New Technologies in the Deepwater Oil Industry*

Cleveland M. Jones[1]

Search and Discovery Article #42197 (2018)**
Posted April 23, 2018

*Adapted from oral presentation given at 2012 AAPG GTW, Deepwater Reservoirs: Multi-Disciplinary Exploration and Development, Houston, Texas, 24-25 January, 2012

[1]Geology Department/UERJ – State University of Rio de Janeiro (clevelandmjones@gmail.com)

Abstract

Major technological breakthroughs in deepwater E&P have been occurring at a fast pace. In particular, some innovations may make certain E&P projects not just less expensive than initially thought, but may actually make the difference between non-go and go-ahead decisions, especially for some projects which were not viable with prior technology. Some game-changing technologies are on the way, and some are here already. I reviewed some of them, just to give an idea of how technology may change the way deepwater E&P projects are handled in the future.

Costs of bringing projects onstream have to do with the technology involved, not only the cost of steel and labor, for example. For some deepwater projects in the well-known post-salt reservoirs of the Campos Basin, with the technology initially foreseen, the required breakeven pricing for oil was estimated to be around US $60/bbl. If only materials and labor prices had changed, as they have indeed, rising precipitously, it is likely that many of these projects would now become economically impossible to justify, even with higher oil prices. But technology ensured their viability, and production is growing at many discoveries heretofore paralyzed, waiting on price or technology breakthroughs.

NEW TECHNOLOGIES IN THE DEEPWATER OIL & GAS INDUSTRY

Prof. Cleveland M. Jones
Researcher, Instituto Nacional de Óleo e Gás

PETROUERJ

A RESEARCH GROUP AT THE GEOLOGY DEPARTMENT OF THE STATE UNIVERSITY OF RIO DE JANEIRO

WE ARE FOCUSED ON FOLLOWING DEVELOPMENTS IN THE ENERGY INDUSTRY, AND SEEKING TO INFLUENCE PUBLIC POLICY TOWARDS TECHNOLOGICAL ADVANCES, SUSTAINABILITY, AND STRATEGIC OBJECTIVES, WITHIN THE CONTEXT OF THE BRAZILIAN PERSPECTIVE.

ONE OF OUR CURRENT THEMES IS UNCONVENTIONAL ENERGY RESOURCES, AS WELL AS YET-TO-FIND OIL ASSESSMENTS, WHICH WE HAVE DONE FOR SEVERAL AREAS IN BRAZIL.

NEW TECHNOLOGIES IN THE DEEPWATER OIL & GAS INDUSTRY

WHAT IS NEW TECHNOLOGY?

Evolutionary Change

Revolutionary Change

New techniques in Exploration Phase

New techniques in Development Phase

New techniques in Production Phase

New Environmental Operating Requirements

New Fundamental Science Concepts

New Engineering Concepts

New Logistic Concepts

New Project Structuring/Finance Concepts

New Fiscal and Legal Regimes

NEW TECHNOLOGY INTRODUCTION

New Technology introductions in the deepwater E&P have been occurring at a fast pace.

This includes evolutionary and revolutionary changes, as well as changes in all categories mentioned.

Naturally, technological breakthroughs achieve high visibility.

EFFECTS OF NEW TECHNOLOGY AVAILABLE, WHEN APPLIED TO NEW PROJECTS

Cost Reductions

Revenue Enhancements

Performance Improvements

Offsetting equipment and labor price increases

Viability of Projects

New technologies utilized may make the difference between non-go and go-ahead decisions

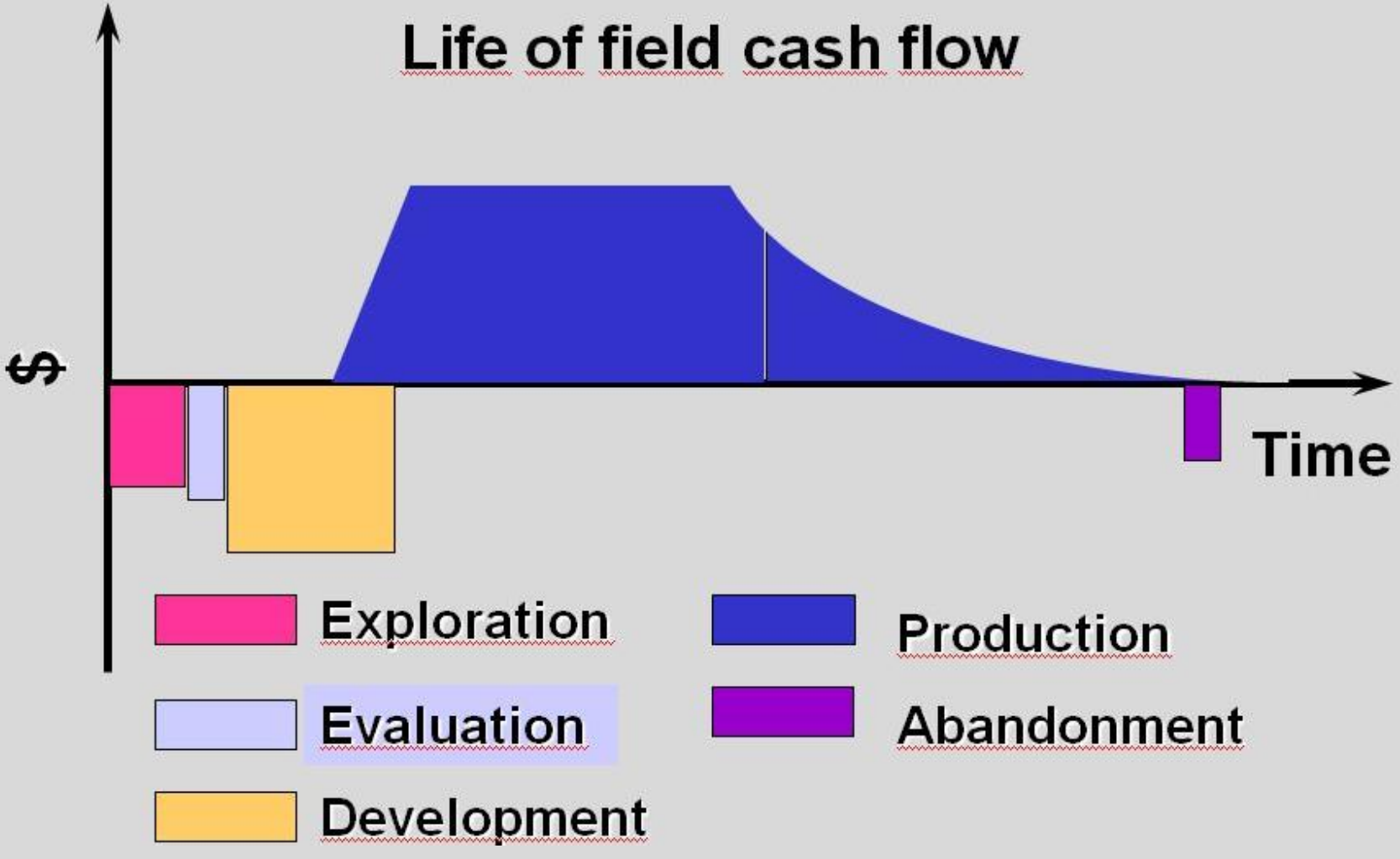
Brazilian Pre-Salt field development break-even oil pricing, under US$50/bbl scenario and different technology environments

New technology developed for Pre-Salt fields reduced break-even project oil price to US$40/bbl and lower

Conventional technology break-even oil price was US$60 to US$80/bbl and higher

EFFECTS OF HIGHER COSTS ON PROJECT VIABILITY

Higher costs can have a very unpredictable effect on the viability of projects. Up-front and near-term cash flow changes have a bigger effect, since project viability depends on discounted cash flows.



ONGOING PROJECTS IMPACTED BY NEW TECHNOLOGY

Cost inflation beyond projections can easily turn viable ongoing projects into projects with negative present value.

Positive cash flow effects due to technology tend to have less effect on ongoing project economics.

