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Investigation of the Influence of Stress Shadows on Multiple Hydraulic Fractures from Adjacent Horizontal Wells Using the Distinct Element Method

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Introduction

Production efficiency from low permeability gas shales require techniques to optimize hydraulic fracture completions. One completion strategy involves the simultaneous or near simultaneous hydraulic fracturing of multiple horizontal wells to maximize the fracture network area and stimulated reservoir volume. However, changes to the in-situ stress field caused by an earlier hydrofrac on subsequent hydraulic fractures are not accounted for in traditional hydrofrac design calculations.

Presented here are the results from a set of transient, coupled hydro-mechanical simulations of a rock mass containing two wellbores using the discontinuum-based distinct-element method. The results demonstrate the influence of **stress-shadows** generated by a hydraulic fracture on the development of subsequent hydrofracs from an adjacent well.

It is shown here that these interactions have the potential to change **the size and effectiveness** of the hydraulic fracture stimulation by changing the extent of the hydraulic fracture around the secondary well.

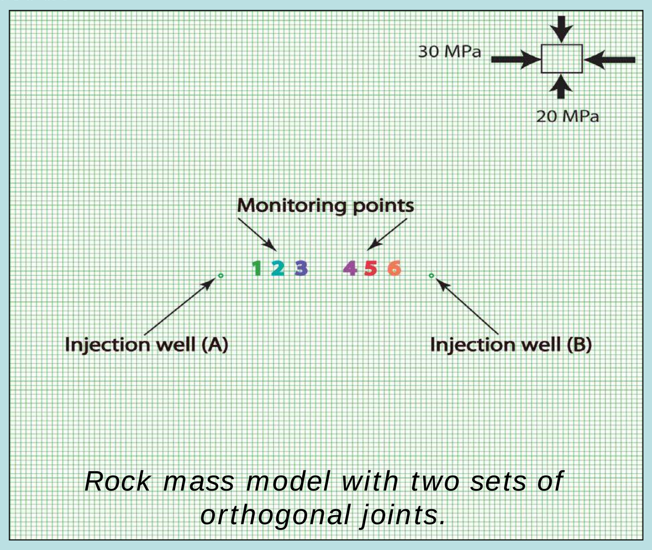
Objectives

1. Investigate the application of distinct element numerical modeling techniques to model stress shadowing effects resulting from multiple hydrofracs from neighbouring wellbores.
2. Elaborate on the concept of stress perturbation through three different hydraulic fracturing scenarios.
3. Improved understanding of stress shadow condition to allow designers and operators to help control the fracture propagation to be extended in the area being treated.
4. Evaluate the utility of 2-D distinct element techniques to model both shear slip and aperture dilation along existing rock joints and tensile rupture of intact rock in response to fluid injection and subsequent changes to the effective stress field.

Scenarios

Three different hydrofrac scenarios were tested:

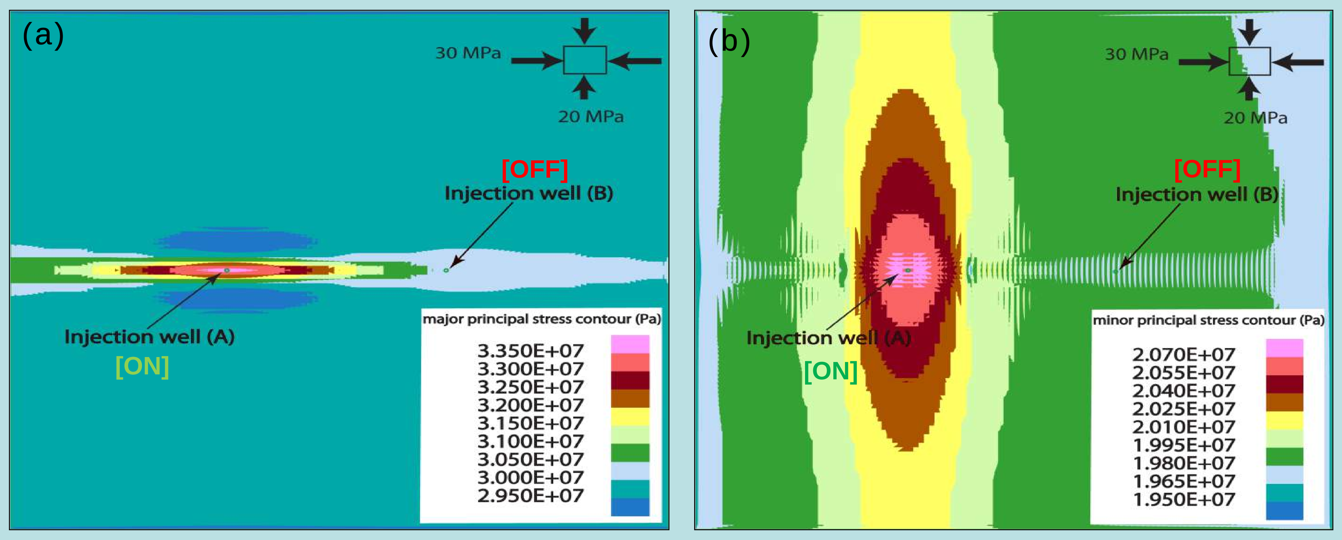
- Conventionally fractured well, where a single well (wellbore A or B) is fractured.
- Two alternating fractured wells (zipperfrac), where first one well (wellbore A) and then the other well (wellbore B) is fractured.
- Two simultaneously fractured wells (simulfrac), where the two wells (wellbore A and wellbore B) are fractured simultaneously.



