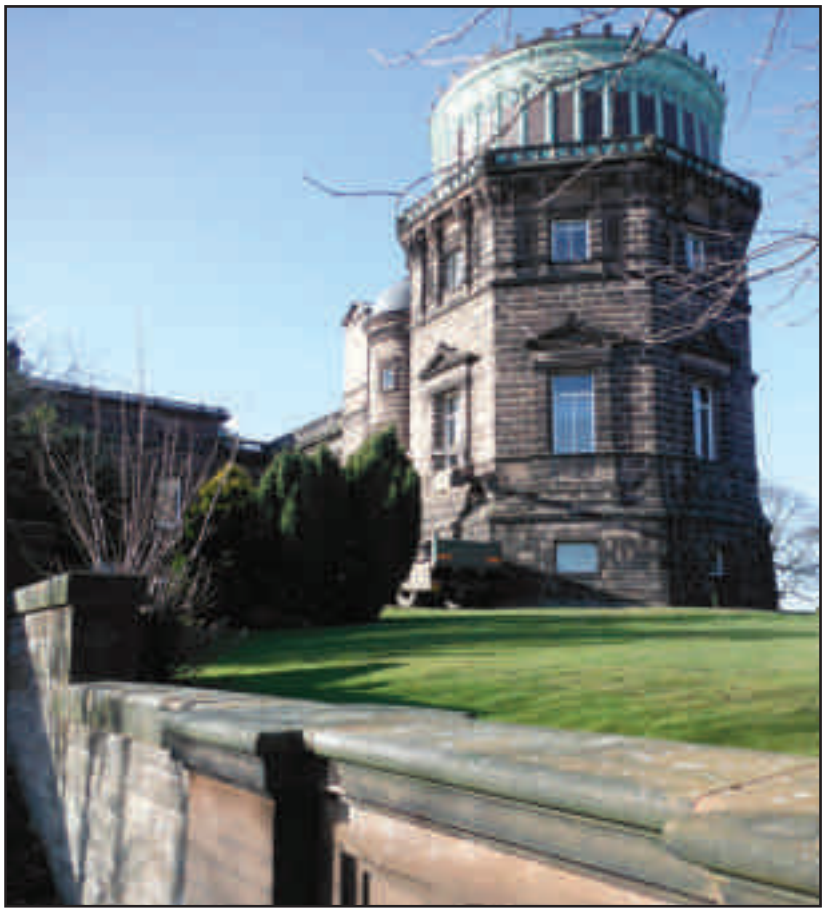
The Landscape of Edinburgh

Investigating the modern landscape of Edinburgh from Blackford Hill.
A geological guide.

The landscape of Edinburgh, built by volcanoes and rivers, sculpted by ice and used by humans. The park is a local nature reserve managed by the Natural Heritage Service, located at the Hermitage of Braid visitor centre.

This guide is aimed for use by teachers and is closely linked to the Curriculum for Excellence years P7-S3. It is meant as a foundation guide, some greater detail is given for the interested party.



Scottish GEODIVERSITY Forum

THE UNIVERSITY OF EDINBURGH

EDINBURGH GEOLOGICAL SOCIETY

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Introduction

Edinburgh has one of the most dramatic landscapes of any capital city, from the Firth of Forth to the seven hills of Edinburgh, with a backdrop of the Pentland Hills and Southern Uplands. This guide takes you through the geological and some historical aspects of Edinburgh's landscape from the viewpoint at Blackford Hill.

The guide takes the reader on a short walk around Blackford Hill from the Observatory to the summit and down into the Glen. A geological history of Edinburgh and its volcanoes is given which allows the reader to understand the large and small scale features of the city.

Some useful websites:
http://www.fohb.org - Friends of the Hermitage of Braid and Blackford Hill Local Nature Reserve.

http://www.edinburghgeolsoc.org - Edinburgh Geological Society home page, for more detailed information on Edinburgh's geology and for a local group of geology enthusiasts, from academics to interested members of the public.

http://www.bgs.ac.uk/education/home.html - The British Geological Survey website gives some excellent activities for within the classroom as well as a wealth of information on geology and the environment. (http://www.bgs.ac.uk/igeology/3D.html - a geology app)

http://geology.com/teacher/ - Some more good educational resources from all over the web.

www.edinburghoutdoors.org.uk - Information on parks in Edinburgh including Blackford Hill

Safety

Walking boots or stout shoes are recommended for walking around the park, especially during wet weather. There are some steep slopes so please take care, some areas have thin soils and slippery rocks. Though the river is not large, care when around the water should be observed.

For those bringing a group, a risk assessment should be completed by the relevant party.

