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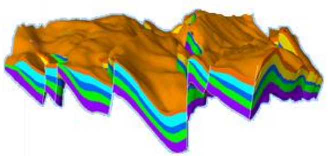
Petrel 2017 Property Modeling
Module 5: Variogram analysis

Petrel 2017 Property modeling

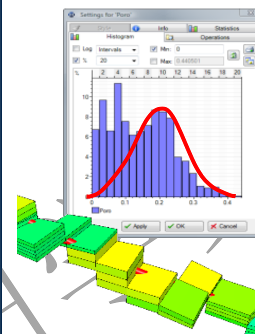


Petrel Property Modeling objective and workflow

Intro

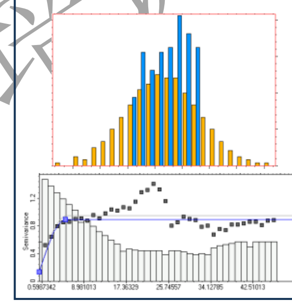
Property modeling data preparation

Scale up well logs

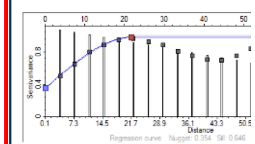


Univariate and bivariate geostatistics

Basic statistics

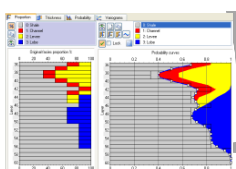


Variogram modeling

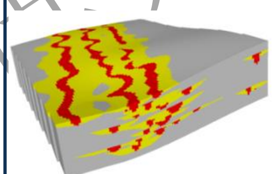


Facies modeling

Discrete data analysis

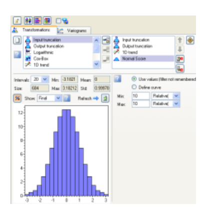


Stochastic facies modeling

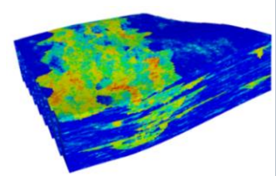


Petrophysical modeling

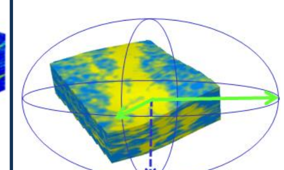
Continuous data analysis



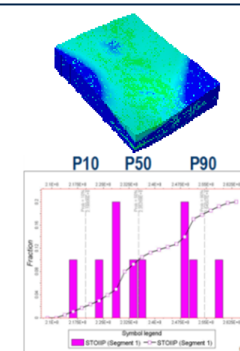
Stochastic and deterministic petrophysical modeling



Use of secondary information for property modeling



Volume calculation and Uncertainty analysis



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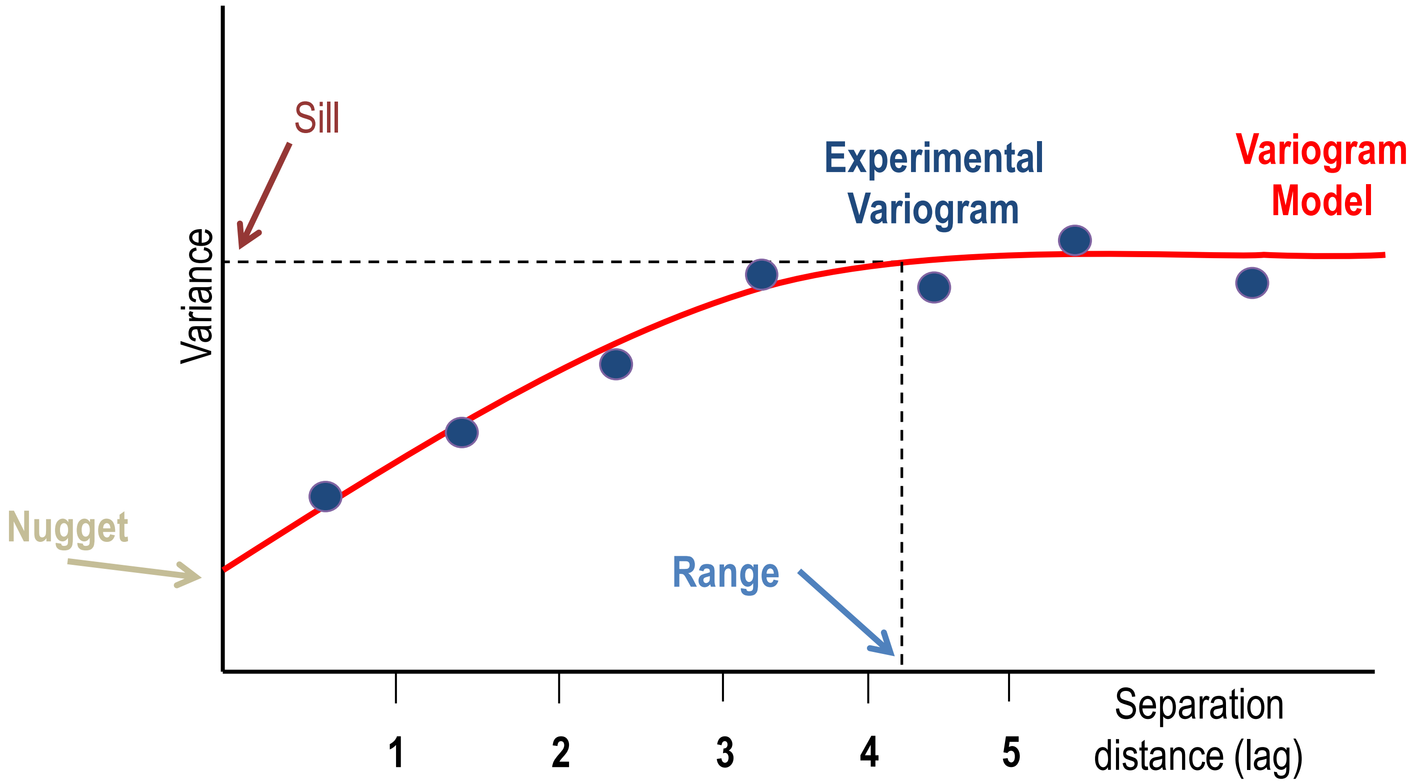
Variogram concept

- A quantitative description of the variation in a property as a function of separation distance between data points.
- Based on the principle that two points close together are more likely to have similar values than points far from each other.
- Two main aspects of a variogram:
  - How similar are two values right next to each other?
  - How far apart are two points before they bear no relation to each other?

