Workflows for Depth-Converting KINGDOM Project Data

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Objective: Depth-Convert Seismic Traces (Part 1) and Horizon and Fault Interpretation (Part 2) so that the depth-converted interpretation products consistently match the depth-converted seismic traces

Part 1: Depth-converting seismic trace data

Option 1: Depth-Converting Seismic Traces Using Shared T/D Chart:
(this approach may be used in the event that velocity trace data are lacking)

Prior to begining: Edit, resample, smooth sonic and density log curves
Generate a synthetic tie to the seismic data
Save the time-depth relationship as a shared T/D Chart

Perform the depth conversion of Amplitudes (time) traces in TracePAK:

Project > TracePAK > Time < > Depth Conversion:
Select line (survey) and input data type: Amplitudes (Time), then Next…
Select output data type: AmplitudesDepth (Depth) or create new type, Next…
Select Conversion Velocity as “Shared Time-Depth Chart”,
Select specific Shared Time-Depth Chart, (if none, then perform sharing)
Verify correct output sample interval and replacement velocity, then Next…
Then Apply or Finish
Save new traces with 8-bit or 32-bit resolution, as desired, then OK
“Progress” dialog shows activity until the processing is finished

Option 2: Depth-Converting Seismic Traces Using Average Velocity trace data:
(a method for depth-converting seismic time traces if interval velocity trace data are lacking)

Background: Average velocity trace data (typically Vrms velocities) may be generated from DMO stacking velocities which are a necessary part of any seismic processing workflow and may be requested in SEG-Y format from your processor. Average velcity (Vavg) traces are typically more smoothed than interval velocity (Vint) traces that may also be available from your processor.

Perform the depth conversion of Amplitudes (time) traces in TracePAK:

Project > TracePAK > Time < > Depth Conversion:
Select line (survey) and input data type: Amplitudes (Time), then Next…
Select output data type: AmplitudesDepth (Depth) or create new type, Next…
Select Conversion Velocity as “Average Velocity Volume”,
Select the specific Vavg trace data type that is available,
Evaluate Maximum Z value and select velocity units (ft/s or m/s),
Verify correct output sample interval and replacement velocity, then Next…
Then Apply or Finish
Save new traces with 8-bit or 32-bit resolution, as desired, then OK
“Progress” dialog shows activity until the processing is finished

Option 3: Depth-Converting Seismic Traces Using Interval Velocity trace data:
(this is the preferred workflow for depth-converting seismic time traces)

Background: Interval velocity trace data may be generated from DMO stacking velocities which are a necessary part of any seismic processing workflow and may be requested in SEG-Y format from your processor. They are typically less smoothed than average velocity traces that may also be available from your processor.

1) Perform the depth conversion of Amplitudes (time) traces in TracePAK:

Project > TracePAK > Time < > Depth Conversion:
Select line (survey) and input data type: Amplitudes (Time), then Next…
Select output data type: AmplitudesDepth (Depth) or create new type, Next…
Select Conversion Velocity as "Interval Velocity Volume",
Select the specific Vint trace data type that is available,
Evaluate Maximum Z value and select velocity units (ft/s or m/s),
Verify correct output sample interval and replacement velocity, then Next…
Then Apply or Finish
Save new traces with 8-bit or 32-bit resolution, as desired, then OK
"Progress" dialog shows activity until the processing is finished

Part 2: Depth-converting horizon and fault interpretation

Option 1: Depth-Converting Horizons using Average Velocity trace data:

Extract Average Velocity (time) data type:

Horizons > Extract Data Type
Select horizon name and Vavg data type to extract (typically this is Vrms)
Click "Apply" and iterate for other horizons, "OK" to finish

Extended Math Calculator:

Tools > Calculators > Extended Math
Double-click to select and expand the Input Surface to be depth-converted
Highlight the "Time" attribute and click >> A to select as Variable A
Highlight the "Vrms" attribute and click >> B to select as Variable B
Formula is (A * B) / 2 (because of two-way time)
Select Output Surface Name and Color (both may be same as Input)
Select "Depth" as the attribute or "Z" type
Click "Compute" to perform the calculation
Iterate for each horizon and then click "Cancel" to close the dialog
The depth-converted horizons should now be visible in the depth displays

Option 2: Depth-Converting Horizons and Faults using Interval Velocity trace data:

Summary Workflow: This workflow contains 2 main and several subsidiary workflows:

