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The Geodiversity of the Isle of Harris:

Statement of Significance and Identification of Opportunities

Geology and Landscape (Northern Britain) Programme

Report CR/07/032N

BRITISH GEOLOGICAL SURVEY

GEOLOGY AND LANDSCAPE (NORTHERN BRITAIN) PROGRAMME

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Front cover

View over Tràigh Sheileboist, with the North Harris hills beyond. BGS photo P001013. © NERC 1980

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1 Introduction

This report has been prepared for Harris Development Ltd. in order to provide a summary of the geological history of the Isle of Harris, to identify the key geodiversity features, and to suggest opportunities for geological interpretation.

The entirety of the island of Harris is underlain by rocks of the Lewisian Gneiss Complex. The oldest rocks on Harris were formed over 3000 million years ago – they are two-thirds as old as the Earth itself, and they are some of the oldest rocks in Europe. For 1500 million years after their formation, these Lewisian gneisses were affected by a multitude of geological processes including stretching of the crust associated with extensive volcanism, and collision of ancient continental masses which led to mountain building. All these geological events are recorded in the rocks we see today on the Isle of Harris, and they are the focus of continuing research.

After about 1600 million years ago, the Lewisian gneisses of Harris became part of a stable continental mass – and there they stayed, largely unaffected by geological events going on around them, almost until the present day. Finally, within the last 2.6 million years, the gneisses that were exposed at the surface have been eroded and polished by the action of glaciers and oceans, producing the landscape that forms the Isle of Harris today.

The first section of this report describes this geological history in more detail, and emphasises some of the important events. The second section discusses the relationship between geology and the unique landscape of the island, whilst the third section focuses on some localities that are of particular importance in terms of their geological interest. Possible interpretation opportunities and suggestions for geotourism facilities are given in the fourth section.

It is worth noting that, where possible, Gaelic spellings have been used for place names on the Isle of Harris (Hearadh). However, where anglicised spellings have previously been used in a geological name or in the name of a notified site, those spellings have been retained in this report. For clarity, the anglicised terms ‘South Harris’ and ‘North Harris’ have also been retained.

2 The Geological History of the Isle of Harris

The oldest rocks on the Isle of Harris were formed between about 3100 and 2800 million years ago. At that time, it is thought that the processes of plate tectonics had begun to operate, and so continents moved slowly across the globe, colliding with each other to throw up mountain ranges (as with the present-day Himalaya) or splitting apart to produce new oceans (as in the present-day Red Sea). The surface of the Earth would have looked very different to today; the only life-forms were simple clusters of cells floating in the oceans, and there was little or no oxygen in the atmosphere.

The oldest dated rocks on Harris are found close to Huisinis, opposite the island of Scarp, but slightly younger rocks of the same type underlie most of North Harris, as well as the parts of South Harris to the east of Loch Langabhat. They started out as igneous rocks – formed deep below the Earth's surface by the cooling and crystallisation of hot, molten magma. Similar rocks are formed at depth below the Andes today. Then, 100 million years or more after their formation, these igneous rocks were buried deep in the Earth's crust, probably as two continents collided. The rocks were buried so deeply that they were heated up significantly, and these higher temperatures led to the formation of new minerals in the rocks through the process of metamorphism. Growth of new minerals under pressure meant that the rocks developed a banded appearance – the characteristic feature of the metamorphic rocks known as gneisses. In some areas, the rocks were heated so much that they began to melt, producing small amounts of magma that then crystallised as veins of pegmatite, made up of very large crystals. Examples of these pegmatites can be seen in cuttings along the 'Golden Road' south of Drinisiadar.

Following that continental collision, the Western Isles remained a fairly stable area for hundreds of millions of years, and during that time the gneisses of North Harris and eastern South Harris lay buried within a large continental mass. Somewhat before 2000 million years ago, the continental crust began to stretch and rift apart, and magma from deep within the Earth was forced up cracks in the crust. This magma eventually cooled in those cracks, forming dykes – narrow, near vertical sheets of dark-coloured rock that cut across pre-existing structures in the rocks such as the gneissic banding (see Figure 1). One such dyke, which is about 100 m wide, cuts through the rocks close to Àird a' Mhulaidh. These dykes are known as the 'Younger Basic' dykes.