Variogram parameters



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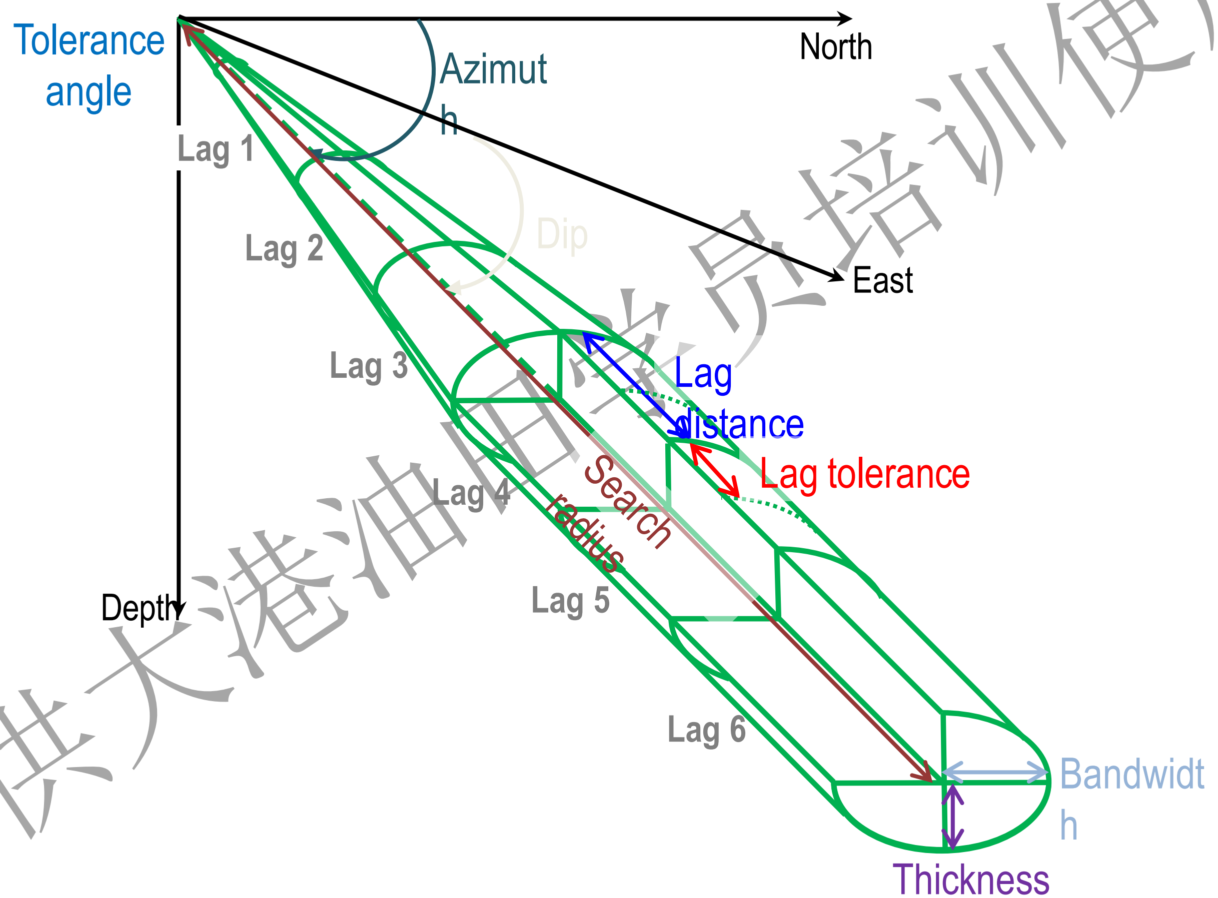
Search cone parameters



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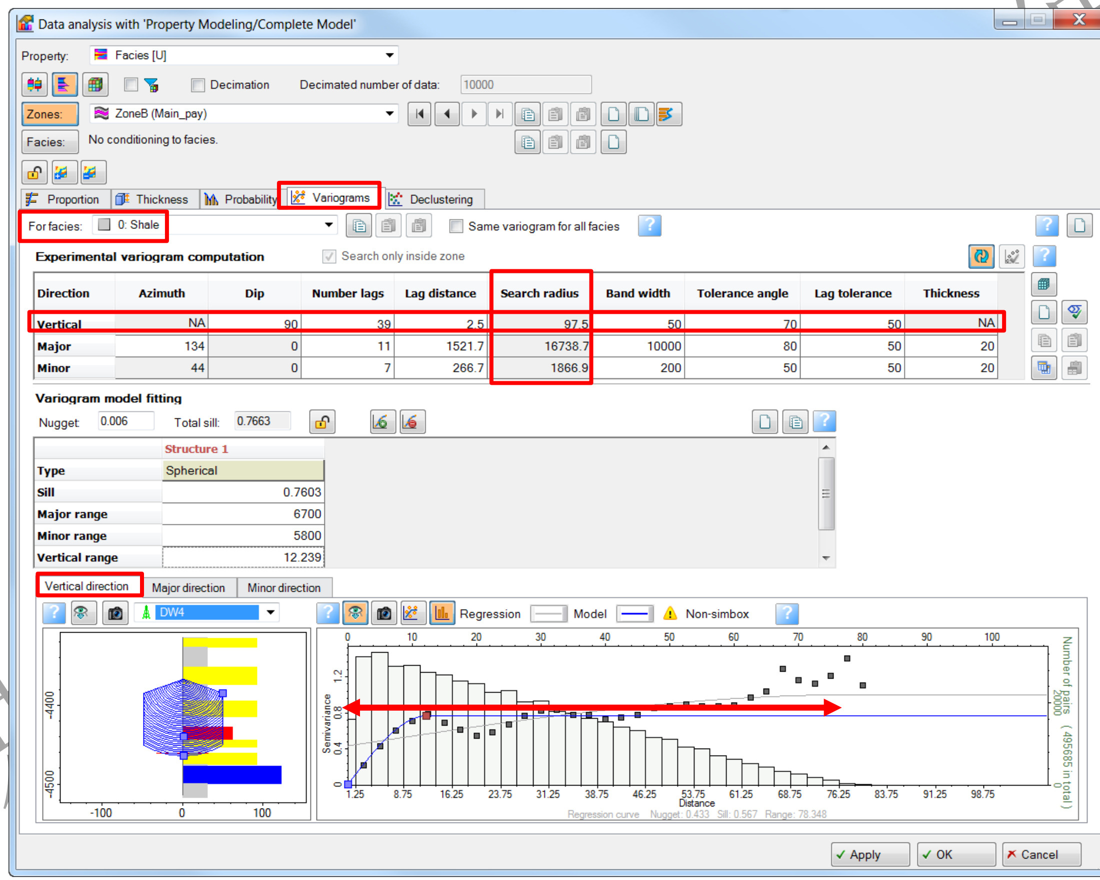
Variogram calculation



