Sampling Gas Hydrates in the Marine Environment: A Review of Techniques and a Summary of Results

By:

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20 April 2011

Gas Hydrates

Deepwater Horizon: Gas Hydrates Create Setback

Rigzone Staff | Saturday, May 08, 2010

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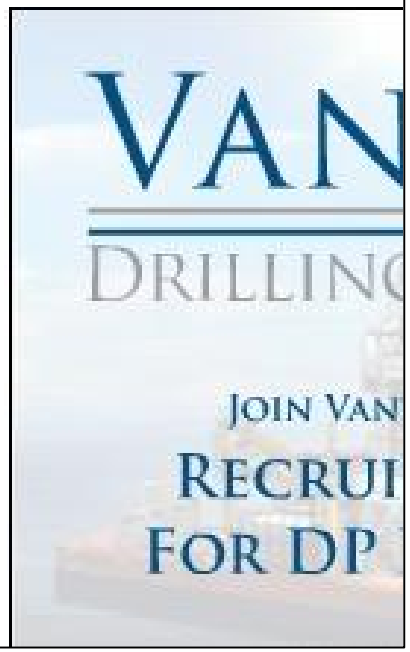
During a Saturday afternoon press conference, BP Chief Operating Officer Doug Suttles reported that gas hydrates had accumulated inside the containment dome.



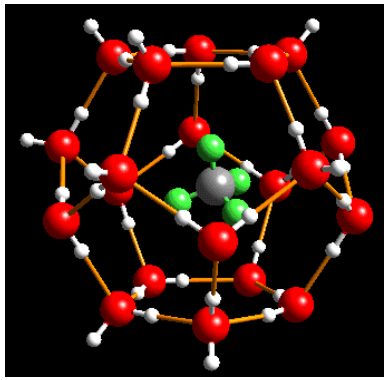
From: Rigzone.com

Outline

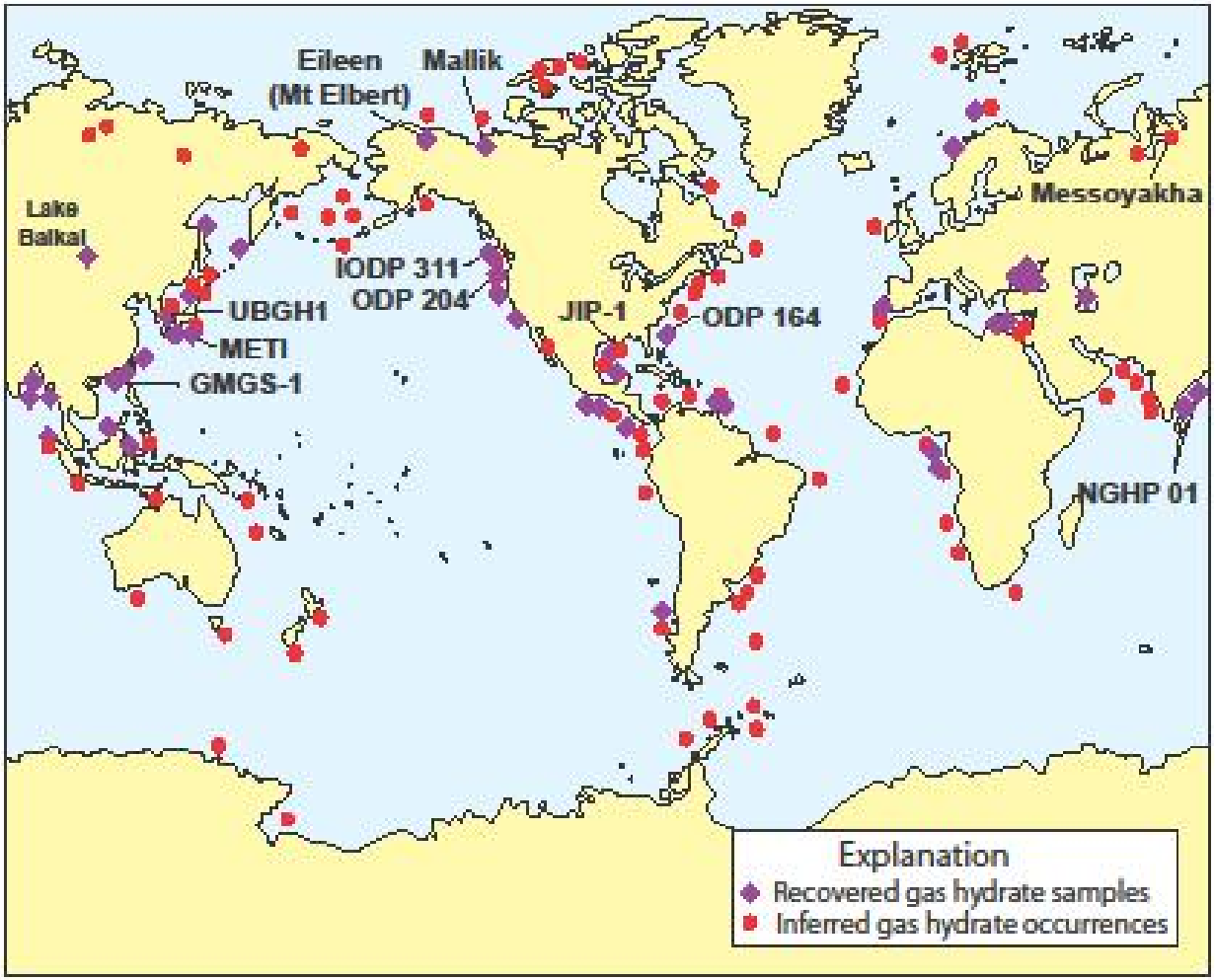
- Introduction to Gas Hydrates
  - What are they?
  - Where do they occur?
  - What's the interest?
- Fugro Involvement
  - Pre-drilling geohazard assessment & site selection
  - Borehole pressure coring, analysis and in-situ testing methods
  - Post cruise analyses and outcomes
- Future plans

What are gas hydrates?

- “Mineralization of gas and water”
- A cage of ice entraps a gas molecule
- They are stable at moderately low temperatures and moderately high pressures
- 1 m^3 of Methane Hydrate releases approximately 170 m^3 of methane gas



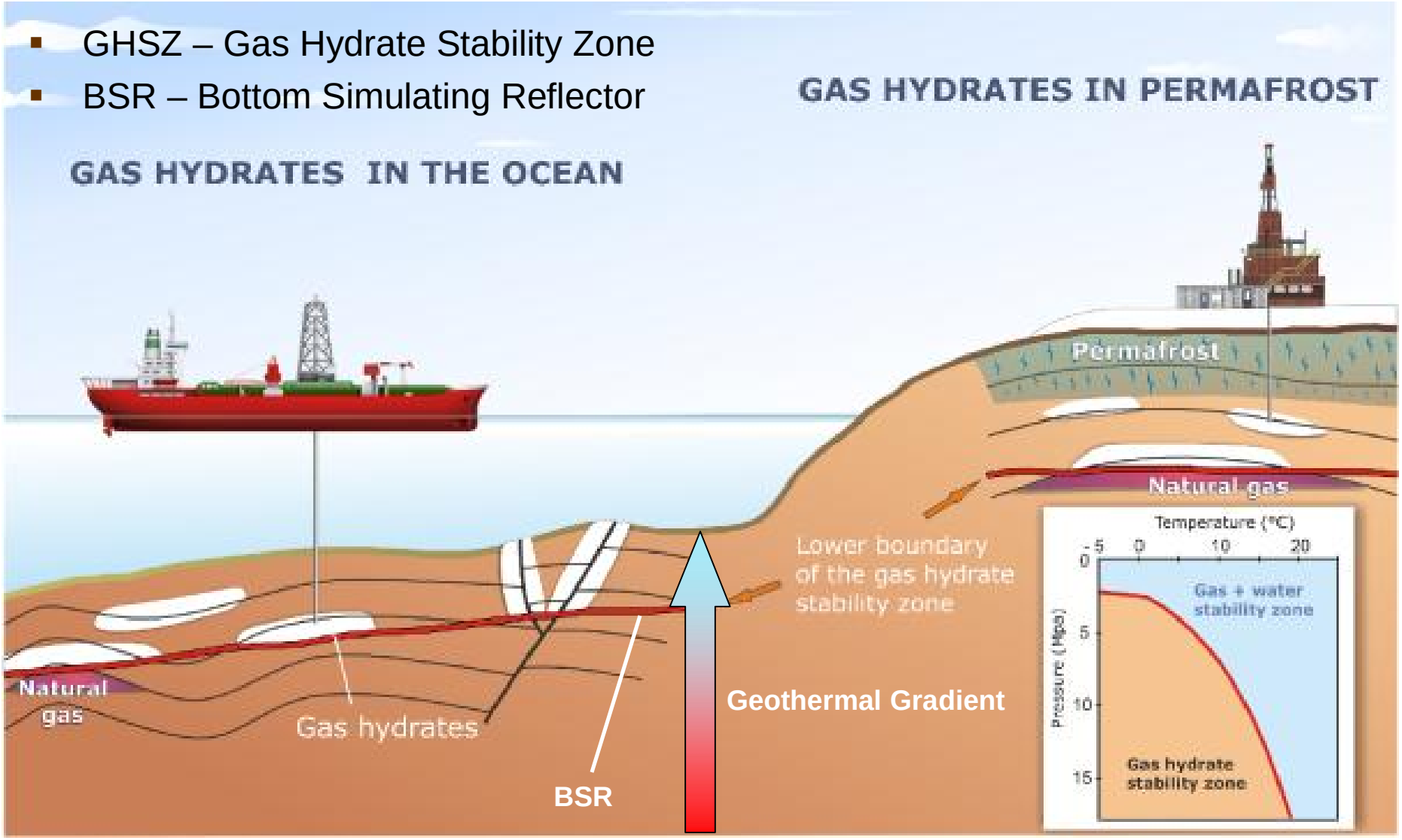
Occurrence Of Gas Hydrates



From: http://www.nap.edu/catalog/12831.html - **2010**

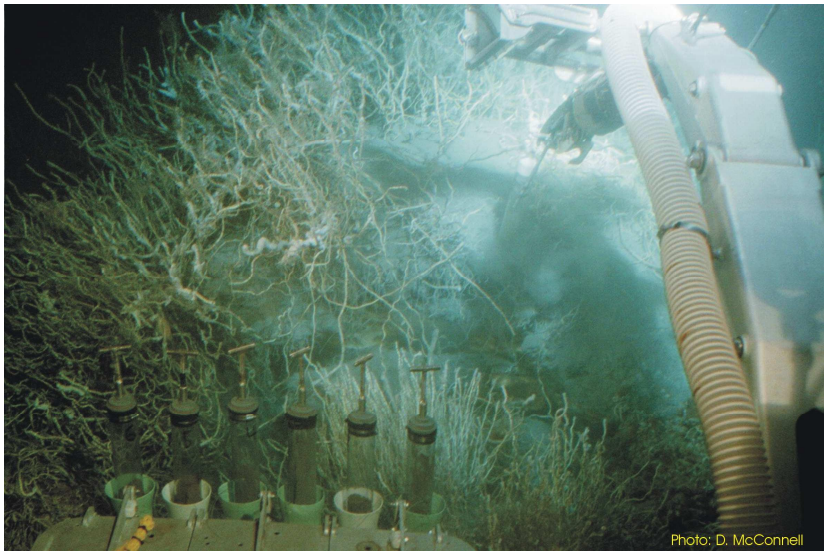
Hydrate Stability Zone

- GHSZ – Gas Hydrate Stability Zone
- BSR – Bottom Simulating Reflector

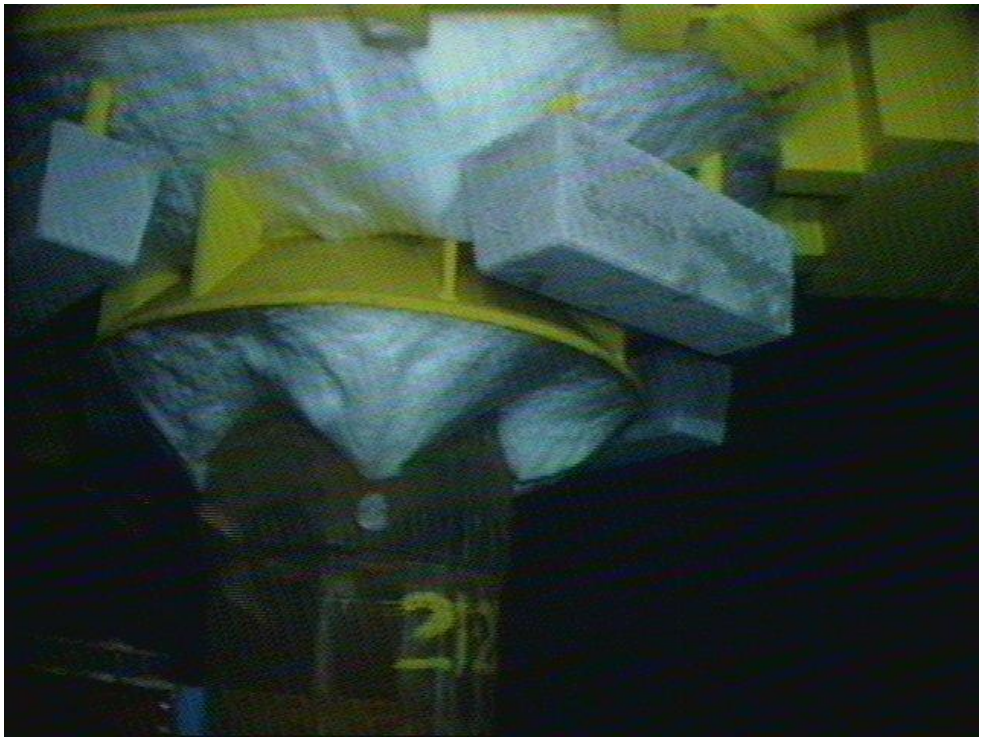


Modified from: http://iopscience.iop.org/1748-9326/4/3/034007/fulltext

Occurrence of Gas Hydrates



- They are either formed by natural processes…
- Or as a result of HC production activities (leakage)



Why the interest?

- Methane captured in gas hydrates is one of the main greenhouse gasses. dissociation of gas hydrates may result in a runaway process – climatic warming further increases this possibility
- Risk to field development due to dissociation resulting in changed or unknown geotechnical properties, increased pore pressures, risk of marine sliding, seafloor heave and subsidence – Geohazard Issues
- Potential energy source – main focus (1) identifying quantity and (2) how to produce?

Greenhouse Gas

BBC NEWS WORLD EDITION

Thursday, 11 August 2005

Siberia's rapid thaw causes alarm

The world's largest frozen peat bog is melting, which could speed the rate of global warming, New Scientist reports.

The huge expanse of western Siberia is thawing for the fi
formation, 11,000 years ago.

The area, which is the size of France and Germany combi
of tonnes of greenhouse gases into the atmosphere.

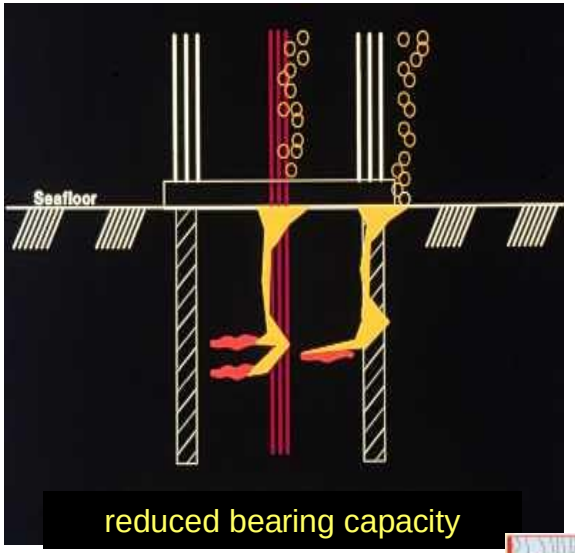
This could potentially act as a tipping point, causing globa
scientists fear.

