ARDSHEAL HILL AND PENINSULA

I. M. Platten

OS Grid Reference: NM96115551–NM00005734

Introduction

The small intrusions of the Appinite Suite occur typically in clusters. The Ardsheal GCR site occurs in the type area as part of the Duror of Appin cluster (Figure 8.37), which is 8 km in diameter but may extend farther beneath Loch Linnhe. Individual intrusions are numbered on Figure 8.37 to facilitate reference in the text. The Ardsheal Hill and Peninsula area was described initially by Bailey and Maufe (1916), Walker (1927) and Bailey (1960). The area was remapped by Bowes and Wright (1961, 1967) and McArthur (1971) who recorded 20 significant intrusions and breccia pipes. Petrological work has been presented by Bowes and McArthur (1976), Bowes et al *et al*. (1964), Hamidullah (1983), Hamidullah and Bowes (1987), Wright and Bowes (1979) and Platten (1991). Local copper mineralization was reported by Rice and Davies (1979) to be spatially related to the intrusions (intrusion 5). Parts of the cluster outside the site have also attracted attention. The well-known Kentallen intrusion (intrusion 1) is at the NE end of the cluster (see the Kentallen GCR site report) and aspects of the southern part of the cluster, particularly some breccia pipes, were documented by Platten (1982, 1984). The site is far more accessible than any of the other appinitic clusters in Scotland and is frequently visited by undergraduate and other field courses.

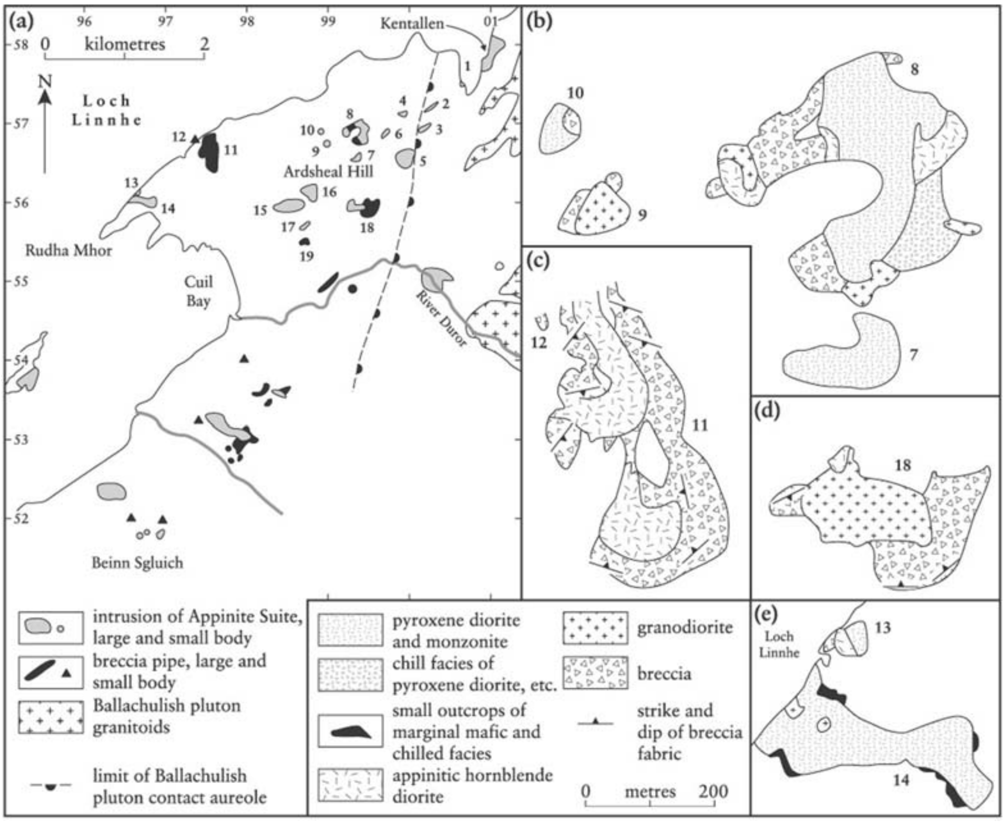


Figure 8.37: (a) The distribution of appinitic intrusions and breccia pipes in the Duror of Appin cluster. Intrusions within the Ardsheal Hill and Peninsula GCR site are numbered for reference in the text. (b), (c), (d) and (e) Examples of outcrop patterns within the Duror of Appin cluster. The intrusion numbers correspond to those given in Figure 8.37a. Figures b, d and e are redrawn with minor modification from Bowes and Wright (1967).