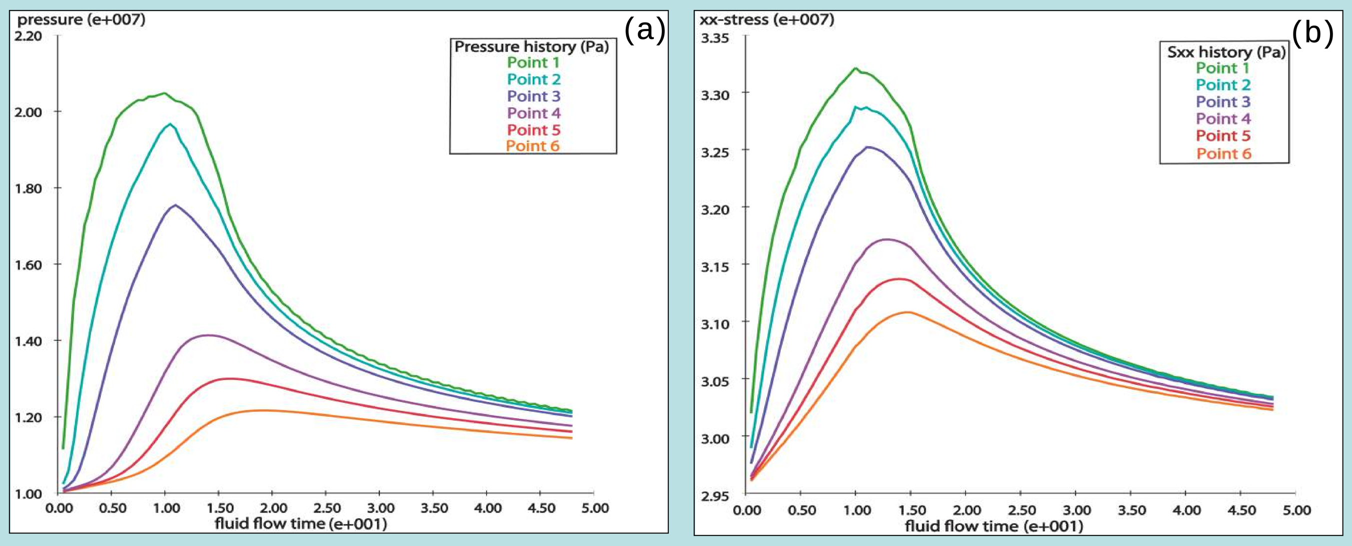
Rock mass model with two sets of orthogonal joints.

