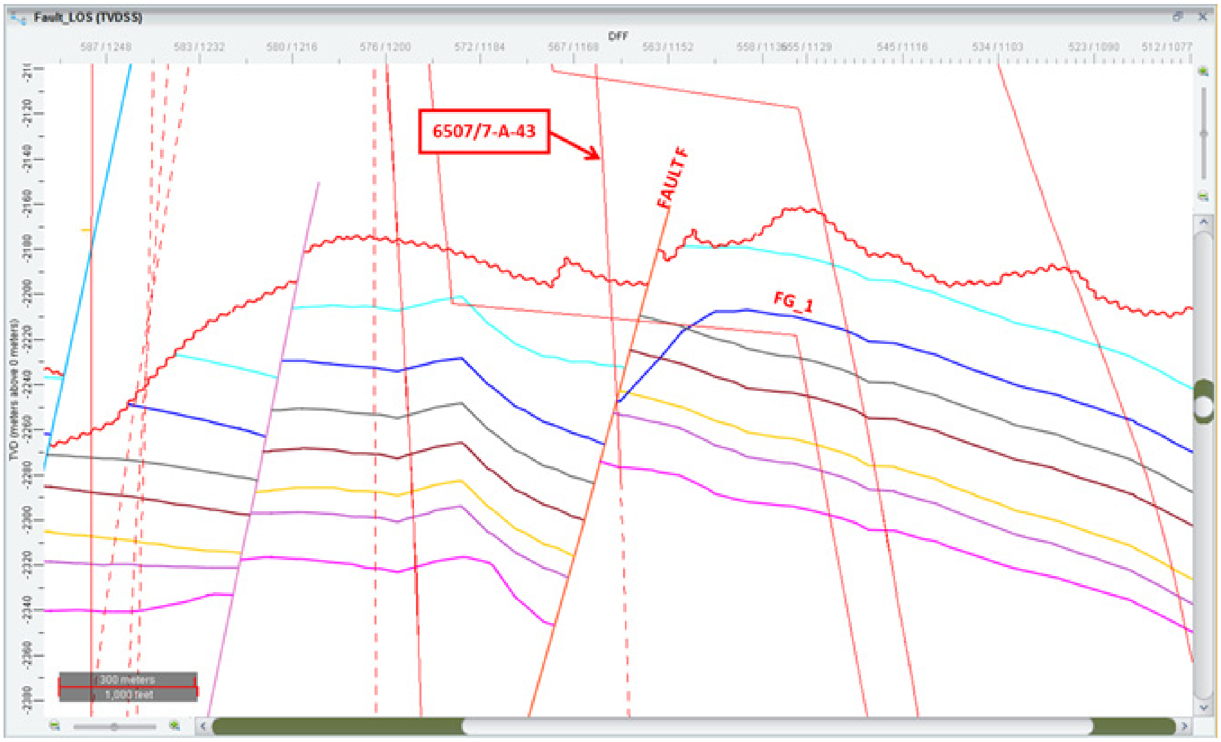
One of the key challenges for seismic workflows that Dynamic Frameworks to Fill effectively resolves is to reconcile seismic fault interpretations with well pick faults. It is a common challenge among the oil and gas industry when the wells are being drilled close to the faults. Many times the wells are expected to be faulted out according to seismic resolution interpretation, but at geology resolution level, when interpreting in cross sections, the well can show fault signatures. Proper integration of both interpretations is a key element to construct better geological maps, and thus, more accurate frameworks. In this section, you will see how to identify faults based on cross sectional geometries. Using seismic faults and the *Dynamic Frameworks to Fill* tools, you will predict fault intersections in wells, pick the faults in *Correlation* view, gap the faults, and constrain fault geometry.

Interpreting Faults with Frameworks

1. Activate *Section* view. From **Select > Section From List**, or clicking directly its icon (). Open the LOS **Fault_LOS**.

2. *Section* view now shows the LOS **Fault_LOS** together with the wells that were projected over the LOS (earlier in this chapter, you learnt how to create and project wells in LOS). Confirm that all the **FW SURFACES** and **FW FAULTS** are displaying.

Your *Section* view should look similar to the following image:



Notice in the picture above and in your display the behavior of the blue surface (**FG_1**). **FG_1** is bent along **Fault_F** at the well **6507/7-A-43**. This type of situation may be due to factors like: the well is faulted, but the fault is not interpreted in the well; the fault is interpreted incorrectly in the well; or the seismic fault shouldn't be crossing the well. In the following exercise, you will explore the behavior of the **Fault_F** along the well **6507/7-A-43** to find out which is the right answer.

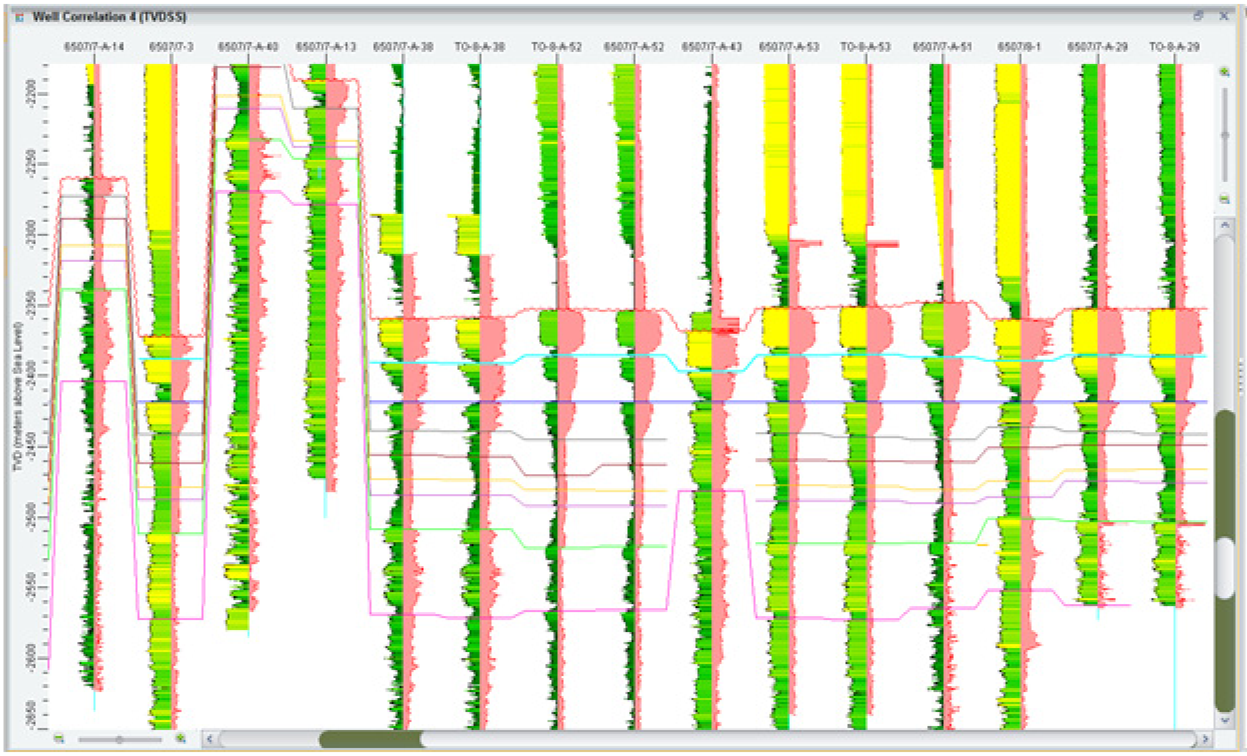
3. In the *Inventory* tree for your *Section* view, confirm that the SURFACE PICKS category is turned **on**.

4. Create a *Correlation* view (tab or window) from the **Fault_LOS** *Section* view.

5. <u>Optional</u> - If your *Correlation* view shows the blue line well indicators, but no log curve panels, then on any well **MB3** and select **Layout: All Wells In View > Open...**. Select and apply layout **DFF_Simple_Class, LGC**. Alternatively, confirm that all LOG CURVES and SURFACE PICKS are turned on.

