LEARNING WITH CHEDDAR GORGE

HOW THE LAND WAS FORMED

All the landscape you see around Cheddar has been created by water, during hundreds of millions of years. It is still being formed, and you can watch the processes which are building and changing it.

MAKING THE HILLS

During the Carboniferous Period (270-350 million years ago) this area was covered by a shallow, warm sea, similar to the Great Barrier Reef or the Caribbean of today. The bed of this sea was the much older old red sandstone laid down in the Devonian Period. When plants and creatures living in the sea died, their shells and skeletal remains (containing calcium carbonate) sank to the bottom, eventually forming a layer of carboniferous limestone hundreds of metres thick. (Fig. 1).

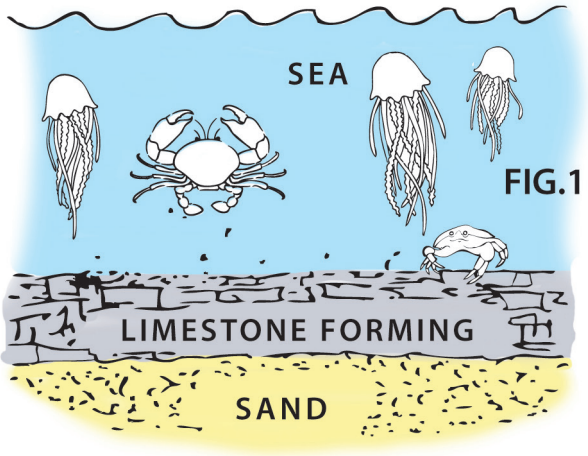


FIG.1

Tremendous earth movements then forced up ridges of rock ("periclines") four of which became the Mendip Hills.
The rock became eroded. Limestone was worn away from the domes of the pericline, leaving old red sandstone exposed. An anticline, running east-west to the South of the Mendips, was also worn away, so that only small knolls remained. (Fig. 2).

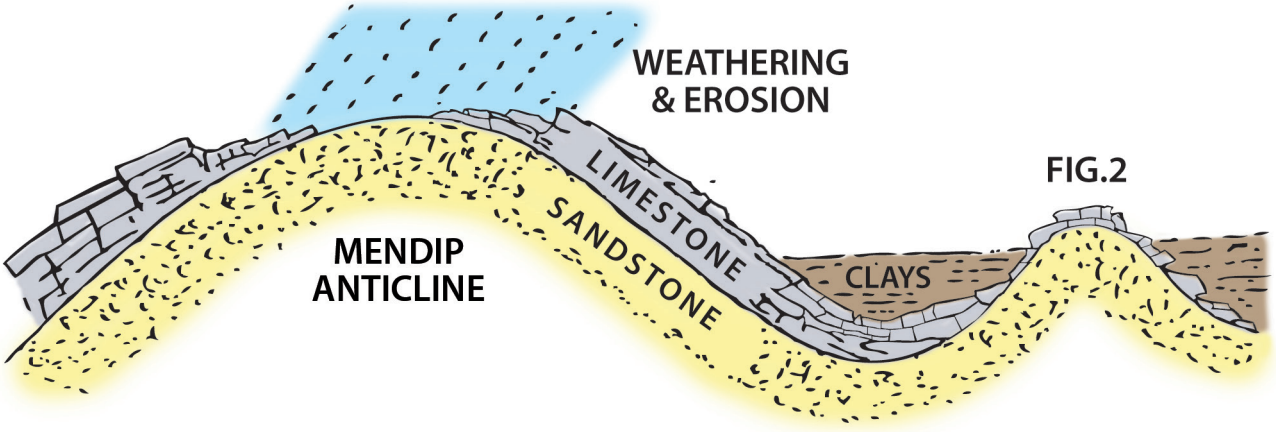


FIG.2

During the Triassic Period (250 million years ago) many of the valleys on the flanks of the hills became filled with eroded sandstone and limestone rocks. These rocks became cemented with water containing calcium and magnesium salts to form dolomitic conglomerate. The rock deposits become jumbled and confused during this process. The Mendip Hills levelled into a plateau.

In the Jurassic Period (200 million years ago) the sea covered the area once more, depositing younger rocks over the limestone and dolomitic conglomerate, which in turn were then worn away once the sea had receded.

During the last one million years (the Pleistocene Epoch) Ice Ages gripped most of Britain. During the glacial phases, sheets of ice reached as far South as the Mendips, which still show some evidence of glaciation.
During "interstadials" torrents of meltwater were released, escaping to the South along existing river valleys.
In the last major stadial the ice did not reach the Mendips but stopped approximately where the M4 is today, but the hills were under periglacial conditions, with the ground frozen and ice caps on the hills. At this time the caves were blocked with ice and frozen mud.

