GEOSCIENCE FOR LEAVING CERTIFICATE GEOGRAPHY

Continuing Professional Development Course 2022

CARBON CAPTURE AND STORAGE LESSON PLAN

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iCRAG
SFI RESEARCH CENTRE IN APPLIED GEOSCIENCES

Geological Survey
Suirbhéireacht Gheolaíochta
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An Roinn Comhshaoil, Aeráide agus Cumarsáide
Department of the Environment, Climate and Communications

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Geoscience for Leaving Certificate Geography Teachers CPD programme

About the Geoscience for Leaving Certificate Geography Teachers CPD programme

Geoscience is vital for our sustainable future, and geography is the key gateway to geoscience for most students. The Geoscience for Leaving Certificate Geography Teachers CPD programme has been developed by iCRAG (the Science Foundation Ireland Centre for Research in Applied Geosciences) and Geological Survey Ireland to create an opportunity for teachers and geoscience professionals to come together to increase the awareness of geoscience within the Leaving Certificate geography curriculum.

During the CPD course, teachers and geoscience professionals from both research and industry are paired together to co-create curriculum facing resources that are freely available for use. Over the course of six evening sessions, teachers learn more about the cutting-edge geoscience being undertaken by their partnered geoscientists, before working together to develop a curriculum-facing resource using their interests, teaching expertise and the knowledge of the geoscientist. So far, the resources produced have included lesson plans, module plans and field guides and the accompanying teacher notes and slides/field booklets for each resource.

The resources link the most recent advances in geoscience to the geography curriculum in a way that is both understandable and relevant. The resources are freely available to be used for classes anywhere in the world. We hope that you and your students enjoy using them.

This resource

This resource has been developed by Cian O'Grady, a geography teacher at Calasanctius College, Galway alongside iCRAG scientist Pablo Rodriguez Salgado. The resource examines Carbon Capture and Storage from the Irish Perspective. Included in this resource pack is a full lesson plan and associated teacher notes, and a PowerPoint of slides. It is suitable for Leaving Certificate Students.

Sincerely,

Elspeth Sinclair

Elspeth Sinclair, Fergus McAuliffe, Siobhán Power
Programme Managers – Geoscience for Leaving Certificate Geography Teachers

Geological Survey Ireland, a division of the Department of Environment, Climate and Communications, has been mapping Ireland since 1845. They continue to map the Irish land and marine territories, as well as mineral and groundwater resources. They have responsibility for actions in the current Climate Action Plan including monitoring coastal change, the Just Transition in the midland counties, and providing data for de-risking offshore renewable energy. Irish geoscience research, particularly as it contributes to the development of government policy, is an important part of their work and they fund and co-fund many research projects, including some of the iCRAG research work. Their data and maps are freely available to all at www.gsi.ie.

iCRAG, the Science Foundation Ireland (SFI) Research Centre in Applied Geosciences, are a team of researchers creating solutions for a sustainable society. They develop innovative science and technologies to better understand Earth's past, present, and future and how people are connected to it. iCRAG drives research into areas that are critical to society, including:

- The minerals and metals we need for decarbonisation and sustainable energy.
- Securing and protecting groundwater and marine resources.
- Protecting society from Earth's hazards, such as floods and landslides.

Further information is available at: www.icrag-centre.org

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Lesson plan: Carbon Capture and Storage

Contents

Lesson plan:

Links to curriculum

1.3 Landform development: The development of landforms is influenced by geological structures which have resulted from the operation of the tectonic cycle

- sedimentary structures, bedding planes, joints etc

1.2 The rock cycle: Rocks are continually formed, modified, destroyed and reconstituted as part of the rock cycle. They are formed and modified by endogenic forces; they are destroyed by exogenic forces of erosion on exposure to weather and climate; they are reconstituted by the deposition of sediments.

- The geotectonic setting of the formation of igneous (both plutonic and volcanic), metamorphic and sedimentary rocks
- The human interaction with the rock cycle, paying particular attention to one of the following: mining, extraction of building materials, oil gas exploitation, geothermal energy production.

4.5 Environmental impact: Economic activities have an environmental impact

- the use of renewable and non-renewable resources in the economy
- the impact of the burning of fossil fuels and the use of alternative energy sources
- environmental pollution at a local/national and global scale
- sustainable economic development so as to control its environmental impact.
- conflicts that may develop between local and global economic interests and environmental interests

Learning Outcomes

Students should be able to:

- understand the process of carbon capture storage
- identify the rock type of the Celtic Sea
- analyse the CO2 emissions by sector in Ireland
- understand the use of geological and seismic data

Keywords and definitions

Trap	A geological structure that contains the fluid
Seal	Impermeable rock that prevents CO_2 from escaping to the surface
Reservoirs	Porous rock in which the fluid is stored
Hydrocarbons	Fossil fuels, e.g. oil and gas

Linkage and Integration

Linkage

- CCS can be linked to the Human Interaction with the Rock Cycle, Corrib Gas Field, Climate Change topic on the Junior Cert Syllabus
- Carbon Dioxide can be linked to Science and also the process involved in converting the carbon at source could be replicated in a lab experiment