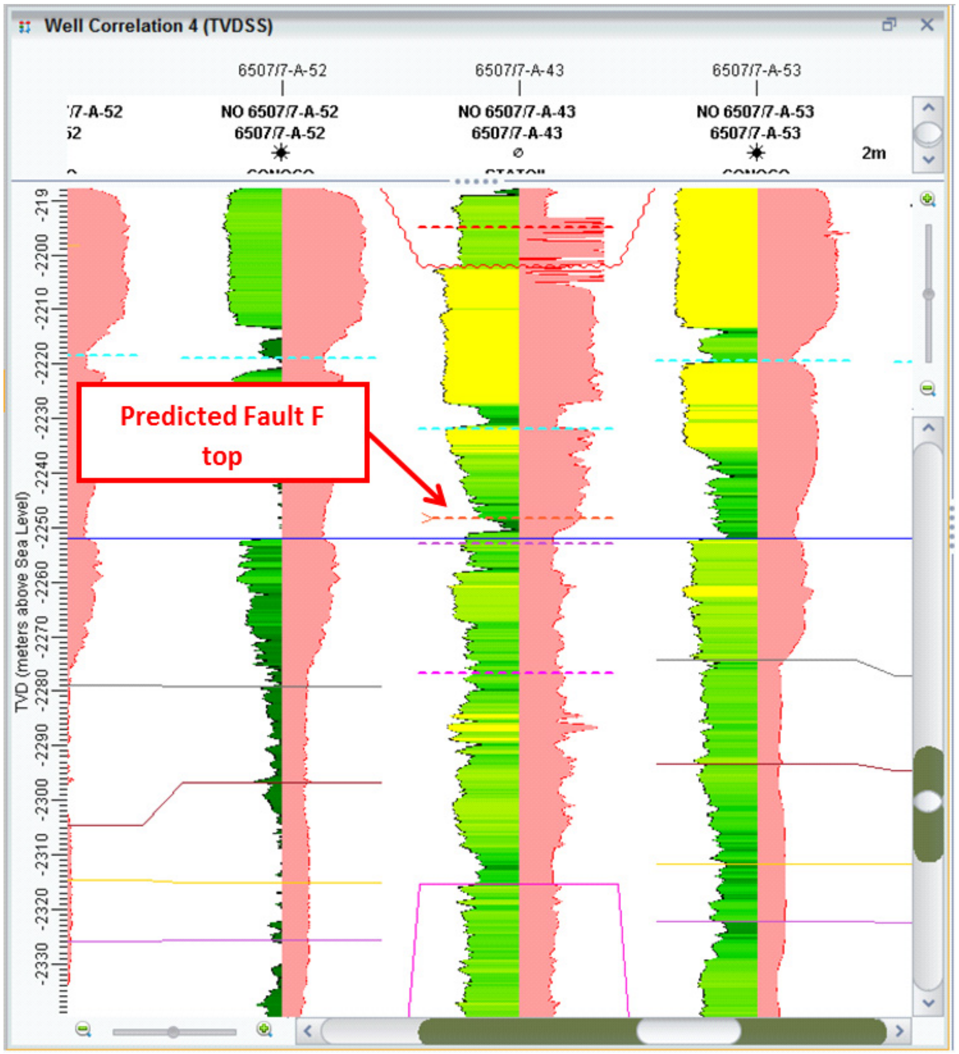
6. In your new *Correlation* view, click the **Select Pick for Flattening** () icon and hang on (click) the **FG_1** pick.

7. Turn Preserve Aspect Ratio **off** if it is on (**View** > **Preserve Aspect Ratio**). Zoom out so you can see all of the wells in the *Correlation* view, as shown in the following image. If you do not see log layout, try toggling on the **Log Curves**. Also, if your wells are trimmed, go to the **Correlation View Editor** > **Well Layout and Range** and make sure the **Include data display range** box is unchecked.

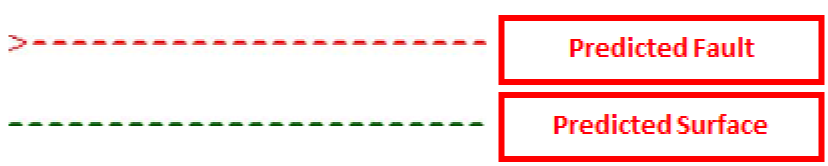


8. Locate the well **6507/7-A-43** in your *Correlation* view and notice the thickness between the surface **FG_1** (blue) and **SM_10** (purple). In the adjacent wells, the thickness between the wells seems to be parallel and conformable, however at the well **6507/7-A-43** you can see the thickness between both formations has been reduced. This is a clear indicator that the well is faulted and that it has a missing section. The **Fault_F** has not been interpreted in that well, in the following steps you will use the predicted tops from frameworks to start your interpretation.

9. Turn on **Display Predicted Tops from Framework** ( ) and zoom into the area around well **6507/7-A-43**. You may want to vertically exaggerate your view to match the following image.



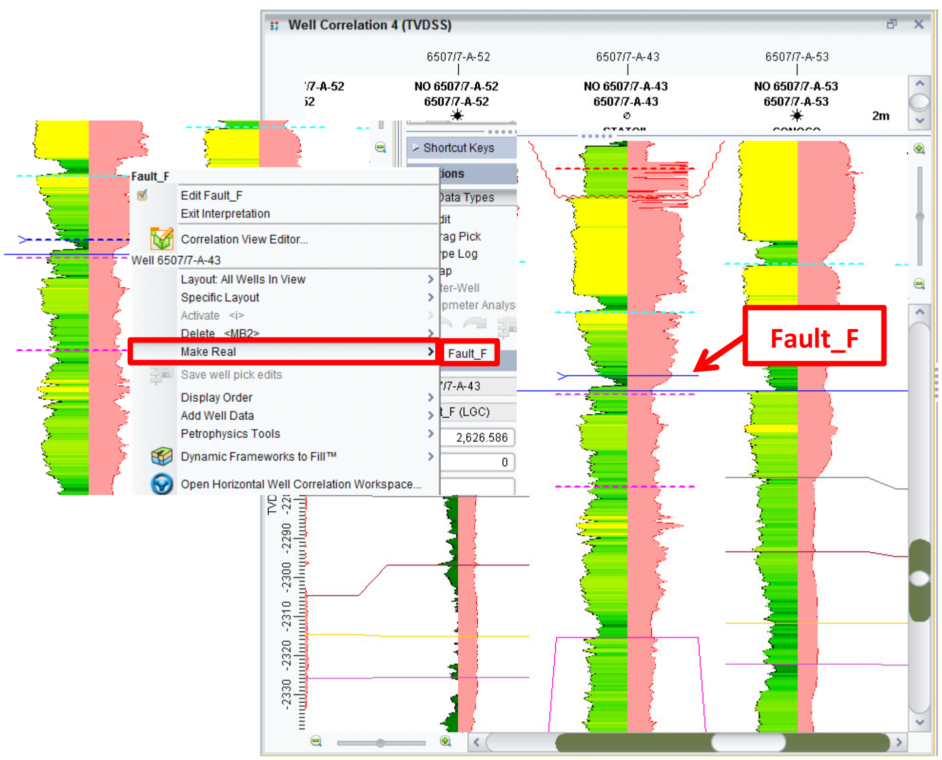
All of the predicted intersections are displayed in different ways to distinguish between predicted surfaces and predicted faults.



> **Note**
>
> When a normal fault cuts through a well, it cuts the well's vertical section and makes top-to-top intervals appear too thin. Since conformance mapping uses top-to-top thicknesses to create isochore maps, well intervals cut by faults will give thinned intervals. These fault-thinned intervals are inappropriate for conformance mapping. A rule of thumb for conformance mapping is that, if there is a fault between two tops that are being conformed, the isochore value is not used in isochore creation. It is critical to properly interpret faults before adding them to a framework and using conformance mapping. Predicted faults from the seismically defined framework are treated as faults for the purposes of the above rule.

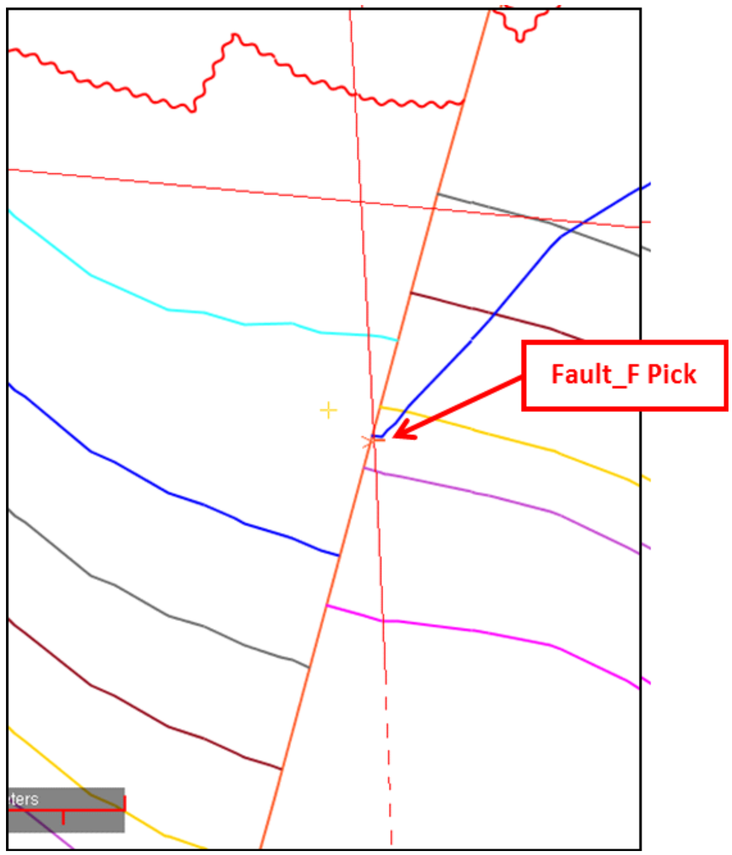
10. To turn a predicted fault pick into a real subsurface fault, turn on **Interpretation** mode (), or select the **Interpretation** mode from the toolbar, and then select the **Well Picks** option.