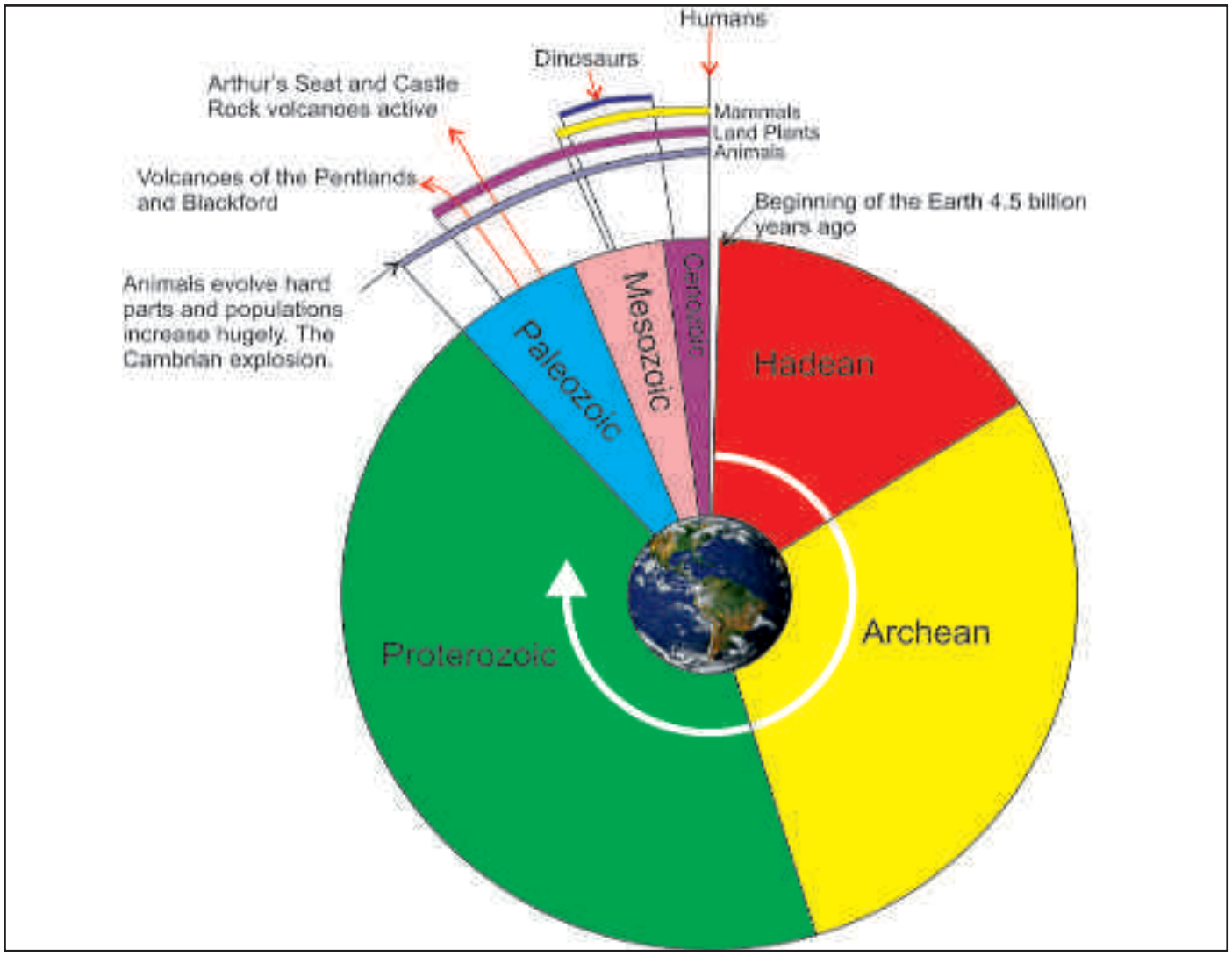
The park is a beautiful local resource, please take home any litter or use the bins and be considerate to others who wish to use the area.

Links with the Curriculum for Excellence

Here are a few of the links to the curriculum, many more can be brought in through Social Science and Science as well as aspects of Maths.

Curriculum for Excellence outcomes	**How the outcomes can be addressed in the area**
Years S1/2	
Having explored the substances that make up Earth's surface, I can compare some of their characteristics and uses. **SCN 2** Through evaluation of a range of data, I can describe the formation, characteristics and uses of soils, minerals and basic types of rocks. **SCN 3-17a** I can participate in practical activities to extract useful substances from natural resources. **SCN 3-17b**	The building blocks of Edinburgh, soft sandstone - malleable and easily cut to blocks. Hard volcanic (igneous) rocks can be used as cobbles or paving slabs. Compare hard and soft rock.
I can describe and recreate the characteristics of my local environment by exploring the features of the landscape. **SOC 1-07a**	This guide walks through the major features of Edinburgh's landscape from their morphology to how they formed.
Having investigated processes which form and shape landscapes, I can explain their impact on selected landscapes in Scotland, Europe and beyond. **SOC 3-07a**	Ice moulded the landscape, the last maximum was around 20,000 years ago and the effects are evident today. Glacial valleys and river valleys. The hills and mountains of Scotland hold some similarities to Edinburgh's hills. Arthur's Seat volcano, Glencoe volcano and many other high points are volcanic (igneous).
I can describe the physical processes of a natural disaster and discuss its impact on people and the landscape. **SOC 2-07b**	Edinburgh is built around volcanoes, though these volcanoes are millions of years extinct understanding the volcanoes of the past allows us to better interpret the volcanoes of the present. The Braid Burn has flooded in the past and though, relatively, these floods are small, never the less they must be managed and understood.

What Does This Guide Cover?



Landscape

How the landscape of Edinburgh was formed through millions of years of volcanic activity, burial under sediments, mountain building, subsequent erosion and moulding of the landscape by glaciers.

Land Use

How humans (who have been on the Earth for the blink of an eye in geological terms) have shaped and used the landscape or its materials. Many of Edinburgh's buildings and roads are built from local stone.

Glaciation

20,000 years ago glaciers were at their greatest known extent, they covered much of Northern Europe with kilometres of ice. The last Scottish glaciers melted some 15,000 years ago leaving behind a landscape scoured by ice and incised by torrents of glacial meltwater. Vast swathes of rock was ground to clay and left behind in valleys by the retreating ice.

