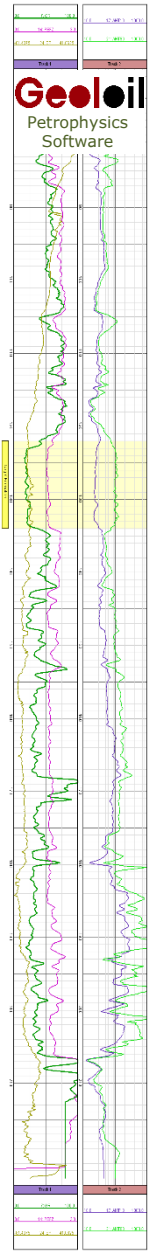

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Modern Programmable Petrophysics Software Workflows

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GeolOil LLC, Software Director

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We introduce a programmable framework for applying user-defined petrophysical workflows to wells that share a common set of raw log curves. Each workflow is structured as a sequential chain of functions and scripts, organized row by row. The output of each row serves as the input for the subsequent row, enabling streamlined and modular data processing.

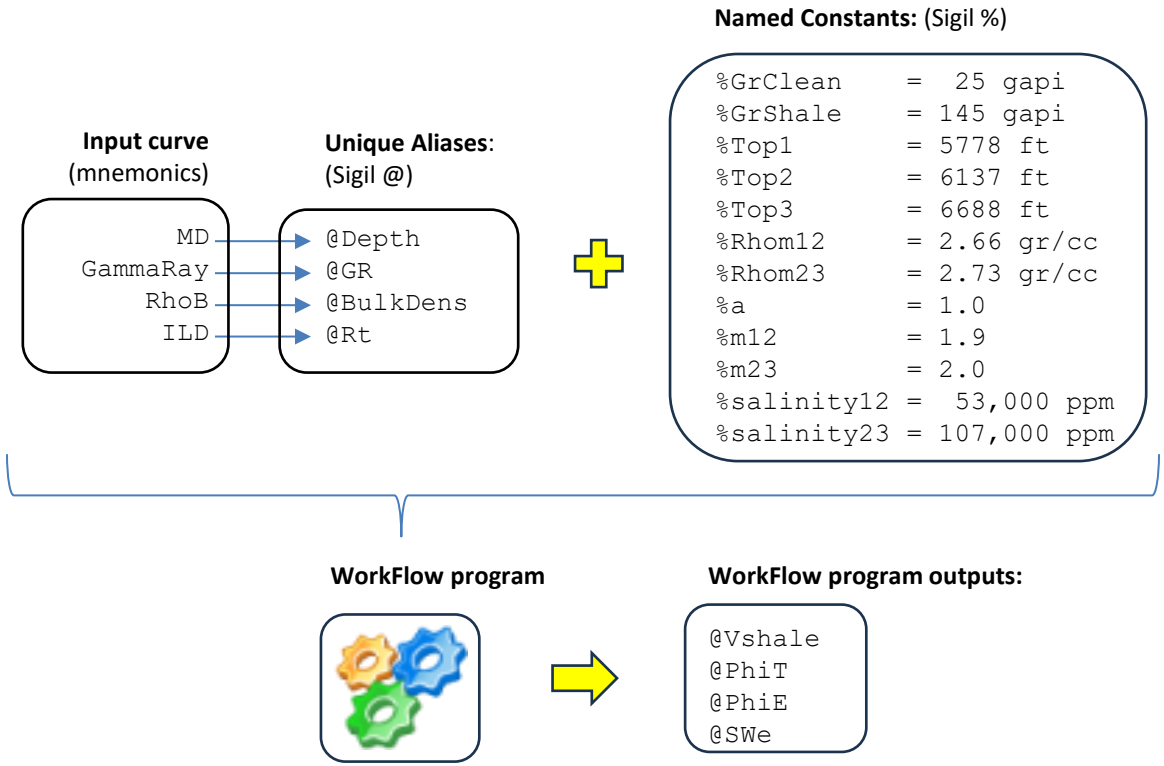
Tasks such as property computations, user-defined equations, algorithms, irregular depth curve stretching, curve merging, and calibration, are efficiently handled using a dedicated, domain-specific petrophysical scripting language. Once curve aliases and named parameters are established, the workflow can be seamlessly applied across a collection of wells, enabling immediate and consistent processing.

What is a workflow program?

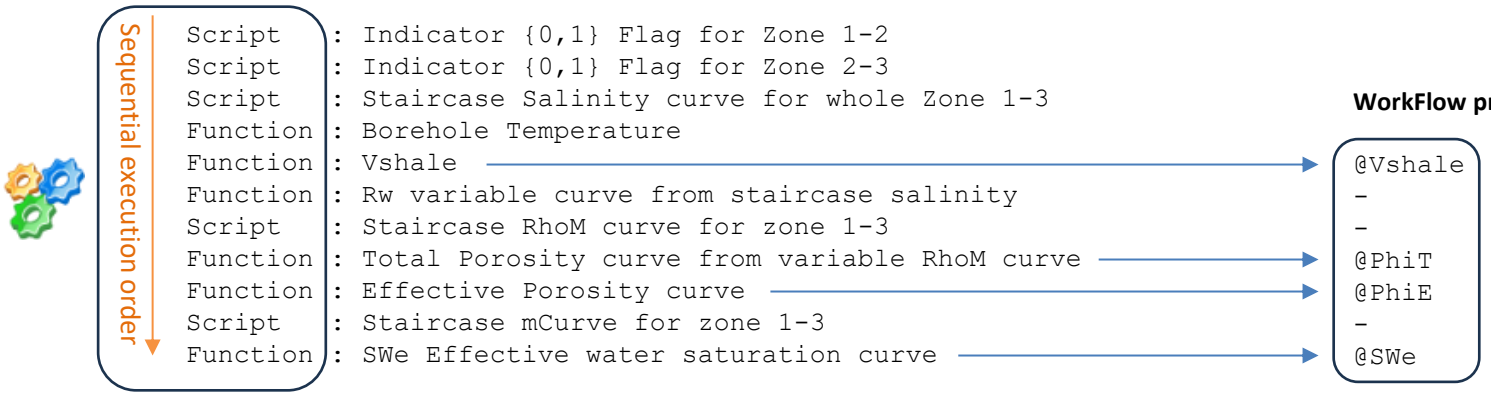
*"A **workflow** program is a chained sequence of functions and script programs applied to a particular set of raw input log curves, that yields a desired collection of output log curves."*

Once a workflow is properly defined, it can be saved and applied to different wells with the same set of input curves, to produce final interpreted log curves. Each workflow entry data consists two elements:

1. ***Curves aliases***: The original raw curve mnemonics are assigned to unique defaults, or user defined aliases.
2. ***Named constants***, or *parameters*. As any constant parameter is easily converted to a curve with constant values per depth, the workflow program can handle variable parameters per zone as step-function constants using composed indicator functions {0,1}



Anatomy of the workflow program



This “meta-program” is a chained, sequential collection of 11 functions and scripts: A collection of programs behind the scenes.

Since all the input information uses aliases and named constants, it can be saved and applied to different wells that use the same collection of original raw input curves.

Modern Math & Computer Science Operations

The internal computations engine that drives functions and scripts uses state of the art math:

- Ordinary scalar algebra
- Matrix algebra
- 4 states tetra-lean logic algebra: Non-applicable, Unknown, True, False. More complex than the standard Boolean two states algebra.
- Fuzzy logic algebra. A continuum measure of “belonging” to a result: 0≤f≤1 (Partially false to partially true). Not to be confused with probability.
- Behind the scenes, each script is internally a program that automatically writes a program: A Compiler.
- Occasional Parallel Programing, when needed to boost speed.
- This framework was carefully designed from the beginning without patches: AI and future ready tools.

