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Model for permeability evolution during viscoelastic compaction of sediments

Elena Suetnova
Institut of Earth phisics, Moskow, Russian Federation (elena_suetnova@mail.ru)

Permeability of saturated porous medium depends on porosity and so, the ability of the matrix to deform and compact during geological history.

A coupled viscoelastic compaction model is developed to predict the permeability evolution for sediments as a function of time. The model is characterized by dimensionless parameters, which are the nonlinear combinations of physical, rheological and hydrodynamic properties of sediments and their accumulation rate. Theoretical analysis indicates that permeability reduction during compaction of sediments is nonlinearly related to sedimentation rate and time. The balance between the elastic and viscous contribution to the deformation is time-dependent. The model demonstrates the relative importance of elastic and viscous compaction for permeability reduction. Elastic pore compressibility is the dominant mechanism for permeability reduction in the upper part of sediment column, which corresponds to the small value of the dimensionless age of sediment and, with increasing of the dimensionless age, viscous compaction becomes increasingly important. The depth of that transition depends on dimensionless characteristic numbers of governing system of equations. Calculations indicate that the decrease of permeability through time results in a boundary layer; within this layer, the permeability decreases from its initial value down to its minimum value and, below this layer, the permeability remains at a minimum value. Calculations with parameters that lie within the range of the available geophysical data showed that, during sedimentary basin formation, the relative thickness of the boundary layer essentially depends on dimensionless time and the dimensionless sedimentation rate.