CICLO DE WEBINARS

Recursos Minerais, Energia e Ambiente para um Futuro Sustentável

+EMPREGO

Desafios tecnológicos na exploração petrolífera em águas profundas e o impacto da transição energética

CERENA
Centro de Recursos Naturais e Ambiente

TÉCNICO LISBOA

UNIVERSIDADE LÚRIO
Ciência . Desenvolvimento . Compromisso

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UNIÃO EUROPEIA

CAMÕES COOPERAÇÃO PORTUGUESA
PORTUGAL
MINISTÉRIO DOS NEGÓCIOS ESTRANGEIROS

Projeto +Emprego para os jovens de Cabo Delgado
Ação financiada pela União Europeia.
Ação cofinanciada e gerida pelo Camões, I.P.

Upstream Industry and Energy Transition

Outline

1. Technological risks and challenges in the Upstream industry

How are hydrocarbons explored ?

What are the main difficulties ?

Is oil or gas the same everywhere ?

How much does it cost to find oil ?

What are the main stages of hydrocarbon exploration ?

How much oil and gas we have left and for how long?

2. Energy Transition and Global changes affecting the E&P industry

What are the drivers for decarbonizing the upstream industry ?

What and where are the sources of emissions?

Solutions for emissions and strategic options already ongoing within the companies ?

What future for oil and gas companies ?

Oil production and oil prices in the future ?

PART 1:

Technological risks and challenges in the Upstream industry

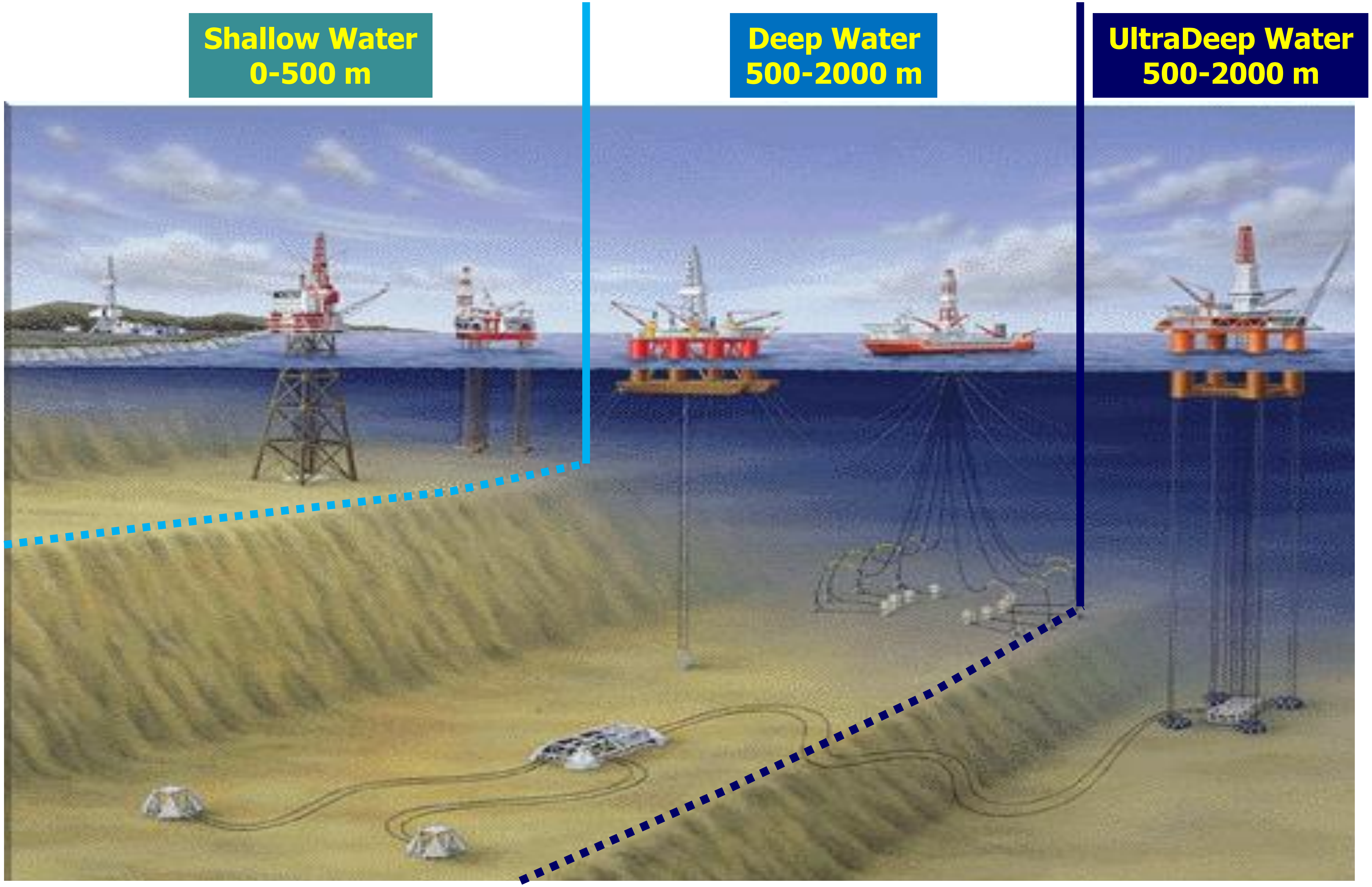
Upstream Industry and Energy Transition

Technological risks and challenges in the Upstream industry

UPSTREAM	MIDSTREAM	DOWNSTREAM
		
EXPLORATION & PRODUCTION	**ENERGY INFRASTRUCTURE**	**END MARKET USERS**
Discovery and production of oil and natural gas	Transportation of oil and gas via pipes and storage of excess	Marketing and distribution of refined oil and gas to end users
• Oil & Gas Exploration & Production • Coal & Consumable Fuels • Oil & Gas Drilling • Oil & Gas Services and Equipment	• Crude Oil & Refined Products Pipeline & Storage • Diversified Midstream Pipeline & Storage • Marine Shipping & Transportation • Natural Gas Gathering & Processing • Natural Gas Pipeline & Storage • Oil Field Services	• Oil & Gas Refining • Oil & Gas Marketing & Distribution • Commercial / Residential • Industrial Gases • Diversified & Specialty Chemicals • Utilities & Power Generation

Upstream Industry and Energy Transition

Technological risks and challenges in the Upstream industry



Upstream Industry and Energy Transition

Technological risks and challenges in the Upstream industry

EXPLORATION

Is there any oil ?

Drilling

Trap interpretation & Depth uncertainty assessment

APPRAISAL

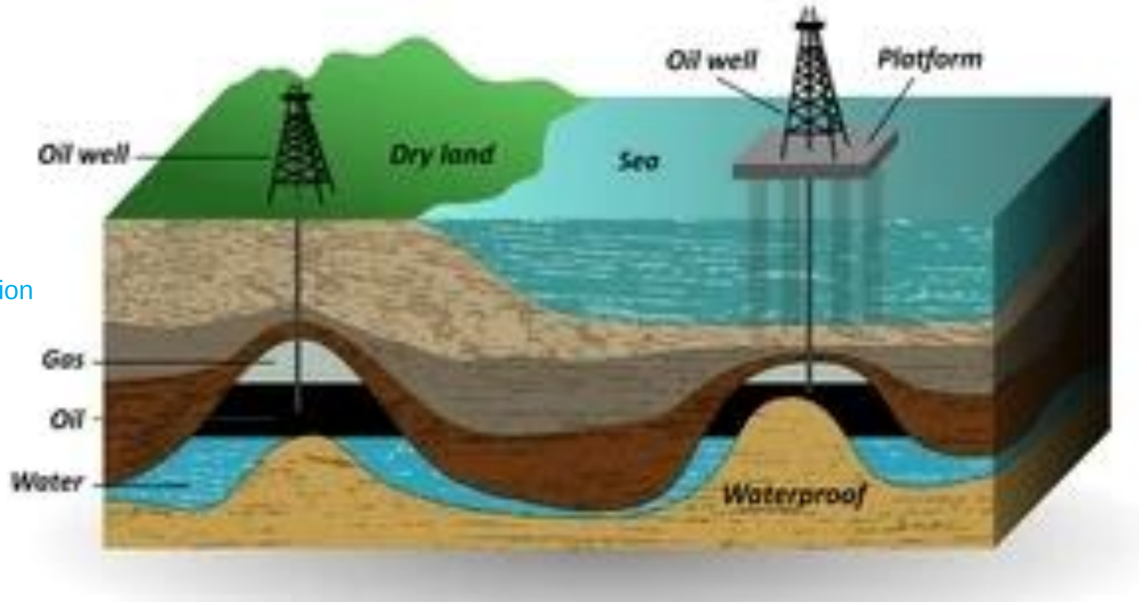
How much ?

Regional geopressure & geothermal assessment

Geomechanical studies for seal integrity & injection rates

Seal capacity, integrity and HC columns

Petroleum system
- Source rock
- Reservoir
- Seal
- Migration
- Trapping and Accumuation



Seismic inversion & Reservoir characterization

Fluid properties

Subsurface Imaging

Risk, Volumetrics & Prospect ranking

DEVELOPMENT

Development costs & Economics

Is it economical to produce?

