Introduction

Welcome to Assynt and Inverpolly

The Northwest Highlands are among the most spectacular areas of Scotland, with dramatic mountains rising above deep lochs, and a wild and beautiful coastline. The varied scenery of this area is largely the product of a fascinating geological history that stretches back many millions of years and encompasses a wide variety of different environments. This book and map will introduce you to the rocks and landscape of Assynt through a set of walks that help you to explore the area. The walks vary from easy coastal and valley walks to harder days out on the mountains — there should be something here to suit everyone!

Numbered locations in the text [0] are shown on the accompanying map and where possible on the illustrations in this book. [0] indicates the start of a walk.

Walking in Assynt and Inverpolly

Much of this area is extremely wild, remote country. When you head for the Assynt and Inverpolly hills always take a map (Ordnance Survey Landranger Sheet 15 is ideal) and a whistle, a compass, warm and waterproof clothing, sturdy boots and some food and water. Make sure that you have plenty of time to complete the walk in daylight. Weather conditions on these hills can change very rapidly, and it is best to be prepared. Always remember to let someone know where you are going, and when you will be back. Some of the walks cross crofted land, so please remember to show respect for the people who work on the land and, if you have a dog, make sure it is under control. Finally, always remember:

'**leave only footprints; take only photographs**'

Plate tectonics

The rocks of Assynt have formed over millions of years, in a variety of different environments — because Scotland has not always been in its present position on the Earth's surface. During this time, Scotland has journeyed across the globe! How has this happened? The answer lies with the theory of plate tectonics.

Although we can't feel it, the surface of the planet is continually moving. The upper part of the Earth is a solid skin about 100 kilometres thick. This is broken up into separate pieces, or plates, which fit together like a jigsaw. The rock below these plates is so hot that it is partially molten, and circulates slowly, causing the plates above to move at a rate of a few millimetres a year — about as fast as our fingernails grow. This process is called plate tectonics.

To maintain the 'fit' of this continually moving jigsaw, the shape of the plates must change. Where two plates move apart, such as in the middle of the Atlantic, molten rock rises up and solidifies at mid-ocean ridges. Where two plates grind past each other, for example on the west coast of the USA, the movement causes earthquakes along the boundary between the plates.

Where two plates move towards each other, continents collide and the rocks at the edges of the continents are squeezed up to form mountain ranges. The Himalaya are being formed by this process, as India moves northwards into Asia. Rocks within mountain ranges are folded and pushed over each other along fractures known as thrusts (see page 11). The Assynt area is famous for examples of thrusts, including the spectacular Moine Thrust, which formed during an ancient period of continental collision that produced a mountain chain known as the Caledonian Mountains.

How rocks form

From the modern-day lavas of Hawaii to the ancient rocks of parts of Greenland, our world contains a huge variety of different rocks. However, all rocks belong to one of three distinct groups, and each of these groups is formed through a different set of processes.

Sedimentary rocks

These are rocks formed through the accumulation of sediments, such as sand and mud, or the remains of organisms, such as shells. This process of accumulation, which occurs in rivers, deltas, beaches and on the sea floor, is called sedimentation. Over time, the sediments compact and harden, changing sand into sandstone, mud into mudstone, and calcareous shells into limestone. Sediments are usually deposited as a series of layers, and these layers are known as 'beds'. When the sediments are deposited in flowing water, a feature known as cross-bedding may form.

Formation of cross-bedding

1 Water flowing over a sandy bed moulds the sand into ripples and dunes.

2 Sand grains move over the ripple crests and are deposited on the downstream slopes.

3 Each ripple gradually builds out downstream, forming a set of sloping layers.

4 Another ripple begins to build on top of the first, forming another set of sloping layers.

5 Over time many sets of sloping layers are built up. This is called cross-bedding.

In a river deposit, all the cross-beds slope the same way, because a river flows in one direction. In a tidal channel, cross-beds slope both ways, as sand is deposited by incoming and outgoing tides.

