Igneous rocks

Igneous rocks crystallise from molten rock, or magma, generated within the Earth's mantle or crust. The buoyant magma rises and much of it may be intruded into rocks at higher levels in the crust to cool and crystallise as igneous intrusions. Large bodies of magma cool slowly forming coarsely crystalline rock such as granite, whilst smaller masses typically cool more quickly to form finer grained rocks. Kilometre-scale intrusions, with a rounded outline on the map, are referred to as plutons. Sheet-like intrusions that are mainly concordant with bedded sedimentary strata are called sills, and those that cross-cut strata are called dykes. Magma may also reach the surface at volcanoes, where it is erupted as lava or ejected explosively as fragments (including volcanic ash and volcanic bombs) that ultimately form pyroclastic rocks. Igneous rocks may be classified based on their silica content: those with low silica, for example basalt and dolerite, are termed basic rocks, whereas those with abundant silica, such as rhyolite and granite, are acid. Intermediate compositions include andesite and trachyte. Examples of all of these compositions and forms of igneous rock are represented within Northumberland National Park.

Igneous rocks in Great Britain

Igneous rocks with a range of compositions, forms and ages have played a significant role in the geological evolution of Great Britain and are exposed in many areas. Erosion during millions of years has exposed the igneous rocks at the surface today and careful study of them provides information both on the contribution these rocks have made to our geological evolution, and to the chemical and physical processes that have operated deep within the Earth throughout its history. Analytical techniques can be employed to determine the date of crystallisation of minerals within these rocks and hence the age of their formation. Interpretation of these dates, alongside other geological evidence, provides a method of assigning absolute dates to key events in geological history.

Most of the igneous rocks in Great Britain were emplaced during four major events: the Caledonian Orogeny, associated with closure of the Iapetus Ocean from late Cambrian to late-Devonian times; the Variscan (or Hercynian) Orogeny, associated with closure of the Tethys Ocean from mid-Devonian to early Permian times; crustal stretching during the Carboniferous and Permian periods; and crustal stretching prior to, and associated with, opening of the North Atlantic Ocean from the end of Cretaceous times to the present day. Older igneous activity is also recognised within Precambrian rocks.

Igneous rocks in the district

Igneous rocks contribute substantially to the geodiversity of Northumberland and give rise to two of the most impressive landscapes of the district, namely the Cheviot Hills in the north and the Hadrian's Wall country in the south. The Cheviot Hills are constructed almost entirely of igneous rocks, both volcanic and intrusive, that were emplaced during Devonian time, towards the end of the Caledonian Orogeny. By contrast, igneous rocks in the south of the district were intruded into the Carboniferous sedimentary rocks during the episode of crustal stretching that lasted from Carboniferous to Permian times. Some representatives of the latest igneous episode, associated with the opening of the North Atlantic Ocean, are also present within the district, particularly in the north.

Igneous rocks in the Cheviot massif

Igneous rocks in the north of the region belong to three of the major events outlined above:

- The Cheviot Volcanic Formation of Devonian age
- The Cheviot Granite Pluton, of Devonian age
- Various dykes and minor intrusions of Devonian age
- The Cottonshope Volcanic Formation of early
- Carboniferous age

- Cainozoic (‘Tertiary’) dykes

Cheviot Volcanic Formation

The Cheviot Volcanic Formation comprises a succession of lavas with intercalated pyroclastic and sedimentary rocks. It is poorly exposed over an area of about 600 square kilometres and its thickness is about 500 metres.

The original thickness of volcanic rocks probably exceeded 2000 metres, making the Cheviot volcanic eruptions comparable in size to the late Ordovician volcanic rocks in the Lake District which record one of the most violent volcanic episodes in our history. The volcanic rocks unconformably overlie steeply dipping, tightly folded sandstone and cleaved mudstone of the Silurian Riccarton Group and are overlain by either Upper Old Red Sandstone Group conglomerates containing abundant andesite and granite clasts, or by lower Carboniferous beds, only some of which contain andesite fragments.

The basal unit of the formation in the south-west of the outcrop is well exposed in a rocky slope above the River Coquet, between Makendon and Fulhope [NT 8111 0992]. Here, about 60 metres of breccia are composed of angular to subangular blocks of rhyolitic volcanic rock along with some mudstone fragments. Intercalations of pyroclastic and volcaniclastic sedimentary rocks are present higher in the succession, though they are sparse. Fragments of green fine-grained sandstone and siltstone are commonly seen in streams suggesting that this lithology is more common in the succession.

The lavas are andesitic and rhyolitic in composition and contain a variety of phenocrysts. There are also a few sheets of trachyte (previously described as ‘mica-felsites’) containing phenocrysts of biotite and feldspar. Many original features of the lavas are well displayed in the roadside exposure alongside the River Coquet. These features include irregular accumulations of blocky fragments on the top of the lava that formed as it flowed. Abundant amygdales that occur near the top of the lavas were originally gas or steam bubbles (vesicles) frozen in the lava and filled later with minerals such as calcite. Flow banding and platy jointing, characteristic of the central parts of the lavas.

