Importance of Recognizing Open Fracture Networks When Estimating Shale Gas Reserves — A Geochemical and Microseismic Perspective*

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Search and Discovery Article #80540 (2016)**
Posted August 1, 2016

*Adapted from oral presentation given at AAPG Annual Convention and Exhibition, Calgary, Alberta, Canada, June 19-22, 2016
See similar article Search and Discovery Article #120183 (2015)

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Abstract

It is important to be able to estimate the volume of shale drained that is associated with a borehole or with a hydraulic stage. The Stimulated Rock Volume (SRV) is commonly based on fitting the microseismic events within an envelope, however, it is semi-quantitative and rely on many assumptions that may not apply to every well hydraulically fracked. Abnormal absence of microseismic events in the vicinity of a horizontal borehole has been observed in various basins. In some cases, the lack of events is linear in nature and corresponds to a vertical fractured zone. In other cases it is more complex as seen in the Montney of the Altares Field; in this field three wells of a pad showed all of the events of some frac stages, 200 meters down from the borehole and within the Belloy, the underlying formation. The critical observation comes from the production log which clearly indicates that 92% of the production comes from the stages where no microseismic events have been recorded in the Montney. The solution to the problem came from the gas composition acquired using a chromatograph: the zones devoid of microseismic events clearly show a gas bimodality, one corresponding to the background gas, the other interpreted to be a dryer gas present in the open fracture system. Thus, geochemistry can give essential information related to the rock fabric; in this case, the presence of open fractures. Moreover, a new type of display involving produced gas geochemistry has brought a new way of looking at shale gas fields and to the rock volume drained. The new approach invokes simultaneously gas composition (C3+/C1+) against carbon isotopes of the ethane or propane if available or against iC4/nC4 in the absence of isotope data. The trends observed through time, for the same wells, are clearly linked to a stimulated rock volume that can be quantified after a simple normalization with respect to the volume produced. That new method can also clearly identify any well interference. This method has been tested successfully on other large shale data sets from various basins and should be kept in mind in field development planning and reserve estimates. Any frac design should take into account the existence of open fractures seen along a borehole through gas chromatography or mass spectroscopy. Plugs between frac stages should attempt to separate open fractured zones from non-fractured ones. It may be wise to first naturally deplete these intervals and fracture them later.

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AAPG Annual Convention & Exhibition 2016

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Acknowledgments

The author would like to thank

Progress Energy Canada Ltd

Sasol Canada Holdings Ltd

For permission to present this work

Presentation Outline

Introduction

Published abnormal microseismic patterns

Montney shale case study (Altares Field, B.C.)

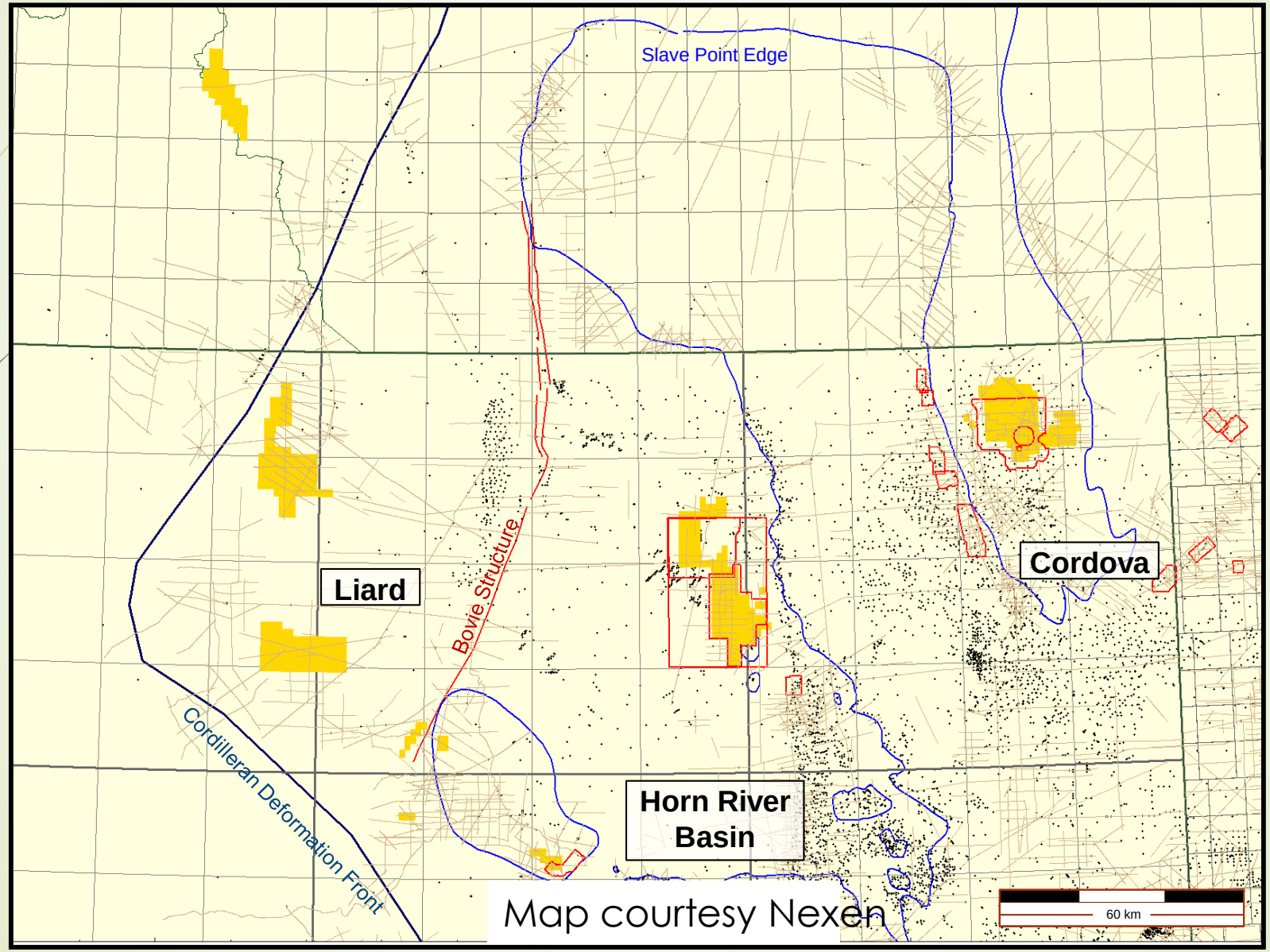
Map view and 3-D views
Microseismic merged with Chromatography
Identification of open fractures

Composition and isotopic changes through production time

A new SRV approach
Signature of open fracture domains

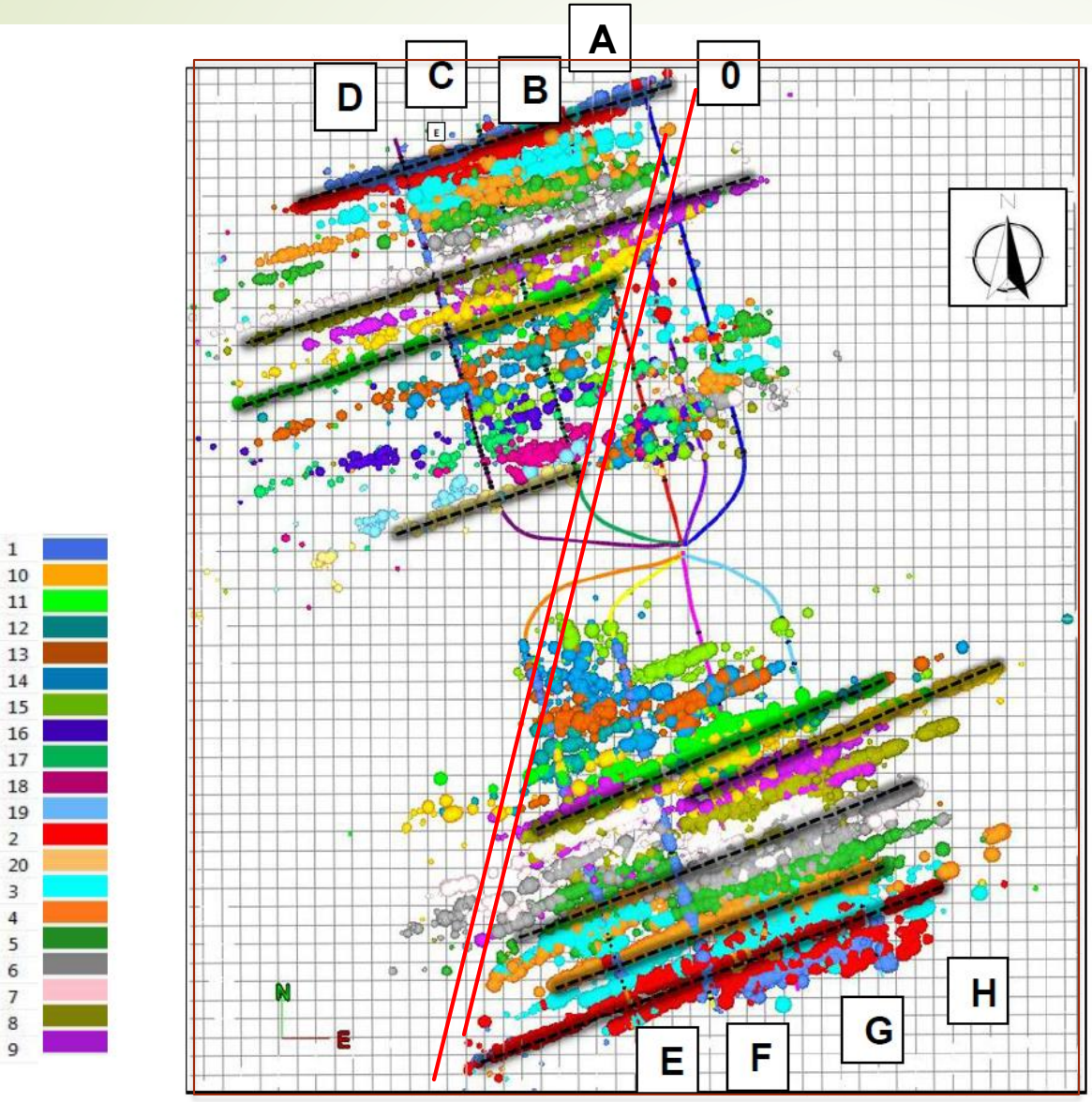
Conclusions

BC Basins - an Overview



Map courtesy Nexen

Subseismic Fault Seen by Microseismic



in North-East BC

Map alignment of absence of Microseismic events

The structural feature is subvertical

It is on a NNE-SSW lineament

Such direction is very common in the Western Canadian Sedimentary Basin (Chatellier, 1992, 2006, 2010...)

These lineaments correspond to subvertical open fracture systems rarely interpreted from seismic

After Ling and Barker, 2014

Case Study:

Montney Shale

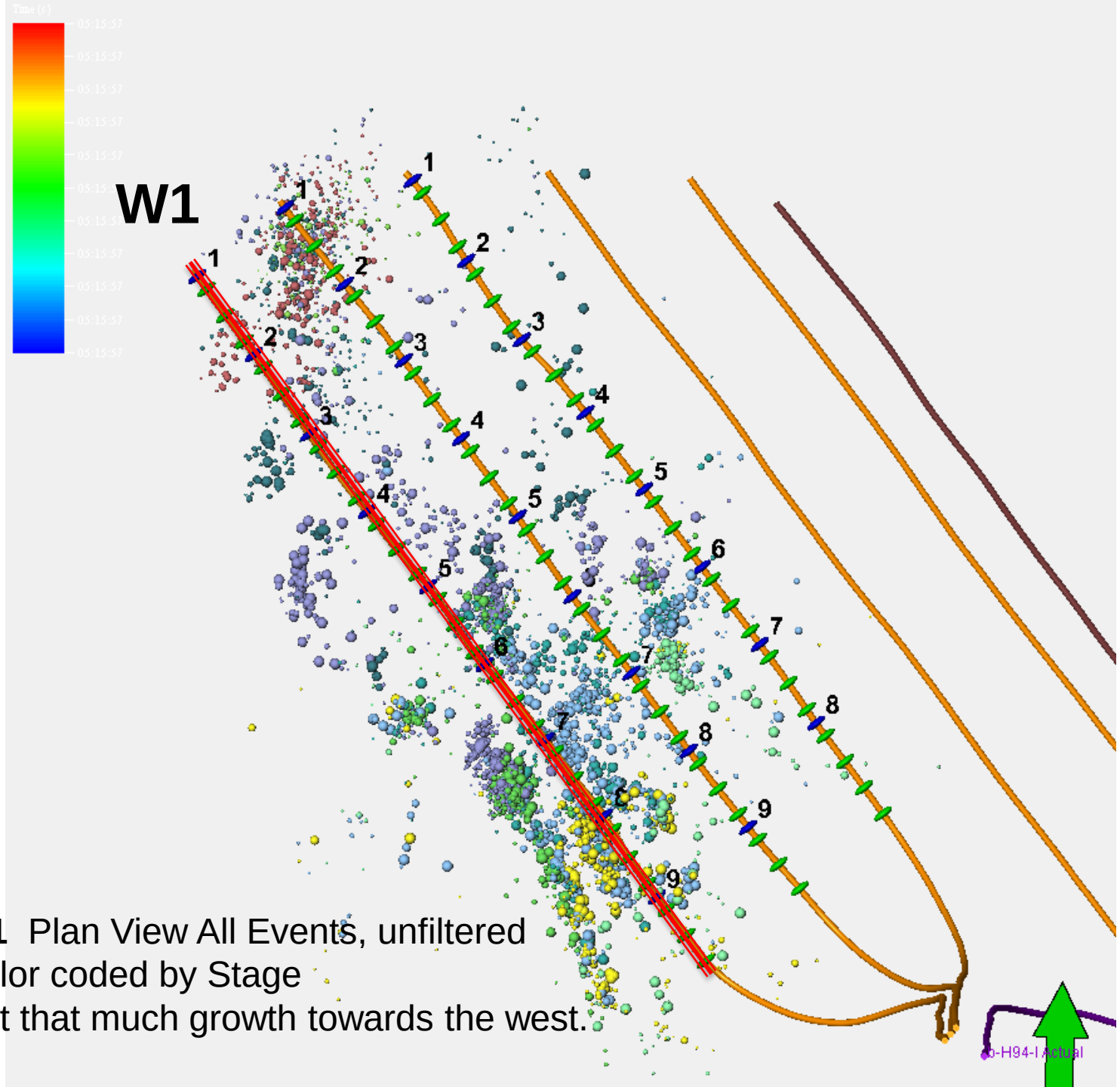
Altares Field, British Columbia

Single Pad Study

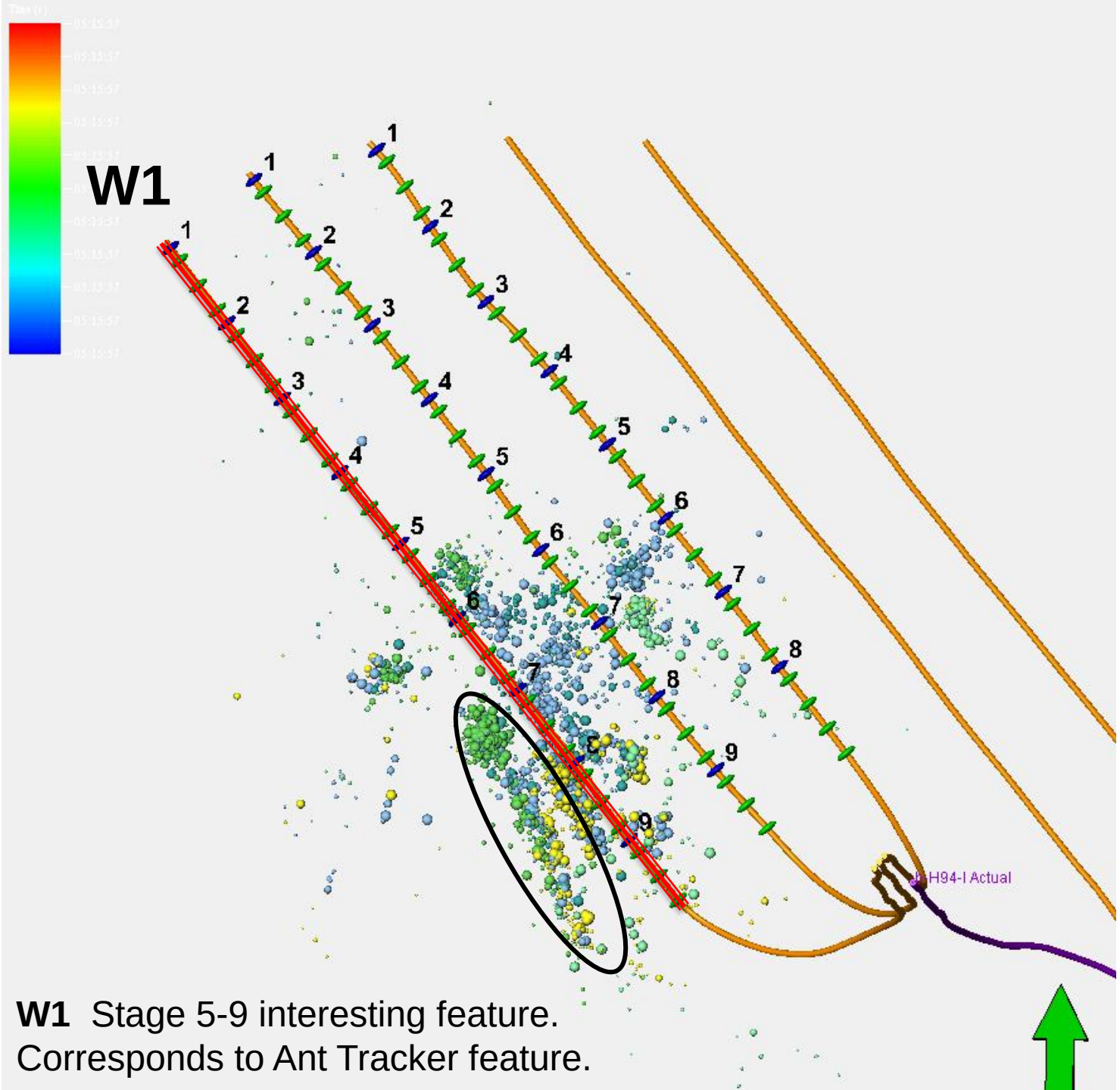
Montney Shale

Zipper Frac

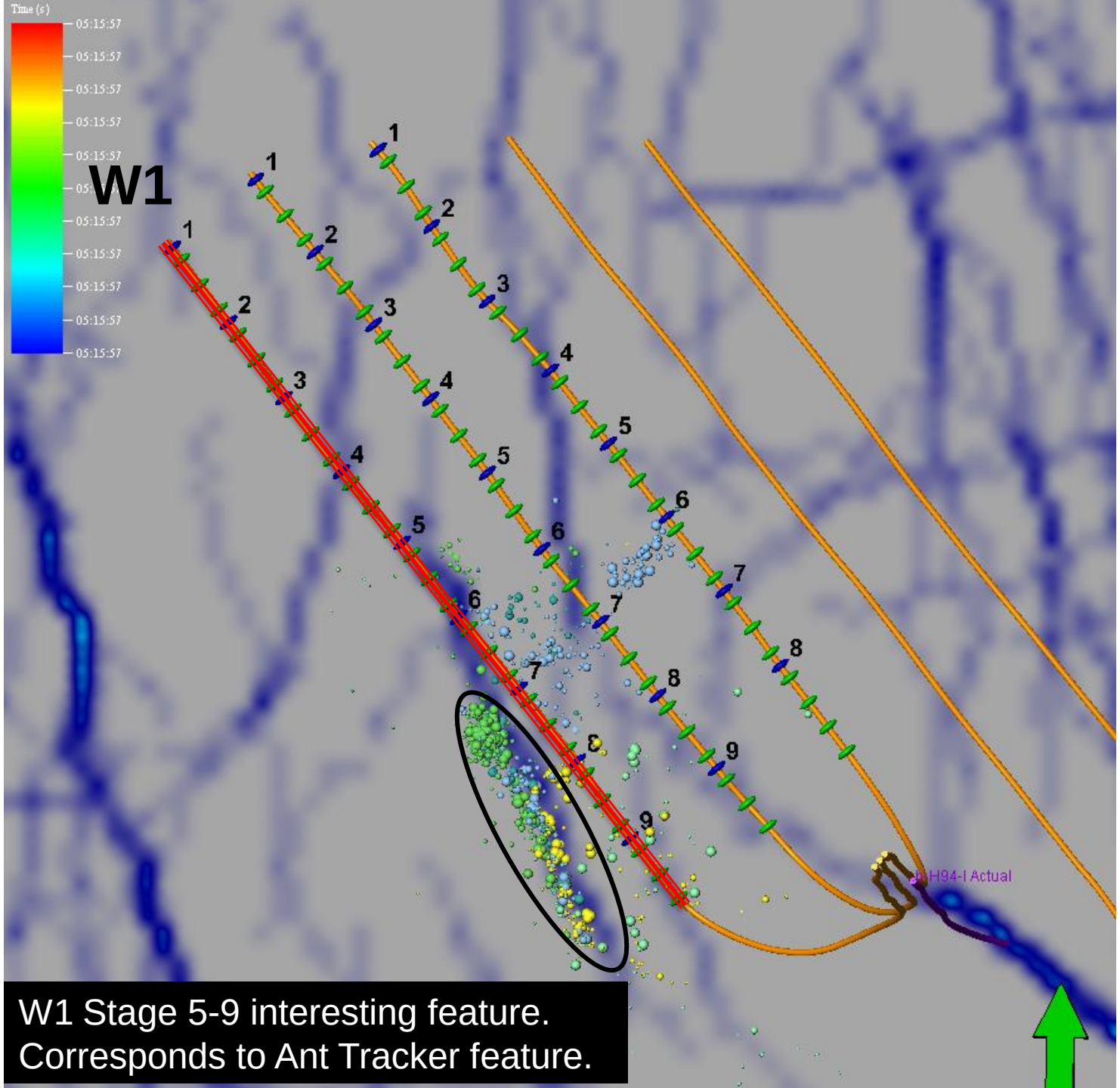
Map view



W1 Plan View All Events, unfiltered
Color coded by Stage
Not that much growth towards the west.



W1 Stage 5-9 interesting feature.
Corresponds to Ant Tracker feature.



