Acoustic Waveform Processing

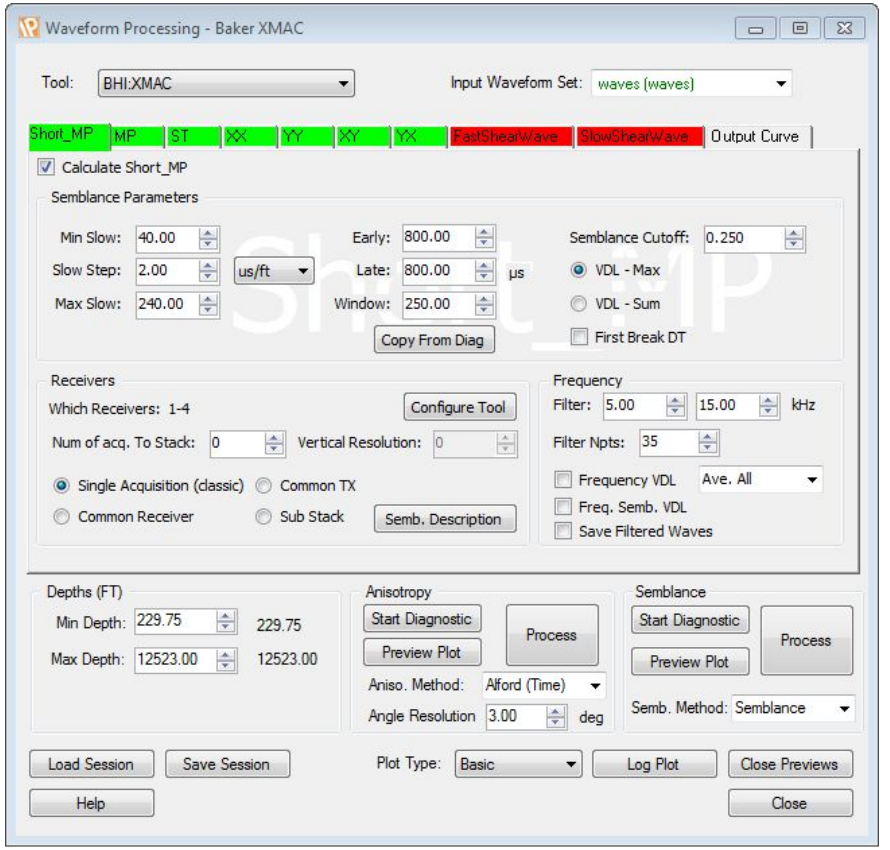
Workflow primer

Lloyd's Register Energy

Working together for a safer world

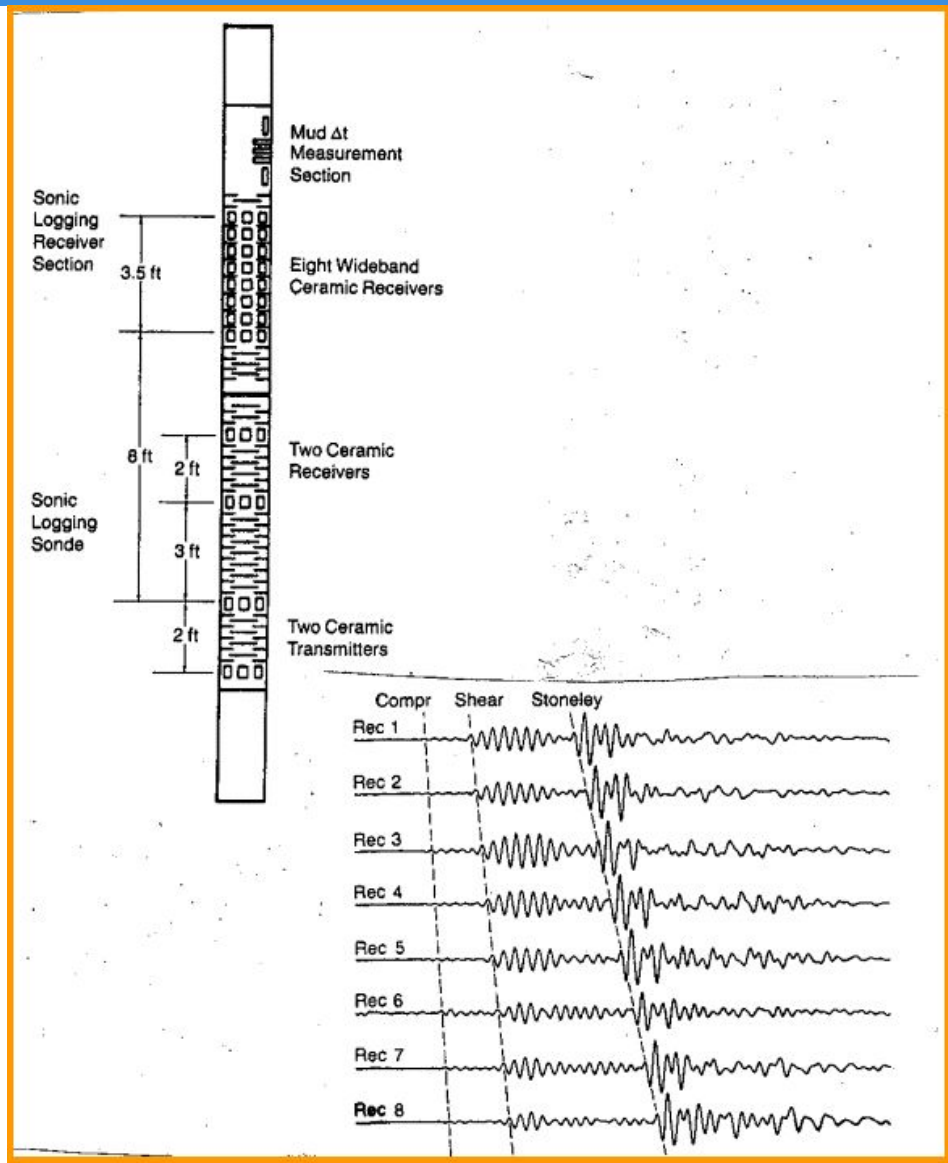
System requirements

- x64 better because wells can be ~4GB
- Memory: overhead is about 250MB per core
- CPU: more physical cores = faster, currently tops out at using 8 physical cores (Intel's Hyperthreading doesn't count as extra cores)
- Matlab 2015a: you're prompted to install it if it is not there.
- Patience because processing is time consuming



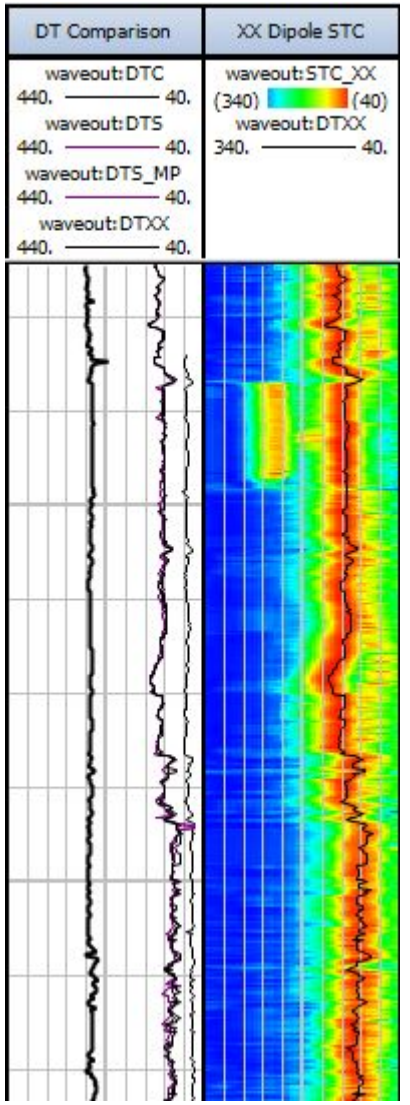
Introducing the data

- This module processes sound waves: examining the ‘types’ of waves their speed through the rock
- The speed of sound in rock can tell us about the type of rock, fluid content and what stresses the rock is under
- A typical Acoustic tool is pictured
- Some standard-looking raw-data is show bottom

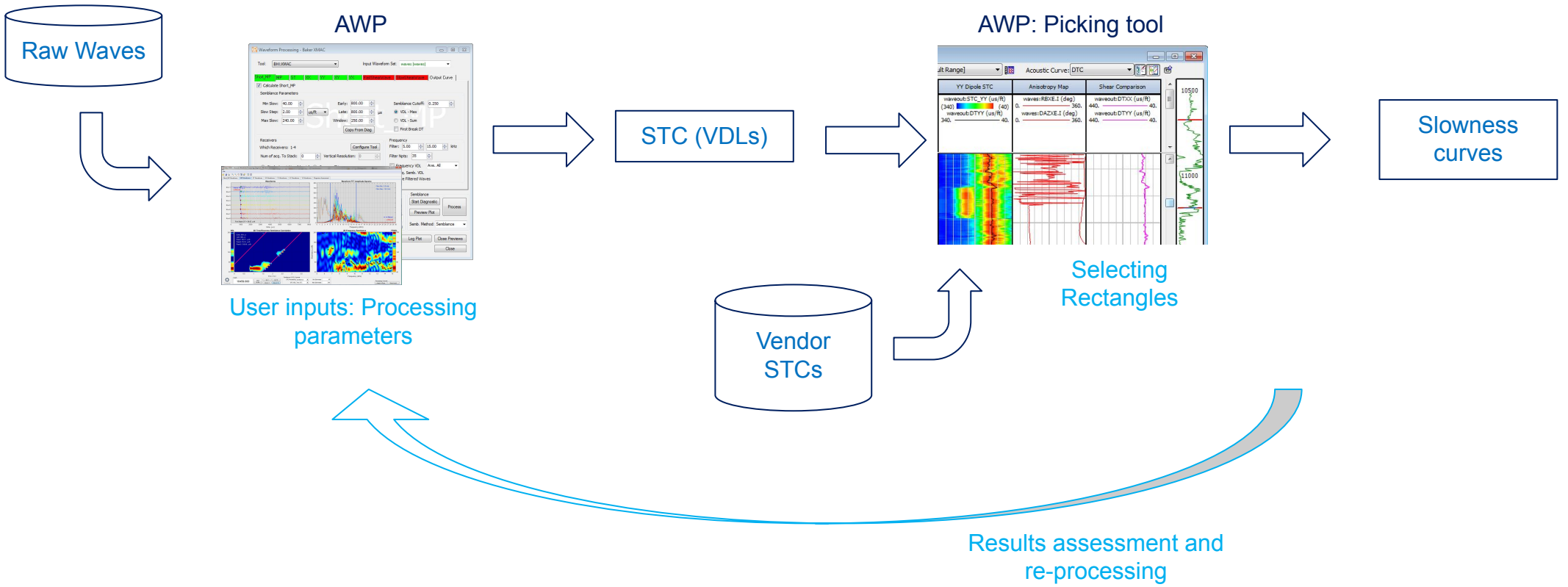


Designed-for Workflows

- Most often, our clients are looking to *verify* the work of others with this module (so our results should generally agree)
- We see a few different uses of the module:
  1. Re-working other's processed data to correct their errors
  2. Re-processing the raw data to verify someone else's interpretation
  3. Re-processing the raw data to derive new information
- Very often the outputs of this module are inputs to other modules (from PhiSw to Geomechanics)



