Garleton Hills volcanic rocks

B.G.J. Upton and R. MacDonald

O.S. 1:50000 Sheet 67 Duns and Dunbar

B.G.S. 1:50000 Sheet 33W Haddington

Route: (Map 13)

Introduction

Contemporaneous with the Lower Carboniferous volcanics that crop out in and around Edinburgh (p. 33), are volcanic rocks which re-appear some 32 km east of the city in the vicinity of North Berwick and the Garleton Hills. The succession is thicker, and with the presence of trachytes, more varied than that of the Arthur's Sent Volcanic Rocks in Edinburgh. The Garleton Hills Volcanic Rocks lie within the Calciferous Sandstone Measures. A generalised succession is as follows:

Trachytic lavas and tuffs 160 m

Basaltic and mugearitic lavas 160 m

Basaltic tuffs 200 m

Whereas the basaltic and mugearitic lavas and the basal ash-beds are well exposed on the coast at North Berwick (p. 88), this excursion is principally concerned with the inland outcrops in the vicinity of the Garleton Hills and Traprain Law. In this region, the basal ashes are thin and largely unexposed, but the basic and trachytic lavas can be easily examined in numerous quarries and natural outcrops. Intrusive phonolite may be examined at Traprain Law, where Pleistocene glaciation has deeply eroded the softer Carboniferous sedimentary rocks and left the tough intrusive rocks as a prominent high-point in the landscape. The excursion also includes one of the late Carboniferous quartz-dolerite dykes (Bangly Hill). A presumed intrusive mass of silica-undersaturated basalt (basanite) containing peridotite inclusions and cut by intrusive tuff is seen at Kidlaw.

The excursion commences among the trachyte lavas of the Garleton Hills, proceeds on to the basic lavas beneath the trachytes in the vicinity of East Linton and then moves south to Traprain Law and finally to Kidlaw, not far from Gifford. Private transport is essential to complete the excursion in one day.

1. Bangly Quarry: trachytic lava and dyke

The quarry [NT 487 752] is reached from a small road leaving the A 1 about 2 km east of Gladsmuir. It is being worked for road-metal and lies apparently within a single massive flow of trachyte. The trachyte is strongly porphyritic with feldspar phenocrysts up to 5 mm. Where fresh the matrix is bluish-grey, although much of the trachyte is reddened through oxidation and alteration. The feldspar phenocrysts consist of sodic plagioclase cores, rimmed by alkali feldspar. This zonation is brought out clearly by differential weathering and is readily seen on weathered surfaces. Small pyroxene (hedenbergite) phenocrysts are also present. The matrix is of fine-grained quartz-trachyte. At the eastern end of the quarry a 4 m dyke of trachybasalt occurs. This dyke is periodically visible in the course of quarrying. Even when obscured by talus fragments of the dyke rock can be recognized from the presence of large (up to 5 cm) glassy-clear crystals of sanidine.

On the northern wall of the quarry the trachyte is finely jointed and shows abundant signs of crushing. In places the closely jointed trachyte passes into a breccia of trachyte blocks in a fine-grained dark matrix. It is unclear whether the brecciation is wholly due to crushing or whether high-pressure gas-fluxing may have been partly responsible.

2. Bangly Hill: quartz-dolerite dyke

Approximately 1 km NNE from Bangly Quarry on the road leading to Phantassie, a small farm road leads north to a hill surmounted by a radio relay station. On the northern side of this hill is an old quarry [NT 493 758] cut into a broad E–W quartz-dolerite dyke with a minimum thickness of 12 m. This dyke is one of the swarm of late Carboniferous (Stephanian) quartz-dolerite dykes and sills, within and adjacent to the Midland Valley. The south wall of the quarry exposes somewhat crushed porphyritic trachyte (similar to that seen in Bangly Quarry) alongside the southern chilled wall of the dyke. The chilled contact of the dolerite against trachyte is well exposed in the south-west corner of the quarry. The chilled facies is very fine-grained with trails of amygdales parallel to the contact wall.

