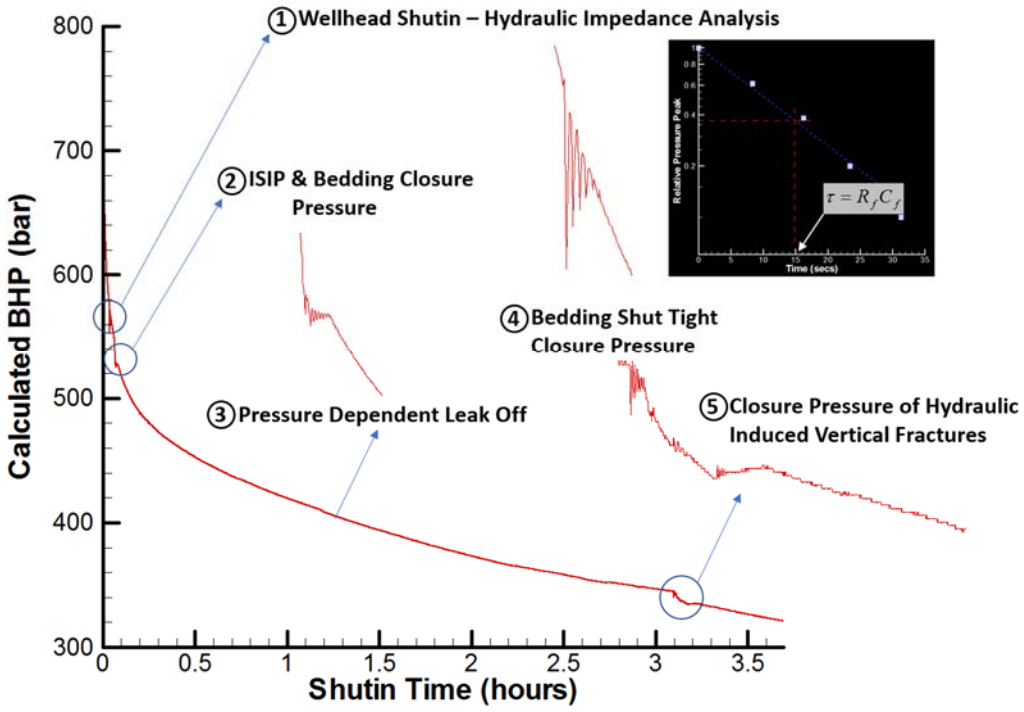
August 15, 2019

Preston New Road Stimulations

Data has been recently released by the UK Oil & Gas Authority of Cuadrilla Resources PNR-1Z horizontal well fracturing operations conducted in 2018 at Preston New Road, Lancashire, UK – data can be sourced from https://www.ogauthority.co.uk/onshore/onshore-reports-and-data/preston-new-road-pnr-1z-hydraulic-fracturing-operations-data/. From a review of this available data, it is clear that the geology impeded the vertical height growth of the induced fractures, similar to the Preese Hall Well 2011 stimulations, of which GeoSierra's Executive Summary review of October 2016 follows. The operator then allowed the BHP (Bottom Hole Pressure) in the PNR-1Z well to rise thus opening hyper-sensitive bedding planes and thus giving rise to a heighten risk of induced seismicity with minimal enhanced gas production. These seismic events were induced by small pumped fluid volumes, as were the events induced in the Preese Hall well. By allowing the BHP to rise sufficiently to open the hyper-sensitive bedding planes, the operator has significantly heightened the risk of induced seismicity from their operations.

Shutin Analysis of Sleeve 38, PNR-1Z December 11th, 2018

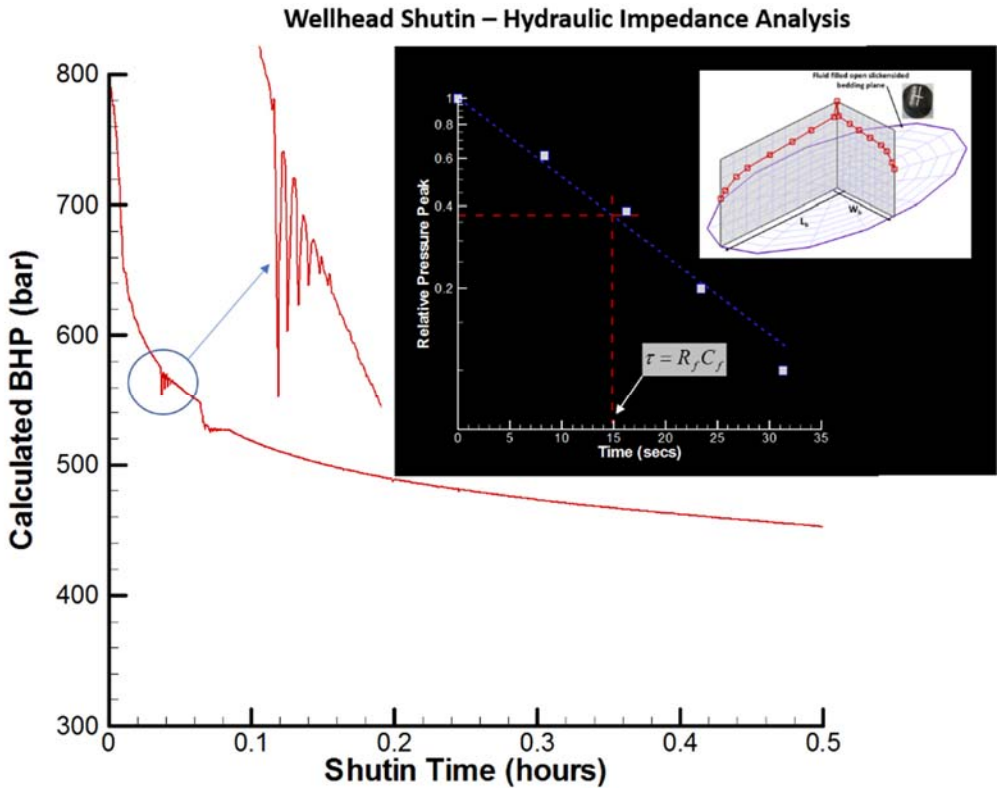
The analysis of the shutin data for sleeve 38 is shown below. The analysis consists of five distinct stages; being, 1) hydraulic impedance analysis of wellhead shutin to provide dimensions of opened bedding planes, 2) ISIP and Closure Pressure of the near horizontal bedding planes, 3) pressure dependent leak off providing data on the bedding fluid conductivity as a function of pressure, 4) shut tight bedding plane closure pressure, at which the bedding planes are virtually impermeable, and 5) Closure Pressure of the hydraulic induced vertical fractures.