Reservoir engineering and simulation

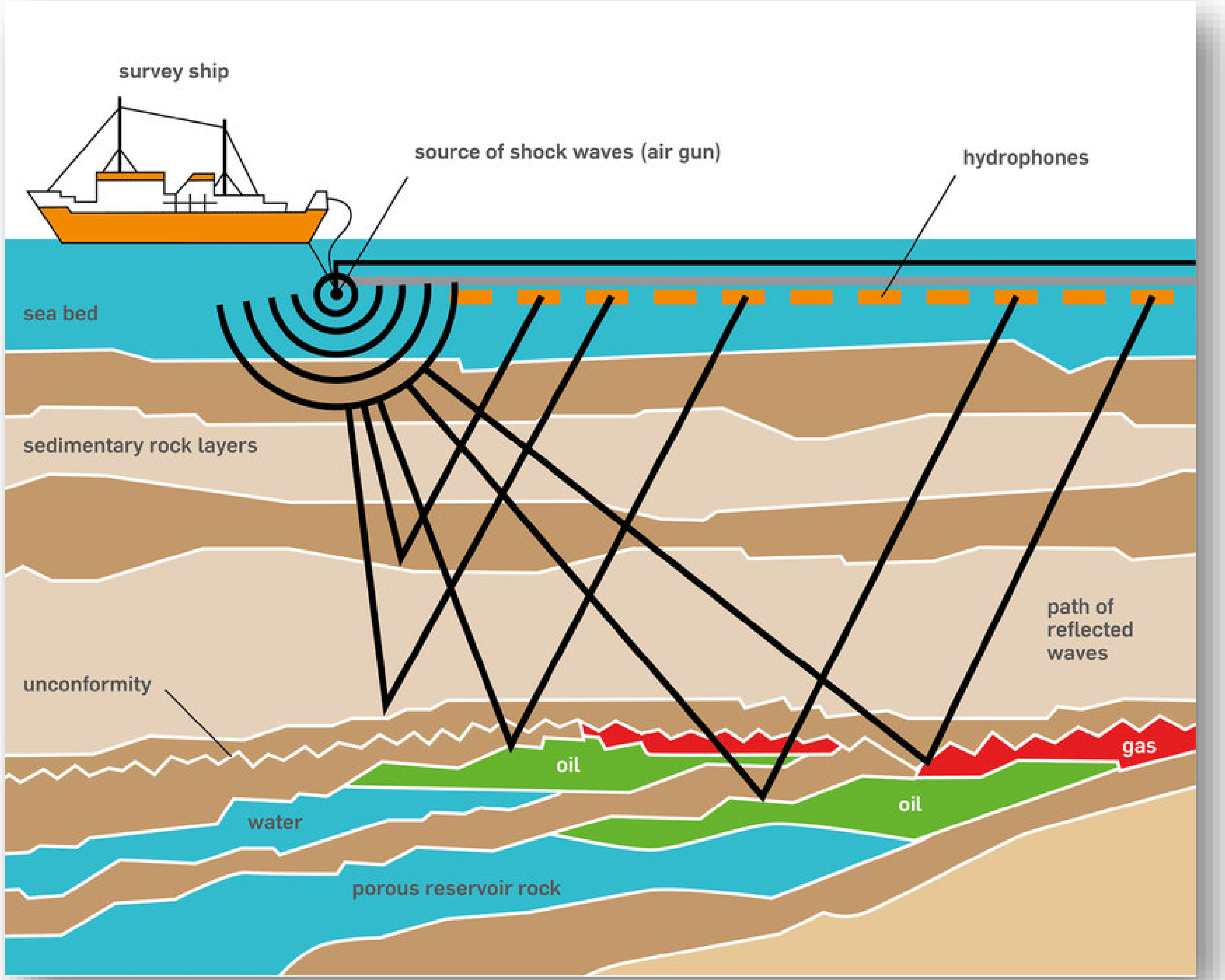
Development Plan and engineering

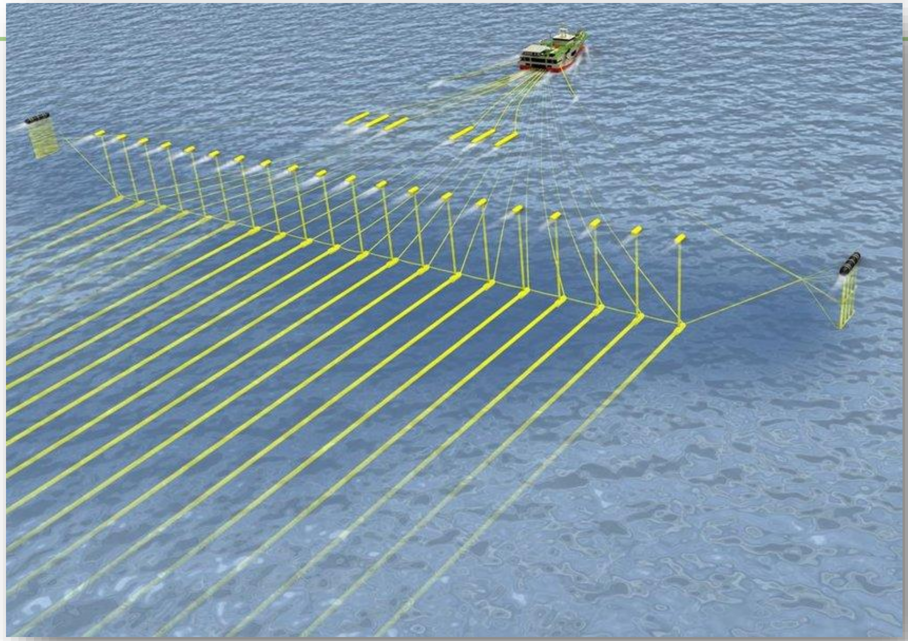
Optimization of Well Design/Engineering

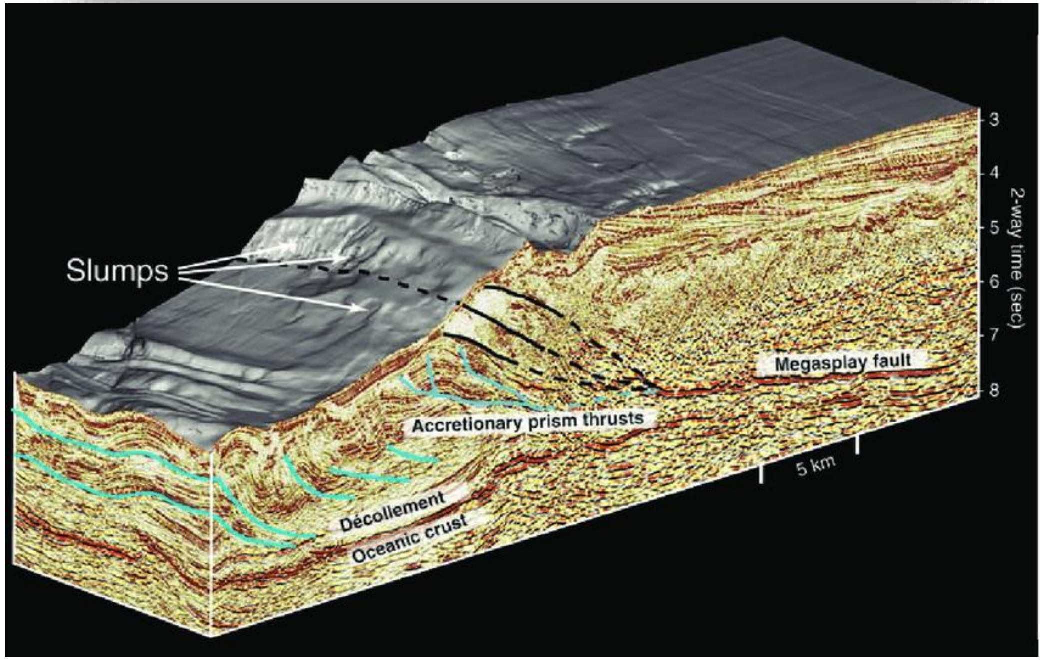
Upstream Industry and Energy Transition

Technological risks and challenges in the Upstream industry

Seismic imaging







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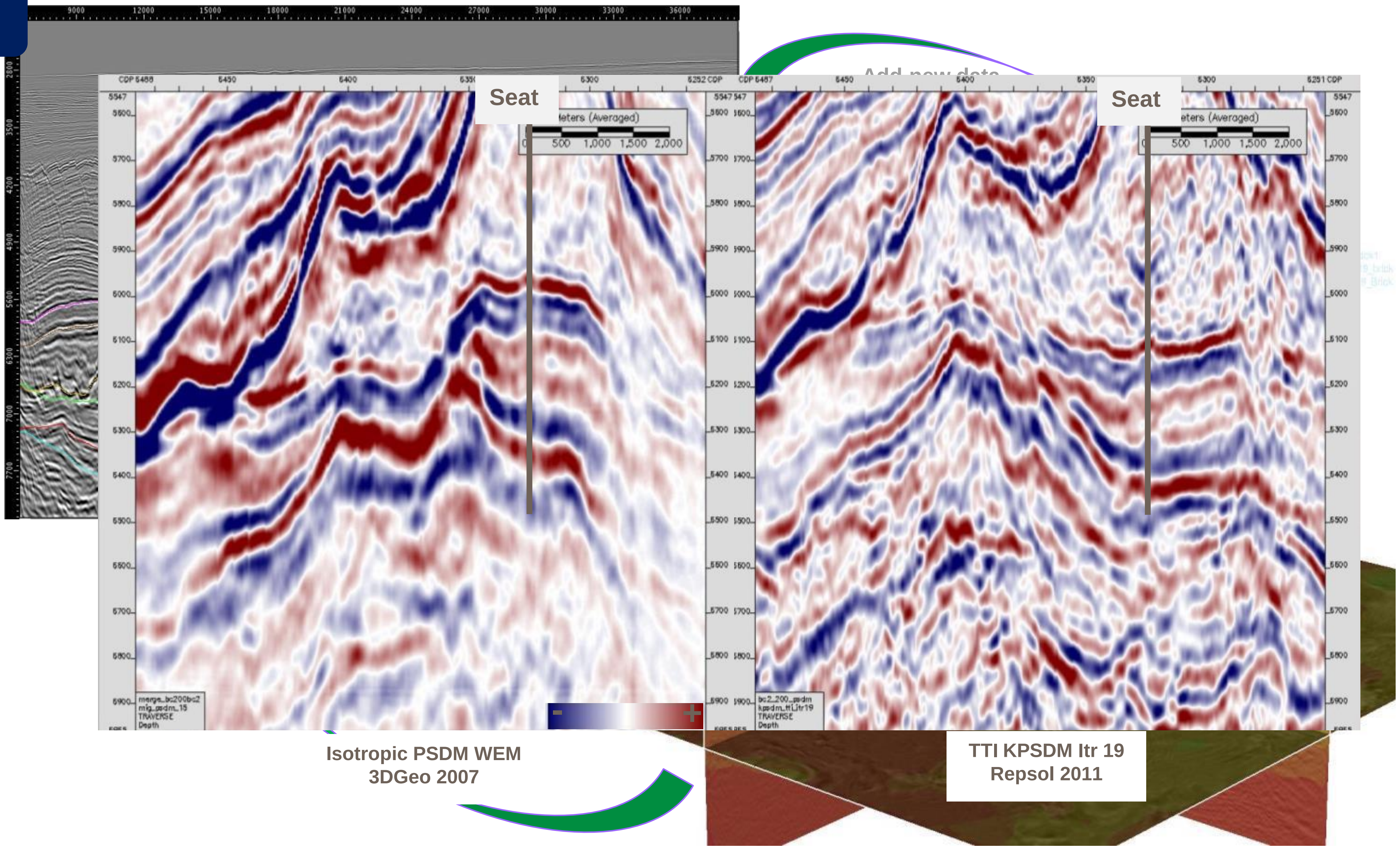
Technological risks and challenges in the Upstream industry

Seismic imaging

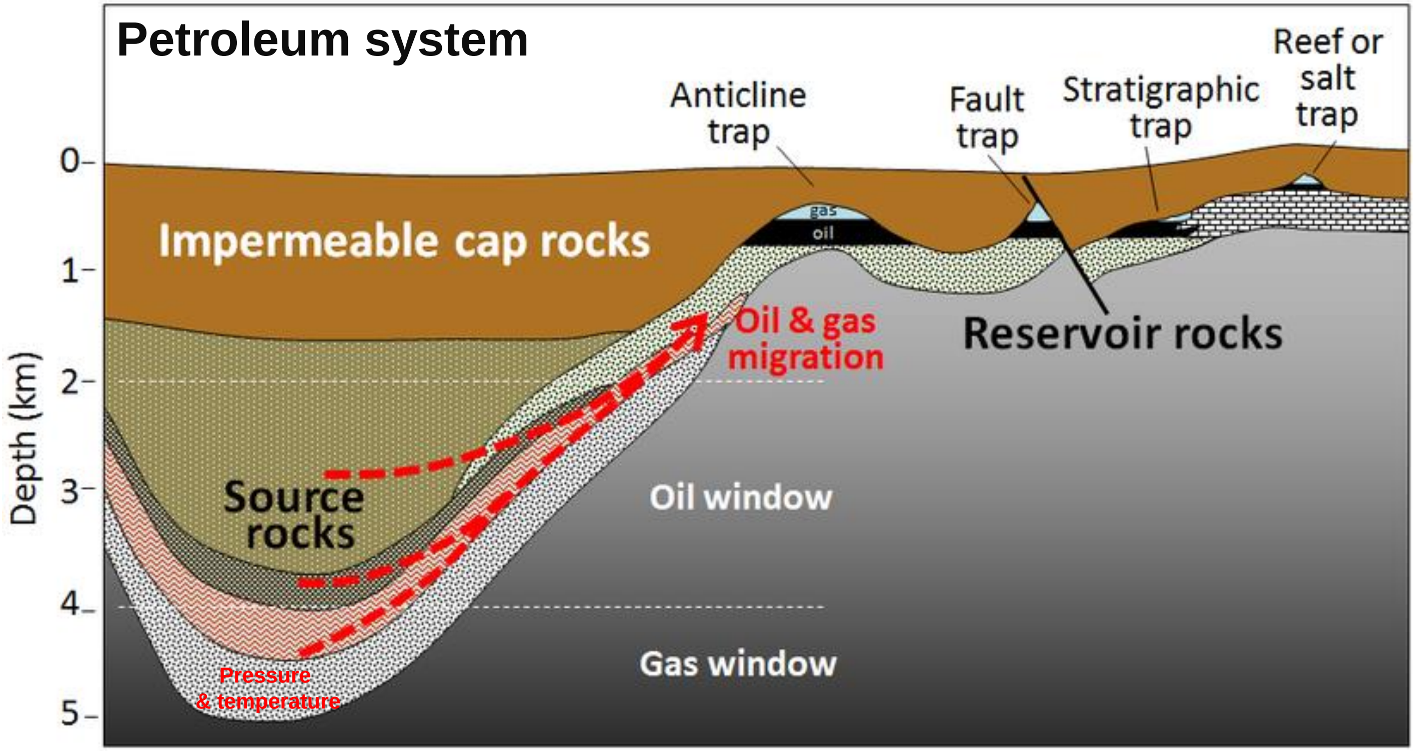


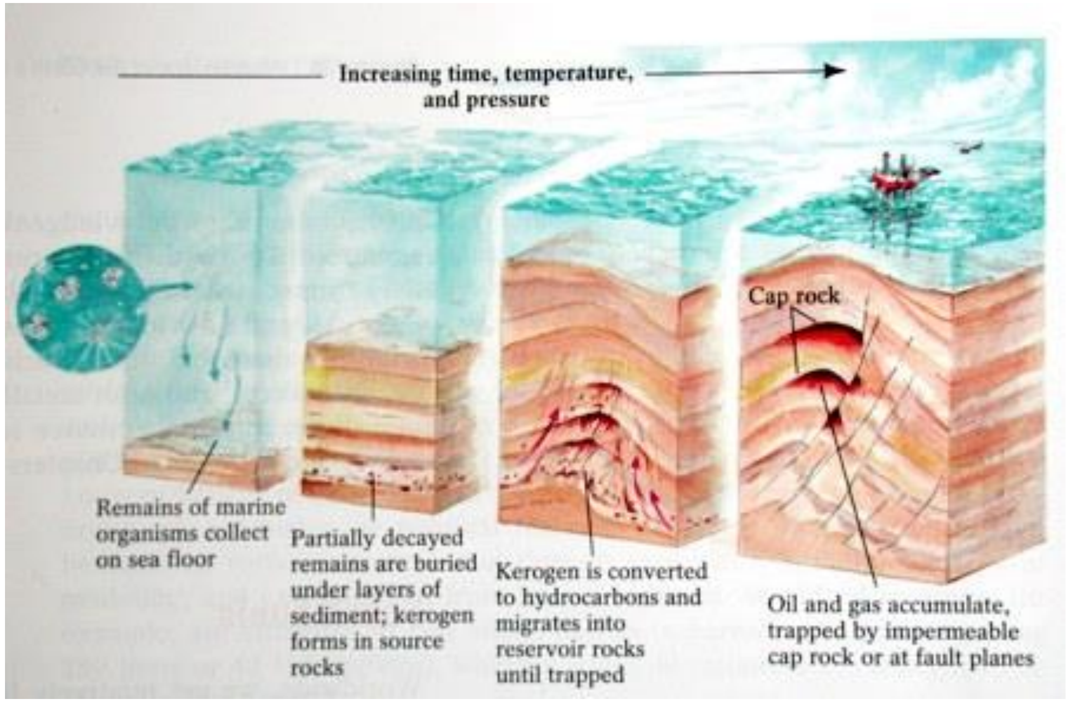
COST OF OFFSHORE 3D SURVEYS
60-100 $MM Seismic surveys

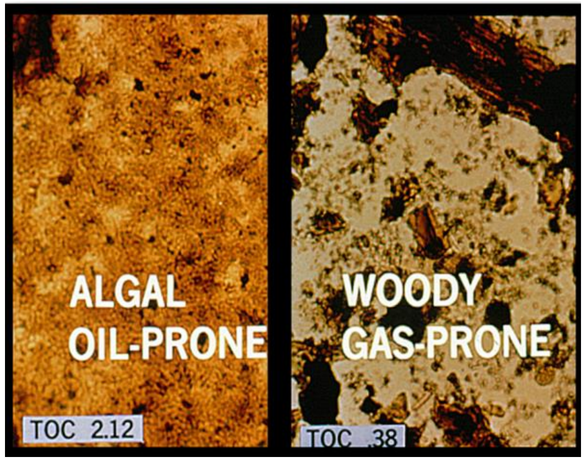
Source rocks

Source rocks are sedimentary rocks that are, may become, or have been able to generate petroleum

Sedimentary rocks commonly contain minerals and organic matter with the pore space occupied by water, bitumen, oil and/or gas.







