Exploration Activity in the Oil & Gas Upstream Cycle

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Eni, San Donato Milanese (Italy)

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Eni…in brief

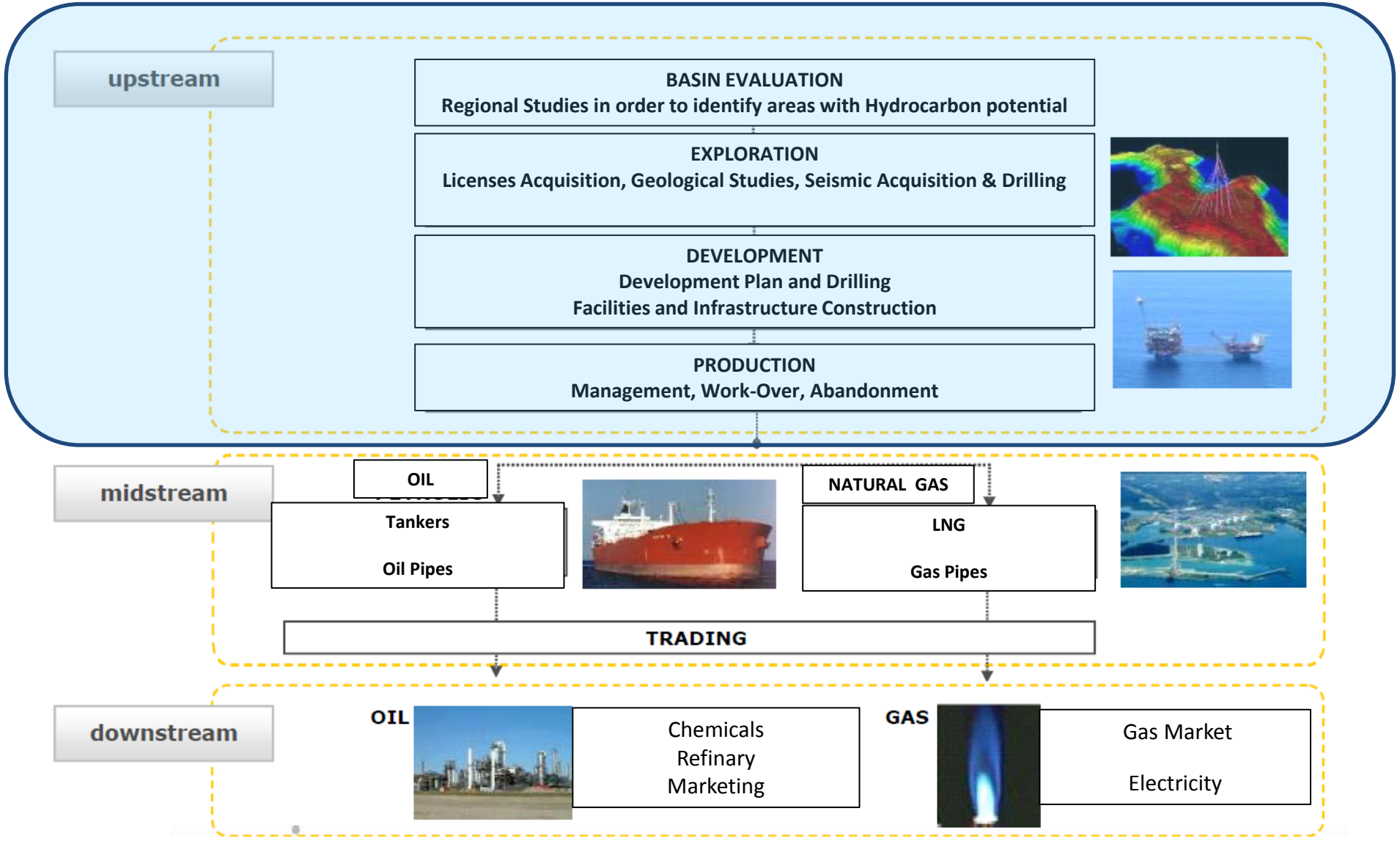
- Founded in 1953 by Enrico Mattei, Eni (Ente Nazionale Idrocarburi) is a supermajor multinational energy company with a worldwide presence

- Operating in all energy sector areas, from its traditional Oil and Gas business to renewables through its subsidiaries and associated companies. Significant investments in Research and Development (over 200 R&D Projects at present)

- Continuous growth oriented towards the sustainable development of energy resources (low-carbon sources: mix of natural gas and renewables, such as photovoltaic, waste recycling, bio-refineries, green chemistry, etc). Investments in CCS (Carbon Capture Sequestration) and CSP (Concentrated Solar Power) and Magnetic-onfinement fusion (with MIT)

- Core activities of Oil & Gas sector cover the entire Oil and Natural Gas supply chain as well the production and marketing of electricity and chemical products

Oil & Gas Cycle: Eni covering the entire chain

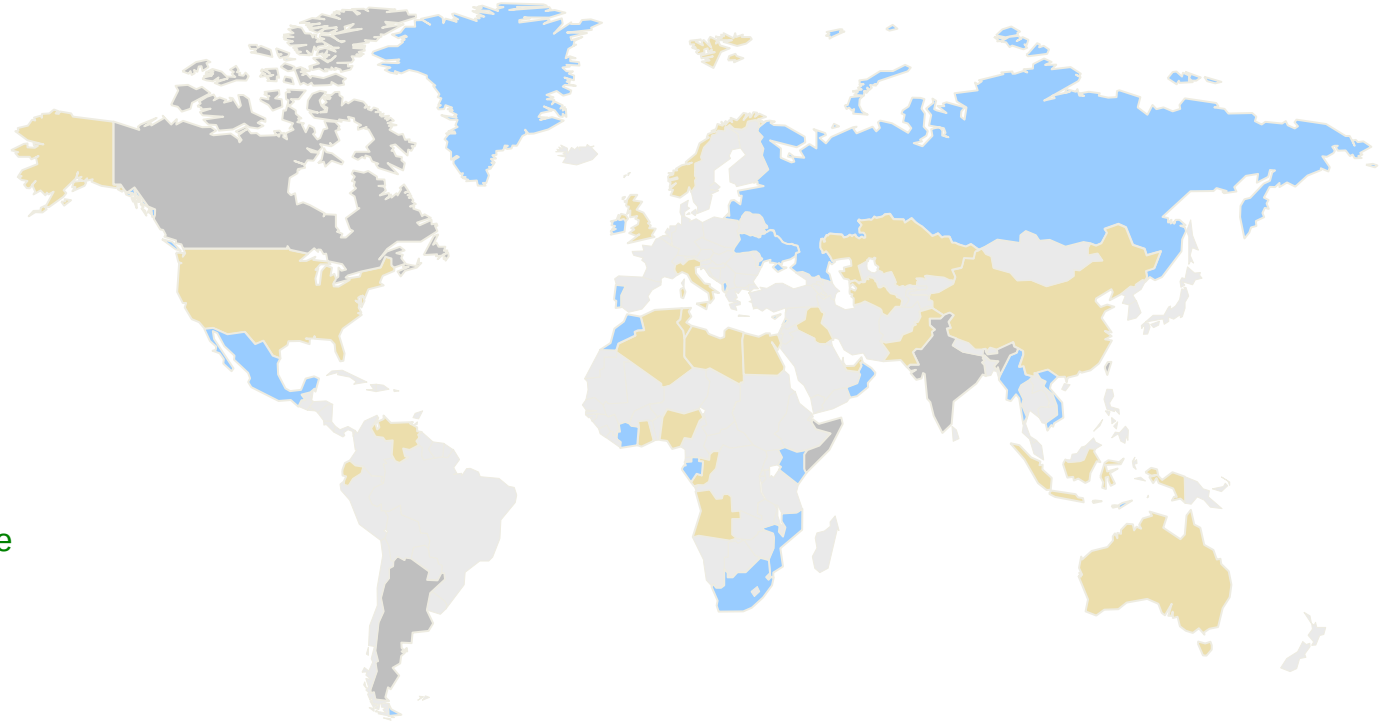


Eni in the world (Upstream Activity)

46 Countries

Exploration only

Argentina
Canada
Cyprus
Gabon
Greenland
India
Ivory Coast
Ireland
Kenya
Lebanon
Mexico
Montenegro
Morocco
Mozambique
Myanmar
Oman
Portugal
Russia
Somalia
South Africa
Taiwan (FM)
Timor Leste
Ukraine
Vietnam

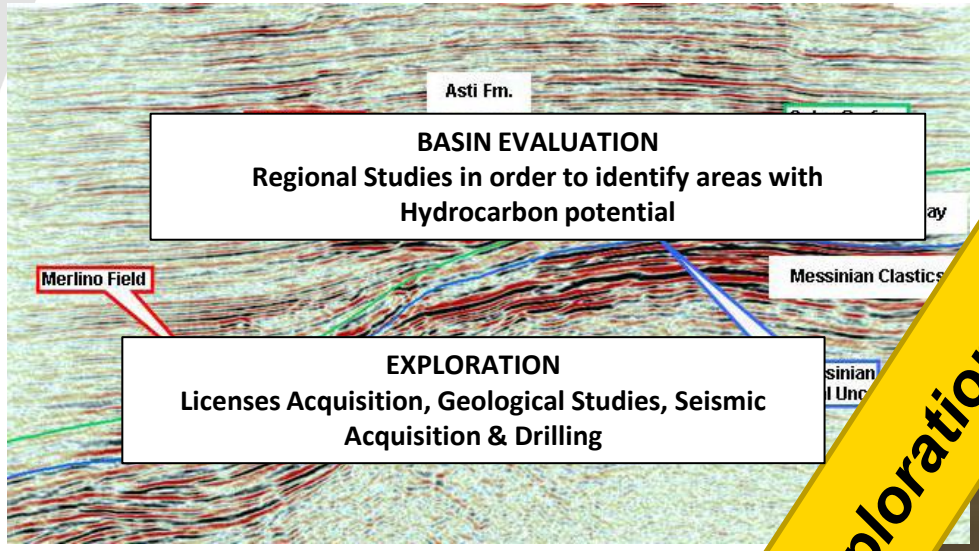


Exploration & Production

Algeria
Angola
Australia
China
Congo
Ecuador
Egypt
Ghana
Kazakhstan
Indonesia
Iraq
Italy
Libya
Nigeria
Norway
Pakistan
Tunisia
Turkmenistan
UAE
UK
USA
Venezuela

updated @ Dec. 31st, 2018

Oil & Gas Activity: Upstream



BASIN EVALUATION
Regional Studies in order to identify areas with Hydrocarbon potential

EXPLORATION
Licenses Acquisition, Geological Studies, Seismic Acquisition & Drilling

Exploration

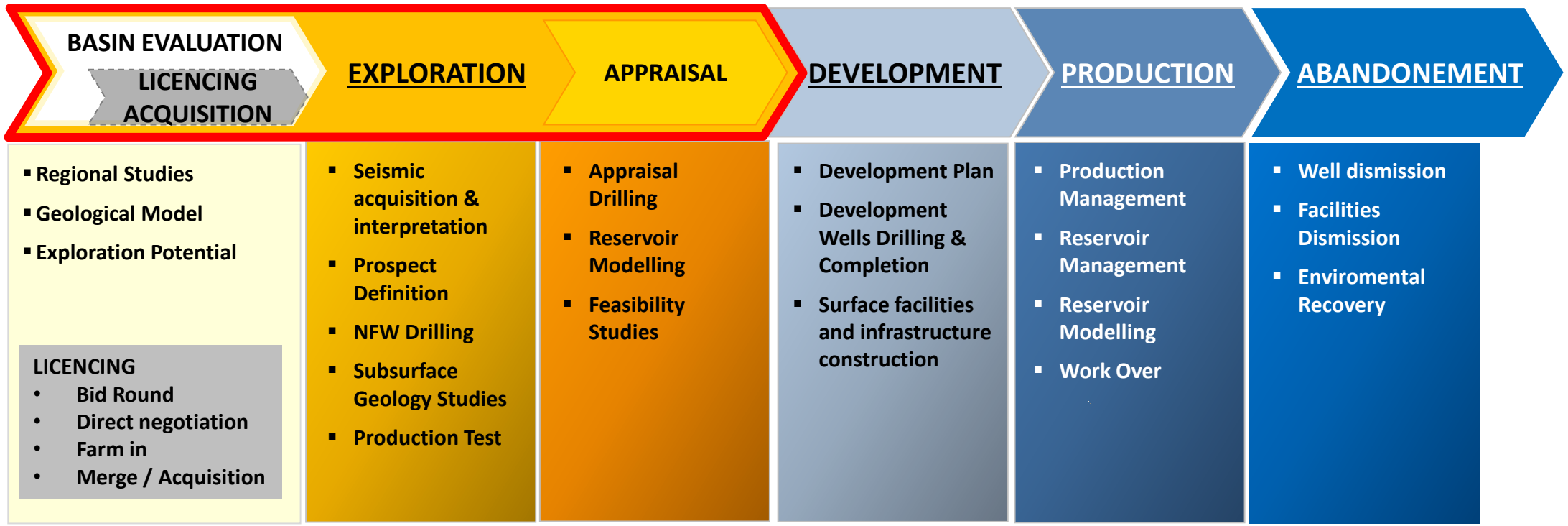
Production

PRODUCTION
Reservoir Management, Work-Over, Abandonment

Development

DEVELOPMENT
Development Plan and Drilling
Facilities and Infrastructure Construction

Upstream Activity Cycle



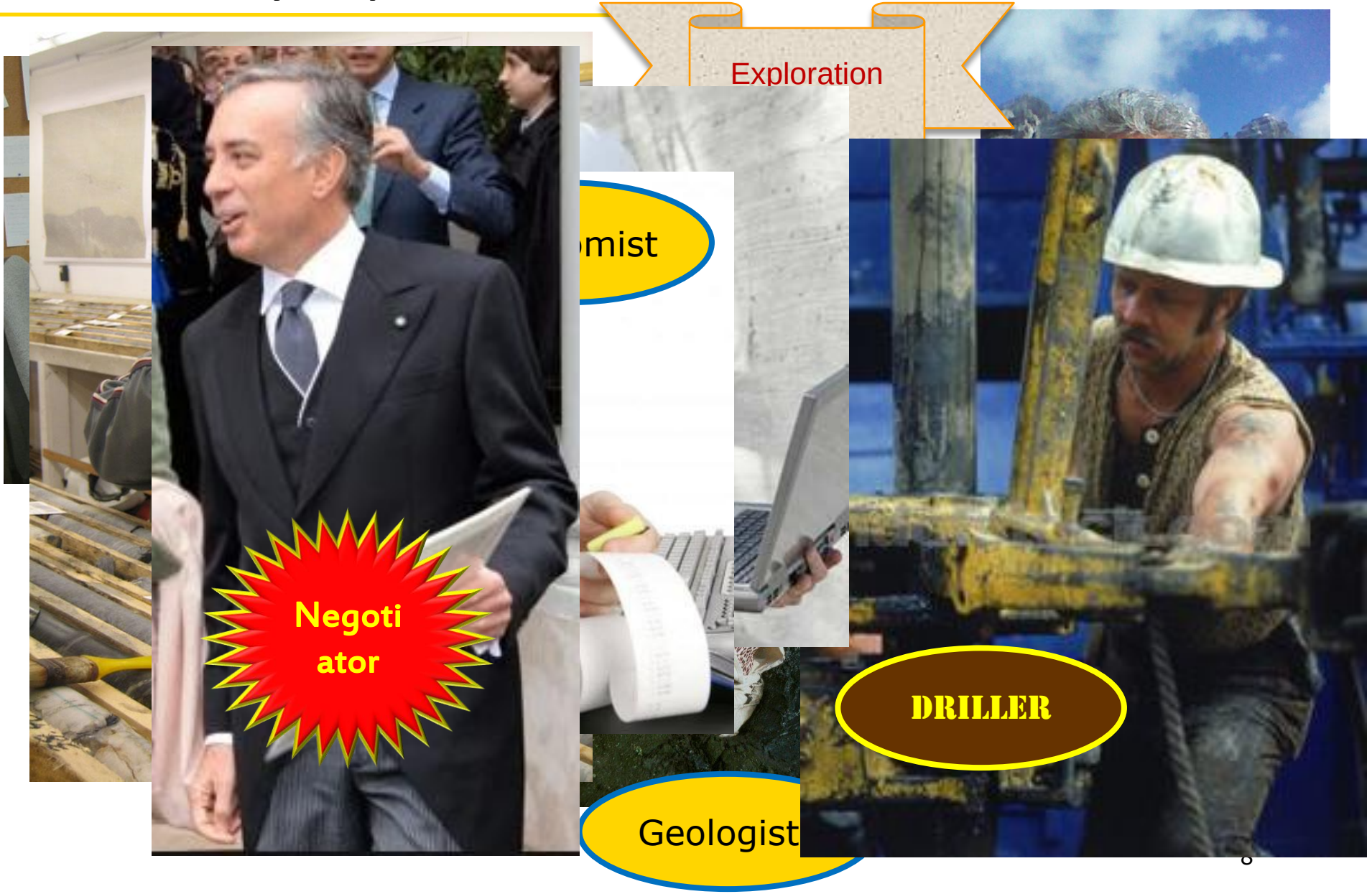
What does “Exploration” mean?

- “Exploration” is a set of coordinated activities from different integrated disciplines, sciences and technologies - not only geology/geophysics – aiming at discovering new oil and gas volumes that could be exploited in a “reasonable” future with an economic return

- To explore, one needs to understand and carefully map the present day subsurface structure of an area, understand its evolution in time, locate the areas where HC’s may be generated, locate and accurately map the structures in which they may be preserved, estimate their volumes, evaluate the chances that our prediction have to be correct…

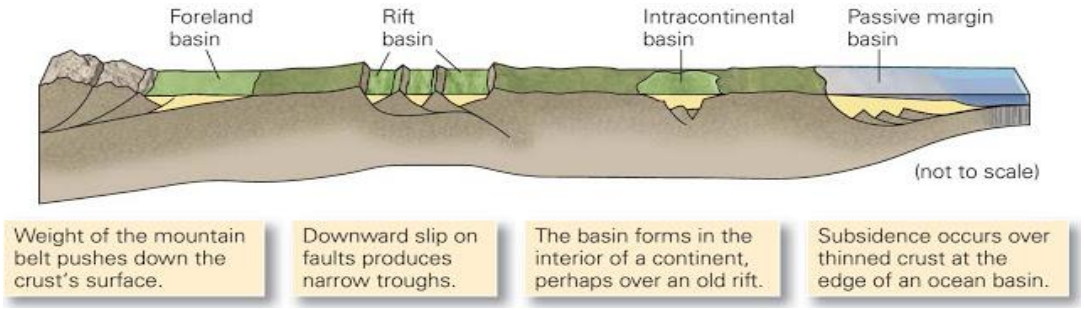
- To achieve such a target in the most efficient way, high level skills and know-how have to be employed together through a powerful digitally integrated approach and along the support of dedicated R&D projects

Exploration Activity : Exploration Team



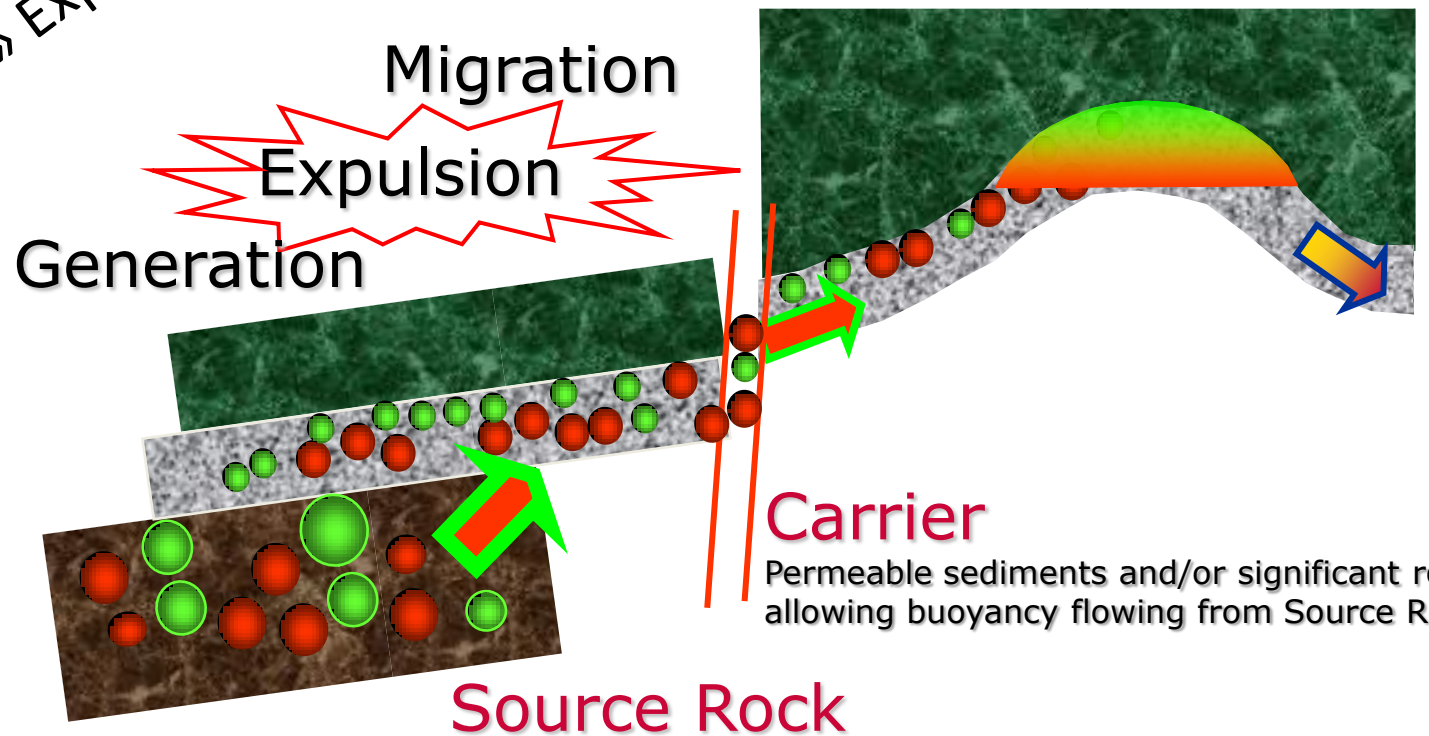
Where do we “explore” to find Hydrocarbons?

