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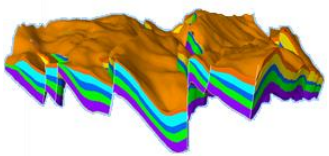
Petrel 2017 Property Modeling Module 9: Sequential indicator simulation

Petrel 2017 Property modeling

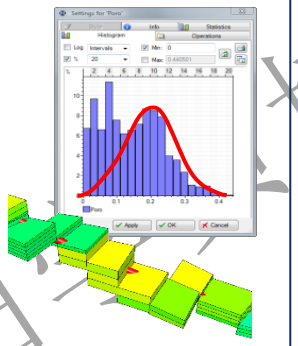


Intro

Petrel Property Modeling objective and workflow

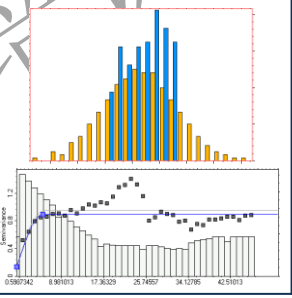
Property modeling data preparation

Scale up well logs

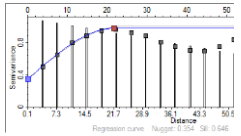


Univariate and bivariate geostatistics

Basic statistics

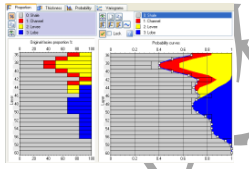


Variogram modeling

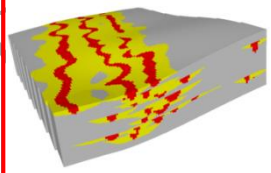


Facies modeling

Discrete data analysis

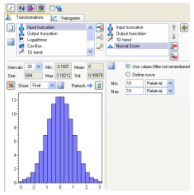


Stochastic facies modeling

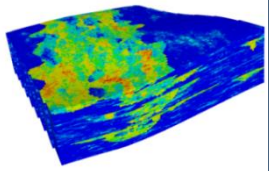


Petrophysical modeling

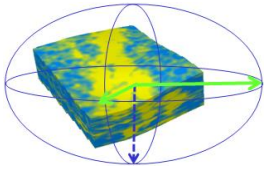
Continuous data analysis



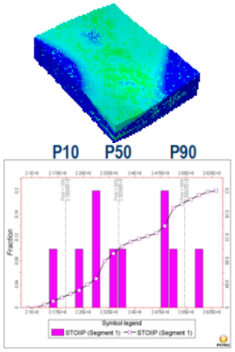
Stochastic and deterministic petrophysical modeling



Use of secondary information for property modeling



Volume calculation and Uncertainty analysis



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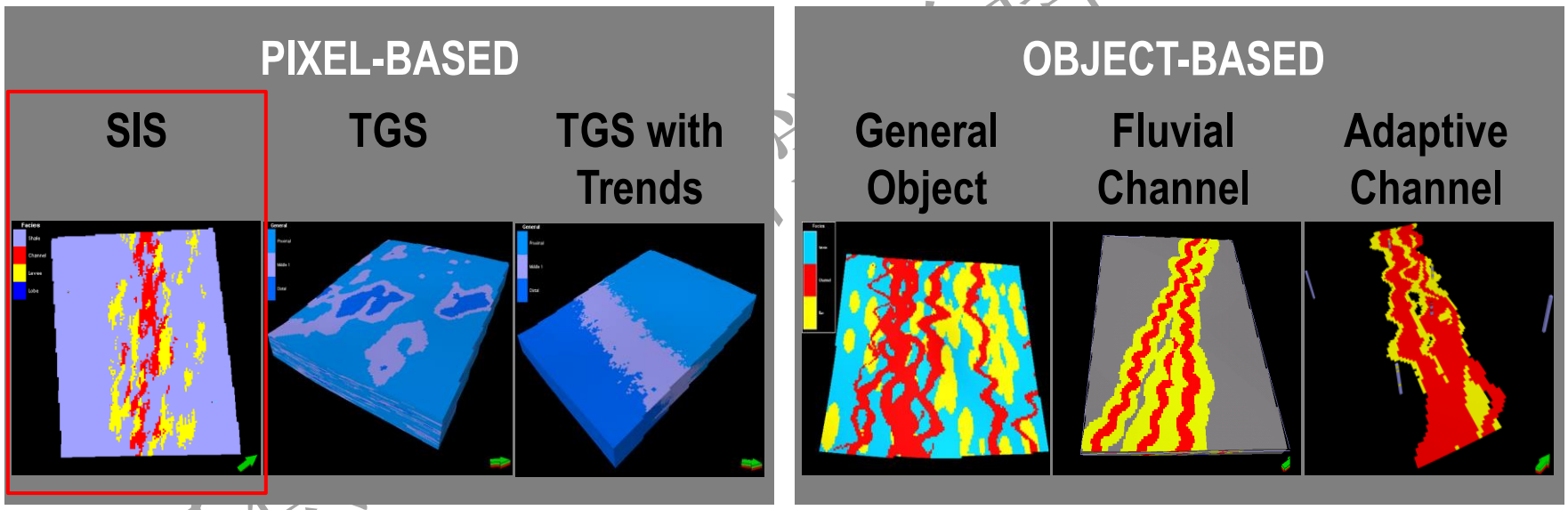
Petrel modeling techniques for discrete properties