The country rocks are quartzites, metalimestones, phyllites and slates of the Dalradian, Appin Group that have been metamorphosed to greenschist facies before emplacement of the appinitic intrusions (Bowes and Wright, 1967; Treagus and Treagus, 1971). The area is also cut by representatives of a number of dyke swarms (Bowes and Wright, 1967; see the Kentallen GCR site report). NE-trending lamprophyric microdiorites are inferred to be closely related to the appinitic rocks, whereas porphyritic microgranodiorites ('porphyrites') are considered to belong to the late Caledonian dyke swarms (Bailey, 1960). The north-eastern end of the site lies within the aureole of the late Caledonian Ballachulish pluton (Bowes and Wright, 1967; Pattison and Harte, 1985). The site is adjacent to the Great Glen Fault and is cut by associated faults and fracture systems.

Description

The intrusions and breccias are all small, ranging from 50 to 500 m across (Figure8.37). Outlines vary from simple, near circular or oval shapes (intrusions 4, 5, 15 and 16), to irregular bodies with intricate outlines (intrusion 8). The most complex shapes result from the intersection of dioritic intrusions with earlier breccia pipes. Exposed contacts between intrusions and breccias and with the external country rocks are generally steep, hence the inferred pipe form. No evidence of upward closure has been found. Intrusions may penetrate locally between the clasts in the breccias, but generally the contacts are sharp.

The main igneous rock type is a pyroxene-bearing mesocratic diorite or monzodiorite with variable amounts of biotite (intrusions 2–8, 14 and 16) (Hamidullah and Bowes, 1987). The pyroxene is augite/salite, occurring either as large, 2–8 mm crystals, giving the rock a porphyritic aspect or as small grains of less than 1.0 mm. Orthopyroxene is absent or very rare; olivine is present as a minor component. Hornblende may occur as overgrowths on the pyroxenes or as co-existing elongate prisms. A porphyritic chilled facies of these diorites with pyroxene phenocrysts in a fine groundmass occurs in intrusions 8 and 14. However, chilled margins are commonly localized or completely absent, with coarse-grained rocks occurring at the contacts in spite of the small size of the intrusions.

Hornblende diorites with conspicuous euhedral, elongate or equant, prisms of pargasitic hornblende are a distinctive and diagnostic feature of the suite throughout the Scottish Caledonides. Small calcite-filled vugs are a common accessory element. These are the rocks that were originally called 'appinites' (Bailey and Maufe, 1916). They occur generally in four different settings.

1. Single, fairly uniform bodies of mesocratic or melanocratic appinitic diorite may form the bulk of a pipe-shaped intrusion, emplaced in breccia or in country rock (intrusions 11 and 15).