1) Depth-converting horizon interpretation
    a. Creation of T-D data type
    b. Extraction of T-D data type for each horizon
    c. Reassignment of T-D data type to Depth data type for each horizon

2) Depth-converting fault interpretation
   a. Creating / loading pseudowells
   b. Extracting T-D data as single traces / loading as TD Charts for pseudowells
   c. Depth-converting faults using shared TD Charts

Detailed Workflow: Step-by-step description of summary workflow:

1a) Depth-Converting Horizons Using Vint (time):

We must calculate a time-depth trace relationship from the Vint (time) traces
(This is a two-part process)
Part 1: Project > TracePAK > Process Multiple Traces: Select line & Vint (time) traces
Select Process > Running Sum: Save output as new data type: RS_Vint (time)
Part 2: Project > TracePAK > Trace Calculator:
Select input survey and data type RS_Vint (time), click to define variable >> A
Formula is: A * 0.002 (if 0.004 sample interval), or
Formula is: A * 0.001 (if 0.002 sample interval)
Select output survey and save as new data type: call it "T-D" (time)

The following spreadsheet shows an example trace extracted from a test project that illustrates the calculations that convert the Vint traces into Time-Depth traces. This is effectively interval velocity summation scaled to produce isopach summation (final calculation has m/s * s = m).

TWTT	=	the input time series, in this case, with a sample interval of 0.002 sec
Vint	=	the input interval velocity value for each corresponding time sample
RS_Vint	=	the running sum of the interval velocity (interval velocity summation)
T-D	=	the "scaled" running sum, equal to summed depth for each time sample

input	*input*	*1, 1+2, 1+2+3, etc*	*RS Vint * 0.001*
TWTT	***Vint***	***RS Vint***	***T-D***
(s)	*(m/s)*	*(m/s)*	*(m/s * s = m)*
0.000	1500	0	0.0
0.002	1500	1500	1.5
0.004	1500	3000	3.0
0.006	1500	4500	4.5
0.008	1600	6100	6.1
0.010	1700	7800	7.8
0.012	1800	9600	9.6
0.014	1900	11500	11.5
0.016	2000	13500	13.5

Figure 1: Spreadsheet illustrating algorithm for calculating T-D trace data from Vint trace data

1b) Extract T-D data type (time domain):

Horizons > Extract Data Type > Select horizon and data type > T-D (Time)

Click “Apply” and iterate for other horizons, then click “OK” to finish

1c) We need to use the Horizon Properties dialog in order to reassign the horizon attribute type:

Horizons > Properties:

Select horizon > Click “Set” to set data type, then

Select Data Type in Horizon > T-D (Time), then

Set New Type > Depth (Depth)

Click “Apply” to iterate for other horizons, then click “OK” to finish

The depth horizons should now display with depth traces in a vertical profile.

2) Depth-Converting Faults Using Local or Shared T/D Chart(s)

(Note: There are two initial data / functionality requirements that must be considered):

Assigned vs Unassigned faults: To depth-convert unassigned fault segments they must first be assigned to an appropriate named fault plane (such as F-1, F-2, etc) or else they must all be assigned to a single named fault plane (such as “All Unassigned Faults”). The latter option is functionally quite acceptable even though the unassigned fault segments may not have any geological affinity to one another. Fault segments may be unassigned from the named fault plane once the depth conversion is completed.

Well Data: Presence / Absence: KINGDOM requires the use of TD Charts loaded in wells to perform depth conversion of faults. If well data are lacking there are two clear alternatives. Either convert fault planes to horizons (not practical for unassigned faults) and then proceed as for horizon depth conversion (above), OR quickly and easily create pseudowells and populate them with TD Charts that may be extracted from the T-D data type. We will illustrate the latter option.

2a) Creating / loading pseudowells: <u>Summary</u>: Export seismic navigation data at an appropriate SP increment in ascii format, then open the ascii file in Excel and modify it to include all essential data required to load wells, then load the ascii data so that each exported seismic SP becomes a pseudowell:

Surveys > Survey Annotation:

Text Options: Display line name and SP annotation text every 200th SP

Line Options: Display survey line and survey symbols every 200th SP

Surveys > Export > World Coordinates:

Select data format: Line Trace X Y

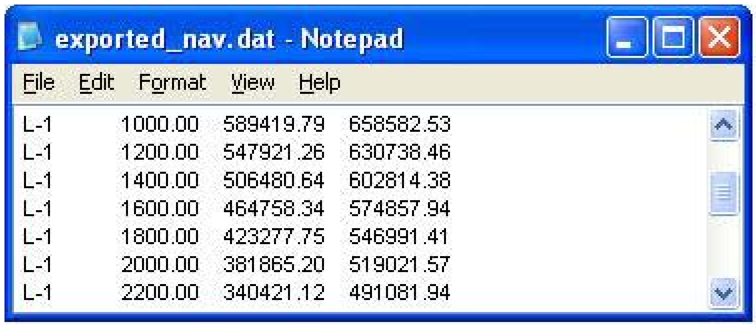
Select output format: Space

Select surveys (for example, L-1)

Select output range: Export world coordinates using current basemap annotation

Click “OK”, browse to an appropriate directory, name file “exported nav.dat”

The exported nav data looks like the illustration shown below:



L-1	1000.00	589419.79	658582.53
L-1	1200.00	547921.26	630738.46
L-1	1400.00	506480.64	602814.38
L-1	1600.00	464758.34	574857.94
L-1	1800.00	423277.75	546991.41
L-1	2000.00	381865.20	519021.57
L-1	2200.00	340421.12	491081.94

Figure 2: Example of ascii seismic navigation data exported for every 200th shotpoint

Open Microsoft Excel, then click File > Open and select “exported nav.dat”

Change the selection of “Files of type:” at the bottom of the browser to “All files”

This action opens Excel’s Text Import Wizard (note Step 1 of 3)

Original data type: Select “Delimited”

Start import at row 1 (no header lines), click “Next”…

Select “Space” as the only delimiter, then click “Finish”

Format each of the four columns appropriately:

Format > Cells > Number > Decimal places > 2 (for example)

Insert row at top and name columns A-D as “Line”, “SP”, “X” and “Y”, respectively

Insert three new columns between “SP” and “X”

Name these new columns “UWI”, “KB” and “TD”

We now have seven columns:

A = “Line”, B = “SP”, C = “UWI”, D = “KB”, E = “TD”, F = “X” and G = “Y”

Create a unique well identifier for each pseudo well by combining Line and SP:

In “UWI” column, type the formula: =A2&"_"&B2

This naming convention will concatenate the values in columns A and B

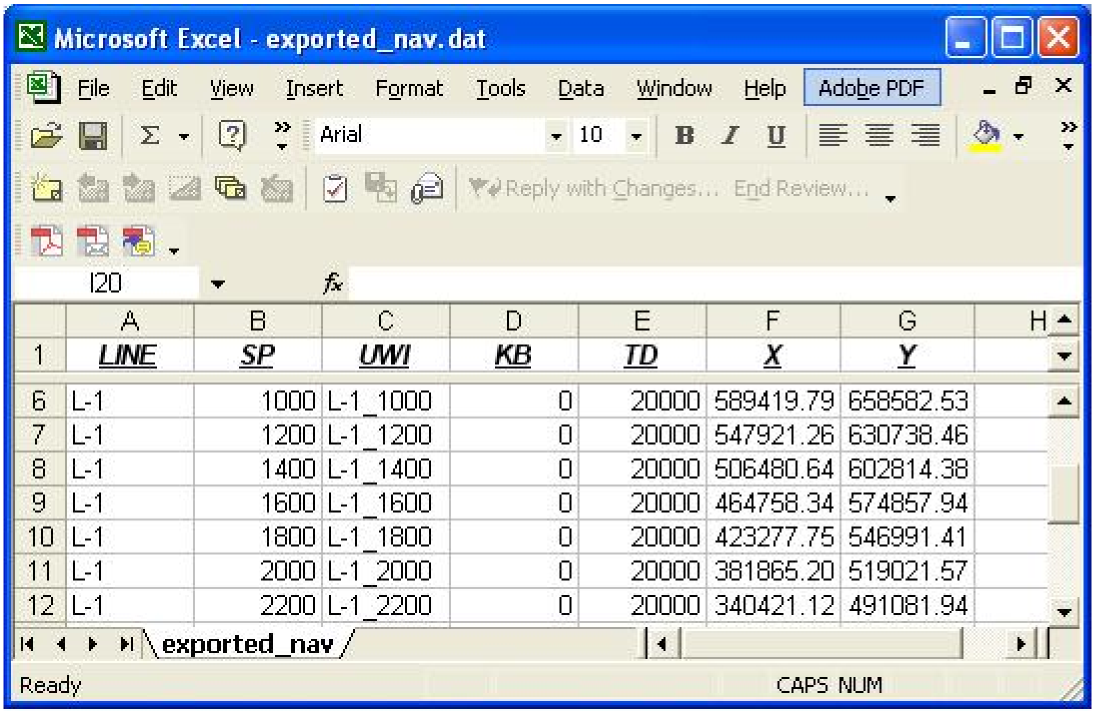
These values are joined by the character shown in quotation marks

Highlight formula, drag to the bottom of column C, then click Control-D

Set value of Column D2 (KB elevation) to 0 (sea level) and copy down for all cells

Set value of Column E2 (TD) to 20000 (20 km) and copy down for all cells

When you have successfully copied down all cells your Excel spreadsheet will look like Figure 3.



