OR/13/015 Geographical and geological context

Gillespie, M R, Everett, P A, Albornoz-Parra, L J, and Tracey, E A. 2013. A survey of building stone and roofing slate in Falkirk town centre. *Nottingham, UK, British geological Survey*. (OR/13/015).

Geographical setting

Falkirk sits approximately in the centre of the Central Belt of Scotland, roughly equidistant from Edinburgh and Glasgow and around four kilometres south-east of the Firth of Forth (Figure 1). The town has for centuries occupied a strategically important position in the centre of the narrowest, most populous, and most industrial part of Scotland, and through-routes have long converged on the area. Drove roads, which brought cattle to markets (trysts) in Falkirk in the 18th Century, were succeeded by highways that generally followed the ancient ways. Later, the Forth and Clyde Canal (1790), the Union Canal (1822), and two railways (1840s) were built through, or close to, Falkirk.

Falkirk town centre is a compact area of irregular streets, wynds and closes lined by buildings constructed in a wide range of architectural styles using natural stone and modern materials. The oldest surviving buildings were constructed in the 17th Century.

The Falkirk Town Centre Conservation area, designated in 1971, includes the main historic parts of the town centre. Falkirk Council was awarded a Round 1 pass for a proposed Townscape Heritage Initiative (THI) in May 2012. The THI area encompasses much of the historic core of the town at the heart of the Conservation Area (Figure 2).