11. In *Correlation* view, **MB3** on the predicted fault pick, and select **Make Real > Fault_F**.

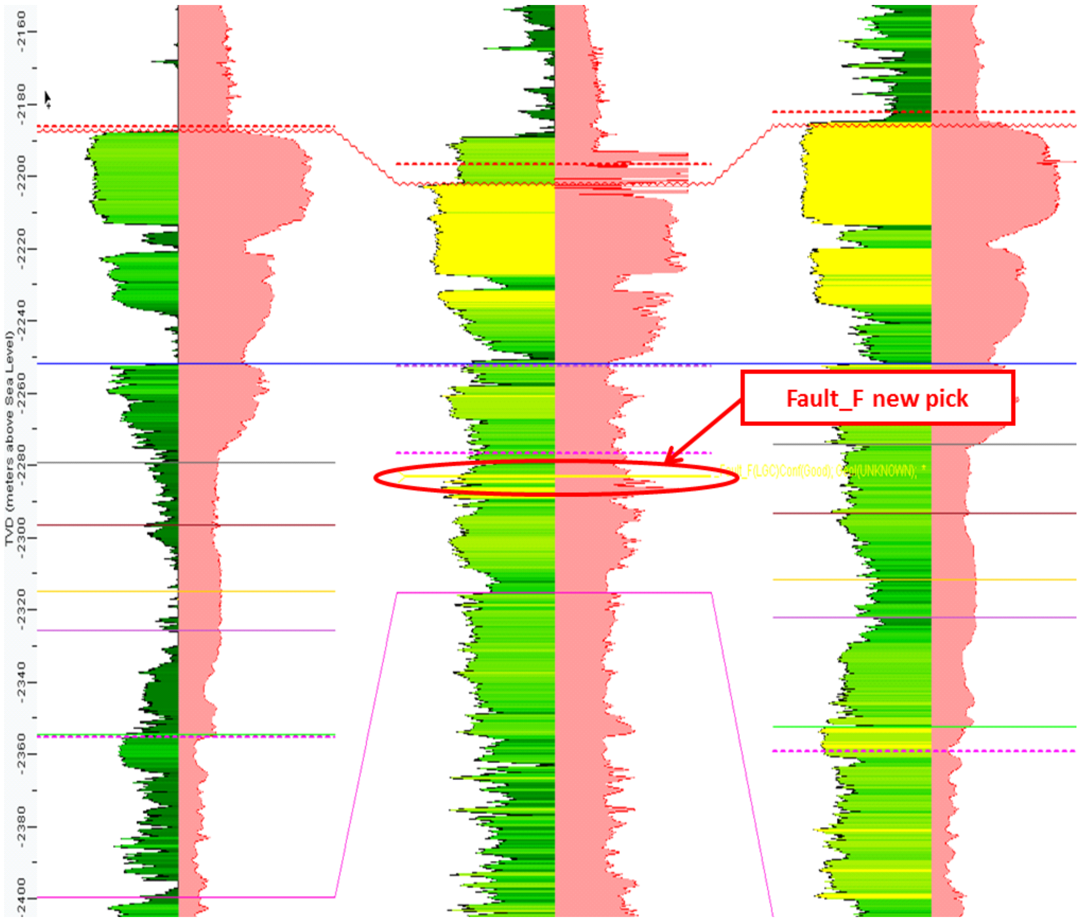


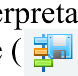
12. In the *Interpretation* task pane–Well Pick Interpretation mode, click the **Save Well Pick Changes to the Database** ()icon.

13. Notice the position of the **Fault_F** pick in the *Section* view. If you do not see it, check the visibility toggle for that FAULT PICK in your *Inventory*. The predicted top displays above **FG_1** surface causing the formation to bend to respect the interpretation. The **Fault_F** should be in some place in between the **FG_1** and **SM_10** surfaces.

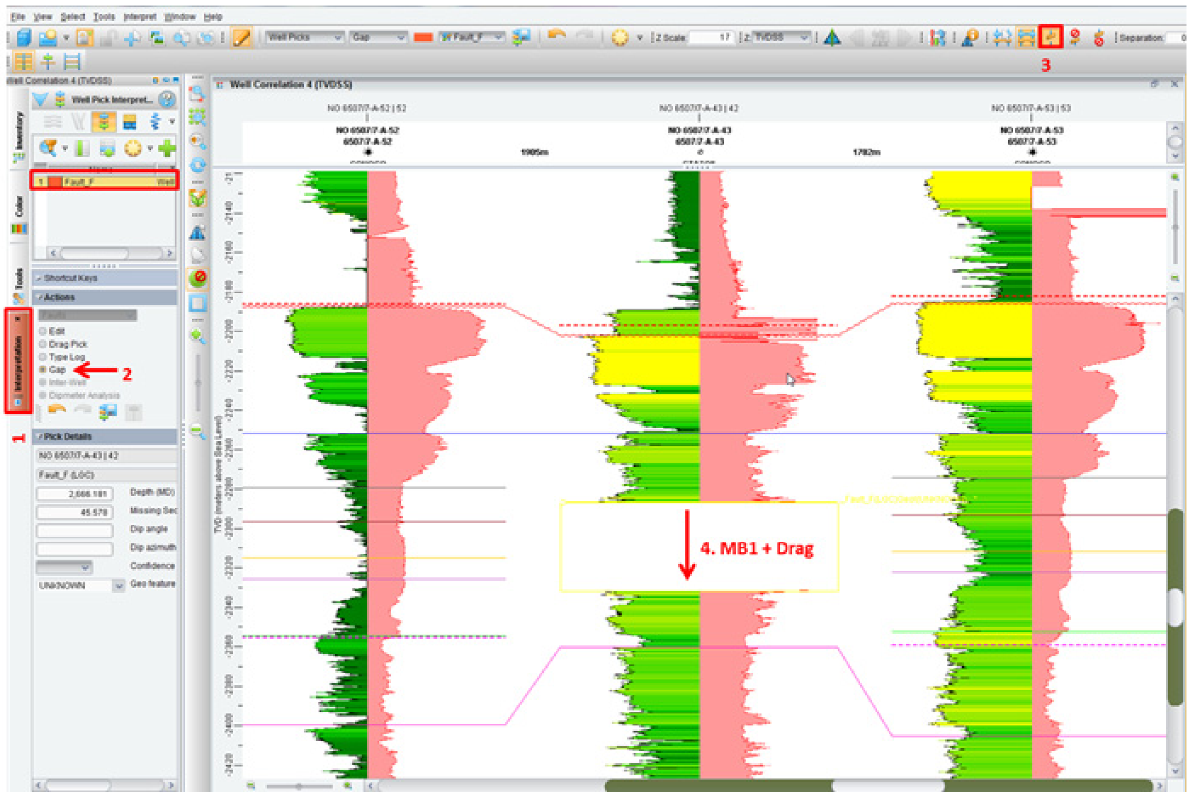


14. Back in *Correlation* view, move the **Fault_F** pick down to about 2662 meters (MD), it is approximately -2290 m (TVD) in the left scale.



15. Exit Interpretation mode and **Save** your pick changes to the database ().

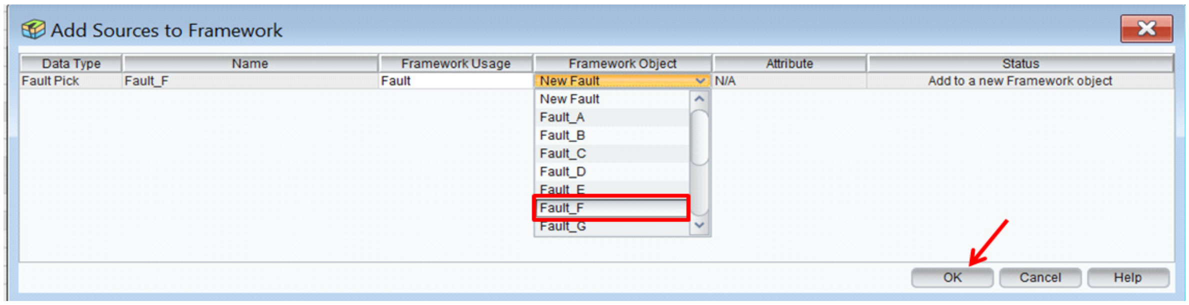
16. To draw the gap (missing section in your well), in the *Interpretation* task pane, under the *Actions* sub-panel, select **Gap**. Turn on **Fault Gapping** by clicking in its icon ( ). Drag the fault pick down to represent the missing section. Follow the sequence in the picture below.



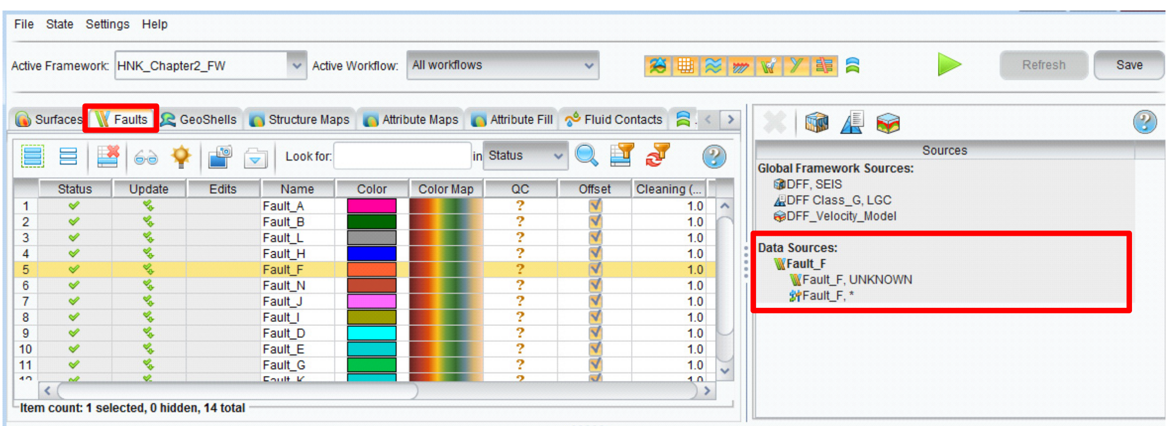
> **Note**
>
> You can turn off fault gapping icon ( ) when you to want to see your cross section back to normal.

