



Ancient volcanoes

You may have heard that some of the local rocks record volcanic islands deep in the ancient past. This is particularly true of the Ordovician rocks, which form the rough hills between Builth, Llandrindod and Llandegley. However, the rock sequence has been chopped up by faults, so there are only a few places where we can see a large chunk of the history in one place. One of those places is Cefnlllys.

We always picture volcanoes in their most impressive phase, but they have a beginning, and they have an end... and a complex story between the two. This exercise will guide you towards imagining the stages in the life of the local volcano.

The track cuttings you will be looking at are an important local geological section, listed in the Regionally Important Geodiversity Sites for Powys. Feel free to look closely, but **do not hammer the outcrops, and take care not to damage the large blocks in the middle section**. Also, be aware of the diverse lichen and insect communities in these habitats (you may also see slow worms or adders), and be careful not to disturb them.

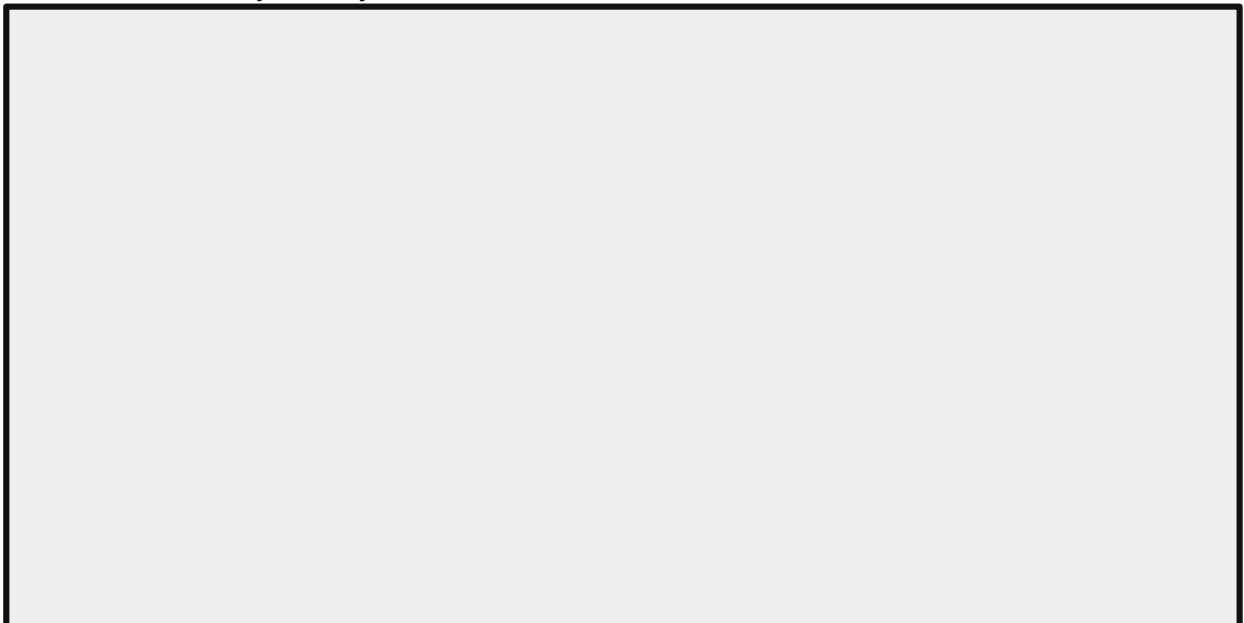
The outcrops for this exercise lie along the side of a track between Cefnlllys Church and the house at the north end of the hill. To begin, go up the hill from the church, and through a gate onto a track that runs left along the side of the hill. As you follow the track, there are three main sets of rock outcrops that you'll be looking at. These are neatly arranged in age order, from the oldest to the youngest, and are thought to span approximately 1 million years.

1. The Llandrindod Tuff Formation

First, you'll encounter some sturdy crags on the right of the path. These continue for around 30 m, but at first glance it's hard to interpret them. The layers are mostly tilted down into the track to the north, but it can be difficult even to make that out!

A close look at the rock reveals that it's made of a large amount of quartz, surrounding small, bubbly lumps of pumice, and lots of little (millimetre-sized) rectangular white crystals (called plagioclase). The quartz explains why it is so hard, and you can probably also find thin white veins of pure quartz that crystallised in cracks in the rock. This type of rock is known as a tuff: a coarse, violently deposited volcanic ash.

The Llandrindod Tuff Formation is a massive deposit, up to 100 m thick (only a small section is visible here) across a wide area. It was created by a very large eruption, equivalent to the eruption of Santorini (a Greek island) that destroyed the Minoan civilization around 1600 BC. The ash was so thick that we can't even tell if it was deposition on land or in water... so imagine a shallow sea, or the slopes of an island, and draw what you feel you would have seen at the time...



