

NIGG BAY TO COVE COASTAL FOOTPATH GEOLOGY AND GEOMORPHOLOGY



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Nigg – Cove Coastal Trail

Geology and Landforms

Background

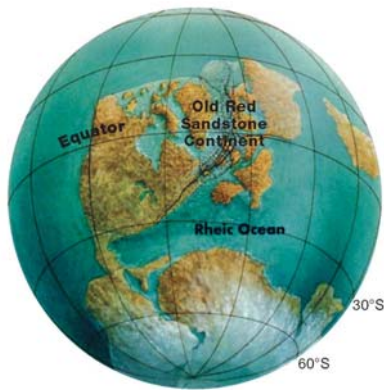
The coast between Nigg and Cove features some dramatic and beautiful scenery. The rocks from which it is made represent some of the oldest in Scotland. They have been sculpted over millions of years by wind, wave and tide to create what we see today as a spectacular landscape of high cliffs and narrow coves filled with pounding surf. Stepping out on top of the cliffs in the fresh air is a walk through history with the different rocks below our feet providing stories of the incredible journey that Scotland has taken through geological history. The rocks and sediments provide clues that help us to reconstruct a remarkable story of past oceans, mountain ranges, volcanoes and glaciers.

Scotland is well known as one of the few areas of the world that possesses a range of rocks stretching back to the beginning of the Earth. For north east Scotland the oldest rocks date back to around 500 million years ago. At that time, due to the drifting of the continents, Scotland was located near the South Pole and forming part of a supercontinent that contained most of the landmass of the Earth that existed at that time. It was a time when the start of life on Earth was just about beginning with the appearance of the first marine organisms. As parts of the supercontinent moved against one another, great mountain ranges some as high as the Himalayas, were formed. These huge mountains have long since disappeared having been worn down by processes of erosion. All that is left are roots of these mountain ranges.



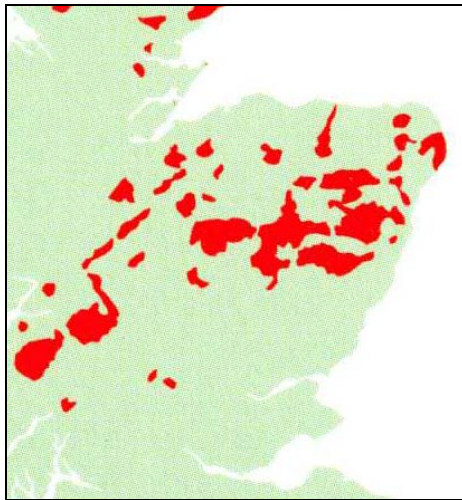
500 million years ago saw the splitting of the supercontinent in which Scotland formed part of Laurentia with the Iapetus Ocean to the south.

In the millions of years that followed, the supercontinent began to break up and spread apart in separate sections. As it did so, it created a huge ocean, known as the Iapetus Ocean. As the ocean widened and deepened its floor became filled with sediments. At a later stage, as the continents continued to move, the ocean began to close up. As it did so, the sediments on its floor began to buckle and fold. The rocks were heated to over 650 degrees Centigrade turning them into tough metamorphic rocks. These rocks we now know as the Dalradian series of rocks that form the majority of the rocks along our North Sea coastline. Across Scotland, the last stages in the closure of the Iapetus Ocean resulted in the development of the Caledonian mountains so huge that they originally stretched from the eastern United States through Scotland to Norway.



By 400 million years ago the Iapetus Ocean had closed and Scotland had started to drift northwards

As the continents continued to collide, some of the Dalradian rocks were baked and squeezed so intensively that they melted – turning themselves into igneous rocks known as granites and gabbros. These igneous rocks were created deep in the Earth's crust at very high temperatures, in the order of 1,000 degrees Centigrade. As this process continued, the hot molten rocks, known as magma, were forced through lines of weakness in the pre-existing Dalradian rocks. This also caused the surrounding rocks to melt producing what we know recognise as the granite areas of north east Scotland. We always need to remember that these granites were probably formed as deep as over 20 km beneath the surface of the Earth and that, subsequently, this amount of erosion has taken place to expose the granite at the ground surface.