Stochastic methods used in this course:



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Sequential Indicator Simulation (SIS) overview (1)

SIS is a stochastic (pixel-based) modeling algorithm that uses upscaled cells as the basis for fraction of facies types to be modeled. The variogram constrains the distribution and connectedness of each facies type. It is widely used to model facies with unclear or undefined shapes or when there is little input data.

Inputs:

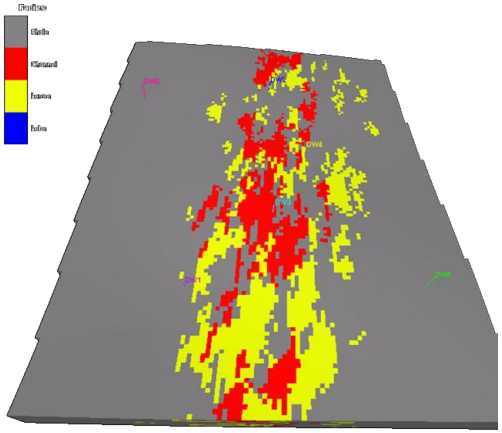
- Facies proportion, facies probability, and 1D, 2D, and 3D trends
- Different variogram for different facies.

Underlying methods:

- Simple kriging (global mean: stable)
- Ordinary kriging (Re-estimates mean: more data).

Output:

- Pixel-based property honoring input data
- Multiple equiprobable realizations can be run for uncertainty.



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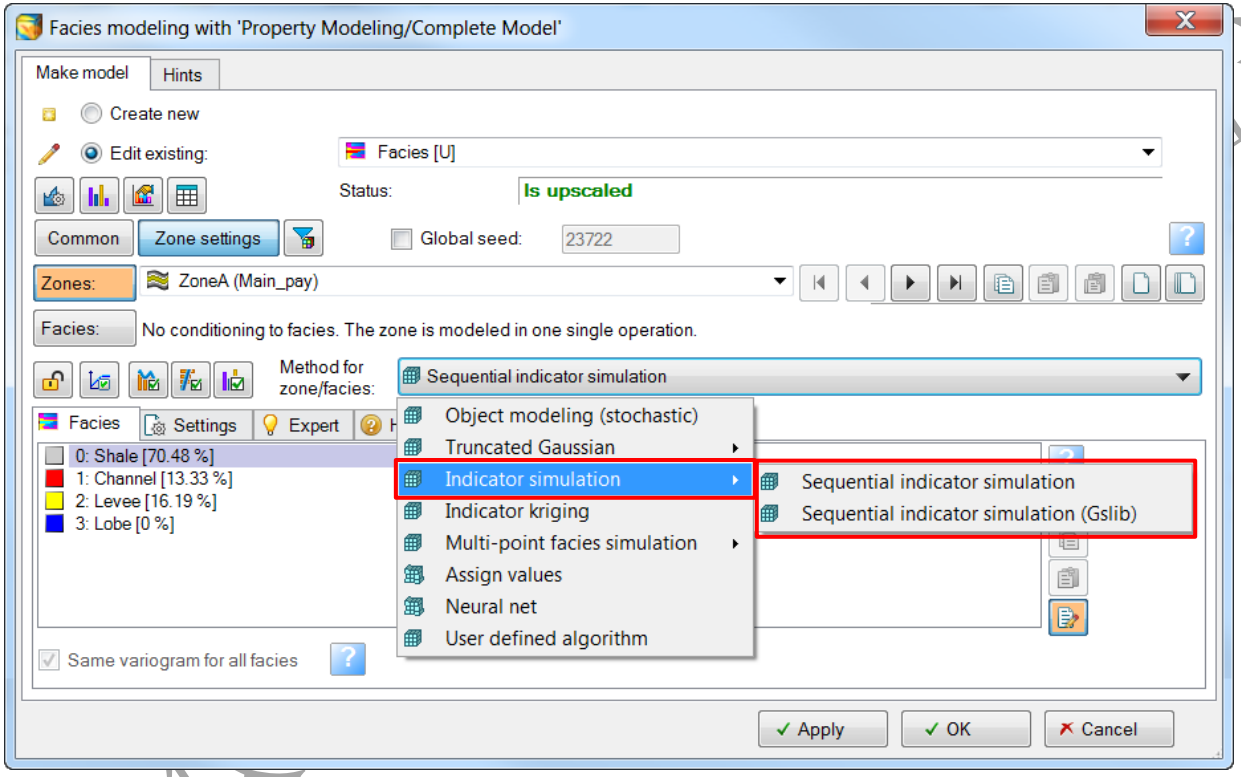
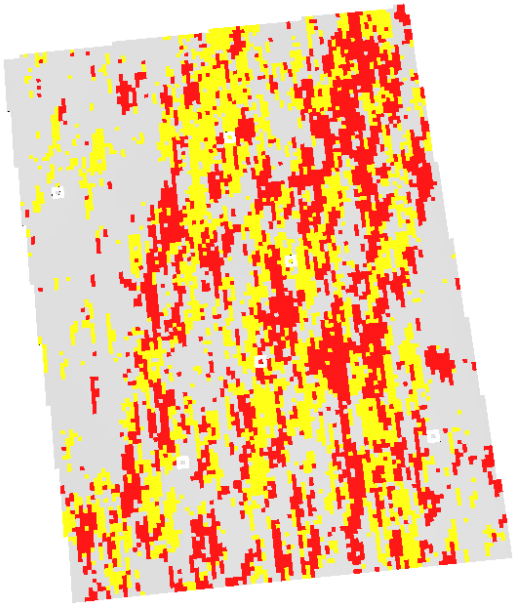
Sequential Indicator Simulation (SIS) overview (2)

