Geology – Vogrie Circular Walk (2)
Vogrie – Crichton – Borthwick – Gorebridge – Newlandrig – Vogrie

Introduction

This publication is a joint venture between the Midlothian Ranger Service at Vogrie and Lothian and Borders GeoConservation, a committee of Edinburgh Geological Society. It describes the geology and social history along the route of a circular walk from Vogrie Country Park. The distance is over 10 miles (16km) and slightly more if the interesting diversion to the limestone quarries is included.

Geology: The geology can be divided into three parts.
1. Sedimentary rocks of the Carboniferous Period (359 to 299 million years ago).
2. Glacial and post-glacial features.
3. Active river and rock fall processes.

The Carboniferous rocks of the area are mainly limestone and sandstone. These, along with unseen coal seams, have been exploited over the centuries for fuel, for making lime, or for building purposes.

During the Carboniferous Period this area was situated just south of the Equator. Continental drift, caused by plate tectonics, has brought these rocks northwards from their place of origin to their present position.

This publication is similar to and complements "Vogrie Circular Walk via D'Arcy and Edgehead", available at www.edinburghgeolsoc.org/downloads/GeologyWalk-VogrieCountryPark.pdf. The final part of the route is the same as in that work, i.e. the descent into Newlandrig (from NT 358 637) and return to Vogrie and is included here for convenience.

Warning. The wall faces and buildings mentioned are dangerous. Do not climb.

SP: Special Point shown on the map on page 2, and described below.

Acknowledgements:
Bill Crook and Margaret Johnstone of Gorebridge and District Environmental Group.
Henry Duncan of Crichton.

Lothian and Borders GeoConservation *identifies and helps designate Local Geodiversity Sites, the most important places for geology, geomorphology and soils outside statutorily protected nature reserves and Sites of Special Scientific Interest (SSSI). The designation of Local Geodiversity Sites is one way of recognising and protecting important earth science and landscape features for future generations to enjoy.*

We also work to raise awareness of sites and geodiversity through publicity such as leaflets, booklets, posters, interpretation boards and the Internet, and by developing access and educational usage of sites and trails.

The LBGC Committee meets twice a year, and includes representatives from the 5 Local Authorities in our area. The Committee discusses Local Geodiversity Sites and related issues. The LBGC Volunteer Group welcomes anyone interested in any aspect of local geology and conservation. The group has evening meetings every month in winter, and gets involved in occasional work parties and other events.

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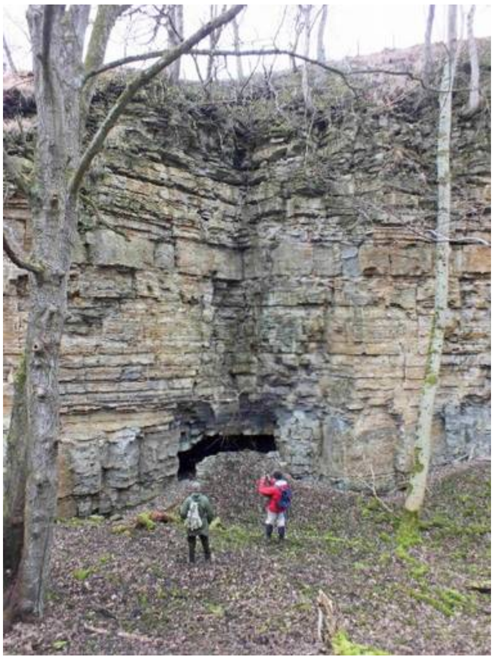
Vogrie to Crichton Kirk and Castle

SP 1a. Currie Lee Limestone Quarries. NT 3817 6240.



This is a short diversion from the circular route, to visit the quarries to west of Tyne Water. Do not cross the three plank bridge, but continue on the footpath which swings right and goes up to extensive limestone quarries and a lime kiln. Then return by the same route, cross the bridge, and continue along the path to Crichton.

It is not known when these quarries were first worked. The OS map of 1892 described all of them as disused or old.

Just off the track lies the sheer face of a limestone quarry which extends from here, the northern end (and last worked) to the southern end NT 3776 6190 (earliest workings). This is the North Greens Limestone. This limestone was created about 325 million years ago in a warm tropical sea when the Lothians were south of the Equator.

