

UDW Portfolio Update

NETL ORD's EAct Complementary Research

Reducing risks associated with ultra-deepwater hydrocarbon systems

Kelly Rose, Ultra-Deepwater Technical Coordinator
September 17th, 2013



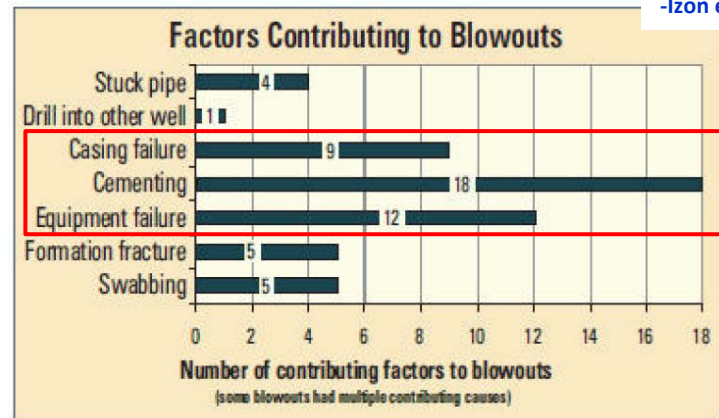
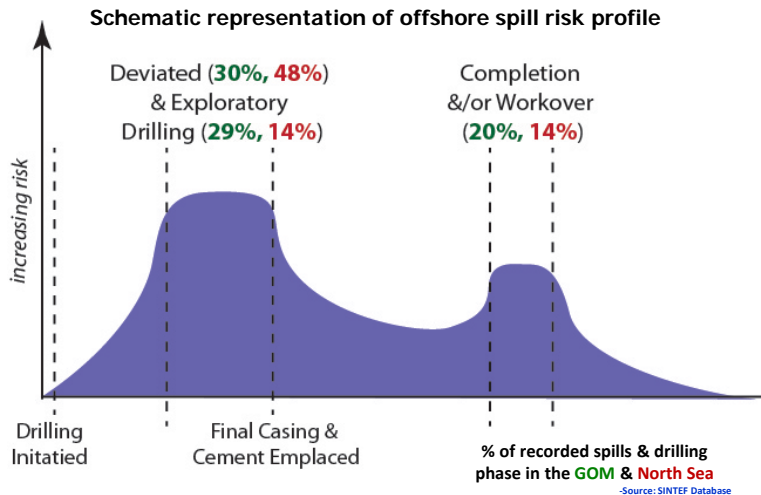
U.S. DEPARTMENT OF

ENERGY

National Energy
Technology Laboratory

Drivers NETL's Complementary UDW R&D Program

Targets Top Offshore Spill Risks



-Izon et al. 2007

- **Cementing Failures**
- **Equipment & Casing Failures**
- **Higher risk targets, "exploratory" systems**



- Recent offshore events, such as Katrina/Rita (2005) & Deepwater Horizon spill (2010)
- 2010 Executive Order 13547, Interagency Ocean Policy Task Force (IOPTF)
 - Executive agencies (including DOE) challenged to enhance national stewardship of the ocean, coasts, & Great Lakes
- 2012 Challenges Identified by DOI's OESAC Spill Prevention Subcommittee

Deep water and offshore frontier areas face production risks that are fundamentally distinct from onshore operations:

 - Drilling phase identified as having highest number of risks and uncertainties
 - Concerns about fracturing the formation can have a big impact on well design, lost circulation, and loss of well control
 - Well design incorporating multiple barriers are essential to safety.