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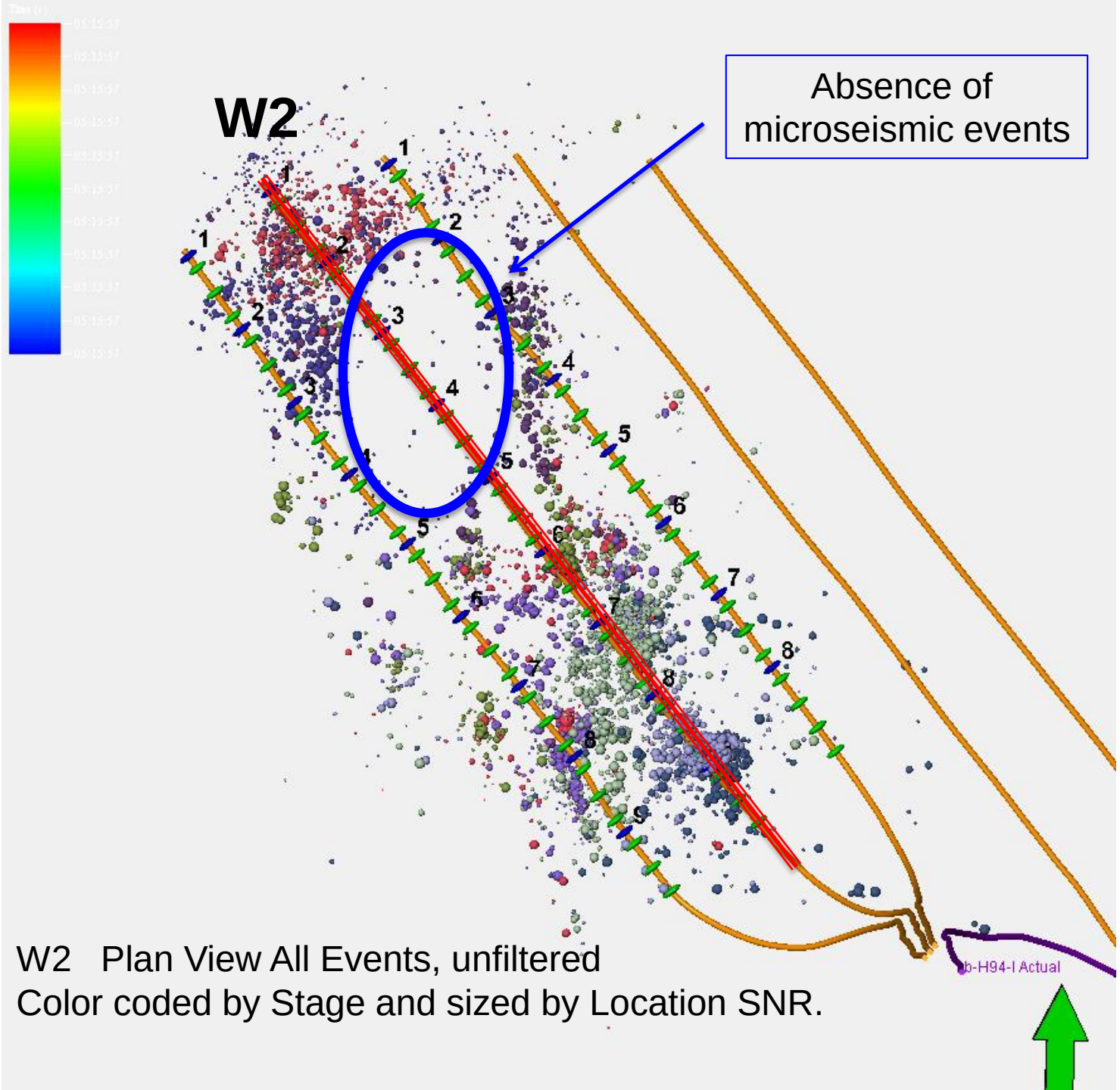
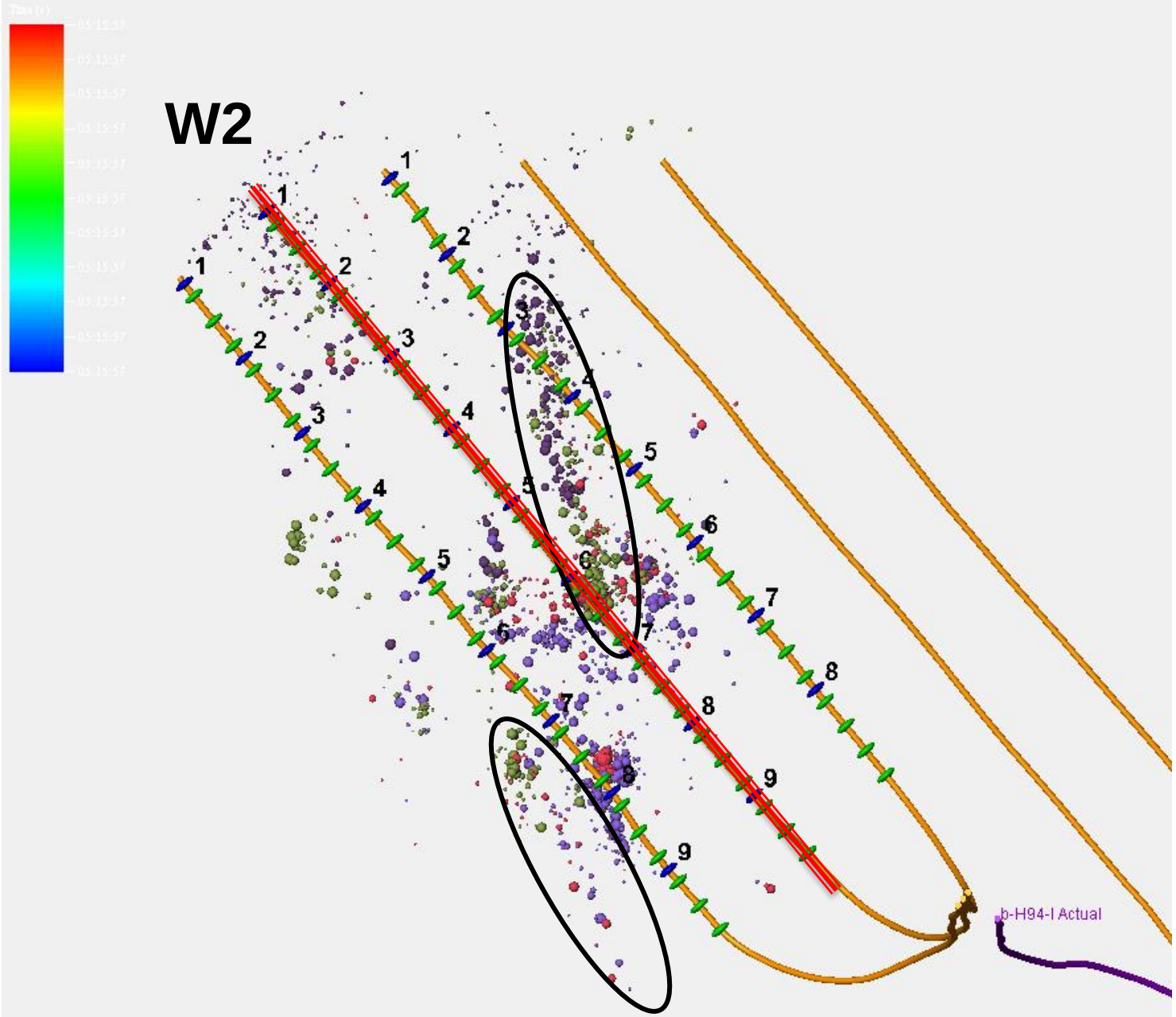
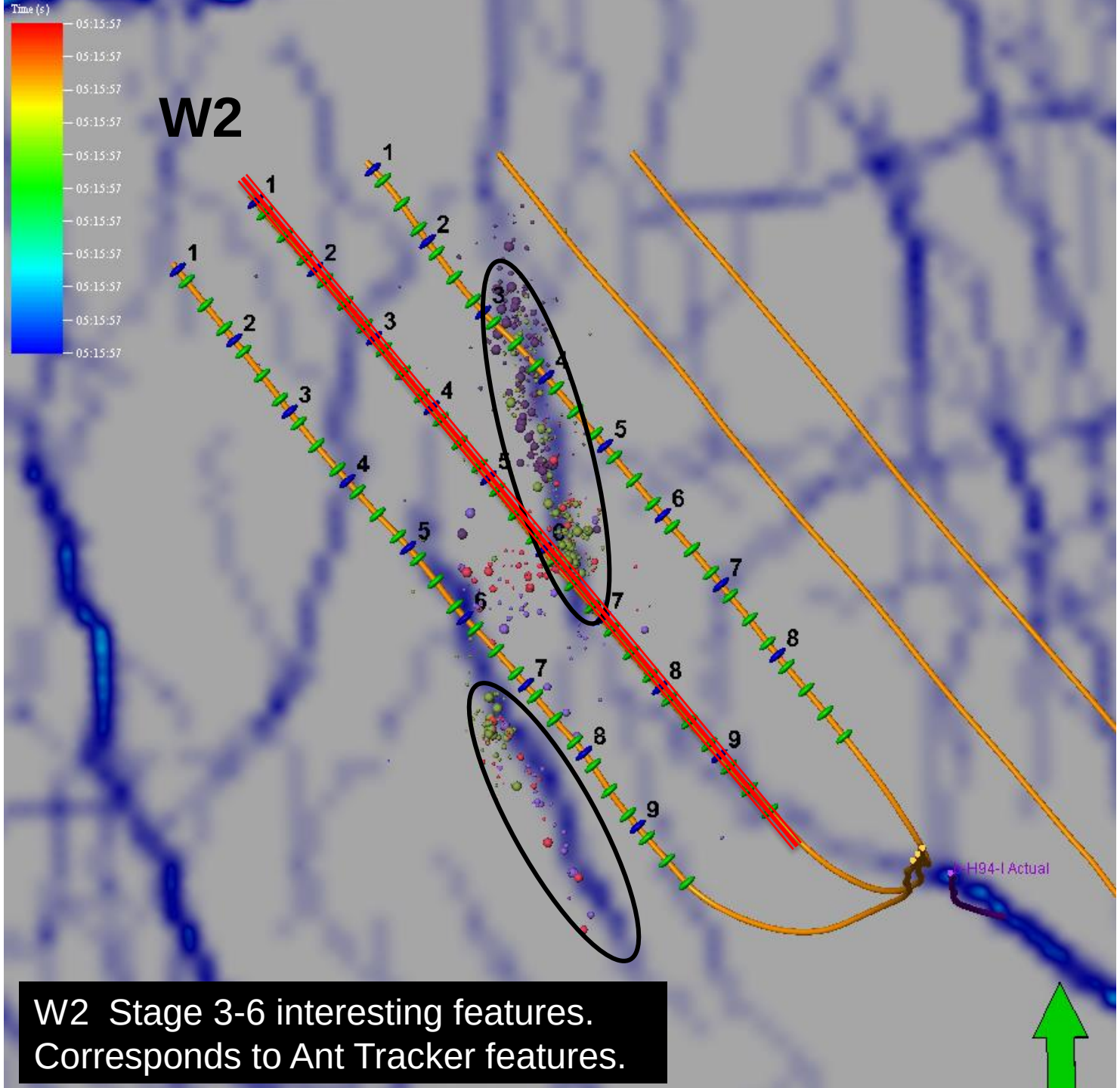


W2 Plan View All Events, unfiltered
Color coded by Stage and sized by Location SNR.



W2 Stage 3-6 interesting features.
Corresponds to Ant Tracker features.



W2 Stage 3-6 interesting features.
Corresponds to Ant Tracker features.

Major Faults

=

Linear pattern of microseismic events

But

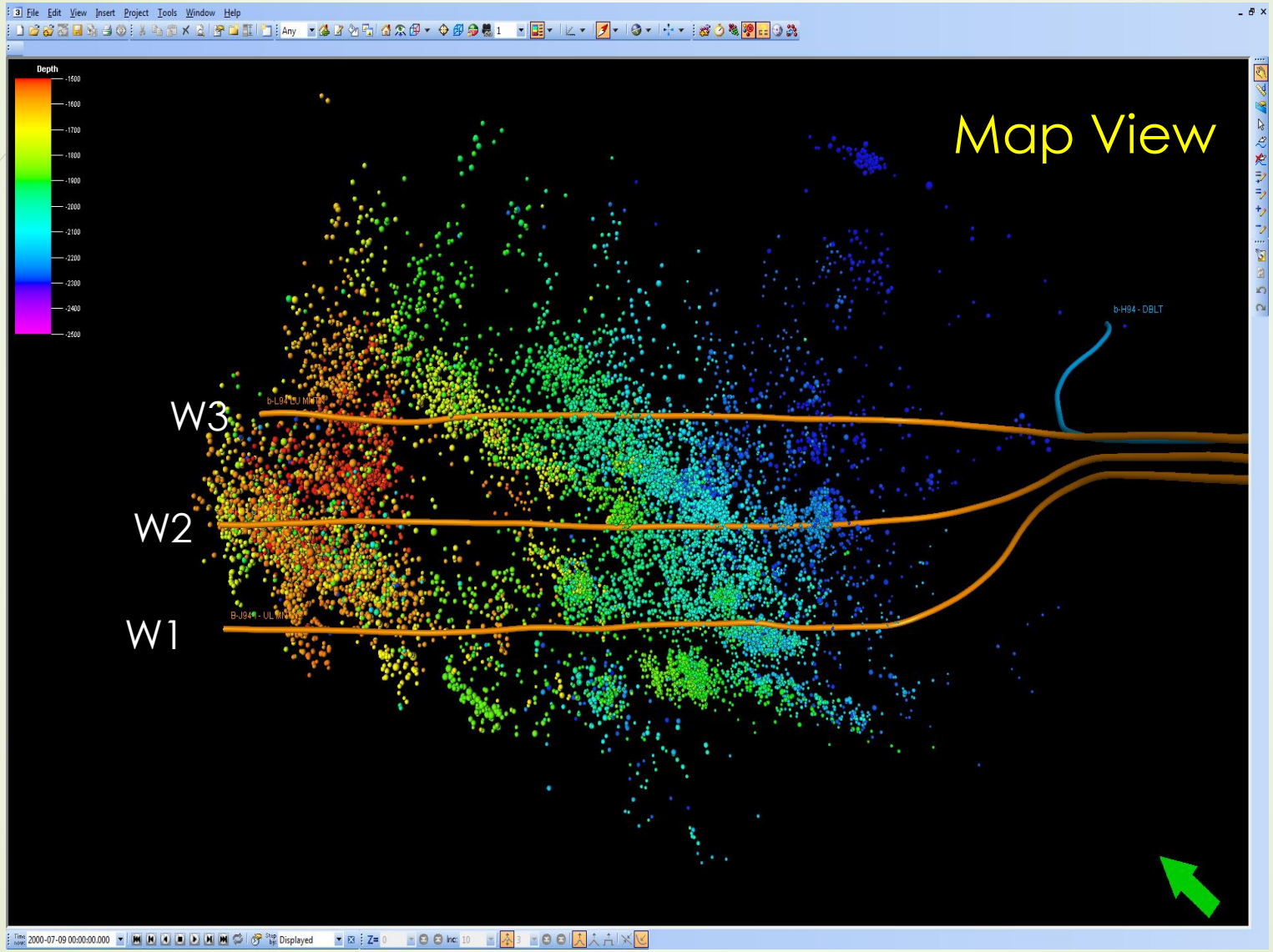
What about the absence of events?