	A	B	C	D	E	F	G
1	LINE	SP	UWI	KB	TD	X	Y
6	L-1	1000	L-1_1000	0	20000	589419.79	658582.53
7	L-1	1200	L-1_1200	0	20000	547921.26	630738.46
8	L-1	1400	L-1_1400	0	20000	506480.64	602814.38
9	L-1	1600	L-1_1600	0	20000	464758.34	574857.94
10	L-1	1800	L-1_1800	0	20000	423277.75	546991.41
11	L-1	2000	L-1_2000	0	20000	381865.20	519021.57
12	L-1	2200	L-1_2200	0	20000	340421.12	491081.94

Figure 3: Example of an Excel spreadsheet built from exported seismic navigation data and modified to create an ascii import file for pseudowells located every 200 shotpoints along the seismic line of interest.

Save the spreadsheet in .xls (Excel) format giving it an appropriate name

Open Notepad

Copy and paste all seven columns of data into Notepad

Include the header row if you wish to preserve this information

Save document (.dat format) with appropriate name for ascii import file

Save As > "exported_nav_as_pseudowells.dat"

Now we can import the nav data as pseudowells:

Wells > Import > Wells: click OK in the Well Import wizard

In the File Import / Export dialog click on the Browse button

In the Open Well Data File dialog change "Files of Type" to "Other Files"

Browse to the appropriate directory and select the file to be imported:

“exported_nav_as_pseudowells.dat”

Click Open, then Next

Accept default to “Use UWI as it exists in import data”, then click Next…

This action opens the “Import Well Information File” dialog, and should look like Figure 4.

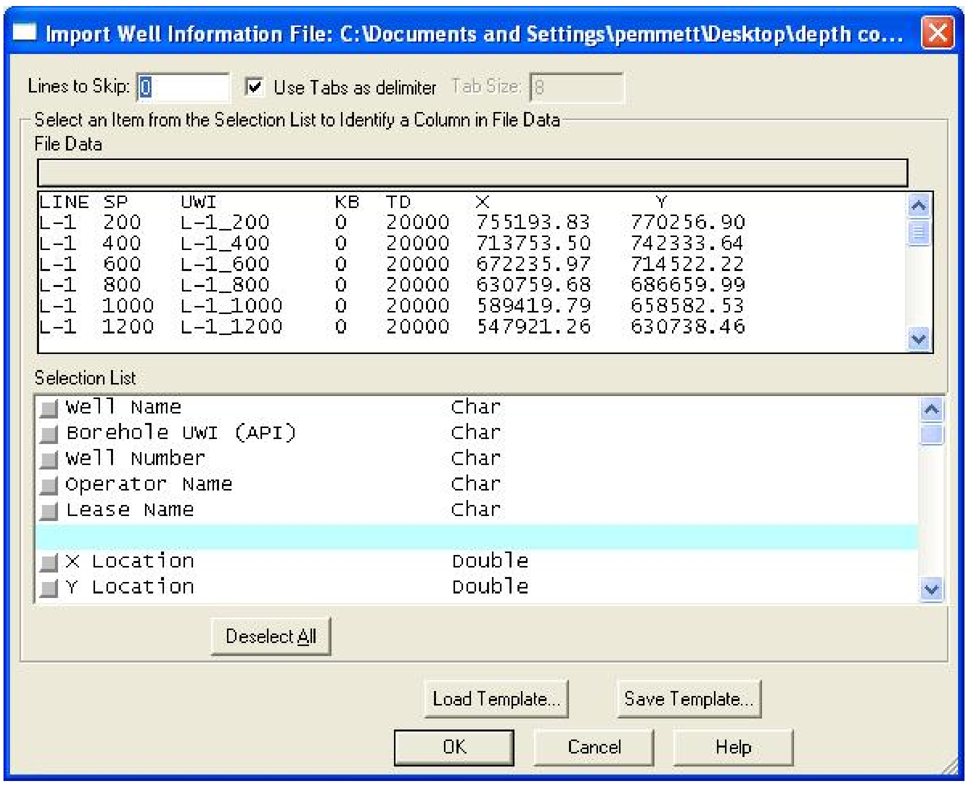


Figure 4: The Import Well Information File dialog as it looks upon import of the ascii well import file shown in Figure 3.

