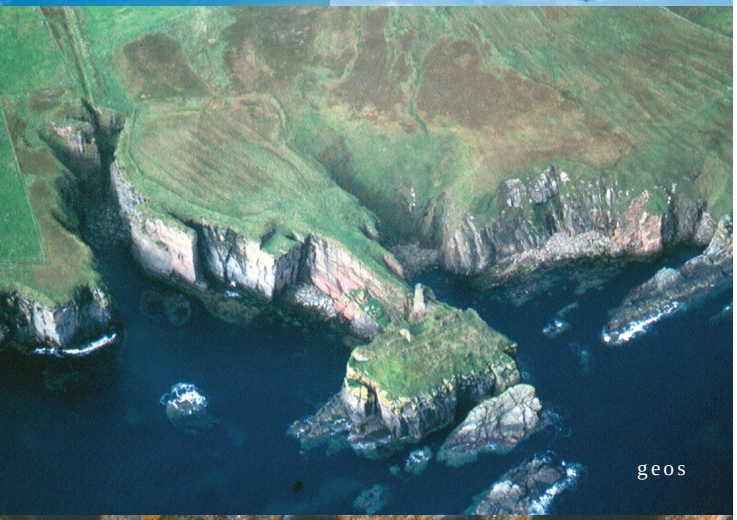


geos

weathered sandstone

cliff scenery

guidance for visitors

Please remember:

- To take care on the cliffs as they can be dangerous
- To avoid disturbing nesting birds
- To keep dogs under control at all times
- To take your litter home with you
- To not pick wild flowers
- To respect private property

photographs: SNH, Iain Ashman design and illustration: Iain Ashman

cover images: top fossil fish bottom sea arch

Orkney's Geology

find out more about our rich and varied island

Orkney's geology

The changing environmental conditions echoed in the rock layer sequences can be seen at various places in Orkney. On Eday 1, the change through time from layers of silty sediment that accumulated in the middle of the lake, to sand and gravel river deposits, and then a return to lake deposits, is well illustrated. At Yesnaby 2, on Mainland, you can see that in the cliffs, the rock layers were once sand dunes. Other features of the ancient environment include ancient dried mud, in which you can clearly see the sediment filled cracks, resulting in a criss-crossed pattern on the surface of some rock layers.

fossil mud cracks

fossil wave marks

There is also evidence of volcanoes, which you can see at the south coast of Deerness 3, on the east Mainland. Here there is a volcanic plug, the remains of a volcano, together with its lava flow and layers of volcanic ash. Volcanic lava and ash also occur on the west side of Hoy and underlie the Old Man 4.

The rock layers not only reveal the environmental conditions of the ancient environment in which the foundations of Orkney were formed, but also disclose other interesting information from the past. In many of the islands, the fossil remains of the life that lived in and around Lake Orcadie can be found within the rock layers. Most famous of the Orkney fossils are the fish. Sometimes found complete, but more frequently as fragments of scale and bone, the fossil fish suggest that Lake Orcadie teemed with life.

head of a fossil fish

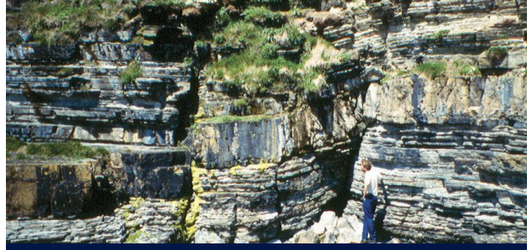
Some of the fish lived entirely on the lake bottom, where they scavenged for food. These fish tended to have boney armour plating to protect themselves from fast-swimming predators. There were also other groups of fish, precursors of the species we see on the fishmonger's slab today, that swam in shoals.

Following algal blooms and other natural environmental factors that 'poisoned' the lake waters, fish mass mortalities seem to have occurred from time to time. The fish bodies drifted from near lake margins, where they tended to live, towards the deeper part of the lake where they sank to the bottom and were covered with fine silt and subsequently fossilised. Rock layers particularly rich in the remains of fossil fish are known as 'fish beds'. The fossil museum in Burray 5 has many fossils from Orkney and elsewhere.

