# The Esk Valley — geology and scenery

Lothian and Borders GeoConservation

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## Exploring the Esk Valley

The Esk Valley is easily accessible from Edinburgh, with paths running along the banks of the rivers for most of the route from source to sea.

## Acknowledgements:

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Photographs: Nicola Coffin. Auchendinny photograph from Robert Gooday, University of Edinburgh.

River map: Esk Valley Trust (www.eskvalleytrust.org)

Geological map: Lothian and Borders GeoConservation

Diagram: www.scottishgeology.com

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## Introduction

The River Esk has two main tributaries; the North Esk and South Esk. The North Esk rises near East Cairn Hill [NT 12776 59395], in the Pentlands, and passes through the North Esk Reservoir [NT 15498 58127] and the village of Carlops [NT 16086 55753].

The South Esk has its source in the Moorfoot Hills near Bowbeat Wind Farm [NT 28909 47119] and passes through the Gladhouse [NT 29685 53555] and Rosebery Reservoirs [NT 30699 56698] as it travels out towards the sea. The rivers converge 2 km northeast of Dalkeith and travel a further 7.8 km to the sea at Musselburgh [NT 34581 73404].

The river has a catchment area of 330 km covering predominantly farmland and semi-natural woodland. All the underlying rock is more than 300 million years old. Younger sediments, such as boulder clay, sand and gravel, all less than 100,000 years old, cover about 85% of this bedrock.

Over the last 600 million years, Scotland has progressively moved northwards from south of the equator to its present position in the northern hemisphere today. Along the way, the rocks of Scotland and England, originally on different continents, joined together. The rocks reveal this history.

Geological Timescale The geological timescale is measured in millions of years, and is shown below. It is a chronological measurement stretching back to the time when the Earth was formed. The ages are defined by dating rocks and fossils, because certain fossils are only found in particular time periods. The timescale is used to describe the timing and relationships of events in the geological past. Earth formed 4.6 billion years ago, but only rocks younger than 480 million years are seen in the Esk Valley. In this leaflet, the story of Scotland will be told from the Cambrian right up to today by focusing on the rocks seen in the Esk Valley. It includes the recent history of the glaciations and industry within the area.

## Recent history

### Glaciations

In the Quaternary, ice sheets at least 1km thick covered the area on several occasions, and the last ice sheet began melting around 19,000 years ago. The ice was concentrated between the Pentland and Moorfoot Hills, where the River Esk is situated, and left evidence such as boulder clay, meltwater channels and striations. As the climate warmed, the ice melted. Initially most of the water flowed within the ice, but eventually found its way to the valley floor and vigorously eroded it. The water finally emerged from the ice as a raging torrent, which continued to cut channels. The picture shows the channel southwest of Carlops [NT 151 549], now floored with debris dumped as the meltwaters subsided. The small hill is Peaked Craig [NT 153 551], a volcanic remnant which resisted erosion. The North Esk flows in a southerly direction from its source, but then turns east as it enters this meltwater channel over the waterfall at Carlops. Northeast of Carlops the North Esk occupies a river valley present before the ice age. The meltwaters further excavated this to create the present day deep trench.

The meltwaters deposited sand and gravel in many places along the valley. One of these, the Hewan Bank [NT 285 647] near Polton, is designated as a Site of Special Scientific Interest (SSSI). The river continues to undercut these deposits, resulting in many landslips.

Raised beaches along the coastline of the Firth of Forth resulted from the land rising due to the removal of the mass of the ice, so that the land is now about 10 metres higher than it was around 6,500 years ago. This process, known as isostatic rebound, rejuvenated the rivers, giving them greater erosive power because they were higher above sea level.

The many mills along the River Esk are testament to the industrial use of the river. The use of the mills was extensive: gunpowder, paper, cotton, flour, flax and iron. Paper mills were by far the most abundant. The last mill closed in 2004. There were many coal mines within the Esk Valley, as it is situated in the Midlothian Coalfield. Sandstone was quarried for building stone, and limestone for agriculture and mortar. Sand and gravel is still quarried from the extensive glacial deposits. The area was productive enough to warrant a railway being built to transport mill and mine goods out of the area. The disused railway track is now a footpath and cycleway.

