Integrating Seismic Derived Rock properties with Horizontal Well Induced Fractures in the Duvernay

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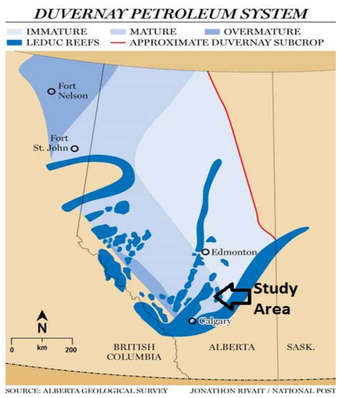
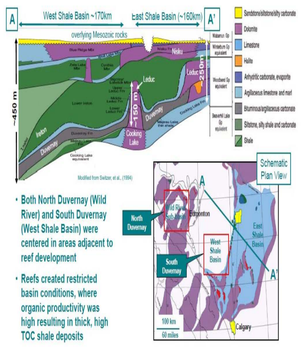
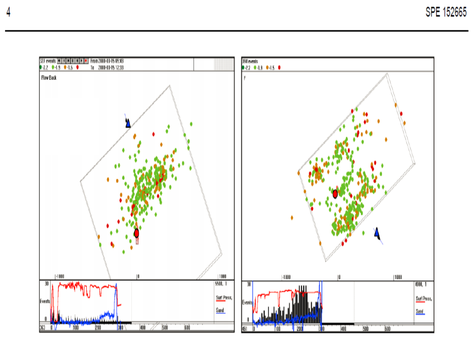
The Duvernay formation is a major zone of interest for unconventional oil production. It is the stratragraphic equivalent of the lower Leduc, and is commonly believed to be the source rock for most of the Devonian age production in Alberta. Microseismic Techniques have been used to evaluate the efficiently of hydraulic fracture stimulations. The Duvernay has been drilled horizontally, and hydraulic fracking has been deployed to enhance oil production. Microseismic surveys have been carried out in a number of areas to determine fracture length, height, and general efficiency of the completion. In this paper, a method of using seismic attributes is proposed to optimize drilling programs. Seismically derived geological attributes can be used in the well placement and fracture stimulation intervals to optimize recovery. To date, most Duvernay drilling patterns have been laid out in a uniform pattern, orthogonal to the regional stress, or parallel to the boundaries of the oil lease. localized geological rock properties are used in the initial planning stage, but not in well placemen; a common assumption is the rock is uniform, and fractures will occur governed by the regional stress regime. Seismic derived attributes can provide valuable information with respect to well placement, and what facies are favorable to hydraulic fracture stimulation, fracture length, and direction. Seismic attributes can and should be used to direct horizontal well placement, as well as completion programs. Some completions perform well, whilst others fail. Fracture patterns and induced seismicity may preferentially follow geologic depositional patterns; this should be considered in well planning.





- Both North Duvernay (Wild River) and South Duvernay (West Shale Basin) were centered in areas adjacent to reef development
- Reefs created restricted basin conditions, where organic productivity was high resulting in thick, high TOC shale deposits

Duvernay source maturity map, the Rangeland study area is highlighted. Note, the study area falls within the mature oil window, Map Courtesy Alberta Geological Survey.



This is an example from the Barnett shale in Texas The different fracture patterns are observed on the Barnett Shale are often assumed to be pre-existing fractures. (Courtesy of Maxwell 2002) The variance in fracture patterns could also be defined by lithology. Soft, less brittle rocks would tend to deform, and not fracture. This formation is commonly considered to be homogeneous.

Australia great Barrier Reef marine park image, Michaelmas CayThe Great Barrier Reef is considered to be a modern analogue to the Devonian Leduc reef. The areas between the reefs are a modern analogue to Duvernay deposition.

Significant stratigraphic variations were observed among both lab and log based mechanical properties manifesting the dissimilarities in geomechanical responses of different lithological zones in the study area (e.g., Figure 1). In the case of Young's modulus, strong relations between static and dynamic values measured in the lab were observed. Inconsistencies between the lab and log based data seemed to be related to sampling frequency and the difference between in situ and laboratory conditions (e.g., stress, pore pressure, temperature). Figures 1a and 1b show significant variations in log based dynamic elastic properties (particularly Poisson's ratio) in different zones especially between the Duvernay and

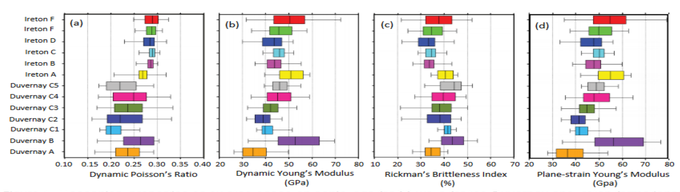
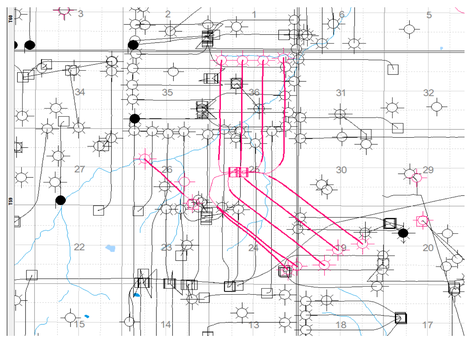
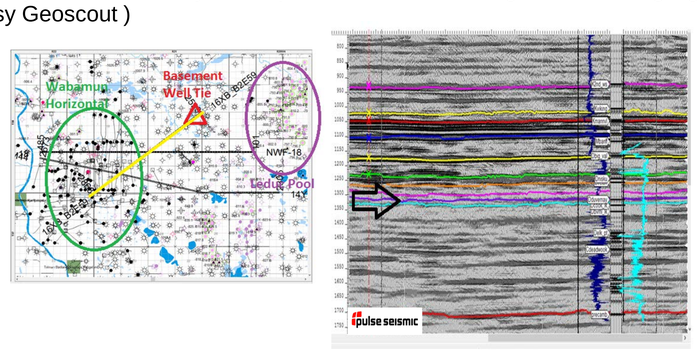


