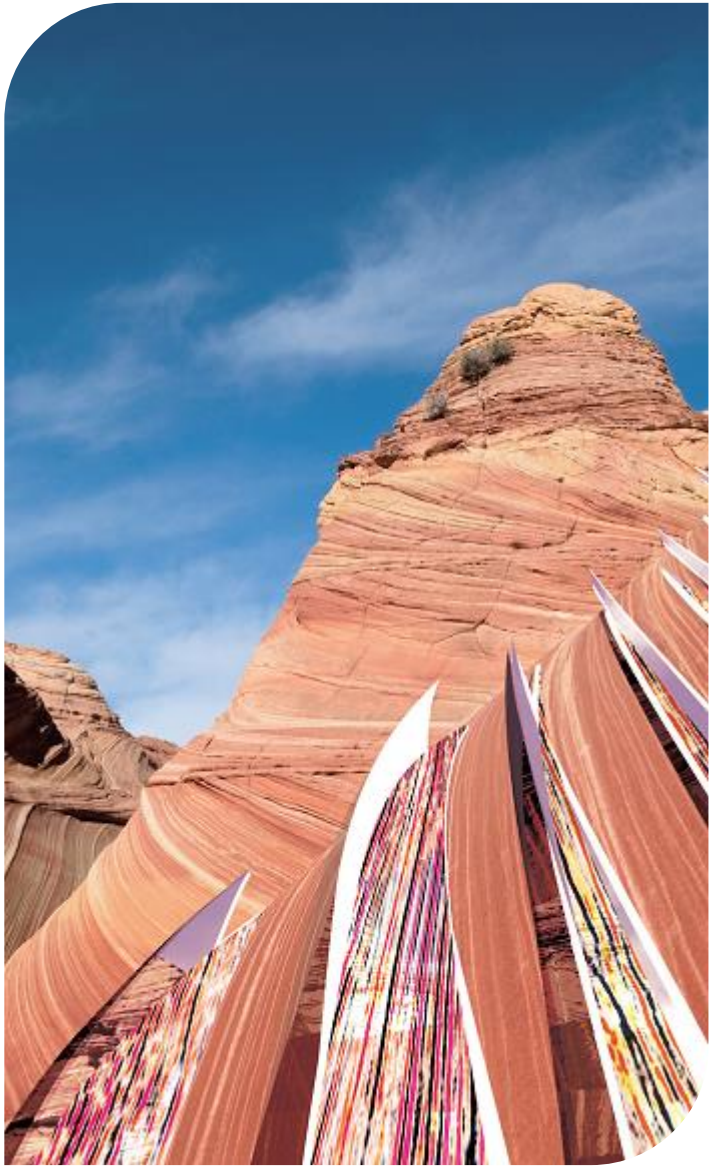


# Interwell

*Seismic Inversion and Characterization*

The major **InterWell 2020.1 release** brings a lot a new functionalities that globally focuses on enhancing two strategic aspects in InterWell software :

- The **input well data** are now available both in **depth** and **time** domains, managing **key conditioning steps** and **time-to-depth conversion**.
- The **seismic characterization** with **key enhancements** of the existing modules and new features, such as the full **fracture characterization workflow** and **characterization applications** for **stochastic inversions**.

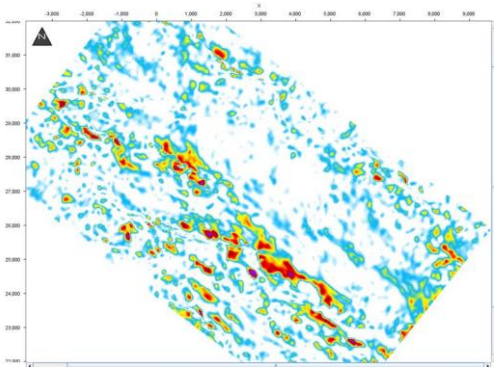
As usual, **many existing features** have also been **improved** in order to provide a better experience for **all InterWell users**.

# *Fracture characterization : full workflow*

The **fracture characterization workflow** can be applied on all volumes but is traditionally applied on synthetic seismic or reflectivity after a **model-based inversion** to take benefit of the seismic data enhancement and decrease of the noise ratio and, for the **reflectivity**, the possible increase of vertical resolution. The workflow is fully available to output both **maps** and **volumes**.

**Step 1**

## *Attribute computation*

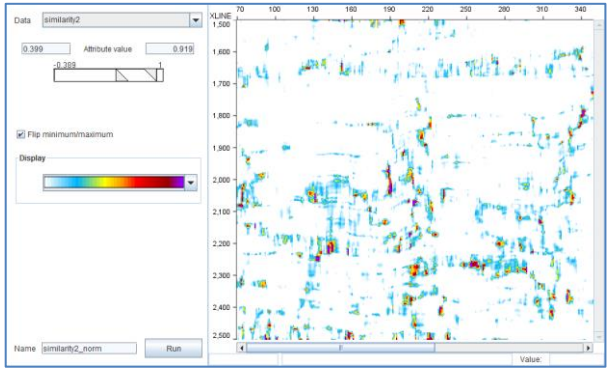


**Brand-new attribute collection** with more than **20 attributes** to compute and **combine**.

The attributes are **pre-selected thanks to Beicip-Franlab experience** on fracture characterization studies, as the best ones to unveil fractures, both in **maps** and **volumes**.

**Step 2**

## *Attribute normalization*

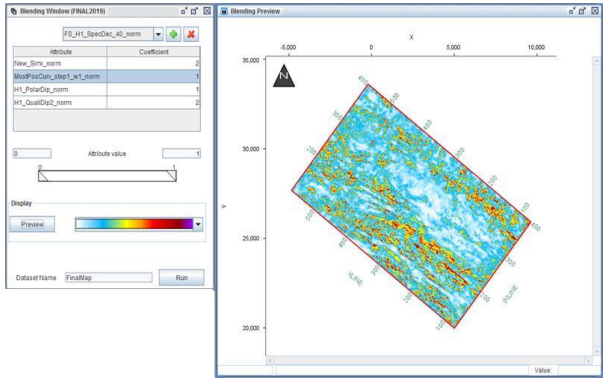


The **fracture detection** is often limited to **a reduced range values** on the attributes.

A **dedicated normalization module** is proposed to **dynamically** choose the **minimum/maximum** of the attribute which focuses on the fracture detection only.

**Step 3**

## *Attribute blending*



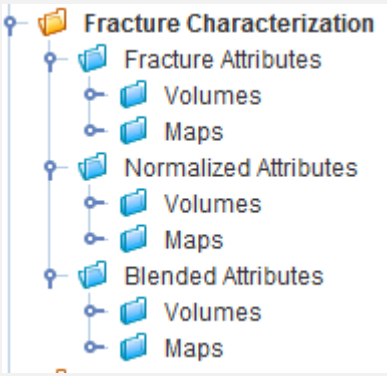
Each attribute brings **specific fracture information** along with **some noise** inherent to its computation. A zone identified as **fractured by several attributes** can be considered fractured with **high confidence**.

The **attribute blending module** allows to combine **with different weights** the fracture attributes to be sure to capture all unique information.

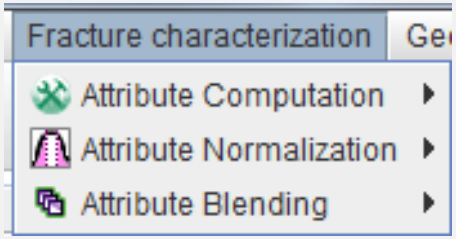
# *Fracture characterization : in InterWell software*

The **fracture characterization workflow** is directly integrated in InterWell software, in its dedicated top menu and subtree.

*Fracture characterization sub-tree*

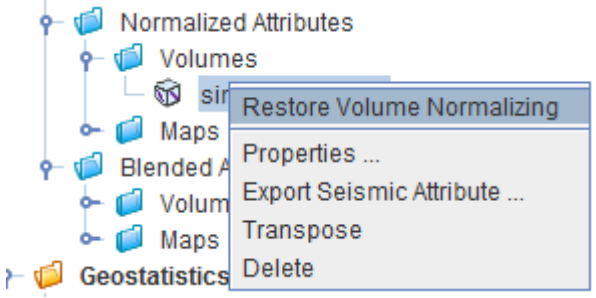



*Fracture characterization top menu*




The different items of the workflow, maps or attributes, can be used for **extractions** or **exported** as any other items in InterWell. Both **normalization** and **blending computation parameters** can be restored from their outputs to give the best user experience.

*The restore allows to track the choice performed by the user*

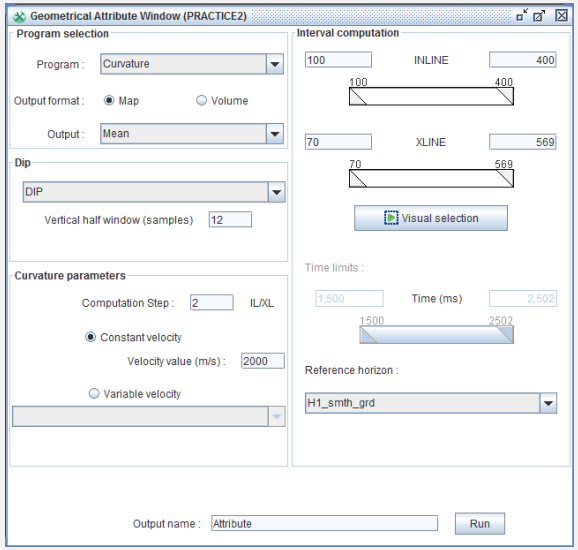


# *Fracture characterization : attribute computation*

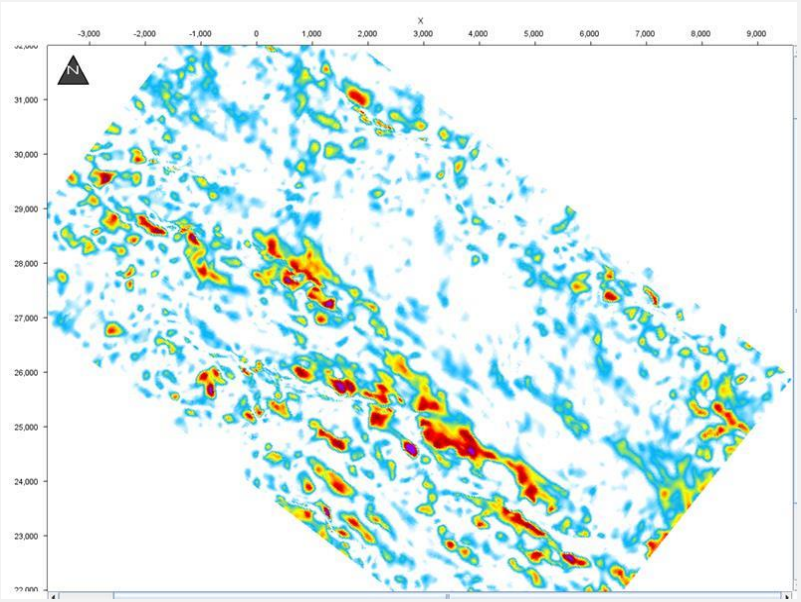
The **attribute computation modules** are divided into three different buttons according to the type of algorithms, optimized for **high performance computation** : **Geometrical attributes**, **coherency attributes** and **instantaneous attributes**.

