

# Mull and Iona

A Landscape Fashioned by Geology

David Stephenson

MULL AND IONA: A LANDSCAPE FASHIONED BY GEOLOGY



Scottish Natural Heritage

All of nature for all of Scotland



British  
Geological Survey

NATURAL ENVIRONMENT RESEARCH COUNCIL

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# Scottish Natural Heritage Dualchas Nàdair na h-Alba

All of nature for all of Scotland  
Nàdar air fad airson Alba air fad

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## Front cover image:

A view over the Ross of Mull to Ardmeanach and the head of Loch Scridain from the summit of Dun Auchabhaich on Iona.

## Back cover image:

Radiating basalt columns at Ardmeanach, Mull.

# **Mull and Iona**

A Landscape Fashioned by Geology

by

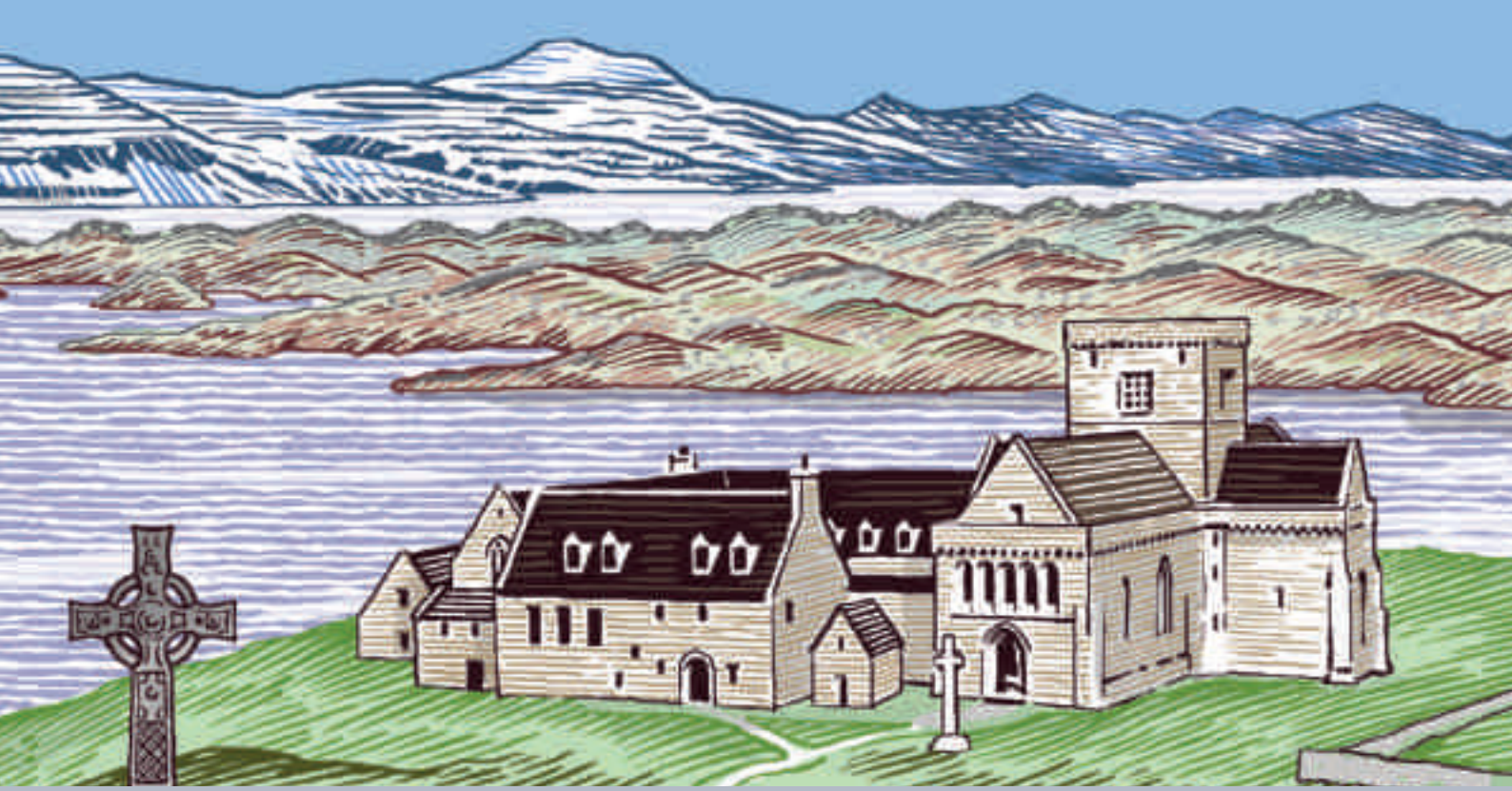
David Stephenson (BGS)



**Staffa, the Ross of Mull, Ardmearach peninsula and Ben More from Iona.**














## Contents

- |    |                               |    |  |
|----|-------------------------------|----|--|
| 1  | Introduction                  | 22 | Moulding of the Landscape and Glaciation                       |
| 2  | Mull and Iona Through Time    | 26 | Landslips  |
| 3  | Map of the Mull and Iona Area | 28 | Coasts and Beaches   |
| 4  | The Lava Plateau              | 30 | The Landscape Today  |
| 8  | Climate and Vegetation        | 32 | Scottish Natural Heritage and the<br>British Geological Survey |
| 10 | The Central Volcano           | 33 | Geological Code  |
| 14 | Pre-lava Sedimentary Rocks    | 34 | Also in the Landscape Fashioned by Geology Series              |
| 16 | Caledonian Rocks              | 35 | SNH Publications Order Form                                    |
| 18 | Even Older Rocks              |    |  |