General Workflow: Slowness



Key:

From DLIS

AWP output

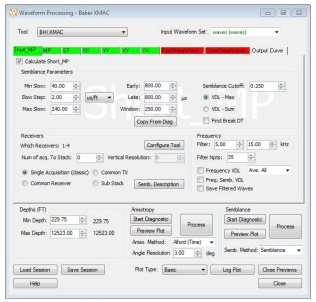
*Slowness is the inverse of Speed, so is seconds-per-metre rather than metres-per-second

General Workflow: Anisotropy

Raw Waves

Slowness curves: DTXX and DTYY

AWP

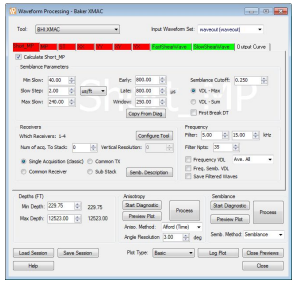


User inputs: Anisotropy parameters

Anisotropy Map

Fast Waves

Slow Waves



User inputs: Processing parameters

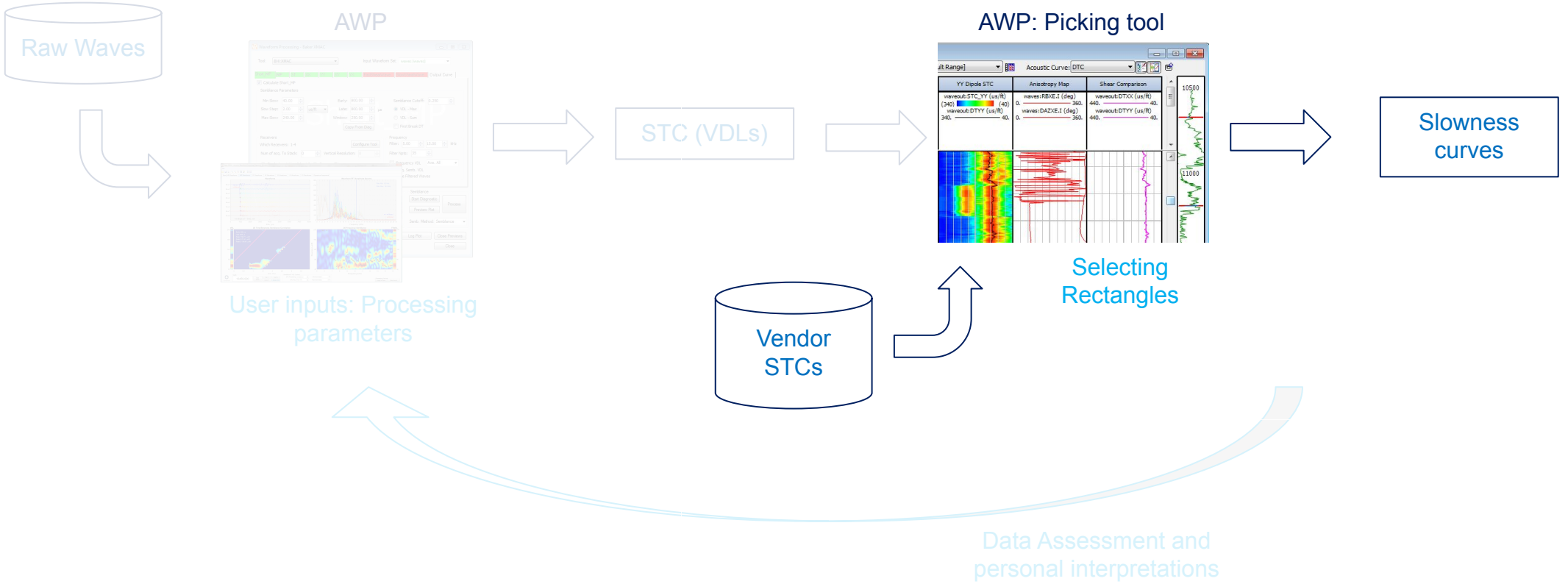
STC (VDLs)

Dispersion Outputs

Key:

From DLIS

AWP output

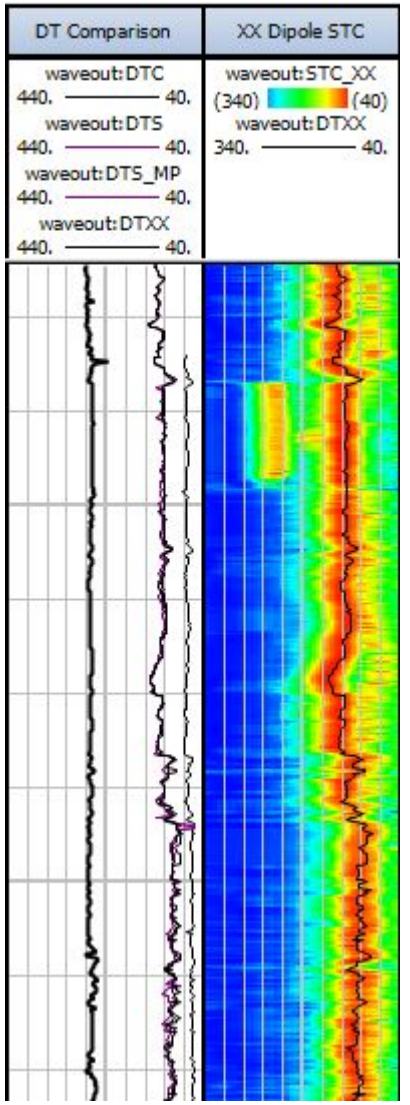


Slowness from other people's processing

WORKFLOW 1: RE-PICKING

Workflow 1: “Re-picking”

- Re-working other’s processed data to correct their errors
- The most trivial use of the module
- Vendors have already created a processed product, we are using that to pick new answers
- Our steps:
  1. Select tool & output set
  2. Present the VDLs using AWP
  3. Drag a rectangle
  4. Enter basic data if needed
  5. Pick until happy



Workflow 1: “Re-picking”

Unfortunately Fossetmaker has no data to perform this task

1. Select tool & output set
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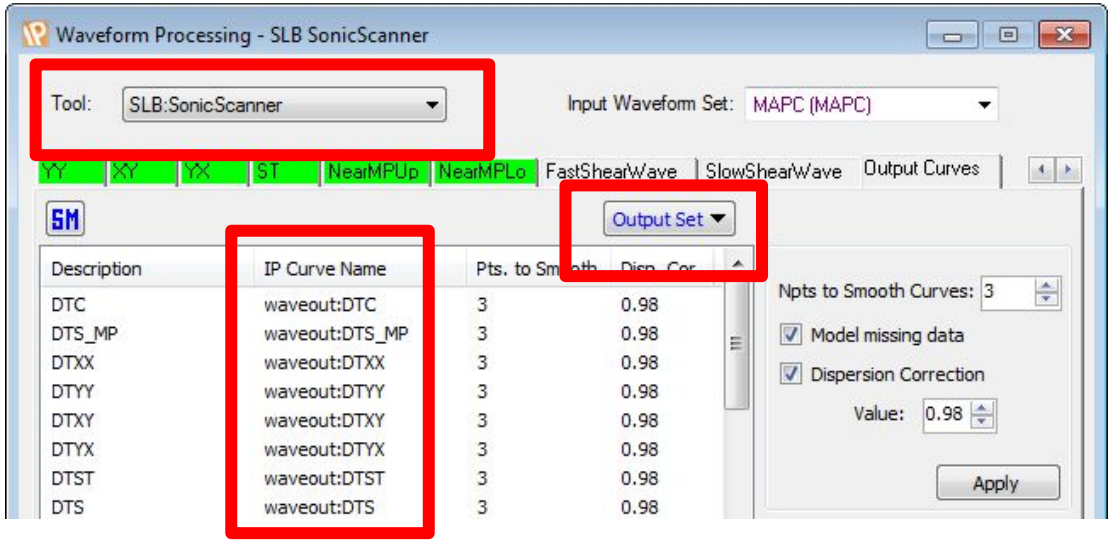

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1. Select tool & output set
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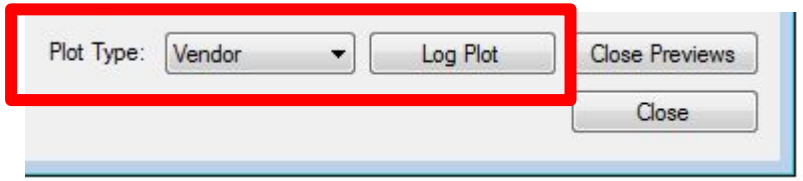

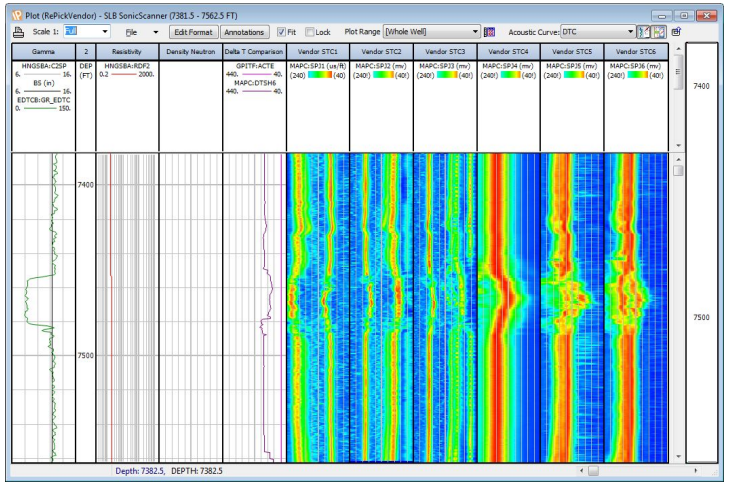

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1. Select tool & output set
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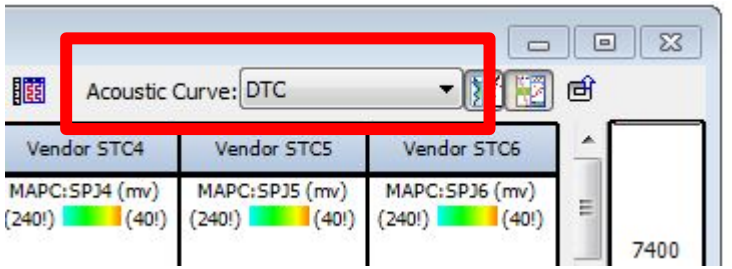
3. Hit the Drop-down for the curve you want to make



