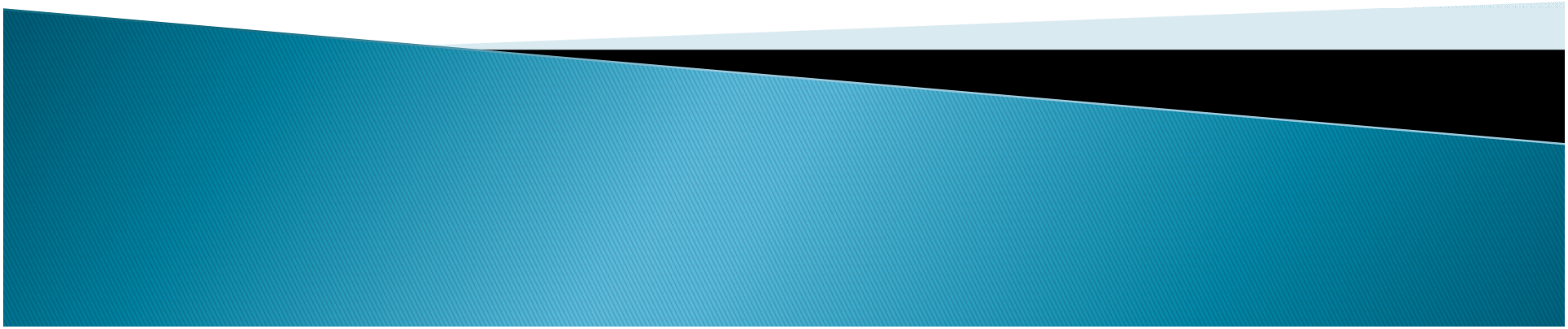
Curaçao to Bermuda to the Jersey Slope to Central Park: The trials and tribulations of developing IODP technologies

Peter Polito
27 July 2012
BEG Summer Seminar Series

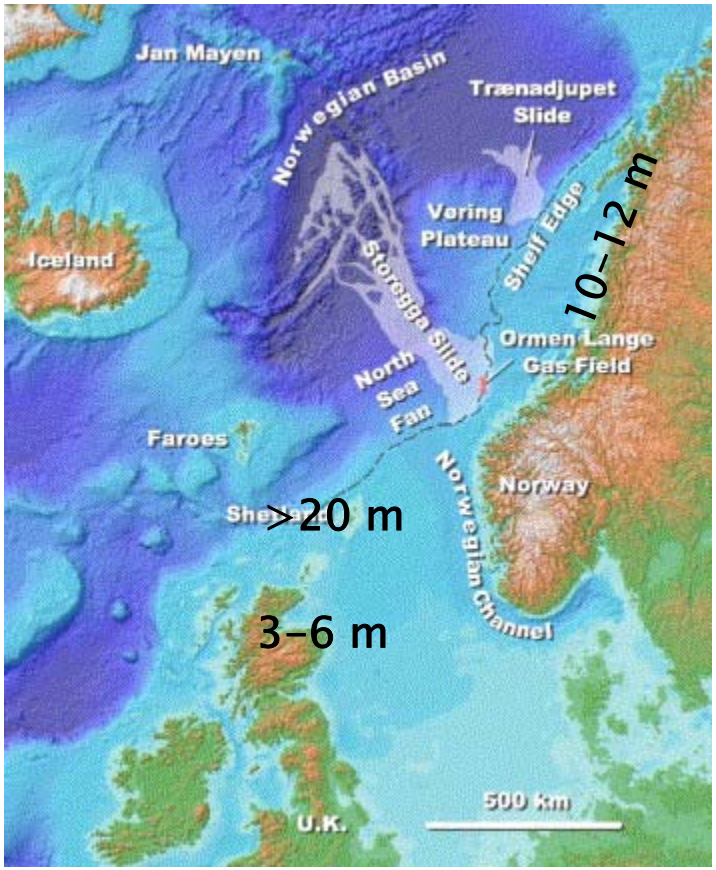


Summary

- Motivation
- Working with IODP
- What is the T2PMDHDSERSMFTM anyway?
  - the old and the new
  - four parts
- Out to sea and life on the JR
- Testing
- The next steps

Motivation

- Understanding sub seafloor pore pressure
  - Oil and gas industry
  - Slope stability
  - Hazard identification & mitigation
- Evidence of large tsunami causing landslides in recent geologic history



Estimated tsunami heights from Bondevik et al., 2005

Motivation

A18 YNE THE NEW YORK TIMES NATIC

Tidal Waves Called Threat to East Coast

Study Says Continental Slope off New Jersey Is Critically Unstable

By ANDREW C. REVKIN

Geologists have long viewed the West Coast as the dynamic side of North America, the shore where earthquakes, tidal waves and other potentially dangerous geological forces are most likely to strike.

But there are increasing signs that the outer sloping edge of the continental shelf along the East Coast has the potential to cave in, possibly abruptly enough to send destructive tidal waves, or tsunamis, speeding toward shore.

The latest evidence comes in a study being published today in the journal Science, which found that rock buried nearly 2,000 feet under the seabed off New Jersey is so porous that it is actually mostly water.

The new research, and similar recent findings, do not suggest that strollers on the Atlantic City boardwalk are in imminent danger of being swept away by a tidal wave. But

versity who wrote the paper with Brandon E. Dugan, a doctoral candidate at the university. What is not yet known, Dr. Flemings said, is if this condition will result in a succession of small crumbling failures or in occasional canyon-carving, wave-spawning collapses.

Using computer models, the scientists calculated that the pressure built up in deeply buried layers of porous rock is more than sufficient to drive the water sideways until it

Could the boardwalk of Atlantic City be engulfed someday?

work needs to be done to determine the level of risk.

"All I can say is there is evidence that this has happened in the past," Dr. Rona said, "and some of these scars look fairly fresh."

Last April, another research team found cracks in the continental slope off Virginia that also signaled the potential for large submarine landslides, which are thought to spawn waves as the water above suddenly sinks to fill a gap in the sea floor, sending a pulse of energy shoreward.

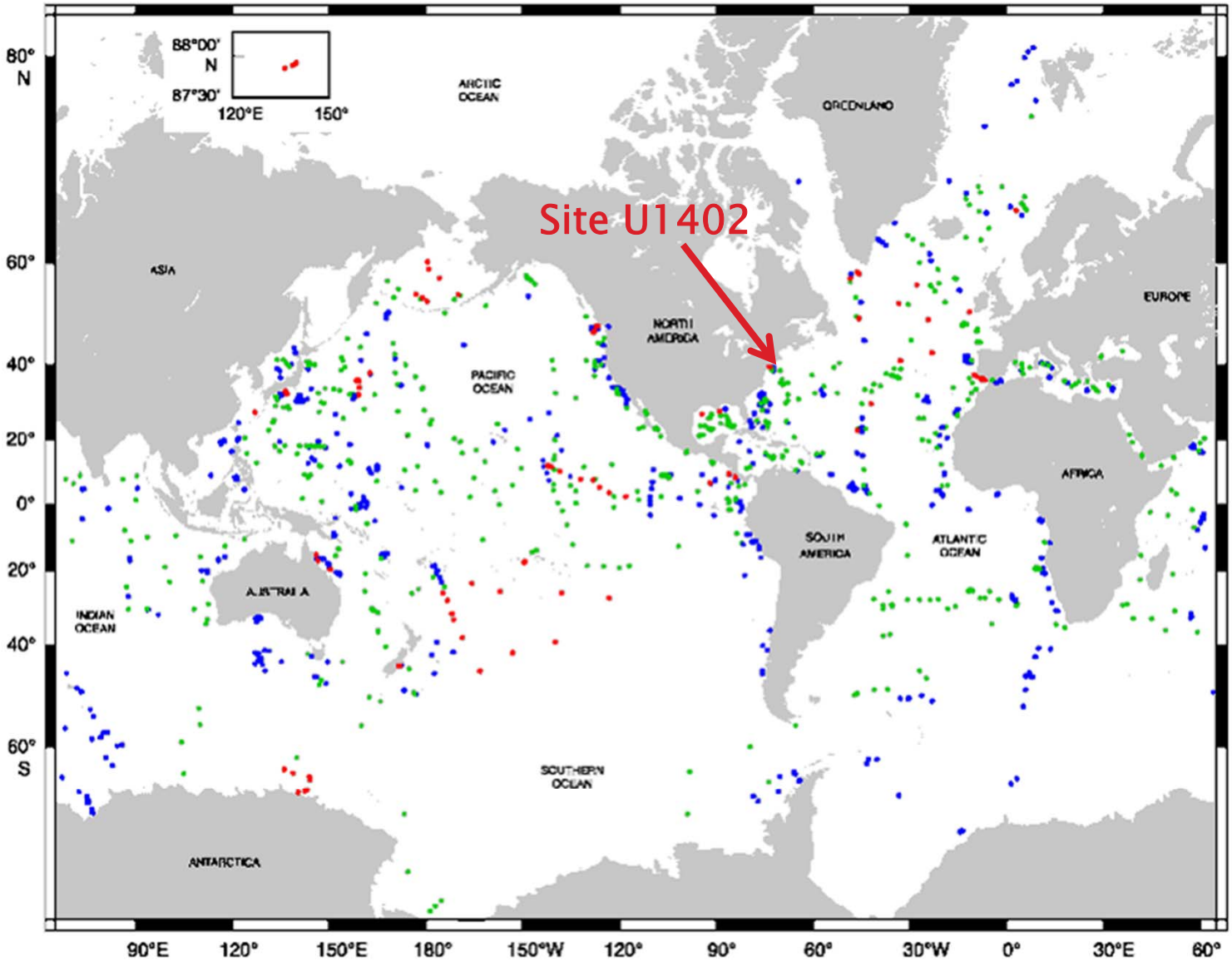
The new findings come on the heels of other work showing that the threat from tsunamis comes not just from earthquakes, as has long been thought, but also from underwater landslides that can occur quite close to shore and can either be triggered by a small quake or happen spontaneously.