The North Esk Reservoir was constructed in 1850 to power the mills along the North Esk. However, the Rosebery and Gladhouse Reservoirs along the South Esk were built to provide freshwater to the Lothians.

## Scotland's geological history

Some of Scotland's geological history can be reconstructed by studying rocks in the Esk Valley.

### A lost ocean

Scotland's geology is intimately linked with the breakup of the supercontinent Rodinia about 590 million years ago. The expanding Iapetus Ocean separated the continents of Laurentia, Baltica and Amazonia. During Proterozoic to Cambrian times marine sands, silts and muds were deposited on the sea floor close to Laurentia, to form the Dalradian rocks of the Grampians. From about 500 million years ago, volcanic activity along the ocean margins heralded the beginning of the closure of Iapetus. Later during the Ordovician and Silurian periods, vast thicknesses of sands and silts formed in deep ocean channels, with black muds accumulating on the ocean floor. Near-shore marine limestones and mudstones were also deposited. Together, these sedimentary rocks now form the Southern Uplands and small outcrops in the Pentland Hills.

### Mountain building

As the Iapetus Ocean closed, the Dalradian rocks of the Grampians were deeply buried, metamorphosed and folded during a period of mountain building. With continued closure the marine sediments to the south, which were to form the South of Scotland, were successively folded and thrust together as the ocean floor was consumed (subducted) by the

overriding continent of Laurentia.

In the upper reaches of the North Esk [NT 1601 5944], the Silurian rocks record a changing environment from marine and deltaic fossiliferous limestones and mudstones to fluvial sandstones. Fossils of sea creatures can be seen, such as brachiopods, gastropods, trilobites and fish. In places the sandstone contains igneous intrusions, which in turn are cut by veins made from hot fluids.

### Prolonged erosion

The Pentland Hills comprise volcanic and sedimentary rocks from the Devonian period. Studies elsewhere show that Scotland was still located south of the equator. The environment was hilly, volcanic and semiarid. It was a time of seasonal rainfall and poor, patchy vegetation cover. The uplands were being eroded, and sediment transported downhill to accumulate in sedimentary basins.

### Coal and volcanoes

During the Carboniferous period Scotland was near the equator with a hot and wet climate all year round. Carboniferous generally means coal-bearing, and the Midlothian Coalfield formed during this time. Most large coal seams have been mined, but a coal seam is well exposed by the bridge over the river on the A68 [NT 34182 69273]. Coal forms from vegetation. At times central Scotland was covered by shallow seas in which limestone and mudstone formed, containing abundant fossils of marine corals and brachiopods, plants, fish and crustaceans. Sometimes freshwater lakes were present, in which mudstone containing bivalves (mussels) formed. At other times river systems dominated the environment and deposited thick layers of sandstone and mudstone with plant roots.

The Carboniferous was a volcanically active time when Arthur's Seat Volcano formed [NT 27528 72938], but in the Esk Valley only small intrusions called sills and dykes can be seen, with examples between Carlops and the North Esk Reservoir. Faulting occurred in the area, and the major faults trend east-west.

Recent erosion by the River Esk has exposed cross sections through the sandstone in some places, such as in [NT 26603 62118]. This allows us to see the changing nature of the sedimentary rocks, and cross sections of ancient river channels.

### Supercontinent formation

Evidence for most of the rest of Scotland's journey cannot be seen in the Esk Valley. Scotland continued to move northwards, and became part of a supercontinent called Pangaea with an arid environment and covered by deserts. Later, Pangaea started to break up forming the continents we see today. This caused sea level to rise and Scotland was temporarily plunged under the sea again. Dinosaurs would have roamed around Scotland, but very few are preserved. Marine reptiles such as Plesiosaurs are more common.