Shutin Data and Analysis of Sleeve 38, PNR-1Z December 11th, 2018

The various stages of the shutin analysis are shown in the following figures, with the hydraulic impedance analysis of wellhead shutin providing dimensions of the opened bedding planes at the end of pumping, conducted first as it occurs immediately following shutin.

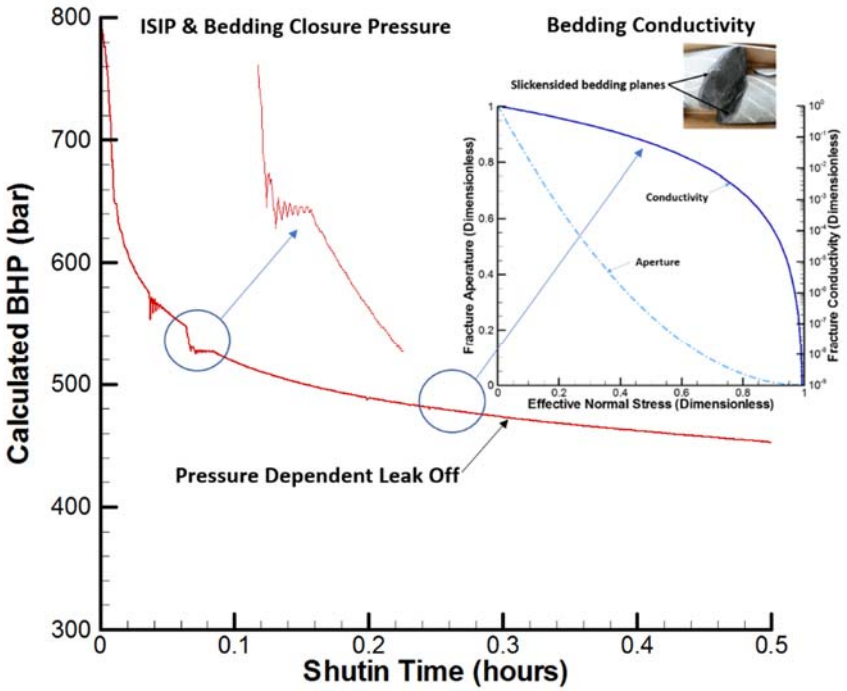
The propagating wave set up by wellhead shutin, produces reflections from the opened bedding planes, so that their opened dimensions can be determined from the hydraulic impedance analysis. The relative decays of the reflected waves are plotted yielding a time constant that is proportional to the opened bedding plane's resistance and capacitance to fluid flow.



Hydraulic Impedance Analysis of Shutin, Sleeve 38, PNR-1Z December 11th, 2018

The pressure dependent leak off analysis, shown in the below figure, quantifies the opened bedding plane fluid conductivity as a function of normal effective stress. At a normal effective stress ratio of >0.4, the bedding planes are effectively closed, and it is this shut tight closure that gives rise to the induced fluid waves shown in the data for analysis of stage 4), as detailed in the figure of the overall shutin data analysis for sleeve 38.

By placing limits on BHPs during injection, opening of near horizontal bedding planes can be avoided, and thus the heightened risk of induced seismicity, without any or minimal gas production enhancement, can be minimized. The stimulation of sleeve 38 had extremely high BHPs, up to 800bar, far exceeding overburden, opening near horizontal bedding planes, and inducing a M_L 0.1 seismic event during pumping, with an induced M_L 1.5 seismic event occurring shortly after pumping stopped. This stimulation had extremely high injected pressures, far exceeding overburden of 530bar.



Pressure Dependent Leak Off Analysis, Sleeve 38, PNR-1Z December 11th, 2018

The stimulation of sleeve 38, initially induced hydraulic near vertical fractures, whose height growth was terminated by the presence of open or slickensided bedding planes. As such the BHPs rose sufficiently to exceed the normal stress of the near horizontal bedding planes, opening these hyper-stress sensitive bedding planes and thus significantly increasing the risk of induced seismicity, without any or minimal gas production enhancement. This heightened risk of induced seismicity can be avoided by placing limits on BHPs during injection.