The situation is an "ecological landslide that is probably ir
undoubtedly connected to climatic warming," researcher S
State University, Russia, told New Scientist magazine.

The whole western Siberian sub-Arctic region has started

Gas Hydrate as a Geohazard

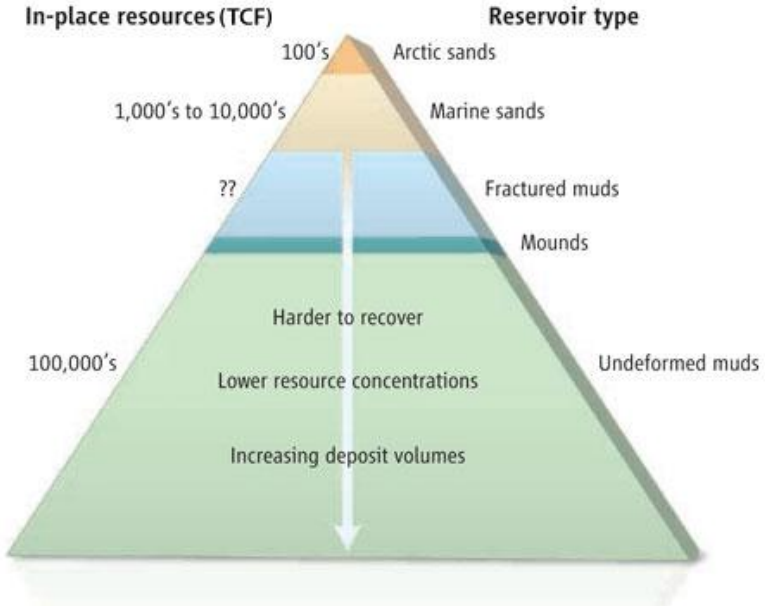
- Risk associated gas hydrate dissociation:
  - **Foundations**
    - Seafloor heave and subsidence
    - Suction & driven piles – loss of anchor capacity
    - Well conductors/casing instability/capacity
  - **Slope stability & Submarine sliding**
    - Pore pressure increase – reduction of effective vertical stress
    - Ormen Lange – Storegga Slide

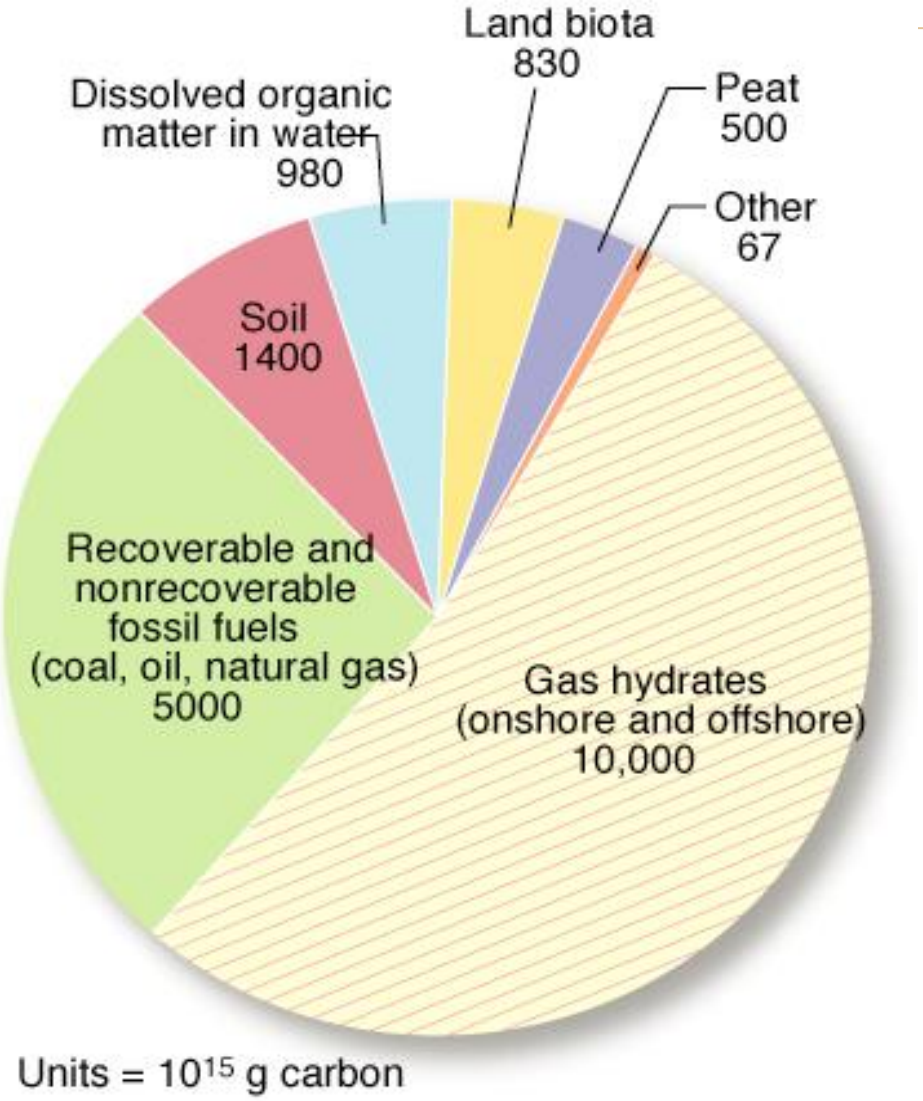


Potential Energy Source

Gas Hydrates:

- Hydrate is estimated to bind immense amounts of methane in sediments
- Large research effort on locating GH resources and developing means for GH production
- Japan, US, India, China, Korea, New Zealand, Taiwan, Mexico, Brazil, Uruguay, Vietnam, Colombia, others





Fugro Involvement

- NANKAI Trough (1999), Offshore Japan
- HYACE Trials – ODP Leg 194 (2001), Offshore WA
- ODP Leg 201 (2002), Offshore Peru
- ODP Leg 204 (2002), Offshore Oregon

- Chinguetti (2003), Offshore Mauritania
- JIP (2005), Gulf of Mexico
- Cascadia Margin IODP Leg 311 (2005), West Coast Canada

- Offshore Field Development (2006), Offshore Malaysia
- DGH, Indian National GH Program (2006), Offshore India
- GMGS, China National GH Program (2007), South China Sea
- KNOC, Korean National GH Program (2007), East Sea
- KNOC, Korean National GH Program (2010), East Sea
- NANKAI Trough (2011), Offshore Japan

Fugro Involvement

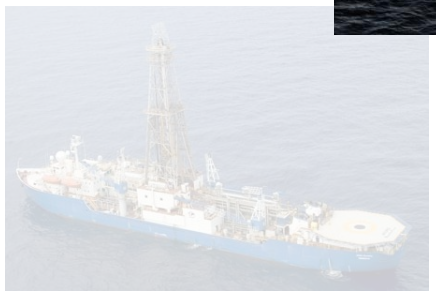
IODP Exp
Cascad
2005

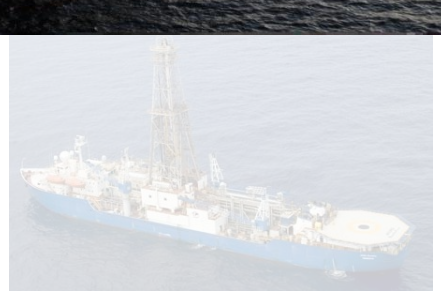
KNOC
East Sea
2010

KNOC/KIGAM
East Sea
2007

ODP Leg 20
Hydrate Ridg
2002

laysia
2006





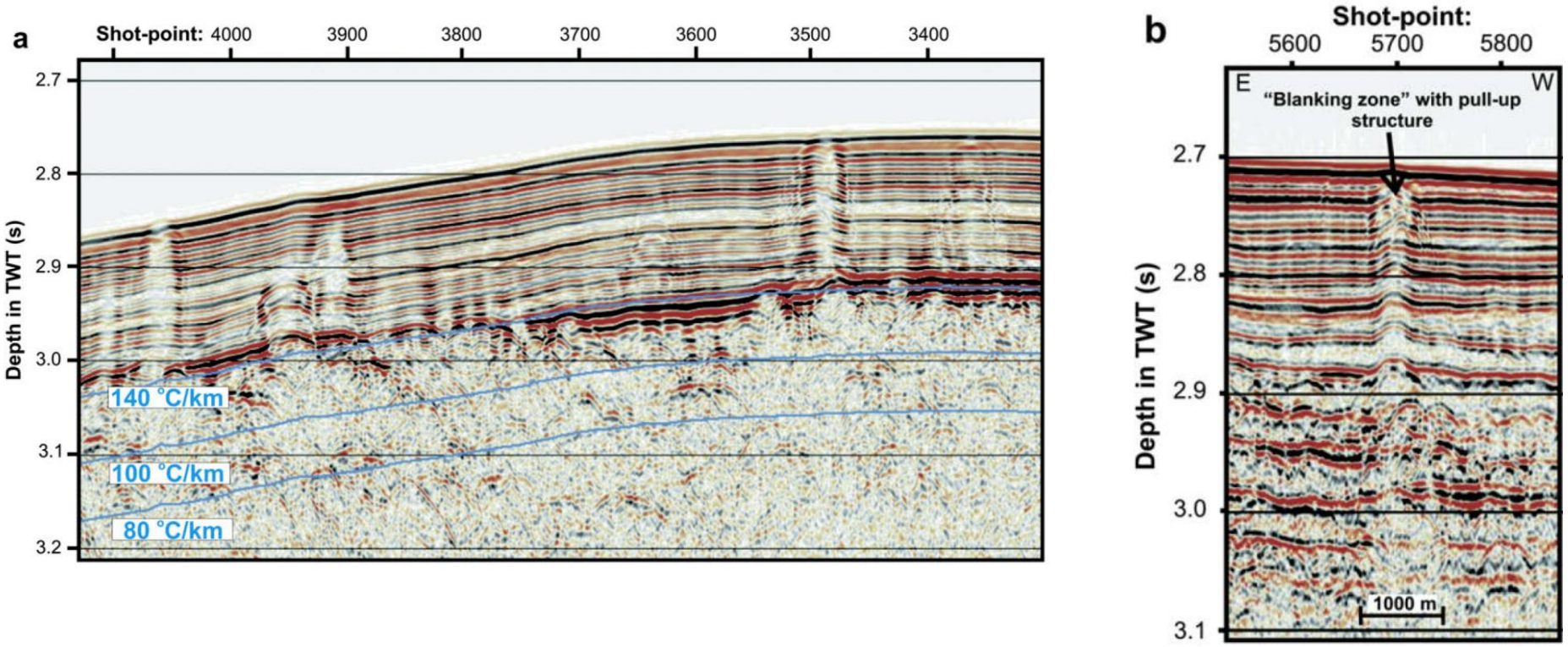
Fugro Capabilities

- Overall Project Management including (sub) contractors involved in actual research and field investigation programs, including partnerships with parties involved in HYACE and HYACINTH programs (GEOTEK)
- Design and development of gas hydrate investigation programs
- Development of new tools and systems
- Desk top research studies, integrated studies, geohazards assessment studies, etc
- Offshore site investigations
- Development of foundation design techniques for facilities sited in regions with gas hydrates
- Evaluation and interpretation of investigation results

Design & Development Gas Hydrate Programs

- Desk top planning studies
- Drilling hazard risk assessments
- Design of the field sampling and in situ testing programs
- Design of the sampling handling, storage and testing procedures
- Integrated analysis of the results with both the geophysical survey and the geotechnical site investigation including logging.

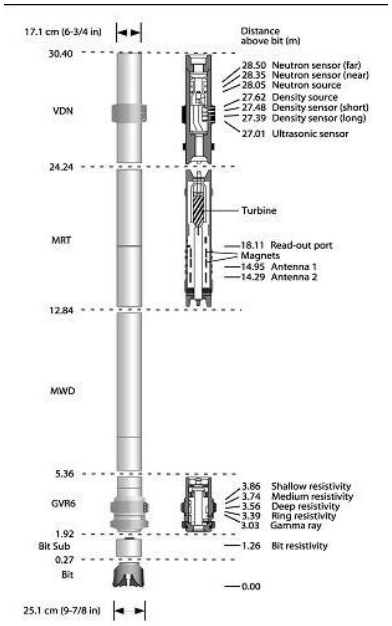
Chimney Structures

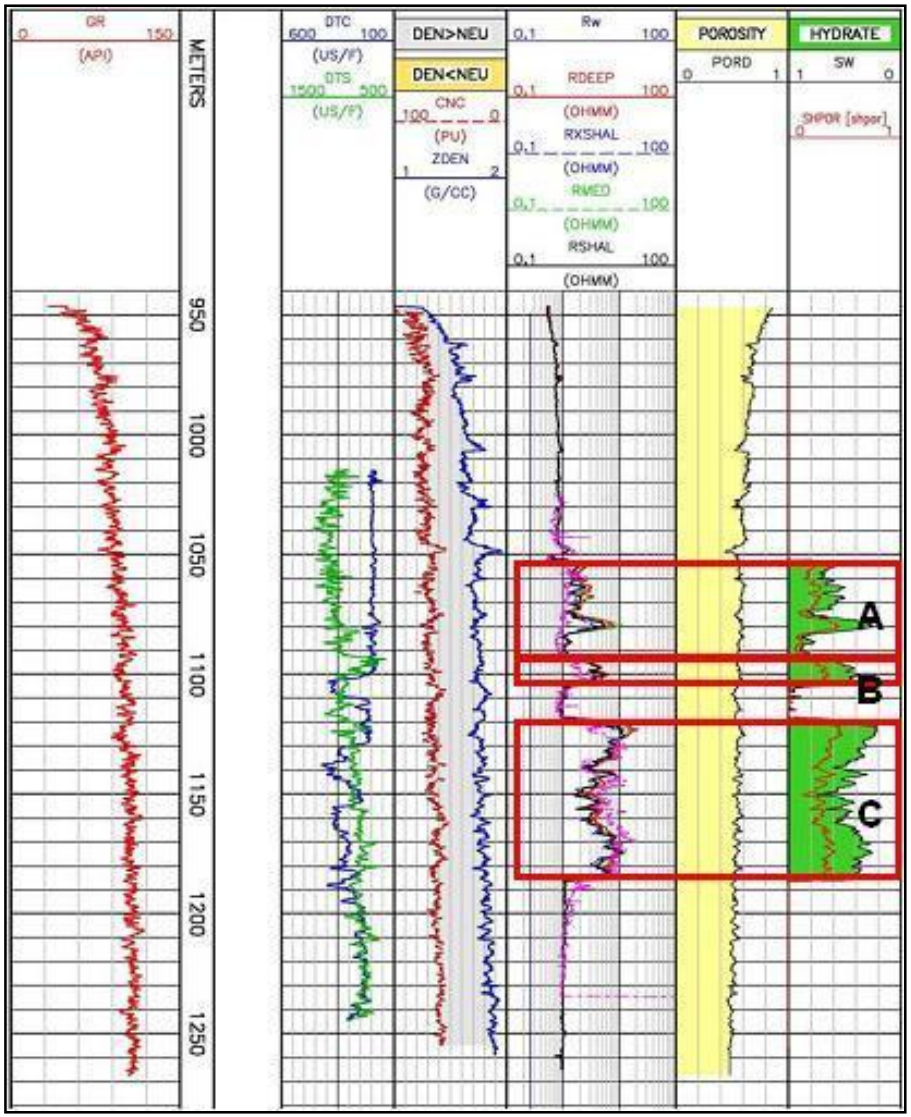


From: Ryu et al (Marine & Petroleum Journal – Feb 2009)

