Exploration Activity in the Oil & Gas Upstream Cycle

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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

**Upstream**
- **Basin Evaluation**: Regional Studies in order to identify areas with Hydrocarbon potential
- **Exploration**: Licenses Acquisition, Geological Studies, Seismic Acquisition & Drilling
- **Development**: Development Plan and Drilling, Facilities and Infrastructure Construction
- **Production**: Management, Work-Over, Abandonment

**Midstream**
- **Oil**: Tankers, Oil Pipes
- **Natural Gas**: LNG, Gas Pipes

**Downstream**
- **Oil**: Chemicals, Refinery Marketing
- **Gas**: Gas Market, Electricity
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

No current activity

□ Exploration & Production
□ Exploration
□ No current activity

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
- **Development**: Development Plan and Drilling, Facilities and Infrastructure Construction
- **Production**: Reservoir Management, Work-Over, Abandonment
Upstream Activity Cycle

- **Regional Studies**
- **Geological Model**
- **Exploration Potential**

**LICENCING**
- Bid Round
- Direct negotiation
- Farm in
- Merge / Acquisition

**EXPLORATION**
- Seismic acquisition & interpretation
- Prospect Definition
- NFW Drilling
- Subsurface Geology Studies
- Production Test

**APPRaisal**
- Appraisal Drilling
- Reservoir Modelling
- Feasibility Studies

**DEVELOPMENT**
- Development Plan
- Development Wells Drilling & Completion
- Surface facilities and infrastructure construction

**PRODUCTION**
- Production Management
- Reservoir Management
- Reservoir Modelling
- Work Over

**ABANDONMENT**
- Well dismission
- Facilities Dismission
- Environmental Recovery

**PROJECT LIFE CYCLE**
- License Awarding
- Time to Discovery
- Discovery
- Time to Market
- Start Production (First Oil)

**CUMULATIVE CASH FLOW**
- 

**PROJECT COST**
- Discovery Start Production (First Oil)

**TIME**
- 

**LICENCING ACQUISITION**
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

- Geologist
- Geophysicist
- Exploration Manager
- Sedimentologist
- Engineer
- Development/Production Economist
- Negotiator
- Driller
- Geologist
- Negotiator
- Driller
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”

**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.

**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).

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

**Expulsion**
Process by which fluids (HCs) are expelled from Source Rock into Reservoir.

**Migration**
Movement of fluids (HCs) from Reservoir to Trap through the Carrier.

**Accumulation**
Geometrical configuration of the Reservoir and Seal couplet allowing accumulation.

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...

Source Rock

Reservoir

Seal

Trap
Theory is Ok, but...where to drill and...at which depth???
Geological Field Trip Data Analyses and Studies

TOURIST FM. (Riphean)
tectonically controlled stromatolitic carbonate ramp of F4 well (equiv. to Chenachane Fm)

Cenophyton-Jacophyton bioherms, black shales and marlstone (Taoudenni Basin, Mauritania) after Kolonic et al., 2004

TOURIST FM. (Riphean)
Depressions characterized by black shales sedimentation drilled by F5 well (equivalent to Oued Souss Fm.)
Remote Sensing: LandSat7 and ASTER* Study: Landcover and Lithotype

- **Code**
  - 1: Road, tracks
  - 2: Uadi
  - 3: Linear dunes
  - 4: Rock veins
  - 5: 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
- GGT* - Tzz (vertical) Component
- Total Magnetic Intensity RTE Reduced to the Equator
- Magnetic Basement C.l. 500 m
- Sill, Dyke
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.

Oil not detectable | Oil detectable | Oil not detectable
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

Massiccio Sella – Passo Gardena

Supergiant Gas Field (Zohr)
Seismic Process

Seismic Acquisition → Seismic Data → Subsurface Image

Seismic Processing & Imaging

Loading → QC → Signal Processing

- Final Depth Imaging
- Post Processing

- Velocity Model Building
- Depth Imaging

Time Imaging

Client delivery and storage
Eni Technology Roadmap: Digital Simplification of Geo Complexity