Distribution of granite rocks that were formed as the Caledonian Mountains were created.

Although Aberdeen is built on granite, this rock is absent from the Nigg-Cove area. Instead we find here other signs of the squeezing of molten rock through lines of weakness in the Dalradian rocks. In some places this squeezing took place along lines of weakness parallel to layers of the existing rock to produce sills, for example at the Cave of Red Rocks.

After the volcanic eruptions had ended, there was a long period of time during which the location of Scotland drifted northward towards the tropics. By 360 million years ago Scotland had entered the Carboniferous era. The landscape then was dominated by rainforest and warm tropical seas. During the early part of this period volcanic activity was widespread. Another set of igneous dykes were formed, for example at the Bridge of One Hair.

For the most part the last 400 million years of geological time are not represented in the Nigg-Cove area. Instead, we find nearly everywhere, accumulations of tough reddish clays and silts containing boulders, resting directly on top of the bedrock. These sediments were laid down by the last ice sheet that buried north east Scotland with several kilometres thickness of ice at the end of the last Ice Age. These soft sediments occur everywhere beneath the ground surface in the fields next to the cliff-top path. In general, the sediment cover is thin except for one area at Nigg Bay where it is exceptionally thick. Here, a large glacial river eroded a huge gorge that later became completely filled by sediment from the melting ice sheet. The extent of this sediment can be appreciated by noticing how bedrock disappears from view along the south side of the bay only to reappear again behind Nigg Bay car park.

STOP 1

Nigg Bay (NJ 967 044) The sheltered position of Nigg Bay between two headlands and a gently sloping seabed offshore has resulted in a well-developed sand and cobble beach. From the car park look right towards the cliffs at the back of the storm beach. The cliffs show sediments that choke an abandoned channel of the River Dee. The former river course is cut down to -40 m below present sea level and formerly was occupied by glacial rivers that drained from an inland ice sheet. The infill of sediment, a part of which is shown in the cliff sections, dates to the last Ice Age. The lowest sediments consist of gravel and boulders some of which appear to have originated in Scandinavia and to have been transported here by glacier ice. The overlying glacial sediments appear to have been derived from farther south down the coast, the reddish colour of the sediment due to the former passage of ice across the Old Red Sandstone rocks of Angus.

The glacial deposits exposed in the cliff section constitute a Site of Special Scientific Interest (SSSI). The cliff sediments at Nigg Bay have been discussed in the scientific literature for over a century with the succession of glacial deposits having long been regarded as a classic location for understanding the glacial history of Scotland.



STOP 2

Coastal Rock Platforms (e.g. NJ 971040; NJ 957015; NJ 963023)

Broad rock-cut shore platforms can be observed along as discontinuous features along the entire length of the coastal walk. As a general rule, these consist of sub-horizontal features up to (and locally exceeding) 100 m in width. The rock surfaces mostly occur at or slightly above the present intertidal zone. The surfaces are generally irregular with upstanding ridges of rock that are most resistant to the power of the waves. In most areas, the Dalradian rocks of which they are composed dip at an angle giving individual areas of rock platform a jagged appearance. The age of the various sections of shore platform is not known although it is possible that planated sections of rock may owe their origins to times in the past when the position of sea level was slightly different than present.