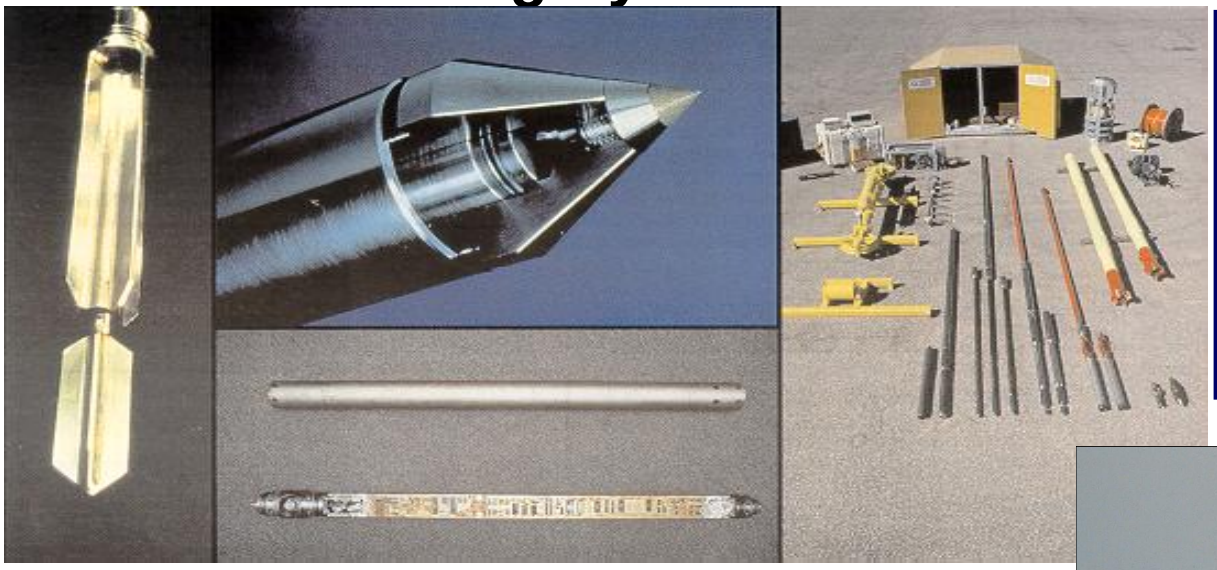
Downhole Geophysical Logging

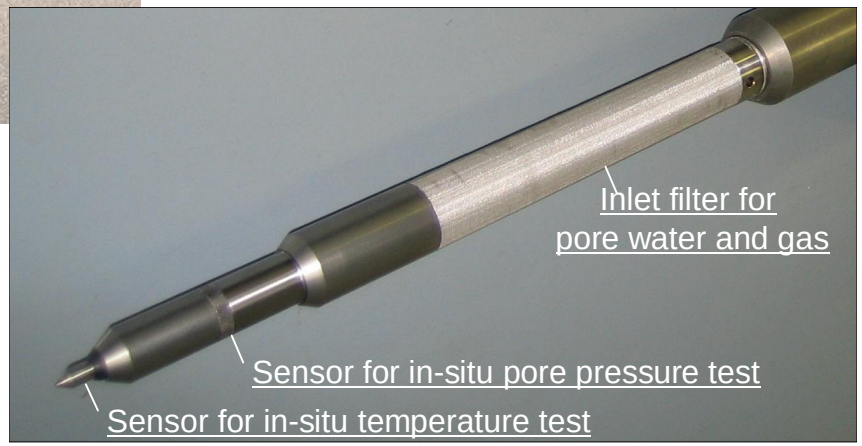
- Resistivity
- Natural gamma
- Neutron density
- Sonic velocity
- Temperature





In Situ Testing Systems



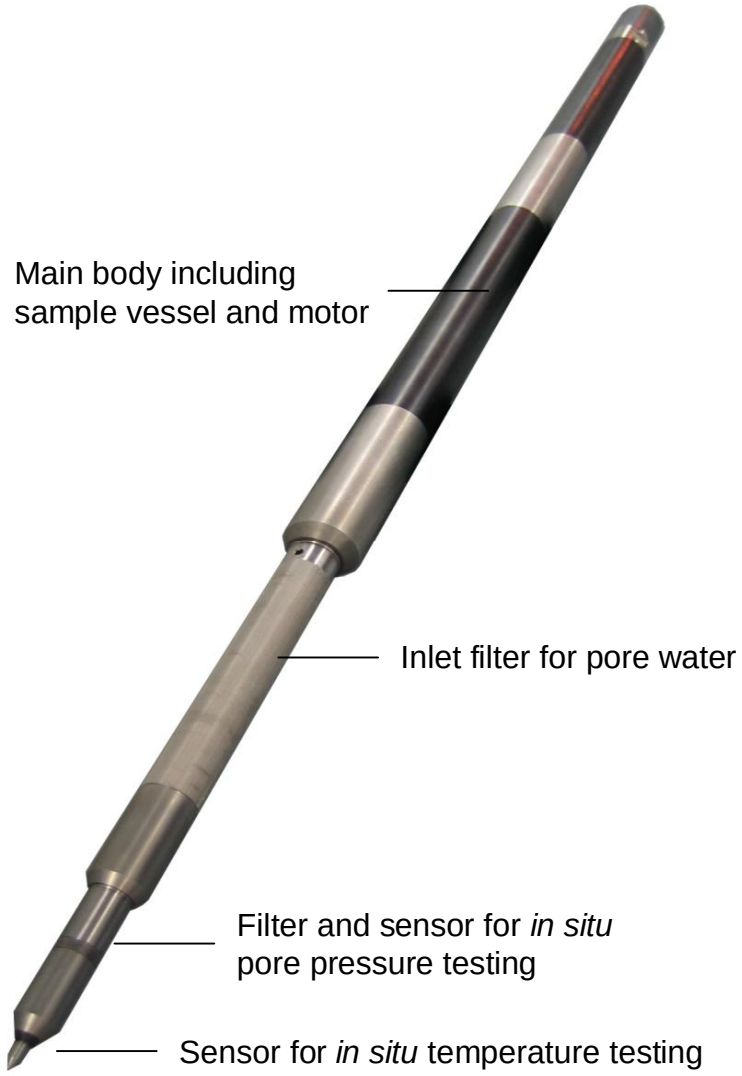


- Temperature
- Pore Water Sampling (PWS)
- Pore Pressure
- Electrical Conductivity (Resistivity)
- Piezocone Penetrometer Testing (PCPT)
- Thermal Conductivity
- Vane Shear
- Ball Penetrometer

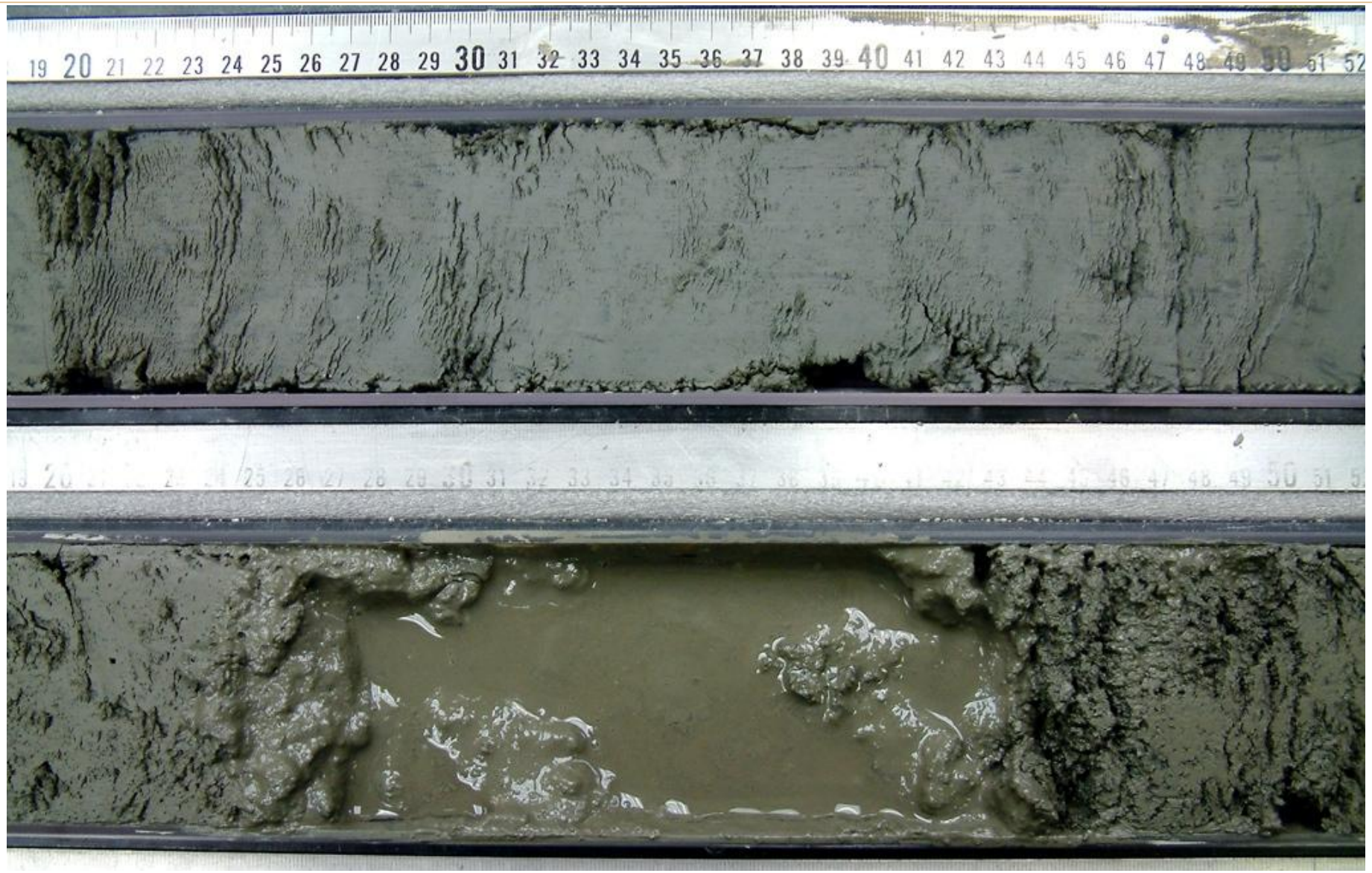
New Tool Development

Pore Water Sampler

- Operates to 3000 m water depth
- in situ pressure and temperature testing
- Real time monitoring of tests and real time controlled thru logging cable
- WISON EP (4.5 m stroke) downhole push system
- Analysis of pore water sample - gas chromatograph (composition/ saturation of porewater)

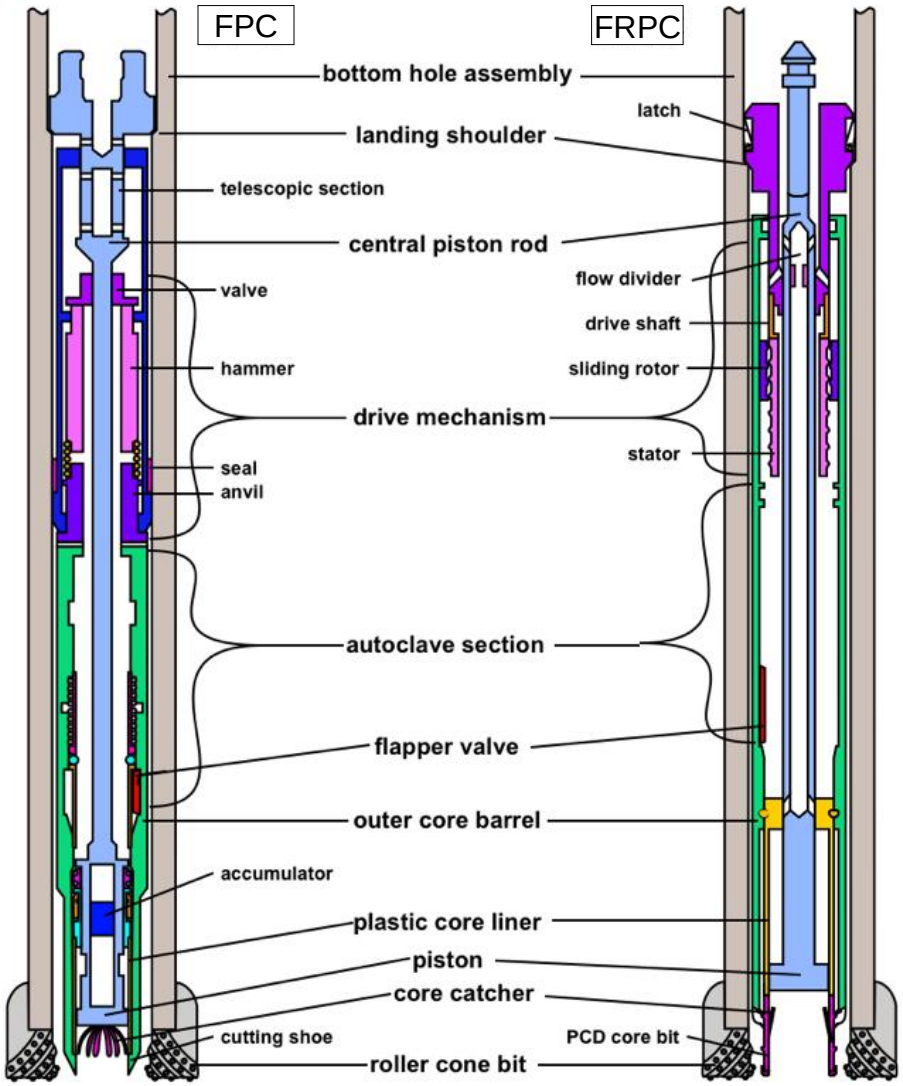


Benefit of Pressure Cores



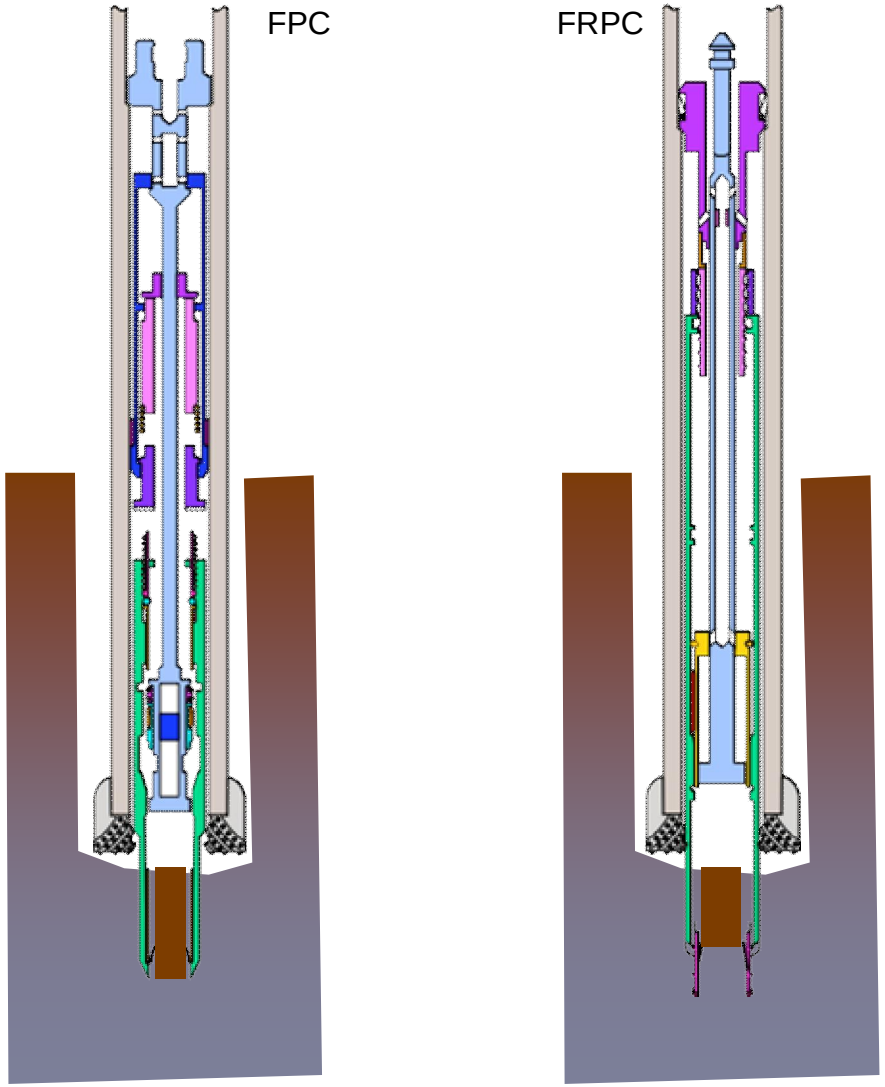
Pressure Corers – FPC & FRPC

- Downhole tools for sampling and deck-to-deck measurement of internal temperature and pressure
- FPC: push + hydraulic percussion
- FRPC: hydraulic rotary coring



