

# Successful 3-D Seismic Imaging: From Industry Selective Targeting to Academic Systematic Research (Part II)

**Michael Enachescu\*, Ph D, P.Geoph.**

Husky Energy Senior Fellow in Exploration Geophysics  
Associate Professor and Consultant, Memorial University

**John Hogg<sup>1</sup>, P. Geo**

Manager New Ventures, EnCana Corporation  
Now at Burlington Resources

9 September 2005

LDEO, New York



**Memorial**  
University of Newfoundland



Oil and Gas Development Program

michaele@mun.ca

# Acknowledgements

- Husky Energy, EnCana, ExxonMobil, Petro-Canada, Chevron Texaco, Shell Canada, Murphy, Norsk Hydro, CNOOC
- Renee Fergusson, Alistair Brown, Judith McIntyre, Fred Hynes, Peter Meehan, Paul and Davey Einarsson, Andy Skuce, Garth Syhlonyk, Reiner Tonn, Satinder Chopra, Kevin Meyer, Hugh Wishart, Nancy Harland, Larry Mewhort, Peter Pilch, David Emery, Jerry Smee, Duc Nguen, Vladimir Zmejkal, Sam Nader
- Geophysical Service Incorporated (GSI), WesternGeco,, PGS, Veritas DGC, ARCIS, SEG, CSEG, AAPG, CREWES
- Landmark Graphics, NSERC, PR-AC, C-NLOPB
- Pan-Atlantic Petroleum Systems Consortium (PPSC)

# Survey Statistics Hibernia Field Seismic

1964

- 1,500 m
- 9,195 km
- 283 days
- 32 km/day

**Dense 2D**

1980

- 2,300 m
- 4,099 km
- 118 days
- 35 km/day

**3D**

1991

- 3,000 m
- 21,247 km
- 127 days
- 167 km/day

**3D**

2001

- 4,050 m
- 43,938 km
- 63 days
- 697 km/day

**undersh.3D**

What is a realistic target for the RS Langseth?  
200km/day?

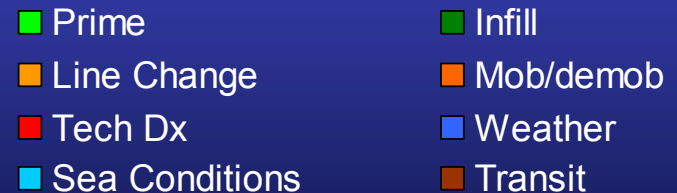
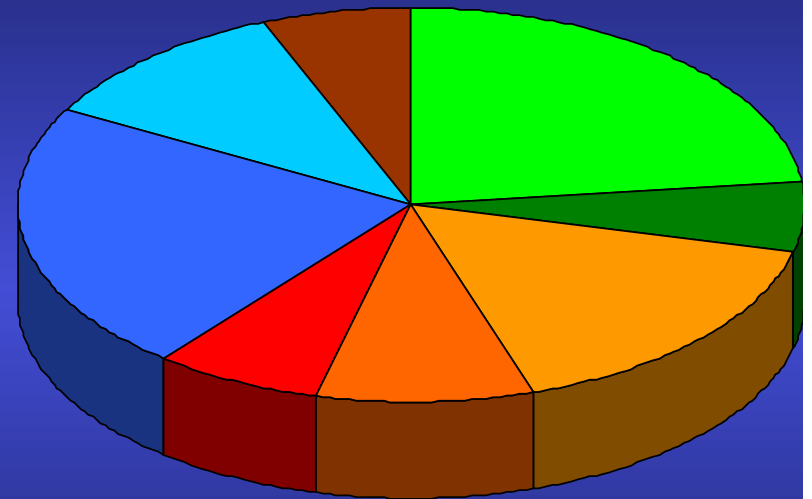
# Worldwide statistics, 1980-2000

