Geophysical Research Abstracts
Vol. 17, EGU2015-4911, 2015
EGU General Assembly 2015

The significance of macrodispersivity in groundwater transport

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Numerous laboratory column experiments of transport suggest that the concentration C of an inert solute is ruled by the advective-dispersion equation (ADE) with longitudinal dispersivity α_L. The latter is constant for granular media and, for the typically high Peclet numbers encountered in applications, of the order of $\alpha_L \sim 10^{-2} \div 10^{-3} m$. There is an increasing evidence from field tests that spreading of solutes at the aquifer scale is much larger than that occurring at the laboratory scale, by orders of magnitude; for that reason α_L is often denoted as macrodispersivity. Transport of a nonreactive solute in natural aquifer is indeed deeply influenced by the spatial distribution of the hydraulic conductivity K. Experimental evidence and the numerous studies carried out in the last decades show that the dynamics of transport is affected by the degree of heterogeneity present in the groundwater system, and in particular when in presence of highly heterogeneous aquifers. Different and interesting transport features have been observed or postulated from theoretical analysis, like e.g. the time and scale dependency of α_L, which is no longer constant in natural aquifers, the non-Fickian behavior of macrodispersivity, distributions of the concentration field far from the Gaussian one implied by the ADE, anomalous transport characterized by an ever increasing or decreasing α_L, significant and persistent tailing of the breakthrough curve measured at given control planes, to mention some. Under such circumstances, which seem to suggest a significant departure from the ADE, the overall meaning of macrodispersivity is questioned. Thus, new approaches for modeling solute transport in heterogeneous formations have emerged in the last years, in the attempt to overcome the ADE limitations. Nevertheless, most of the numerical codes used in applications employ the concept of dispersivity and implicitly assume that ADE holds true. The significance of macrodispersivity, its main features and its relevance in applications are discussed by means of recent theoretical work and experimental evidence, as function of the particular scope for which transport is analyzed and the heterogeneous structure of K.