Volcanoes

Millions of years ago Edinburgh was volcanically active. This booklet will investigate the two major periods of volcanism seen in Edinburgh's hills.

Geological Time

The first thing to understand about geological time is that there is a lot of it! The image on page 4 shows that the Earth has been around for 4.5 billion years, if we break this down into a 24 hour clock then humans evolve in the last 30 seconds of the day. Humans were one species of a “tribe” called Hominins, who evolved around 5 million years ago. All other species of which are now extinct. This guide focuses on volcanoes which were active 100 million years before dinosaurs, when amphibians took their first steps onto land.

Outcomes

After this field trip, a pupil can be expected to:

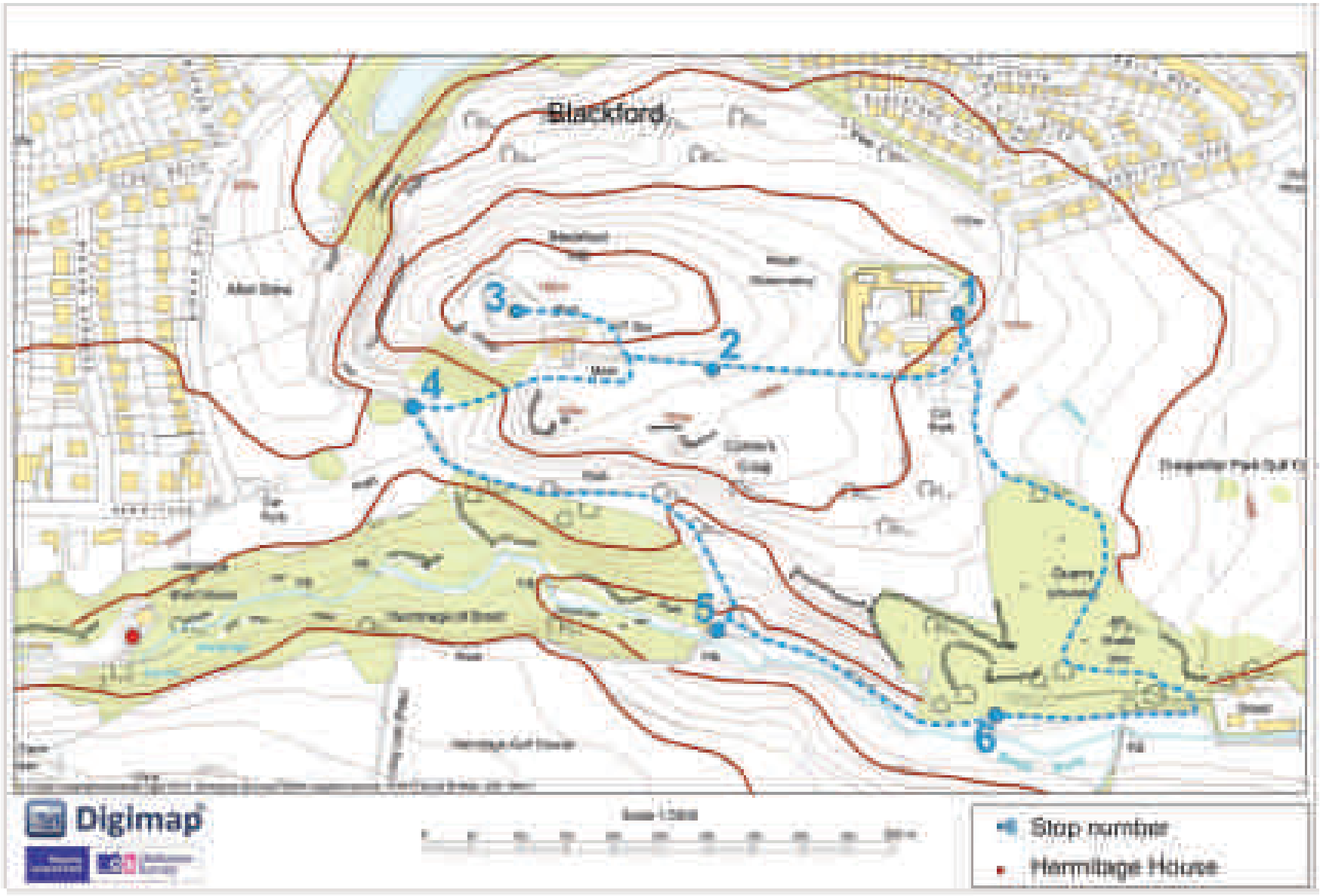
- Know the difference between sedimentary and igneous rocks.
- Understand what glaciers can do and how they shape the landscape.
- Understand that the environment of Scotland has changed through time.
- Understand Edinburgh’s two volcanic periods.
- Understand what rocks can be used for.
- Understand how landscape affects land use and that ultimately this is all controlled by the rocks.

A Walking Guide

There are several access points to Blackford Hill, this guide starts from the Observatory. There are maps and information boards dotted all around the park.

