Multidisciplinary Integration and Tools to Better Address the Utica Shale Stratigraphy, Rock Properties and Fraccability*

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Abstract

A series of horizontal and vertical wells in the Utica Shale of Quebec have shed new light on multidisciplinary approaches and tools for the evaluation of its stratigraphy, rock properties and ability to fracture. Two of the horizontal wells drilled are displayed in Figure 1.

Method

In horizontal wells, delineation of open fracture zones and faults has been achieved using gas chromatography. The combination of gas chromatography with image logs has demonstrated that wetter gas can be locally attributed to increased density of open fractures and not to a change in source rock maturity. These results led to fine-tuning the fracture design in such a way as to avoid areas of potential placement problems.

Geomechanical modeling based on data from wells in the Saint Lawrence Lowlands in Quebec had predicted that an increase in pore pressure had the potential to change the stress regime from strike slip to thrusting, implying the possibility of limited height “pancake fractures” (Figure 2 from Brodylo et al. 2011). In one horizontal well, the close proximity of the borehole to a boundary between two rheologically different shale units was deemed susceptible to horizontal fracture propagation. The geomechanical model was correct as shown by some post fracture deformation of the 4” liner in the horizontal section caused by bed parallel shortening. As such, a borehole geometry that gently and gradually crosses stratigraphy should reduce the potential for casing deformation associated with horizontal fracture propagation.

For various operational or economic reasons, a decision not to run wireline logs or not to monitor the stimulation with microseismic may be taken; this may have a substantial negative impact on our understanding of what happened during the hydraulic fracturing process. In one horizontal well in Quebec, the ease of placement in one particular fracture stage seemingly contradicted the petrophysical prediction. Log derived geomechanical properties of the Utica in the horizontal borehole indicated the presence of a less brittle facies where fracture initiation should be more difficult to achieve (Figure 3 and Figure 4). However, that particular zone recorded the best fracture placement among the eight fracture stages.

Discussion

Confidence in petrophysical prediction could have suffered if the stimulation had not been monitored by microseismic, which demonstrated that a successful stimulation of that particular stage was not achieved as the fracture placement was restricted to a linear feature interpreted as a fault or fracture zone (Figure 5). It is important to note that having a good velocity model, as input for the microseismic processing is necessary in order to obtain a reliable position of the microseismic events (Figure 6).

We extensively tested one tool that can potentially and partially replace the use of wireline logs in horizontal wells: x-ray fluorescence on cuttings. It has been tested and calibrated on vertical wells that have both wireline log and core coverage. The elemental composition has been studied against the dynamic Young's modulus and Poisson Ratio derived from dipole sonic (Figure 4).

X-ray fluorescence on cuttings has proven to be helpful in identifying borehole placement with respect to Utica stratigraphy. It also permits the identification of relative mineral assemblages and the assessment of inferred rock properties such as brittleness. The latter can be extremely important in the absence of wireline logs (planned or unplanned).

Conclusions

Multidisciplinary integration delivers better interpretations as long as each part and each discipline is given enough calibration and quality control. In the absence of some tools (e.g. microseismic or wireline logs) the results of any integration may not be as reliable, and we showed that in some cases the interpretation may even be erroneous.

