Wallstale, Stirling

[NS 763 900]–[NS 776 923]

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Introduction

The Wallstale GCR site shows an exceptional example of the abrupt step-like transgression of the Midland Valley Sill-complex along a preexisting fault-line. The transgressive nature of the sill-complex in relation to the Carboniferous strata it intrudes has long been recognized on the basis of borehole and mining data, but this important structural feature is rarely seen at outcrop. Three examples of such a structure are exposed in the Stirling area but this is the best exposed and the most representative. A fault plane containing a dyke-like body (a 'fault riser') links two quartz-dolerite sills that are at the same stratigraphical level but different structural levels. These field relationships prove that the magma was emplaced after movement on the fault but, despite the name 'riser', magma probably moved down the fault plane rather than up it.

The site is located about 4 km south-west of Stirling on a segment of the Midland Valley Sill-complex commonly known as the 'Stirling Sill' (Figure 6.1). The sill crops out along the western limb of the Clackmannan Syncline and forms a striking west-facing scarp extending south from Abbey Craig and Stirling Castle. As a result of transgression it is intruded at various stratigraphical levels within the Limestone Coal Formation.

The Stirling Sill is similar petrographically to other outcrops of the quartz-dolerite sill-complex except that it has pegmatitic patches a few centimetres wide, fringing quartzo-feldspathic veins in its lower part. Petrographical accounts include those by Goodchild (in Monckton, 1892), Monckton (1895) and Dinham (1927), and a detailed account of differentiation in the southern part of the sill was given by Walker (1952). General accounts, including the field relationships, were produced by Dinham and Haldane (1932), Robertson and Haldane (1937), Francis (1956), Read and Wilson (1959) and Francis *et al.* (1970). There are several aggregate quarries within the area of the site.

Description

The Stirling Sill is up to 100 m thick and dips at 5°–15° to the east. There are a number of significant E–W-trending faults in the area that pre-date the sill, one of which is known as the Wallstale Fault'. South of the Wallstale Fault the sill forms a continuous west-facing escarpment that runs from North Third Reservoir [NS 757 895] along the east banks of the Bannock Burn (Figure 6.10). In this area the sill is intruded near the base of the Lower Limestone Formation. The disused Touchadam limestone quarry lies at the foot of the escarpment just south of the Wallstale Fault. The dolerite escarpment swings abruptly to the east in the vicinity of the fault and forms an E–W-orientated line of crags (Sauchie Craig) that follow the southern banks of the Bannock Burn almost as far as Wester Craigend. Along the top of Sauchie Craig is a prominent ridge of quartz-dolerite that rises well above the upper surface of the sill. The sill dips down to the east beneath sedimentary rocks of the Lower Limestone Formation but the ridge continues beyond the eastern end of the crags [NS 769 906] as a dyke-like body 30–60 m wide. It extends for almost 400 m and then merges with the sill that forms Gillies Hill [NS 772 916] and the west-facing escarpment, north of the Wallstale Fault. The dyke-like ridge coincides almost exactly with the line of the Wallstale Fault. The fault has a downthrow to the south of 130–150 m (Dinham and Haldane, 1932) and yet the sill is intruded at the same stratigraphical level (lower part of the Lower Limestone Formation) on both sides, apparently linked by the dyke in the fault plane.

The quartz-dolerite has been quarried extensively to the north of the Wallstale Fault at the Murrayshall Quarry [NS 771 913], where the chilled base of the sill is in contact with baked coals, ironstones and mudstones. About 200 m ESE of the quarry, the base of the sill has been thrown down 13 m to the south by a late ESE-trending fault; this is one of the only places in the region where a quartz-dolerite sill is clearly seen to be affected by later faulting. Farther north, on the southern edge of Cambusbarron Quarry [NS 770 920] (Figure 6.11), there is a 4 m-thick sheet of dolerite separated from the base of the main sill by just over 1 m of indurated mudstone.

Below Cambusbarron Quarry is the site of a mine from which the Murrayshall Limestone was recovered. The sill outcrop ends abruptly just north of Cambusbarron Quarry and borehole records show that farther to the north the sill is intruded into a horizon below the Murrayshall Limestone. East of the GCR site, boreholes reveal that the sill divides into a number of distinct intrusive sheets; for example the Polmaise No. 5 shaft [NS 837 914] intersects at least three.