1) The Observatory

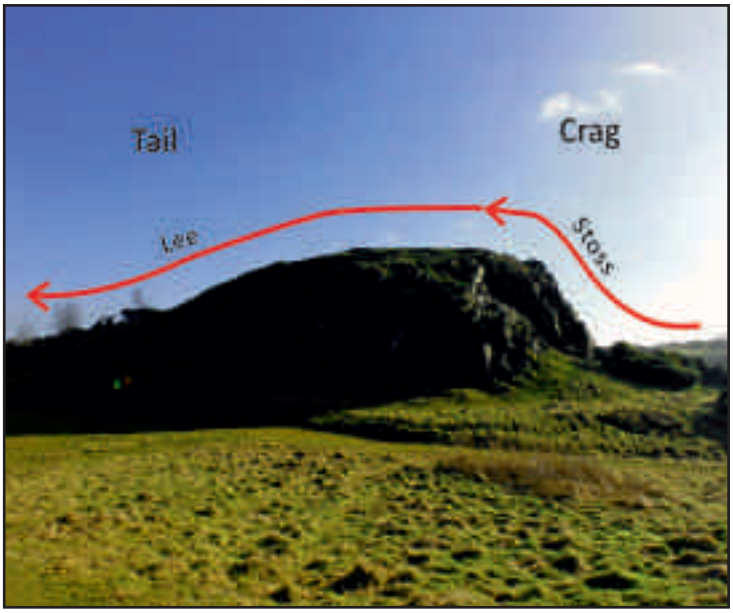
The main Observatory tower is built from sandstone formed during the Carboniferous age (359-299 million years ago). This comes from the local Hailes Quarry in Kingsknowe. The dressings are of Northumberland sandstone. Some of the extensions are built from Yorkshire sandstone of a similar age to the Edinburgh sandstones. Sandstone is a sedimentary rock composed alomast entirely of quartz grains. These rocks may have formed in deltaic environments where lots of sand is being deposited.



This map shows the positions of the individual stops within this guide. The tour starts with an overview of Edinburgh and then moves to smaller scale outcrops of volcanic rocks and the shape of glacial landforms. Note the contours on the map a steep western side, a shollow eastern side.

2) Corbie's Craig

A "crag-and-tail" landform, the crag is the steep rocky face and the tail is the long, shallow slope. A crag-and-tail is a glacial landform, a hard bit of rock that the ice couldn't shift. From far away you can see that the rock is dark and angular, this tough rock stood in the way of the ice. On the north side of the path, there is a small outcrop of rock with two plaques upon it, this is the same rock as Corbie's is made from. As the ice moved over the hard rock, there was a pressure "shadow" behind it, where the ice couldn't gouge, this acts as a direction arrow. The ice must have been flowing eastwards.



3) Blackford Summit

Near the top you walk up a small section of rocky ground to the summit. This rocky ground demonstrates how thin the soil is on the top of the hill. Soils form when water or lichens and mosses, weather the rocks into clays rich in nutrients. The clays then allow plants with roots to grasp the land. The roots, along with subsurface dwelling animals, rework the clays into soils. Rock type is extremely important in determining the minerals in the soils.

The landscape of Edinburgh from here is described from page 11.

There are remains of an Iron Age Settlement around the summit.

4) Blackford's rocks

As you walk towards stop 4 at the western end of Blackford Hill, take note of the steep steps you must walk down. This is the stoss (crag) slope of Blackford Hill.

The wall at the bottom of the steps surrounds much of the park and used to encompass the farmland in the fields to the west. These are now housing, another example of humans changing the landscape and land use changing with time.

This wall is composed of 3 rock types:

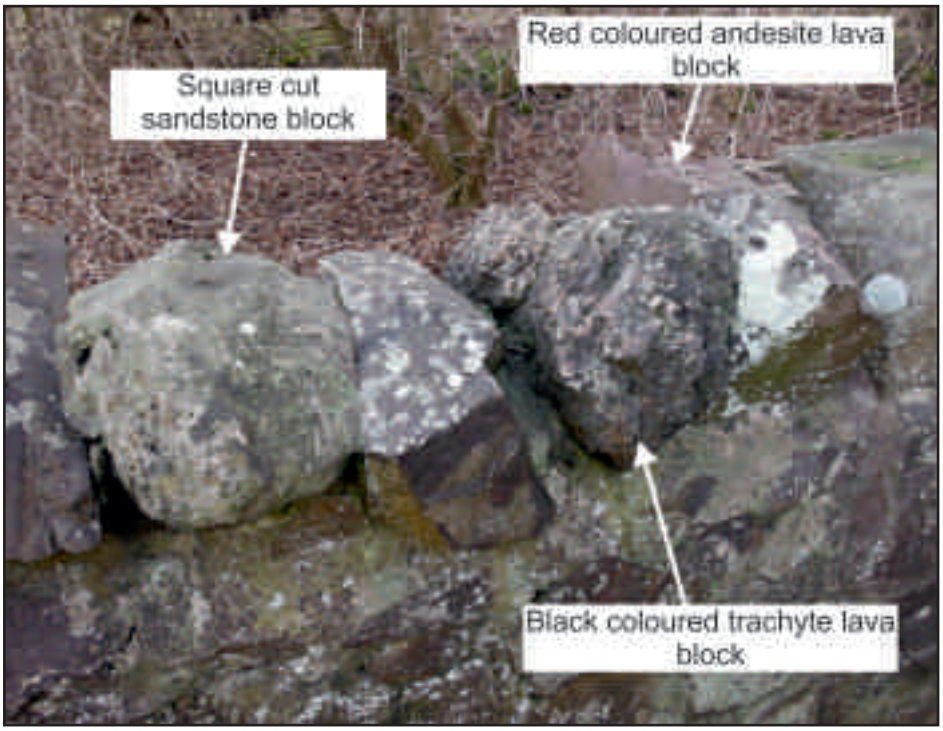
1. Sedimentary blocks - Sandstone from lowland Edinburgh. Sandstone is easily cut into square blocks and drilled into (note the remains of iron fence posts in most of the sandstone blocks).

