Challenging the Paradigm

“missing section = normal fault”

Implications for hydrocarbon exploration

Jean-Yves Chatellier

Talisman Energy Inc
“pozo mata sismica”

Meaning that data from a well has to prevail in a seismic interpretation.

Major problem: when interpretation is taken as data

  e.g. observation = normal fault

Observation = Missing section
Interpretation = Normal fault
Outline

Borehole geometry only

Misinterpreted Geology
- Syn-sedimentary tectonics
- Strike-slip settings
- Reactivated reverse faults
- Detachments and low angle backthrusts

Summary and conclusions
Misinterpretation due to borehole geometry

Missing section = reverse fault

Repeated section = normal fault
Four geological settings with misinterpretations

**Synsedimentary tectonics**
- Furrial Field, Eastern Venezuela
- Dunlin Field, UK

**Strike slip setting**
- Lama Field, Lake Maracaibo (Venezuela)

**Reactivated Reverse faults**
- Santa Barbara Field, Eastern Venezuela
- Carito Field, Eastern Venezuela

**Detachments and low angle backthrusts**
- Santa Barbara Field, Eastern Venezuela
Eastern Venezuela Examples

Geographic Location

Venezuela
Columbia
Brazil

El Furrial Trend
Map view of El Furrial Trend

- Contours based on well data only
3-D view
Syn-sedimentary tectonics

Most important points:

- Missing sections of the same units in many wells
- Geometric pattern on map
- Best blocky sands next to missing sections
Syn-sedimentary tectonics in El Furrial Field
Many more wells are missing sands at the exact same stratigraphic interval.
Horsts and grabens

- Missing sections on horsts
- Blocky sands in grabens
- Geometric pattern on a map
Best sand in Furrial

(Close Up View)

- The best sand is blocky and laterally equivalent to missing sections

Modified after Uroza 2002
Dunlin Field

UK North Sea
OGIP = 0.827 Billion bbls

Blocks where the Upper Ness EIs is missing
Blocky Best Sands

Dunlin Field
827 MM bbls
Starting points:

- Problem with the pressure support scheme
- Many wells show missing sections
- One fault shows a small repeat section
Icotea Fault: Major Strike-slip fault
Lama Field

Block VLA-31

- No pressure support
- Geological model needs to be revised
Multiple Bischke Plot Analysis

Normal faults displace the trends (no rotation, trends stay parallel)

- Example from Seria Field (Brunei)

After Chatellier and Porras 2004
Multiple Bischke Plot Analysis

Geological misinterpretation at the red dot level

After Chatellier and Porras 2004
Angular patterns in MBPA

Visualization of a correlation problem through the use of a Bischke Plot

Example from VLA-31 block (Maracaibo) Chatellier et al. 1999
Angular patterns in MBPA

The MBPA is telling us that:

- The fault cut-outs are at the right depths
- They cannot be interpreted as normal faults

The beginning of a solution came from:

- Abnormal well terminations
- Mechanical failures led to stop 29 wells short of their objective
29 abnormal TDs (Total Depth)

All of the abnormal TDs could be fitted on three well defined planes

After Chatellier et al. 1999
North-South Cross-section

Only wells with no faults
Recognizing a blocky sand across the whole of the block has been essential to understanding the stratigraphy.

C-44 unit = catastrophic storm deposit

- In a few wells the C-44 tempestite is repeated but the facies above the unit are different.
Why has everyone missed the repeats?
Map view of sedimentology in Block VLA-31

Final Interpretation

Channels dissecting the marine bars.

Channels are perpendicular to the Icotea Fault
New main faults in VLA-31 block

- Injection well
Schematic cross-section

Block VLA-31 Strike-Slip

Icotea fault
Seismic Section of the VLA-31 block

Seismic interpretation by Richard Hyde

From Chatellier et al (1999)
Most important points:

- It could be very common but you have to be lucky to get a good example.
- This first example gives a time frame for the fault activity.
3-D View

SANTA BARBARA  CARITO  FURRIGAL

[3D View Image]
Nobody wanted to study the MUC-13 cores.

The white bands scared the sedimentologists away!
Note the fairly constant thickness of the deformation band
One fault system linking all “missing sections”

- Shallow fault in the Tertiary sand of every well
Schematic diagram of the proposed mechanism

NNW Northern Flank of Carito Central SSE

Fault Fractures Reactivated fault
Previous interpretation
New interpretation

Reverse Fault Interpretation
Reactivated reverse faults

(Example 2)

Most important points:

 Problem with the hydrocarbon map (oil over gas...)
 Each well had one major missing section
 These faults were not seen on the 3-D seismic
 Fault plane dip and stratigraphy are oblique to each other
3-D View

SANTA BARBARA  CARITO  FURRIAL
Note the NE dip of the top structure.
Missing sections in Santa Barbara Central Block

Fault picks by F. Ruiz (stratigrapher)

Fault dip 43°
Fault plane

Fault plane generated during first phase of compression

Oblique slip generated by second compression phase
Schematic block diagram for Fault F103

“bird’eyes” view of beds below Fault plane (footwall expression)
Lateral movement along Fault (simplification)

Viewed from the NE

Beds with 14° dip towards NE

“Hanging wall”

“Footwall”

Fault F103
43° dip towards NW
Missing Sections associated with Fault F103

Final view

Missing sections
Only the lateral displacement has been invoked
Tectonic post hydrocarbon emplacement is reflected in the pressure trends. Reverse faulting is interpreted from pressure data (despite a missing section).
Detachments

and

low angle backthrusts
Santa Barbara Field
Cross-section Block 3
Projected well see to the right

Detachment
3-D View

SANTA BARBARA  CARITO  FURRIAL
Study Area

Top Naricual in Santa Barbara
Depth of fault intersections

Note the very high similarity of depth of fault cutouts:
All points are close to 14970’ or between 15100’ and 15300’
Only variant = fault in PIC-01
Fault throw map

Repetitions

Well 7

Missing sections

No fault recognized

1km
Bird’s eye map of low angle fault

Well 7 = 60 degrees
Well 8 = 11 degrees

Wells with Dipmeter:
- NS
- Ni
- K

SCALE: 500m

NI and K need to be more precisely placed only NS is OK
Pressure data gives some clues

Horizontal detachments @ 14850’

Despegue

Detachment

RFT

SBC-96 (02-99)  SBC-52 (08-96)  SBC-61 (03-97)
Example from the Santa Barbara block 2

Section from 3-D modelling
Santa Barbara Structural Map

Integration = Better map with engineers approval

Scar of decapitation to the North

Scar of decapitation to the South

4 Km

Chatellier et al. 2002
Decapitation and the hidden giant

Wells with relative poor production

Calgary tower as a scale

Modified after Chatellier et al 2002
Conclusions

Missing sections not always linked to normal faults

Look for:

- Missing sections at the same stratigraphic level
- Missing section at similar depth
- Reactivated faults (different bed and fault azimuths)
Potential Rewards

- Much better and reliable geological model
- Better development plan (e.g. Injection)
- Identify by-passed pays
- Potential for new discoveries

It is worth challenging an old paradigm
Acknowledgements

- PDVSA for letting us present many of our findings
- Talisman Energy Inc. my present employer
- AAPG, especially Susan Nash
- Ken Molay for his help organizing this webinar
Challenging the Paradigm

“missing section = normal fault”

Implications for hydrocarbon exploration

Jean-Yves Chatellier

Talisman Energy Inc