In general, the quartz-dolerite of the Stirling Sill is petrographically identical to that described elsewhere in the Midland Valley. Particularly good examples of hornblende and biotite, commonly mantling the augite and oxides, can be found in samples from Cambusbarron Quarry (Francis *et al.,* 1970). Samples showing skeletal patterns of iron oxide in the interstitial glass can also be found at this locality. As in many parts of the Midland Valley Sill-complex and the Whin Sill-complex, a pegmatitic zone occurs one-third of the way down from the top of the sill (Robertson and Haldane, 1937). However, an unusual feature of this sill is that there are additional quartzo-feldspathic veins in its lower part (Figure 6.12). These are fringed by a pegmatitic zone a few centimetres wide, comprising distinctive long feathery clusters of augite in a pink quartzo-feldspathic matrix (Walker, 1952; Francis *et al.,* 1970). The dolerite of the dyke-like 'riser' is a deeply weathered quartz-dolerite identical to that of the main sill.

Interpretation

The Midland Valley Sill-complex has been shown to be remarkably transgressive in relation to the sedimentary rocks into which it is intruded. Across the Midland Valley, sills are intruded into such widely differing stratigraphical levels that for many years the sill-complex was thought to represent numerous separate intrusions of different ages. In the coalfields adjacent to the Wallstale GCR site, borehole data and mine plans show that transgressions typically involve abrupt, step-like changes in horizon along dyke-like bodies known as 'risers'. Many of the risers exploit pre-existing fault planes but in some places the sill directly crosses a fault plane to a different stratigraphical level. Transgression is an important structural feature throughout the sill-complex but it is rarely seen at outcrop. The dyke-like body of quartz-dolerite at this site has been interpreted as a 'fault riser' and the site is unusual in that the transgressive dyke can clearly be seen to link the two sill outcrops. As a consequence of the transgression, the sills intrude the same stratigraphical horizon on both sides of the fault, despite a considerable offset on the fault prior to intrusion. The Wallstale Fault is one of three major E–W-trending faults in this area along which it is believed that transgressions have taken place, the others being the Auchenbowie and Abbey Craig faults. At the Abbey Craig Fault the sill does change stratigraphical horizon, but this was only confirmed by sub-surface evidence and hence Wallstale is certainly the clearest and most instructive example.

The quartz-dolerite sill is younger than most faulting in the Stirling area, the small fault near Murrayshall Quarry being the only proven example of a later fault. Immediately north of Cambusbarron Quarry, where the sill outcrop comes to an abrupt end, old mine plans show a small fault that was once considered to have thrown down the sill to the north. However, Dinham and Haldane (1932) and Read and Wilson (1959) considered it more likely that the abrupt drop of the base of the sill to the north is due to transgression of the dolerite into a lower level, possibly along an earlier fault. The dip-slope of the Stirling Sill in this area is dissected by many erosive channels, which appear to follow prominent joint planes. Read (1956) attributed this preferential erosion to hydro-thermal alteration of the dolerite along the joints and was unable to detect any evidence of fault movement.