Acknowledgments

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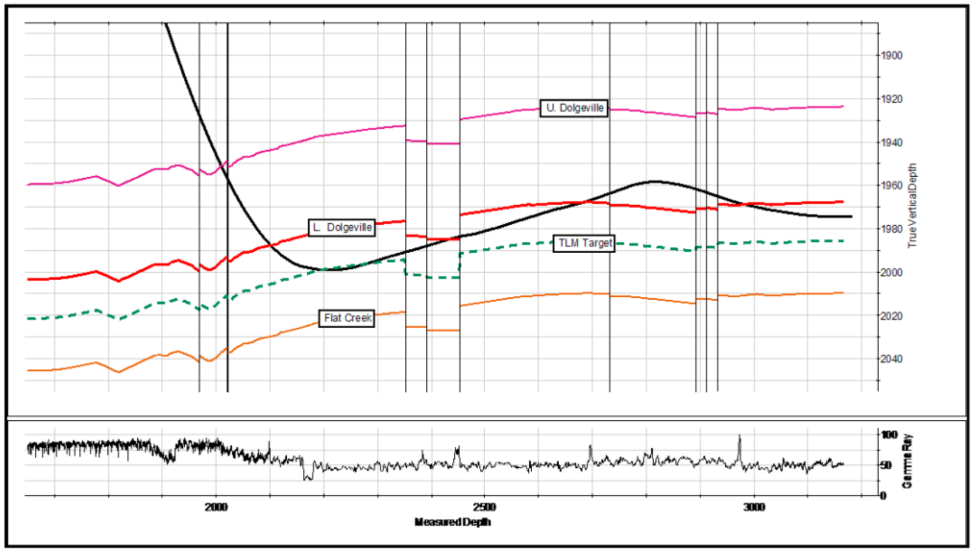
Reference Cited

Brodylo, J., J.-Y. Chatellier, G. Matton, and M. Rheault, 2011, The stability of fault systems in the south shore of the St. Lawrence Lowlands of Quebec – implications for shale gas development: SPE-CSUG Meeting Calgary, paper #149307, 27 p.

St Edouard Hz1 welll



Leclercville Hz1 welll

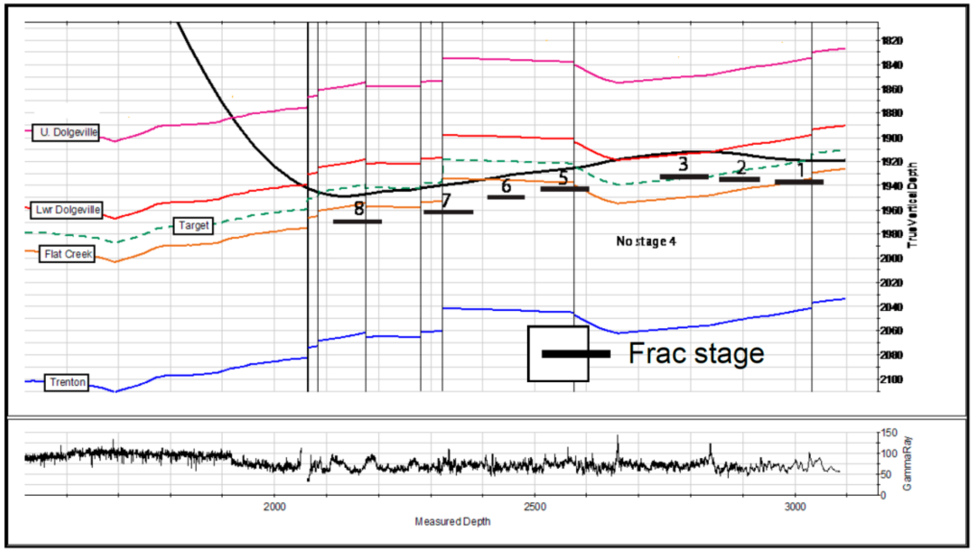


Figure 1. Uncorrected interpreted profiles of two horizontal wells drilled through the Utica Shale, profile based on MWD GR only and before conventional logging.