17. In the *Inventory* task pane, **MB3** on the **Fault_F** fault pick and select **Dynamic Frameworks to Fill > Add to Existing Framework… > YOU_Chapter2_FW**.

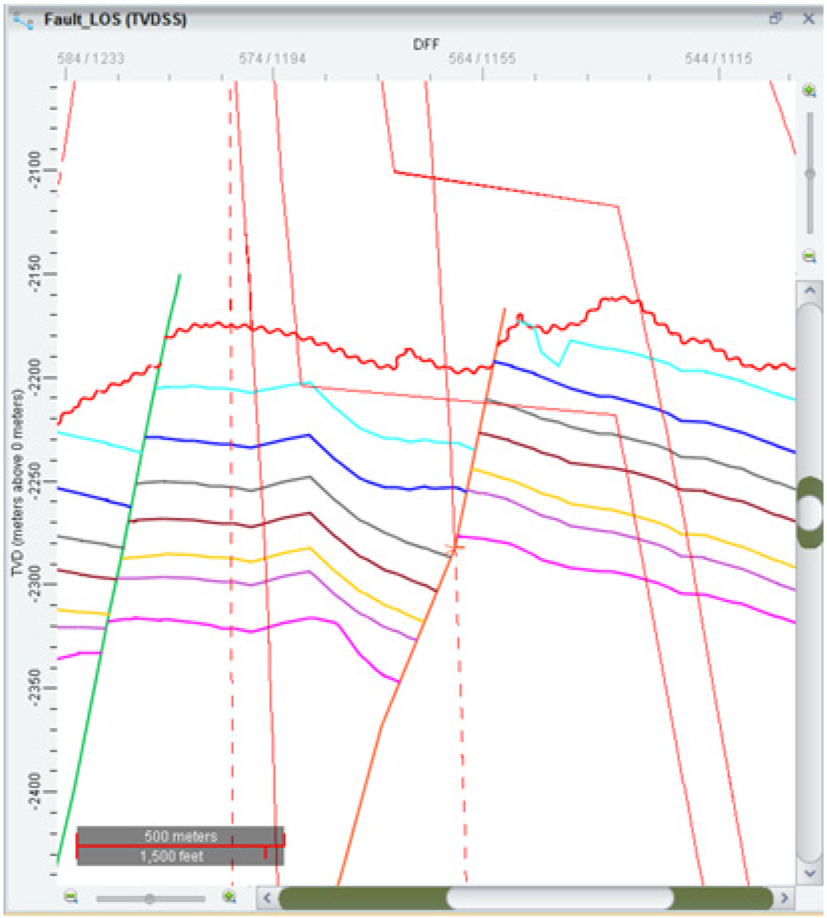
18. The *Add Sources to Framework* dialog box displays. Under the *Framework Object* section designate that it will be associated with **Fault_F** by clicking in the down arrow in the **Framework Object** column as illustrated in the picture below. Click **OK** to finish adding the **Fault_F** pick as a secondary data source for the existing seismic **Fault_F**.



19. The **Fault_F** fault pick will be added as a Data Source for **Fault_F**. This can be seen in the *Sources* sub-panel of the *Fault* tab.



20. In your *Section* view you will notice that the geometry of **Fault_F** has changed to represent the new data that has been added to the Framework. This will happen automatically if you have your Framework set to **Dynamic, Auto Refresh** mode.



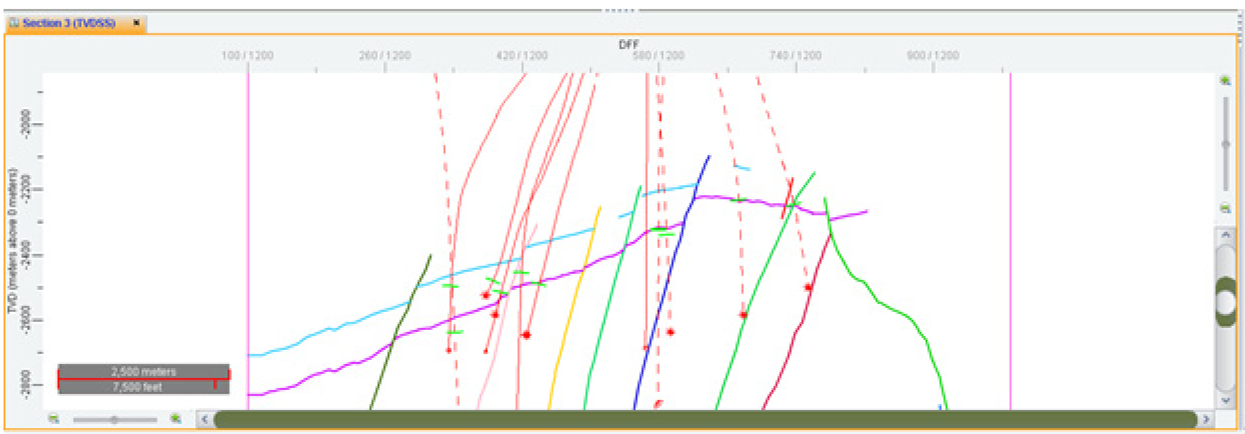
Exercise 2.8: Mapping Sparse Data

In this section you will learn some of the options within *DecisionSpace Geosciences* to add additional control points to a mapped surface in scenarios such as:

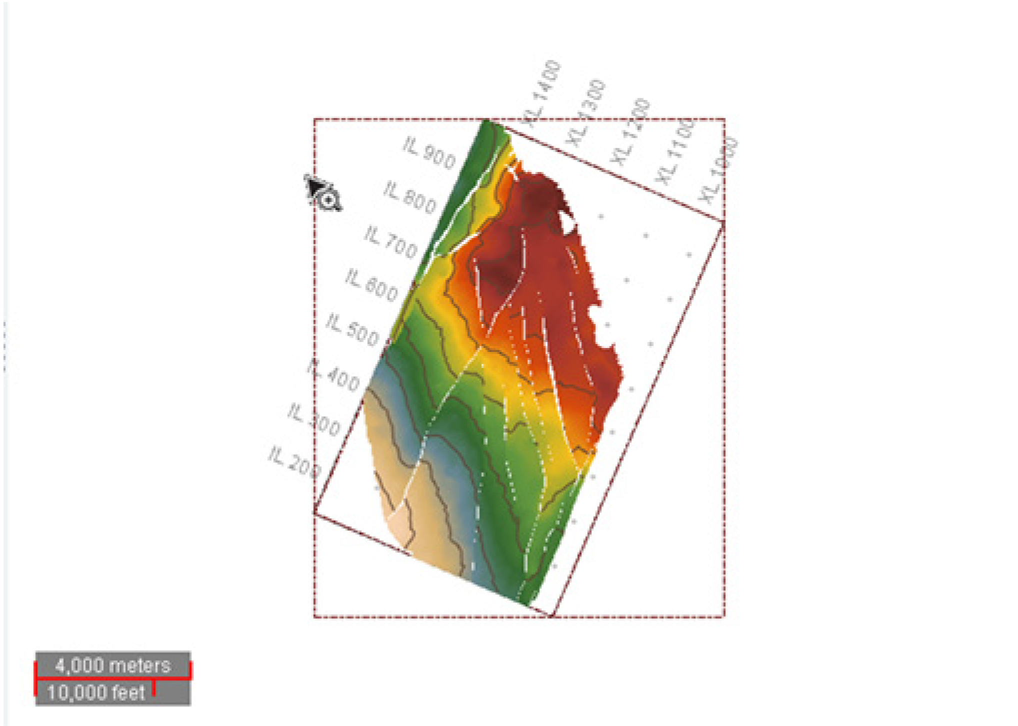
- Sparse well control, or
- The regional interpretation needs to be extended into areas where there is no seismic data control.

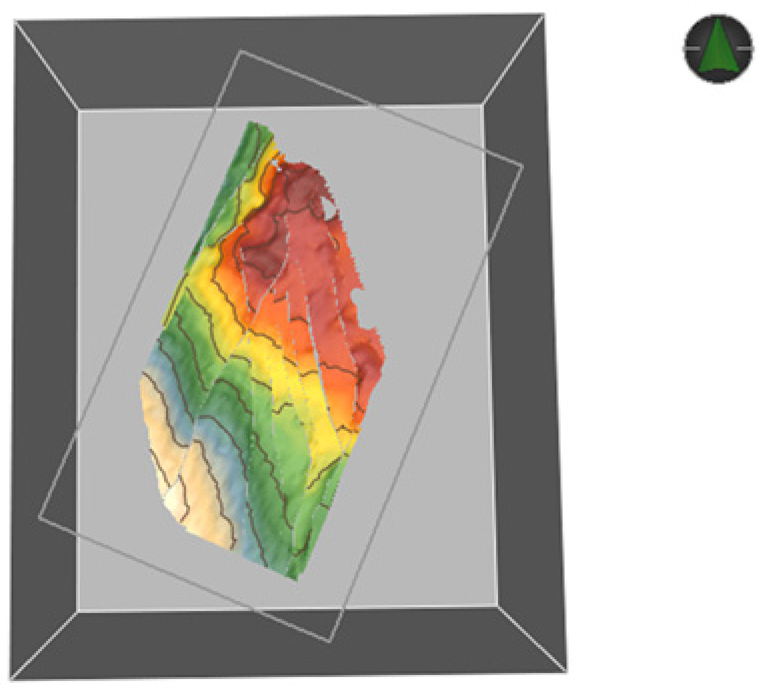
You can use Inter-well points, GeoShapers, and contours as additional control points and observe how you can influence surfaces within the framework.

