

# Development of Machine Learning Prediction Model to Monitor Fracture Progression in Oil Shale Reservoir while Hydraulic Fracturing

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## Abstract

Hydraulic fracture (HF) is a technique that used to stimulate oil and gas production by injecting fluid at high pressure to create fractures in rock formations. These fractures allow oil and gas from the formation to flow freely onto the surface. During this operation, it was observed that fracture behavior in shale formation is not well understood and can propagate and interact with unwanted formation zones. As it has an impact on the environment and economy, it is projected that it will be possible to appreciate fracture behavior in the future. In this research, the progression of fractures in hydraulic fracture will be mentored by the development of a model prediction using machine learning, which helps to save energy production and reduce the environmental impact of the hydraulic fracture operation in Oman. As the oil and gas driving force of the Omani economy.

## Aim and Objectives

### Monitor Fracture Progression:

To monitor and analyze fracture progression during hydraulic fracturing operations in order to gain a better understanding of fracture behavior and optimize treatment design.

### Minimize Risks to Unwanted Zones:

To protect sensitive zones, such as freshwater aquifers, and avoid interference between adjacent wells in multi-well configurations during hydraulic fracturing.

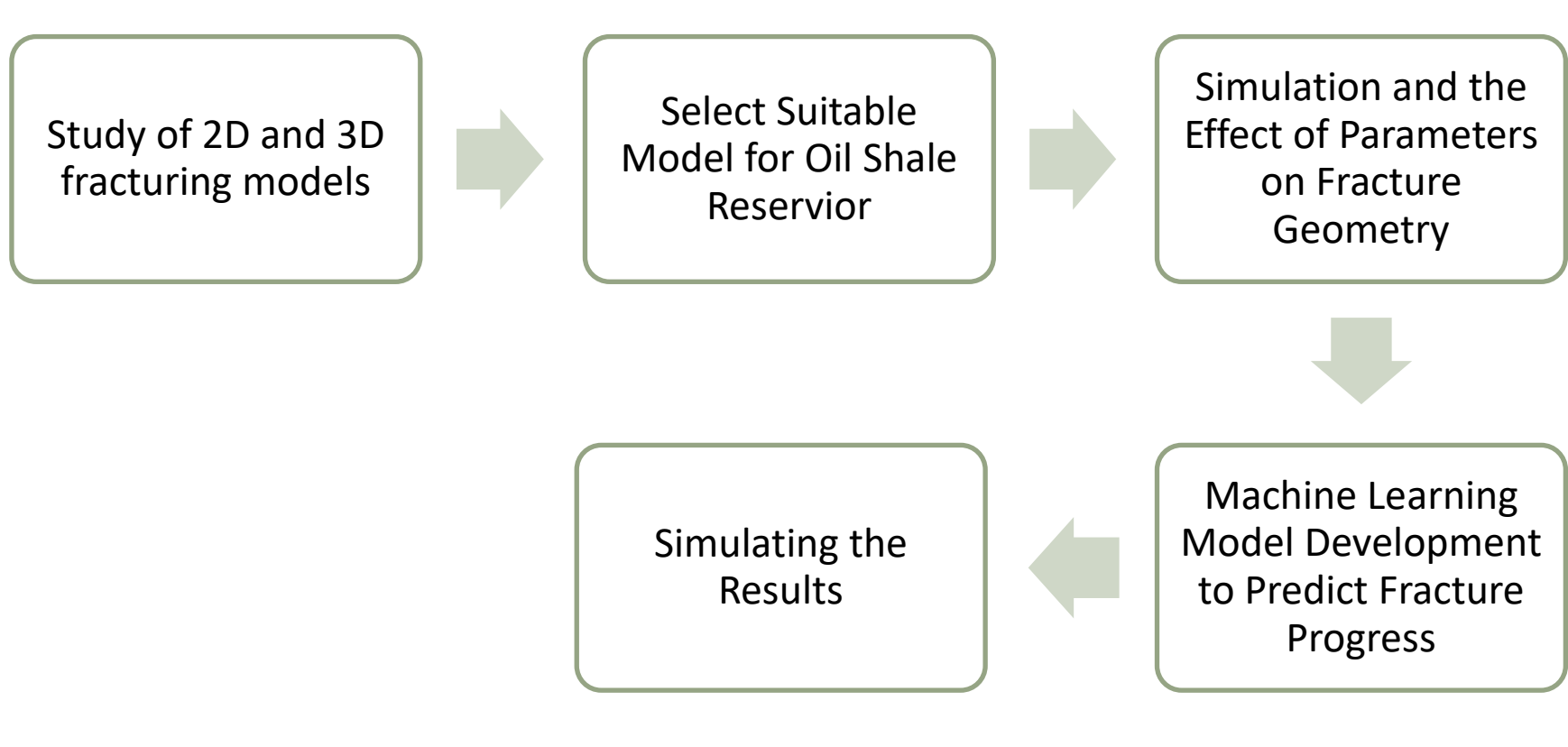
### Develop Predictive Models Using Machine Learning:

To implement and test machine learning algorithms written in Python for accurately predicting fracture-related parameters and outcomes in an oil shale reservoir.

### Conduct Sensitivity Analysis:

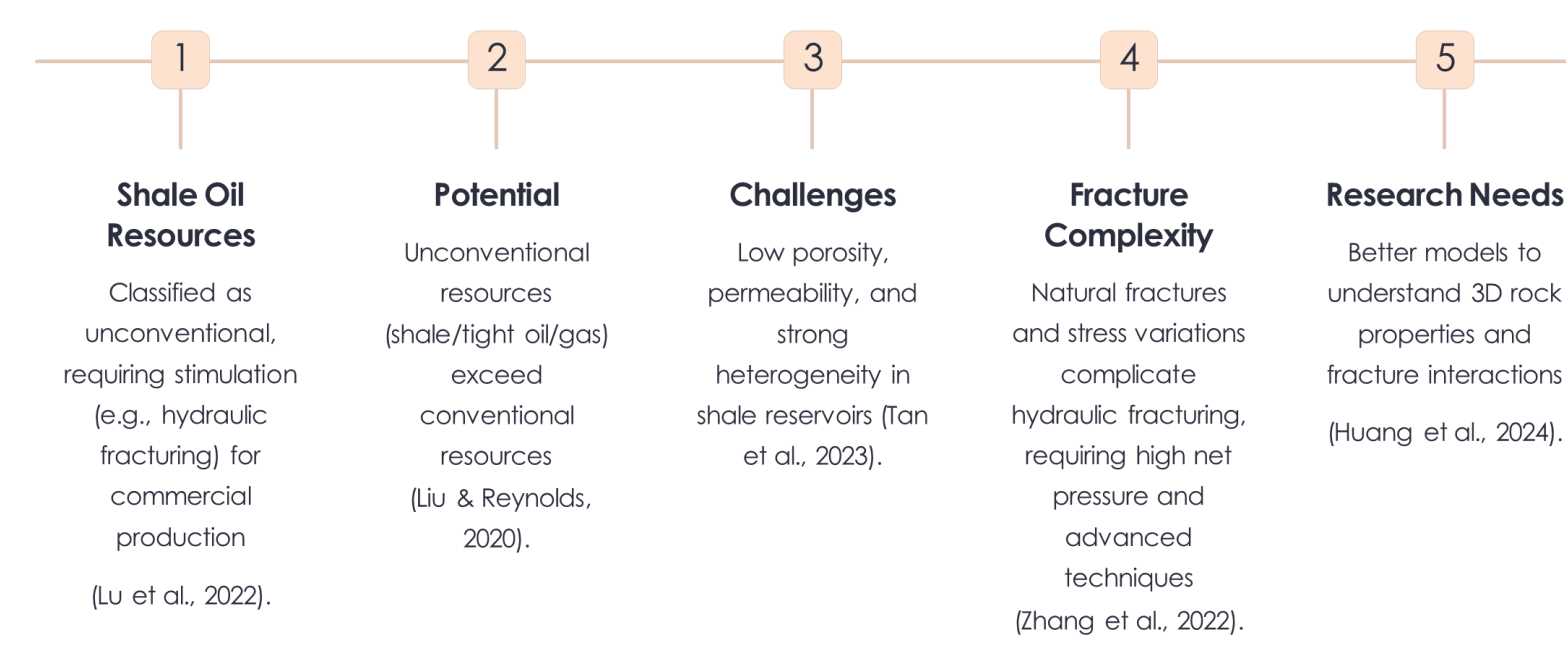
To conduct a thorough sensitivity analysis to determine the effect of key operational parameters such as operation time, injection fluid rate, and dynamic viscosity.