Complementary Program Portfolio

Ultra-Deepwater (UDW)

Improved Science Base for Materials and Wellbore Integrity

- Characterizing the Behavior of Metal-Based Systems Used for Control Devices in Extreme Environments [*Lead: Jeff Hawk*] 2010 to present
- Improving Science-Base for Wellbore Integrity, Foam Cements [*Lead: Barbara Kutchko*] 2010 to present
 - FY13 merit review, Excellent rating
- Evaluation of Lithology:Cement:Casing Barrier Integrity under UDW Subsurface Conditions [*Leads: Margaret Ziomek-Moroz and Barbara Kutchko*] **NEW**

Reducing Risks & Mitigating Impacts Associated with Extreme Offshore Conditions

- Quantifying Complex Fluid-Phase Properties at High Pressure/High Temperature (HPHT) [*Lead: Isaac Gamwo*] 2010 to present
- Assessing Risks and the Potential for Environmental Impacts for Deepwater and Ultra-Deepwater GOM Resources [*Lead: Kelly Rose*] 2010 to present
 - FY13 merit review, Very Good rating

Improving Safety through Rapid Detection and *In Situ* Characterization

- Improving Deepwater Drilling Safety through Enhanced Understanding of Multiphase Flow Dynamics of Hydrocarbon Mixtures [*Leads: Bob Warzinski and Frank Shaffer*] 2010 to present
 - FY13 merit review, Very Good rating
- Risk Reduction at the Drill Bit - Adaptation of Existing Technology to Reduce Risks Associated with Deep and Ultra-Deep Drilling [*Lead: Kelly Rose*] 2013 to present

UDW Tech Transfer to Date:



www.edx.netl.doe.gov/udw

47 Conference Presentations

20 Published Articles & Reports

- Additional manuscripts undergoing internal and external peer review

12 Datasets released via EDX

2 Data-driven tool/app via EDX



***NOW UPDATED WITH FY13 Q3 PUBS,
PRESENTATIONS, TOOLS, ETC***

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Improving Safety through Rapid Detection and *In Situ* Characterization

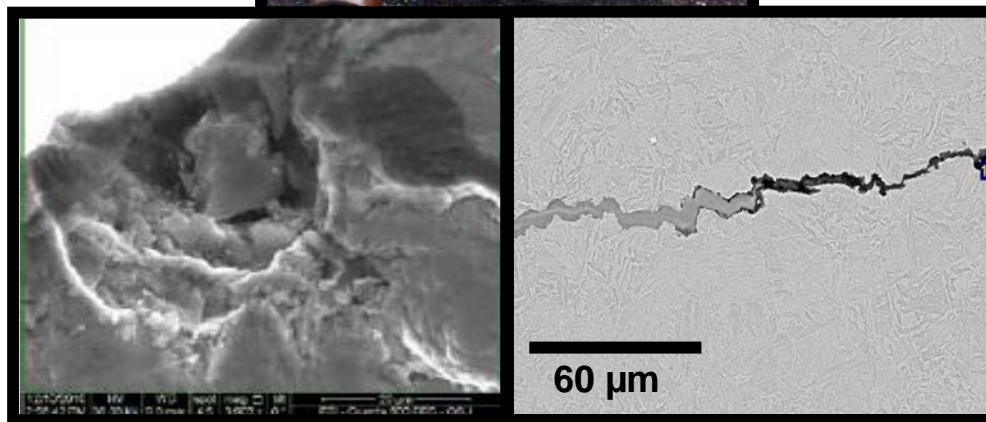
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Characterizing the Behavior of Metal-Based Systems Used for Control Devices in Extreme Environments (Lead: *Hawk*)

Reducing Risk of
Material Failures
During Offshore
Operations



Studying corrosion &
fatigue performance
of high-strength
tubulars in seawater
& sour brine
environments



Improving understanding of how conventional alloys & advanced alloys and
surface treatments may allow for safe and reliable use of metallic
components in extreme wellbore conditions

Characterizing the Behavior of Metal-Based Systems Used for Control Devices in Extreme Environments (Lead: *Hawk*)

Driver: Lack of data on key safety-performance metrics for metallic components at extreme conditions

Project Goal: Expand the science base on the performance of new HPHT alloys and surface treatments designed for use in extreme conditions