At the eastern end of the quarry. well-developed jointing (crudely columnar) in the dolerite dips at c. 10° S. suggesting that the dyke as a whole has a steep dip (c. 80°) towards the north. The dyke here displays an excellent example of spheroidal weathering. The northern contact of the dolerite is not exposed.

3. Phantassie Hill: trachyte lavas and mineralization

Return to the public road and proceed east to the junction with the A6137. Continue east across the junction on a farm road for 300 m until a gate is reached on the left-hand side, with a prominent escarpment visible across a small field [NT 507 757]. This escarpment is composed of one or more thick flows of sub-horizontal trachyte. The trachyte is generally similar to that seen at the last two localities but has zones which are reddened, much altered and cut by veins of baryte. The baryte occurs as rosette-like aggregates of thin tabular crystals coloured pink with hematite. Hematite is not particularly well developed in the veins on this escarpment but was formerly mined in the vicinity, some 200 m across the field to the north-west where the entrance to the old mine-workings can still be seen [NT 513 761].

The trachyte of the escarpment is porphyritic (including plagioclase, alkali feldspar, altered clinopyroxene and scarce apatite phenocrysts) and is, in places, highly vesicular. The freshest samples may be obtained from a shallow hole in the floor of the upper part of the old quarry.

4. View eastwards from the Garleton Hills

From the roadside [NT 509 763] at the entrance to Skid Hill Quarry the view eastwards clearly reveals the relationship between the basic and trachytic lavas of the area. The valley leading away from the viewpoint is a glacial outwash channel which cuts down through the rocky outcrop of the trachytes of the Kae Heughs escarpment into the underlying, poorly exposed basaltic and mugearitic flows forming the valley floor.

5. Skid Hill Quarry: trachytic lava

The disused quarry [NT 507 757] appears to be excavated within a single flow of quartz-trachyte some 20 m or more thick. The rock here is massive with no sign of vesiculation. Small hematite veinlets are well exposed cutting the trachyte of the quarry floor. Fresh bluish-grey trachyte, containing sanidine, plagioclase and augite phenocrysts in a matrix of alkali feldspar, quartz, aegirine-augite, magnetite and hematite, can be obtained in the quarry.

6. Pencraig Wood: trachyte intrusion

In a small quarry [NT 573 765] beside a lay-by on the north of the A1 road, can be seen the pale purple, non-porphyritic intrusive trachyte which underlies Pencraig Wood. This rock has been exploited for road metal in Markle Mains Quarry [NT 565 770] just to the north.

7. Markle Quarry: Markle basalt lava

Some 150 m north of the A1 road, about 1 km west of East Linton, a path leading off alongside an electricity sub-station leads to a disused quarry [NT 583 769]. The quarry is excavated in a low escarpment extending north-eastwards from Pencraig Wood, revealing a section through one of the more basic lavas underlying the trachytes. The quarry reveals a 7–8 m thickness of lava, which is non-vesicular in its lower and central parts but which grades into distinctly vesicular material in the topmost 1.5 to 2 m. This is clearly the near-surface facies of a flow of 'aa' type. The flow is remarkable for the abundance of tabular plagioclase phenocrysts in all but its uppermost parts. This distribution may be due either to the gravitational settling of crystals that were denser than the liquid in which they were suspended, or alternatively to late-stage pulses of phenocryst-deficient lava overriding earlier phenocryst-rich material. The lava is much altered and reddened by hematitisation, but reddish-brown pseudomorphs after former olivine phenocrysts and small phenocrysts of magnetite may still be seen in hand-specimen. Apatite microphenocrysts have been recognized in thinsection. The flow is the type locality of Markle basalt (MacGregor 1928), which contains abundant large phenocrysts of plagioclase, subordinate olivine phenocrysts, but no pyroxene phenocrysts. The type is of widespread occurrence in the lower Carboniferous lavas of the Midland Valley.