## Methodology

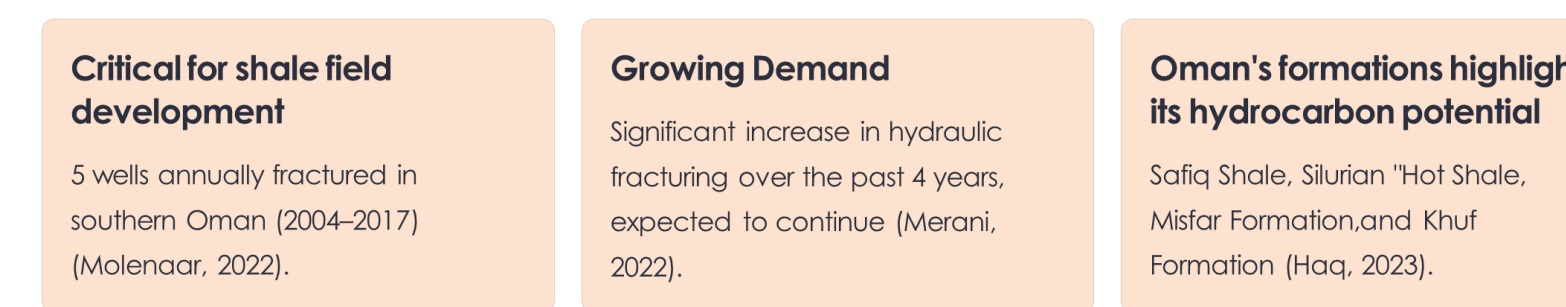


## Literature Review

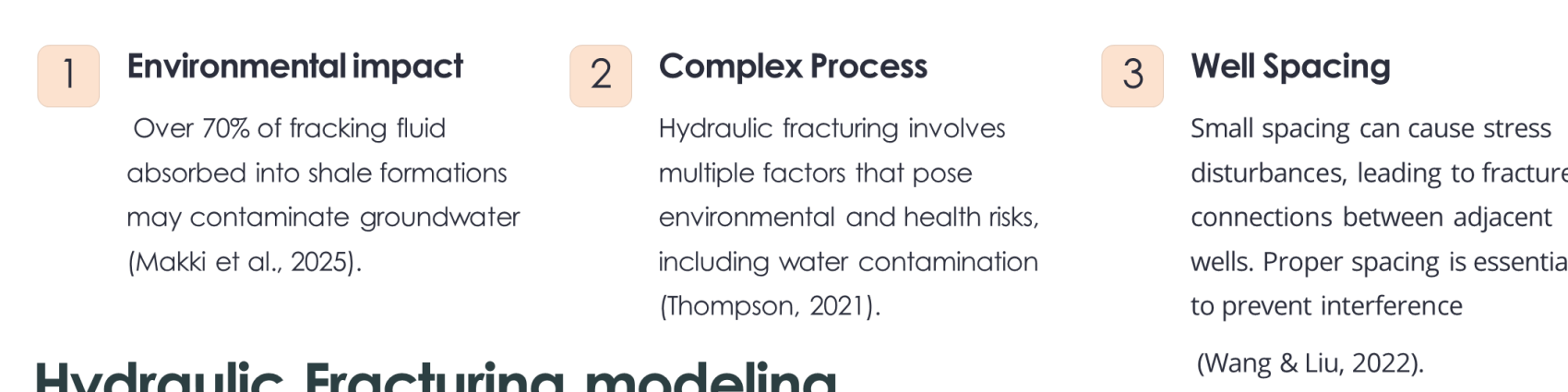
### Oil Shale Challenges



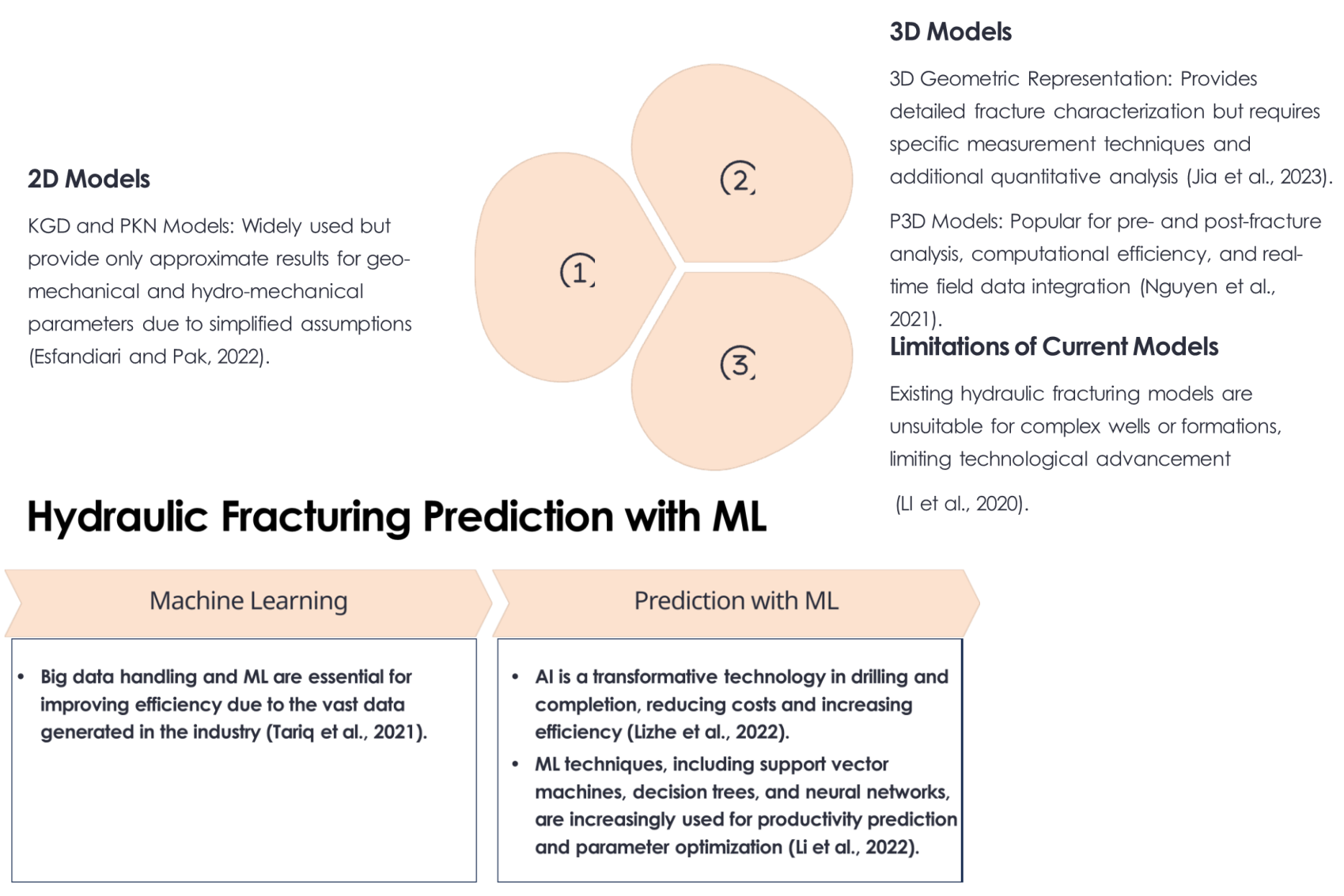
### Hydraulic Fracturing in Oman



### Hydraulic Fracturing impact



### Hydraulic Fracturing modeling



## Results

### EFFECT OF THE PARAMETRS ON FRACTURE GOEMTRY:

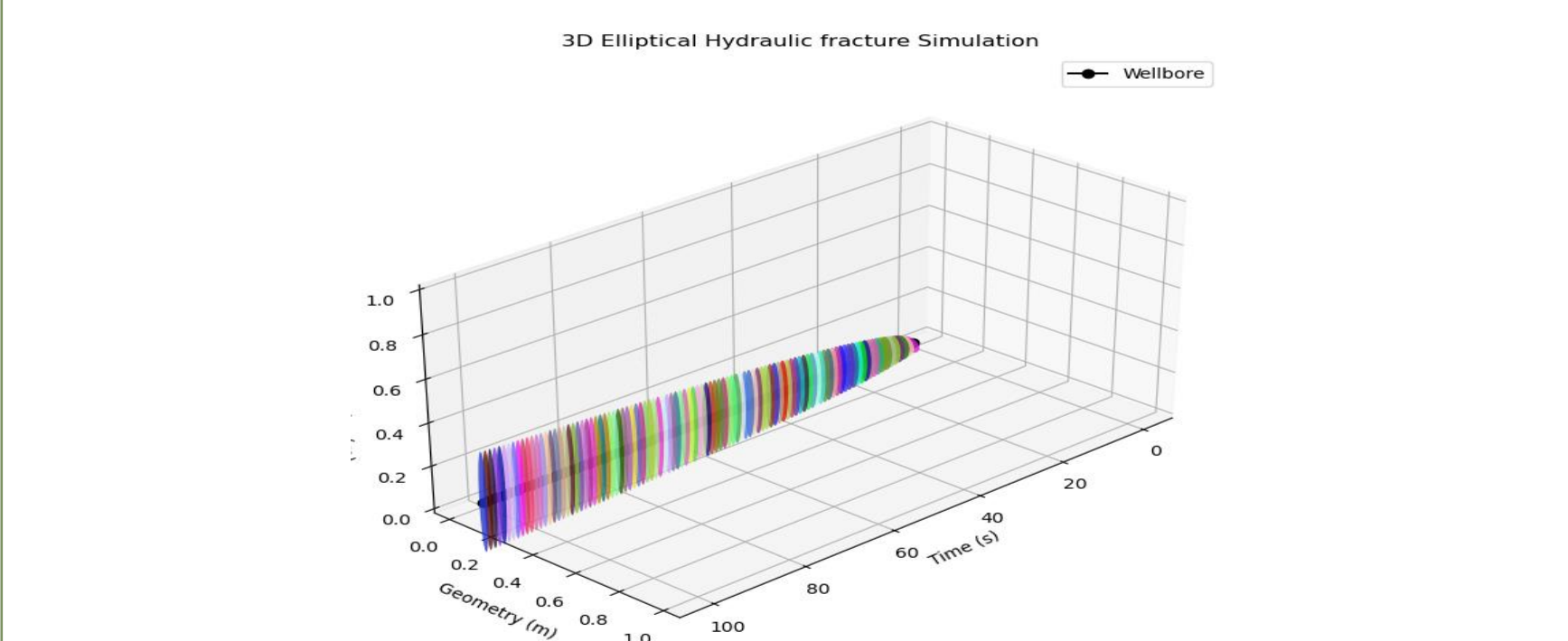