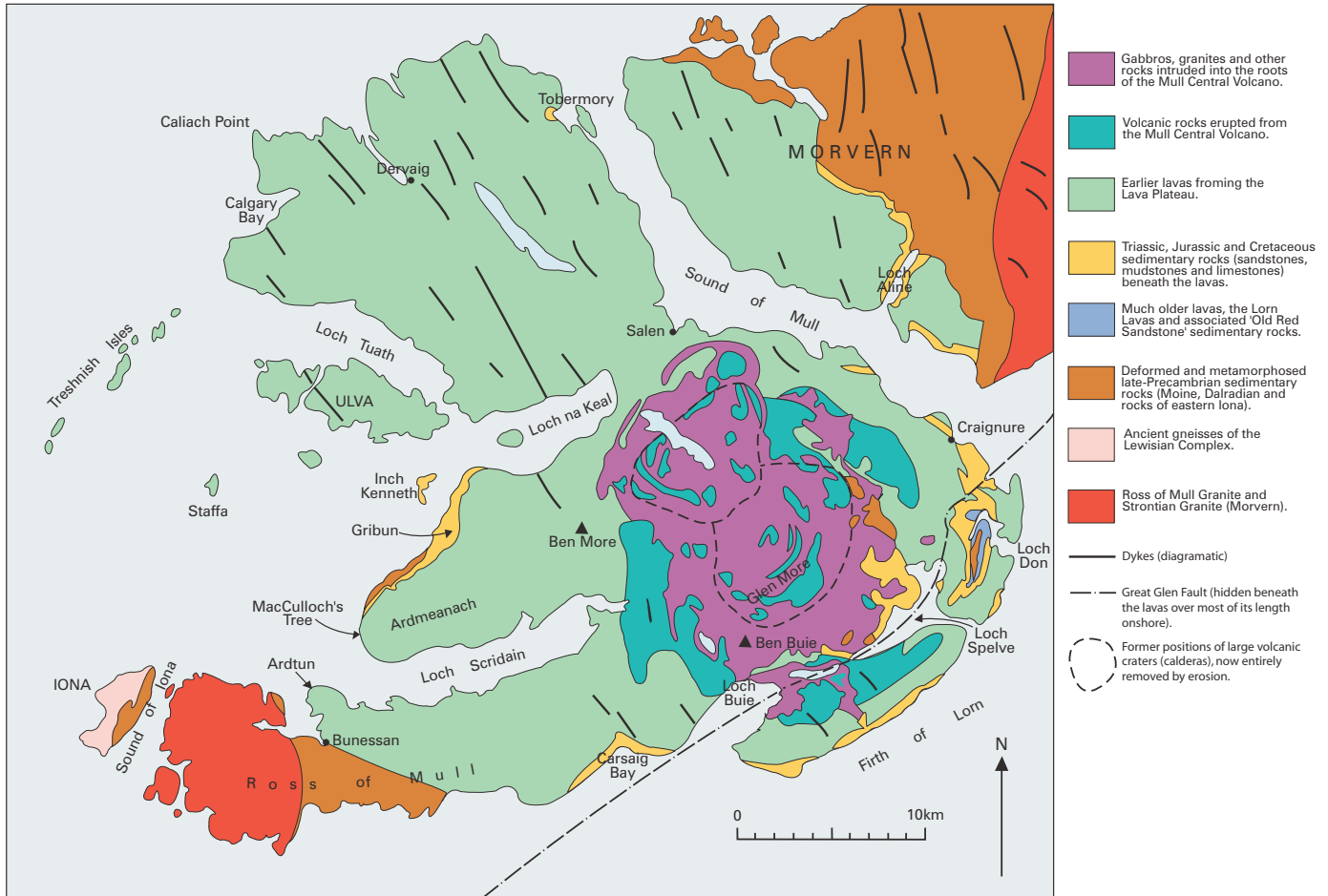
The islands of Mull, Iona and Staffa in the Inner Hebrides have been among the most popular destinations for visitors to Scotland for well over two hundred years. Although much interest has centred upon the historical and religious significance of Iona, the varied and spectacular landscapes and world famous geological sights of these islands have undoubtedly widened their appeal. When Fingal's Cave on Staffa became the inspiration for Mendelssohn's Hebrides Overture in 1832, the resulting surge in interest was an early example of public imagination being fired by a geological feature. This is a part of Scotland in which the underlying geology truly dominates the landscape. Steep cliffs of lava, like those of Staffa, dominate northern Mull, while the high mountains of the south expose the roots of a huge volcano that erupted 60 million years ago. In marked contrast are the low-lying rounded knolls of pink granite and the welcoming sandy beaches of the Ross of Mull. Just a short distance across the Sound of Iona, some of the oldest rocks in Scotland form the low, craggy hills of Iona. The mountains show the effects of glaciers that covered the area during the Ice Age and all around the coast are signs of changing sea levels that followed the melting of the ice in recent geological time. In this booklet we show how these landscapes relate to the underlying geology, by explaining how the rocks were formed and by telling something of the long history of the islands that spans millions of years before St Columba first landed on Iona.

# The Mull and Iona Area Through Time

<p><b>QUATERNARY</b> (‘The Ice Age’) 1.8 million years ago to the present time</p> 	<p><b>11,500 years ago to the present time.</b> Changes in sea level followed melting of the ice. River gravels, peat, beach deposits and blown sand were deposited. Landslips continued.  <b>12,500 to 11,500 years ago.</b> The last local glaciation occurred in the mountains of Mull. Moraines and scree were formed. Landslips occurred.  <b>14,700 years ago.</b> Climate warmed rapidly with summer temperatures like those of today. Glaciers melted. Sand and gravel were deposited. Sea level was much higher than today.  <b>29,000 to 14,700 years ago.</b> The last widespread glaciation covered all of Scotland with ice. Till was deposited beneath the ice.  <b>Before 29,000 years ago</b> there were several very cold glacial episodes interspersed with warmer periods. Deposits of this age have been swept away by the later glaciations.</p>
<p><b>NEOGENE</b> 23 to 1.8 million years ago</p> 	<p><b>2.6 million years ago.</b> The climate cooled and the ice age began.  <b>52 to 2.6 million years ago.</b> The North Atlantic Ocean continued to widen. There was much erosion in a subtropical to warm temperate climate, eventually cooling gradually as the Ice Age approached. Much of the present day topography and coastline were initiated.</p>
<p><b>PALAEOGENE</b> 65 to 23 million years ago</p> 	<p><b>55 million years ago.</b> Stretching of the Earth’s crust pulled Greenland away from Europe to form the North Atlantic Ocean.  <b>61 to 55 million years ago.</b> Widespread eruption of plateau lavas in a warm temperate climate was followed by the formation of a large central volcano fed from underlying complex magma chambers.</p>
<p><b>CRETACEOUS</b> 145 to 65 million years ago</p> 	<p>Warm shallow seas were widespread over most of NW Europe. Marine sands and chalk were deposited. Later gentle folding, uplift and erosion may have created a lowland landscape around the Hebrides at about 45 degrees north.</p>
<p><b>JURASSIC</b> 200 to 145 million years ago</p> 	<p>The Hebrides area had drifted to 30 to 40 degrees north of the Equator. Plant and animal life flourished on land and sea; dinosaur remains have now been found on Skye. Sedimentation took place in shallow seas, estuaries and near-coastal areas; mostly sands, muds and limy deposits; abundant shelly fossils.</p>
<p><b>TRIASSIC</b> 251 to 200 million years ago</p> 	<p>Arid continental plains covered the area of the Hebrides, which lay 10 to 20 degrees north of the Equator. Silts, sands and pebbly gravels were deposited from seasonal floods.</p>
<p><b>PERMIAN</b> 299 to 251 million years ago</p> 	<p>Desert sands accumulated in rift valleys around the western margins of present-day Scotland, but no deposits are found on Mull.</p>
<p><b>CARBONIFEROUS</b> 359 to 299 million years ago</p> 	<p>The Hebrides had drifted north into equatorial latitudes. Warm shallow seas fringed low-lying coastal areas, which were densely forested. Coal formed extensively in central Scotland and locally near Lochaline but there are no deposits on Mull.</p>
<p><b>DEVONIAN</b> 416 to 359 million years ago</p> 	<p>The Hebrides area lay about 10 degrees south of the Equator in the southern arid belt. Sands and gravels were deposited in intermontane basins by seasonally flowing rivers, but these are not seen on Mull.</p>
<p><b>SILURIAN</b> 444 to 416 million years ago</p> 	<p>Volcanic activity occurred in the arid setting of the ‘Old Red Sandstone’ continent that formed by rapid crystal uplift at the end of the Caledonian Orogeny.          Intrusion of the Ross of Mull granite.          Major movements of the Moine Thrust and the Great Glen Fault</p>
<p><b>ORDOVICIAN</b> 488 to 444 million years ago</p> 	<p>The Caledonian Orogeny; formation of the Caledonian Mountain Belt as three supercontinents collided and the Iapetus Ocean closed. The main folding and metamorphism of Moine and Dalradian rocks occurred.</p>
<p><b>CAMBRIAN</b> 542 to 488 million years ago</p> 	<p>Deposition of sands and limy muds on top of the Precambrian rocks; now only seen to the north of Mull.</p>
<p><b>PRECAMBRIAN</b> Before 542 million years ago</p> 	<p><b>1,000 to 600 million years ago.</b> Deposition of Moine and Dalradian sediments in continental rifts, shallow seas and later on the edge of a widening ocean, the Iapetus Ocean.  <b>2,800 to 1,700 million years ago.</b> Formation of the Lewisian gneisses by metamorphism of older igneous and sedimentary rocks.  <b>4,000 million years.</b> Oldest known rocks on Earth.  <b>4,500 million years.</b> Age of the Earth.</p>