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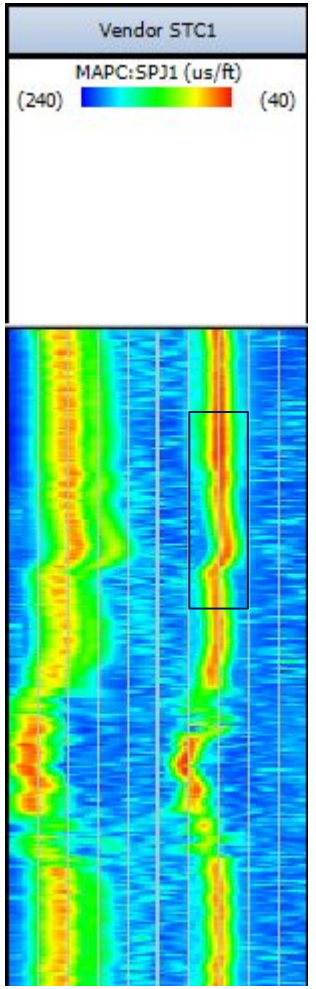

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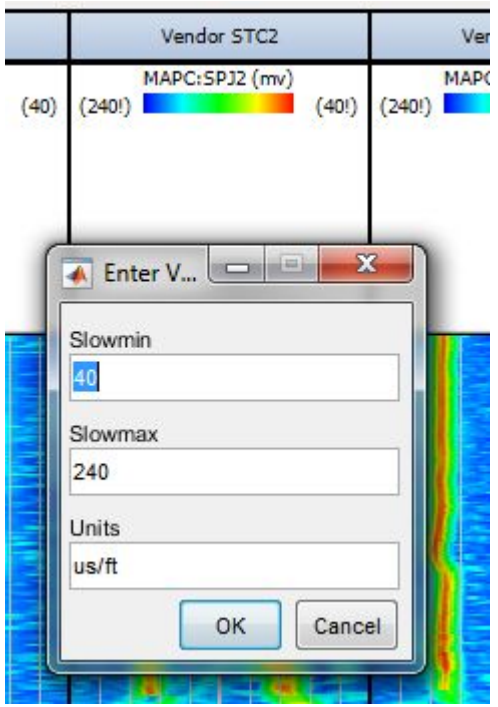
5. On first rectangle, you should be asked “What are the scales”, also note the !’s on the scales… this is IP telling you that it does not know the scales of *the data*



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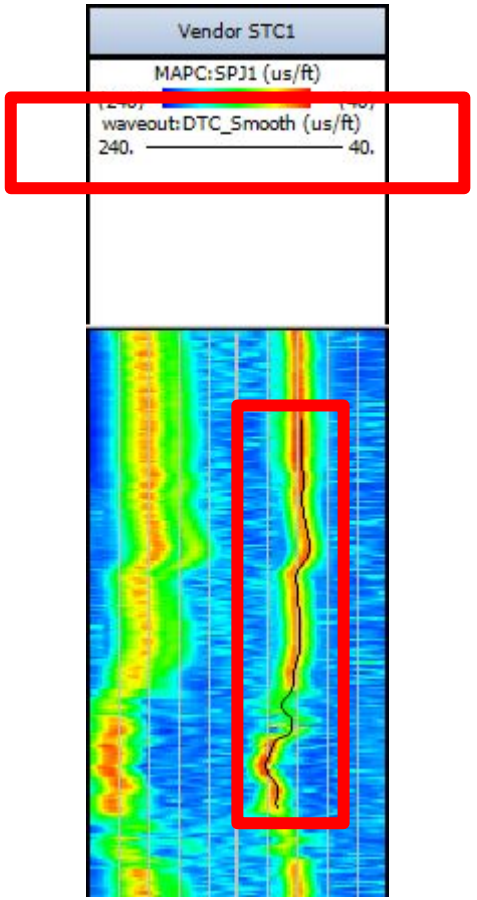
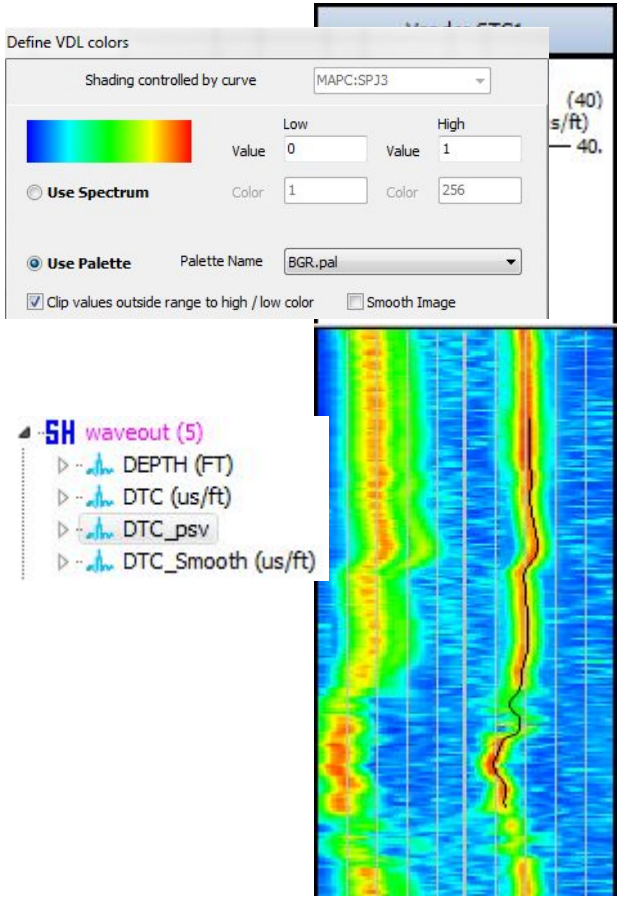
6. Rectangle picking can continue, picking whatever…

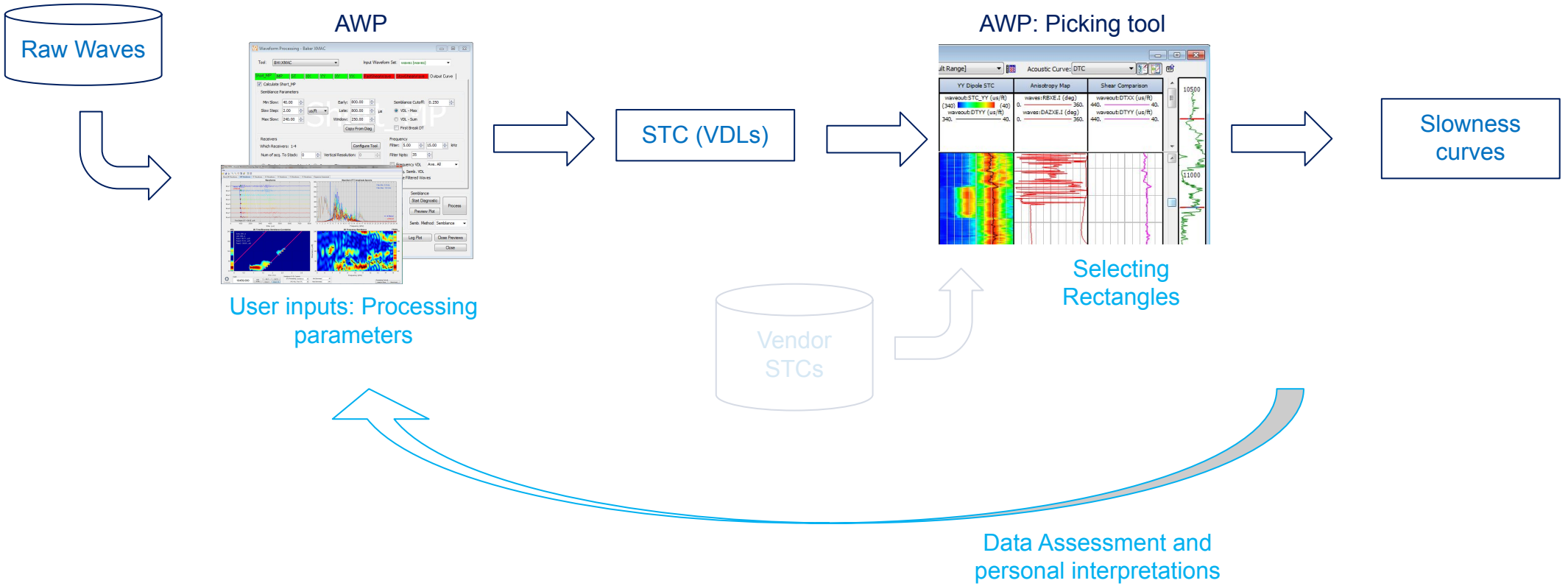


Workflow 1: “Re-picking”

Notes on Rectangle picking:

- Selections are made from one VDL at a time
- Default scales are 0..1 some vendors use 0..100!
- 3 curves are made: the curve name you picked from the dropdown (step 3 above), a smoothed version and a _psv “peak semblance value” curve, representing the height of the VDL colour map and is a quality indicator