8. Kippielaw Scarp: basalt and mugearite lavas

The route now continues eastwards across the River Tyne to the junction [NT 593 768] of the A1 and the minor road leading south towards Traprain Farm. Seattered outcrops seen at this junction and in the fields to the south-east are in basalt lavas low in the volcanic succession. At Traprain Farm [NT 592 757] the minor road leading westwards towards Kippielaw Farm should be followed for about 200 m until, beyond a patch of woodland, there is access to a low southward-facing escarpment. At this vantage point a good view may be had of the surrounding countryside. To the north rise the prominent phonolitic trachyte plugs of North Berwick Law and Bass Rock and to the west, across the Tyne Valley, are the trachytes of the Garleton Hills. Arthur's Seat can be seen still farther west where the Lower Carboniferous lavas re-emerge on the western limb of the Midlothian coalfield.

About 1 km south of the escarpment, the steep-sided Traprain Law rises out of fields underlain by rocks of the Calciferous Sandstone Measures. These rocks are brought up in the core of the anticlinal structure created by the Traprain Law intrusion.

Three or four kilometres beyond Traprain is the fault-line scarp of the Southern Uplands where barren moorlands mark the outcrop of the older Lower Palaeozoic shales and greywackes and contrast with the cultivated farmlands overlying the younger Upper Palaeozoic sediments in the foreground and middle distance.

The mugearite now near Traprain Farm lies low in the lava sequence. The lavas themselves are separated from the underlying Calciferous Sandstone Measures by a horizon of ashes, correlative with the thick basal ash sequence so well seen on the foreshore at North Berwick. The ash-horizon here, however, is much attenuated and largely unexposed; if time permits it may be examined later in the uncultivated fields to the west of Kippielaw Farm, around [NT 580 755].

Where first seen the mugearite is a fine-grained, lustrous and relatively fresh rock with a prominent platy jointing which, dipping north at less than 5°, indicates the local dip of the lava sequence. The rock here is non-vesicular. Tabular phenocrysts of plagioclase occur very sparingly. In thin-section, this rock is seen to consist of now-aligned oligoclase, Fe-Ti oxides and altered olivines. Alkali feldspar occurs interstitially and biotite is a prominent accessory mineral. Progressing west along the scarp front the upper facies of this now can be found forming a 20–40 cm thick zone of vesicular and rubbly material.

Continuing west to a point about 30 m east of a drystone wall running approximately N-S, one leaves the mugearite now and descends on to the upper surface of the underlying basalt now. The scoriaceous upper surface of this now is, from time to time, revealed by ploughing and loose blocks of the now-surface material are normally to be encountered close to the wall.

This now is a basalt of Dunsapie type (MacGregor 1928) characterised by relatively abundant reddened plagioclase phenocrysts, scarcer black augite phenocrysts and brown pseudomorphs after former olivine phenocrysts.

On the west side of the wall good outcrops are seen of the massive central facies of this flow. Continuing west along the front of the escarpment, here about 6 m high, one encounters more coarsely grained basalt, still of Dunsapie type with phenocrysts of all three main silicate phases. The rock is well seen in an old quarry immediately south of Kippiclaw Farm. It is likely that this basalt belongs to a second flow of Dunsapie basalt beneath that first encountered, since it becomes more vesicular towards the top of the quarry, which may be close to the flow top. From Kippielaw Farm one has the choice of either returning along the Traprain Law farm road and then taking transport to Traprain Law quarry or alternatively, walking southwards by the farm track to the quarry.

9. Traprain Law: phonolite laccolith

The dome-shaped mass of Traprain Law (Plate 2) appears to reflect the form of the upper surface of the intrusion virtually unmodified by erosion. In the large road-metal quarry [NT 584 750] on the north-east side of the hill, a prominent set of joints lies approximately parallel to the contacts. The intrusion is generally believed to have a laccolithic form and to have been responsible for arching up the surrounding sediments and lavas. The phonolite exhibits considerable variety in terms of colour and texture (Tomkeieff 1952). Pronounced flow-banding can be seen on the east face of the quarry, involving layers of grey rock and layers of a pinker, more speckled variety. There is some evidence that the pink bands owe their origin to a slight hydrothermal alteration of the grey. Sedimentary xenoliths, mainly of black shale and sandstone in varying states of assimilation, are common in the intrusion, blocks up to 10 m long having been recovered by Day (1929). Xenoliths of basic igneous rocks, including an unusual analcime-trachybasalt (Tomkeieff 1952) are much scarcer.