The scene at Cefnlllys, approximately 461,000,000 years ago.

2. The Gilwern Volcanic Formation

The Llandrindod Tuff Formation records the largest, cataclysmic eruption of this volcanic island. After that, things were... bubbling away nicely. There were further large eruptions, but nothing on quite the same scale. The rocks at Cefnlllys do tell us some quite different parts of the story, though.

As you walk up the track the next set of exposures that you come to (around a third of the way up) are rather rubbly-looking, with the slope being colonised by plants and breaking down rapidly into soil. Even a few years ago, these exposures were much better... but you'll just have to work with what you've got.

The first thing to look for is a **bubbly texture** to the rock: lots of small holes, making it seem almost like pumice. This isn't quite pumice, though, in the sense of light, bubble-rich magma thrown from a volcano and cooling as it flew through the air... the bubbly areas are too big, and are spread through the whole outcrop. For more clues, look for large blocks of the bubbly stuff, where they show a bubble-free edge. You should be able to spot bits where the smooth edge is strongly curved, and if you're lucky (or observant) you can see the same thing in the outcrops. What you'll hopefully see is that the bubbly areas are the interiors of **pillow-like, rounded lumps**, all piled up on each other. This is what we call pillow basalt, and the pillows form by the eruption of lava under water: as the lava squeezes out, it cools and freezes very rapidly into blobs. The rapid freezing of the edge of each pillow gives it the non-bubbly margin.

There's another way to prove that these pillow basalts were under water, but you'll have to hunt for it... follow the outcrops up the track, until the pillows start to disappear. In one or two places, you can see fine, **dark grey sediment layers draped over the top** and between them. Even better, we know from better exposures when the track was first cut, that these layers contain small fossils—tiny shells of brachiopods, which lived underwater!

So... What would the area have looked like at this time? These rocks are probably only a few hundred thousand years younger than the first outcrop, but the volcano (or at least the type of eruption) has changed dramatically since that time. Imagine you had a boat, or a diving suit... and draw what you might have seen, based on these rocks.



The scene at Cefnlllys, approximately 460,800,000 years ago.

3. The *murchisoni* Shales

After the previous pillow basalt outcrops, there is a long gap before the next ones. Near the top of the track, as it starts to rise more steeply, you'll find a long series of intermittent, low outcrops, on both sides. To start with they are on the right, and reveal a complex mixture of odd-coloured (often pale), fine-grained rocks. These are very obviously layered... but they're not entirely sedimentary. A very close look (ideally with a microscope) reveals lots of tiny crystals forming the bulk of the palest rock layers. Other layers are darker, and contain a lot more mud particles, and some layers are a mixture of the two. These pale layers are volcanic ash: the result of settling clouds of fine particles, blasted out from a volcano. There are no large chunks, because this was perhaps five to ten miles away from the eruption, and only the finer particles made it this far.

We know these rocks were deposited in the sea, as well... because further up the track, the outcrops are replaced almost entirely by shale. (There are still thin layers of ash, but they're only a centimetre or so thick; you can probably see some of these harder bands standing out from the weathered outcrops.) This flaky, crumbly grey rock is made largely of mud and silt laid down on the sea floor in thin layers, and indicates quiet, deep water a long way from land. Fossils have been found here, as well, including the remains of planktonic graptolites: colonies of tiny animals that drifted through the surface water. The species found here is *Didymograptus murchisoni*, which thrived for a brief interval some 461 million years ago... and is, indeed, how we know how old these particular rocks are. There are also small shells of brachiopods, fragments of sponges... and even rare trilobites have been found.

From these fossils, we can deduce the environment: definitely in the sea, and in quiet water, deep beneath the wave zone. A little sunlight would have filtered down, but only enough to colour the sea floor a deep twilight blue. Volcanic rumblings in the distance interrupt the peace, with blankets of ash settling slowly down through the water. At other times, the ash arrives as a slurry rolling down the underwater slopes, and burying everything in its path. This was a challenging world to live in... but life was finding a way.

So... what would you have seen this time, if you had a wetsuit or a boat? Time to draw the last act.



The scene at Cefnlllys, approximately 460,500,000 years ago.*

Note: The dates are very approximate! Some published estimates give substantially longer timescales (so that the sequence may be up to 3 million years long, rather than 1 million!)

To see what happened before this sequence, or after it, you will need other rocks, exposed in other places. But of course, that can be arranged... another day (to see more chapters of this story, visit the Radnorshire Museum in Llandrindod... or try the other worksheets at The Pales and Llandegley Rocks!)