Deepwater Horizon Accident

Gulf of Mexico on Tuesday, April 20, 2010

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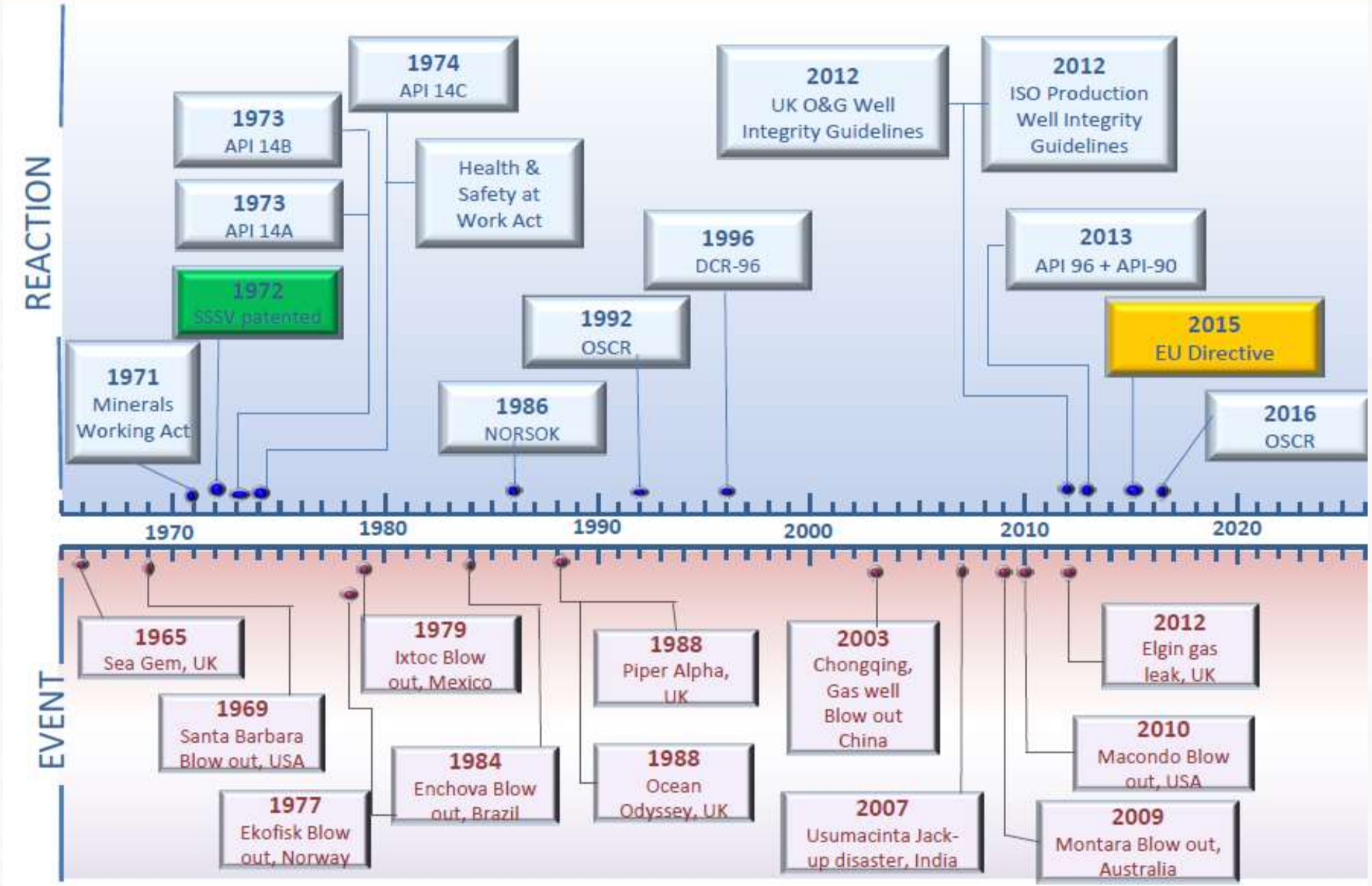
Short Biography	**Mahmoud Radwan is a Subsurface & Integrity Operations Dept. Head at AMAL Petroleum Company (AMAPETCO) with more than 13 years of experience in oil & gas industry. Mahmoud worked in Well Engineering, Intervention, Integrity & Work-over at several companies, including Badr El-Din Pet. Co. (BAPETCO), Qarun Pet. Co. (QPC) and Wadi El-Sahel Petroleum Co. (WASPETCO).** **Also, a freelance instructor at upstream Oil & Gas in Egypt & UAE since 2008.** **Mahmoud received a BSc degree in Petroleum Engineering from Al-Azhar University in 2007.**
Publications	**- Evaluating Sustainable Annulus Pressure (SAP) in Sour Wells and the Possible Causes to Avoid Recurrence to the Well Integrity Annual Middle East Conference in Abu Dhabi; UAE in Apr 2015** **- Implementing NDT methods for maintenance and inspection to the Asset Integrity Management North Africa Conference in Cairo; Egypt in Nov 2015** **- Feasibility Evaluation of Using Downhole Gas-water Separation Technology in gas Reservoirs with Bottom Water; paper number: SPE-183739-MS to the 20th Middle East Oil & Gas Show and Conference in Mar 2017 http://dx.doi.org/10.2118/183739-MS** **- Managing the Operational Challenges in Corroded Wells through Well Integrity Management System to the Improving Brownfield Performance Technical Convention, in Cairo; Egypt in Dec 2019** **- Safe and Economic Attractive Rigless Operations Using a Digital Slickline in Unmanned Platform with Low Structure Loads and Spacing; paper number: SPE--202857-MS to the Abu Dhabi International Petroleum Exhibition & Conference (ADIPEC) in Nov 2020 http://dx.doi.org/10.2118/183739-MS**

Significant Industry Events



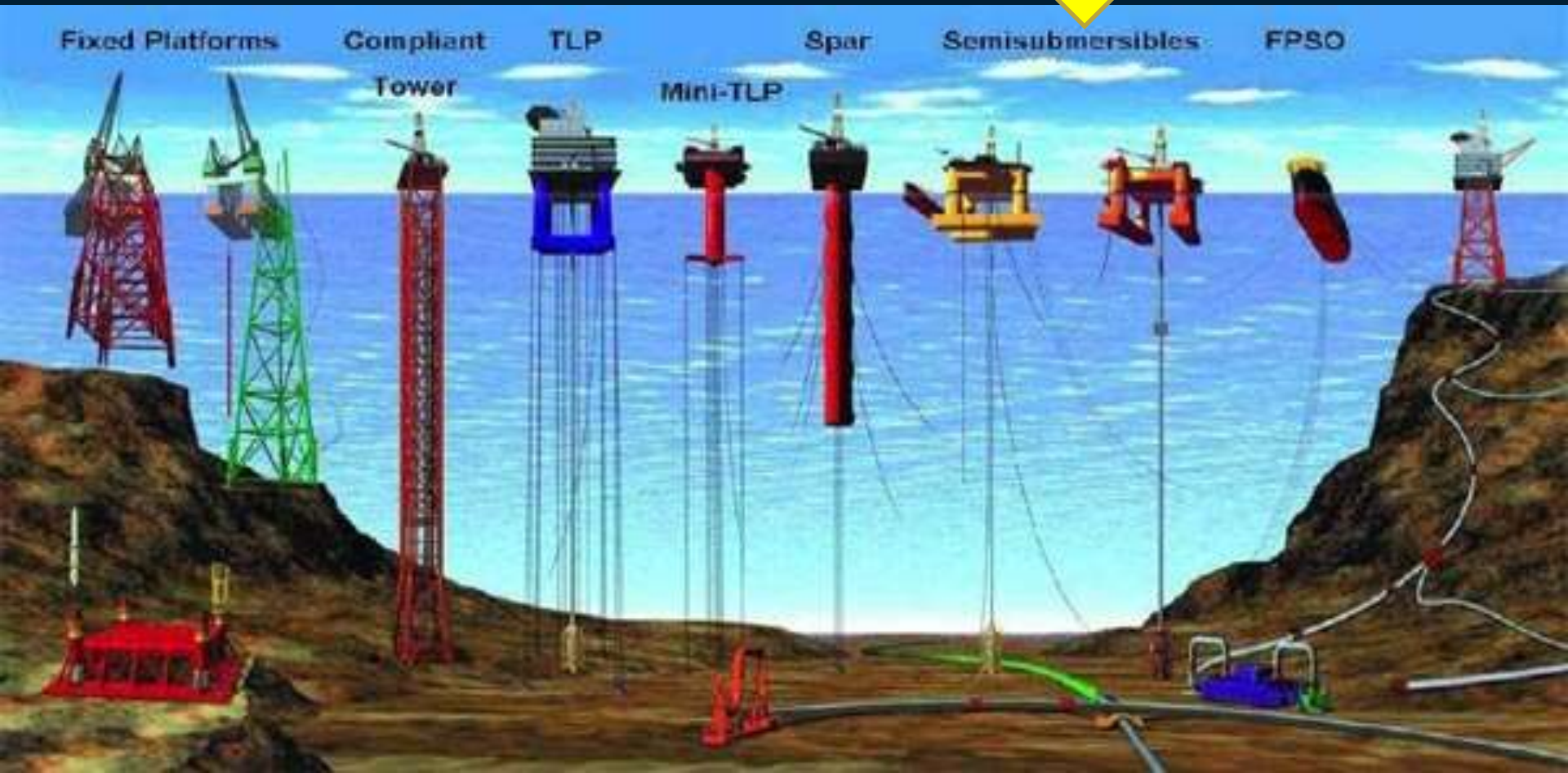
Incidents will happen – Incidents change regulation – Regulation requirements will change

