BASIC PETROLEUM GEOLOGY

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PEEL HUNT

Oil & Gas: Introduction

In response to popular demand, we are republishing a report that aims to outline some of the basic concepts, facts and definitions within the upstream oil and gas sector.

The following presentation therefore gives a high- level introduction to a subject area that we understand can often feel as if there is a high knowledge barrier to entry, with regards to terminology and where there can be significant variability in the reporting quality of certain metrics.

If further clarification is required on any of the content, or how it relates to particular companies, then by all means please feel free to get in touch with either Matt or myself and if we can help, then of course we will!

Enjoy!

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Soft rock vs hard rock

1. The Oil & Gas and Mining sectors are fundamentally different

Oil & Gas

'Soft rock geology'. Formed from deposition of **sedimentary** rocks over millions of years.

Mining

'Hard rock geology'. Typically covers crystalline rocks formed via **igneous** and **metamorphic** events.

2. Sedimentary rocks

- Comprises rock types originating from the erosion of the earth's surface, which are subsequently deposited and accumulate in 'basins' either onshore or offshore.
- Sedimentary rocks include sandstones and mudstones. Both are deposited in layers, which get buried over time.
- Mudstones have a high organic content, are fine-grained and represent the 'source' of hydrocarbon, or oil and gas generation.
- Sandstones comprise larger grained quartz-rich rocks and often represent an oil and gas 'reservoir'.

Elements of a petroleum system

Source rock

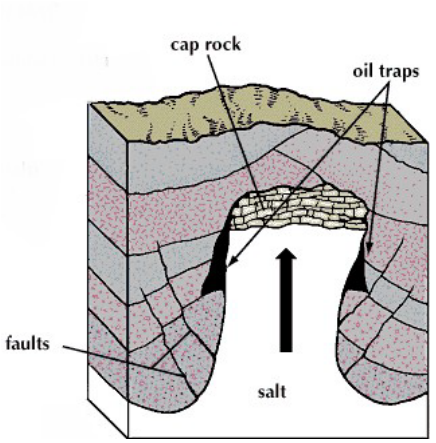
An organic-rich sedimentary rock with either a marine or terrestrial origin, which under the right temperature and pressure regime generates hydrocarbons

Reservoir rock

A porous and permeable sedimentary rock that allows hydrocarbon change, accumulation and flow to the wellbore. Can be 'clastic' i.e. sandstone or 'carbonate' i.e limestone

Seal/cap rock

An impermeable layer of rock that prevents upwards migration of hydrocarbons, i.e. salt layer

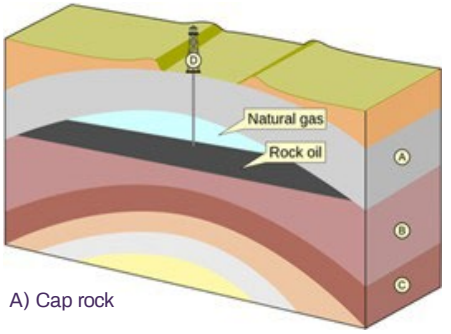


Trap

A configuration of rocks suitable for containing hydrocarbons and sealed by an impermeable cap rock

- Stratigraphic i.e. channel edge

- Structural i.e. fault/fold



A) Cap rock

B) Reservoir rock

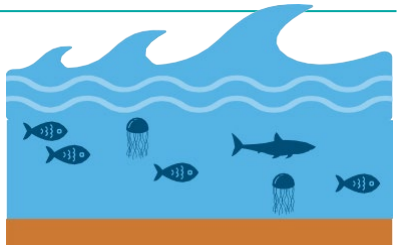
C) Source rock

D) Well

How is oil and gas formed?

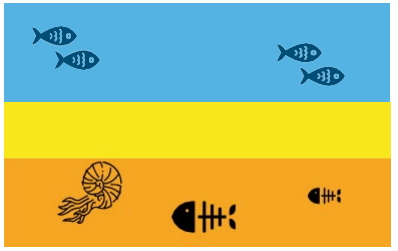
Erosion and deposition of organic-rich sediments or ‘source rocks’ into basins

Dead plants and animals fall to the seabed



Continued accumulation and burial of source material over time

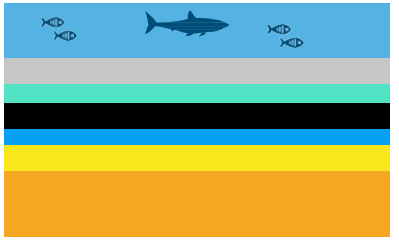
Organic matter builds up over millions of years



Increased burial depth increases the temperature and pressure exerted on the sediment

