

# Other nearby geological sites

If you have enjoyed your visit to Balmaha why not visit other sites in the area to discover more about Scotland's varied geology? Here are some suggestions:

## Fossil Grove

Located in Victoria Park, Glasgow. You can see the remains of an ancient fossilised forest which grew about 300 million years ago. For opening times, go to [www.glasgow.gov.uk](http://www.glasgow.gov.uk), navigate to Glasgow Museums, and then to Fossil Grove.

## Ardmore Point

Located between Cardross and Helensburgh. You can see folding and faulting in sandstone which formed in an arid desert 375 million years ago.

## Campsie Glen

Located on the southern slopes of the Campsie Fells west of Lennoxtown. You can see limestones cut by igneous dykes lying beneath the thick lava flows of the Campsie Fells.

Site information is posted at Strathclyde Geoconservation webpage – go to [www.geologyglasgow.org.uk](http://www.geologyglasgow.org.uk) and click on Strathclyde Geoconservation.



Cliff formed of conglomerate

Beds of sandstone breccia



This leaflet was written and originally produced by the Strathclyde Geoconservation Group which is part of the Geological Society of Glasgow. We are a mainly amateur group whose aim is to conserve and promote local geology and identify sites which highlight local geodiversity and earth heritage. Geodiversity is the variety of rocks, minerals, fossils, soils and landscape and the natural processes which form them.

If you would like to find out more about us, visit our page on [www.geologyglasgow.org.uk](http://www.geologyglasgow.org.uk). To find out more about Scotland's geology visit [www.scottishgeology.com](http://www.scottishgeology.com).

This edition was produced on behalf of the Strathclyde Geoconservation Group by Loch Lomond & The Trossachs National Park Authority.  
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- **care for the environment.**

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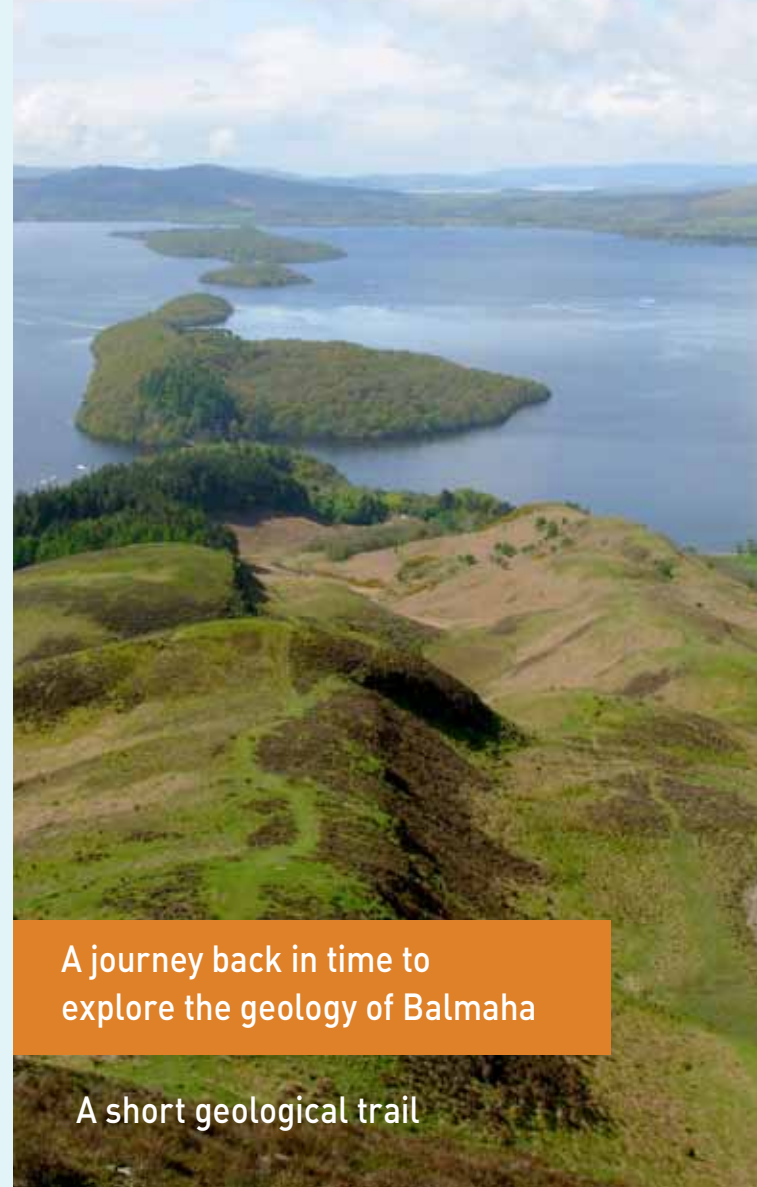


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# Balmaha

## Where the Lowlands meet the Highlands



A journey back in time to  
explore the geology of Balmaha

A short geological trail

# Introduction

**Have you ever wondered why Scotland's landscape is so sharply divided into Highlands and Lowlands?**

Balmaha is special to geologists because it is one of the best places to study the Highland Boundary Fault. Follow a scenic trail of only a few miles on good paths along the shore of the loch. Here you can visit three different fragments of the Earth's crust which have come together from different parts of the globe. You will discover how solid rock can be squeezed, folded, tilted upwards and split apart by faults. Many of these events happened over 600 million years ago, long before the appearance of the first animals or plants on land.