The attribute outputs can be maps or volumes, the selection is performed using a drop-down list for **programs** and **sub-programs** if any. The seismic Dip, used in geometrical and coherency attributes is computed using the existing **Dip analysis module**.

*Brand-new fracture attribute toolbox*




*Post-processed most positive curvature*



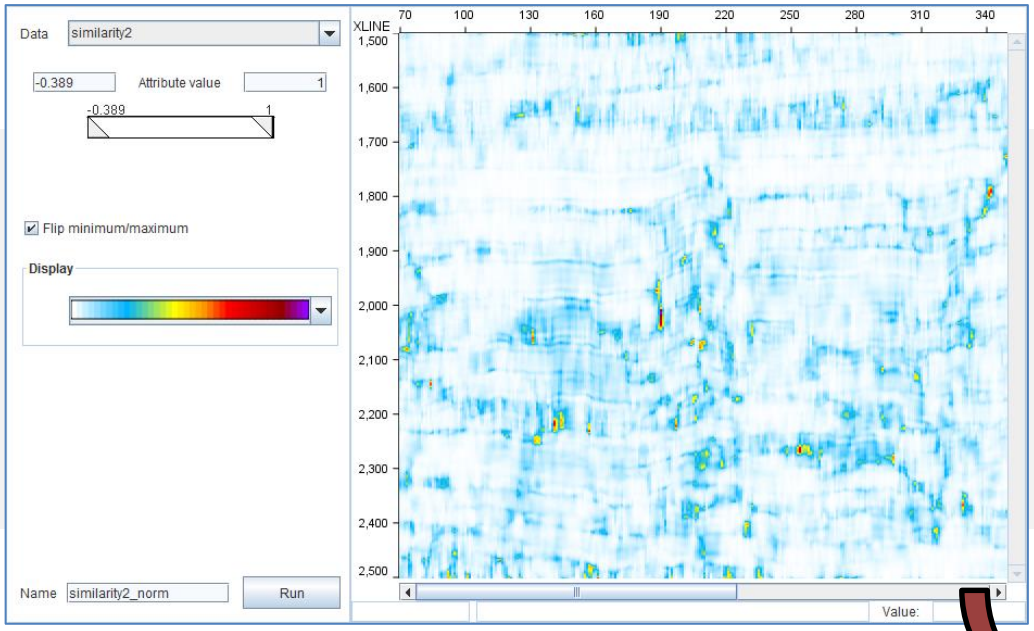
*Attribute list at a glance*

- *Geometrical attribute :*
  - *Dip (IL Dip, XL Dip, Polar Dip, Dip Quality…)*
  - *Curvature (Minimum, Maximum, Most positive…)*
  - *Edge (map only)*
- *Coherency attribute :*
  - *Similarity (Minimum, Maximum, Average…)*
  - *Dip-guided similarity (Minimum, Maximum, Average…)*
  - *Horizon-guided similarity (Minimum, Maximum, Average…)*
- *Instantaneous attribute :*
  - *Variance, Standard deviation, Spectral decomposition, RMS….*

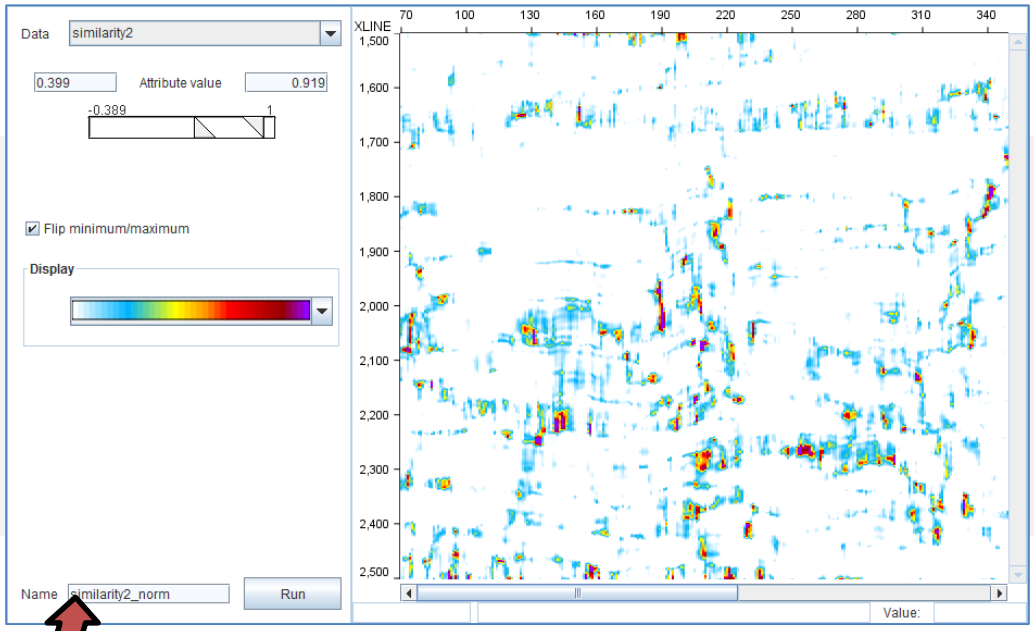
# *Fracture characterization : attribute normalization*

This new module integrates a **section or map view** which dynamically changes while sliding the minimum and maximum, changing the colorbar and checking/unchecking the “flip attribute” option. Once the parameters selected, the attribute is **processed** and set in a new dedicated node.

*Section view before working on the normalization*




*Section view after focusing only on faults and fractures*



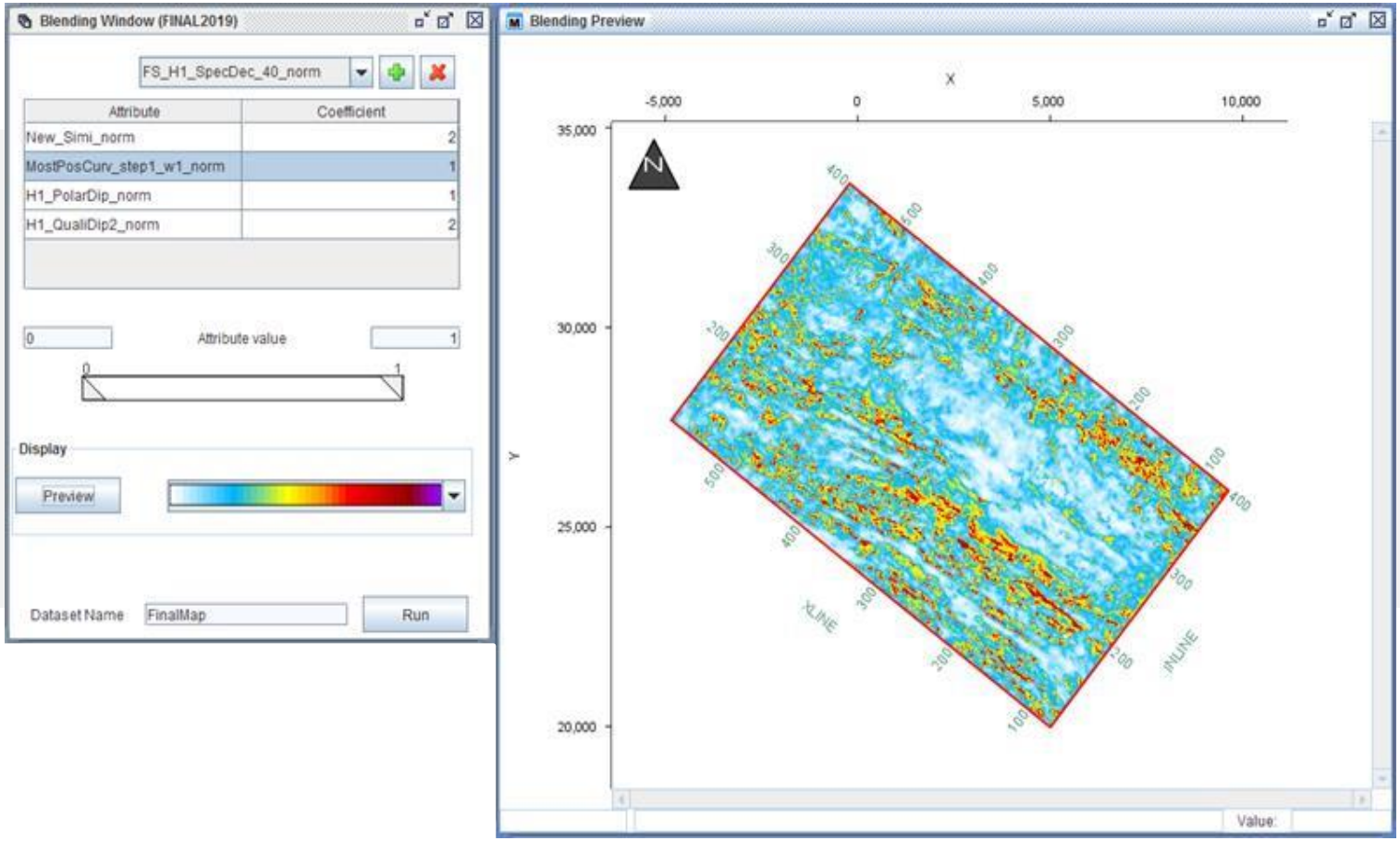

*Dynamic change while using the buttons*

# *Fracture characterization : attribute blending*

The new blending module allows to select the preferred attributes after normalization to perform a weighted combination. It is also possible to re-normalize the output synthesis attribute.