STOP 3

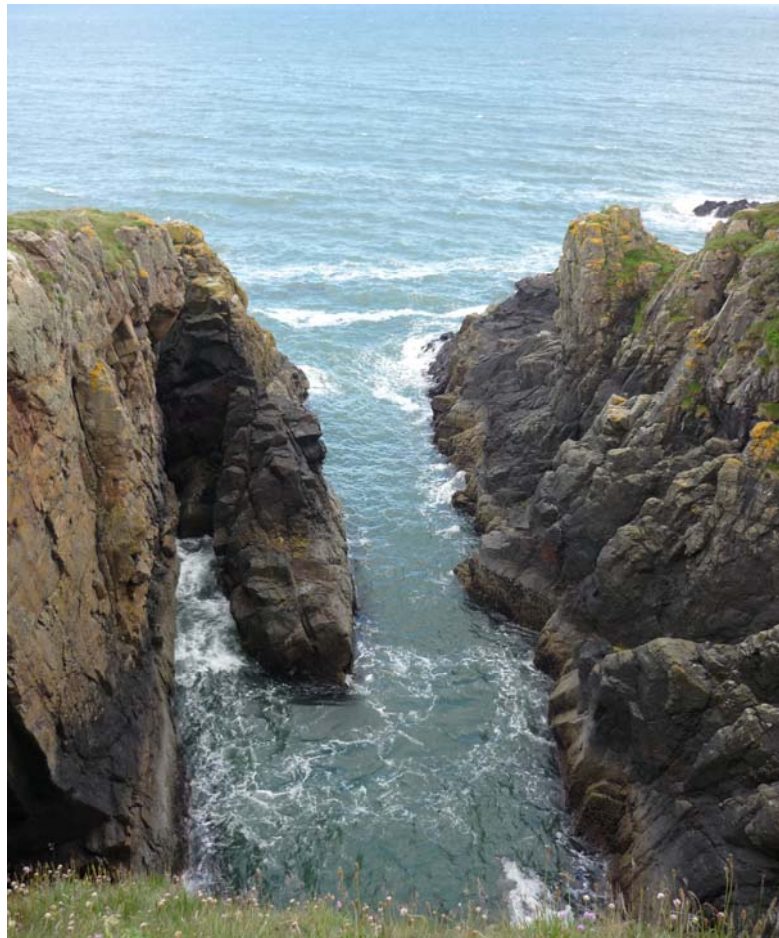
Bridge of One Hair (NJ 969 038) Follow the path for 200 m south of the coastguard station. Looking seaward, there is a near-vertical igneous dyke around 15 m thick and extending over 70 m towards the sea. The dyke is made of a tough igneous rock known as quartz-dolerite. It was squeezed through the surrounding Dalradian rocks during a period of volcanic activity during the Carboniferous era. The quartz-dolerite shows signs in places of spherical (onion-skin) weathering along joints in the rock. Whereas the quartz-dolerite is resistant to weathering, the same cannot be said of the Dalradian rocks located on both sides of the dyke and which show signs of extensive fracturing. Stepping onto the Bridge of One Hair is dangerous and should not be attempted.



STOP 4

Geos (e.g. NJ 968034; NJ 964024; NJ 964030; NJ 963022)

Geos are narrow ravines at the coast and are common features of the coastal scenery between Nigg and Cove. Most geos are precipitous, steep-sided features and extend from the coastal path down to sea level. Many geos owe their origins to erosion by the sea along fault lines where the Dalradian rocks are riddled with joints. Here, pounding by the sea during storms over thousands of years has led to the loosening and removal of debris by storm waves. In some areas, geos have formed along lines of rock weakness where igneous dykes are juxtaposed against the surrounding Dalradian rock (e.g at the Bridge of One Hair). In these places, wave erosion has removed areas of jointed rock along the edge of the dyke – producing a deep geo. Although geos represent some of the most spectacular features in the landscape along this coastline, they are also some of the most dangerous. Walkers should take care in these areas



STOP 5

Cave of Red Rocks (NJ 965 029)

In the inlet here we can see clear traces of the igneous activity that took place during the time of the Caledonian mountain building period (in contrast to the younger period of volcanic activity that took place during the Carboniferous period). The evidence consists of a thick (5 m) sill composed of felsite rock. The sill can be seen on both sides of the inlet with its top surface mostly buried by glacial deposits. In some places the sill can be observed as occurring both beneath and above the Dalradian rocks through which it was squeezed. The felsite sill is not restricted to this inlet – it also can be traced southwards along the coast for over 300 m. The felsite is mostly massive in character in marked contrast to the foliated nature of the Dalradian rocks above and below. Within the sill, however, the felsite is faintly banded, this due to the flow of the igneous magma when it was first moved through the rocks.