MAKING THE GORGE

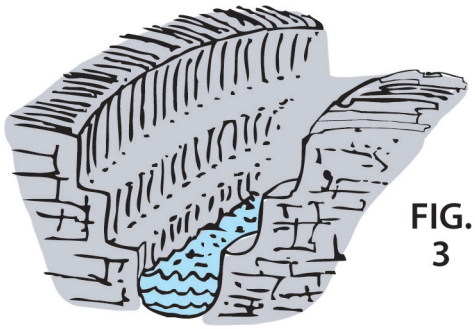


FIG. 3

After each warm period a new torrent of meltwater was released, sweeping boulders and gravel along with it. This process enlarged and scoured out the river bed. The Cheddar river eventually cuts itself a gorge 400 feet deep and three miles long, the biggest in Britain. You can see from the ledges which remain on the sides of Cheddar Gorge that the river bed used to be much higher up. The river has cut a deeper "gorge within a gorge" several times, possibly as sea level has fallen, and the ledges are what remain. (Fig. 3) Today the only river in Cheddar Gorge is the Cheddar Yeo, which rises in Gough's Cave, and which joins the River Axe to reach the sea at Uphill.

Earth movements caused the limestone to crack vertically creating 'joints'. Subsequently erosion, weathering and frost, shattered the limestone of the Mendips, which was full of cracks on the surface. The line of Cheddar Gorge shows where an existing deep joint has become widened and deepened by water, which exploits every weakness in the rock. Some of these weaknesses also enabled water to disappear underground and form caves.

MAKING THE CAVES

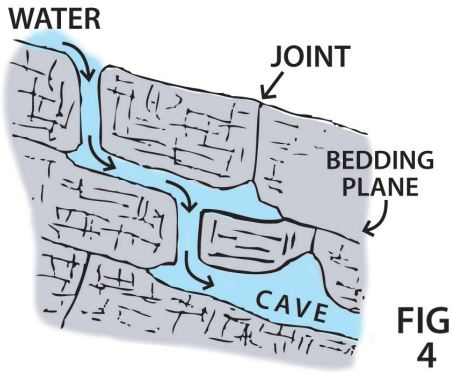


FIG. 4

After the younger rock deposits were eroded, the limestone was exposed to water and when the ground was not frozen, floodwater was able to fill up cracks on the Mendip limestone plateau. Rainwater and river water (H_2O) are able to absorb carbon dioxide (CO_2) from air and soil, turning the water into carbonic acid (H_2CO_3). It is then able to dissolve calcium carbonate within the limestone ($CaCo_3$), carrying it along in the water as calcium bicarbonate ($Ca(HCO_3)_2$). This acidic ("aggressive") water ate away the rock below ground. Limestone is full of weaker areas between different sections of the stone: vertical "joints" and horizontal "bedding planes". This makes it permeable. The floodwater set out to find an underground route down to the sea, seeping through tiny gaps in the limestone, enlarging them as it went.

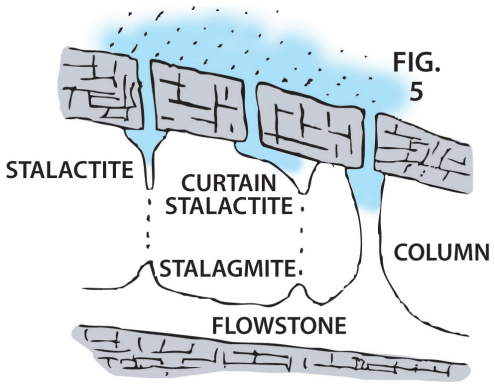
All limestone caves are formed by water. They are either underground river beds, or carved out by wave action on the seashore. River caves are either "swallets" (where a surface river disappears underground) or "resurgences" (where an underground river re-appears again). You can find both on Mendip. The Cheddar Caves are resurgences. There is always a geological reason for the position and shape of any cave. Gough's Cave, for example, runs along one slope of an anticline at right angles to the dip ('strike'). (Fig. 4).

Below the limestone is a layer of old red sandstone, both this and the limestone are pervious (water travels through weaker areas such as joints and bedding planes). When saturated water collects above this, flooding the cracks in the lower part of the limestone. The surface of the flooded area is the "water table". Caves which are formed on or below the water table were completely full of water while they were being formed, like a water main. These caves are called "phreatic". The smooth, polished roof and rounded shape, the domes and the "scalloping" within Gough's Cave shows that it is phreatic. A cave formed above the water-table is called a "vadose" cave and is trench-shaped,

A complicated underground "rabbit-warren" of passages and chambers (large spaces where the roof of a passage has collapsed) was formed around Cheddar Gorge. As the water table falls, the water will form a series of deeper passages, almost independent of the higher ones. These passages loop up and down, because of the head of pressure within the enclosed system, finding the route of least resistance. This is quite different to a surface stream, as this means the water can flow uphill.

Below the Showcave is an active river cave, Gough's River Cave, still being carved out by the Cheddar Yeo. Divers explore this cave every year, hoping to trace it back to its headwaters. (The river originates at swallets at Charterhouse and Chewton Mendip, so they have some way to go!). One of the chambers in the river cave is larger than any you can see in the Showcaves, with "sumps" up to 200 feet deep.

