Mudstone Compaction Trends and their Use in Pore-Pressure Prediction

Nazmul Haque Mondol, Knut Bjorlykke, and Jens Jahren

Department of Geosciences, University of Oslo, P.O. Box 1047, Blindern, Oslo, 0316, Norway

ABSTRACT

A general way of predicting pore pressure in sedimentary basins is to use relationships of sonic travel time and/or seismic interval velocity versus depth / effective stress in mudstones. Pore pressure is then estimated from the divergence from generalized compaction trends. The key to a successful conversion of mudstone compaction trends to pore-pressure prediction is to characterize the mudstones as functions of lithology and textural variations and to establish relationships between porosity/density/velocity/permeability versus effective stress. Sedimentary basins are awfully heterogeneous as functions of sedimentary facies, tectonic development, and diagenetic history. Fluid transport in sedimentary basins is therefore controlled largely by the heterogeneity of the basin fill. Overpressure generation is the function of fluid flux generated by compaction (porosity loss) and the permeability along the most permeable pathways to the surface. Generation of fluids from kerogen and dehydration of minerals may add to this fluid fluxes, but permeability is the most critical parameter determining the development of overpressure. A series of laboratory measurements were conducted to investigate the relationships between velocity/porosity/density/permeability versus effective stress for pure smectite, kaolinite, and silt, and their mixtures. Experimental compaction has shown that the permeability of clay minerals vary by a factor of 10^4 to 10^5 for the same porosity. The smectite-rich mudstones have very low permeability compared to others and have potentiality to develop overpressure even at shallow or moderate burial depth. Calculations assuming vertical flow show that fracture pressure will be reached if the effective permeability of the shale forming the seal is less than 0.1-0.01 nD (nanodarcies). The experimental results of relationships between velocity/porosity/density/permeability versus effective stress of well-characterized mudstones were compared to the field data which demonstrated a close match, confirming that experimental data can be useful to distinguish mudstones for pore-pressure prediction.

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