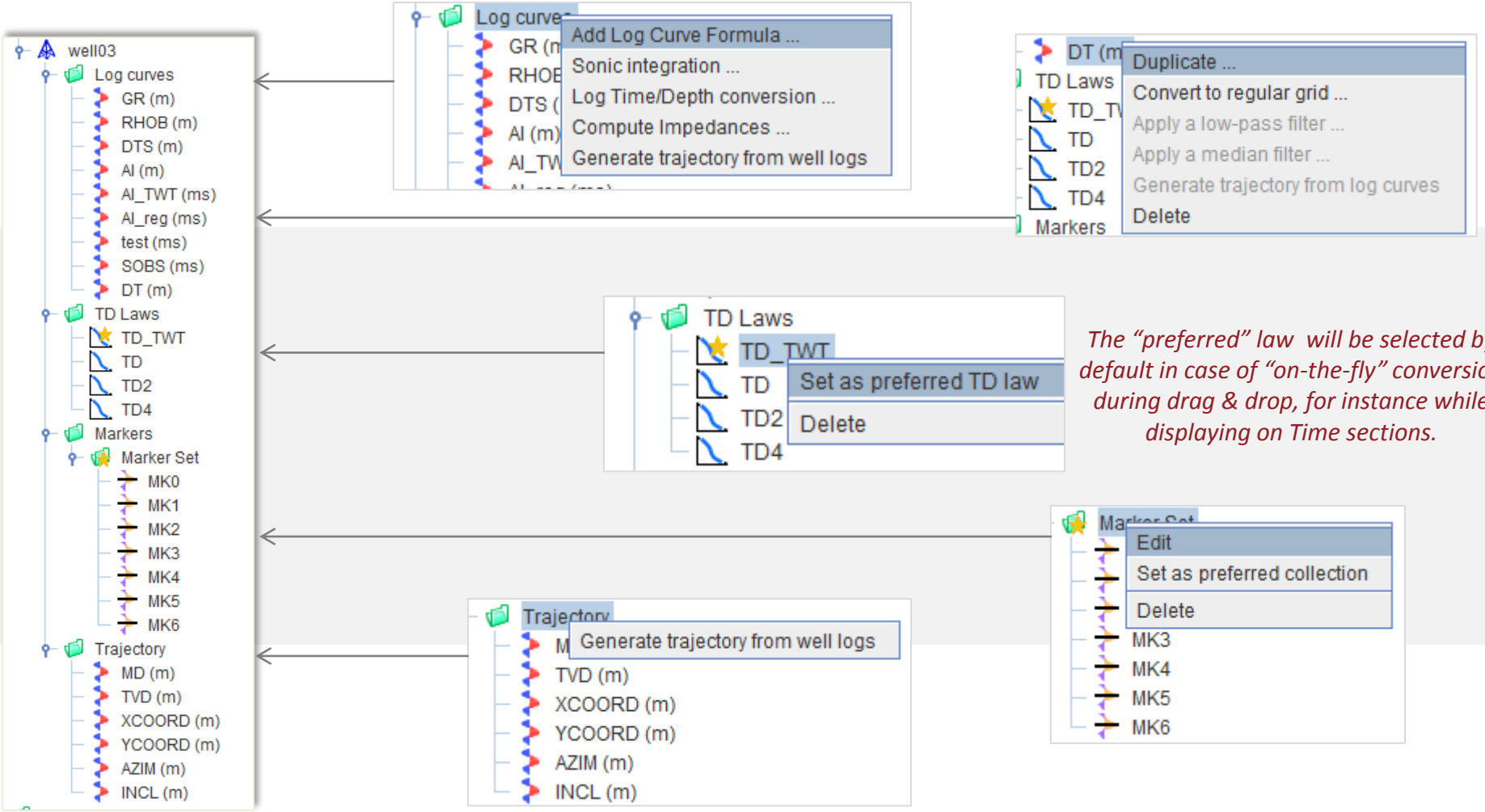
To support the choices of the user, the module integrates a **preview mode** to plot the resulting map or section, to check **interactively** the impact and save computation time before applying in 3D.

*Attribute selection, weighting and preview*



# *Input Well Data : in the survey tree*

The data model for the input well data has been completely reviewed to propose many more functionalities, including the management of **curves in different domains** (MD, TVD, Depth, Time), **time-to-depth laws**, **markers sets** and **trajectory** (represented by consistent MD, TVD, X, Y, Azimuth and Inclination curves, in depth or Time domain). This database extension comes along with many options available in right click to condition the well data.



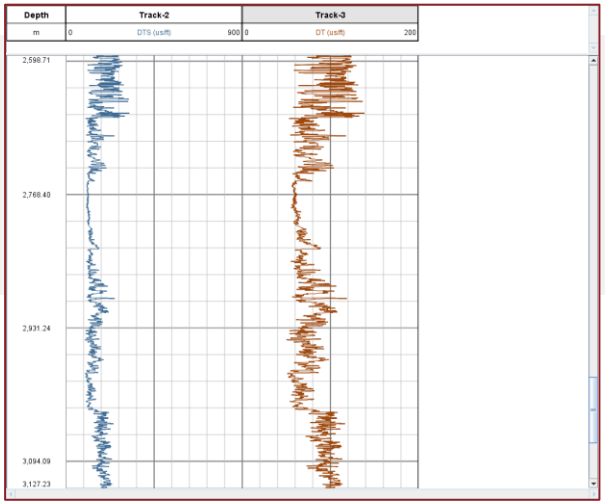

*The "preferred" law will be selected by default in case of "on-the-fly" conversion during drag & drop, for instance while displaying on Time sections.*

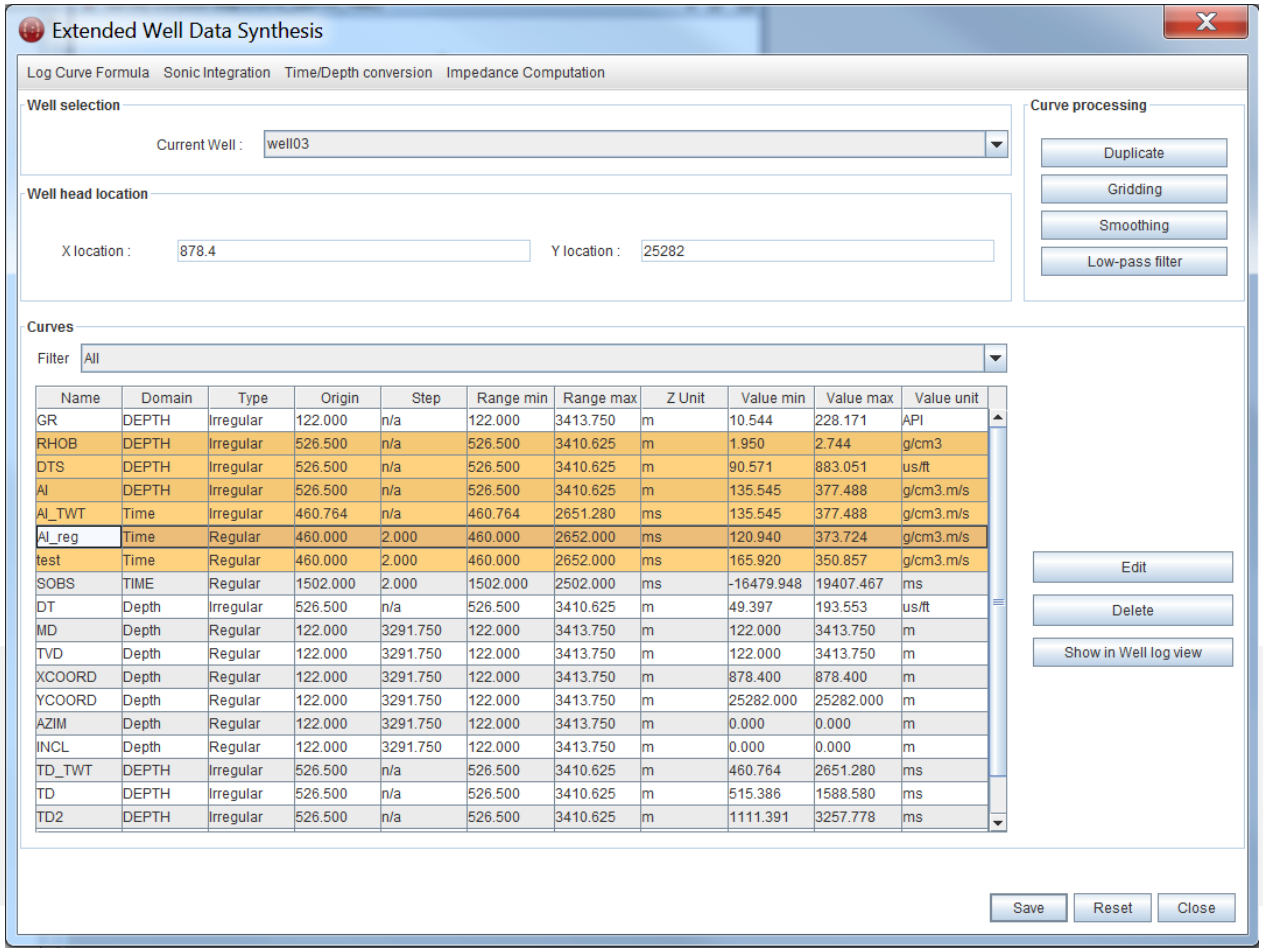
# *Input Well Data : Well Synthesis Window*

The synthesis window provides **more information** about the well data content. It is also possible to **edit** the curve **names**, their **units**, their **domains**, and to check if they are **regular/irregular**.

**Curve value edition** or any other **actions** within the window can be either **reset** or **saved**, allowing **safe data operations,** with the ability to **quickly visualize data**, even the intermediate computed data before save!