THE POSITIVE SIDE OF NEW TECHNOLOGY

New technology can change the whole economics of cash flow projections:

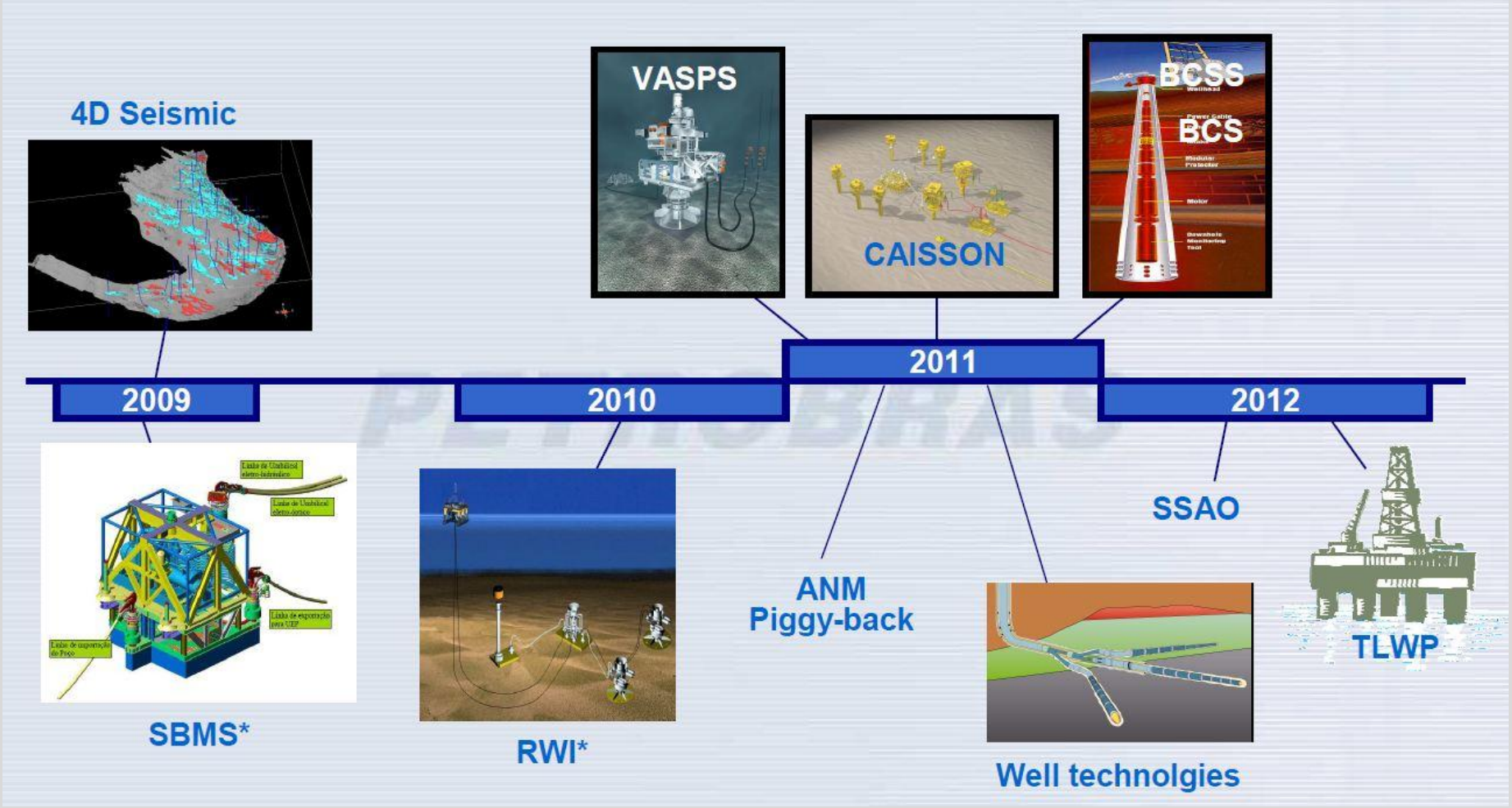
Reduced up-front investments

Reduced operating costs

Reduced time to reach positive cash flows

Increased revenues from higher productivity or better recovery factor

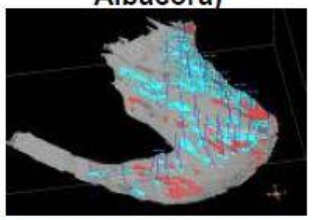
TECHNOLOGY WATCHING



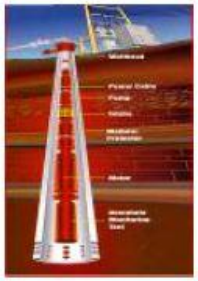
Technology watch list tracked by Petrobras in 2008 (Guedes, 2008)

TECHNOLOGY WATCHING

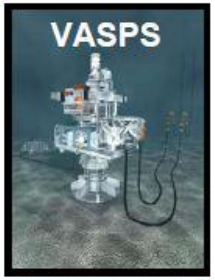
4D Seismic
(Marlim; Marlim Sul; Albacora)



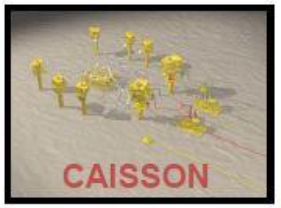
ESP in a skid on the sea-bed
(Espadarte-Fase III)



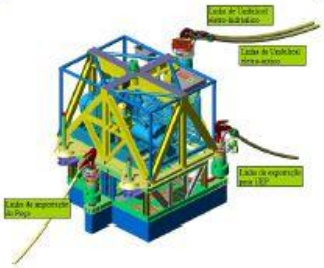
Vertical Annular Separation and Pumping System
(Congro; Malhado; Corvina)



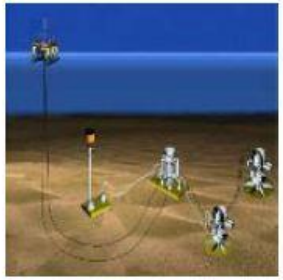
(Parque dos Temperos;)
Bonito



2009 2010 2011 2012



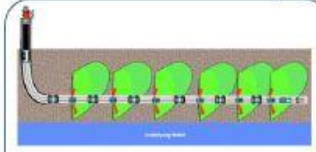
SBMS - Subsea Multiphase Pumping System
(Marlim)



RWI – Raw Water Injection
(Albacora)

Subsea Christmas Tree.
"Piggy-back"
(Marimbá; Barracuda)

Oil Water Subsea Separation
(Marlim)



Multifractured Well
(Bonito)

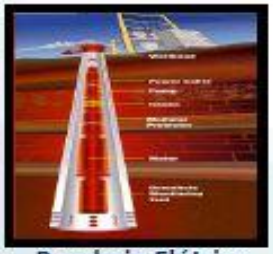
TLWP
(Papa-terra)

Technology watch list tracked by Petrobras in 2010 (Petrobras, 2010)

TECHNOLOGY WATCHING

Solução Tecnológica	Tecnologia	Situação Atual
Sistemas de Bombeamento submarino	BCS Submarino	Em Operação
	Módulo de Bombeio Submarino	Em Operação (Jubarte e Golfinho)
	Skid BCS (leito marinho)	Protótipo em TLD ESP 23 (Out/11)
	Bomba Multifásica Submarina BMSHA	Protótipo em Barracuda (Dez/11)
Separação submarina gás-líquido	VASPS	Protótipo Testado na P-08 (2011)
Separação submarina água-óleo	SSAO	Protótipo em Marlim (Final de 2011)
Injeção submarina de água do mar	SRWI	Protótipo em Albacora (Final de 2011)
Transmissão e distribuição elétrica submarina	Em Qualificação	Previsão de Protótipo em 2015

VASPS



Bombeio Elétrico Submarino em Skid

Captação e Injeção de Água Submarina

Separação Submarina Óleo/Água

Technology watch list tracked by Petrobras in 2011 (Petrobras, 2011)

