Cardium Formation Hydraulic "Frac" Microseismic: Observations and Conclusions*

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Abstract

In 2010, Petrobakken Energy acquired several companies with resource play potential in the Cardium of Central Alberta. After the first year of encouraging results, the company set out to further evaluate these properties in 2011 and drilled an additional 120 wells into the Cardium Formation. Multistage hydraulic fracture stimulations ("fracs") from horizontal wellbores were employed to evaluate these properties with varying results. After reviewing several months of production profiles, several questions were being asked. Why were the results so variable? Was it because of the geology, the reservoir pressure, or the frac style, and what technologies should we utilize to maximize our frac efficiencies and well productivity? Microseismic was acquired in eight separate projects to answer some of these questions. As this work is still ongoing at PetroBakken, this article presents some of the current observations and poses further questions to be answered from additional technical work.

Introduction and Background

PetroBakken's Cardium lands lie from just north of Cochrane to the "halo" flanks of the East and West Pembina Cardium pools south of Drayton Valley. The Upper Cretaceous, Turorian, Cardium Formation includes repeated, stacked successions of silty mudstone through siltstones to very fine- to fine-grained sandstones. These units are unconformably overlain by chert-pebble conglomerates which in turn are overlain by marine mudstones.

The thicker, highly permeable, conventional reservoirs have been exploited since the 1950's. The current focus on the tight oil Cardium play is on the margins of conventional fields where the gross reservoir is up to twelve meters thick, with the net sandstone thickness varying between three and seven meters.

The measured reservoir pressure over the study area varies from a depleted pressure of 7 mPa to virgin pressures of over 22 mPa. The maximum stress direction based on published literature was estimated to be perpendicular to the Rocky Mountains or towards the NE.

PetroBakken monitors its frac performance, seeking to improve frac efficiencies, and so during this study time several frac types were analyzed, including Slick water, Gelled oil, and Foamed water.

Observations

All of the microseismic jobs in this study were acquired, using single downhole monitoring wells, with the exception of one, which was a dual downhole project. As the study grew, it became obvious that even though micro seismic events were recorded beyond 800 m, the more reliable events were recorded within 525 m of the monitor well.

The majority of these event clouds also trended approximately N45E - S45W from the treatment well no matter the azimuth of treatment was. In addition to the consistent frac-wing azimuth, it was noted that the frac-wings were not symmetric. A significant portion of the microseismic events were found to be toward the NE without regard to what side the observation well was relative to the treatment well. (Figures 1 and 2)

Most fracs stayed within 100 m vertically from where the treatment well landed within the Cardium sand; however, it was observed that the odd frac wing would reach 150 - 200 m or more, due to higher treatment pressure or encountering a pre-existing fault (Figure 3).

Conclusions and Next Steps

Microseismic events from a stimulated Cardium well can be imaged by utilizing downhole monitor wells, if these observation wells are within 525 m of the frac ports..
In the study area it was noted that the frac wings in general trend N45E and that they are asymmetrical.

The frac height typically are within 100 m of the placement zone, with the exceptions of breaking-out due to higher treatment pressure or pre-existing faults. The Gelled oil and fluid fracs tended to create well defined frac wings, whereas the Slickwater fracs tended toward a more complex pattern. Frac lengths typically reached out to 200-300 m, in some cases 400m, to the NE and typically extended 60-100 m to the SW.

This article was prepared to illustrate several observations about Cardium hydraulic fracs recorded through Microseismic images. The answer to the question of "Why are the results so variable?" is still being answered by the Cardium Team at Petrobakken. The next steps for improving "Frac Efficiencies" in this project are to integrate more thoroughly into the analysis the geology, reservoir engineering, and frac monitoring.

