

# **PS Earthquakes Alignments Linked to Hydrocarbon Sweet-spots in the Western Canadian Sedimentary Basin**

**Jean-Yves Chatellier<sup>1</sup>, Monica v d Vreede<sup>2</sup>, and Michael Chatellier<sup>2</sup>**

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<sup>1</sup>Talisman Energy Inc, Calgary, AB, Canada ([Jchatellier@talisman-energy.com](mailto:Jchatellier@talisman-energy.com))

<sup>2</sup>Tecto Sedi Integrated Inc, Calgary, AB, Canada

## **Abstract**

Alternating fault activity can be demonstrated using 4D views of earthquakes in areas where seismic events are frequent. Examples studied and published by the authors includes the December 26th 2004 Aceh earthquake that led to the infamous tsunami and the New Madrid Seismic Zone in the central part of the USA known for formation of Reelfoot Lake in 1812.

For this subsequent study, the Canadian government data available and used encompasses 11,800 earthquakes in Western Canada, 1,024 of which are located in Alberta

The general picture in British Columbia is that of many major west-plunging and south-plunging seismic planes. In Eastern BC, our 3-D earthquake analysis shows a series of large seismic trends of similar strikes but variable dips, these are sub-parallel to hydrocarbon trends from the Rocky Mountain Foothills farther to the East.

In Alberta, the limited number of earthquakes recorded does not allow identification of any major plane encompassing many seismic events. However, 2D and 3D analyses covering Alberta, BC and part of Montana unravelled deep seated patterns of direct interest to the oil industry: many anomalous producers are perfectly aligned with seismicity trends.

Thus, in Alberta a different series of rules and methods had to be applied to decipher patterns of interest. Rule 1: as earthquakes are commonly located at the crossing between faults, each earthquake site can be used to define two separate fault trends. Rule 2: regular spacing between faults can be used as a guide to define the structural grain in the Alberta Plains.

A map-based approach and some outstanding results are outlined with three selected structural directions common in Alberta, North 93, North 9 and North 72 degrees. The former corresponds to deep seated faults commonly reactivated in left-lateral strike-slip mode, the other

two directions are respectively the antithetic and synthetic Riedel shears. Examples of Hydrocarbon sweet spots linked to such earthquake trends will be taken from Paleozoic carbonate and Cretaceous sandstone fields.

### **References**

Chatellier, J-Y., M. Chatellier, and A. Hargreaves, 2009, Data mining, 3-D views and some characterization of fractures, faults and migration paths in the Western Canadian Sedimentary Basin: Web accessed November 5, 2010, [Search and Discovery Article #40462 \(2009\)](#).

Chatellier, J-Y., 2009, Fault locking and alternate fault Activity in outcrop and subsurface, a transfer mechanism: Web accessed November 5, 2010, [Search and Discovery Article #40368 \(2009\)](#).

Chatellier, J-Y. and M. Chatellier, 2006, Data mining and exploratory statistics to visualize fractures and migration paths in the WCBS: CSPG Convention 2006, Calgary, Extended Abstract, 8 p.

# Earthquake Alignments Linked to Hydrocarbon Sweet-spots

**TALISMAN**  
ENERGY

In the Western Canadian Sedimentary  
Basin



**Jean-Yves Chatellier**

Talisman Energy Inc. Calgary

**Monica v d Vreede & Michael Chatellier**

Tecto Sedi Integrated Inc., Calgary

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Alternate fault activity can be demonstrated using 4D views of earthquakes in areas where seismic events are frequent. Examples studied and published by the authors includes the December 26th 2004 Aceh earthquake that led to the infamous tsunami and the New Madrid Seismic Zone in the central part of the USA known for formation of Reelfoot Lake in 1812.

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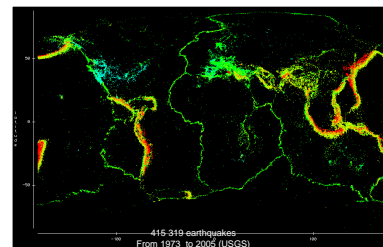
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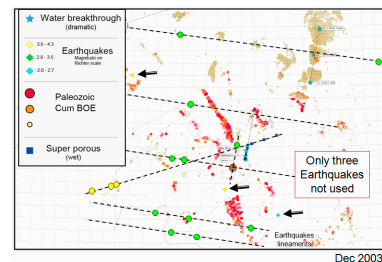
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## Poster in a nutshell