TECHNOLOGICAL INNOVATIONS WITH POSSIBLY SIGNIFICANT CONSEQUENCES FOR THE DEEPWATER OIL & GAS INDUSTRY

NEW FUNDAMENTAL SCIENTIFIC KNOWLEDGE AND NEW CONCEPTS

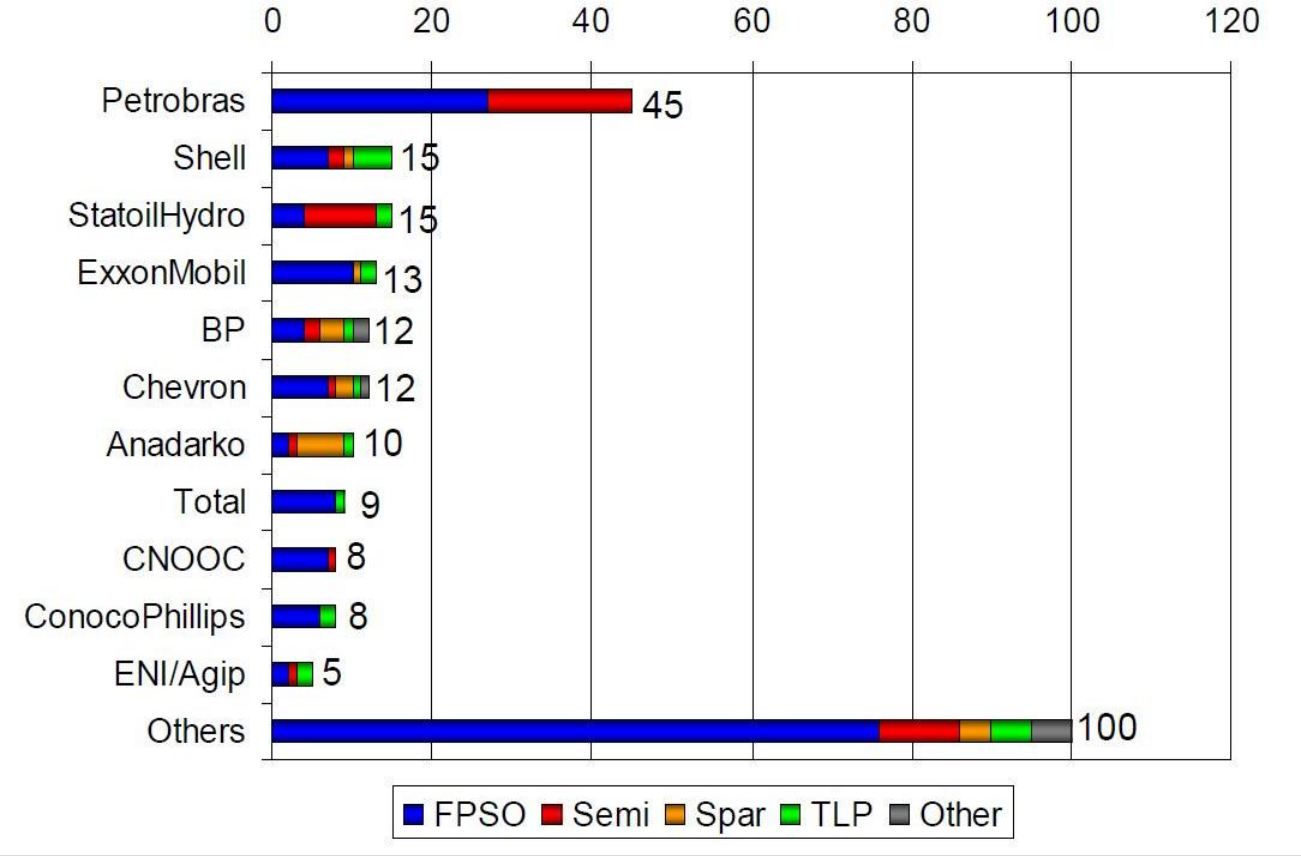
VS

ENGINEERING INNOVATIONS

TECHNOLOGICAL INNOVATIONS WITH POSSIBLY SIGNIFICANT CONSEQUENCES FOR THE DEEPWATER OIL & GAS INDUSTRY

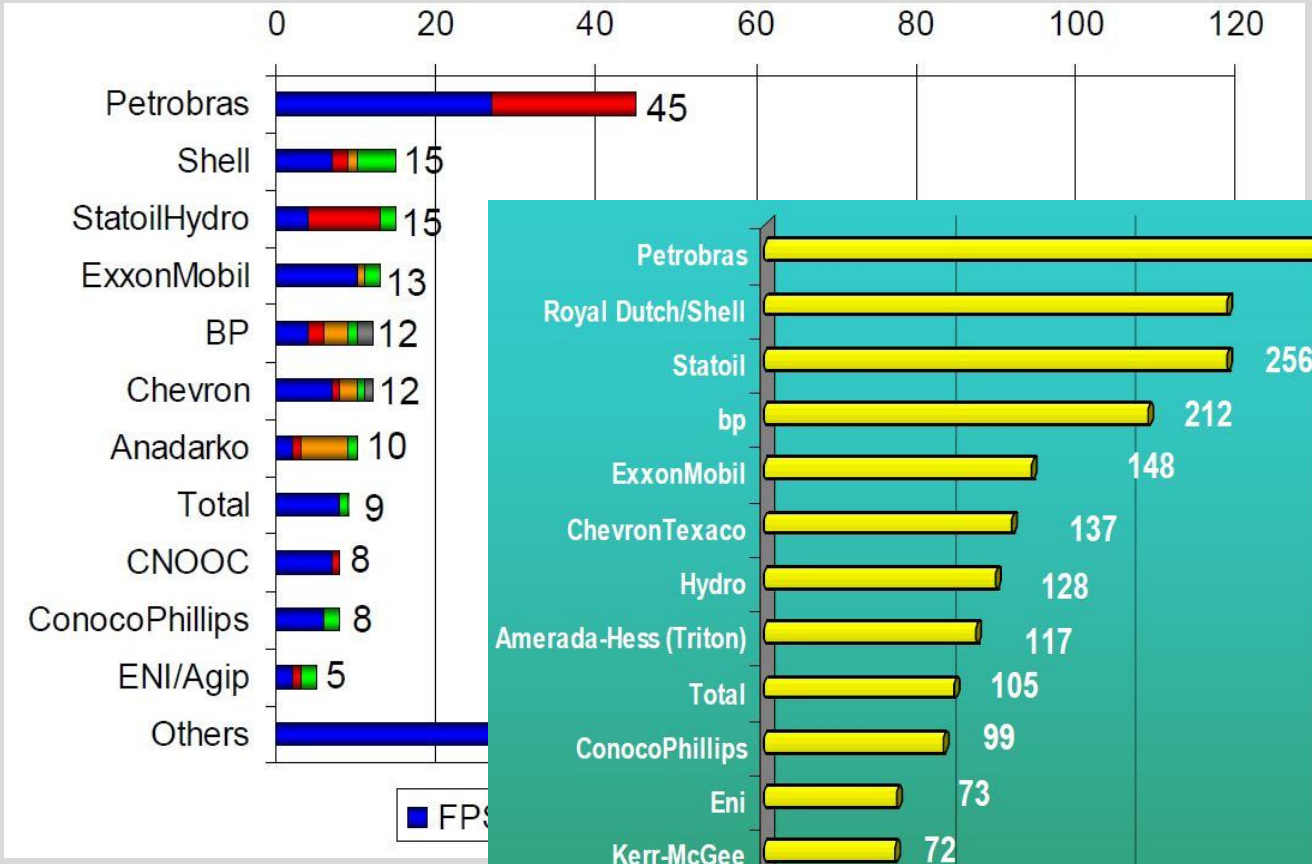
Petrobras FPSO BW Pioneer, with disconnectable turret, in 2,600m of water depth, in the Gulf of Mexico (Cascade and Chinook).

TECHNOLOGICAL INNOVATIONS WITH POSSIBLY SIGNIFICANT CONSEQUENCES FOR THE DEEPWATER OIL & GAS INDUSTRY

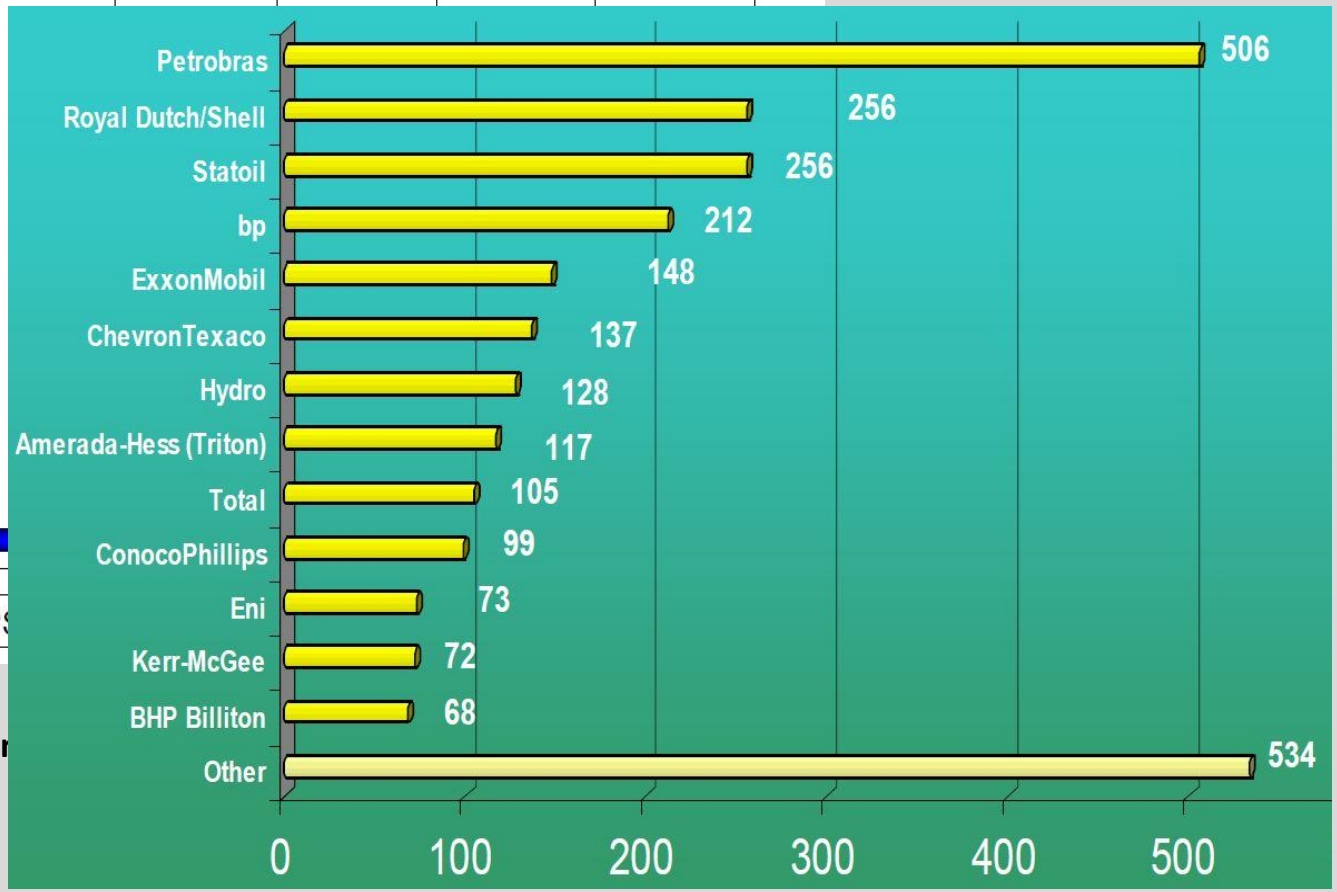


Floating production systems contracted, by operating company -2008

TECHNOLOGICAL INNOVATIONS WITH POSSIBLY SIGNIFICANT CONSEQUENCES FOR THE DEEPWATER OIL & GAS INDUSTRY



Floating production syster



Subsea well trees, by operating company -2008

TECHNOLOGICAL INNOVATIONS WITH POSSIBLY SIGNIFICANT CONSEQUENCES FOR THE DEEPWATER OIL & GAS INDUSTRY

Double Derrick Systems

Dual derrick West Orion contracted to Petrobras (www.akersolutions.com)