Brown bars indicate periods of time represented by the rocks seen on Mull and Iona.

# Geological Map of the Mull and Iona Area



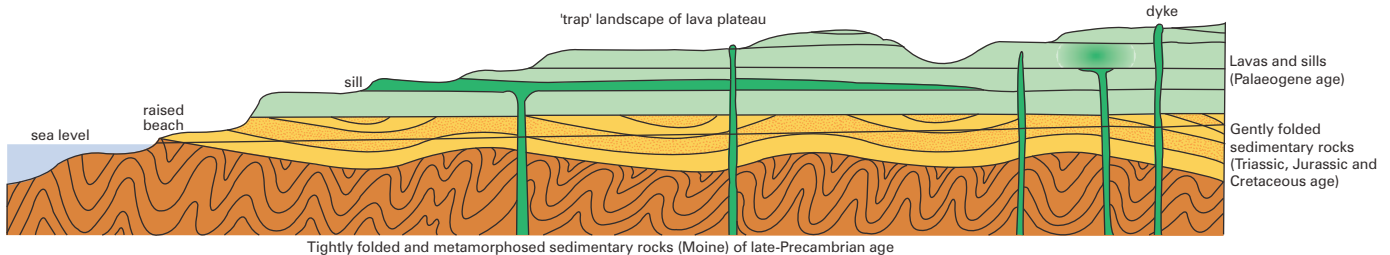


# The Lava Plateau



**Basalt columns, Boat Cave and Fingal's Cave, Staffa**

## A typical section through the lava plateau of northern and western Mull



**B**efore 60 million years ago north-western Europe, Greenland and North America were all part of one huge continent; the North Atlantic Ocean did not exist. However, at about this time, movements of the crustal plates that make up the outer layer of the Earth caused the Earth's crust to become stretched. Parts of the Earth's interior (the mantle) began to melt and the molten rock (magma) welled up beneath the crust to form a hot-spot, commonly known as a mantle plume. The stretching created deep fractures through the crust, and magma rose along these fractures to erupt at the surface in what was probably the greatest volcanic episode ever to occur in north-western Europe. Lavas from these eruptions are found today on and around the Faroe Islands, Skye, the Small Isles, Ardnamurchan, Morvern, Mull and Antrim, as well as beneath the sea over much of the continental shelf north-west of Scotland. On the opposite side of the Atlantic Ocean, lavas of similar age are found in east Greenland. Eventually, about 55 million years ago, the stretching led to complete rupturing of the crust and Greenland split away from Europe along a line that was to become the North Atlantic. The volcanic activity continued, forming new

crust in the centre of the ever-widening North Atlantic Ocean, as can be seen today on Iceland.

At first, the lava flows from these eruptions built up vast lava plateaux in the Inner Hebrides and Northern Ireland that were possibly well over two kilometres thick in places. The lava plateau on Mull forms the whole of the northern part of the island and much of the west.

Individual lava flows can be up to fifteen metres thick and vary considerably through that thickness. The central parts are hard and solid, commonly with distinctive columns that formed as the lava solidified, cooled and shrank. These are best seen at Fingal's Cave on Staffa, but you can see them almost anywhere in the lava field. The tops and bottoms of the flows are usually more broken and rubbly with many cavities and gas bubbles that have been filled by later minerals; some contain attractive crystals or semiprecious stones such as agates. To the geologist these minerals are very useful as natural depth gauges, which tell how thick the lava pile was before erosion.



### The stepped or trap landscape of the lava plateau at Ardmeanach on the Isle of Mull

The rubble material is much more easily eroded than the central parts of the flows, and the contrast results in the characteristic stepped or 'trap' landscape of the lava plateau.

Most of the lavas are composed of dark, fine-grained basalt. They were erupted rapidly, but with little explosive activity, flowing from long fissures that ran roughly north-west to

south-east. Volcanic ash, which indicates more-explosive activity, is rarely found but can be seen in some places, such as beneath the columnar flow on Staffa. In the upper part of the lava pile, many of the lavas are more silica-rich than the basalts. These lavas tend to be paler in colour and form distinctive features around the tops of the higher mountains, including Ben More.



**A basalt dyke  
at Calgary  
Bay, Mull**

The fractures in the Earth's crust that fed these volcanic eruptions continued to act as pathways for molten magma for long after the surface volcanic activity had ceased, possibly until around 52 million years ago. The magma eventually solidified in the cracks to form vertical sheets of rock, known as 'dykes'. Some of these dykes extend from Mull, across the south-west Highlands and southern Scotland and into northern England. The longest one can be traced as far as Whitby in North Yorkshire, a distance of over 400 kilometres from Mull. There are many good examples of dykes on Mull, but they are particularly well seen around the coast, and where they cut through softer sedimentary rocks as at Gribun and Carsaig, some stand proud like walls because they erode less easily than the rocks around them.

The magma also forced its way sideways to form gently sloping sheets, called 'sills'. Many display well-developed columns throughout their thickness and can be difficult to spot among the lava flows. But, where they have forced their way between layers of sedimentary rocks below the lavas, they are much more obvious. On the west side of Carsaig Bay a sill has been intruded into mudstones, which have been baked by the heat to such an extent that new minerals have formed. Fragments of mudstone included within the sill contain impure blue sapphires, which can be spotted in the boulders on the shore on a sunny day by those with a keen eye. Similar inclusions, with sapphires, are also found in sills that intrude lavas around the shores of Loch Scridain; the magma that formed these sills must also have passed through mudstones beneath the lavas.

# Climate and Vegetation



Weathered lava flow top in a roadside quarry, Ensay

**T**hin beds of sedimentary rock between the lava flows show that there was sufficient time between volcanic eruptions for rivers and lakes to develop on the lava surface. These deposits tell us a lot about the climate and vegetation of the area 60 million years ago. One locality at Ardtun on the Ross of Mull is famous for its leaf beds. Here leaves fell into a lake and were beautifully preserved by the clays and silts accumulating on the lakebed. Among the many types of leaf are oak, hazel,

plane, magnolia and ginkgo (maidenhair tree), and many more trees have been identified from fossil pollen. Equally famous is 'MacCulloch's Tree' on the tip of the wild and remote Ardmeanach Peninsula. Remarkably, this coniferous tree trunk, 12 metres high and 1.5 metres in diameter, has been preserved in its position of growth, despite having been totally engulfed by a lava flow.