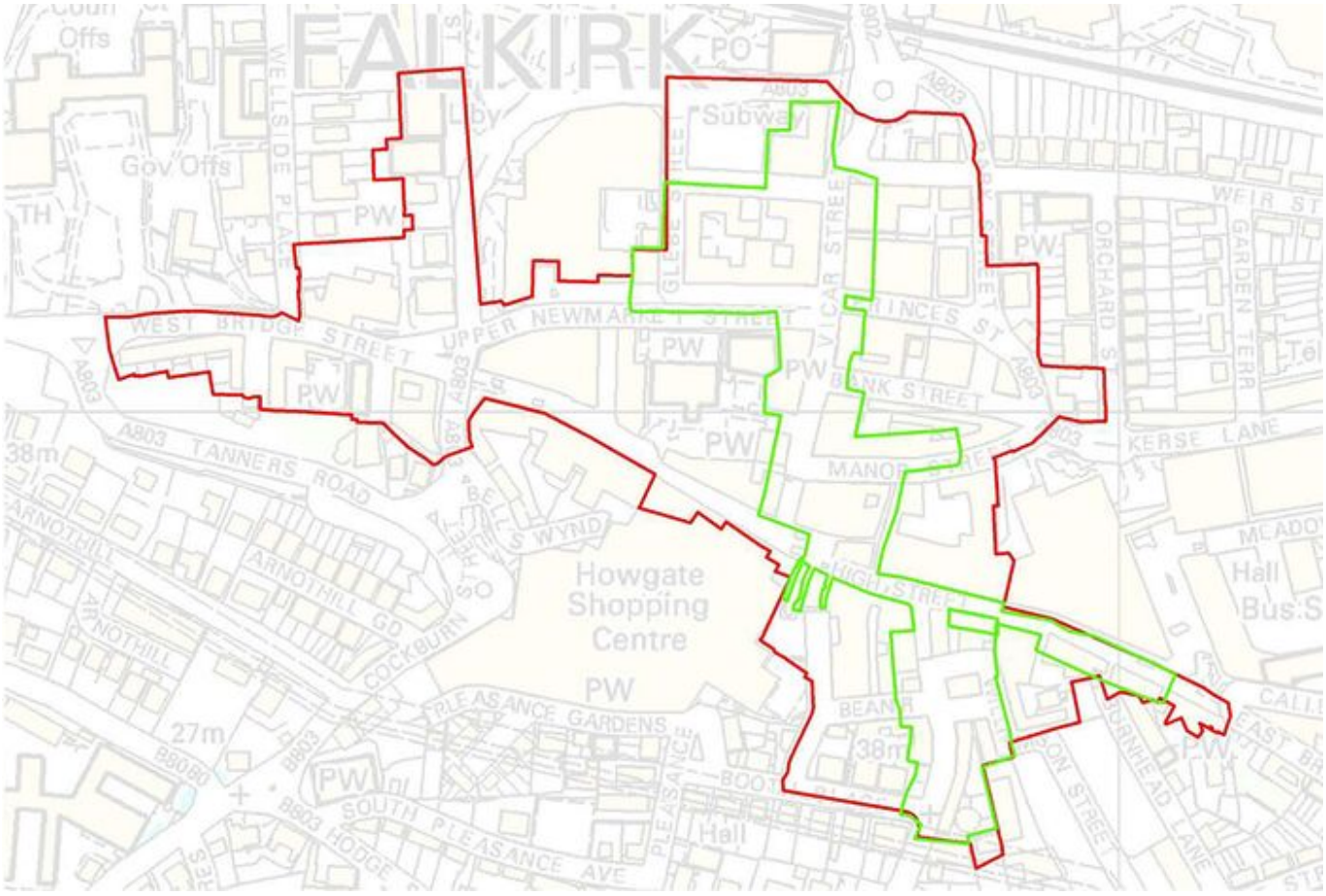

Figure 2 Topographic map of Falkirk town centre.
Red outline is the Falkirk Town Centre Conservation Area. Green outline is the Falkirk Townscape Heritage Initiative (THI) area. The map includes mapping data licensed from Ordnance Survey. © Crown Copyright and/or database right 2013. Licence number 100037272.

Geological setting

Introduction

The Central Belt of Scotland is underlain by the *Midland Valley terrane*, one of several major blocks of crust on which Scotland sits (Figure 3). The Midland Valley terrane is bounded by two major geological faults: the Highland Boundary Fault to the north and the Southern Upland Fault to the south. The Midland Valley terrane has been downthrown on these faults relative to the blocks to the north and south, with the result that the rocks underlying the Central Belt are younger than those beneath the Highlands and Southern Uplands. All rocks currently at outcrop in the Falkirk district formed during the *Carboniferous Period*, between approximately 350 and 300 million years ago. At that time, the land that has become Scotland lay close to the equator and the climate was tropical.

The bedrock geology of the Falkirk district is dominated by layers (strata) of sedimentary rock interrupted in places by thick piles of volcanic lava. Tabular intrusions of igneous rock, forming steeply inclined *dykes* and gently inclined *sills*, cut the sedimentary rocks in places. On geological maps and in descriptions of the bedrock geology, the sedimentary and volcanic strata are divided according to their age, position in the sequence, and rock character. The resulting *lithostratigraphy* of the Falkirk district is summarised in Figure 4, and a map of the bedrock geology is presented in Figure 5. The following section should be read while referring to these two figures.