Igneous rocks

These rocks are formed when magma (molten rock from deep within the Earth) cools and solidifies. If magma rises to the surface and erupts as lava from a volcano, it cools very rapidly, and forms fine-grained extrusive rock such as basalt. If magma is trapped beneath the Earth's surface, it cools more slowly, and forms coarse- grained intrusive rocks such as dolerite, granite or syenite. Intrusive rocks occur in a variety of forms, including dykes (near-vertical sheets), sills (horizontal or gently inclined sheets) or plutons (large irregular masses).

Metamorphic rocks

Under conditions of high temperature and pressure, rocks can be changed, or metamorphosed, to form metamorphic rocks. This can happen when the rocks are deeply buried during continental collision. The process of metamorphism typically involves chemical reactions and the formation of new minerals. Sandstone can be changed into psammite, mudstone into schist, and limestone into marble. Another example of a metamorphic rock is gneiss, which has a distinctive stripy appearance, and can form from a variety of rocks under very high temperatures. If the rocks are squeezed and moved against each other, a finely layered rock called mylonite may be formed.

The rocks of Assynt

The Northwest Highlands are characterised by a wide variety of rock types that formed in many different environments, from the depths of the Earth to fast flowing rivers and shallow seas. This section describes the rocks that you will see as you explore.

Igneous rocks

Several different types of igneous rocks occur in Assynt. The most common is syenite; this is a coarse-grained rock, similar to granite but containing more feldspar and less quartz. Two large plutons of syenite occur around Loch Ailsh and Loch Borralan. Dykes and sills of various types of igneous rock are also common throughout Assynt.

Durness Limestone

The Durness Limestone is the youngest of the sedimentary rocks in Assynt, and formed in a shallow sea between 520 and 500 million years ago. The limestone is generally light or dark grey, although in places it weathers to a creamy yellow colour, and shows typical features of 'karst' weathering such as caves (see box on page 20). The limestone is typically well drained and covered in a rich flora; the verdant green fields of Elphin and Inchnadamph are underlain by limestone.

Fucoid Beds and Salterella Grit

Below the Durness Limestone is a thin layer of rock that looks like a dirty version of the Cambrian Quartzite (see below) — this is known as the Salterella Grit, because it contains abundant tiny cone-shaped fossils of a snail called Salterella. Beneath the Salterella Grit lies the orange-brown Fucoid Beds. They are marked with wavy lines that early geologists thought were the traces of seaweed (fucoids), but which are actually the feeding traces of worms. The Fucoid Beds were laid down in a shallow lagoon some 520 million years ago. They are soft potassium-rich mudstones that form a layer only a few metres thick, and weather to a fertile soil that can be traced through the landscape by lines of vegetation.

Cambrian Quartzite

The Cambrian Quartzite is a hard, blocky rock, white or pink in colour, with a sugary appearance. It formed from the white sand of a beach that existed about 530 million years ago. There are two types of quartzite: the upper Pipe Rock and the lower Basal Quartzite. From a distance they are hard to tell apart, but close up they are quite distinctive. The Pipe Rock is white or pink, and characterised by 'pipes'. These pipes appear as rounded bumps a few millimetres across on flat surfaces, and as vertical stripes on steep faces. The pipes are fossil worm burrows, formed by worms sifting through the sand. The Basal Quartzite is usually white and shows cross-bedding.

Torridonian Sandstone

The Torridonian Sandstone consists largely of thick layers of coarse-grained red sandstone. In places, bands of pebbles or thin layers of purple mudstone also occur. The sandstone typically shows clear cross-bedding. It was laid down around 1000 million years ago, when the land was totally devoid of vegetation. Torrential rivers spread out across a wide area, carrying sand and pebbles that were dumped on floodplains. Over millions of years, these deposits accumulated to form a pile of Torridonian Sandstone several kilometres thick.