2. Red/purple lava blocks - these are formed from lava called andesite (named because of its abundance in the Andes), this lava is fairly high in silica and iron (Fe), the iron weathers/rusts to a red

colour giving the rock a purple-red tinge.

3. Black lava blocks - These are composed of a lava called trachyte.

The lava blocks are all from Blackford and Braid and the sandstone is likely to have been quarried close by. The two lavas types are common throughout the Pentland Hills too.



Q) Why did they build a wall out of these difficult to quarry and cut rocks?

A) It was close by. The effort of breaking these rocks was counter balanced by the fact that the rocks are found next to where the wall is built and little effort is required to dig them out and move them. Also, it's less important for a farm wall to be very strong and well built compared to a house wall.

5) Braid Burn and Scout Bridge

The next stop is due south of stop 4, walk through the wood and down into the valley where the Braid Burn flows. The burn is known as a 'misfit' river, one that appears too small for the gorge or valley it runs through. This is relatively common in environments that were once glaciated.

Towards the end of the last ice age glacial melt water surged through this valley and cut a deep gorge through the hills. If you walk west from here the valley slopes become craggy and steep with trachyte lava exposed in cliffs. Now the ice has gone, the river discharge (amount of water flowing per minute) has decreased significantly leaving

the gorge cut by water. Recent flood waters in 2000 and 2012 caused the Braid Burn to burst its banks. Flood prevention plans can be found on the Edinburgh council web page.

There are active scree slopes above Blackford Glen. The screes form from mechanical weathering of the crags where small blocks of rock fall from the crags into scree slopes. Scree can eventually build up and cover the crag creating it.

6) Blackford Quarry and Agassiz Rock

This abandoned quarry once supplied stone to Edinburgh during the early 19th Century. The quarry closed in 1853 and since then was used as a landfill site. The visible rock is now used for climbing, bolts have been drilled into the rock at the top of the quarry allowing the wall to be used by groups and beginners in relative safety.

Blackford Quarry and climbers

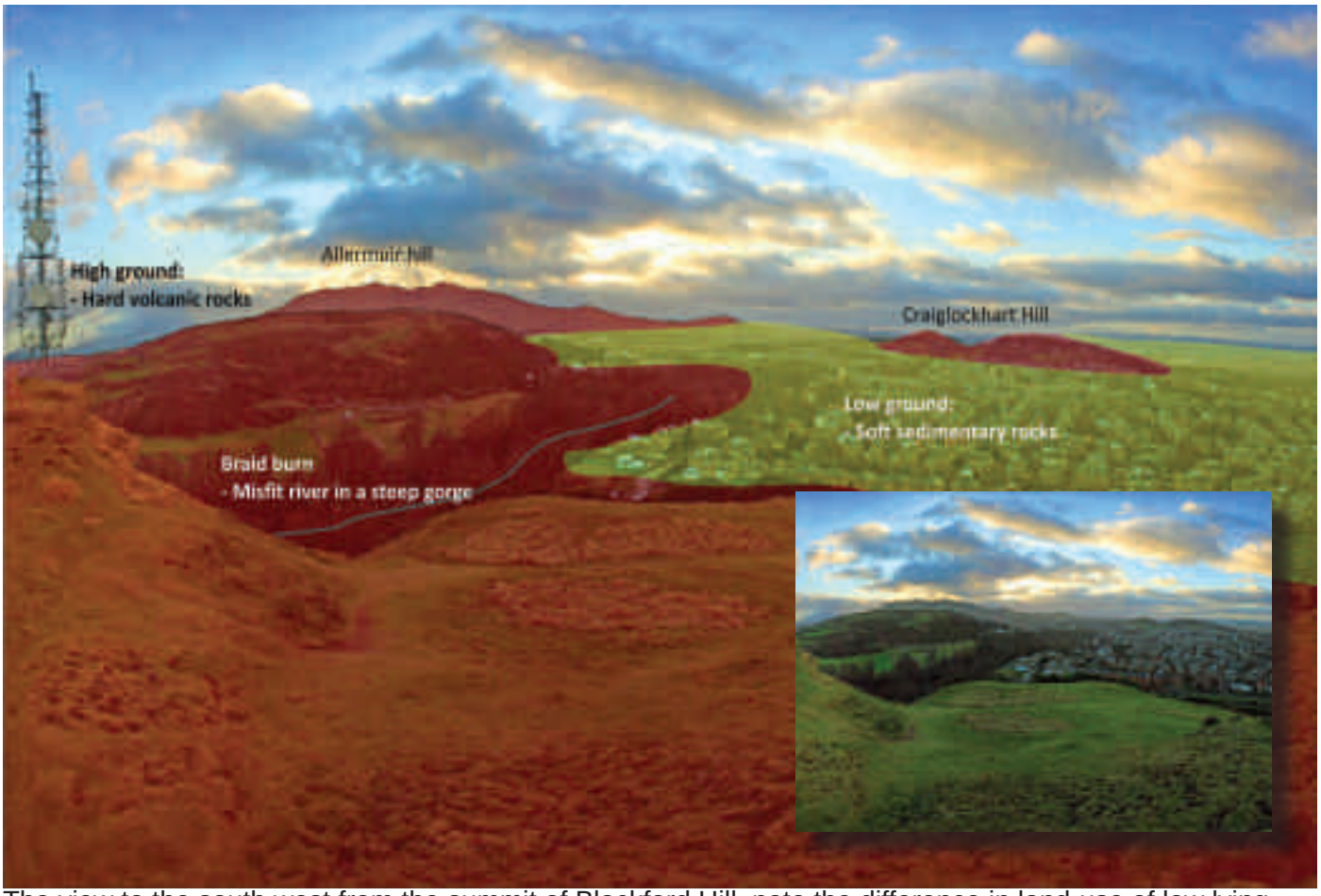
The rock here is andesite lava with its purplish red hue, as is Agassiz Rock.