## Modern acquisition :

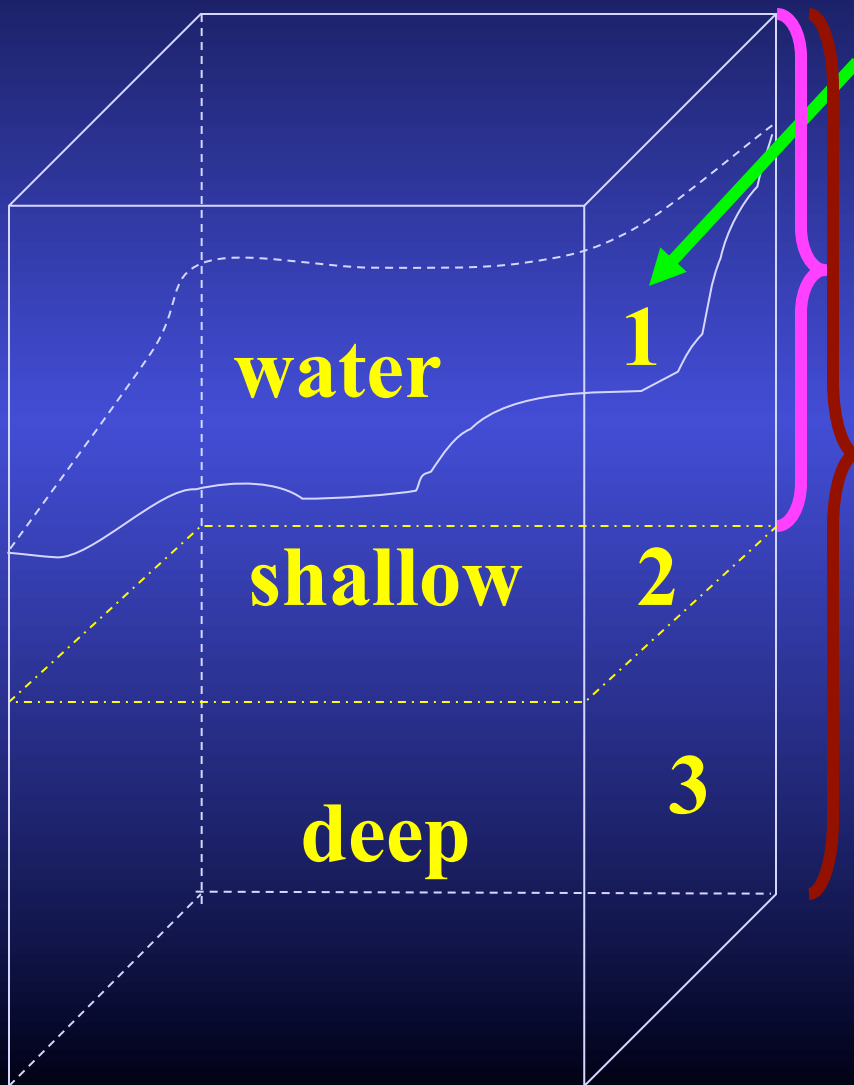
- Project duration average - 6 weeks
- Exploration surveys increasing size
- Small, dense reservoir 3D projects

## Vessel efficiency :

- <25% of time spent on prime lines
- Acquisition = prime + infill  
30% of the total time