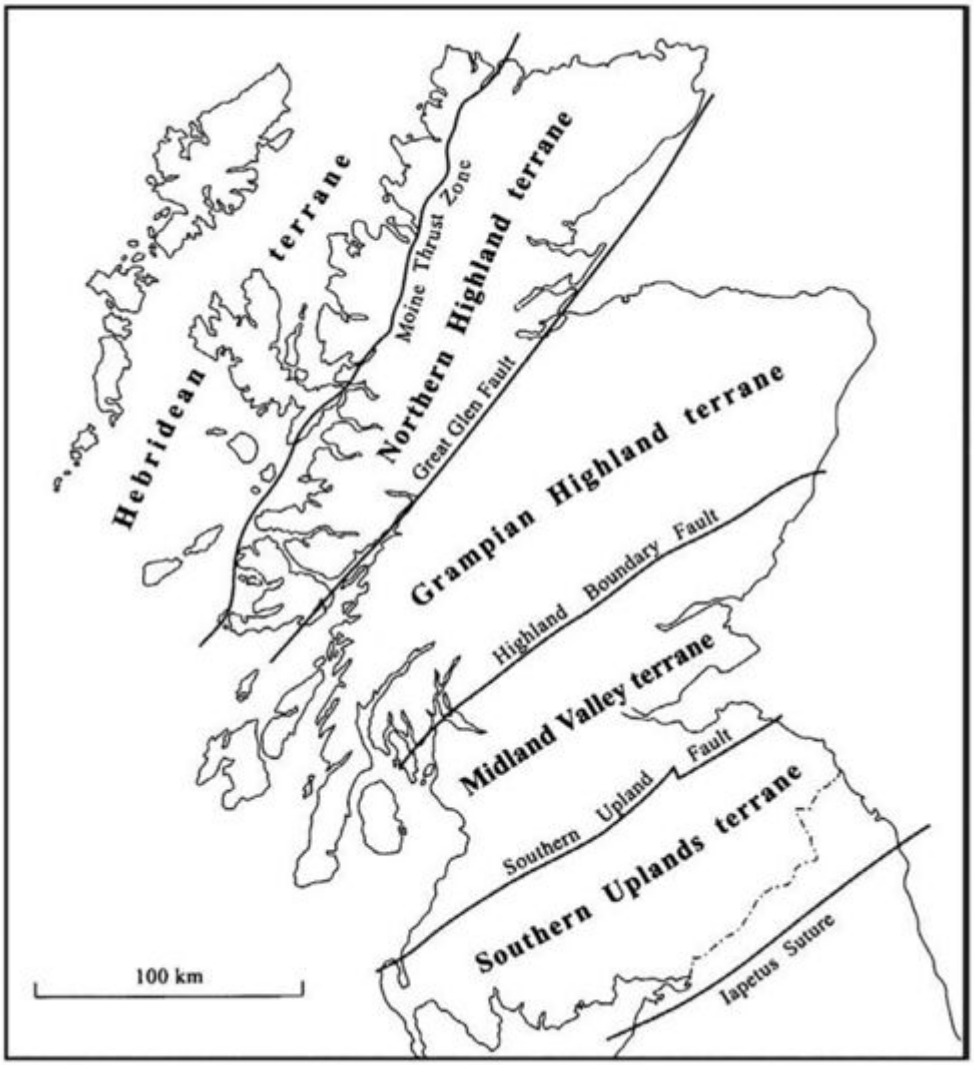

Figure 3 The major geological terranes and geological faults of Scotland.
After Trewin and Rollin (2002).

Lithostratigraphy divisions		Age of deposition		
Group	Formation	Million years ago	Stage	Period
Scottish Coal Measures Group	Scottish Upper Coal Measures Formation	c. 310-309	Westphalian	Carboniferous
	Scottish Middle Coal Measures Formation	c. 312-310		
	Scottish Lower Coal Measures Formation	c. 314-312		
Clackmannan Group	Passage Formation	c. 318-314	Namurian	
Bathgate Group	Upper Limestone Formation	c. 323-318		
	Limestone Coal Formation	c.326-323		
	Lower Limestone Formation	c. 328-326	Visean	
	West Lothian Oil-Shale Formation	c. 333-328		
Strathclyde Group	Clyde Plateau Volcanic Formation	c. 345-333		

Figure 4 Lithostratigraphy for the Falkirk district.
Each Formation is a sequence of strata that is distinct from the sequence above and below. Each

‘Group’ unites two or more formations. Information from the BGS Lexicon of Named Rock Units.