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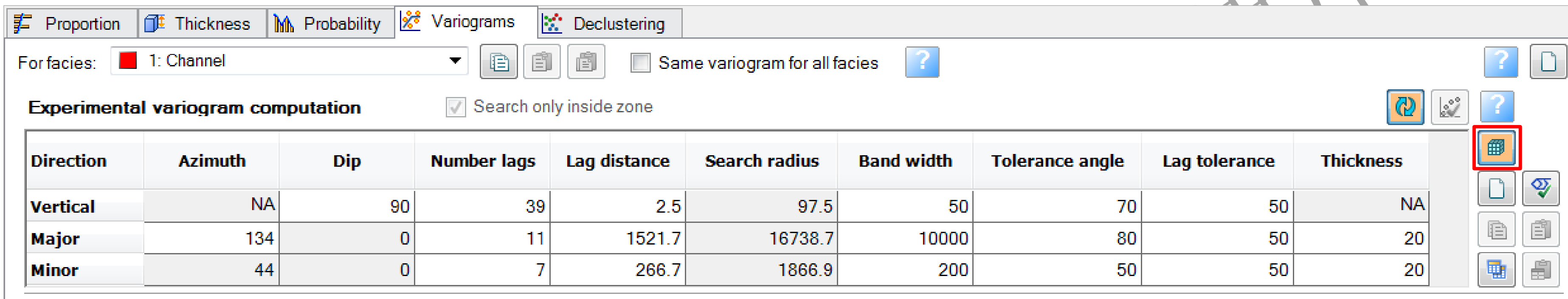
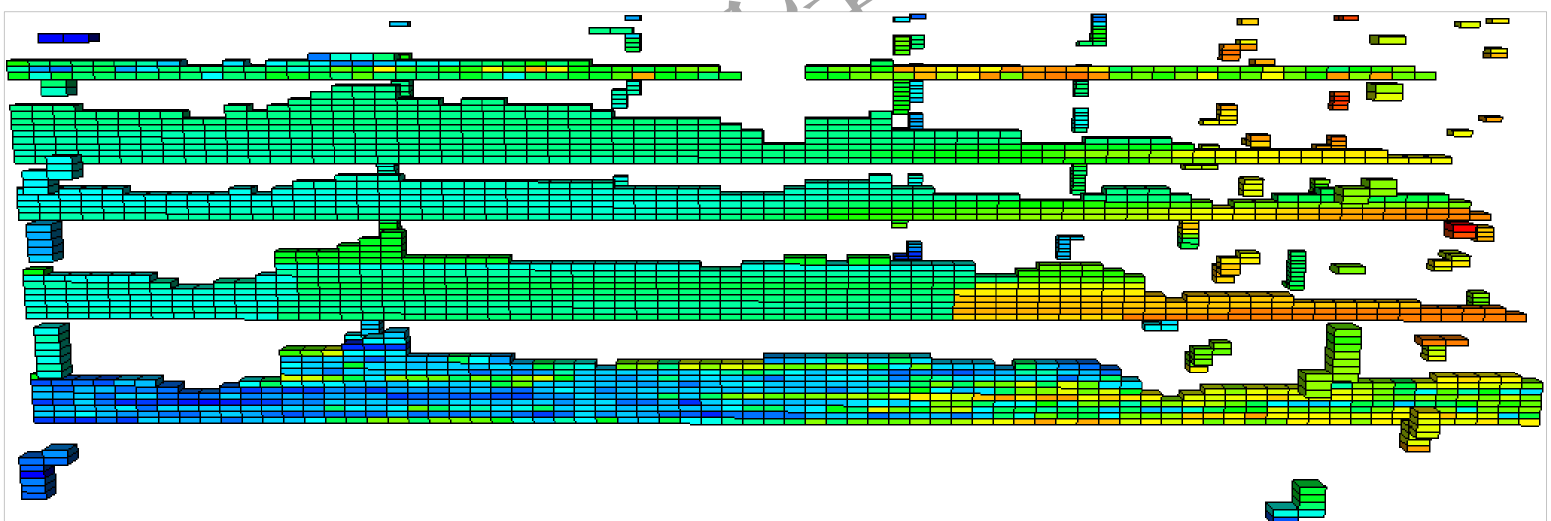
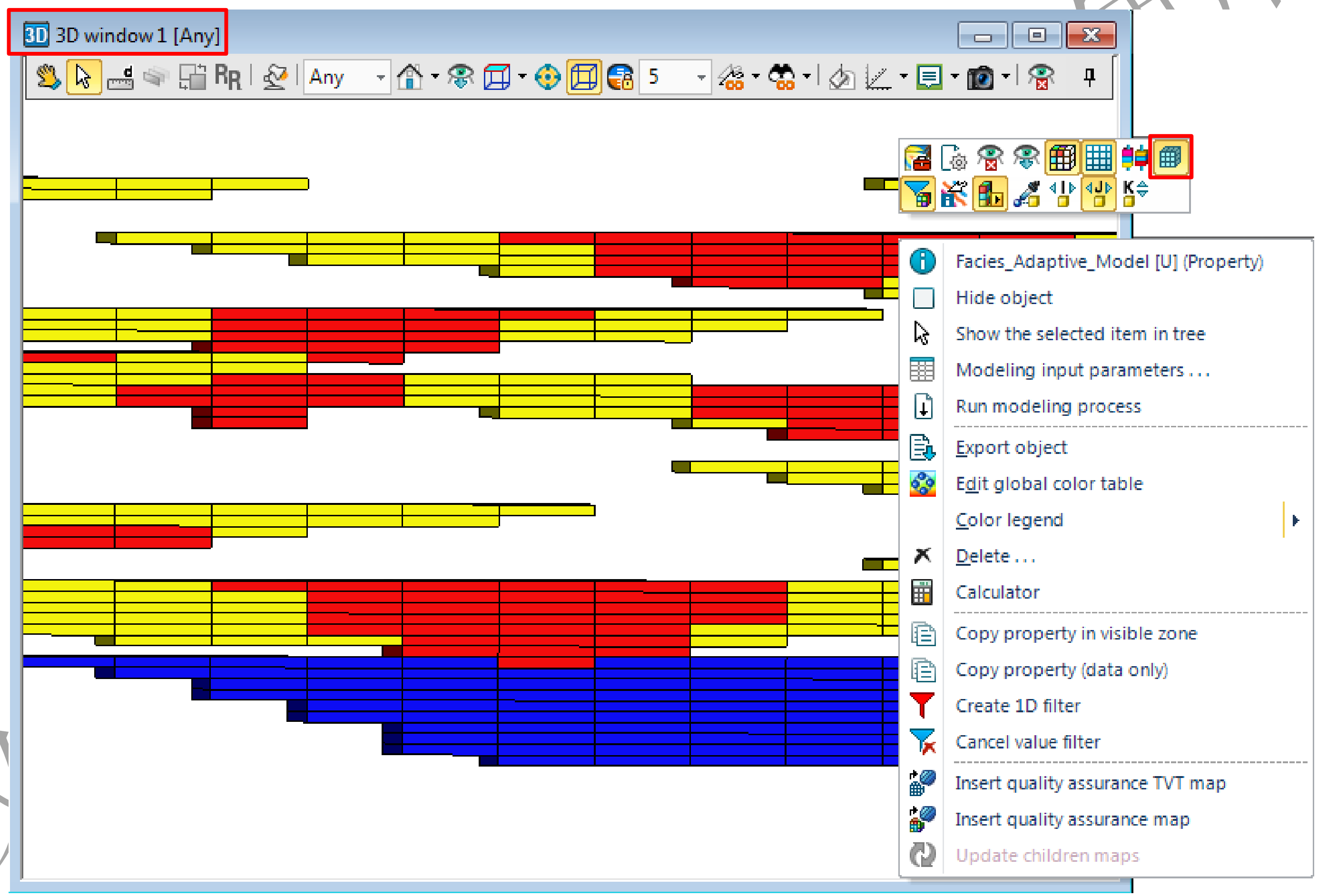
Simbox mode



Direction	Azimuth	Dip	Number lags	Lag distance	Search radius	Band width	Tolerance angle	Lag tolerance	Thickness
Vertical	NA	90	39	2.5	97.5	50	70	50	NA
Major	134	0	11	1521.7	16738.7	10000	80	50	20
Minor	44	0	7	266.7	1866.9	200	50	50	20



Simbox view



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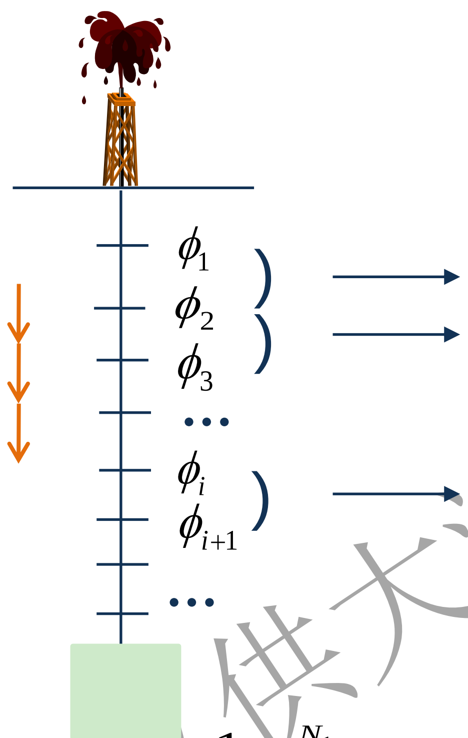
Example of experimental variogram calculation

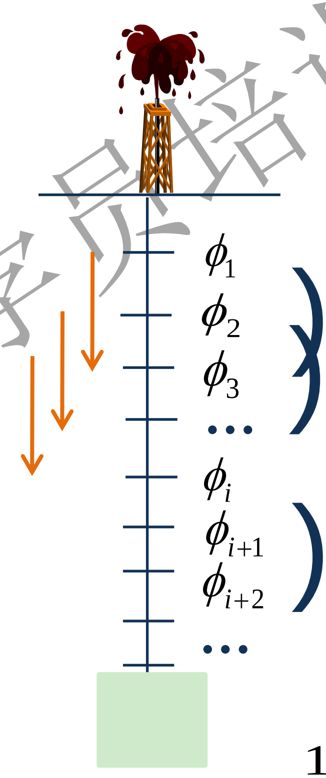
Semi-variance for 1 lag distance



$$(\phi_2 - \phi_1)^2 + (\phi_3 - \phi_2)^2 + \dots + (\phi_{i+1} - \phi_i)^2 + \dots$$

$$\gamma_{(h1)} = \frac{1}{2N_1}\sum_{i=1}^{N_1}\left((\phi_{\boxed{i+1}}) - (\phi_i)\right)^2$$