The phonolite contains phenocrysts of oligoclase and cryptoperthite with small, scarce phenocrysts of clinopyroxene, apatite and much-oxidized and corroded hornblende. The matrix consists of antiperthite, aegirine-augite, fayalite, sodalite and magnetite. The presence of small quantities of nepheline has also been reported (MacGregor and Ennos 1922). Late crystallising components, largely concentrated into thin veinlets include analcime, calcite, apophyllite and alkali feldspar. Prehnite, pectolite, natrolite, datolite, anhydrite, selenite and stilpnomelane have also been recorded.

The phonolite, though devoid of vesicles on the lower flanks of Traprain, becomes highly vesicular near the summit suggesting that the rock crystallised under near-surface conditions and that the intrusion may even have acted as a feeder for surface extrusions.

10. Balfour Monument: Craiglockhart basalt and kulaite lavas

Take the road east and then south of Traprain Law to the minor road junction [NT 603 739] and then travel westwards to the monument set on a prominent north-facing lava escarpment [NT 575 737]. Just as at the Kippielaw escarpment, the arable land between the escarpment and the steep contact wall of the Traprain intrusion lies on Calciferous Sandstone Measures sedimentary rocks.

The lava forming the main scarp feature here is some 15 m thick and shows a roughly columnar jointing pattern. It is an ankaramitic basalt, rich in large augite crystals (up to 1 cm) and conspicuous brown pseudomorphs after olivine (up to 0.5 cm). This rock, following MacGregor's (1928) classification, is a basalt of Craiglockhart type.

A subordinate scarp feature, below and some way east of the monument, is formed from an underlying trachybasaltic flow. This much decomposed rock, which has been called a kulaite, contains a high concentration of pseudomorphed (oxidised) hornblende phenocrysts. In the fine-grained matrix, plagioclase and analcime are among the least altered components.

11. Kidlaw Quarry: tuffs, analcime-basanite intrusion and peridotite (lherzolite) inclusions

This locality, some 5 km south-west of Gifford and about 13 km south-west of Traprain Law, is reached by a sunken grassy track leading from the junction of the two minor near Kidlaw [NT 506 642] into the disused quarry. On entering the quarry, small outcrops of reddish tuff may be seen on the right-hand bank beside the path. These consist of small (< 5 mm) particles of what appear to be altered volcanic glass. These scoria fragments are very vesicular, often showing deformed and streaked-out vesicles. The matrix between the volcanic fragments consists largely of angular quartz grains and lesser amounts of microcline.