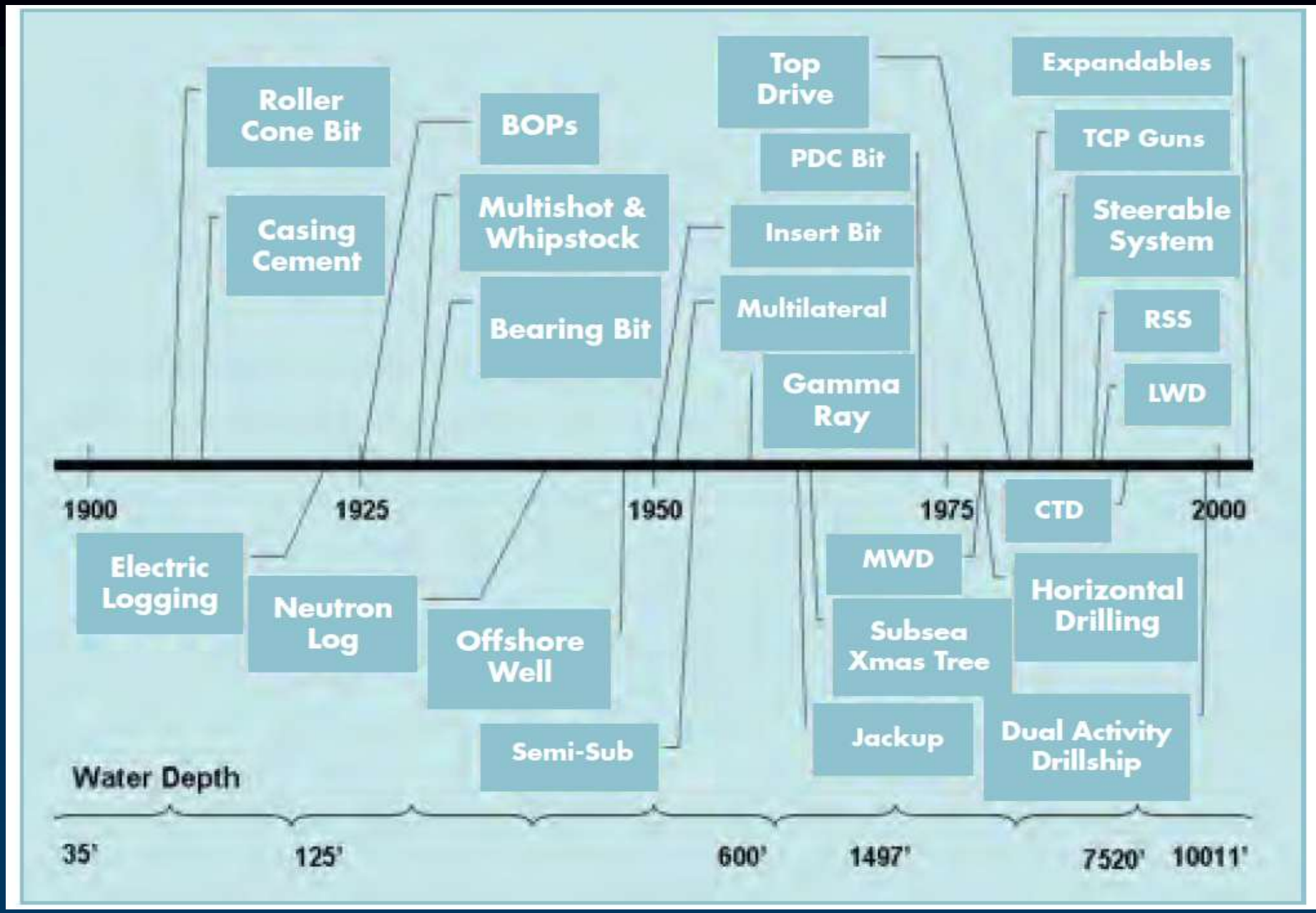
Response to Macondo Accident

- BP, Safety and operation risk (SOR) assurance and audit structure, 2011
- API STD 53: Blowout Prevention Equipment System for Drilling, 4th Edition, Jan 2012
- API RP 96: Deepwater Well Design and Construction, 1st Edition, Jan 2013
- NORSOK D-010: Well Integrity in Drilling Well Operations, Revs 4, Jun 2013
- ISO/TS 16530-2: Well integrity for operation phase, 2013
- ISO/DIS 16530-1: Life cycle governance, 2017

Different platforms are used depending on the depth of the water at the drill site.

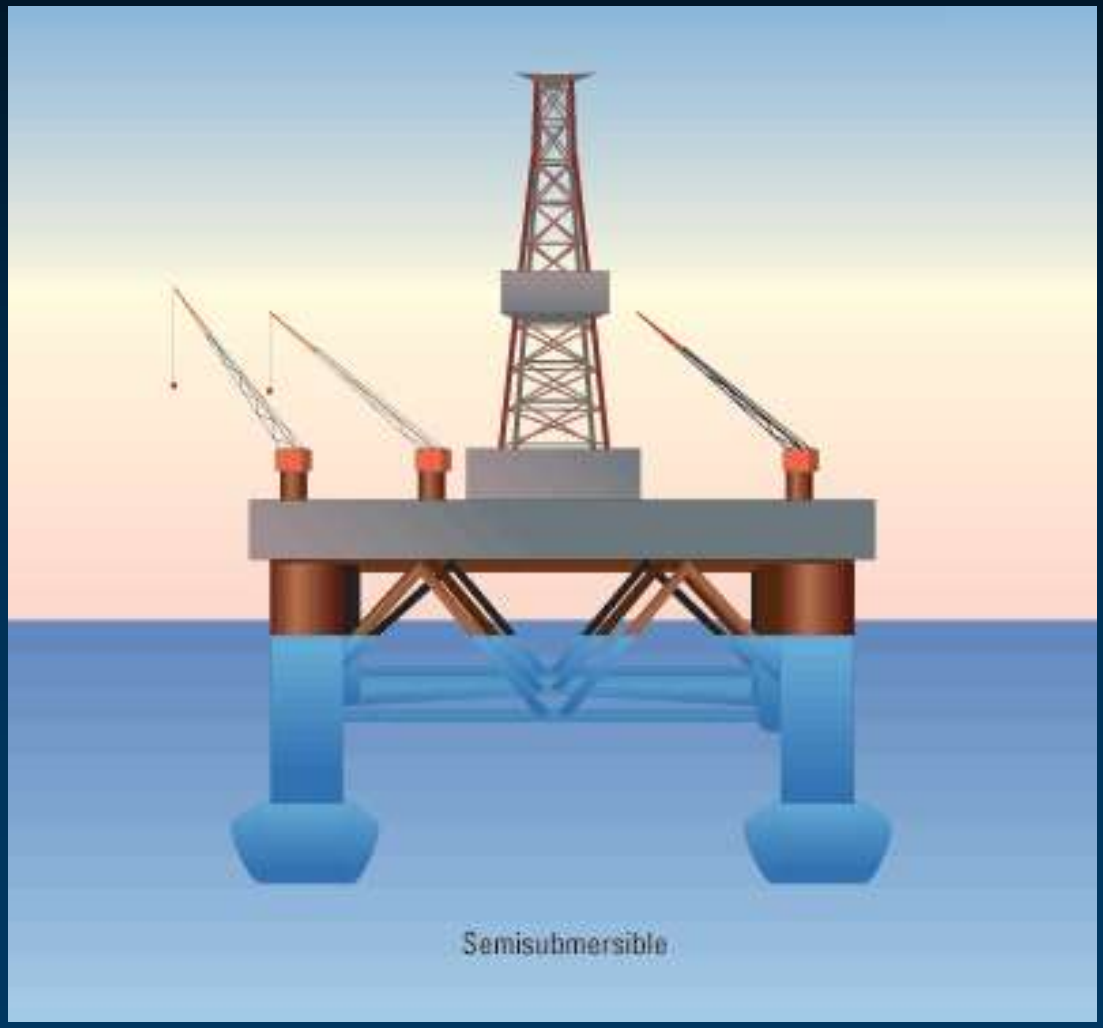
Deepwater Horizon was a semi-submersible oil rig.



