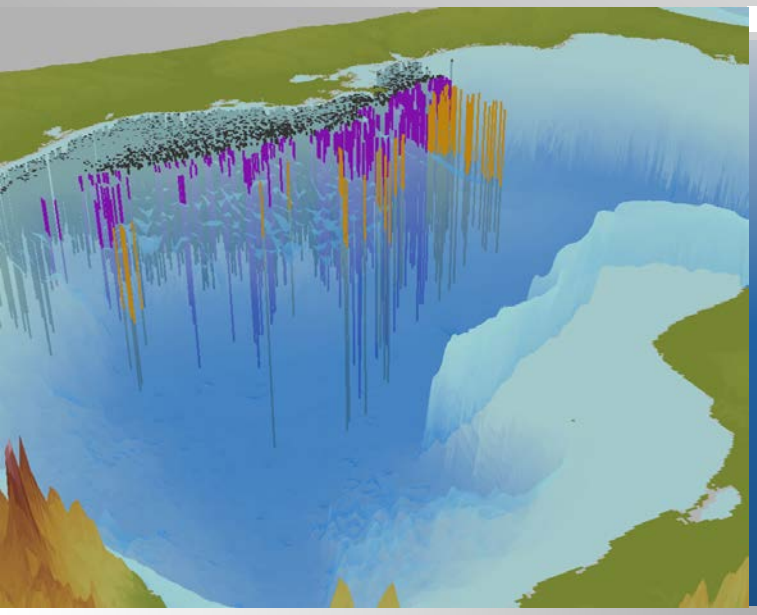


UDW Portfolio Update

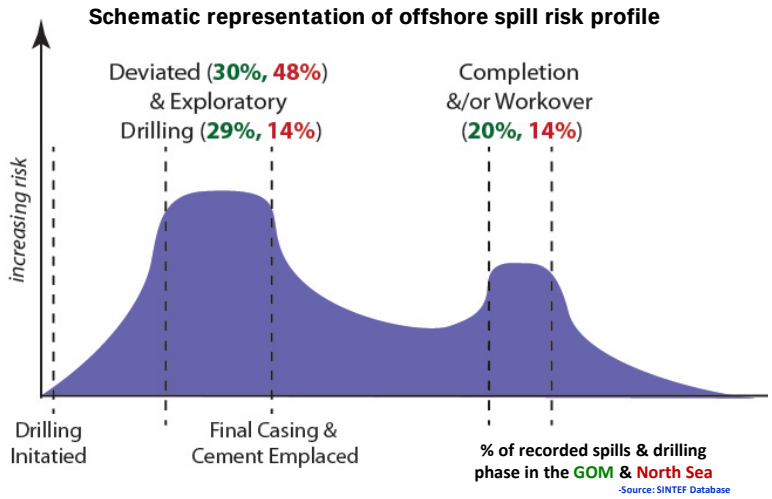
NETL ORD's EPAct Complementary Research

Reducing risks associated with ultra-deepwater hydrocarbon systems

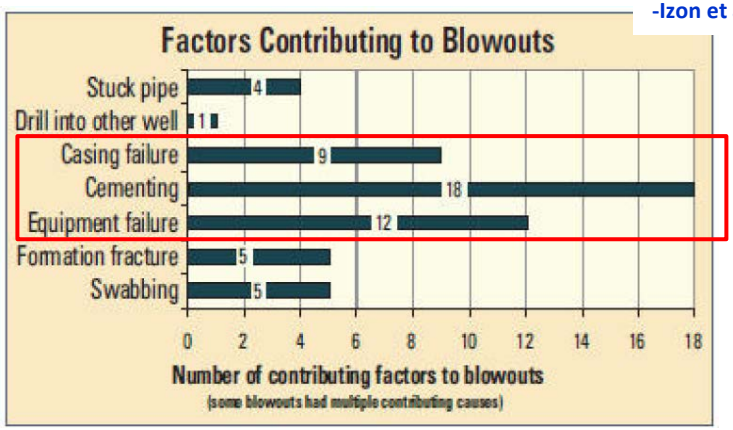
Kelly Rose, Ultra-Deepwater Technical Coordinator