When temperature reaches 60˚C, kerogen within organic material begins to ‘crack’, this is the start of hydrocarbon generation

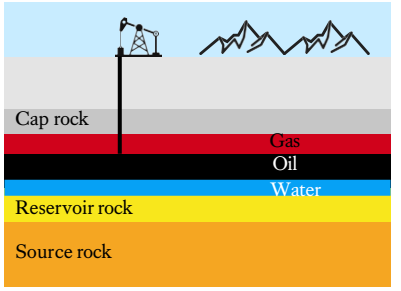
Increasing burial depth increases temperature and pressure causing oil and gas to be expelled



Oil begins to form first between 60-120˚C Increasing burial depth increases temperature/pressure, then between 100-200˚C the cracking process enters ‘gas window’

Hydrocarbons then migrate out of the source rock into reservoir rock and become trapped (usually over a few ten’s of km’s, but sometimes over very long distances >100 km)

Oil and gas migrates into reservoir rock and gets trapped by cap rock/seal

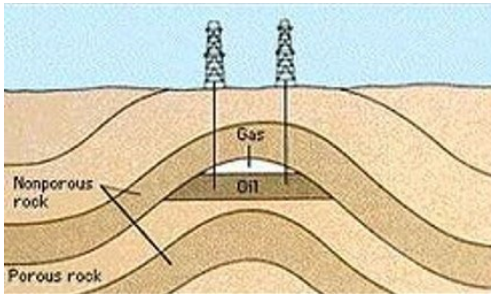


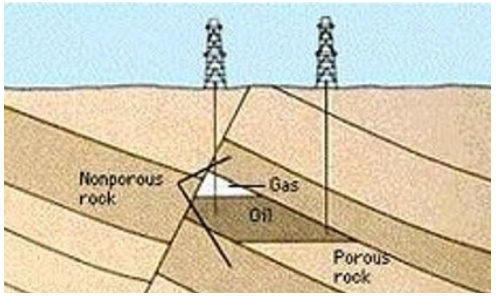
Soft rock vs hard rock

1. Structural

Hydrocarbon traps that form in geologic structures such as folds and faults.

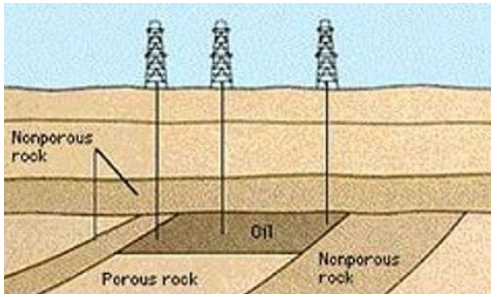
Typically more easily defined on seismic and lower risk than stratigraphic traps.

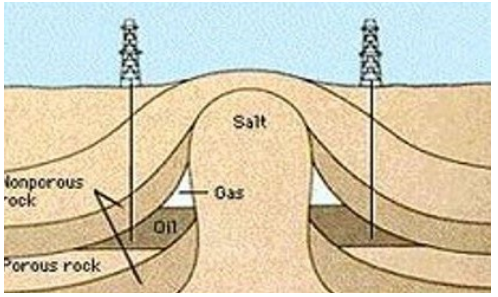




2. Stratigraphic

Hydrocarbon traps that result from changes in rock type or pinch-outs, unconformities, or other sedimentary features such as reefs.





Seismic surveys help to develop a picture of the subsurface. Acoustic energy sent into the earth passes through rocks of varying density.

The 'travel time' of acoustic energy reflected off different rock strata yields information about rock type and subsurface geometry.

Seismic data is the primary geophysical tool that assists the de-risking of an exploration project.

- Helps define geological structures, faults and stratigraphy.
- Helps understand potential formation fluid content.
- Helps generate more accurate hydrocarbon volumetric assessments.
- Helps geologists construct predictive subsurface models.
- Helps refine well locations when approaching drilling phase.

Improved imaging & processing

PH

Sparse line 2D

Discrete strips of data that hint at subsurface features.

Early processed 3D

A rough image showing all of the structure but with little precision of boundaries.

Modern, fully processed 3D

High-resolution of features with accurate geometry & structural compostion.

Hydrocarbon fluid quality

API gravity

American Petroleum Institute gravity (API) is a measure of how heavy a petroleum liquid is compared to water. If API is >10 it is lighter and floats. If API <10 it is more dense and sinks. API gravity is one important indication of crude quality; lighter API crudes contain the higher value, 'lighter ends' of hydrocarbon chains, which can command a premium to Brent (38˚ API) and international prices.