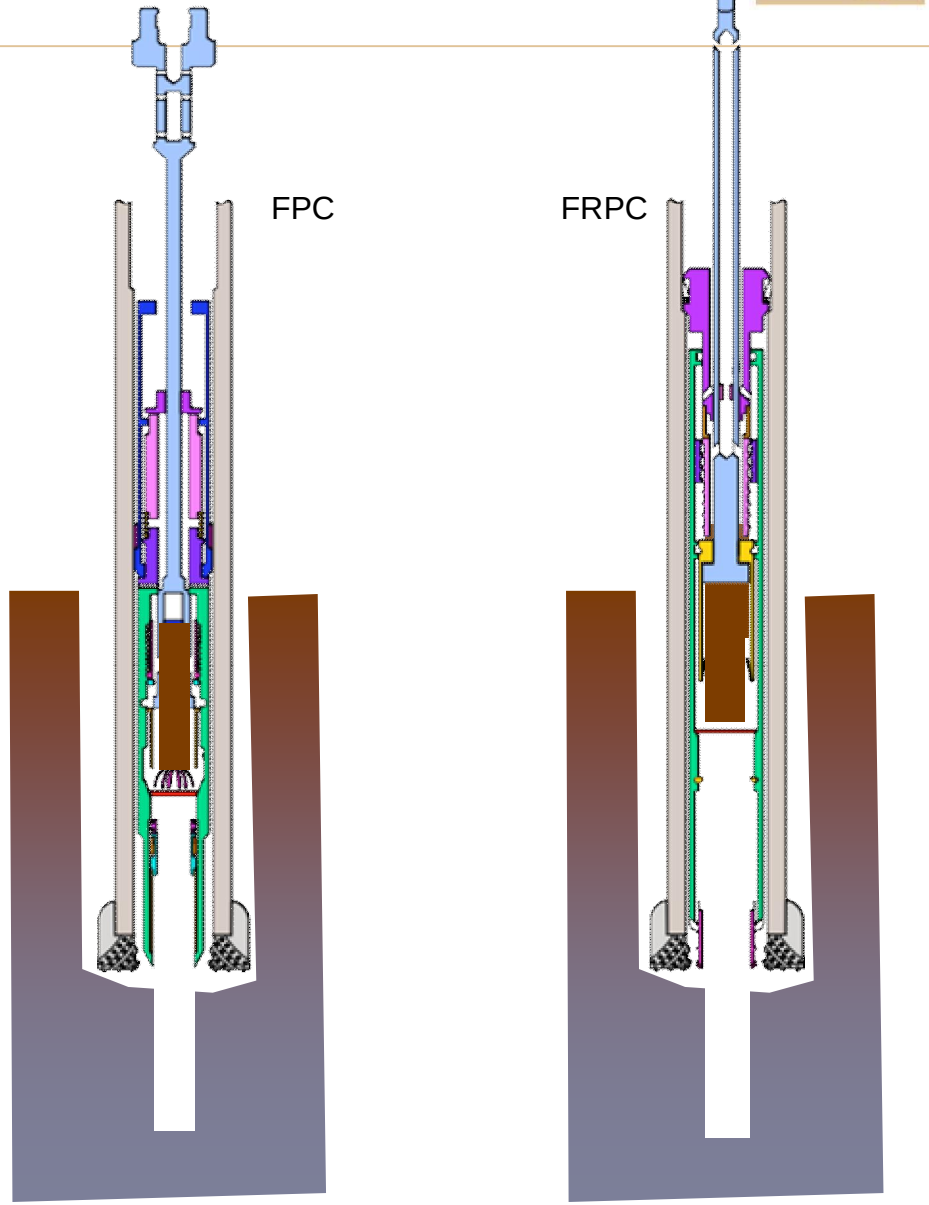
Wireline Pressure Coring: Coring operations

- Core is cut in undisturbed formation ahead of the drill bit



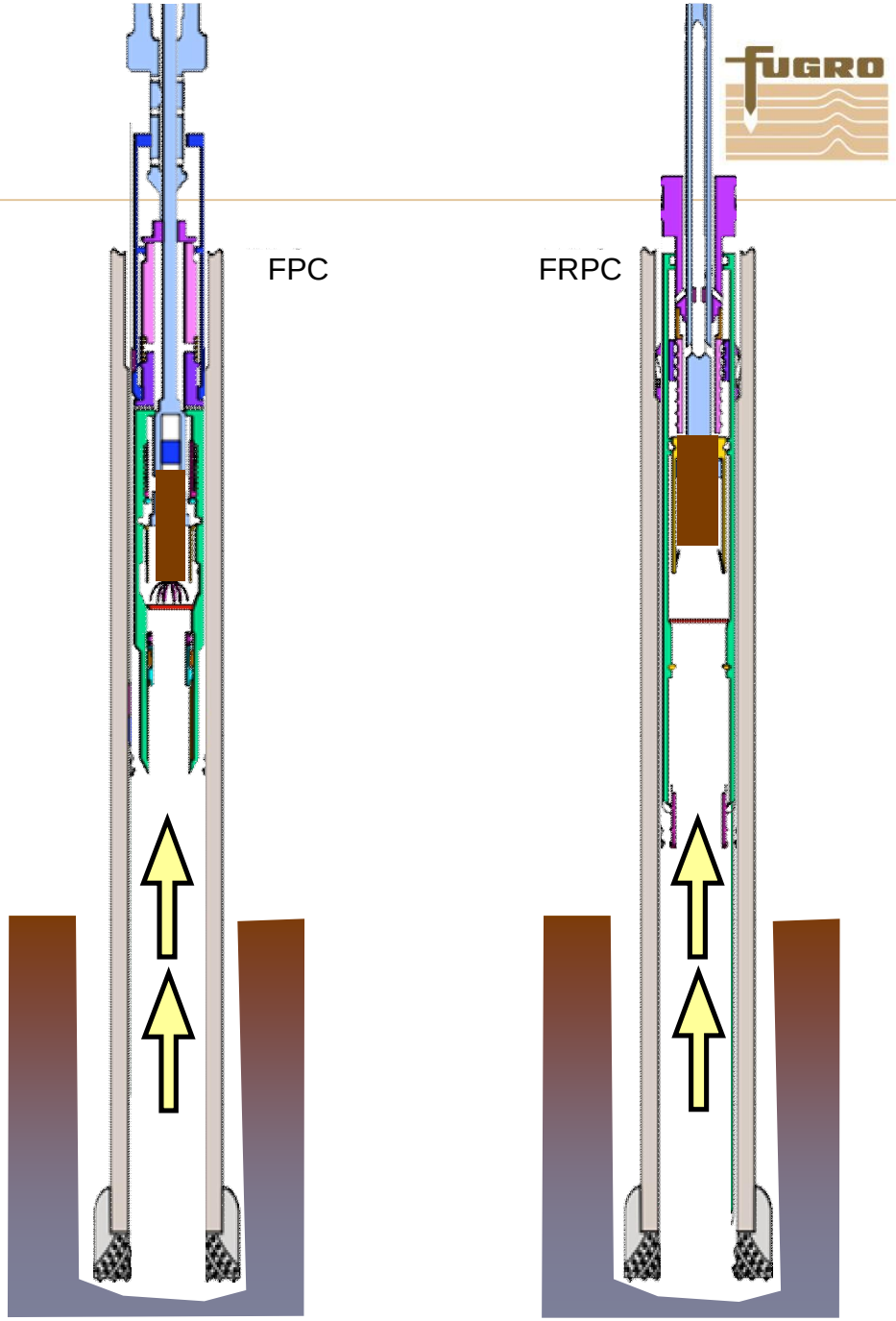
Wireline Pressure Coring: Retraction

- Core is retracted into the autoclave pressure chamber



Wireline Pressure Coring: Retrieval

- Core is sealed in autoclave and retrieved to the drill floor

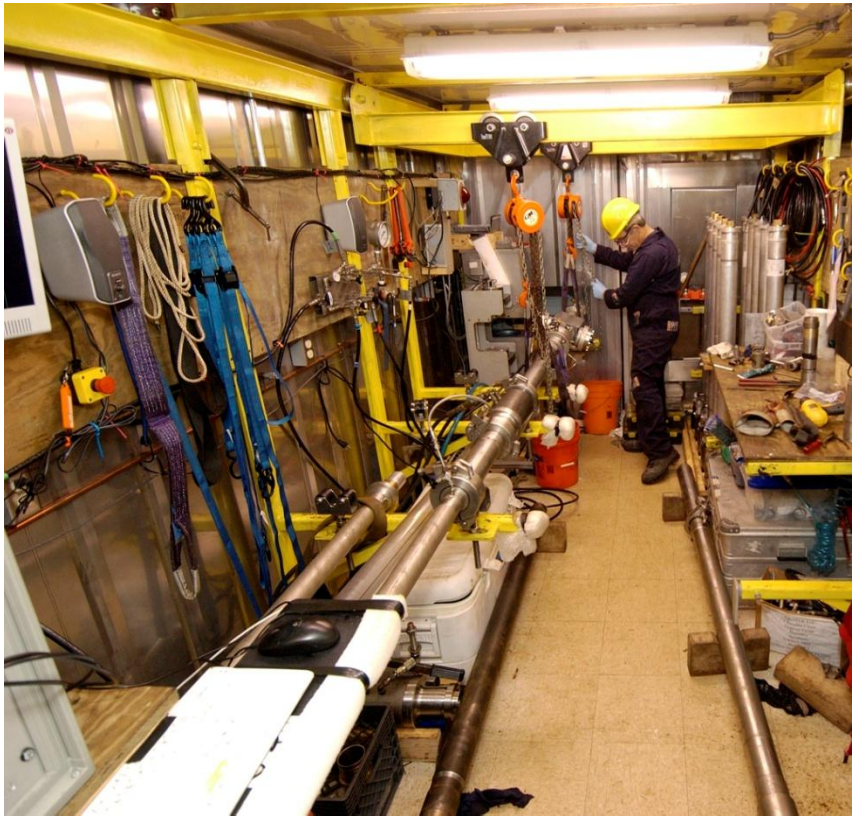


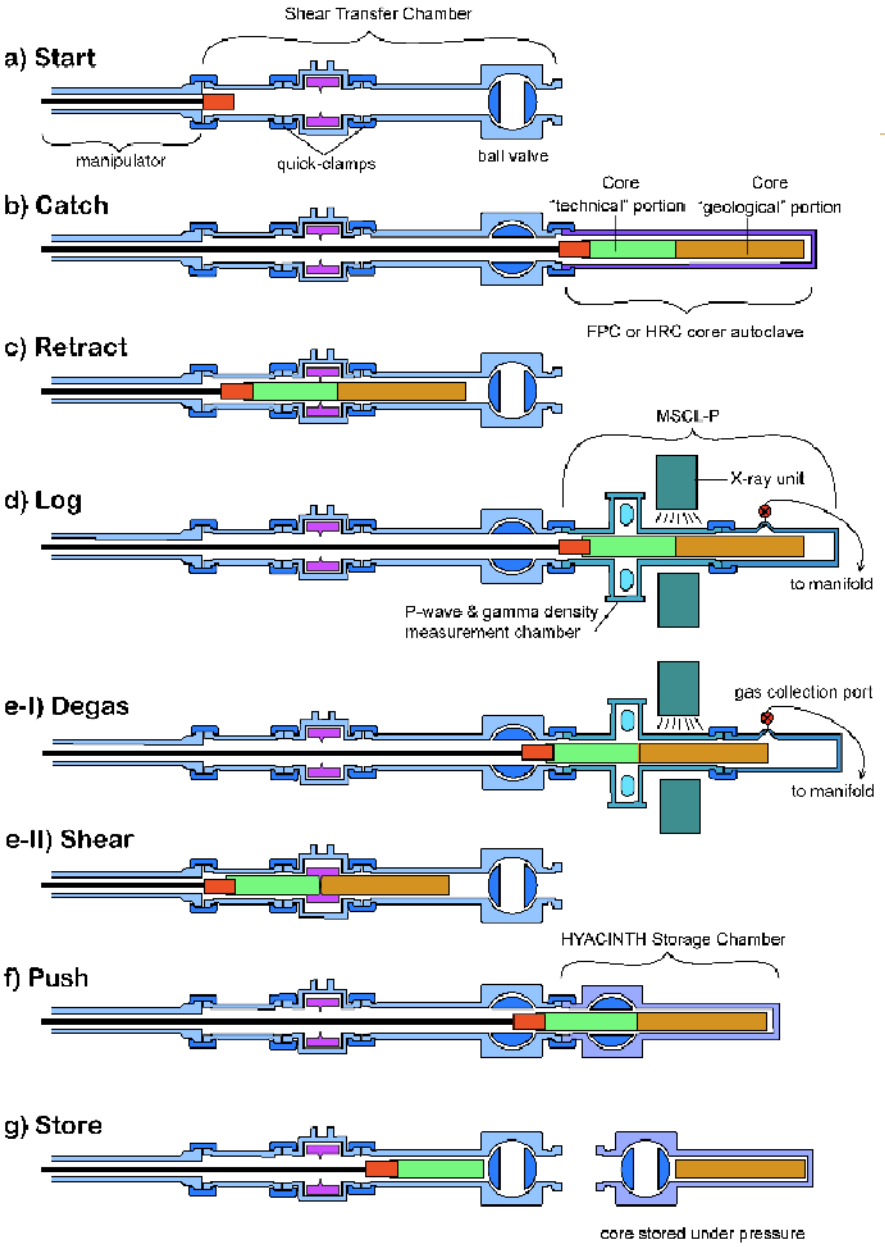
Practical Temperature Control

Pressure & Temperature Sensors

Pressure Core Analysis and Transfer System - PCATS

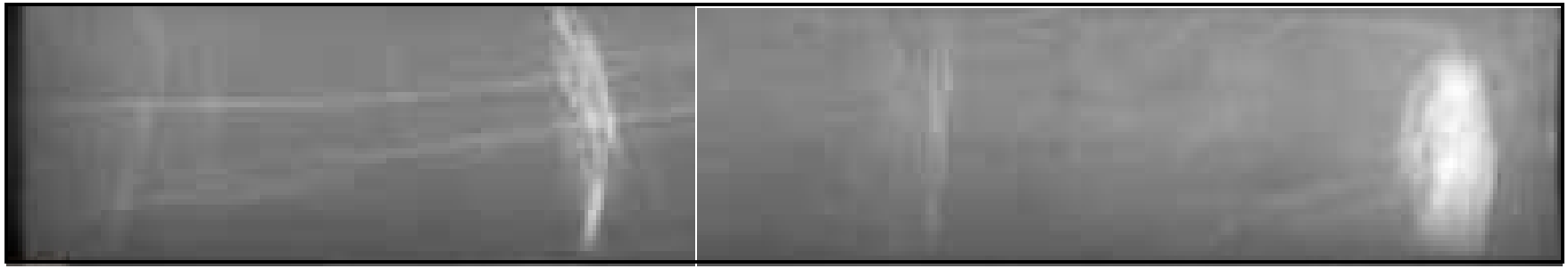
- Why collect pressure cores if you have to release the pressure to analyze the core?
- The pressure coring tools were built together with the analysis system.





