

NEXT

A Schlumberger Company

Petrel 2017 Property Modeling Module 3: Scale-up well logs



Schlumberger-Private

Petrel 2017 Property modeling

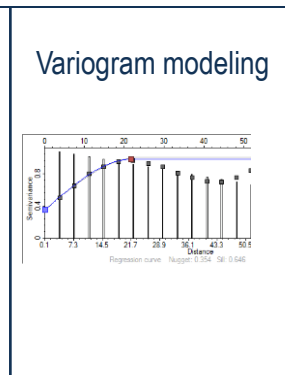
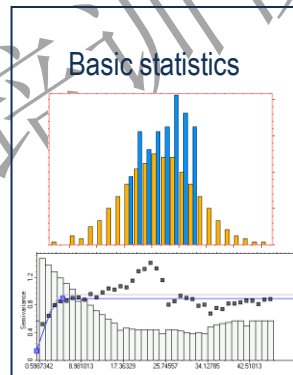
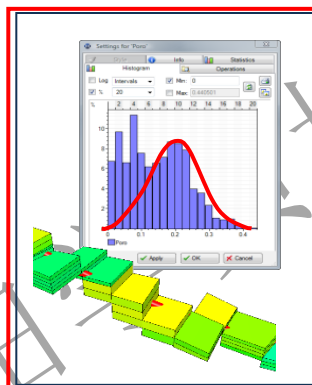
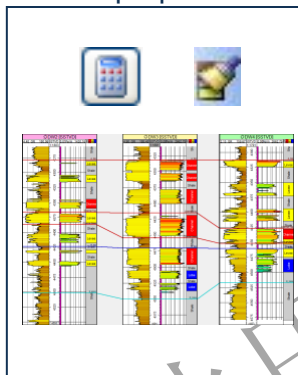
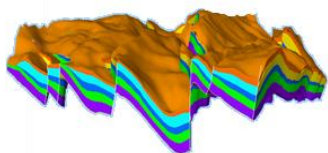
Intro

Property modeling
data preparation

Scale up well logs

Univariate and bivariate geostatistics

Petrel Property Modeling
objective and workflow

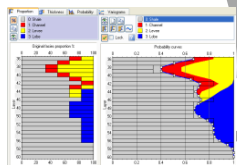


Facies modeling

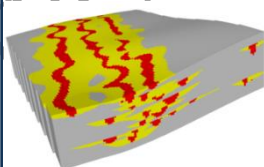
Petrophysical modeling

Volume calculation and
Uncertainty analysis

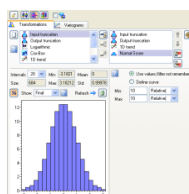
Discrete
data analysis



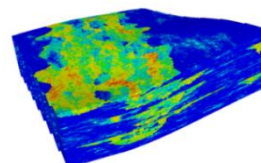
Stochastic facies
modeling



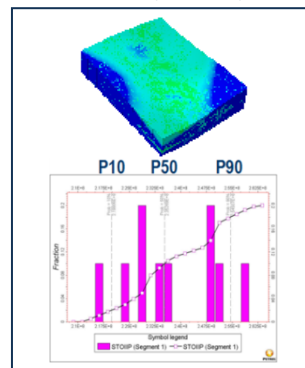
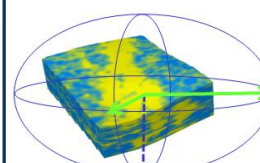
Continuous
data analysis



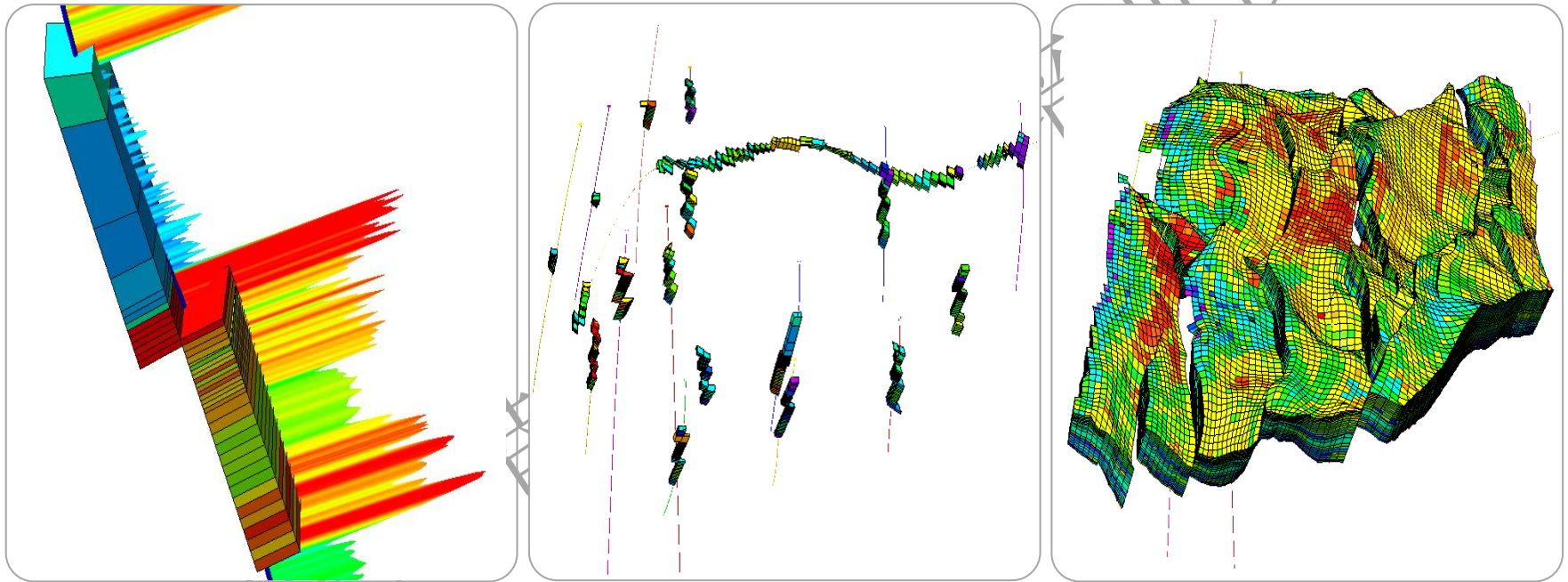
Stochastic and
deterministic
petrophysical modeling



Use of secondary
information for
property modeling



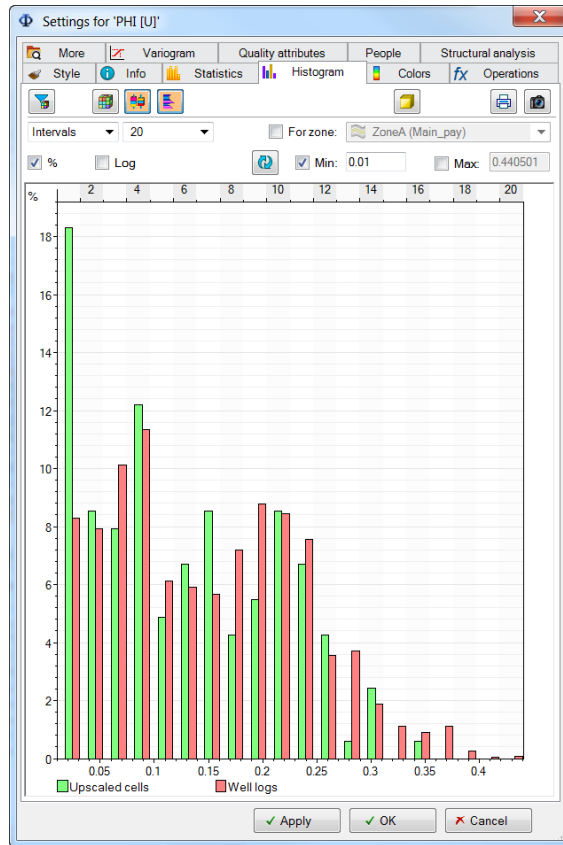
Scale up well logs: Process



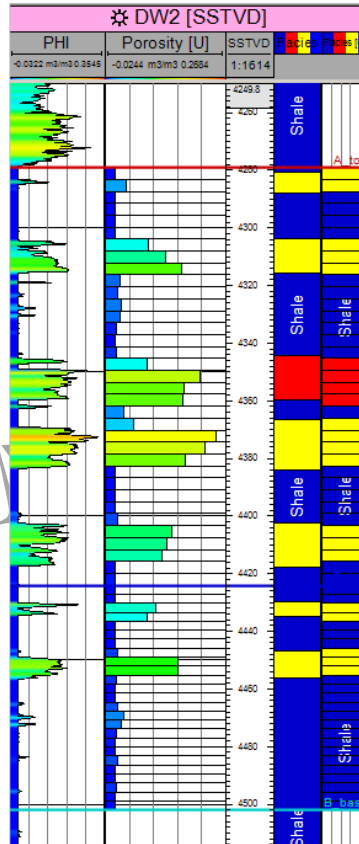
Scale up well logs:

