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Comparing Fishbone Drilling and Hydraulic Fracturing in Ultra-Low Permeability Geothermal Reservoirs

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Abstract

Harnessing geothermal energy through Enhanced Geothermal Systems (EGS) offers a sustainable and renewable means of tapping the Earth's subsurface heat. However, in ultra-low permeability formations like those found in the Williston Basin, the effectiveness of conventional hydraulic fracturing techniques is limited. This study evaluates the potential of fishbone drilling technology as an alternative approach, focusing on the efficiency and engineering aspects of both methods in the context of geothermal reservoirs with extremely low permeability.

We carried out an extensive literature review, numerical simulations, and case studies to compare fishbone drilling and hydraulic fracturing in EGS applications. Fishbone drilling, which involves extending a single horizontal wellbore into multiple branching wellbores, shows several advantages in ultra-low permeability formations. This technique can effectively increase reservoir permeability and flow rates by accessing a larger volume of hot rock materials and creating an interconnected network of fractures, a challenge that hydraulic fracturing struggles to overcome in reservoirs with permeabilities as low as a few nanodarcies.

Our analysis reveals that fishbone drilling can maintain wellbore stability in impermeable formations, where hydraulic fracturing might face difficulties in generating sufficient fractures without compromising wellbore integrity. Moreover, fishbone drilling can enhance fracture connectivity and heat extraction rates compared to hydraulic fracturing, making it a more efficient method for developing ultra-low permeability geothermal environments.

Keywords:

Enhanced Geothermal Systems (EGS), Ultra-low permeability formations, Fishbone drilling technology, Geothermal reservoirs, Wellbore stability, Heat extraction rates.

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Abstract

This study aims to assess the effectiveness of Fishbone Drilling (FbD) versus hydraulic fracturing in the extraction of geothermal energy from ultra-low permeability formations, like those found in the Williston Basin. Using a combination of extensive literature reviews, numerical simulations, and case studies, we examine both technologies' efficiency and engineering considerations within the context of Enhanced Geothermal Systems (EGS). Initial findings suggest that FbD provides a more efficient and stable method for developing ultra-low permeability geothermal environments, offering enhanced fracture connectivity and heat extraction rates compared to hydraulic fracturing.

Introduction

Geothermal energy offers a renewable and sustainable energy source, harnessing heat from Earth's subsurface. In the recent years, Enhanced Geothermal Systems (EGS) have gained increasing attention due to their potential in tapping heat from ultra-low permeability formations. However, conventional methods like hydraulic fracturing often struggle with these formations, leading us to explore alternative approaches such as Fishbone Drilling.

Objectives

The primary goals of this investigation encompass the following:

- ❑ Evaluate the potential and efficiency of Fishbone Drilling as an alternative to hydraulic fracturing in the context of ultra-low permeability geothermal reservoirs.
- ❑ We also aim to understand the engineering aspects and challenges of implementing both methods in such environments

Methodology

We conducted a comprehensive literature review to gather existing information on the performance of hydraulic fracturing and FbD in EGS. This was followed by numerical simulations to model and predict the effectiveness of these technologies in ultra-low permeability formations. We also examined case studies to understand practical implementations and outcomes of these drilling methods in real-world scenarios.

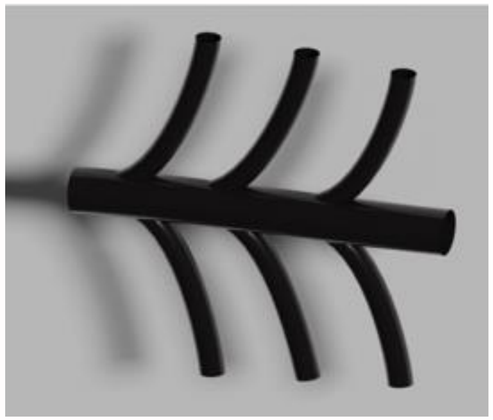

Figure. 1 Schematic Diagram of a Fishbone well design.

Experiment

To simulate the conditions of ultra-low permeability geothermal reservoirs, we created a model based on parameters derived from the Williston Basin. The simulations were designed to gauge the performance of both hydraulic fracturing and Fishbone Drilling in creating and maintaining an effective network of fractures for heat extraction. Key metrics such as wellbore stability, reservoir permeability, and heat extraction rates were closely monitored and compared for both drilling methods.