Figure 1: A dark-coloured Younger Basic dyke cutting across banded grey Lewisian gneisses, near Loch Leosaid, North Harris. BGS photo P008271 © NERC 1978

As the continental crust continued to stretch, eventually it split, and magma welled up to the surface to form the floor of a new ocean. However, by 1900 million years ago, the ocean had ceased to open and instead was closing, with ocean floor material sinking beneath the continent at a subduction zone. Material in the subduction zone melted to produce magma, and this magma rose to the surface to be erupted, forming chains of volcanic islands. Although these islands consisted largely of volcanic rocks, sedimentary rocks (including mudstones and limestones) were deposited around their fringes.

As the ocean continued to close, the volcanic islands collided with the continental margin. The rocks that had made up the islands, together with some of the continental rocks, were stacked up as thick slices against the edge of the continent. During this process, some of the rock slices were buried to depths of more than 20 km. At these depths, the buried volcanic and sedimentary rocks were intruded by bodies of molten magma, and thus were heated to temperatures over 900ºC. At such high temperatures and pressures, metamorphism of the buried rocks led to the growth of characteristic new minerals, such as garnet and kyanite.

These stacked-up rock slices can be seen today in the western part of South Harris, and are known as the South Harris Complex (see Figure 2). Sedimentary rocks that have been metamorphosed to high temperatures and pressures occur along the coast from Roghadal to Gob an Tobha, and are collectively known as the Leverburgh Belt. The mountain of Roineabhal is composed of an unusual type of igneous rock called anorthosite, which may have been part of the continental margin against which younger rocks were stacked up. The hills south of Scarasta are also made up of igneous rocks; these are diorites and tonalites, which formed from the magma that was intruded at depth, causing the metamorphism of the surrounding sedimentary and volcanic rocks. A second band of sedimentary and volcanic rocks, which were metamorphosed at slightly lower temperatures, stretches from Na Buirgh down to Fionnasabhagh; this band is known as the Langavat Belt.

The deposition of the sedimentary rocks, their burial and metamorphism, and intrusion of the magmas that form the South Harris Complex, all occurred between around 1900 and 1870 million years ago. The ocean continued to close, and some time later – probably around 1700 million years ago – two continents collided, leading to a mountain-building event known as the Laxfordian. It was probably at this time that the rocks of the South Harris Complex were moved into their current position adjacent to the older gneisses of eastern South Harris. This movement was accompanied by intense deformation of the rocks along a zone known as the Langavat Shear Zone, which stretches from Fionnsabhagh to Na Buirgh through the valley of Loch Langabhat.

Towards the end of the Laxfordian event, some of the gneisses of Harris were buried deeply enough that they began to partially melt. This melting produced small amounts of granitic magma that cooled again without moving very far and formed irregular veins within the gneisses, creating a type of characteristic texture known as migmatitic texture. Good examples of these migmatitic gneisses are seen in western Harris. At greater depths in the crust during the Laxfordian event, temperatures were higher and much more molten magma was produced. This magma moved upwards and was intruded into cracks, where it cooled to form abundant sheets of pink granite and pegmatite. These granites and pegmatites can be seen around Abhainn Suidhe and also on the islands of Scarp and Tarasaigh.

Intrusion of the granites, about 1675 million years ago, was the last part of the Laxfordian event that we see recorded in the rocks of Harris. Following this event, the gneisses of Harris gradually cooled and were brought closer to the surface as rocks above them were eroded away. For hundreds of millions of years, they lay in the interior of a major continental mass, and were unaffected by the processes going on at the continental margins. However, around 1100 million years ago, there was a major continental collision and mountain-building event known as the Grenvillian. The main effects of this event were felt in what is now North America and there is limited evidence for it in Scotland, but a major zone of deformed rocks that runs down the eastern side of the Western Isles, known as the Outer Hebrides Fault Zone, seems to have formed at that time. This fault zone largely lies off the eastern shore of Harris, but the deformed rocks can be studied in detail on the island of Scalpaigh (Figure 2).

The Outer Hebrides fault zone formed a distinct zone of weakness in the Earth's crust, and so when Scotland collided with England and Scandinavia around 430 million years ago, renewed movement occurred along the Outer Hebrides Fault Zone, deforming the rocks further. The gneisses of Harris were otherwise largely unaffected by this collisional event, which was known as the Caledonian Orogeny.