Sedimentary Basin are regions of the earth of long term subsidence creating space for infilling by sediments
For Hydrocarbon Exploration deep sedimentary basins are needed (usually over 2500m of sediment thickness)



Within a Sedimentary Basin: the 5 Elements of the “Petroleum System”

«Conventional» Exploration



Trap

Geometrical configuration of the Reservoir and Seal couplet allowing accumulation

Seal

Sediments (usually) with no permeability Capable to create a barrier above and around the reservoir

Reservoir

Sediments (usually) with porosity and Permeability capable to contain and flow HCs during production

Carrier

Permeable sediments and/or significant rock fractures (Faults) allowing buoyancy flowing from Source Rock into Reservoir

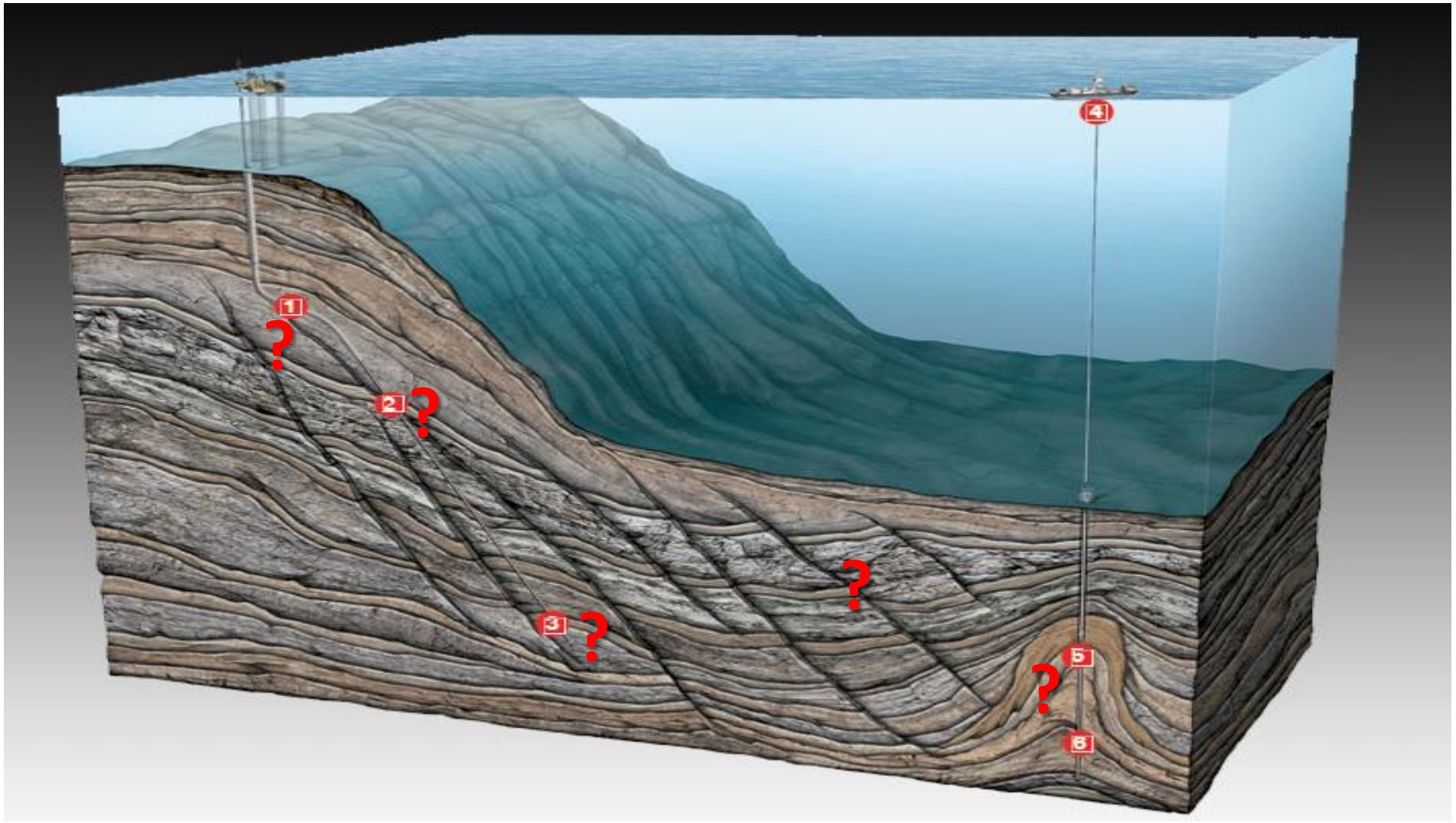
Source Rock

Sediments rich in Organic Matter (shales, marls, carbonates coals) capable to generate HCs during thermal evolution (if deep enough to crack organic matter to HCs). Oil vs Gas generation depends on quality of Source Rock and/or its thermal evolution. Exception: bio-gas (no need of thermal alteration)

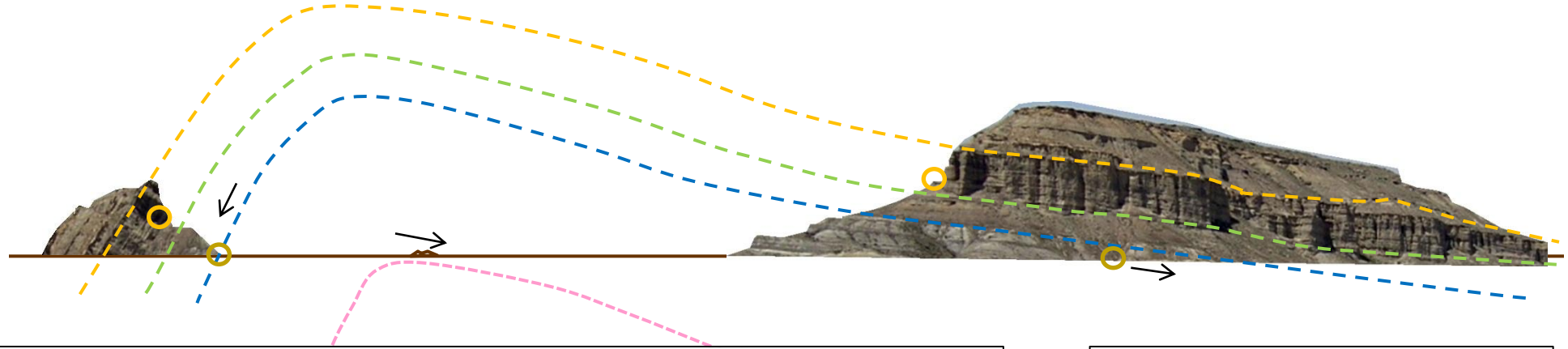
Presence of the 5 Elements of the Petroleum System is necessary but not sufficient: precise timing occurrence of each elements/phase is necessary

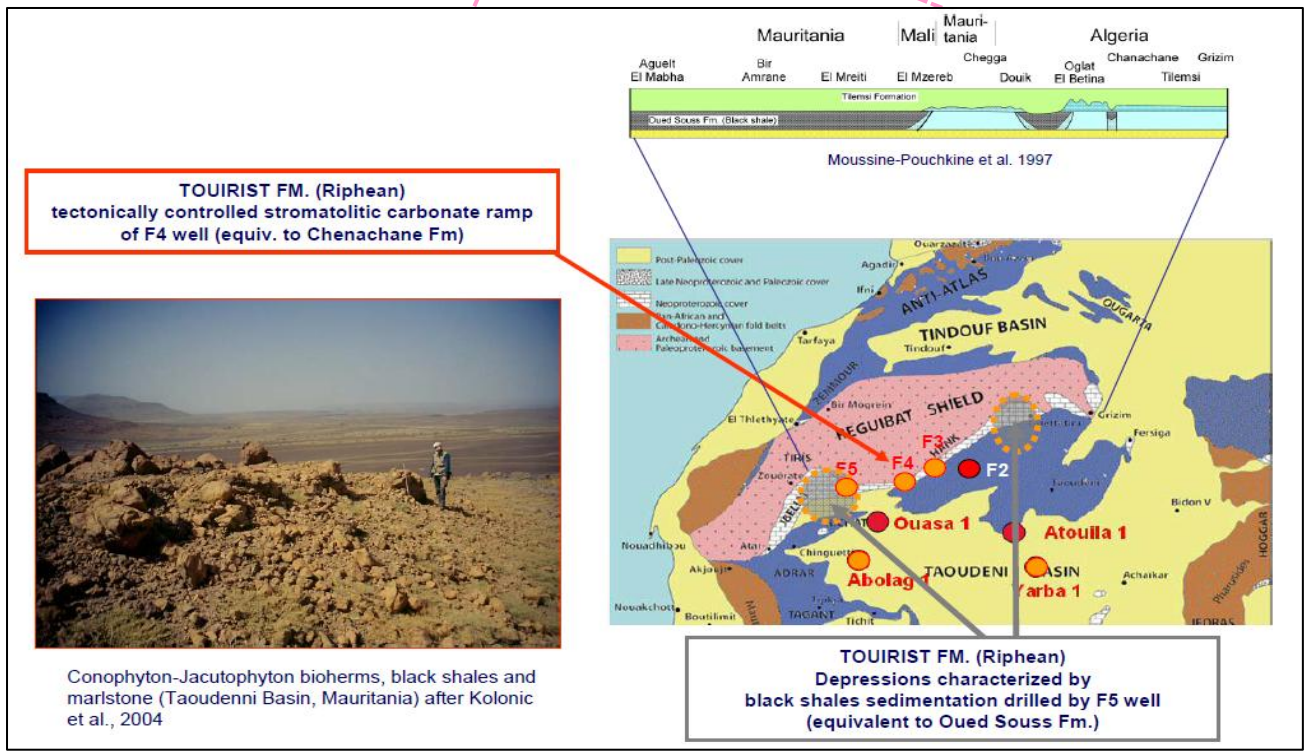
In the Outcrops…

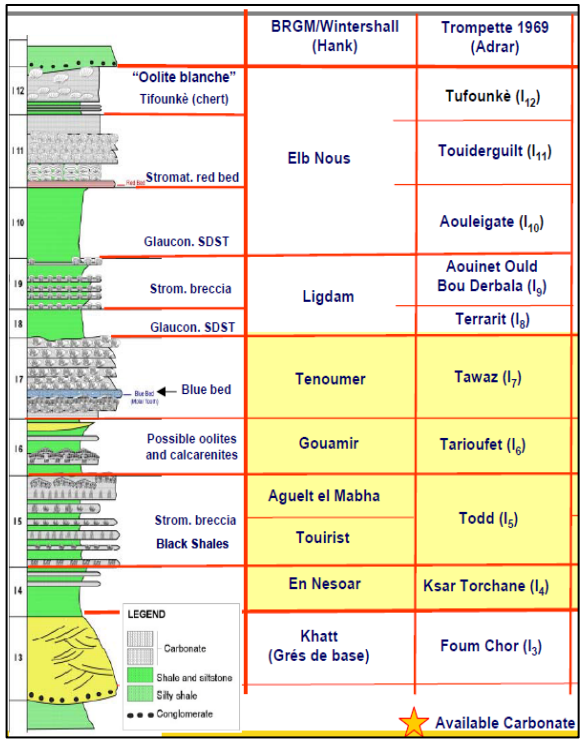
Theory is Ok, but…where to drill and…at which depth???



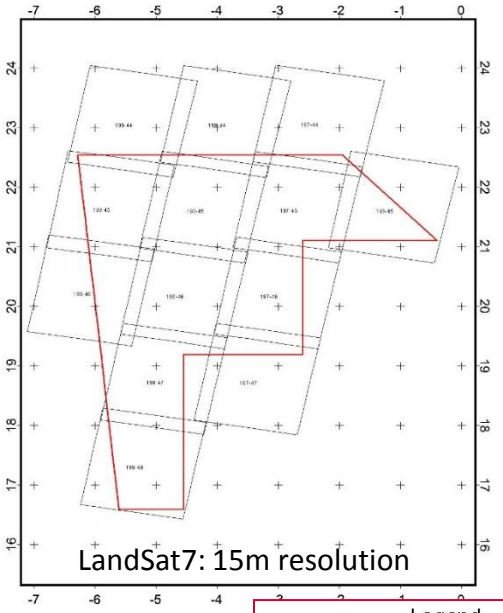
Geological Field Trip Data Analyses and Studies

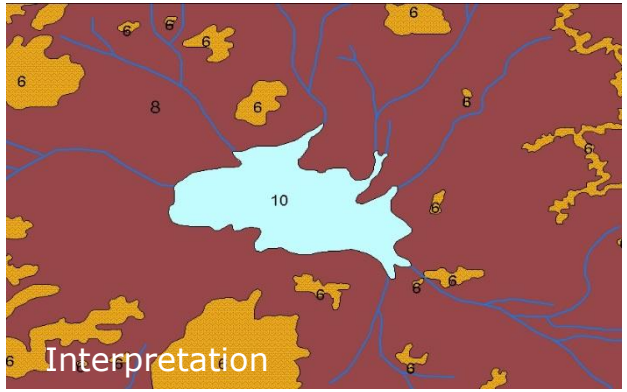


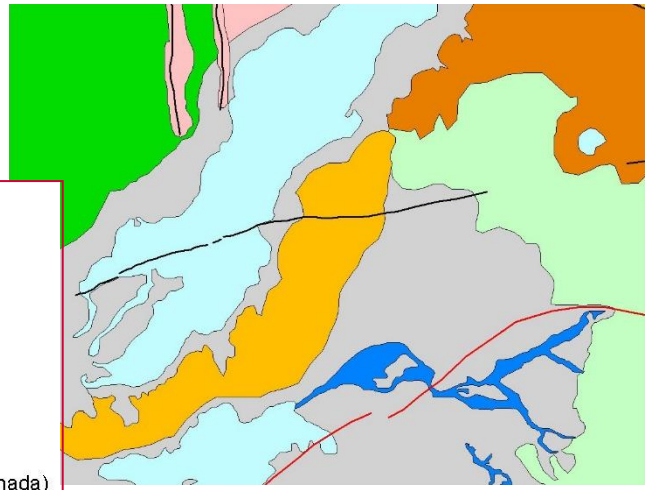




Remote Sensing: LandSat7 and ASTER* Study: Landcover and Lithotype



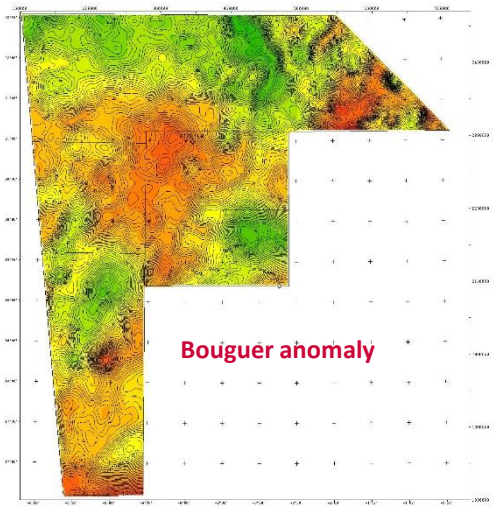




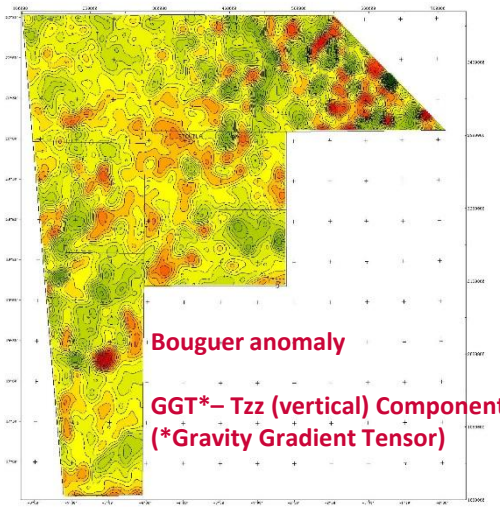
Code	Linear elements
1	Roads, tracks
2	Uadi
3	Linear dunes
4	Rock veins
	Areal classification
1	Urban areas
2	Cropland and oasis
3	Natural vegetation
4	Surface waters
5	Bare land (or with poor vegetation)
6	Rock outcrops
7	Sandy desert (Erg)
8	Rocky desert (Reg)
9	Dry riverbed (Uadi)
10	Evaporitic deposit (Sebkha)

* Advance Space-born Thermal Emission and Reflection Radiometer (2m resolution)

Grav-Mag Acquisition and Studies

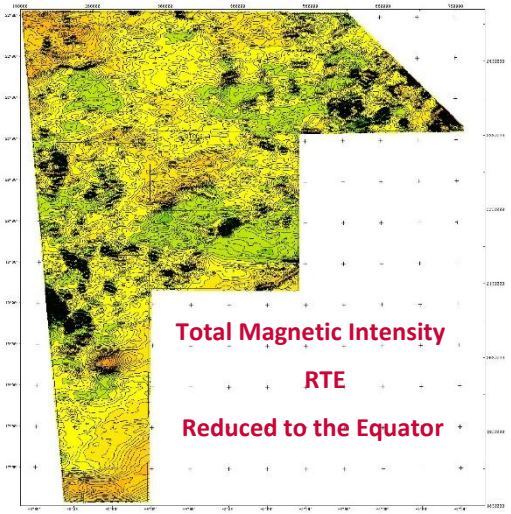


Bouguer anomaly



Bouguer anomaly

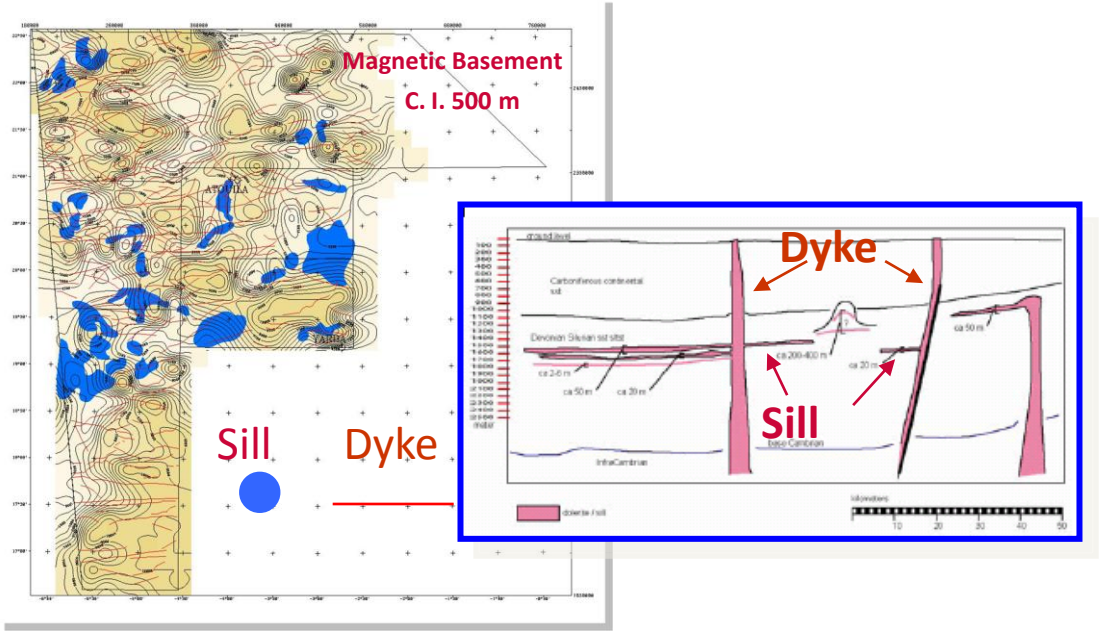
GGT*– Tzz (vertical) Component
(*Gravity Gradient Tensor)