Algae = Hydrogen rich = Oil-prone

Wood = Hydrogen poor = Gas-prone

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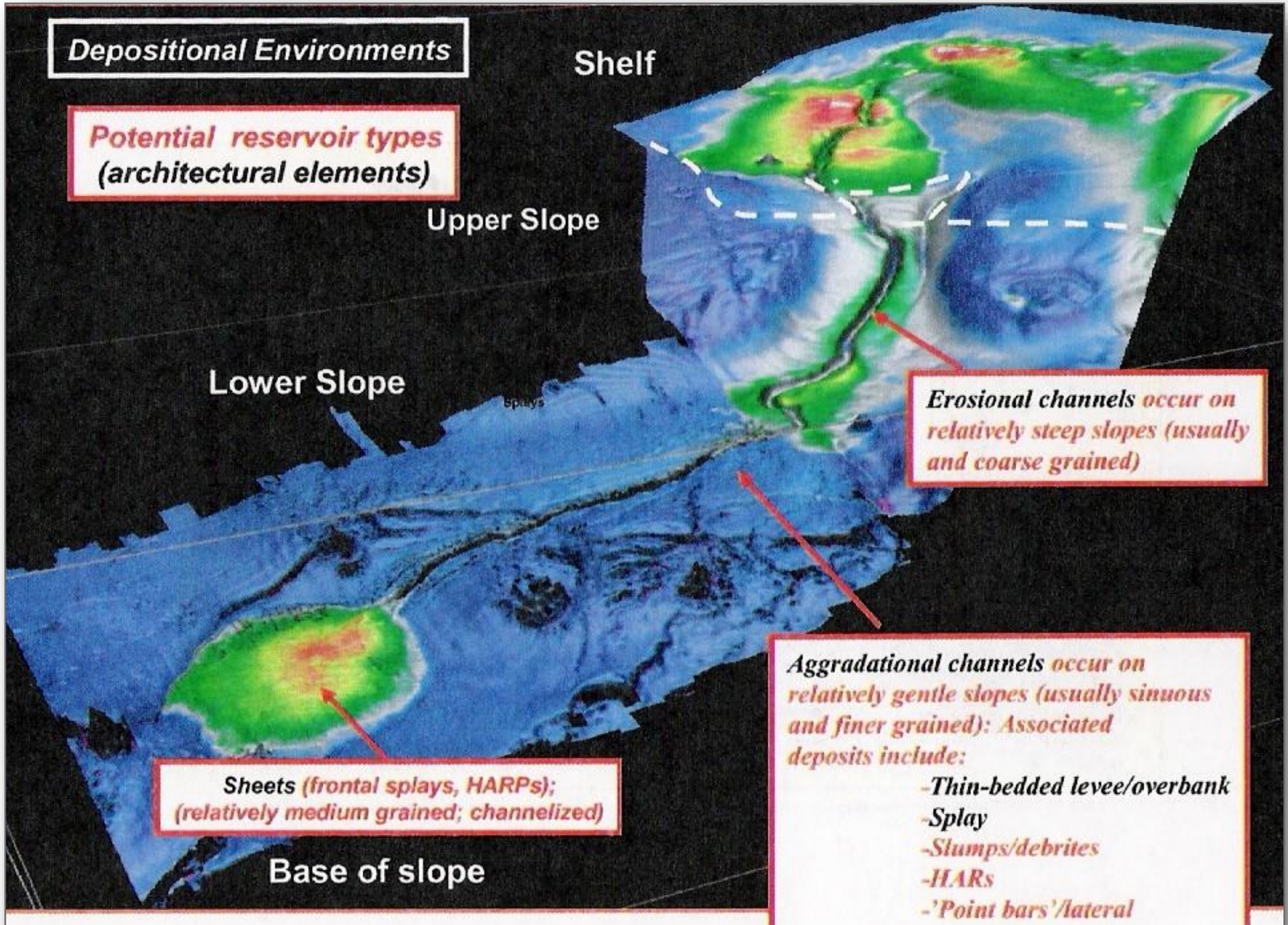
Reservoir



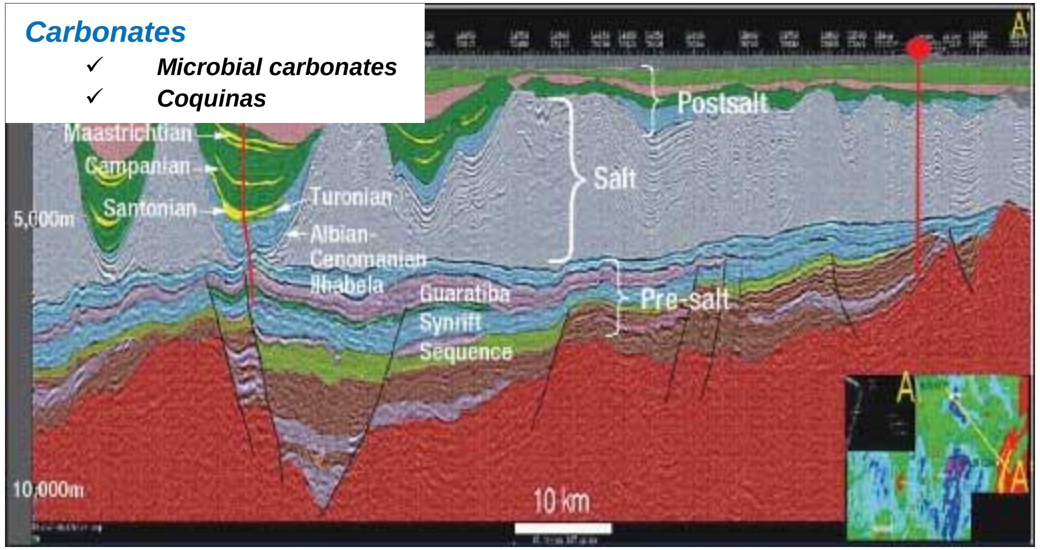
Source – Veeken, 2007

Upstream Industry and Energy Transition

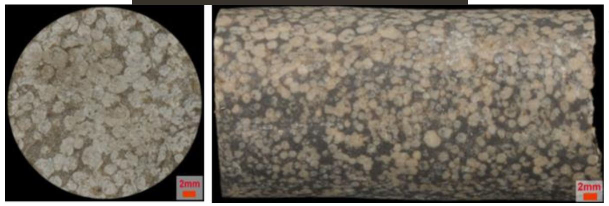
Technological risks and challenges in the Upstream industry

Reservoir

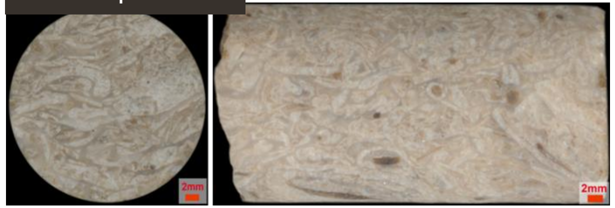
Carbonates
- ✓ ***Microbial carbonates***
- ✓ ***Coquinas***



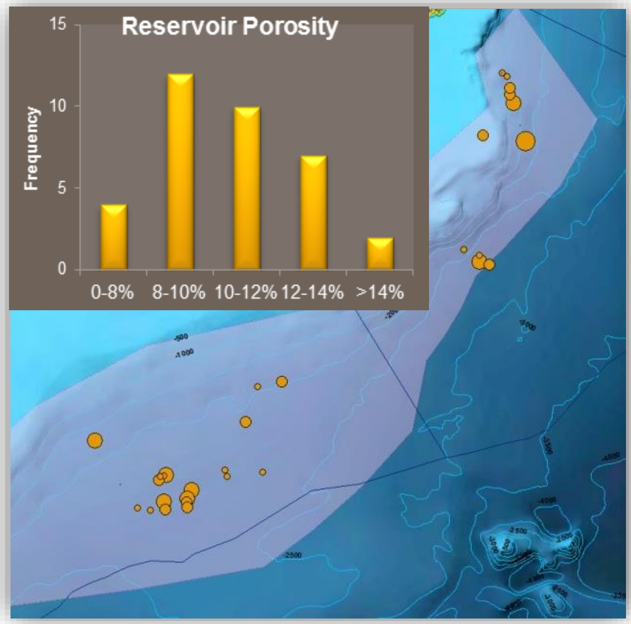
Spherulitic Microbialite

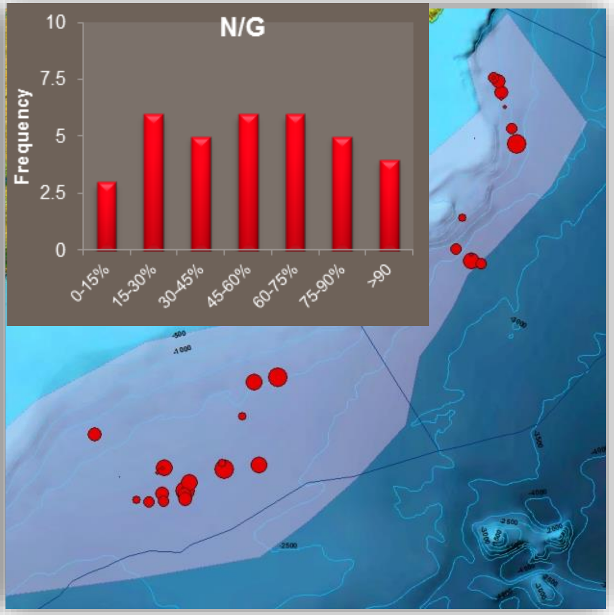


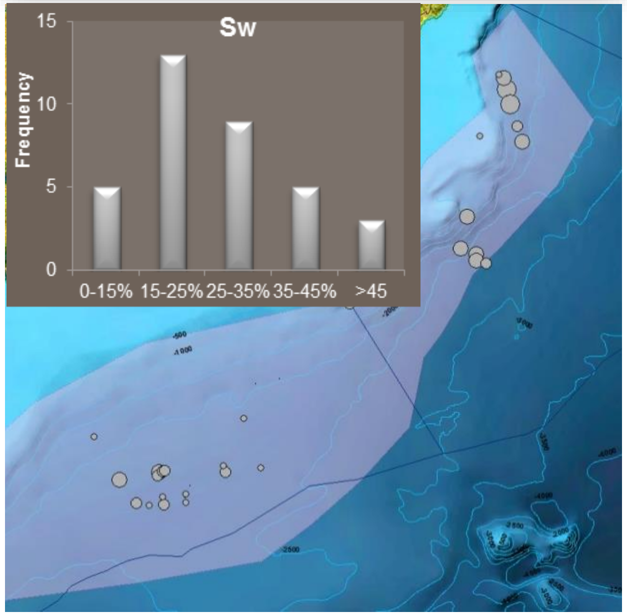
Coquina

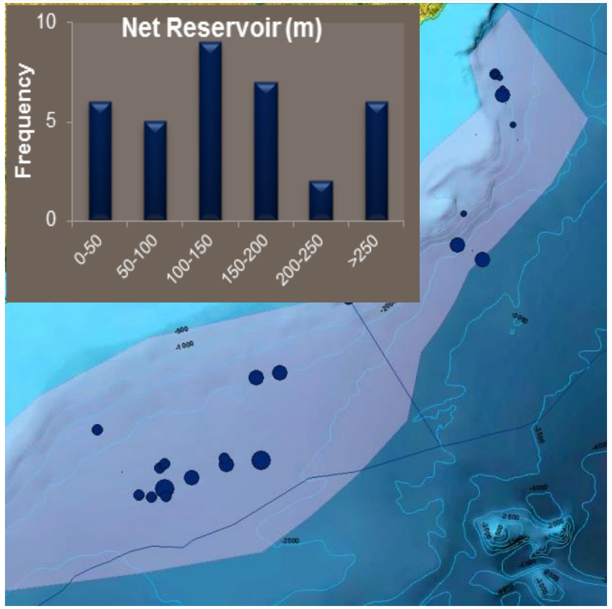


- **Early diagenesis**
  - ✓ **Dolomite**
  - ✓ **Mg-clays concentration**
  - ✓ **Silicification**
- **Late diagenesis**
  - ✓ **Silica replacement and cementation**
  - ✓ **Fracturing, hydrofracturing**
  - ✓ **Late cementation**









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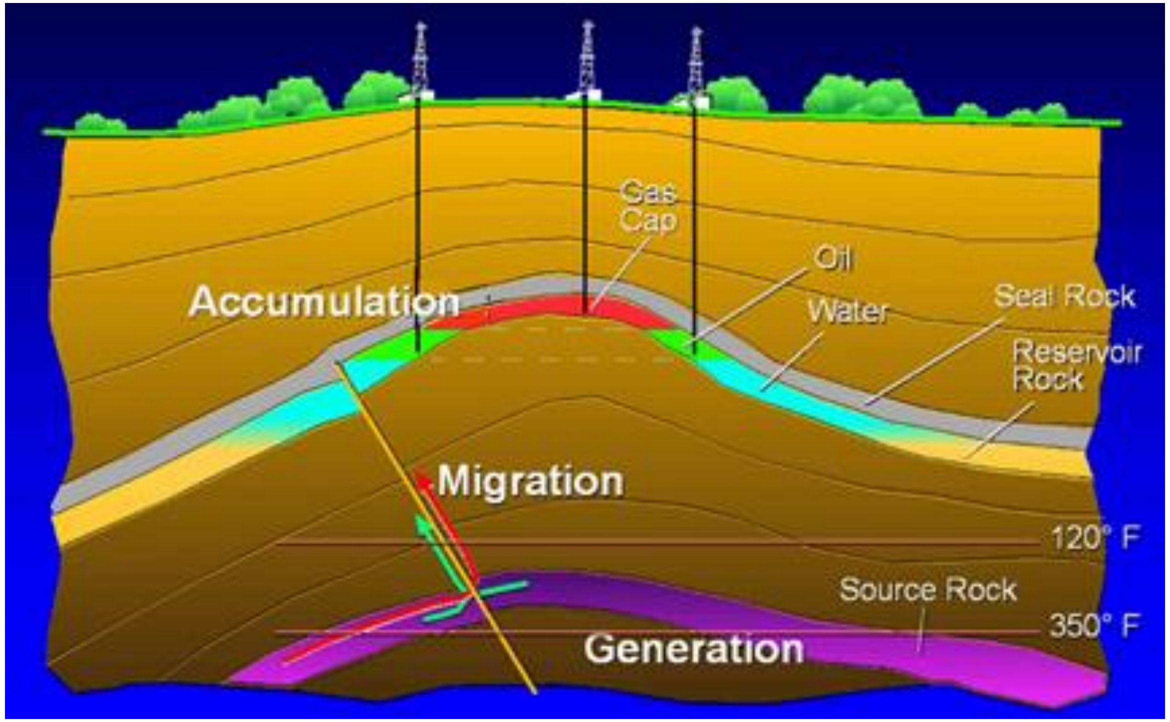
Technological risks and challenges in the Upstream industry

Seal

- Seal: An interface that supports a (fluid) pressure difference on either side of the seal !!
- Hydrocarbon densities have a big effect on trap fill. Same seal quality will give different trap fills for oil or gas.
- Seal failure is the single most important factor in exploration. Data from SIS Survey of 20 companies shows that the cause of failure is about 45%.