*Well log view directly computed from the synthesis window curve selection*

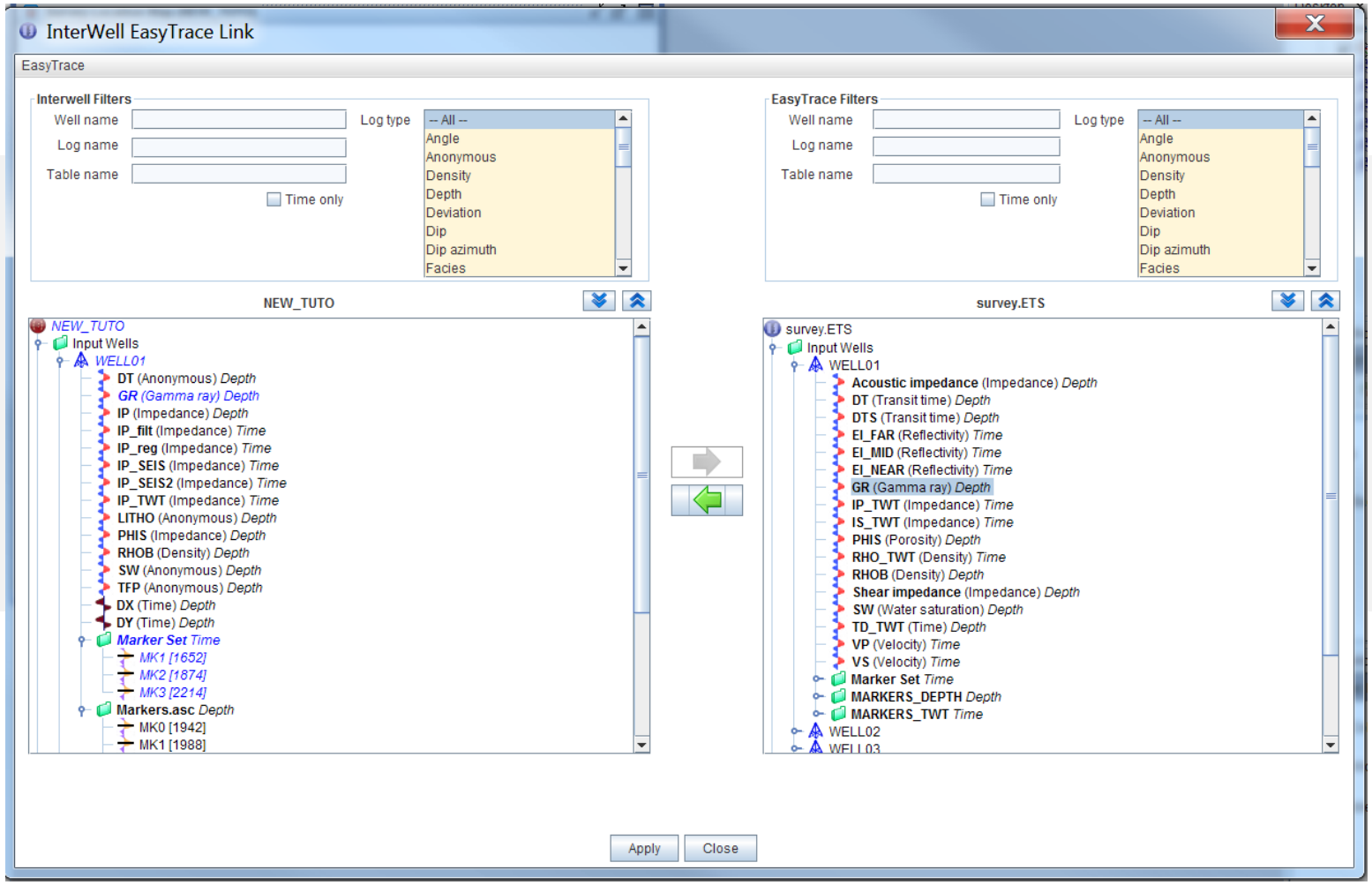



| Name | Domain | Type | Origin | Step | Range min | Range max | Z Unit | Value min | Value max | Value unit |
|---|---|---|---|---|---|---|---|---|---|---|
| GR | DEPTH | Irregular | 122.000 | n/a | 122.000 | 3413.750 | m | 10.544 | 228.171 | API |
| RHOB | DEPTH | Irregular | 526.500 | n/a | 526.500 | 3410.625 | m | 1.950 | 2.744 | g/cm3 |
| DTS | DEPTH | Irregular | 526.500 | n/a | 526.500 | 3410.625 | m | 90.571 | 883.051 | us/ft |
| AI | DEPTH | Irregular | 526.500 | n/a | 526.500 | 3410.625 | m | 135.545 | 377.488 | g/cm3.m/s |
| AI_TWT | Time | Irregular | 460.764 | n/a | 460.764 | 2651.280 | ms | 135.545 | 377.488 | g/cm3.m/s |
| AI_reg | Time | Regular | 460.000 | 2.000 | 460.000 | 2652.000 | ms | 120.940 | 373.724 | g/cm3.m/s |
| test | Time | Regular | 460.000 | 2.000 | 460.000 | 2652.000 | ms | 165.920 | 350.857 | g/cm3.m/s |
| SOBS | TIME | Regular | 1502.000 | 2.000 | 1502.000 | 2502.000 | ms | -16479.948 | 19407.467 | ms |
| DT | Depth | Irregular | 526.500 | n/a | 526.500 | 3410.625 | m | 49.397 | 193.553 | us/ft |
| MD | Depth | Regular | 122.000 | 3291.750 | 122.000 | 3413.750 | m | 122.000 | 3413.750 | m |
| TVD | Depth | Regular | 122.000 | 3291.750 | 122.000 | 3413.750 | m | 122.000 | 3413.750 | m |
| XCOORD | Depth | Regular | 122.000 | 3291.750 | 122.000 | 3413.750 | m | 878.400 | 878.400 | m |
| YCOORD | Depth | Regular | 122.000 | 3291.750 | 122.000 | 3413.750 | m | 25282.000 | 25282.000 | m |
| AZIM | Depth | Regular | 122.000 | 3291.750 | 122.000 | 3413.750 | m | 0.000 | 0.000 | m |
| INCL | Depth | Regular | 122.000 | 3291.750 | 122.000 | 3413.750 | m | 0.000 | 0.000 | m |
| TD_TWT | DEPTH | Irregular | 526.500 | n/a | 526.500 | 3410.625 | m | 460.764 | 2651.280 | ms |
| TD | DEPTH | Irregular | 526.500 | n/a | 526.500 | 3410.625 | m | 515.386 | 1588.580 | ms |
| TD2 | DEPTH | Irregular | 526.500 | n/a | 526.500 | 3410.625 | m | 1111.391 | 3257.778 | ms |

# *Input Well Data : EasyTrace link*

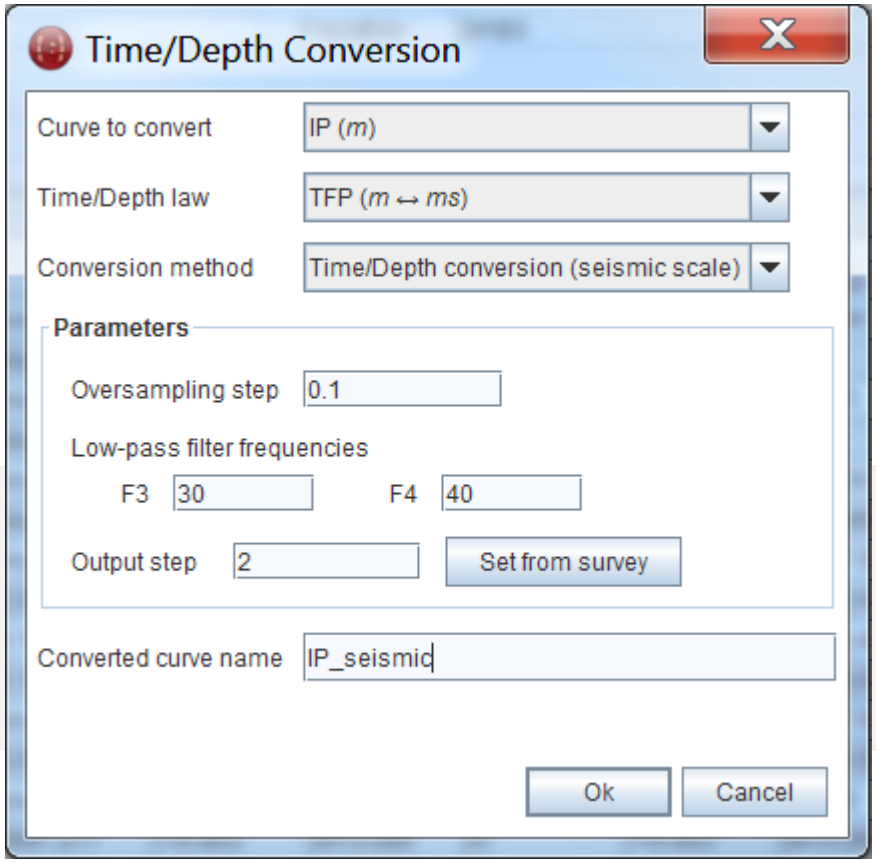
The **EasyTrace link** has been extended to exchange **marker collections**, **markers**, and **depth curves** with input well data.



# *Input Well Data : Time/Depth conversion module*

The **Time/Depth conversion module** offers two conversion methods :

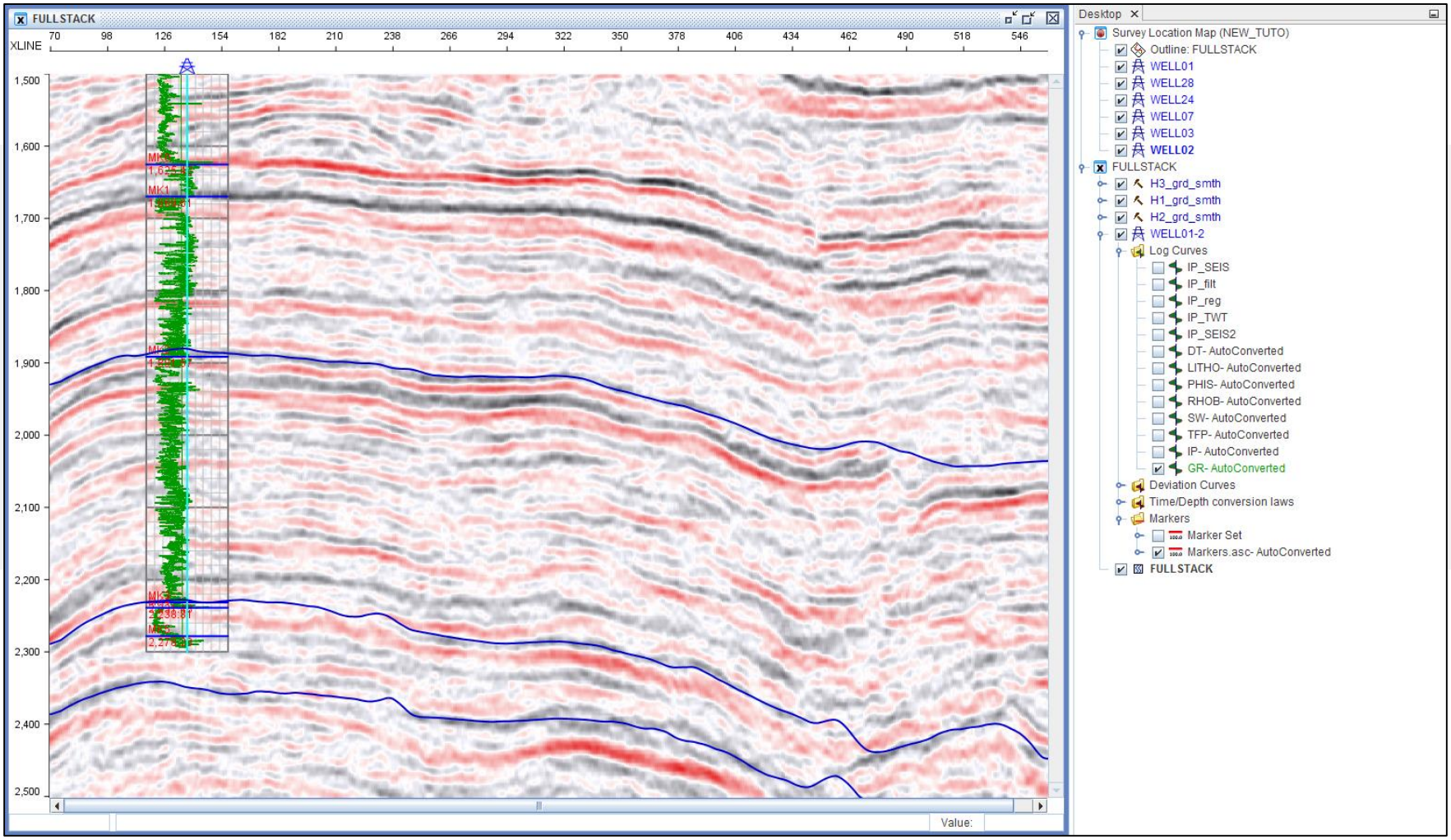
- a **default method**, converting directly the curve in the new domain as an **irregular curve**;
- a method including the **upscaling at seismic scale** with filtering into the seismic bandpass (available for continuous logs), to be directly compatible with the seismic data for the **wavelet estimation** and **modeling** steps.



