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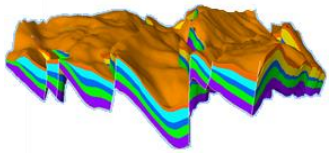
Petrel 2017 Property Modeling Module 4: Univariate and Bivariate geostatistical analysis

Petrel 2017 Property modeling

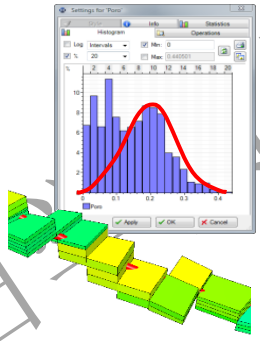


Intro

Petrel Property Modeling objective and workflow

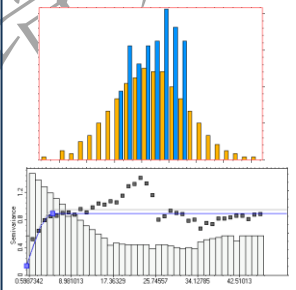
Property modeling data preparation

Scale up well logs

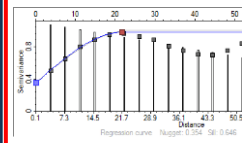


Univariate and bivariate geostatistics

Basic statistics

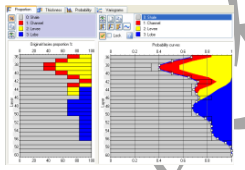


Variogram modeling

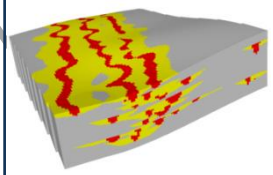


Facies modeling

Discrete data analysis

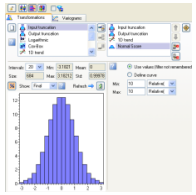


Stochastic facies modeling

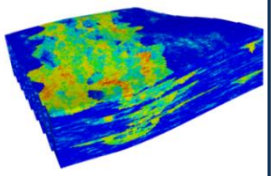


Petrophysical modeling

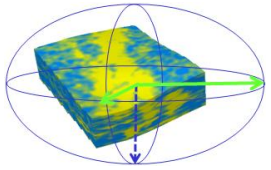
Continuous data analysis



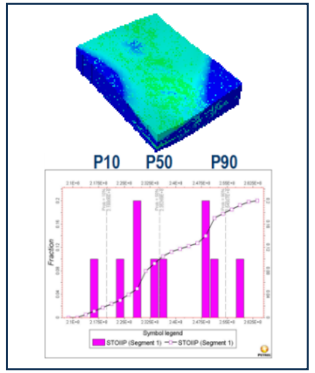
Stochastic and deterministic petrophysical modeling



Use of secondary information for property modeling



Volume calculation and Uncertainty analysis



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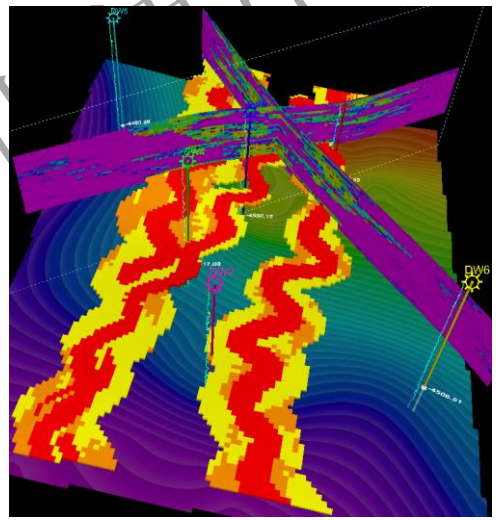
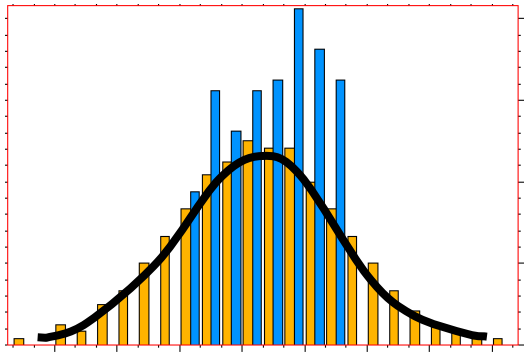
What is geostatistics?

- *Geostatistics* is a branch of applied statistics that places emphasis on the geological context of the data and the spatial relationship between the data.
- Geostatistical techniques are an indispensable part of reservoir management because quantitative numerical models are required for planning the field/reservoir development to optimize time, resources, and economic gain.

Why should you use geostatistics in reservoir modeling?

- Very few direct observations
- Analysis of variables in space and their correlation
- Description of the reservoir's heterogeneity
- Provide the means for populating a 3D model in a consistent and reproducible way
- Systematic method of describing and handling reservoir uncertainty





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Definitions

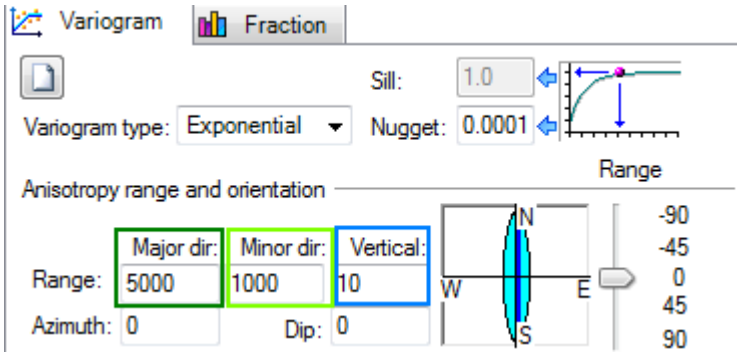
Probability: A measurement of the likelihood of an event. (Measured in percent.)

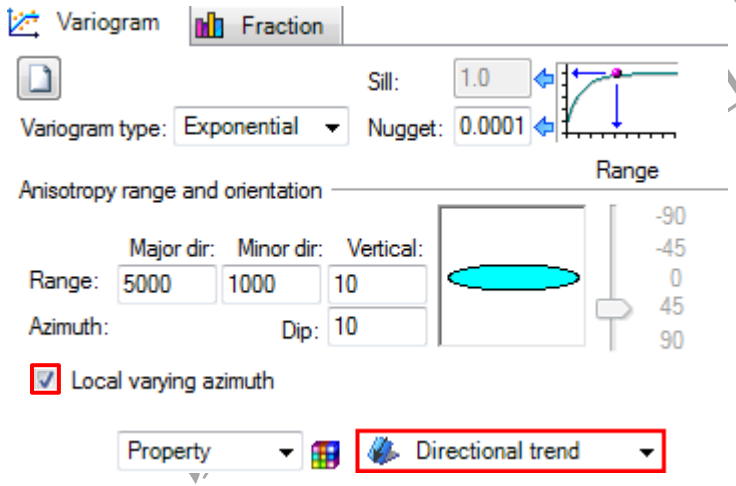
Variance: A measurement of the amount of difference between the members of a collection. (Measured in units of the collection.)