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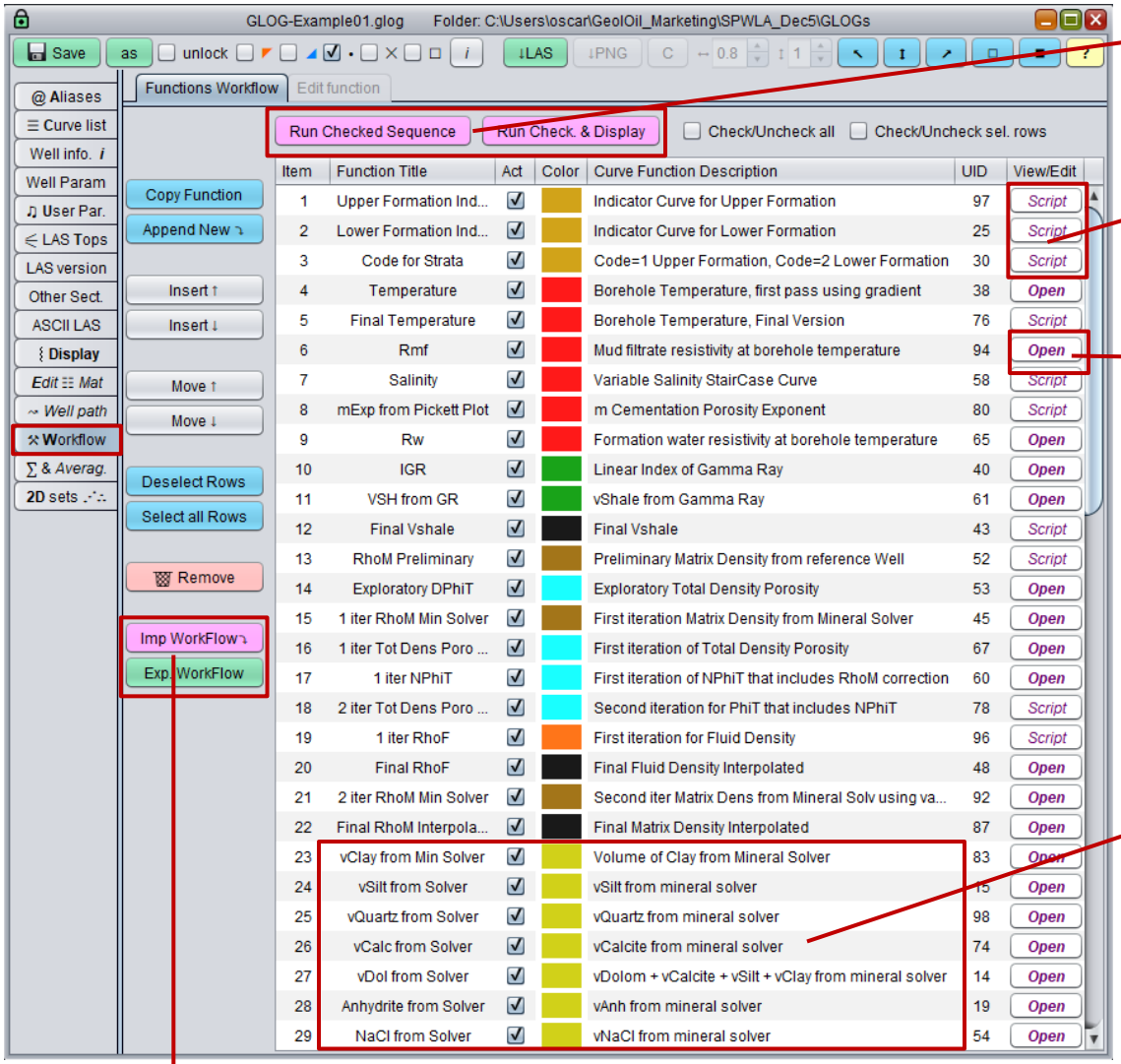
A Workflow program example



Item	Function Title	Act	Color	Curve Function Description	UID	View/Edit
1	Upper Formation Ind...	☑		Indicator Curve for Upper Formation	97	Script
2	Lower Formation Ind...	☑		Indicator Curve for Lower Formation	25	Script
3	Code for Strata	☑		Code=1 Upper Formation, Code=2 Lower Formation	30	Script
4	Temperature	☑		Borehole Temperature, first pass using gradient	38	Open
5	Final Temperature	☑		Borehole Temperature, Final Version	76	Script
6	Rmf	☑		Mud filtrate resistivity at borehole temperature	94	Open
7	Salinity	☑		Variable Salinity StairCase Curve	58	Script
8	mExp from Pickett Plot	☑		m Cementation Porosity Exponent	80	Script
9	Rw	☑		Formation water resistivity at borehole temperature	65	Open
10	IGR	☑		Linear Index of Gamma Ray	40	Open
11	VSH from GR	☑		vShale from Gamma Ray	61	Open
12	Final Vshale	☑		Final Vshale	43	Script
13	RhoM Preliminary	☑		Preliminary Matrix Density from reference Well	52	Script
14	Exploratory DPhiT	☑		Exploratory Total Density Porosity	53	Open
15	1 iter RhoM Min Solver	☑		First iteration Matrix Density from Mineral Solver	45	Open
16	1 iter Tot Dens Poro ...	☑		First iteration of Total Density Porosity	67	Open
17	1 iter NPhiT	☑		First iteration of NPhiT that includes RhoM correction	60	Open
18	2 iter Tot Dens Poro ...	☑		Second iteration for PhiT that includes NPhiT	78	Script
19	1 iter RhoF	☑		First iteration for Fluid Density	96	Script
20	Final RhoF	☑		Final Fluid Density Interpolated	48	Open
21	2 iter RhoM Min Solver	☑		Second iter Matrix Dens from Mineral Solv using va...	92	Open
22	Final RhoM Interpola...	☑		Final Matrix Density Interpolated	87	Open
23	vClay from Min Solver	☑		Volume of Clay from Mineral Solver	83	Open
24	vSilt from Solver	☑		vSilt from mineral solver	15	Open
25	vQuartz from Solver	☑		vQuartz from mineral solver	98	Open
26	vCalc from Solver	☑		vCalcite from mineral solver	74	Open
27	vDol from Solver	☑		vDolom + vCalcite + vSilt + vClay from mineral solver	14	Open
28	Anhydrite from Solver	☑		vAnh from mineral solver	19	Open
29	NaCl from Solver	☑		vNaCl from mineral solver	54	Open

Runs the selected, checked rows in sequential order, the curve output of a row may be an input to the next row.

The first three rows are user scripts that yield indicator curves for different zones, like formations, members, or other.

A regular function, just a default built-in algorithm.

This advanced workflow program for a complex reservoir, uses 77 rows combining functions and scripts.

It uses different parameters per formation, so properties like salinity and matrix density are staircase curves on their own, instead of being constant.

The workflow shows computations for the mineral solver using pseudo-AI fuzzy sets logic.