Model Simulations

Conventional hydrofrac (single well):

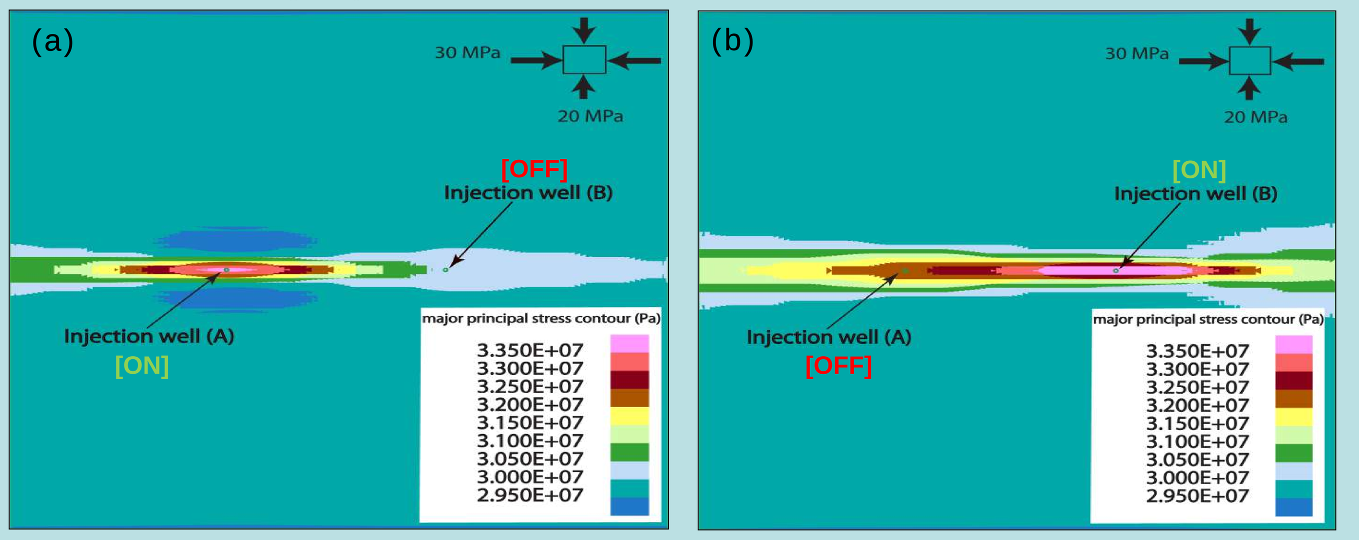


Principal stress distributions (a) major, and (b) minor, resulting from the conventional hydrofrac scenario by pressurization of wellbore A.

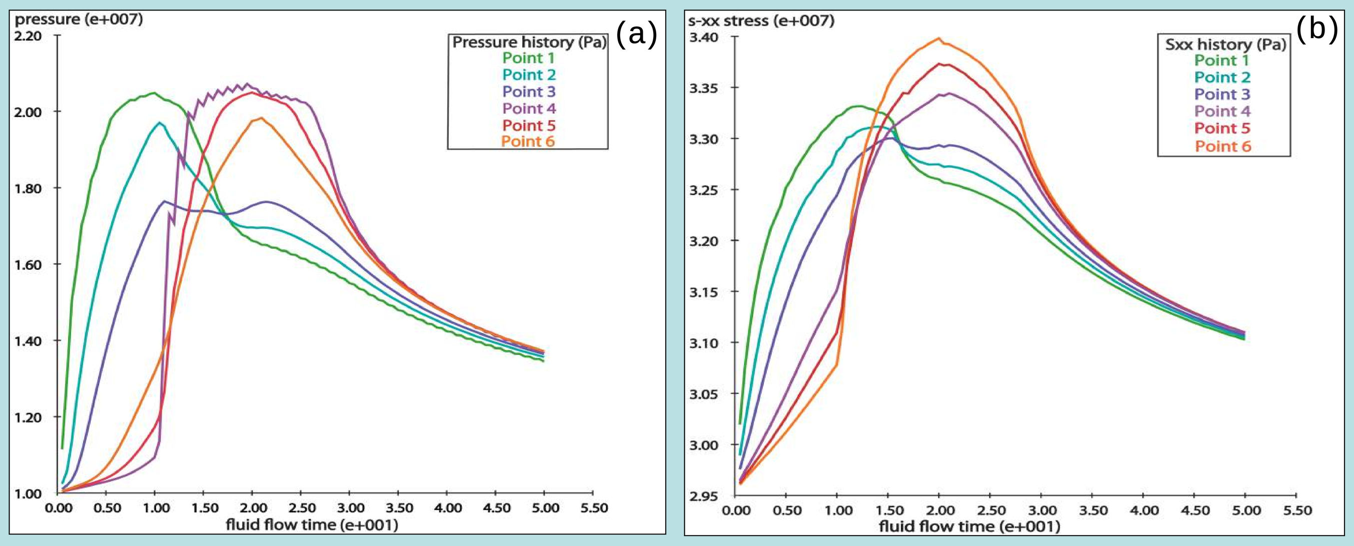


(a) Pressure histories, and (b) Stress histories, for different monitoring points.