Fig 1 : Operation Time Vs Fracture Geometry with Ordination

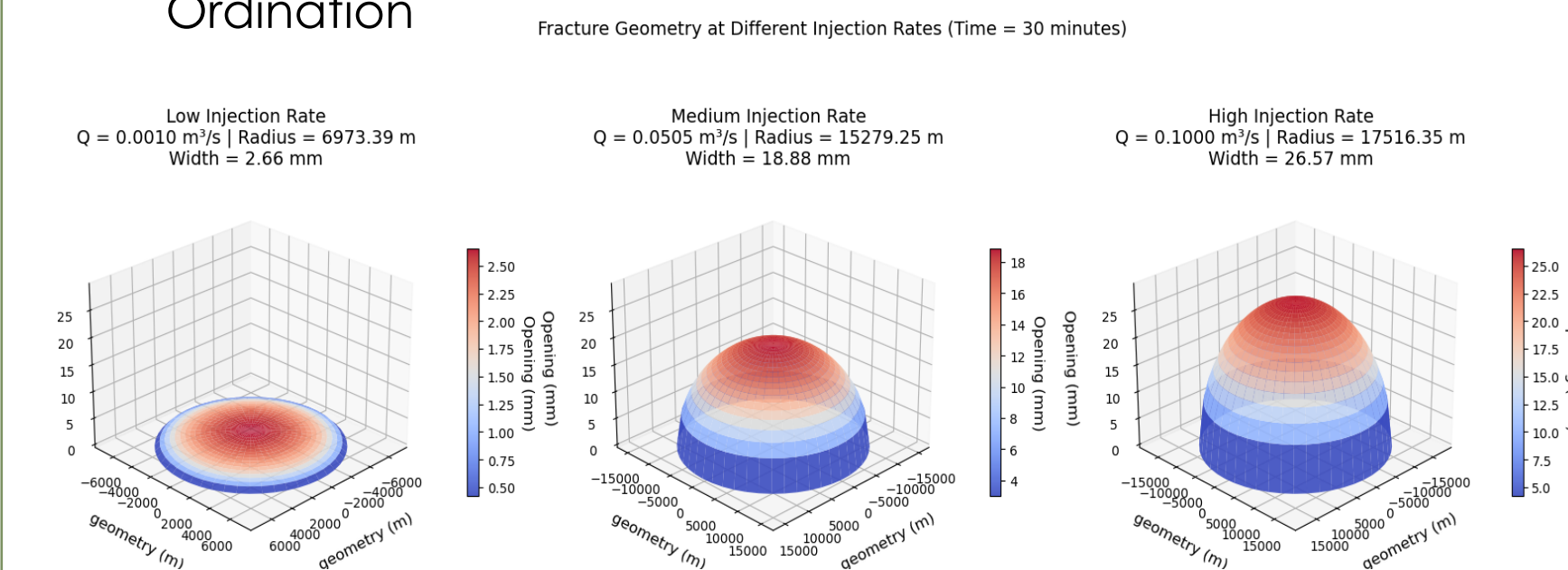


Fig 2 : Injection Fluid Rate Vs Fracture Geometry

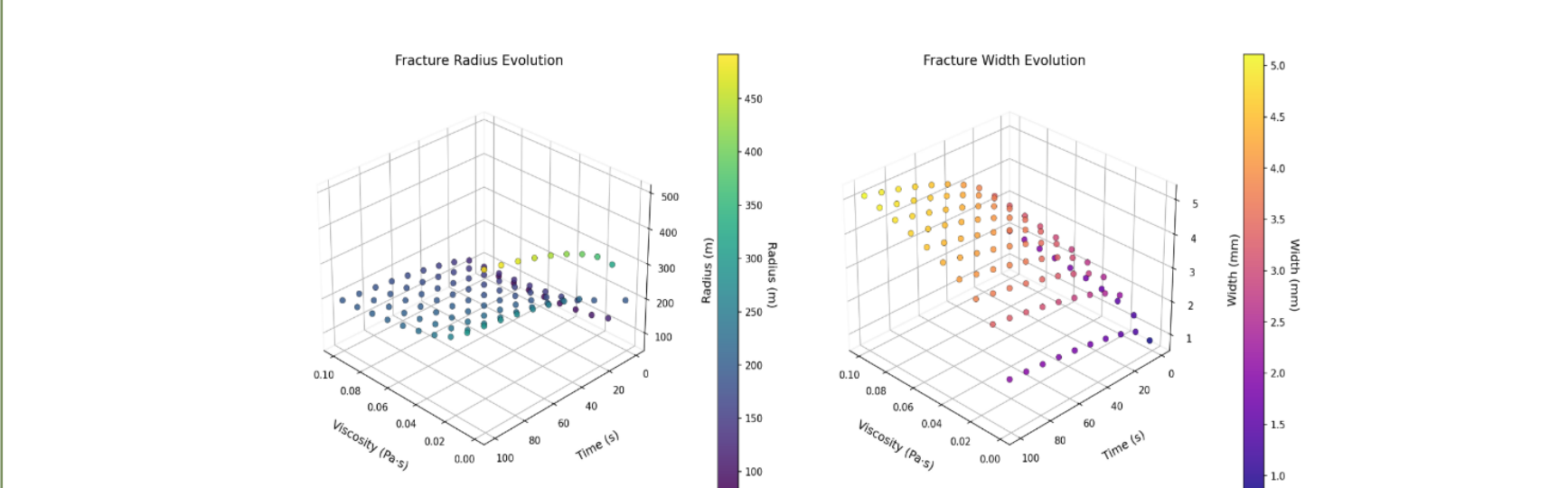


Fig 3 : Injection Fluid Viscosity Vs Fracture Geometry

### DEVELOPING MACHINE LEARNING PREDICTION MODEL:

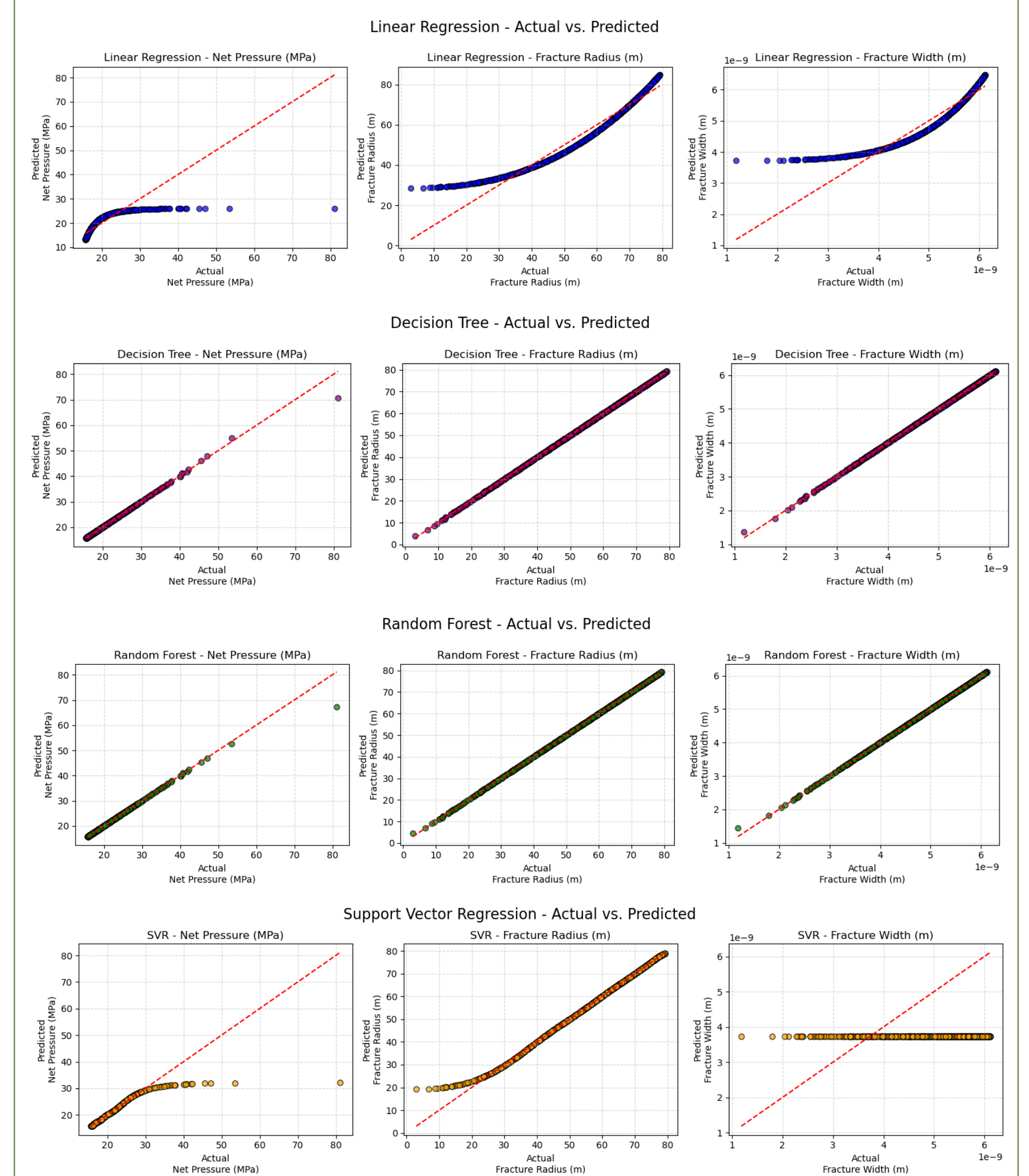


Fig 4 : Actual Vs Predicted Values

| Model /R <sup>2</sup> | Net Pressure (MPa) | Radius (m) | Width (m) |