TECHNOLOGICAL INNOVATIONS WITH POSSIBLY SIGNIFICANT CONSEQUENCES FOR THE DEEPWATER OIL & GAS INDUSTRY

The P-54 FPSO started to operate in 2007 in Roncador (Campos Basin) - 180,000 bpd oil production capacity (plus 6 million m3/d gas compression), 2 million bbl storage capacity

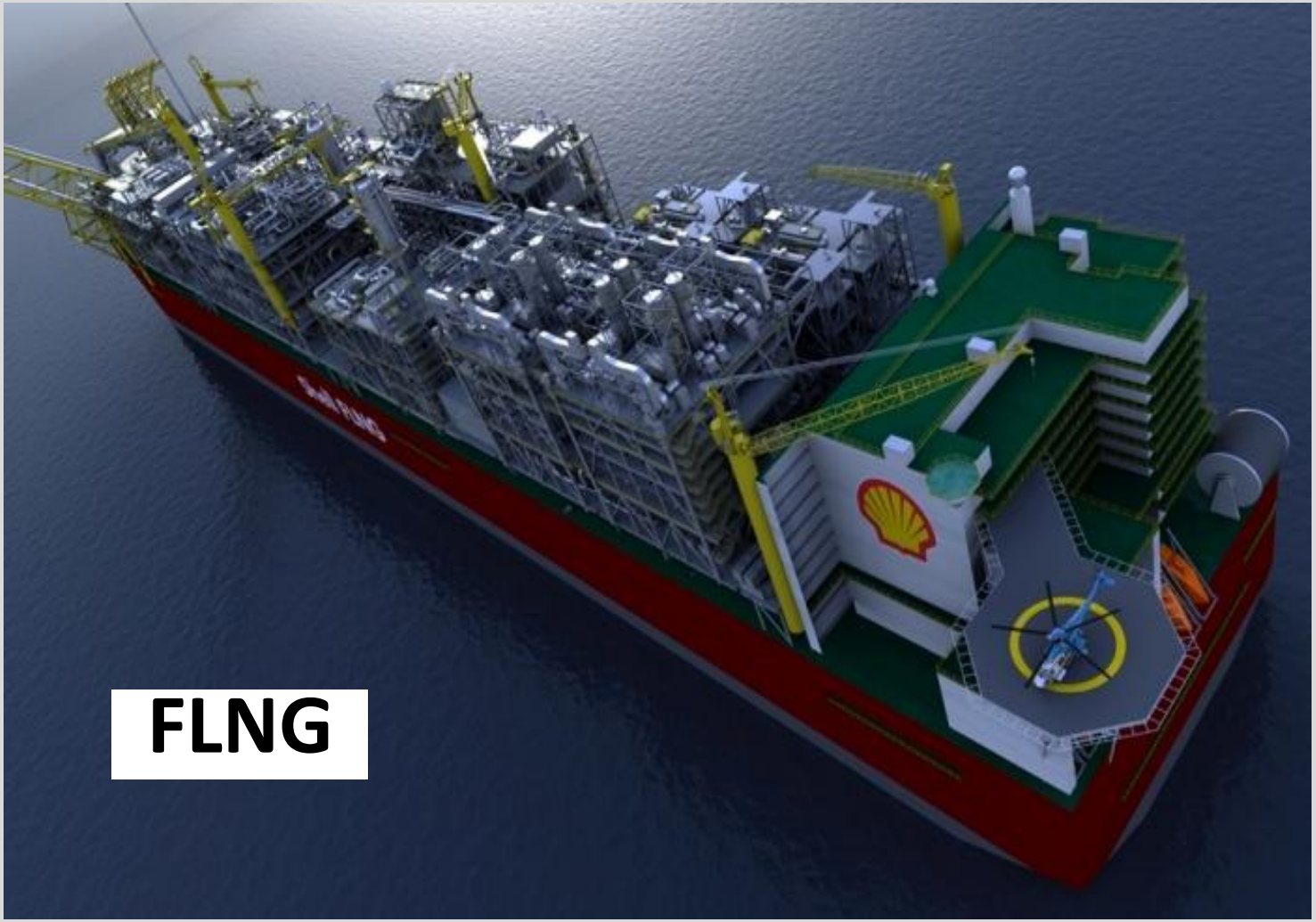
TECHNOLOGICAL INNOVATIONS WITH POSSIBLY SIGNIFICANT CONSEQUENCES FOR THE DEEPWATER OIL & GAS INDUSTRY

The P-54 FPSO started to
capacity (plus

Bigger and Bigger!

Usan FPSO, for Total in Nigeria - 320m long, 180,000 bpd production capacity, 2 million bbl storage capacity, to begin production in 2012 (www.petroleumafrica.com).

TECHNOLOGICAL INNOVATIONS WITH POSSIBLY SIGNIFICANT CONSEQUENCES FOR THE DEEPWATER OIL & GAS INDUSTRY



Prelude – Shell FLNG (488m, 600kt) to operate in Australia, to be built by Samsung, in Korea

TECHNOLOGICAL INNOVATIONS WITH POSSIBLY SIGNIFICANT CONSEQUENCES FOR THE DEEPWATER OIL & GAS INDUSTRY

Better ROVs

Typical heavy-duty, high-end ROV (Fugro)

TECHNOLOGICAL INNOVATIONS WITH POSSIBLY SIGNIFICANT CONSEQUENCES FOR THE DEEPWATER OIL & GAS INDUSTRY

Better ROVs

Typical heavy-du

Typical new generation ROV with sophisticated manipulators and tooling package (Delphinus Group)

