Geophysical Research Abstracts
Vol. 17, EGU2015-2237-1, 2015
EGU General Assembly 2015

The geometric mean concept for interpreting the permeability of heterogeneous geomaterials

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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. The general consensus is that the flow path in a test needs to be drastically reduced if steady state tests are considered as a suitable experimental technique. The disadvantage of flow path reduction is that the tested volume may not be altogether representative of the rock, particularly if it displays heterogeneity in the scale of the sample being tested. Also, if the sample is not correctly restrained, the differential pressures needed to initiate steady flow can introduce damage in the sample leading to erroneous estimates of permeability. The alternative approach is to use large enough samples that can capture the spatial heterogeneity but develop testing procedures that can test examine the steady state flow process as a problem in three-dimensional fluid flow that can capture the spatial distribution of permeability. The paper discusses theoretical and computational approaches that have been developed for the estimation of the spatial distribution of permeability in a cuboidal Indiana Limestone sample measuring 450 mm. The “Patch Permeability Test” developed in connection with the research allows the measurements of the surface permeability of the block and through kriging techniques estimate the permeability within the block sample. The research promotes the use of the “Geometric Mean” concept for the description of the effective permeability of the heterogeneous porous medium where the spatial distribution conforms to a lognormal pattern. The effectiveness of the approach is that the techniques can be applied to examine the effective permeability of heterogeneous low permeability materials such as argillaceous limestone. In the case of very low permeability geomaterials, patch pulse tests are used to estimate the local permeability of the rock. The near-surface distribution can be used to provide a geometric mean estimate of the permeability of intact low permeability rock. Such a measure of permeability is a useful adjunct for conducting computations treatments of fluid movement where representative regions of the porous medium can be modelled as a single region of uniform permeability.

References

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