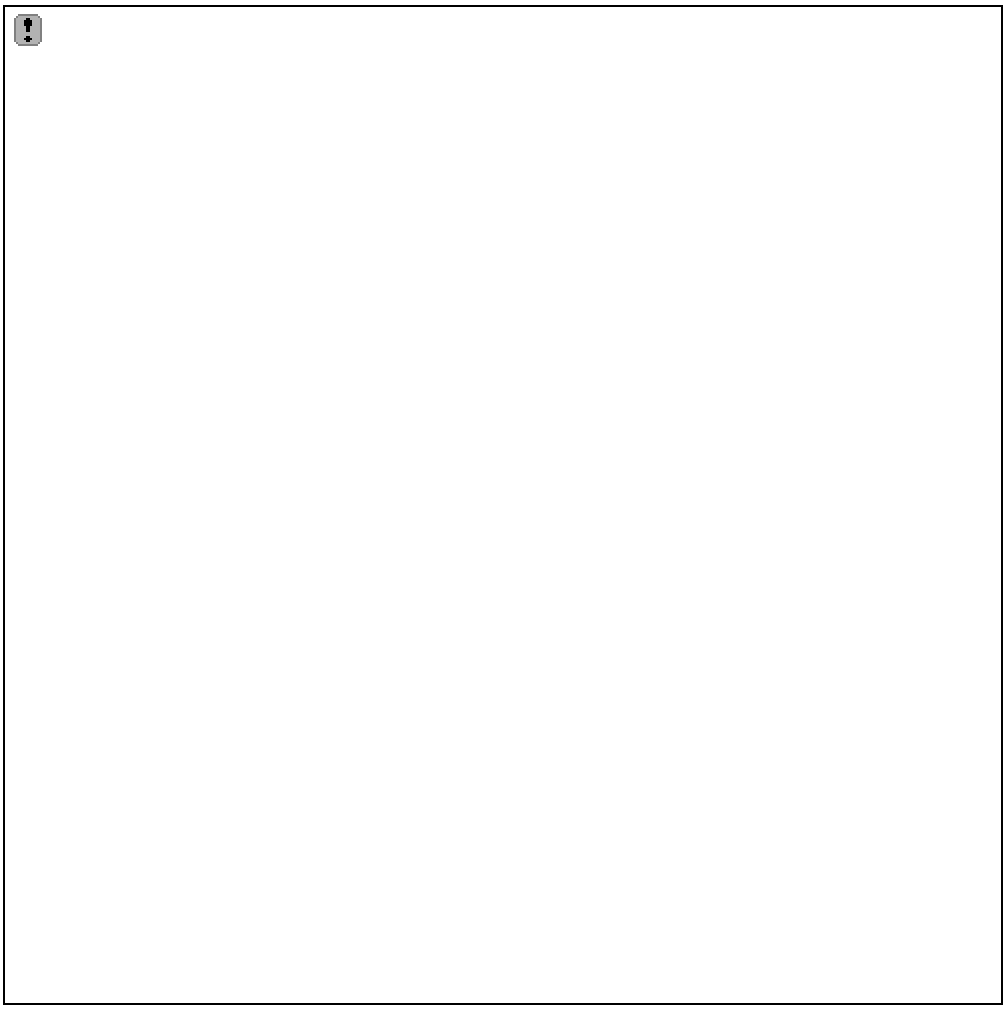
2. Small bodies of meladiorite and hornblendite occur at the margins of pyroxene- and hornblende-bearing diorite intrusions (intrusions 8 and 13). These include near-vertical layers of comb-textured hornblende that point to in-situ growth on the walls of the pipe. These bodies commonly show steep layering, marked by colour index or textural variation.

3. Small (< 20 m) bodies of very variable hornblende meladiorite and hornblendite with characteristically equant, euhedral to subhedral hornblendes developed by alteration of earlier dioritic rocks (intrusions 11 and 12).

4. Pegmatitic veins and patches of mesocratic or leucocratic hornblende diorite may be found in all of the three above situations.

Leucocratic hornblende and pyroxene quartz-diorites and monzonites, and biotite and hornblende granodiorites are present. Small druses and minor sulphides are not uncommon in these rocks. Some form discrete bodies with only minor amounts of dioritic or mafic material at their margins (intrusion 18). They also occur as pipes, dykes, patches and veins in the other igneous rocks (intrusions 5, 8 and 14). Some granodiorite dykes penetrate the country rocks for a short distance (intrusions 14 and 18).

Small bodies of melanocratic or ultramafic rock are a common regional feature of the Appinite Suite. At the Ardsheal GCR site, biotite pyroxenite and biotite peridotite are common as small bodies at the margins of pyroxene diorite intrusions (intrusion 14). Thin (1–20 mm) anorthosite layers occur at the inner margins of these ultramafic bodies (Figure8.38a) and within the main pyroxene diorite intrusions (intrusion 14). Hornblendite and meladiorite occur as small bodies at the margins of both hornblende diorite and pyroxene diorite intrusions (intrusions 3 and 8).