remains of stromatolites

fossil wormcasts

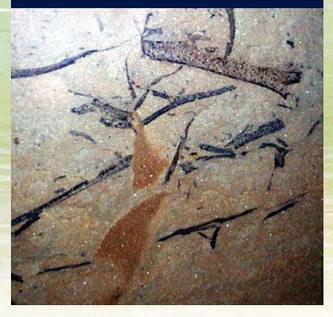
Other more unusual fossils known as stromatolites also occur and can be seen at Yesnaby 2. These are seen as ocherous layers between some of the flagstones and form the 'Horse tooth stone' found in a sequence of rock layers known as the Lower Stromness Flags. Stromatolites are the fossil remains of blue-green algae that flourished in the beach areas of the ancient lake. The algae are considered to be part of the army of agents that worked by photosynthesis in very early geological time to produce the oxygen that supports us today. Also encased in the rock, it is possible to see old worm burrows and worm casts of long ago, preserved through time in what used to be layers of soft sediment.



fault showing rock sequence

With the passage of time, the mountains around the lake became worn down, the lake and surrounding lowlying areas were filled in with sediment, and eventually, the whole area became a desert. Beneath the ground surface the layer upon layer of sediment that had accumulated turned to rock. Millions of years later, tensions in the Earth crust, brought about by continuing continental drift, folded the rock layers and in places the rock sequence was sliced through by geological breaks or faults.

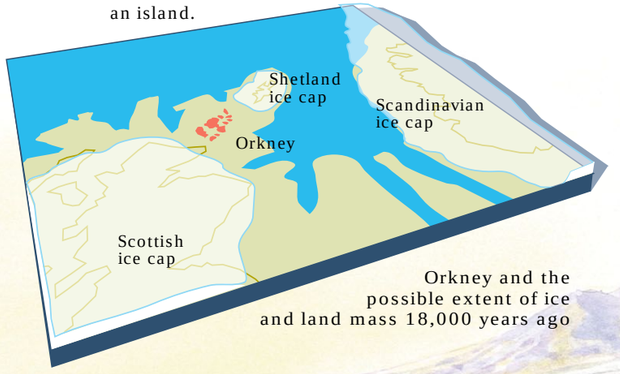
plant fossils



The fossil remains of plants also occur in the rock layers of Orkney. This indicates that despite the hot and arid climate, there were plants established on the margins of the lake and associated river systems. These plants were some of the earliest known. When the plants died, fragments were washed into the lake to become fossilised along with the fish.

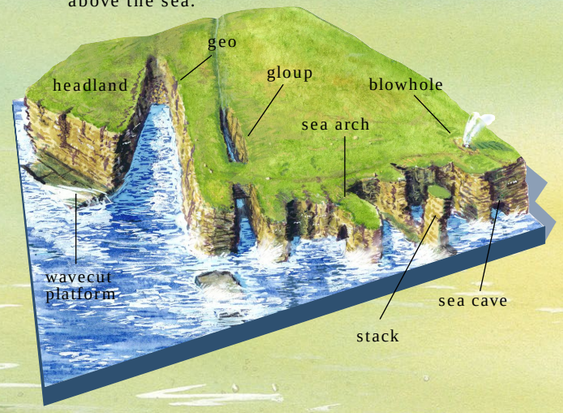
The next 350 million years passed without further upheavals in Orkney until, around two million years ago, global temperatures plummeted and the world was plunged into an ice age.

As recently as 17,000 years ago, the earth was still in the grips of this ice age and, world-wide, sea level was more than 100 metres lower than it is today. Orkney was then a range of hills and valleys surrounded by low-lying land stretching as far as the Scottish mainland. Over the following 11,000 years, temperatures rose, ending the ice age and causing sea levels to rise. The land around Orkney was soon flooded, creating an island.



Orkney and the possible extent of ice and land mass 18,000 years ago

Gradually the deeper valleys were also submerged, leaving only the hill tops and high ground standing clear of the water as islands. The sea level stabilised about 6000 years ago, by which time the islands looked roughly as they do today. But like an unfinished sculpture, they lacked detail. This was provided by the force of the sea which even today continues to chisel away at the Orkney coastline. On inner, sheltered coasts, the landscape is generally rather gentle, but on the exposed, westerly coasts of Hoy and Mainland, the rocks have borne the full brunt of the weather. Here, waves driven thousands of miles across the Atlantic have slowly scoured away the sandstone, producing the highest perpendicular cliffs in Britain, at St John's Head on Hoy, which towers 346 metres above the sea.