A section through a thin lava, resting on an irregular surface cut in the underlying lapilli-tuff (volcanic ash) is well exposed at Blindburn [NT 8298 1079] in the upper Coquet valley. The more readily weathered pyroclastic and sedimentary rocks between the lavas have been eroded in some areas to form a prominent bench and scarp landscape. The benches reflect the gentle eastward dip of the sequence.

Fossils have not been found in these rocks. The lavas are thought to have been erupted in a subaerial setting though some of the sheets may be sills, intruded at shallow levels within the volcanic pile. There is no evidence that the volcanoes were like the classic conical structures such as those seen in the Andes of South America, rather there were probably a cluster of smaller volcanoes with gentle slopes. The radiometric age of about 396 million years determined on these rocks indicates that volcanism occurred in mid-Devonian time.

Over parts of the outcrop the volcanic rocks are completely weathered to a clay deposit, which in parts may be more than 10 metres thick. The primary igneous textures are preserved, indicating that the alteration occurred in situ (p. 69).

Cheviot Granite Pluton

The Cheviot Granite is a broadly conical-shaped pluton that forms the central core of the Cheviot massif. The pluton has an outcrop of about 60 square kilometres, and a diameter of nearly 20 kilometres at a depth of 4 kilometres. Several phases of intrusion emplaced a suite of grey, pinkish grey and pink granitic and related rocks. In addition to the typical minerals associated with granitic rocks (quartz, orthoclase, plagioclase and biotite) some pyroxene is also present, and this is a rare feature of rocks of this composition in Great Britain.

The Cheviot Granite was intruded into the surrounding Cheviot volcanic rocks, with which it is considered to be related, about 395 million years ago in mid-Devonian time. At the pluton margin, in Common Burn [NT 930 265] and Hawsen Burn [NT 953 225], granite penetrates the adjacent volcanic rocks in a complex of dykes and veins, providing an insight into how this large igneous intrusion was emplaced. The volcanic rocks were thermally metamorphosed, in places up to 2

kilometres away from the contact (p. 54).

In this upland moorland region the granite is poorly exposed, except in some valleys and on the tors, such as Little Standrop and Great Standrop, for which the region is renowned (p. 69). A notable feature is the preservation locally of deeply weathered granitic rock. Here, grains of quartz are set in a matrix of clay minerals derived from the complete alteration of the original feldspar, biotite and pyroxene crystals. The original igneous texture is preserved, indicating that the alteration occurred in situ.

Devonian dykes and minor intrusions

A swarm of rhyolitic and trachytic dykes was intruded into the volcanic rocks and granite during Devonian time. These dykes form an impressive radial pattern centred on the granite, which together with compositional similarities to the granite and volcanic rocks suggests that they all belong to the same event. The reddish colour of the weathered surface of many of the dykes, compared with the grey or purple of the volcanic rocks, has enabled some to be traced for several kilometres across country. The dykes are typically up to 10 metres wide, but one example, exposed in the River Coquet, near Kateshaw Crag [NT 8794 0784], is at least 30 metres wide.

A distinctive red porphyritic rhyolitic rock, allied to the above dykes, crops out on the southern margin of the Cheviot Hills near Biddlestone [NT 961 084] and is extracted at Harden Quarry. This intrusion has been interpreted as a laccolith, a body of igneous rock that is roughly concordant with the strata into which it is intruded, but which has a planar base and a domed roof.

Cottonshope Volcanic Formation

The Cottonshope Volcanic Formation is a thin succession of basaltic lavas, that represents the only exposed record of volcanic activity associated with development of the Northumberland Trough in early Carboniferous time. The lavas crop out in a handful of localities south-west of the Cheviot massif, including Spithope Burn [NT 760 050), Hungry Law [NT 747 062], and between the Baseinghope Burn [NT 700 045] and the Chattlehope Burn [NT 730 028]. They are thickest and best exposed in the valley of the Cottonshope Burn, in Upper Redesdale [NT 803 058].

The upper part of the Cottonshope valley provides a complete section through the lava succession. There, lower Carboniferous strata dip about 10° to the south- south-west or south. The lowest basalt is underlain by sandstone and mudstone of the Kinnesswood Formation. The volcanic rocks are overlain by rocks belonging to the Ballagan Formation.

Three basalt lavas comprise the volcanic succession, the lowest two are exposed in a small road-metal quarry. The lowest is 12 metres thick and has an undulating scoriaceous (fragmented and clinkery) top containing pockets of sandstone. This is overlain directly by vesicular basalt, 6 metres thick. The uppermost basalt is also 6 metres thick, but is separated from the underlying ones by 6 metres of bedded mudstone, flaggy sandstone and ‘cementstone’. The basalt contains small phenocrysts of olivine.