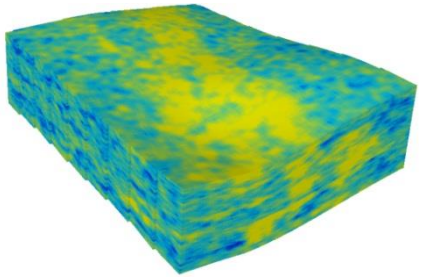


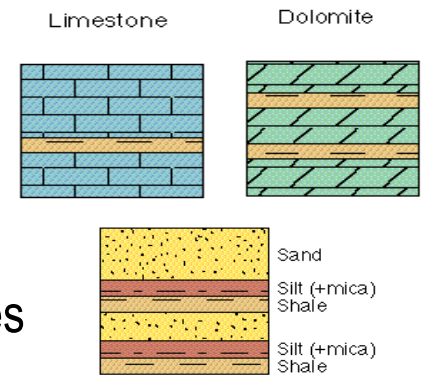


Sequential Indicator Simulation (SIS): When can you use SIS?

SIS is used for depositional environments, especially those with a small amount of available input data (wells). Other considerations are seismic and facies environments.

- Seismic: When a 3D seismic survey is available with correlated attributes, SIS is strong because it integrates easily:
  - 3D probability trends from seismic
  - Attribute probability from seismic in data analysis
  - Horizontal variogram ranges derived from resampled seismic
- Facies environments:
  - Useful in carbonates that do not have defined shapes or direct facies relationships.
  - Clastic environments where connectivity and geometry of facies objects are not determined yet





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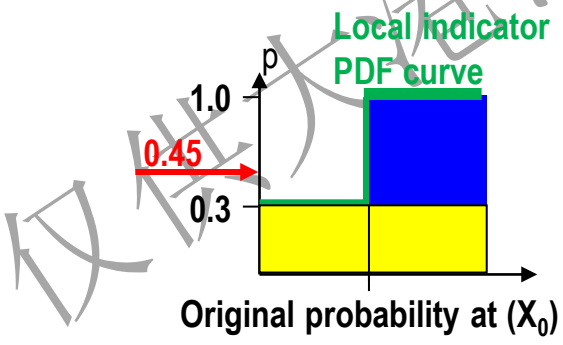
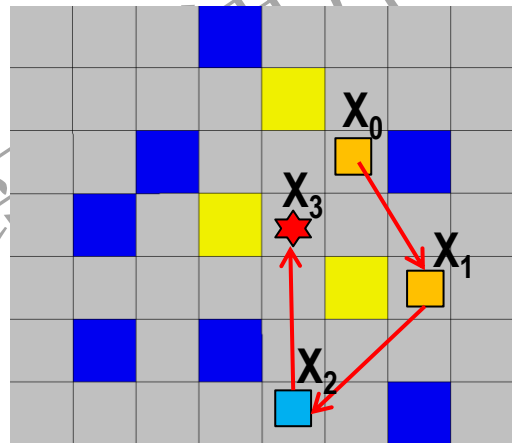
Sequential Indicator Simulation (SIS) theory

- Cell ★ (X_3) is chosen along a random path (decided by seed number).
- A probability distribution function (**PDF**) is derived from Indicator Kriging (IK).
- Upscaled and simulated cells are used for facies probability calculation.
- A simulated value (**Shale**) is drawn from the **PDF** curve using random **MC sampling (0-1)**.