TECHNOLOGICAL INNOVATIONS WITH POSSIBLY SIGNIFICANT CONSEQUENCES FOR THE DEEPWATER OIL & GAS INDUSTRY

All electric seabottom equipment

CameronDC subsea electric tree

TECHNOLOGICAL INNOVATIONS WITH POSSIBLY SIGNIFICANT CONSEQUENCES FOR THE DEEPWATER OIL & GAS INDUSTRY

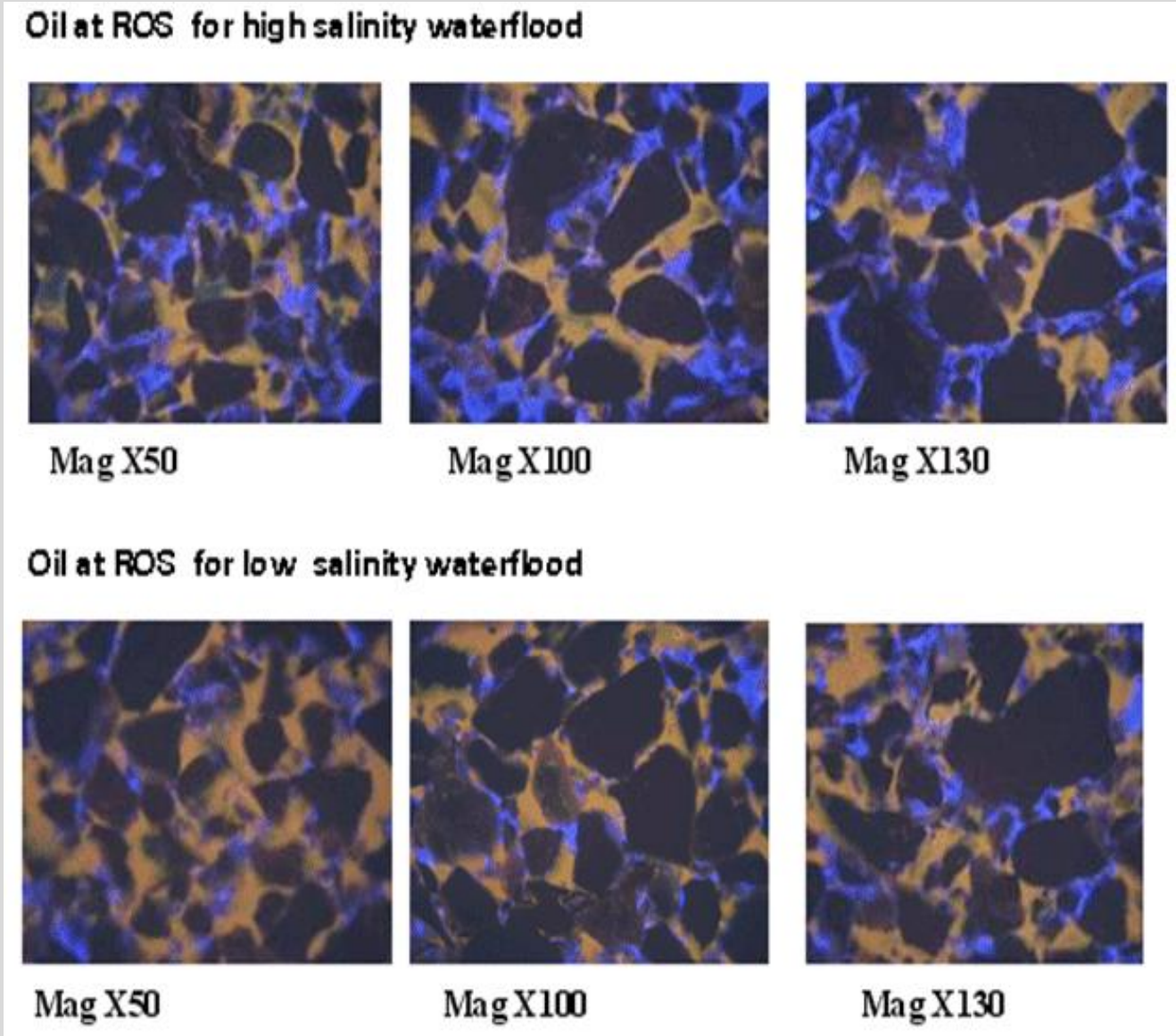
All electric seabottom equipment

CameronDC subsea electric tree

CameronDC all electric subsea production system

TECHNOLOGICAL INNOVATIONS WITH POSSIBLY SIGNIFICANT CONSEQUENCES FOR THE DEEPWATER OIL & GAS INDUSTRY

Very Low Salinity Water Injection



Low Salinity Waterflooding - A Revolution in Waterflooding.. Webb, K., Cockin, A. http://ior.senergyltd.com/issue12/articles/BP/

TECHNOLOGICAL INNOVATIONS WITH POSSIBLY SIGNIFICANT CONSEQUENCES FOR THE DEEPWATER OIL & GAS INDUSTRY

CORROSION PREVENTION

PHYSICAL AND CHEMICAL METHODS

BIOLOGICAL METHODS

TECHNOLOGICAL INNOVATIONS WITH POSSIBLY SIGNIFICANT CONSEQUENCES FOR THE DEEPWATER OIL & GAS INDUSTRY

EXTRA HEAVY OIL TECHNOLOGIES

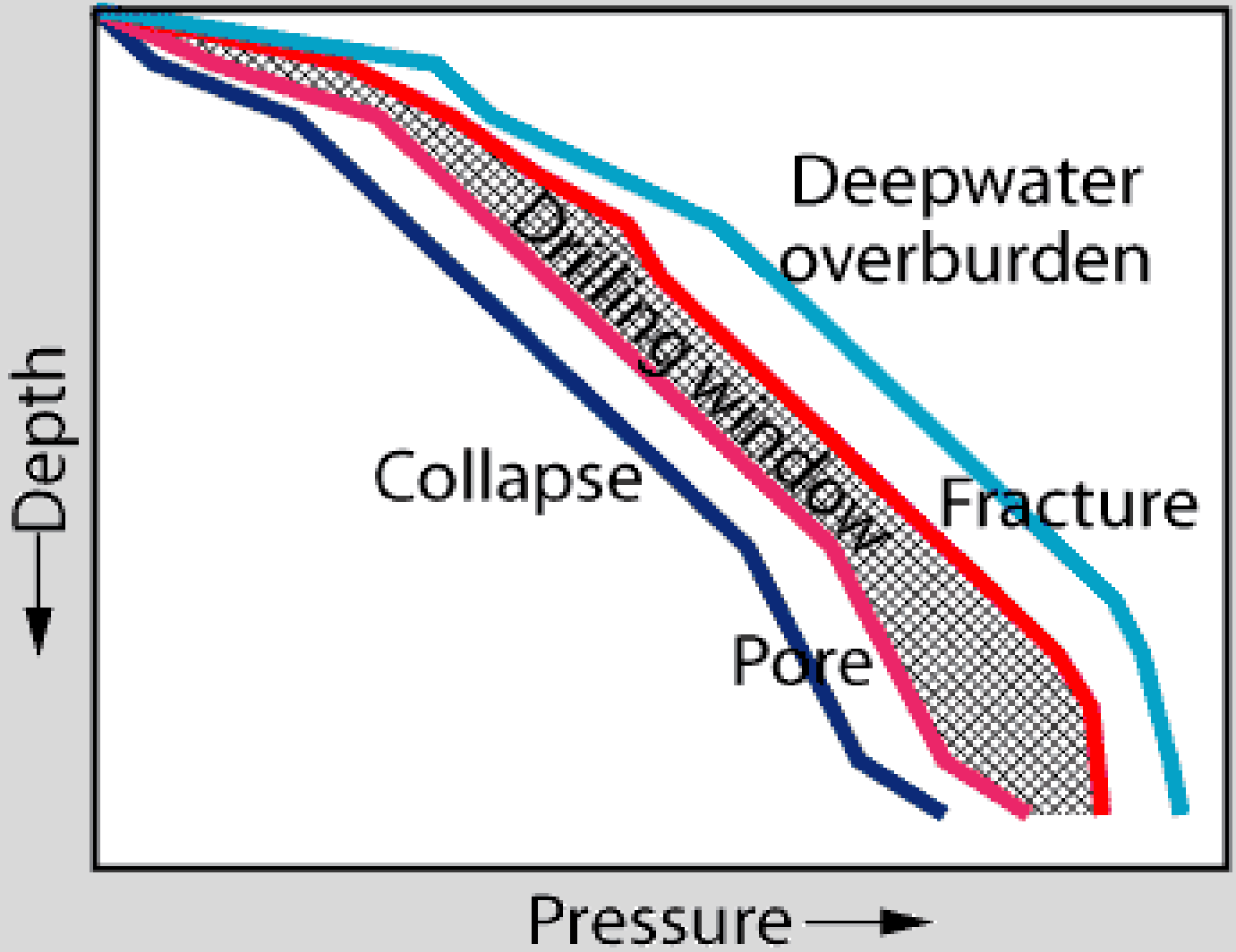
OIL WATER SEPARTION

GAS OIL SEPARTION

METALLURGY, WELDING AND PIPE MAINTENANCE

TECHNOLOGICAL INNOVATIONS WITH POSSIBLY SIGNIFICANT CONSEQUENCES FOR THE DEEPWATER OIL & GAS INDUSTRY

DRILLING TECHNOLOGIES
MPD - MANAGED PRESSURE DRILLING



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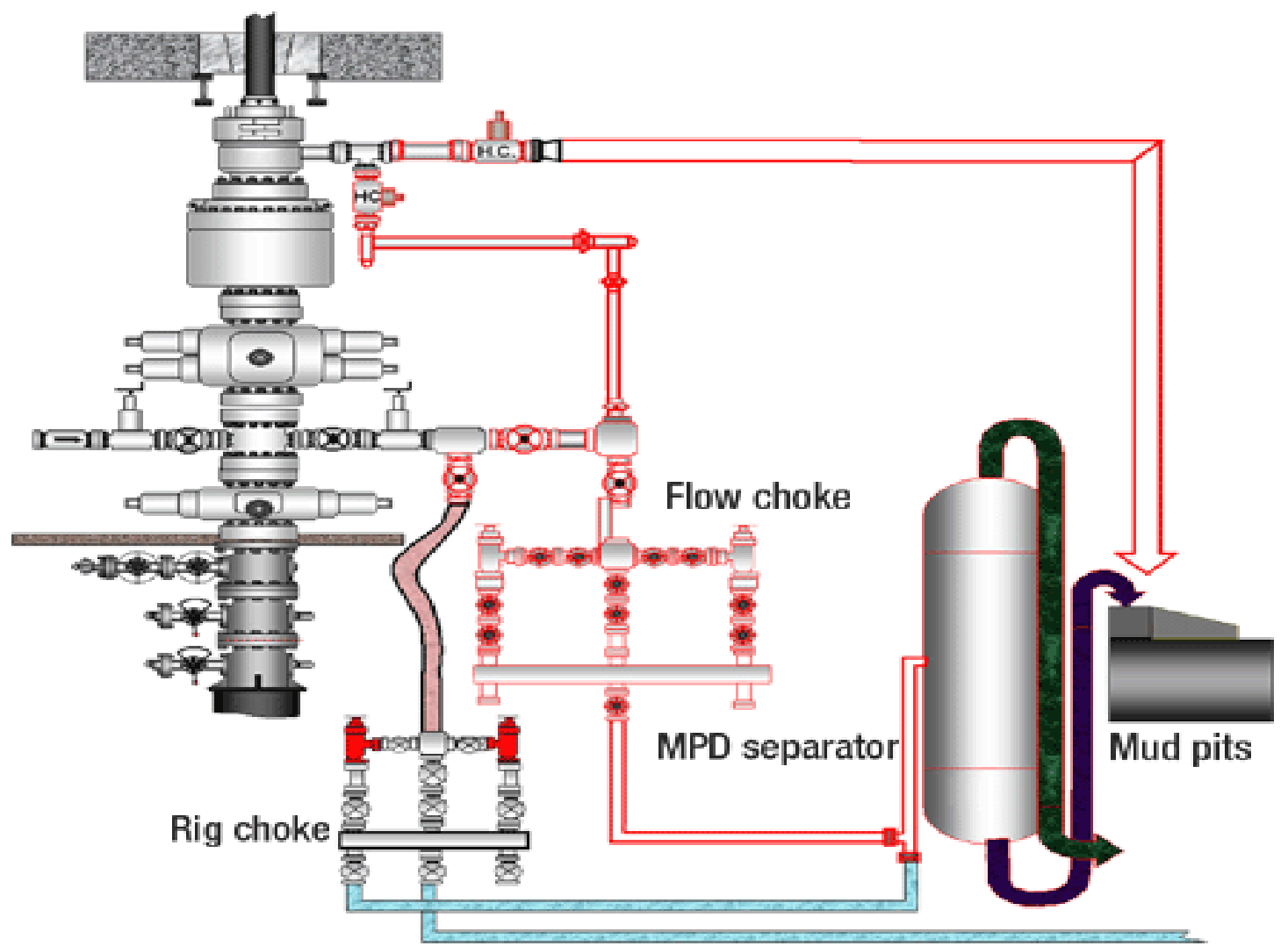