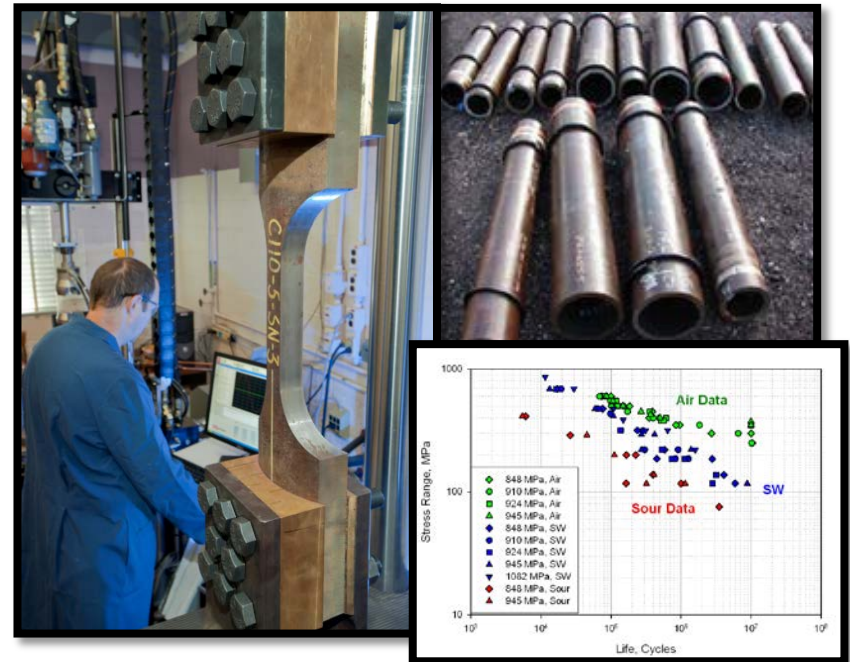
pre-FY13 Status: ORD strength/ corrosion experiments of common **UDW** alloys to date found:

- No evidence one alloy is superior to another
- Best materials for conventional drilling do not translate to extreme conditions
- Prior seawater and air tests not relevant for HPHT or sour systems
- Identified preferential locations for pit and fatigue crack development = point of weakness in HPHT/UDW

FY13 R&D Focus: On corrosion & fatigue performance at HPHT conditions of advanced metallic surface treatments & metallic welds

Anticipated FY13 Products:

- Report characterizing the behavior of “welded” metal-based systems used for piping and control devices in extreme conditions
- Report summarizing evaluation of surface treatments on corrosion & fatigue behavior at HPHT
 - Hammer peening vs. Low Plasticity Burnishing (LPB)



Improving Science-base for Wellbore Integrity of Foamed Cements (Lead: Kutchko)

API RP10-B at room P,T



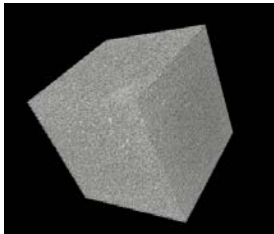
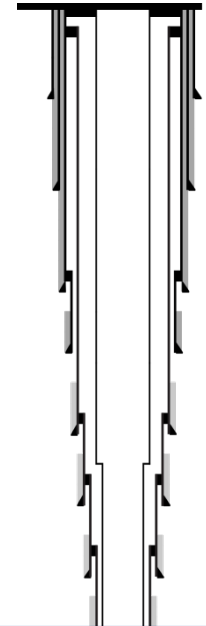
Lab-based Pressure Vessel
(on loan from Schlumberger)



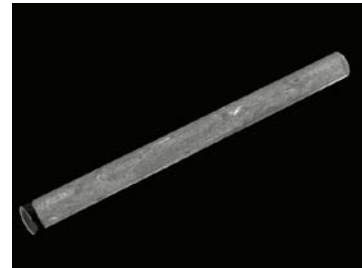
Slip Stream at Wellhead
(with BP & Schlumberger)



In situ Conditions



**Reducing Risk of
Cement-Related
Failures During
Offshore
Operations**

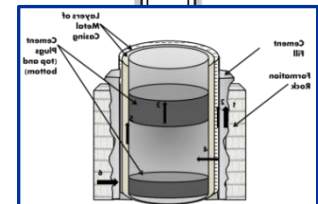


Development of imaging
and analysis protocols

Evaluation over range of
mix-design parameters



Evaluation of mix designs
under field conditions



CFD to simulate
mesostructure

Improving Science-base for Wellbore Integrity of Foamed Cements (Lead: Kutchko)

Driver: Unknown properties of foamed cements under downhole conditions (high P, T). Need to know strength & permeability.