What to consider when upscaling well logs

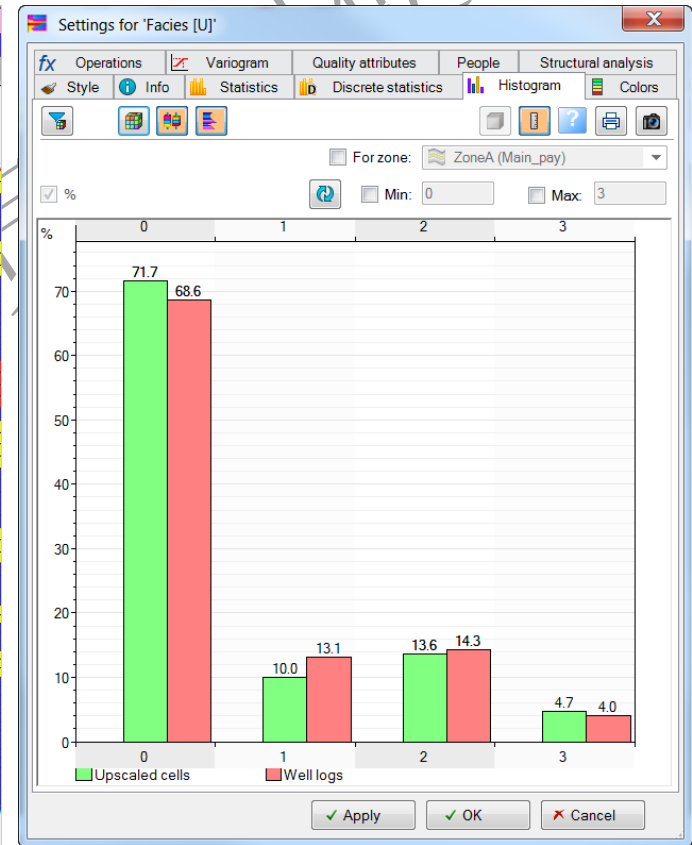
Continuous logs



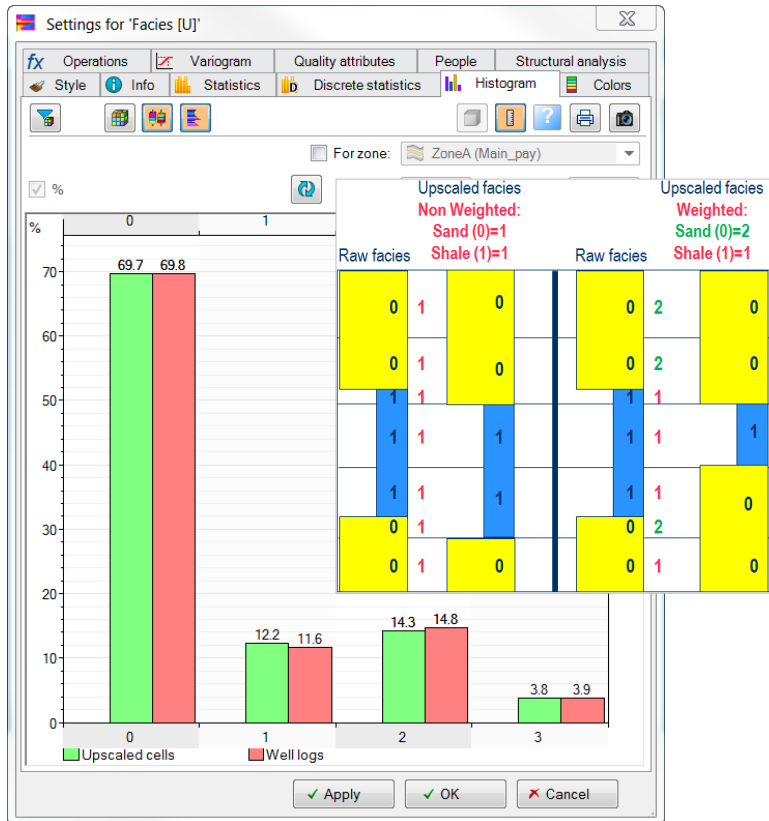
Well track



Discrete logs



Scale up well logs: Discrete logs facies/lithology



Input

Well logs

Welltop attributes

Points attribute

Select log: Facies

Settings Zones Weighted Seed Horizon mapping

Average method: Most of

Wells: None All

Use bias

Upscaled property: Fluvial f

Upscaled from: Fluvial facies

Use weighting

Treat log: As lines

Method: Neighbor cell

Min. number of points in cell: 3

Wells

A10

A15

A16

B1

B2

B4

B8

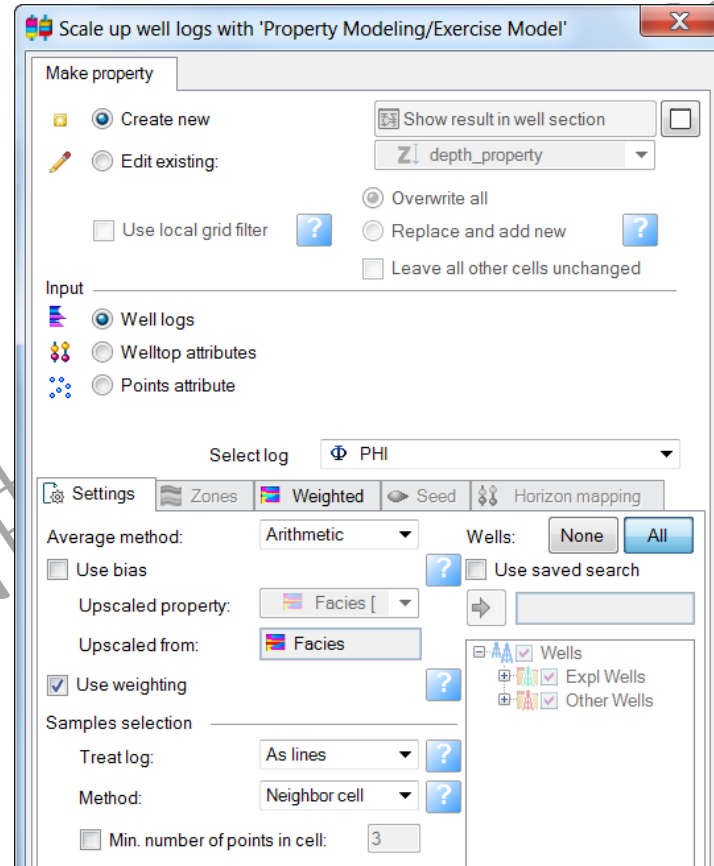
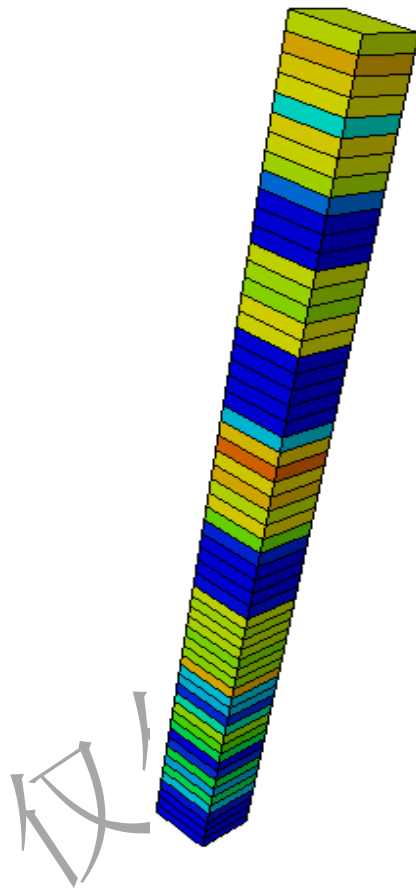
B9