Total Magnetic Intensity

RTE

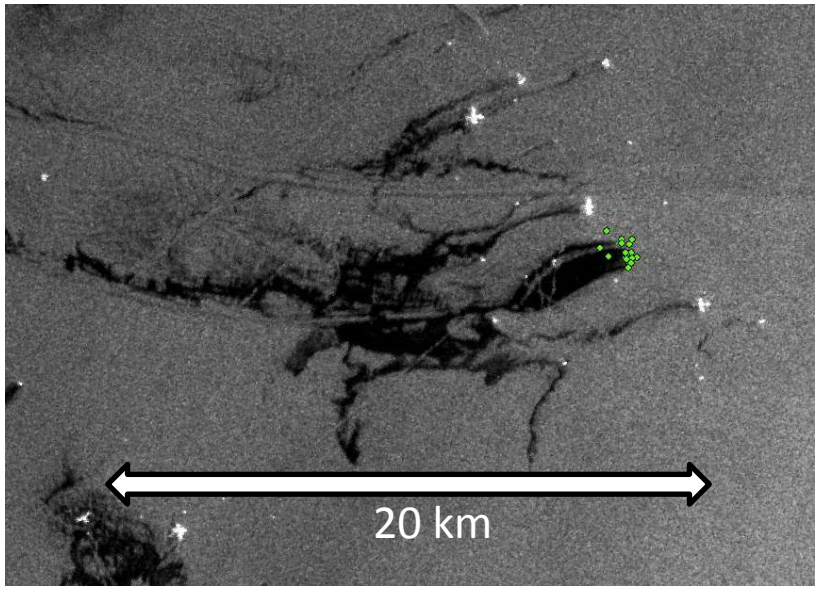
Reduced to the Equator

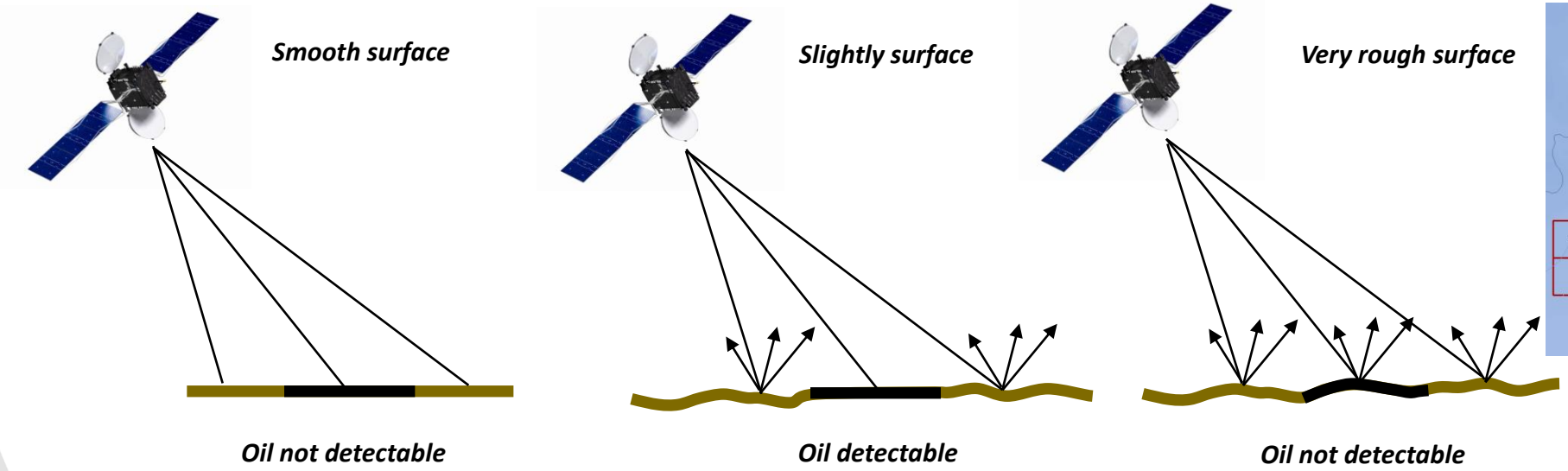


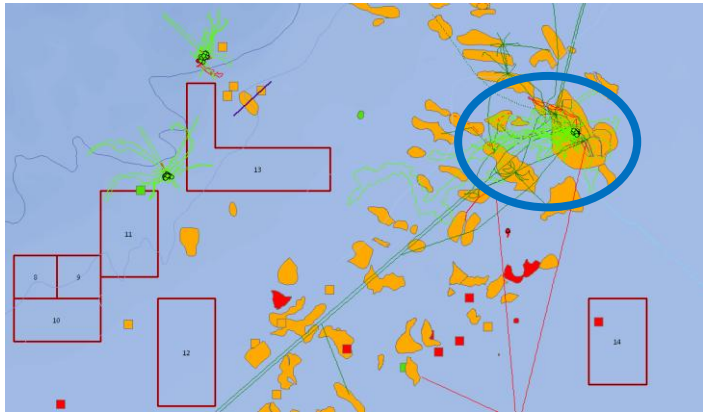
Oil Slicks

Slicks:

- Slicks are ‘flat’ parts of the sea surface in mm-cm amplitudes similar to the wavelength of the radar
- Small amounts of oil create slicks by suppressing mm-cm amplitude waves
- Smooth areas (slicks) result in no return to the radar
- ERS, Radarsat & Envisat wavelength: 5.6 cm
- This is perfect for mapping the wind-generated capillary waves that are ‘damped’ by oil

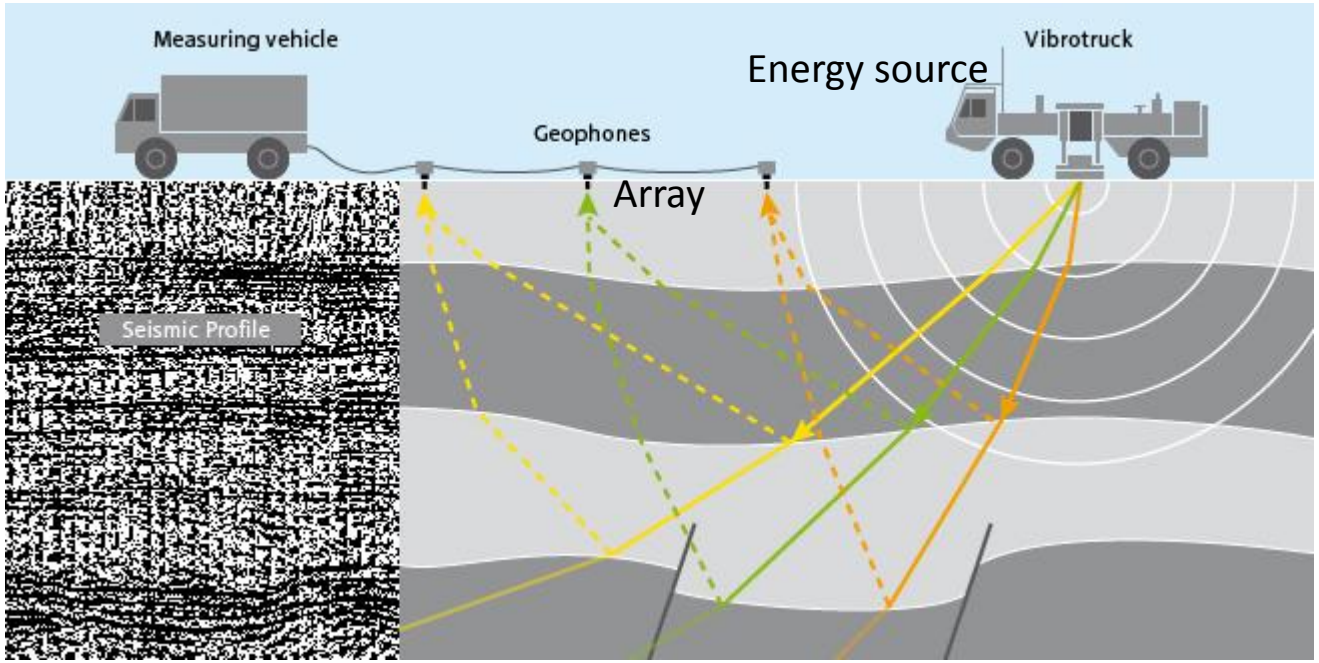


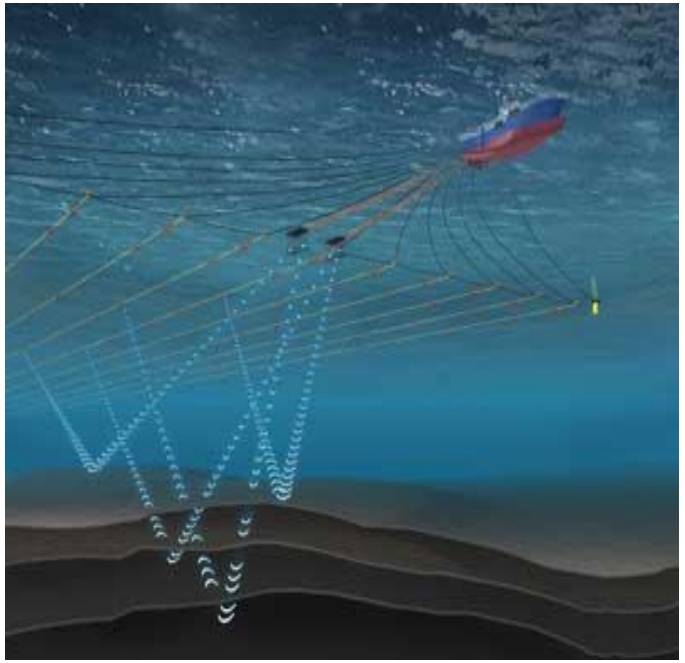




Seismics

- Seismic is the most important and most used exploration tool
- It allows visualizing and describing the subsurface in 3 dimensions
- Acquired seismic signals require complex mathematical processing (months-long) before they can be displayed in an “understandable” way and used by geologist for interpretation
- «Migration» is referred to the processing step that allows reflections’ origins to be correctly located and displayed in a way that mimics a geological profile on a two-way-time scale

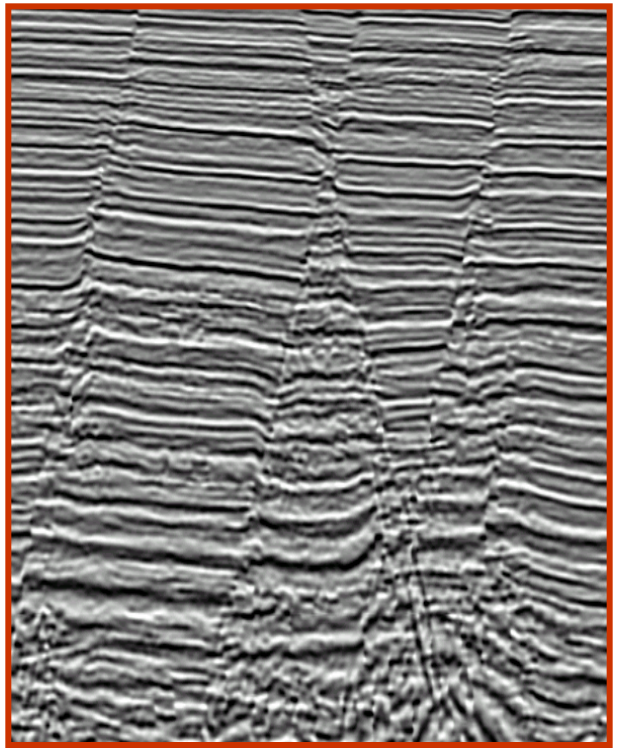




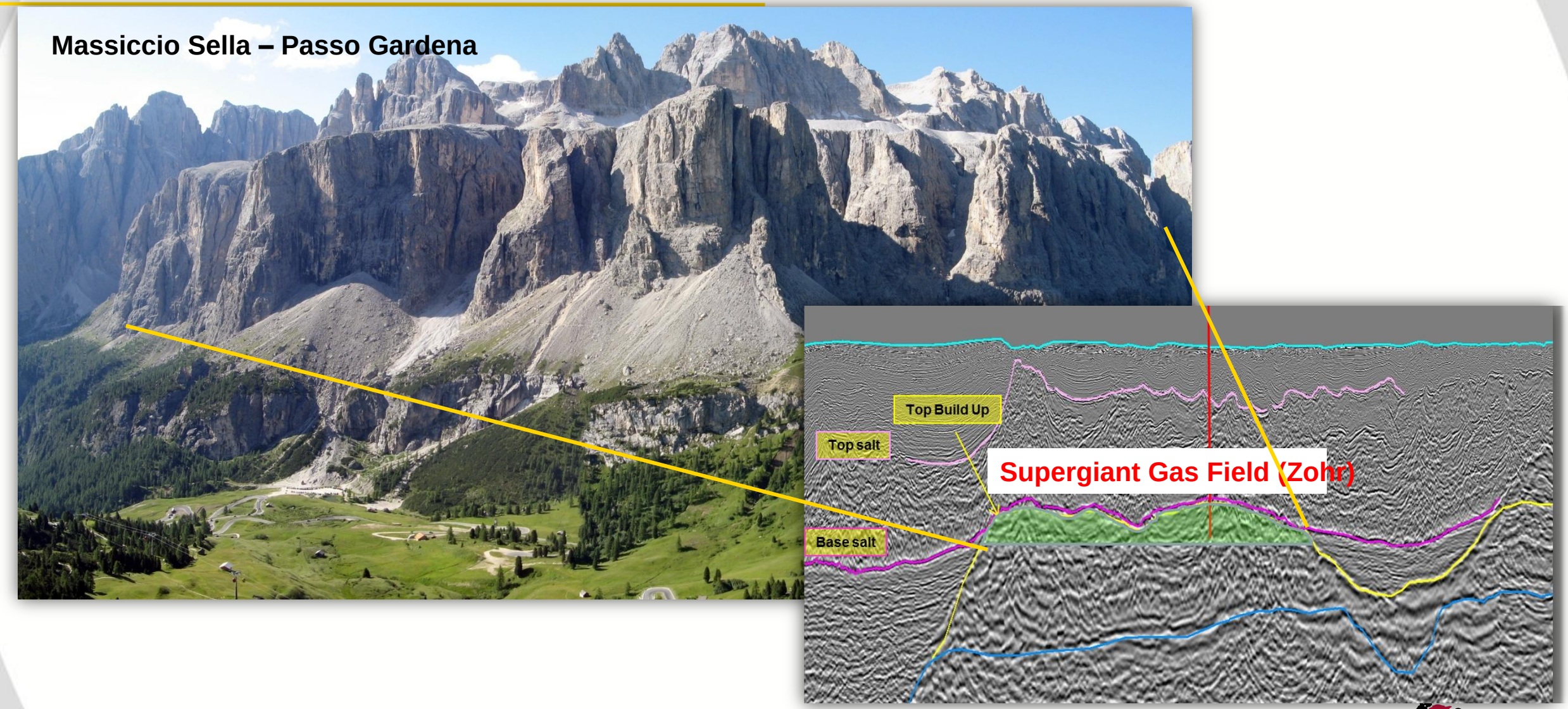
What Is a Seismic Volume?

It looks like a 3D echography,
but at a different scale (resolution: dam vs. mm)