**Fossil hazel-like leaf  
from Ardtun**

The bark has been converted to charcoal and most of the inside has been cast in lava, but some sections of wood fibre are preserved as silica. Other tree trunks have been found in lavas elsewhere in Mull, some in the position of growth and others as fallen logs. Some low-quality coals are found between the lavas, indicating that low-lying swampy conditions occurred in some places, whereas deposits of pebbles and cobbles indicate the presence of fast flowing rivers at times. It is clear that the area was densely forested and the types of trees suggest a moist, warm temperate climate comparable to that of the Mediterranean today. In these climatic regions, especially in volcanic areas, reddish brown clay soils rich in aluminium and iron often form above deeply weathered rocks. Soils are easily eroded away and are not normally preserved in the geological record, but in volcanic areas they are commonly covered up by later lavas and hence protected from erosion. On Mull, red-brown layers of 'fossil soil' are very common between the flows

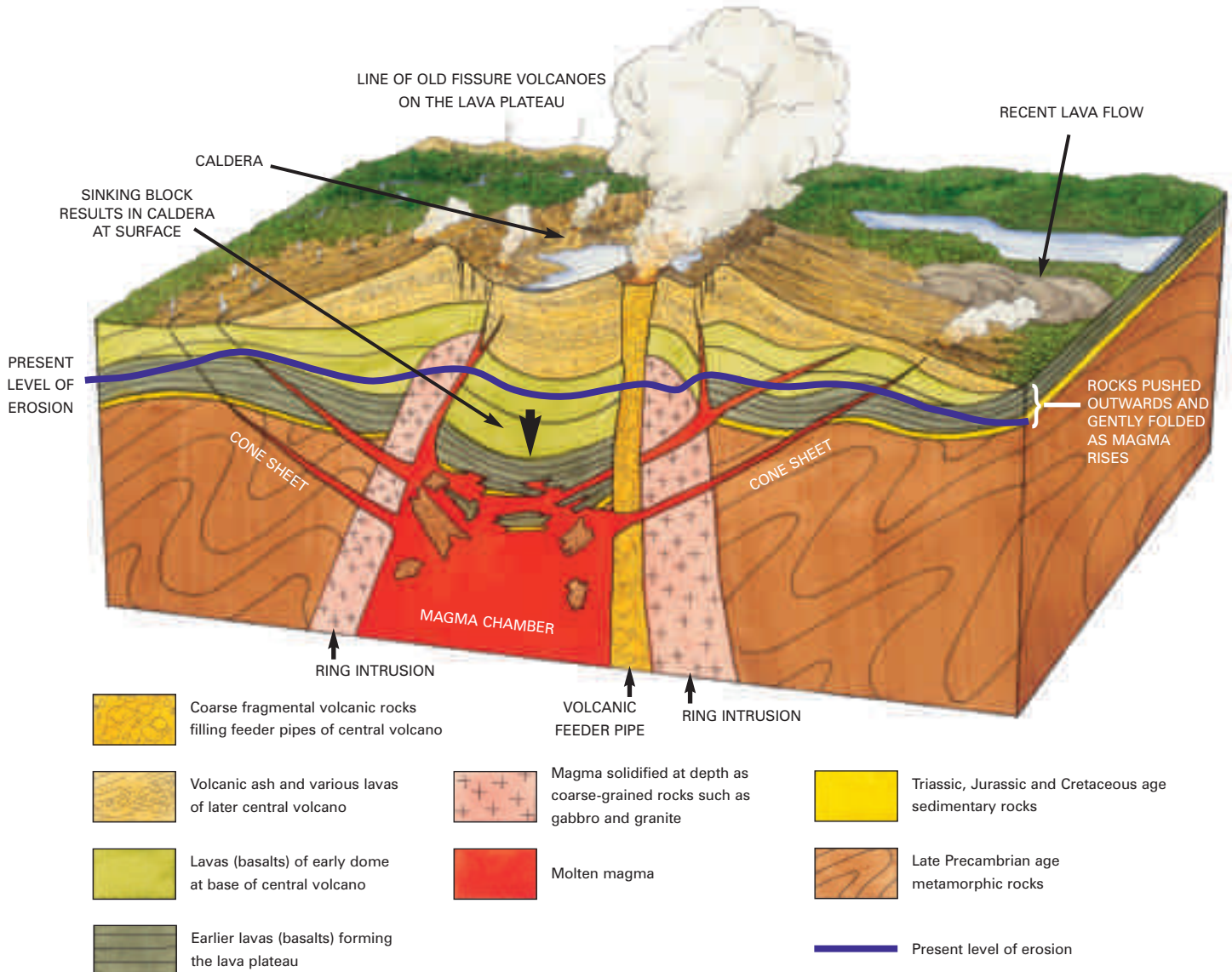


**MacCulloch's Tree is the large, upright cylindrical cast,  
immediately left of the figure**

and are easily seen in most cliff sections. They show, not only that the eruptions occurred on land, but also that there was sufficient time between eruptions for soil to form and hence for the vegetation to become well established.

# The Central Volcano

A reconstruction of the Mull Central Volcano, 58 million years ago. Only the roots are now exposed in south-east Mull



Some time after the formation of the lava plateau by widespread fissure eruptions, the volcanic activity became more centralised in what is now the south-eastern part of Mull. At first the volcano formed a broad, shield-like shallow dome of basalt lavas, similar in appearance to those of the lava plateau. Some of these lavas are made up of distinctive pillow-like blobs, showing that they were erupted under water and were chilled and solidified very quickly. Maybe the lavas dammed up river valleys to form lakes or perhaps there were crater lakes into which later lavas were erupted. Still later, as the central volcano continued to grow, magma began to accumulate at depth and to well up beneath the overlying lavas, which were tilted upwards and buckled into a series of folds encircling the volcano. From time to time, probably following particularly large eruptions, the whole of the upper part of the volcano collapsed and sank into the space in the underlying magma chamber created by the eruption. Such events created huge volcanic depressions known as 'calderas'. One caldera, possibly 10 kilometres in diameter, was centred upon present-day Glen More, and a later one was centred upon what is now the southern end of Loch Bà.

Magmas that were trapped at depth cooled slowly and crystallised into coarse-grained rocks in which the individual crystals are clearly visible to the naked eye; an example of this is gabbro, which is simply a coarsely crystalline version of the basalts that were erupted as lavas. The trapped magmas accumulated in magma chambers beneath the Earth's surface and in some of these the various crystals settled to form layers,

such as are more commonly seen in sedimentary rocks; such layers are especially well seen in the gabbros of Ben Buie and Corra-bheinn. As the crystals formed, the magma left behind changed in composition (imagine removing all the toffees from a tin of assorted sweets, so that you are left with a different mixture). The modified magma then crystallised as a different rock. Some magma became contaminated by swallowing up significant amounts of the surrounding rocks; and the heat from the magma even caused the nearby rocks to melt in places to produce new magmas. In these ways a wide range of different magmas was produced, and in some places different magmas became mixed at depth to produce even more varieties. The resulting rocks range from gabbros and basalts (the basic rocks), to rocks with much higher silica content (the silicic rocks) such as coarse-grained granites and their fine-grained equivalents, rhyolites.