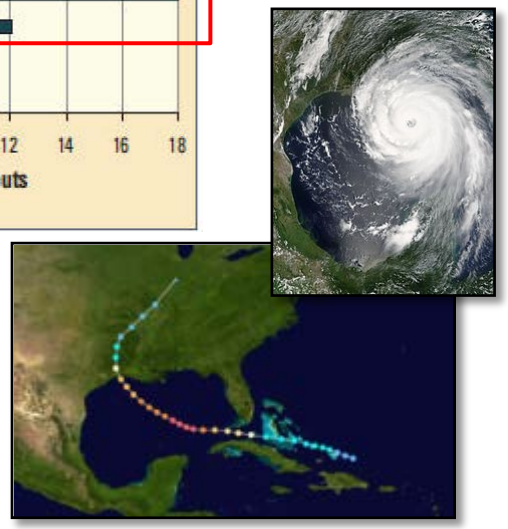
September 17th, 2013

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*

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- 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

Complementary Program Portfolio
Ultra-Deepwater (UDW)

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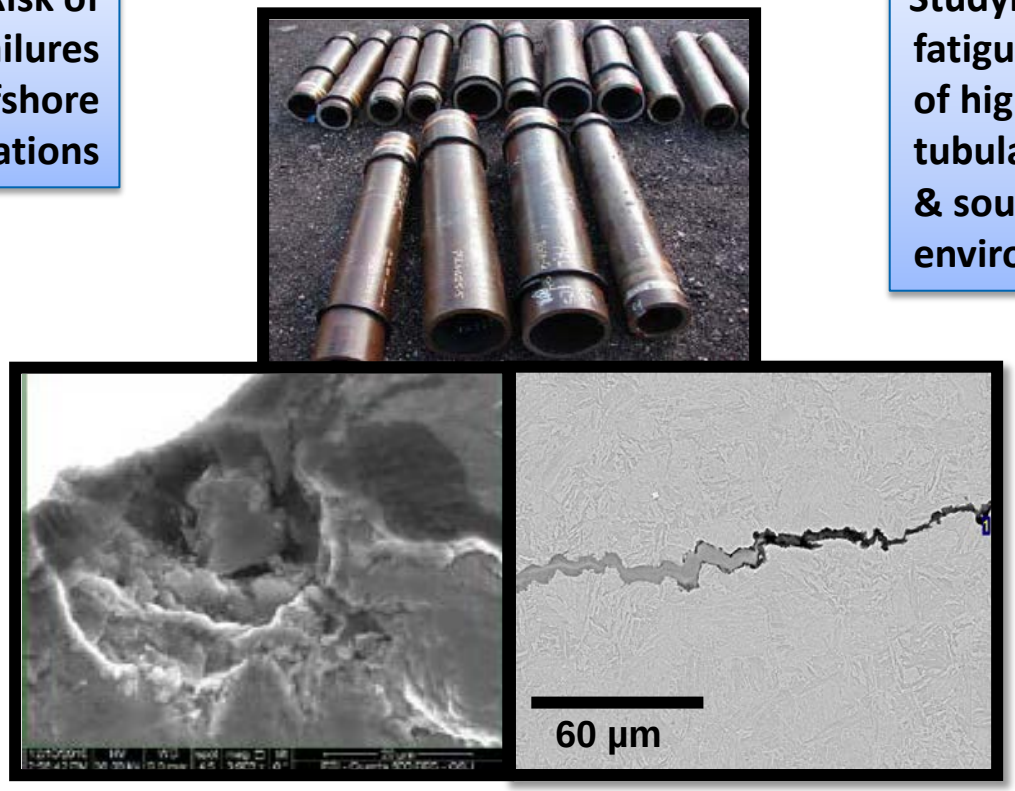
Characterizing the Behavior of Metal-Based Systems Used for Control Devices in Extreme Environments (Lead: *Hawk)*