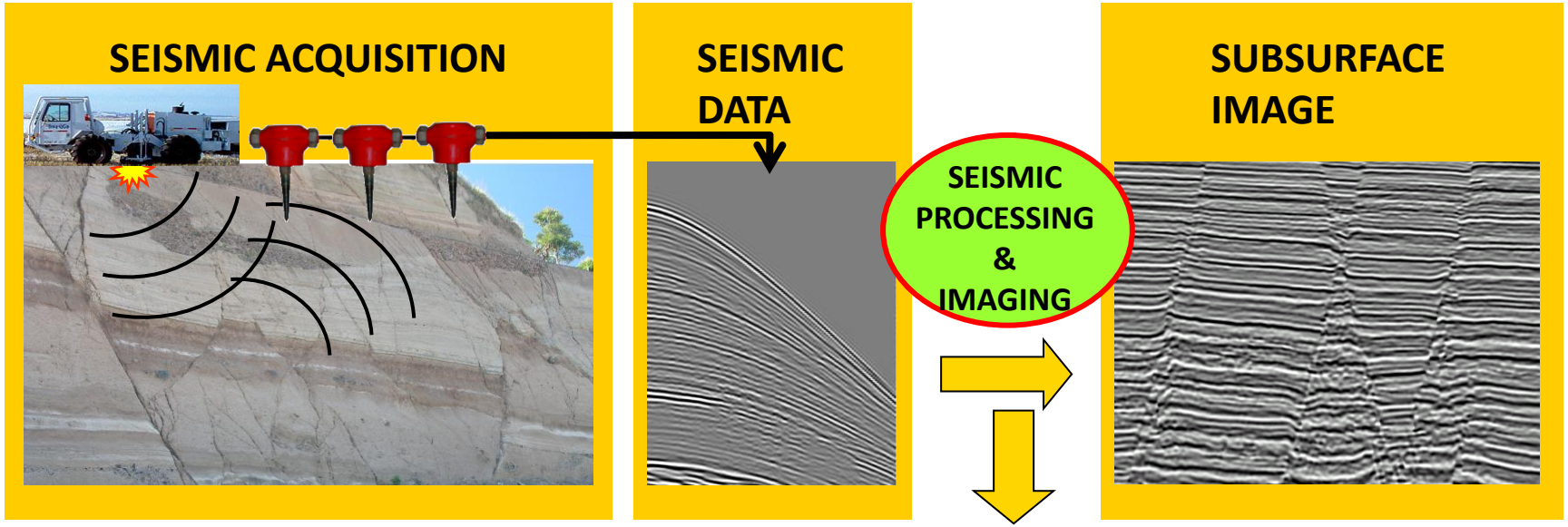
Define Subsurface

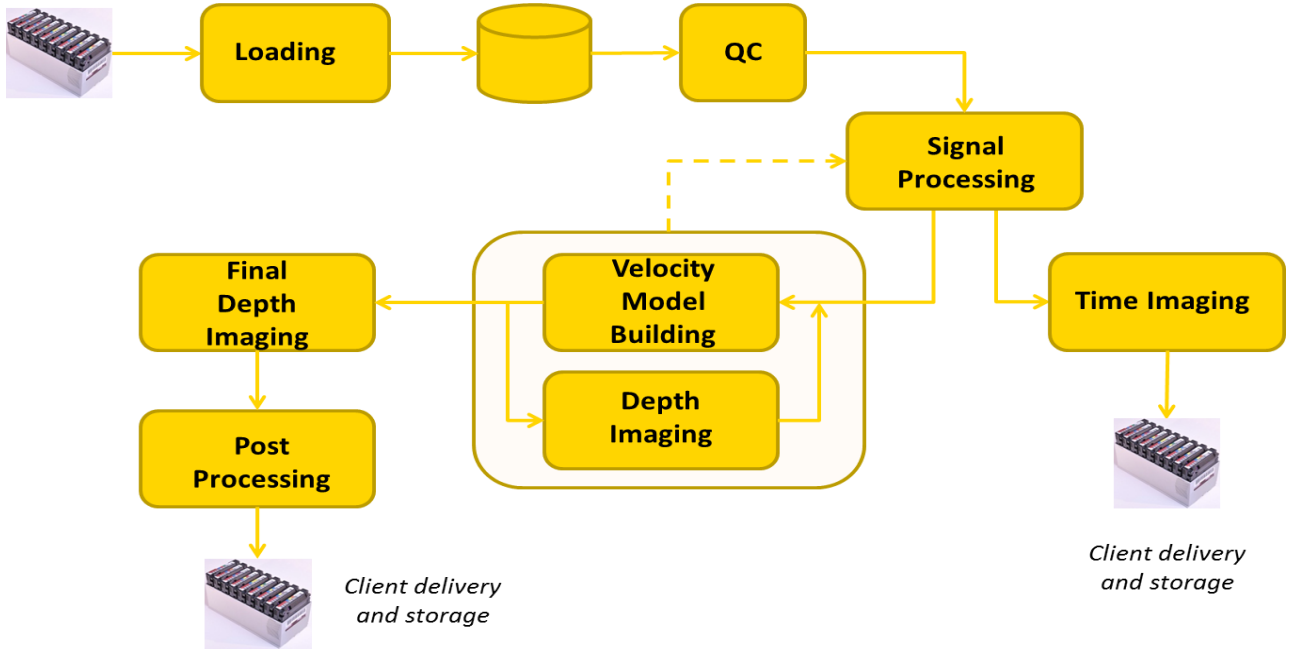


Outcrops vs Subsurface through Seismics



Seismic Process





Eni Technology Roadmap: Digital Simplification of Geo Complexity

Computing Power

Accuracy

Reduction of turnaround times

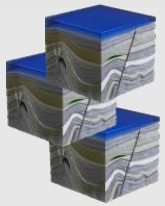
2012

0,5 PFlops

8 months

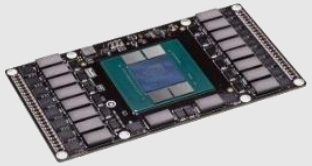
2014

5,1 PFlops

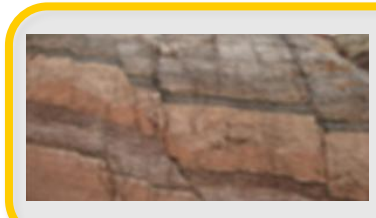


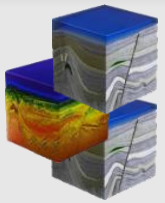
6 months

2018

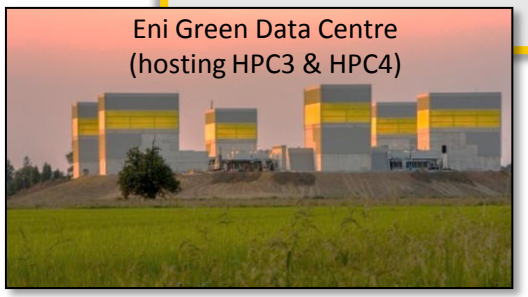


22,4 PFlops



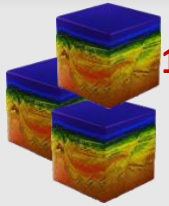


2 months



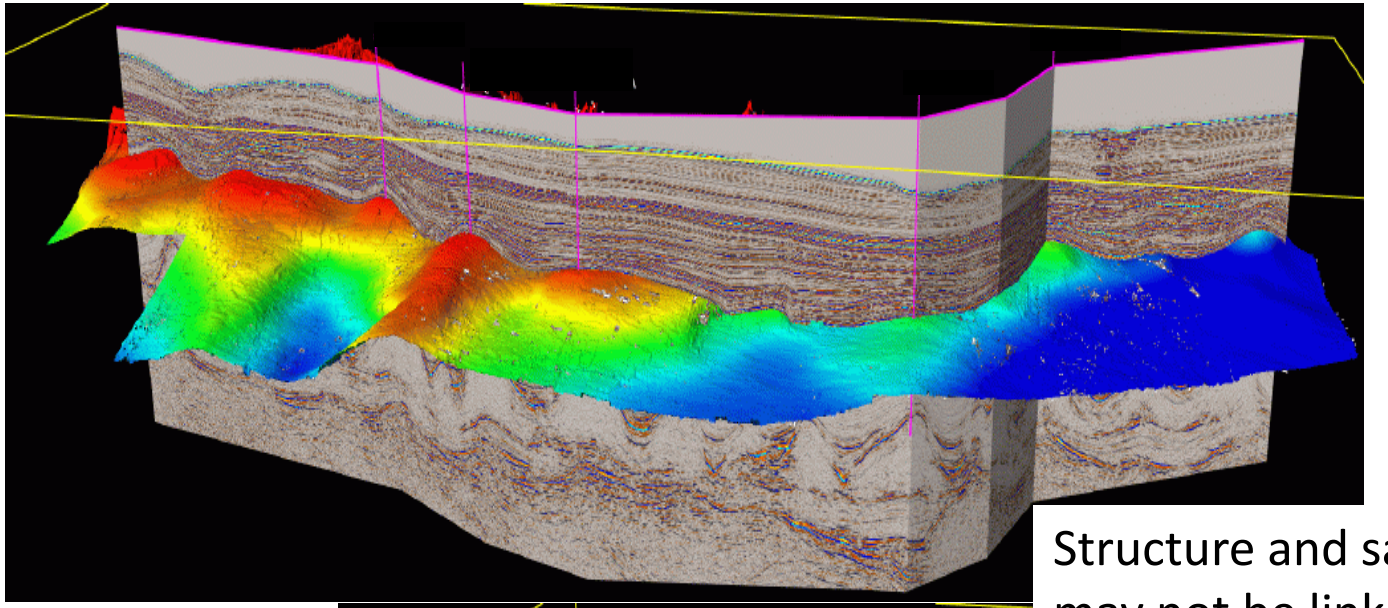
Next

1000 PFlops

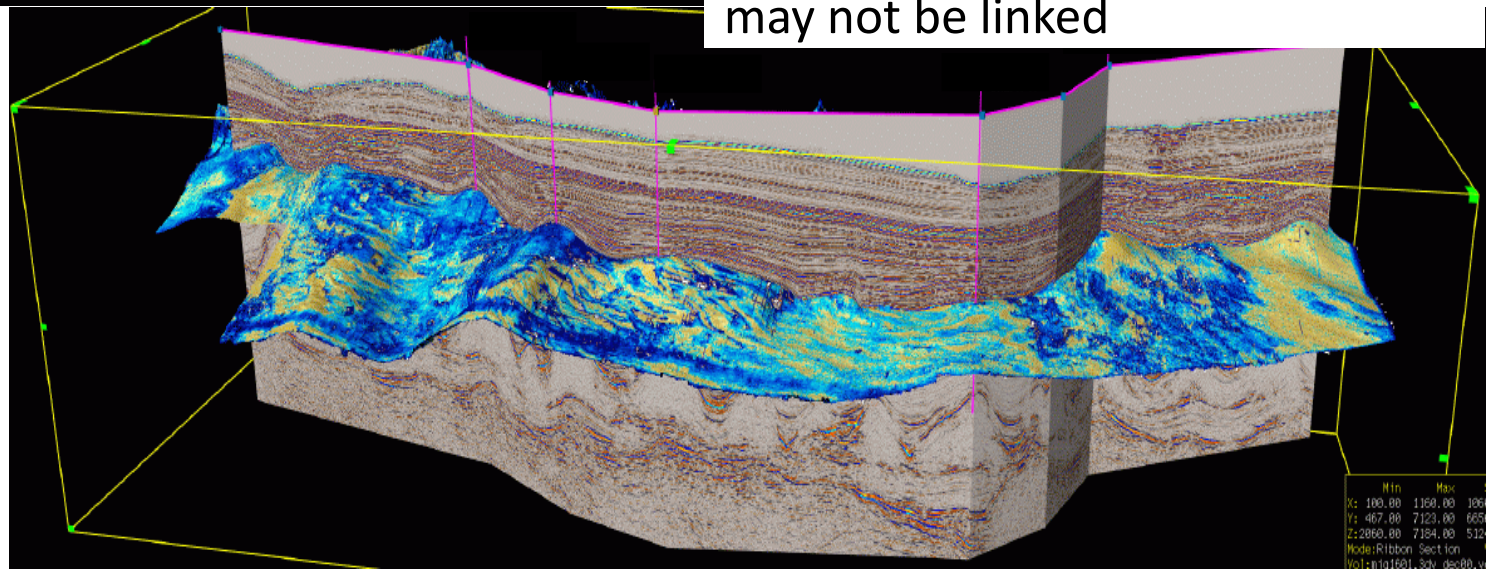


1 wk

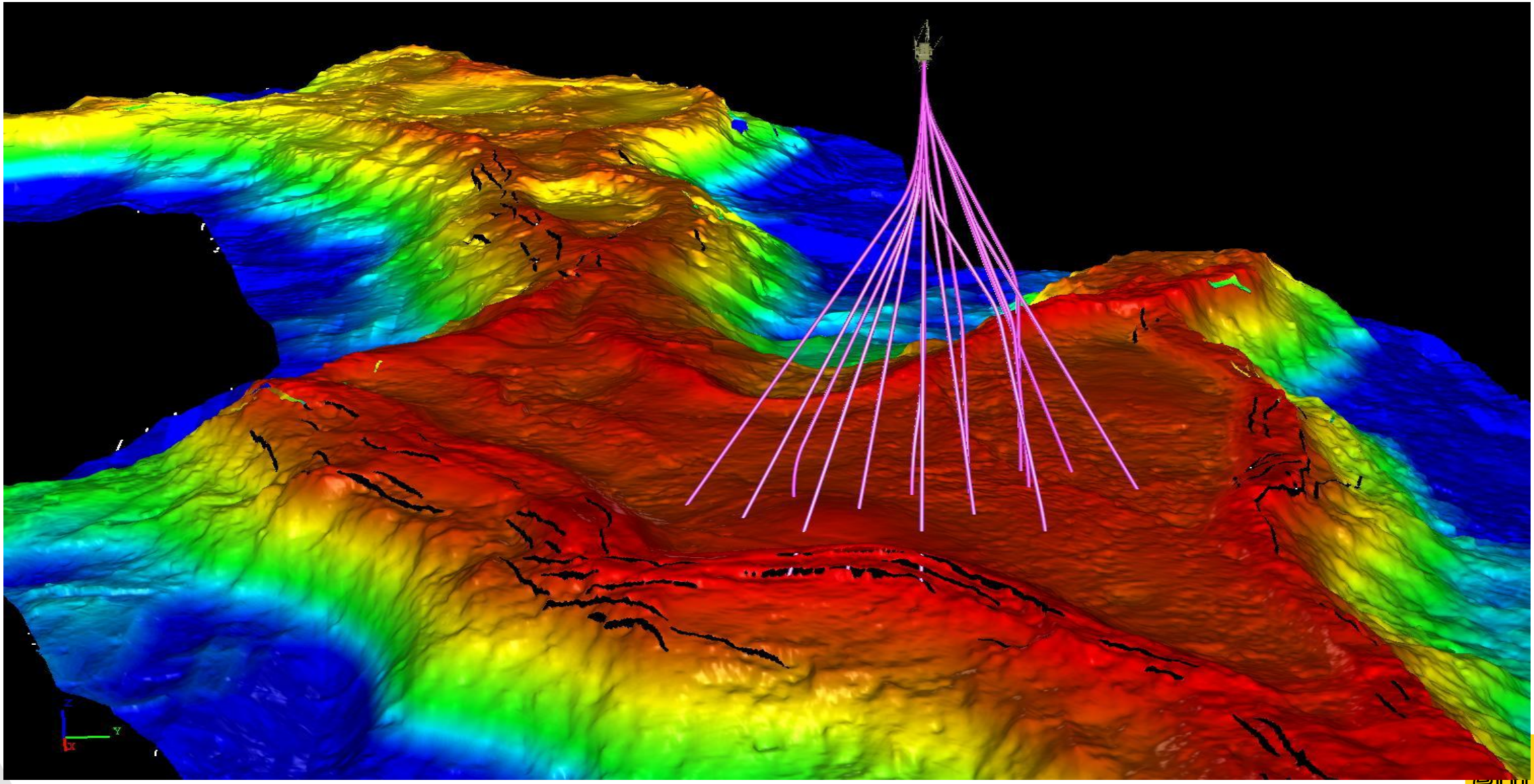
3D Visualization: Structural vs Sedimentary Facies Rendering



Structure and sand distribution may not be linked

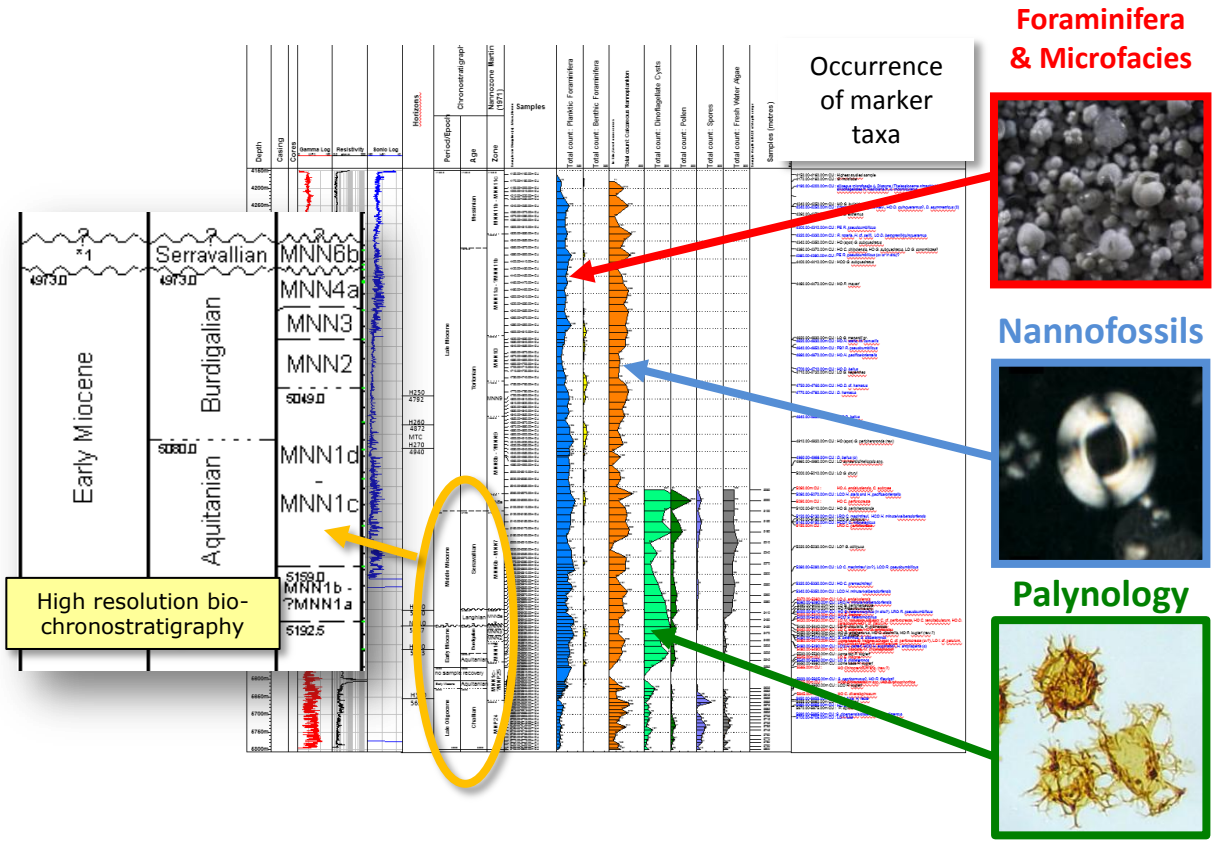


3D Structural Map

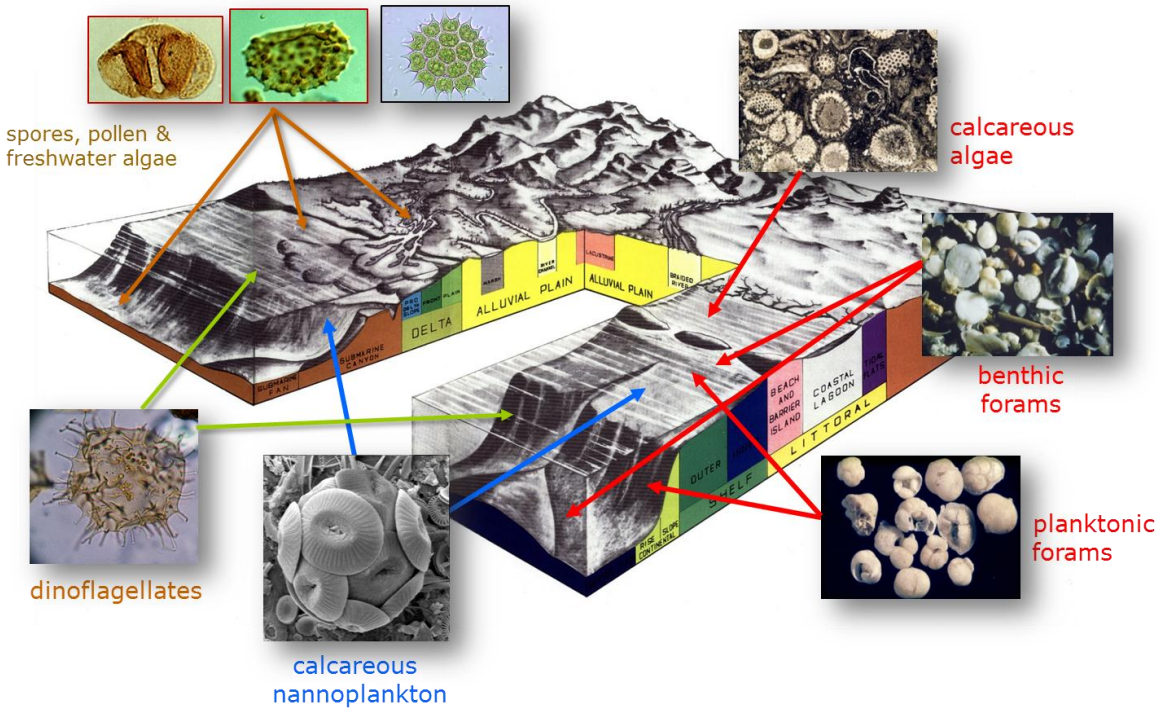


G&G Studies: Biostratigraphy

Integrated High resolution biostratigraphy

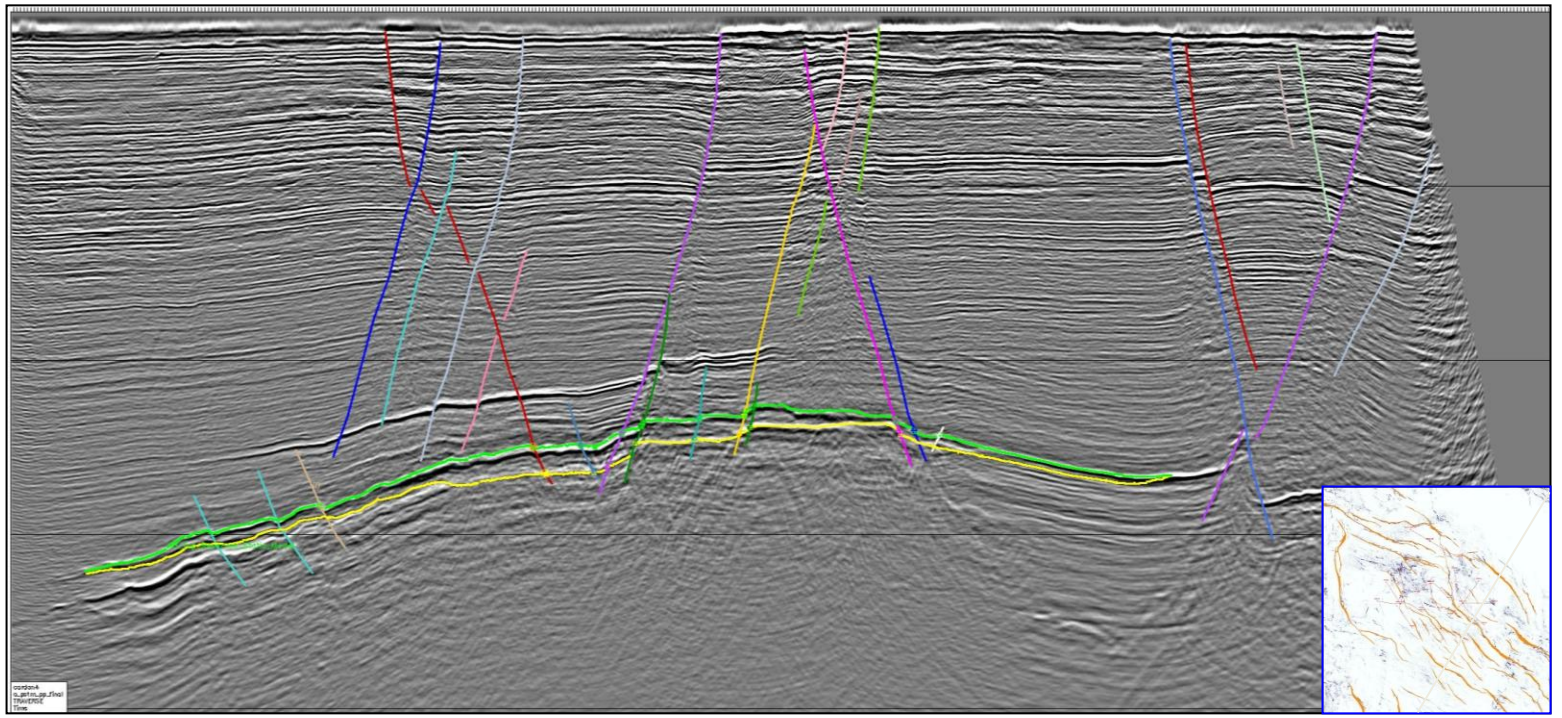


Paleoecology & Paleoenvironmental Reconstruction



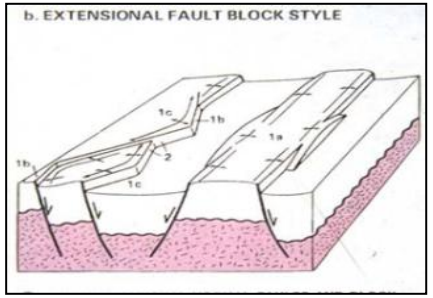
G&G Studies: Structural Characterization