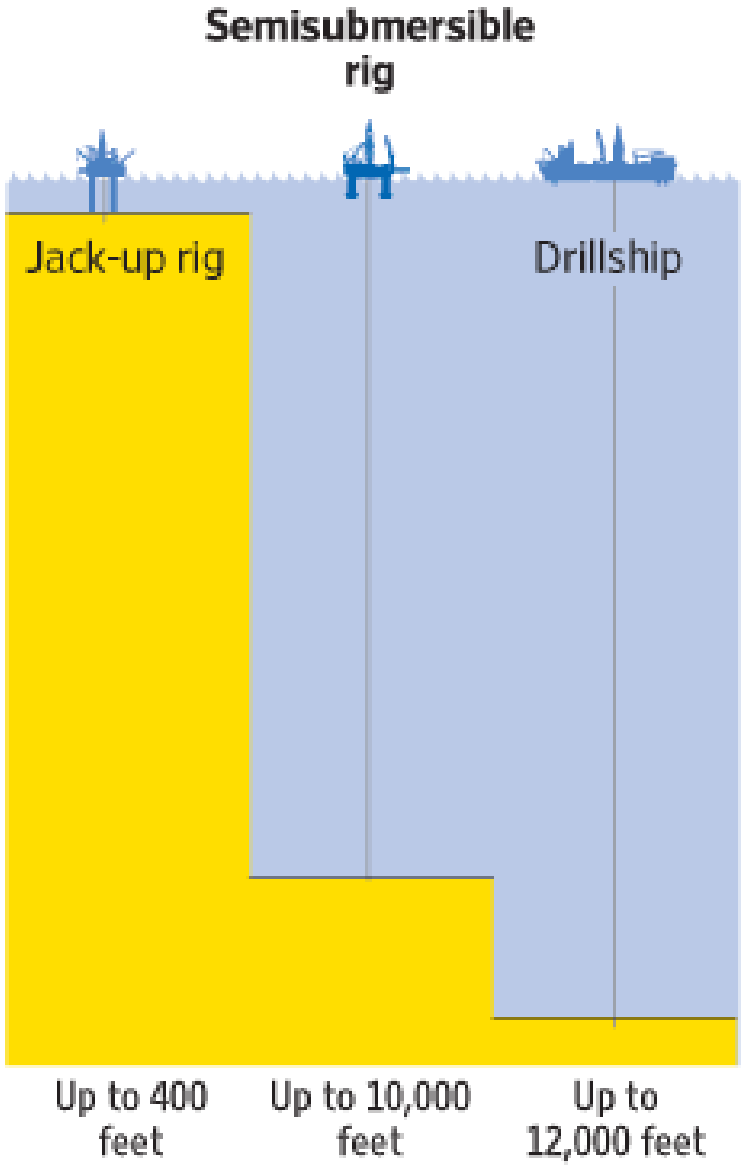


Water Depth vs Time vs Technical Achievements

A semi-submersible platform is partially filled with water for stability.

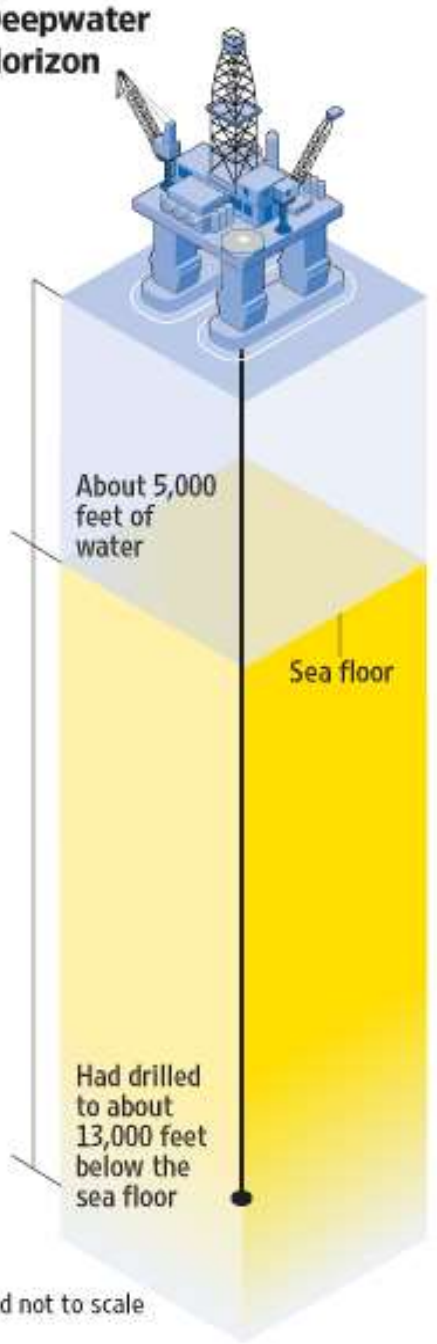


Maximum water depths by rig type



Deep Dives

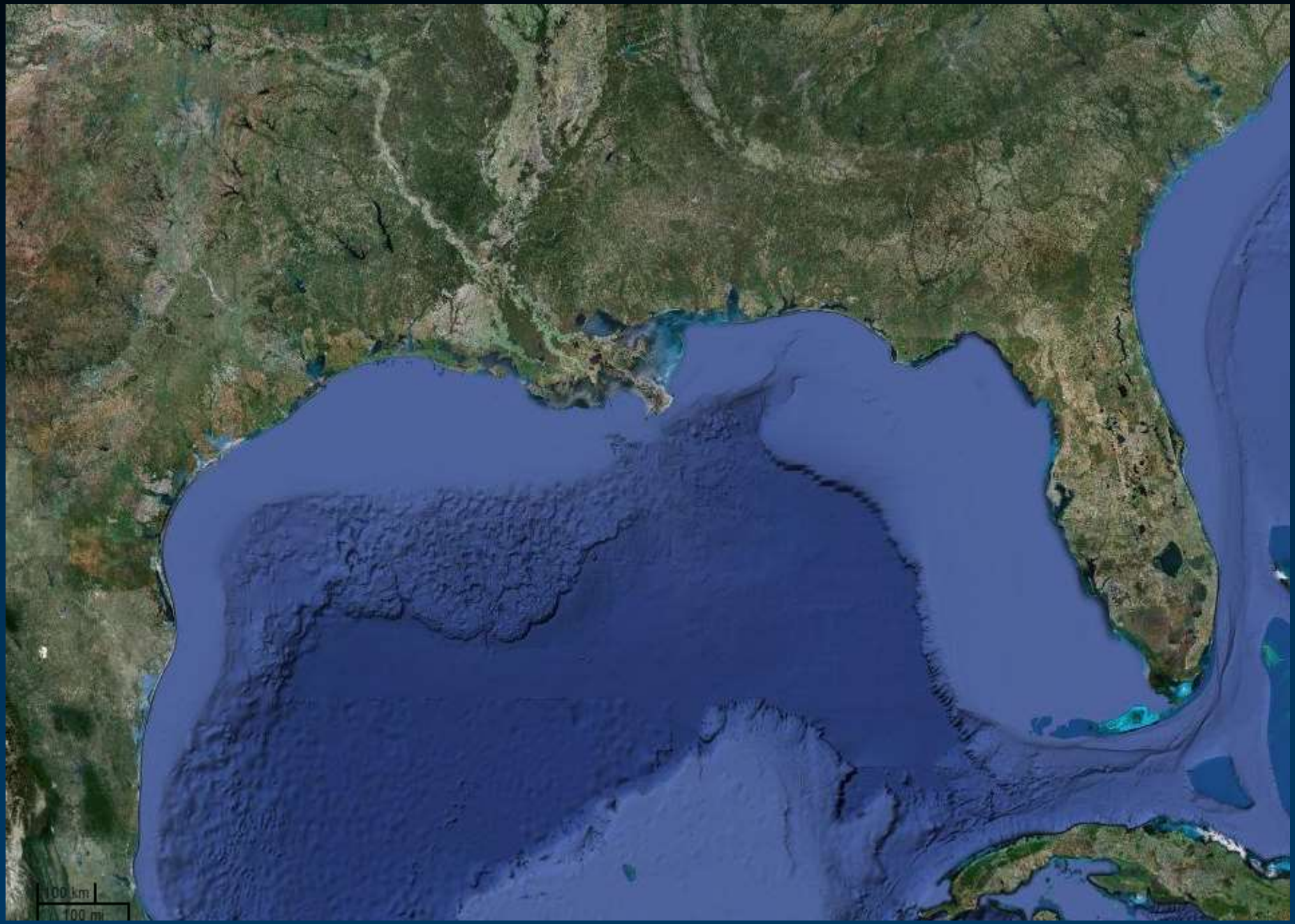
The Deepwater Horizon is a **semisubmersible rig,** designed to drill in very deep waters. It is partially filled with water for stability.



Note: Drawings are schematic and not to scale
Source: WSJ research

Zooming in…

Gulf of Mexico: The light blue is shallow water near land. The darker blue is deeper water.