Settings Zones Weighted Seed Horizon mapping

Equal for all zones

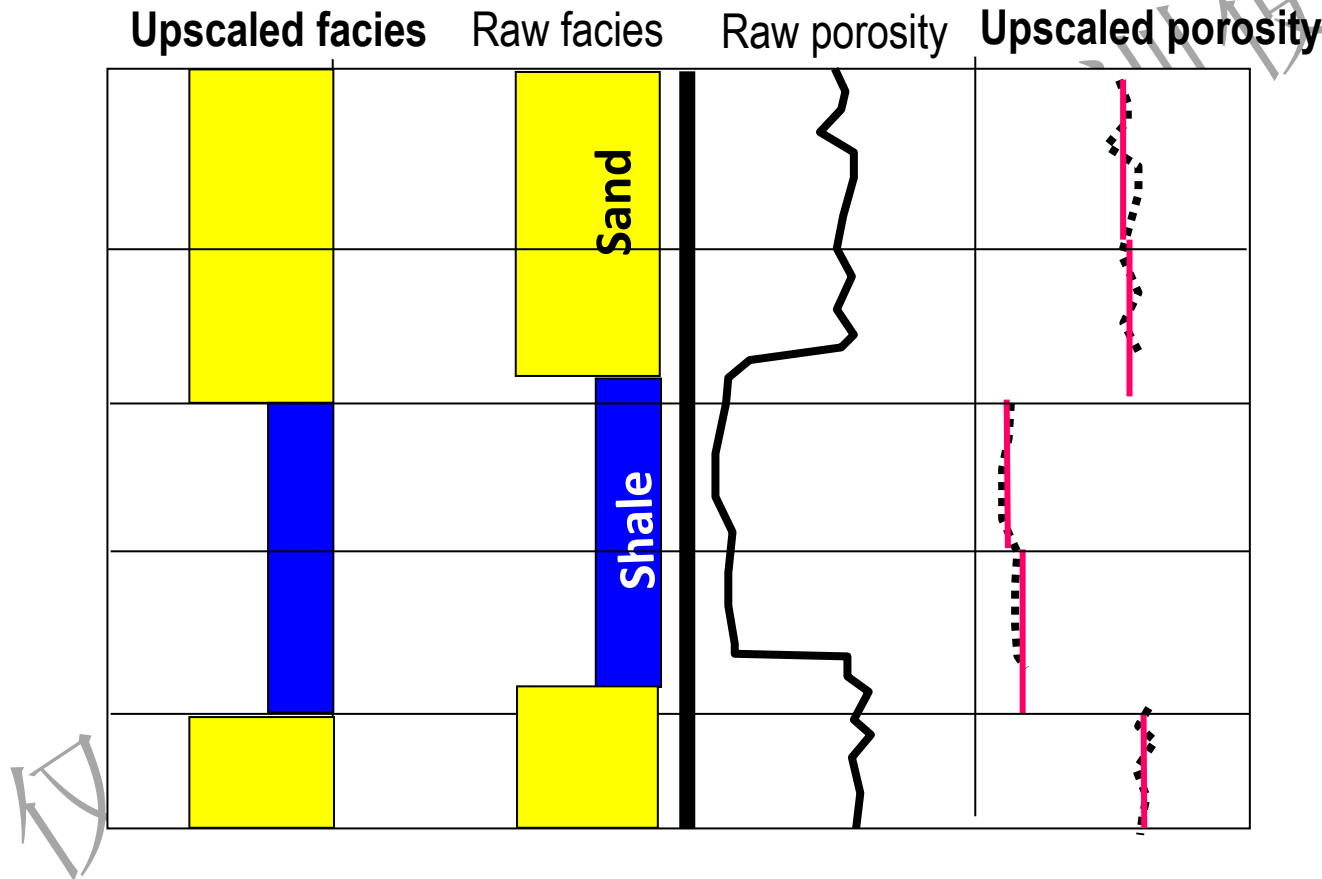
Zone	Clay	Sand	Silt	Fine Silt
All zones	1.00	1.00	1.00	1.00

Scale up well logs: Continuous logs petrophysical properties

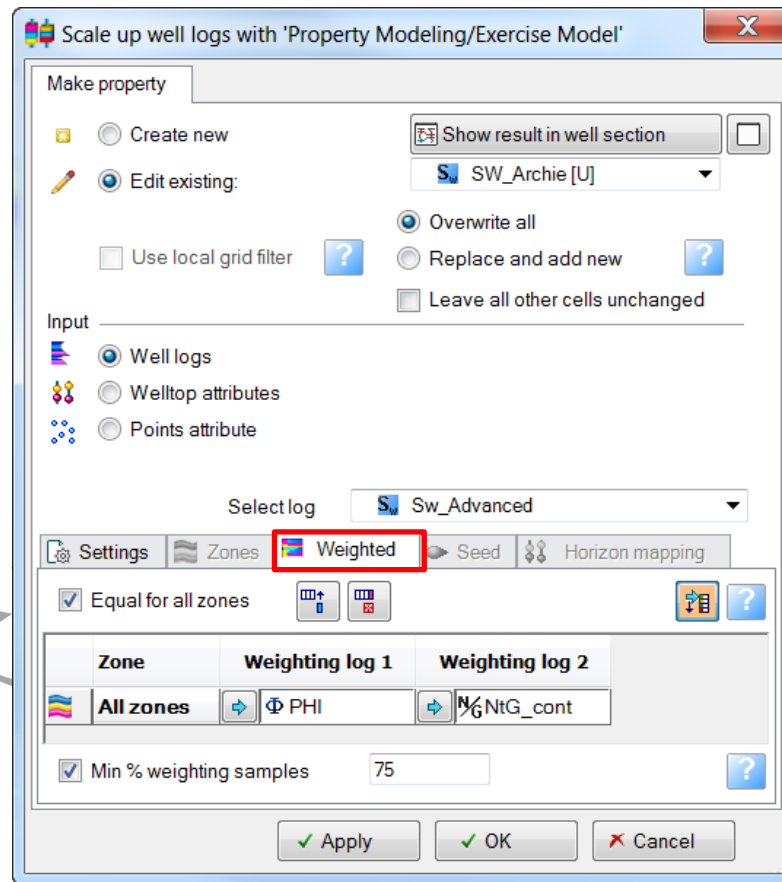


Scale up well logs:

Concept of biasing to a discrete log



Scale up well logs: Continuous logs petrophysical properties – Use weighting

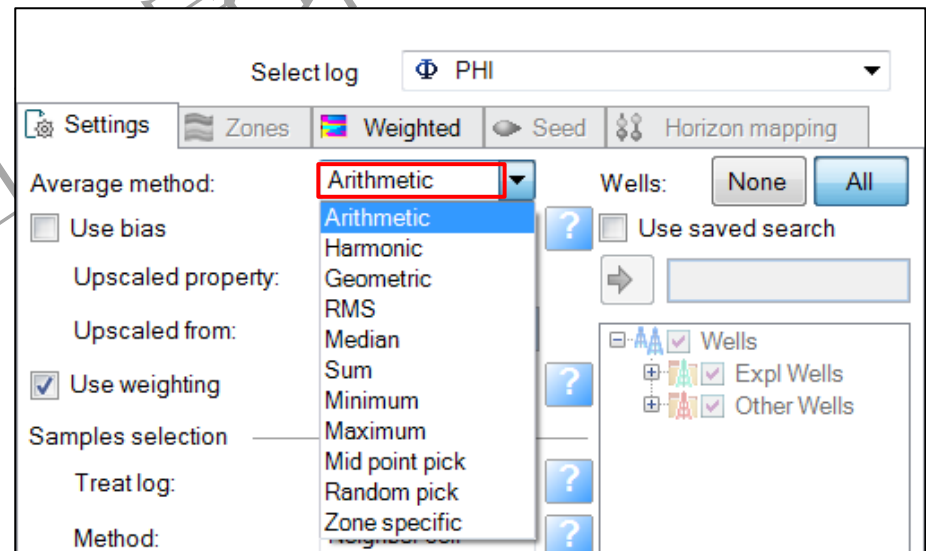
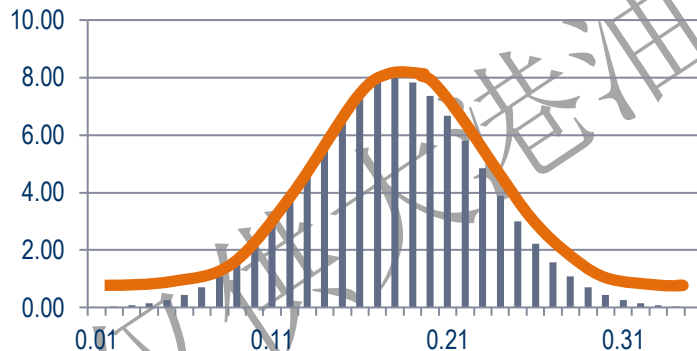


