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The impact of transverse mixing on spreading of solutes in highly heterogeneous aquifers

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Transport of solutes in aquifers has been investigated intensively in a stochastic framework in the last three decades. The main aim was to relate the spreading and mixing of solute to the aquifer spatial distribution of hydraulic conductivity K and to water flow conditions. Due to the seemingly erratic distribution and uncertainty, *Y=lnK* is usually modeled as a stationary random space function characterized by the geometric mean K_G,the variance σ_Y^2 and the horizontal I_h and verticalI_v integral scales. For simplicity, natural gradient flow is modeled as of mean uniform flow of velocity U and mean head gradient $--J$. With an initial solute plume of constant concentration C_0 , solute spreading is characterized by global measures, e.g. the spatial (centroid location and second moments) and temporal (the mean and variance of mass arrival at control planes) ones. For large, ergodic, plumes, the longitudinal $\alpha_L$and transverse α_T macrodispersivities are defined with the aid of the second moments. Simple analytical results were obtained in the past for weak heterogeneity (σ_Y^2 <1), for which the mean concentration is approximately Gaussian and satisfies an advective dispersion equation. Molecular diffusion and transverse pore-scale dispersion were found to have a negligible effect on α_L, i.e. transport is dominated by advection (infinite *Peclet* number). Finally, α_L grows along a travel distance of a few integral scales and it stabilizes then at constant, asymptotic, values.

In contrast, for highly heterogeneous aquifers (σ_Y^2 >1), the flow and transport equations were solved in the past only numerically or by semi-analytical approximations. It was found that solute plumes become skewed and $\alpha_L$may display an apparent anomalous behavior, by growing for a considerable time or distance from the injection zone. In such cases, transverse pore scale dispersion may affect considerably spreading.

The main aim of the presentation is to discuss the influence of the finite Peclet number on α_L for highly heterogeneous formations. The analysis is focused on the essential differences between transport in flow parallel to the bedding in stratified formations (I_h $/I_v$ $\rightarrow$ ∞) analyzed in the past by *Matheron and de Marsily* and recent results obtained for isotropic formations. The practical implications of these findings on prediction of contaminant spreading are discussed.