The lavas were probably erupted at approximately the same time as other basaltic lavas and intrusions from Central Scotland south to Derbyshire, including the Birrenswark and Kelso lavas in the nearby Southern Uplands, and the Cockermouth lavas in north Cumbria.

Cainozoic (‘Tertiary’) dykes

The rocks of northern England are cut by numerous basalt and dolerite dykes trending approximately east-south-east. The distinctive magnetic signature of these dykes reveals that they belong to a swarm of dykes that emanated from the large volcano centred on the Isle of Mull approximately 58 million years ago in Paleocene times. The orientation and composition of these Cainozoic dolerite dykes distinguishes them from the late Carboniferous dykes associated with the Whin Sill-swarm. At outcrop many, but not all, of the Cainozoic dykes contain small but conspicuous phenocrysts of plagioclase.

Some of the dykes are impressive in their length. The most prominent of this suite of intrusions in the National Park is the Acklington Dyke which intrudes Silurian to Carboniferous rocks from the Scottish Borders through Northumberland and into the North Sea. Small exposures of this dyke may still be seen in the River Coquet [NT 8646 0864], east of Dumbhope, and in the Cartington area. At Acklington the dyke was reported to be up to 10 metres wide.

Though the dykes individually appear not to be very significant, collectively they were derived from a huge volume of magma. It has been estimated that the Cleveland Dyke, seen to the south-west from Cumbria to North Yorkshire, represents a volume of at least 85 cubic kilometres. Numerical modelling of this dyke suggests that it emanated in a single pulse from a magma reservoir beneath Mull at a velocity of up to 18 kilometres per hour, reaching its furthest point in less than five days.

Igneous rocks in the centre and south of the district

The igneous rocks of this region are entirely intrusive into the Carboniferous succession. They belong to the Whin Sill-swarm and were associated with contemporaneous dykes that were emplaced during late Carboniferous to early Permian times.

Geological SSSIs

Carboniferous and Permian Igneous rocks:

Cottonshope Head Quarry [NT 803 058]

Steel Rigg to Sewingshields Crags [NY 751 676] to [NY 813 704]

Wydon [NY 695 629]

Geological SNCIs

Allerhope Burn [NT 925 105]

Barrasford Quarry [NY 910 742]

Toddle [NY 91965 75381]

Reaver [NY 92878 75678]

Blindburn [NT 8307 1087]

Canker Cleugh [NT 795 070]

Carshope [NT 840 109]

Cawfield Crags [NY 71779 66812]

Divethill and Claywalls [NY 97 80], [NY 979 797]

Earlehill Quarry

Flodden Quarry [NT 91294 35878]

Fredden [NT 95481 26737]

Preston [NU 18533 25461]

Yeavering Bell [NT 92812 29295]

Haltwhistle Burn [NY 710 658]–[NY 708 645]

Harelaw etc. Burns [NT 985 195]

Horsdon Channel

Kyloe Hills [NU 04865 39014]

Raker Crag [NT 84885 10019]

Shiellow Crags [NU 05174 37465]

Shillhope Cleugh [NT 869 088]

Upper Breamish and Bloodybush Edge [NT 902 143]

Usway Burn [NT 875 105], [NT 885 155]

Walltown Quarry [NY 670 660] and Walltown Crags [NY 668 658]

Windyhaugh [NT 715 049]

Whin Sill-swarm and associated dykes

The group of four dolerite sills that comprise the Whin Sill- swarm has a roughly arcuate outcrop that extends across northern England from the Farne Islands in the north, south to Lunedale in the North Pennines. Three of these sills are present in Northumberland, the best known being the Great Whin Sill. From their surface outcrop, the sills dip gently to the east, south-east and south, more or less concordantly with the Carboniferous rocks into which they were intruded. Overall, these intrusive igneous bodies underlie more than 4500 square kilometres of northern England and beyond, beneath the North Sea.

The sills were intruded during late Carboniferous to early Permian times, probably between 301 and 294 million years ago. At this time, the rising Variscan mountains across mainland Europe and southern Britain, coupled with the reconfiguration of the Earth's tectonic plates far to the east, caused the crust in the area of what is now northern England, the Midland Valley of Scotland and parts of the North Sea to be stretched and ruptured. The rupturing allowed huge volumes of magma (at least 215 cubic kilometres in northern England alone), derived from the Earth's mantle, to be intruded between the layers of pre-existing sedimentary rocks at relatively shallow depths beneath the contemporary surface.

The intrusion of such large volumes of molten rock, at temperatures of 1100°C or more, affected the adjacent rocks, baking and altering them (p. 54).