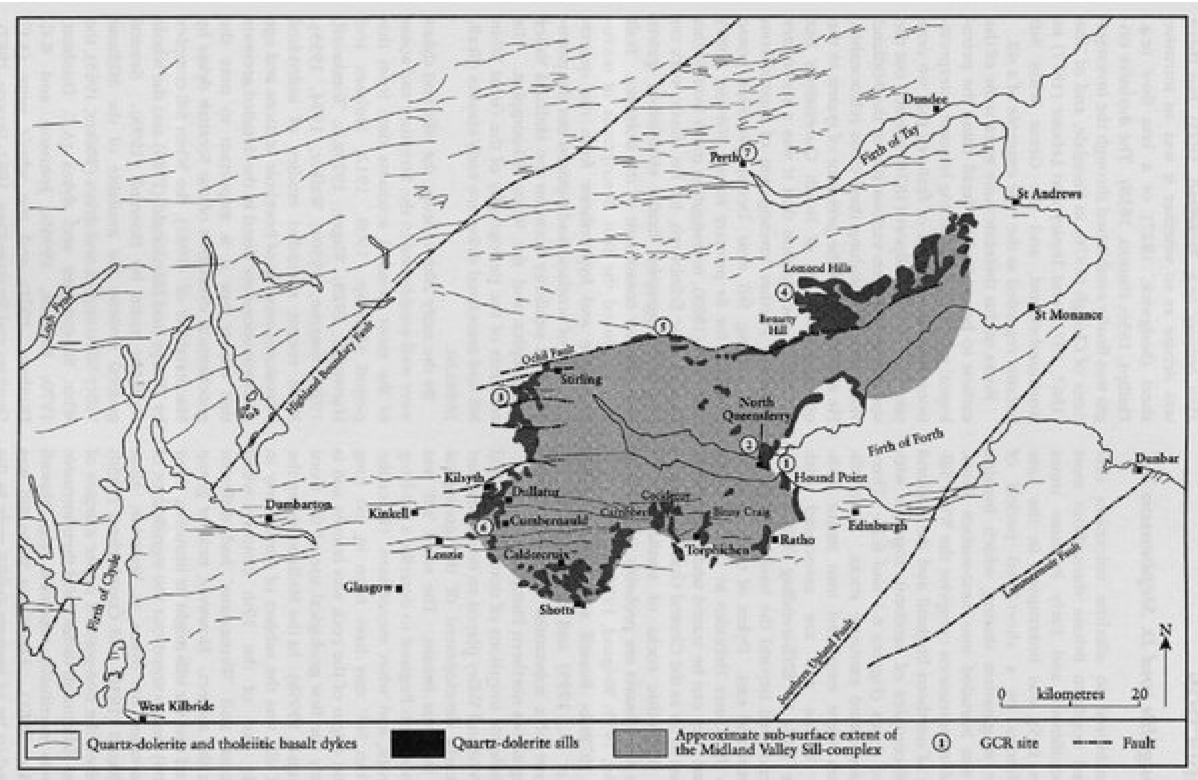
Francis (1982) showed that the shapes of the Midland Valley Sill-complex and the Whin Sill-complex approximate to a series of saucers, with the lowest, thickest parts coinciding with the centres of synsedimentary Carboniferous basins. The magma was probably introduced into the basins via marginal dykes and then flowed gravitationally from higher levels down bedding planes to the centre of the basins (Francis, 1982; see 'Introduction' to this chapter). The transgressive steps, such as the one observed at this site, are therefore believed to have occurred in a downward sense even though the old name 'risers' implies the opposite sense of movement. At Wallstale, the Midland Valley Sill-complex is at one of its lowest stratigraphical levels and is also very thick (explaining the fine development of in-situ differentiation features).

Conclusions

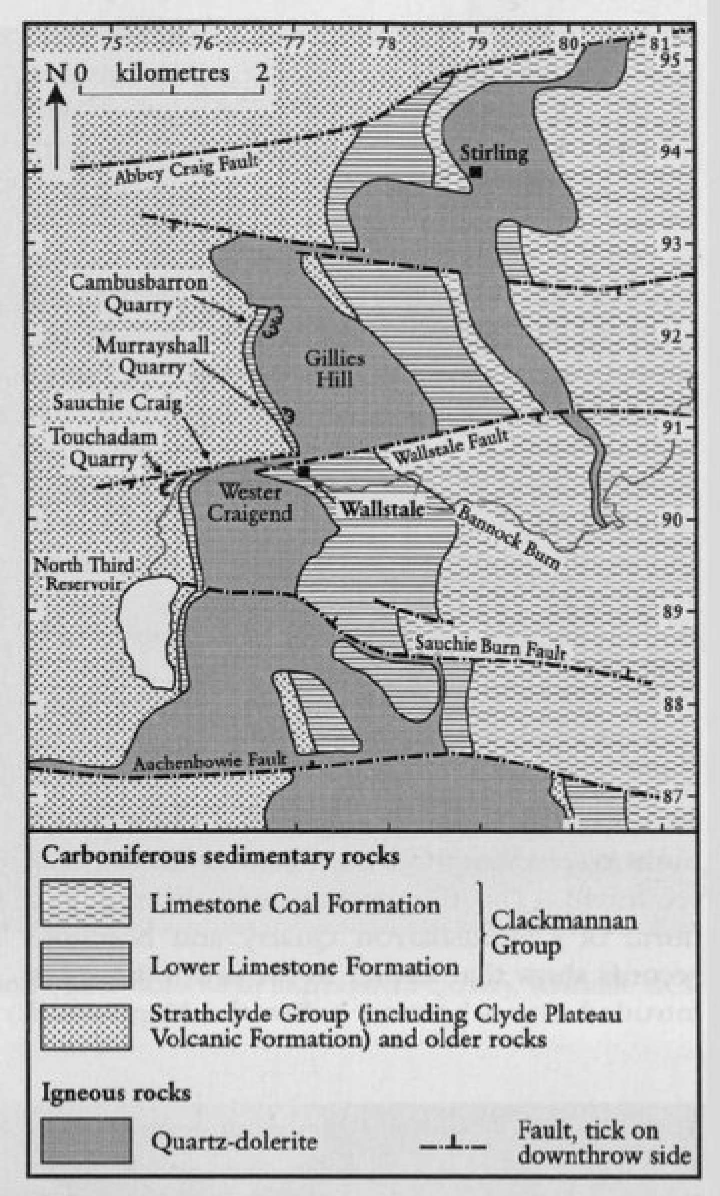
The Midland Valley Sill-complex has been shown to be remarkably transgressive, changing horizons within the Carboniferous succession both gradually and in a series of abrupt step-like jumps along fault planes. This behaviour, which results in complex surface and sub-surface relationships, is rarely observed at outcrop. At the Wallstale GCR site the relationships between the quartz-dolerite intrusion and a fault are clearly evident. The pre-existing E–W-trending fault let down the Carboniferous strata vertically by 130–150 m to the south. North of the fault, magma was intruded into the lower part of the Lower Limestone Formation and moved gravitationally down the gently inclined bedding of the strata towards the fault. It then flowed down the fault plane and intruded the same stratigraphical level on the south side of the fault.