TECHNOLOGICAL INNOVATIONS WITH POSSIBLY SIGNIFICANT CONSEQUENCES FOR THE DEEPWATER OIL & GAS INDUSTRY

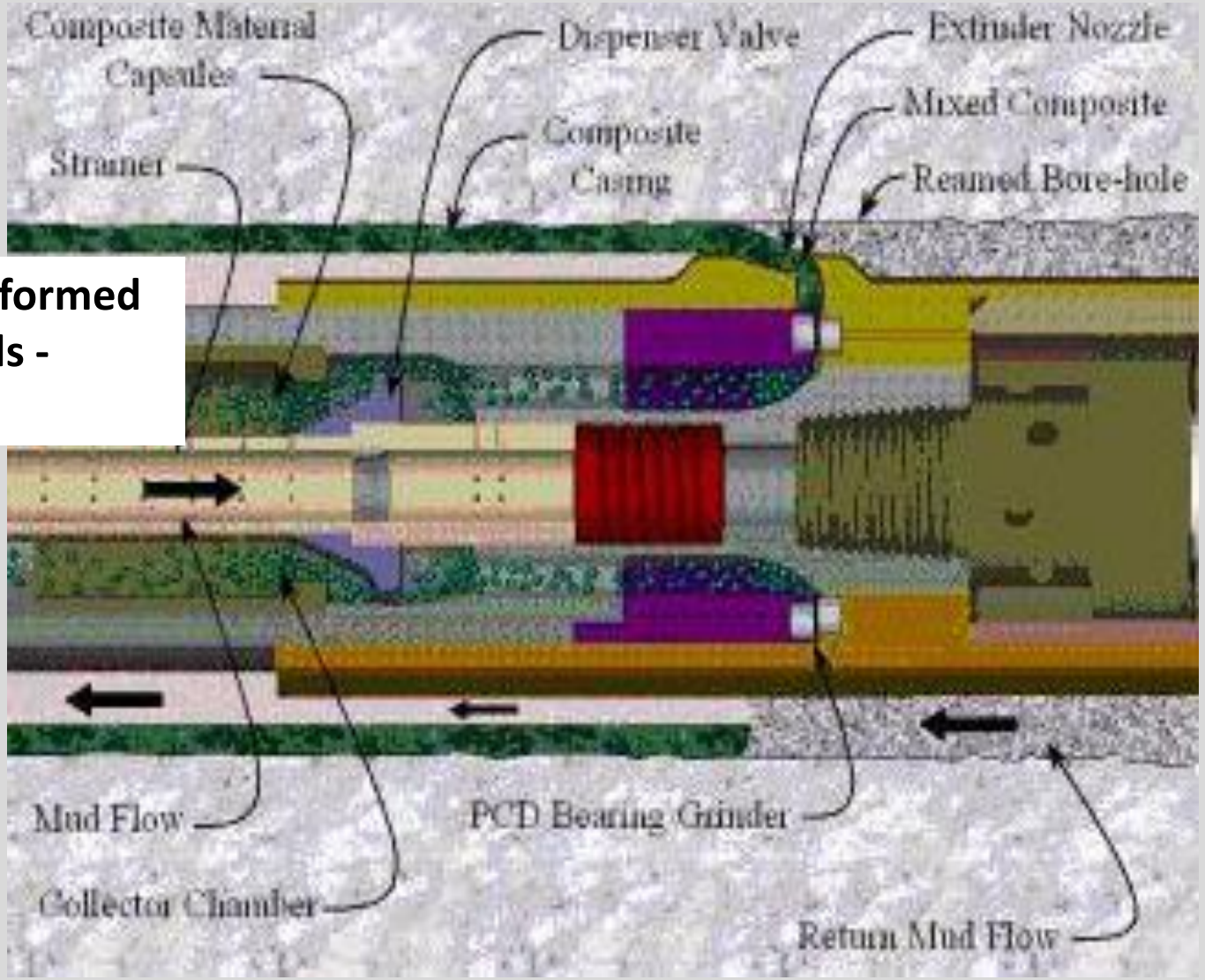
DRILLING TECHNOLOGIES
DWC - DRILLING WITH CASING

Weatherford's DwC™ system

TECHNOLOGICAL INNOVATIONS WITH POSSIBLY SIGNIFICANT CONSEQUENCES FOR THE DEEPWATER OIL & GAS INDUSTRY

DRILLING TECHNOLOGIES
DWC - DRILLING WITH CASING

Composite casing formed as drilling proceeds - Novatek, Inc.



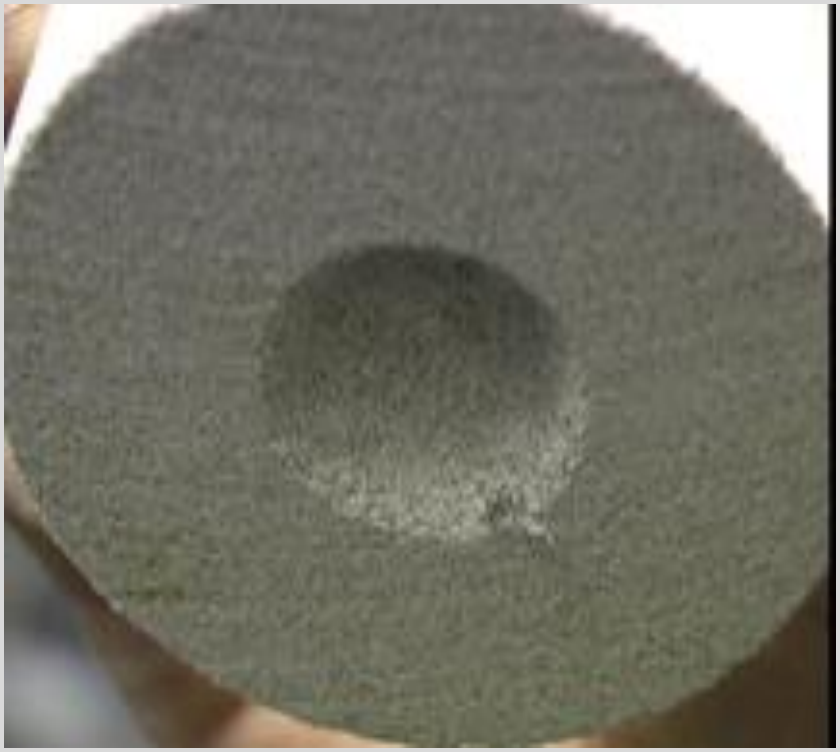
TECHNOLOGICAL INNOVATIONS WITH POSSIBLY SIGNIFICANT CONSEQUENCES FOR THE DEEPWATER OIL & GAS INDUSTRY