Though the sills are broadly concordant with bedding in the sedimentary rocks into which they were intruded, each sill is up to 50 metres thick in Northumberland, and saucer shaped, rising by a series of steps to higher stratigraphical levels towards their outer extents. Whereas in much of the outcrop the sills occur as single sheets, east of Throckrington at least two, and in the Kyloe Hills up to five, separate sheets are present at different stratigraphical horizons. The change in stratigraphical level is best illustrated by the geological maps of the region, though small-scale changes in level can be seen at outcrop, for example at Cawfield's Quarry.

The sills are characterised by features that are typical of sills worldwide. Locally, for example at Barrasford Quarry, narrow, dyke-like masses of dolerite protrude from the upper surface of the sill into the overlying strata. At the base of the sill in places, the underlying sedimentary rocks have been levered up into the sill during intrusion; this is seen for example at Howick Quarry. Also, fragments of sedimentary strata ranging in size from just a few centimetres to several tens of metres ('rafts'), have become detached to 'float' within the body of the sill, as seen at Barrasford and Longhoughton quarries. Columnar joints, developed during cooling of the intrusion, occur in many natural exposures and

in quarries, for example at Sewingshields and Walltown.

The dolerite is a dark greenish grey rock in which individual constituent minerals are visible with the aid of a hand lens. Close to the sill contacts with the surrounding sedimentary rocks, the magma chilled rapidly, resulting in a very fine-grained or almost glassy rock. Irregular patches and veins of coarser grained, pegmatitic dolerite, characterised by clusters of long, feathery pyroxene crystals, and of fine-grained pink (aplitic) rock, are rare in Northumberland, though the former rock type has been observed recently in Keepershield Quarry [NY 896 727] and the latter from Barrasford Quarry [NY 910 742]. Spherical cavities (vesicles) up to 0.3 metres across, but generally smaller, are a common feature just beneath the top contact of the sills. These represent gas bubbles frozen in the cooling magma. The original vesicles were filled later by minerals such as calcite and these can be seen in fresh rock in the quarries, but in surface exposures the mineral fills have been weathered out leaving the original vesicles.

Three linear clusters of dolerite dykes, arranged en- echelon within each cluster, and similar in composition to the sills, trend between north-east and east-north-east across Northumberland. The dykes are typically 3 to 10 metres wide and are considered to have been feeders to the sills. The northern set of dykes, the Holy Island Subswarm, lie to the north, between Ford and the Kyloe Hills. South of the Cheviot Hills, and emplaced along the Swindon and Cragend-Chartners faults, is the High Green Subswarm which can be traced for over 80 kilometres; one of the dykes has a width of up to 65 meters. And, farther south, the St Oswald's Chapel Subswarm can be traced from the Tyne valley, eastwards to the coast at Druridge Bay. One of this last set of dykes, the Haydon Bridge Dyke, is exposed in the north bank of the River Tyne at Wydon Nabb, near Haltwhistle.

Influence on the landscape

The Devonian lavas and granitic rocks form the massive rounded hills of the Cheviot massif, much of which lies above 300 meters, with the highest point on The Cheviot at 815 meters. The valleys are deep with steep- sided convex slopes. The rocks are not well exposed, except in the valley bottoms and on the tors, which characterise the hilltops on the granite, and where the volcanic rocks have been metamorphosed in contact with the granite. Crags are few, though notable exceptions are Bizzle Crags and Hen Hole to the north and west of The Cheviot respectively. In the eastern half of the massif, the drainage pattern that has developed on the igneous rocks is relatively simple and the density of streams is low. This contrasts markedly with that on the western side where the drainage pattern is intricate and dense. The wide, strikingly linear valley of the Harthope Burn has been carved along a major fault through the massif.

The lavas of the Cottonshope Volcanic Formation are marked by small, dark-coloured craggy outcrops which contrast with the surrounding outcrops of Dinantian sedimentary rocks. Small, long-abandoned quarries mark the outcrops. Because of their very small surface outcrop these rocks have only a modest effect of the district's landscape.

The Whin Sill-swarm is one of the best known features of Northumberland geology and is responsible for some of the county's finest, and most distinctive scenery.

The north-facing cliffs, with the long, gentle southerly slopes, provided the Roman civil engineers with a natural defensive site for the construction of Hadrian's Wall. The massive, hard and resistant columnar-jointed dolerite imparts a distinctive character to these outcrops, which contrasts strikingly with the generally lower ridges and crags (cuestas) formed by parallel outcrops of Carboniferous sandstone and limestone.

The Great Whin Sill was formerly worked on a large scale in quarries at Walltown and Cawfields. Landscaping of the former site has significantly lessened its visual impact as a man-made feature. In contrast, the profile of Cawfields Quarry stands as an obvious interruption to the line of Whin Sill crags. Both quarries offer opportunities to appreciate the nature of the Whin Sill and its role in creating the distinctive landscape of the Hadrian's Wall country. The crags at Steel Rigg and elsewhere are popular rock climbing localities.