# Surveys for Deepwater Drilling



**1. Multi-beam bath**

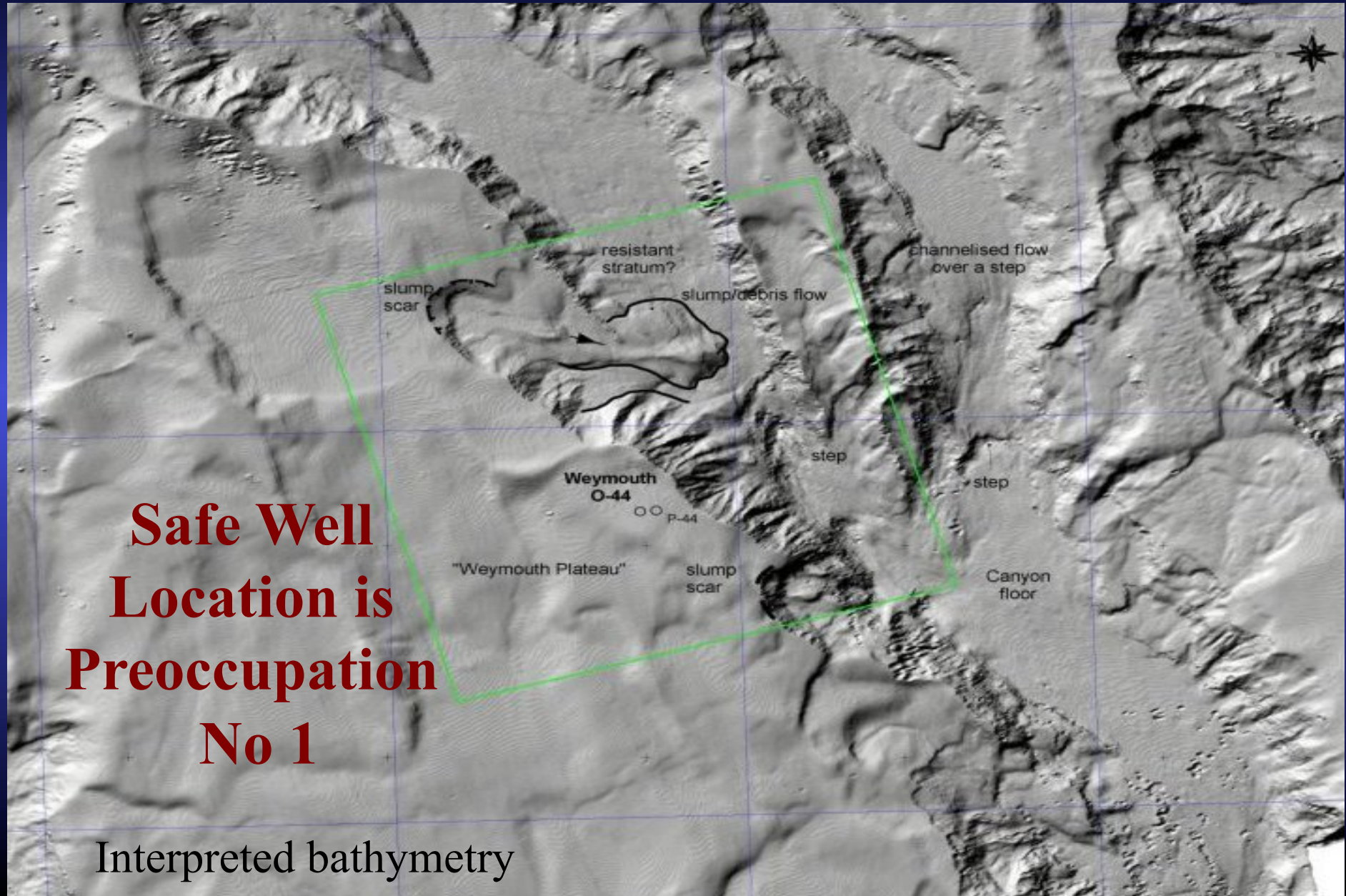
**2. 3D HR Site survey**

**3. Prospect 3D**

**All three are compulsory!**



# Deepwater Hazards – Slumps and Debris Flows



# Academic Systematic Research

- **Despite recent advancements in marine seismic acquisition methods and the use of multi-streamer vessels (up to 20 streamers were deployed) only a very small portion of the ocean and sea surface has been surveyed by 3D.**

**Industry covered 1% from world oceans  
Academic Research left with 99%**

- **Most of the industry generated 3D seismic cubes have yet to be fully mined for geoscience information, as petroleum geoscientists are primarily focused on those particular zones that are recognized to contain petroleum.**
- **Moreover, the petroleum industry is active only in sedimentary basins with recognized petroleum potential and 3D seismic is selectively targeted to structures and stratigraphic features that have been pre-selected from dense MCS 2D surveys or to areas near existing oil and gas discoveries.**