STOP 6

Cliffs and storm beaches

The coastal walk provides view of spectacular cliff scenery and home to many nesting birds. In some areas the cliffs plunge straight into the sea (e.g. north of Cove). In other areas, the cliffs are associated with rock platforms at their bases. Elsewhere, the products of erosion by storm waves are isolated boulder beaches. In some places these boulder accumulations occur at the head of geos (e.g. at Burnbanks NJ 961021) while elsewhere they occur as pocket beaches between rock ridges. In all cases, the pounding of storm waves has created thousands of beautifully-rounded boulders. At Nigg Bay, in addition to boulders derived from the erosion of nearby glacial sediments, angular granite slabs from former buildings have been rounded and smoothed by the action of storm waves.

As you walk along the coastal path, observe the bare areas of rock up to 15m above sea level that are repeatedly pounded and washed over by waves during winter storms. In most areas, the upper limit of storm waves is marked by the lower limit of yellow lichens. Also, the presence of isolated boulders perched high and dry on the tops of the cliffs well above the reach of normal wave action, reminds us of the immense power of winter storm waves along this coastline.

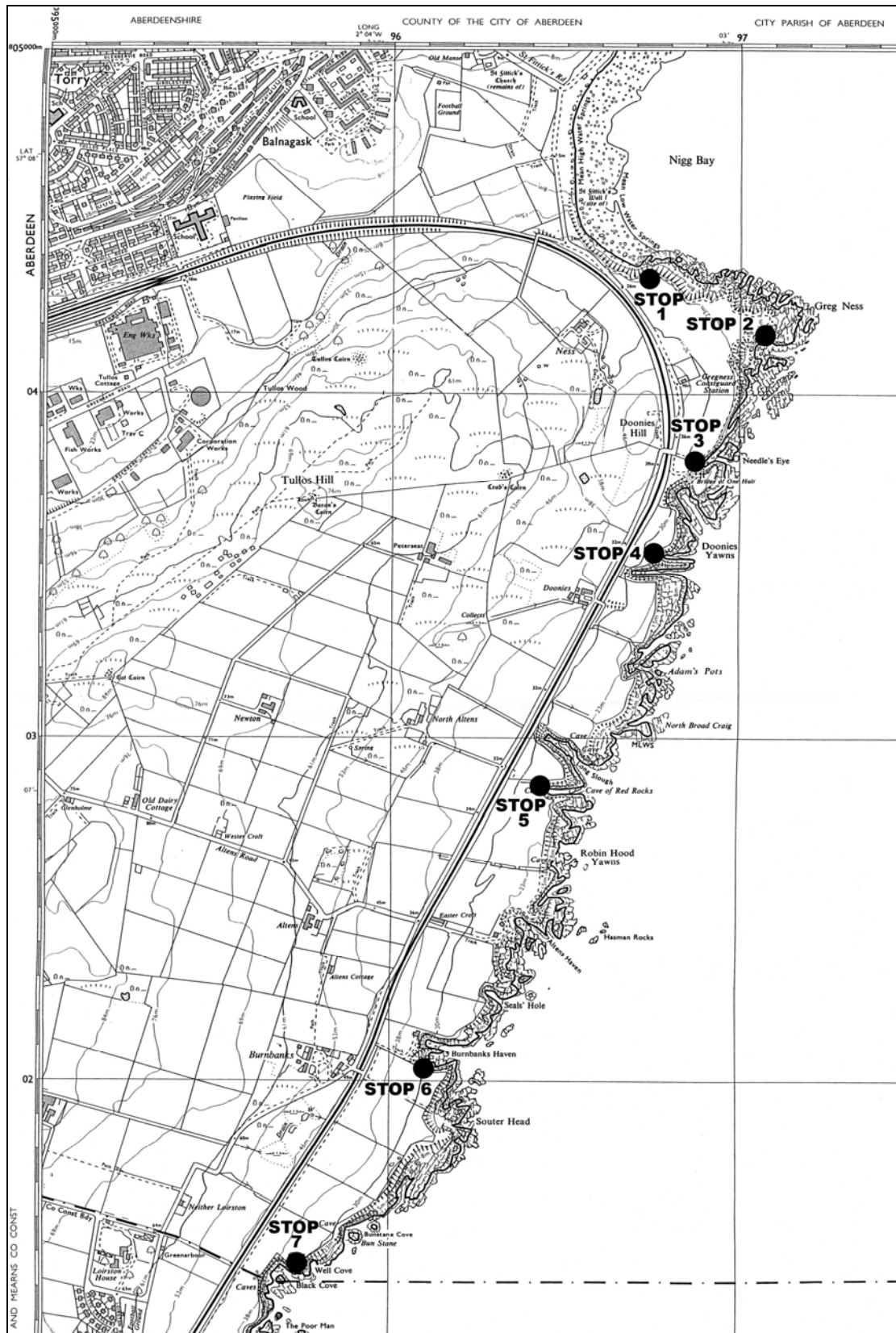


STOP 7

Sea Caves (NJ 958015; NJ 965027; NJ 957014)

Sea caves can be seen at various places along this coastline. They usually occur at or slightly above present sea level and they are nearly always cut in the foliated Dalradian rocks. An excellent view of one of the largest caves can be seen from the coastal path just north of Cove (NJ 957015). A spectacular view of the coast looking southward can be seen from here. Below and in the foreground is a large sea cave with a tall entrance and inaccessible apart from by boat. The caves are to a large extent structural features of the coastline, namely that the pounding of waves has exploited areas where the Dalradian rocks are extensively fractured. Also, however, the caves were produced as a result of past changes in sea level. For example, sea level along this coast has only been at its approximate present level for the last *circa* 2000 years.





Location stops

Proposed Plinths

Plinth 1

Location close to wooden structure adjacent to coastal path on south side of Nigg Bay (NJ 968043)

