Assessing the Potential of Geothermal Energy in Cambrian Complexes for Renewable Energy Transition in Lithuania.

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Abstract

Several depleted Cambrian oil fields in Lithuania, with water-cuts reaching 99%, present promising opportunities for geothermal energy utilization. This study focused on five sites selected from Lithuania's Cambrian reservoir complexes, which have the highest water production rates among all wells. The study aimed to explore the advantages of horizontal wells, a technology not previously employed for geothermal production in Lithuania, over traditional vertical wells. To optimize field development, various scenarios were evaluated using mechanistic models, with insights subsequently applied to real field conditions. The results from the mechanistic model demonstrated that horizontal wells outperform vertical wells in both water production and power generation. Furthermore, increasing fracture intensity was shown to enhance water output and power generation by operating the wells at pressures above fracture propagation, facilitating re-injection. The real field model reinforced these findings, revealing that strategic well placement and injector selection could significantly improve energy recovery and operational efficiency in geothermal projects. However, the study also emphasized the importance of thorough reservoir characterization and modeling to account for geological complexities and improve production outcomes. In conclusion, the research underscores that horizontal wells offer several advantages over vertical wells for geothermal energy production. These include increased water production, higher power generation, reduced drilling costs, and enhanced operational efficiency. These benefits align with technological advancements observed in the hydrocarbon industry, making horizontal wells a viable solution for maximizing geothermal energy potential in Lithuania's depleted oil fields.

Introduction

Lithuania exhibits a geothermal anomaly in its southwestern region, which is attributed to Middle Proterozoic cratonic granitoid intrusions enriched with radiogenic heat-producing elements such as thorium (Th), uranium (U), and potassium (K). The sedimentary cover in western Lithuania includes three hydrothermal complexes: Cambrian (140 meters), Middle-Lower Devonian (400 meters), and Upper-Middle Devonian (200 meters). Table 1 provides a historical overview of geothermal energy development in Lithuania.

1989	First Geothermal Well – Vydmantai -1
1992	Baltic Geothermal Project initiated
1993	Second Geothermal Well – Vydmantai -2
1993-99	Further geothermal exploration wells drilled (19)
1995-96	KGDP conceptualized – Devonian waters
2000	KGDP starts operation (700 m^3/h @ 40° C)
2002-2010	KGDP operational issues (re-injection)
2010-16	Injection remediation work – unsuccessful
2017	Financial issues and plant ceases operations

Table 1: Geothermal historic Overview in Lithuania.

Methodology

The geological screening process entails a comprehensive analysis of the petrophysical properties of selected reservoirs, considering factors such as porosity, permeability, depth, average subsurface temperature, water salinity, injection water temperature, reservoir pressure, projected flow rates, reservoir thickness, and Net-to-Gross (NTG) ratios. Additionally, the screening study evaluates the geothermal energy production potential of Cambrian geothermal complexes in Lithuania, encompassing geological assessment, technical modeling, and the challenges associated with repurposing hydrocarbon wells for geothermal use. The study employs advanced multiphysics numerical models to simulate the evolution of transport properties in coupled thermo-hydro processes.

Results

Following scenarios is evaluated:

1. First a development of mechanistic box model to represent the top Cambrian site property and horizontal well extension has been studied.
2. Findings from the above study has been applied to the real field model and checked for sensitivity analysis.

