

Petroleum Exploration

Upstream | Petroleum Exploration

The role of exploration is to provide the information required to exploit the best opportunities presented in the choice of areas, and to manage research operations on the acquired blocks.

An oil company may work for several years on a prospective area before an exploration well is spudded and during this period the geological history of the area is studied and the likelihood of hydrocarbons being present quantified.

Stages of a typical exploration program

Exploration is responsible for handling the risk intrinsic in this activity, and this is generally achieved by selection of a range of options in probabilistic and economic terms.

Indeed, exploration is a risk activity and the management of exploration assets and associated operations is a major task for oil companies.

The risk cannot be eliminated entirely but can be controlled and reduced adopting appropriate workflow, conceptual and technological innovations.

When it's been decided to start up with an exploration project in a basin or in a larger area containing several basins, the quantity and quality of available data must be acquired and evaluated – geological data, type of reserves, production of existing fields (if any), etc.

Basin assessment/evaluation is the first step to undertake the study of the area under interest.

Technological development has provided oil companies with

Basin Modeling – which is a numerical simulations that allows the temporal reconstruction of the history of a sedimentary basin and the associated evolution of the processes related to the formation of petroleum accumulations.

Basin modeling – Petroleum system

On the basis of data and evidences collected from the preliminary studies, the company management, in the light of the possibilities and the probabilities of a discovery based on G&G data, aside from considerations of an economic nature, may decide to move to the following stage, which is the acquisition (through direct negotiations or by taking part in bids, etc.) of the legal right to perform prospecting in the selected area/block.

The owner of the mining right is normally the State, with which the oil company stipulates a contract establishing the contracting parties' rights.

Production Sharing Contracts and service contracts are frequently adopted nowadays.

The sequence of activities covered by an exploration permit is fairly uniform, and include

- the creation of a database
- the analysis of available data
- the programming of mapping and geological and photo-geological surveys
- seismic surveys and interpretation of seismic data
- the choice of well locations, drilling
- the analysis of results and the decision as to whether or not to proceed with the application for a lease or to release the area after fulfilling obligations

Goal of exploration is to identify and locate a prospect, to quantify the volume of hydrocarbon which might be contained in the potential reservoirs and to evaluate the risk inherent the

project itself.

A prospect is a viable target evidenced by geological and geophysical indications that is recommended for drilling an exploration well.

A detail of seismic section (time) and A horizon depth map (meters) referred to prospect X – (Treccani Petroleum Encyclopedia)

The prospects identified must be technically practicable and meet the market conditions to guarantee a financial return on investments.

The results obtained by drilling the exploratory wells indicate whether the initial geological hypotheses are correct or whether variations are found.

All this will allow the fine-tuning of the economic analysis of the project possibly turning hypothetical reserves into proved ones.

Where profitability does not meet the standards of the company, it leads to the termination of further investments.

The main petroleum exploration techniques

Geological mapping and prospecting

Geological mapping and prospecting are valuable techniques in an petroleum exploration.

Geological mapping It is basically a technique which allows a graphical presentation of geological observations and interpretations.

Geological prospecting make use of geological disciplines such as petrography, stratigraphy, sedimentology, structural geology, geochemistry.

Such disciplines are used to achieve different targets but it

must be stressed that their integration is fundamental to depict a picture of reality.

Geophysical methods

Geophysical methods allow to study the physical properties of the subsurface rocks and they can be used in different phases of the exploration in order to collect different types of information.

Geophysical methods such as gravimetric, magnetometric, magnetotelluric, seismic are often combined to obtain more accurate and reliable results.

- *Gravimetric prospecting*

- Gravimetric prospecting is a geophysical technique which is able to identify anomalies in the gravity acceleration generated by contrasts in density among bodies in the subsurface.
- Gravimetric prospecting is used to reconstruct of the main structural elements of sedimentary basins such as:
 - extension, thickness, salt domes, intrusive plutons and dislocations or fault lines.

- *Magnetometric prospecting*

- This method involves measuring local anomalies in the Earth's magnetic fields.
- The method enable acquisition of data on structural characteristics and depth of the susceptible basement and therefore, indirectly, on the thickness of sedimentary overburden and identifies the presence, depth and extension of volcanic or plutonic masses within the sedimentary sequences.

- *Seismic prospecting*

- Seismic prospecting has become the most valuable technique to reduce exploration risk of being

unsuccessful in locating a prospect.

- The technique is based on determinations of the time interval that elapses between the initiation of a seismic wave at a selected shot point and the arrival of reflected or refracted impulses at one or more seismic detectors.
- The phase of seismic data acquisition is followed by the seismic data processing phase (aimed to the alteration of seismic data to suppress noise, enhance signal and migrate seismic events to the appropriate location in space) than by the interpretation of the generated subsurface image.

Left: Onshore seismic survey

Right: Marine seismic survey

Geophysicists interpret the processed seismic data and integrate other geoscientific information to make assessments of where oil and gas reservoirs may be accumulated.

A 2D interpreted seismic section

Powered by advanced supercomputer power, rapid data loading, high-speed networking and high-resolution graphics, visualization centers provide the ability to display and manipulate complex volumes of 3D data resulting in better interpretation of more data in less time.

▪ *Drilling the exploration well*

- Once geological and geophysical information have defined and evaluated (technically and economically) the drillable prospect, it is possible to move to a fundamental phase of the exploration project – the drilling of the first exploratory well.
- The drilling of the exploration well is aimed to confirm the presence of the petroleum accumulation.

- *Well logging*

- The well logging technique consists of lowering a 'logging tool' into the well to acquire geological data and to reveal reservoir fluids characteristics.
- Well logging help geoscientists and engineers to understand:
 - Presence of reservoir
 - Presence of hydrocarbons and characteristics
- Reservoir properties, etc..

- *Coring*

- Coring provides the only means of obtaining highquality samples for the direct measurement of rock and reservoir properties.
- Core samples are then used to perform Routine Core Analysis and/or Special Core Analysis to obtain detailed petrophysical data.

Coring and coring equipment at surface

- *Well testing*

- A well test is the measurement under controlled conditions of all factors relating to the production of oil, gas, and water from a well.
- Well tests are conducted to acquire dynamic rate, pressure, temperature, and fluid property data.
- The acquired information is used to determine reservoir capabilities and important decisions such as production methods, well production equipment, and field development drilling are made from the interpretation of well test results.

Well testing on board of semisub rig