# Academic Systematic Research

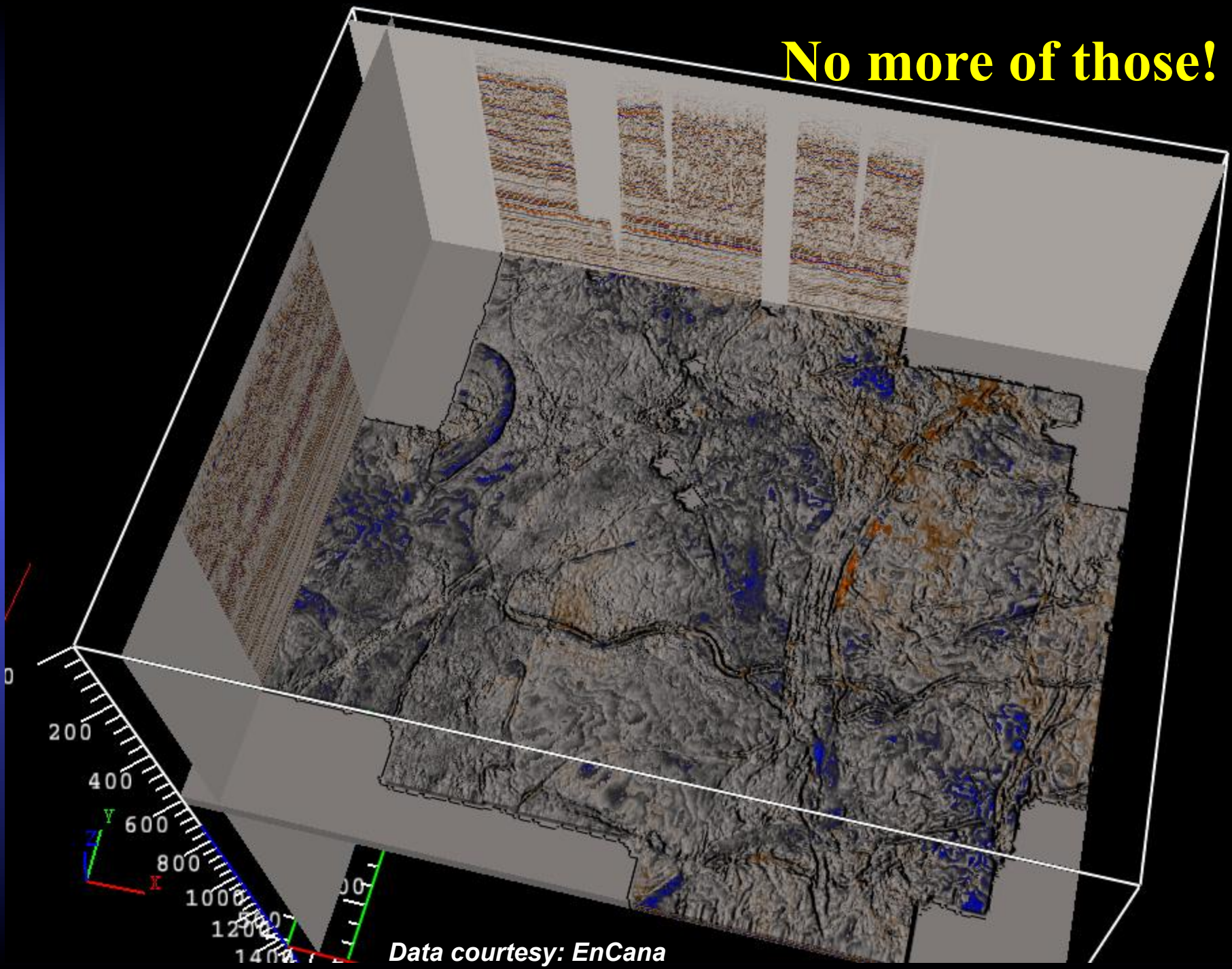
- **Where to do 3D?**
- **Are enough money allocated to operate ship?**
- **Is academia prepared to do 3D processing?**
- **Work in blue water and English speaking countries, seismic friendly jurisdictions**
- **Integrated science; closely related to IODP as 3D interpretation deserves ground- truthing!**
- **Education an important aspect: USA consumes 25 % of world oil graduate; less than 100 graduates every year, while exploration professionals are required in greater numbers**



# Academic Systematic Research

- **Academic 3D can provide fundamental data to researchers from areas and environments that are unlikely to be surveyed by the petroleum industry.**
- **Certain depositional environments, suture zones and subduction zones that are non-conducive to deposition of petroleum reservoir and source rocks have been ignored by the 3D seismic industry.**
- **Many geological provinces under the world's seas and oceans including those with thinner sedimentary cover, volcanic terranes, or located on distal parts of the continental slope, within transitional zones, serpentinitized peridotite ridges, oceanic crust domain, large igneous provinces, transform zones or mid-oceanic ridges, to mention only a few, remain to be investigated by 3D seismic in order to reveal their in depth constitution and spatial architecture.**