Semi-variance for 2 lag distance



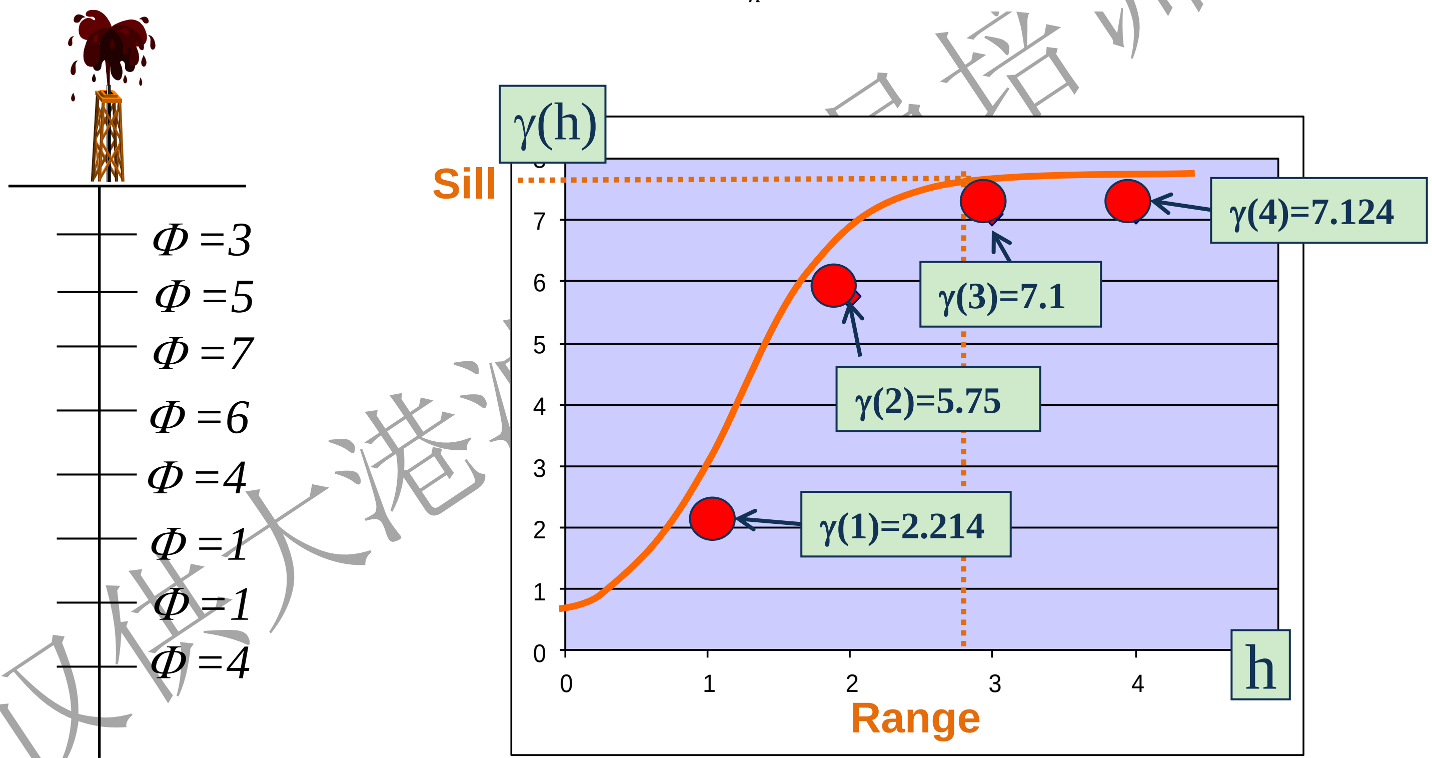
$$(\phi_3 - \phi_1)^2 + (\phi_4 - \phi_2)^2 + \dots + (\phi_{i+2} - \phi_i)^2 + \dots$$

$$\gamma_{(h2)} = \frac{1}{2N_2}\sum_{i=1}^{N_2}\left((\phi_{\boxed{i+2}}) - (\phi_i)\right)^2$$

Result of experimental variogram calculation

Experimental variogram

$$\gamma_{(h)} = \frac{1}{2N_h}\sum_{i=1}^{N_h}\left(\left(\Phi_{(i+h)}\right)-\left(\Phi_i\right)\right)^2$$

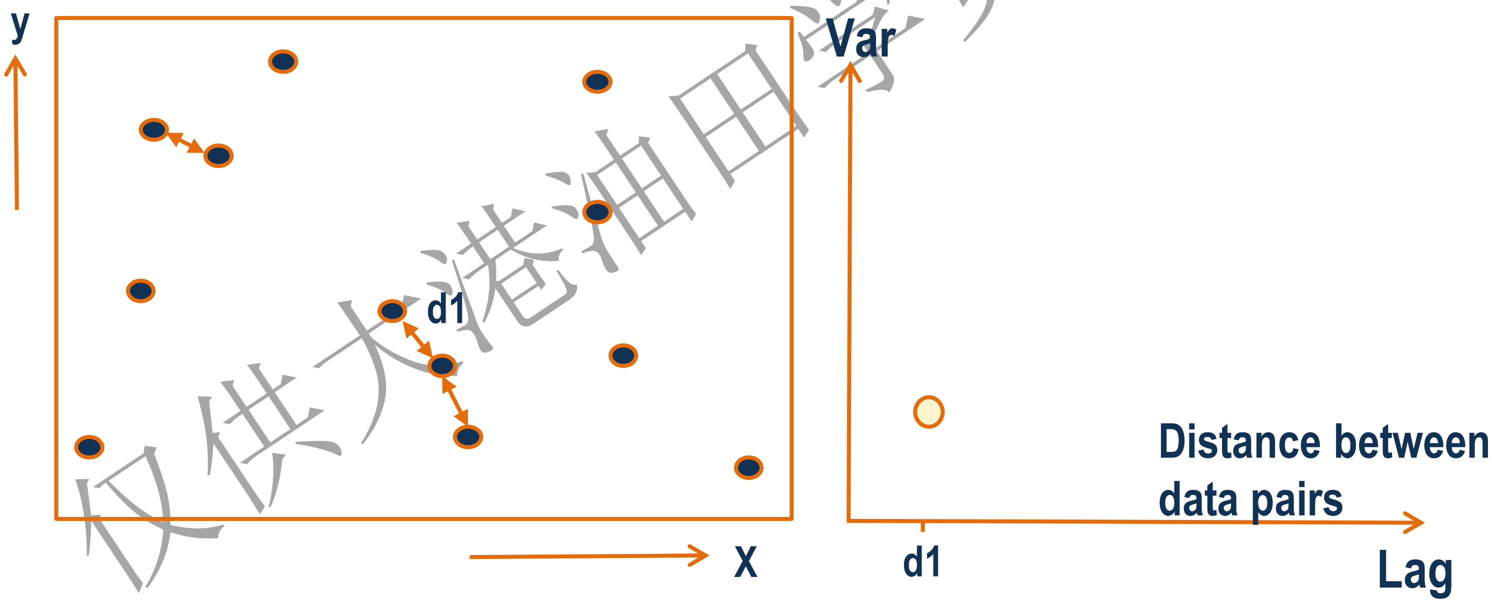


Construct the horizontal variogram

STEP 1 – LAG 1:

a. Calculate the variance between all data pairs of distance d1.

b. Average the variance and plot them in the sample variogram.