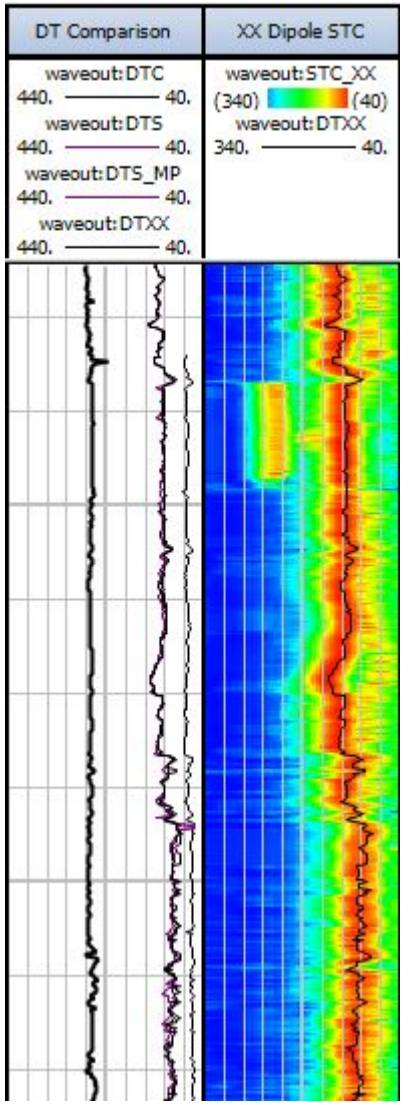


Slowness from my own processing

WORKFLOW 2: PROCESSING RAW

Workflow 2: Processing Raw Waves

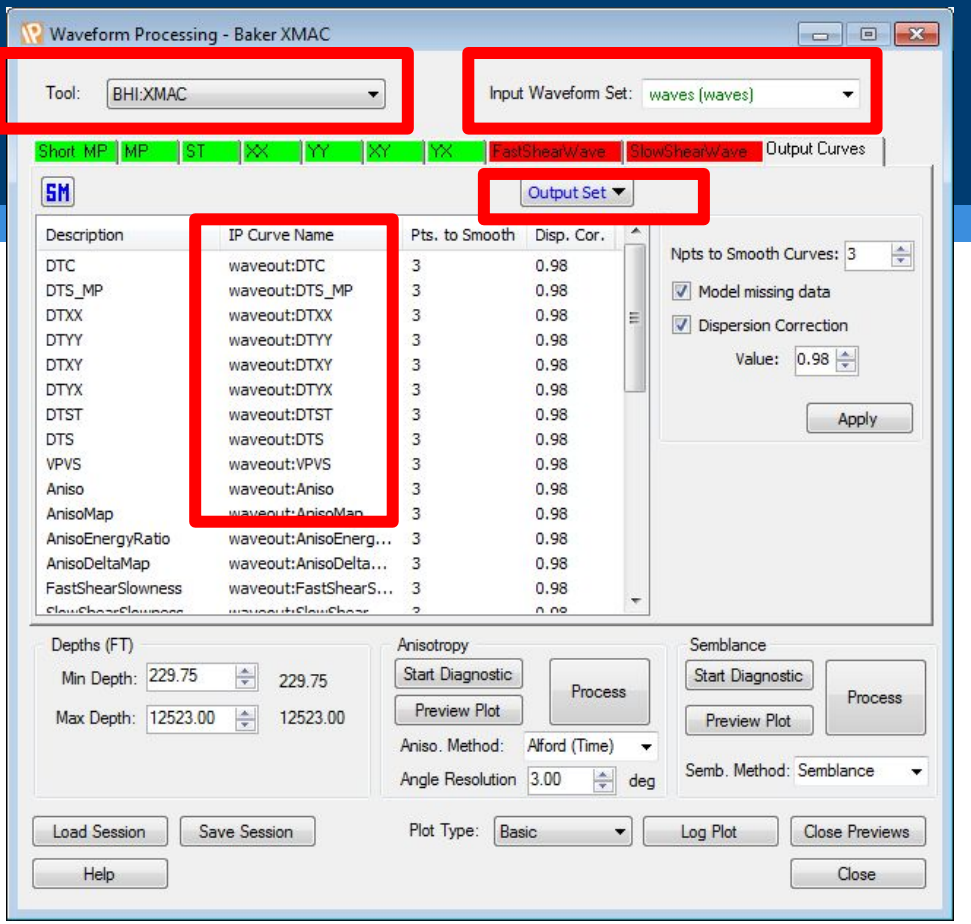
- The picking part of this workflow is the same
- Bulk of the processing work here
- Our steps:
  1. Select tool, input & output sets
  2. Deactivate the modes you don't want to process now
  3. View Diagnostic pane
  4. Set up parameters in Diag. or manual
  5. Process or Preview
  6. Return to step 4, refining parameters or processing interval

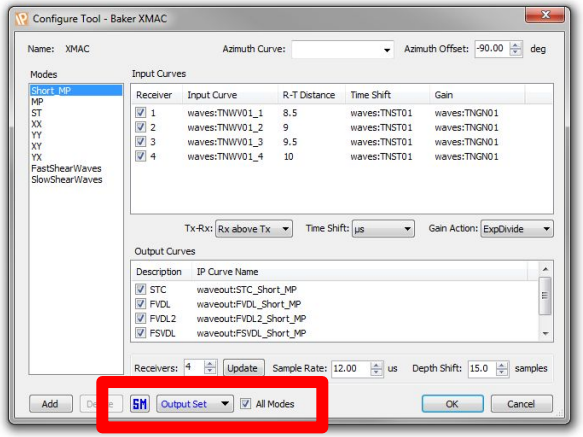


Workflow 2: Processing Raw Waves

1. Select tool, input & output set
   a) ‘Tool’ specifies the ‘modes’ (Short_MP, MP, ST etc..) and output curve names
   b) Output set in Output Curve tabs is where *some* outputs go
   c) Output set in Configure Tool is where most Array outputs go
   d) Input Waveform Set is where to pick up the raw waves from (shown in Configure Tool)

You should inspect both Output Curves





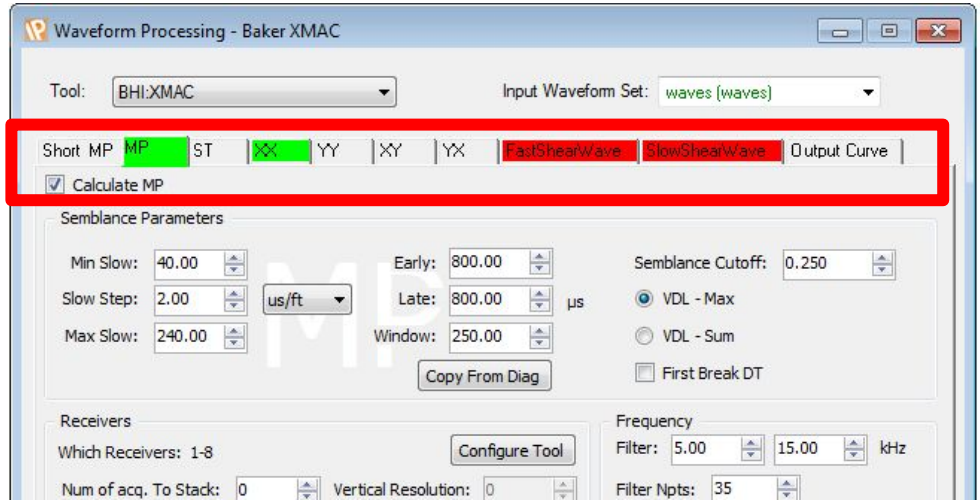
Workflow 2: Processing Raw Waves

2. Pick the Modes you want:
   a) Un-check the “Calculate ??” to turn off ??
   b) Today we want to process MP but not any others