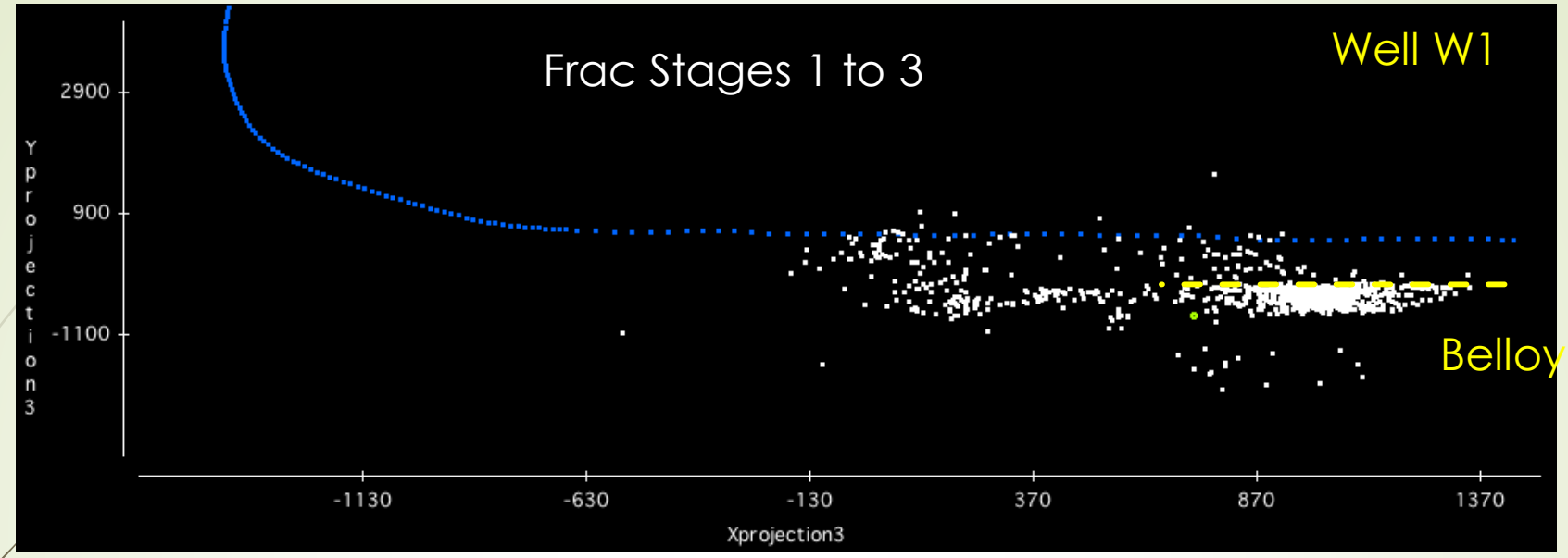
Single Pad Study

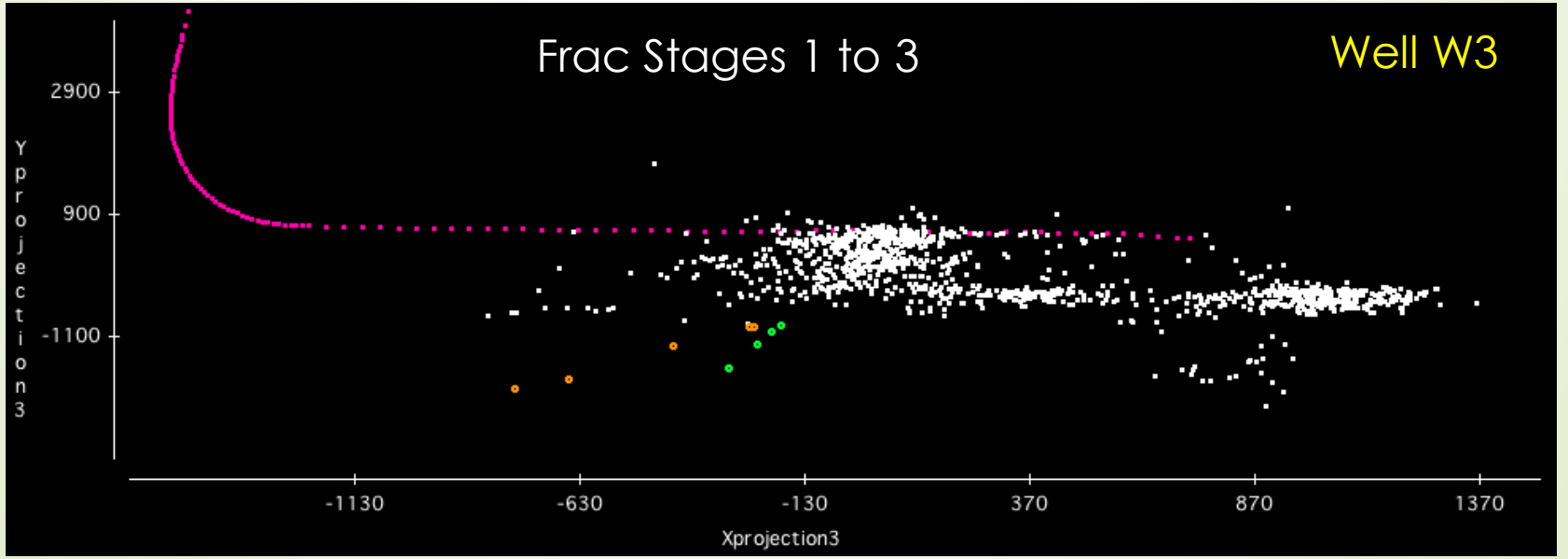
Montney Shale

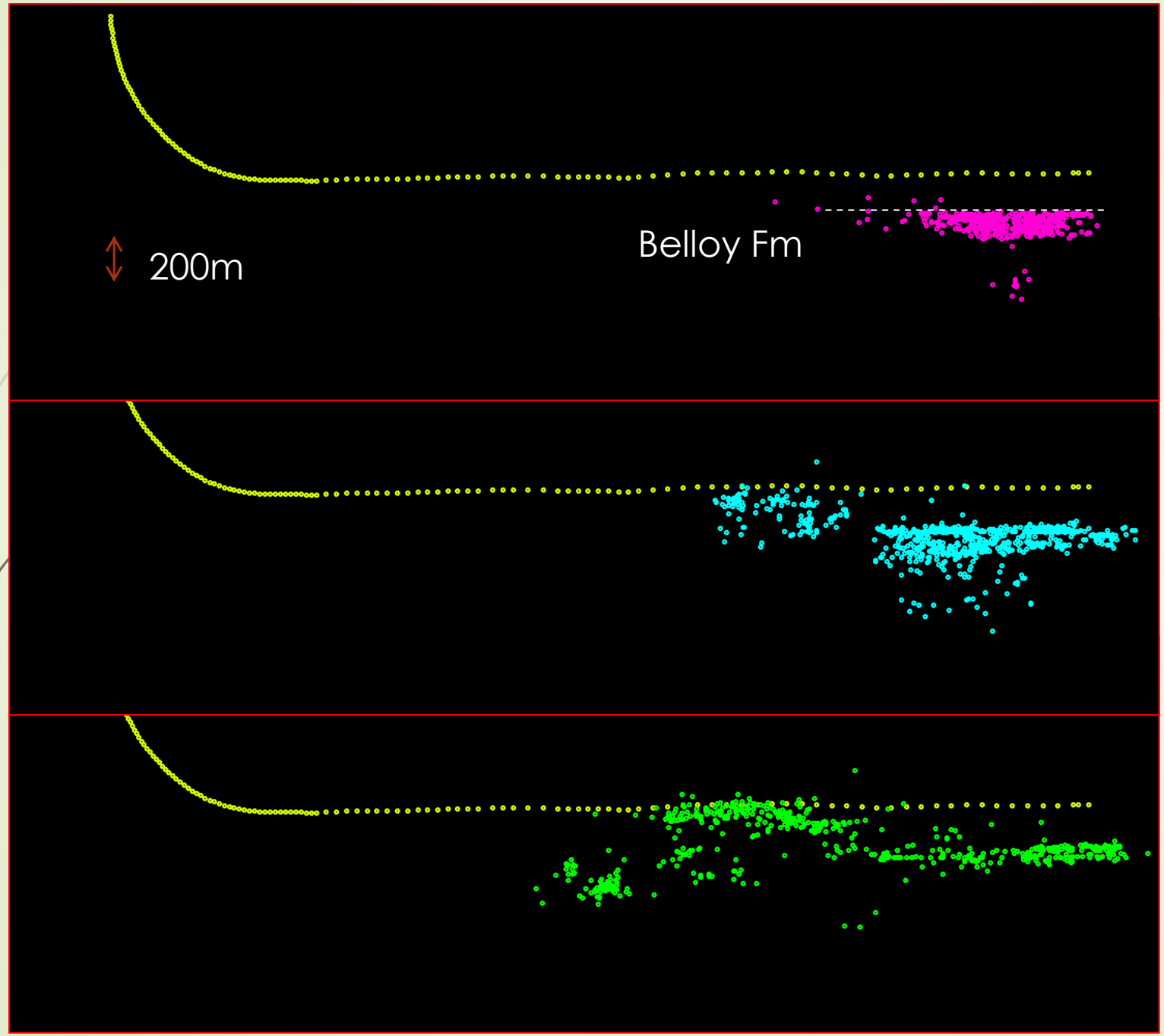
Zipper Frac

3-D view


Map View
Depth
-1500
-1600
-1700
-1800
-1900
-2000
-2100
-2200
-2300
-2400
-2500
W3
W2
W1
b-H94 - DBLT


Frac Stages 1 to 3
Well W1
Belloy
2900
900
-1100
Yprojection3
-1130
-630
-130
370
870
1370
Xprojection3


Frac Stages 1 to 3
Well W3
2900
900
-1100
Yprojection3
-1130
-630
-130
370
870
1370
Xprojection3



