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ar son na hAeráide & Comhshaoil
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Climate Action & Environment



Petroleum exploration in Ireland's offshore basins

science & technology
in action
www.sta.ie
13th edition

Introduction

Since the **Industrial Revolution** the burning of **fossil fuels** has raised the concentration of atmospheric carbon dioxide (CO₂) from 280 **ppm** to over 400 ppm. This increase is the major cause of the **enhanced greenhouse effect** causing global warming. It is almost universally agreed that we must reduce CO₂ emissions and develop alternative energy sources.

During the transition to a low-carbon future we will continue to require fuel for transport, heat and electricity generation. With limited fossil fuel resources, Ireland relies heavily on foreign imports. Currently all of Ireland's oil demand is met through imports. Corrib and Kinsale gas fields provide Ireland with a portion of its energy needs but those fields are not in a position to meet all of the country's annual gas demand and so we will continue to rely on gas via the United Kingdom for the foreseeable future.

Tectonic plates

Plate tectonics is the study of the **lithosphere**, the outer portion of the earth consisting of the crust and part of the upper **mantle**. The lithosphere is divided into some very large and several smaller plates. The plates slowly move through time, changing size and shape. When the plates interact with each other, they create geologic events such as earthquakes, volcanoes, mountains, mid-oceanic ridges and the formation of sedimentary basins. The type of event depends on the composition of the plates and how they move relative to each other.

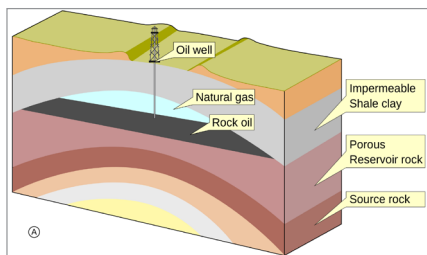
Approximately 300 mya (million years ago) the plates were assembled into a supercontinent called Pangea. Pangea began to break up during the early Jurassic (approximately 200 mya) eventually forming the modern continents and the Atlantic and Indian Oceans.

Many of the Earth's natural resources of energy, minerals, and soil are concentrated near past or present plate boundaries. Understanding the movement of the Earth's surface and the historical position of the plates assists petroleum geoscientists in locating oil and natural gas deposits. This is particularly the case for Ireland where understanding the reconstruction of the plates in the North Atlantic is an essential tool for the exploration of oil and gas offshore Ireland.

The formation of fossil fuels

Most oil and gas is formed from the remains of **plankton** (both **zooplankton** and **phytoplankton**) that sinks to the ocean floor. Fossil fuels can also form from land plants. In order for fossil fuels to form, the plankton and land plants must be buried in **anoxic** (without oxygen) conditions. Over long periods of time (millions of years) these organic layers are covered with sediment and, with heat and pressure, eventually form coal, oil and natural gas.

Oil and gas, if present in the pore spaces of the sedimentary rock moves through the subsurface and escapes, unless it is trapped by an **impermeable** layer of rock (e.g. **shale**, salt, carbonate).

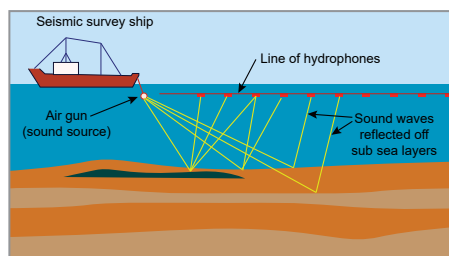


Geological oil trap (Source: Wikimedia Commons)

Methods of finding oil/gas reserves

Drilling wells offshore using **oil rigs** and **drill ships** is not cheap; for example, a well drilled offshore Ireland in 2014 cost in the order of 200 million euro. The actual cost of drilling a well depends on a number of factors, including water depth, rig type and rig availability. So, before attempting to drill for oil it is essential to survey the area in order to identify the most likely locations of trapped oil or gas. The main types of survey used for this purpose are **seismic**, gravity and magnetic.

Typically, in a marine seismic survey sound pulses are produced in a moving ship and the resulting echoes from the subsea rock layers are detected by a long line of **hydrophones** towed behind the ship. As the ship travels, the accumulated data are recorded and later processed and uploaded to high specification computers for interpretation by geoscientists.



Gravity surveys measure variations in the Earth's gravitational field. Local gravity variations are generally less than 0.1%. The actual value varies with **latitude** and the relative positions of the Earth, the Moon and the Sun. The difference between the expected gravity and the measured value is called an **anomaly**; it can be positive or negative. Negative anomalies indicate lower than average local densities.