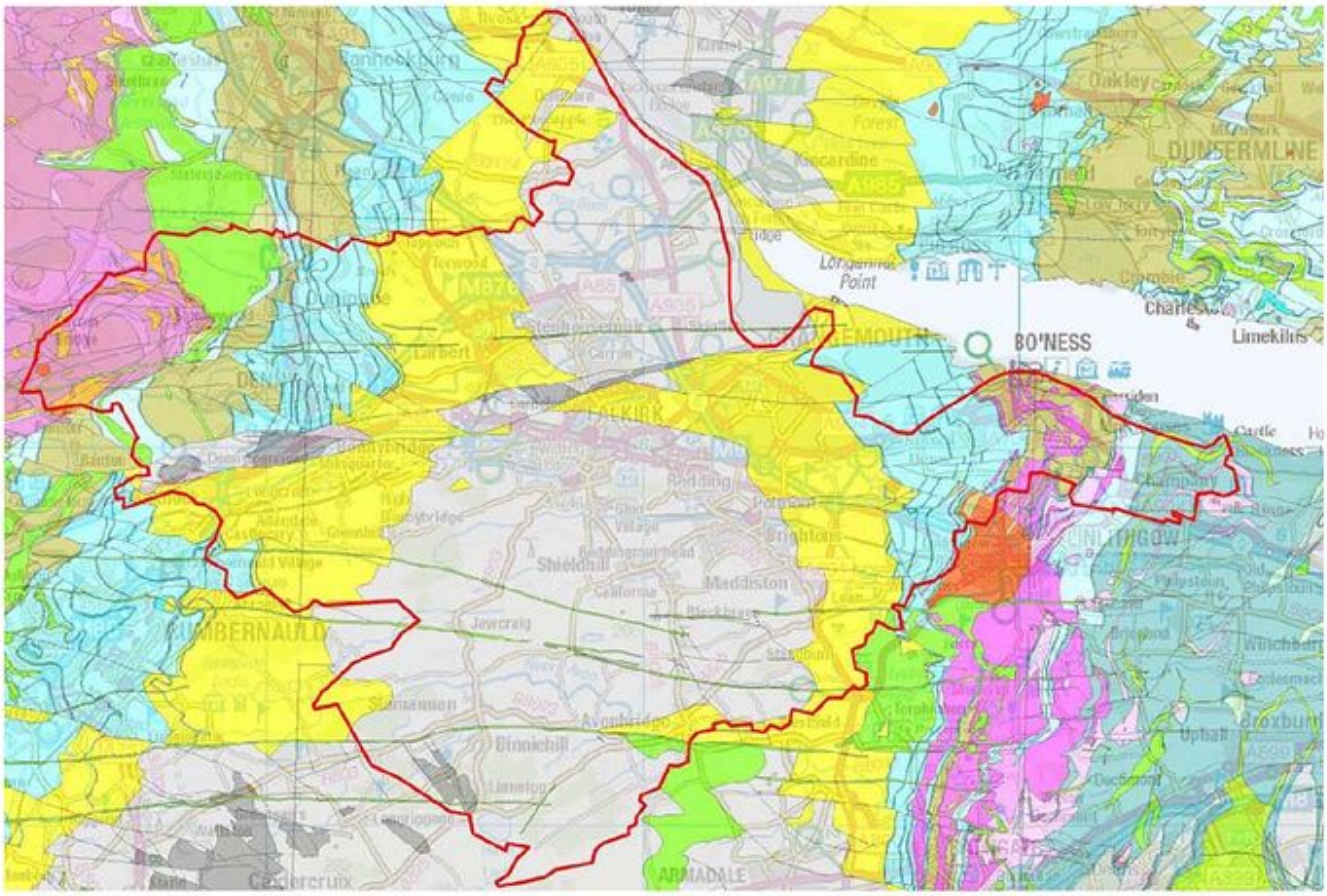

Figure 5 Bedrock geology of the Falkirk district.
Colours match those used in Figure 4. The pink area at top left is the Clyde Plateau Volcanic Formation. The pink and orange areas at lower right are the Bathgate Hills Volcanic Formation. Green areas are intrusions (dykes and sills) of igneous rock. The Scottish Upper Coal Measures Formation does not appear on this map. The axis of the Clackmannan Syncline (not shown) runs roughly north-south through the middle of the Scottish Lower Coal Measures Formation (light grey), with the same sedimentary units repeated on either side. Faults have been omitted for clarity. Red outline is Falkirk Council area (approximate). Geology information from BGS DiGMapGB50 (the BGS 1:50 000 scale digital geological map of Great Britain).

Igneous rocks

A thick pile of lava flows forming the *Clyde Plateau Volcanic Formation* underlies the Campsie Fells and Gargunnock Hills in the north-west part of the district. These rocks, formed during the Visean Stage, are the oldest in the district. Another thick pile of lava flows forms the Bathgate Hills Volcanic Formation (part of the *Bathgate Group*). This was deposited slightly later, during the late Visean and Namurian stages, and underlies the Bathgate Hills in the east part of the district. The igneous rocks forming these lava piles generally erode more slowly than the sedimentary rocks between them, hence they tend to form upstanding massifs.

Sedimentary rocks

The sedimentary strata consist principally of sandstone and mudstone. Beds of limestone, coal and (in the oldest rocks) oil shale form a relatively small proportion of the total thickness of sedimentary strata. The sedimentary rocks were deposited as part of a very extensive river and river delta system that occupied most of north-west Europe during the Carboniferous Period. Sediment carried by rivers from a major mountain range to the north was deposited at or near sea level in a subsiding

geological basin; the sediment accumulated over tens of millions of years to form a pile of sedimentary strata several kilometres thick.

Dense forests covered the land throughout the Carboniferous Period, and large quantities of plant debris were deposited with the sedimentary materials. Thick accumulations consisting exclusively of plant debris formed from time to time, and these have since become coal. Coal seams are an economically important feature of Carboniferous strata in many parts of the world; the word *Carboniferous* means 'coal-bearing', reflecting the fact that coal beds formed globally during this time. Sandstone beds between the coal seams commonly and characteristically contain scattered black fragments of former plant matter.

During the early part of the Carboniferous Period, fine-grained sedimentary strata — including mudstone, limestone and oil shale — were deposited in lake, delta and sea-floor environments; beds of coarser rocks like sandstone are relatively rare. In the Falkirk district these strata form the *West Lothian Oil-Shale Formation*.