The last large destructive tidal wave, which killed more then 2,200

Integrated Ocean Drilling Program

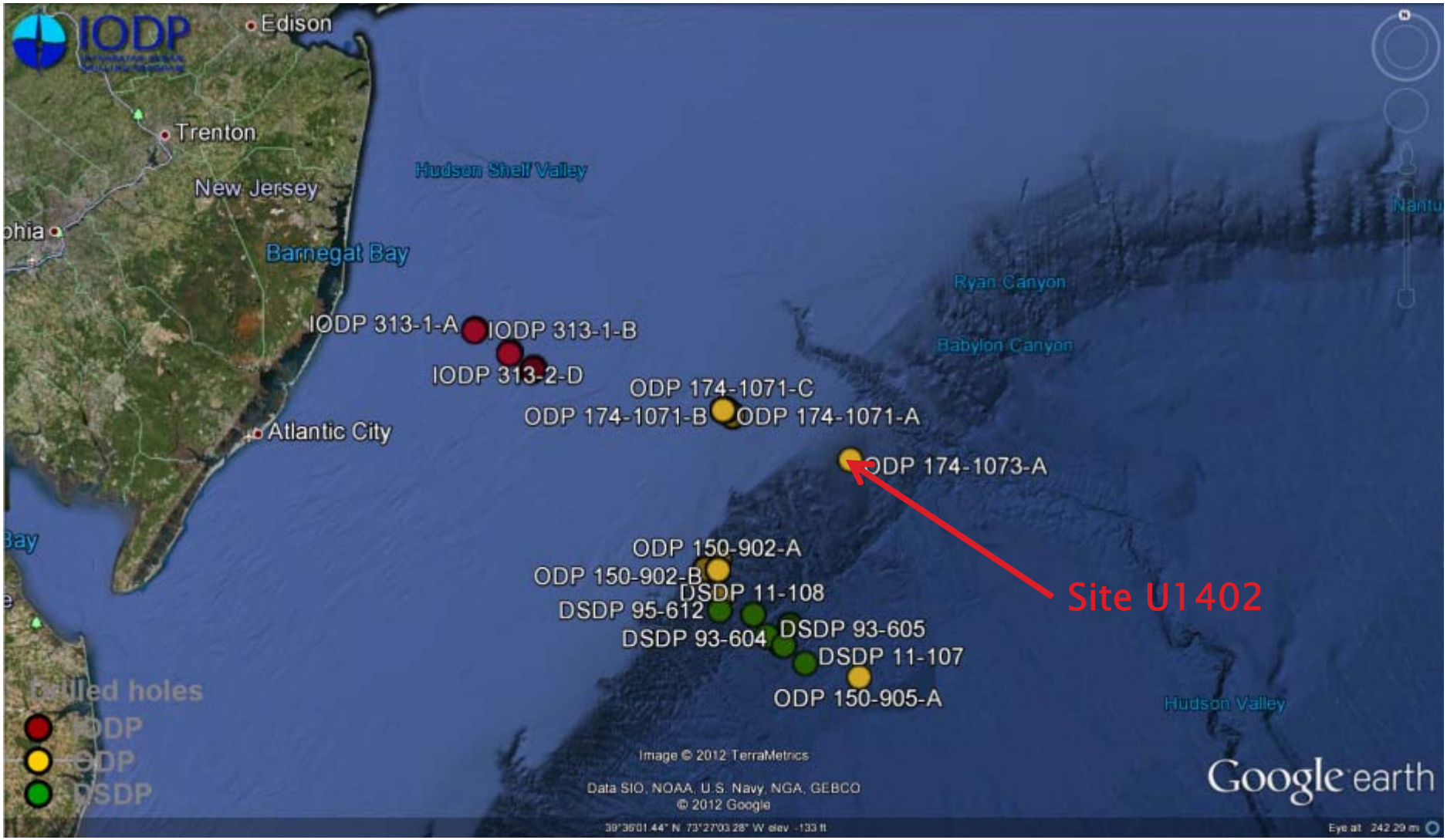
"The Integrated Ocean Drilling Program (IODP) is an international scientific research program that addresses important questions in Earth, Ocean, Environmental and Life sciences based on drill cores, borehole imaging, borehole observatories, and related geophysical imaging of drill sites."

- Two major drill ships
  - JOIDES Resolution and Chikyu (Patrick Fulton)



DSDP Legs 1–96 (●), ODP Legs 100–210 (●), IODP Expeditions 301–339 (●)

Source: IODP


IODP
Edison
Trenton
New Jersey
Barnegat Bay
Hudson Shelf Valley
Ryan Canyon
Babylon Canyon
IODP 313-1-A
IODP 313-1-B
IODP 313-2-D
ODP 174-1071-C
ODP 174-1071-B
ODP 174-1071-A
Atlantic City
ODP 174-1073-A
ODP 150-902-A
ODP 150-902-B
DSDP 11-108
DSDP 95-612
DSDP 93-604
DSDP 93-605
DSDP 11-107
ODP 150-905-A
Site U1402
Hudson Valley
Image © 2012 TerraMetrics
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
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Google earth


Source: Gerry Iturrino

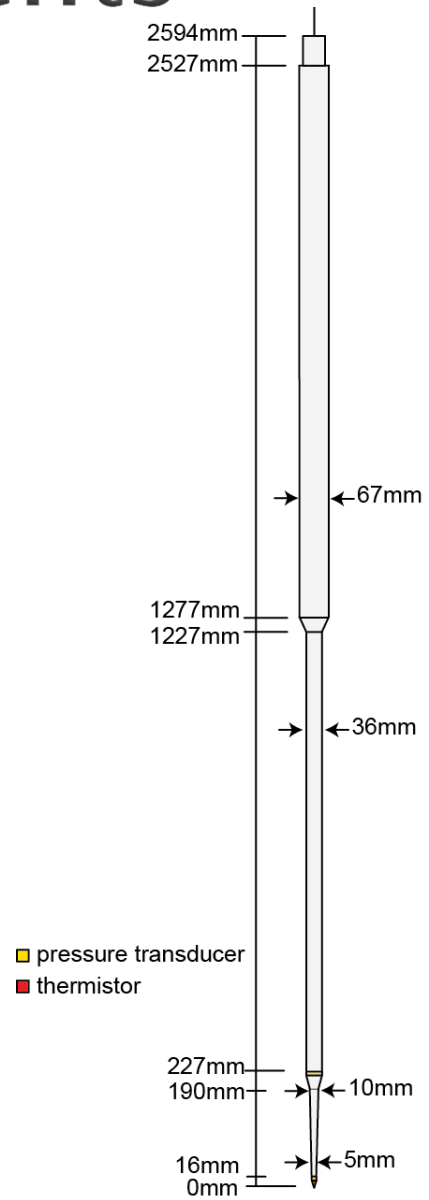
IODP Data Acquisition

- Key Question:
  - How do you acquire useful penetrometer data from a penetrometer attached to a rigid drill string, attached to a ship, that's heaving?

- Secondary Questions
  - What is a penetrometer?
  - What is a drill string?
  - What is heave?

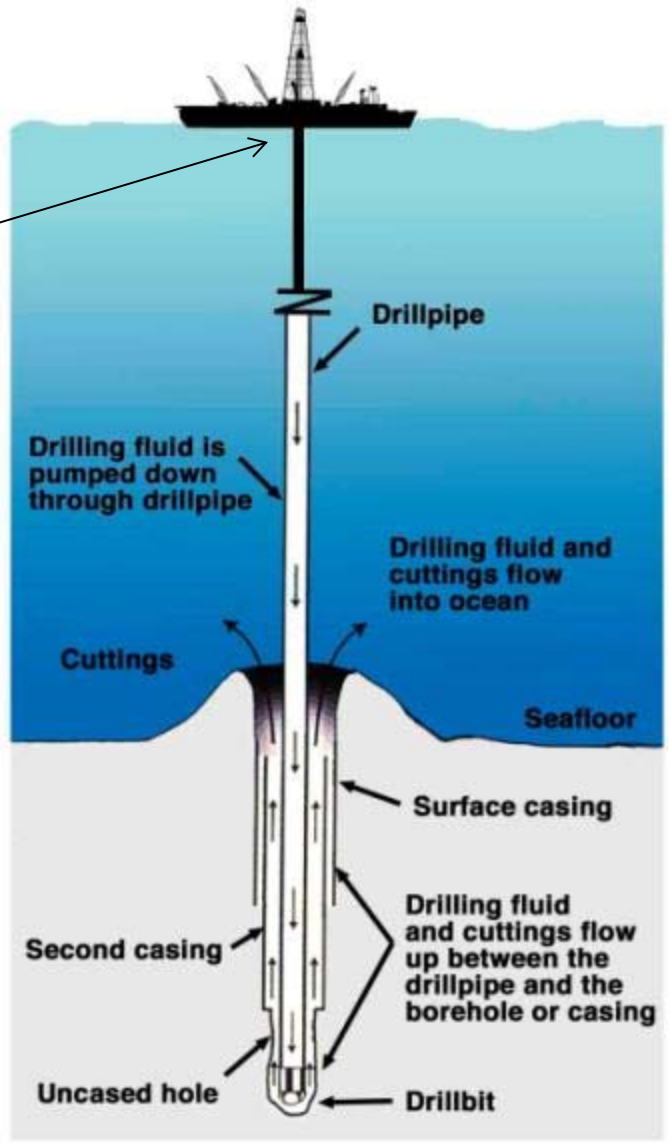
Penetrometer Measurements

- Benefits:
  - Collect data in the formation before it is disturbed by drilling
  - A direct reading, not calculated, predicted, etc.
  - Used often in geotechnical engineering (i.e. we feel good about the data)
- Drawbacks:
  - Takes about an hour per measurement
  - Needs to be "decoupled" from the ship for accuracy
  - The better the reading the more 'delicate' the tool needs to be



Drilling from a ship

Drill string is rigidly attached to the ship



Source: IODP

As the ship heaves (goes up and down) everything heaves

How do you acquire useful penetrometer data from a penetrometer attached to a rigid drill string, attached to a ship, that's heaving?