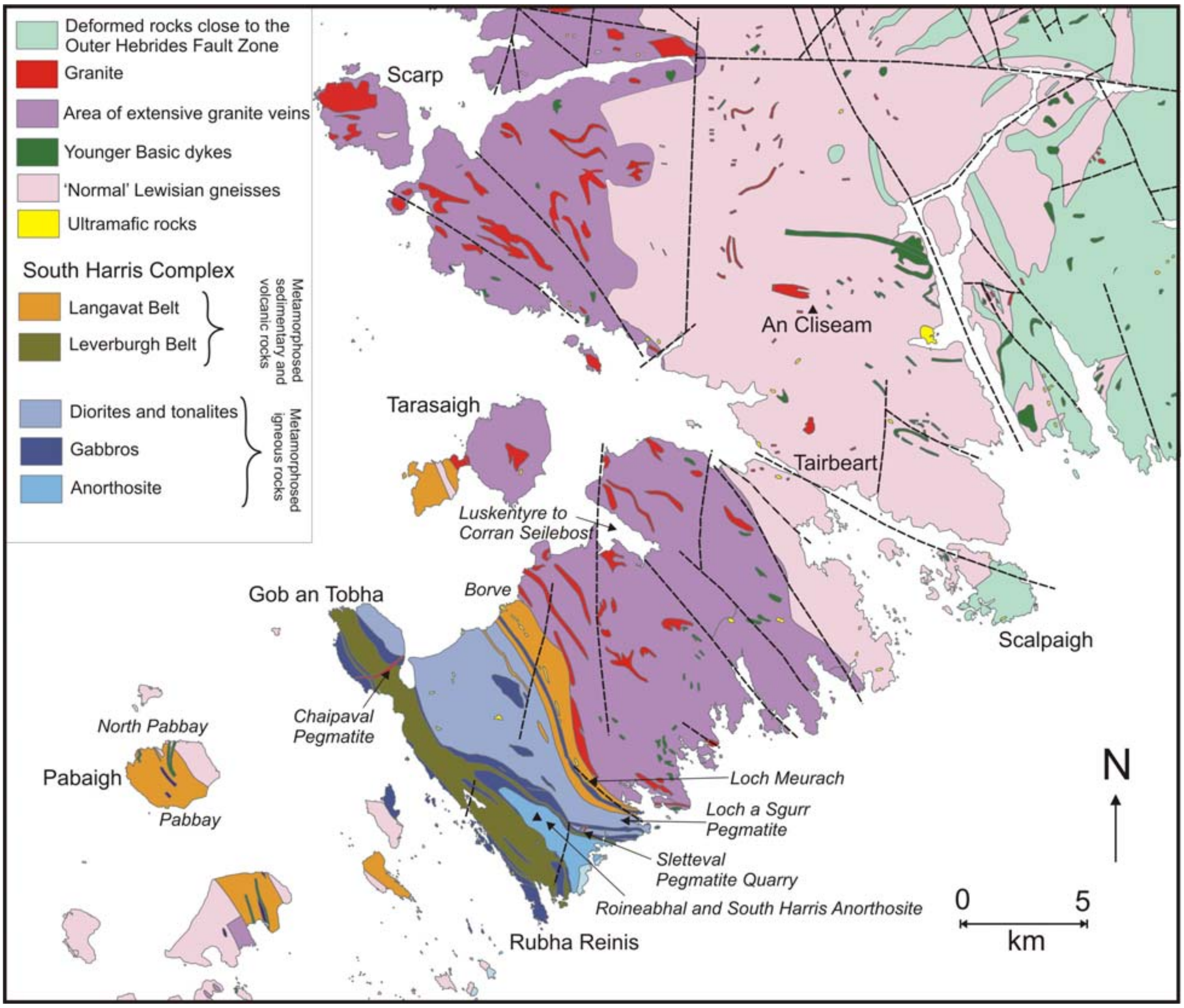

Figure 2: a simplified geological map showing the main elements of the Lewisian Gneiss Complex on the Isle of Harris. GCR sites (section 4.1) are shown in italics. Heavy dashed lines indicate faults.

Following the Caledonian Orogeny, the gneisses of Harris again lay within a stable continent for hundreds of millions of years. At various times the land surface of what is now the Isle of Harris was covered by desert, rivers, and even by the sea; but no rocks that were laid down at that time are preserved in Harris. However, at some point during this time, crustal movements led to the development of a series of faults across the island, many with a north-west – south-east trend.

