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The Fractal/Facies Concept: An Alternative to Using Variograms for Generating Subsurface Heterogeneity

Past applications of stochastic theory in geology have been based mainly on treating heterogeneous property distributions as stationary, correlated, random processes, with short correlation lengths. A convenient way to characterize such distributions is through computation of a variogram, which should reach a sill as one approaches a measurement separation equal to the correlation length. This approach has had limited success, because often a sill is not reached or is poorly defined. An explanation for such behavior is given by modern fractal-based theories that conceptualize natural heterogeneity as non-stationary stochastic processes with stationary increments, the mathematical basis for stochastic fractals. Statistical analysis is then applied to the increment distributions, with the resulting probability density functions (PDFs) usually displaying properties of the Levy PDF. However, there are problems with the Levy approach, such as the extreme variability displayed by these probability distributions. A potential explanation for the appearance of Levy PDFs is that they actually represent a superposition of several Gaussian distributions of different variance. This leads to a working hypothesis that within a single facies, increment distributions of heterogeneous properties, such as Log(permeability), appear Gaussian. This hypothesis, called the fractal/facies concept, is supported by previous applications to an alluvial fan environment and by approximately 500 permeability measurements from an outcrop of the Upper Cretaceous Straight Cliffs Formation near Escalante, Utah. Analysis of the facies data demonstrates that Gaussian stochastic fractal structure is present. The fractal/facies concept represents a melding of facies sedimentology with fractal theory for generating distributions of subsurface properties.