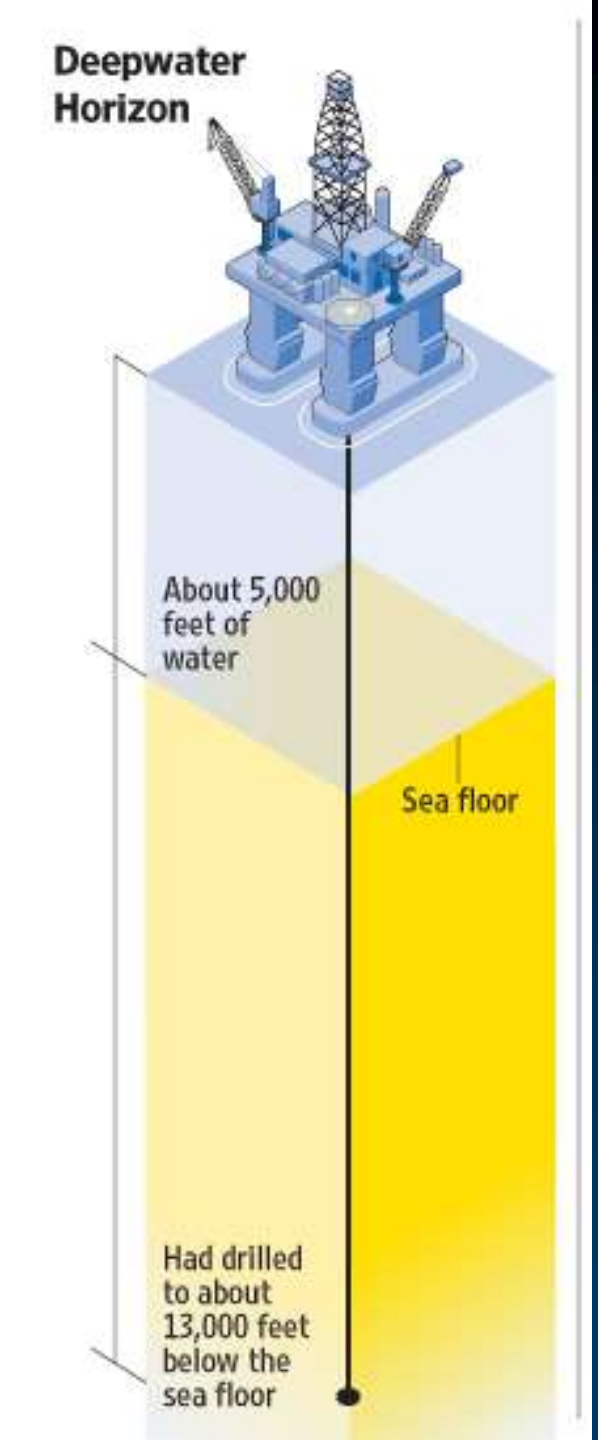

Deepwater Horizon
Wellhead
0 km
100 mi
Zoom Level: 6
Location: 32.08257°, -78.77197°

What happened?

Exploratory work had been completed and the well was being prepped for Deepwater Horizon to move to another location.

A different rig would be used to pump the oil they had found.

The reservoir was estimated to contain 15 billion gallons of oil.

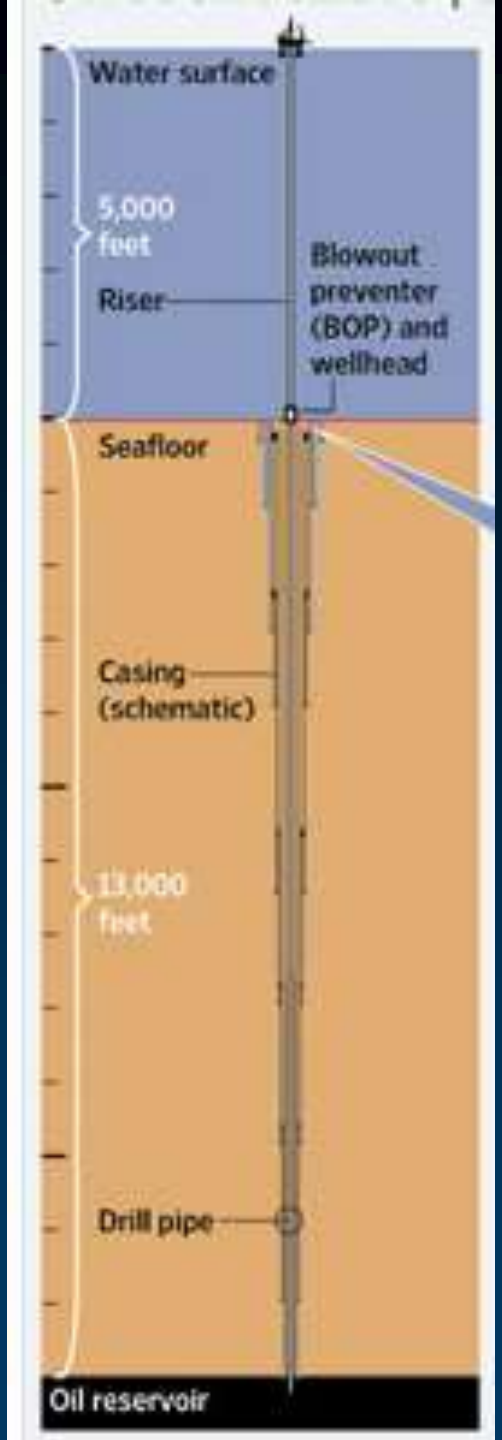


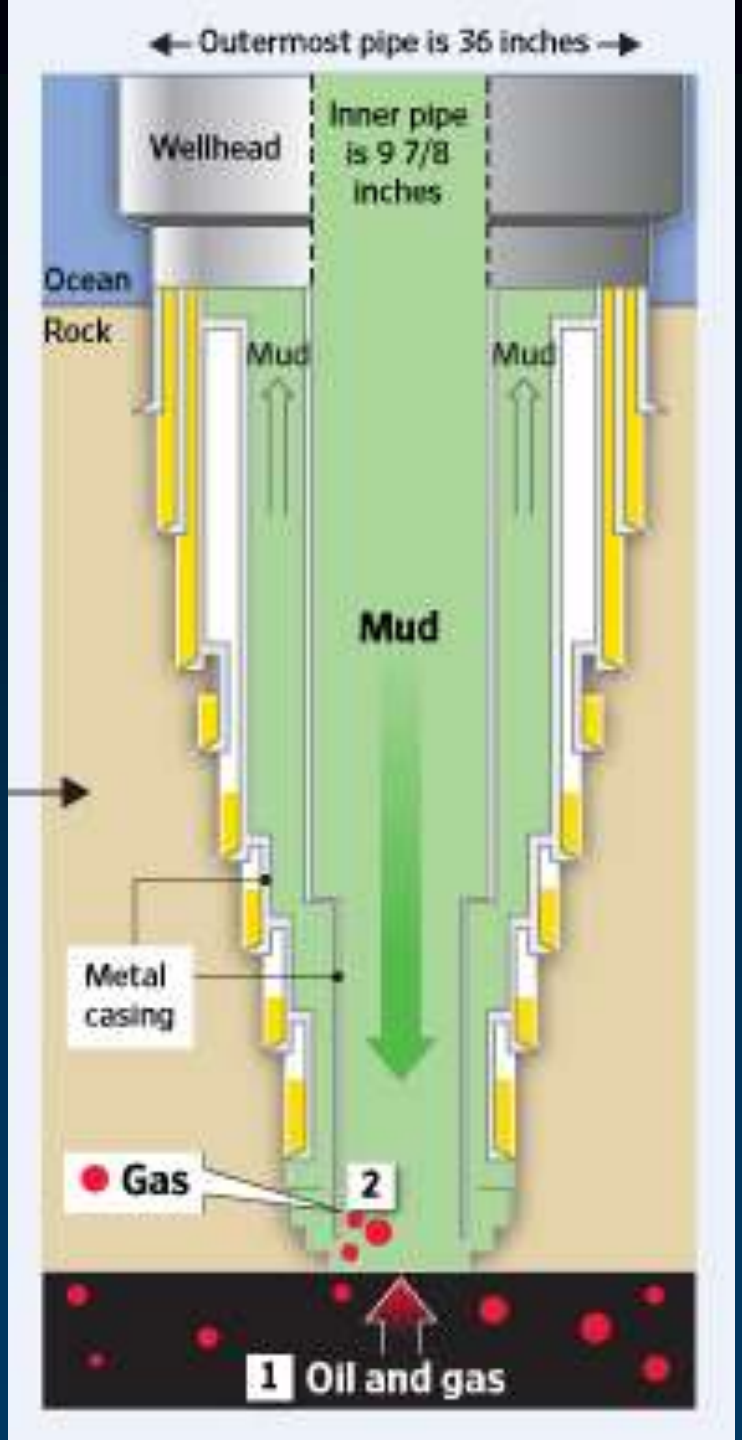
Step-by-Step

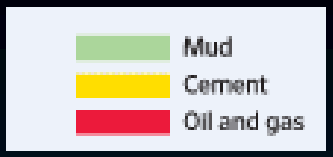
The following slides will show a cross section of the drilling pipe.

The illustration is NOT to scale.