**Computing Power**
- **2012**: 0.5 PFlops
- **2014**: 5.1 PFlops
- **2018**: 22.4 PFlops

**Eni Green Data Centre** (hosting HPC3 & HPC4)

**Accuracy**
- **2012**: 8 months
- **2014**: 6 months
- **2018**: 2 months

**Reduction of turnaround times**
- **2018**: 1 week

**Next**: 1000 PFlops
3D Visualization: Structural vs Sedimentary Facies Rendering

Structure and sand distribution may not be linked
G&G Studies: Biostratigraphy

Integrated High resolution biostratigraphy

Palynology

Nannofossils

Foraminifera & Microfacies

Occurrence of marker taxa

High resolution biochronostratigraphy

Paleoecology & Paleoenvironmental Reconstruction

spores, pollen & freshwater algae

calcareous algae

benthic forams

planktonic forams

calcareous nannoplankton

dinoflagellates

Early Miocene

Aquitanian

Serravallian

Gondwana

Aquitanian

Early Miocene

MNN7

MNN8

MNN9

MNN10

MNN11a

MNN11b

MNN11c

MNN12
G&G Studies: Structural Characterization

Relay Ramps

Extentional Normal Faults
G&G Studies: Clastic and Carbonate Sedimentology

Integrated exploration and reservoir scale studies

Stratigraphic and sedimentological modelling

Clastic and carbonate Sedimentology
Overbank Sheets

Channel axis (youngermost system)

Confined overbanks (youngermost system)

Meander terraces

Sand filled channel belt (older system)

Thicker channel axis (older system)

Well

G&G Studies: Sedimentology

CONTINUITY

+ 10 Hz
+ 20 Hz
+ 40 Hz

Meandering River (Google Map)
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.
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.
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- 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

- **Drillship**: Operates at water depths up to 12,000ft.
- **Semi-submersible**: Operates at water depths up to 10,000ft.
- **Jack-Up Rig**: Operates at water depths up to 500ft.
- **Drilling Barge**: Operates in shallow waters.
- **Landrig**:
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%

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

**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%

Eni Petrophysical Interpretation, 03 Sep. 2009
NFW and OUT Wells (example from Perla Field, Venezuela)

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

- **Tight Oil**
- **Tight Gas**
- **Shale Oil**
- **Shale Gas**
- **Oil Shale**
- **Coalbed gas or Shallow Biogenic Methane**
- **Bituminous Sand/Heavy Oil**
- **Conventional structural gas accumulation**
- **Conventional structural oil accumulation**
- **Conventional stratigraphic gas accumulation**
- **Conventional oil generation window**
- **Gas generation window**

- **WATER**
- **0.6% Ro**
- **1.3% Ro**

- **Overpressured Cell**

- **Tens of miles**
Conventional vs Unconventional Exploration and Production

Conventional Field

Unconventional Field

Source Rock
Unconventional Fields

- Development of Unconventional Fields needs much more production wells compared to Conventional 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)
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

- **Eni**
- **Statoil**
- **Total**
- **Exxon Mobil**
- **Shell**
- **Chevron**
- **CoP**
- **BP**

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<td>BP</td>
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Why still Oil & Gas? Primary Energy Demand

End-use sector

Region

Fuel

BP Energy Outlook, 2018
Alternative Scenarios

Primary energy consumption by fuel

- Billion toe

Carbon emissions

- Billion tonnes CO₂

BP Energy Outlook, 2018
New discoveries are required to fill the future global needs of Liquid Fuels

Peak liquid demand in 2032 (WoodMac scenario)

EXPLORATION IS NEEDED!

ONSTREAM

15 mboe/d!
Forecast of Sources of Energy required to meet World Energy Demand to 2100

[Graph showing projected energy demands from 1900 to 2100, with labels for Crude Oil, Natural Gas, Coal, Nuclear Electric, Solar Wind, Geothermal, Careers in Oil & Gas Remains Important, and Hydroelectric.]

World Energy Demand

Billion Barrels of Oil Equivalent per Year (GBOE)

1900 1920 1940 1960 1980 2000 2020 2040 2060 2080 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

- The shale-gas fracking debate
- Arctic drilling and climate change
- Groundwater Contamination
- The Macondo Disaster
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)

1960  1970  2015
52  35%  72

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

1970  2015
42.5  13%

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

1960  2015
185  42.5

*After Lambert Energy Advisory
**ANATOMIA DO GEÓLOGO**

A mochila do geólogo é feita de materiais desconhecidos que aliam o peso das amostras e que são um segredo para a ciência moderna.

A bússola do geólogo carrega segredos milenares de como ser mantida. Encostado nos demais, os usam só para tentar se orientar, nós os utilizamos para definir como as rochas se comportam.

O chapéu é essencial, alguns preferem bonecos, outros usam aqueles estilo baléideiro, tem até quem vai à campo de sambo. Portanto, o mais tradicional é o estilo legionário.

Os óculos escuros vistam o céu, um Grandes ou pequenos todos sabemos que a sua real função é proteger os olhos na hora de usar o martelo.

O martelo está para o geólogo, como o tratador está para a cirurgia. São depósitos de anos de experiência que se consegui dominar todas as técnicas de como utilizar esse aparato.

As botas são sagradas para o geólogo. Elas nos trazem sobre caminhos secretos até os depósitos minerais que só nós sabemos encontrar. O geólogo que não se importa com sua bota, sempre anda com um rolo de fita de silicone na mochila.