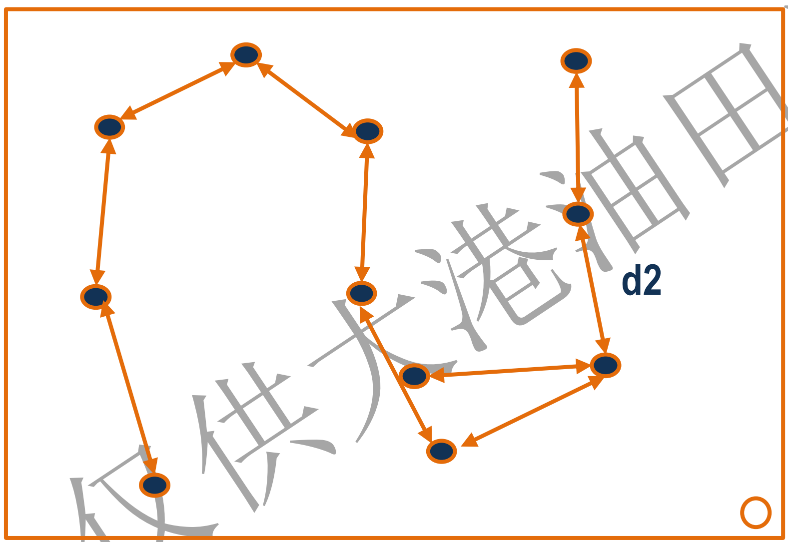


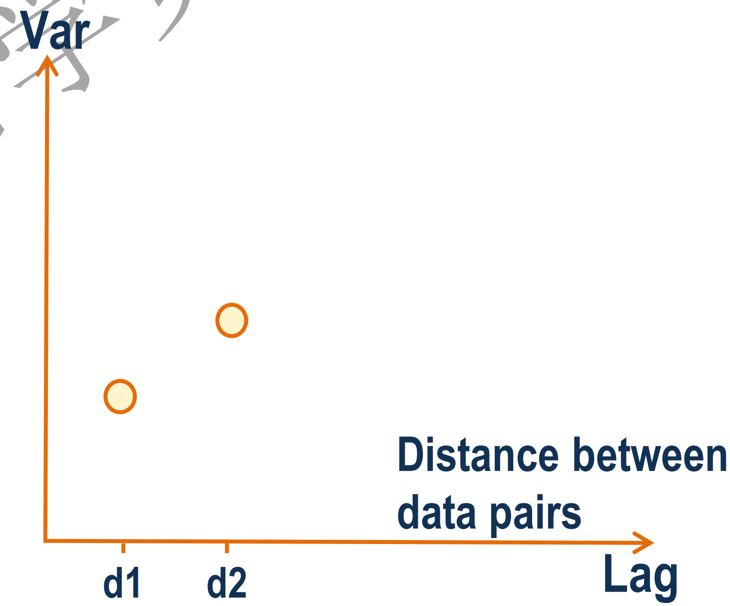
Construct the experimental variogram

STEP 2 – LAG 2:

a. Calculate the variance between all data pairs of distance d2.

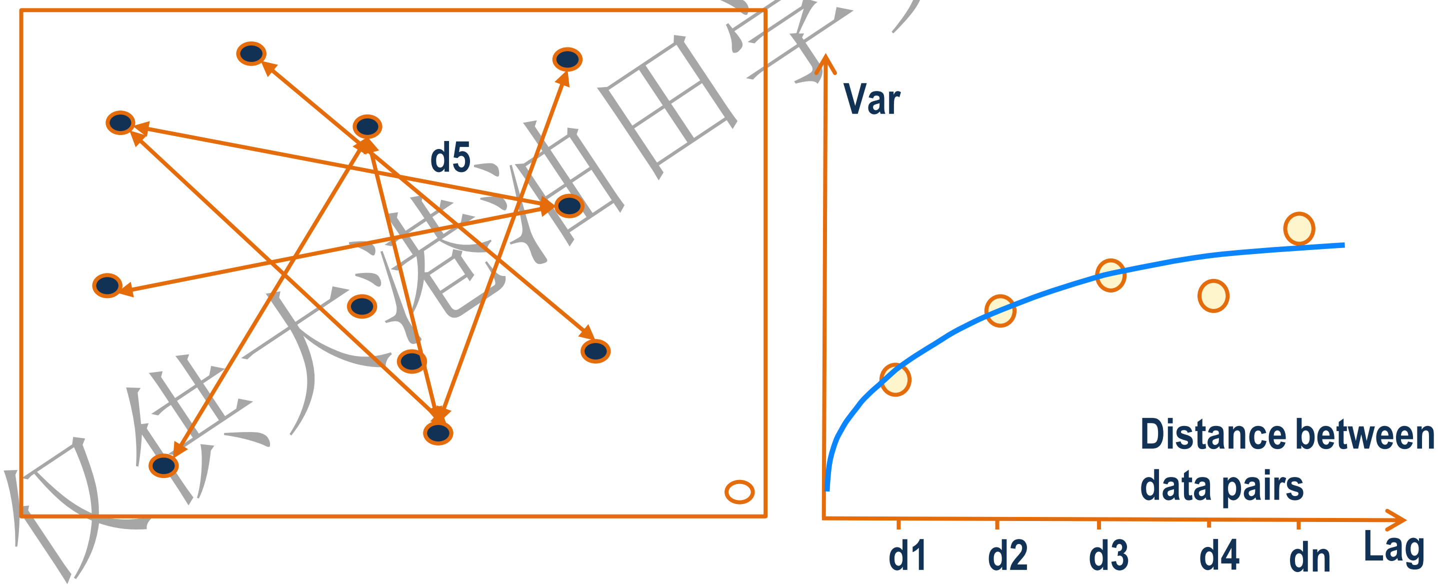
b. Average the variance and plot them in the sample variogram.





Construct the sample variogram

c. Calculate the variance between all data pairs of distance dn.
d. Average the variance and plot them in the sample variogram.
e. The continuous blue line is the model variogram.

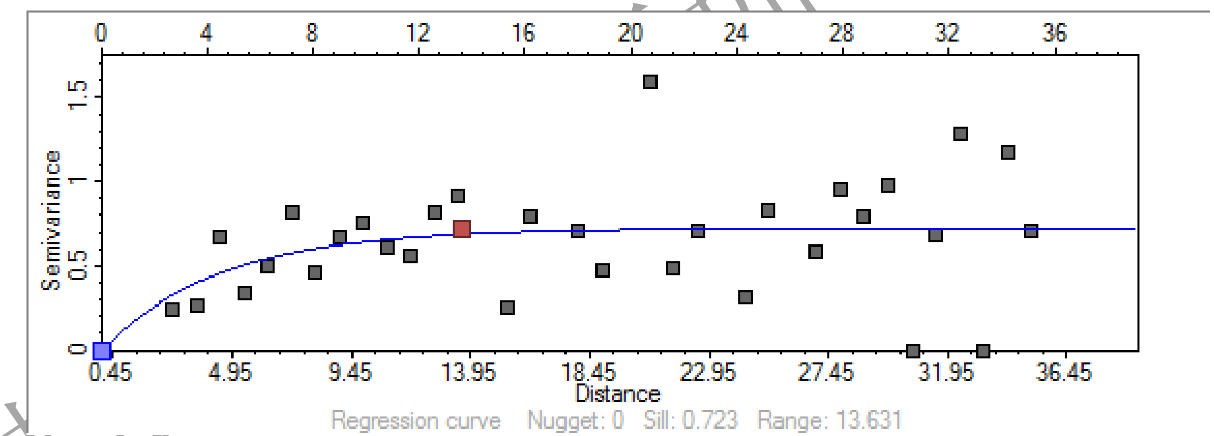


Applied variogram modeling

Variogram model fitting

Nugget: 0 Total sill: 0.7228

	Structure 1	
Type	Exponential	Spherical
Sill	0.7228	Exponential
Major range	6700	Spherical
Minor range	5800	Gaussian
Vertical range	13.631	



