The subsurface flow of weakly compressible fluids such as oil and water is governed by a nonlinear parabolic system of partial differential equations. A crucial precursor to the practical modeling of such multi-phase flow is the estimation of the associated subsurface parameters, such as permeability, throughout the whole region under study using measurements obtained from a limited number of discrete locations. The combination of the natural instabilities associated with an inverse problem and the presence of delta functions that model the flow at the discrete locations gives rise to a very difficult inverse problem. We show that these difficulties can be successfully circumnavigated by the use of a new variational approach for this problem. (Received January 28, 2015)