Differentiation

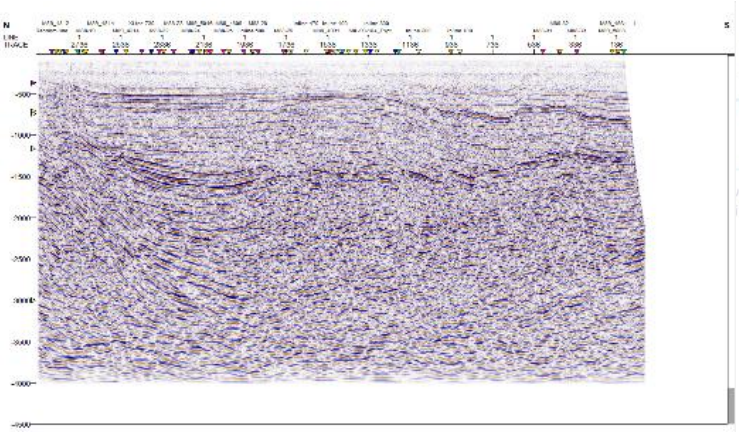
- Exceptionally gifted students can be given the seismic profile and asked to identify the trap, seal and reservoir
- They can also be given extra work to explore the GSI Map Viewer
- Students may use a scatter plot to chart the data available

Teacher Notes

Carbon Capture and Storage

Learning Activities

- Menti question to assess if students can guess the sectors that produce the most carbon
- A blank map of Ireland and students can locate the top carbon emitting industries on a map if given a list of them.
- Could students locate an area on the map of Ireland where the gas fields are, the motorway networks, ports, the different rock geology of Ireland etc.
- GSI website online map viewer to access the data on seismic and bore hole sampling
- GSI website online map viewer to see the layers of bedrock (Cretaceous Period). Explore hydrocarbon exploration database and identify which parts of Ireland contain more subsurface information.
- Give the students a print copy of a seismic profile from the Kinsale gas field and identify with colour pencils the seal, reservoir and trap. Below there is an example of a profile they could interpret:



- Give the students a scatter plot of temperature and depths from boreholes in the Celtic Sea. They need to draw a best-fit line and explore the geothermal gradient in Ireland.

- Use the GIS online map viewer to look at the different rock types in Ireland (which ones can act as a reservoir (sedimentary), which ones are good for geothermal energy (granites). Explore hydrocarbon exploration database, and identify which parts of Ireland contain more subsurface information.

Detailed instructions

The key to the lesson is to explain that the data available already has been utilised to show that this is possible in the Celtic Sea. The research has been carried out on the borehole data that was carried out as part of the oil and gas exploration that has taken place over the last 50 years and has given us the Kinsale Gas Field as an example. Also, seismic data has been analysed to assess that there is very little seismic activity that would disrupt the sedimentary layers and ensure that the bedrock is ideal to store the carbon.

This new technology is being used in other countries and it must be explained in the context of Carbon Limits and the area of taxing Carbon – Norway can be mentioned and the fact that other EU

countries are purchasing Carbon Credits from Norway despite the fact that Norway has large stores of oil and gas. Also, Iceland is engaged in CCS.
It is important to mention that the carbon has to be brought to the site however key to the Celtic Sea being chosen as an optimal site is the depth of the sea floor which is very shallow in relative terms and would reduce the cost of storing the carbon dioxide.
This links in well with the gas pipeline and other communications that we have in Ireland. Many students aren't aware of Ireland's gas fields and the pipeline and students will understand that because the pipeline operates at high pressure it could be a solution to transporting the carbon.
It can be explained to students that we already use depleted gas fields in the Celtic Sea to store gas purchased at a cheaper price during the summer months, and we extract it during the winter months, essentially a large gas tank to store the gas. This shows the sites are suitable for storage of Carbon.
You can show an image of the rock after it has crystalised with the carbon once stored and explain that this process takes place within a matter of months. It is important to note that the carbon is stored in between the rock itself and not in an empty void.

Methodologies:

- Online videos and news articles are widely available
- Menti website can be used to pose an introductory question
- GSI Website
- Google Maps
- Use RaspberryShake.org website to show Ireland's current seismic activity
- Different rock samples (sedimentary) may be shown in the classroom to show how the bedrock will crystalise with the Carbon

Extra information

- Carbon Capture and Storage (ervia.ie)
- Carbon Capture and Storage (gsi.ie)
- Carbon capture and storage - BBC News
- What is carbon capture? - BBC What's New - YouTube
- Influence of basement fabrics on fault reactivation during rifting and inversion: a case study from the Celtic Sea basins, offshore Ireland | Journal of the Geological Society (lyellcollection.org)
- Earthquake & Earth Monitoring Solutions | Raspberry Shake
- There is a KSI file that can be used with Google Maps to locate the top producing entities in Ireland.
- The lesson can be further explored by investigating the price of Carbon and Carbon Taxing and the cost of investing in the CCS technology.

Further types of geoenergy storage can also be explored:

Geothermal: Use of the Earth's natural heat flow that occurs due to decay of radioactive elements inside certain types of rocks (mostly Granites). As a reference value, in NW Europe there is a geothermal gradient of 31°C/Km. There are many types of geothermal energy (deep, shallow) and many different ways of using this energy (i.e., direct hot water production, use of conductive materials to produce heat directly from the borehole instead of water), etc.

Hydrogen storage: It works similarly to CO2 storage, the main difference being that due to the small size of the Hydrogen molecule, seal requirements are more demanding than for CO2 (Hydrogen can escape even from airtight steel containers!). Hydrogen is typically produced from sea water, which after applying an electric current (electrolysis) releases hydrogen and oxygen. Hydrogen can then be burned (reacts with oxygen to produce water) to generate energy (house heating, cooking, or electricity generation in gas turbines). Since Hydrogen storage requires an input of energy (i.e. electrolysis) it is not a source of energy, but an energy vector; It allows to store the excess electricity that cannot be stored (it is usually lost) and then it can be converted back to electricity or heat when needed.