- Experimental variogram

Experimental variogram computation ☑ Search only inside zone

Direction	Azimuth	Dip	Number lags	Lag distance	Search radius	Band width	Tolerance angle	Lag tolerance	Thickness
Vertical	NA	90	39	0.9	35.1	50	70	50	NA

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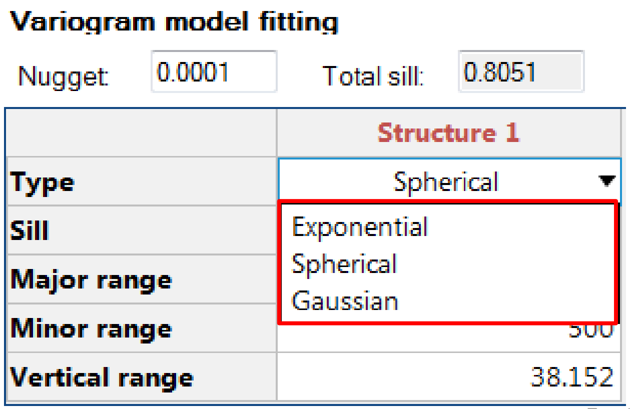
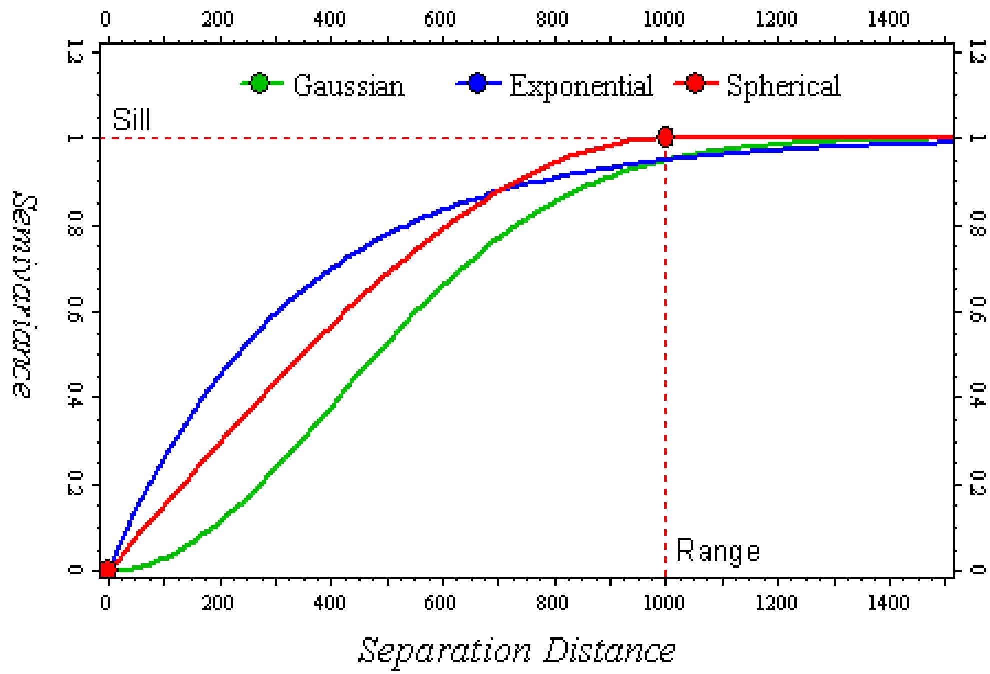
Variogram model types





Spherical: Good general algorithm
Exponential: Produces the most noisy result
Gaussian: Produces the smoothest result

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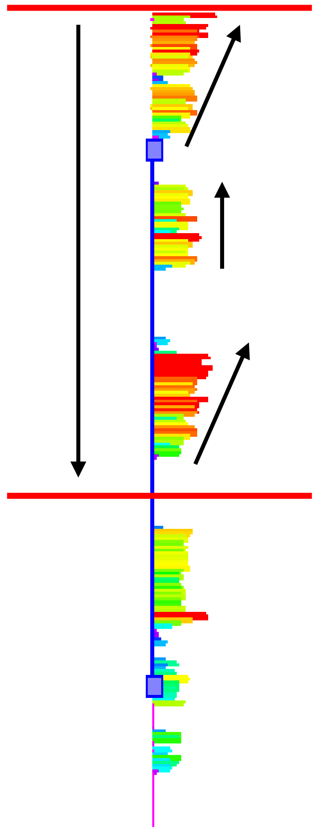
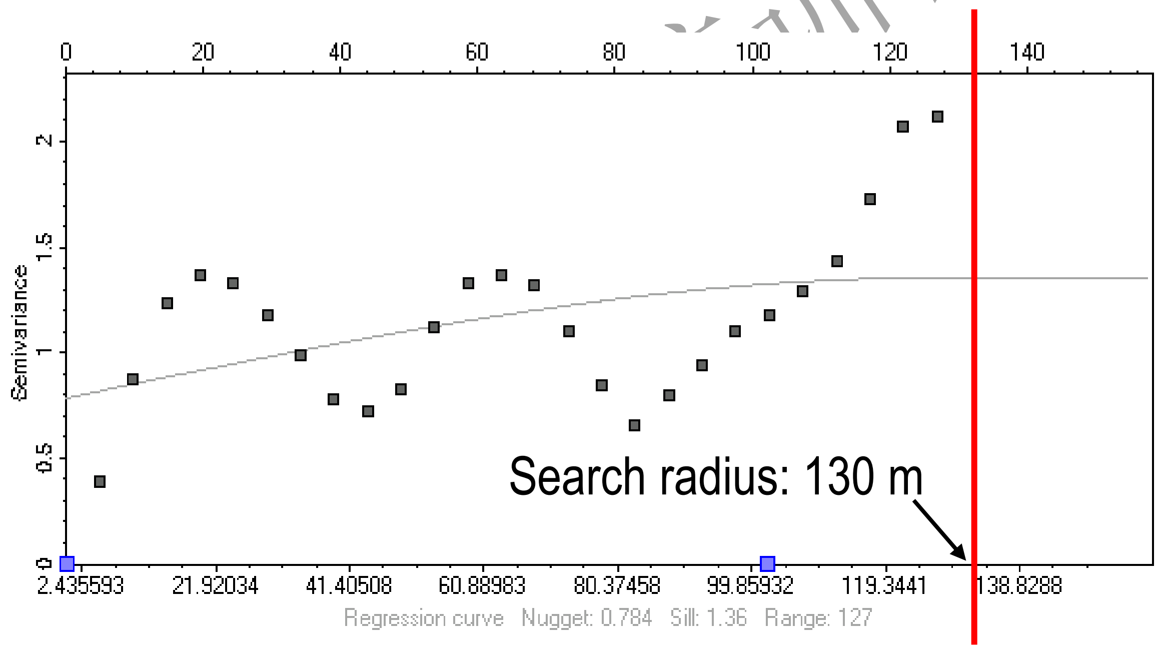
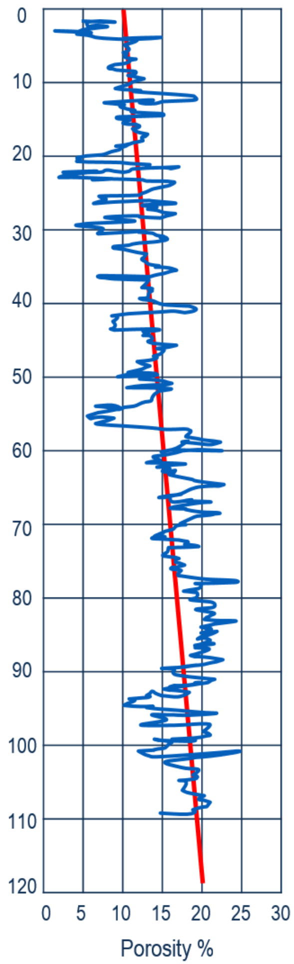
Applied variogram modeling: Cyclicity