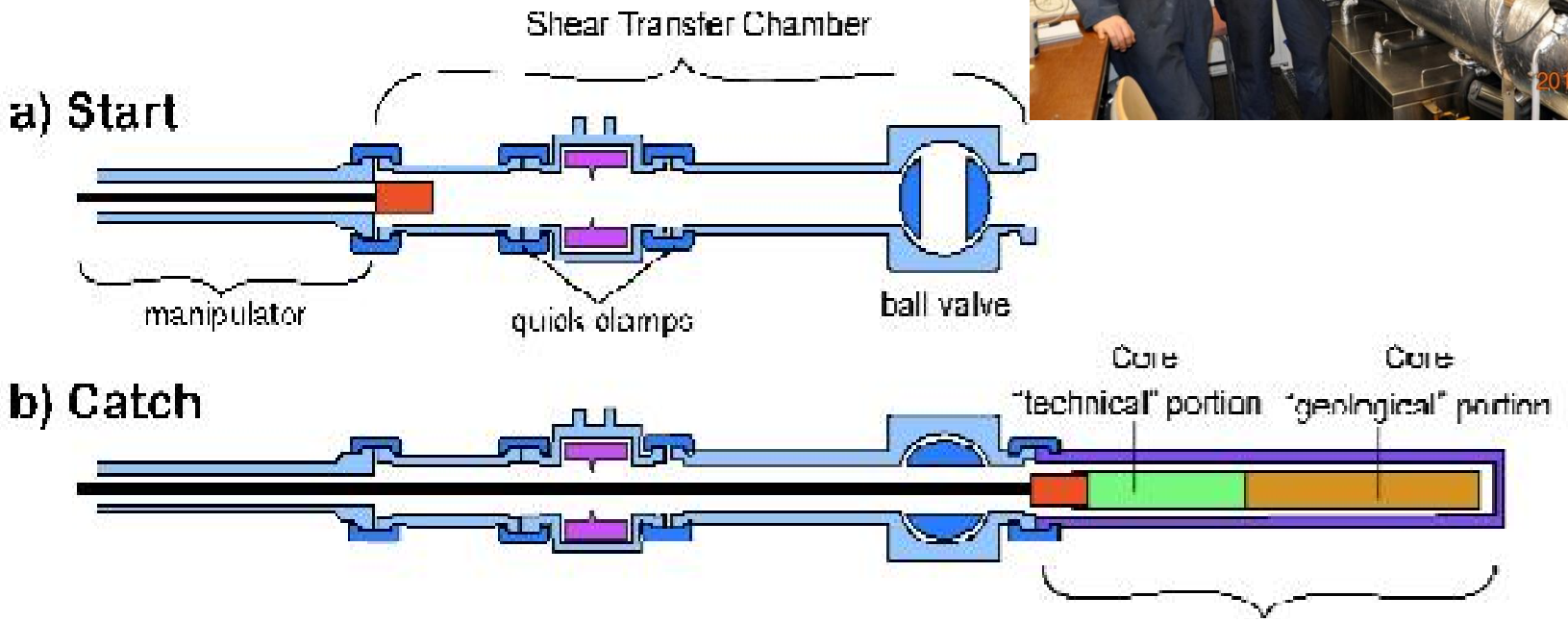
Pressure Core Analysis

- Multi-sensor core logging (including density, P-wave and x-ray)
- Controlled depressurization of gas for gas chromatograph analyses (similar to pore water sampler) and precise gas hydrate quantification
- Extrude samples for geotechnical/geological analysis
- Selected parts of de-pressurized sample can be squeezed in a press to extract pore water
- Geochemical testing on extracted pore water



Pressure Core Analysis & Transfer System

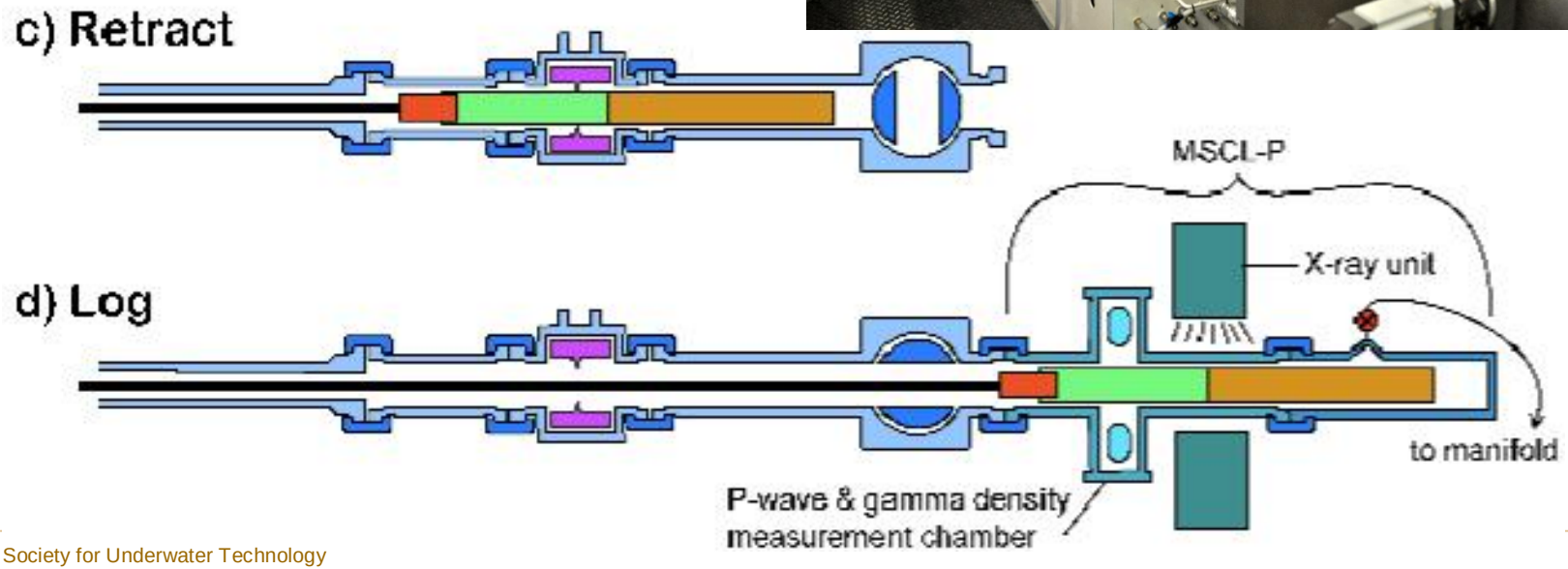
- Core manipulation



FPC, FRPC or other's autoclaves

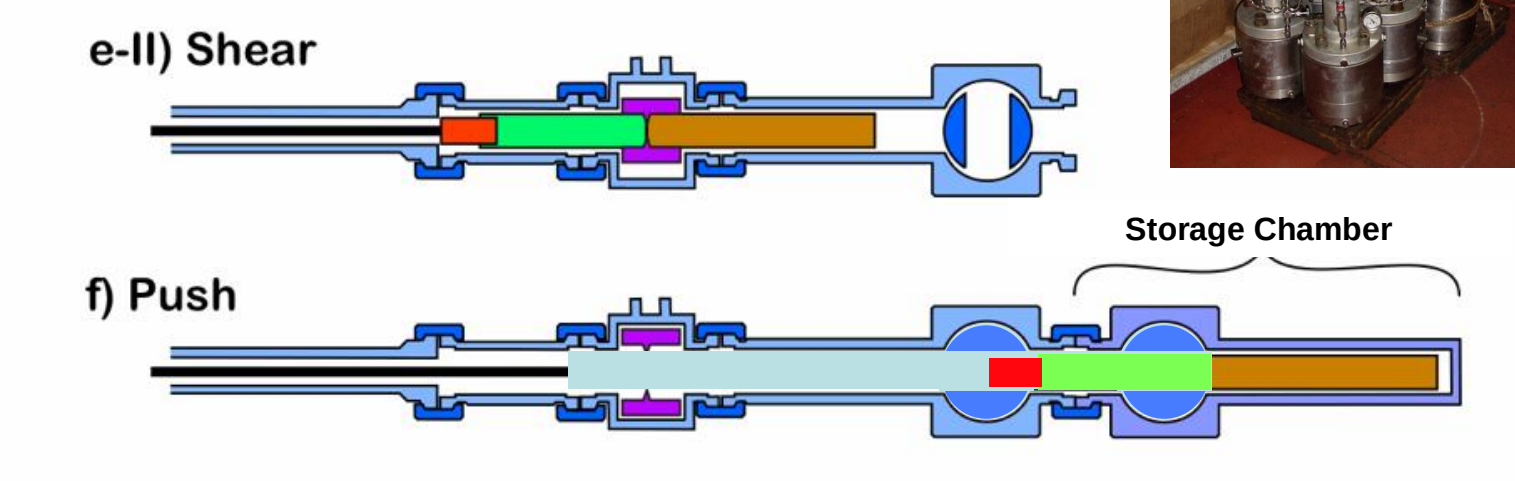
Pressure Core Analysis & Transfer System

- Core transfer into PCATS



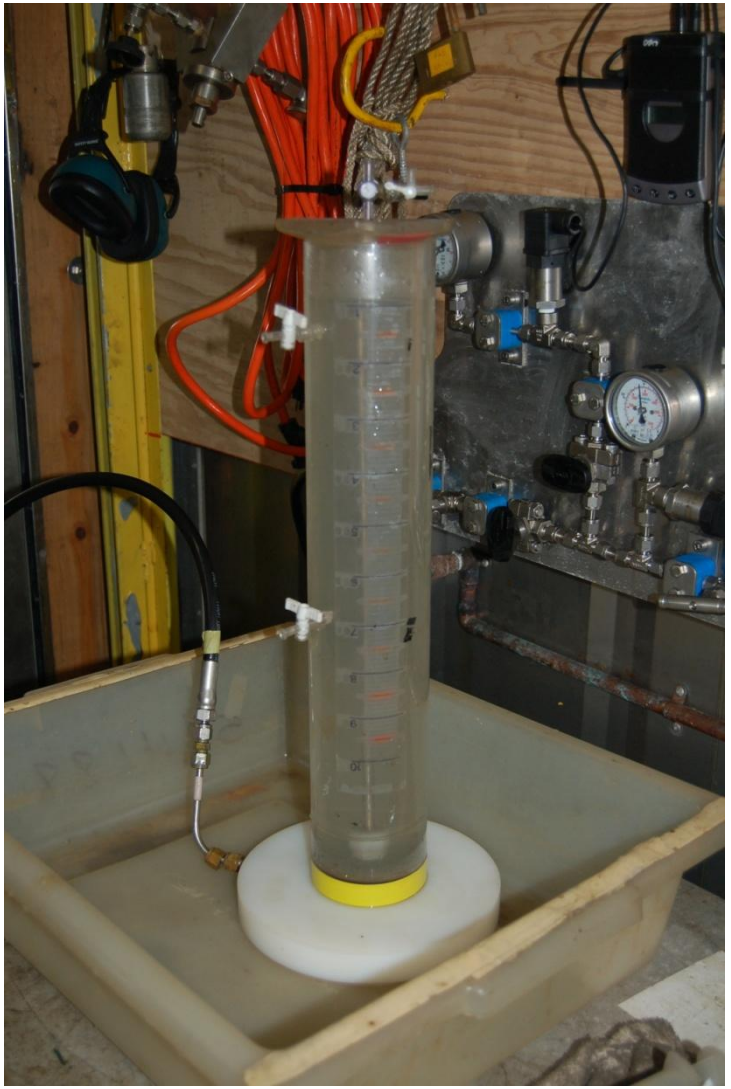
Pressure Core Analysis & Transfer System

- Sub-sampling
- Core transfer to storage chambers



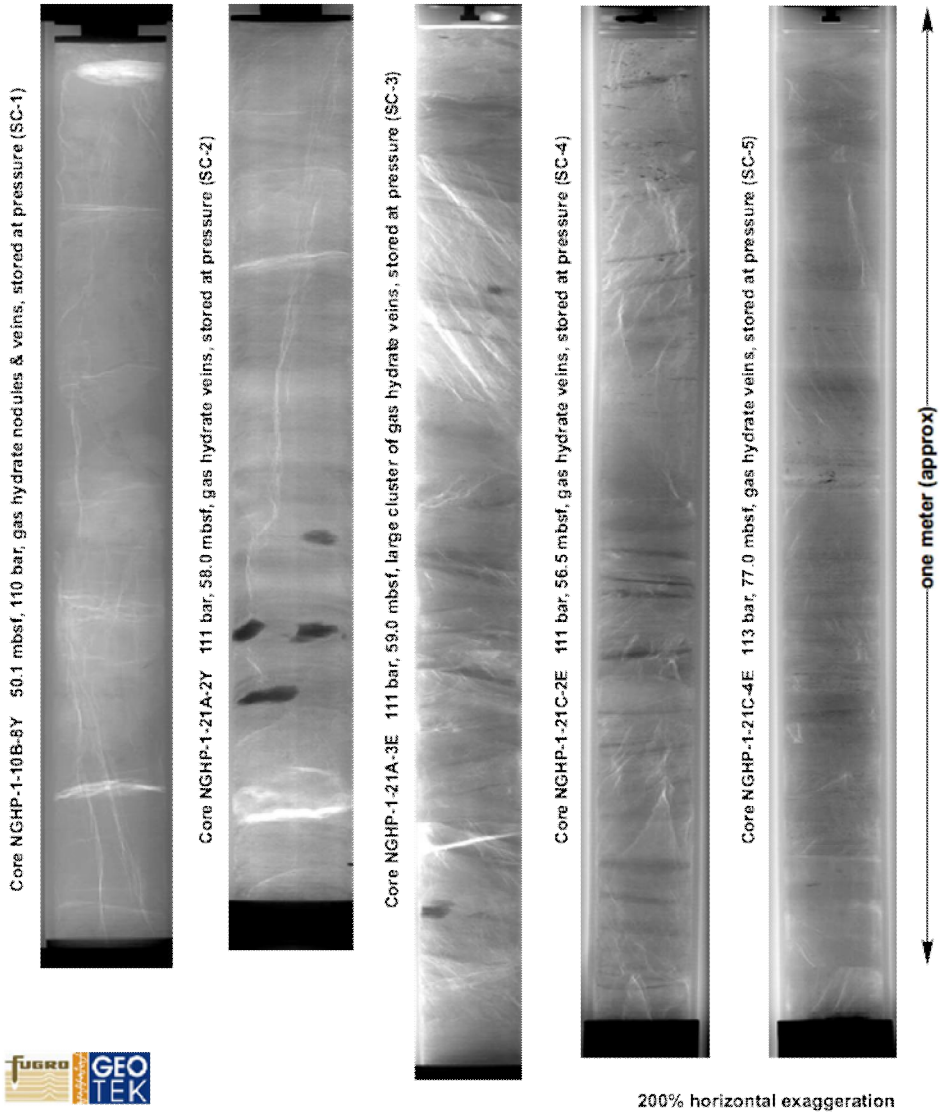
Testing - destructive

- Pore water chemistry
- Gas composition
- Gas concentration
- Hydrate quantification

