Lomond Hills, Fife

[NO 178 043]–[NO 248 068]

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Introduction

The Midland Valley quartz-dolerite sill-complex is the most extensive and arguably the most important single intrusion in central Scotland. Detailed mapping and data from various mines in the adjacent coalfields have shown that it crops out around the margins of a large area (see 'Introduction' to this chapter, and (Figure 6.1)). It may remain at a constant level in the stratigraphical succession for long distances but it may also change horizon, often abruptly via fault-controlled dyke-like bodies or 'risers' (Dinham and Haldane, 1932) and often in a step-like manner (Knox, 1954; see Wallstale GCR site report). The somewhat undulatory nature of the sill in areas not generally affected by such structures is an important feature and is shown very clearly in the scarp face of the Lomond Hills in central Fife. This exends westward from East Lomond above the village of Falkland, towards West Lomond, then south via Bishop Hill to Kinneston Craigs above Scotlandwell (Figure 6.13). Throughout this outcrop the sill is intruded mainly into rocks of the Lower Limestone Formation of the (Upper Visean) Clackmannan Group. Small details of the contact phenomena associated with the sill are also of merit, providing evidence of partial melting of the intruded strata (Walker, 1958).

The site is also of considerable interest because it includes two sub-volcanic necks, with plugs of alkali dolerite and basanite, at the summits of East Lomond and West Lomond, and a basanite plug at the summit of Green Hill. Their respective age relations to the sill are of critical importance in any consideration of the evolution of igneous activity in the Midland Valley and consequently have been the subject of much debate (e.g. Irving, 1924; Walker and Irving, 1928; Macgregor and MacGregor, 1948; Francis, 1965; Browne and Woodhall, 2000).

The first published geological map of this area (Sheet 40) was released by the Geological Survey in 1867. The second edition of the map was published in 1898 and was accompanied by two memoirs (Geikie, 1900, 1902). Since then the area has undergone a number of revisions and re-surveys and the latest edition was published in 1999 with accompanying sheet explanation and sheet description (Browne and Woodhall, 1999, 2000). Two field excursions, to the East Lomond and Bishop Hill areas of the site, have been described by MacGregor (1996).

The petrography and geochemistry of the quartz-dolerite at this GCR site is typical of the Midland Valley Sill-complex (Walker and Irving, 1928; see 'Introduction' to this chapter).

Description

The Midland Valley Sill-complex is here largely confined to the Lower Limestone Formation except at a few localities where it transgresses up as far as the Limestone Coal Formation or down into the Pathhead Formation (Strathclyde Group). Its total vertical range is in the order of 225 m and in thickness it varies from *c.* 50 m to *c.* 95 m. From East Lomond hill [NO 244 062] to Kinneston Craigs [NO 193 023], a distance of about 12 km, the sill forms a distinctive scarp (Figure 6.14) and is mostly intruded between two prominent limestones — the Hurlet (Figure 6.14) The escarpment formed by the Midland Valley Sill-complex on the north-west side of the Lomond Hills, with the basanitic plugs of West Lomond (nearest) and East Lomond (in the distance) protruding above the level of the sill. (Photo: P Macdonald.)

Limestone (formerly the Charlestown Station Limestone) and the Blackhall Limestone (formerly the Charlestown Main Limestone). The Hurlet Limestone marks the base of the Lower Limestone Formation while the latter occurs some way above.

At Hume's Head spring [NO 2395 0630] on the north-western side of East Lomond hill, baked fossiliferous mudstones of the Lower Limestone Formation can be observed and, just a metre or so below, the top of the sill is also exposed. The position of the Blackhall Limestone is marked by a line of old workings which extend from just above the spring southwards to East Lomond Quarry. The limestone exposed in some of the workings is recrystallized hut the top of the sill is not exposed in any. The rolling heather-covered slopes between East Lomond hill and West Lomond hill [NO 197 065] are composed of quartz-dolerite.

The lower part of the sill is clearly exposed at Craigmead Quarry [NO 228 061] (and also in Falklandhill Quarry [NO 228 062], but not as clearly), where it is spheroidally weathered, red-brown and columnar jointed (Figure 6.15). The base of the sill is chilled to a fine-grained, dense, black basaltic rock a few millimetres thick. The basal contact with underlying horizontally bedded sandstone is clearly transgressive and irregular, with tongues of dolerite extending into the baked sandstones.