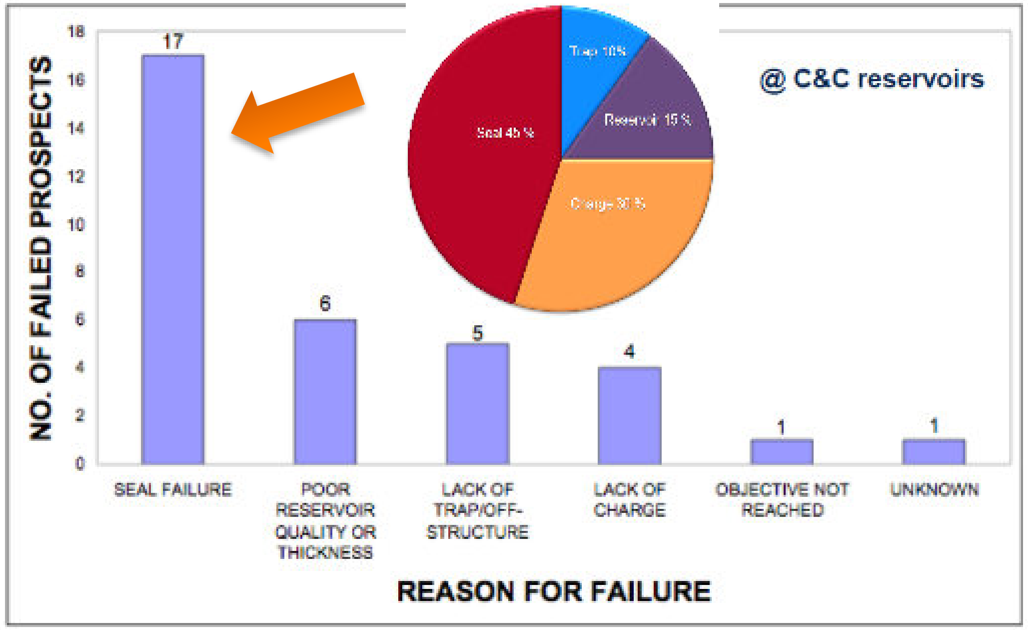


Figure 1.1 – Histogram of failed prospects in the Gulf of Mexico, the Bonaparte Basin of Australia, and the North Sea Central Graben (compiled from Houston Geological Society, 2000, 2003).

Low permeability
Low porosity

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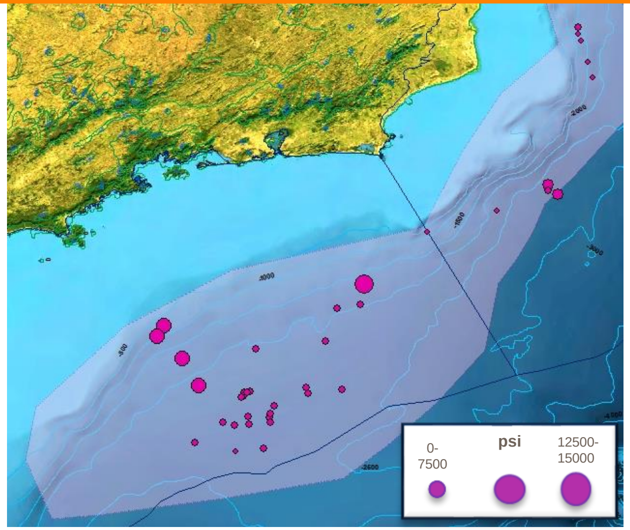
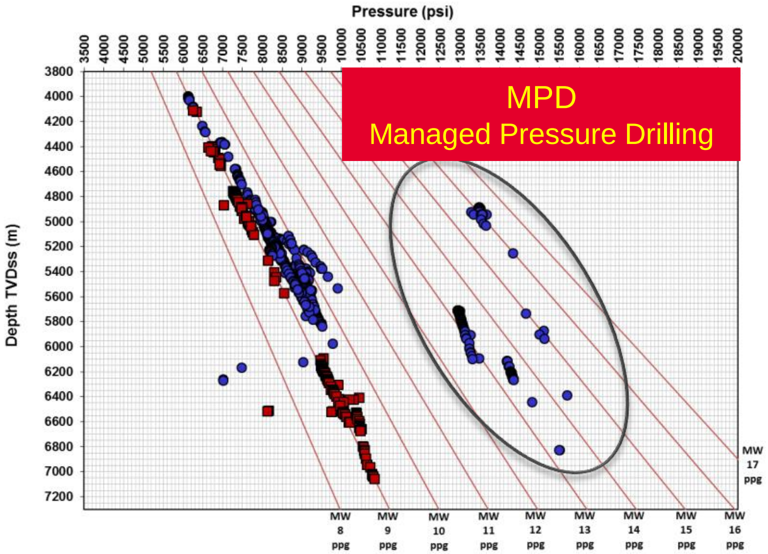
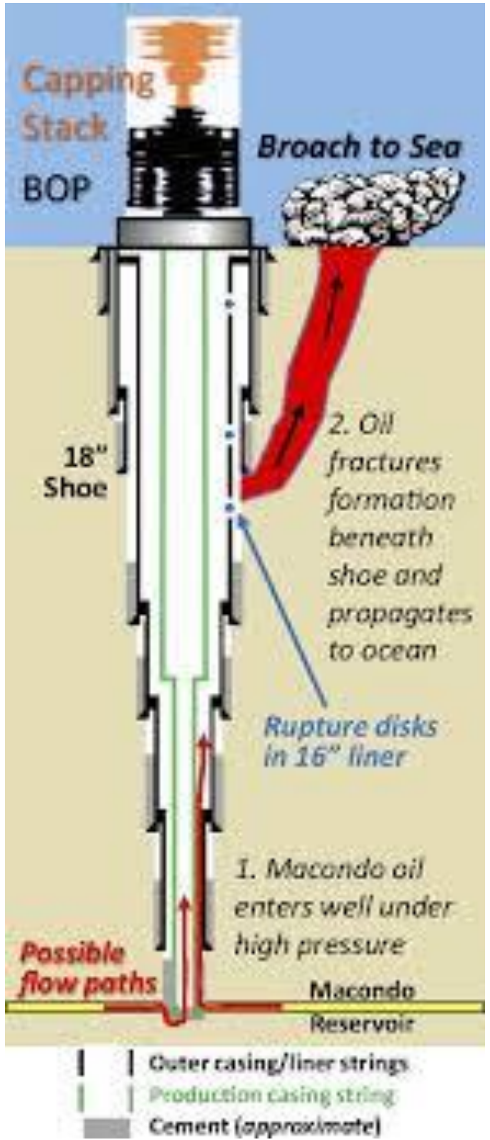
Reservoir Pressure

Pressure distribution at base salt in Campos and Santos







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Technological risks and challenges in the Upstream industry

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Fluid properties and field development

API

<u>The American Petroleum Institute gravity, or *API gravity*, is a measure of how heavy or light a petroleum liquid is compared to water.</u>

If its API gravity is greater than 10, it is lighter and floats on water; if less than 10, it is heavier and sinks. API gravity is thus a measure of the relative density of a petroleum liquid and the density of water, but it is used to compare the relative densities of petroleum liquids.

For example, if one petroleum liquid floats on another and is therefore less dense, it has a greater API gravity. Although mathematically API gravity has no units (see the formula below), it is nevertheless referred to as being in “degrees”.

- **Light crude oil** is defined as having an API gravity higher than 31.1 °API
- **Medium oil** is defined as having an API gravity between 22.3 °API and 31.1 °API
- **Heavy oil** is defined as having an API gravity below 22.3 °API.
- **Extra heavy oil or bitumen** is crude oil with API gravity less than 10 °API.Bitumen derived from the oil sands deposits in the Alberta, Canada area has an API gravity of around 8 °API. It is 'upgraded' to an API gravity of 31 °API to 33 °API and the upgraded oil is known as synthetic crude.

Light Texas Crude
Palo Pinto Field
North Texas

Heavy Texas Crude
Humble Oil Field
Southwest Texas

H2S content

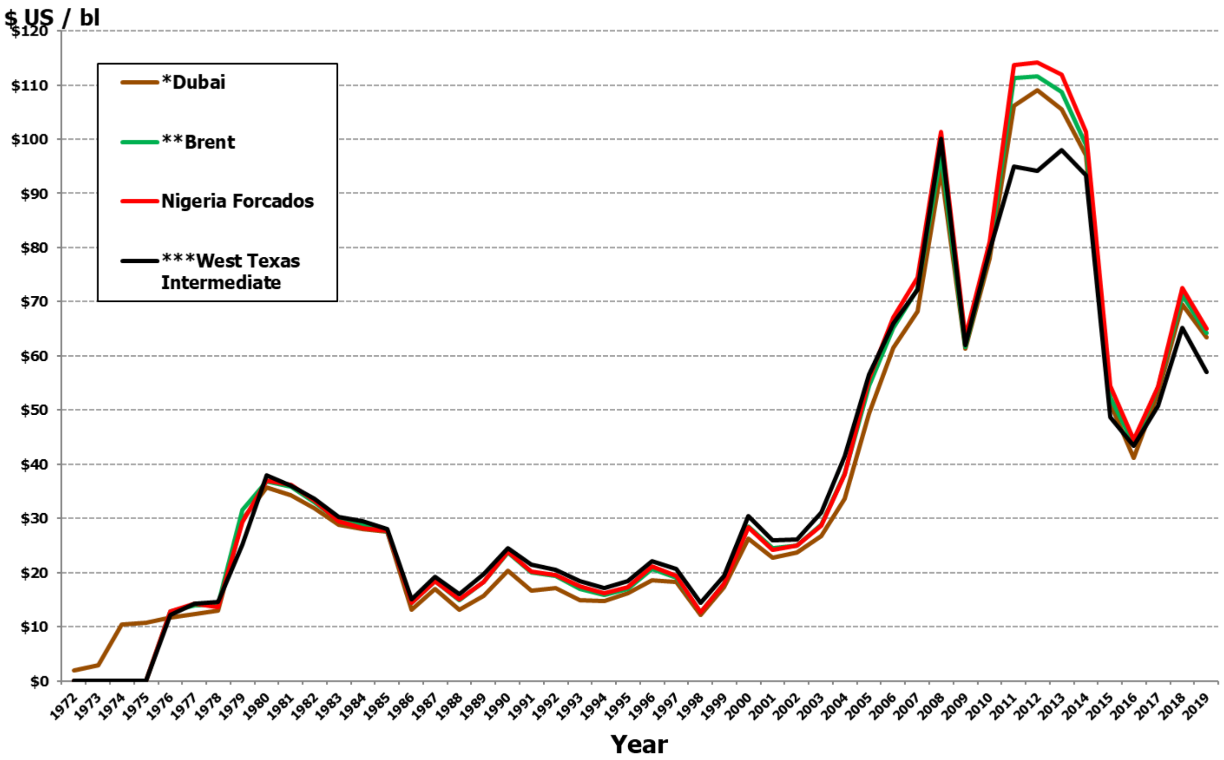
Crude is considered "sweet" if it is low in sulphur content (< 0.5%/weight), or "sour" if high (> 1.0%/weight). Generally, the higher the API gravity (the "lighter" it is), the more valuable the crude.

Also, for health reasons it is very dangerous. The limits are....

CO2 content

The presence of CO_2 will react with water and create carbonic acid. This in turn will corrode the pipes and other metal structures.