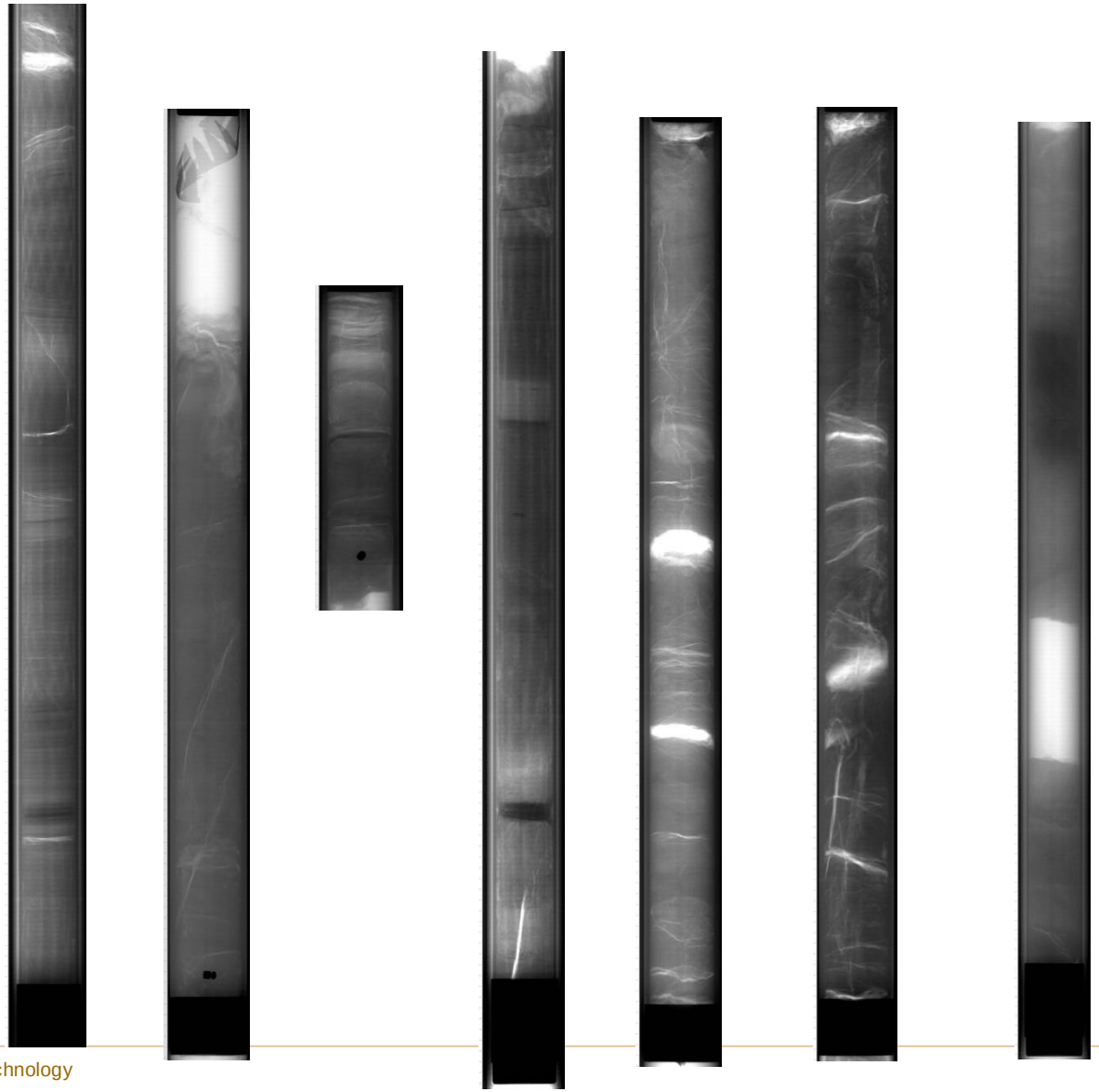


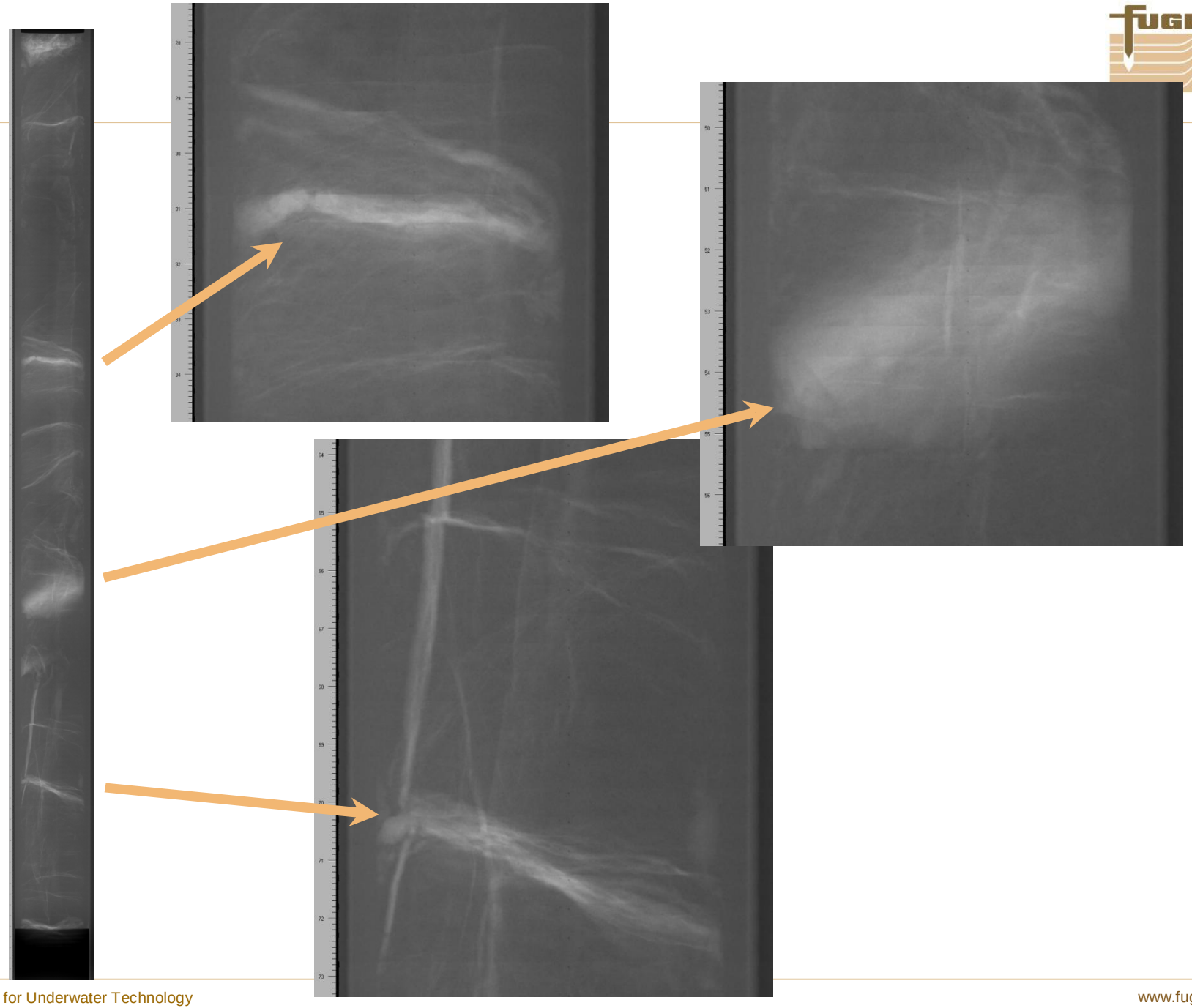
Pressure cores with massive hydrate veins from offshore India