Scale up well logs: Porosity/Sw/NtG (Arithmetic Mean)

Arithmetic mean is used for properties such as Porosity, Water saturation (Sw)*, and Net-to-Gross (N/G) because these are additive variables.

Arithmetic Mean

$$x_a = \frac{1}{n} \sum_{i=1}^n x_i$$



Scale-up well logs: Sw (Arithmetic Mean vs. Median/Mid-Point Pick)

Select log: **SW_Archie**

Settings | Zones | Weighted | Seed | Horizon mapping

Average method: **Median** (dropdown menu)
Wells: **None** | **All**

☐ Use bias

Upscaled property: Geometric
RMS

Upscaled from: **Median** (dropdown menu)
Sum
Minimum
Maximum
Mid point pick (dropdown menu)
Random pick
Zone specific

☒ Use weighting

Samples selection

Treat log: **Mid point pick** (dropdown menu)
Random pick
Zone specific

Method: **Mid point pick** (dropdown menu)

☐ Min. number of points in cell: 3

☐ Zone correction

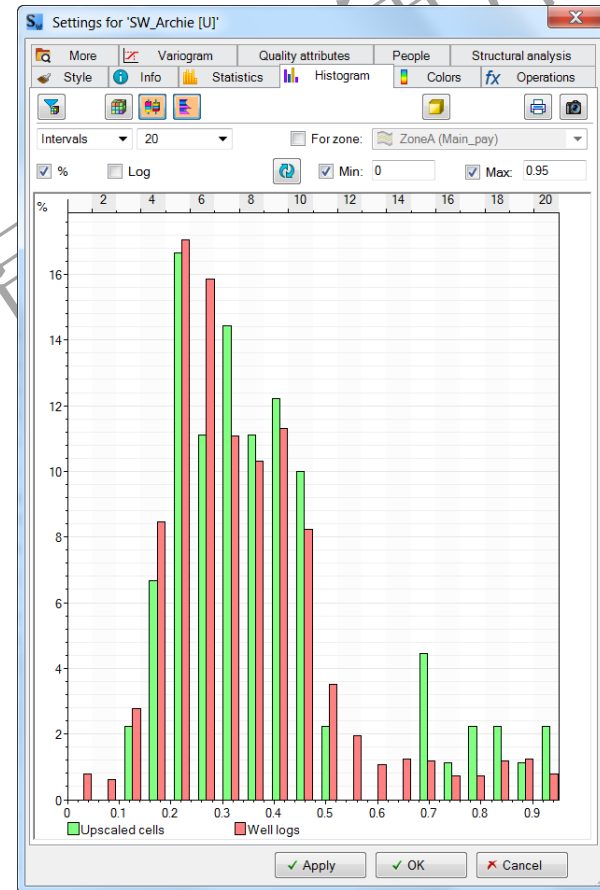
Outputs

☐ Well report
☐ Reset output sheet

☐ Zone corrected log

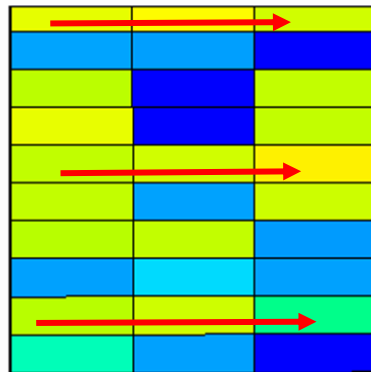
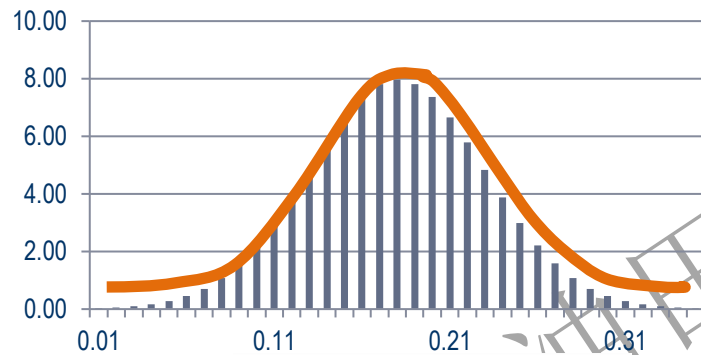
☐ 3D grid zone log

☐ 3D grid well tops



Scale up well logs: Permeability logs (Arithmetic Mean)

Arithmetic Mean $x_a = \frac{1}{n} \sum_{i=1}^n x_i$



Select log: k Perm

Settings | Zones | Weighted | Seed | Horizon mapping

Average method: Arithmetic Wells: None All

☐ Use bias ? ☐ Use saved search

Upscaled property: Facies →

Upscaled from: Facies

☒ Use weighting ?

Samples selection

Treat log: As lines ?

Method: Neighbor cell ?

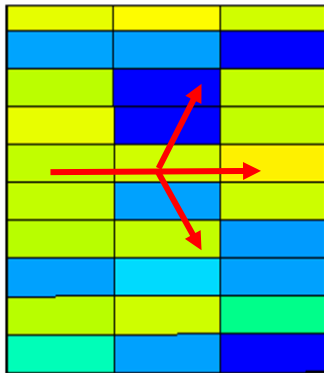
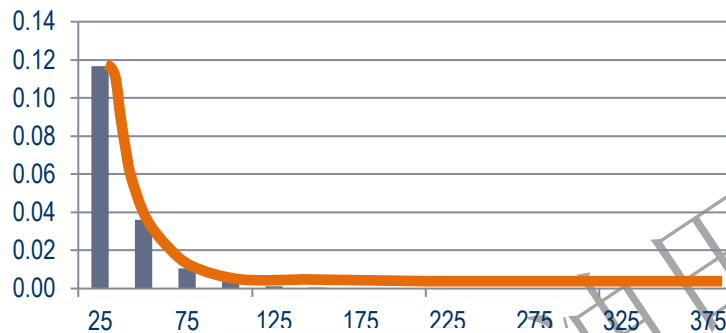
☐ Min. number of points in cell: 3

Wells

- ☒ Expl Wells
- ☒ Other Wells

Scale up well logs: Permeability logs (Harmonic Mean)

Harmonic Mean $x_h = \frac{n}{\sum_{i=1}^n \frac{1}{x_i}}$



Select log: **k Perm**

Settings | Zones | **Weighted** | Seed | Horizon mapping

Average method: **Harmonic** Wells: **None** | **All**

☐ Use bias ☐ Use saved search

Upscaled property: **Facies**

Upscaled from: **Facies**

☒ Use weighting

Samples selection

Treat log: **As lines**

Method: **Neighbor cell**

☐ Min. number of points in cell: **3**

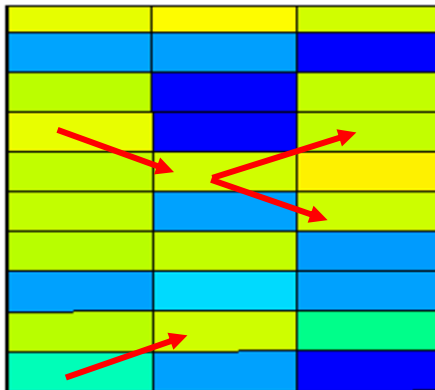
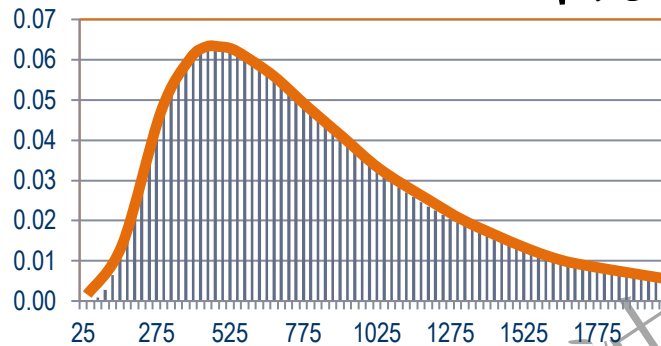
Wells