The sill is relatively thick at this site and shows good examples of very coarse-grained pegmatitic dolerite and veins rich in pale quartzo-feldspathic minerals, both formed during the final stages of crystallization of the magma.

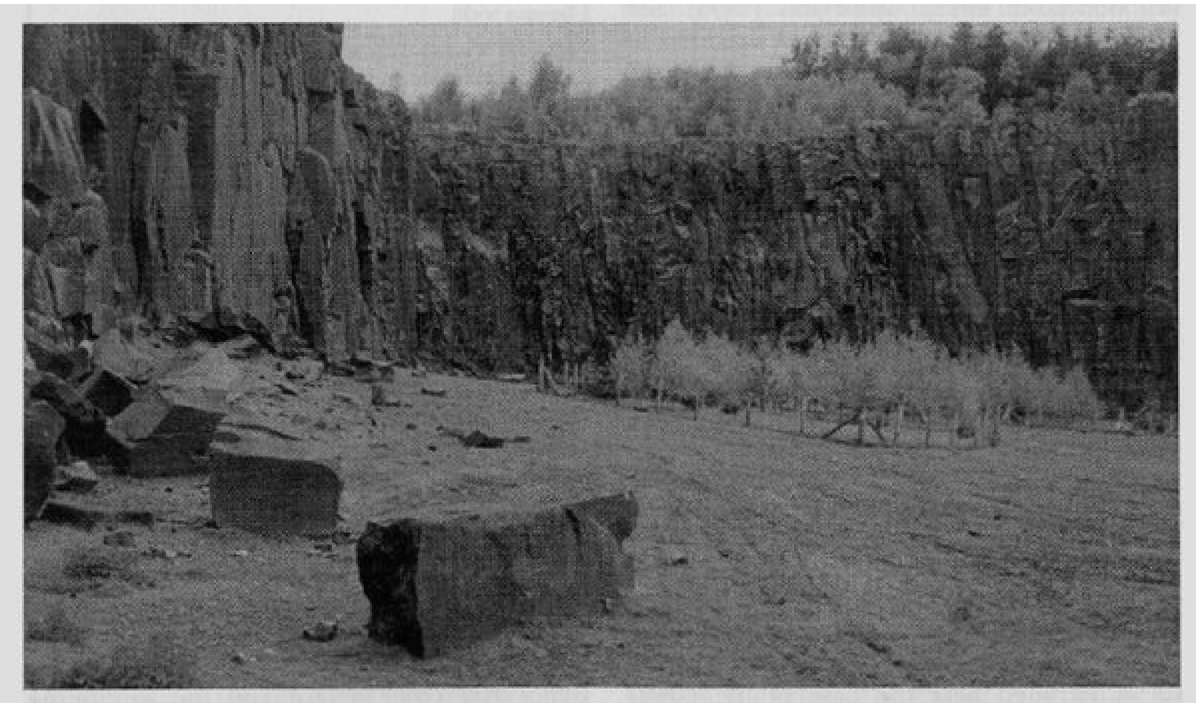
[References](#)