GOR



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Technological risks and challenges in the Upstream industry

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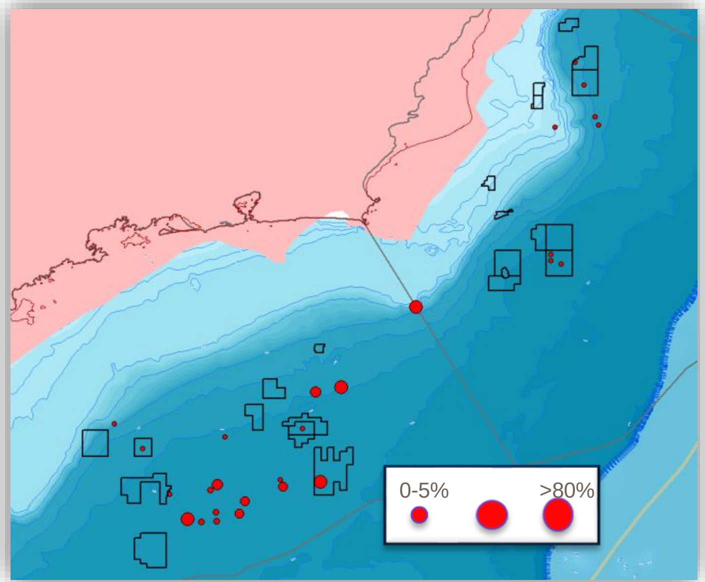
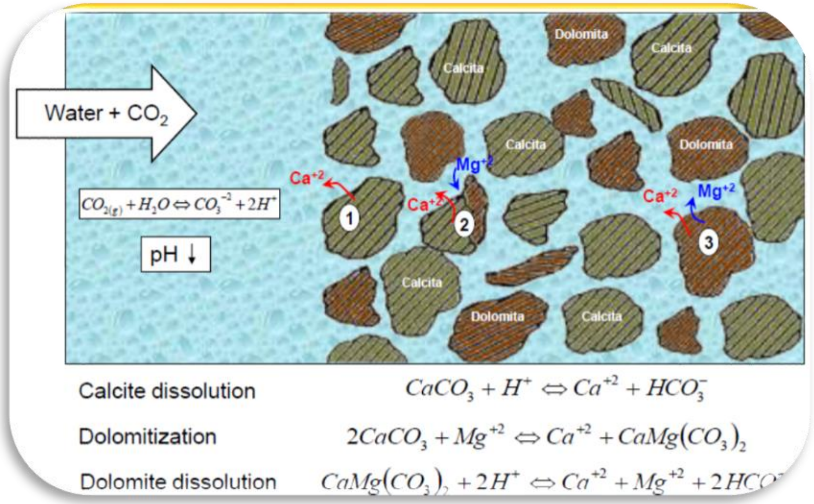
Fluid properties and field development

- Carbon dioxide is one of the most common non-hydrocarbon gases found in petroleum reservoirs.
- However, petroleum accumulations with CO2 >20% can be considered relatively rare.
- The most important source of the large volumes of CO2 found in petroleum accumulations is the mantle.
- Nevertheless, contribution from inorganic CO2 after carbonate corrosion cannot be ruled out to eventually occur
- Commonly, areas with major CO2 risks are associated with "hot basement" (GG > 30° C/km), deep seated faults, igneous intrusions and basin rifting.



Rock fluid interaction

- Carbonates reactivity
- Mineral scaling
- Porosity enhancement
- Mineralogical changes
- Changes in oil and water production



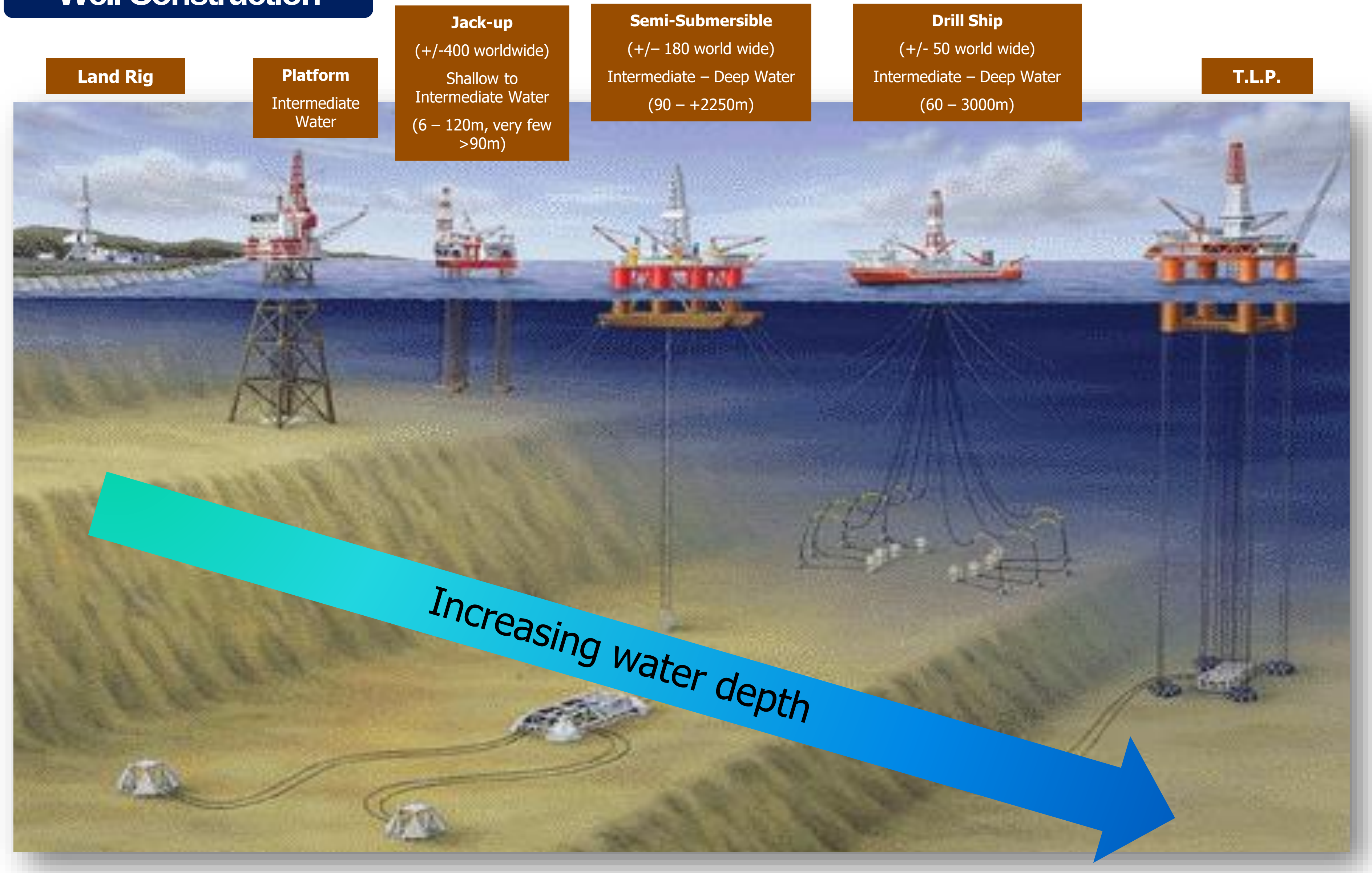
Materials and integrity management (Corrosion Control and Fatigue)

- Corrosive environment for metallic materials (CO2)
- Compatibility of non-metallic materials with CO2
- Interaction of corrosion and dynamic loads in risers

Upstream Industry and Energy Transition

Technological risks and challenges in the Upstream industry

Well Construction



- ✓ Drilling horizontal wells through salt
- ✓ Geomechanical problems (salt and carbonate)
- ✓ Long term wellbore integrity (cementing)
- ✓ Strategy for well stimulation
- ✓ Well geometries to provide high productivity (vertical vs. horizontal)
- ✓ Interval selectivity

Technological risks and challenges in the Upstream industry

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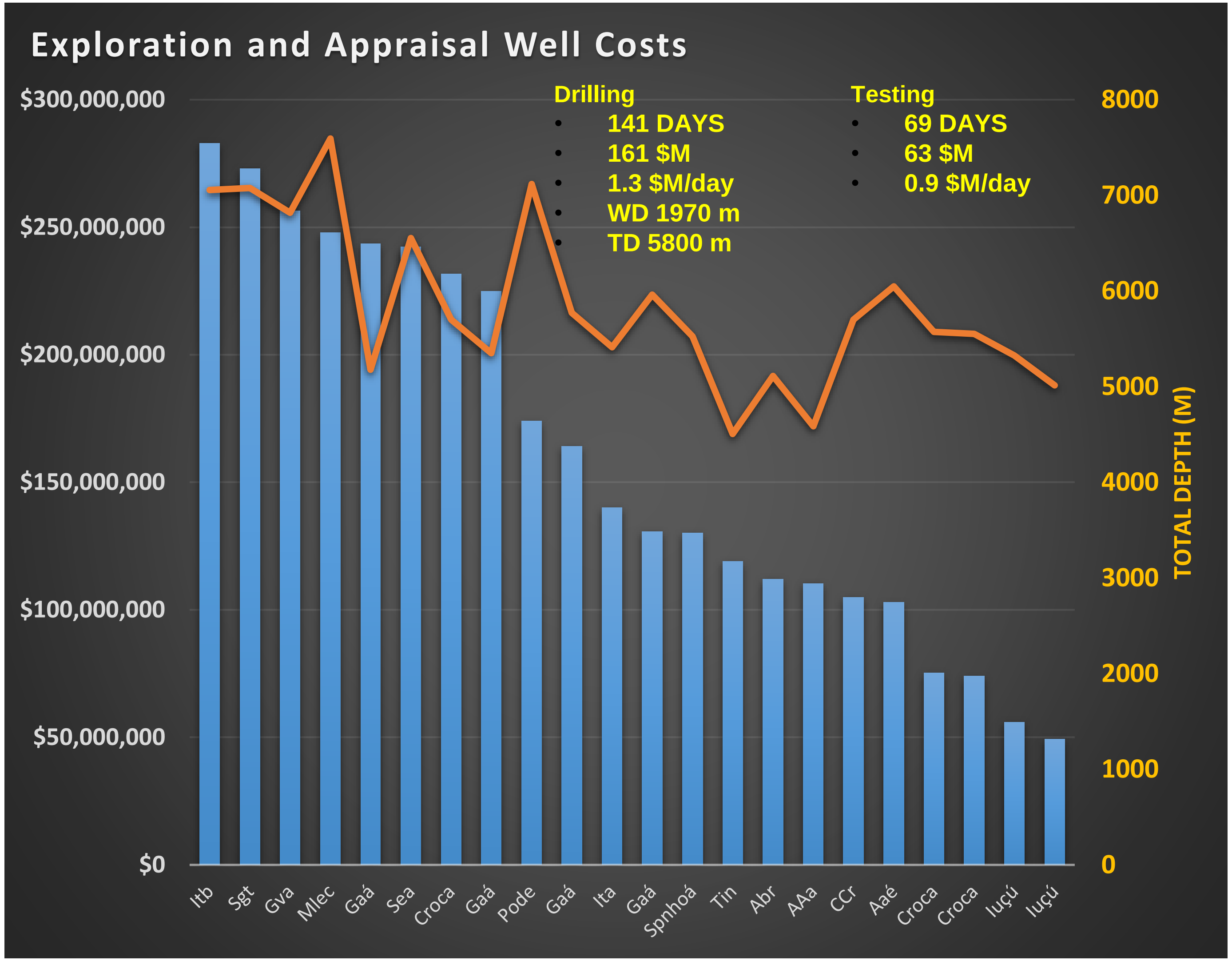
Well Costs



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Technological risks and challenges in the Upstream industry

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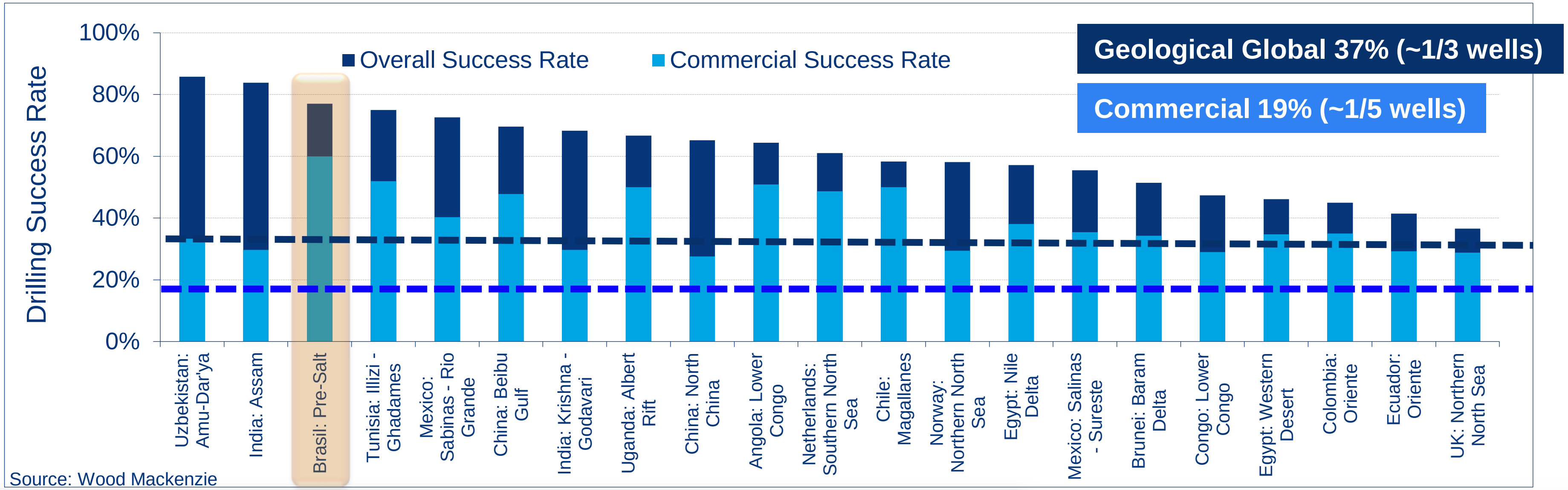
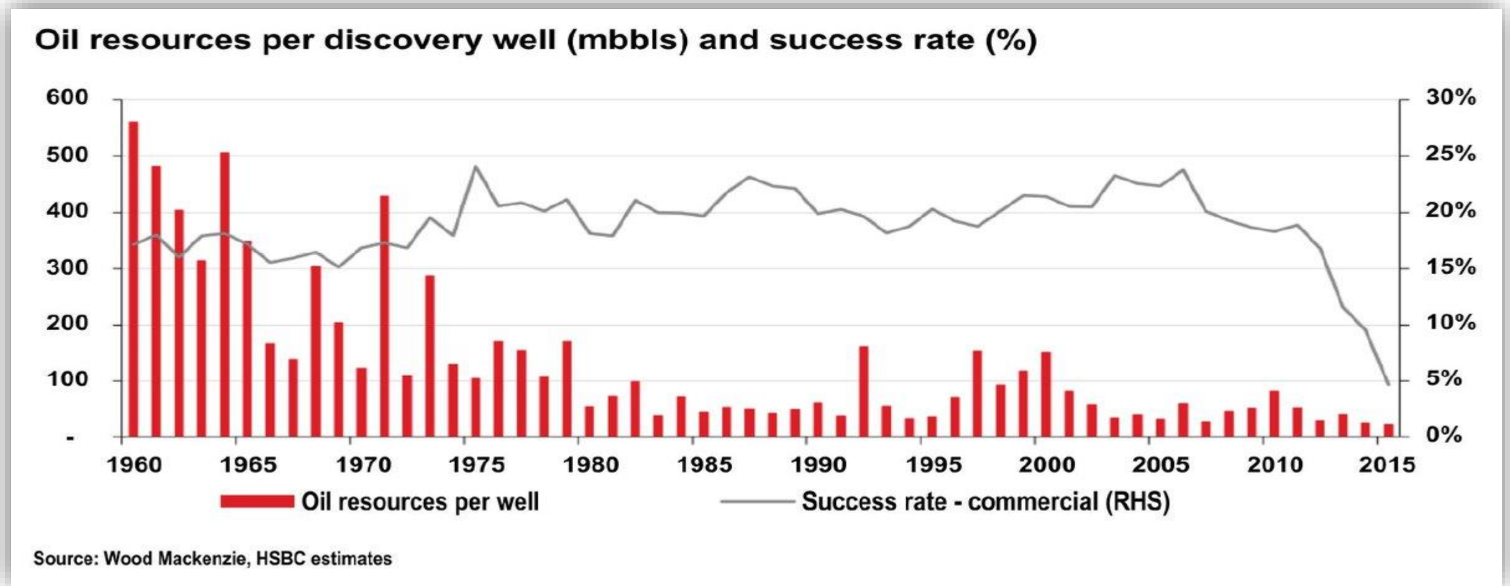
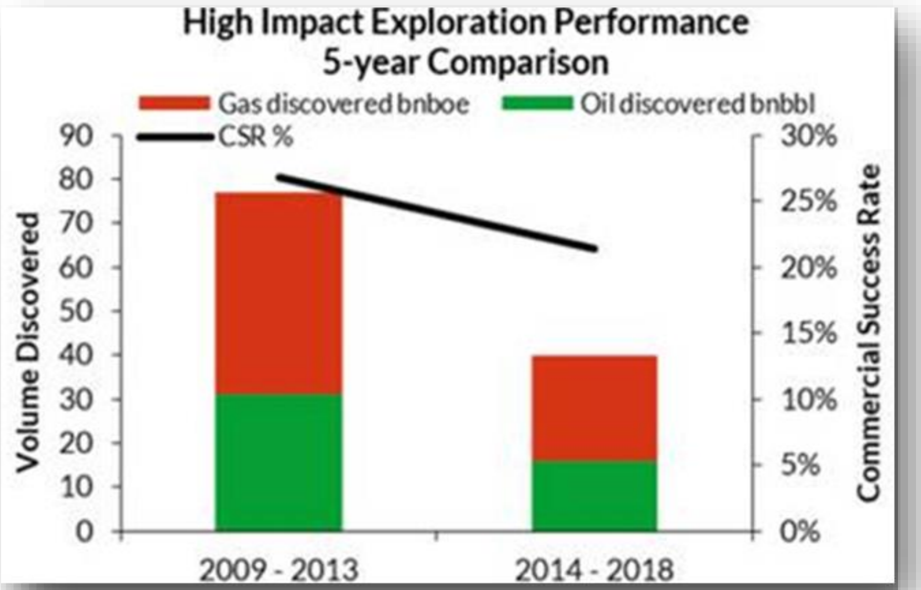
…so what about the Success Rate ?