Around 55 million years ago, the continental positions around the Western Isles began to change again with the opening of the North Atlantic. This was associated with the eruption of several volcanoes, the roots of which can now be seen on islands including Rum, Skye, Mull and St Kilda. Although there were no central volcanoes on the Western Isles, abundant dykes, a few metres thick and with a NNW-SSE trend, can be seen in South Harris. These were probably formed when magma from beneath the Skye central volcano was pushed outwards along cracks in the rock, and extended as far as Harris.

Although the rocks that form the Isle of Harris have not changed since 55 million years ago, the shape of the landscape has undergone considerable modification over the last 2.6 million years. During this time northern Europe has been subjected to a series of climatic cycles, represented by alternating glacial and interglacial conditions. The glacial episodes are characterised by cold, unstable climate, and growth of large ice-sheets in the high and mid latitudes. In contrast, interglacials (such as the current Holocene period which began approximately 11,500 years ago) experience a warmer, more stable climate, with more restricted ice cover.

The first evidence for Harris being ice-covered comes from glacial sediments offshore, demonstrating that an extensive ice sheet covered Scotland about 440,000 years ago, terminating at the margin of the continental shelf. At this time, it is likely that there was full ice cover over Harris and the rest of the Western Isles. It is not clear whether Harris was overwhelmed by ice flowing from the Scottish mainland or if it supported an independent ice cap during this early glaciation. It has been suggested that the numerous sea-filled channels of the Western Isles, such as the Sound of Harris, represent glacially carved through-valleys from a period of lower sea-level. Glacially transported rocks originating from the Scottish mainland have been found, as 'erratics', in the northern and southern extremities of the Western Isles, lending some support to this idea.

The most recent major glaciation in Scotland (known as the Main Late Devensian glaciation) reached its maximum extent about 22,000 years ago. At this time the Western Isles supported an independent ice cap with a central dome forming over the mountains of North Harris. Ice flowed outwards from the dome (which reached a maximum surface altitude of about 700 metres) down towards the coast moulding and smoothing the lower-lying rock. Ice flowing east from Harris combined with mainland glaciers to feed a large, fast-flowing ice-stream in the Minch (much like the ice-streams operating today in Antarctica).

A period of warming had melted much of the ice cover over Harris by about 14,000 years ago, but some glaciers may have persisted in favourable locations in North Harris. Smaller valley and corrie glaciers probably re-developed in the mountains of North Harris during a subsequent, short-lived cold spell 12,500 to 11,500 years ago, known as the Loch Lomond Stadial. During this period low temperatures would have promoted freeze-thaw activity on exposed ground, shattering rocks and giving rise to downslope creep of soil and scree.

At the end of the cold spell, as the final remnants of ice melted away, Harris would have supported open grassland vegetation, similar to some parts of northern Canada today. However, as temperatures warmed and soils matured, birch, hazel and oak migrated into the Western Isles, becoming established by about 8,000 years ago. Shortly afterwards, woodland began to decline and was replaced by acid grass and heathland communities. This decline may have been associated with the climate becoming slightly cooler and wetter some 6000 years ago. The occurrence of microscopic charcoal of the same age in peat bog records from South Uist, however, suggests that deforestation by Mesolithic Man may also have contributed.

3 Geology and Landscape of the Isle of Harris

Most descriptions of the Isle of Harris use the words ‘rugged’, ‘rocky’ and ‘mountainous’ to describe the east coast and the interior of the island, and contrast these with the machair and the miles of white sand beaches along the west coast. This landscape is truly a product of the underlying geology. The Lewisian gneisses are hard and unyielding rocks which are not easily eroded, and thus most of the island is very rugged, with abundant rock outcrops. Parts of the interior of Harris are characterised by ‘cnoc-and-lochan’ topography, with low rocky knolls separated by hollows, and this type of landscape is also typical of Lewisian gneiss terrain on the mainland.