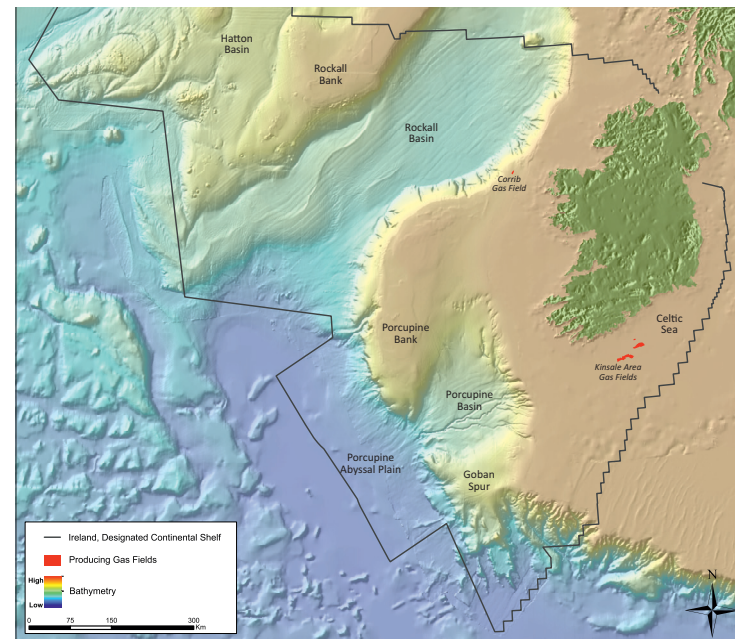
Similarly, magnetic surveys measure variations in the Earth's magnetic field. Airborne/shipborne magnetic and gravity measurements can be taken simultaneously. Although gravity and magnetic surveys have less **resolution** than seismic surveys they help in the identification of sedimentary basin geometry, oceanic/continental crust, salt/**igneous** bodies, the estimation of depth to basement and geological **faults**. Even when the survey data and interpretation indicate the likely presence of commercial quantities of oil or gas, success is not guaranteed.

What is the Irish Shelf

The designated Irish **Continental Shelf** is the area mostly to the west of Ireland which is designated as an area for the exploration of the seabed and its subsoil with regard to natural resources, including oil and gas resources. This area, which is almost 10 times the size of the island of Ireland, ranges in water depth from less than 200 m in the shallower parts to more than 4500 m in the deepest parts.

Oil and gas exploration in Ireland

Following the drilling of some uncommercial on-shore (i.e. land-based) **wells** in Ireland in 1962 and 1963, exploration moved offshore in 1970. The first two wells drilled were unsuccessful but the third well, off Kinsale Head, produced commercial quantities of natural gas and came on stream in 1978. Neighbouring **fields** came on stream in 1991, 1999 and 2003. Exploration continued in all offshore basins including Celtic Sea, Porcupine, Slyne, Erris and Rockall basins. In 1996 the Corrib Gas Field was discovered and came into production at the end of 2015. Oil has been discovered in a number of basins offshore Ireland, but not in commercial quantities and as such there is no oil production to date.



The Irish Shelf

Uses for oil and gas

- energy for transport, heating and electricity
- fertiliser
- pharmaceuticals, detergents, perfumes
- inks, dyes, paints, nail polish
- synthetic fibres and fabrics, foam, fibre-glass bonding
- adhesives, lubricants, candles
- synthetic rubber, tyres, plastics (containers, pipes etc.)



(Source: Calgary Herald)

Energy is indispensable to our society and economy and, in common with all developed economies, Ireland's energy policy seeks to balance the competing aspects of sustainability, competitiveness and supply.

The discovery of natural gas fields offshore Ireland has enabled the transition from fuel sources such as peat, coal and wood to natural gas. Natural gas is now used for domestic heating in many cities and towns in Ireland. Continued offshore exploration for natural gas can help secure Ireland's energy supply and help meet our current and future energy needs.

Petroleum products are a part of everyday life for Irish citizens. In order to move to a low carbon economy we must reassess our use of fossil fuels, make conscious decisions on the products we buy and seek alternatives where possible.

DCCAE (the Department of Communications, Climate Action and Environment) is responsible for communications, climate action, environment, broadcasting, energy, natural resources and postal services.

Petroleum Affairs Division

The role of DCCAE's Petroleum Affairs Division (PAD) is to maximise the benefits to the State from exploration for and production of Ireland's oil and gas resources. It ensures that activities are conducted with due regard to their impact on the environment and other land/sea users.

PAD is responsible for licensing and regulating activities relating to exploration and production of oil and gas, both offshore and onshore Ireland. It promotes investment in exploration in the Irish waters and supports research directed at deepening knowledge of the oil and gas potential of the Irish offshore. (Link)

For more details visit: www.dccae.ie

The Petroleum Infrastructure Programme (PIP)

The Petroleum Infrastructure Programme was set up by the Petroleum Affairs Division (PAD) in 1997. Research under the programme goes beyond normal licence area-specific work and avoids duplicating the efforts of other groups or of commercial contractors. PIP is funded by oil companies with frontier licences offshore Ireland and the PAD.