Import workflow allows to append a workflow of additional rows or load a new one for a new well.
Export workflow exports the checked workflow rows so other wells with the same raw input curves can import it and run it automatically

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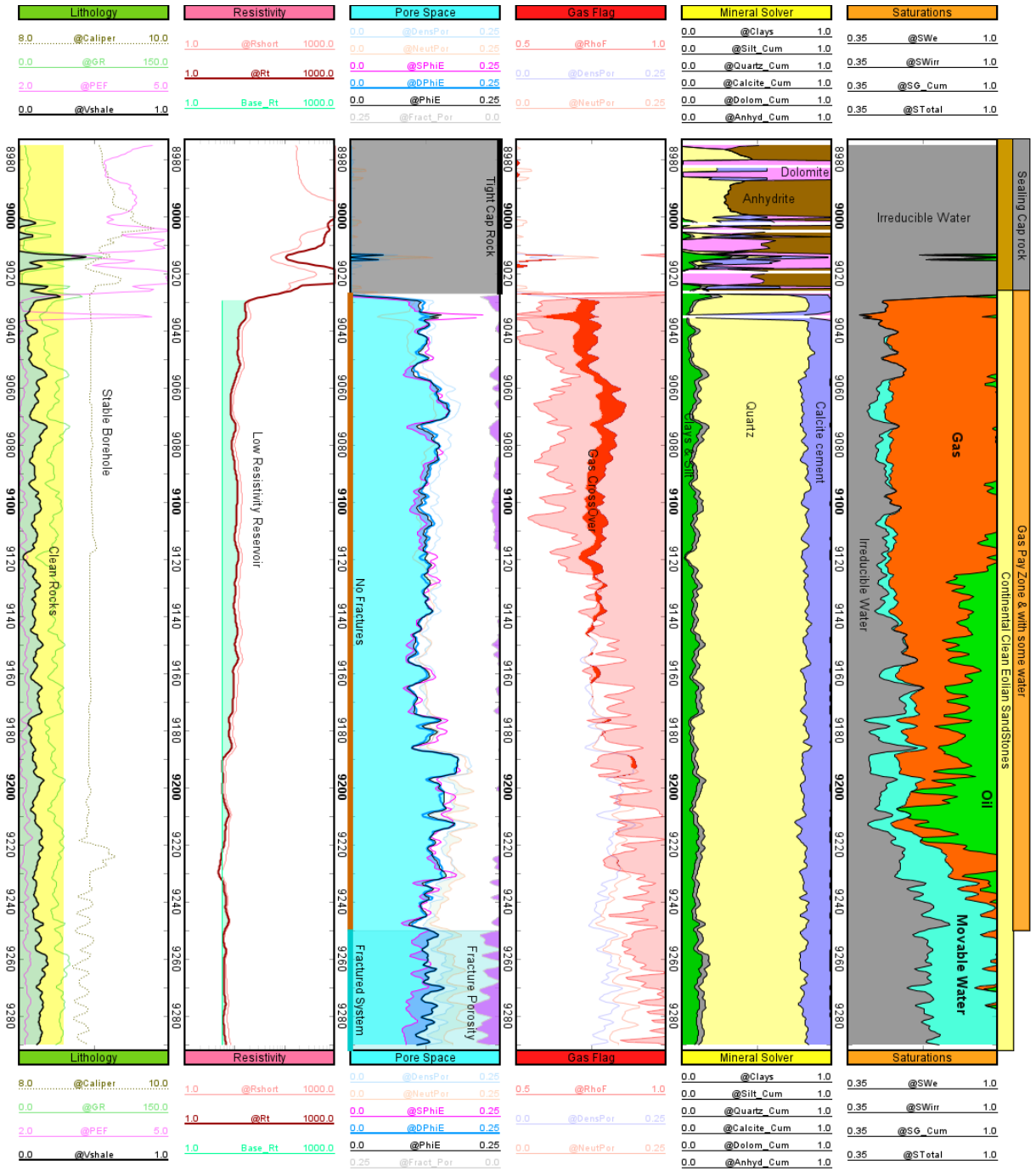

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Workflow output

Running the workflow and displaying the results takes few seconds to some minutes depending on the complexity. Then, the user designed workflow program is applied to other wells to produce immediate results.

This complex workflow outputs:

a. Four saturation curves: Irreducible Water Saturation, Movable Water Saturation, Gas Saturation, and Oil Saturation.

b. Mineral solver

c. Porosity and Fracture Porosity

d. Iterated Fluid Density RhoF and its consistency with gas cross-over.

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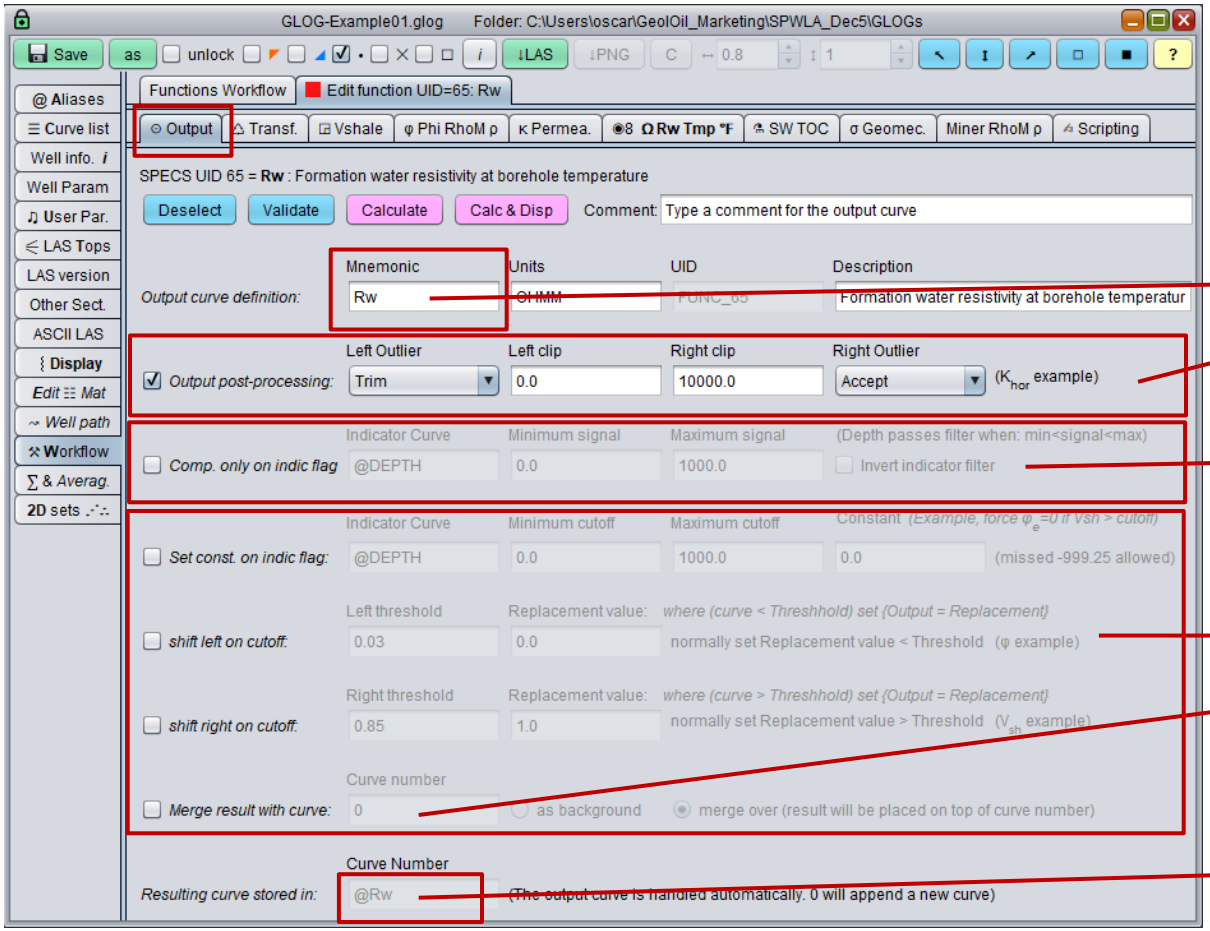
Each workflow row has its own output panel



User defined mnemonic output

Post-processing filtering and outlier controls.

Conditional pre-processing indicator filter.

Post-processing options, including merging over or under former curves.