Correlation: A measurement of the relationship between two collections. (Measured in percent.)

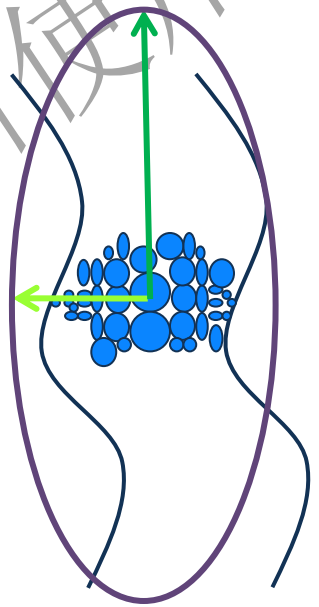
Anisotropy: A measurement that indicates if a variance within a collection of data is determined by direction. (Measured in azimuth and percent eccentricity.)

Anisotropy vs. Trend

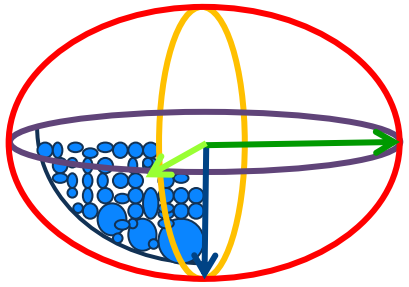




ANISOTROPY



TREND (fining upwards)



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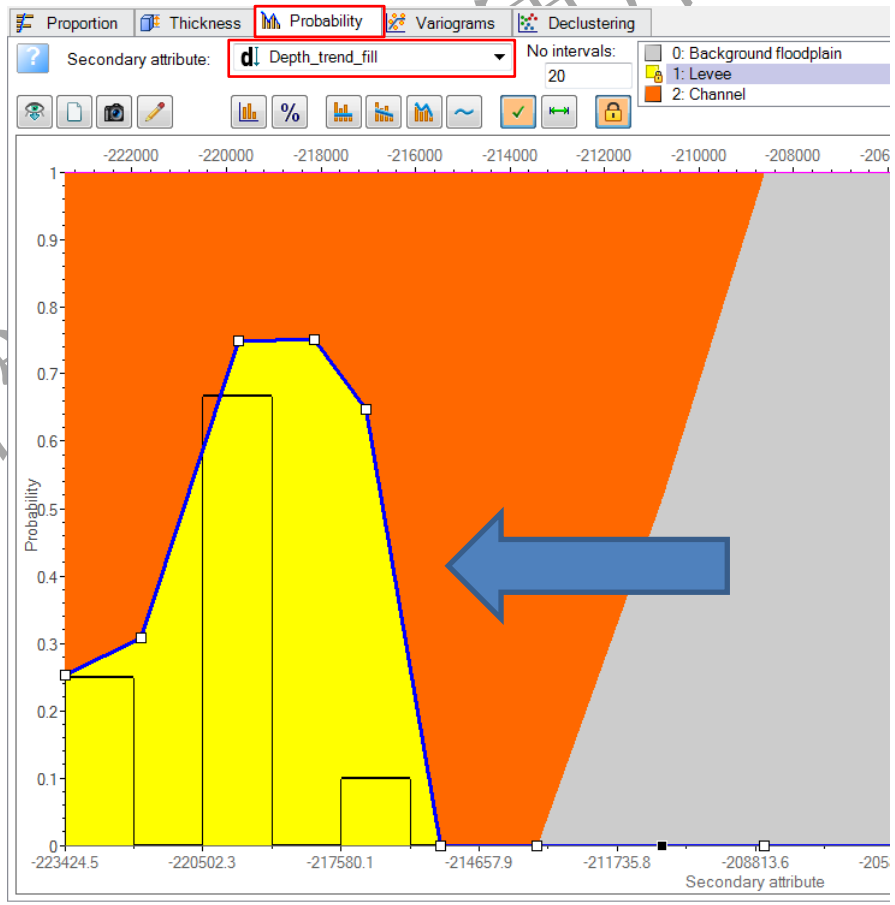
Apply vertical trends

You can use a depth trend as a secondary property to specify the probability of finding specific facies at specific depths.

You can edit the attribute probability curves manually and use them directly in Facies modeling with the icon.

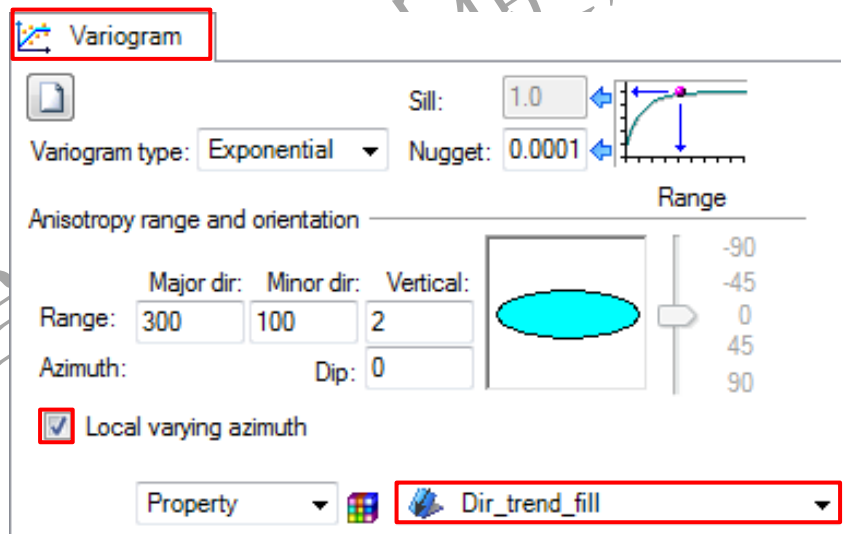
Note: Apply vertical trends in other ways, such as functions or 3D properties.



Apply horizontal trends (major direction)

Use an azimuth to orient the model towards the major trend in the model.

Set the azimuth to vary in each cell according to a specific directional property or surface using the *Local varying azimuth* check box.



Note: You can apply horizontal trends in other ways, such as 2D surfaces or 3D properties.