Moine Rocks

The Moine Rocks include psammite (metamorphosed sandstone) and schist (metamorphosed mudstone). The sandstone and mudstone were deposited in a shallow sea at roughly the same time as the Torridonian Sandstone was laid down on land. During subsequent mountain building events, the sandstone and mudstone were squeezed and metamorphosed, then forced tens of kilometres westwards along the Moine Thrust. As the rocks moved, the layers of psammite just above the thrust were intensely squeezed and flattened, forming a thinly banded rock called mylonite, which can be seen at Knockan Crag.

Lewisian Gneiss

The Lewisian Gneiss is about 3000 million years old, and among the oldest rocks in Europe. Usually it has a stripy appearance; the darker stripes are largely made of minerals such as amphibole and biotite, and the paler stripes are composed of quartz and feldspar. In places you can see these different minerals with the naked eye. The Lewisian Gneiss has had a turbulent history; originally it was formed as igneous rocks, which were squeezed, metamorphosed, and turned into gneiss by at least two mountain building events. These processes led to the formation of fantastically contorted banding within the gneiss. Sheets of dark-coloured dolerite, known as the Scourie Dykes, occur within the gneiss.

The Ice Age

The ‘Ice Age’, which began about 2.4 million years ago, actually comprises a series of very cold ice ages alternating with warmer periods. When the last major ice age was at its peak, about 20 000 years ago, the Northwest Highlands were almost entirely ice covered. At this time, the ice was about 800 metres thick in the valleys, so that only some of the higher peaks such as Ben More Assynt and Quinag protruded above the ice as ‘nunataks’. During the most recent cold phase, about 12 000 years ago, only small corrie glaciers occurred in Assynt.

The landscape that we see today has been shaped by the action of glaciers. They have scoured the bedrock, leaving tell-tale signs of erosion, and they have also deposited loose sediment on valley sides and as moraine ridges. The fjords of Loch Glencoul and Loch Glendhu were formed by glacial erosion on a large scale, whereas the ice-scoured Lewisian Gneiss terrain west of Inchnadamph has a cnoc-and-lochan landscape, with characteristic low rocky hills and water-filled hollows. On a smaller scale, glacial striae were formed when rock fragments, frozen into the ice, scratched the bedrock as a glacier moved over it. In Assynt, glacial striae are especially well developed on the Cambrian Quartzite.

Loose, eroded material was picked up and transported some distance by the glaciers before being deposited. Moraines are mounds and ridges on valley floors that developed as the loose sediment was deposited at the margins of the glaciers. Erratics are large boulders that were transported by glaciers; they are common in Assynt, and are usually recognisable because they are composed of a different rock type from the bedrock on which they lie.

Rocks that were not covered by ice still felt the cold of the Ice Age. For instance, the extensive blockfields on the summits of Conival, Ben More Assynt and Quinag are the result of thousands of years of repeated frost shattering, splintering the bedrock into fragments. These blocks have not been carried away by ice, and this is how we know that these mountains formed nunataks during the last ice age.

Assynt through time

3000 – 2700 million years ago — Formation of Lewisian Gneiss: granites are deformed and metamorphosed into gneiss in a period of mountain building

2400 million years ago — Scourie Dykes intrude the Lewisian Gneiss

1700 million years ago — Final mountain-building event to affect the Lewisian Gneiss

1100 – 900 million years ago — Lewisian Gneiss eroded to form a hilly, barren landscape upon which Torridonian Sandstone is deposited in large river systems. Sand and mud that will eventually become the Moine Rocks are deposited in the sea farther east

540 – 480 million years ago — Scotland, Greenland and North America form a single continent, known as Laurentia. The Cambrian Quartzite and Durness Limestone are deposited in a shallow sea at the edge of this continent

440 – 410 million years ago — The continent of Laurentia collides with continents containing England and Scandinavia, and the great Caledonian Mountain Range is born. The Moine Rocks are forced westwards over the top of the sedimentary rocks in Assynt, along the Moine Thrust. The syenites of Loch Ailsh and Loch Borralan are formed as magma rises up from the mantle and solidifies

400 – 60 million years ago — Scotland is part of the supercontinent of Pangaea, but no rocks of this period are preserved in Assynt