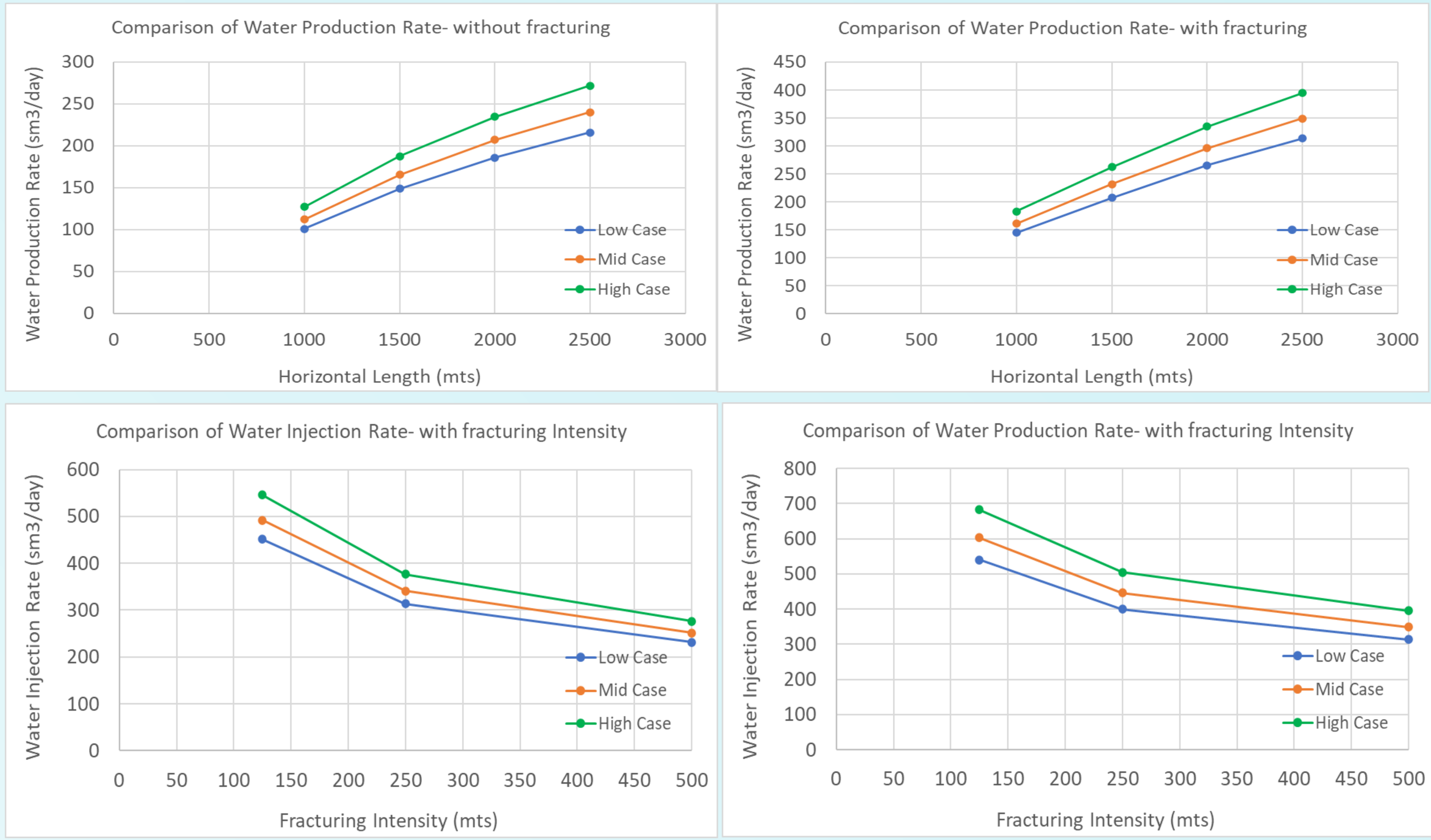

Figure 1: Comparison of low, mid, and high case without and with fracturing (Mechanistic Model)

Horizontal Well Length (2500 mts long) - With Fracturing Sensitivity - 25 years							
Sr. No	Fracture Intensity (mts)	Case	Avg. Water Injection Rate (sm3/day)	Avg. Water Production Rate (sm3/day)	Power (W)	Power (MWh)	Power (GWh)
1	125	Low Case	450.76	540.62	7.725E+14	2.14580E+05	214.58
		Mid Case	492.11	603.32	8.621E+14	2.39466E+05	239.47
		High Case	545.53	683.28	9.763E+14	2.71204E+05	271.20
2	250	Low Case	313.64	399.95	5.715E+14	1.58746E+05	158.75
		Mid Case	340.93	445.83	6.370E+14	1.76956E+05	176.96
		High Case	376.63	504.67	7.211E+14	2.00311E+05	200.31
3	500	Low Case	231.41	313.04	4.473E+14	1.24250E+05	124.25
		Mid Case	250.79	348.77	4.984E+14	1.38432E+05	138.43
		High Case	276.25	394.67	5.639E+14	1.56650E+05	156.65

Table 2: Power calculation of low, mid, and high case with fracturing (Mechanistic Model)