The transgressive nature of the sill can also be seen clearly on the northern side of West Lomond hill in the vicinity of Longcraig Quarries [NO 202 072], where the undulose base cuts down through the sandstones and mudstones of the Lower Limestone Formation, through the Hurlet Limestone and into mudstones of the underlying Pathhead Formation. On the western slopes of West Lomond hill the sill rises back up through the sedimentary sequence to its original stratigraphical level just above the Hurlet Limestone in the Lower Limestone Formation. The quartz-dolerite in the area known as the 'Devil's Burdens' [NO 193 061] is deeply altered to a distinctive orange-brown coloured sandy gravel. The sill stays at this level along most of the western scarp of the Lomond Hills and the position of the underlying Hurlet limestone is marked by a line of small quarry workings. North of Bishop Hill [NO 1830 0440] a combination of columnar jointing and weathering of the sill has formed an impressive needle of rock which is popular with climbers.

A succession through the Pathhead Formation, the Lower Limestone Formation and up to the base of the quartz-dolerite sill is exposed at the head of Kinnesswood Row, a steep gully 500 m north-east of Kinnesswood and the type locality for the Kinnesswood Formation. The top metre or so of sandstone has been recrystallized by the sill, and the highest mudstone bed is bleached and hardened. The basal margin of the sill is chilled, and above, the characteristic crude columnar joints and spheroidal weathering of the sill can be observed.

Around the summit of Bishop Hill, the Blackhall Limestone above the sill has been quarried extensively; in this area it is relatively thick due to microbial bioherm build-ups. The limestone is typically bedded and very rich in crinoids; in addition, two distinct reef mounds can be identified at Clatteringwell Quarry [NO 1875 0375]. Just south of White Craigs, above Kinnesswood village [NO 184 032], the sill changes horizon abruptly to a level above the Blackhall Limestone so that on the southern side of Bishop Hill, several metres of fossiliferous sandstones and mudstones above the limestone are recrystallized by the overlying sill. A line of small quarries marks the position of the Blackhall Limestone below the sill.

Three prominent summits rise above the general land surface of the Lomond Hills.

East Lomond (442 m) is a steep-sided, rounded hill with a distinct 'shoulder' on its western side. It stands above the scarp formed by the sill just south of Falkland. The gentle lower slopes of the hill are underlain by the Lower Limestone Formation, which directly overlies the sill. The summit of the hill is composed of a dark-green to black analcime-bearing olivine-dolerite. In hand specimen olivine phenocrysts are conspicuous and alter to a reddish colour on weathered surfaces. Crude joints radiate outwards from the centre of this intrusive body suggesting that it is probably a plug (Irving, 1924). Vesicles with an infilling of green serpentine occur widely but the rock generally has a 'fresh' appearance in contrast to the deeply weathered quartz-dolerite sill. The shoulder of the hill is composed of a friable pale-olive-green volcaniclastic breccia containing angular fragments of altered basaltic rock. Just to the east of East Lomond is a smaller, poorly exposed outcrop of olivine-dolerite, also with a basaltic breccia at its eastern margin. The olivine-dolerite of the main plug comprises mainly large olivine phenocrysts, laths of labradorite and intersertal (rather than ophitic) mauve-pink titaniferous augite. Accessory minerals include titaniferous magnetite, apatite and analcime with some devitrified glass.

West Lomond (522 m) is a cone-shaped hill also standing above the scarp of the sill. The hill is composed of nepheline basanite with a thin sliver of breccia on its northern margin, and is interpreted as a sub-volcanic neck and plug. The lower slopes are composed of sedimentary rocks of the Lower Limestone Formation which overlie the sill. Two smaller plugs occur just east of West Lomond (Browne and Woodhall, 2000).

Between East and West Lomond is the rounded summit of Green Hill (305 m), which lies below the scarp of the sill. It is composed of black, fine-grained nepheline basanite, slightly finer grained than that of West Lomond. The contacts with the surrounding sedimentary rocks are not exposed but it is assumed to be a plug (M.A.E. Browne, pers. comm., 2000).