Agassiz Rock is a Site of Special Scientific Interest (SSSI). In 1840, Louis Agassiz, a Swiss geologist, visited this wall which now bears his name. He noted glacial striations upon the rock, which he recognised from his Alpine homeland. The story goes that he threw his cap in the air and exclaimed “this is the work of glaciers!”. This discovery was important in proving the geological theory of glaciation in Scotland. Agassiz rock is also now used by climbers.

To complete a circular route, you can continue eastwards to some small steps that lead through the ‘community wood’ to the Observatory and car park.

Agazzis Rock

The Pentland Hills



The view to the south west from the summit of Blackford Hill, note the difference in land-use of low lying land to the right (west) and the higher ground to the left (east).

Look south from Blackford Hill, the summit of Braid is obvious. Tall masts protrude from close to the summit, these two hills are good choices for masts. They are easily accessible in order to allow

Some questions to ask.

Why build masts on these hills?

What are the most obvious features of the landscape to the south?

What are the land uses of these different scapes?

Why didn't the ice flatten everything?

What is the hard rock?

construction, Arthur's Seat is a tourist attraction and SSSI so nothing is built upon it.

Possibly the most notable feature of the landscape is the large range of hills behind Braid, the Pentland Hills. The highest summit visible is Allermuir Hill, 493 metres elevation.

The landscape you see here was fashioned by ice, the last glacial ice left Scotland around 15, 000 years ago and its effect on the landscape is still seen today.

Imagine standing at this point during the last glaciation where the ice could have been as thick as 1000 metres! The ice could scour and scrape the landscape forming many of Scotland's hills and valleys.

The hills all around are made of hard rocks that the glaciers couldn't flatten. The ice was deflected up, over and around the hard rocks, when the ice was deflected around it could create even deeper gouges in the surrounding soft rock. These gouges can be seen as Blackford Pond or Duddingston Loch.

What is this hard rock? All of Edinburgh's hills are formed from volcanic rocks, the Pentlands and Blackford Hill are connected, as part of an ancient chain of desert volcanoes.

Desert Volcanoes

Lascar volcano, Chile. A desert volcano that erupts lava and ash of andesitic to trachytic composition. The Pentland Hills and Blackford would have looked much like modern day Chile.

The Pentland Hills volcanic rocks formed during the Devonian period (419-359 million years ago (2 hours ago in the 24 hour clock)). During the Devonian animal life was abundant in the seas, amphibians and arthropods live on land. Many fossils of Devonian animals and plants can be found around Scotland, some within the sedimentary rocks of the Pentlands.

At this time 2 great continents existed: Gondwana and Laurasia. At this time Scotland was in

roughly the same latitude as the Tropic of Capricorn and was a dry desert. In this landscape, flash floods, lasting hours to days, brought great swathes of boulders, gravel and sand, depositing them in large scree fans that spread out from the high ground.

The high ground in this desert was dominated by volcanoes. These volcanoes, unlike the Carboniferous ones, were much larger and more explosive. The lavas they erupted were often very thick and viscous, not runny lavas like those of Arthur's Seat were. So these lavas couldn't flow far, their high viscosity meant they could often grow to great thicknesses. Blackford Hill is composed of one 40 metre thick lava flow of a lava called andesite. Below the lava is a layer of ash from an explosive eruption, the ash layer can be seen at the old quarry near Blackford Pond.

Some questions to ask.

Why did settlers choose to build a castle here?

Could an attacking army tunnel beneath the castle and weaken the foundations?

Could the castle survive a siege?

So how could they dig through the hard rock to get water?

How did Castle Rock come to be formed into a shape so useful for humankind?

Which way was the ice flowing?

Was this lava the same as Blackford Hill's lava?

Looking northwards from Blackford Hill's summit is Edinburgh Castle. Sat atop Castle Rock it commands a good defensive position over the city, with 360° views and just one entrance. Castle rock may have been inhabited as long ago as the 9th century BC, but the castle we see today is much younger. The other hills also had small settlements which may date back to the Iron Age or older.

The shape of Castle Rock should be recognisable from stop 2. Corbie's Craig is a miniature version of Castle Rock, with steep cliffs of dark, hard volcanic rock. Castle Rock is another crag-and-tail feature formed by ice, with a tail pointing east down the Royal Mile.

Digging under the Castle would be very difficult, the rock is a very hard volcanic rock, almost impossible to dig into. Luckily for the Castle's inhabitants there's a well inside which

provides a source of fresh water. The water flows up from aquifers within the rock and can be accessed by the well. The well was dug through a small weakness in the rock.

Swamp Volcanoes

During the Carboniferous (359-299 million years ago), 50 million years after the Pentlands volcanoes, Scotland was warm, wet and covered with plant and animal life. After millions of years of burial deep in the Earth the plants turned into the huge coal reserves of the Lothian coal fields.

