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Scaling of fracture network in Al Hajeb Lias aquifer (Morocco)

M. Rouai (1), F. Moreau (2) and O. Dauteuil (2)

1. University of Meknès, Morocco (mrouai@fs-umi.ac.ma / Fax: +212 35536808)
2. Géosciences Rennes, UMR CNRS 6118, Rennes, France (frederique.moreau@univ-rennes1.fr, olivier.dauteuil@univ-rennes1.fr / Fax : + 33 2 23236100)

The Middle Atlas reservoir is one of the most important aquifers in northern Morocco. It is mainly a water table fractured reservoir consisting of Lias limestone and dolomite. The matrix permeability is very low and water flows essentially along open fractures. The quantification and modeling of fractures is thus of great interest for studying fracture connectivity and hydraulic properties of water and potential pollution.

2D fracture pattern from geological map of the El Hajeb region was analyzed by fractal and multifractal analysis. The results suggest that the spatial distribution of fracture intensity has not a homogeneous fractal structure but a heterogeneous one with generalized positive fractal dimensions D_0= 1.74>D_1=1.68>D_2=1.63>.....>D_{12}=1.40). D_0, D_1, and D_2 are respectively the capacity, information and correlation dimension. The value D_{12}=D_∞ is the fractal dimension of the most intensive clustering in the heterogeneous set. One fractal dimension is not enough to describe the fracture properties related to scale. A full spectrum of generalized dimensions is then required to take into account the fracture clustering which affects connectivity.

The cumulative frequency distribution of fracture length (n=976) shows a power-law behavior $n(>l)\alpha\, l^{-c}$ with exponent c$\sim$1.99. Over more than two decades a best fit was obtained, with a good linearity between 1 and 10km length. The maximum extrapolated fracture length is about 25km. This power-law can be used to estimate also the number of small fractures; the same law and the same fractal exponent will be valid for the entire Lias reservoir. According to numerical modeling studies on the basis of

percolation theory, the connectivity of fractured media depends upon the power-law exponent and the fracture density. In our case, $c \sim 2$ may be a critical value where 50% of fractures belong to the infinite cluster or correlation length. Analyzing the fracture connectivity in the reservoir on the light of relation of exponent c to capacity fractal dimension D_0, the fracture connectivity seems to be independent of scale. The results lead to some hydrogeological implications that will contribute to best conduct water prospecting in such discontinuous reservoir by optimizing water well implantation to reduce dry boreholes.