Original probability of Sand/Shale given by upscaled well logs:

P_{sand}= 0.3 & P_{shale}= 0.7

- ★ Cell at location (X0) to be simulated
- Upscaled cell (Shale)
- Upscaled cell (Sand)
- Simulated cell (Shale)
- Simulated cell (Sand)

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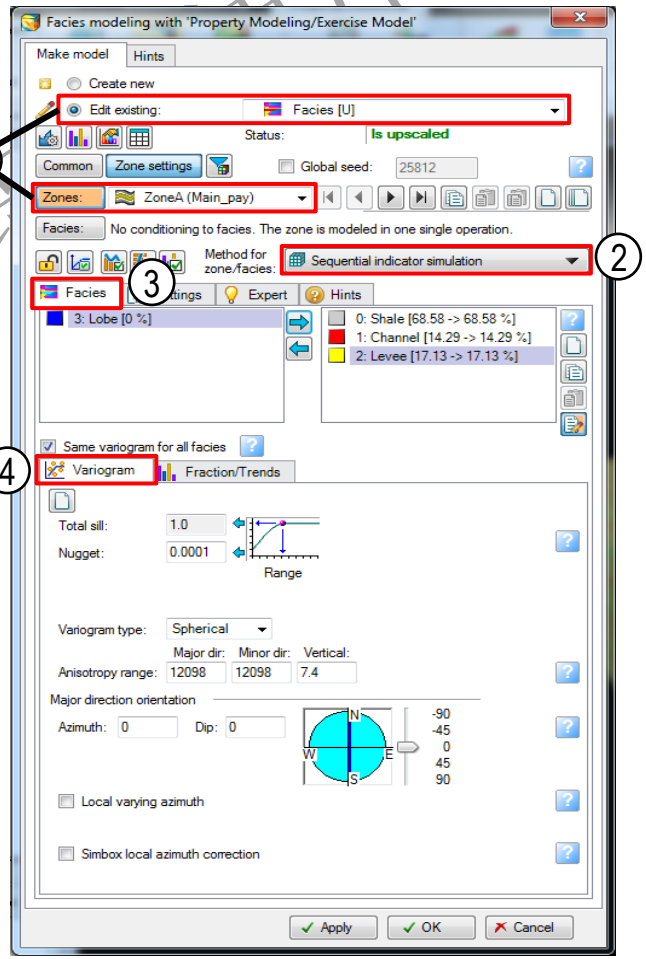
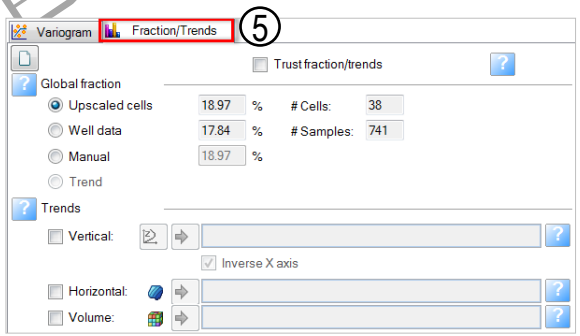
Zone settings setup

1. Edit an existing upscaled well log.
   Select the structural zone to model.
2. Select the SIS method.
3. Choose the **Facies** to be simulated.
4. Enter the **Variogram** settings.
5. Set the targeted **Fraction/Trends**.





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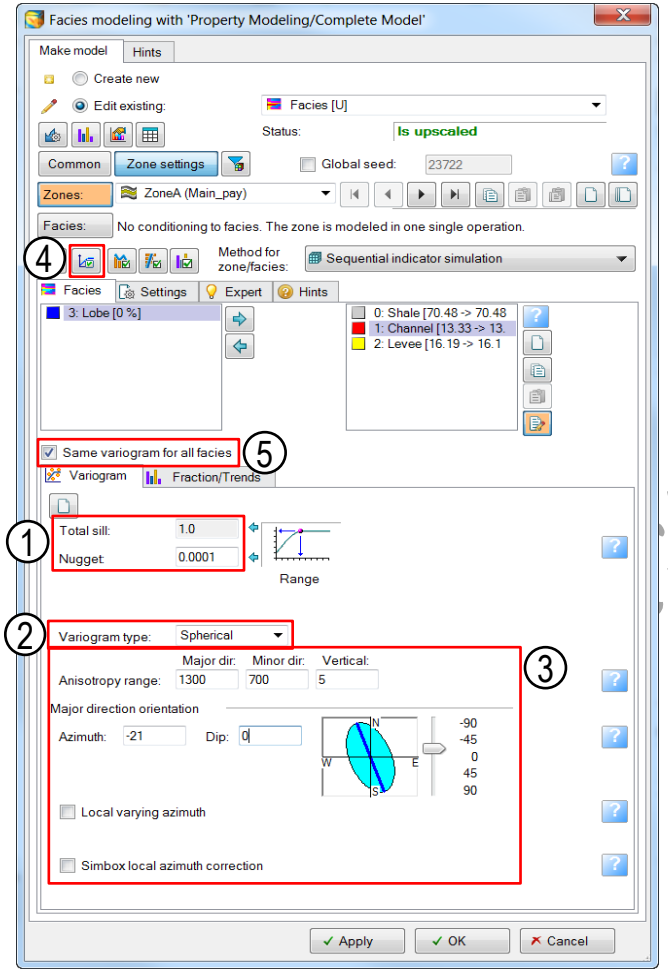
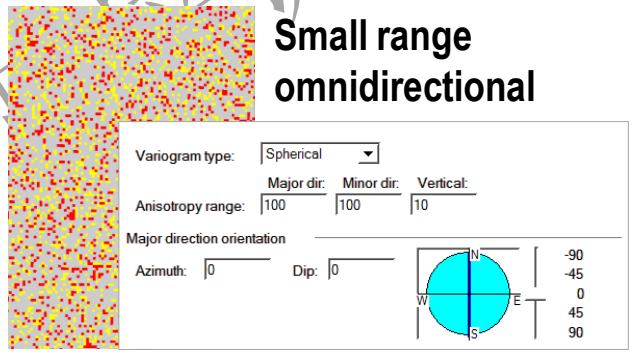
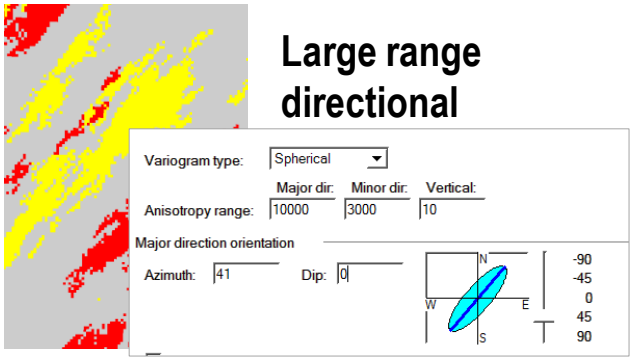
Variogram set up