## Follow the trail in this leaflet on a short journey of discovery...

Please do not damage any of the rocks you see on this trail by hammering them as we want future generations to appreciate them too.

# What do the rocks tell us about the past?

## The Highland Boundary Fault

A fault is a fracture in the Earth's crust where two blocks of rock have moved relative to each other. The Highland Boundary Fault stretches across Scotland from the Isle of Bute to Stonehaven. Along the line of the fault, over 140 miles from end to end, the gently rolling Lowlands suddenly give way to the mountainous Highlands.

## The Highlands north of Balmaha

The rocks which today form the Southern Highlands were laid down as sediment at the bottom of the sea more than 600 million years ago. As the sediment piled up, the lower layers were compacted and slowly turned to rock.

Later, the solid rock was squeezed and folded by tremendous forces and became buried to a depth of about 15 to 20 kilometres. The heat and pressure at that depth caused the original minerals in the rock to recrystallise into new minerals forming harder rocks. The mudstone turned into slate or schist, the sandstone became quartzite, and limestone became marble. The process by which solid rock changes its structure in this way is called 'metamorphism'.

These changes to sedimentary rocks occur deep within mountain belts and are occurring today beneath the Himalayas. In older mountains, such as the Alps, these changes have stopped and the mountains are being actively eroded. The final episode in the formation of our own Caledonian Mountains led to the rocks being uplifted back to the surface about 400 million years ago and since then they have suffered continuing erosion. They would originally have been as high as the Alps are today or perhaps even the Himalayas. Today's Scottish Highlands are just the eroded stumps.

## The Lowlands south of Balmaha

The Lowlands are made of much softer sedimentary rocks which have never been metamorphosed and still look quite like the sediments they once were. The red sandstone was deposited in rivers when the climate was much hotter than it is today and the limestone formed in balmy lagoons. Coal formed when fallen trees decomposed in a humid environment. Climate change is not new!



# Why are the Highlands so different to the Lowlands?

**The difference in height is partly because the hard Highland rocks have been more resistant to erosion. The Highlands have also been uplifted relative to the Lowlands due to vertical movements along the Highland Boundary Fault.**

Many geologists believe that the Highland and Lowland blocks formed in different places and that three continental fragments (called terranes) joined together around 400 million years ago. Plates of the Earth's crust, about 120 km thick, can move across the surface of the planet, spreading apart, slipping past or colliding with each other. They move incredibly slowly, just a few centimetres each year, about the speed your fingernails grow. Similar processes are occurring today in places such as Indonesia and along the San Andreas Fault in California.

Many geologists believe that the Dalradian terrane which today forms the southern Highlands originated in western South America, then became attached to North America before finally becoming part of the northwest fringe of Europe! The Highland Border terrane is a narrow band of rock just a few hundred metres wide. It contains fossils which are more like North American fossils than European ones. The Midland Valley terrane forms the Lowlands south of Balmaha. It is covered by sedimentary rocks which were laid down after all three terranes came together. What lies beneath is still enigmatic.

## What's the evidence for terranes at Balmaha?

On the trail you will be able to compare two rocks called conglomerate and breccia. Both contain large fragments of older rocks which had broken up and become embedded in sediment to form the new rocks.

You would expect to see fragments of Highland rock embedded in these sediments having been carried by rivers from their source just a few miles away. The breccia contains many fragments of a typical Highland rock called schist, however the older conglomerate does not. Therefore many geologists believe that when the pebbly sediment was being deposited in the Midland Valley terrane, it was not adjacent to the Dalradian terrane. They only came together in the time interval between the formation of these two rocks.

It is interesting that today the professionals are not united in one view of the nature and significance of the Highland Boundary Fault zone. Geology is a dynamic and ever-changing field of study.





# The Trail

**Start:** The national park visitor centre in the large car park at Balmaha which can be reached by bus from Balloch.

**Terrain:** The trail follows good paths, mainly on the West Highland Way. It keeps close to the shore of the loch so is easy to follow. You should wear appropriate footwear as the paths can be muddy and uneven in places. The paths are mostly fairly flat but the short detour up to the viewpoint is steep.

**Distance:** The distance to the furthest point of the walk is a mile and a half, or three miles there and back. The return journey should take you around two hours on foot although you can turn back at any point.

**Toilets:** There are toilets and refreshments available in Balmaha at the start of the trail. In the summer months there are also toilets at the furthest point of the route at the Milarrochy Bay car park.