55 million years ago — The supercontinent of Pangaea breaks in two. The rift develops into the North Atlantic Ocean, separating North America from Europe, and Scotland is stranded on the European side of the Atlantic

2.4 million years ago — World climate cools and the Ice Age begins; Scotland will periodically be covered by ice until the present day

480 000 – 420 000 years ago — Furthest advance of ice; Britain is covered by an ice sheet that reaches as far south as the River Thames

44 000 – 26 000 years ago — Reindeer and other arctic animals live in Assynt during a warmer period and some of their remains end up in the Bone Caves at Inchnadamph

26 000 – 15 000 years ago — Last major ice sheet covers Scotland. In the north-west only the highest peaks remain ice free

12 000 – 11 000 years ago — The last glaciers in Scotland; in Assynt there are only small corrie glaciers on the higher mountains

9000 – 4000 years ago — Ice has melted and vegetation returns; first low shrubs, then birch woodland, and then pine forest

~ 2500 years ago — Clachtoll Broch built by Iron Age people. By this time, people had probably been living in Assynt for thousands of years

Figures

(Figure 3) Plate tectonics painting.

(Figure 4) Formation of cross bedding.

(Figure 5) Coarse-grained syenite.

(Figure 6) Light and dark grey Durness Limestone.

(Figure 7) Orange-brown Fucoid Beds.

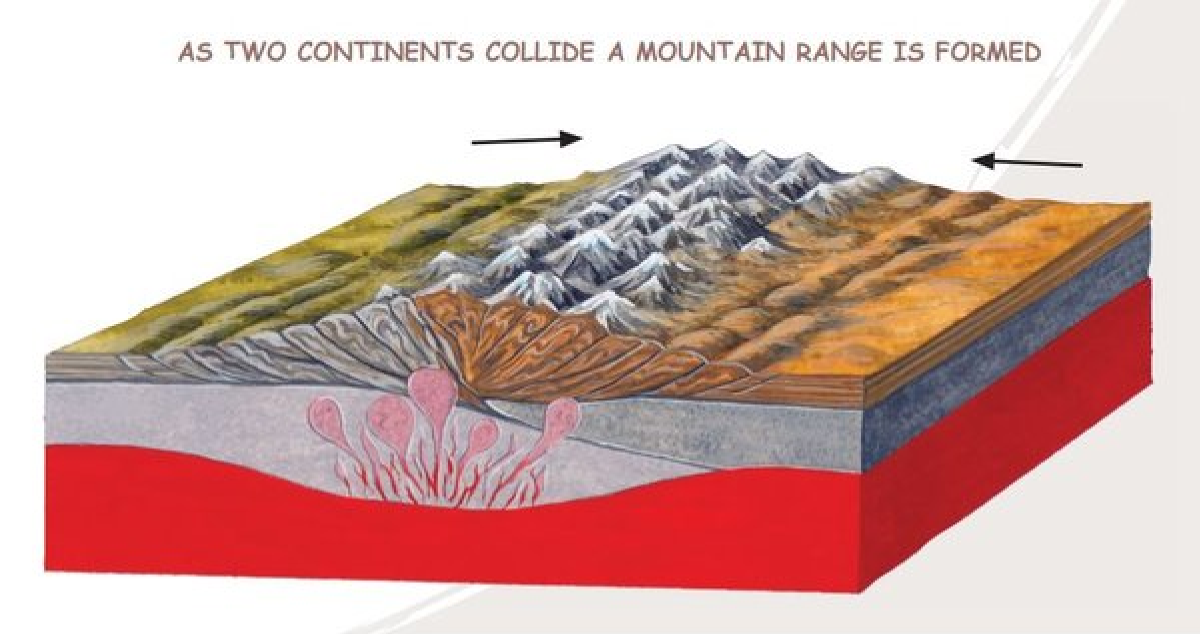
(Figure 8) Cross-bedded Basal Quartzite.

(Figure 9) Coarse-grained cross-bedded Torridonian Sandstone.

(Figure 10) Folded Moine psammite.

(Figure 11) Stripy Lewisian Gneiss.