The old way: CDS

- Colleted Delivery System—like a telescoping rod
  - Failure rate is 80%
  - Truly decoupled measurements are rare
  - Penetrometer delivery is unprotected, which led to broken tips on occasion

The New Way: MDHDS

- Motion Decoupled Hydraulic Delivery System
  - Deployed on the wireline
  - Remotely unlatched
  - Potential for real-time communication
  - Remotely retrieved
  - Complete decoupling from the drill string
- One of three components that work in tandem with the penetrometer

The New Way: MDHDS

Four key components:

- Penetrometer: Temperature 2 Pressure Probe
- Delivery: Motion Decoupled Hydraulic Delivery System
- Recovery Tool: Electronic Recovery System
- Data Acquisition: Multi-Functional Telemetry Module

The New Way: MDHDS

Four key components:

- Penetrometer: T2P
- Delivery: MDHDS
- Recovery Tool: ERS
- Data Acquisition: MFTM

- T2P-MDHDS-ERS-MFTM

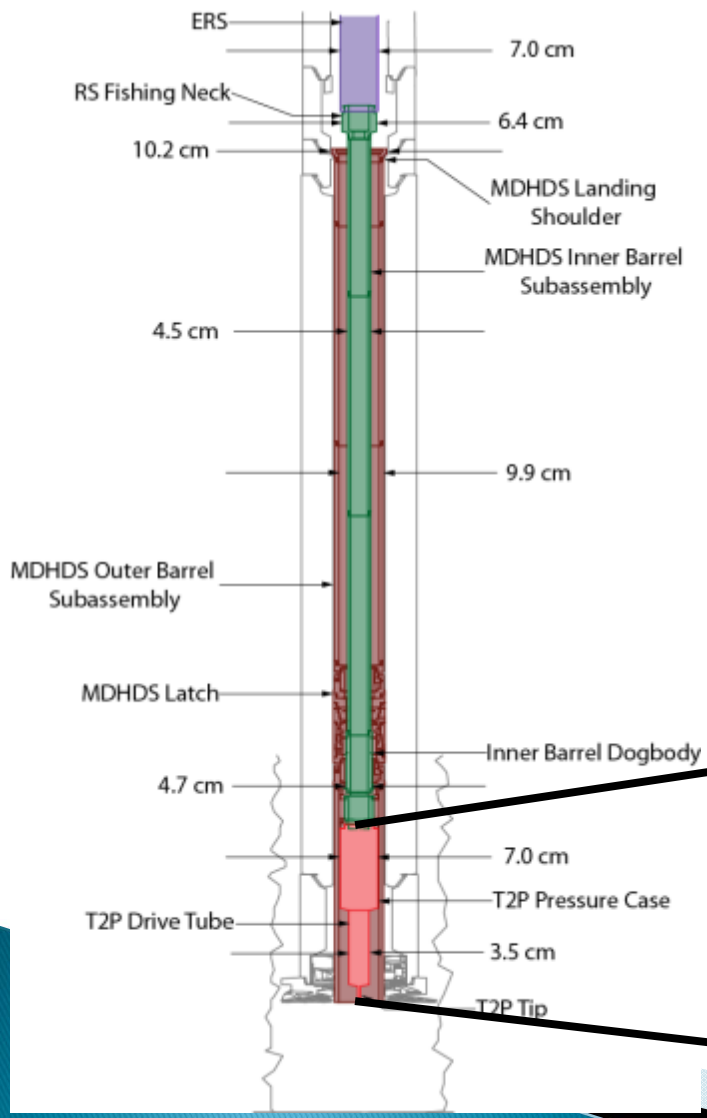
The New Way: MDHDS

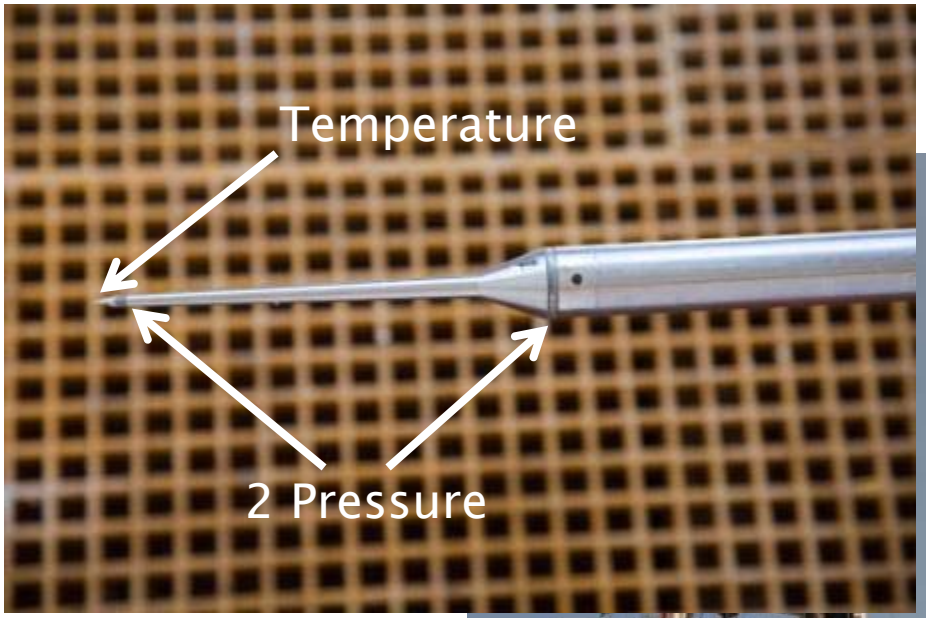
Four key components:

- Penetrometer: T2P
- Delivery: MDHDS
- Recovery Tool: ERS
- Data Acquisition: MFTM

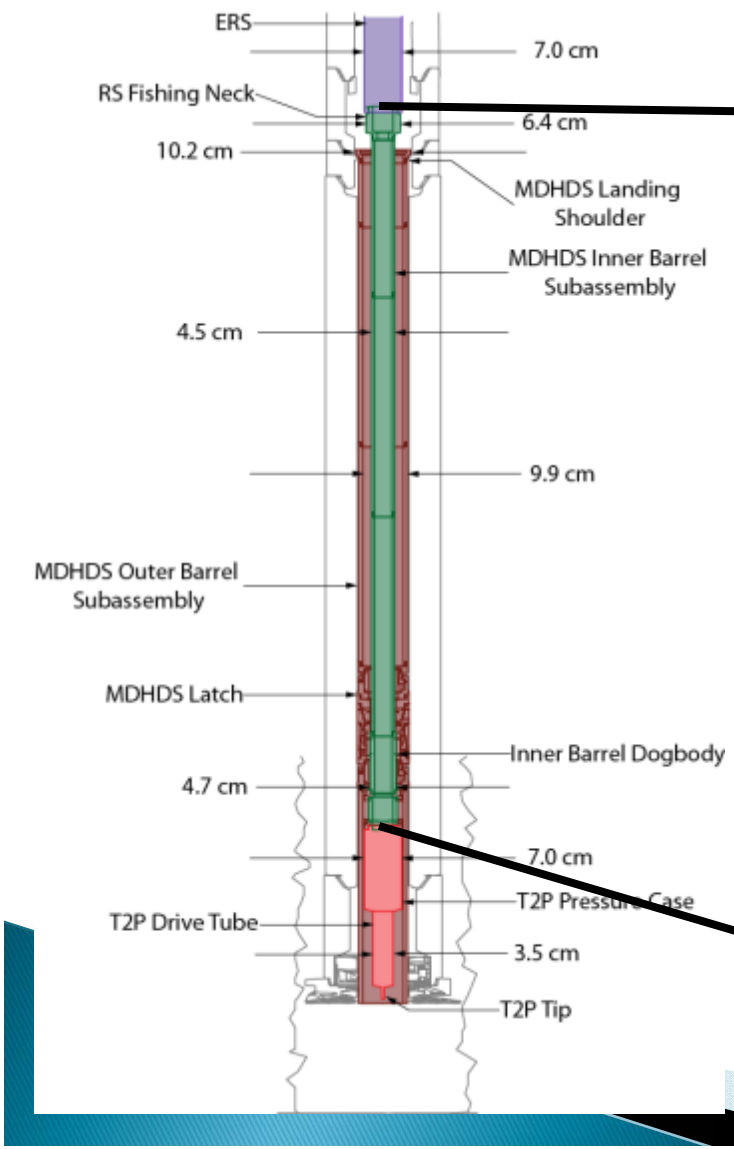
- Penetrometer-Deploy-Recover-Daq

The Penetrometer (T2P)