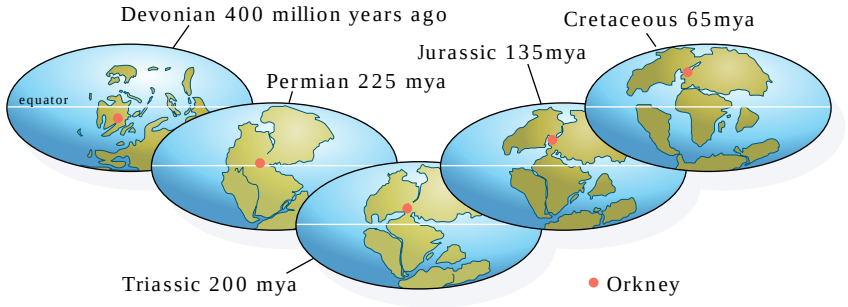
The variation in hardness of rock causes erosion to occur at different rates. Headlands have formed where the rock is harder, bays where it is softer. Erosion has also shaped sea-stacks and geos. Geos are deep indentations in the cliffs formed where the waves have scoured and hollowed out fractures in the sandstone.

prehistoric Orkney

Where there are now seventy or so islands in Orkney, dotted over an area of sea that lies between the North Sea and the Atlantic, there used to be a great freshwater lake. This once vast lake existed nearly four hundred million years ago, during the Devonian geological period, and stretched from what we now know as the Moray Firth, across Caithness to Orkney, Shetland and beyond to the Norwegian coast. Given the name 'Lake Orcadie' by geologists, this huge lake was ringed by high mountains, the ancestors of the Grampian and Northern Highlands. The mountains were drained by mighty river systems that transported enormous amounts of sediment into the low lying areas. Sand and other loose sediment that did not reach as far as the lake, was blown around by the wind to form sand dunes that would have migrated across what was a hot, arid, desert-like landscape.

cross section of ancient sand dunes, Yesnaby

This Devonian landscape and environment would have been totally unlike that of today, because 400 million years ago Scotland and the rest of Britain, was part of a continent called 'Laurussia' that also included north America, Greenland and northwestern Scandinavia. This continent was located south of the equator. Stresses and strains in the crust of Devonian Scotland, induced by continental drift, sometimes gave rise to volcanic activity, with the eruption of lava and ash over the landscape from volcanoes. It was a result of continental drift over the subsequent few hundred million years, that brought about Scotland's northward drift to its present latitude and the split between Britain and America with the formation of the Atlantic Ocean and North Sea.



Where was Orkney within this ancient environment? What is the evidence that allows the reconstruction of the events outlined here? The answer to both these questions is held within the bedrock of the islands. The bedrock of Orkney is very much in evidence where the sea meets the land and the rocky foundations are laid bare by the action of the sea.

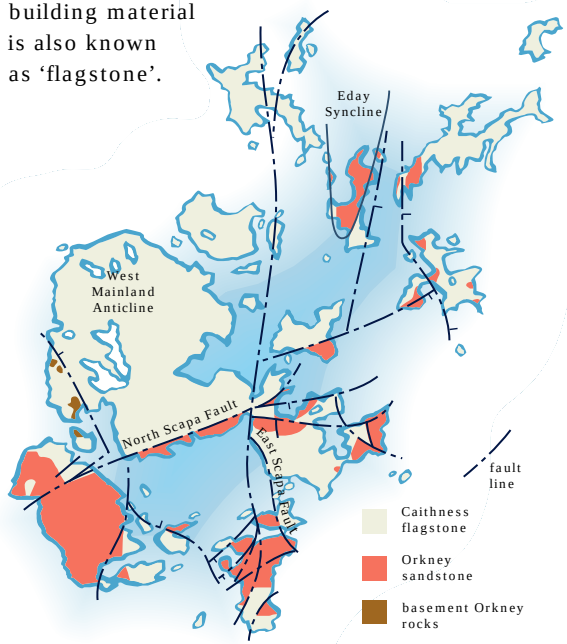
When we look at the cliff edges of the islands, we see near horizontal layers of rock piled one upon the other. These rock layers once extended from island to island, during a time when the archipelago and the mainland of Caithness existed as a continuous landmass. The action of sea and the ice over the ages has worn away this landmass, leaving behind the islands which are still being eroded by the sea; the numerous caves and sea stacks are evidence of this continuing erosion.

sea arch

sea caves

flagstone

These generally flat-lying rock layers, which persist underneath the land and dictate the low-lying landscape of Orkney, are popularly known as the 'Old Red Sandstone'. As well as sandstones there are also layers of siltstone and mudstone. Owing to the ease with which the stone can be used for building houses and walls, this natural building material is also known as 'flagstone'.



These layers represent the sediment that was washed into Lake Orcadie from the surrounding mountains. It is thought that muds and sands to a depth of 4,000 metres were deposited and piled up in the lake and its surroundings. As time passed and as environmental conditions changed over thousands and millions of years, the lake level fluctuated and areas which were previously dry land were engulfed by water. At other times, the lake almost dried up completely.