User defined output alias

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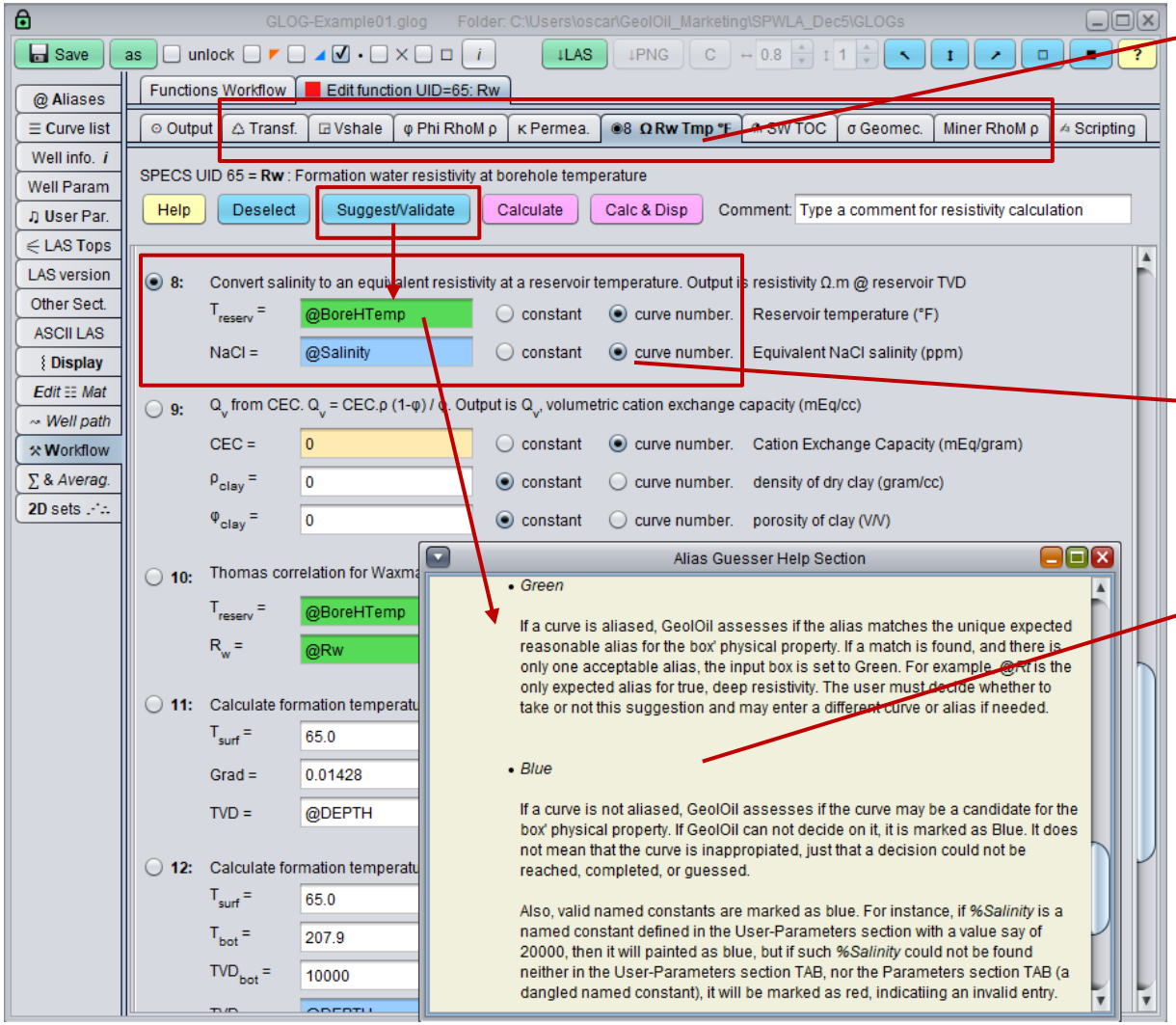
Each workflow function row has its own computations panel



A large collection of built-in +130 algorithms, from Math Transforms, Vshale, Pore Space, Permeability, Temperature, Saturations & Shale Oil, Geomechanics, and Mineral Solvers.

The eight function on the Rw algorithms tab was selected. This converts Salinity to Rw, using a salinity curve as input, instead of a constant salinity value.

A color code guesses and suggests aliases for each input box. Each input can be a:

- Numerical constant
- Named constant (% Sigil)
- Mnemonic curve
- Aliased curve (@ Sigil)

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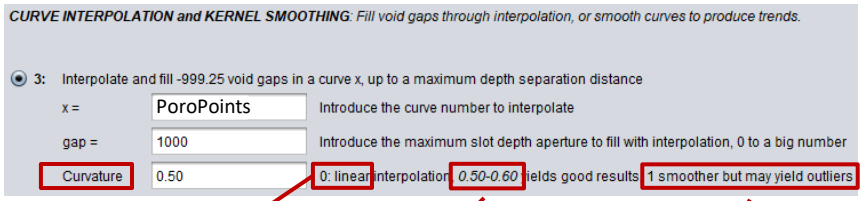
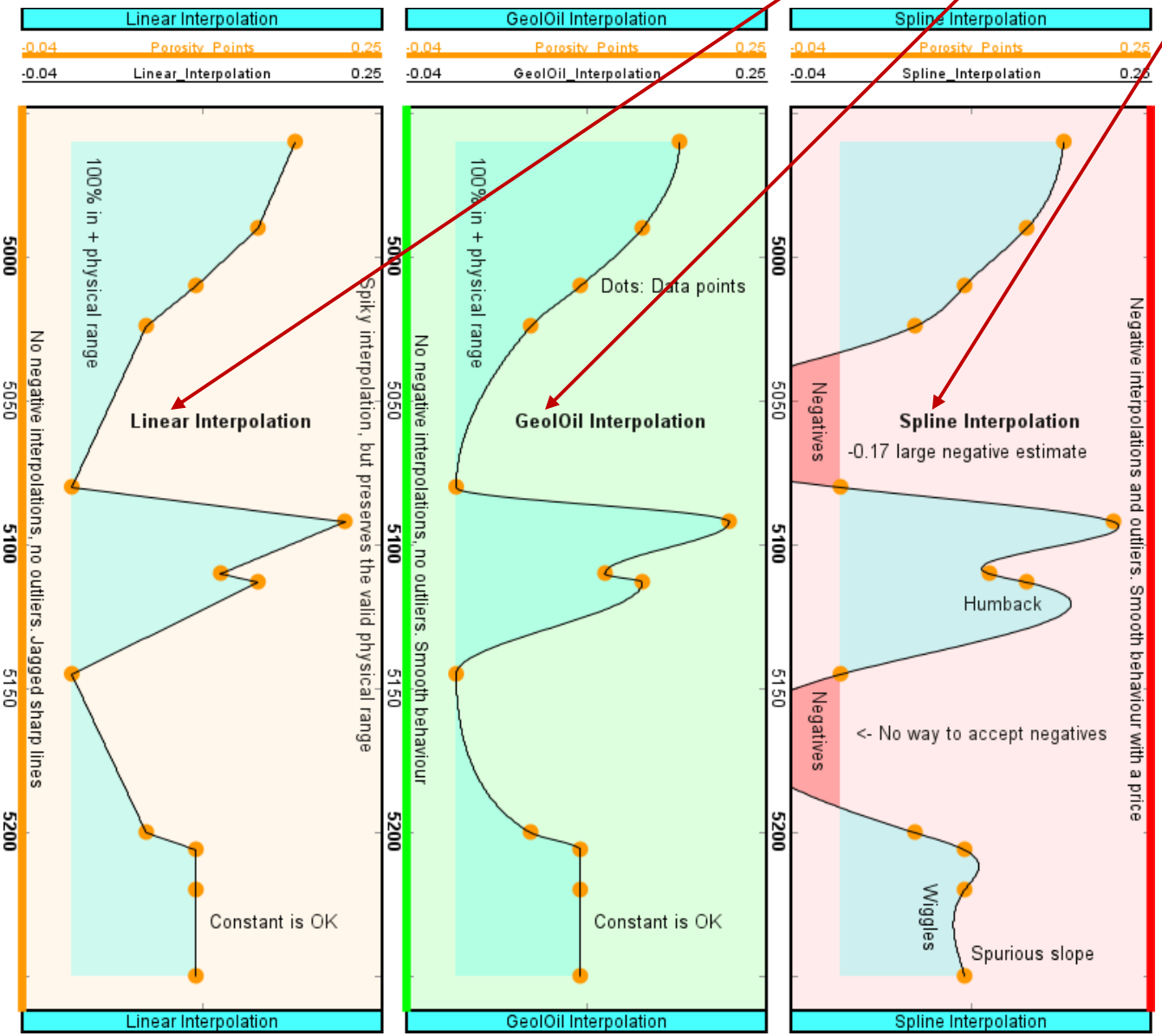
Special math function:

"Safe" range interpolation: Outlier free





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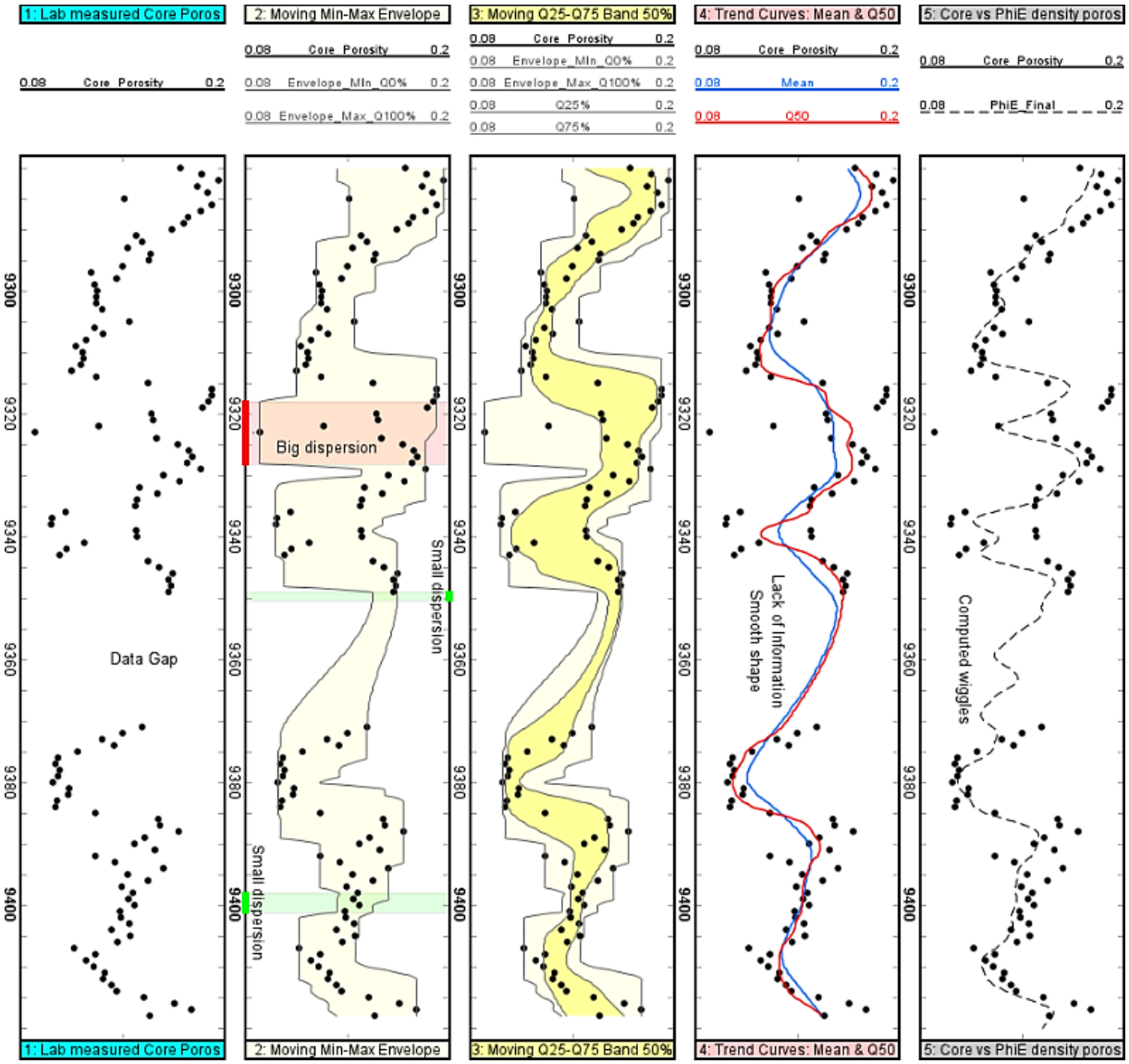
Special math function:

Uncertainty probability envelopes

10: Create a moving uncertainty envelope for a curve, like min or max wrapping curve, avg, and quantile confidence bands.

x =	@PhiE	Introduce the curve number of X to produce a moving envelope probability curve
gap =	100.0	Introduce the maximum slot depth aperture to fill with interpolation, 0 to a big number
h =	10.0	◉ constant ○ curve number, vertical bandwdith to compute moving envelope
		◉ If a quantile envelope is selected, specify the left 0.0≤area≤1.0 covered in the h depth band-width
LeftArea	0.75	◉ constant ○ curve number. 0 for min, 0.25 low, 0.50 median, 0.75 high, 1 max
		○ If a generalized moving average is selected, specify its power, like 1.0 for a regular arithmetic mean
Power =	1.0	◉ constant ○ curve number. -∞ for min, -1 harmonic, 0 geomet, 1 mean, ∞ max