- ☒ Expl Wells
- ☒ Other Wells

Scale up well logs: Permeability logs (Geometric Mean)

Geometric Mean

$$x_g = \sqrt[n]{\prod_{i=1}^n x_i}$$



Select log: k Perm

Settings Zones Weighted Seed Horizon mapping

Average method: Geometric

☐ Use bias

Upscaled property: Facies

Upscaled from: Facies

☒ Use weighting

Samples selection

Treat log: As lines

Method: Neighbor cell

☐ Min. number of points in cell: 3

Wells: None All

☐ Use saved search

Wells

- ☒ Expl Wells
- ☒ Other Wells

Scale up well logs: Zone-specific scale up

Settings Zones Weighted Seed Horizon mapping

Average method: **Zone specific** Wells: None All

☐ Use bias ? ☐ Use saved search

Upscaled property: Facies []

Upscaled from: Facies

☐ Use weighting ?

Wells

- ☒ Wells
- ☒ Expl Wells
- ☐ Other Wells

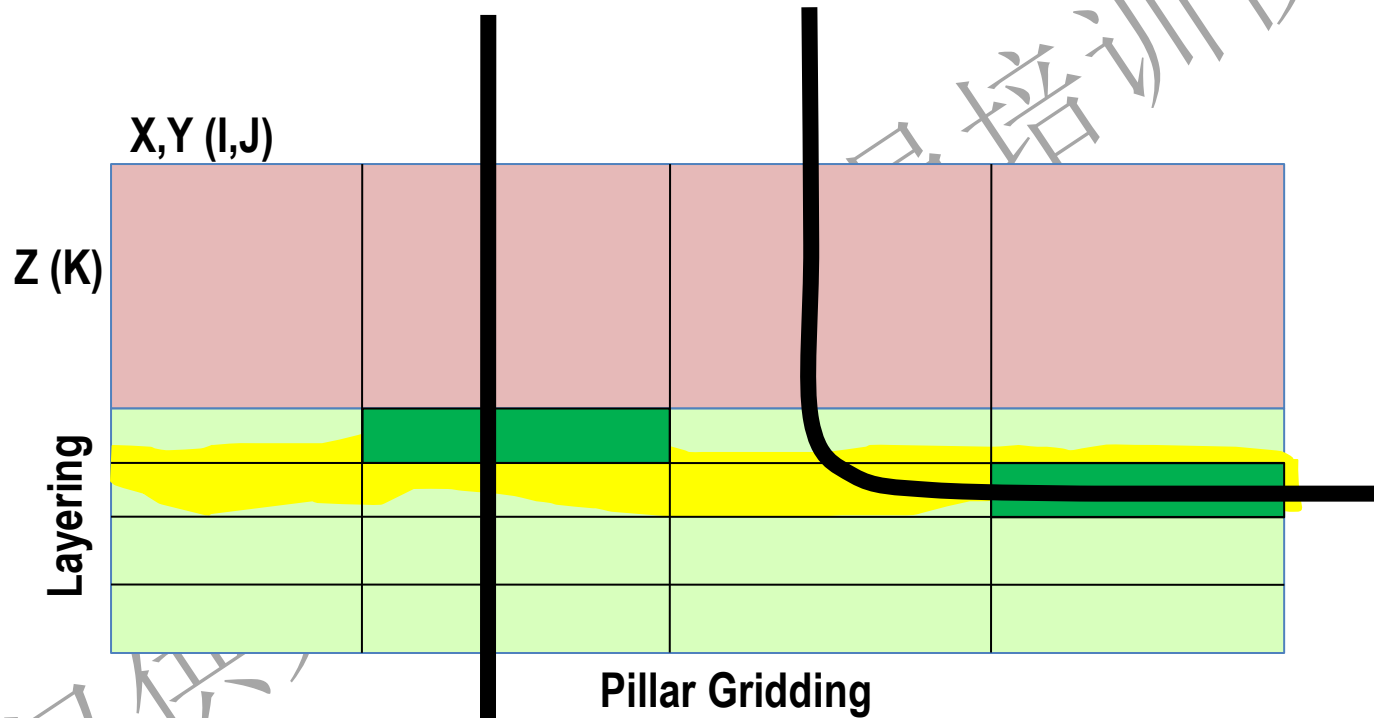
Settings **Zones** Weighted Seed Horizon mapping

Zone specific averaging ?

	Zone	Calculate	Method
	ZoneA	<input checked="" type="checkbox"/> Yes	Arithmetic
	ZoneB	<input checked="" type="checkbox"/> Yes	Mid point pick

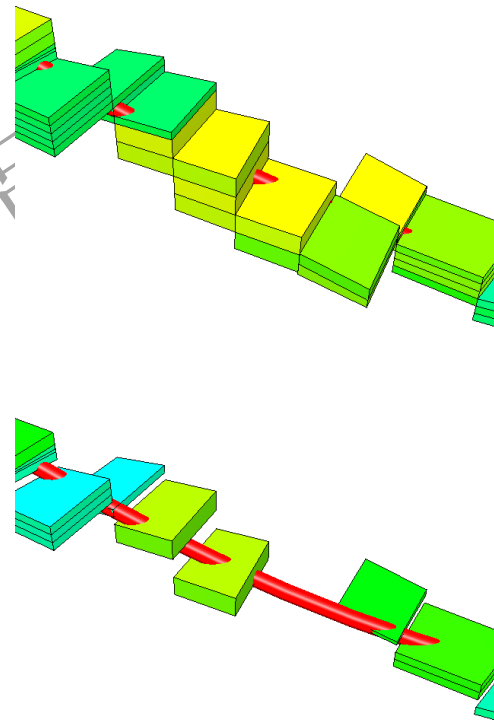
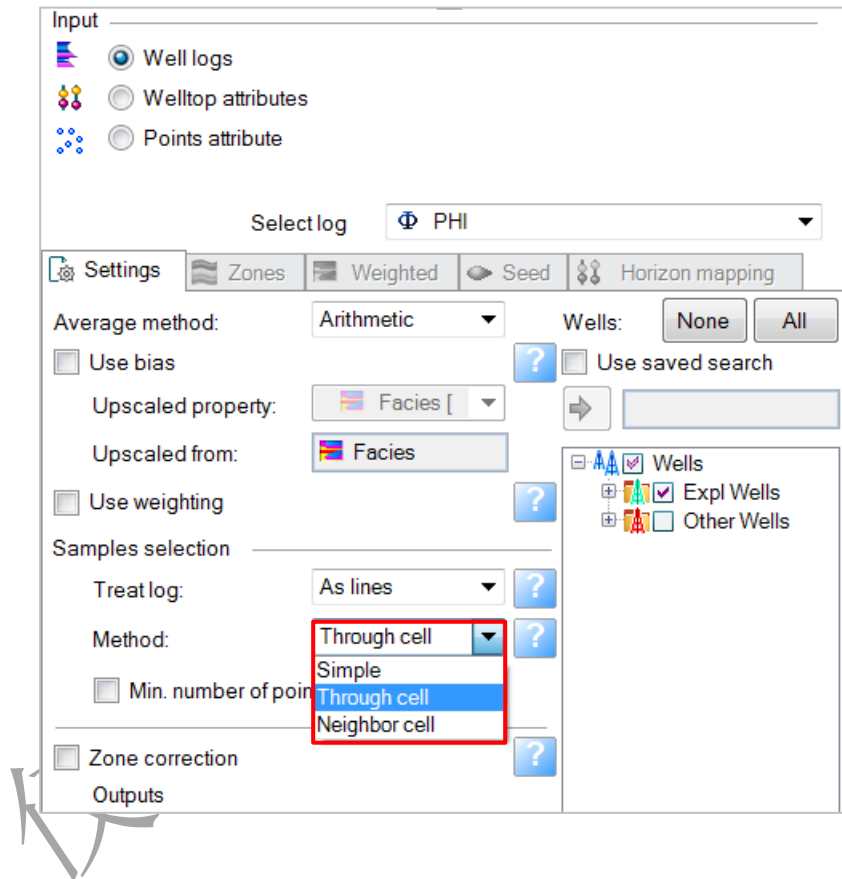
Scale up well logs: 3D grid considerations