(Figure 12) Glacial features. Painting by Elizabeth Pickett.



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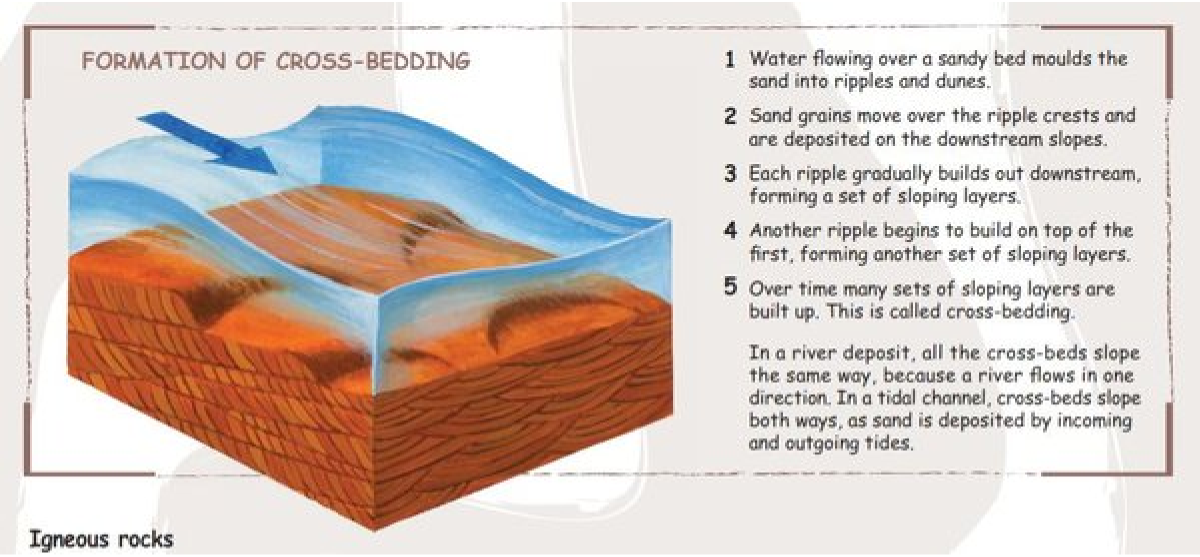

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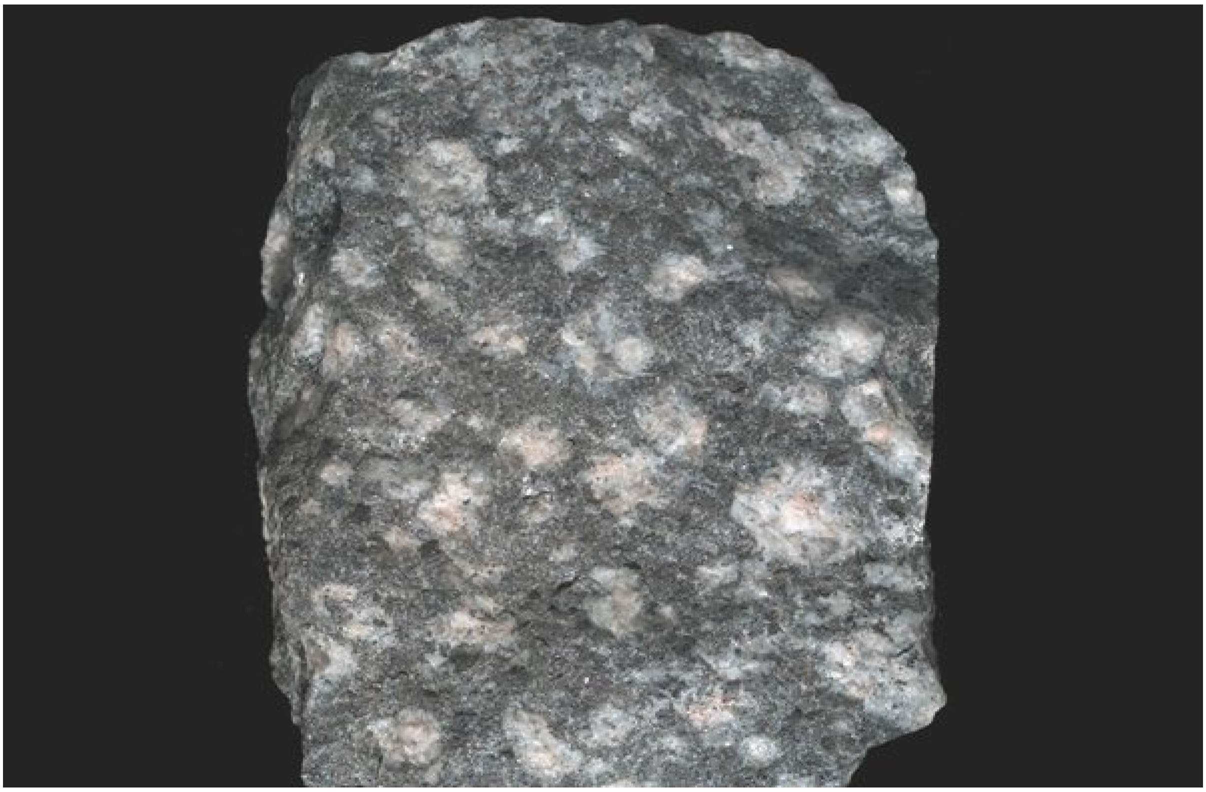