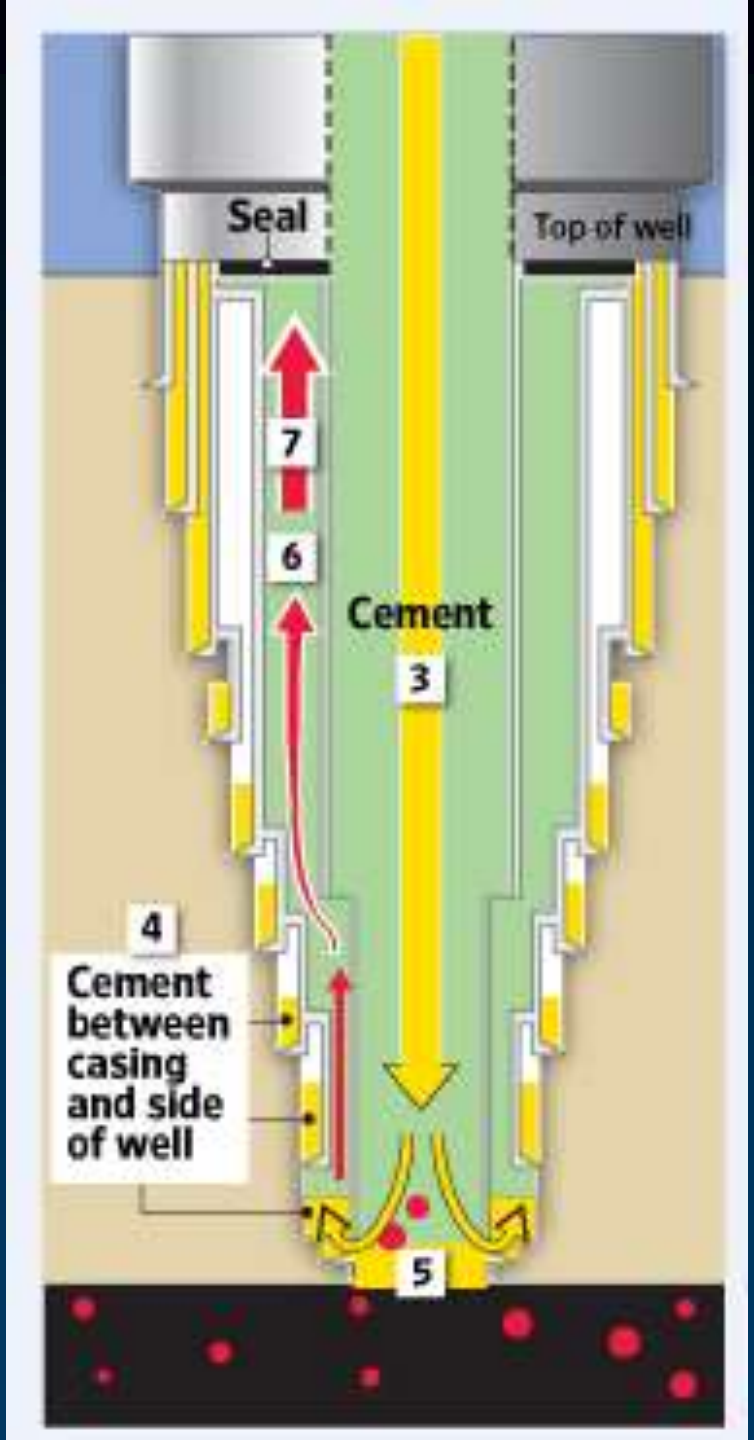
Different colors represent the thick drilling fluid known as “mud,” the cement used to temporarily shutdown the well, and the gas that made its way to the surface.





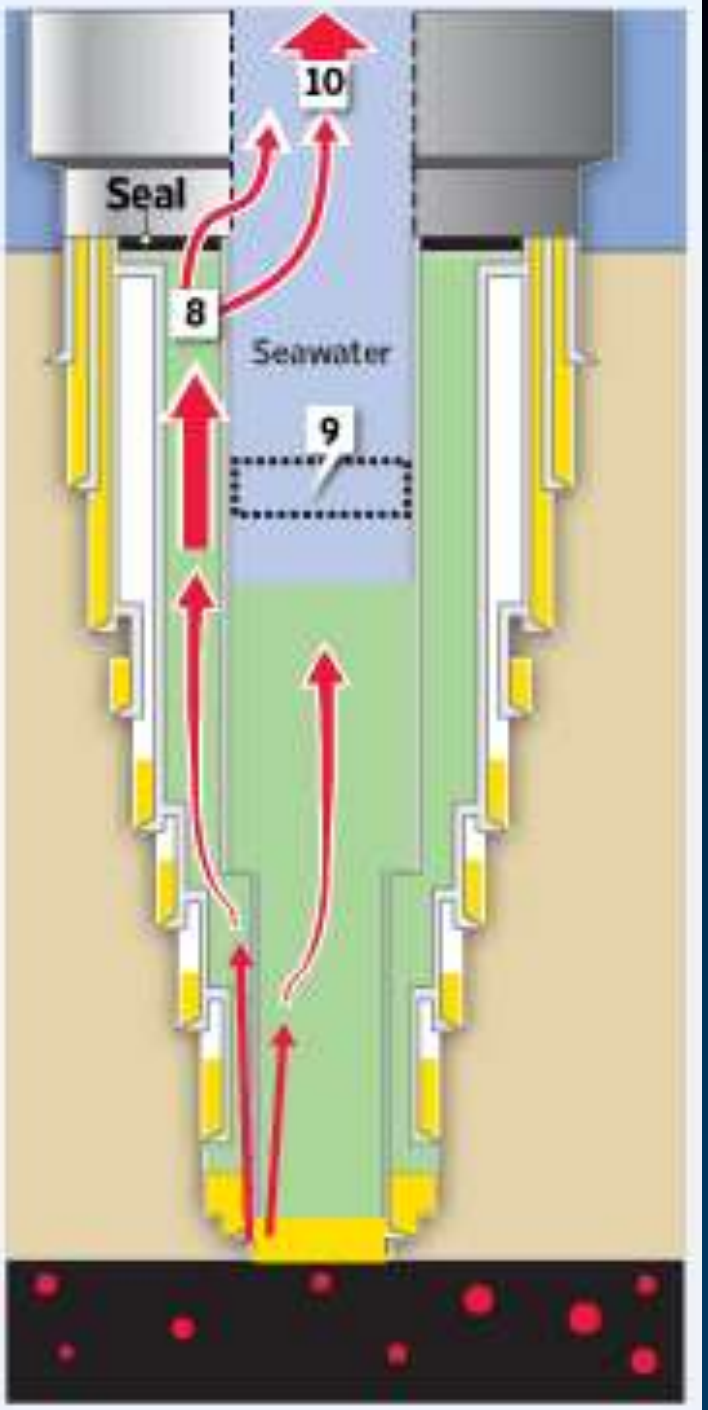


Heavy drilling fluid, “mud,” was used during exploratory drilling operations to keep any gas from rising up the pipe.



As they prepared to leave the site, cement was pumped into the well to seal it until the next rig came to remove the oil.

Because the cement is heavier than the mud, it sinks to the bottom of the well.

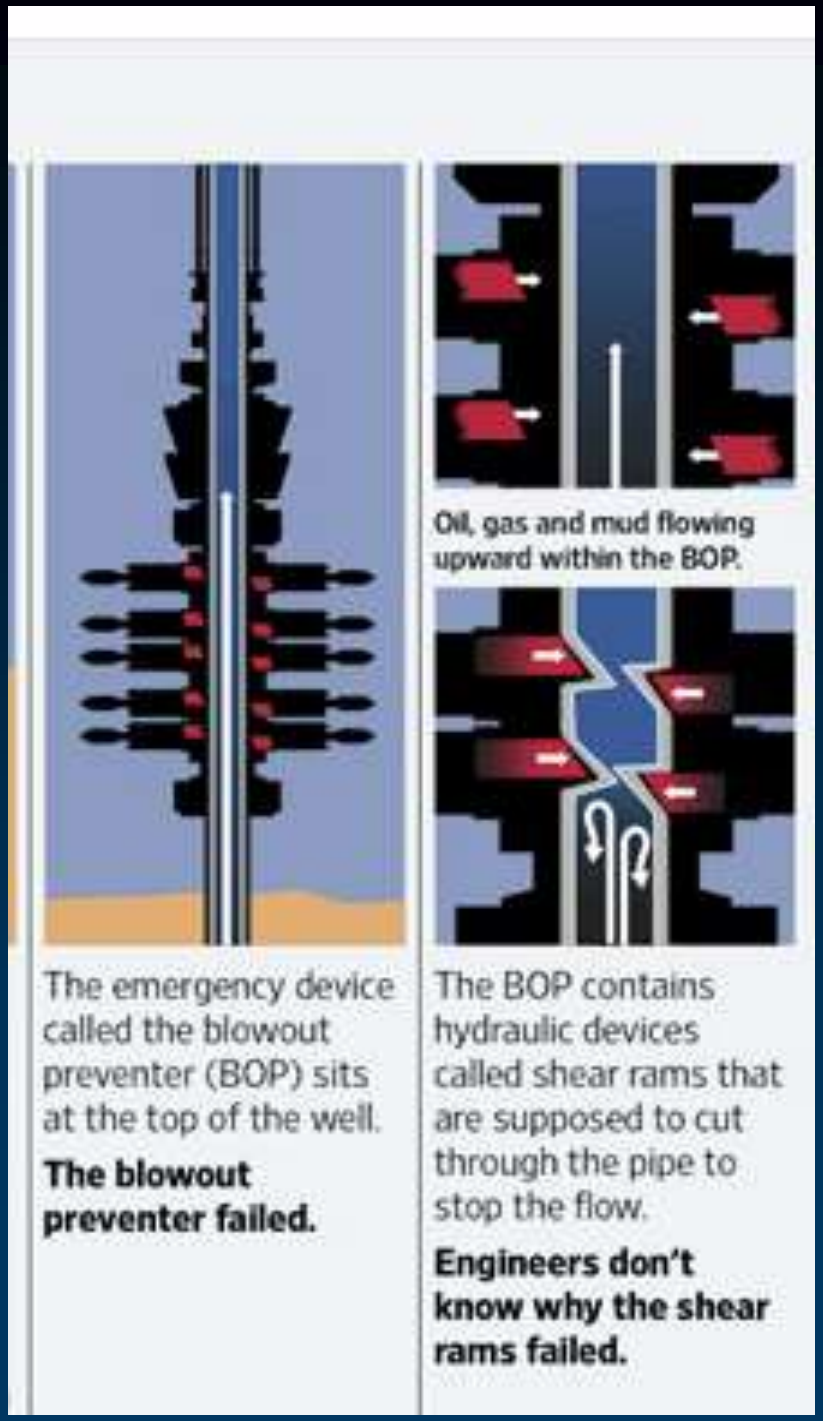


As one of the final steps to prep the pipe, the heavy mud was removed and replaced with much lighter seawater.

