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Scale Dependence of Equivalent Permeability Tensor in Naturally Fractured Reservoirs

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Fracture geometries in naturally fractured reservoirs are usually inferred from sparse subsurface observations from well logs or cores. Since the largest fractures tend to be the least frequent, they are often undersampled. Therefore, interpretations based on samples taken at any scale smaller than that of interest contain a bias, misrepresenting the true characteristics of the fracture system. This bias may lead to the incorrect characterisation of the reservoir, upscaling and gridding. In this work, we investigate the variation of the equivalent permeability and its anisotropy in naturally fractured rocks as a function of sample size. We use a two dimensional linear elastic model of fracture aperture, taking into account the far-field stresses in conjunction with the parallel plate model, to determine fracture permeability. These apertures are applied to fractured reservoir analogues mapped in the field to numerically estimate permeability. We then employ a finite element scheme to compute equivalent permeability tensors for random samples of the fractured porous medium at specific length scales.

We find that the distribution of the principle component of equivalent permeability tensor computed at each scale size appears to be dependent upon the underlying attributes of the fracture networks. We notice a clear trend between the mean equivalent permeability and sample size. Our findings suggest that fracture geometries in naturally fractured reservoirs should be sampled at the scales of interest; if not, the equivalent permeability of such reservoirs might be significantly underestimated.