Edinburgh was low lying land covered in forest and swamp. Huge rivers wound their way through the landscape into a shallow sea. The small volcanoes scattered around the region were the only high ground. These volcanoes erupted runny lavas that could flow for many kilometres, different from Blackford's viscous lava.

If the volcano's vent was submerged, the rising magma would instantly boil the water. The volume of water increases when liquid water is converted to steam, this causes an explosive eruption which throws ash high into the atmosphere. The ash fell down on the landscape to create ash beds as seen at Arthur's Seat.

When the volcanoes became extinct they were buried by sediment, during distant mountain building events the rocks here were compressed and tilted to the east.

Eyjafjallajökull eruption in 2010. Photo's courtesy of Thorvaldur Thordarson (University of Iceland). The eruptions at Arthur's Seat vent will have been much like the early stages of this eruption. The lower image is a volcanic vent and lava fountain (people for scale) that feeds a lava flow (top), the volcanic vent is relatively small and lava flows can flow for many kilometres.

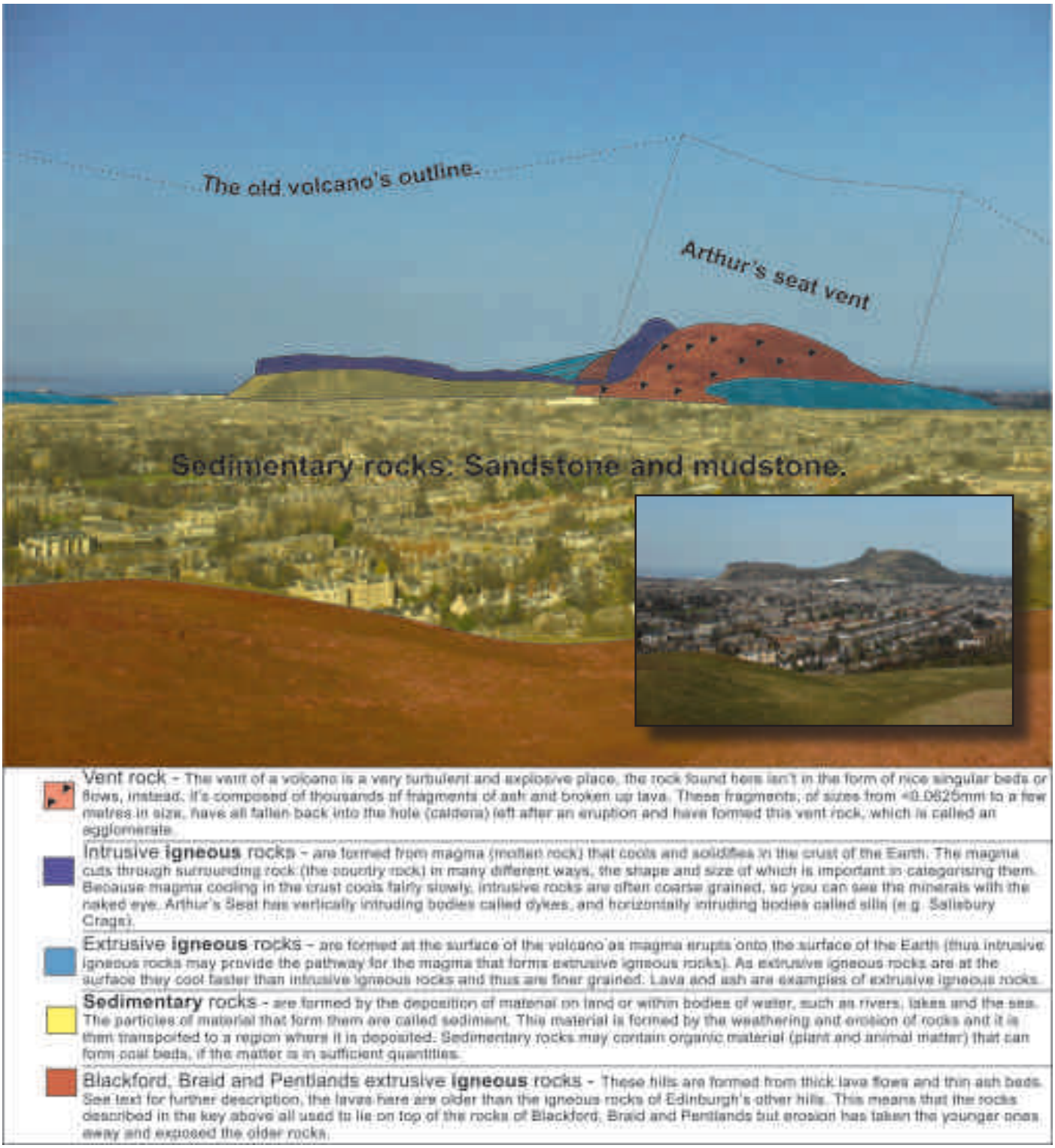
Extra sites:

At the north entrance, by Blackford pond, you can see glacial erratics (large blocks carried by glaciers).

A small quarry south of the pond shows the contact between the volcanic lavas and ash of Blackford Hill, a small board gives further details.

There is a small trial adit for a barite mine in Blackford Glen, it is found around 300 metres downstream of Hermitage House.