1. In *Section* view, navigate to **XL 1200** and scroll to the right of the section. Show the following:
    - FW SURFACES: **05_Base_Interval** and **my_pick_YOU**
    - FW FAULTS: **All**
    - WELL LISTS: **DFF_Class_G**
    - SURFACE PICKS: **SM_12**



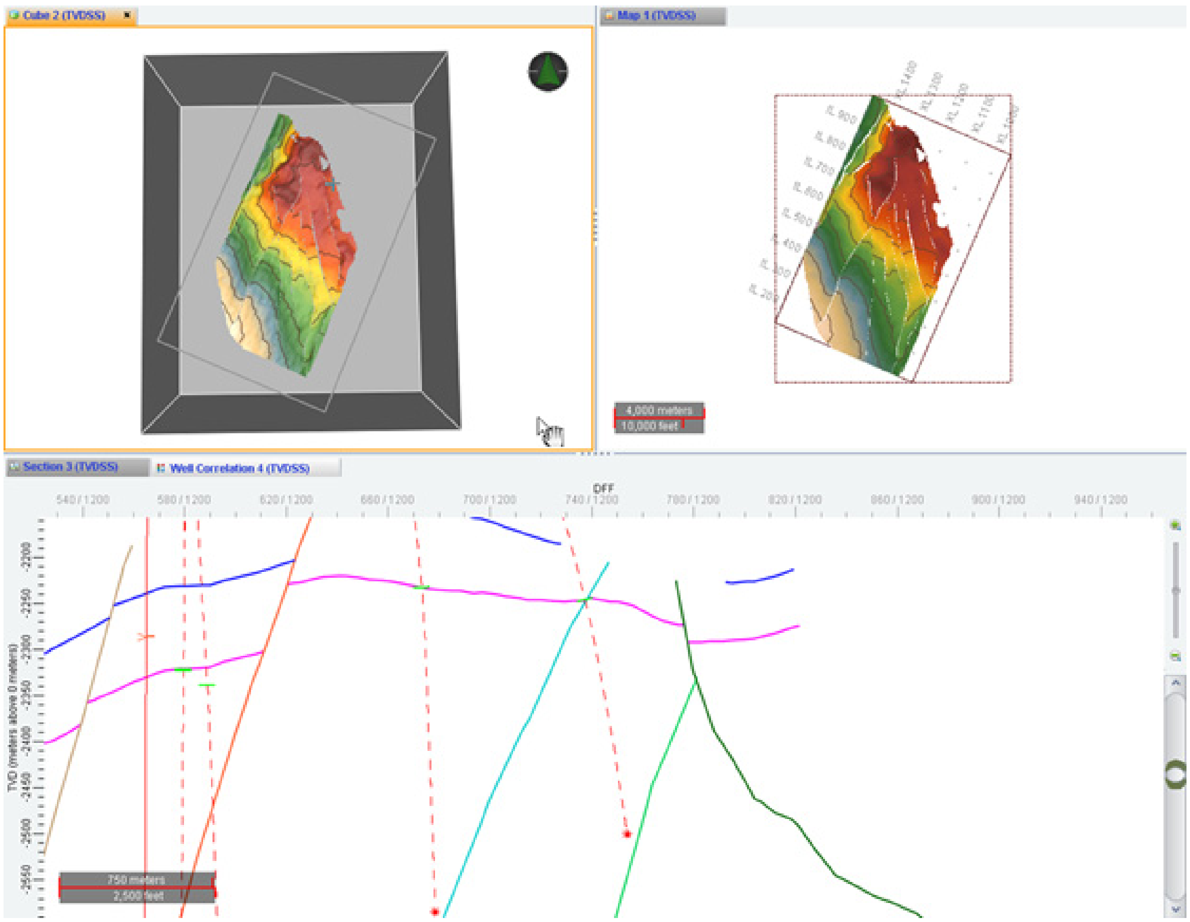
2. In *Map* view and *Cube* view, turn on only the **05_Base_Interval_Decimate_100** framework surface.





3. In the *Dynamic Frameworks to Fill* task pane, ensure that the **YOU_Chapter2_FW** framework is set to **Dynamic, Auto Refresh**.

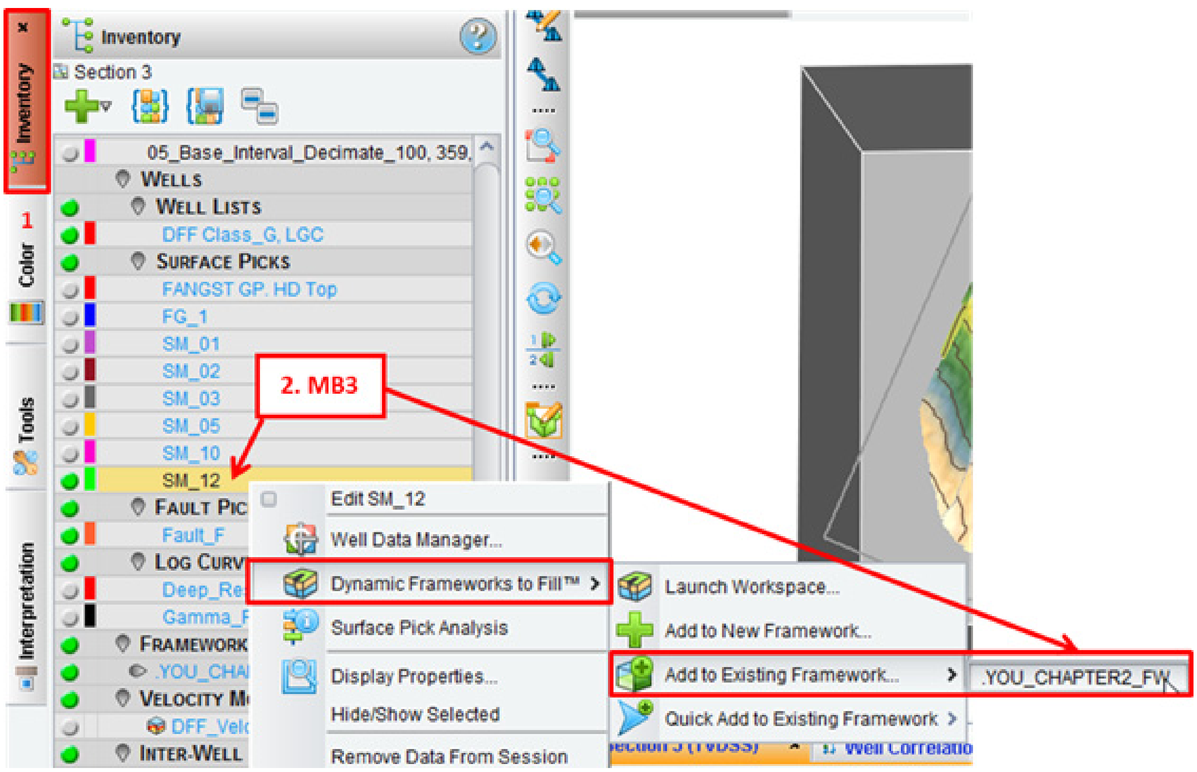
4. Set your three views as shown below.



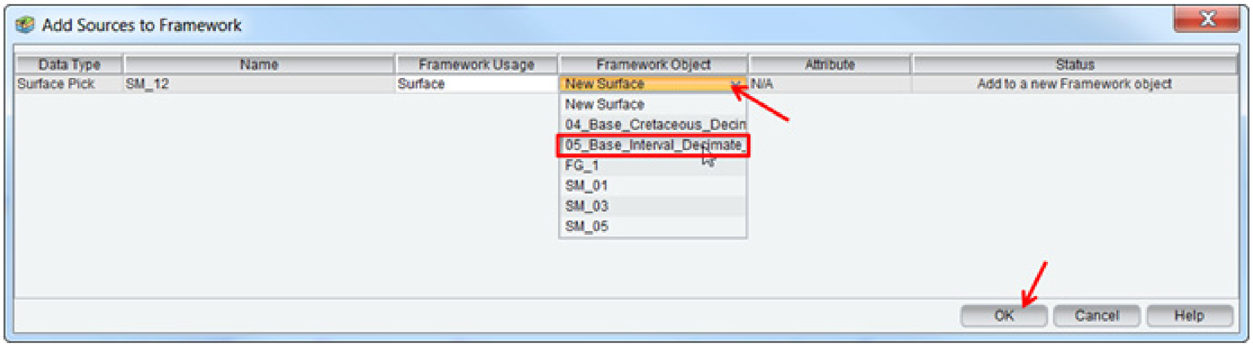
Applying Additional Control Points

You can add control points beyond the map extents.

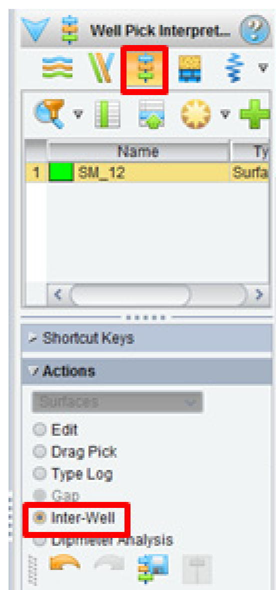
5. Add the SURFACE PICK **SM_12** as a secondary data source for the framework surface **05_Base_Interval_Decimate_100** (this is the base of the reservoir). In the *Inventory* task pane under the SURFACE PICK, **MB3** on **SM_12** and then select **Dynamic Frameworks to Fill > Add to Existing Framework > YOU_Chapter2_FW**.