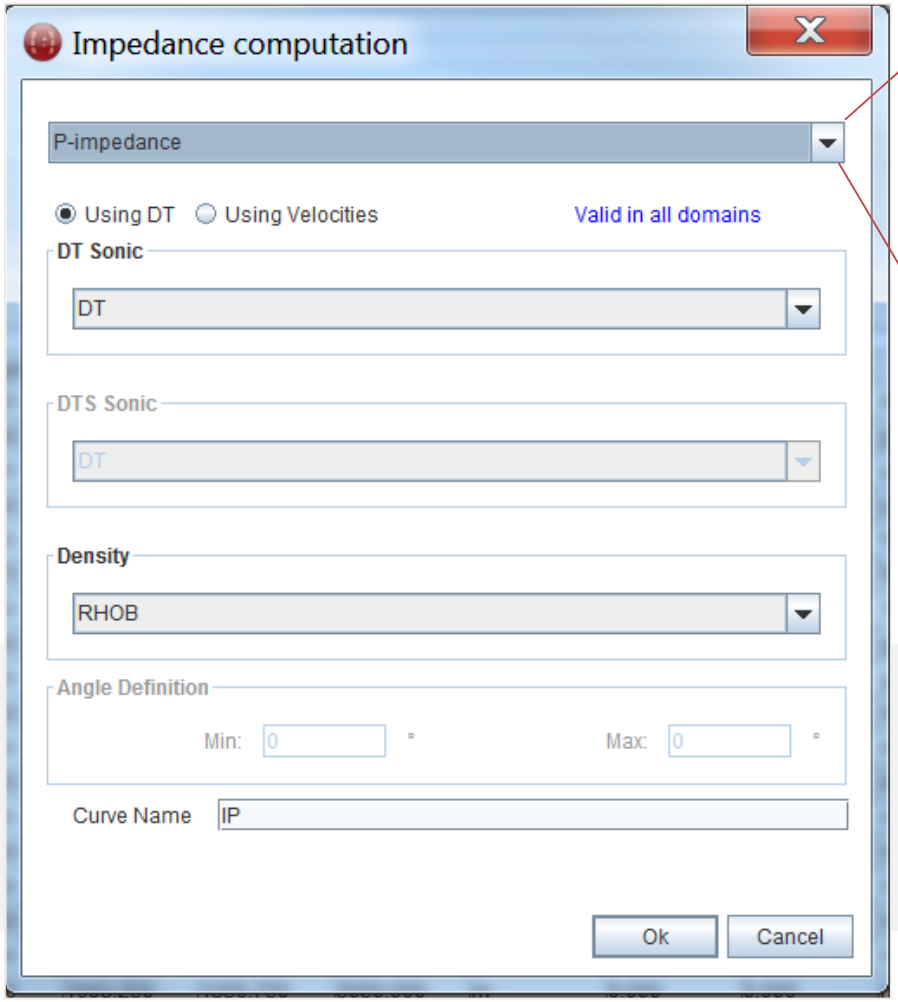
# *Input Well Data : Depth curve visualization on seismic data*

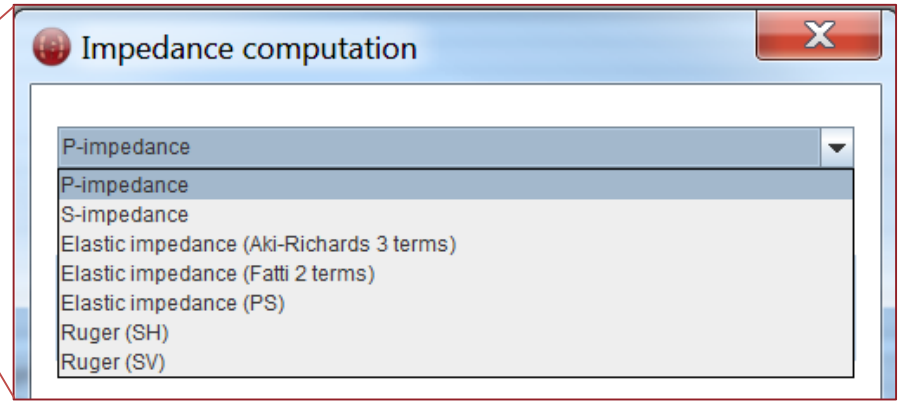
The **Depth curves, marker collections and trajectories** are automatically converted with the preferred **Time/Depth law** when the well is displayed with seismic data in Time.

*Gamma-Ray on seismic section, preferred time-depth law after well tie*



# *Input Well Data : Impedance computation*



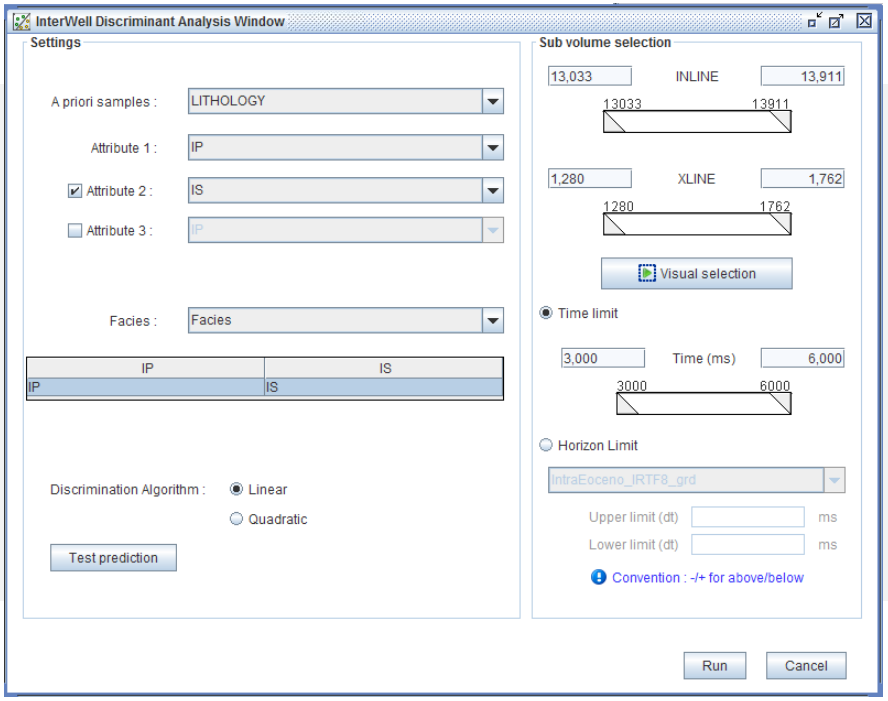




All kind of **impedances**, necessary in the **many workflows** available in InterWell, are pre-defined and accessible from this module.

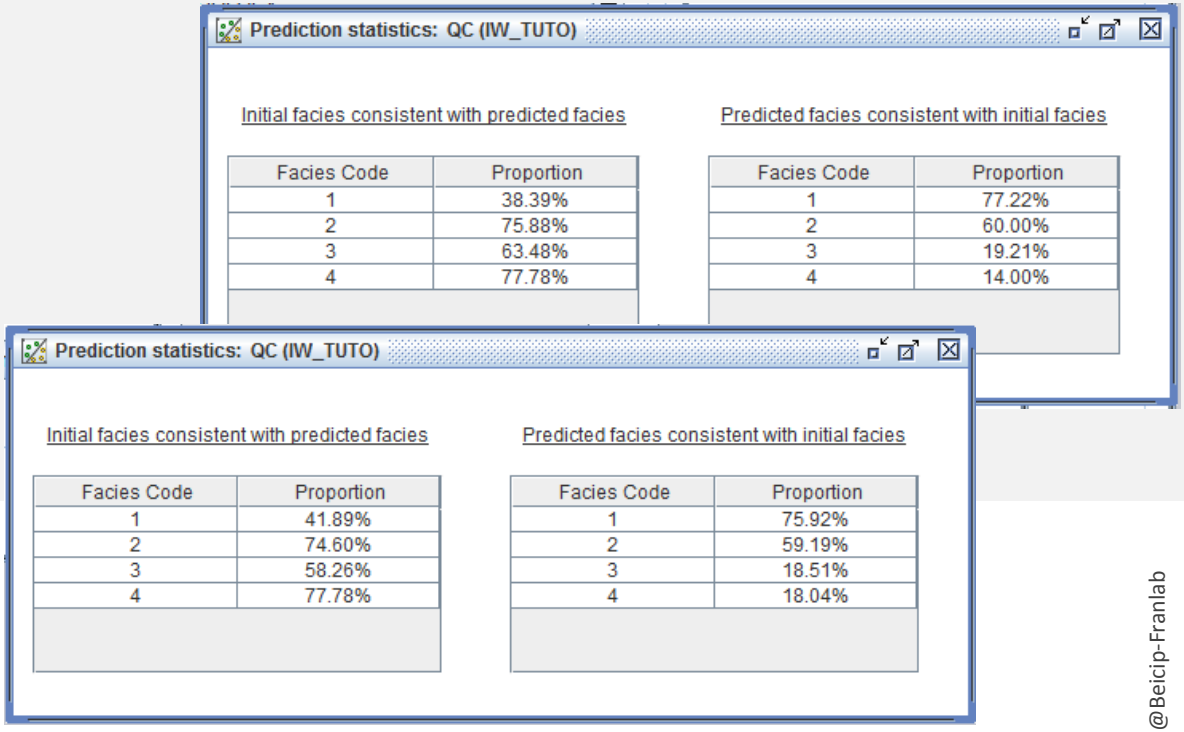
# *Matrix characterization : Preview mode in the discriminant analysis module*

The module now integrates a **preview mode** with the "Test prediction" button to only apply the discriminant analysis process to the training samples and **automatically plot the statistics on the prediction**, in order to choose the best parameters and the most appropriate method before applying the computation in 3D.

*Parameter selection with the new preview mode button*




*Statistics on the prediction before applying the discrimination in 3D*
*- Linear and quadratic method -*

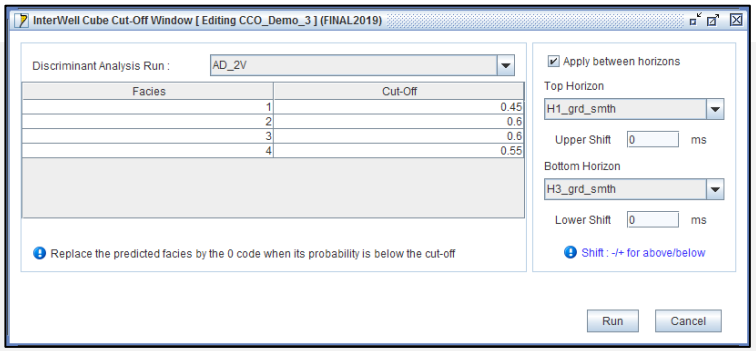


# *Matrix characterization : Post-processing the Discriminant Analysis results – Cube Cut-Off module*

This **module** allows a more comprehensive **finalization of the facies prediction workflow** in InterWell. Based on the outputs of the discriminant analysis (most probable facies and probabilities of good assignment), it allows a fine-tuning of the classes' boundaries based on probability values in order to **capture the more robust areas** and remove the predictions associated to higher uncertainties.