|-----------------------|--------------------|------------|-----------|
| LR                    | 0.56               | 0.937      | 0.868     |
| RF                    | 0.9907             | 1          | 0.9999    |
| DT                    | 0.9945             | 1          | 0.9999    |
| SVR                   | 0.8030             | 0.9932     | -2.03     |

Table 1 : R<sup>2</sup> Values

| Model /RMSE | Net Pressure (MPa) | Radius (m) | Width (m) |
|-------------|--------------------|------------|-----------|
| LR          | 3.5613             | 4.4032     | 0         |
| RF          | 0.518              | 0.0582     | 0         |
| DT          | 0.3982             | 0.0518     | 0         |
| SVR         | 2.3901             | 1.4426     | 0         |

Table 2 : Root Mean Square Error Values

## Conclusions

The research aimed to develop prediction models for fracture progression in oil shale reservoirs during hydraulic fracturing operation. Simulations were conducted to study the impact of operation time, injection fluid rate, and dynamic viscosity on fracture propagation. Four machine learning algorithms were used: Linear Regression, Decision Tree, Random Forest, and Support Vector Regression. The Decision Tree model outperformed all other models in predicting two of the three parameters, demonstrating its ability to handle structured data and capture nonlinear relationships. Random Forest showed better accuracy in predicting only one parameter. Support Vector Regression and Linear Regression performed poorly, especially with complex or non-linear data.

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