Teacher's Notes

Activity 4: THE ROCKS UNDER MY FEET

Activity summary:

Students will look at the three main bedrock types that are found in the Burren region.

Level: 5th and 6th class

Time required: 30 mins (activity)

Curriculum links: *SESE Geography:*

Strand: Natural Environments

- Unit: The local natural environment
- Unit: Rocks and Soil
- Unit: Land, rivers and seas of Ireland

Strand: Human Environments

- Unit: People living and working in the local area and a contrasting part of Ireland

SESE Science:

Strand: Materials

- Unit: Properties and characteristics of materials
- Unit: Science and the Environment

Objectives:

- To understand the difference between the three main rock types in the Burren region
- To learn of the origin of each of the 3 rock types

Northern Environmental Education Development
Northern Periphery Programme 2007–2013
European Union European Regional Development Fund

Skills and concepts development:

Maps, Globes and Graphical Skills

- Using Pictures, Maps and Models

A Sense of Place and Space

- A Sense of Place

Geographical Investigation Skills\Working Scientifically\Designing and Making

- Observing
- Predicting
- Investigating and Experimenting
- Estimating and Measuring
- Analysing
- Recording and communicating

Background information and context:

The landscape of the Burren region is mainly underlain by three different rock types. Limestone occurs in the north and east, i.e. the Gort-Kinvarra lowlands and most of the 'Burren'. Sandstones, siltstones and shales occur in the south and west, i.e. the Cliffs of Moher, and high ground in the west and centre of the Burren e.g. Slieve Elva.

The rocks in the Burren region were deposited when Ireland was located ~ 10°S of the Equator, during the Carboniferous period in Earth history (359-299 Ma) (megaannum: millions of years ago).

The **limestones** were deposited during the Viséan stage (345-326 Ma) of the Carboniferous. The **sandstones**, **siltstones** and **shales**, during the Namurian stage (326-315 Ma).

(Please see below for a complete guide to the geological history of the Burren)

Prior Knowledge:

Students should be familiar with the following:

- Limestone reacts with acid – such as dilute Hydrochloric Acid – in the same way as acid rain dissolves limestone
- Fossil Goniatites are found in the Clare Shales. These are related to modern day squid and octopus.

Apparatus and materials:

- Rock samples (limestone; shale; sandstone or siltstone)
- Dilute HCL acid
- Sandpaper
- Student worksheets

Organisation of Students:

- Students can work in groups of five.

Activity:

- Each student is given a worksheet.
- Students study the maps on the worksheet and try to answer the accompanying questions

Student questions and answers:

LIMESTONE

Q. What happens when you put a drop of dilute HCl acid on limestone?

A. It fizzes – releasing Carbon Dioxide as the rock dissolves.

Q. Why do you think this is?

A. Because the acid reacts with the limestone (Calcium Carbonate).

Q. Could this happen naturally outdoors?

A. Yes

Q. If so, how?

A. Natural rain is weakly acidic (~ ph 5.6), due to Carbonic Acid (H_2CO_3) in the rainwater. The rain could dissolve natural limestone outcrops.

Q. How might this affect the Burren limestone landscape in the far off future?

A. Rainfall will drastically change the landscape - eventually dissolving much of the limestone uplands away. This is what is understood to have happened in the Gort lowlands.

LIMESTONE WORD PUZZLE

The Burren limestones were formed in a MARINE environment, during the CARBONIFEROUS time period. At this time, sea-level was LOWER than it is today. This is because the Earth was in the middle of a great ICE age. The Burren limestones were deposited when Ireland was SOUTH of the Equator.

Limestone is composed of the mineral CALCIUM-CARBONATE. The Burren limestones were formed from layers of the HARD parts of sea-creatures. Sometimes these parts are visible today in the rocks – these are called FOSSILS.

The limestone layers are sometimes separated by thin layers of MUDSTONE which was lain down on top of the limestone when sea-level FELL.