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

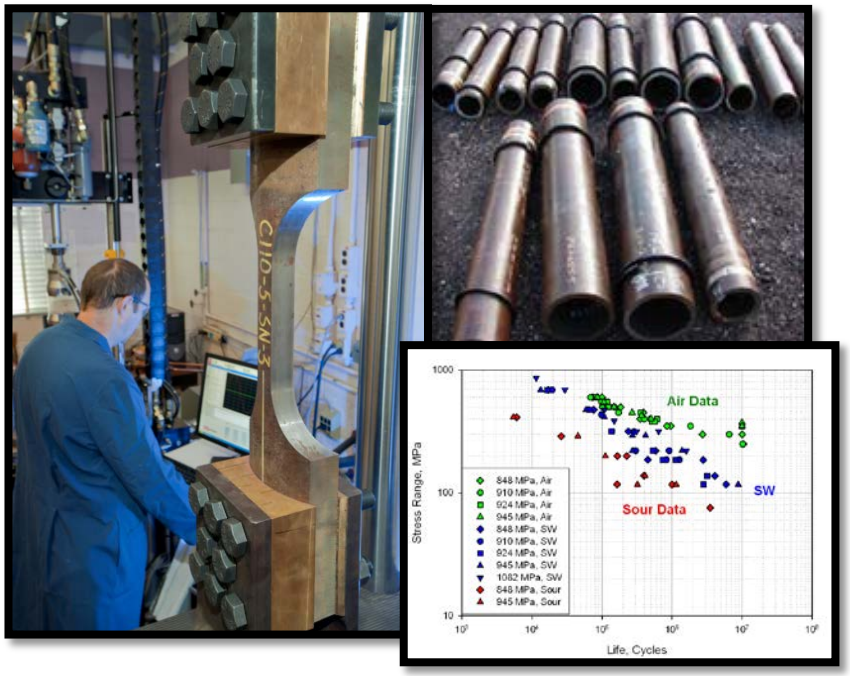
Characterizing the Behavior of Metal-Based Systems Used for Control Devices in Extreme Environments (Lead: *Hawk)*

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



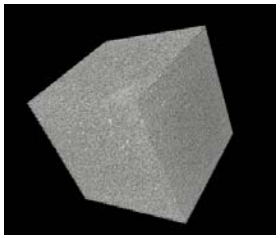
FY13 R&D Focus: On corrosion & fatigue performance at HPHT conditions of advanced metallic surface treatments & metallic welds

Anticipated FY13 Products:

- Report characterizing the behavior of "welded" metal-based systems used for piping and control devices in extreme conditions
- Report summarizing evaulation 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



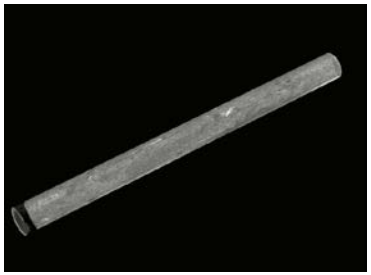
Development of imaging and analysis protocols

Lab-based Pressure Vessel (on loan from Schlumberger)

Reducing Risk of Cement-Related Failures During Offshore Operations

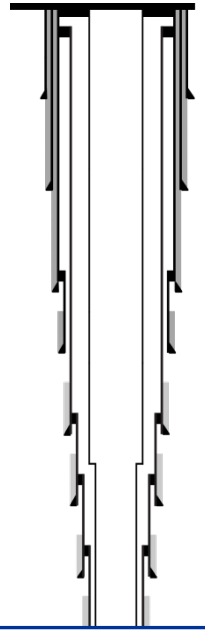
Evaluation over range of mix-design parameters

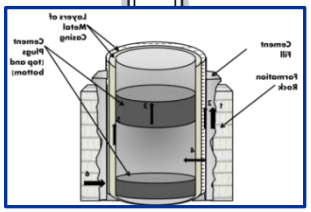
Slip Stream at Wellhead (with BP & Schlumberger)