For more details visit: www.pip.ie/page/1

Irish Shelf Petroleum Study Group (ISPSG)

The ISPSG Group was set up by the Petroleum Affairs Division (PAD) in 2002 to address common industry problems anywhere in the Irish Offshore. It supports relevant geophysical surveys, studies to improve cost effectiveness and environmental monitoring and other agreed projects.

For more details visit: www.pip.ie/page/24

To view the lesson from the DCCAE on Climate Change from Edition 12 please click the link below.
<http://sta.ie/lesson/climate-change-an-overview>

Find this and other lessons on www.sta.ie



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Syllabus References

The main syllabus references for the lesson are:

Leaving Certificate Geography

- The tectonic cycle. The rock cycle: ... oil gas exploitation, geothermal energy production. (p. 10)
- structures of deformation including folding, doming, and faulting. (p. 11)

Leaving Certificate Physics

- Longitudinal and transverse waves: frequency, amplitude, wavelength, velocity. Reflection, refraction, diffraction. (p. 30)
- Newton's law of gravitation (p. 26)
- Magnetic poles and fields; Earth's magnetic field (pp. 18, 19)

Science and Technology in Action is also widely used by **Transition Year** classes.

Learning Outcomes

On completion of this lesson, students should be able to:

- Outline how today's land masses were formed by the movement of tectonic plates
- Explain why parts of Ireland, the United Kingdom and Canada have the same rock types
- Explain the origin of fossil fuels
- Outline the methods used to identify likely fossil fuel reserves
- Summarise the main uses of fossil fuels

General Learning Points

These are additional relevant points which are used to extend knowledge and facilitate discussion.

- The Earth formed about 4560 mya (million years ago) and around 580 mya the first multicellular organisms appeared.
- Fossil fuels formed millions of years ago from the buried remains of plants and animals.
- Commercial gas reserves were discovered off Co. Cork coast (Kinsale gas field) and off Co. Mayo coast (Corrib gas field) but there has been no commercial discovery of oil in Irish waters so far.
- The main types of survey used to identify the most likely locations of trapped oil or gas are seismic, gravity and magnetic.
- Oil and gas exploration and production bring many benefits, including greater energy security and revenue for the State..
- Apart from their use as fuels, oil and gas are raw materials for the production of plastics, pharmaceuticals, detergents, perfumes, paints, synthetic fibres, adhesives etc.

Student Activities

1. Make a chart summarising key stages in the geological history of the Earth and the formation of fossil fuels.
2. List the number of petroleum products you have used within the last 24 hours. Which ones do not yet have a readily available alternative?
3. Describe how an offshore oil rig drills a well.
4. Explore what is meant by traps and seals in the context of oil/gas reservoirs. Summarise your findings.
5. Which countries have the most oil and gas production? How does Irish production compare with these?
6. What are the main sources of energy used in Ireland? From where does Ireland import its gas and oil? How much is produced offshore Ireland and how much of our energy needs does that amount meet?
7. Challenging task:
If 129 exploration wells have been drilled offshore Ireland since 1970 yielding 4 commercial discoveries. Calculate the percentage probability of making a commercial discovery.
If the cost of drilling an exploration well offshore Ireland is €200m and the estimated post tax value of the potential discovery is €8,900m, would you drill the well?
Justify your answer.
(See: <http://gis.dcenr.gov.ie/internet/IPAS/servlet/internet/IPAS2IDisplayGlobalMFViewer> or <https://atlas.marine.ie/> and <https://www.ogauthority.co.uk/data-centre/interactive-maps-and-tools/>)

True/False Questions

- | | |
|--|-----|
| a) The best way to find oil and gas is by gravity surveys. | T F |
| b) Most fossil fuels were formed in the last 10,000 years | T F |
| c) Most oil and gas formed from the remains of plankton. | T F |
| d) Offshore oil rigs can cost about 200 million euro. | T F |
| e) Photosynthetic microbes evolved about 3000 mya. | T F |
| f) Hydrophones are used in seismic surveys. | T F |
| g) An understanding of geology is not necessary for oil or gas exploration. | T F |
| h) The Corrib Gas Field was discovered in 2015. | T F |
| i) The acceleration due to gravity is the same at all points at the same latitude. | T F |
| j) Seismic surveys have better resolution than magnetic or gravity surveys. | T F |
| k) Currently all of Ireland's oil requirement is imported. | T F |
| l) Ireland does import natural gas. | T F |

Check your answers to these questions on www.sta.ie.