Layers of a dark grey and black coloured rock, called CHERT also formed between the limestones. The limestones stopped forming when sea-level rose around 326 million years ago.

Northern Environmental Education Development
Northern Periphery Programme 2007–2013
European Union
European Regional Development Fund

Student questions and answers:

SHALE

Q. What age are the Clare Shales?

A. ~ 318 million years old

Q. What happens when you put a drop of dilute HCl acid on shales?

A. Nothing.

Q. Why do you think this is?

A. Because shale is made up of mostly clay particles – which do not react with HCL like limestone does.

Q. Does the rock scratch easily?

A. Yes. It can be eroded easily.

Q. Name an extinct animal that can be found as a fossil in the Clare Shales?

A. Goniatite. Goniatites are extinct ammonoids, shelled cephalopods related to squid and octopus. Goniatite shells are small to medium in size, almost always less than 15 centimetres (6 inches) in diameter and often smaller than 5 centimetres (2 inches) in diameter.

Q. Name a living creature that is related to this fossil?

A. Octupus/Squid

SHALE WORD PUZZLE

Shale is a SEDIMENTARY rock, which means it forms from compacted particles of other rocks. Shale is a FINE-grained rock. The Clare Shales are a BLACK colour. This is because they formed in an environment that had very low OXYGEN levels.

In the 1940s the mineral PHOSPHATE was extracted from the shales by people in the Burren for making chemical FERTILISER.

Shale is only found at the surface in the Burren along a narrow band. This is because it has been ERODED in the north and because it is COVERED by the sandstones and siltstones in the south.

Student questions and answers:

SANDSTONE & SILTSTONE

Q. What age are the sandstones and siltstones in the Burren region?

A. ~ 318 million years old

Q. What happens when you put a drop of dilute HCl acid on sandstone?

A. Nothing.

Q. Why do you think this is?

A. Because sandstone is made up of mostly quartz and feldspar particles – which do not react with HCL like limestone does.

Q. Does the rock scratch easily?

A. Yes. It can be eroded easily.

Q. Name a famous type of Flagstone that is quarried near the Cliffs of Moher?

A. Liscannor Stone

SANDSTONE & SILTSTONE WORD PUZZLE

The Burren sandstones and siltstones were laid down in the sea by a large DELTA at the mouth a great river system.

The sandstones and siltstones were deposited when sediments were washed into the SEA after huge FLOOD happened on land. Mudstones were also deposited when the seafloor was calm. We can still see evidence of sea current in the RIPPLES left in the mudstones.

There is also evidence of life on the seafloor from the FOSSILS trails left in the fine grain sediments.

As more and more sediments were deposited, the sea became SHALLOW . SEA level rose and fell five times. We know this because of repeating units of sandstone and siltstone visible in the Cliffs of MOHER These units are called cyclothems. The changes were caused by the same ICE-AGE that affected the formation of the older Burren limestones

Northern Environmental Education Development

Northern Periphery Programme 2007-2013

European Union European Regional Development Fund

The Geological History of the Burren

The limestones of the Burren region are about 800 m thick. Only about 500 m, however, is exposed at the Earth's surface; the rest is below ground. The limestones formed in a **warm, shallow, tropical sea** that once extended across most of Ireland, the UK, and large parts of northeast Europe. The limestones contain the fossilised hard skeletons of a variety of marine organisms; the soft tissues of these organisms decayed and are not preserved. The most common fossils are crinoids (relatives of starfish), corals (very similar to those alive today), brachiopods (a filter-feeding animal with two shells that is found today on the ocean floor in the deep sea), and gastropods (snails). Most of the fossils are broken to some degree, and very few are found in their life position. Fossils make up only a small proportion of the limestones, however. Most of the grey mass of the limestones is composed of microscopic particles of calcium carbonate. These particles have a variety of origins: some precipitated directly out of the water column, others are the faecal pellets of zooplankton and other invertebrates, and others still represent microscopic ground-up fragments of the hard skeletons of marine animals such as corals and brachiopods. There are very few particles of clay and sand in the limestones. This shows that there were no major rivers flowing into the tropical sea in the Burren region, possibly because the climate was too dry. Although the limestones appear relatively uniform, different layers do show subtle changes in composition. These changes reflect variations in environmental conditions.