Project Goals:

- Database of foamed cement properties—mesostructure (e.g., gas distribution), strength, permeability for various mix designs.
- Predictive relationship for properties as function of mesostructure.
- Predictive relationship for mesostructure based on mix design, placement conditions, etc.

pre-FY13 Status:

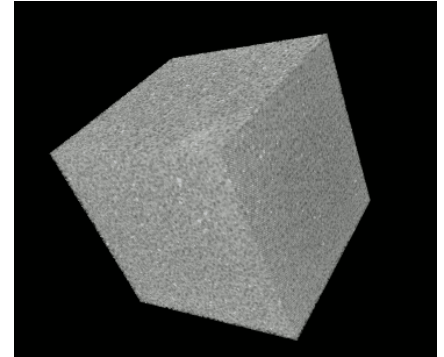
- Completed gap assessment (NETL-TRS-003-2012)
- Developed imaging & analysis techniques (NETL-TRS-2-2013)
- Analyzed first field sample (slip-stream) using CT (TRS under develop.)

FY13 Focus:

- Characterize multiple slip-stream samples from 3 major service companies
- Characterize lab-based samples for different foaming agents, stabilizers, and foam qualities at two pressures (500 psi, 1000 psi)

Anticipated FY13 Products:

- TRS describing imaging & analysis data on slip-stream samples
- TRS describing data on variation in physical properties as function of mix design



3D CT Scan of a 10.4 mm³
digital subsection of 10%
foam quality cement



3D CT Scan of field-generated
foamed cement. Foam
quality 47.8%; collected at a
pressure of ~290 psi

NEW Evaluation of Lithology:Cement:Casing Barrier Integrity under UDW Subsurface Conditions (Leads: Ziomek-Moroz & Kutchko)

Driver: Changes in pressure and temperature cycles or corrosion can cause the development of microannuli (potential flow paths) in offshore cement barriers. This is especially significant in ultra-deepwater wells, which are large heat exchangers and are drilled in extreme HP/HT environments.

Project Goal: Study the interactions between wellbore materials that may lead to catastrophic failure of the well over time

pre-FY13 Status: This is a new project

FY13 Focus:

- Complete a knowledge/gap analysis study to constrain key research concerns.
- Use the results of the gap analysis to drive initial FY13 experiments.

Anticipated FY13 Products:

- Report summarizing findings of scoping and gap study
- Results from initial experiments to determine potential flow paths in HP/HT environments



Complementary Program Portfolio

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Reducing Risks & Mitigating Impacts Associated with Extreme Offshore Conditions