Well W2

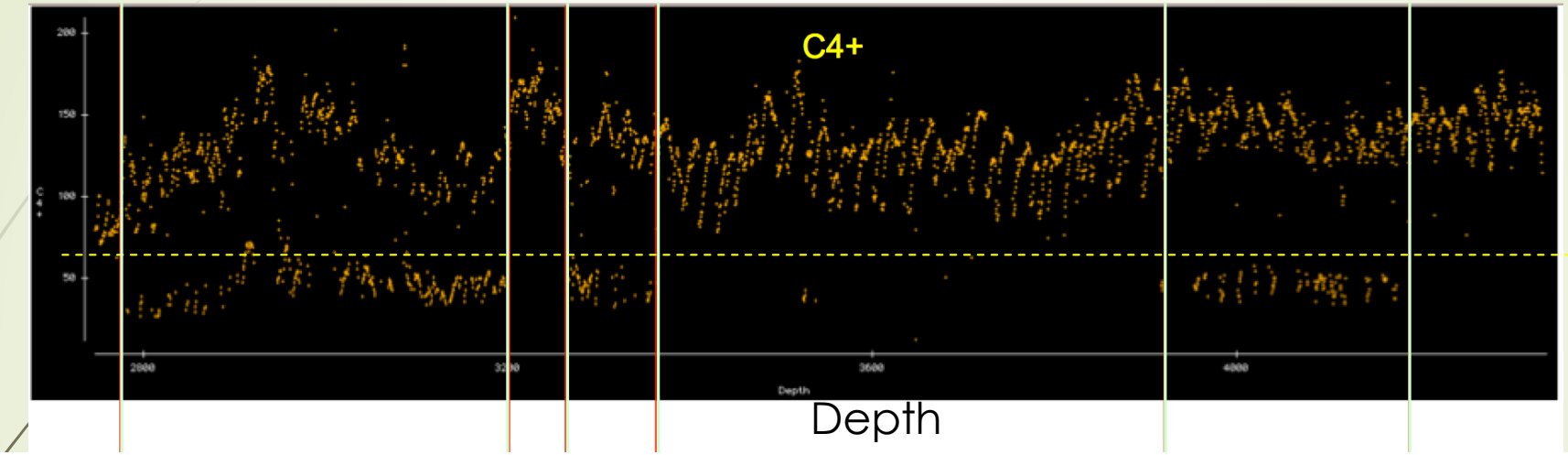
Stage 1

Stage 2

Stage 3

Chromatography in Well W2

Measurements every 0.5 m



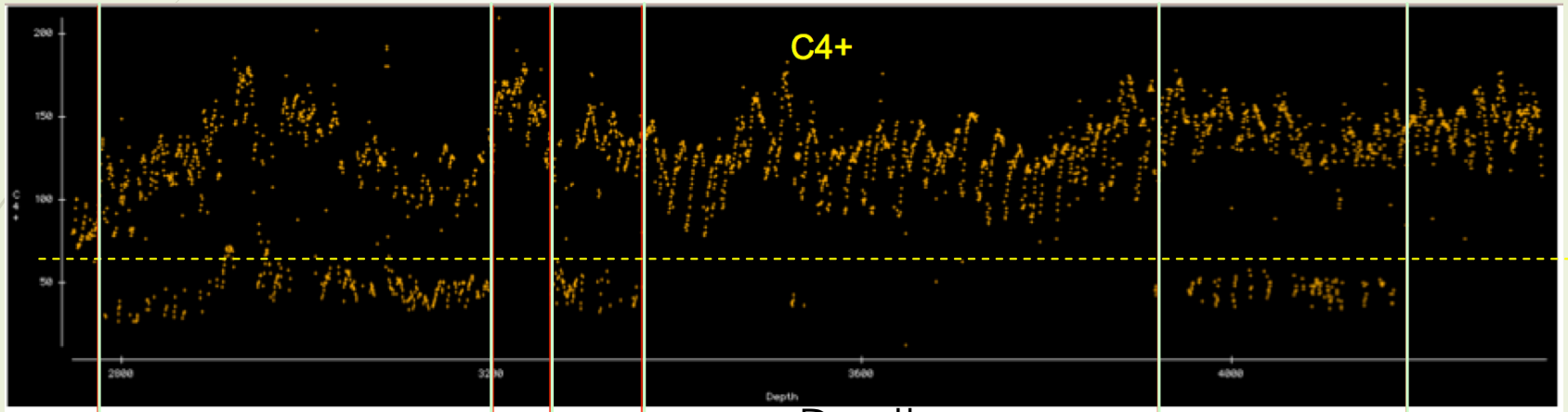
Wetter Gas

Dry Gas

Depth

Chromatography in Well W2

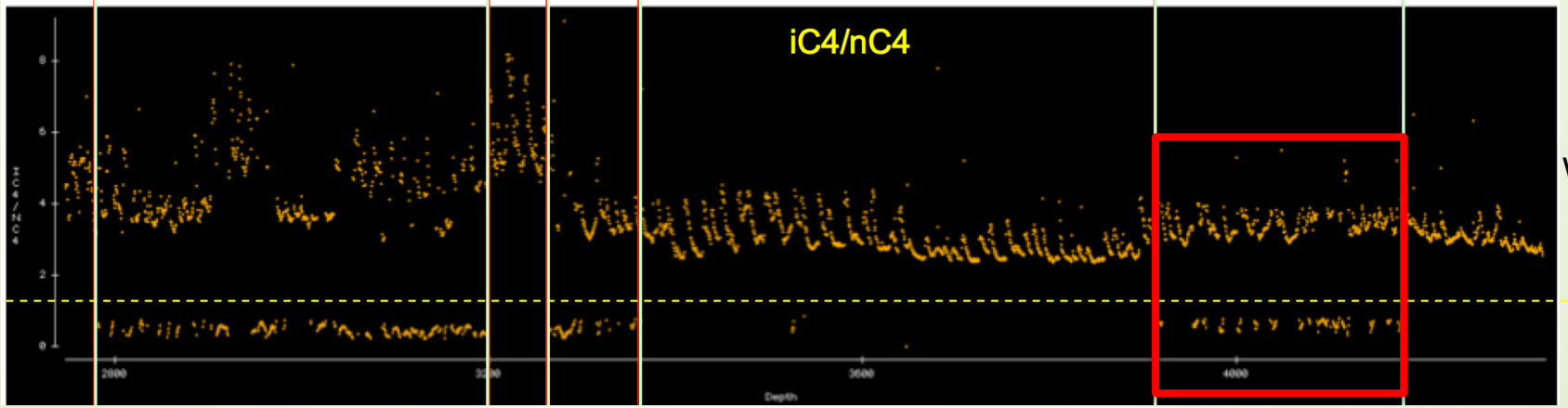
Measurements every 0.5 m



Wetter Gas

Dry Gas

Depth



Wetter Gas

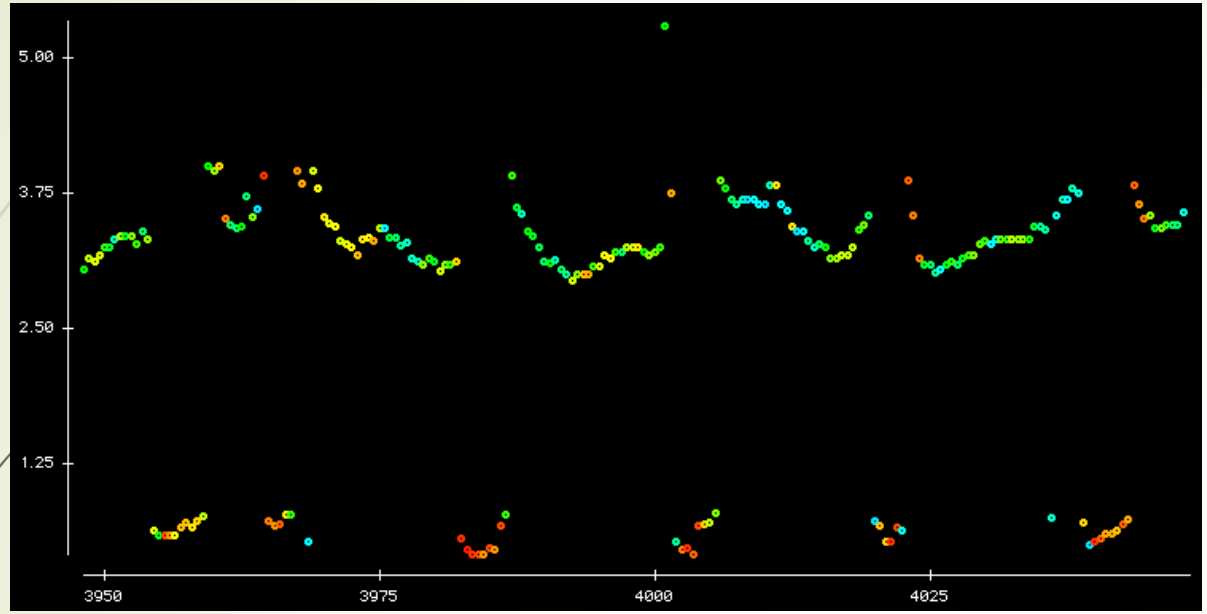
Dry Gas

Depth

Zoomed view of Gas Bimodality

Measurements every 0.5 m

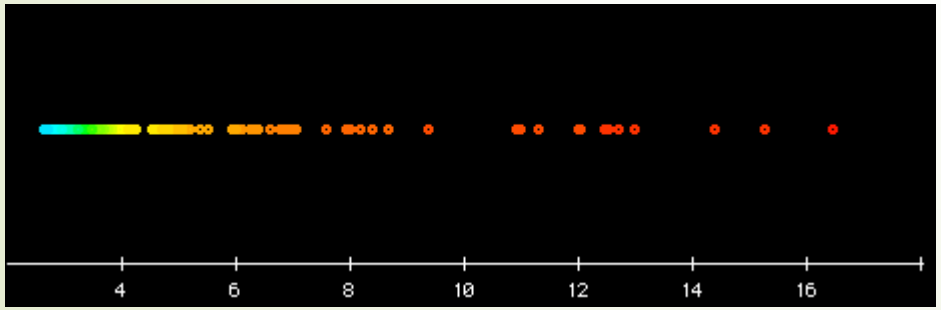
iC4/nC4



Depth

"unfractured" intervals associated with lower ROPs

Intervals with **open fracture** with higher ROP



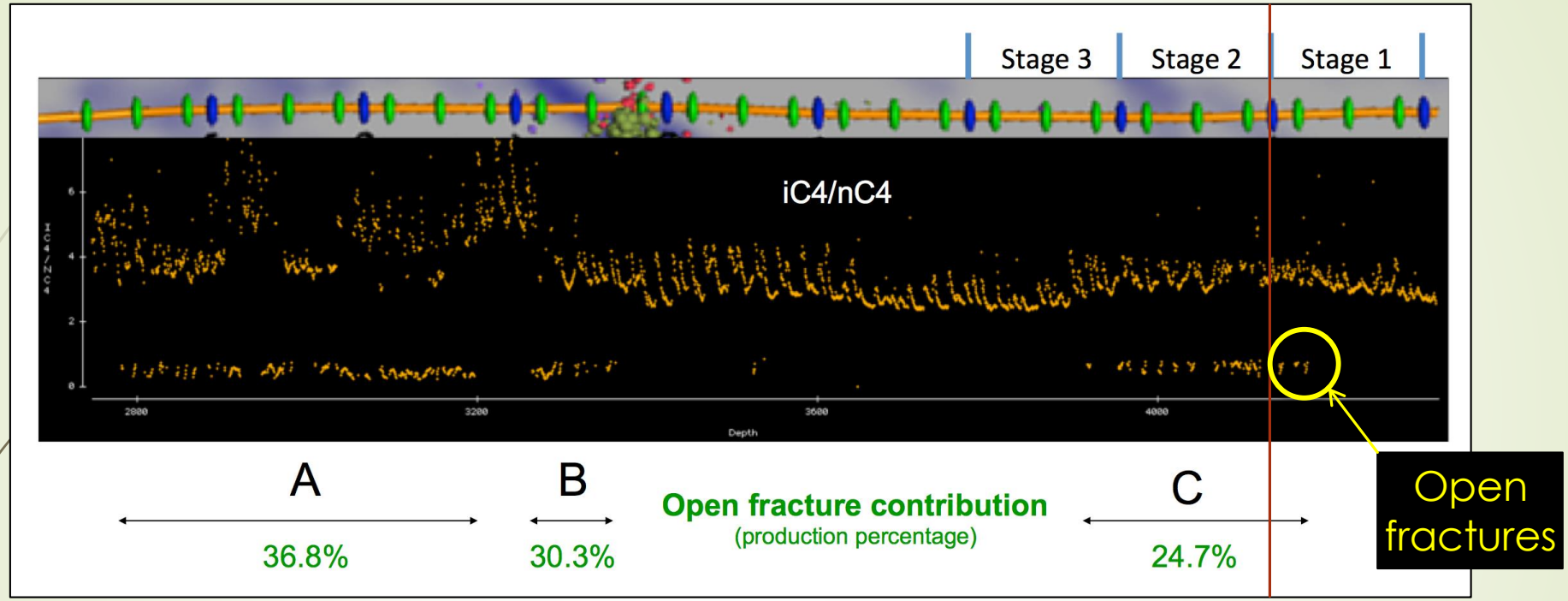
Color = ROP (meter/hour)

1 meter spacing between each gas chromatography measurement

Open fractured intervals: **3 to 5m** wide

Gas Bimodality in Well W2

Measurements every 0.5 m



When bimodal,
One gas corresponds to the gas from the matrix
One gas corresponds to the gas composition from the open fractures

Stage one has encountered open fractures that diverted the frac placement with no events recorded in that stage

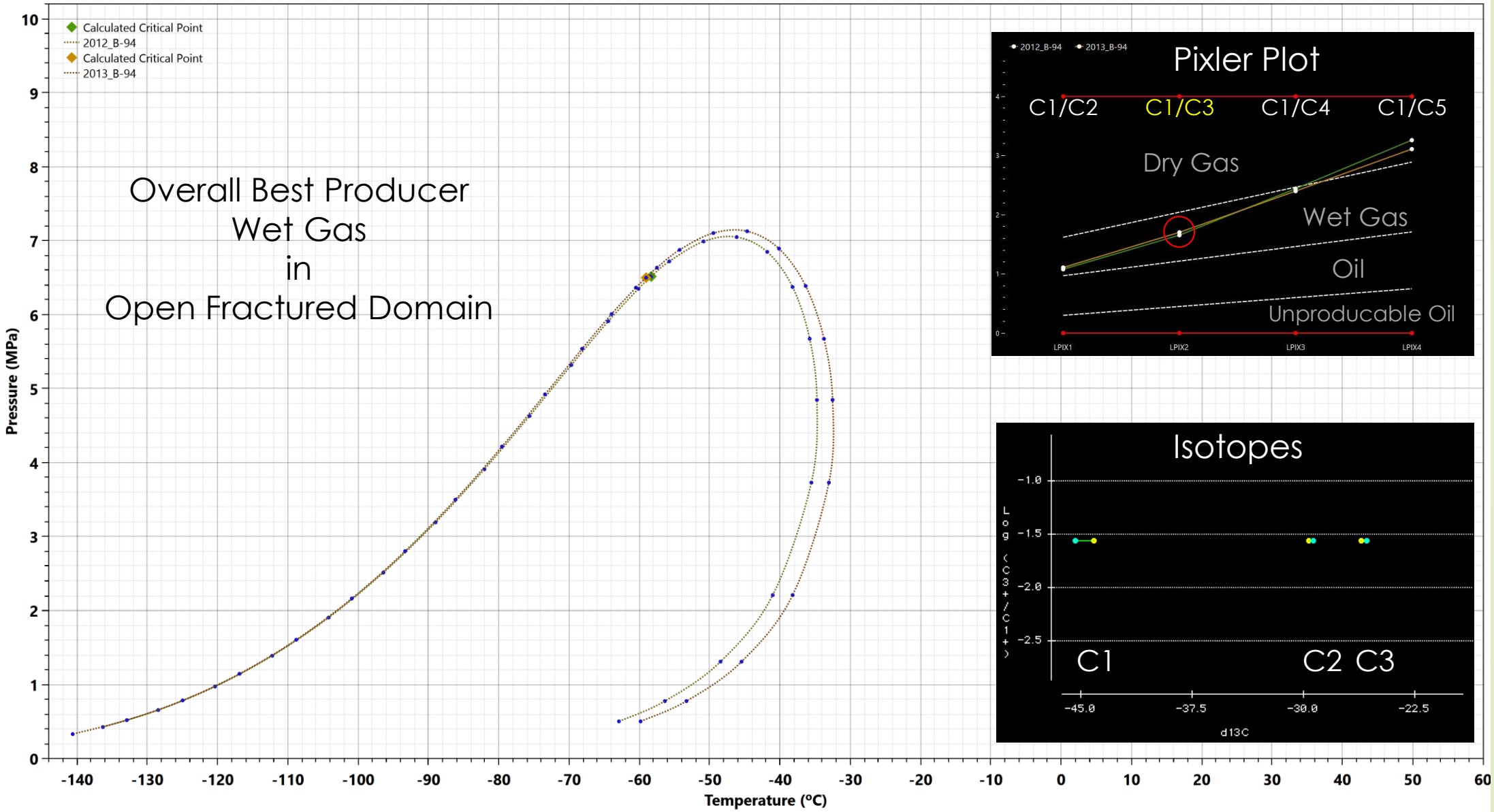
Some geochemical views of open fracture systems from the studied pad