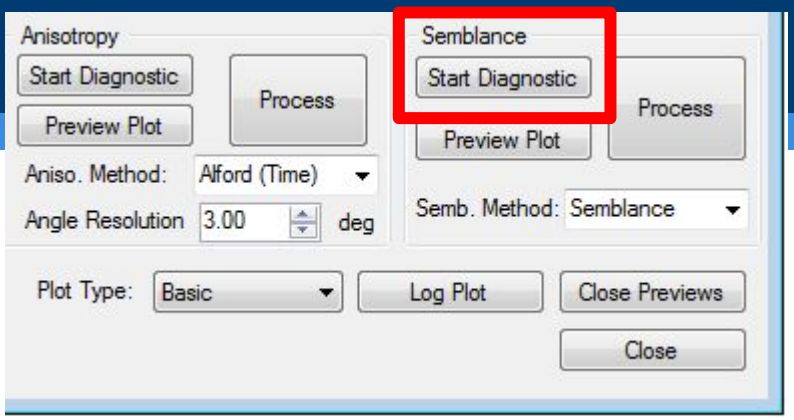
Grey tab = no process

Red tab = no waves, can’t process

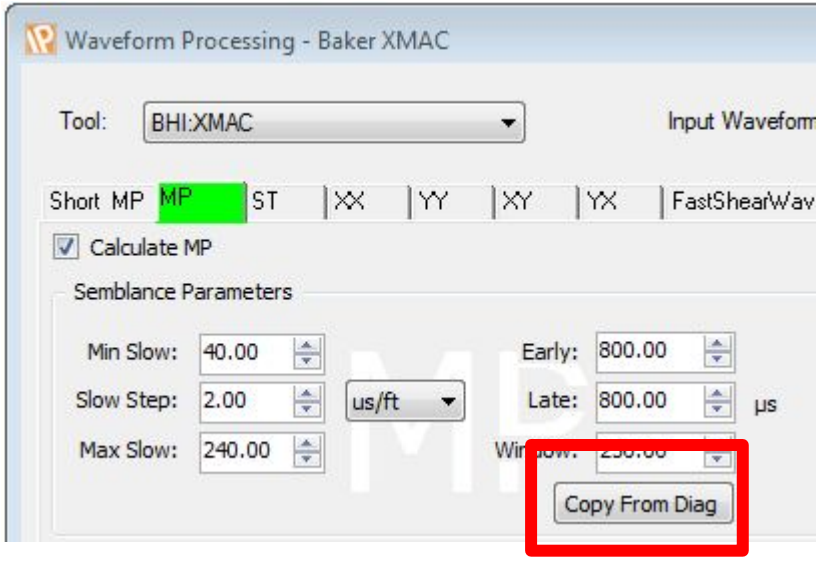
Green tab = have waves will process

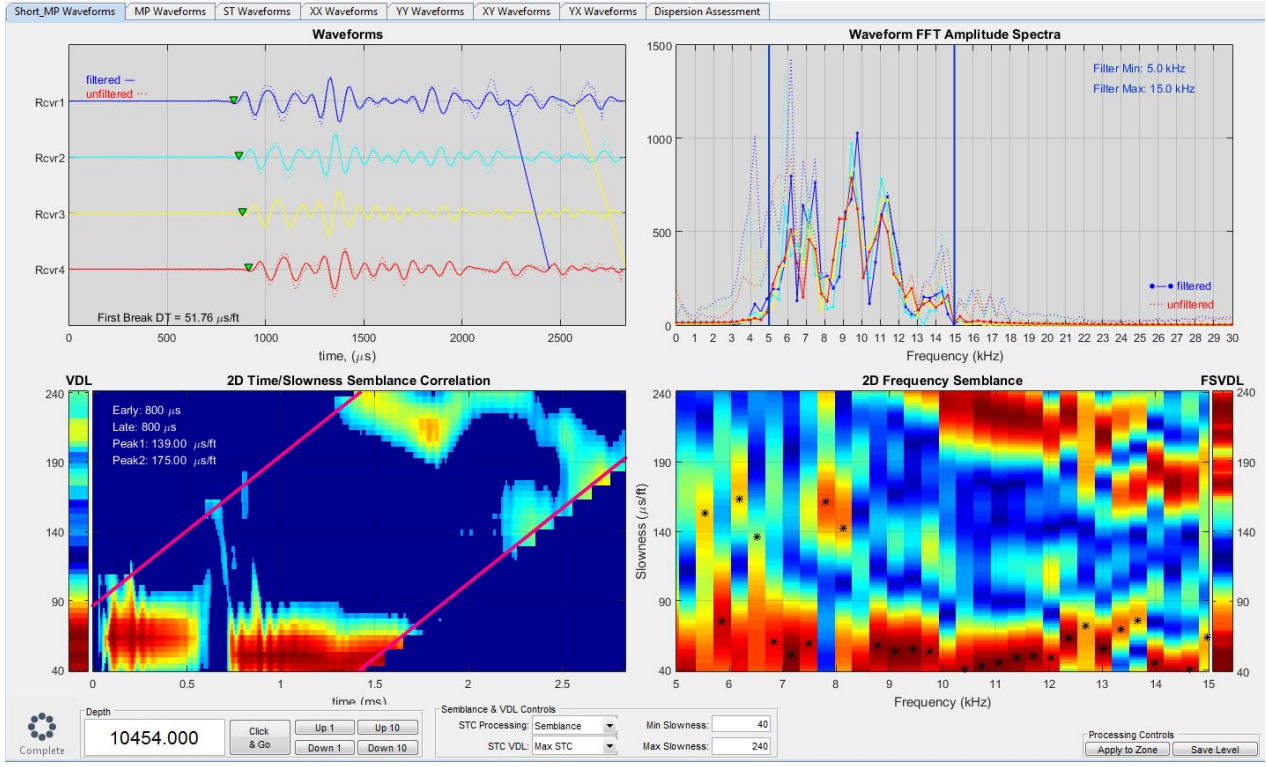


Workflow 2: Processing Raw Waves

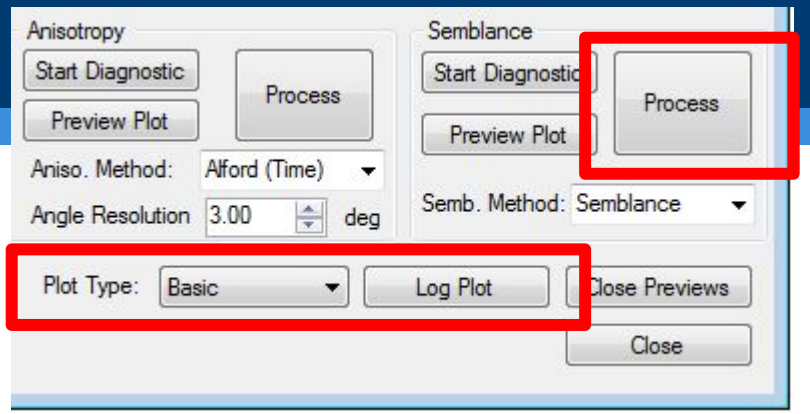


3. Start Diagnostic Pane
   a) Here we view and modify processing parameters visually
   b) All tabs that can be green are shown (because it's very convenient to compare)
   c) Interactive lines… yay!
   d) Copy from Diag

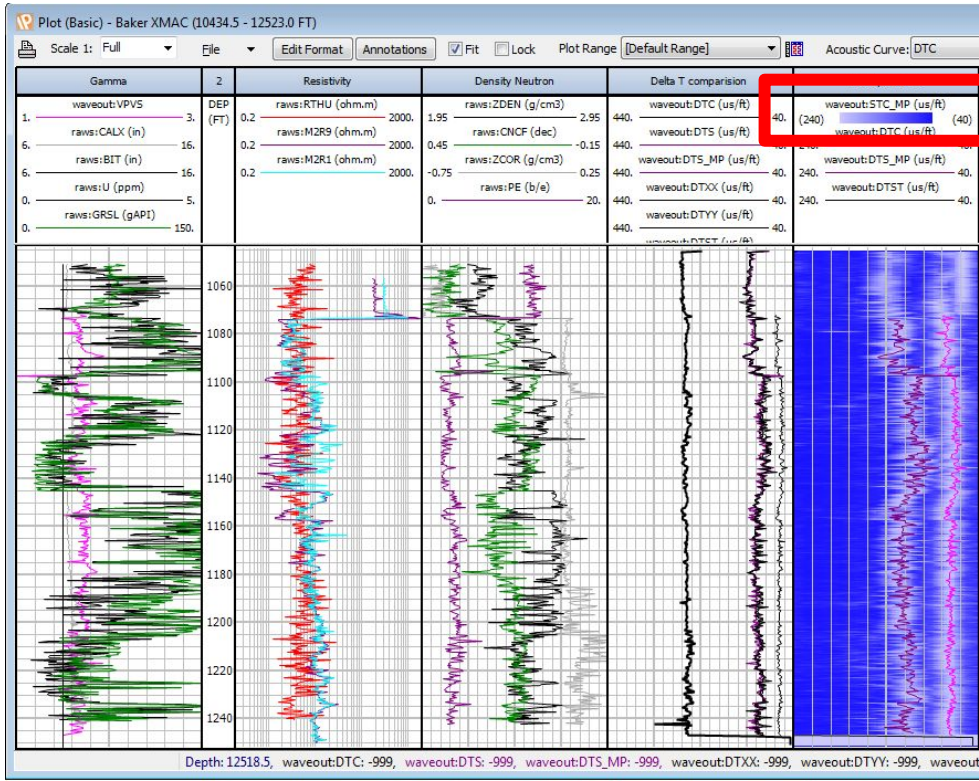




Workflow 2: Processing Raw Waves

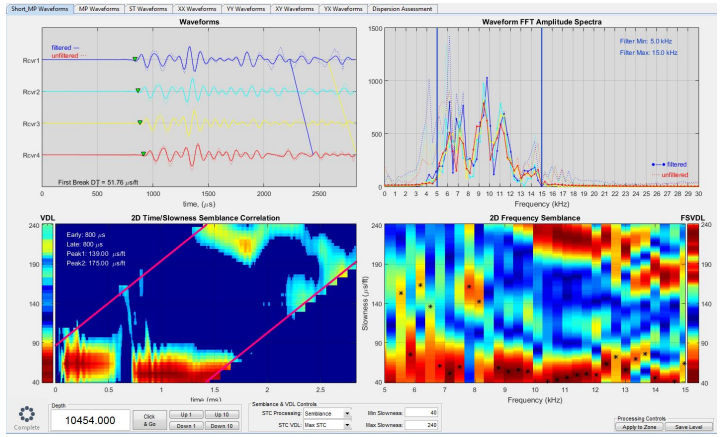


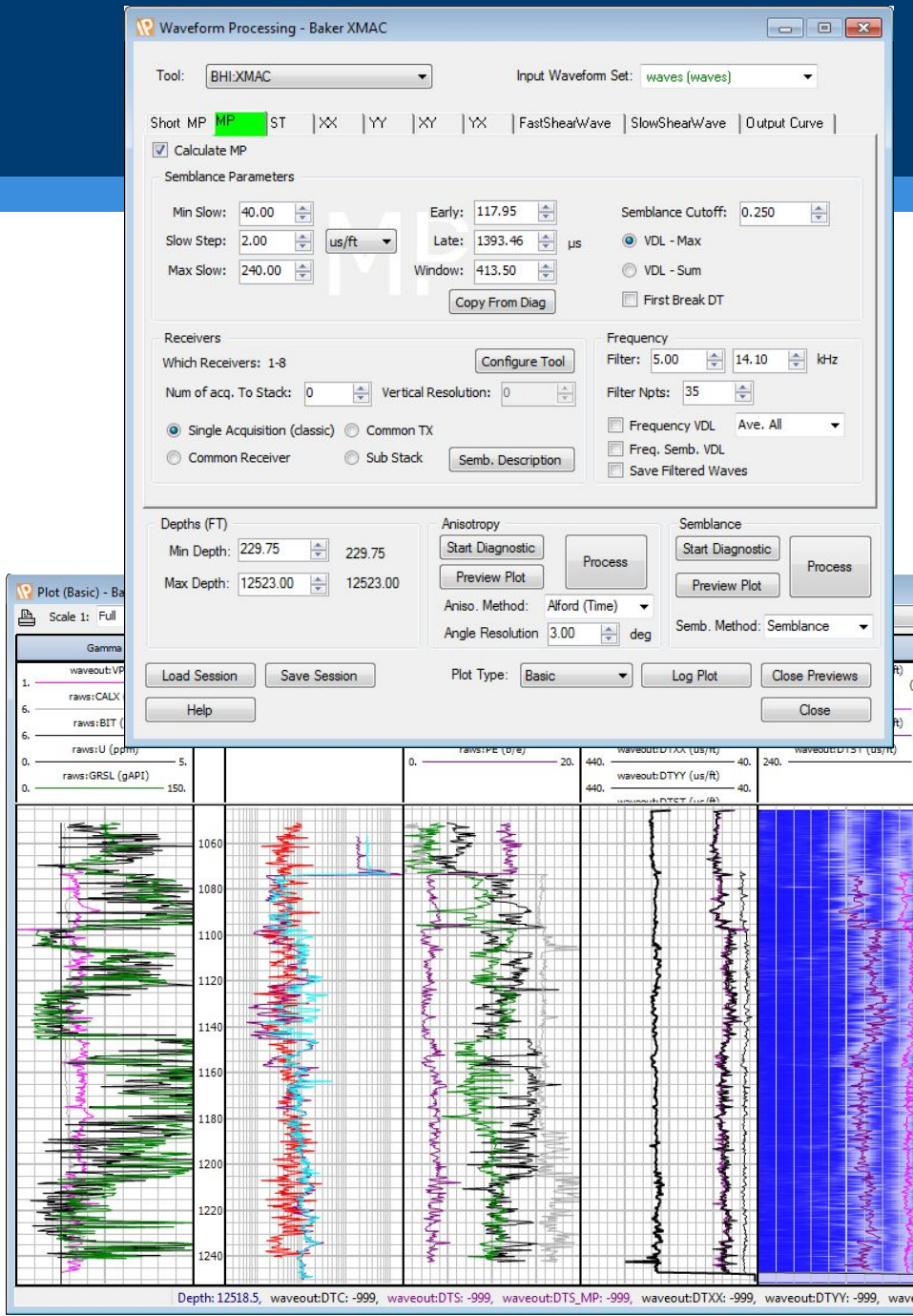
3. Process whole well
   a) Using Diagnostic we'd pick general parameters that work most places and process the whole well
   b) Hit the Process button
   c) Processing can take a while (about a minute for MP on this well)
   d) Output is an STC_MP, which we can use in the picking process outlined in Workflow 1
   e) Launch a 'Basic' Log plot, then pick DTC etc. like in Workflow 1



Workflow 2: Processing Raw Waves

4. Process whole well
   a) After seeing the whole well, we may choose to reprocess all or part-sections
   b) Ordinarily this is driven by inspecting problem sections with Diagnostic window, re-adjusting parameters and processing the bad parts again
   c) Once happy with the STC outcome, can re-pick DTC etc. again