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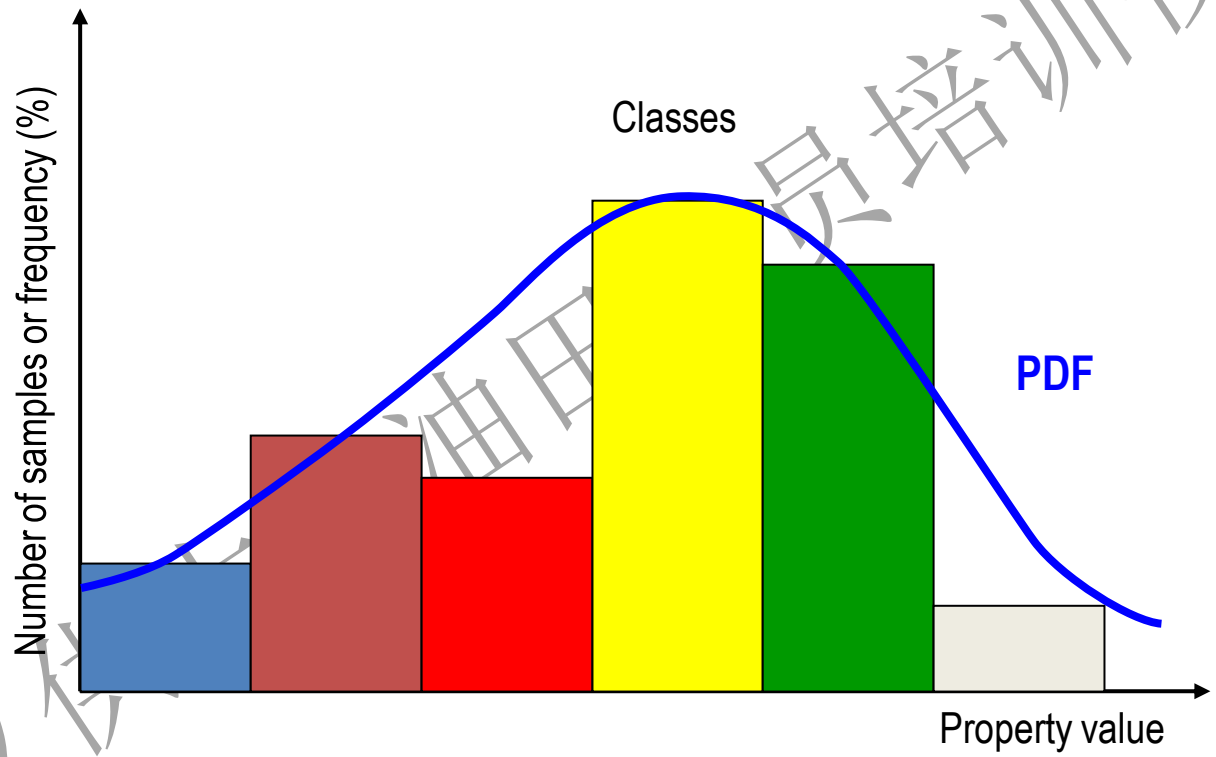
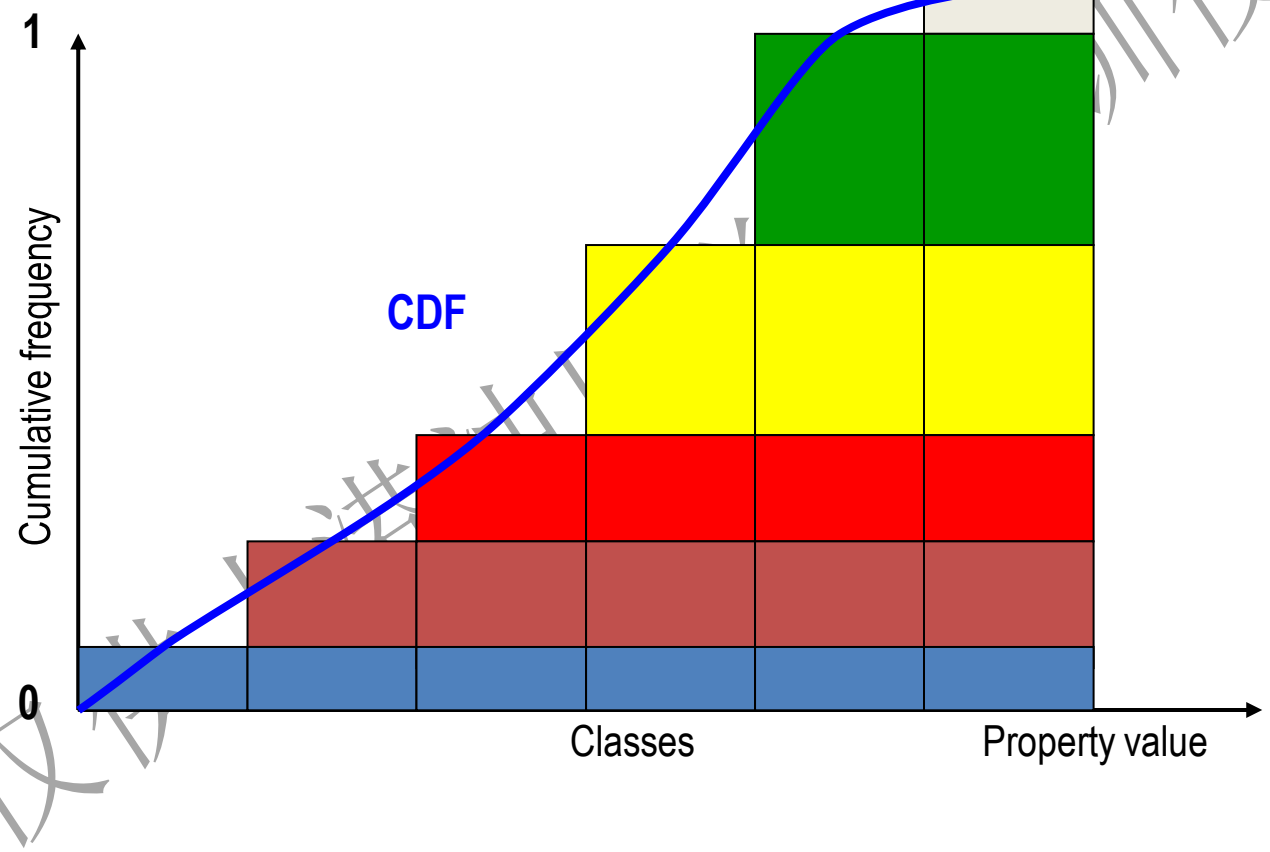
Univariate analysis: Histogram and Probability Distribution Function (PDF)



Univariate analysis: Cumulative Distribution Function (CDF)