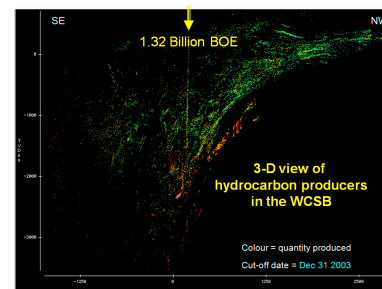
**Earthquakes  
in the world**



**Earthquakes  
in west-central  
Alberta  
against  
Paleozoic  
production**

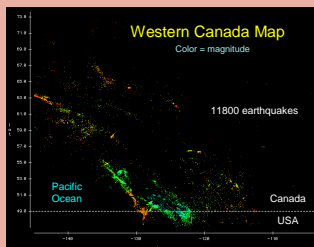


**Incredible  
hydrocarbon trend  
linked to  
Earthquake  
planar alignments**

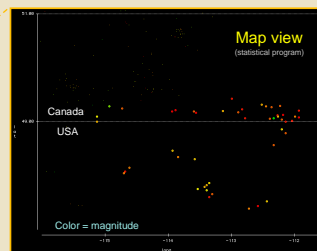
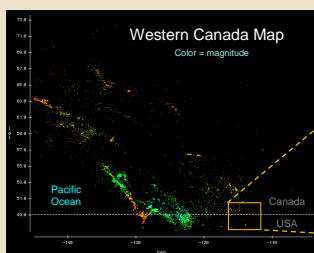
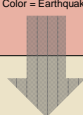
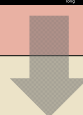
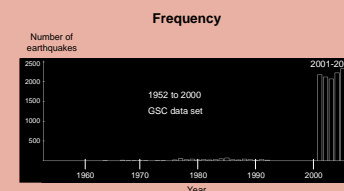
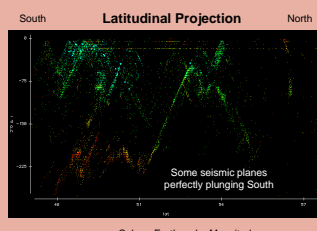
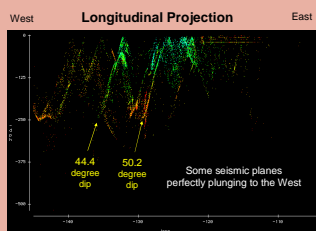
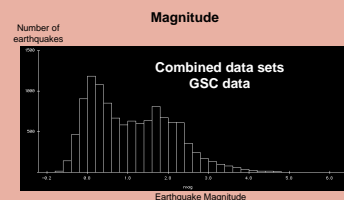


# Western Canada Earthquake Distribution

The Big Picture

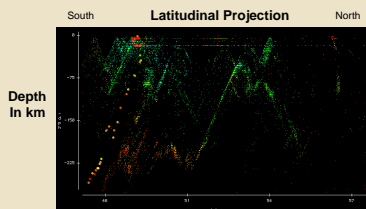


**Incredible alignments of earthquakes  
on preferential N-S and W-E planes  
Majority of planes plunging South or West**



**Large number of earthquakes  
Some of them very deep > 225km  
Dipping nearly perfectly to the South**

From big picture to hydrocarbon

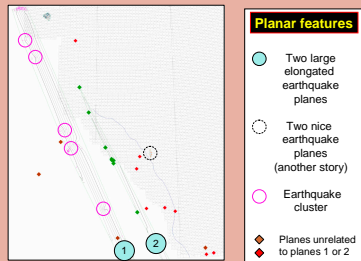


**Observations near surface:  
Unusual high concentration of  
CO<sub>2</sub>, N<sub>2</sub>, H<sub>2</sub>S  
and  
Dolomite**

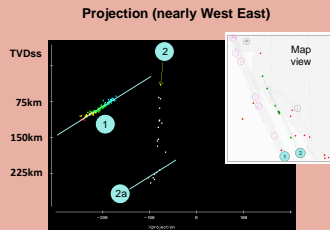
# Earthquakes and Big Hydrocarbon producing trends

Defining planes in 3-D

## Earthquake planes on a map

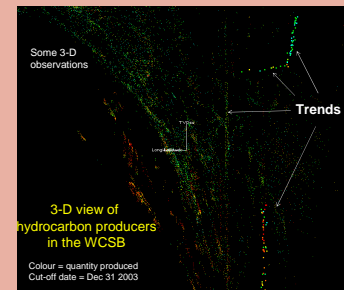


## Earthquake planes in 3-D projection



Here are two earthquake planes with very similar strikes  
Trend 2a is further South in Montana; At the map scale it belongs to trend 2

## Hydrocarbon pools in 3-D

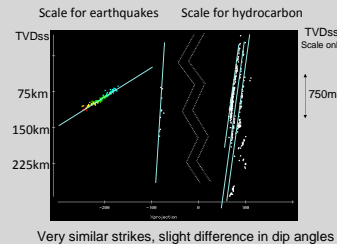
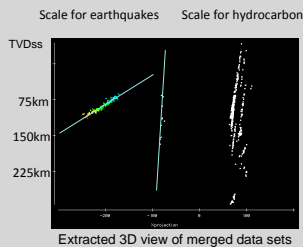