**1**

From the car park go to the main road then turn right and follow it round the north side of the bay. Do not follow the main road as it turns right up the steep hill. Instead, keep to the shore-side road and look for a wooden marker post on the right at the start of a stepped path which climbs quite steeply up the hillside. Take it slowly – it should take you about five to ten minutes to get to the top. At the summit you will be rewarded with a magnificent view across Loch Lomond. Notice the stark contrast between the high mountains to the north and the lower ground to the south. The loch to the north is much narrower (and deeper) than the southern part closer to you. Loch Lomond was formed when glaciers flowed from north to south during the last ice age between about 2 million and 10,000 years ago.

The metamorphic rock underlying the northern part of the loch is very hard and resistant to erosion compared to the softer sandstone underlying the southern part. Soil is formed by chemical weathering of the underlying bedrock. That's why the best farmland can be found in the Lowlands where the sedimentary rock breaks down more readily to form fertile soil. The front cover of this leaflet shows a similar view from Conic Hill which is the higher hill behind you. Notice the line of islands stretching away to the southwest across the loch. This line of islands indicates the northernmost edge of the Scottish Lowlands marked by the zone of the Highland Boundary Fault.

**4**

Continue on the trail and after you leave the gravel beach, just beyond a small stream, you will see inclined beds of a purple-red rock at the water's edge. This rock contains very angular broken fragments of rock and is therefore a type of sandstone called a breccia (pronounced bretch-iy-a). The angular fragments of rock within the breccia are in stark contrast to the rounded fragments which you saw in the conglomerate. The broken rock did not have enough time to be rounded in the rivers and so must have travelled a shorter distance from its source.

The fragments of rock in the breccia are mostly silvery-coloured schist which is the same type of rock found in the Highlands just to the north. In contrast, the conglomerate you saw earlier contained no fragments of these common Highland rocks. One theory is that the sedimentary basin in which the conglomerate was formed was nowhere near the Highlands at that time!

**2**

Return downhill to the road and turn right. Where the road ends at the old pier take a narrow rocky path on the right beside the loch. The path here is cut into a rock called conglomerate, the same rock you stood on at the viewpoint. It is made up of large rounded cobbles of quartzite, volcanic rock, and some granite, packed together in a finer-grained sandy material. There are several cliffs to the right of the path between here and the metal bridge. You will see that the conglomerate is comprised of beds which are inclined steeply to the right, roughly to the southeast. The beds were deposited by large rivers which carried sediment eroded from high mountains to the northeast. The broken pieces of rock became rounded as they tumbled against each other in the powerful river currents. The sediments were laid down in almost horizontal beds but these were later tilted up at a steep angle following vertical movements along a fault just to the north.

**5**

Continue on the path through the woods for about 600 metres. Just beyond the third wooden plank bridge look up to your right where you will see a small crag. It is an uncommon green rock with a soapy texture called serpentinite. It is part of a thin group of rocks called the Highland Border Complex which is sandwiched between the lowland and highland rocks. You have therefore crossed a major geological boundary. So far on this walk you have seen sedimentary rocks (containing fragments of metamorphic rock) deposited by rivers flowing over land. The Highland Border rocks are very different. They are about 50 million years older than the conglomerate and they were formed on the sea floor rather than on land. The serpentinite was originally erupted as molten magma

beneath an ocean floor and was later metamorphosed. This shows that rock can go through many, many cycles of eruption, erosion, deposition and metamorphism over millions or even billions of years. If you go to the far northwest of Scotland you will see rock which has not changed for over two billion years. However in Scotland most of the rock you see has been 'recycled' many times and is therefore of much younger age, just a few hundred million years!

**6**

Continue on the path to the car park at Milarrochy Bay. For the first time on this walk you are now in the Highlands! Since leaving the serpentinite you have crossed the Highland Boundary Fault although you can't actually see any sign of it on the path as the fault is now buried deep underground. There are no exposures of bedrock in the bay so if you want to see what typical highland

rock looks like, you should drive to Rowardennan where you will see large exposures of the silvery folded schist around the car park. The shiny silvery colour is due to a mineral called mica and the exposures are formed into smooth humps ground down by glaciers during the last ice age.

**3**

Continue on the shore-side path across the metal bridge and after about 400 metres you will emerge from the woodland at a long gently curving bay with a gravel beach. The high ground is now behind you and the bay backs onto fairly flat fields. This is because the rock beneath the bay is sandstone which eroded more easily than the harder conglomerate which forms the hilltop viewpoint. When you look out to the loch you can see the same contrast as the wooded island of Inchcailloch towards your left is quite hilly compared to the flatter one ahead of you (called Inchfad). The high hills at the far side of the loch are in the Highlands so the Highland Boundary Fault must cross the loch somewhere behind the islands.

**7**

If you have time explore the area of bouldery foreshore which extends about 100 metres south of the ranger station. The low cliff about a metre high behind the foreshore is formed of till, often called boulder clay. It consists of sediment containing fragments of widely varying sizes left behind when a glacier melts and releases the sediment which had been locked up in the ice.

**6**

FROM MILARROCHY BAY RETURN THE WAY YOU CAME ON THE PATH BESIDE THE LOCH

**8**

START HERE NATIONAL PARK VISITOR CENTRE