When these magmas reached the surface, they erupted in a variety of styles. Some eruptions of silicic magma were explosive and very violent, in marked contrast to the earlier quiet eruptions of basic magma. Consequently the volcano grew into a large complex structure made of lavas of various compositions, layers of volcanic ash and piles of coarse debris. In addition to the large calderas there would have been numerous cones and craters, large and small, each representing the site of one or more explosive eruptions. All these surface features have long since been eroded away and what we are left with are the deep roots of the volcano, something that cannot be seen in most of the more recent and active volcanoes around the world.



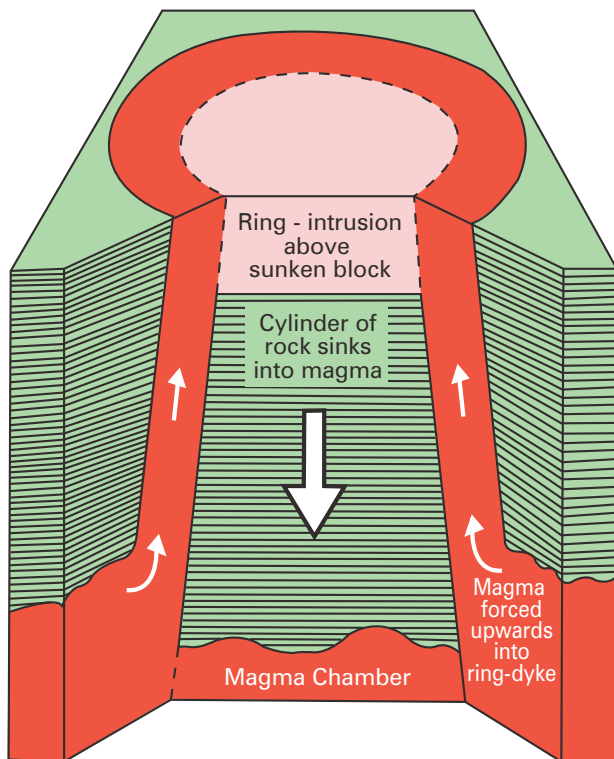


### Typical granite exposures on Beinn à Ghraig

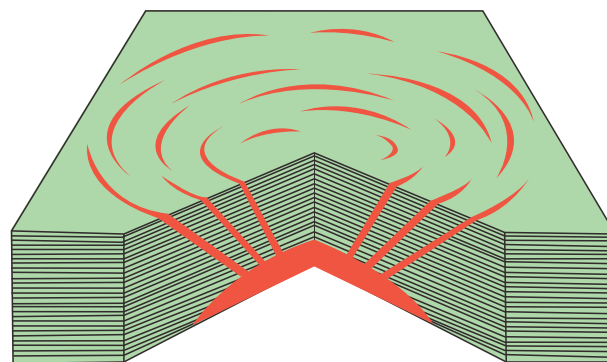
Here are the remains of the magma chambers and 'plumbing systems' that fed the eruptions and which provide geologists with so much information about the development of volcanoes, making Mull a centre of worldwide importance.

The roots of this volcano occupy most of the mountainous area of south-east Mull. There, the outcrops of gabbro, granite and other rocks appear on a geological map as a series of intersecting arcs, punctuated here and there by more irregular areas of fragmental rocks that mark the sites of explosive

volcanic vents. The arcuate outcrops are due to the cylindrical three-dimensional form of most of the intrusions. Imagine a very full wine bottle as a magma chamber in which the wine represents magma and the cork represents the overlying rocks. If you push the cork down, the wine (magma) will rise up to completely encircle the cork; many of the arcuate intrusions on Mull were formed in this way and are called 'ring-dykes'. If you continue to push down, the wine (magma) will eventually well up over the top of the cork to form a complete cylindrical 'intrusion' in the neck of the bottle.



**Formation of ring-dykes and ring-intrusions above a magma chamber**



**Arrangement of concentric cone-sheets above a magma chamber**

Because this happened over and over again in the same general area during the life of the volcano, earlier intrusions were effectively 'cored out' by later ones, leaving a series of intersecting arcuate outcrops.

In addition to the ring-dykes and other major intrusions, the roots of the volcano include many smaller intrusions, commonly of finer grained rock types more like those of the surface lavas. Dykes and sills abound, but the root zone is characterised in particular by concentric sets of cone-sheets – sloping sheets that have the form of huge cones several kilometres in diameter at the surface, dipping inwards towards the deep centre of the volcano. It is impossible to recognise their conical shape from a single outcrop, but inclined sheets of fine-grained igneous rock that dip in towards the mountains are abundant in most of the stream and coast sections of south-east Mull and are almost certainly cone-sheets.

# Pre-lava Sedimentary Rocks



## The cliffs at Gribun show a section from Precambrian to Palaeogene rocks

The most common fossils are various types of oyster, sea-snail, coral and the ancestors of octopus, squid and cuttlefish – coiled ammonites and straight bullet-like belemnites, that characterise rocks of this age throughout the world. Later Jurassic sedimentary rocks and those of Cretaceous age are more sandy, and at a few places there are small outcrops of the famous Loch Aline glass-sand. This very pure silica sand is mined at Loch Aline, on the mainland side of the Fishnish ferry and, as its name suggests, it is in great demand for glassmaking as well as for abrasives.

The plateau lavas of Mull rest upon sedimentary rocks of Triassic, Jurassic and Cretaceous age, which are best seen around the south-east coast and on the south side of Loch na Keal. Cliff sections at Gribun and Carsaig are particularly impressive. They are also seen inland, where they have been arched up to the surface in the cores of the folds that surround the central volcano between Craignure and Loch Spelve.

The sedimentary rocks are varied and range from red sandstones and pebbly deposits, formed from rivers that flowed infrequently over a desert landscape during Triassic time, to fossil-bearing mudstones and thin limestones that formed in Early Jurassic time on the floor of a shallow tropical sea.



Fossil ammonite from Carsaig Bay

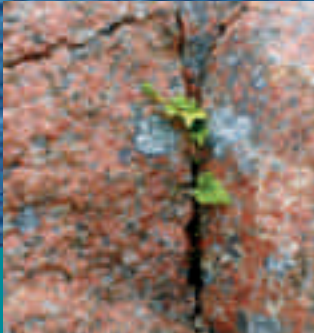


### **Jurassic-age sedimentary rocks at Carsaig Bay**

In some places there is a thin layer of impure chalky limestone, a remnant of the limy ooze that formed the Chalk of eastern and southern England when almost the whole of the British Isles was covered by sea. It even contains hard misshapen nodules of flint, just like the English Chalk.

All of these rocks were gently folded by earth movements and then eroded to form an irregular land surface before being buried by the lavas.