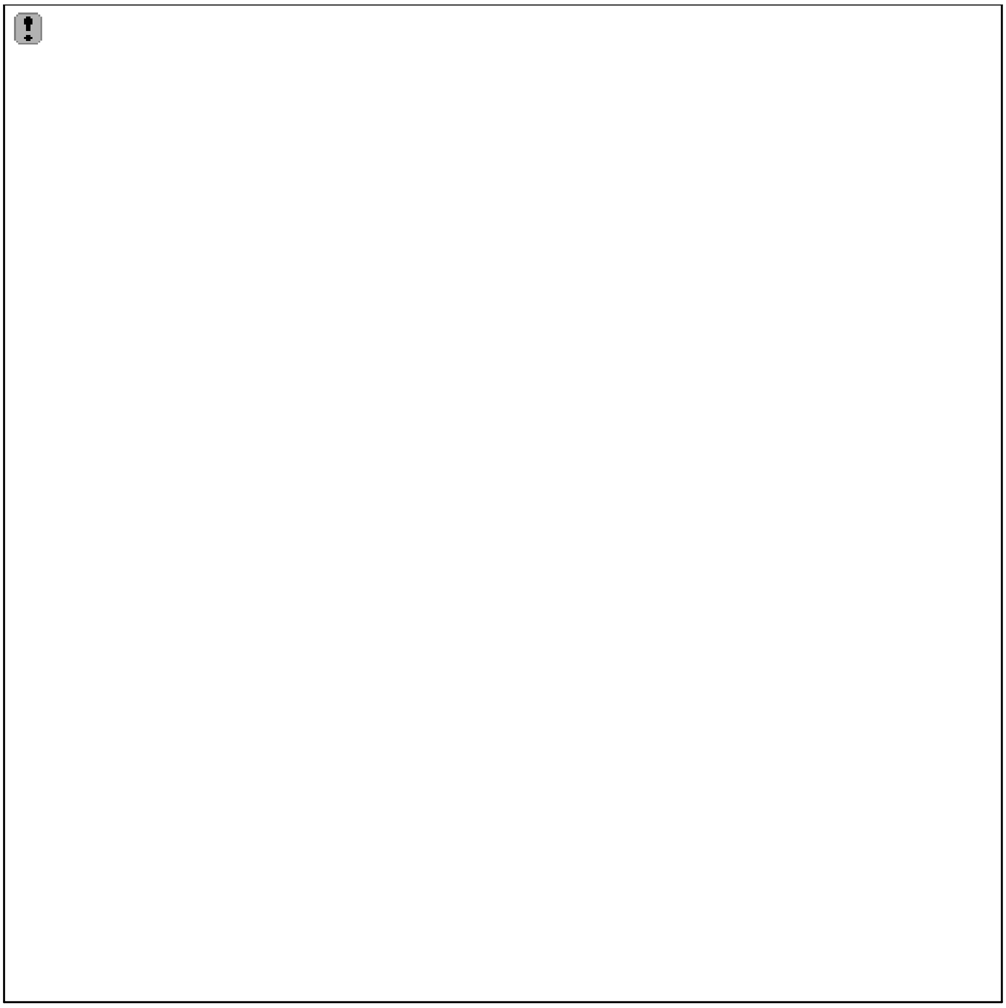


Figure 8.38: (a) Wall-parallel, steeply dipping layering of meladiorite and anorthosite at the SW margin of intrusion 14, in the Duror of Appin cluster (see Figure 8.37). (Photo: I.M. Platten.) (b) Composite dyke, Back Settlement, Ardsheal. The dyke, which cuts intrusion 12 to the NE, dips steeply towards the observer, with breccia in the footwall and lamprophyric microdiorite in the hanging wall. Magma has penetrated between breccia clasts at the irregular contact. (Photo: D. Stephenson.)