Acknowledgements

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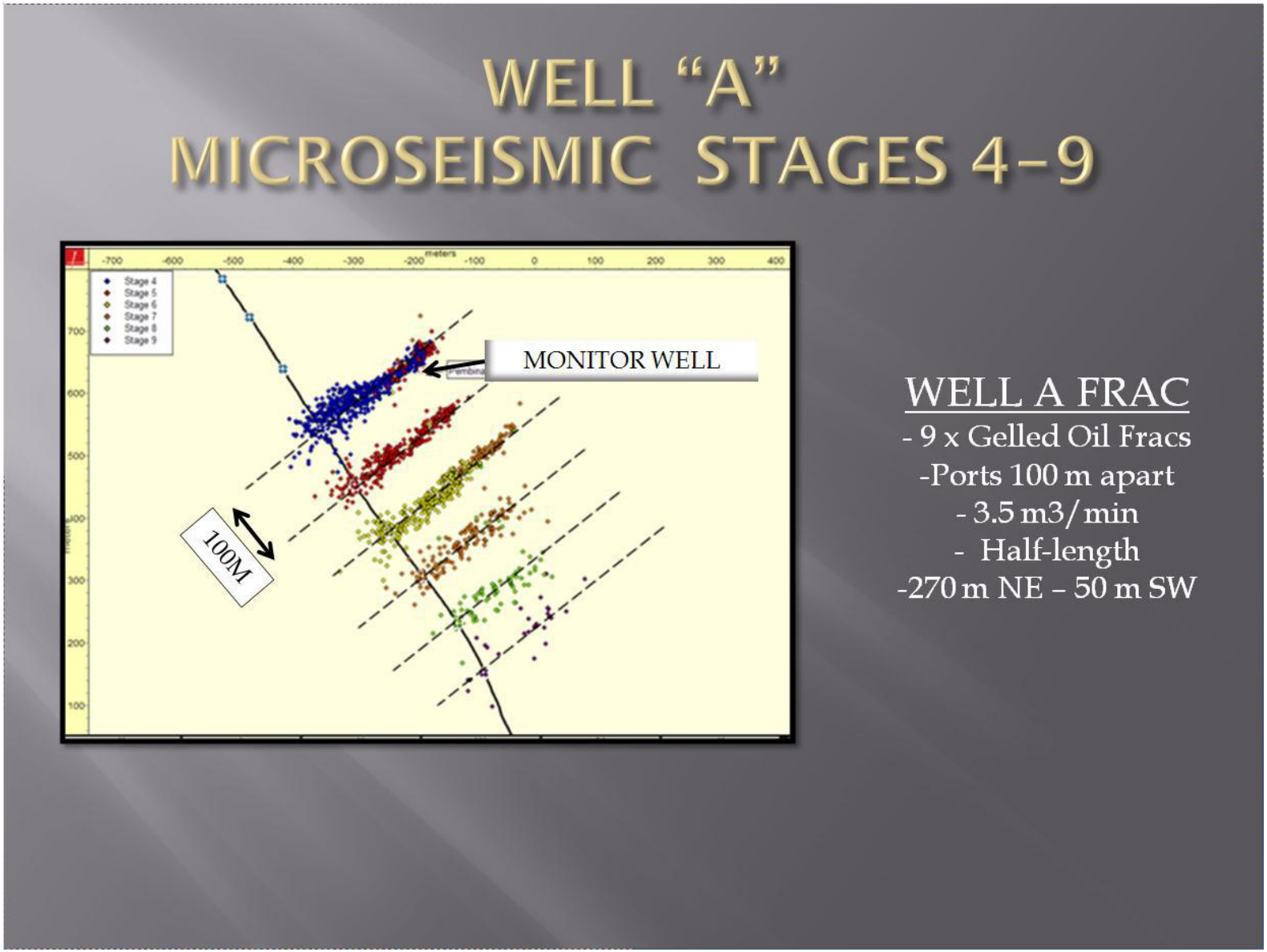

Figure 1. Plan view of microseismic events due to frac stimulations in Well "A," showing their asymmetry with NE-SW trend and with clear separation between the frac wings or event "clouds." This well was treated with a Gelled oil frac. The monitoring well is on the NE side of the treatment well.