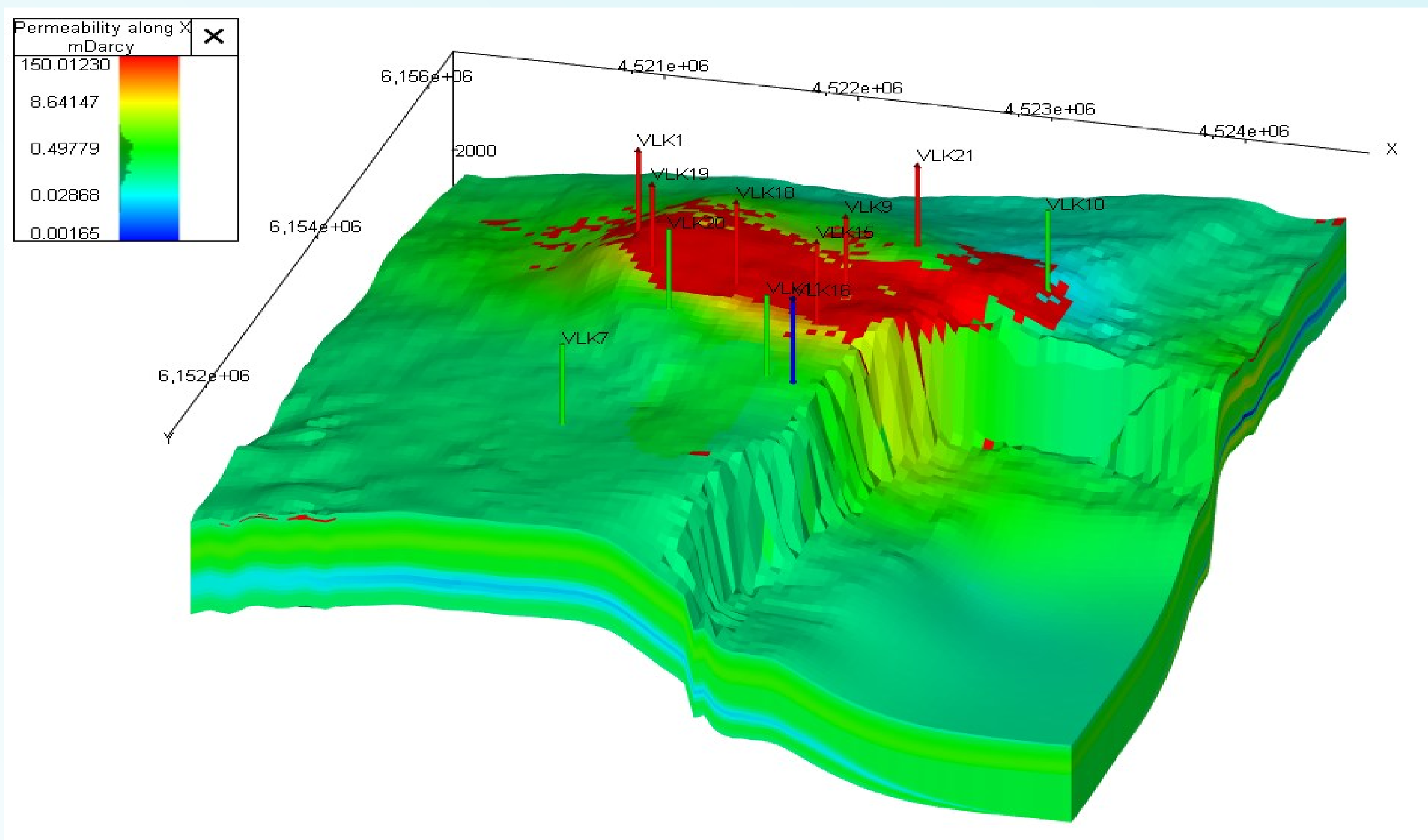

Figure 2: Full Field Model of Vilkyciai reservoir.

Conclusions

1. The study successfully describes using horizontal wells to enhance water production, injection rates, and power output in geothermal development in Lithuania.
2. Utilizing the mechanistic model for the Vilkyciai field's FDP, the optimal location for injectors and producers maximizes water production and injection rates with 1200 m well spacing.
3. The findings show that water production and injection rates increase linearly with horizontal length. While induced fracturing at regular intervals doubles these rates as shown in mechanistic model.
4. Heightened fracture intensity correlates exponentially with increased water production and injection rates, highlighting its significant impact as shown in both mechanistic and full field model.
5. With the increment in the above parameters, temperature front does not breach the vicinity of the producer well.
6. The analysis shows that low, mid, and high cases follow similar water production and reinjection trends, mirroring those in vertical wells in mechanistic model.

References

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