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Quantifying sample bias in clast fabric measurements

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Sampling elongate clasts that protrude from a planar face for clast macro-fabric analysis introduces a bias into reconstructed fabrics because clasts aligned perpendicular to the sampling face are over-represented relative to those aligned parallel to the face. Here, we develop a probability-based mathematical analysis to quantify sample bias for a variety of clast shapes and population fabrics, including isotropic, clustered and girdled fabric styles. Bias is expressed in terms of sample eigenvalues and eigenvectors relative to those of the parent population. Results indicate that sampling always has the effect of artificially drawing fabrics towards perpendicularity to the sampling face relative to the populations from which they are drawn. This rotation generally has the effect of artificially strengthening population fabrics, by up to 30 % in the case of very weakly clustered or girdled populations. However, fabric strengthening is by no means universal and sampling alters different parent populations in different, sometimes complex, ways: our analysis identifies situations where sampling can strengthen or weaken parent fabrics, it can rotate parent fabrics (by up to 90º in the case of a very weak population fabric), and it can even change the style of a population fabric. For example, near-isotropic population fabrics can appear clustered, weakly clustered and weakly girdled population fabrics can appear isotropic, weakly clustered population fabrics can appear weakly girdled, and girdled population fabrics can even appear clustered. Overall, our analysis indicates that weakly orientated population fabrics are most susceptible to bias. Thus, a weakly clustered population fabric aligned parallel to a sample face is particularly susceptible to major sample bias in both fabric strength (artificially overestimated) and orientation (artificially rotated perpendicular to the face).