An Analysis of Simulated Pore Scale Fluid Flow to Determine Spatially Correlated Behaviour

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Abstract:
This paper presents a statistical study of the simulated fluid flow within micro computed tomographic (CT) images of 2 sandstones and 2 limestones. The full Navier-Stokes equations were solved at the resolution of the images for statistical analysis. The aim of this analysis is to assess the spatial scales over which correlated behaviour is visible in the porosity ($\varphi$), velocity ($u$) and travel-time ($u-1$) fields through calculation of an autocorrelation coefficient $C$ between values, a distance $\lambda$ apart. All three fields exhibit exponential decay of $C(\lambda)$ for small distances, it is proposed this behaviour resembles the Markovian nature of each field. More enduring decay rates, than visible in porosity fields, have been linked with the presence of correlated behaviour forming flow channels, visible in velocity fields, rapid decay has been linked to highly chaotic and uncorrelated behaviour, visible in travel-time fields. For large $\lambda$ values oscillatory behaviour was observed in both porosity and velocity analyses, it is proposed the oscillation period $\approx$ grainsize, travel-time analysis yielded no such behaviour. A strong link between grainsize distributions (from grain networks) and oscillation period distributions, was found for both sandstones, no link was found for limestones. The degree to which grains are sorted, is the proposed variable controlling the link; well sorted grains exhibit consistent oscillations, poorly sorted grains exhibit little or no oscillations. Ultimately, velocity fields exhibit some predictable features related to the porosity field, whereas travel-time behaviour is significantly more chaotic and cannot be associated with rock properties.