DRILLING TECHNOLOGIES

LASER DRILLING

1cm holes -2003

2.5cm holes – CO2 laser



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DRILLING TECHNOLOGIES

LASER DRILLING

1cm ho

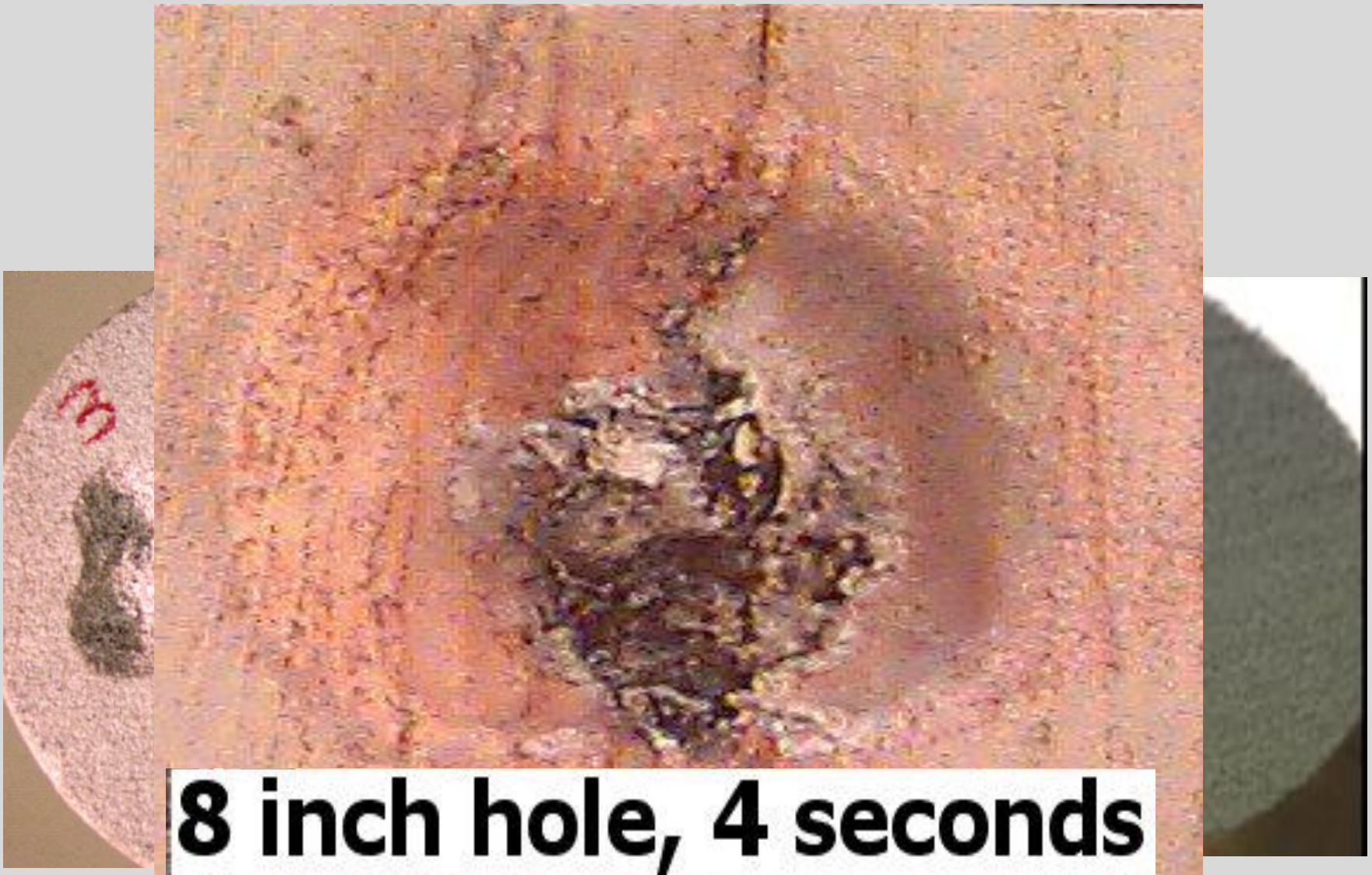
2.5cm hole – pulsed laser - 2004

CO2 laser

TECHNOLOGICAL INNOVATIONS WITH POSSIBLY SIGNIFICANT CONSEQUENCES FOR THE DEEPWATER OIL & GAS INDUSTRY

DRILLING TECHNOLOGIES

LASER DRILLING



TECHNOLOGICAL INNOVATIONS WITH POSSIBLY SIGNIFICANT CONSEQUENCES FOR THE DEEPWATER OIL & GAS INDUSTRY

NANOTECHNOLOGY

CONTRAST AGENTS – nanoparticles with custom designed properties

NANOMATERIAL SENSORS – nanoparticles with changeable properties

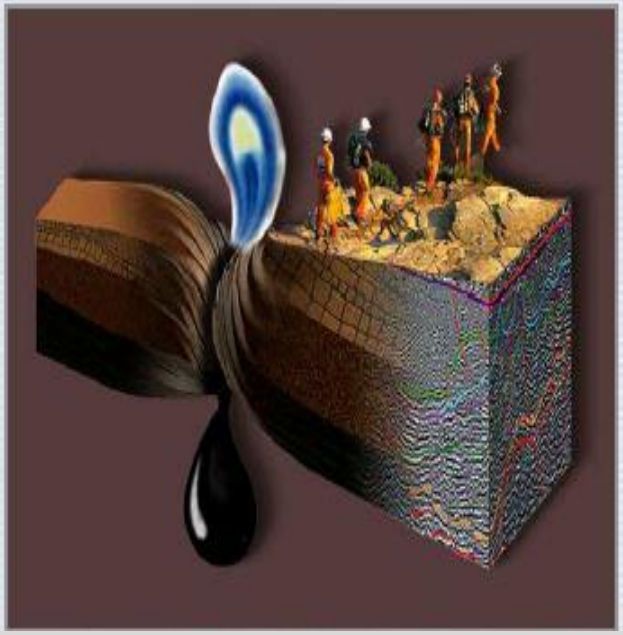
MICROFABRICATED SENSORS – miniature robotic sensors

(MEMS and NEMS)

TECHNOLOGICAL INNOVATIONS WITH POSSIBLY SIGNIFICANT CONSEQUENCES FOR THE DEEPWATER OIL & GAS INDUSTRY

HIGH RECOVERY FACTOR LIFE-OF-FIELD PROGRAMS

- Water injection
- HC gas injection
- 4D Seismics
- Raw sea water injection
- WAG
- MEOR
- Steam
- CO2 injection
- Polymer injection



- Conventional wells
- Horizontal wells
- Multilateral wells
- SMART wells
- ERD wells
- HRMF wells
- Light Well Intervention

TECHNOLOGICAL INNOVATIONS WITH POSSIBLY SIGNIFICANT CONSEQUENCES FOR THE DEEPWATER OIL & GAS INDUSTRY

HIGH RECOVERY FACTOR LIFE-OF-FIELD PROGRAMS

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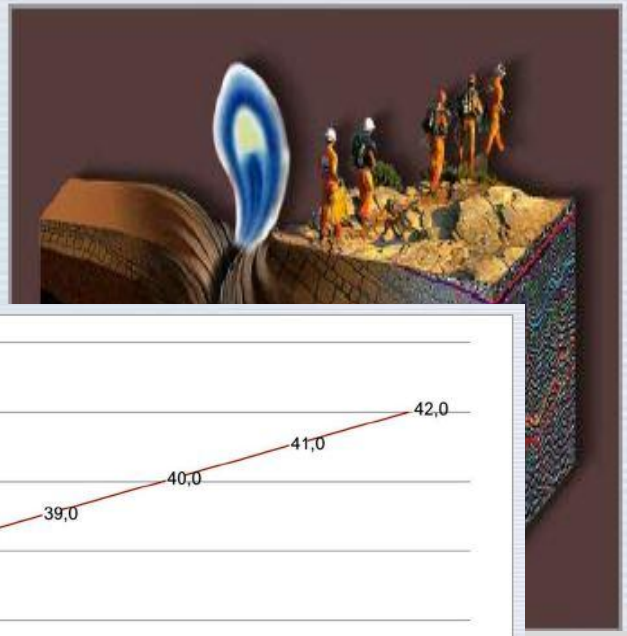

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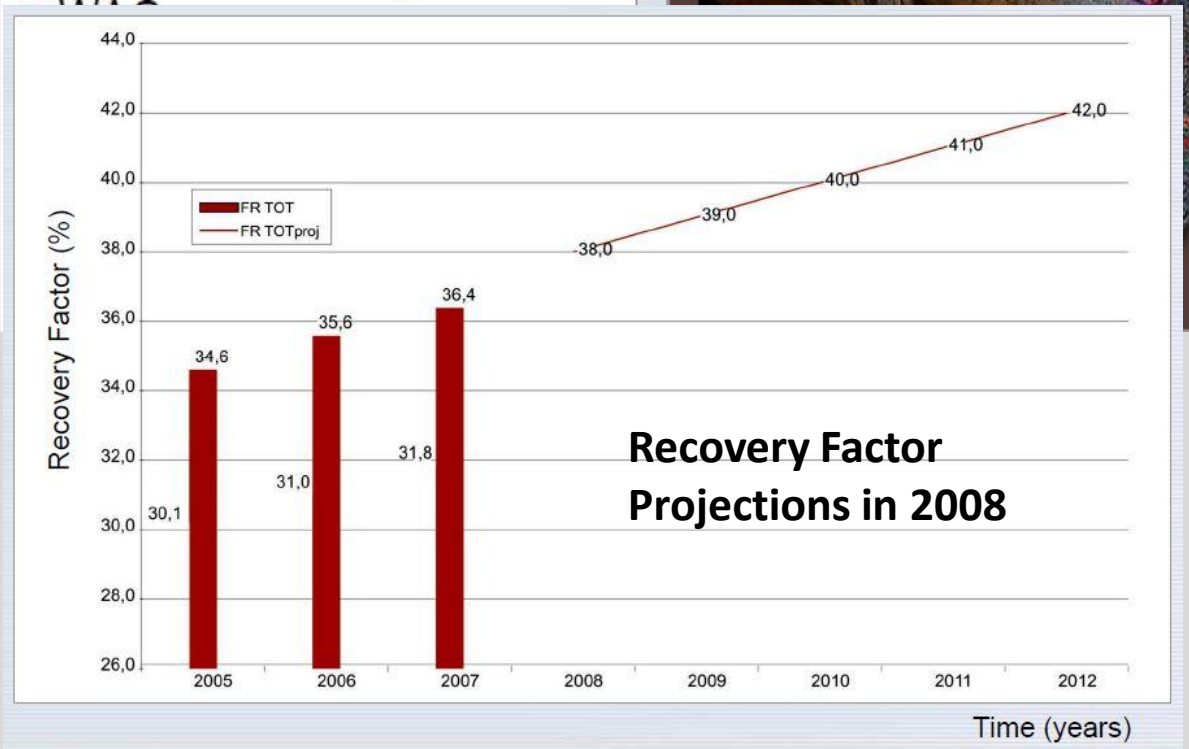