Examination Questions

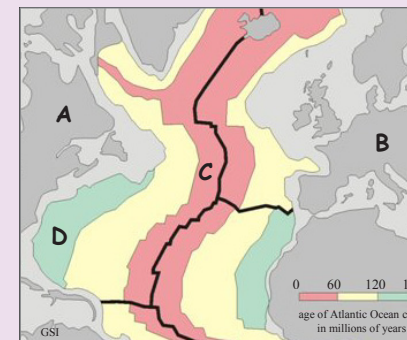
Leaving Certificate Geography (HL) 2017, Part II, Q. 2 C

Examine how the tectonic cycle helps to explain the global distribution of one of the following:
volcanoes, earthquakes, fold mountains.

Leaving Certificate Geography (HL) 2013, Part I, Q. 1

Examine the map and answer the following questions.

- (i) Name the plate at A and the plate at B.
- (ii) Name the type of igneous rock most frequently found at C.
- (iii) State the age range of the ocean crust at C and the age range of the ocean crust at D.
- (iv) Explain briefly why the ocean crust at D is older than the ocean crust at C.



Leaving Certificate Geography (HL) 2009, Part II, Q. 1B

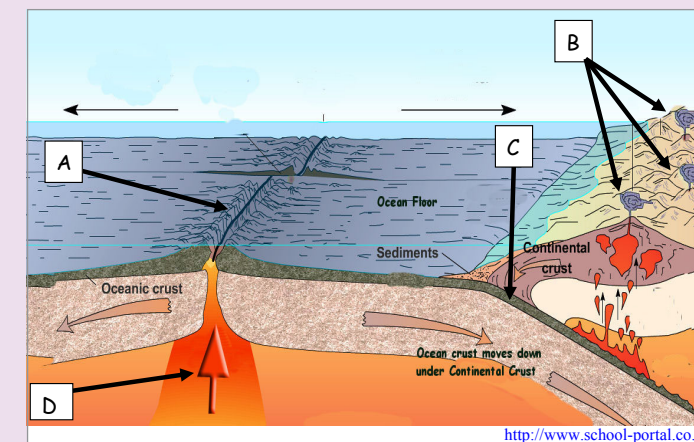
Explain, with reference to examples you have studied, how plate tectonics helps us understand the forces at work along crustal plate boundaries.

Leaving Certificate Geography (HL) 2013, Part II, Q. 1C

Examine the influence of tectonic activity on the development of the Irish landscape.

Leaving Certificate Geography (HL) 2009, Part I, Q. 2

Match each of the named landforms in the with one of the letters in the diagram:
volcanoes, mid-ocean ridge, subduction zone, rising magma.



Did You Know

- A total of just under 160 exploration and appraisal wells have been drilled offshore from 1970 to 2017. This is a very small number when compared to countries like UK and Norway and highlights the underexplored nature of our offshore.
- Over the past few years the number of exploration authorisations has increased to its highest ever level.
- There has also been an increase in recent years in the amount of seismic data acquired, including data from the Department's Regional Seismic Survey acquired in 2013 and 2014. However, Ireland still remains relatively underexplored.
- The Irish Government makes exploration data available to researchers on the following web page:
<http://gis.dcenr.gov.ie/internet/IPAS/servlet/internet/IPAS2IHome>
- In 2015 a new Petroleum Production Tax (PPT) was introduced for new licences, significantly increasing the potential financial benefit to the State of commercial oil and gas production in Ireland.

Biographical Note

Rory Dunphy, Regional Manager - Ireland, Nexen Petroleum U.K. Limited

Rory completed his Leaving Certificate at the Good Counsel College in New Ross, Co. Wexford. From there he went on to study Geology at Trinity College Dublin where he graduated with a Masters in Geology in 2003 and developed important scientific skills. He began work in DCCAE as a Junior Geologist in both the Geological Survey of Ireland (GSI) and the Petroleum Affairs Division (PAD).

In 2004 he moved to Calgary (Canada) where he worked for an oil rig service company before moving to Nexen, a subsidiary of CNOOC Limited — one of the largest oil and gas companies in the world.

In his current role as manager of Nexen's regional office in Ireland, he is exploring Ireland's offshore basins where cutting edge science, technology and engineering are all essential for success.

"When you contemplate how complex it is to try find and develop hydrocarbons kilometres beneath the ground in 100's to 1000's of metres of water it is mindboggling, but very exciting to be a part of!"

Rory Dunphy

Revise The Terms

Can you recall the meaning of the following terms?
Revising terminology is a powerful aid to recall and retention.

anomaly, anoxic, continental shelf, drillships, enhanced greenhouse effect, faults, fields, fossil fuels, hydrophones, igneous, impermeable, Industrial Revolution, latitude, oil rigs, phytoplankton, plankton, resolution, seismic, shale, wells, zooplankton.

Check the Glossary of terms for this lesson on www.sta.ie