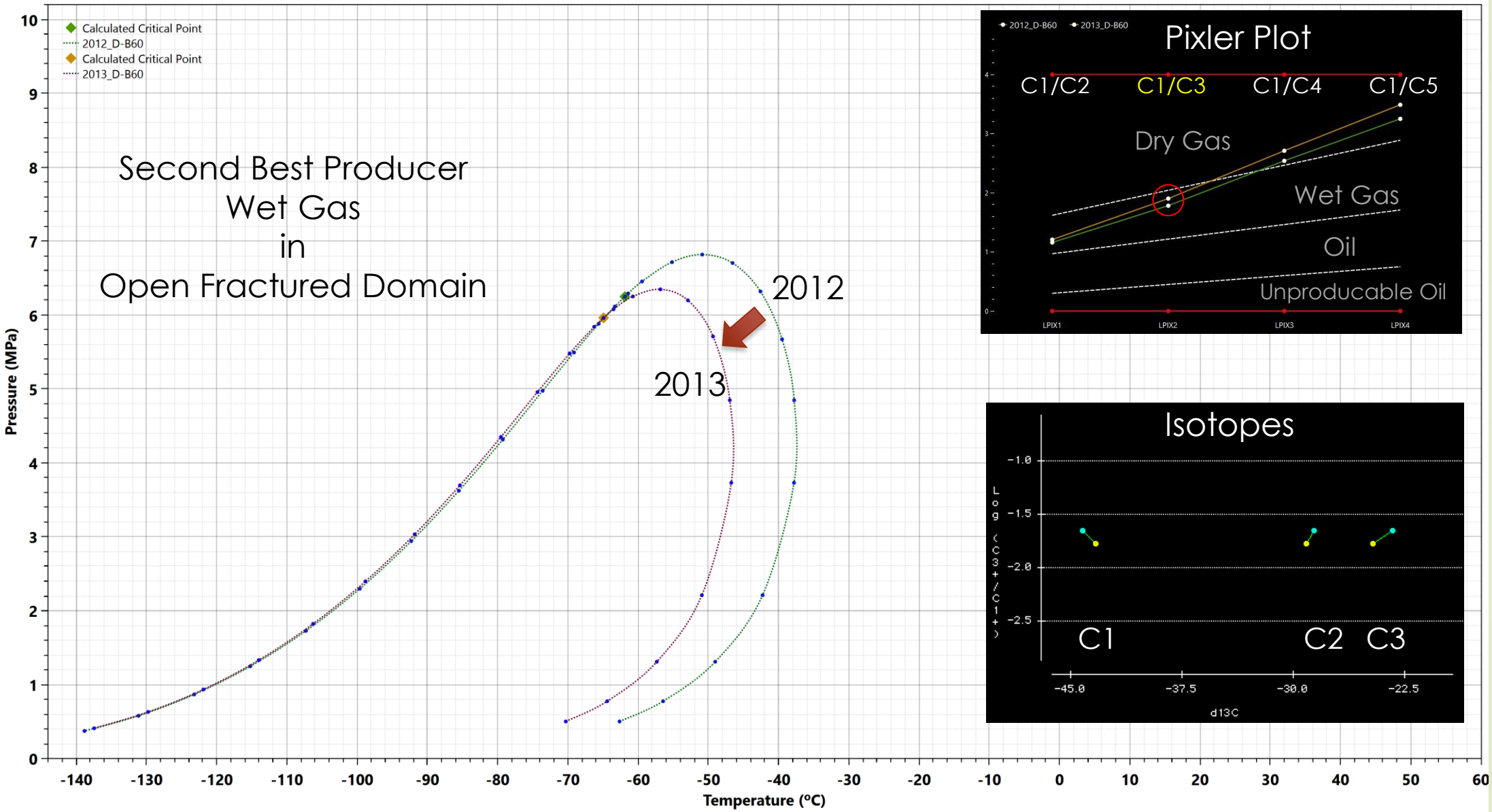
Data from Feb 2012 and May 2013

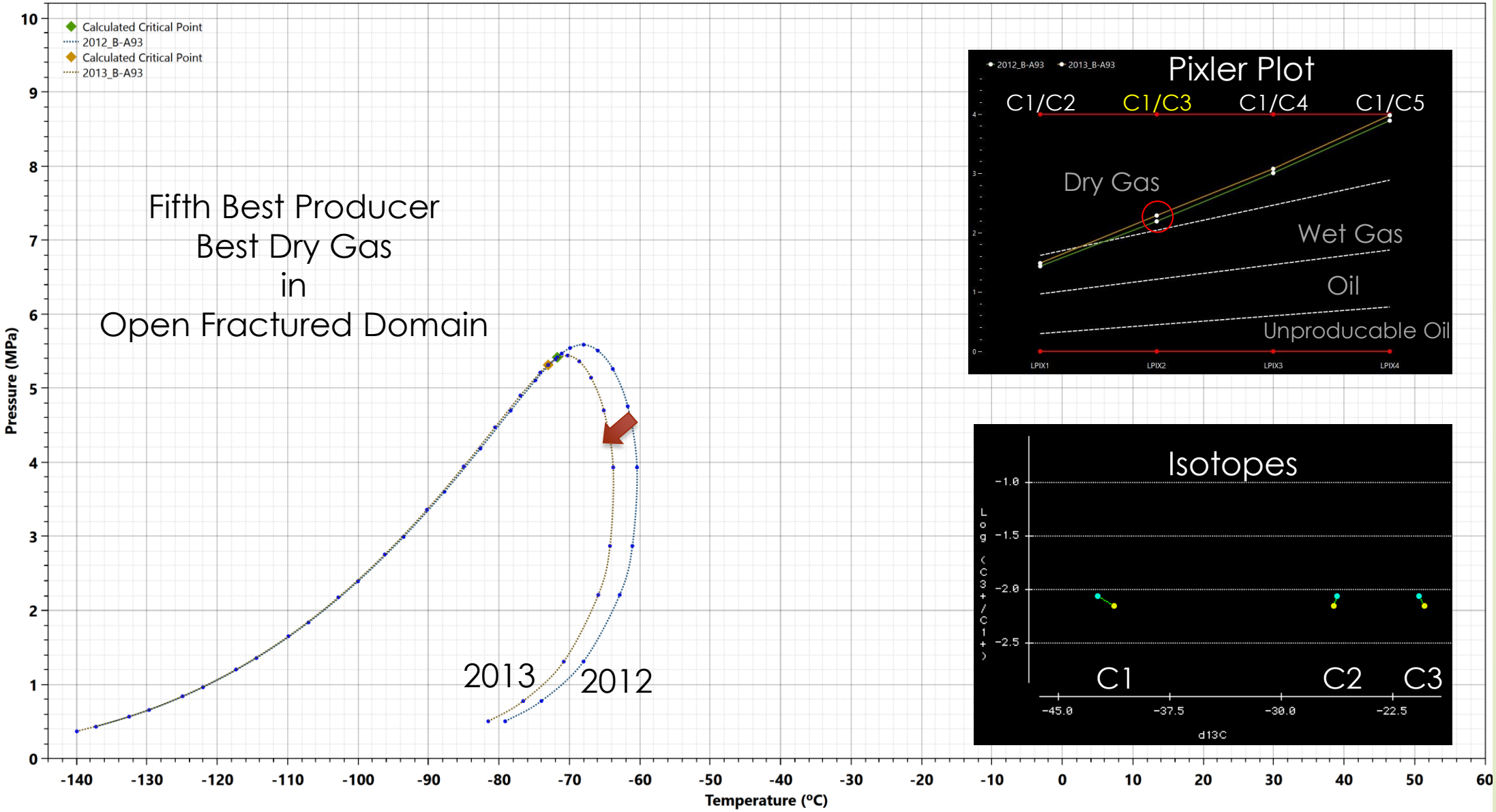
Phase envelopes

Pixler Plots

Carbon isotopes


Calculated Critical Point
2012_B-94
Calculated Critical Point
2013_B-94
Overall Best Producer
Wet Gas
in
Open Fractured Domain
Pressure (MPa)
Temperature (°C)
Pixler Plot
2012_B-94
2013_B-94
C1/C2
C1/C3
C1/C4
C1/C5
Dry Gas
Wet Gas
Oil
Unproducable Oil
LPIX1
LPIX2
LPIX3
LPIX4
Isotopes
Log (C3+/C1+)
C1
C2 C3
d13C


Calculated Critical Point
2012_D-B60
Calculated Critical Point
2013_D-B60
Second Best Producer
Wet Gas
in
Open Fractured Domain
2012
2013
Pressure (MPa)
Temperature (°C)
Pixler Plot
2012_D-B60
2013_D-B60
C1/C2
C1/C3
C1/C4
C1/C5
Dry Gas
Wet Gas
Oil
Unproducable Oil
LPIX1
LPIX2
LPIX3
LPIX4
Isotopes
Log (C3+/C1+)
C1
C2
C3
d13C


Calculated Critical Point
2012_B-A93
Calculated Critical Point
2013_B-A93
Fifth Best Producer
Best Dry Gas
in
Open Fractured Domain
2013
2012
Pressure (MPa)
Temperature (°C)
Pixler Plot
C1/C2
C1/C3
C1/C4
C1/C5
Dry Gas
Wet Gas
Oil
Unproducable Oil
LPIX1
LPIX2
LPIX3
LPIX4
Isotopes
C1
C2
C3
d13C

Stimulated Rock Volume

A new approach using Geochemistry

Log (C3+/C1+)