At the northern end the quarry face is about 10 m high, consisting mainly of thinly bedded limestone with a 1m thick massive bed at the bottom. Piles of spoil opposite the quarry face are where the inferior limestone (with more clay content) and mudstone was discarded during quarrying operations. This is now covered in moss and is unstable in places. There is minor evidence of underground mining in the quarry at NT 3802 6231, as seen in the picture. Nearby is a square stone enclosure with an entrance, which was probably a powder store.

SP 1b. Lime Kiln. NT 3794 6224.

This lime kiln near the quarry face is made of sandstone blocks. The limestone and coal were hauled up the access road, which is behind this kiln. The coal was burnt to convert the limestone to quick lime, which was raked out from below.

See Appendix 1 at end for further information about limestone, lime burning and the uses of lime.

Return to the circular route: Cross the three plank bridge, head up the steps through woods and turn right onto a grassy track. Follow this for about 1.5km through limestone workings to the tarred Colegate Road. Turn right and after 100m, just before the bridge, turn left onto a path (circular sign with green arrow). Go up the steps and, shortly before reaching the top, turn left into the wood to visit the quarries SP 2.

SP 2. Currie Lee Limestone Quarries.

These old limestone quarries start at NT 3833 6247 below Currie Lee Farm and extend south to just below Crichton Kirk at NT 3800 6170. The worked rock is usually the North Greens Limestone, approximately 15 m thick. The upper part is rather impure with beds of mudstone. The lower part is more massive and pure (95% calcium carbonate) and was the target for quarrying.

Quarry below Crichton Kirk NT 3803 6168. This shows the upper part of the Upper Crichton Limestone with overlying cross bedded sandstone. This is the oldest limestone seen on this walk *(See Appendix 2 at end for further information about the ages of the rocks)*.

The following features can be seen on the quarry face:

Bedding. Layers of sedimentary rock showing different phases of deposition, separated by bedding planes which indicate a break, or change, in the process of deposition.

Joints. Cracks, or breaks, in rocks, approximately at right angles to the bedding planes. These are commonly created by stresses in rocks caused by earth movements. Usually there is no movement at a joint, but sometimes there may be a little in one or two beds. This is unlike at a fault, where there is significant movement of the rocks relative to each other. Joints and bedding planes are penetrated by weathering processes and are accentuated in exposed sites like this.

Fossils. Various fossils can be found in the limestone. The most common are crinoids. Many of these are in good condition, indicating rapid fossilization after death. Unfortunately they were usually broken into small pieces soon after they died, by currents in the shallow sea.

SP 3. Lime Kiln at NT 3795 6205.

Like most lime kilns in the area, this was probably abandoned in the last two decades of the nineteenth century. The access road can be seen at top left.

SP 4. Crichton Kirk. NT 3811 6161.

The Kirk is constructed from buff and red-hued sandstone from local quarries. Can you find the mason's mark, to the left on the east side?

Cross bedding in sandstone

Many of the building stones in the Kirk and Castle, and the local bedrock exposures, show cross bedding. In rivers, water currents often build up sand bars or dunes with inclined sand layers that are laid down at an angle across, or within, the roughly horizontal bed itself; this is called cross bedding. Changing conditions might then result in erosion and, later, in more sand being deposited on top with horizontal layering.

The sandstone block pictured is in the left buttress on the east side of Kirk. The impact marks were caused by Cromwell's troops firing their muskets at it in 1650. Geologically, this block is laid upside-down: the first layers deposited are at the top of the block, and were laid down at an angle. Then the tops of these layers were eroded before the second set of layers were laid down horizontally.

Soft sand deformation: north wall, left buttress.