Two alternating injection wells (zipperfrac):

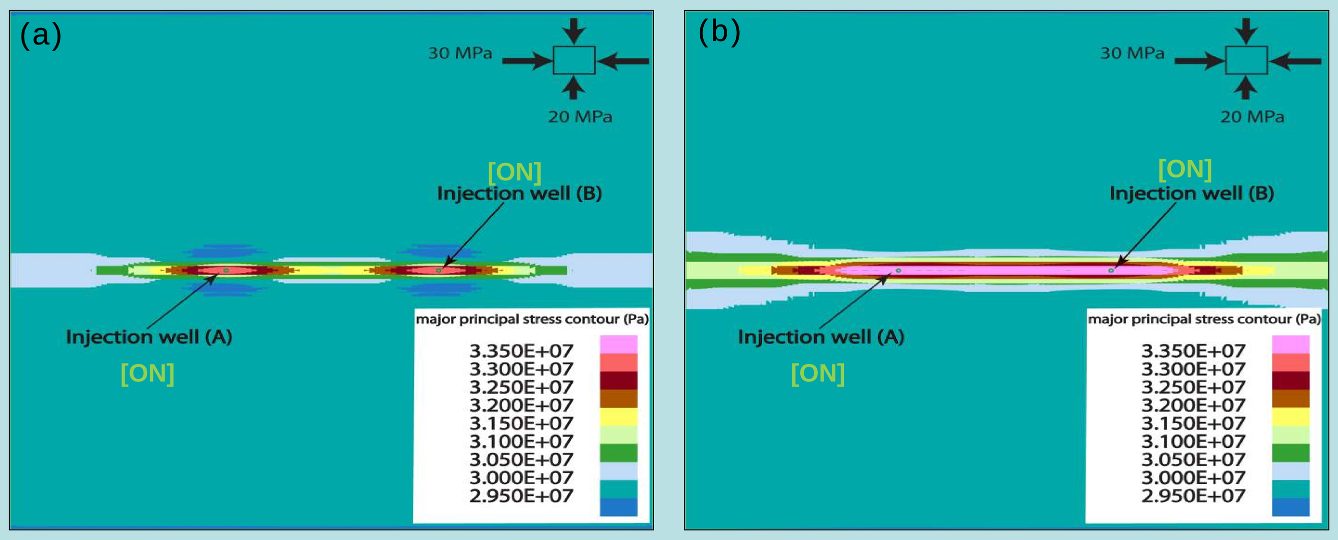


Stress distributions arising from the zipperfrac scenario: (a) after injection into wellbore A; and (b) after injection into wellbore A ceases and injection into wellbore B commences.

