Permeability-porosity relationships in sedimentary rocks

In many consolidated sandstone and carbonate formations, plots of core data show that the logarithm of permeability ($k$) is often linearly proportional to porosity ($\phi$). The slope, intercept, and degree of scatter of these log($k$)-$\phi$ trends vary from formation to formation, and these variations are attributed to differences in initial grain size and sorting, diagenetic history, and compaction history. In unconsolidated sands, better sorting systematically increases both permeability and porosity. In sands and sandstones, an increase in gravel and coarse grain size content causes $k$ to increase even while decreasing. Diagenetic minerals in the pore space of sandstones, such as cement and some clay types, tend to decrease log($k$) proportionately as $\phi$ decreases. Models to predict permeability from porosity and other measurable rock parameters fall into three classes based on either grain, surface area, or pore dimension considerations. (Models that directly incorporate well log measurements but have no particular theoretical underpinnings form a fourth class.) Grain-based models show permeability proportional to the square of grain size times porosity raised to (roughly) the fifth power, with grain sorting as an additional parameter. Surface-area models show permeability proportional to the inverse square of pore surface area times porosity raised to (roughly) the fourth power; measures of surface area include irreducible water saturation and nuclear magnetic resonance. Pore-dimension models show permeability proportional to the square of a pore dimension times porosity raised to a power of (roughly) two and produce curves of constant pore size that transgress the linear data trends on a log($k$)-$\phi$ plot. The pore dimension is obtained from mercury injection measurements and is interpreted as the pore opening size of some interconnected fraction of the pore system. The linear log($k$)-$\phi$ data trends cut the curves of constant pore size from the pore-dimension models, which shows that porosity reduction is always accompanied by a reduction in characteristic pore size. The high powers of porosity of the grain-based and surface-area models are required to compensate for the inclusion of the small end of the pore size spectrum.

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PetroWiki was initially created from the seven volume Petroleum Engineering Handbook (PEH) published by the Society of Petroleum Engineers (SPE).
The SEG Wiki is a useful collection of information for working geophysicists, educators, and students in the field of geophysics. The initial content has been derived from: Robert E. Sheriff’s Encyclopedic Dictionary of Applied Geophysics, fourth edition.