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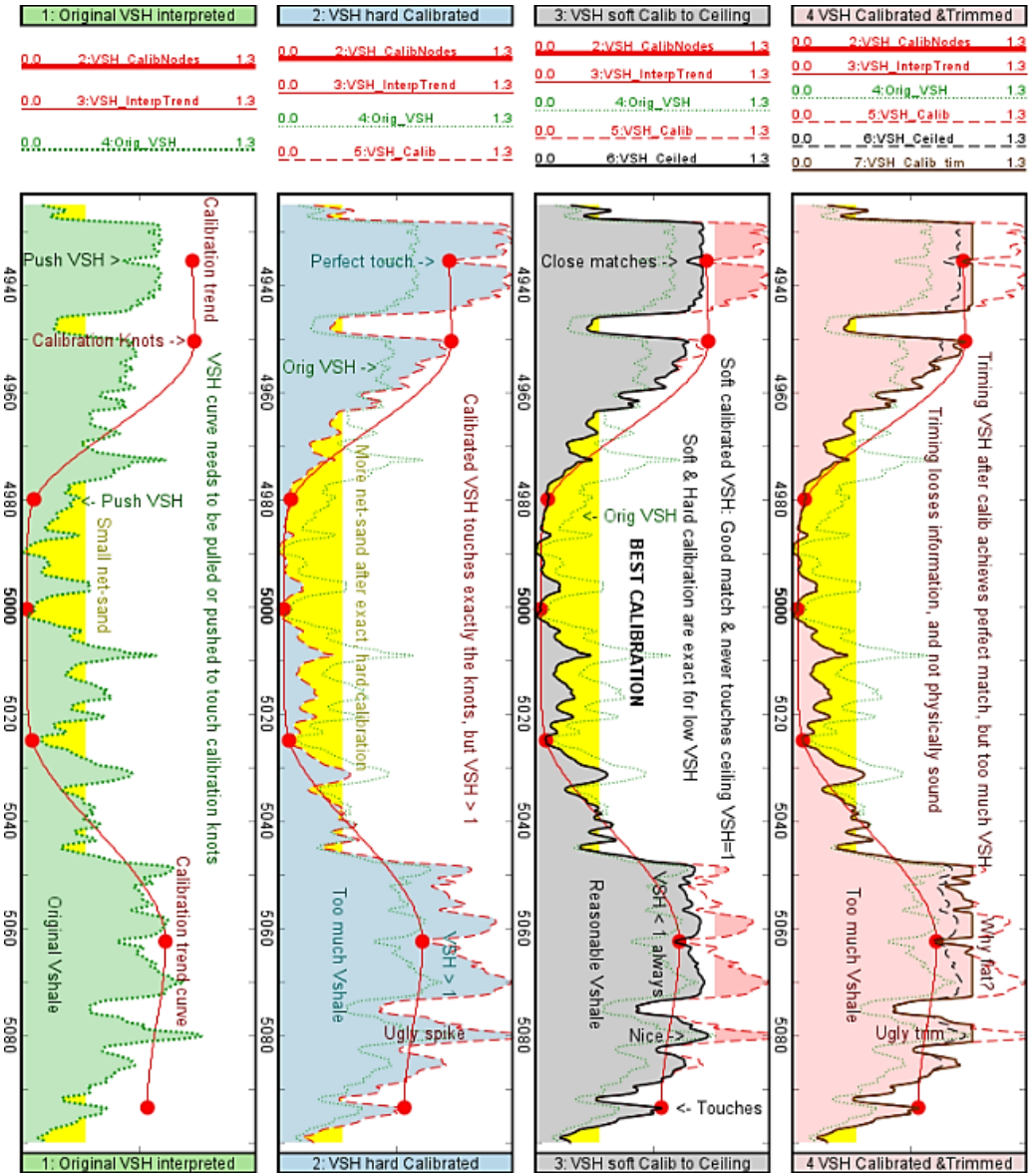
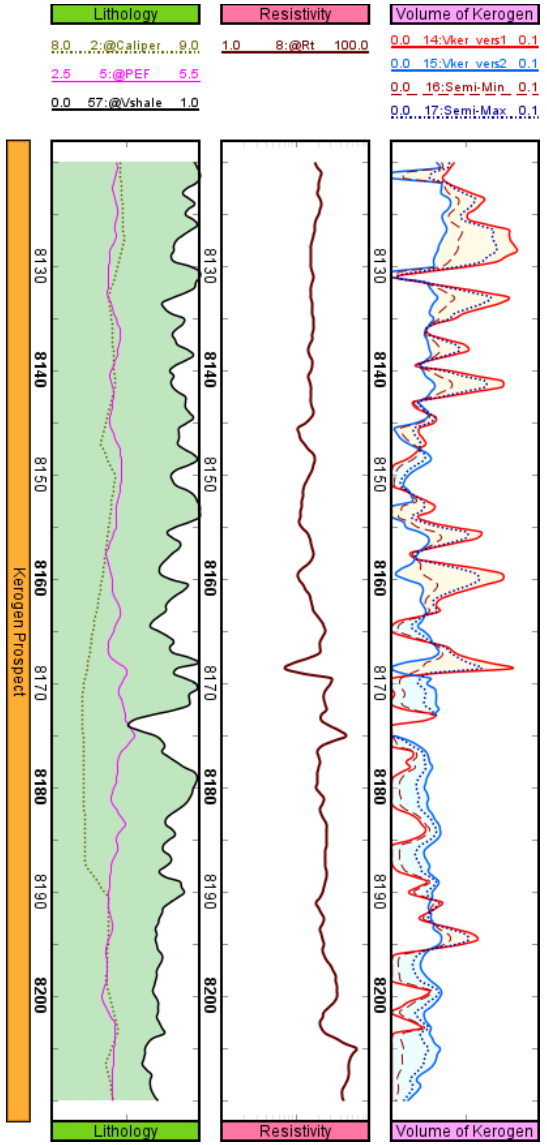
Special math functions:

Left: Conditional soft calibration, and

Right: semi-extremes





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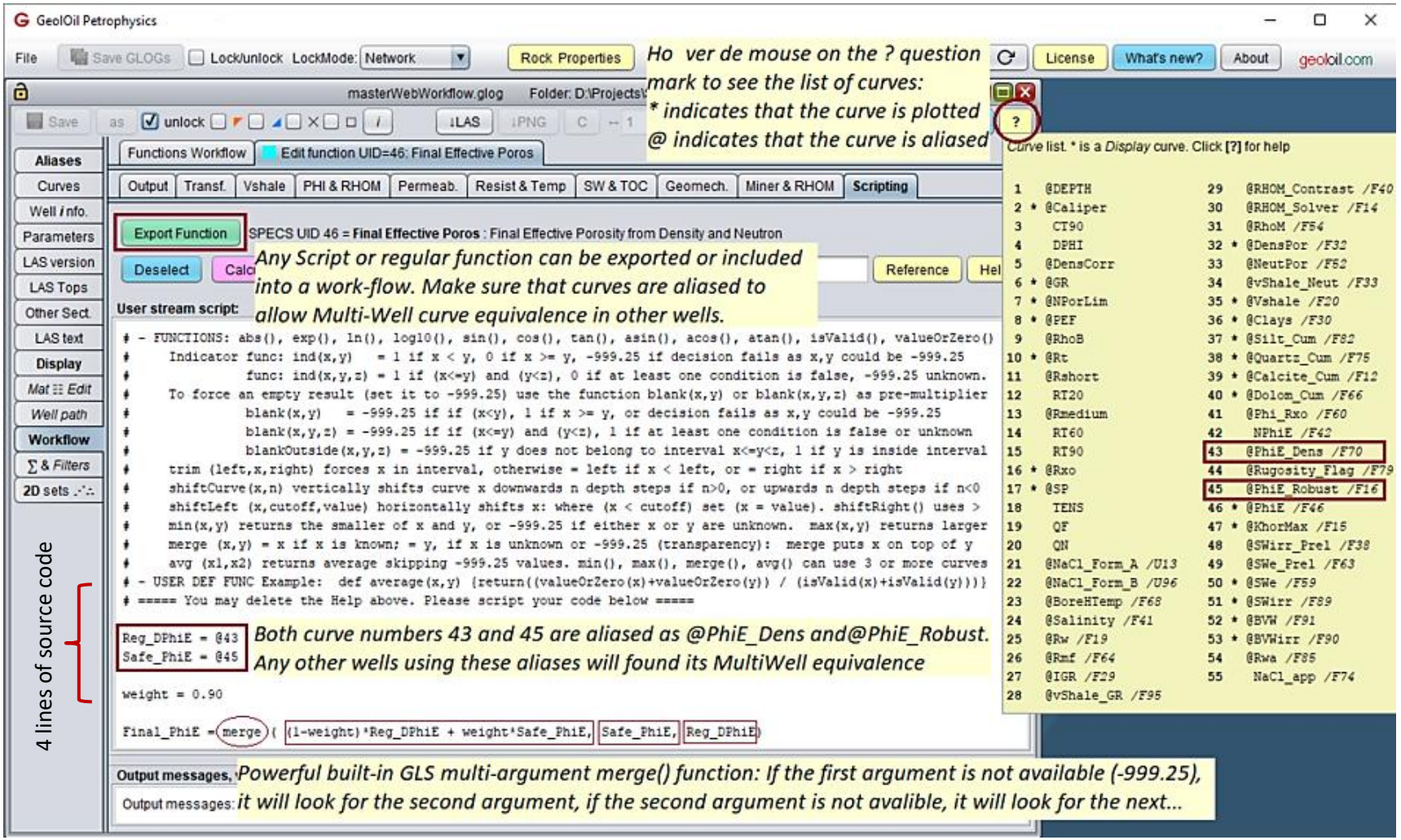
The Scripting engine takes curve aliases and named constants

Just <u>four lines</u> of source code. Try to do this in Python. This is a dedicated, domain specific scripting language for petrophysics and log processing.