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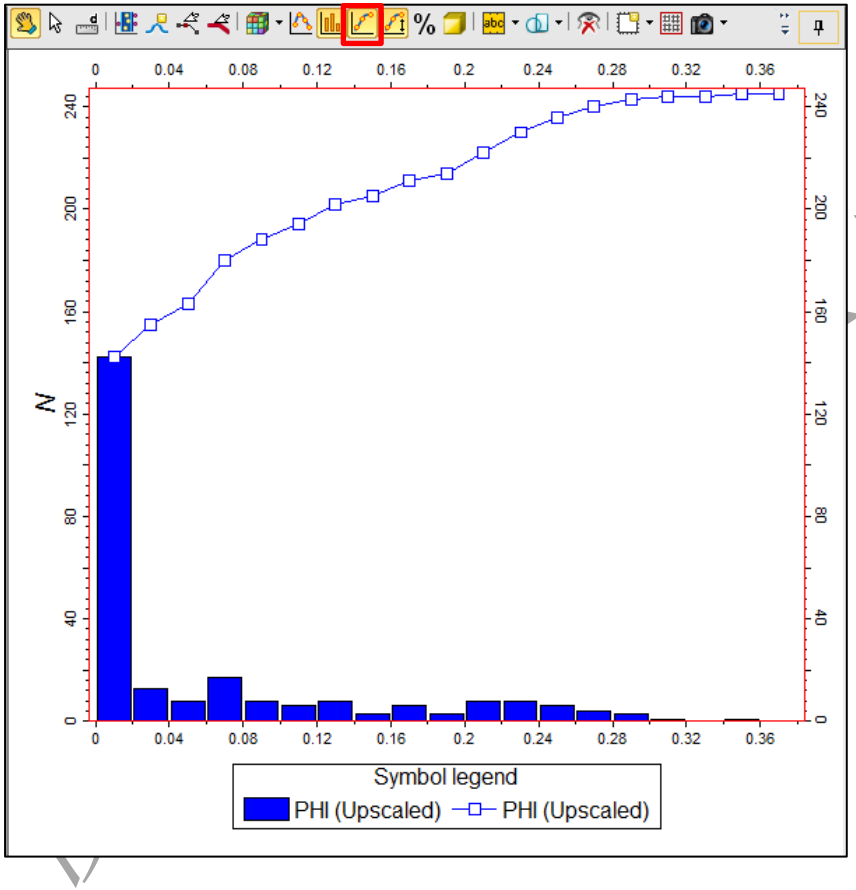
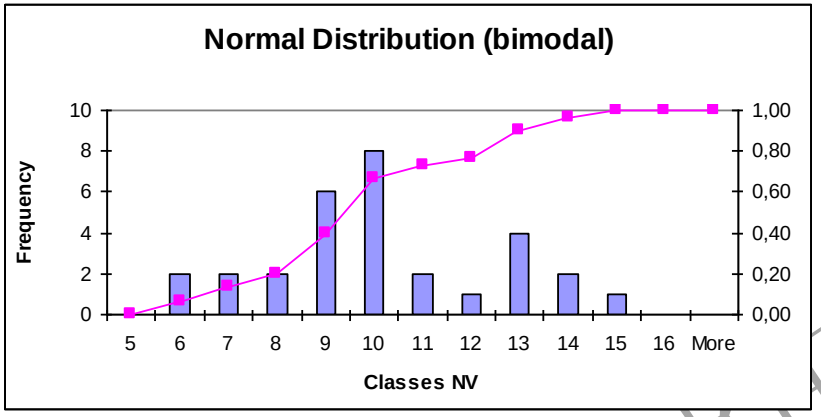
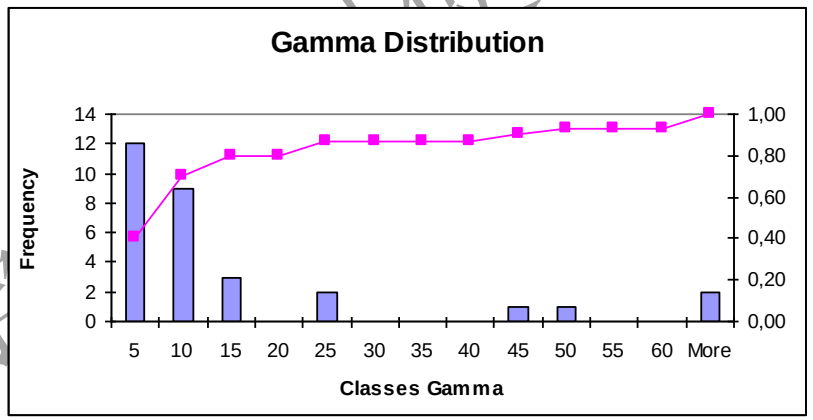
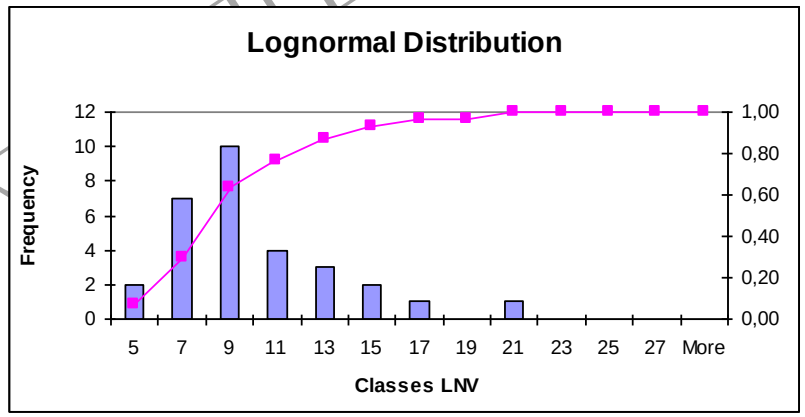
PDF and CDF in Petrel: Histogram