Changes in sea level and an ancient ice age

During deposition of the limestones, the Earth was in the grip of an ice age, with alternating advances and retreats of polar ice caps. As a result, global sea level fluctuated constantly, and occasionally was low enough to expose the limestones of the Burren at the Earth's surface. When this happened, the limestones were weathered and dissolved by rainwater, forming ancient karst landscapes. Sometimes these exposed limestones were covered by soil. These ancient soil layers are visible today as thin bands of mudstone ("clay wayboards"; < 1 m thick) that occur at several horizons in the limestone sequence. The mudstones contain particles of volcanic ash that were probably transported by wind from volcanoes in Co. Limerick that were actively erupting at the time.

The limestones also contain occasional thin (50-200 mm thick) bands of dark grey to black chert. Chert is a hard rock composed of silica (which makes up most sand) and so it often stands proud of the limestones by a few centimetres. Unlike the clay wayboards, the bands of chert were not deposited along with the limestones. In fact, the chert formed much later, from the remains of the silica-rich shells of microscopic algae that lived in the tropical sea and were deposited in the lime sediments. The pressure of the overlying layers of sediment caused the silica in the shells of these algae to dissolve and to form a gel that flowed through the limestone along bedding planes, where it eventually precipitated out as hard, silica-rich layers of chert.

The sea deepens and all is quiet

Over time, the shallow tropical sea in which the limestones were forming began to deepen as the sea floor slowly subsided (lowered due to stretching of the Earth's crust). Eventually, despite ongoing fluctuations in sea level due to the glaciation, the limestones that were forming ceased being exposed at the Earth's surface; as the sea deepened, the limestones were no longer affected by waves, except during

Northern Environmental Education Development
Northern Periphery Programme 2007-2013
European Union European Regional Development Fund

storms (which can agitate sediments in deeper waters). Suddenly, ~ 326 Ma, there was a major rise in sea level as the basin deepened very rapidly, and formation of limestone ceased abruptly. For several million years, almost no sediment was deposited on top of the limestones in this deep sea, except for the teeth and bones of fish (and other marine vertebrates) that settled out of the water column above. These hard tissues are rich in phosphate, and because of the very low inputs of other types of sediment, the phosphate from these tissue remains was concentrated into a thin band of black, phosphate-rich sediment on top of the limestones. These phosphate deposits are up to 2 m thick near Doolin and were once mined as an ingredient for fertiliser.

Later on, small amounts of very fine clay particles began to settle to the sea floor, forming black shales. The clay particles probably came from very fine river sediments carried far away from the coast by currents, and were the only sediment deposited in the region for about five million years. At this time, the deep sea floor was extremely inhospitable to life: there was no light, very low oxygen levels, abundant dissolved sulphides, and no organic matter in the sediment. The only fossils found in the shales are therefore the remains of animals that lived higher up in the water column, close to the water surface, e.g. cephalopods. Pyrite (fool's gold) also occurs in the shales, and often replaces the shells of the cephalopod fossils.

A delta approaches

About 318 Ma this quiet, deep-water environment was overwhelmed by the influx of extremely large volumes of silt and fine sand. These coarse-grained sediments built up a slope in front of a massive, complex delta system that was prograding from a land mass to the west. The sediments on this slope were deposited so quickly that they became gravitationally unstable, and slid and slumped down the slope before they were fully lithified. The results of this can be seen in the spectacular slump folds in the rocks on the south side of Fisherstreet Bay.