Repeating cycles of sedimentation, dominated by sandstone and mudstone but including coal, lasted from the later part of the Visean Stage to the Westphalian Stage. During the late Visean and Namurian stages, fluctuations in sea-level caused periodic marine flooding of the land and these events were accompanied by the deposition of thin but widespread beds of limestone. The strata deposited during this period in the Central Belt have been divided into three lithostratigraphical formations: *the Lower Limestone Formation, Limestone Coal Formation*, and *Upper Limestone Formation*. Despite their names, limestone is generally not the dominant rock- type in these units; they consist instead of interbedded layers of limestone, black to grey mudstone, and pale grey, yellow and buff sandstone deposited in repeated cycles. Seams of coal and ironstone are generally rare and relatively thin. In the Bathgate Hills area, marine limestones of Visean age were deposited on the fringes of volcanic islands. An unusual assemblage of animal fossils, including the earliest-known reptile, amphibians and land-based invertebrates, has been recovered from a bed of limestone in East Kirkton Quarry, near Bathgate (Wood et al., 1985[1]; Rolfe et al., 1994).

In the late part of the Namurian Stage, widespread uplift of the crust and erosion accompanied a period of river- (rather than river-and-delta) dominated sediment deposition. The resulting strata, called the *Passage Formation*, consist dominantly of sandstone with subordinate mudstone and relatively rare, thin beds of limestone, coal and ironstone. The sandstones of the Passage Formation are white, pale grey or yellow and occur mainly in beds that are coarse-grained at the base and become finer-grained upwards.

The Westphalian Stage saw a return to a river-and-delta environment in which was deposited the *Scottish Coal Measures Group*. The group is divided into three formations: *Scottish Lower Coal Measures Formation, Scottish Middle Coal Measures Formation* and *Scottish Upper Coal Measures Formation*. The first (oldest) of these has an extensive area of outcrop in the Falkirk district, while the middle one crops out only as small areas within the older unit. The Scottish Upper Coal Measures Formation does not crop out in the Falkirk district; the nearest outcrop lies to the south-west, around Uddingston, Bellshill and Coatbridge. The strata consist of pale yellow, grey or brown sandstone, mudstone, and coal seams, which tend to occur in upward-coarsening cycles with mudstone at the base of each cycle and a coal seam at the top.

The Falkirk district lies in the eastern part of the Central Coalfield of the Midland Valley of Scotland, and most of the district is underlain by coal-bearing strata.

Geological structure

Around 300 million years ago, the Carboniferous strata in the Falkirk district (which originally would have been essentially flat-lying) were folded into a large, shallow 'U' shape: a *syncline*. The axis of the syncline runs roughly north-south; to the north of Falkirk the structure is known as the *Clackmannan Syncline* while to the south of Falkirk it is the *Falkirk–Stane Syncline*. The syncline is asymmetric, with the strata on its west side being gently inclined while those on its east side are relatively steeply inclined. Subsequent deformation caused brittle displacement on numerous geological faults. Many of the larger faults trend roughly east-west, with smaller fault sets in other orientations. Faults are omitted from Figure 5, for clarity.

Post-Carboniferous history

There are no bedrock strata younger than Carboniferous age in the Falkirk district, and little is known of the geological history in the 300 million years that have elapsed since this period.

The entire region was overwhelmed by ice, probably on several occasions, during the geologically recent Quaternary Period (also known as the Ice Age, which began 2.6 million years ago and continues today). At different stages during the Ice Age, ice has eroded the bedrock and deposited new sediment; ice is therefore responsible for much of the present-day topography.

Economic geology

Seams of coal and ironstone within the Carboniferous strata have been mined in many parts of the Falkirk district. Oil shales were also worked in the south-eastern part of the district on the western margin of the West Lothian oil shale field. Mining was at one time the principal occupation, and coal and ironstone were the foundation of industrialisation in the district.

Sandstone for building stone has been extracted from numerous quarries in the district (see Building stone quarries in the Falkirk area), and the igneous rock in dykes and sills has been quarried in many places for aggregate.

Sand and gravel in glacial deposits has been quarried extensively for aggregate and related uses.

1. ↑ WOOD, S P, PANCHEN, A L and SMITHSON, T R. 1985. A terrestrial fauna from the Scottish Lower Carboniferous. *Nature*, Vol. 314, 355–356.

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