NGHP Exp 1 gas hydrate in HYACINTH storage chambers

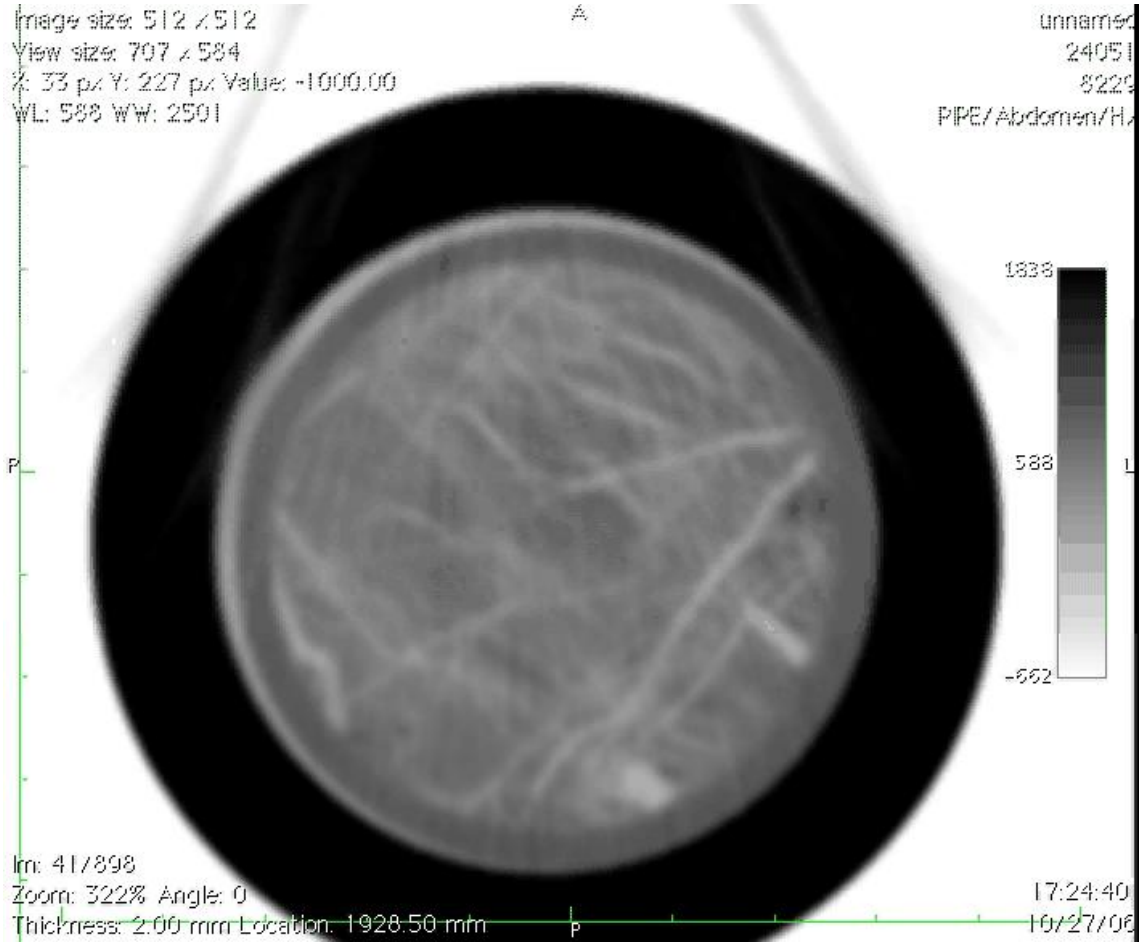


PC’s with massive hydrate veins and layers from offshore Korea

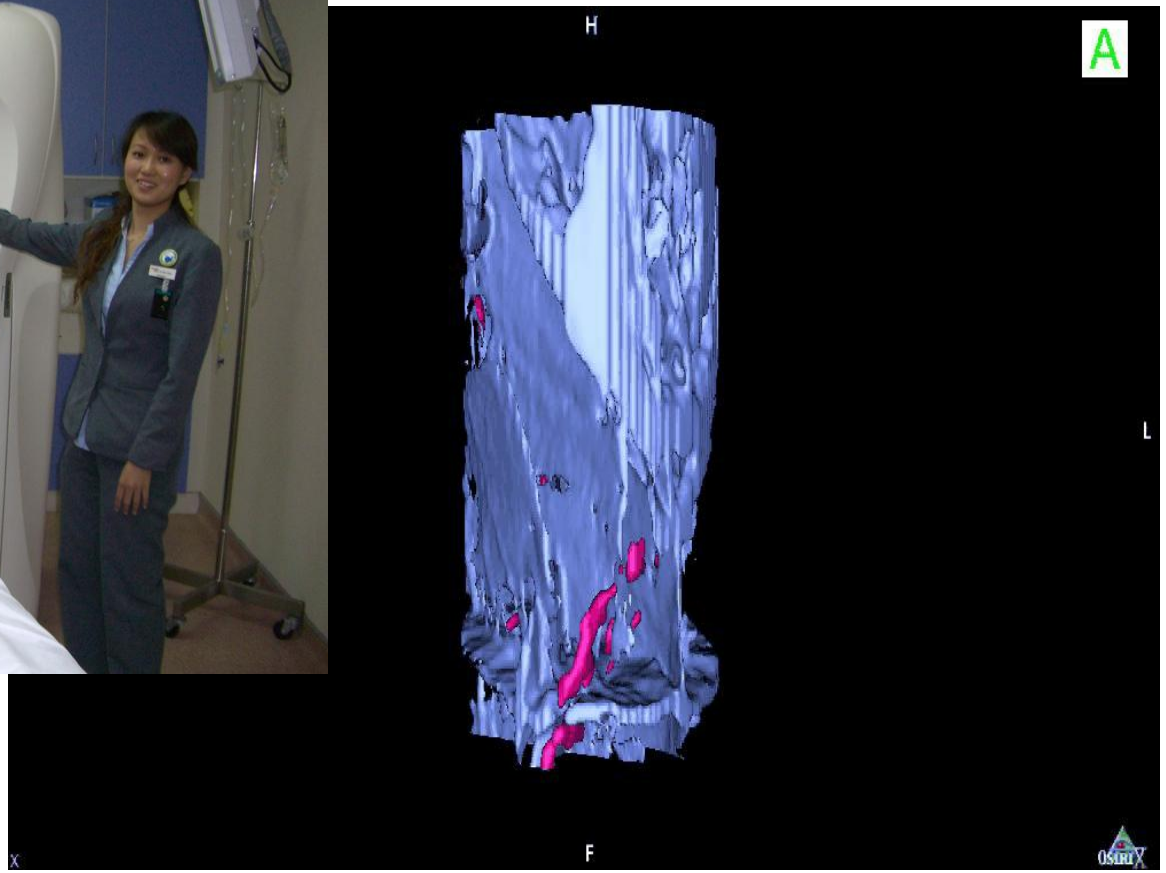




3D X-ray visualization
Journey through a pressure core in ~1mm slices

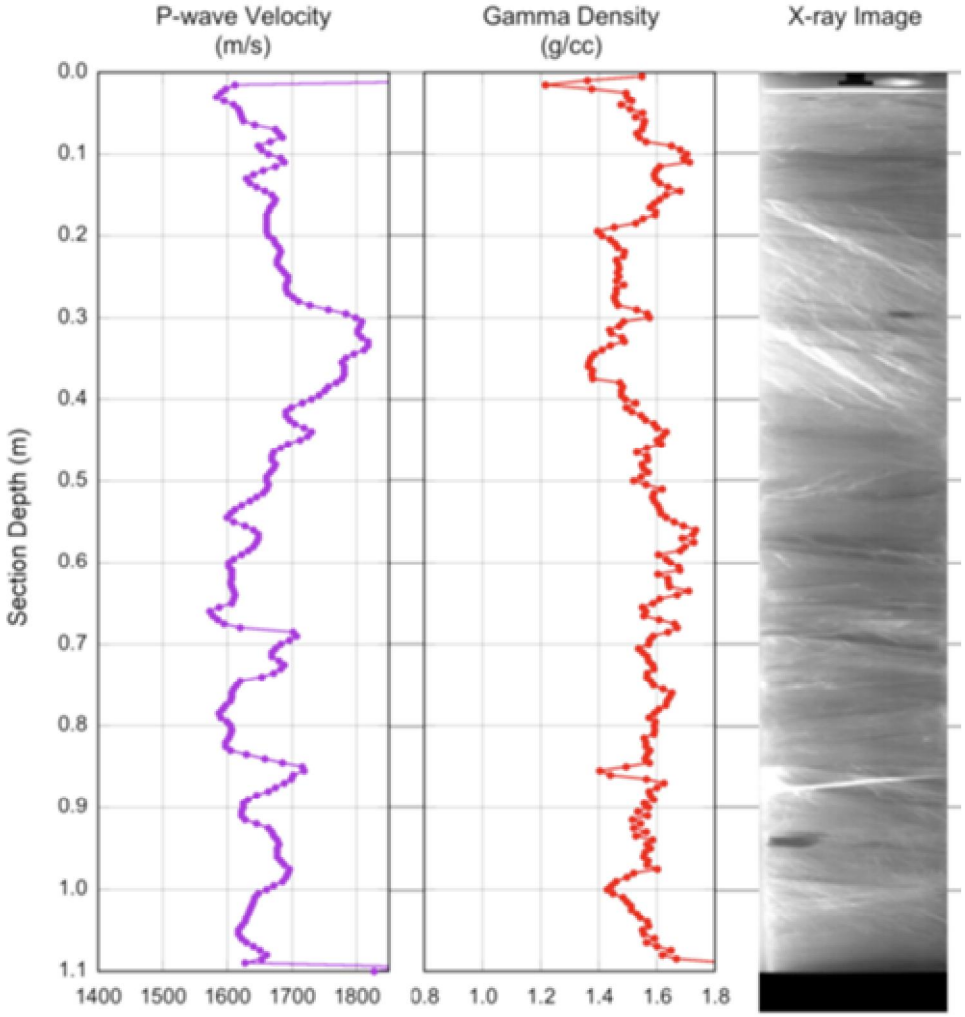


Evaluation, interpretation of investigation results – CT Scan



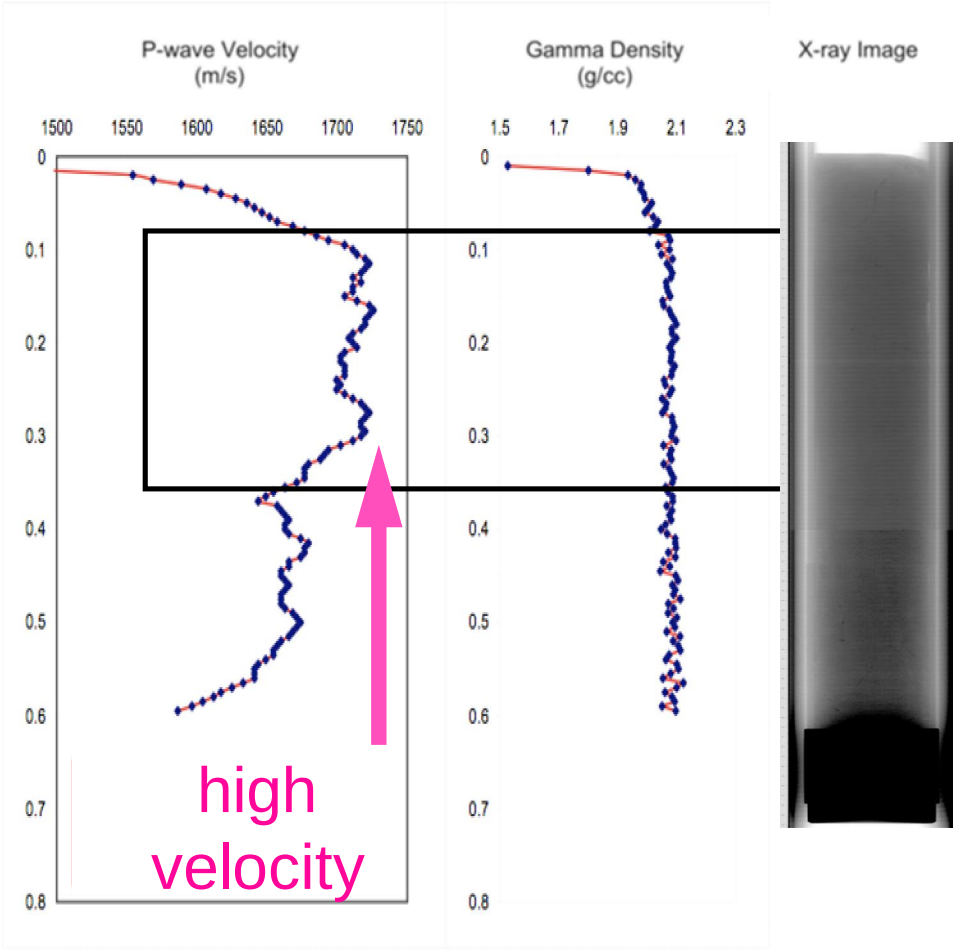
Evaluation, interpretation of investigation results – Gas Hydrate Morphologies - MSCL

- X-ray images sometimes show very complex vein structures in fine grained sediments
- Core with hydrate veins crosscutting sedimentary strata
- Low-density areas on gamma & X-ray (white)
- Elevated acoustic velocity with complex structure



Evaluation, interpretation of investigation results – Gas Hydrate Morphologies – MSCL

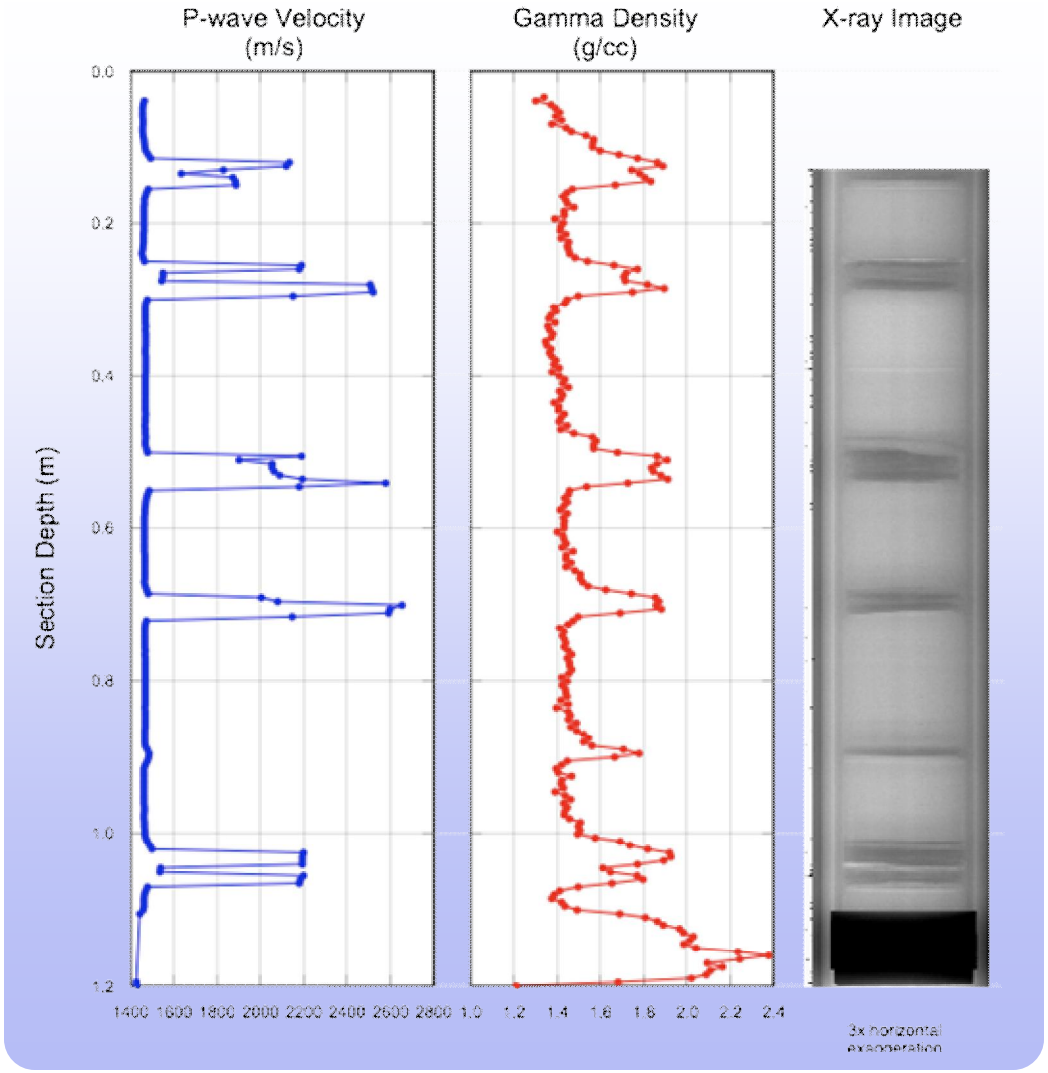
- When the gas hydrate is disseminated there is little or no X - ray evidence
- Uniform clay core with pore-filling hydrate
- Hydrate in core is invisible in X-ray and also to naked eye
- No change in density
- Uniform, elevated acoustic velocity



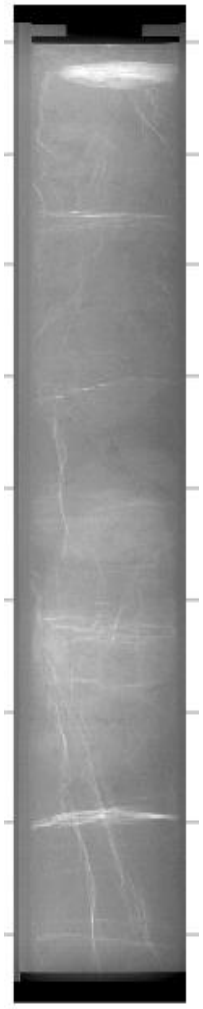
Evaluation, interpretation of investigation results – Gas Hydrate Morphologies - MSCL

- Where silts and sands exist gas hydrate preferentialy forms in these zones

  - Gas hydrate in silts and sands can be disseminated and massive.
  - velocities and densities are unusually high

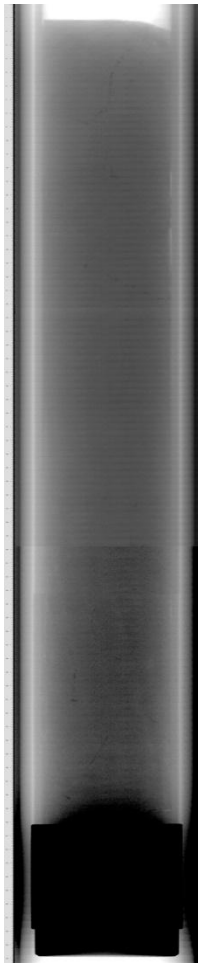


Vein network can contain much hydrate



= 40% gas hydrate by pore volume!

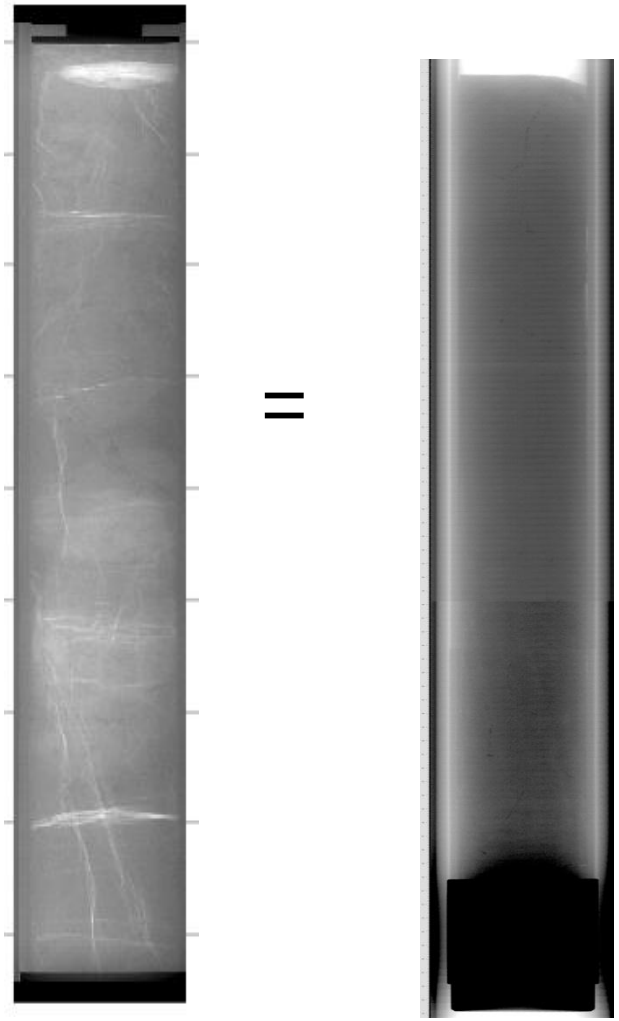
Pore-filling hydrate may not be visible



...but can still be in high concentrations

= 40% gas hydrate by pore volume!

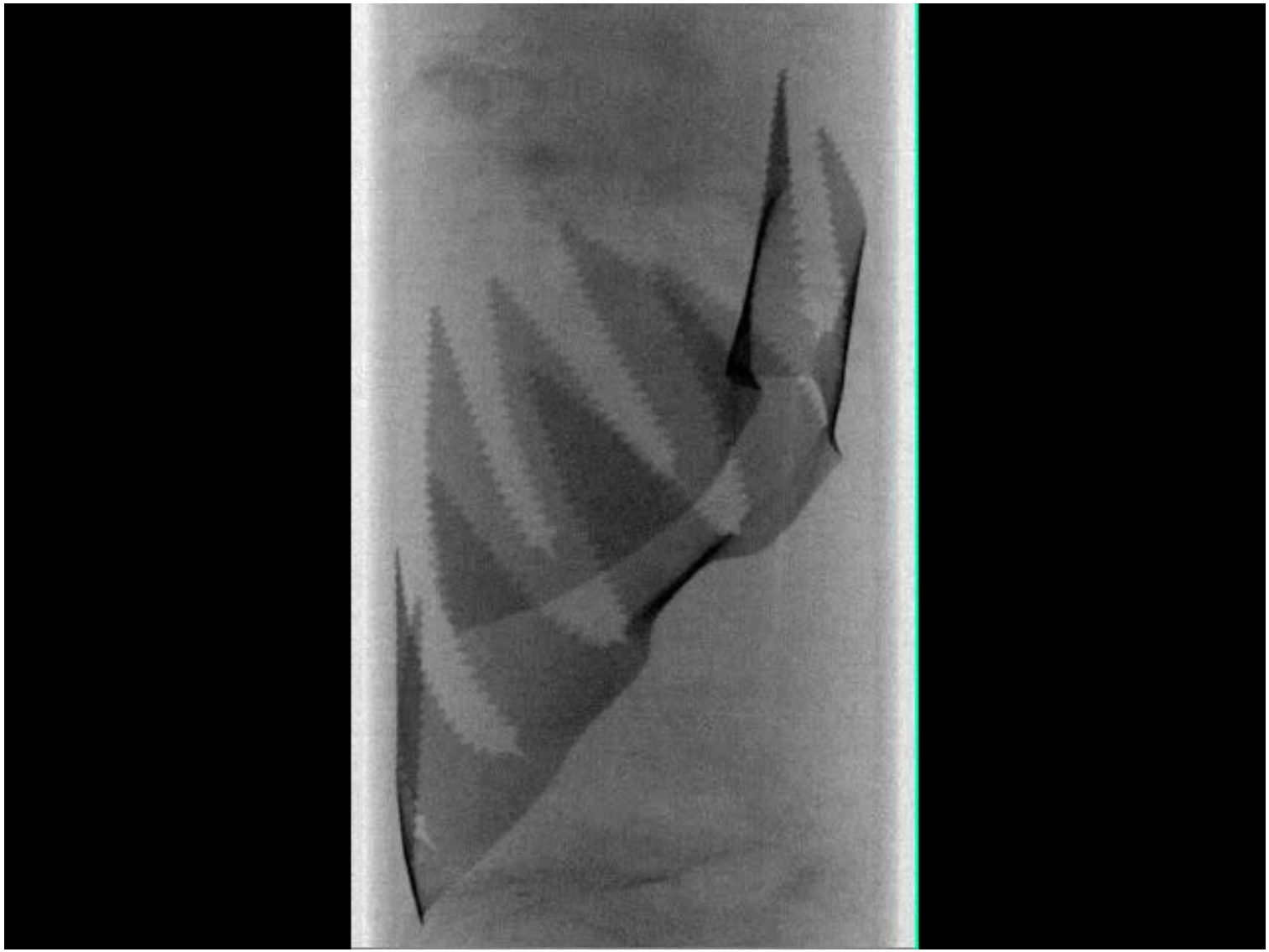
Both forms of hydrate can be concentrated!