3-D views in particular preferential orientation unravel some very well defined alignments of hydrocarbon producers

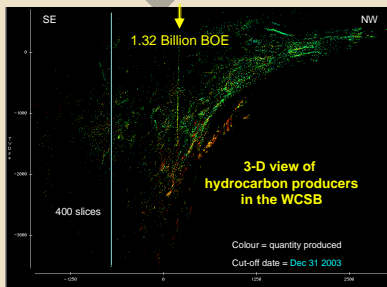
Merged sets

Seismic trends 1 and 2 have been merged to a series of en-echelon Producing pools

This was done in a 3-D volume by changing the vertical scale of the earthquakes by a factor 100  
i.e. 75km = 750m  
150km = 1500m

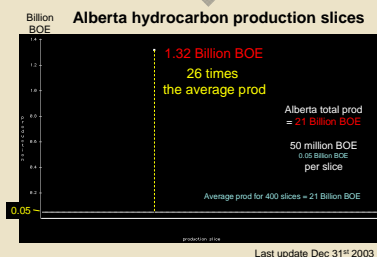


Hydrocarbon



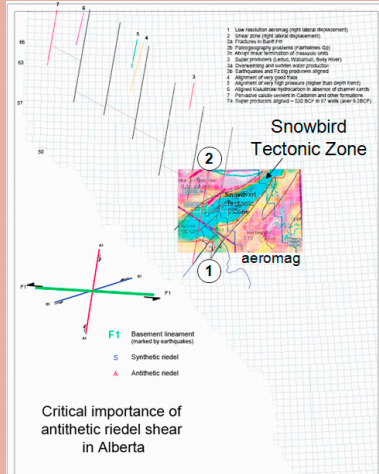
The best vertical alignment of hydrocarbon pools is parallel to the newly identified earthquake planes

It is estimated that the cumulative production along that trend is more than 125 times the Alberta average per rock volume



# Earthquake and deep seated strike slip faults

Structural grain

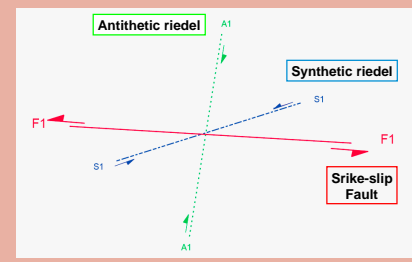


All started with the North 9 degrees lineaments

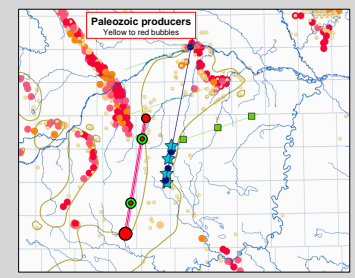
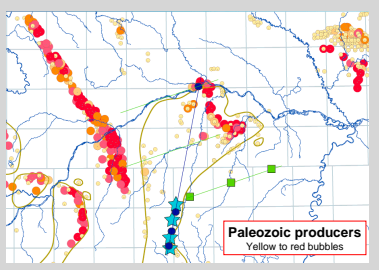
**Banff Formation**  
Devonian Fairholme  
(lineament 2)

**Aeromag** confirms that direction  
(lineament 1)

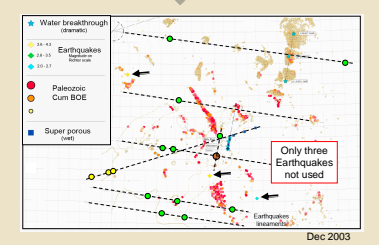
Three associated deep seated structural elements



Hydrocarbon



Earthquakes



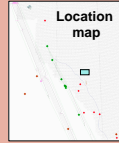
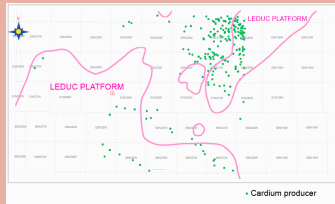
The earthquake trends are mimicking the patterns shown by abnormal production behavior; they are linked to the deep seated fault system

<b>F1</b> Deep seated strike slip fault Upward hydrocarbon migration prospects where crossing carbonate bank	<b>Incredible opportunity</b> for some of the lineaments
<b>S1</b> Synthetic riedel shears Very extensive vertical open fracture system Extensive dissolution Essentially water bearing because of lack of traps	<b>Relatively high risk</b> in map area
<b>A1</b> Antithetic riedel shears Extensive vertical fracture system Excellent production when trap is present Dramatic water breakthrough	<b>Great opportunity</b> Production should be restricted to minimize dry water breakthrough Water migration in deeper units of the same well to be avoided