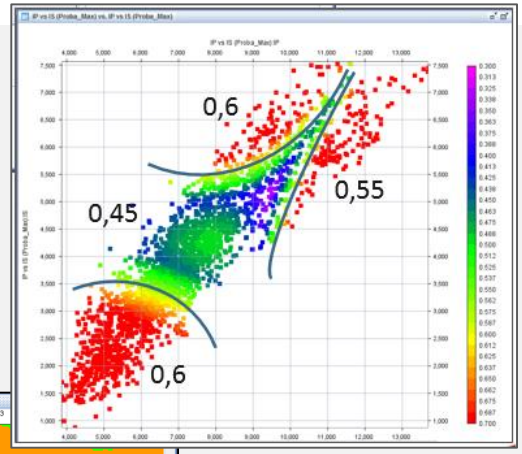
The runs are in the **Matrix Characterization sub-folder** and accessible through the **Matrix Characterization** menu. The module outputs the final post-processed facies volume in 3D.

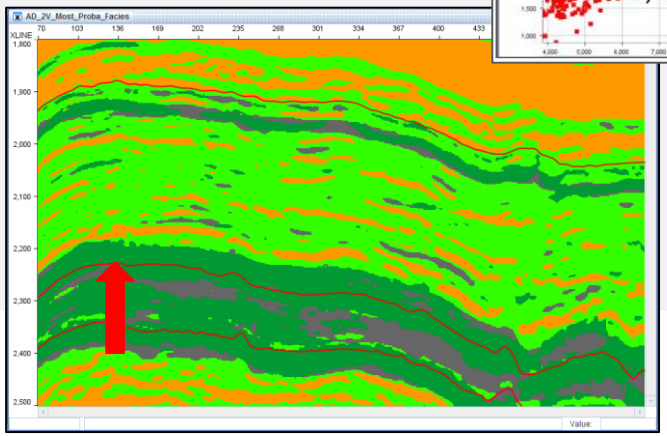
*Parameters selection : specify probability cut-off for each facies*

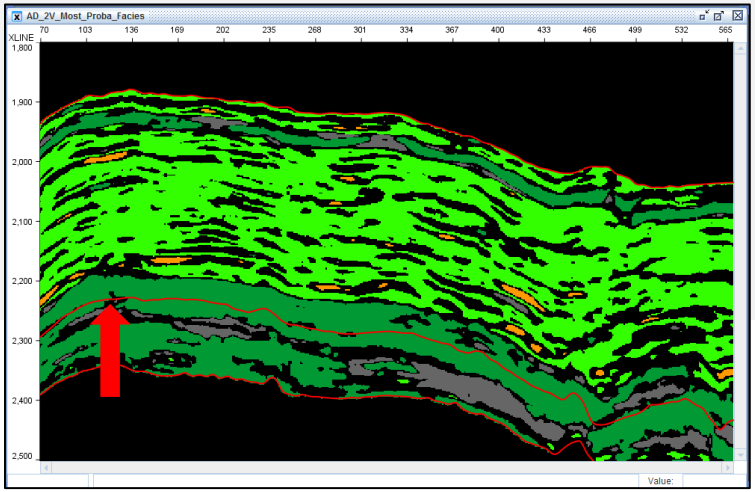



*Included: possibility to crop the fine-tuned result to its interval of validity*

*Discriminant Analysis results with most probable facies (section below) and associated probability of good assignment (view in cross-plot)*




*Final predicted facies section with uncertain assignments removed and cropped at the target level*

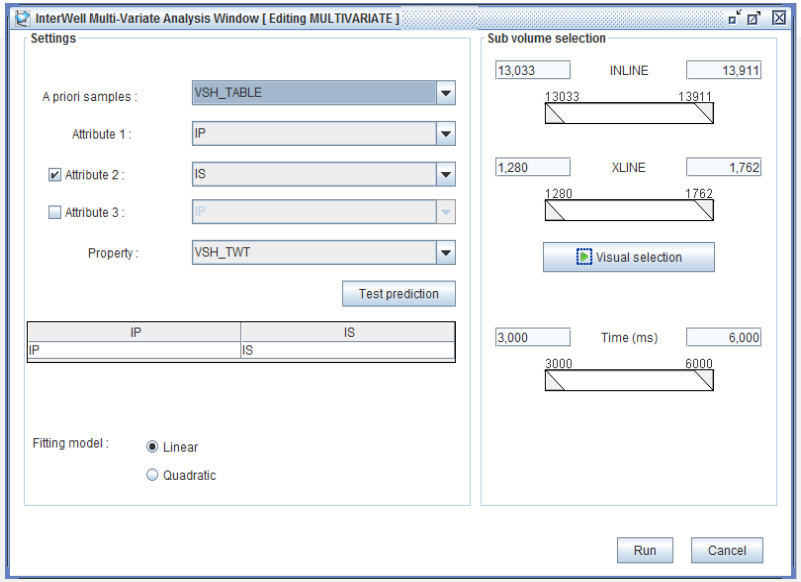
# *Matrix characterization : New Feature – Multi-variate analysis module*

This **new module** estimates a continuous property, such as porosity or volume of shale, using a **least-mean square optimization** on a training sample dataset, represented by a table in InterWell. The module supports a least-square problem using **1, 2 or 3 variables** in a **linear** function or **2nd order polynomial** function.

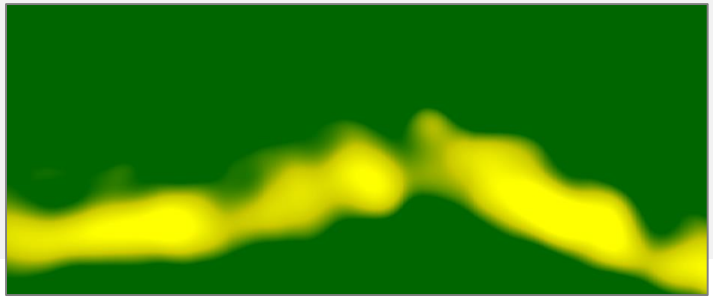
The runs are in the **Matrix Characterization sub-folder** and accessible through the **Matrix Characterization** menu. The module outputs the estimation of the property on the training sample, as a table, and the prediction in 3D.

The module integrates a **preview mode** with the "Test prediction" button which solves the least square problem using different available variables and both possible fitting model to **automatically plot the estimated property against the real property**, in order to estimate the prediction power of the model before applying the computation in 3D.

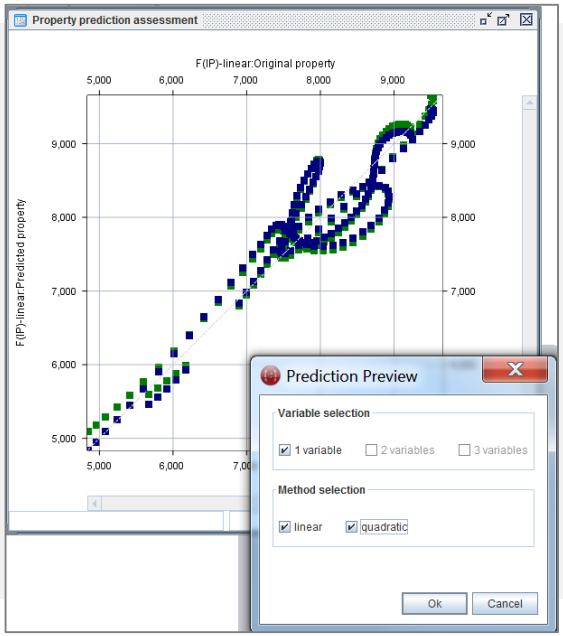
*Parameter selection*




*VSH prediction to identify a sand body using P- and S- impedance after inversion process*



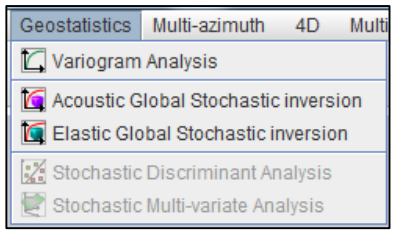
*Preview to assess the prediction quality with 1 variable, with statistics available through InterWell cross-plot capabilities*



# *Matrix characterization : Workflow adapted to the GSI stochastic inversion**

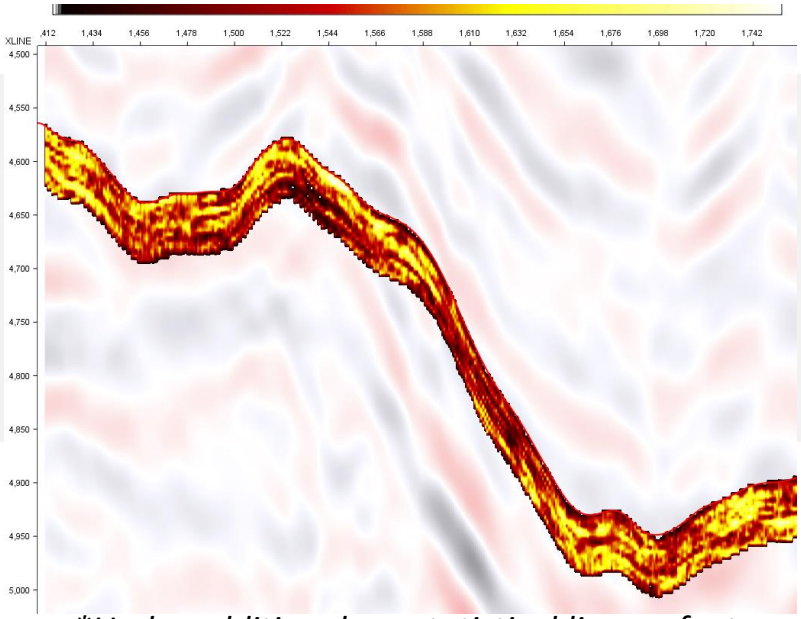
Both **discriminant analysis** and **multi-variate analysis** can be applied on **InterWell GSI** results to directly traduce the **uncertainties** captured by the stochastic inversion in **seismic characterization applications**. **The processes** are applied on each simulation (or couple simulation - co-simulation for elastic inversion), then **key statistics** are computed in 3D and outputted back on the structural grid.