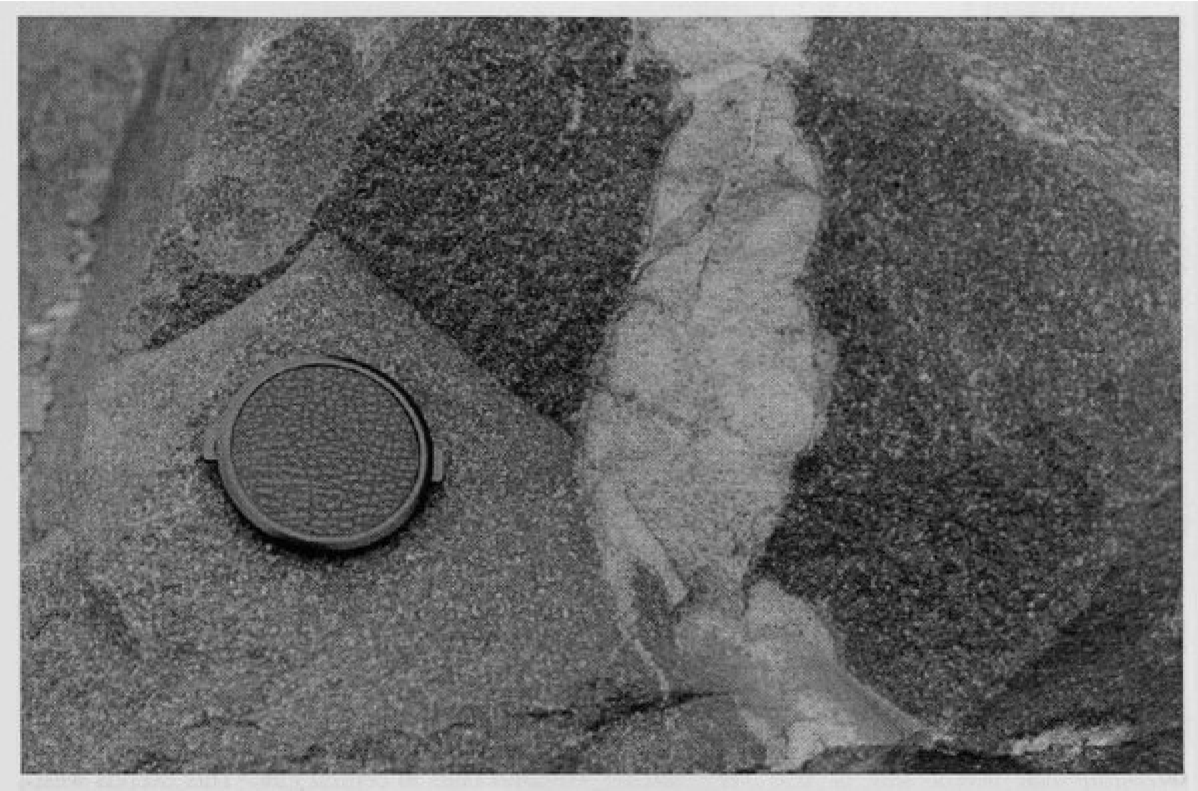
(Figure 6.1) Map of the Midland Valley and southern Highlands of Scotland, showing the distribution of the Late Carboniferous tholeiitic Midland Valley Sill-complex and the associated dyke-swarm. GCR sites: 1 = South Queensferry to Hound Point (see Chapter 5); 2 = North Queensferry Road Cuttings; 3 = Wallstale; 4 = Lomond Hills; 5 = Gloom Hill, Dollar; 6 = Mollinsburn Cuttings; 7 = Corsiehill Quarry. After Cameron and Stephenson (1985).



(Figure 6.10) Map of the Midland Valley Sill-complex in the area around the Wallstale GCR site. After Read and Wilson (1959).



(Figure 6.11) Quartz-dolerite of the Midland Valley Sill-complex with strong vertical joints in Cambusbarron Quarry, Wallstale GCR site. The quarry face is 25–27 m high. (Photo: K.M. Goodenough.)



(Figure 6.12) Pale-coloured felsic segregation vein cutting quartz-dolerite in Murrayshall Quarry Wallstale GCR site. The lens cap is 50 mm in diameter. (Photo: K.M. Goodenough.)