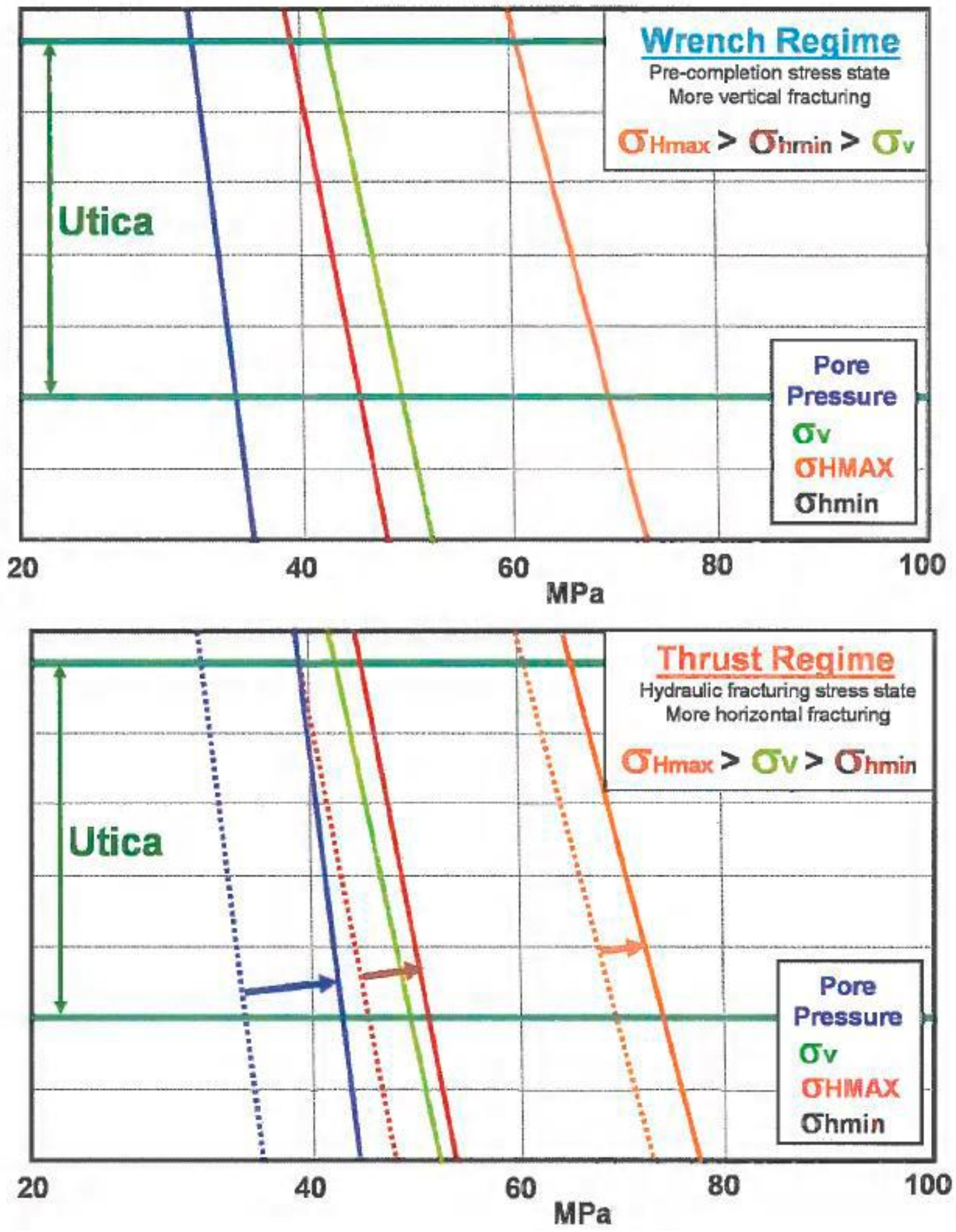


Figure 2. Modified stress regime can lead to pancake fractures because of pore pressure increase in deeply buried terranes.