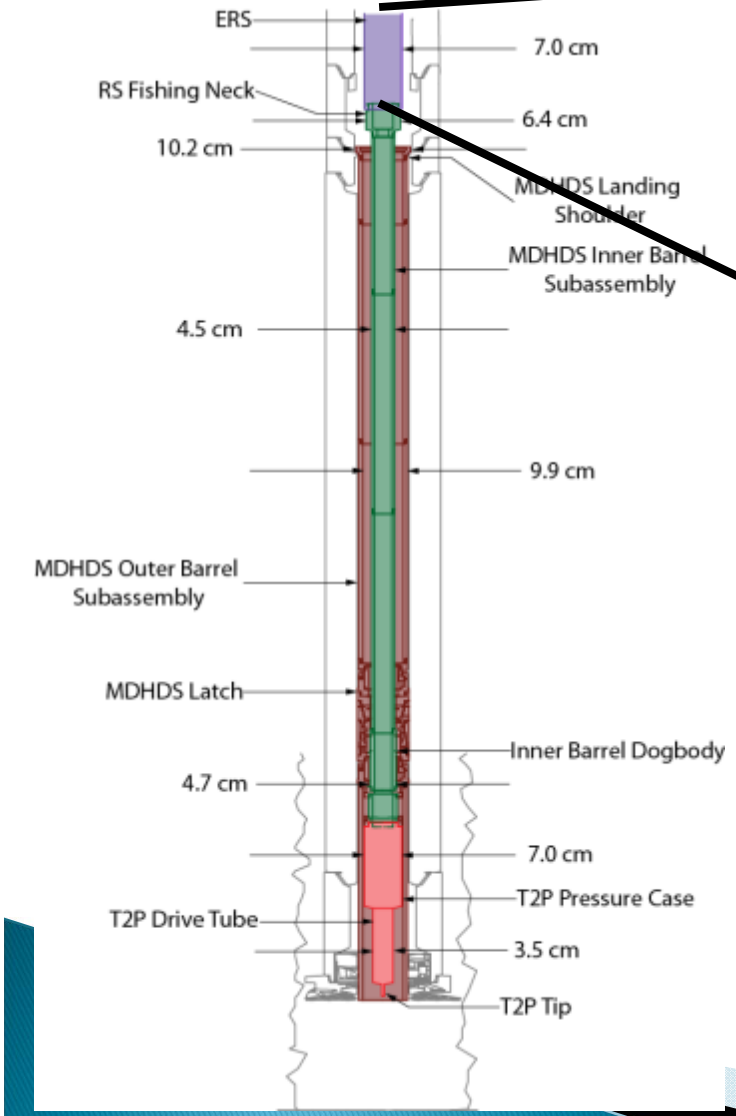


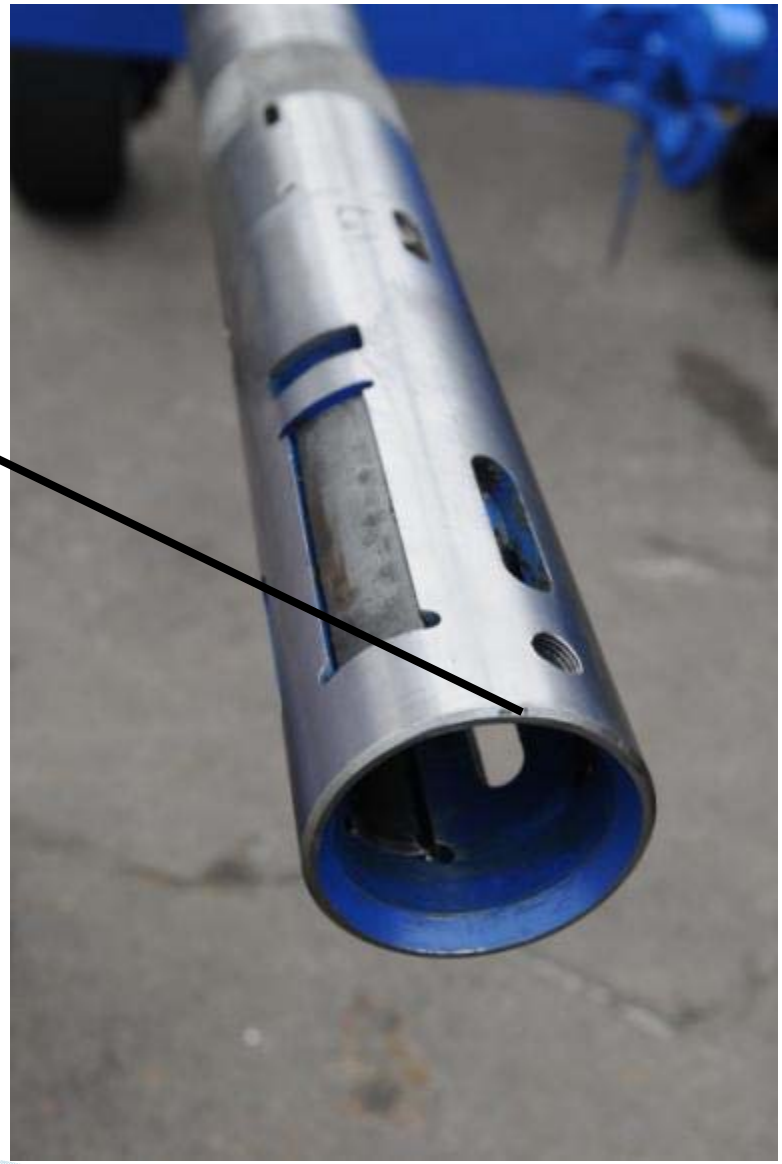


Deploy Tool (MDHDS)

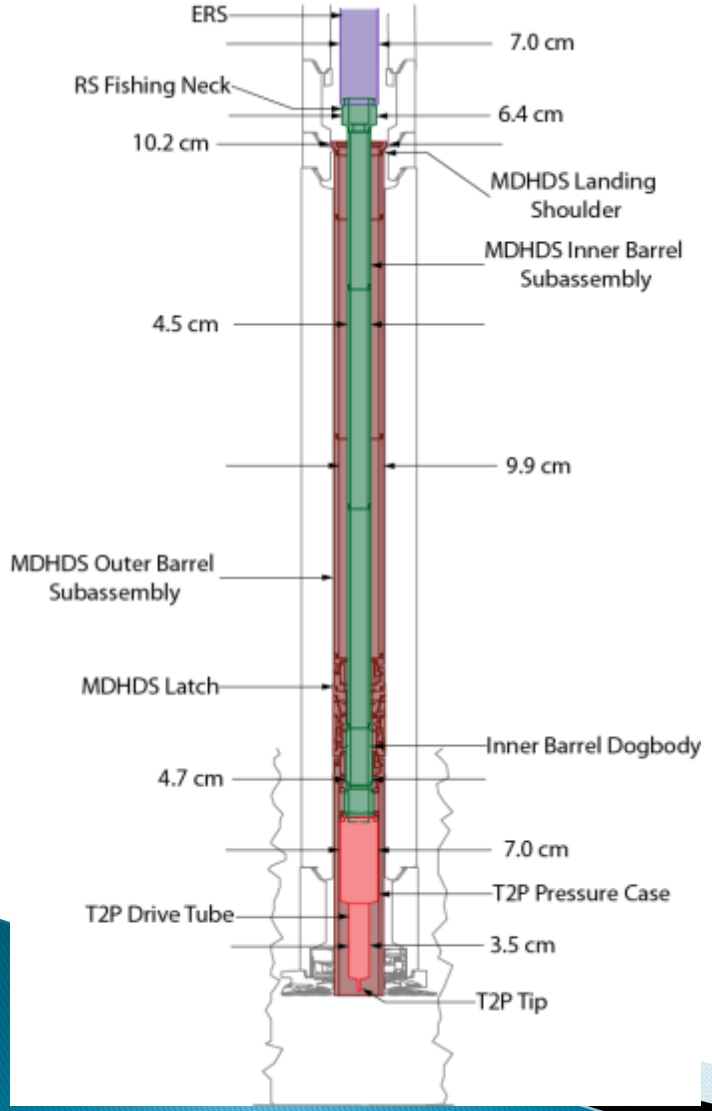


Recovery Tool (ERS)

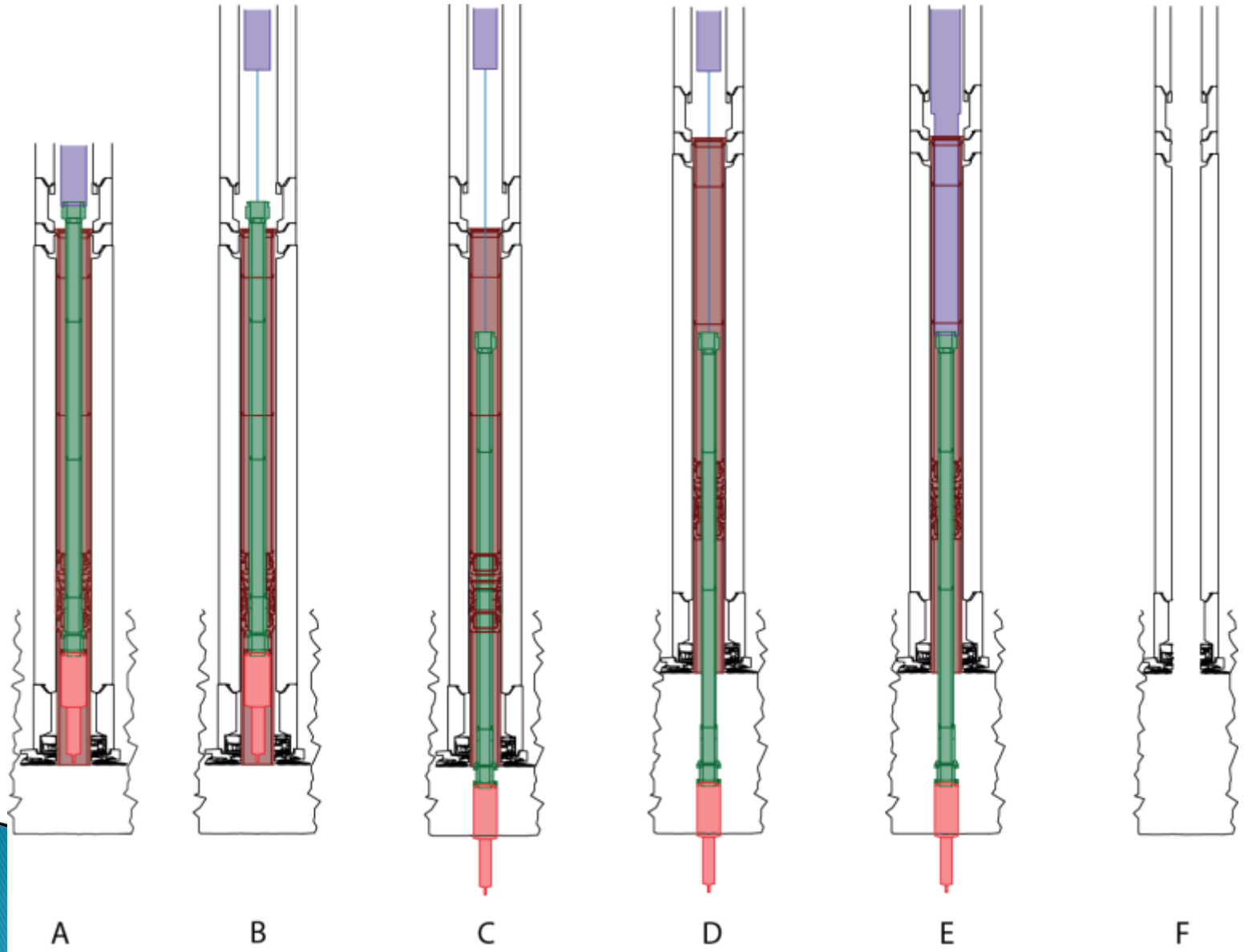




Daq Tool (MFTM)