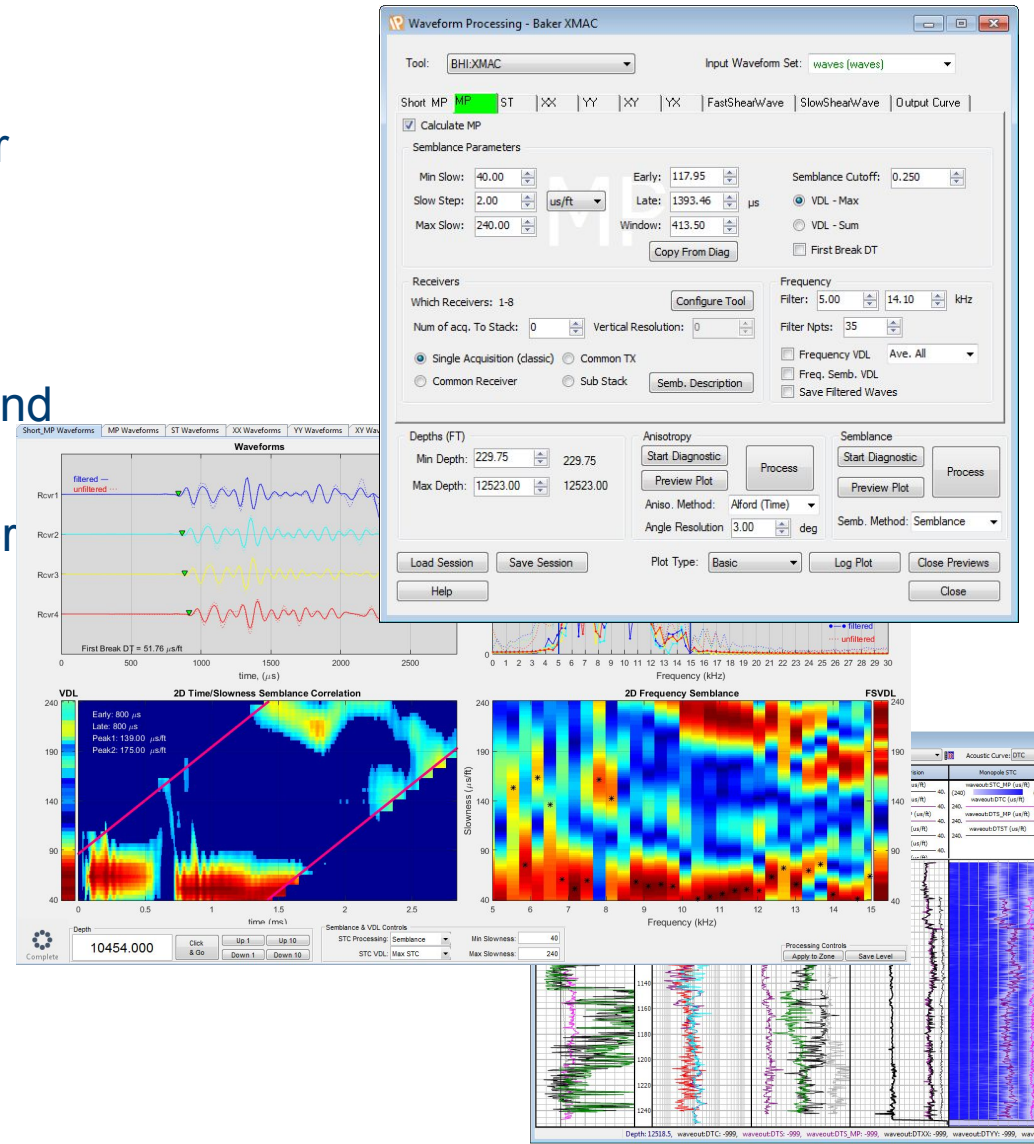


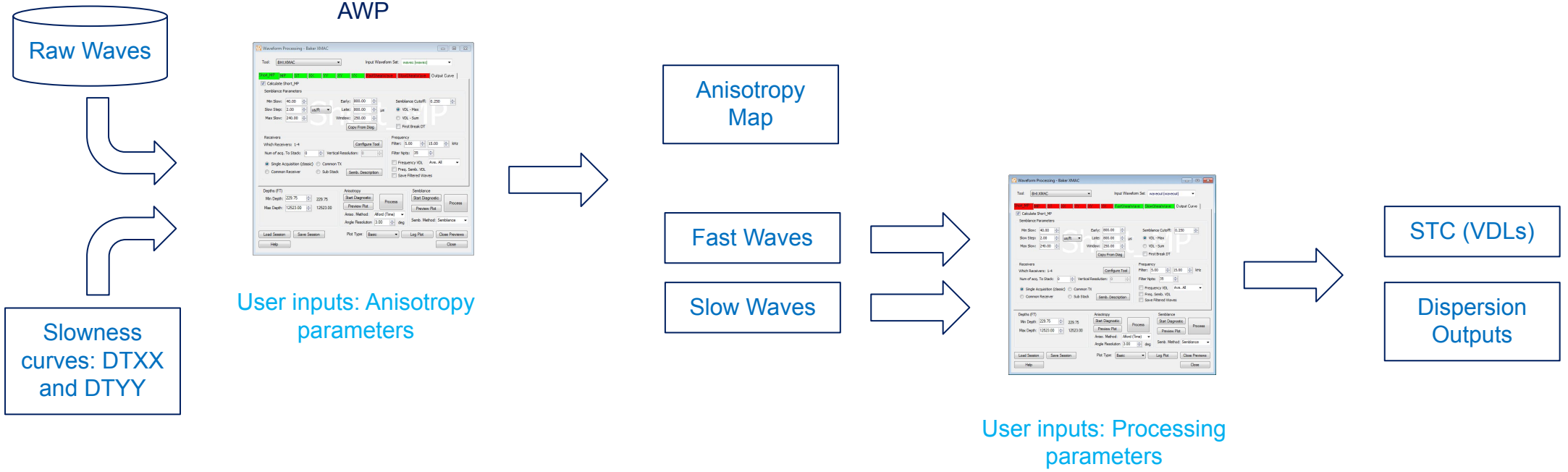


Workflow 2: Processing Raw Waves

Notes on processing:

- Like everything else in IP, there's no 'right' answer
- Changing parameters can make yours look very different: don't get too hung up
- There are many different ways to process and interpret (NthRoot, Common Rx, VDL Max/Sum and lots of parameters…) so expect variation
- But! Same settings should make the same answer in the same well



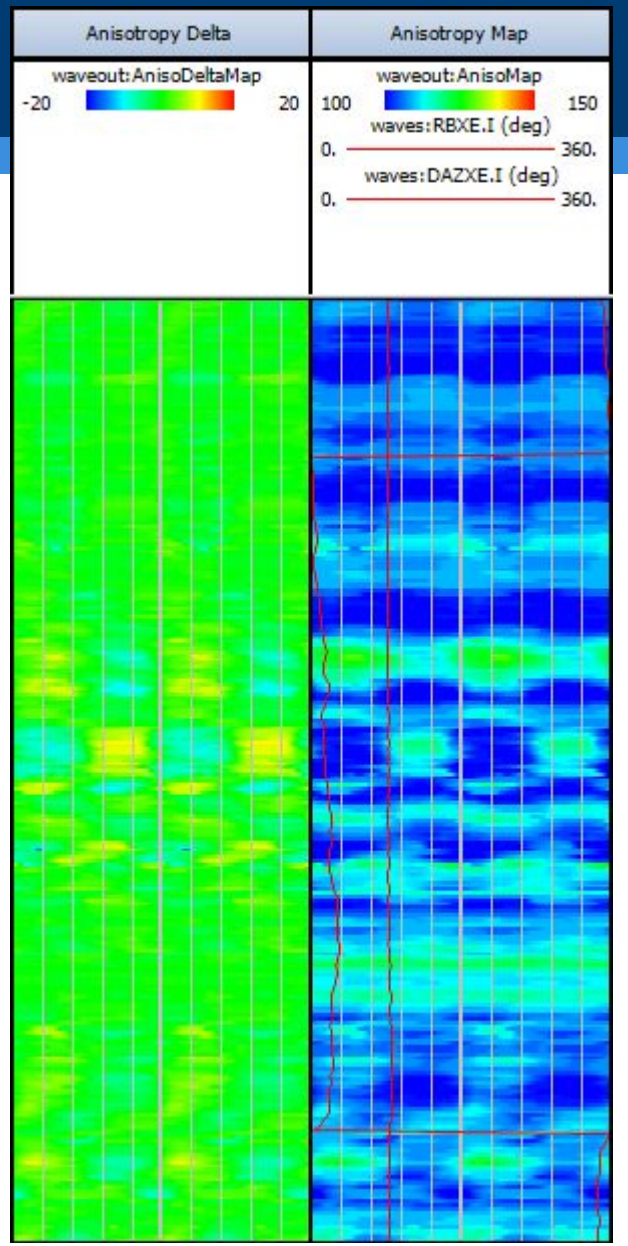


Azimuthally changing slowess

WORKFLOW 3: ANISOTROPY

Workflow 3: Anisotropy Processing

- The most time consuming and tedious
- Fairly simple to run… kind-of
- Our steps:
  1. Select tool, input & output sets
  2. Process XX & YY for DTXX and DTYY as shown in Workflow 2
  3. View Anisotropy Diagnostic pane & parameter outcomes
  4. Process or Preview
  5. Return to step 3, refining parameters or processing interval
  6. Process FastWaves and SlowWaves as in Workflow 2, with additional outputs