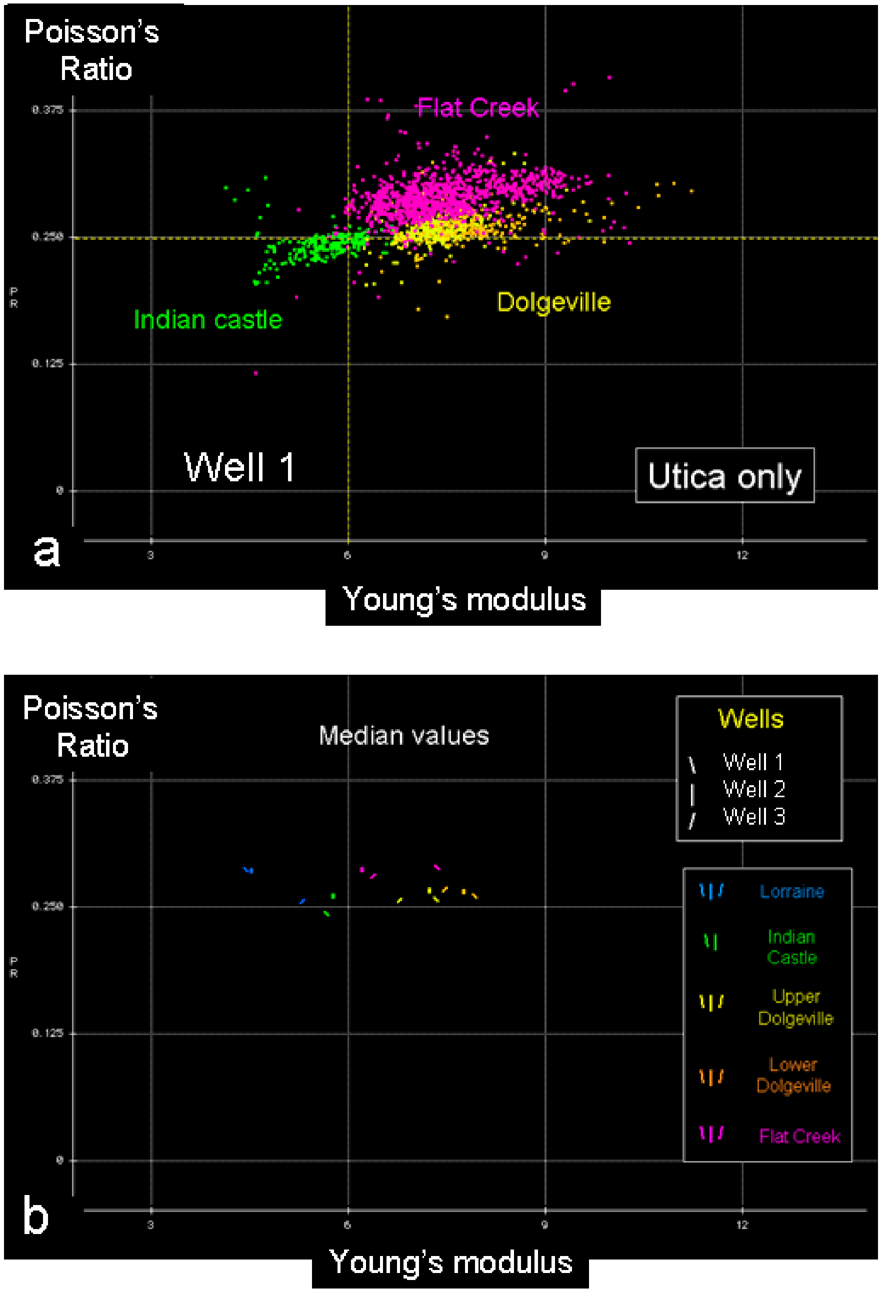


Figure 3. Dynamic brittleness indices derived from wireline logs in a) one well and b) per Utica member in three wells.