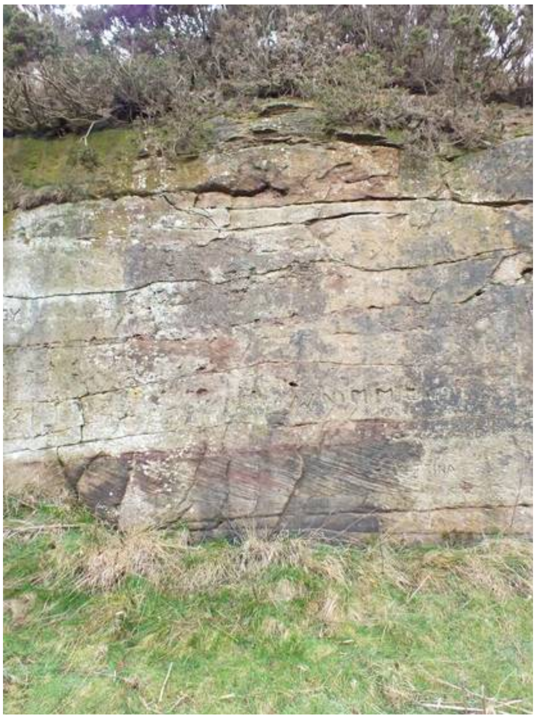
The sediment was originally laid down in parallel beds, but was deformed into these small folds by an earthquake whilst still wet, before it had been compressed and cemented into rock.

Several examples of cross bedding can be seen in the Kirk walls. They include this one in the north wall, left of the low felt roof, which, geologically, is laid on its side. You are looking down onto the top of cross bedding, which is inclined from right to left. Weathering has accentuated its features. The tops of the thin layers of sand can be clearly seen indicating how they were successively swept over the top of the sand bar and deposited on the downstream side.

SP 5. Crichton Castle. NT 3802 6114.

SP 5a. The Castle is built mainly of sandstone of the Aberlady Formation. This was obtained from two quarries nearby. The sand was laid down here by rivers when this area was south of the Equator and the climate was hot and humid.

SP 5b. NT 3805 6115. Opposite the entrance to the Castle is an outcrop of red sandstone, which shows cross bedding.



SP 5c. NT 3807 6103 and NT 3807 6112. **Two quarries,** of yellow and red sandstone, can be found upslope behind the Stables. The larger, and more accessible, quarry shows 6 to 7m of thick bedded sandstone. Tool marks can be seen on the quarry face with cross bedding below.

Crichton to Gorebridge

SP 6. Tyne Water exposure. NT 3804 6052.

Instead of turning right and following the footpath across the flood plain, continue upstream to this site. Gently dipping, rotted mudstone of the Aberlady Formation, above sandstone in the bed of the stream; overlain by weathered rock.

SP 7. Stile. NT 3790 6052.

After climbing up the steep slope from the Tyne flood plain you get a good view of the Tyne Valley, which has been shaped and deepened more by torrents of melt waters, than by glaciers.

SP 8. Former Railway. NT 3788 6036.

Various items, like this old sleeper, were left behind after the dismantling of railway sidings, which were built for the disposal of industrial waste in the 19th and 20th centuries.

Currie Glen (Diversion)

SP 9. Sandstone exposure on Gore Water. NT 376 595.

This 10 metre thick exposure is by the path on the north side of the Gore Water. It lies at the bottom of the Gullane Formation and consists mainly of pale sandstones interbedded with purple or reddish mudstones and siltstones. These beds were laid down on volcanic rocks which were erupted about 343 million years ago as part of the Garleton Hills Volcanic Formation and are the oldest rocks on the walk. The volcanic rocks cannot be seen at this site, but they are exposed further upstream on the opposite bank near to a small bridge. The Garleton Hills are about 30 km away, north of Haddington.

SP 10. Sandstone exposure. NT 3745 5963.

This exposure, at the same site as above, shows trough cross bedding and small cavities where clay pellets have been weathered out.

SP 11. Rockfall. NT 3728 5960.

This rockfall, opposite the path leading into Borthwick, demonstrates active erosion in the glen.

SP 12. Borthwick Castle. NT 370 598.

The sandstone varies from pink to yellow and was quarried not far away in Currie Glen. The quarry is now overgrown and no rocks can be seen.

SP 13. Stone in wall to right of entrance to Borthwick Castle NT 369 597.

This shows circular bands called liesegang rings. There is some dispute about this yellow concentric limonitic staining but the most popular explanation is that they were created by rapid flows of water through the sandstone.

SP 14. Misfit Stream.

View down the Gore Valley from the entrance to Borthwick Castle.

The valley was created by torrential meltwater about 15,000 years ago as the ice sheet melted and glaciers retreated. The present day *misfit stream* is too small to have cut the valley through which it flows.