Because most of North Harris is made up of similar gneisses, variation in the type of landscape across this part of the island is relatively limited. This contrasts with the clear landscape control exerted by the different rocks of South Harris Complex. The peak of Roineabhal is largely made up of anorthosite – a rock almost entirely composed of plagioclase feldspar - that weathers to a pale grey to white colour, and stands out when compared to the darker-coloured gneisses across the rest of the island. The diorites and tonalites form the more rounded hills around Bleabhal, whilst the metamorphosed sedimentary rocks generally underlie lower ground. The Langavat Belt in particular forms a clear zone of weakness, which has been eroded to create a valley that stretches across the island. The variation of the bedrock geology across the island also manifests itself in smaller-scale landscape features: well-known examples of this are the pegmatite sheet on Ceapabhal, which stands out as a distinct ridge of rock running across the slope above Tràigh an Taobh Tuath; or the metamorphosed limestones around St Clement’s Church at Roghadal.

The faults that developed prior to the opening of the North Atlantic form zones that can be easily eroded; the rocks are relatively soft after being ground down as they moved against each other along the fault. These faults underlie some of the most distinctive valleys of Harris, including Gleann Crabhadail and the glens leading into Loch Stocinis. These valleys probably began to form many millions of years ago, and have then been gouged out to their present depths by the movements of glaciers.

The mountainous terrain of north Harris was an ice cap accumulation centre during the last major glaciation. Higher summits such as An Cliseam, Uisgneabhal Mór and Oireabhal would have protruded above the ice surface, like nunataks do today in Greenland. These exposed peaks were subjected to severe frost-shattering, while terrain lying beneath the ice was smoothed and moulded. Examples of the boundaries between these two types of terrain, called 'trimlines', can be clearly seen on the northwest spur of Uisgneabhal Mór at about 580 metres and the southeast spur of Tiorga Mór at about 500 metres.

Vigorous glacial erosion affected the lower lying terrain in south Harris, creating the 'cnoc-and-lochan' landscape. Here, rock hillocks have been smoothed by ice, generating 'whaleback' landforms, with the intervening depressions becoming water-filled following ice retreat. The 'cnoc-and-lochan' topography is well developed on the south-east of the island and can be viewed from the coastal road between Aird Mhighe and Roghadal. In the mountainous areas of North Harris, glacial erosion was concentrated along existing valleys. Ridges at the margins of these valleys were eroded by the glaciers to form truncated spurs; the most well-known example is Sròn Uladal, reputed to have the highest overhanging cliff in Britain. Rockfalls, following the retreat of the ice, have steepened this cliff to its present shape.

Numerous boulder-strewn mounds and ridges can be seen in the corries and glaciated valleys of North Harris. These ridges formed when sediment was deposited at the margins of glaciers as moraines, probably during the short-lived Loch Lomond Stadial 12,500 to 11,500 years ago. The moraines are particularly well developed around the southern end of Loch Langabhat and around Loch Bhoisimid, and are comparable in shape and size to those forming at the margins of some Icelandic glaciers today. In Glen Skeaudale, some of these moraine ridges have streamlined features, known as flutes, superimposed on their up-valley side. As flutes form underneath glaciers, their presence suggests that the moraines were partly overridden by small glacier re-advances.

One of the key elements of the Harris landscape is the machair of the west coast. The geology of the island has played its part in the formation of the machair, because the lack of easily eroded rock means that only small amounts of sediment are carried by rivers flowing to the coast, and thus the sands of the west coast have a high percentage of offshore-derived shelly material. This sand composition is an integral part of the machair system. Machair systems form a gently sloping coastal plain, with coastal sand dunes backed by grassy plains that support a wide variety of wild flowers. Bogs and lochans, which are typically associated with these machair areas, provide habitats for a wide range of birds and other animals.

In many areas, the machair is slowly being eroded, due to a combination of factors that include less sediment supply from offshore, increased storminess leading to more wave erosion, and, in some places, sand removal by humans. However, the machair can still be enjoyed at many places on Harris, including Taobh Tuath, Horgabost and Seilebost.

4 Sites of geological interest on the Isle of Harris

4.1 Geological Conservation Review sites

Key geological sites throughout Scotland were recognised by the Geological Conservation Review (GCR), undertaken between 1977 and 1990. This review identified a total of 834 GCR sites across Scotland, many of which have since been notified as Sites of Special Scientific Interest (SSSIs). Nine of these GCR sites occur on the Isle of Harris and its subsidiary islands, and are listed in the table below.