Interpretation

Geikie (1900) recognized the intrusive nature of the Midland Valley Sill-complex and described the transgressive contacts and chilled margins in this area. He cited the undulose nature of the sill in the Lomond Hills as a particularly good example of transgression. The recrystallized limestones and baked mudstones above the sill at East Lomond provide clear evidence of the intrusive nature, and the sharp contacts with host sedimentary rocks observed throughout the GCR site indicate that the sediments were compacted and lithified prior to intrusion.

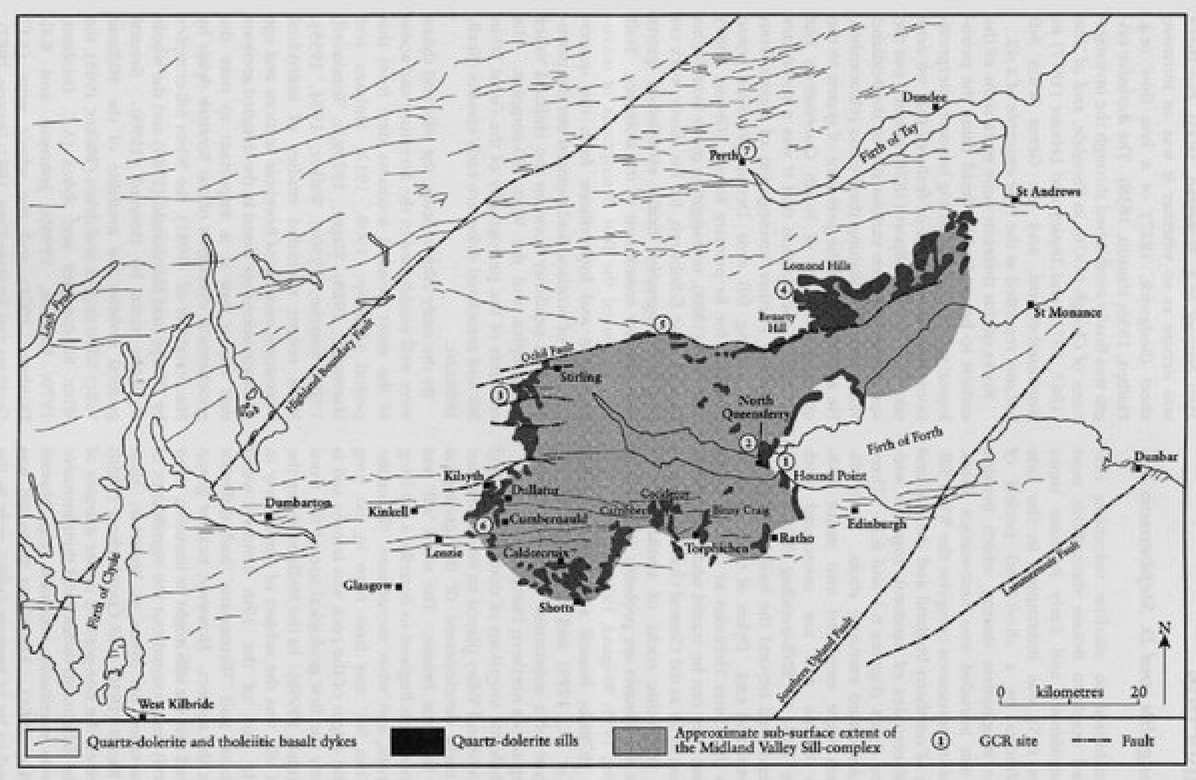
Walker (1958) investigated the contact between the sill and the sandstones and mudstones of the Lower Limestone Formation at East Lomond and found petrographical evidence for remobilization of the sedimentary host rocks. He observed a zone of alkali-feldspar-rich material, 1–3 mm thick, along the contacts; in places, thin veins of this material actually cut through the adjacent sedimentary layers but they do not cut the sill. The source of this remobilized material was thought to be the thin mudstone laminae intercalated with the sandstones.