How it Works



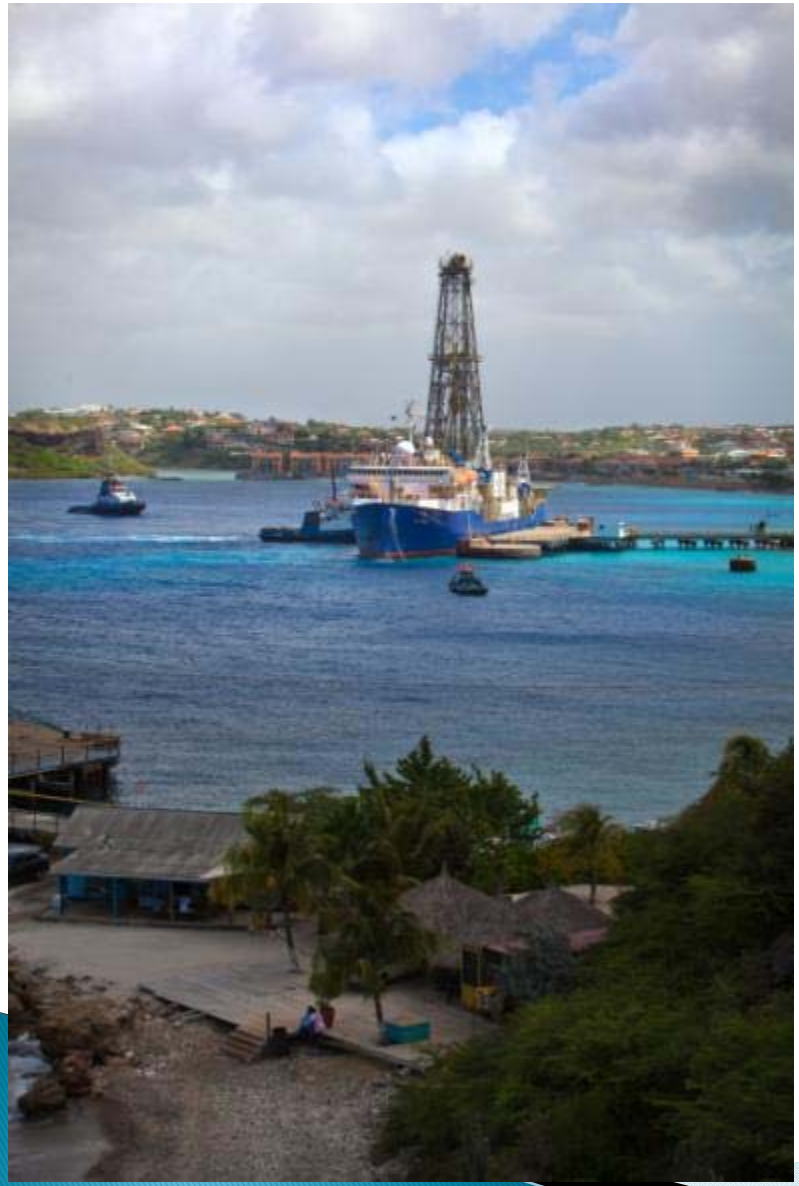
Timeline

- 1997: Original drilling on Jersey Slope
  - Stratigraphy to pore pressure
- 2001–2005: Pore Pressure Penetrometers
  - Penetrometer development
  - Exp. 308 testing
- 2007–2012: MDHDS & Engineering Development
- 2012: Expedition 342

A Busy 12 Months

1. **May 2011**: LDEO Borehole Facility (Lamont, NY)—Communications and latch test at 7000 psi
2. **August 2011**: Schlumberger Test Facility (Sugar Land, TX)—Test T2P, MDHDS, ERS, and MFTM in a downhole environment.
3. **December 2011**: Mohr Engineering (Houston, TX)—Test modifications made to the MDHDS latching
4. **January 2012**: BEG (Austin, TX)—Space out the inner and outer barrels of the MDHDS
5. **January 2012**: Schlumberger Test Facility (Sugar Land, TX)—Test the MDHDS latching mechanism in a downhole environment
6. **March 2012**: Mohr Engineering (Houston, TX)—Bench-top testing of the modified ERS
7. **April 2012**: Schlumberger Test Facility (Sugar Land, TX)—Repeat September 2011 test with newly modified components
8. **May-June 2012**: JOIDES Resolution (North Atlantic)—repeat April 2012 test in downhole environment

The JOIDES Resolution



The JOIDES Resolution

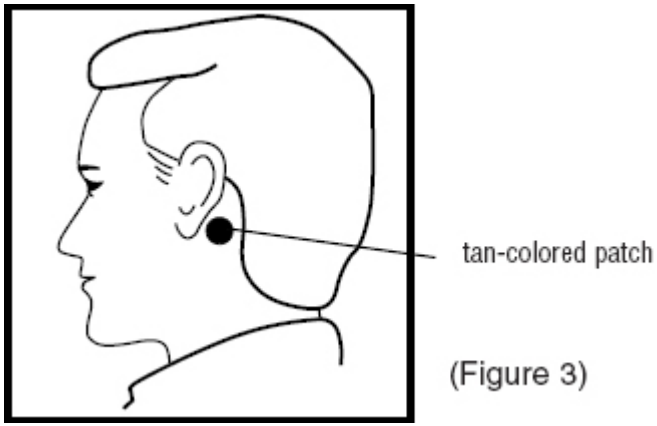
- 470.5’ long
- 70’ wide
- 202’ tall
- Completed >140 expeditions
- >250 km of core recovered

Logging Office: where we spent most our days for 2 weeks

Exercise keeps the mind sharp

Three things you need to survive

Three things you need to survive



(Figure 3)

Three things you need to survive

Sea Trials

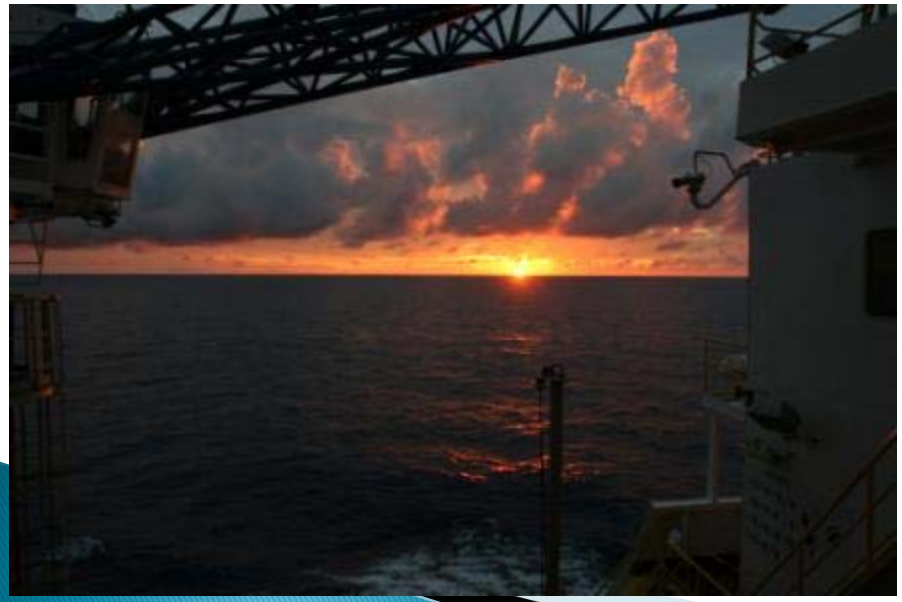
- 26 May—Arrive in Curaçao
- 28 May—Depart Curaçao
- 2 June—Arrive in Bermuda
- 4 June—Depart Bermuda
- 6 June—Arrive at Site U1402
- 6-8 June—Complete Sea Trials
- 8 June—Depart JR/Arrive in NJ