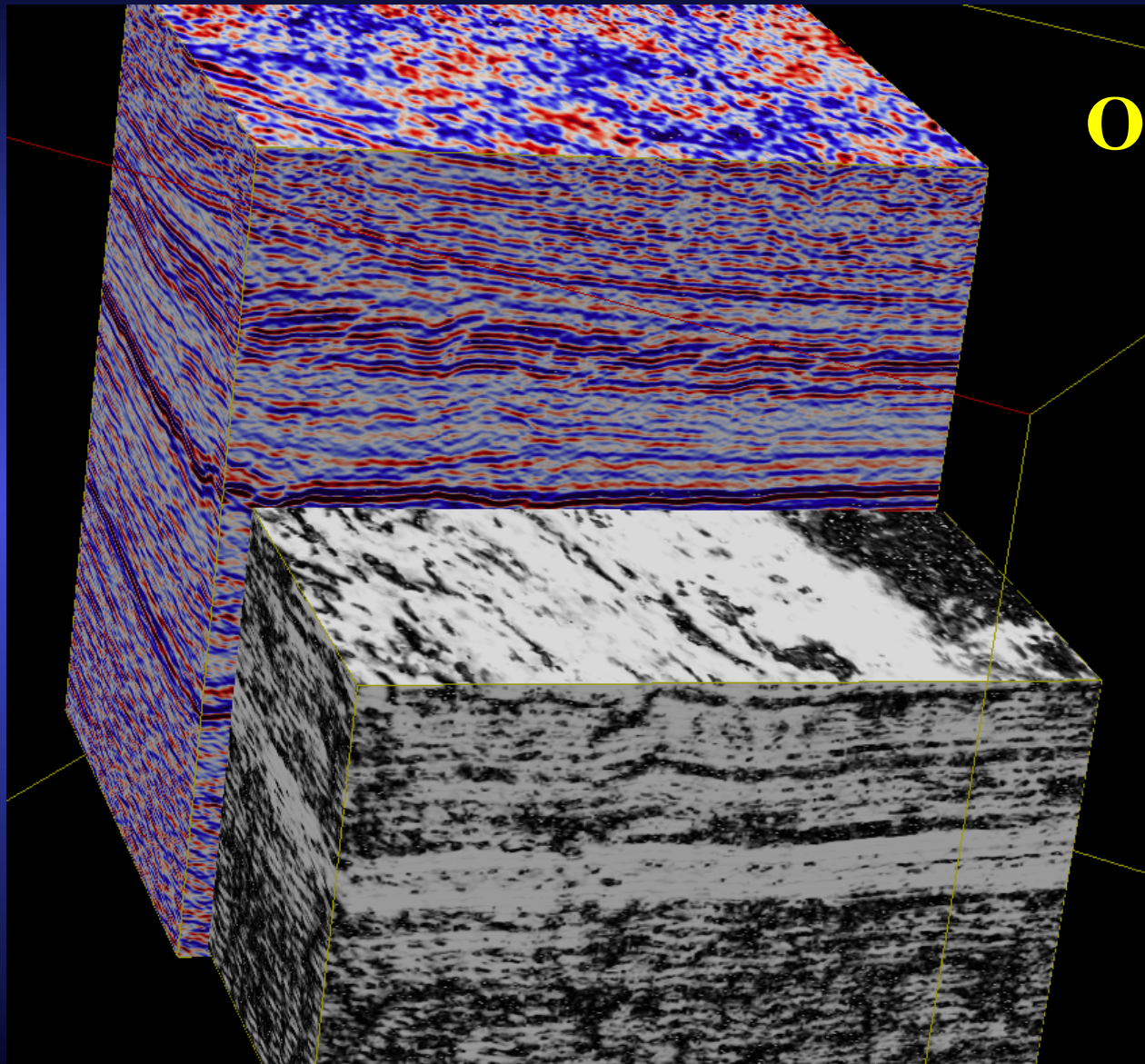
**No more of those!**



*Data courtesy: EnCana*



# Using coherence and the seismic volume to understand the distribution of faults in 3D space



**Or that!**

*(Image courtesy: Arcis Corporation, Calgary; Data courtesy: Olympic Seismic, Calgary)*

# Academic Systematic Research

- **Thick sedimentary accumulations located on plate margins including non-disturbed passive margin sequences or the distal part of the fans of major fluvial systems (e.g. Bengal, Indus) also remain to be studied by this method.**
- **Other lines of research that can benefit from systematic study by 3D seismic include process geoscience studies such as investigating source to sink depositional processes, shallow depth sedimentary processes, modern rift systems, earthquake generation by known and blind fracture zones, climate change, etc.**