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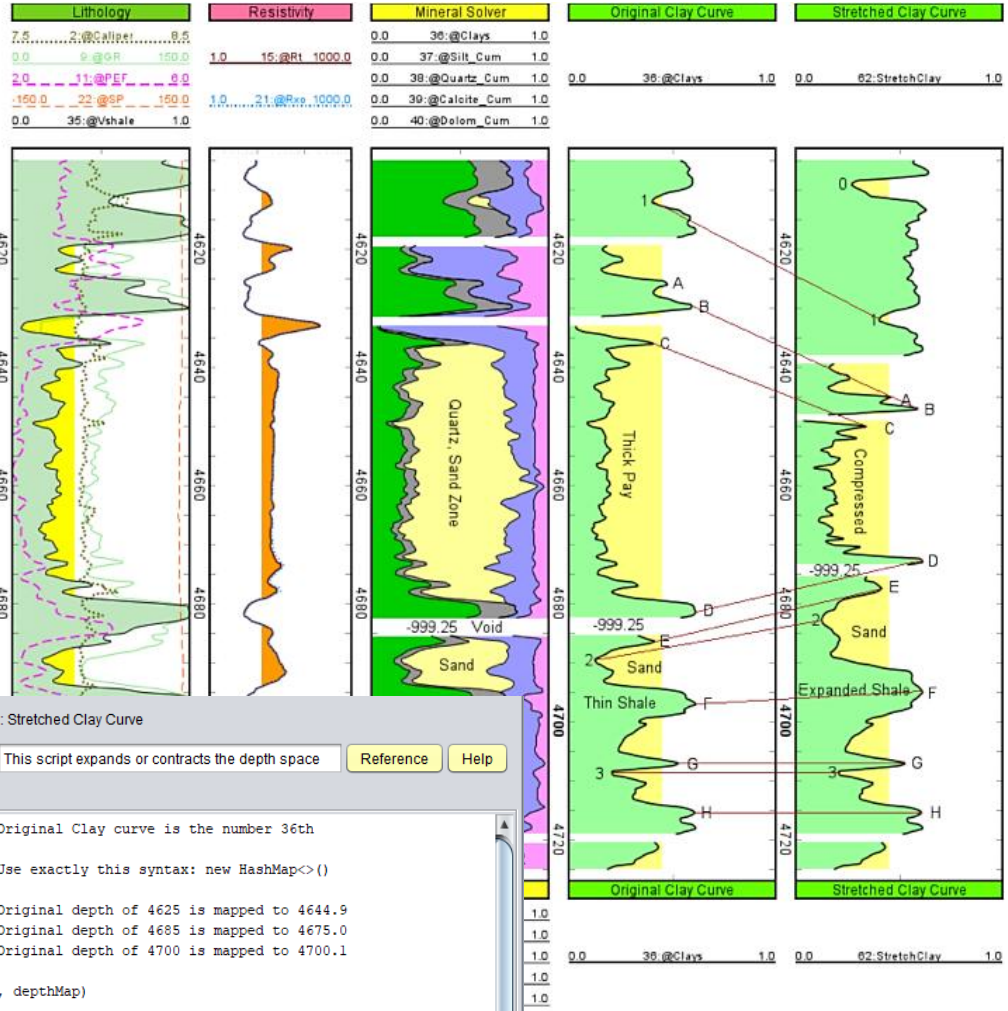
A Script example to stretch a log curve

Just six lines of source code. (return command is optional)



Export Function | SPECS UID 25 = **Stretched Clay** : Stretched Clay Curve

Deselect | Calculate | Active | Comments: This script expands or contracts the depth space | Reference | Help

User Script:

```
1  Clay = @36                          # Original Clay curve is the number 36th
2
3  def depthMap = new HashMap <> ();  # Use exactly this syntax: new HashMap<>()
4
5  depthMap.put (4625.0, 4644.9);     # Original depth of 4625 is mapped to 4644.9
6  depthMap.put (4685.0, 4675.0);     # Original depth of 4685 is mapped to 4675.0
7  depthMap.put (4700.0, 4700.1);     # Original depth of 4700 is mapped to 4700.1
8
9  def deformedDepthClay = stretch (Clay, depthMap)
10
11 return (deformedDepthClay)         # Return creates a new stretched curve from Clay
12
13 # That is all: Line  3 declares a depth map correspondence Original - Destiny
14 #              Lines 5-6 defines a contraction of depths, like a pinchout thining
15 #              Lines 6-7 defines an expansion depths, like stretching a rubber band
16 #              Line  9 stretch() peforms the contraction-expansion, defining a new curve
17 #              Line 11 returns and exits from the script.
```

Output messages, warnings and errors:

```
** SUCCESSFUL Script compilation and execution. **

Please validate the result with 'Edit Table' or by Plotting the curve.
```

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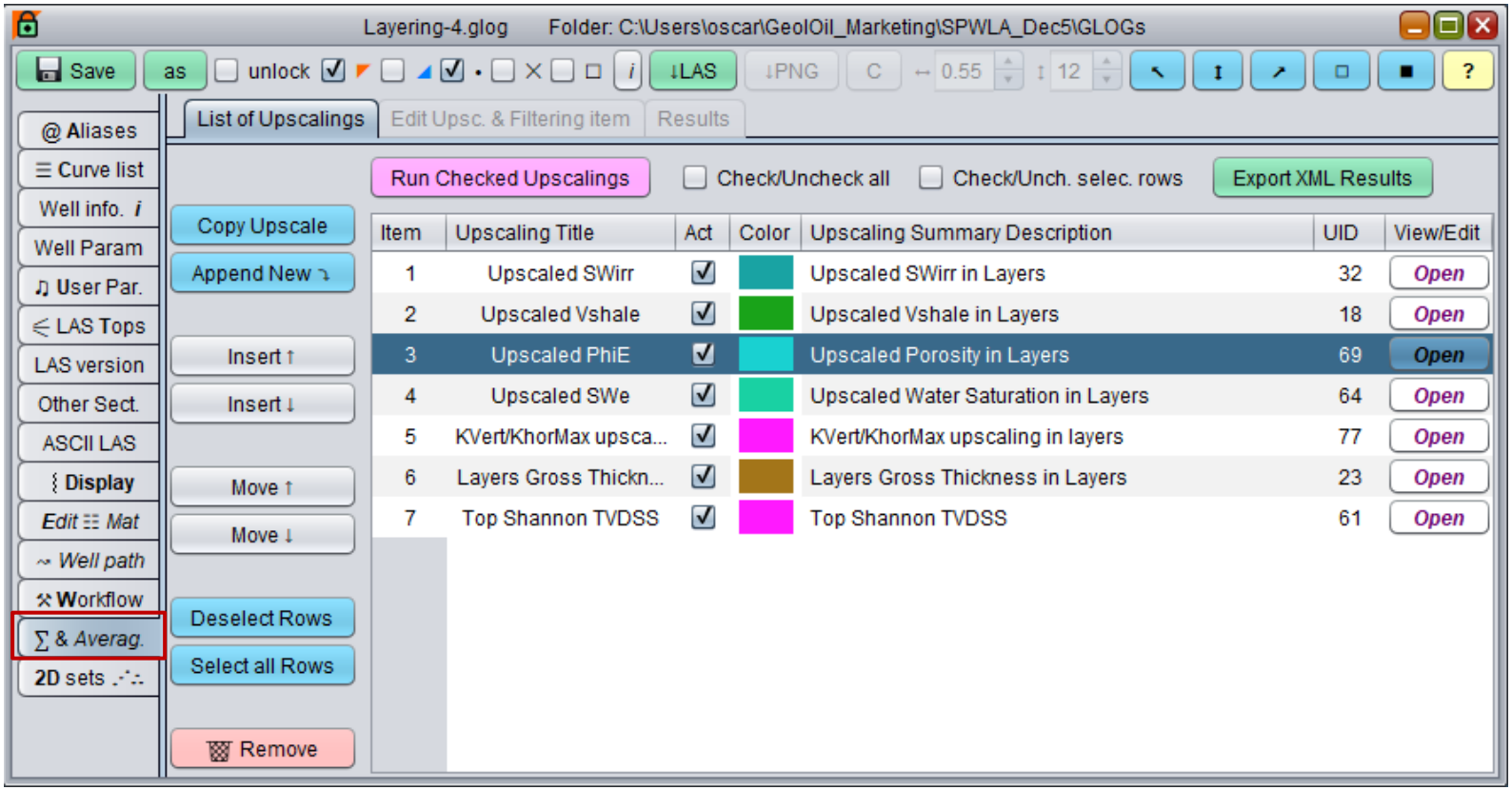
The Upscalings Workflow