Upstream Industry and Energy Transition

Technological risks and challenges in the Upstream industry

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How long does it take to put into production ?

Field	Basin	Water Depth (m)	Operator	Oil kb/d	Gas MMcm/d	Discovery	First Oil	Duration
Lula Central	Santos	2250	Petrobras	150	6	2006	2016	10
Lula Sul	Santos	2126	Petrobras	150	6	2006	2016	10
Papa Terra	Campos	1200	Petrobras	180	6	2003	2013	10
Lula NE	Santos	2130	Petrobras	120	5	2006	2013	7
Lapa (Carioca)	Santos	2140	Petrobras	100	5	2007	2016	9
Norte Parque das baleias	Campos	1399	Petrobras	180	6	2008	2014	6
Sapinhoá Sul	Santos	1800	Petrobras	120	5	2008	2013	5
Iracema (Cernambi) Sul	Santos	2210	Petrobras	150	8	2009	2014	5
Iracema (Cernambi) Norte	Santos	2010	Petrobras	150	-	2009	2015	6
Sapinhoá Norte	Santos	2300	Petrobras	150	6	2010	2014	4
Tartaruga Mestiça	Campos	934	Petrobras	180	3.5	2010	2018	8
Tartaruga Verde	Campos	976	Petrobras			2009	2017	8
Franco (Buzios) 1	Santos	1889	Petrobras	150	7	2010	2016	6
Franco (Buzios) SW	Santos	1889	Petrobras	150	7	2010	2016	6
Carcará	Santos	2160	Petrobras	-	-	2012	2018	6

Average Duration (general)	7.07
Average Duration (discoveries since 2008)	6.00

Source: **IHS Connect**

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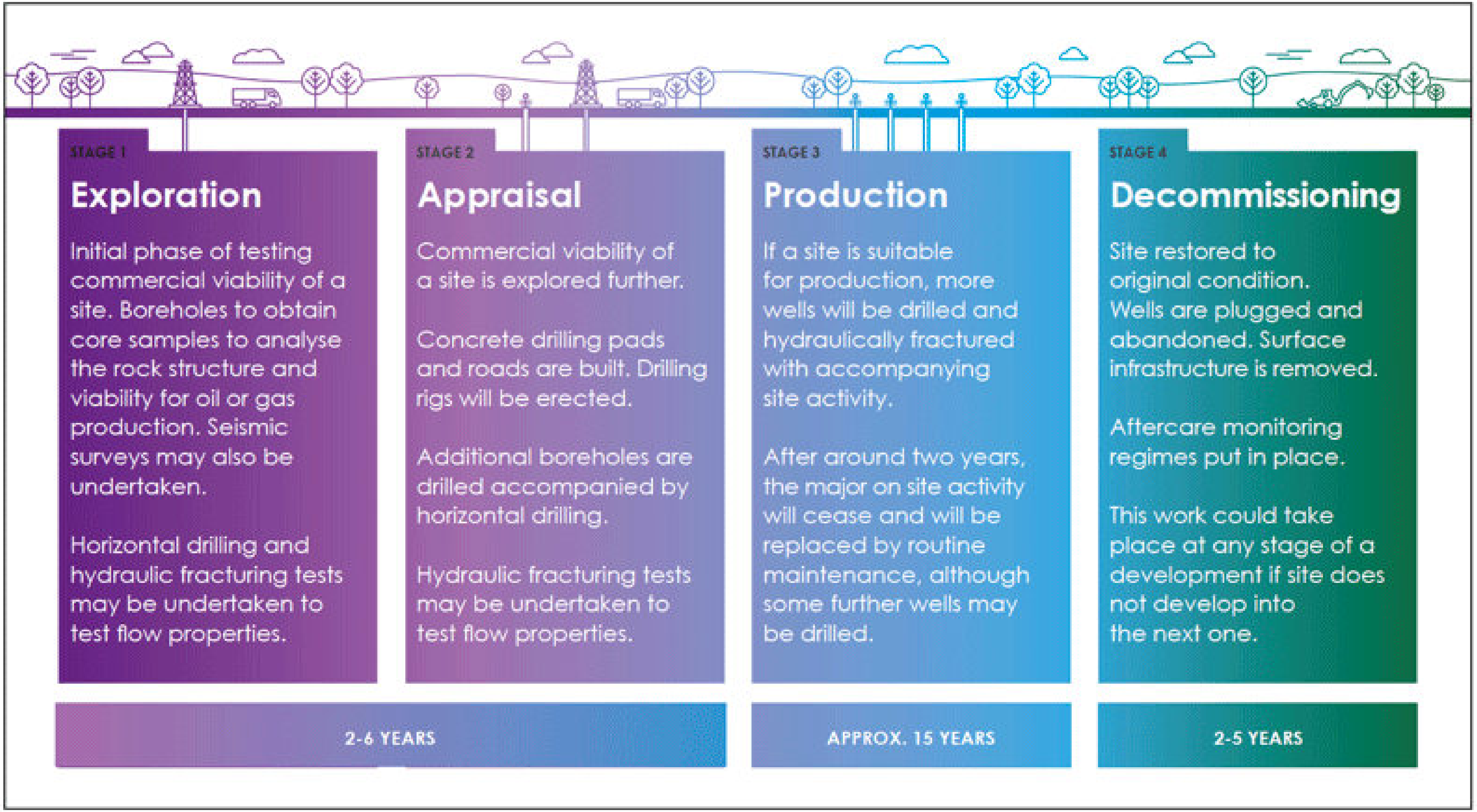
Technological risks and challenges in the Upstream industry



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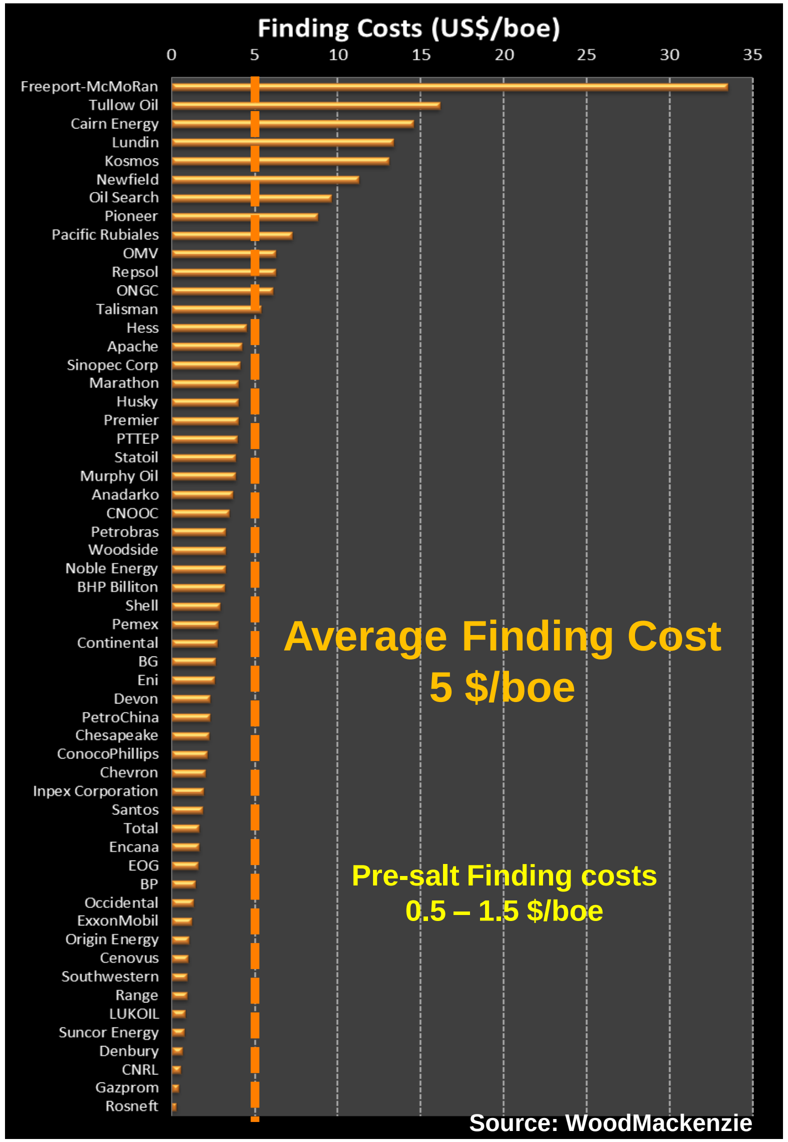
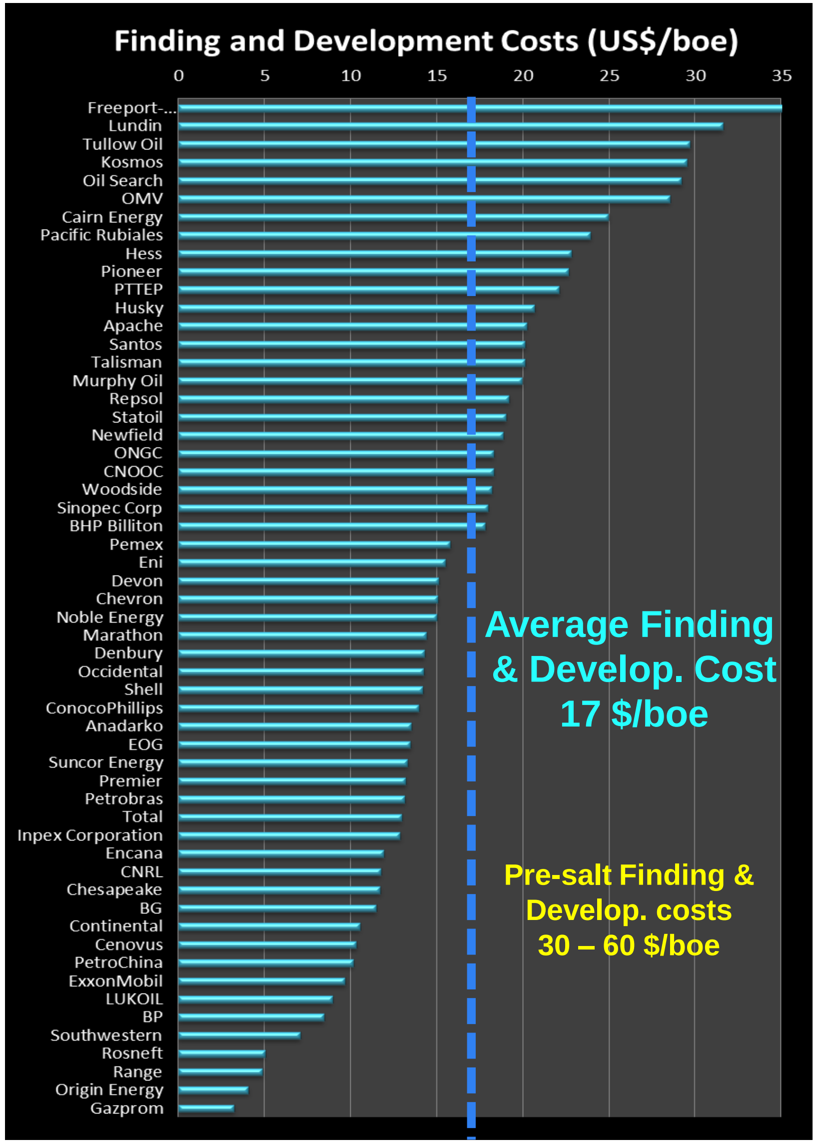
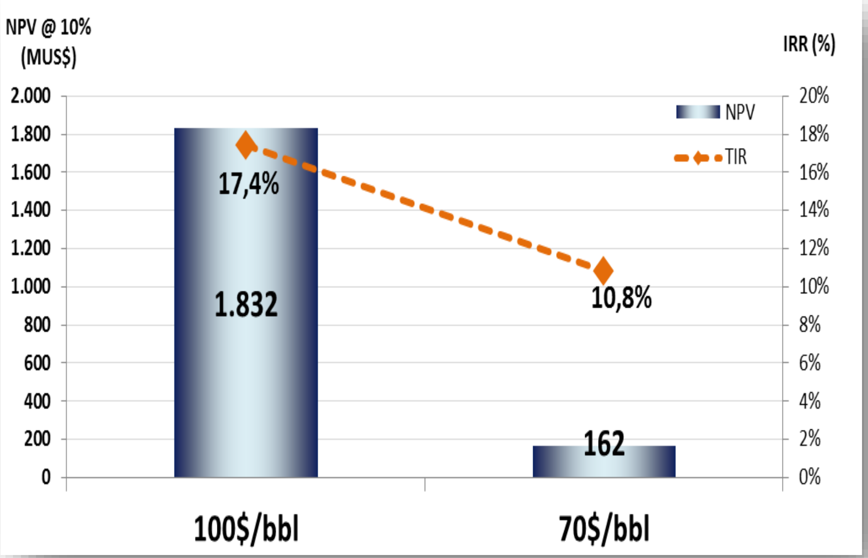
Technological risks and challenges in the Upstream industry