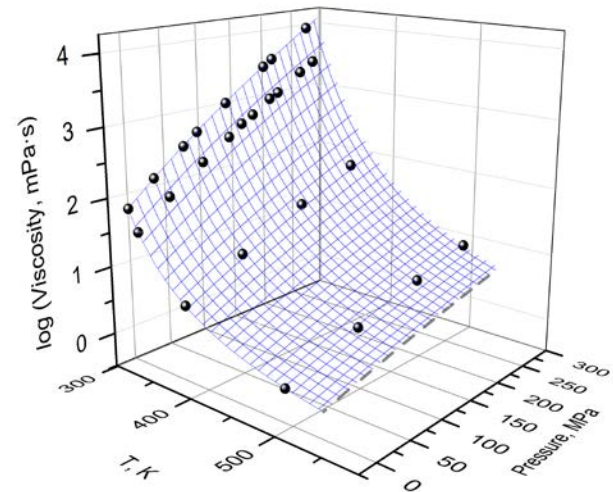
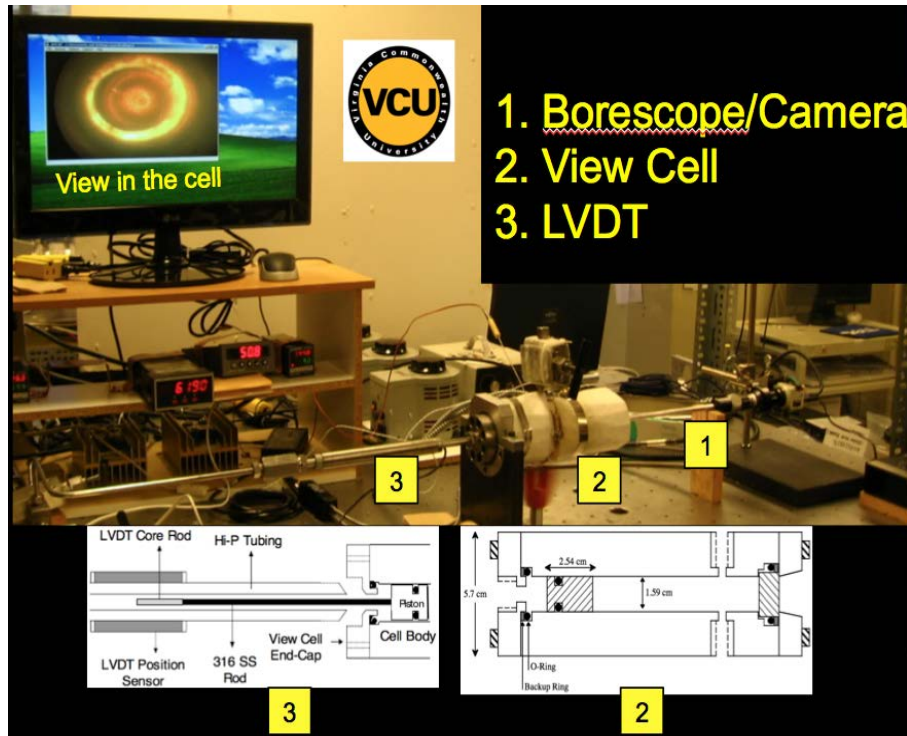
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Quantifying Complex Fluid-Phase Properties at High Pressure/High Temperature [Project Lead: Gamwo]

Expand data on density & viscosity to 40 kpsi, 500 °F
(pure compounds, mixtures, crude)



Develop higher accuracy equations of state

Quantifying Complex Fluid-Phase Properties at High Pressure/High Temperature [Project Lead: Gamwo]

Driver: Limited availability of hydrocarbon fluid properties at high PT associated with deepwater wells

Project Goals:

- 1) Expand database on hydrocarbons to 40kpsi & 500 °F
- 2) Develop higher accuracy equations of state for high PT
- 3) Develop standards for high PT property measurement

pre-FY13 Status:

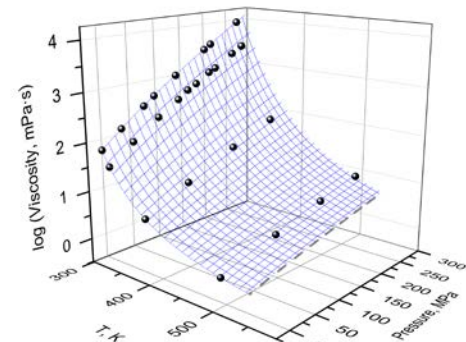
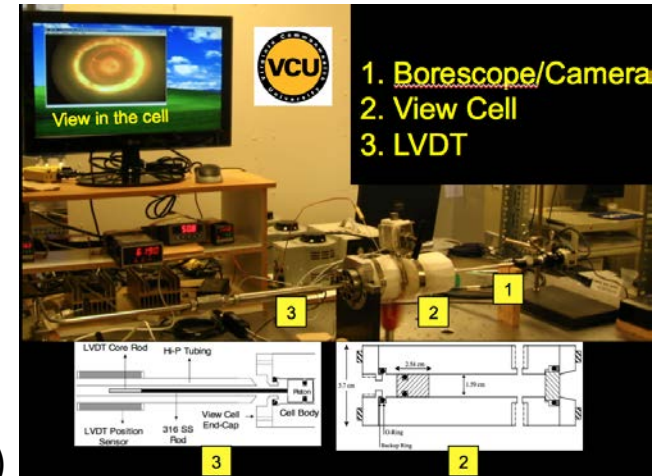
- Built apparatuses for density & viscosity measurement
- Characterized pure compounds: densities (19), viscosities (4)
- Characterized density of binary mixture (C3+C10)
- Developed higher accuracy EOS for pure compounds
- Identified/characterized viscosity standard

