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Well-test flow responses of highly heterogeneous porous and fractured media

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Well tests are a key source of hydraulic data, classically interpreted within the 2D framework of Theis yielding a unique value of transmissivity. They may contain much more information on the medium structure. For highly heterogeneous porous and fractured media, transient flow is strongly influenced by the spatial organization of heterogeneity leading to non-classical drawdown signals (drawdown that cannot be fitted by Theis function). Barker's model has been increasingly popular because of its capacity to interpret such non-classical drawdown curves. However, expressed as a generalized differential equation, Barker's model does not provide for a relationship between the medium heterogeneity and the observed drawdown.

By numerically solving the transient-state flow equation in a broad range of 2D heterogeneous fractal, multifractal and fractured media, we have looked for the relation between heterogeneity structure and drawdown responses. We show that non-classical drawdown comes necessarily from scaling structures that can be characterized by two scaling parameters the hydraulic dimension n and the anomalous diffusion exponent d_w. These dimensions are not only determined by global characteristics like the medium dimensionality, correlation pattern and connectivity. They are also strongly influenced by local parameters like the permeability values at and around the well and more generally by the position of the well within the heterogeneity structure.

Comparing the (n,d_w) values of the synthetic structures in a 2D graph to field data pauses the first step of the resolution of the inverse problem. For the site of Ploemeur (Brittany, France) on which n and d_w have been previously determined [*Le Borgne*, 2004], the absence of overlap shows that the heterogeneity structure is more complex than those presented in this study.