NHF25

The Use of Seismic Emission Tomography (SET) for the Direct Mapping of Frac-Induced Fracture Networks and their Connectivity

L.B. Thompson* (UF3)

SUMMARY

A microseismic study was conducted in a shale gas reservoir in the eastern US in order to monitor a nitrogen frac job and to determine if direct observation could be made of the frac and the natural fault and fracture fairways that were the main producing features in the reservoir. Using data from a series of frac stages, combined with an array of other data sets including field-wide pressure monitoring, interference testing as well as chemical and radioactive tracer testing, a thorough understanding of the reservoir production system was attained. It was further shown that Imaging micro-seismic acoustic energy can yield results that give significant insights into reservoir performance, that crustal deformation theory which predicts fracture control on permeability attributes appears sound and when integrated with other data sets, micro-seismic is a powerful tool for optimizing complex reservoirs.

Introduction

Microseismic studies in the oil and gas industry have consisted of identifying the hypocenters of energy activity during the creating of an artificial fracture during a frac job. This new technique uses Seismic Emission Tomography (SET) processing to not only identify the location of the frac job but also the network of natural faults and fractures in the rock volume that the frac job connects into. Thus, one is able to image the permeability field in the rock volume where the permeability has been impacted by the change in pressure created by the frac job.

Method and/or Theory

A passive surface array of listening devices is used to image the Acoustic Energy (AE) that is generated in the rock volume by the frac process. Following the theory that (a) the Earth's crust is at frictional equilibrium and (b) that a change in pressure as small as 0.01Kb will create conditions conducive to shear failure in the rock, then (c) as a connected permeability field is perturbed by the frac job, one would expect to see AE generated not only along the hydrofrac itself, but also in the natural permeability system inherent in the rock.

Examples (Optional)

A microseismic study was conducted in a shale gas reservoir in the eastern US in order to monitor a nitrogen frac job and to determine if direct observation could be made of the frac and the natural fault and fracture fairways that were the main producing features in the reservoir. Using data from a series of frac stages, combined with an array of other data sets including field-wide pressure monitoring, interference testing as well as chemical and radioactive tracer testing, a thorough understanding of the reservoir production system was attained.

Figure 1 Example of frac energy near the wellbore. Shale Frac – 3D View from South. Cumulative stack of semblance values over total frac, for a duration of 26 min. and 40 sec. Large study volume: 200 ft. voxels, 20 sec. stacking interval,. All voxels with semblance values below 1.45 are eliminated.

Figure 2 Example of surface AE noise vs reservoir response. Frac 4 stage 2, 20 second volumes for 25 minutes and 20 seconds.

As can be seen from Figures 1 and 2, one can distinguish among the frac job AE, surface noise from the field operations and a more widely distributed permeability response to the change in pressure.

Conclusions

It was shown that imaging micro-seismic acoustic energy can yield results that give significant insights into reservoir performance, that crustal deformation theory which predicts fracture control on permeability attributes appears sound and when integrated with other data sets, micro-seismic is a powerful tool for optimizing complex reservoirs.