*Geostatistics top menu with the new characterization applications*



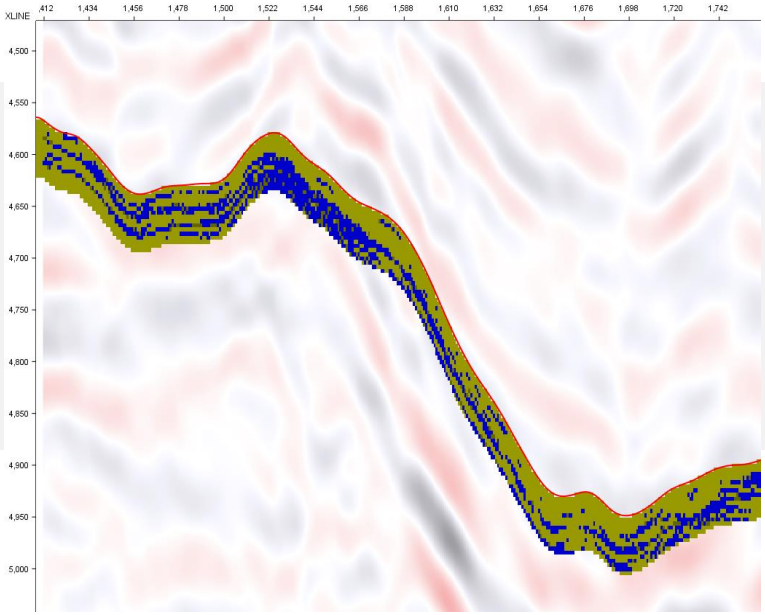

- The available **statistics** for the stochastic multi-variate analysis are :
  - **Average**, **minimum**, **maximum**;
  - **Variance** and **standard deviation**;
  - **User-defined quantiles**, **inter-quantile** and **inter-quartile ranges**.

*I90-10 traducing the predicted property variability over the simulations*



- The available **statistics** for the stochastic discriminant analysis are :
  - The **most frequently assigned facies**;
  - The **assignment frequency** for each facies.

*Most assigned facies among the simulations*

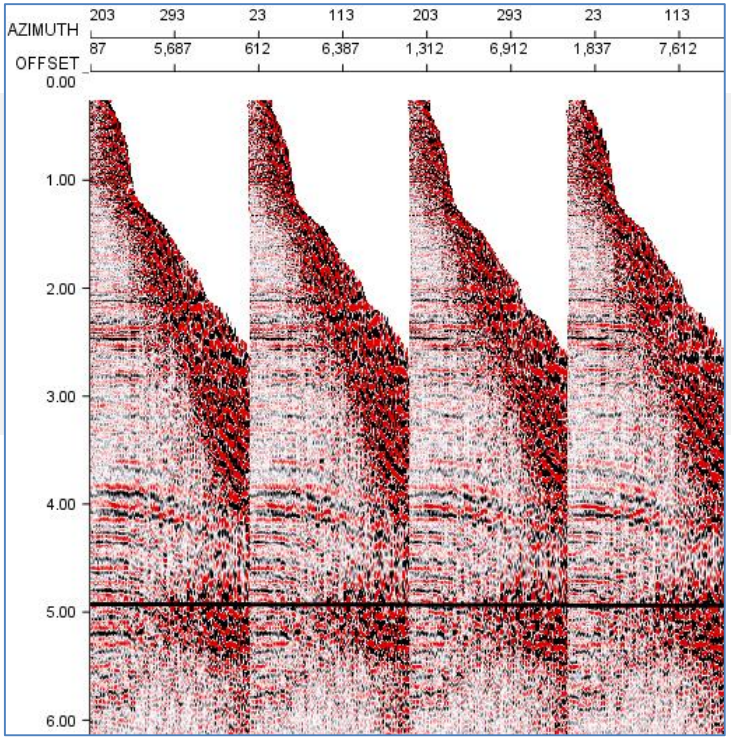


**Under additional geostatistical license feature*

# *Data operations : Multi-azimuth workflow enhancements **

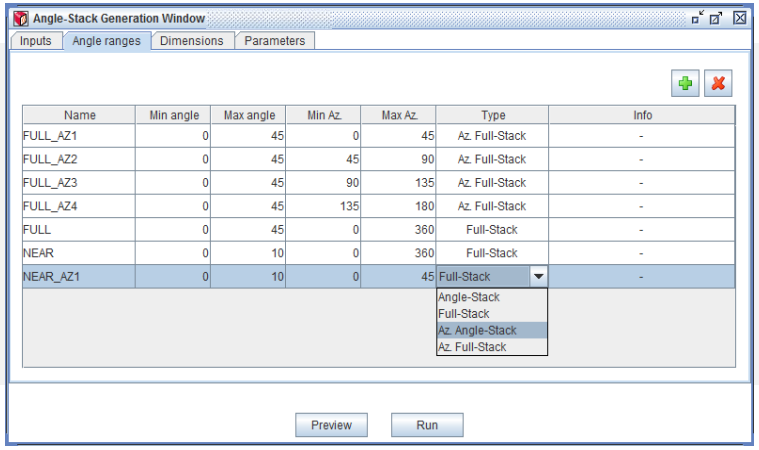
Some enhancements have been brought for the **azimuthal workflow,** which now support **full-azimuth gathers**, including for **data visualization**, combined with **horizons** and **wells**. The **angle stack generation** can be applied on **full-azimuth gathers** which includes, in addition to the offset keys, the azimuthal keys. Finally, the **final anisotropy maps** can be overlaid by **arrow or line symbols** to highlight the **anisotropy orientation**.

*Super gathers with both azimuth and offset keys*

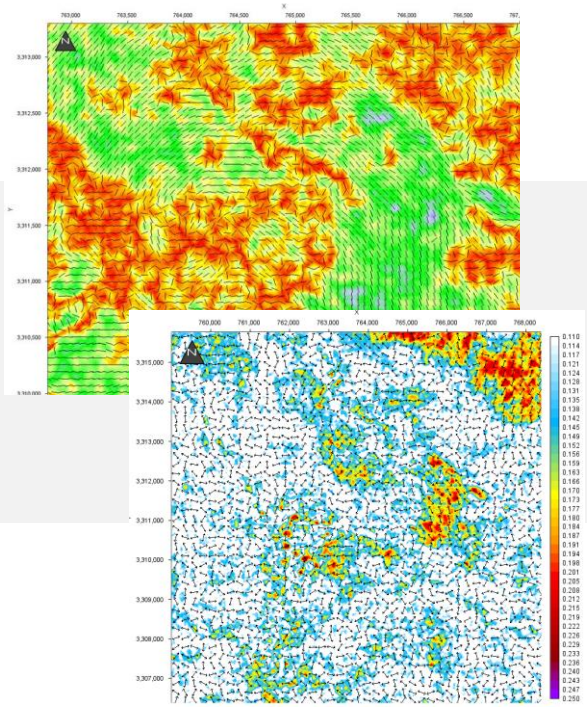



*Horizon*

*Enriched angle selection panel*



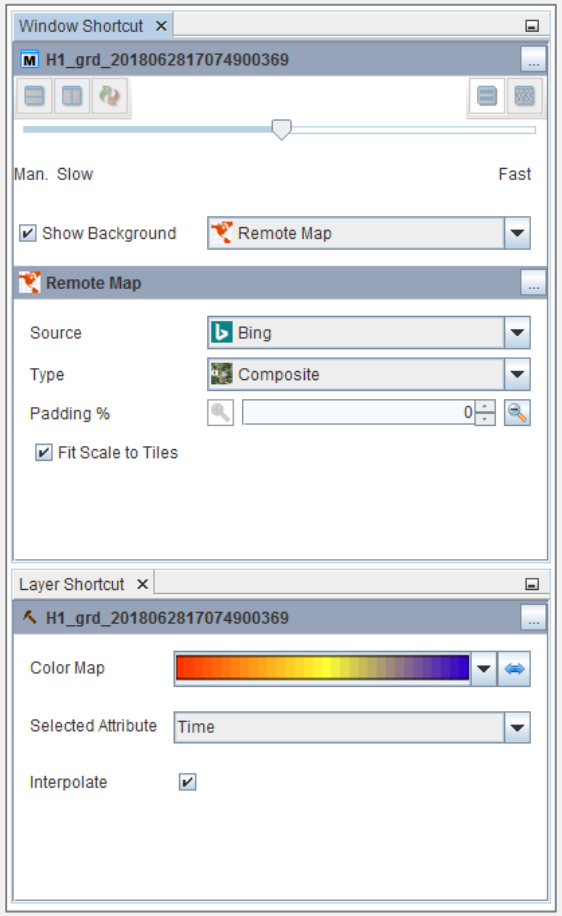

*Map view with arrows for orientation*



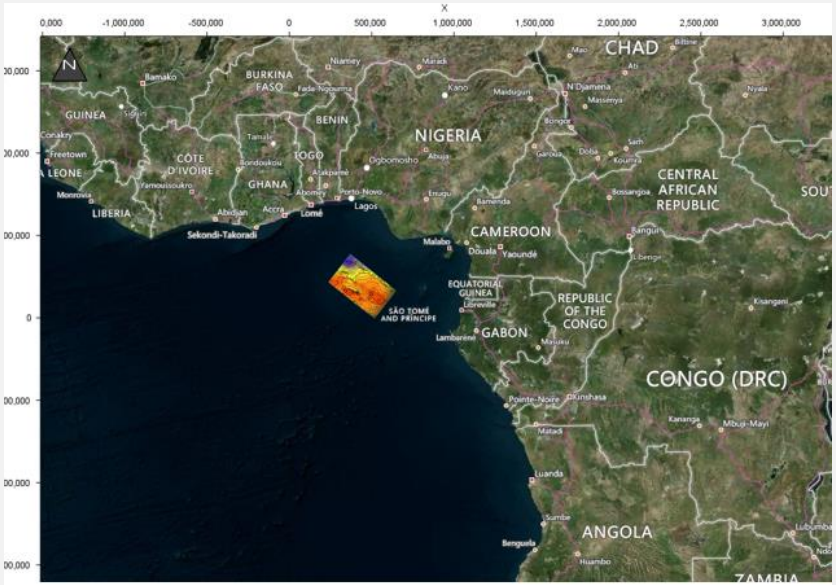
**Under additional azimuthal license feature*

# *Data operations : Coordinate Reference System*

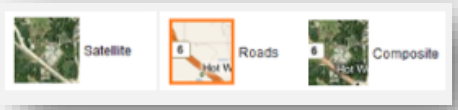
A **coordinate reference system** can be specified when **creating** or **editing** a survey. It is now possible to **convert locations from a CRS to another** during the import of the data in InterWell survey. Once a CRS defined, the **Remote Map** plugin connects InterWell Map View to a Web Map Service (WMS), to provide **Google** or **Bing Maps** as a background for your InterWell displays, providing **an effective QC tool** to check **the data location** and its **consistency**.