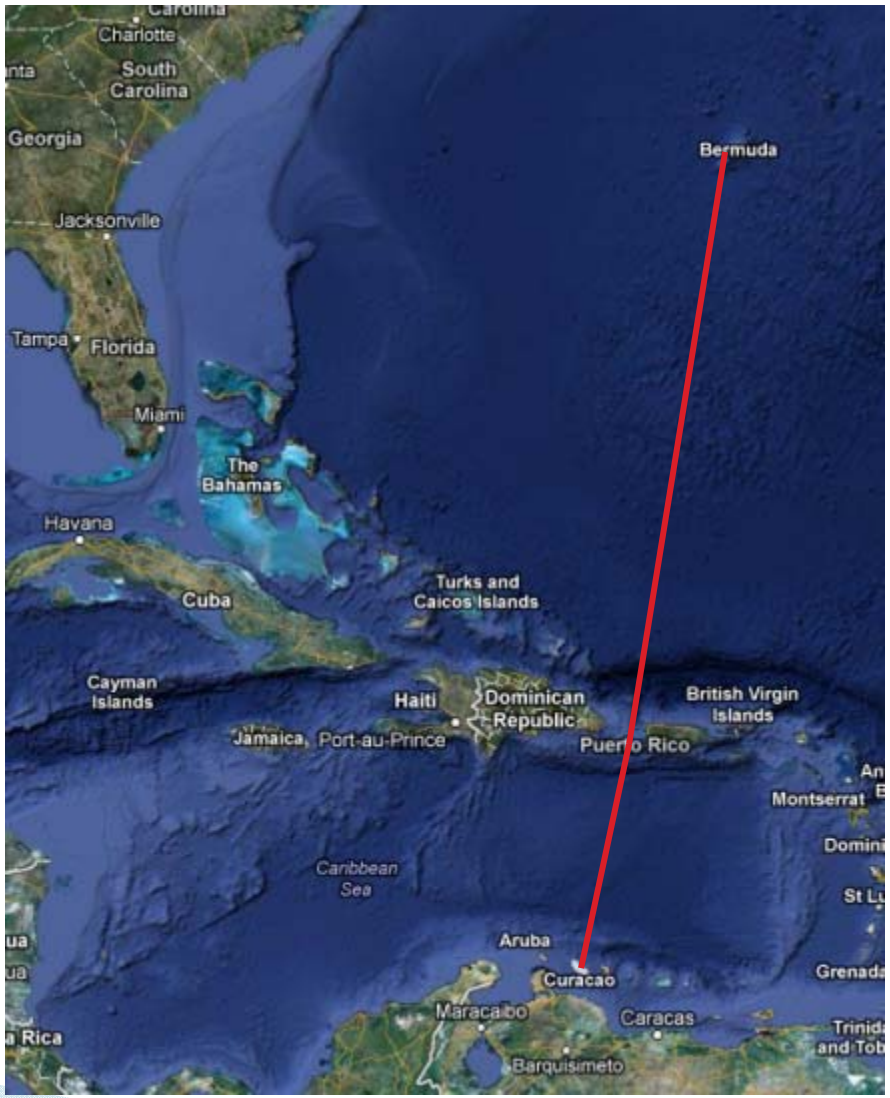
Curçao

- Former Dutch colony
- Lots of Amstel Light
- Beautiful island with a repressed economy

Curaçao to Bermuda

- 4.5 days at sea
- 1 day sea sick
- Lots of pre-testing preparations





Bermuda

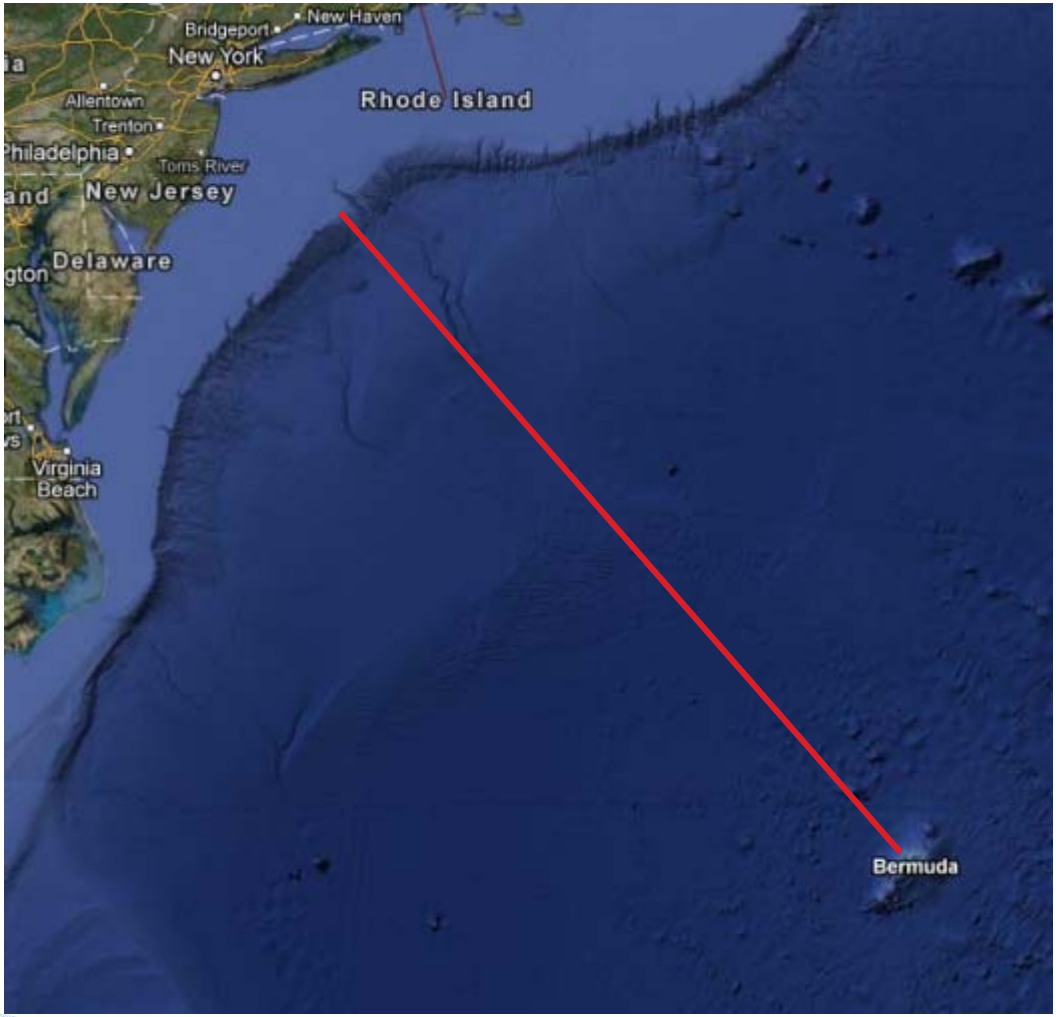
- Better beer than Curaçao
- 2 day port call
- 1 long hike

Bermuda

- Better beer than Curaçao
- 2 day port call
- 1 long hike

Bermuda to U1402 (Jersey Slope)

- 2 day transit
- 12-15 ft seas
- 40 mph winds
- Lots of sleep
- Lots of soft-serve ice cream



Sea Trials

Proposed Plan:

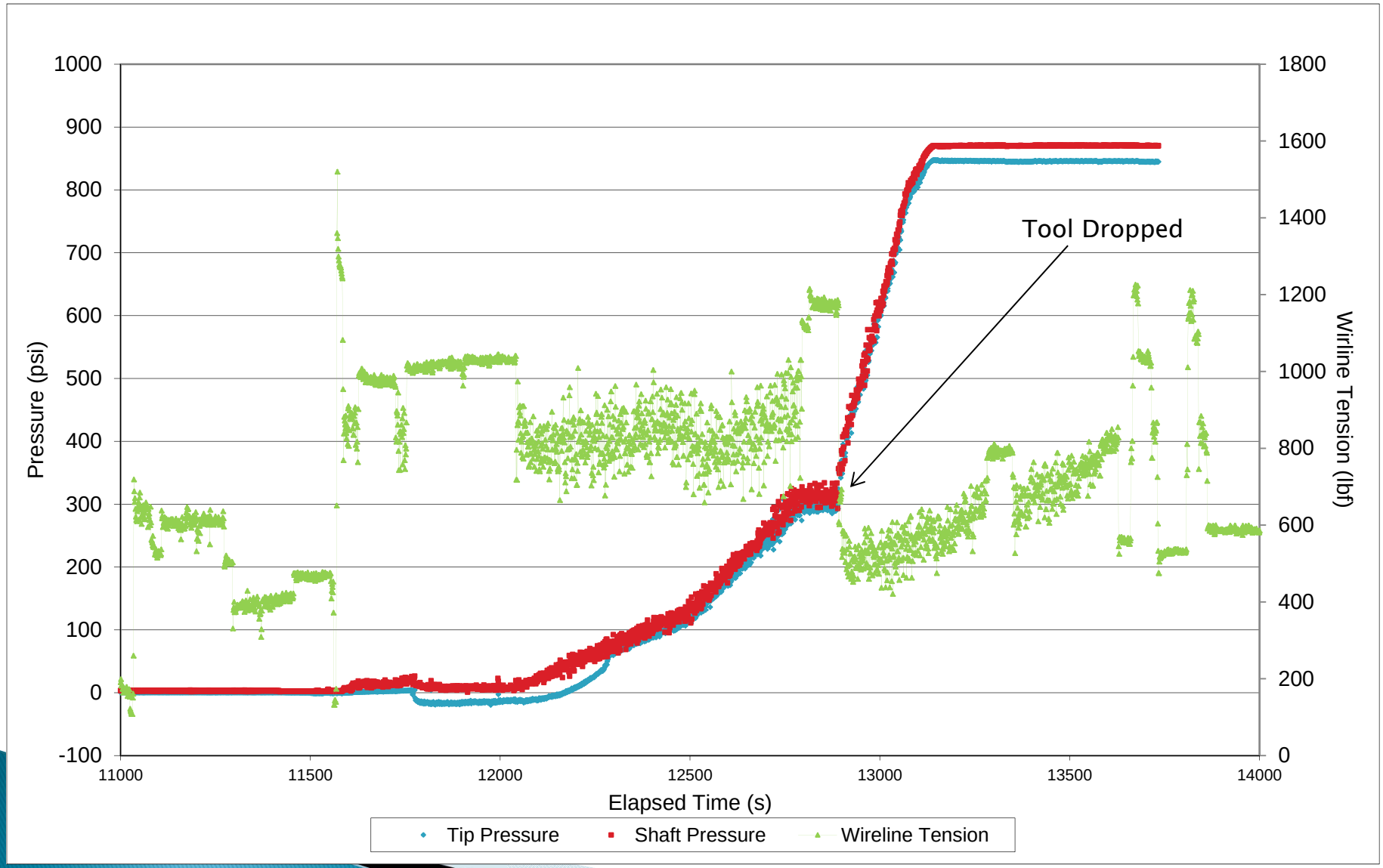
- Wash to 100 mbsf
- Deploy T2P, wash 2m
- Deploy T2P, wash 2m
- Deploy SET-P,
- Piston Core!
- Deploy T2P, wash 2m
- Deploy T2P, wash 2m
- 3 Piston Cores