The intrusions have narrow (40–100 m) contact metamorphic aureoles (Platten, 1982) showing fine-grained, flinty hornfels with cordierite spots in pelites (intrusions 15 and 18). Localized partial melting and mobilization has been noted in pelites and feldspathic quartzites within a few metres of contacts with intrusions 14 and 18 (Platten, 1982). In the northern intrusions (1, 2, 3 and 5), later contact metamorphic effects of the Ballachulish pluton obscure the contact metamorphism due to the appinitic rocks (see the GCR site report).

Breccia pipes and rare dykes are associated with the appinitic intrusions (Bowes and Wright, 1961, 1967; Platten, 1982, 1984). These are characteristically composed of local country rock fragments that show evidence of rotation and local transport. Clasts are generally angular and most lie in the size range 0.05–1.0 m; sand-sized material is usually absent. Rounded clasts, mostly of quartzite, do occur as a minor component in some breccias (intrusion 11). Internal divisions may be mapped within some breccia pipes based on variations in clast size, rounding and lithology (intrusions 8 and 11). Breccias with abundant plate-shaped fragments show planar fabrics defined by parallel orientation of clasts (intrusions 11 and 18). In breccias dominated by phyllite clasts, most of the clasts are deformed and show face to face contacts leaving little pore space (intrusions 8 and 18). Breccias dominated by quartzite clasts show less deformation of clasts and some trace of pre-cement pore space may remain. This has a drusy quartz filling with minor pyrite and a carbonate mineral.

Interpretation

Bowes and Wright (1961, 1967) interpreted the breccias as forming as the result of explosions, largely based on the extensive fracturing of the Dalradian host rocks and the deformation of the breccia fragments. However the diorite intrusions, breccias, contact hornfels and later dykes of microdiorite and porphyritic microgranodiorite are also fractured and cut by drusy quartz veins. The timing of fracturing is discussed in the Kentallen GCR site description in which it is shown that the extensive fracturing is a very late event and thus unrelated to breccia emplacement. The breccia pipes at Ardsheal are now interpreted as having formed by the mechanisms proposed by Platten and Money (1987) for the Cruachan Cruinn breccias, near Crianlarich. Country rock collapse occurred above intrusions of volatile rich magma from which a vapour phase had separated. This produced narrow columns of fractured country rock which were fluidized and slightly transported as the vapour phase vented to the surface. Deformation of the clasts is interpreted as a post-breccia compaction driven by gravitational loading from overlying breccia and hydraulic loading by adjacent magma.

Emplacement of pipe-shaped intrusions resulted from the collapse of the country rock between the breccia pipes into an underlying, locally differentiated and de-gassed, magma chamber. Some very small intrusions (6, 7, 9 and 10) may have resulted from the removal, either upwards or downwards, of the clastic fill of breccia pipes. The relatively coarse-grained nature of the intrusions in even the smallest pipes and the evidence of local partial melting of wall rocks points to an active circulation of magma, probably with throughput to the surface. The cumulate marginal mafic and ultramafic rocks and the anorthositic layered rocks crystallized *in situ* on the walls from the convecting dioritic magmas. The more uniform cores, occupied by dioritic or evolved granodiorite, crystallized after convection ceased. Variation in the effectiveness of venting volatiles to the surface controlled the ferromagnesian mineralogy, pyroxene marking an open system and hornblende a closed system. Evolved leucocratic rocks intruded into the diorites may reflect the continued presence of magma bodies at depth below hot, but crystalline, diorite intrusions or simple filter-pressing of the lower parts of the diorite. A return to breccia formation is only known at one site (intrusion 12) where a breccia dyke cuts intrusive rocks (Figure 8.38b).

Conclusions

This is the type area of the Appinite Suite. It illustrates the extreme range of rock types (ultramafic, intermediate and acid) present in these highly differentiated intrusions, including the hornblende meladiorites with conspicuous euhedral hornblendes that characterize the suite. The site also provides excellent examples of the breccia pipes that are widely associated with the suite.