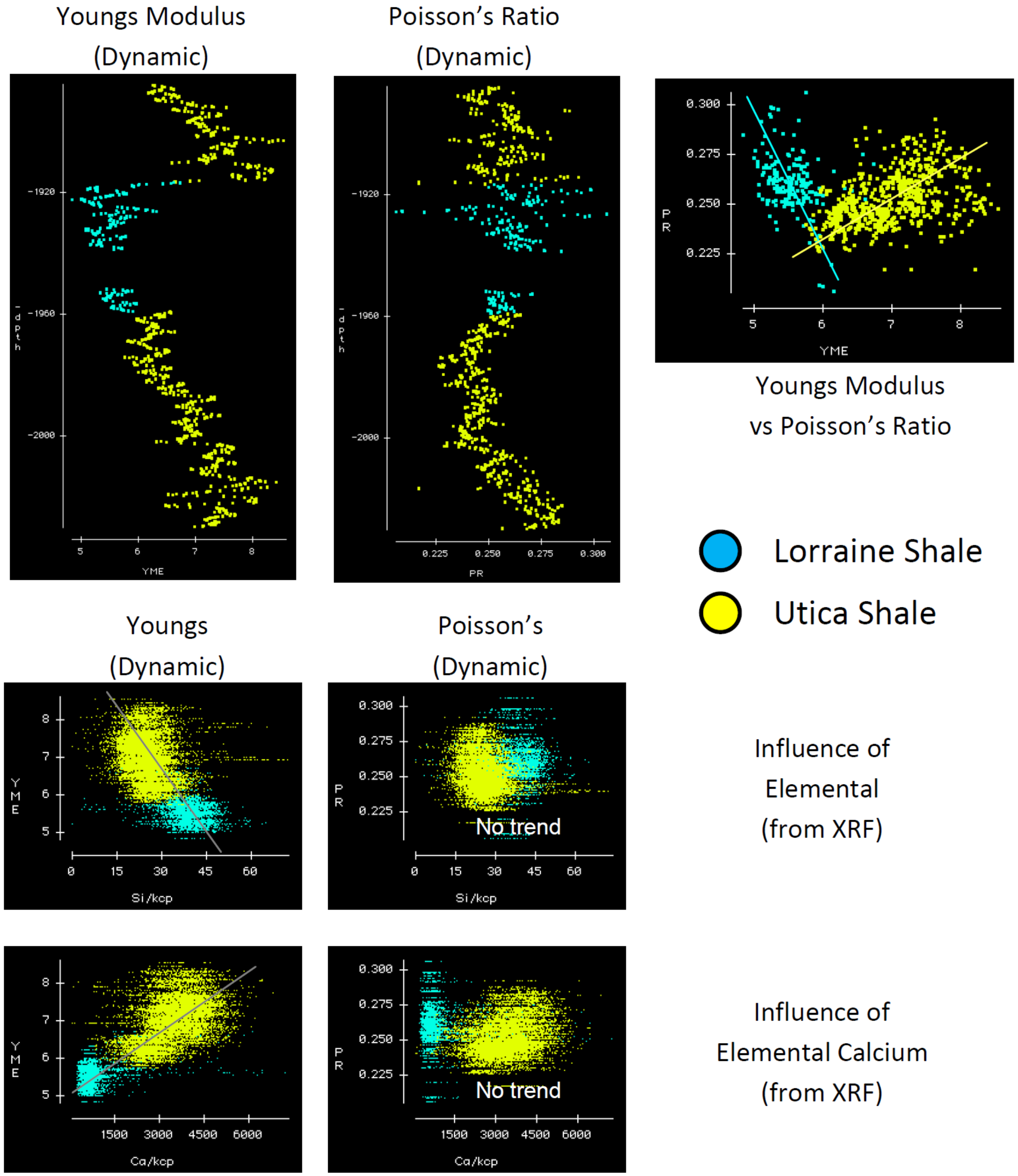


Figure 4. Wireline log based dynamic brittleness indices from a Quebec well.