Evaluation of mix designs under field conditions

In situ 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:

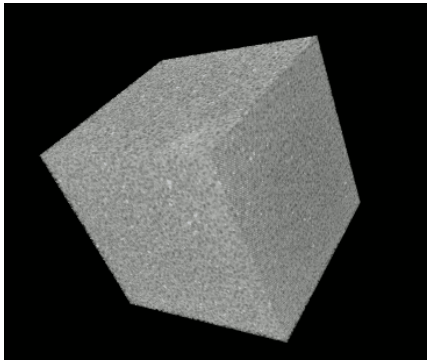
- Completed gap assessment (NETL-TRS-003-2012)
- Developed imaging & analysis techniques (NETL-TRS-2-2013)
- Analyzed first field sample (slip-stream) using CT (TRS under develop.)

FY13 Focus:

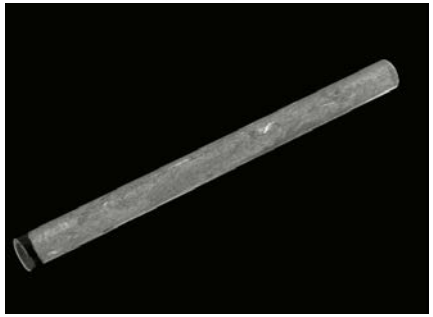
- Characterize multiple slip-stream samples from 3 major service companies
- Characterize lab-based samples for different foaming agents, stabilizers, and foam qualities at two pressures (500 psi, 1000 psi)

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 mm^3 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
Ultra-Deepwater (UDW)

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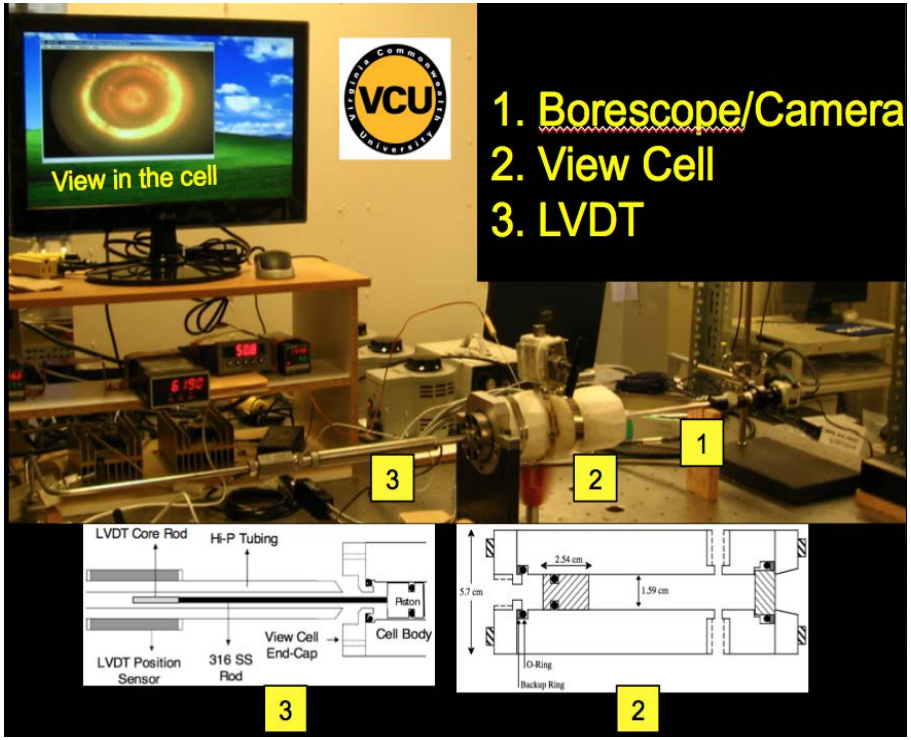
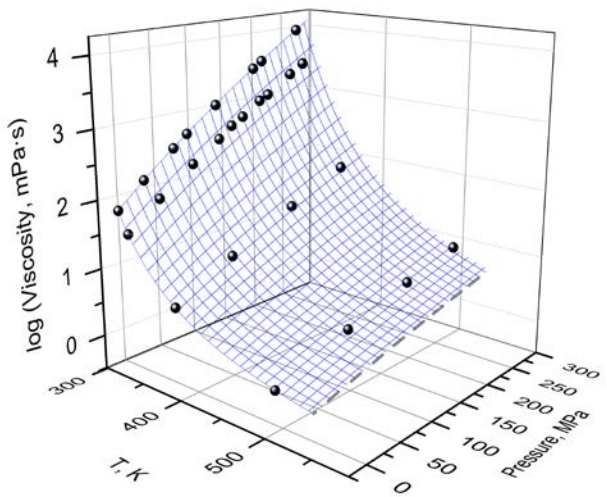
Quantifying Complex Fluid-Phase Properties at High Pressure/High Temperature