Cell size (I, J, K)

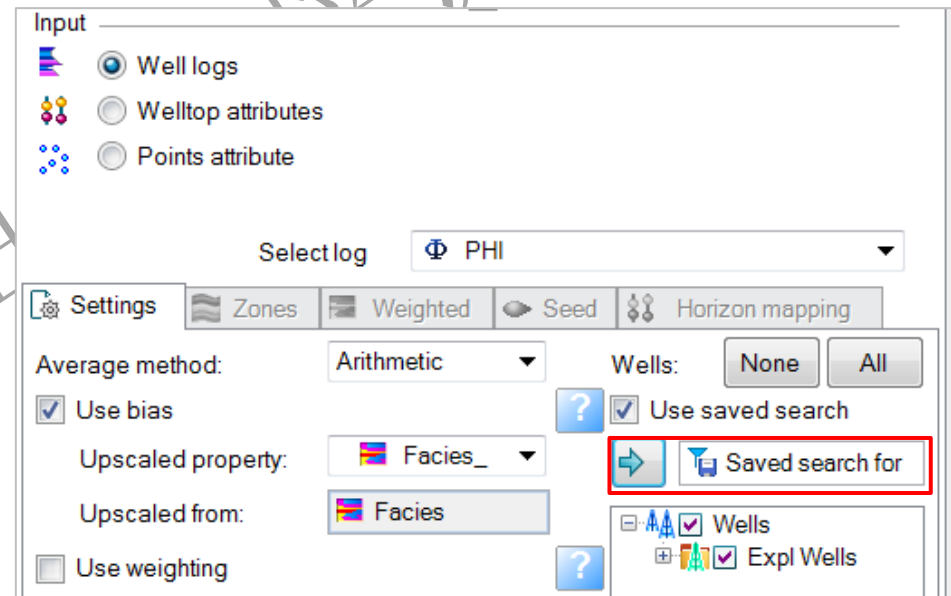
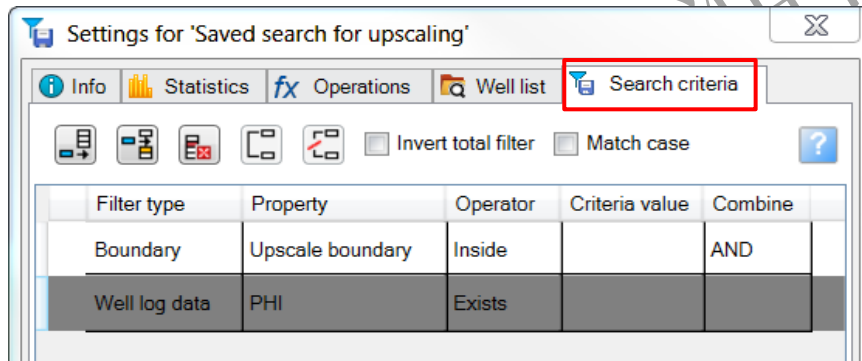
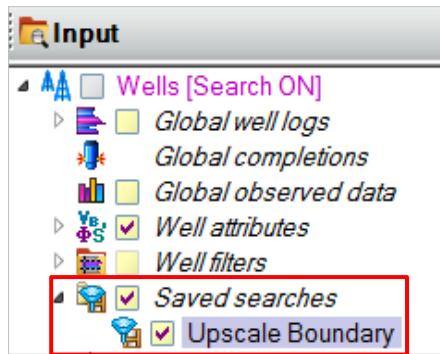


Scale up well logs: 3D grid considerations

Well type and spacing

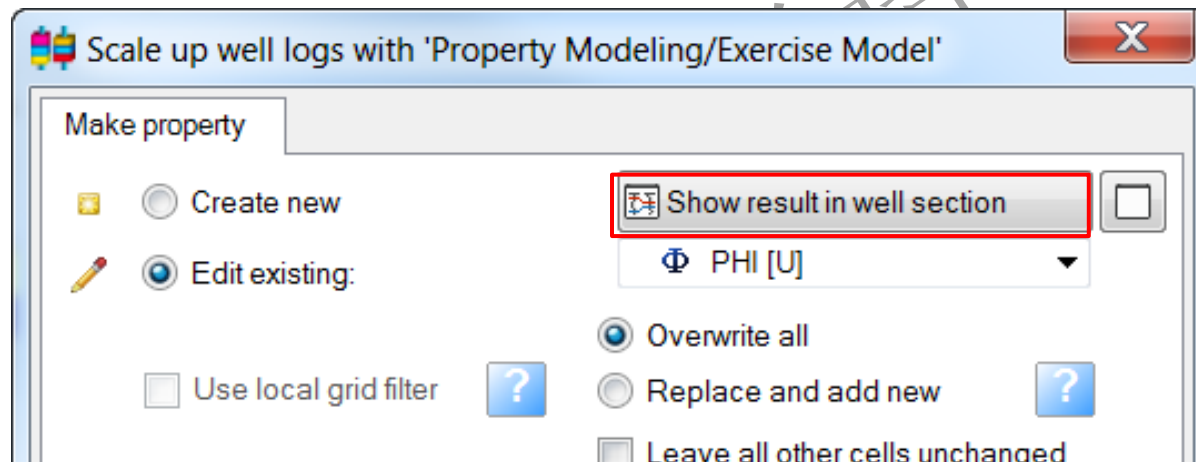


Scale up well logs: Filter by well saved search



Scale up well logs:

Upscaled logs quality control well section



Scale up well logs: Upscaled logs quality control filters

The screenshot shows the 'Settings for Properties' dialog box with the 'Filter' tab selected. The 'Upscaled' dropdown is set to 'As normal cells'. The 'Value filter' section shows a list of properties including 'Facies [U]', which is selected. The 'Facies' legend on the right indicates four facies types: Shale (grey), Channel (red), Levee (yellow), and Lobe (blue). The diagram illustrates the application of quality control filters to well logs. It shows a vertical stack of well logs with a 'Facies' legend on the left. The logs are divided into four sections: Shale, Channel, Levee, and Lobe. A red arrow points to the 'Channel' section, indicating the application of a filter. The resulting logs show only the 'Channel' facies (red) and the 'Lobe' facies (blue), with the 'Shale' and 'Levee' sections removed.

Settings for 'Properties'

Composite | Quality attributes | People | Structural analysis

Style | Info | Statistics | Operations | Filter

Upscaled: As normal cells

☐ Use index filter

☒ Use value filter

☒ Use visible filters

☒ Defined values only

Get limits from selected

☐ Min ☒ Start Width Skip ☐ Max And/or

☒ I (111): 1 1 10 111

☒ J (140): 1 1 10 140

☐ K (60): 1 1 5 60

Value filter

AI

AI_rescaled

Layers

Upscaled

Facies [U]

Facies_weighning [U]

Φ PHI [U]

k Perm [U]

Facies_models

Facies_Variogram [U]