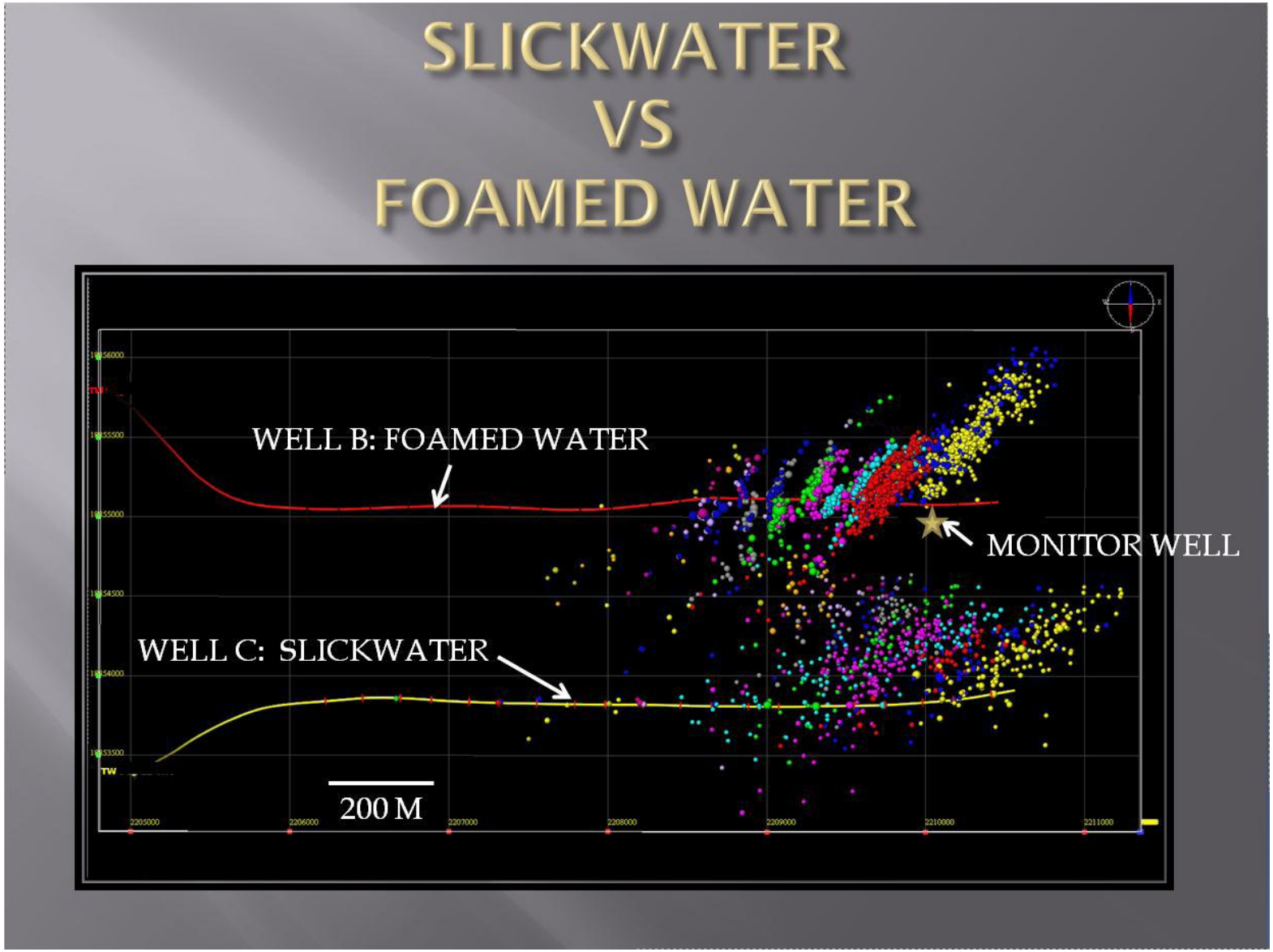

Figure 2. Plan view of microseismic events due to frac stimulations in Wells B and C, illustrating the NE-SW asymmetric character of the event clouds without bias based on the monitor well location. This figure also shows the more complex nature of the slickwater frac versus the more defined frac-wings from the foamed water frac .Clear distinct event clouds can be observed with some frac lengths exceeding 400 m.

