Clustering and Connectivity of Fractal-Fracture Networks: Are they related?

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It well known that fracture networks display self-similarity in many cases and the connectivity and flow behavior of such networks are influenced by their respective fractal dimensions. One of the authors have previously implemented the concept of lacunarity, a parameter that quantifies spatial clustering, to demonstrate that a set of 7 nested natural fracture maps belonging to a single fractal system, but different visual appearances have different clustering attributes. Any scale-dependency in the clustering of fractures will also likely have significant implications for flow processes that depend upon fracture connectivity. It is therefore important to address the question as to whether the fractal dimension serves as a reasonable proxy for the connectivity of a fractal-fracture network or is it the lacunarity parameter that may be used instead. The present study attempts to address this issue by studying the clustering behavior (lacunarity) and connectivity of fractal-fracture patterns. We compare the set of 7 nested fracture maps mentioned earlier which belong to a single fractal system, in terms of their lacunarity and connectivity values. The results indicate that while the maps that have the same fractal dimension have almost similar connectivity values, there exist subtle differences such that both the connectivity and clustering change systematically with the scale at which the networks are mapped. It is further noted that there appears to be an exact correlation between clustering and connectivity values. Therefore, it may be concluded that rather than fractal dimension, it is the lacunarity or scale-dependent clustering attribute that control connectivity in fracture networks.