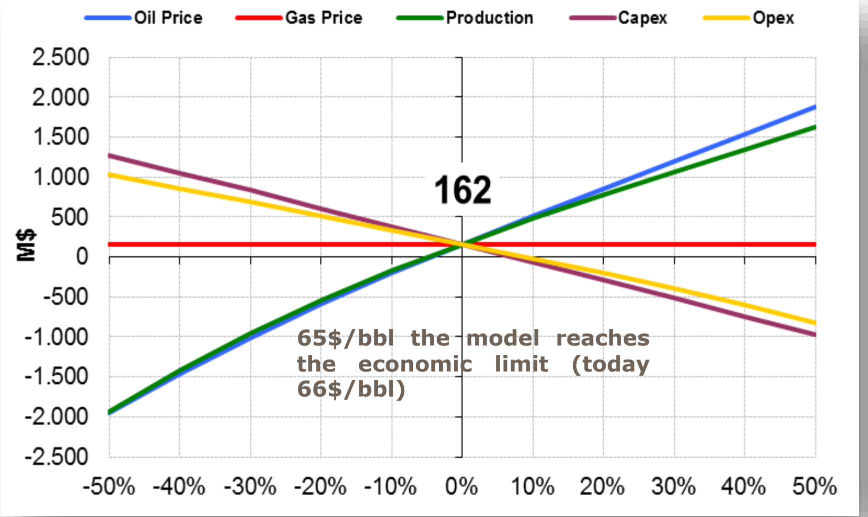
How much does it cost to find oil ?

Break-even costs









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Technological risks and challenges in the Upstream industry

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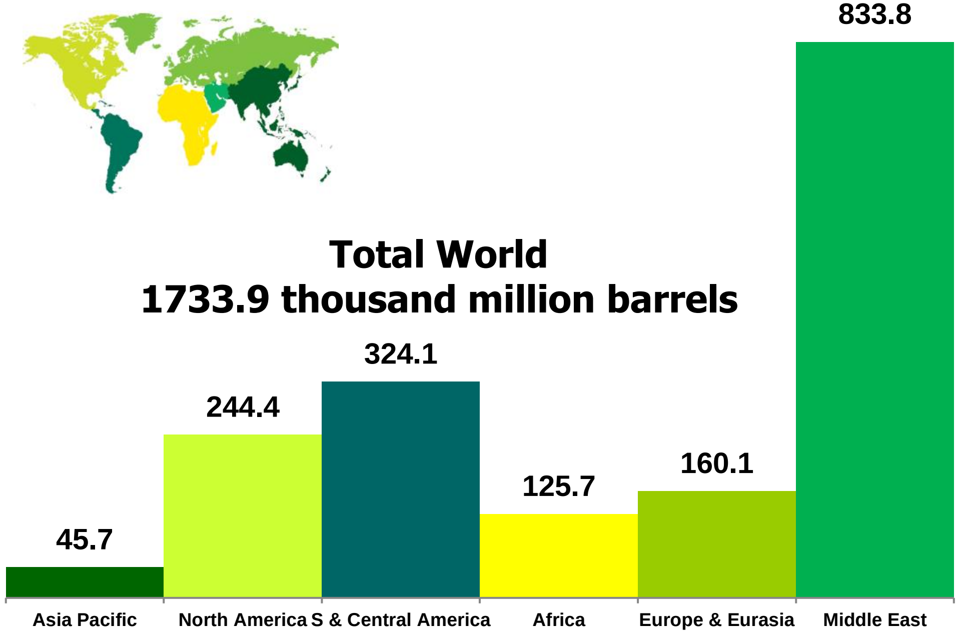
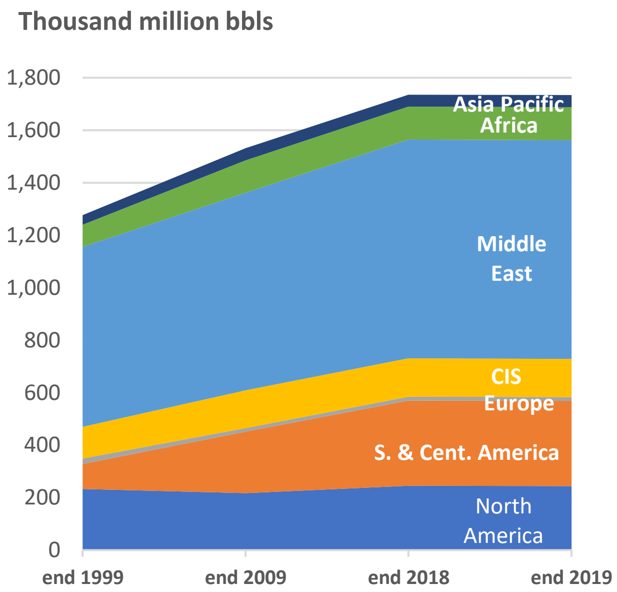
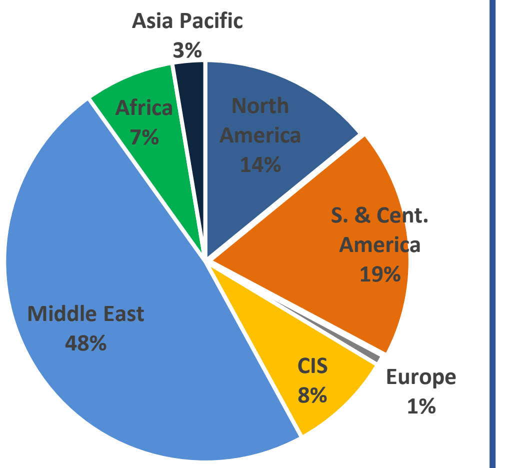
How much ?



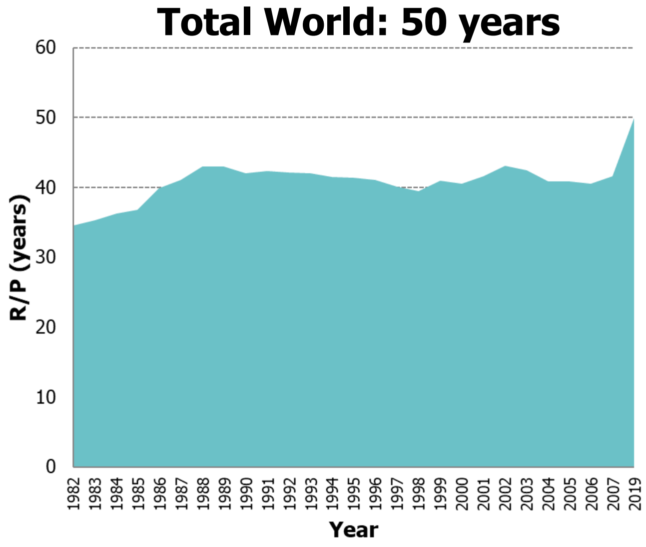
- 26.3% increase in World reserves in the last 20 yrs
- Growth rate per annum is 1.5%
- Middle East kept the leadership
- S. C. America saw big increase due to Brazil pre-salt exploration
- Europe negligible role

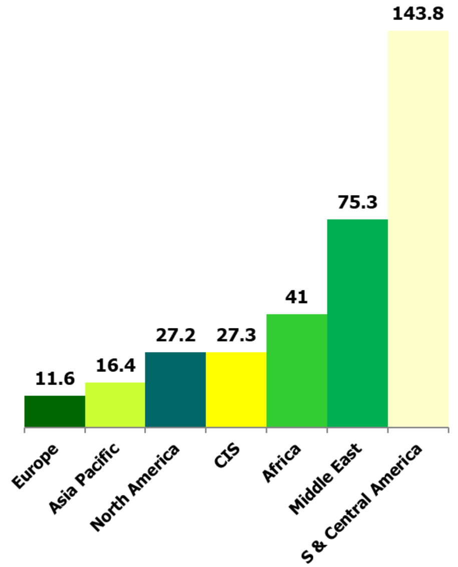
Where ?





For how long ?





PART 2:

Energy Transition and Global changes affecting the E&P industry

Upstream Industry and Energy Transition

Decarbonization: the drivers

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World emissions today

51

billion tons
greenhouse gases/year
(carbon dioxide equivalents)

37

billion tons
CO2/year

Net Zero 2050

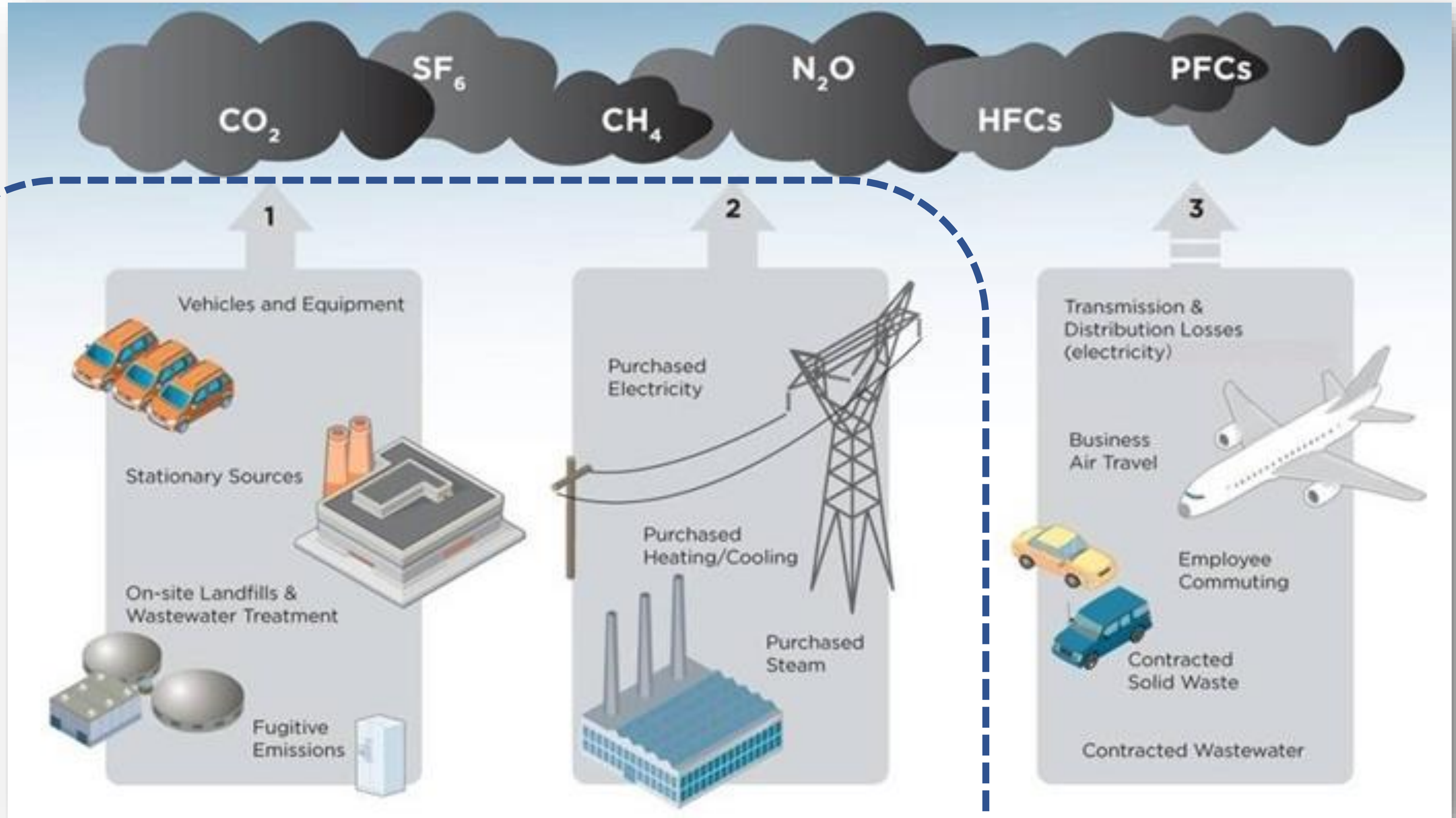
0

billion tons
CO_2/year

Source: WoodMackenzie Report: How to Decarbonize the Upstream Industry

Upstream Industry and Energy Transition

IPCC…



Scope 1
direct greenhouse gas (GHG) emissions that are from sources owned or controlled by the reporting entity.