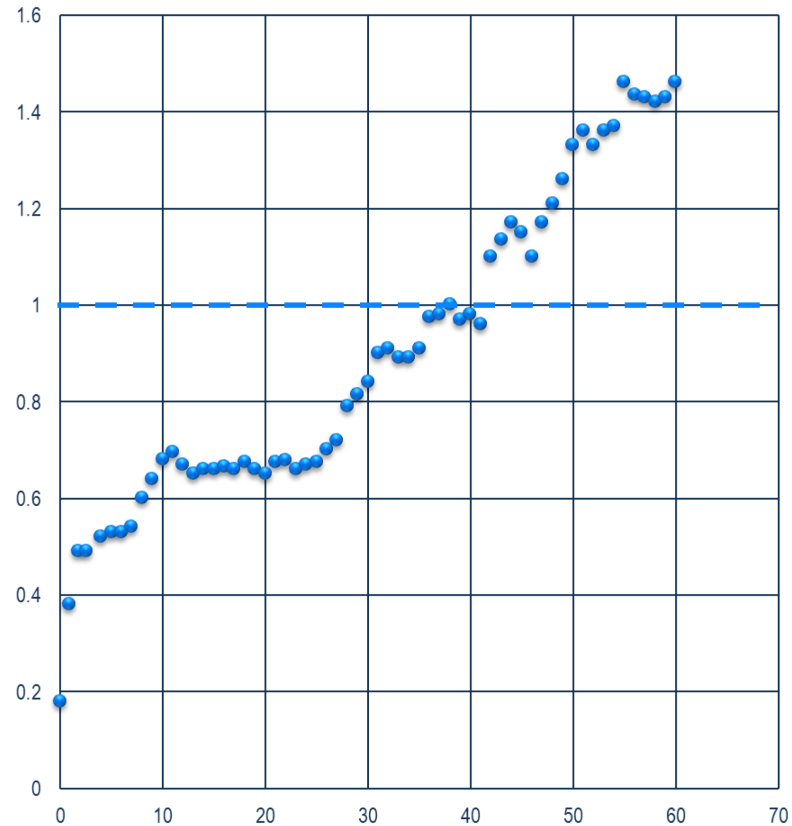
Search radius: 130 m





Applied variogram modeling: Trend





Adapted from CV Deutsch, 2002

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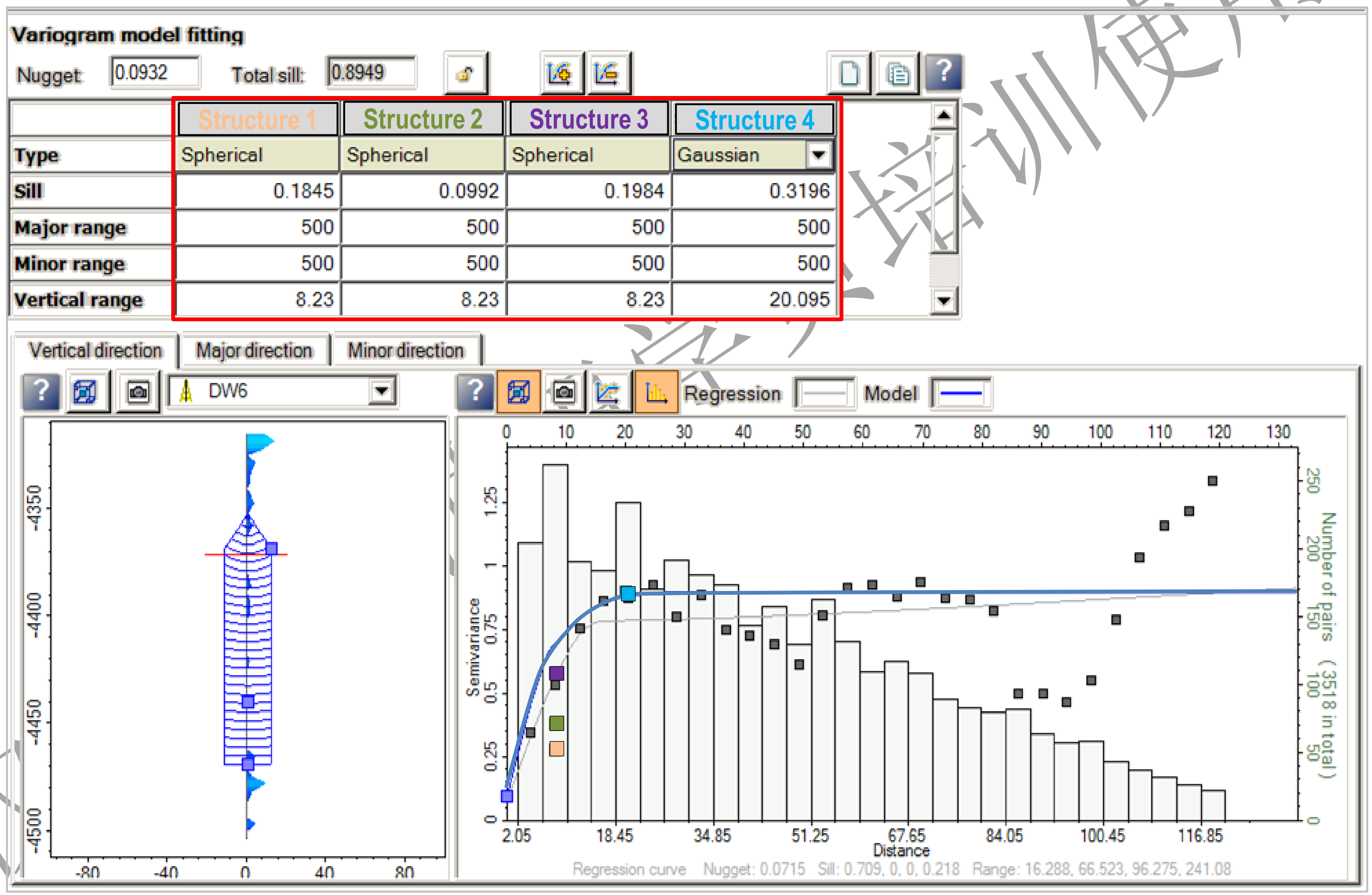
Variogram: Nested variogram in data analysis



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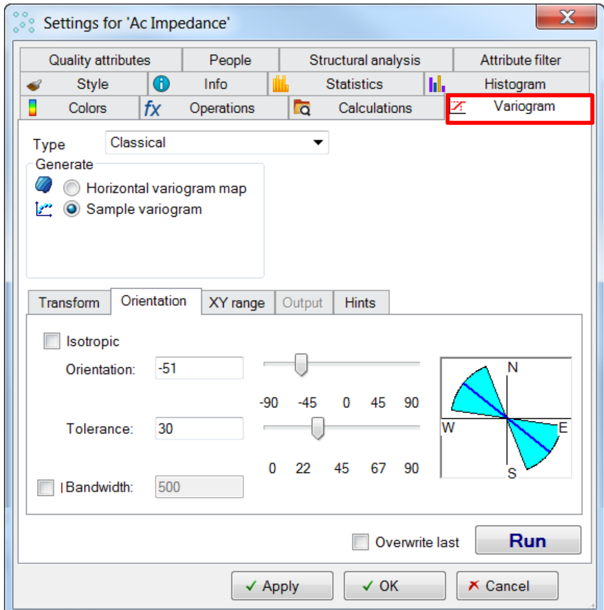
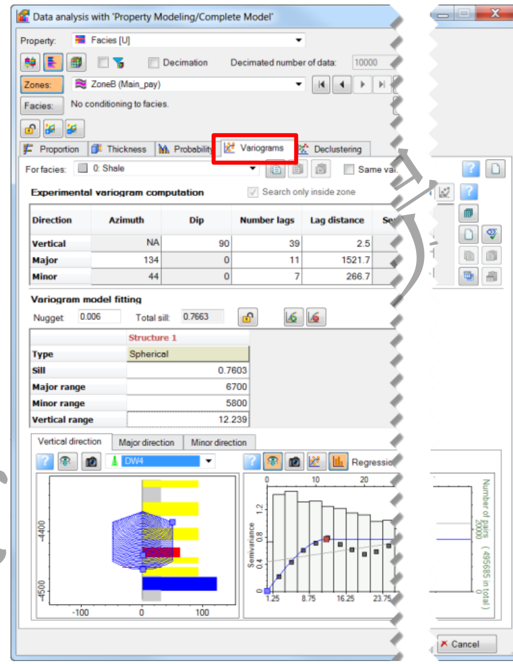
Variogram modeling in Petrel