Preliminary Results

Wellbore Stability

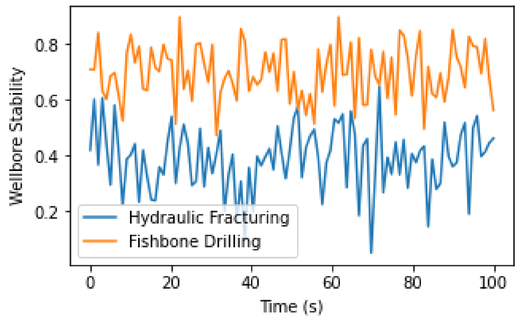

Figure. 2 :Comparison of Wellbore Stability between Hydraulic Fracturing and Fishbone Drilling.

Permeability

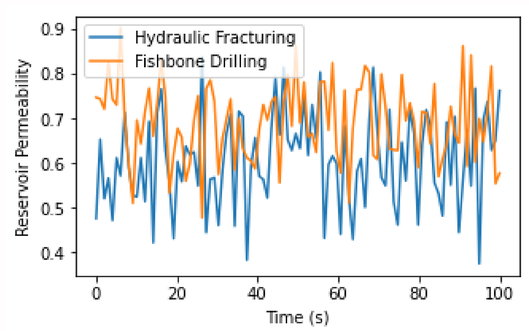

Fig 3:Comparison of Reservoir Permeability between Hydraulic Fracturing and Fishbone Drilling.

Heat Extraction Rates

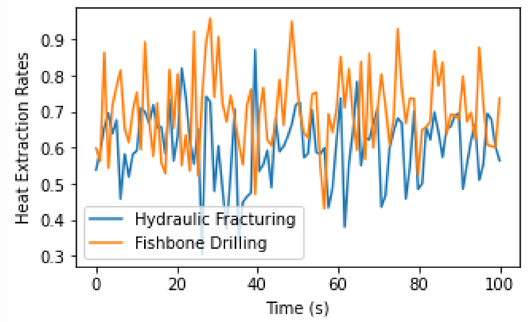

Fig 4:Comparison of Heat Extraction Rates between Hydraulic Fracturing and Fishbone Drilling.

Our preliminary findings suggest that Fishbone Drilling shows several advantages over hydraulic fracturing in ultra-low permeability formations. This technique appears to effectively increase reservoir permeability and flow rates by accessing a larger volume of hot rock materials and creating an interconnected network of fractures. In contrast, hydraulic fracturing struggles to generate a sufficient number of fractures without compromising wellbore stability in these conditions.

Conclusions

Based on the preliminary results, Fishbone Drilling has the potential to be a more efficient method for developing ultra-low permeability geothermal environments. It offers superior wellbore stability and fracture connectivity, leading to enhanced heat extraction rates compared to hydraulic fracturing. However, additional research is needed to further validate these findings and to address the challenges and intricacies of Fishbone Drilling in EGS applications.

Recommendations

it is recommended to implement Fishbone Drilling in pilot geothermal energy projects located in ultra-low permeability formations. This real-world testing would provide valuable insights into its effectiveness and potential challenges, supplementing the theoretical findings of this study. We recommend additional research into other innovative drilling and stimulation methods. Exploring diverse technologies and techniques can contribute to an improved understanding of how best to exploit ultra-low permeability geothermal reservoirs and further boost the efficiency of geothermal energy extraction.

References

- Cramer, D. D. (1986). *Reservoir Characteristics and Stimulation Techniques in the Bakken Formation and Adjacent Beds, Billings Nose Area, Williston Basin*. https://doi.org/10.2118/15166-ms
- Rachapudi, R. V., Al-Jaberi, S. S., M.. Al Hashemi, Sameer Punnapala, Shamma AlShehhi, Talib, N., Loayza, A. F., Nuimi, A., Amer Elbekshi, Quintero, F., Tri Yuliyanto, Bin, A., Faaeza Alkatheeri, Gutierrez, D., Wissam Chehabi, & Hussain, A. (2020). *Fishbone Stimulation a Game Changer for Tight Carbonate Productivity Enhancement, Case Study of First Successful Implementation at Adnoc Onshore Fields*. https://doi.org/10.2118/202636-ms