Assessing Fishbone Drilling vs. Hydraulic Fracturing in Ultra-Low Permeability Geothermal Reservoirs

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Abstract

The increasing demand for sustainable and renewable energy has led to the exploration of Enhanced Geothermal Systems (EGS) as a viable solution. In ultra-low permeability formations, such as those found in the Williston Basin, conventional hydraulic fracturing techniques exhibit limited effectiveness. This study investigates fishbone drilling technology as an alternative, focusing on efficiency and engineering aspects in the context of geothermal reservoirs with extremely low permeability. We conducted an extensive literature review, numerical simulations, and case studies to compare fishbone drilling and hydraulic fracturing in EGS applications. Fishbone drilling, which involves expanding a single horizontal wellbore into multiple branching wellbores, demonstrates several advantages in ultra-low permeability formations. The technique effectively increases reservoir permeability and flow rates by accessing a larger volume of hot rock materials and generating an interconnected network of fractures, which hydraulic fracturing struggles to achieve in reservoirs with permeabilities as low as a few nanodarcies. Our analysis reveals that fishbone drilling maintains wellbore stability in impermeable formations, whereas hydraulic fracturing faces challenges in creating sufficient fractures without compromising wellbore integrity. Moreover, fishbone drilling enhances fracture connectivity and heat extraction rates compared to hydraulic fracturing, making it a more efficient method for developing ultra-low permeability geothermal environments. The results of this study provide valuable insights for engineers and researchers in the pursuit of innovative and effective solutions for geothermal energy extraction from challenging reservoirs.