5. Use the same variograms for all facies selected by default.





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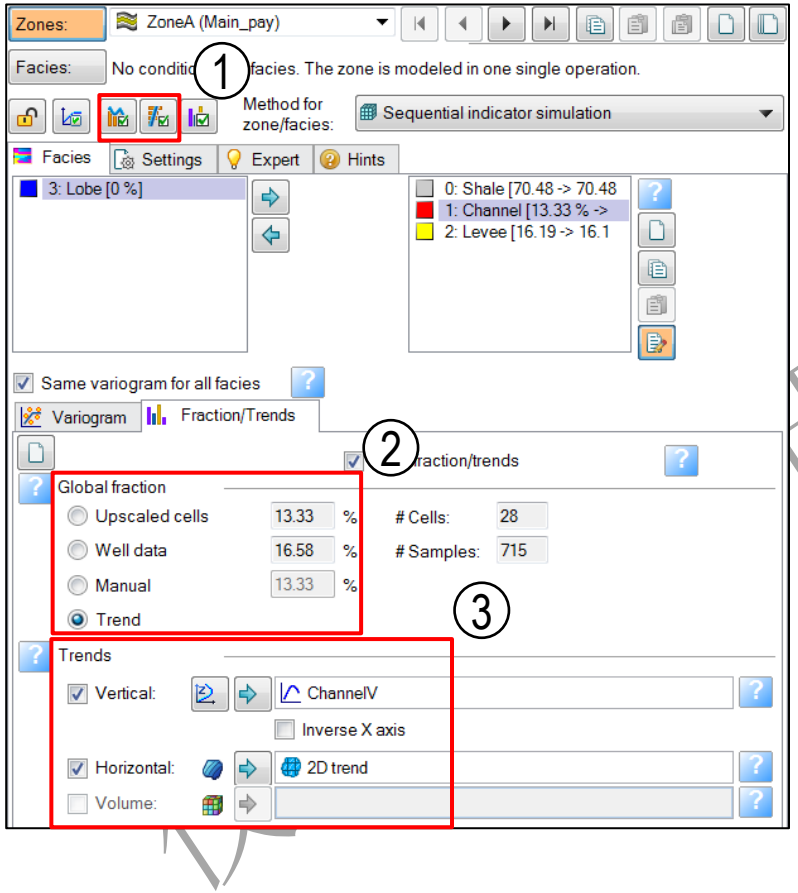
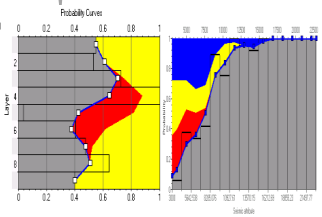
Global facies distribution control



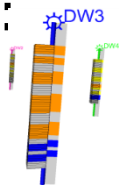
1. From data analysis:

- Attribute Probability curves
- Vertical Proportion curves



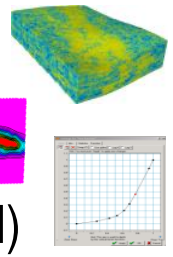
2. From well data or manually entered:

- Based initially on upscaled facies
- Facies logs directly or manual input



3. From Probabilities:

- Probability property cube (3D trend)
- Probability surface (2D trend)
- Vertical probability function (1D trend)



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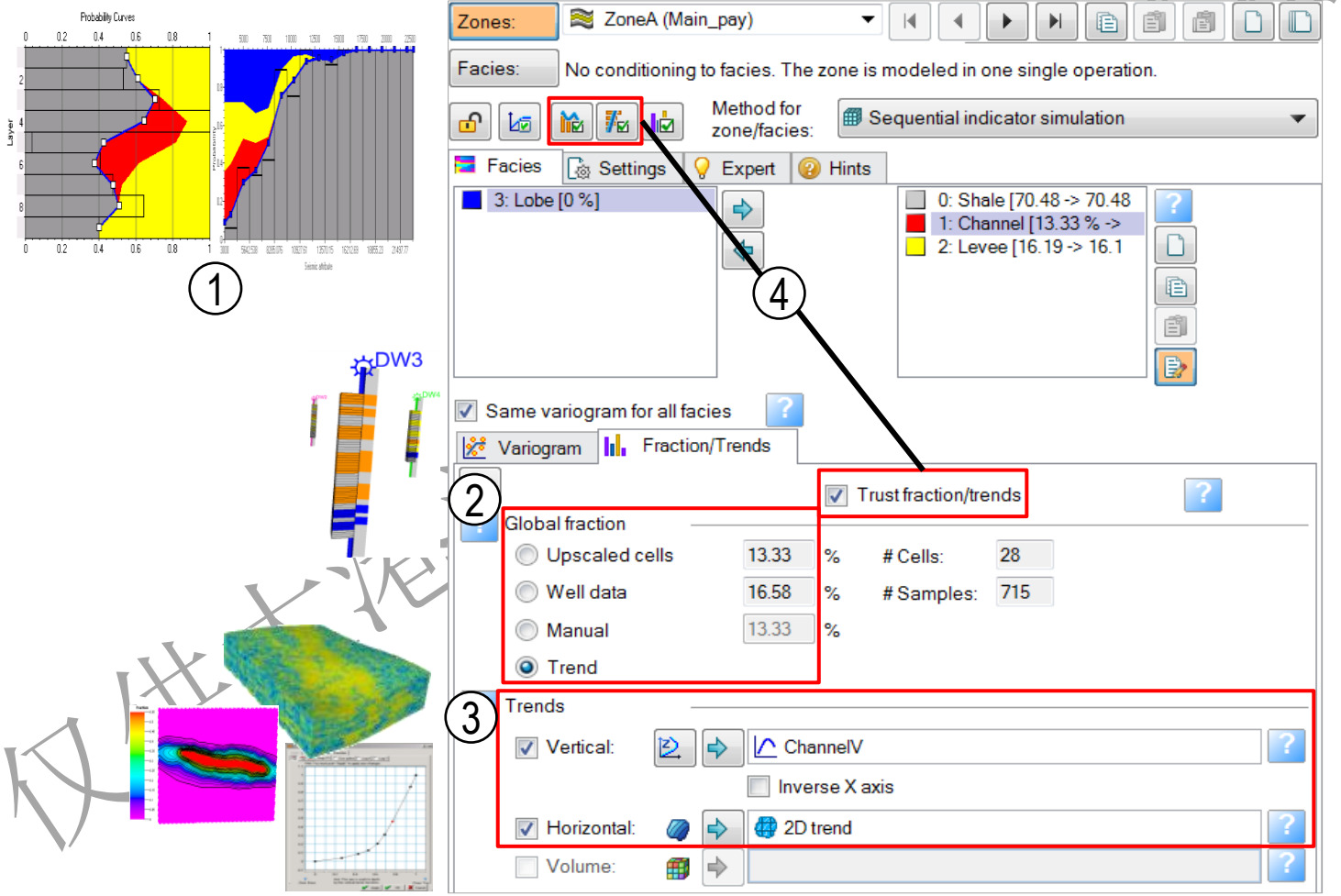
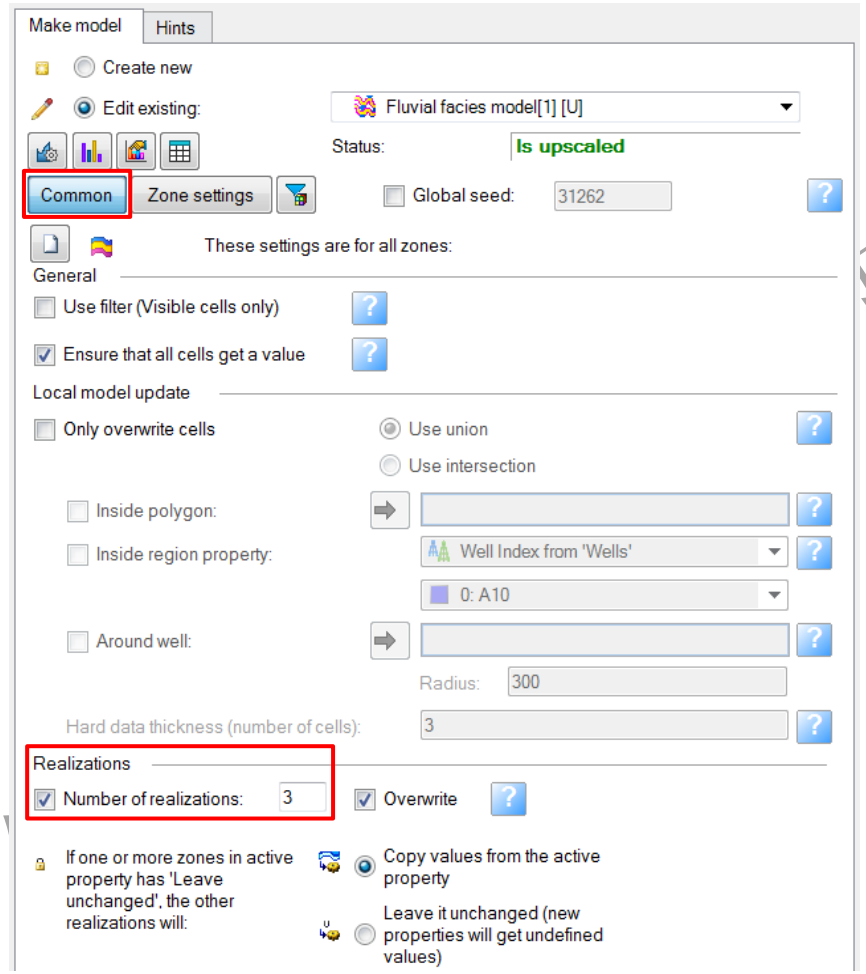
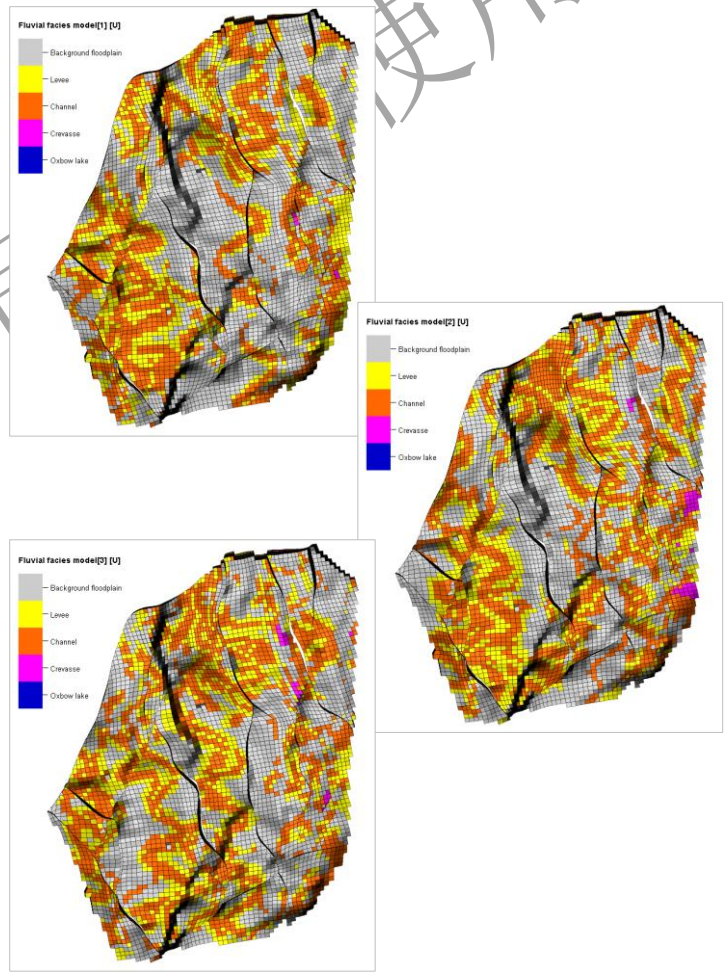