SW



NE

Relay Ramps

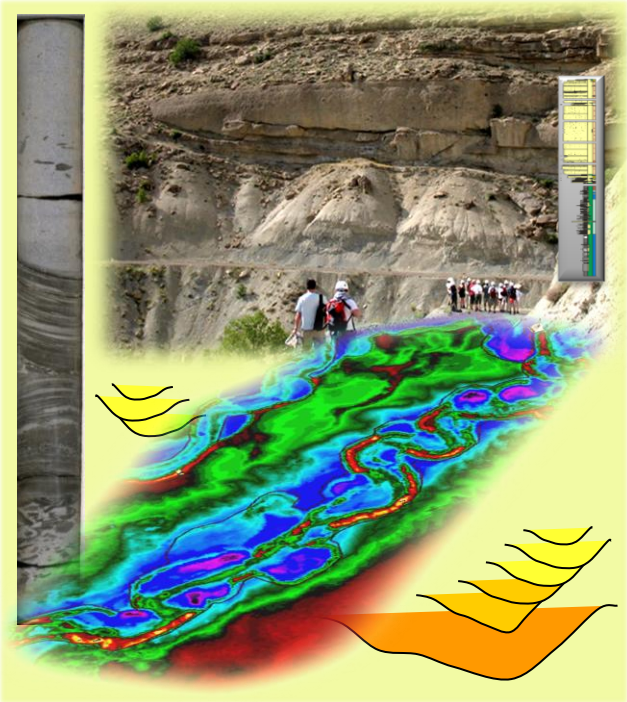


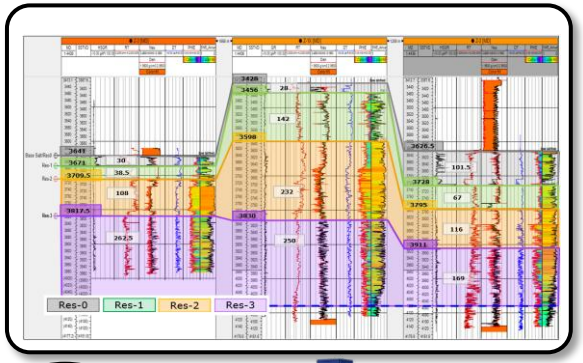
Extentional Normal Faults

G&G Studies: Clastic and Carbonate Sedimentology

Integrated exploration and reservoir scale studies

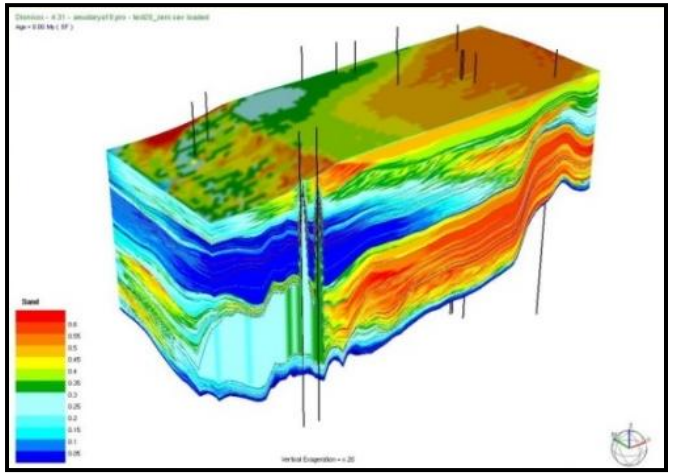
Clastic and carbonate Sedimentology

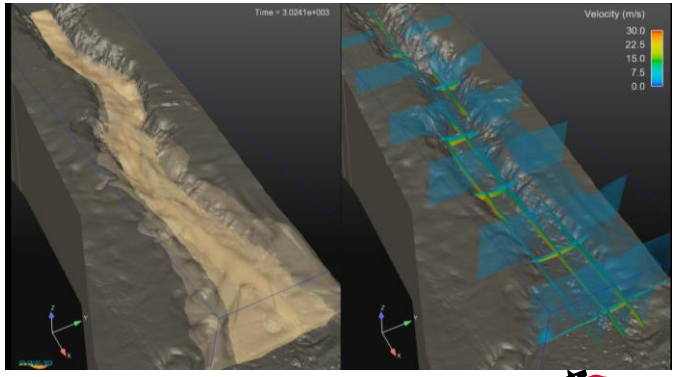




petrography and diagenetical study

Stratigraphic and sedimentological modelling





G&G Studies: Sedimentology

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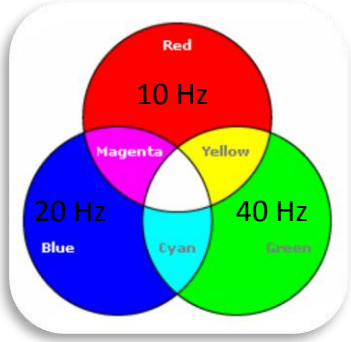
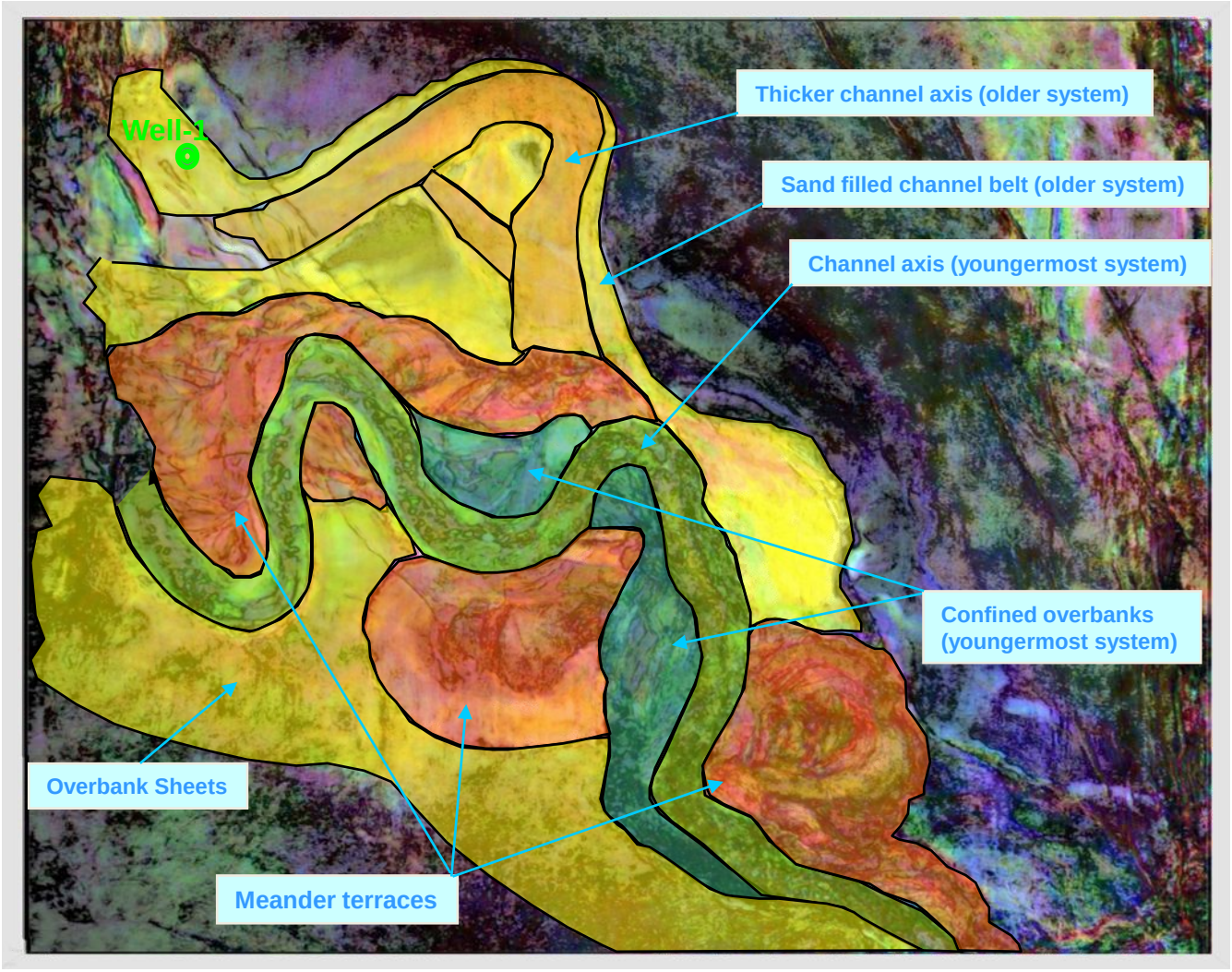
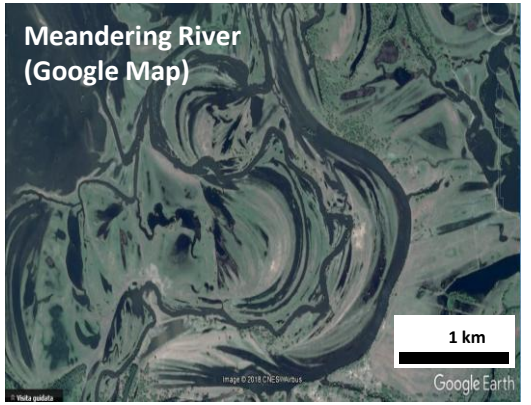




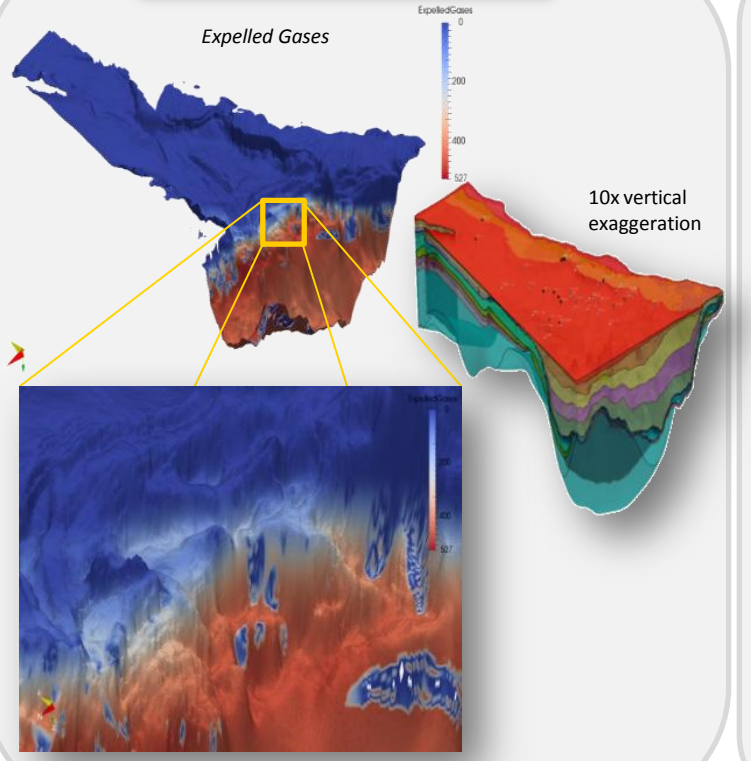


G&G Studies: Petroleum System Modeling

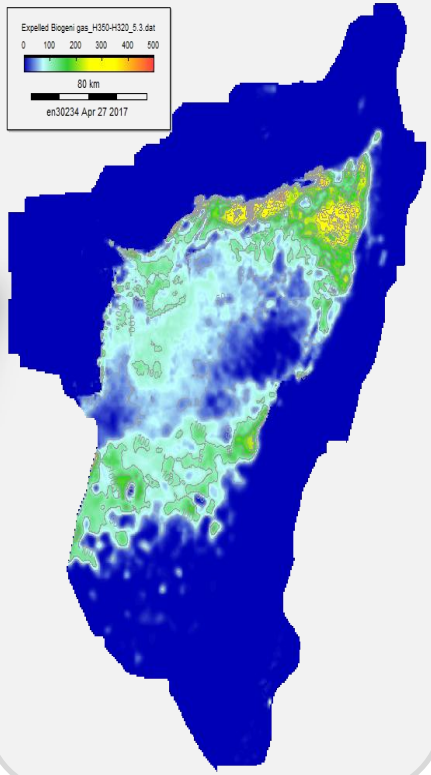
The PSM methodology considers all the variables and associated uncertainties that define the possible hydrocarbon distribution, reducing the exploration risks

Basin Geometry → Temperature & Pressure → Source Rock Geochemistry → Generation & Expulsion → Migration & Trapping → Exploration Risk Evaluation

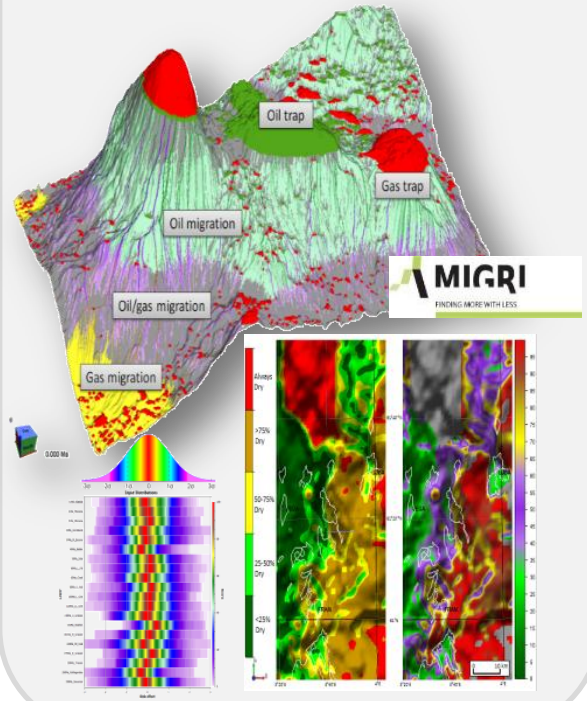
High Resolution PSM



Biogenic gas



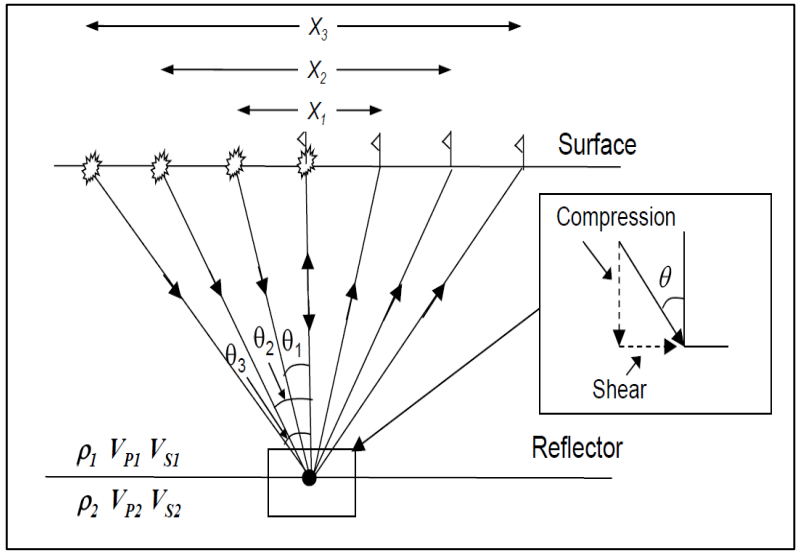
Secondary Migration



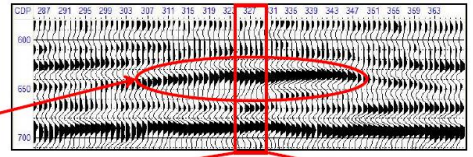
e-simba eni basin simulation

Eni Award 2008

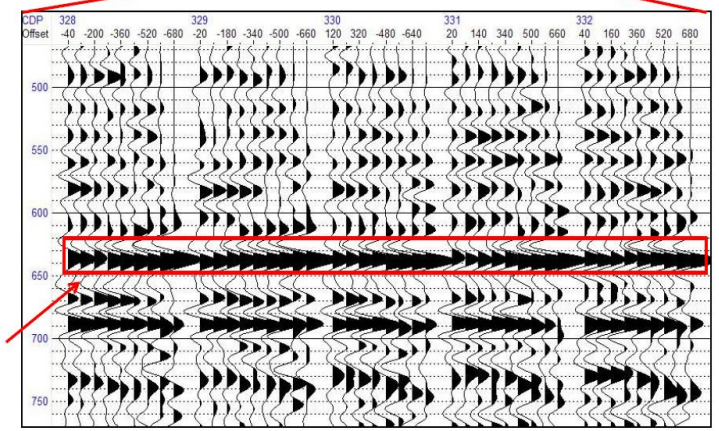
G&G Studies: Seismic AVO (Amplitude versus Offset)



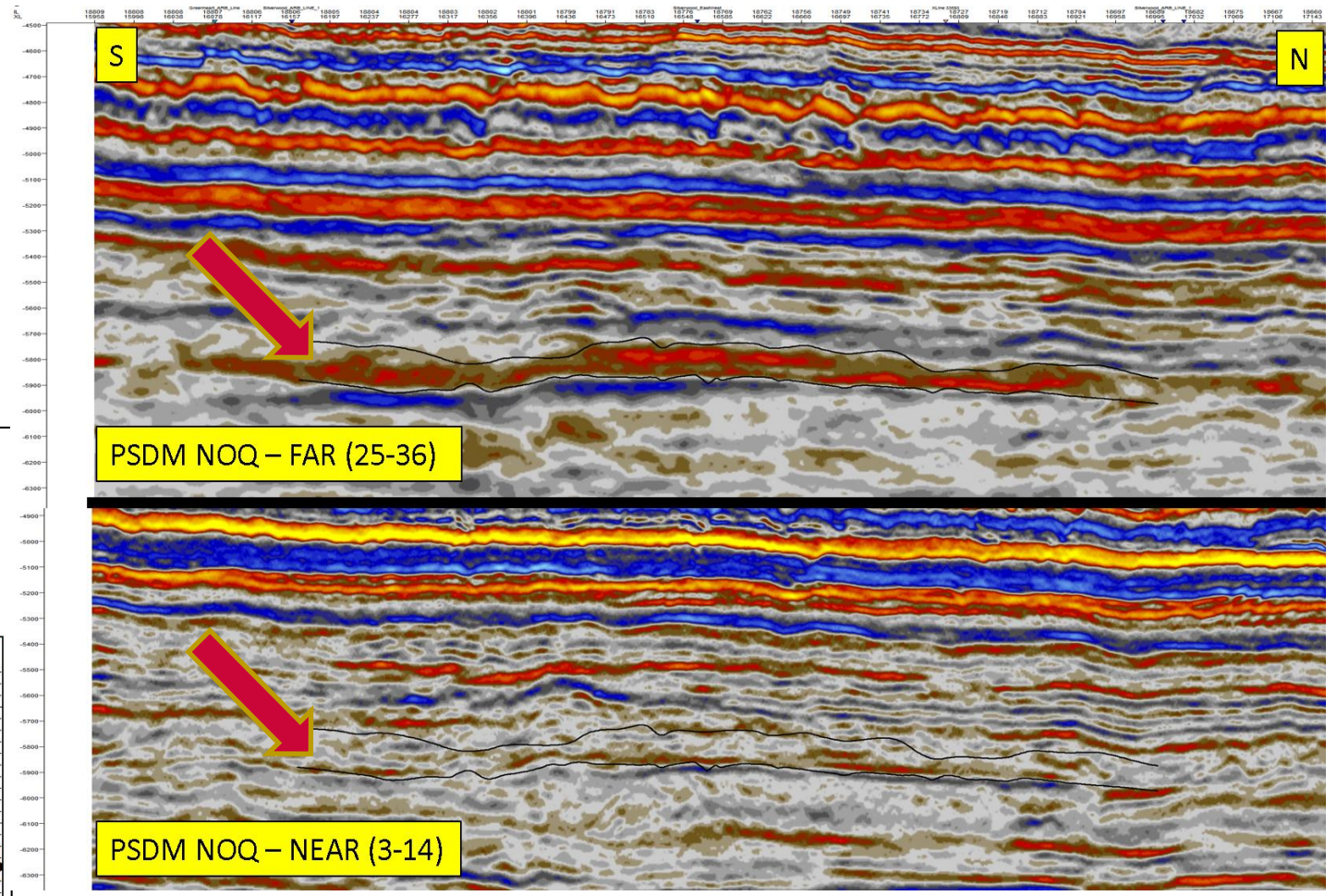
Here is a portion of a 2D seismic line showing a gas sand "bright-spot".



