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The permeability of heterogeneous rocks

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Darcy's original concept of permeability is largely associated with estimation of the hydraulic conductivity characteristics of isotropic and homogeneous porous media where the fluid flow characteristics can be estimated by appeal to a single scalar measure. Naturally occurring geomaterials are heterogeneous and the estimation of the effective permeability characteristics of such geomaterials presents a challenge not only in terms of the experimental procedures that should be used to ensure flow through the porous medium but also in the correct use of the theoretical concepts needed to accurately interpret the data. Relatively widely referred to rocks such as Indiana Limestone can exhibit spatial heterogeneity in the permeability characteristics even though the visual appearance can suggest the absence of such spatial and directional attributes (Selvadurai and Selvadurai, 2010). Argillaceous rocks such as the Cobourg Limestone found in southern Ontario, Canada can display hydraulic heterogeneity that is attributed to the presence of dolomitic and calcite nodular regions separated by calcite rock partings that contain an argillaceous component (Figure 1). Also, these rocks have extremely low permeability that requires the use of transient hydraulic pulse tests for the estimation of permeability. The performance of such pulse tests will be influenced by the bulk compressibility and bulk porosity of the porous skeleton consisting of the identifiable phases and their spatial distributions. The concepts of effective compressibilities and porosities therefore needs to be introduced if convenient procedures are to be developed for the accurate interpretation of even bench scale experiments (Selvadurai and G[U+026B]owacki, 2017). The paper will describe both experimental and theoretical approaches for interpreting the effective Darcy permeability of the heterogeneous rocks using both experimental and computational approaches. In particular, the applicability of the "Geometric Mean" based estimates arriving at an effective measure for the permeability characteristics for a heterogeneous rock.