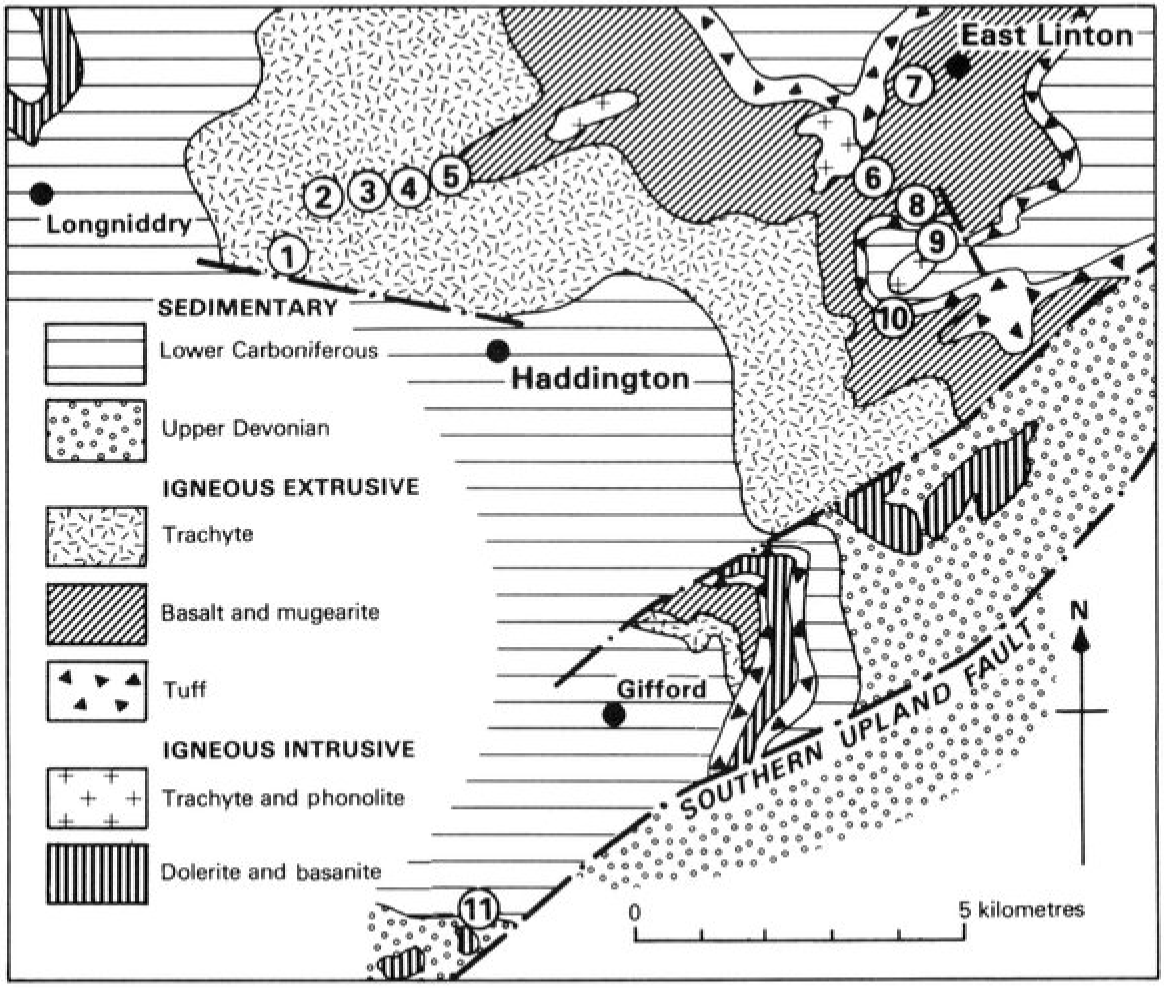
The quarry itself, however, is mainly cut into a fine-grained tough and well-jointed analcime-basanite (or monchiquitic basalt). From the non-vesicular nature of the mass it is likely to be a hypabyssal intrusion although there is no clear guide to the overall form. Clough et. al. (1910) considered it to be a sill intruded into the Calciferous Sandstone Measures though, on the basis of a vertical contact between tuff and basanite exposed during quarrying operations in the 1920s. Simpson (1928) has suggested that it is a plug in a vent. The rock is slightly porphyritic, carrying small scattered phenocrysts of olivine, augite and plagioclase. The groundmass is composed of augite, magnetite, biotite, plagioclase and alkali feldspar with analcime forming poikilitic patches up to 2 mm across. The latter accounts for the speckled appearance of many of the weathered rock surfaces.

The intrusion is of interest in that it contains relatively abundant ultrabasic 'nodules', generally less than 5 cm across and consisting of olivine. enstatite, diopside and spinel in varying stages of alteration, they can be best described as altered spinel lherzolites. On weathered surfaces they 'weather in' to form shallow hollows, often with an associated set of radial cracks in the adjacent host rock.