East and north of Sewingshields the Whin Sill outcrops are locally concealed beneath spreads of superficial deposits. However, steep escarpments with bare crags of dolerite can be seen at Teppermoor Hill, around Gunnerton Nick and in the Swinburne, Thockrington, Sweethope, Bavington, Fontburn and Kyloe areas. Large working quarries at Keepershield, Barrasford, Swinburne, Divethill, Howick and Longhoughton are conspicuous features in the local landscape, though their

visual impact is subject to strict planning and environmental constraints. There are also abandoned quarries at Thockrington, West Whelpington, Ward's Hill and Ewesley.

Neither the Carboniferous, nor the Cainozoic dykes make any significant impact on the district's landscape; small long-abandoned quarries are still visible in the Acklington Dyke near Cartington.

Influence on biodiversity

The steep-sided valleys on the Cheviot volcanic rocks typically host grassland dominated by bent and fescue grasses or bracken, which alternates with areas of broken rock; much of this current pattern of vegetation results from modification by sheep grazing. The screes have sparse vegetation dominated by ferns including lemon- scented and parsley ferns. Soils derived from the volcanic rocks are usually base-rich and support some uncommon species such as maiden pink, Jacob's ladder, common rockrose and hairy rock cress. At higher levels where slopes have lower angles, this gives way to a heather heath/acid grassland mosaic. On the flatter summits extensive areas of blanket bog have formed in the cool wet climate. Here species such as Sphagnum mosses, cottongrasses, cross-leaved heath and cloudberry are characteristic. Arctic alpine species and communities persist on The Cheviot, particularly on ungrazed ledges. Upland lichen species such as *Umbilicaria torrefacta*, *Melanelia hepatizon* and *Sphaerophorus fragilis* occur on Cheviot itself, the Bizzle and Henhole have the richest flora and *Cladonia rangiferina* has been recorded from Braydon Crag.

Where free, or comparatively free, of superficial deposits, Whin Sill outcrops typically support rather thin, acid soils, which in places support a distinctive Whin Sill grassland flora including wild chives, biting stonecrop, rue-leaved saxifrage and mountain pansy.

Craggy outcrops, including those in abandoned quarries, offer important nesting sites for birds including kestrels, raven and peregrines, and possibly roosting sites for bats.

Economic use

The physical properties of the Whin Sill dolerite make it a good source of roadstone, crushed rock aggregate, rip- rap and armour stone. 'Northumberland Whinstone' has long been exploited for these purposes from quarries across the outcrop. Its intractable nature generally precludes its use as a building stone, though it has been employed locally in a few buildings, notably the now abandoned quarrymens' cottages at Barrasford Quarry. Large, abandoned quarries in the main sill at Walltown, Cawfields and West Whelpington were once important sources both of crushed rock for roadstone, and as shaped blocks or setts, for road paving and kerb stones. Similar dolerite was formerly worked from the Haydon Bridge Dyke, at West Mill Hills, east of Haydon Bridge: this quarry was backfilled and the site completely landscaped in the early 1980s. It was also formerly worked from one of the Carboniferous dykes north of Bellingham.

Very small pits have been worked for dolerite from the Cainozoic Acklington Dyke in the Cartington area, though there are no operating quarries within the present district.

'Whinstone' quarrying remains an important industry in Northumberland today, with quarries at Keepershield, Barrasford, Swinburne, Divethill, and, just outside the district, Howick and Longhoughton supplying crushed dolerite products for use widely across northern England.

On the south side of the Cheviot massif, the small intrusion of Devonian age near Biddleston has been worked for crushed rock and roadstone at Harden Quarry [NT 958 086]. The natural bright red colour of the rock makes it sought after for specialised uses such as surfacing the hard shoulders on Britain's motorways and, perhaps most famously, for lining The Mall in London.

The Cottonshope basalts have been quarried on a modest scale, probably mainly for local use as roadstone and walling stone. There is extensive use of local volcanic stone for walling despite its round profile.

Future working of any mineral deposit is dependent upon a complex range of commercial and planning considerations, but it seems likely that demand for roadstone, crushed rock and the other products currently extracted within the district

will continue for the foreseeable future. Substantial reserves of rock of satisfactory quality are understood to remain at several, or all, of the working quarries within the district. Additional workable reserves of dolerite capable of meeting commercial specifications could no doubt be identified within the district, though planning and environmental conditions would have to be met in any proposals for working.

Conservation issues

The natural exposures of igneous rocks within the district are generally robust and none appears to be under threat.

Working quarries typically provide excellent representative sections of the geology, but by definition quarrying destroys the materials worked. However, the continually changing nature of the sections can yield invaluable insights into the rocks exposed. Accurate recording of such sections, accompanied by the collection and curation of representative specimens, can play a vital role in maintaining and furthering knowledge and understanding of the local geology.