The age relationships between the alkaline basic plugs and the tholeiitic sill at this site are equivocal, but historically they were regarded as fundamental to determining the overall sequence of Carboniferous-Permian igneous events. Geikie (1900) interpreted the outcrops that form the summits of East and West Lomond as erosional outliers of sills intruded above the main sill. However, Irving (1924) and Walker and Irving (1928) concluded that they are irregular plugs marking the sites of Late Carboniferous necks that penetrated the sill, and this interpretation was re-asserted by Macgregor and MacGregor (1948). Francis (1965), whilst accepting the interpretation of plugs, pointed out that there is no satisfactory field evidence for their age relationship with the sill. No contacts are exposed, no xenoliths of quartz-dolerite have been found in the plugs or associated breccias and, in addition, the East Lomond olivine-dolerite is petrographically similar to olivine-dolerite sills demonstrably older than the Midland Valley Sill-complex. The petrography and geochemistry of the plugs reveals that they are related to a separate period of alkaline volcanism, but this could be either before or after emplacement of the tholeiitic sill-complex. There is no doubt that olivine-dolerite sills, plugs and contemporaneous volcanic rocks were emplaced throughout Fife during a period of multiphase alkali magmatism throughout mid- to late Carboniferous and Early Permian times (see 'Introduction' to Chapter 4; and 'Introduction' to Chapter 5). The more highly silica-undersaturated alkaline basic rocks, such as nepheline basanites, are generally assigned to the later phases of igneous activity in the Midland Valley, but Browne and Woodhall (2000) consider that the alkaline basic plugs in the Lomond Hills area were intruded during late Visean or Namurian times, when the sediments were still unlithified and contained pore water. The volcaniclastic breccias exposed at East Lomond and West Lomond are therefore assumed to be the products of explosive volcanism, which occurred as a result of magma-water interaction.