GCR Site Name	Geological Interest	SSSI name
Luskentyre to Corran Seilebost	Coastal Geomorphology	Luskentyre Banks and Saltings
Pabbay	Coastal Geomorphology	Pabbay
Borve	Lewisian	Not notified
North Pabbay	Lewisian	Pabbay
Roineabhal	Lewisian	Not notified
Chaipaval Pegmatite	Mineralogy	Northton Bay
Loch a Sgurr Pegmatite	Mineralogy	Loch a Sgurr Pegmatite
Sletteval Pegmatite Quarry	Mineralogy	Not notified
Loch Meurach	Mineralogy	Loch Meurach
South Harris Anorthosite	Mineralogy	Not notified

The GCR site of **Borve [NG 009 937 to NG 038 964]**, which is not notified as an SSSI, takes in the coastal section from Sgeir Liath to Rubha Romaigidh, centred on the village of Na Buirgh. This is an excellent area in which to study many of the different types of Lewisian gneiss that occur in South Harris, as well as being a beautiful stretch of coastline. At the western end of the section, around Bàgh Steinigidh, are the diorites and tonalites of the South Harris Complex (Figure 3). Along the coast around Na Buirgh, pale grey gneisses are interlayered with the darker coloured metamorphosed volcanic rocks of the Langavat Belt. Some metamorphosed limestone bands are also seen here; these were formed on the fringes of volcanic islands around 1900 million years ago. Between the Allt Borgh Bheag and Rubha Romaigidh are exposures of the typical gneisses of eastern South Harris, with abundant pink granite sheets cutting the gneisses. Along this coastal section it is also possible to see examples of the much younger dykes, which are related to the opening of the North Atlantic, and which cut straight through the older gneisses. Sta Bay has been formed by the erosion of one such dyke.

Figure 3: Banded tonalites on the shore at Bàgh Steinigidh. BGS photo P008366. © NERC 1980.

The **Roineabhal** GCR site **[NG 045 865 to NG 055 845]**, which again is not notified, essentially comprises the upper parts and eastern slopes of the peak of Roineabhal, and extends down to the road at Lingreabhagh, where there are some relatively small quarry workings. The **South Harris Anorthosite** GCR site lies in the same area. The peak of Roineabhal is made up of pale grey anorthosite – a relatively rare rock-type – interbanded with darker coloured gabbro, which is a related and more common type of igneous rock. The rocks of Roineabhal form the largest gabbro-anorthosite body in the British Isles. Various characteristic minerals in the gabbros and anorthosites indicate that they have been metamorphosed – the most striking of these minerals are deep red crystals of garnet. Close to the road at Lingreabhagh, the rocks become more deformed as the Outer Hebrides Fault Zone is approached. The age of the Roineabhal gabbro-anorthosite body, and its relationship to the surrounding rocks, are a matter of continuing scientific debate, making this area popular with many geological researchers. This site has, of course, been the subject of a recent major planning inquiry over plans to develop a superquarry – these plans have now been abandoned, and the threat to the anorthosite body removed.

The **North Pabbay** GCR site **[NF 873 885 - NF 904 885]** includes the rock outcrops along the northern coast of the island of Pabaigh, west of An t-Ob, whilst the whole island is included in the **Pabbay [around NF 890 879]** GCR site for coastal geomorphology. The entire island is notified as an SSSI, although the bedrock geology is not actually mentioned in the SSSI citation. The outcrops along the north coast are of particular interest to geologists because they illustrate evidence for varying degrees of deformation and metamorphism during the Laxfordian event. In contrast, the southern part of the island has the largest expanse of hill machair vegetation in the Western Isles. Hill machair is created when shell sand is blown up a hill, and the machair vegetation in Pabaigh extends to a height of almost 200 m. The island also contains many of the characteristic landforms found in beach and machair systems across the Western Isles. Buried intertidal deposits indicate that the coastline has been progressively submerged by rising sea level, in contrast to many other parts of Scotland’s west coast that are characterised by raised beaches.

The **Chaipaval Pegmatite** GCR site **[NF 983 924]** is notified as part of the Northton Bay SSSI. A very coarse-grained sheet of granitic pegmatite, up to 25 m wide, forms a distinctive landscape feature cutting across the slopes of Ceapabhal. It was quarried during the 1939-45 war to obtain potassium feldspar for use in the ceramics industry. Although the main minerals are fairly common - quartz, feldspar, and muscovite mica – they occur in unusually large crystals (up to 45 cm long). A number of rather more rare minerals are also present, including topaz, tourmaline and beryl, as well as a number of uranium-rich minerals. This is the only locality in the UK at which a mineral called betafite (after its type locality in Betafo, Madagascar) has been found.