By contrast, abandoned quarries are potentially at risk of becoming degraded or overgrown, either due to natural deterioration or by inappropriate after-use and management. The planting of trees adjacent to the fine Whin Sill section at Walltown Quarry may be cited as an example of inappropriate management of a valuable and instructive geological site. The use of old quarries for landfill may threaten to damage or totally obliterate important sections, though none is known to be under any such immediate threat within the district.

The quarry faces at Cottonshope Head Quarry are now rather weathered, and in places degraded. Consideration might be given to restoring this section. The district also includes several abandoned quarries which, because of the significant geological features exposed, merit consideration for protection. Of particular note are the sections through the Whin Sill and adjacent country rocks at Ward's Hill Quarry. In addition to the range of geological features exposed here, the site has considerable historical significance for its place in the development of ideas on the nature and origin of the Whin Sill.

Exposures of the Acklington Dyke and adjoining wall- rocks at Cartington, though comparatively modest, offer a rare opportunity to examine this important, though otherwise poorly exposed, intrusion.

The Scroggs is an example of an SNCI listed for botanical interest that has geological links. This is an exceptional piece of grassland on the contact zone between the Whin Sill and limestones in the Tyne Limestone Formation. The pasture is among the richest found on any of the Whin Sill sites and its flora is outstanding with many species uncommon in north-east England.

Wider significance

The Cheviot volcanic rocks and Cheviot Granite are among the southernmost occurrences of a suite of igneous rocks of late Silurian to Devonian age, the members of which are distributed northwards to Orkney and Shetland. Volcanic rocks of this suite form such notable areas as the Ochil and Sidlaw Hills in the Midland Valley of Scotland, and the caldera-volcano at Glencoe in the Highlands. Though modern studies of the Cheviot rocks are few, these rocks contribute to our wider understanding of this important phase of igneous activity in the evolution of the British Isles.

The Whin Sill is generally regarded as the original sill of geological science and therefore has to be regarded as one of the district's most important natural heritage features. It takes its name from the north of England quarryman's term 'whin', meaning a black, generally hard and intractable rock, and 'sill', meaning any more or less horizontal or flat-lying body of rock. Recognition of an intrusive igneous origin for the Whin Sill during the 19th century was based largely on studies within the present district, notably on sections exposed at Ward's Hill Quarry. Consequently, the term 'sill' became adopted by geological science for all near-horizontal and, within stratified sequences, broadly concordant, intrusive igneous bodies.

Since then, many studies of the Whin Sill-swarm and its associated dykes have drawn upon evidence gathered from its exposures in Northumberland and much of the large volume of earth science literature derived from these studies has significance well beyond the county.

In addition to its geological importance, the striking geomorphological expression of the Whin Sill, and its exploitation by the Romans, has produced an internationally recognised landscape.