# Areas of high interest

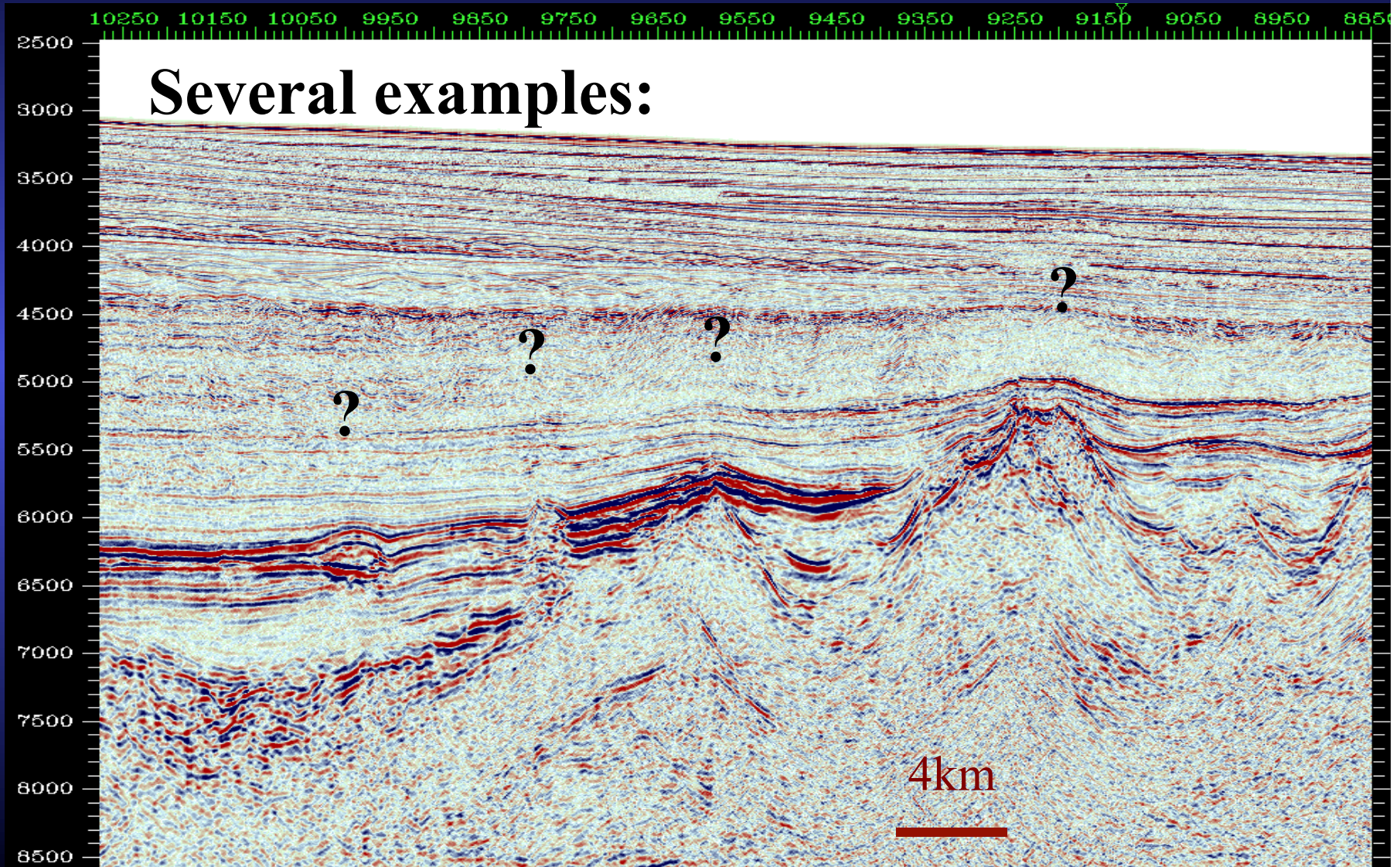
- Earthquakes and tsunami triggering faults
- Hurricane induce changes in deltaic and shelf environments
- Monitoring growth of volcanic islands
- Active rift systems
- Accretionary prisms