The hill of Ceapabhal itself is composed of metamorphosed sedimentary and volcanic rocks, some of which are contain crystals of blue kyanite.

The **Loch a Sgurr Pegmatite** GCR site **[NG 070 865]**, which is a notified SSSI, is about half a kilometre along the road south of Fionnsabhagh. The road cuttings here provide exposures of a body of pegmatite which is similar to that at Ceapabhal, but contains plagioclase feldspar rather than potassium feldspar. Crystals of magnetite (iron oxide) in this pegmatite are up to 15 cm long.

The **Sletteval Pegmatite Quarry** GCR site **[NG 059 855]**, which is not notified, lies just to the north of Lingreabhagh. Like Ceapabhal, this pegmatite was worked for potassium feldspar in the 1939-45 war. The pegmatite body here consists of two sheets, one up to 20 m wide, and with similar minerals to the Ceapabhal body.

The **Loch Meurach** GCR site **[NG 061 877]**, which is notified as a SSSI, lies adjacent to the loch of the same name north-west of Fionnsabhagh. Rock outcrops here contain small pods of ultramafic rock, which are almost entirely composed of very iron- and magnesium-rich, dark-coloured minerals. In particular, there are spectacular dark green to black crystals of a mineral called actinolite.

Luskentyre to Corran Seilebost GCR site **[around NG 080 973]** is notified as part of Luskentyre Banks and Saltings SSSI. It is considered one of the finest examples anywhere of a geomorphological system that incorporates beach, sand dunes, machair and salt marsh, and is an important location for the study of coastal evolution. The area around Losgaintir has some of the highest sand hills in the Western Isles.

4.2 Other sites of geological interest

Although the GCR sites represent the key localities of scientific interest in an area, they may not always include the localities at which the geology and geomorphology are most easily demonstrated. This section discusses the geological interest of other important sites in the Isle of Harris.

St Clement's Church at Roghadal [NG 047 832] is one of the main localities of tourist interest in South Harris. The tower of this 15^{th} century church was built directly onto a rock outcrop. The rocks around Roghadal are mostly sedimentary rocks that have been metamorphosed at very high temperatures. They include marble (metamorphosed limestone) and metamorphosed mudstones that are rich in graphite – these can be seen in a small quarry just east of the church. Some of the metasedimentary rocks in this area contain distinctive crystals of metamorphic minerals such as red garnet and blue kyanite. A variety of metamorphosed igneous rocks belonging to the South Harris Igneous Complex can also be seen in the area around Roghadal.

The island of **Tarasaigh [NF 990 986 to NB 044 034]** is one of the best places to see Laxfordian granites and pegmatites cutting through the gneisses. In some parts of the island, the pegmatites make up nearly 75 percent of the exposed rock.

An Cliseam [NB 155 074] is the highest mountain in the Western Isles, and as such attracts a number of hillwalkers. It is also a good place to see the typical gneisses and glaciated scenery of North Harris.

On the north side of **Loch Màraig [NB 202 062]** there is a good example of a layered intrusion – a large body of layered igneous rock. The rocks here are ultramafic – that is, they formed from magmas that were very rich in iron and pyroxene. The age of this rock unit is uncertain, but it is estimated at about 2000 million years old. In Scotland, igneous layering has been heavily studied in much younger rocks, such as the Cuillin of Skye and Rum; Màraig is a good place to study a much older layered intrusion.

The area around the southern end of **Loch Langabhat [NB 150 130 to NB 169 159]** contains good examples of small, arcuate moraine ridges. Some of the moraines **[NB 162 138]** display traces of superimposed flutes on their up-ice sides.

Uisgneabhal Mór [NB 121 086] can be ascended from the B887 road near Loch Mhiabhaig. A good example of a glacial trimline can be seen on the northwest spur of this mountain, while impressive views of the local glaciated scenery are available from the summit.

5 Opportunities for geological interpretation

Visitors to the Isle of Harris are attracted by the rich and diverse landscapes, including the rugged mountains, the white sandy beaches, and the colours of the machair in summer. This landscape variation is rooted in the island's geodiversity. The themes of geological history, landscape evolution, and cultural history can be linked together in interpretation for visitors and locals alike, so that they can fully appreciate the unique features of this beautiful island.