In the delta

As the delta approached, sediment was being deposited faster than the basin was deepening, and so the environment became progressively shallower. As a result, the slope sediments are overlain by sandstones and siltstones that were deposited on the delta itself, both on the shallow-water delta shelf and at the delta front (where the shelf slopes down to the basin floor). The rate of deposition was extremely fast: hundreds of metres of sediment were laid down in less than 2 million years – compare this to the black shales, where it took ~ 8 million years to deposit only 12 metres! The deltaic sediments are exposed spectacularly at the Cliffs of Moher, where repeating cycles of sandstone, siltstone and mudstone are visible. These cycles reflect changes in sea level that were caused by the same glaciation that affected deposition of the limestones. Each time sea level rose, the delta shelf was flooded by the sea, and marine mudstones were deposited on top of the deltaic sands and silts. After the rise in sea level, however, the delta would have continued carrying sand and silt out into the ocean, resulting in sandy sediments being deposited on top of the mudstones. The siltstones and sandstones were laid down during flood events; in between the flood events, the sea floor was relatively calm, allowing current ripples to form on the sediment surface, and organisms to make trails in the sediment (Fig. 8, overleaf). The siltstones and fine-grained sandstones of Liscannor show extremely abundant trails (trace fossils) made by an extinct arthropod (a woodlouse-like animal) and / or a gastropod (snail).

Northern Environmental Education Development
Northern Periphery Programme 2007-2013
European Union European Regional Development Fund

Burial, gentle squashing and uplift

After deposition, the rock sequence of the Burren region was gradually buried up to depths of ~ 2.5 km below the surface. About 300 Ma, there was a mountain-building episode in southern Europe that caused compressive (squashing) stresses to travel through the Earth's crust. By the time these stresses reached the Burren region, they did not have enough energy to bend the rocks into tight folds, but only to tilt them slightly and fold them gently. The rocks are usually tilted at between 2 and 5° to the south, and gentle folds can be seen at Slieve Roe and Mullaghmore (Fig. 9, overleaf).

The tectonic forces that caused this tilting and folding also resulted in the formation of many joints, or fractures, in the limestone. These fractures were initially microscopic but were widened by hot mineral-rich fluids that forced their way through the rocks during burial. Evidence of these fluids is seen today in the mineral-bearing veins that run roughly N-S through the entire limestone sequence. In most cases, the minerals have been weathered away and the spaces widened by dissolution of the limestone to form N-S fissures. Some of the veins, however, still contain minerals such as calcite, fluorite, galena and pyrite.

The rock sequence is thought to have been uplifted in several phases over approximately 250 million years. Each phase of uplift would have eroded rocks exposed at the surface, relieving the pressure on the rocks underneath. This "depressurisation" would have allowed the underlying rocks to relax and expand, forming microscopic fractures in the rocks. Such fractures are extremely abundant in the limestones of the Burren region and are visible today as fissures; unlike the fissures formed by the N-S veins, however, these younger fissures have no regular orientation. In fact, these younger fissures often run in different directions in successive limestone beds. This reflects slight differences in the way different limestone layers relaxed according to their precise composition.

Exposure at the surface

The Burren region has probably been above sea level for the past 50-60 million years, and so more sediments did not accumulate. Instead, the exposed rocks experienced prolonged weathering and erosion at the Earth's surface. These processes removed the siltstones and sandstones from over much of the region, and eventually the underlying shales. The shales in particular are easily weathered to friable (crumbly) masses of rock fragments and would easily have been eroded, thus exposing the limestone at the surface. The limestones of the Gort Lowlands were exposed about 20-30 Ma, and their surface has been lowered to only a few tens of metres above sea level by slow but continuous dissolution of the limestone. It is thought that shales still covered the Burren until the start of the most recent ice age (the Pleistocene glaciation). The ice sheets would easily have eroded most of the weathered shale, exposing limestone at the surface in places. The Pleistocene ice age ended in Ireland ~ 13,000 years ago, at which point parts of the Burren may have had a soil cover of some description. Evidence from pollen suggests that much of this soil cover was removed during the Bronze age ~ 1600 BC. Faults (surfaces in which the rocks on either side have moved past each other) are extremely rare in the Burren region.