Settings on the **Variogram** tab



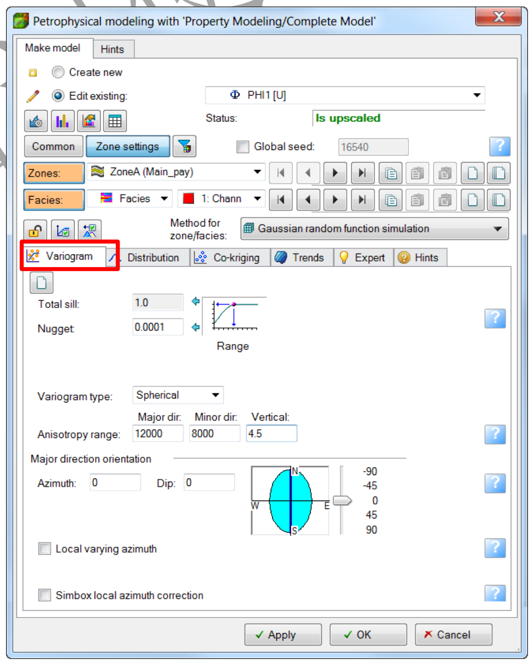
Sample or Horizontal variogram to find anisotropy.

Data analysis



Can calculate variograms for all three directions, on upscaled well logs, raw well logs, or 3D property data. Also can see the effect of search cone settings.

Facies/petrophysical modeling



Set up range (model dependent by default), nugget, and azimuth directly into the process dialog box.

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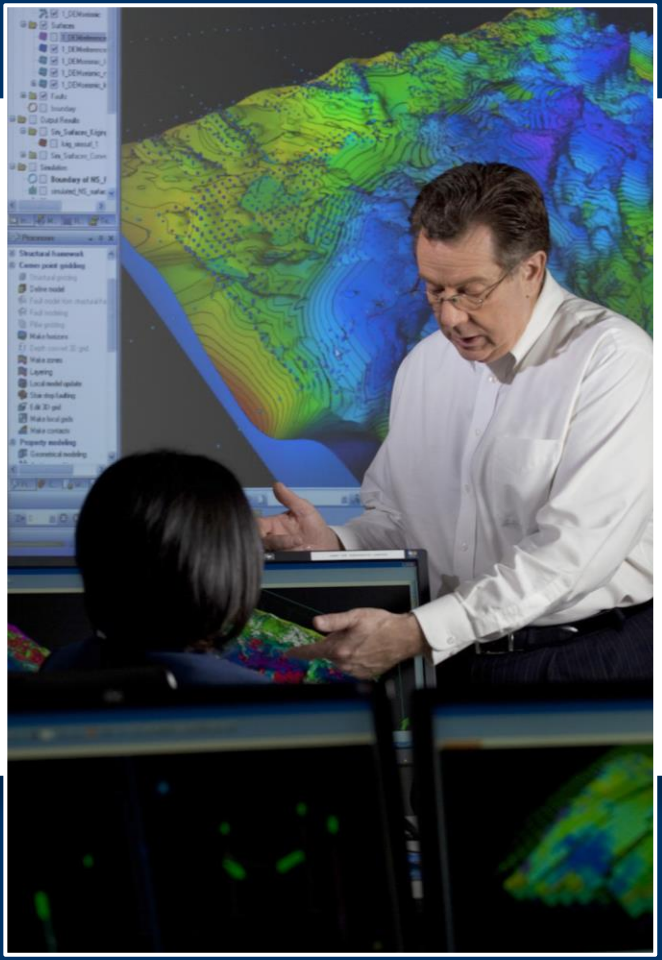
Exercises



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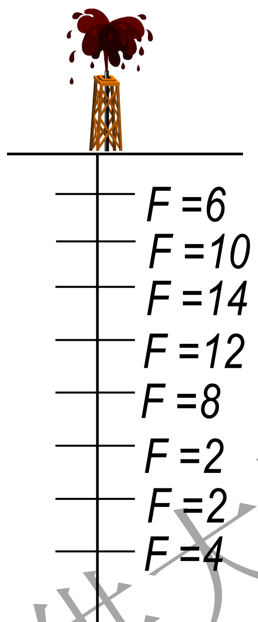
Exercise: Calculate the experimental variogram

Calculate the variogram values for lags 1, 2, 3, 4, and 5 meters.



$$\gamma_{(h)} = \frac{\sum_{i=1}^{n} \left(X_i - X_{(i+h)} \right)^2}{n}$$

Note: You create the semivariogram (from top to bottom), so you must divide by n - not 2n.

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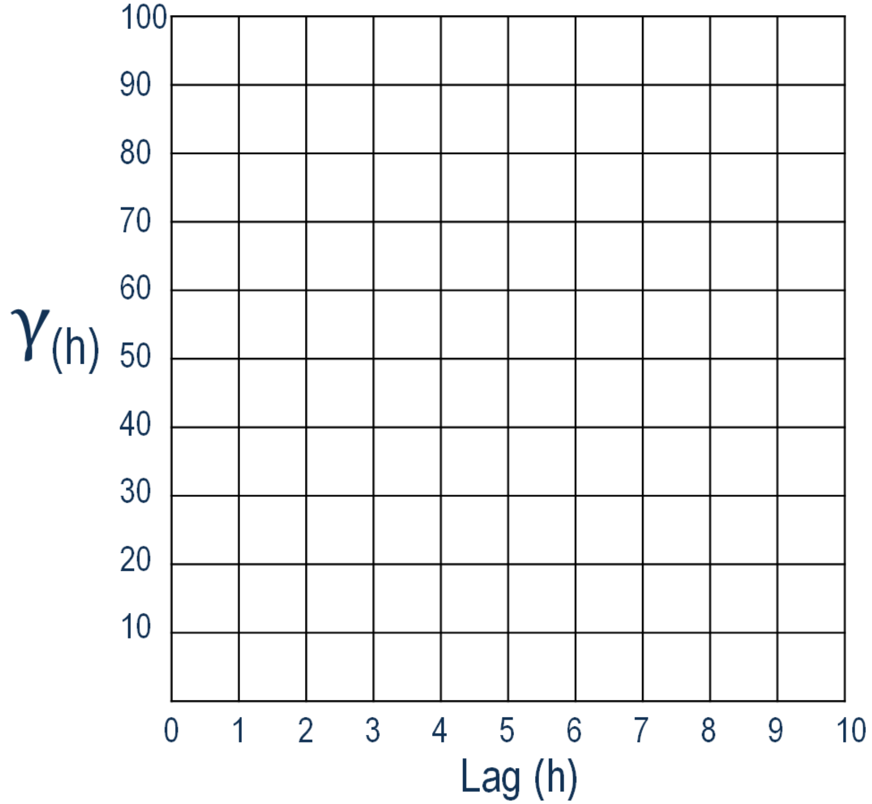
Exercise: Fit the model variogram

Plot the experimental variogram.

Can you fit the Model variogram to the Experimental variogram you just created?

Identify the range and explain what information that value tells us.



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