Workflow 3: Anisotropy Processing

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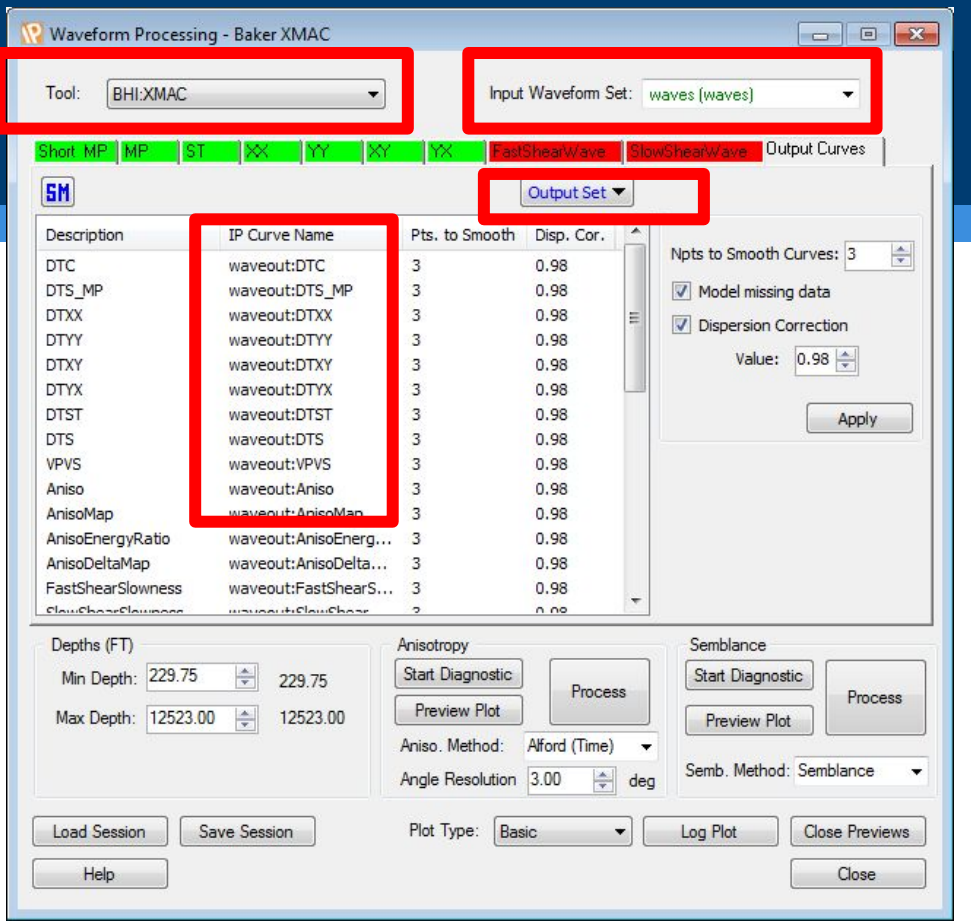
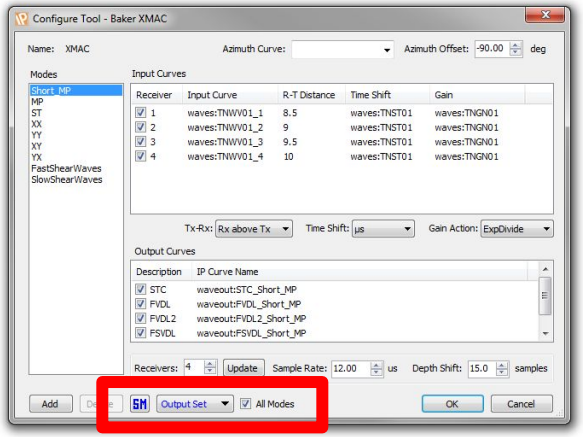
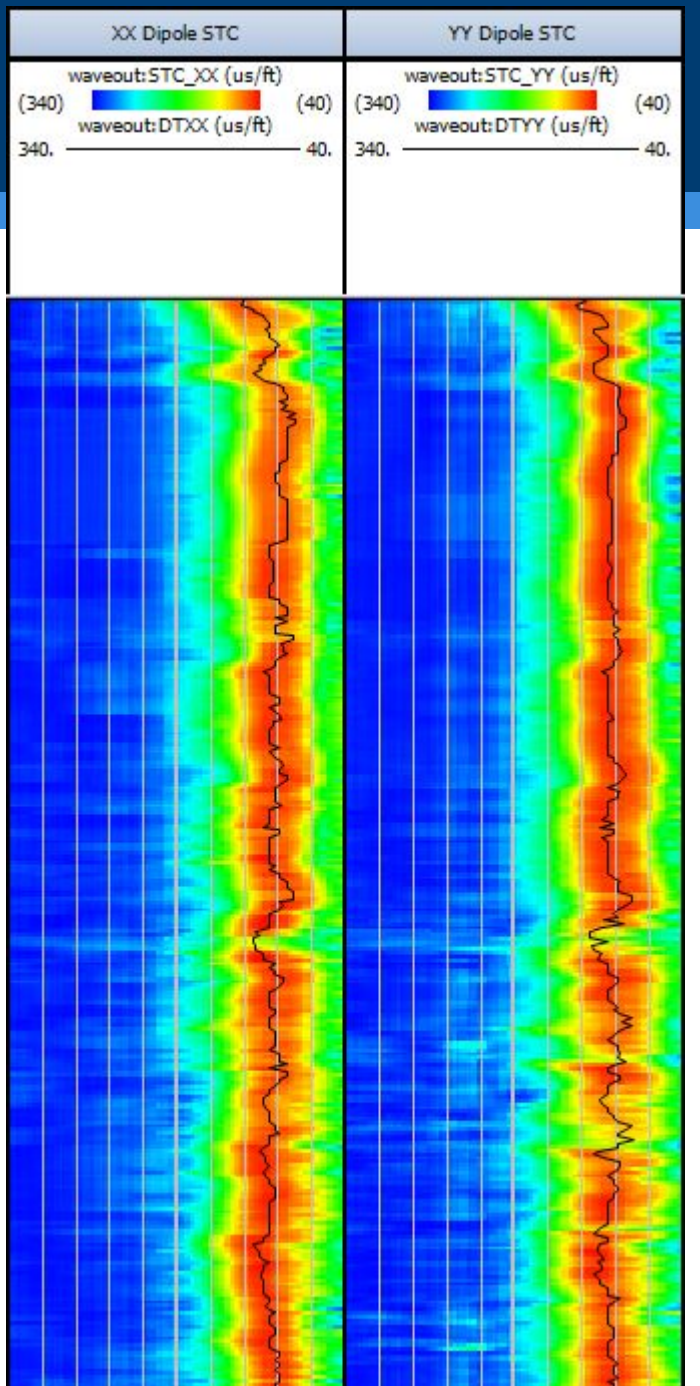


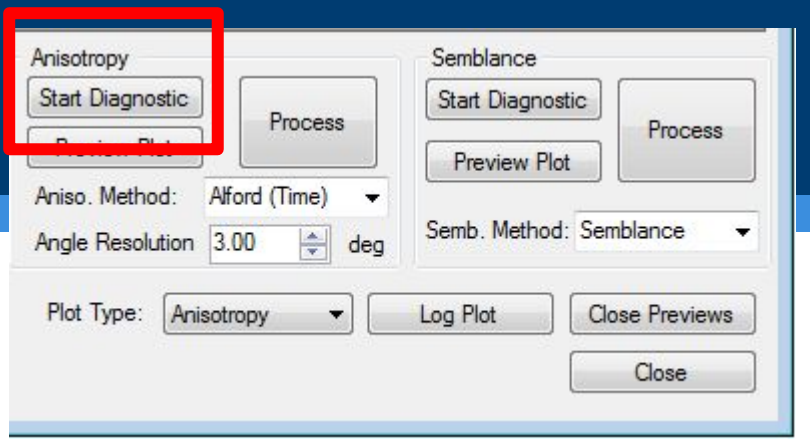


Workflow 3: Anisotropy Processing

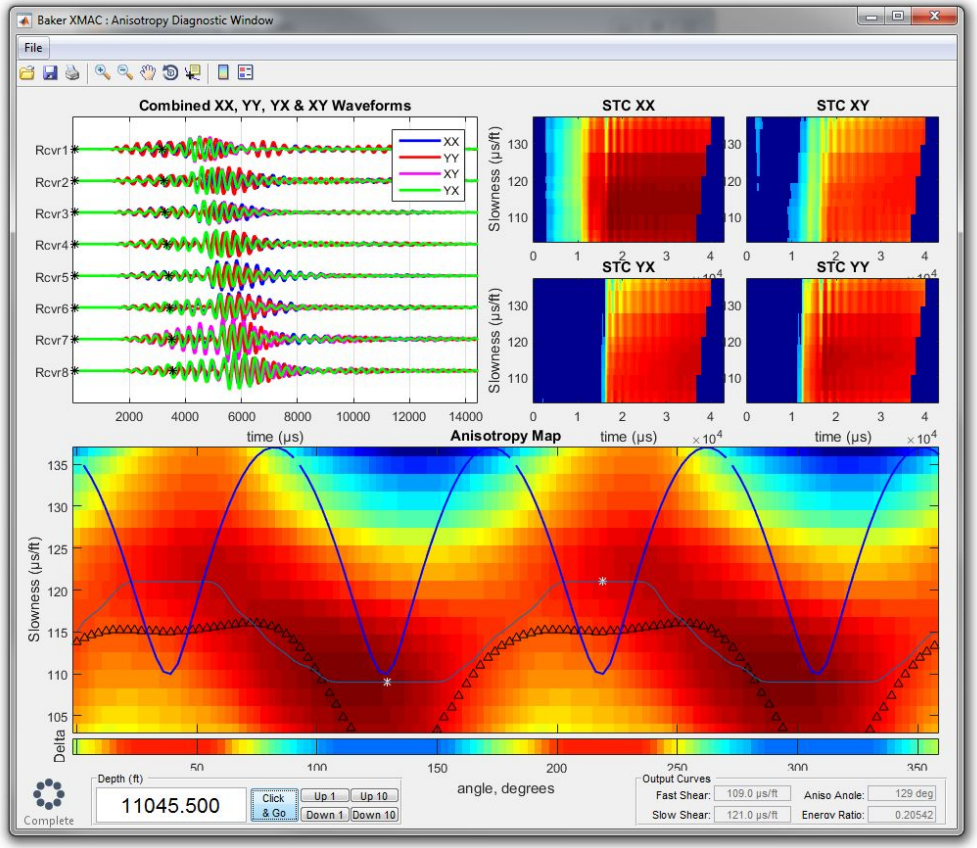
2. Process XX & YY for DTXX and DTYY
   a) Using Workflow 2 you need to create a DTXX and DTYY; invalid DTXX or invalid DTYY prevent anisotropy being calculated at that depth



Workflow 3: Anisotropy Processing

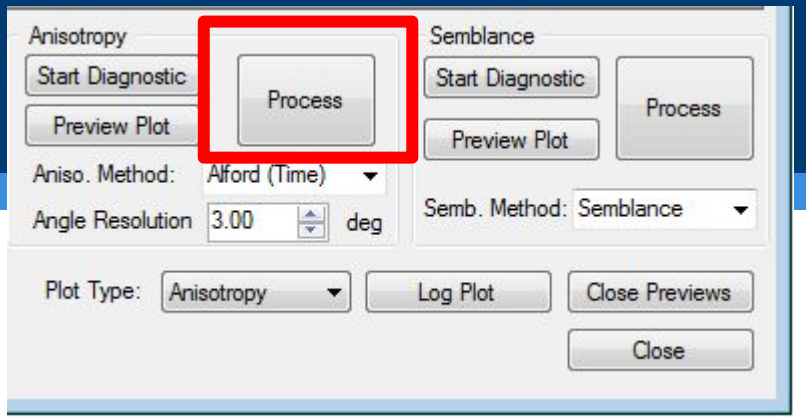


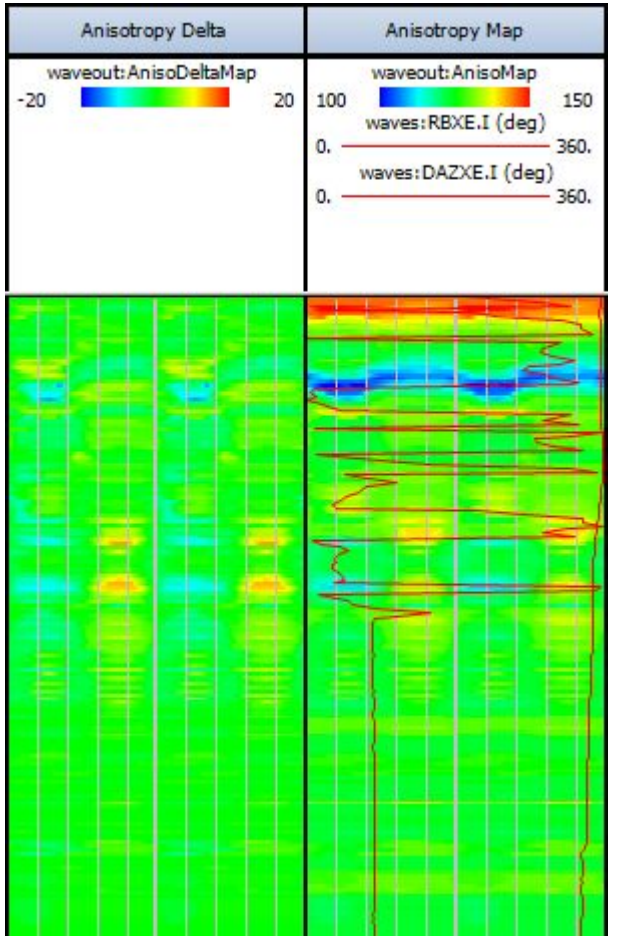
3. Inspect the Diagnostic Window for Anisotropy
   a) This shows all the waveforms used, how semblance looks for each mode (XX YY XY and YX) and the Anisotropy outputs
   b) There is no interactivity on the plots in this window
   c) All processing parameters are inherited from the XX tab, therefore it's useful to alter XX parameters in the other diagnostic window then review