FY13 Focus:

- Characterize binary mixtures: densities & viscosities
- Characterize crude oil: density
- Extend EOS to real oil mixtures; develop EOS tool

Anticipated FY13 Products:

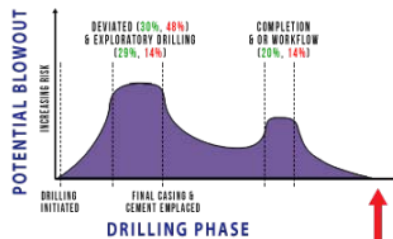
- TRS detailing density datasets on binary mixtures
- Web-based, user-friendly program for density EOS



Assessing Risks and the Potential for Environmental Impacts for Deep & Ultra-Deepwater GOM

[Project Lead: Rose]

Developing tools and information to evaluate and predict what happens in extreme offshore hydrocarbon systems



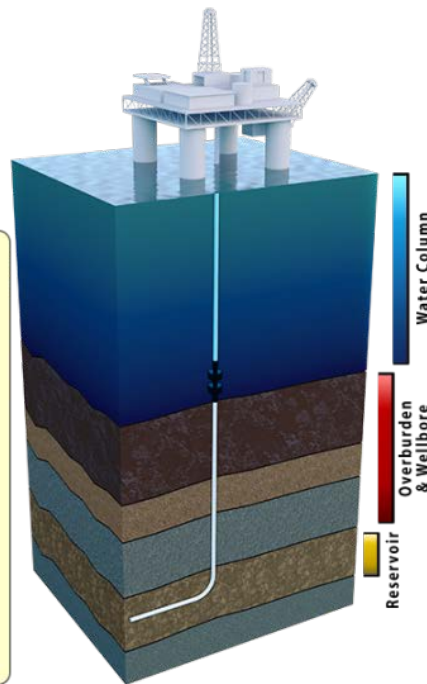
**GOM
IAM**

POTENTIAL RECEPTORS OR
IMPACT MEDIA

TRANSPORT MEDIA/
MECHANISMS

SUBSURFACE
FORMATION

Integrated Assessment Models to Predict
Behavior of Engineered-Natural System

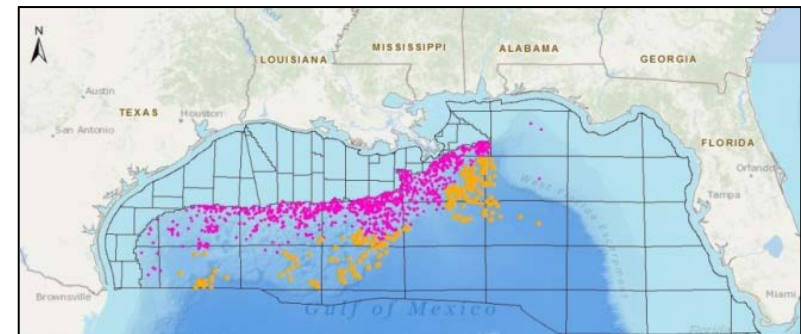


NETL Gulf of Mexico IAM

1st coordinated platform to allow for:

- independent,
- rapid-response,
- science based prediction

of UDW hydrocarbon production risks and environmental impacts



BLOSUM + **EDX** + **GEO CUBE** + **VGM TOOL**
Energy Data exchange

Coordinated data:simulation system for oil
spill impact & risk evaluation

Assessing Risks and the Potential for Environmental Impacts for Deep & Ultra-Deepwater GOM

[Project Lead: Rose]

Driver: Need for a cohesive suite of tools and data to support independent, rapid science-based prediction of UDW hydrocarbon risks and assessment of spills

Project Goal: Reducing risks and environmental impacts from extreme offshore hydrocarbon production