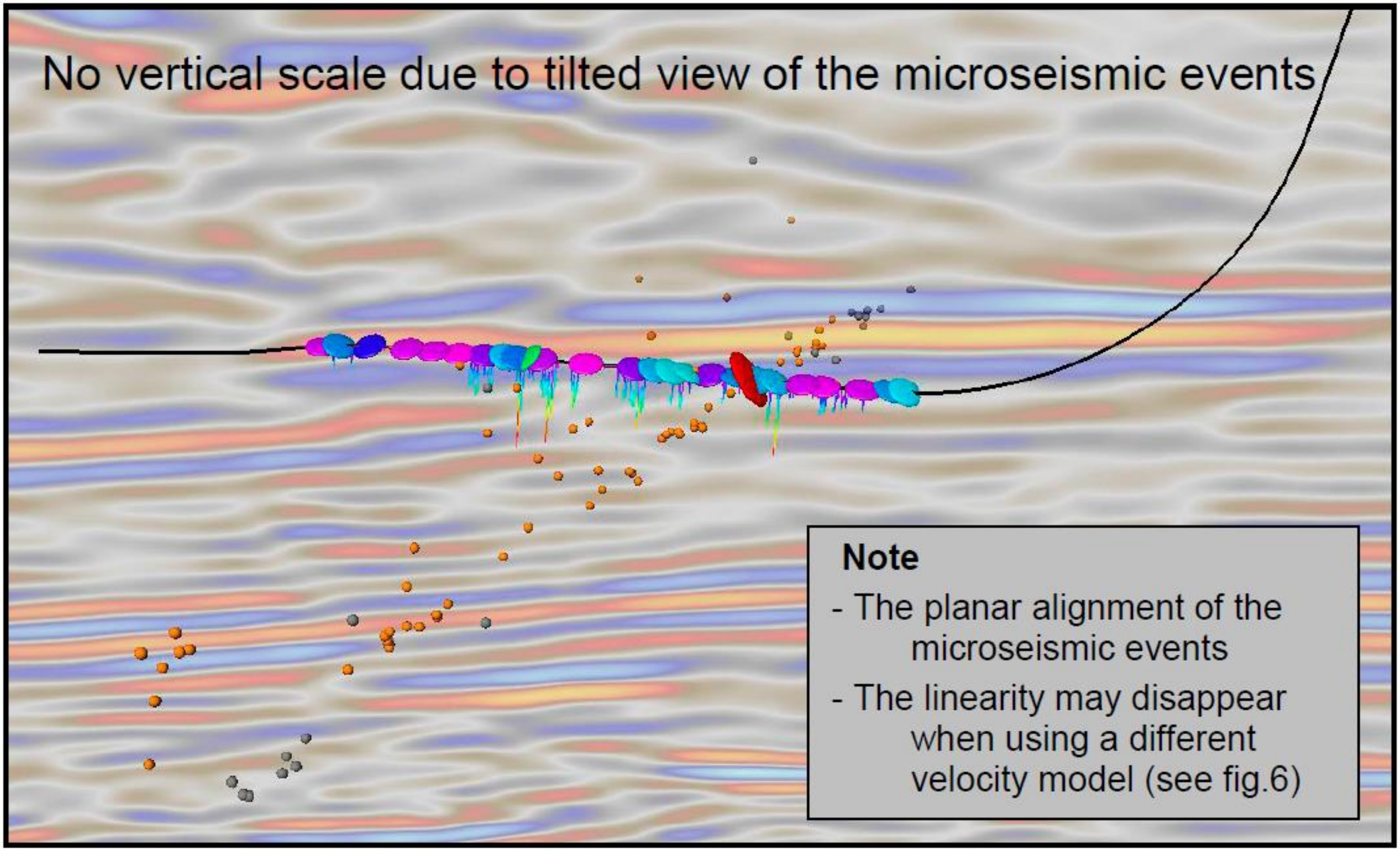
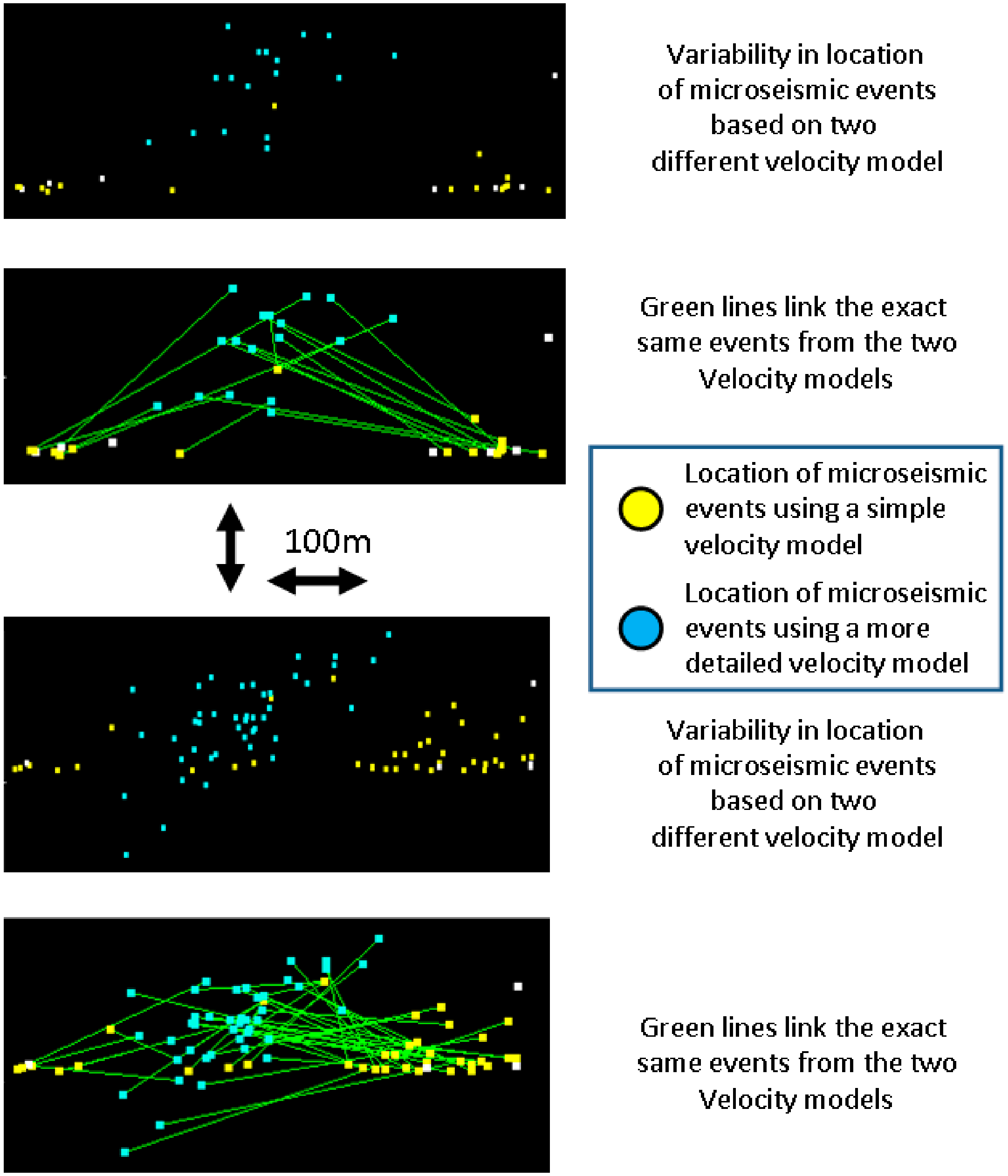


Figure 5. Integrating fractures from image log and the microseismic events from two fracture stages in one Quebec Utica well; 3D image orientation to emphasize linearity of microseismic events.



Variability in location of microseismic events based on two different velocity model

Green lines link the exact same events from the two Velocity models

● Location of microseismic events using a simple velocity model

● Location of microseismic events using a more detailed velocity model

Variability in location of microseismic events based on two different velocity model

Green lines link the exact same events from the two Velocity models

Figure 6. On the extreme importance of having a good velocity model to get a reliable XYZ event location (based on microseismic data from two stages in the same horizontal well in Quebec).