# Caledonian Rocks



**Above: The Ross of Mull granite near Fionnphort in the Sound of Iona**  
**Left: Close-up of Ross of Mull granite**

Around Loch Don the Triassic rocks rest upon even older rocks in the core of a fold. These older rocks are mainly lavas that were erupted about 420 million years ago at the end of the Caledonian Orogeny, the great period of major earth movements that was ultimately responsible for the Scottish Highlands. They are part of the Lorn Lavas, much older than the lavas of the Hebrides and interbedded with sandstones and pebbly deposits of the Old Red Sandstone sequence of late Silurian to early Devonian age. On the mainland, they form a

lava plateau that covers a large area between Loch Creran, Craignish and the Pass of Brander.

Rocks that were deformed by the Caledonian earth movements and recrystallised by the combined effects of heat and pressure (metamorphic rocks) can be seen beneath the Lorn Lavas near Loch Don. These are mainly schists and limestones of the Dalradian, the sequence of metamorphic rocks that forms most of the Grampian Highlands.



### **The curved trace of the Great Glen Fault, passing through Loch Spelve and Loch Uisg**

On the other side of Loch Spelve, other old deformed rocks are caught up in the roots of the central volcano, mainly around Beinn Bheag. These are dominantly metamorphosed sandstones of the Moine, the sequence of metamorphic rocks that forms the north-west Highlands. The Moine rocks are also exposed beneath the Triassic rocks at Gribun and Inch Kenneth, but are most extensive on the Ross of Mull, around Bunessan.

The reason that the older rocks are Dalradian around Loch Don and Moine elsewhere is that the great dislocation of the Scottish Highlands, the Great Glen Fault, cuts through the south-eastern part of Mull. Throughout the rest of the Highlands its trace is absolutely straight, but on Mull it is markedly curved, extending from Duart Bay, through Loch Spelve and Loch Uisg, to Loch Buie. The reason for this curve is that the fault is older than the great central volcano of Mull and it was pushed outwards by the upwelling magma.

The granite that forms the end of the Ross of Mull is similar in age to the Lorn Lavas and formed by the intrusion of a huge mass of silicic magma into the Moine rocks when they were still buried deep in the Earth's crust. The pink, coarse-grained granite breaks naturally along joints that are well seen in the rounded exposures of bare rock that give the Ross its distinctive landscape character. The granite was once quarried extensively; many old quarries and the piers for loading the blocks onto ships can still be seen. Widely spaced joints enabled some very large blocks to be quarried, although most stone was cut and dressed on site for very precise construction use, as in the renowned lighthouses of the Inner Hebrides at Oigh-skeir, Ardnamurchan, Skerryvore and Dubh Artach. The granite was used in the building of the abbey and most of the early Christian buildings on Iona, and farther afield in bridges such as Holborn Viaduct and Blackfriars Bridge in London, docks at Liverpool, Glasgow and New York, and numerous monuments around the world.

## Even Older Rocks



Spoil heaps at the old marble quarry on the south coast of Iona

Many people feel the presence of a special cultural and spiritual atmosphere as they cross the Sound of Iona, but the sound also marks a fundamental geological boundary. To the east, the oldest rocks on Mull (the Moine and Dalradian) were deformed and metamorphosed during the Caledonian Orogeny, like the rocks which form the mountains of the Scottish Highlands. To the west, on Iona, are much older rocks that were largely unaffected by the Caledonian mountain building. They are comparable to the so called Foreland rocks of the Outer Hebrides and north-west Highlands – the ancient rigid block of the Earth’s crust that the Caledonian rocks were crumpled up against to form the mountains. As they were being folded, the Caledonian rocks slid over the top of the rigid Foreland rocks, so that the contact is commonly marked by a zone of very fine-grained rock formed by intense grinding and stretching during the movement. In the north-west Highlands, this contact is the famous ‘Moine Thrust Belt’; along the south-east coast of Iona, fine-grained stretched rocks, called ‘mylonites’, indicate that a similar major dislocation must have been very close by.

Mylonites usually split easily into flat platy slabs and on Iona they have commonly been used for grave slabs, several of which can be seen in and around the abbey.

Much of Iona consists of metamorphic rocks that formed over 2500 million years ago from a wide variety of even older rocks, which were modified by heat and intense pressure deep in the Earth’s crust. The original rocks included both sedimentary rocks, deposited by rivers or on a lake- or sea-bed, and igneous rocks, formed from magma that crystallised at depth. However, they have been so altered by repeated earth movements during their long history that any traces of the original rock have been obliterated. They now appear as coarse-grained streaked and banded rocks, known collectively as ‘gneisses’ and form the Lewisian Gneiss Complex. The landscape that develops on these hard resistant rocks is typically one of low, well-rounded rocky knolls separated by boggy hollows with poor acid soils, just as one sees over most of the Outer Hebrides.





Knolls of Lewisian gneiss, dunes and machair on Iona



**Ross of Mull granite used as building stone, Iona Abbey**



**A Celtic cross at Iona Abbey made from a dark green crystalline rock that is not of local origin**

One distinctive rock type is the 'Iona Marble', a metamorphosed limestone, white with streaks of pale and dark green, that crops out in the south of the island. It was quarried intermittently on a small scale from medieval times until around 1914 and was used mainly for ornamental slabs, including the communion table in the Iona Abbey Church.

Some rocks on the south-east side of Iona appear to have had a less traumatic history and are still recognisable as metamorphosed sandstones and siltstones. Their affinities are uncertain, but they may be related to the 'Torridonian' sandstones that overlie the Lewisian in the north-west Highlands and form most of the large mountains of the Foreland area.

The large Celtic crosses of Iona are mostly carved out of a dark green crystalline rock that is not of local origin. Most of the local rocks are too hard or too brittle to carve easily, so these rocks, which are metamorphosed basalts, were imported from south-west Argyll on the mainland. Crosses of similar rock are found throughout western Scotland and Ireland.

# Moulding of the Landscape and Glaciation



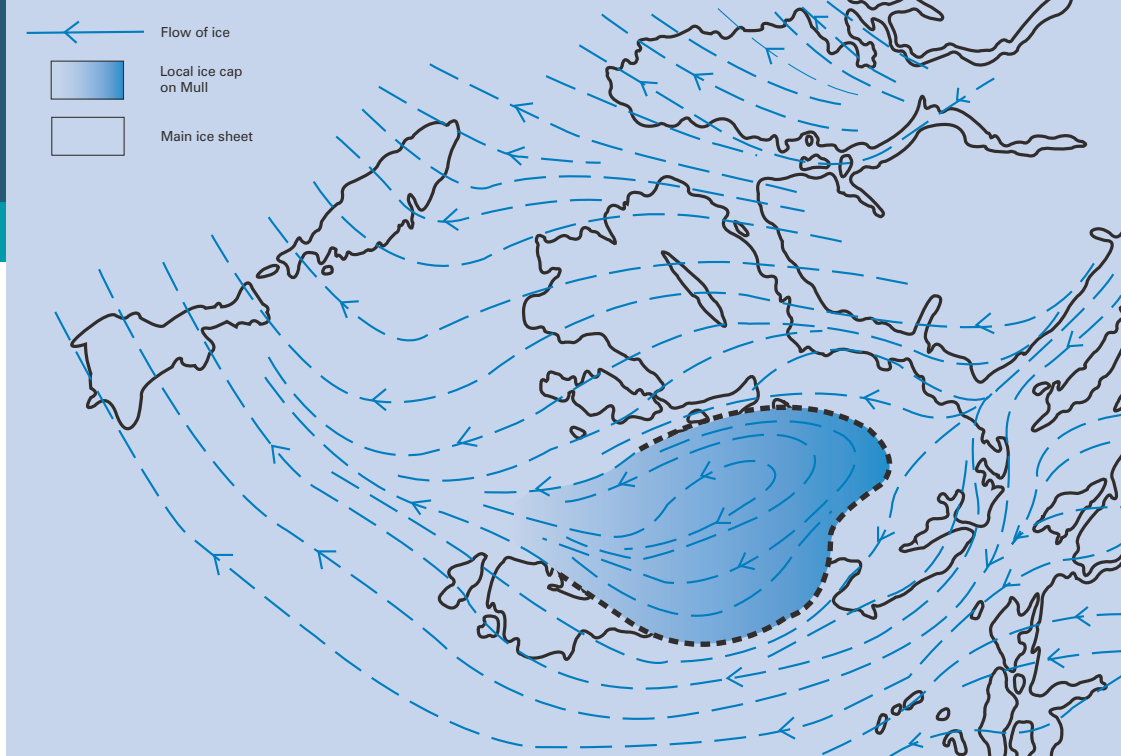
**Hummocky glacial debris (moraines) in Glen More**