Figure 1. Mechanical properties calculated based on sonic logs for 26 wells for the Duvernay and Ireton formations: (a) dynamic Poisson's ratio, (b) dynamic Young's Modulus, (c) Rickman's brittleness Index, and (d) plane-strain Young's modulus.

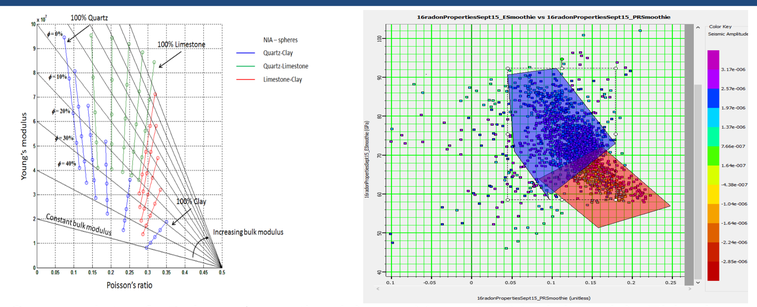
Mechanical properties variance in the Ireton and Duvernay. Scoltanzadeh and Fox published this in 2014. It shows significant variability in the Duvernay rock properties over their study area in NW Alberta. The brittleness of the Duvernay and Ireton using core.



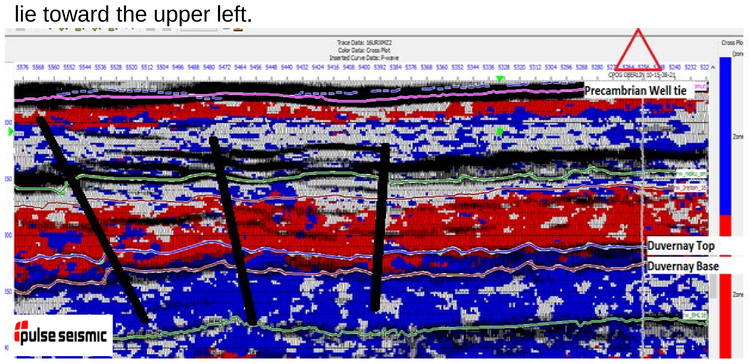
Duvernay horizontal development, T59 R20 W5, Kaybob, 2014 drilling program. The wells are positioned orthogonal to the regional stress, or aligned to the land ownership. Du This pattern is typical of Duvernay development to date. Well alignments are highlighted in red. (Courtesy Geoscout)



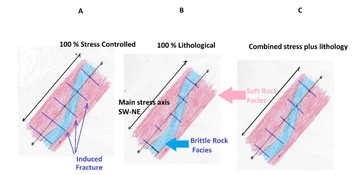
The subject seismic line (yellow) and the Leduc pool (purple), the Wabamun pool (Green).aligned to the land ownership. (Courtesy Geoscout). The figure on the right shows the synthetic tie to the conventional processed stack.

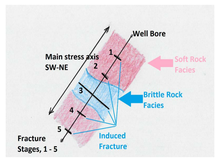


Cross plot of Poisson`s ratio (x) vs Young's Modulus (y) This is a summation of all the Poisson`s data points inside from the seismic Duvernay interval. The seismic plot below shows all points on the seismic line that meets these conditions. The data in red is less brittle, the data in blue is more brittle and capable of maintain a fracture. The boundaries between red and blue are user defined. The left figure shows the theoretical plot of the same data, the desired points for fracture stimulation lie toward the upper left.



Seismic display of Young's Modulus Vs Poisson`s Ratio after inversion. The colours are derived from the E (Young's Modulus) vs. Poison Ration Cross Plot. The zone of interest, The Duvernay is marked at 1325 ms. Note the variance from NE to SW. in the Duvernay interval. The Blue zone indicates more brittle rock, the red, less. According to this, a hydraulic fracture at the well bore would perform well; an induced fracture at 5426 (red colour) would perform poorly.





A proposed scenario from a hydraulically induced fracture stimulation. Given the scenario depicted here, the question would be asked as to why stimulation # 3 performed so much better than 1,2,4, or 5. This type of unpredictable behavior is commonly observed on microseismic surveys over what is believed to be homogeneous rocks. (Figure 2, Maxwell 2002). This behavior is often attributed to pre existing fractures.

Future Work. Acquire a large 3-D over a Duvernay microseismic project and compare the results predicted by seismic inversion to hydraulic fracture microseismic events.

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