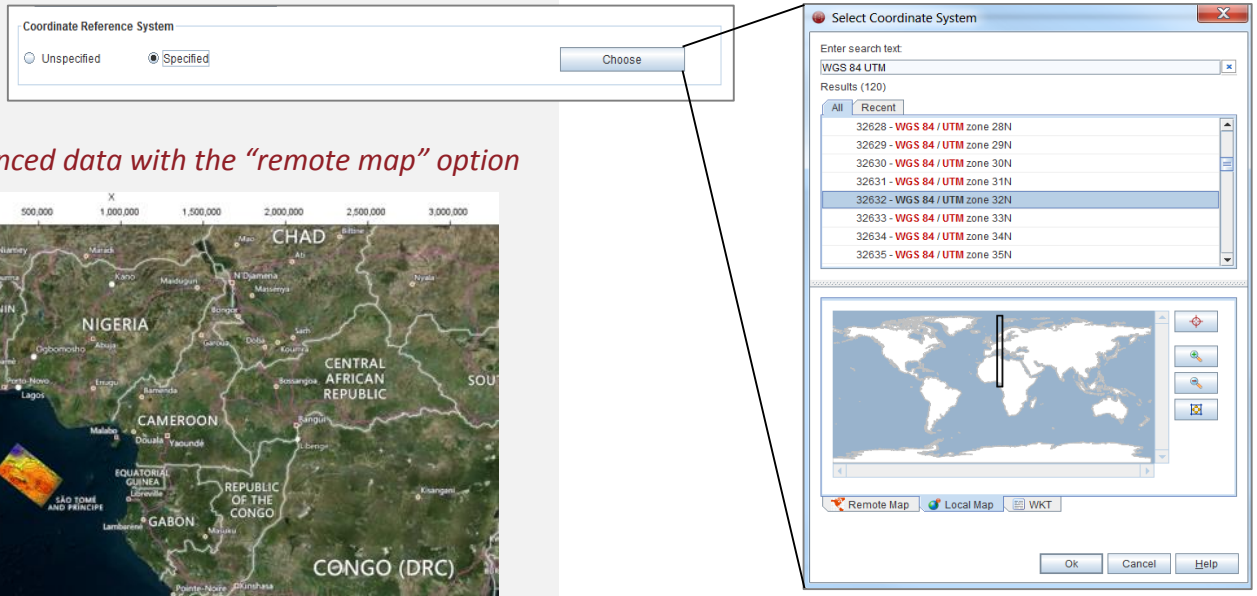

*Visualize your georeferenced data with the "remote map" option*




*Available view modes*




*CRS selector*



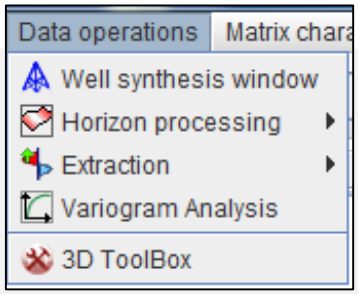

*Data import supporting CRS conversion :*

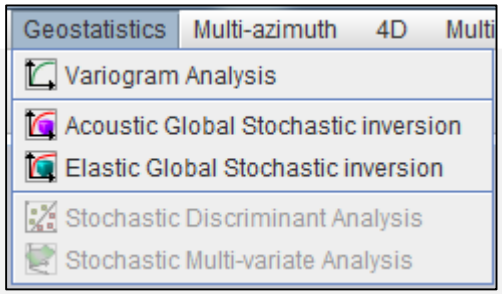
- *Seismic data in SEGY format;*
- *Horizon/Map data in ASCII –X/Y format;*
- *Pointset data;*
- *Well data in LAS format or through EasyTrace Link.*

# *Data operations : New variogram tool*

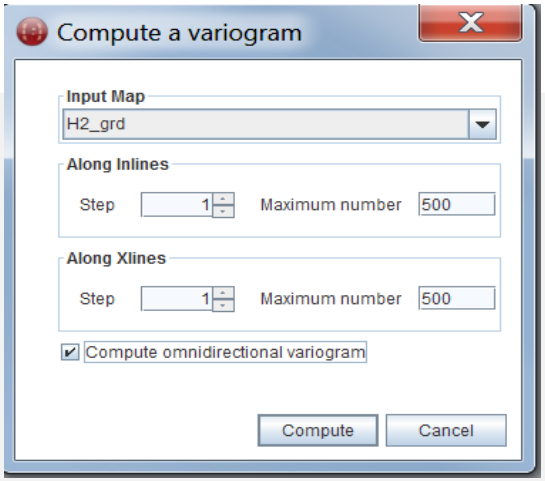
This new feature provides the **ability to compute experimental variograms** in a gridded map or horizon, scanned in Inline direction, Xline direction or both (Omnidirectional). A dedicated tool provides the **ability to fit interactively a variogram model**, including **anisotropy**, to be able to apply it in **Trend Modeling** or in the **Global Stochastic Inversion** modules

*Accessible through two different menus*

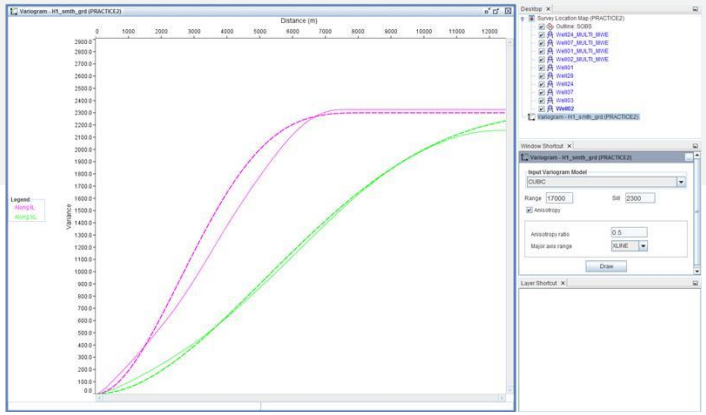


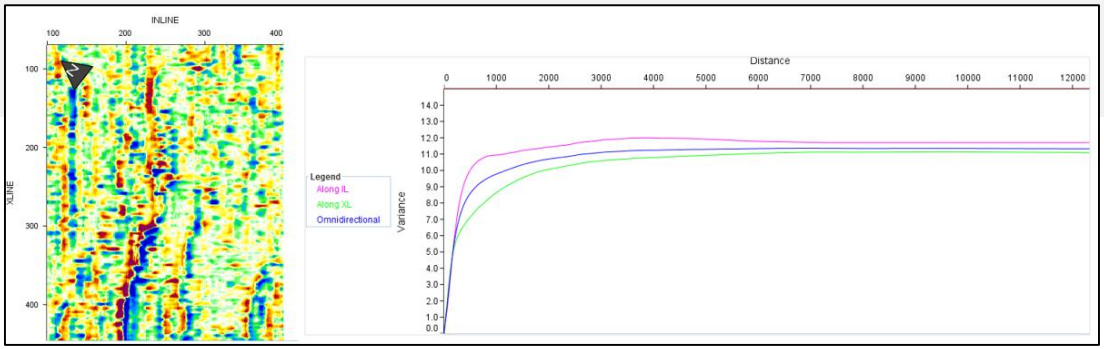

*Easy-to-use editor*




*Interactive variogram fitting*

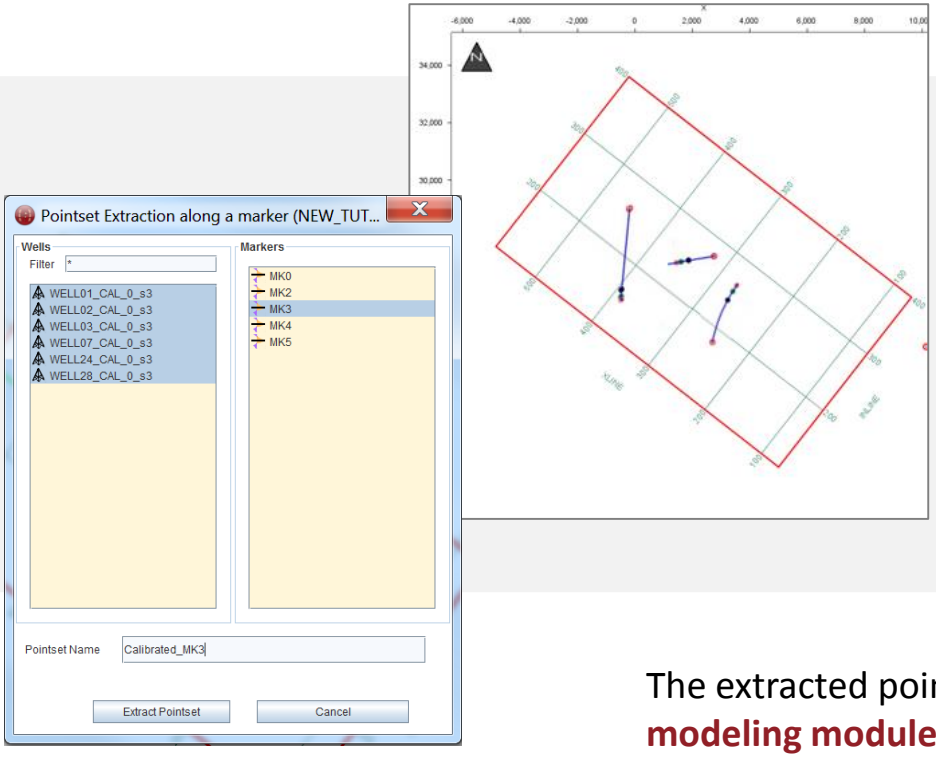


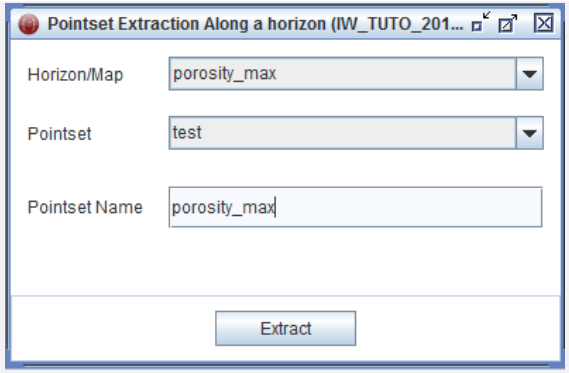
*Computed experimental variogram on a residual map*



# *Data operations : New Pointset Extraction tools*

It is now possible to **create a pointset from wells** at a given marker position to visualize a marker along the well trajectory in map view. In addition, the new version provides the ability to **extract a map or horizon value** at pointset locations, to be compared with properties in the pointset data (impedance, porosity, ..etc.) using the existing **cross-plot capabilities** in InterWell.




The extracted pointset can be used either as **contextual data** or as input to **trend modeling module** to generate an interpolation map.

# *Survey management : open recent survey, current survey edition*

**5 last recent surveys** are stored to be **quickly reopened using a dedicated action** in the Top Menu to get directly to work ! If empty of seismic volumes and runs, the opened **survey geometry** can be **edited.** Its **Coordinate Reference System** can be edited at any time during the study.