# Earthquakes and Cardium Pools Orientation

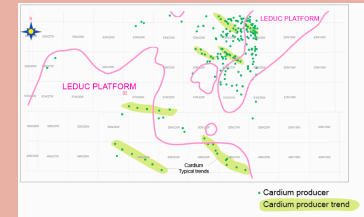
Observations

## Cardium Producers

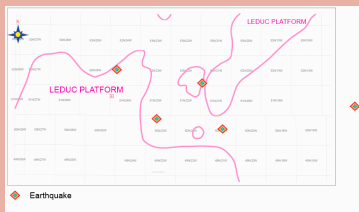


Cardium producers are commonly aligned on NW-SE trends  
With one exception one trend is WNW-ESE

## Cardium Producers



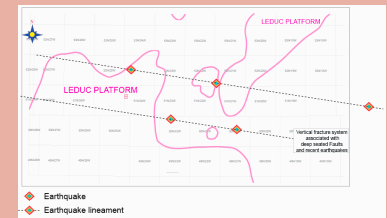
## Earthquakes



There are five important earthquakes in the study area  
All between 2.8 and 3.5 on Richter scale

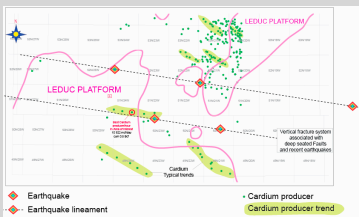
Perfect alignment along two parallel trends

## Earthquakes



Problems

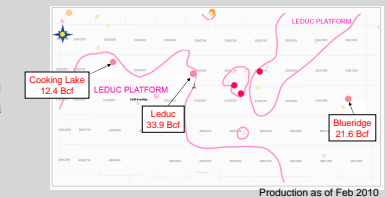
## Cardium Producers



Note the alignment of the southern earthquake trend with the anomalous Cardium producer trend

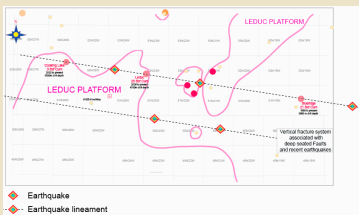
Large and very large Devonian oil producers in the study area

## Devonian Producers



Lessons

## Cardium Producers

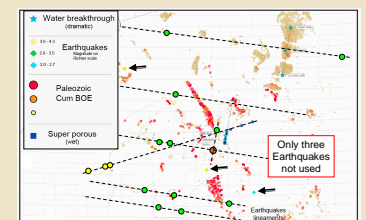


Perfect alignment of the Northern Earthquake trend and three very large Devonian producers in the study area

The Blairidge pool to the East needs the seismic trend to make some sense

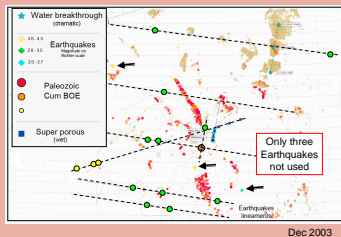
Regular pattern of earthquakes and its relationship with Paleozoic hydrocarbon production

## Merged data sets



Dec 2003

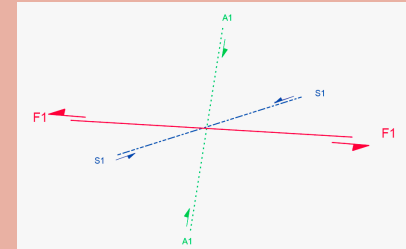
## Merged data sets



## Conclusions

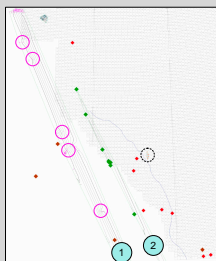
The great majority of all of the earthquakes recorded in recent years are aligned on known trends of big hydrocarbon producing anomalies.

Their geographic distribution and the relative geometry of the observed trends are best explained by a simple sets of deep seated faults that are riminescent of strike slip faults and their Riedel shears



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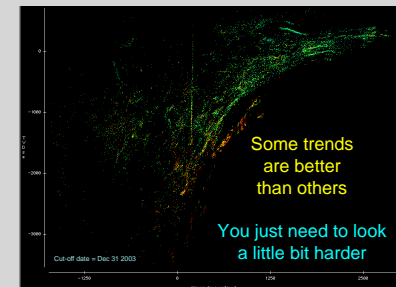
## Mega earthquake planes



The mega scale earthquake planes in Western Alberta and Eastern British Columbia are parallel to a mega scale hydrocarbon trend.

Deep seated structural features are linked to many hydrocarbon sweet-spots in Western Canada

## 1.32 billion barrels trend



## References

- Chatellier, J-Y., Chatellier, M. and Hargreaves, A., 2009, Data Mining, 3-D Views and some Characterization of Fractures, Faults and Migration Paths in the Western Canadian Sedimentary Basin, AAPG Annual Convention, Denver, Abstract only
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## Acknowledgments

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