The seismic line is the "stack" of a series of CMP gathers, as shown here.



The gas sand is a typical Class 3 AVO anomaly.



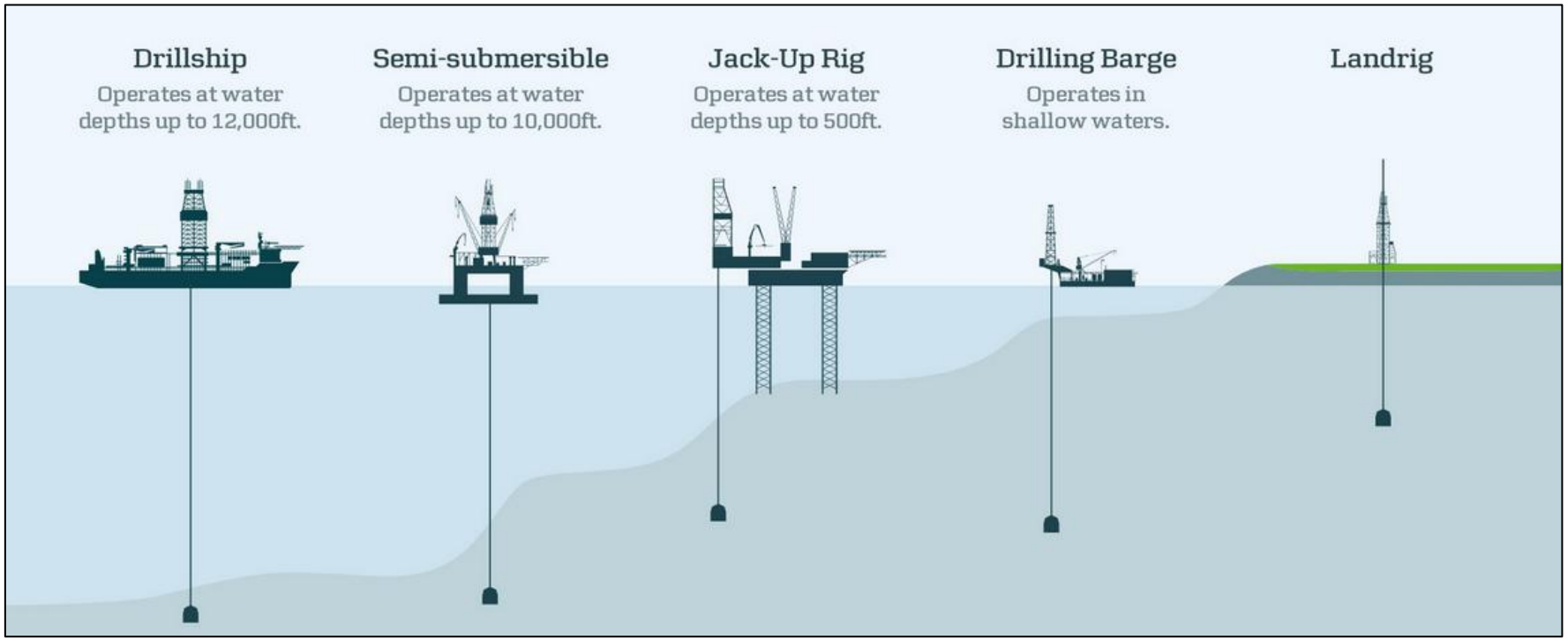
What does “Exploration” mean?

- “Exploration” is a set of coordinated activities from different integrated disciplines, sciences and technologies - not only geology/geophysics – aiming at discovering new oil and gas volumes that could be exploited in a “reasonable” future with an economic return

- To explore, one needs to understand and carefully map the present day subsurface structure of an area, understand its evolution in time, locate the areas where HC’s may be generated, locate and accurately map the structures in which they may be preserved, estimate their volumes, evaluate the chances that our prediction have to be correct (PoS, Probability of Success)

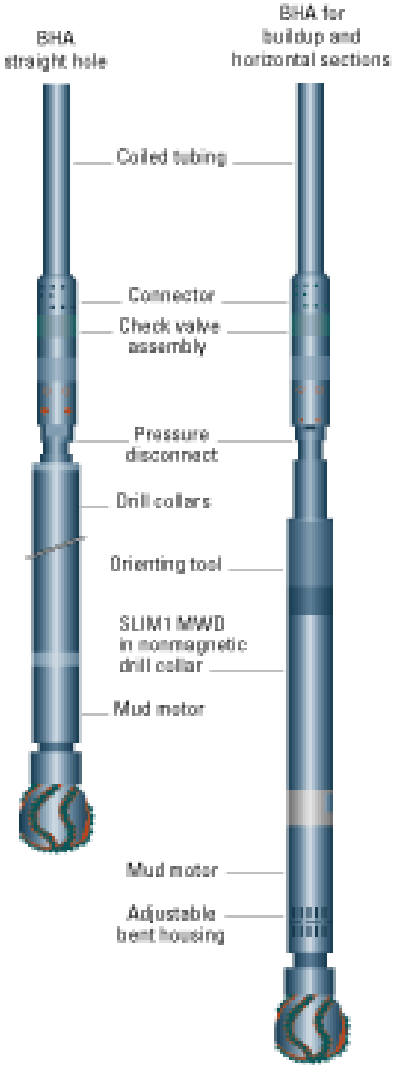
- To achieve such a target in the most efficient way, high level skills and know-how have to be employed together through a powerful digitally integrated approach and along the support of dedicated R&D projects

Rigs vs Water Depth

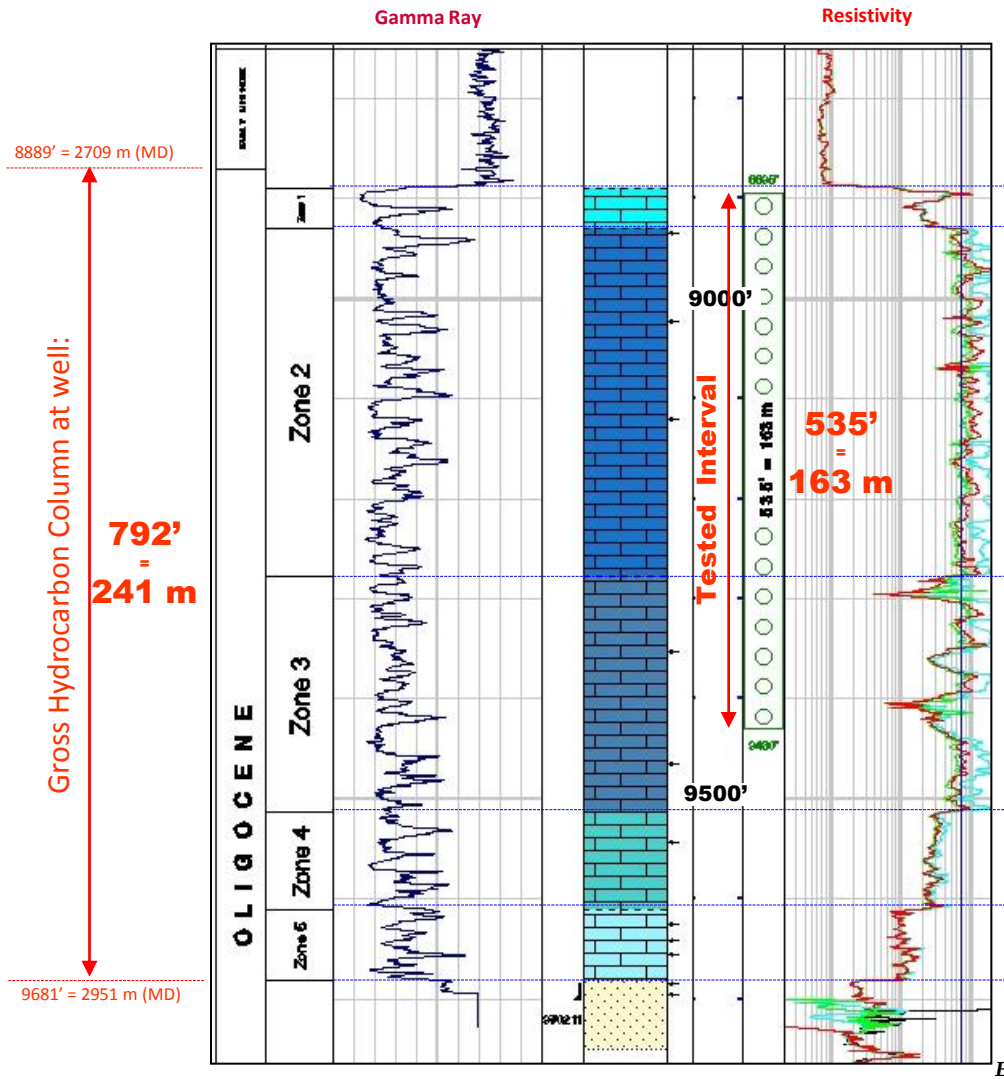


Rotary Drilling

- Rotary drilling is the most commonly used because it is faster and cheaper
- A «bit» is attached to the end of a string of steel pipes (rods) and is made to spin (rotate) by an engine located at the surface or at the bottom end of the string
- Hard steel or diamond dents on the bit grind the rocks and the string progressively sinks in the bore driven by its weight and rotation
- The string is extended by screwing in more and more rods
- Bits wear out and must be periodically changed by lifting the whole string to the surface



Perla-1X Preliminary Petrophysical Zonation



Zone 1 8889' ÷ 8929' = **40'** (**12.20 m**)
N/G = 73%
Avg. Φ = 21.20% Avg. Sw = 14%

Zone 2
8929' ÷ 9278' = **349'** (**106.40 m**)
N/G = 100%
Avg. Φ = 24.90%
Avg. Sw = 5%

Zone 3
9278' ÷ 9513' = **235'** (**71.60 m**)
N/G = 100%
Avg. Φ = 18.50%
Avg. Sw = 11%

Zone 4 9513' ÷ 9611' = **98'** (**29.90 m**)
N/G = 100%
Avg. Φ = 17.50% Avg. Sw = 16%

Zone 5 9611' ÷ 9681' = **70'** (**21.30 m**)
N/G = 73%
Avg. Φ = 15.80% Avg. Sw = 31%

Eni Petrophysical Interpretation, 03 Sep. 2009

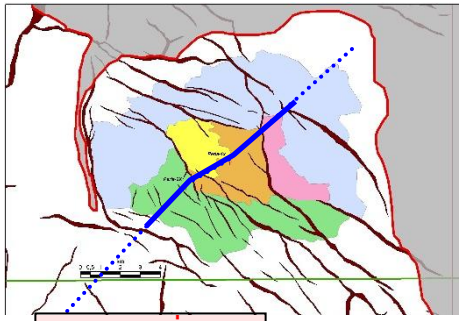
Official Flow Results

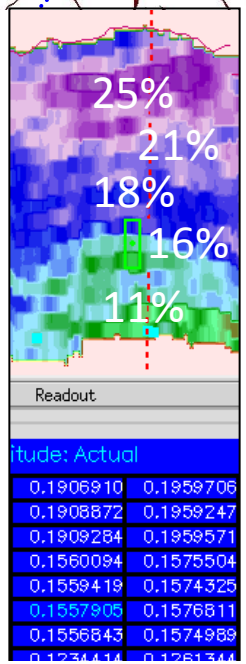
On 09 Oct 2009 the well flowed on **36/64" choke** for **Official Flow**:

- FWHP : 3051 psi
- Qgas : **20,7** MMScf/d = **586000** scm/d
- Qoil : 442 bbl/d
- Qw : 12,7 bbl/d
- GOR : 47000 Scf/bbl
- Gas SG : 0,660
- Oil density : 47,5 °API @ 60 °F
- W. Salinity : 150 ppm Cl-
- H2S : 0 ppm
- CO2 : 2%

WHOLE RESERVOIR
8889' ÷ 9681' (MD)
792' (**241.40 m**)
N/G = 97%
Avg. Φ = 21%
Avg. Sw = 10%

NFW and OUT WellS (example from Perla Field, Venezuela)





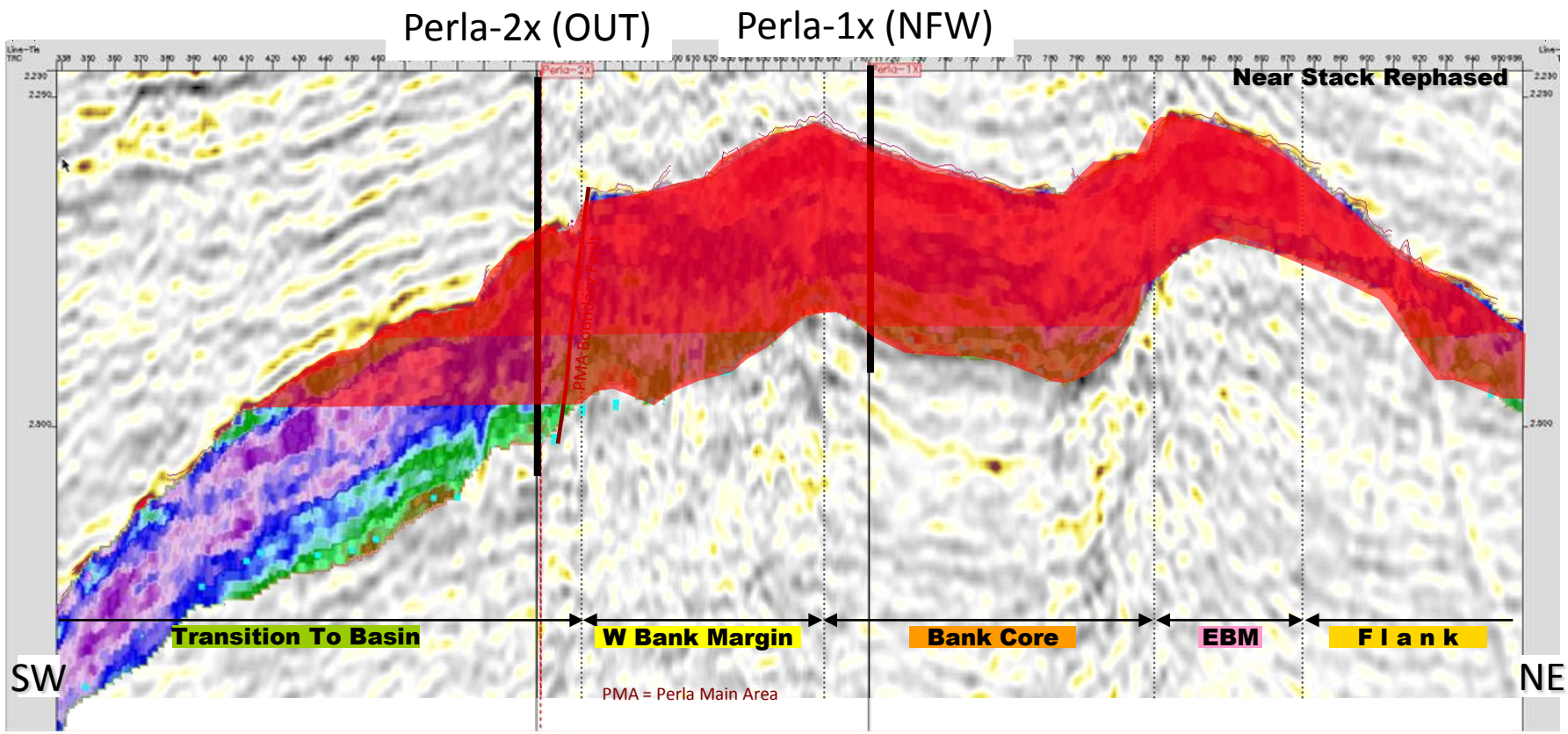
Porosity Unit Color Scale

OUT (Outpost or Appraisal)

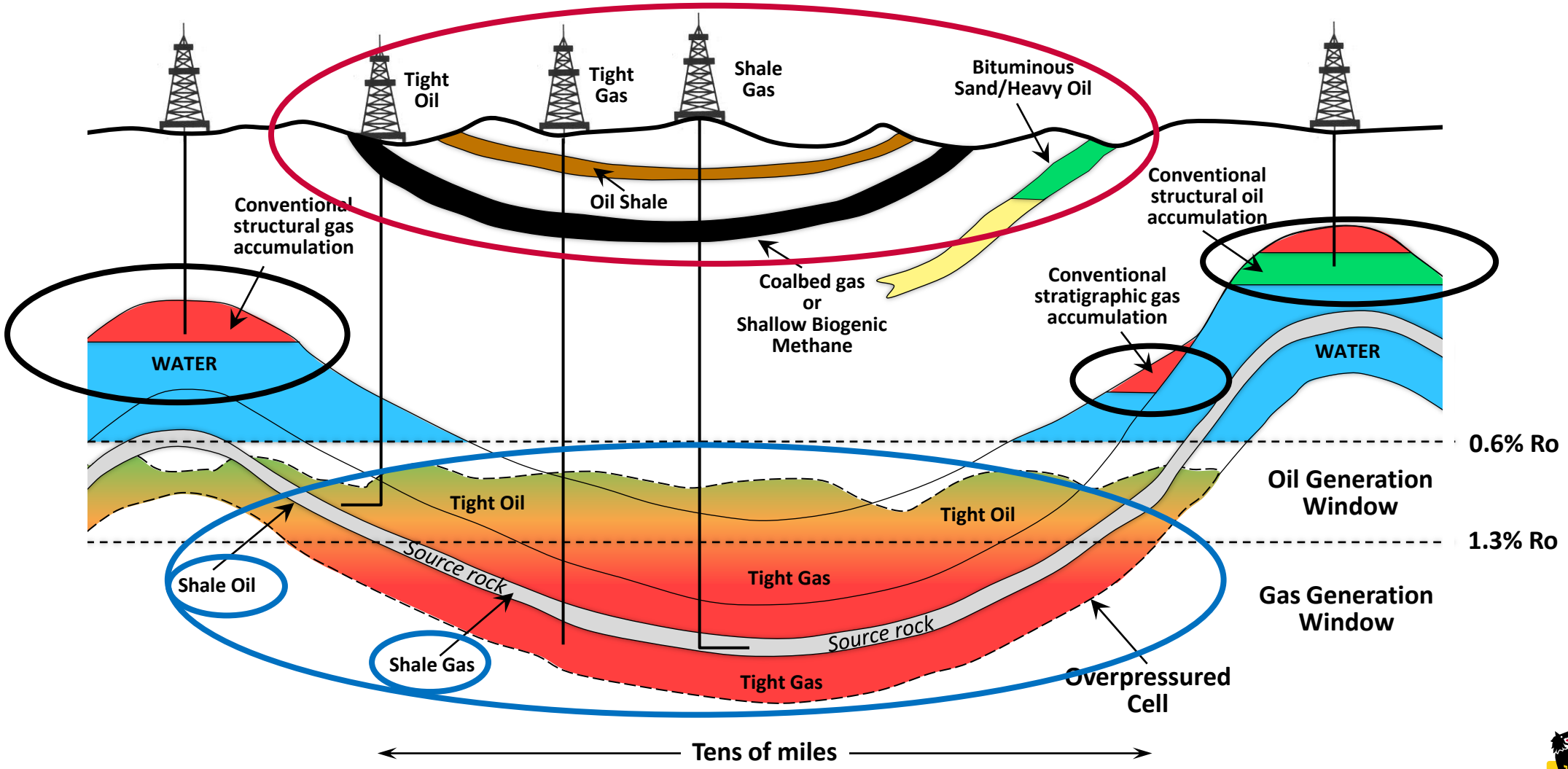
Well to be drilled on a structure
In order to define extension of an already proven HC bearing reservoir

NFW (New Field Wildcat)