iC4/nC4

C1 isotope

C2 isotope

C3 isotope

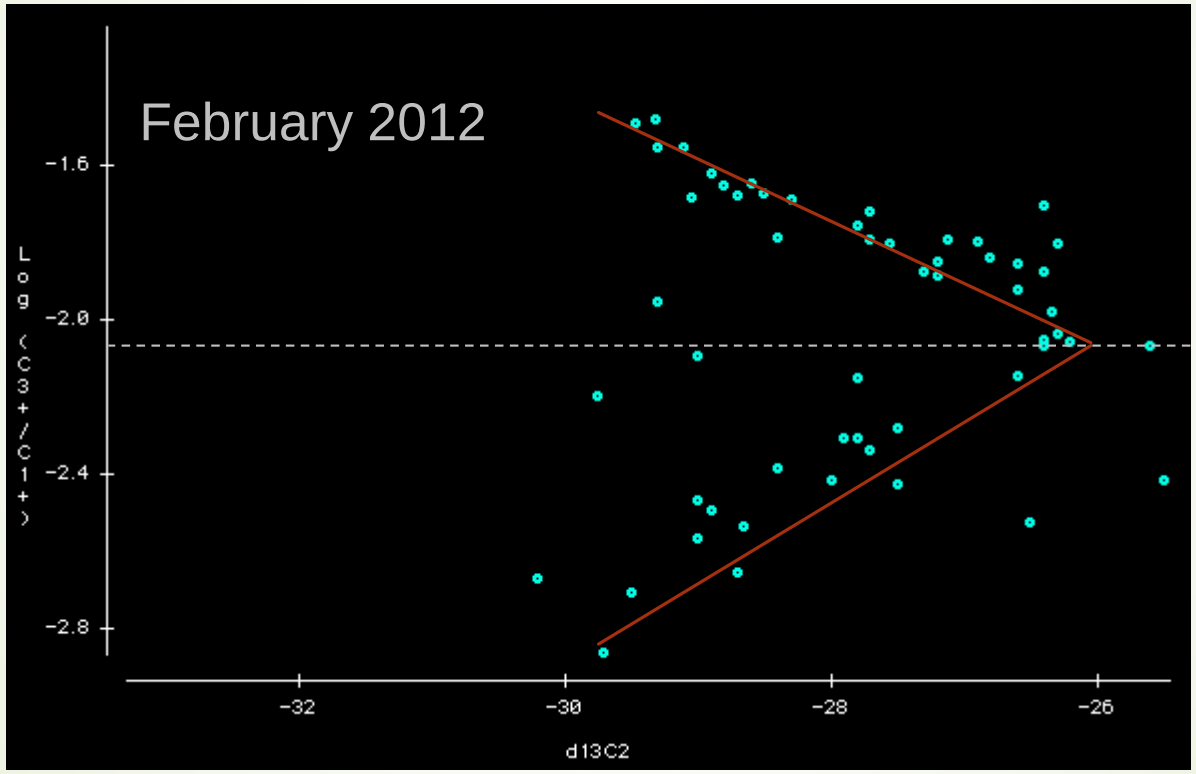
Produced Gas Composition

Wetness vs Ethane isotope

Log C3+/C1+

Wetter

Dryer



C2 Carbone isotope

Wet gas

Isotope reversal

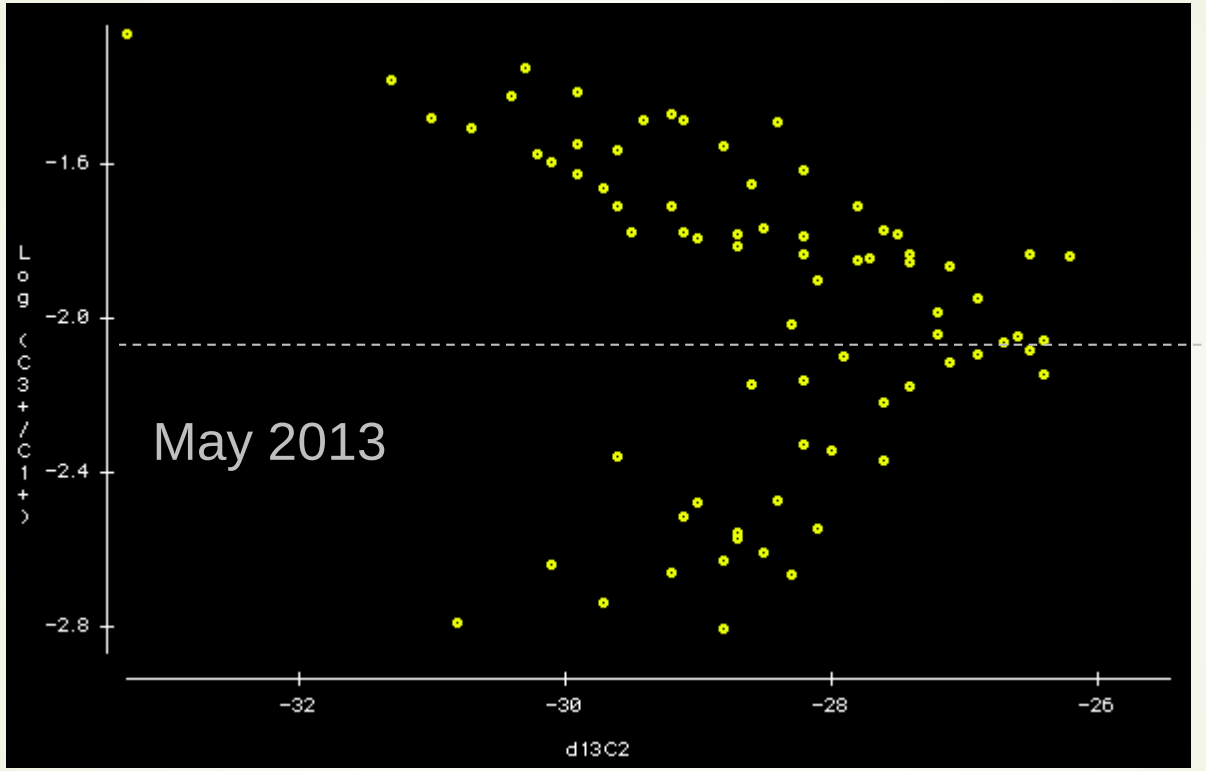
Dry Gas

Produced Gas Composition

Log C3+/C1+

Wetter

Dryer



Wet gas

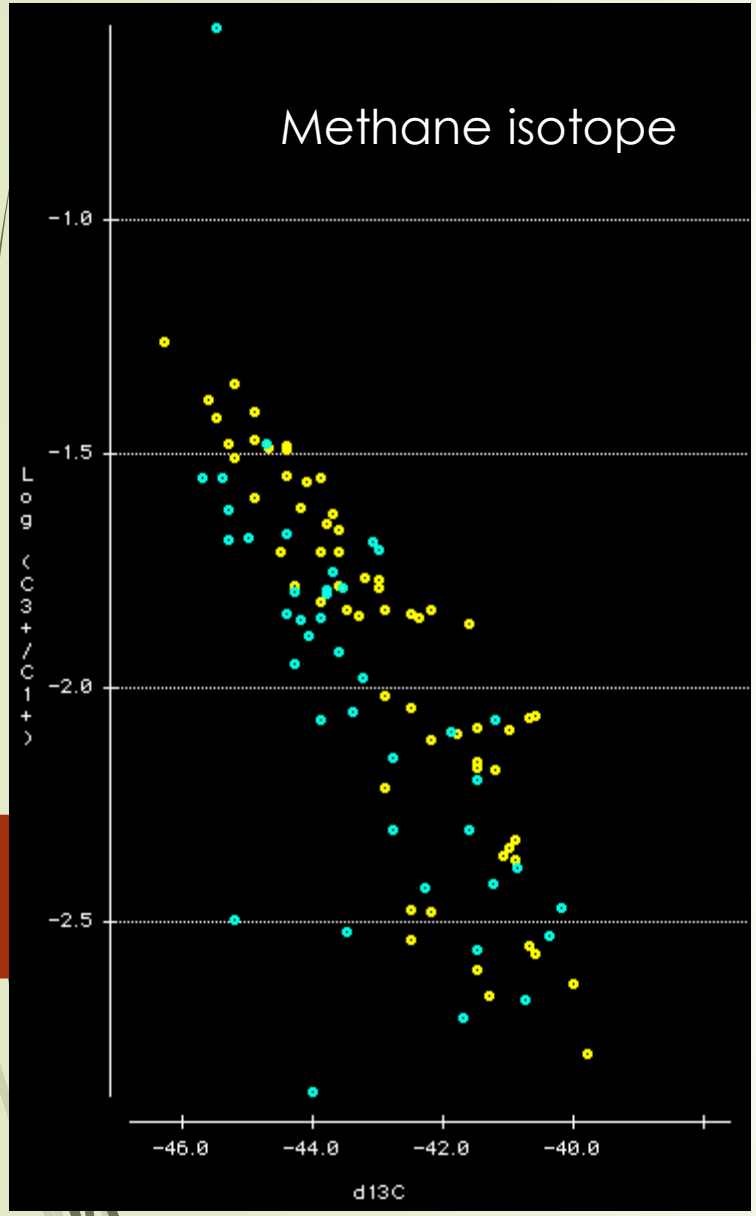
Isotope reversal

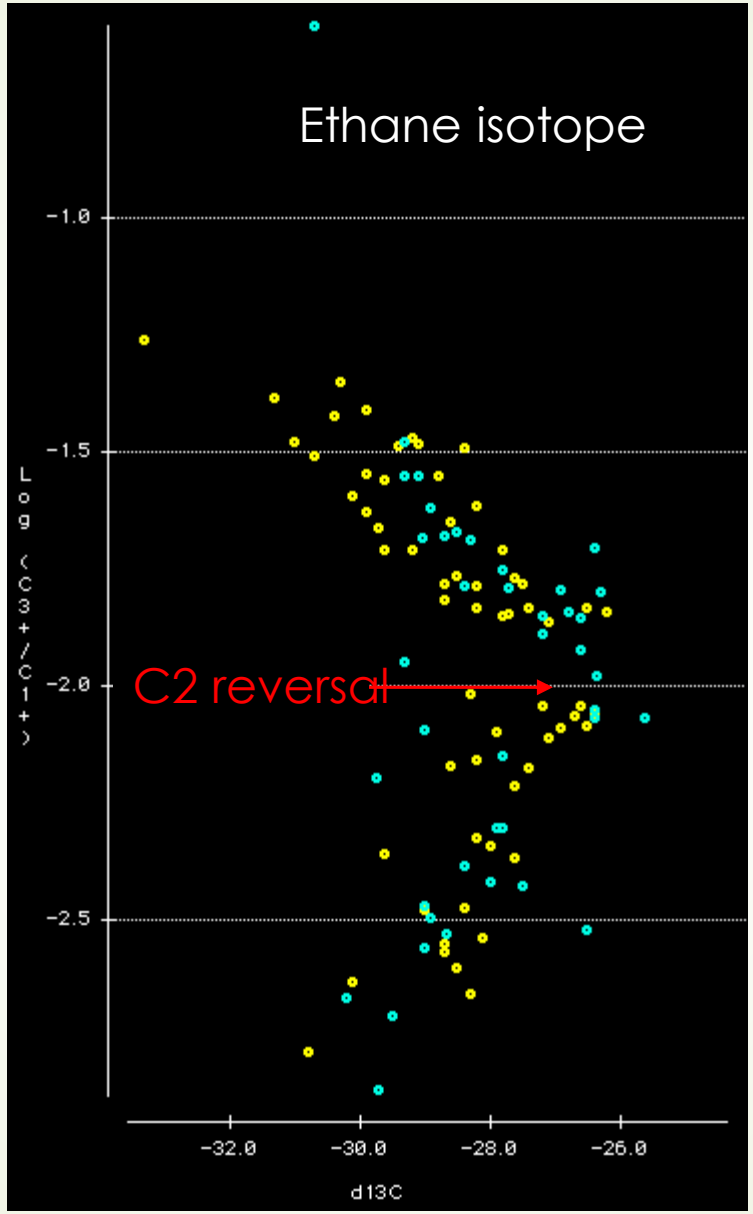
Dry Gas

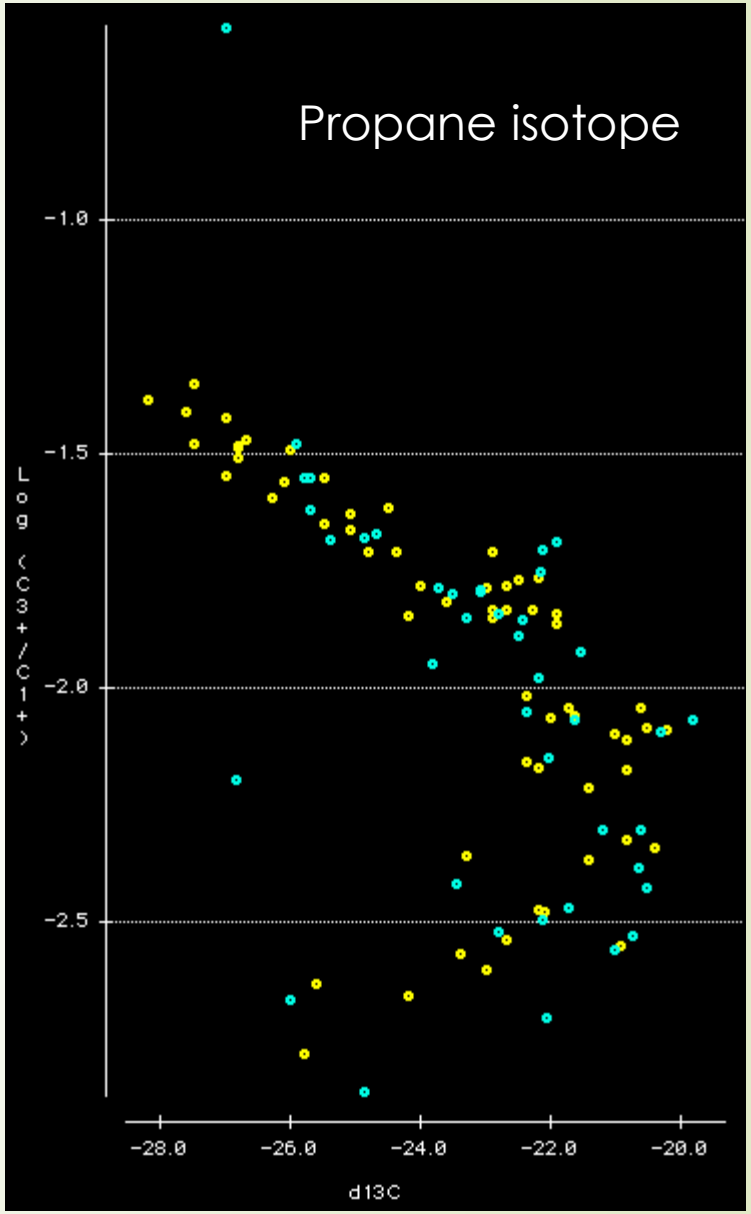
C2 Carbone isotope

Produced gas and isotope compositions exhibit extremely well behaved trends. The pattern is barely altered by the timing of the sampling with respect to the start of production and is obvious in the 2012 or 2013 data sets
There are new wells (liquid richer) put in production in 2013 (upper right)

Carbon Isotope Behaviour







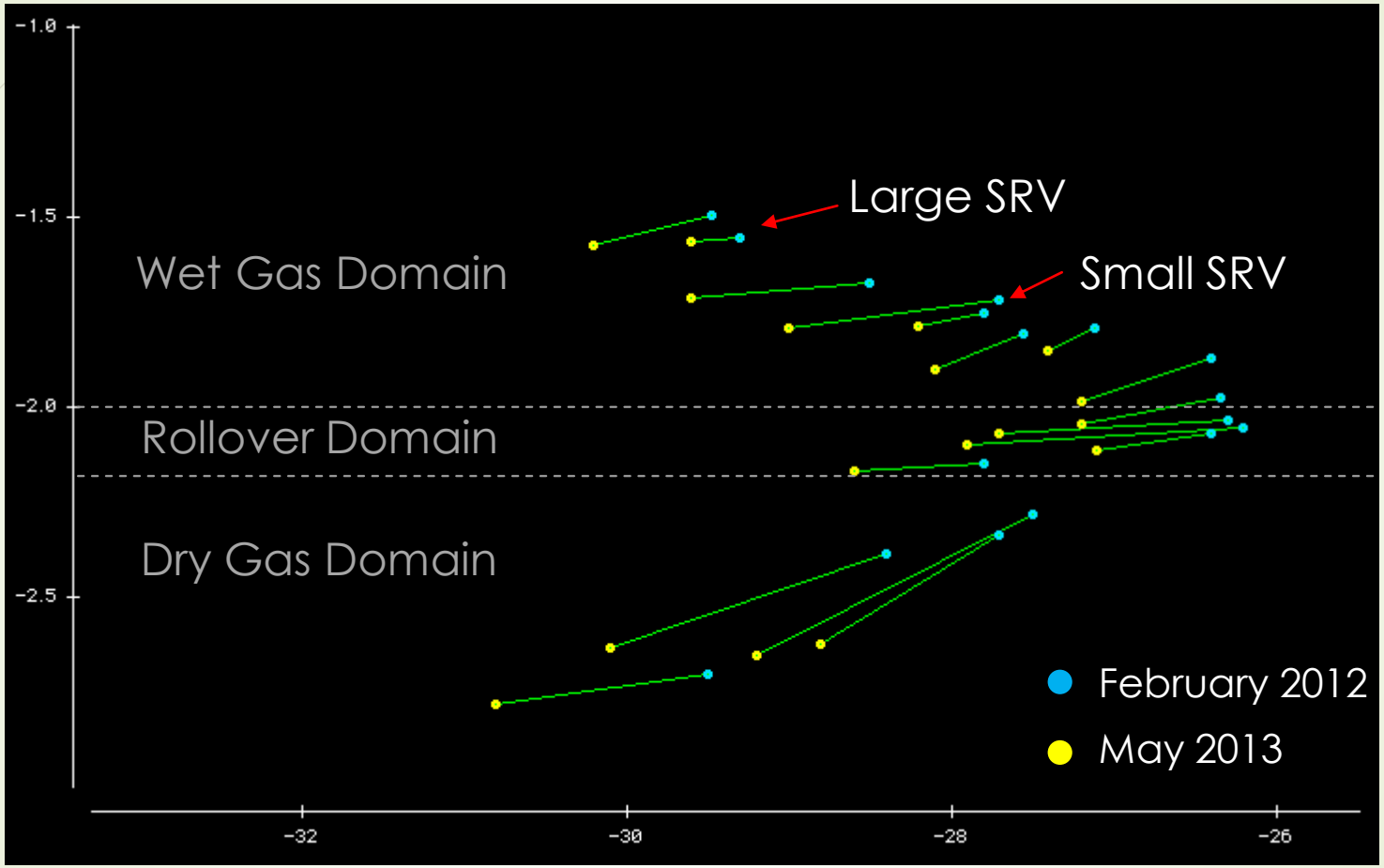
Methane isotope

Ethane isotope

Propane isotope

Geochemical SRV
from produced gas

Log (C3+/C1+)