Begin the import process by skipping one line (the header row)

In the Selection List click on “Well Name”

Edit the color-filled column so that it paints only the LINE text

Now click on “Well Number” in the Selection List

Edit the color-filled column so that it paints only the SP values

Now click on “Borehole UWI” in the Selection List

Edit the color-filled column so that it paints only the UWI values

Now scroll down quite a way in the Selection List and click on “Elevation” (not Elevation Reference)

Edit the color-filled column so that it paints only the KB values

Just above “Elevation” in the Selection List click on “Total Depth”

Edit the color-filled column so that it paints only the TD values

Finally, scroll up a bit and do the same for “X Location” and “Y Location”

Tip: You may wish to scroll up and down the vertical range of your import data to insure that none of the data values lie outside the range that is painted by the import wizard. In some cases you may wish to exit the wizard in order to manually edit the import file (a space here and there can fix most allignment problems). In other cases you may wish to re-export the data from Excel in .prn format in order to force a fixed width to your data columns.

When you’ve verified that the columns are properly painted, click OK

Review the Define Coordinate System of Imported Data and click OK

Select a Well Import Option (a “merge” option); Add/Update, click Next

Click Next as no additional changes are needed to Data Import Options

In the Select Depth/Time Type dialog select MD and click Next

Click Next to default values for Well Import Area Limit options

Review Selection Summary and then click Next to initiate well import

Review Import Report, then click Finish to finalize well import

Verify in the base map that the pseudo wells have been imported (you may wish to display them by UWI instead of by Well Name)

Wells > Post Data on Map > Well Information > UWI

Verify that the pseudowells display in vertical profiles (they should only post on the ruler at the top of time displays since not TD Chart has yet been loaded)

2b) Extracting single traces from our T-D data and loading them as TD Charts for pseudowells: Summary: For any given SP that correlates with a pseudowell we will extract the T-D data type as a trace, save it as a text file and then import it into the pseudowell as a TD Chart

Project > TracePAK > Process Single Trace

In the Trace Selection dialog select the desired Survey and SP values

Then select the Seismic Data Type as “T-D”, then click Process

Verify that the Process Trace dialog shows a correct time-depth curve

Save the time-depth curve by clicking Trace > Export Text

Browse to an appropriate directory and give the trace a name

Repeat the last steps to extract and save other traces

Now the T-D traces can be loaded as TD Charts for the pseudowells

In Base Map, Wells > Edit > T/D Charts > verify well selection on list, or
In Base Map, double-click on desired well > Borehole > T/D Charts, or
In Vertical Profile, right click on well symbol > Edit Time-Depth Charts…

In the Time-Depth Charts dialog go to File > Open…

In the Open dialog, browse to the appropriate directory

Select the ascii T-D trace that was exported for this pseudowell

Note that you may have to select the file type Other Files (*.*)

Click “Open” to begin the ascii loading wizard

Skip the appropriate number of header lines

Select Time (seconds) as the Z type for Column 1 (Time/Depth)

Select MD or TVD (they’re the same since KB = 0) for Column 2

Scroll down to insure that the columns are painted correctly

Click OK to finish import and OK to respond to extrapolation warning

Click OK to close the Time-Depth Charts dialog

Click Yes to apply the changes

Click OK once more to respond to a redundant extrapolation warning

Click Yes to overwrite the existing Time-Depth Chart

The borehole of the pseudowell should now display in time sections

Repeat the loading process for other pseudowells

2c) Depth-converting faults using local and / or shared TD Charts

Simply go to Faults > Convert Fault Surfaces - Time < > Depth

In the dialog select the wells to use (all?) and the faults to convert (all?)

Be sure to make the radio button selection for Time-to-Depth or Depth-to-Time

Click OK; the depth-converted faults should now display in a depth profile

Summary:

The workflows documented above illustrate in detail the conversion of seismic traces, horizons and faults from time domain to depth domain. Several options are prescribed to match the data available for conversion to specific workflows. In each case presented the depth conversion of the interpretation products is consistent with the depth-converted seismic traces.