Much of the valley floor is covered in *alluvium*. This is recently deposited loose, unconsolidated sediment left behind as flood waters recede. The Gore flows northwards in gentle meanders and the fall of the general water level between Borthwick and Gorebridge is about 10 m.

SP 15. Slumping on River Bank. NT 3627 5974.

The stream has cut into the base of the river bank, causing some previously deposited alluvium to slump. This photograph was taken on 26th April 2016. Do you notice any changes since then?

The embankment of the former railway can be seen in the right background (see below).

SP 16. Broken Bridge. NT 3539 5990.

This bridge, with its embankments, formed part of a busy railway network in the area in the 19th Century mainly for the transport of coal and lime, but also for gunpowder which was manufactured locally.* In particular this line was used to bring lime from Esperston Limeworks (NT 345 575) to the main line at Catcune. It used a switchback to get up to the main Edinburgh to Carlisle line (now the Borders Railway). Although the main line had reached as far as Stow in 1848 and Hawick in 1849, this light railway was not built until 1878-79.

The arch on the left took water to Catcune Mills. Other features of these water control works can also be seen at this site. The masonry of the bridge on the south bank comprises cross-bedded yellow sandstone and brick.

**See "Gorebridge Circular Walk and Gore Way" leaflet, obtainable from Gorebridge Library.*

SP 17. Point bar and alluvial terrace. NT 3523 6007.

This gravel mound, known as a *point bar*, is approximately 12m long, 3m wide and 30 to 40cm high. It is typical of gently meandering rivers when a minor current, or secondary flow, sweeps and rolls sand and gravel across the floor of the stream into a long mound on the inside bend.

26th April 2016.

30th November 2016.

This point bar is a good example of the fact that river erosion is an intermittent rather than a continuous process. The second photograph was taken after the highest, and overbank, river flow between these two dates on 22nd November. Much of the point bar was removed by the rising and peak flow flood water and new stones deposited by the subsiding flow. The net result, on this occasion, was a lowering of the height of the point bar.

An *alluvial terrace* is a record of the former flood plain before the river cut deeper into the base of the valley. It can be seen here in the background as the level surface at the top of the opposite bank, partially obscured by trees.

SP 18. Catcune Mills. NT 35107 60268.

Mill wheels of coarse sandstone can be seen near the house.

SP 19. Sandstone. NT 3505 6044.

The first exposure of bedrock downstream.

SP 20. Weir. NT 3502 6050.

Downstream from Catcune Mills, the land on the opposite side was part of the Harvieston Estate which extended onto this side of the river for much of the nineteenth century.

The house itself, which cannot be seen, was here in 1770 and probably much earlier. In the decade 1830-40 a wall was built enclosing a large area, which was landscaped; this included the planting of trees and shrubs.

The first edition of the 6 inch Ordnance Survey map of 1854 shows that the estate extended across to this side of the stream and that four footbridges provided access to this land. The 1895 map does not show this land as part of the estate. This weir was probably built at about the same time to increase the amenity value of the river by creating a larger and smoother expanse of water.

SP 21. Ford? NT 3501 6048.

This construction on the stream bed was probably also part of the amenity works and may have been a ford.

SP 22. Glacial Till in River Bank. NT 3490 6072.

As the ice sheet advanced it pushed, or slid over, everything in its path. Much of this material was reduced to small grains by the grinding action of the ice to become silt and clay. Other material was not reduced to this state and some pieces were still big enough to be called boulders; hence the name *boulder clay*. It was smeared over the land beneath the ice. Here the grey boulder clay, or *glacial till,* overlain by brown alluvium, rises about 2m from the Gore Water.

SP 23. Drain. NT 3484 6075.

This drain is discharging water from old coal workings nearby into the Gore Water, which can be seen flowing from left to right in the middle distance.

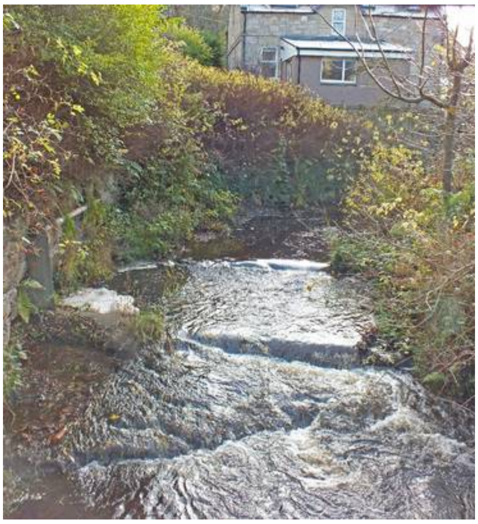
The water contains iron salts which are precipitated as red iron oxide.