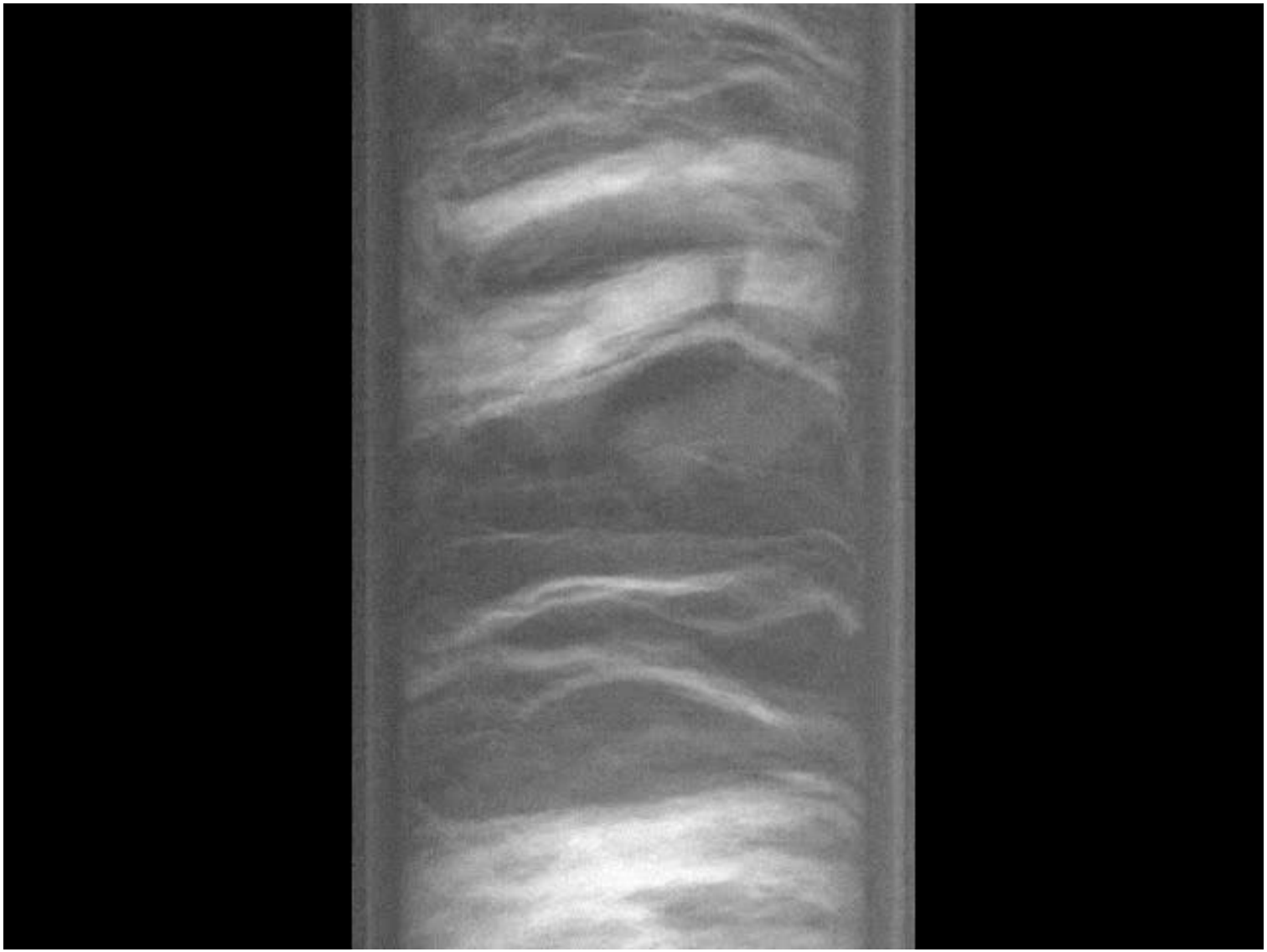
=

= 40% gas hydrate by pore volume!

CoreCatcher Trapped in Sediment

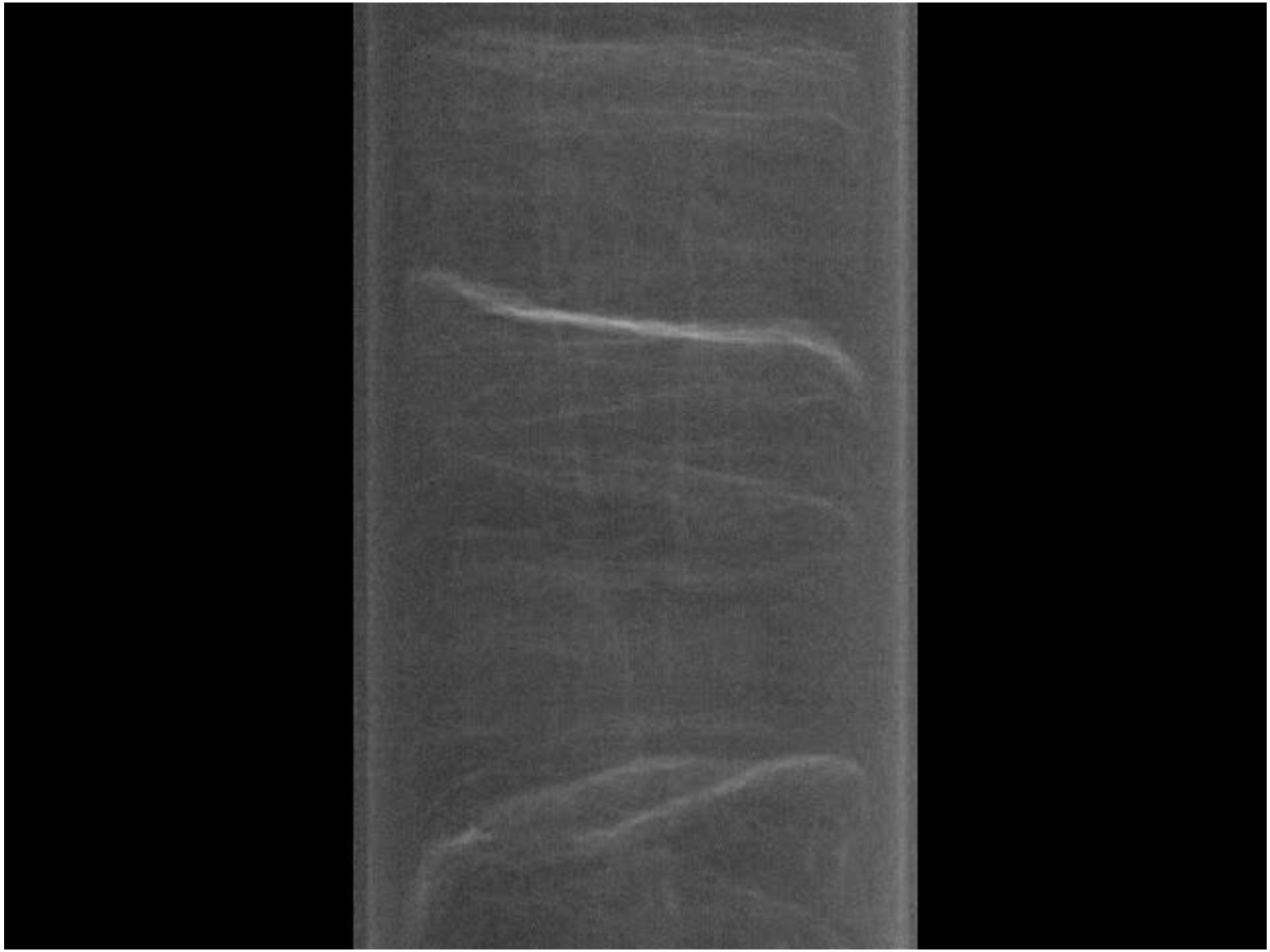


Hydrate CT Movie



Oreo Shaped Hydrate Movie

Tiny Hydrate Movie



Cutting and Sub-sampling of Stored Korean Cores

- Core stored in storage chambers since 2007
- Core transferred into PCATS
- Core X-rayed
- Core cut; sample pushed into GT/KIGAM Effective Stress cells
  - repeated 5 times
- Remaining core kept under pressure

- Repeated this process 12 times onboard in fall of 2010

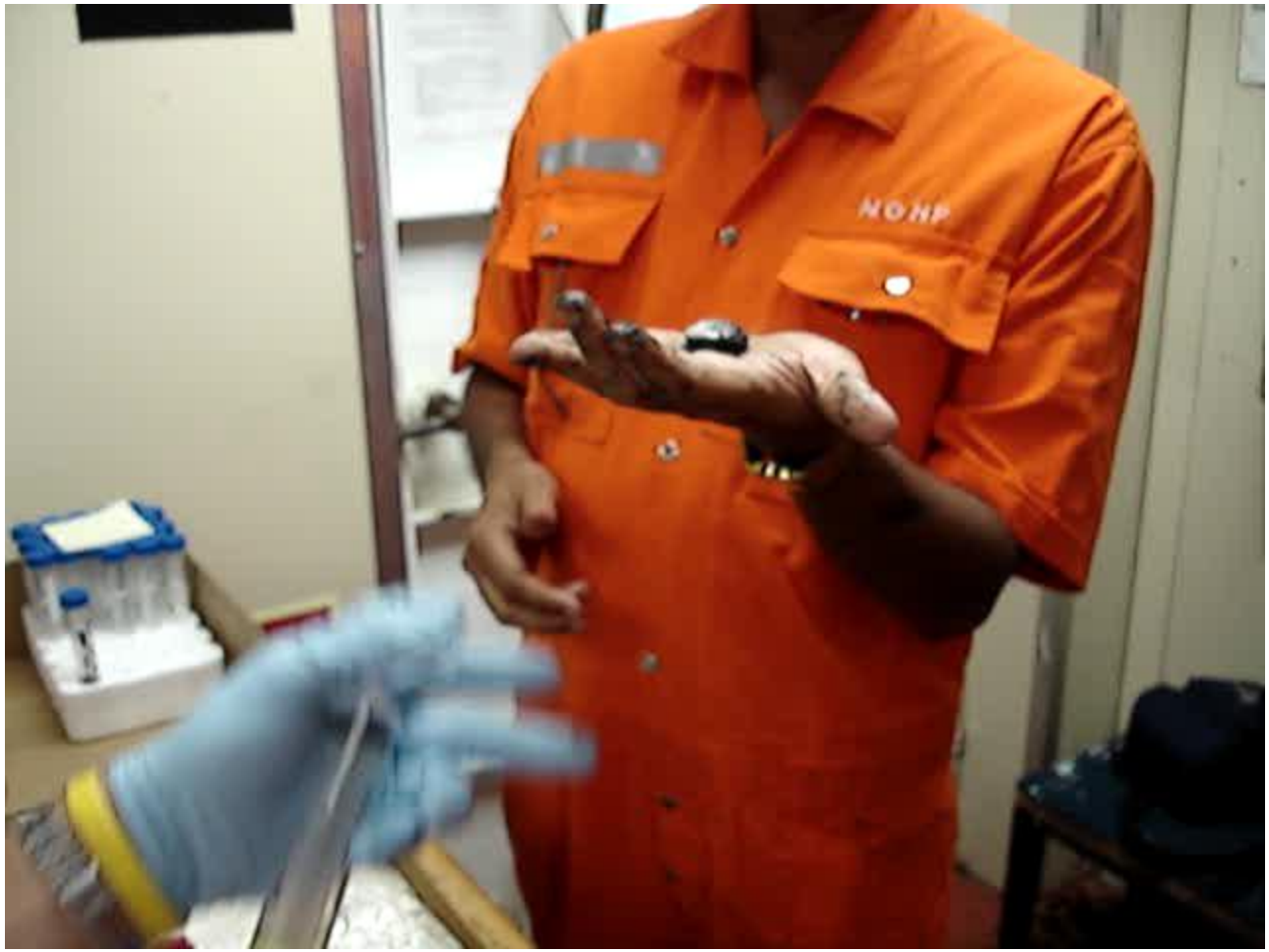
Future plans

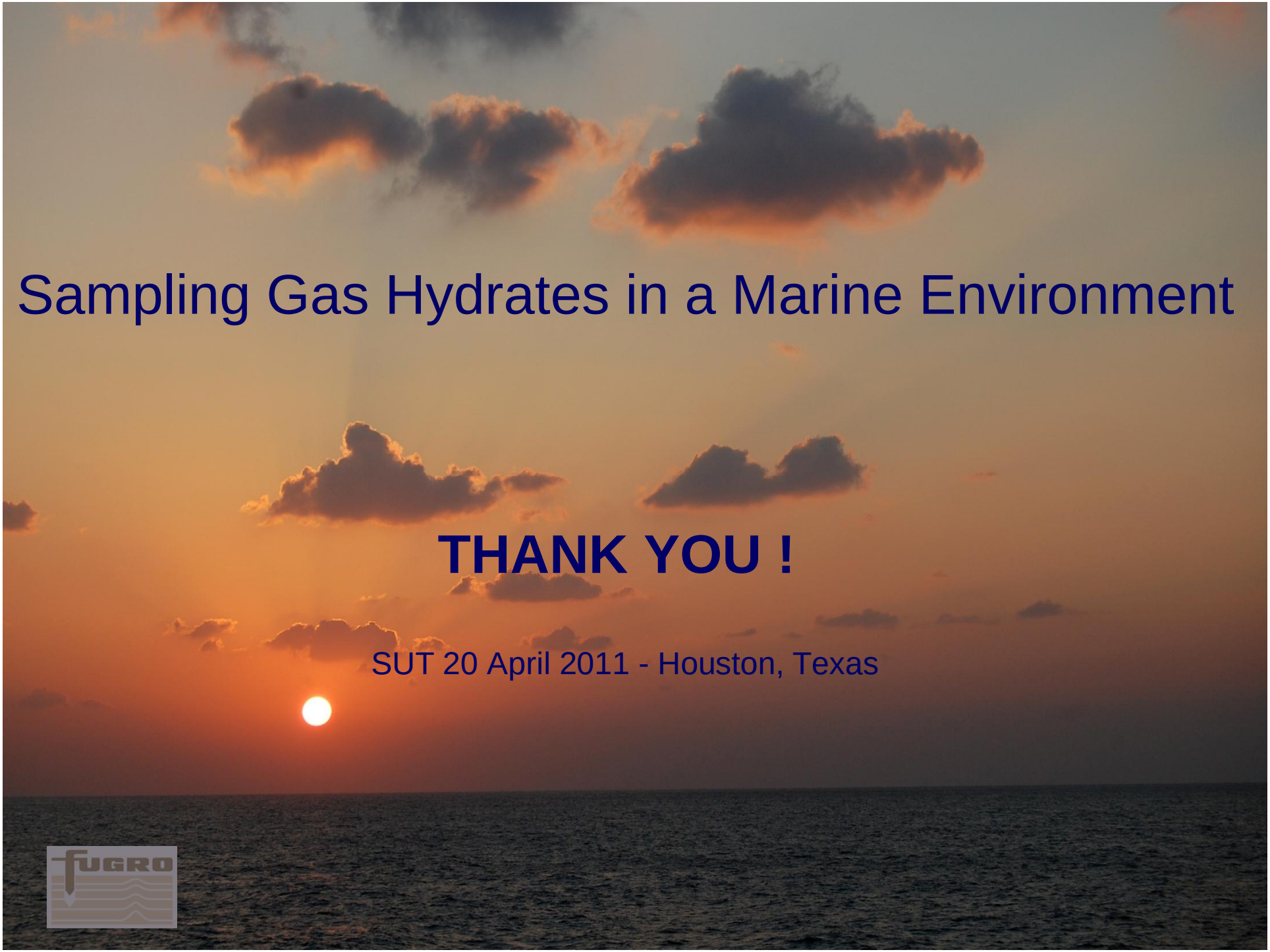
- Continue to be actively involved at the forefront of offshore gas hydrates investigations and research initiatives.
- Improve current suite of tools - improved sampling and in-situ testing of gas hydrate bearing strata
- Design, build and operate equipment that is specifically designed to meet gas hydrate project requirements
- Monitor developments in the Alaskan Arctic and Japan's First Offshore Marine Production Tests for Methane Hydrates

Pressure Core Analysis for Gas Hydrate Assessment

- Ability to take pressure cores is currently still ahead of our ability to fully analyze them.
- Quality Pressure Core Acquisition and quick analysis is ‘near routine’ - improvements continually being made (e.g. longer cores, higher pressure capability).
- Sub sampling capabilities well demonstrated .....integrated sub sampling / testing systems need to be built.
- Design of specialized equipment for geomechnical, geophysical, geochemical testing of pressure core sub samples is urgently needed.

Funny Movie




Sampling Gas Hydrates in a Marine Environment
THANK YOU !
SUT 20 April 2011 - Houston, Texas
FUGRO