General discrete

Facies_Adaptive_Mode

None

All

☒ Use filter

☐ Invert filter

0: Shale

1: Channel

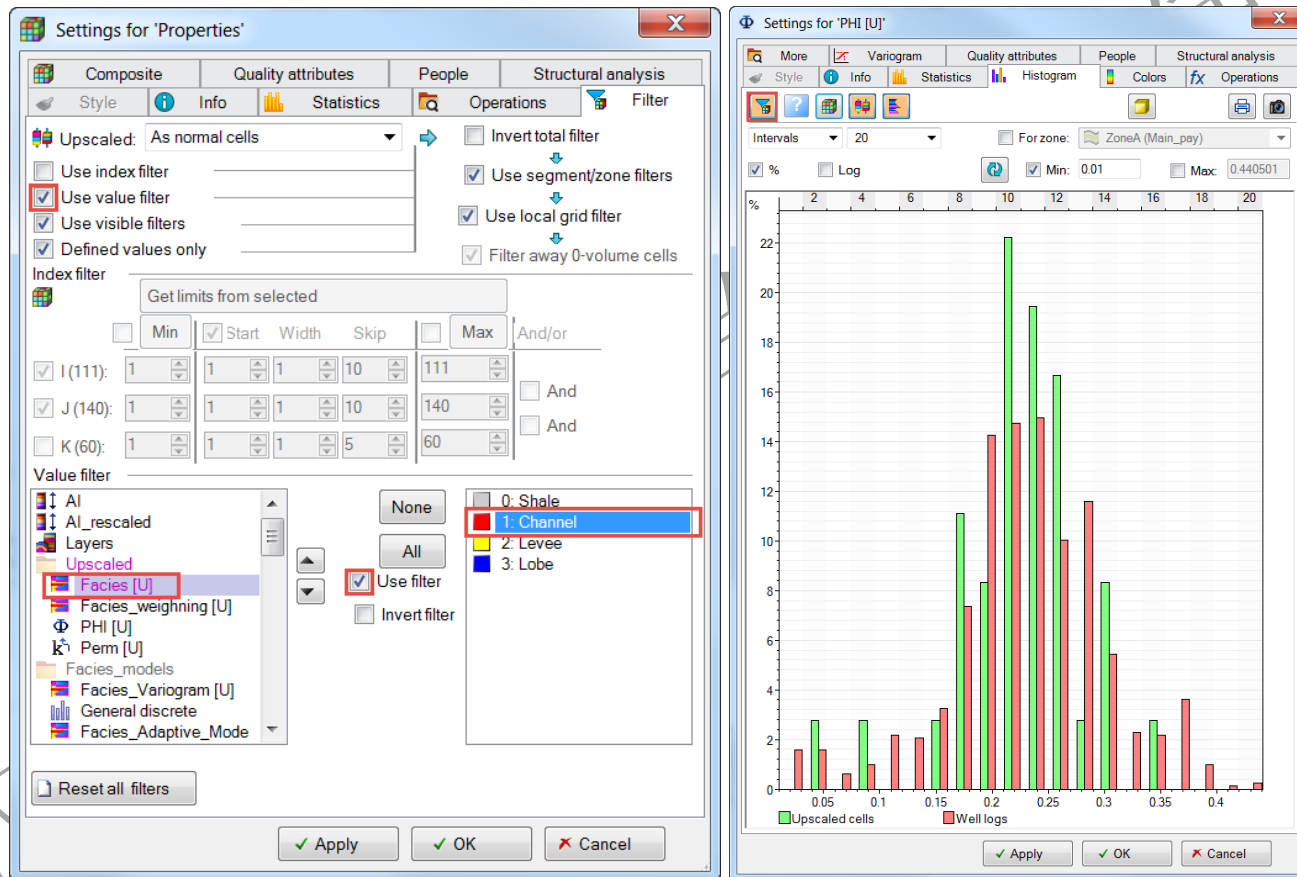
2: Levee

3: Lobe

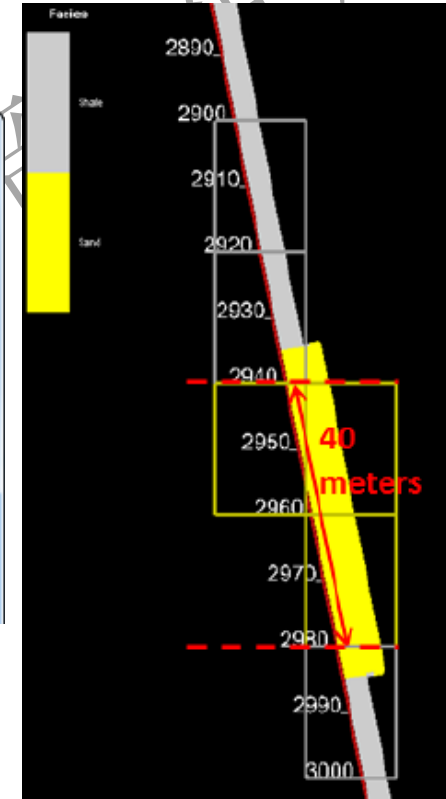
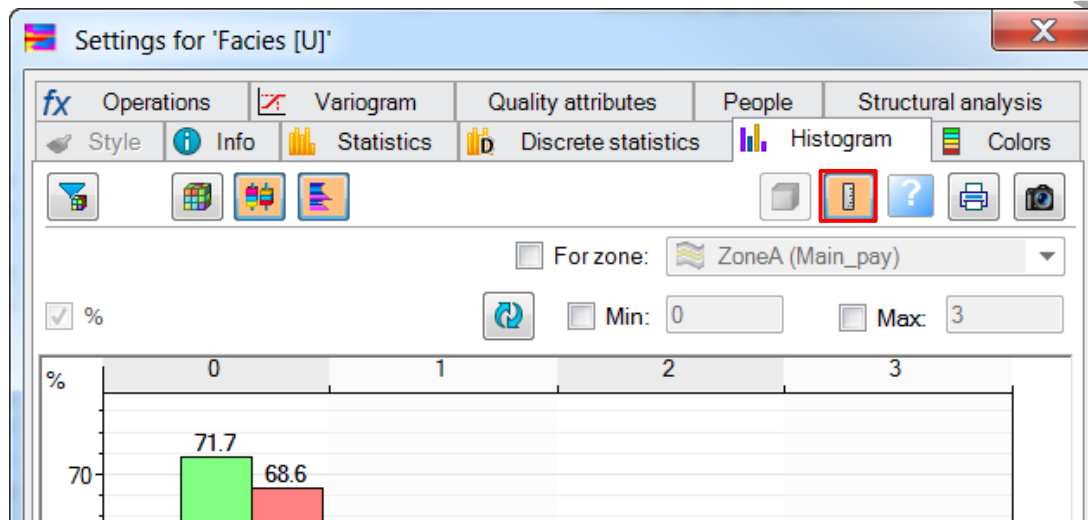
Reset all filters

Apply OK Cancel

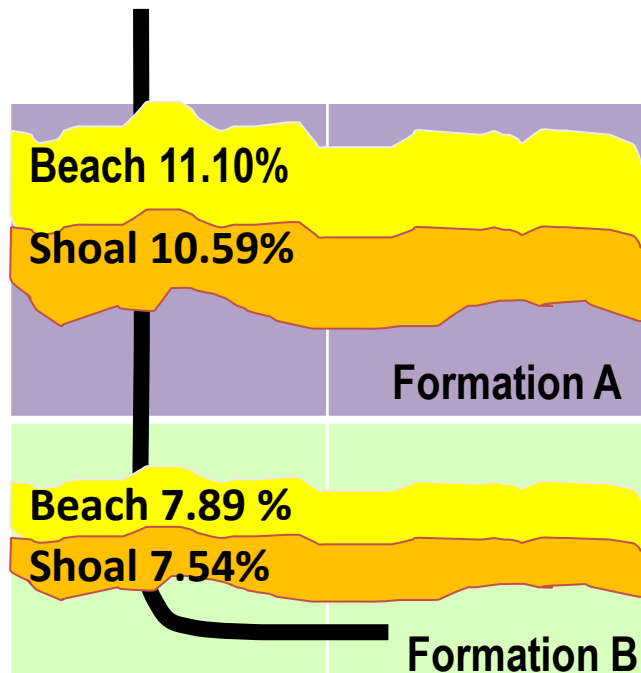
Scale up well logs: Upscaled logs quality control histogram and filter (applied result)



Scale up well logs: Upscaled logs quality control histogram and filter (applied result)



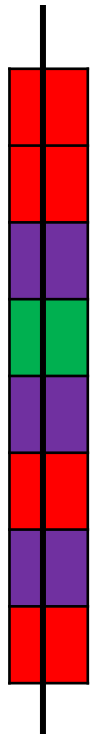
Simpson's paradox: The importance of upscaling