# Work in “Friendly” Areas

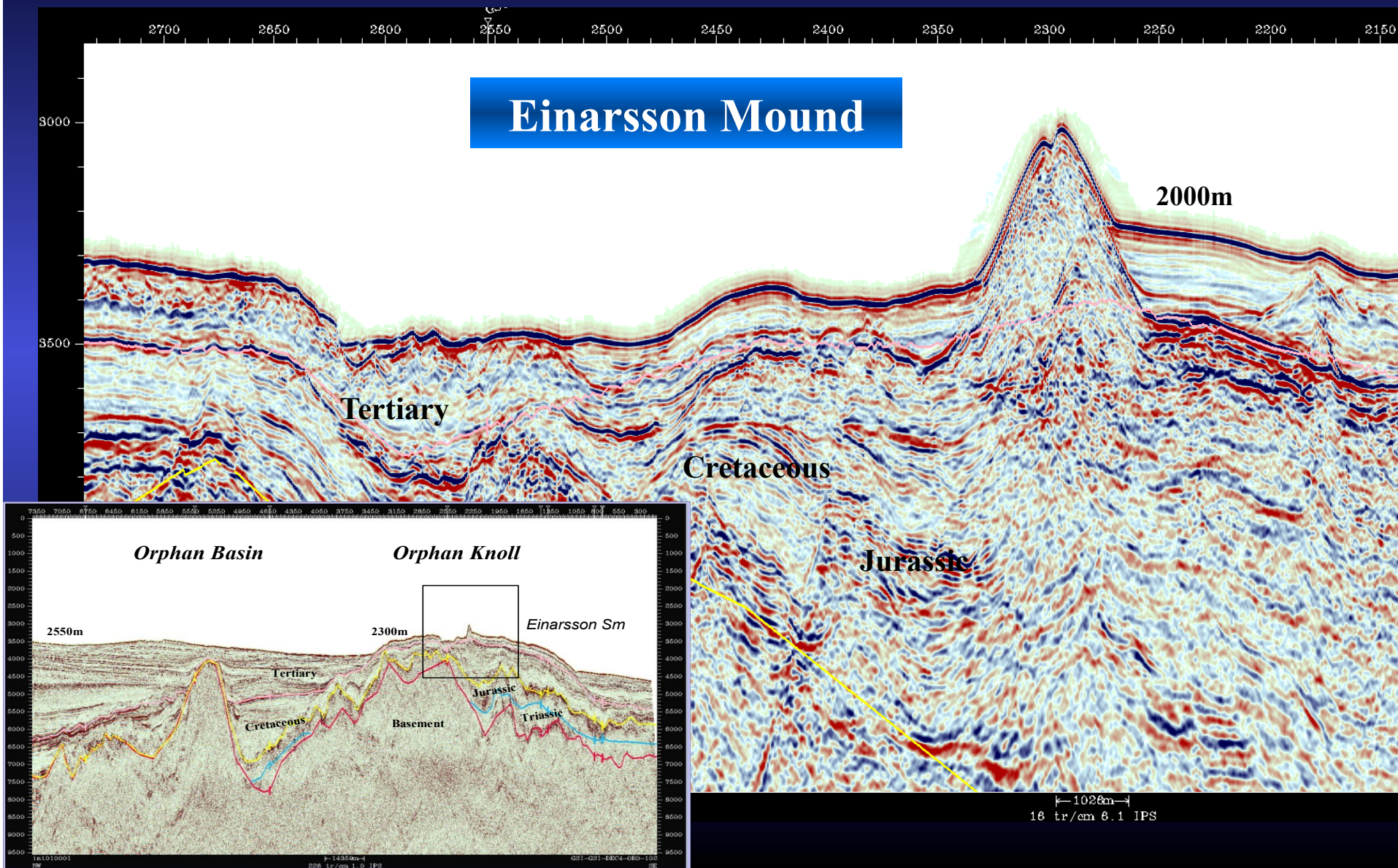
- Continental margins in safe areas: countries/states/provinces with friendly attitude toward research and exploration. Example: Newfoundland and Labrador, Greenland, Norwegian Sea, certain South Atlantic countries
- International seas with high IODP priority targets
- Start with “not too complex geology, not too noisy areas” to demonstrate capability and establish a research flow of events and costs