MAKING THE CALCITE



No sooner had water succeeded in hollowing out a cave then it set about filling it up again. Boulders and sand were washed through the cave by floods, helping to scour it out, but leaving behind plugs of mud and boulders in the narrow chokes. But the most interesting form of "cave-filling" is calcite.

When rain water leaks through into a cave, or a river trickles gently through it, the water loses some of its carbon dioxide to the air in the cave. This means that it cannot carry as much calcium bicarbonate, and has to leave some behind as calcium carbonate on the roof or floor of the cave. This produces sparkling white calcite.
(A similar process happens when "hard" water is evaporated in a boiling kettle, leaving limescale.)

Calcite can either take the form of "flowstone", a solidified river covering the floor of the cave, or "stalactites", where water dripping through a crack in the roof has caused a cone-shaped "icicle" of calcite to build up. Sometimes water runs along the roof to create a long, thin "curtain" stalactite. Water which drips off a stalactite builds up a "stalagmite" below it. If the two ever meet in the middle, the result is a continuous column. (Fig. 5)

Stalactites and flowstone were formed in the Cheddar Caves during interstadials, and are still being formed today. Calcite forms very slowly (only a few cubic centimetres every thousand years) and our formations are anything up to 260,000 years old. (Those in the higher - and drier - chambers are the oldest).

Just as water is able to "decorate" the cave it has formed, so it can choose its own colour scheme. Water passing through limestone dissolves trace elements of many minerals, and these colour the calcite when they are re-deposited. A red or brown colouring in flowstone indicates the presence of iron oxide. Copper carbonate contributes the greens and blues, while the grey is lead.

MAKING THE LEVELS

All the water in the Gorge and Caves ended up in the Somerset Levels, which have been covered by the sea at various stages of their history. They were variously desert, sea, swamp and until only 1,500 years ago marshland, when efforts to drain and reclaim them began. What is left is a bed of silt, filling up the "syncline" or hollow between the Mendips and the Polden Hills. Rotting swamp vegetation has composted into a layer of peat between Bridgwater and Glastonbury, and a ridge of clay has built up along the present-day coastline, making drainage difficult.
The isolated hills which interrupt the Levels were islands in historic times, and are all that remain of other periclines less fortunate than the Mendips.

GLOSSARY OF GEOLOGICAL TERMS

Anticline - A ridge of stratified rock raised by folding.

Bedding Planes - Natural boundaries between beds of rock laid down as a discrete layer.

Calcite - Carbon dioxide in the air associated with water to form carbonic acid. This acid slowly dissolves the calcium carbonate component of limestone to form calcium bicarbonate, and a cave is formed. In air, the calcium bicarbonate reverts to carbon dioxide gas and insoluble calcium carbonate, which is deposited in caves as calcite.

Carboniferous Period - A geological period 400 – 350 million years ago, when the Coal Measures and Carboniferous Limestone were laid down.

Column - In time, a stalactite and stalagmite may lengthen and join to form a column or pillar.

Devonian Period - A geological period 350 – 300 million years ago, when the Old Red Sandstone (Portishead Formation) was laid down at the bottom of lakes and coastal inlets.

Dolomitic conglomerate - Pebbles cemented together to form a solid rock, formed during the Triassic period 230-180 million years ago.

Faults - Vertical cracks through stratified rock where adjacent blocks are displaced by earth movements.

Flowstone - Calcite deposited on the wall or floor of a cave.

Glaciation - A period of intense cold, when precipitation covers the land as ice, causing sea levels to fall. The last Ice Age began around 2.6 million years ago.

Interstadial - A warm period between glaciations, when the ice melts and sea levels rise. The current interstadial began around 10,000 years ago.

Joints - Vertical cracks through stratified rock, with no displacement of the adjacent blocks.

Knoll - An isolated hill.

Pericline - A dome-shaped formation of stratified rock.

Phreatic - Cave development which occurs under the water table, in the absence of air. Typical cave passages are rounded or elliptical in section.

Resurgences - Springs or risings at the foot of the hill where subterranean water finds its way to the surface.

Scalloping - Turbulent water in phreatic conditions can form spoon-shaped depressions in the rock. They may be centimetre to metre-sized. The steepest part of the scallop occurs at the upstream end of the flow.

Stalactite - A tapering rod of calcite suspended from a cave roof.

Stalagmite - A squat cone of calcite formed on a cave floor.

Sumps - Sections of the cave passage which dip under water level. They may be of any length; the longer ones can only be passed by divers.

Swallets - Places of engulfment at the boundary of the impervious sandstone and limestone where surface streams sink underground.

Syncline - A downward fold of stratified rock (See Anticline).

Vadose - Cave development where the passage contains air. Further expansion of the cave mainly occurs under the water surface, leading to high narrow passages.