The gas easily moved through the seawater and up the pipe to the surface where it caught fire.

This is commonly known as a “blowout.”

Blowouts rarely happen.



Both of the emergency devices meant to prevent such an accident failed:

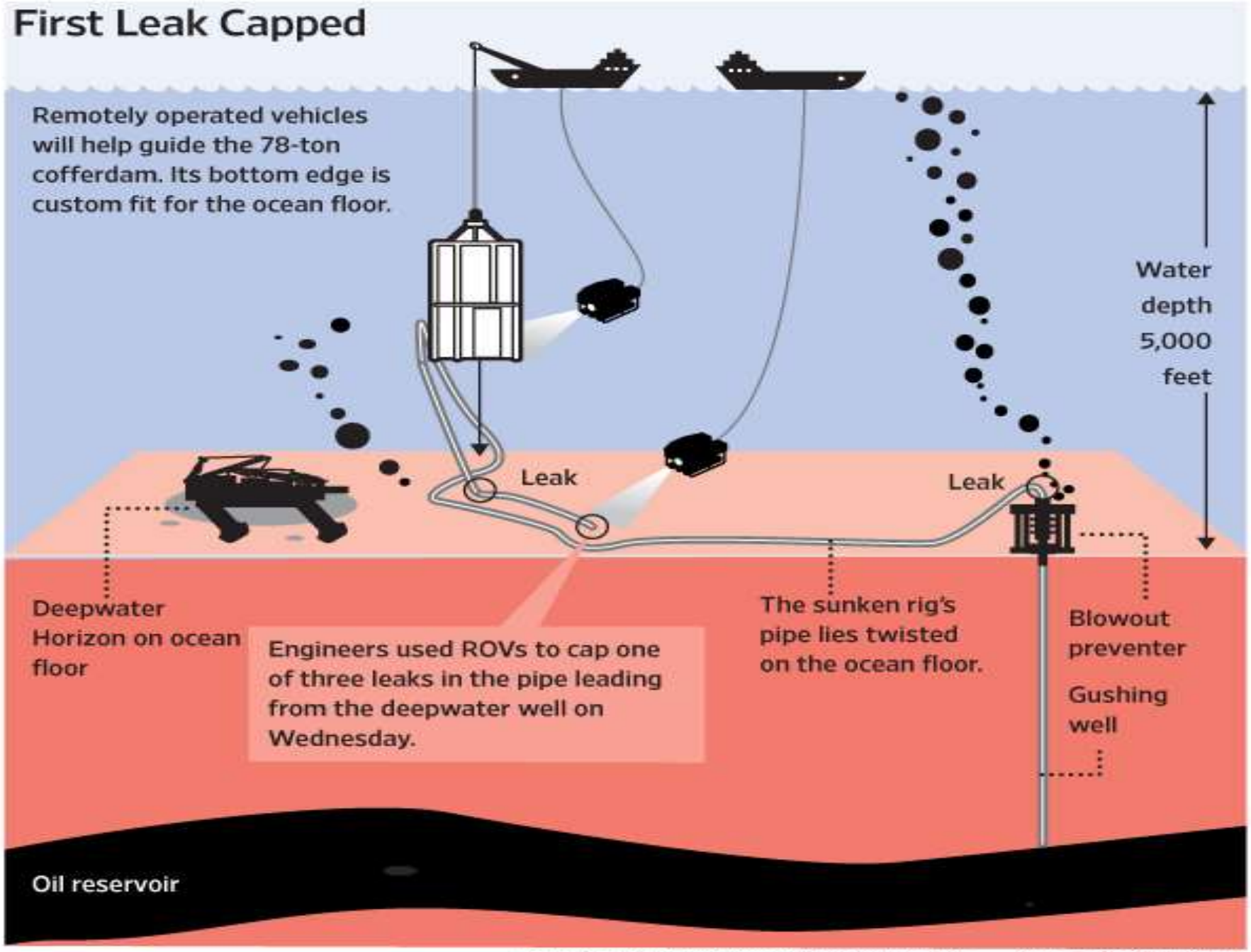
Blowout preventer

Sheer rams

On Tuesday, April 20, 2010 an explosion rocked the oil drilling platform.

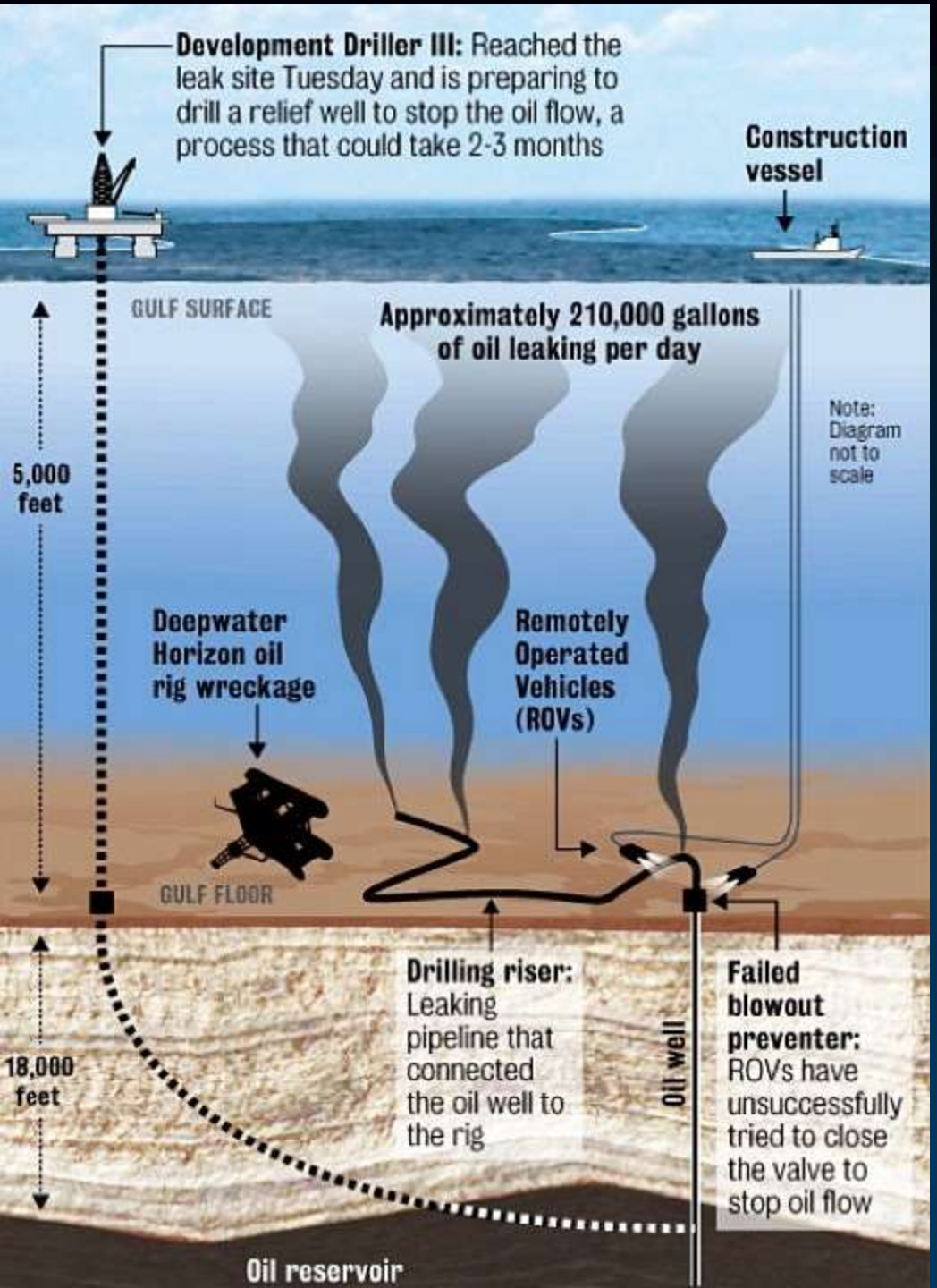
After burning for 36 hours, the rig sank on April 22, 2010

