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# Biased versus random samples of fracture measurements in limestone marl alternations

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It is well established that sampling bias, that is, some members of a population being more likely to be included in a sample than others, leads to systematic errors in statistical analyses. For example, in the majority of studies focussing on the relationship between fracture spacing and bed thickness in limestone-marl alternations (LMA), most fractures are measured in well-bedded limestones. Semi-nodular limestones, however, become underrepresented in the analyzed samples. Hence, there is a clear bias in selection of the investigated beds. Fluid flow models based on such biased samples, however, may be erroneous and lead to unprecise conclusions.

Here we present fracture parameters for a data set of 6059 joints in the LMA of the Blue Lias Formation, Bristol Channel Basin, UK. In six outcrops, each of 15 m width and 2 m height, we analyzed the fracture propagation through multiple layers. For every single fracture cross-cutting a scanline on the ground we measured its attitude, aperture, height, spacing and arrest or connectivity in every layer. In addition we obtained the local thickness of the bed, and documented the lithofacies in detail. All outcrops consist of laterally continuous beds ('well-bedded limestones') and beds with bedding plane irregularities ('nodular limestones'), interbedded with shale or marl layers. The selected outcrops represent various interbedding types, layer thicknesses as well as different degrees of tectonic deformation. Thereby we obtained complete representations of the fracture parameters in these outcrops. We compare random samples, i.e. samples taken from the complete data sets with typical biased samples where fractures in well-bedded limestones are overrepresented. We show how fracture parameters based on biased samples differ from random samples, and investigate optimum numbers of fracture measurements representative for single outcrops and entire successions, respectively.

Results show that fracture spacing and propagation in individual well-bedded limestone beds are not necessarily representative for whole successions of LMAs. With this study we contribute to quantifying uncertainty in fracture system characterization in LMAs with wide implications for permeability prediction of fluid reservoirs in the subsurface (e.g. geothermal-, hydrocarbon- and groundwater-exploration).