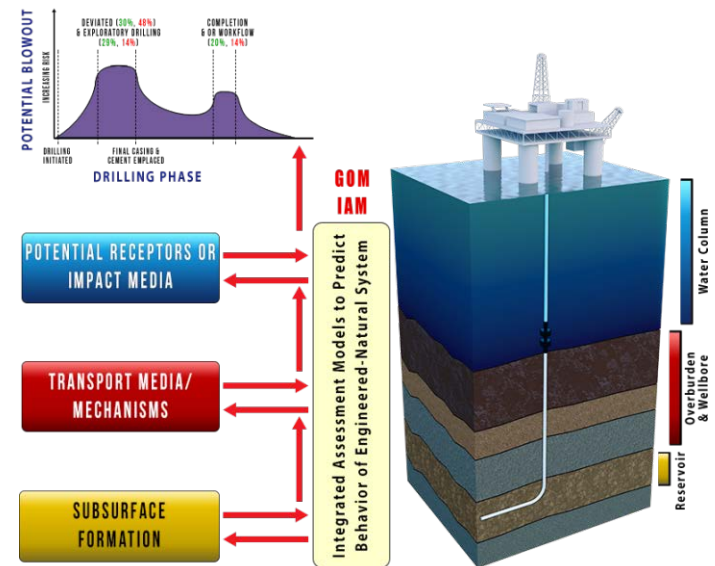
pre-FY13 Status:

- Released GOM Geocube, online map based tool containing key spatial data for the GOM
- TRS summarizing key GOM impact receptor analysis
- Completed beta water column component model, BLOSOM
- Continued development of GOM subsurface database

FY13 Focus:

- Complete beta GOM subsurface database
- Complete beta development of cumulative risk tool
- Complete integration of 3 IAM component models
- Shakedown BLOSOM, run in API oil spill modeling study

Anticipated FY13 Products: Beta integrated platform to allow for independent, rapid-response, & science based prediction of UDW hydrocarbon production risks and environmental impacts



BLOSOM + EDX + GEO CUBE + VGM TOOL
 Energy Data exchange
Coordinated data:simulation system for oil spill impact & risk evaluation

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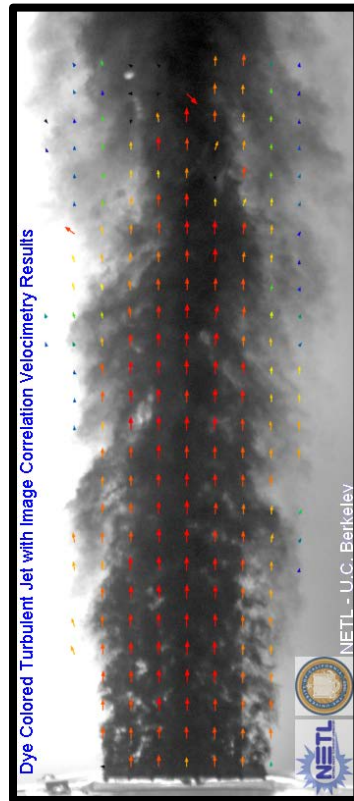
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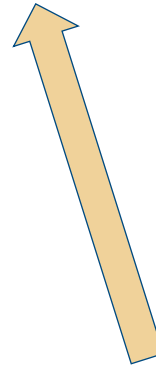
Improving Deepwater Drilling Safety through Enhanced Understanding of Multiphase Flow Dynamics of Hydrocarbon Mixtures

[Project Lead: Warzinski]

Develop software to quantify flow accurately using high speed video from ROV



4" turbulent dyed water jet studied at UCB



CH₄ bubble w/ hydrate shell

Develop science base to predict hydrate formation & hydrocarbon compositions & volumes in water column plumes

Improving Deepwater Drilling Safety through Enhanced Understanding of Multiphase Flow Dynamics of Hydrocarbon Mixtures

[Project Lead: Warzinski]

Driver: Quantification of gas/oil flows using high-speed video from ROVs

Project Goals: Develop video-analysis tool for accurate quantification of oil/gas plume rates; incorporate hydrate formation in quantification tool

pre-FY13 Status:

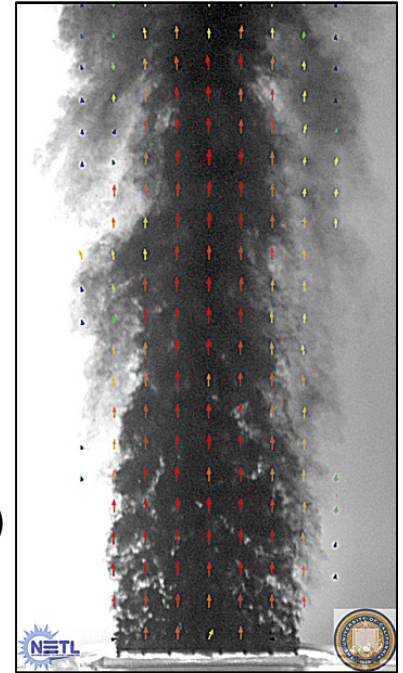
- Completed scoping for appropriate surrogate multi-phase conditions for validation
- Completed data collection for water-water and air-water plumes (UC-B facility).
- Completed data collection for Type I/II hydrates (methane, ethane, propane) (NETL facility)

FY13 Focus:

- [Perform oil-water(-gas) experiments at OHMSETT (funded by BSEE)]
- Validate video-analysis tool using datasets on air-water, water-water, and oil-water
- Complete analysis of experimental data on Type I/II hydrates
- Initiate incorporation of hydrates into video-analysis tool

Anticipated FY13 Products:

- Video-analysis tool (prototype) for quantifying plume rates using high speed images from ROV



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CH₄ bubble w/ hydrate shell

Risk Reduction at the Drill Bit - Adaptation of Existing Technology to Reduce Risks Associated with Deep and Ultra-Deep Drilling

[Project Lead: Rose]

Driver: Significant concerns have been raised about how to safely develop UDW resources and ensure domestic supply. Detecting in a timely, efficient manner when there is a kick is a significant challenge in deepwater systems.

Project Goal:

To develop a low cost means for detecting kicks when they happen at the bit, utilizing largely existing wellbore data

pre-FY13 Status:

- Initiated scoping and feasibility study
- Filed “report of invention” in preparation for NETL patent review process

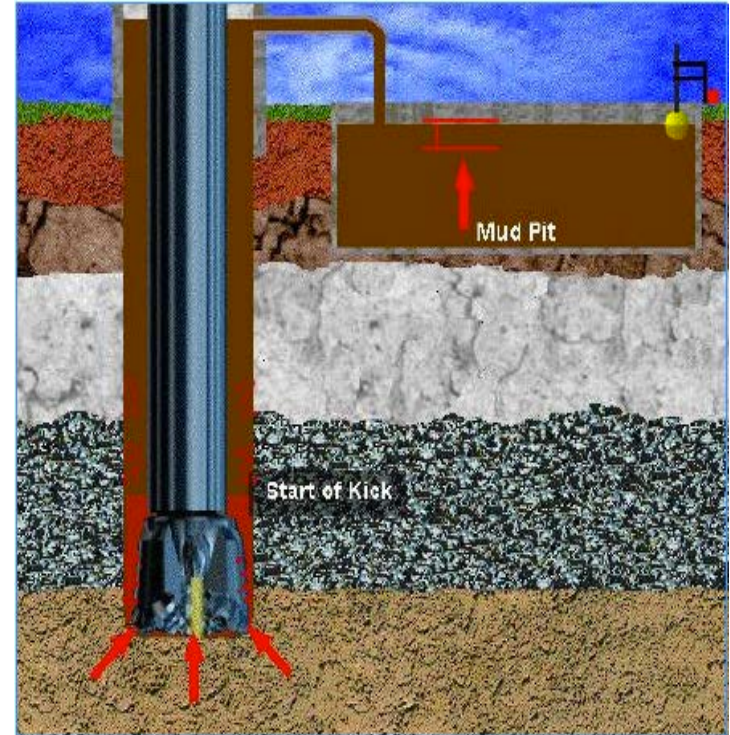
FY13 Focus:

- Complete scoping and approach feasibility study
- Initiate numerical and experimental efforts to validate and implement approach for supporting early kick detection

Anticipated FY13 Products:

- Preliminary tool/approach for early kick detection

Early Detection is Critical



- Maintain control of well
- Reduce environmental, human, and economic impacts

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