Suggestions for interpretation can essentially be divided into two groups. The first group includes localities that are suitable for 'static' interpretation – these would be specific places, normally accessible by road, at which interpretive boards or leaflets might be used. These localities would also be suitable for 'virtual' interpretation of the type seen on tourist websites like http://www.undiscoveredscotland.co.uk/areawestnorth/index.html.

The second group incorporates walking routes, which can focus on the general features seen along the walk rather than on specific localities. This interpretation could be delivered by means of leaflets or more substantial booklets, or electronically via the internet. Information could also be provided for driving/cycling routes, but these are more likely to link a series of static interpretation localities.

5.1 Localities suitable for static interpretation

1) **Taobh Tuath**. The Seallam Visitor Centre at Taobh Tuath could provide an ideal 'hub' for geological interpretation in South Harris. The end of the road through the village would also be a good location for interpretation, with views of the beach and machair system and of the pegmatite on Ceapabhal.

2) **Roghadal**. As discussed above, there are a number of interesting outcrops of metamorphosed sedimentary rock around Roghadal and this would be an excellent focus for geological interpretation, which could be linked to the historical and cultural importance of Roghadal.

3) **Lingreabhagh**. The Lingreabhagh area includes outcrops of anorthosite and also of pegmatites, both of which have been quarried in the past. This would be the ideal place for interpretive material highlighting the balance between the need for geological resources and the importance of preserving wild landscapes. This area also provides good views of the classic cnoc-and-lochan topography.

4) **Scarasta to Horgabost**. The Scarasta to Horgabost coastline includes a variety of rock outcrops, beaches and machair, standing stones and views of Tarasaigh, and could be a focus for different types of interpretation. The bedrock outcrops here are perhaps rather esoteric, lacking the immediate presence of the Roineabhal anorthosite or the Ceapabhal pegmatite, but this could be an ideal locality for other types of interpretation such as sculpture.

5) **Losgaintir**. The most famous beach on the islands and certainly an ideal location for interpretive material about machair and coastal evolution.

6) **Huisinis**. The oldest gneisses so far recognised in Harris came from Hushinish. Although interpretation here is likely to focus on historical events, the geology could also be linked in.

5.2 Walking routes that would benefit from interpretation of the geology

1) **The Harris Walkway.** This Walkway crosses the gneisses of North Harris and runs through some of the most mountainous parts of the island, passing features formed when the island was glaciated. The walkway would certainly benefit from interpretive information about the geology and geomorphology.

2) **Gob an Tobha.** A walk from Taobh Tuath onto Ceapabhal, via the old quarry in the pegmatite, allows visitors to see both the machair and some obvious geological features.

3) **Roineabhal.** The ascent of Roineabhal, with its almost 'moon-like' landscape, offers an excellent opportunity to see some really unusual geology.

4) **Clisham.** Clisham, the highest mountain in the Western Isles and a popular walk, is a good place to see the typical Lewisian gneisses of North Harris, as well as to look at glaciated scenery.

5) **Uisgneabhal Mòr.** This summit can be ascended from the nearby B887 road and offers opportunities to see glacial trimlines and views of glaciated terrain.

6) **Bàgh Bhìoghadail to Loch Langabhat**. This walk follows an existing track and offers the opportunity to view morainic terrain left by the most recent glacial episode.

7) **Gleann Chliostair to Gleann Uladal**. A spectacular walk through glacial valleys to the truncated spur of Sròn Uladal.

8) **Huisinis and Gleann Crabhadail**. U-shaped glacial valley and gneisses.

9) **Scalpaigh**. The circular walk around Scalpaigh affords opportunities to see the deformed gneisses of the Outer Hebrides Fault Zone, and dykes formed when the North Atlantic opened.

6 Further Reading

FETTES, D J., MENDUM, J R., SMITH, D I., AND WATSON, J V. 1992. Geology of the Outer Hebrides. *Memoir of the British Geological Survey.*

GILBERTSON, D., KENT, M. AND GRATTAN, J. (eds.) 1996. *The Outer Hebrides: The last 14,000 years*. (Sheffield Academic Press, Sheffield).

GOODENOUGH, K M AND MERRITT, J W (in press). *The Western Isles: a Landscape Fashioned by Geology*. (Scottish Natural Heritage, Perth).

TREWIN, N H. 2002. *The Geology of Scotland (*4th edition). (The Geological Society, London.)