ABSTRACT

Sampling Bias of Fracture Orientation caused by Linear Borehole Sampling

Elizabeth Bullock

Fracture orientation analysis is especially important in the preliminary investigation of geothermal projects which require accurate fracture data to be collected. This study comparatively analysed existing bias reduction methods on a qualitative and quantitative level for fracture orientation data. The credibility of each method was examined for recommended further use and improvement strategies. Boreholes are known to impose a bias on fractures sampled within their drill path. This sampling bias causes steeply dipping fractures which intersect the borehole at small angles to be under-sampled. Acoustic image logs generated by a borehole televiewer were obtained from the 1912 m borehole located in Kimama, Snake River Province, Idaho. These image logs were interpreted using WellCAD™ to match and generate orientation data of the natural fractures intersected. Linear 1-D boreholes impose a bias towards perpendicular fractures from linear 'scanline' sampling along the borehole axis. This prevents accurate estimations of the fracture intensity from being achieved. The Terzaghi (1965) correction was performed and yielded a highest weighting factor of 14 which found the method to be limiting. The Fouché (2004) correction yielded a highest weighting factor of 9, significantly less than the former method but also limiting with regards to correcting the fracture orientation bias of the borehole. The chi-squared (χ^2) test proved independence between observed and expected fracture orientation distributions. The Kolmogorov-Smirnov (KS) test found the mismatch between the cumulative distribution functions (cdf) of the observed and modelled distributions for any sample chosen from the population becomes negligible with increasing sample size for a uniform-biased distribution. Applications of this study include, but are not restricted to, reservoir evaluation, fracture network analysis, modelling and feasibility calculations for geothermal and hydrocarbon exploration, which can result in direct benefits for geothermal development in the Caribbean.

Keywords: Acoustic image logs; borehole; Chi-squared test; Fouché; geothermal; hydrocarbon; KS Test; sampling bias; scanline; Snake River Plain; Terzaghi.