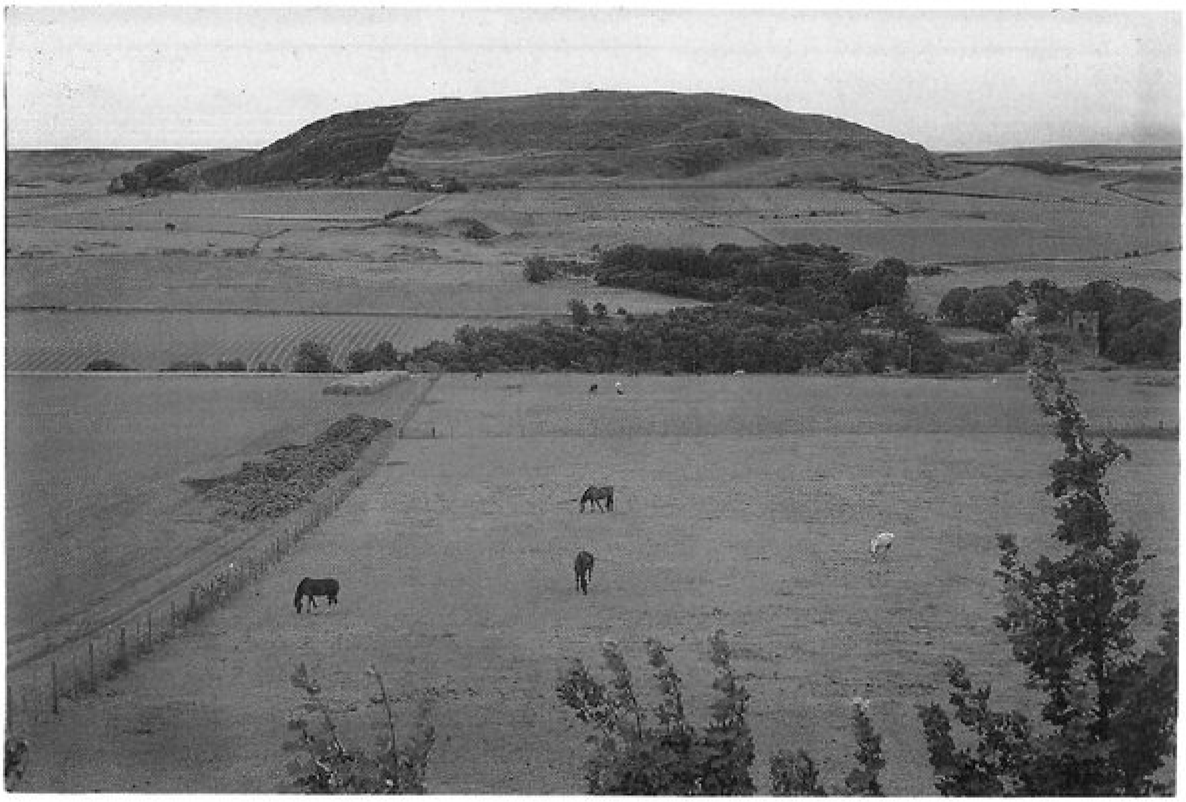
In the central part of the quarry wall a small sheet (about 20 cm thick) of intrusive tuff cuts the basanite. The clasts in this greenish tuff are of varied lithologies, but consist largely of sandstone and biotite-granite, in a matrix composed mainly of quartz grains,

The intrusive tuff is quite dissimilar to the red tuff which outcrops on the south side of the quarry, It is less well sorted in terms of grain-size and variety of components and lacks the opaque fragments of volcanic rock that characterise the red tuff. The fragments of biotite-granite which it contains are of some interest: they possibly have some with the granitic mass of probably Lower Old Red Sandstone age exposed some 500 m to the ESE, on the southern side of the Southern Upland Fault (Simpson 1928).

References



(Map 13) Garleton Hills.



(Plate 2) Phonolitc laccolith, Traprain Law, from Pencraig.