SP 24. Crossgatehall Fault.

The Crossgatehall Fault is just downstream from the bridge over the Gore Water at the bottom of Robertson Bank in Gorebridge. Unfortunately it cannot be seen either in the river banks or on the bed of the river. The miniature waterfalls in the picture are possibly minor faults in the sandstone on the up thrown side.

Its significance lies in the fact that it is part of the Southern Uplands Fault (SUF). This is a major geological feature which stretches from the Rhins of Galloway in the south-west to Dunbar on the coast of East Lothian.

The SUF marks the abrupt change from the older rocks of the Southern Uplands and the younger rocks of the Midland Valley. It is not just a single fault, but a complex system of many small faults, or breaks, in the rocks. Movement occurred intermittently along these faults over a long period of more than 140 million years, only dying out towards the end of the Carboniferous Period.



Gorebridge to Newlandrig and Vogrie

SP 25. Path to Camp Wood. NT 350 626.

This path uphill from Gorebridge (Signposted Camp Wood ¾ mile) passes through fields which were once a site for the opencast mining of coal, Blinkbonny Mine. This was part of the Midlothian Coalfield stretching towards the Pentlands, where coal was mined up until 2003. Coal was central to Midlothian's history, and many of the fields, like the ones here, were first stripped of the top few metres of soil and then mined for coal in opencast operations. The land has more or less been restored to agriculture or forestry but there are still many relics of its mining past. Looking north-west you can see the old mining settlement of Newtongrange, still with its tall chimney and pit-head gear which are now part of the National Mining Museum.

The coal owes its origin to the tropical swamps that existed here 323 million years ago, in which scaly, fern-like trees known as lycopsids grew. After they died, millions of years of the heat and pressure produced by burial transformed these dead forests into hard, black coal.

SP 26. NT 3536 6212. Opencast Coal Mine.

The worked seam is the Bryans Splint Coal. The top part of this can just be seen at the base of the quarry face. Unfortunately, most of the seam is obscured by recent infill of the quarry floor. Long Plantation can be seen above the quarry. These photographs were taken in July 2000. The land has since been restored.

Plate tectonics, which are responsible for moving this area from the Tropics, are also responsible for tilting the rocks from their original virtually horizontal position. These, the youngest rocks on the walk, belong to the Limestone Coal Formation. They are overlain by glacial till (SP 22) and soil.

A typical rock face in this area shows alternating layers of some or all of the following: coal, limestone, mudstone and sandstone. These alternating beds clearly illustrate the changing nature of the environment and of the processes involved. Fluctuating sea levels turned the area, by repeated cycles, into dry land with flowing rivers, estuaries, swamps, and shallow seas. The flowing rivers produced the **sandstone.** Finer material was carried out to sea, or deposited in lakes, to become **mudstone**. Swamps and estuaries produced the vegetation which rotted away to become **coal.** The shallow seas converted the remains of shellfish and plankton into **limestone.**

SP 27. Coarse-grained well cemented sandstone. NT 3518 6298.

This lies beside the first bend in the road which you reach having walked up from Gorebridge. It was probably unearthed during opencast coal mining and was too big and tough to crunch up and use for roads on the site.

SP 28. Igneous Boulder. NT 3522 6295.

This boulder is opposite the previous one. It was carried along by the ice until being dumped here when the glacier melted about 15,000 years ago, at the end of the last ice age. It may even have been broken off from the igneous sill in the Ochils, about 60km to the north. As it did not originate here and is not related to the local rocks, it is known as an *erratic.*

SP 29. Limestone Boulders NT 3521 6303.

Two boulders can be seen either side of the gate at the entrance to the track towards Newlandrig. They are dark grey and possibly show signs of small fossils. They are probably limestone and, along with the nearby lime kiln, a reminder of the former limestone quarries in the Camp Wood –Blinkbonny area.

SP 30. Spoil Heap. NT 3519 6335.