6. In the *Add Sources to Framework* dialog box *Framework Object* column, select **05_Base_Interval_Decimate_100**. Click **OK** to close the dialog box and add the geological top as secondary source of the framework surface.



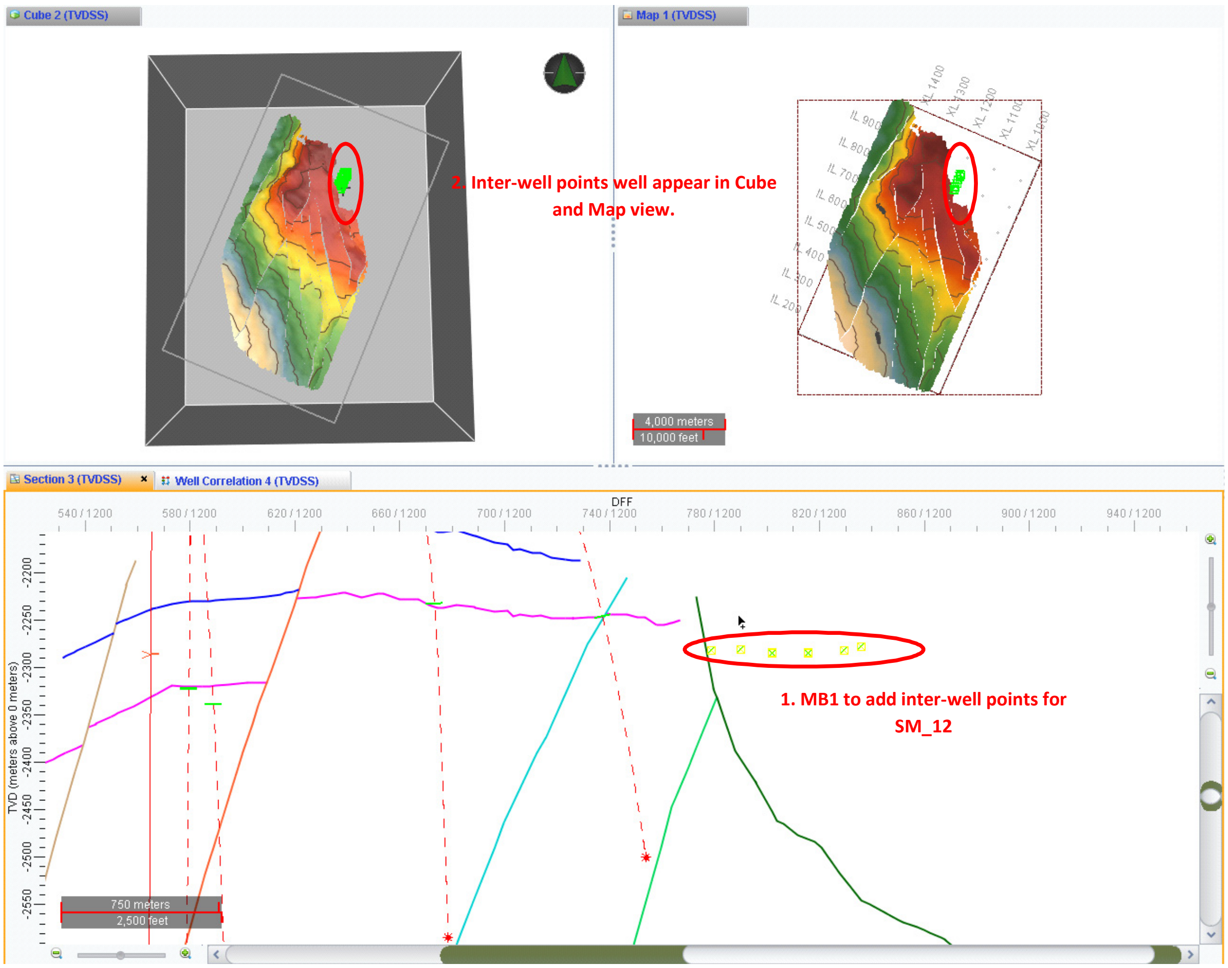
7. Activate *Section* view and open the *Interpretation* task pane for Well Pick Interpretation. Highlight the **SM_12** pick and then select the **Inter-Well** action. Verify that interpretation mode is **on**.



Note

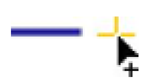
When *Inter-Well* action is selected, the *Single Pick Interpretation* mode greys out.

8. In the *Section* view, add several Inter-Well **points** beyond the extent of the framework surface **05_Base_Interval_Decimate_100** (purple in the picture below) using **MB1**. Click the **Save Well Pick Changes to the Database** () icon when finished adding a couple of points.

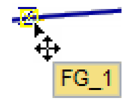


Pay attention to cursor shape; it indicates what action will be taken.

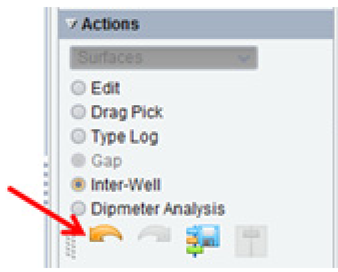
- You can add control points when the cursor shows a small + symbol added to its tail.



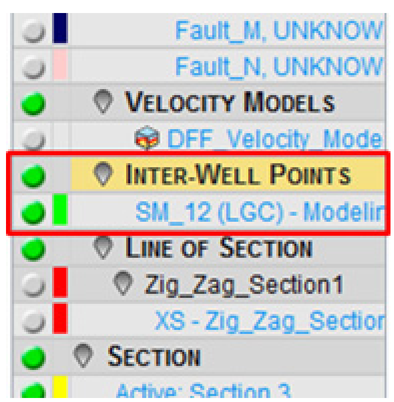
- You can adjust control points after interpreting them. Hover the cursor over a control point and observe that it changes to a four-way arrow. You can then move (drag-and-drop) the control point to a new location.



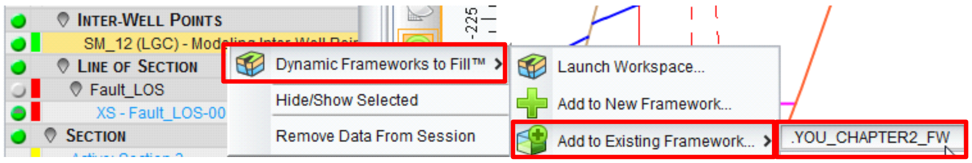
- Regardless of the cursor shape, you can put your cursor on a control point and click **MB2** to remove it.

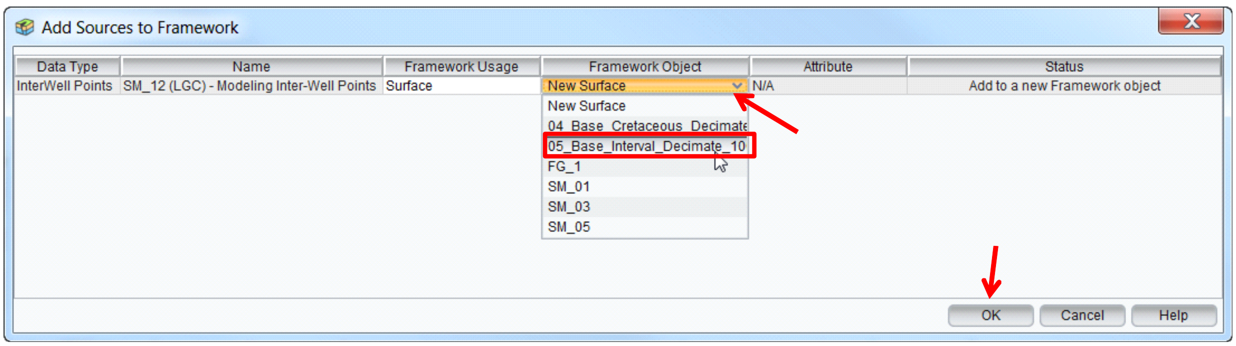
> **Note**
>
> Remember, you can access Undo and Redo buttons in the task pane. Alternatively, apply those Actions with Ctrl+Y or Ctrl+Z, respectively.
>
> 
>

9. Notice that a new entry was added to the *Inventory* tree: INTER-WELL POINTS. This represents the Inter-Well points that were added manually.