First Leak Capped



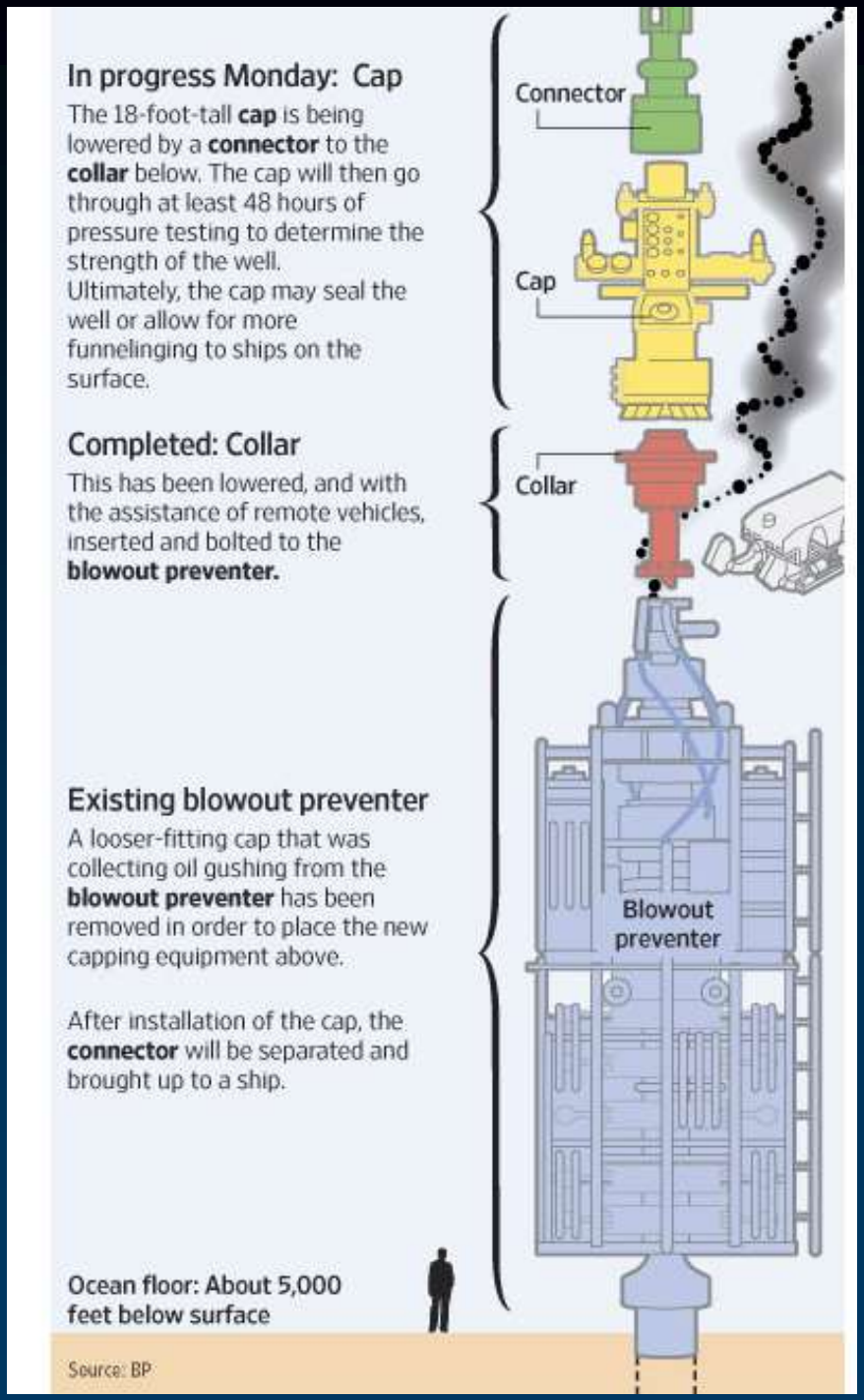
Note: Drawings are schematic and not to scale Source: BP, Coast Guard

Oil flows into the Gulf



Remotely operated vehicles (ROVs) were used to attempt to close the blowout preventer valve which would have stopped the oil flow.

They were unsuccessful.



Another attempt to stop the flow

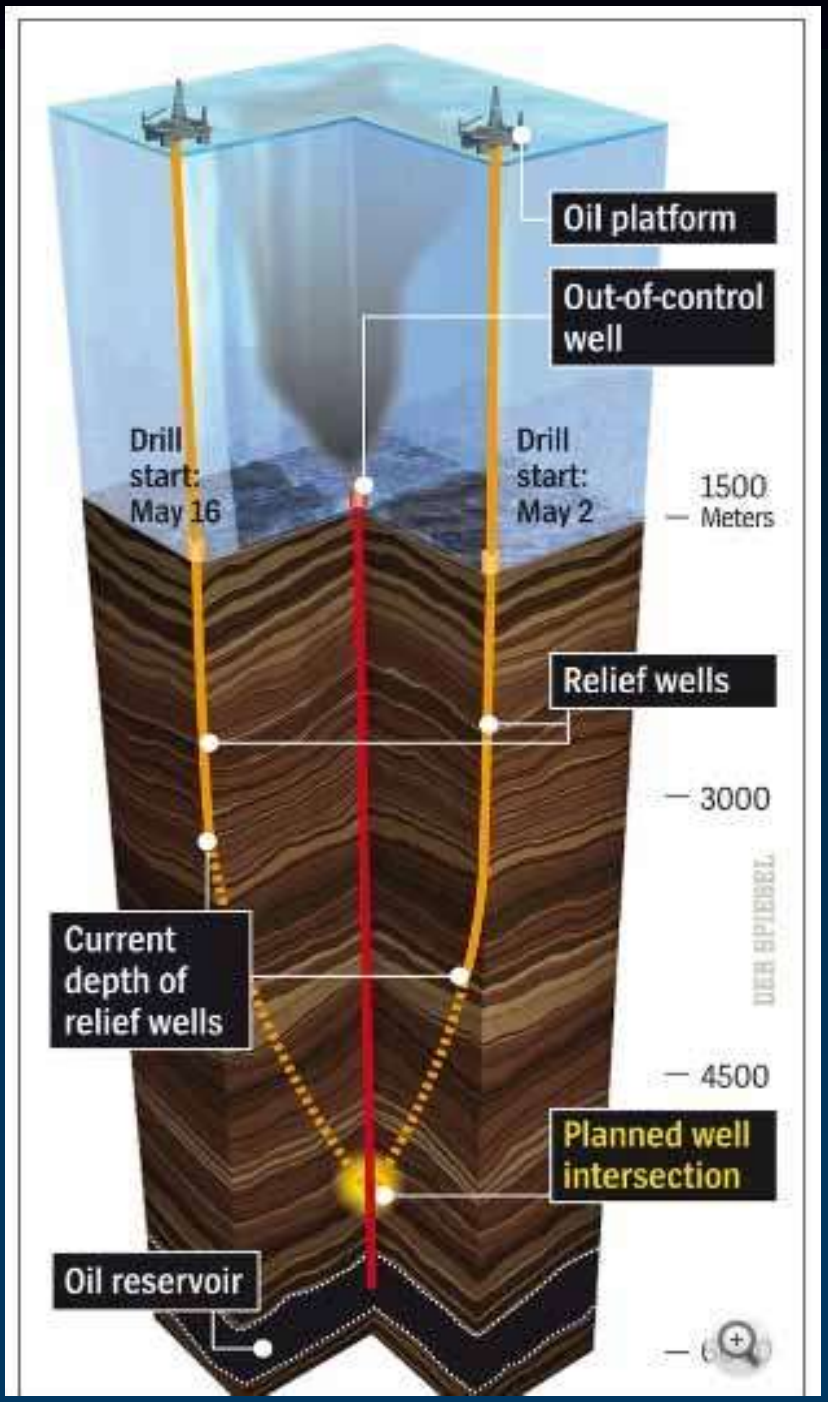
The initial collar and cap didn't work because of the force of the oil flowing from the blowout preventer.

In this drawing you get a sense of the size of the blowout preventer.

A man is standing on the left for scale.

After a number of attempts, on July 15, a 75-ton cap stopped the oil flow

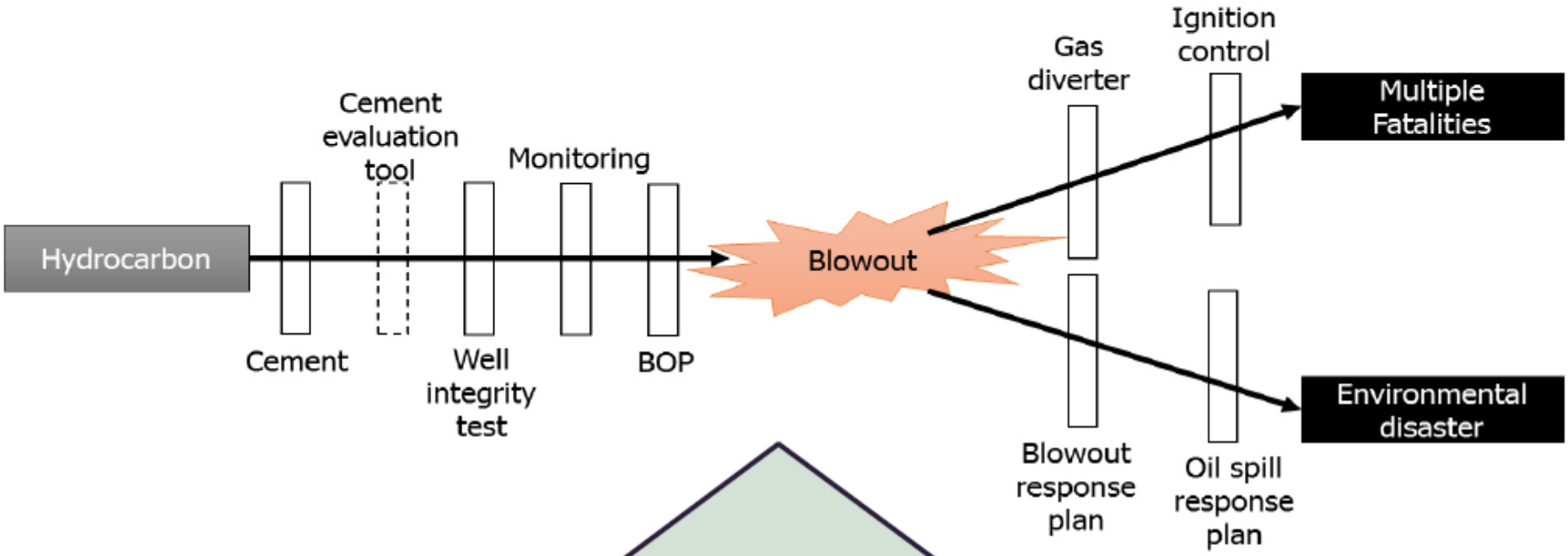
An estimated 184 million gallons of oil flowed into the Gulf before they were able to cap the well.