[Project Lead: Gamwo]

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



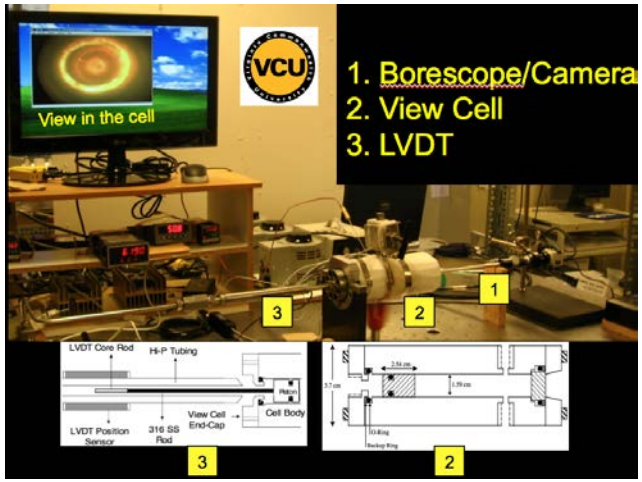


Develop higher accuracy equations of state

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

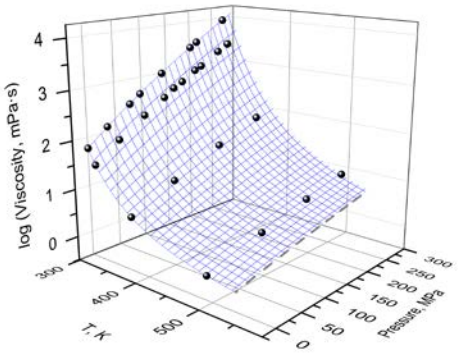


Project Goals:

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

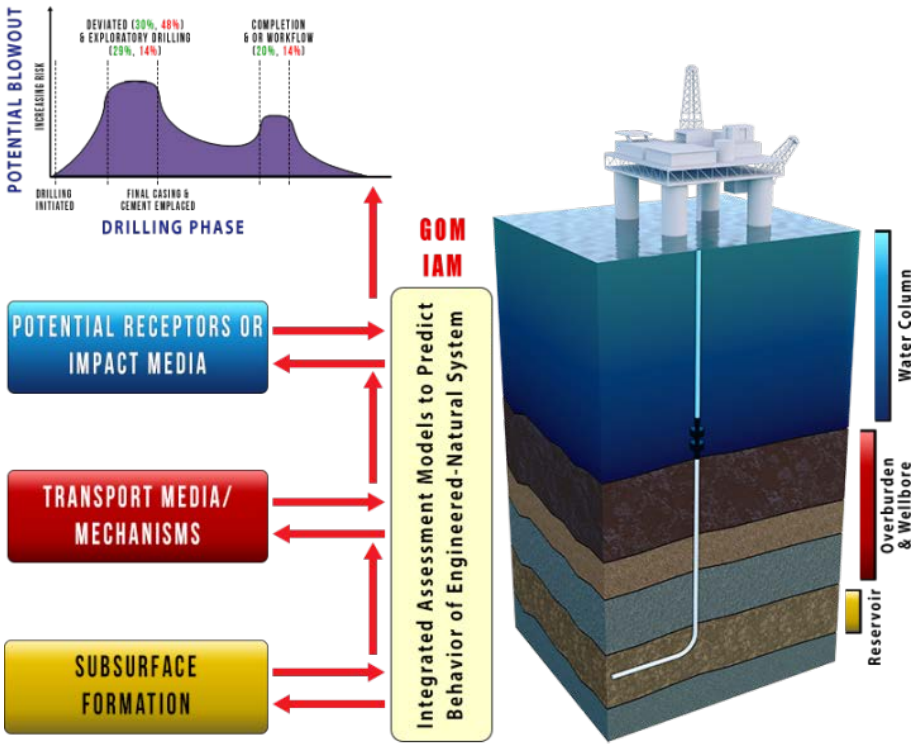
Anticipated FY13 Products:

