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Simultaneous Active and Passive Seismic in the Montney: a case history

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Summary

Reservoir imaging using 3-D reflection seismic is now industry standard. Passive seismic (microseismic) imaging of hydraulic fracturing using large aperture/large fold surface arrays is known to be one of the best methods for obtaining a comprehensive image of the stimulation treatment (Duncan et al., 2010). Both methods require extensive line cutting for the deployment of surface arrays at an often prohibitively large cost.

In this paper we describe a field project in the Montney play of northern Alberta where we tested the hypothesis that one could perform a frac monitoring at the same time as acquiring 3-D active seismic data, using the same receiver array, thus realizing significant savings on line cutting and operational costs. Further, during this test, a second set of receiver stations was deployed along the seismic source lines to determine if the extra listening effort (fold) would improve the microseismic results sufficiently to justify the extra equipment and analysis expense.

We conclude that the results achieved here confirm it is possible to acquire useful frac monitoring passive seismic data with the same receiver arrays being used to acquire active seismic data at the same time.

Workflow

Figure 1 shows the approximately 42 km^2 project layout in map view. Receiver lines run east-west with a 60 m station spacing and 380m line spacing. Receivers were also laid out on the north-northeast bearing shot lines at a station interval of 60 m. Each receiver station consisted of a vertical component 1-C Inova Quantum node, recording at 2 ms sampling. There are a total of 3,025 receiver stations in the spread of which 1,535 are on the active seismic receiver lines.

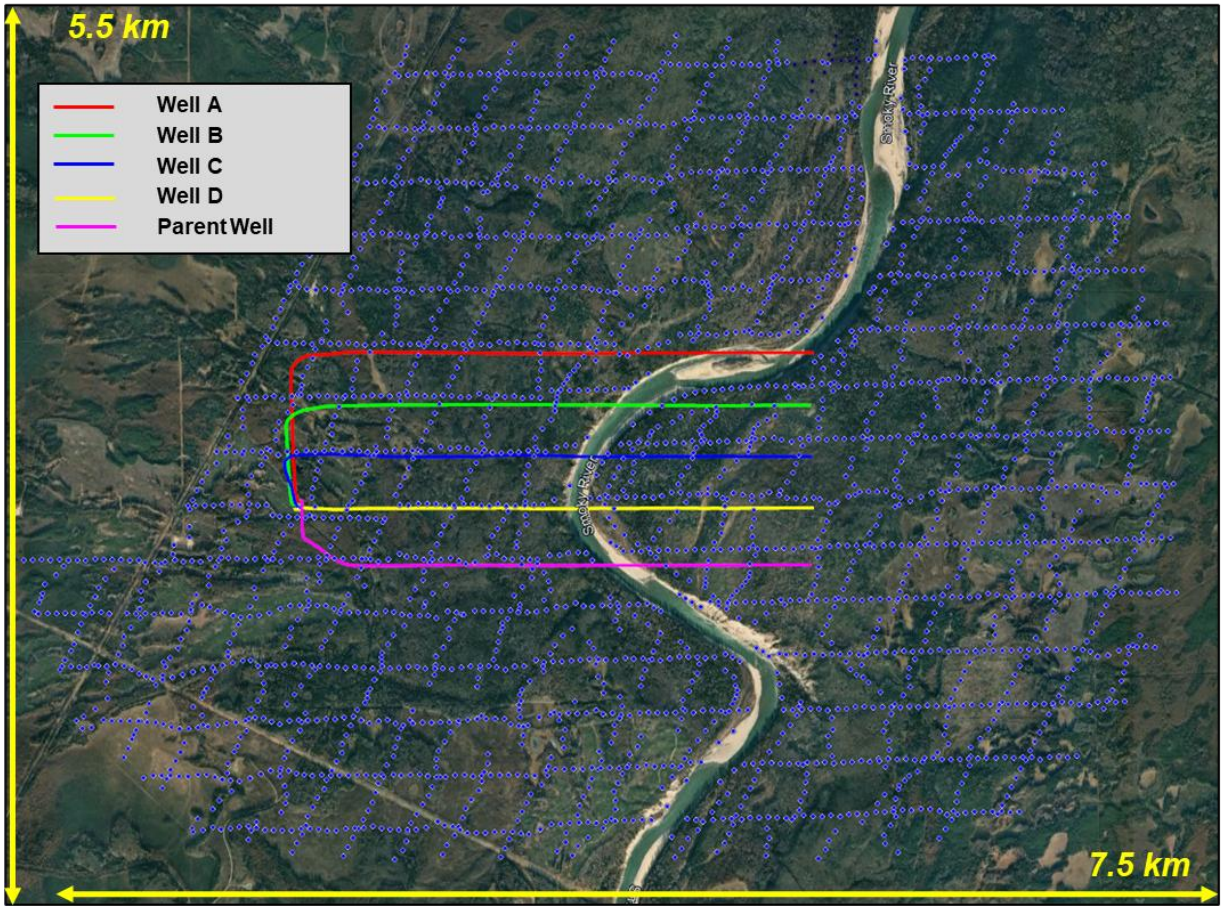

Figure 1. Receiver array map for the project. East-west lines represent the active and passive seismic receiver lines. The NNE trending lines represent the active seismic shot lines along which an additional set of receiver nodes was deployed. Well tracks for 5 horizontal Montney wells at approximately 1,575m TVDSS are shown. The northern-most 4 (A, B, C, D) were hydraulically fractured during this project. The southern-most parent well was treated previously.

