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Dimensional threshold for fracture linkage and hooking

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Abstract

Fracture connectivity in rocks depends on spatial properties of the pattern including length, abundance and orientation. When fractures form a single-strike set, they hardly cross-cut each other and the connectivity is limited. Linkage probability increases with increasing fracture abudance and length as small fractures connect to each other to form longer ones. A process for parallel fracture linkage is the "hooking", where two converging fracture tips mutually deviate and then converge to connect due to the interaction of their crack-tip stresses. Quantifying the processes and conditions for fracture linkage in single-strike fracture sets is crucial to better predicting fluid flow in Naturally Fractured Reservoirs. For 1734 fractures in Permian shales of the Lodève Basin, SE France, we measured geometrical parameters in 2D, characterizing three stages of the hooking process: underlapping, overlapping and linkage. We deciphered the threshold values, shape ratios and limiting conditions to switch from one stage to another one. The hook set up depends on the spacing (S) and fracture length (L_h) with the relation $S \approx 0.15\ L_h$. Once the hooking is initiated, with the fracture deviation length (L) $L \approx 0.4\ L_h$, the fractures reaches the linkage stage only when the spacing is reduced to $S \approx 0.02\ L_h$ and the convergence (C) is <0.1 L. These conditions apply to multi-scale fractures with a shape ratio L/S=10 and for fracture curvature of 10° to 20°.

Key Words: fracture, hook, interaction, linkage, network, Naturally Fractured Réservoirs, Lodève basin