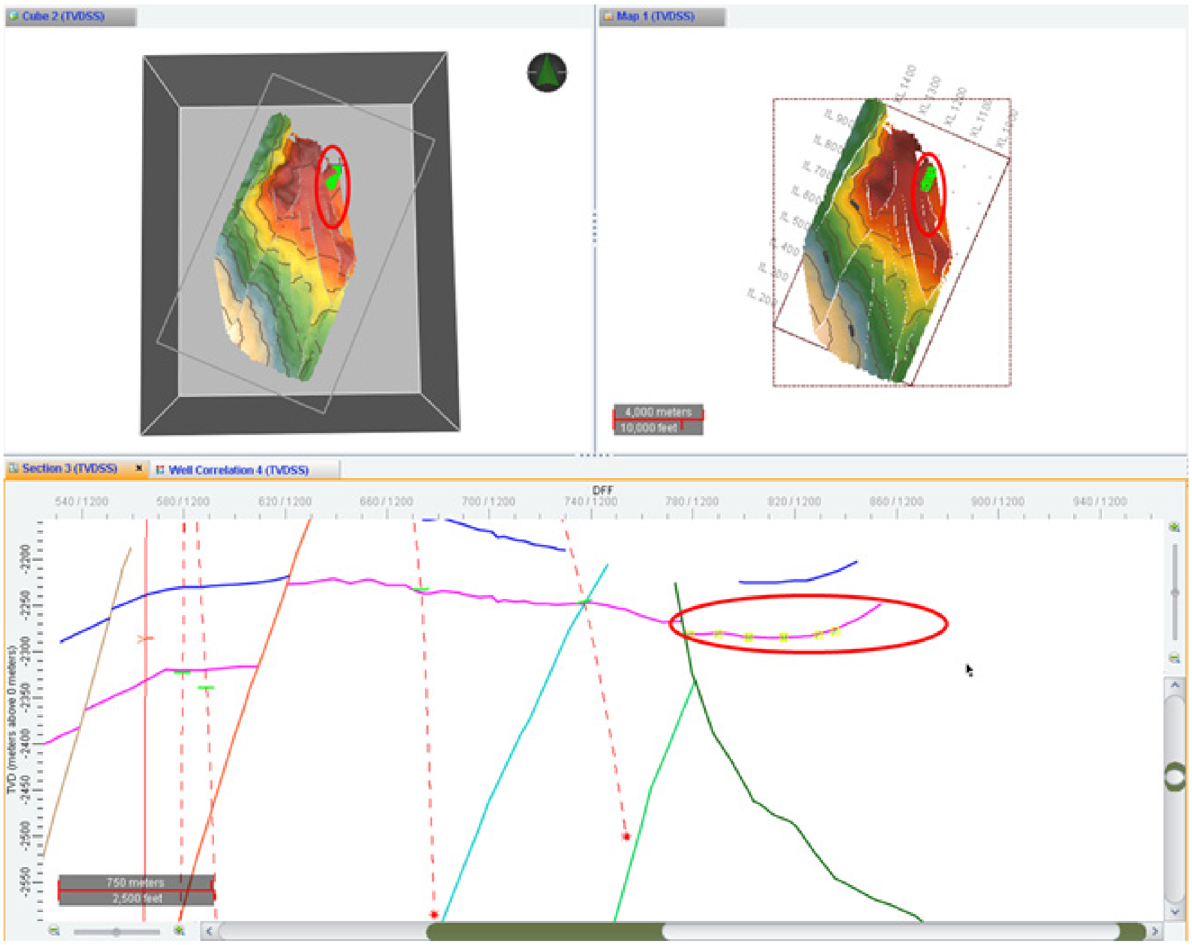


10. Add the **SM_12** Inter-Well points to the framework as another source for the framework surface **05_Base_Interval_decimate_100**. Follow the same steps you did to add the surface pick **SM_12**.

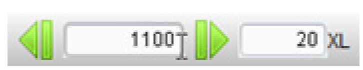




11. *Cube*, *Map*, and *Section* views should automatically update showing that the framework surface **05_Base_Interval_decimate_100** has been extended by the Inter-Well points.

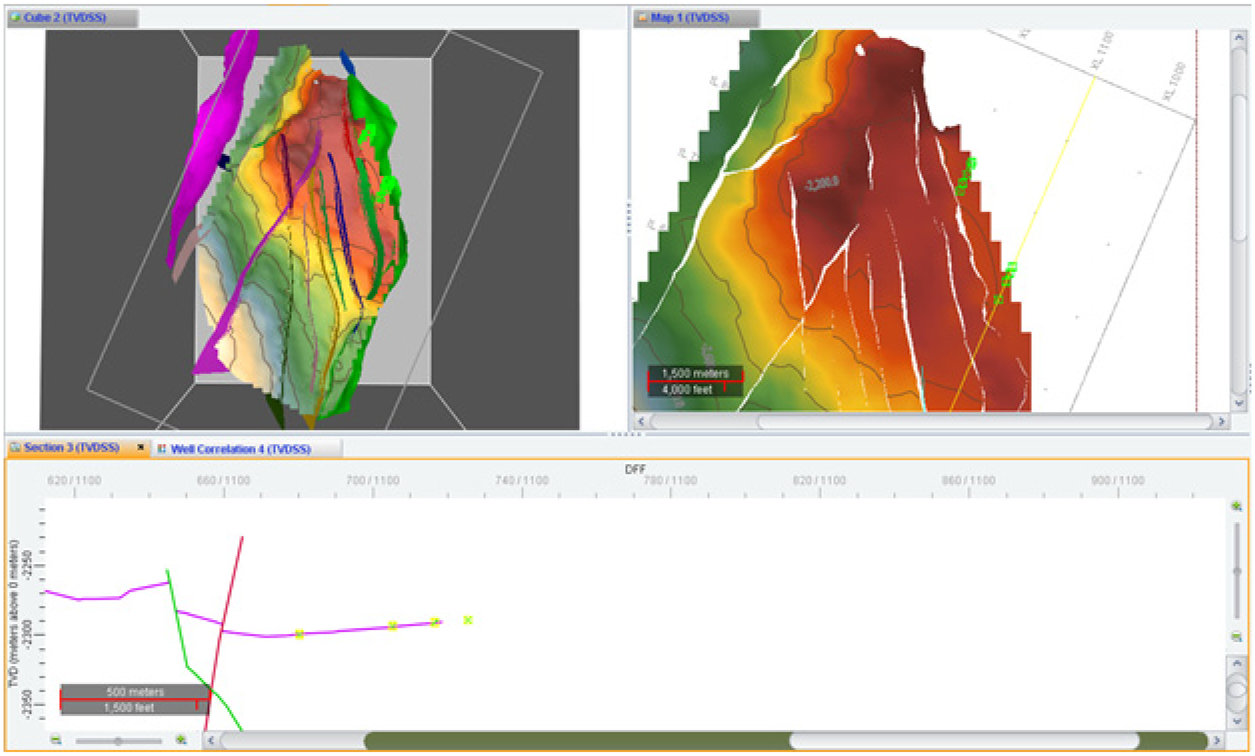


12. With *Section* view active, use the section stepper (VCR controls) on the tool bar, navigate to **XL 1100**.



13. Add more **control points** on the new section. Save the pick changes to the database () and watch the surface grow in the *Map* and *Cube* views after the framework refreshes.

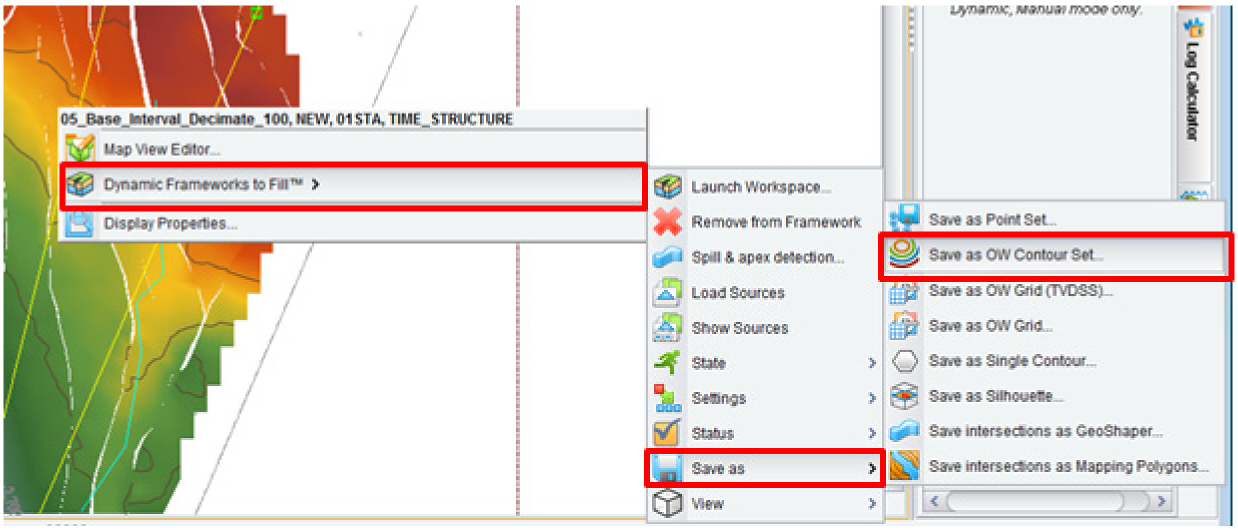
14. Notice that the inter-well points are represented by a green box with an x. You can modify these points in *Map* view, but not *Cube* view.