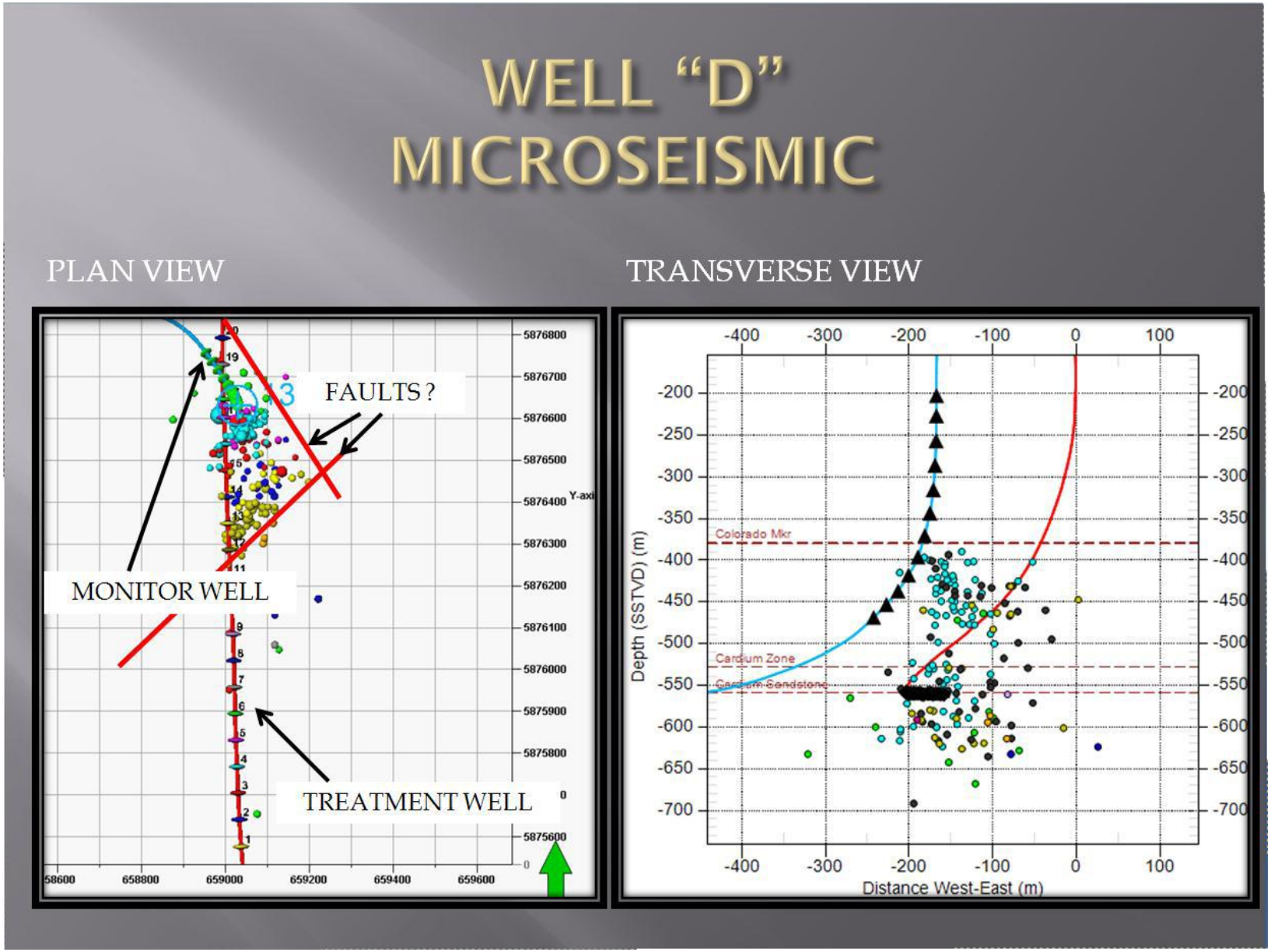

Figure 3. Plan and transverse views of microseismic events due to frac stimulations in Well "D." Microseismic events show a frac height of 170 m in the transverse view. Fault interpretation is shown in the plan view.