API Gravity	Hydrocarbon type	Relative density
>55	Condensate	Lightest
38 - 55	Light crude	
22 - 38	Medium crude	
10 - 22	Heavy crude	
0 - 10	Extra heavy crude	Heaviest

Viscosity

A property of fluids that indicates their resistance to flow. The unit for measuring crude viscosity is Centipoise (Cp). Viscosity is an important property for estimating the productivity of an oil well. Low viscosity crude can support well productivity and be positive for the economics of a field development (can reduce the number of wells required, and can aid higher production upfront).

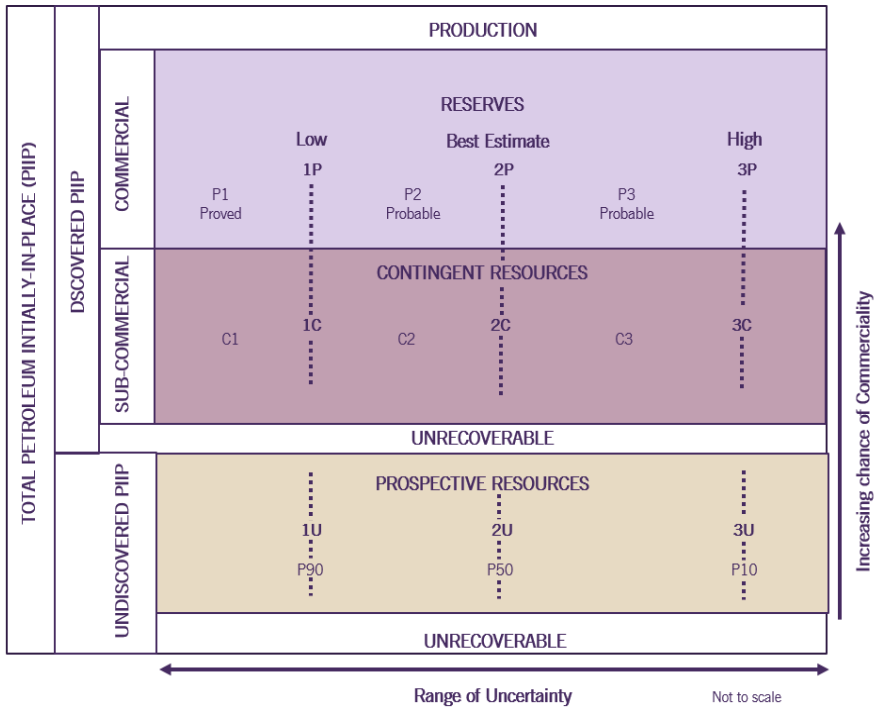
Fluid	Cp	Oil field example	Cp	API
Water	1 - 5	Brent, UK NS	<1	38
Blood	10 - 20	Alba, UK NS	7	20
Vegetable oil	40 - 50	Shaikan, Kurdistan	48	18 - 26
Heavy crude oil 100		Captain, UK NS	88	19 - 21
Maple syrup	150 - 100	Morichal, Venezuela	145	16
Thick motor oil	500 to 1k	Bentley, UK NS	627	10 - 12
Glycerine	1k - 2k	Pelican Lake, Canada	1,000	15
Honey	2k - 3k	Faja, Venezuela	4,500	8 - 9
Bitumen	10k	Tar sands, Alberta	>10k	8 - 9

Reserves & resources

Reserves
"Those quantities of petrolem which are anticipated to be commercially recovered from known accumulations"; usually deterministic calculations i.e. 1P-2P-3P reserves.

Contingent resource
"Those quantities of petroleum which are estimated to be potentially recoverable from known accumulations, but which are not currently considered to be commercially recoverable"; usually deterministic calculations i.e. 1C-2C-3C resources.

Prospective resource
"Those quantities of petroleum which are estimated to be potentially recoverable from undiscovered accumulations"; usually probabilistic calculations i.e. P90- P50-P10 resources.



Basic oil & gas units

Volume

- Oil volume is measured in barrels (bbl). Gas volume is measured in cubic feet (cf).
- Gas volumes expressed in terms of barrels are
- 'barrels of oil equivalent' (boe).

The industry uses Roman numerals for unit of volume: 1,000 = M; 1,000,000 = MM; and 1,000,000,000 = B.

Oil to gas conversion

- 1bbl = 5,600cf
- 1 MMbbls = 5.6Bcf 100MMbbls = 560Bcf = 0.56Tcf
- 1,000MMbbls = 1Bbbls = 5.6Tcf

API Gravity

API Gravity is measured in 'degrees' “."
= (151.5/Specific gravity) - 131.5

Specific gravity is a ratio of the density of one substance to the density of a reference substance, usually water. The API gravity is nothing more than the standard specific gravity used by the oil industry, which compares the density of oil to that of water.