Theoretical distribution

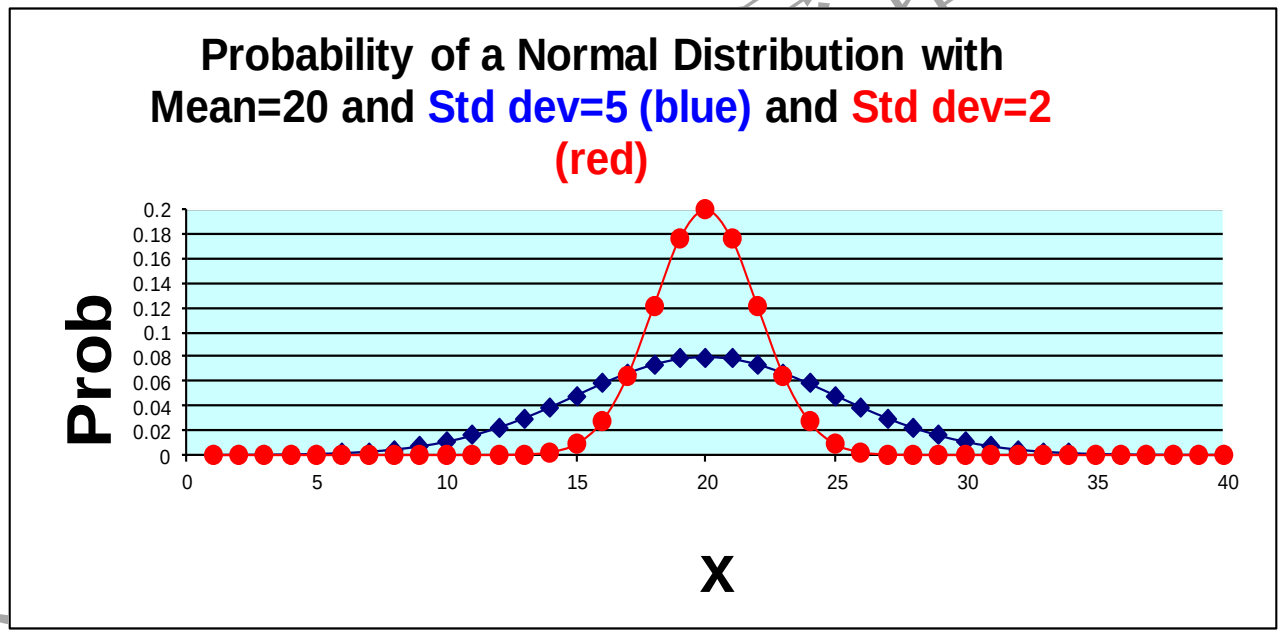






Normal distribution

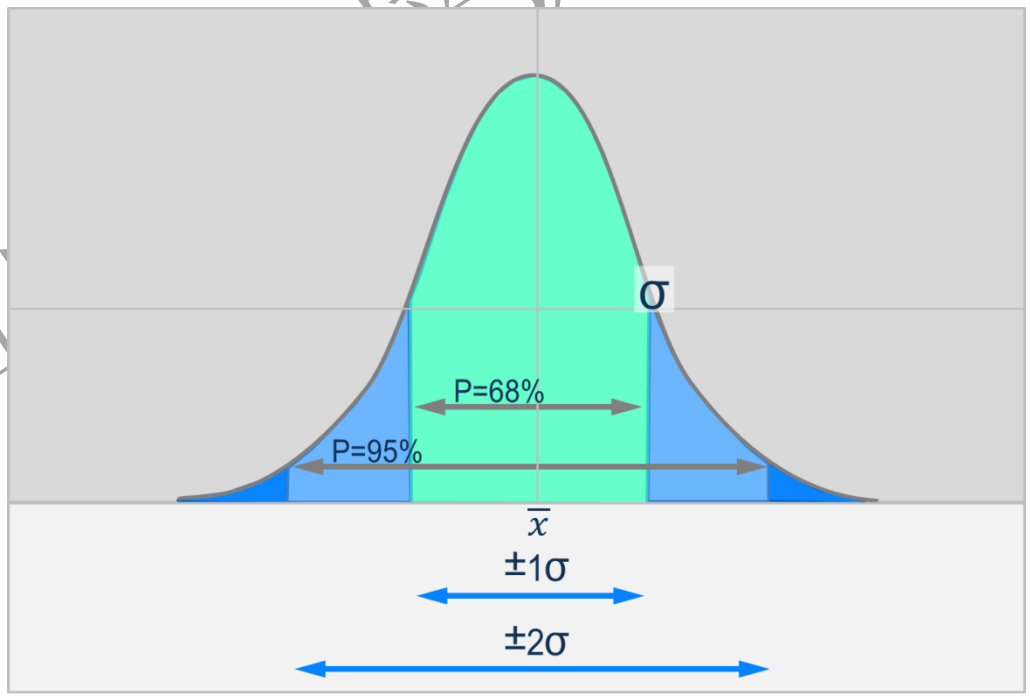
Probability of normal distribution: $p(x;\mu,\sigma) = \frac{1}{\sigma\sqrt{2\pi}} e^{-\left(\frac{(x-\mu)^2}{2\sigma^2}\right)}$



Normal score transformation

$$p(x;\mu,\sigma)=\frac{1}{\sigma\sqrt{2\pi}}e^{-\left(\frac{(x-\mu)^2}{2\sigma^2}\right)} \quad --->\quad p(x;0,1)=\frac{1}{\sqrt{2\pi}}e^{-\left(\frac{x}{2}\right)^2}$$

Statistical confidence level S=1 - α (%)	Risk α(%)	Factor in terms of standard deviation
68.3	31.7	1.000
90.0	10.0	1.645
95.0	5.0	1.960
95.5	4.5	2.000
99.0	1.0	2.576
99.7	0.3	3.000