A short distance further on this spoil heap from an old limestone quarry can be seen, but may not be accessible if the gate is locked. The limestone rubble is now used to make farm tracks, as you will see as you continue your walk.

SP 31. Arch.

On the same site you may be able to see this arch over a shallow trench. This was the exit from a short tunnel through which a wagon way passed; now, obviously, mainly infilled. It was used for hauling lime down to Mayfield and beyond. There are records that in 1837 much of this lime went to Edinburgh for building purposes.

The final part of the route – the descent into Newlandrig (from NT 358 637) and return to Vogrie – is the same as "Geology Walk 1: Vogrie Circular Walk via D'Arcy and Edgehead" and key points are included here for convenience.

SP 32 (Walk 1 SP 12). North Viewpoint. NT 358 638.

To the north-west we can see the Pentland Hills round to Arthur's Seat (251m) and then looking north and east over to Fife, on a clear day, you may be able to see the twin tops of the extinct volcanoes Largo Law (290m) and, still farther east, Kellie Law (184m).

- The Pentland Hills to the north-west provide much evidence of volcanic activity of about 410 million years ago, of later desert conditions, and of the last period of intense geological activity 15,000 to 11,500 years ago, when the ice which covered Scotland thawed and released huge quantities of water to shape hills and create valleys. Scald Law (579m) is the highest hill of the Pentlands and is composed of volcanic rock.

- Arthur's Seat with its distinctive lion's head and body shape is the remains of volcanic eruption around 340 million years ago. This has now eroded leaving us the main lava flows and exposing the internal volcanic structure.

- Salisbury Crags starting with a sheer cliff in the west and tapering to Arthur's Seat in the east, is a "sill", part of the internal structure of a volcano. Sills are formed during eruption when some magma is forced sideways through the rock, instead of erupting through the vent, and eventually cools to form very hard rock. Erosion has exposed this sill, and local tilting has lifted the west end high above the plain.

- Castle Rock. Edinburgh Castle stands upon the plug of an extinct volcano which is estimated to have erupted about 340 million years ago. When volcanic activity ceased the magma still in the pipe cooled to form very hard dolerite, a type of basalt. This hard plug resisted glacial erosion from the west creating a "crag and tail" formation, starting with the castle and a gentle descent down the High Street to Holyrood Park. The summit of the Castle Rock is 430 ft (130 metres) above sea level.

SP 33 (Walk 1 SP 7). East and South Viewpoint. NT 363 633.

From here we have a view, starting in the north- east, of North Berwick Law (187m) and, moving clockwise, the Hopetoun Monument (204m), Traprain Law (221m) and the Lammermuirs (Meikle Says Law 525m) round to the Moorfoot Hills (Windlestraw Law 659m) in the south-west.

North Berwick Law is a conical hill which stands at 613 ft (187 m) above sea level. Geologically, the law is the "plug" of one of the many extinct volcanoes which erupted here about 345 million years ago. The plug was formed in the pipe, through which the magma (molten rock) erupted, when volcanic activity ceased and the rock still in the pipe cooled to form very hard phonolitic trachyte.

The Law has survived the scraping glaciers of the Ice Age from the west and protected the softer rock to the east, creating a "crag and tail" formation, with a prominent tail extending eastwards.

Traprain Law is a long flattish hill about 724 ft (221m) above sea level. Geologically, it is a sheet intrusion or concordant pluton known as a laccolith . These occur when magma has been injected between two layers of sedimentary rock and the pressure of the magma is high enough to force the overlying strata upwards into a dome or mushroom-like shape. Traprain Law was created during the volcanic activity of 345 million years ago.

The Bass Rock is a steep-sided volcanic island which stands 351 ft (107 metres) at its highest point, about 2 kilometres (1.2 miles) north-east of town of North Berwick. It is sometimes called "the Ailsa Craig of the East" and is geologically a volcanic plug of phonolitic trachyte like nearby North Berwick Law. It is home to a large colony of gannets.

The Lammermuirs, Moorfoots and other hills surrounding Vogrie are part of the Southern Uplands, originally a belt of mountains stretching right across Scotland, which was thrown up when the tectonic plates carrying "Scotland" and "England" collided 420 million years ago. Much of the Southern Uplands consist of Ordovician and Silurian rocks that were once sand and mud deposited on the floor of the Iapetus Ocean south of the Equator between 490 and 420 million years ago. Erosion since then has reduced the mountains to the hills you see today, which have been further carved and smoothed during the last Ice Age which ended 11,500 years ago.