Recovery Factor Projections in 2008

TECHNOLOGICAL INNOVATIONS WITH POSSIBLY SIGNIFICANT CONSEQUENCES FOR THE DEEPWATER OIL & GAS INDUSTRY

HIGH RECOVERY FACTOR LIFE-OF-FIELD PROGRAMS

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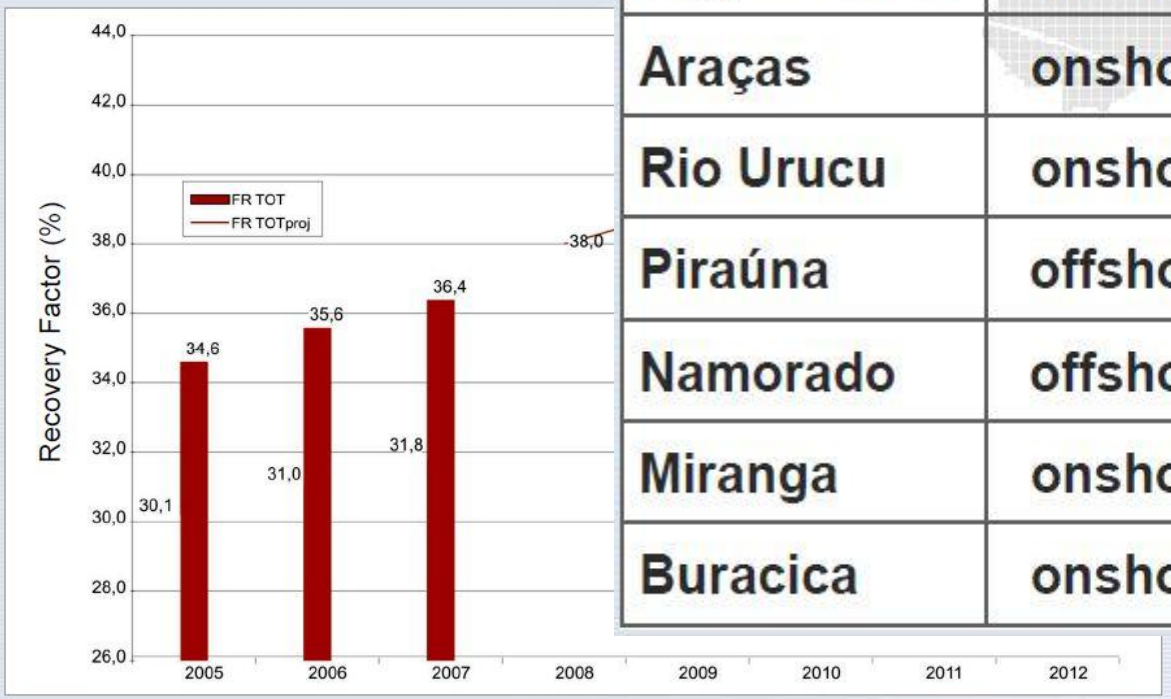


Field	Location	Recovery Factor (%)
Marlim	offshore	56
Bicudo	offshore	56
Lagoa Parda	onshore	61
Araças	onshore	61
Rio Urucu	onshore	61
Piraúna	offshore	63
Namorado	offshore	64
Miranga	onshore	67
Buracica	onshore	69

TECHNOLOGICAL INNOVATIONS WITH POSSIBLY SIGNIFICANT CONSEQUENCES FOR THE DEEPWATER OIL & GAS INDUSTRY

ADVANCED SEISMIC TECHNOLOGIES

Seabottom node technology

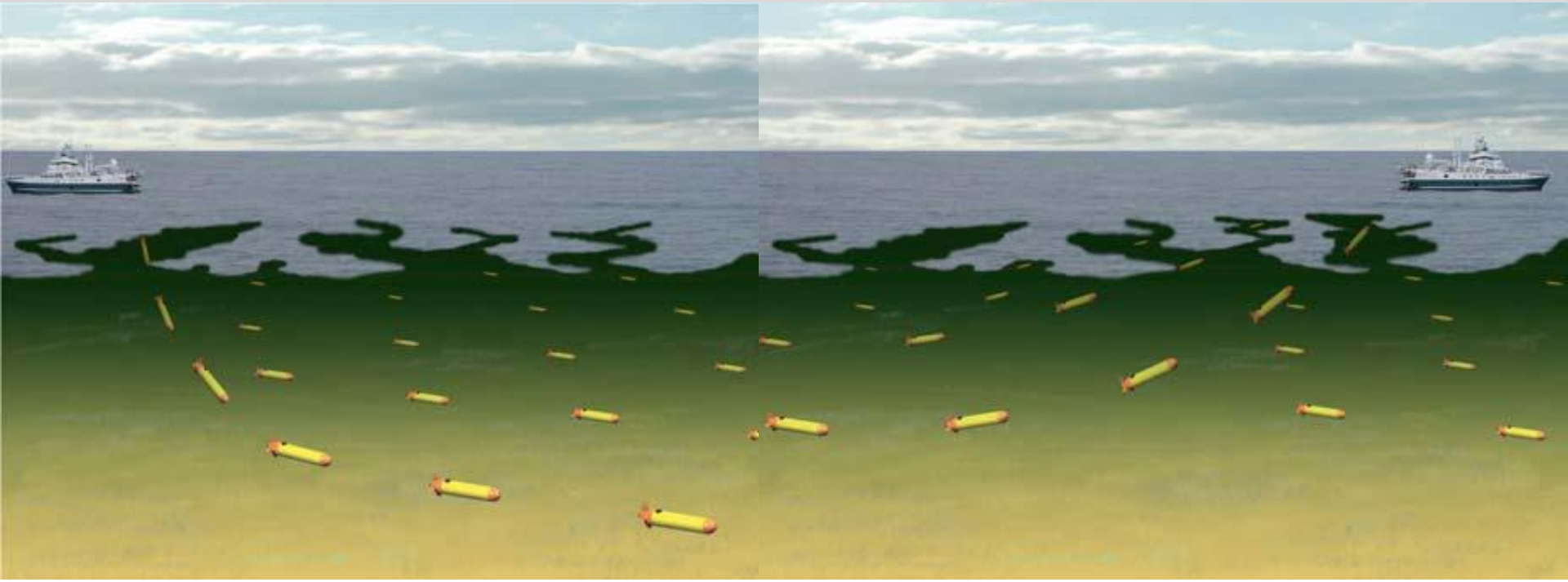
Other techniques:
Receivers as sources
Common Reflection Amplitude Migration (CRAM)
Full Waveform Inversion – FWI technique
Sonic log of drilling mud to track fluid flows

Submerged cable seismic acquisition

Coil shooting for full-azimuth seismic acquisition

TECHNOLOGICAL INNOVATIONS WITH POSSIBLY SIGNIFICANT CONSEQUENCES FOR THE DEEPWATER OIL & GAS INDUSTRY

ADVANCED SEISMIC TECHNOLOGIES



Autonomous underwater vehicles (AUVs) for seismic acquisition – remotely controlled to reach predetermined acquisition locations, record survey, then return to mother ship on their own for retrieval

TECHNOLOGICAL INNOVATIONS WITH POSSIBLY SIGNIFICANT CONSEQUENCES FOR THE DEEPWATER OIL & GAS INDUSTRY

MICROSEISMIC AND HIGH DEFINITION

4D SEISMIC

TRUE 4D IS NOT 3D REPEATED A FEW TIMES!

THE FUTURE IN SEISMIC IS HIGH DEFINITION CONTINUOUS MONITORING!

TECHNOLOGICAL INNOVATIONS WITH POSSIBLY SIGNIFICANT CONSEQUENCES FOR THE DEEPWATER OIL & GAS INDUSTRY

MEOR – Microbial Enhanced Oil Recovery

- Biocompetitive exclusion of SRBs
- Microbial production of biosurfactants in situ
- Solubilization of heavy oils
- Microbial transformation of paraffins
- Selective biodegradation of heavy oil
- Microbial production of polymers – MFD
- Microbial gasification of oil into methane and other gas fractions
- Microbial conversion of CO2 into methane
- Microbial desulfurization of sour oil and gas
- Microbial emulsification of oil and water
- Microbial de-emulsification of oil and water
- Bioremediation of contaminated sites
- Overlap of nanotechnology and MEOR: microbial markers
- Microbial dissociation of gas hydrates
- Microbial production of CO2 and organic acids

CONCLUSION

Geologists cannot stay removed from ongoing engineering developments affecting any area of the oil and gas industry.

We have to follow such developments, and introduce ourselves into them, so as to become ACTIVE PROTAGONISTS.

We must not just USE new engineering tools, but help DEVELOP them, and GUIDE NEW TECHNOLOGY TRENDS in the industry.

THANK YOU!

cmjones@mensa.org.br
cmjones@uerj.br

Grupo de Pesquisa
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