First well to be drilled on a structure
in order to prove a HC bearing reservoir

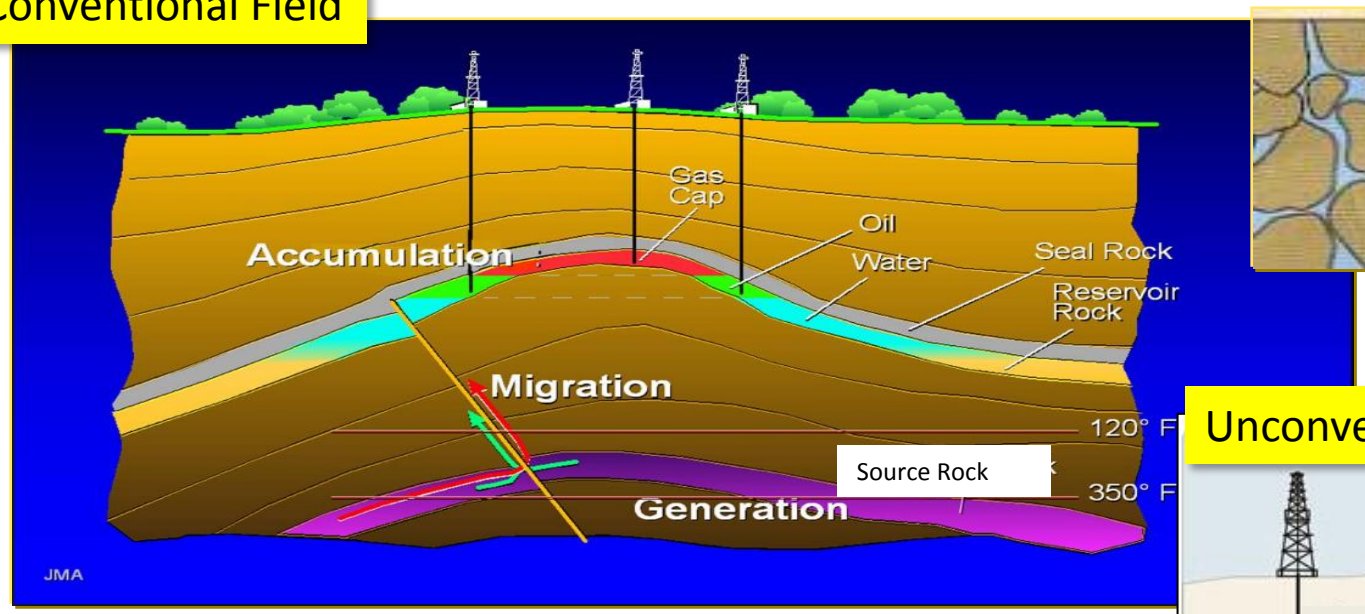


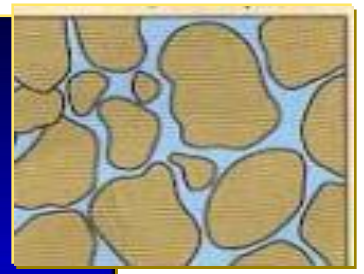
Characteristics and distribution of ‘conventional’ and ‘unconventional’ petroleum systems



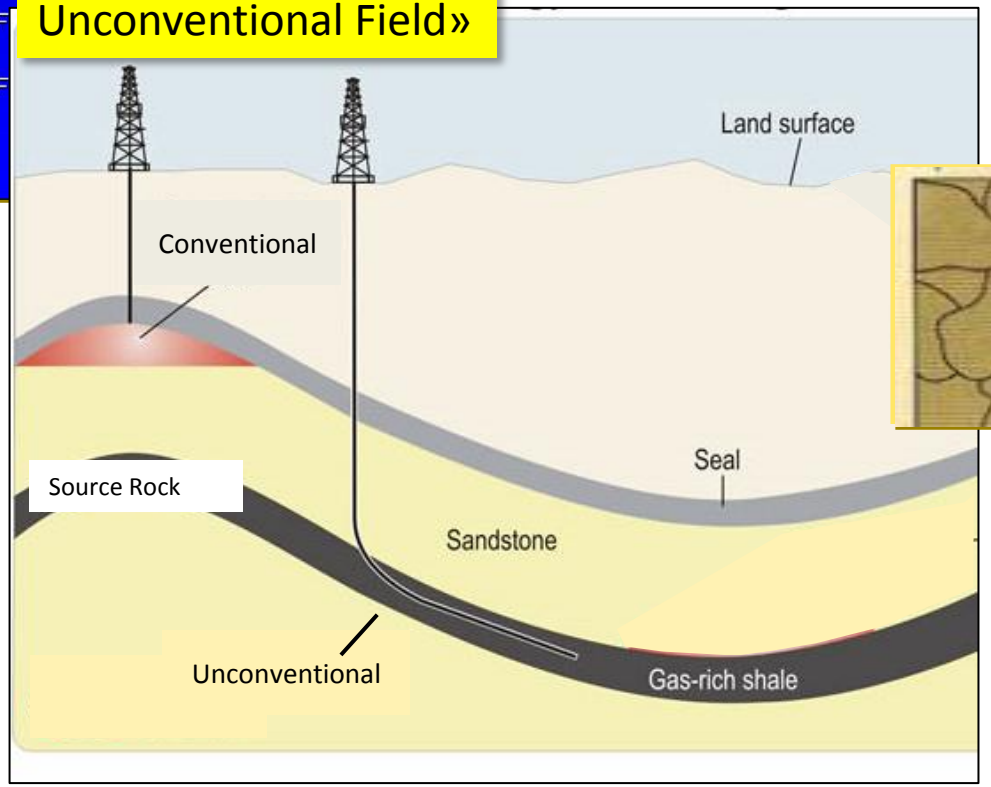
Conventional vs Unconventional Exploration and Production

Conventional Field





Unconventional Field»

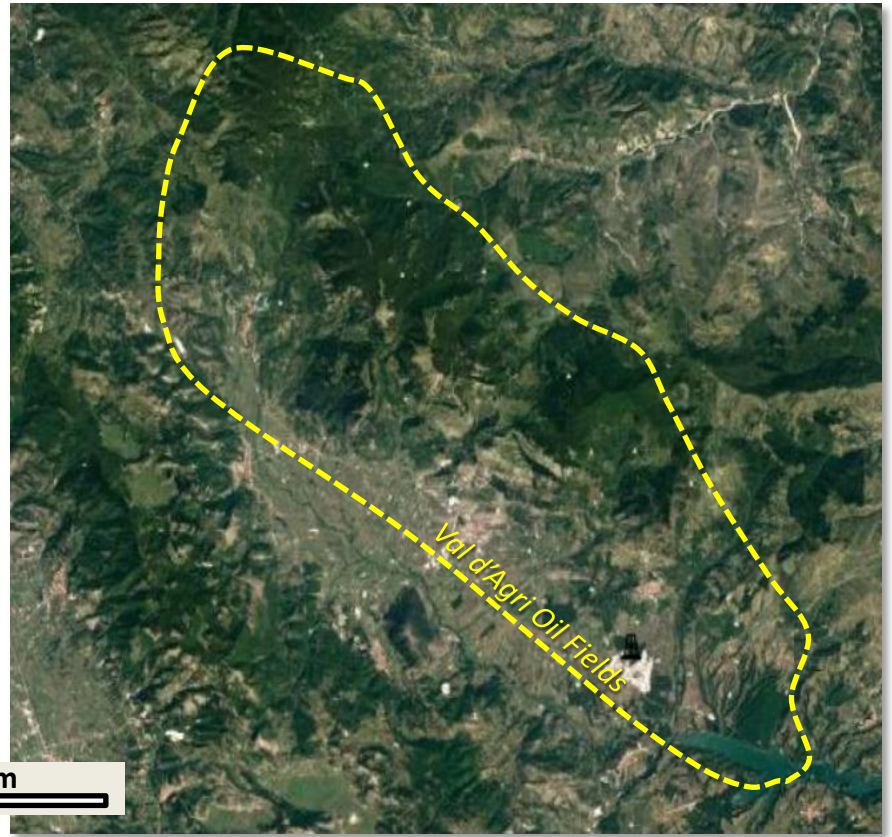


Unconventional Fields

- *Development of Unconventional Fields needs much more production wells compared to Conventinal development (high costs)*
- *It requests huge quantities of water (competition with drinking water supplies, agriculture, industry)*
- *High Environmental Impact (visival, noise)*
- *Induces seismicity*

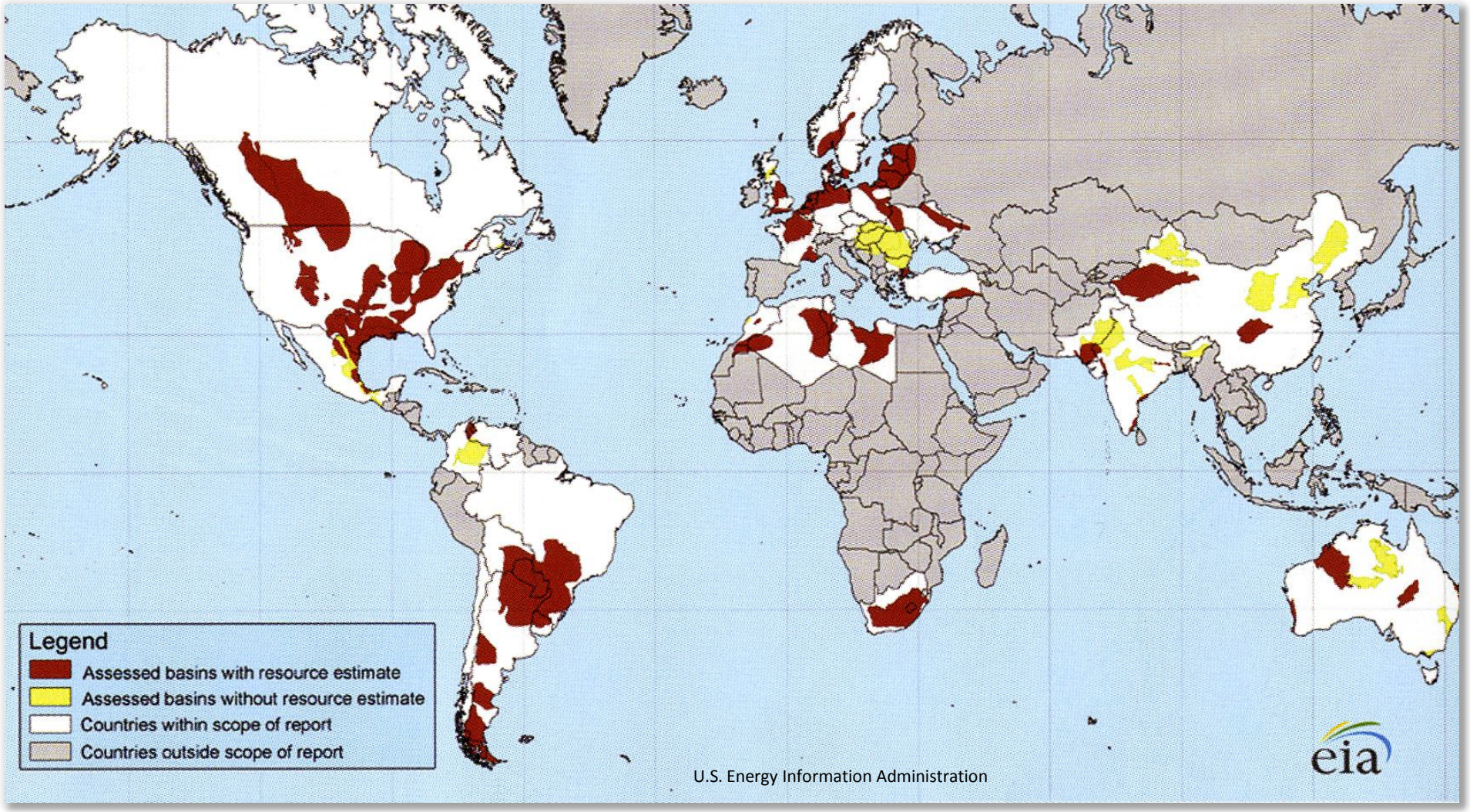
Unconventional Oil Fields
Permian Basin (Midland TX – USA)

Conventional Oil Fields
Val d'Agri – Italia



Global ‘Unconventional’ Plays

- Estimated technically recoverable gas reserves of 6,622 Tcf (48 shale basins in 32 countries)

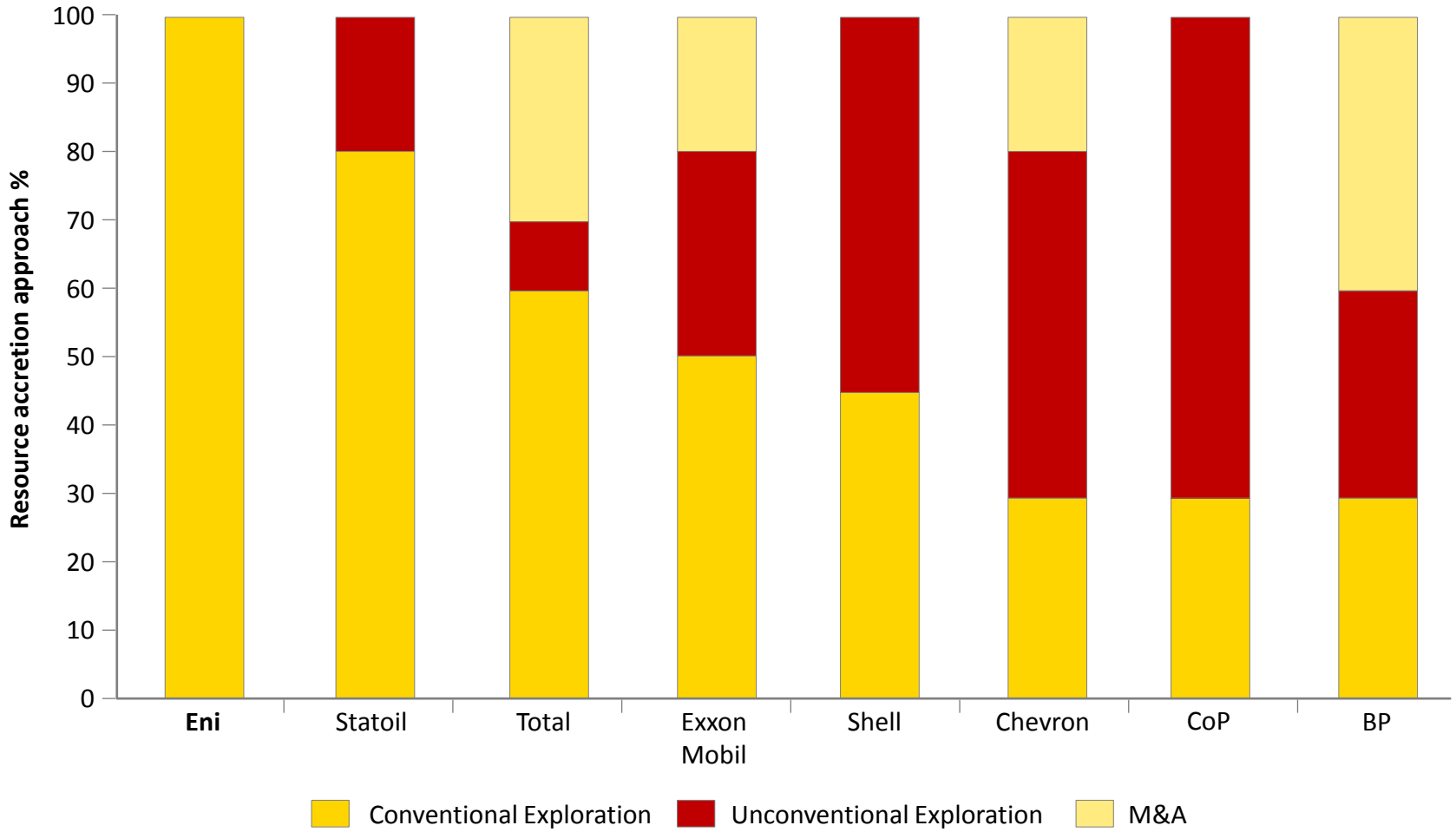


U.S. Energy Information Administration

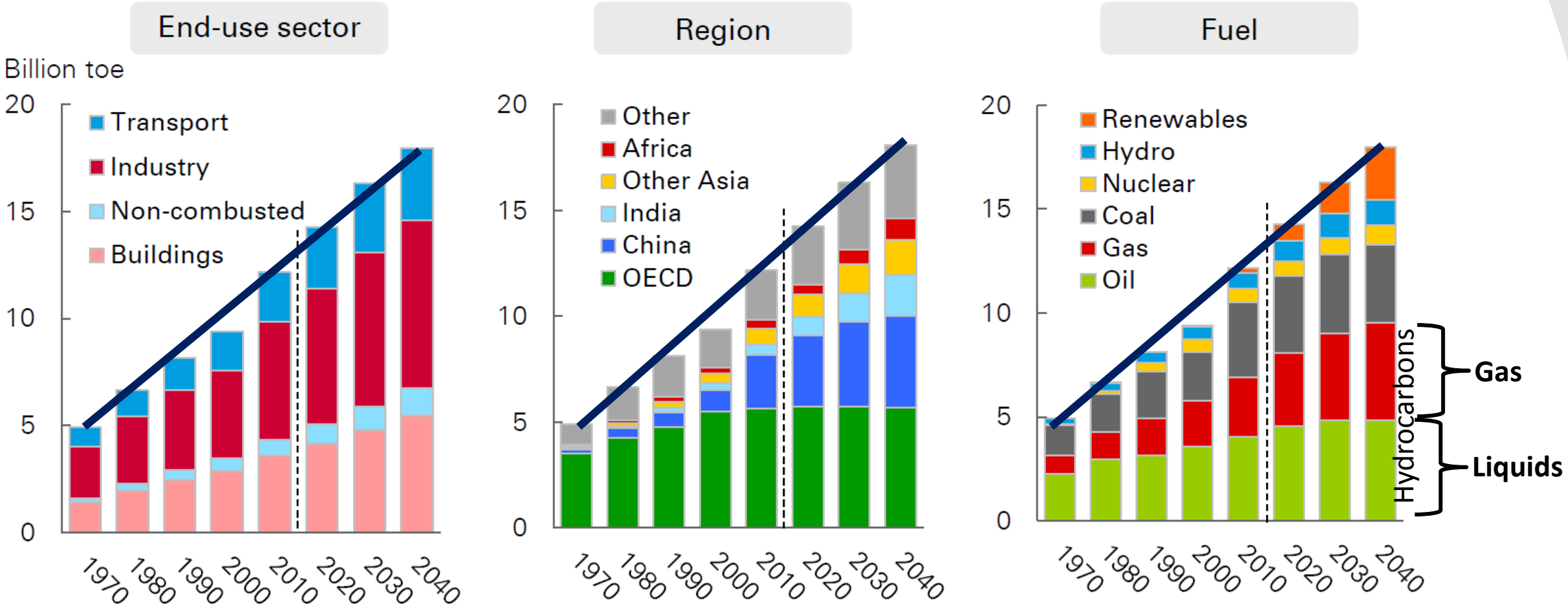
Eni Strategy

Unconventional and M&A play an important role in reserves replacement for most majors
Eni has a unique strategy entirely based on conventional exploration