Common button





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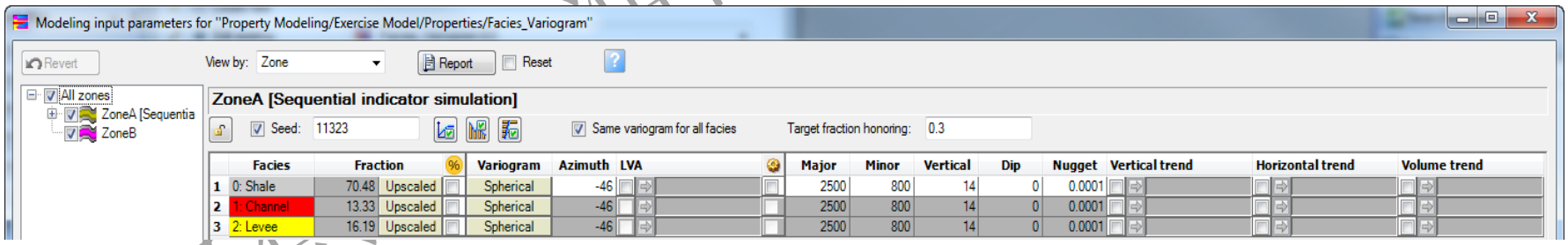
Modeling input parameters editor (MIP) (1)

The **Modeling input parameters** (MIP) editor offers a quick overview and easy access to most facies modeling parameters.