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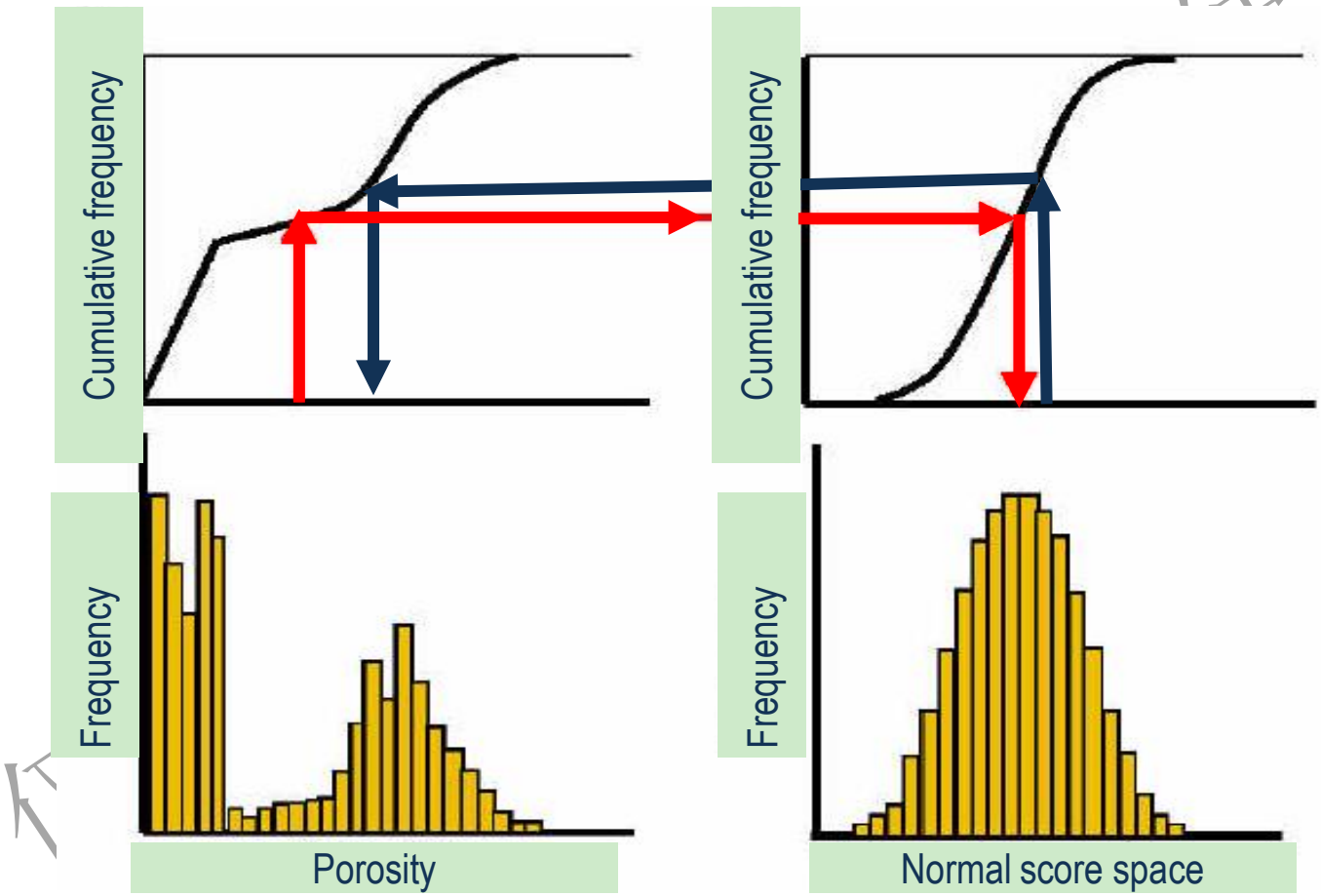
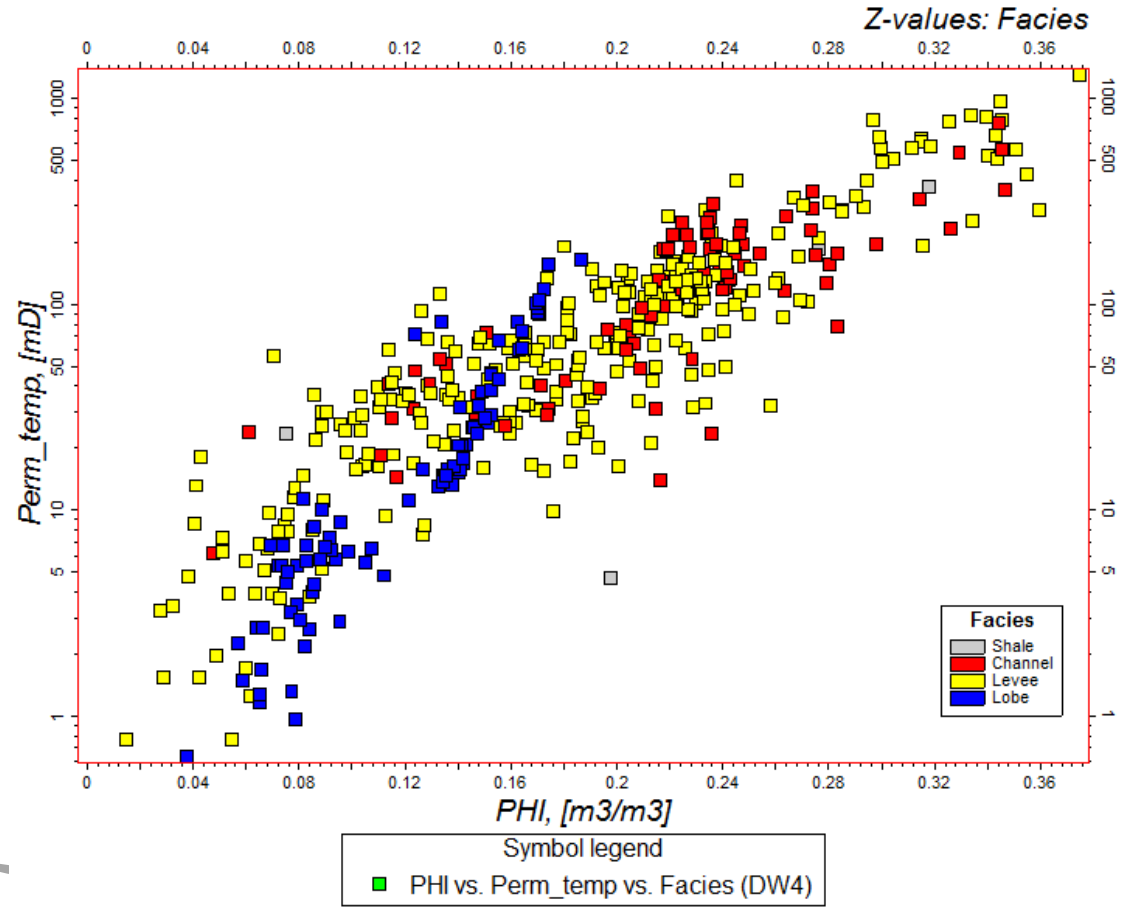
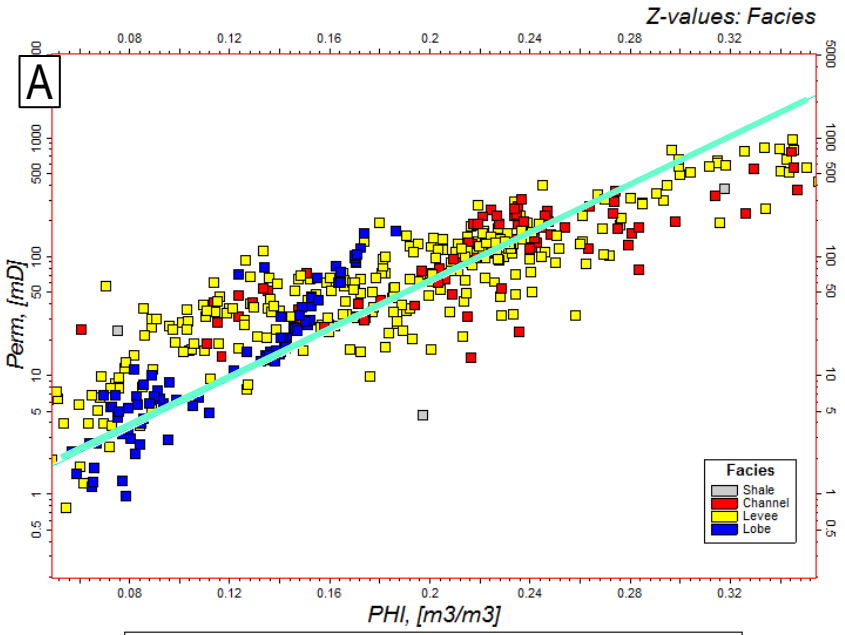
Transforming and back-transforming distributions