Sea Trials

Actual Sequence:

- Begin deploy of T2P
- Drop T2P and MDHDS 300 m
- Spend ~8 hrs getting it back
- Wash to 100 mbsf
- Deploy T2P
- Have a successful test
- Get T2P stuck for 5 hrs
- 2 Piston Cores

Sea Trials: Deployment One



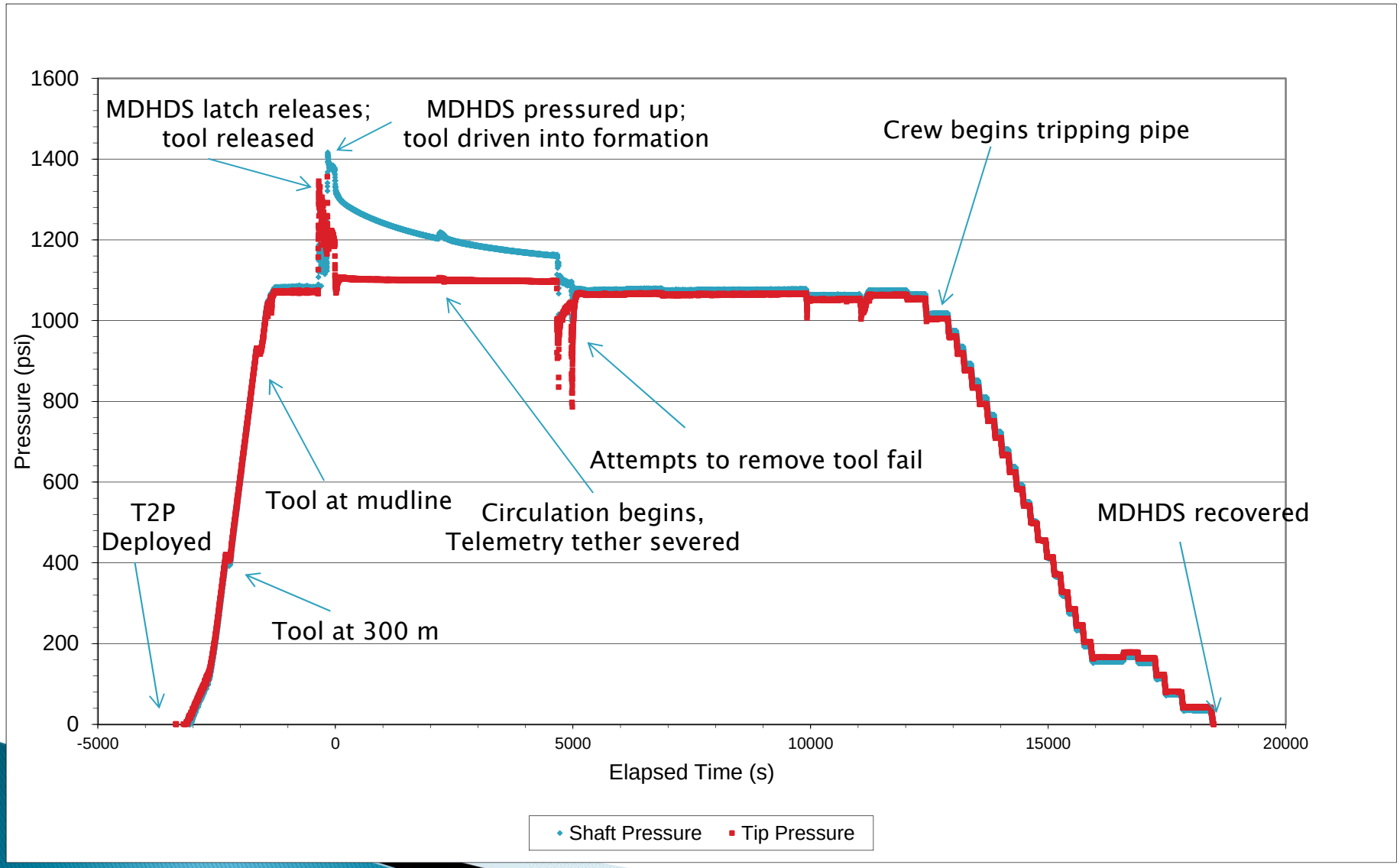
Sea Trials: Deployment One

What Happened?

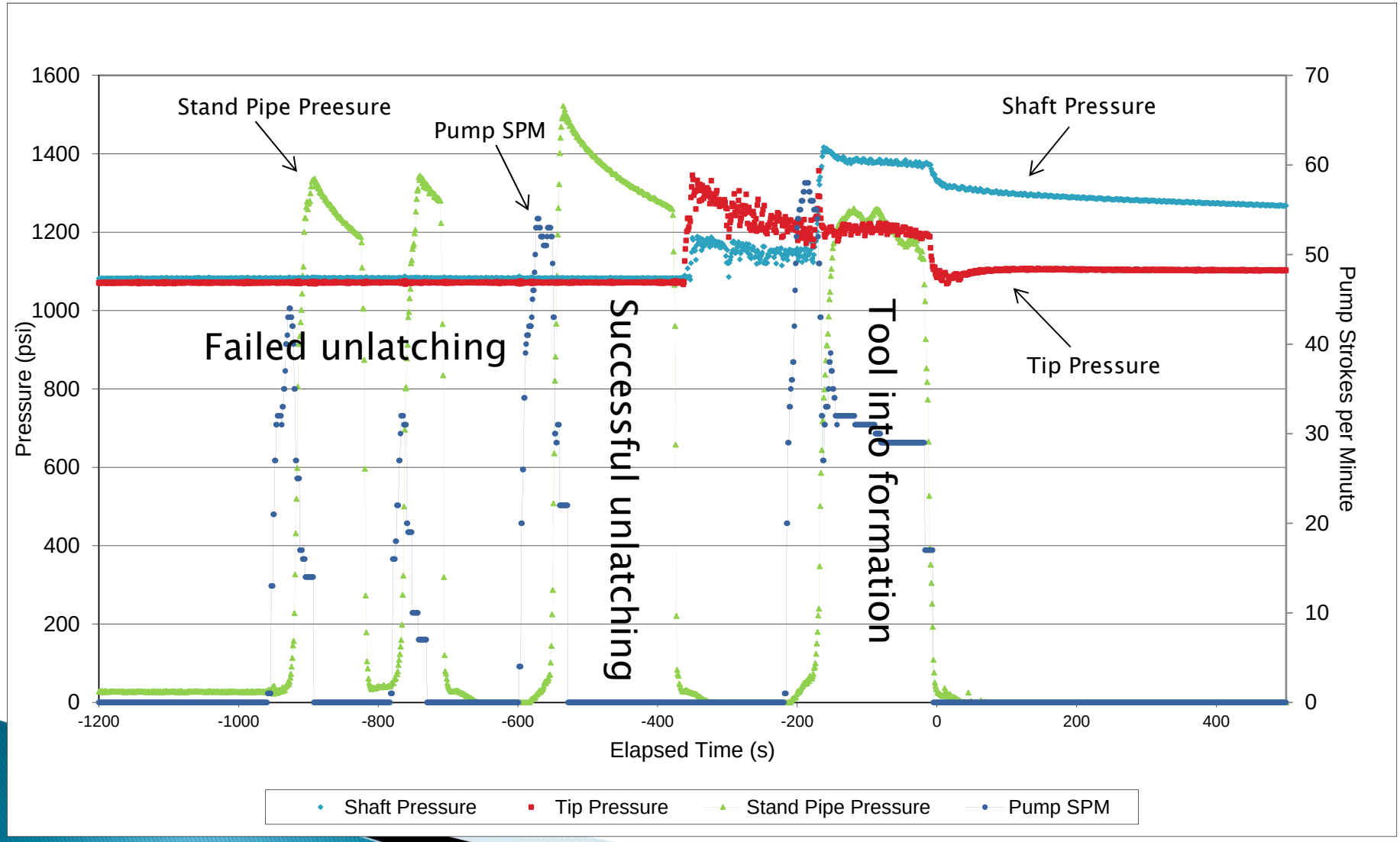
- Very strong sub-surface currents
  - The drill string was literally chattering!
- Faulty latch mechanism on the recovery tool
  - Caused premature release and inability to recover
- Faulty connection between penetrometer and Daq (no real-time communication)

- In our defense:
  - We applied for and received funds to make changes to recovery tool to address known problems
  - But, we didn't receive funds until a week before shipping tools