The Lammermuirs to the south-east are a significant range of hills. The highest point is Meikle Says Law at 1755 feet (535m) with nearby windfarm. In certain parts there are exposures of coarse sandstones and conglomerates, coloured red as evidence of geological conditions here 390 million years ago when this area was arid, without vegetation, and subject to flash floods.

The Moorfoot Hills lie to the south west. The highest of these gently rolling hills is Windlestraw Law at 2162 feet (659 metres). To the right and slightly lower is Blackhope Scar at 2136 feet (651m) which is classed as a 'Marilyn', one of the 1217 hills in Scotland with a drop all round of 150 metres or more.

SP 34 (Walk 1 SP 6). Borehole. NT 364 632.

Coal seams lie a few metres beneath the surface of these fields and this metal capped borehole may have been an observation point to check water quality underground.

SP 35 (Walk 1 SP 5). Steadings nearby of brick. NT 365 630.

Brick and tile making is usually a by-product of coal mining and the colour of the waste material determines the colour of the brick. Here it is predominately yellow, at Vogrie Park, it is red. However there was a clay pit in Newlandrig.

SP 36 (Walk 1 SP 4). Boulders beside Path. NT 366 630.

The clay soils and landscapes of the surrounding countryside are relics of the last ice age. The fields originally started off as sediments left behind as the great ice sheet, which covered this area, started to melt and retreat some 18,000 years ago. The boulders beside the path are mainly 300 to 330 million years old Carboniferous sandstone, but there is a dark rounded one of igneous origin, dolerite from the 300 million years old Midland Valley Sill. Similar boulders come to the surface every year during ploughing.

SP 37 (Walk 1 SP 3). Vogrie Burn Boulder Clay. NT 367 628.

This clay, quite rich in pebbles and cobbles, is the product of ice melting at the base of an ice sheet.

We hope you have enjoyed this walk. If you would like further details on geological walks in the Edinburgh area and beyond please visit the following websites …

Lothian and Borders Geoconservation leaflets – www.edinburghgeolsoc.org/r_download.html
Geowalks – www.geowalks.co.uk

Appendix 1: About Limestone

The limestone contains few fossils which can be seen with the naked eye. Microscopic marine plants and animals existed in various forms, including algae, bacteria and plankton. Several of these extracted calcium from sea water to make the hard parts of their bodies. Over millions of years their hard remains became compressed into the limestone we see today. Some calcium carbonate may even have been precipitated directly onto the sea bed. The rock is rarely pure calcium carbonate, as sand or mud were probably accumulating on the sea bed at the same time.

Uses of limestone. The local rock was too brittle to use as building stone, although it was used for making roads.

Much, of course, was converted to lime in kilns. Latterly, finely crushed limestone was liberally strewn around in mines to keep down coal dust, which was a major fire hazard.

Uses of lime. Some was used for building purposes; mortar was made from lime, sand and water. A lime wash (whitewash) was used for coating walls. Lime was also distributed for use as a fertiliser, because it reduced the acidity of the soils and improved crop yields.

Operating the kiln.

The limestone was broken up into pieces of about 2 to 4cm, which allowed the free movement of air. This could then be loaded into the kiln to be heated by fires below. Another method was to load the kiln with alternating layers of limestone and coal, and ignite the coal.

Limestone needs to be heated to above 825°C. 0.5 tonne of coal was required to produce 1 tonne of lime. The local abundant supply of coal made lime burning economically possible.

The resulting lime, also known as quick lime, would fall through the grating and was collected after cooling.

A typical cycle was as follows.

Day	1	Load the kiln with limestone and coal.
Day	2-4	Fire the kiln.
Day	5-7	Cooling of the lime.
Day	8	Unloading and collection of the lime.

Appendix 2: Carboniferous Period: comparative ages of rocks referred to in the text.

299 million years ago (mya)

Limestone Coal Formation 325 mya (SP 25)

Lower Limestone Formation 328 mya (SP 1)

Aberlady Formation 335 mya (SP 6)

Gullane Formation (SP 9)

Garleton Hills Volcanics 343 mya

359 mya