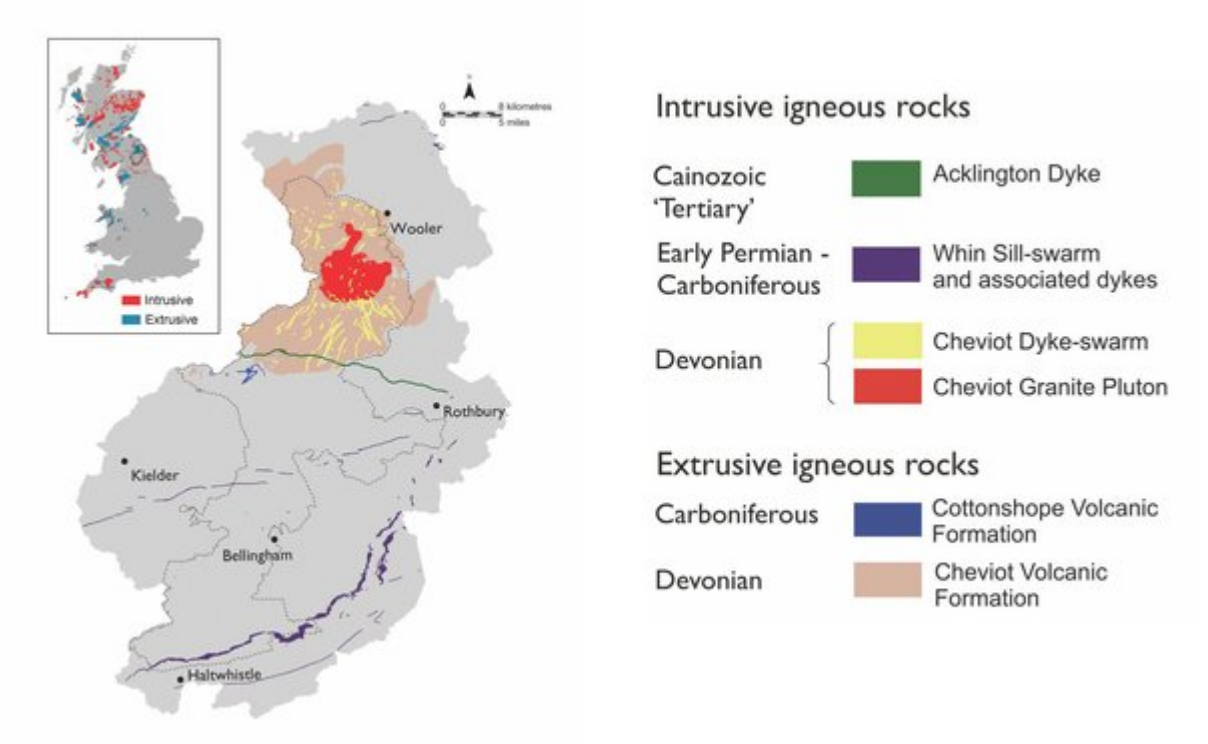
Figures

(Figure 35) The distribution of igneous rocks in the district.

(Figure 36) Photomicrographs of thin sections of igneous rocks taken under crossed polarizers A — Granitic rock from the Cheviot Pluton. The speckled grey mineral is feldspar, the smaller irregular white and grey mineral is quartz and the brightly coloured minerals are mica (biotite) and a small amount of pyroxene. B — Pegmatitic dolerite from the Whin Sills: the brightly coloured mineral is pyroxene, the grey mineral is plagioclase feldspar and the small black grains are an iron oxide.

(Figure 37) Outcrops of the Acklington Dyke in the River Coquet at Dumbhope.

(Figure 38) Crudely polygonal columnar jointing in Whin Sill, Sewingshields Crags.



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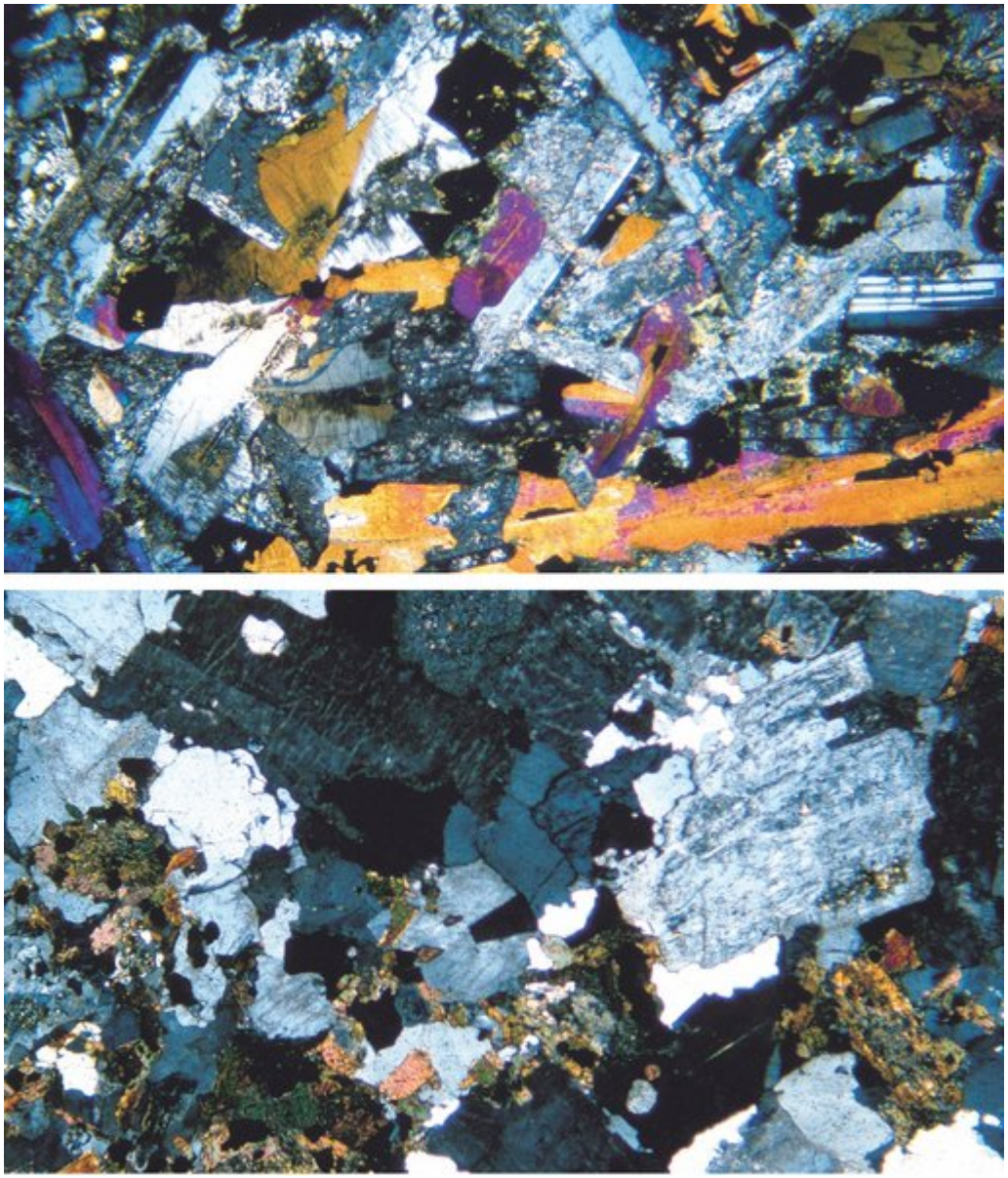