# Keep Inventory of USObjects





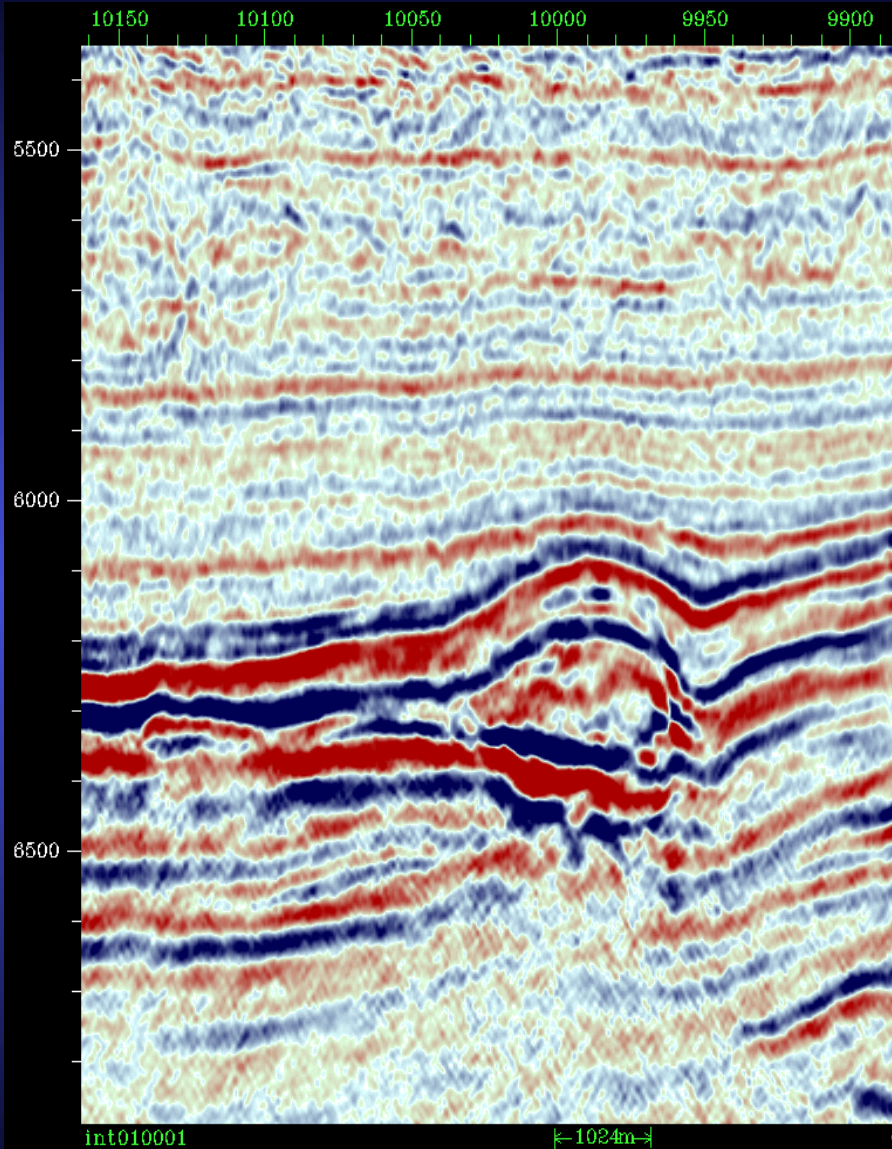
# Line GSI-OR0-102



# Academic Limitations and Recommendations

- Research 3D is limited only by 1) money, 2) personnel and 3) time; You will be the unique scientific acquisition outlet
- There are many interpretation labs: Rice, Cardiff, Memorial, CSM, Imperial College, U of Texas: **Use them!**
- Work in teams of geoscientists
- Make data sets public /do not hoard!





**If any artist should let himself believe that he was able to stare up in himself all the forms and effects of nature, certainly he would seem to me to be possessed of great ignorance; because those effects are infinite and our memory is not of sufficient capacity**

**Leonardo da Vinci  
(1452-1519)**

**(First geoscientist)**



# A Look Ahead

- These are but a few potential applications; the range of possible investigative projects is immense and new research is almost certain to bring surprises and more than a few breakthroughs.
- However, benefits will be limited without integration with other geophysical methods and broad access to data by geoscientists with different interests and specializations.
- The International Ocean Drilling Program, which provides essential ground truthing for the modern geological paradigm, is in great need of a year-round, reliable and cheaper alternative to contracting industry 3D seismic programs for project definition and drillhole guiding.
- The oil industry can be counted on to provide some access to proprietary data in areas of lesser exploration interest, but 21st century geoscience will benefit greatly from permanent access to a US publicly funded 3D seismic vessel.
- With dedicated operators and committed research community, the academic use of the 3D seismic method will considerably improve our knowledge of the earth's crust and advance understanding of our evolving planet.

**Welcome to 3D surveying, keep it safe for all involved!**

**THANK YOU**