Splitting of Scotland and America

About 65 million years ago, America started moving away from Europe, initiating the Atlantic Ocean. This formed the Mid-Atlantic Ridge. It caused large scale volcanism, forming some of the Western Isles of Scotland, such as parts of Rum, Mull and Skye. Scotland is no longer moving north but the Atlantic Ocean is still opening, with America moving away from Scotland at a rate of 2.5cm per year. The volcanism is concentrated along the Mid-Atlantic Ridge, where new crust is still forming under the ocean and in some places, creating islands like Iceland.

## Glossary

**Bedrock** — The solid rock beneath unconsolidated material.

**Boulder clay** MdasAlso known as till. Glacial deposits laid down beneath the ice, with material varying in size from grains of clay to boulders.

**Cross-bedding** — a common feature in sandstone resulting from accumulation of sand on inclined surfaces such as ripples, sand waves or dunes.

**Dyke** — A sheet-like igneous intrusion which cuts horizontal or gently dipping rock units at a different angle. Often they are near vertical.

**Fault** — A discontinuity surface across which the rock has been displaced.

**Glaciofluvial** — Referring to glacial meltwater activity. Intrusive igneous body — An igneous body that is pushed into the surrounding rock at depth.

**Meltwater channel** — A channel cut by glacial meltwater under, along and in front of an ice margin.

**Metamorphism** — The process of changing the nature of rocks by heat, pressure or fluids.

**Mid-Atlantic Ridge** — The middle of the Atlantic Ocean where new oceanic plate is created. It rises above and is hotter than the surrounding sea floor.

**Sill** — A sheet-like igneous intrusion that follows the bedding. They are planar structures.

**Striations** — Scratch marks on bedrock made by stones embedded in the moving ice.

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(Front cover)

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(Figure 3) Stratigraphic column

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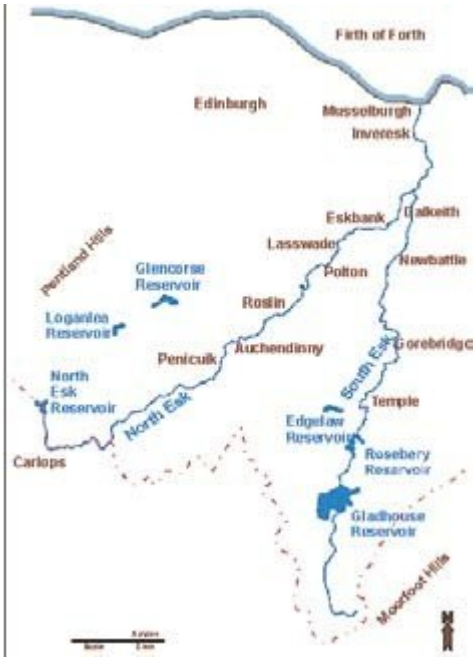
(Figure 10) Sandstone in Auchendinny [NT 258 616] from the Early Carboniferous showing a boundary between two different sets of sandstone layers deposited by river currents. The upper set shows cross-bedding, where sand is deposited at an angle by moving sand 'ripples'.

(Figure 11) The coal seam in the Upper Carboniferous sandstones in Midlothian Coalfield under the A68.

(Figure 12) The base of ancient river channels in Carboniferous sandstone in Roslin Glen, by the Gunpowder Mill, with finer horizontal beds underlying it.

(Figure 13) Upper Carboniferous mudstone in Gore Glen [NT 33343 61799], it is interbedded with sandstones along the river.