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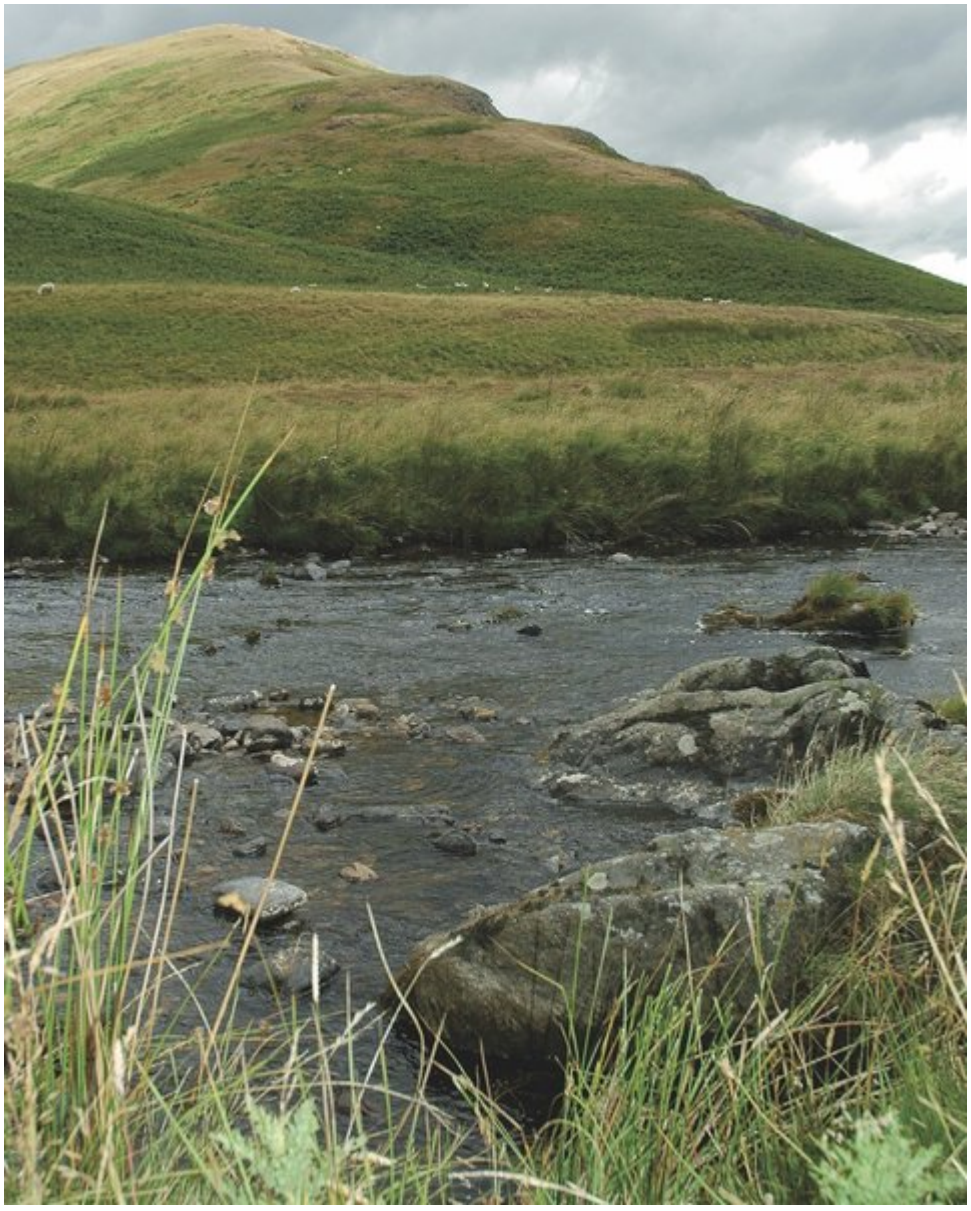

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