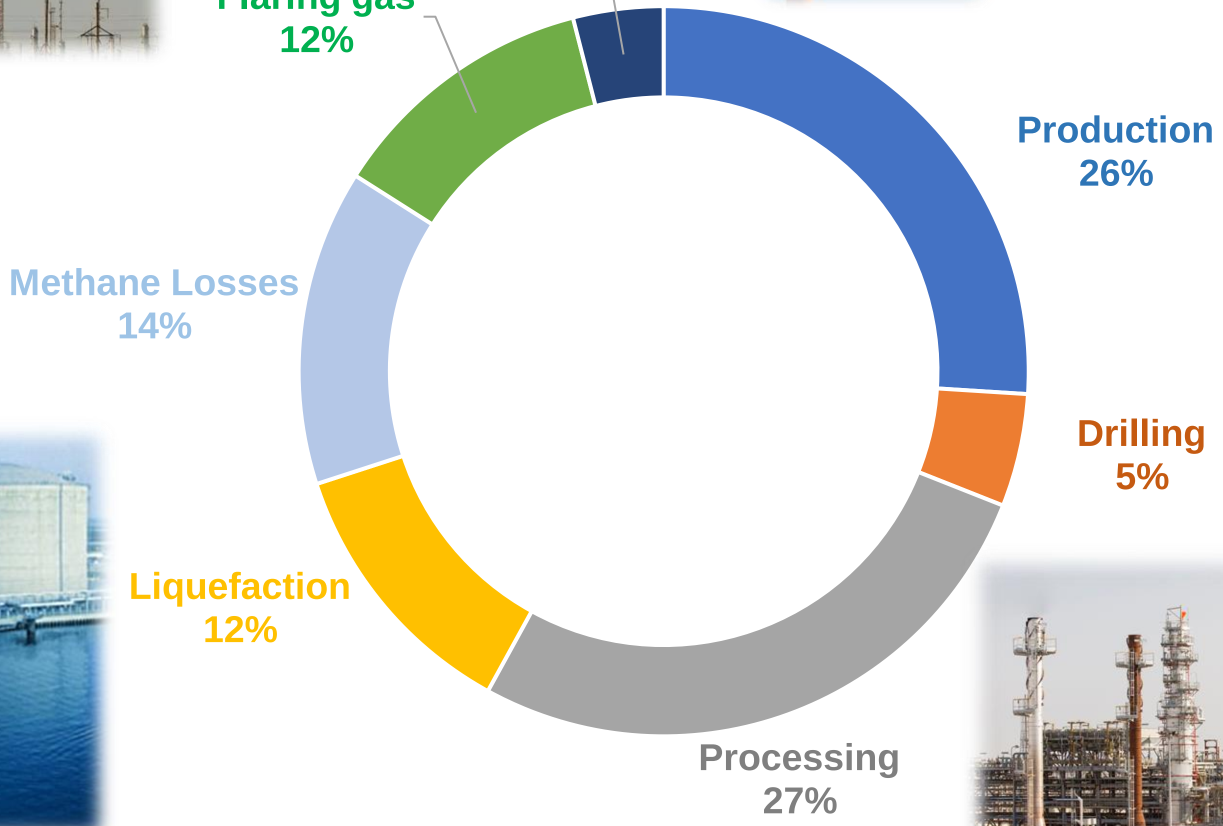
Scope 2
indicates indirect GHG emissions associated with the production of electricity, heat, or steam purchased by the reporting entity.

Scope 3
all other indirect emissions, i.e., emissions associated with the extraction and production of purchased materials, fuels, and services, including transport in vehicles not owned or controlled by the reporting entity, outsourced activities, waste disposal, etc

Upstream Industry and Energy Transition

What are the big sources of upstream emissions ?

A great deal of energy is required to extract and process oil and gas – power needed to drill wells, so well depth and length are factors; artificial recovery for certain types of reservoirs, mature fields or heavy oil; and the quality of hydrocarbons – oil sands require a lot of processing before they can be sold into the market, as does LNG.



Production & Processing
53% emissions

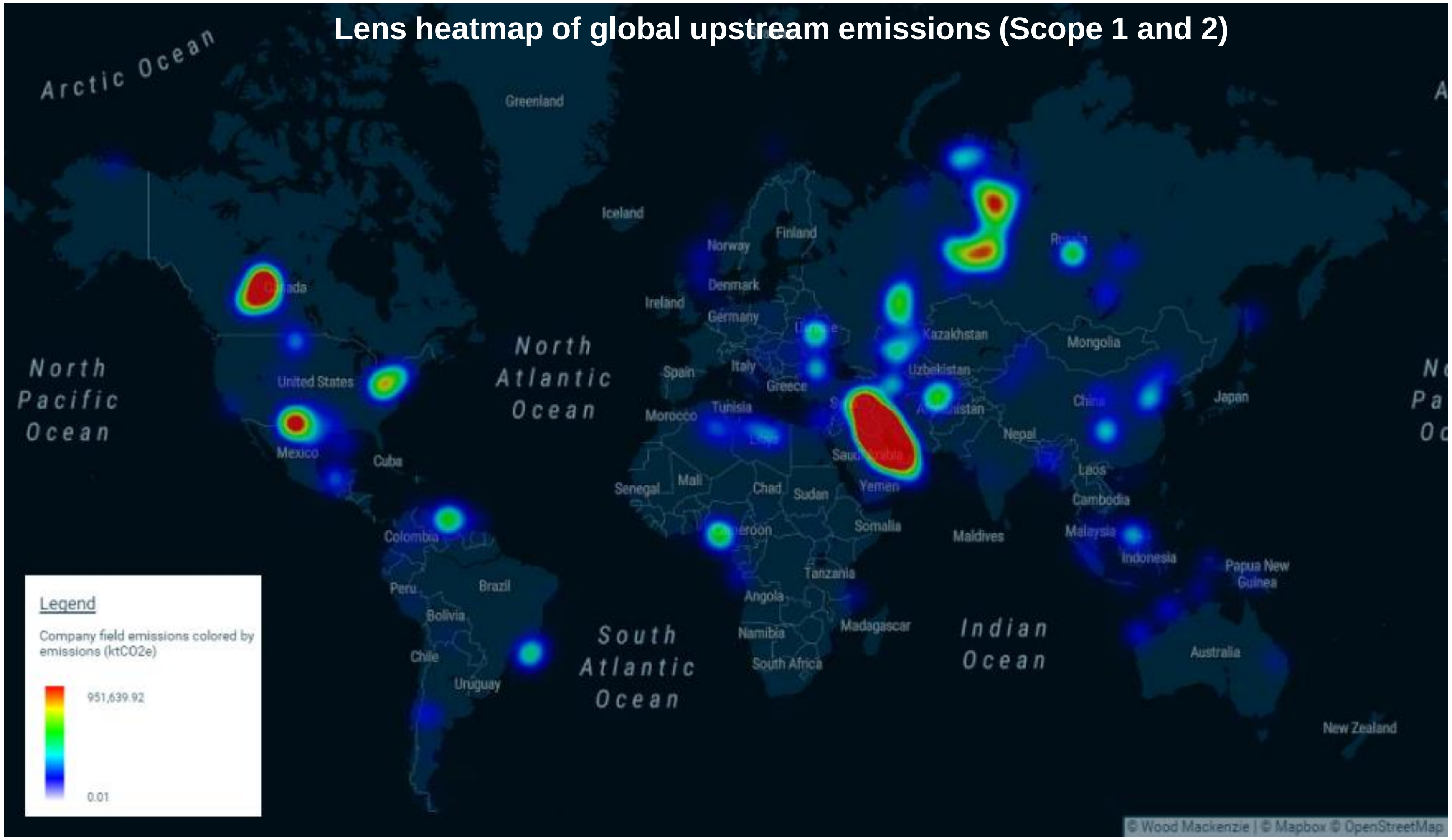
Gas release
methane leakages, venting and flaring
30% emissions

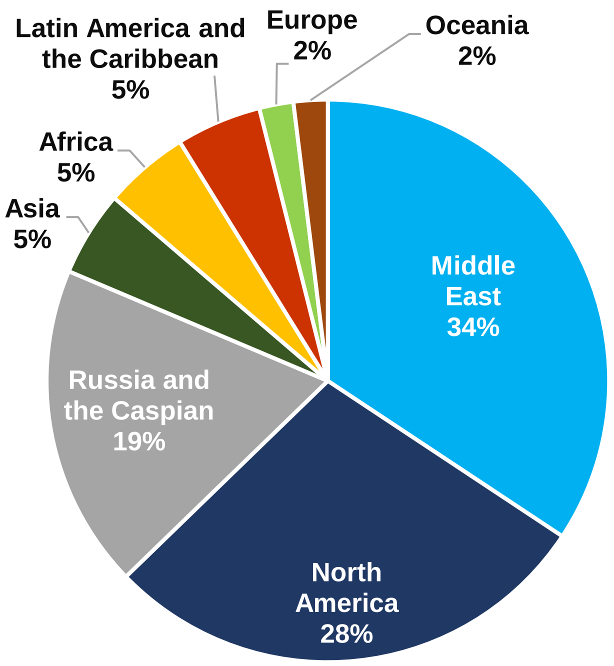
Source: Wood Mackenzie, The Edge, 24/6/2021

Upstream Industry and Energy Transition

Do emissions vary by region?

Total upstream emissions are driven by the big three producing regions: Middle East, North America and Russia/Caspian





Source: WoodMackenzie Report: How to Decarbonize the Upstream Industry

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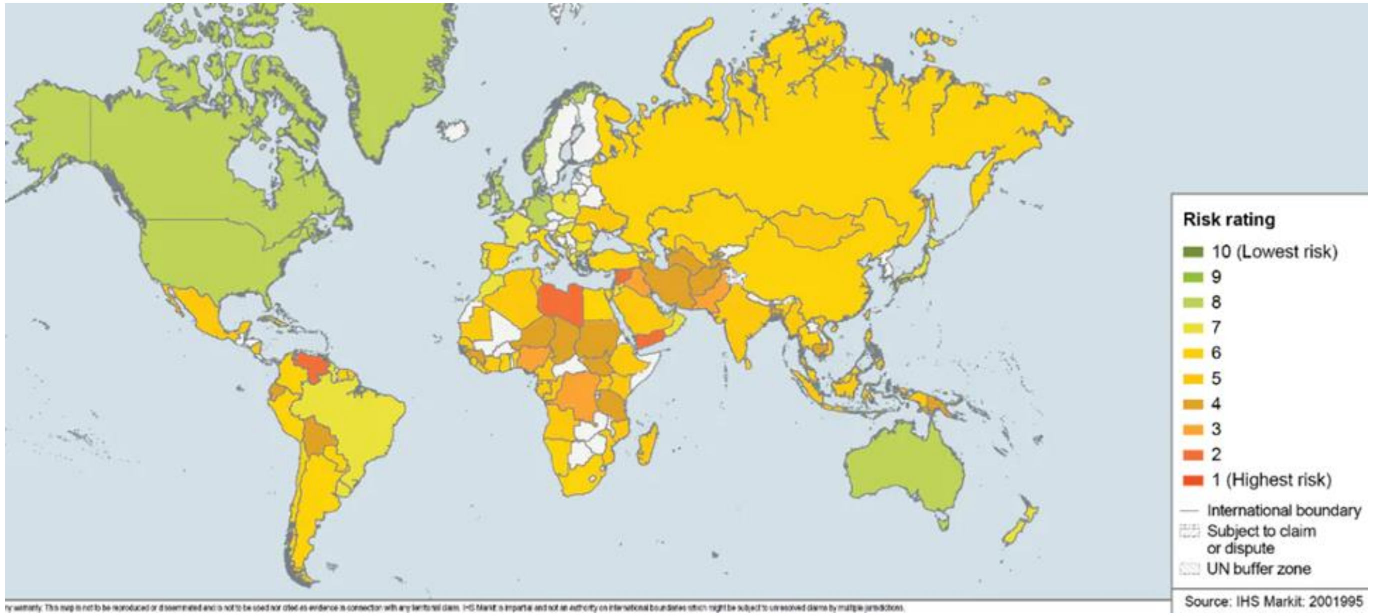
What's the motivation to cut emissions?

The upstream above-ground risk environment varies dramatically across the 118 countries rated by IHS Markit E&P Terms and Above-ground Risk.



The expectation of a modest (albeit potentially volatile) recovery for oil and gas markets in 2021 is good news for E&P investors and governments of hydrocarbon-producing states alike, but the outlook is not without serious above-ground risks.

- **Shifting geopolitical dynamics**
- **climate change mitigation efforts**
- **energy transition pressures**
- **intensifying political, economic, and social challenges** in a number of producing states will drive changes to the above-ground investment environment, creating new risks alongside the potential for new opportunities.

Ultimately, the social licence to operate is at risk.
It's already getting harder to access finance, and stakeholder pressure is intensifying.

LNG is the canary in the mine. A number of LNG buyers in the last year have started to insist sellers include detailed reporting of emissions, from wellhead to berth, for LNG cargoes. It's a trend that will become prevalent in LNG, and we expect all oil and gas operators will have to go down this path to make their production marketable.

Source: Wood Mackenzie, The Edge, 24/6/2021

Upstream Industry and Energy Transition

...what about the future ?

What we know about energy transition.....

....what is yet to be understood!

Thank you !