So far we have described the bedrock that forms the solid foundations of Mull and its surrounding islands, starting with the volcanic rocks that erupted 60 million years ago and gradually ‘stripping off’ the layers of successively older rocks until we reached the ancient 2500 million year old crystalline basement that is exposed on Iona. Now we need to consider the events that have happened since the volcanic eruptions, for it is those largely surface processes that have transformed the landscape, by carving out all the detail that we see today and covering parts of the islands with a blanket of superficial deposits. Most of this transformation has happened in the last 2.5 million years.

After the end of igneous activity, about 52 million years ago, most of the Hebrides area experienced weathering and erosion in a warm, subtropical climate. It was during this long period of

erosion that the main elements of the present-day landscape of Mull were developed. The great central volcano was eroded down to its roots and the lava plateau was reduced in height. Although hills, valleys and coastlines were sculpted broadly according to the strength or weakness of the different rock types, much of the detailed shape of coastlines and valleys is controlled by dislocations (faults) and other lines of structural weakness in the rocks. This early landscape was then modified considerably by glaciers during the Ice Age.

The climate cooled rapidly some 2.6 million years ago and major cycles of climate change began. These cycles consisted of cold episodes that were long enough for glaciers to form (glacial periods), separated by shorter warm interglacial periods. During the first widespread glaciation, most of the soils, sediments and



**Ice flow around the mountains of southern Mull during the last widespread glaciation of Scotland, 29,000 to 14,700 years ago**

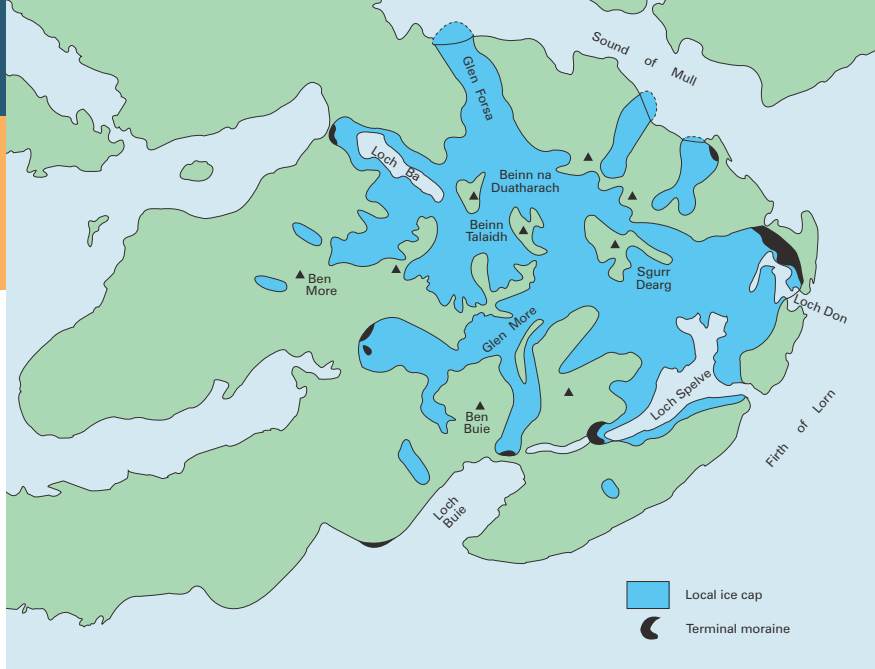
weathered rocks that had formed over the previous 50 million years were swept away by ice and meltwater. Valleys were deepened and it was probably at that time that Mull first became an island. Subsequent glaciations tended to clear away deposits from each preceding climatic cycle and consequently we have little detailed evidence of those times. However, in the last 450,000 years, we can recognise four cycles of glacial and intervening interglacial periods at roughly 100,000 year intervals.

The last widespread glaciation in Scotland occurred 29,000 to 14,700 years ago. At this time most of the Scottish mainland was covered by an ice sheet. The mountains of southern Mull had their own local ice cap, which at times probably covered even the highest peaks. Evidence from scratch marks and ice-smoothed

rocks shows that ice from the mainland flowed westwards and was diverted around both sides of this ice cap. Consequently boulders of distinctive rock types carried from the mainland by the ice (glacial erratics) are found all over Mull, except in the southern mountains. On the southern shore of Loch na Keal, around Scarisdale, the bedrock surface is particularly well polished and scoured where the mainland ice flowed past the edge of the local ice cap. Here, spectacular hollows and sinuous grooves up to 1.5 m deep were probably formed by the abrasive action of rock debris embedded in the base of the ice, aided by meltwater flowing beneath the ice. When it melted the ice-sheet left behind, on the lower ground, a widespread undulating blanket of gravelly debris (till), which infilled hollows, covered the benches between lava flows and generally smoothed out the topography.



Channels formed beneath an ice-sheet  
on the shore of Loch na Keal



The last local ice cap on Mull, 12,000 years ago. It was this ice cap that sculpted the landscape that we see today in the mountains

'nunataks' above the ice cap, whereas Ben More lay outwith the ice cap and had only small glaciers in some corries. The farthest point reached by the ice is marked by crescentic lines of gravelly deposits (terminal moraines), which are particularly well seen at Kinlochspelve and on the east side of Loch Don. When the ice finally started to melt, the glaciers shrank back up the valleys,

About 14,700 years ago the climate warmed suddenly, melting the ice cap, and for about 1800 years summer temperatures were similar to those of today. Pollen from sediment in old lakebeds tells us that grass and heathland type vegetation colonised the land. Sea-shells found in clays around Loch Spelve are similar to modern shells, but include some species that inhabit colder waters.