Workflow 3: Anisotropy Processing

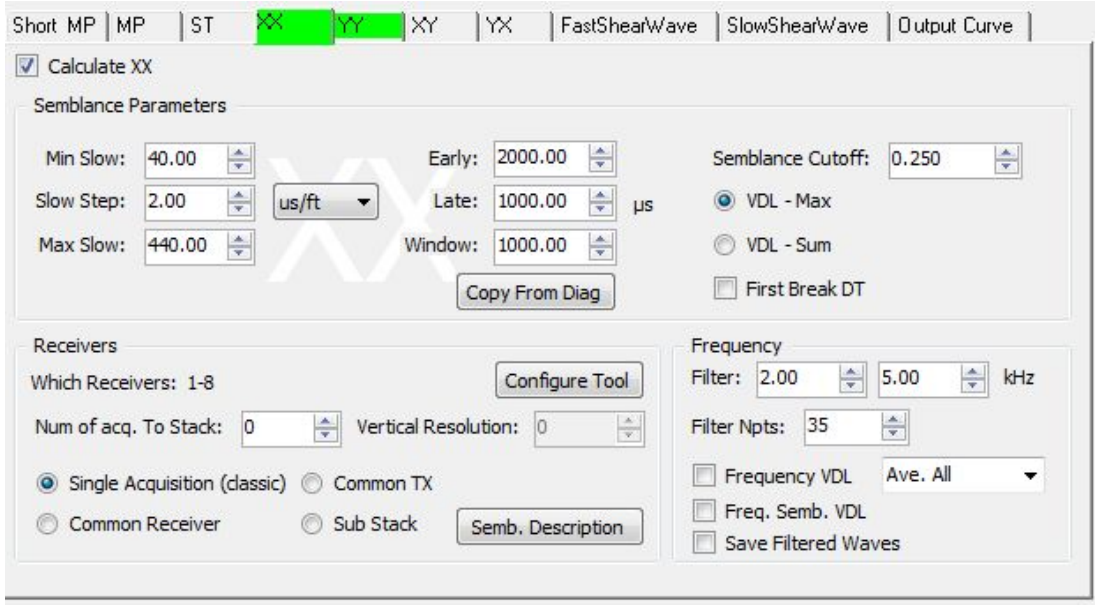
4. Process for Anisotropy
   a) This takes a long time!
   b) A very long time!
   c) For sanity, work on 100ft sections unless you are departing for lunch

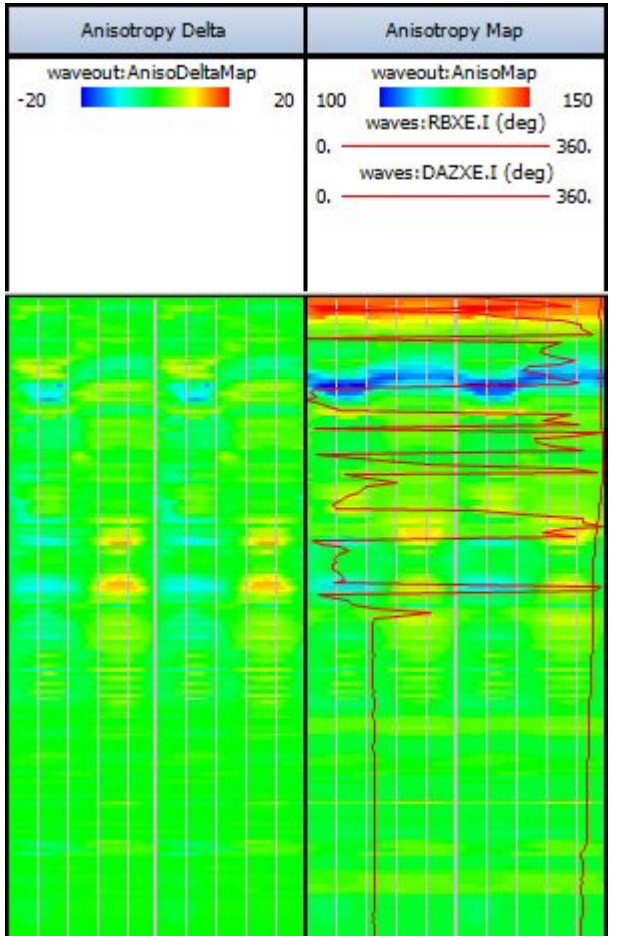




Workflow 3: Anisotropy Processing

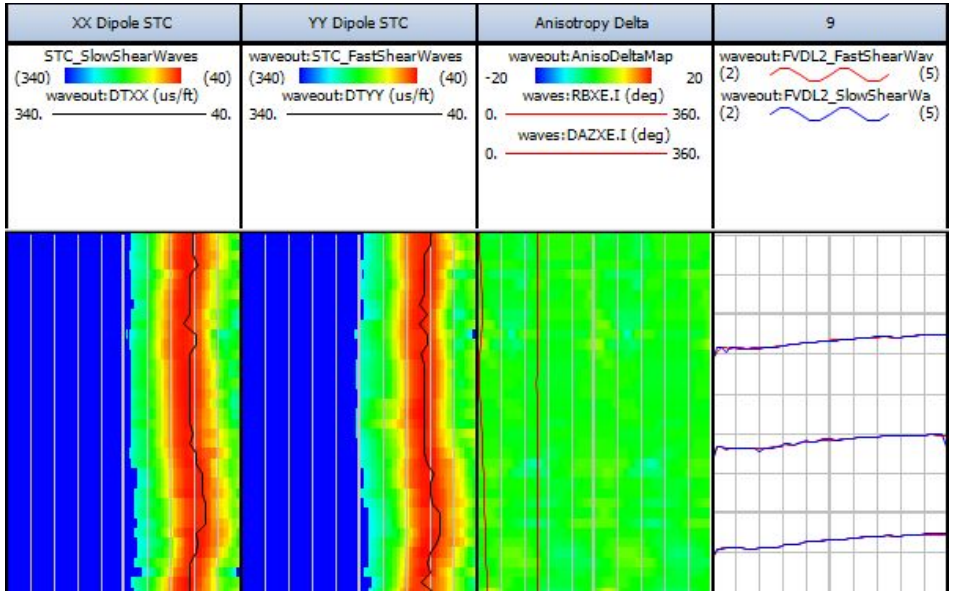
5. Refine parameters
   a) Parameters used for Anisotropy come from the XX tab
   b) Use the XX tab to control time & filtering

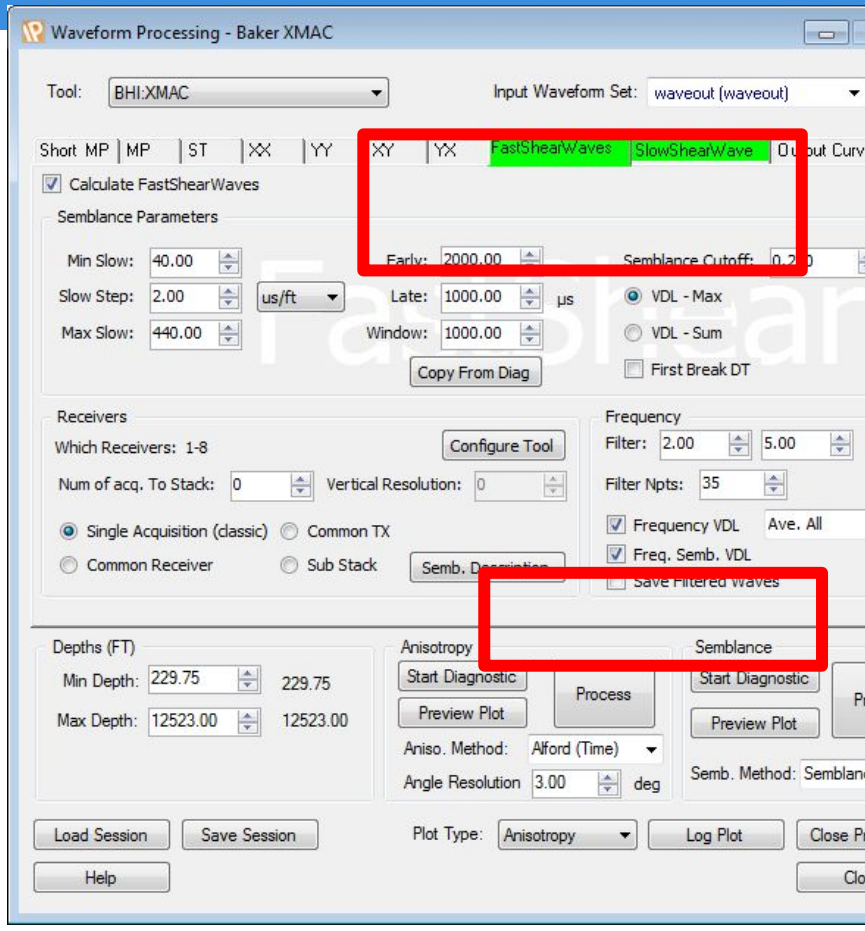




Workflow 3: Anisotropy Processing

6. Process FastWaves and SlowWaves
   a) Switch the Input Waveform Set to pick up FastShearWaves & SlowShearWaves
   b) Process these waves like Workflow 2, but with ‘Frequency VDL’ and ‘Freq. Semb. VDL’ checked
   c) Comparison of FVDL2’s can be made





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