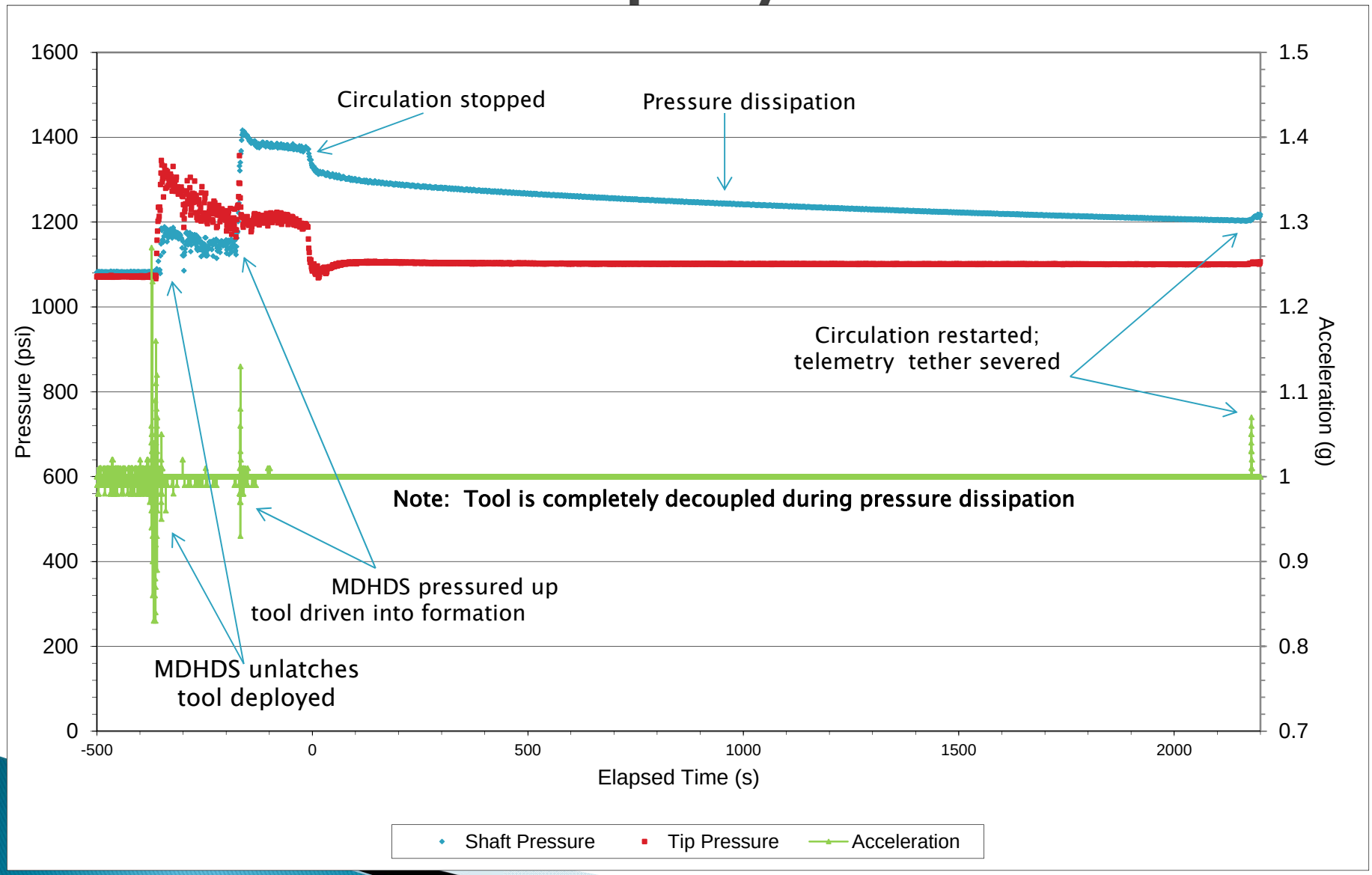
Sea Trials: Deployment Two



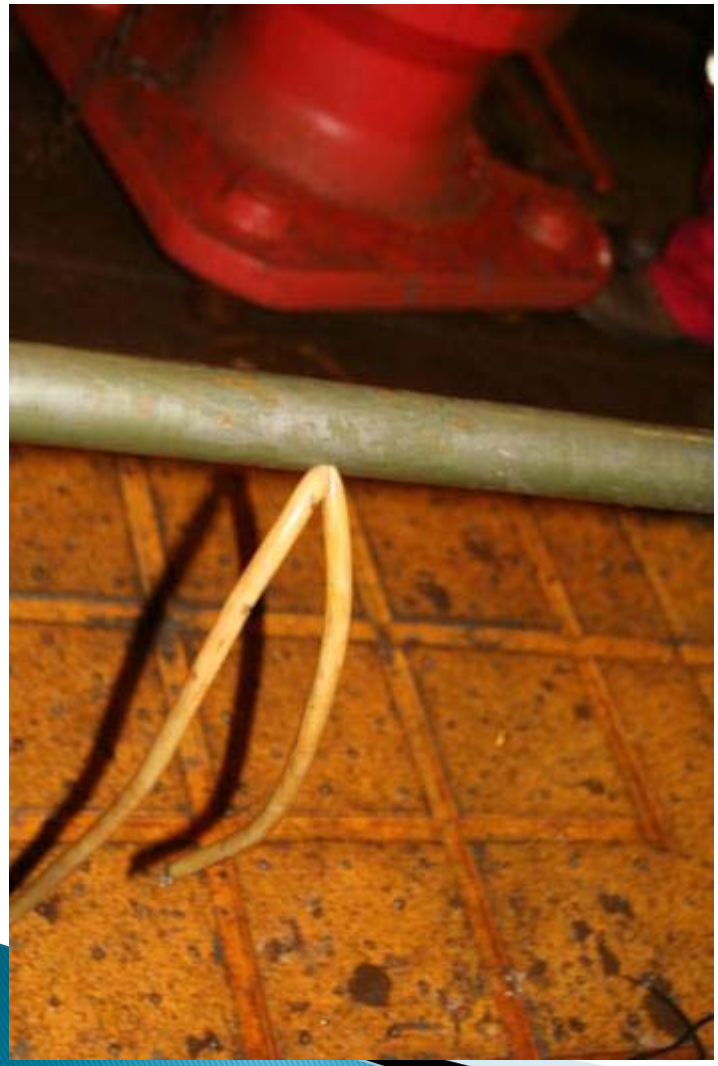
Sea Trials: Deployment Two



Sea Trials: Deployment Two



Sea Trials: Deployment Two



Summary of Results

- Core objectives of Sea Trial were achieved:
  - Penetrometer was remotely deployed
  - Penetrometer was completely decoupled from drill string
- Problems with recovery tool #1 resulted in poor latching and no real-time data
- Restarting circulation resulted in sanding the delivery tool in drill string
- The real-time data tether, although partially successful, may not be viable in the long-term

Departing the JR in Style

Departing the JR in Style

Where do we go from here?

- Complete funded modifications to the recovery system
- Make a few changes to the delivery system
  - Ditch the real-time Daq tether for the time being
  - Install stronger spring
- Back to Sea!
  - May 2013
  - Depart Victoria BC for ~5 days of tests

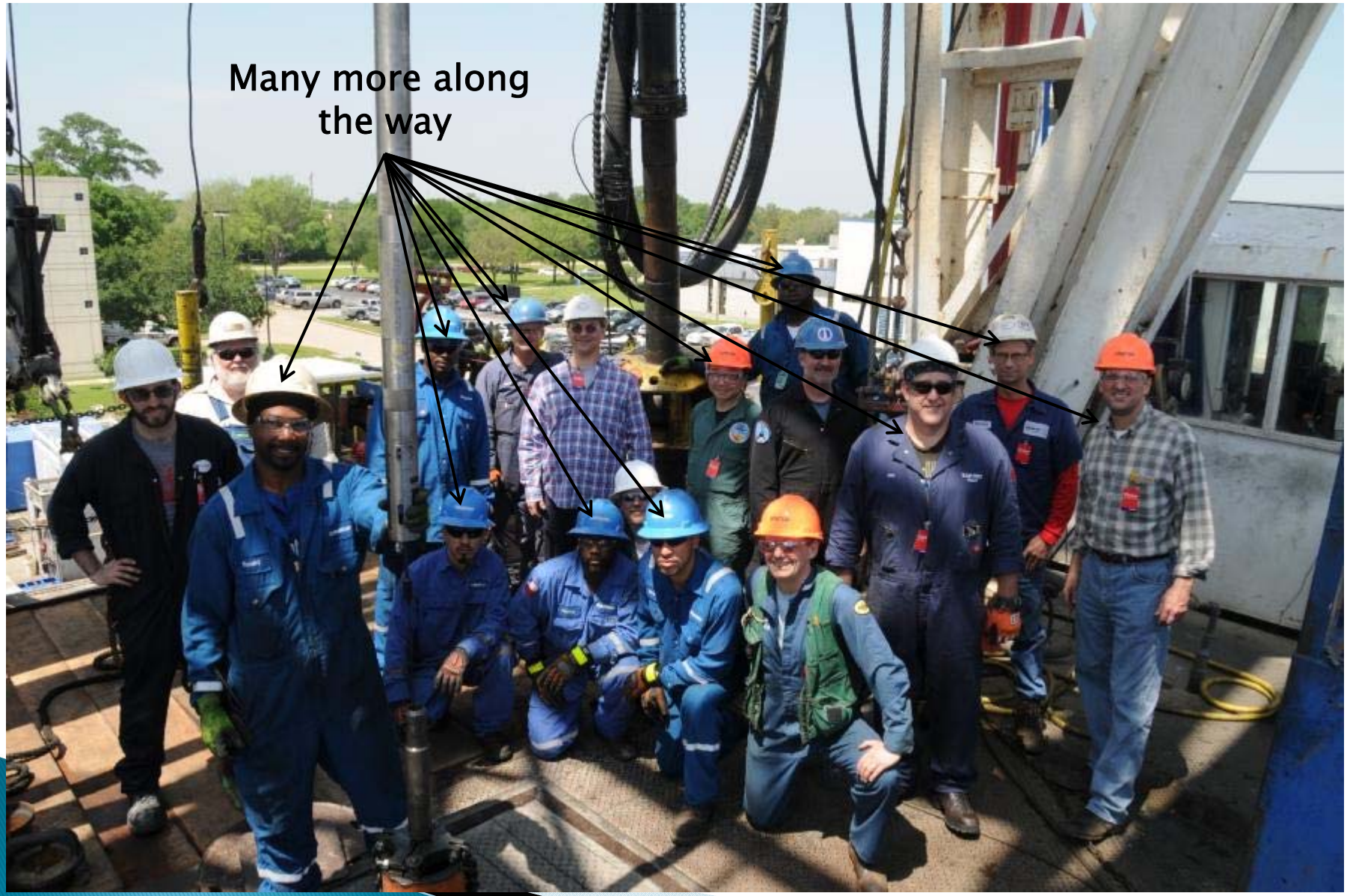
The Team

The Team

The Team

The Team

The Team



Thank you