Bivariate analysis: Correlation



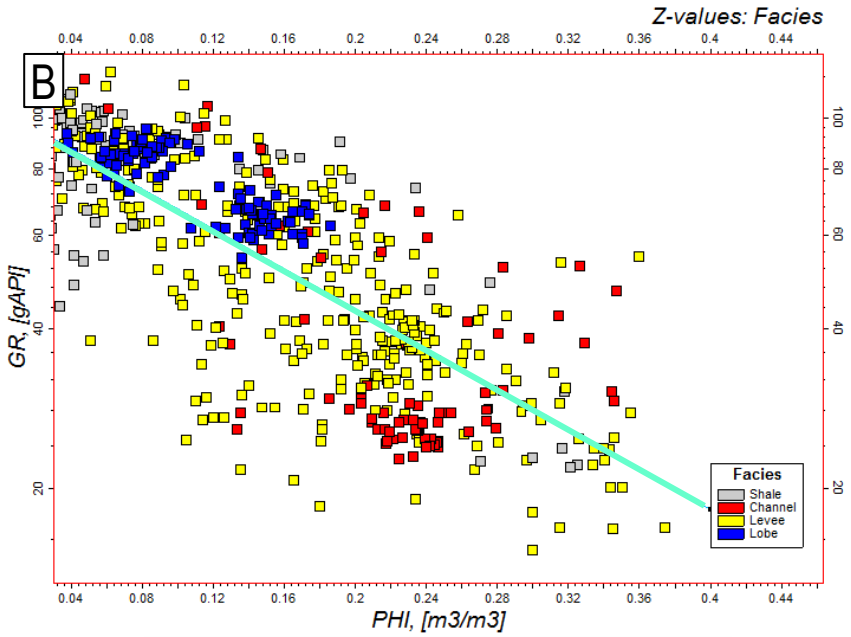
Bivariate analysis: Crossplot and correlation



Symbol legend

Perm_vs_PHI — PHI vs. Perm vs. Facies (DW4)

Description	Value
Correlation coeff:	0.907385
Covariance:	0.137238
Linear function:	log(Y) = 17.2023 * X - 1.95152
Name of function:	Perm_vs_PHI



Symbol legend

GR_vs_PHI — PHI vs. GR vs. Facies (DW4)

Description	Value
Correlation coeff:	-0.828689
Covariance:	-0.0151199
Linear function:	log(Y) = -1.89522 * X + 2.01879
Name of function:	GR_vs_PHI

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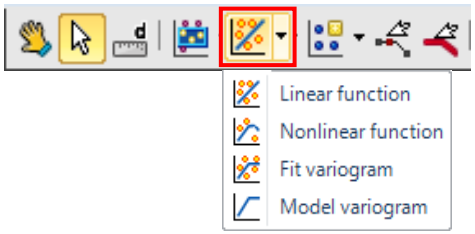
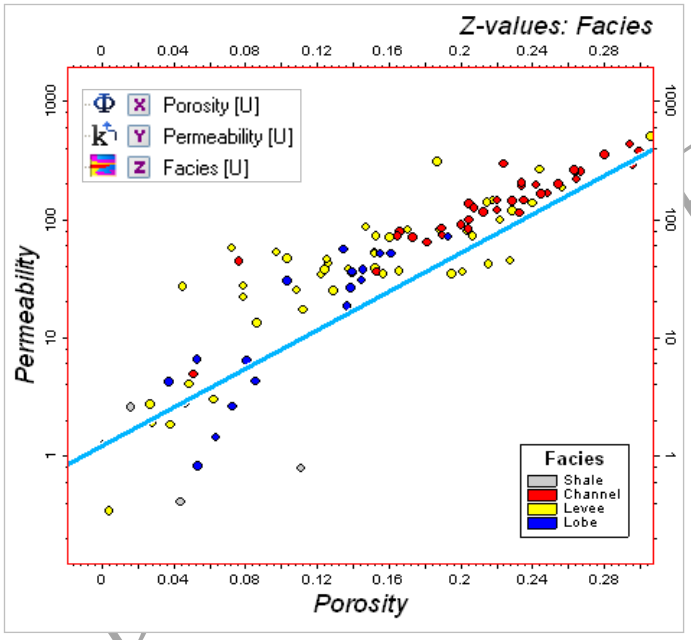
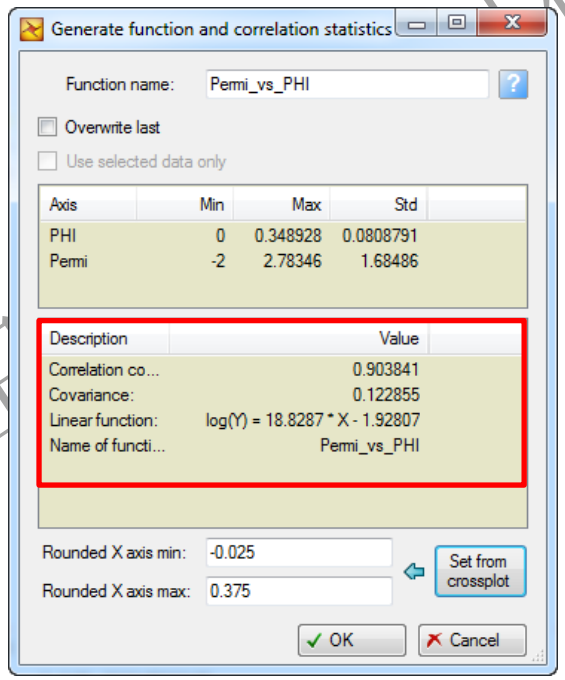
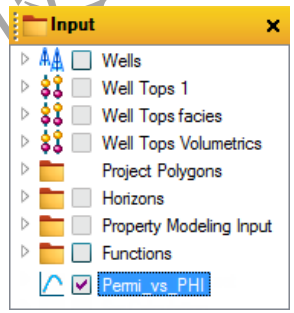
Correlation analysis in Petrel: Function window