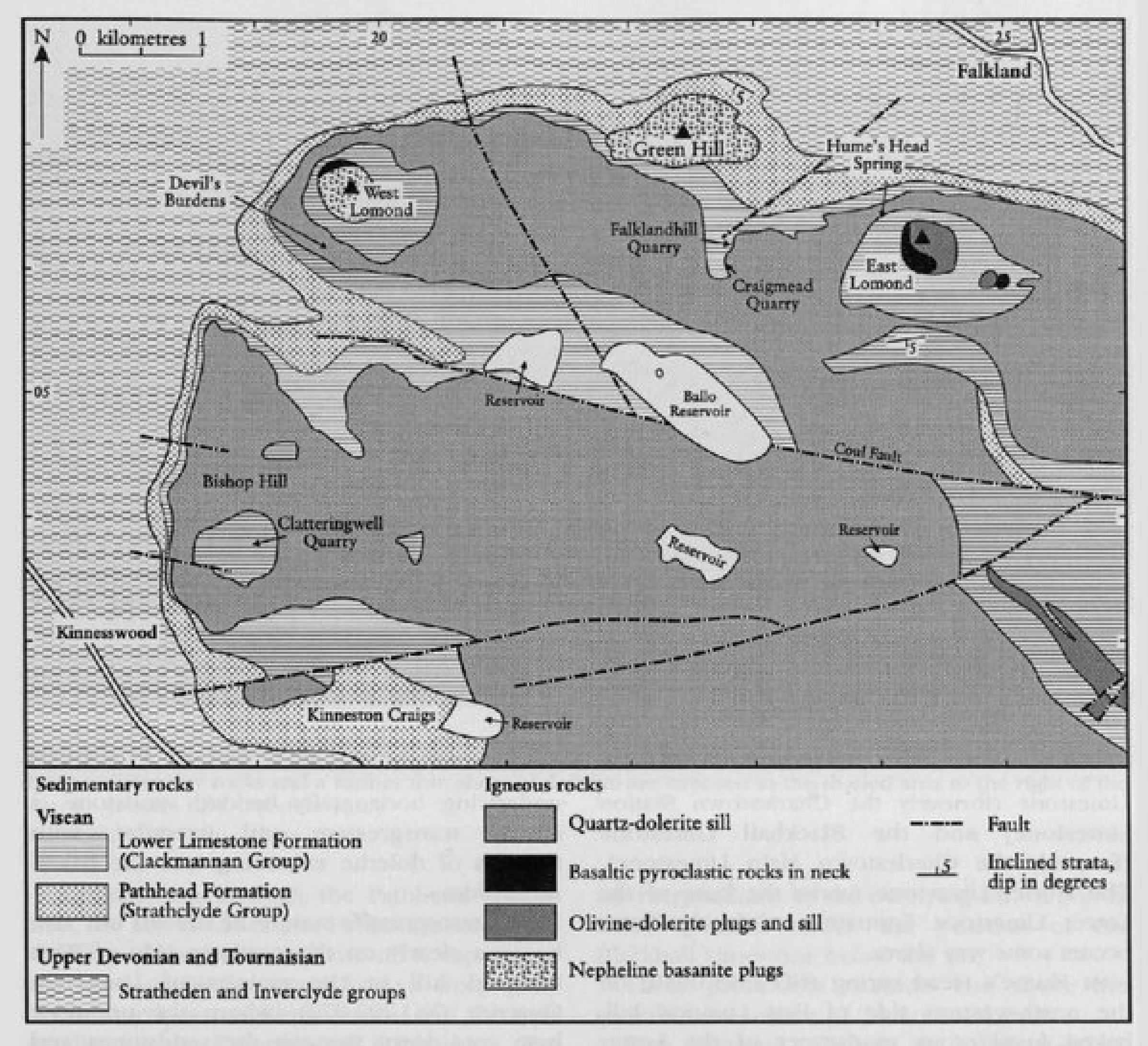
Conclusions

The Lomond Hills GCR site is representative of the Midland Valley Sill-complex, a geological feature that has a profound effect on the topography of eastern central Scotland. At this site the quartz-dolerite sill and underlying sedimentary rocks form a steep escarpment that extends for a total distance of about 12 km. The margins of the sill are gently undulating and in several places the basal contact can be seen to transgress through several levels of the underlying strata. There is also evidence that the thermal effects of sill emplacement have partly melted the sedimentary rocks immediately adjacent to the sill. Baking and recrystallization of sedimentary rocks above the quartz-dolerite provides evidence that it is an intrusive sill and not an extrusive lava. Sub-volcanic necks with plugs of alkaline basic rock occur above the escarpment and provide evidence of explosive volcanic activity in the region. The composition of the plugs suggests that this volcanism was unrelated to the sill, but the exposed field evidence cannot resolve whether it was earlier or later. The age relationships at this site were once regarded as crucial to determining the sequence of igneous events in the Midland Valley and consequently have been the subject of much debate.

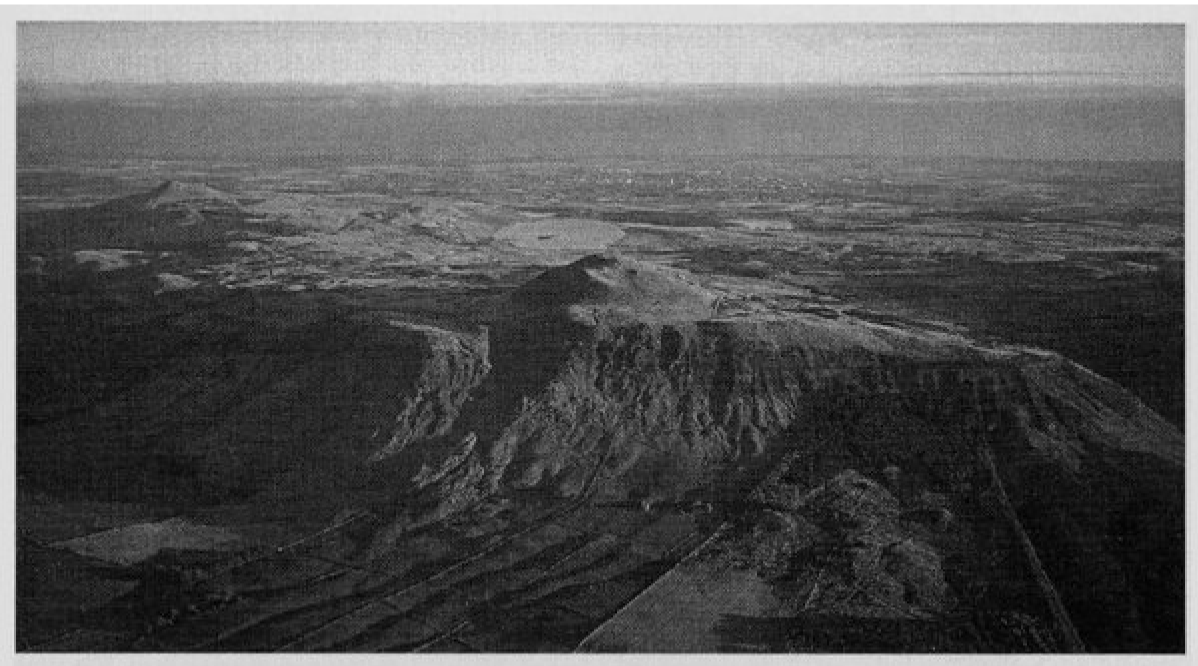
[References]