- 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

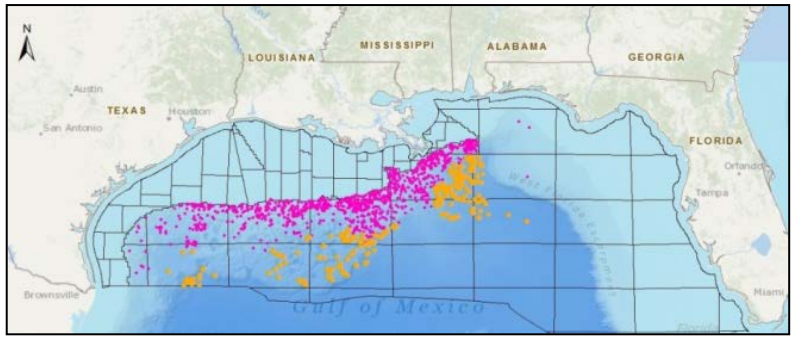


NETL Gulf of Mexico IAM

1st coordinated platform to allow for:

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

of UDW hydrocarbon production risks and environmental impacts



BLOSOM + EDX Energy Data eXchange + GEO CUBE + VGM TOOL

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

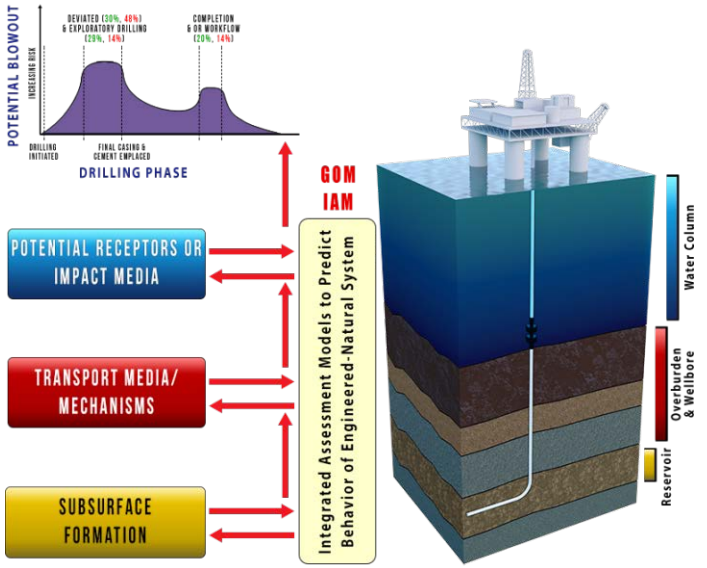
pre-FY13 Status:

- 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



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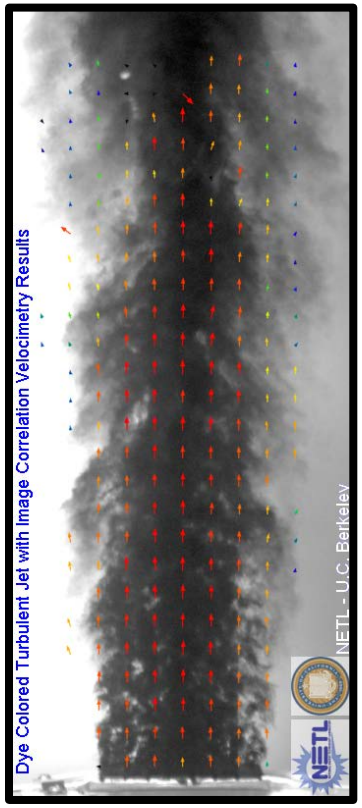
Improving Deepwater Drilling Safety through Enhanced Understanding of Multiphase Flow Dynamics of Hydrocarbon Mixtures

[Project Lead: Warzinski]

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



4" turbulent dyed water jet studied at UCB

CH_4 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:

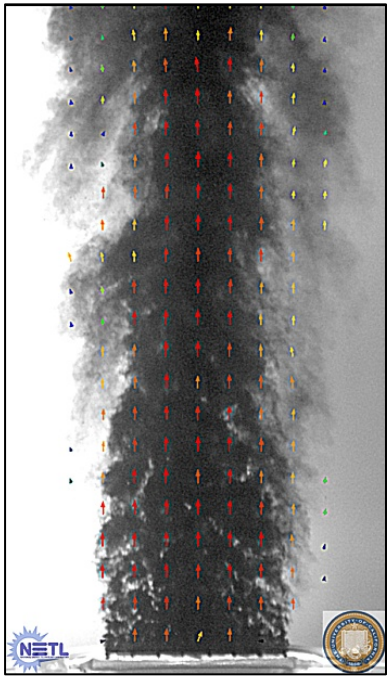
- Completed scoping for appropriate surrogate multi-phase conditions for validation
- Completed data collection for water-water and air-water plumes (UC-B facility).
- Completed data collection for Type I/II hydrates (methane, ethane, propane) (NETL facility)

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



4” turbulent dyed water jet studied at UCB

CH_4 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

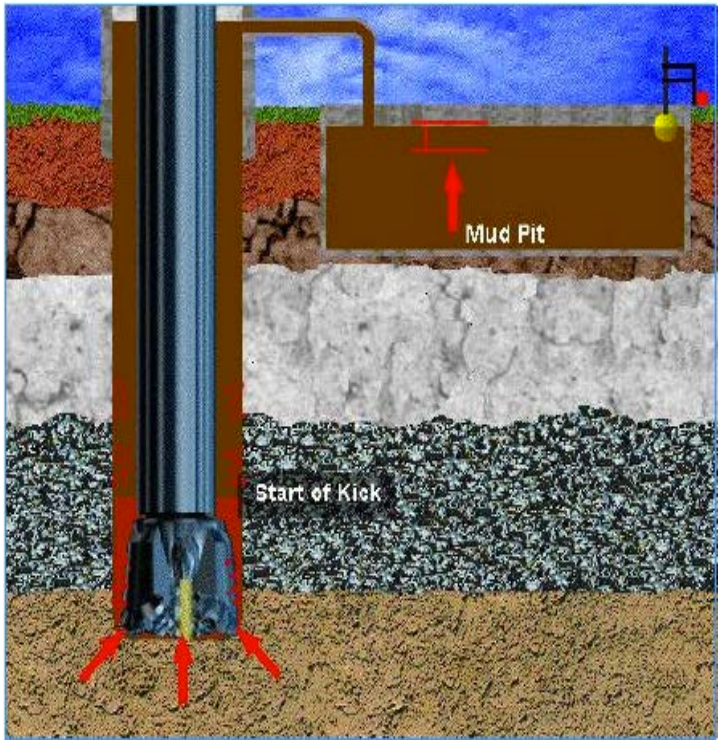
FY13 Focus:

- 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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20 Published Articles & Reports

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