Competitors Resources Accretion Strategy @ 2018

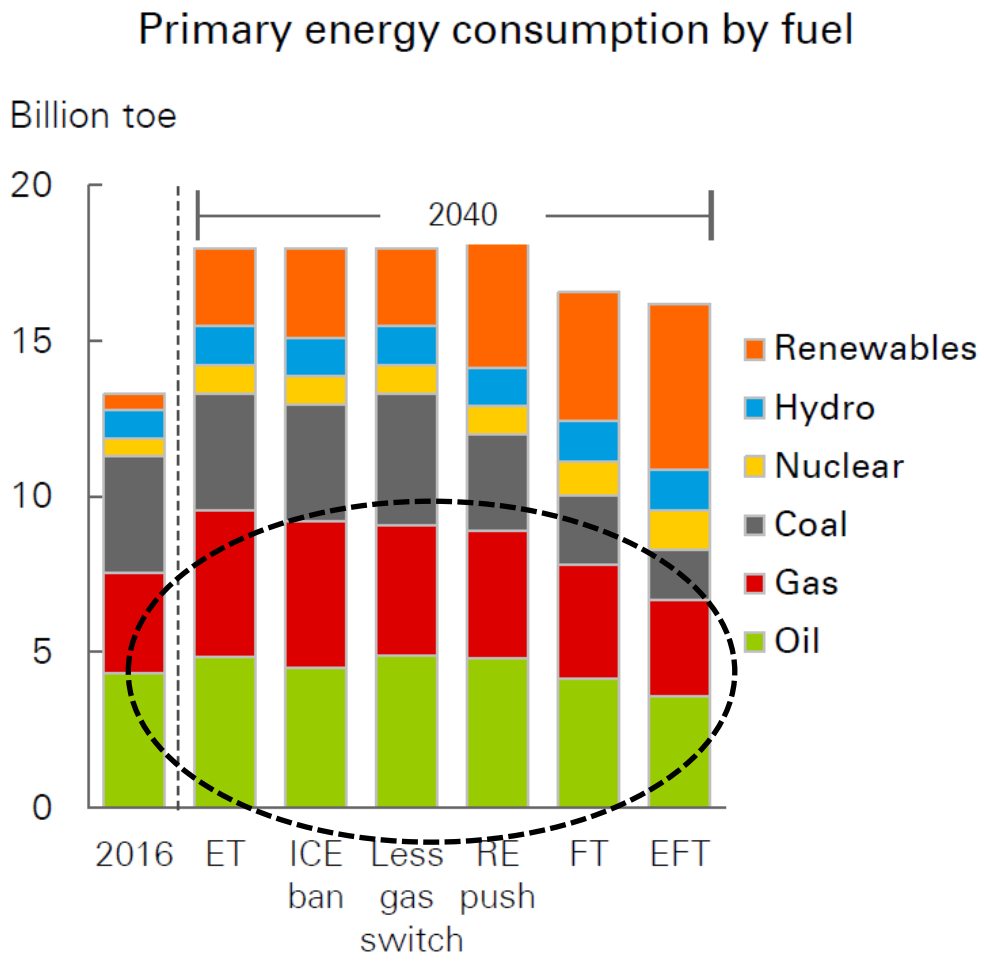


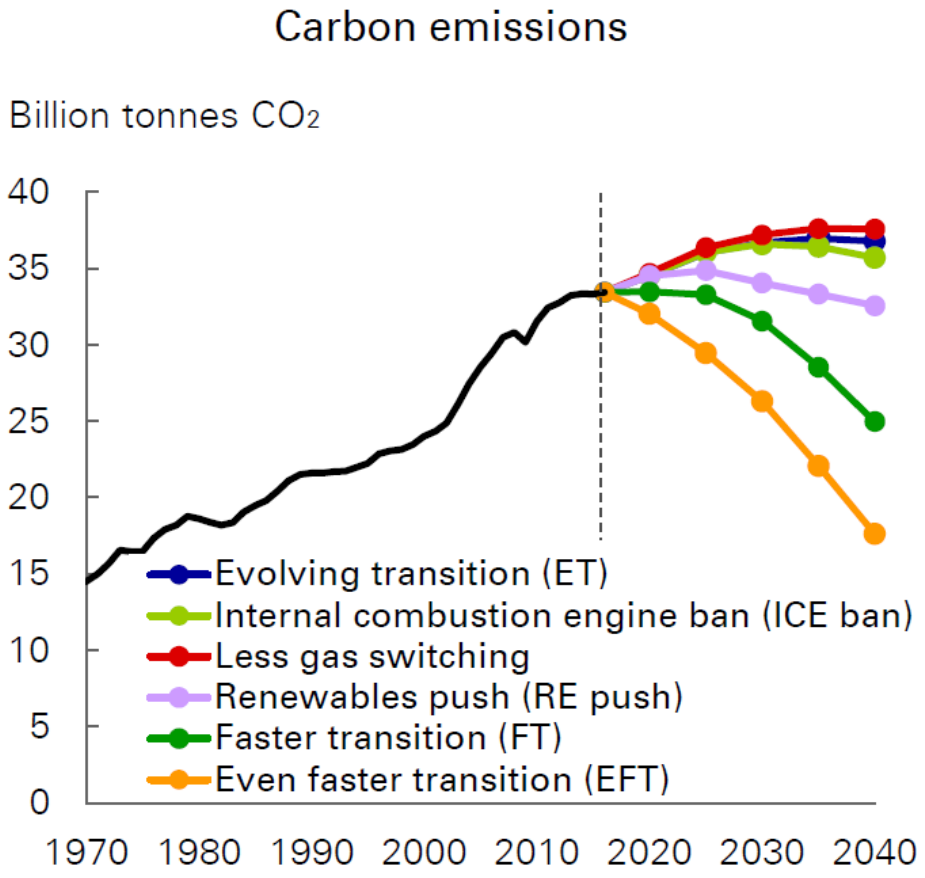
Why still Oil & Gas ? Primary Energy Demand



BP Energy Outlook, 2018

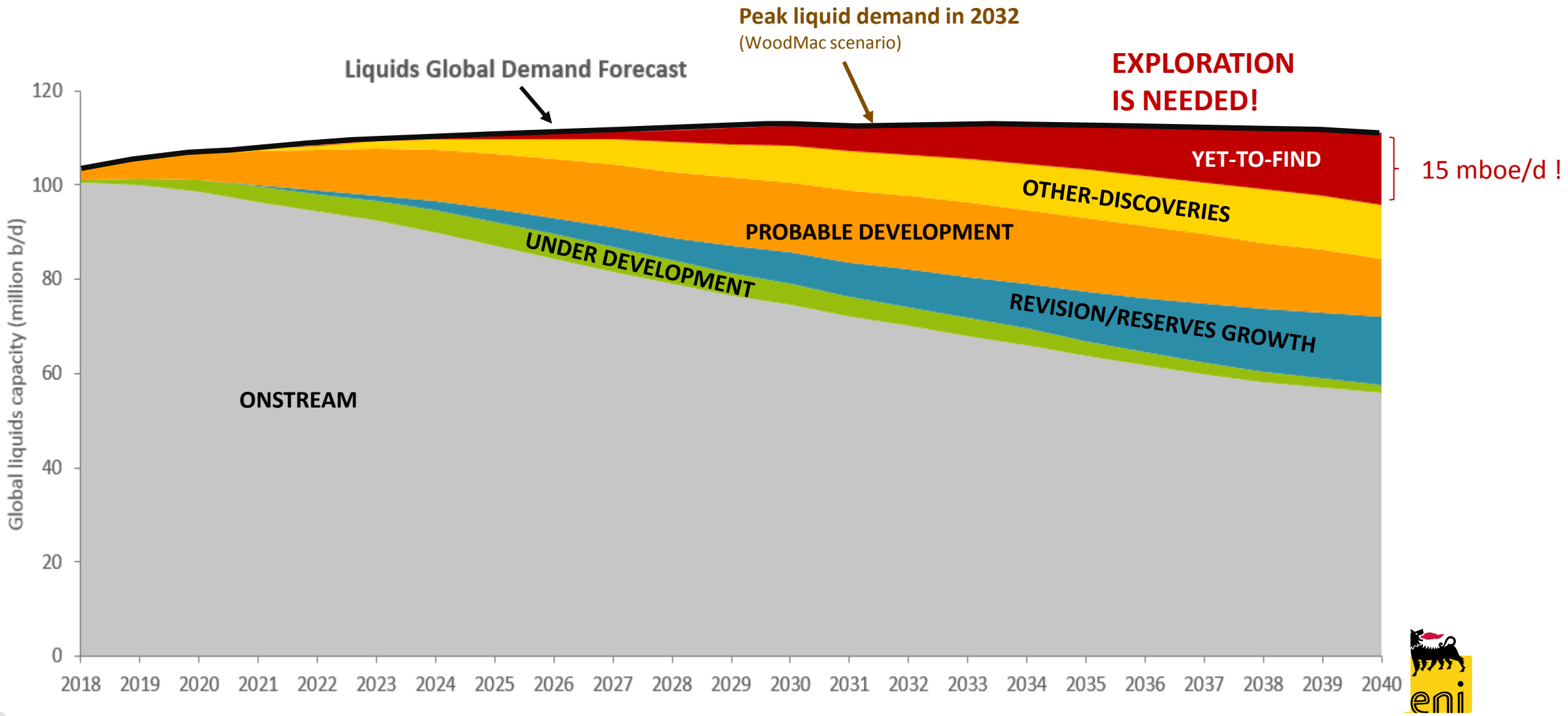
Alternative Scenarios



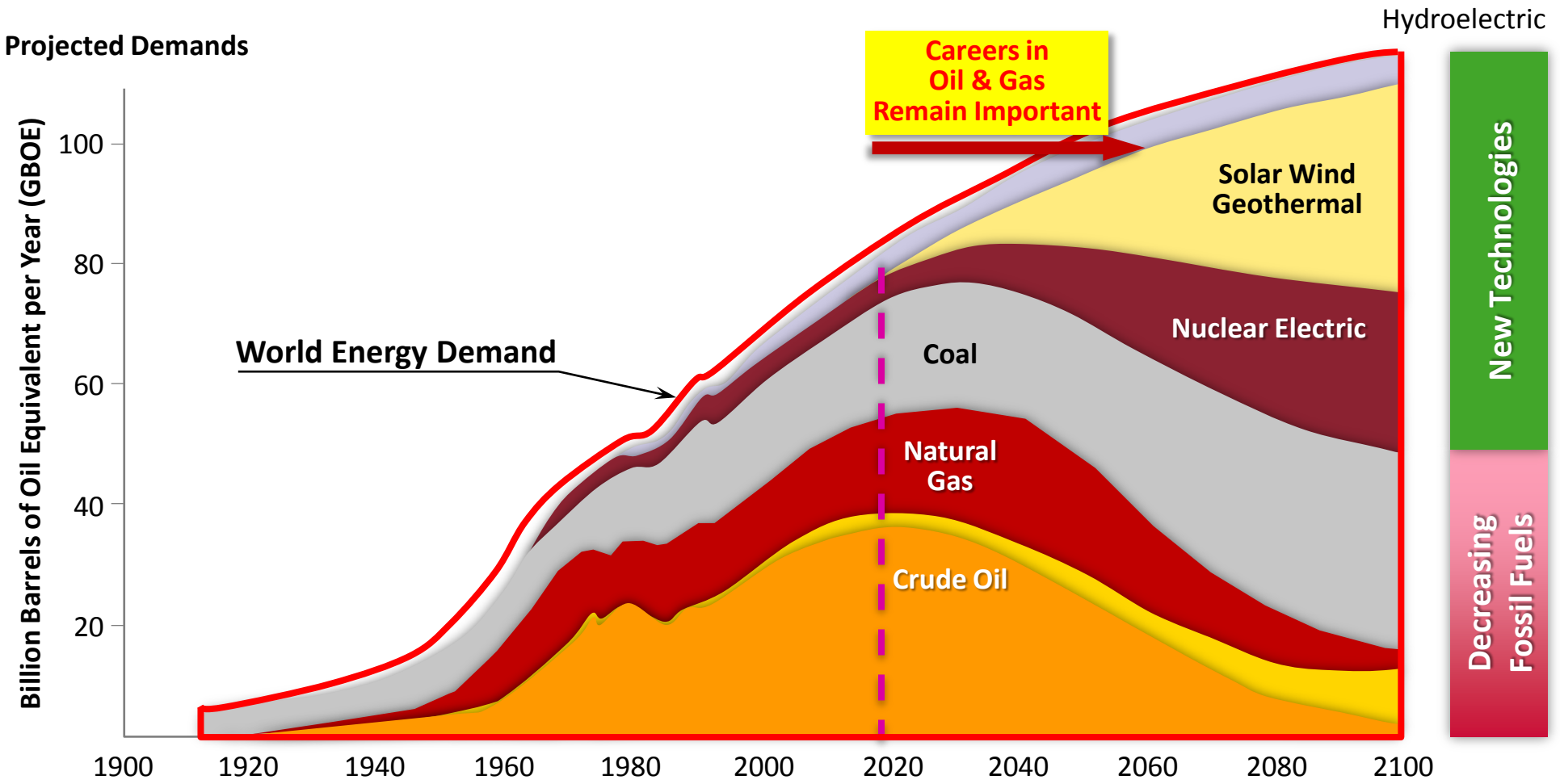


BP Energy Outlook, 2018

New discoveries are required to fill the future global needs of Liquid Fuels



Forecast of Sources of Energy required to meet World Energy Demand to 2100



Shortage of Geoscientists in the U.S. by 2021 (American Geosciences Institute prediction, 2016)

262,627 geoscience jobs in the United States in 2016

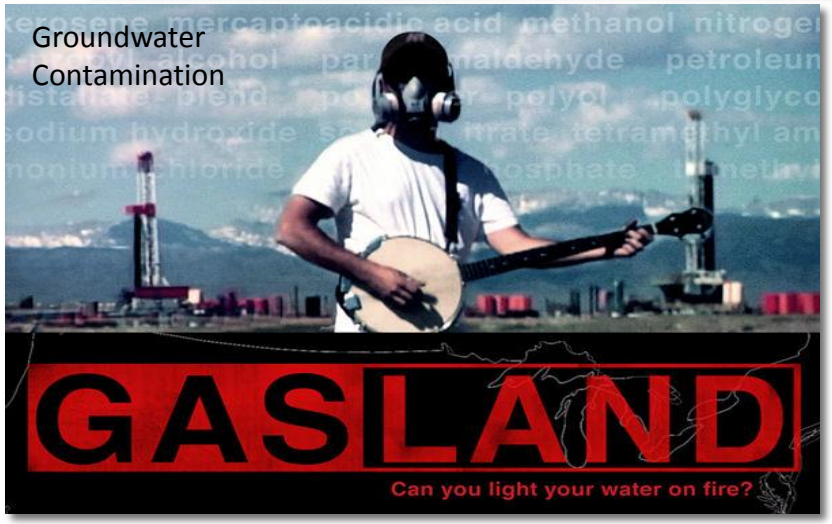
130,000 geoscientists expected to retire by 2021

72,000 new geoscience jobs by 2021

15,000 new graduates (M.Sc. or Ph.D.) or **45,000** new graduates, if also hiring B.Sc. and B.A.

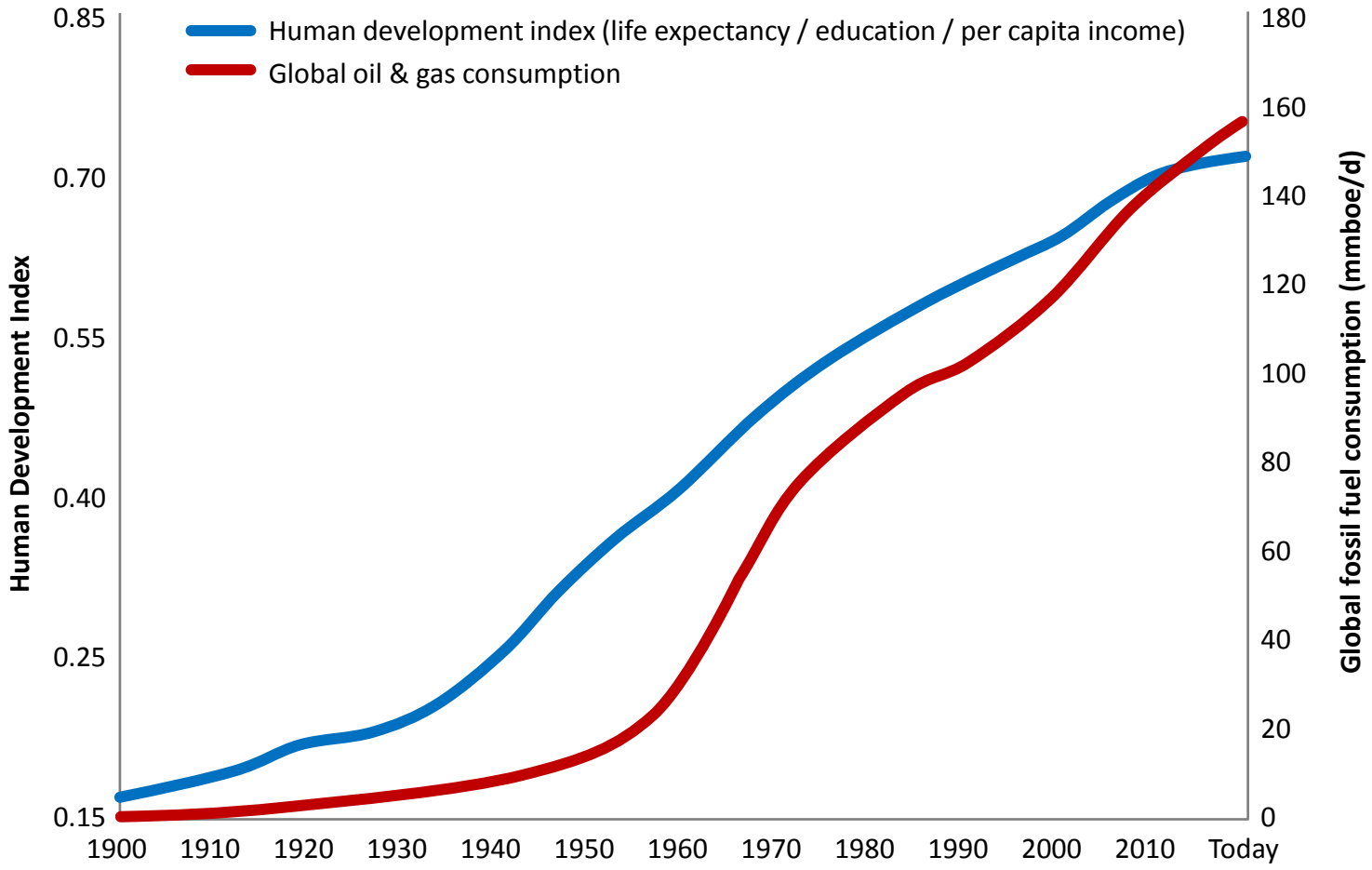
Net shortage of over **150,000** geoscientists in the United States by 2021

The Public Perception of today's E&P Industry

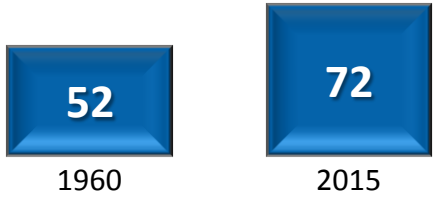


But we should be proud of our industry – it has fuelled huge improvements in the quality of life for billions of people around the world*

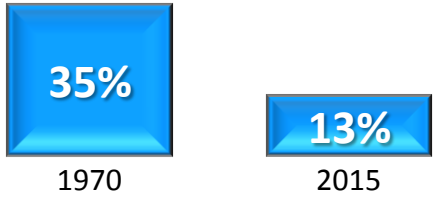
Abundant and affordable energy has underpinned huge progress in the human condition
Global Human Development Index vs oil & gas consumption



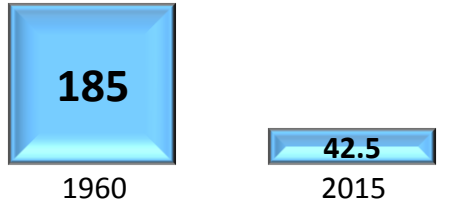
Life expectancy has surged
(global average, years at birth)

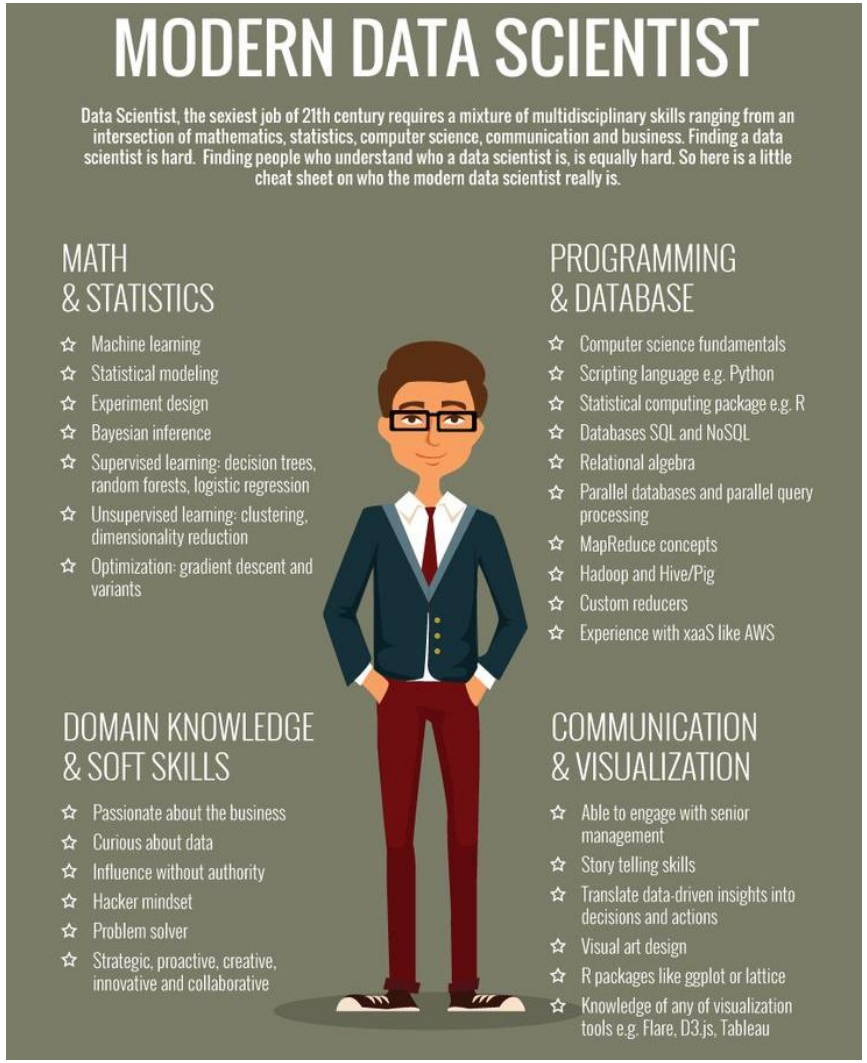


Global hunger is in decline (% pop. malnourished in developing countries)



Infant mortality has plummeted
(global average infant deaths per 1000 births)



*After Lambert Energy Advisory

The ingredients in the mixer……