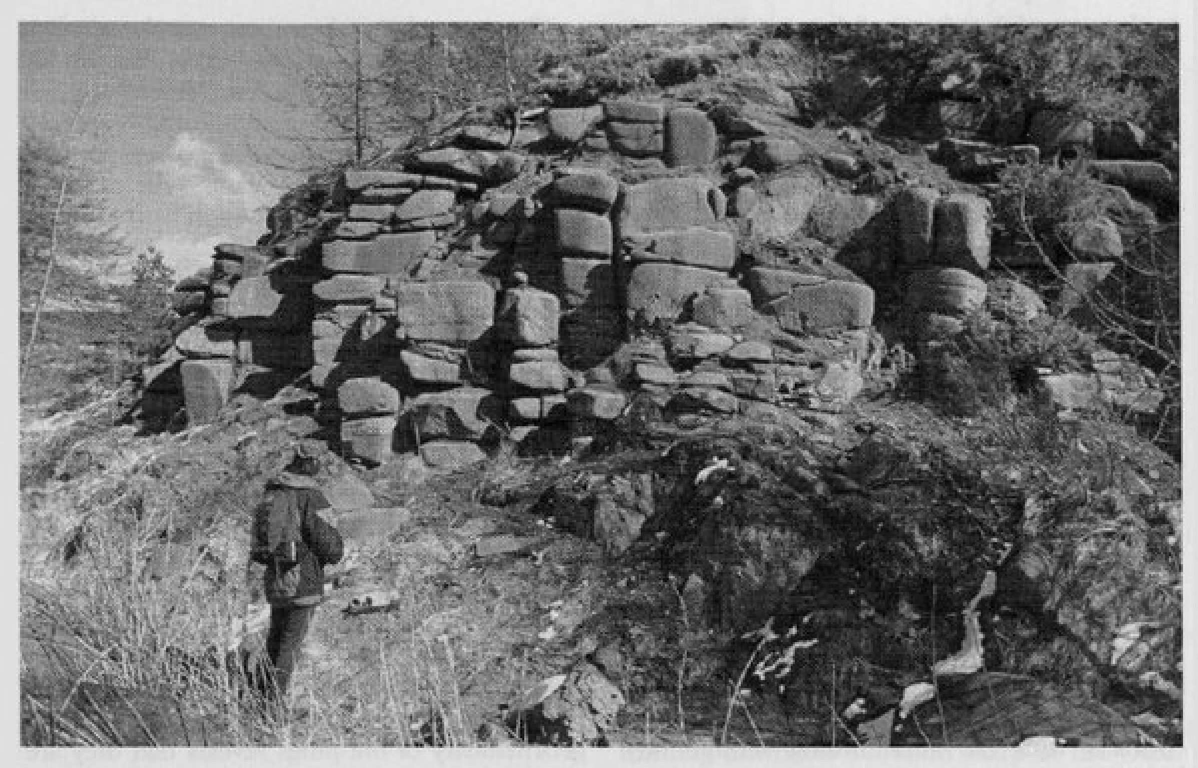
(Figure 6.1) Map of the Midland Valley and southern Highlands of Scotland, showing the distribution of the Late Carboniferous tholeiitic Midland Valley Sill-complex and the associated dyke-swarm. GCR sites: 1 = South Queensferry to Hound Point (see Chapter 5); 2 = North Queensferry Road Cuttings; 3 =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



(Figure 6.13) Map of the Midland Valley Sill-complex in the Lomond Hills. Based on Geological Survey 1:63 360 Sheet 40, Kinross (1971); and British Geological Survey 1:50 000 Sheet 40E, Kirkaldy (1999).



(Figure 6.14) The escarpment formed by the Midland Valley Sill-complex on the north-west side of the Lomond Hills, with the basanitic plugs of West Lomond (nearest) and East Lomond (in the distance) protruding above the level of the sill. (Photo: P Macdonald.)



(Figure 6.15) The base of the Lomond Hills quartz-dolerite sill in Craigmead Quarry. The contact, the underlying sedimentary rocks and a further thin sheet of dolerite are exposed in the shaded area to the right of the figure. (Photo: K.M. Goodenough.)