Heavy drilling fluid (mud) and cement will permanently cap the well. This is commonly known as "bottom kill."

Notice how the plug will be set far below the sea floor and wellhead.

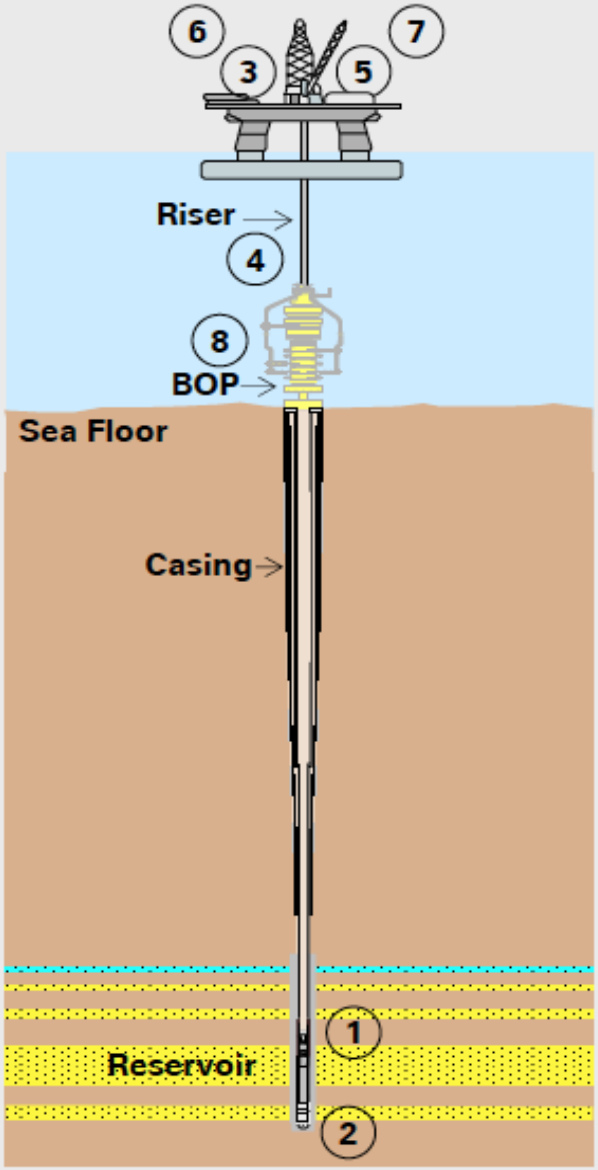
MACONDO Accidental Model



Poor (engineering & operation) decision - making

- Focus on commercial risk, not major hazard risk
- Heavy focus on personal safety as opposed to process safety
- Failure to adapt process safety to drilling

Eight Barriers Were Breached



Well integrity was not established or failed

1. Annulus cement barrier did not isolate hydrocarbons
2. Shoe track barriers did not isolate hydrocarbons

Hydrocarbons entered the well undetected and well control was lost

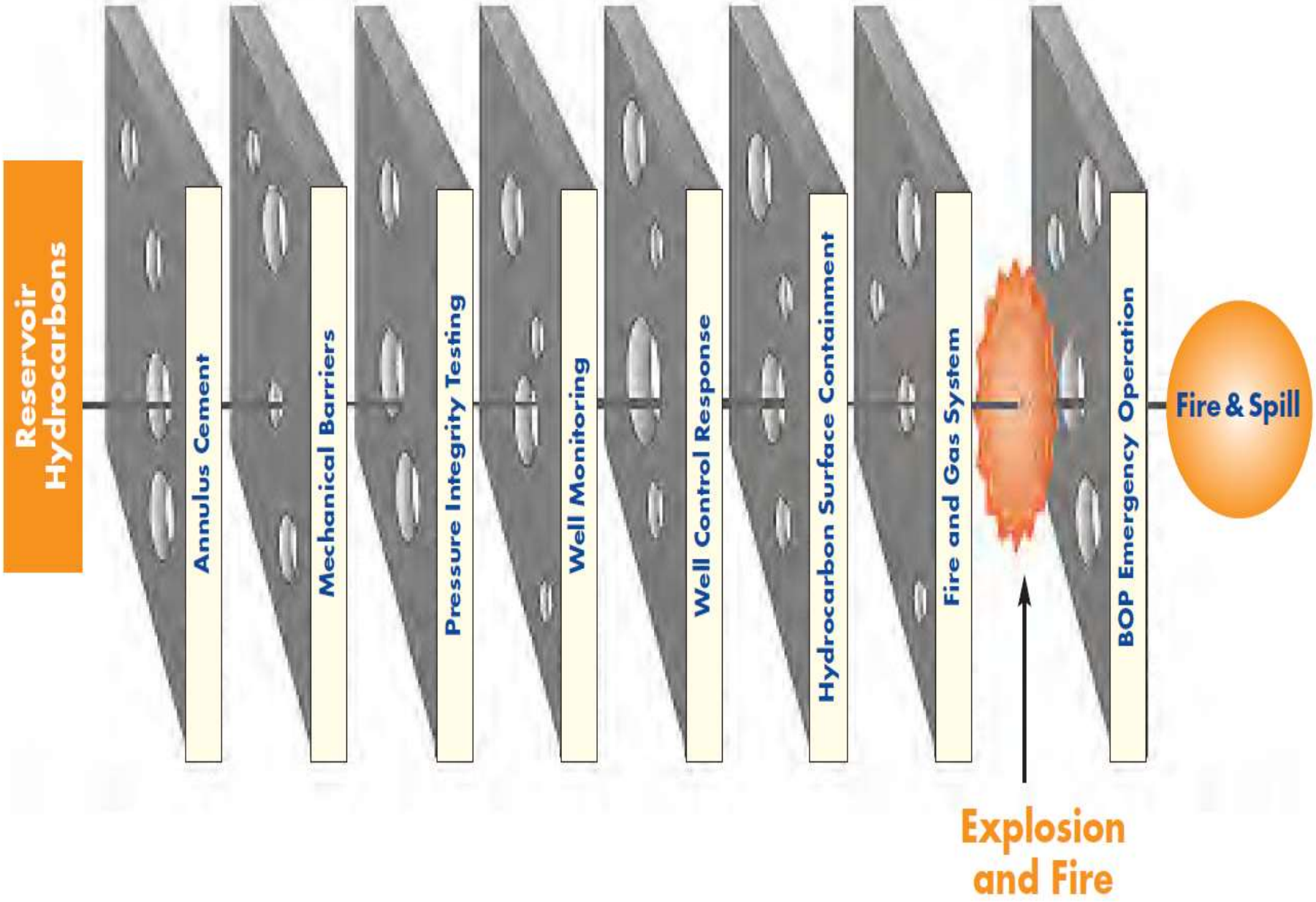
3. Negative pressure test was accepted although well integrity had not been established
4. Influx was not recognized until hydrocarbons were in riser
5. Well control response actions failed to regain control of well

Hydrocarbons ignited on the *Deepwater Horizon*

6. Diversion to mud gas separator resulted in gas venting onto rig
7. Fire and gas system did not prevent hydrocarbon ignition

Blowout preventer did not seal the well

8. Blowout preventer (BOP) emergency mode did not seal well



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Well Integrity: Barrier Standard

10 Critical Requirements

Design and planning

Identify well conditions, define barriers, and obtain operator approval.

Barriers

Utilize two barriers as a minimum. Identify, define, and express responsibility.

MOC and Exemptions standard

Follow standard to manage variation in operational risk resulting from deviation and significant change.

Certification, Maintenance and Traceability

Ensure manufacture, maintenance, modification, and transfers are defined, and documents validated.

Training and Competency

Confirm training is up to date and documented.

Compliance Audits

CAT

LTO

Confirm compliance audits are up to date and documented.

Risk Assessment and Mitigation

HARC

Perform HARC analysis, confirm ERP. Verify well conditions and establish shutdown criteria.

Operating Procedures

WBEAC

Follow operational requirements and guidelines.

Barrier failure or Loss

- All activity other than that of restoring the barrier must stop
- Ensure safety of the well
- Select alternative barrier if appropriate
- Perform risk evaluation

Reporting

QUEST

Investigate all incidents and share lessons learned.

References

- **Sage Lichtenwalner; Rutgers University Trouble in the Gulf Deepwater Horizon Presentation.**
- **BP; Deepwater Horizon Accident Investigation Report Sep. 8, 2010.**
- **OGP; Deepwater Wells Global Industry Response Group Recommendations Report No. 463 in May, 2011.**

Thank You