Gas to boe conversion

- Divide by 5.6
- 300Bcf = 53.6MMboe
- 3Tcf = 536MMboe
- 30Tcf = 5.36Bboe

Convert various oil & gas units here or here

Exploration prospect risking

PH

Geological chance of success (GCoS)

- Characterises the chance of making a hydrocarbon discovery.
- GCoS is determined by multiplying individual petroleum system elements together.
- Exploration prospects can become 'de-risked' through application of geological and geophysical techniques, 'G&G' work.
- Or via acquisition and interpretation of additional data such as; 3D Seismic, gravity surveys, geochemical analysis, nearby well control.

Element risk	%	
P(Source)	60	x
P(Seal)	65	x
P(Reservoir)	65	x
P(Trap)	65	x
P(Migration)	60	
GCoS	**10%**	

"1 in 10"

Element risk	%	
P(Source)	80	x
P(Seal)	80	x
P(Reservoir)	65	x
P(Trap)	75	x
P(Migration)	80	
GCoS	**25%**	

"1 in 4"

E&P valuation methodology

The market tends to value E&P companies in the early stages of the upstream life cycle (exploration & appraisal phase) on a sum-of-the-parts asset value basis. Peel Hunt SOTP NAV valuation is structured into three parts:

1. **Core NAV:** Discounted future cash flows of existing proved producing assets in addition to the discounted cash flows of projects sanctioned for development. Against the summed NPVs of the producing/development assets, we offset the net debt and other financial liabilities.

2. **Risked NAV:** Core NAV plus discounted future cash flows of contingent resources risked to reflect various financial and development uncertainty. Risk is reflected by applying a Chance of Development (CoD) multiplier to the NPV of each appraisal/development asset.

3. **RENAV:** Risked NAV plus risked discounted future cash flows of exploration upside on a per prospect basis. We typically only include prospects that are going to be drilled on a 12-month view, or have drilling rig capacity booked.

E&P target prices & share prices

The devil's work

- Recommendations and target prices for E&Ps are not based on absolute value analysis alone. Potential 'catalysts' for share price and sentiment are equally important, e.g. share in a company with an attractive near-term drilling programme tend to outperform those without, all else equal. M&A is another key driver for share price performance. Given the subjectivity of our valuation framework, M&A transaction metrics provide valuation checks and allow read-across to peers.
- Target prices therefore include an element of judgement and sensitivity to prevailing market conditions.
- The discount/premium to Core/Risked NAV for an E&P company can largely be driven by
- sentiment, e.g. what is the historic exploration performance? Does management have a track
- record of successful deal execution/delivering production targets? Is it a potential M&A target? Is there a near-term funding requirement?
- E&P share prices rarely trade materially above Risked NAV, i.e. the market tends not to recognise the full risked exploration upside potential of a company.

In summary, some of key value drivers for E&P companies are:

- Key events, i.e. drilling newsflow, M&A. Reserves/production growth.
- Funding situation.
- Oil price/macro backdrop.

E&P RNS jargon

- **DST** = **Drill Stem Test.** Synonymous with ‘flow test’. DST’s are carried out to determine if a well has found a producible, commercial hydrocarbon reservoir.
- **FPSO** = **Floating, Production Storage and Offloading**. A vessel that receives fluids from a subsea reservoir through risers and then separates them into crude oil, natural gas and water within on-board ‘topside’ production facilities.
- **FDP** = **Field Development Plan.** Comprises all activities and processes required to develop a field from environmental impact, geology, reservoir and production engineering, infrastructure, well design, economics and risk assessment.
- **FEED** = **Front End Engineering and Design**. A post-feasibility study engineering design approach to define expenses and plan a project to support an investment decision.
- **FID = Final Investment Decision**. The point in the capital project planning process when the decision to sanction major financial commitments is taken.
- **Gross pay** = Overall reservoir interval of interest within the well (measured in metres or feet).
- **Net pay** = Portion of reservoir in the well that contains economically producible hydrocarbons (measured in m or ft). **PSC** = **Production Sharing Contract**. An agreement between parties to a well and a host country regarding the % of production each party will receive after a specified amount of costs and expenses have been recovered.
- **Seismic data** = Measures the ‘acoustic impedance’ or relative density of rocks in the subsurface. It’s used to interpret fluid content, geometry and, with respect to drilling, helps ‘de-risk’ exploration prospects and define drilling locations. **Spud** = The operation of drilling the first part of a new well.
- **TD** = The ‘Total Depth’ of a well.
- **Wireline logs** = Data/measurement of reservoir formation/fluid properties acquired by tools down the wellbore lowered by an electric cable.

Search for oil and gas definitions here

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