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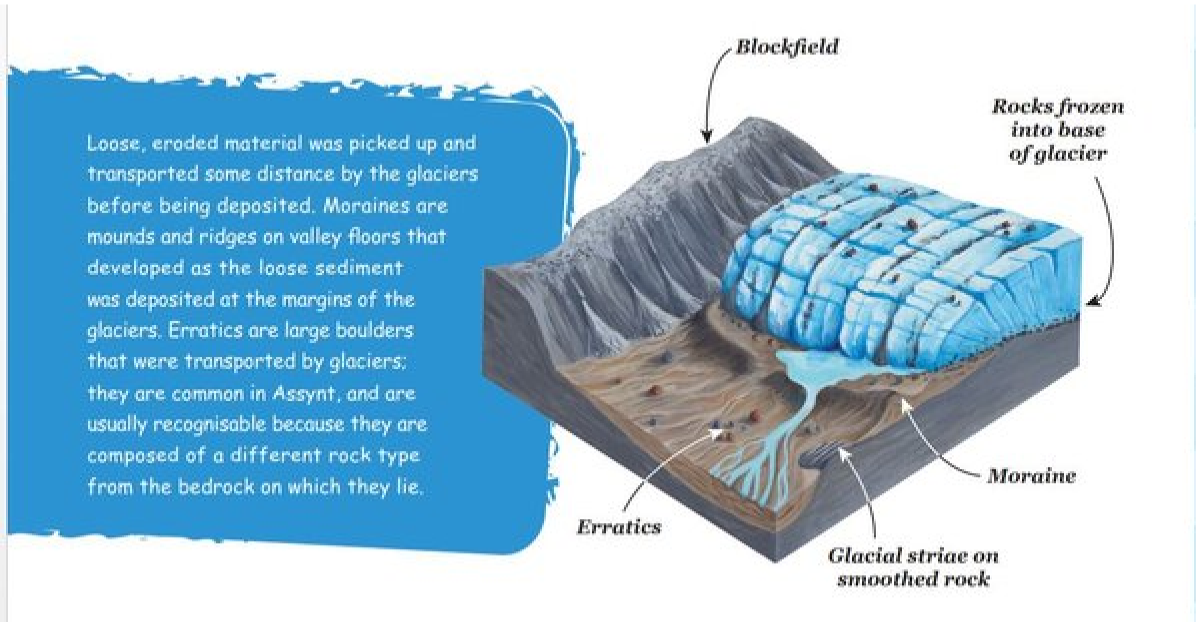

(Figure 12) Diagram of glacial landforms. Painting of walk by Elizabeth Pickett.