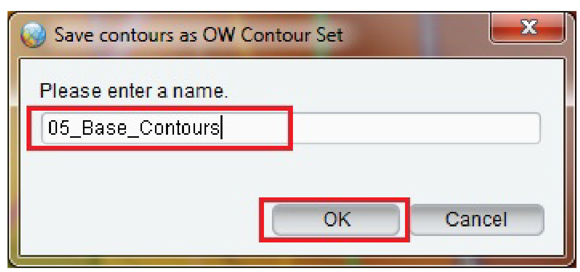
Mapping with Contours

15. Double-click the *Map* view to maximize that view. The tab will expand to fill the tile.

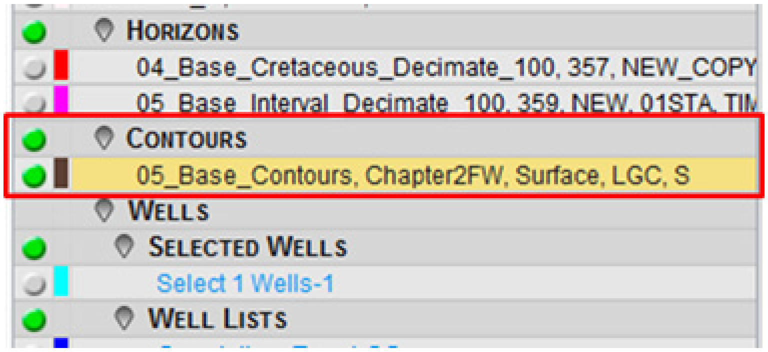
16. Anywhere on the displayed surface, **MB3** and then select **Dynamic Frameworks to Fill > Save as > Save as OW Contour Set…**.



17. In the *Save contours as OW Contour Set* dialog box, enter "**05_Base_Contours**" in the text field, and then click **OK**.



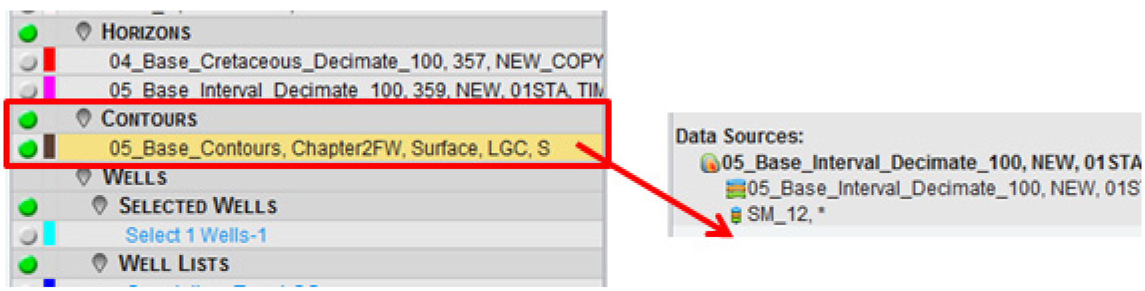
18. Notice that a new category, CONTOURS, was created in the *Inventory* tree, immediately below HORIZONS, displaying the newly saved contour set.



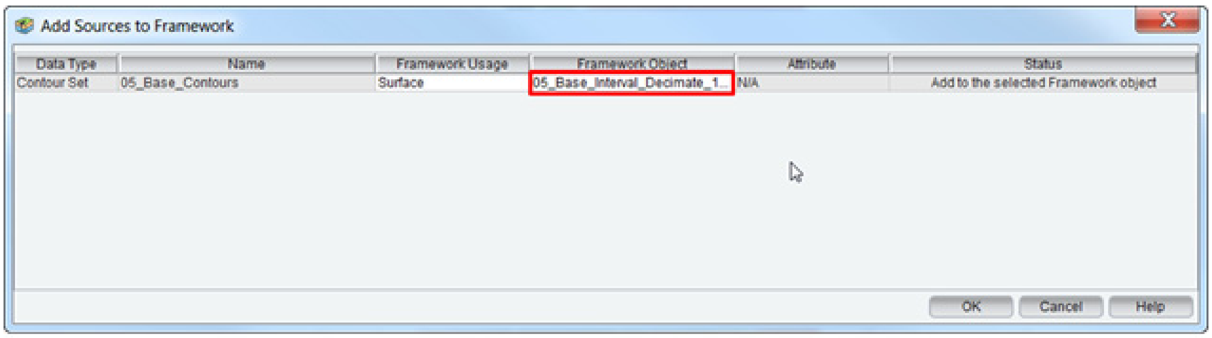
19. Launch the *Dynamic Frameworks to Fill Workspace*. Move the *Workspace* dialog box to another screen or position it so you can see the *Inventory* tree.

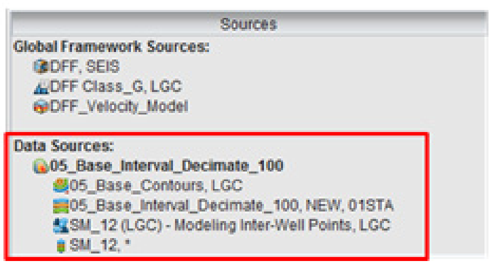
20. On the *Surface* tab, highlight the **05_Base_Interval** surface.

21. In the *Inventory* tree, highlight the recently created **contour set** and drag it into the **Data Sources** portion in the *Sources* sub-panel, beneath Inter-Well Points.



22. The *Add Sources to Framework* dialog box displays. Under *Framework Object*, select **05_Base_Interval_Decimate** to make sure that it is a secondary source. This means that when you change the Contours it will update the **05_Base_Interval_Decimate_100** surface. Notice that your data sources for **05_Base_Interval_Decimate_100** is now composed of four objects. This highlights the power of the frameworks and the use of multiple interpretation objects to get a final surface. In the next chapters, you will also learn how to add polygons as sources for existing surfaces.

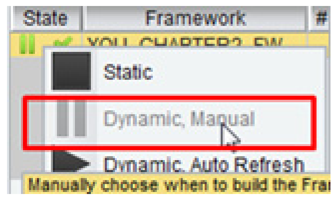


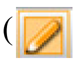


23. In the *Inventory* tree, make sure your **05_Base_Contours** contours, and your **05_Base_Interval_Decimate_100** framework surface are turned on for your *Map* view.

24. **MB3** on the **05_Base_Interval_Decimate_100** framework surface in *Map* view or in the *Inventory* tree, and navigate to the **Display Properties**. Within the *Display Properties* dialog box, uncheck the **Show Contours** box. This will make it easier to see the contours you will be editing.

25. Before you start editing the contours, change the state of your framework to **Dynamic, Manual**. You don't want that the framework automatically update every time you modify a node, instead, it is better to make all the editions to the nodes and when finished, refresh your framework **manually**.



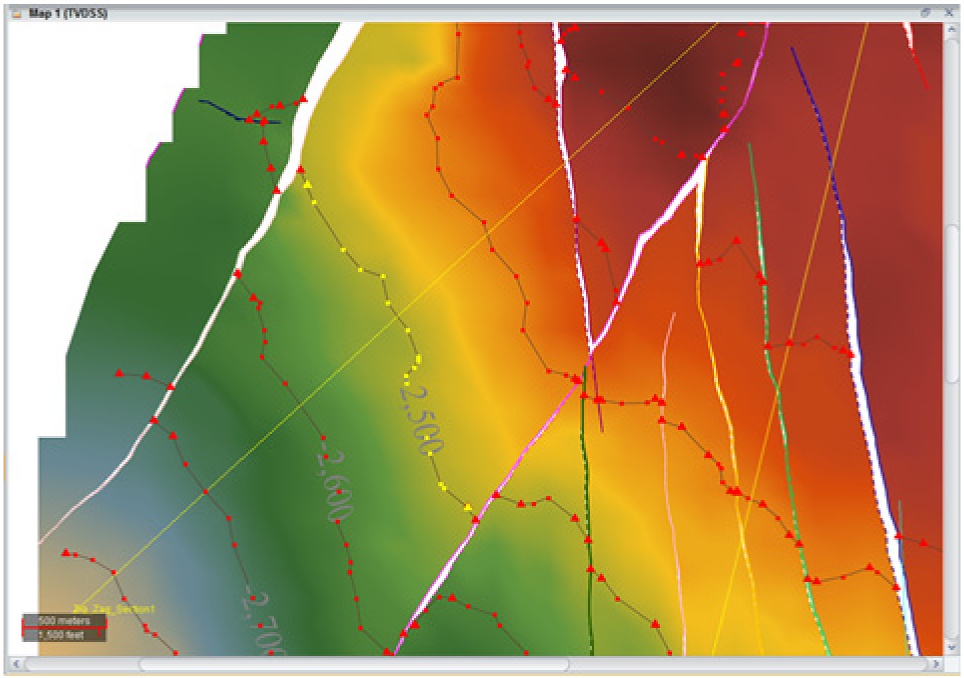
26. With *Map* view active, turn on the **Interpretation Mode** () icon, and select the interpretation data type as **Contours**.

> **Note**
>
> The nodes of the contours will be red, meaning they are editable.

27. **MB1** on any of the nodes. The nodes of that contour will turn yellow.

> **Note**
>
> If you MB1 on the contour and not on one of the nodes, it will add a new node to the contour.

28. **MB1** on any node you wish to edit, and drag it to a new position. Make some other changes to the contours. Refresh your framework () and observe the changes in your surface.



29. When you finish, close DecisionSpace Geoscience. In the next exercise we will start with a brand new session. It is not necessary to save.

Review

This chapter presented the tools and workflows within DecisionSpace and Dynamic Frameworks to Fill to enable geologic structural interpretation and mapping. All DecisionSpace views were used in an integrated manner, especially *Well Correlation* and *Map* views.

The activities in this chapter included:

- Learning about cross sections, both *Well Correlation* and *Section* types
- Optimizing well layout displays
- Interpreting Surface Picks
- Using the ghost curve while correlating logs
- Updating the framework with Surface Picks
- Integrating geophysical and geologic fault interpretations
- Integrating interpretation (correlation) and mapping
- Using conformance technology (based on horizon surface, in this case) to guide well-top surfaces
- Applying additional sparse data control for mapping improvements