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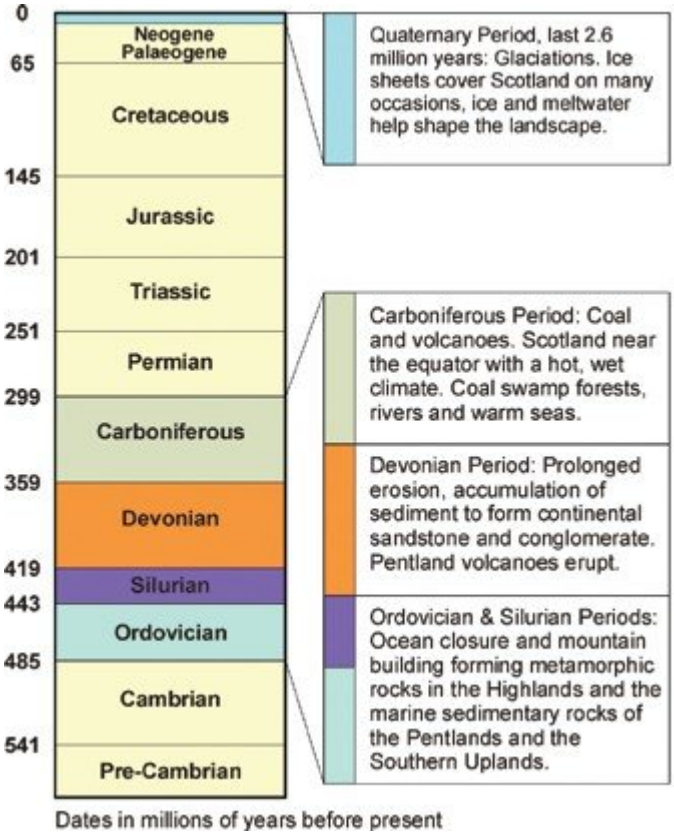


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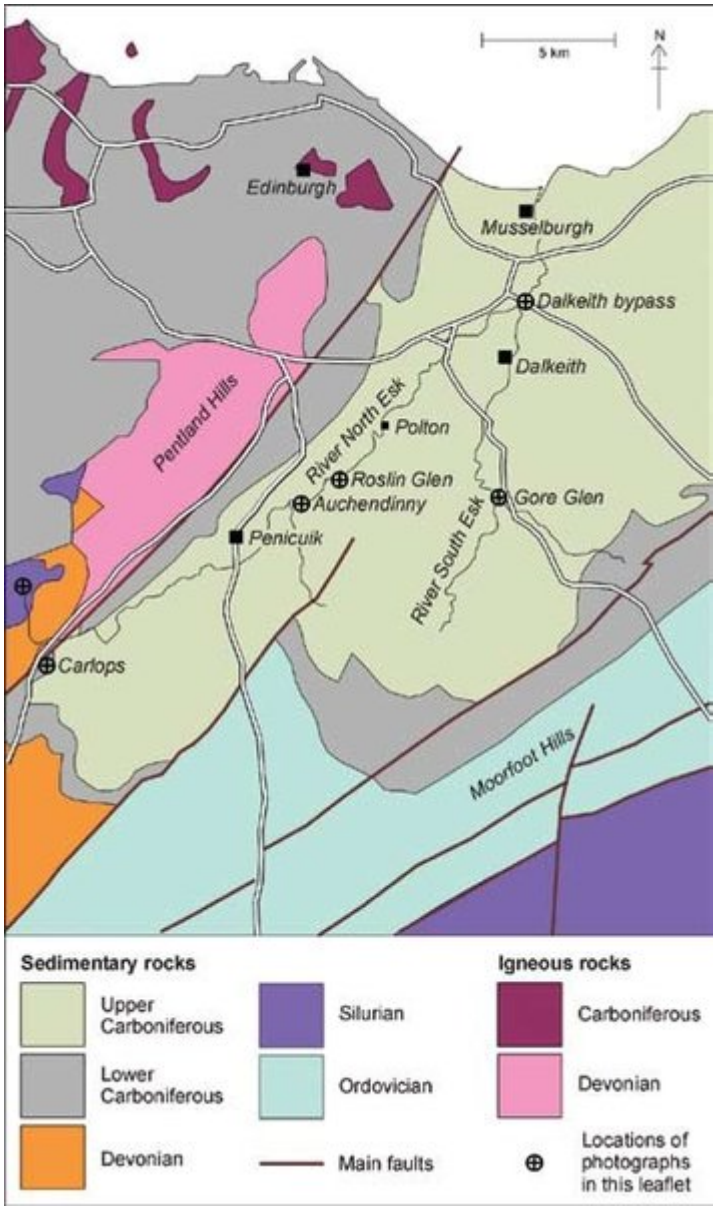


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