Over the period 1/20/2024 to 2/7/2024 wells A, B, C and D were hydraulically fractured. Passive seismic data were recorded during the stimulation. Wells A and C were completed with a different procedure than wells C and D as part of this test. During the frac'ing, active dynamite shooting into the array was taking place with the shot locations becoming closer to the passive recording as the treatment progressed. Active shooting took place only during daylight hours affording the opportunity to determine the effect shooting had on the microseismic results (see Figure 2).

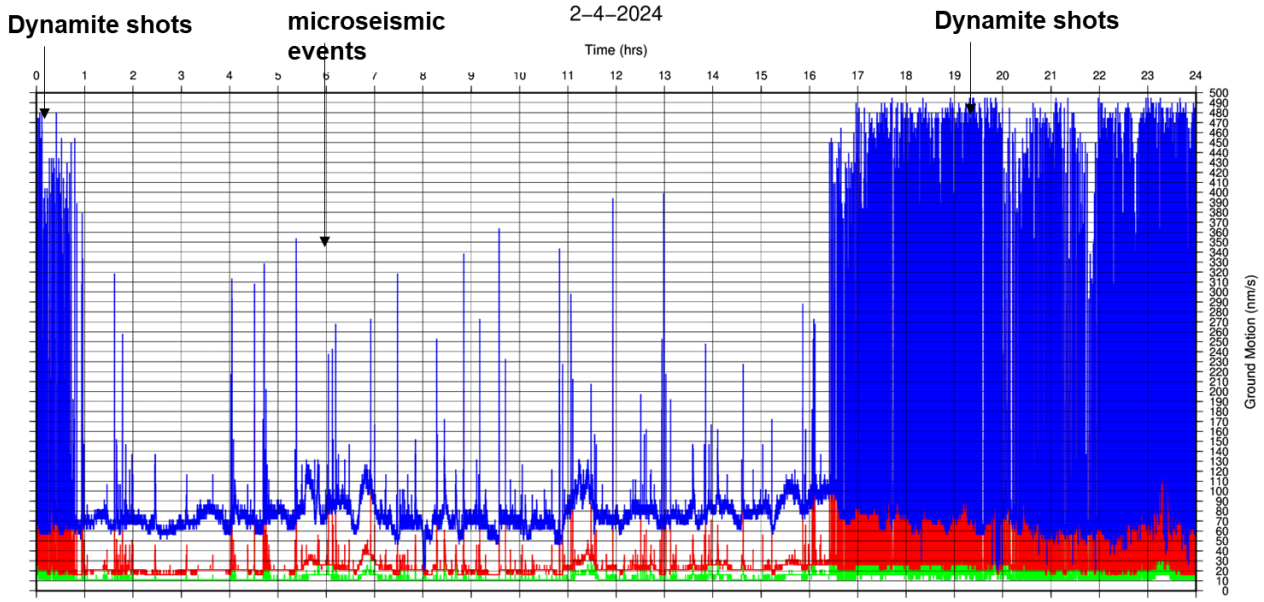

Figure 2. Seismic noise observed on the passive array over a 24-hour period illustrating the difference in ambient noise level when active shooting is taking place. Background noise values are calculated as a percentile of 1 s. rms values over the recorded data. Average values are shown at the 15th, 50th , and 84th percentiles. Times are in UTC.

Results, Observations, Conclusions

Our analysis of this dataset led to the following observations:

1) The microseismic imaging of the frac'ing of these wells was successful even though the recording was made concurrently with the acquisition of 3-D seismic data using the same receivers.
2) A magnitude of completeness of about -1.8 was achieved.
3) Modelling of the expected results using the final surveyed receiver station locations slightly underestimated the event detection capability of the array. Some of this was that we overestimated the detrimental effect of the shooting noise on the microseismic data.
4) There were 3 main noise sources; two windstorms, and the dynamite shots occurring close to the spread. Without those, the smaller array (receiver stations only) performed just as well as the larger array (receiver and shot line stations) in defining the fractures. However, the location uncertainty increases with lower fold. Using only the smaller array:

- The magnitude of completeness would be within 0.1 magnitude units of that achieved with the larger array
- The XY uncertainty increases by 35%
- The Z uncertainty increases by 59%

5) For this project, the increased cost of adding in the shot line stations was in the range of 5 to 10%. Estimating the value of the extra stations pre-mission through modelling can assist in making the decision to undertake the increased monitoring effort.

The paper will provide illustrations of these observations.

Novel/Additive Information

The project demonstrates that it is possible to record microseismic data to monitor a frac while recording active seismic data using the same receiver array.

Acknowledgements

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References

Duncan P. and L. Eisner, 2010, Reservoir characterization using surface microseismic monitoring, Geophysics, 75, 75A139–75A146