Similarly to the Function & Scripting workflow, a WorkFlow of Upscalings and Petrophysical Summaries framework is defined.

This allows (among other things) to define a layering strategy to build 3D geo-cellular models, compute petrophysical cutoffs, net-rock and net-pay per zones, and other computations.



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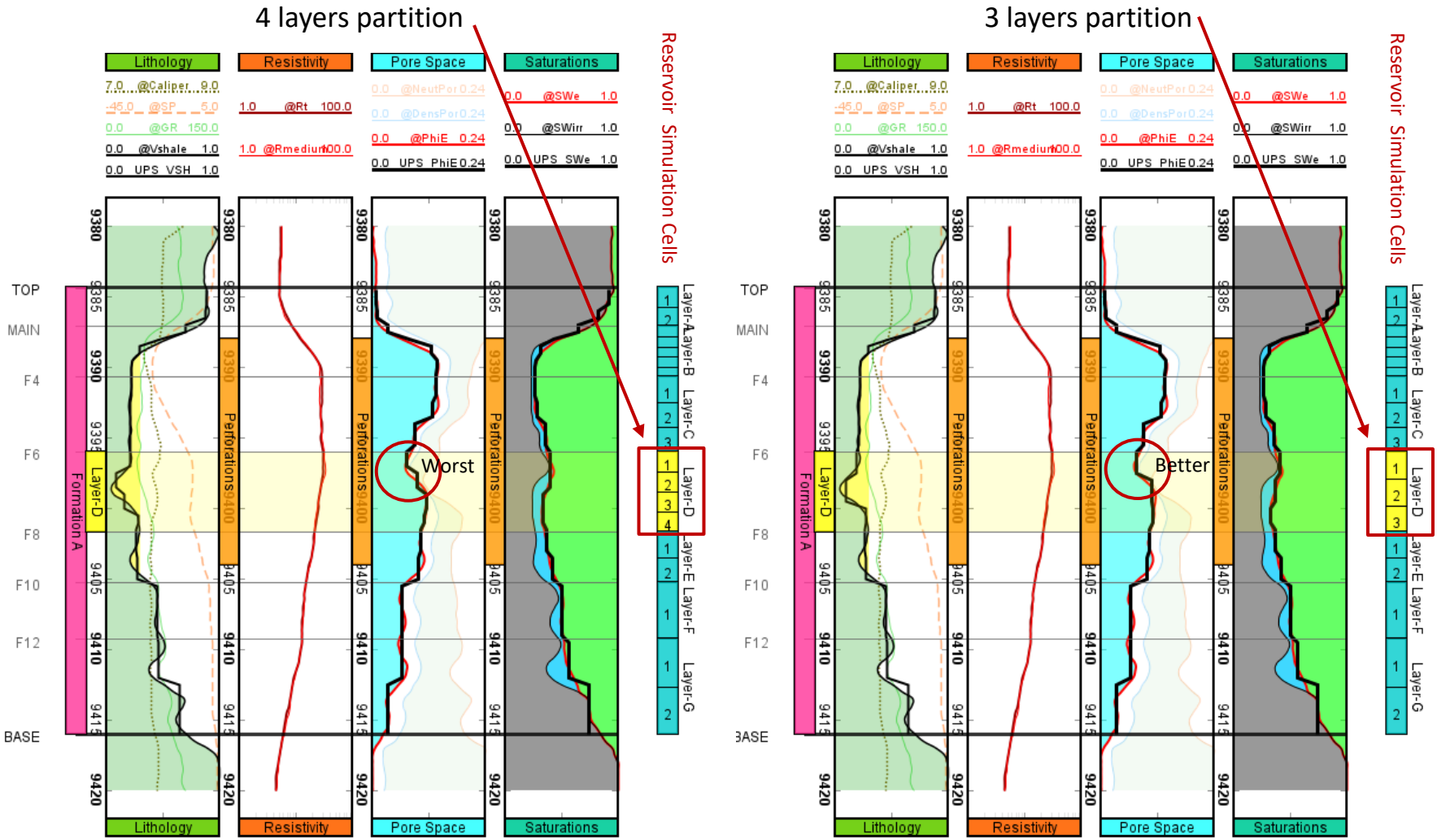
A layering framework for the zone “Layer-D”



Not always a finer vertical resolution yields a better model to capture reservoir heterogeneity and baffles. The split of “Layer-D” to the right into only 3 layers follows better the porosity than the partition into 4 layers to the left. This visual representation of the upscalings, is essential to define to good 3D geo-cellular models for simulation purposes.

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Thank you!

"A great petrophysics software must excel in four aspects:
1.- Designed after decades of petrophysics consulting.
2.- Modern programming practices in compiler design and threads.
3.- Advanced & innovative applied mathematical algorithms.
4.- An outstanding and fast customer service.
Well, we have all these traits." *Oscar Gonzalez. GeolOil LLC, Director* ■

TESTIMONIALS↓ *48 testimonials→* *26 Google reviews→*

2025 November: *"I continue to transition from PowerLog to GeolOil, and I am now recommending GeolOil to companies for which I consult. Congratulations on a fine and ingenious product. Cheers."*

Douglass Sharp. *Independent Senior PetroPhysicist Consultant. Texas, USA.*■

2024 August: *" I think GeolOil is amazing. I've been using the software on almost a daily basis and the petrophysical capabilities are making my life so much easier. "*

Emre Cankut Kondakci. *Senior Geologist. IPT Well Solutions. Houston, Texas, USA.*■

2024 July: *" The GeolOil software is working nicely on a Macintosh computer. I have to admit that initially I was too dummy to get GeolOil started on Mac-OS, but a colleague helped me to got on a right track."*

Heikki Bauert. *Geological Survey of Estonia (EGT), an Estonian Republic Government Agency. Geological Survey of Estonia. Rakvere, Estonia.*■

2024 January: *"... In a world where exceptional service is increasingly rare, you have truly set a standard to aspire to, and I wanted to take a moment to acknowledge and appreciate your outstanding contribution. Your dedication makes a real difference, and we are grateful to have such a reliable partner." Read more.*

Enis Aliko. *Senior Drilling Engineer. Wellynx Engineering. Pescara, Italy.*■

2023 August: *"I've been impressed by the programme, and it works for my purposes on my small laptop."*

Michael McCaughey. *Senior GeoScientist, ELGOL Geoscience. Director. Twyford, England, UK.*■

2023 February: *"I was a Geolog user for many years so I know it pretty well. Geoloil is really good, it just takes a while to get used to like any software."*

Sheldon Murphy. *Senior Petrophysics Consultant. Epoch Geologic, LLC. Pittsburgh, Pennsylvania, USA.*■

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