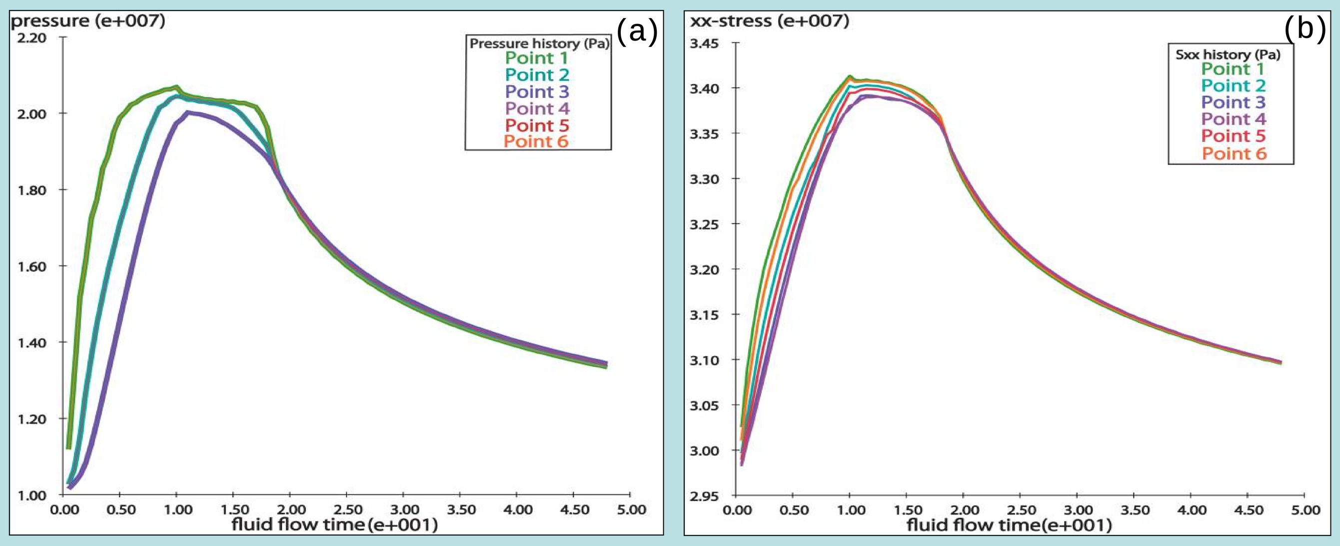


(a) Pressure histories, and (b) Stress histories, for different monitoring points.

Two simultaneous injection wells (simulfrac):



Stress distributions arising from the simulfrac scenario: (a) Initial, and (b) Final, stress distributions around the two simultaneously pressurized wellbores.

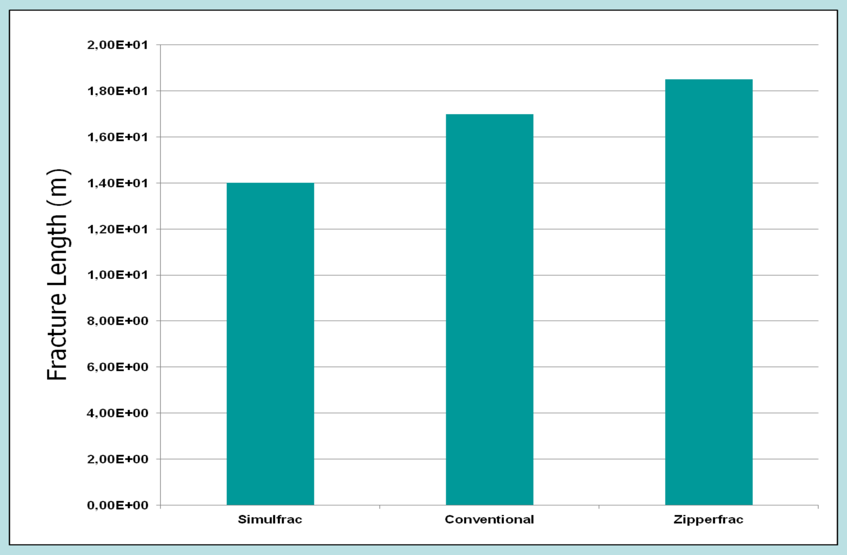


(a) Pressure histories, and (b) Stress histories, for different monitoring points.

Discussion

Vermylen & Zoback (2011) compared the **activity level** of conventional frac, zipperfrac and simulfrac, per stage. They showed that the simulfrac underperforms both the zipperfrac and the conventional frac.

Here, the lengths of simulated fractures, which is a reasonable indication of their activity level, is compared for the three different scenarios. The results for the simulated fracture length, shown in the Figure below, are consistent with conclusions arrived at by Vermylen & Zoback (2011) from their results.



Conclusions

1. The results of this study elaborate on the concept of stress perturbation through hydraulic fracturing.
2. The simulations show great potential in providing a deeper understanding of the influence of stress shadow effects on the propagation of hydraulically induced fractures.
3. Improved understanding of this condition will allow designers and operators to help control the fracture propagation to be extended in the area being treated.

Future Work

Future work will include the simulation of proppant and use of microseismic data to help calibrate and ground-truth the models.

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