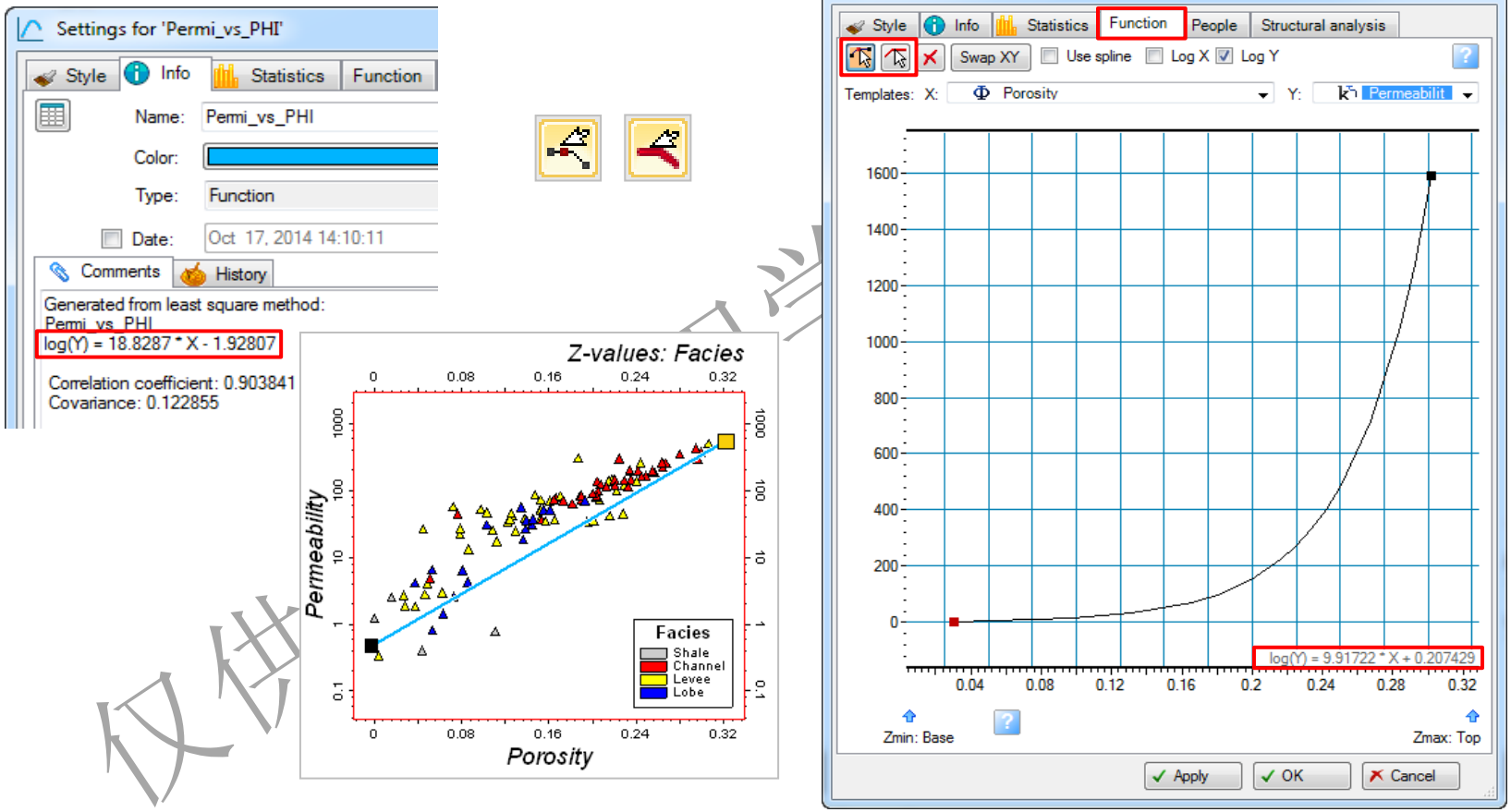




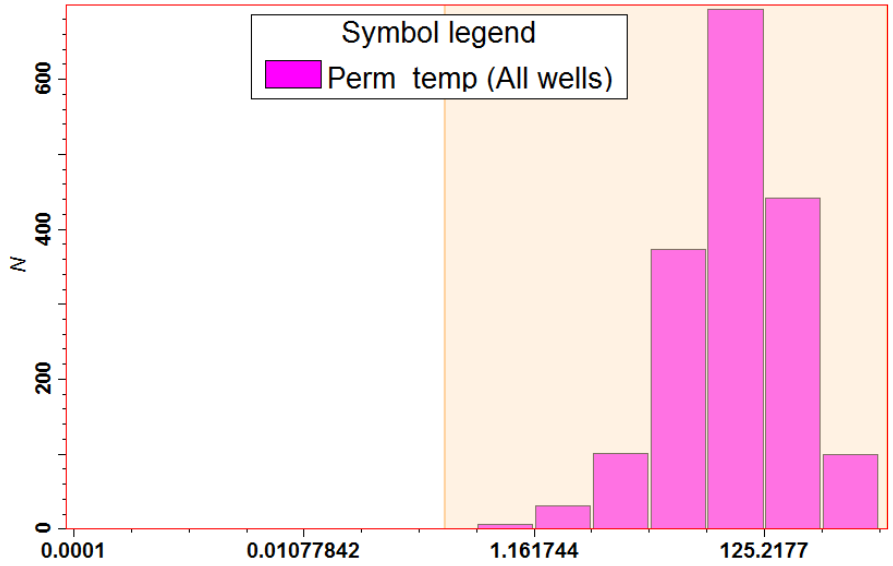


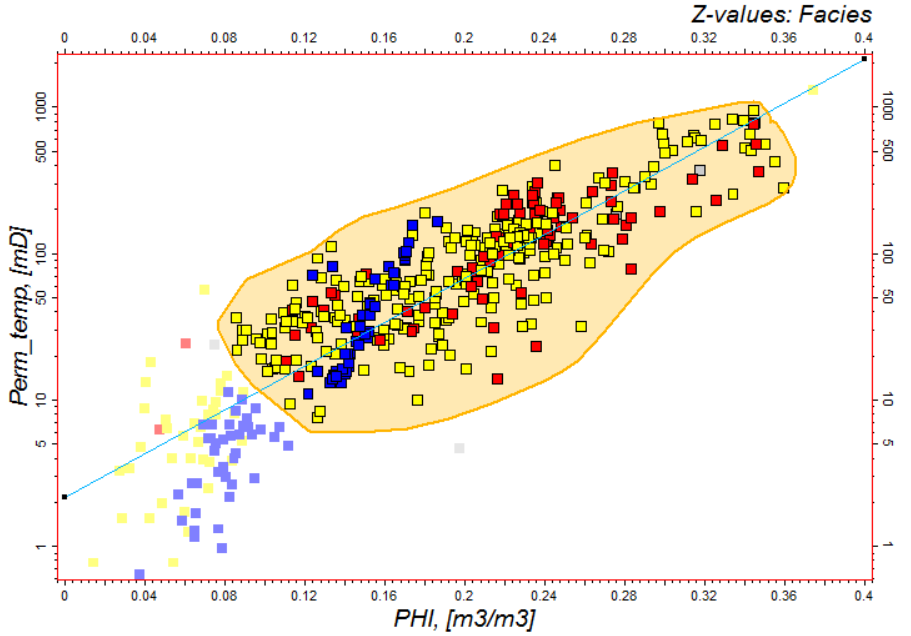


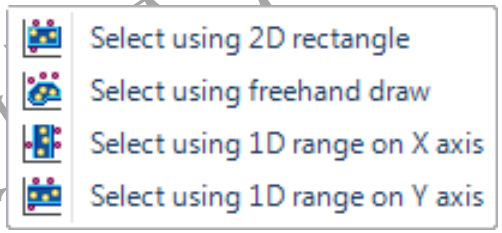
Regression analysis in Petrel: Function window

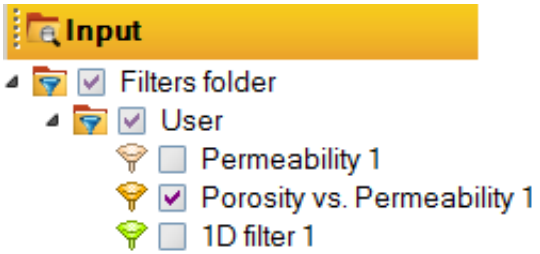


Generic filters in Petrel: Histogram and crossplot









Exercises

- Use basic statistics for:
  - Histograms
  - Crossplots
  - Cumulative density functions
  - Normal distribution
  - Correlation coefficient
- Use generic filters