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Reducing the Risk of Felt Seismicity During Hydraulic Fracturing: How close is too close? An Analysis of the Effect of Operational Parameters on the Stress Change to Pre-existing Faults.

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Hydraulic fracturing is widely used in the petroleum industry to enhance oil and gas production, especially for the extraction of shale gas from unconventional reservoirs. A good understanding of the vertical distance which should be preserved between hydraulic stimulation and overlying aquifers (potable water) has been previously demonstrated as being greater than 600 metres (2000 feet). However, the effective application of this technique depends on many factors; one of particular importance is the influence of the fracturing process on pre-existing fractures and faults in the reservoir. Specifically, the identification of the required respect distance, that is distance which must be maintained between the hydraulic fracturing location and pre-existing faults, is of paramount importance in minimizing the risk of induced seismicity. This is an important consideration for setting the guidelines for operational procedures by legislative authorities.

We investigate the respect distance using a Monte Carlo approach, generating fifty discrete fracture networks for each of three fracture intensities, on which a hydraulic fracturing simulation is run, using FracMan®. The Coulomb stress change of the rock surrounding the simulated injection stage is calculated for three weighted source mechanisms combining inflation, strike-slip and reverse. The lateral respect distance is obtained using values from literature of the amount of stress required to induce movement on a pre-existing fault. We find that the lateral respect distance is dependent on fracture intensity and the failure threshold. However, the weighting of the source mechanism has limited effect on the lateral respect distance.

We then investigate the effect that changing two operational parameters (flow rate and pumping time) and differential pressure has on the flow distance, fracture network area and the minimum lateral distance that hydraulic fracturing should occur from a pre-existing fault in order not to reactivate it; thus reducing the risk of felt seismicity. Sensitivity analyses are conducted using a Monte Carlo approach. Results show that the flow rate has the smallest rate of change for fracture area (3700 m^2per 0.01 m^3/s) and flow distance (8.3 m per 0.01 m^3/s). We find that differential pressure has the largest impact on stimulated fracture area. The pumping time has the most significant effect on the flow distance (48 m/hr) and the stress threshold value has the most significant effect on the lateral respect distance.

We suggest that to reduce the lateral distance, a compromise is required between flow distance and fracture area. The results obtained by this research provide invaluable guidance for operational practice in determining the potential area of the induced fracture network and generated stress field under realistic hydraulic fracturing conditions, an important aspect for risk assessments.

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