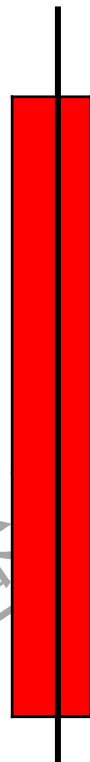
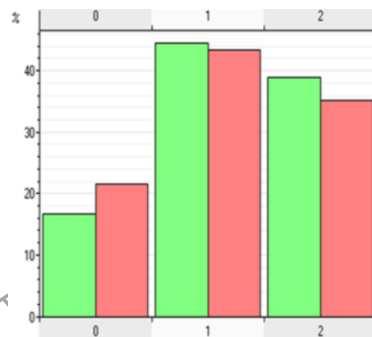
Well-Log Average Porosity				
	Shoal		Beach	
	Avg Por	# Samples	Avg Por	# Samples
Form A	10.59%	10.526 M_1	11.10%	1.023 N_1
Form B	7.54%	6.597 M_2	7.89%	1.641 N_2
Aggregate	9.41%		9.13%	

Change of support problem: Upscaling method

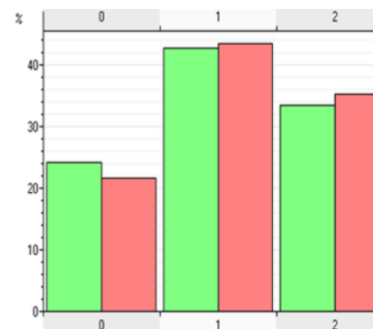
Average method: Most of



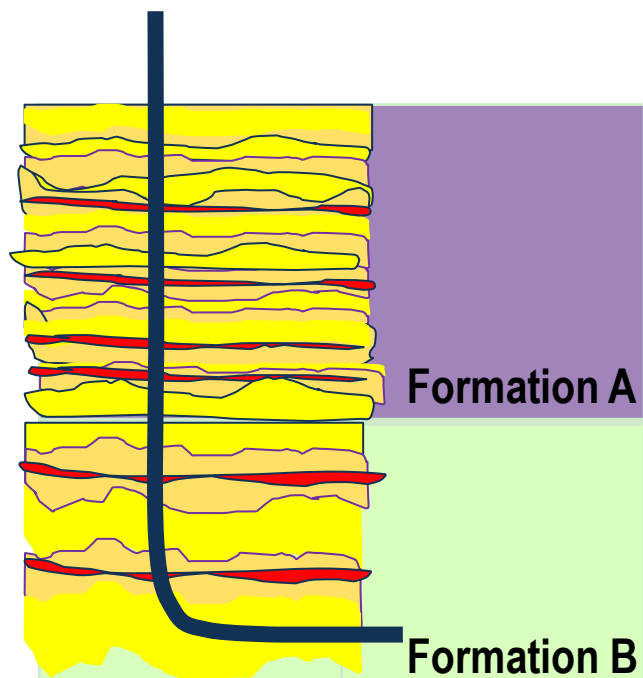
Average method: Most of



Average method: Mid point pick



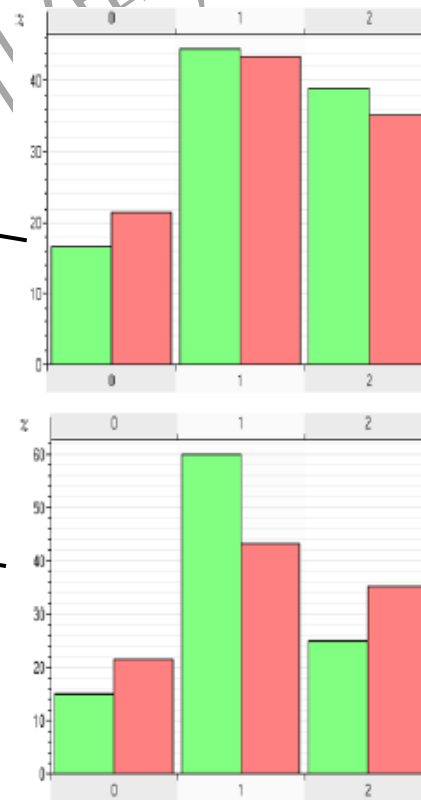
Change of support problem: Layering



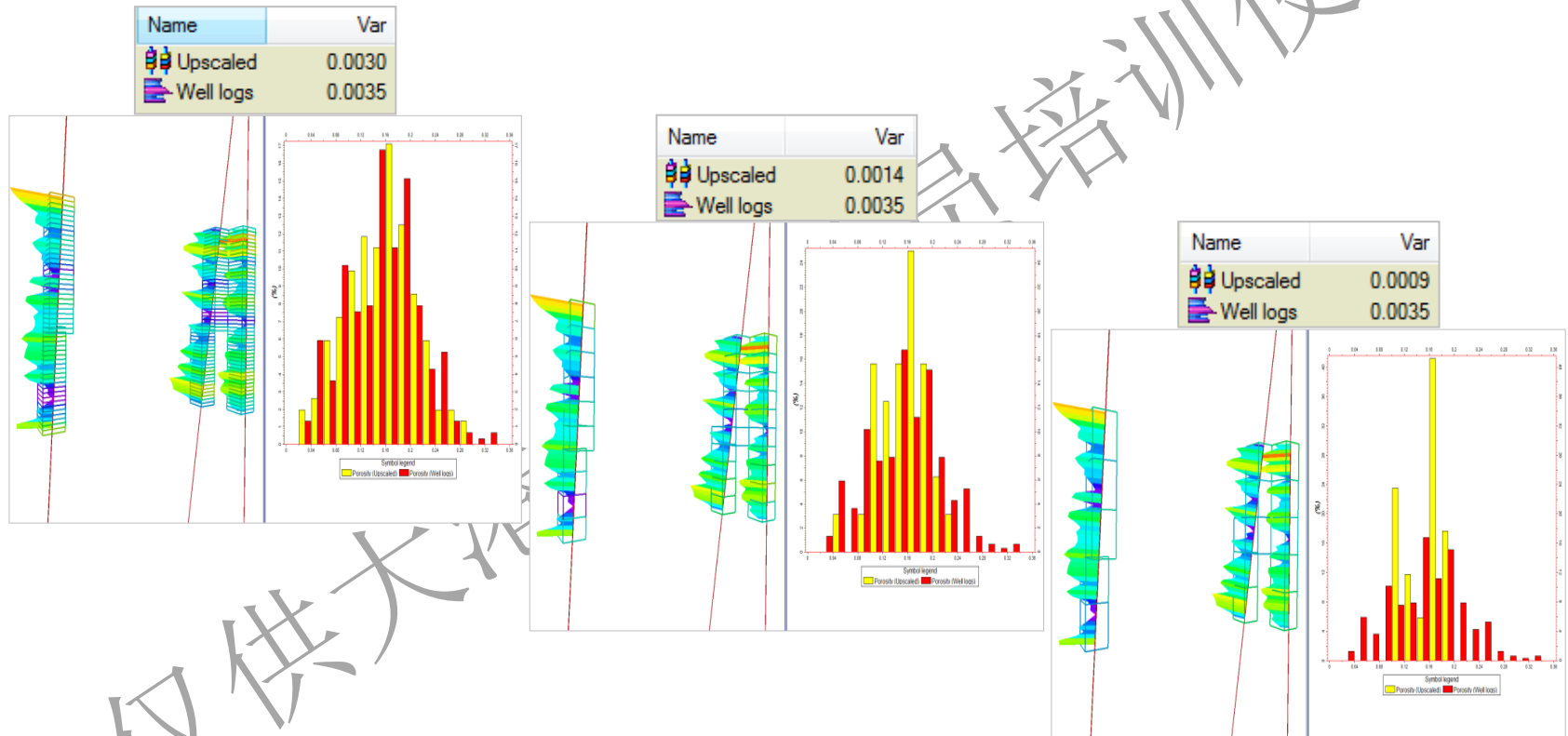
Upscaling with 2 ft thick grid cells

Upscaling with 8 ft thick grid cells

Note: The original well log sample rate is 0.25 ft.



Scale up well logs: Practical considerations



Exercises

- Scale up discrete logs: Facies
- Scale up continuous logs:
 - Porosity
 - Water saturation
 - Permeability