Click the *MIP* button and choose to view by Zone or by Facies/objects, then adjust the settings. It also is possible to copy/paste parameters from the tree node with a right-click at either the zone level or at the facies/object level.



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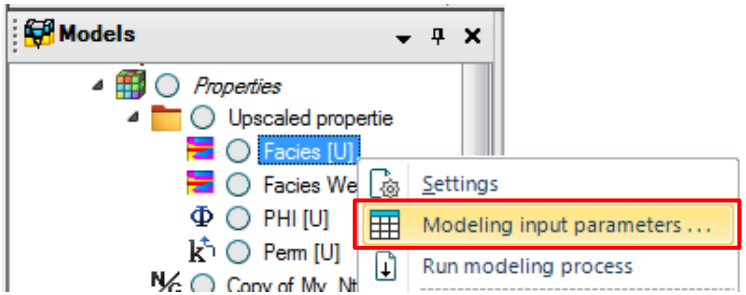
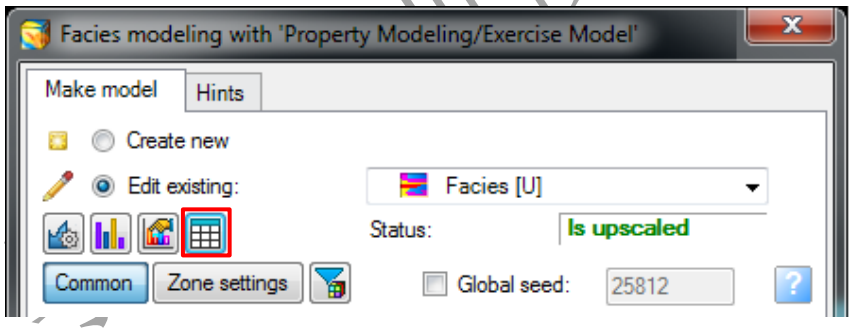
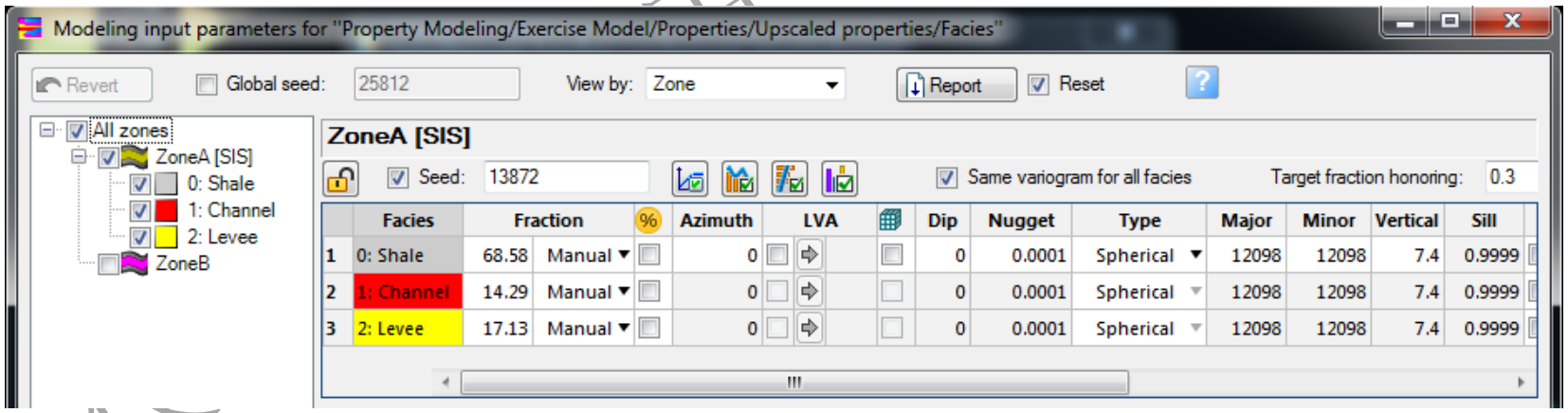
Modeling input parameters editor (MIP) (2)







Exercises

- Calculate the influence of a variogram on a SIS facies model
- Calculate the influence of facies fraction on a SIS facies model
- Use variograms and probabilities for SIS
- Use SIS with seismic attributes