C2 isotope

These are only 2 out of 5 useful parameters
Need to normalize against amount produced to be quantitatively useful

Normalization

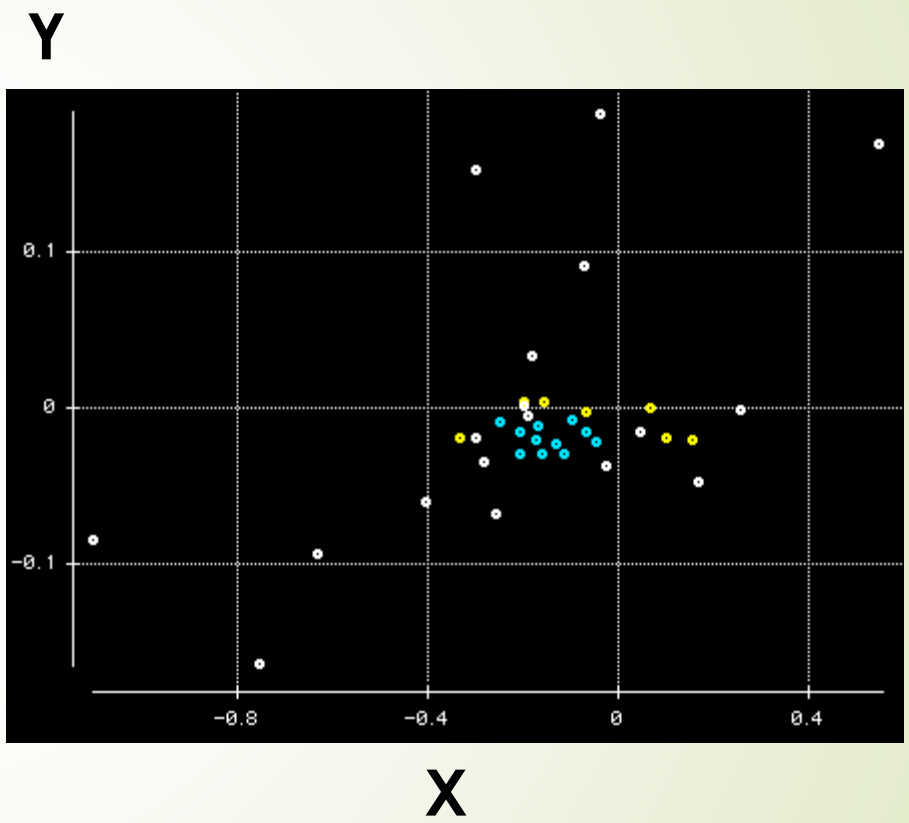
Normalization based on:
Cum Prod 2013 – Cum Prod 2012

Y = Normalized gas wetness diff

Difference Log (C3+/C1+) (2013-2012)
Log (Cum Prod 2013 – Cum Prod 2012)

X = Normalized C2 isotope diff

Difference isotope C2 (2013-2012)
Log (Cum Prod 2013 – Cum Prod 2012)



Geochemical SRV Approach

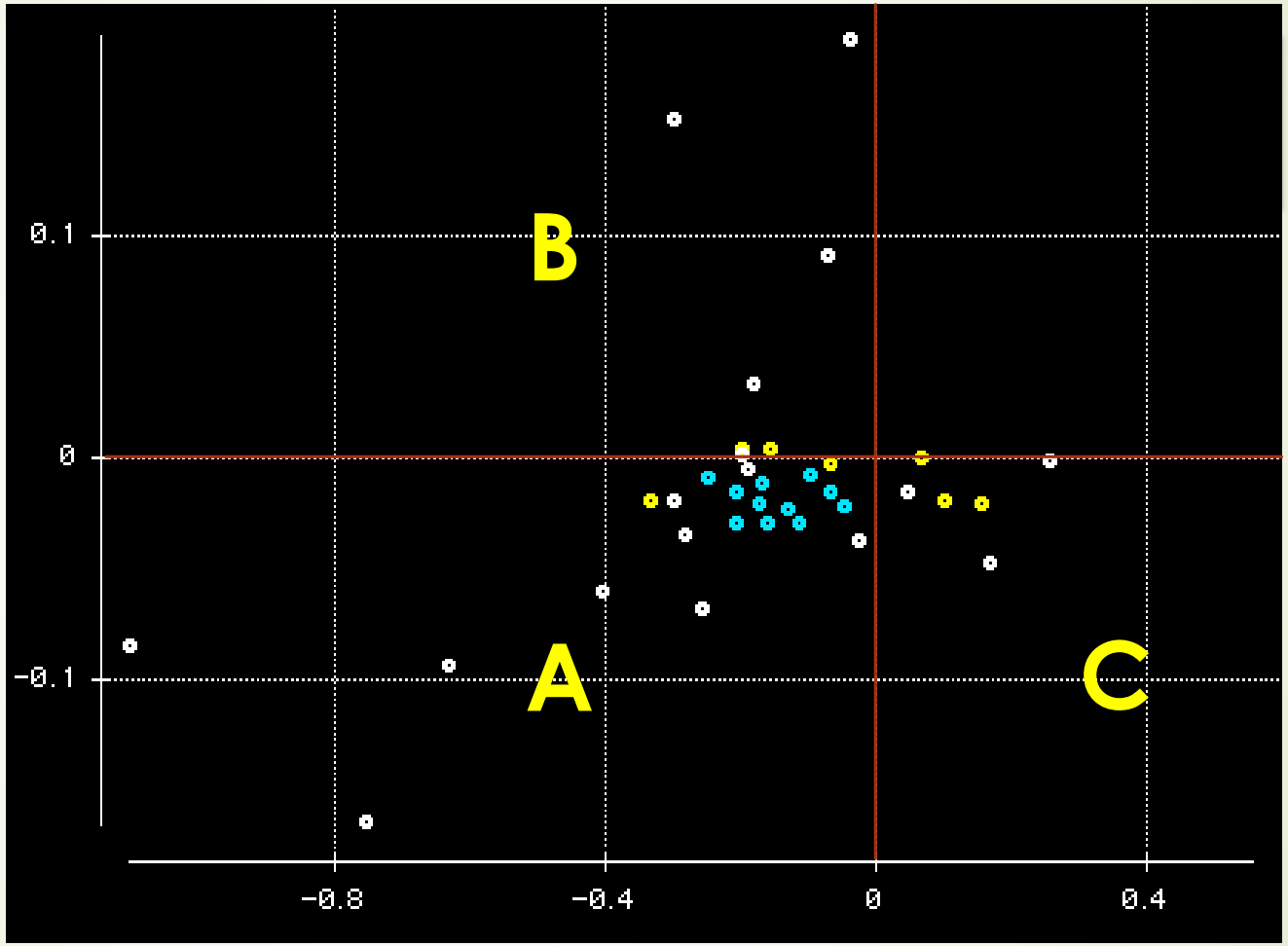
from produced gas

Difference
Log (C3+/C1+)

Wetter and more negative C2 isotopes

(Possible well Interference)

Dryer and more negative C2 isotopes Normal behavior



Difference C2 isotope

Yellow dots:

Wells with

open fractures

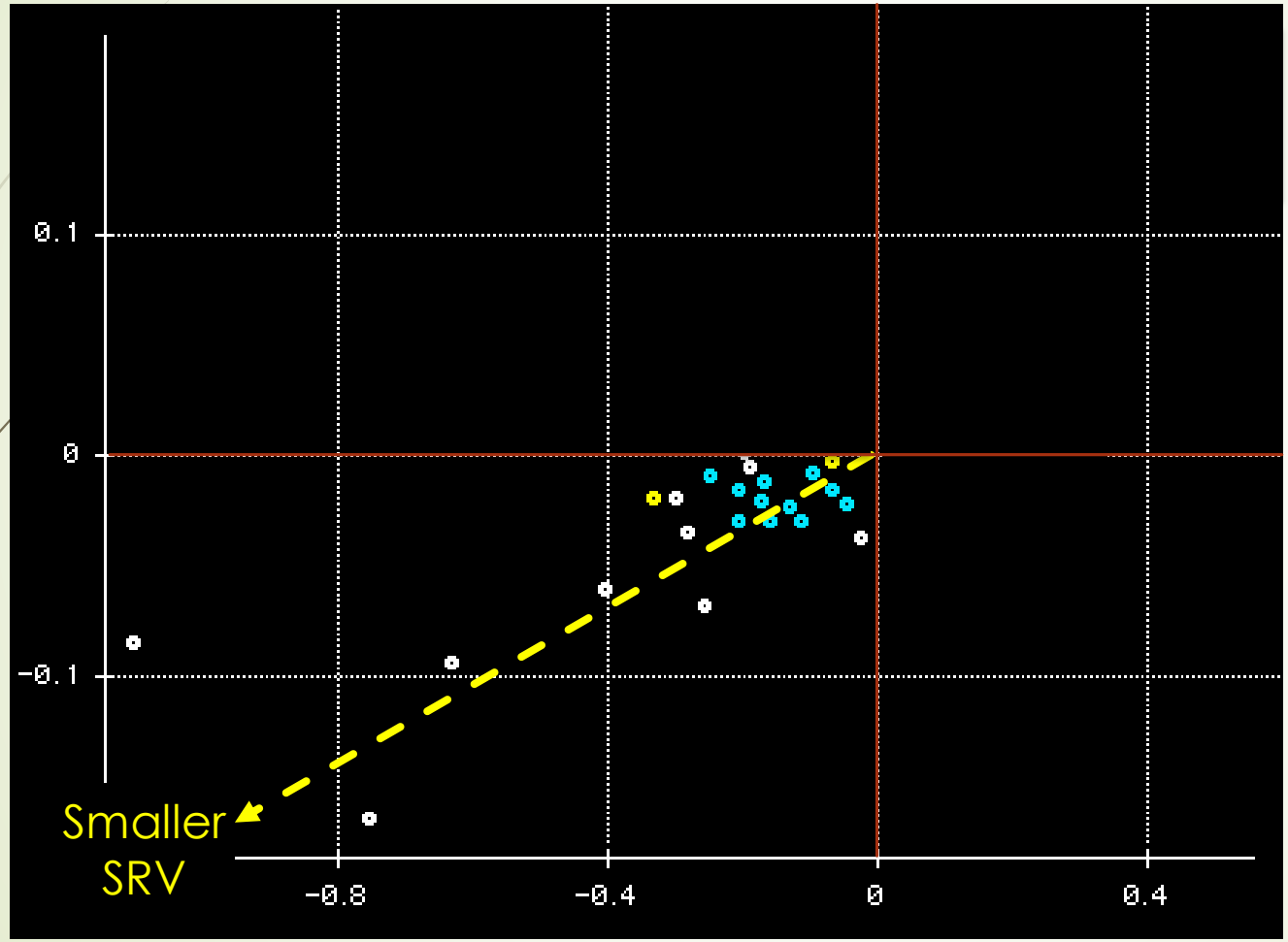
(gas bimodality)

Dryer and less negative C2 isotopes (tapping into deeper zones or into matrix)

Geochemical SRV Approach

from produced gas

Difference
Log (C3+/C1+)



Difference C2 isotope

After normalization geochemical SRV quantification can be used to compare with other reserve estimates

Conclusions

- An Integration of geochemistry with **microseismic** has shed new light to some anomalous patterns with many events away from the stimulation
- **Open fractures** are responsible for the stress transfer away from the perforations and a notable absence of microseismic events
- **Chromatography** can be used to better design the fracs and avoid open fracture networks as it reflects rock fabric changes
- **Gas bimodality** has been observed associated with open fractures in various shale: Utica, Duvernay and Montney
- Best production can be associated with absence of microseismic events and poor frac placement
- **Isotopes** and gas compositions can be satisfactorily used to estimate the **Stimulated Rock Volumes**