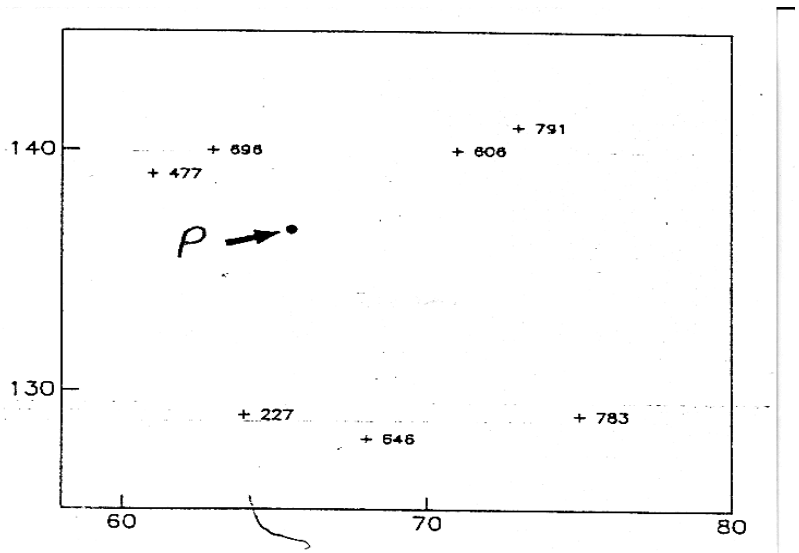
Application of Geostatistics

A simple example: simulating 1D water flow in an aquifer

- Collect data of controlling parameters (e.g. porosity, hydraulic conductivity)



Application of Geostatistics

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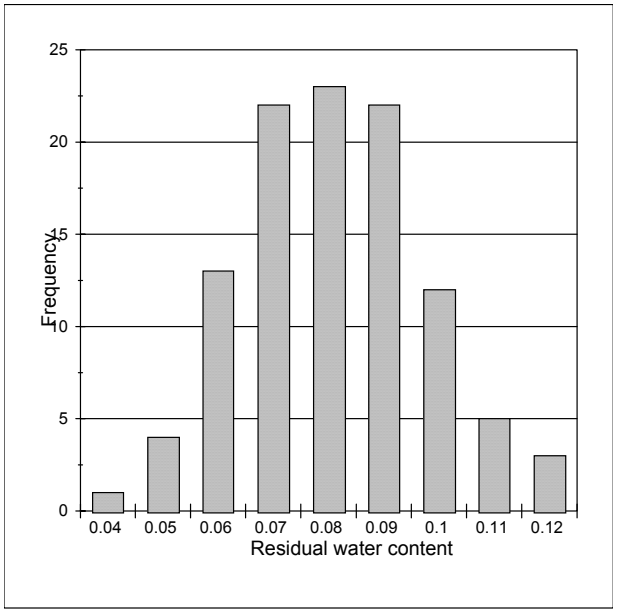
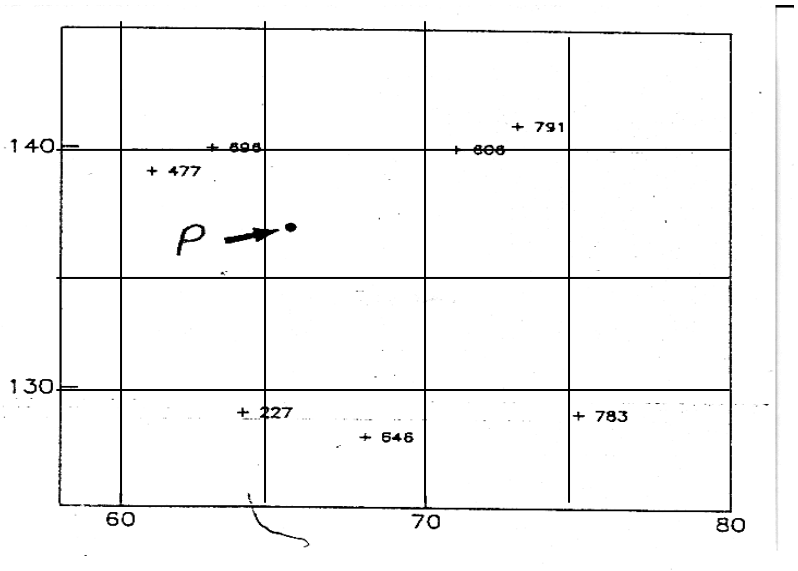
- Analyze the available data sets and compute their statistics.