Igneous activity began with the formation of breccia pipes above underlying, volatile-saturated basic magma bodies. Primitive and more-evolved magmas were then emplaced, both into the breccia pipes and the country rock. Convection within the magma led to the accumulation of crystals against the walls of the pipes, which changed the composition of the remaining magma (crystal fractionation) to produce varied rock types. If the pipes remained sealed, volatiles were trapped and hydrous minerals crystallized (e.g. hornblende). These ‘closed system' conditions alternated with ‘open system' conditions in which the pipes functioned as feeders to surface volcanoes. Volatiles were released, possibly by explosive eruptions, and non-hydrous minerals crystallized in the remaining magma (e.g. pyroxene). Subsequently the cluster was cut by the late Caledonian Ballachulish pluton.

Reference list

Bailey, E. B. (1960) The geology of Ben Nevis and Glencoe and the surrounding country, 2nd edition. *Memoir of the Geological Survey of Great Britain*, Sheet 53 (Scotland).
Bailey, E. B. and Maufe, H. B. (1916) The geology of Ben Nevis and Glen Coe and the surrounding country, 1st edn. *Memoir of the Geological Survey of Great Britain*, Sheet 53 (Scotland).
Bowes, D. R. and McArthur, A. C. (1976) Nature and genesis of the appinite suite. *Krystalinikum*, **12**, 31–46.
Bowes, D. R. and Wright, A. E. (1961) An explosion-breccia complex at Back Settlement, near Kentallen, Argyll. *Transactions of the Edinburgh Geological Society*, **18**, 293–313.

Bowes, D. R. and Wright, A. E. (1967) The explosion breccia pipes near Kentallen, Scotland and their geological setting. *Transactions of the Royal Society of Edinburgh*, **67**, 109–43.

Hamidullah, S. (1983) Petrogenetic studies of the appinite suite, northwestern Scotland. Unpublished PhD thesis, University of Glasgow.

Hamidullah, S. and Bowes, D. R. (1987) Petro-genesis of the appinite suite, Appin District, Western Scotland. *Acta Universitas Carolinae – geologica*, **4,** 295–396.

McArthur, A. C. (1971) On the structural control of Caledonian igneous masses in the southwest Highlands of Scotland. Unpublished PhD thesis, University of Glasgow.

Pattison, D. R. M. and Harte, B. (1985) A petrogenetic grid for pelites in the Ballachulish and other Scottish thermal aureoles. *Journal of the Geological Society of London*, **142**, 7–28.

Platten, I. M. (1982) Partial melting of feldspathic quartzite around late Caledonian minor intrusions in Appin, Scotland. *Geological Magazine*, **119**, 413–19.

Platten, I. M. (1984) Fluidised mixtures of magma and rock in a late Caledonian breccia dyke and associated breccia pipes in Appin, Scotland. *Geological Journal*, **19**, 209–26.

Platten, I. M. (1991) Zoning and layering in diorites of the Scottish Caledonian Appinite suite. *Geological Journal*, **26**, 329–48.

Platten, I. M. and Money, M. S. (1987) Formation of late Caledonian subvolcanic breccia pipes at Cruachan Cruinn, Grampian Highlands, Scotland. *Transactions of the Royal Society of Edinburgh: Earth Sciences*, **78**, 85–103.

Rice, C. M. and Davies, B. (1979) Copper mineralisation associated with an appinite pipe in Argyll, Scotland. *Transactions of the Institution of Mining and Metallurgy (Section B: Applied Earth Sciences*), **88**, 154–60.

Treagus, J. E. and Treagus, S. H. (1971) The structures of the Ardsheal peninsula, their age and regional significance. *Geological Journal*, **7,** 335–46.

Walker, F. (1927) The igneous geology of Ardsheal Hill, Argyllshire. *Transactions of the Royal Society of Edinburgh*, **55**, 147–57.

Wright, A. E. and Bowes, D. R. (1979) Geochemistry of the Appinite Suite. In *The Caledonides of the British Isles – Reviewed* (eds A. L. Harris, C. H. Holland and B. E. Leake), *Geological Society of London Special Publication*, No. **8,** pp. 599–704.