Arthur's Seat Cross Section



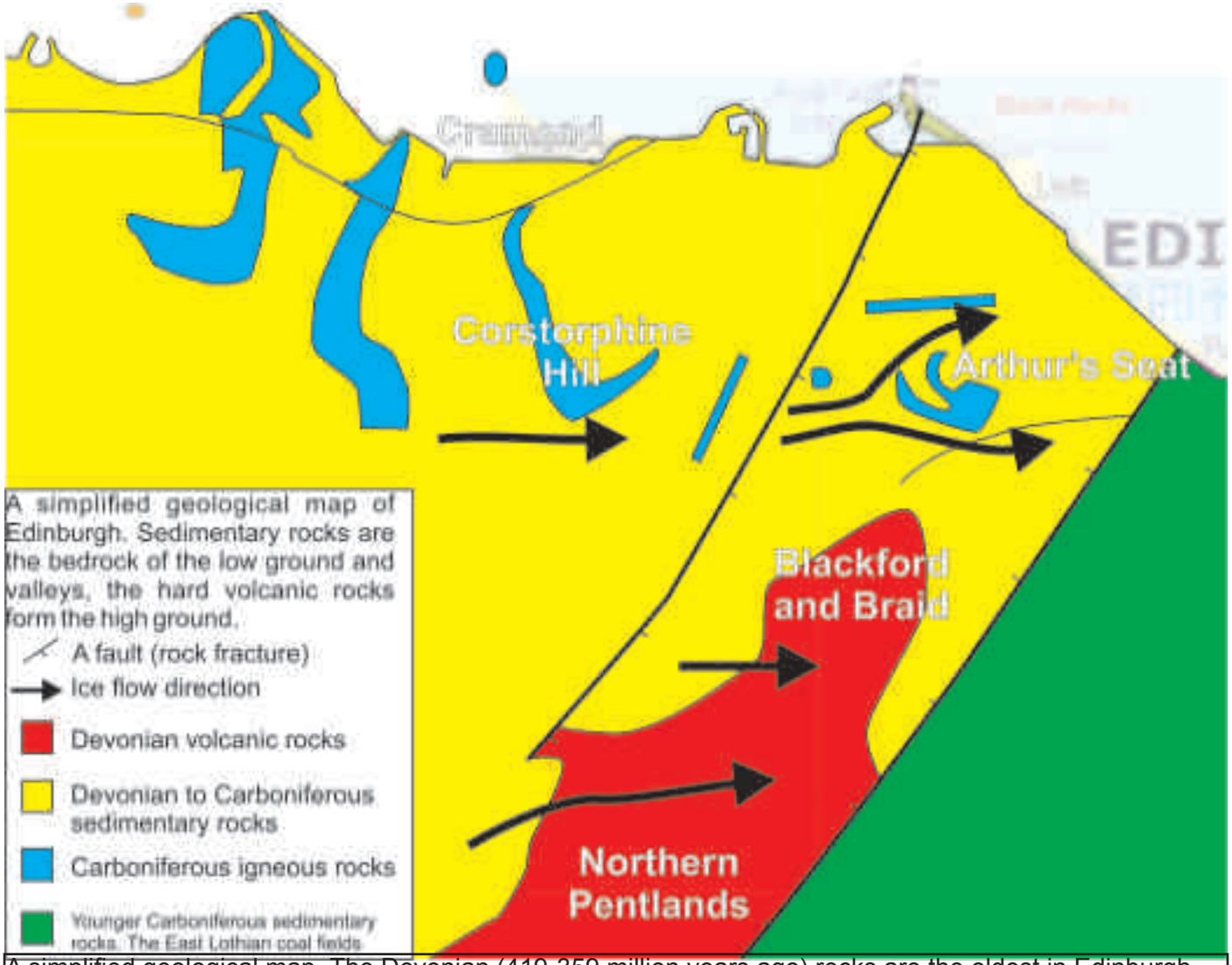
Extra Information

The Arthur's Seat and Castle Rock magma formed at depth in a dry mantle, unlike the Pentland magma which was wet.

The magmas that formed the lavas of the Pentlands were formed after an oceanic plate was forced beneath Scotland as the ocean between here and England closed and the two eventually collided. When an oceanic plate is forced beneath a continent (subduction) the wet sediments on the plate melt forming magma. This magma rises and hits the bottom of the continent. The magma can rise up and erupt at volcanoes if there is a gap for it, this is what is happening to create the Andes in South America.

However, in Scotland, no gap formed because the crust was too compressed and there's no way

Geological Map



A simplified geological map. The Devonian (419-359 million years ago) rocks are the oldest in Edinburgh. The Pentland volcanoes stopped erupting 400 million years ago and were then covered by sediment. 350 million years ago Arthur's Seat, Castle Rock and North Berwick Law erupted. They became extinct and covered by more sediment, tectonic forces caused the land to tilt from horizontal.

for the magma to force its way through. Then once the collision stopped, everything spread out again and the magma rose up. It worked its way through the continent slowly and became more silica rich. The magma eventually erupted onto the surface as lava or ash, a few million years after the collision.

Arthur's Seat magma formed when the crust extended slightly and formed low lying land, hot magma rose up quickly through cracks in the thin crust. The magma erupted as lava or ash without spending much time in the crust.

Acknowledgements

Most of the images within this document are the authors own, except for the Eyjafjallajokull eruption courtesy of Thorvaldur Thordarson at the University of Iceland and Lascar in Chile courtesy of Neil K. (Santiago, Chile) taken from Wikipedia and Flickr. The book "The Geology of Lothian" by Euan Clarkson and Brian Upton from the University of Edinburgh is a fantastic resource for anybody wishing to learn more of the natural history of this magnificent landscape, the book was invaluable in the writing of this document.

Thanks must be given to members of the Lothian and Borders Geoconservation group for their input into this work.