Nigg Bay was the site of an old course of the river Dee during the last Ice Age. The channel, whose base descends to around 40 m below sea level, was later buried by sediments deposited by the last ice sheet that covered this area. In the sediment at the base of the cliffs at the back of the beach can be found boulders originating in Scandinavia and brought here by an ancient ice sheet. However, the sediments nearer the top of the cliff tell a story of a younger tongue of ice that moved across this area from the Scottish mainland out to sea.

Plinth 2

Location adjacent to Bridge of One Hair next to coastal path (NJ969038).

The linear vertical ridge in the foreground (looking north) is part of an igneous dyke composed of quartz-dolerite. The dyke was produced during a period of volcanic activity that characterised part of the Carboniferous era. Similar dykes can be seen at various locations between here and Cove.

Plinth 3

Location at head of geo looking downward near the Cave of Red Rocks (NJ 965029).

The near-horizontal slab of rock in the foreground is a thick (up to 5 m) igneous sill of felsite rock. The sill, which can be traced southward along the coast for over 300 m, was emplaced during a period of igneous activity during a famous period of mountain building, known as the Caledonian Orogeny, that took place during the closure of the Iapetus Ocean around 500 million years ago.

Plinth 4

Location at headland looking southward towards Cove (NJ 957015).

Spectacular view towards Cove of coastal cliffs cut in Dalradian rocks. In the foreground the base of the cliff is marked by a large sea cave while nearby, traces of rock platforms can be seen in the intertidal zone.

Note: This author has a serious concern about safety for this coastal path. Many sections of the path occur close to the top of the cliffs as well as also adjacent to geos and other precipitous slopes. Measures need to be in place to prevent access to dangerous areas, such as the bridge of One Hair and Cave of Red Rocks. Perhaps there should be a protecting fence along the seaward side of the path for the whole of its length OR parts of its length.

Figures A, B and C courtesy of John Gordon – from McKirdy, A., Gordon, J. and R Crofts 2007 Land of Mountain and Flood, the geology and Landforms of Scotland, Birlinn, Edinburgh.

Further Reading:

Jamieson, T. F. 1882 On the Red Clay of the Aberdeenshire coast and the direction of ice movement in that quarter. Quarterly Journal of the Geological Society of London, 38, 160-77.

Trewin, N.H., Kneller, B.C. and C Gillen 1987 Excursion guide to the geology of the Aberdeen area, Scottish Academic Press, Edinburgh.

Gordon, J.E. 1993 Nigg Bay, In, Gordon, J.E. and D.G. Sutherland (eds.) 'Quaternary of Scotland – Geological Conservation Review Series', Chapman and Hall, 479-482.

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