During a final, relatively short glaciation 12,500 to 11,500 years ago, glaciers formed only in the mountainous part of south-east Mull. The surrounding lowland areas were frozen wastes like the arctic tundra of today. It was this last glaciation that produced most of the landscape features that we see in the mountains, such as steep cliffs plucked clean by the ice, and sharp ridges that formed between glaciers in neighbouring corries. Glaciers reached sea level at the bottom of Glen Forsa and Loch Bà, where spreads of gravel, deposited by meltwater can be seen. Some of the higher peaks, such as Beinn na Duatharach, Beinn Talaidh and Sgurr Dearg, protruded as

leaving behind hummocky moraines. These are particularly well seen in Glen Fuaron on the south side of Glen More, which is consequently known as 'the valley of the hundred hills'. Most scree slopes formed at this time, as frost-shattered rocks collapsed down the mountain-sides when they were no longer supported by ice; some are still being added to by local rock falls, but mostly they are inactive.

The climate warmed rapidly 11,500 years ago, probably within the space of 50 to 100 years, and the last glaciers melted. Modern vegetation was soon established and humans appeared on the scene. Woodland flourished until about 5000 years ago when a wetter climate, coinciding with the start of tree felling by early farmers, resulted in a trend towards grass and heather moorland and an accumulation of peat. Since then the landscape has been more affected by human activities than by geological processes or climate change, although in some places flash floods and landslides continue to have a dramatic effect to this day.

# Landslips



**Scree slopes on the coast of Mull near Gribun**

**T**hroughout the Hebrides, wherever a thick pile of lavas rests upon relatively weak sedimentary rocks with slippery clay layers, huge sections of cliff collapse from time to time. These 'landslips' result in chaotic labyrinths of enormous tilted blocks, commonly separated by awesome chasms. The most dramatic landslips of the Hebrides are in northern Skye, but many good

examples are seen in the coastal cliffs of Mull, particularly at Gribun, in the area to the south-west known as The Wilderness and around Carsaig. Some occurred before the last widespread glaciation but most have formed since the ice retreated and movements continue to the present day.

# Coasts and Beaches

## The Spouting Cave, a blowhole on the west coast of Iona

The overall shape of the coastline of Mull has probably changed little since early glacial times. However, long level benches and notches carved at heights of up to 30 metres above present sea level are dramatic illustrations of many changes of sea level over the past 500,000 years. These rock platforms represent ancient shorelines and commonly show all the features of a modern shoreline, such as abandoned cliffs, sea-stacks and caves. Some are even capped by beach shingle and are known as raised beaches.

There are many reasons for changes in sea level. During glacial periods, areas of the Earth's crust that are covered by ice-sheets slowly sag under the enormous weight of the ice, so that sea level rises. When the ice melts, global sea levels initially rise further, but once the weight of the ice has been removed the depressed areas of crust slowly begin to rise or 'rebound' and consequently, over the next few thousands of years, sea level falls. These processes all interact with each other as ice-sheets wax and wane, so the detailed history of sea-level changes in the Hebrides is very complicated. However, most of the raised shorelines that we see today are the result of the upward rebound of the crust following its depression during the last major ice-sheet glaciation. In effect the islands are rising so that, in general, the lower shorelines are younger than the higher ones.



The highest rock platforms on the coastlines around Mull were probably formed before the last widespread glaciation, 30,000 years ago. Good examples of platforms at about 30 metres above sea level are seen, even from a great distance, in the Treshnish Isles (the 'brim' of the Dutchman's Cap is the best example) and on the mainland of north-west Mull around Caliach Point.





A continuous bench at this level along the north side of Loch Tuath, from Treshnish Point to Torloisk, makes a very pleasant and easy walk. Lower raised shorelines, formed at various levels during and since the melting of the ice, are well developed in southern and eastern Mull, in particular on the Duart peninsula, at Carsaig, on Iona and around Ardalánish on the Ross, where several abandoned shorelines can be seen in the same area.

Much of the present coastline of Mull consists of steep cliffs of basalt or other hard, resistant rocks that are constantly battered by Atlantic storms and swept clear of all but the coarsest debris. Sandy beaches are rare, except where sedimentary rocks, granite and glacial deposits have been more readily broken down to provide a source of sand, which is then washed into sheltered bays, as at the head of Loch Buie and in numerous coves around the Ross of Mull. On some beaches, the waves have piled up broken shells from the nearby seabed, as on Iona, parts of the Ross and Calgary Bay. In places the wind has blown the fine shell-sand inland to accumulate as sand dunes behind the beach, as on the north coast of Iona where there is a small area of 'machair', the colourful meadowland of seaside grasses and lime-loving wild flowers that is so extensive in the Outer Hebrides.

**The high raised shoreline at Treshnish Point, Mull**



**Shell sand, Calgary Bay, Mull**



Raised beach on the east side of Iona

# The Landscape Today



**Hayfields at Gribun on Loch na Keal with Ben More in the distance, Mull**



**Lewisian rock in the foreground on Iona and Ross of Mull granite and lavas in the background on Mull**

An astonishing variety of seascapes characterises the Isle of Mull and her family of outlying islands. Sheltered bays are massaged by gentle waves, towering cliffs rise in tiers above crashing Atlantic rollers and small islands fragment the sea in shallow waters. All contribute to the extraordinary sequence of vistas experienced from the shoreline and inland waters.

Habitation of any size is focussed on the coast, particularly where shelter can be found for harbours, such as that of Tobermory, one of the finest in the Hebrides. These settlements are linked by meandering roads, which cling to the winding shoreline, seek out crossing places over the lava plateau and follow broad glens through the otherwise impenetrable mountainous south.

A long-settled landscape, grazed fields and scattered farms emphasise the continuing agriculture. But within the glens, as in much of the rest of the Highlands and Islands, the expansion of commercial forestry has been the most visible change in the landscape in recent times.

Both the dramatic and the more contemplative qualities of this landscape are found in the relationship between land and sea, not least around the Isle of Ulva, which is nationally designated to conserve its scenic beauty. Here is the essence of the island landscape, where the dancing sparkle of the sea is peppered with innumerable skerries, contrasting with the robust and formidable mass of the elegantly shaped mountain massif.

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# Remember the Geological Code!



Always identify the rock sample you are collecting and record the location, date and weather conditions.



Be careful to follow the instructions for the use of the code.

The number of a rock sample is always given in the order of the code.



Always use the same hammer and chisel for all samples.



Always use the right 'big' or 'small' for the rock you are using.



Use the same hammer and chisel for all samples.



Use the same hammer and chisel for all samples.

Be careful to follow the instructions for the use of the code.

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## ALWAYS REMEMBER:

- 1) Use the same hammer and chisel for all samples.
- 2) Use the same 'big' or 'small' for all samples.
- 3) Use the same 'big' or 'small' for all samples.
- 4) Use the same 'big' or 'small' for all samples.
- 5) Use the same 'big' or 'small' for all samples.

- Remember to use the same 'big' or 'small' for all samples.
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*Vanessa Collingridge, author and broadcaster*

### About the Authors

**David Stephenson** has worked as a field geologist in Scotland for over twenty-five years, concentrating mainly upon volcanic rocks of the Midland Valley and metamorphic rocks of the Grampian Highlands. In addition he has investigated igneous intrusions in Greenland, volcanic rocks in Burma and ancient oceanic crust in Arabia. Mull is one of his favourite 'retreats', where the variety of the mountain and coastal landscapes can inspire and encourage activity in almost any weather.



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