Application of Geostatistics

A simple example: simulating 1D water flow in an aquifer

- Construct geostatistical models for:
  - Spatial variability (i.e. variograms)
  - Estimation of parameters at unsampled locations (i.e. kriging)
  - Conditional simulation
- Geostatistical approach is based on a probabilistic model that recognizes uncertainty at unsampled locations.

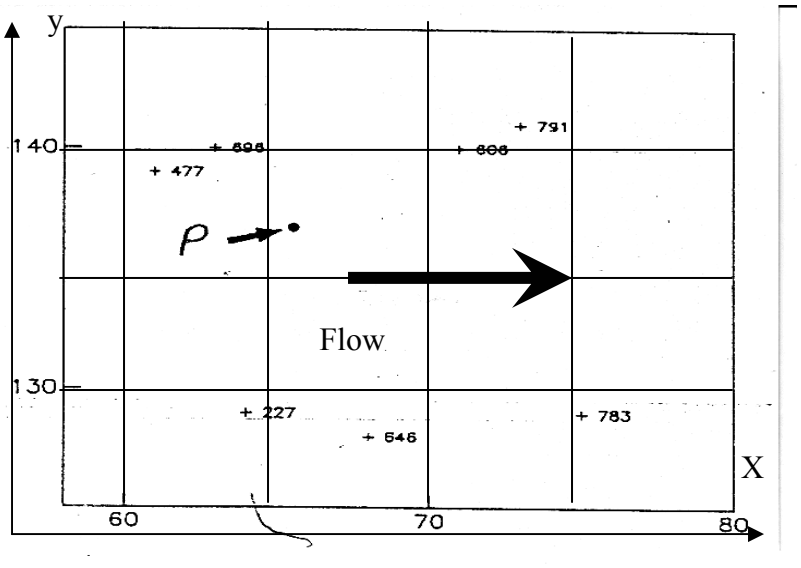


Application of Geostatistics

A simple example: simulating 1D water flow in an aquifer

- Run a flow simulator with appropriate boundary and initial conditions

$$\frac{\partial}{\partial x}\left(K_x \frac{\partial h}{\partial x} \right) = S_s \frac{\partial h}{\partial t}$$



Geostatistics and Natural Processes

- Processes that constructed an ore deposit, a petroleum reservoir, or a hazardous waste site are extremely complicated.

- The human understanding of these processes is very poor that complexity appears as random behavior to us.

- This does not mean that the processes are random, but we are ignorant!

- That's why geostatistics, which is based on probabilistic models, is used to deal with geological problems.

Geology and Statistics

- Geologic variable (parameter): a certain property that can be estimated by analyzing field / lab specimens or interpreting geological / geophysical measurements (e.g. porosity, mineral grade, thickness)

- Data set (sample): a limited number of measurements of a geologic property. A data set is usually sampled from a larger population of data.

- Population: A set of all possible values of a geologic variable from which statistical inference (analysis) can be performed. In nature population composed of infinite number of samples, so it can not be sampled and modeled exactly. Population can be modeled and its parameters can be "estimated" approximately from a data set.

Random Variable

- Random (stochastic) variable: An independent variable which can take one of several possible values. The values are “stochastically” generated according to some “unseen” probabilistic mechanism and natural ordering.

    - Any geologic parameter is considered as a random variable.
    - Example: measurement of porosity from a core that one does not know which value it will have. However, from literature all possible values are known (i.e. porosity range of geologic materials is 0.03 - 0.61).
    - In statistical/ geostatistical terminology the numerical outcome of a random variable is refereed to as: z (x) (small z)

Random Function

- Random function (field): A set of random variables that have some spatial locations and whose dependence on each other is specified by some probabilistic mechanism.

  - Infinite number of realizations can be generated from a random function using statistical and geostatistical engines as well as random number generators (e.g. conditional simulation outputs).
  - In statistical / geostatistical terminology the random function is refereed to as: Z (x) (capital Z at a specific location).

$$Z(x) : x \in D$$

Univariate Statistics

- Univariate statistics deals with the organization, presentation, and summary of data of ONE variable.
- Statistical modeling is an approach for fitting mathematical equations to data in order to predict unknown quantities from measurements.
  - Postulate a model that describes the data & fit its parameters
  - Validate (test) the model
  - Predict the unknown

Probability

- Knowledge of probability distributions is needed to construct a statistical model.
- Probability is a measure of how likely (probable) specific observations of a variable may or may not occur.

  – Example:

    » P(porosity <= 0.15) = 10% or 0.10

    » P(porosity <= 0.23) = 82% or 0.82

Probability

- To apply geostatistical approach to a real-life problem, one does not need to completely define a complex random (stochastic) process.

- It is sufficient to specify only certain parameters of the random process like:
  - » mean
  - » variance
  - » PDF and CDF
  - » statistical correlation
  - » spatial correlation