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A case study on the 3-D fracture network model of Devonian carbonate reef in Alberta, Canada

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We established a stochastic three-dimensional fracture network system for fractured rock masses of Devonian carbonate reef of Cairns Formation in Alberta, Canada to represent the rock mass fracture system in a comprehensive manner. To model fracture geometry in 3-D space it is necessary to estimate the number of fracture sets, and for each fracture set, the intensity, spacing, location, orientation, shape and size distributions. These fracture parameters are inherently statistical. Hence, their quantification demands the application of stochastic methods. An attempt was made in this study to acquire fracture data at the field outcrops using digital photogrammetric technique. The ShapeMetrix3D(TM) was implemented to measure locations of fracture traces that appear on rock faces. Also, the technique was used to measure an orientation of a fracture if the fracture plane was exposed. Two to three fracture sets were found to exist in the study area. Goodness-of-fit tests were performed to find the suitable probability distributions as well as the best probability distribution to represent the statistical distribution of fracture spacing and trace length for each fracture set. Lognormal, gamma and exponential distributions were highly suitable to represent the statistical distribution of fracture spacing and trace length for any of the fracture sets. To build up 3-D fracture network model, Monte Carlo simulation was applied based on best probabilistic distributions of orientation, size and 3-D frequency of the disk shaped fractures. One of the questions addressed in this study was how to represent the complex rock mass fracture system to simulate the 3-D geometrical structures. A computer code was developed to solve the non-linear simultaneous equations related to the disk shaped fractures and the plane equations of the visualization domains of the rock masses in 3-D space. Validation attempts turned out to be successful. The generated 3-D fracture networks will be used in the future to investigate hydraulic and mechanical characteristics of the hydrocarbon reservoir.